Status of the PRad Experiment (E12-11-106)

Jefferson Lab User Group Meeting 2016

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For the PRad Collaboration

PRadius

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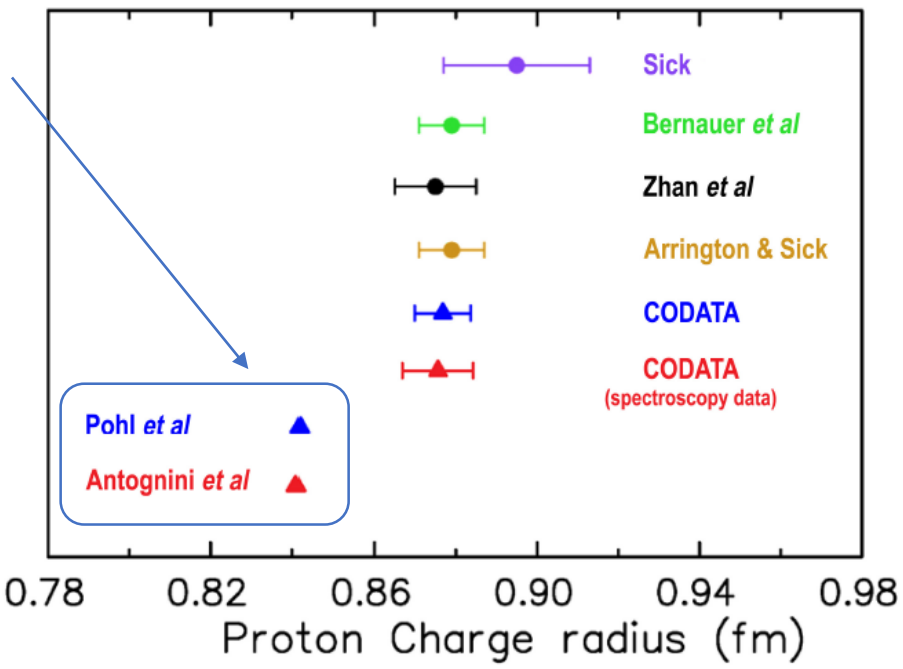
Outline

- PRad Physics Motivation
- Experimental Setup
- Current Status
- Preliminary analysis

Proton Radius Puzzle

- μp Lamb shift measurements by CREMA (2010, 2013)
  - Unprecedented precision, <0.1%
  - 7σ away from CODATA 2012 recommended value
- The discrepancy is not understoc yet. New experiment with different systematic is necessary

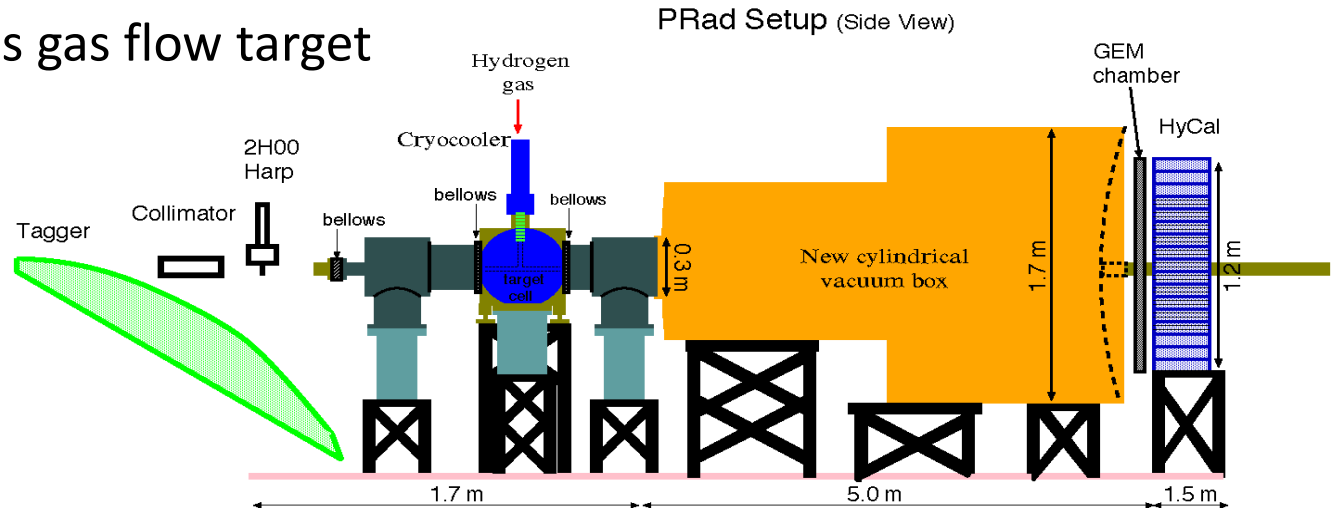


PRad Experiment

- Non-magnetic and calorimetric method with GEM detectors, aiming at an unprecedented low Q^2 region, $Q^2 = 2\times10^{-4} - 1\times10^{-1}\ (\mathrm{GeV/c})^2$ with sub-percent precision

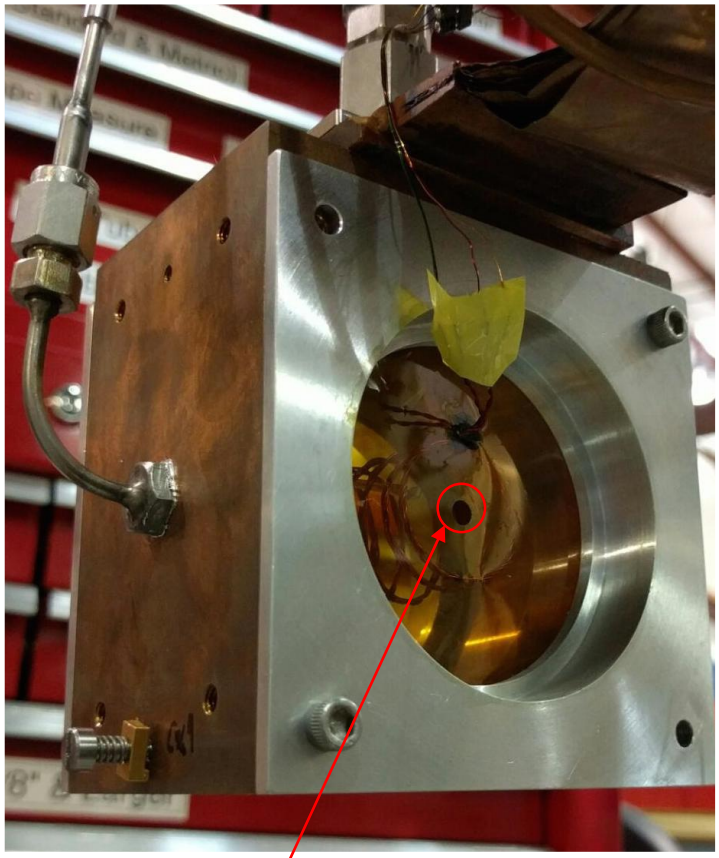
- Simultaneous measurement of e-p elastic scat. and Møller processes

- Windowless gas flow target



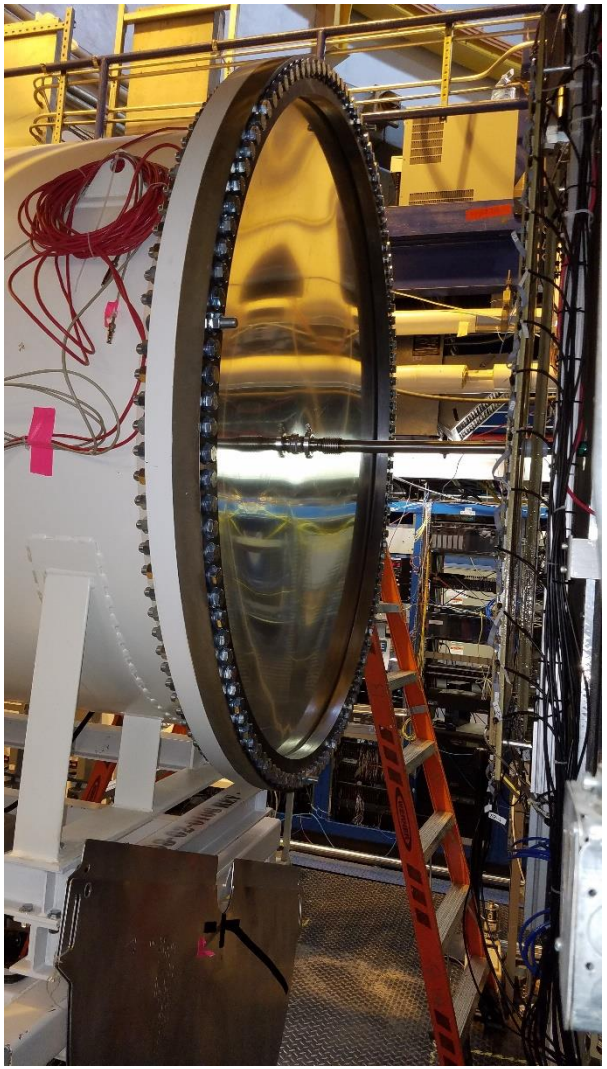
Windowless Gas Flow Target

- Target chamber is differentially pumped with four high speed turbo pumps.
- Cell orifices up- and down-stream
- Four-axis motion system to position the target cell, ~10 μm accuracy
- 20 K, 0.5 torr Hydrogen gas inside the cell.
  - Cell pressure vs. chamber pressure ~ 200 : 1



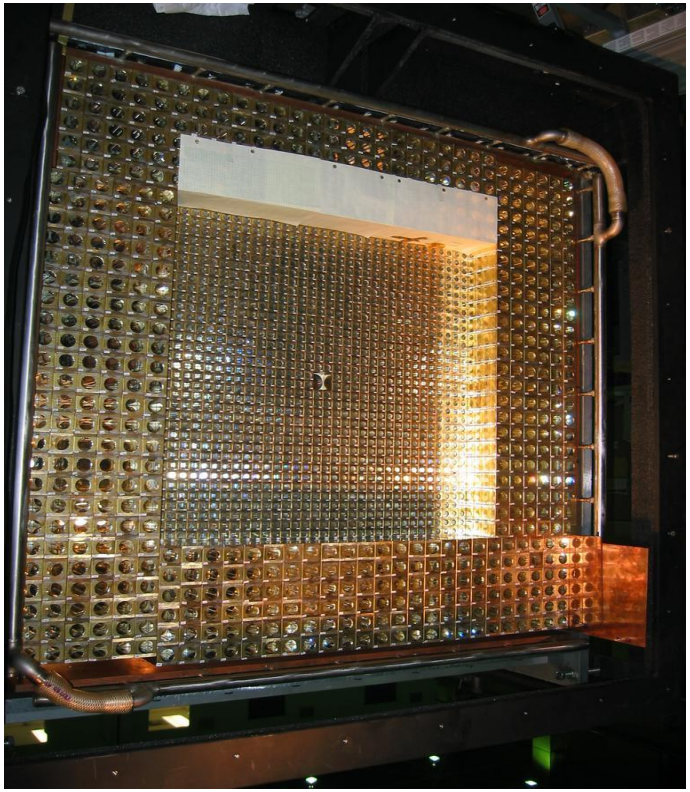
Vacuum Box

- Engineering design done by Duke/JLab
- Installed in May, 2016
- Connect to beam pipe at the end, no material on the beamline



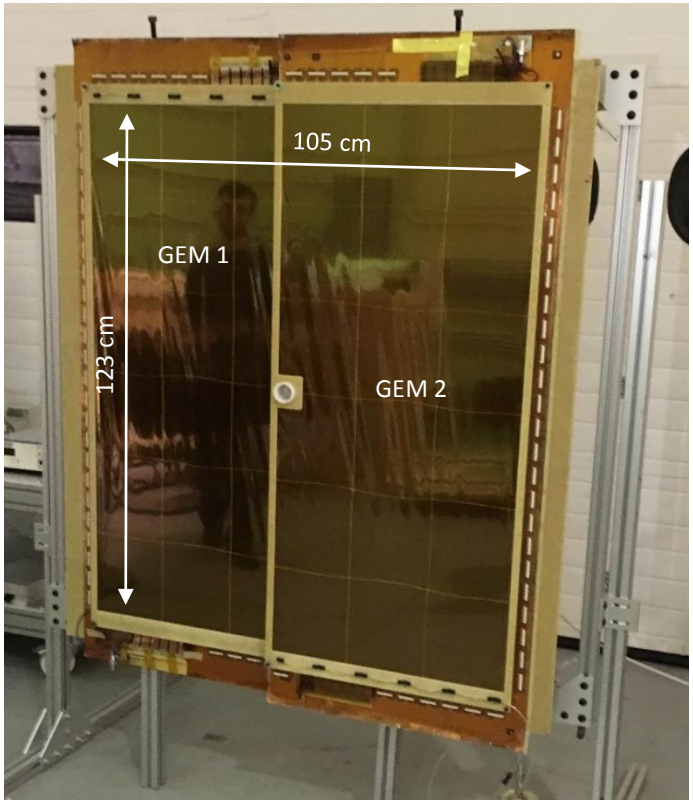
Electromagnetic Calorimeter - HyCal

- Hybrid Calorimeter, combination of $PbWO_4$ and Pb-Glass modules
- High resolution, high efficiency detector
  - $\sigma_E/E = 2.6\%/\sqrt{E}$, $\sigma_{x,y}/E = 2.5\ mm/\sqrt{E}$
  - ~ 99% efficiency
- 5.8 m away from target center (~ 0.5 sr acceptance)



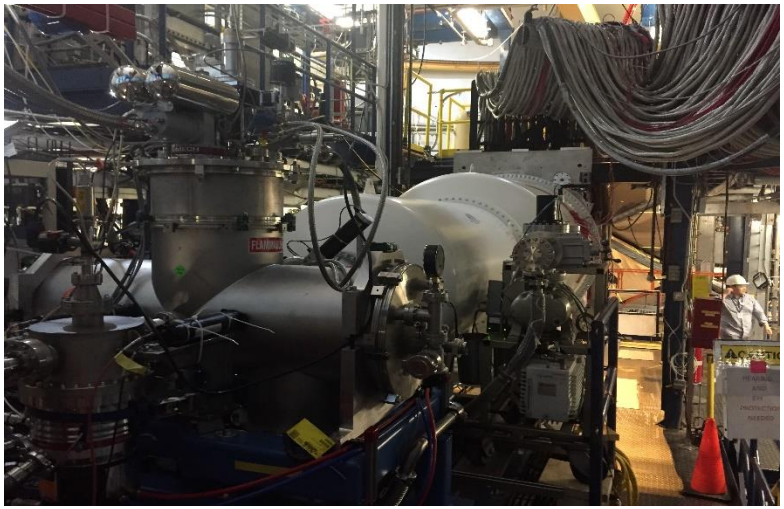
GEM Detectors

- Largest GEM detector ever built in the world. Two chambers to cover the entire region of HyCal
- Two modules overlap in the central part, opening for beam pipe
- COMPASS-like strip readout (1.3 m long vertical strips, acceptable capacitance noise level)
- Mounted on HyCal box

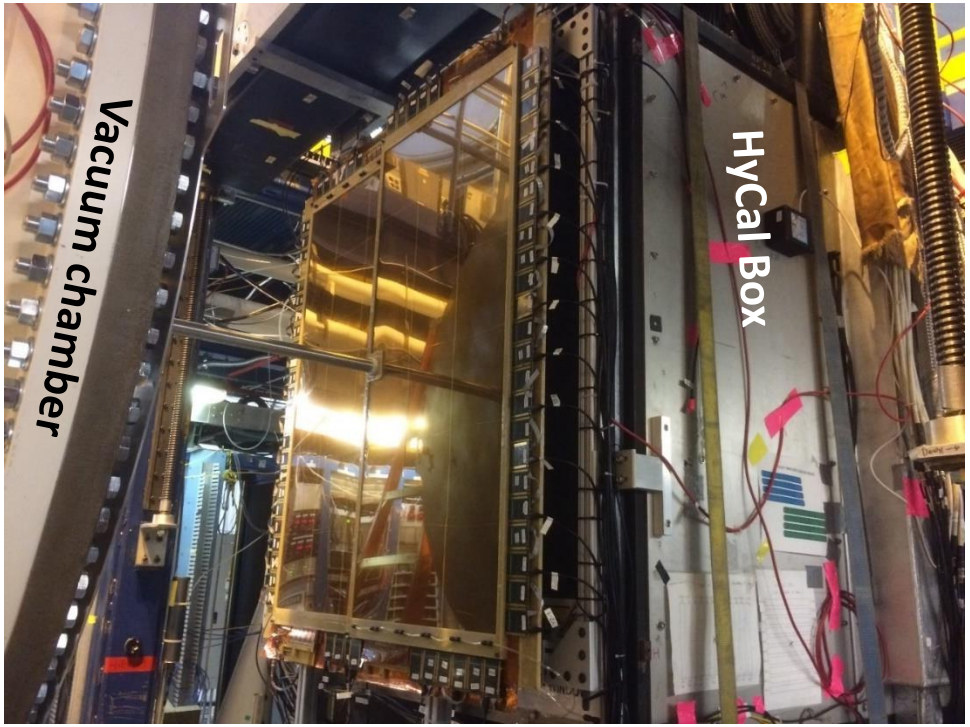


Two modules mounted on the holding frame in PRad GEM configuration before the cosmic run in EEL (March 2016)

Installation done on May 11, 2016

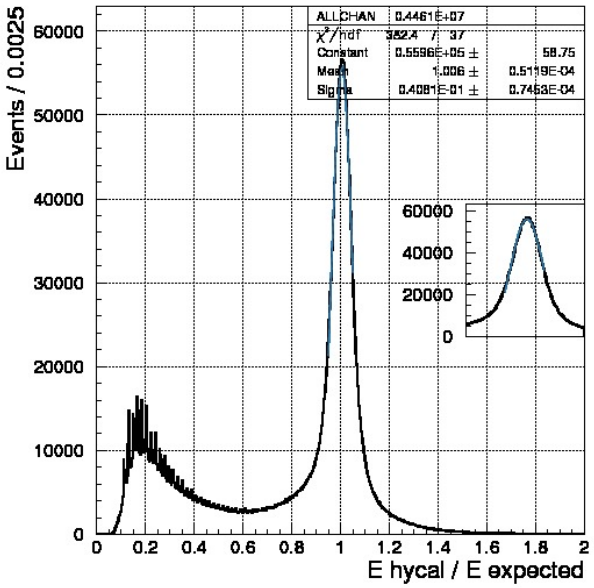


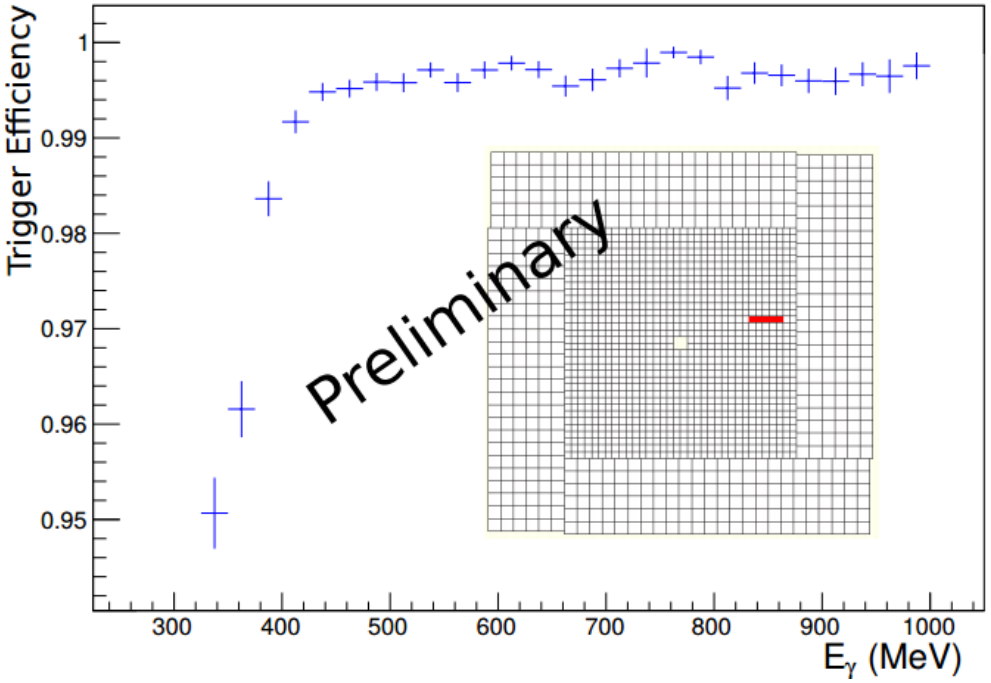
(Thanks to Hall B Technical Group (D. Tilles and All)



Gain Equalizing and Calibration

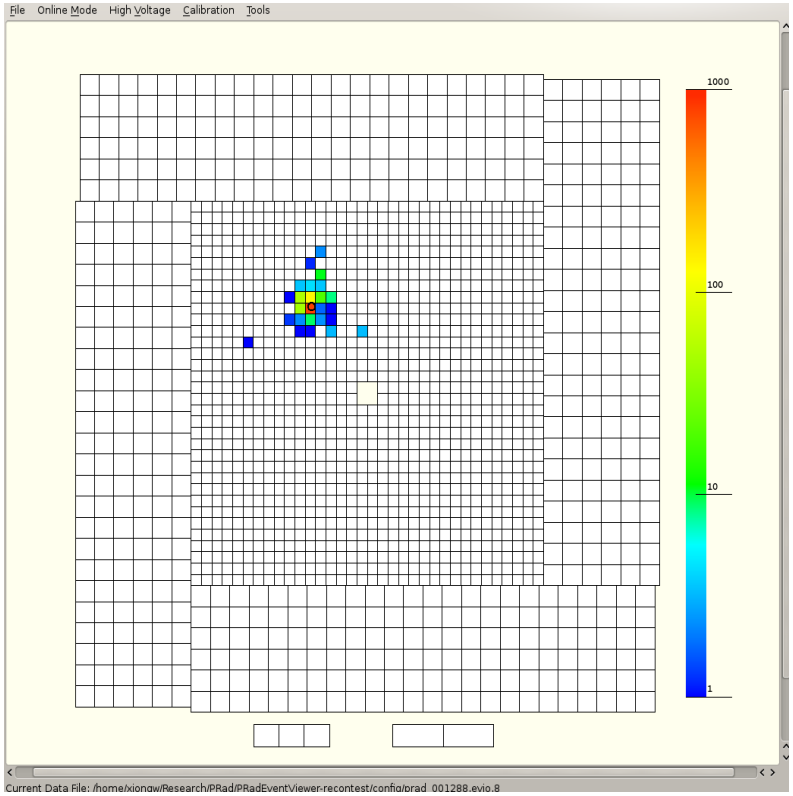
- Gain equalizing and calibration data-taking completed (May 25 – May 31)
- Analysis is on going

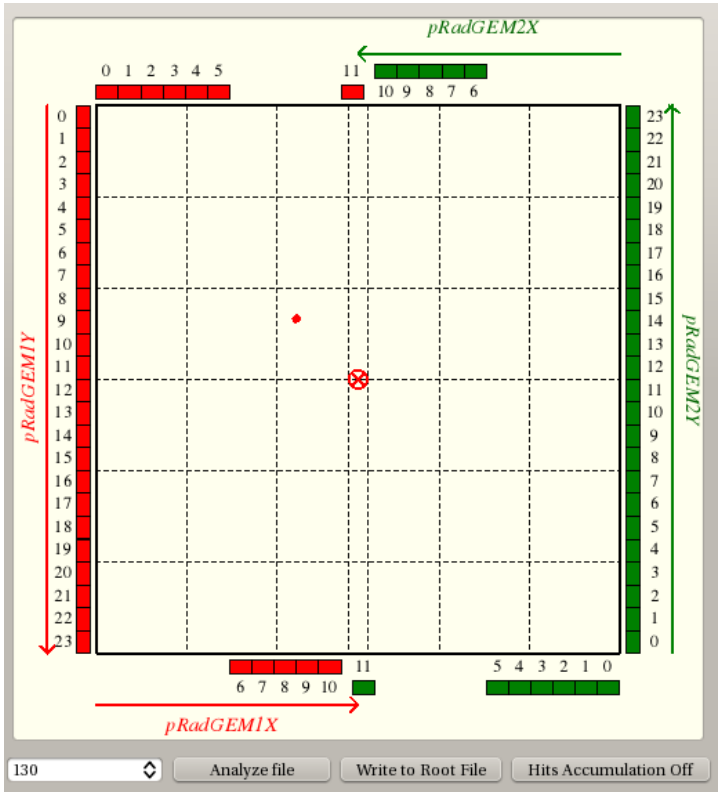




HyCal – GEM Matching

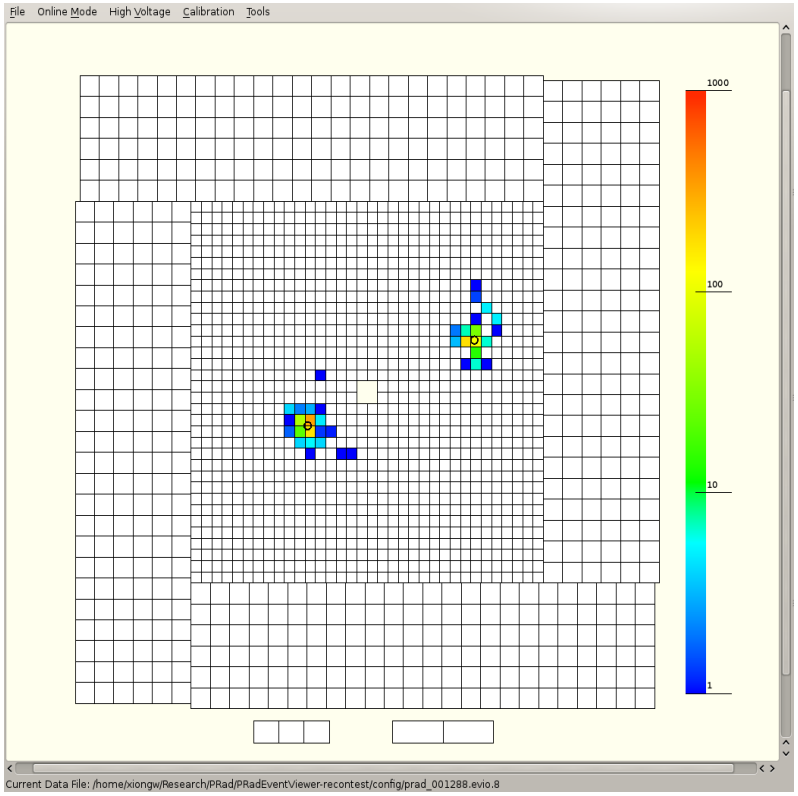
- Online matching, e-p elastic scattering event candidate

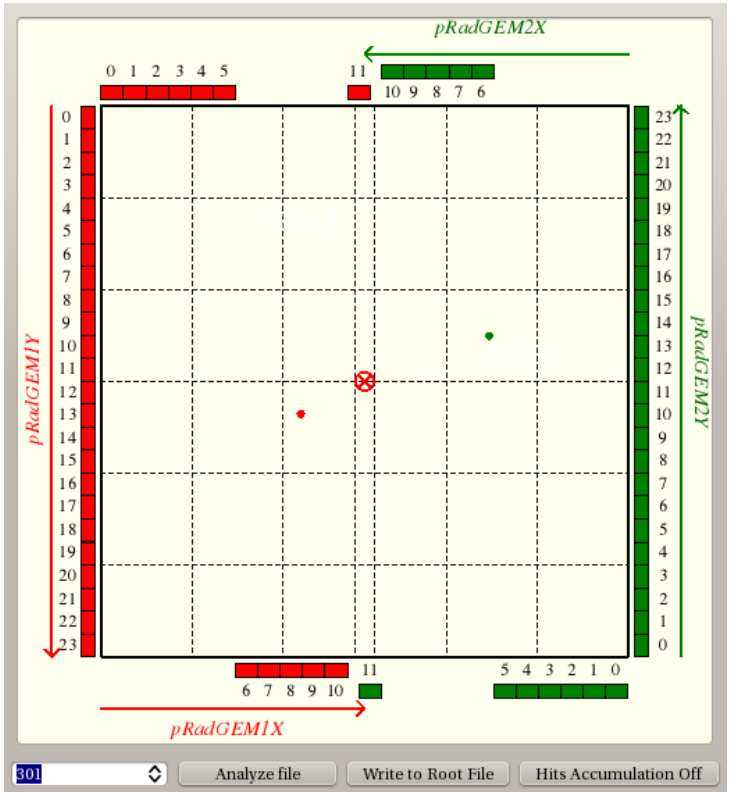




HyCal – GEM Matching

- Online matching, Møller event candidate



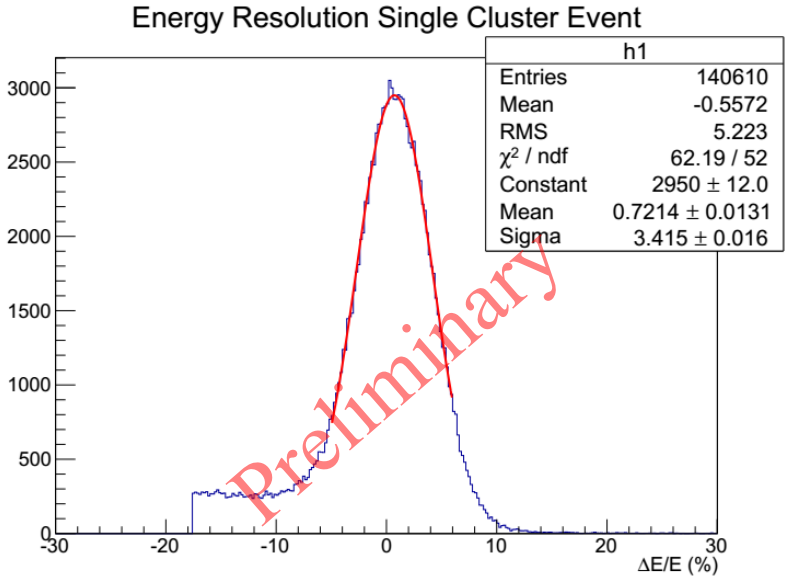


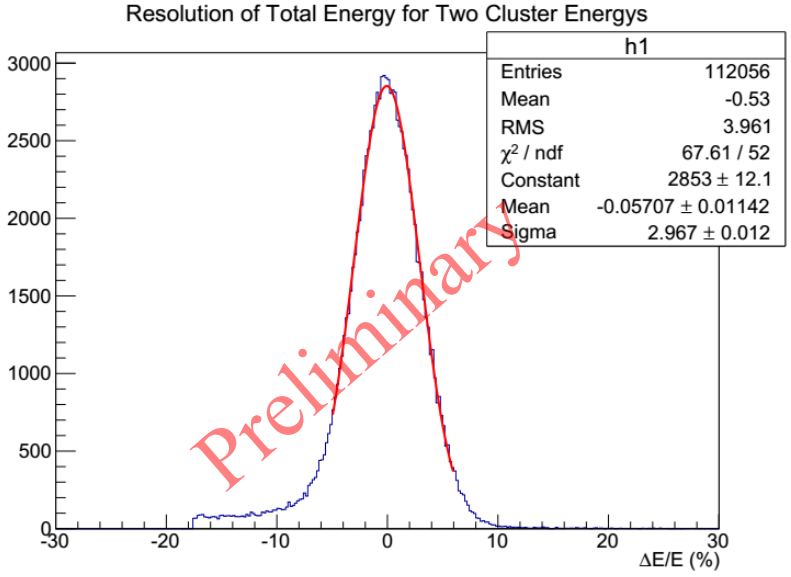
Data taking status

- End on June 22, status by June 20
- 1.1 GeV data-taking completed
  - 10 nA/ 15 nA beam current, 400 Mb/s data rate with 86% live time
  - 600 M production events taken, 50 M events taken with empty target
  - 24 M events taken with carbon foil target
- 2.2 GeV data-taking ongoing
  - 25 nA/ 60 nA beam current, 320 Mb/s data rate with 89% live time
  - 450 M production events taken, 15 M events taken with empty target
  - Plan on carbon foil target and on background study on June 21 and June 22

Preliminary analysis

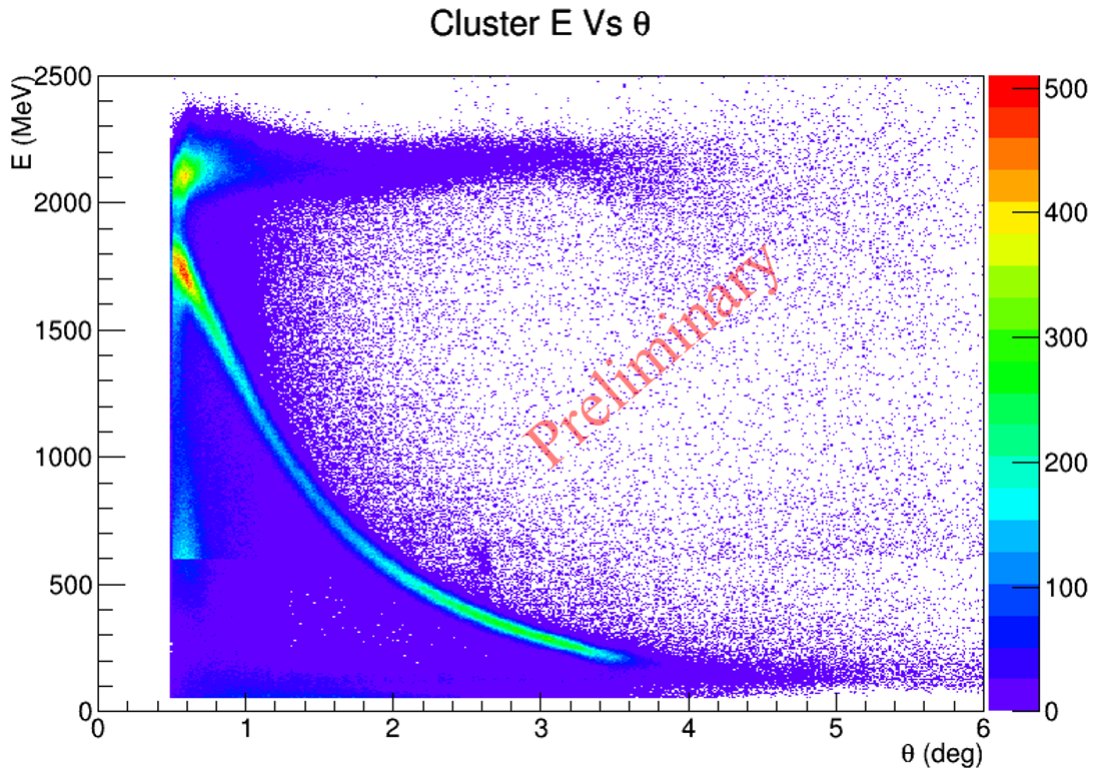
- Energy resolution from 1st iteration of calibration
  - Single cluster event (e-p elastic scat. candidate) ~ 3.4%
  - Total energy of two clusters event (Møller candidate) ~ 3.0%





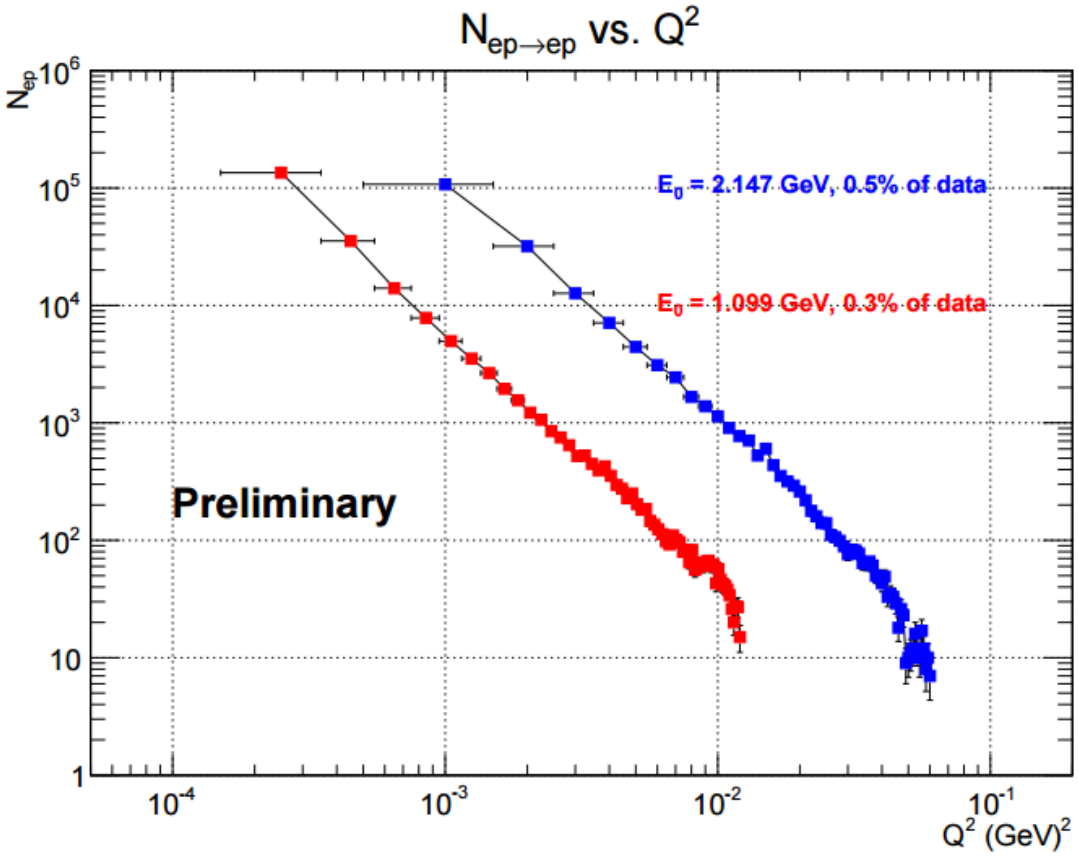
Preliminary analysis

- 2D-map of cluster energy vs. theta (from latest 2.2 GeV data)



Preliminary analysis

- Q^2 distribution of e-p elastic scattering event candidates



Thank you

- Jefferson Lab
  - Administration
  - Accelerator division
  - Hall B staff and technical staff
  - 12 GeV poject team
  - Target group
  - Data acquisition group and fast electronics group
  - Physics division
  - Engineering division
  - Collaboration

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