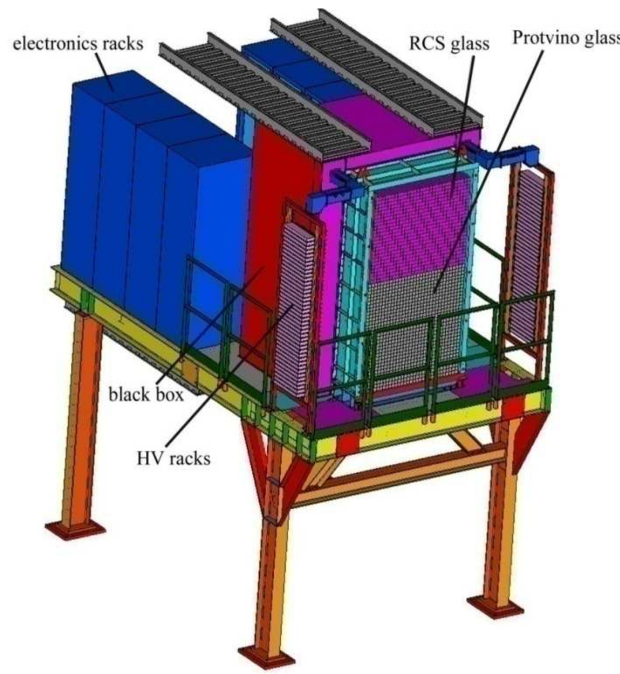
# BigCal Elastic Calibrations for SANE Experiment

**Garth Huber**
**Cornel Butuceanu**
UNIVERSITY OF REGINA




**SANE Collaboration Meeting, 30 May 2008**

# Outline

- Elastics Simulations and Run Plan.
- ep Calibrations from Gep-3.
- Outlook.

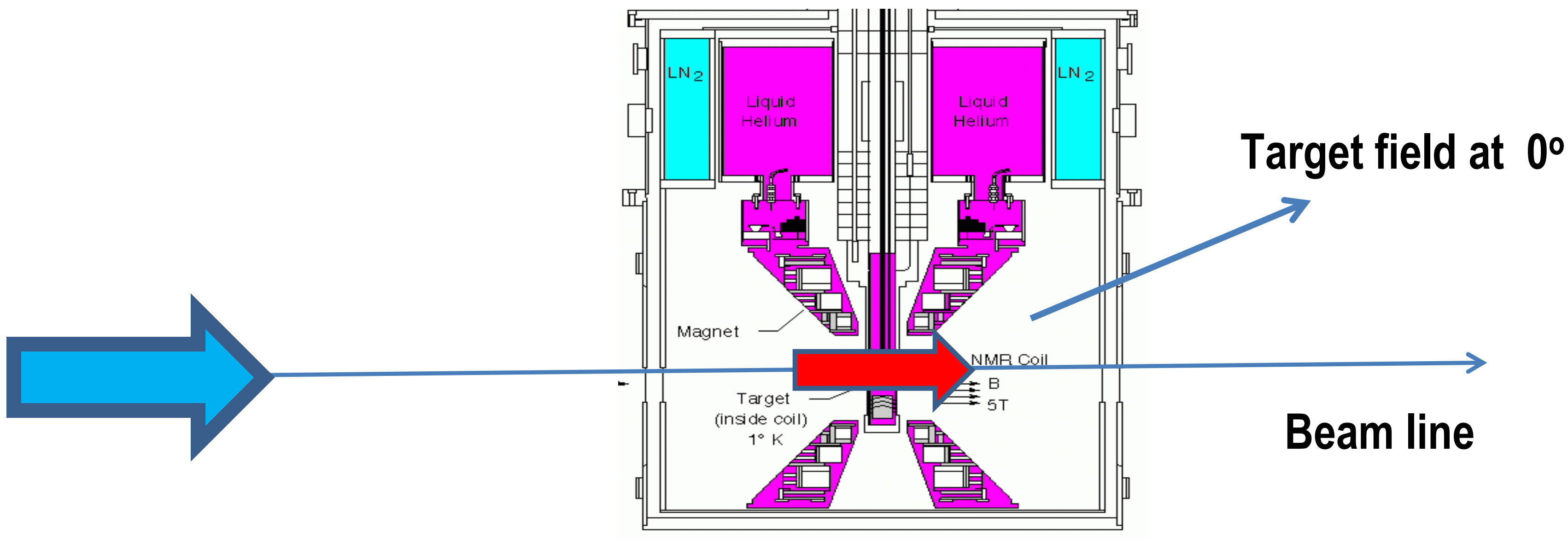
# Ep Elastics Energy Calibration

- The purpose of the elastic calibrations is to provide an absolute energy calibration of scattered electrons in the calorimeter.
- Coincidence events with an electron detected in BigCal tagged with a proton in the HMS.
- Constraints in selecting the appropriate calibration kinematics:

  - Deflection of the incident electron beam by the target magnetic field.
  - Proton and electron angles must not be obstructed by the target coils.
  - Desirable to calibrate with electrons of 0.8-2.4 GeV energy.

- An energy of 2.4 GeV beam and 0°/180° target orientation are planned to be available (compatible with these requirements).
- As the target material will not be polarized, beam current up to 1 μA can be used to reduce the total beam-time required.

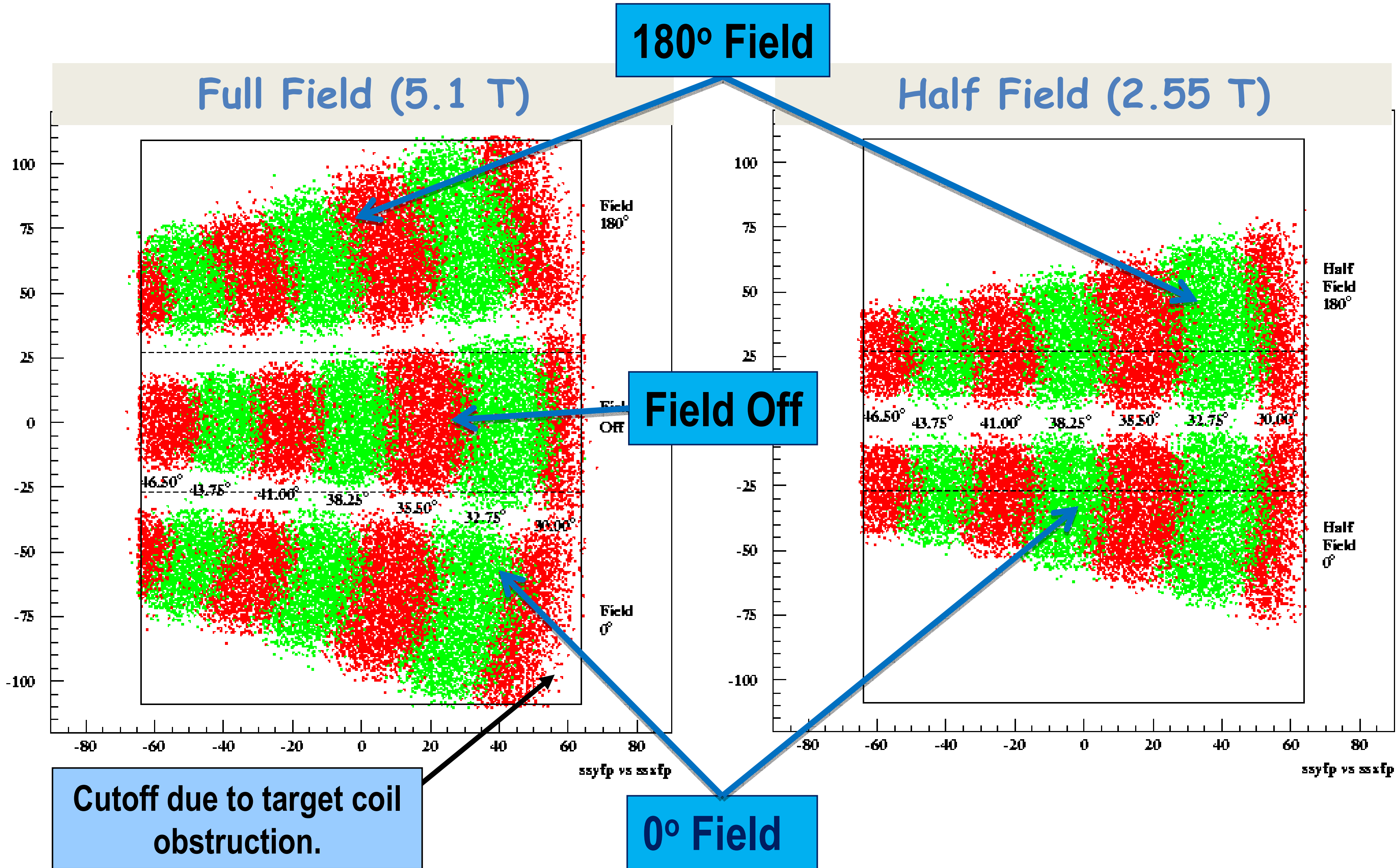
# Target Magnetic Field Configuration




In order to calibrate most of the BigCal several scans will be needed as well as several HMS angular settings.

- Full strength (5.1 T) parallel & anti-parallel fields.
- Half strength (2.55 T) parallel & anti-parallel fields.
- Magnetic field turned off.

# Simulated BigCal Coverage ($E_{beam}$=2.400 GeV)



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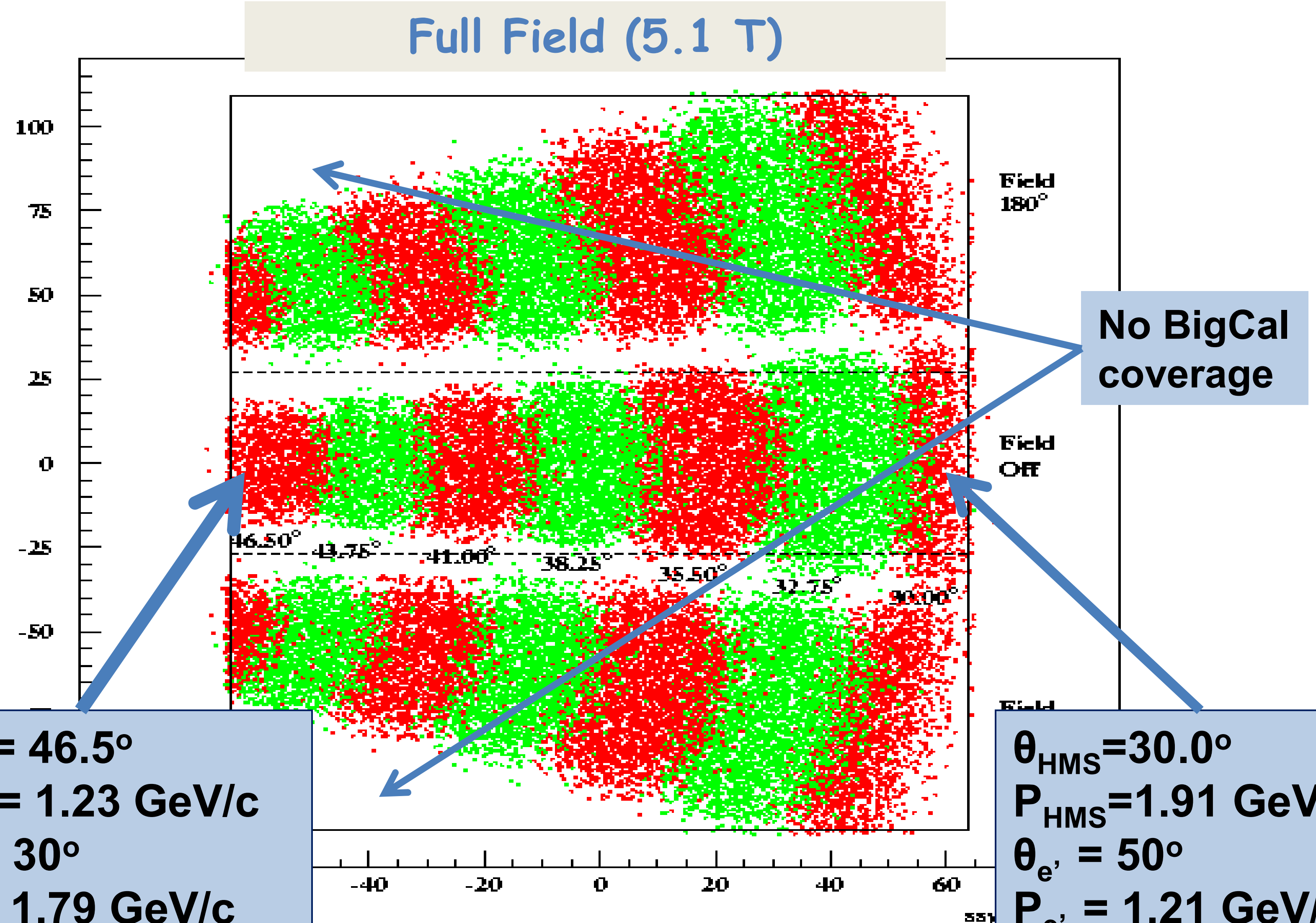



$\theta_{HMS}$= 46.5°
$P_{HMS}$= 1.23 GeV/c
$\theta_{e'}$ = 30°
$P_{e'}$ = 1.79 GeV/c

$\theta_{HMS}$=30.0°
$P_{HMS}$=1.91 GeV/c
$\theta_{e'}$ = 50°
$P_{e'}$ = 1.21 GeV/c

# Elastic Coincidence Rates – $E_{beam}$=2.400 GeV

- In comparison to the 2.317 GeV beam energy assumed in the original calibration run-plan:
  - $Q^2$ is about 0.1GeV$^2$ higher.
    - BigCal is at same angle, but the beam energy is higher.
  - ep coincidence rates are about 20% lower.

- Simulation now takes the cutoff due to the target coil obstruction into account.
  - This eliminates about half of the events for the $\theta_{HMS}$=30.0$^o$ setting.
  - Take only half statistics there to keep the run-times reasonable.

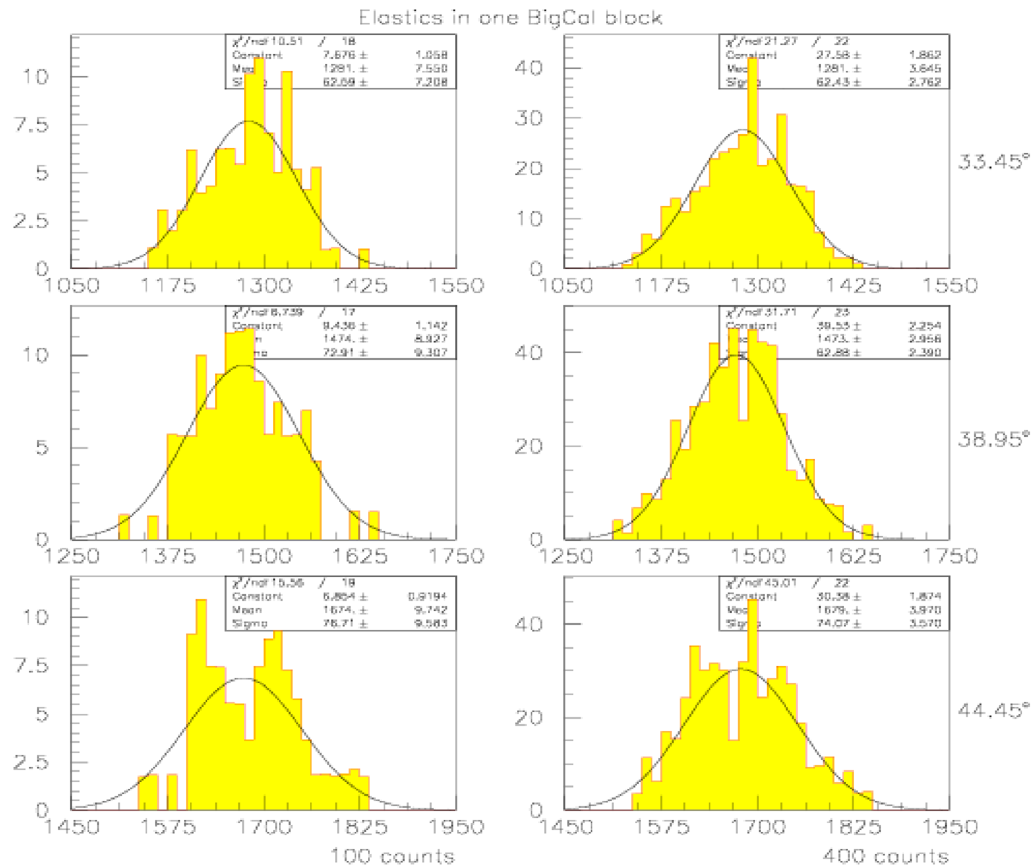
- At 60% beam taking efficiency, it will take 4 days of beam to calibrate ~ 90% of the calorimeter with ~400 elastic counts per 4x4 cm$^2$ crystal.
  - 5 target field configurations (Full @ 0,180$^o$; Half @0,180$^o$; Off).

# Elastic Rates per Setting

| $E_{e'}$ (GeV) | $\theta_{e'}$ (deg) | $P_p$ (GeV) | $\theta_p$ (deg) | Counts/cell/hr $0^o$ | $180^o$ | Off | Beam-time (hrs) $0^o$ | $180^o$ | Off |
|---|---|---|---|---|---|---|---|---|---|
| 1.789 | 30 | 1.233 | 46.50 | 810 | 810 | 2160 | 0.5 | 0.5 | 0.2 |
| 1.706 | 33 | 1.334 | 43.75 | 1480 | 1440 | 1550 | 0.3 | 0.3 | 0.3 |
| 1.617 | 36 | 1.443 | 41.00 | 830 | 830 | 880 | 0.5 | 0.5 | 0.5 |
| 1.522 | 39 | 1.555 | 38.25 | 450 | 450 | 470 | 0.9 | 0.9 | 0.9 |
| 1.423 | 43 | 1.670 | 35.50 | 240 | 250 | 260 | 1.7 | 1.6 | 1.5 |
| 1.318 | 47 | 1.789 | 32.75 | 118 | 120 | 122 | 3.4 | 3.3 | 3.3 |
| 1.213 | 50 | 1.907 | 30.00 | 36 | 36 | 42 | 5.6* | 5.6* | 4.8* |
| Total Time (100% efficiency) | | | | | | | 13 | 13 | 12 |

* Take 200/cell instead of 400.

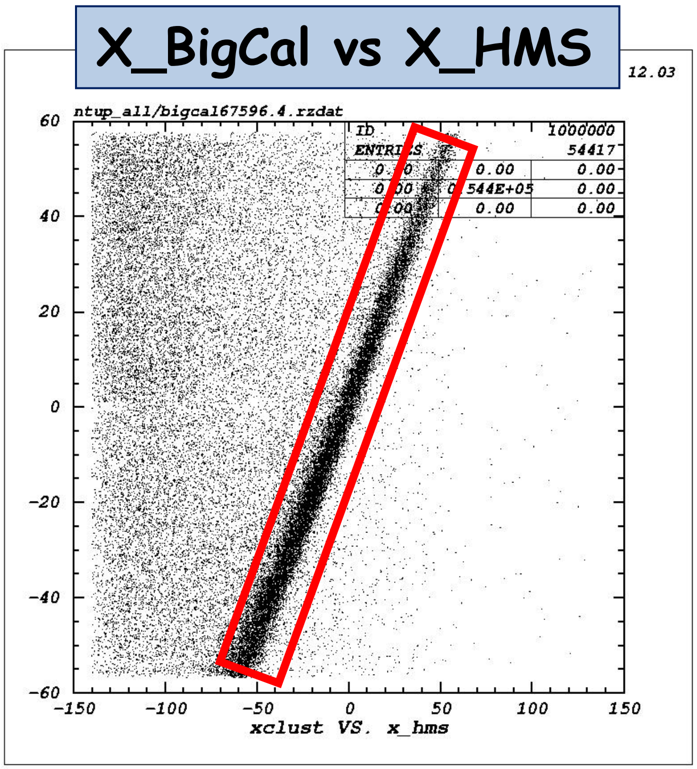
# 100 counts vs. 400 counts per 4x4 cm2 crystal ?

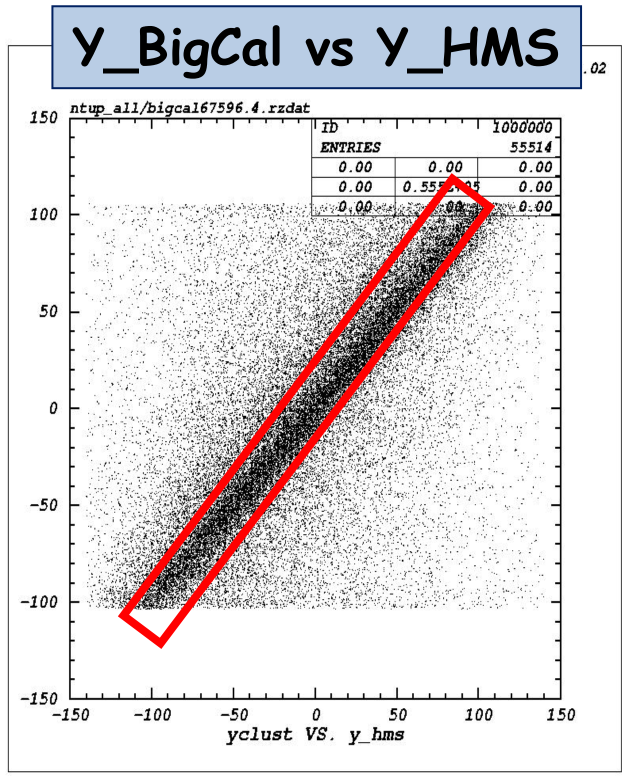


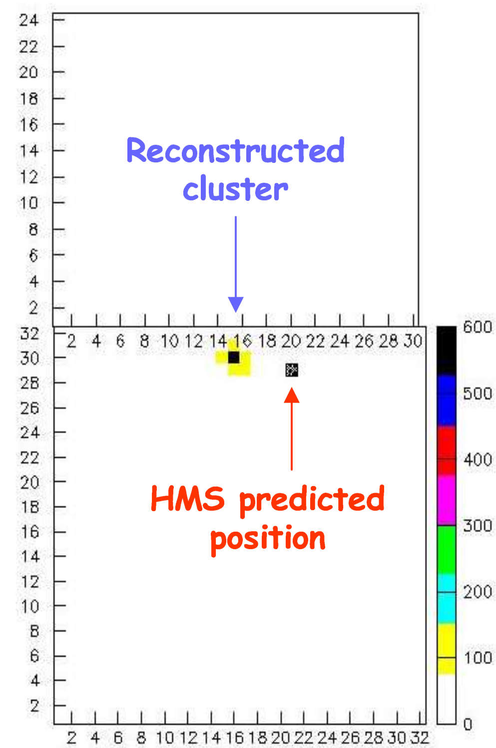

- No significant improvement in the energy resolution, but no background processes included in the simulation.
- The actual number of elastic events to be acquired will depend on the background conditions obtained when using ammonia target.

# Elastic Events Selection for BigCal Calibration

- Assuming elastic scattering use the HMS tracking & proton momentum to calculate electron hit position in the BigCal.
- Use a cut on the correlation between the predicted electron position (X,Y) by the HMS and respectively the BigCal cluster position.



# BigCal Calibration using Elastic Electrons

$$E_{ij} = C_j A_{ij} \qquad (1)$$

$$E_i = \sum_{j=1}^{1744} C_j A_{ij} \qquad (2)$$

$$\sum_i E_i A_{ik} = \sum_{j=1}^{1744} C_j X_{kj} \qquad (3)$$

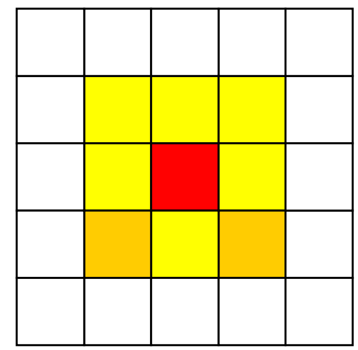
**E—electron energy (e_hms)**

**A—ADC value**

**C—calibration coefficient**

**i—event number**

**j—block number**



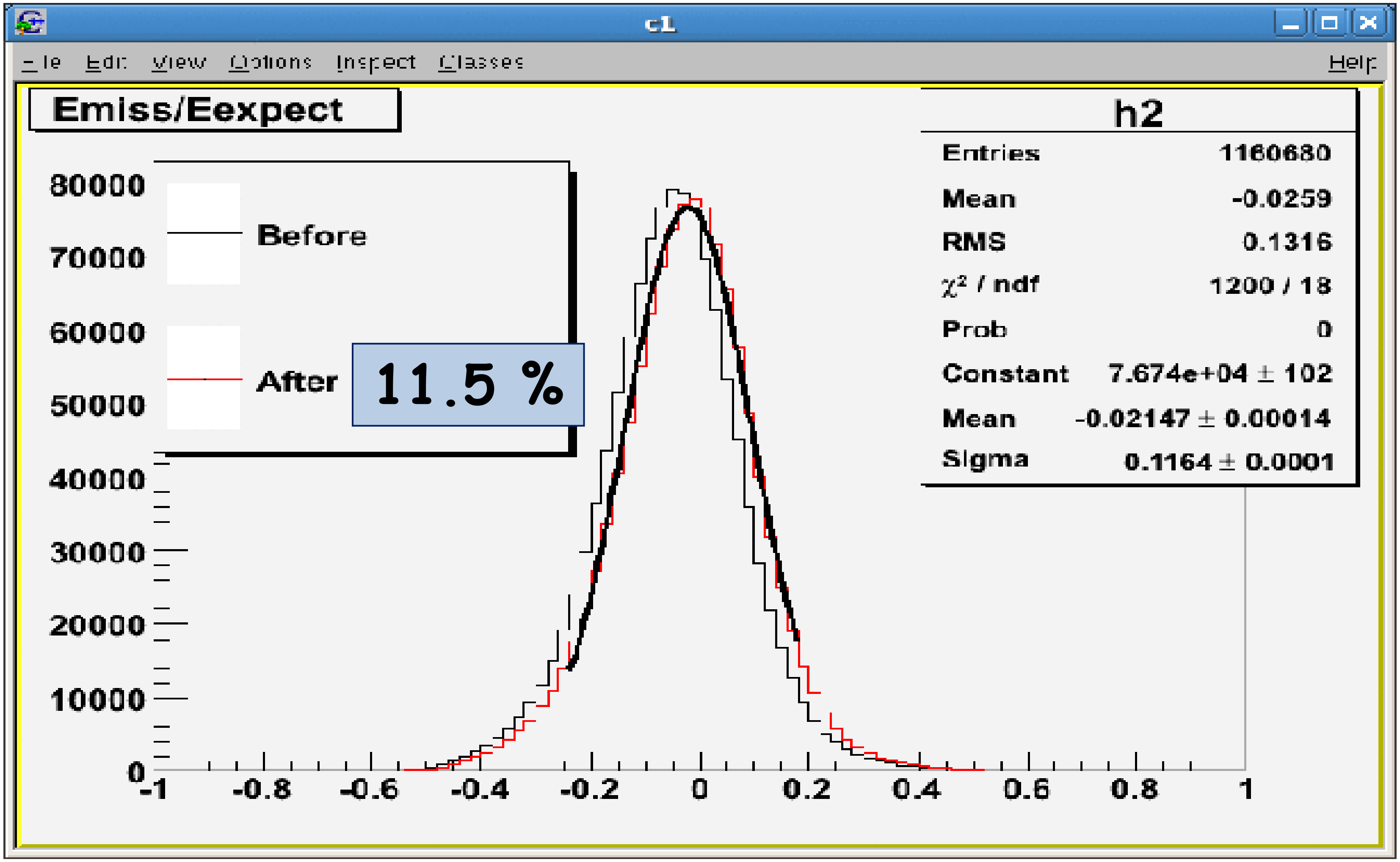
**Where** $X_{jk} = \sum_i A_{ij} A_{ik}$

- **k=1,1744**
- **Solve 1744 linear equations (3) for calibration coefficients $C_j$,**

$$A \propto e^{\alpha V} \qquad (4)$$

- **Use $C_j$ to calculate new High Voltage.**
- **1ADC channel=1MeV**

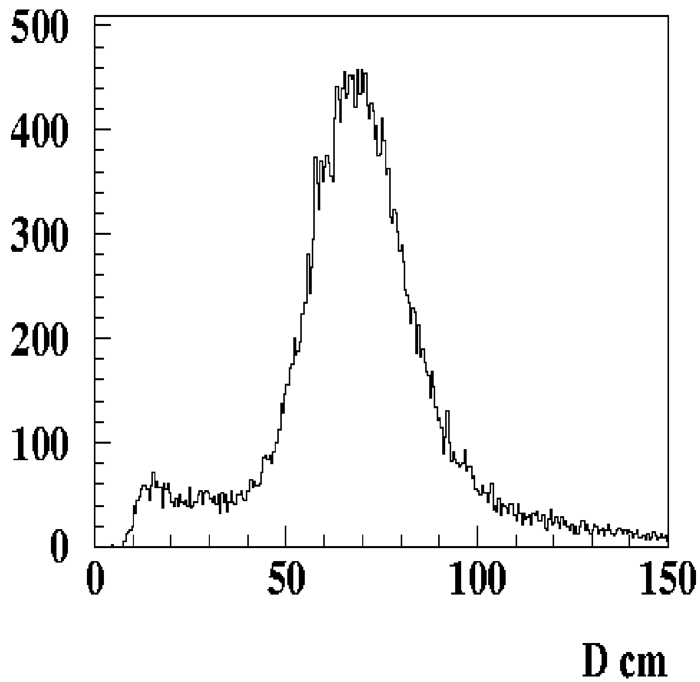
# Energy Calibration Results in Gep3

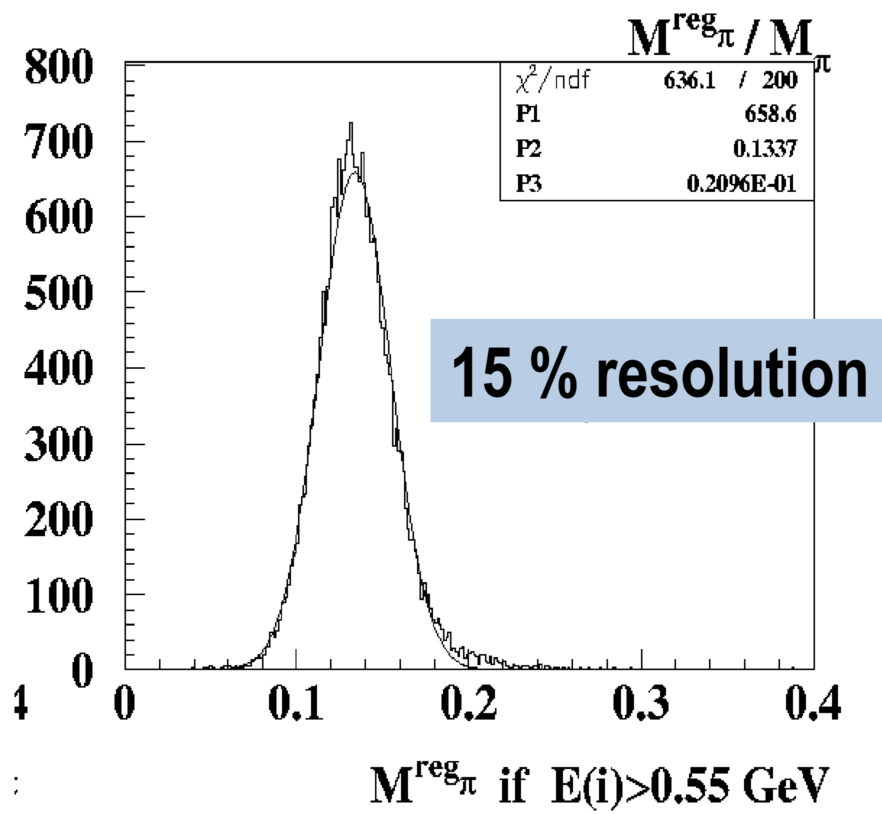



HMS proton momentum was used to predict the electron energy.

# Parasitic Calibration using $\pi^0$ Events

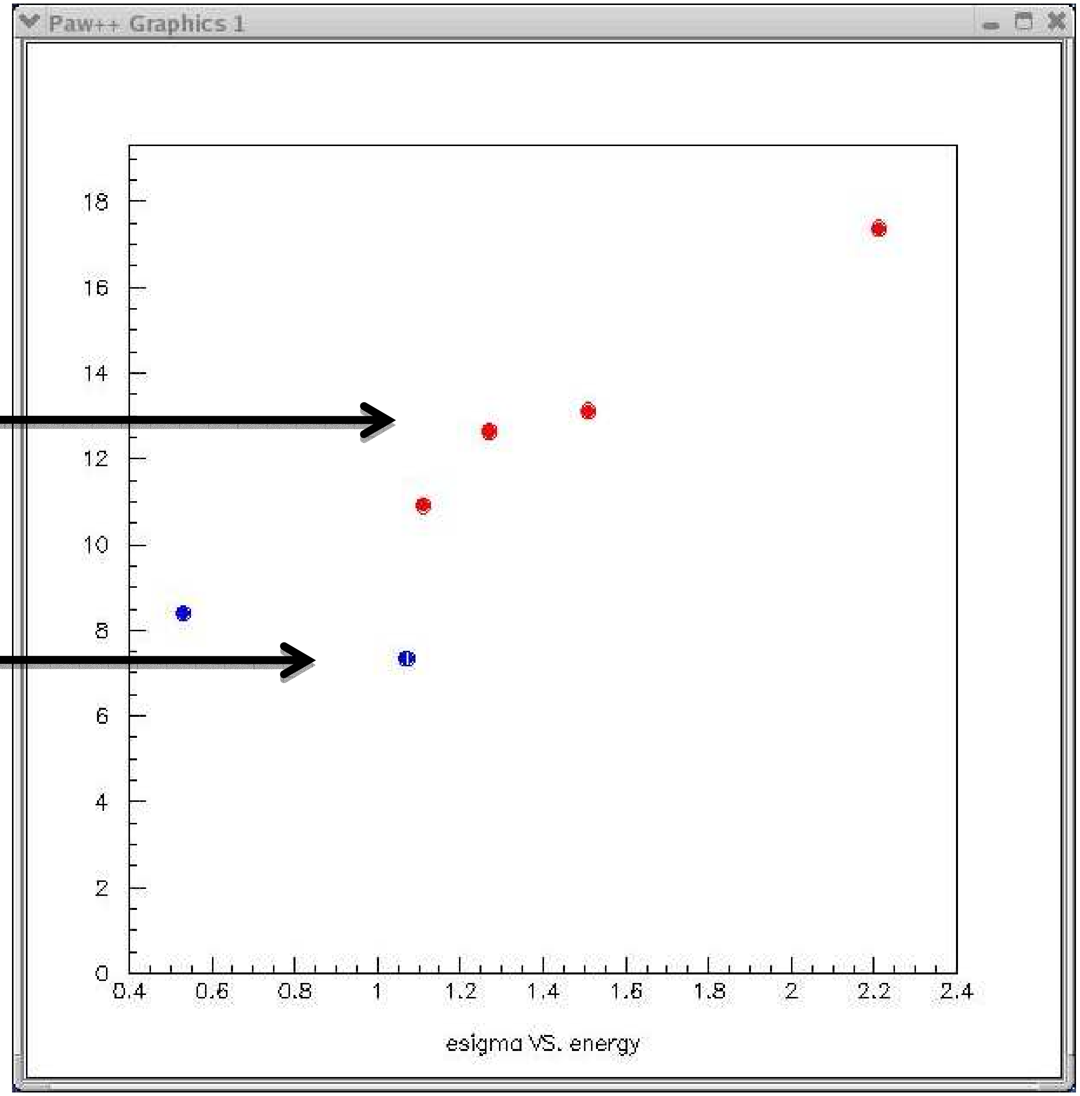
- Select two cluster events with at least 4 blocks/cluster, with a deposited energy of at least 550 MeV/block and with a minimum 50 cm distance between the clusters.
- The ratio between the reconstructed mass of these events and the expected pion mass is used to calibrate each block.



# Energy Resolution vs Electron Energy

Energy Resolution*E$^{1/2}$ vs Elastic Electron Energy




10 cm absorber

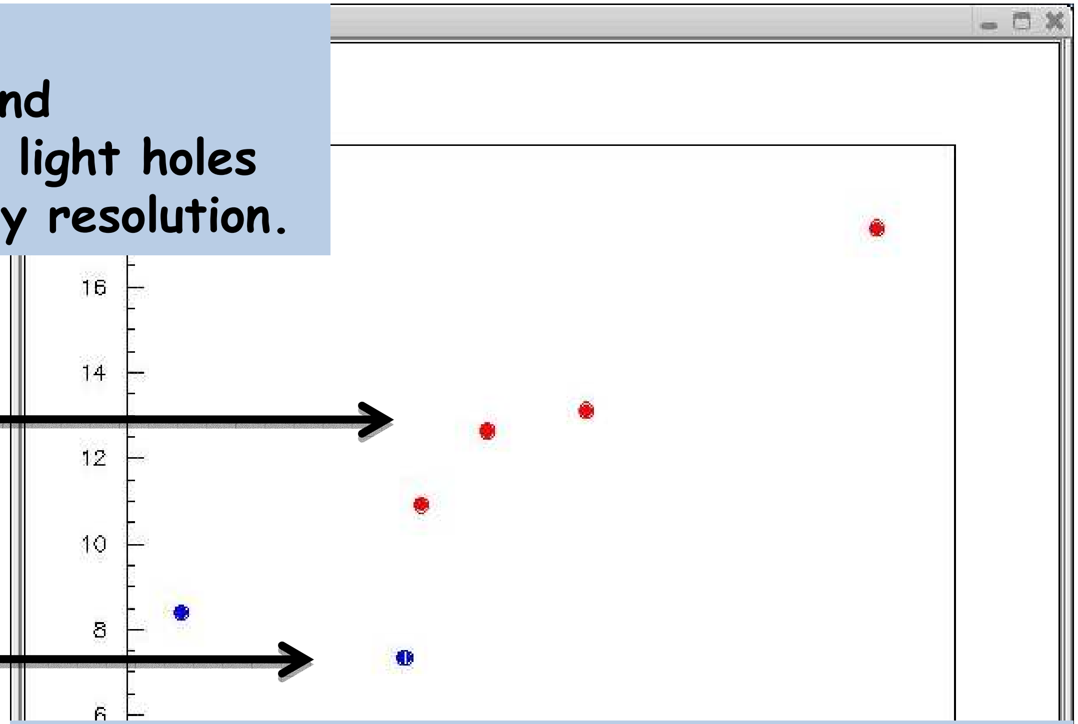
2.5 cm absorber

$$\frac{\sigma}{\sqrt{E}} = A\sqrt{E} + B + \frac{C}{\sqrt{E}}$$

# Energy Resolution vs Electron Energy

Energy Resolution*$E^{1/2}$ vs Elastic Electron Energy

SANE – no absorber
Removing lucite gain monitor and
the support plate with 0.5 cm light holes
will further improve the energy resolution.




10 cm absorber

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$$\frac{\sigma}{\sqrt{E}} = A\sqrt{E} + B + \frac{C}{\sqrt{E}}$$

pi0 resolution is not directly related to the electron resolution because of the extra contribution due to the 2 gamma angle reconstruction. ep Elastic Events are free of this contribution.
The absorber thickness correction will also be different for photons and electrons.

## To do list:

- Implement the target magnetic field in the HMS tracking code (use the RSS target field map).
- Implement the slow beam raster in the Analyzer.
- Look at backgrounds obtained in April Test Run. (conditions were similar to SANE Target Field Off configuration.)
- Complete a more detailed draft at 2.400 GeV for BigCal Elastic Calibration Run Plan by August.

# Parasitic Energy Calibration Monitor

- The use of HMS coincidences to parasitically monitor the BigCal energy calibration during the 4.6, 5.7 GeV physics runs has also been investigated.
- The elastic cross section drops steeply with angle, so the low rates preclude the use of more than one HMS angle per beam energy.
- Only a few dozen coincidences per crystal per 100 hours of running are expected.
- The most important use of these events may ultimately be to provide two higher energy calibration points to verify the linearity of the energy calibration.
  - Would need to sum over several dozen adjacent crystals to obtain the necessary statistical precision.
- Might also measure the target packing fraction by comparing to the known elastic cross sections.