Thin Quartz Cerenkov Detector R&D

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Thanks to: Carlos Bula, Brady Lowe

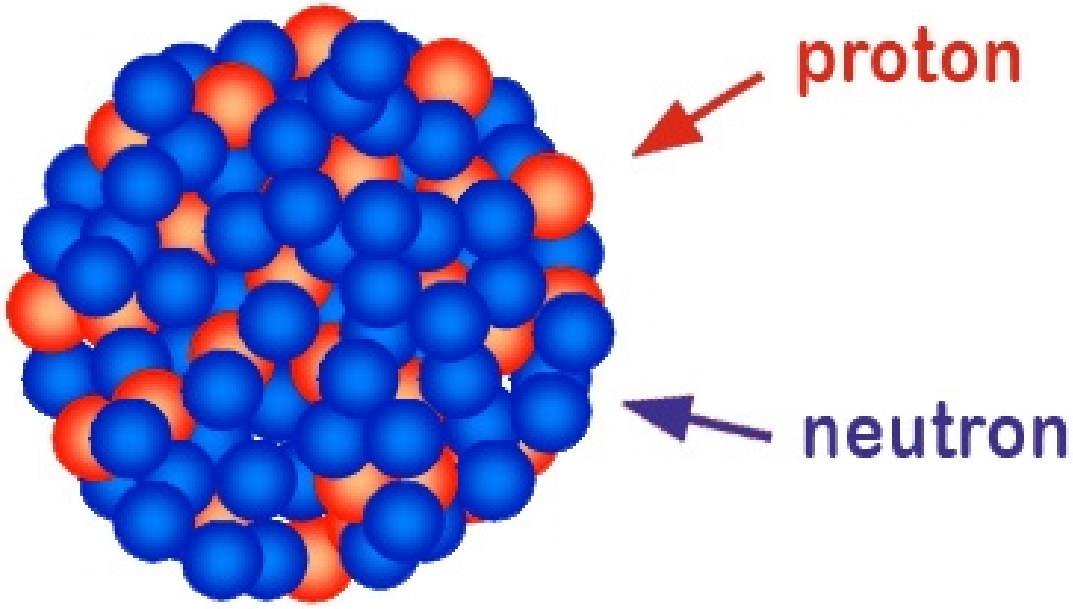
May 20, 2014

Ongoing Work at ISU for PREx and CREx

Quartz Cerenkov detector development

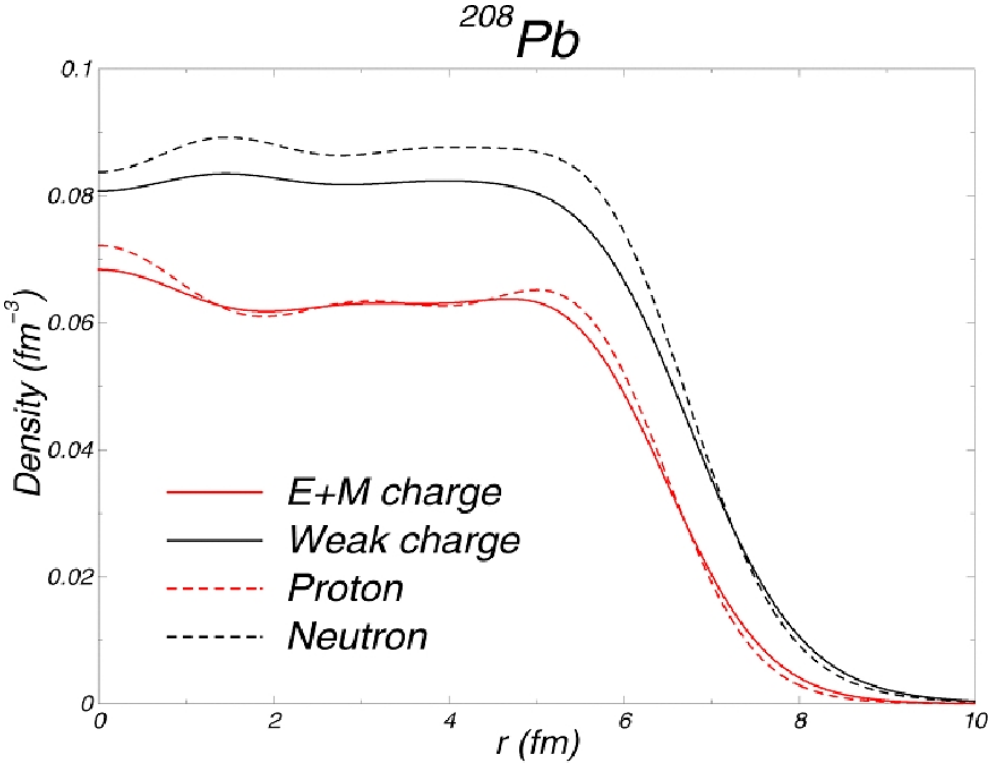
- Cosmic ray tests
  - –Constructed baseline prototype detector
  - –Constructed cosmic/beam test stand
  - –Established counting Data Acquisition System (DAQ)
- Optical Monte Carlo Simulation
  - –Using "qsim" framework: GEANT4, C++ based
  - –Modeled precise geometry of cosmic test setup
  - –Continuing to develop and refine.
  - –Once benchmarked, will use to optimize detector design

What is the size of a ^{208}Pb nucleus (82p+126n)?



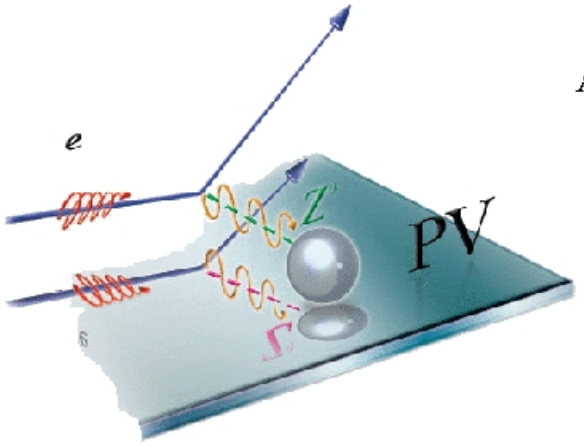
- What do we mean by size? The mass radius, the charge radius?
- PREx (Pb Radius Experiment) addresses this question in a unique way: Uses a "Weak" nuclear force probe to measure how much neutrons stick out past protons (The Neutron "skin")
- CREx (Calcium Radius Experiment) performs same measurement but on ^{48}Ca nucleus

Fundamental Forces and the Standard Model

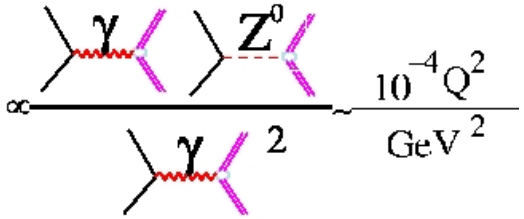


- Electromagnetism: Force mediated by γ exchange; Protons have EM charge "+e" while neutrons have 0...
- Weak Nuclear: Force mediated by Z^0 and $W^{\pm}$; Neutrons have 12 times more Q_{weak} than protons

PREx Measurement (Parity Violation)

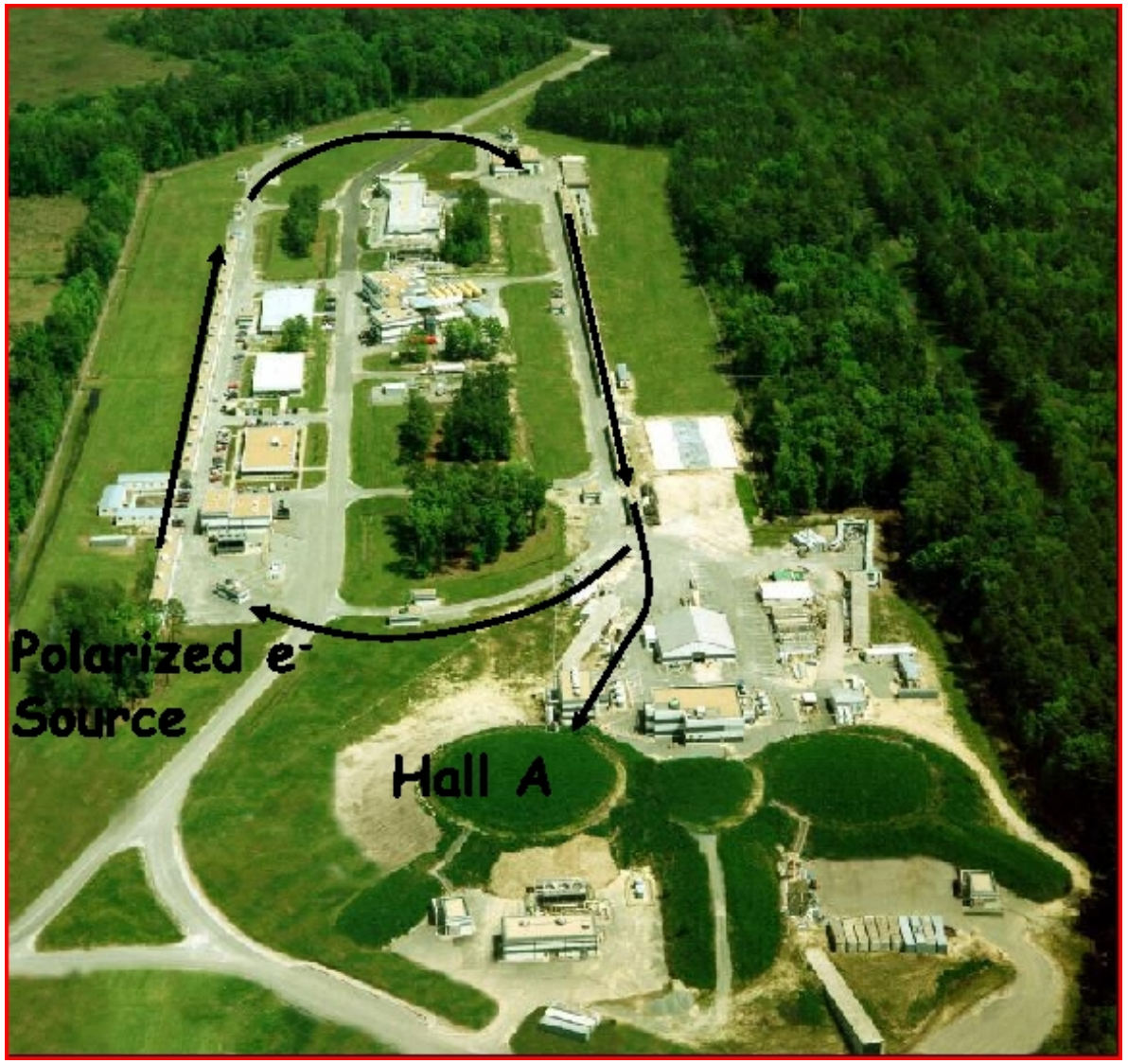


$$A^{PV} = \frac{\sigma_R - \sigma_L}{\sigma_R + \sigma_L}$$



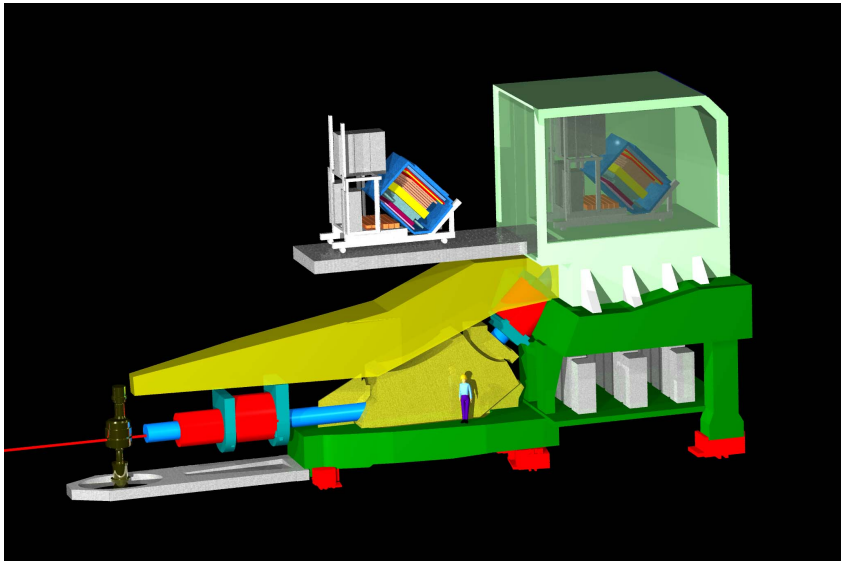
- Uses ∼1 GeV elastically scattered electrons off 0.5 mm thick isotopically pure ^{208}Pb target
- e^- beam is longitudinally spin-polarized, target is unpolarized
- Measurement relies on the maximal parity-symmetry violating nature of the Weak force
- e^-'s dominant interaction is EM, but it can also interact via the Weak force; but it only does so for one of the polarization states and not the other

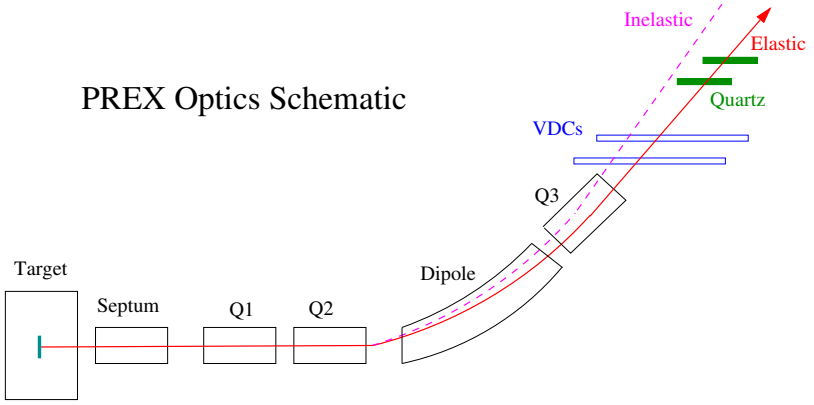
Jefferson Lab (Newport News, Virginia)



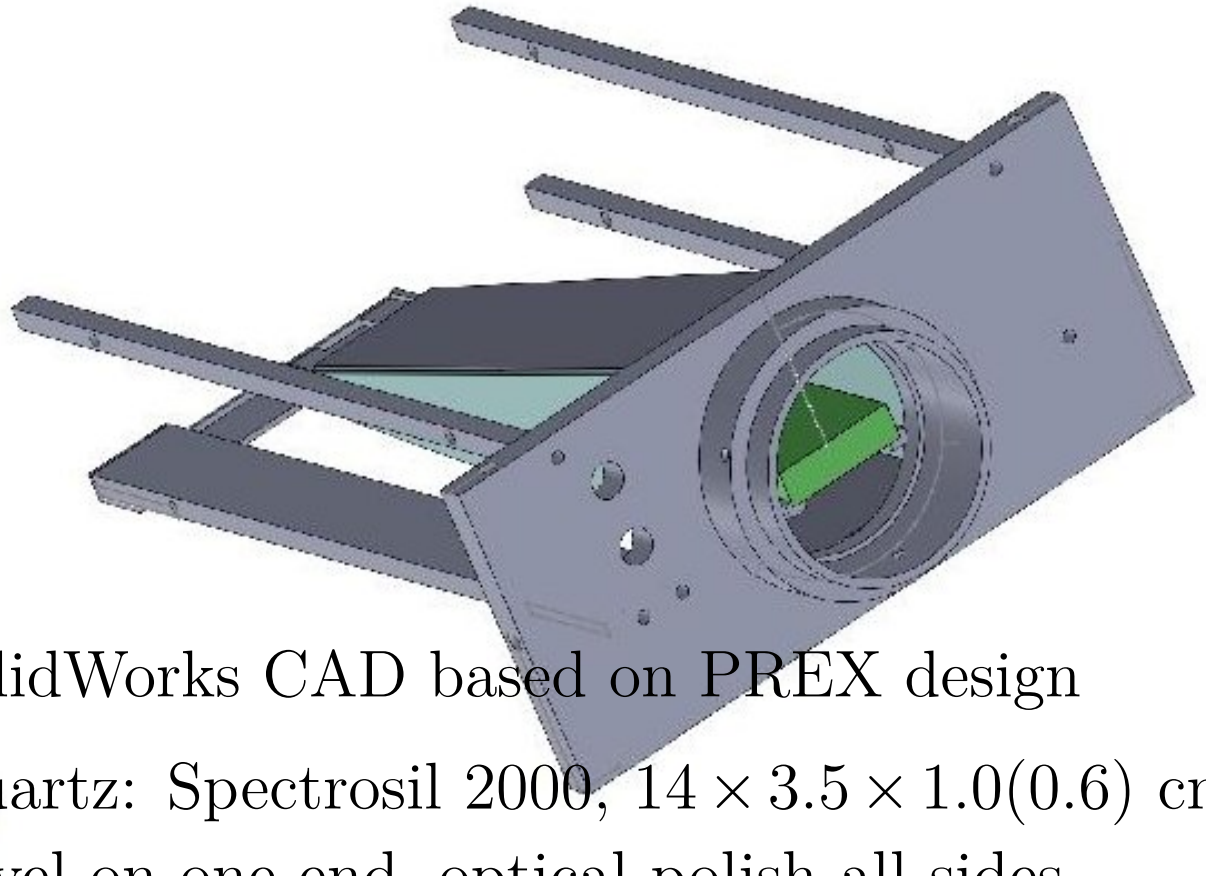
Experimental Setup (Spectrometer & Detectors)

- Thin quartz Cerenkov detectors with PMTs used to measure scattered electron flux
- Highly relativistic electrons travel faster than light travels through the quartz, thus creating Cerenkov radiation (UV light)
- High purity quartz necessary due to its extreme radiation hardness (maintains transparency during high doses of radiation)



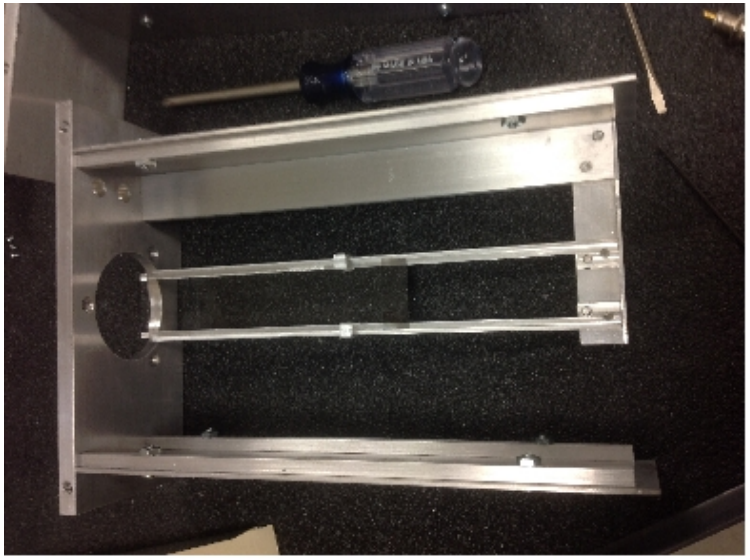


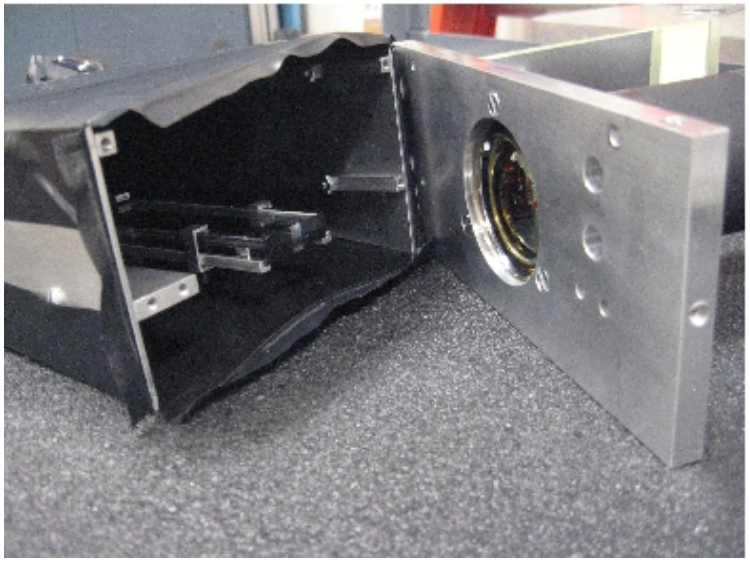
Baseline prototype Quartz Detector

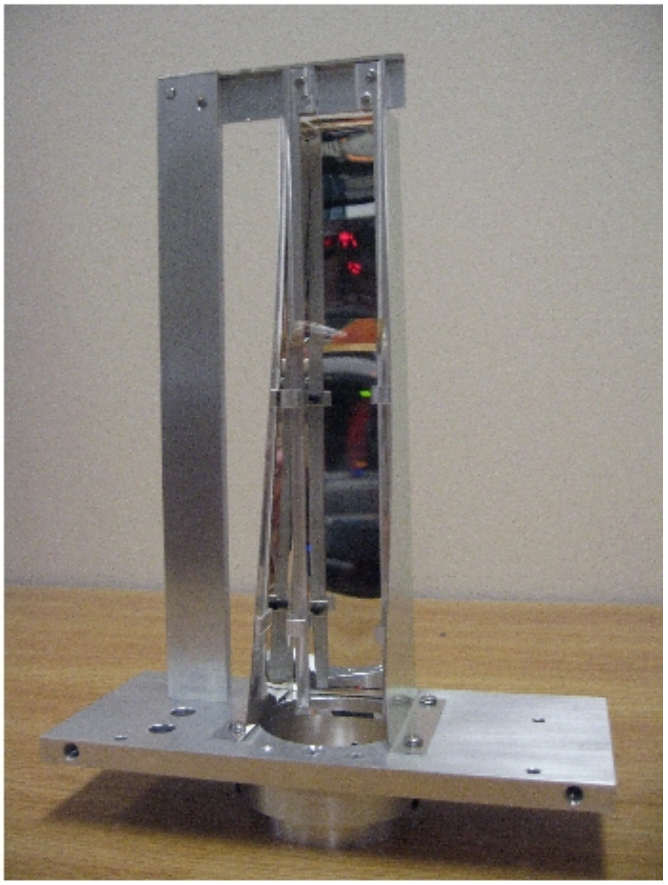


- SolidWorks CAD based on PREX design
- Quartz: Spectrosil 2000, $14 \times 3.5 \times 1.0(0.6)$ cm^3, 45° bevel on one end, optical polish all sides
- Light guide: Anolux Miro-silver 4270AG, ...

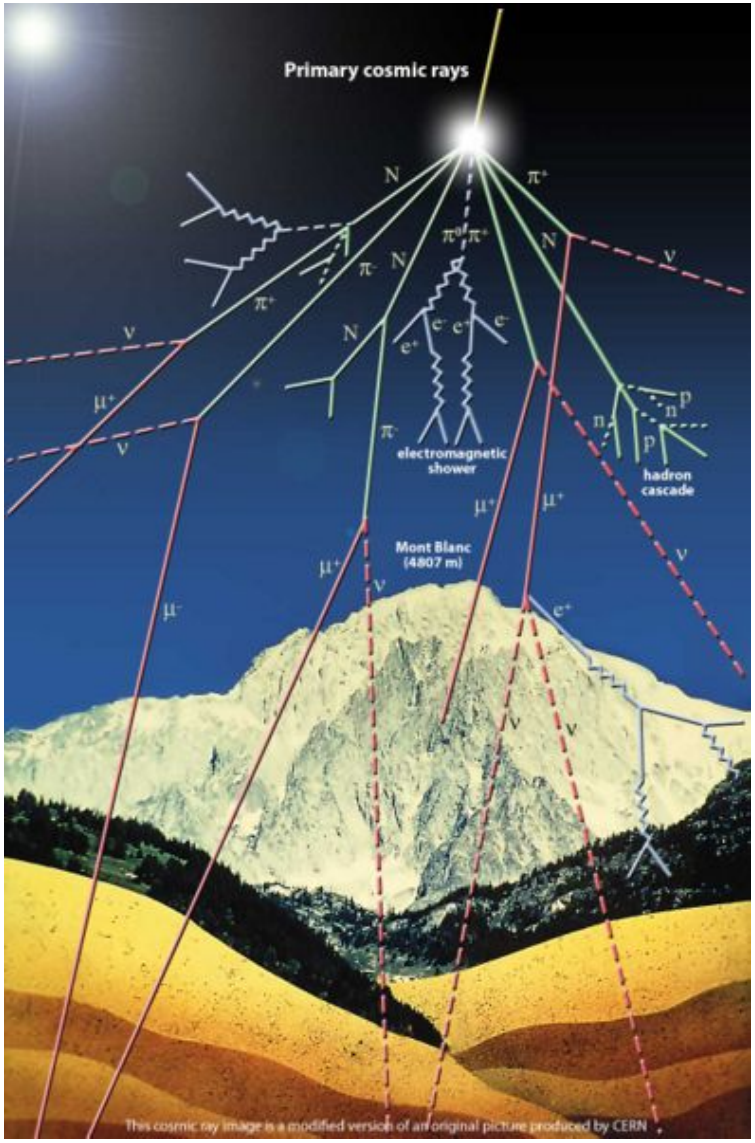
Baseline prototype Quartz Detector



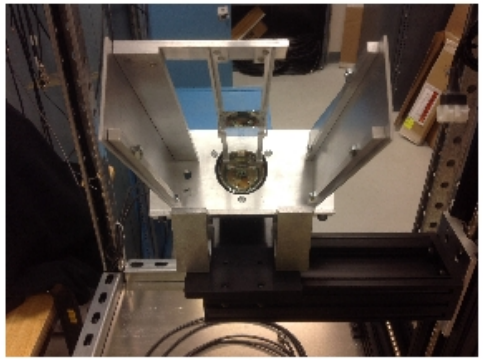


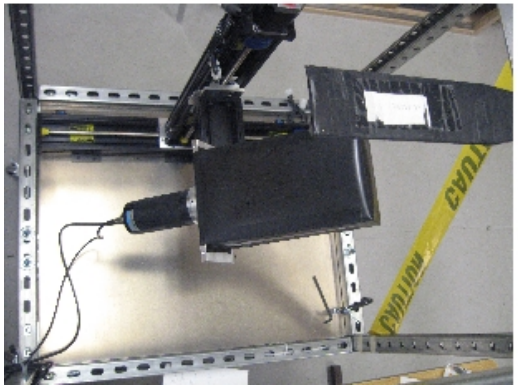


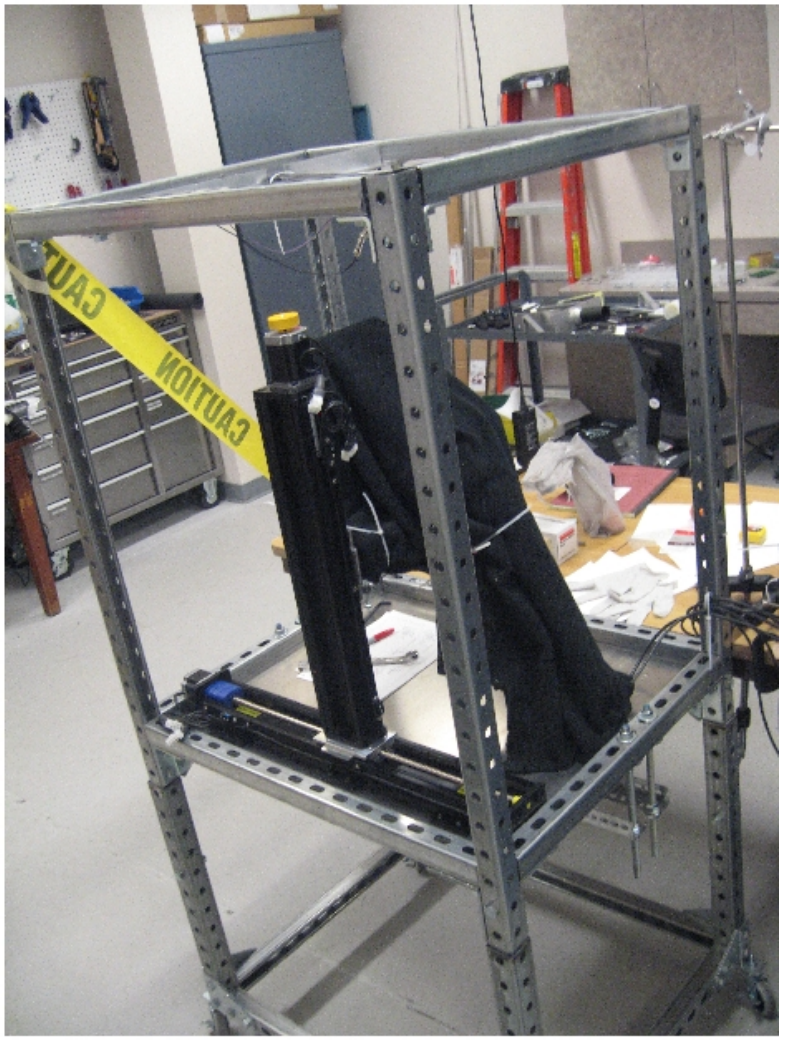
Cosmic Rays


Primary cosmic rays
electromagnetic shower
hadron cascade
Mont Blanc (4807 m)
This cosmic ray image is a modified version of an original picture produced by CERN

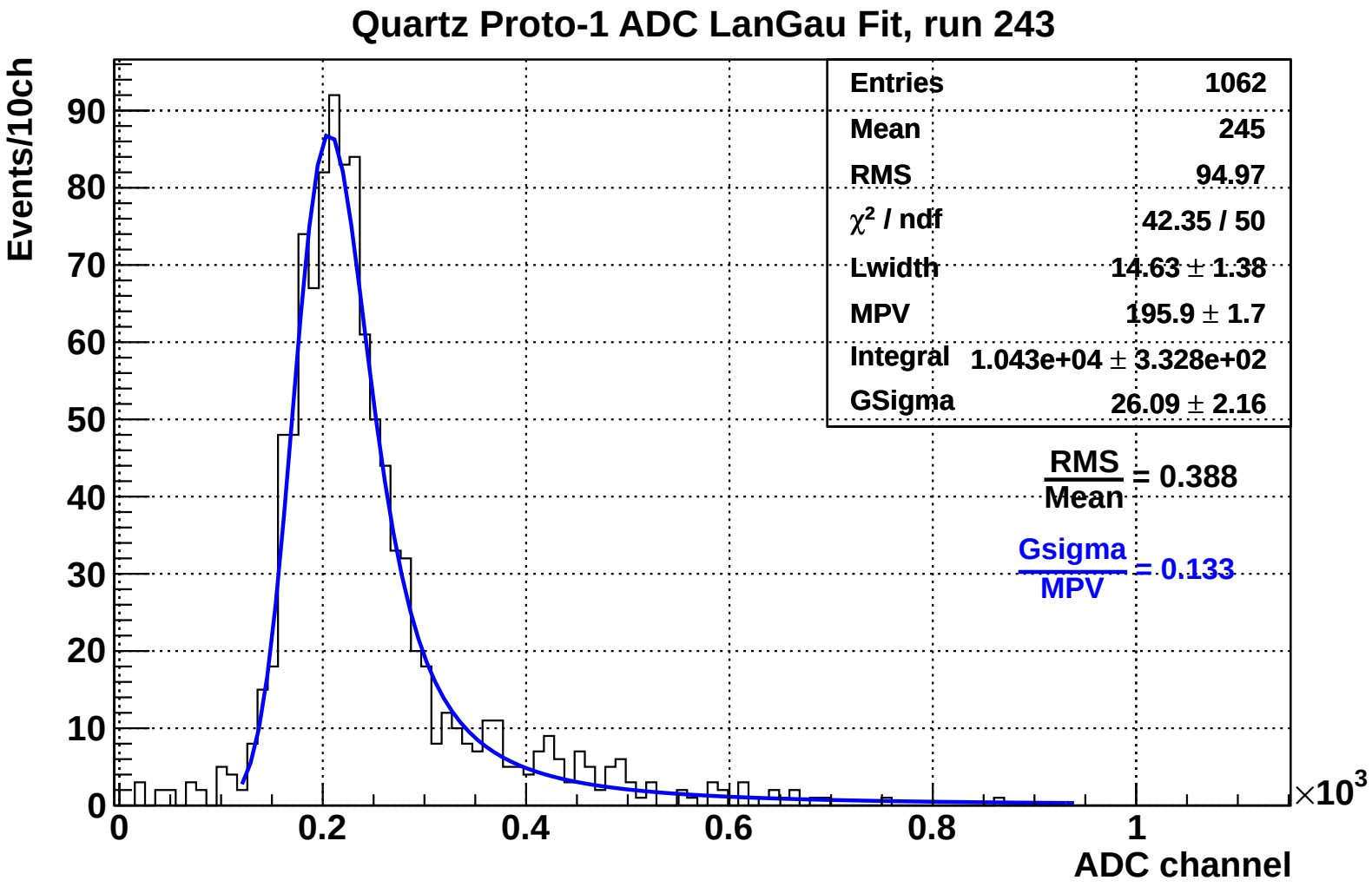
Cosmic/Beam Test Stand



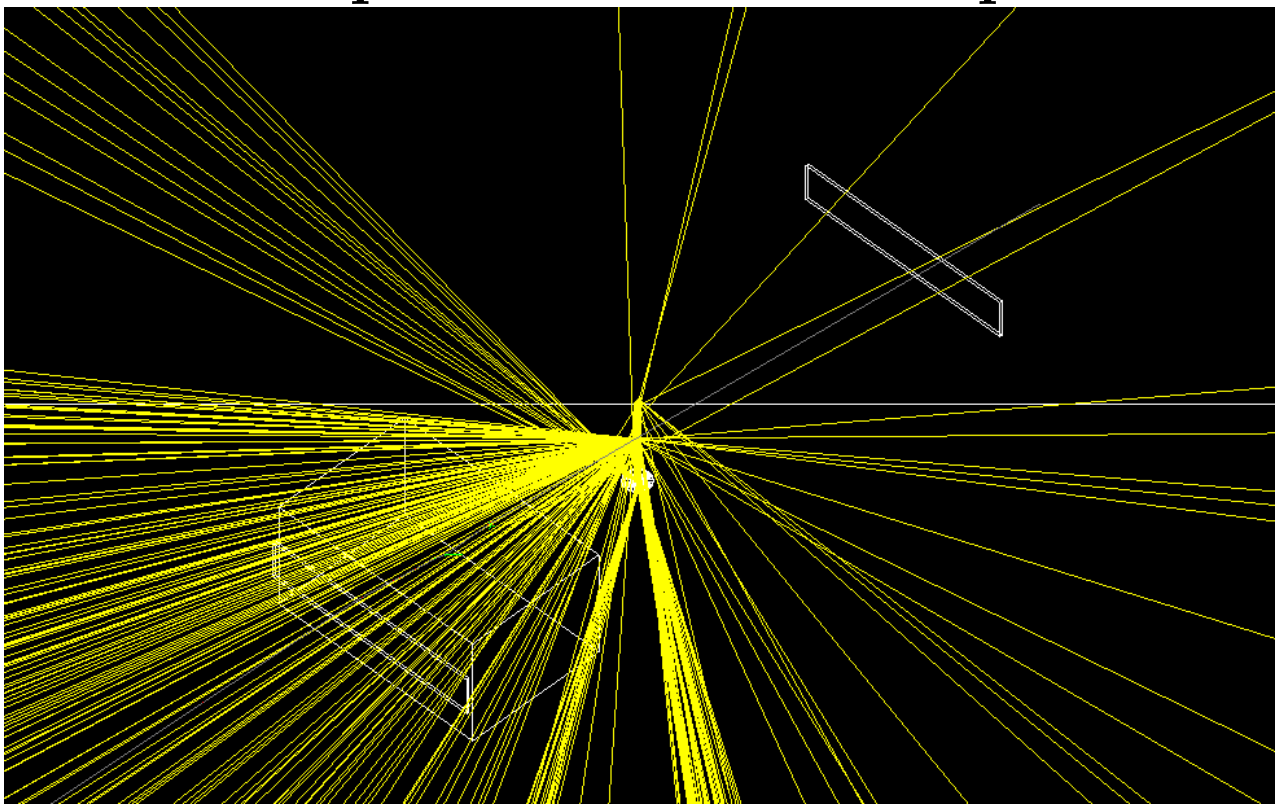




Initial Cosmic Test Results

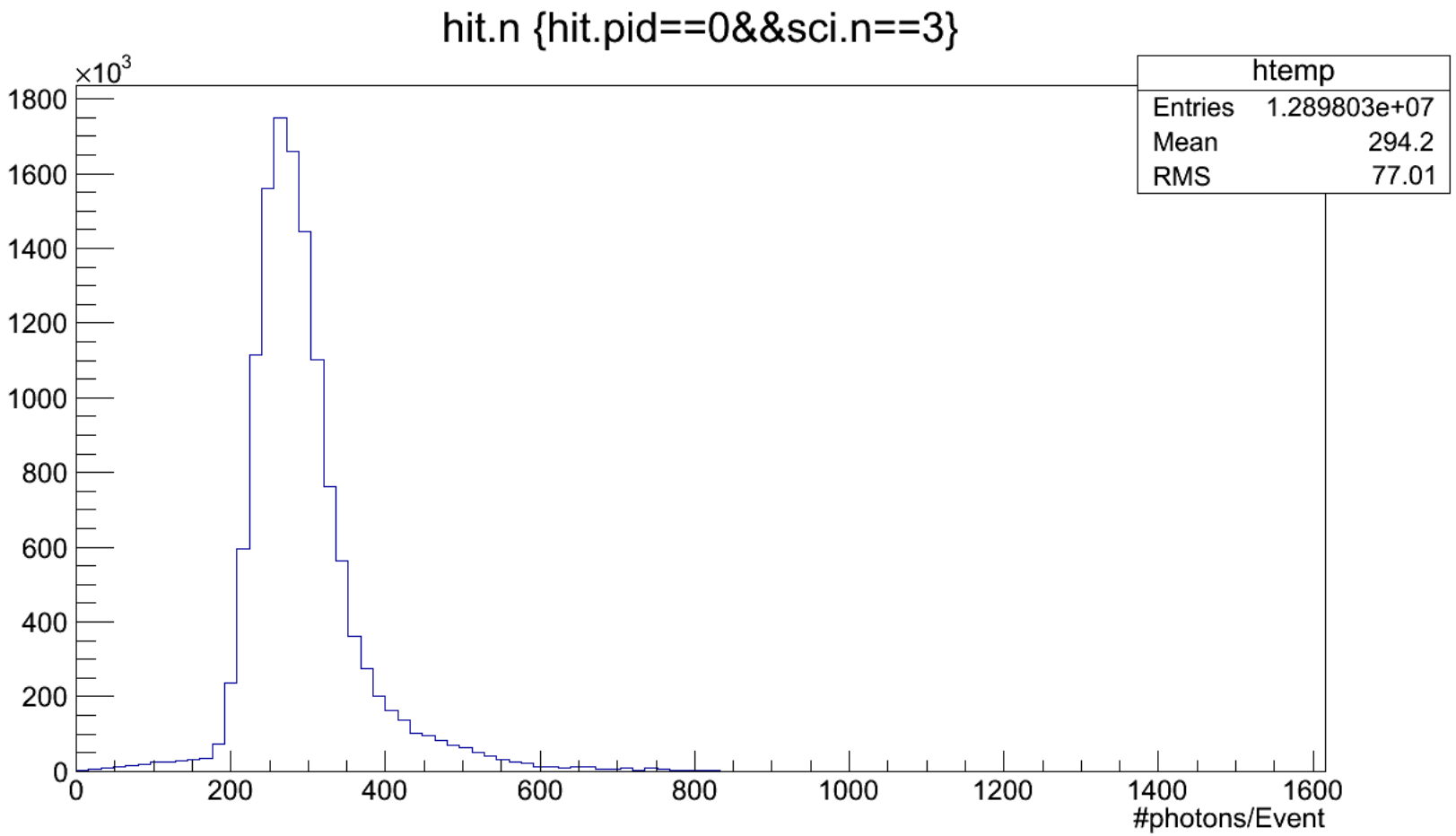


G4 Optical Simulation: qsim

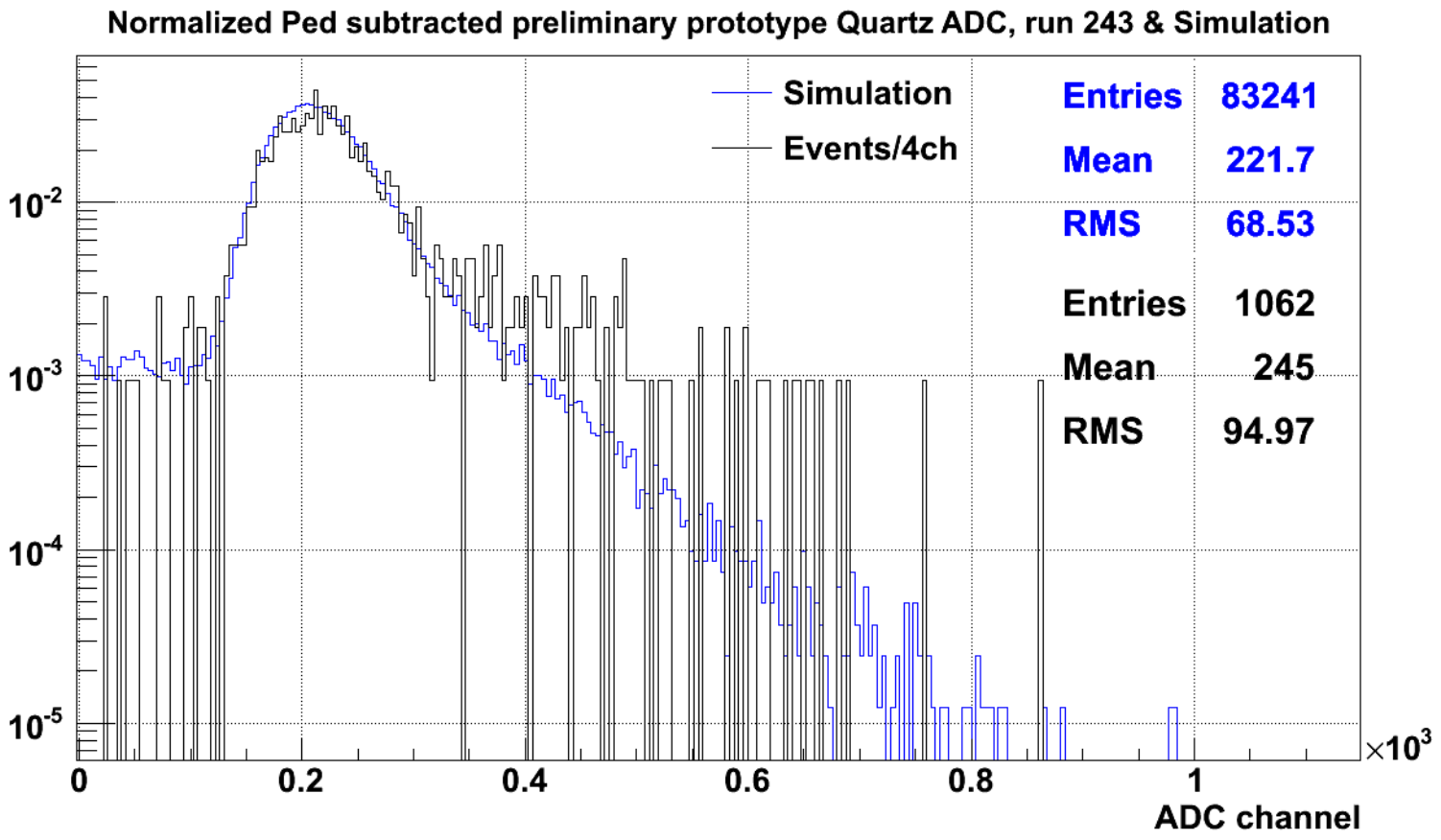


- qsim framework developed by Seamus Riordan
- Geometry adapted to ISU cosmic test setup
- Additional realistic features implemented: muon angle smearing, PMT QE, scintillator coinc. trigger

Distribution of Photons/Muon Hitting PMT



Comparison between Simulation and Experiment



Summary and Plans

- Continued cosmic ray testing of baseline prototype
- Continued refinement of optical simulation by Carlos Bula
- New prototype design currently being developed by Brady Lowe
- Plans to construct new prototype and test with cosmics next month
- Planning for Late summer/early fall quartz detector beamtest at ISU using 12MeV HRRL electron beam

More info can be found at http://www.isu.edu/~mcnudust