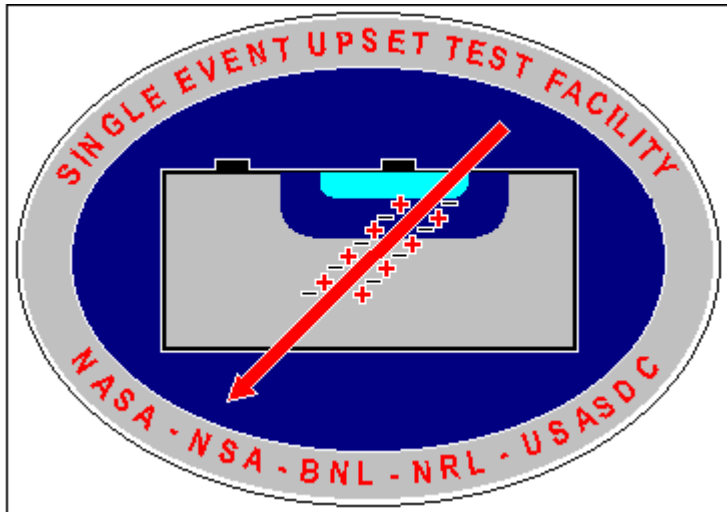


History of the SEU Test Facility



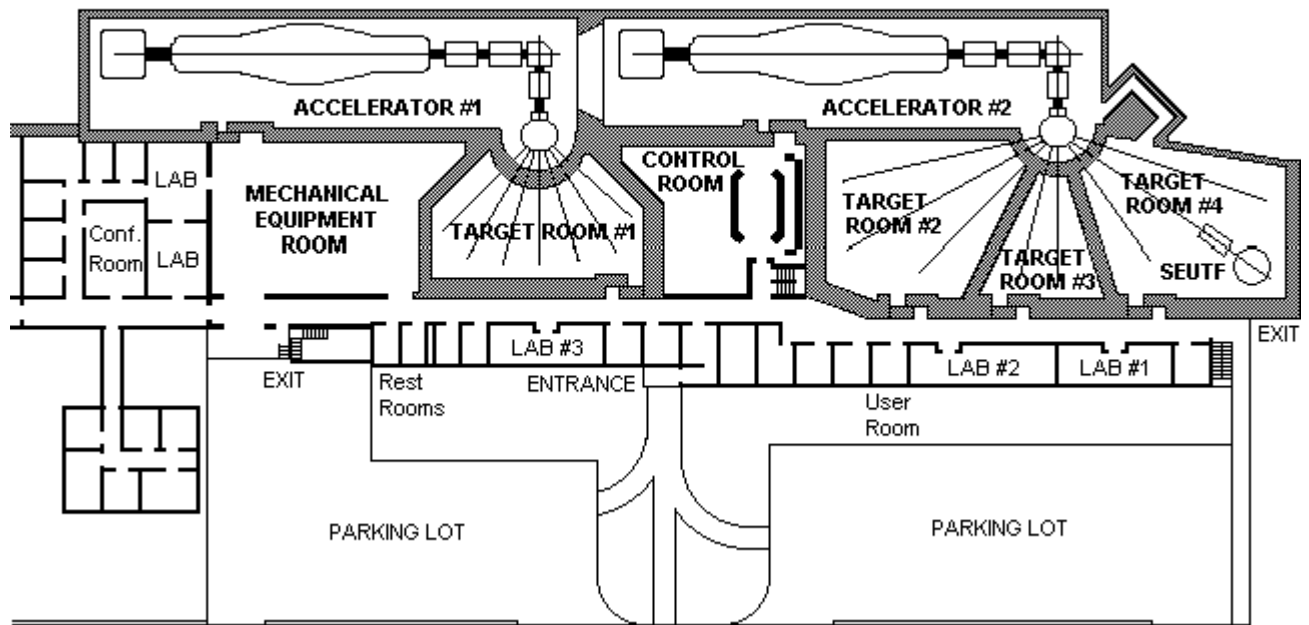
- In response to the raising demand for testing, the Single Event Facility Group was formalized in 1987 as a consortium of several U.S. Government agencies:

- NSA - National Security Agency
- NASA - National Aeronautic and Space Administration
- NRL - Naval Research Laboratory
- USASDC - U.S. Army Strategic Defense Command

with a goal to develop the Single Event Upset Test Facility available to all outside users including government, industry, and academic institutions. From the beginning the emphasis was given to simple, efficient, flexible, and user friendly operation with minimum user training and crew requirements, resulting in high data throughput and low cost per data point.

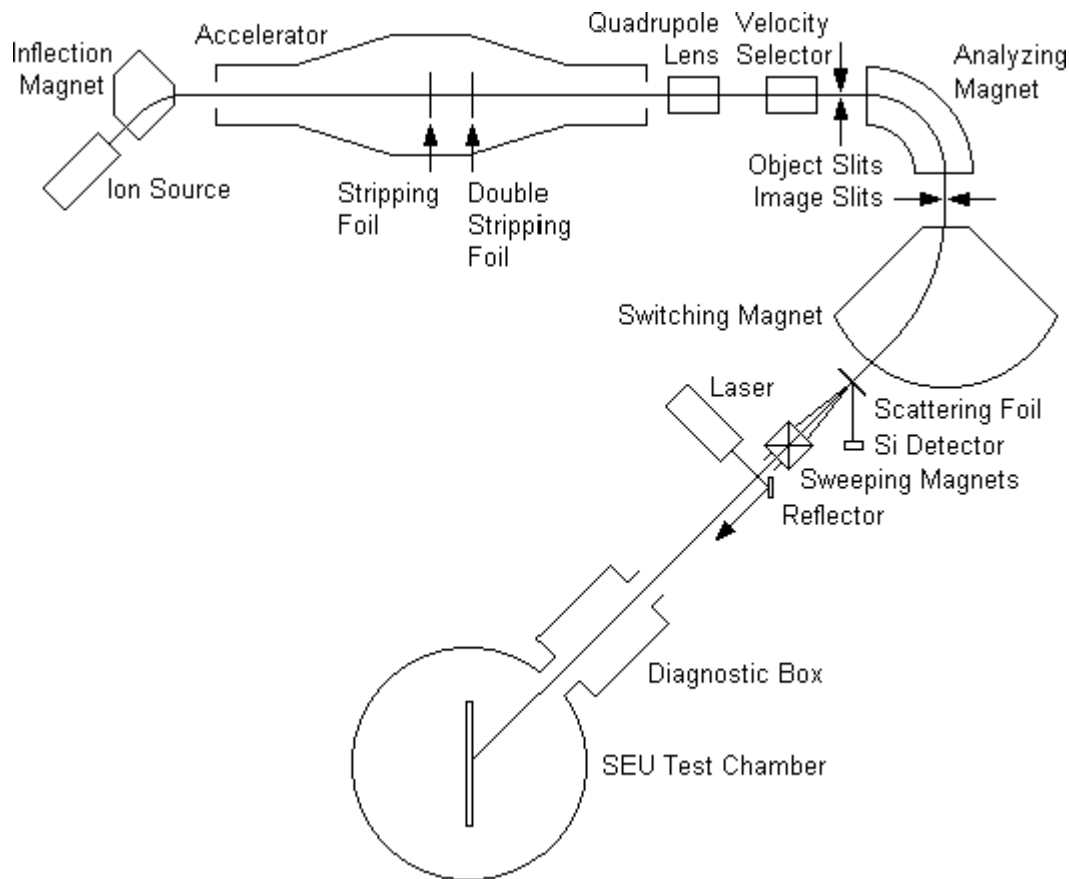
- The facility was built in 1987 as a joint project of the Single Event Facility Group and Brookhaven National Laboratory and became operational in March 1988. The Brookhaven Twin Tandem Van de Graaff accelerator provides the heavy ion beams. At about this time, one of the twin accelerators (serial number MP7) had been modified and improved in performance in order to function as a heavy ion injector for the 30 GeV Alternating Gradient Synchrotron. Since the low energy nuclear physics research was discontinued and the heavy ion operation of AGS was carried on for only a small part of each year, there were large blocks of operating time available for SEU testing. In 2001, the MP7 accelerator became the main injector of the new Relativistic Heavy Ion Collider (RHIC). Since the beam demand for the RHIC accelerator would not be compatible with the continuous use of the SEU Test Facility, the second twin accelerator (serial number MP6) has been upgraded in a similar way as the MP7 accelerator a decade ago. This arrangement also necessitated design and installation of a bypass beamline from the MP6 around the MP7. The MP6 accelerator can now be used by the SEU Test Facility when the MP7 is not available and the facility can operate without major interruptions throughout the entire year. The SEU Test Facility is located at the 55° east beam line in Target Room 4, Building 901-A.

**TWIN TANDEM VAN DE GRAAFF ACCELERATOR FACILITY
BROOKHAVEN NATIONAL LABORATORY**



- Over the past years the Brookhaven SEU Test Facility has built a solid reputation in providing the controlled environment required for SEU testing of electronic devices and the use of the facility has been steadily increasing. In 1991, the facility was upgraded by replacing the main computer running under Rocky Mountain (HP) Basic, rebuilding the positioning stage, and developing a new user friendly operating software with pull-down menus, pop-up windows, and mouse support running under Microsoft DOS. Other systems, such as the vacuum interlock, shutter control, and the photomultiplier high voltage control were redesigned and/or rebuilt a year later. Since 1993 the operating software has been running under Microsoft Windows 3.1 and since 1996 under Microsoft Windows for Workgroups 3.11. A completely new software running under Microsoft Windows 98 was completed in 2001. All necessary information to operate the facility can be found in this help file, which supersedes the printed User Guide, now obsolete.

Beam Quality Control



- Single charged negative ions are generated in a sputter-type ion source operated at -150 kV. Preliminary mass selection is performed by an inflection magnet with resolution 2.5 %. The magnet is operated at -120 kV and provided with a hall-probe gaussmeter. The negative 150 keV ions are then injected into the accelerator contained in a pressure vessel filled with insulating gas (45 % SF₆ + 47 % N₂ + 8 % CO₂) pressurized to about 10 atm. They are accelerated in an evacuated acceleration tube to the positive high voltage terminal operated at voltages 1 to 14.5 MV, gaining energy 1 to 14.5 MeV.
- In the high voltage terminal, the single charged negative ions are converted into multiple charged positive ions by passing through a thin carbon stripping foil. The foil strips away several electrons from the ions but it is thin enough (typically 5 mg/cm²) to cause a negligible energy loss (less than 0.05 % of the final energy for the heaviest ions). The multiple charged positive ions (with a discrete gaussian charge state distribution) are then accelerated away from the positive high voltage terminal, gaining energy up to 14.5 MeV/e. A second stripping foil located at 75 % of terminal voltage can be optionally used to achieve higher charge states and higher energy gain in the last stage of acceleration.
- A single charge component is selected by a highly precise double focusing analyzing magnet in conjunction with narrow object and image slits according to its magnetic rigidity (momentum divided by charge). A cross-field electrostatic and magnetic velocity selector (Wien filter) has been installed in front of the analyzing magnet. This velocity selector acts as a highly effective additional filter, which has essentially eliminated weak beam contaminants that were occasionally observed in the past. The field of this magnet is measured by a nuclear magnetic resonance probe and the magnetic rigidity of the selected component is determined with resolution better than 0.1 %. A computer search is performed to identify possible beam contaminants and charge states which may generate contaminants with similar magnetic rigidities are avoided. For further verification, at least three different charge states are selected by varying the terminal voltage. The measured terminal voltages and the components relative intensities are evaluated.

- The selected beam is deflected by the switcher magnet into the 55° east beamline and allowed to traverse a thin multiple scattering gold foil (600 mg/cm² or more). Some ions are scattered into the ion-implanted silicon detector, the pulse-height spectrum of which is recorded by a multichannel analyzer. If different charge components are present they will have different energies and produce multiple peaks. If a single peak is observed at the correct position, a small energy loss in the scattering foil is calculated and the beam is sent to the target room 4.
- The beam flux can be adjusted by utilizing ion source controls, a variable aperture at the accelerator entrance, object and image slits settings, scattering foil thickness, and variable beam sweeping amplitudes with the help of a sweeping magnet. Beam uniformity is achieved by multiple beam scattering in the gold foil (about 70 ft upstream from the user test board), by horizontal and vertical sweeping, or by combination of the two methods. Different sweeping frequencies between 5 and 20 Hz are selected for the vertical and horizontal magnets and their lack of synchronization is checked by an oscilloscope.

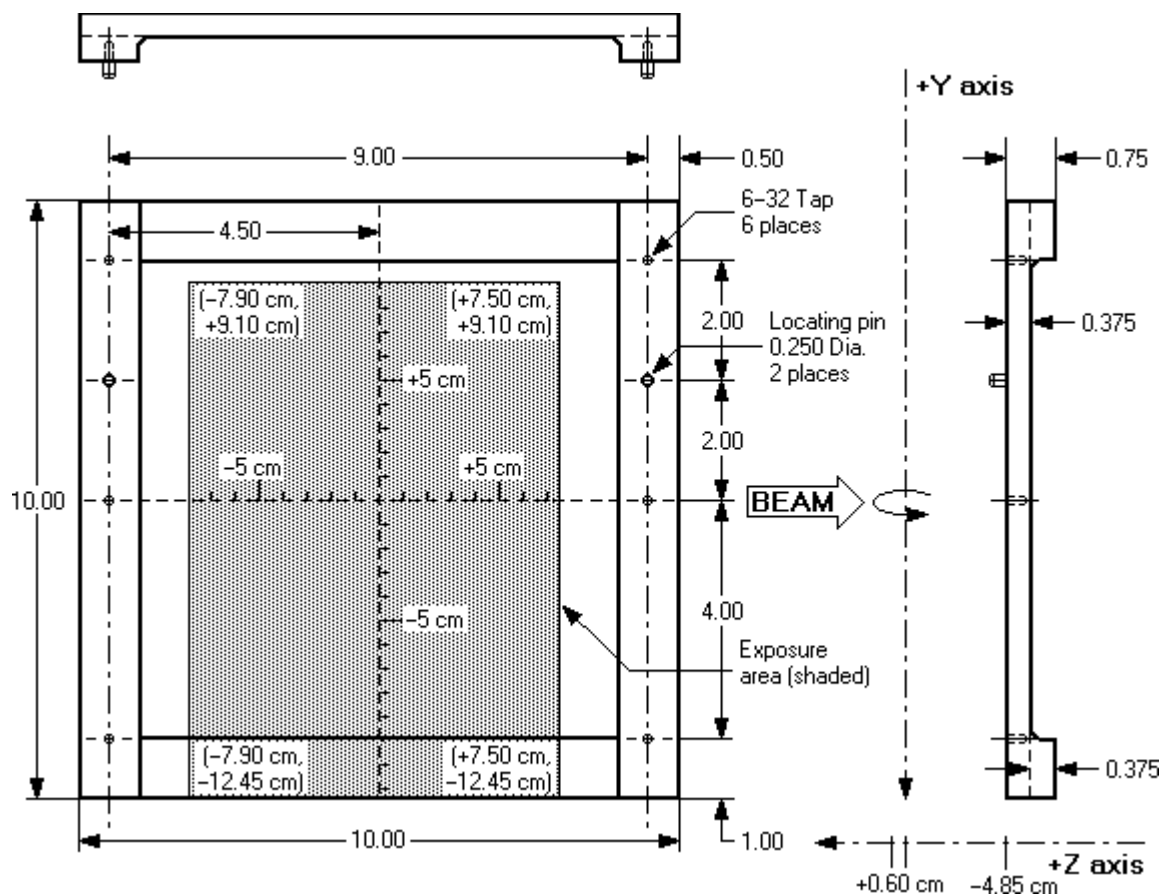
SEU Test Facility Features

- Over 40 different elements including 60 different isotopes over the full range of the periodic table are routinely accelerated. Most isotopes can be changed in less than 30 minutes and energy changes can be accomplished in less than 5 minutes.
- The beam can be focused down to less than 2 mm in diameter or, on the other hand, easily defocused and/or swept for uniformly exposing areas as large as 3 cm in diameter.
- The beam dosimetry hardware such as detectors, apertures, and beam shutters are installed in a separate diagnostic vacuum chamber. The beam dosimetry can be performed while the experimental vacuum chamber is under atmospheric pressure and open.
- Evacuation and ventilation of the diagnostic and test vacuum chambers are fully automatic. Evacuation takes less than 5 minutes, ventilation less than 1 minute.
- Several different vacuum feedthrough plates for cable connections between the tester and the device under test are readily available. Other plates can be custom made. Two different plates can be installed simultaneously.
- The device positioning stage features seven types of motion. The device can be positioned into the beam by moving in X- and Y-directions (horizontal and vertical coordinates perpendicular to the beam) and rotated around the horizontal axis perpendicular to the test board. The beam diameter can be adjusted by a variable iris aperture. The particle angle of arrival can be changed by tilting the test board around the vertical axis. Changing of the particle angle of arrival requires placing the device on the vertical axis of rotation. This is accomplished by moving the device in the Z-direction (horizontal coordinate parallel to the beam) in order to compensate for the device and/or socket height above the user test board. The iris aperture tilt is slaved to the board tilt in order to keep the beam spot circular at any particle angle of arrival.
- Devices are initially positioned by simulating the beam with visible laser light and by using a joystick. The positions are saved and can be recalled at a later time.
- Calculation of LET and range in Si, GaAs, and other target materials is based on Ziegler's Tables. Correction of the beam energy, LET, and range for an energy loss in a composite passivation layer is possible.
- The automatic beam energy and LET monitoring system is calibrated by Am-241 alpha particles and thus independent of the accelerator controls. Hard copies and text data files of the energy spectra are available.
- The user selected fluence is accumulated for the device under test regardless of the particle angle of arrival. The flux level can be adjusted in approximately 2 minutes.
- A test run can be started and aborted either manually from the keyboard, externally by a user supplied TTL compatible signal, or by sending an appropriate command from a host computer equipped with a GPIB interface.
- Automatic on-line plotting of the upset cross section as a function of effective LET for each device under test provides the user an early feedback. Hard copies of the on-line plots are available.

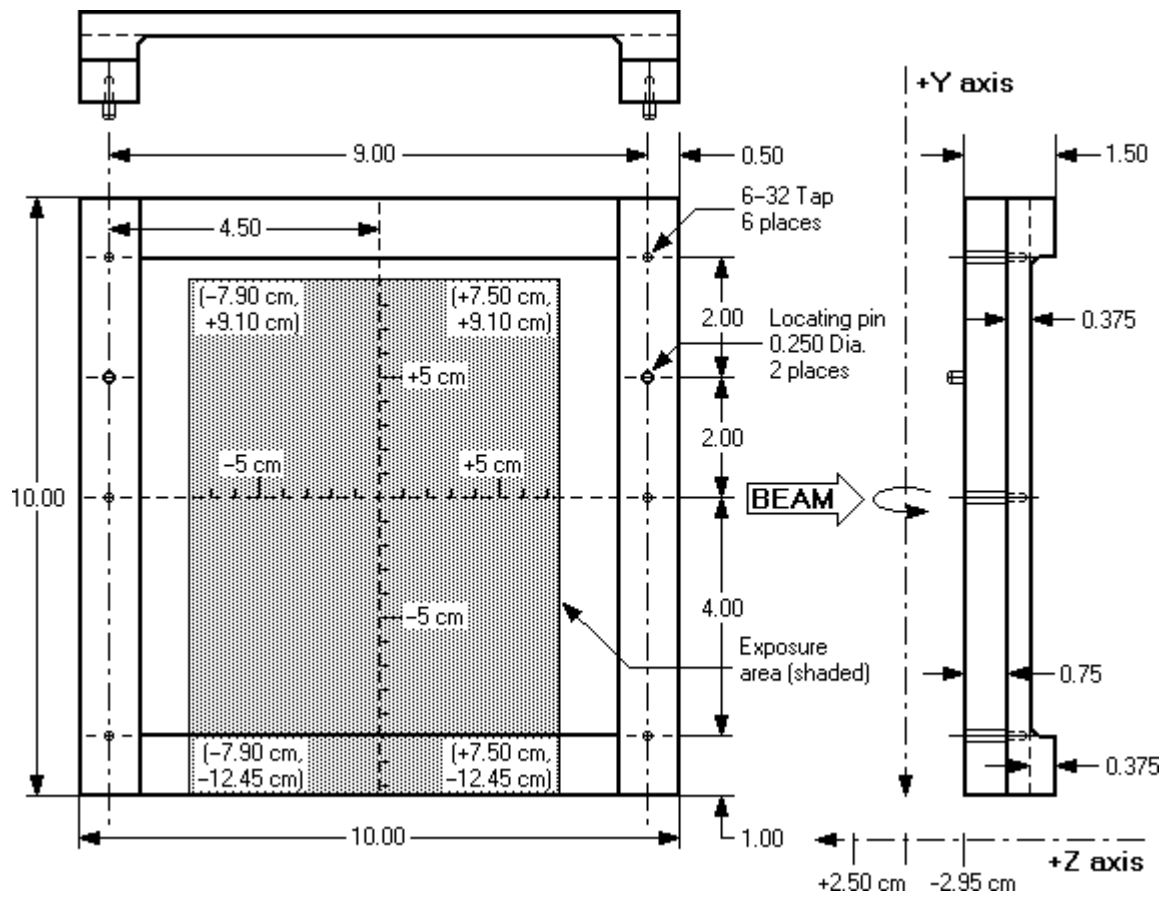
- Data management is fully automatic. Data is automatically printed and saved on a file after every test run. Data files are in ASCII format and can be processed by any text editor (such as Windows Notepad or Wordpad) or imported to a spreadsheet program (such as Microsoft Excel).
- The SEU Test Facility can be controlled from a host computer as a device on the GPIB interface bus.
- The SEU Test Facility application runs under Microsoft Windows 98. It can be executed and control the SEU Test Facility from any computer connected in the Local Area Network (LAN).
- The test equipment is supplied by the user.

Test Board

- Test board dimensions:
 - 10 x 10 inch normally
 - 18 x 18 inch possible when mounting the test board symmetrically on the frame.
 - 6 x 10 inch working area
- The test board must have two appropriately spaced and sized holes for the mounting frame locating pins and at least four (out of six) holes for No. 6 mounting screws.
- Test boards smaller than 10 x 10 inch can be mounted with the help of various custom made mounting adapters. For test boards larger than 10 x 10 inch, any excess dimension over the 10 x 10 inch mounting frame (except at the top) necessitate disabling of the roll angle rotation.

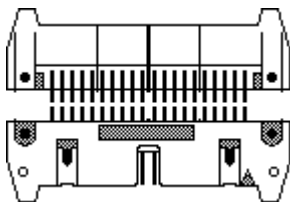


- When varying the effective LET by changing the particle angle of arrival (i.e., by tilting the test board around the vertical axis), the device under test has to be located on the vertical axis of rotation in order to stay in the beam at all tilt angles. To compensate for the device and/or socket height above the test board, it is usually necessary to move the test board backwards in the direction of the beam. The available travel in this direction (and consequently the maximum acceptable height of the test board, socket and the device itself combined) used to be approximately 1 inch. The positioning stage has been equipped with a new test board mounting frame which allows to compensate for the socket and device height up to almost 2 inches. The new frame allows less space than the old frame in the back of the test board. Test boards with large electronic components and/or connectors mounted on their back side (prepared for the old frame in the past) can still be mounted on the new frame when using two test board adapters (available at the SEU Test Facility), which essentially convert the new frame to the old one, but reduce the available travel in the beam direction back to 1 inch.



Cable Connections

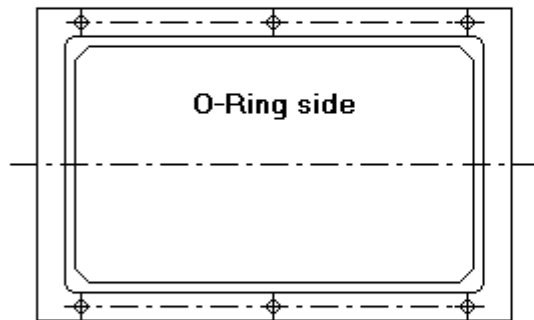
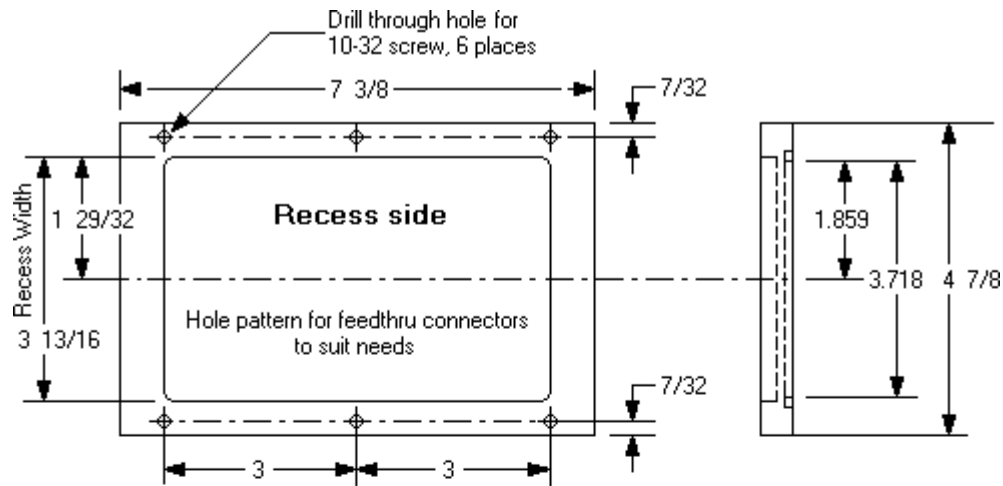
- Minimum cable lengths:
 - 2-3 ft outside the test vacuum chamber, depending on the connections to your tester
 - 3 ft inside the test vacuum chamber (2 ft when disabling the roll angle rotation)
- The connector feedthrough plates are exchangeable. Two plates can be used simultaneously.
- The connector feedthrough plates can be custom made (see the attached blank plate drawing). Proper O-rings are available at the SET Test Facility. It is recommended that any home made feedthrough plate be sent to the SEU Test Facility for a vacuum leak check prior to your scheduled experiment.
- The readily available plates include:
 - Six male-to-male 40-pin insulation displacement ribbon cable connectors (IDC connectors). Each feedthrough consists of two sealed IDC male headers soldered back-to-back and therefore inverts the pin pattern in the plane of the connector. Simple 40-pin adapters (12 pieces) are available at the SEU Test Facility to invert the pins one more time in the same plane resulting in one-to-one pin pattern. Each adapter consists of a short piece of ribbon cable (about 2 inches) with IDC female connectors on both ends plus another pair of IDC male headers soldered back-to-back.



- Four male-to-male 50-pin insulation displacement ribbon cable connectors (IDC connectors). Each feedthrough consists of two sealed IDC male headers soldered back-to-back, just like the 40-pin headers of the above feedthrough plate, and therefore inverts the pin pattern in the plane of the connector. Simple 50-pin adapters (5 pieces) are available at the SEU Test Facility to invert the pins one more time in the same plane resulting in one-to-one pin pattern.
- Eight male-to-male 60-pin insulation displacement ribbon cable connectors (IDC connectors). Each feedthrough consists of one sealed IDC male header facing the atmosphere side and its bare pins on the vacuum side. This feedthrough also inverts the pin pattern in the plane of the connector. Simple 60-pin adapters (8 pieces) are available at the SEU Test Facility to invert the pins one more time in the same plane resulting in one-to-one pin pattern.
- Eight 37-pin D-subminiature connector (four of each sex) to 50-pin female ribbon cable IDC connector adapters are available at the SEU Test Facility. The adapters can be used with the above 50-pin IDC connector feedthrough and pin pattern reflecting adapters to achieve 37-pin D-subminiature connector one-to-one pin pattern. Male and female 37-pin D-subminiature connectors can be placed inside or outside the vacuum chamber as necessary.
- Six male-to-female 37-pin D-subminiature cable connectors (D-sub connectors). Each feedthrough consists of two sealed D-sub connectors, male and female, soldered back-to-back. Three male and three female connectors face the atmosphere side, each with the opposite sex on the vacuum side. The pin pattern of this feedthrough is one-to-one and no adapters are necessary.
- One 37-pin and one 25-pin male-to-female D-subminiature connector plus six female-to-female BNC coaxial connectors. The plate material is aluminum. Shielding connections of all 6 coaxial connectors are grounded to the vacuum chamber. The male D-sub connectors are outside and the female ones inside the experimental vacuum chamber. The pin pattern is one-to-one. Gender changers of both sexes (male-to-female and female-to-male, one each) for both the 37-pin and 25-pin connector are also available. When this feedthrough is left mounted but disconnected, the

dangling D-sub connectors outside the test vacuum chamber are occasionally caught by the hydraulic scissor table and damaged. Since the feedthrough is not well designed, its use is discouraged.

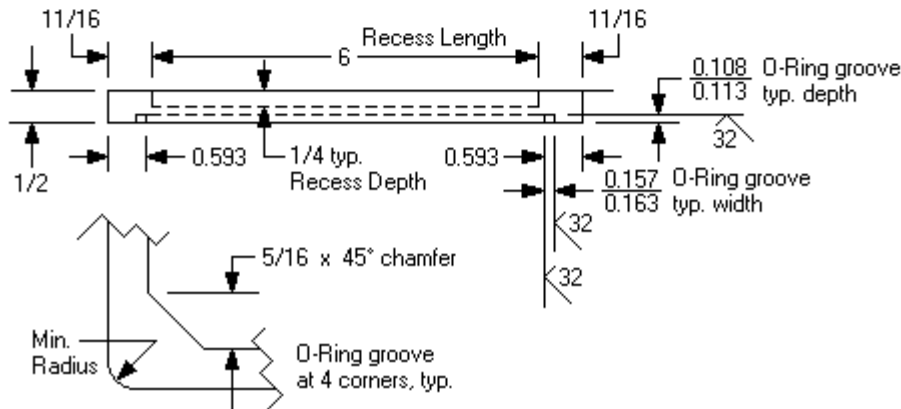
- Thirty female-to-female SMA coaxial connectors. The plate material is aluminum. Shielding connections of all 30 SMA coaxial connectors are grounded to the vacuum chamber.
- Fifteen female-to-female BNC coaxial connectors. The BNC coaxial connectors can be easily changed to the high voltage SHV coaxial connectors. The plate material is aluminum. Shielding connections of all 15 BNC or SHV coaxial connectors are grounded to the vacuum chamber.
- Fifteen female-to-female BNC coaxial connectors plus 0.25 inch diameter plastic tubing for cooling water input and output. The BNC coaxial connectors can be easily changed to the high voltage SHV coaxial connectors. The plate material is aluminum. Shielding connections of all 15 BNC or SHV coaxial connectors are grounded to the vacuum chamber.
- Fifteen female-to-female BNC coaxial connectors. The BNC coaxial connectors can be easily changed to the high voltage SHV coaxial connectors. The plate material is plastic. Shielding connections of all 15 BNC or SHV coaxial connectors are insulated from each other and from the vacuum chamber.



Material:
6061-T6 Aluminum

Use a 9/64 Dia O-Ring

NOTE:
Must be a $\sqrt{32}$ finish
on both sides and bottom
of O-Ring groove

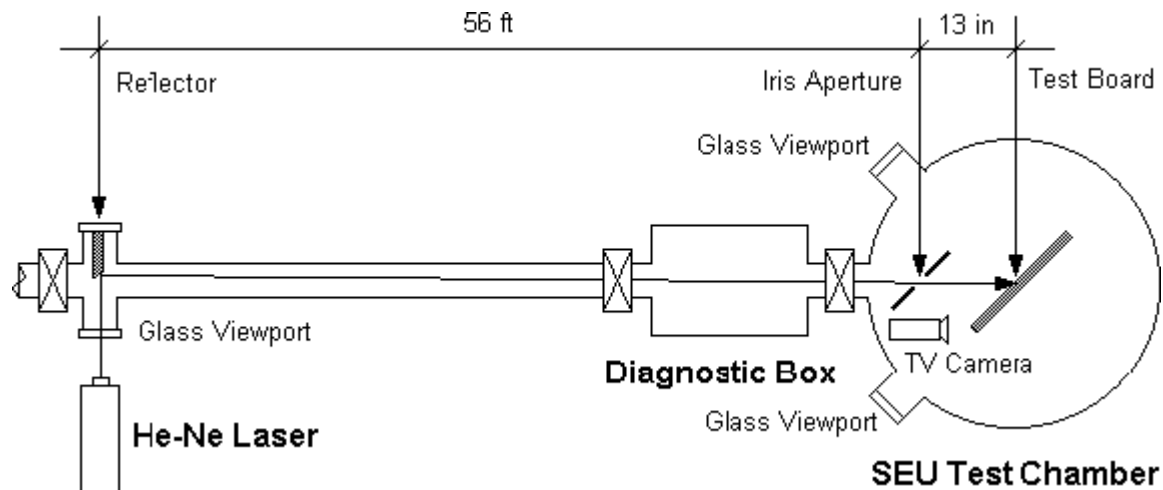


Vacuum Requirements

- Pumping and venting of both the diagnostic and test vacuum chambers is fully automatic. Pumping takes less than 5 min, venting less than 1 min.
- The vacuum pressure in the test chamber is typically less than $8\text{E-}04$ torr at the end of the pumping sequence and less than $2\text{E-}04$ torr 10 min later. The vacuum pressure eventually drops below $5\text{E-}06$ torr after about three days of pumping.
- The vacuum pressure may deteriorate due to outgassing from certain types of aluminum heat sinks and electrolytic capacitors on the test board. Please note that electrolytic capacitors may also explode or otherwise fail when placed in vacuum.

Laser Beam

- The laser beam nearly coincidental with the ion beam serves as a visual aid in positioning the device under test into the invisible heavy ion beam. The laser beam is reflected into the beamline by a permanently mounted reflector prism approximately 1 inch off the beamline center in order not to block the heavy ion beam. Using the distance from the reflector to the iris aperture (56 ft) and the distance from the iris aperture to the test board (13 inch), the laser beam spot is estimated to be less than 0.02 inch (0.5 mm) right of the heavy ion beam spot when looking at the test board down the beamline.



- The following information is provided in order to help you in estimating the effects (if any) of the laser beam on the devices under test:

• Laser type:	He-Ne		
• Wavelength:	6,320 Å	11,520 Å	33,910 Å
• Output power:	6 mW	1 mW	1.2 mW
• Beam diameter:	0.79 mm	0.72 mm	1.88 mm
• Divergence:	1.0 mrad	1.2 mrad	2.3 mrad

The optical path between the laser and the test board is approximately 60 ± 0.5 ft. Please note that the infrared components are severely attenuated by the glass viewport and do not reach the test board.

Heavy Ion Beams

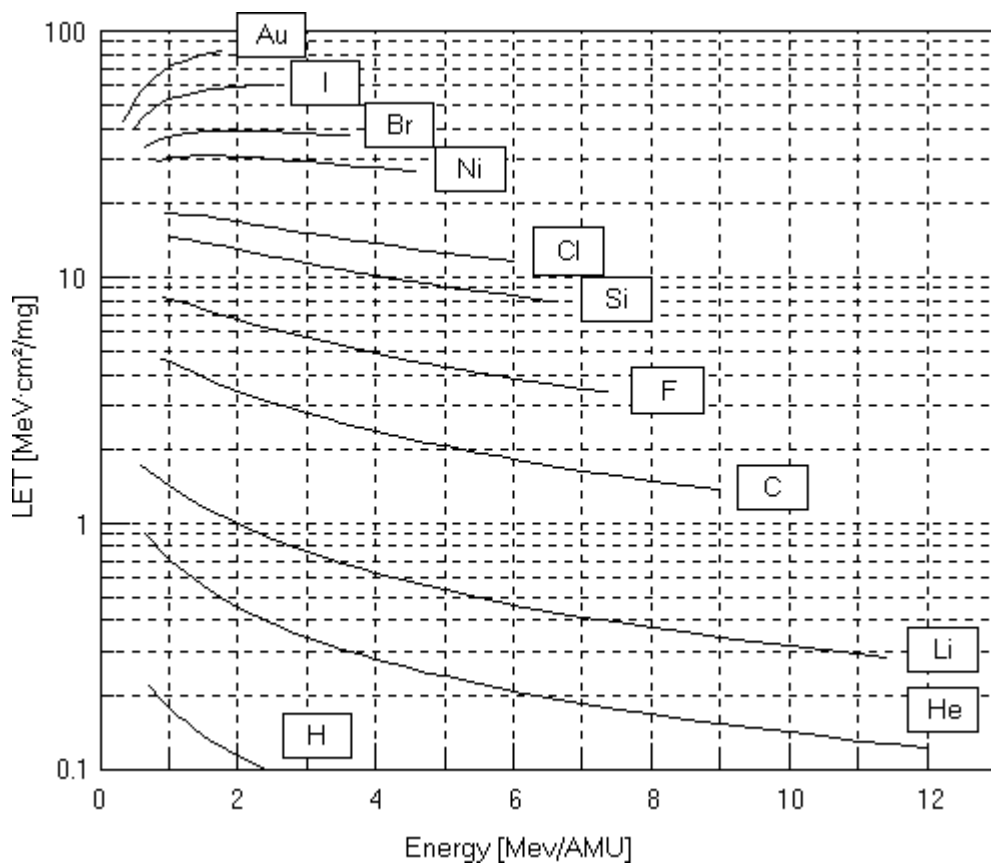
- The available heavy ion beams with their maximum energies are listed in the following table. Their LET and range values in Si and GaAs are calculated at the maximum beam energies. It is possible to vary the LET by decreasing the ion energy, especially for lighter ions when the range is not a limiting factor.

Ion	Max. Energy [MeV]	Range (Si) [μm]	LET (Si) [MeV·cm ² /mg]	Range (GaAs) [μm]	LET (GaAs) [MeV·cm ² /mg]
H-1	29	4610	0.0152	2660	0.0118
H-2	29	2710	0.0262	1620	0.0168
Li-7	58	404	0.365	250	0.269
B-11	87	221	1.04	138	0.766
C-12	102	194	1.41	120	1.04
N-14	116	164	1.94	102	1.43
O-16	131	145	2.53	90.8	1.86
F-19	145	123	3.30	79.8	2.43
Na-23	170	105	4.86	69.3	3.51
Mg-24	180	97.7	5.63	61.8	4.14
Al-27	192	90.2	6.68	57.4	4.90
Si-28	203	85.8	7.51	54.6	5.51
P-31	206	76.4	8.85	49.1	6.46

Ion	Max. Energy [MeV]	Range (Si) [μm]	LET (Si) [MeV·cm ² /mg]	Range (GaAs) [μm]	LET (GaAs) [MeV·cm ² /mg]
S-32	217	73.8	9.75	47.4	7.13
Cl-35	224	68.8	11.1	44.4	8.08
K-39	235	61.3	13.6	39.9	9.90
Ca-40	242	59.0	14.7	38.5	10.7
Sc-45	242	54.4	16.7	35.8	12.0
Ti-48	253	53.6	18.0	35.4	13.0
V-51	253	50.5	19.7	33.5	14.1
Cr-52	264	50.2	20.7	33.3	14.9
Mn-55	264	47.7	22.4	31.9	16.1
Fe-56	270	43.7	24.1	31.2	17.0
Co-59	270	44.7	25.3	30.0	18.1
Ni-58	280	44.6	26.2	29.9	18.8
Cu-63	285	43.7	27.9	29.4	20.0

Ion	Max. Energy [MeV]	Range (Si) [μm]	LET (Si) [MeV·cm ² /mg]	Range (GaAs) [μm]	LET (GaAs) [MeV·cm ² /mg]
Zn-64	285	42.2	29.4	28.4	21.0
Ga-69	290	41.6	31.1	28.2	22.1
Ge-72	290	40.4	32.8	27.6	23.3
As-75	295	39.9	34.1	27.2	24.2
Se-80	295	38.9	35.8	26.7	25.3
Br-79	305	39.0	36.8	26.7	26.1
Sr-88	305	36.6	41.2	25.3	29.0
Zr-90	315	36.0	43.7	24.9	30.8
Nb-93	313	35.2	45.1	24.4	31.7
Ru-102	320	34.3	49.1	23.9	34.3
Rh-103	330	34.6	50.3	24.1	35.2
Ag-107	345	34.8	52.7	24.2	36.9
Sn-120	340	33.5	56.4	23.6	39.2

Ion	Max. Energy [MeV]	Range (Si) [μm]	LET (Si) [$\text{MeV}\cdot\text{cm}^2/\text{mg}$]	Range (GaAs) [μm]	LET (GaAs) [$\text{MeV}\cdot\text{cm}^2/\text{mg}$]
Sb-121	340	33.0	57.6	23.3	40.0
Te-130	350	33.8	57.7	23.9	40.7
I-127	370	34.6	59.9	24.3	41.7
Tb-159	370	31.4	72.2	22.5	49.5
Ho-165	370	31.1	73.9	22.3	50.5
Ta-181	375	30.5	78.9	21.9	53.7
W-184	375	30.3	79.7	21.9	54.1
Re-187	372	30.1	80.3	21.7	54.4
Os-192	377	30.3	81.0	21.9	54.9
Ir-193	377	30.1	81.9	21.7	55.4
Pt-195	380	30.1	82.8	21.8	56.0
Au-197	390	30.5	83.9	22.0	56.8
U-238	385	29.4	91.0	21.4	60.8



- The flux range is $1\text{E}+03$ to $1\text{E}+06$ ions/ cm^2/sec under normal operation. The flux can be reduced to $1\text{E}+02$ ions/ cm^2/sec or, for some ions, increased to $1\text{E}+07$ ions/ cm^2/sec upon request. This shift of the flux range by a factor of 10 requires installation of larger or smaller scintillation detector apertures in the diagnostic vacuum chamber.
- The fluence range is $1\text{E}+04$ to $1\text{E}+09$ ions/ cm^2 under normal operation with test run times 10 to 1000 sec. The fluence can be reduced to $1\text{E}+03$ ions/ cm^2 or increased to $1\text{E}+10$ ions/ cm^2 when installing the non-standard scintillation detector apertures.
- The beam uniformity is better than $\pm 1\%$ for lighter ions (such as C-12) and better than $\pm 15\%$ for heavier ions (such as Au-197) over a 3.0 cm diameter beam spot. Please note that the beam uniformity is much better over a smaller area of a typical electronic device under test.

- A higher flux ($1\text{E}+06$ to $1\text{E}+09$ ions/cm²/sec, or up to $1\text{E}+12$ protons/cm²/sec) can be delivered if lower than maximum ion energy is adequate. The bank of scintillation detectors and counters has to be replaced with a set of faraday cups and electrometers for beam dosimetry.
- Fluence of $1\text{E}+07$ to $1\text{E}+12$ ions/cm² (or up to $1\text{E}+15$ protons/cm²) can be delivered with test run times 10 to 1000 sec when using the faraday cups and electrometers for the beam dosimetry.
- The beam diameter is continuously variable from 0.2 to 3.0 cm.

Particle Angle of Arrival

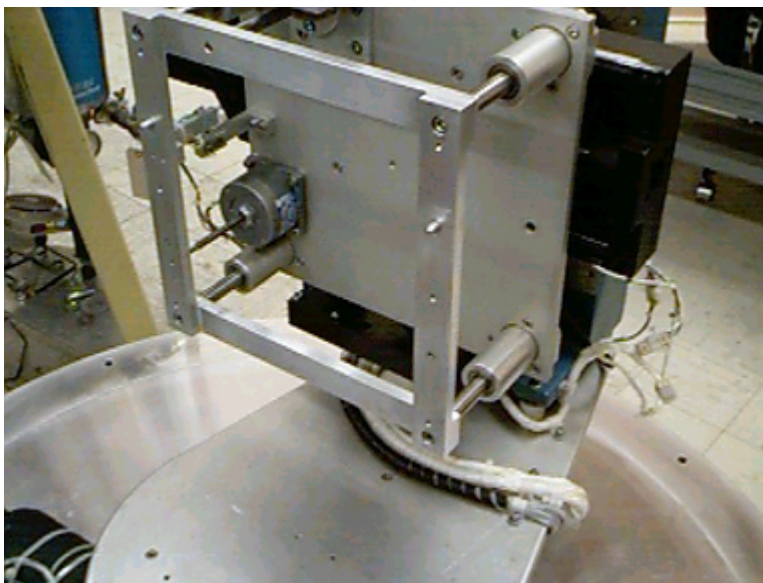
- The tilt angle rotation (around the vertical axis) is from -84° to 75° under normal operation. Tilt angle up to -90° is possible.
- The roll angle rotation (around the horizontal axis perpendicular to the test board) is from -90° to $+84^{\circ}$ under normal operation. Roll angle up to $+90^{\circ}$ is possible.
- The absolute accuracy is better than $0^{\circ}10'$, reproducibility better than $0^{\circ}02'$ for both angles.
- Combination of the two angles makes it possible to hit the device under test from virtually any direction.
- The effective linear energy transfer (LET) is continuously variable from 0.015 to about 165 MeV·cm²/mg, taking into account an energy loss in a typical passivation layer (equivalent to about 1 mg/cm² or about 5 μm of silicon oxide), by changing the beam isotope (H-1 to Au-197), beam energy, and the particle angle of arrival (tilt angle 0° to 75°), with overlaps between ions.

System Reset

- The SEU Test Facility application program is resistant against a computer crash in the sense that all settings are saved in the application Windows registry key. It always starts in exactly the same state it was before the crash or before normal closing of the program. However, it is imperative that you clear all system setting to their default values, by means of the Clear_All command on the the first menu (the Positioning_menu) at least once at the beginning of your experiment. This is absolutely the first thing to do before you begin to use the program. Otherwise, the program may be using some settings left behind by the previous users and not all parameter values are displayed in the Main_Window.
- The Clear_All command does not clear so called vital system setting, such as the enabled stepper motors and absolute encoders, software limits of motion, current dosimetry method, scintillation detector or current collector apertures, and the silicon detector properties and calibration. These parameters have to be checked and/or changed separately, if necessary

Positioning Stage

- Make sure that the hydraulic scissors table has been either pushed all the way in under the test vacuum chamber (the IN sensor is active, i.e. pressed) or it has been pulled all the way out (the cable tray operated OUT sensor is active, i.e. released). The positioning stage movements are totally disabled if neither sensor is active, in order to protect the positioning stage from hitting the bottom rim of the test chamber.
- Check the positions of all axes of motion in the Positions_area of the Main_Window. If you executed the Clear_All command on the the Positioning_menu, and sent all axes of motion to their home positions, all positions should be zero except for the iris diameter, which should be 1.78 cm (0.70 inch).
- Check the enabled stepper motors and enabled absolute encoders using the Enable_Motors and Enable_Encoders commands on the the Positioning_menu. Normally, all stepper motors and all absolute encoders should be enabled. If you are not going to use some type of motion and if you want to make absolutely sure that the corresponding axis never moves, for example because it might damage your test board or cables, you may disable the stepper motor for that axis. You do not have to disable the corresponding absolute encoder; if the axis does not move, the encoder never reads its position. Absolute encoders should be disabled only if they are damaged, in order to allow the SEU Test Facility operation (with reduced reliability).
- Generally, you do not have to use the Find_Home command on the Positioning_menu for a positioning stage equipped with the absolute encoders. The command is time consuming and may put stress on your cables if they are already connected to the test board (especially initializing the tilt angle, roll angle, or both). The Find_Home command is necessary to initialize the absolute encoders, a task usually performed by the Tandem Van de Graaff personnel. In addition, the tilt and roll angle encoders can be initialized far more accurately by other means. The tilt angle is initialized with the help of the laser beam, while a good quality mirror (such as a silicon wafer) is mounted flat on the test board. The roll angle is initialized with the help of a water level. Again, these tasks are performed by the Tandem Van de Graaff personnel. Please note that the Find_Home command must be executed for axes with the disabled absolute encoders following a cold reboot of the computer (power-off or using the reset button) because it resets the motion controller, but it is not necessary following a warm reboot (using the restart option in the Windows shut down dialog box or by the <Ctrl+Alt+Del> key combination). In addition, every time an axis with the disabled absolute encoder does not complete a move or fails to move altogether (for example because the stepper motor power supply is OFF), the Find_Home command for this axis must be executed again.

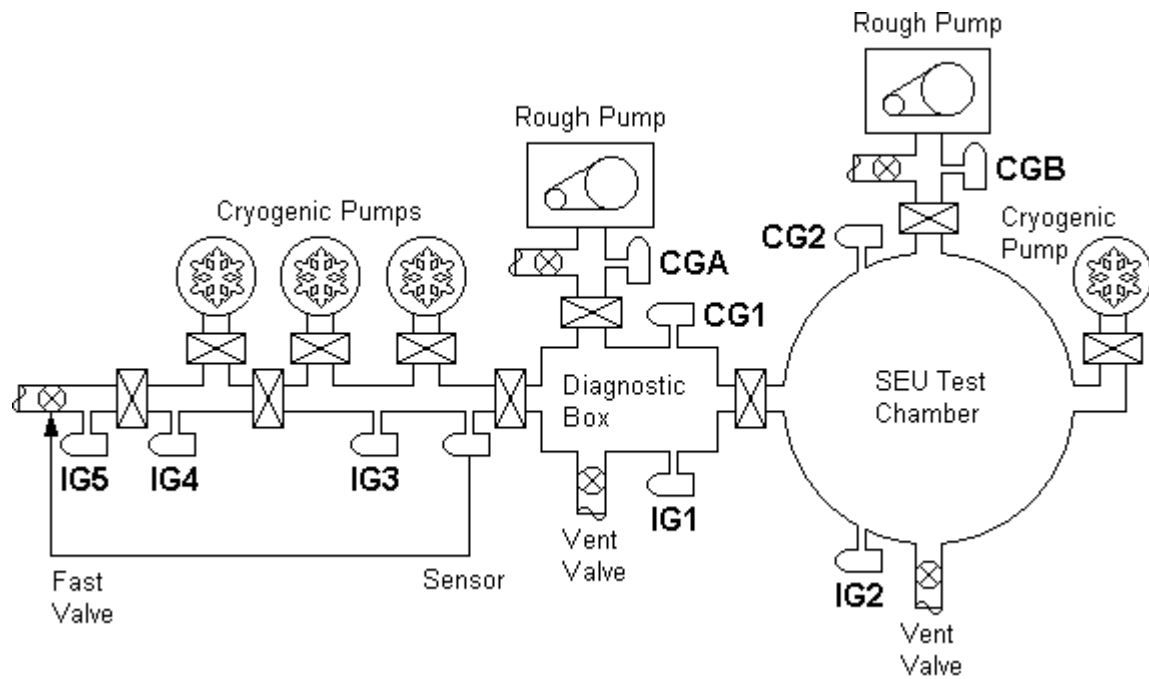


- Mount your test board on the positioning stage and the desired cable feedthrough plates(s) on the bottom flange of the test chamber (see Cable_Connections for a list of available feedthrough plates). When mounting a feedthrough plate, clean carefully the surface facing the bottom flange of the test chamber, the O-ring and its groove (use ethanol, tissue wipes, and cotton swabs as necessary), and apply a thin coat of silicon vacuum grease. You may also ask the operators to mount the desired feedthrough plates. When using a custom feedthrough plate, please ask the operators to leak check it before mounting. Connect all cables between the feedthrough plate(s) and your test board. Make sure the cables have sufficient length for all desired types of motion. If not sure, move the positioning stage with the help of manual or mouse joysticks (using the Joysticks command on the Positioning_menu) until the axis in question hits a limit switch and stops. If you notice any stress on your cables before reaching the limit switch, stop and record the current position of the axis. Make sure that you never move beyond that position. Perform this maneuver especially with the tilt angle, and also with the roll angle if you plan to use it. Keep the X- and Y-axes in the least favorable position during the maneuver. The test board can also move back and forth (Z-axis) to keep the device under test on the vertical axis of rotation when the test board is tilted. If you have anything mounted on the back of the test board and if you plan to tilt the board (and therefore adjust the Z-axis), try to move it all the way back to make sure no component on your test board is susceptible to damage. Fasten your cables to the positioning stage as necessary. Use cable ties whenever possible, adhesive tape may outgas and increase the pumping time when evacuating the test vacuum chamber.
- Please note that raising the test board mounting frame (moving the Y-axis above its home position, i.e. negative) inserts a steel locking pin either in the hydraulic scissors table bottom eye or in the cable tray groove, depending on whether the table is inside or outside of the test chamber. Consequently, it is not possible to pull the table out or push it in until the Y-axis is lowered, in order to make enough clearance between the positioning stage top and the bottom rim of the test chamber.
- If your experiment requires tilting or rolling the test board beyond the hardware limits (-84° to $+75^{\circ}$ for the tilt angle, -90° to $+84^{\circ}$ for the roll angle), consult the Tandem Van de Graaff personnel. The negative tilt angle limit switch and/or the positive roll angle limit switch can be defeated to allow tilt angle up to -90° and/or roll angle up to $+90^{\circ}$ with the help of the Ignore_Limits command on the Positioning_menu. Please note that the command is password protected.

Pumping and Venting

- Before pumping down the test vacuum chamber, the hydraulic scissors table with the positioning stage must be lowered, manually pushed under the chamber, and raised again. Make sure that all user cables from the vacuum feedthrough plate(s) exit through the gap between the bottom flange of the test chamber and the user equipment shelf attached to top of the table. Any cables left dangling around the scissors will almost certainly be crushed. Make also sure that no user cables come across the scissors table rail under the user equipment shelf when lowering the table. Carefully push the table all the way in under the test vacuum chamber until its base hits the IN sensor. If you are unable to push the table all the way in, make sure that the Y-axis is at its home position or below (zero or positive) and that the steel locking pin is withdrawn from the cable tray groove. If not, pull the table out and lower the Y-axis with the help of manual or mouse joystick (using the Joysticks command on the Positioning_menu). Raise the table using the <Up> button of the yellow pendant until the chamber is fully closed. As soon as you begin to raise the table, the base is held in place by the steel locking pin to prevent you from pulling the table out if not completely lowered. The hydraulic pump automatically turns off when the chamber is fully closed.
- Use the Vacuum command on the Beamline_menu to pump down the test vacuum chamber by pressing the <Pump> button. If you closed the chamber properly, the roughing pump is turned on and the SEU Test Facility system waits for a drop in pressure. If the pressure does not drop, the roughing pump is turned off after about 10 sec and an error message appears on the computer monitor. The pumping sequence takes less than 5 min (usually about 3.5 min) and is fully automatic: After the roughing pump is turned on and the roughing pump valve opens, the chamber is pumped down to approximately 5E-02 torr. At this pressure, the roughing pump valve is closed and the high vacuum cryogenic pump valve opens. The pressure rather quickly drops below 1E-03 torr, the ionization vacuum gauge is turned on and the test chamber beamline valve opens. The SEU Test Facility application shuts down the roughing pump and the pump vents itself. The evacuation is now complete.
- Use the Vacuum command on the Beamline_menu to vent the test vacuum chamber by pressing the <Vent> button. The SEU Test Facility application moves the X- and Y-axes to their home positions, in order to prevent the possibility of hitting the positioning stage with the bottom rim of the test chamber when pulling the hydraulic scissors table out. If the homing maneuver fails, for example because you turned the stepper motor power supply off using the Motor_Power command on the Positioning_menu, no venting takes place and an error message is displayed. The venting sequence is also fully automatic: First, the ionization vacuum gauge is turned off and both the test chamber beamline valve and the high vacuum cryogenic pump valve close. After about 10 sec delay (to allow for safe closing of the high vacuum valves), the venting valve opens. During the safety delay, you can change your mind and stop the venting sequence using the <Stop> button in the Progress_box. Please note that the ionization gauge is not turned back on (and consequently the test chamber beamline valve stays closed); you can turn it back on using the Ionization_Gauges command on the Beamline_menu. If you did not stop the venting sequence, wait for the hissing sound of air flowing into the test vacuum chamber to cease. The ventilation is now complete.
- Lower the hydraulic scissors table completely using the <Down> button of the yellow pendant. Do not leave the pendant cable (or any other cable) laying across the scissors table rail. Pull the hydraulic scissors table out far enough until the cable tray operated OUT sensor is released. This arrangement makes sure that the positioning stage does not hit the bottom rim of the SEU test chamber (or any vacuum port protruding from the chamber) when you raise the table again. If you cannot pull the hydraulic scissors table out, make sure you lowered it completely, the Y-axis is at its home position or below (zero or positive), and the steel locking pin is withdrawn from the eye in the base of the table.
- The following figure shows the vacuum system schematic. Both the diagnostic and SEU test vacuum chambers have separate roughing pumps and vent valves, but only the test vacuum chamber is equipped with a cryogenic pump. Consequently, when pumping the diagnostic vacuum chamber, the test chamber and/or the diagnostic beamline valves must open after closing the diagnostic box

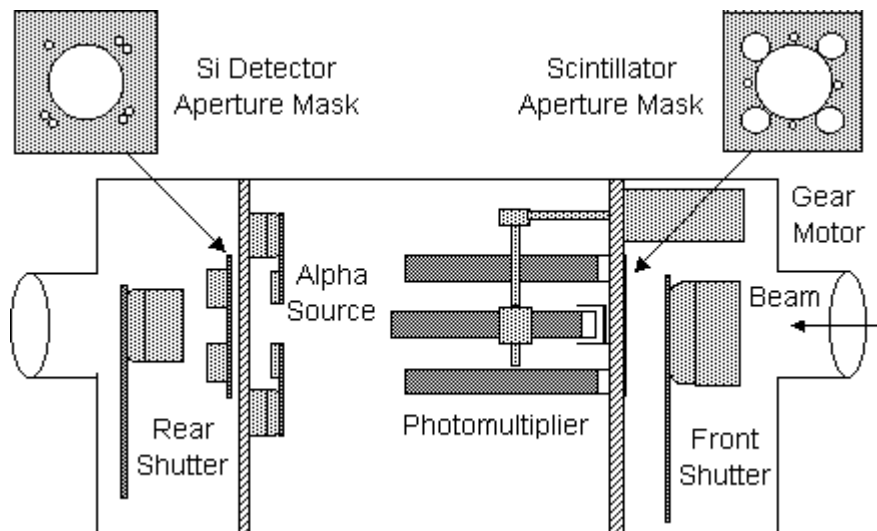
roughing pump valve. Pumping and venting of both vacuum chambers is controlled by a programmable vacuum controller with 12 process control channels. The programmable vacuum controller is capable of reading two convection gauges, CG1 and CG2 (with pressure range 1E+03 to 1E-03 torr) and two ionization vacuum gauges, IG1 and IG2 (with pressure range 1E-02 to 1E-10 torr), one pair for each vacuum chamber. Each process control channel can be assigned one vacuum gauge, pressure set point and hysteresis, delay and interval timers, and an external enable signal. The programmable vacuum controller is supplemented by two single convection gauge controllers and three single ionization gauge controllers with one process control channel each. The convection gauges CGA and CGB prevent opening of the roughing pump valves in case the corresponding roughing pump is not on and pumping. The ionization gauges IG3, IG4, and IG5 make sure that the diagnostic, middle, and wall beamline valves do not open unless vacuum is good on both sides of the valve. The fast valve is an emergency device to stop venting the accelerator in case of a vacuum accident; the air would travel up the beamline with the speed of sound and the ordinary vacuum valves are not capable of responding that fast. The fast valve sensor is a miniature high vacuum ion pump.



Test Board Setup

- All device coordinates (the X-, Y-, and Z-coordinates, and the iris aperture diameter) can be entered and displayed either in centimeters or inches. Use the Linear_Unit command on the Board_menu to select the unit you prefer. If you are going to use the laser alignment system to find device coordinates (rather than to enter predetermined coordinates manually), the unit is not important and you can keep the default selection (cm). Use the Find_Limits command on the Positioning_menu menu and press the <View Limits> button in its dialog box to check the limits for the individual axes of motion.
- Clear the present board configuration (if any) using the New command on the Board_menu. If you executed the Clear_All command on the the Positioning_menu, the board configuration is already empty and you can skip the New command.
- Use the Edit command on the Board_menu to add devices to the board configuration and to enter or find their coordinates. When you are finished, save the board configuration under a new board file name using the Save_As command on the Board_menu, even if you have only one test board. Otherwise, the SEU Test Facility application will not be able to recall the board configuration in case of a computer crash or if you close and restart the program.
- Select the target material of your devices using the Target_Material command on the Board_menu. Most often it will be silicon (which is the default) or gallium arsenide. The SEU Test Facility application will use this target material for the calculation of LET and range of the heavy ion beams.
- If you have the proper information (the material and thickness of individual sublayers on top of the device sensitive region) from the manufacturer of your devices, you can also build a composite passivation or dead layer using the Dead_Layer command on the Board_menu. The SEU Test Facility application will then always correct the beam energy, effective LET, and the penetration depth for an energy loss in the passivation at all tilt angles. Building the dead layer gives you a good on-line picture of the energy loss and it may save you time when you evaluate your data later on. The maximum effective LET in the sensitive region under a typical passivation layer (equivalent to about 1 mg/cm², i.e. 5 µm of silicon oxide), which can be induced by the heavy ion beams available at the Brookhaven SEU Test Facility, is about 165 MeV·cm²/mg if you require a minimum penetration depth in the sensitive region of at least 5 µm.
- The SEU Test Facility application keeps track of the total dose accumulated on every device. Since the dose is calculated by multiplying the effective fluence and effective LET (or the normal fluence and normal LET) and transformed to the units of RAD, it depends on the target material for a given beam isotope, energy, and fluence. By default, the dose is calculated in the substrate material of your devices selected by the Target_Material command on the Board_menu, but you can select any sublayer of the passivation layer for the dose calculation. Use the <Dose> pushbutton in the Dead_Layer dialog box. For example, if you want just to change the dose unit from RAD(Si) to RAD(SiO₂), enter the silicon oxide passivation layer of zero thickness and select it for the total dose calculation.
- If you changed the Target_Material and/or Dead_Layer, save the present board configuration again, using the Save command on the Board_menu.

Beam Dosimetry



- The above figure shows the diagnostic vacuum chamber schematics. Normally, the heavy ion beam is monitored by counting pulses from a bank of four plastic scintillation detectors with precisely machined apertures in front of them. The default aperture area is 0.1 cm^2 and used for the beam flux from $1\text{E}+03$ to $1\text{E}+06 \text{ ions/cm}^2/\text{sec}$. If you wish to use lower or higher flux, the aperture area can be increased to 1 cm^2 or decreased to 0.01 cm^2 , respectively, by changing the scintillator aperture mask in the diagnostic chamber. If you need a flux higher than $1\text{E}+07 \text{ ions/cm}^2/\text{sec}$, the heavy ion beam must be monitored by measuring beam current in a pair of faraday cups. Check the present dosimetry method (scintillation detectors and counters or faraday cups and electrometers) by executing the `Dosimetry_Method` command on the `Dosimetry_menu`. The beam source (scattering foil or sweeping magnet) is required to calculate the inverse square fall-off of the heavy ion beam from the detectors to your test board. Usually, the scattering foil is used with the scintillation detectors and the sweeping magnet with the faraday cups, but the operators may choose to keep the scattering foil for protons even when the faraday cups are used, or to help spread the beam of heavier ions with the sweeping magnet even when the scintillation detectors are used. Changes in the `Dosimetry_Method` dialog box are password protected. Any change has to be accompanied by replacing the corresponding hardware in the diagnostic vacuum chamber, a task performed by the Tandem Van de Graaff personnel only.
- The beam can be intercepted by the front and rear shutters mounted on rotary solenoids. The front shutter opens for beam dosimetry only, both shutters open when irradiating a device. The time required for activation of these shutters is about 80-100 msec. In order to keep the non-uniformity of the accumulated fluence and the test run time uncertainty caused by this time interval low, the test run time must be at least 5 sec.
- When you perform a test run, the beam is monitored only by the four outside scintillation detectors located just outside of the beam area available to the users. When using the faraday cups for the beam dosimetry, the beam is monitored only by the annular faraday cup or collector plate, both geometrically inferior to the center faraday cup used for the flux measurement. However, the SEU Test Facility application occasionally checks the beam center by rotating in the fifth scintillation detector of the same type (or using the center faraday cup). The automatic check of the beam center is performed after you change the beam isotope and/or energy, after you request a flux change by more than the maximum drift factor (2.0 by default), or after the beam alignment falls below the acceptable level (85 % by default). If everything is all right, the automatic check of the beam center is performed every half an hour. Use the `Warning_Levels` command on the `Dosimetry_menu` to make sure the automatic check of the beam center is enabled. The default warning levels are carefully selected to alert you quickly about any beam deterioration while keeping false alarms at a minimum. If you are using an extremely low flux ($1\text{E}+03 \text{ ions/cm}^2/\text{sec}$ or less) you may consider lowering the minimum acceptable beam alignment to about 80 % to avoid frequent false alarms caused by random errors of a low pulse count. Although the

flux profile over the beam area is always flat or convex (never concave), the beam uniformity for lighter ions (H-1 to F-19) is usually so good that the beam center pulse count can be occasionally a percent or two lower than the outside average pulse count simply because of random fluctuations of the pulse count. If you are using these light ions, you may consider lowering the minimum acceptable beam center from 0 to -5 % to avoid false alarms.

- Measure the beam flux using the Measure_Flux command on the Dosimetry_menu. If scintillation detectors (or a faraday cup on the test board) are used to monitor the beam, you will hear a sharp click from the diagnostic box as the front shutter opens. The flux measurement takes about 5 sec (10 sec if the center scintillation detector is in or if faraday cups are used for the beam dosimetry), but you can stop it earlier using the <Stop> button in the command Progress_box. The result of the measurement is the normal flux (the flux at the normal angle of incidence) and it is displayed in the Beam_area of the Main_window. On the other hand, the effective flux (the flux multiplied by the cosine of the present tilt angle θ) is displayed in the Data_area of the Main_window. Whenever you request a flux change, always refer to the normal flux or ask for a flux increase or reduction by a factor. The operators in the control room have no way of knowing what the present tilt angle is.
- Measure the beam energy and/or LET if you want to be absolutely sure you have the heavy ion beam you asked for and it is free of impurities. Use the Measure_Energy_&_LET command on the Dosimetry_menu. Please note that the beam energy measured by means of the accelerator analyzing magnet and supplied by the operators is far more accurate. Also, please note that the LET measurements for lighter ions (Li-7 to Ni-58) consistently agree with the LET calculation based on Ziegler's Tables, while the LET measurements for heavier ions (Br-79 to Au-197) are consistently 4-8 % higher. After the beam energy spectrum is processed, you can print it for your records or save it with the help of the Save_Spectrum_As command on the Dosimetry_menu for later reference and/or processing. Saved energy spectra can be converted to text files using the Convert_To_Text command on the same menu.
- If you have doubts about one of the ion-implanted silicon detectors and/or the aluminum foil thickness used to measure the beam energy and energy loss, use the Alpha_Calibration command on the Dosimetry_menu to recalibrate the detector by a permanently installed Am-241 alpha source, one for each silicon detector.

First Test Run

- Before the SEU Test Facility application allows you to make a Test_Run from the Test_menu, several parameters must be defined:
 - Select beam isotope and energy using the Ion/Energy command on the Test_menu. Verify the energy with the operators to make sure that no verbal misunderstanding took place. Use the <Calculate> button in the Ion/Energy dialog box to calculate beam LET and range in the target material of your devices. If the faraday cups and electrometers (rather than the scintillation detectors and counters) are used for the beam dosimetry, you also have to enter the ion charge state supplied by the operators.
 - Move a device into the beam position using the Move_Device command on the Test_menu or by double-clicking the device ID with the left mouse button in the Board_area of the Main_window. If a device is positioned in the beam, the device ID on the Board_area is highlighted. Check the device position using the Laser command on the Beamline_menu, then turn the laser off.
 - Enter the desired effective fluence using the Fluence command on the Test_menu; $1\text{E}+05$ to $1\text{E}+07$ ions/cm² are usually the reasonable values to start with. Please note that what you actually enter is the effective fluence (the fluence multiplied by the cosine of the present tilt angle θ). If the value you entered is too high, the SEU Test Facility application defaults to the maximum possible fluence to prevent the counters from overflowing. The maximum permissible fluence equals to $1\text{E}+08$ ions divided by the scintillation detector aperture area in cm². If the faraday cups and electrometers are used for the beam dosimetry, there is no upper limit for the fluence. Check the estimated time of the next test run in the Data_area of the Main_window. If the estimated run time is longer than you are willing to spend on a single test run, reduce the desired effective fluence or ask the operators to increase the beam flux. If the estimated run time is too short (less than 5 sec) to neglect the uncertainty caused by opening and closing of the beam shutters (about 80-100 msec), increase the desired effective fluence or ask the operators to reduce the beam flux.
 - Alternately, you can specify the run time rather than the fluence, but not both. Use the Run_Time command on the Test_menu. Execution of the Run_Time command cancels any previously executed Fluence command vice versa. The last command executed has a check mark on the Test_menu and the corresponding Toolbar button is depressed.

If any of the above parameters are undefined (e.g. the beam isotope, energy, LET, device ID, and either fluence or run time), an attempt to make a test run will only cause an error message to appear on the computer monitor.

- Enter the title of your experiment using the Test_Title command on the Test_menu. This command has a cosmetic effect only: the test title appears in the Caption_bar of the Main_window, in the header of your data file, and on the on-line data plots.
- Make sure the next run number is one before you make the first test run. If you executed the Clear_All command on the Positioning_menu, the run number is already one. Otherwise, set it to one using the Run_Number command on the Data_menu.
- Open a new data file using the Open command on the Data_menu, otherwise the test run data will be appended to the present data file shown in the Data_area of the Main_window. If the present data file name is happens to be "Untitled.dat" (the default), the SEU Test Facility application will prompt you to open a new data file after the first test run.
- If the internal light in the test chamber is on, turned it off with the help of the Light command on the Beamline_menu. Please note that a de-lidded chip may fail a test when exposed to the light from the SEU test chamber internal lamps even though it passed the same test when exposed to the scattered

ambient light in the target room.

- Reset the device under test using your tester and start a test run the with the help of the Test_Run command on the Test_menu. The SEU Test Facility application will start the counters (or initialize the electrometers, depending on the present Dosimetry_Method) and open both the front and rear beam shutters in the diagnostic box to irradiate the device under test. You can stop the test run before the desired fluence is accumulated (or before the desired run time elapsed) using the <Stop> button in the command Progress_box. The SEU Test Facility application will close both beam shutters, stop the counters (or electrometers), and report the average effective flux, accumulated effective fluence, elapsed run time, and some other test run related data (such as the effective LET) in the Enter_Upsets dialog box. You can either enter the number of upsets obtained by means of your tester or discard the test run using the <Cancel> button. The upset cross section and its uncertainty are immediately updated as you enter the number of upsets. You can recall the dialog box even if you discarded the test run using the Enter_Upsets command on the Test_menu, but you have to do that before you perform another test run. If you do not discard the test run, the SEU Test Facility application appends a data record to your data file on the hard disk, prints the data record on a line printer, and adds a data point to the on-line plot for the device under test. If no on-line plot exists for the device, it is automatically created at this time. The run number is incremented by one and the SEU Test Facility application is ready for another test run.

Remote Control

- The first and most simple method of the SEU Test Facility application remote control is the TTL interrupt, which allows you to start and/or stop a Test_Run by applying TTL compatible signals or pulses from the user equipment to the appropriate inputs of the SEU Test Facility. Two separate digital inputs are provided, each terminated with a BNC coaxial connector, one to start and the other to stop a test run. In order to use the TTL interrupt, one or both inputs must be enabled by the TTL_Interrupts command on the Control_menu and the appropriate input must be armed. The SEU Test Facility application arms the START input (if enabled) immediately after you press the <OK> button in the TTL_Interrupts dialog box. The START input is disarmed and the STOP input armed (if enabled) when you start a test run. The STOP input is disarmed immediately after the test run is completed and the START input is armed (if enabled) when you enter the number of upsets. The two inputs are never armed simultaneously. Some other commands controlling various beamline devices such as the beam shutters, beamline valves, faraday cups, etc. may temporarily disarm the START input, but it is automatically rearmed (if enabled) when the commands are completed and their dialog boxes (if any) closed. It is possible to select the logic levels as either active low or active high, but they have to be the same for both the START and STOP inputs. The inputs are level sensitive. If the input is enabled, the active level is latched (and the TTL interrupt generated) if applied for more than 15 μ sec. An active level on the START input (if enabled and used) should be removed sometimes during the test run, certainly before you enter the number of upsets, otherwise the SEU Test Facility application will start another test run immediately. Likewise, an active level on the STOP input (if enabled and used) should be removed before you start another test run, otherwise the test run will be stopped immediately.
- A relay contact to monitor the test runs by the user equipment is also available. The relay turns on when both the front and rear beam shutters open at the start of the test run and it turns off when the beam shutters are closed. The user output cable is connected to the SEU Test Facility shutter control using a 4-pin black plastic circular connector available at the SEU Test Facility. The output voltage is 24 VDC and it can be divided and debounced as necessary.
- The second, and quite comprehensive method of the SEU Test Facility application remote control is possible by a host computer over the GPIB interface bus (General Purpose Interface Bus). In order to use the GPIB control, it must be enabled by the GPIB_Host command on the Control_menu. The entire SEU Test Facility then behaves just like another device on your GPIB bus. The SEU Test Facility computer has two GPIB interfaces, one configured as a system controller and used to control its own devices, the other configured as a non-system controller and used to communicate with the host computer. See the GPIB_Control for a complete description and programming examples and the Command_types for a list of available commands.

Data Files

- From the moment you open a new (or an existing) data file using the Open command on the Data_menu, the data management is fully automatic and all test results are saved in that file. You can open another data file and save all subsequent test results in this new file at any time. You can insert comment lines following every test run using the Enter_Comment command on the Test_menu. A comment line begins with an exclamation point, which is automatically inserted in the front of the comment text.
- The data file is an ordinary text file which you can process it with the help of any text file editor. The Edit command on the Data_menu does just that. You can correct errors, such as an improper experiment title, incorrect number of upsets, or a wrong plot symbol. See a sample_data_file for the actual data format. In order to reflect any changes you have made in the data file in the on-line plots, use the Search command on the Data_menu. Please note that the SEU Test facility application uses the accumulated fluence and number of upsets to recalculate the upset cross section for the on-line plot. You can also use this command to combine data for data for two or more devices in a single plot.
- The SEU Test Facility application generates a single print copy of the data file by printing one data record following every test run. You can get more print copies using the Print command on the Data_menu. The command prints the entire data file or any portion of it. You can also copy the data file on a floppy disk when your test is completed using the Copy command and then delete the data file using the Destroy command on the same menu. Please note that for a better protection against unauthorized copying of proprietary data, all information on the destroyed data file is completely lost and impossible to recover by various undelete utilities.

On-line Plots

- The SEU Test Facility application automatically generates an on-line data plot (upset cross section vs. effective LET) for each device, for which you have made at least one test run and entered the number of upsets. The on-line plot is created when the first test run for the device is finished and a number of upsets entered. Results of all subsequent test runs with the same device are added to the plot, one point after every test run. The on-line plot is displayed and updated every time a data point is added to this plot. Data points for zero number of upsets are displayed as upset cross section thresholds, i.e. as if the number of upsets was one and a little down arrow is added to the plot symbol. The default plot scale is linear for the effective LET and logarithmic for the upset cross section, but you can change that using the Plot_Scale command on the Data_menu. The default lower and upper bounds for both the effective LET and the upset cross section are chosen (and adjusted after every test run) so that the new data point is visible.
- You can display any of the available on-line data plots with the help of the View_Plot command on the Data_menu, for example, to examine an existing data plot for another device when you move it back to the beam and before you make another test run. You can also change the present lower and/or upper bounds for the effective LET and/or the upset cross section using the <Set Bounds> button in the View_Plot dialog box, for example, to make the bounds the same for the on-line plots of several different devices, or to examine some portion of the plot in more details. Hard copies of the on-line data plots are available using the Hard_Copy command on the Data_menu.

Error Messages

- If the SEU Test Facility application cannot execute a command or if the command cannot be executed properly or completely, an error message box explaining the nature of the error appears on the computer monitor. Serious conditions preventing proper operation of the system show a stop sign icon in the error message dialog box, conditions preventing the command execution completely or properly show an exclamation point icon. Common examples of errors of the first type (with the stop sign icon) include a serial port being unavailable to the program, device timeout, etc. Common examples of errors of the second type (with exclamation point icon) include a disabled stepper motor for an axis you are trying to move, incomplete test board move, undefined beam isotope, or desired fluence, no device in the beam when attempting a execute test run, beamline shutters under operator control, improperly closed SEU test chamber when pumping it down, beamline blocked by some obstruction such as a closed vacuum valve or inserted faraday cup when using the laser, measuring flux, or executing a test run, etc.
- Please read the error messages !!! If you cannot correct the error yourself or if you are not sure that you can ignore a warning, ask the Tandem Van de Graaff personnel for help.

Device Timeouts

- If the SEU Test Facility application cannot communicate with one of its own devices connected to the GPIB bus or to the serial ports, or with the host computer (if any) connected to a separate GPIB bus, a device timeout message box appears on the computer monitor. The message box identifies the device that caused the timeout and its GPIB address or serial port number. You can select one of the three buttons: <Retry>, <Exit>, and <Cancel>. Use the <Retry> button a few times. If that fails, try to abort the command that caused the device timeout using the <Cancel> button and execute the command again to see if it fails for the second time too. The <Exit> button is used as the last resort only if the SEU Test Facility application is trapped in an infinite loop (usually only during software development). Locate the specified device and make sure it is on. Check the other suggested possibilities (such as cable connected, printer on line, etc.). Most device timeouts can be resolved by recycling the device power.
- Never recycle power for the vacuum controller, unless you turn off the power for all vacuum valves. The vacuum controller losing power may, on rare occasions, twitch its process control relays and shortly open inappropriate valves. This may cause serious vacuum system failure requiring several hours to recover from. If not absolutely sure how to turn off the power for the vacuum valves, ask the Tandem Van de Graaff personnel for help.
- Power for all other devices can be safely recycled at any time.

Beam Flux and Alignment

- If you receive a low beam alignment warning, try to measure the beam flux and alignment with the help of the Measure_Flux command on the Dosimetry_menu. If you receive a low or high beam center warning, try to rotate the center scintillator in the beam using the Center_Scintillator command on the Beamline_menu before you measure the flux. If you receive the same warning again, ask the operators in the accelerator control room (over the intercom) to restore the beam alignment and/or uniformity. If the SEU Test Facility application issues such warnings frequently at an extremely low flux (less than $1\text{E}+03$ ions/cm²/sec), consider lowering the minimum acceptable beam alignment from 85 % to about 80 % with the help of the Warning_Levels command on the Dosimetry_menu.
- If the beam flux drifts away but the beam alignment stays above the warning level, you will not receive any warning, but you may notice a considerable increase in the estimated time for the next test run (in the Data_area of the Main_window. Do not tolerate this condition for long, ask the operators to restore the desired flux level. Unless your test requires long test runs at a low flux, try to keep the estimated time between 10 sec and 1 min. You will probably waste more beam time by making long test runs than by letting the operators take control of the beam shutters for a moment and restore the required flux level.
- If you receive an error message that the high voltage on the scintillation detector photomultipliers is off, make sure that the laser is off, the ionization gauge filament in the diagnostic vacuum chamber is not burned or broken, and the gauge is lit. If everything is all right, turn the photomultiplier bias on using the All_Devices command on the Beamline_menu.

Vacuum Problems

- If the SEU Operating system reports that it cannot pump down the test vacuum chamber, make sure you closed the chamber properly, that the large O-ring is firmly pressed in its groove in the bottom rim of the chamber, and that no cables or other objects are caught between the chamber rim and the bottom flange of the chamber. Then try to evacuate the chamber again.
- If the pump-down time takes more than 5 min, make sure that a proper care was observed when mounting the vacuum cable feedthrough plates to the bottom flange of the SEU test vacuum chamber. The plate surface facing the flange and especially the plate O-ring must be absolutely clean and greased with special vacuum grease. Custom made vacuum feedthrough plates must be also leak checked by the Tandem Van de Graaff personnel prior to mounting. Make also sure that the vacuum ionization gauge in the SEU test vacuum chamber is properly connected, its filament is not burned or broken, and the gauge is lit.

Hydraulic Scissors Table

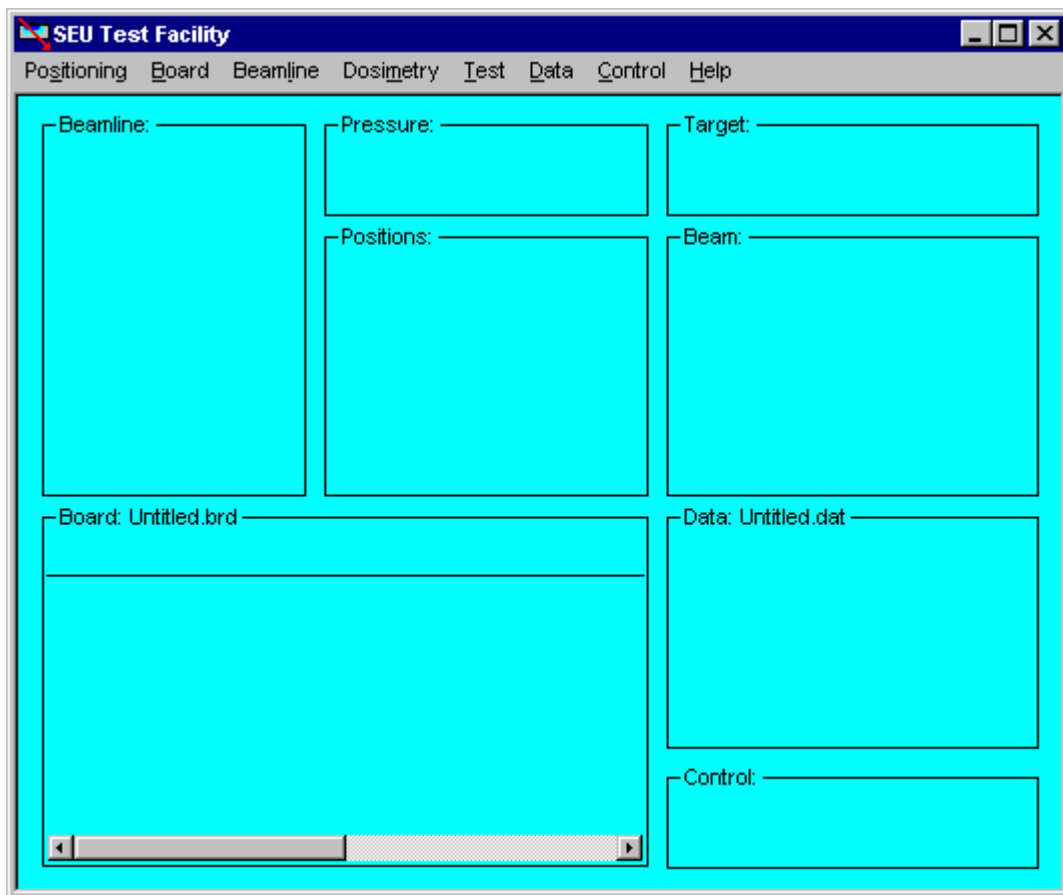
- The user equipment shelf attached sideways to the top of the hydraulic scissors table (next to the bottom flange of the test vacuum chamber with the positioning stage) is rated for a load of 200 lb. Do not overload the shelf. Distribute weight on the shelf symmetrically left and right, otherwise the bottom flange of the test chamber may slightly tilt and the back of the positioning stage may hit the chamber wall as you close it. The scissors table is the weakest in the low position. If you cannot raise the table because of the load, try to help the hydraulics by manually lifting the table while pushing the <Up> button of the yellow pendant.
- If you cannot raise the hydraulic scissors table inside the test chamber to close it and pump it down, make sure that you pushed the table all the way in until its base hit the appropriate sensor. If you cannot pull the hydraulic scissors table out after venting the test chamber and lowering the table, make sure you lowered it completely, the Y-axis of the positioning stage is at its home position or lower (zero or positive), and the steel locking pin released the base of the table.
- If you cannot raise the hydraulic scissors table outside the test chamber after venting and pulling the table out, make sure that you pulled the table all the way out until the cable tray attached to the table base released the appropriate sensor. If you cannot push the hydraulic scissors table inside the test chamber, make sure that the Y-axis of the positioning stage is at its home position or lower (zero or positive), and the steel locking pin is not inserted in the cable tray groove. When the table is outside of the test chamber, an active state of the locking pin is indicated by a red light on the chamber front side.

Electrical Noise

- A holding torque (about 1/3 of the full torque) is applied to all stepping motors of the positioning stage when they are not moving. If your device is failing a test without being exposed to the beam, try to temporarily shut down the power for the stepping motors with the help of the Motor_Power command on the Positioning_menu. Remember that you should restore the power before you attempt another move. The SEU Test Facility application restores the stepping motor power on demand automatically, after issuing a warning message.
- Make sure that the internal light in test vacuum chamber is off. If not, turn it off with the help of the Light command on the Beamline_menu. Please note that a de-lidded chip may fail a test when exposed to the light from an internal lamps in the test chamber even if it passed the same test before, when exposed to the ambient light in the target room.
- Avoid running your test equipment cables over any SEU Test Facility display monitors. The monitors may cause a significant contribution to the noise pickup.

Main Window

- The Main Window of the SEU Test Facility program has a Resizing_border, standard Caption_bar and Menu_bar, optional Toolbar and Status_bar, and a document view window. The document view window is divided into several rectangular areas that show the SEU Test Facility status (beamline status, vacuum pressure, etc.), various parameters set by the user (board configuration, device under test, target material, beam isotope, energy, range, LET, tilt and roll angles, penetration depth, effective LET, etc.), and the basic dosimetry data (normal flux, effective flux, effective fluence, run time, etc.).
- The color scheme of the Main Window can be changed according to your esthetical preferences using the Colors command on the Control_menu.



Beamline_are
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Board_ar
ea

Caption bar



- The Caption bar contains the System menu, Test_Title, Minimize box, either the Maximize or Restore boxes, and the Close button. You can move the Main_window around by dragging the Caption bar with the left mouse button. Double clicking the Caption bar with the left mouse button has the same effect as clicking the Maximize or Restore boxes. All these task can also be accomplished by executing various System menu commands, even from the keyboard. These features are common to all Windows applications and do not require any additional explanation.
- Since the Main_window of the SEU Test Facility application has a fixed layout, the Maximize box is not very useful - the maximized window does not display any more information than the default size window.
- By default, the test title is the application name - SEU Test Facility. You can choose a different test title using the Test_Title command on the Data_menu.

Menu bar



Positioning Board Beamline Dosimetry Test Data Control Help

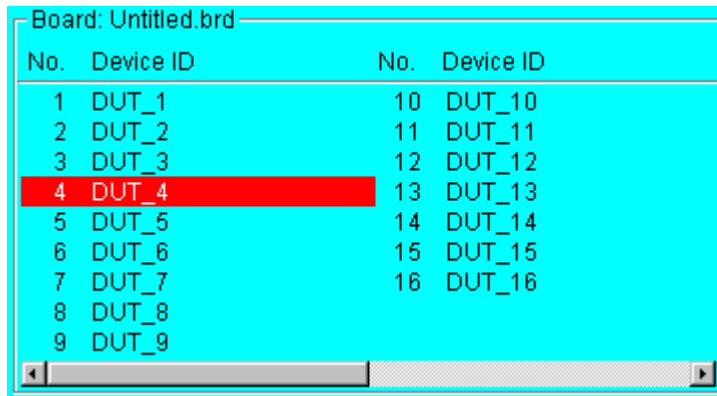
- The Menu bar simply lists all available SEU Test Facility application popup menus. Popup menus can be opened by clicking one of them with the left mouse button and then moving the mouse left and right to open another popup menu or up and down to select a menu command. Alternately, you can open popup menus from the keyboard by pressing the <Alt> key and either the <Enter> key or one of the underlined mnemonics keys, and then using the <Left> and <Right> direction keys to open another popup menu or the <Up> and <Down> direction keys (or the underlined mnemonics keys) to select a menu command. This type of menu control is common to all Windows applications.
- The SEU Test Facility application Menu bar contains the following list of popup menus:
 - Positioning_menu
 - Board_menu
 - Beamline_menu
 - Dosimetry_menu
 - Test_menu
 - Data_menu
 - Control_menu
 - Help_menu

Beamline area



- The Beamline area of the Main_window shows the status of most beamline devices located in target room 4 portion of the beamline and in the diagnostic box that can be either moved to block/open the beamline (i.e., the wall, middle, diagnostic box, and test chamber beamline valves, wall and diagnostic faraday cups, front and rear diagnostic box beam shutter, and the center scintillation detector) or just turned on/off (i.e., the beam tuning, laser, and the photomultiplier bias). The only beamline device not shown in the Beamline area is the diagnostic beam viewer, not used by the SEU Test Facility application for any purpose. Any device blocking the beamline is shown in inverted colors, while any device turned on is highlighted. In a quiescent state, the front and rear beam shutters should be closed and, if using the scintillation detectors and counters for the beam dosimetry, the photomultiplier bias should be on.
- Most of these beamline devices (including the diagnostic beam viewer and the test chamber light) can be individually operated with the help of the All_Devices command on the Beamline_menu. The two exceptions are the beam tuning and the test chamber beamline valve, which are only sensed by the SEU Test Facility application. The beam tuning is operated manually by the Tandem Van de Graaff operators in the accelerator control room, while the test chamber beamline valve is operated automatically by the vacuum controller. Other beamline devices may be used by the various SEU Test Facility application menu commands. For example, the Laser command on the Beamline_menu closes the wall beamline valve, turns the photomultiplier bias off, the laser on, and opens both the front and rear diagnostic box shutters. The Measure_Flux command on the Dosimetry_menu opens just the front diagnostic box shutter, while the Test_Run command on the Test_menu opens both the front and rear shutters.
- When the beam tuning is on (usually in the final stages of the beam setup or when the Tandem Van de Graaff operators are adjusting the beam flux level), the SEU Test Facility application is prevented from operating the diagnostic box beam shutters and the center scintillation detector, which are under manual control of operators in the accelerator control room. It is not a good idea to operate other beamline devices either (such as the Laser or the faraday cups), because they may disrupt the beam tuning process.

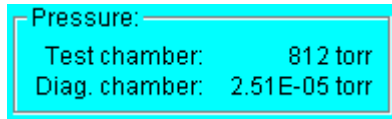
Board area



No.	Device ID	No.	Device ID
1	DUT_1	10	DUT_10
2	DUT_2	11	DUT_11
3	DUT_3	12	DUT_12
4	DUT_4	13	DUT_13
5	DUT_5	14	DUT_14
6	DUT_6	15	DUT_15
7	DUT_7	16	DUT_16
8	DUT_8		
9	DUT_9		

- The Board area of the Main_window shows the present board file name created by the Save_As command, loaded by the Open command, or selected from the list of Recent_boards on the Board_menu.
- The Board area also shows the list of device IDs in the current board configuration build by the Edit command or loaded from the above board file. Except for the standard Windows application controls (such as the Caption_bar, Menu_bar, Toolbar, and the Resizing_border), the Board area the only active area of the Main_window.
- When the number of devices in the present board configuration is more than 10, a horizontal scrollbar appears at the bottom edge of the Board area. You can use this scrollbar to scroll through the board configuration in pages of 9 devices.
- The device positioned in the beam is highlighted. You can move other devices into the beam either with the help of the Move_Device command on the Test_menu or double-clicking them with the left mouse button in the Board area.

Pressure area



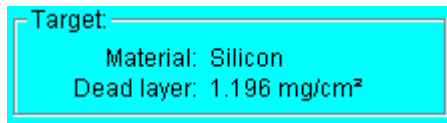
- The Pressure area of the Main_window shows the vacuum pressure in the test chamber and the diagnostic box. The pressure is monitored by the SEU Test Facility application only for the display in the Pressure area, otherwise it is not essential for running the program. If the pressure monitoring causes trouble, it can be stopped by the Monitor_Pressure command on the Beamline_menu. The pressure values in both vacuum chambers are then replaced with question marks. See the Monitor_Pressure command for details.

Positions area

Positions:	
Motor power: ON	
X-axis:	-1.15 cm
Y-axis:	2.64 cm
Z-axis:	-1.08 cm
Iris diameter:	1.78 cm
Tilt angle:	60.00°
Roll angle:	-0.00°
Iris angle:	60.00°

- The Positions area of the Main_window shows the stepper motor DC power supply status (on/off) and the current positions of all seven axes of motion of the positioning stage.
- The stepper motor DC power supply is automatically turned on when SEU Test Facility program starts and automatically turned off when you quit the program. Normally, the status should be on at all times. If it causes noise pick-up by the device under test, you can turn this power supply temporarily off before executing a Test_Run using the Motor_Power command on the Positioning_menu. When you subsequently try to move the positioning stage by commands such as Move_Device, Effective_LET, Tilt_Angle, or Roll_Angle commands on the Test_menu, the SEU Test application turns the DC power supply on for the appropriate axes. Since the axes of motion are divided into two batches, each connected to one half of the dual power supply, the Positions area may also indicate the power supply status on/off or off/on. On the other hand, the Motor_Power always turns both halves on or both off.
- Alternately, if the stepper motor DC power supply causes noise pick-up by the device under test, you can keep it off at all times except during the test board moves. This automatic power supply management can be enable by the Enable_Motors command on the Positioning_menu.
- The current positions of the translational axes of motion (X-, Y-, and Z-axes and the iris aperture diameter are given units set by the Linear_Unit command on the Board_menu (cm or inch), while the positions of the angular axes (tilt, roll, and iris angles) are always given in degrees. If the stepper motor for a particular axis of motion is disabled by the Enable_Motors command on the Positioning_menu, the axis position is replaced by the word "disabled".

Target area



- The Target area of the Main_window shows the present target material of the devices in the current board configuration (silicon, gallium arsenide, etc.) selected by the Target_Material command on the Board_menu.
- The Target area also indicates the absence or presence of a dead layer on top of the device sensitive region build by the Dead_Layer command on the Board_menu. If no dead layer is present, the Target area shows dead layer "none", otherwise it shows the total thickness of the composite dead layer in units of mg/cm².

Beam area

```
Beam:
  Isotope: F-19
  Energy: 140 MeV
  Charge state: not required
    LET: 3.38 MeV·cm²/mg
    Range: 120 µm
  Normal flux: 9.66E+03 /cm²/sec
  Alignment: 93 %
  Center / ring: +9 %
```

- The Beam area of the Main_window shows the present beam isotope, beam energy (in MeV), charge state (if required, i.e., if the faraday cups and electrometers are used for the beam dosimetry), and the beam LET (in MeV·cm²/mg) and range (in µm) in the present Target_Material. These parameters are set by the Ion/Energy command on the Test_menu. The users request the beam isotope and the approximate beam energy. The actual beam energy and charge state (if required) are obtained from the Tandem Van de Graaff operators, and the beam LET and range are usually calculated in the Ion/Energy dialog box.
- The Beam area also shows the most recent normal beam flux (in ions/cm²/sec), regardless of the current Tilt_Angle, the beam alignment and center-to-ring ratio (when using the scintillation detectors and counters for the beam dosimetry), or the center-to-collector ratio (when using the faraday cups and electrometers). These dosimetry parameters are updated upon executing the Measure_Flux or Measure_Energy_&_LET commands on the Dosimetry_menu and the Test_Run command on the Test_menu.
- When using the scintillation detectors and counters for the beam dosimetry, the center-to-ring ratio is updated only when executing the Measure_Flux command with the Center_Scintillator inserted in the beam or when the beam center is automatically checked after a test run as required by the Warning_Levels command on the Dosimetry_menu. When using the faraday cups and electrometers for the beam dosimetry, the center-to-collector ratio is updated after every flux measurement, either by the Measure_Flux command or when the beam center is automatically checked after a test run.

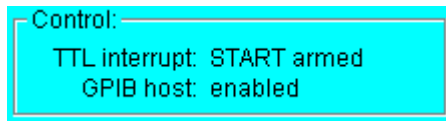
Data area

```

Data: Untitled.dat
Run number: 251
Energy- Δ E: 134.1 MeV
LET/cosθ: 4.916 MeV·cm²/mg
Range-cosθ: 79.9 μm
Fluence-cosθ: 1.00E+05 /cm²
Flux-cosθ: 6.83E+03 /cm²/sec
Run time: 15 sec
    
```

- The Data area of the Main_window shows the present data file name created or opened by the Open command on the Data_menu.
- The Data area also shows the parameters under which the next Test_Run command on the Test_menu would be executed, such as the next test run number, effective beam energy (in MeV), effective LET (in MeV·cm²/mg), penetration depth (in μm), effective flux (in ions/cm²/sec), effective fluence (in ions/cm²), and the estimated run time (in hr:min:sec).
- The displayed run number is the next test run number. It is cleared to number 1 by the Clear_All command on the Positioning_menu and it can be set to any number between 1 and 9999 by the Run_Number command on the Data_menu. The run number is automatically incremented every time you execute the Test_Run command on the Test_menu and enter the number of upsets.
- The beam energy, normal LET, and range in the current Target_Material are set by the Ion/Energy command on the Test_menu. The displayed effective energy is lowered by an energy loss in the Dead_Layer (if any). The energy loss depends not only on the dead layer composition and thickness, but also on the current tilt angle set by the Tilt_Angle or Effective_LET commands on the Test_menu. The effective LET and penetration depth are obtained by recalculating the normal LET and range at the effective energy (instead of at the beam energy) and then adjusting the calculated values for the particle angle of arrival by dividing resp. multiplying by the cosine of the current tilt angle θ .
- The effective flux is calculated from the normal flux by multiplying by the cosine of the current tilt angle θ . It is updated simultaneously with the normal flux shown in the Beam_area of the Main_window, i.e., when you execute the Measure_Flux and Measure_Energy_&_LET commands on the Dosimetry_menu and the Test_Run command on the Test_menu.
- You can set either the desired effective fluence or the desired run time (but not both) by the Fluence and Run_Time commands, respectively, both on the Test_menu. These parameters are then shown in the Data area. If you set the desired effective fluence, the run time is estimated based on the most recent flux measurement. On the other hand, if you set the desired run time, the effective fluence is estimated based on the most recent flux measurement. Due to the beam flux fluctuations, the actual run time (if you set the effective fluence) or the accumulated effective fluence (if you set the run time) may be slightly different from the estimated values when you make a Test_Run.

Control area

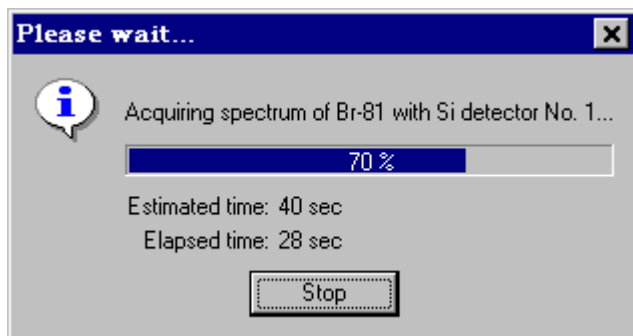


- The Control area of the Main_window shows the status of the two available methods for the remote control of the SEU Test Facility application.
- The SEU Test Facility application can be remotely controlled by applying TTL pulses to the appropriate coaxial BNC connector inputs (START and/or STOP) in order to remotely start and/or stop a single test run. When the method is disabled, the Control area shows the TTL interrupt disabled, when enabled, the the Control area shows the TTL interrupt either START armed, STOP armed, or unarmed. The STOP input can be armed only when executing the Test_Run command on the Test_menu, while the START input can be armed only at all other times - the two inputs are never armed simultaneously. See the TTL_Interrupts command on the Control_menu for details.
- The SEU Test Facility application can be also remotely controlled by sending appropriate commands over the GPIB bus with your tester as the system (bus) controller and the SEU Test Facility as a device on the bus. This control is far more comprehensive than the control via the TTL_Interrupts. It allows you to remotely control the beamline devices, move the positioning stage, measure the beam flux, perform and/or stop test runs, enter upsets, etc. You can also monitor the SEU Test application status by reading back various parameters such as the present device, tilt angle, effective LET, penetration depth, fluence, flux, run time, and many others. When the method is disabled, the Control area shows the GPIB host disabled, when enabled, the Control area shows the GPIB host enabled. See the GPIB_Host command on the Control_menu for details.

Resizing border

- The Main_window of the SEU Test Facility application has a resizing border. Since the window also has a fixed layout, resizing the window with its Resizing border is not very useful - a larger size window does not display any more information than the default size window and a smaller size window does not display all the information shown in the default size window.

Progress box



- The Progress box shows the status of a command in progress. It always contains a brief description of the command. In addition, the Progress box may contain a progress gauge and timer with the estimated and elapsed times, a <Stop> button, or both. Complex progress boxes (such as those opened by the Measure_Flux command on the Dosimetry_menu or the Test_Run command on the Test_menu) may also show the beam fluence, flux, and a graphical beam alignment.
- A progress box with the command description only is usually displayed when the SEU Test Facility application performs some lengthy communication (up to 5 sec) with a remote device or installed hardware.
- A progress box with the progress gauge and timer, but without the <Stop> button is usually displayed by commands that initiate some simple action of a single remote device or installed hardware that is supposed to take a fixed amount of time (up to 10 sec) and then monitor the device to make sure the action is completed.
- A progress box with the <Stop> button is usually displayed by commands that initiate some complex action of remote devices and/or installed hardware that may take a variable amount of time (from a few seconds to several minutes) and then monitor the device(s) until the action is completed. If the progress box contains the <Stop> button, you can stop the command in progress either by using the <Stop> button or by pressing the <Esc> key.
- Commands that display a progress box with the <Stop> button are called interruptible commands. These commands can be also stopped by the KILL command send by a host computer controlling the SEU Test Facility application over the GPIB bus. See the GPIB_Host command on the Control_menu for details.

Positioning menu

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Board menu

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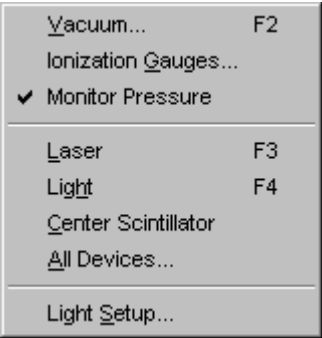
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Beamline menu

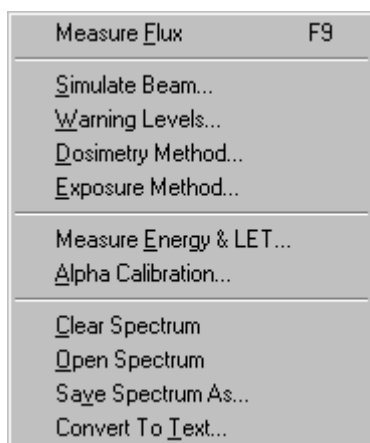


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Dosimetry menu



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Test menu

<u>T</u> est Run	F10
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Enter <u>C</u> omment...	
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✓ <u>F</u> luence...	F5
Run <u>T</u> ime...	F6
<u>I</u> on/Energy...	
<u>E</u> ffective LET...	F7
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Data menu

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Control menu



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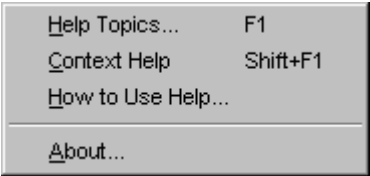
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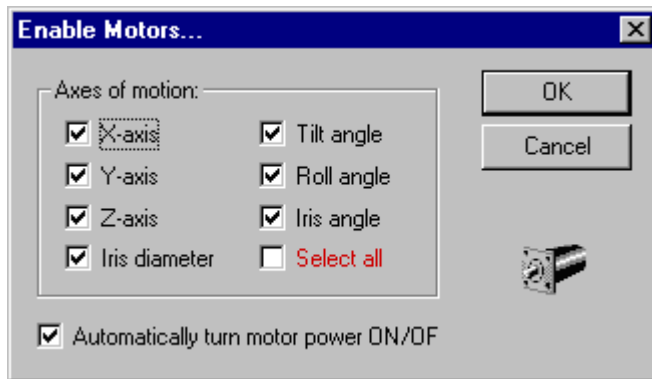
Help menu



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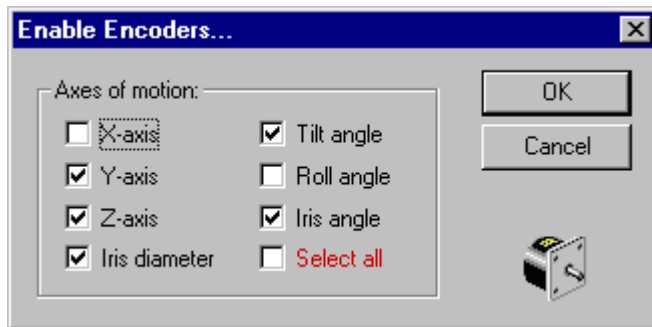
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Enable Motors...



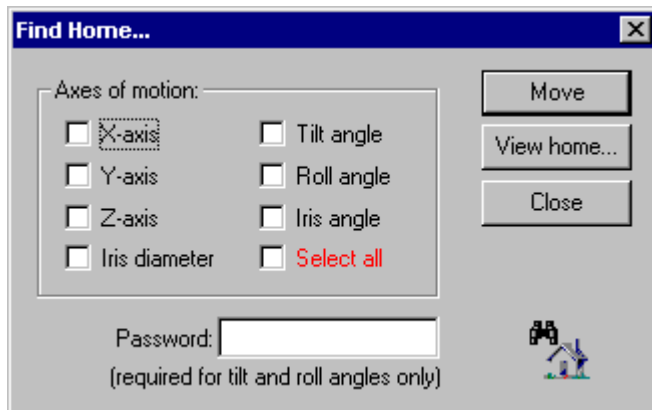
- The Enable Motors command enables or disables the remote control of stepper motors for the selected axes of motion. You can disable the individual motors if you want to make absolutely sure that they do not move if you accidentally try to later on.
- When a stepper motor is under the remote control or enabled, the current position of the corresponding axis of motion is displayed in the Positions_area of the Main_window . When the motor is disabled, the axis position is replaced by the word disabled.
- When a stepper motor is disabled, both the manual and mouse joysticks for the corresponding axis of motion are also disabled. This prevents moving the axis accidentally.
- When disabling the stepper motor for the tilt angle, the stepper motor for the iris angle is automatically disabled as well. On the other hand, the tilt angle stepper motor can be enabled without enabling the iris angle stepper motor.
- The information regarding which stepper motors are enabled or disabled for the remote control is not cleared by the Clear_All command.
- Since the stepping motor power turned ON at all times in order to maintain some holding torque on the positioning stage stepping motors is a common source of excessive noise, the Enable Motors command also allows you to turn the Motor_Power automatically ON/OFF as necessary for all motion maneuvers (i.e., for maneuvers executed by the Find_Home, Find_Limits, and Go_Home commands on the Positioning_menu, Verify command on the Board_menu, Move_Device, Effective_LET, Tilt_Angle, and Roll_Angle commands on the Test_menu, and for positioning devices into the beam by double-clicking their name with the left mouse button in the Board_area of the Main_window).
- Automatic turning the Motor_Power ON/OFF does not work for the manual and mouse joysticks . When using the joysticks , you have either disable this option or turn the stepping motor power ON by the Motor_Power command.

Enable Encoders...

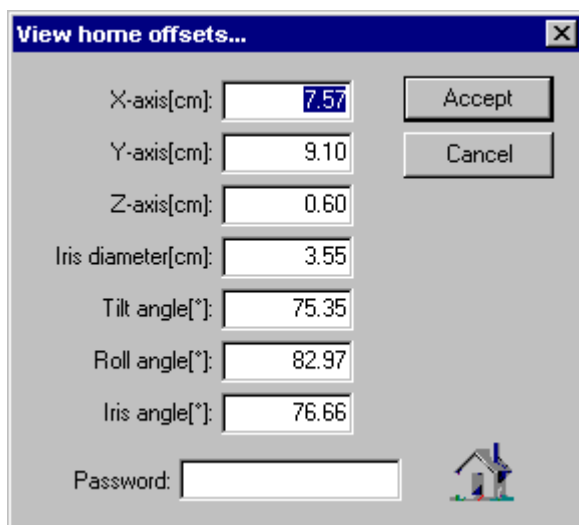


- The Enable Encoders command enables or disables the remote control of absolute encoders for the selected axes of motion. An absolute encoders should be disabled only if it does not operate properly, for example because of broken or intermittent connections.
- When an absolute encoder is under the remote control or enabled, the current position of the corresponding axis of motion is checked before and after every move of that axis for enhanced system reliability. When the absolute encoder is disabled, the motion controller has to keep track of the current axis position since the controller power-up or reset and the positioning stage initialization by the Find_Home command. Please note that the motion controller is reset by rebooting the computer with the <Reset> button, but not by rebooting with the <Ctrl+Alt+Del> key combination.
- The main motion controller can only keep track of attempted maneuvers, but it has no means to check their success. Therefore, the current positions for the axes with disabled absolute encoders, as reported by the motion controller, may be incorrect after an attempt to move fails, for example because of no power for the stepper motor or because the motor stalls. However, it is possible to operate the SEU Test Facility application for extended periods of time with some absolute encoders disabled.
- The absolute encoders are necessary for the operation of the manual joysticks. Each manual joystick is actually a separate two-axis motion controller. The main motion controller is not aware of the maneuvers performed with these auxiliary joystick motion controllers and therefore it cannot keep track of the current positions of the affected axes. During and after every joystick maneuver, the current positions of the affected axes must be read with the help of the absolute encoders and loaded into the main motion controller. The SEU Test Facility application monitors the activity of the manual joysticks and performs this task automatically and it also automatically disables the manual joysticks for the axes of motion with the disabled absolute encoders.
- Since the joystick maneuvers are essential for editing the present board configuration by the Edit command on the Board_menu, the manual joysticks for the axes with the disabled absolute encoders have to be simulated by mouse joysticks available in the Joysticks dialog box and also in various dialog boxes opened by the Edit command.
- The information regarding which absolute encoders are enabled or disabled for the remote control is not cleared by the Clear_All command.

Find Home...



- The Find Home command finds the home (zero) positions for the selected axes of motion. Only the axes with the stepper motors enabled by the Enable_Motors command can be selected for finding their home positions. By default, no axis is selected for the find home maneuver.
- Each selected axis moves at first in its positive direction at one fourth of its normal velocity until its positive limit switch, identical with its home switch, is tripped. Since the position offset of the positive (home) limit switch is known, this offset is now loaded into the motion controller. When the positive (home) limit switches for all selected axes are found, all axes move back to their home (zero) positions at their normal speed. You can always stop the move before it is completed by pressing the <Stop> button in the Progress_box displayed during the move.
- Following the find home maneuver for the selected axes, you have to reset the corresponding absolute encoders to make them read zero positions. The new position offsets can be saved in their non-volatile memory, so that they are not lost on power-off. This requires entering a password known to the Tandem Van de Graaff personnel only. See the Zero_Positions command for the Corresponding dialog box. To see the present offsets from the positive (home) limit switches, use the <View offsets> button. Changing the present offsets requires entering the password as well.

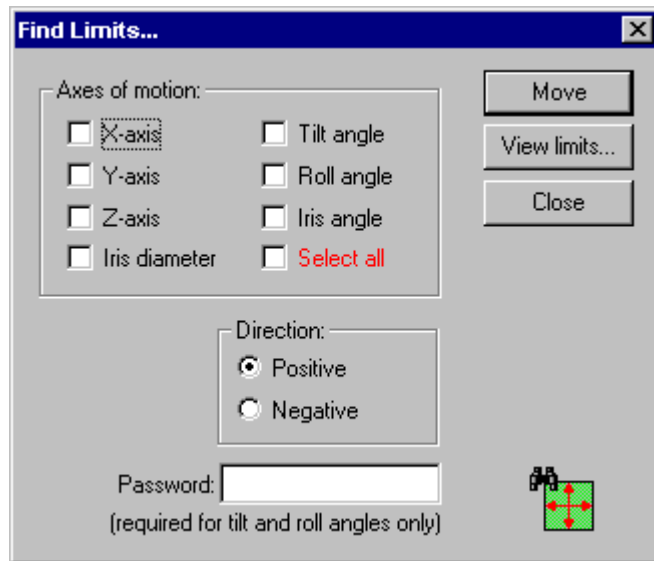


- The find home maneuver is essential for the proper operation of almost any automatic motion control system after a reset or power-up. However, it is redundant for the SEU Test Facility positioning stage equipped with the absolute encoders, as long as they are enabled for the remote control and properly initialized. Instead of going through the find home maneuver after a computer reset or power-up, the

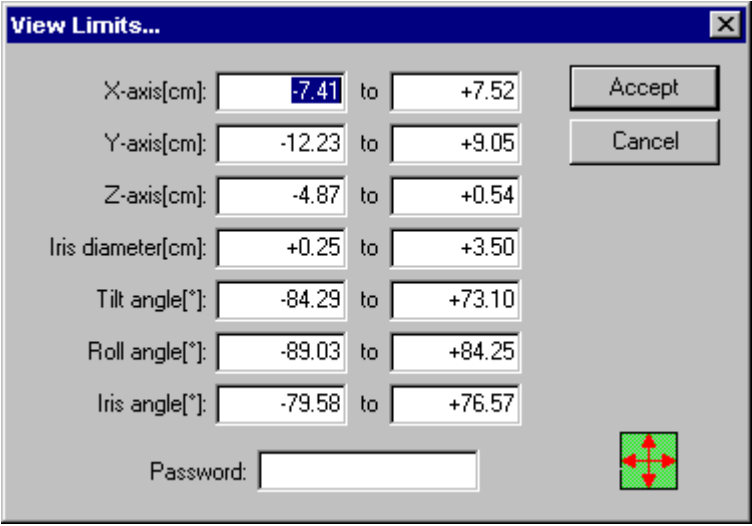
current axis positions can be simply read by the absolute encoders and loaded into the motion controller.

- Users are not allowed to execute the Find Home command for the tilt and/or roll angles. These two axes of motion can (and should) be calibrated with a far better accuracy than the fixed offsets from their positive (home) limit switches with the help of Zero_Positions command. If the command is executed for the tilt and/or roll angles, the positioning stage must be watched and the maneuver stopped immediately if anything goes wrong. For example, a failure of the positive (home) limit switch to trip can cause a heavy damage to the positioning stage. In addition, if the user cables are too short (less than about 3 ft.), they can damage connectors on the vacuum feedthrough plates and on the user test board.

Find Limits...



- The Find Limits command finds either the positive or negative limit switch positions for the selected axes of motion. Only the axes with the stepper motors enabled by the Enable_Motors command can be selected for finding their limit switch positions. By default, no axis is selected for the find limits maneuver.
- Each selected axis moves at first in its positive or negative direction at one fourth of its normal velocity until its positive or negative limit switches are tripped. When the limit switches for all the selected axes of motion are found, the current positions are read by the absolute encoders, and all axes then move back to their home (zero) positions at their normal speed. You can always stop the move before it is completed by pressing the <Stop> button in the Progress_box displayed during the move.
- Following the find limits maneuver of the selected axes, the new software limit positions are displayed. Please note that the software limits are slightly reduced (closer to the home positions) than positions of the actual limit switches. This arrangement protects the limit switches from being tripped frequently. The difference amounts to approximately 0.05 cm for the translational axes and 0.1° for the rotational axes. You have to accept the new software limits so that they are not lost on power-off. This requires entering a password known to the Tandem Van de Graaff personnel only. To see the present software limits, use the <View limits> button.

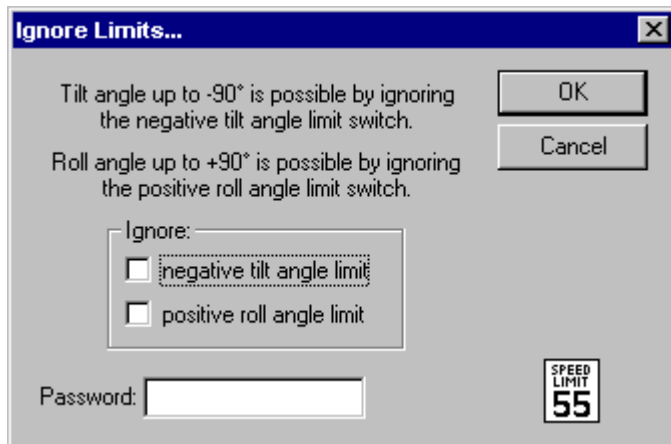


The 'View Limits...' dialog box displays the current limits for various axes. The X-axis is set from -7.41 to +7.52 cm, Y-axis from -12.23 to +9.05 cm, and Z-axis from -4.87 to +0.54 cm. The Iris diameter is set from +0.25 to +3.50 cm. The Tilt angle is set from -84.29 to +73.10 degrees, and the Roll angle is set from -89.03 to +84.25 degrees. The Iris angle is set from -79.58 to +76.57 degrees. There is a Password field and a green square button with a red crosshair icon.

Parameter	Value	Unit
X-axis	-7.41 to +7.52	cm
Y-axis	-12.23 to +9.05	cm
Z-axis	-4.87 to +0.54	cm
Iris diameter	+0.25 to +3.50	cm
Tilt angle	-84.29 to +73.10	°
Roll angle	-89.03 to +84.25	°
Iris angle	-79.58 to +76.57	°

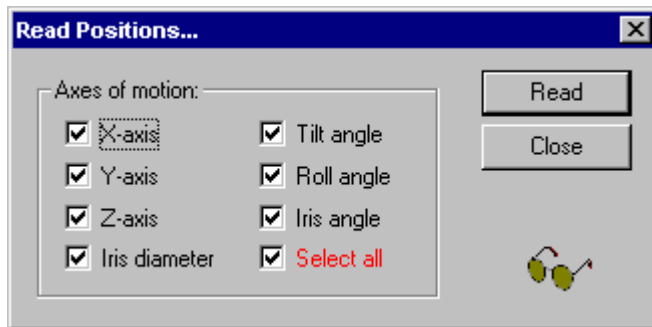
- Users are not allowed to execute the Find Limits command for the tilt and/or roll angles. If the command is executed for these two axes, the positioning stage must be watched and the maneuver stopped immediately if anything goes wrong. For example, a failure of the positive or negative limit switches to trip can cause a heavy damage to the positioning stage. In addition, if the user cables are too short (less than about 3 ft.), they can damage connectors on the vacuum feedthrough plates and on the user test board.

Ignore Limits...



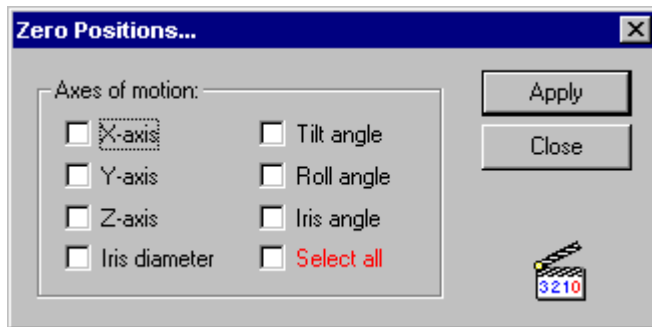
- The Ignore Limits command allows you to move the tilt angle axis up to -90° by ignoring its negative limit switch and/or the roll angle axis up to $+90^\circ$ by ignoring its positive limit switch. The feature is enabled by entering a password known to the Tandem Van de Graaff personnel only. Ask the operators for assistance if moving to any of these angles is required for your test setup. No password is necessary to disable this feature.
- The limit switches are not ignored until a move beyond the software limit is attempted using the Tilt_Angle and/or Roll_Angle commands on the Test_menu menu and the attempt is confirmed one more time by the user. The operation of the limit switches is restored immediately following the move. They are ignored again if another move beyond the software limits is attempted and confirmed. When any of these angles is outside of the limit switch range, both the manual and mouse joysticks for the corresponding axis are disabled.
- Never use the Zero_Positions command for the tilt and/or roll angles when their current positions are outside of the limit switch range. A subsequent move of the affected axis in a wrong direction can cause a heavy damage to the positioning stage. Please note that it is never necessary, even for the tilt angle. Since cosine of 90° is zero, it is ignored in the calculation of the effective LET, penetration depth, effective flux, and effective fluence, resulting in values identical to those for 0° tilt angle.

Read Positions...

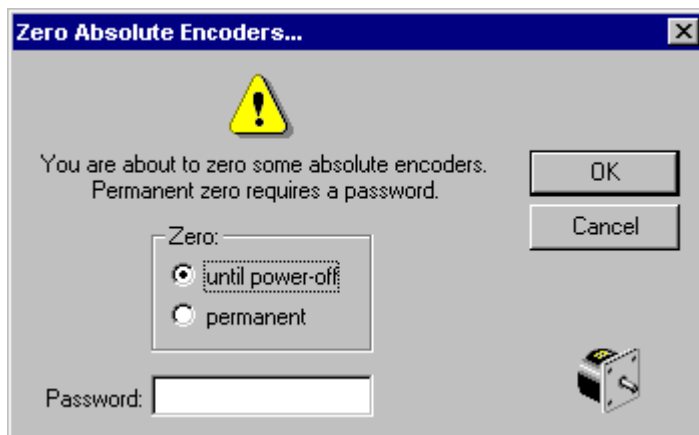


- The Read Positions command reads the current positions for the selected axes of motion. The positions can be reported only for the axes with their absolute encoders enabled by the Enable_Encoders command. However, positions for axes with the stepper motors disabled by the Enable_Motors command are not displayed - their positions are replaced by the word disabled.
- The position of each selected axis is first read by the corresponding absolute encoder and then loaded into the motion controller. Depending on the number of the selected axes, the Read Positions command may take up to 2 sec to complete. By default, all axes with the absolute encoders enabled are selected for reading their positions.
- The SEU Test Facility program reads the positions before and after every move. It is also capable of detecting motion performed by the manual joysticks and read the corresponding absolute encoders automatically. Consequently, the displayed positions are always correct (as long as all the absolute encoders are enabled) and the command is redundant. Execute the Read Positions command only if you are in doubt about the displayed current positions.

Zero Positions...

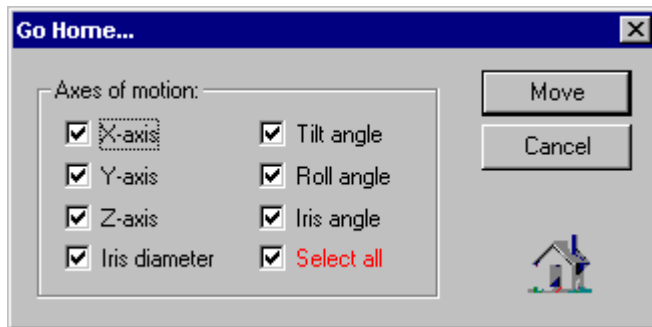


- The Zero Positions command makes the current positions zero for the selected axes of motion. Only the axes with the stepper motors enabled by the Enable_Motors command can be zeroed. By default, no axis is selected for zeroing their positions.
- The zero position for each selected axis is loaded into the motion controller. If the corresponding absolute encoder for the axis is enabled by the Enable_Encoders command, it is also reset to read zero at the current position. The new position offset can be saved in the absolute encoder non-volatile memory so that it is not lost on power-off. This requires entering a password known to the Tandem Van de Graaff personnel only.



- The Zero Positions command is useful for an accurate calibration of the tilt and roll angles by means of the laser beam and water level, respectively. This calibration is far more accurate than the fixed offset from the positive (home) limit switch used by the Find_Home command.

Go Home...

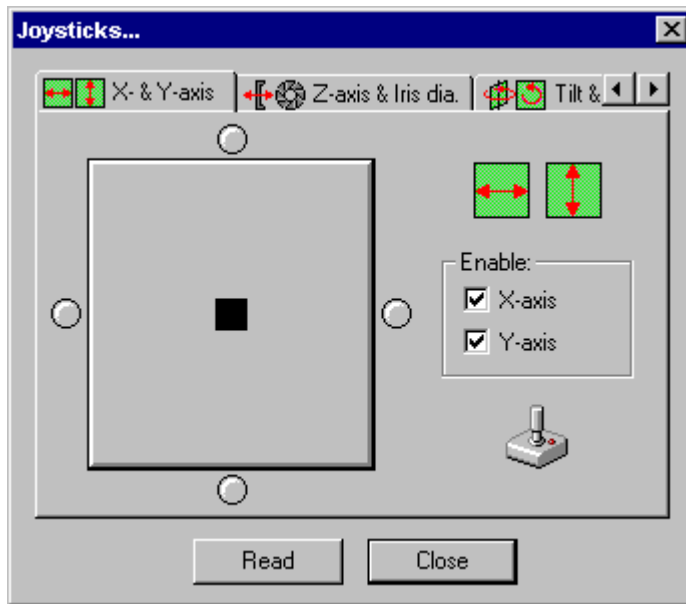


- The Go Home command moves the selected axes of motion to their home (zero) positions. Only the axes with the stepper motors enabled by the Enable_Motors command can be moved to their home positions. By default, all axes with enabled stepper motors are selected for moving to their home positions.
- You can always stop the move before it is completed by pressing the <Stop> button in the Progress_box displayed during the move.
- Before you vent the SEU test chamber and pull the positioning stage outside, the X- and Y-axes are automatically moved to their home positions in order to protect the positioning stage from hitting the bottom rim of the chamber, when you pull it out. If, outside of the SEU test chamber, you move the test board up, for example by the Y-axis joystick or by selecting a device with the negative Y-coordinate from the present board configuration displayed in the Board_area of the Main_window, a steel pin is automatically inserted into the cable tray groove in order to protect the positioning stage from hitting the bottom rim of the chamber, when you push it in. Simultaneously, a red light on the test chamber side wall is turned on. In this case, you should execute the Go Home command at least for the X- and Y-axes before pushing the positioning stage in and pumping the test chamber down. Otherwise, the steel pin is not withdrawn from the groove, preventing to push the positioning stage underneath the test chamber. Excessive force of momentum may permanently bent the pin.

Motor Power

- The stepper motor DC power supply is automatically turned on when the SEU Test application starts and automatically turned off when you quit the program.
- The stepper motor drivers maintain a holding torque on all stepper motors when the motors are in a stationary state. The holding torque power may interfere with the device under test operation due to some noise pickup. If any noise pickup is observed, the Motor Power command allows you to turn the stepper motor power off for testing the device operation with your tester and for executing test runs.
- When the power is on, the Motor Power command on the Positioning_menu is checked and the corresponding Toolbar button depressed. The power status is also shown in the Positions_area of the Main_window .
- The stepper motors are divided into two batches for their DC power. The motors for the four device coordinates (the X-, Y-, Z-coordinates and the iris diameter) are in the first batch, while the motors for the angles (the tilt, roll, and iris angles) are in the second batch. If you attempt to move the positioning stage with the stepper motor power off, the SEU Test Facility program issues a warning, turns the power on for the appropriate stepper motor batch and completes the move. Normally, the Motor Power command toggles the stepper motor power for both batches simultaneously. It turns the power off if the power is on for at least one batch.

Joysticks...



- The Joystick command allows you to simulate the manual joysticks. The joystick simulator looks like a large button with a little black square in its center. Each of the four tabs in the Joystick dialog box control a pair of axes, just like the manual joysticks. If you wish to move only one axis, you can temporarily disable the other one in the pair. To move the single axis or the axis pair, drag the little black square with the computer mouse. The axis speed is proportional to the little black square deflection, again, just like for the manual joysticks. Please note that the manual joysticks are also equipped with switches that allow you to select the velocity range as high, medium, or low.
- Each manual joystick is actually a separate two-axis motion controller. The main motion controller is not aware of the maneuvers performed with these auxiliary joystick motion controllers and therefore it cannot keep track of the current positions of the affected axes. During and after every joystick maneuver, the current positions of the affected axes must be read with the help of the absolute encoders and loaded into the main motion controller. The SEU Test Facility application monitors the activity of the manual joysticks and performs this task automatically and it also automatically disables the manual joysticks for the axes of motion with the disabled absolute encoders. Since the manual joysticks must be disabled for the axes of motion with the corresponding absolute encoders not enabled by the Enable_Encoders command, the joystick maneuvers for these axes should be performed with the mouse joysticks. The mouse joysticks remain operational even for the axes with their absolute encoders disabled. Maneuvers performed with the mouse joysticks are executed by the main motion controller and the absolute encoders are therefore not necessary to keep track of the current positions.

Clear All

- The Clear All command clears or resets to their default values all user settings of the SEU Test Facility program. This is the first command you should execute before starting to use the program. The user settings include:
 - the board configuration and board file name,
 - the target material of the devices or samples and their dead layer (if any),
 - the linear unit is set to centimeters.
 - no tilt and/or roll angle limit switches are ignored,
 - the beam isotope, energy, linear energy transfer (LET), and the range,
 - the last measured flux, beam alignment, and the center-to-ring ratio,
 - the last time of the beam center check,
 - the beam beam quality warning levels for beam alignment, center-to-ring and the flux drift,
 - the frequency of checking the beam center is set to automatic,
 - the desired effective fluence or test run time,
 - the test run termination is set to be done by reaching the desired effective fluence,
 - the data file name, test title and the run number,
 - the plot symbol and plot scale,
 - all on-line data plots are erased,
 - any remote control by the TTL interrupts and/or GPIB host is disabled.
- After executing the Clear All command, the previous user settings are completely lost and impossible to retrieve. On the other hand, various hardware settings of the SEU Test Facility program are neither cleared nor reset. They must be explicitly changed, if necessary, by the corresponding menu commands, usually after the equipment is mounted, connected, tested and/or calibrated. The hardware settings include:
 - the enabled stepper motors and absolute encoders,
 - the most recent values of all limit switch positions and home position offsets from the positive (home) limit switches,
 - the dosimetry method including the beam scattering method (scattering foil or sweeping magnets), detector type (photomultipliers with scintillators or faraday cups), and aperture area(s).
 - the exposure method (single device or area scans),
 - the silicon detector properties (resistivity and nominal bias), material of the energy loss foil, and the detector and foil calibration (calibration constant and its uncertainty, foil thickness and its uncertainty),
 - the line printer and plot monitor.
- The Clear All command also turns off the laser beam, chamber light, and closes all beam shutters if any of these devices were activated. Then the command deletes all on-line plots and attempts to home all axes of motion with the enabled stepper motors. You can reject deleting the plots and/or cancel the homing maneuver. If you cancel the homing maneuver, no axis is moved and no axis position is cleared either.

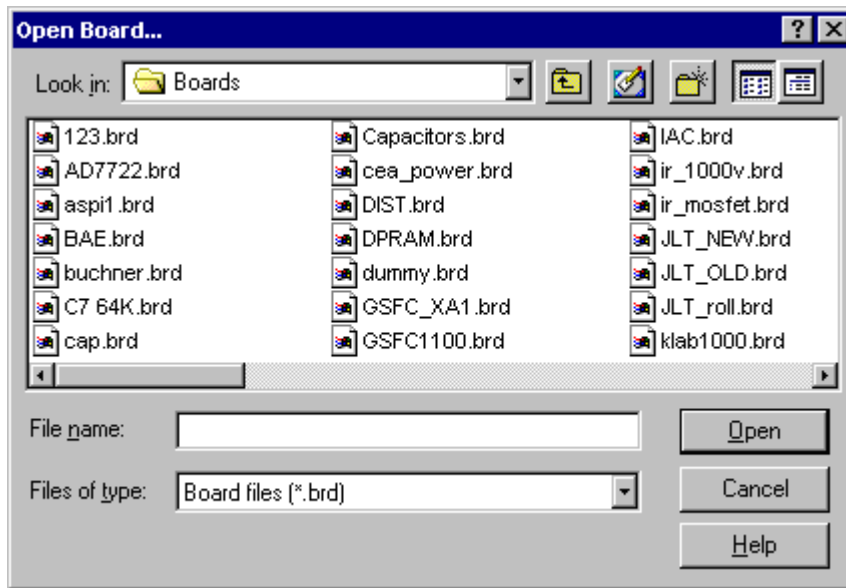
Exit

- The Exit command terminates the SEU Test Facility program.
- If you have made changes in the present board configuration and did not save it using either the Save or Save_As commands, you will receive a prompt to save it now, before the program exits.

New

- The New command allows you to clear the present board configuration displayed in the Board_area of the Main_window . You should use the New command before you start editing a new board configuration from the scratch by the Edit command.
- If you have made changes in the present board configuration and did not save it using either the Save or Save_As commands, you will receive a prompt to save it now, before it is cleared.

Open...

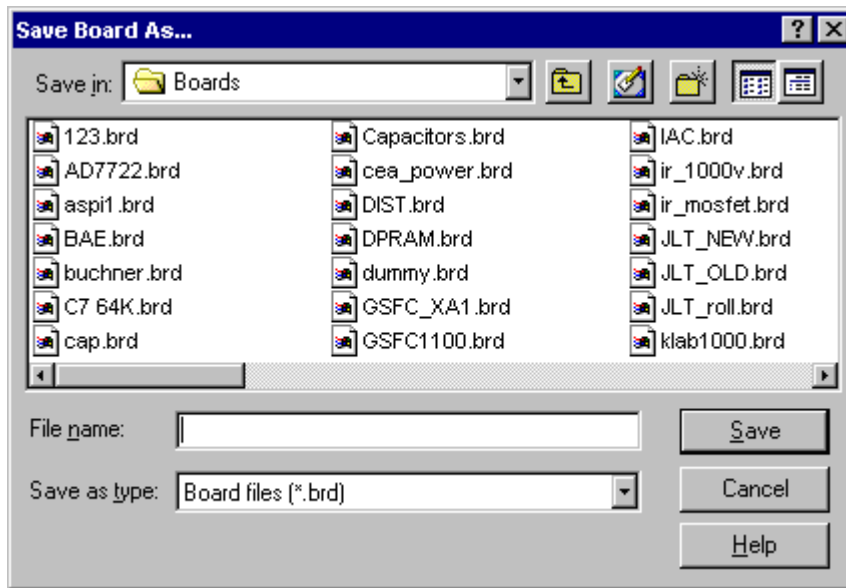


- The Open command allows you to retrieve a previously saved board configuration by opening an existing board file and display it in the Board_area of the Main_window as the present board configuration.
- The file list is filled by files in the ...\\Boards subfolder with the *.brd file filter for board files. There is no default file name. You either have to type it in or you can select an existing board file from the file list. When typing in the board file name, no file extension has to be included. If you omit the extension, the default board file extension .brd is used.
- If you do not remember the board file name of the board configuration you wish to retrieve, try to sort the board files by date in the descending order. The topmost file or a file close to the top are the most likely choices.
- If you have made changes in the present board configuration and did not save it using either the Save or Save_As commands, you will receive a prompt to save it now, before it is replaced by another board configuration.

Save

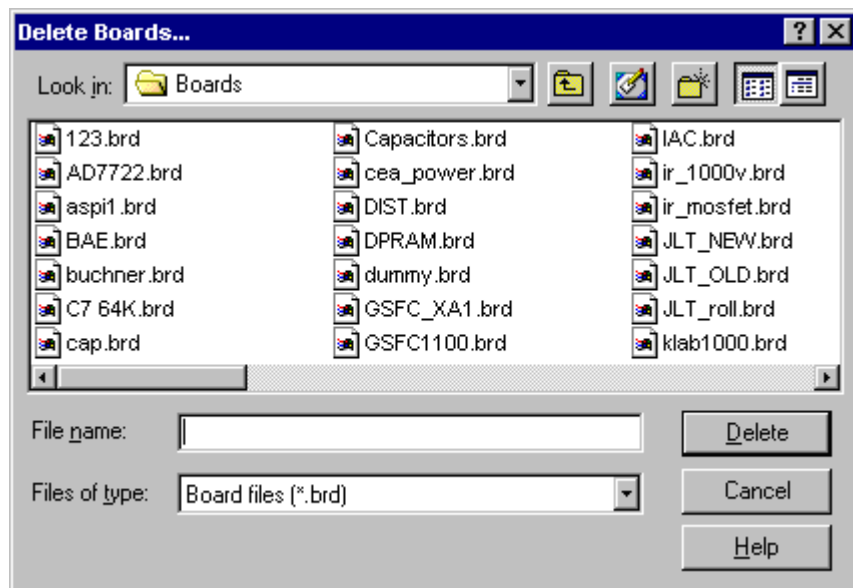
- After you have made changes in the present board configuration, you can (and should) save it in a board file. The Save command saves the present board configuration displayed in the Board_area of the Main_window in the present board file, so that you do not have to type in the file name or select from the file list. The present board file name is set by the Save_As command and it is also shown in the Board_area .
- If the present board file name is Untitled.brd, the Save command defaults to the Save_As command.
- The board file is saved in an internal binary format recognized only by the SEU Test Facility program.
- If you have made changes in the present board configuration and did not save it using either the Save or Save_As commands, you will receive a prompt to save it when you try to:
 - clear the present board configuration using the New command,
 - open another board file using the Open command,
 - exit the SEU Test Facility program.
- Please note that the present board configuration is automatically saved in the present board file at the end of every Test_Run .

Save As...



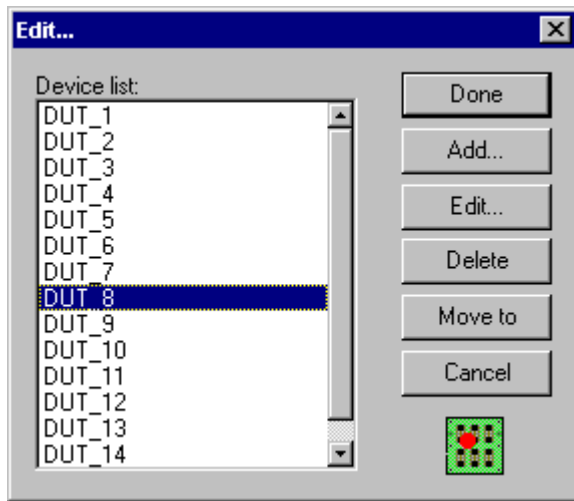
- After you have made changes in the board configuration, you can (and should) save it in a board file. The Save As command allows you to save the present board configuration displayed in the Board_area of the Main_window in a new board file.
- The file list is filled by files in the ...\\Boards subfolder with the *.brd file filter for board files. There is no default file name. You either have to type in a new file name or you can select an existing board file and overwrite it. If the board file already exists, you will receive a warning and you have to confirm your intention before the command can proceed. When typing in a new board file name, no file extension has to be included. If you omit the extension, default board file extension .brd is used. Using other board file extensions is not recommended, because the *.brd file filter is used by all other board file commands (Open and Delete).
- The board file is saved in an internal binary format recognized only by the SEU Test Facility program.
- If you have made changes in the present board configuration and did not save it using either the Save or Save As commands, you will receive a prompt to save it when you try to:
 - clear the board configuration using the New command.
 - open another board file using the Open command.
 - exit the SEU Test Facility program.
- Please note that the present board configuration is automatically saved in the present board file at the end of every Test_Run .

Delete...

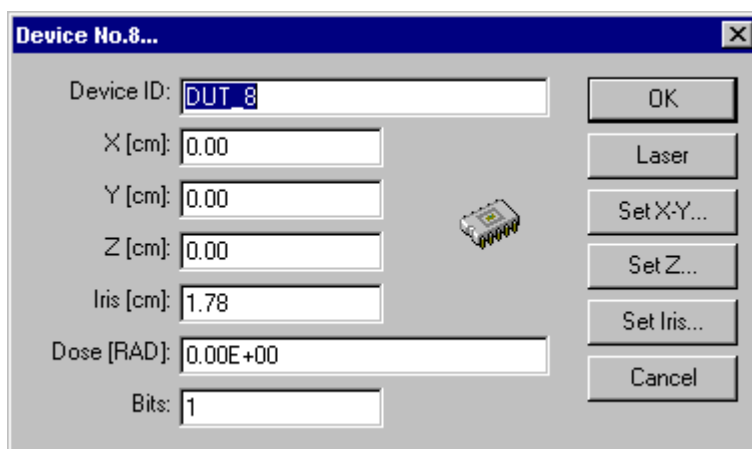


- The Delete command allows you to delete a board file or files.
- The file list is filled by files in the ...\\Boards subfolder with the *.brd file filter for board files. There is no default file name in order to limit the possibility of accidental deleting. You either have to type it in or you can select multiple files from the file list. You have to confirm your intention to delete a board file or files one more time before the command can proceed.

Edit...



- The Edit command allows you to edit the present board configuration. The SEU Test Facility program accepts any number of device sockets on a single test board. You can either add a new device socket, or you can edit, copy, delete, or move an existing one into the beam position. If you plan to plug various devices in the same socket, you can create several device sockets with the same positions but different device IDs. On the other hand, you can also create more than one device socket with the same device ID. Since the on-line plots of the test run results are automatically sorted by device IDs, results for the different device sockets with the same ID will be plotted together.
- Make sure that the tilt angle is in its home position (zero). The board configuration should be edited at the normal angle of beam incidence. If you execute the Edit command and the tilt angle is not zero, the SEU Test Facility program issues a warning and asks you to home the tilt angle now.
- If you want to add another device socket, simply use the <Add> button. If you want to edit or delete an existing device socket, select its device ID from the list. Selecting the device ID enables the <Edit>, <Delete> and <Move To> buttons. When creating or editing a device socket, the SEU Test Facility program opens another dialog box that allows you to enter the device ID, socket coordinates, and the number of bits and to initialize the radiation dose accumulated in the device.

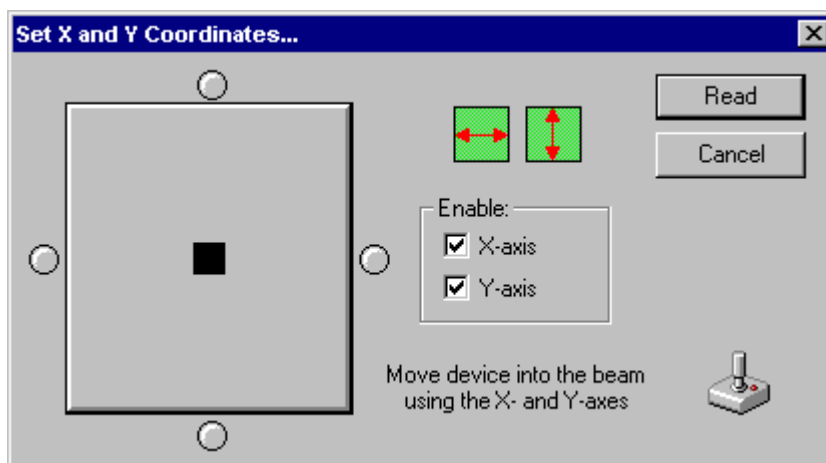


- You can enter the device position (X-, Y-, and Z-coordinates, and the iris diameter) in one of two ways. The first method is to enter predetermined coordinates manually from the keyboard. The second and easier way is to use a laser alignment system installed in the beamline. Use of the laser beam requires

that the entire test board be fully installed in the experimental test chamber and the chamber be evacuated. This is required prior to opening the beamline vacuum valves that allow the laser beam to illuminate the device in-situ and observe it either by a small video camera or through one of the test chamber glass viewports. Then you can move the X-, Y-, Z- and iris diameter axes by means of the manual or mouse joysticks. When the device is correctly aligned, you can read the current positions by the absolute encoders using the <Read> button. In general, using this method is so easy that the predetermined coordinates are very seldom used.

- **Perform the following steps when creating a new device socket:**

- Use the <Add> button. If no existing device ID is selected (highlighted) in the list, the default device coordinates are X = 0, Y = 0, Z = 0, and iris diameter = 1.78 cm (0.7 inch). If a device ID is selected, the default coordinates are coordinates of the selected device. Copying of the coordinates of an existing device is useful if you plan to plug more than one device into the same socket. To unselect a device from the list, use the <Add>, <Edit> or <Delete> button and immediately close the subsequent dialog or message box by selecting the <Cancel> or <No> buttons.
- Type in the device ID. The Edit command will refuse to create a new device socket without giving it a device ID. The device ID can be a maximum of 16 characters long, because longer device IDs would not fit in the data file format (see the sample_data_file for details).
- Leave the accumulated dose at zero.
- Leave the number of bits at one if you want to express the upset cross section in cm². Type in the number of bits if you want to express the upset cross section in cm²/bit rather than in cm². Suffixes like K, M, and G for Kilo, Mega, and Giga, respectively, are supported.
- Turn the laser beam on (if not already on) using the <Laser> button.
- Set the X- and Y-coordinates using the <Set X-Y> button. At this point, all manual joysticks except the X- and Y-axes become disabled. The reason is that the user aligning the device is typically watching the laser beam and the device on the video monitor or through one of the test chamber viewport and not his hand operating the joystick. Deflecting the wrong joystick would ruin the device position. The SEU Test Facility program prompts you to position the device into the laser beam using the manual or mouse joystick. When you are satisfied with the device position, use the <Read> button to read the current X- and Y-axis positions by the absolute encoders (or by the motion controller if the encoders are disabled).

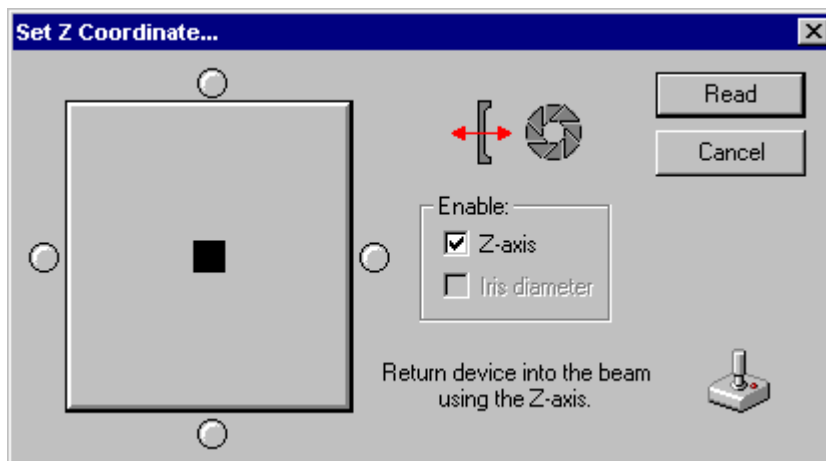


- If you plan to vary the effective linear energy transfer by changing the tilt angle, the device must be positioned on the vertical axis of rotation by moving the device back or forth in order to compensate for the chip and/or socket height. If this is the case, you must set the device Z-coordinate. On the other hand, if you want you use only the normal angle of incidence, you can ignore the device Z-coordinate.

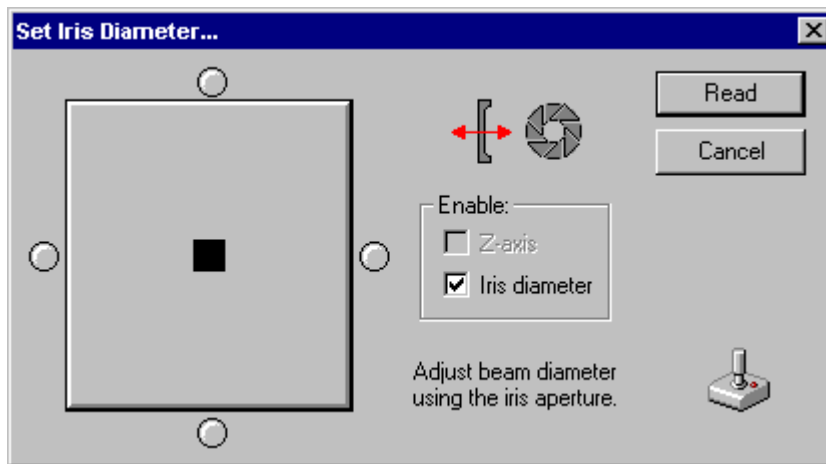
- Set the Z-coordinate using the <Set Z> button. The tilt angle axis automatically moves to 45° (you may select any other tilt angle). In general, positive tilt angles should be used when observing the device through the video camera or through the left test chamber viewport, while negative tilt angles give a better view when observing the device through the right test chamber viewport. Do not stare into the laser beam through the glass viewport when the test board is being tilted, as at the angle +22.5° (for the left viewport) or -22.5° (for the right viewport) the laser beam could be reflected directly into your eyes.



If your device is not on the vertical axis of rotation, it will move away from the laser spot. At this point, all manual joysticks except the Z-axis become disabled. The SEU Test Facility program prompts you to return the device into the laser beam using the manual or mouse joystick. When you are satisfied with the device position, use the <Read> button to read the current Z-axis position by the absolute encoder (or by the motion controller if the encoder is disabled). Finally, the tilt angle axis automatically returns to its home (zero) position.



- Set the iris diameter using the <Set Iris> button. At this point, all joysticks except the iris diameter axis become disabled. The SEU Test Facility program prompts you to adjust the beam diameter using the manual or mouse joystick. Keep in mind that due to about 5" (angular minutes) misalignment between the heavy ion and laser beams and about 35 cm distance between the iris aperture and test board vertical axis of rotation, the (visible) laser beam spot is shifted approximately 0.5 mm to the right of the (invisible) heavy ion beam spot. When you are satisfied with the size of the beam spot, use the <Read> button to read the iris diameter by the absolute encoder (or by the motion controller if the encoder is disabled).

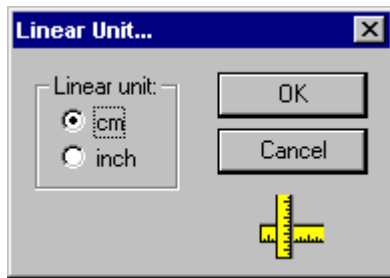


- In order to find the most accurate device positions, it is a good practice to perform all device alignment with a very small iris aperture and skip the step setting the aperture diameter for each device. When you are finished, you can simply edit each device socket to enter the desired aperture diameter, either from the keyboard or using the <Set Iris> button.
- You can also edit, copy, delete, or move to an existing device socket. When editing a socket, select the device ID you wish to edit from the list. Selecting a device ID enables the <Edit>, <Delete>, and <Move> buttons. Use the <Edit> button to edit an existing device socket. Editing a socket is similar to creating a new one. Use the <Add> button (with an existing socket selected) to quickly create a new device socket with all positions copied from the selected one - all you have to do is to type in a new device ID. Use the <Delete> button to delete an existing device socket. The SEU Test Facility program prompts you to confirm your intention before the socket is deleted.
- The <Move To> button in the Edit command dialog box is not intended to move devices into the heavy ion beam for a test run. Use the Move_Device command on the Test_menu or simply double-click the device ID in the Board_area of the main_window using the left mouse button. Use the <Move To> button to move into the laser beam an existing device socket you want to edit without closing the Edit command dialog box. Please note that the selected device socket is in the board configuration being edited. If you have made any changes already, the selected device may not even exist in the present board configuration shown in the Board_area.
- The <Move To> button provides another method of copying the position of an existing device socket. For example, you can copy the position or just the selected coordinates from one existing device socket to another. First, move into the laser beam the device socket you want to copy from. Then select the other device ID and use the <Edit> button. Use the <Set X-Y>, <Set Z>, and/or <Set Iris> buttons followed by the <Read> button without ever touching the joysticks - the positioning stage already is at the desired position. To save time when copying the Z-axis coordinate, you can even enter 0° tilt (rather than the default value 45°).
- When you are finished editing the board configuration, use the <Done> button to accept the changes. If you try to throw away the changes, the SEU Test Facility program will prompt you to confirm your intention before the command proceeds. It is always a good idea to save the changed board configuration immediately using the Save or Save_As commands in case of the program or computer crash,

Verify

- The Verify command allows you to test the present board configuration at the present tilt angle to make sure that the coordinates for all devices have been entered correctly.
- The Verify command closes the wall vacuum valve, turns on the laser beam, and then moves through all the device sockets in the present board configuration, stopping at each for about three seconds. Finally, it turns the laser beam off on opens the wall valve. You can stop the verification maneuver at any time using the <Stop> button in the Progress_box displayed during the moves as also during the stops.

Linear Unit...



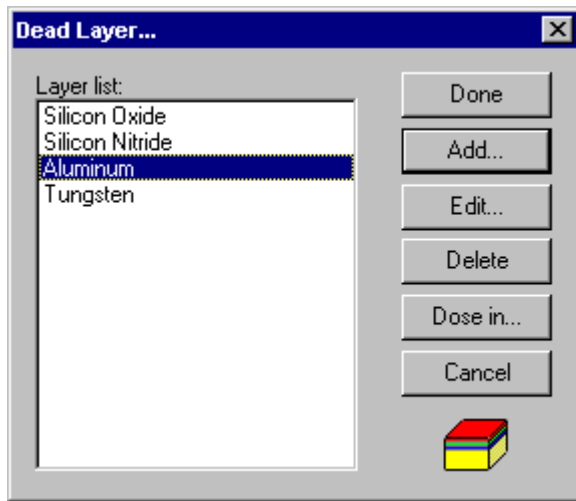
- The Linear Unit command allows you use either centimeters or inches as the length unit for the translational (non-rotational) coordinates. The translational coordinates include the X-, Y-, and Z-coordinates of the device or sample and the iris aperture diameter. Default linear unit used after executing the Clear_All command is centimeter. Rotational coordinates, including the tilt, roll, and iris angles, are always expressed in degrees.
- Device coordinates have to be entered in the present linear units (centimeters or inches) when editing the present board configuration by the Edit command. Since the coordinates are usually entered by moving the device to the desired position (into the laser beam) with the help of joysticks and then reading the current axis positions by the absolute encoders, the linear unit is not important from the user point of view and the Linear Unit command is seldom used.
- The present linear unit is used to express the current positions of translation axes displayed in the Positions_area of the Main_window .

Target Material...

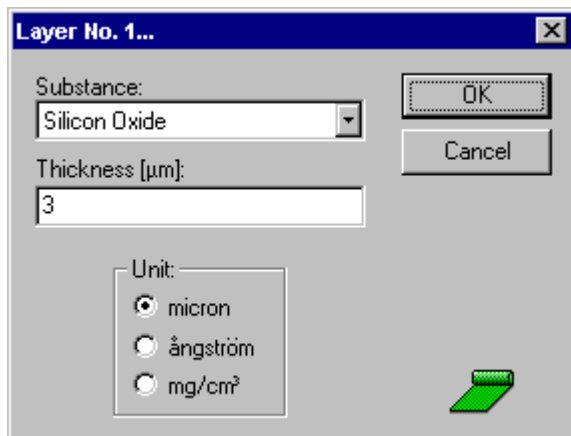


- The Target Material command allows you to select the material of your devices or samples. This material is then used by the Ion/Energy command on the Test_menu in every calculation of the linear energy transfer (LET) and range of the incident heavy ions. After selecting a new target material, the SEU Test Facility program automatically recalculates these quantities for the present heavy ion beam and then executes the Ion/Energy command in order to alert you of the recalculated values.
- Present target material is displayed in the Target_area of the Main_window .
- Default target material after clearing the board configuration by the New command is silicon. When testing electronic components, silicon and gallium arsenide are the only two reasonable choices. When irradiating samples of different nature, material of which is not on the list, you can expand the list of available materials using the Materials command.
- The target material is saved on the board file. Consequently, you should save the board configuration by the Save or Save_As commands after selecting a new target material from the list.

Dead Layer...

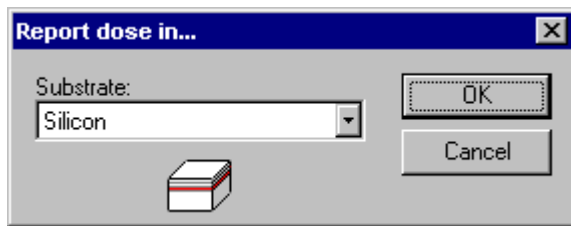


- The Dead Layer command allows you to build a composite dead layer on top of the device sensitive region if you wish to perform a more realistic calculation of the residual energy, linear energy transfer (LET), and range of the incident heavy ions in the device sensitive region. The dead layer composition and thickness have to be obtained from the device manufacturer. You can add a new sublayer on top of the device sensitive region or on top of any previously added sublayer, edit an existing sublayer, or delete an existing sublayer. When you try to delete a sublayer, you will receive a warning and you have to confirm your intention before the command can proceed.
- When adding a new sublayer, select the layer material from the list of available materials and enter the sublayer thickness in ångströms, microns, or mg/cm³. Zero thickness is a valid entry. If the sublayer material is not on the list, you can expand the list of available materials using the Materials command.



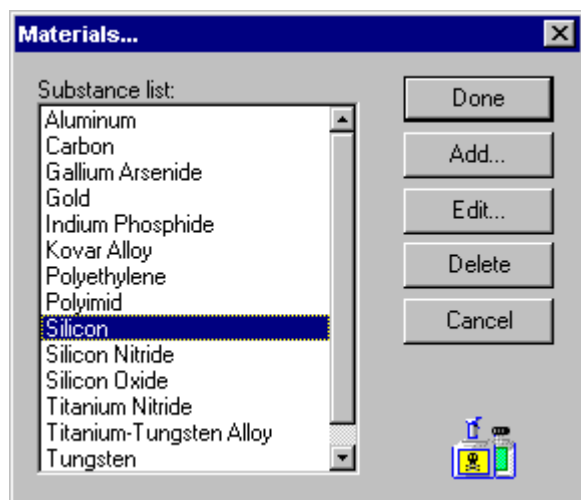
- Total thickness of the present dead layer is displayed in the Target_area of the Main_window . If no dead layer has been built, the total thickness is replaced by the word none.
- In addition to obtaining more realistic values for the residual energy, linear energy transfer (LET), and the range of the incident heavy ions in the device sensitive region, you can choose one sublayer to keep track of radiation dose accumulated in each device. By default, the dose is reported in the material of the device sensitive region with the help of the <Dose> button. Since the dose (absorbed energy per unit mass) is equal to the fluence multiplied by linear energy transfer (LET) of the incident heavy ions in a given material, the same fluence will cause slightly different dose in different materials of

the individual sublayers.

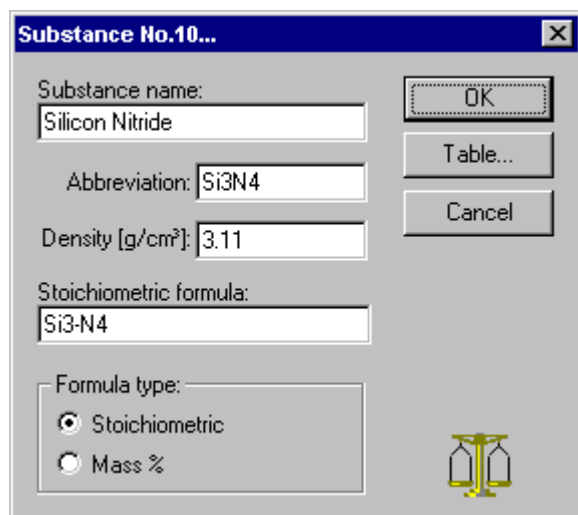


- The permanent degradation of the device parameters due to the absorbed dose is usually associated with radiation damage in the insulating layer of silicon oxide. The silicon oxide sublayer is therefore the most reasonable choice for keeping track of the accumulated dose. Even if you have no information about its thickness, you can still force the SEU Test Facility program to report the dose in silicon oxide. Just add a silicon oxide dead layer of zero thickness and select it with the <Dose in> button.
- The residual energy, linear energy transfer (LET), and range of the incident heavy ions are automatically recalculated after building a new or changing the existing dead layer.
- The dead layer composition and thickness are saved on the board file. Consequently, you should save the board configuration by the Save or Save_As commands after building the composite dead layer.

Materials...



- The Materials command allows you to expand the list of materials available for the Target_Material and Dead_Layer commands. Using the Materials command, you can add a new material to the list, edit an existing material on the list, or delete an existing material from the list. If you want to edit or delete an existing material, select it from the list. Selecting the material enables the <Edit> and <Delete> buttons. When you try to delete an existing material, you will receive a warning and you have to confirm your intention before the command can proceed.
- When adding a new material, in addition of the material name and its abbreviation, you have to enter the material density and either its stoichiometric or its mass percent formula. The stoichiometric formula would be used for chemical compounds, while the mass percent formula is more suitable for mixtures and alloys.



- The required format for the chemical formula is the first element chemical symbol followed by its stoichiometric or mass percent ratio, dash, the second element chemical symbol followed by its stoichiometric or mass percent ratio, dash, etc., the last element chemical symbol followed by its stoichiometric or mass percent ratio. The stoichiometric (but not mass percent) ratios equal to one can be omitted. When using the mass percent formula, the entered mass percent ratio of the last element is ignored and the actual ratio is calculated as 100% minus the sum of mass percent ratios of all preceding elements. For example, the stoichiometric formula would be Si for silicon, Si-O2 for silicon oxide, Si3-N4 for silicon nitride, or Ga-As for gallium arsenide. The mass percent formula would be

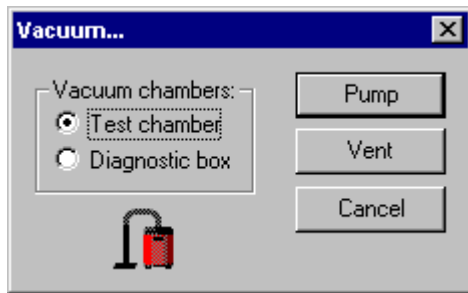
Co17-Ni29.5-Fe53.5 for the Kovar alloy or N78-O21-Ar1 for air. Although the stoichiometric ratios are usually integers, both the stoichiometric and mass percent ratios can contain decimal fractions. The recognized decimal symbol is a period. If you do not follow the required chemical formula format, you will receive an error message and you can either make corrections or cancel.

- Alternately, you can insert element symbols at the end of the stoichiometric or mass percent formulas from the periodic_table of elements using the <Table> button. The SEU Test Facility program always assumes the average atomic mass of the natural isotopic mixture, regardless of how you enter the element symbol (by typing it in or by selecting it from the periodic table).
- The SEU Test Facility program supports only elements from hydrogen to uranium. Transuranium elements are not supported.
- Using the <Convert> button, you can convert the stoichiometric formula to the mass percent formula and vice versa. Please note that the ordinary stoichiometric formula is defined up to an arbitrary factor. When converting a mass percent formula to stoichiometric, the SEU Test Facility application will try to find a factor to make all stoichiometric ratios integers. If it cannot find such a factor for the first stoichiometric ratio less or equal 20, it will use the stoichiometric percent. This arrangement works for a great variety of stoichiometric formulas, but it may occasionally produce minor side-effects. For example, the stoichiometric formula may convey information about the actual number of atoms in one molecule of the material, i.e., C₆H₆ for benzene, C₆H₁₂O₆ for glucose, or N₂ for nitrogen. This information is lost in converting such a stoichiometric formula into the corresponding mass percent formula and it cannot be recovered in converting the mass percent formula back to stoichiometric. The SEU Test Facility application will always use the smallest set of integers, i.e., C-H, C-H₂-O, or N. This side-effect does not affect the LET or range calculation in any way.
- The material list is saved in the Materials.let file in an internal binary format recognized by the SEU Test Facility program only.

Recent Boards

- Up to four recent board configuration files are available on the Board_menu. These recent board files can be loaded by selecting them from the menu without executing the Open command. The recent board file names are saved in the application registry key and they are therefore persistent on the program exit and restart.

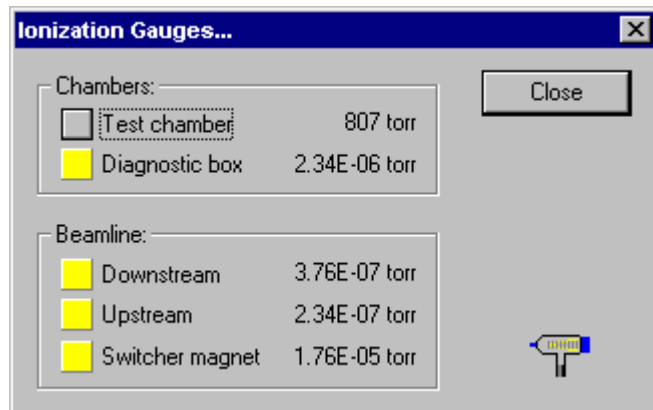
Vacuum...



- The Vacuum command allows you to pump down or vent the test chamber or the diagnostic box. The test chamber containing your test board is the default. The <Pump> and <Vent> buttons start the pumping and venting sequences, respectively, but otherwise the SEU Test Facility application does not control these processes - they are executed by the vacuum controller. These sequences are fully automatic and do not require any further user actions.
- If the pressure monitoring is turned on by the Monitor_Pressure command, the pressure in the corresponding vacuum chamber is monitored for about 10 sec at the beginning of both the pumping and venting sequences. If no significant pressure change (drop for the pumping sequence or increase for the venting sequence) is detected within this time interval, the sequence is stopped and the user is alerted of the problem. If the pressure begins to change, the SEU Test Facility application returns control to the user, who can perform other tasks while pumping or venting the chamber. Typically, it takes less than 5 min to pump down the test chamber and less than 1 min to vent it.
- Before starting the pumping sequence, the appropriate rough pump (either for the test chamber or for the diagnostic box) is turned on. In addition, the SEU Test Facility application makes sure that the test chamber is closed properly, otherwise it does not even attempt to turn on the test chamber rough pump. After the rough pump is turned on, the pumping sequence waits for the corresponding rough valve to open. The rough pump valves open at the pressure about 0.2 torr inside the rough pump. The pumping sequence is stopped and the user is alerted of the problem, if the corresponding rough pump valves fail to open.
- The test chamber pumping sequence ends when the test chamber ionization gauge is automatically turned on, the test chamber beamline valve opens, and the test chamber rough pump stops and vents itself. Since the diagnostic box itself is not connected to any cryogenic pump, either the test chamber or the diagnostic box beamline valves have to open before the ionization gauge can be turned on. The pressure set point is much lower for the diagnostic box beamline valve, and therefore the diagnostic box pumping sequence takes much longer if the test chamber is under atmospheric pressure than if the test chamber is under vacuum. When the diagnostic box pumping sequence ends, the diagnostic box rough pump also stops and vents itself.
- Before starting the venting sequence for the test chamber, the X- and Y-axes are automatically moved to their home positions, in order to make sure that the positioning stage clears the bottom rim of the test chamber when you subsequently lower the hydraulic scissor table and pull it out.
- The venting sequence for each vacuum chamber starts with closing all beamline and cryogenic pump valves. After a 10 sec safety delay, during which the venting sequence can be stopped without spoiling the chamber vacuum pressure, the corresponding vent valve opens. This is the end of the venting sequence. The vent valves remain open for the next 10 min only, in order to protect them from excessive heat. Of course, the vent valve is closed when starting another pumping sequence earlier than 10 min after venting the chamber.

- Users are not supposed to vent the diagnostic box containing the beam monitoring system - the beam shutters, scintillation detectors, and the ion-implanted silicon detectors. If you try to vent the diagnostic box, the SEU Test Facility application issues warning and ask you to confirm your intention.

Ionization Gauges...



- The Ionization Gauges command allows you to read the vacuum pressure along the beamline as well as in the two vacuum chambers (test chamber and diagnostic box). You can also toggle the ionization gauges on/off.
- When pumping down the test chamber or the diagnostic box, the corresponding ionization gauges are automatically turned on at the appropriate pressure (about 5E-03 torr). Likewise, they are automatically turned off before venting the chambers. The beamline ionization gauges remain turned on at all times. The opportunity for operating the ionization gauges manually is therefore limited.
- When venting the test chamber using the Vacuum command, the test chamber beamline and cryogenic pump vacuum valves are closed and the ionization gauge is turned off immediately after you press the <Vent> button, but the test chamber vent valve does not open until 10 sec later. During this time, users or operators can change their mind and stop the venting sequence. Since the test chamber vacuum is preserved, the test chamber cryogenic pump vacuum valve automatically reopens, but the test chamber ionization gauge remains off. Since the test chamber beamline vacuum valve cannot open unless a sufficiently low pressure is measured by this ionization gauge, it also remains closed. To reopen the test chamber beamline valve, make sure that the test chamber pressure measured by the convectron gauge is 1E-02 torr or less and then turn the test chamber ionization gauge back on.
- When venting the diagnostic box using the Vacuum command, both the test chamber and diagnostic box beamline vacuum valves are closed and both the ionization gauge and photomultiplier bias are turned off immediately after you press the <Vent> button, but the diagnostic box vent valve does not open until 10 sec later. During this time, operators can change their mind and stop the venting sequence. Since the diagnostic box vacuum is preserved, both the test chamber and diagnostic box beamline vacuum valves automatically open, but the diagnostic box ionization gauge remains off. Since the photomultiplier bias cannot be turned on unless a sufficiently low pressure is measured by this ionization gauge, it also remains off. To turn the photomultiplier bias back on, make sure that the diagnostic box pressure measured by the convectron gauge is 1E-02 torr or less and then turn the diagnostic box ionization gauge back on. However, the photomultiplier bias does not turn back on automatically, it must be turned on manually in the All_Devices dialog box.

Monitor Pressure

- In addition to communicating with various hardware devices in response to the user actions, the SEU Test Facility application constantly monitors the following parameters and hardware:
 - The beamline status shown in the Beamline_area of the Main_window, using a digital I/O card in the SEU Test Facility main computer SEUTF1.
 - The vacuum pressure in both the test chamber and the diagnostic box, shown in the Pressure_area of the Main_window, by checking for service requests (SRQ) from the vacuum controller over the GPIB bus and reading the pressure when available.
 - The TTL interrupt status, shown in the Control_area of the Main_window, by checking for service requests (SRQ) from the multiprogrammer over the GPIB bus and initiating a Test_Run when the external START signal is detected. This is done only if the START test run on external TTL signal is enabled by the TTL_Interrupts command on the Control_menu.
 - The host computer GPIB interface status, shown in the Control_area of the Main_window, using the second GPIB interface card (the non-system controller) in the SEU Test Facility main computer SEUTF1, executing the host computer commands, and sending back the requested parameters. This is done only if the host computer GPIB control is enabled by the GPIB_Host command on the Control_menu.
 - The beam current in the diagnostic, center, and/or the collector faraday cups, by checking for service requests (SRQ) from the electrometers over the GPIB bus and reading the current when available. This is done only if one or more Keithley electrometer programs are running on any computers in the local area network (usually in the accelerator control room) and they are connected to the SEU Test Facility application. You can check the current network DDE connections with the help of the Disconnect command on the Control_menu.
 - The current axis positions (X-, Y-, and Z-axes, iris diameter, tilt, roll, and iris angles), by reading the absolute encoders over the serial ports. This is done only if the manual joysticks are active and only for the affected axes.

This monitoring is performed in the background thread of the SEU Test Facility application. The software driver for the two National Instruments GPIB interfaces (the system and non-system controllers) is thread safe and can be simultaneously called by different program threads. However, making a software driver thread safe is a relatively new and difficult task and the driver performance is not always flawless. If the background thread becomes too busy, it may hinder the user actions and/or you may experience occasional vacuum controller timeouts.

- The Monitor Pressure command allows you to toggle on/off the most demanding action of the background thread. Since the SEU Test Facility application only initiates the pumping or venting sequences for the test chamber and the diagnostic box by the Vacuum command, but otherwise does not control these processes, the pressure information is not essential for its operation. In fact, this information is only used to display the pressure in the Pressure_area of the Main_window. If you experience frequent vacuum controller or other device timeouts, you may consider turning the pressure monitoring off. The pressure monitoring is automatically turned off when you experience the vacuum controller timeout and press the <Cancel> button.
- When the pressure is being monitored, the Monitor Pressure command on the Beamline_menu is checked. The test chamber and the diagnostic box pressure values are shown in the Pressure_area of the Main_window. If you turn the pressure monitoring off, these values are replaced by question marks.
- Please note that the SEU Test Facility does not read the pressure when the Progress_box is shown,

because it is usually very busy communicating with other hardware and devices, such as the counters or electrometers during the execution of the Measure_Flux command on the Dosimetry_menu or the Test_Run command on the Test_menu.

Laser

- The laser beam is used for the initial alignment of each device in the board configuration by the Edit command on the Board_menu. It can be also used to periodically check the alignment of the device under test prior to executing a Test_Run. The Laser command toggles the laser beam on and off. The command also operates both the front and rear beam shutters in the diagnostic chamber in order to illuminate the device in-situ on the test board. When the laser is on, the Laser command on the Beamline_menu is checked and the corresponding Toolbar button depressed. The laser status is also shown in the Beamline_area of the Main_window. The test chamber internal lights can be slaved with the laser beam to switch on and/or off simultaneously with the laser beam by the Light_Setup command.
- In order to protect the device under test from being hit by the heavy ion beam when using the laser, the vacuum valve at the target room wall (upstream from the laser exciter) is automatically closed before you turn the laser beam on and automatically opened after you turn the laser off. The scintillation detectors are partially protected from an exposure to the light or laser beam by aluminum covered Mylar foils. As these foils are not completely opaque, the high voltage for the photomultipliers is automatically turned off when switching the laser on (and vice versa). Three second delay is introduced when turning of the laser on to allow for the discharge of any residual high voltage on the photomultipliers.
- If you turn the laser beam on and do not see the laser spot on the TV monitor or through one of the test chamber glass viewports, make sure that both the diagnostic and test chambers have been evacuated. Ask the accelerator control room for permission to remove all faraday cups from the beam by the All_Devices command and to give you the control over the beam shutters.

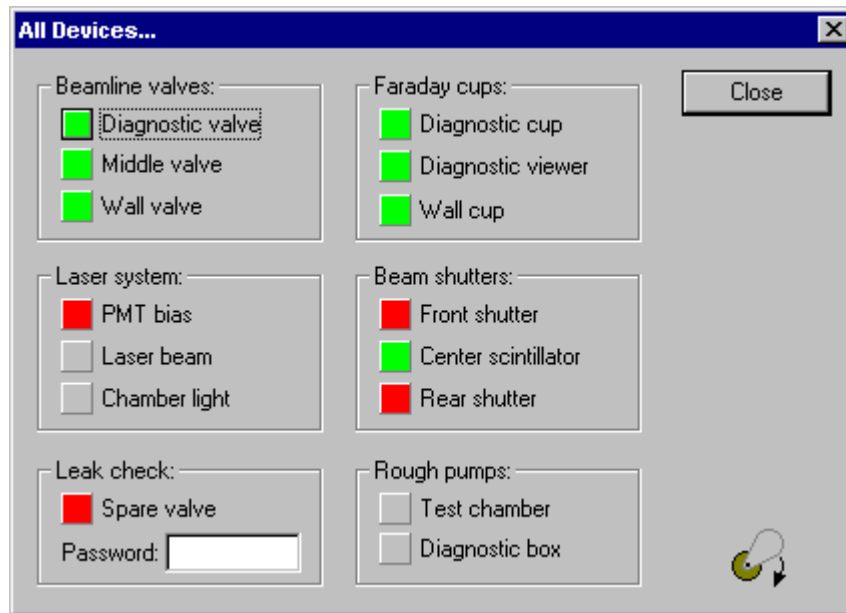
Light

- There are two internal light fixtures in the vacuum test chamber, one mounted on the ceiling and the other in front of the positioning stage with the test board. The individual lamps can be enabled or disabled by the Light_Setup command. The Light command toggles one or both of these lamps on and off. When the light is on, the Light command on the Beamline_menu is checked and the corresponding Toolbar button depressed.
- The light is used to watch the device under test through a small video camera or through one of the test chamber glass viewports. The light is usually required when the Laser beam is on. On the other hand, the light should be turned off when executing a Test_Run, in case the device under test (with its lid removed) is light sensitive. You can slave the Light command to the Laser command in the Light_Setup dialog box. The light then automatically turns on when you turn the laser beam on and/or it automatically turns off when you turn the laser beam off .

Center Scintillator

- The initially focused heavy ion beam is spread out by scattering on a thin gold foil, by a pair of sweeping magnets (horizontal and vertical) oscillating with two different out-of-step frequencies, or by a combination of the two methods. Because of the strong angular dependence of multiple coulombic scattering cross section, the flux in the beam center (where the device under test is located) is usually somewhat higher than the average normal flux measured by a ring of four scintillation detectors outside of beam area available for testing devices or irradiating samples.
- The Center Scintillator command rotates a fifth scintillation detector into or out of the beam center. When the center scintillation detector is in the beam, the Center Scintillator command on the Beamline_menu is checked and the corresponding Toolbar button depressed. The center scintillator status is also shown in the Beamline_area of the Main_window. In combination with the Measure_Flux command on the Dosimetry_menu, the center scintillation detector allows to check the center flux deviation from the average normal flux measured by the ring of the four outside scintillation detectors.
- Since the center scintillation detector rotated into the beam blocks both the laser beam and the heavy ion beam, the SEU Test Facility program automatically removes the detector from the beam center when you try to turn on the Laser beam or start a Test_Run.
- The center scintillation detector is used by the Tandem Van de Graaff operators during the beam setup and tuning. The SEU Test Facility program also occasionally rotates the center scintillation detector into the beam after test runs and automatically measures the center flux deviation. See the Warning_Levels command on the Dosimetry_menu for the rules for checking the center flux deviation.

All Devices...

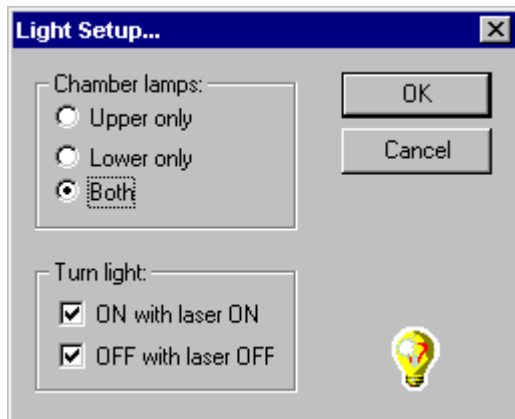


- The All Devices command allows an independent control of all beamline devices located in the target room 4. The beamline devices include:
 - the wall, middle, and the diagnostic beamline vacuum valves,
 - the wall and diagnostic faraday cups and the diagnostic beam viewer,
 - the front and rear beam shutters and the center scintillation detector,
 - the laser beam, photomultiplier high voltage, and the test chamber lamps,
 - the diagnostic box and test chamber rough pumps,
 - the test chamber spare vacuum valve.

Except for the light, diagnostic viewer, and both the rough pumps, status of the beamline devices appears in the Beamline_area of the main_window.

- The SEU Test Facility program controls all these beamline devices as necessary. The All Devices command serves primarily for testing their operation. It is also useful if some these devices are left in an improper state, for example because of some other command failed to complete.
- Users are not allowed to open the test chamber spare valve. This valve serves for vacuum leak checking of the test chamber and the diagnostic box. It must remain closed if the leak check detector is disconnected or turned off. Opening of this valve requires a password known to the Tandem Van de Graaff personnel only. The safety interlock for the spare valve protects only the beamline, but not the test chamber or the diagnostic box. More specifically, the diagnostic box beamline valve, the test chamber beamline valve, or both must be closed, otherwise the spare valve will not open.

Light Setup...

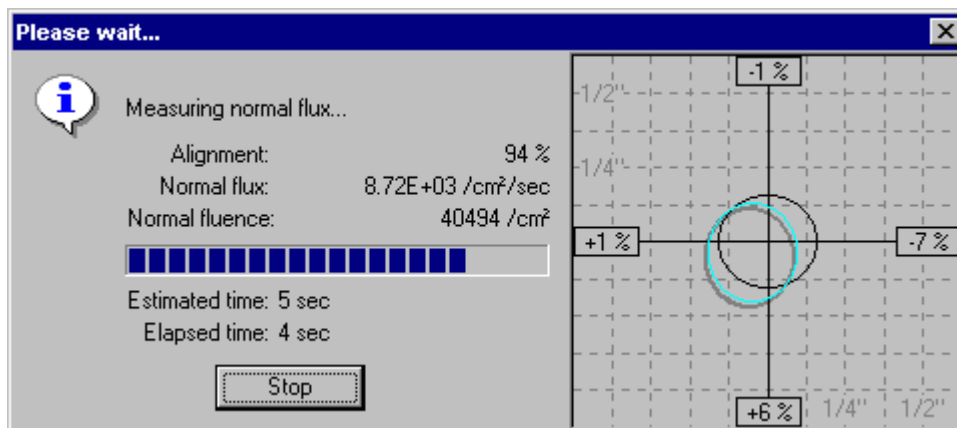


- There are two internal light fixtures in the vacuum test chamber, one mounted on the ceiling and the other in front of the positioning stage with the test board. The Light Setup command enables or disables the individual lamps. At least one lamp should be enabled, otherwise the Light command has no effect.
- The light is used to watch the device under test through a small video camera or through one of the test chamber glass viewports. The light is usually required when the Laser beam is on. On the other hand, the light should be off when executing a Test_Run, in case the device under test (with its lid removed) is light sensitive. You can slave the Light command to the Laser command. The light then automatically turns on when you turn the laser beam on and/or it automatically turns off when you turn the laser beam off.

Measure Flux...

- The Measure Flux command measures the normal beam flux and beam alignment using a ring of four plastic scintillation detectors (top, left, bottom, and right) located just outside the user available beam area (1-1/8 inch diameter in the diagnostic box). Optionally, a fifth scintillation detector of the same type can be moved into the beam center in order to measure the center-to-ring ratio. Since the center scintillation detector prevents the heavy ion beam from reaching the test chamber, no devices can be irradiated when using the center scintillation detector.
- The Measure Flux command has the following requirements on the status of the beamline (see the Beamline_area of the Main_window):
 - The beamline up to and including the diagnostic box should be free of all obstacles (i.e., all beamline vacuum valves except the test chamber valve must be open and all beamline devices such as the faraday cups and beam viewers must be out of the beam). The diagnostic box front beam shutter, operated by the Measure Flux command itself, should be initially closed. The rear beam shutter must remain closed in order to protect any devices from being irradiated.
 - When using the faraday cups for the beam dosimetry, the Measure Flux command operates the front and rear beam shutters in a different manner. The center faraday cup can be mounted either on the front beam shutter or on the test board. The front shutter center faraday cup requires an annular faraday cup to be installed in the diagnostic box as a collector and both beam shutters have to remain closed. The test board faraday cup requires a collector plate to be mounted in the test chamber in place of the iris aperture and both beam shutters have to open. In addition, the SEU Test Facility application automatically moves the test board to the device named "Faraday_cup" (not case sensitive). prior to the flux measurement and returns the test board to the previous device (if any) when the flux measurement is completed. If the device ID "Faraday_cup" does not exist in the present board configuration, you will receive a warning whenever you attempt to measure the flux.
 - The beamline should be ready (i.e., the beam tuning and laser should be off and, if using the scintillation detectors for the beam dosimetry, the photomultiplier bias should be on).

If the the beamline is blocked or not ready, you will receive a warning indicating the problem, but the flux measurement can be performed. Of course, you will not be able to collect any valid data. This arrangement is implemented mainly to test the SEU Test Facility software and hardware. Most beamline status problems can be corrected with the help of the All_Devices command on the Beamline_menu.



When using the scintillation detectors and counter for the beam dosimetry, the normal flux is calculated using the average count from the four outside scintillation detectors:

$$\text{Flux [ions/cm}^2\text{/sec]} = \frac{\text{Average count}}{\Delta t \cdot \text{Aperture area}} \cdot \text{Center-to-ring} \cdot \text{Distance fall-off}$$

$$\text{Average count} = \frac{\text{Left count} + \text{Top count} + \text{Right count} + \text{Bottom count}}{4}$$

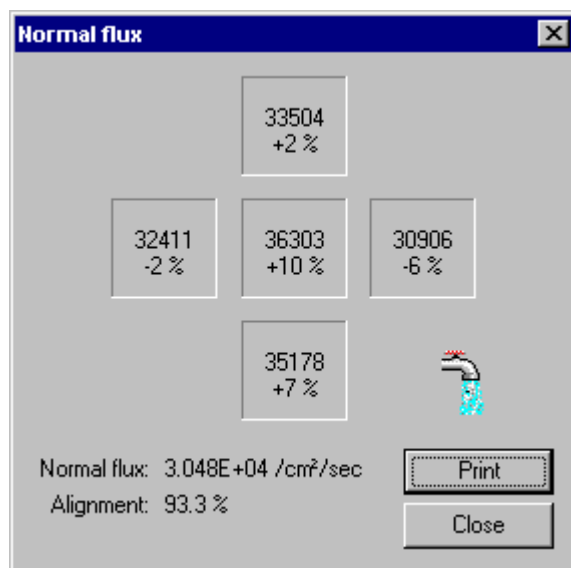
The time interval Δt between opening and closing the front beam shutter is approximately 5 sec (10 sec if the center scintillation detector is in the beam) and it is accurately determined by means of the internal computer clock. If the center scintillation detector is in the beam, the normal flux is simply calculated using the center count:

$$\text{Flux [ions/cm}^2\text{/sec]} = \frac{\text{Center count}}{\Delta t \cdot \text{Aperture area}} \cdot \text{Distance fall-off}$$

In addition, the flux center-to-ring correction is determined as a ratio of the center count to the average count from the outside scintillation detectors:

$$\text{Center-to-ring} = \frac{\text{Center count}}{\text{Average count}} \geq 1$$

- Since the beam profile is always convex, the center count should be always greater than or equal to the average outside count, except for statistically insignificant variations for very uniform (flat) beams of lighter ions. If the beam alignment is good and the center-to-ring ratio greater than or equal to one, the ratio is saved and subsequently applied to the normal flux measured by the Measure Flux command without the center scintillator and to the effective flux and fluence measured by the Test_Run command on the Test_menu, until the next beam center check. This beam center check can be performed automatically after every test run or occasionally (every 30 min or after a significant beam change), depending on the selection in the Warning_Levels dialog box. See the Warning_Levels command for an explanation of the significant beam change.



- The distance fall-off correction is due to the inverse square fall-off of the beam flux from the scintillation detectors in the diagnostic box to the test board in the test chamber. If we consider the scattering foil used to spread the originally focused heavy ion beam as a point source, the measured flux has to be multiplied by a factor:

$$\text{Distance fall-off} = \left[\frac{x(\text{SF}) - x(\text{SD})}{x(\text{SF}) - x(\text{TB})} \right]^2 = 0.870$$

where $x(\text{SF})$, $x(\text{SD})$, and $x(\text{TB})$ are the locations of the scattering foil, scintillation detectors, and the test board, respectively. The distance from the scattering foil to the test board is approximately 70 ft, while the distance from the scattering foil to the scintillation detectors is about 5 ft less.

- While the center-to-ring ratio is a good measure of the beam uniformity over the beam area available to the users (1-1/8 inch diameter circle in the diagnostic box or 1.2 inch diameter circle on the test board, it is not available during test runs. In order to detect any beam misalignment as soon as possible, the beam alignment over the outside detector ring is calculated as

$$\text{Alignment} [\%] = \frac{100 \%}{1 + \delta M}$$

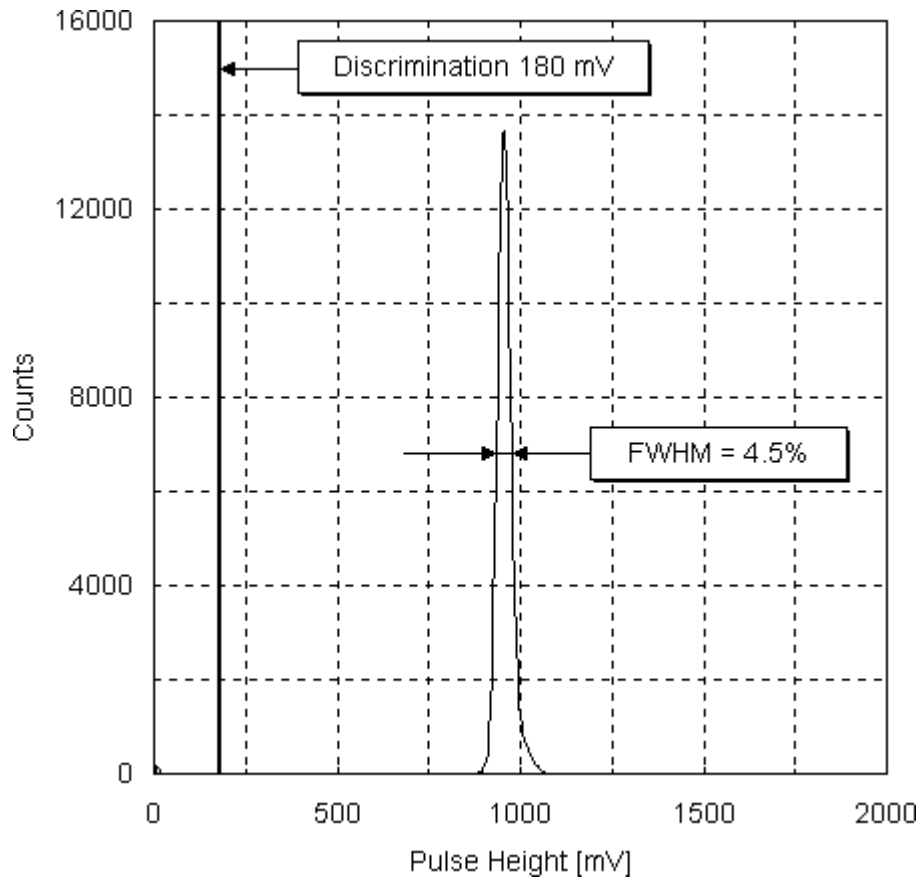
$$\delta M = \sqrt{\frac{(\delta L - \delta R)^2 + (\delta T - \delta B)^2 + [(\delta L + \delta R) - (\delta T + \delta B)]^2}{6}}$$

where δL , δT , δR , and δB are the individual relative deviations of the left, top, right, and center counts from the average, respectively. The above formula takes into account the statistical dependence of the left vs. right and top vs. bottom counts due to the beam steering and the statistical dependence of left-right vs. top-bottom average counts due to the beam blow-up. All correlation coefficients are considered to be close to -1. The formula can be simplified to

$$\delta M = \sqrt{\frac{\delta L^2 + \delta T^2 + \delta R^2 + \delta B^2 - (\delta L + \delta R)(\delta T + \delta B)}{3}}$$

which would reduce to the usual formula for statistically independent deviations if the correlation coefficients were equal to zero.

- The following figure shows the typical scintillation detector spectrum and discrimination level. Please note that a spectrum peak with the full width at half maximum (FWHM) of 3 to 5 % can be achieved only after sanding the active scintillator surface and polishing it with an abrasive paste. This treatment results in 4 to 9 times increase of the scintillator light output and, consequently, in 2 to 3 times reduction of the peak FWHM.



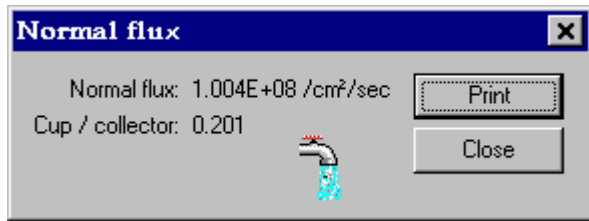
- In order to measure the beam flux $\sim 1\text{E}+07$ ions/cm²/sec or higher, the scintillation detectors in the diagnostic box must be masked off. The beam dosimetry is performed by a set of two faraday cups, center and collector. The faraday cup current is sampled by electrometers about four times per second. The time interval Δt of the flux measurement is approximately 10 sec, but it does not enter the flux calculation. The normal flux is calculated as

$$\text{Flux [ions/cm}^2\text{/sec]} = \frac{\text{Average center current}}{eQ \cdot \text{Center cup area}} \cdot \text{Distance fall-off}$$

where e is the elementary charge and Q the beam charge state. During every flux measurement, the center-to-collector current ratio is determined as

$$\text{Center-to-collector} = \frac{\text{Average center current}}{\text{Average collector current}} \leq 1$$

Since the collection of the secondary electrons knocked out by the incident heavy ions from the surface of the geometrically inferior annular cup or collector plate is not perfect (in fact, almost non-existent for the collector plate), the collector current is usually higher (up to 5-10 times for the collector plate) than the center cup current and the center-to-collector ratio is usually (much) lower than one. The center-to-collector is saved and subsequently applied to the effective flux and fluence measured by the Test_Run command on the Test_menu, until the next flux measurement. This flux measurement can be performed automatically after every test run or occasionally (every 30 min or after a significant beam change), depending on the selection in the Warning_Levels dialog box. See the Warning_Levels command for an explanation of the significant beam change.

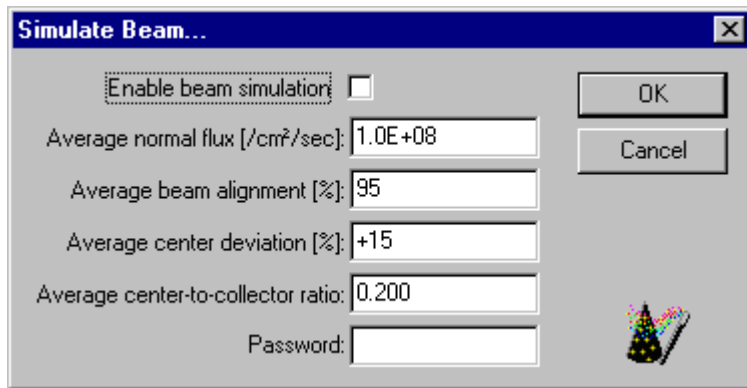


- The distance fall-off correction is due to the inverse square fall-off of the beam flux from the center faraday cup to the test board in the test chamber. If we consider the sweeping magnet used to spread the originally focused heavy ion beam as a point source, the measured flux has to be multiplied by a factor:

$$\text{Distance fall-off} = \left[\frac{x(\text{SM}) - x(\text{FC})}{x(\text{SM}) - x(\text{TB})} \right]^2 = 0.780 \text{ or } 1$$

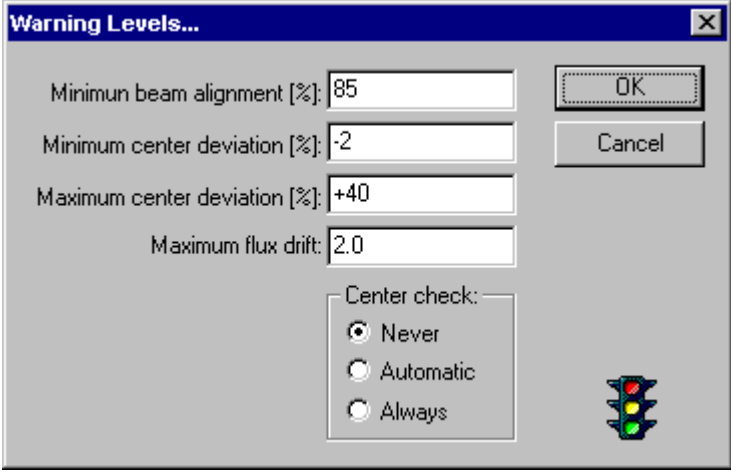
where $x(\text{SM})$, $x(\text{FC})$, and $x(\text{TB})$ are the locations of the sweeping magnet, center faraday cup, and the test board, respectively. The distance from the sweeping magnet to the test board is approximately 40 ft, while the distance from the sweeping magnet to the front shutter faraday cup is about 5 ft less. Obviously, when the center faraday cup is mounted on the test board (rather than on the front beam shutter), $x(\text{FC}) = x(\text{TB})$, and the distance fall-off equals to one.

Simulate Beam...



- The Simulate Beam command allows you to enable beam simulation with a help of pseudorandom numbers. You can select the simulated beam flux, beam alignment, and/or the average beam center deviation from the average flux outside average (i.e., deviation from the average flux on the 1-1/4 inch diameter circle around the center).
- The Simulate Beam command is designed to test the SEU Test Facility application, specifically the routines controlling the Measure_Flux and Test_Run commands. It can be also used for demonstration purposes. Since the simulation is very realistic, a warning message is displayed for 2 seconds before every flux measurement or test run, when the simulation is enabled.

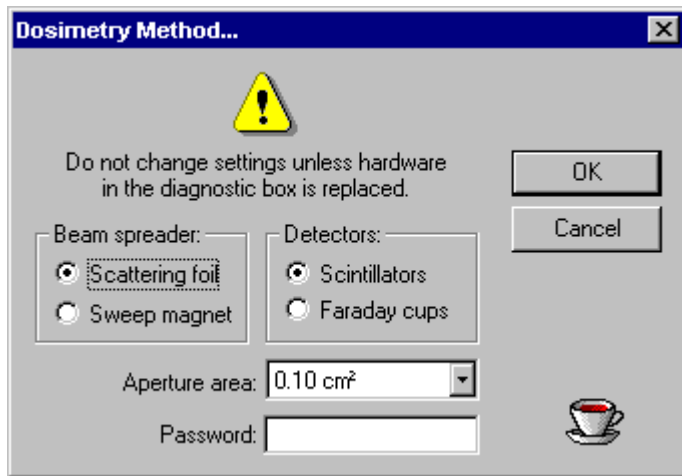
Warning Levels...



The image shows a Windows-style dialog box titled "Warning Levels...". It contains four input fields for setting warning thresholds: "Minimum beam alignment [%]" with a value of 85, "Minimum center deviation [%]" with a value of -2, "Maximum center deviation [%]" with a value of +40, and "Maximum flux drift" with a value of 2.0. To the right of these fields are "OK" and "Cancel" buttons. Below the input fields is a section labeled "Center check:" with three radio button options: "Never" (which is selected), "Automatic", and "Always". In the bottom right corner of the dialog, there is a small icon of a traffic light with red, yellow, and green lights.

- The SEU Test Facility application issues a warning whenever the beam alignment falls below the acceptable level and/or the beam center deviation exceeds the acceptable level. It may also performs an automatic check of the beam center after completing every test run or whenever one or more of the following conditions are met:
 - the beam isotope and/or energy has been changed,
 - the beam alignment fell below the minimum acceptable level,
 - the beam center deviation fell below the minimum or exceeded the maximum acceptable levels,
 - the flux has been changed by a factor higher than the acceptable flux drift,
 - 30 minutes have elapsed since the last check of the beam center.
- The Warning Levels command allows you to change the default warning levels (minimum 85% beam alignment, minimum -2% and maximum +40% beam center deviation, and maximum flux drift by a factor of 2.0). You can also choose to perform the the automatic check of the beam center after every test run, only when the above conditions are met, or not at all.
- The beam center deviation should be always greater than or equal to zero. However, for very uniform beams, especially light ion beams such as carbon, it can fall a few percent below zero due to statistical fluctuations. It is recommended that you use the default warning levels and the automatic beam center check. You may consider lowering the minimum beam alignment down to 80% only for very low flux levels (1E+3 ions/cm²/sec or less), if you receive too frequent warnings. You may also consider to perform the beam center check after every test run if the beam center deviation fluctuates by more than 10%.

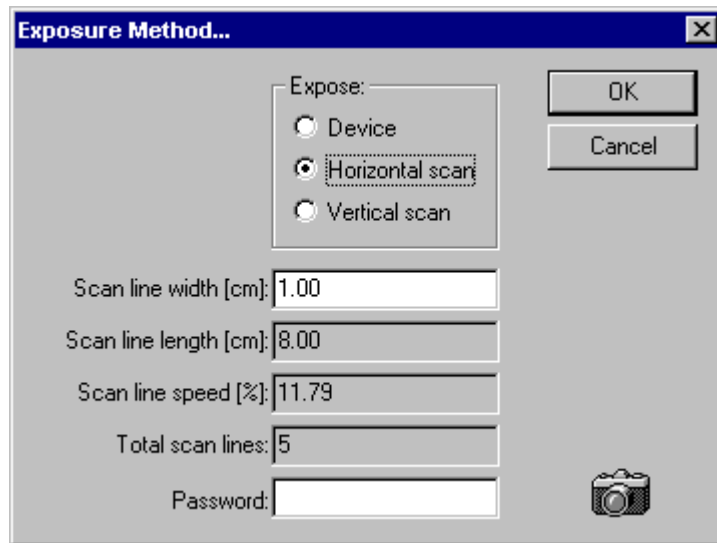
Dosimetry Method...



- The Dosimetry Method command selects the the detector type (scintillation detectors or faraday cups) used to measure the beam flux and fluence, the beam point source (scattering foil or sweeping magnet) required for the calculation of the inverse square fall-off of the heavy ion beam from the detectors to the test board, and the detector aperture area.
- In case of the scintillation detectors, aperture plates (for the left, top, right, and bottom detectors) and caps (for the center detector) with 4 different circular aperture areas (0.01, 0.1, 0.5, and 1 cm²) are available. Each plate and cap are available in aluminum or tantalum, both with thickness of 1.6 mm. The aluminum apertures are sufficient to stop all heavy ions beams available at the Brookhaven Tandem Van de Graaff accelerator with the exception of the proton beam. The tantalum apertures are necessary for protons with energy higher than about 17 MeV. They should be also used for lighter ions such as lithium, due to the lower activation of heavy materials. By default, the tantalum apertures with 0.1 cm² area are installed in the diagnostic box. In order to maintain reasonable count rates, the aperture area of 0.01 cm² is recommended for the beam flux above 1E+6 ions/cm²/sec and the aperture area of 1 cm² for the beam flux bellow 1E+3 /cm²/sec. For the beam flux above 1E+7 ions/cm²/sec, the faraday cups must be used, because the scintillation detectors would not survive for more than a few hours of total exposure.
- In case of the faraday cups, collector plates with 3 different rectangular aperture areas (0.75, 1.2, and 1.8 cm²) are available. These collector plates are mounted in the SEU test chamber on the iris aperture. Consequently, the iris aperture cannot be used and the beam area is determined by the collector plate aperture area. In addition, a faraday cup must be mounted on the test board, its position must be determined by the Edit on the Board_menu, and its device ID set to "Farady_cup" (not case sensitive). This is necessary because the flux measurement with the collector plate/faraday cup combination requires opening of the diagnostic box rear shutter, resulting in an unintended irradiation of devices or samples. When executing the Measure_Flux command, the SEU Test Facility application automatically moves the test board to the device named "Farady_cup" (not case sensitive) prior to opening the beam shutters and returns the test board to the previous device (if any) when the flux measurement is completed. If the device ID "Farady_cup" does not exist in the present board configuration, you will receive a warning whenever you attempt to measure the flux.
- Alternately, a faraday cup mounted on the diagnostic box front shutter (with the area of 5 cm²) can be used, in combination with an annular faraday cup of an equal area mounted in the diagnostic box in a fixed position. This arrangement does not require opening of any beam shutters (front or rear) for the flux measurement. However, the heavy ion beam must be swept over much larger area and it is consequently more difficult to achieve and/or maintain the beam flux at a high level.

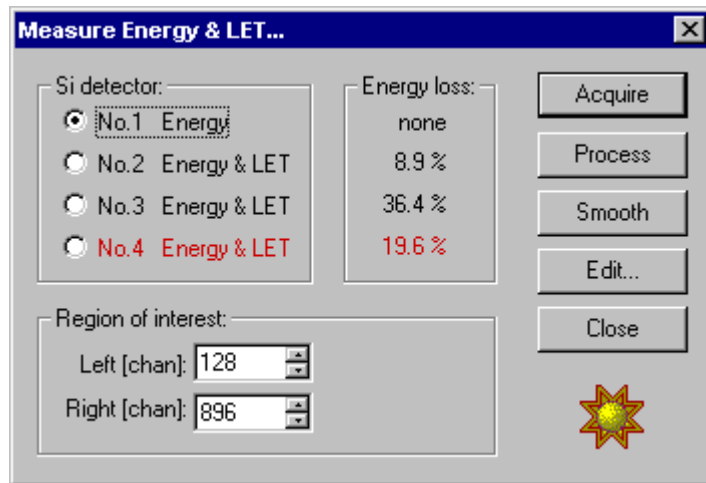
- When the aperture area of the scintillation detectors is changed using the Dosimetry Method command, both the corresponding aperture plate and cap must be installed in the diagnostic box. Similarly, whenever the aperture area of the faraday cups is changed, the corresponding collector plate must be installed in the SEU test chamber or the front shutter and annular faraday cups installed in the diagnostic box. These tasks are performed by the Tandem Van de Graaff personnel. To accept any change, the Dosimetry Method command requires a password known to the Tandem Van de Graaff personnel only. Users are thus prevented from accidentally changing any settings for the detector type, beam source, and/or the aperture area.

Exposure Method...



- The Exposure Method command selects the method for irradiating the devices or samples. By far the most common method is to expose every device at rest, until the desired effective fluence set by the Fluence command on the Test_menu is accumulated or until the run time set by the Run_Time command on the Test_menu is reached.
- The horizontal and vertical scan allow you to uniformly expose any rectangular area within the X- and Y-axis limits. To make the horizontal or vertical scans, the iris aperture must be replaced by a square diamond shaped opening and the scan line width must be equal to one half of its height (i.e., half of the square diagonal), 1 cm by default. The scan line length and the number of scan lines are then determined by the top right and bottom left points of the rectangular area to be exposed. The top right point is given by the X- and Y-coordinates of the present device in the current board configuration, while the bottom left point is given by the X- and Y-coordinates of the device that follows. If no device is positioned in the beam, the maximum resp. minimum limits for the X- and Y-axes are assumed.
- The desired effective fluence for the entire exposed area is selected by the Fluence command on the Test_menu and the estimated run time in Data_area of the Main_window is the estimated time to expose one scan line. When executing the Test_Run command on the Test_menu, the desired rectangular area is exposed line by line, with the velocity based for each scan line on the last flux measurement. The actual run time, average effective flux, and the average effective fluence for each scan line are recorded in order to retain some information about the fluence uniformity over the exposed area.

Measure Energy & LET...



- The Measure Energy & LET command measures the beam energy independently of information from the accelerator control room. Optionally, you can use the command to measure also the beam LET. The beam energy is measured by one of the four ion-implanted silicon detectors installed in the diagnostic box. Since the silicon detectors are radiation sensitive and rather slow, each silicon detector has small individual shutter mounted on a miniature rotary solenoid. The shutter is allowed to open only if the flux, as measured by the scintillation detectors, is not too high. Not only would the quickly accumulated high fluence damage the silicon detectors, but the charge sensitive preamplifier and the spectroscopy amplifier would be overloaded by the high flux due to the pile-up effect. We found empirically that this does not happen if the flux does not exceed

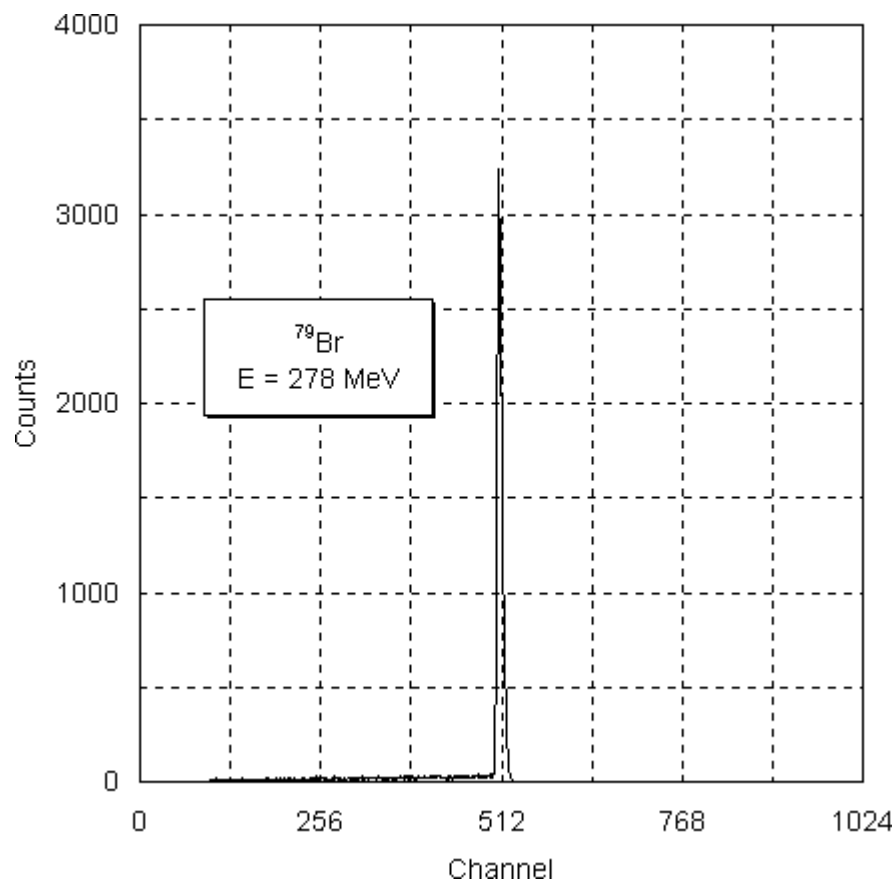
$$\text{Maximum flux [ions/cm}^2\text{/sec]} = \frac{1\text{E}+07}{E}$$

where E [MeV] is the estimated energy of the incident heavy ions. In order to obtain adequate statistical accuracy and, at the same time, to avoid excessive damage to the silicon detector, the fluence accumulated on the selected silicon detector in one exposure is kept approximately at

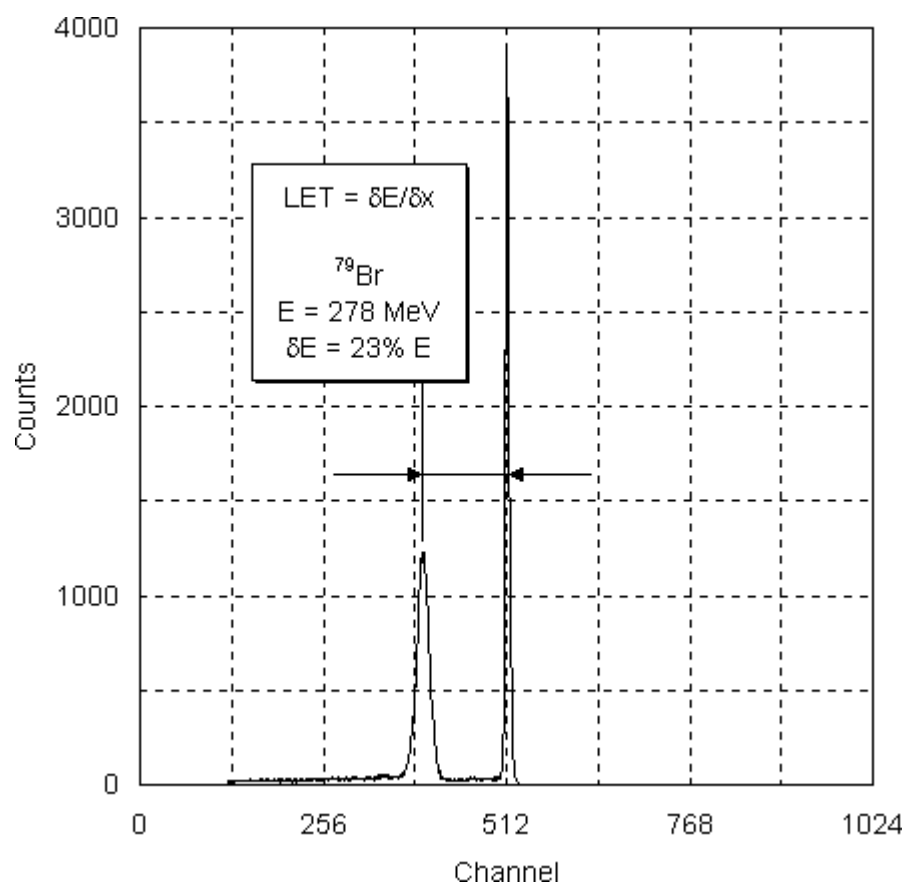
$$\text{Fluence [ions/cm}^2\text{]} = \text{Maximum flux} \cdot 10 \text{ sec} = \text{Flux} \cdot \Delta t$$

by varying the spectrum acquisition time Δt . When you press the <Acquire> button to start the energy spectrum acquisition, the SEU Test Facility application automatically measures the beam flux and reject the beam energy measurement if the flux is too high.

- Silicon detector No.1 has only one aperture and it is used to measure the beam energy only. The energy spectrum acquired by silicon detector No.1 should have only one peak:



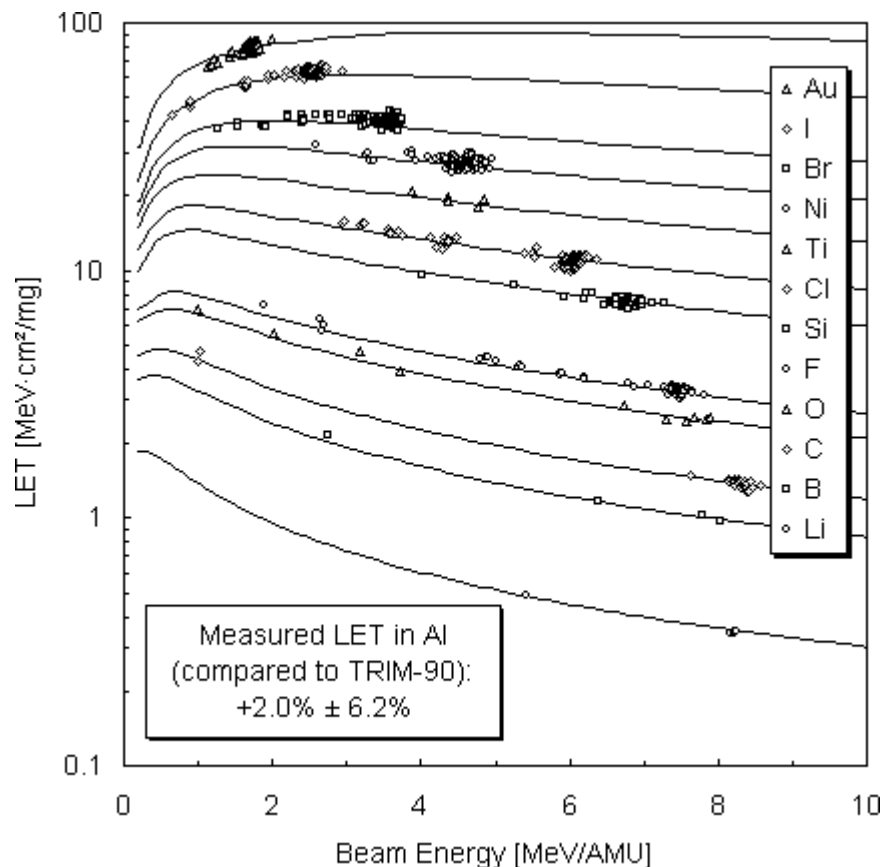
- Silicon detectors No.2, 3, and 4 have two apertures each, one covered by a thin aluminum foil. The foils have thickness of approximately 0.65, 1.55, and 2.65 mg/cm², respectively. The SEU Test Facility application calculates the expected energy loss in the foil marks red the silicon detector with the energy loss in the foil closest to 15%. This detector should be used for the simultaneous beam energy and LET measurement, in order to obtain adequate resolution of the two peaks and, at the same time, keep the calculated correction for the finite foil thickness small. If space allowed for one more silicon detector, another aluminum foil with thickness about 5 mg/cm² could be used to measure LET of light ions such as C-12, Be-9, or Li-7. Still, the energy resolution for these ions is much better compared to that for heavier ions, and a higher energy loss is not absolutely necessary. In addition to the main energy peak, the energy spectrum of silicon detectors No.2, 3, and 4 also has a lower energy peak resulting from ions passing though the foil before hitting the silicon detector:



The energy loss ΔE in the aluminum foil is measured as an energy difference of the two peaks. Using the known foil thickness Δx , the experimental LET in aluminum is calculated as

$$\text{LET(Al)} = \frac{\Delta E}{\Delta x(\text{Al})}$$

The following figure compares results of such measurements with the calculated LET in aluminum:



- Aluminum was selected because its atomic number ($Z = 13$) differs only by one from the atomic number of silicon ($Z = 14$), the most common semiconductor material. Since silicon and aluminum are neighbors in the periodic table of the elements, a small adjustment (about -3%) can be calculated using Ziegler's semi-empirical formulas for heavy ion stopping in order to obtain an "experimental value" of LET in silicon:

$$\text{LET}(\text{Si}) = \frac{\text{Calculated LET}(\text{Si})}{\text{Calculated LET}(\text{Al})} \cdot \text{LET}(\text{Al})$$

Comparing the calculated and measured LET in silicon makes it possible for the SEU Test Facility users to verify the requested beam isotope. Please note that the Measure Energy & LET command is not conceptually well suited to measure LET in semiconductor materials other than Si, such as GaAs, etc.

- Based on the flux measurement, the SEU Test Facility application either rejects to measure the beam energy in order to protect the silicon detectors, or it estimates the acquisition time (300 sec maximum) to accumulate the above fluence on the selected silicon detector. In case of a rejection, the program also reports the maximum permissible beam flux and demands the flux to be lowered. Knowing the present calibration constant, the spectroscopy amplifier gain is adjusted so that the peak is expected at the center of the multichannel analyzer conversion range. However, for highly ionizing particles such as heavy ions, the silicon detector response is not simply proportional to the beam energy because of the pulse height defect caused by the detector window, nuclear stopping and electron hole recombination in the detector:

$$\text{Peak}[\text{chan}] = G \cdot C [E - \text{PHD}(E, Z, A, \dots)]$$

where G is the main amplifier gain, C [chan/MeV] the calibration constant, E [MeV] the beam energy, and PHD [MeV] the pulse height defect:

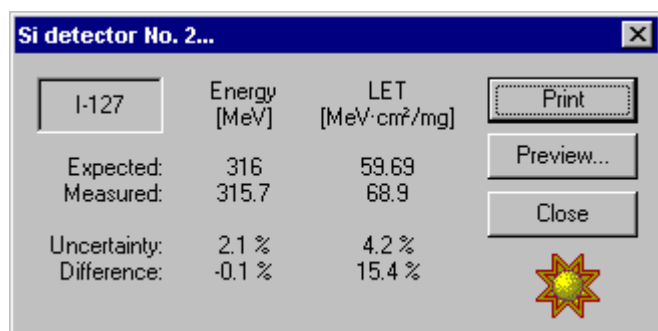
$$\text{PHD}(E, Z, A, \dots) = \delta_1 (1 + \delta_2)$$

$$\delta_1 [\text{MeV}] = 2.33\text{E-}04 \cdot (ZA)^{6/5} \cdot (E/A)^{1/2}$$

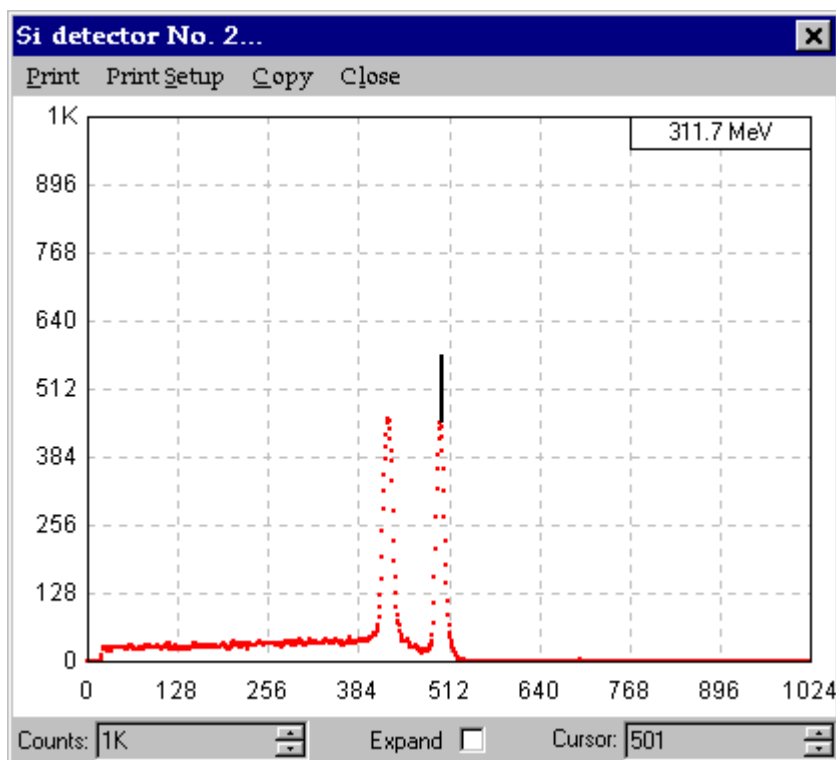
$$\delta_2 = 1.33\text{E+}03 \cdot Z \frac{[\text{LET}(\text{Si}) E^2]^{1/3}}{\rho^{1/4} F}$$

where Z and A are the incident ion atomic and mass numbers, respectively, LET(Si) [MeV·cm²/mg] the stopping power in Si, ρ [W·cm] the detector resistivity, and F [V/cm] the average electric field along the incident ion track in the detector depletion layer. The above formulas for the pulse height defect were suggested by Ogiwara et al. in "Systematic Measurement of Pulse Height Defect for Heavy Ions in Surface-barrier Detectors," Nuclear Instruments and Methods A251, pp. 313-320 (1986).

- Following the spectrum acquisition, the SEU Test Facility application directs the multichannel analyzer to perform a peak search for the highest peak and, in case of silicon detectors No.2, 3, and 4, also for the second highest peak. If the peak search is successful, the SEU Test Facility reports the measured beam energy and, if the second peak was found, also measured LET.



Use the <Print> button to print the spectrum and results of the energy and LET measurement on the default printer. Use the <Preview> button to preview the spectrum before sending it to the printer. You have an opportunity to change the linear scale, select a logarithmic scale, expand the spectrum, copy the spectrum to the clipboard (in color or black & white clipboard bitmap format), print the spectrum on the default printer, or to choose a different printer. The displayed spectrum shows a bar cursor that you can move by dragging it with the left mouse button or with the help of the <Left> and <Right> direction keys. Pressing the <Ctrl> in combination with the above direction keys increases the bar cursor speed.



- If the peak search fails to find one or both peaks, you can try to smooth the spectrum of the selected silicon detector using the <Smooth> button, perhaps multiple times, adjust the search region of interest, and then reprocess it with the help of <Process> button. Please note that you do not have to re-enter the previous beam isotope and energy when reprocessing an existing spectrum. This information is stored in the spectrum label and the SEU Test Facility application checks for that.
- The <Edit> button is used to change the silicon detector parameters, such as its nominal bias and resistivity. These parameters are required to calculate the detector pulse height defect. They can be also used to estimate the actual depletion depth of the silicon detector, always larger than its nominal depletion depth, and compare it to the the range of the present heavy ion beam in silicon. It is also possible to change the detector calibration constant and its uncertainty. These changes should be performed by the Tandem Van de Graaff personnel only.

The <Edit foil> button (if enabled, i.e., for silicon detectors No.2, 3, 4) is used to select the foil material from the list of available materials and to change foil thickness and its uncertainty. Again, these changes should be performed by the Tandem Van de Graaff personnel only.

Si detector No. 2... [X]


Substance: [v]

Thickness [mg/cm²]:

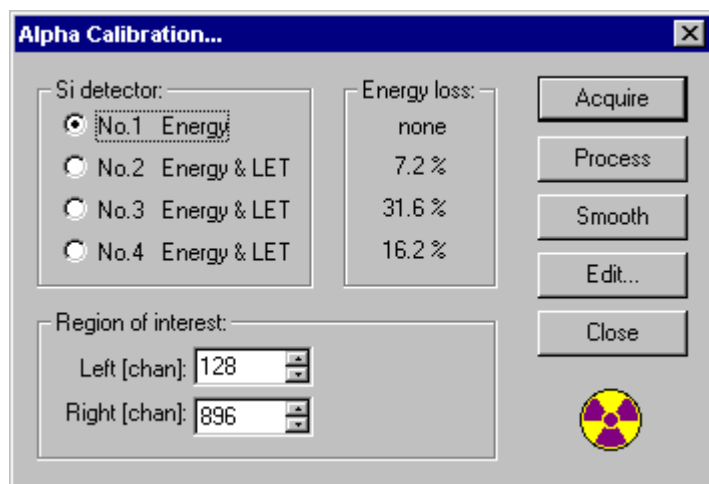
Uncertainty [%]:

Ag-107 $\Delta E/E$ [%]:

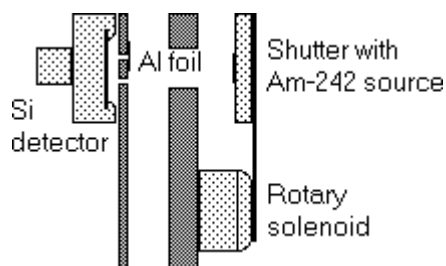
[OK] [Update] [Cancel]

 FOIL

Alpha Calibration...



- The Alpha Calibration command calibrates the ion-implanted silicon detectors by means of Am-241 alpha sources. Four silicon detectors are installed in the diagnostic box. Each of them has a separate alpha source mounted on its shutter. Radiation damage due to the constant exposure to alpha particles is negligible compared to that caused by an occasional exposure to heavy ions.

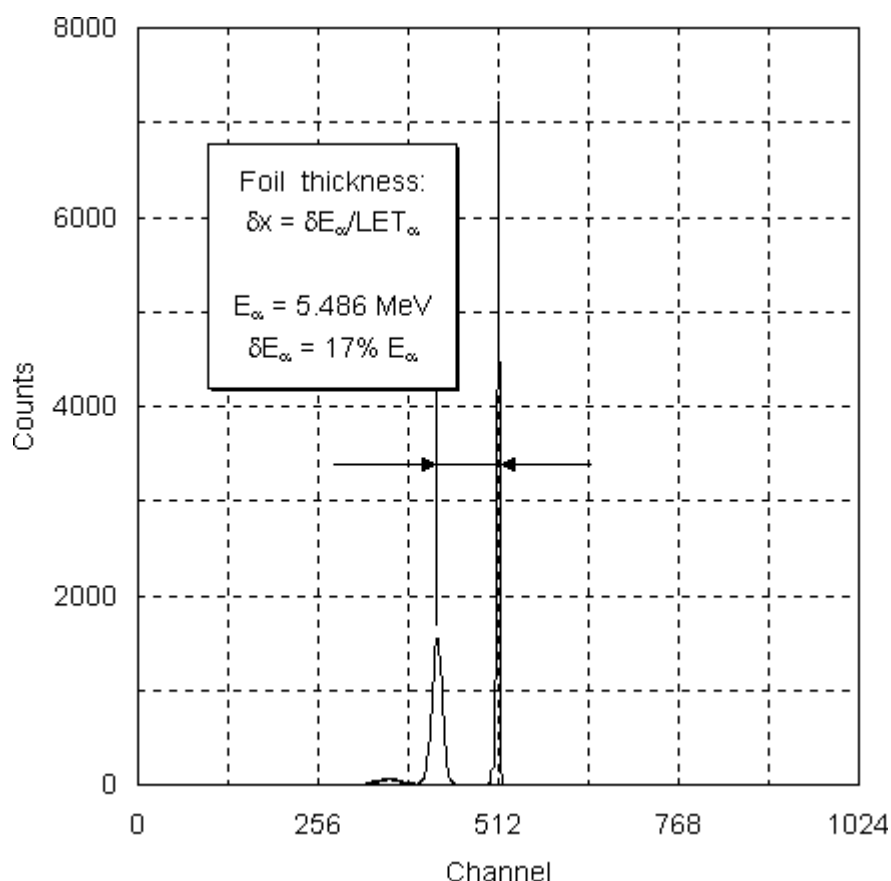


Select the silicon detector you want to calibrate and press the <Acquire> button. Based on the present calibration constant, the spectroscopy amplifier gain is adjusted so that the peak of 5.486 MeV is expected at the center of the multichannel analyzer conversion range. Following the data acquisition, spectrum smoothing, and peak search, the calibration constant is updated based on the peak shift (if any) from this position.

- Silicon detector No.1 has only one aperture, but the silicon detectors No.2, 3, and 4 have two apertures each, one of them covered by a thin aluminum foil. The foils have thickness of approximately 0.65, 1.55, and 2.65 mg/cm², respectively. Since the LET of Am-241 alpha particles in aluminum is well known, the alpha sources can be also used to measure the foil thickness $\Delta x(\text{Al})$, by measuring the energy loss $\Delta E(\alpha)$ of the alpha particles in the foil:

$$\Delta x(\text{Al}) = \frac{\Delta E(\alpha)}{\text{LET}(\alpha, \text{Al})}$$


The following figure shows a sample Am-241 alpha spectrum collected with the help of silicon detector #3.



- The data acquisition takes 2, 4, 6, and 8 min for silicon detectors No.1, 2, 3, and 4, respectively. At the end of the data acquisition and peak search, you are presented with the old and new calibration constants and, for the silicon detectors No.2, 3, and 4, also with the old and new foil thicknesses. You can either accept or reject the new calibration.

Si detector No. 2...		
Alpha	Calibration [chan/MeV]	Foil thickness [mg/cm ²]
Previous:	0.5117	0.6663
Measured:	0.5108	0.6816
Uncertainty:	0.65 %	0.6 %
Difference:	-0.18 %	2.3 %

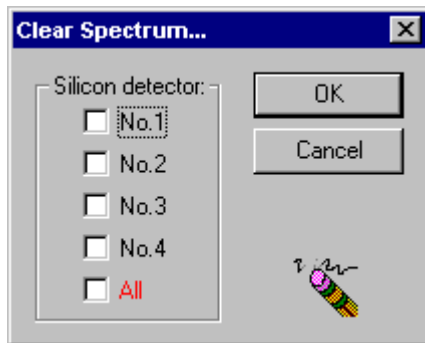
Accept
Cancel



- Use the <Smooth> button to smooth the spectrum (multiple times) in case the peak search failed to find one (or both) of the spectrum peaks because of large statistical variations. Adjust the search region of interest, for example, to eliminate noise. Use the <Process> button to process a previously acquired alpha spectrum. However, do not process the alpha spectrum again after the calibration constant has been updated based on this spectrum. The new calibration constant would be incorrect. Repeated processing of the same alpha spectrum and accepting the new calibration constant would cause the calibration constant to walk in small steps in one direction.
- The <Edit> button is used to change the silicon detector parameters, such as its nominal bias and resistivity. These parameters are required to calculate the detector pulse height defect. They can be also used to estimate the actual depletion depth of the silicon detector, always larger than its nominal depletion depth, and compare it to the the range of the present heavy ion beam in silicon. It is also possible to change the detector calibration constant and its uncertainty, the foil material (if any), foil thickness and its uncertainty. These changes should be performed by the Tandem Van de Graaff

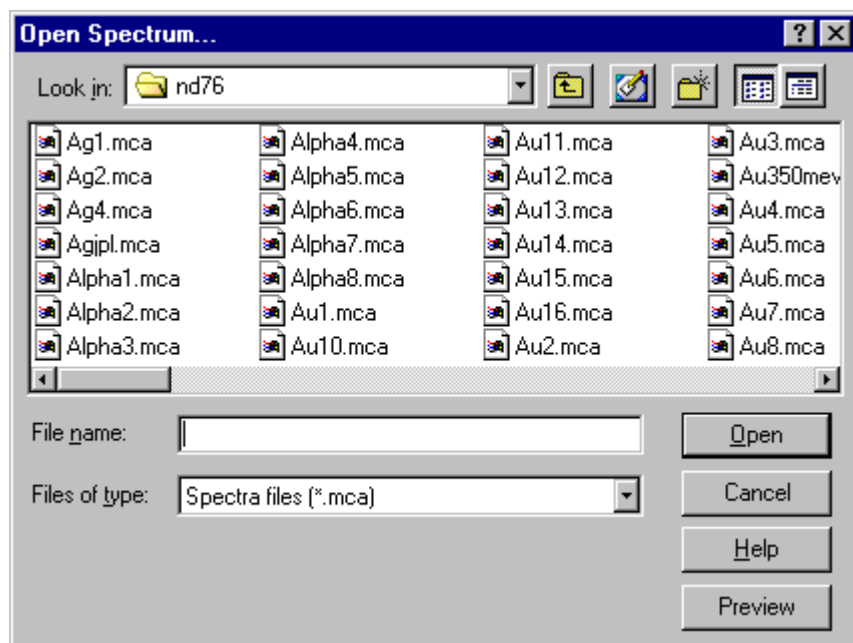
personnel only. See the Measure_Energy_&_LET command for details.

Clear Spectrum...

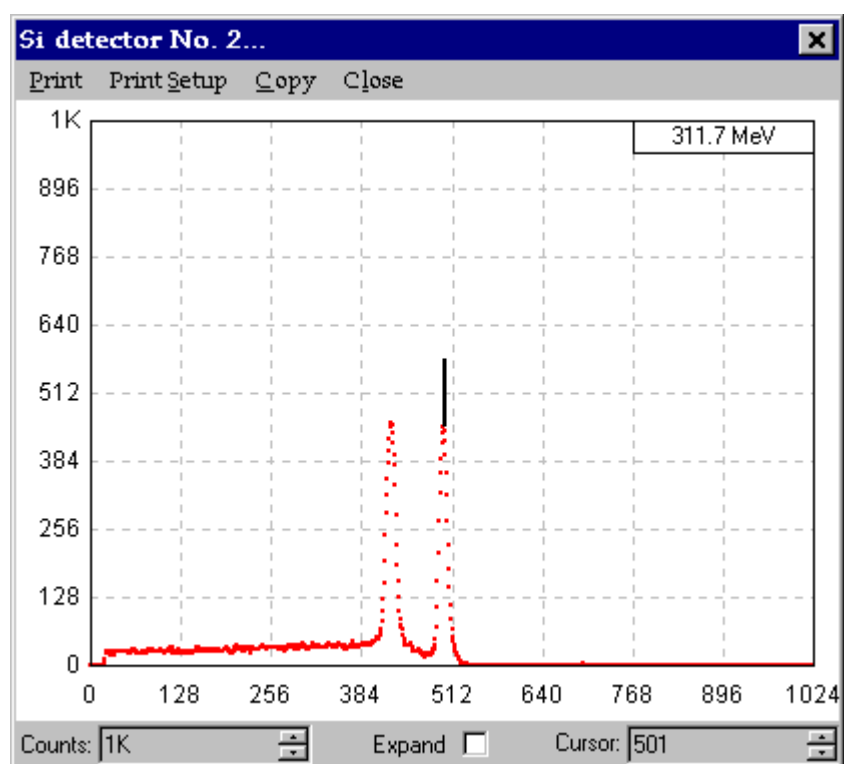


- The Clear Spectrum command clears the multichannel analyzer energy spectra for the selected ion-implanted silicon detectors. Since the energy spectrum for the appropriate silicon detector is automatically cleared before starting the acquisition of a new spectrum by the Measure_Energy_&_LET or Alpha_Calibration commands and also before loading a previously saved spectrum by the Open_Spectrum command, the Clear Spectrum command is seldom used. Perhaps the only occasion is to initialize the multichannel analyzer following the power-up by dividing its memory into four groups, one for each silicon detector. However, this step is not required, because the memory initialization is also automatically performed prior to the spectrum acquisition or loading.

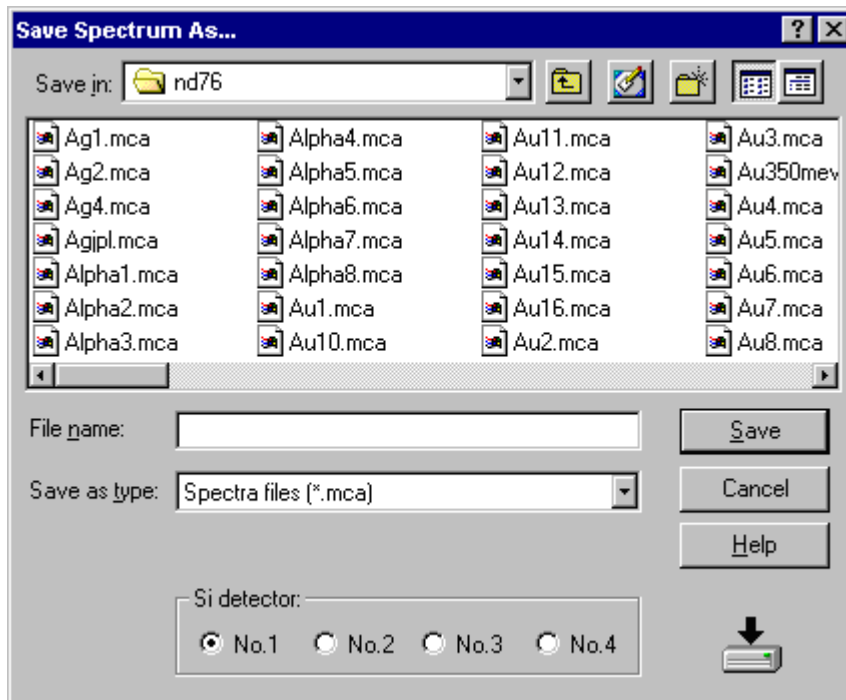
Open Spectrum...



- The Open Spectrum command allows you to retrieve a previously saved energy spectrum by opening an existing spectrum file and load it into the current multichannel analyzer for reprocessing by the Measure_Energy_&_LET or Alpha_Calibration commands.
- The file list is filled by files in the ...\\Spectra subfolder, with the *.mca file filter for spectrum files. There is no default file name. You either have to type it in or you can select an existing spectrum file from the file list. When typing in the spectrum file name, no file extension has to be included. If you omit the extension, the default spectrum file extension .mca is used.
- If you do not remember the spectrum file name of the energy spectrum you wish to retrieve, try to sort the spectrum files by date in descending order. The topmost file or a file close to the top are the most likely choices.
- Use the the <Preview> button to preview the spectrum before sending it to the multichannel analyzer. You have an opportunity to change the linear scale, select a logarithmic scale, expand the spectrum, copy the spectrum to the clipboard (in color or black & white clipboard bitmap format), print the spectrum on the default printer, or to choose a different printer. The displayed spectrum shows a bar cursor that you can move by dragging it with the left mouse button or with the help of the <Left> and <Right> direction keys. Pressing the <Ctrl> in combination with the above direction keys increases the bar cursor speed.

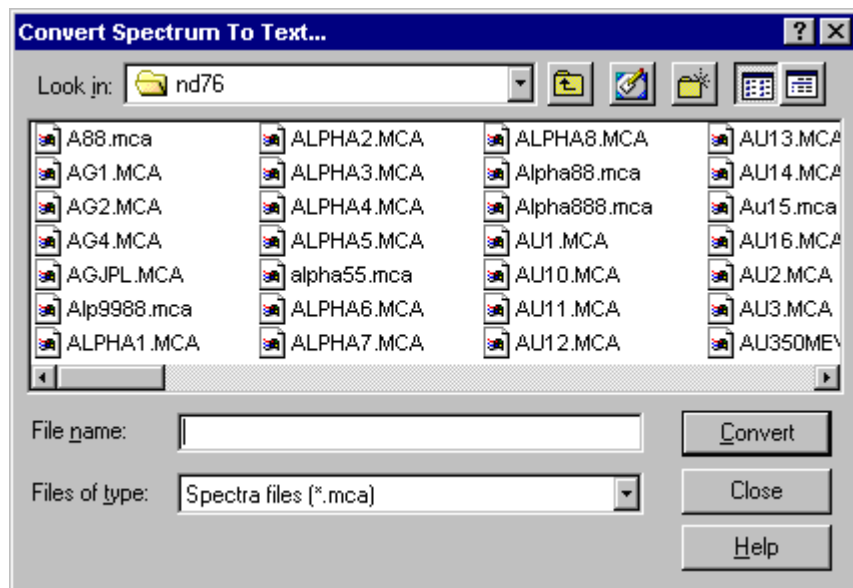


Save Spectrum As...



- After you have collected an energy spectrum, you can save it in a binary spectrum file for later processing. This is seldom used for any other purpose than the software testing of the SEU Test Facility application. However, it is necessary to save the energy spectrum in a binary format in order to convert it to a text format by the Convert_To_Text command. The Save Spectrum As command allows you to save the energy spectrum of the selected silicon detector in a new spectrum file.
- The file list is filled by files in the ...\\Spectra subfolder, with the *.mca file filter for spectrum files. There is no default file name. You either have to type in a new file name or you can select an existing spectrum file and overwrite it. If the spectrum file already exists, you will receive a warning and will have to confirm your intention before the command can proceed. When typing in a new spectrum file name, no file extension has to be included. If you omit the extension, default spectrum file extension .mca is be used. Using other spectrum file extensions is not recommended, because the *.mca file filter is used by all other spectrum file commands (Open_Spectrum and Convert_To_Text).
- Before you can save a spectrum file, you also have to specify the ion-implanted silicon detector number. As soon as you select the detector, the corresponding energy spectrum is immediately displayed on the screen of the current multichannel analyzer.
- The spectrum file format is an internal binary format recognized by the multichannel analyzer software and by the SEU Test Facility program. It consists of a fixed length binary header (80 hexadecimal for the S-100 spectrum files) followed by the spectral data (4 bytes per channel for the S-100 spectrum files). The binary header contains information such as the spectrum label, acquisition time, calibration constants, multichannel analyzer mode of operation, etc.

Convert To Text...



- The Convert to Text command converts a binary spectrum file with the **.mca** extension, previously saved by the Save_Spectrum_As command, into a spectrum file in the text format. The text spectrum files can be opened by a spreadsheet programs such as Microsoft Excel. The spreadsheet programs usually include tools to create a spectrum chart in any desired format.
- The file list is filled by files in the ...S-100 subfolders, with the ***.mca** file filter for spectrum files. There is no default file name. You either have to type it in or you can select an existing spectrum file from the file list. When typing in the spectrum file name, no file extension has to be included. If you omit the extension, the default spectrum file extension **.mca** is used.
- The converted text spectrum file is saved in the same directory and with the same name as the original binary spectrum file, except the file extension is changed to **.txt** for a text file. The command then calls a text editor (Windows Notepad) and loads the converted text file. The file contains several lines of header information, such as the beam isotope, energy, date and time of acquisition, acquisition time, and the calibration constants, followed by a table of channel numbers vs. channel counts. See the sample_spectrum_file for details.

Sample spectrum file

Detector: 3
Spectrum ID: BR-79, ENERGY = 278 MEV
Acquisition Date/Time: Thu May 09 03:43:08 1991

Elapsed live time: 30.00 sec
Elapsed real time: 31.00 sec

Conversion gain: 1024 chan
Calibration: $-0.000023824 * \text{chan}^2 + 0.555090 * \text{chan} + 0.000 \text{ MeV}$

chan.	counts
-----	-----
1:	0
2:	0
3:	0
4:	0
.	
.	
.	
496:	35
497:	26
498:	29
499:	42
500:	36
501:	32
502:	40
503:	34
504:	34
505:	52
506:	74
507:	165
508:	365
509:	805
510:	1733
511:	2858
512:	3581
513:	3904
514:	3363
515:	2648
516:	1840
517:	1198
518:	781
519:	468
520:	252
521:	174
522:	111
523:	72
524:	43
525:	29
526:	29
527:	18
528:	11
529:	6
530:	4
531:	5
532:	0
.	
.	
.	
1021:	0
1022:	0

1023:	1
1024:	0

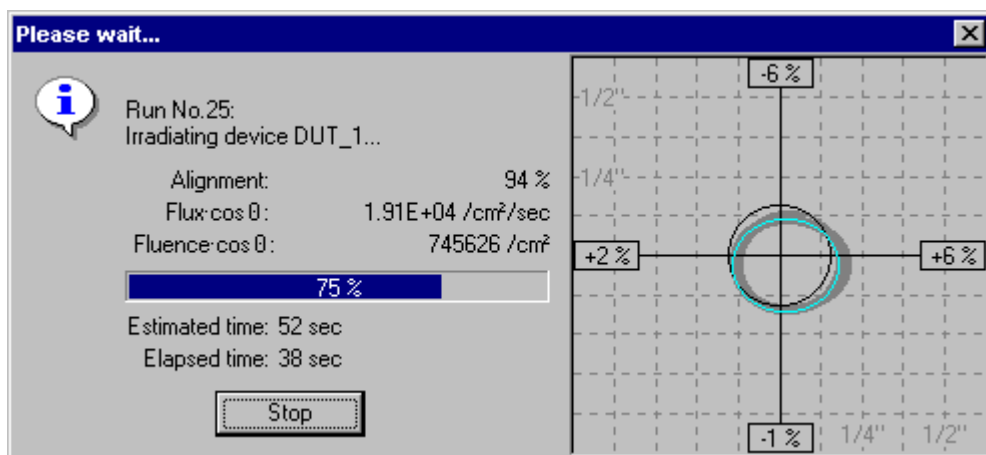
Test Run

- The Test Run command performs a single test run. The command has three basic requirements:
 - The beam isotope, energy, and LET have been defined by the Ion/Energy command.
 - Either the desired fluence has been set by the Fluence command or the desired run time has been set by the Run_Time command.
 - A device has been positioned in the beam by the Move_Device command or by double-clicking the device ID in the Board_area of the Main_window.

If these three basic conditions are not met, you will receive an error message and no test run will be performed.

- Other requirements concern the status of the beamline (see the Beamline_area of the Main_window):
 - The beamline up to and including the test chamber should be free of all obstacles (i.e., all beamline vacuum valves must be open and all beamline devices such as the faraday cups, beam viewers, and the center scintillation detector must be out of the beam). The diagnostic box front and rear beam shutters, operated by the Test Run command itself, should be initially closed.
 - The beamline should be ready (i.e., the beam tuning and laser should be off and, if using the scintillation detectors for the beam dosimetry, the photomultiplier bias should be on).

If the the beamline is blocked or not ready, you will receive a warning indicating the problem, but the test run can be performed. Of course, you will not be able to collect any valid data. This arrangement is implemented mainly to test the SEU Test Facility software and hardware. Most beamline status problems can be corrected with the help of the All_Devices command on the Beamline_menu.



- If all the above test run requirements are satisfied, the SEU Test Run application opens the diagnostic box front and rear beam shutters and waits until the desired effective fluence set by the Fluence command is accumulated or until the desired run time set by the Run_Time command is reached, while monitoring the beam flux. You can stop the Test Run command before it is completed by pressing the <Stop> button in the test run Progress_box, by applying a TTL level pulse (active low by default) to the SEU Test Facility STOP input, or by sending the KILL command over the GPIB bus (see the TTL_Interrupts and GPIB_Host commands on the Control_menu).
- When the Test Run command is completed or interrupted by the user, it closes the beam shutters, makes a copy of the general dosimetry data and saves it in the application registry key, updates the total dose accumulated on the device under test and saves it with the present board configuration, and

then automatically calls the Enter_Upsets command in order to display the test run parameters and collected data, accept the number of upsets obtained by means of your tester, save and print the test run data record, and update the on-line plot for the device under test. See the Enter_Upsets command help page for details.

Enter Upsets...

Enter upsets for run No.25...

Device ID: DUT_1

LET/cos θ [MeV·cm²/mg]: 26.58

Run time [sec]: 34.7

Flux·cos θ [/cm²/sec]: 2.920E+04

Fluence·cos θ [/cm²]: 1.014E+06

Number of upsets: 153

Cross section [cm²]: 1.509E-04

2Σ uncertainty [%]: 16

OK

Cancel

- The Enter Upsets command displays the selected test run parameters and collected data (such as the run number, device ID, effective LET, run time, average effective flux, and the accumulated effective fluence) and waits for you to enter the number of upsets, obtained by means of your tester. If the scintillation detectors and counters are used for the beam dosimetry, the accumulated normal fluence is calculated as:

$$\text{Fluence [ions/cm}^2\text{]} = \frac{\text{Average count}}{\text{Aperture area}} \cdot \text{Center-to-ring} \cdot \text{Distance fall-off}$$

taking into account the center-to-ring and distance fall-off corrections (see the Measure_Flux command on the Dosimetry_menu for details). If the faraday cups and electrometers are used for the beam dosimetry, the accumulated normal fluence is calculated as:

$$\text{Fluence [ions/cm}^2\text{]} = \frac{\sum \text{Collector current} \cdot \delta t}{eQ \cdot \text{Center cup area}} \cdot \text{Center-to-collector} \cdot \text{Distance fall-off}$$

where e is the elementary charge, Q the beam charge state, and δt the short time intervals (about 250 msec) between the consecutive beam current measurements. Monitoring the beam current is far more stable and accurate than measuring the accumulated beam charge used in the past. The average normal flux during the test run is calculated by dividing the accumulated normal fluence by the test run time (time between opening and closing the beam shutters) regardless of the current Dosimetry_Method:

$$\text{Flux [ions/cm}^2\text{/sec]} = \frac{\text{Fluence}}{\Delta t}$$

Taking into account the particle angle of arrival, the effective fluence and effective flux are calculated by multiplying the normal fluence and normal flux, respectively, by the cosine of the tilt angle θ :

$$\text{Effective fluence} = \text{Fluence} \cdot \cos \theta$$

$$\text{Effective flux} = \text{Flux} \cdot \cos \theta$$

When you type in the number of upsets, the upset cross section and its 2σ uncertainty are immediately updated, based on the accumulated effective fluence and the number of device bits (one by default) set by the Edit command on the Board_menu:

$$\text{Cross section [cm}^2\text{]} = \frac{\text{Upsets}}{\text{Fluence} \cdot \cos \theta \cdot \text{Bits}}$$

$$2\sigma \text{ uncertainty} = \frac{2 \sqrt{\text{Upsets}}}{\text{Upsets}} \cdot 100\%$$

- The general dosimetry data (run time, normal flux, normal fluence, beam alignment, and center-to-ring or center-to-collector ratios) is updated every time you execute the Measure_Flux or Measure_Energy_&_LET commands on the Dosimetry_menu or the Test_Run command on the Test_menu. A copy of the last test run dosimetry data is kept separately from the general dosimetry data and saved in the SEU Test Facility application registry key at the end of every test immediately after closing the beam shutters. The Enter Upsets command can be called even after you restart the SEU Test Facility application following its termination or a computer crash.

The Enter Upsets command is called automatically by the SEU Test Facility application at the end of every Test_Run. It can be recalled from the Test_menu, if you discard the test run and then change your mind or if you are entering the number of upsets multiple times.

- When you enter the number of upsets and press the <OK> button, the test run record is first saved in the current data file selected by the Open command on the Data_menu, then printed by the Line_Printer, and finally the on-line plot for the present device ID is shown (if not already shown) and updated by adding the last data point. This is done even if you enter zero upsets. In this case, the upset cross section in the on-line plot is replaced by the upset cross section upper limit. The upper limit is calculated by simply replacing zero upsets with one upset. A down arrow is added to the current plot symbol in order to distinguish the upper limit data point from ordinary (non-zero upset cross section) data points. If you do not enter the number of upsets and press the <Cancel> button, the SEU Test Facility gives you a warning that you are about to discard the last test run. However, the data is not really discarded until you execute another test run. Before you do that, you can always call the Enter Upsets command again.
- The following parameters are included in every test run data record (see the sample_data_file for details):
 - run number,
 - date and time,
 - device ID,
 - beam isotope,
 - beam energy [MeV]
 - penetration depth [μm],
 - effective LET [$\text{MeV} \cdot \text{cm}^2/\text{mg}$],
 - tilt angle [deg],
 - roll angle [deg],
 - run time [sec],
 - average effective flux [$\text{ions}/\text{cm}^2/\text{sec}$],
 - accumulated effective fluence [ions/cm^2],
 - dose [rad],
 - total dose [rad],
 - number of upsets,
 - upset cross section [cm^2],
 - right scintillator deviation [%],

- top scintillator deviation [%],
- bottom scintillator deviation [%],
- left scintillator deviation [%],
- beam alignment [%],
- plot symbol initial.

The effective LET is calculated by dividing the normal LET of the current beam isotope (set by the `Ion_Energy` command) in the present `Target_Material` by the cosine of the current tilt angle θ , while the penetration depth by multiplying the ion range by the cosine of this angle. The beam energy, effective LET, and the penetration depth are also corrected for an energy loss in the device `Dead_Layer` (if any).

$$\text{Effective LET} = \text{LET} / \cos \theta$$

$$\text{Penetration depth} = \text{Range} \cdot \cos \theta$$

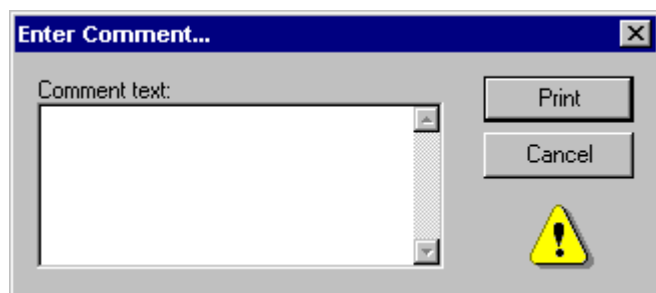
The dose accumulated in a single test run is calculated by multiplying the fluence and LET (both normal or both effective) and transforming the units (MeV/mg to rad):

$$\text{Dose [rad]} = 1\text{E}+14 \cdot e [\text{C}] \cdot \text{Normal fluence [ions/cm}^2] \cdot \text{LET [MeV}\cdot\text{cm}^2/\text{mg}]$$

where $e = 1.6\text{E}-19$ coulombs is the elementary charge. The total dose is the dose accumulated on the device under test so far. i.e., the sum of the doses from the last and all previous test runs (if any) performed with this device. The SEU Test Facility application keeps track of the total dose accumulated on each device in the present board configuration. Since the total dose is updated at the end of every test run immediately after closing the beam shutters, it makes no difference whether you enter the number of upsets or discard the test run.

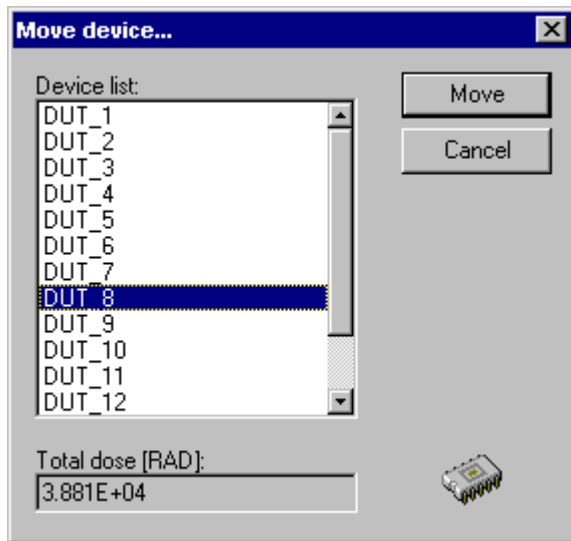
- The Enter Upset command increments the test `Run_Number` only the first time after you enter the number of upsets and press the <OK> button. It is therefore possible to enter the number of upsets multiple times and thus obtain multiple data points from a single test run. This arrangement is useful if you wish to record separately upsets from several different segments of the same device or if you wish to record different kinds of events, for example both upsets and latchups.
- For the first (and usually the only) entry after the test run, the plot symbol is the one selected by the `Plot_Symbol` command on the `Data_menu`. For each subsequent upset entry for the same test run (if any), the SEU Test Facility application cycles through the eight available plot symbols (square, diamond, asterisk, cross, triangle, yield, pound, and ring) in order to visually separate cross sections for different types of events. By default, the program also cycles through these eight plot symbols after every beam isotope change. If you plan to enter upsets multiple times for some or all test runs, it is recommended that you disable the second cycling with the help of the `Plot_Symbol` command in order to avoid confusion. Data points for different beam isotopes will be still visually separated in the on-line plots by different plot symbol colors.

Enter Comment...



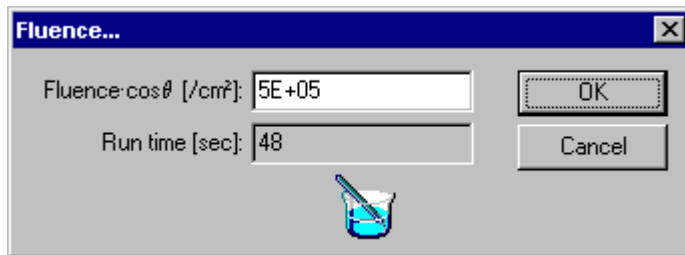
- The Enter Comment command allows you to place a comment line (up to 250 characters) in the present data file describing, for example, the test conditions or parameters of the last test run. The SEU Test Facility application adds an exclamation mark at the beginning of the comment line. Comment lines are ignored by the SEU Test Facility application in any subsequent processing of the data file by the Search command on the Data_menu
- You cannot place a comment line in an empty data file. You have to execute at least one Test_Run, enter the number of upsets, and save the data point before using the Enter Comment command.

Move Device...



- The Move Device command moves a device selected from the present board configuration into the beam. The present device ID (if any) is the default, but you can select a different device ID from the list. The device position is comprised of the X-, Y-, and Z-coordinates and the iris aperture diameter. The stepping motors at least for the X- and Y-axes have to be enabled by the Enable_Motors command on the Positioning_menu in order to use the Move Device command.
- The SEU Test Facility application checks the current test board position and iris diameter with help of the absolute encoders, then moves the test board and opens or closes the iris aperture. You can stop the move before it is completed by using the <Stop> button in the Progress_box shown during the move. The final test board position and iris diameter are also reported by the absolute encoders and shown in the Positions_area of the Main_window. If the move is successfully completed (i.e., if all four coordinates of the final position are within 0.05 cm of the target device coordinates, the device ID in the Board_area of the Main_window is highlighted. If the move fails you will receive a warning and information, how far from the target device position the motion stopped and which limit switches (if any) have been tripped.
- You can also move a device into the beam by double-clicking the device ID in the Board_area of the Main_window. Since positioning the device into the beam by this second method is more convenient, the Move Device command is seldom used. However, in the Move Device dialog box you can also check the total accumulated dose for the selected device ID, even without moving it. The total dose can be also checked by the Edit command on the Board_menu, but you have to open three levels of dialog boxes before you can see the total dose value.

Fluence...



- The Fluence command defines the desired effective fluence (the number of ions per cm²) to be accumulated on the device under test; the present effective fluence is the default. Whenever you change the desired effective fluence by typing, the estimated test run time value is immediately updated, based on the most recent flux measurement by the Measure_Flux or Measure_Energy & LET commands on the Dosimetry_menu or by the Test_Run command on the Test_menu. Note that the value you enter is actually the effective fluence, or the normal fluence multiplied by cosine of the tilt angle. When executing a Test_Run, the SEU Test Facility application always irradiates the selected device until the desired effective fluence is accumulated on the device, regardless of the current tilt angle set by the Effective_LET or Tilt_Angle commands.
- You can specify either the desired effective fluence or the run time, but not both. Executing the Fluence command cancels any previously executed Run_Time command. The last command executed (either Fluence or Run_Time) on the Test_menu is checked and the corresponding Toolbar button depressed.
- When using the scintillation detectors and counters for the beam dosimetry, the maximum fluence that can be accumulated on the device before the counters overflow is given by:

$$\text{Maximum normal fluence [ions/cm}^2\text{]} = \frac{1\text{E}+09}{\text{Aperture area}}$$

The aperture area is set by the Dosimetry_Method command on the Dosimetry_menu. This is the maximum effective fluence you can set by the Fluence command. However, since the counters always count the normal and not the effective fluence and since some counters may overflow earlier than the others due to the less than perfect beam alignment, the maximum effective fluence is further multiplied by the cosine of the current tilt angle, slightly reduced based on the beam inverse square root fall-off with the distance, and slightly modified based on the current beam alignment and center-to-ring ratio just before executing a Test_Run:

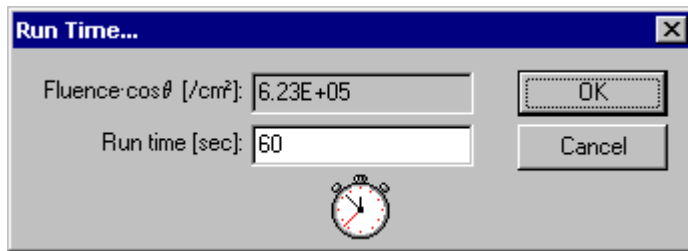
$$\text{Maximum fluence [ions/cm}^2\text{]} = \frac{1\text{E}+09}{\text{Aperture area}} \cdot \frac{\text{Alignment}}{200\% - \text{Alignment}} \cdot \text{Center-to-ring} \cdot \text{Distance fall-off} \cdot \cos \theta$$

If the desired effective fluence is too high, you will receive an overflow warning.

- When using the faraday cups and electrometers for the beam dosimetry, there is no upper limit on the desired effective fluence. The electrometers actually measure the beam current and the beam flux is calculated using the present faraday cup area set by the Dosimetry_Method command on the Dosimetry_menu and the beam charge state set by the Ion/Energy command. The accumulated fluence is obtained by adding counts equal to the flux multiplied by the short intervals (about 250 msec) between the individual beam current measurements.

- The Fluence command does not impose any lower limit on the desired effective fluence except that it must be greater than or equal to zero. Of course, if you enter zero effective fluence, you will not be able to make a Test_Run. If the estimated run time is less than 4 sec, you will receive a warning when you try to execute the test run, because the fluence uncertainty caused by the time necessary to open and close the beam shutters (about 80-100 msec) becomes significant.
- The desired effective fluence and the estimated run time, based on the most recent flux measurement by the Measure_Flux or Measure_Energy & LET commands on the Dosimetry_menu or by the Test_Run command on the Test_menu, are always shown in the Data_area of the Main_window. Typical run time is 30 sec to 1 min. If the estimated run time is too short, ask the Tandem Van de Graaff operators to reduce the beam flux, if it is too long, ask the operators to increase the flux.

Run Time...



- The Run Time command defines the run time for which the device under test is to be irradiated; the present run time is the default. Whenever you change the desired run time by typing, the estimated effective fluence value is immediately updated, based on the most recent flux measurement by the Measure_Flux or Measure_Energy & LET commands on the Dosimetry_menu or by the Test_Run command on the Test_menu and on the current Tilt_Angle. The maximum run time you can enter is 28800 sec or 8 hours.
- You can specify either the desired effective fluence or the run time, but not both. Executing the Run Time command cancels any previously executed Fluence command. The last command executed (either Fluence or Run Time) on the Test_menu is checked and the corresponding Toolbar button depressed.
- When using the scintillation detectors and counters for the beam dosimetry, the maximum fluence that can be accumulated on the device before the counters overflow is $1\text{E}+09 \text{ /cm}^2$ divided by the current aperture area set by the Dosimetry_Method command on the Dosimetry_menu. However, since the counters always count the normal and not the effective fluence and since some counters may overflow earlier due to the less than perfect beam alignment, the maximum effective fluence is further multiplied by the cosine of the current tilt angle, slightly reduced based on the beam inverse square root fall-off with the distance, and slightly modified based on the current beam alignment and center-to-ring ratio just before executing the Test_Run just before executing a Test_Run. If the estimated effective fluence is too high, you will receive an overflow warning.
- The Run Time command does not impose any lower limit on the desired run time except that it must be greater than or equal to zero. Of course, if you enter zero run time, you will not be able to make a Test_Run. If the run time is less than 4 sec, you will receive a warning, because the effective fluence uncertainty caused by the time necessary to open and close the beam shutters (about 80-100 msec) becomes significant.
- The desired run time and the estimated effective fluence, based on the most recent flux measurement by either the Measure_Flux command on the Dosimetry_menu or by the Test_Run command and on the current Tilt_Angle, are always shown in the Data_area of the Main_window. Typical run time is 30 sec to 1 min. If the estimated fluence is too high, ask the Tandem Van de Graaff operators to reduce the beam flux, if it is too low, ask the operators to increase the flux.

Ion/Energy...

- The Ion/Energy command defines the beam isotope, energy, charge state, and its LET and range in the current target material (Si, GaAs, etc.) selected by the Target_Material command on the Board_menu; the current values of these parameters are the defaults. The beam charge state is not required if the scintillation detectors and counters are used for the beam dosimetry (see the Dosimetry_Method command on the Dosimetry_menu).
- Enter the element chemical symbol and, optionally, the desired isotope atomic weight. The chemical symbol can be in lower or upper case (for example, Ge, GE, ge, or gE for germanium). Only the first two alphabetical characters are recognized. The chemical symbol can be followed by the atomic mass (approximately equal to the mass number A). The atomic mass can but does not have to be separated from the element chemical symbol by any non-alphanumeric character except the period, which is reserved for the decimal symbol. Hyphen or space are commonly used. Only the elements from hydrogen to uranium are supported. The transuranium elements are not supported.
- Alternately, you can select the desired heavy ion from the periodic_table of elements using the <Table> button. The SEU Test Facility application inserts the most abundant isotope of the selected element.
- The acceptable atomic weights are limited to the range from $2 \cdot Z - 1$ to $2.7 \cdot Z$, where Z is the element atomic number. No stable or reasonable unstable isotopes are found outside of this range. If you omit the atomic weight, the atomic weight of the naturally most abundant isotope will be adopted.
- If desired, the SEU Test Facility application calculates both the heavy ion LET and range in the present Target_Material. The LET calculation is based on the semi-empirical formulas developed by J. F. Ziegler et al:
 - H. H. Andersen and J. F. Ziegler, "Hydrogen Stopping Powers and Ranges in All Elements," Vol. 3 of "The Stopping Powers and Ranges of Ions in Matter," Pergamon Press (New York: 1977).
 - J. F. Ziegler, "Helium Stopping Powers and Ranges in All Elements," Vol. 4 of "The Stopping Powers and Ranges of Ions in Matter," Pergamon Press (New York: 1977).
 - J. F. Ziegler, "Stopping Cross-sections for Energetic Ions in All Elements," Vol. 5 of "The Stopping Powers and Ranges of Ions in Matter," Pergamon Press (New York: 1977).

The total LET is calculated as a sum of the electronic and nuclear stopping S_e and S_n respectively:

$$LET = S_e + S_n$$

The electronic stopping for heavy ions is obtained from that for protons by scaling the heavy ion energy E to E/A, where A is the mass number, and multiplying by the square of effective charge ratio:

$$\text{Heavy ion } Se(E) = \text{Proton } Se(E/A) \cdot (Z_{HI}^* / Z_P^*)^2$$

Results of this calculation are compared to Ziegler's tables in the following table:

Ion	Energy [MeV]	LET(Si) [MeV·cm ² /mg] (calculation)	LET(Si) [MeV·cm ² /mg] (by Ziegler)
C-12	102	1.4	1.4
F-19	140	3.4	3.4
Si-28	186	7.9	7.9
Cl-35	208	11.5	11.6
Ni-58	265	26.6	26.7
Br-79	285	37.2	37.4
I-127	320	59.7	59.7
Au-197	345	81.9	82

- The heavy ion range is calculated as the total path length by integrating the linear energy transfer over the energy, which is actually slightly longer than the range due to possibility of changing direction (straggling), especially at the end of the heavy ion path:

$$\text{Range} = \int_0^E \frac{dE}{LET}$$

Since the LET is a rapidly varying function of the heavy ion energy at low energies and a slowly varying function at higher energies (above the LET maximum), an appropriate numerical method is necessary to accurately calculate the integral for heavy ion energies over several orders of magnitude. Above 0.1 keV/AMU, the integration is performed decade by decade. In every decade, a table of $k = 10$ $1/LET$ vs. energy/AMU points is calculated at first. This table is then used to obtain the $k + 2$ coefficients of a third order natural_spline by solving a set of $k + 2$ linear equations using the LU-resolution method. The spline approximates the $1/LET$ vs. energy/AMU function through the decade and it is used to calculate the contribution to above integral over the decade. Since the third order natural_spline is a piecewise polynomial function, its integral can be calculated directly. In addition, because of the continuous first and second derivatives, common methods of successive approximations can be used to find its roots and extrema.

Periodic Table

Periodic Table

IA

H

Li

Na

K

Rb

Cs

Fr

IIA

Be

Mg

Ca

Sr

Ba

Ra

IIIA

Sc

Y

La

IVA

Ti

Zr

Hf

VA

V

Nb

Ta

VIA

Cr

Mo

W

VIIA

Mn

Tc

Re

VIIIA

Fe

Ru

Os

VIIIA

Co

Rh

Ir

VIIIA

Ni

Pd

Pt

IB

Cu

Ag

Au

IIB

Zn

Cd

Hg

IIIB

Ga

In

Tl

IVB

Ge

Sn

Pb

VB

As

Sb

Bi

VIB

Se

Te

Po

VII

Br

I

At

VIIIB

Kr

Xe

Rn

Mass: 58.690 AMU

57.935 AMU

natural

most abundant

28

Ni

VIIIB

He

Ne

Ar

Kr

Xe

Rn

Insert

Close

Lanthanoides:

Ce

Pr

Nd

Pm

Sm

Eu

Gd

Tb

Dy

Ho

Er

Tm

Yb

Lu

Actinoides:

Th

Pa

U

Transuranium elements are not supported.

- The Periodic Table dialog box opens by using the <Table> button in the Materials or Ion/Energy or dialog boxes. You can insert the selected element into the chemical formula in the Materials dialog box or the most abundant isotope of the selected element into the Ion/Energy dialog box.
- To select an element in the Periodic Table, click it with the left mouse button. Alternately, you can give it the focus with the <Tab> key and then press the <Space> key. To insert the selected element into the chemical formula in the Materials dialog box or the most abundant isotope of the selected element into the Ion/Energy dialog box, press the <Insert> button.
- The Periodic Table dialog box shows the full element name of the selected element, its atomic number Z, atomic mass of the natural isotopic mixture, and the atomic mass of the most abundant isotope. The mass number A of the most abundant isotope is always an integer very close to its atomic mass.

Natural Spline

- A spline of the n -th order is a piecewise polynomial function of the n -th order with continuous derivatives up to the $(n - 1)$ -th order. Splines provide an excellent approximation of a function given by a table, without the tendency to oscillate common to the interpolation polynomials. A natural spline of the $(2m - 1)$ -th order is a spline that becomes a polynomial of the $(m - 1)$ -th order outside the table. Only odd order natural splines do exist. For example, a natural spline of the first order is a piecewise linear function inside the table that turns to constants outside the table. For a given table of k points, there is one and only one $(2m - 1)$ -th order natural spline ($1 \leq m \leq k$) that can be uniquely expressed as

$$S_{2m-1}(x) = \sum_{i=1}^k C_i [x - x_i]_+^{2m-1} + P_{m-1}(x)$$

where the operator $[]_+$ means "the positive part of" and $P(x)$ is a $(m - 1)$ -th order polynomial. To learn more about natural splines, consult:

- J. H. Ahlberg, E. N. Nilman, and J. L. Walsh, "The Theory of Splines and Their Applications," Academic Press (New York: 1967).

Effective LET...

- The Effective LET command allows you to select the effective LET rather than the tilt angle; the present effective LET is the default. However, the sign of the tilt angle is not determined by specifying the effective LET. You can force the test board to rotate to the positive or negative tilt angles (clockwise or counterclockwise, respectively); the sign of the present tilt angle is the default. If the present tilt angle is zero (actually less than 0.05° in absolute value), the positive sign (clockwise) is the default. Otherwise the Effective LET command works just like the Tilt_Angle command.
- Obviously, the Effective LET command requires the beam isotope, energy, and LET to be specified by the Ion/Energy command. The minimum effective LET is the LET at the normal angle of incidence (zero tilt angle).
- If no dead layer has been specified by the Dead_Layer command on the Board_menu, the effective LET simply equals to the normal LET divided by cosine of the tilt angle θ and the tilt angle corresponding to the desired effective LET can be calculated directly. If a dead layer is present, tilting the test board increases the energy loss in the dead layer, reduces the effective beam energy, and changes the normal LET in the device sensitive region. The appropriate tilt angle must then be calculated by the method of successive approximation. After you type in the desired effective LET angle, you can preview the corresponding values of the tilt angle, its cosine, effective energy, and the penetration depth before you move the test board by pressing the <Update> button.
- The SEU Test Facility application checks the current tilt and iris angles with help of the absolute encoders, then tilts the test board and the iris aperture. You can stop the move before it is completed by using the <Stop> button in the Progress_box shown during the move. The final tilt and iris angles are also reported by the absolute encoders and shown in the Positions_area of the Main_window. The move is successfully completed if the final tilt and iris angles are within 0.05° of the target tilt angle. If the move fails, you will receive a warning and information, how far from the target tilt angle the motion stopped and which limit switches (if any) have been tripped.
- When the motion is successfully completed, manually stopped, or it fails, the effective energy, effective LET, and the penetration depth in the Data_area of the Main_window are automatically updated to reflect the current tilt angle and taking into account the current dead layer (if any).

Tilt Angle...

The dialog box 'Tilt Angle...' has the following fields and values:

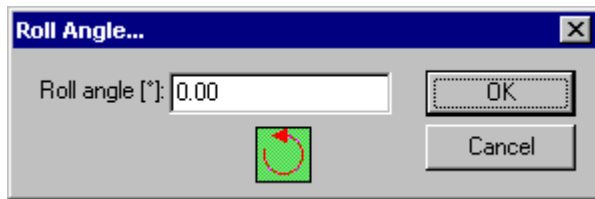
Field	Value
Energy - ΔE [MeV]	320
LET/cos θ [MeV·cm ² /mg]	59.86
Range·cos θ [μm]	32.7
Tilt angle [°]	0.00
cos θ	1.0000

Buttons: OK, Update, Cancel.

Diagram: A 3D representation of a rectangular plate tilted at an angle, with a red arrow indicating the axis of rotation.

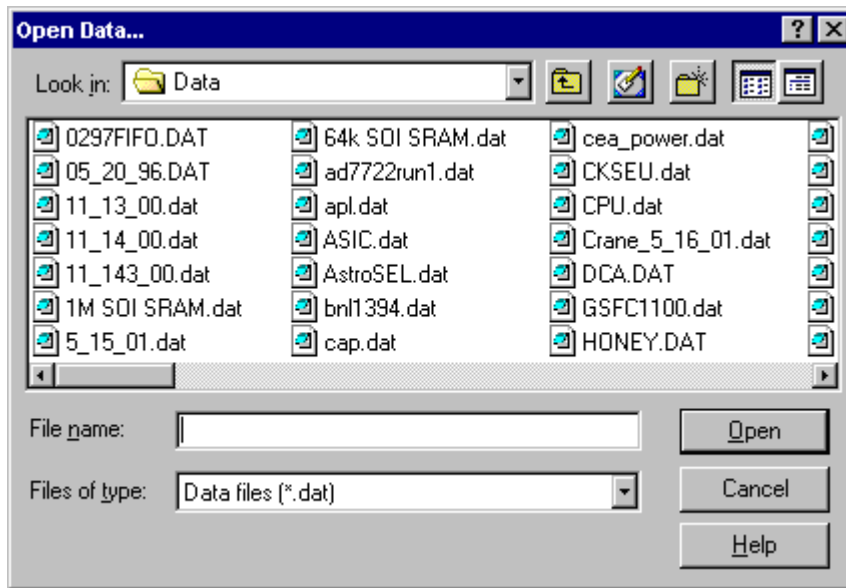
- The Tilt Angle command rotates the test board around the vertical axis; the present tilt angle is the default. The device under test must be positioned on the vertical axis of rotation in order to stay in the beam. This is accomplished by moving the test board back and forth along the horizontal Z-axis perpendicular to the board during the test board configuration setup by the Edit command on the Board_menu. The iris aperture in front of the test board is simultaneously tilted by the same angle in order to keep the beam spot on the test board circular.
- The Tilt Angle command is primarily used to vary the heavy ion beam angle of incidence and thereby to increase the effective LET compared to the LET at the normal angle of incidence. If no dead layer has been specified by the Dead_Layer command on the Board_menu, the effective LET simply equals to the normal LET divided by cosine of the tilt angle θ . This of course reduces the penetration depth of the heavy ions and, if a dead layer has been specified, also the effective beam energy (i.e., the heavy ion energy after penetrating the dead layer). After you type in the desired tilt angle, you can preview the corresponding values of its cosine, the effective energy, effective LET and the penetration depth before you move the test board by pressing the <Update> button.
- The SEU Test Facility application checks the current tilt and iris angles with help of the absolute encoders, then tilts the test board and the iris aperture. You can stop the move before it is completed by using the <Stop> button in the Progress_box shown during the move. The final tilt and iris angles are also reported by the absolute encoders and shown in the Positions_area of the Main_window. The move is successfully completed if the final tilt and iris angles are within 0.05° of the target tilt angle. If the move fails, you will receive a warning and information, how far from the target tilt angle the motion stopped and which limit switches (if any) have been tripped.
- When the motion is successfully completed, manually stopped, or it fails, the effective energy, effective LET, and the penetration depth in the Data_area of the Main_window are automatically updated to reflect the current tilt angle and taking into account the current dead layer (if any).
- If the SEU Facility application has been compromised by ignoring the negative limit switch for the tilt angle axis of motion (set by the Ignore_Limits command on the Positioning_menu) and if you attempt to tilt the test board beyond the hardware limit switch, the SEU Test Facility application prompts you to confirm your intention. If your answer is <No>, the positioning stage will move and stop at the negative limit switch. If your answer is <Yes>, the positioning stage will move beyond the negative limit switch up to +90°. Extreme caution should be exercised when ignoring the limit switch in order to avoid possible heavy damage to the positioning stage.

Roll Angle...



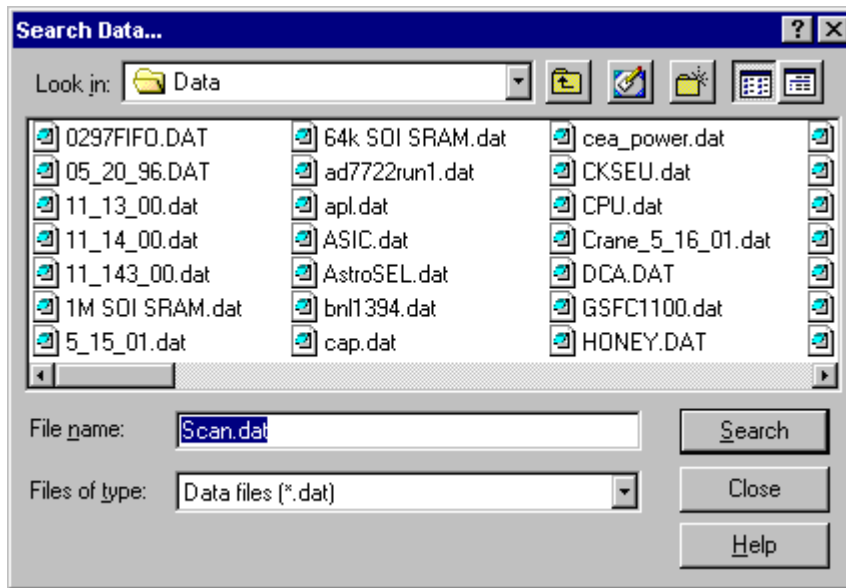
- The Roll Angle command rotates the test board around the horizontal axis perpendicular to the test board; the present roll angle is the default. The roll angle must be enabled by the Enable_Motors command on the Positioning_menu in order to roll the test board.
- The combination of the tilt and roll angles makes it possible to hit the device under test by the heavy ion beam from virtually any direction. However, since the roll angle does not change the effective LET of the heavy ion beam, it is seldom used. If it is used, then usually only to roll the test board to +90° or -90°. One common reason for the use of the roll angle is to avoid beam shadows when the device under test is mounted in a socket with raised vertical shoulders and the Effective_LET is varied by changing the particle angle of arrival - the Tilt_Angle. Another common reason is the chip layout geometry, for example short but wide transistor channels. The upset cross section may be different when a tilted device is hit by the heavy ion beam along the transistor channel lengths or the channel widths.
- The SEU Test Facility application checks the current roll angle with help of the absolute encoder, then rolls the test board. You can stop the move before it is completed by using the <Stop> button in the Progress_box shown during the move. The final roll angle is also reported by the absolute encoder and shown in the Positions_area of the Main_window. The move is successfully completed if the final roll angle is within 0.05° of the target roll angle. If the move fails, you will receive a warning and information, how far from the target roll angle the motion stopped and which limit switch (if any) has been tripped.
- If the SEU Facility application has been compromised by ignoring the positive limit switch for the roll angle axis of motion (set by the Ignore_Limits command on the Positioning_menu) and if you attempt to roll the test board beyond the hardware limit switch, the SEU Test Facility application prompts you to confirm your intention. If your answer is <No>, the positioning stage will move and stop at the positive limit switch. If your answer is <Yes>, the positioning stage will move beyond the positive limit switch up to +90°. Extreme caution should be exercised when ignoring the limit switch in order to avoid possible heavy damage to the positioning stage.

Open...

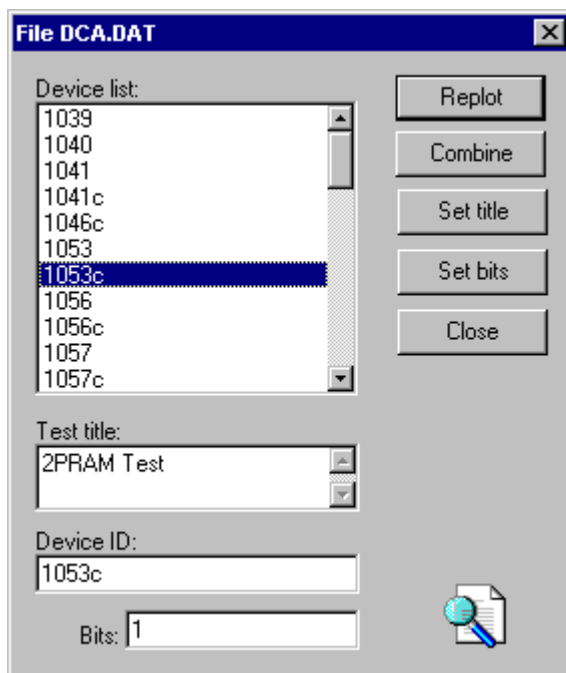


- The Open command allows you to open a new data file or append data to an existing one. The file list is filled by files in the ...\\Data subfolder with the *.dat file filter for data files. There is no default file name. You either have to type it in or you can select an existing data file from the file list. When typing in the data file name, no file extension has to be included. If you omit the extension, the default data file extension .dat is be used. Using other data file extension is not recommended, because the *.dat file filter is used by all other data file commands (Search, Copy, Destroy, Edit, and Print).
- If you type in a new file name, an empty data file is created and the data file name is remembered by the SEU Test Facility program. If you select an existing data file to append data, the data file name is just remembered and otherwise the Open command does nothing. From now on, this data file is used to save all test run data records.
- If you do not remember the data file name you wish to append, try to sort the data files by date in descending order. The topmost file or a file close to the top are the most likely choices.
- The data files are in the text format. They can be opened by any text editor (for example, the Windows Notepad or Wordpad, depending on the data file size) or imported to spreadsheet programs (such as the Microsoft Excel). See the Edit command and the sample_data_file for details.

Search...



- The Search command allows you to find all device IDs in the selected data file and to replot the data for the selected devices, i.e., to create the on-line plots. The file list is filled by files in the ...Data subfolder with the *.dat file filter for data files. The present data file is the default, but you can select a different data file to search from the file list.

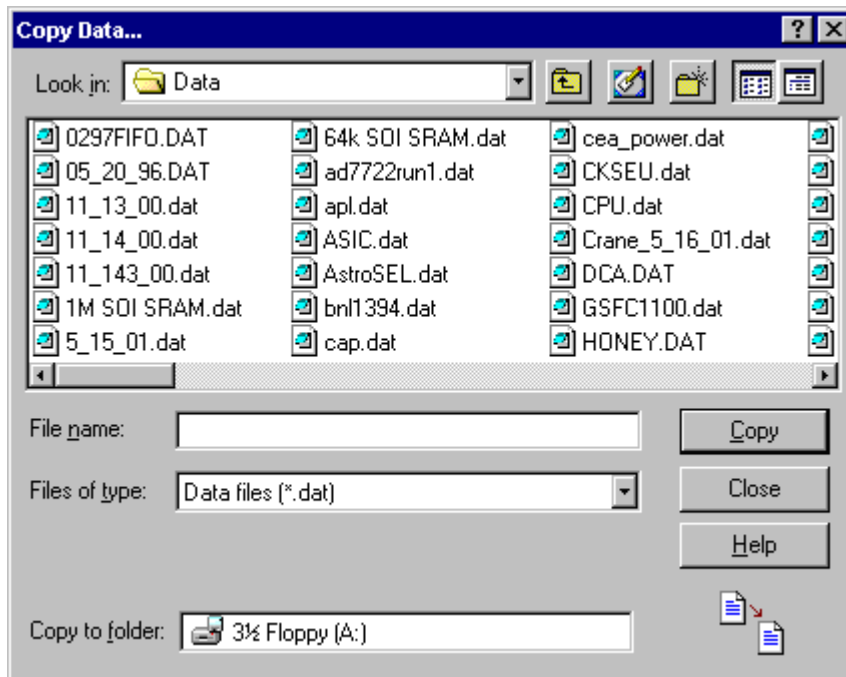


- You can select multiple device IDs from the list and either replot the individual on-line plots by pressing the <Replot> button, or you can combine data for the selected device IDs into one plot with the help of the <Combine> button.
- For each device ID, the Search command finds the corresponding test title. Although usually not the case, a data file can contain multiple headers entered by the Test_Title command. Each device ID is assigned the last test title before the last data point collected for this device. The test title edit control in

the dialog box shows the test title for the device ID with the focus. Please note that in multiple selection listboxes, the selection (i.e., the highlight) is different from the focus. One and only one item can have the focus, which is indicated by the focus rectangle drawn around the item. You can change the assigned test title by typing in a different text and pressing the <Set title> button. Since the <Set title> button changes the test title for individual device IDs, it is not necessary to use it when combining the selected device IDs into one plot using the <Combine> button. In this case, the SEU Test Facility application simply uses the current text in the test title edit control.

- For each device ID, the Search command also finds for the corresponding number of device bits used to calculate the upset cross section. Since the upset cross section is calculated as the number of upsets divided by the accumulated effective fluence and by the number of device bits (one by default) and since the number of device bits is not included in the test run data records, the SEU Test Facility application looks at the current board configuration created by the Edit command, loaded by the Open command, or selected from the list of Recent_Boards or on the Board_menu. If the selected device ID is not found in the current board configuration, the SEU Test Facility application attempts to calculate the number of device bits by dividing the upset cross section by the accumulated effective fluence and the number of upsets for all the test runs with the selected device ID and rounding the average value to the nearest KBit, MBit, or GBit as appropriate. Test runs with no upsets are not included in calculating the average. Of course, this is not possible when the number of upsets is zero for all test runs with the selected device ID. Therefore, when replotting data for a device ID not present in the current board configuration and with no upsets in any test run, you always have to reenter the number of device bits (if more than one) in order to correctly display the upset cross section upper limit in the on-line plot. The device bits edit control in the dialog box shows the number of device bits for the device ID with the focus, just like the test title edit control. You can change the assigned number of device bits by typing in a different value and pressing the <Set bits> button. Suffixes like K, M, and G for Kilo, Mega, and Giga, respectively, are supported. Since the <Set bits> button changes the number of device bits for the individual device IDs, it is not necessary to use it when combining the selected device IDs into one plot using the <Combine> button. The SEU Test Facility application in this case simply uses the current value in the device bits edit control.

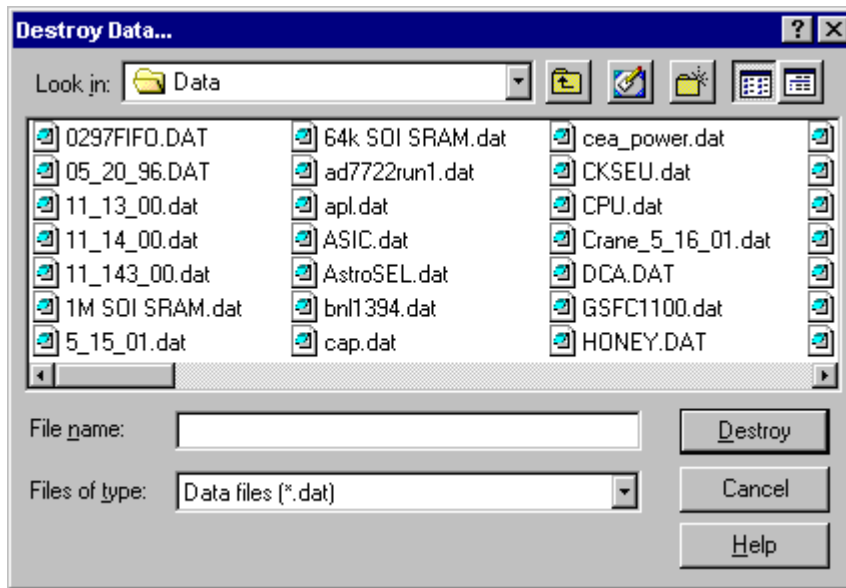
Copy...



- The Copy command allows you to copy the selected data file or files to a different folder, most likely from the SEU Test Facility main computer SEUTF1 hard disk to a floppy disk. The file list is filled by files in the ...Data subfolder with the *.dat file filter for data files. There is no default file name. You either have to type it in or you can select multiple existing data files from the file list.
- If you do not remember the data file name or names you wish to copy, try to sort the data files by date in descending order. The topmost file or files close to the top are the most likely choices.
- You can select the destination folder; the root directory of the floppy disk drive A:\ is the default. If you wish to copy the data file to a different folder, click the destination folder control with the left mouse button. Alternately, give it an input focus using the <Tab> key and then press the <Space> key. The SEU Test Facility program opens another dialog box, where you can browse for the destination folder.

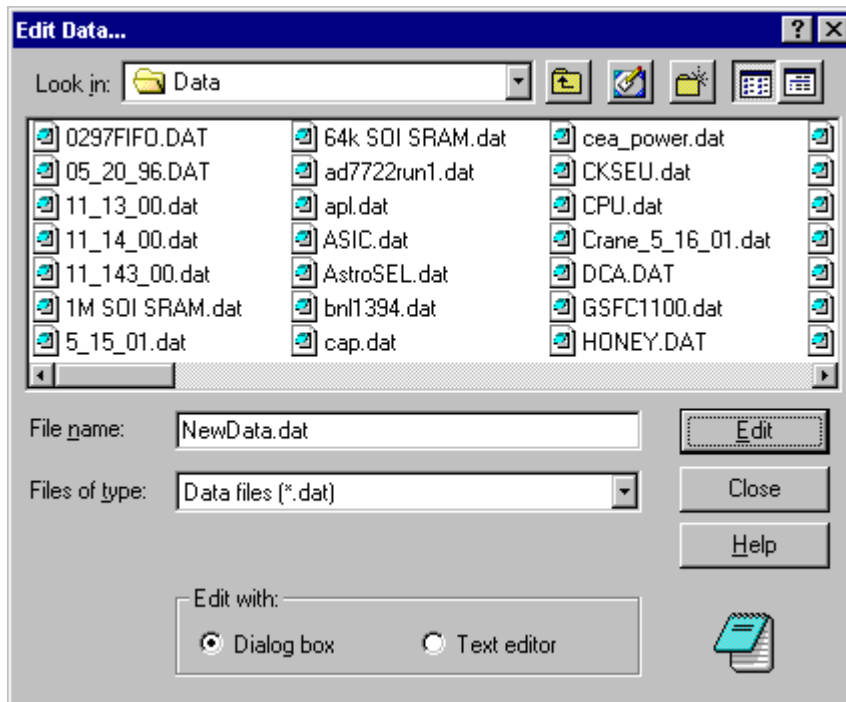


Destroy...



- If you do not delete your data files after you finish your experiment at the SEU Test Facility, they can be inspected by the subsequent user groups. If you delete a file by ordinary means, the file directory entry is just marked invalid (by changing the first character of the deleted file name to @) and the disk space becomes available for any subsequent file storage. However, until the Windows operating system chooses this particular disk space for a file storage operation, the entire file or some of its fragments are still present on the disk and they can be recovered by various undelete utilities. The Destroy command provides a better protection against an unauthorized inspecting and/or copying of proprietary data. Before the data file is deleted, it is overwritten by nulls and its size truncated to zero. Consequently, files destroyed by the Destroy command are impossible to recover.
- The Destroy command allows you to completely destroy the selected data file or files. The file list is filled by files in the ...\\Data subfolder with the *.dat file filter for data files. There is no default file name. You either have to type it in or you can select multiple existing data files from the file list. You also have to confirm your intention to destroy the selected data file(s) one more time before the command can proceed.
- Make sure that you have a floppy disk copy of your data files before you destroy them. The files are not just moved to the Windows Recycle Bin or simply deleted. They are always completely destroyed and impossible to recover by any undelete utility.

Edit...



- The Edit command allows you to edit the selected data file, either by single test run data records in a dialog box or the entire data file in a text editor. The file list is filled by files in the ...Data subfolder with the *.dat file filter for data files. The present data file is the default, but you can select a different data file to edit from the file list.
- If you decide to edit the data file by individual test run data records in a dialog box, you have to select the test run number, and load the test run data record from the data file with the <Load run> button. By default, the last test run in the data file is loaded when you open the dialog box. Any changes in the loaded test run should be stored (i.e., written into the data file) with the <Store run> button.

- The dialog box contains the test run parameters selected or entered by the user (the device ID, beam isotope, energy, tilt and roll angles, number of upsets, device bits, and the plot symbol) and measured by the SEU Test Facility application (the date and time, beam fluence, and the test run time) at the left, and the parameters calculated by the SEU Test Facility application based on the user selected and/or measured values (the effective LET, penetration depth, beam flux, test run dose, total dose, upset cross section, and the beam alignment) at the right. If you believe that some user selected and/or measured values are incorrect, you can change them by typing in different values. On the other hand, the calculated values can be changed only by pressing the <Update> button, based on the current values of the selected and/or measured parameters. The only exception is the test run date and time. The dialog box does not allow you to change it, because, together with the test run number, it uniquely identifies the test run.
- Since the most common mistake, difficult to handle by editing the data file in a text editor, is the user omission to enter a new beam isotope and/or energy after the beam change, the <Insert ion> button insert the current beam isotope and energy parameters selected by the Ion/Energy command on the Test_menu. After inserting the current beam isotope and energy, you still have to press the <Update> button to calculate the corresponding values of the effective LET, penetration depth, test run dose and the total dose. Since the target material and dead layer composition and thickness are not included in the test run data records, the current target material and dead layer selected by the Target_Material and Dead_Layer commands, respectively, on the Board_menu are always assumed.
- Another common mistake is entering an incorrect number of upsets, used to calculate the upset cross section. Since the upset cross section is calculated as the number of upsets divided by the accumulated effective fluence and by the number of device bits (one by default) and since the number of device bits is not included in the test run data records, the SEU Test Facility application looks at the current board configuration created by the Edit command, loaded by the Open command, or selected from the list of the Recent_Boards on the Board_menu. If the test run device ID is not found in the current board configuration, the SEU Test Facility application attempts to calculate the number of device bits by dividing the upset cross section by the accumulated effective fluence and by the entered number of upsets and rounding the value to the nearest KBit, MBit, or GBit as appropriate. Of course, this is not possible when the number of upsets is zero. However, since the calculated upset cross section for zero upsets is zero regardless of the number of bits, the number of bits in this case can be ignored.

- If you decide to edit the entire data file by a text editor, do not change the data file format, for example by skipping or adding columns. If you do, the SEU Test Facility program will not be able to process the data file, i.e., to make the on-line plots, prints, and/or to edit the individual test run data records in the the dialog box. See the sample_data_file for details.
- The Edit command calls a text editor (the Windows Notepad if the data file is less than about 50 kBytes, the Windows Wordpad otherwise) and loads the selected data file. Please note that the Notepad loads a copy of the entire data file into a memory buffer and immediately closes the file. Consequently, other Windows applications, including the SEU Test Facility application, can read and/or write into the data file. On the other hand, the Wordpad keeps the data file open and locked against writing by other applications, including the SEU Test Facility application. When using the Wordpad to edit the current data file, the text editor must close and release the file before you start another Test_Run from the Test_menu or before you execute any other command writing into the data file (i.e., the dialog box editor and possibly the Measure_Flux command on the Dosimetry_menu or the Test_Title command on the Data_menu). Otherwise, the program would not be able to write into the data file and the above commands would fail. Please note that the SEU Test Facility application automatically closes or instances of the Windows Wordpad when closing the Edit command dialog, in order to prevent this from happening.

Sample data file

Untitled

SEU Test

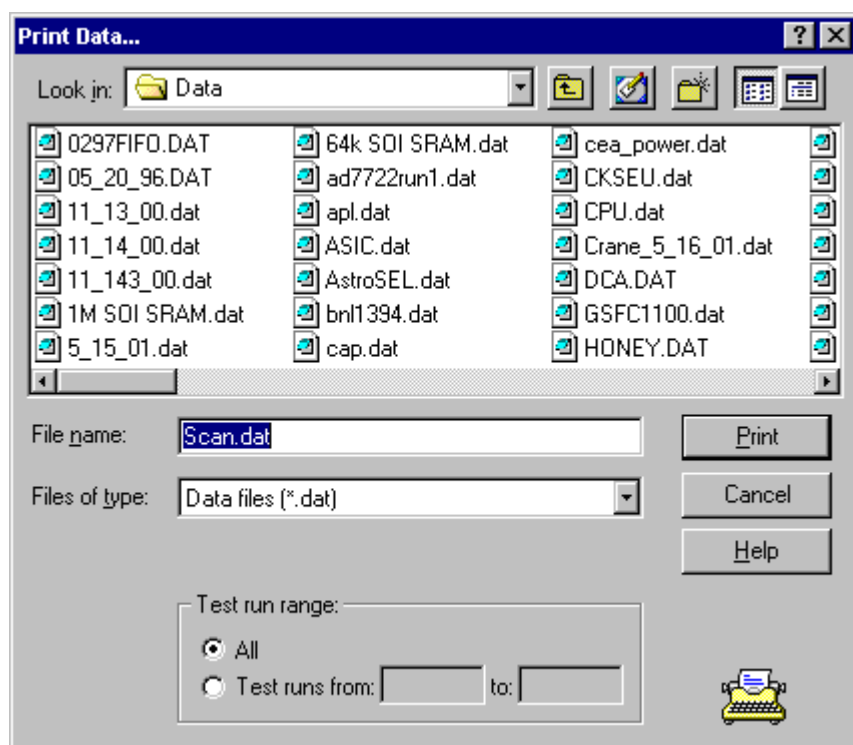
Run	Date/Time	Part ID	Ion	Energy	Depth	LET	Tilt	Roll	Time
Flux	Fluence	Dose	Acc.Dose	Upset	Cross Sec.	Left	Top	Bottom	
Right	Align.	Center							
#				MeV	um	MeV.cm2/mg	deg	deg	sec
#/cm2/sec	#/cm2	RAD(Si)	RAD(Si)		cm2	%	%	%	%
0	24Apr91 10:55	Center	Ni-58	230.0	36.7	27.6	0.0	0.0	10.0
3.653E+04	3.653E+05	0.000E+00	0.000E+00	0	0.000E+00	1.2	-1.9	-0.5	
1.3	98.5	13.3							
1	24Apr91 10:55	DUT_#1	Ni-58	230.0	36.7	27.6	0.0	0.0	31.1
3.666E+04	1.140E+06	5.035E+02	5.035E+02	1597	1.401E-03	1.0	-2.2	0.3	
0.8	98.6	S							
2	24Apr91 10:57	DUT_#1	Ni-58	230.0	36.7	27.6	0.0	0.0	27.4
3.687E+04	1.008E+06	4.455E+02	9.491E+02	1520	1.507E-03	1.0	-2.1	-0.5	
1.6	98.4	S							
3	24Apr91 10:58	DUT_#1	Ni-58	230.0	36.7	27.6	0.0	0.0	27.1
3.708E+04	1.006E+06	4.444E+02	1.393E+03	1817	1.806E-03	0.7	-1.3	-0.2	
0.8	99.0	S							
4	24Apr91 11:01	DUT_#1	Ni-58	230.0	36.7	27.6	0.0	0.0	27.0
3.724E+04	1.006E+06	4.446E+02	2.282E+03	3153	3.133E-03	0.8	-2.1	-0.1	
1.4	98.5	S							
5	24Apr91 11:02	DUT_#1	Ni-58	230.0	36.7	27.6	0.0	0.0	27.0
3.727E+04	1.007E+06	4.451E+02	2.727E+03	3247	3.223E-03	1.2	-1.8	-0.8	
1.4	98.5	S							
! This is a comment.									
! This is also a comment.									
6	24Apr91 11:04	DUT_#2	Ni-58	230.0	36.7	27.6	0.0	0.0	26.8
3.767E+04	1.010E+06	4.461E+02	4.461E+02	2124	2.104E-03	1.4	-2.5	-0.1	
1.3	98.2	S							
7	24Apr91 11:05	DUT_#2	Ni-58	230.0	36.7	27.6	0.0	0.0	27.5
3.657E+04	1.004E+06	4.437E+02	8.898E+02	2227	2.217E-03	1.5	-2.6	-0.3	
1.4	98.1	S							
8	24Apr91 11:06	DUT_#2	Ni-58	230.0	36.7	27.6	0.0	0.0	27.6
3.648E+04	1.006E+06	4.446E+02	1.334E+03	2144	2.131E-03	1.4	-2.4	-0.2	
1.1	98.3	S							
9	24Apr91 11:07	DUT_#2	Ni-58	230.0	36.7	27.6	0.0	0.0	27.8
3.616E+04	1.005E+06	4.442E+02	1.779E+03	3530	3.511E-03	1.2	-2.5	0.0	
1.3	98.3	S							
10	24Apr91 11:08	DUT_#2	Ni-58	230.0	36.7	27.6	0.0	0.0	28.8
3.498E+04	1.007E+06	4.448E+02	2.223E+03	3510	3.487E-03	1.5	-2.6	-0.1	
1.2	98.2	S							
11	24Apr91 11:09	DUT_#3	Ni-58	230.0	36.7	27.6	0.0	0.0	28.2
3.574E+04	1.009E+06	4.458E+02	4.458E+02	2395	2.374E-03	1.2	-2.0	-0.1	
0.9	98.6	S							
12	24Apr91 11:10	DUT_#3	Ni-58	230.0	36.7	27.6	0.0	0.0	28.3
3.551E+04	1.006E+06	4.447E+02	8.905E+02	2411	2.395E-03	0.7	-1.8	-0.2	
1.3	98.7	S							
13	24Apr91 11:10	DUT_#3	Ni-58	230.0	36.7	27.6	0.0	0.0	28.8
3.492E+04	1.005E+06	4.440E+02	1.335E+03	1595	1.587E-03	1.3	-1.8	-0.7	
1.2	98.5	S							
14	24Apr91 11:11	DUT_#3	Ni-58	230.0	36.7	27.6	0.0	0.0	29.2
3.442E+04	1.006E+06	4.443E+02	1.779E+03	1565	1.556E-03	1.3	-2.3	-0.2	
1.3	98.3	S							

```

15 24Apr91 11:12 DUT_#3 Ni-58 230.0 36.7 27.6 0.0 0.0 28.9
3.478E+04 1.005E+06 4.440E+02 2.223E+03 1553 1.545E-03 1.5 -1.6 -0.1
0.3 98.7 S
0 24Apr91 11:52 Center F-19 118.0 93.9 3.8 0.0 0.2 10.0
1.350E+04 1.350E+05 0.000E+00 0.000E+00 0 0.000E+00 -4.1 3.9 3.7
-3.4 95.8 16.8
16 24Apr91 11:52 DUT_#1 F-19 118.0 81.3 4.4 30.0 0.2 88.4
1.325E+04 1.171E+06 8.160E+01 2.809E+03 337 2.878E-04 -4.5 4.3 3.5
-3.3 95.7 T
17 24Apr91 11:53 DUT_#1 F-19 118.0 81.3 4.4 30.0 0.2 73.3
1.370E+04 1.004E+06 6.997E+01 2.879E+03 292 2.909E-04 -4.5 4.7 3.4
-3.7 95.4 T
18 24Apr91 11:55 DUT_#1 F-19 118.0 81.3 4.4 30.0 0.2 72.4
1.385E+04 1.003E+06 6.993E+01 2.949E+03 287 2.862E-04 -4.3 4.4 3.3
-3.4 95.7 T
19 24Apr91 11:57 DUT_#1 F-19 118.0 81.3 4.4 30.0 0.2 85.0
1.198E+04 1.019E+06 7.101E+01 3.020E+03 500 4.906E-04 -3.6 4.1 3.7
-4.2 95.7 T
20 24Apr91 11:58 DUT_#1 F-19 118.0 81.3 4.4 30.0 0.2 86.3
1.161E+04 1.002E+06 6.983E+01 3.089E+03 533 5.318E-04 -4.3 4.5 4.0
-4.1 95.4 T
21 24Apr91 12:02 DUT_#2 F-19 118.0 81.3 4.4 30.0 0.2 95.6
1.049E+04 1.003E+06 6.991E+01 2.293E+03 443 4.418E-04 -4.0 4.6 3.8
-4.3 95.4 T
22 24Apr91 12:12 DUT_#2 F-19 118.0 81.3 4.4 30.0 0.2 88.1
1.138E+04 1.003E+06 6.992E+01 2.363E+03 422 4.209E-04 -3.9 4.9 3.3
-4.3 95.5 T
0 24Apr91 12:03 Center F-19 118.0 93.9 3.8 0.0 0.2 10.0
1.802E+04 1.802E+05 0.000E+00 0.000E+00 0 0.000E+00 -6.7 5.6 3.4
-2.3 94.7 17.6
23 24Apr91 12:12 DUT_#2 F-19 118.0 81.3 4.4 30.0 0.2 70.6
1.669E+04 1.179E+06 8.217E+01 2.445E+03 532 4.513E-04 -6.7 6.0 4.4
-3.6 94.2 T
24 24Apr91 12:14 DUT_#2 F-19 118.0 81.3 4.4 30.0 0.2 61.8
1.623E+04 1.004E+06 6.995E+01 2.515E+03 607 6.049E-04 -6.6 6.3 4.0
-3.7 94.2 T
25 24Apr91 12:15 DUT_#2 F-19 118.0 81.3 4.4 30.0 0.2 57.5
1.747E+04 1.003E+06 6.994E+01 2.585E+03 541 5.391E-04 -6.7 6.9 3.4
-3.7 94.1 T
26 24Apr91 12:17 DUT_#3 F-19 118.0 81.3 4.4 30.0 0.2 59.6
1.682E+04 1.003E+06 6.993E+01 2.293E+03 273 2.721E-04 -7.5 7.1 4.1
-3.8 93.7 T
27 24Apr91 12:18 DUT_#3 F-19 118.0 81.3 4.4 30.0 0.2 58.3
1.721E+04 1.004E+06 6.996E+01 2.363E+03 261 2.600E-04 -7.3 6.8 4.3
-3.8 93.8 T
28 24Apr91 12:19 DUT_#3 F-19 118.0 81.3 4.4 30.0 0.2 55.6
1.806E+04 1.004E+06 6.996E+01 2.433E+03 254 2.530E-04 -7.3 7.4 4.0
-4.1 93.6 T
29 24Apr91 12:20 DUT_#3 F-19 118.0 81.3 4.4 30.0 0.2 59.7
1.681E+04 1.003E+06 6.988E+01 2.503E+03 565 5.635E-04 -7.0 6.6 4.3
-3.9 93.9 T
30 24Apr91 12:22 DUT_#3 F-19 118.0 81.3 4.4 30.0 0.2 62.4
1.607E+04 1.003E+06 6.989E+01 2.573E+03 574 5.724E-04 -7.1 7.7 4.5
-5.0 93.3 T

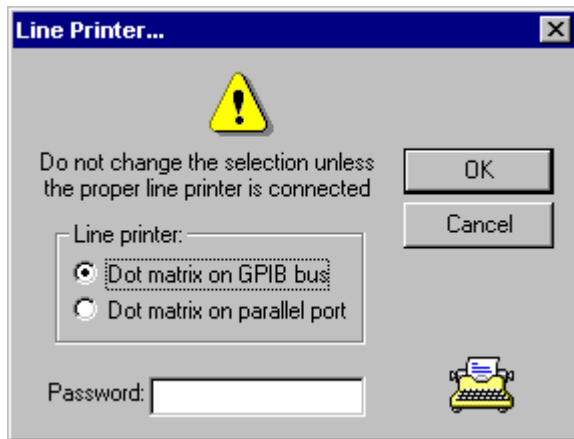
```

Print...



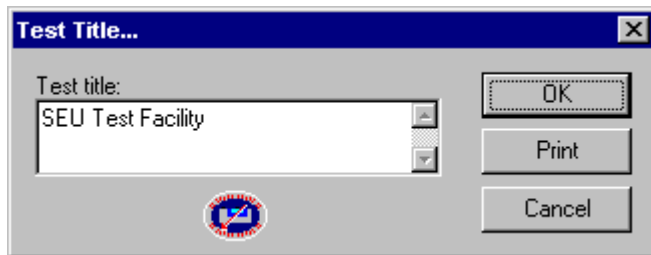
- The Print command allows you to print the selected data file or any portion of it. The file list is filled by files in the ...Data subfolder with the *.dat file filter for data files. The present data file is the default, but you can select a different data file to print from the file list.
- You can either print the entire data file or you can specify the initial and/or the final test run numbers. If you do not specify the initial test run number, the selected data file is printed from the beginning. Similarly, if you do not specify the final run number, the selected data file is printed to the end. If either the initial and/or the final run numbers are specified, only the data records with the test run numbers in between are printed. Note that the final run number does not have to be greater than the initial run number (for example, as a consequence of changing the test run number by the Run_Number command in the middle of your experiment). The SEU Test Facility program simply begins to print when finding the initial test run number and stops when finding the final run number. The data records with both the initial and the final test run numbers are included in the printout.
- Do not use other Windows utilities or programs to print a data file. The print job would be, most likely, directed to the default Windows printer (the laser printer on the parallel port LPT1 normally used to print the on-line plots using the Hard_Copy command and the beam energy spectra using the Measure_Energy_&_LET command). This laser printer supports only the letter paper size 8½x 11 inch, which is insufficient for the length of the data records or lines.

Line Printer...



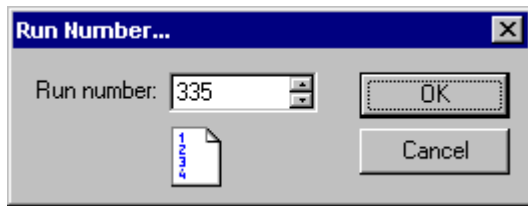
- The Line Printer command allows you to select the line printer (the Hewlett-Packard dot matrix printer on the GPIB bus or the Epson dot matrix printer on the parallel port) to print the data files and the individual data records after every test run. The Hewlett-Packard dot matrix printer is more convenient for inspecting the individual test run data records as they are printed.
- The Hewlett-Packard dot matrix printer on the GPIB bus is always attached to the SEU Test Facility main computer SEUTF1 in target room 4, even when controlling the SEU Test Facility from a remote network computer.
- The Epson dot matrix printer on the parallel port, on the other hand, can be moved around and attached to the parallel port LPT1 of any remote network computer controlling the SEU Test Facility. Since the only available parallel port on the SEU Test Facility main computer SEUTF1 in target room 4 is occupied by the laser printer (the default Windows printer used to print the on-line plots using the Hard_Copy command and the beam energy spectra using the Measure_Energy_&_LET command), the Epson dot matrix printer is normally disconnected. main computer SEUTF1.

Test Title...



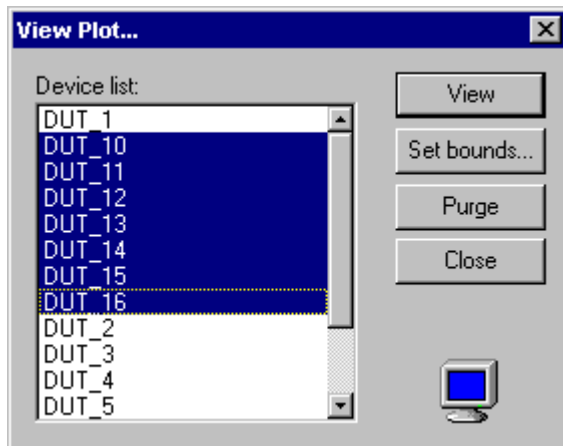
- The Test Title command allows you to change the title of your experiment; the present test title is the default. The effect of this command only esthetical. The test title appears:
 - in the Caption_bar of the SEU Test Facility Main_window,
 - as a header of your data file opened by the Open command (see the sample_data_file),
 - as the title of the on-line plots (see the Hard_Copy command for a sample plot).
- The data file header including the test title, data labels (for example Energy), and units (for example MeV) is automatically printed and inserted at the beginning of every data file. The <Print> button allows you to print and insert another data file header in your data file whenever you wish. This is useful when you want to visually examine the on-line printed copy of a large data file.
- To change the experiment title previously inserted into the data file, use the Edit command and a text editor (i.e., the Windows Notepad or Wordpad, depending on the data file size). Note that the data file change is not reflected in the on-line plots until you replot them with the Search command. By default, the Search command uses the last test title inserted before the last data point collected for a particular device. It also allows you to change the test title for the individual on-line plots before you make a Hard_Copy. However, every time you add a data point to an on-line plot by executing the Test_Run command for the corresponding device, the on-line plot title reverts to the present experiment title.
- Because of the on-line plot layout limitations, the experiment title must be a maximum of 64 characters long.

Run Number...

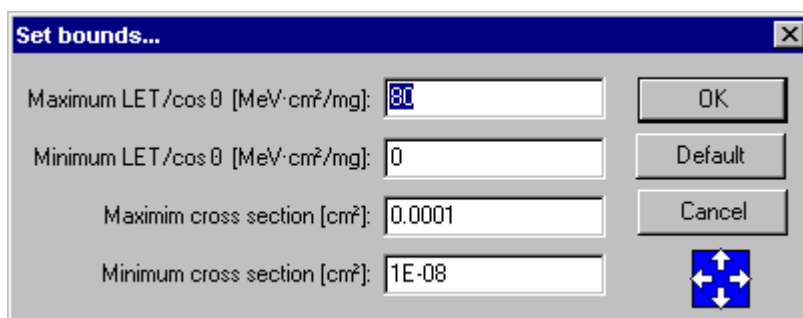


- The Run Number command allows you to change the test run number; the present run number is the default. Since the run number is automatically incremented by one after every Test_Run, you should use this command to set the test run number to one only at the beginning of your experiment. This is also done automatically by the Clear_All command on the Positioning_menu.
- Using the Enter_Upsets command on the Test_Menu, you can enter the number of upsets multiple times (for example, both the upsets and latch-ups, or the upsets for several memory segments) following a single Test_Run. The test run number is incremented only the first time you enter the number of upsets. If you discard the Test_Run without entering the number of upsets at least once, the test run number is not incremented at all.

View Plot...



- Following the Test_Run and after you enter the number of upsets, the SEU Test Facility application automatically displays an on-line plot of the upset cross section vs. effective LET for the device ID that has been irradiated. The View Plot command allows you to inspect the on-line plots for other devices, for which the test run data have been collected earlier. See the Hard_Copy command for a sample on-line plot.
- You can select multiple devices from the list. If you only wish to inspect the on-line plots, the multiple selection does not make much sense, for the plots would just flash on the plot monitor and only the last one would remain on the display. However, the View Plot command also allows you to change the plot bounds for the selected device IDs with the help of the <Set bounds> button or to delete the plots using the <Purge> button. Deleting the on-line plots is recommended when destroying your data files by means of the Destroy as a protection against unauthorized copying of proprietary data. The purged plots can always be replotted using the Search command as long as the data file has not been deleted or destroyed.

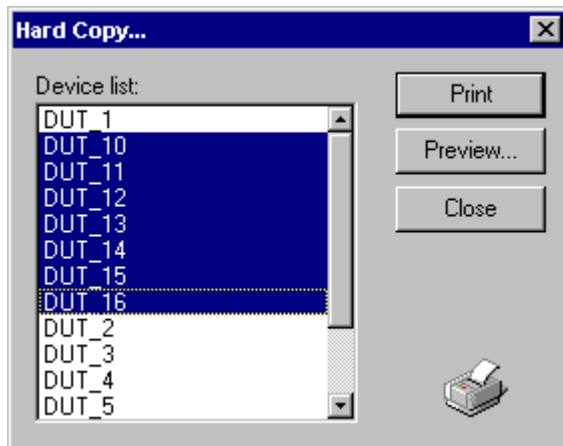


- The scales for both the effective LET and the upset cross section axes can be made either linear or logarithmic with the help of the Plot_Scale command. When the on-line plot for a particular device ID is created (i.e., after collecting the first data point), the effective LET scale extent is greater than or equal to the LET values between 0° and 60° Tilt_Angle (i.e., between the normal LET and its double), and the upset cross section axis extent is greater than or equal to the cross section values between that of the first data point and its double. In addition, if either axis scale is logarithmic, the scale extent is at least one order of magnitude. When a data point is added to the on-line plot for a particular device ID, the plot bounds are automatically expanded in order to make all the collected data points visible. Consequently, plots for similar devices subjected to similar tests do not necessarily have exactly the same plot bounds and, if one or both axes are linear, the lower bound(s) may be greater than zero. With the help of the <Set bounds> button, you can change the plot bounds for individual device IDs or you can make them the same for a group of selected device IDs. The default bounds in the Set Bounds dialog box (minimum and maximum LET, minimum and maximum cross section) are the present plot

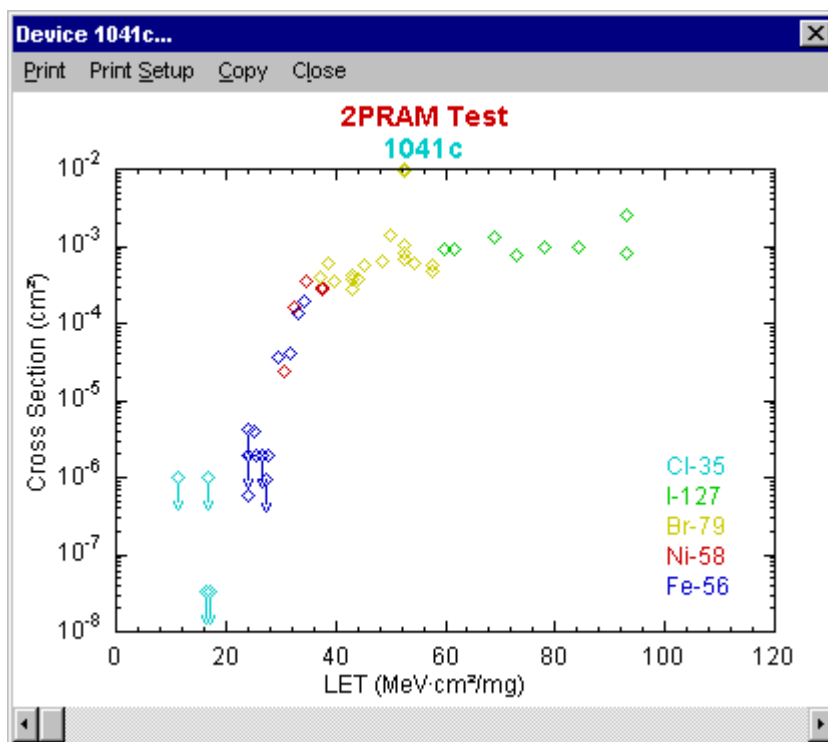
bounds for a single device or the plot bounds defining the union of the plot extents for a group of devices. The <Default> button in the Set Bounds dialog box returns the plot bounds of all selected devices to the minimum plot extent that makes all their data points visible.

- Since the SEU Test Facility application keeps track of the devices for which some data has been collected and/or replotted, the list is usually different from the device IDs on the current board configuration, either because you did not collect any data for some devices, because you used more than one test board configuration, or because of some on-line plots left behind by the previous users.

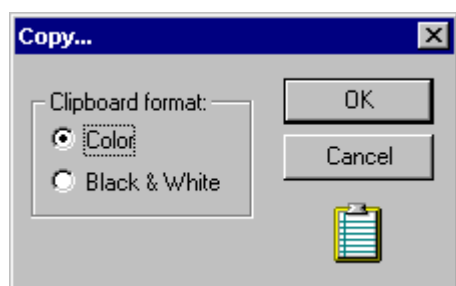
Hard Copy...



- The Hard Copy command presents a list of device IDs for which the on-line plots are available. You can select multiple device IDs from the list and either print them directly on the default printer by pressing the <Print> button or preview them with the <Preview> button. At present, the default printer is a black-and-white laser jet and consequently, the color information is lost on the hard copies.

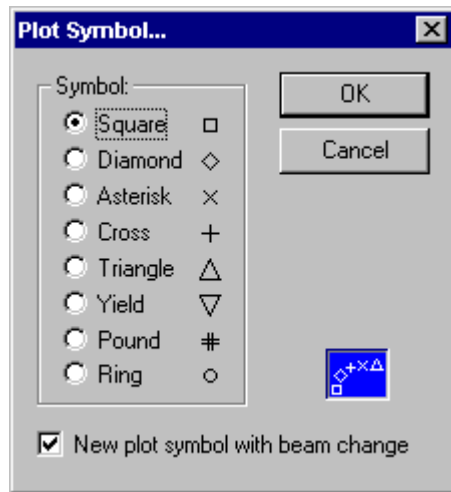


- From the preview window, you can initiate the print job with the <Print> menu command, select a different printer or change other print options such as the number of copies with the <Print Setup> menu command, or copy the currently displayed plot to the clipboard with the <Copy> menu command. From the clipboard, you can paste the plot to other Windows applications recognizing either the bitmap or enhanced metafile clipboard formats (such as the Microsoft Paint, Word, or Excel). When previewing the on-line plots for multiple device IDs, you can step through the plots for the individual device IDs with the help of the horizontal scrollbar or using the <Left>, <Right>, <PgDn>, <PgUp>, <Home>, and <End> direction keys.



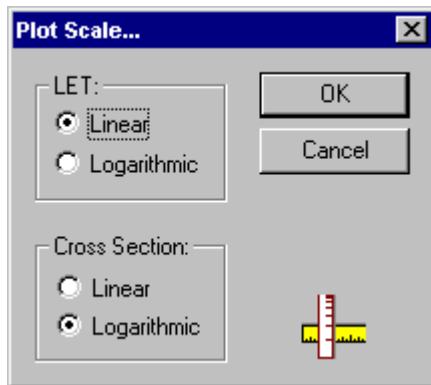
- Before copying the current plot to the clipboard, you can select either color or black & white clipboard bitmap format.

Plot Symbol...



- The Plot Symbol command allows you to select one of the 8 possible plot symbols for the on-line graphics (i.e., square, diamond, triangle, yield, pound, asterisk, cross, and ring); the present plot symbol is the default. Any number of different plot symbols can be present in a single on-line plot.
- The last character of every data record in data files contains the initial of the plot symbol (S, D, T, Y, P, A, C, or R) for the data point (see the sample_data_file). To change the plot symbols for previously collected data points, first use the Edit command on the Data_menu to change the plot symbols for the desired test runs and then replot the data for a selected device(s) using the Search command.
- The SEU Test Facility application cycles through 6 different plot symbol colors (blue, red, yellow, green, cyan, and magenta) with every beam isotope change (but not with the beam energy change). If the plot background is not white but one of these colors, the corresponding plot symbol color is changed to white. However when printing the on-line plots with the help of the Hard_Copy command on a black-and-white printer, the colors are not visible. To alleviate this problem, the SEU Test Facility application can also cycle through the above 8 different plot symbols, depending on the checkmark in the Plot Symbol dialog box.

Plot Scale...



- The Plot Scale Scale command allows you to choose linear or logarithmic scales for the on-line plot axes, i.e. for the effective LET (horizontal axis) and for the upset cross section (vertical axis). The present scales are the defaults. If you change the axis scales, the command auto-scales and replots the data for all devices using the new scales and default bounds. Default plot bounds are the maximum lower limit and the minimum upper limit, rounded down (for the lower bound) and up (for the upper bound) to a full axis step, that result in all data points being visible.
- Linear scale for the effective LET and logarithmic scale for the upset cross section are commonly used. However, Ed Peterson argues that the saturated upset cross section with this choice of the axis scales is an artifact and recommends the opposite choice - logarithmic scale for the effective LET and linear scale for the upset cross section.

Toolbar



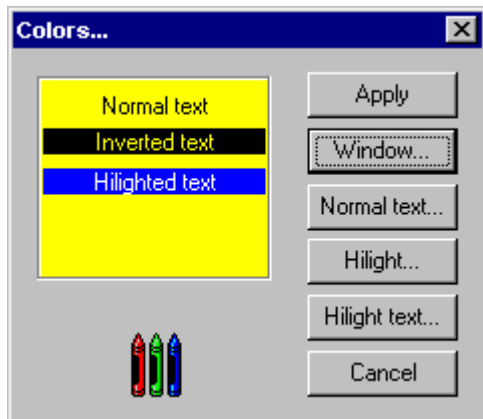
- The Toolbar can float or it can be docked to the top or bottom edges of the Main_window by dragging its unused area with the left mouse button. You can toggle the Toolbar visibility (i.e., show or hide the bar) using the Toolbar command on the Control_Menu .
- The individual Toolbar buttons emulate the corresponding menu commands. The little button images are supposed to be descriptive of the corresponding commands. In addition, each tool button shows the same command prompt in the leftmost pane of the the Status_Bar as the corresponding menu command, when the button is pressed with the left mouse button until it is released or (after a short delay) when the mouse cursor is simply placed directly above the tool button. Placing the mouse cursor above the tool button also causes a small tooltip window with the command name to pop up temporarily next to the button.

Status Bar



- The Status Bar is always located at the bottom edge of the Main_window. You can toggle the Status bar visibility (i.e., show or hide the bar) using the Status Bar command on the Control_Menu .
- The first (leftmost) pane of the Status Bar shows the corresponding command prompt when a menu command is selected (highlighted) until it is executed. The command prompt is also displayed when a tool button on the Toolbar is pressed with the left mouse button until it is released or when the mouse cursor is simply placed directly above the tool button.
- The remaining two panes of the Status Bar show the current system date and time.

Colors...



- The Colors command allows you to choose the background, text, highlight, and highlight text colors of the Main_window . For the background color, the Windows system colors (such as the button face) of the present desktop theme are also available as predefined custom colors. When you change the background color, the complementary highlight color is selected. Similarly, when you change the text color, the complementary highlight text color is selected. You can choose different highlight and/or highlight text colors when you are satisfied with your choice of the background and text colors in the sample window of the Color command dialog box.
- **Caution:** While you can create very pleasant color combinations, you can also create (and this is far easier) outright ugly and/or totally unfit color combinations.

TTL Interrupts...



- The TTL Interrupts command allows you to enable the TTL interrupt control of the Test_Run command on the Test_menu . External, user supplied, TTL signals or pulses can be used to start and/or stop a test run. The TTL Interrupts command also allows you to select the active logic level of these signals (low or high) expected by the SEU Test Facility application; active low is the default. Separate coaxial BNC connectors are provided for the START and STOP signals. Each signal should be at least 15 μ sec long; there is no upper limit on the length of the pulse. The user supplied signals are applied to the inputs of Schmitt trigger circuits with 10 k Ω pull-up resistors with these specifications:
 - Logic high = 2.0 to 5.25 V
 - Logic low = 0.0 to 0.50 V
- The driving output signal must be able to sink at least 1 mA in the logic low state.
- The inputs are level (not edge) sensitive. If an input is armed and the driving signal level becomes active for at least 15 μ sec, it is latched and the test run is either started (for the START signal) or stopped (for the STOP signal).
- The Test_Run command is susceptible to the START and STOP signals only if the corresponding inputs are armed. If you enable the START on external signal, the START input is armed as soon as the SEU Test Facility application becomes idle, i.e., when you close the TTL Interrupts dialog box. It remains armed as long as you do not execute any command using the multiprogrammer (e.i., the Vacuum, Ionization_Gauges, Laser, Light, Center_Scintillator, or All_Devices commands on the Beamline_menu, the Measure_Flux, Measure_Energy_&_LET, or Alpha_Calibration commands on the Dosimetry_menu, and the Test_Run command on the Test_menu). These commands operate assorted beamline devices such as the beam shutters, faraday cups, beamline valves, etc. controlled by the multiprogrammer, and therefore they disarm the the START input. The START input is rearmed as soon as the SEU Test Facility application becomes idle again, i.e., when these commands are completed and you close all dialog boxes (if any). On the other hand, if you enable the STOP on external signal, the STOP input is armed as soon as you start a test run. Since the STOP input is armed only during test runs and since the Test_Run command disarms the START input, it follows that the START and STOP inputs are never both armed at the same time. You are free to enable and operate the START input only, the STOP input only, or both.
- If you are not using short signal pulses (at least 15 μ sec) but signal levels operated, for example, by a switch, you have to remove the START signal sometimes during the test run, certainly before you enter the number of upsets, otherwise another test run would start immediately. Likewise, you have to remove the STOP signal before you start another test run, otherwise the test run would stop immediately.
- **Caution:** You should never enable the START on external signal, select the active high level, and disconnect your tester from the START input, which is now supposed to keep the input low. The SEU Test Facility application will keep trying to start test runs and you will not be able to use the TTL Interrupt

command to change the enable status and/or the active logic level. If that happens, temporarily short the START input to the ground (for example, by connecting a 50 Ω BNC terminator) and then disable the START on external signal and/or select the active low level using the TTL Interrupt command. Alternately, turn off the power for the multiprogrammer, wait for the device timeout message, and press the <Cancel> button.

GPIB Host...

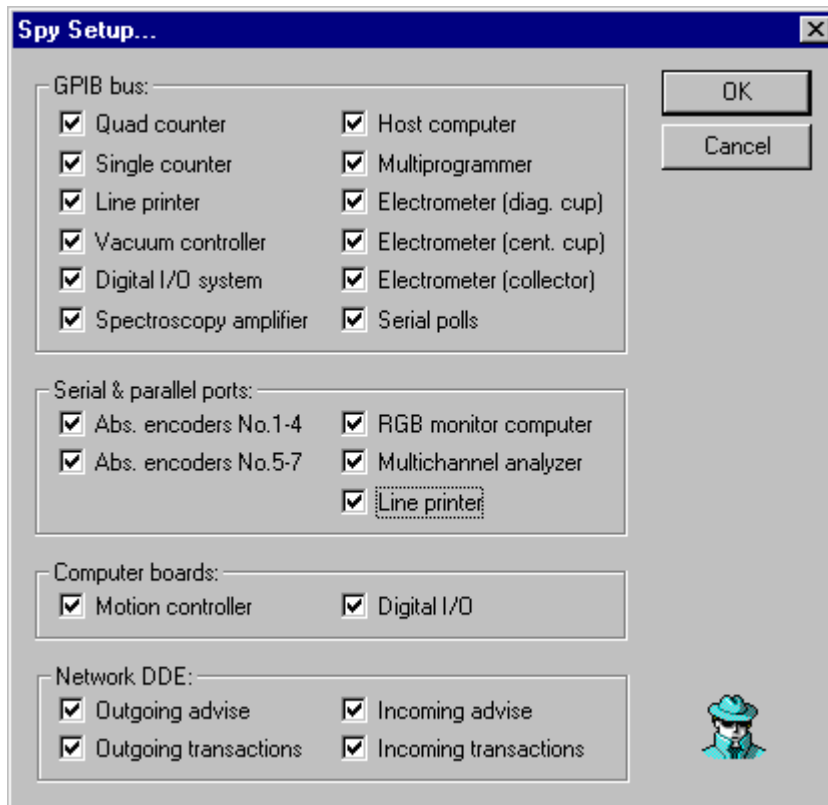


- The GPIB Host command allows you to enable the remote control of the SEU Test Facility application by a host computer equipped with a GPIB interface bus. The host computer should be configured as the system controller. The SEU Test Facility main computer SEUTF1 has a dedicated GPIB interface installed and configured as a non-system controller with the GPIB primary address 20. However, no control passing between the two computers is necessary. The whole SEU Test Facility behaves just like another device on your GPIB bus.
- The GPIB Host command also allows you to specify conditions under which the SEU Test Facility application issues a service request for the host computer. By default, the service request is issued when a test run, flux measurement, or any test board move is completed, and also in case of a command failure. However, it is possible to completely disable the service requests and monitor other bits in the serial poll status byte instead. See the GPIB_control for details.
- The GPIB Host dialog box contains a list of available GPIB commands. Every command must be terminated by a line feed (LF) character (ASCII code hex 0A). A few general commands initiate some action, such as flux measurement or test run. These commands do not require any parameters and do not generate any response except of the service request upon completion or failure. The SET commands set the value(s) of some parameter(s) that may require moving the test board. They require parameters separated from the command string by a colon and from each other by space or punctuation characters (such as comma or semicolon). They do not generate any response apart from the service request upon completion or failure. The SHOW commands report the value(s) of some parameter(s). They do not take any parameters and they never generate any service requests. See the Command_types for a complete GPIB command reference.

Spy...

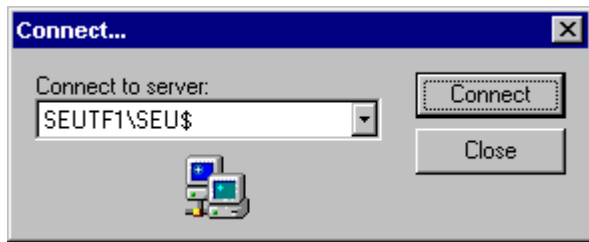
- The Spy is a communication debugging tool. The Spy command opens a spy window where you can watch all commands sent to the selected attached devices and/or installed hardware and all responses received from the devices and hardware. The outgoing data (usually device commands) is displayed in red, while the incoming data (usually device responses) is displayed in blue. The exchanged data is often quite cryptic and meaningful, without further explanation, only to persons familiar with the device manuals such as the SEU Test Facility application developer. Even if you do not understand the meaning of these commands and responses, presence of the exchanged data indicates that the selected attached devices and/or installed hardware are functioning properly.
- Use the Spy_Setup command to select the attached devices and/or installed hardware you want to spy on and then execute a menu command exercising the device. For example, the Measure_Flux on the the Dosimetry_Menu will exercise the multiprogrammer to operate the beam shutters and either the counters or electrometers, depending on the current Dosimetry_Method. Any positioning stage command, such as Go_Home and Joysticks on the Positioning_Menu or the Move_Device, Effective_LET, Tilt_Angle, and the Roll_Angle commands on the Test_Menu will exercise the motion controller, the absolute encoders, etc. The Spy can be set-up and used to check the SEU Test Facility main computer communication with a host computer by users attempting the remote control of the SEU Test Facility application over the GPIB bus (see the GPIB_Host command).
- The current Spy status (hidden or shown) is saved in the application registry key and it is therefore persistent on the program exit and restart. The main purpose of this is the capability to see the initialization commands and responses send to the attached devices and installed hardware at the program startup.

Spy Setup...



- The Spy Setup command allows you to select the attached devices and installed hardware to spy on. The devices and hardware are divided into four basic groups: devices on the GPIB bus, COM devices controlled through the serial (COM) ports, plug-in boards installed in the SEU Test Facility main computer SEUTF1, and the network dynamic data exchange (DDE) protocol used to communicate with the client/server programs running on other computers in the local area network (LAN) (see the Connect, Disconnect, and the Autoconnect commands).
- The host computer in the GPIB device group is of particular interest to the users attempting remote control of the SEU Test Facility application over the GPIB bus (see the GPIB_Host command).
- When spying on the GPIB devices, you can include the serial request polls of all the selected devices.
- The network DDE communication with the clients and/or servers include client transaction such as the request data, poke data, and the execute commands on the server. Only the client transaction involving data transfers are spied on. Other client transaction may include, for example, starting and stopping the server advise loops on a particular data item when the item data has changed. Data advised by the servers (usually very frequently) can be spied on independently of the client transactions (performed occasionally).

Connect...



- The Connect command can be used to connect the SEU Test Facility application (both the server instance running on the SEUTF1 computer in target room 4 and any client instance running on another computer) to their network Dynamic Data Exchange (DDE) server applications, such as the S-100 Canberra multichannel analyzer software running on the MCA1 computer also in target room 4. In addition, the Connect command can be used to connect the client instance of the SEU Test Facility application to the server instance.
- All the necessary network connections are executed automatically. The Connect command can be used to restore the required connections in case of an unexpected crash of any server or client application, because the crashing instance usually fails to disconnect and the other application may not be aware that the connection has been broken.

Disconnect...



- The Disconnect command allows you to inspect all network DDE server and client applications connected to the SEU Test Facility application. Please note that the server instance of the SEU Test Facility application running on the SEUTF1 computer in target room 4 can be connected to several client instances running elsewhere, but each client instance can be connected only to this one server instance.
- The Disconnect command can be also used to disconnect any network DDE server or client application, such as the S-100 Canberra multichannel analyzer software (a server application running on the MCA1 computer in target room 4) or the SEU Test Facility Plotting Service (a client application usually running also on the MCA1 computer but capable of running elsewhere). Disconnecting is useful mainly for testing the network DDE connections or for removing a broken connection to a crashed application that failed to disconnect itself. Please note that all client applications (such as the client instance of the SEU Test Facility application or the SEU Test Facility Plotting Service) are responsible for restoring their connections, usually at the application startup or at about 1 min interval until the connection succeeds if their Autoconnect command is checked. On the other hand, connections to the server applications (such as the S-100 Canberra multichannel analyzer software) are automatically restored on service demand.

Autoconnect

- When running the SEU Test Facility application on the SEU Test Facility main computer SEUTF1 (the server instance) in target room 4, the Autoconnect command is disabled. When running the SEU Test Facility application on another computer (a client instance), the SEU Test Facility specific hardware is not present and the application automatically tries to connect through the Local Area Network (LAN) to the server as it starts.
- If the Autoconnect command is checked and if the client instance of the SEU Test Facility application is not connected to the server instance, for example because the initial connection attempt failed or because the server instance has been disconnected and/or terminated, the client instance of the SEU Test Facility application tries to connect to the server instance every 1 minute until it succeeds. You can also connect manually using the Connect command whether the Autoconnect command is checked or not.

Configuration

- The Configuration command is used to assign unique GPIB addresses to the external devices connected to the GPIB interface bus and unique serial port numbers to the external devices connected to the serial ports. The command is password protected. Any changes in the GPIB address and serial port assignment are to be performed by the Tanden Van de Graaff personal only.

Help Topics...

- The Help Topics command opens the application help finder. You can select a topic in the help finder tree, a help keyword from the alphabetical index, or you can type a keyword and search for it.
- The corresponding accelerator key <F1> actually provides context sensitive help, i.e. help on the menu item, dialog box, or the Main_window control directly beneath the mouse cursor.

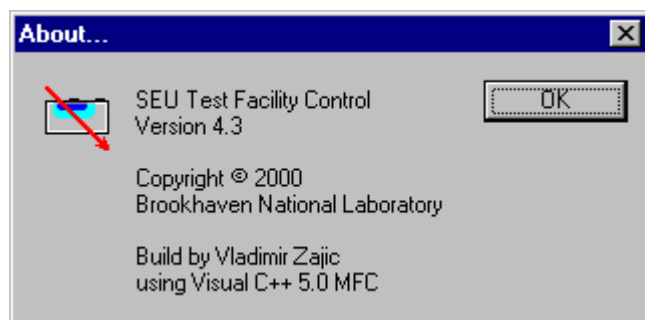
Context Help

- The Context Help command and the corresponding accelerator key <Shift+F1> put the SEU Test Facility program into a special help mode, indicated by changing the mouse cursor from a simple arrow into the arrow overlaid with a question mark. Selecting a menu command in the help mode does not execute that command, but opens the corresponding help page. You can also mouse-click and receive help on the individual Main_window active controls and areas.
- Clicking the left mouse button or pressing the <Enter> key not only opens the corresponding help page, it also returns the application to the normal mode.
- The help mode is not available when a dialog box is open.

How to Use Help...

- The How to Use Help... command displays general directions on how to use the Windows help engine.

About...



- The About... command shows the application icon, application name, version number, copyright notice, name of the author, and the software development tool.

GPIB control

- The SEU Test Facility application can be controlled from a host computer over the GPIB interface bus. The primary address of the SEU Test Facility main computer SEUTF1 is 20 (a customary choice for a non-system controller) and the host computer should be configured as the system controller. No control passing between the two computers is necessary. Simply connect the GPIB interface of the host computer to the unused GPIB interface of the SEU Test Facility main computer SEUTF1. The entire SEU Test Facility will behave just like another device on your GPIB bus.
- There is no difference between the remote and local states of the SEU Test Facility application. GPIB commands such as REMOTE, LOCAL, or LOCAL LOCKOUT (or their equivalents for your GPIB driver) have no effect. Although it would be possible, for example, to disable all menus in the local lockout state, it does not appear to have any purpose. On the contrary, it might create problems for users who do not realize that their GPIB driver puts all devices (including the SEU Test Facility application) in the local lockout state by default.
- All commands sent over the GPIB interface bus must be terminated by the line feed (LF) character (ASCII code hex 0A). The SEU Test Facility application could be easily reconfigured to expect a different terminating character, such as carriage return (CR) character (ASCII code hex 0D). The terminating character is added automatically in Rocky Mountain (HP) BASIC, but not every GPIB driver does that (most drivers do not, including the popular National Instruments GPIB driver). If your GPIB driver does not automatically add the terminating character, you have to add it explicitly at the end of every command. The command string must be separated from the operands (if any) by a colon (ASCII code hex 3A). If a command requires more than one operand, they must be separated from each other by space, comma, or semicolon (ASCII hex 20, 2C, or 3B). In fact, any non-alphanumeric character other than null, plus, minus, period, colon, underscore (ASCII codes hex 00, 2B, 2D, 2E, 3A, and 5F), and the above terminating characters is acceptable. The response (if any) is terminated by CR and LF. The SEU Test Facility application also sets the end-of-identify (EOI) line with the last byte sent.
- The serial poll provides basic information about the status of the SEU Test Facility application. Individual bits of the serial poll status byte are set by the following conditions:
 - hex 01 CMD unrecognized command received
 - hex 02 DATA data available
 - hex 04 STOP interruptible command in progress
 - hex 08 DONE command completed
 - hex 10 BUSY SEUTF application busy
 - hex 20 TIMO device timeout detected
 - hex 40 SRQ service request issued
 - hex 80 ERR command failed
- Commands that open a Progress_box also set the BUSY bit (hex 10) in the serial poll status byte. Interruptible commands are commands that open a Progress_box with the <Stop> button. When an interruptible command is in progress, the STOP bit (hex 04) in the serial poll status byte is also set (in addition to the BUSY bit). Under this condition, the SEU Test Facility application is able to execute only the KILL command and the SHOW_commands. All other General and all SET_commands are received and recognized, but ignored without causing an error. See Command_types for an explanation of the three different command types.
- Every command (except the SHOW_commands) can generate a service request and set the SRQ bit (hex 40) in the serial poll status byte when completed. Most of the time you can disable or ignore these service requests. Some commands, such as test board moving, flux measurement, or a single test run take considerable time to complete. The service request then provides a convenient way to monitor the command in progress, either by serial polling or via interrupt on service request. Just remember that before attempting to monitor a command in progress by serial polling for service request, you have

to clear all pending service requests by serial polling until the service request bit (hex 40) in the serial poll byte returns zero. The SEU Test Facility application can issue service requests, at your discretion, on:

- test run done
- flux measurement done
- test board move completed
- any command done
- command failure

or any combination thereof. By default, service requests on the test run done, flux measurement done, test board move completed, and a command failure are enabled. The commands generating the service requests upon completion are FLUX, TEST, SET_DEVICE_NO, SET_EFFECTIVE_LET, SET_TILT_ANGLE, and SET_ROLL_ANGLE (or their menu command equivalents Measure_Flux, Test_Run, Effective_LET, Tile_Angle, and Roll_Angle). Except for the above five menu commands, other menu commands (including the test board move commands without any GPIB host equivalents such as Find_Home, Find_Limits, and Go_Home on the Positioning_menu or Verify on the Board_menu) generate service requests only if service requests on all commands are enabled.

- Alternately, you can monitor a command in progress by serial polling and inspecting the DONE and ERR bits in the serial poll status byte. Every command selected from the Menu_Bar or received over the GPIB bus (except the SHOW_commands) sets the serial poll status byte to zero. All commands (again, except the SHOW_commands) set the DONE bit (hex 08) in the serial poll status byte when successfully completed, or the ERR bit (hex 80) if they fail. Service requests are generated (and the SRQ bit set) only if the service requests on command done and/or command failure are enabled and they are cleared by the first serial polling. On the other hand, the DONE and ERR bits are set independently of the service requests and you can read them as many times as you wish. When monitoring the DONE and ERR bits, there is no need to clear all pending service requests. In fact, the service requests can be completely disabled if you decide to use the serial polling rather than an interrupt on service request.
- The SHOW_commands set the DATA bit (hex 02) in the serial poll status byte, indicating that a response is available. The DATA bit is cleared when you actually read the response or when you ignore it and send another GPIB host command. However, the SHOW_commands do not set the DONE bit (hex 08) in the serial poll byte when completed and they never generate any service requests. This arrangement allows you to monitor the values of selected test parameters while an interruptible command is in progress. For example, you may read the fluence accumulated so far during a test run.
- Caution: Keep the service requests on any command done disabled if possible. If you send two GPIB commands in a quick sequence, if they happen to be a SET_command followed by an interruptible command, if you ignore the service request from the first one (the SET command), then clear all pending service requests, and wait for a service request from the second one (the interruptible command), the SEU Test Facility application may receive the second command before the first command is completed. The next service request, issued while you are already waiting for the second command to complete, may actually originate from the first command. Therefore if you enable the service requests on any command and if you use the above command sequence, do not ignore any service requests.
- When a command cannot proceed for one reason or another, it can generate a service request and set the SRQ and ERR bits (hex 40 and 80) in the serial poll status byte. The service request is generated and the SRQ bit set only if the service request on command error is enabled, but the ERR bit is always set. The SEU Test Facility application displays an error message box and the host computer can then obtain information about what caused the error by examining the serial poll status byte and check for the CMD (hex 01) or TIMO (hex 20) bits. You can also obtain the error message with the help of the SHOW_ERROR_MESSAGE command. To recover from the error, read the error message and press one of the available buttons to cancel the command or proceed in spite of the error. The error recovery

cannot be performed by the host computer over the GPIB bus, but manually from the SEU Test application user interface.

- If the SEU Test Facility application cannot communicate with one of its own devices (connected on a separate GPIB interface bus or to the serial ports), it sets the TIMO bit (hex 20) in the serial poll status byte (in addition to the SRQ and ERR bits) and displays a device timeout message box. To recover from this error, check the unresponsive device and then use the <Retry> or <Cancel> button in the device timeout message box. The <Exit> provides an emergency program exit in case the device does not respond to repeated communication attempts (even after recycling the power) and causes another device timeout when the communication attempt is canceled.
- An unrecognized or misspelled command sets the CMD bit (hex 01) in the serial poll status byte (in addition to the SRQ and ERR bits).

Command types

- All supported GPIB host commands can be divided into three groups:
 - General commands
 - SET commands
 - SHOW commands
- The general commands perform some action, such as flux measurement or test run, which does not require any operands. The only possible response is a service request (if enabled).
- The SET commands set the value(s) of some parameter(s) supplied as one or more operands. Setting the parameter value(s) may require moving of the test board. The parameter(s) must be separated from the command string by a colon and from each other by spaces or punctuation characters (such as comma or semicolon). The only possible response is a service request (if enabled).
- The SHOW commands report the value(s) of some parameter(s), which are sent back to the host computer as a string of ASCII characters. The SHOW commands do not require any parameters and they never generate any service requests. This arrangement makes it possible for the GPIB host to monitor the progress of an interruptible command such as the test board moving, flux measurement, or the test run.
- An interruptible command (a GPIB host command or its menu command equivalent) is a command that opens a Progress_box with the <Stop> button, such as test board moving, flux measurement, test run, energy spectrum acquisition, data file printing, etc. These commands can be stopped by the KILL command send over the GPIB bus. When an interruptible command is in progress, all General_commands and all SET_commands are ignored (except for the KILL command). This arrangement prevents changing various SEU Test Facility application parameters when the application is busy. Not only might such changes confuse the program, they would also result in an invalid data.
- You can use the command string in its full form, just the minimum command string listed with each command (according to the minimum uniqueness), or anything in between. In other words, you do not have to complete the command tokens (separated by underscore characters) beyond the minimum and you can omit trailing command tokens completely if they do not show up at least partially in the minimum command string. For example, command strings SHOW_ACCUMULATED_FLUENCE, SHOW_ACC_FLUE, and SH_AC are equivalent, while SHOW_ACU_FLUENCE is misspelled and not recognized.

Serial polling example

- This programming example shows the use of serial polling in HP Basic. Please note that on HP computers, the primary (system controller) GPIB interface has always number 7 and this number precedes the primary GPIB address of the SEU Test Facility application (20).

```

10:      ASSIGN @Seutf TO 720
.
.
.
100:      ! Measure and read the beam flux:
110:      OUTPUT @Seutf;"FLUX"
120:      GOSUB Wait_loop
130:      IF NOT Error THEN
140:          OUTPUT @Seutf;"SHOW_NORM_FLUX"
150:          ENTER @Seutf;Flux
160:      END IF
.
.
.
200:      ! Set the desired fluence:
210:      OUTPUT @Seutf;"SET_FLUENCE:";1E+06
.
.
.
300:      ! Set the tilt angle to 30 degrees and read effective LET:
310:      OUTPUT @Seutf;"SET_TILT_ANGLE:";30
320:      GOSUB Wait_loop
330:      IF NOT Error THEN
340:          OUTPUT @Seutf;"SHOW_EFF_LET"
350:          ENTER @Seutf;Eff_let
360:      END IF
.
.
.
400:      ! Make a single test run and enter the number of upsets:
410:      OUTPUT @Seutf;"TEST"
420:      GOSUB Wait_loop
430:      IF NOT Error THEN
440:          OUTPUT @Seutf;"SET_UPSETS:";Upsets
450:      END IF
.
.
.
500:      ASSIGN @Seutf TO *
510:      STOP
.
.
.
2000:     Wait_loop: ! Wait for command done or error:
2010:     Done=0
2020:     Error=0
2030:     REPEAT
2040:         A=SPOLL(@Seutf)
2050:         IF BINAND(A,8) THEN Done=1
2060:         IF BINAND(A,128) THEN Error=1
2070:     UNTIL Done OR Error
2080:     IF Error THEN
2090:         GOSUB Show_error_message
2100:     END IF

```

```
2110:    RETURN
      .
      .
      .
2500:    Show_error_message: ! Displays error message:
2510:    OUTPUT @Seutf;"SHOW_ERROR_MESSAGE"
2520:    ENTER @Seutf;Lines
2530:    FOR I=1 TO Lines
2540:        ENTER @Seutf;A$
2550:        PRINT A$
2560:    NEXT I
2570:    RETURN
      .
      .
      .
3000:    END
```

Interrupt on SRQ example

- This programming example shows the use of interrupt on service request (SRQ) in HP Basic. Please note that on HP computers, the primary (system controller) GPIB interface has always number 7 and this number precedes the primary GPIB address of the SEU Test Facility application (20).

```

10:      ! Set interrupt on SRQ:
20:      ON INTR 7 GOSUB Handle_srq
30:      ENABLE INTR 7,2
40:      ASSIGN @Seutf TO 720
.
.
.
100:     ! Measure and read the beam flux:
110:     OUTPUT @Seutf;"FLUX"
120:     GOSUB Wait_loop
130:     IF NOT Error THEN
140:         OUTPUT @Seutf;"SHOW_NORM_FLUX"
150:         ENTER @Seutf;Flux
160:     END IF
.
.
.
200:     ! Set the desired fluence:
210:     OUTPUT @Seutf;"SET_FLUENCE:";1E+06
.
.
.
300:     ! Set the tilt angle to 30 degrees and read effective LET:
310:     OUTPUT @Seutf;"SET_TILT_ANGLE:";30
320:     GOSUB Wait_loop
330:     IF NOT Error THEN
340:         OUTPUT @Seutf;"SHOW_EFF_LET"
350:         ENTER @Seutf;Eff_let
360:     END IF
.
.
.
400:     ! Make a single test run and enter the number of upsets:
410:     OUTPUT @Seutf;"TEST"
420:     GOSUB Wait_loop
430:     IF NOT Error THEN
440:         OUTPUT @Seutf;"SET_UPSETS:";Upsets
450:     END IF
.
.
.
500:     ASSIGN @Seutf TO *
510:     OFF INTR 7
520:     STOP
.
.
.
1000:    Handle_srq: ! Handle service request:
1010:    A=SPOLL(@Seutf)
1020:    IF BINAND(A,64) THEN
1030:        IF BINAND(A,8) THEN Done=1
1040:        IF BINAND(A,128) THEN Error=1
1050:    END IF
1060:    ENABLE INTR 7, 2
1070:    RETURN

```



```
.
.
.
2000:   Wait_loop: ! Wait for a service request:
2010:   Done=0
2020:   Error=0
2030:   REPEAT
2040:   UNTIL Done OR Error
2050:   IF Error THEN
2060:       GOSUB Show_error_message
2060:   END IF
2070:   RETURN
.
.
.
2500:   Show_error_message: ! Displays error message:
2510:   OUTPUT @Seutf;"SHOW_ERROR_MESSAGE"
2520:   ENTER @Seutf;Lines
2530:   FOR I=1 TO Lines
2540:       ENTER @Seutf;A$
2550:       PRINT A$
2560:   NEXT I
2570:   RETURN
.
.
.
3000:   END
```

General commands

- The general commands perform some action, such as flux measurement or test run, which does not require any operands. The only possible response is a service request (if enabled by the GPIB_Host command on the Control_menu). The general commands always set the DONE bit (hex 08) in the serial poll status byte when completed and the ERR bit (hex 80) if they fail.

Full command	Minimum
POWER	P
LASER	LA
LIGHT	LI
CENTER	C
FLUX	F
TEST	T
KILL	K

SET commands

- The SET commands set the value(s) of some parameter(s) supplied as one or more operands. Setting the parameter value(s) may require moving of the test board. The parameter(s) must be separated from the command string by a colon (ASCII code hex 39) and from each other by spaces (ASCII code hex 20) or punctuation characters such as comma (ASCII code hex 2B) or semicolon (ASCII code hex 3A). The only response is a service request (if enabled by the GPIB_Host command on the Control_menu). The SET commands always set the DONE bit (hex 08) in the serial poll status byte when completed and the ERR bit (hex 80) if they fail.

Full command	Minimum	Parameter(s)
SET_POWER:	SE_PO:	int
SET_BOARD_FILE:	SE_B:	string
SET_LASER:	SE_LA:	int
SET_LIGHT:	SE_LI:	int
SET_CENTER:	SE_C:	int
SET_WARNING_LEVELS:	SE_W:	int, float, float, float, float
SET_UPSETS:	SE_U:	long int
SET_DEVICE_NO:	SE_DE:	int
SET_FLUENCE:	SE_F:	scient
SET_RUN_TIME:	SE_RU_T:	int
SET_ION_ENERGY:	SE_I:	string, float [, int]
SET_EFFECTIVE_LET:	SE_E:	float
SET_TILT_ANGLE:	SE_T:	float
SET_ROLL_ANGLE:	SE_RO:	float
SET_DATA_FILE:	SE_DA:	string
SET_HEADER:	SE_H:	string
SET_RUN_NUMBER:	SE_RU_N:	int
SET_PLOT_SYMBOL:	SE_PL:	char
SET_SERVICE_REQUEST:	SE_S:	hex int

SHOW commands

- The SHOW commands report the value(s) of some parameter(s), which are sent back to the host computer as a string of ASCII characters. They do not require any parameters. The SHOW commands set the DATA bit (hex 02) in the serial poll status byte, indicating that a response is available. The DATA bit is cleared when you actually read the response or when you ignore it and send another GPIB host command. However, the SHOW commands do not set the DONE bit (hex 08) when completed and they never generate any service requests. This arrangement makes it possible for the GPIB host to monitor the values of selected test parameters while interruptible commands such as the test board move, flux measurement, or the test run are in progress.
- Certain SHOW commands (such as SHOW_BOARD_DIRECTORY, SHOW_DEVICE_LIST, SHOW_DATA_DIRECTORY, and SHOW_ERROR_MESSAGE) generate multiple responses. The first response of these SHOW commands is always the number of additional responses to follow. If you read the first response, you must proceed to read exactly the number of additional responses indicated by the first one, otherwise the SEU Test application or the host computer will experience a device timeout (depending on whether you try to read less or more responses, respectively). The DATA bit in the serial poll status byte is not cleared until you read the last response.

Full command	Minimum	Response(s)
SHOW_POWER	SH_PO	int
SHOW_BOARD_FILE	SH_BO_F	string
SHOW_BOARD_DIRECTORY	SH_BO_D	int, string, string, ..., string
SHOW_MEDIUM	SH_M	string
SHOW_DEAD_LAYER	SH_DEA	float
SHOW_PRESSURE	SH_PR	float;float
SHOW_BEAMLINE_STATUS	SH_BE	int; int; ...; int (13 ints)
SHOW_NORMAL_FLUX	SH_N	scient
SHOW_EFFECTIVE_FLUX	SH_EF_F	scient
SHOW_ALIGNMENT	SH_AL	float
SHOW_WARNING_LEVELS	SH_W	int; float; float; float; float
SHOW_CROSS_SECTION	SH_CR	scient
SHOW_DEVICE_ID	SH_DEV_I	string
SHOW_DEVICE_LIST	SH_DEV_L	int, string, string, ..., string
SHOW_DEVICE_POSITIONS	SH_DEV_P	float; float; float; float
SHOW_FLUENCE	SH_F	scient
SHOW_ACCUMULATED_FLUENCE	SH_AC	scient
SHOW_ESTIMATED_TIME	SH_ES	int
SHOW_ELAPSED_TIME	SH_EL	float
SHOW_ION_ENERGY	SH_I	string; float
SHOW_CHARGE_STATE	SH_CH	int
SHOW_EFFECTIVE_ENERGY	SH_EF_E	float
SHOW_LET	SH_L	float
SHOW_EFFECTIVE_LET	SH_EF_L	float
SHOW_RANGE	SH_RA	float
SHOW_PENETRATION_DEPTH	SH_PE	float
SHOW_TILT_ANGLE	SH_T	float
SHOW_ROLL_ANGLE	SH_RO	float

SHOW_DATA_FILE	SH_DA_F	string
SHOW_DATA_DIRECTORY	SH_DA_D	int, string, string, ..., string
SHOW_HEADER	SH_H	string
SHOW_RUN_NUMBER	SH_RU	int
SHOW_PLOT_SYMBOL	SH_PL	char
SHOW_SERVICE_REQUEST	SH_S	hex int
SHOW_ERROR_MESSAGE	SH_ER	int, string, string, ..., string

POWER

- Minimum command string: **P**
- The POWER command toggles ON/OFF the stepper motor power. This command is supported for compatibility with earlier versions of the SEU Test Facility application. The SET_POWER command is preferred, because it turns the stepper motor power into a definite state.

LASER

- Minimum command string: **LA**
- The LASER command toggles ON/OFF the laser beam. This command is supported for compatibility with earlier versions of the SEU Test Facility application. The SET_LASER command is preferred, because it turns the laser beam into a definite state.

LIGHT

- Minimum command string: LI
- The LIGHT command toggles ON/OFF the internal chamber light. This command is supported for compatibility with earlier versions of the SEU Test Facility application. The SET_LIGHT command is preferred, because it turns the internal chamber light into a definite state.

CENTER

- Minimum command string: **C**
- The CENTER command toggles IN/OUT the center scintillation detector. This command is supported for compatibility with earlier versions of the SEU Test Facility application. The SET_CENTER command is preferred, because it rotates the center scintillation detector into a definite state.

FLUX

- Minimum command string: **F**
- The FLUX command measures the normal flux and the beam alignment. Takes 5 sec to complete (10 sec if the center scintillation detector is in the beam).

TEST

- Minimum command string: T
- The TEST command starts a single test run.

KILL

- Minimum command string: **K**
- The KILL command terminates an interruptible command in progress, such as test board moving, flux measurement, test run, energy spectrum acquisition, data file printing, etc. Interruptible commands are commands that open a Progress_box with the <Stop> button. The KILL command is an equivalent of the <Stop> button. Please note that the service request (if enabled) originates from the terminated command, not from the KILL command itself
- In a quiescent state (i.e., if no interruptible command is in progress), the KILL command is ignored.

SET_POWER:

- Minimum command string: SE_PO
- Parameter: int (d)
- The SET_POWER command turns ON/OFF the stepper motor power. The integer parameter should be 0 (OFF) or 1 (ON).

SET_BOARD_FILE:

- Minimum command string: **SE_B**
- Parameter: string (128a max)
- The SET_BOARD_FILE command opens an existing board file. The string parameter should be a valid long file name. If no extension (and no period) are specified in the string parameter, the extension ".brd" for board files is appended. No wild card characters (* and/or ?) are allowed.

SET_LASER:

- Minimum command string: SE_LA
- Parameter: int (d)
- The SET_LASER command turns ON/OFF the laser beam. The integer parameter should be 0 (OFF) or 1 (ON).

SET_LIGHT:

- Minimum command string: SE_LI
- Parameter: int (d)
- The SET_LIGHT command turns ON/OFF the internal chamber light. The integer parameter should be 0 (OFF) or 1 (ON).

SET_CENTER:

- Minimum command string: **SE_C**
- Parameter: int (d)
- The SET_CENTER command rotates IN/OUT the center scintillation detector. The integer parameter should be 0 (OUT) or 1 (IN).

SET_WARNING_LEVELS:

- Minimum command string: **SE_W**
- Parameters: int (d), float (dd.d), float(dd.d), float(dd.d), float (dd.d)
- The SET_WARNING_LEVELS command enables/disables the automatic check of the beam center and selects how often (following the test runs) is this check performed (never, automatic, or always). The command also sets the desired warning levels for the minimum acceptable beam alignment, minimum and maximum acceptable center deviations, and the maximum acceptable flux drift. The integer parameter for the beam center check is 0 (never), 1 (automatic), or 2 (always). The next four floating point parameters are the minimum beam alignment in %, minimum and maximum center deviations in %, and the maximum flux drift. All the parameters must be supplied even if only one is being changed. Use the SHOW_WARNING_LEVELS command to get the current values of the above parameters.

SET_UPSETS:

- Minimum command string: **SE_U**
- Parameter: long int (9d max)
- The SET_UPSETS command enters the number of upsets. It calculates the upset cross section using the accumulated effective in the last test run and the number of bits of the present device (1 by default), and then it saves and prints the last test run data record. The SET_UPSETS command should be used immediately after a single test run even if no upsets were detected, certainly before any system settings are changed or another test run performed, otherwise the test run results are invalid. The long integer parameter is the number of upsets detected by your tester.

SET_DEVICE_NO:

- Minimum command string: SE_DE
- Parameter: int (ddd)
- The SET_DEVICE_NO command moves a device into the beam. The integer parameter is the device number (1 to the number of devices in the present board configuration).

SET_FLUENCE:

- Minimum command string: **SE_F**
- Parameter: scient (d.dde+dd) or float
- The SET_FLUENCE command sets the desired effective fluence. A single test run terminates upon reaching this fluence if not aborted earlier by the <Stop> button, <Esc> key, or by the KILL command. The scientific format parameter is the desired effective fluence in ions/cm². The SET_FLUENCE command cancels any previous executed SET_RUN_TIME command (or its menu command equivalent Run_Time).

SET_RUN_TIME:

- Minimum command string: SE_RU_T
- Parameter: int (dddd)
- The SET_RUN_TIME command Sets the desired test run time. A single test run terminates upon reaching this run time if not aborted earlier by the <Stop> button, <Esc> key, or by the KILL command. The integer parameter is the desired run time in seconds. The SET_RUN_TIME command cancels any previously executed SET_FLUENCE command (or its menu command equivalent Fluence).

SET_ION_ENERGY:

- Minimum command string: **SE_I**
- Parameters: string (16a max), float (ddd.ddd) or scient [, int (dd)]
- The SET_ION_ENERGY command sets the beam ion, energy, and (optionally) charge state. It calculates the LET and range in the present Target_Material (Si, GaAs, etc. ...). The first two alphabetical characters of the string parameter represent the ion symbol. Numerical characters (plus the decimal point, if any) of the string parameter represent the mass number. The most abundant mass number of the specified ion is adopted if the string parameter does not contains any numerical characters or if the decoded mass number is invalid. The floating point parameter is the beam energy in MeV. The integer parameter is the charge state. If no charge is specified, it defaults to the value of atomic number Z. Please note that the charge state is required only if the faraday cups and electrometers are used for the beam dosimetry (but not if the scintillation detectors and counters are used).

SET_EFFECTIVE_LET

- Minimum command string: **SE_E**
- Parameter: float (ddd.dd) or scient, int (d)
- The SET_EFFECTIVE_LET command sets the effective LET within the limits of normal LET and LET divided by the cosine of the maximum tilt angle (about 75°). The floating point parameter is the desired effective LET in MeV·cm²/mg. The SEU Test Facility application calculates the required tilt angle taking into account an energy loss in the Dead_Layer (if any) and then rotates the test board to either the positive (CW) or negative (CCW) tilt angles, depending on the value of the integer parameter. The integer parameter is 0 for positive (CW) or 1 negative (CCW) tilt angles, respectively.

SET_TILT_ANGLE

- Minimum command string: **SE_T**
- Parameter: float (dd.dd) or scient
- The SET_TILT_ANGLE command rotates the test board to the desired tilt angle (around the vertical axis) and updates the effective LET taking into account an energy loss in the Dead_Layer (if any). The floating point parameter is the desired tilt angle in degrees.

SET_ROLL_ANGLE

- Minimum command string: **SE_RO**
- Parameter: float (dd.dd) or scient
- The SET_ROLL_ANGLE command rotates the test board to the desired roll angle (around the horizontal axis perpendicular to the test board). The floating point parameter is the desired roll angle in degrees.

SET_DATA_FILE

- Minimum command string: **SE_DA**
- Parameter: string (128a max)
- The SET_DATA_FILE command creates a new data file or opens an existing one for appending. The string parameter should be a valid long file name. If no extension (and no period) is specified in the string parameter, the extension ".dat" for data files is appended . No wild card characters (* and/or ?) are allowed.

SET_HEADER

- Minimum command string: SE_H
- Parameter: string (64a max)
- The SET_HEADER command sets the test title. The string parameter is the new test title.

SET_RUN_NUMBER

- Minimum command string: SE_RU_N
- Parameter: int (dddd)
- The SET_RUN_NUMBER command sets the next test run number. The integer parameter is the next test run number. Please note that the run number is also automatically incremented upon entering the number of upsets either from the keyboard in the Enter_Upsets dialog box or with the help of the SET_UPSETS command.

SET_PLOT_SYMBOL

- Minimum command string: **SE_PL**
- Parameter: char (a)
- The SET_PLOT_SYMBOL command sets the plot symbol to square, diamond, triangle, yield, pound, asterisk, cross, or ring. The character parameter is the initial of the desired plot symbol (S, D, T, Y, P, A, C, or R).

SET_SERVICE_REQUEST

- Minimum command string: **SE_S**
- Parameter: hex int (hh)
- The SET_SERVICE_REQUEST command enables/disables service requests on certain conditions. The five least significant bits of the integer parameter correspond to different conditions:
 - hex 01 test run done
 - hex 02 flux measurement done
 - hex 04 test board move completed
 - hex 08 any command done
 - hex 10 command failure

If any of the five least significant bits is set, the the service request on the corresponding condition is enabled.

SHOW_POWER

- Minimum command string: **SH_PO**
- Response: int (d)
- The SHOW_POWER command reports the present status of the stepper motor power (0=OFF, 1=ON, 2=unknown). The response format is an integer. Please note that the stepper motor power is unknown if some stepper motors are on and some off.

SHOW_BOARD_FILE

- Minimum command string: SH_BO_F
- Response: string (128a max)
- The SHOW_BOARD_FILE command reports the present board file name. The response format is a string.

SHOW_BOARD_DIRECTORY

- Minimum command string: **SH_BO_D**
- Responses: int (ddd), string (128a max), string, (128a max),, string (128a max)
- The SHOW_BOARD_DIRECTORY command reports the number of files and a list of files names in the board subdirectory. The number of files is reported first, in an integer format, followed by the file names, in a string format. The file names are separated from the number of files and from each other by carriage return (CR, ASCII code hex 0D) and line feed (LF, ASCII code hex 0A). Since LF is the terminating character, you have to read the number of files and each file name separately. If you read the number of files, you must proceed reading exactly that many file names, otherwise the SEU Test Facility application or the host computer will experience a device timeout (depending on whether you try to read less or more file names, respectively).

SHOW_MEDIUM

- Minimum command string: SH_M
- Response: string (32a max)
- The SHOW_MEDIUM command reports the present target material. The response format is a string.

SHOW_DEAD_LAYER

- Minimum command string: **SH_DEA**
- Response: float (dd.ddd)
- The SHOW_DEAD_LAYER command reports the total thickness of the present dead layer in mg/cm². The response format is a floating point number.

SHOW_PRESSURE

- Minimum command string: **SH_PR**
- Response: scient (d.dde+dd); scient (d.dde+dd)
- The SHOW_PRESSURE command reports the present pressure in both the diagnostic box and the test chamber in torrs. The response format is two scientific format numbers separated by a semicolon. Please note that the pressure is updated approximately every half a second.

SHOW_BEAMLINE_STATUS

- Minimum command string: **SH_BE**
- Response: int (d); int(d); ... ; int (d)
- The SHOW_BEAMLINE_STATUS command reports the present status of some beamline devices (0=OFF, OUT, or open, 1=ON, IN, or closed, 2=moving or unknown). The response format is 13 integers separated by semicolons. The 13 beamline devices are:
 - 1 - wall beamline valve
 - 2 - wall faraday cup
 - 3 - laser beam
 - 4 - middle beamline valve
 - 5 - diagnostic faraday cup
 - 6 - diagnostic box beamline valve
 - 7 - front shutter
 - 8 - PMT high voltage
 - 9 - center scintillation detector
 - 10 - rear shutter
 - 11 - test chamber beamline valve
 - 12 - test chamber bottom flange
 - 13 - hydraulic scissors table

SHOW_NORMAL_FLUX

- Minimum command string: **SH_N**
- Response: scient (d.dddde+dd)
- The SHOW_NORMAL_FLUX command reports the last measured normal flux in ions/cm²/sec. The response format is a scientific format number. Please note that the normal flux is updated upon execution of either the FLUX and TEST commands (or their menu command equivalents Measure_Flux and Test_Run).

SHOW_EFFECTIVE_FLUX

- Minimum command string: **SH_EF_F**
- Response: scient (d.dddde+dd)
- The SHOW_EFFECTIVE_FLUX command reports the last measured effective flux (i.e., the normal flux multiplied by the cosine of the present tilt angle θ) in ions/cm²/sec. The response format is a scientific format number. Please note that the effective flux is updated upon execution of the FLUX and TEST commands (or their menu command equivalents Measure_Flux and Test_Run), just like the normal flux, upon execution of the SET_EFFECTIVE_LET and SET_TILT_ANGLE commands (or their menu command equivalents Effective_LET and Tilt_Angle), and also all other commands that rotate the test board around the vertical axis.
- While it is possible to monitor the effective flux during the test run with the help of the SHOW_EFFECTIVE_FLUX command, the effective flux may change after the test run if the SEU Test Facility application performs the check of the beam center. A safe method to obtain the average effective flux of the last test run is to get the accumulated fluence and the test run time with the help of the SHOW_ACCUMULATED_FLUENCE and SHOW_ELAPSED_TIME commands, respectively, and then divide the two numbers.
- You can also calculate the effective flux yourself if you obtain the normal flux and the present tilt angle with the help of the SHOW_NORMAL_FLUX and SHOW_TILT_ANGLE commands, respectively.

SHOW_ALIGNMENT

- Minimum command string: **SH_AL**
- Response: float (ddd.d)
- The SHOW_ALIGNMENT command reports the last measured beam alignment in %. The response format is a floating point number. Please note that the alignment is updated upon execution of the FLUX and TEST commands (or their menu command equivalents Measure_Flux and Test_Run).

SHOW_WARNING_LEVELS

- Minimum command string: **SH_W**
- Response: int (d); float (dd.d); float (dd.d); float (dd.d); float (dd.d)
- The SHOW_WARNING_LEVELS command reports the status of automatic check of the beam center (0=never, 1=automatic, 2=always) performed by the SEU Test Facility application following the test runs, the minimum acceptable beam alignment in % (85 % by default), minimum and maximum acceptable center deviations in % (0 % and 40 % by default, respectively), and the maximum acceptable flux drift (2x by default). The response format is an integer followed by four floating point numbers separated by semicolons.

SHOW_DEVICE_ID

- Minimum command string: **SH_DEV_I**
- Response: string (16a max)
- The SHOW_DEVICE_ID command reports ID of the device positioned in the beam (or "NONE" if no device is positioned in the beam). The response format is a string.

SHOW_DEVICE_LIST

- Minimum command string: **SH_DEV_L**
- Responses: int (ddd), string (16a max), string (16a max), ..., string (16a max)
- The SHOW_DEVICE_LIST command reports the number of devices and a list of device IDs on the present board configuration. The number of devices is reported first, in an integer format (ddd), followed by the device IDs, in a string format. The device IDs are separated from the number of devices and from each other by carriage return (CR, ASCII code hex 0D) and line feed (LF, ASCII code hex 0A). Since LF is the terminating character, you have to read the number of devices and each device ID separately. If you read the number of devices, you must proceed reading exactly that many device IDs, otherwise the SEU Test Facility application or the host computer will experience a device timeout (depending on whether you try to read less or more device IDs, respectively).

SHOW_DEVICE_POSITIONS

- Minimum command string: **SH_DEV_P**
- Response: float (dd.dd); float (dd.dd); float (dd.dd); float (dd.dd);
- The SHOW_DEVICE_POSITIONS command reports the present device positions (X-, Y-, and Z-coordinates and the iris diameter) in cm, even if no device is positioned in the beam. The response format is four floating point numbers separated by semicolons.

SHOW_FLUENCE

- Minimum command string: **SH_F**
- Response: scient (d.ddde+dd)
- The SHOW_FLUENCE command reports the desired (or the estimated) effective fluence in the next single test run in ions/cm². The response format is a scientific format number. The desired (or the estimated) effective fluence is updated upon execution of the of the SET_FLUENCE and SET_RUN_TIME commands (or their menu command equivalents Fluence and Run_Time). If the test run is set to be terminated upon reaching the desired run time, the estimated effective fluence is also updated upon execution of the FLUX and TEST commands (or their menu command equivalents Measure_Flux and Test_Run).

SHOW_ACCUMULATED_FLUENCE

- Minimum command string: **SH_AC**
- Response: (d.12de+dd)
- The SHOW_ACCUMULATED_FLUENCE command reports the effective fluence accumulated during the last single test run in ions/cm². The response format is a scientific format number. The accumulated effective fluence is updated during execution and upon completion of the TEST command (or its menu command equivalent Test_Run). Because of a small delay between reaching the desired effective fluence and closing the beam shutters, the measured accumulated fluence is always slightly (less than 1 %) higher than the desired effective fluence set by the SET_FLUENCE command (or its menu command equivalent Set_Fluence).
- Since the fluence accumulated in a flux measurement is of no particular interest, the accumulated fluence is never updated during execution or upon completion of the flux measurement. This arrangement makes it possible to obtain the last test run accumulated fluence (and together with the SHOW_ELAPSED_TIME also the last test run average effective flux) even if the SEU Test Facility performs the beam center check following the test run.

SHOW_ESTIMATED_TIME

- Minimum command string: **SH_ES**
- Response: int (dddd)
- The SHOW_ESTIMATED_TIME command reports the estimated (or the desired) run time of the next single test run in seconds. The response format is an integer. The estimated (or the desired) run time is updated upon execution of the SET_FLUENCE and SET_RUN_TIME commands (or their menu command equivalents Fluence and Run_Time). If the test run is set to be terminated upon reaching the desired effective fluence, the estimated run time is also updated upon execution of the FLUX and TEST commands (or their menu command equivalents Measure_Flux and Test_Run).

SHOW_ELAPSED_TIME

- Minimum command string: **SH_EL**
- Response: float (dddd.d)
- The SHOW_ELAPSED_TIME command reports the run time of the last single test run in seconds. The response format is a floating point number. The test run time is updated upon completion of the TEST command (or its menu command equivalent Test_Run).
- Since the run time of a flux measurement is of no particular interest, the run time is never updated by the FLUX command (or its menu command equivalent Measure_Flux). This arrangement makes it possible to obtain the last test run time (and together with the SHOW_ACCUMULATED_FLUENCE also the last test run average effective flux) even if the SEU Test Facility performs the beam center check following the test run.

SHOW_CROSS_SECTION

- Minimum command string: **SH_CR**
- Response: scient (d.dddde+dd)
- The SHOW_CROSS_SECTION command reports the calculated upset cross section (number of upsets divided by the accumulated fluence and by the number of device bits) in cm^2/bit . The response format is a scientific format number. The upset cross section is updated upon entering the number of upsets either from the keyboard in the Enter_Upsets dialog box or with the help of the SET_UPSETS command.

SHOW_ION_ENERGY

- Minimum command string: **SH_I**
- Response: string (6a max); float (ddd.dd)
- The SHOW_ION_ENERGY command reports the present beam isotope and energy in MeV. The response format is a string and a scientific format number separated by semicolons. The beam isotope and energy are updated upon execution of the SET_ION_ENERGY command (or its menu command equivalent Ion/Energy)

SHOW_CHARGE_STATE

- Minimum command string: **SH_CH**
- Response: int (dd)
- The SHOW_CHARGE_STATE command reports present beam charge state. The response format is an integer. The charge state is updated upon execution of the SET_ION_ENERGY command (or its menu command equivalent Ion/Energy). Please note that the charge state is required only if the faraday cups and electrometers are used for the beam dosimetry. Otherwise (i.e., if the scintillation detectors and counters are used), the charge state may be incorrect (equal to the atomic number Z of the present beam isotope).

SHOW_EFFECTIVE_ENERGY

- Minimum command string: **SH_EF_E**
- Response: float (ddd.dd)
- The SHOW_EFFECTIVE_ENERGY command reports the effective energy, i.e., the beam energy corrected for an energy loss in the Dead_Layer (if any) in MeV. The response format is a scientific format number. The effective energy is updated upon execution of the SET_ION_ENERGY command (or its menu command equivalent Ion/Energy), upon execution of the SET_EFFECTIVE_LET and SET_TILT_ANGLE commands (or their menu command equivalents Effective_LET and Tilt_Angle), and also all other commands that rotate the test board around the vertical axis.
- If no dead layer on top of the device sensitive region is defined, the effective energy always equals to the beam energy, regardless of the tilt angle.

SHOW_LET

- Minimum command string: **SH_L**
- Response: float (ddd.dd)
- The SHOW_LET command reports the heavy ion LET (at normal angle of incidence) in the present Target_Material in MeV·cm²/mg. No dead layer correction is ever included. The response format is a scientific format number. The LET is updated upon execution of the SET_ION_ENERGY command (or its menu command equivalent Ion/Energy).

SHOW_EFFECTIVE_LET

- Minimum command string: **SH_EF_L**
- Response: float (ddd.dd)
- The SHOW_EFFECTIVE_LET command reports the heavy ion effective LET (the heavy ion LET in the present Target_Material divided by the cosine of the present tilt angle) corrected for an energy loss in the Dead_Layer (if any) in MeV·cm²/mg. The response format is a scientific format number (d.ddde+dd). The effective LET is updated upon execution of the SET_ION_ENERGY command (or its menu command equivalent Ion/Energy), upon execution of the SET_EFFECTIVE_LET and SET_TILT_ANGLE commands (or their menu command equivalents Effective_LET and Tilt_Angle), and also all other commands that rotate the test board around the vertical axis.
- If no dead layer is present, you can also calculate the effective LET yourself if you obtain the heavy ion LET and the present tilt angle with the help of the SHOW_LET and SHOW_TILT_ANGLE commands, respectively.

SHOW_RANGE

- Minimum command string: **SH_RA**
- Response: float (ddd.d)
- The SHOW_RANGE command reports the heavy ion range (at normal angle of incidence) in the present Target_Material in μm . No dead layer correction is ever included. The response format is a floating point number. The range is updated upon execution of the SET_ION_ENERGY command (or its menu command equivalent Ion/Energy)

SHOW_PENETRATION_DEPTH

- Minimum command string: **SH_PE**
- Response: float (ddd.d)
- The SHOW_PENETRATION_DEPTH command reports the heavy ion penetration depth (i.e., the heavy ion range in the present Target_Material multiplied by the cosine of the present tilt angle) corrected for an energy loss in the Dead_Layer (if any) in μm . The response format is a floating point number. The penetration depth is updated upon execution of the SET_ION_ENERGY command (or its menu command equivalent Ion/Energy), upon execution of the SET_EFFECTIVE_LET and SET_TILT_ANGLE commands (or their menu command equivalents Effective_LET and Tilt_Angle), and also all other commands that rotate the test board around the vertical axis.
- If no dead layer is present, you can also calculate the penetration depth yourself if you obtain the heavy ion range and the present tilt angle with the help of the SHOW_RANGE and SHOW_TILT_ANGLE commands, respectively.

SHOW_TILT_ANGLE

- Minimum command string: **SH_T**
- Response: float (dd.dd)
- The SHOW_TILT_ANGLE command reports the present tilt angle in degrees. The response format is a floating point number. The tilt angle is updated upon execution of the SET_EFFECTIVE_LET and SET_TILT_ANGLE commands (or their menu command equivalents Effective_LET and Tilt_Angle), and also all other commands that rotate the test board around the vertical axis.

SHOW_ROLL_ANGLE

- Minimum command string: **SH_RO**
- Response: float (dd.dd)
- The SHOW_ROLL_ANGLE command reports the present roll angle in degrees. The response format is a floating point number. The roll angle is updated upon execution of the SET_ROLL_ANGLE command (or its menu command equivalent Roll_Angle), and also all other commands that rotate the test board around the horizontal axis perpendicular to the test board.

SHOW_DATA_FILE

- Minimum command string: SH_DA_F
- Response: string (128a max)
- The SHOW_DATA_FILE command reports the present data file name. The response format is a string.

SHOW_DATA_DIRECTORY

- Minimum command string: **SH_DA_D**
- Responses: int (ddd), string (128a max), string (128a max), ..., string (128a max)
- The SHOW_DATA_DIRECTORY command reports the number of files and a list of files names in the data sub-directory. The number of files is reported first, in an integer format, followed by the file names, in a string format. The file names are separated from the number of files and from each other by carriage return (CR, ASCII code hex 0D) and line feed (LF, ASCII code hex 0A). Since LF is the terminating character, you have to read the number of files and each file name separately. If you read the number of files, you must proceed reading exactly that many file names, otherwise the SEU Test Facility application or the host computer will experience a device timeout (depending on whether you try to read less or more file names, respectively).

SHOW_HEADER

- Minimum command string: SH_H
- Response: string (64a max)
- The SHOW_HEADER command reports the present test title. The response format is a string.

SHOW_RUN_NUMBER

- Minimum command string: **SH_RU**
- Response: int (dddd)
- The SHOW_RUN_NUMBER command reports the run number of the next single test run. The response format is an integer. Please note that the run number is automatically incremented upon entering the number of upsets either from the keyboard in the Enter_Upsets dialog box or with the help of the SET_UPSETS command.

SHOW_PLOT_SYMBOL

- Minimum command string: SH_PL
- Response: char (a)
- The SHOW_PLOT_SYMBOL command reports the initial of the present plot symbol (S, D, T, Y, P, A, C, or R). The response format is a single character.

SHOW_SERVICE_REQUEST

- Minimum command string: **SH_S**
- Response: hex int (hh)
- The SHOW_SERVICE_REQUEST command reports the selected conditions which can generate a service request. The response format is an integer in the hexadecimal form. The five least significant bits of the integer response value correspond to different conditions:
 - hex 01 test run done
 - hex 02 flux measurement done
 - hex 04 test board move run done
 - hex 08 any command run done
 - hex 10 command failure

If any of the five least significant bits is set, the corresponding condition is enabled.

SHOW_ERROR_MESSAGE

- Minimum command string: SH_ER
- Responses: int (ddd), string (128a max), string (128a max), ..., string (128a max)
-