Signal Response to Pions in Testbeam Measurements and Geant Simulation

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PHOBOS Collaboration Meeting

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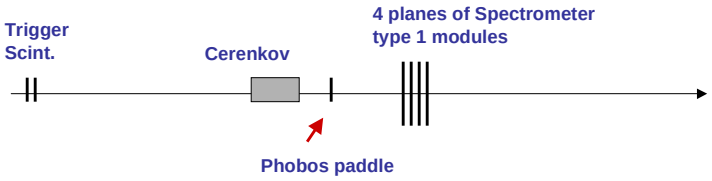
TestBeam '98

The high momentum beam line setup:
π- beam from 0.5 to 8GeV/c



The beam and trigger:

- π- beam
- veto e- with Cerenkov
- muon contents <2%
- no protons
- Δp/p = 0.5%
- cross checked absolute energy with calorimeter - better than 4%

Recorded 40000-50000 tracks at each energy point (~200k hits)

Energy points: 0.5, 0.75, 1, 2, 3, 4, 6, 8 GeV/c

Signal Processing and Calculation

- The Initialization: Get start values for pedestal and noise
  - `TPhFECDetector::PedPreProcess`
  - `TPhFECDetector::PedProcess`
  - `TPhFECDetector::NoiseProcess`
- The Event Loop: Correct common mode noise shifts and zero-suppress empty channels
  - `TPhFECDetector::CMNProcess`
  - `TPhFECDetector::ZeroSuppress`

Signal Processing and Calculation

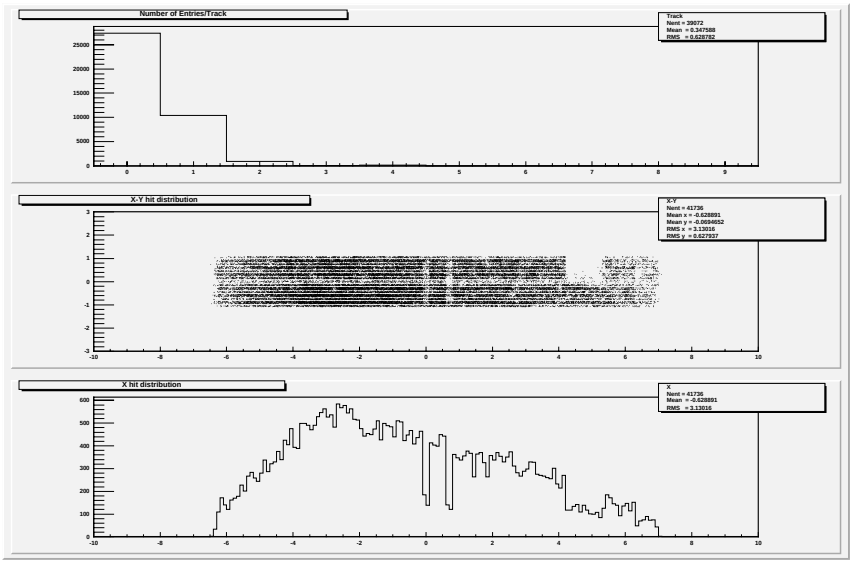
- Signal Processing: Get the detector geometry, our sensor layout and the FEC assignment to sensors: all processing is based on physical sensors
  - `TPhDetector::MakeHitArrays`
  - `TPhDetector::Calibrate`
  - `TPhDetector::MakeHitsOutOfHitArray`

➨ Ready to merge hits,
➨ start the TrackSeedFinder and
➨ reconstruct the tracks with Inkyu's code

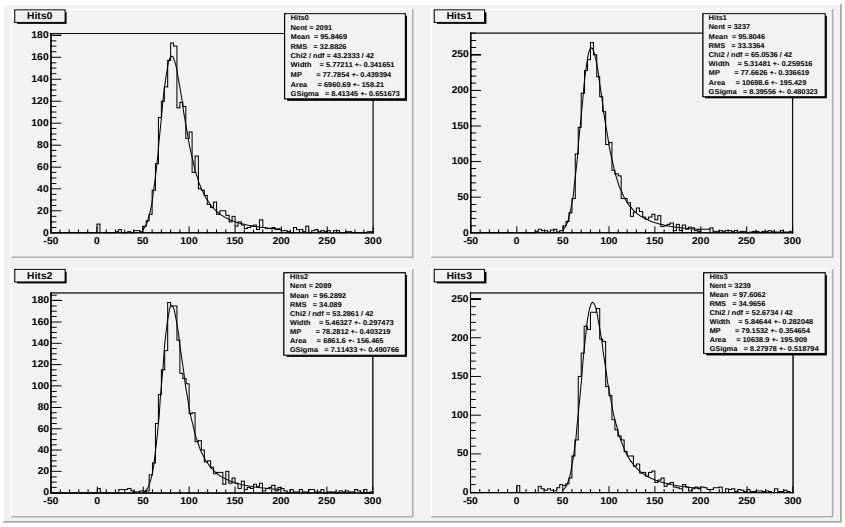
Reconstructed Track

Event #37450

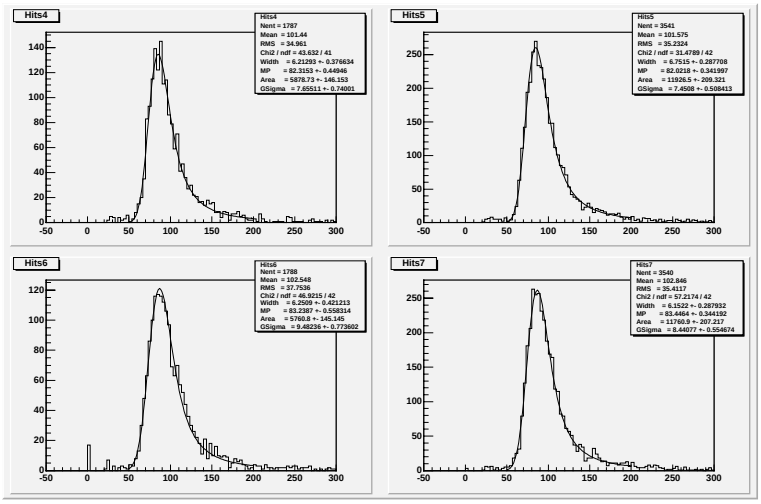
Run12: 1GeV pions, reconstructed



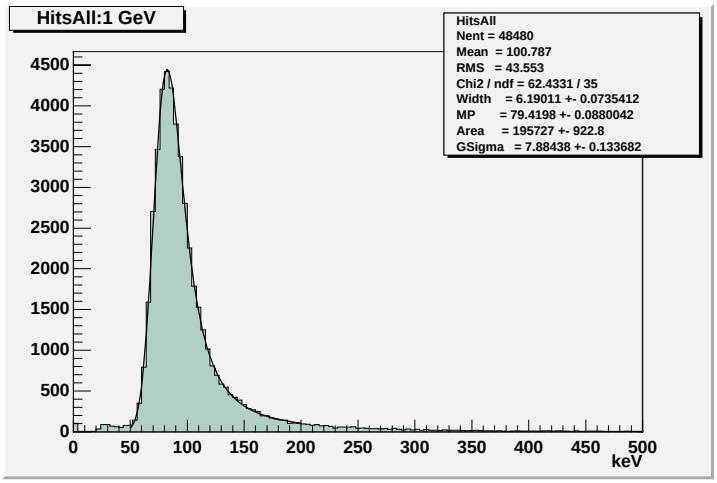
Signal: 1 GeV, Planes 1 and 2



Signal: 1 GeV, Planes 3 and 4



Signal Distribution, All Sensors

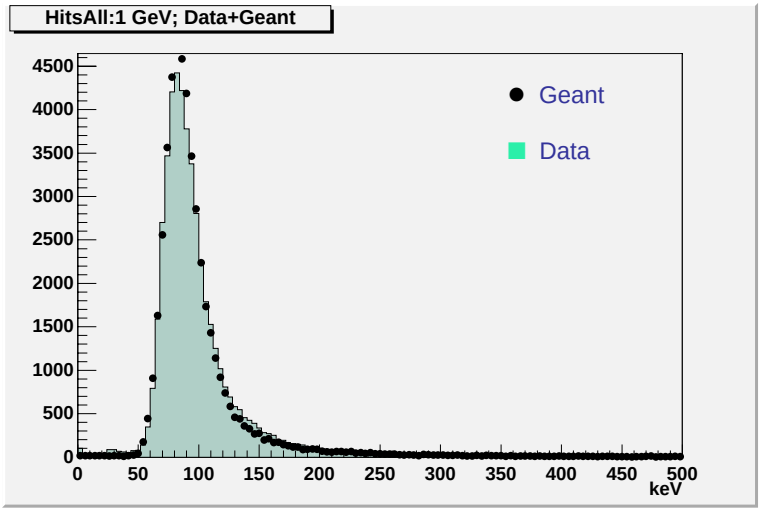


- Each sensor is normalized to 300μm thickness
- Planes 3 and 4 corrected for overdepletion of modules

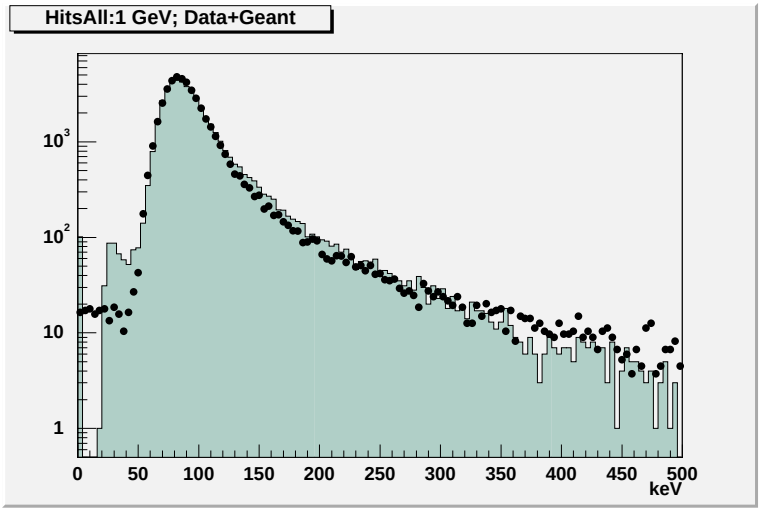
Geant Simulation

- 16000 π tracks per energy point
- Control Parameters:
  - MULS=1: Multiple scattering according to Molière theory
  - DCAY=1: Decay in flight with generation of secondaries
  - HADR=1: Hadronic interactions with generation of secondaries
  - LOSS=1: Continuous energy loss with generation of δ -rays above DCUTE and restricted Landau fluctuations below DCUTE (=1MeV)
  - PAIR=1: Pair production
  - BREM=1: Bremsstrahlung with generation of γ
  - COMP=1: Compton scattering
  - PHOT=1: Photo-electric effect with generation of the electron
  - DRAY=1: δ -rays production
  - ANNI=1: Positron annihilation with generation of photons

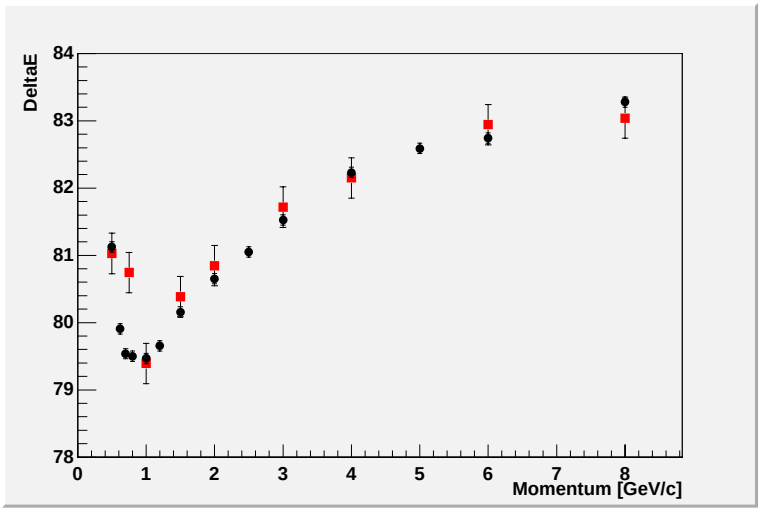
Data + Geant - I



Data + Geant - II



Momentum Dependence: Data + Geant



Energy Loss

• Energy loss by charged particles in matter is primarily due to ionization.

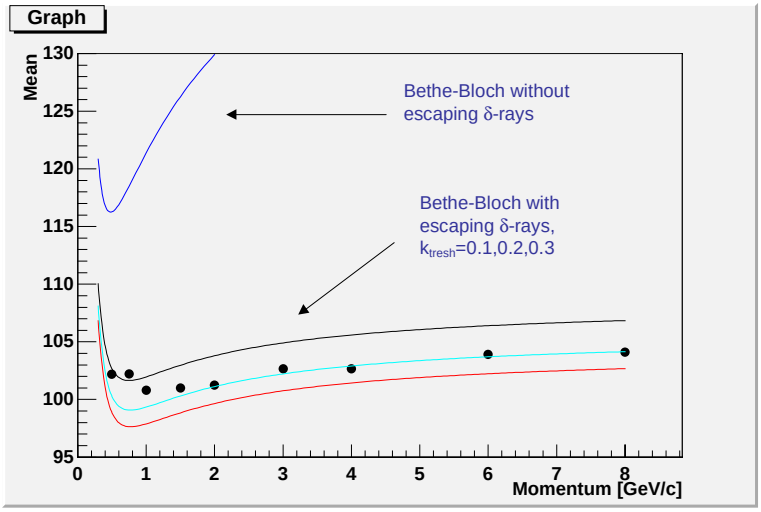
• The momentum dependence of the mean energy loss for moderately relativistic particles is described by Bethe-Bloch formula

• MIP: minimum ionizing particles, with momentum corresponding to the Bethe-Bloch function minimum.

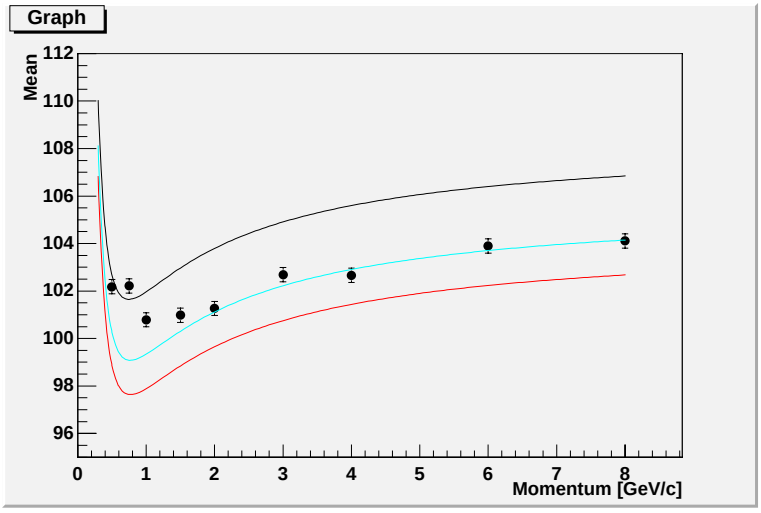
• In thin detectors, not all the energy lost is deposited, remaining is carried away by energetic knock-on electrons (δ-rays)

⇒ Energy loss ➨ Restricted Energy loss

Data + Bethe-Bloch - I



Data + Bethe-Bloch - II



Conclusions - I

• Primary aim: to measure our detectors' signal response and compare it to simulation with the final Phobos detector

• Additional major benefit: preparation of the full raw signal processing for Phat data analysis (mainly by Cracow group)

Conclusions - The Results

• We achieved extremely high precision

• Mapped the dE/dx log rise: MIP~800-1000MeV, $\Delta E_{rel}/\Delta E_{MIP}$ = 4%

• Geant is able to accurately describe the dE/dx gain and straggling when the electronics noise and Gaussian modifications ("Shulek") are taken into account.

• Bethe-Bloch gives a reasonable approximation when restricted energy loss is considered (~10%)

  • MIP point is higher than predicted by pure Bethe-Bloch

  • Log rise is overestimated by pure Bethe-Bloch