Status of the PANDA TPC simulation software

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PANDA collaboration meeting @ GSI
March 2, 2009

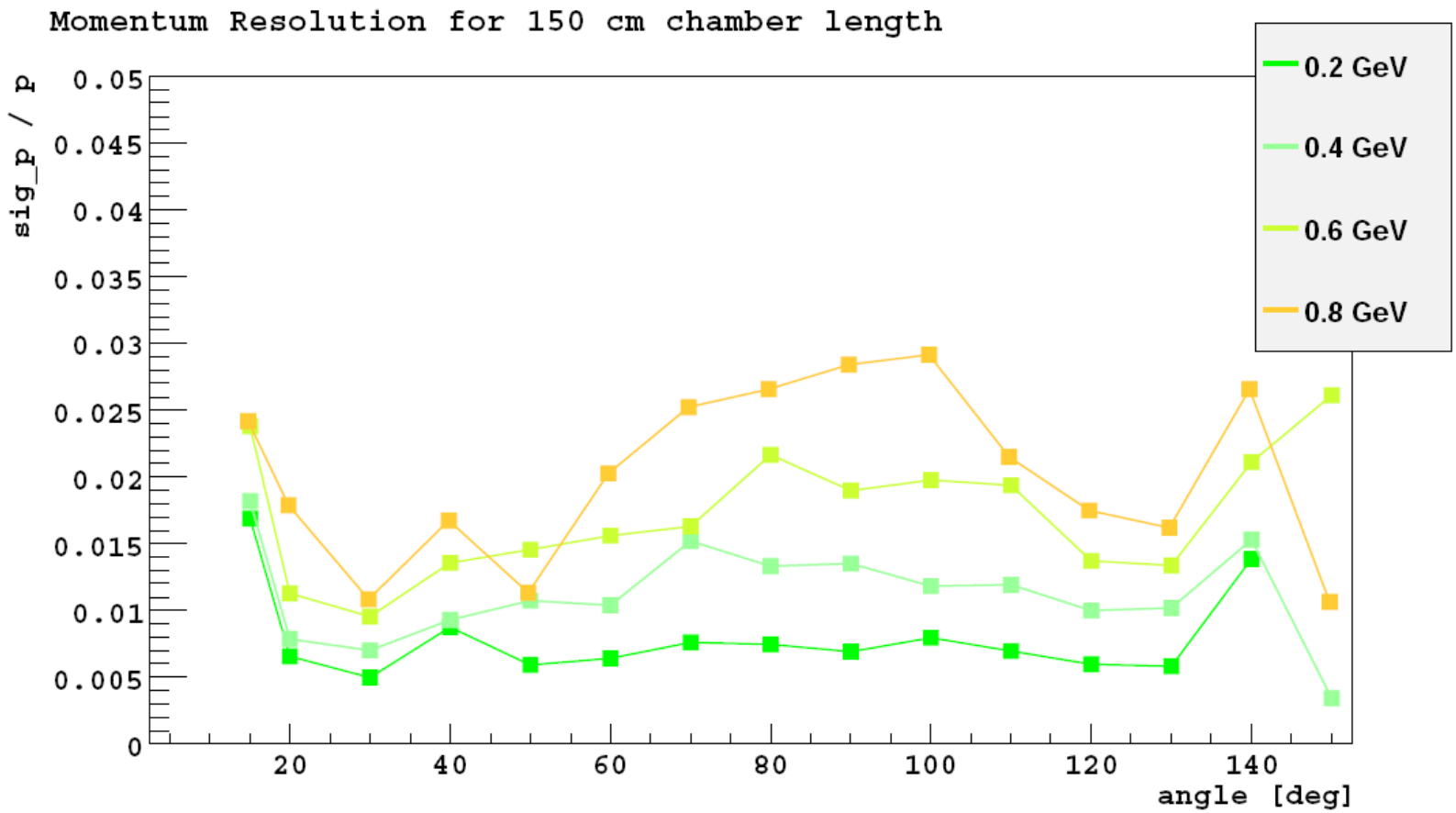
Overview

- Update on TPC momentum resolution studies
  - Review of data from December
  - New results
  - Comparison to short TPC chamber (120cm)
  - Current problems

- Energy loss studies for GEANT3 standard and GEANT3 ”ALICE”
  - Comparison of energy loss models
  - Problems
  - Conclusion

Remember December ...

- Preliminary results shown at PANDA collaboration meeting in December:

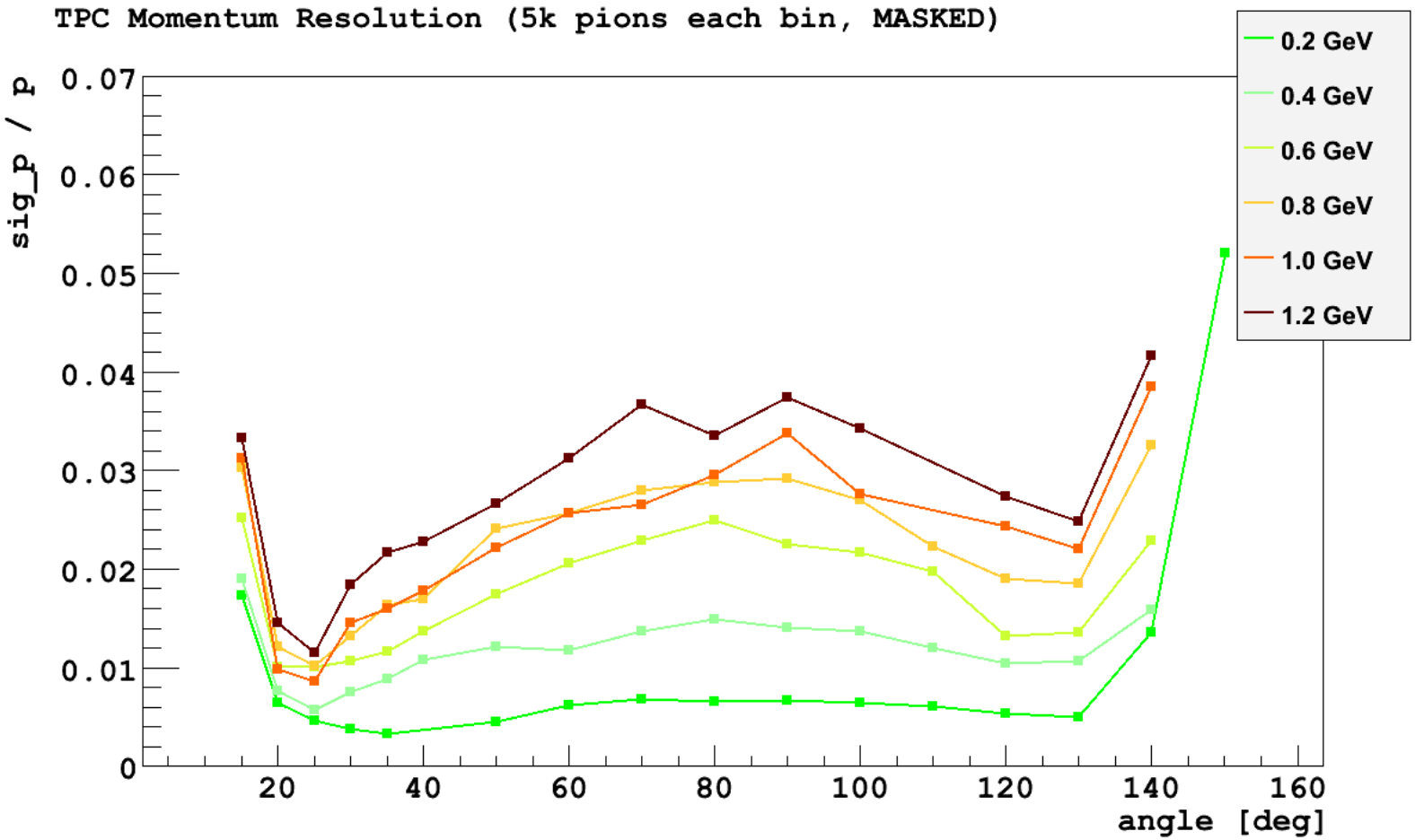


Since then

- Increased statistics by factor 5
- Fixed minor bugs in the reconstruction
- Studied and tuned ALICE MC parameters

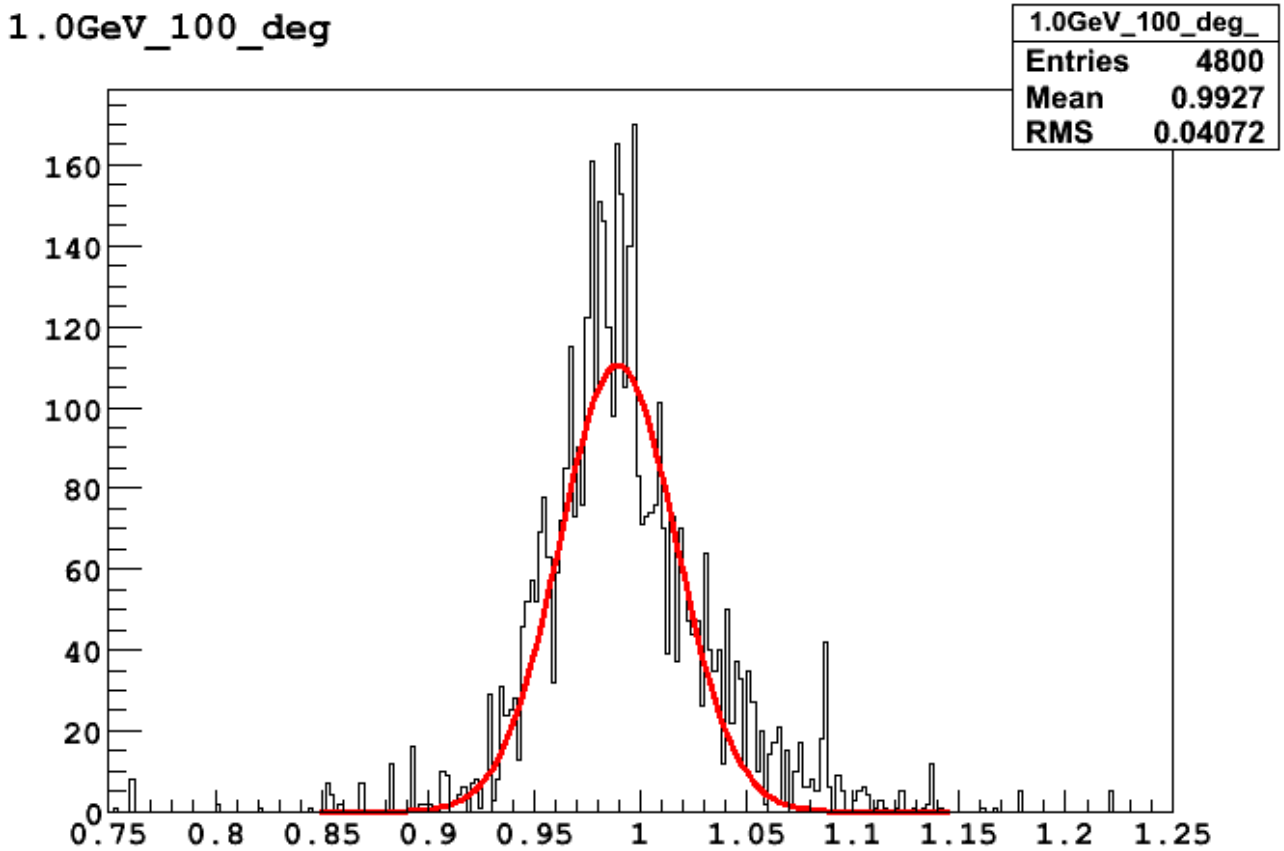
- Data features:
  - ALICE MC model (more to come)
  - 5000 pion tracks (FairBoxGenerator) for each bin at fixed momentum, fixed scattering angle, azimuth free
  - Full digitization: Clusterizing (ALICE!), diffusion, pad response, electronics
  - Reconstruction using **genfit** (track finding based on MC truth, GEANE track representation, Kalman Fitter)
  - TPC hits only!

Results 1: Long chamber (150cm)

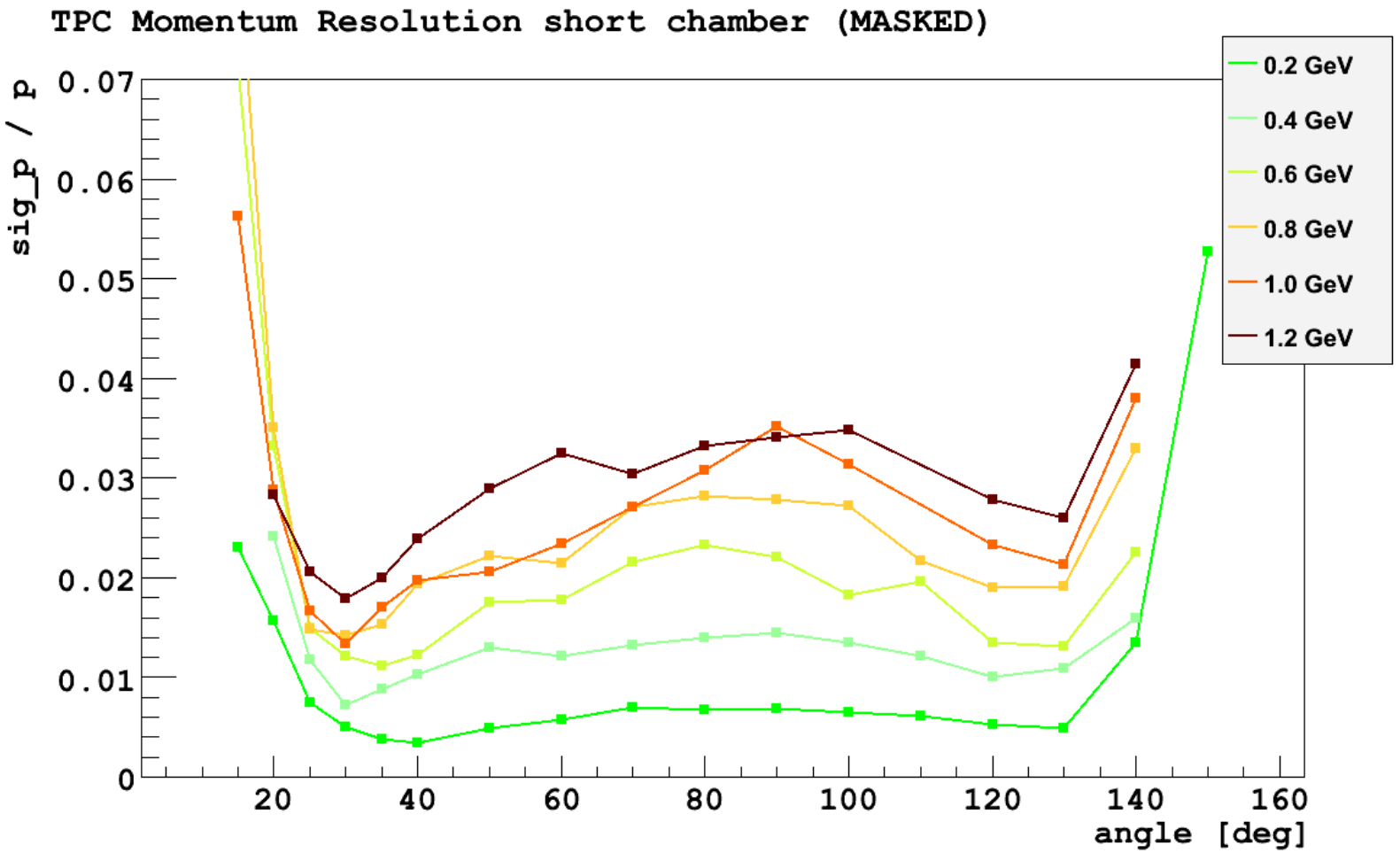


Results 1: Methodology

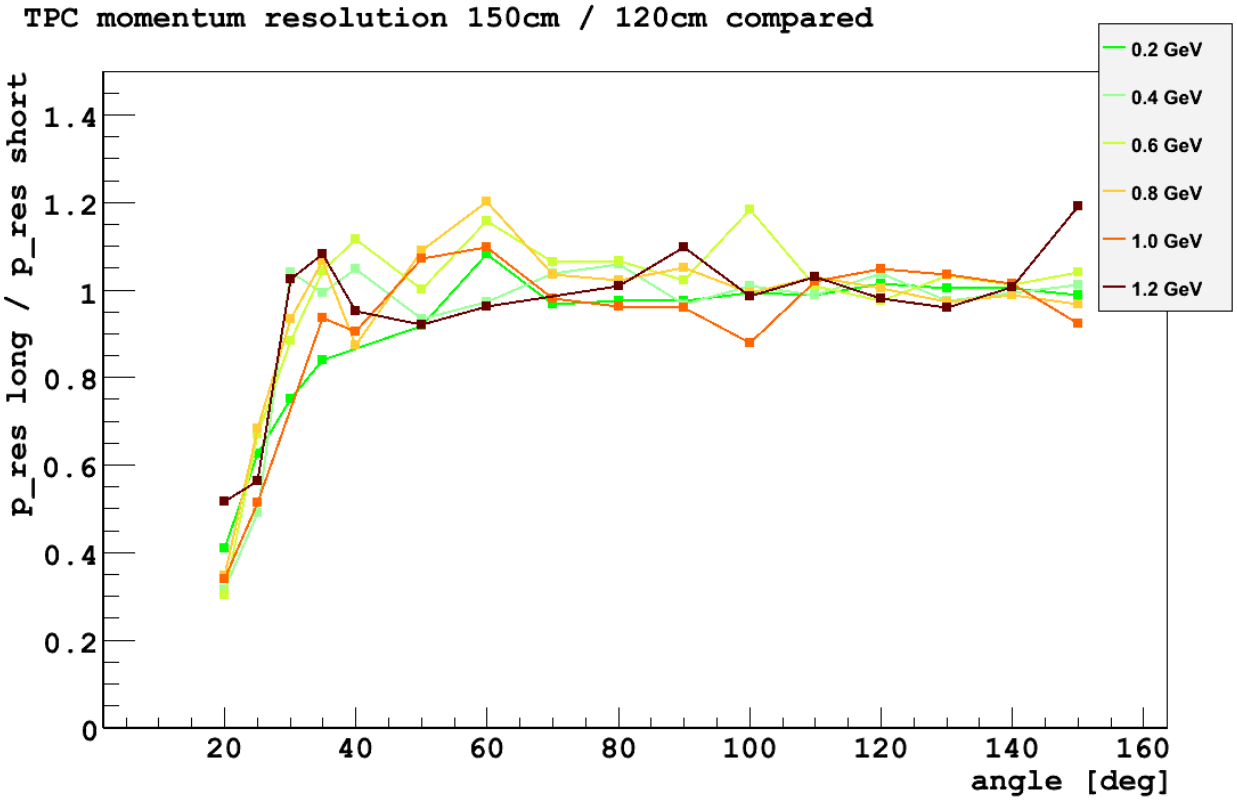
- acquire momentum from successful fit
- fit distribution with gaussian and extract sigma



Results 2: Short chamber (120cm)



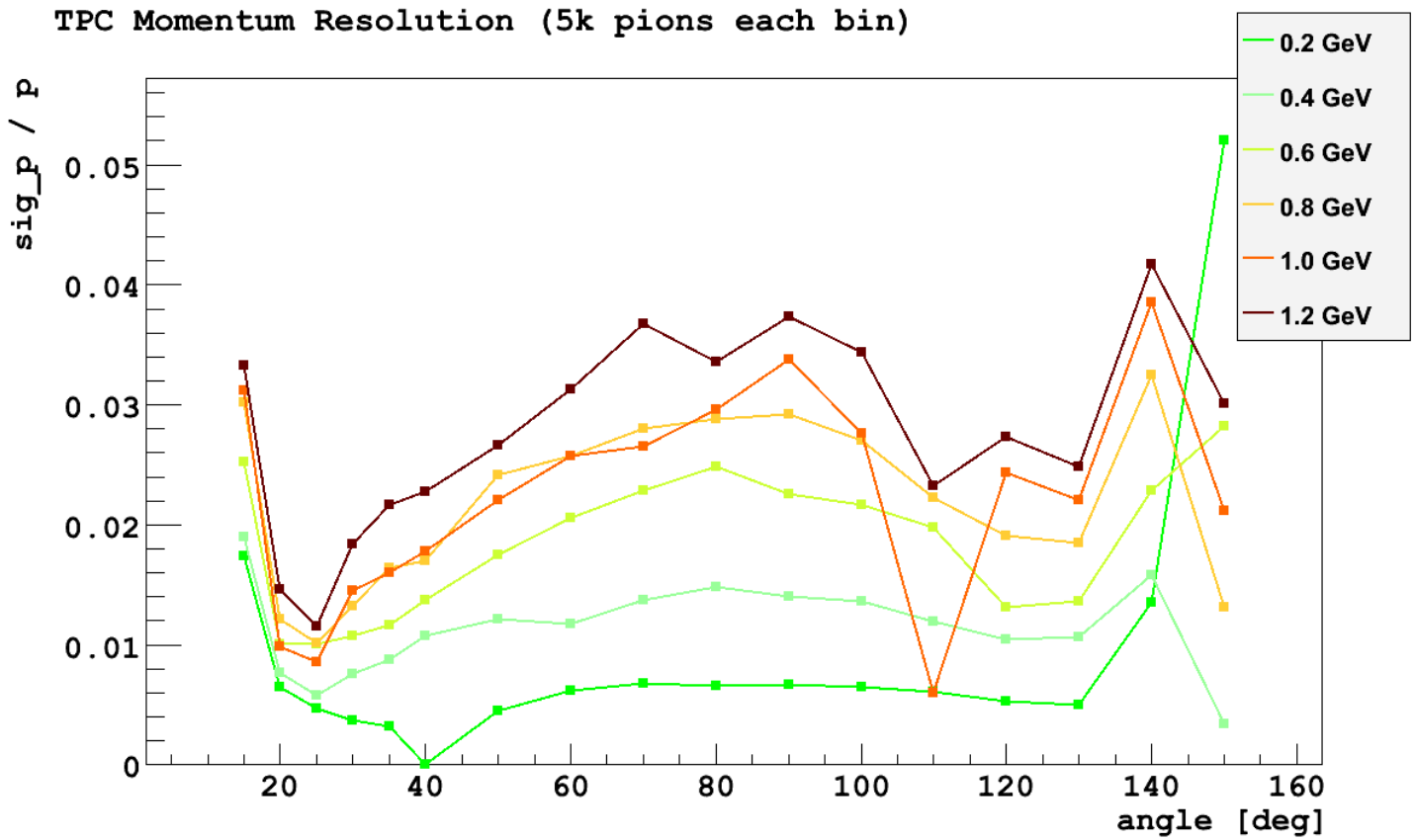
Results 3: Direct comparison



- Conclusion: We lose 5-10 degrees of good momentum resolution

Problem 1: Reconstruction broken for some bins

- Some bins had been masked out so far ...
- Reason: Reconstruction problems



Some bins in the momentum resolution are too low

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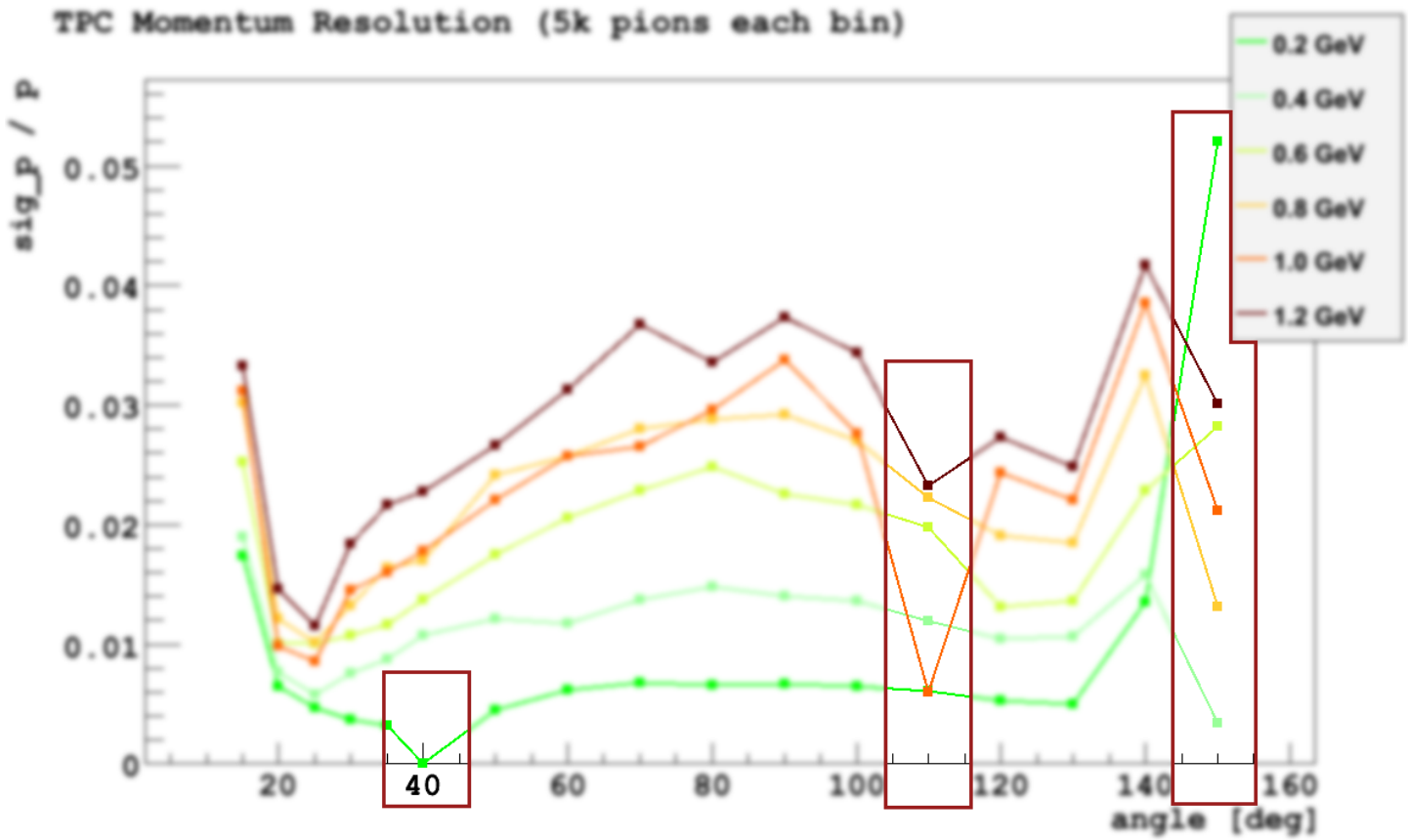
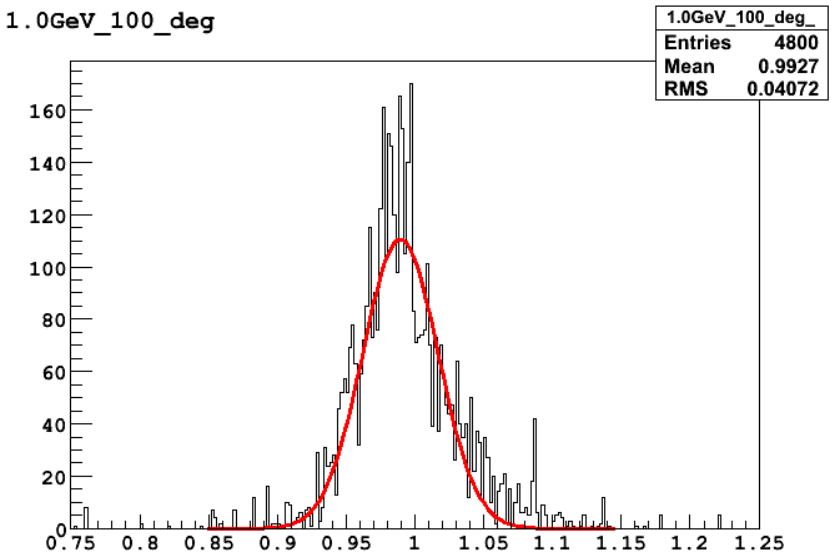
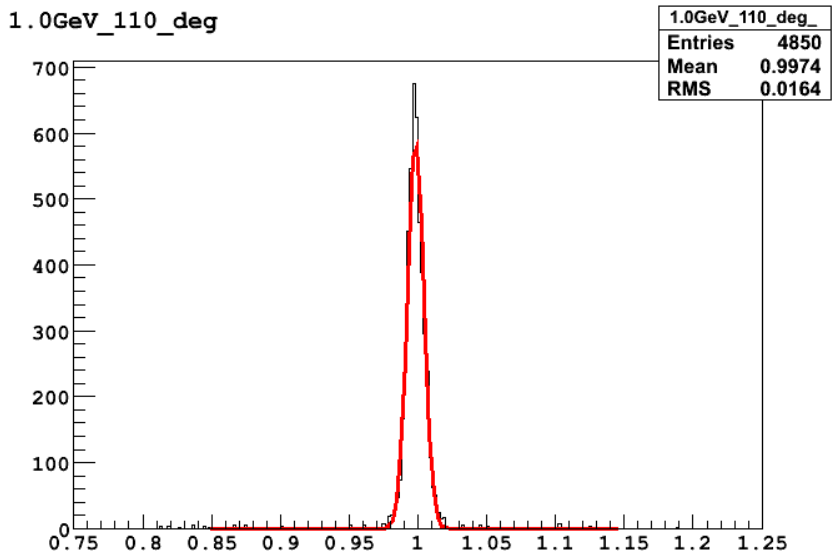


Some bins in the momentum resolution are too low

Problem 1: Reconstruction broken for some bins

- Issue is reproducible for certain angles (already seen in old data from December)

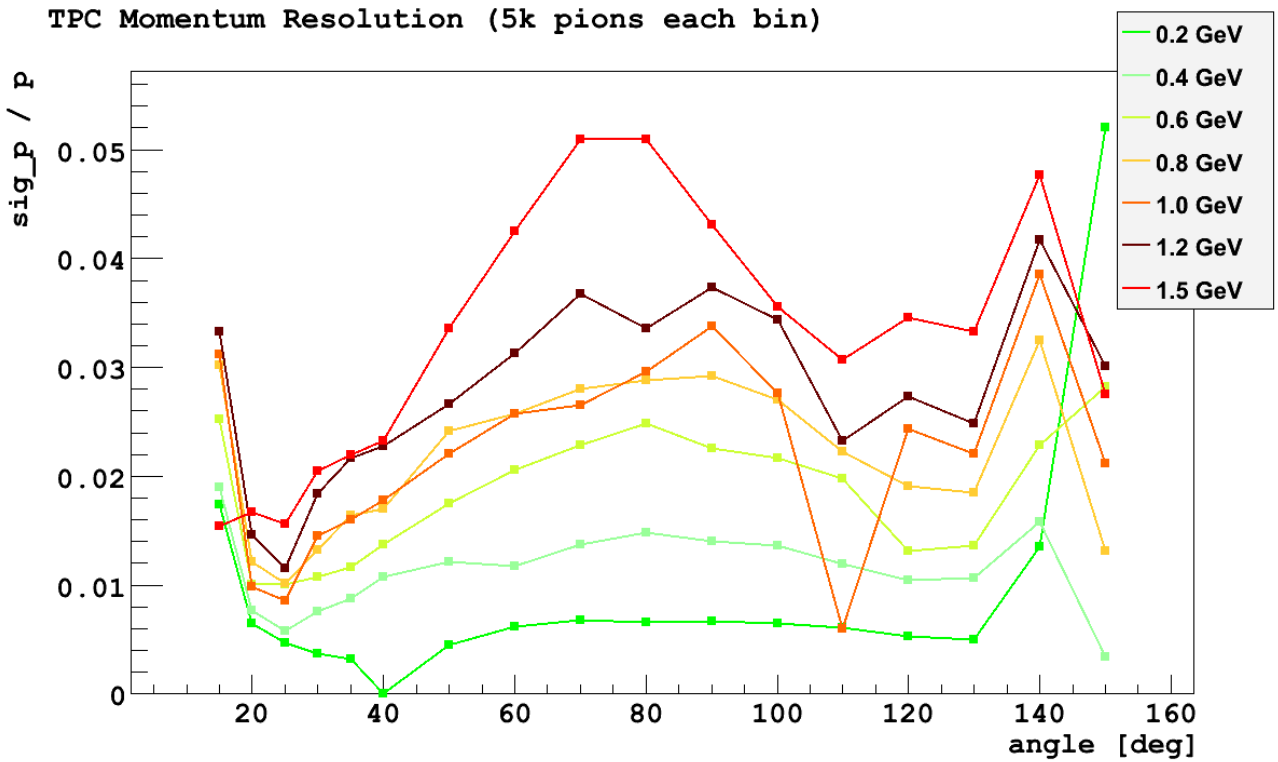




- Speculation:
  - Track initialized with MC truth
  - Idea: Covariance matrix for one Kalman steps gets too small
    $\longrightarrow$ rest of the hits wil not be taken into account
  - Connection to geometry (110 deg) unclear
- Under investigation

Problem 2: Behaviour at high momenta

- Another issue: higher momenta
- Fluctuations around the true momentum resolution grow bigger



- Reason: Statistics
  $\longrightarrow$ need more tracks for smoother distributions and better fits

Conclusion & Outlook momentum resolution

- Presented momentum resolution for full simulation based on TPC hits only from ALICE MC data
- Resolution better than 3% for 1 GeV momentum
- Cutting the chamber to 120cm length removes 5-10 deg of effective angle with good resolution

- There are still problems with the reconstruction:
  - Strange behaviour for certain (momentum,angle) combinations
  - Occasional crashes, e.g. GEANE producing floating point exceptions
- High momenta require more statistics

Outlook

Next step: Simulation with long setup & 3 GEM stations and short setup & 4 GEM stations

Why ALICE MC ?

GEANT3 standard:

- Create MC hits only when crossing boundaries between different media or when reaching a certain energy loss threshold
- Soft energy loss from tables + Landau-Vavilov straggling

Problems

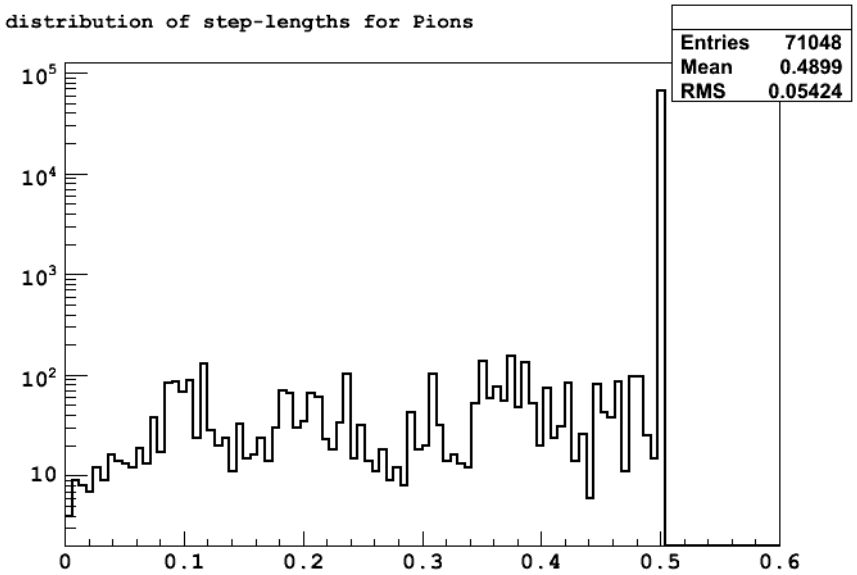
- MC hits have nothing to do with the real physical hits
- Unsatisfactory cluster distribution method for a TPC
- This method also may produce unphysical depletion / accumulation of clusters around the MC hits
- GEANT3 standard produces some features that are not understood, e.g. dE/dx distribution

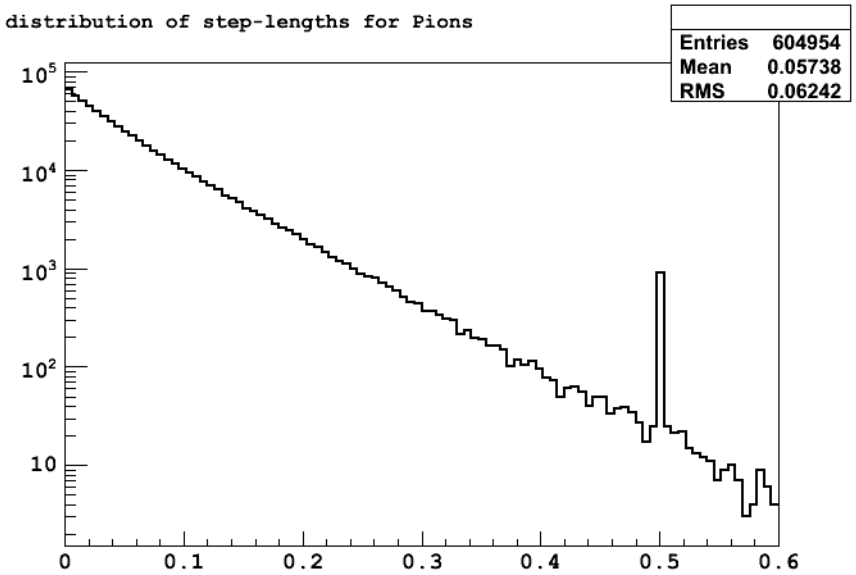
How does ALICE MC work?

GEANT3 ALICE:

- Sample next steplength L from from pdf $f(x) = \frac{1}{\lambda} exp^{(-\frac{x}{\lambda})}$

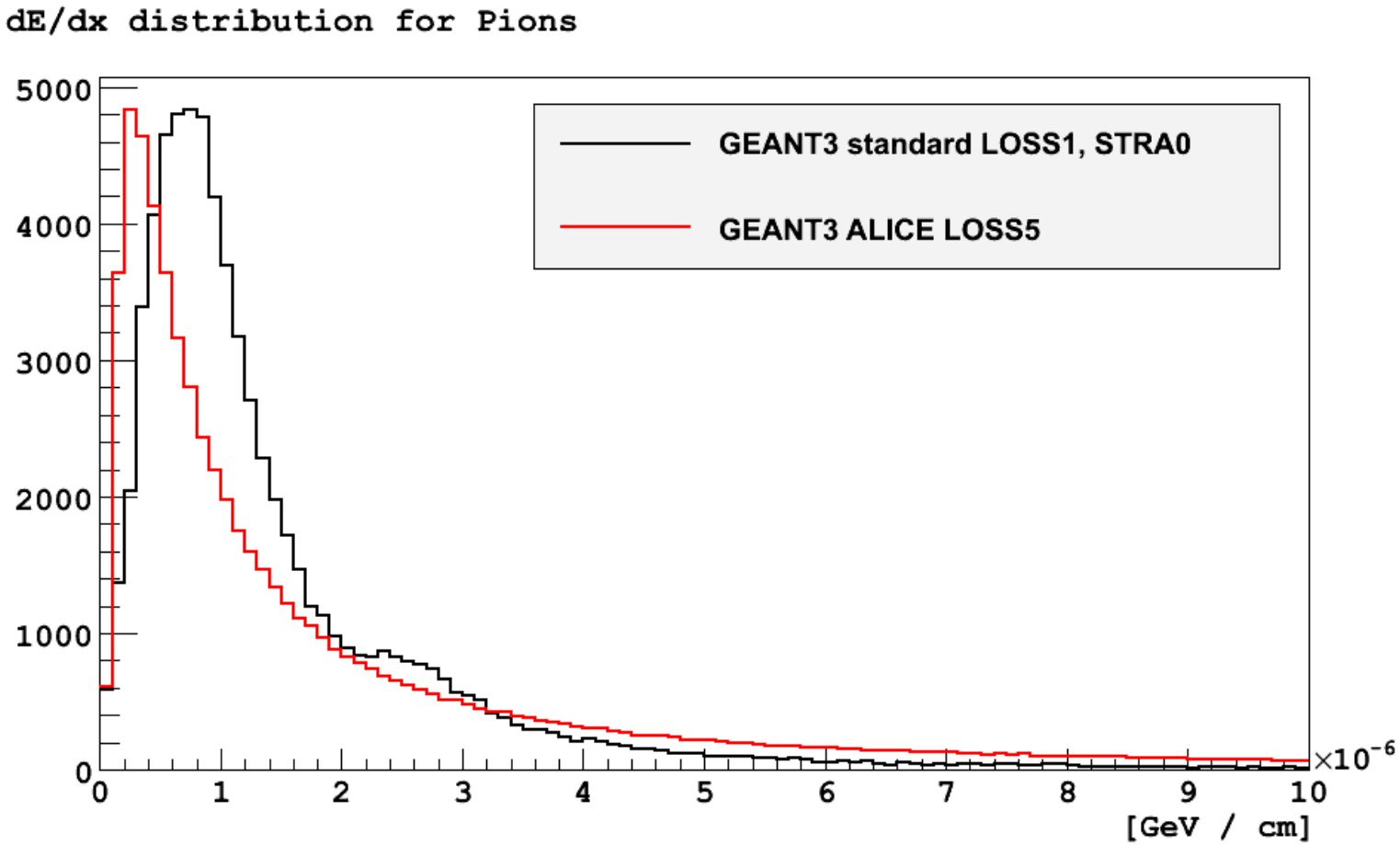
  $L = -\lambda ln(r)$ (λ: mean free path, r: random number $\in$ [0,1])
- Force GEANT to make a step there
- $\lambda(p) \propto (\frac{dE}{dx})^{-1}$ from normalized Bethe-Bloch parameterization
- Energy loss directly obtained from a tuned Rutherford cross section
  `[ B. Lasiuk, NIM A409, 402-406 ]`





Energy loss in G3 and G3 ALICE

- GEANT3 standard shows a strange second bump (for STRA=0) in the energy loss distribution:



Conclusion

- GEANT3 in standard configuration not optimal for a gas detector
  - MC point creation unphysical
  - Energy loss distribution unclear
- ALICE configuration much more transparent:
  - Physical cluster distribution, no clustering ”by hand”
  - Simple and transparent energy loss model (LOSS=5, see gfluct.F in the geant package)
- Performance: Slower, but acceptable

$\longrightarrow$ G3 ALICE will be the default for the TPC simulations

Thank you for your attention!

Backup slide: TPC geometry

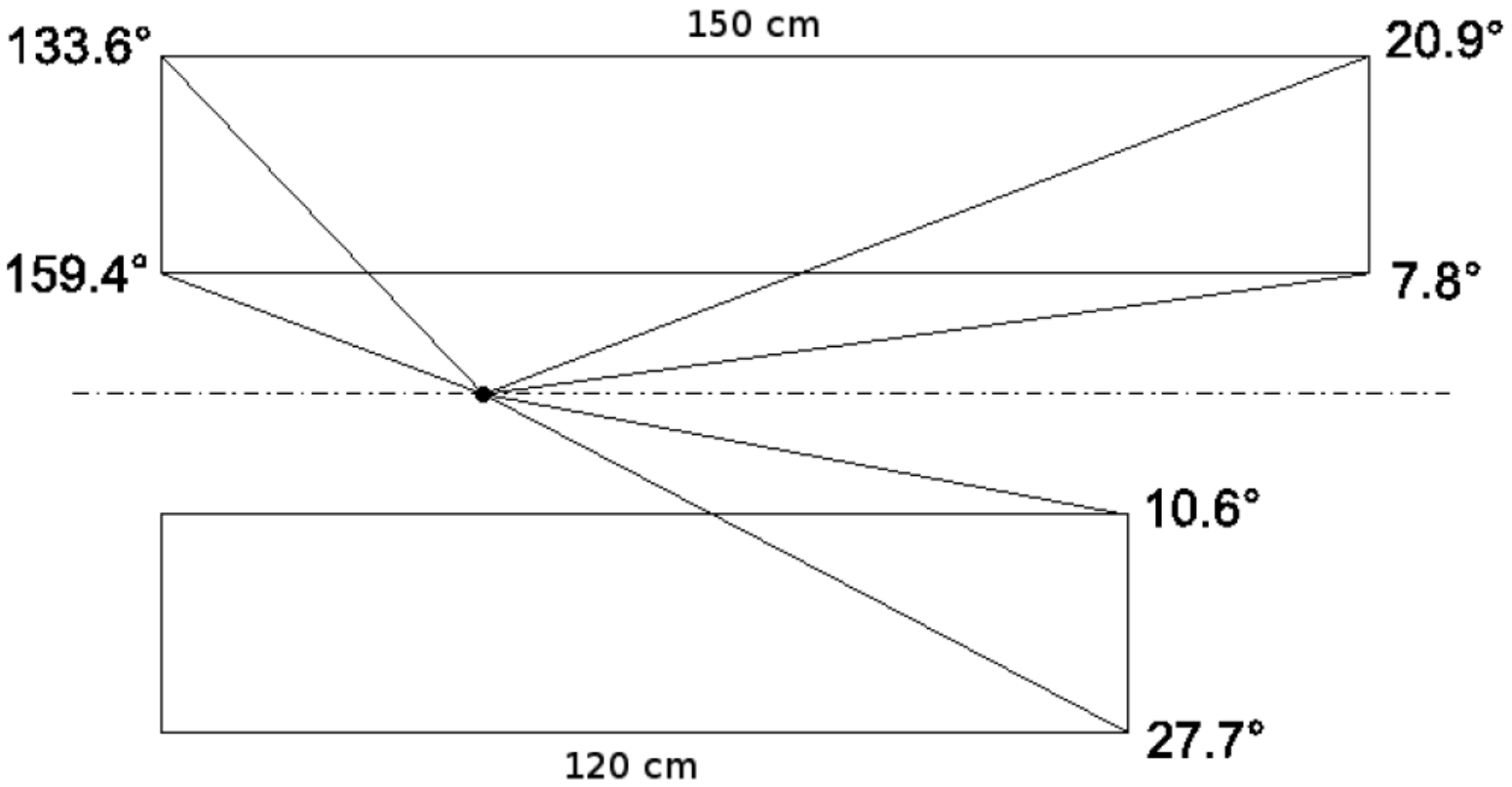
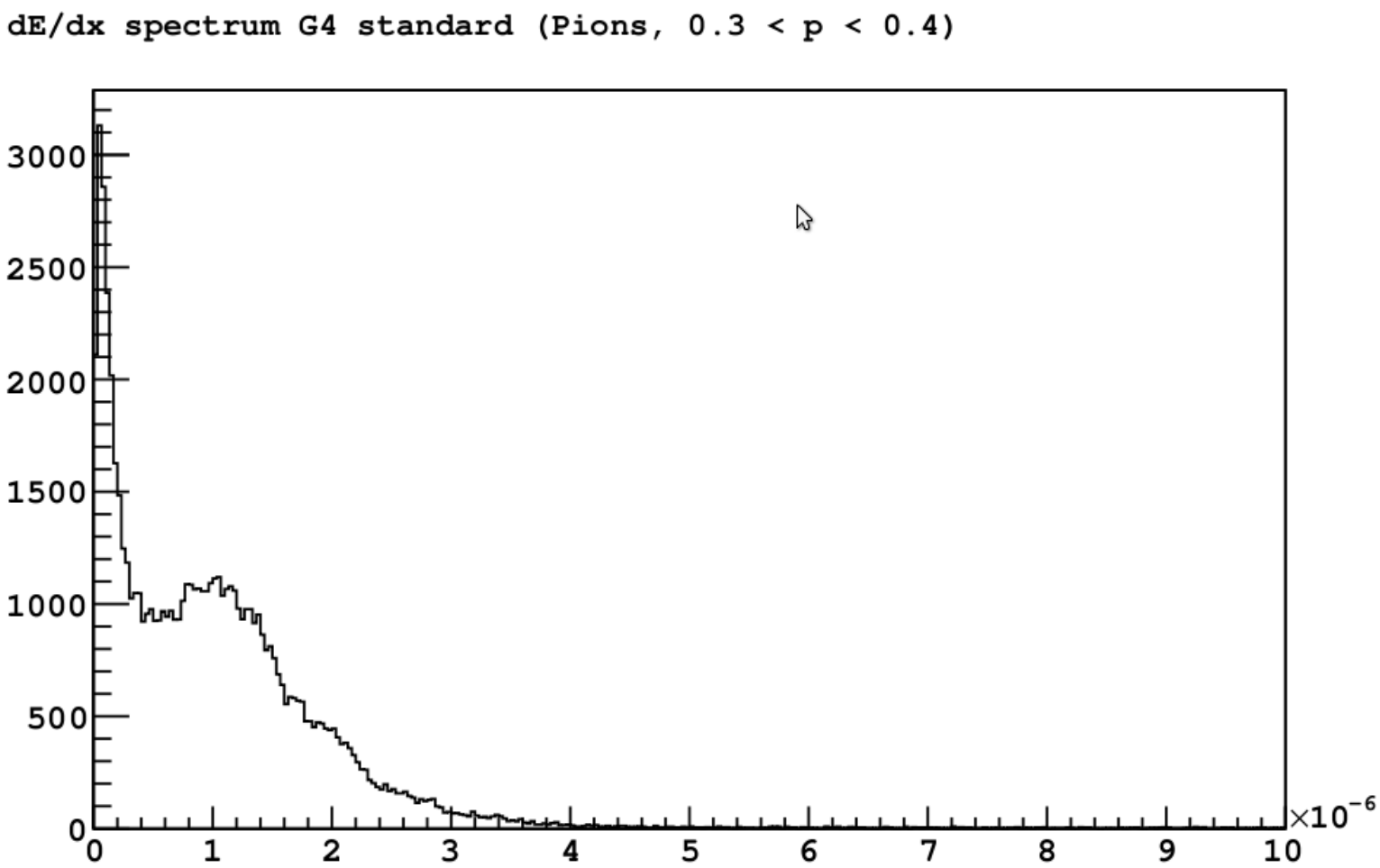
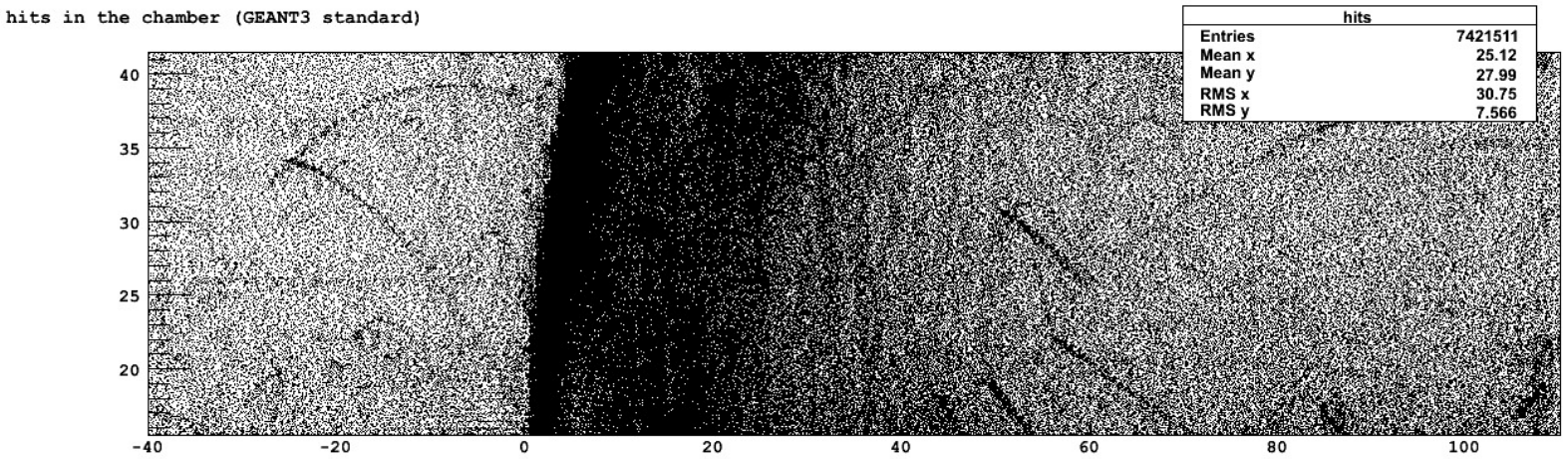


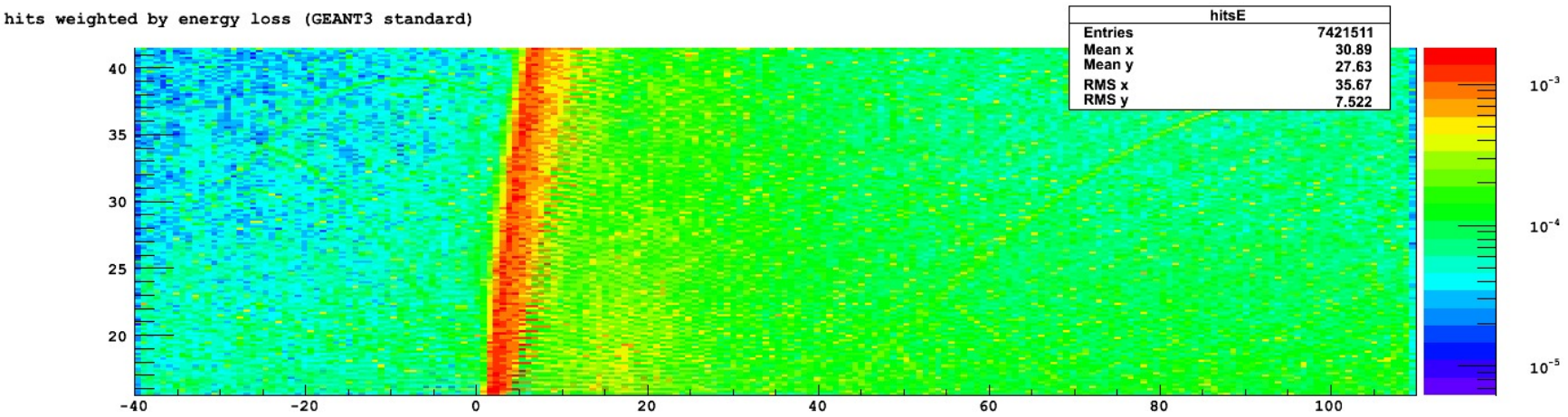
Figure: The two length options and resulting key angles

Backup slide: GEANT4 energy loss

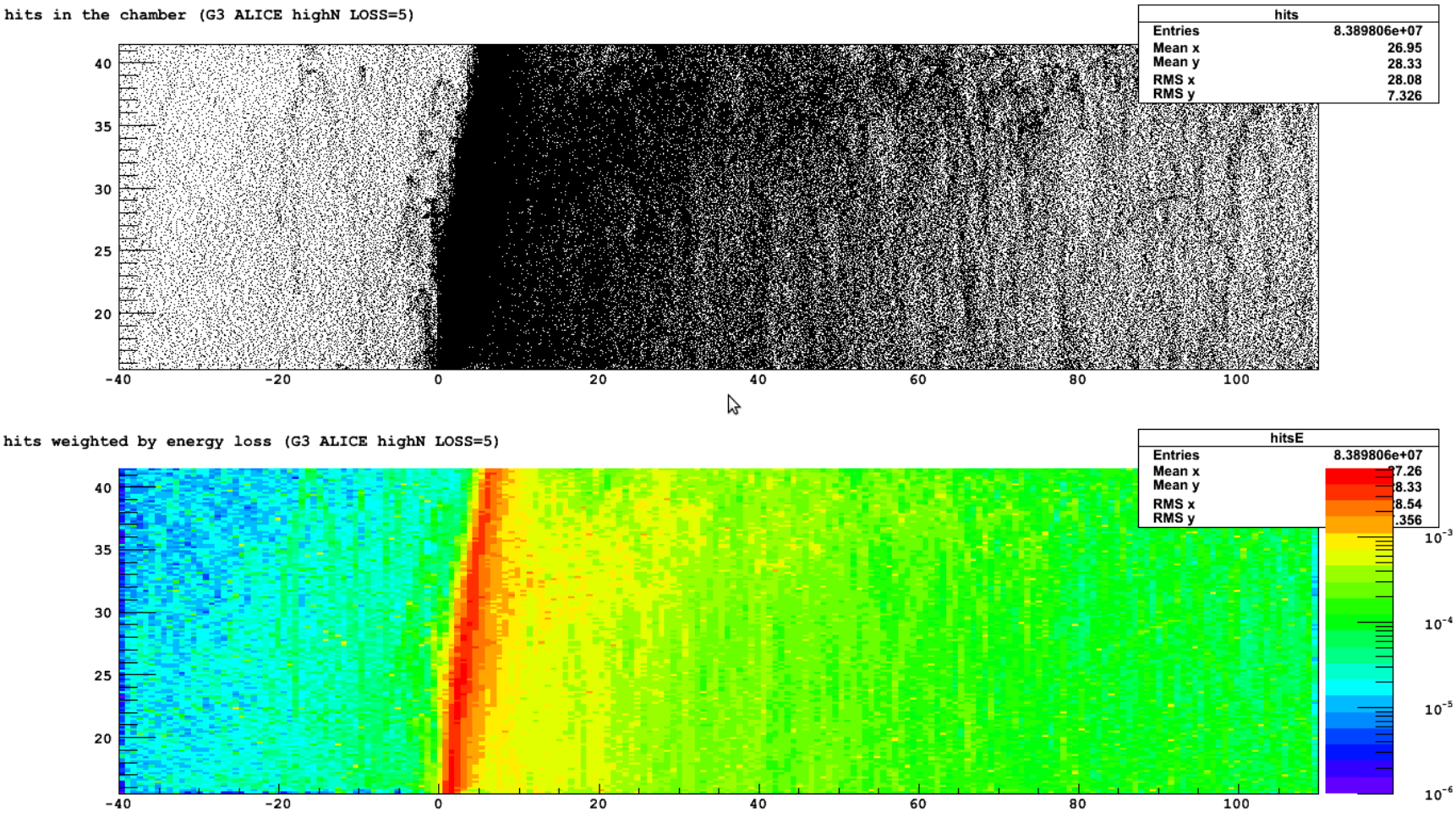


Backup slide: GEANT3 standard TPC hits

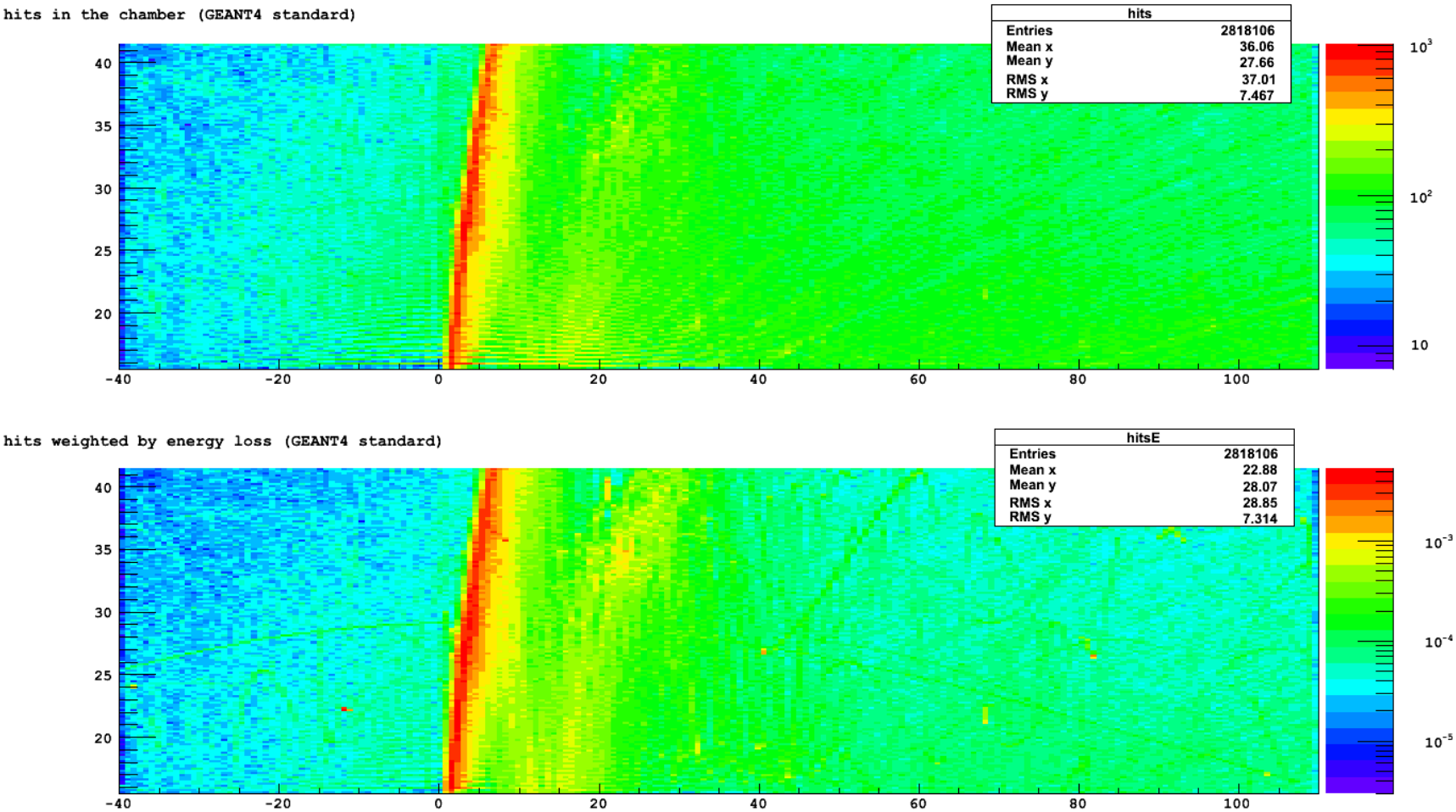




Backup slide: GEANT3 ALICE TPC hits



Backup slide: GEANT4 standard TPC hits



Backup slide: G3 ALICE configuration

- Set max. number of G3 steps to very high value:
  `geant3->SetMaxNStep(1000000);`
- Set energy LOSS energy model to ”unofficial” value 5 (see gfluct.F):
  `gMC->SetProcess("LOSS",5);`
- Calculate steplengths etc. in the FairDetector class
- Adapt clusterization

- Delta electrons: Just as you like, set
  - DCUTE
  - DCUTM
  - CUTELE