BROOKHAVEN
NATIONAL LABORATORY

NSRL-06A RUN

March – April 2006

FINAL REPORT

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http://www.bnl.gov/medical/NASA

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EXECUTIVE SUMMARY

During the spring of 2006, a series of radiobiological and physics experiments were performed using the NASA Space Radiation Laboratory to accelerate heavy ion beams. These experiments were part of the eighth NSRL scientific run (NSRL-06A) sponsored by NASA's Space Radiation Health Program (SRHP) heavy ion radiobiology research program at BNL.

A total of thirty three proposals were approved for participation in the NSRL-06A run, all but one of which ran experiments in NSRL-06A. Thirty one institutions from the United States were represented, totaling 91 users. Nearly 3000 biological samples were exposed at the NSRL beam line, employing 252:02 hours of beam time (28:44 hours for in vivo studies, 132:27 hours for in vitro studies and 90:51 hours for physics experiments) delivered in a six-week period. In addition, 13:05 hours were used for dosimetry development and beam development. Machine set-up took a total of 59:30 hours, with an additional 13:30 hours for wrap-up of the beam. Accelerator problems accounted for 36:04 hours lost. This gave a total NSRL usage time of 374:11 hours.

During NSRL-06A, Booster provided iron (300, 600 and 1000 MeV/nucleon), protons (1000 MeV/n), sequential fields of iron and protons (1000 MeV/n), carbon (300 MeV/n), and silicon (300, 380 and 1000 MeV/n) beams for biology and physics experiments. The maximum dose/rates used for biology experiments were as high as 5 Gy/min (Si 300 MeV/n). The general spill rate employed was 20 spills per minute with durations of 300 msec/spill. The spill fluence range was (particles/spill) from 1.5 x 10^{11} (max) and 2 x 10^{2} (min). Square beam spots as big as 20 x 20 cm^2 and as small as 1 x 1 cm^2 were employed for biology and physics experiments. The Tandem-Booster-NSRL complex delivered a sequential field composed of iron and protons with energies of 1000 MeV/n with steady and repeatable switching from protons to iron.

During NSRL-06A additional investigators used the sequential field modality as part of the operational beam manifesto.

Tandem-Booster set-up started on March 1 with the transport and circulation of Fe beams at the NSRL complex. Beam was tuned into the target cave on March 1 and 1000 MeV/n Fe beams were available for tuning at 7:00 AM 1 March 2006. NSRL-06A officially ended at 2:00 PM 7 April 2006.

Projects Reviewed by the BNL Scientific Advisory Committee in Radiobiology

Proposal	PI	Sponsor	NSRL-06A Participation
B-7	RABIN	NASA	Yes
B-52	SUTHERLAND/GEWIRTZ*	NSBRI	Yes
N-64	VAZQUEZ	NSBRI	Yes
N-65	VAZQUEZ	NSBRI	Yes
N-86	WANG	NASA	Yes
N-88	SUTHERLAND	NASA	Yes
N-89	HELD	NASA	Yes
N-97	KRONENBERG	NASA	Yes
N-102	HALL*	NASA	Yes
N-103	BARCELLOSHOFF*	NASA	Yes
N-104	WEIL	NASA	Yes
N-108	PECAUT/OBENAUS*	NASA	No
N-116	BENTON	NASA	Yes
N-120	REDPATH	DOE/NASA	Yes
N-121	MOYERS	NASA	Yes
N-124	LI*	NASA	Yes
N-134	CHEN*	NASA	Yes
N-135	PLUTH	NASA	Yes
N-137	WILKINS*	NASA-JSC	Yes
N-140	SAGANTI	NASA-CARR	Yes
N-142	BURNS	NASA	Yes
N-146	WU	NASA	Yes
N-153	MINNA*/STORY/SHAY*	NASA	Yes
N-154	MAURER	NASA	Yes
N-156	PISACANE	NASA	Yes
N-157	SCHIESTL*	NASA	Yes
N-158	TAKAI	NASA	Yes
N-159	KLEIMAN	NASA	Yes
N-160	SPENCE	NASA	Yes
N-162	WARE	NASA	Yes
N-164	YU	NASA	Yes
N-166	KENNEDY	NASA	Yes
N-167	BURMA	NASA	Yes

***Not Present During Actual Run**

PARTICIPANTS (Principal Investigators are highlighted)

Exp.	Participants	Affiliation	Title
B-7	**RABIN**	University of Maryland	Ph.D, Principal Investigator
	SHUKITTHALE	U.S. Department of Agriculture	Guest Scientist
	CARRIHILL	University of Maryland	Guest Research Associate
	CHENG	University of Maryland	Guest Jr Research Associate
B-52	**GEWIRTZ***	University of Pennsylvania	Ph.D, Principal Investigator
	BENNETT	BNL, Biology Dept., Upton, NY	M.S., Co-Worker
	ROY	BNL, Biology Dept., Upton, NY	PhD., Co-Worker
	NAIDU	BNL, Biology Dept., Upton, NY	PhD., Co-Worker
	SUTHERLAND	BNL, Biology Dept., Upton, NY	PhD., Co-Worker
	MONTELEONE	BNL, Biology Dept., Upton, NY	B.S., Co-Worker
	TRUNK	BNL, Biology Dept., Upton, NY	PhD., Co-Worker
N-64	**VAZQUEZ**	BNL, Medical Dept., Upton, NY	MD, PhD.,Principal Invest.
	GUIDA	BNL, Medical Dept., Upton, NY	Ph.D., Co-Worker
	BILLUPS	BNL, Medical Dept., Upton, NY	B.A., Co-Worker
	PYATT	BNL, Medical Dept., Upton, NY	M.S., Co-Worker
	THOMPSON	BNL, Medical Dept., Upton, NY	B.S., Co-Worker
	KIM	BNL, Medical Dept., Upton, NY	B.S., Co-Worker
N-65	**VAZQUEZ**	BNL, Medical Dept., Upton, NY	MD, PhD.,Principal Invest.
B-73	**SUTHERLAND**	BNL, Biology Dept., Upton, NY	Ph.D, Principal Investigator
N-86	**Y. WANG**	Thomas Jefferson University	Ph.D, Principal Investigator
	X. WANG	Thomas Jefferson University	Guest Jr Research Associate
N-88	**SUTHERLAND**	BNL, Biology Dept., Upton, NY	Ph.D, Principal Investigator
N-89	**HELD**	Massachusetts Gen. Hosp./Harvard Med.	Ph.D, Principal Investigator
	ANZENBERG	Massachusetts General Hospital	Guest Jr Research Associate
	SCHUSSLER	Massachusetts General Hospital	Guest Scientific Associate
	PURSCHKE	Massachusetts General Hospital	Guest Research Associate
N-97	**KRONENBERG**	Lawrence Berkeley National Laboratory	Ph.D, Principal Investigator
	KWOH	Lawrence Berkeley National Laboratory	Guest Scientific Associate
	SUDO	Lawrence Berkeley National Laboratory	Guest Research Associate
	GAUNY	Lawrence Berkeley National Laboratory	Guest Scientific Associate
	DAN	Oregon Health & Science University	Guest Scientific Associate
	TURKER	Oregon Health & Science University	Guest Scientist
N-102	**HALL**	Columbia University	Ph.D, Principal Investigator
	SMILENOV	Columbia University, Nevis Laboratories	Guest Scientist
	ZHOU	Columbia University	Guest Scientist
N-103	**BARCELLOSHOFF***	Lawrence Berkeley National Laboratory	Ph.D, Principal Investigator
	KRONENBERG	Lawrence Berkeley National Laboratory	Guest Scientist
	SUDO	Lawrence Berkeley National Laboratory	Guest Research Associate
	DING	Lawrence Berkeley National Laboratory	Guest Research Associate
N-104	**WEIL**	Colorado State University	Ph.D, Principal Investigator
	RAY	Colorado State University	Guest Scientist
	GENIK	Colorado State University	Guest Scientist
	CALLAN	Colorado State University	Guest Scientific Associate
N-108	**PECAUT*/OBENAUS***	Loma Linda University	Ph.D, Principal Investigator
N-116	**BENTON**	Eril Research, Inc.	Ph.D, Principal Investigator
	KALCHGRUBER	Oklahoma State University	Guest Research Associate
	SAWAKUCHI	Oklahoma State University	Guest Research Assistant

Exp.	Participants	Affiliation	Title
N-120	**REDPATH**	University of California @ Irvine	Ph.D, Principal Investigator
	ELMORE	University of California @ Irvine	Guest Scientist
N-121	**MOYERS**	Loma Linda University	Ph.D, Principal Investigator
	RIGHTNAR	Loma Linda University	Guest Scientific Associate
N-124	**LI***	Duke University	Ph.D, Principal Investigator
	YUAN	Duke University	Guest Scientist
N-134	**CHEN***	University of Texas Southwestern	Ph.D, Principal Investigator
	UEMATSU	University of Texas Medical Branch	Guest Jr Research Associate
	DING	Lawrence Berkeley National Laboratory	Guest Research Associate
	STORY	University of Texas Southwestern	Guest Scientist
	BURMA	University of Texas Medical Branch	Guest Scientist
N-135	**PLUTH**	Lawrence Berkeley National Laboratory	Ph.D, Principal Investigator
	NAIR	Lawrence Berkeley National Laboratory	Guest Research Assistant
N-137	**WILKINS***	Prairie View A&M University	Ph.D, Principal Investigator
N-140	**SAGANTI**	Prairie View A&M University	Ph.D, Principal Investigator
	ZEITLIN	Lawrence Berkeley National Laboratory	Guest Scientist
N-142	**BURNS**	New York University	Ph.D, Principal Investigator
	ZHANG	New York University	Guest Scientific Associate
	WU	New York University	Guest Scientific Associate
N-146	**WU**	NASA - Johnson Space Center	Ph.D, Principal Investigator
	EMAMI	NASA - Johnson Space Center	Guest Scientific Associate
N-153	**MINNA*/STORY**	University of Texas Southwestern	Ph.D, Principal Investigator
	SHAY*	University of Texas Southwestern	Ph.D, Principal Investigator
	DELGADO	University of Texas Southwestern	Guest Jr Research Associate
	ROIG	University of Texas Southwestern	Guest Jr Research Associate
	MINNA	University of Texas Southwestern	Guest Scientific Associate
	THOMPSON	University of Texas Southwestern	Guest Jr Research Associate
	PEYTON	University of Texas Southwestern	Guest Scientist
	SHERIDAN	University of Texas Southwestern	Guest Jr Research Associate
	BURMA	University of Texas Medical Branch	Guest Scientist
N-154	**MAURER**	Johns Hopkins University	Ph.D, Principal Investigator
	ZEITLIN	Lawrence Berkeley National Laboratory	Guest Scientist
	DELAUNE	NASA - Johnson Space Center	Guest Scientific Associate
	ROTH	Johns Hopkins University	Guest Scientist
N-156	**PISACANE**	U.S. Naval Academy	Ph.D, Principal Investigator
	ZHAO	University of Cincinnati	Guest Scientist
	TADDEI	U.S. Naval Academy	Guest Scientist
	WROE	Loma Linda University Medical Center	Guest Jr Research Associate
	HOUGH	U.S. Naval Academy	Guest Jr Research Associate
	GAUGHAN	U.S. Naval Academy	Guest Jr Research Associate
	DICELLO	Johns Hopkins University	Guest Scientist
N-157	**SCHIESTL***	University of California Los Angeles	Ph.D, Principal Investigator
	RELIENE	University of California Los Angeles	Guest Scientist
	HAFER	University of California Los Angeles	Guest Jr Research Associate
	YAMAMOTO	University of California Los Angeles	Guest Jr Research Associate
N-158	**TAKAI**	BNL, Physics Dept., Upton, NY	Ph.D, Principal Investigator
	GROSSBERG	SUNY @ Stony Brook	Guest Research Assistant
	ERALY	SUNY @ Stony Brook	Guest Jr Research Associate
	TKACZYK	SUNY @ Stony Brook	Guest Jr Research Associate
	SCHAMBERGER	SUNY @ Stony Brook	Guest Scientist

Exp.	Participants	Affiliation	Title
N-158	MARX	SUNY @ Stony Brook	Guest Scientist
	SIVERTZ	BNL, Physics Dept., Upton, NY	Physicist
	DJURIC	SUNY @ Stony Brook	Guest Scientist
	FORMAN	SUNY @ Stony Brook	Guest Scientist
	ZHANG	SUNY @ Stony Brook	Guest Jr Research Associate
	FERNANDEZBUGALLO	SUNY @ Stony Brook	Guest Scientist
N-159	**KLEIMAN**	Columbia University	Ph.D, Principal Investigator
	DAVID	Columbia University	Guest Scientific Associate
N-160	**SPENCE**	Boston University	Ph.D, Principal Investigator
	SWEENEY	Boston University	Guest Scientist
	FOSTER	Massachusetts Institute of Technology	Guest Scientific Associate
	KASPER	Massachusetts Institute of Technology	Guest Scientist
	KEPKO	Boston University	Guest Scientist
	MAZUR	Aerospace Corporation	Guest Scientist
N-162	**WARE**	University of Pennsylvania	Ph.D, Principal Investigator
	KENNEDY	University of Pennsylvania	Guest Scientist
	WAMBI	University of Pennsylvania	Guest Research Associate
	STEWART	University of Pennsylvania	Guest Scientist
	DONAHUE	University of Pennsylvania	Guest Scientific Associate
N-164	**YU**	University of Texas Medical Branch	Ph.D, Principal Investigator
N-166	**KENNEDY**	University of Pennsylvania	Ph.D, Principal Investigator
	DONAHUE	University of Pennsylvania	Guest Scientific Associate
	WARE	University of Pennsylvania	Guest Scientist
	STEWART	University of Pennsylvania	Guest Scientist
	DONAHUE	University of Pennsylvania	Guest Scientific Associate
N-167	**BURMA**	University of Texas Medical Branch	Ph.D, Principal Investigator

***Not Present During Actual Run**

PARTICIPANT INSTITUTIONS

Universities (23)

Boston University
Colorado State University
Columbia University
Columbia University, Nevis Laboratories
Duke University
Johns Hopkins University
Loma Linda University Medical Center
Massachusetts Institute of Technology
New York University
Oklahoma State University
Oregon Health & Science University
Prairie View A&M University
SUNY @ Stony Brook
Thomas Jefferson University
University of California @ Irvine
University of California @ Los Angeles
University of Cincinnati
University of Maryland
University of Pennsylvania
University of Texas Medical Branch
University of Texas Southwestern
University of Penn State
U.S. Naval Academy

National Laboratories/Institutes (2)

Brookhaven National Laboratory
Lawrence Berkeley National Laboratory

NASA Related Centers/Institutes (2)

NASA - Johnson Space Center
NSBRI

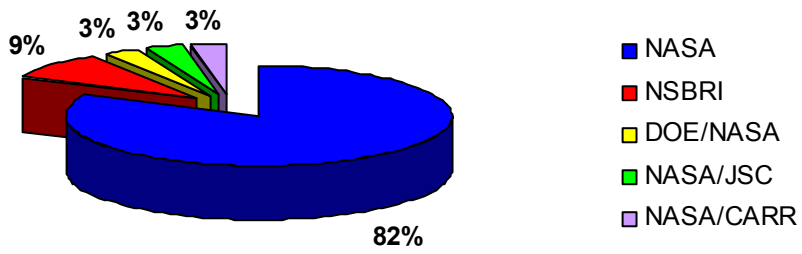
Private Institutions (3)

Massachusetts Gen. Hosp./Harvard M. School
Eril Research, Inc.
Aerospace Corporation

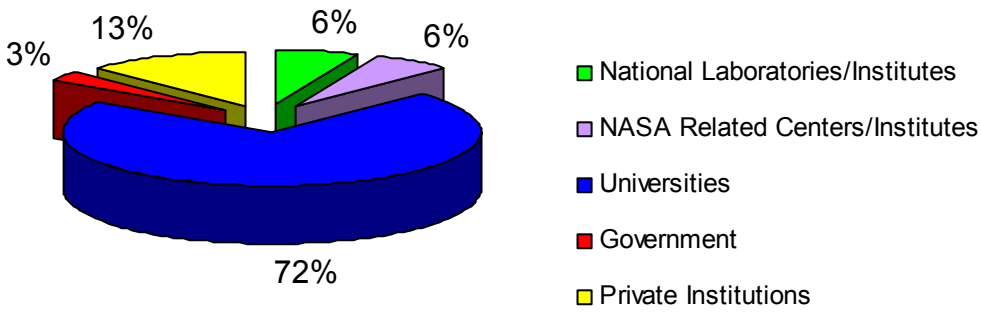
Government (1)

U.S. Department of Agriculture

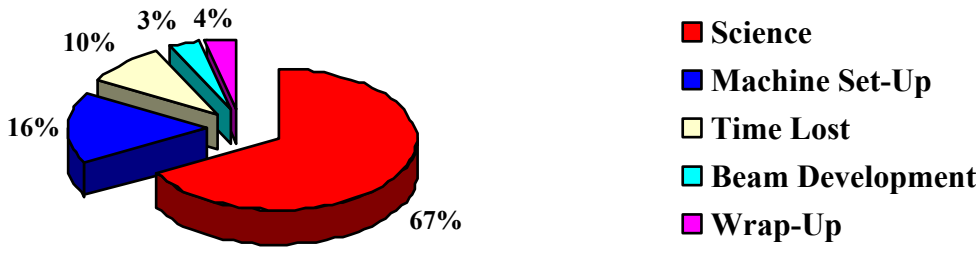
RESEARCH PROJECT SPONSORS



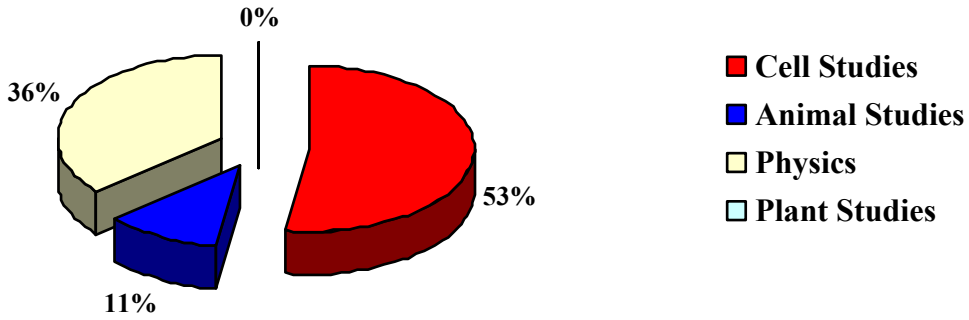
INSTITUTIONS STATISTICS



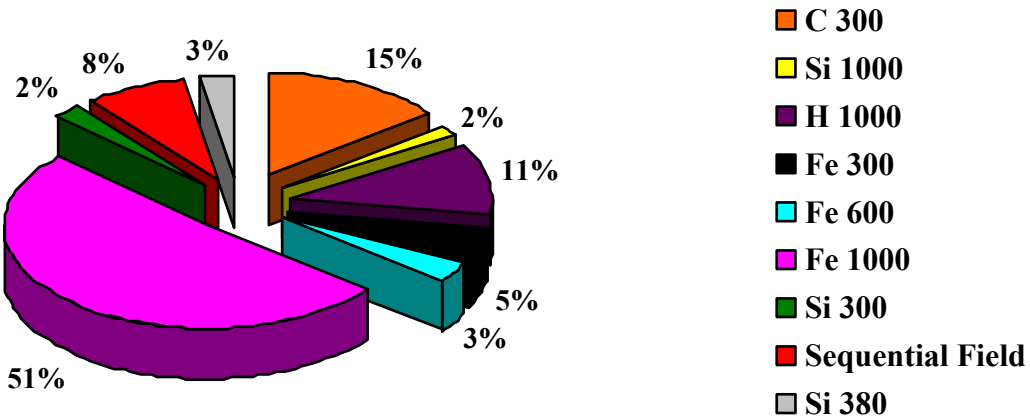
TOTAL RUN-TIME STATISTICS



SCIENCE STUDIES STATISTICS



ION SPECIES AND ENERGY (MeV/n) DISTRIBUTION OF HOURS USED



RUN TIME DESCRIPTION (hours)

NSRL-06A	ION SPECIES AND ENERGIES (MeV/nucleon)									
	H 1000	Fe 300	Fe 600	Fe 1000	Fe-H 1000	Si 1000	Si 380	Si 300	C 300	Totals
Machine Set-up	5:00	4:00	0:00	27:00	9:00	0:00	5:00	2:30	7:00	59:30
Wrap-Up	2:00	0:30	0:30	6:30	1:00	0:30	0:30	0:30	1:30	13:30
Non-Science Sub-Total:										73:00
Development	4:00	0:00	2:35	6:30	0:00	0:00	0:00	0:00	0:00	13:05
Biology										
In Vitro	14:32	10:50	7:30	62:42	17:18	5:25	0:00	4:10	10:00	132:27
In Vivo	3:15	0:00	0:00	17:44	0:00	0:00	4:15	0:00	3:30	28:44
Others	0:00	0:00	0:00	0:00	0:00	0:00	0:00	0:00	0:00	0:00
Physics	7:25	2:20	0:00	53:31	0:00	0:00	0:00	0:00	27:35	90:51
Science Sub Total:										252:02
Time lost	2:35	5:05	1:00	16:29	3:15	0:00	0:00	0:30	7:10	36:04
Totals	38:47	22:45	11:35	190:26	30:33	5:55	9:45	7:40	56:45	374:11

BEAM CHARACTERISTICS

Ion	Fe			H	Sequential Field	Si			C
Energy (MeV/n)									
Planned	300	600	1000	1000	1000	300	380	1000	300
Extracted	300	600	1000	1000	1000	300	380	1000	300
On Target	306	596	967	1000*	967	305	381	977	293
Fluence (particles/cm^2/sec)									
Maximum on target	2.60E+06	2.60E+06	7.50E+06	2.10E+08	1.60E+07	1.60E+07	1.60E+07	1.60E+07	5.80E+06
Minimum on target	200	200	200	200	200	200	200	200	200
Spill Period (sec)	3	3	3	3	3	3	3	3	3
Spill rate (spills/min)	20	20	20	20	20	20	20	20	20
Spill length (msec)	300	300	300	300	300	300	300	300	300
Particles/spill									
Maximum	1.20E+09	1.20E+09	2.60E+09	9.00E+10	3.50E+09	3.50E+09	3.50E+09	3.50E+09	2.00E+09
Minimum	1.00E+05	1.00E+05	1.00E+05	2.00E+02	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05
Beam Cut Off Accuracy	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%	0.50%
Actual LET on Target (keV/µm)	235.5	174	151.4	0.222*	151.4	68.6	61.1	43.8	12.9
Max. Dose Rate									
(Gy/min)/Beam Size									
20 cm x 20 cm	1	3.5	4	0.7	5	5	0.6	5	2
Total Dose (Gy)									
Maximum	2	10	10	10	20	10	1.5	10	6
Minimum	0.01	.02	0.05	0.01	0.1	0.2	0.5	0.1	0.5

* No Bragg results are available for H beam running.

DOSIMETRY AND BEAM DEVELOPMENTS (Collider-Accelerator Dept.)

Energy Ramping:

Energy ramping for the Solar Event Simulation (SES) was developed further during the NSRL-06A run. Limited progress was made. One lesson learned is that the protons for this activity must come from the TANDEM, not the LINAC, unless the latter can deliver lower energy protons to the BOOSTER. While studying the energy ramping with Fe, we recorded beam with energies of 90, 114, 260, 300 and 600 MeV/n.

Exposure Incubator:

The exposure incubator was completed before this run. We have tested it to make sure it survived the modifications, which it did. We have a problem with condensation on the kapton windows we made too allow beam through the incubator wall. This problem will be addressed as soon as the run is over.

Sample flipper:

We have introduced a remotely controlled sample flipper, which allows users who do cell work to place flasks with little fluid covering the surface where the cells are attached on the device, facing down, and lift them into position only during exposures. This prevents the drying up of the cells as the user is dealing with access, which was slow during NSRL-06A due to simultaneous RHIC running.

Remote-controlled motion for EG&G dosimetry counter:

We introduced a holder for the EG&G dosimetry counter which allows remote controlled motion both horizontal and vertical in the plane transverse to the beam direction. We can now calibrate the ion chamber without needing access to place and remove the EG&G counter.

Quick energy changes:

We changed the energy of the beam on demand during this run. Changes took about 4 minutes, but additional recording and fine tuning added more time. 15 minutes seems to be a reasonable time for energy change planning.

Locally-captured sweep key:

Doing target-room sweeps with a locally captured sweep key made life much easier for all. We lost sweeps several times this run, but lost only a few minutes for each. In the past we lost about 20 minutes per sweep, and some times even more.

Fragmentation measurements:

We used the NSRL data acquisition system during the running of biology experiments and in dedicated study periods to accumulate statistics on the make-up of the incident beam for Fe and C beams of energies 300 and 1000 MeV/nucleon. We used a proton beam of 1000 MeV to calibrate the performance of the detectors. We compared the results from small and large beam measurements, and counters of various sizes in order to relate the counting rates to delivered doses.

Time-of-flight measurements:

Silicon beams of energies 300, 600 and 1000 MeV/nucleon were measured using a time of flight method, comparing the results with Bragg peak results and measurements based on the RF of the Booster.

Fast extracted beam:

We developed fast extracted beam into NSRL, in which all the beam from the BOOSTER is extracted in one cycle, about 600 ns. We tested our ability to do dosimetry with such beams, and have concluded that we can, as long as the intensities are not too high. This development came following discussions with a user.

Structured beam:

At the request of Betsy Sutherland, we developed a structured beam with full intensity modulation at frequencies between 10 and 60 Hz. The beam spill period was kept fixed at ~300 ms, but a time structure was imposed on the extracted beam in order to understand the importance of uniformity in extracted beam intensity throughout the spill. Since the normal NSRL beam unavoidably contains some time structure, it is important to understand whether or not the DNA damage is sensitive to fluctuations on these time scales.

LONG-TERM SUPPORT FACILITY DEVELOPMENTS (Medical Dept.)

Laboratory operations:

During NSRL-06A, the Medical department supported 67 scientists performing in vivo, in vitro as well as physics experiments at NSRL. The users employed 15 tissue culture laboratories, 50 incubators and 13 laminar flow hoods in addition to an extensive number of ancillary equipment and facilities.

Set-up of new imaging system for live cell studies:

In order to enhance the Medical Dept. scientific support for cell studies, a new microscope was purchased, installed, tested and used during NSRL-06A. The Zeiss Axiovert 200 Live Cell Observation system is uniquely designed, integrated and equipped to address the stringent demands of modern live cell research microscopy. A dedicated laboratory and a satellite workstation were inaugurated in order to house the new optical device and image analysis workstation. After extensive testing and calibration, the system was used by local (Vazquez) and external (Story and Chen) investigators.

NSRL Exposure Incubator:

Medical personnel performed extensive testing and calibration of the cell incubator before employing it at NSRL. A full series of mechanical and functional tests were performed before the beginning of the run. Expected operational profiles were tested at the Medical department, checking multiple functional parameters such as temperature, humidity and CO2 levels.

Brookhaven Laboratory Animal Care Facility (BLAF):

For NSRL operations using animals, BLAF personnel performed extensive operations at BLAF and at NSRL in support of NASA users. A total of 888 animals were housed at BLAF (328 rats and 560 mice) for the last NASA run.

RUN DATES

Ion Beam / Energy	Scheduled		Actual	
Fe 1000 MeV/n	Date	Time	Date	Time
R 1 Start	3/01	07:00	3/01	07:00
End	3/01	23:00	3/02	00:45

Fe 300 MeV/n	Date	Time	Date	Time
R 1 Start	3/02	07:00	3/02	07:00
End	3/02	15:00	3/02	14:20

C 300 MeV/n	Date	Time	Date	Time
R 1 Start	3/02	15:00	3/02	18:00
End	3/07	17:30	3/07	17:15

Fe 300 MeV/n	Date	Time	Date	Time
R 2 Start	3/08	07:00	3/08	07:00
End	3/08	11:30	3/08	11:25

Fe 1000 MeV/n	Date	Time	Date	Time
R 2 Start	3/08	11:30	3/08	11:25
End	3/08	15:30	3/08	15:00

Fe 300 MeV/n	Date	Time	Date	Time
R 3 Start	3/08	15:30	3/08	15:00
End	3/08	19:00	3/08	17:10

Fe 1000 MeV/n	Date	Time	Date	Time
R 3 Start	3/09	07:00	3/09	07:00
End	3/10	12:00	3/10	13:10

Fe 600 MeV/n	Date	Time	Date	Time
R 1 Start	3/10	12:00	3/10	13:10
End	3/10	16:00	3/10	16:45

Fe 1000 MeV/n	Date	Time	Date	Time
R 4 Start	3/13	07:00	3/13	07:00
End	3/21	12:00	3/21	13:45

Fe 300 MeV/n	Date	Time	Date	Time
R 4 Start	3/21	12:00	3/21	13:45
End	3/21	15:00	3/21	15:40

Fe 1000 MeV/n	Date	Time	Date	Time
R 5 Start	3/21	15:00	3/21	15:40
End	3/22	18:00	3/22	13:40

Fe 300 MeV/n	Date	Time	Date	Time
R 5 Start	3/23	07:00	3/23	07:00
End	3/23	13:00	3/23	13:45

RUN DATES (cont.)

Fe 1000 MeV/n	Date	Time	Date	Time
R 6 Start	3/23	13:00	3/23	13:45
End	3/27	18:00	3/27	15:45

Sequential Field (Fe + H) 1000 MeV/n	Date	Time	Date	Time
R 1 Start	3/28	07:00	3/28	07:00
End	3/31	14:00	3/31	15:43

H 1000 MeV	Date	Time	Date	Time
R 1 Start	3/31	14:00	3/31	15:43
End	4/04	19:00	4/04	22:10

Si 380 MeV/n	Date	Time	Date	Time
R 1 Start	4/05	07:00	4/05	07:00
End	4/05	16:30	4/05	16:15

Si 300-1000 MeV/n	Date	Time	Date	Time
R 1 Start	4/06	07:00	4/06	07:00
End	4/07	13:00	4/07	13:30

EXPERIMENTERS AND RUN STATISTICS

Exp. ID	Principal Investigator	Ion	Energy (MeV/n)	Beam Time Approved (hours)	Beam Time Used (hours)	Dose Range (cGy)	Dose/Rate (cGy/min)	Number of Samples
B-7	RABIN	C	300	5:30	3:30	1-150	10-60	80
		Si	380	5:30	4:15	0.5-150	60	45
		Fe	1000	0:00	1:15	150, 250	100	16
B-52	GEWIRTZ*	Fe+H	1000	12:00	4:59	10-1000	10-500	16
		Si	1000	0:00	0:30	10-1000	50-500	10
N-64	VAZQUEZ	Fe	1000	6:48	2:24	60-240	30-100	12
		H	1000	4:48	3:15	200-800	50-70	48
N-65	VAZQUEZ	Fe	300	2:00	1:35	10-100	20-100	15
		Fe	1000	4:30	2:24	50-240	100	26
		Cl	500	2:00	0:00	-	-	-
		Fe+H	1000	0:00	1:38	35-100	50	28
N-86	WANG	Fe	1000	3:00	1:30	100-1000	100-200	44
N-88	SUTHERLAND	Fe+H	1000	13:00	11:00	0.00003-2000	0.01-500	170
		Fe	600	0:00	7:30	50	20-200	165
		Fe	300	0:00	2:25	10-100	20-200	186
		C	300	0:00	2:15	10-100	20-200	80
		Si	300	0:00	2:10	10-1000	50-500	30
		Si	600	0:00	1:35	10-1000	50-500	20
		Si	1000	0:00	0:30	10-1000	50-500	51
N-89	HELD	Fe	1000	7:00	7:40	0-300	0.01-200	57
		C	300	6:12	6:00	300-4500 ions/cm^2	120	39
		H	1000	6:12	6:00	0.0001-500	0.01-40	33
		Fe+H	1000	4:15	4:40	10	15-20	52
N-97	KRONENBERG	Fe	1000	11:00	8:50	50-300	50-100	138
N-102	HALL*	Fe	1000	2:30	1:05	10-30	50-100	28
N-103	BARCELLOS-HOFF*	Fe	1000	12:00	1:30	50-300	50-100	12
N-104	WEIL	Fe	1000	3:00	1:40	100	100	14

Exp. ID	Principal Investigator	Ion	Energy (MeV/n)	Beam Time Approved (hours)	Beam Time Used (hours)	Dose Range (cGy)	Dose/Rate (cGy/min)	Number of Samples
N-116	BENTON	Fe	1000	12:00	5:06	0.002-1000	0.003-10	30
		H	1000	6:00	7:25	0.002-1000	0.001-200	30
		Cl	500	12:00	0:00	-	-	-
N-120	REDPATH	Si	300	2:00	2:00	5-50	5-10	76
N-121	MOYERS	Fe	1000	6:00	6:25	N/A	N/A	1
		C	300	28:00	24:40	N/A	N/A	1
N-124	LI*	Fe	1000	2:30	2:45	50-500	400	160
N-134	CHEN*	Fe	300	3:00	0:00	-	-	-
		Si	300	2:30	0:00	-	-	-
		Si	1000	2:30	0:00	-	-	-
		Fe	1000	0:00	1:47	50-200	1-100	52
N-135	PLUTH	Fe	1000	8:00	6:00	5-600	10-200	86
N-137	WILKINS*	Fe	300	17:30	2:20	150-15000	N/A	120
		Si	300	17:30	0:00	-	-	-
N-140	SAGANTI	C	300	3:00	2:55	N/A	N/A	1
		Cl	500	3:00	0:00	-	-	-
N-142	BURNS	Fe	1000	6:00	4:35	300	100	23
N-146	WU	Fe	1000	3:00	2:10	50-200	50-100	16
		Fe	300	3:00	1:25	25-200	50-100	12
		C	300	3:00	1:45	50-200	50-100	15
N-153	MINNA*/STORY/SHAY*	Fe	300	19:00	5:25	50-200	100	100
		Fe	1000	0:00	14:50	20-150	100	0
		Si	1000	0:00	2:50	100-600	200	0
		Si	300	3:00	2:00	100-300	200	200
N-154	MAURER	Fe	1000	16:00	16:20	N/A	0.00001	1
N-156	PISACANE	Fe	1000	16:00	21:15	N/A	0.00001	1
		Fe	300	16:00	0:00	-	-	-
		C	300	8:00	0:00	-	-	-
		Si	300	8:00	0:00	-	-	-
		H	1000	8:00	0:00	-	-	-
		Cl	500	8:00	0:00	-	-	-

Exp. ID	Principal Investigator	Ion	Energy (MeV/n)	Beam Time Approved (hours)	Beam Time Used (hours)	Dose Range (cGy)	Dose/Rate (cGy/min)	Number of Samples
N-157	SCHIESTL*	Fe	1000	4:00	1:26	10-100	50	33
N-158	TAKAI	Fe	1000	0:00	0:00	N/A	N/A	N/A
N-159	KLEIMAN	Fe	1000	5:30	4:45	25	25-50	100
N-160	SPENCE	Fe	1000	2:00	4:25	6	1	1
		Fe	300	2:00	0:00	6	1	1
N-162	WARE	Fe	1000	1:30	2:15	100-400	200	72
		H	1000	2:00	000	150-600	40-60	72
N-164	YU	Fe	1000	4:00	1:05	10-200	20-100	8
N-166	KENNEDY	Fe	1000	6:30	5:20	10-600	20-200	272
		H	1000	3:00	4:55	20-600	40-60	72
N-167	BURMA	Fe	1000	3:00	1:47	50-200	100	20
		Si	1000	2:00	0:00	-	-	-