ELECTROMAGNETIC CALORIMETER STUDIES FOR THE *GEp*(5) EXPERIMENT

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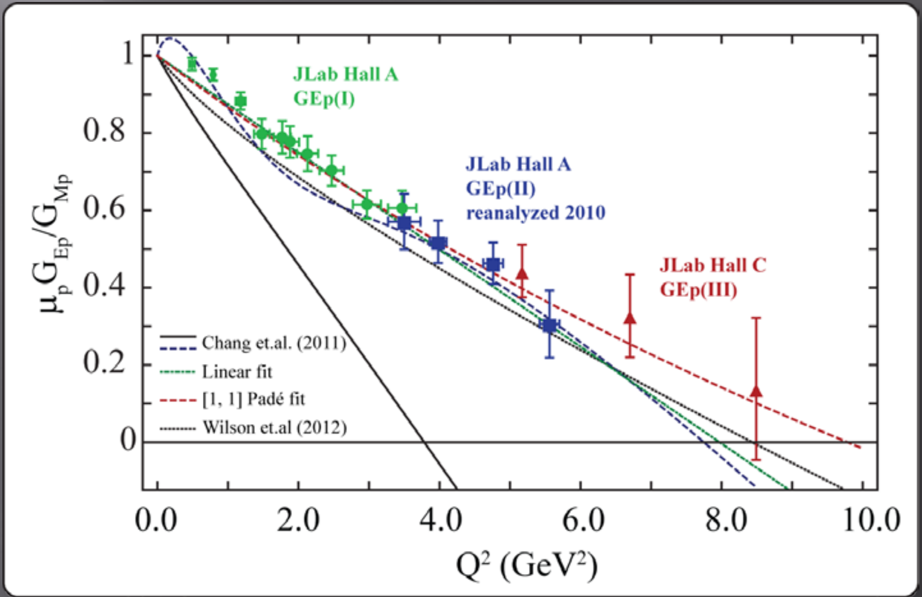
The Gep(5) experiment

Will be the fourth of a successful series of experiments related to measure the proton elastic form factors ratio using the recoil polarization technique

C.F.Perdrisat et.al, *Large Acceptance Proton Form Factor Ratio Measurements at 13 and 15(GeV/c)^2 Using Recoil Polarization Method*. E12-07-109 approved by PAC 32. Jefferson Lab

- Several measurement, show a great discrepancy between polarization technique (PT) and Rosenbluth separation (RS) results
- RS has a strong kinematical dependence of radiative corrections whereas in PT they are small (the decrease of the ratio was predicted before experiments)
- Current database suggests that ratio may cross zero ~10 GeV^2
- This experiment will measure the ratio beyond this point

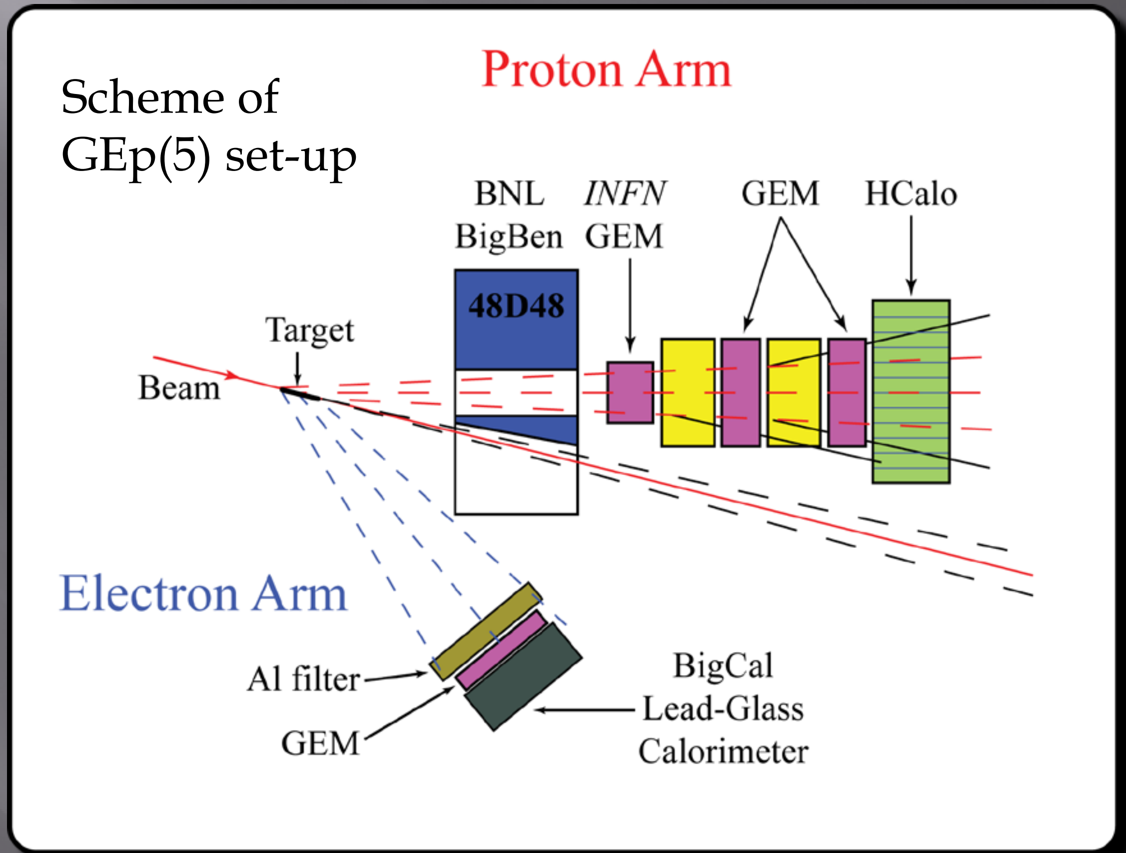


Super-BigBite Spectrometer

- SBS is a new spectrometer for Jlab Hall A designed to be an improvement, to use advantage of CEBAF upgrade, increasing the acceptance with respect to HRS, HMS or SHMS and capable to operate at much larger luminosity than CLAS12

- ✓ Many experiments will make use of the spectrometer with small modifications in its detector package

- ✓ More details: **E. Cisbani. PH.00001 :** *Large acceptance magnetic spectrometer for the 12 GeV^2 GEp experiment.*

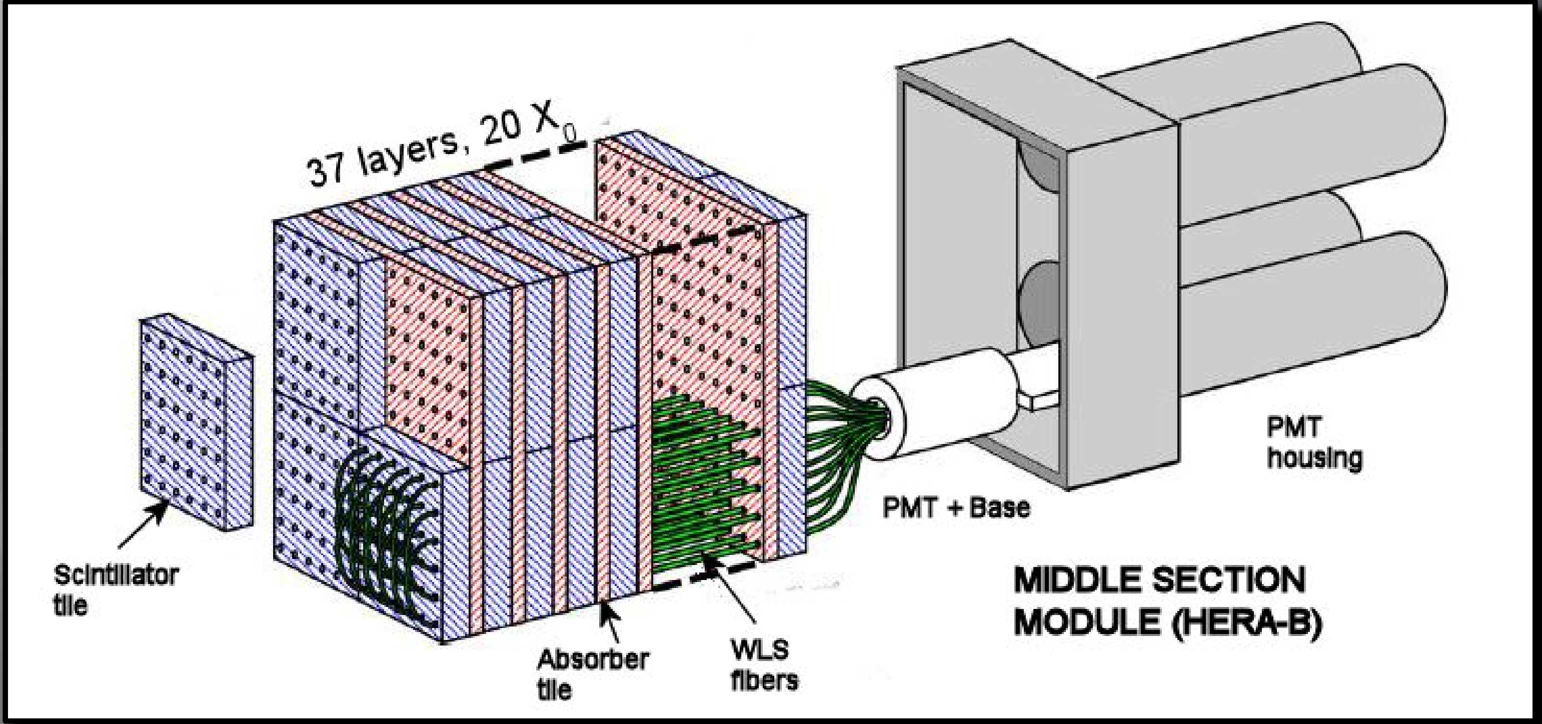


Electromagnetic Calorimeter

- Measure of G_{Ep}/G_{Mp} through recoil polarization method, demands a good energy resolution of scattered electron besides a position determination for trigger purposes
- GEp(5) requires an energy resolution of ~10%
- The experiment will make use of BigCal, a lead-glass calorimeter, already used in GEp III at JLab Hall C
- An advantageous alternative to BigCal is the use of sampling calorimeter, eliminating the UV curing needed to recover transparency and gain of lead-glass from radiation damage
- But before spending time on a replacement for BigCal, we have studied performance of a few modules of the 'shakshlik' kind, lent by HERA-B collaboration, to test their suitability in our experiment

Electromagnetic Calorimeter

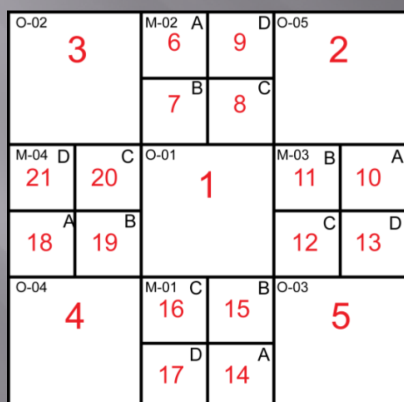
- 10 HERA-B ECal modules have been brought to JLab last November.
  - 5 outer and 5 middle sections
  - 11.2x11.2 cm^2 cross section
  - 3 mm Pb + 6 mm Sci tiles thickness
  - FEU-84 PMT



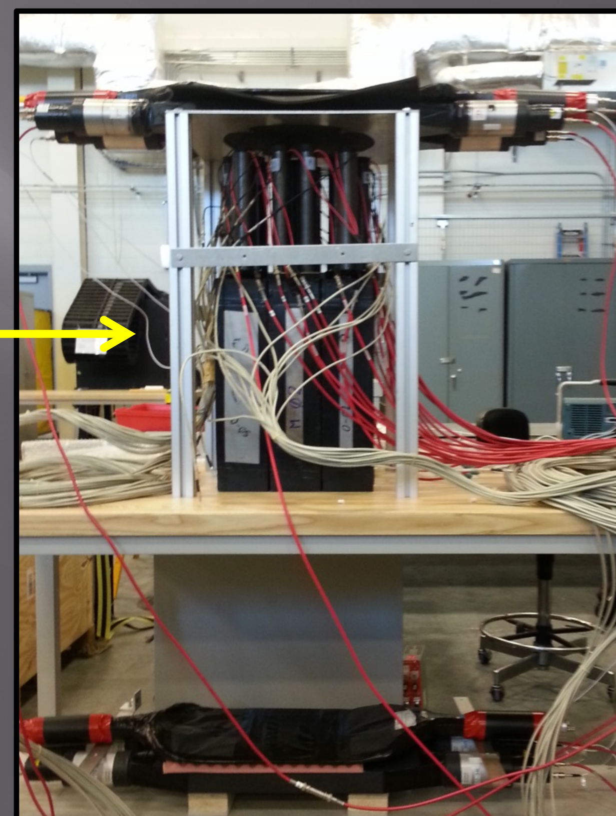
Test at JLab

- Modules were tested at JLab with cosmic rays
- Standard DAQ equipment (VME ADC, NIM logic)
- Trigger with coincidences between top AND bottom scintillator paddles

One scintillator 12''x6''

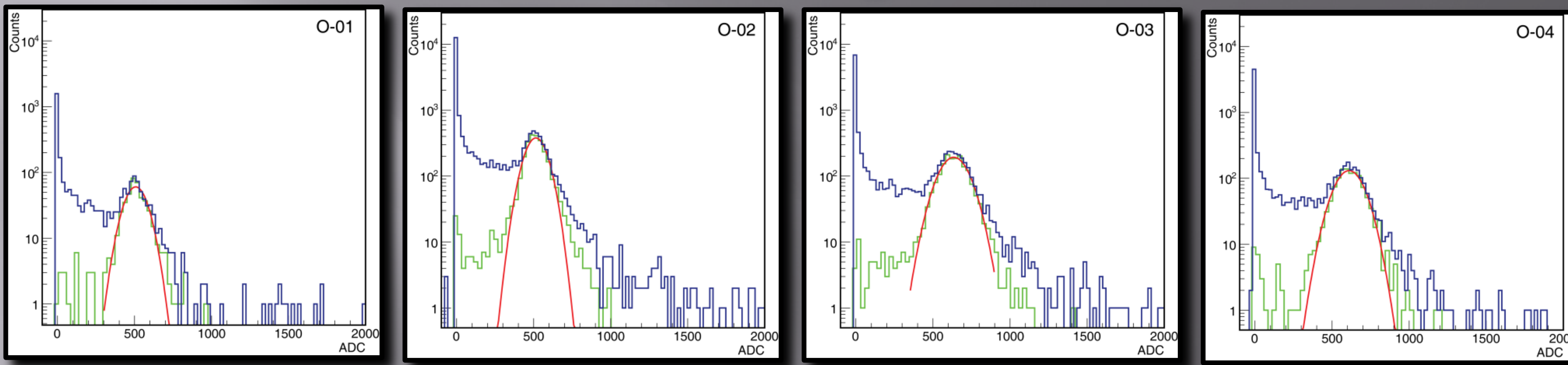


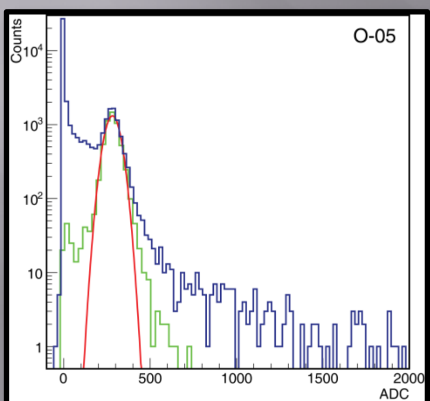
Arrangement of the modules



One scintillator 12''x6''

Test at JLab





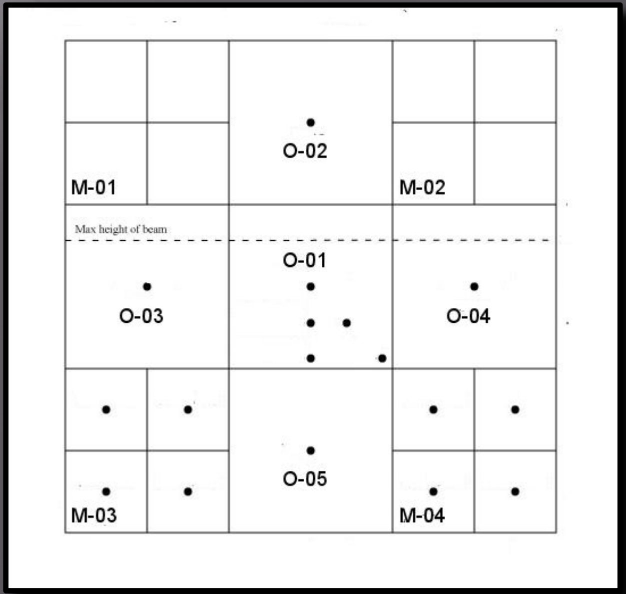
- Spectra of the outer modules. Blue line, raw spectra, the green line is the spectra requiring single hit in module
- Considering muons as mips at surface (~4GeV) the estimated energy deposited in the modules is ~50MeV ($20X_0$)
- From a Poisson approach, the number of photo electrons is estimated 1130-1480 pe/GeV in good agreement with HERA-B

Avoni, G., et.al., *The electromagnetic calorimeter of the HERA-B experiment*. NIM-A, Vol 580-3, 1209 (2007)

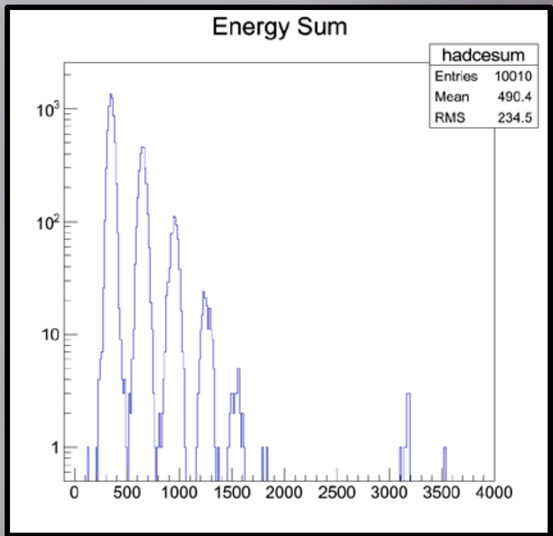
→ 1300 pe/GeV

Test at SLAC

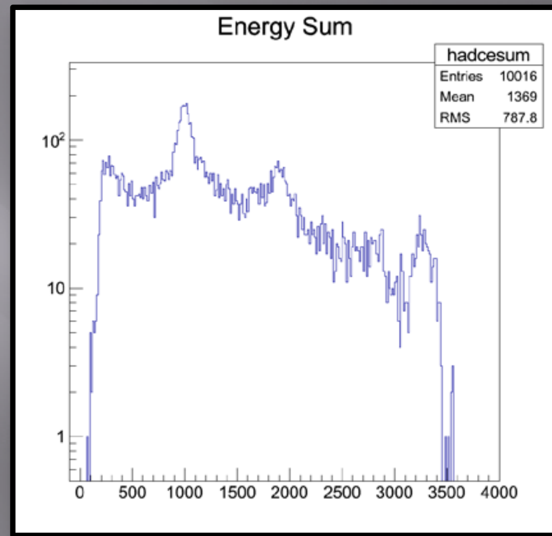
- Last June, 9 modules were tested with test beam (ESTB) at SLAC
- Modules were placed in a X-Y stage, remotely controlled , in order to take data at different positions. Also different electron beam energies: 3, 9 and 12 GeV
- Standard DAQ equipment (VME ADC, NIM logic)
- Trigger:
  - Signals from outer modules to an adder module (OR among all modules)
  - Adder output in coincidence (AND) with signal provided by machine



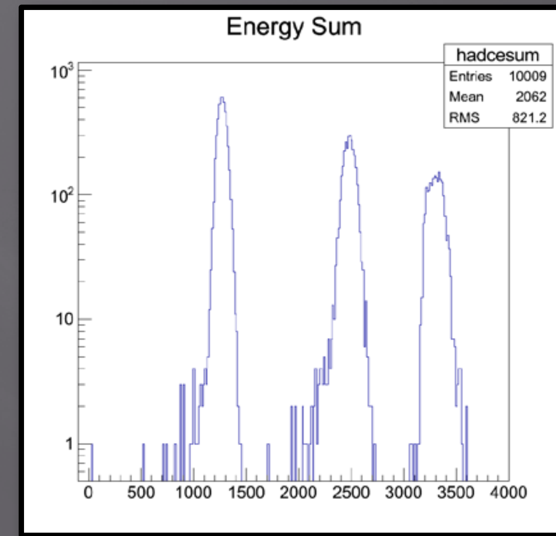
Energy spectra



3 GeV



9 GeV



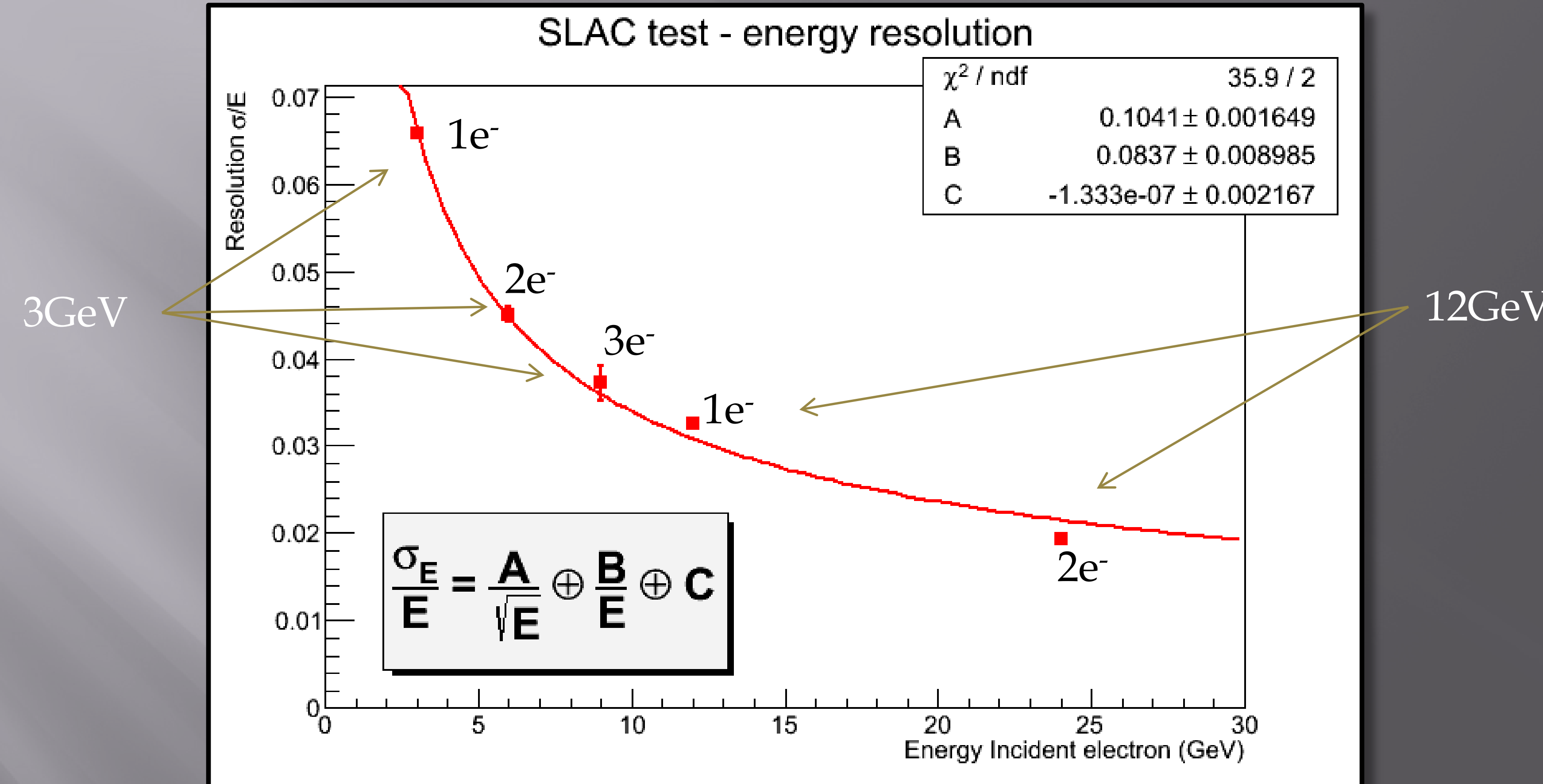
12 GeV

- For 3 GeV energy beam, the system is able to discern till 5 electrons/bunch.
- Magnets modulation of beam to 9 GeV introduces a lot of uncertainty in energy
- Three peaks are visible in 12 GeV case. The third peak is distorted, perhaps ADC overflow or PMT saturation

Position Resolution

- A. Losada, et.al. EA.00175 : **Resolution Performance of HERA-B Lead-Glass Calorimeters.** Poster Session, Thursday, October 24, 2013.

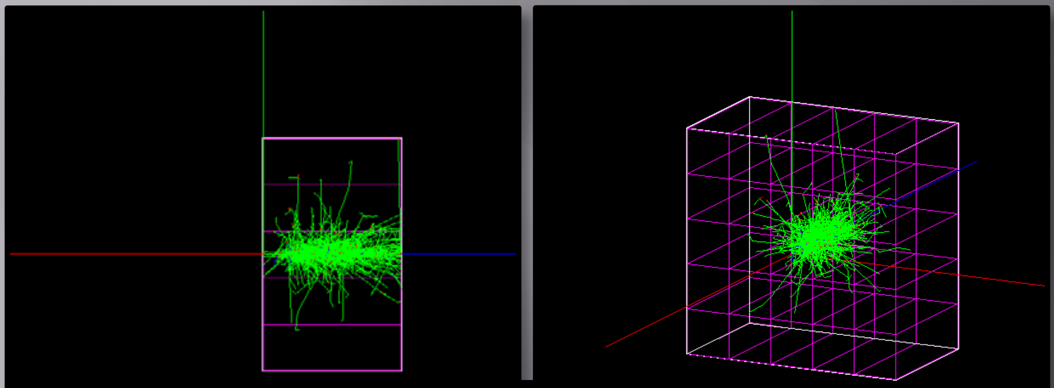
Energy Resolution



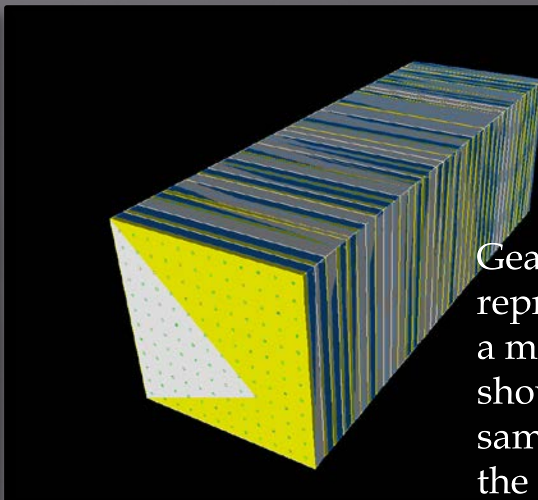
$$\frac{\sigma_E}{E}(\%) = \frac{\mathbf{10.8}}{\sqrt{E}} \oplus \mathbf{1.4}$$

Avoni, G., et.al., *The electromagnetic calorimeter of the HERA-B experiment.* NIM-A, Vol 580-3, 1209 (2007)

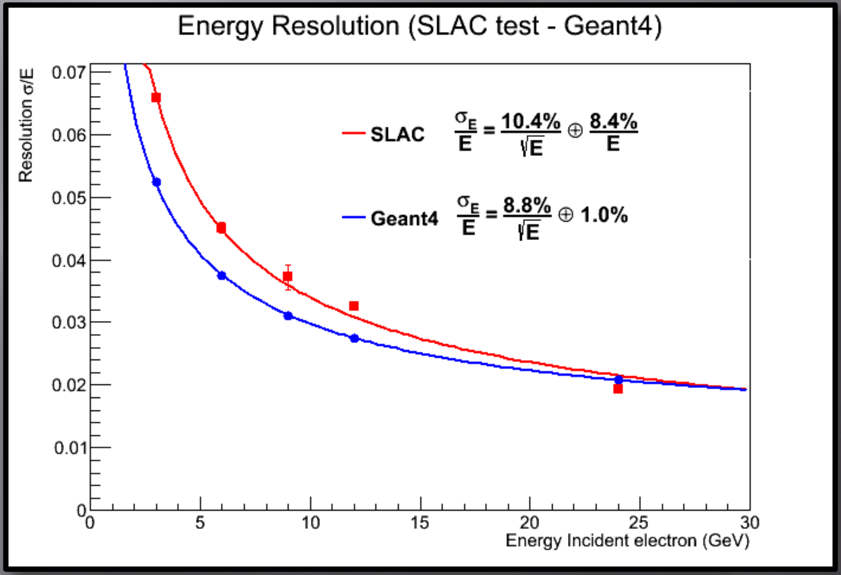
Geant4 Studies



5x5 arrangement
with em shower



Geant4 detailed representation of a module, showing the sampling and the fibers



- A Geant4 detector simulation has been designed
- Now is a stand alone simulation for the 'Shakshlik' calorimeter
- Some fine tuning is still required (see energy resolution plot)
- Close future, the program modules will be incorporated into the SBS simulation of S. Riordan (UMass)

Summary

- The GEp(5) experiment, within the SBS collaboration, is an approved experiment to measure the G_{Ep}/G_{Mp} with the recoil polarization method to Q^2>10GeV^2
- An electromagnetic calorimeter to complement the SBS detector package, is mandatory for such measurement. A lead-glass calorimeter (BigCal) will be used, although other alternatives are being studied
- Ten calorimeter modules of the 'Shakshlik' kind have been borrowed from HERA-B and tested with cosmic rays and an electron beam at SLAC
- Position and energy resolution are in good agreement with HERA-B claims
- An electromagnetic calorimeter simulation in Geant4 is currently under development, to be incorporated into the general SBS simulation