Comparison of results of Geant4.9.2-beta to ATLAS TileCal test beam data and Geant4.9.1

Tancredi Carli
CERN
Margar Simonyan
LAPP

LCG Physics Validation meeting

Outline

1. Introduction
   - ATLAS Tile Calorimeter
   - Test Beam Setup

2. Data and Monte Carlo Comparison, G4.9.2 vs G4.9.1
   - Pion and Proton Response
   - Shower Lateral Spread
   - Shower Longitudinal Profile

3. Summary

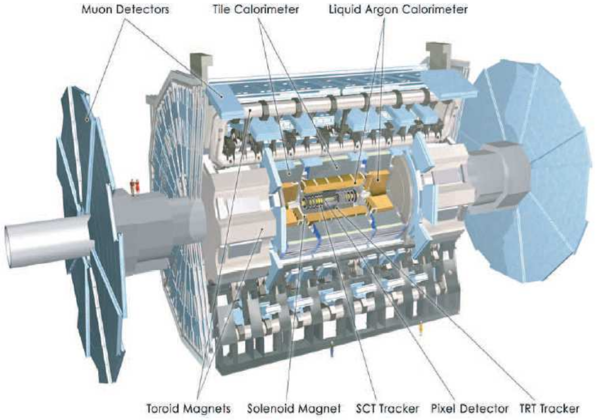
Outline

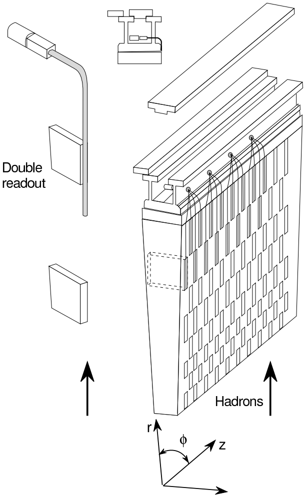
Outline

1. Introduction
   - ATLAS Tile Calorimeter
   - Test Beam Setup
2. Data and Monte Carlo Comparison, G4.9.2 vs G4.9.1
   - Pion and Proton Response
   - Shower Lateral Spread
   - Shower Longitudinal Profile
3. Summary

ATLAS Tile Calorimeter

- Iron-scintillator hadronic calorimeter located in the central region of the ATLAS detector.
- Scintillating tiles are placed perpendicular to the LHC colliding beams.

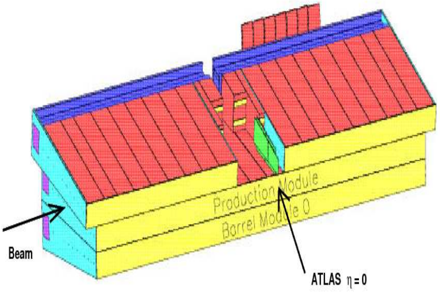




Test Beam Setup

Special Runs

- Beam impinging the detector from the side.
- The depth is more than 25 nuclear interaction lengths (λ).
- Longitudinally showers are fully contained.
- Lateral containment of showers is more than 99%.
- Pion/proton separation is done by Cherenkov detector.

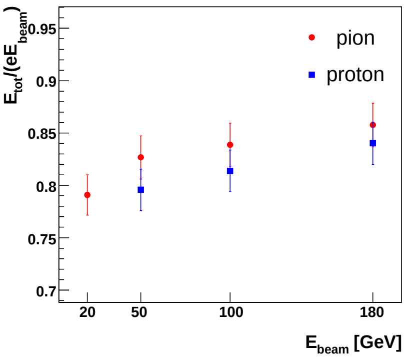


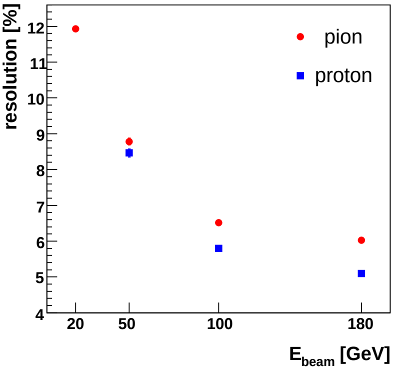
New TileCal Cell Calibration

- The whole chain of Tile Calorimeter calibration has been revised. Several small effects have been corrected.
- These data supersede the previous ones.
- The difference is small, but a more careful error analysis is done. In particular, the response errors have increased due to cell non-uniformities.
- A conservative error calculation is applied.

Pion and Proton Response

EM-scale from electron response.

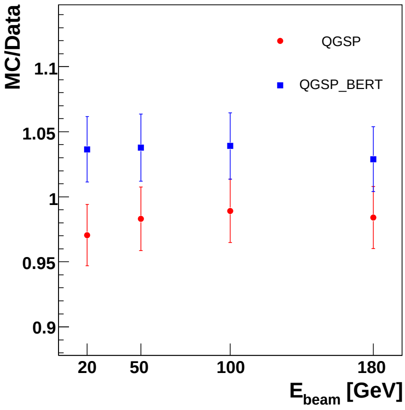




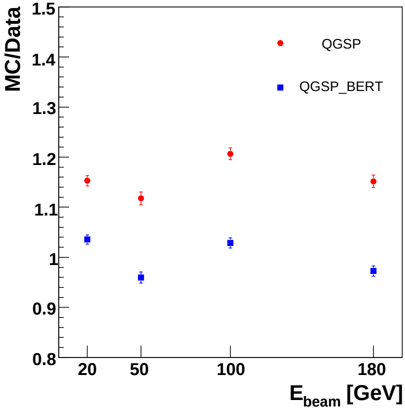
- Pions have larger response, but worse resolution.
- Large errors due to overall normalization uncertainties.

Pion Response

Response



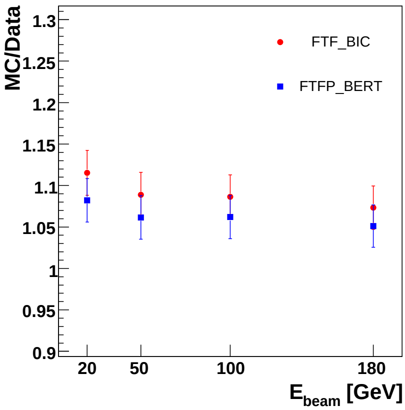
Resolution



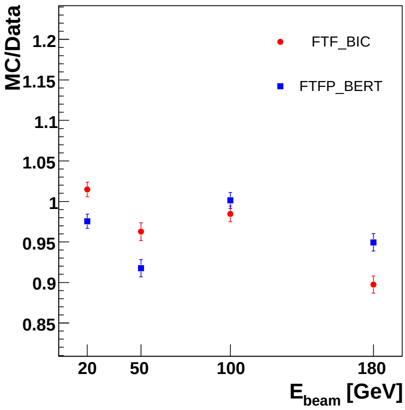
- Bertini cascade increases response. The data are described within uncertainties.
- 10-20% worse resolution with QGSP, within $\pm$ 10% with cascade model (BERT).

Pion Response

Response



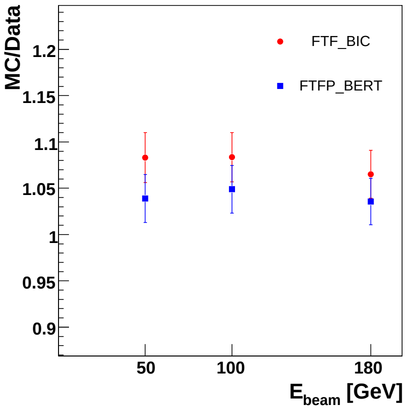
Resolution



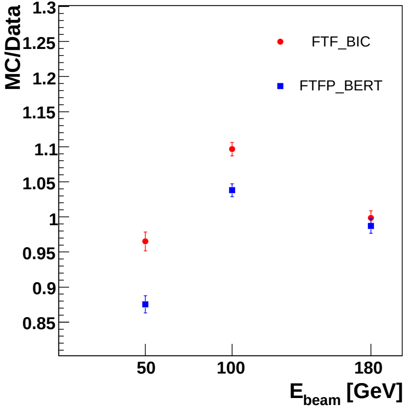
- The response is too high.
- Pion resolution within 10% with FTF_BIC and FTFP_BERT.

Proton Response

Response



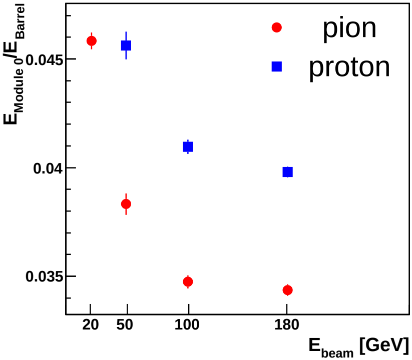
Resolution

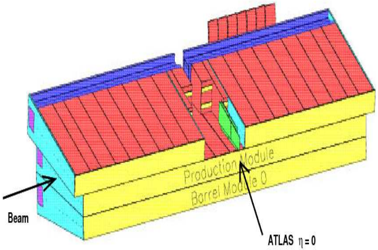


- Response is too high in FTF based physics lists.
- Within $\pm$ 10% with cascade models.

Lateral Spread

The ratio of energy measured in the bottom and central modules is an estimate of lateral spread.

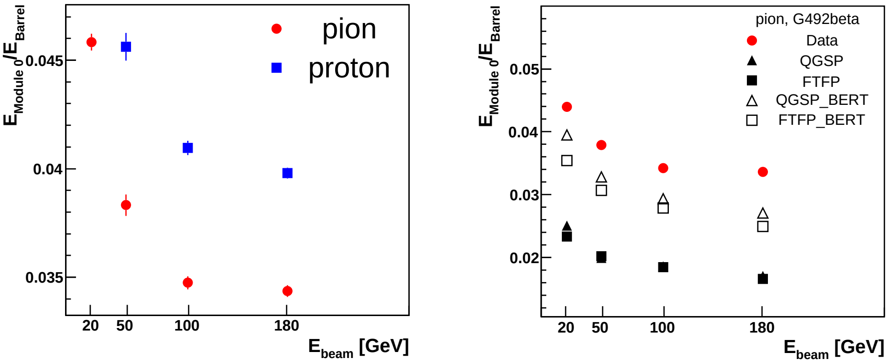




- Proton induced showers are wider than pion induced ones.
- Showers simulated using QGSP and FTFP are too narrow.
- Better description with cascade models.

Lateral Spread

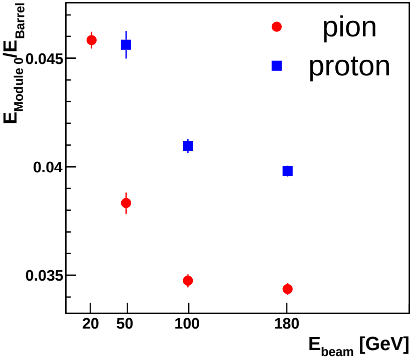
The ratio of energy measured in the bottom and central modules is an estimate of lateral spread.

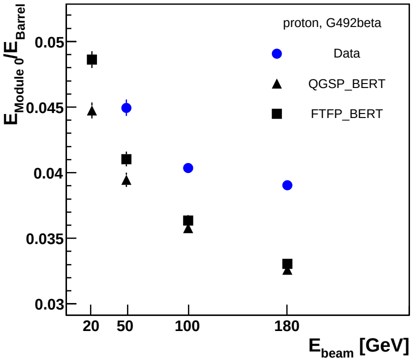


- Proton induced showers are wider than pion induced ones.
- Showers simulated using QGSP and FTFP are too narrow.
- Better description with cascade models.

Lateral Spread

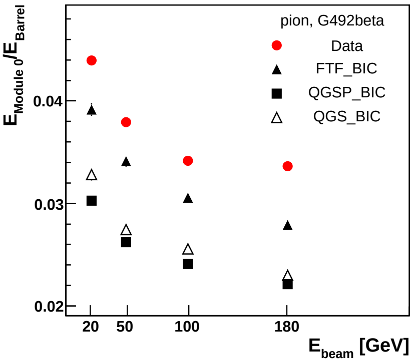
The ratio of energy measured in the bottom and central modules is an estimate of lateral spread.

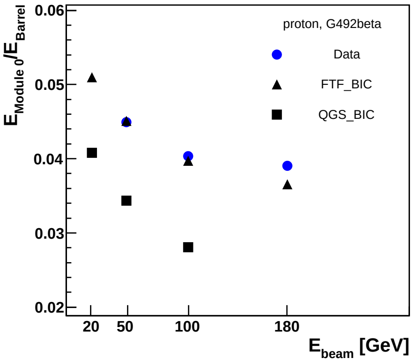




- Proton induced showers are wider than pion induced ones.
- Showers simulated using QGSP and FTFP are too narrow.
- Better description with cascade models.

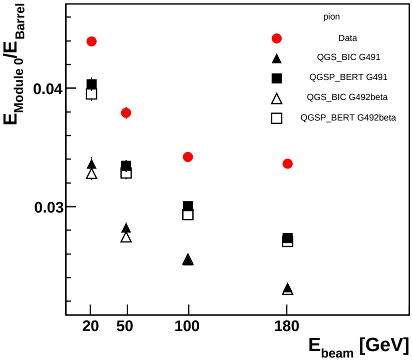
Lateral Spread

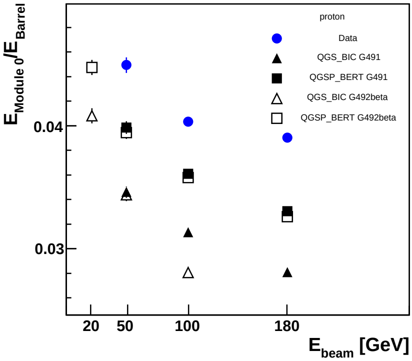




- Too narrow showers with QGS(P)_BIC.
- Good description with FTF_BIC.

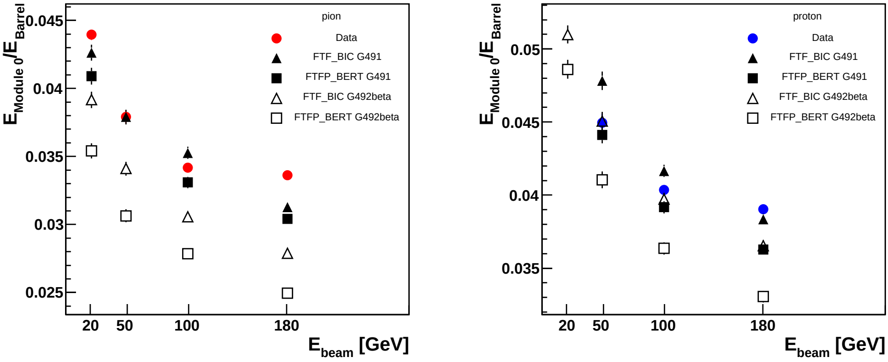
Lateral Spread





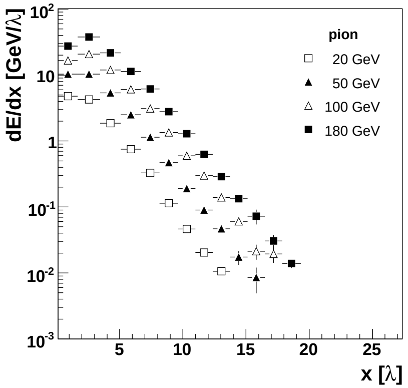
- Showers became slightly narrower in G4.9.2 with QGS(P)_BIC and QGS(P)_BERT.

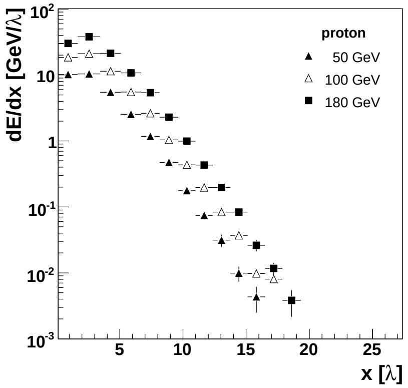
Lateral Spread



- Showers became significantly narrow in G4.9.2 with FTF(P)_BIC and FTF(P)_BERT.

- The first measurement of longitudinal profile of pion and proton induced showers up to 20λ.



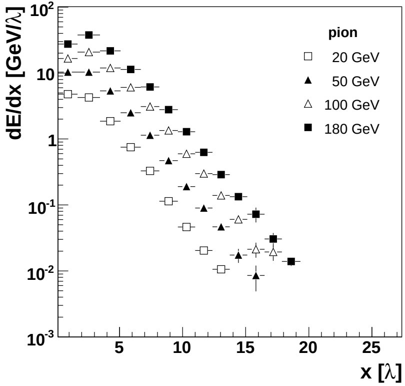


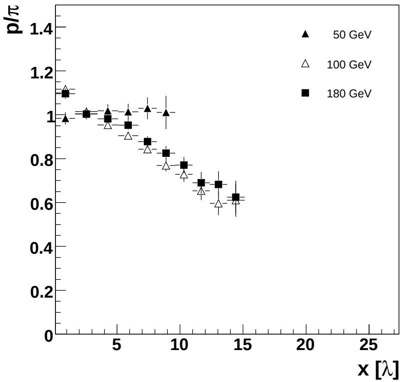
- Pion induced showers are longer at high energies.

Longitudinal Profile

Pions and Protons

- The first measurement of longitudinal profile of pion and proton induced showers up to 20λ.

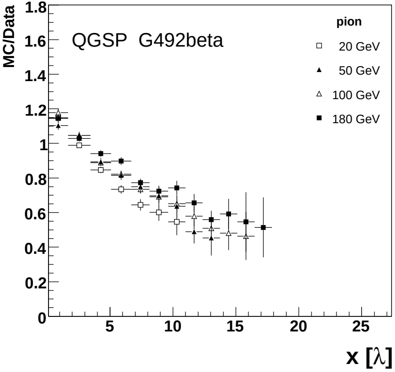


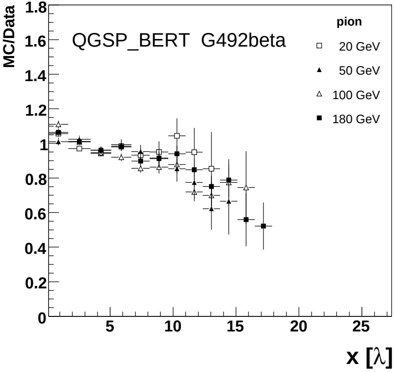


- Pion induced showers are longer at high energies.

Longitudinal Profile

Pions

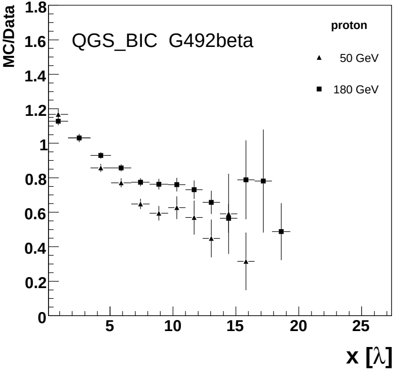


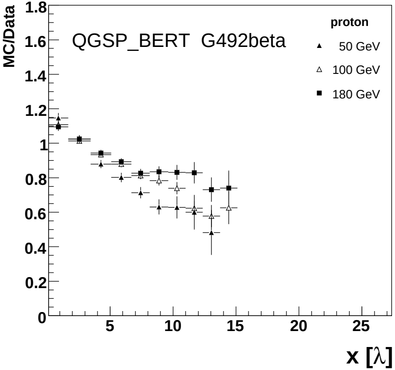


- Showers simulated with QGSP are too short, 20 – 40% less energy at 10λ.
- Adding Bertini makes showers longer, up to 10λ within $\pm 15\%$.

Longitudinal Profile

Protons

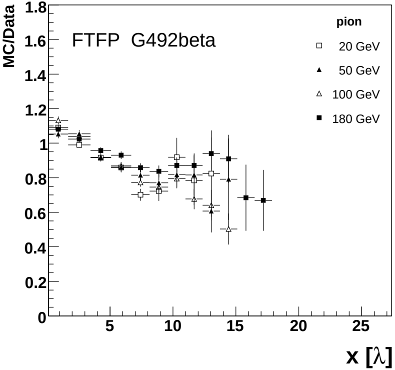


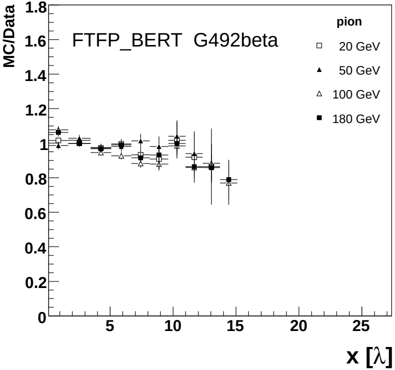


- Simulated showers are too short, at 10λ $20-40\%$ less energy.
- With Bertini at 10λ 20-40% less energy.
- Protons are described worse than pions.

Longitudinal Profile

Pions

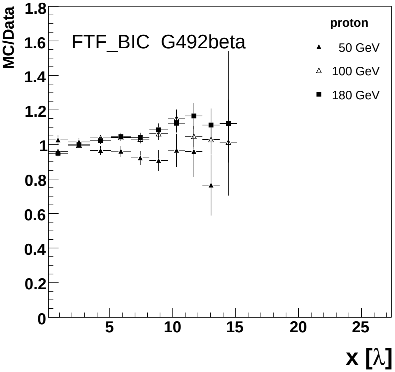


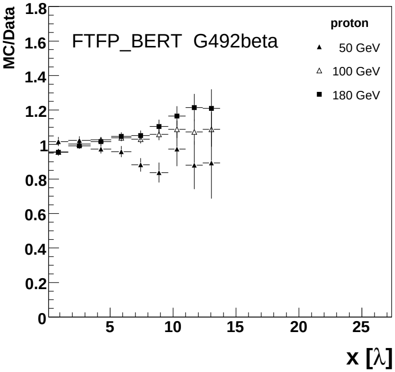


- With Fritiof model showers are a bit shorter, up to 10λ within $\pm 20\%$.
- With Bertini cascade MC describes data up to 10λ within $\pm 10\%$.

Longitudinal Profile

Protons

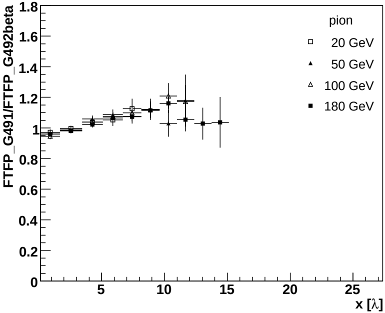


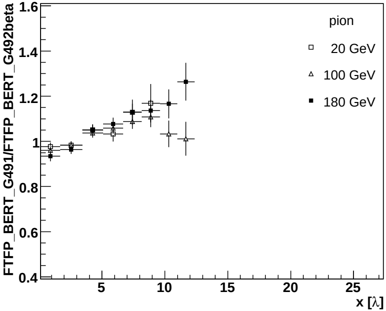


- Up to 10λ $\pm$20% agreement.
- Good description at high energies.

Longitudinal Profile

Pions

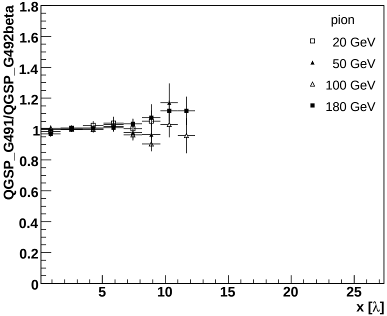


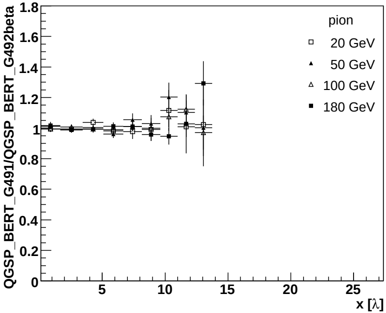


- Showers became longer in G4.9.2 with respect G4.9.1 in FTFP based physics lists.

Longitudinal Profile

Pions

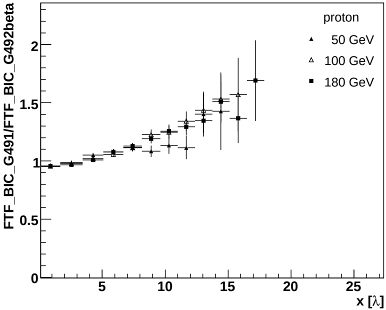


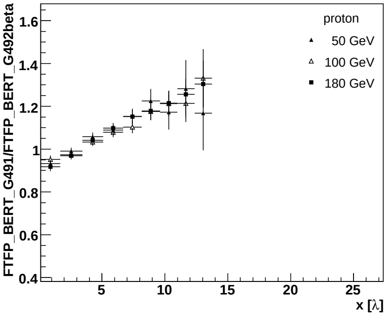


- No change across versions in QGSP based physics lists.

Longitudinal Profile

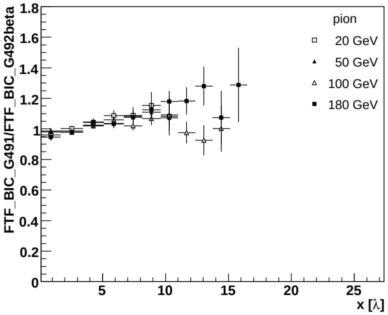
Protons

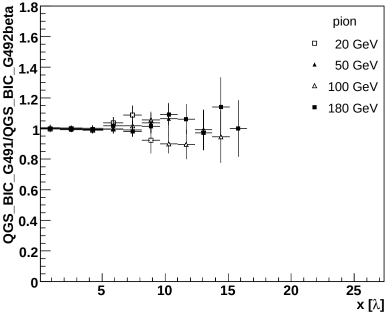




- Proton induced showers became longer in G4.9.2 with respect G4.9.1 in FTFP based physics lists.

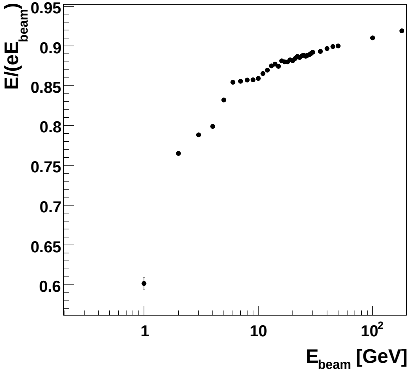
Longitudinal Profile

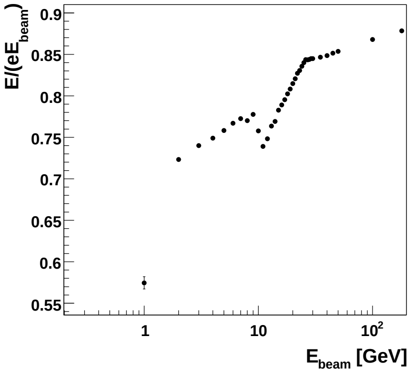




- Slightly longer showers are predicted in G4.9.2 using FTF_BIC.
- No change in QGS_BIC.

Fine Energy Scan





- Relatively smooth energy response with FTF_BIC, but some flattening below 10 GeV.
- Non-smooth energy response with QGSP_BERT.

Summary

- Hadronic showers simulated by QGSP are too short and too narrow.
- FTFP predicts too narrow showers, response is too high, longitudinal development description is better than in the case of QGSP.
- Addition of cascade models results in longer and wider showers as well as higher response and better resolution, which is generally in better agreement with the data.
- FTF based simulated showers became narrower in G4.9.2 with respect to G4.9.1, which is in worse agreement with the data. No significant change in QGS based physics list.
- Showers simulated with FTF based physics list became longer in G4.9.2, better agreement with the data. No change in QGS based physics lists.
- Non-smooth energy response dependence on beam energy is observed with in QGSP_BERT physics list in the interaction model transition regions. FTF_BIC has significantly less discontinuities.

Backup