MC simulation for future SBS experiments

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Performed Tasks

- GEp 5
  - HCal
    - Counting rates
  - ECal
    - Energy and coordinate resolution
- HCal
  - Efficiency
  - Energy and coordinate resolution
- GEn (with polarimeter)
  - HCal
    - Counting rates
  - Hodoscope
    - Counting rates
- GEn
  - HCal
    - Counting rates

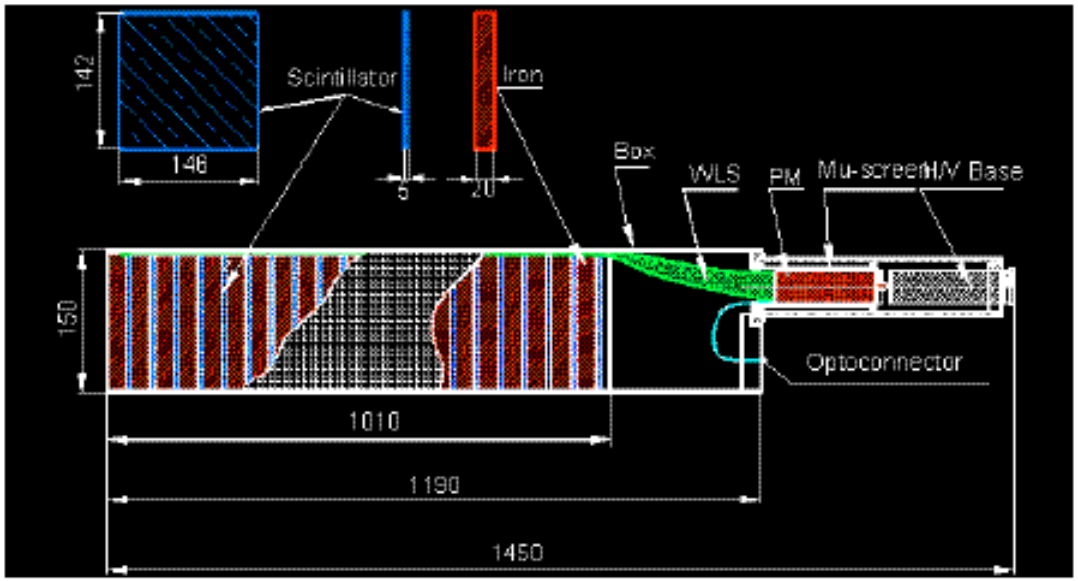
Hadron Calorimeter Block

- Iron/Scintillator sandwich, 40 each

- Scintillator:
  - 148 142 5 mm
  - 200 mm = 0.25 λ_{nucl}
  - 3.2 % of total mass

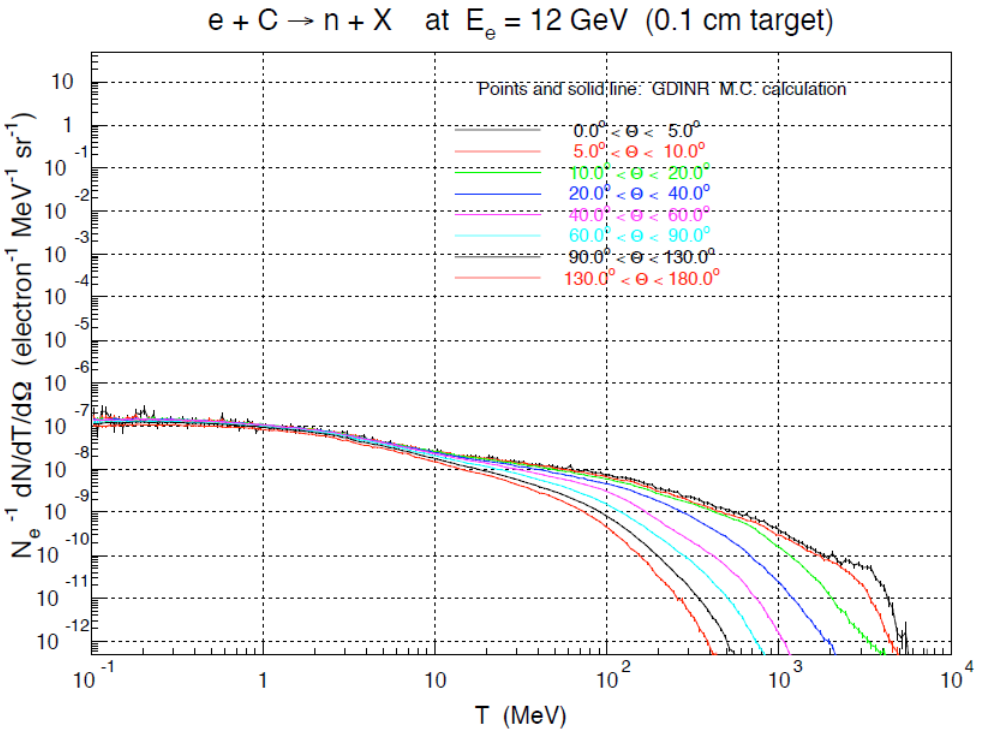
- Iron:
  - 148 142 20 mm
  - 800 mm = 4.7 λ_{nucl}
  - 96.8 % of total mass

One module of HCAL hadron calorimeter.
All dimensions are in mm.



Geant 3 + DINREG

- Geant 3
  - Geometry description
  - Initial particles
  - Electromagnetic iteractions
- DINREG (P. Degtiarenko)
  - Hadron iteractions
  - Reasonable run-time/statistics
    - Hadron cross-sections scaling
    - Different random seed for each job

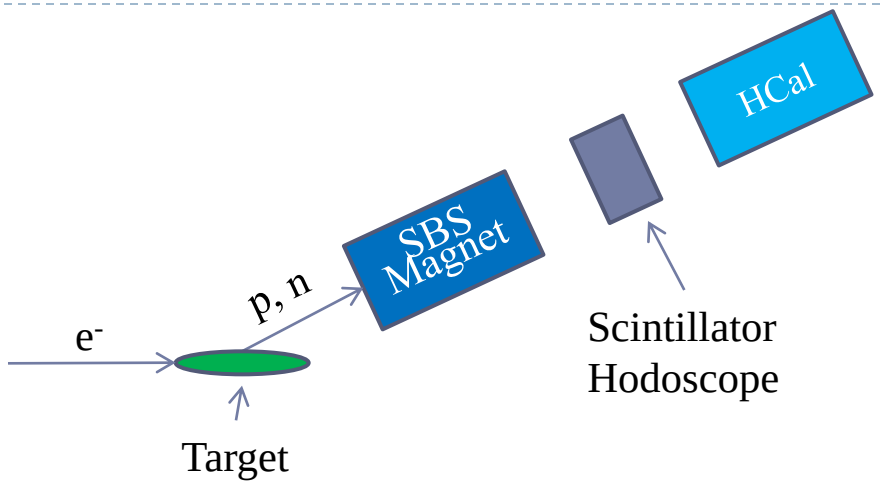


MC structure

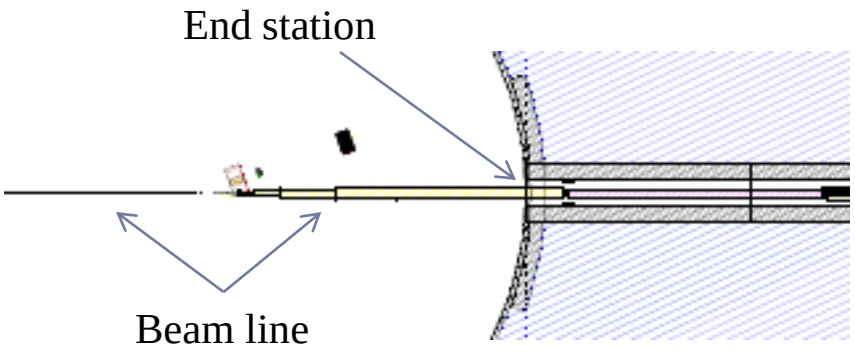
- MC Input
  - Geometry parameters (angles, distances)
  - Target parameters (material, thickness)

- MC Output
  - Scintillator response (Birk equation) for each module
  - X and Y coordinates on the front of Hcal
  - X and Y coordinates, calculated by weighting amplitude in cluster blocks

Geometry configurations



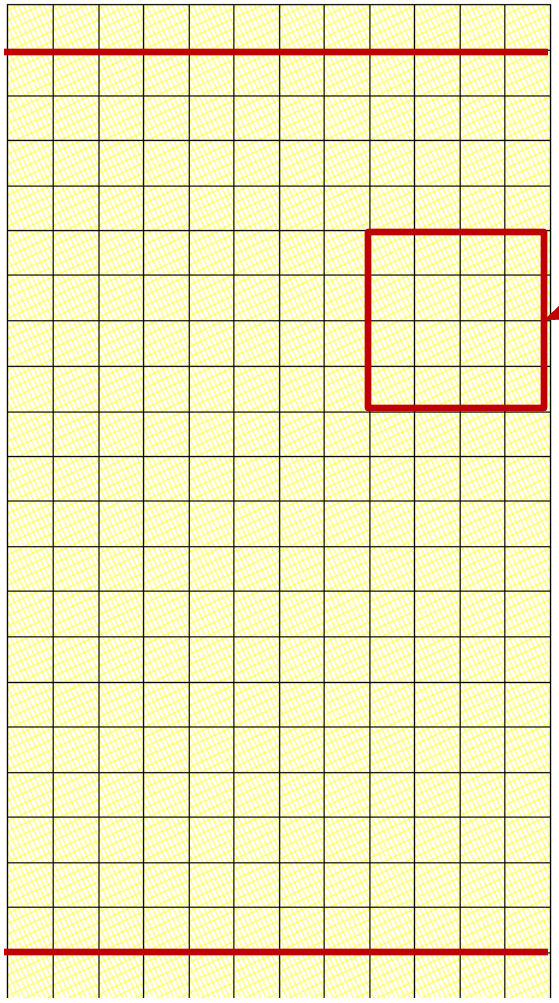
- Basic setup (SBS Magnet + HCal)
  - energy resolution
  - coordinate resolution
  - Efficiency



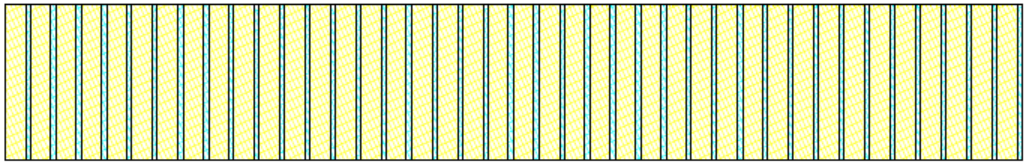
- Target
- Detailed Hall A geometry
- Additional detectors
  - counting rates
  - threshold values

HCal Geometry and clusters

Front view



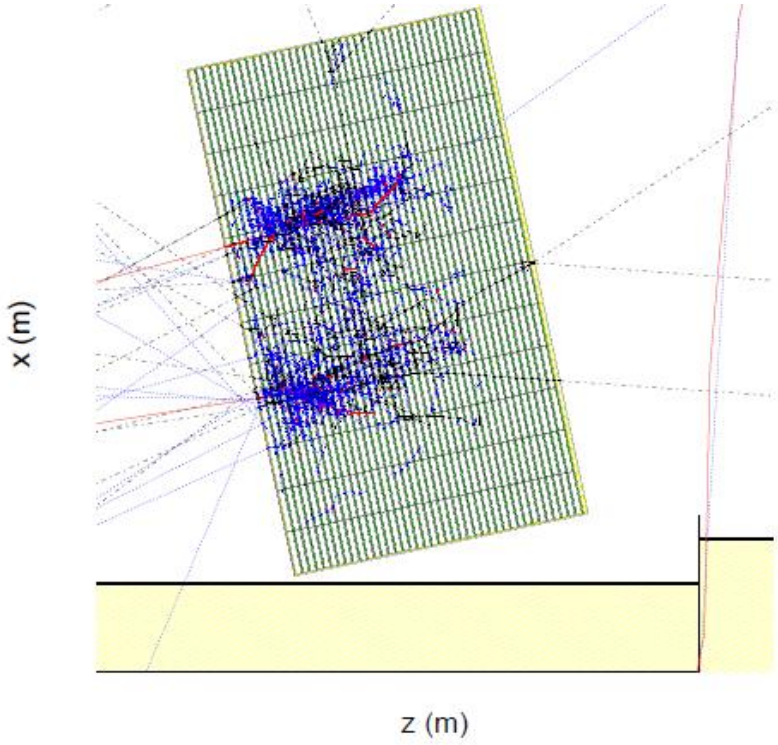
Side view, 1 Block



- Cluster
  - 4 4 Blocks
- HCal
  - 264 blocks: 12 22
  - 15 Independent clusters: 3 5
  - top and bottom layers doesn't participate in any cluster

Event sample

7.5 GeV Proton
2 events



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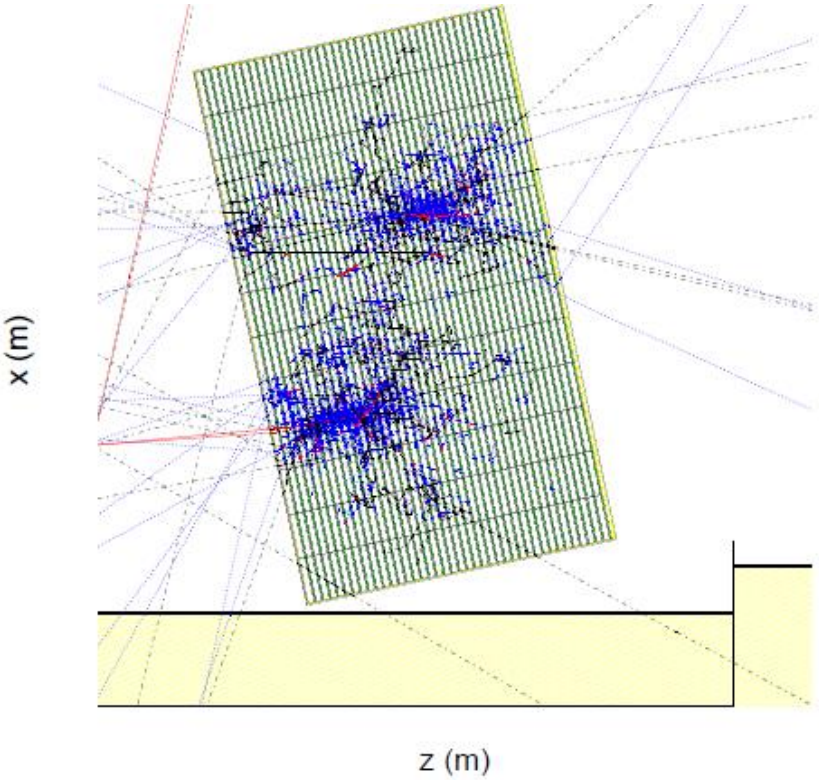
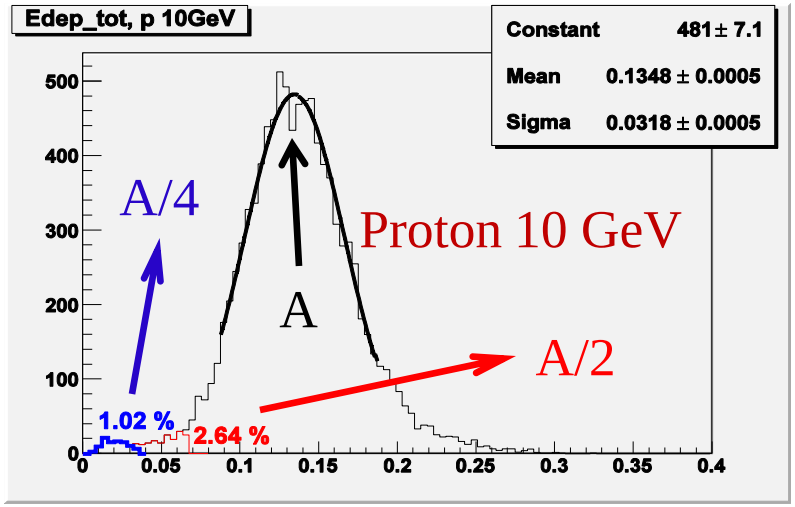
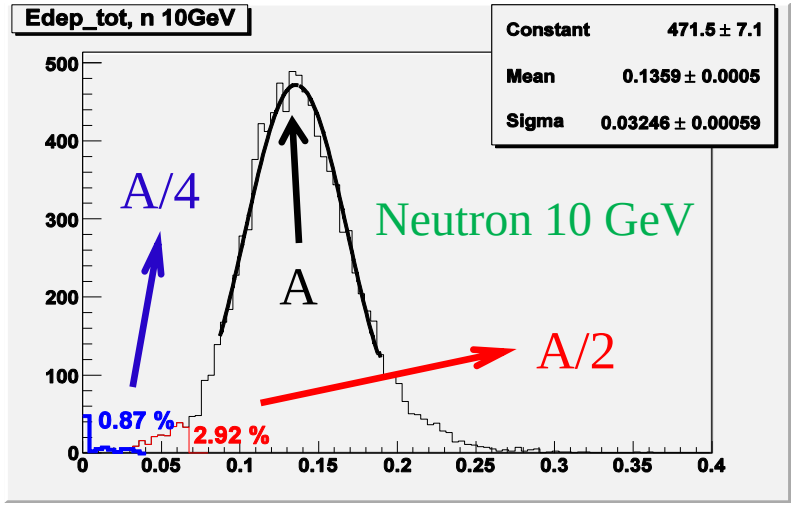


Resolutions, efficiencies





- High efficiency for both protons and neutrons with thresholds: A/2, A/4
- 20% Energy resolution for 10 GeV hadrons
- Coordinate resolution
  2.1 cm at block center
  2.8 cm at block edge

Coordinate resolution for 10 GeV protons

dX from center [cm]	0.0	2.5	5.0	7.3
σ_x (gaus)[cm]	1.73	1.83	2.26	2.73
σ_x (mean quad.)[cm]	2.08	2.26	2.83	2.80

Resolutions, efficiencies

Neutrons

E[GeV]	2.5	5.0	7.5	10.0
A[MeV]	21	55	94	135
σ_A [MeV]	10	17	25	30
$<$ A/2 [%]	11.14	4.71	3.29	2.81
$<$ A/4 [%]	2.67	0.80	0.89	0.87
σ_x (gaus)[cm]	2.77	2.19	1.81	1.56
σ_x (mean quad.)[cm]	3.67	2.73	2.13	1.81

Protons

E[GeV]	2.5	5.0	7.5	10.0
A[MeV]	20	55	93	135
σ_A [MeV]	8	17	24	30
$<$ A/2 [%]	7.60	3.62	2.89	2.60
$<$ A/4 [%]	1.19	0.40	0.62	1.01
σ_x (gaus)[cm]	2.24	2.01	1.80	1.55
σ_x (mean quad.)[cm]	3.28	2.58	2.17	1.83

- Coordinate resolution within 4cm
- Energy resolution within 30%
- Efficiency within 95% for $E_{hadron} \geq 5$GeV, for threshold A/2

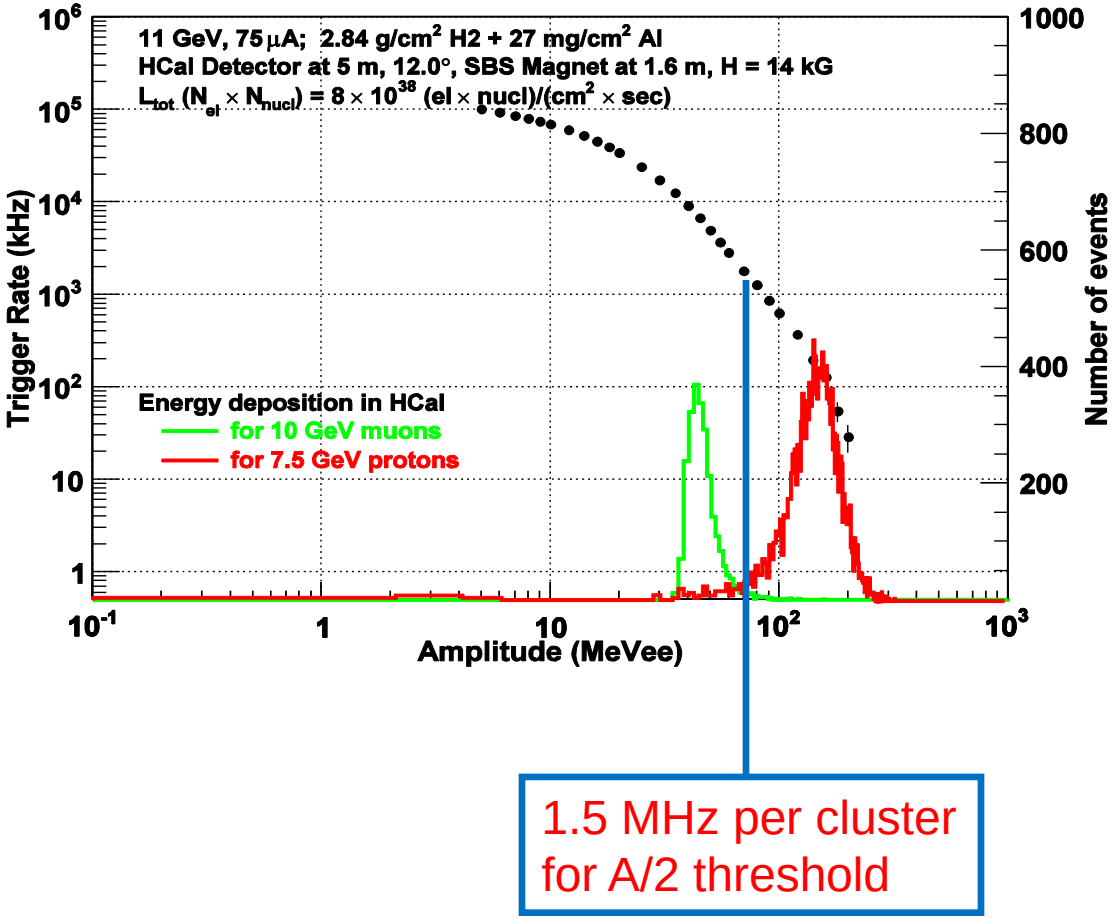
- All parameters almost the same for protons and neutrons.

Counting rates (parameters for Gep 5)

L_{tot} = 8 10^{38} (el nucl)/(cm^2 sec)

- Beam
  - 11.0 GeV, 75 μA
- Target
  - 2.84 g/cm^2 H2
  - 0.027 g/cm^2 Al windows
- Magnet
  - 12.0 , 1.6 m, H = 14 kG
- Hcal
  - 12.0 , 5.0 m

Rate per cluster (kHz): 4 4 blocks

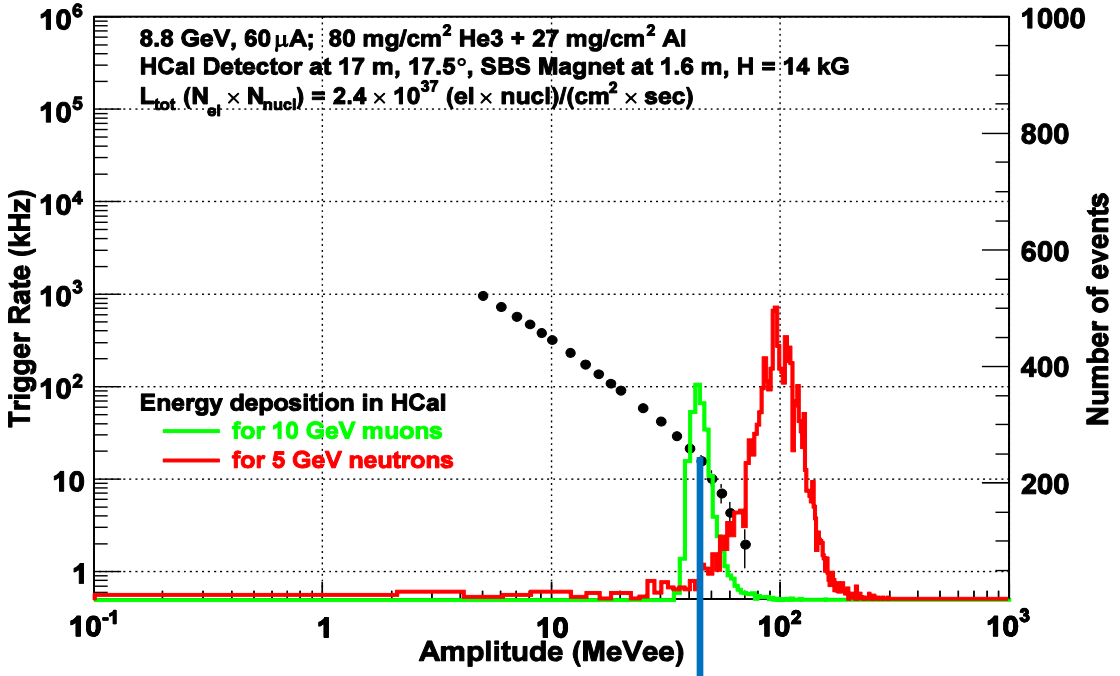


Counting rates (parameters for GEn)

L_{tot} = 2.4 10^{37} (el nucl)/(cm^2 sec)

- Beam
  - 8.8 GeV, 60 μA
- Target
  - 0.080 g/cm^2 He3
  - 0.027 g/cm^2 Al windows
- Magnet
  - 17.5 , 1.6 m, H = 14 kG
- Hcal
  - 17.5 , 17.0 m

Rate per cluster (kHz): 4 4 blocks

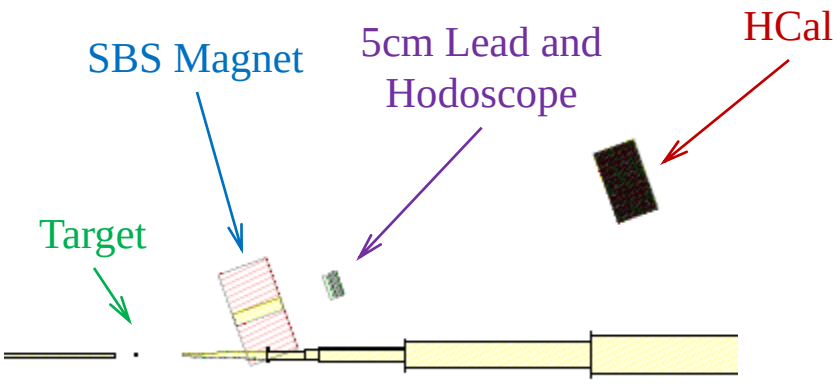


Were used to estimate background rates for PAC proposal

15 kHz per cluster for A/2 threshold

GEn with polarimeter

- Scintillator hodoscope
  - 12 20 blocks
  - 5 5 20 cm each
  - 19.5 , 5 m
- HCal
  - 19.5 , 12 m



L_{tot} = 3 10^{38} (el nucl)/(cm^2 sec)

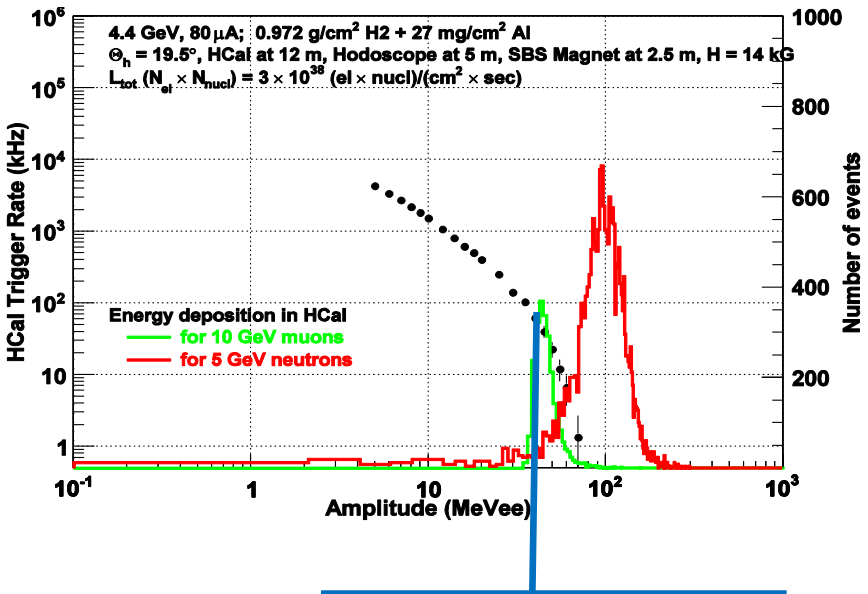
Q^2 = 5.4 $(GeV/c)^2$

- Beam
  - 4.4 GeV, 80 μA
- Target
  - 0.972 g/cm^2 D
  - 0.027 g/cm^2 Al windows
- Magnet
  - 19.5 , 2.5 m, H = 14 kG

Counting rates (GEn with polarimeter)

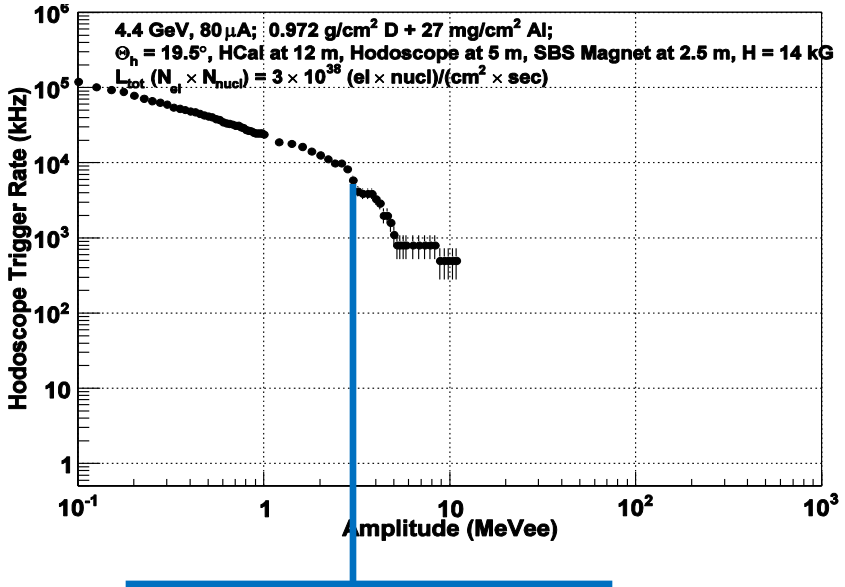
$L_{tot} = 3 \quad 10^{38}$ (el nucl)/(cm^2 sec)

HCal trigger rate per cluster (kHz)



50 kHz per cluster for A/2 threshold

Hodoscope trigger rate per module (kHz)



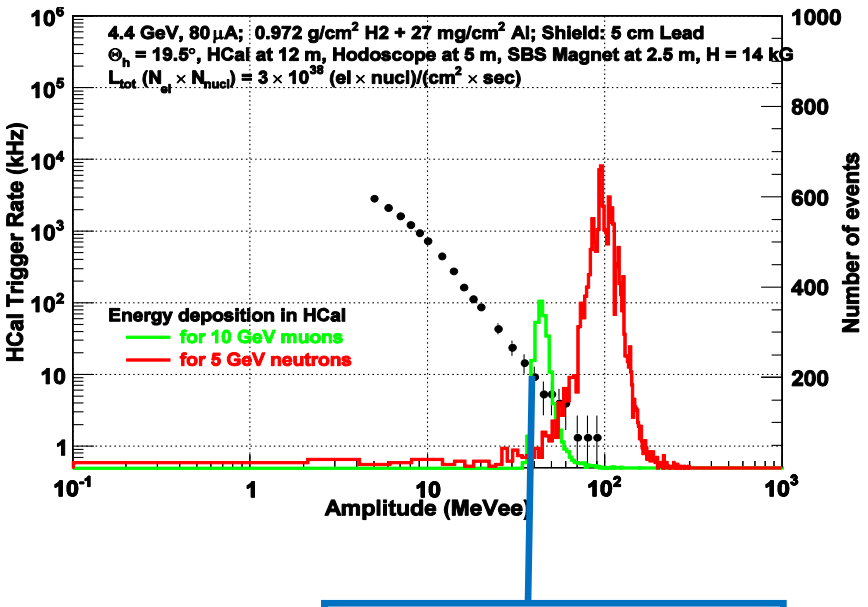
5.9 MHz per module for 3MeV threshold

Counting rates (GEn with polarimeter)

$L_{tot} = 3 \quad 10^{38}$ (el nucl)/(cm^2 sec)

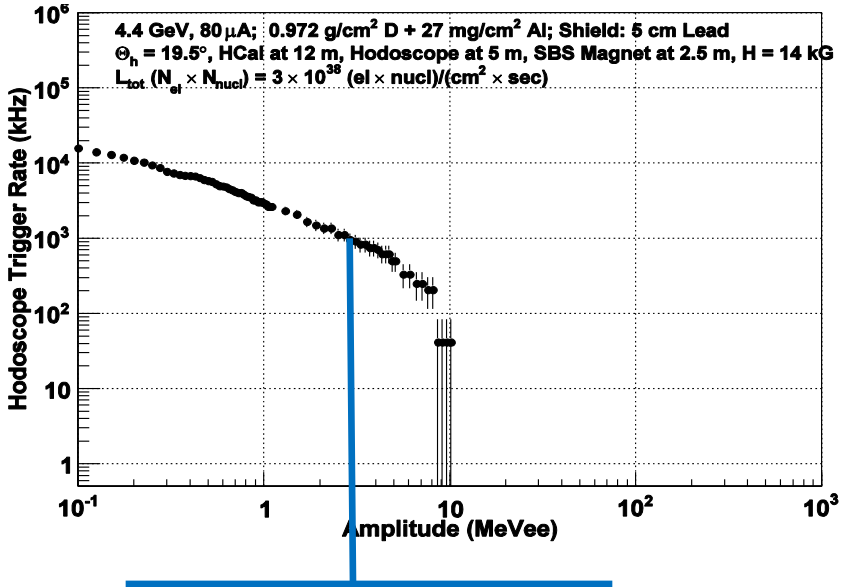
5 cm Lead shield

HCal trigger rate per cluster (kHz)



10 kHz per cluster for A/2 threshold

Hodoscope trigger rate per module (kHz)



900 kHz per module for 3MeV threshold

Background estimation (GEn with polarimeter)

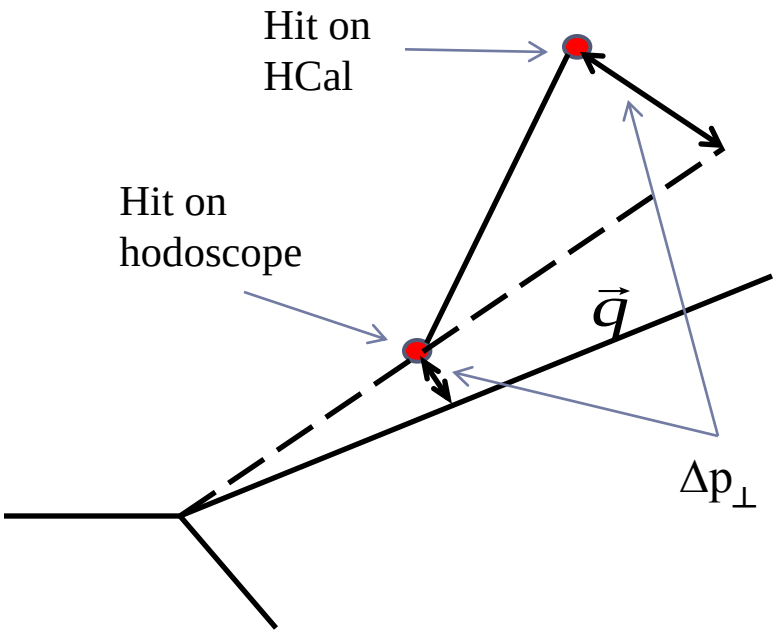
Hall A

- L_{tot} = 3 10^{38} (el nucl)/(cm^2 sec)
- $\Delta\Omega$ = 90 msr

- Accidental background hodoscope
  - $\Delta p_\perp$ = 70 MeV/c
  - 3% accidental with 2 ns window
- Accidental Background HCal
  - $\Delta p_\perp$ = 700 MeV/c
  - 2.5% accidental with 10 ns window

Hall C

- L_{max} = 1 10^{39} (el nucl)/(cm^2 sec)
- $\Delta\Omega$ = 5 msr



Conclusion

- Geometry of Hcal and Ecal on Geant 3
- Integrated to full Hall A geometry
- Counting rates for different configuration
- Estimation of possible threshold values
- Estimation of Energy and Coordinate resolution
- Estimation of Efficiency