LEAF

International Symposium on Ultrafast Accelerators for Pulse Radiolysis

June 25-28, 2004

Chemistry Department

Brookhaven National Laboratory

Office of Basic Energy Sciences
U.S. Department of Energy

Advanced Energy Systems

BROOKHAVEN NATIONAL LABORATORY

Tabata Meeting and Satellite Symposia

March 10 and 11, 2000

"New Applications and Facilities of Radiation on Radiation Chemistry, Material Science, And Radiation Biology for Future Radiation Science and Technology"

Osaka University Institute of Scientific and Industrial Research, Osaka

March 13 – 17, 2000

"International Symposium on Prospects for Application of Radiation Towards the 21st Century"

Waseda University, Tokyo

March 20, 2000

"Development of Ultrafast Detection Systems for Radiation Chemistry"

Univ. of Tokyo Nuclear Engineering Research Laboratory in Tokai-Mura

LEAF

The Brookhaven LEAF Pulse Radiolysis Facility

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BROOKHAVEN NATIONAL LABORATORY

Pulse Radiolysis Facility Workshop

Sept 8th & 9th, 1989

Accelerator Design Considerations:

- **10 MeV is sufficient for our purposes.**
- **A pulsewidth of 5 ps is needed to study ion recombination in nonpolar solvents and primary radicals in aqueous solutions. For work involving second-order reactions, 30 ps is adequate.**
- **The vault and beam transport system should accommodate several experimental stations.**

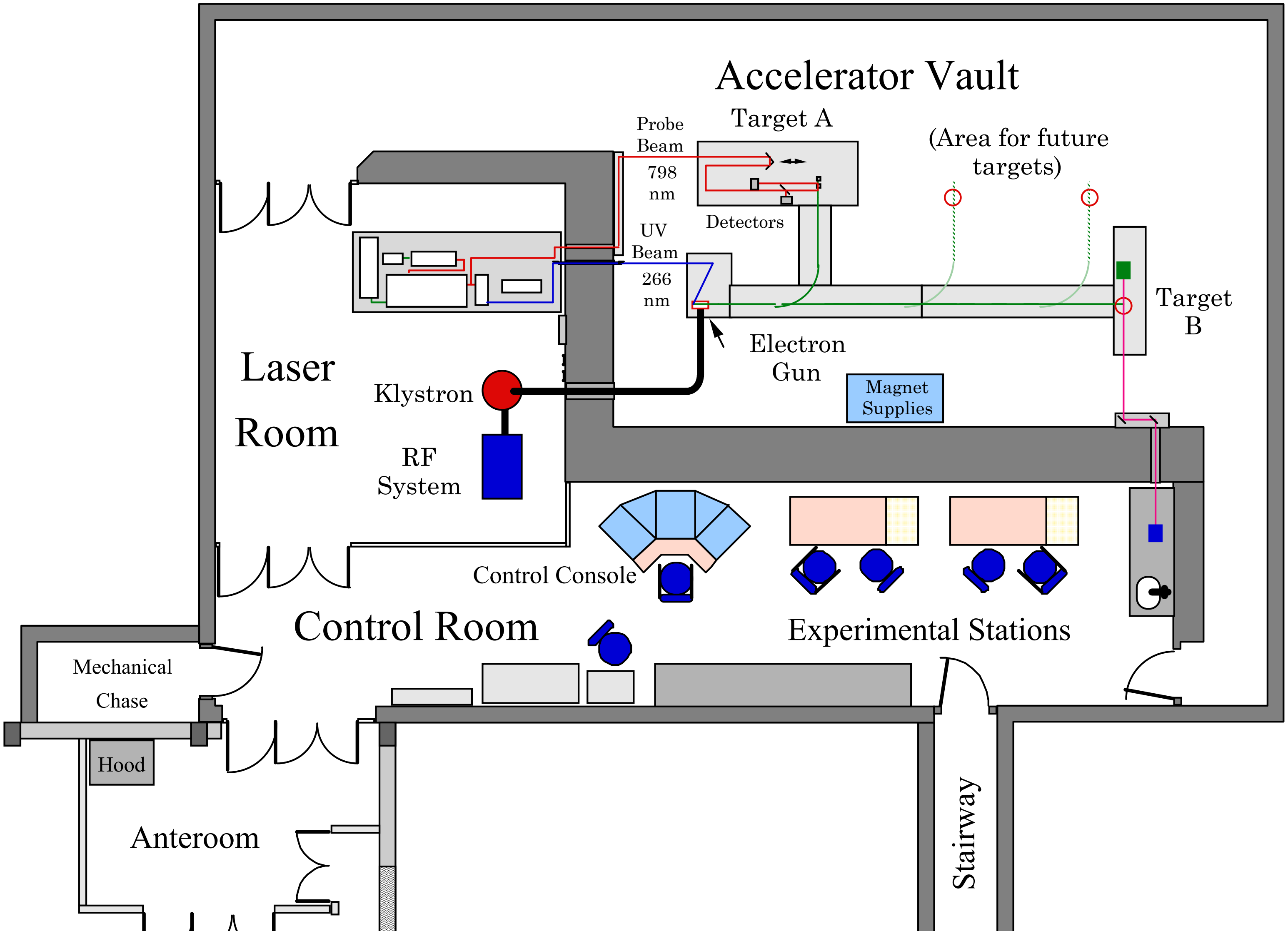
Techniques:

- **Picosecond-synchronized laser and electron pulses**
  - **Pulse / probe - laser or continuum detection at very short times**
  - **Pulse / pump / probe - laser excitation of transients**
- **Transient absorption**
  - **30 ps – 100 s +**
  - **Minimize sample volume.**
  - **Improve sensitivity.**
  - **Flow systems.**
  - **Optical multichannel analyzer, streak camera, fast detectors.**
- **Pressure variation: 1-2000 atmospheres**
  - **Quantitative absorbance values and bigger signals for more accurate high pressure work.**
- **DC conductivity**
  - **Ion recombination and electron mobility in nonpolar solvents.**

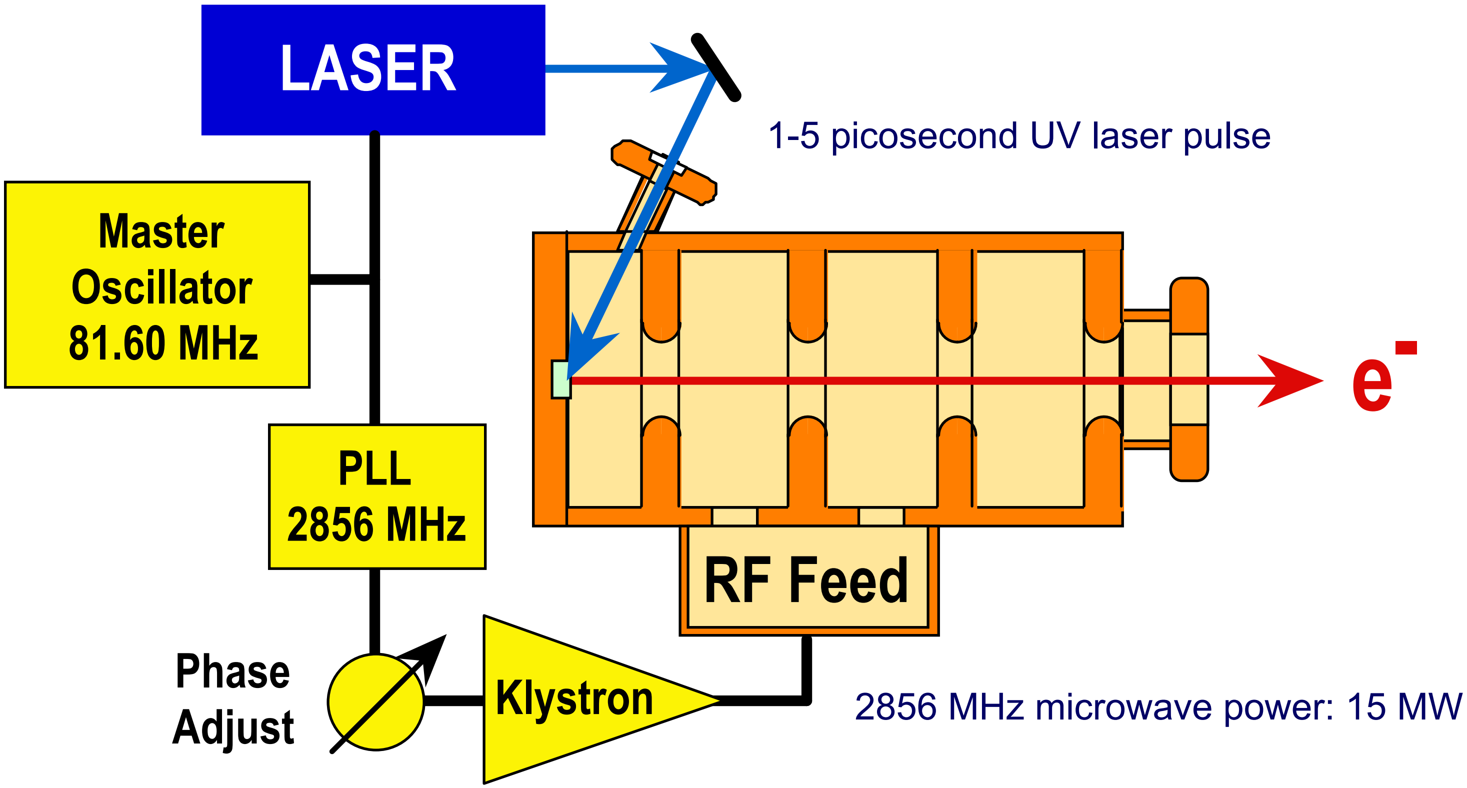
Collaborative mode strongly preferred.

Construction: 1994 Routine Operations: 1998

LEAF Facility Layout



Laser-RF Synchronization at LEAF

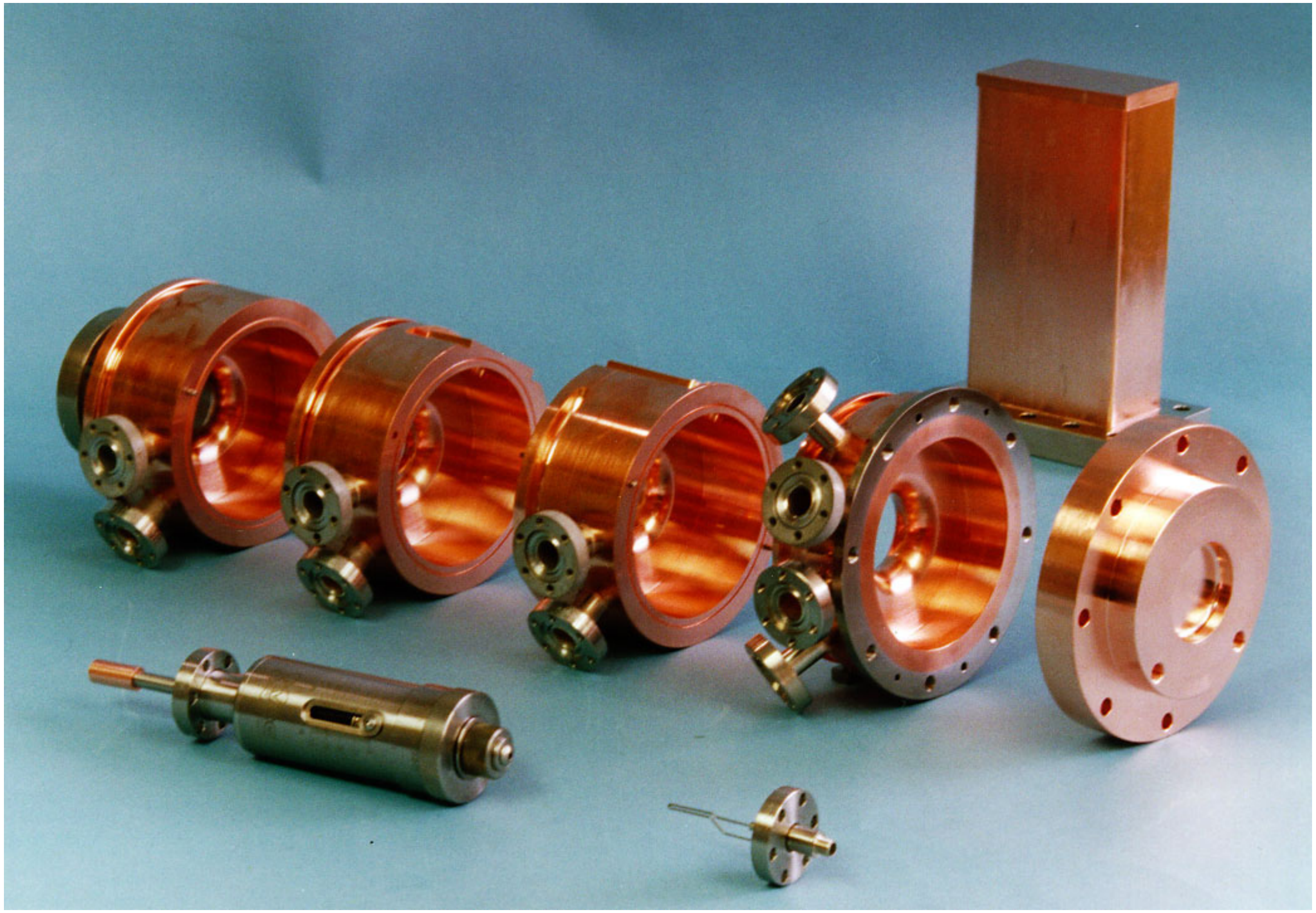


One-piece 3.5-cell design developed by BNL ATF and Grumman (Gun II and CIRFEL).

Photoelectrons generated at Mg cathode by a UV laser pulse are accelerated to 9 MeV by high fields (80 MV/m) in the **30-cm long** resonant-cavity structure.

Injector and booster are one unit. Simple to operate, less flexible.

LEAF Accelerator (before assembly)



Picture credit: Advanced Energy Systems

LEAF Accelerator (Installed)

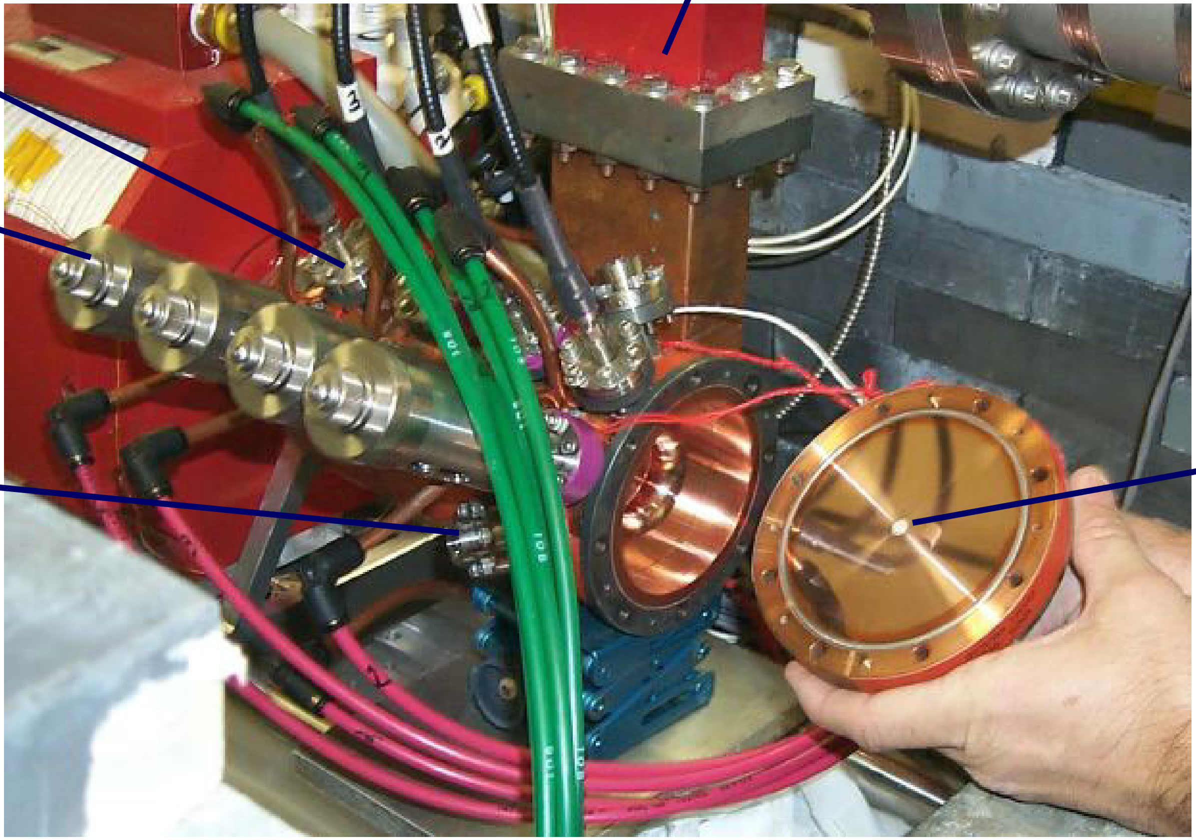
RF Waveguide (2.856 GHz, 15MW)

RF Pickup Loops

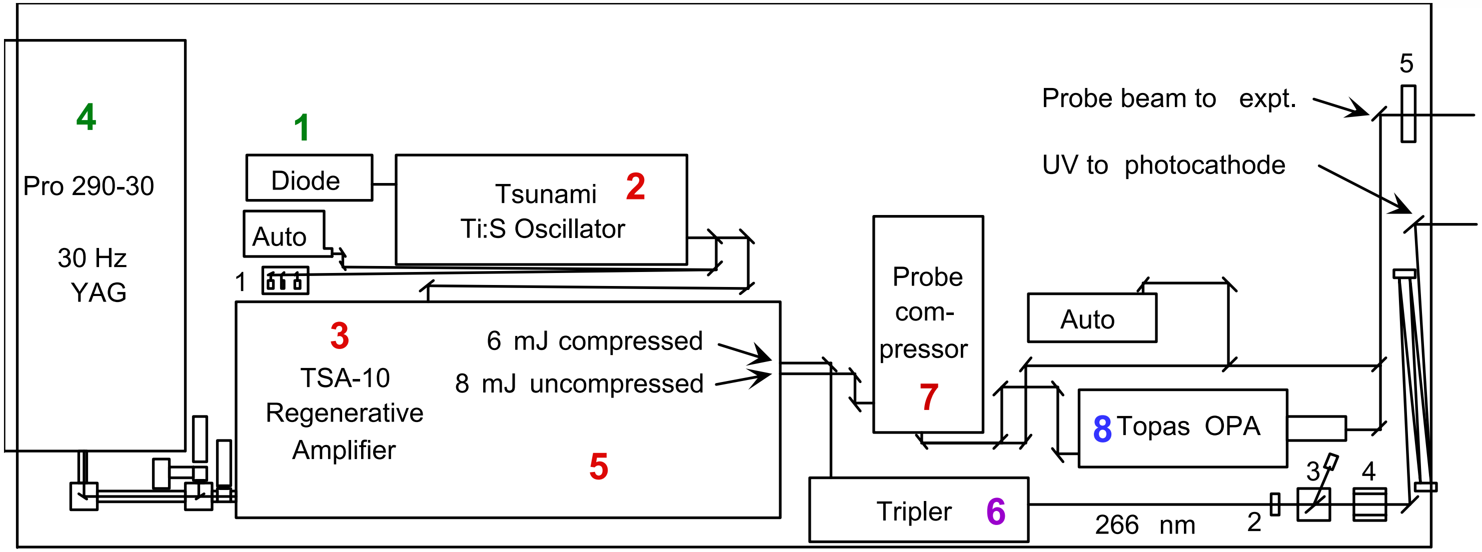
Tuning Slug Actuators

Laser Window

Mg Cathode



LEAF Laser System



1) Diode-pumped Nd:YVO_4 laser, 5 Watts, 532 nm, pumps picosecond Ti:Sapphire laser.

2) Ti:Sapphire oscillator produces ~50 fs pulses, ~ 7 nJ energy, 798 nm, at 81.60 MHz.

3) Pulse stretcher stretches oscillator pulse to > 200 ps, then injects the pulse into the Ti:Sapphire regenerative amplifier.

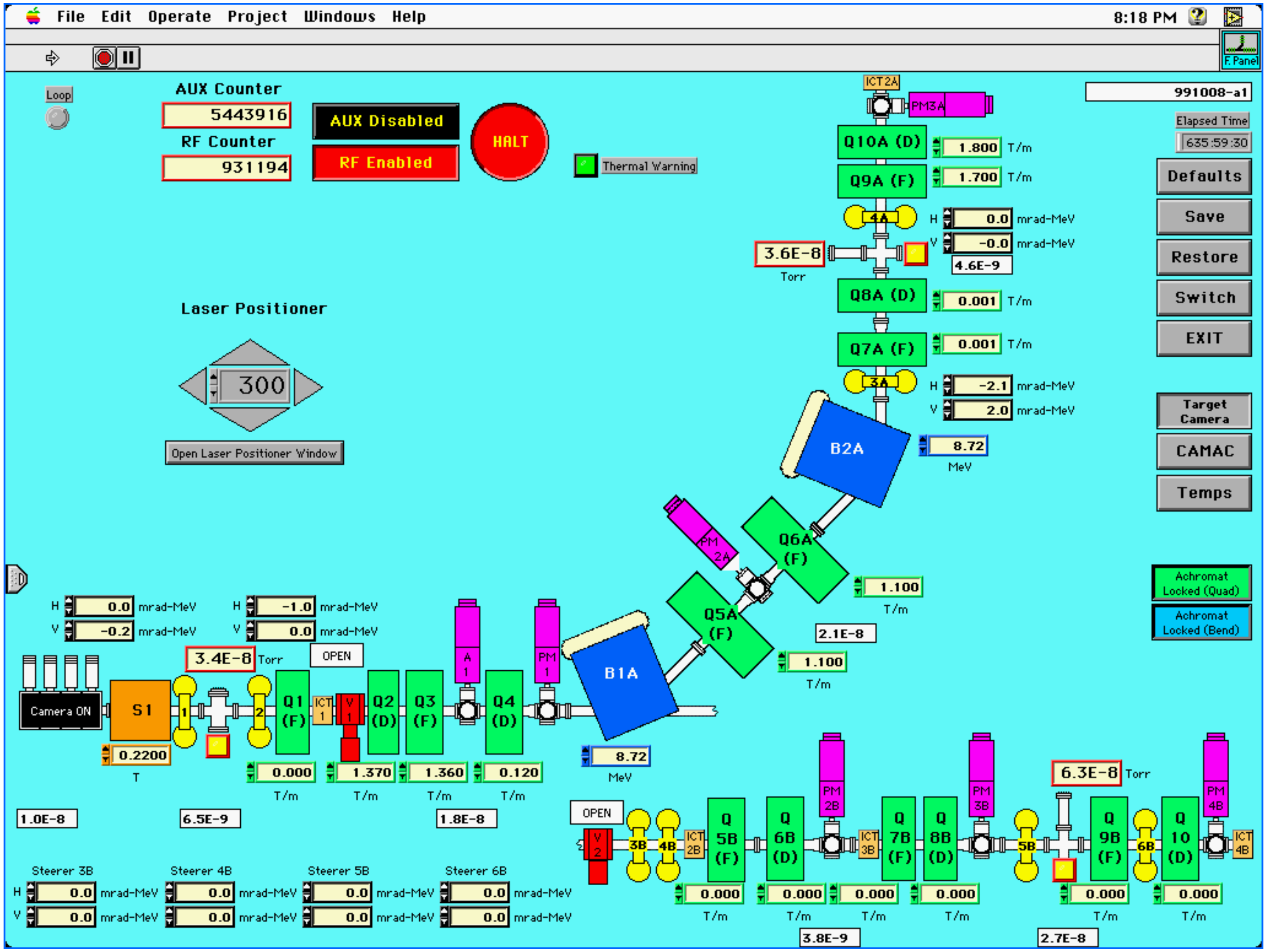
4) Simultaneously, the doubled, Q-switched Nd-YAG laser pumps the Ti:Sapphire regen.

5) Stretched ~200 ps pulse is amplified to ~12 mJ level. Half is compressed to 1-3 ps for THG

6) 1-3 ps pulse is frequency tripled to 266 nm (≤ 0.4 mJ) for excitation of Mg photocathode.

7) Half of regen output compressed to ~100 fs for use as probe or TOPAS OPA pump (8)

LEAF Beam Transport Control



Control:
LabVIEW on
Mac clone
GPIB, CAMAC
All-purpose card

Magnet P/S
Pop-up and valve
actuators
Vacuum pumps
and gauges
Cameras
UV laser power
and position

Save and restore
settings.

Diagnostics: Pop-up OTR beam profilers, Integrating current transformers.

Operation and Performance

Repetition rates: Laser: 10 or 30 Hz

Modulator: Digitizer experiments at 1 Hz, pulse probe higher (5, 10, 15 Hz)

Gun temperature control, tuning settings differ between modes.

Pulse-widths: Target A (pulse-probe): ≥ 7 ps, Target B (digitizer) < 120 ps (30)

Rise-time of e^-_{aq} is diagnostic for Target A transport tune-up.

Charge/pulse, dose: Target A: 2-8 nC, Target B: ≤ 11 nC (9 is standard)

Recent P-P data: 4.5 nC gave 13 μM e^-_{aq} at 20 ps in 5 mm cell.

Digitizer: 9.7 nC gives 26 Gy (KSCN).

Mg cathode emission: Depends on history - if surface is not very clean, UV laser pulses degrade efficiency on seconds timescale.

Vacuum: ≤ 1.5 x 10^{-8} torr (mid-nines near gun), Viton O-rings in some places.

SRS residual gas analyzer (M/Z ≤ 200) on line. (SF_5: 127)

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U.S. Department of Energy
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Division of Chemical Sciences