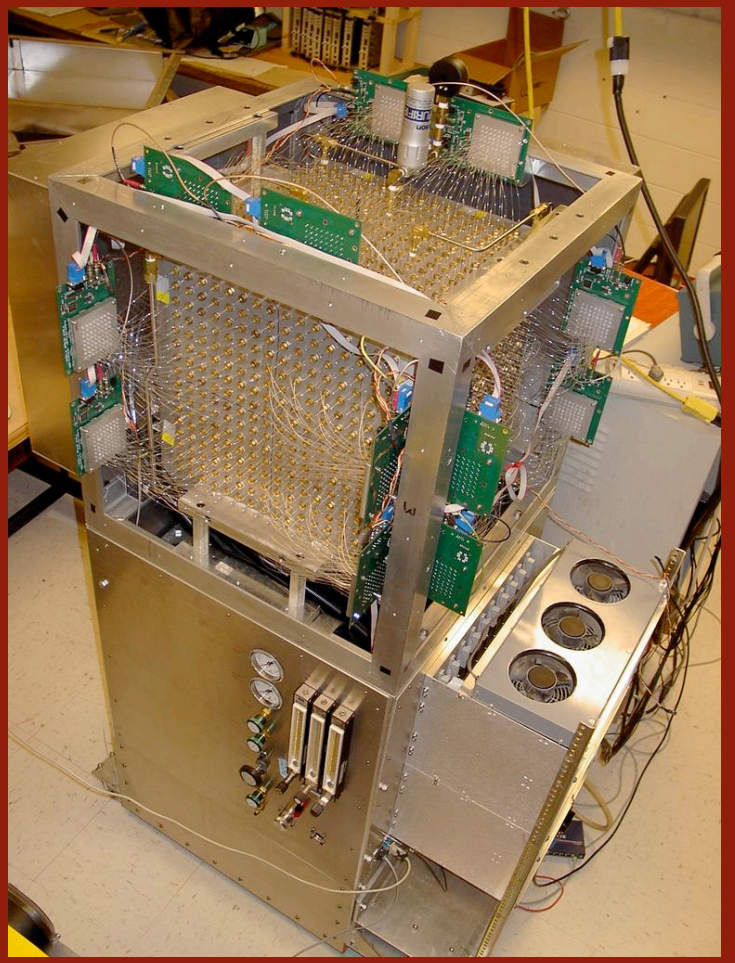
The SciBath Detector

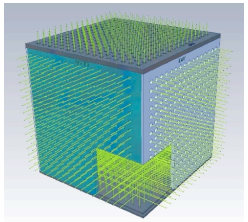


Robert Cooper

L. Garrison, L. Rebenitsch,
R. Tayloe, R. Thornton

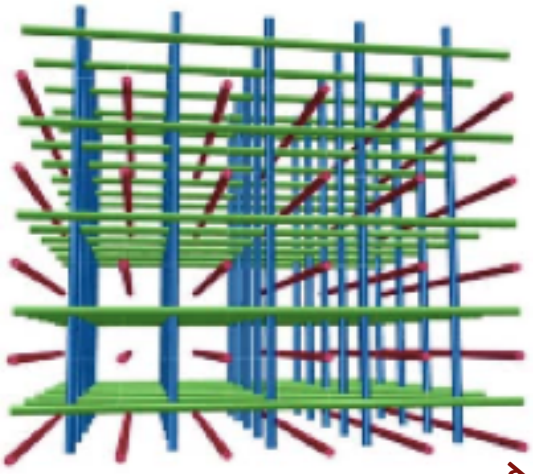
INDIANA UNIVERSITY

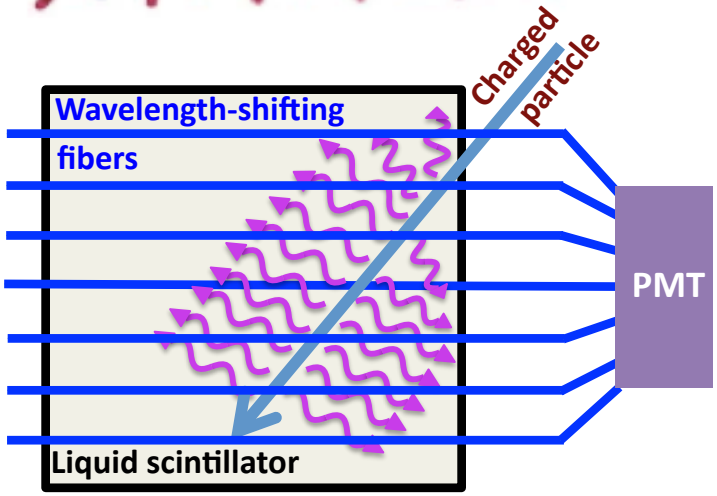
THE SCIBATH DETECTOR

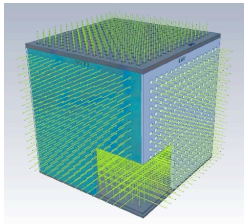


Design Concept

- Bath of liquid scintillator
- ~40 cm length cubic volume
- 3D array, crossed wave-length shifting fiber readout
- 768-channel with 64-anode PMT system (x12)
- IU custom-built DAQ ($70 per channel with PMT)

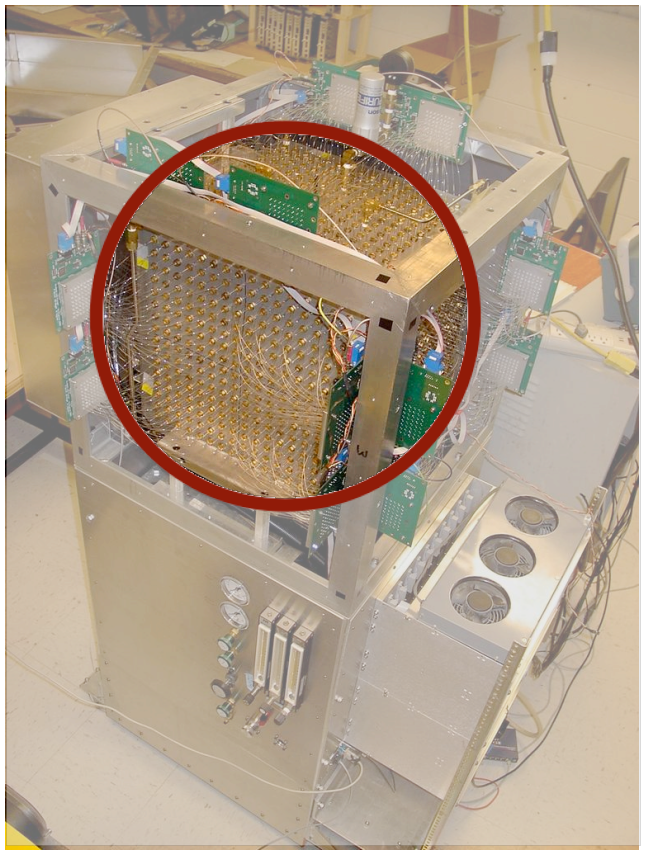


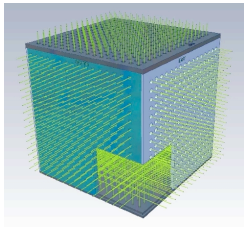




The SciBath Detector

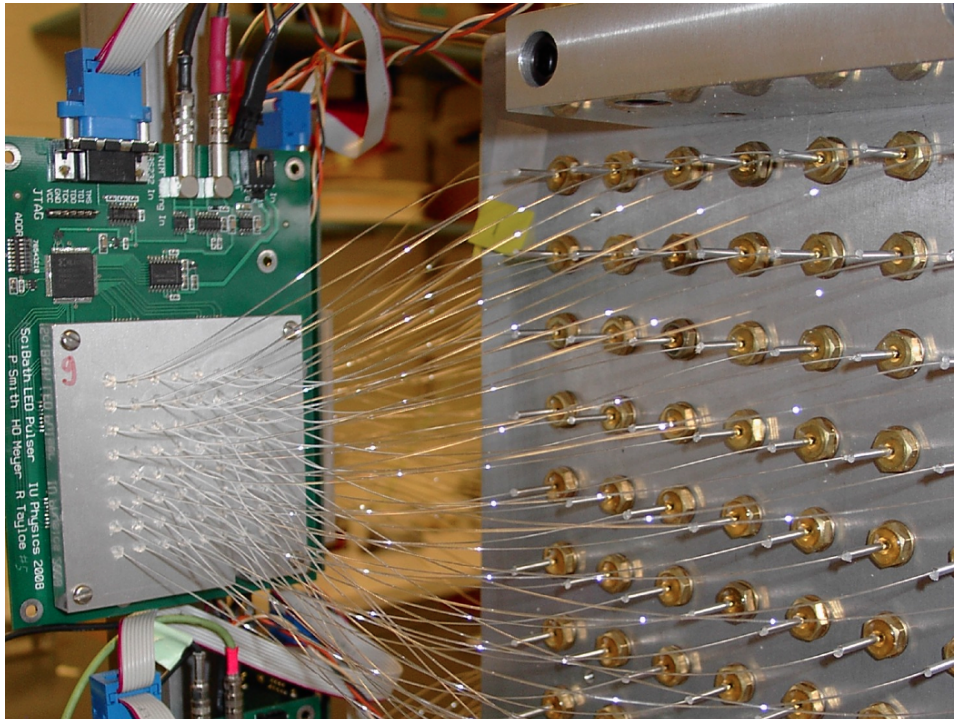
- 80 L liquid scintillator (LS)
  - 88% mineral oil
  - 11% pseudocumene
  - 1% PPO
- 768 (3-16x16) array wavelength-shifting fibers (x,y,z axes)
  - 1.5 mm diameter
  - 2.5 cm spacing
  - UV → blue

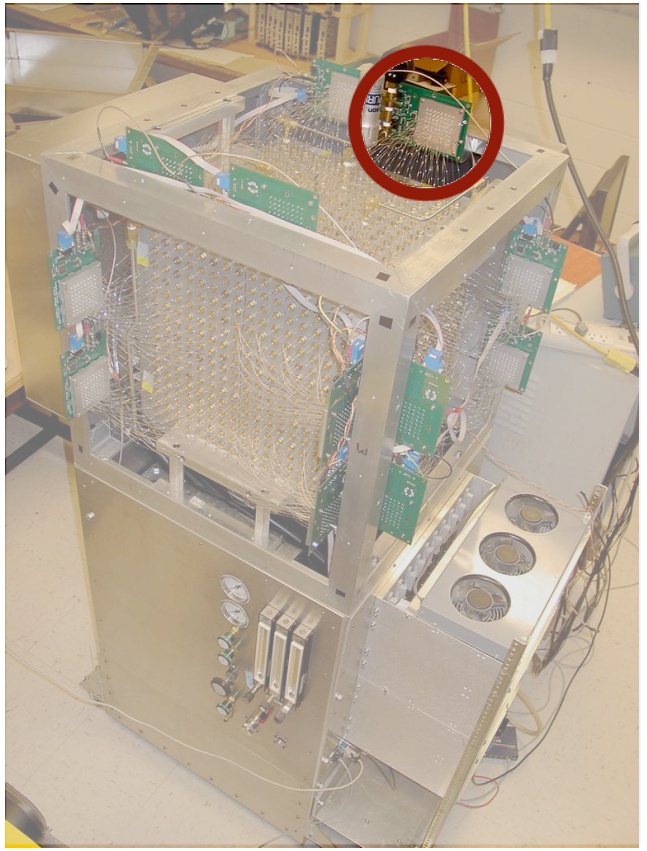


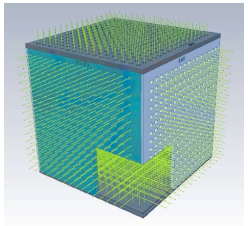


The SciBath Detector

- Pulsed LED calibration

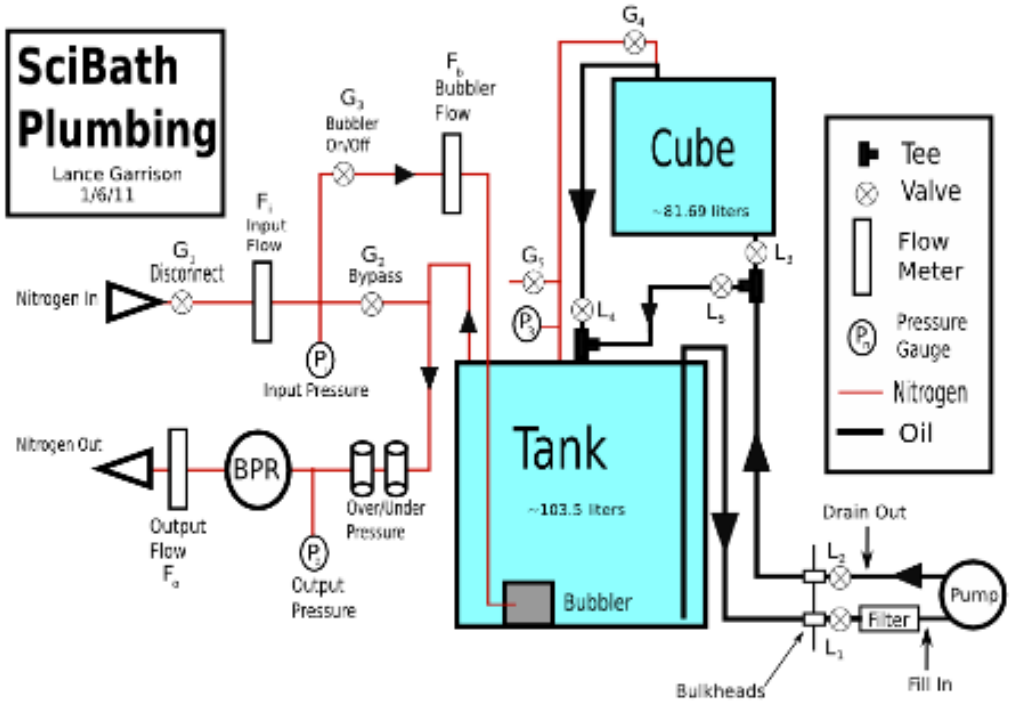


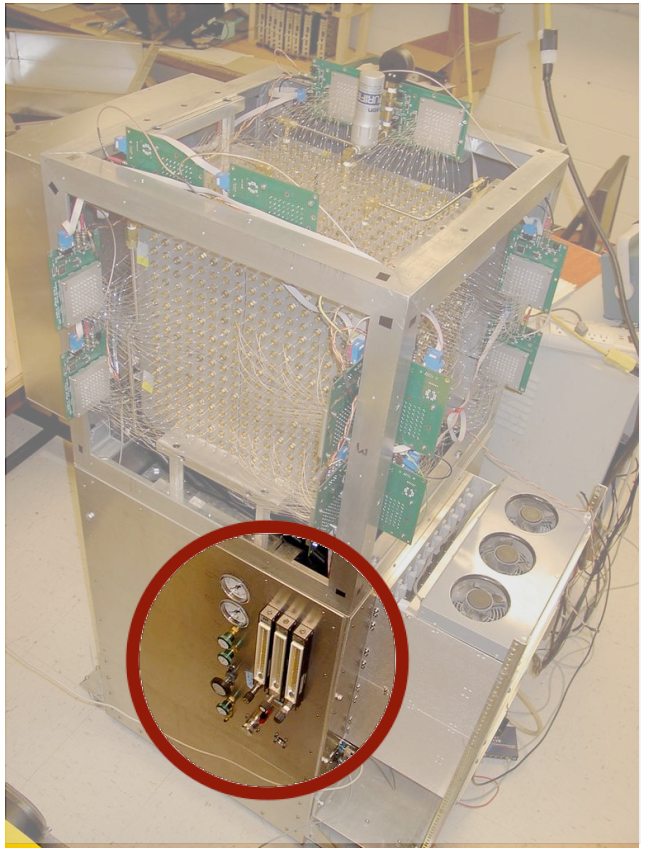


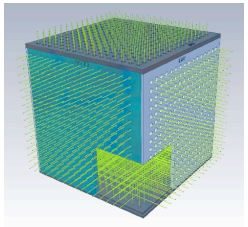


The SciBath Detector

- N_2 and LS plumbing

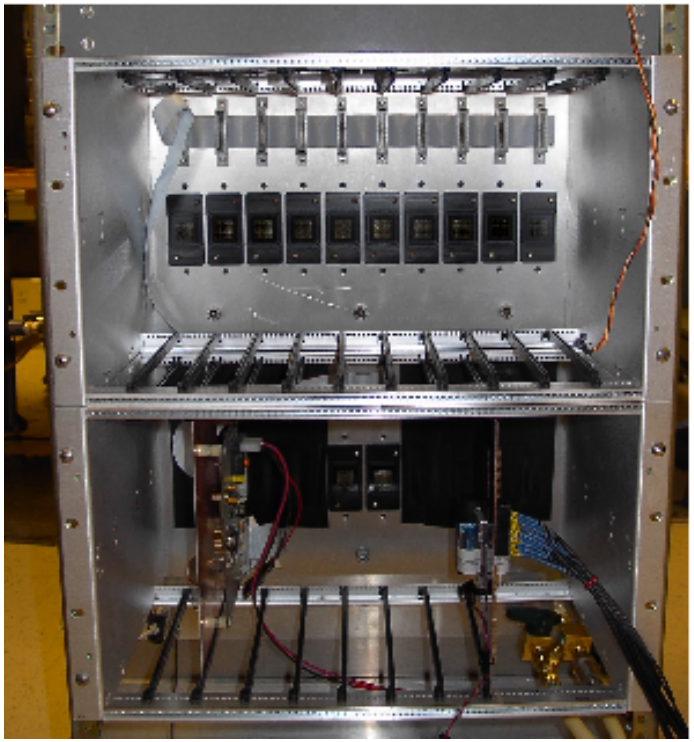


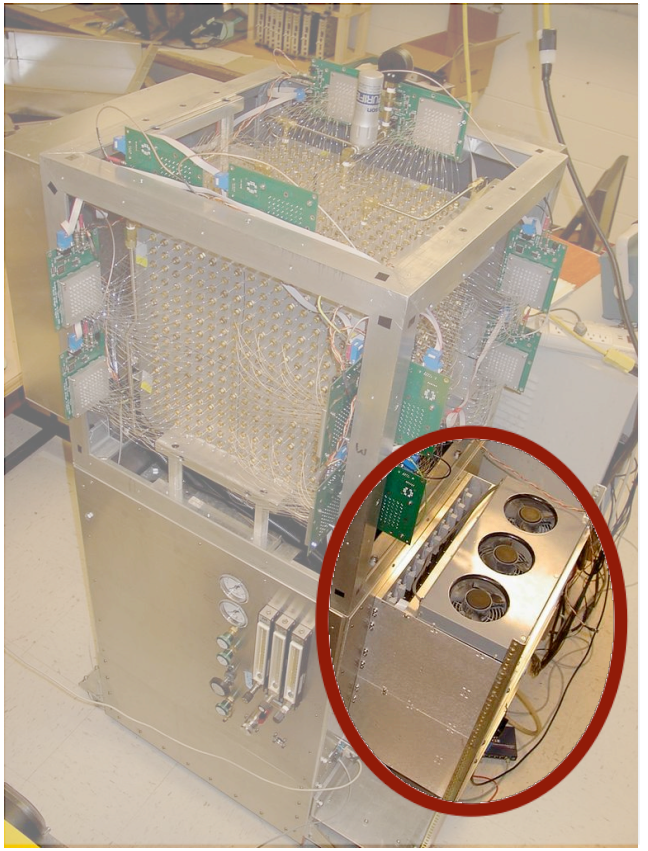


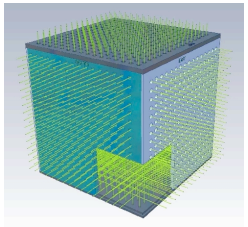


The SciBath Detector

- Electronics readout & PMTs







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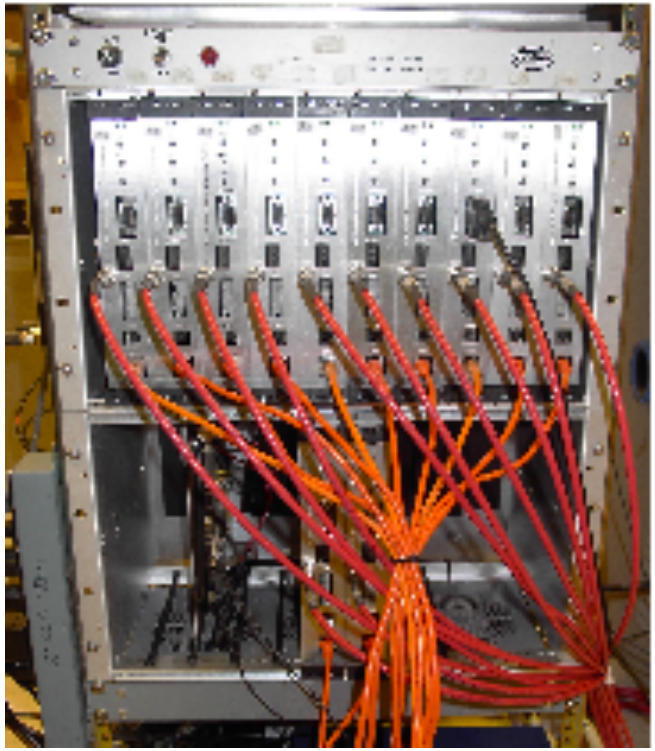
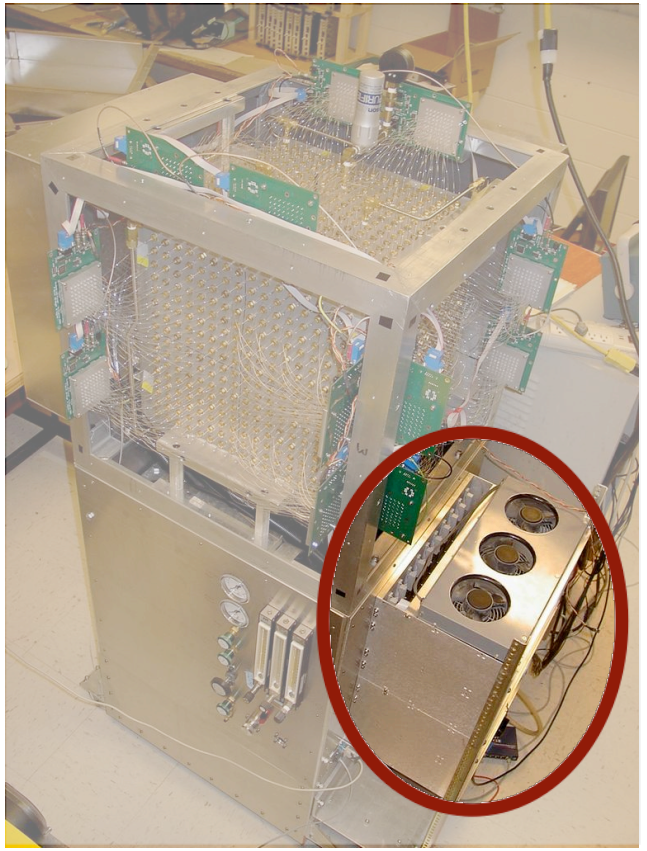
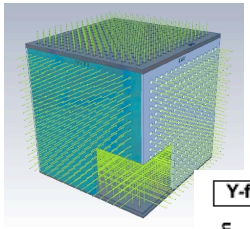
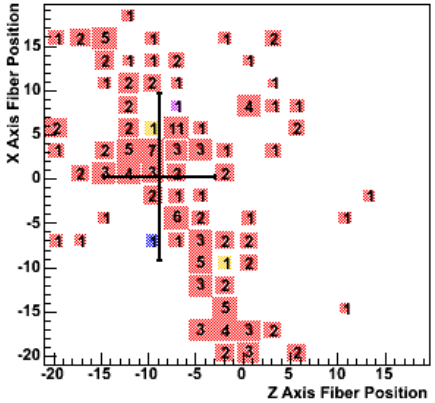


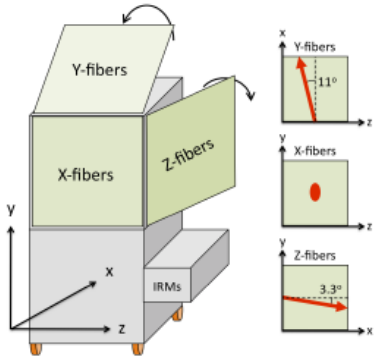




Sample Event

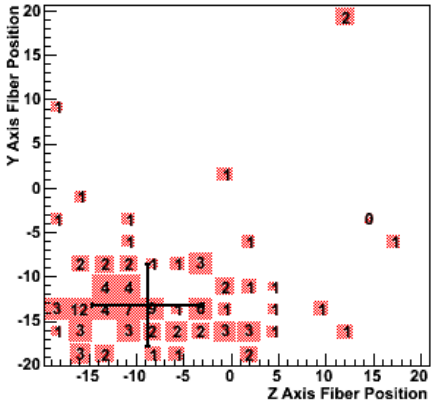
Y-fibers: Photons per Fiber



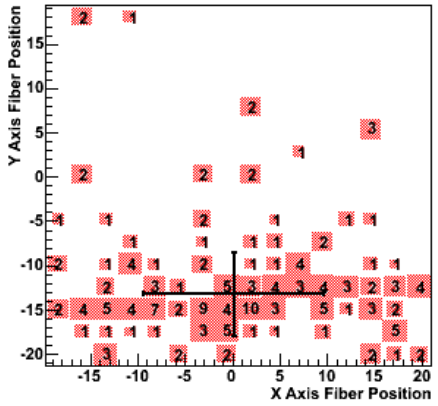


Selected Event Num: 44432
Raw Event Num: 1023824
Multiplicity: 189
Total PEs: 439.3
PEs -- X-fbers: 107.2
PEs -- Y-fbers: 156.8
PEs -- Z-fbers: 175.3
T0: 273.6180107 s
Time to last BIB: 0.0002228 s
$\bar{x}$ = 0.2 ± 9.5 cm
$\bar{y}$ = -13.3 ± 4.7 cm
$\bar{z}$ = -8.7 ± 5.9 cm

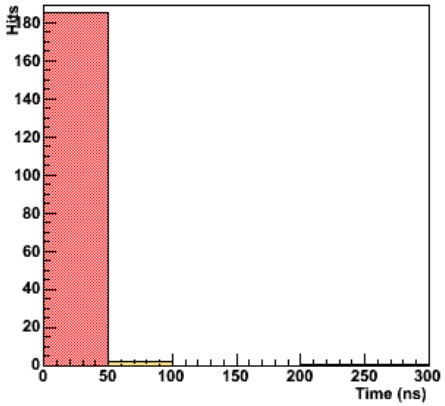
X-fibers: Photons per Fiber

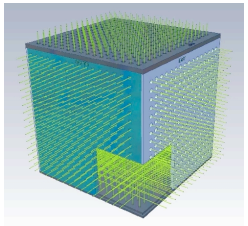


Z-fibers: Photons per Fiber

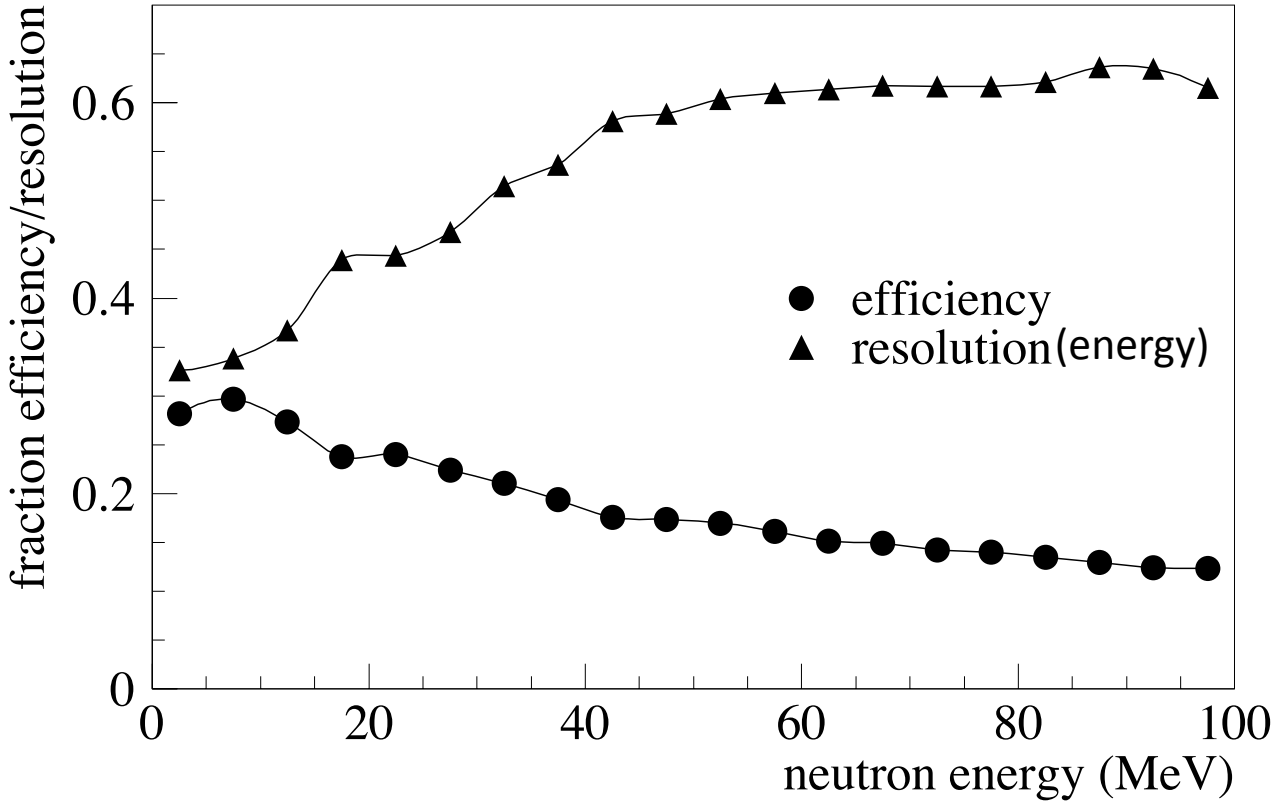


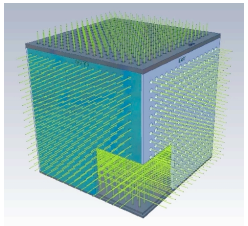
Event Timing Distribution



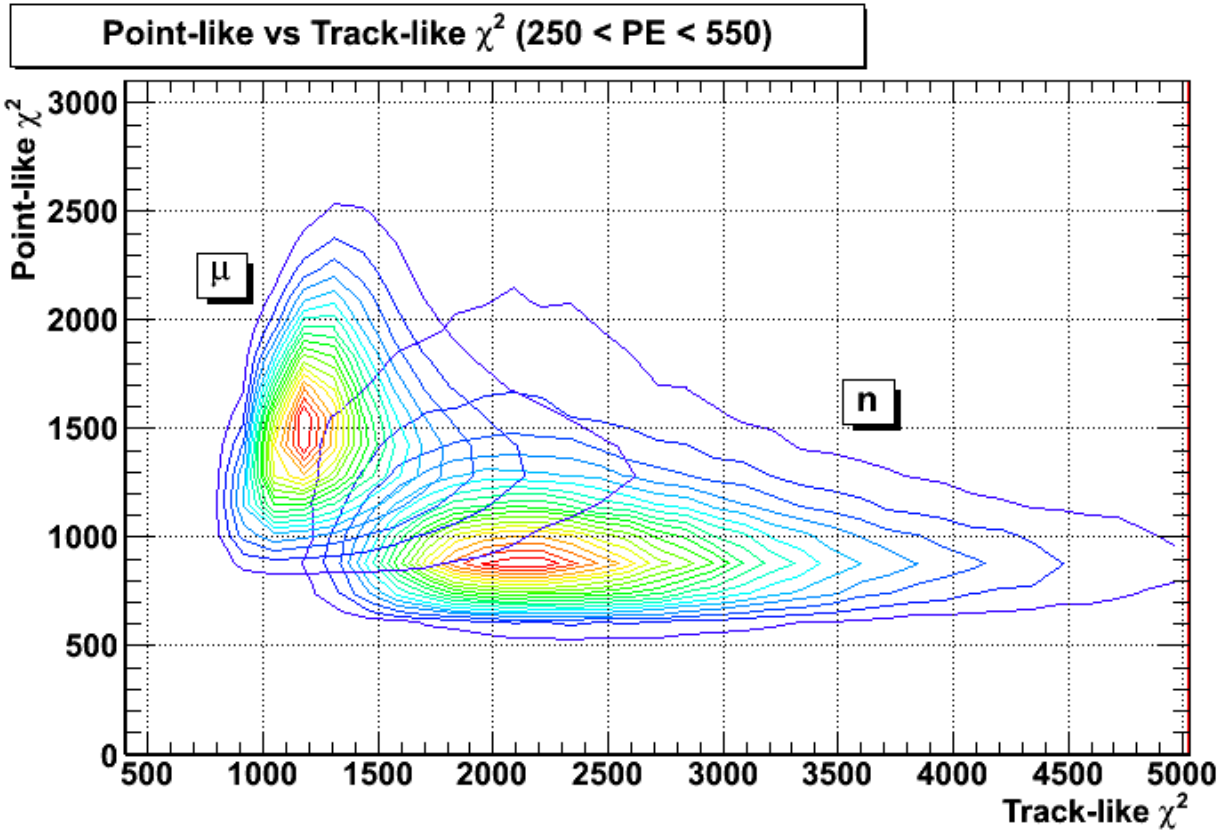


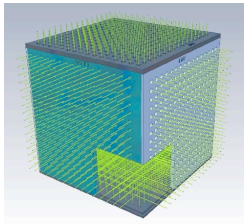
Anticipated Sensitivity (*n* events)





n / μ Particle Discrimination





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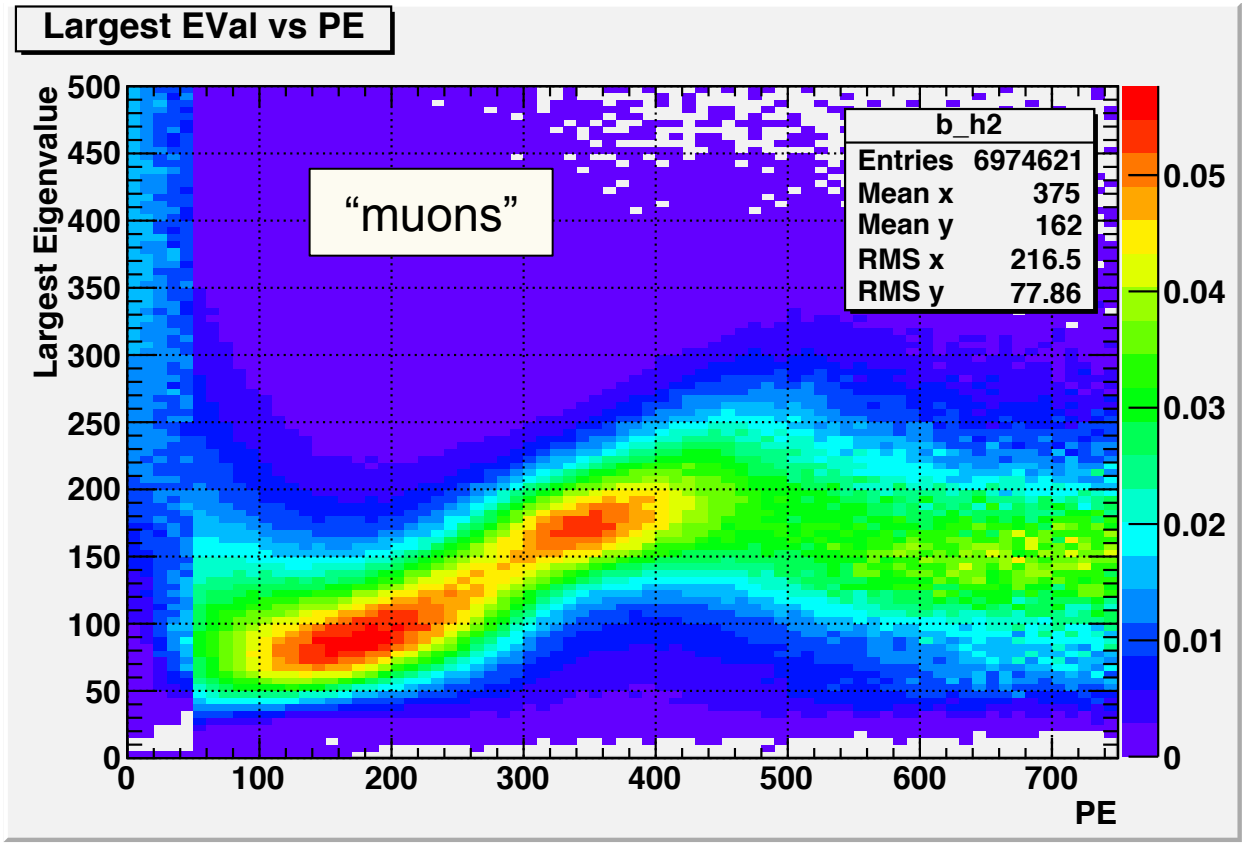

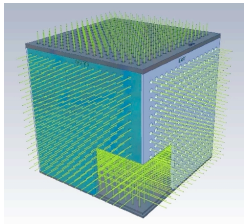

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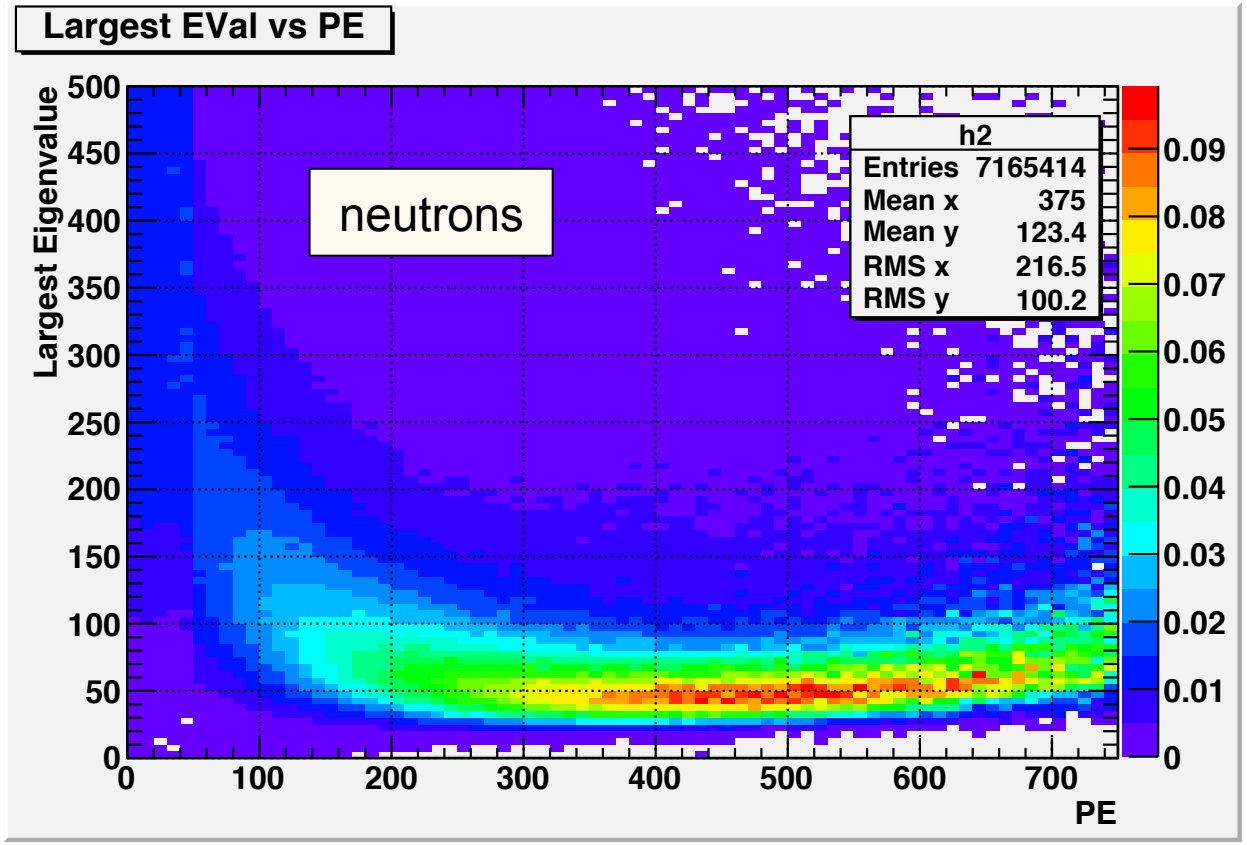
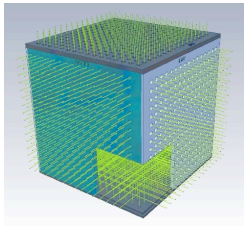
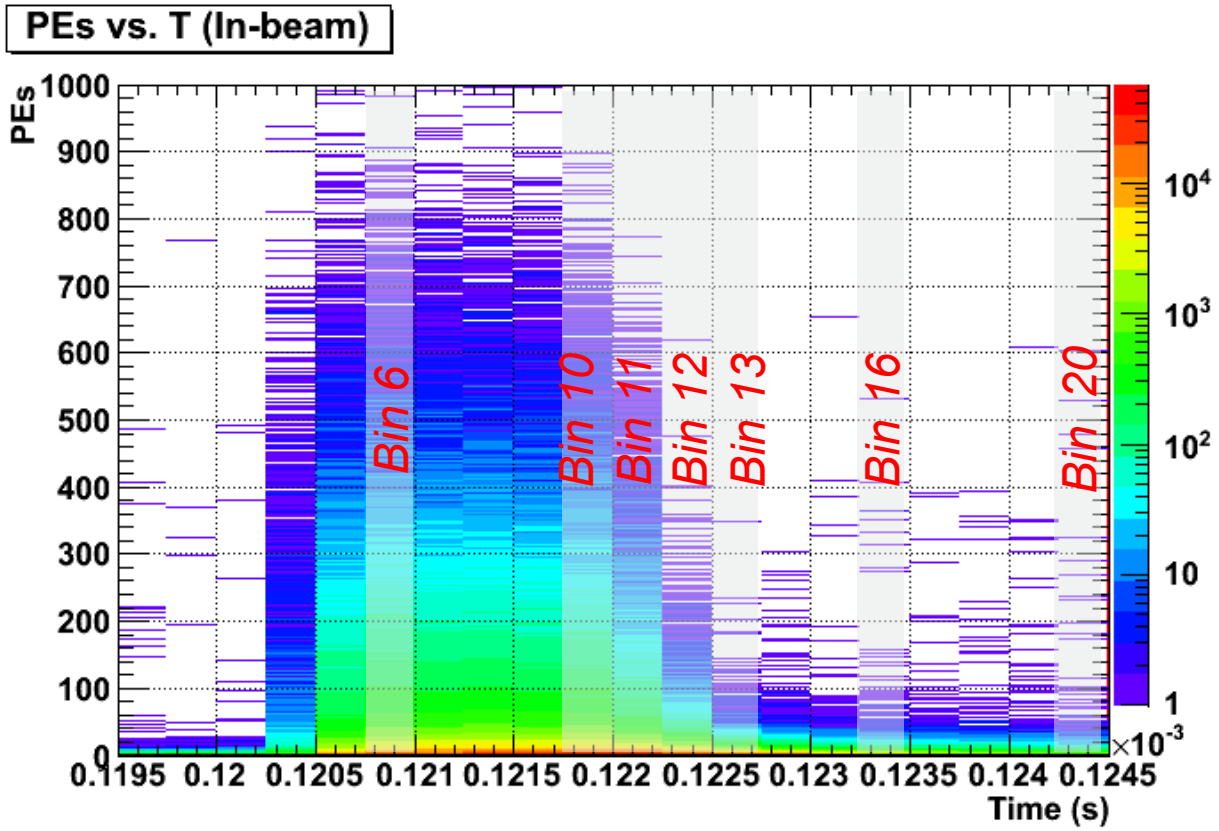
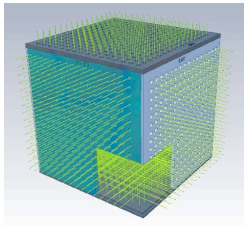


PRELIMINARY NEUTRON ENERGY SPECTRUM



Beam Spill Time / PE Structure





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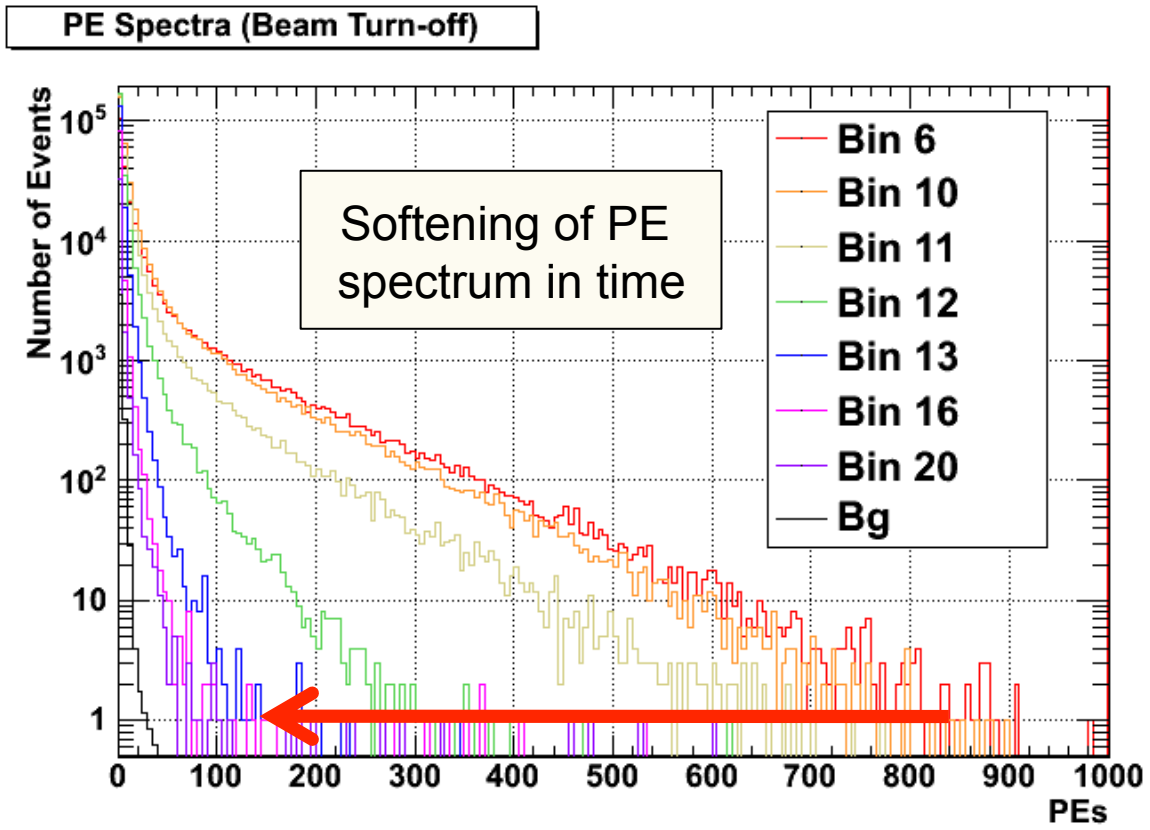
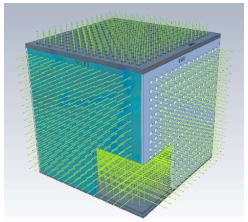
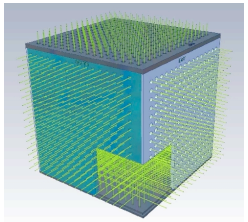




Preliminary Analysis Roadmap

1. Measure proton PE response
2. Convert proton PEs to energy scale
3. Unfold spectrum of neutrons from protons
4. Divide detector efficiency
5. Normalize to *X* units
   (*X* = time, POT, triggers, etc.)

Future spectra will combine 3. and 4. in MC



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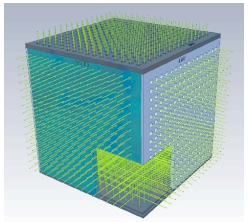
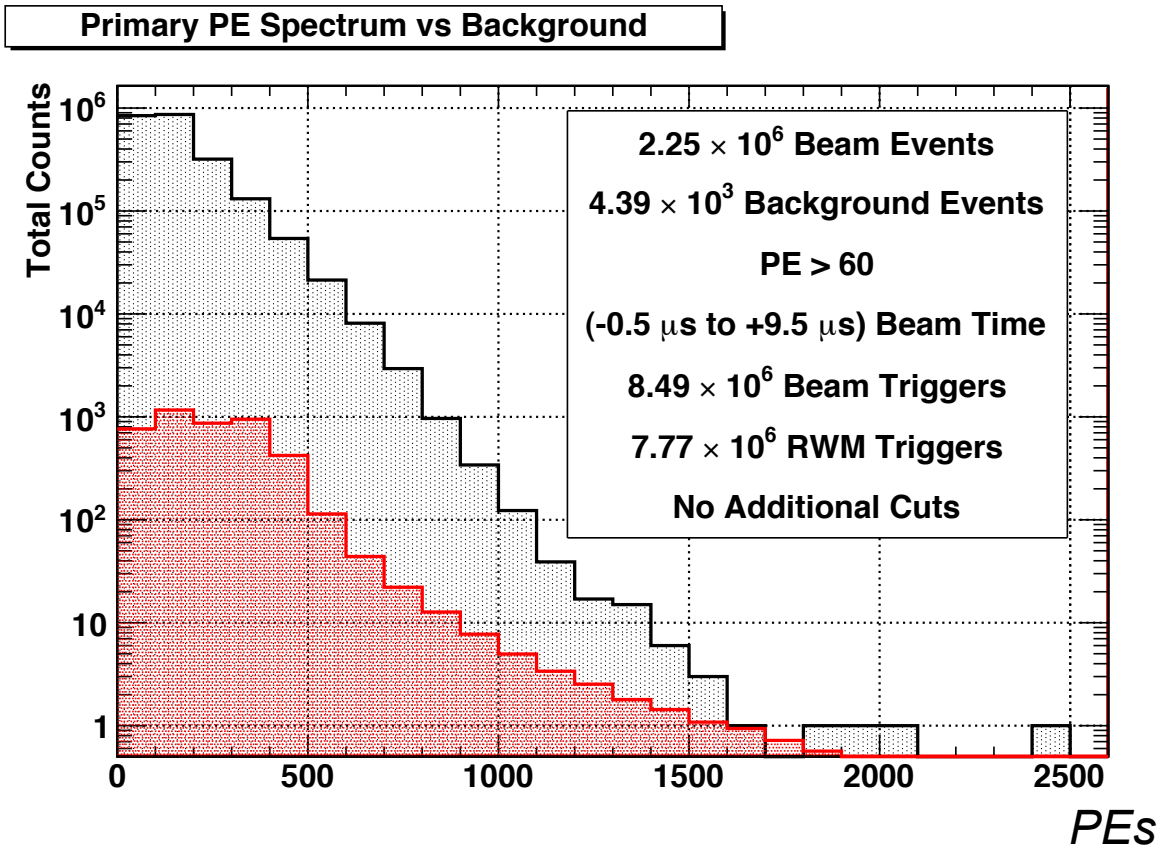
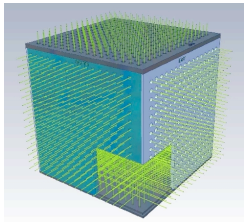


SciBath In-Beam PE Spectrum





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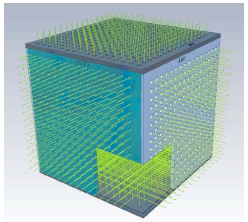
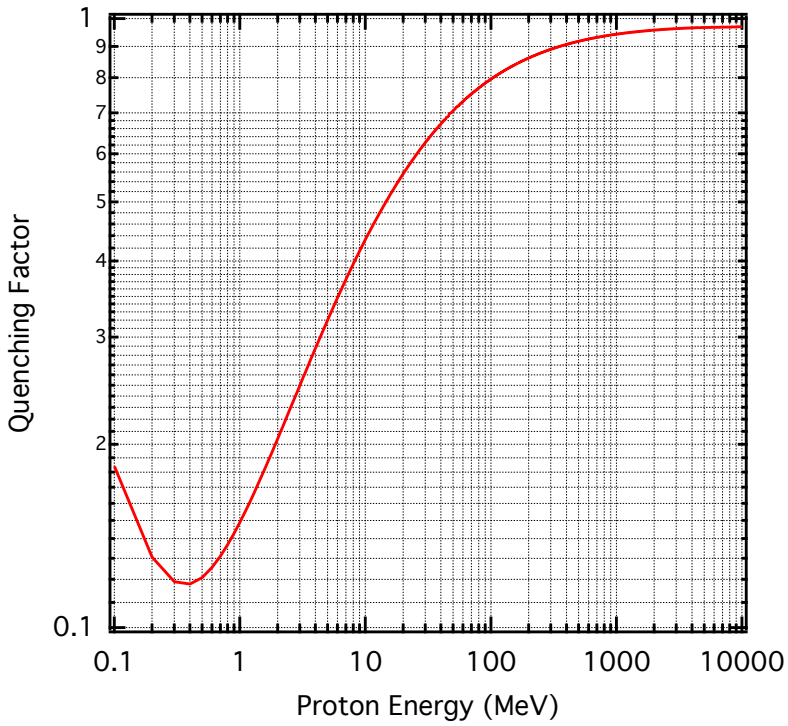


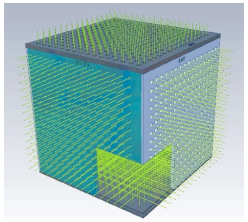
Proton Response and Quenching

- Birk's Law used to convert to energy deposit
- Handles quenching for large dE / dx

$$\frac{dL}{dx} \propto \frac{dE/dx}{(1 + k_B \; dE/dx)}$$

$$k_B \approx 0.013 \; \mathrm{MeV}^{-1} \cdot \mathrm{g/cm}^2$$





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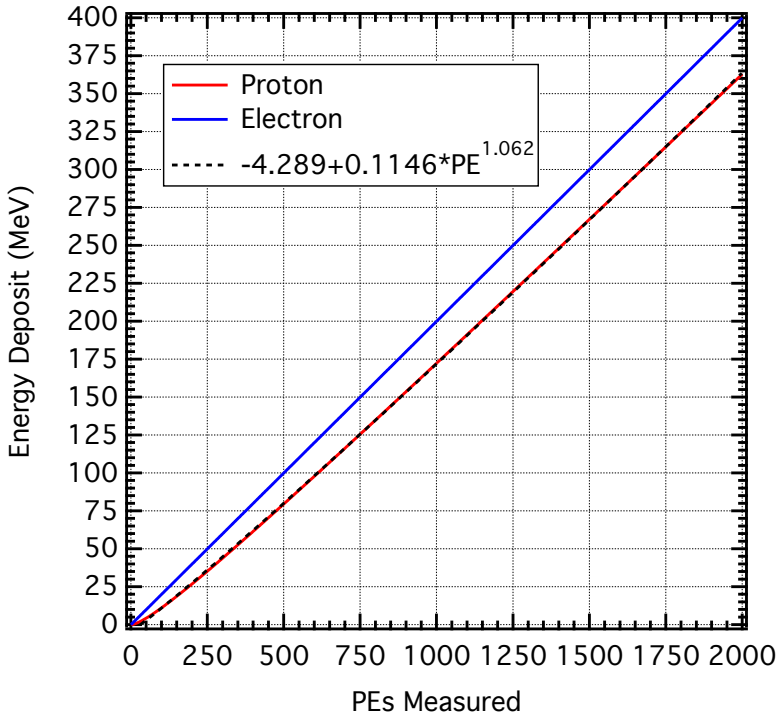
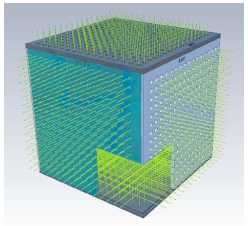
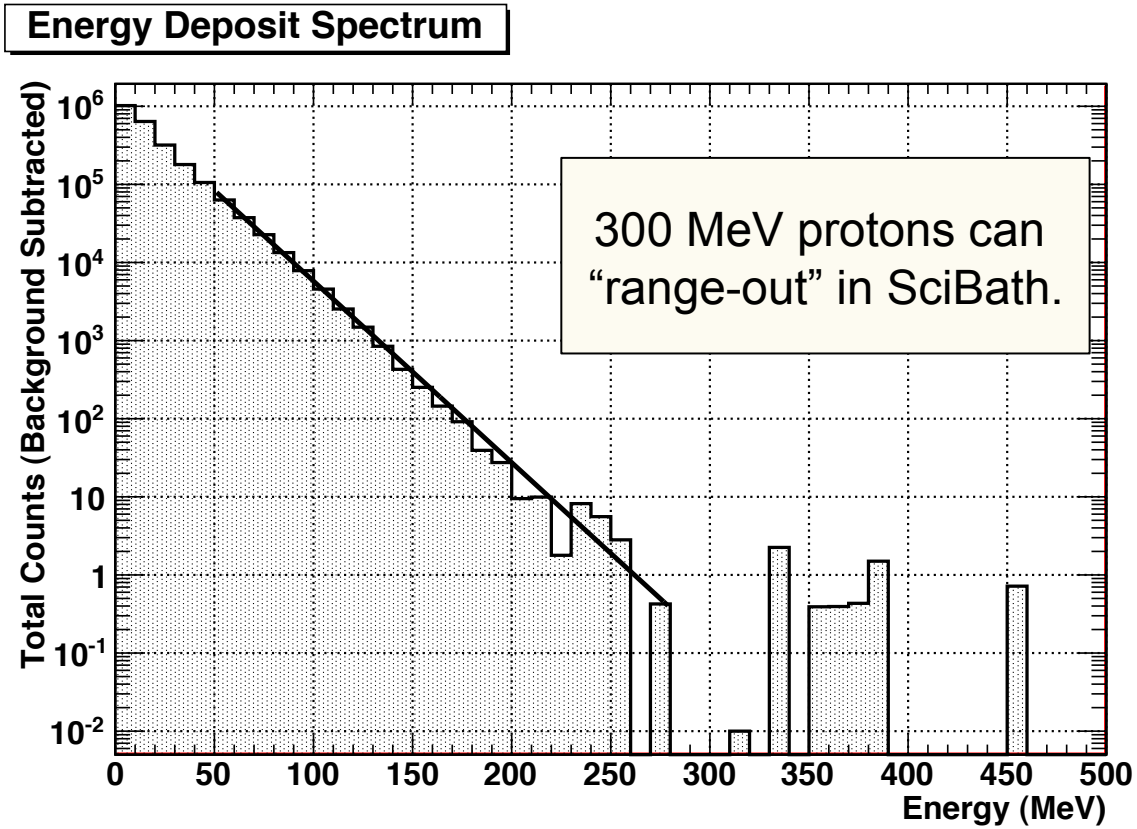
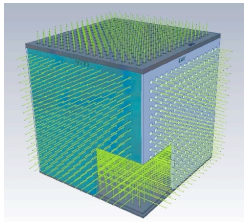




Energy Deposit Spectrum





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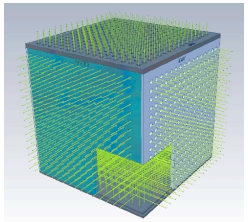
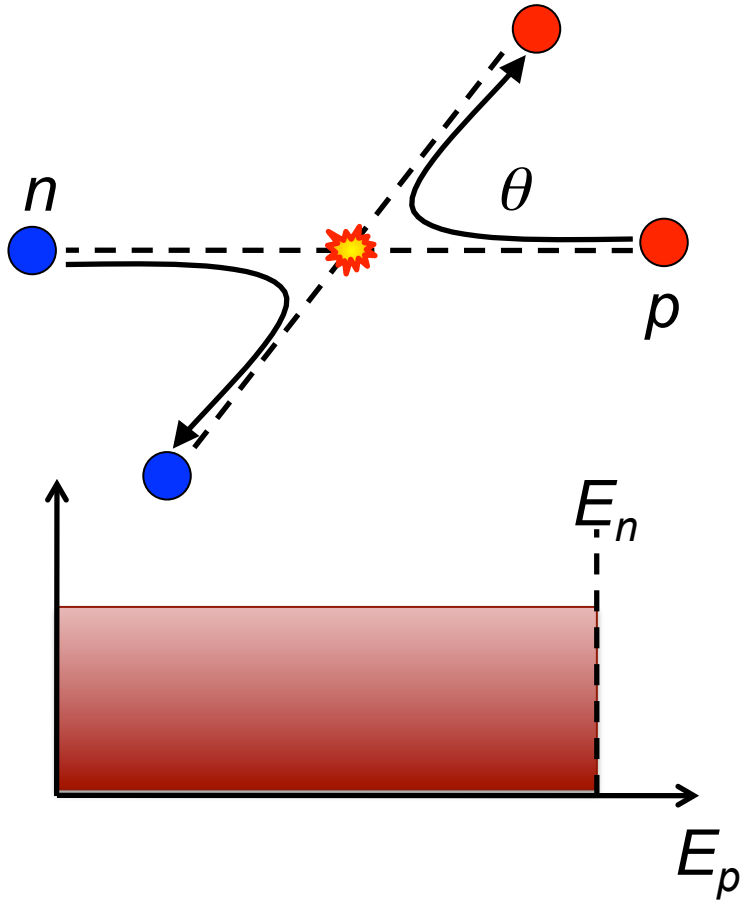
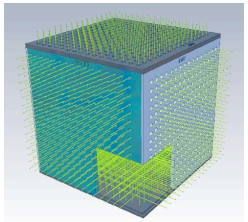


A Quick Unfolding Algorithm

- Assume isotropic CM scattering
- Assume uniform energy deposit
- Assume monotonic with endpoint
- Integrate uniform "cake layers"





A Quick Unfolding Algorithm

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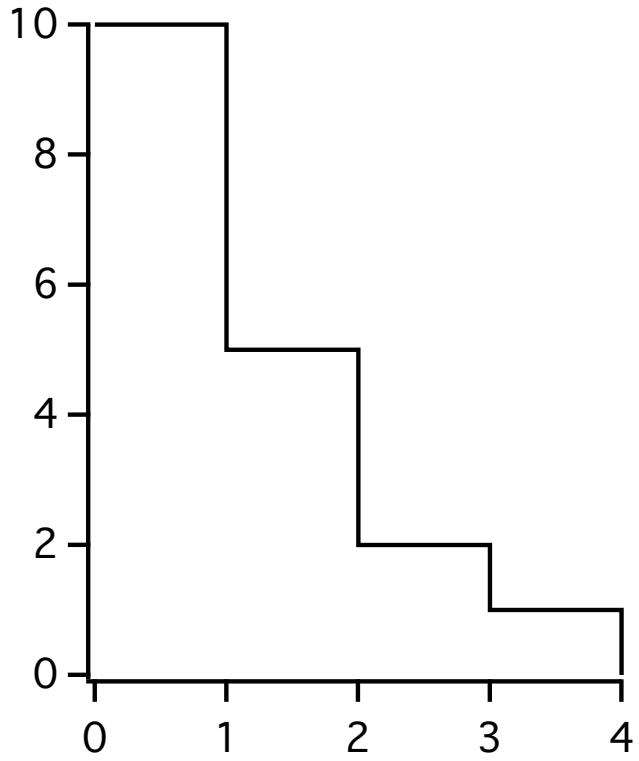

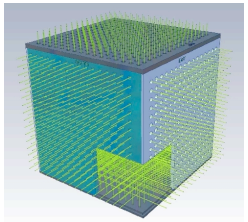

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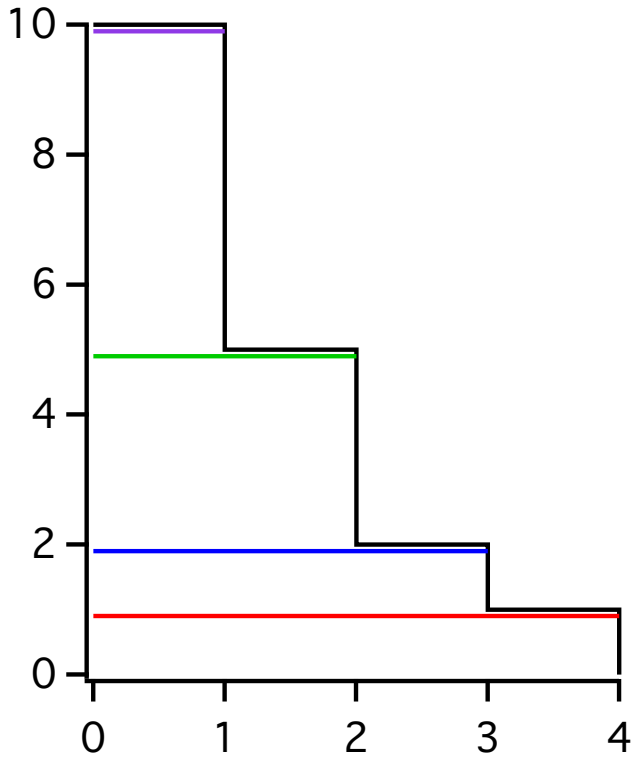

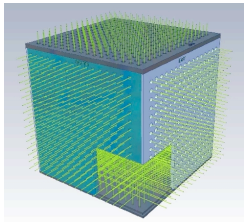

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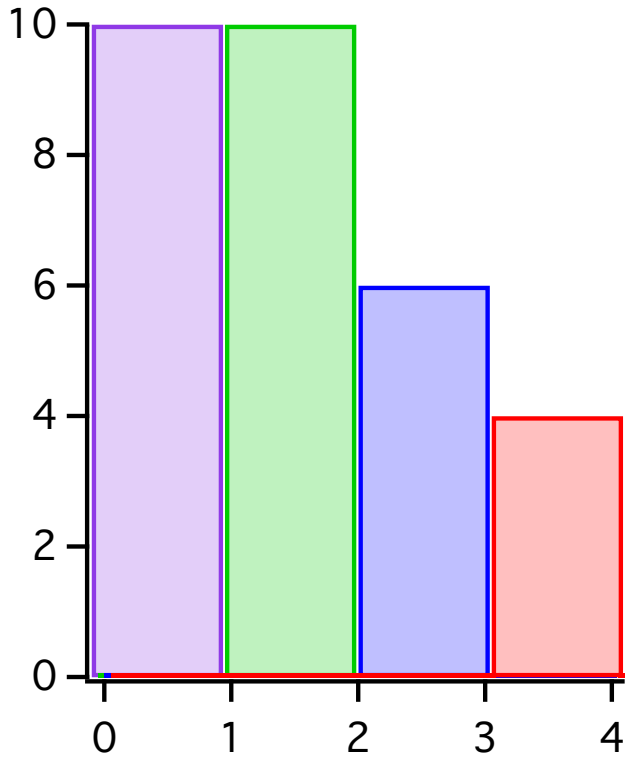
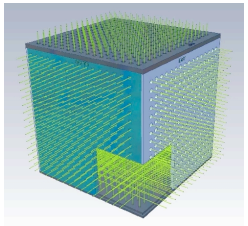
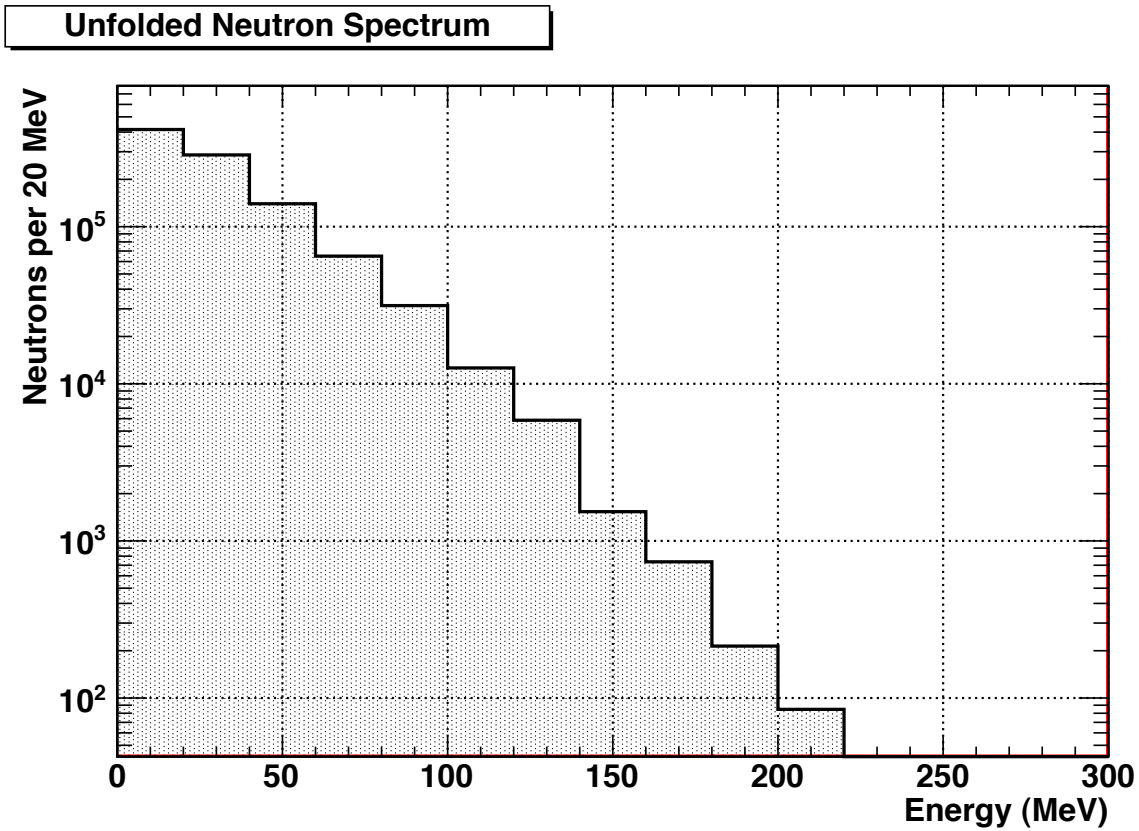
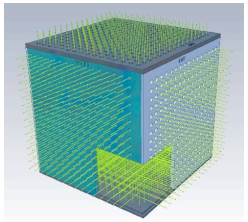




Unfolded Neutron Spectrum

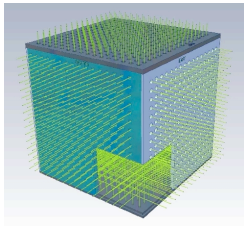




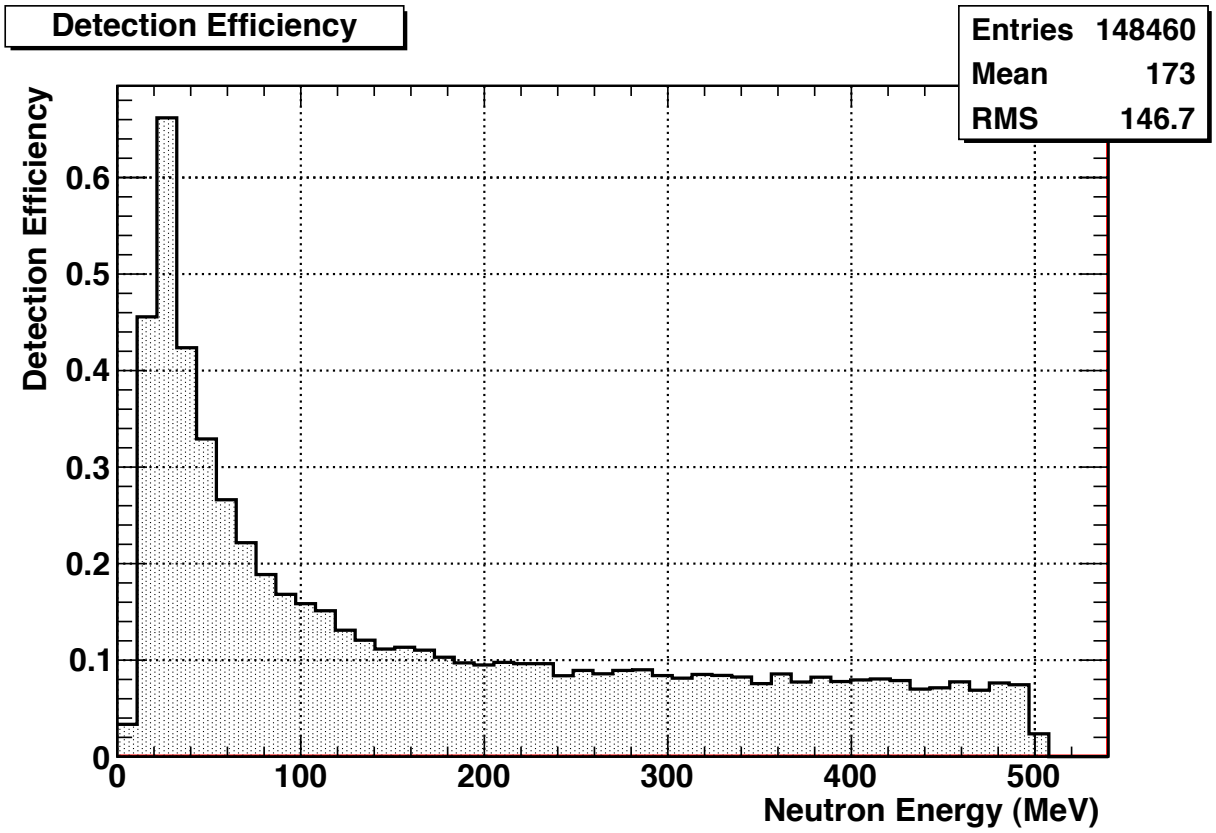
Preliminary Analysis Roadmap

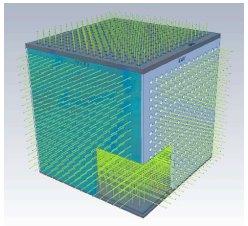
1. Measure proton PE response
2. Convert proton PEs to energy scale
3. Unfold spectrum of neutrons from protons
4. **Divide detector efficiency**
5. Normalize to *X* units
   (*X* = time, POT, triggers, etc.)

Future spectra will combine 3. and 4. in MC

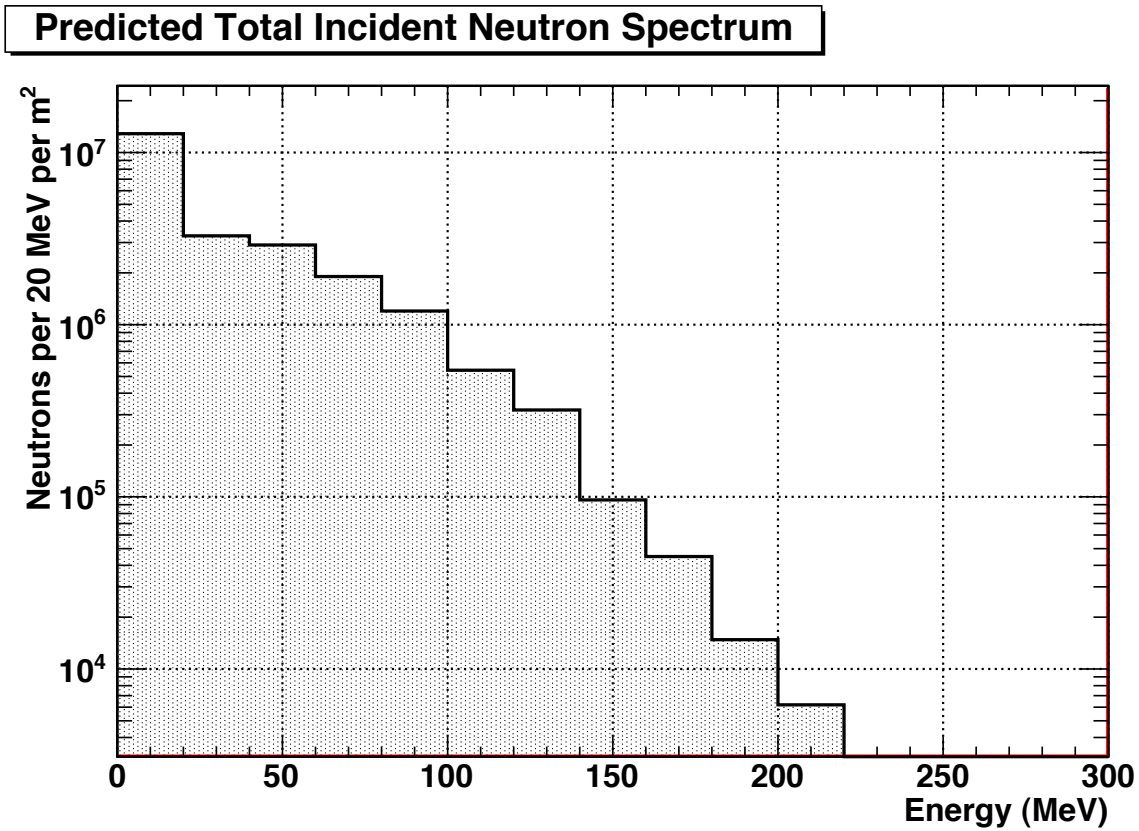


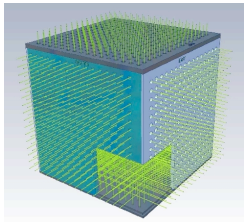
Detection Efficiency (MC)





Predicted Neutron Spectrum





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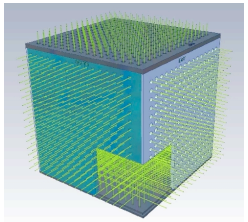
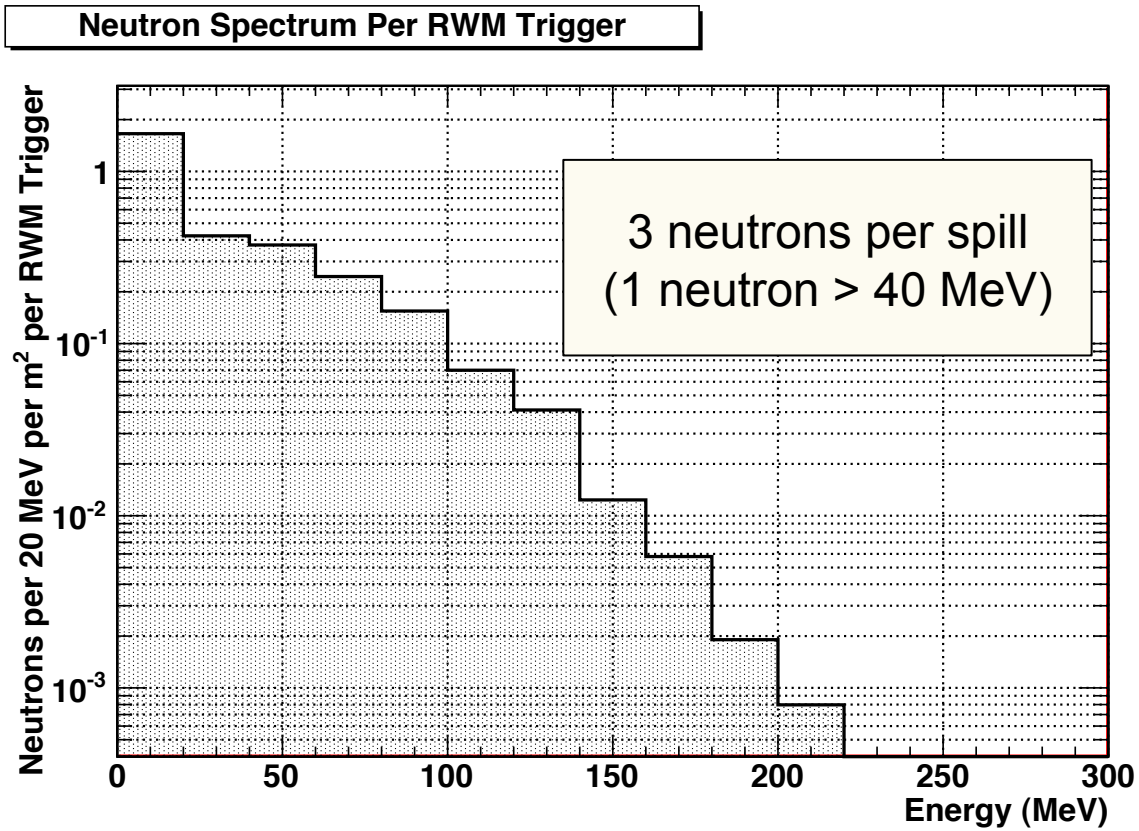


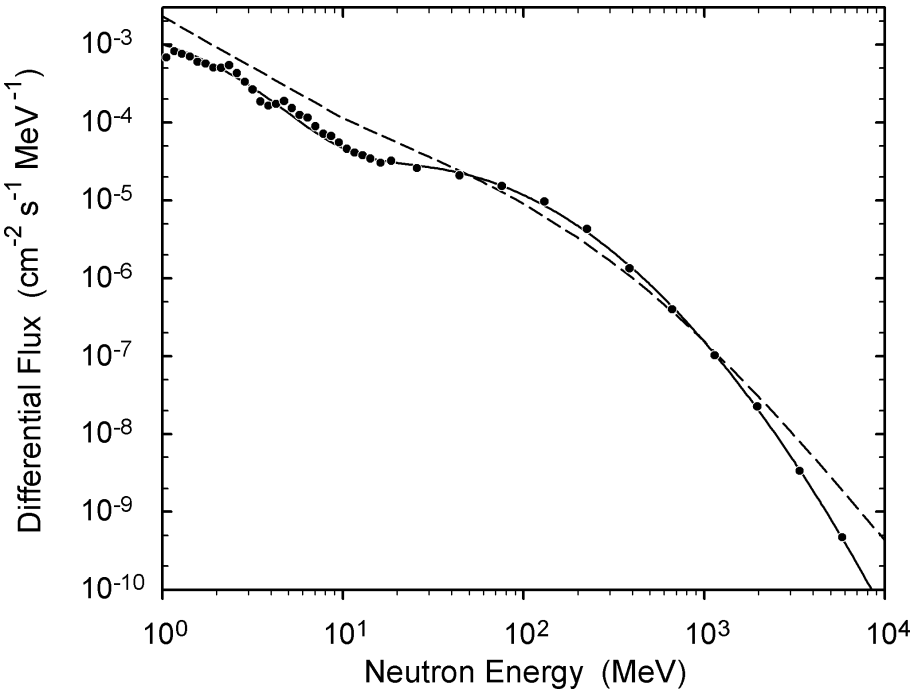
Neutron Spectrum per Beam Spill



NEXT STEPS

Underway

- Implement MC unfolding
- Least squares fit or maximum likelihood?
- POT analysis
- Explore effect of n-capture tagging, fiducial cuts, and PID
- Directional analysis
- Double scatter analysis

More Aggressive

- n / γ discrimination
- Validate with cosmic n's