# Calorimeter Elastic Calibrations

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SANE Collaboration Meeting, December 1, 2006.

# Purpose

- The purpose of the elastic calibrations is to provide an absolute energy calibration of scattered electrons in the calorimeter.
- Elastically scattered electrons are tagged by the detection of the conjugate protons 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 0.8-2.2 GeV energy.
- Only the 2 pass=2.32 GeV beam and target field along the beam axis orientation are compatible with these requirements.

- As the target material will not be polarized, beam current up to 1 $\mu$A can be used to reduce the total beam-time required.
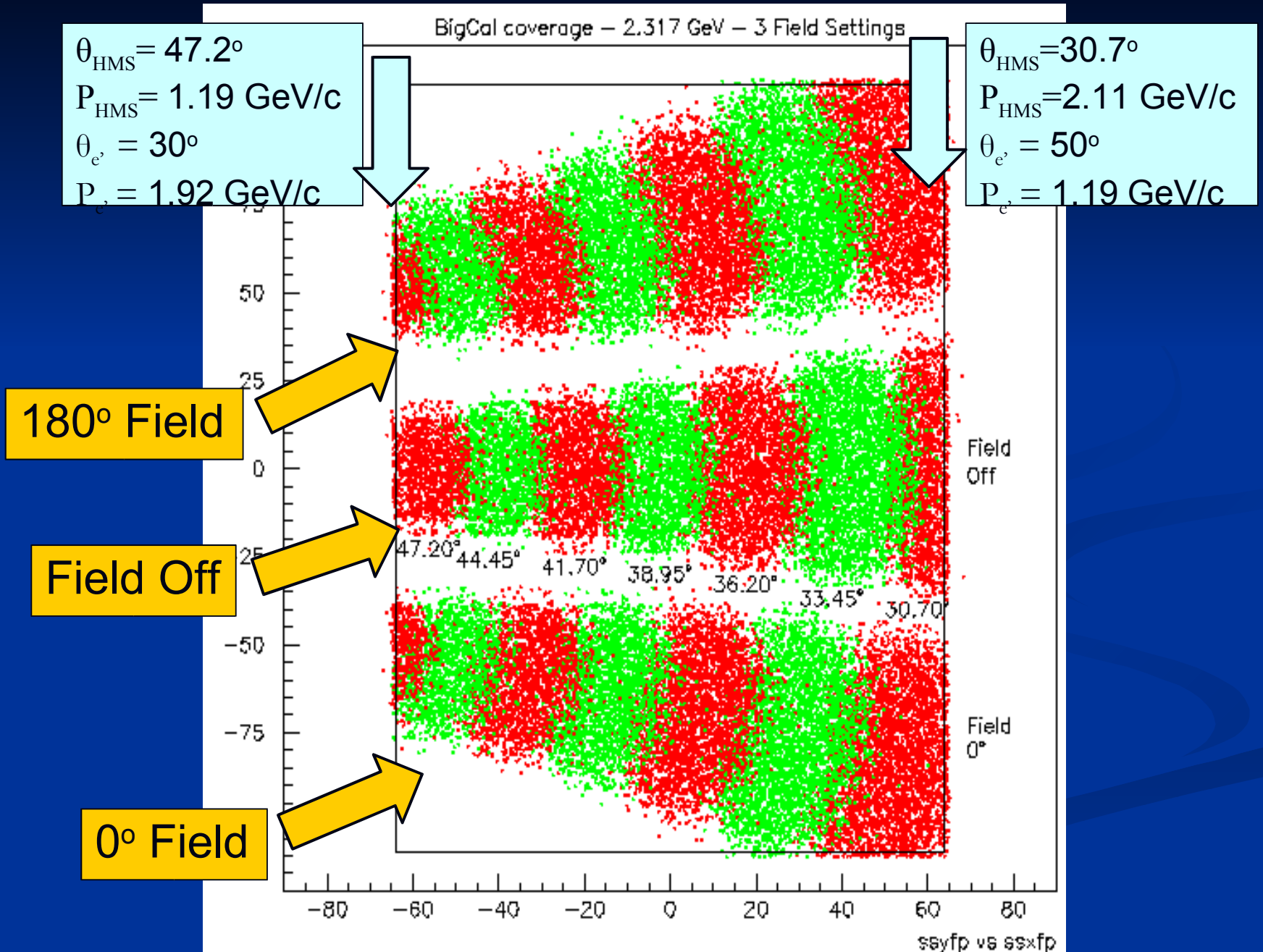
SANE Magnet Configuration
(Target field at 180 deg)
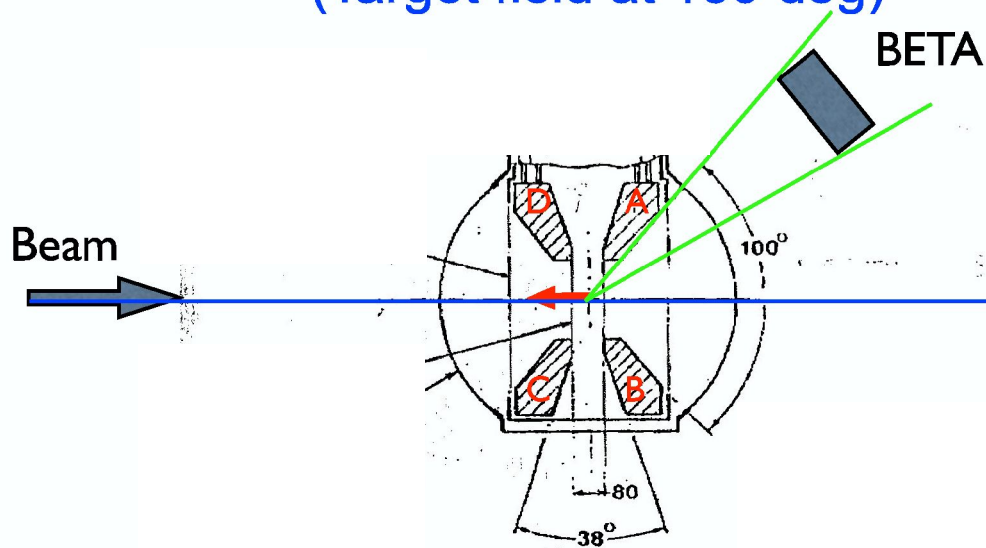
- Even though 2.32 GeV beam energy is relatively low, the beam will be undeflected by the parallel or anti-parallel magnetic field.
- Calibrations will be performed with the target field at $0°$, $180°$, and with the field off in order to calibrate blocks below, above, and at beam-height.
- SIMC simulations incorporating:
  - deflection of the proton and the scattered electron in the target field.
  - $e+p$ coincidence in the HMS and calorimeter acceptances.

were used to determine the optimal kinematic settings, and expected coincidence rates per unit calorimeter area.

# SIMC electron hits on BigCal – 2.32 GeV elastics



$\theta_{HMS}$ = 47.2°
$P_{HMS}$ = 1.19 GeV/c
$\theta_{e'}$ = 30°
$P_{e'}$ = 1.92 GeV/c

$\theta_{HMS}$ = 30.7°
$P_{HMS}$ = 2.11 GeV/c
$\theta_{e'}$ = 50°
$P_{e'}$ = 1.19 GeV/c

180° Field

Field Off

0° Field

# Rates – 2.32 GeV Elastics

| $E_{e'}$ (GeV) | $\theta_{e'}$ (deg) | $P_p$ (GeV) | $\theta_p$ (deg) | Counts/cell/hr | | | Beam-time (hrs) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 0° | 180° | Off | 0° | 180° | Off |
| 1.92 | 30 | 1.19 | 47.20 | 1810 | 1820 | 6800 | 0.3 | 0.3 | 0.1 |
| 1.66 | 33 | 1.29 | 44.45 | 1860 | 1820 | 1980 | 0.3 | 0.3 | 0.3 |
| 1.58 | 36 | 1.39 | 41.70 | 1010 | 1010 | 1090 | 0.4 | 0.4 | 0.4 |
| 1.49 | 39 | 1.50 | 38.95 | 560 | 550 | 600 | 0.8 | 0.8 | 0.7 |
| 1.39 | 43 | 1.61 | 36.20 | 310 | 300 | 330 | 1.3 | 1.4 | 1.3 |
| 1.29 | 47 | 1.72 | 33.45 | 160 | 170 | 180 | 2.5 | 2.4 | 2.3 |
| 1.19 | 50 | 1.84 | 30.70 | 94 | 95 | 104 | 4.3 | 4.3 | 3.9 |
| Total Time (100% efficiency) | | | | | | | 10 | 10 | 9 |

Desired minimum: 400 elastic counts per 4x4 cm$^2$ crystal.
Two days of beam should calibrate ~75% of the calorimeter.

# 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.
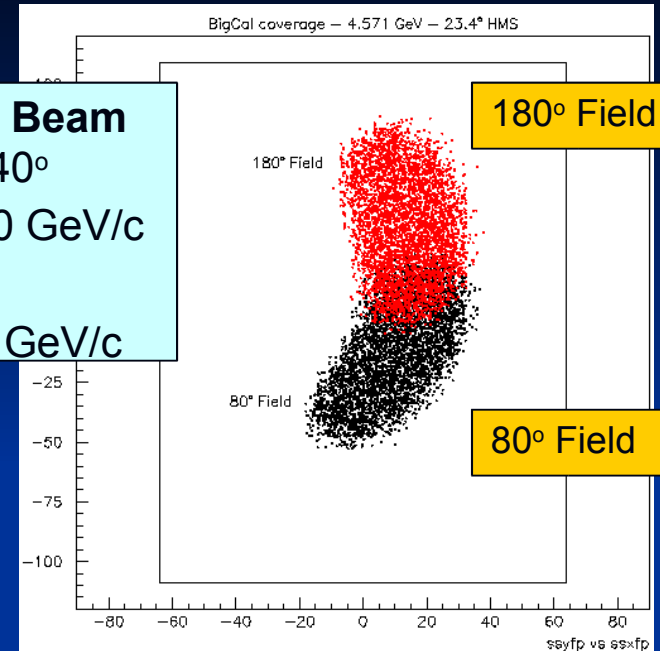


**4.57 GeV Beam**
$\theta_{HMS}$= 23.40°
$P_{HMS}$= 3.40 GeV/c
$\theta_{e'}$ = 43°
$P_{e'}$ = 1.98 GeV/c

180° Field

80° Field

**5.70 GeV Beam**
$\theta_{HMS}$= 22.60°
$P_{HMS}$= 4.00 GeV/c
$\theta_{e'}$ = 37°
$P_{e'}$ = 2.53 GeV/c

180° Field

80° Field
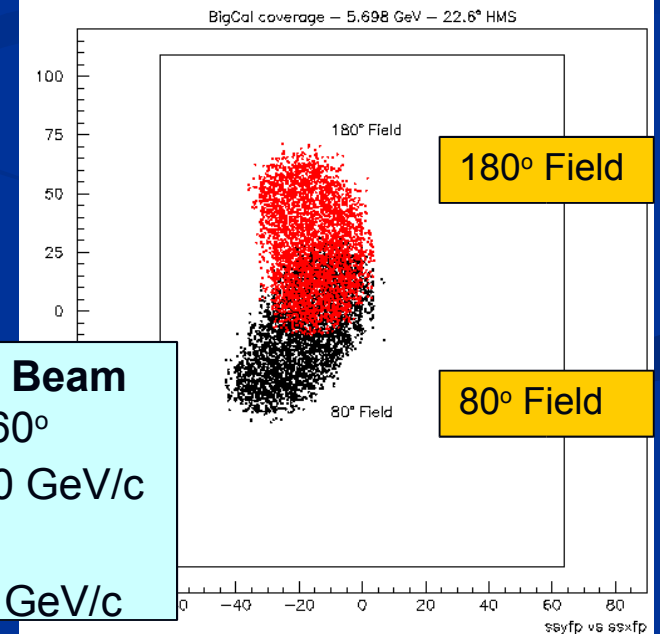
# Summary

- Simulations project that ~75% of the BigCal can be elastically calibrated via the use of three magnetic field settings.

- Aiming for 400 coincidences per crystal, the full calibration scan should take about 2 days of

  2.32 GeV beam.

- A parasitic energy monitor is also possible, but the coincidence rate is only a few dozen counts per crystal per 100 hours of beam.

- The SIMC simulations do not yet incorporate any acceptance blockage caused by the target coils.
  - Would only affect the largest angle calibration settings.
  - Planning to write the relevant routine in the near future.