Track Segments in Hadronic Showers

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Detailed MC Comparisons

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Calorimeter for ILC

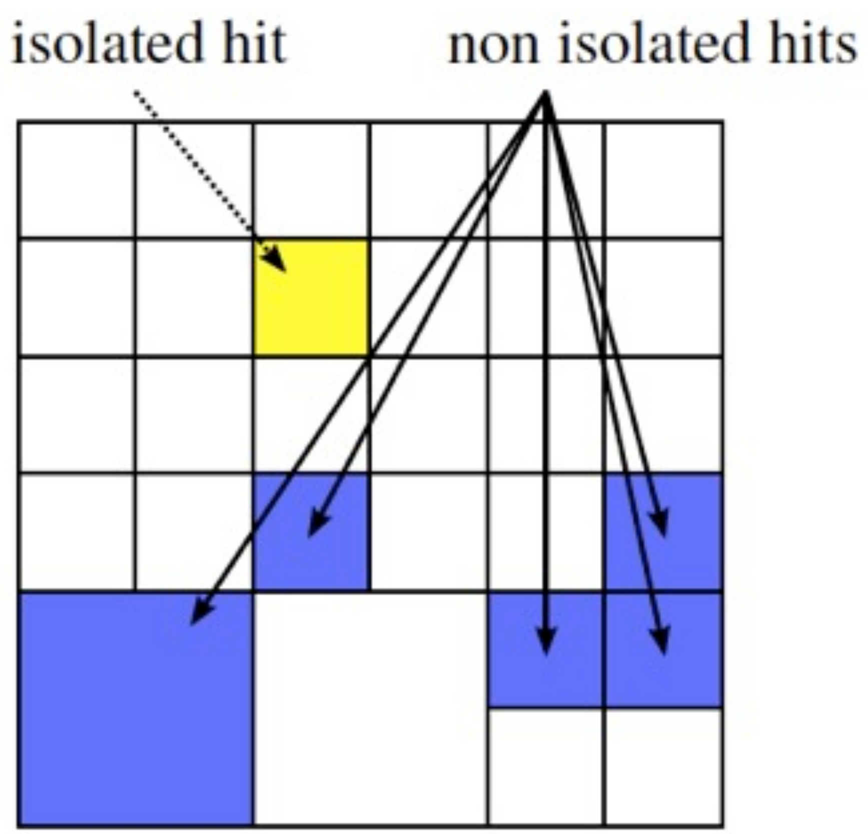
TUM
LMU
Excellence Cluster
Universe

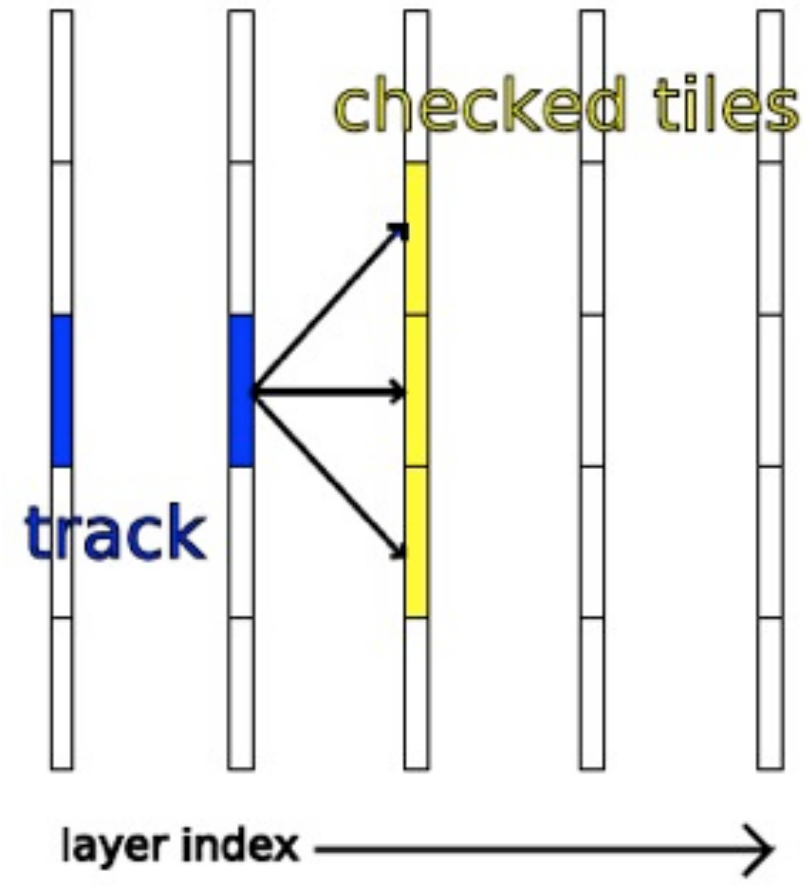
Overview

- The Tracking Algorithm
- Properties of Hits on Tracks
- Comparisons to Simulation
- Summary

Reminder: The Tracking Algorithm

- The goal: identify cells that were crossed by exactly one particle
- The strategy: A "follow-your-nose" tracker considering all isolated hits

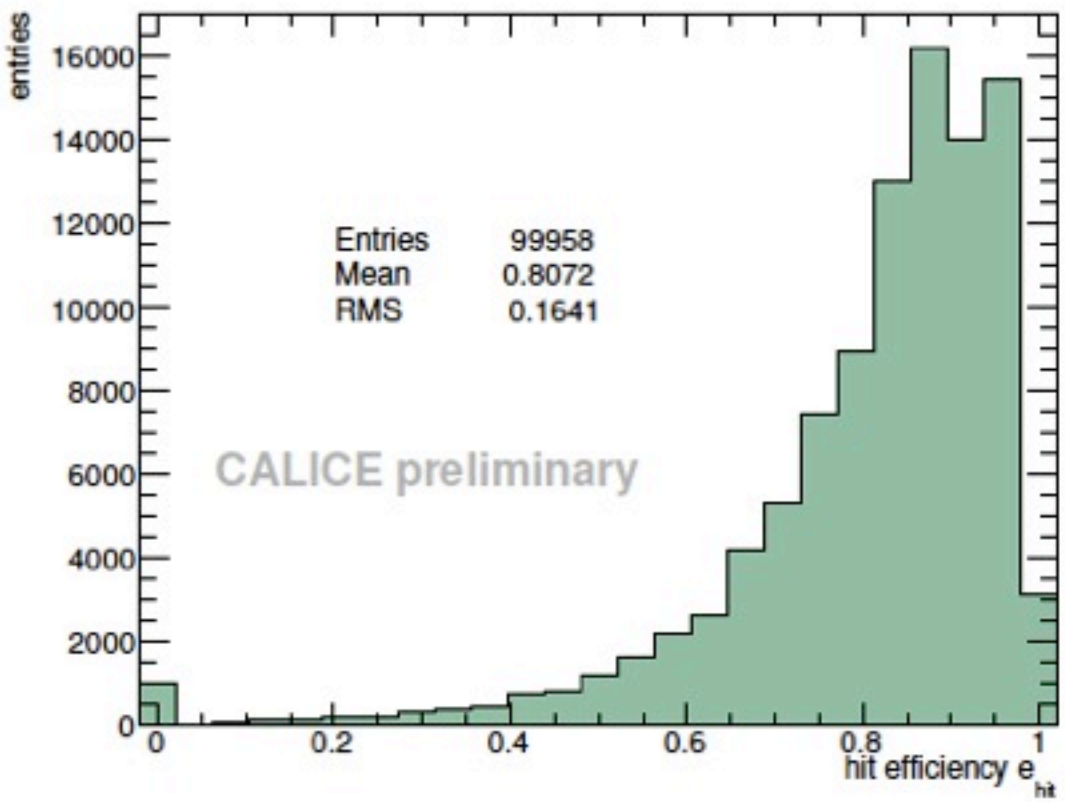




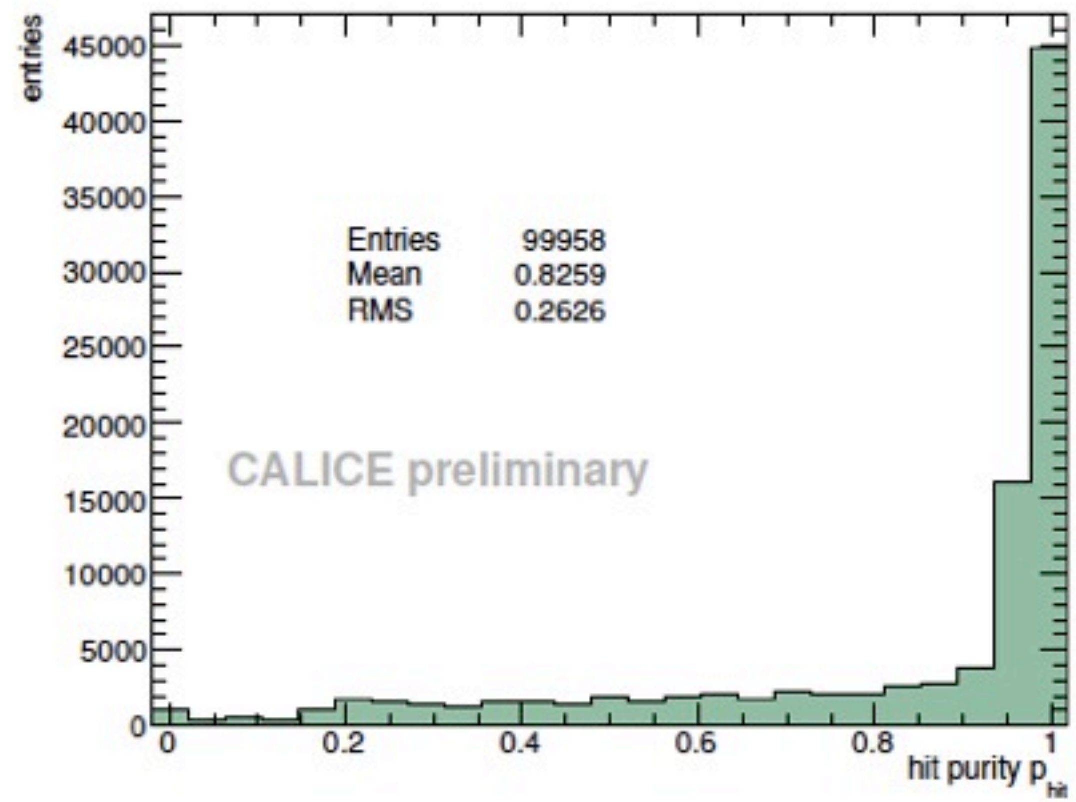
- Track from calorimeter front to back (no magnetic field: straight tracks!)
    - start with a track seed, then attempt to extend it
    - allow inclined tracks, gaps, ...

Algorithm Performance

- Evaluated with simulated muon tracks



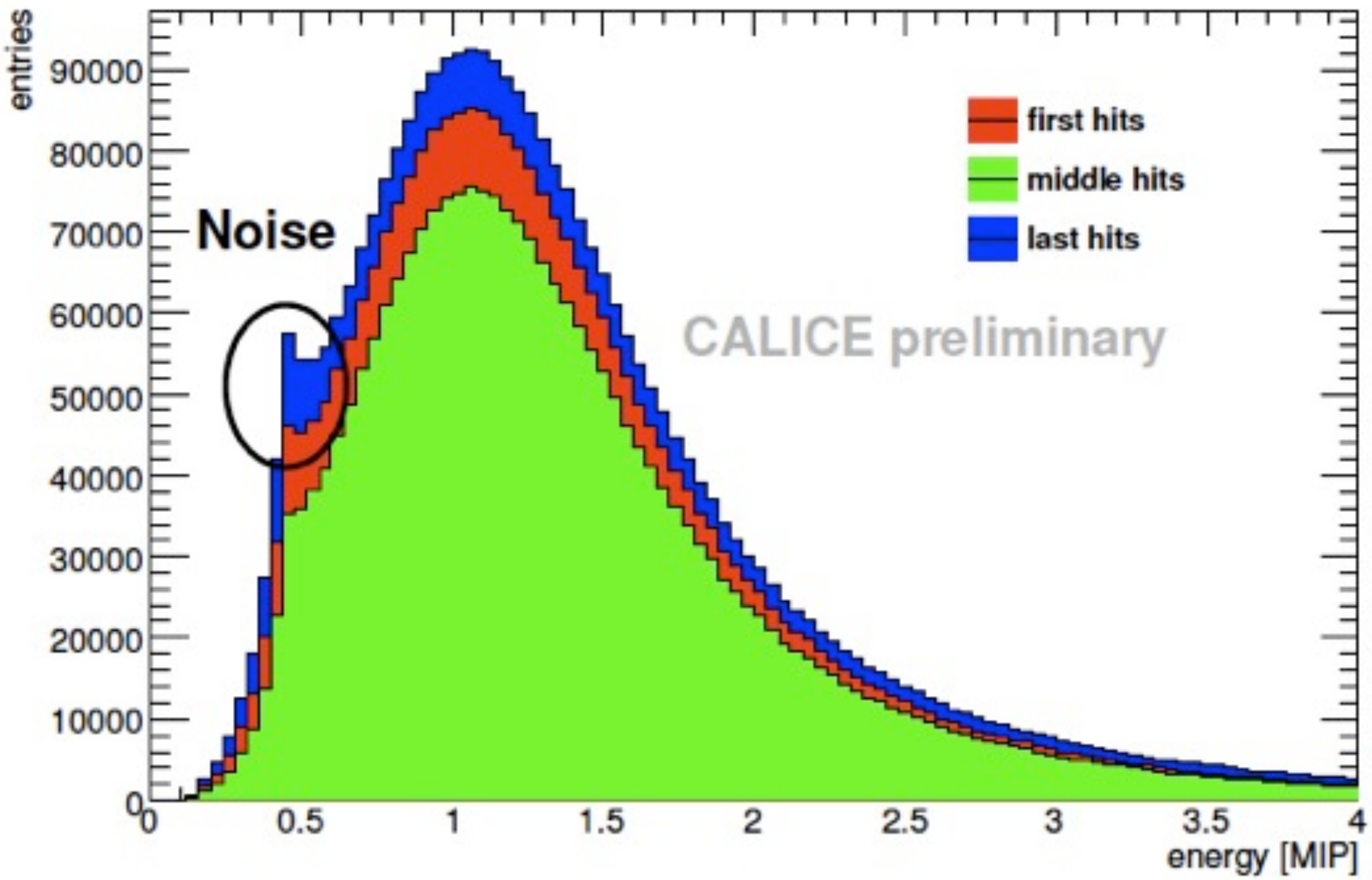
(a) hit efficiency



(b) hit purity

- hit efficiency: number of identified hits / number of total hits on track
- hit purity: number of identified hits / (number of identified hits + fake hits)
- Total track finding efficiency: 98.9% without purity requirement (~85% for purity > 0.5)

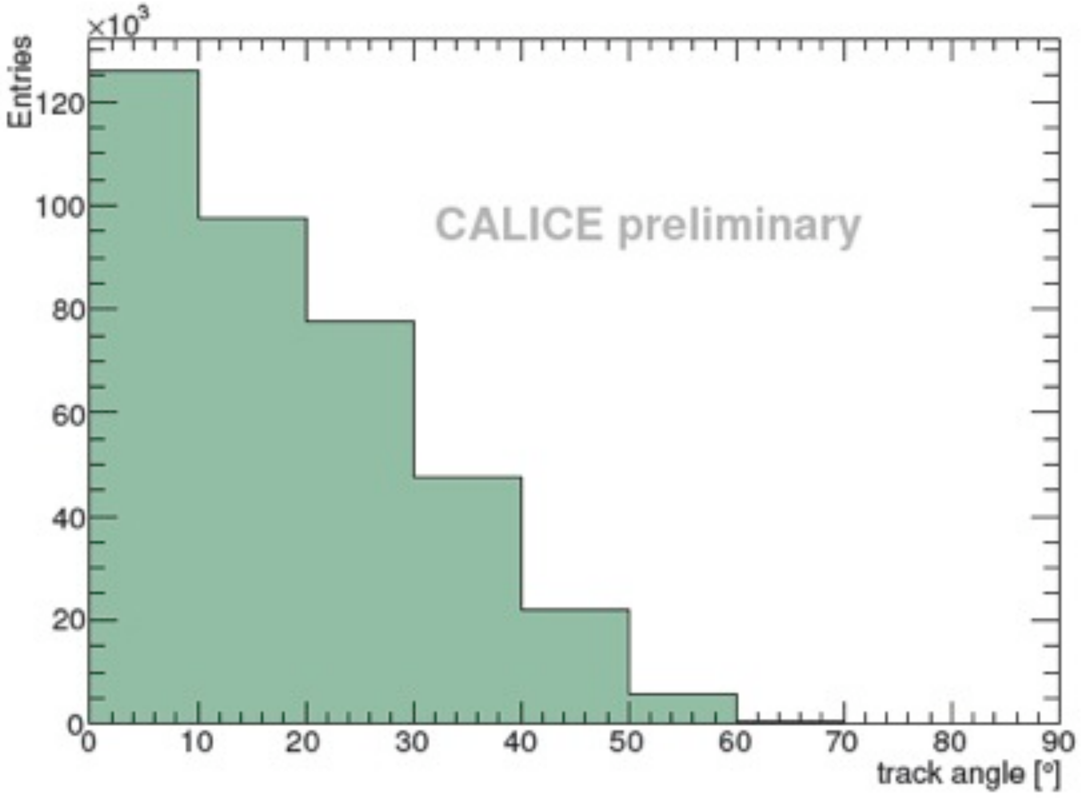
Single Hit Energy



- Energy spectrum for single hits on identified tracks: Expected shape for MIPs
  - The basis for the use of hadronic track segments as calibration tools
- Noise contributions on first and last hit on a track

Track Angle & Corrections

- The algorithm can find inclined tracks (up to ~60° for 3 x 3 cells, up to ~ 70° for 6 x 6
- The single hit energy deposit depends on this angle: Path length in the scintillator $\propto \frac{1}{cos\theta}$



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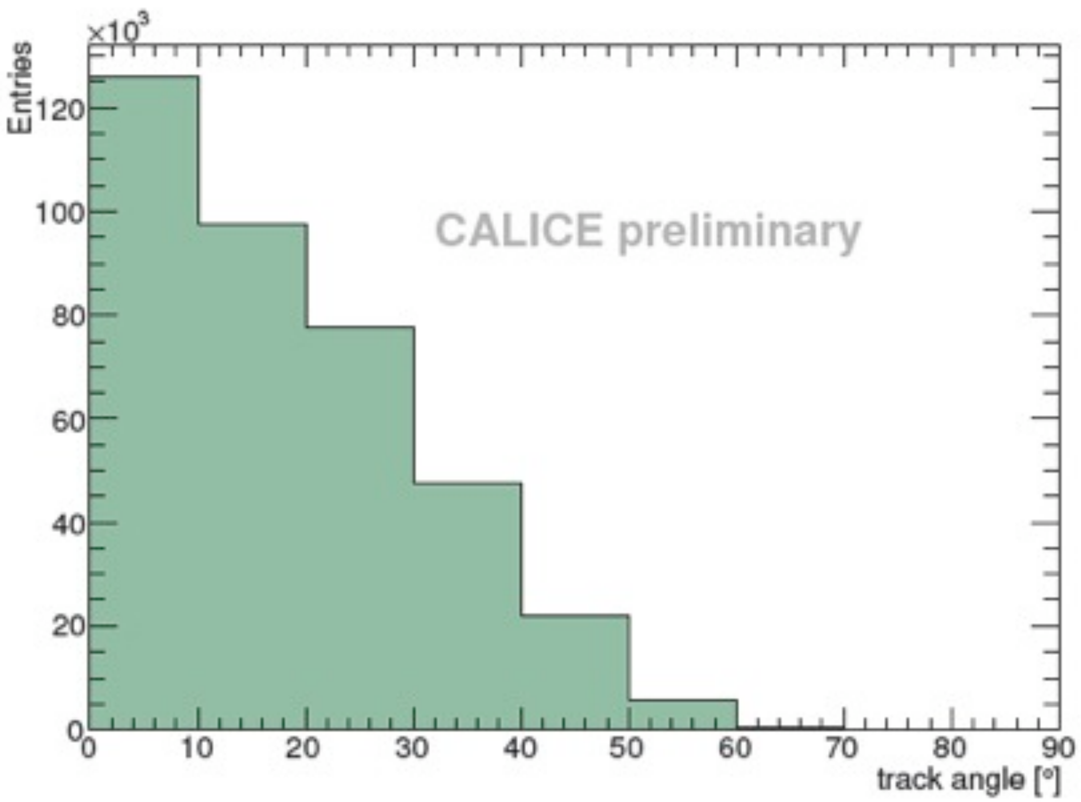
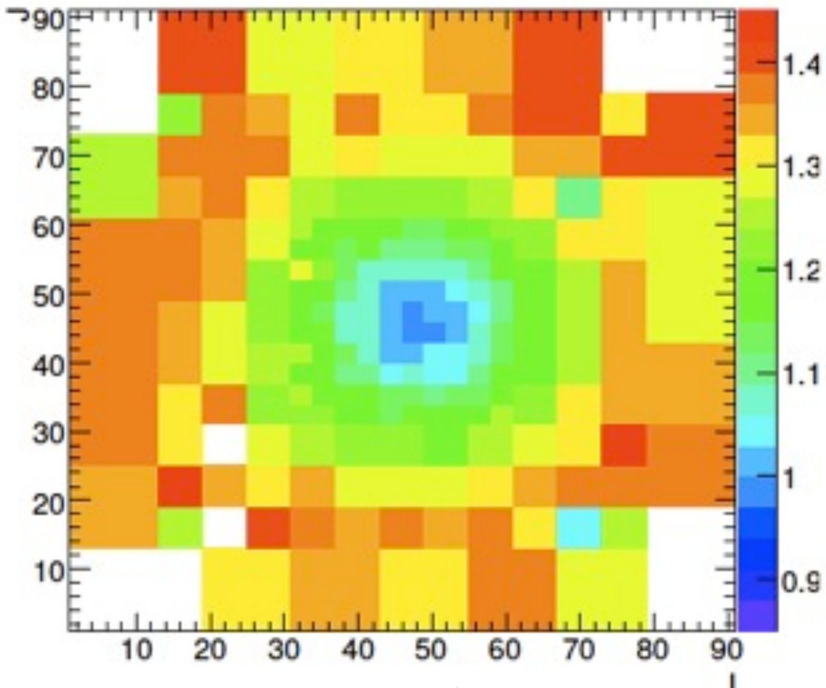
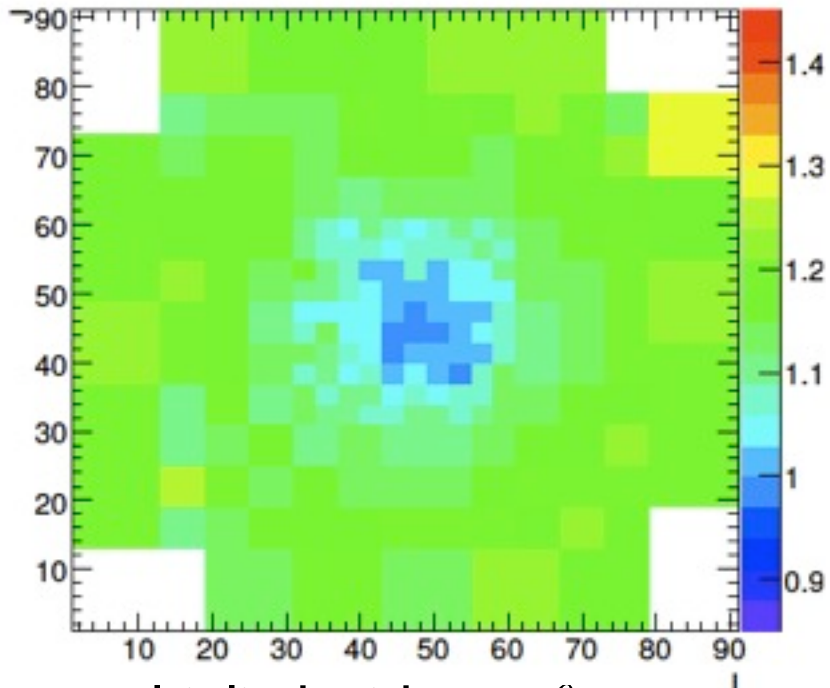


- Simple study: Look at "towers" in i, j: off-center hits are from inclined tracks



no correction



multiplied with $cos\theta$

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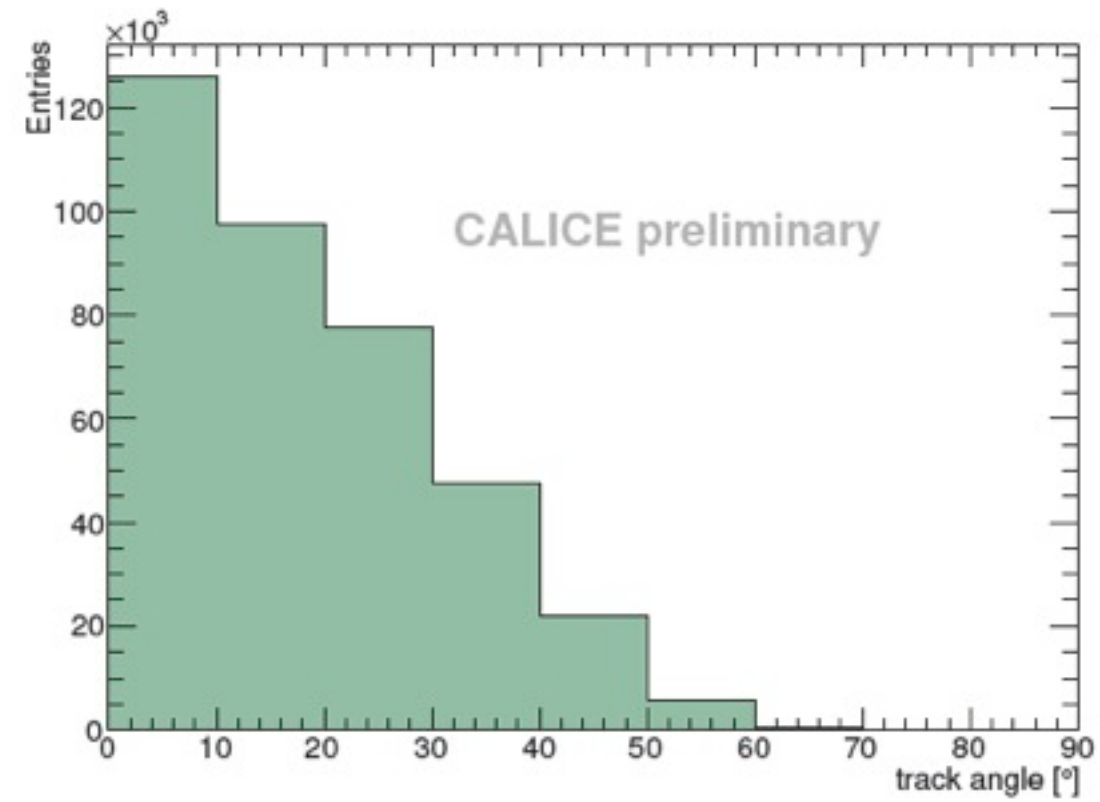

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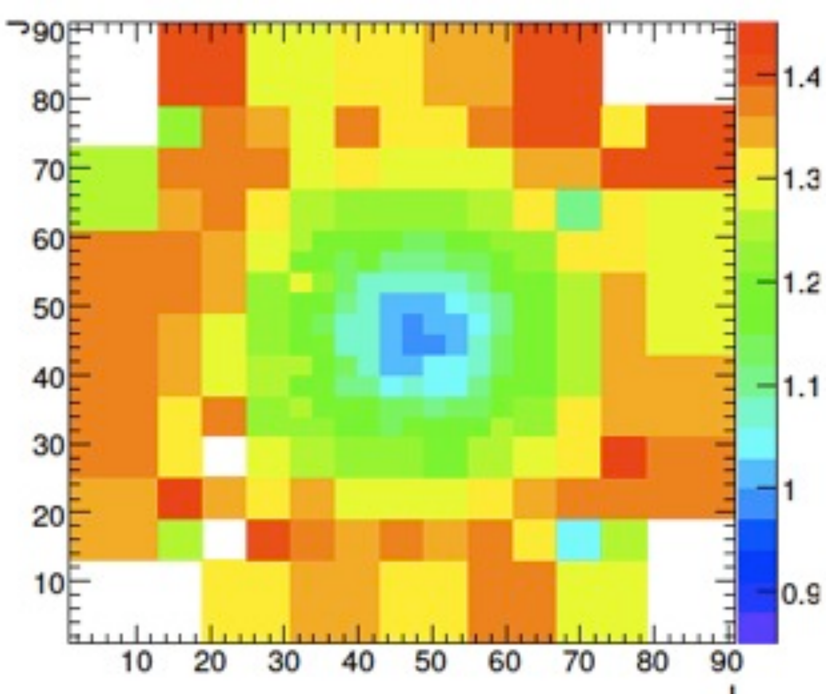
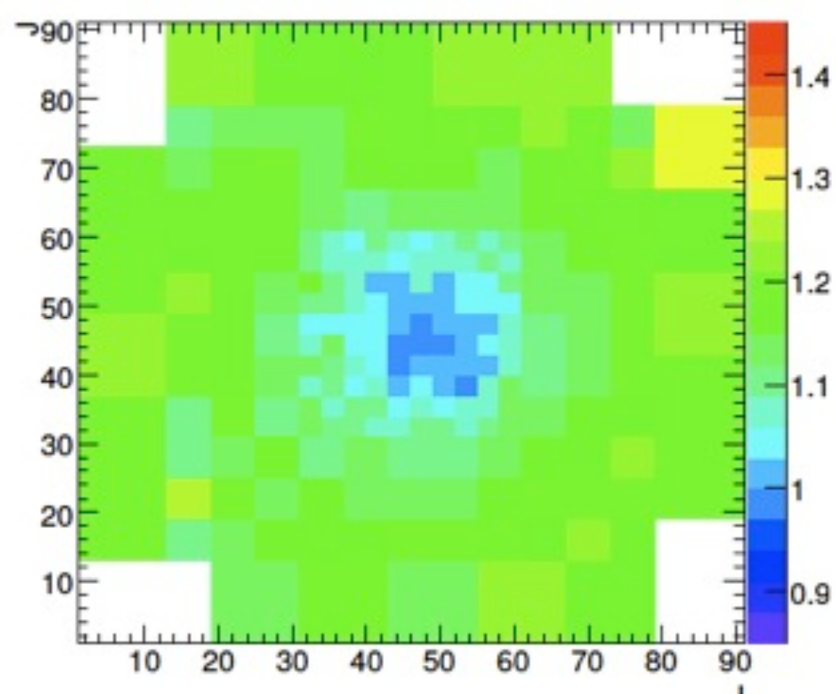


no correction

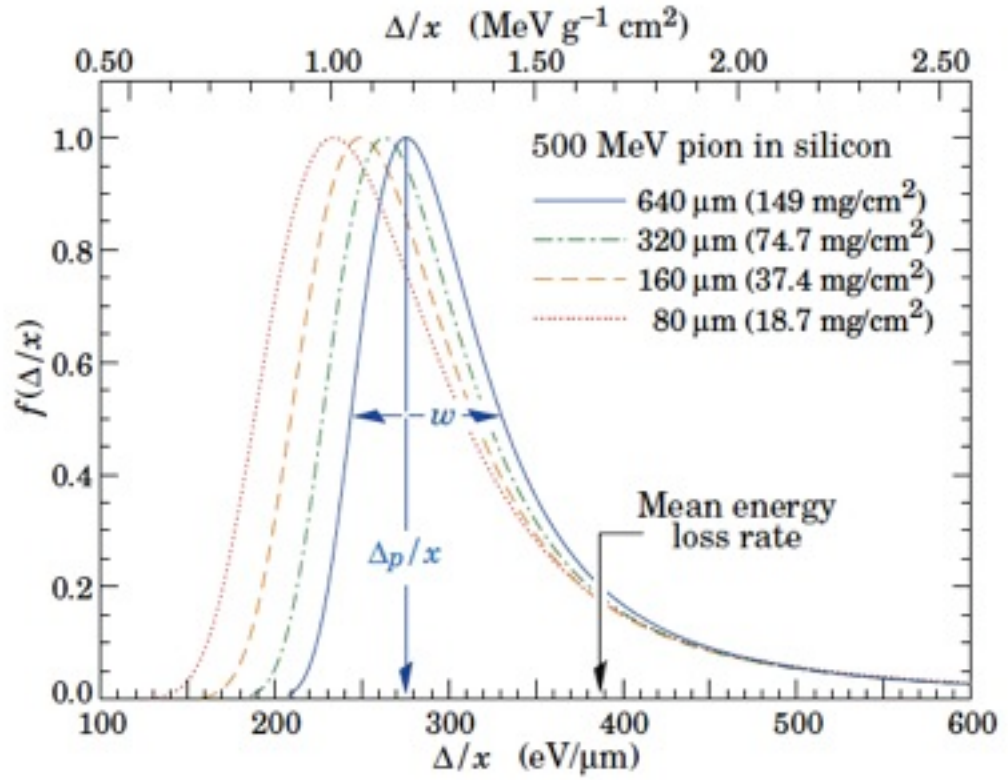


multiplied with $cos\theta$

clearly, the simple correction is not enough!

Track Angle & Corrections

- Simple scaling with path length in scintillator not sufficient to correct for track angle
  - No surprise, just look in PDG!



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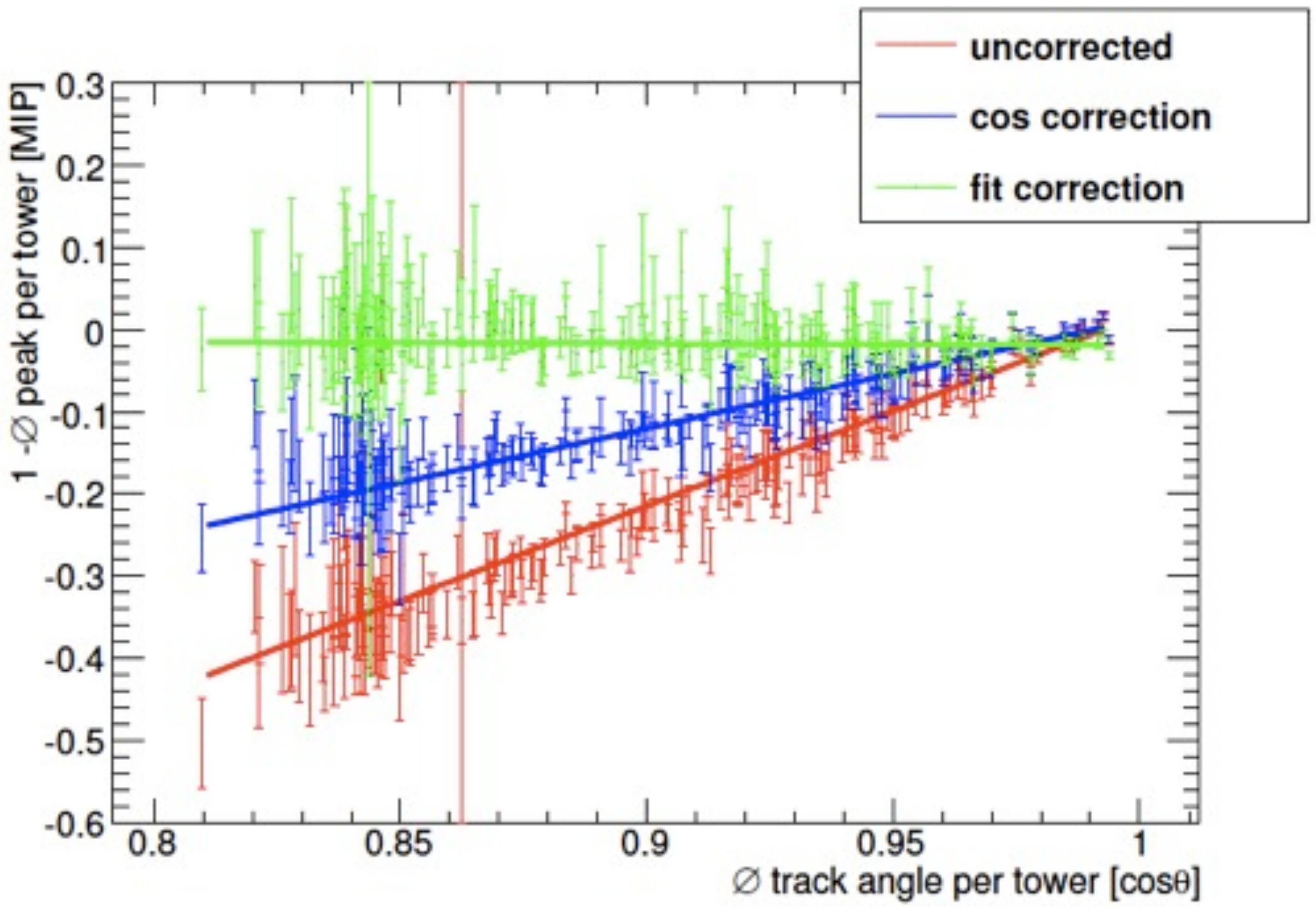
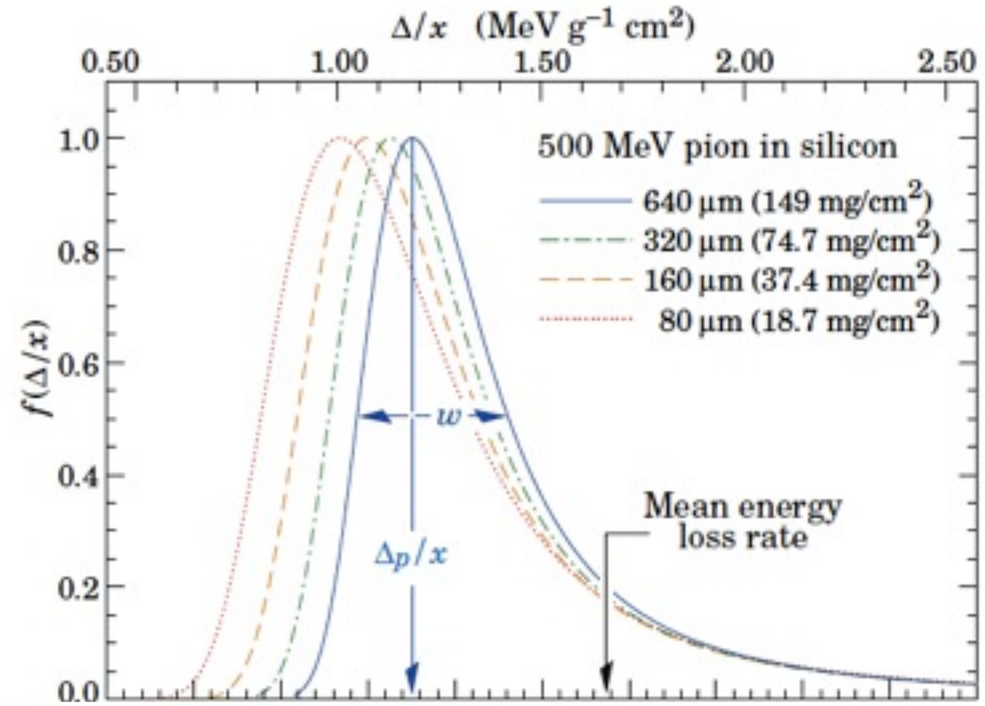
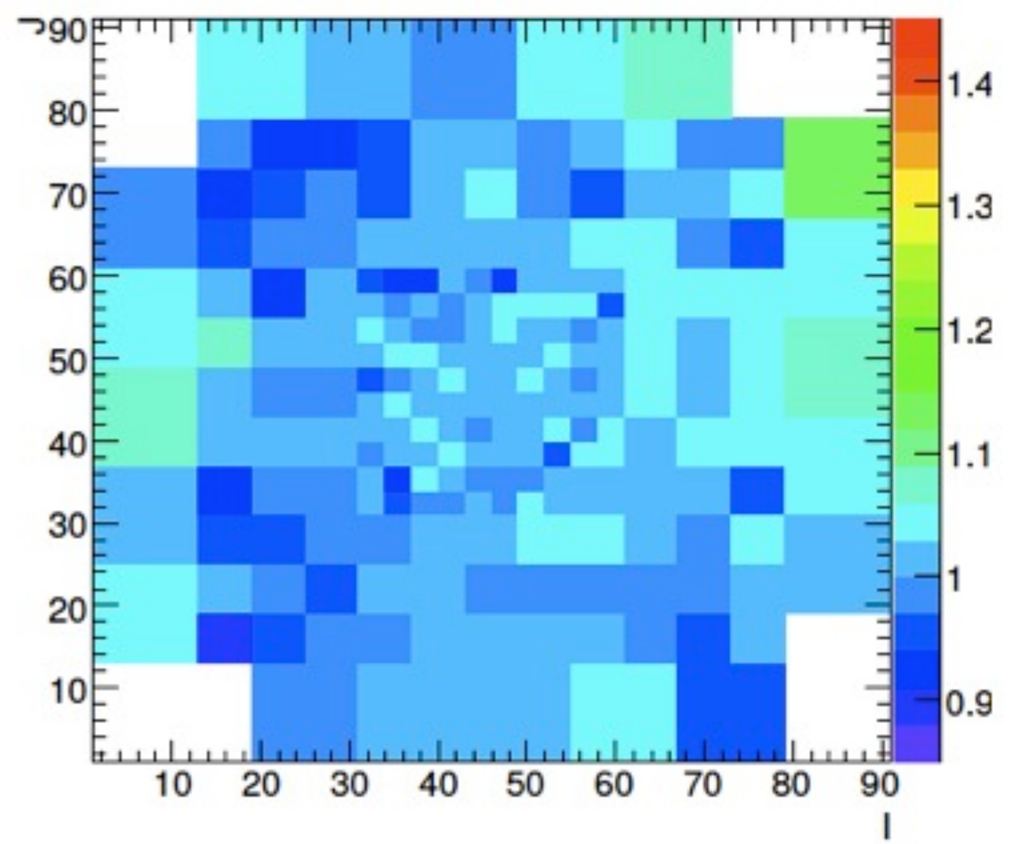


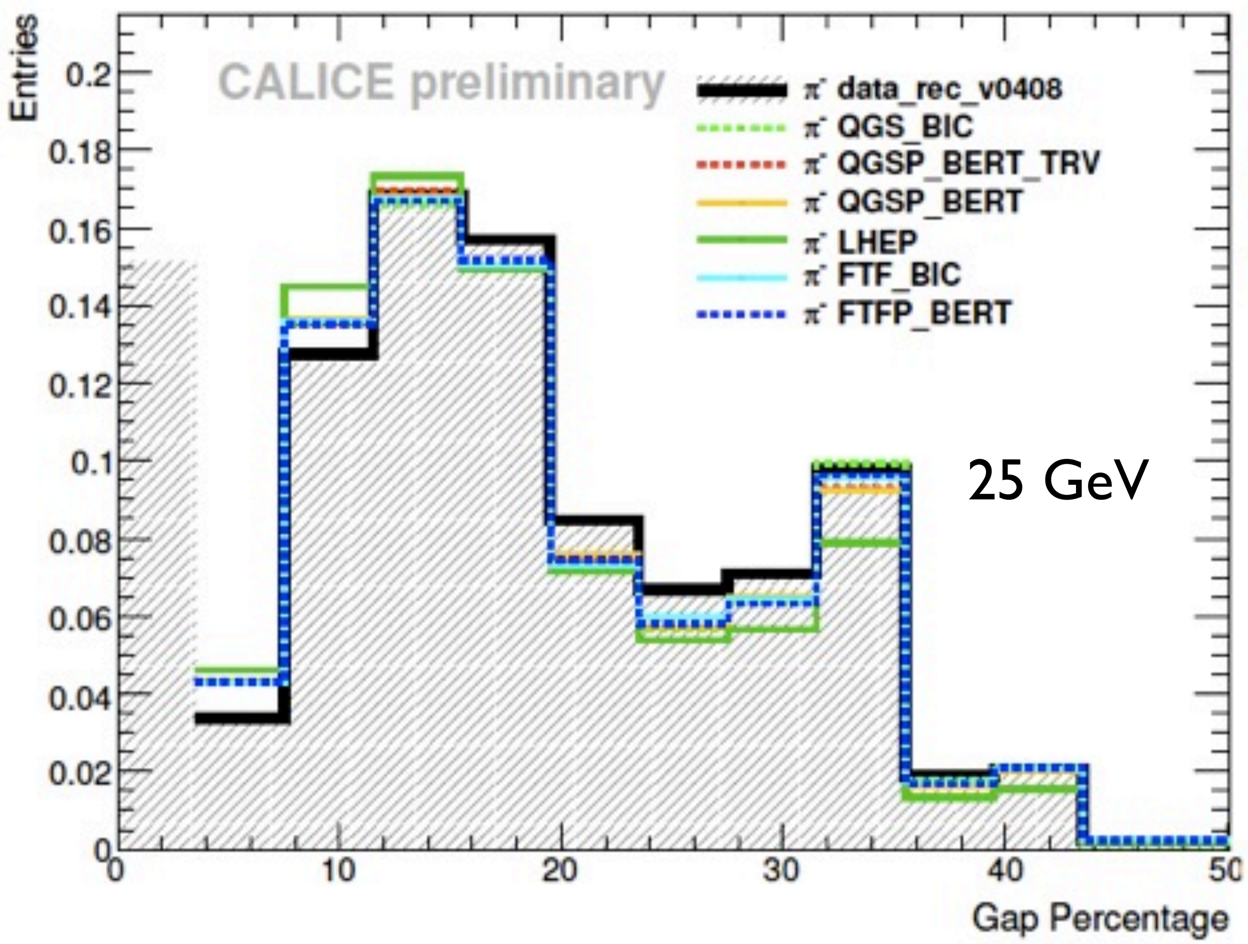


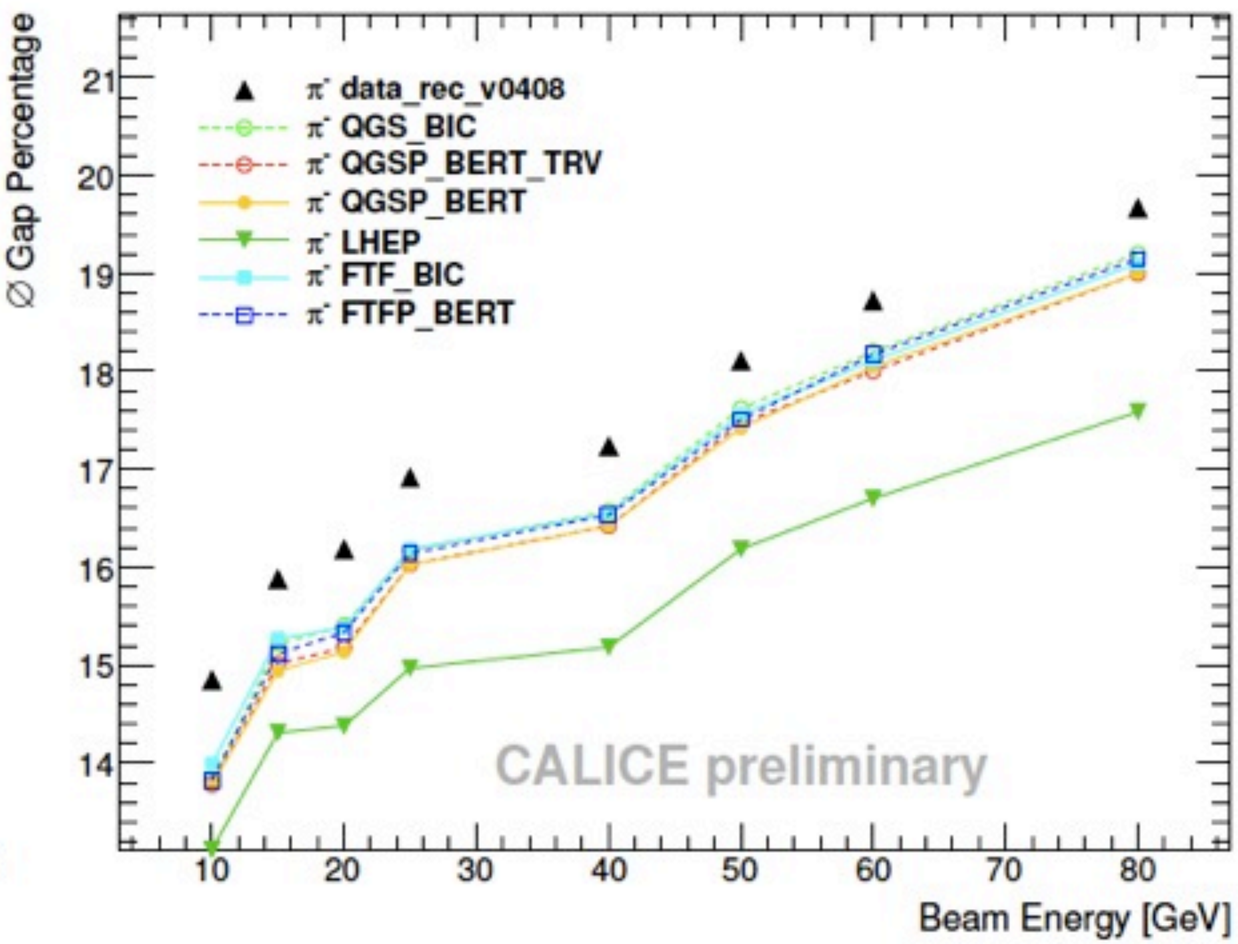


tower histogram after all corrections

Data-MC: Gaps

- Mostly influenced by simulation of noise, cross-talk, but also affected by track distribution and shower shape

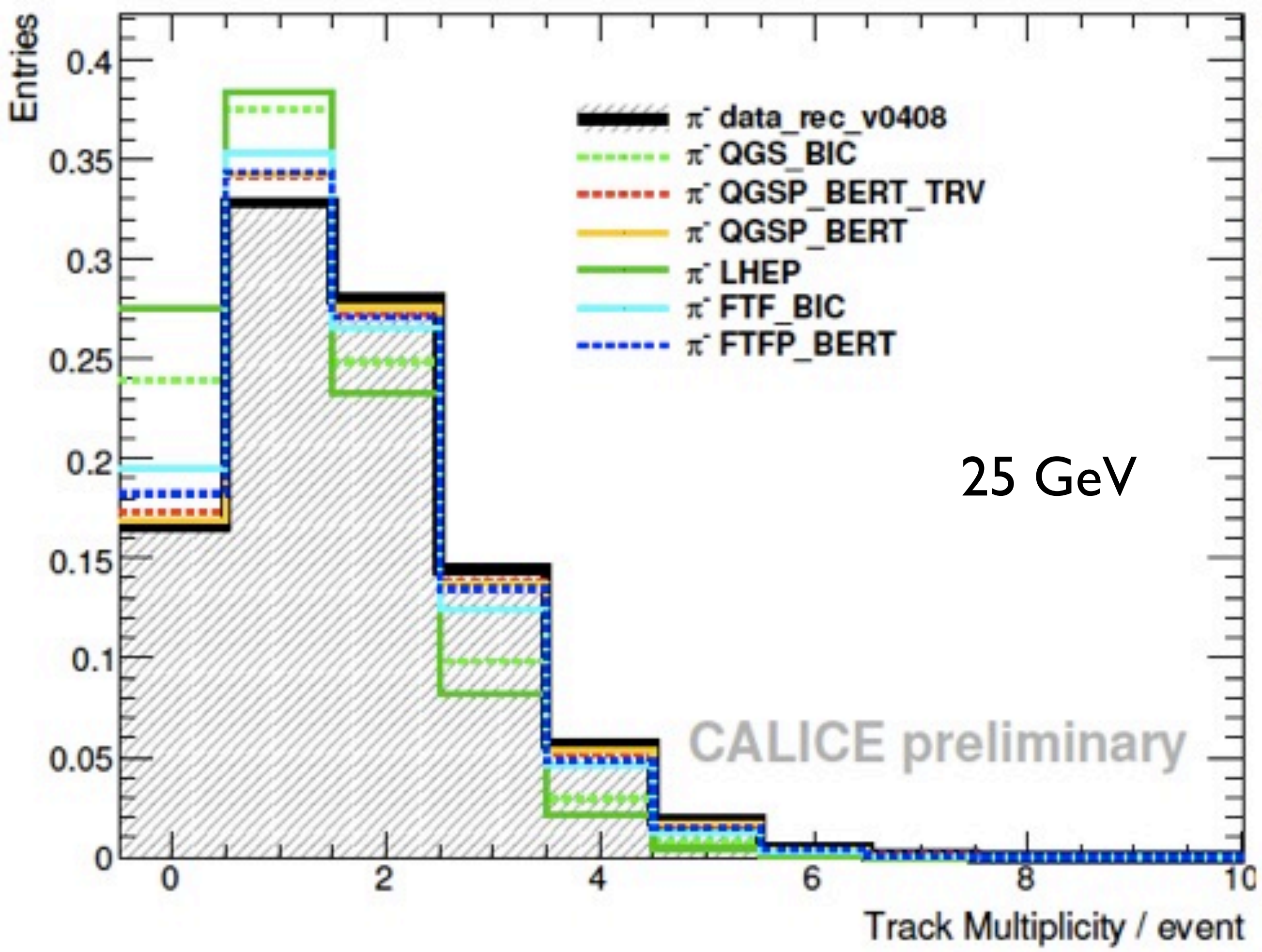


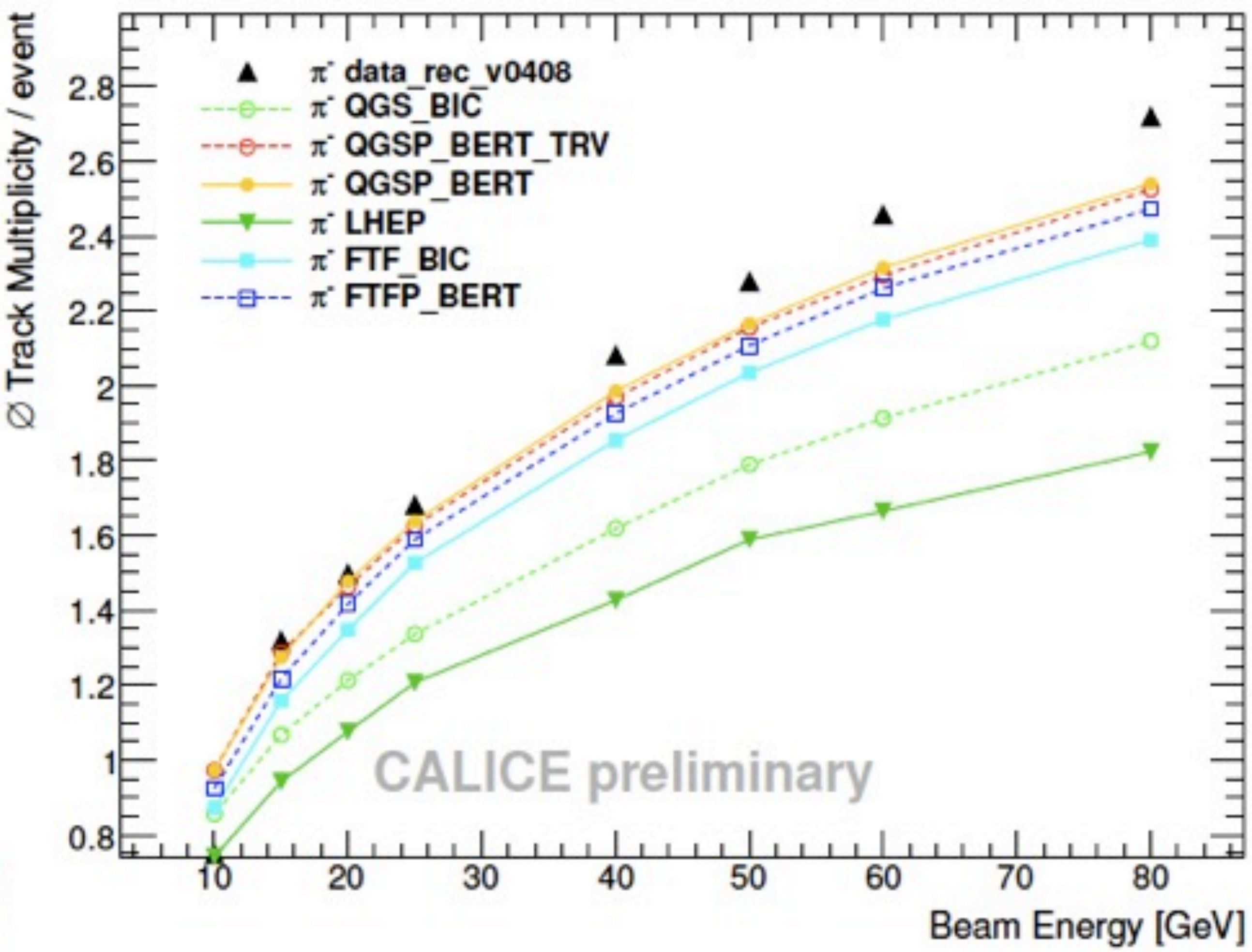


- In general: Too few gaps in all simulations (typically on the 5%-7% level): Not enough noise, cross talk?
- LHEP sticks out: Issues with the track distribution

Data-MC: Multiplicity

- Mostly influenced by shower topology, quality of simulation contributes through the reproduction of finding and splitting of tracks due to noise etc.

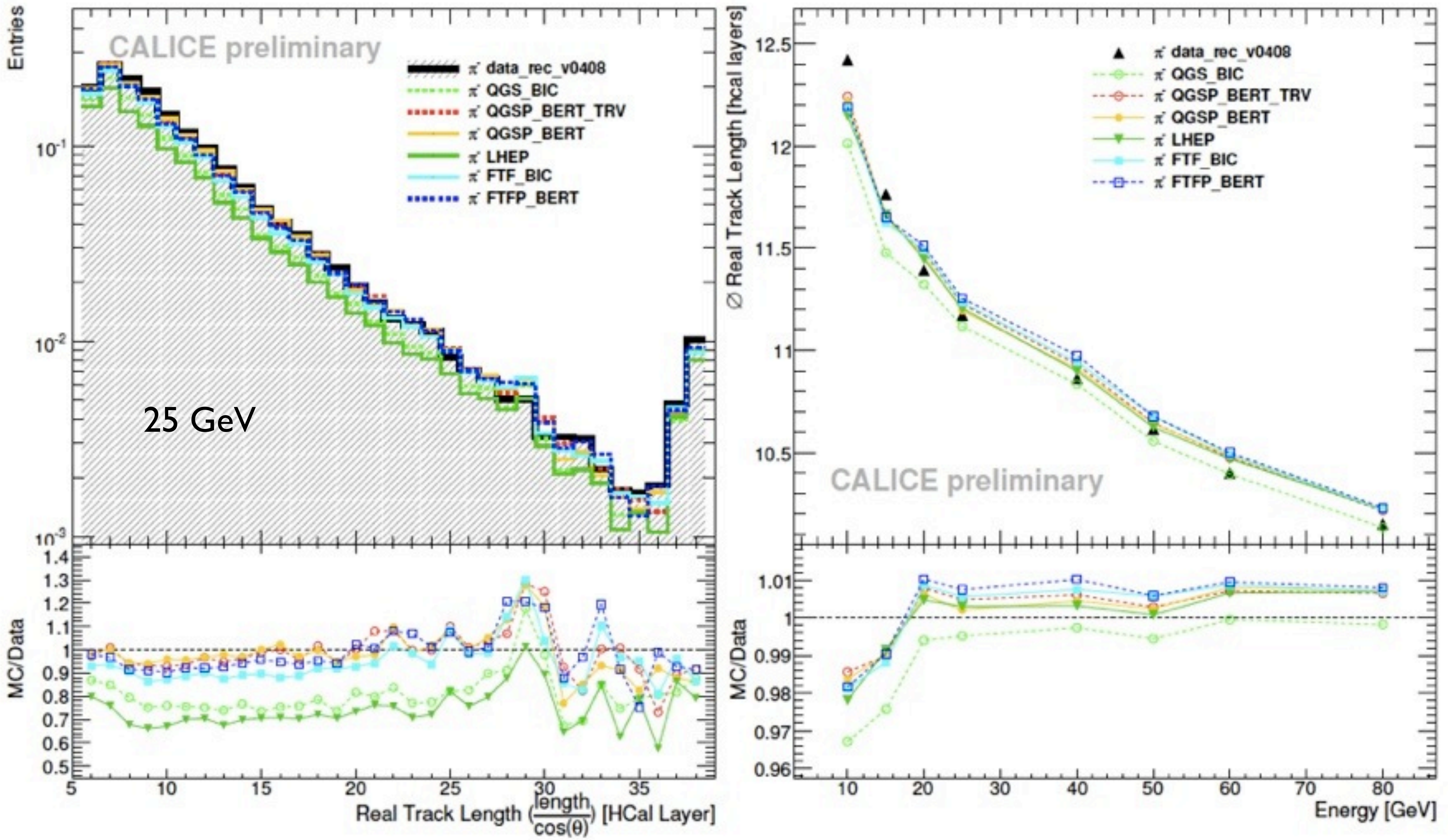




- All models reproduce the trend with energy
- LHEP and QGS_BIC have too few tracks essentially over the full energy range

Data-MC: Track Length

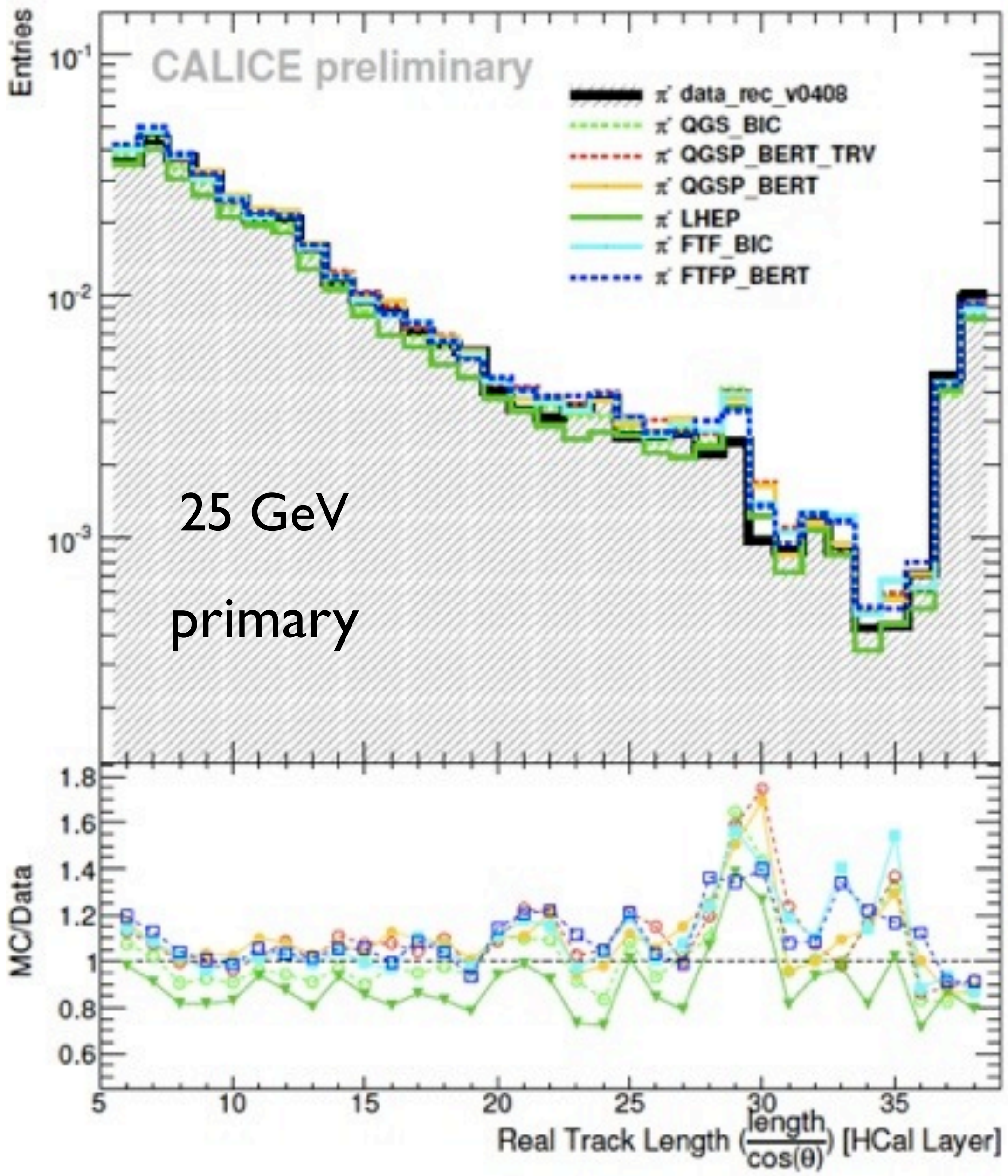
- Sensitive mostly to high-energy cross sections

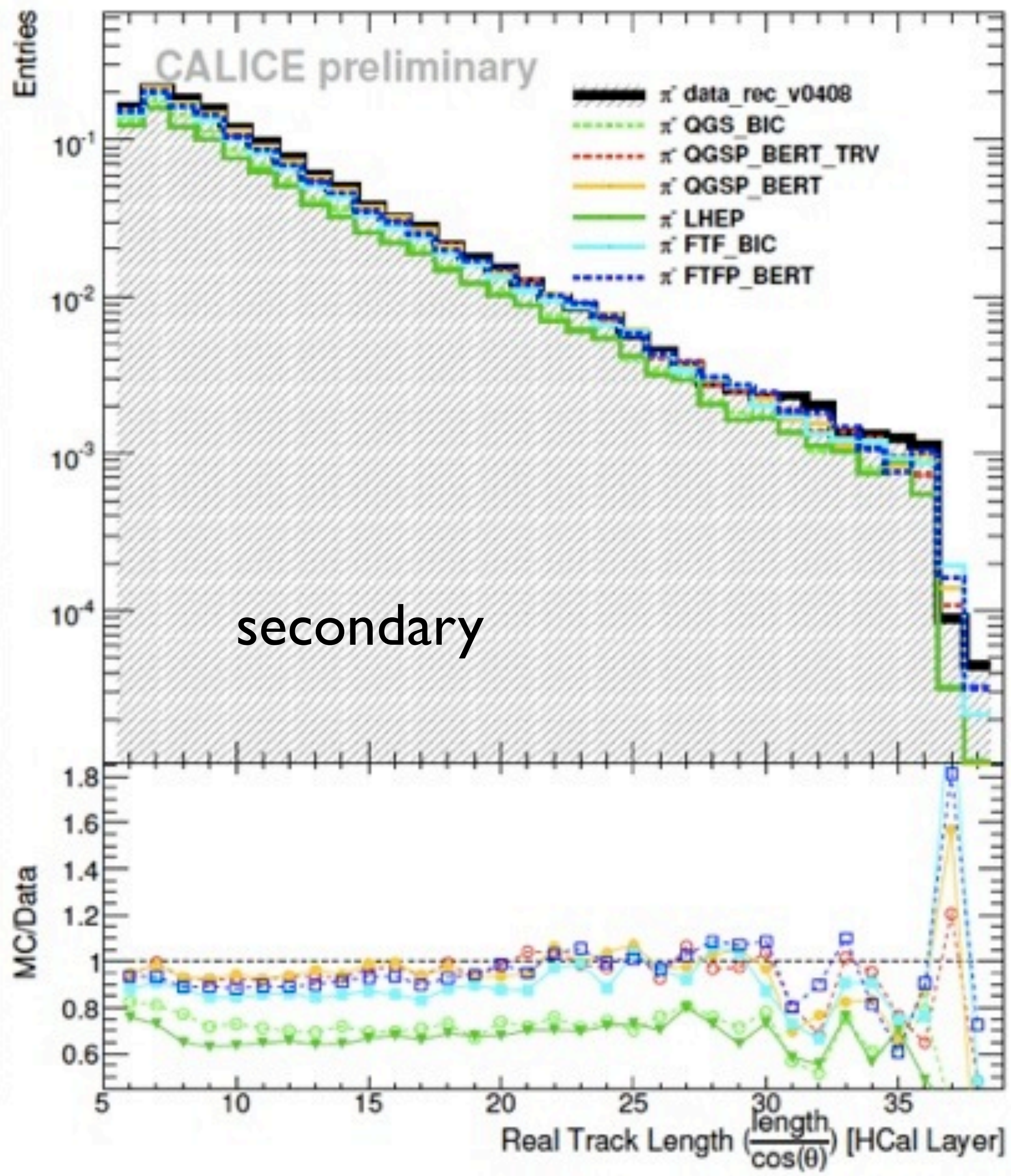


- In general consistent slopes, average length agrees on the percent level, except for low energies

Data-MC: Track Length Details

- Investigate primary (starting in the first 2 layers) and secondary tracks separately

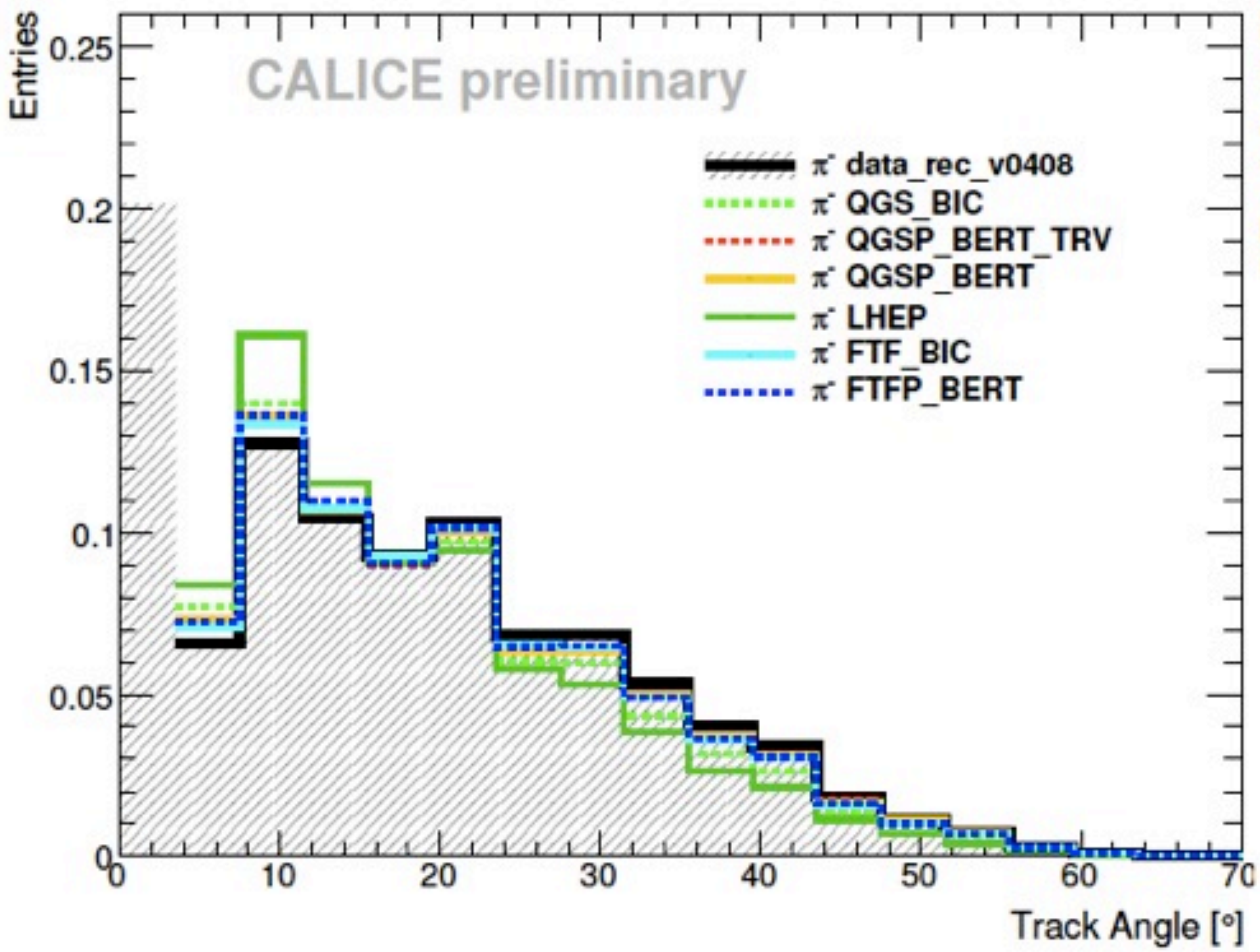


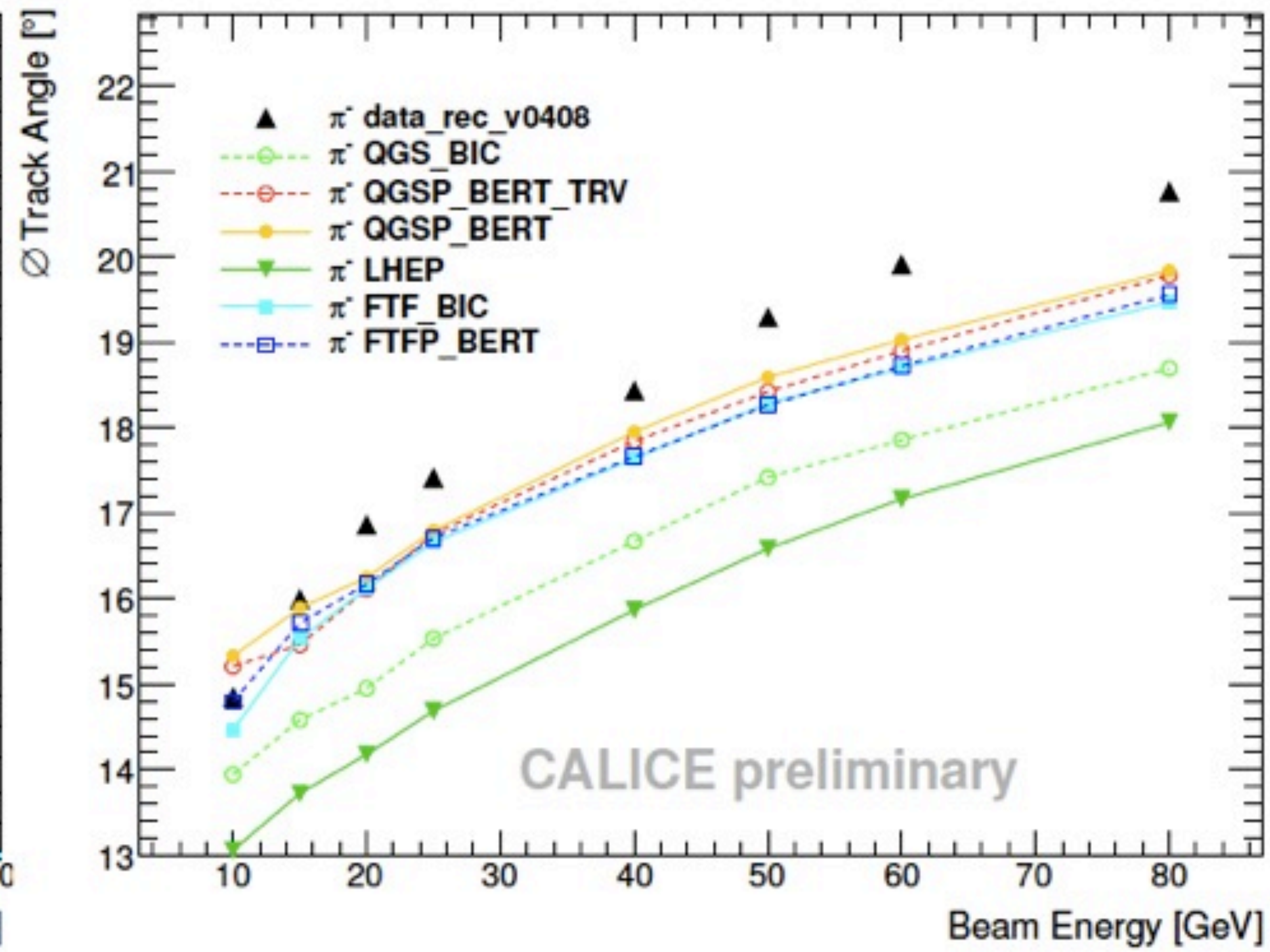


- Satisfactory description of length distribution of primary tracks, issues at the interface between fine and coarse section, muons clearly visible and well reproduced
- Good agreement of slopes: Good modeling of high-energy cross sections

Data-MC: Track Angle

- Sensitive to shower structure: scattering angle of secondary particles





- All models reproduce the trend with energy: Increasing mean track angle, more secondary production
- LHEP and QGS_BIC have significantly too low track angles

Summary

- Track finding in hadronic showers: A powerful tool for calibration and for studies of shower structure
  - Corrections for track angle to get good MIP energy distribution for inclined tracks

- Detailed Data-MC comparisons to a variety of Geant4.9.3 Physics Lists
  - In general, the qualitative energy dependence of investigated variables is well modeled
  - Satisfactory description of track length distribution: Good modeling of high-energy cross sections
  - Discrepancies between physics lists in particular for track multiplicity and track angle:
    - LHEP and QGS_BIC perform worst: Track multiplicity and average angle too low
    - ‣ These models seem to have insufficient production of secondaries at large angles outside the shower core

➩ CAN-022 in the editorial board, for presentation at LCWS