Tracks in CALICE Si-W ECAL physics prototype

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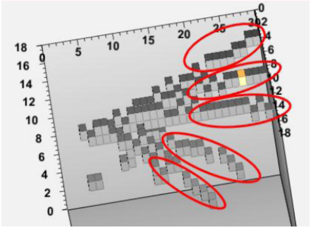
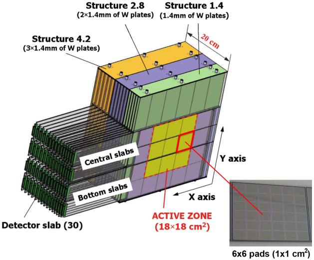
Objective

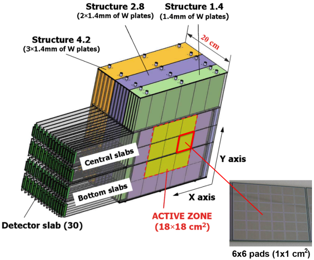
- Compare various Monte Carlo models to the data using a new set of tracking observables from a developed track-finding algorithm
- Data studied
  - π^- between 2 and 10 GeV (FNAL, 2008)
- Monte Carlo studied
  - QGSP_BERT and FTFP_BERT in GEANT4 9.6 P01
- This studies extend the analysis done by N. Kolk arXiv: [phys. ins.-det.] 1411.7215v2; Nucl.Instrum.Meth. A794 (2015) 240-254
- The results are summarized in a CALICE note CAN-055





Si-W ECAL physics prototype

- Developed by CALICE
- $1 \times 1\ cm^2$ silicon pixel
- 18×18 pixels in each layer
- 3 modules of 10 layers each with different W width
- Approximately 24 X_0 and 1 λ_I thickness

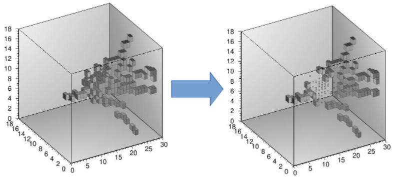


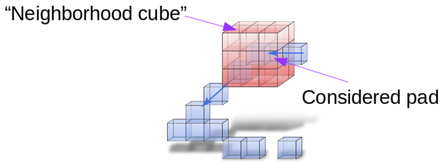
Track finding algorithm in the ECal

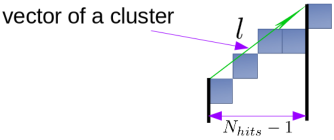
- Select events by interaction layer number from 6 to 15
- Separate out and analyze the interaction region (IR)
- Run clusterization algorithm on non-IR hits
- Classify each cluster as track like or not track like
  - Criteria:

$$\xi = \frac{l}{N_{hits} - 1} + \varepsilon N_{hits} \geq 1$$

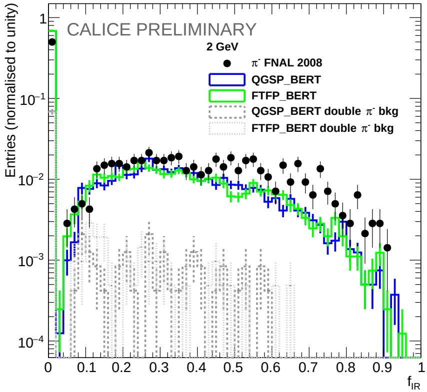
  - ε - a free parameter introduced as a correction for non-ideal 'pencil-like' tracks

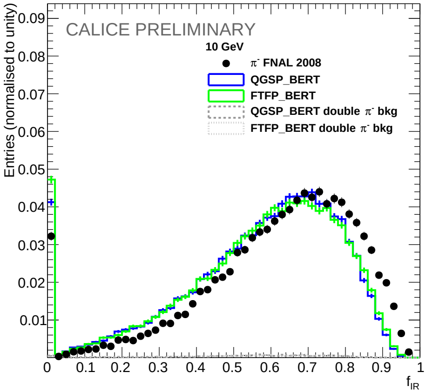






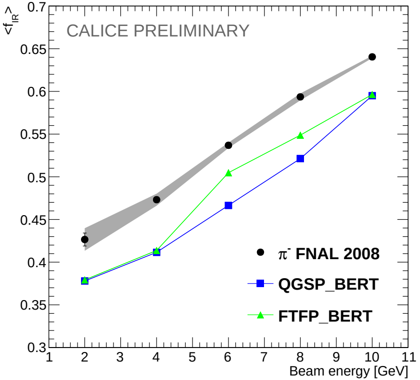
Energy fraction of the interaction region





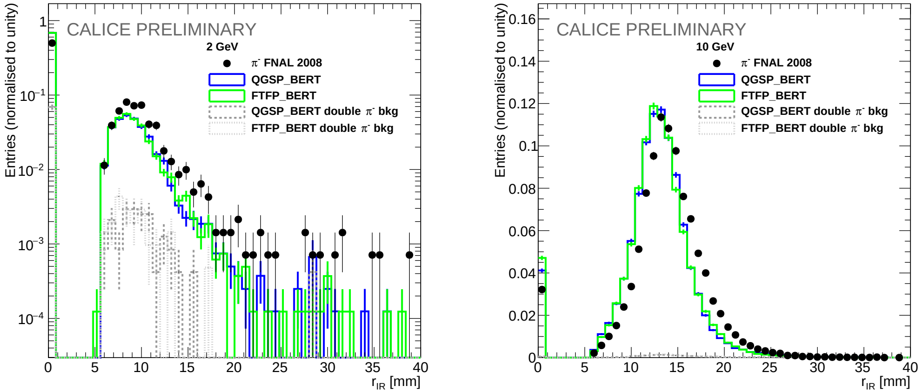
- Comparison of the energy fraction of the interaction region $f_{IR} = \frac{E_{IR}}{E_{total}}$ for 2 and 10 GeV beam energy. In the data there is more energy deposition in interaction region.

Energy fraction of the interaction region



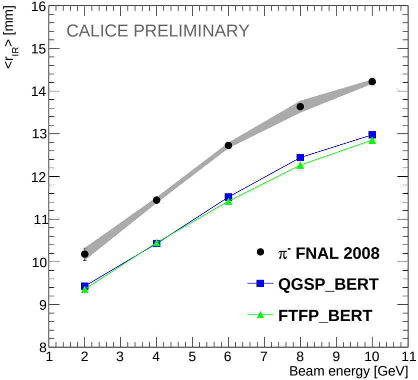
- Mean energy fraction of the interaction region as a function of beam energy. Data events have 11% and 8% higher $< f_{IR} >$ on average than QGSP_BERT and FTFP_BERT events, respectively.

Lateral radius of the IR



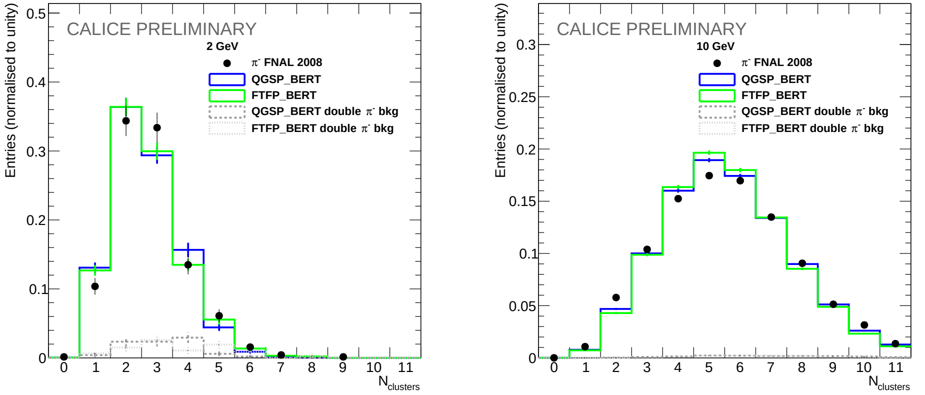
- Comparison of the lateral radius of the interaction region r_{IR} for 2 and 10 GeV beam energy. Data points shifted towards larger radii.

Lateral radius of the IR



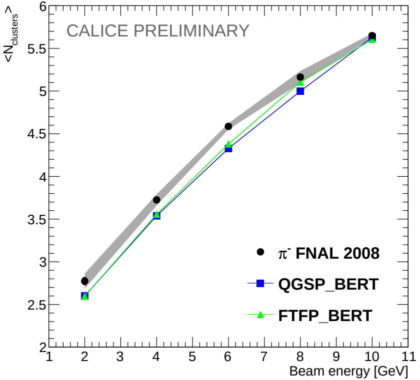
- Mean lateral radius of the interaction region as a function of beam energy. Data has 9% wider interaction region than Monte Carlo for all beam energies.

Number of clusters



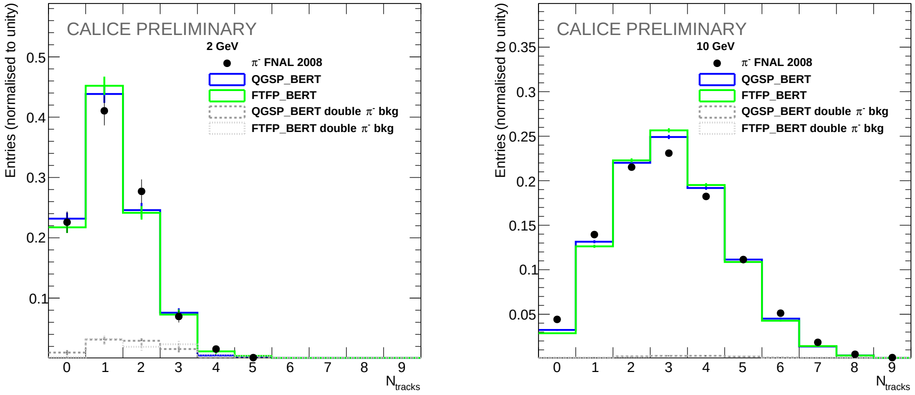
- Comparison of the number of clusters for 2 and 10 GeV pion data and two Monte Carlo physics lists. Both models well describe the data.

Number of clusters



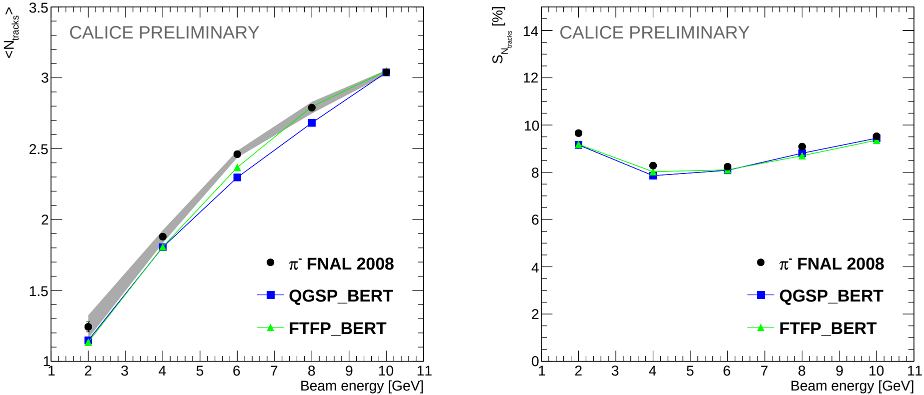
- Mean number of the clusters as a function of beam energy. Both physics lists agree with the data within 5% of precision.

Number of tracks



- Comparison plots of the number of tracks for 2 and 10 GeV pion data and two Monte Carlo physics lists. Both models well describe the data.

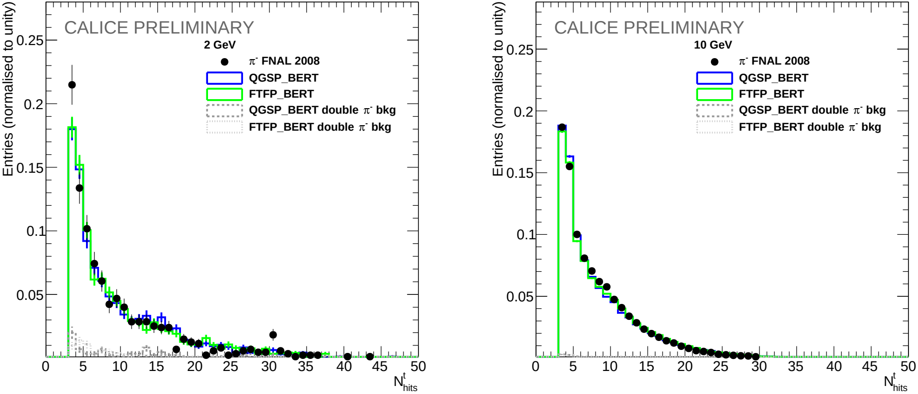
Number of tracks



- Mean number of secondary tracks as a function of beam energy. Sensitivity plot is calculated using

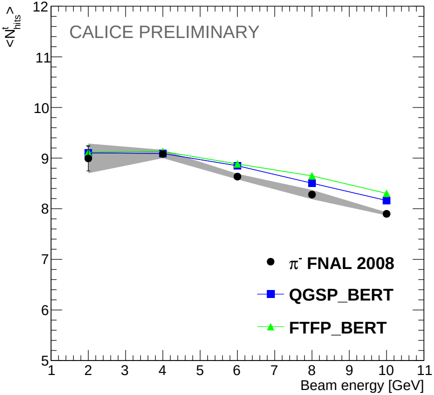
$$S_{N_{tracks}} = \frac{< N_{tracks}(\varepsilon = 0.04) - N_{tracks}(\varepsilon = 0.02) >}{< N_{tracks}(\varepsilon = 0.03) >}.$$

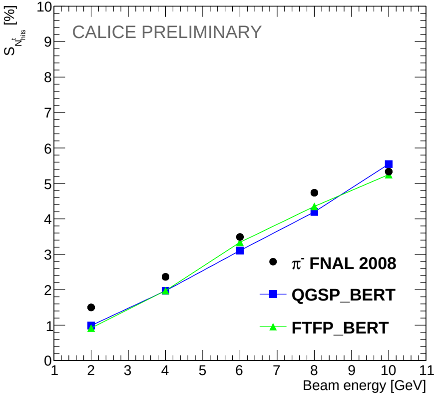
Number of hits per track



- Comparison of the number of hits per secondary track for 2 and 10 GeV pion data and two Monte Carlo physics lists. Both models well describe the data.

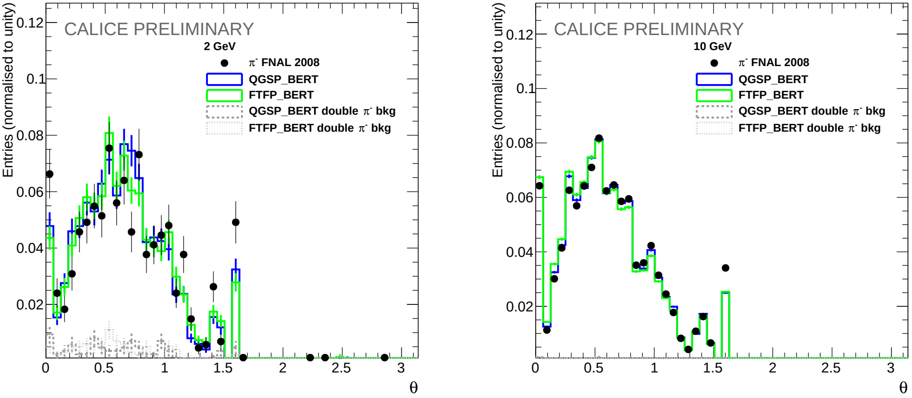
Number of hits per track





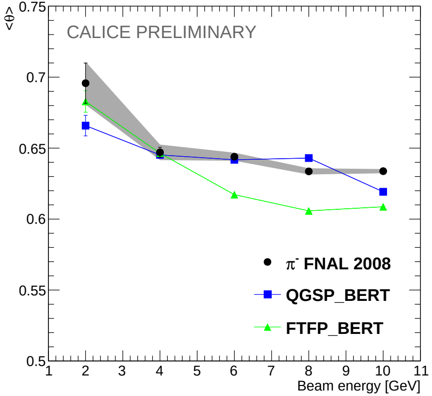
- Mean number of hits per track as a function of beam energy. Both simulation models agree with the data within 5% of precision.

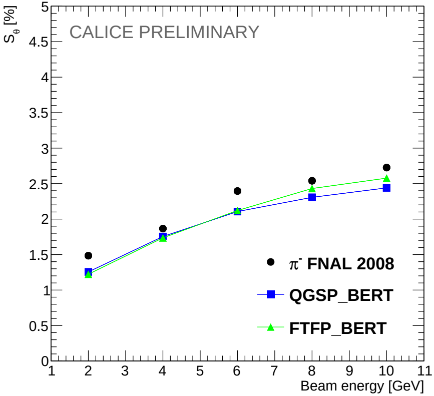
Polar angle distribution



- Comparison plots of polar angle θ of secondary tracks for 2 and 10 GeV pion data and two Monte Carlo physics lists.

Polar angle distribution

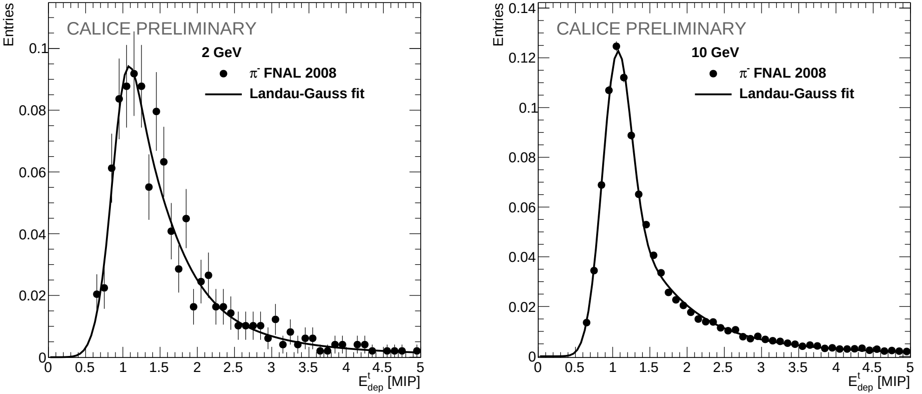




- Mean polar angle θ as a function of beam energy. Both simulation models agree with the data within 5% of precision.

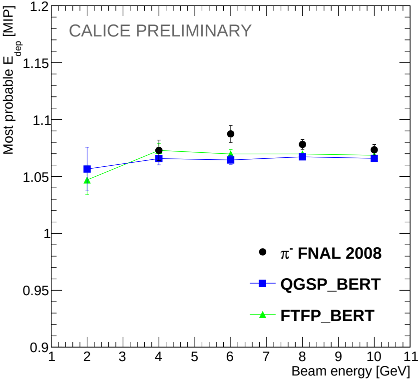
Energy deposition by secondary tracks

Towards an in-situ calibration of the Si-W ECAL



- The E_{hit} distribution for different beam energies and two physics lists. Both histograms are fitted by a sum of a Landau and a Gaussian function.

Energy deposition by secondary tracks



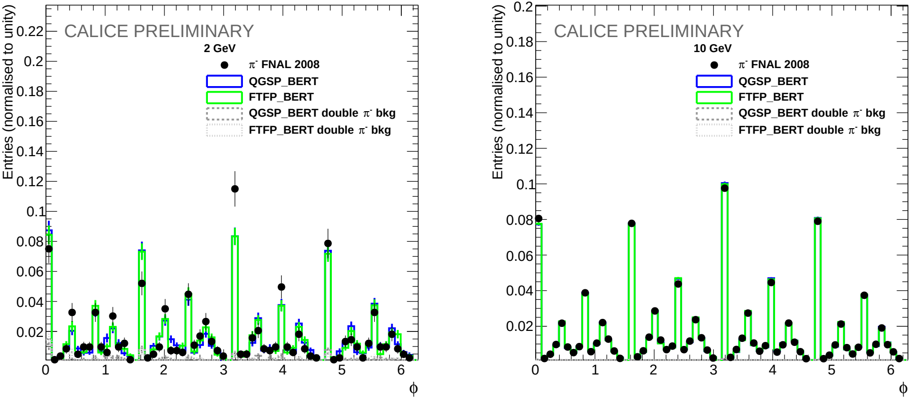
- The MPV of energy deposition spectrum in secondary tracks as a function of beam energy. Both simulation models agree with the data within 2% of precision.

Conclusion

- We have developed and tested a simple algorithm that finds the secondary tracks in hadronic showers in the Si-W ECAL physics prototype. Both physics lists show good performance in terms of tracking observables
- The largest discrepancy found in energy fraction and radius of the interaction region - up to 15% difference
- The systematic effects of the algorithm and double pion background events are studied and taken into account
- The results are summarized in the CALICE note CAN-055
- Further work:
  - Include more physics lists into comparison
  - Use GEANT4 10
  - Optimize the track-finding algorithm

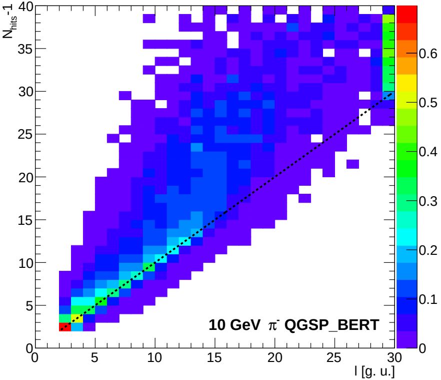
Thank you!

Azimuthal angle distribution



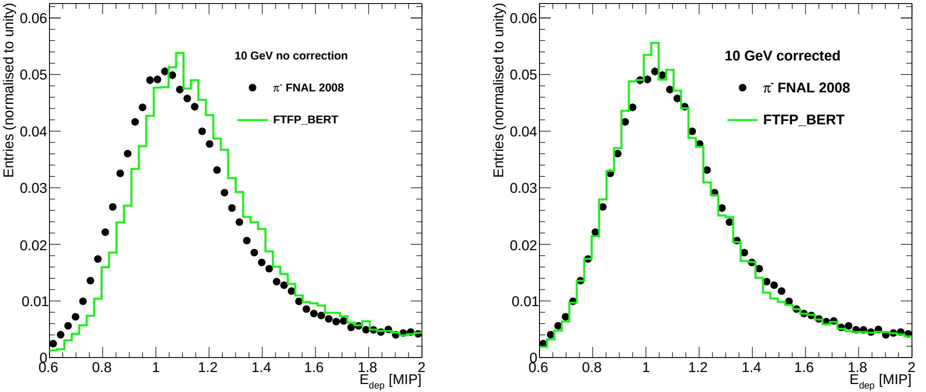
- Comparison of azimuthal angle ϕ of secondary tracks for 2 and 10 GeV pion data and two Monte Carlo physics lists.

Motivation for the classification choice



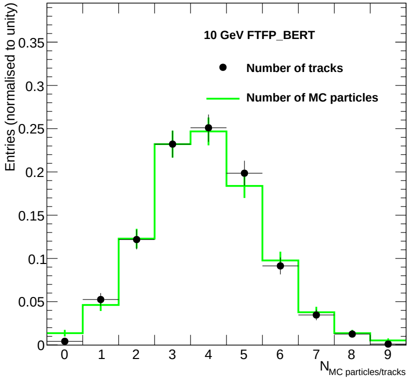
- Correlation between $N_{hits} - 1$ and cluster length l at the example of simulated pions with an energy of 10 GeV using the QGSP_BERT physics list.

Energy deposition by primary π^-



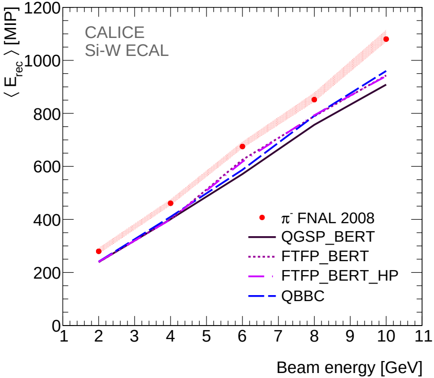
- The E_{hit} distribution for different 10 GeV beam energy before and after MIP energy factor correction for the simulation (from 147 KeV to 155 KeV by S. Morozov, K. Seidel, M. Chadeeva). The results are summarized in CIN-024.

Generated particles



- Correlation between number of generated particles and number of reconstructed tracks by the algorithm.

Total energy



- Total energy deposited in the Si-W ECAL physics prototype as a function of beam energy.