Central Particle Tracking Detectors in the PEN Experiment

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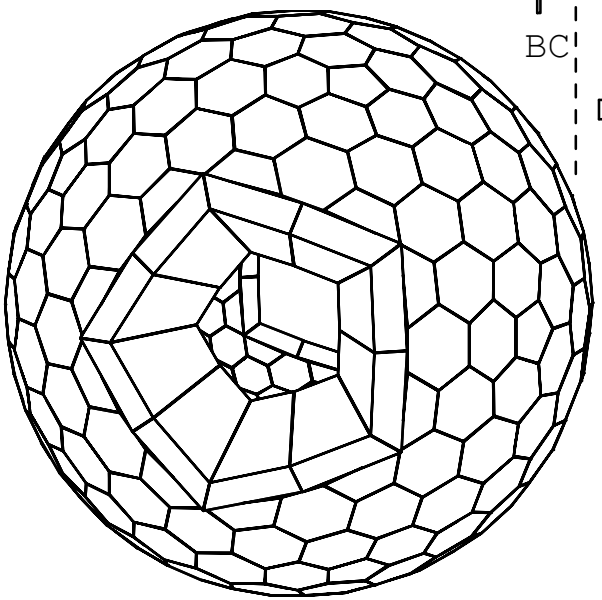
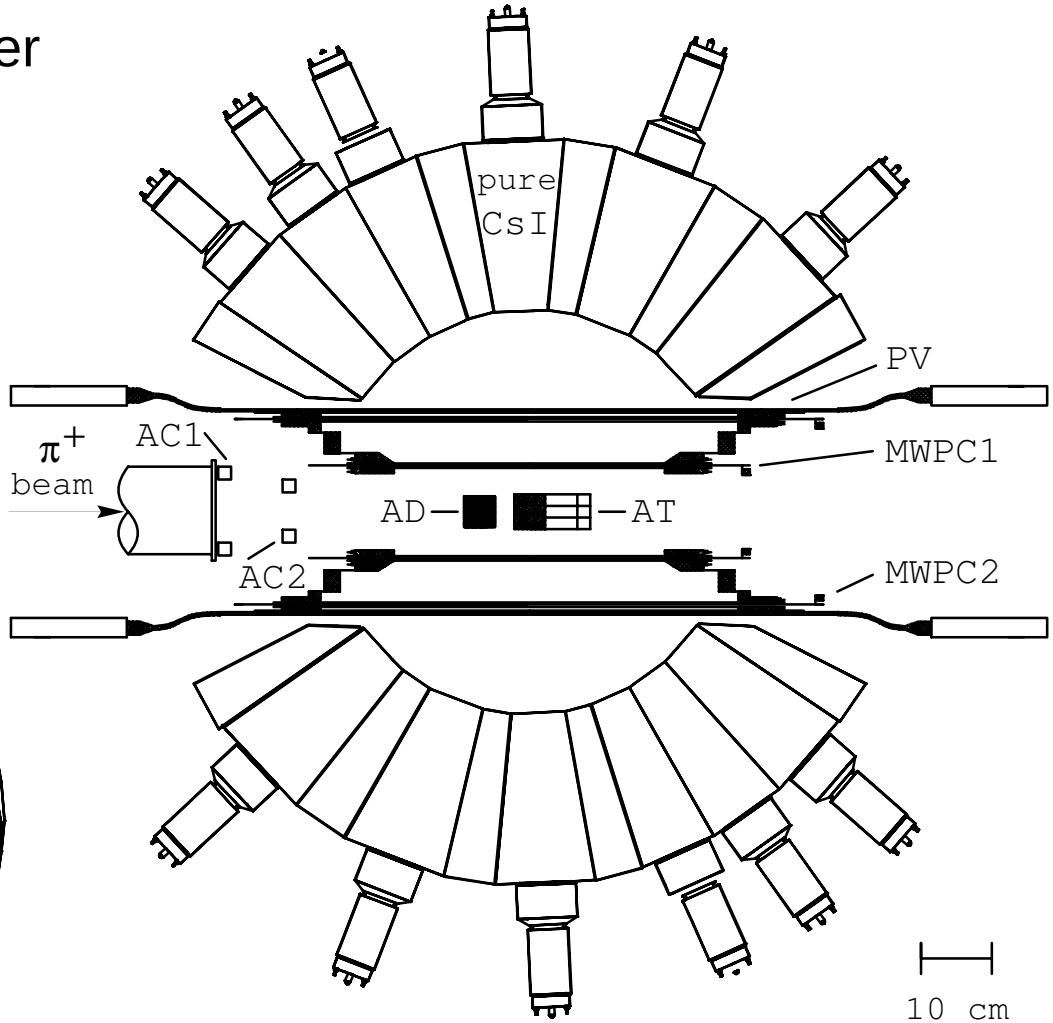
2008 Annual Fall Meeting of
the APS Division of Nuclear Physics
Oakland, 23-26 October 2008

Outline

The PIBETA/PEN Apparatus: Basic Subsystems

- stopped π^+ beam
- active tracking degrader
- active target counter
- 240-det. CsI(p) calo.
- central tracking
- digitized PMT signals
- stable temp./humidity



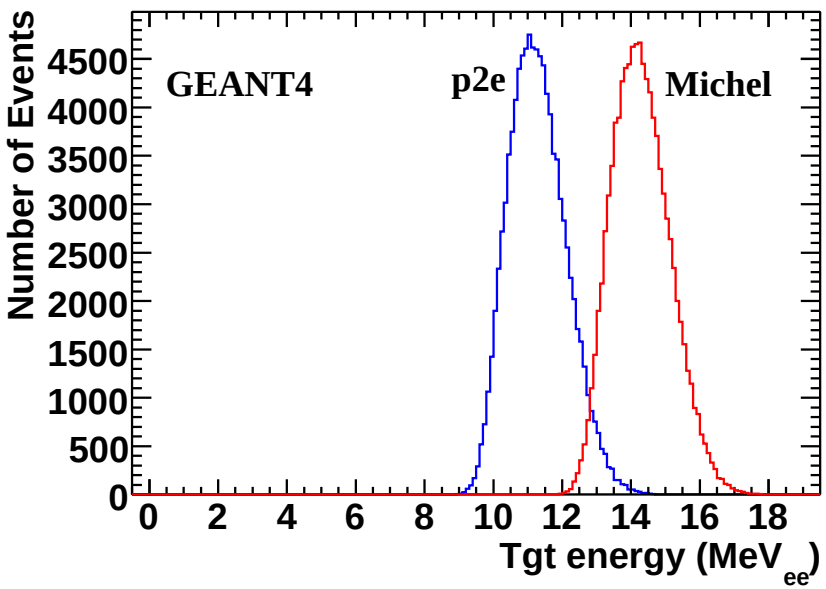


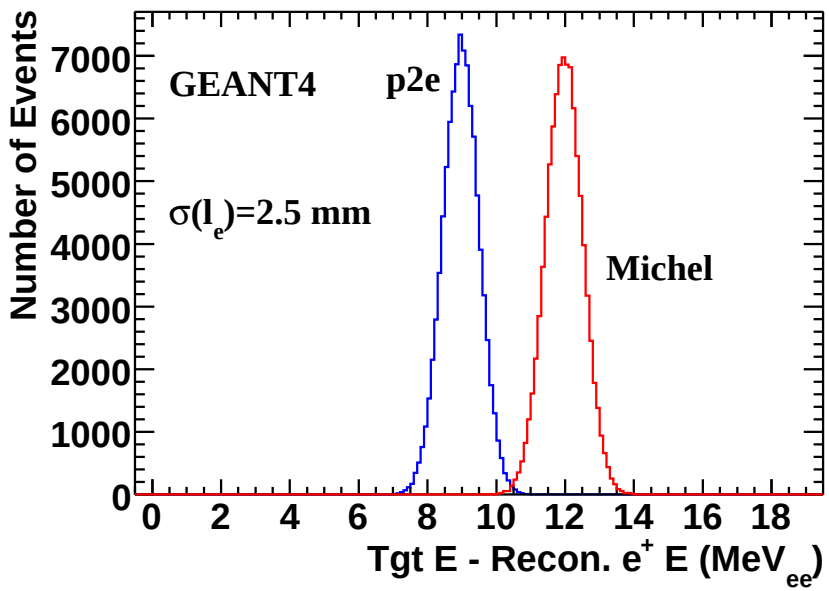
$\pi^+/\mu^+ \rightarrow e^+$ Tracking: Goals

- Monitor the center and the shape of π^+ and μ^+ stopping distributions (for Monte Carlo acceptance calculation).
- Tag π^+ and μ^+ decays-in-flight.
- Use knowledge of the decay vertex (x_V, y_V, z_V) inside the active target in order to improve the energy resolution of π^+'s and μ^+ (light collection probability correction).
- Reconstruct the decay e^+ pathlength inside the target in order to predict the e^+ energy deposition in AT on event-by-event basis.

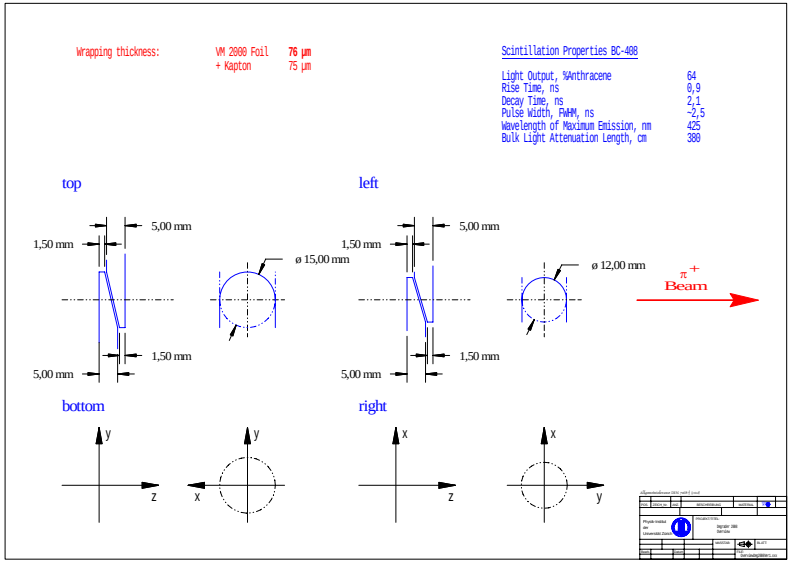
Decay Discrimination Using TGT ADCs/Waveforms

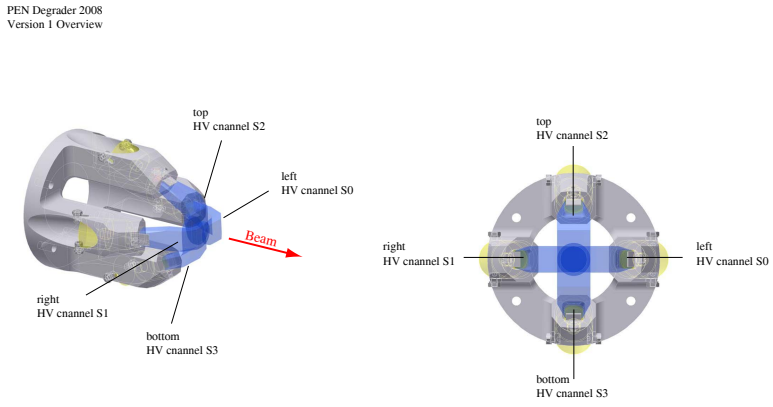
MC simulation: realistic detector resolutions, electron-equivalent energy depositions, e^+ pathlength *rms* uncertainty of 2.5 mm





4-wedge Tracking Active Degrader 2008



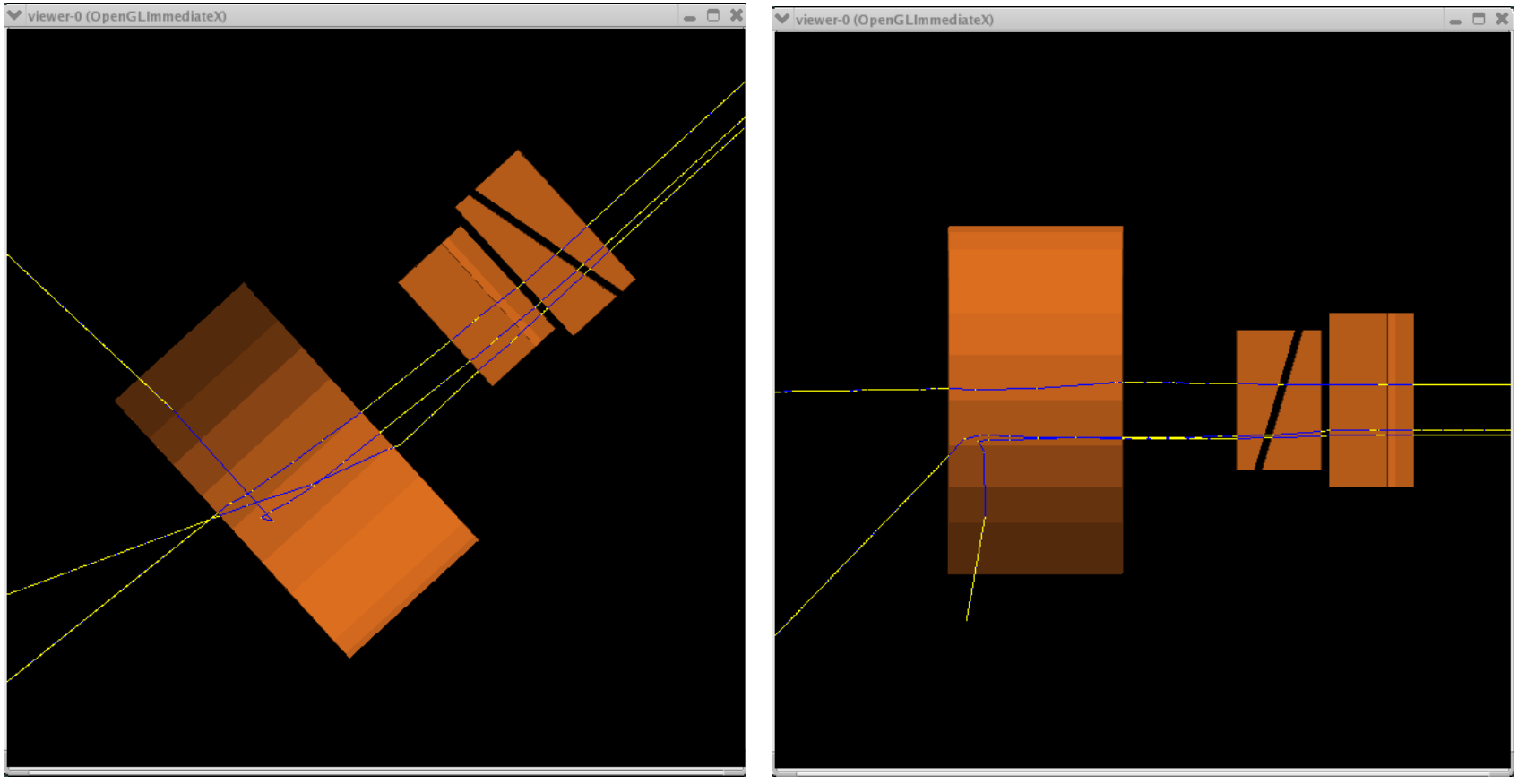


- AD π^+ + MWPC e^+ Tracking = e^+ pathlength in Target= suppresion of In-Flight Decays
- BC-408 Scintillator
- 0.9 ns Rise Time
- 2.1 ns Decay Time
- 160 Phel/MeV
- two *x* and two *y* Wedges
- 3 cm Upstream of Target

Acqiris Digitizer for Target Counters

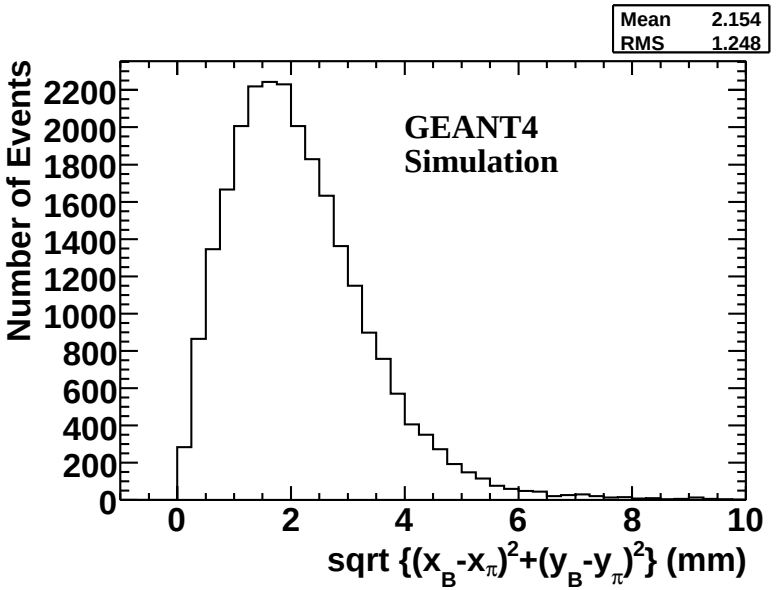
- High-Speed 10-bit PXI/CompactPCI
- 1 ch=8 G/s, 2 ch=4 G/s, 4 ch=2 G/s
- DAQ memory: 256-1024 kpoints
- Complete pre- and post-triggering
- Low 350 ns dead time
- 400 MB/s PCI bus transfers data
- High-res. TTI for accurate timing

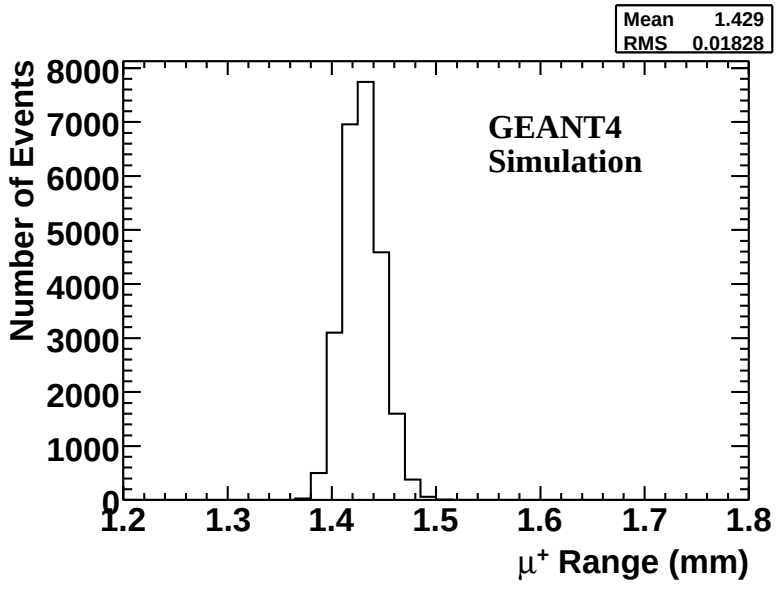
GEANT4 Simulation of $\pi \rightarrow \mu \rightarrow e$ Decays

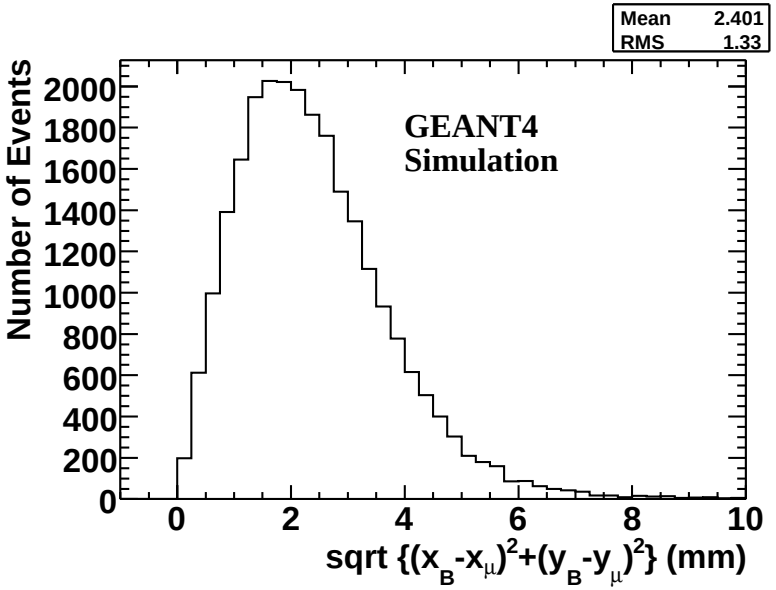


- Realistic incident π^+ beam and detector shapes, realistic detector geometry and software cuts

π^+/μ^+ Decay Vertex Uncertainty: 4-Wedge Degrader

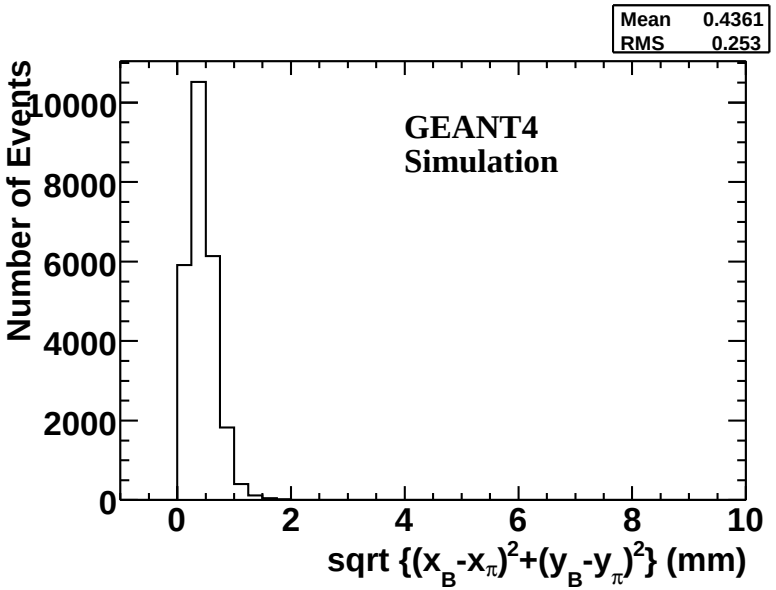


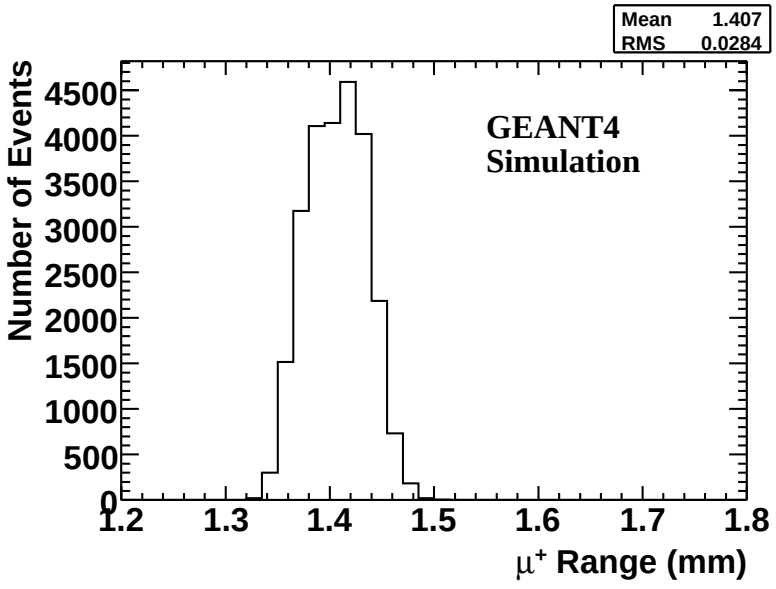


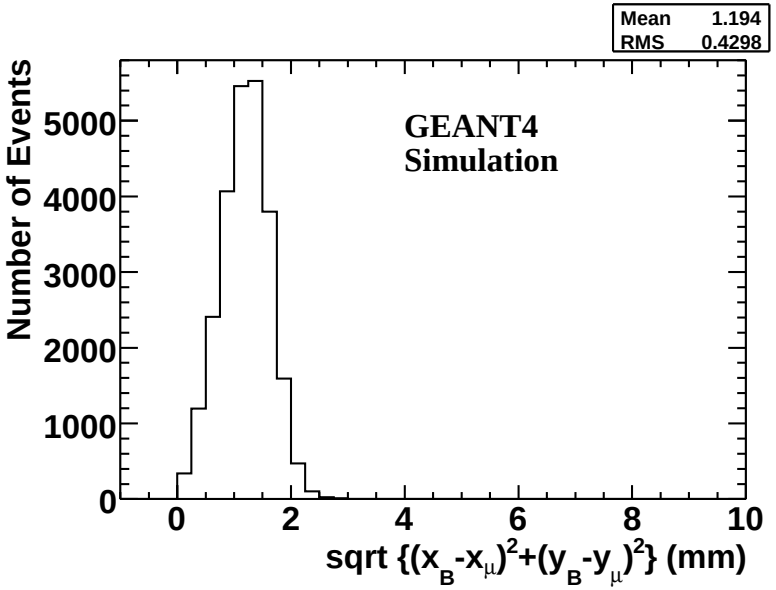


- π^+ Lat. Multiple Scatt.: 2.2 mm
- μ^+ Range: (1.43 ± 0.02) mm
- μ^+ Tot. Vertex Uncert.: 2.4 mm

π^+/μ^+ Decay Vertex Uncertainty: miniTPC Chamber



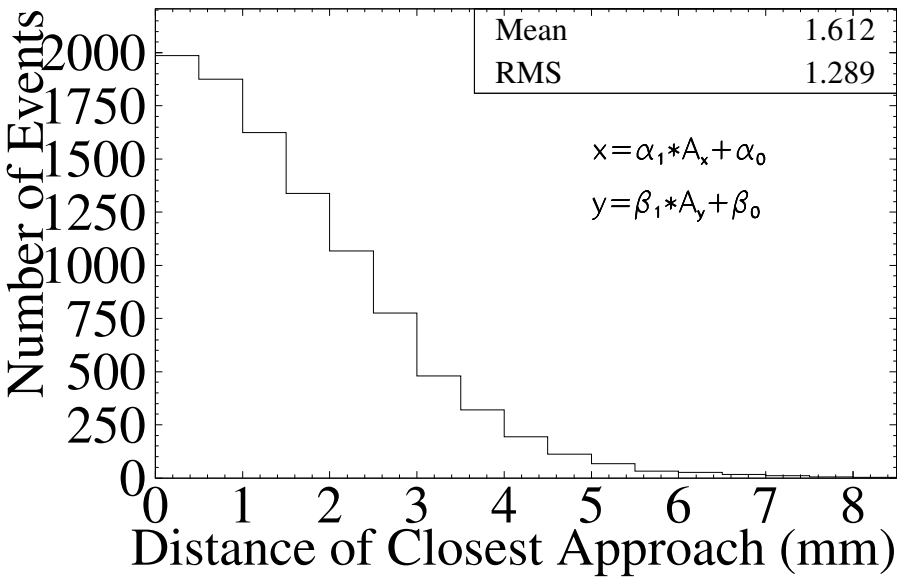


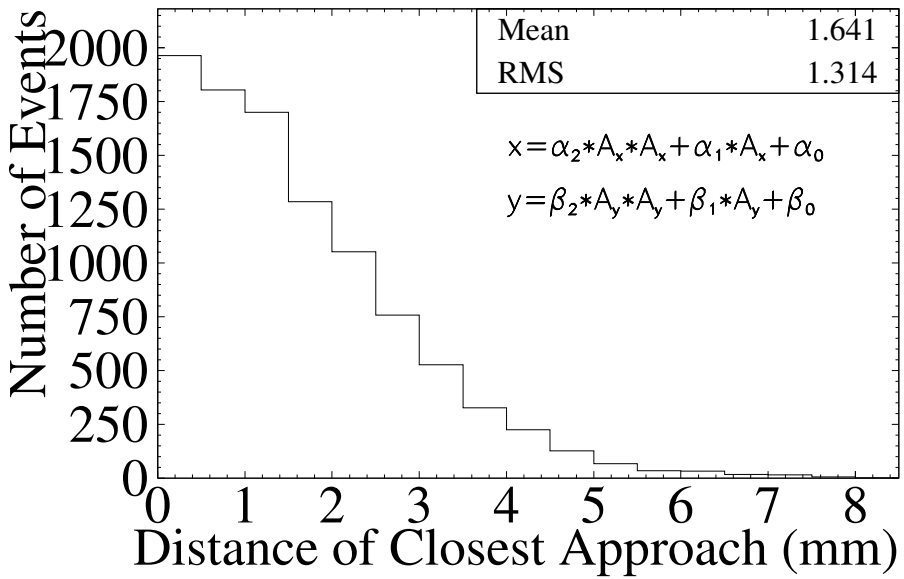


- π^+ Lat. Multiple Scatt.: 0.4 mm
- μ^+ Range: (1.41 ± 0.03) mm
- μ^+ Tot. Vertex Uncert.: 1.2 mm

G4 MC ADC-to-Position Calibration: MINUIT Minimization

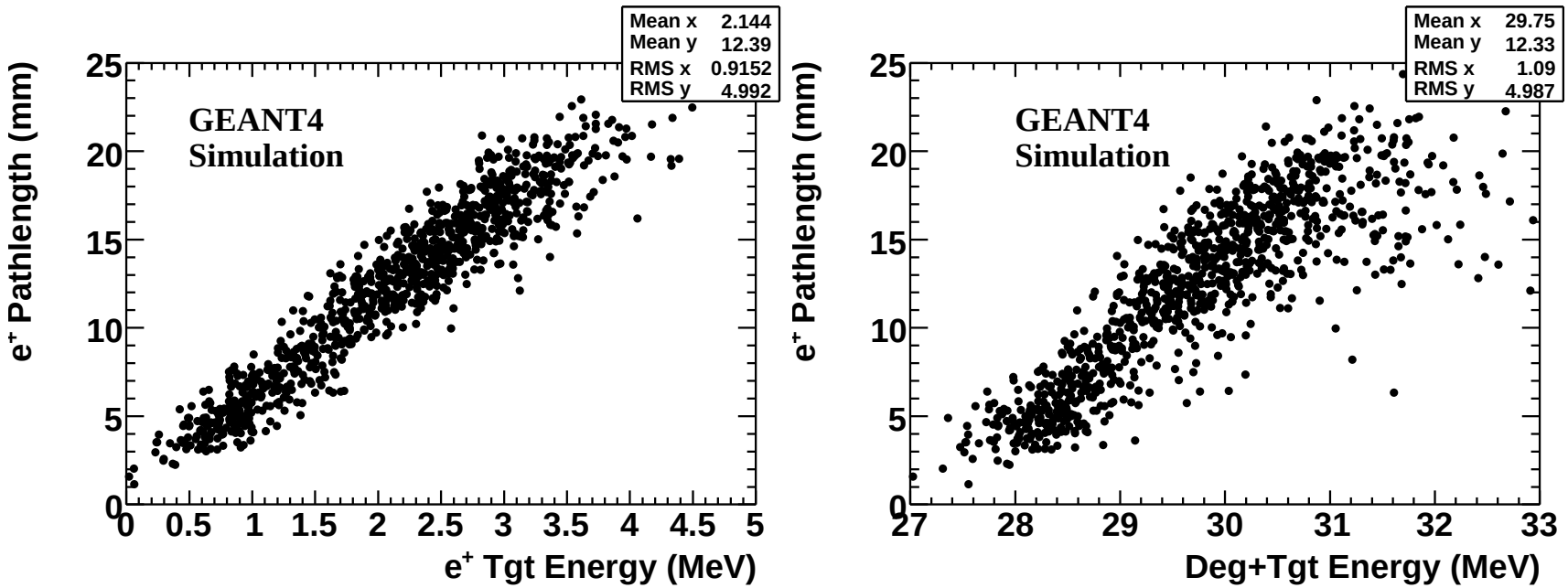
- The simplest assumption: $x = \alpha_1 \cdot A_x + \alpha_0$,
  $A_x = (ADC_L - ADC_R)/(ADC_L + ADC_R)$
- Find PCAs of π^+ track and e^+ track
- Minimize the DCA between π^+ and e^+ tracks





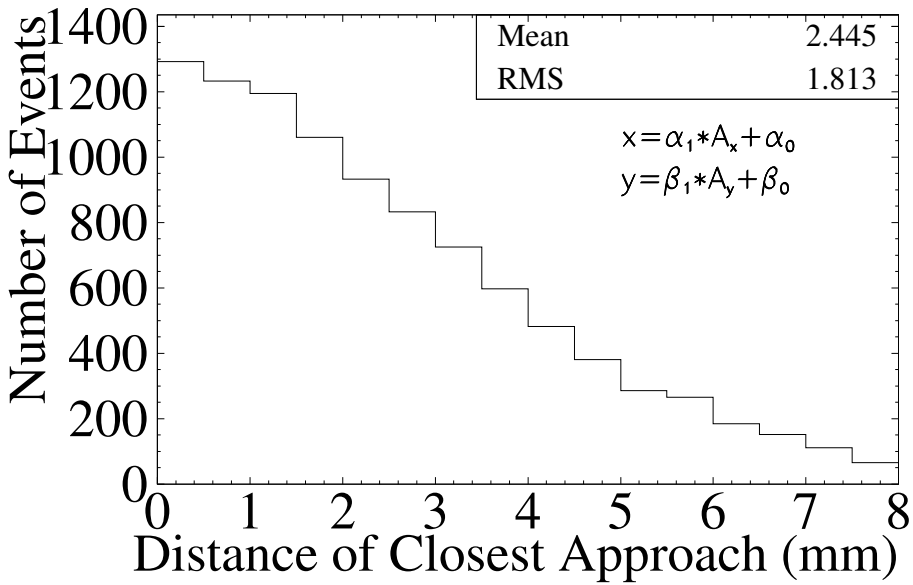
e^+ Pathlenghts and TGT ADCs

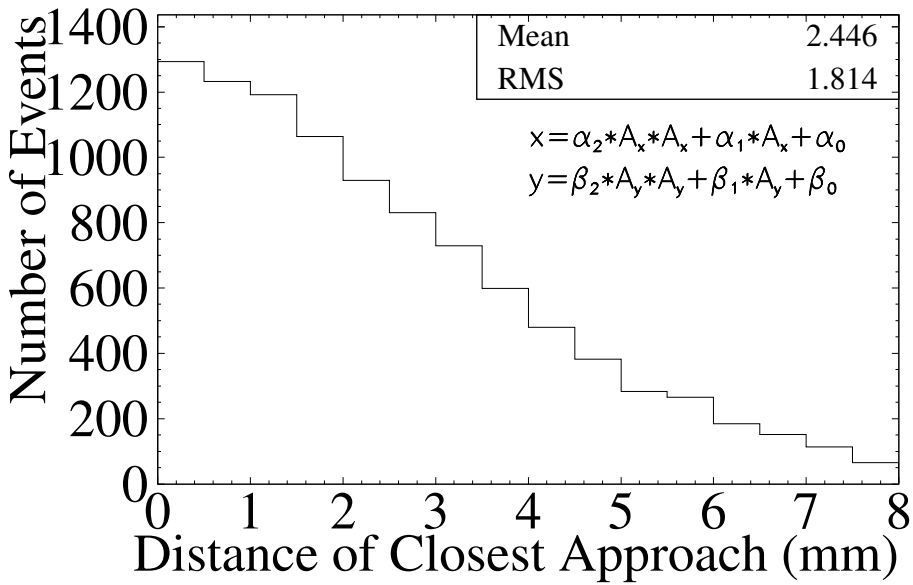
Left Panel: e^+ pathlength vs e^+ TGT response
Right Panel: e^+ pathlength vs TGT total energy deposition



PEN08 Data: AD Response and Coordinate Calibration

- The simplest assumption: $x = \alpha_1 \cdot A_x + \alpha_0$,
  $A_x = (ADC_L - ADC_R)/(ADC_L + ADC_R)$
- Find PCAs of π^+ track and e^+ track
- Minimize the DCA between π^+ and e^+ tracks





PEN Summary & Future Plans

- Two PEN development runs, in 2007 and 2008, ramping up beam stop and DAQ rates to design specifications: up to 30,000 stopped π^+/sec at 85 MeV/c momentum.
- Digitized signals (ADC & PMT waveforms) of beam detectors: forward (B0) beam counter, active degrader (AD), and active target (AT).
- In 2008 run used position-sensitive four-wedge active degrader, planning to replace it with mini-time-projection chamber (mTPC) for 2009 data production run.
- Calibrated ADC-to-position response of the four-wedge active degrader: MC resolution 0.8 mm, preliminary data resolution 1.2 mm
- Detailed data analysis under way in preparation for a 2009 run, planned to complete the required event statistics.
- PEN Web page: `http://pen.phys.virginia.edu`

PSI Experiment R-05-01 (PEN) collaboration members:

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