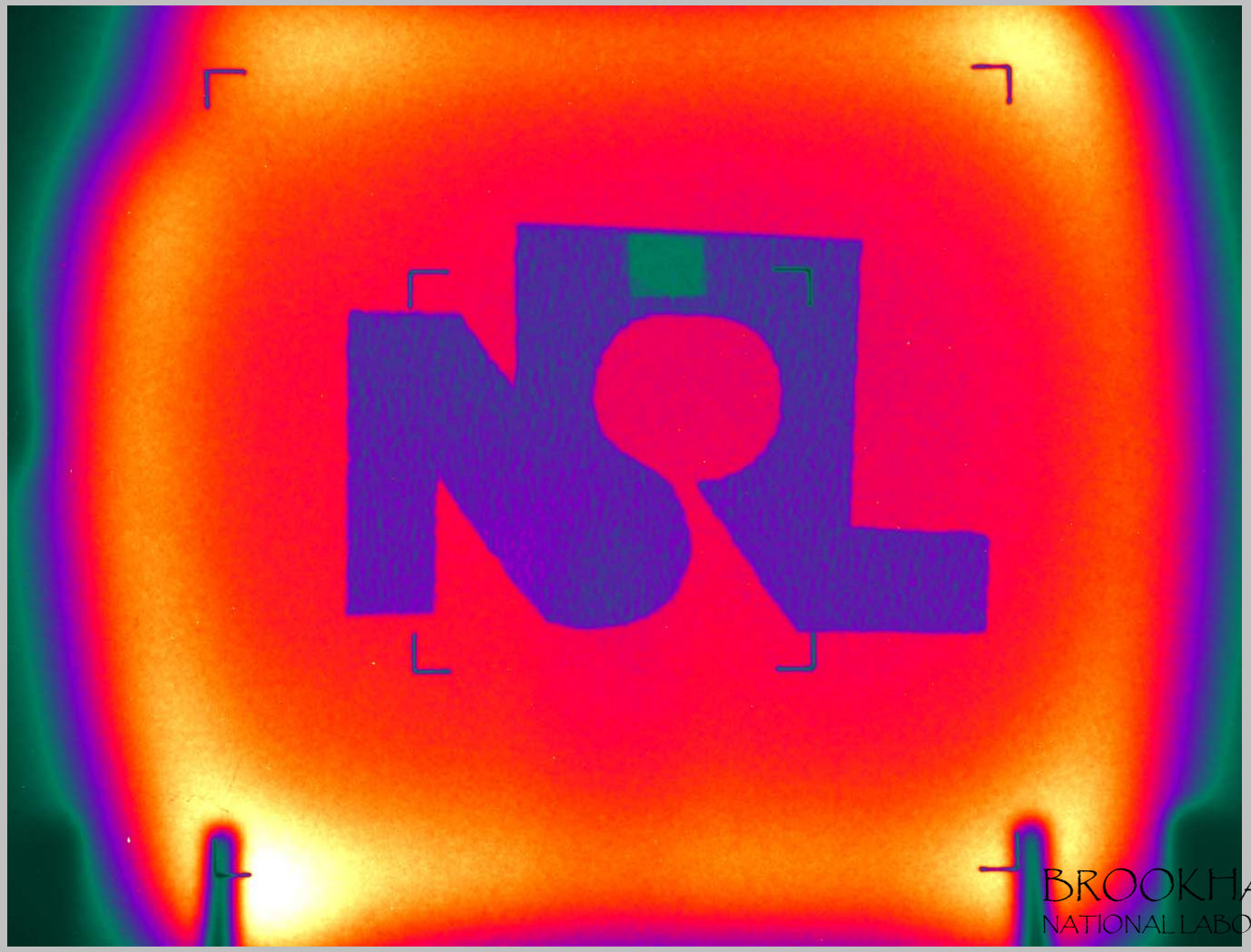
NSRL Operations Overview

NSRL-06A to NSRL-06C

A. Rusek



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NSRL Operations Overview
NSRL-06A to NSRL-06C

- NASA Items of Interest (from SOW)
- Operations
- New Developments
  - Methods and Techniques, Infrastructure
- Beam/Dosimetry Development Time
- Future Developments and Directions

NASA Items of Interest

SOW:

- Beam to be developed in 2006
  - H at 2500 MeV
  - O at 150 MeV/n
  - C at 1000 MeV/n

Runs 06A – 06C:

- Beam developed/used in 2006
  - ✓ H at 200 – 2500 MeV
  - ✓ O at 150 – 1000 MeV/n
  - ✓ C at 300 – 1000 MeV/n

  and much more.

Energy changes should no longer be considered "development".

NASA Items of Interest

SOW:

- End of Run Report to be delivered no more than 1 month after end of run.

Runs 06A – 06C:

- ✓ NSRL-06A report: 1 month
- ✓ NSRL-06B report: 1 month
- ✓ NSRL-06C report: 1 month

Effort coordinated by M.Sivertz, who will report later on.

NASA Items of Interest

SOW:

- ❖ Infrastructure Developments:
  - Solar Particle Event Simulator

Runs 06A – 06C:

- ❖ Infrastructure Developments:
  - ✓ Solar Particle Event Simulator

We are ready to commission the technique during NSRL-07A. It will be labor intensive in the beginning, but this will help guide us towards automation. There will be plenty of tweaking, no doubt. I will revisit later in the talk.

Operations: The Crew
NSRL-06A to NSRL-06C

- Adam Rusek, Ph.D. (physicist)
  - ✓ Liaison Physicist, dosimetry, physics, instrumentation, beam line.
- I-Hung Chiang, Ph.D. (physicist)
  - ✓ Dosimetry, physics, instrumentation.
- Mike Sivertz. Ph.D. (physicist)
  - ✓ Physics, physics instrumentation. Dosimetry
- Travis Shrey, B.S. (operations coordinator)
  - ✓ Dosimetry.

- Dave Phillips M.S. (engineer)
  - ✓ infrastructure
- Charlie Pearson B.S. (engineer)
  - ✓ Instrumentation, gadgetry.

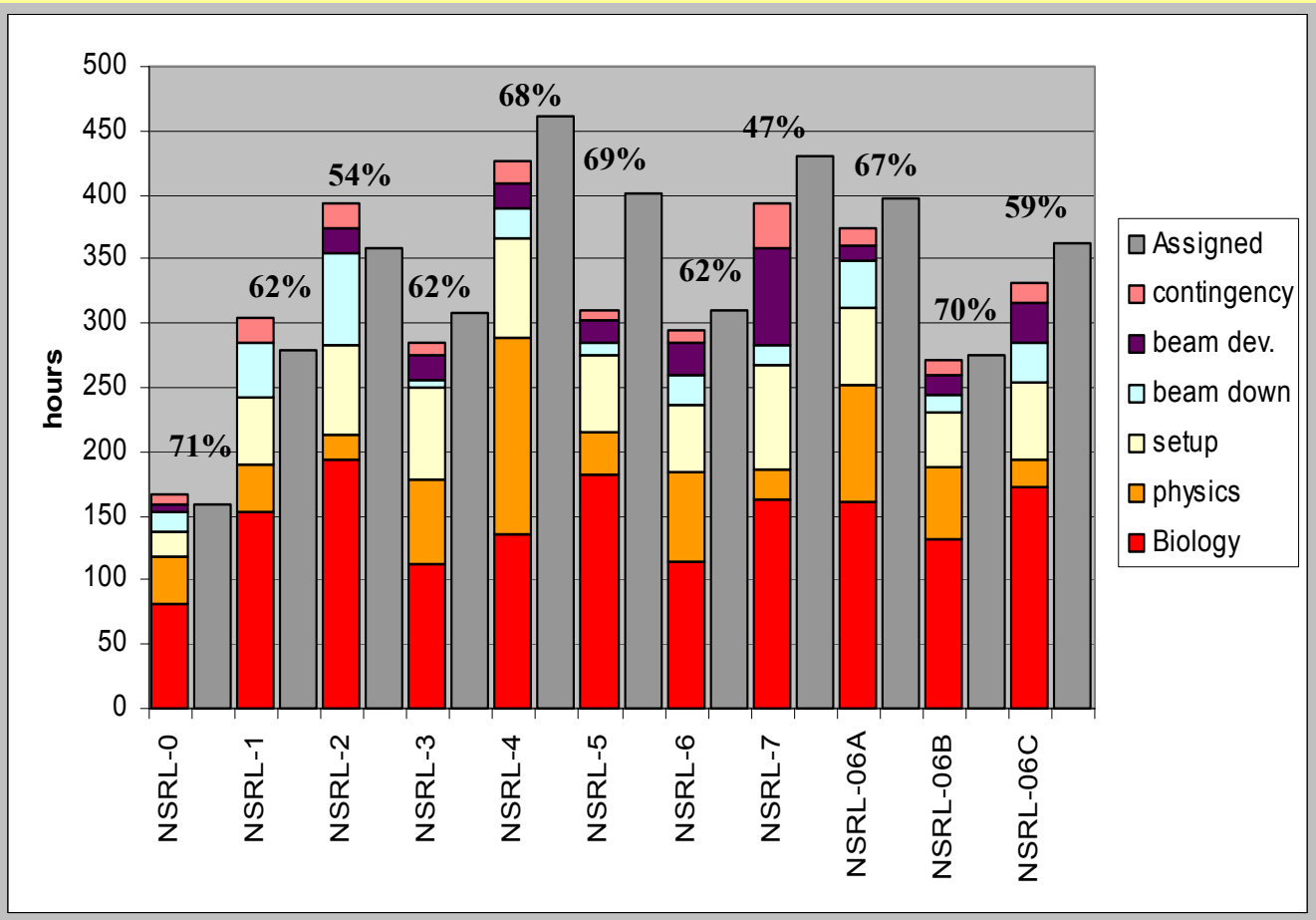
And many more……

Kristine Ferrone had left BNL for more schooling.
She has just landed a job with NASA as a Mission Support Scientist.

Operations

- NSRL continues to run very smoothly.
- We have around 1 year worth of running under our belt.
- We have been enjoying very good cooperation between all departments and groups during NSRL operations, including Medical, Biology, CA (MCR, Tandem, Linac, Access Control, Instrumentation,Training, Safety, HP etc.)

Operations
NSRL Time Usage



% science shown

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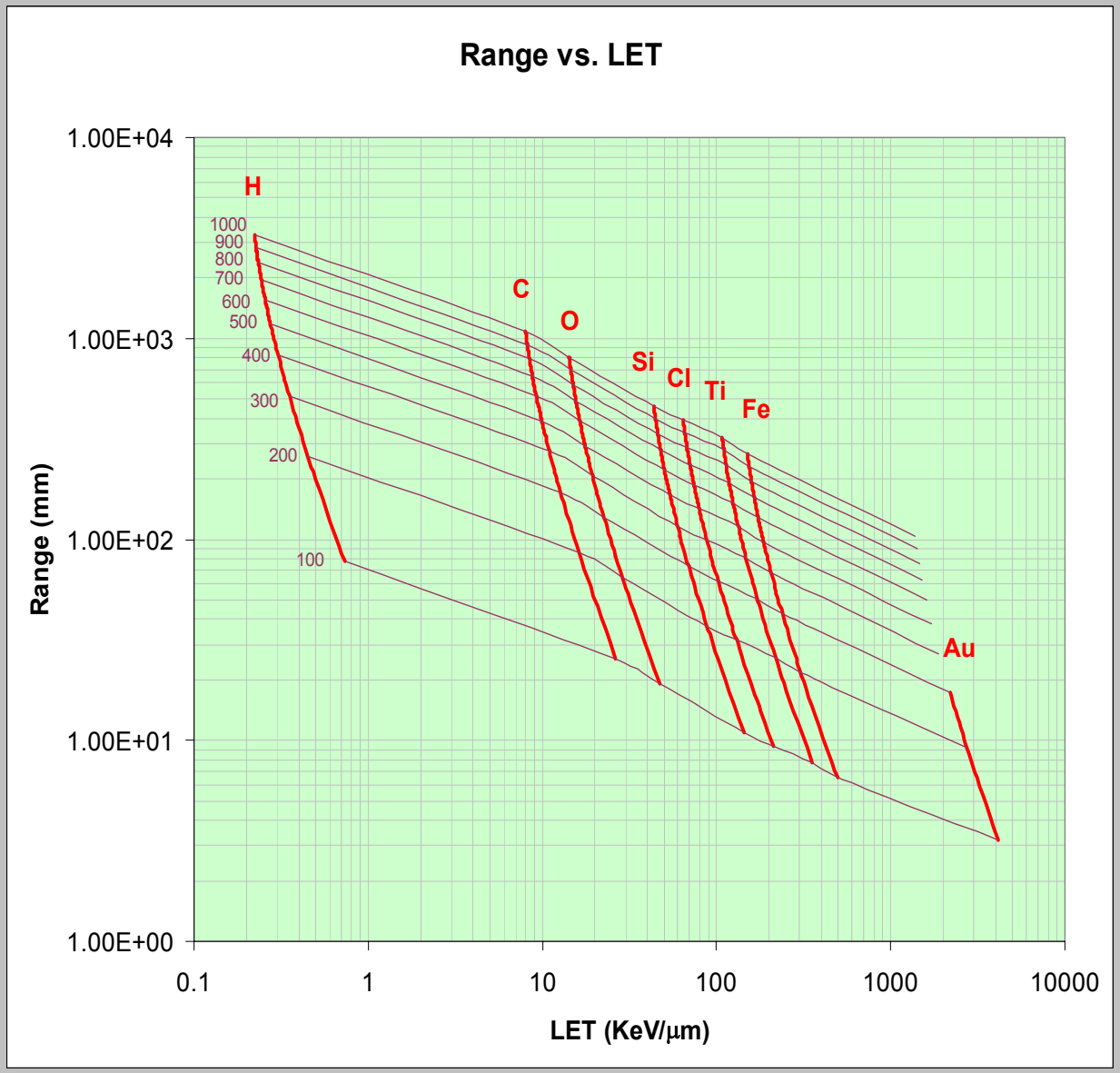
Operations

Ions and Energies used so far

Ion	Energy (MeV/n)	Intensity
p	200 - 1000	3.4×10^{10}
C	290	1.2×10^{10}
O	600 - 1000	4.0×10^{9}
Si	300 - 1000	3.0×10^{9}
Cl	500 - 1000	2.0×10^{9}
Ti	1100	8.0×10^{8}
Fe	90 - 1000	2.0×10^{9}

LET and range for several ion species

- LET coverage from 8 – 500 KeV/μm, but
- Some of it is with low range beam.



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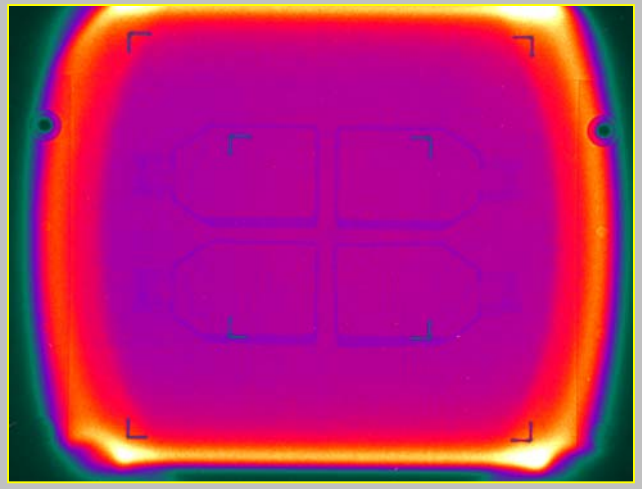
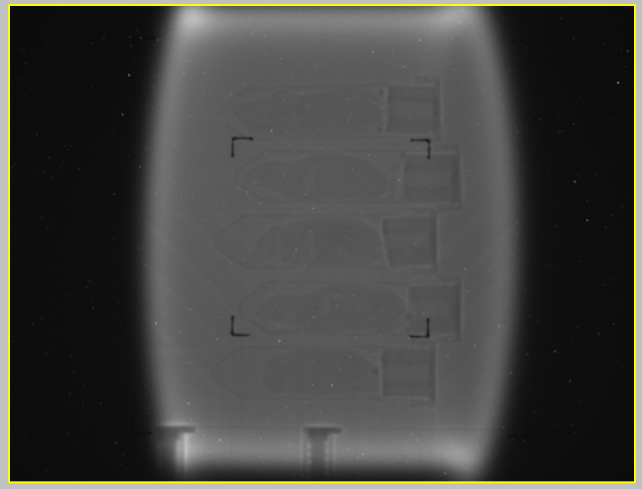
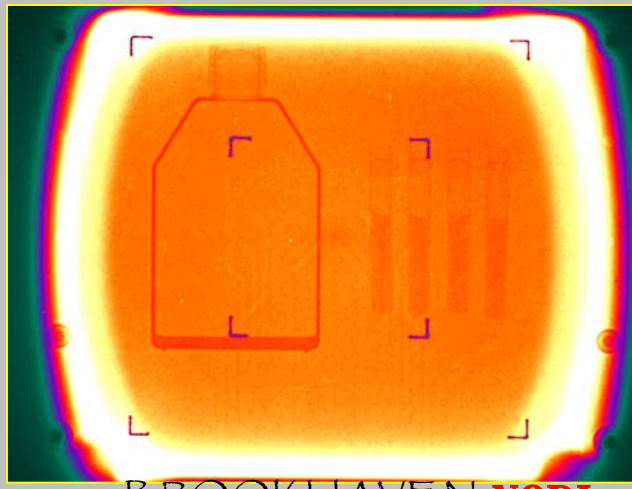
New Devices and Techniques

Foam Target Holders

- Easy to produce: with a short lead time, about 30 minutes, we can produce a pair of custom holders.
- Easy to load.
- Invisible to beam. This is important for proton beams.







New Devices and Techniques

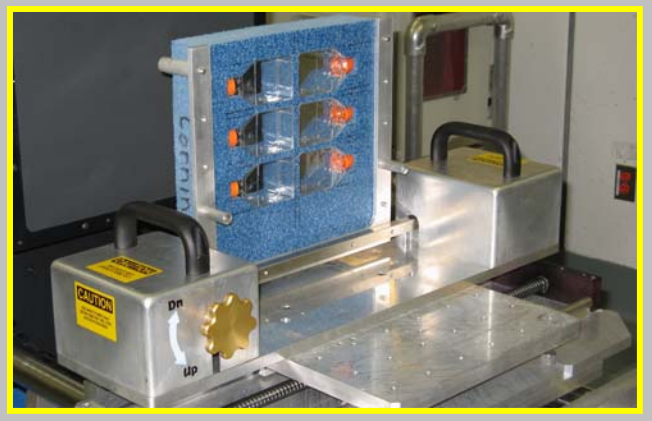
Foam Target Holders

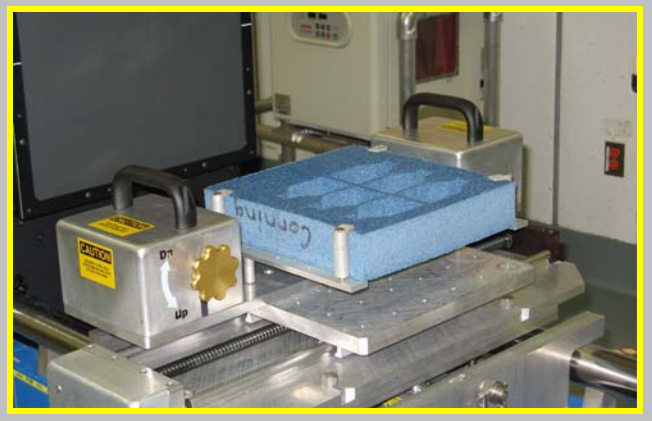
- The “factory”.

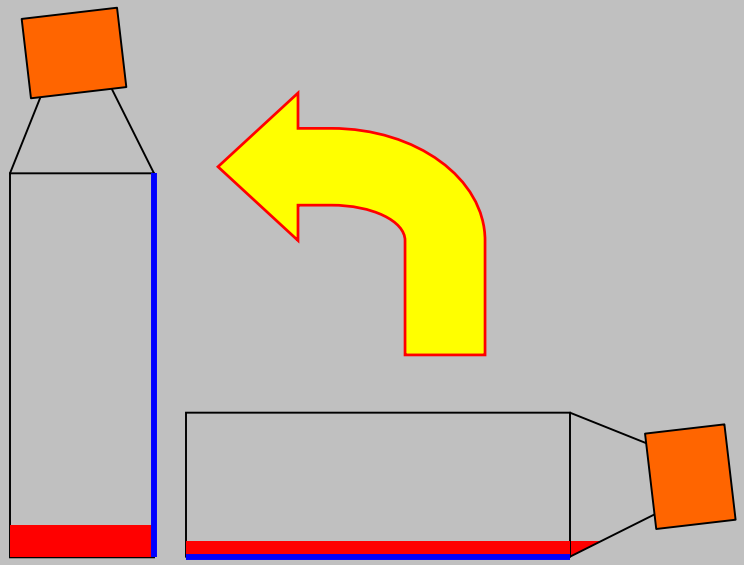
New Devices and Techniques

Target Flipper (Polly Flipper)

- For work with cells attached to flask wall.
- Remote-controllable.
- A user favorite.



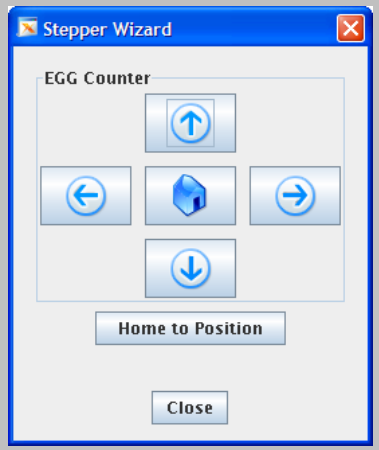


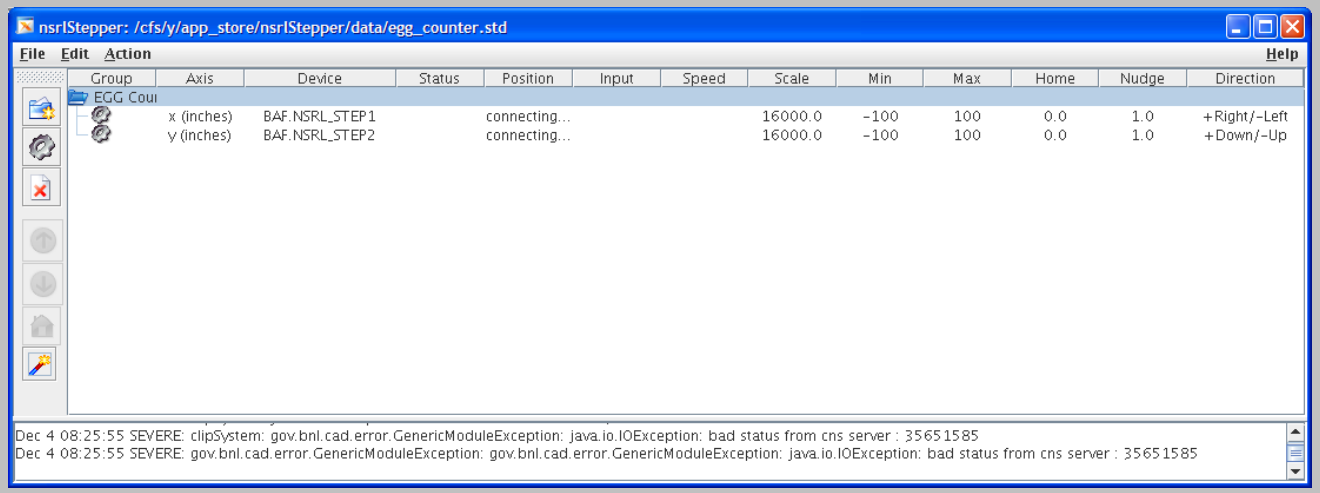


New Devices and Techniques

Stepper Motor Drivers and GUI

- Up to 6 motors, all controllable from the GUI.
- Easy to setup and customize to individual user's needs. (choice of direction of motion, units of measure, preset step size)
- Currently we have an EG&G counter translator, a rotational stage and a 4 ft translation stage.
- Other possibilities open.





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New Devices and Techniques

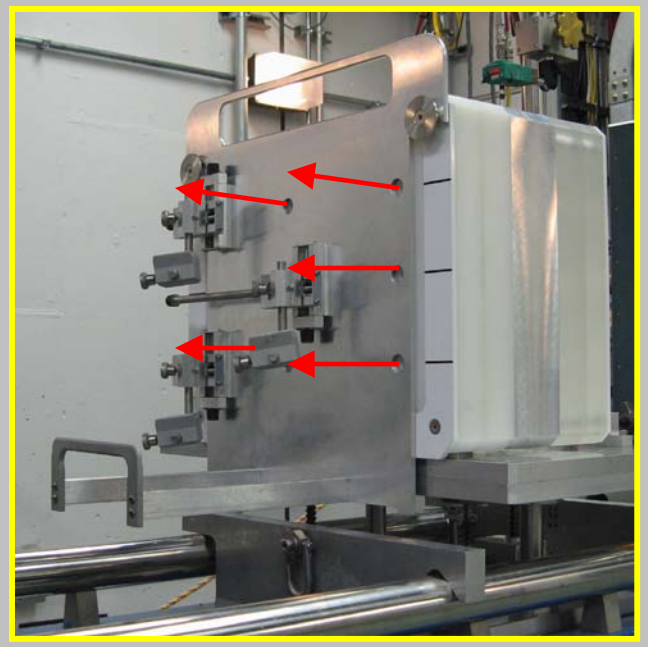
EG&G Counter Translator

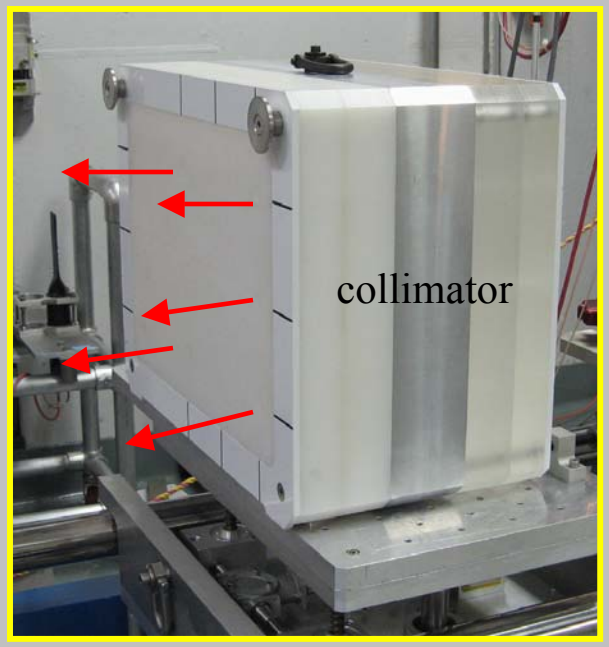
- Saves time and reduces target area exposure.
- Operations.
- Measurements.

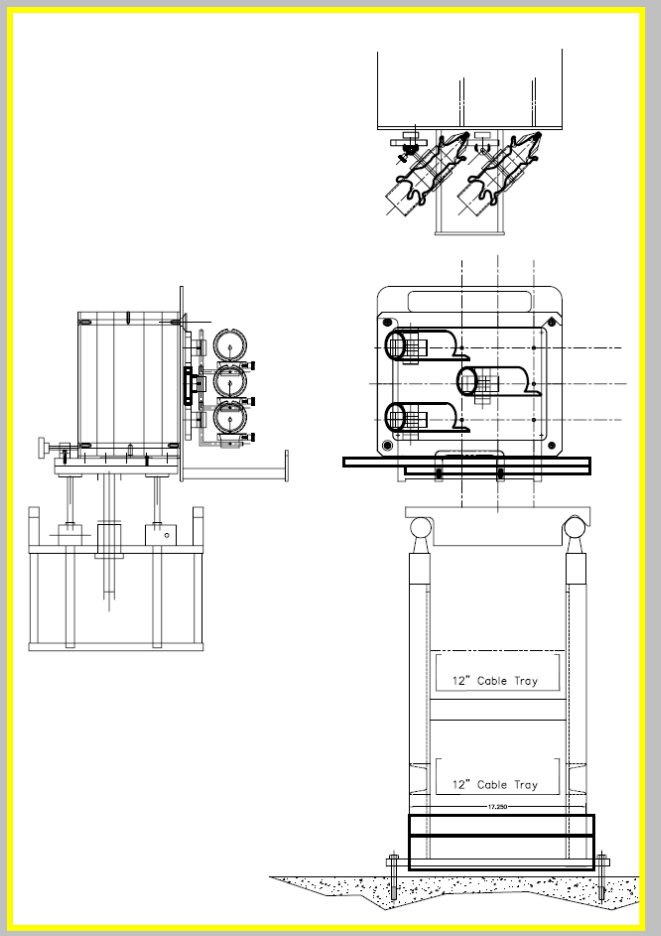
New Devices and Techniques

Single Eye Exposure

- Right eyes of three rats at a time.







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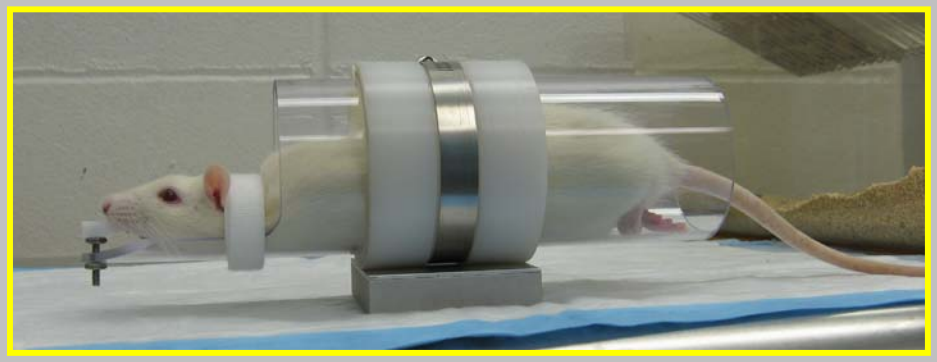
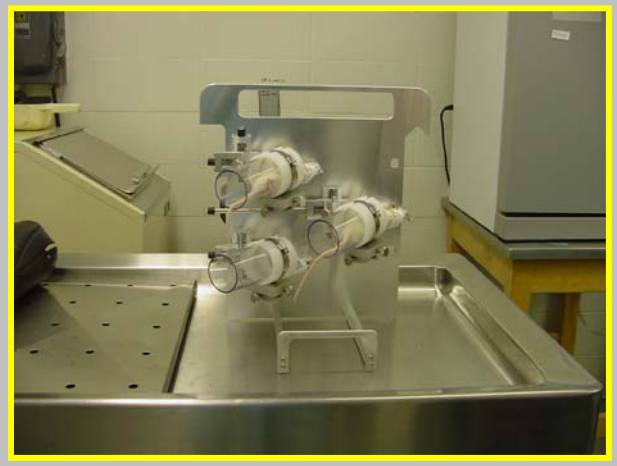
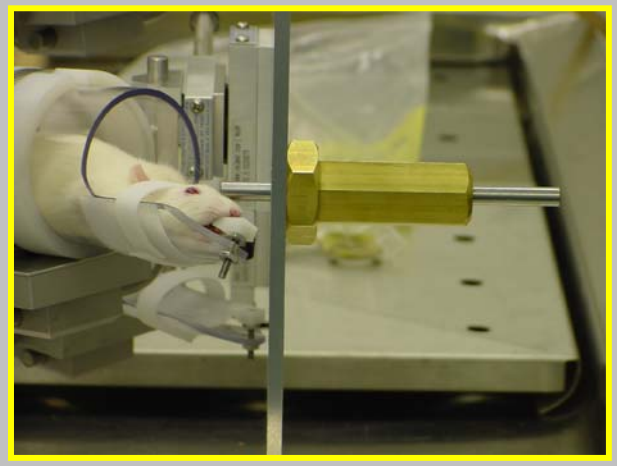
New Devices and Techniques

Single Eye Exposure

- Right eyes of three rats at a time.
- Two plates, 9 tubes, for streamlined operation.
- Lots of flexibility, easy alignment.







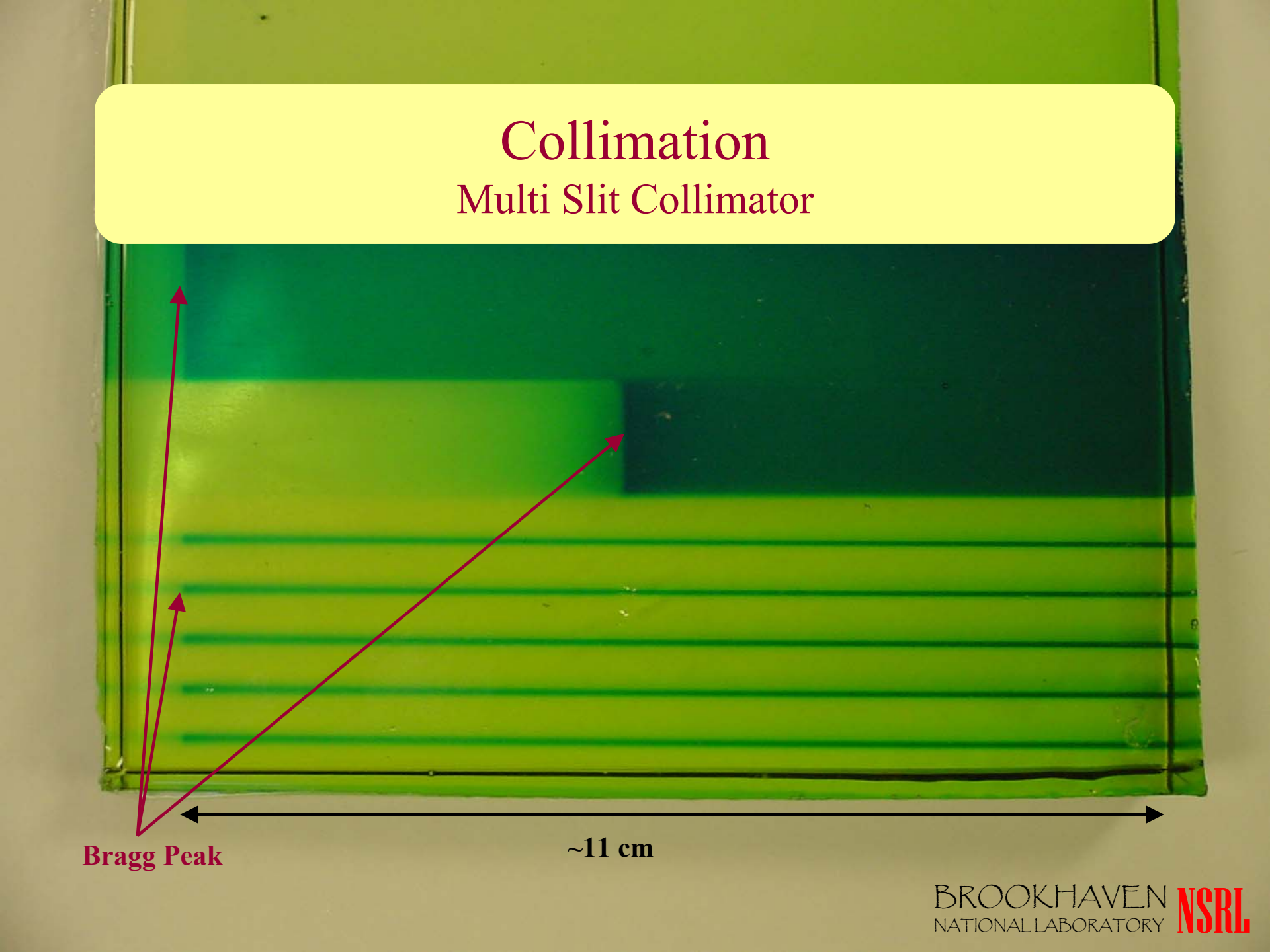
Beam/Dosimetry Development Time

Four Hours per Week During the Run

- Fragmentation
- Time of Flight
- Collimation
- Shielding
- Dose distribution
- Special beams
- Scintillator/ion chamber calibration
  - ✓ Scintillator overlap with dosimetry chambers, EG&G counter and chamber with gain.
  - ✓ Possibility of using a chamber with gain for dosimetry at extremely low doses.
- Incubator test

Collimation

Multi Slit Collimator



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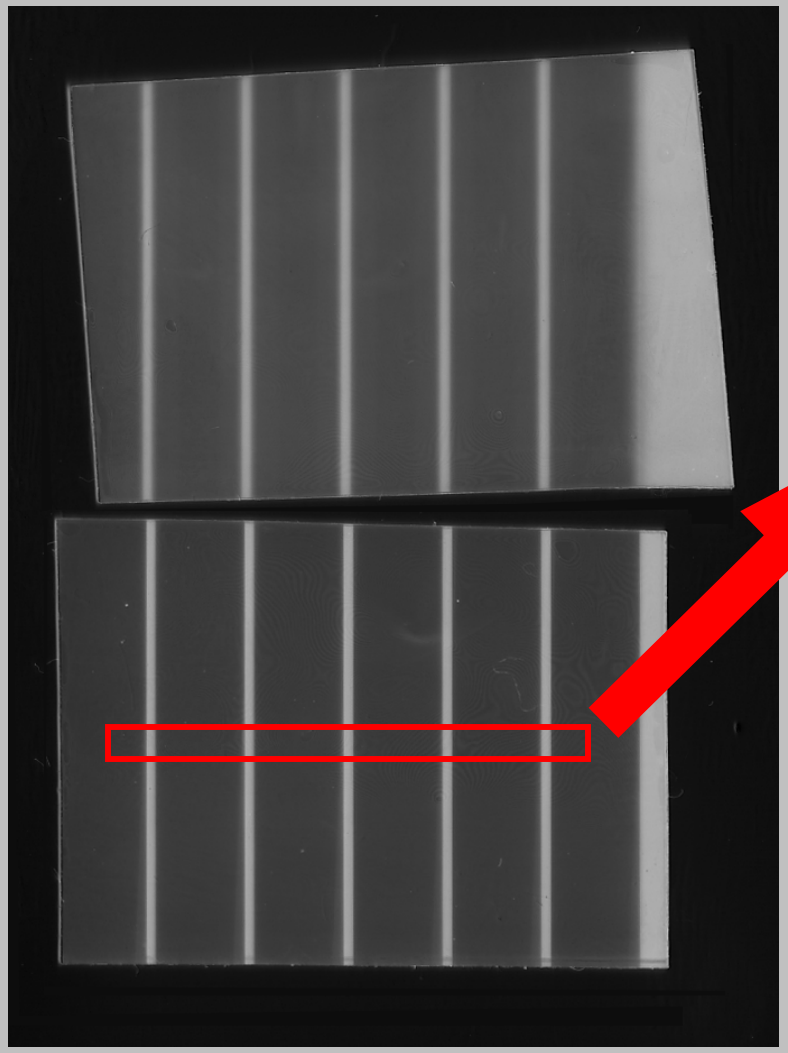
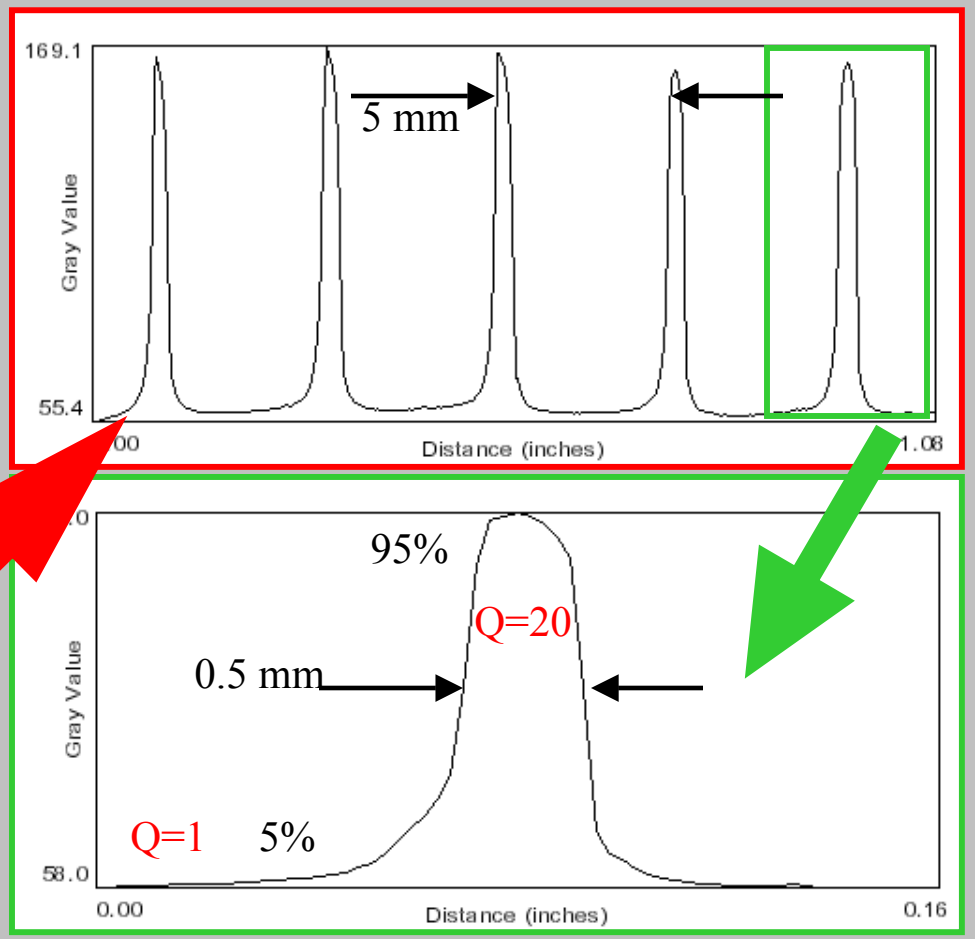
Collimation
Multi Slit Collimator





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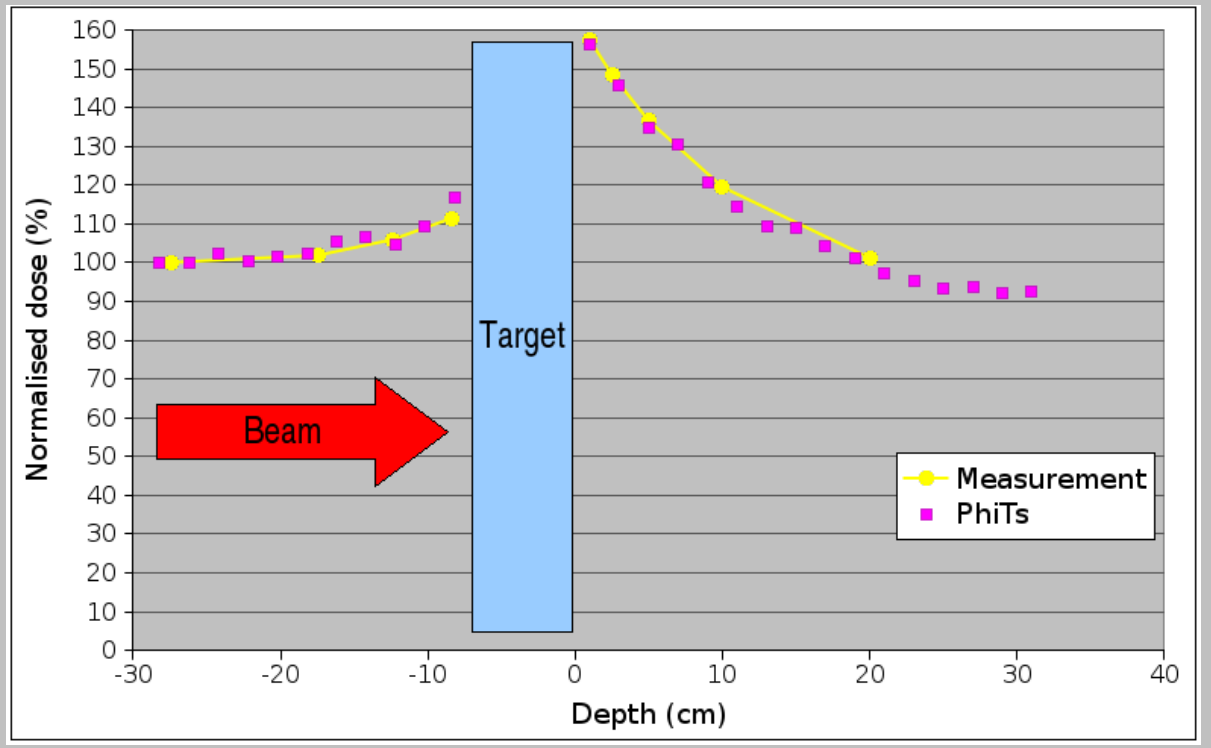
Shielding Measurements
protons on an aluminum shield

- 1000 MeV protons on a 20 gr/cm^2 aluminum shield.
- Measurement done with EG&G counter.
- Simulation matches very well
- Excess dose shown to be due to secondary protons mainly.



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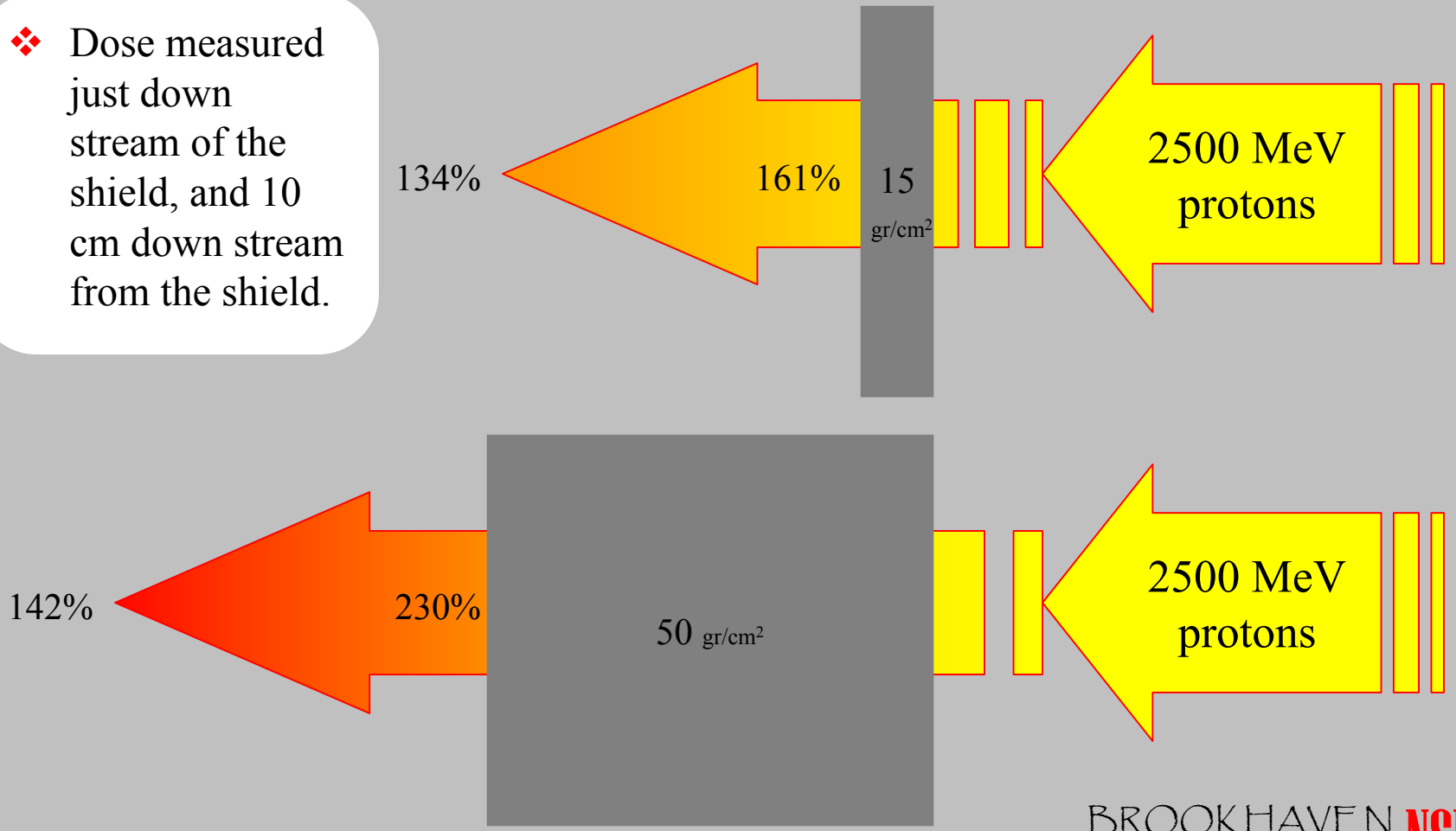
Dose Behind Aluminum Shielding

- Dose measured just down stream of the shield, and 10 cm down stream from the shield.



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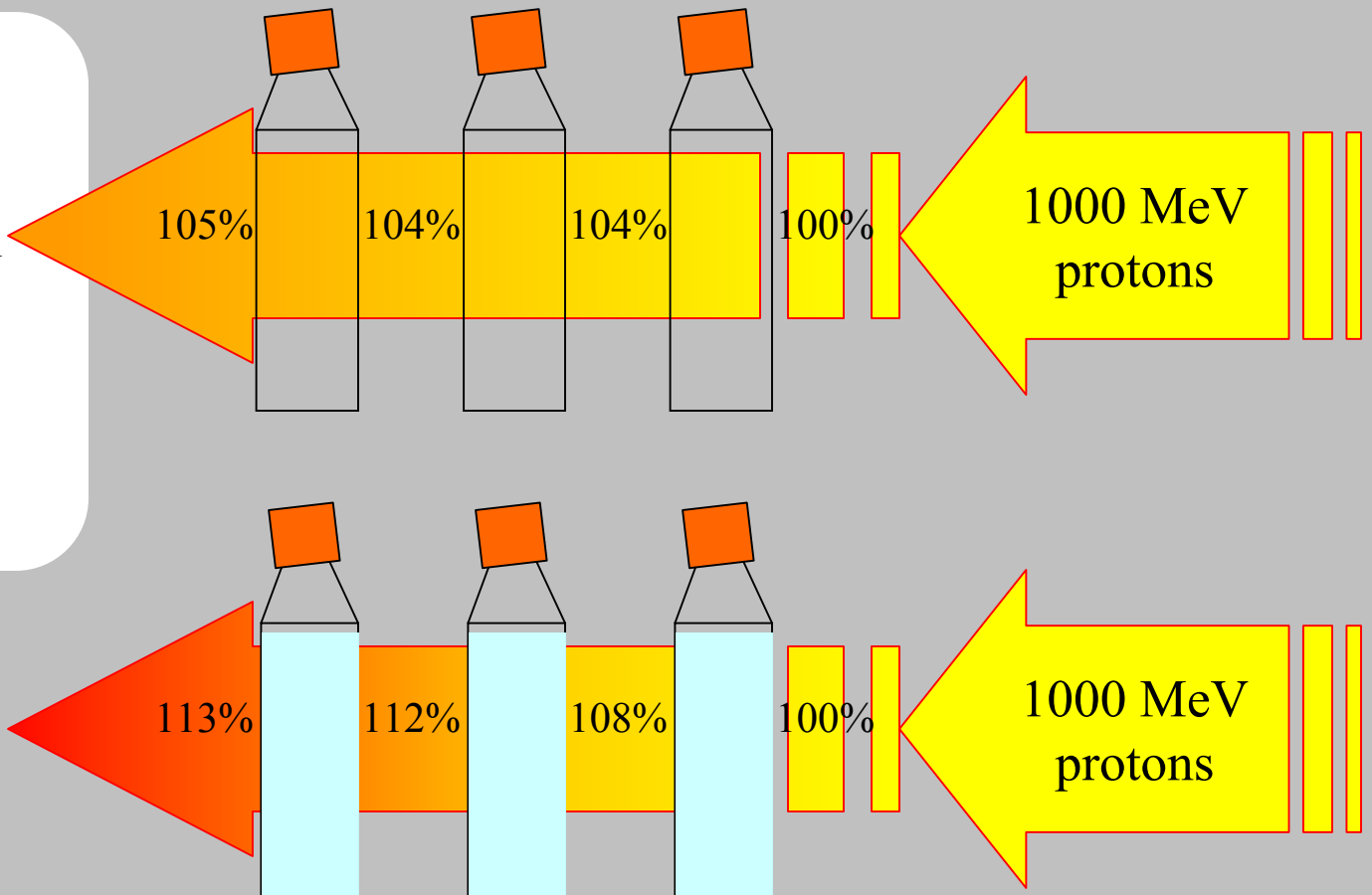
Dose Behind T25 flasks, with and without medium

- Information to help users make decisions on whether or not to stack their samples



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Dose Near the Lift Table

- The dose increase due to scattering is small with Fe beam. It is much larger with protons

1.0” - 100.20%

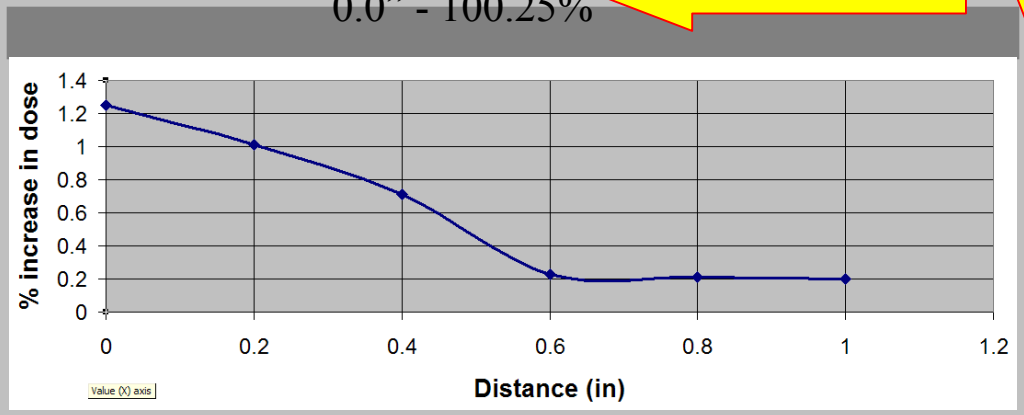
0.8” - 100.21%

0.6” - 100.23%

0.4” - 100.71%

0.2” - 101.01%

0.0” - 100.25%



1000 MeV/n Fe

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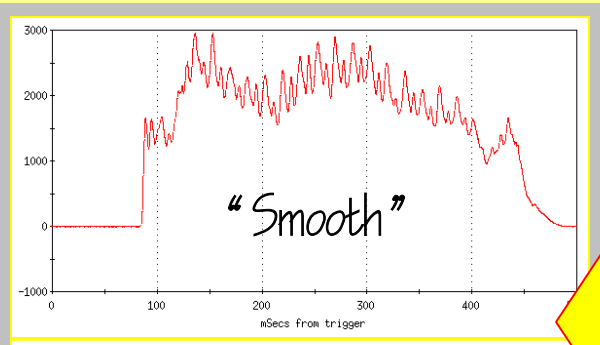
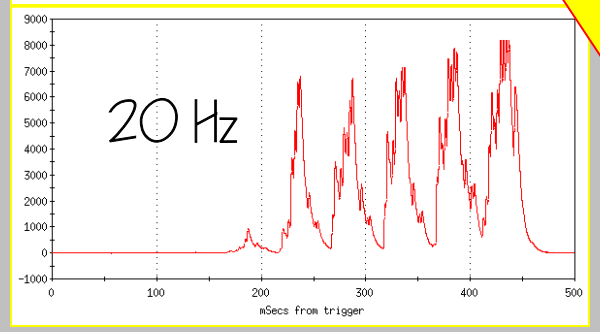
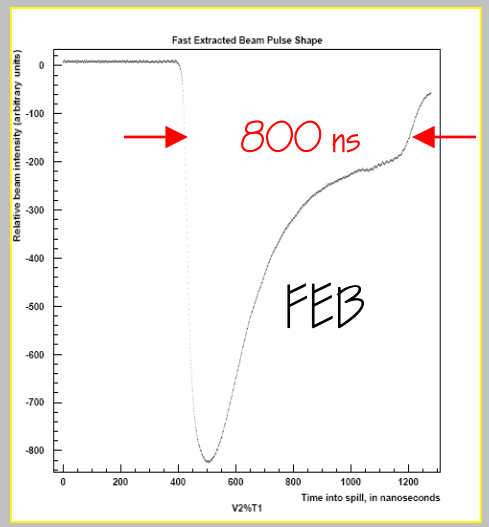
Special Beams

- Time-structured beams
  - ✓ "smooth" beam
  - ✓ 10-60Hz beam
- Fast-extracted beam
  - ✓ Beam extracted in one booster cycle, in about 800 ns.

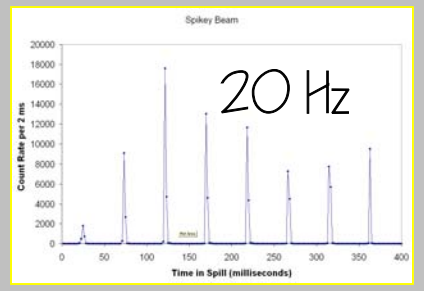


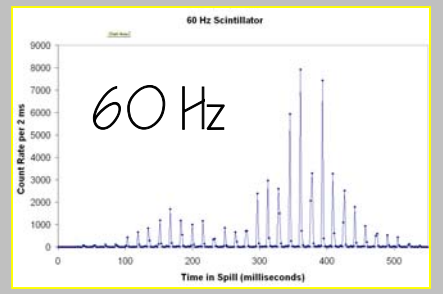


Ion Chamber, C-A Readout



Scintillator, NSRL DAQ





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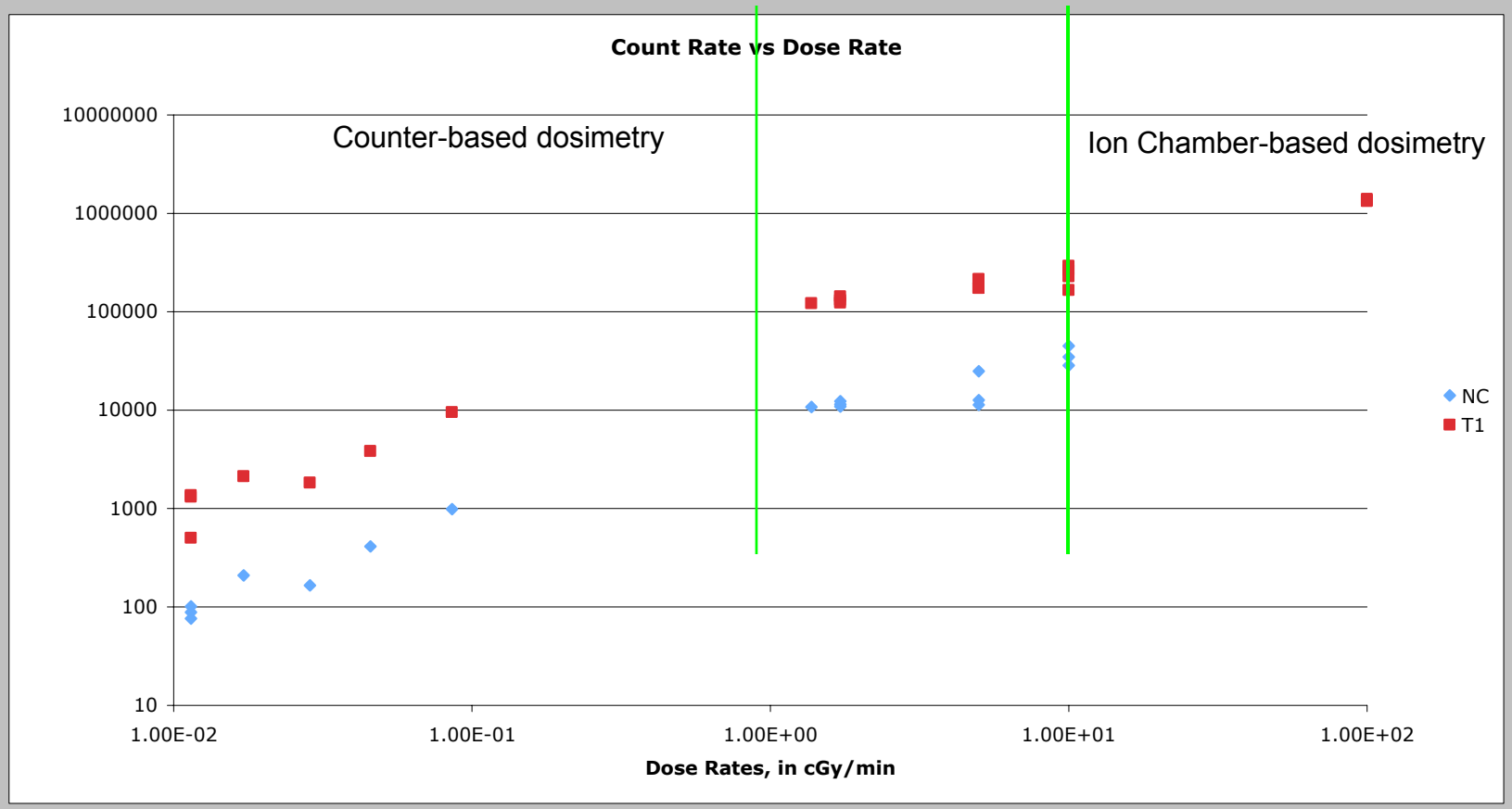
Smooth transition between PMT/Scintillator-based dosimetry for low dose rate work, and Ion Chamber-based dosimetry for high dose rate work. The horizontal axis is the dose as measured with a thin scintillator in the beam for doses less than 10 cGy/min, and with an Ion Chamber for dose rates above 10 cGy/min. The vertical axis shows the counting rate in two detectors: Red squares are for a small off-axis scintillator, Blue diamonds are for a thermal neutron counter located in the middle of the labyrinth. Both detectors show continuity across the transition from one dosimetry technique to another.



protons at 1000 MeV

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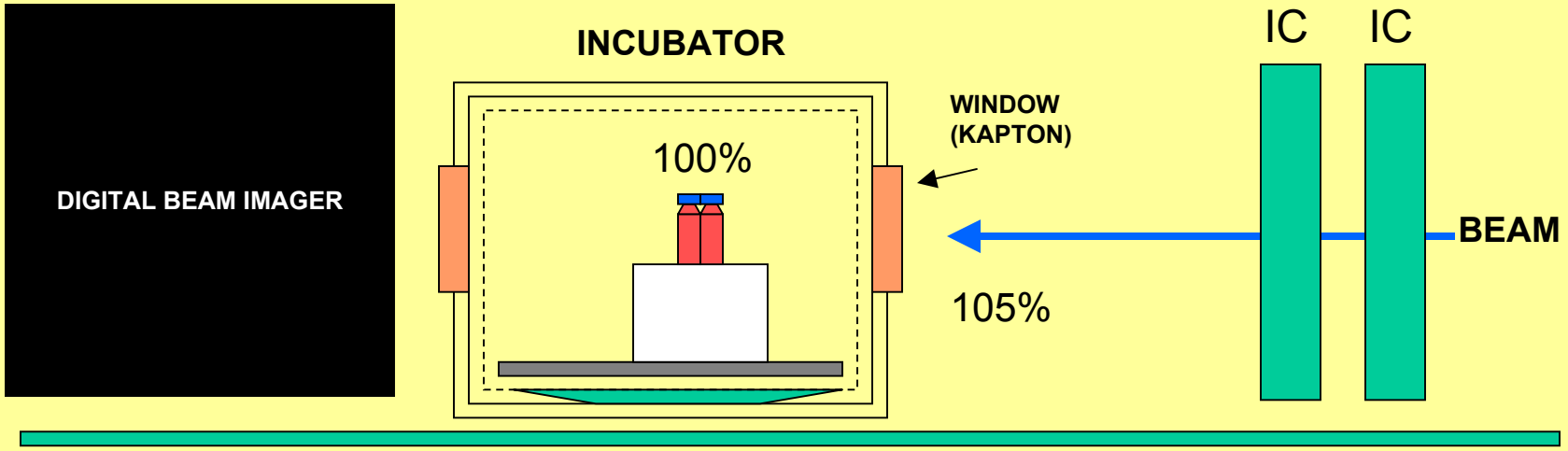
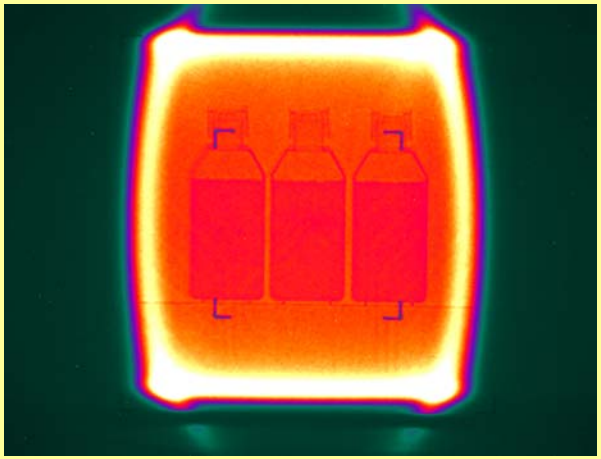
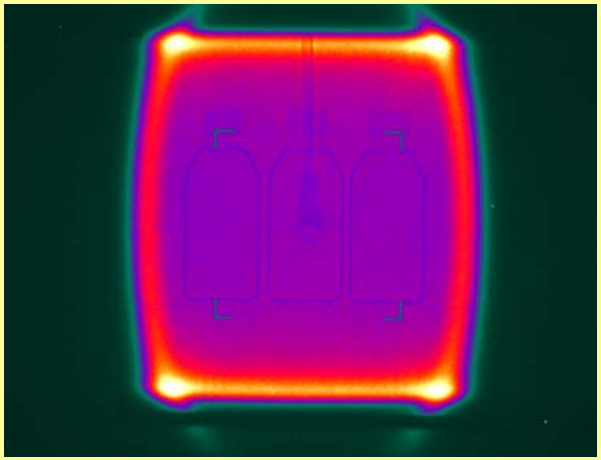
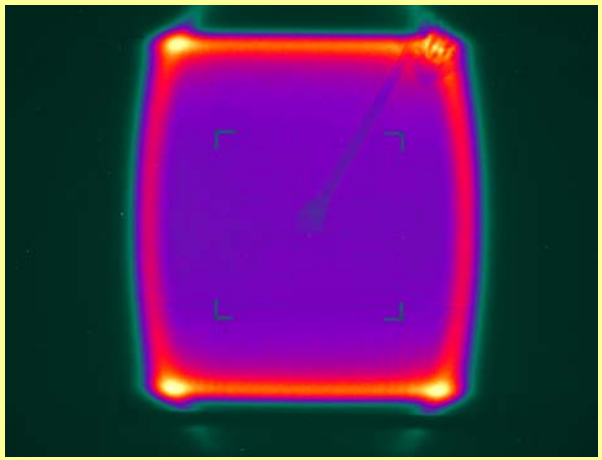
Beamline Incubator Set Up at NSRL

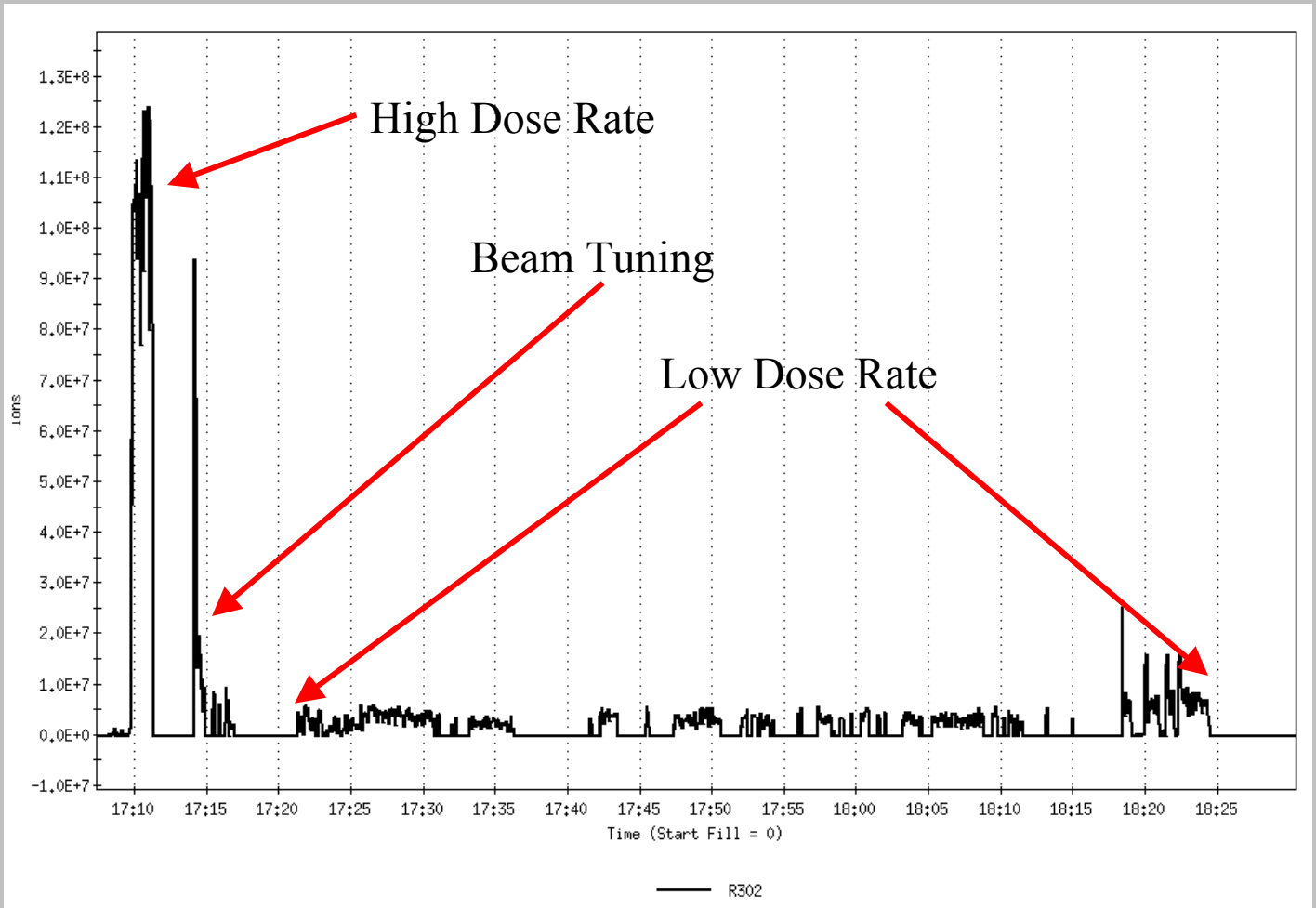








Particle/Spill Profile (actual)



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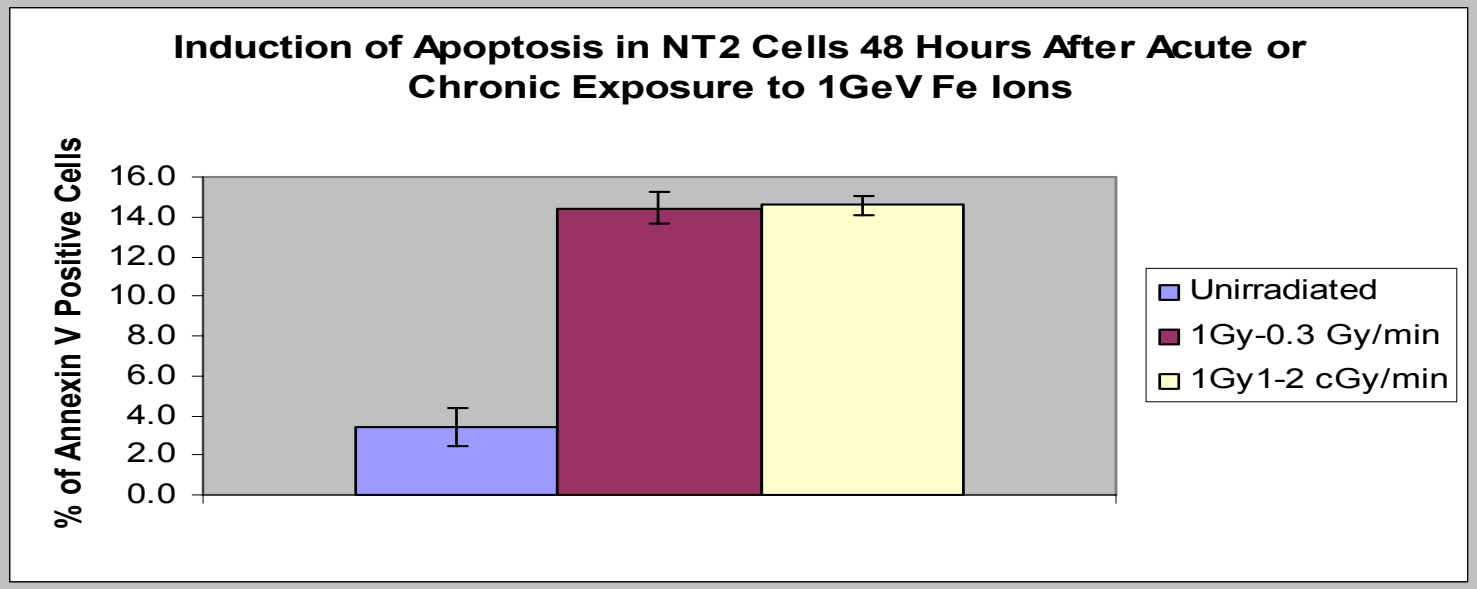
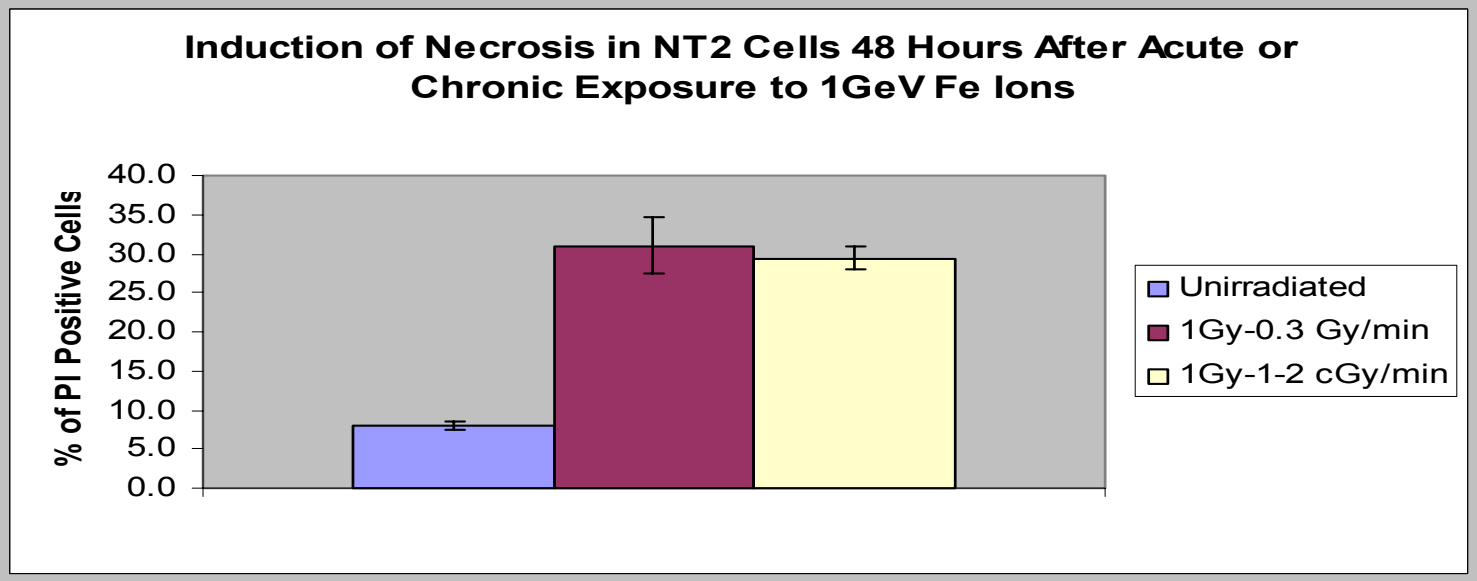

Induction of Apoptosis in NT2 Cells 48 Hours After Acute or Chronic Exposure to 1GeV Fe Ions
% of Annexin V Positive Cells
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Unirradiated
1Gy-0.3 Gy/min
1Gy1-2 cGy/min


Induction of Necrosis in NT2 Cells 48 Hours After Acute or Chronic Exposure to 1GeV Fe Ions
% of PI Positive Cells
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Unirradiated
1Gy-0.3 Gy/min
1Gy-1-2 cGy/min

Energy Ramping

- We have succeeded in changing energy in few minutes many times during, NSRL-06A NSRL-06B and NSRL-06C.
- We also failed to do so more times than we care to admit.
- We believe all the kinks were worked out by the latter part of NSRL-06C and the system is working very smoothly now.

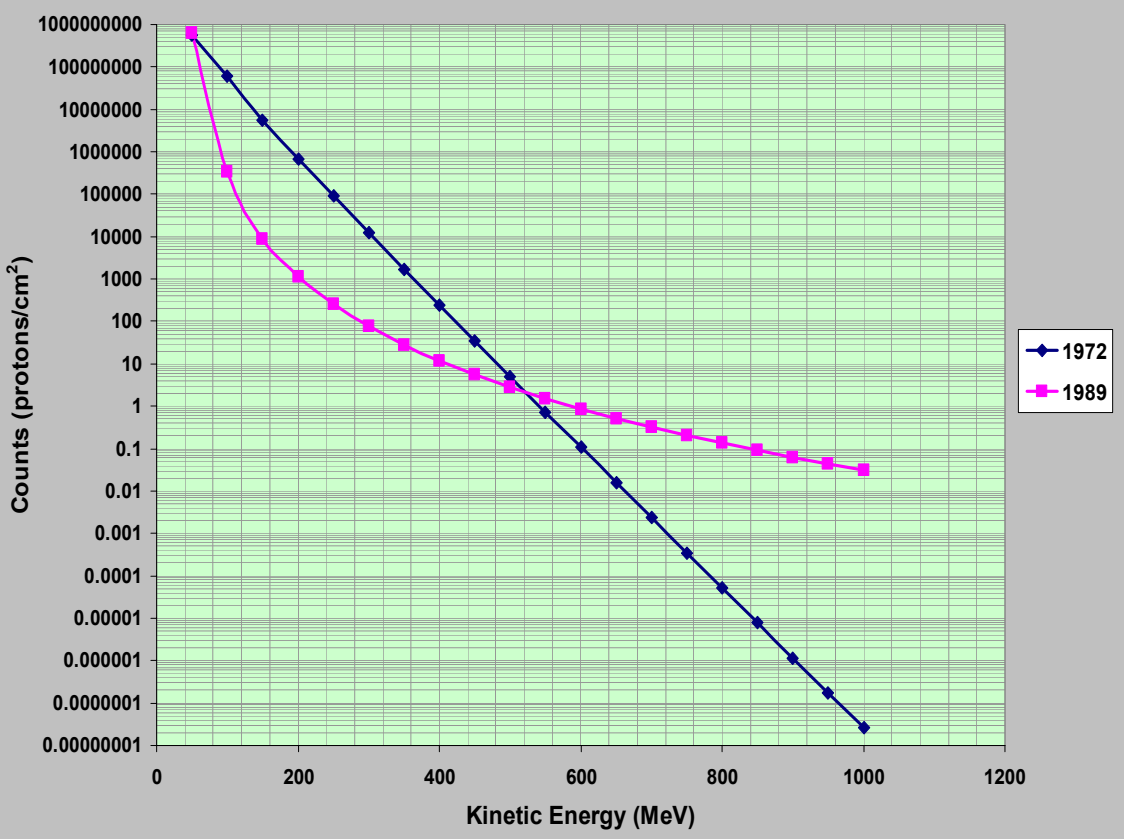
Solar Particle Event Simulator

- We have used the energy ramping machinery to change the machine/beam line energy from 100 MeV to 1000 MeV.
- Beam shape remains good throughout this exercise.
- Lower energies can be obtained with the binary filter, as well as by energy ramping.

Solar Particle Event Simulator

Energy	1972	1989
50	555,281,883	623,871,921
100	6,2684,236	337,207
150	5457,332	9,032
200	682,167	1,156
250	89,984	254
300	12,277	76
350	1,712	27
400	242	11
450	34	5
500	5	3
550	0.7	2
600	0.1	0.9
650	0.02	0.5
700	0.002	0.3
750	0.0003	0.2
800	5E-05	0.1
850	8E-06	0.09
900	1E-06	0.06
950	2E-07	0.04
1000	3E-08	0.03

Count distribution, per Gy



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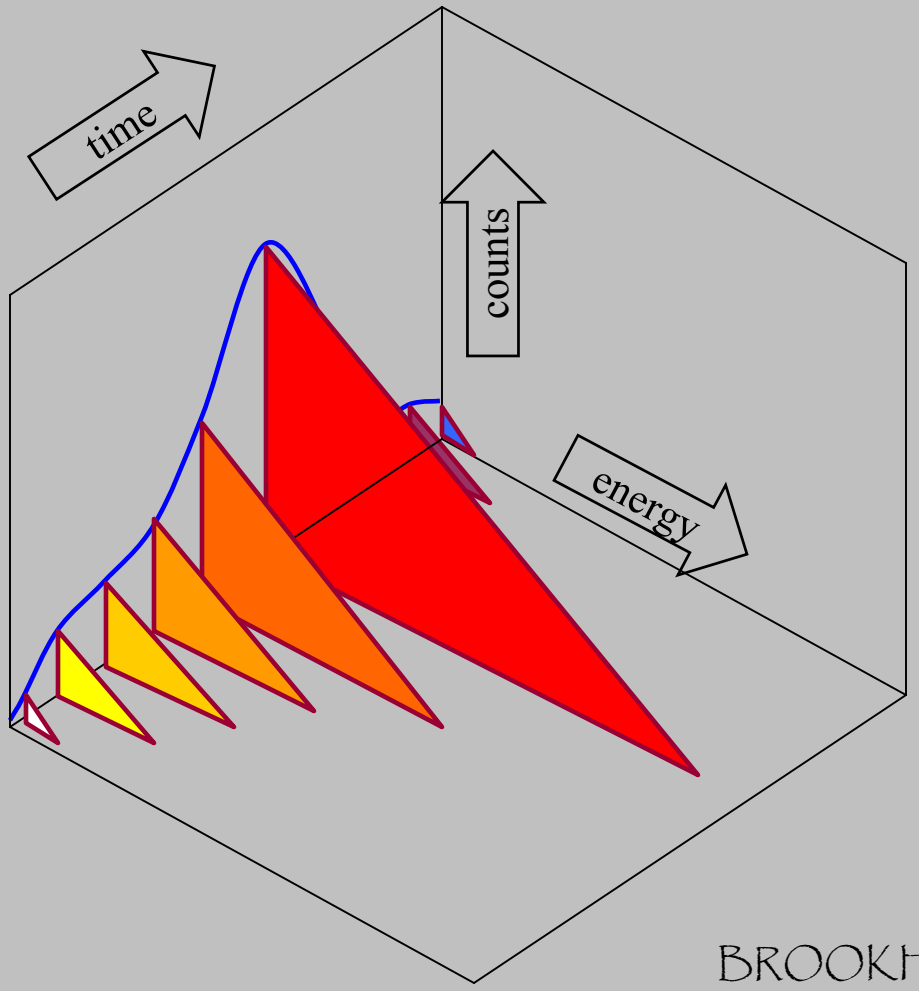
Solar Particle Event Simulator

- Full simulation would automatically deliver specified counts per energy, and a dose distribution over time.
- Expect much less in the beginning, namely, much more operator interaction.



Digital Beam Imager

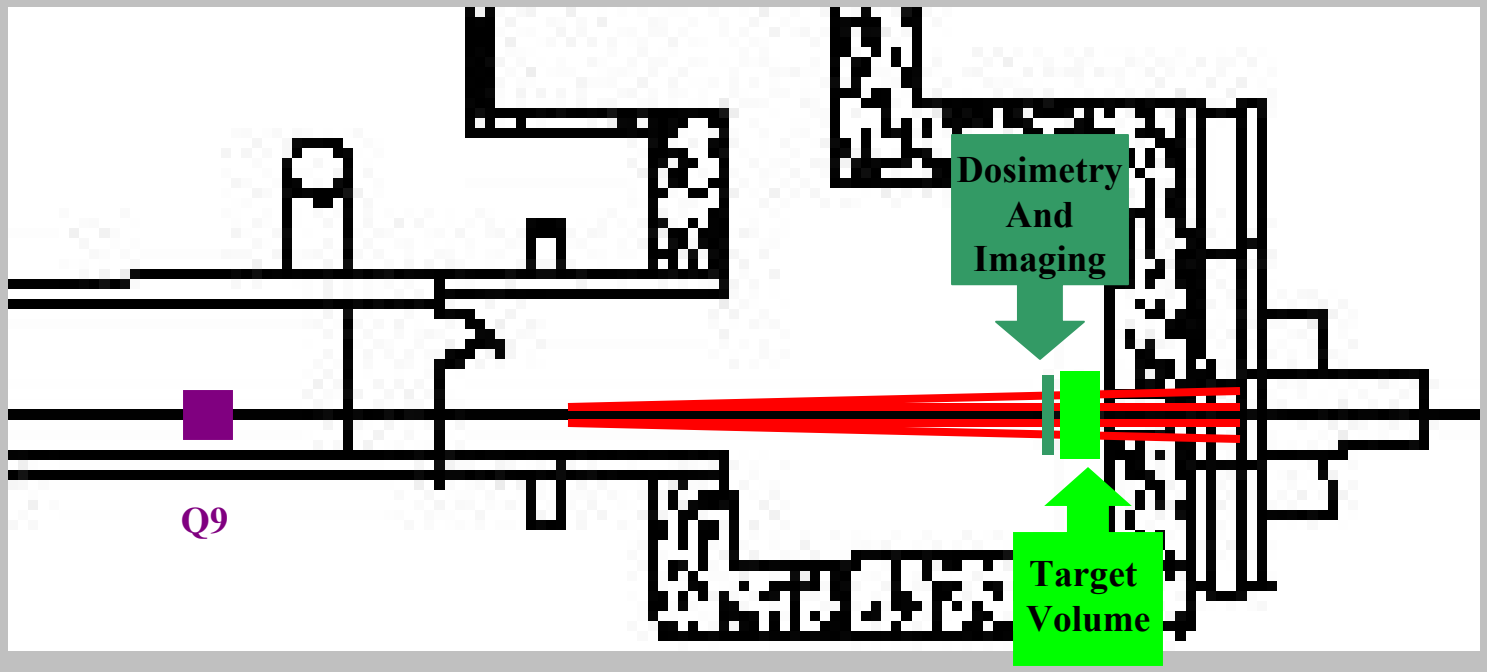
- Continuing work on Linux based system
  - ✓ Reliable triggering is the current impediment.
  - ✓ Should be working by NSRL-07A.
- Software is under continuous development:
  - ✓ Basic display
  - ✓ Integrated image for exposure record.
  - ✓ File handling, archiving.
  - ✓ Pseudo-color controller
  - ✓ Profile analysis (as in ImageJ)
  - ➢ Digitsl dosimetry?

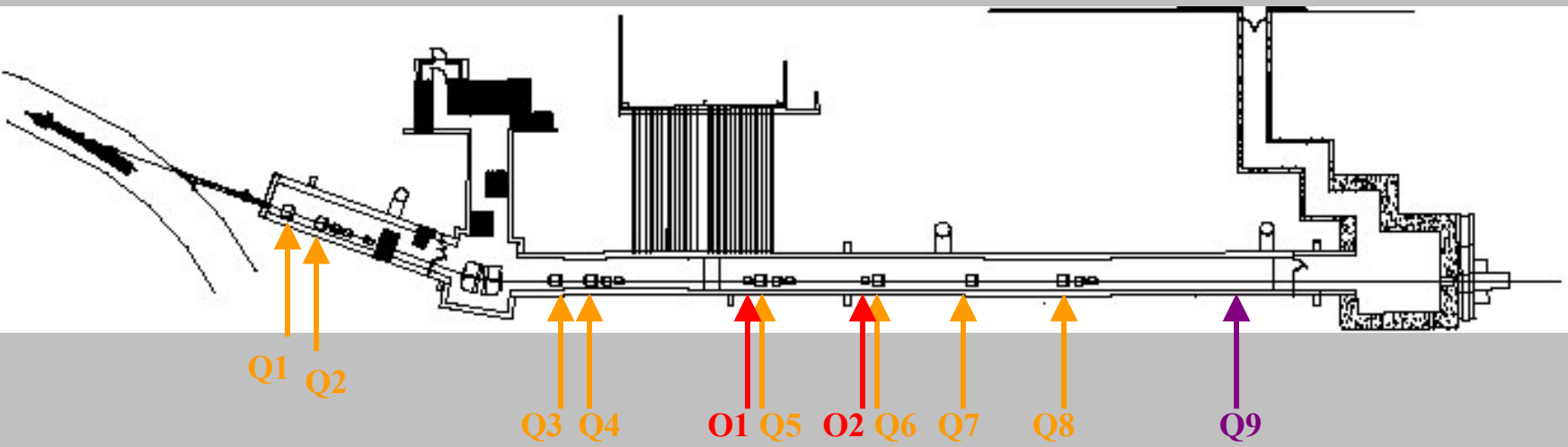
Future Developments
Large Beam for Low Fluence Work

- Take advantage of NSRL strengths.
- We can make a 60×60 cm^2 area beam (45×45 cm^2 useful area), by adding a new quadrupole magnet, about 1m before end of beam line.
- Direct measurement of beam distribution and dose.

- Uniform, stable beam, with wide fluence and energy range.
- The limiting factor is the re-entry cavity size. No need for new beam pipe(!).

- Do the dosimetry and imaging with one device, just upstream of the target volume.





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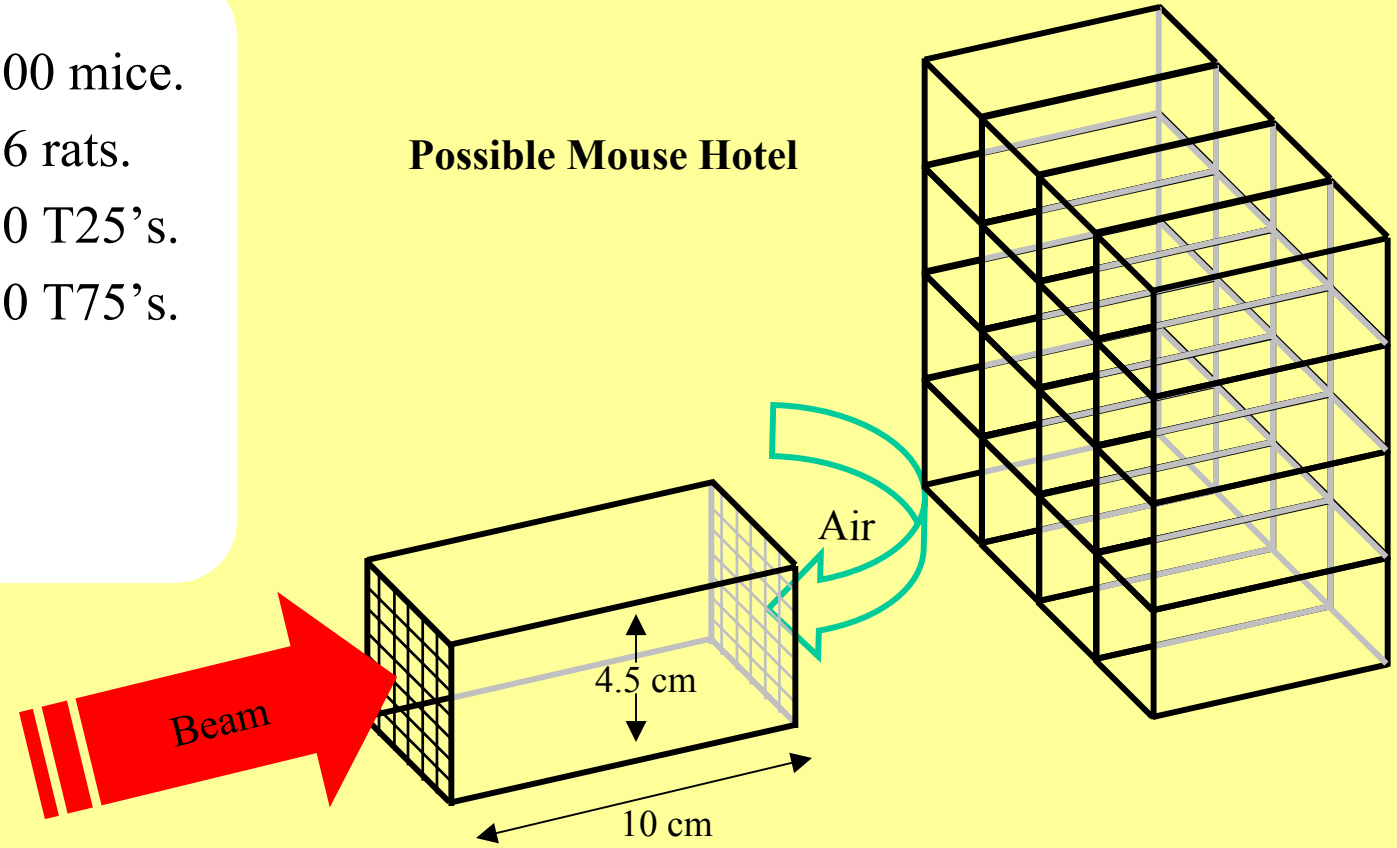
Future Developments
Target Volume

- 100 mice.
- 36 rats.
- 50 T25's.
- 30 T75's.

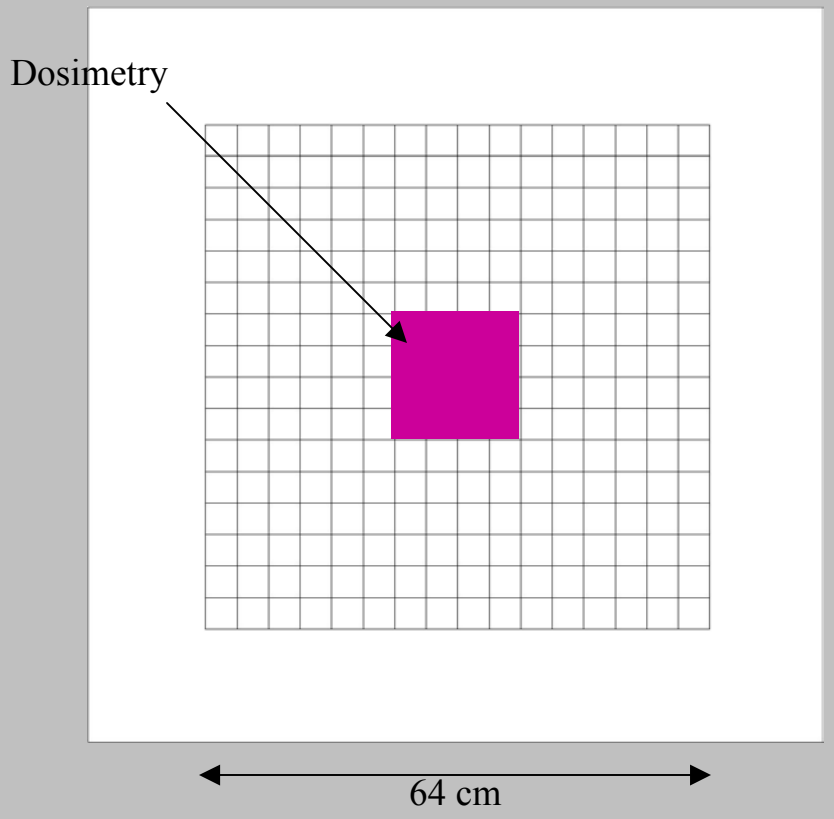
Possible Mouse Hotel



Infrastructure Developments

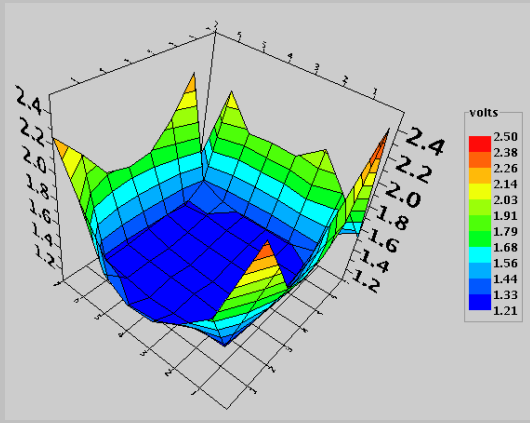
Pixel Chamber with Gain (Imaging & Dosimetry)

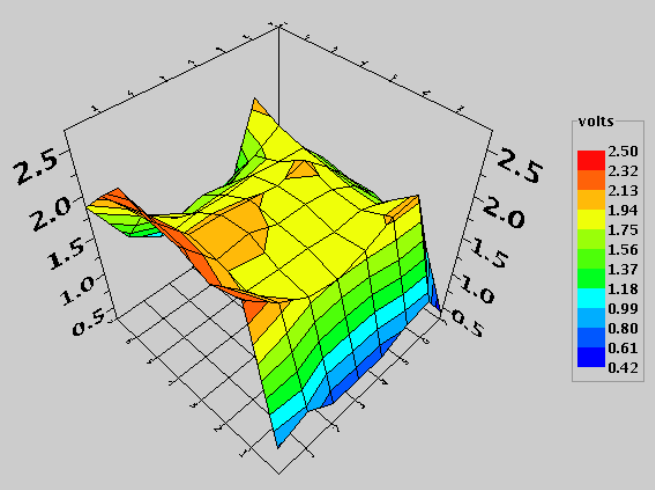
- We have been studying the possibility of using a chamber with gain for dosimetry as well as for imaging.
- Requires development for which there is money set aside, but not yet released.
  - Bi-polar recycling integrators.
  - Modifications to Dosimetry Control System



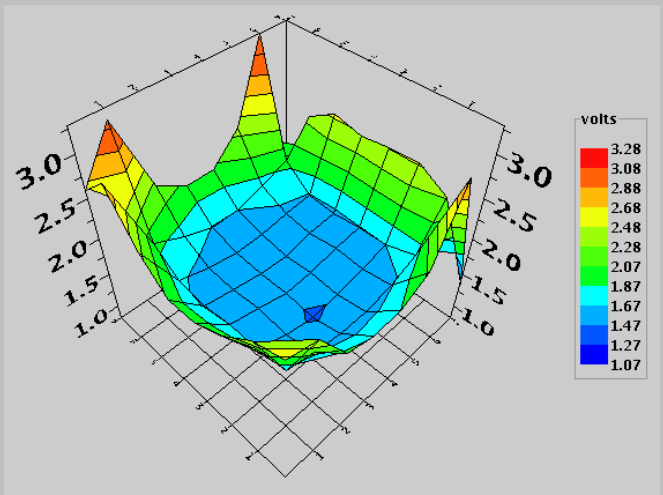
Pixel Ion Chamber with Gain

- Can image the beam at very low fluence
  - ✓~2 Fe/cm^2
  - ✓~1,000 p/cm^2





30,000 p/cm^2



22,500 Fe/cm^2

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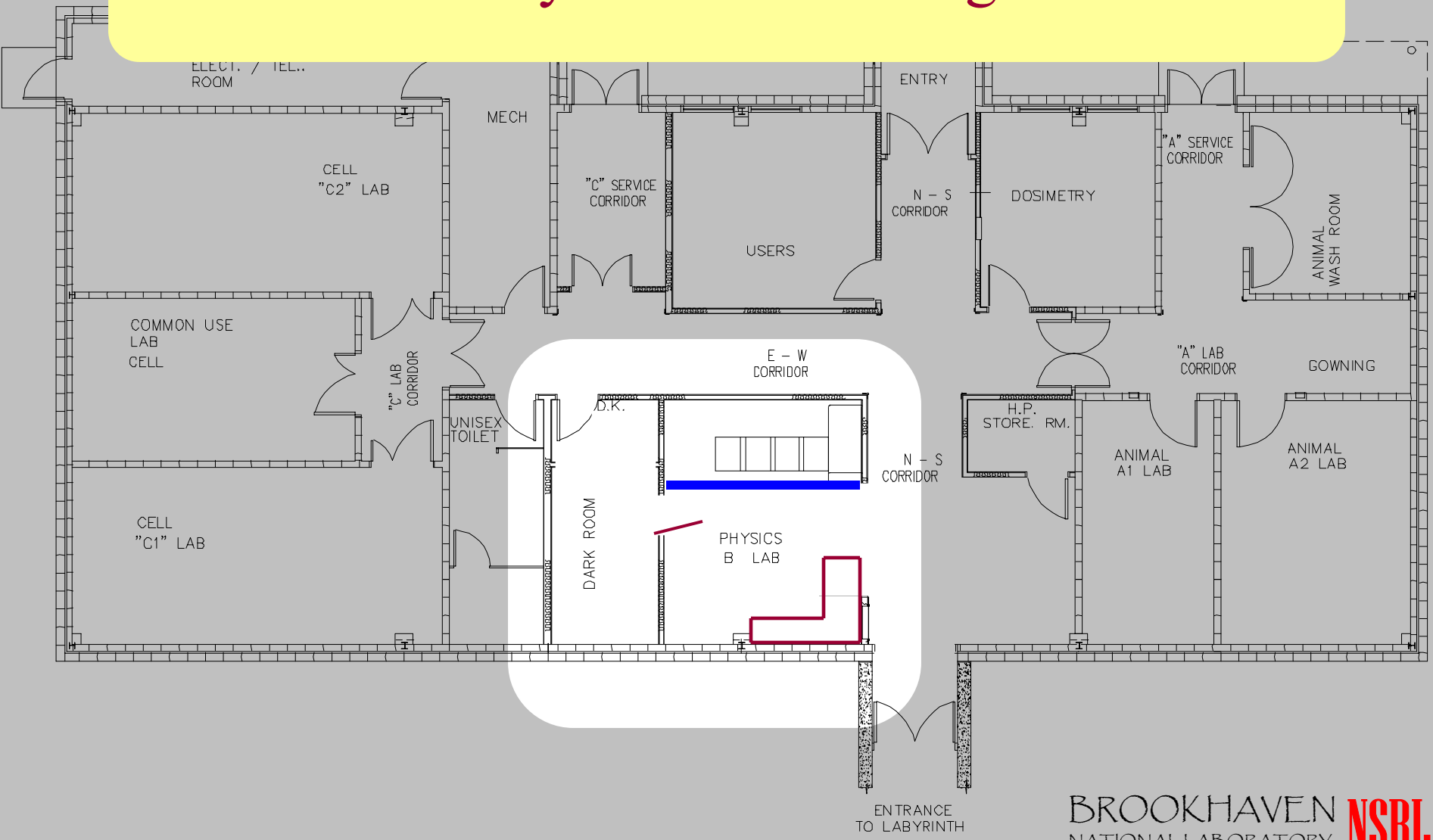
MCR-Free Access

- The Intelligent Video component of the system has been sent out for bid (ROP). RSC is waiting to see the proposals before approving the system.

Dosimetry Room Rearrangement



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What to Walk Away With

- NSRL continues to run very smoothly and effectively.
- We continue to cultivate a “research first” atmosphere, and the response from the user community is positive.
- Relations with users are very good, open and relaxed.
- We continue to be proactive in our approach towards users needs and NASA’s short and long term plans.