AHCAL Track Segments Paper - Status

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Calorimeter for ILC

LMU
Excellence Cluster
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The Status in Short

- First draft for Editorial Board available since 5 days
  - Editorial board was set up end of February, not clear if all members are still available - Up to now only one confirmation
  - Reasons for delay:
    - Additional study performed (multiplicity correlation in MC)
    - One overcommitted PA (Software Compensation paper, CLIC CDR, ILD DBD / CALICE Document,...)
- Hope to now make progress reasonably quickly

What is in it?

- Description of algorithm
  - Nearest-neighbor track/pattern recognition on isolated hits
  - Filtering using Hough transformation to clean up tracks
- Energy distribution of hits on track: Good MIPs, can serve as calibration tools
- Various track parameters in comparison to simulations
- Study of possible sources of systematic errors

Tracks in a Shower

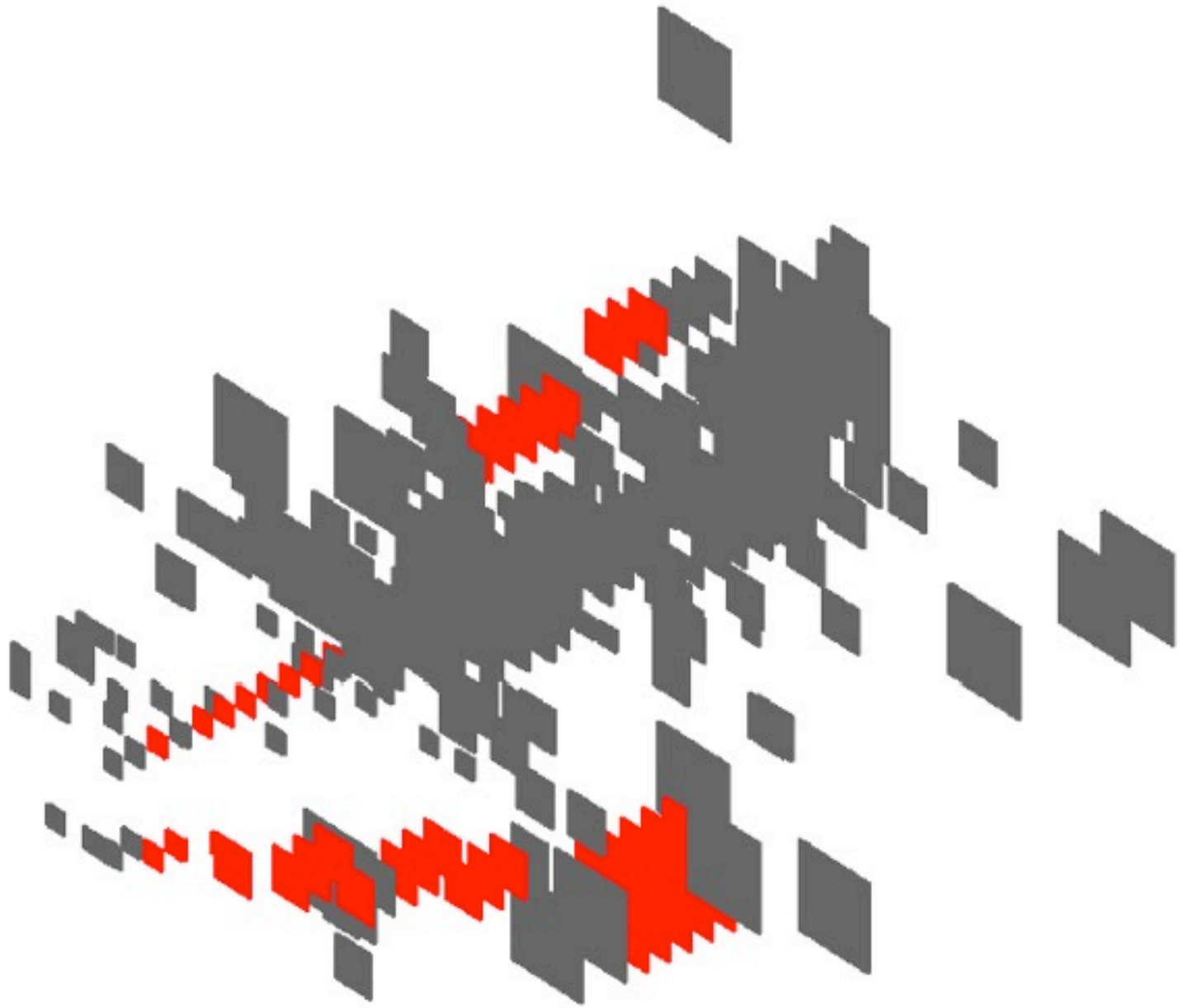


Figure 2: Event display of a typical hadronic shower in the CALICE AHCAL initiated by a negative pion with an energy of 60 GeV. The identified minimum-ionising track segments highlighted in red. The beam enters from the lower left.

Energy Distribution

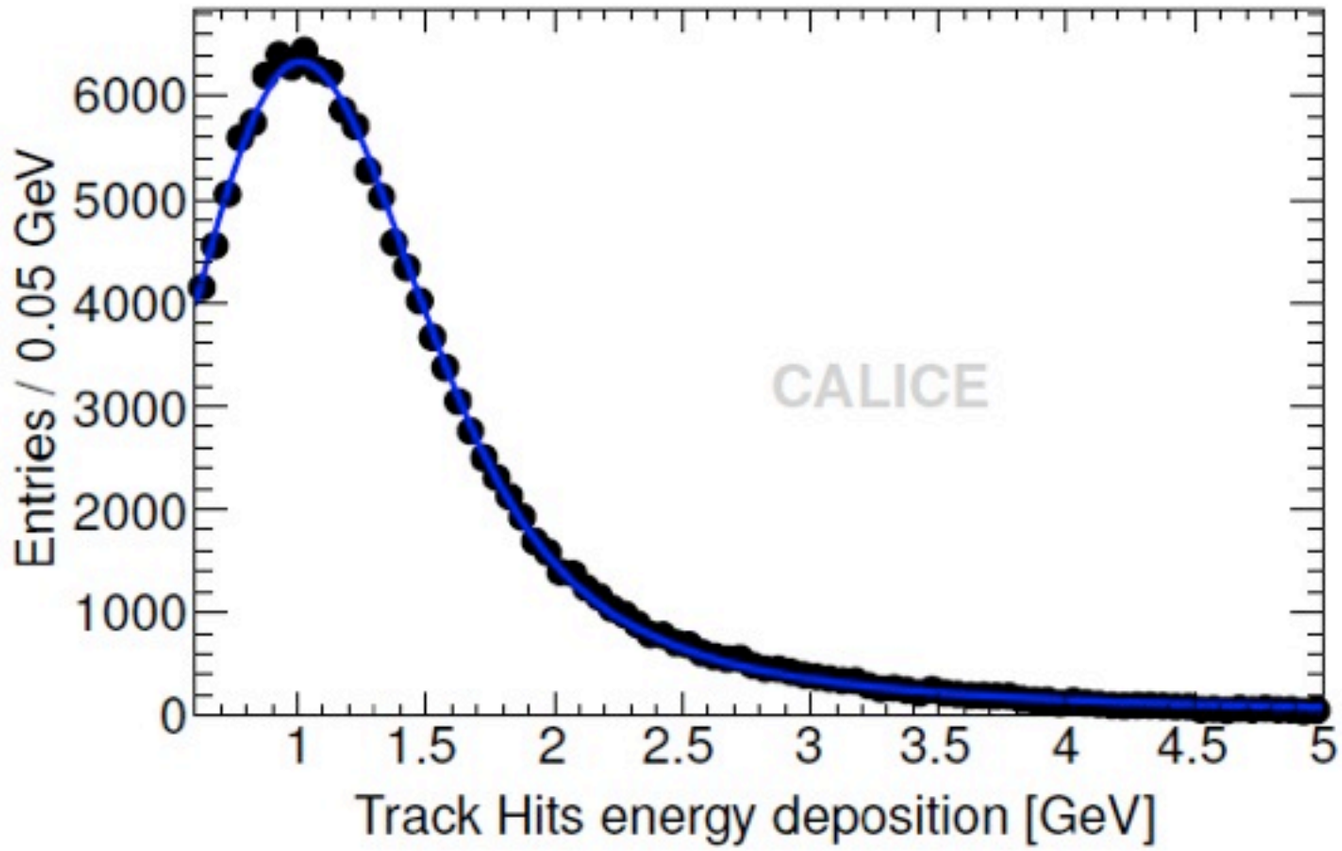


Figure 4: Distribution of single cell signal amplitude on identified tracks in 25 GeV pion showers with small inclination, corresponding to a mean cosθ of 0.99. The distribution is fit with a convolution of a Landau function and a Gaussian to describe the energy deposition together with the response of the photon sensor and the readout electronics.

Multiplicity Correlation

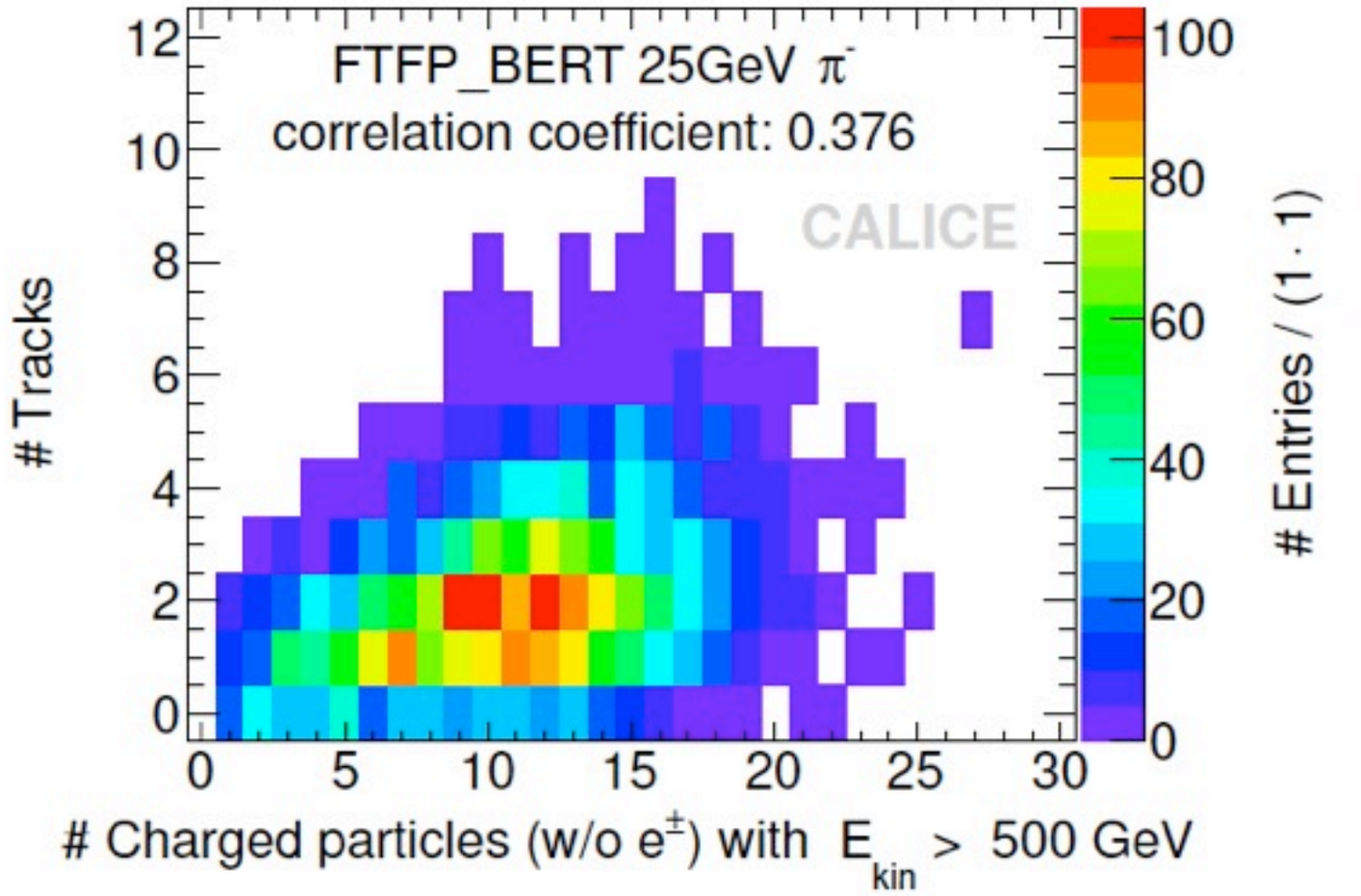


Figure 5: Correlation of the number of identified track segments and the true number of charged particles except electrons and positrons with a kinetic energy of greater than 500 MeV for 10000 simulated events at an energy of 25 GeV using the FTFP_BERT physics list. The Pearson correlation coefficient of the distribution is 0.38.

- Taken from the G4StackingAction: All charged particles (except e^-, e^+) above 500 GeV

Track Multiplicity

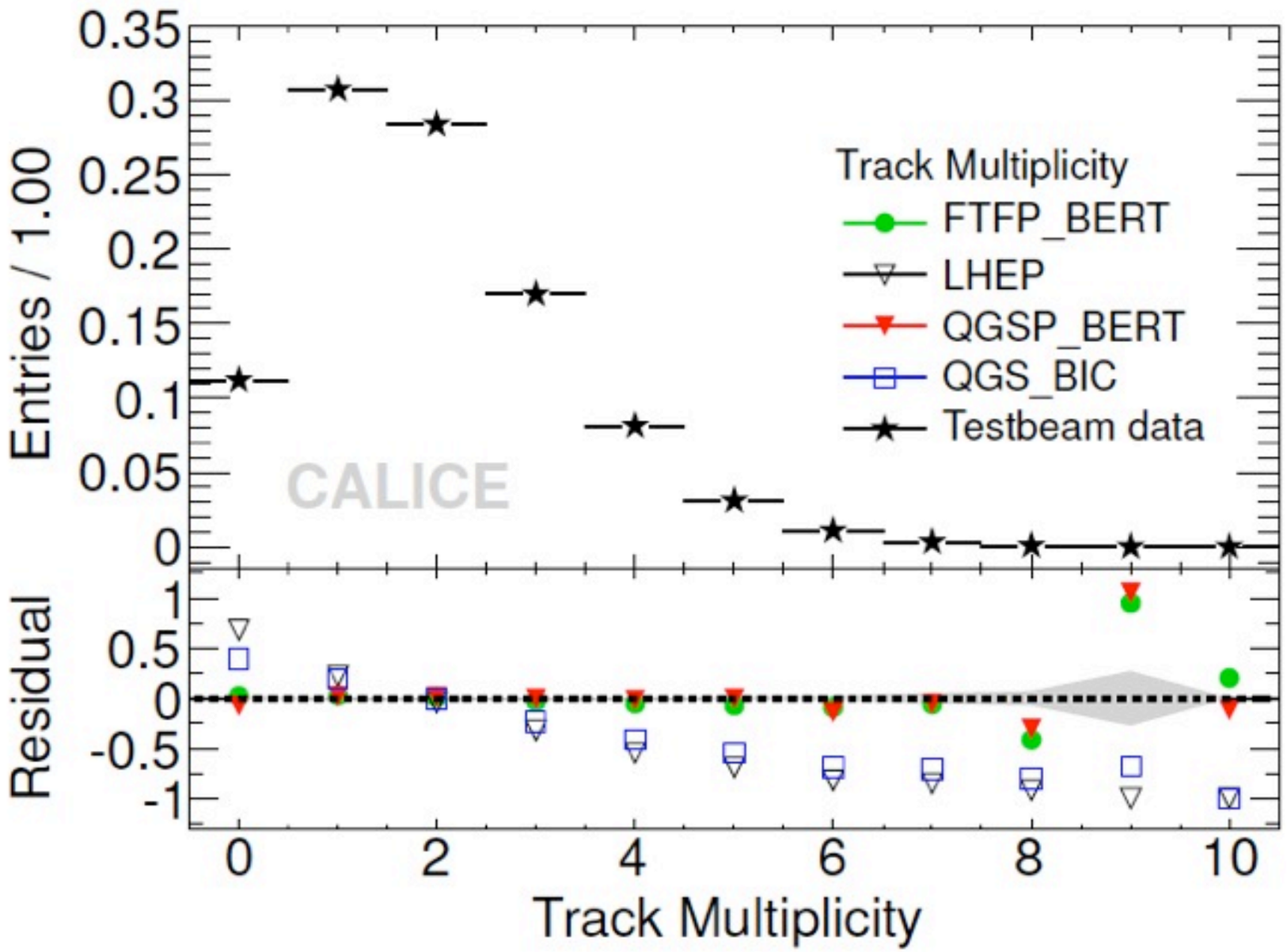


Figure 6: Distribution of track multiplicity for 25 GeV pion showers. The upper panel shows the normalised distribution for test beam data, while the lower panel shows the residuals for the different physics lists. The grey area indicates the statistical error of the residual between test beam data and QGS_BIC.

Mean Track Multiplicity

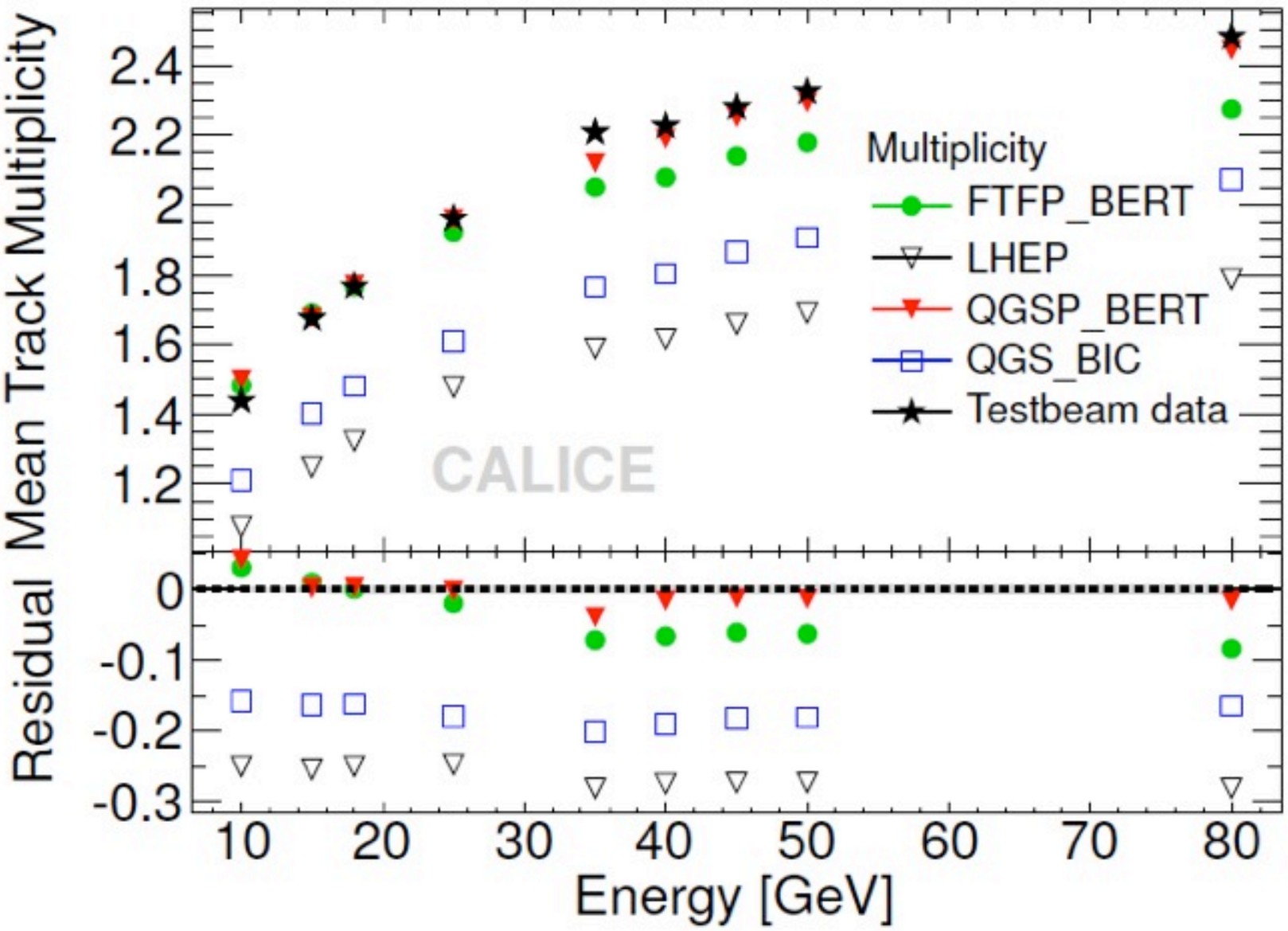


Figure 7: Mean track multiplicity as a function of energy. The upper panel shows data while the lower one shows the residuals between test beam data and the different physics lists. The grey area indicates the statistical error of the residual of test beam data and QGS_BIC.

Track Inclination

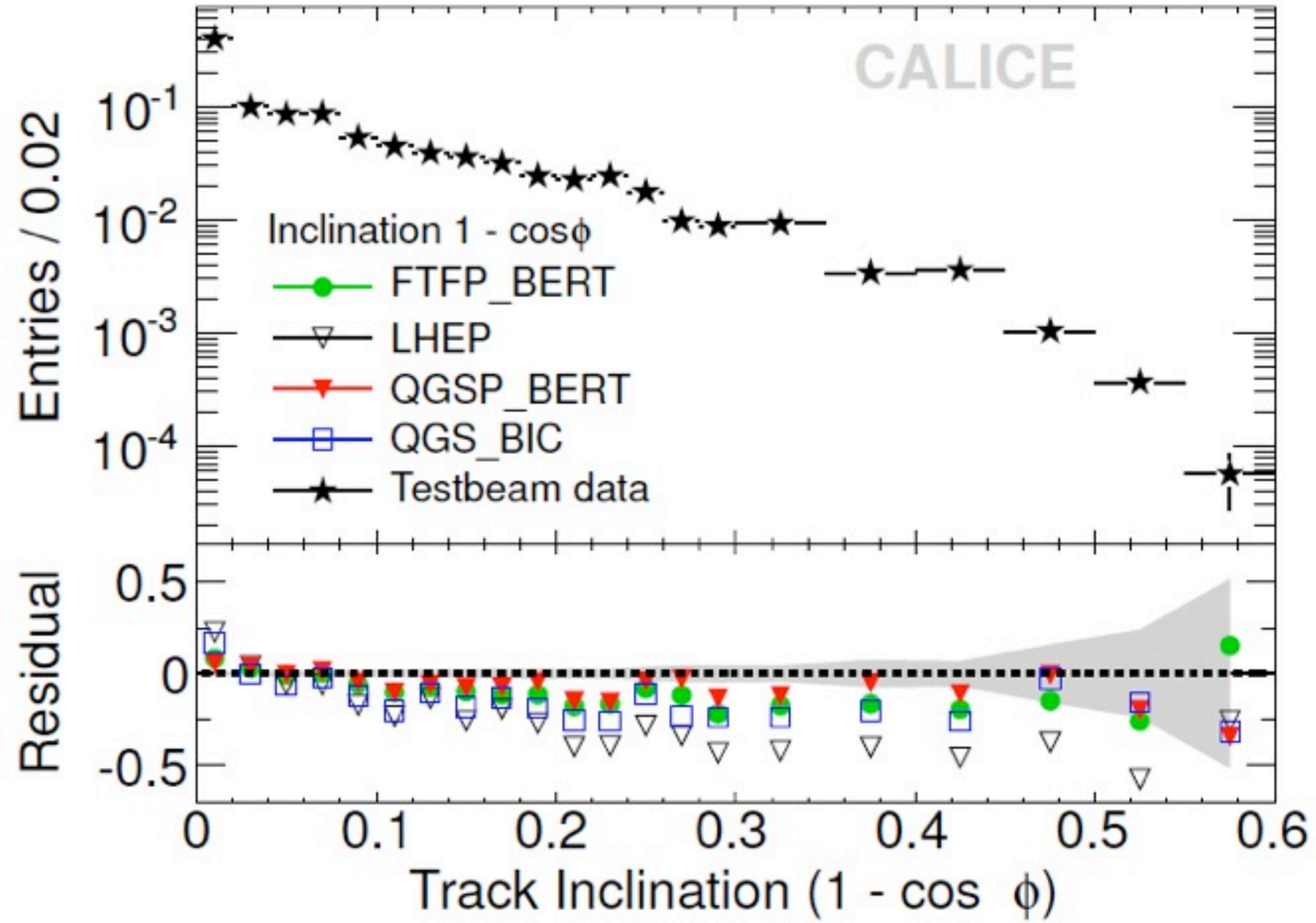


Figure 8: Normalised distribution of inclination of identified tracks for 25 GeV pion showers. The upper panel shows the distribution for test beam data normalised to an integral of 1, while the lower panel shows the residuals of data and the different physics lists. The grey area indicates the statistical uncertainty of the residual of data and the QGS_BIC physics list.

Mean Track Inclination

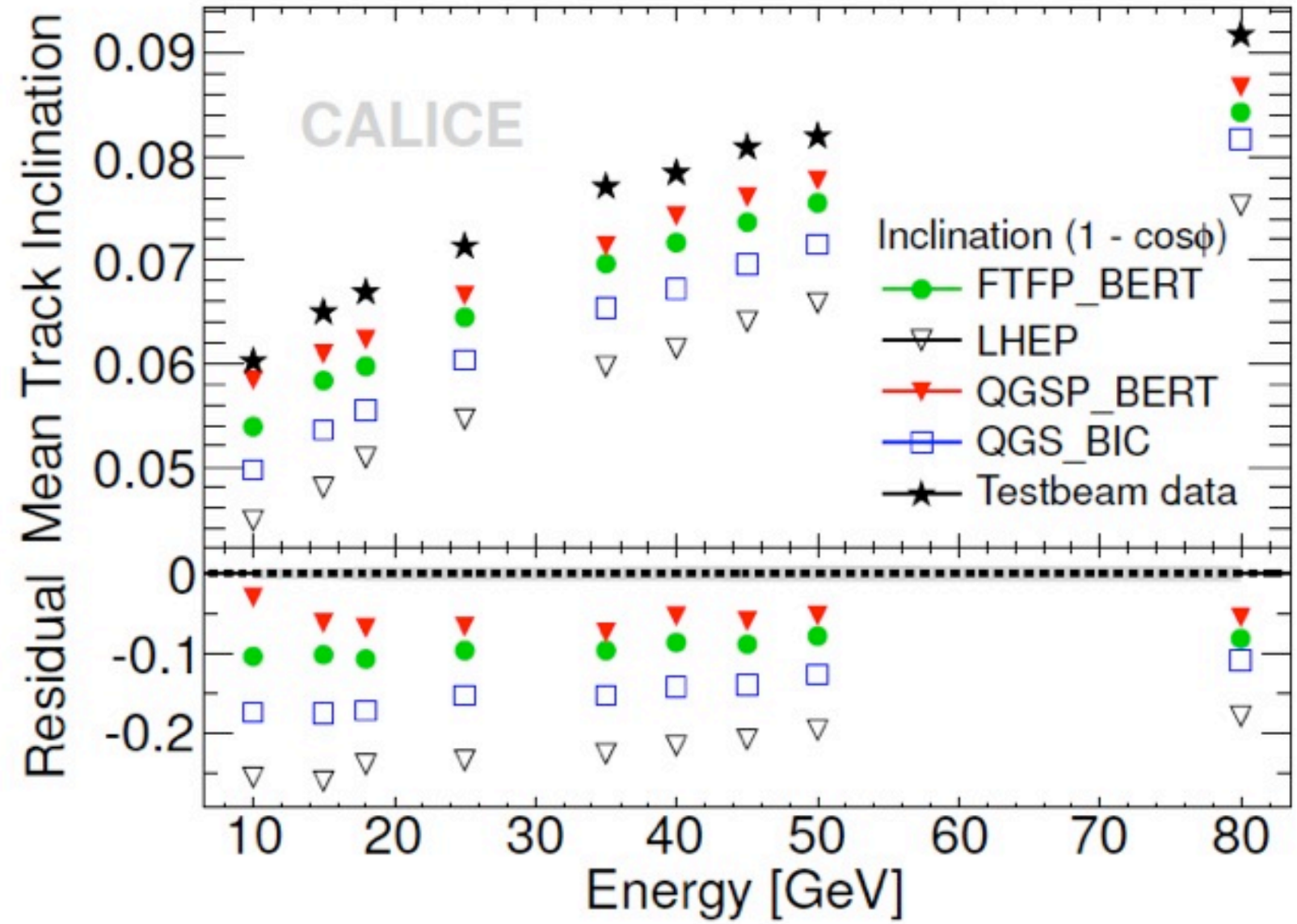


Figure 9: Mean track inclination as a function of energy. The upper panel shows the mean track inclination $(1-\cos\theta)$ for all physics lists and test beam data. The lower panel shows the residuals of data and simulations with the grey area showing the statistical uncertainty of the residual of data and QGS_BIC.

Track Length

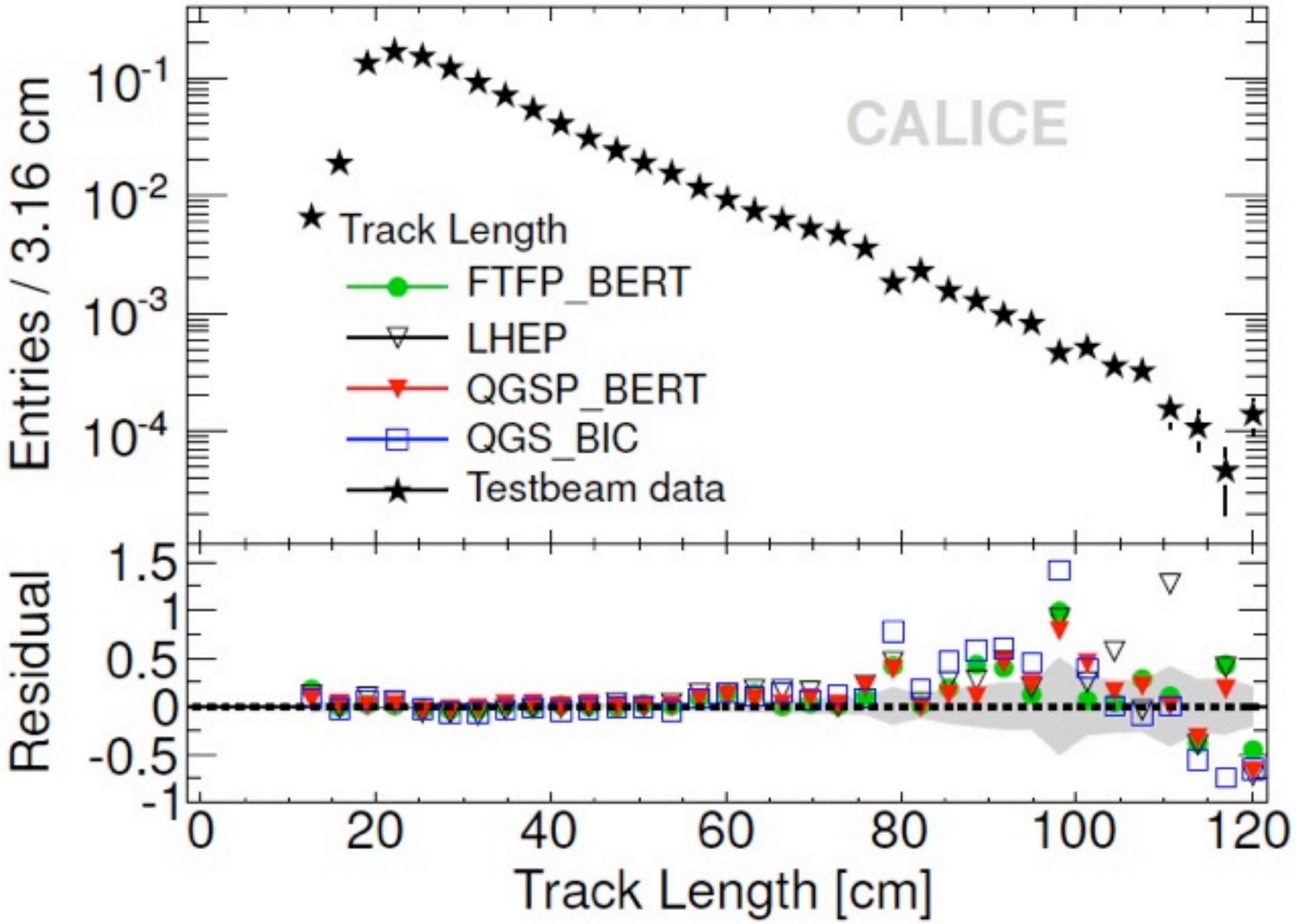
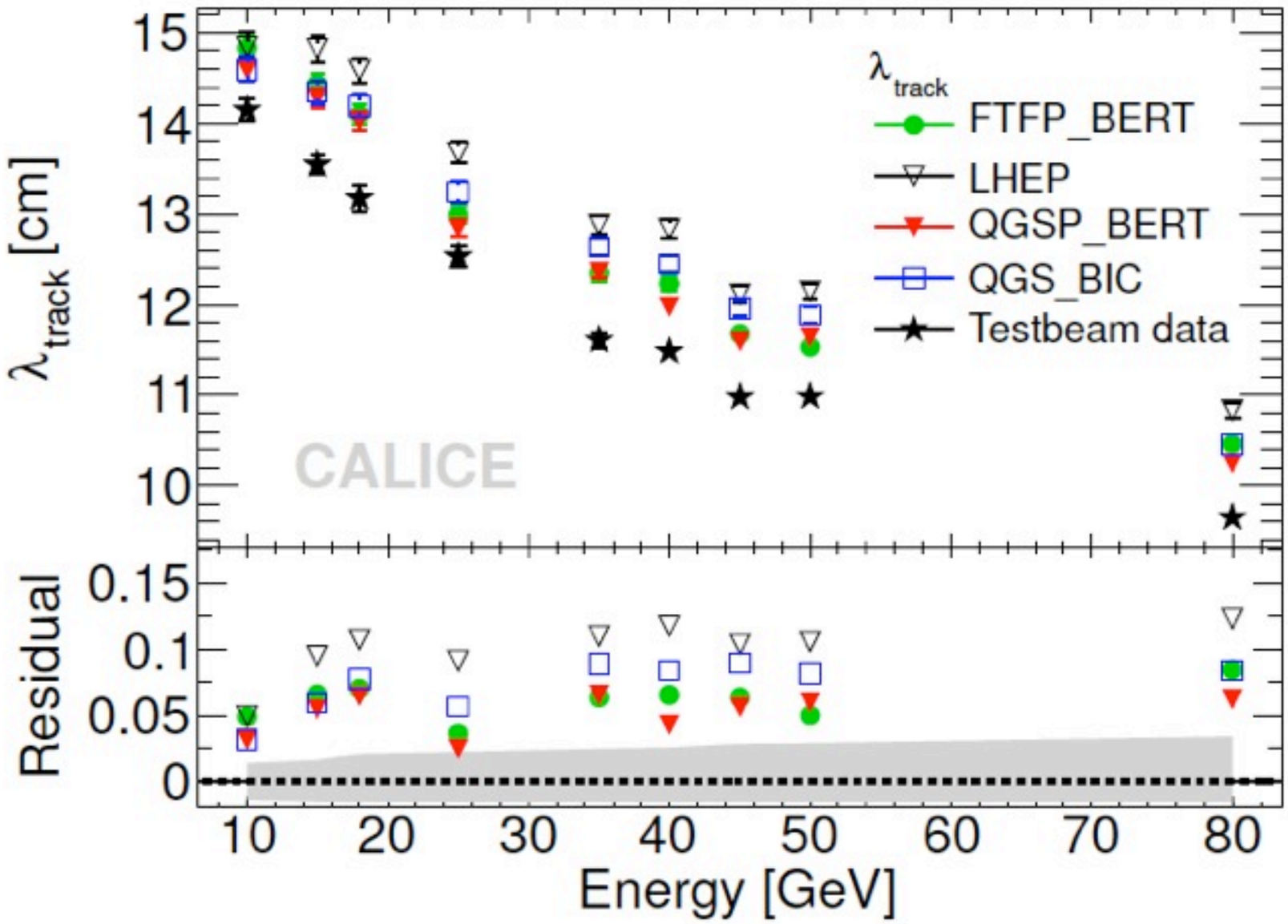


Figure 10: Normalised distribution of the length of identified tracks for a beam energy of 25 GeV. The upper panel shows the distribution for data, while the lower panel shows the residuals of data and simulations.The grey area indicates the statistical uncertainty of the residual of QGS_BIC compared to data.

Mean Inverse Slope Parameter



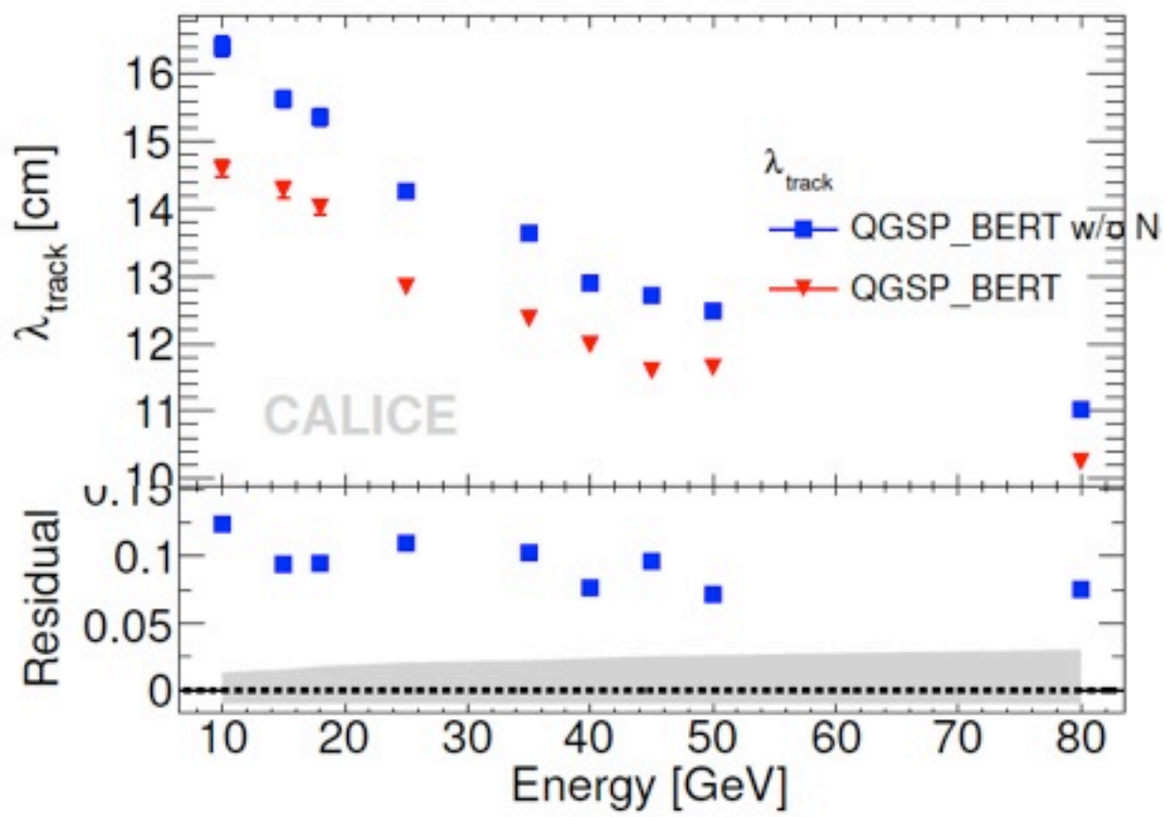
For comparison
AHCAL λ_π = 28 cm

Figure 11: Negative inverse slope parameter of the exponential fit to the track length distribution as a function of beam energy. The upper panel shows data and simulations. The lower panel shows the residuals of test beam data and simulations with the different physics lists with the grey band indicating the statistical uncertainties of the residuals of data and QGS_BIC.

Systematics

- Tracks are overall very robust: Insensitive to saturation, no direct dependence on cell energy calibration
  - A dependence comes in through the noise rejection cut
  - Have varied the MIP energy scale by 4% and 8% (outrageously conservative)
    Only for 8% variation an effect comparable to stat. uncertainties is seen
- Noise has an effect, on track length only, all other observables unaffected

- Difference between MC with and w/o noise comparable to difference between data and LHEP
  - But: Noise in simulations is well modeled - taken directly from data runs



Summary

- Track Segments paper finally back on track - Next step depends on Editorial Board, please read/comment soon!
  - Hope to submit to journal still this year

- Overall conclusions:
  - Hadronic showers really do look like Geant4 predicts: Not amorphous blobs, but a tree-like structure of MIP-like hadrons connecting regions of denser shower activity
  - Modern physics lists, in particular QGSP_BERT, do quite well in reproducing the track observables, older lists, in particular LHEP, show large discrepancies