Comparison of Geant4.9.3 results to ATLAS TileCal test-beam data

Tancredi Carli
CERN
Margar Simonyan
Niels Bohr Institute, Copenhagen University

LCG Physics Validation meeting

Outline

1. Introduction
   - ATLAS Tile Calorimeter
   - Test Beam Setup
2. Data vs. G4.9.3
   - Pion and Proton Response
   - Shower Lateral Spread
   - Longitudinal Shower Profile
3. Fine Energy Scan
4. Summary

Outline

1. Introduction
   - ATLAS Tile Calorimeter
   - Test Beam Setup
2. Data vs. G4.9.3
   - Pion and Proton Response
   - Shower Lateral Spread
   - Longitudinal Shower Profile
3. Fine Energy Scan
4. Summary

Outline

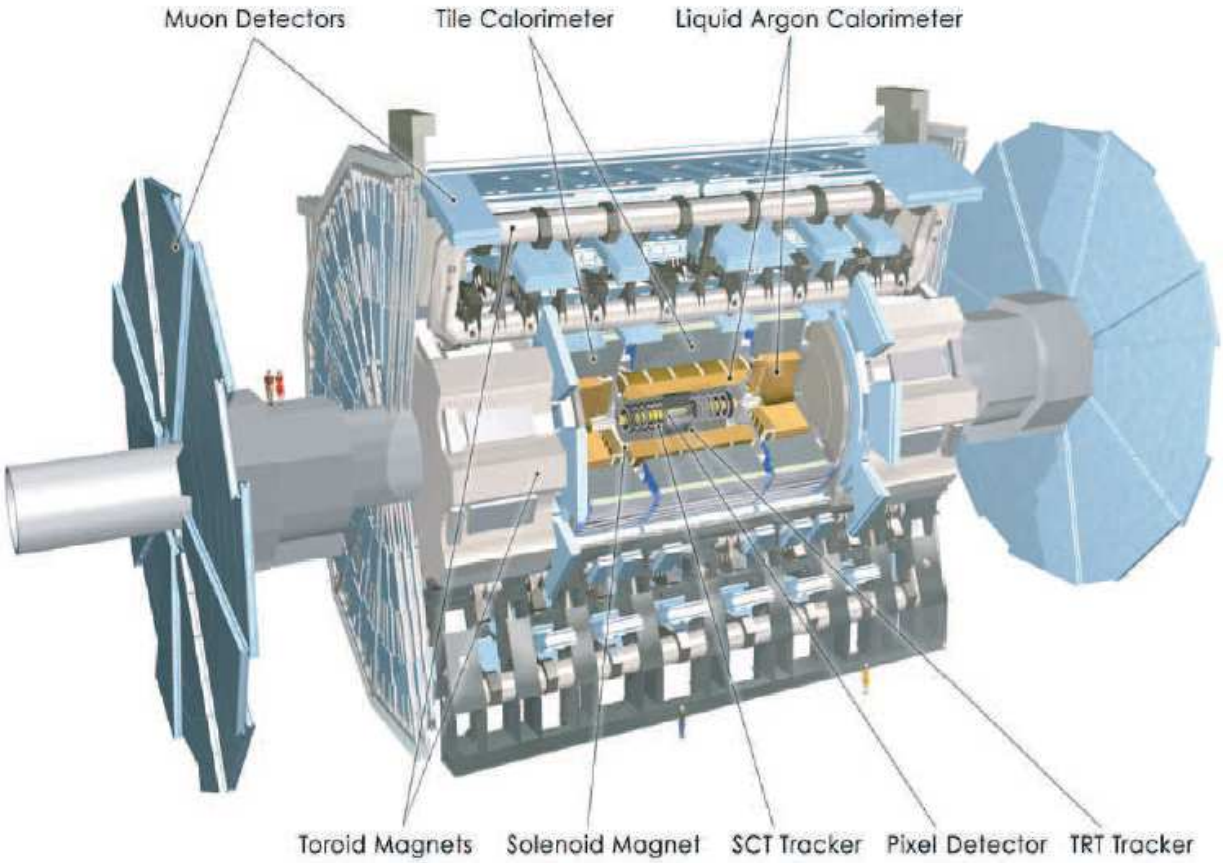
1. Introduction
   - ATLAS Tile Calorimeter
   - Test Beam Setup
2. Data vs. G4.9.3
   - Pion and Proton Response
   - Shower Lateral Spread
   - Longitudinal Shower Profile
3. Fine Energy Scan
4. Summary

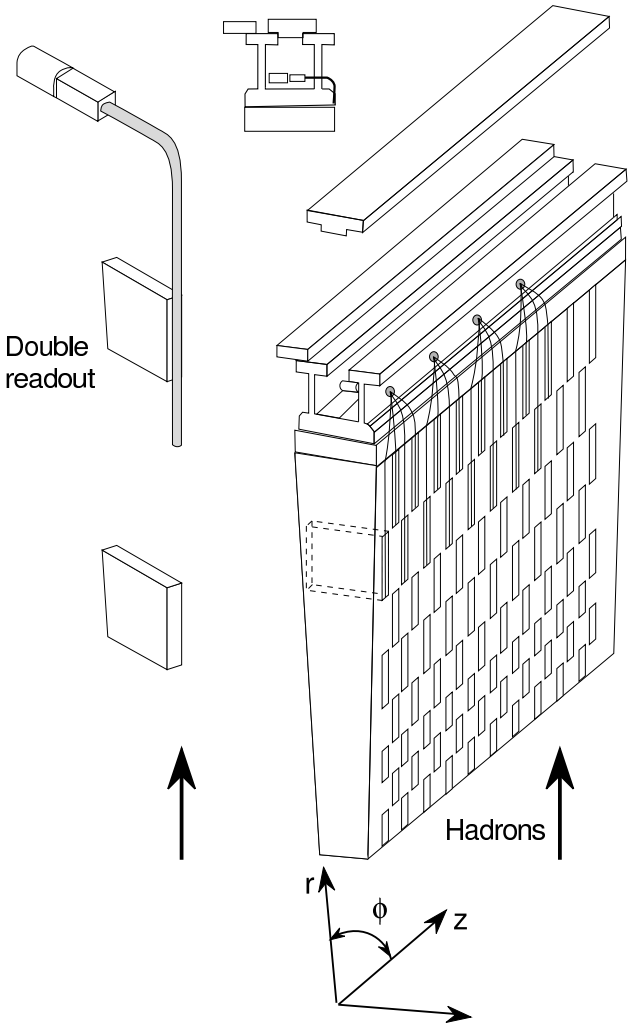
Outline

1. Introduction
   - ATLAS Tile Calorimeter
   - Test Beam Setup
2. Data vs. G4.9.3
   - Pion and Proton Response
   - Shower Lateral Spread
   - Longitudinal Shower Profile
3. Fine Energy Scan
4. Summary

ATLAS Tile Calorimeter

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

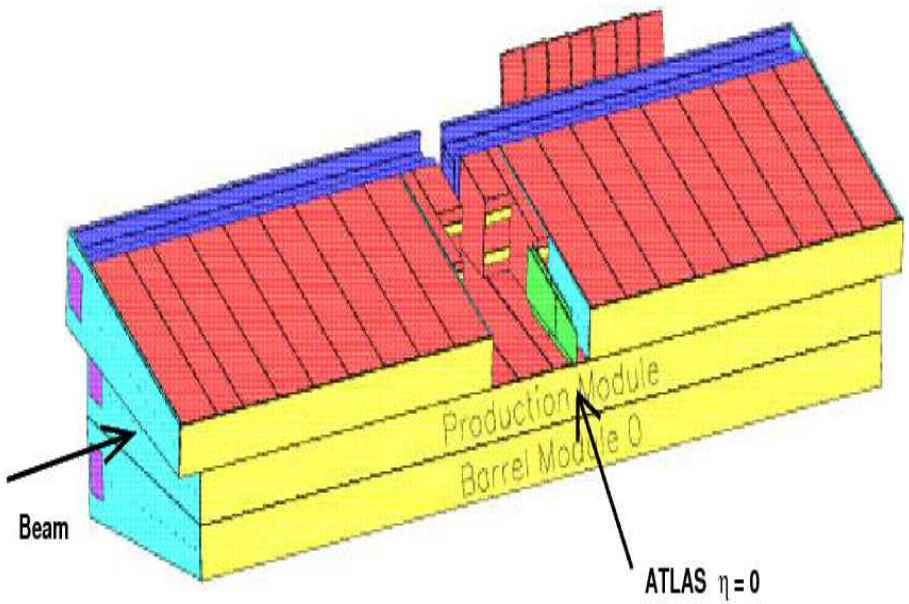




Test Beam Setup

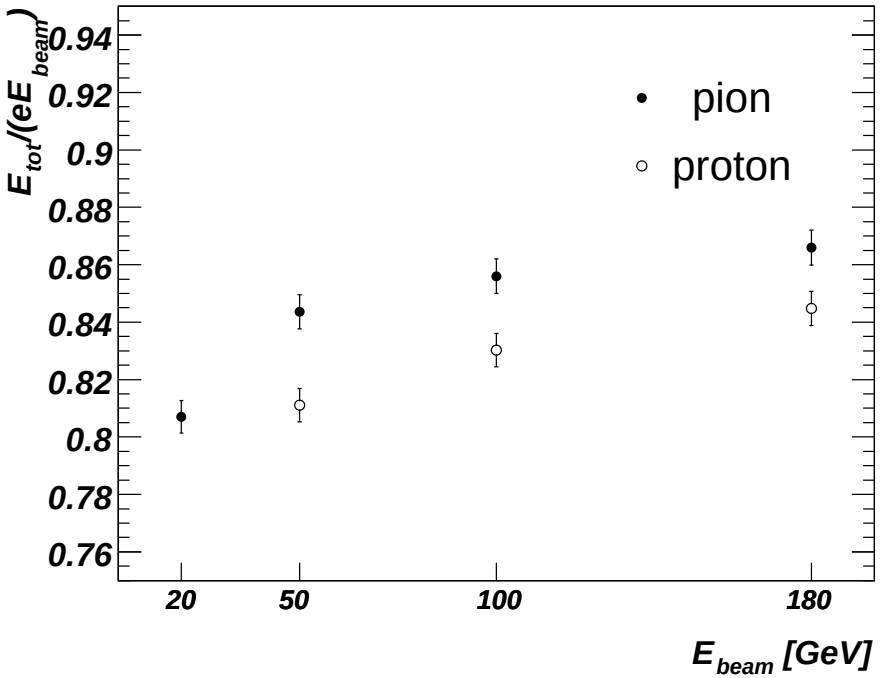
Special Runs

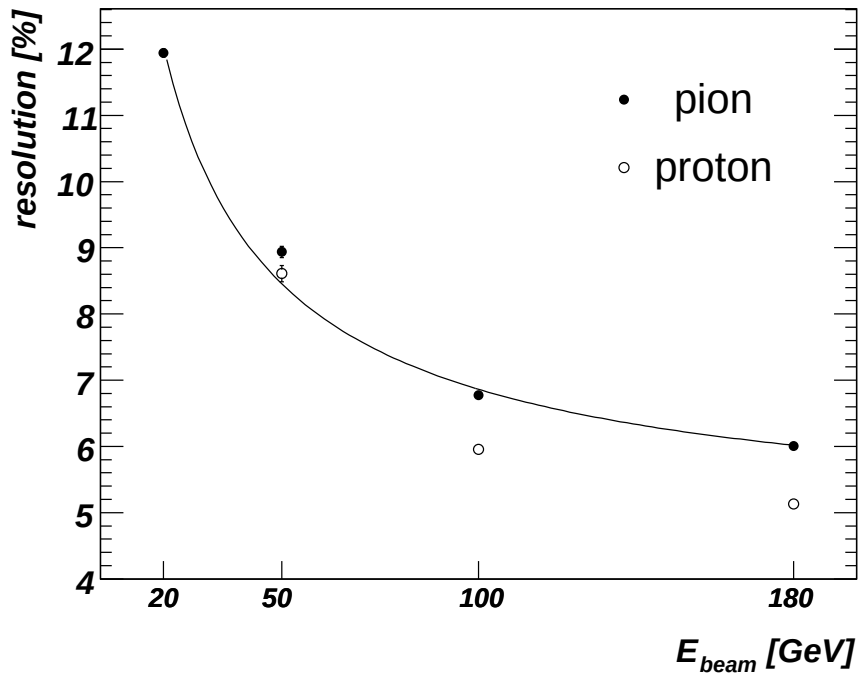
- Beam impinging the detector from the side.
- The depth is more than 25 nuclear interaction lengths (λ).
- Longitudinally showers are fully contained.
- Lateral containment of showers is more than 99%.
- Pion/proton separation is done by Cherenkov detector.



Pion and Proton Response

EM-scale from electron response.

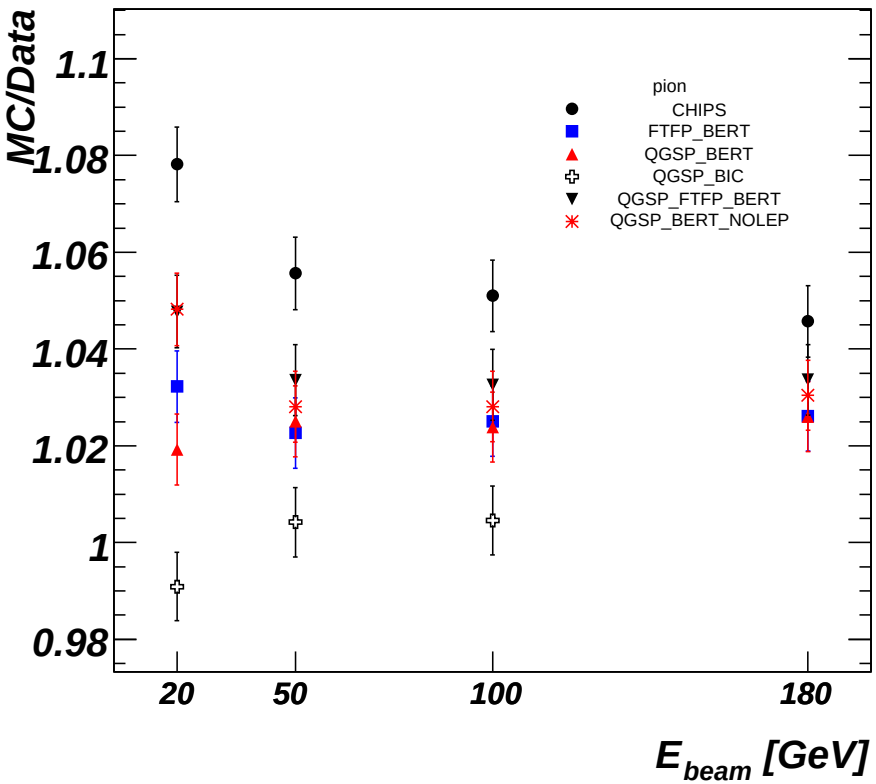




- Pions have larger response, but worse resolution.

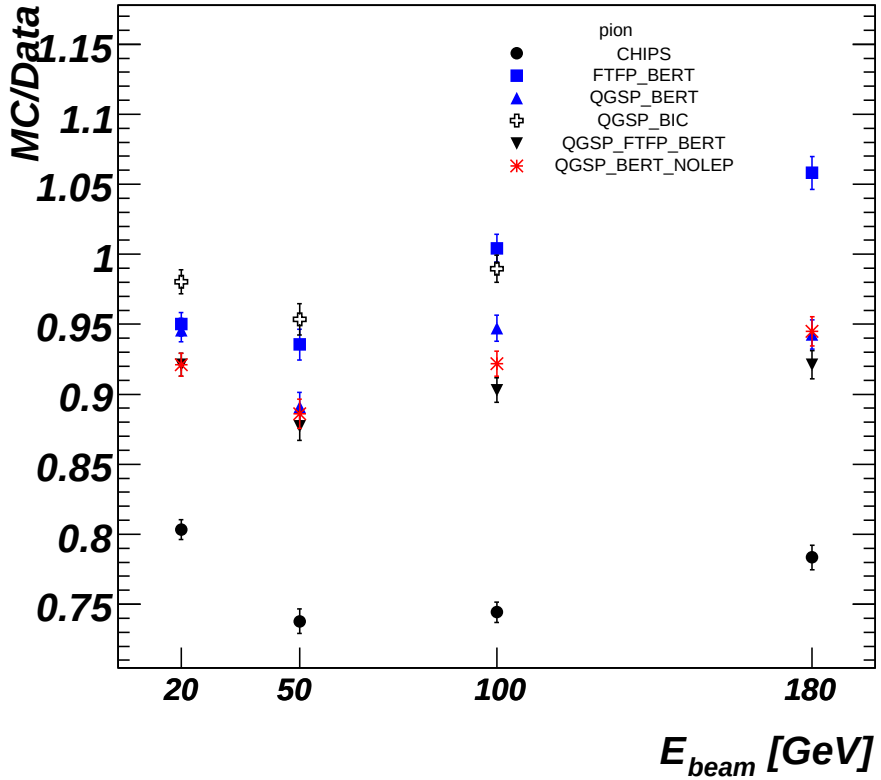
Pion Response and Resolution

Response



- CHIPS predicts too high response. QGSP_BIC describes data better.

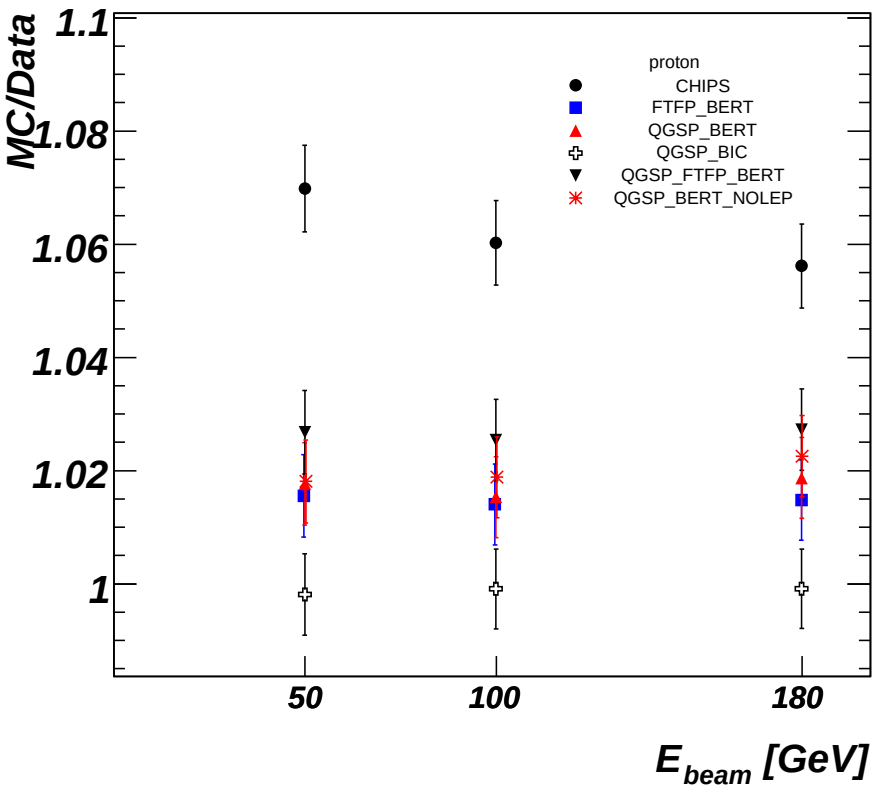
Resolution



- Too good resolution with CHIPS, within $\pm$ 10% with cascade models.

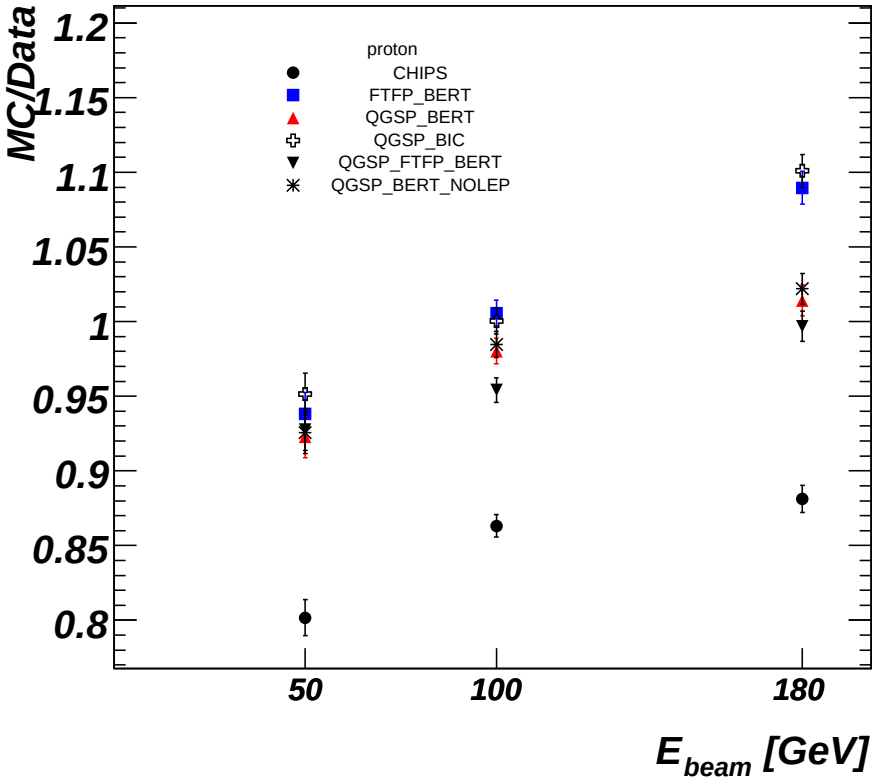
Proton Response and Resolution

Response



- The response is too high with CHIPS. Best description by QGSP_BIC.

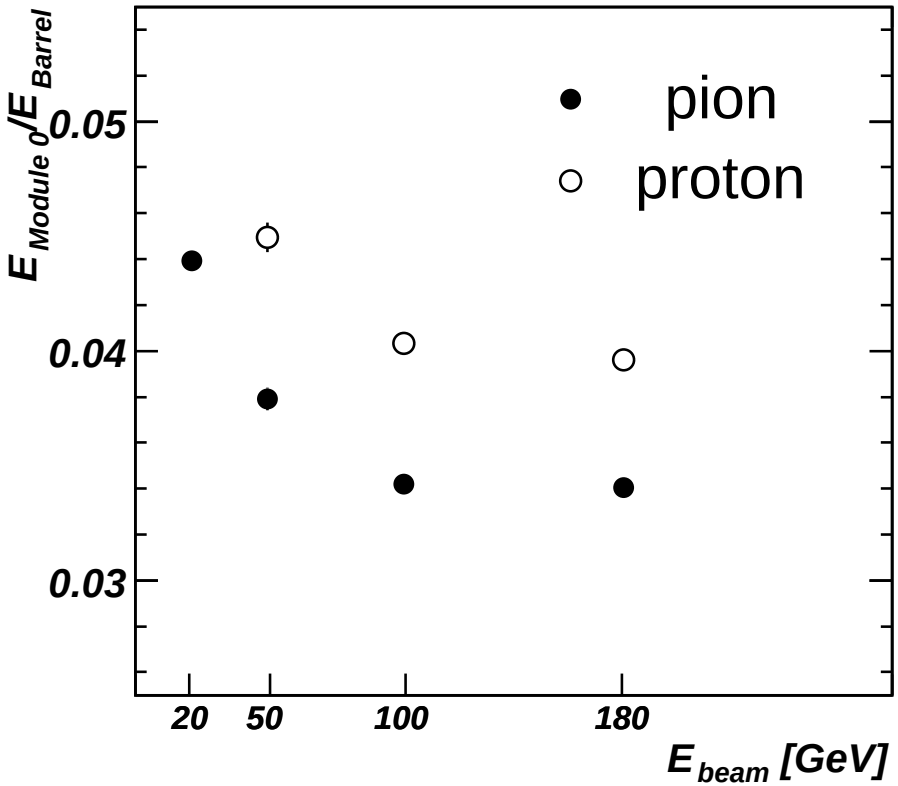
Resolution

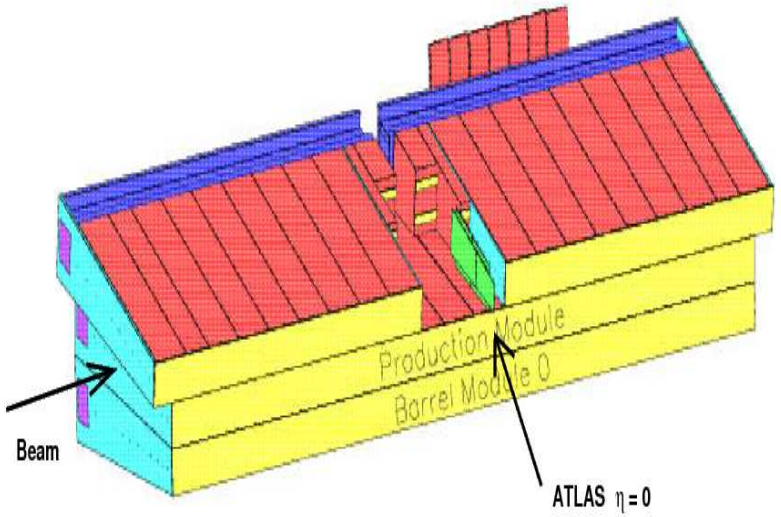


- Too good resolution with CHIPS.

Lateral Spread

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

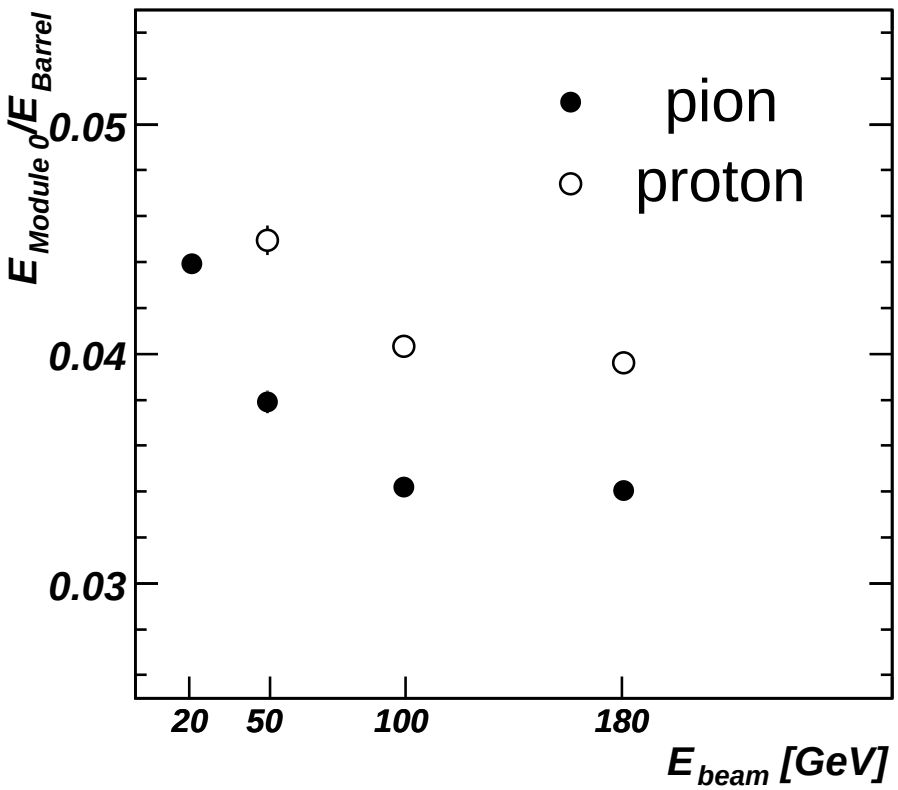


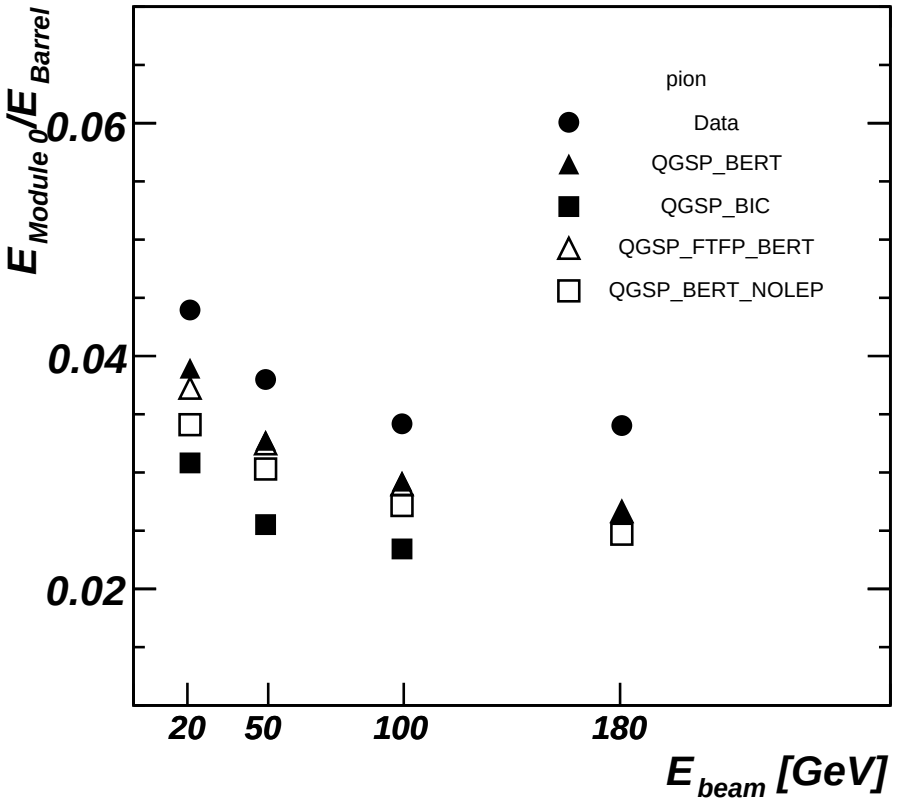


- Proton induced showers are wider than pion induced ones.
- All models predict narrow showers.
- QGSP_BERT is closer to data.

Lateral Spread

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

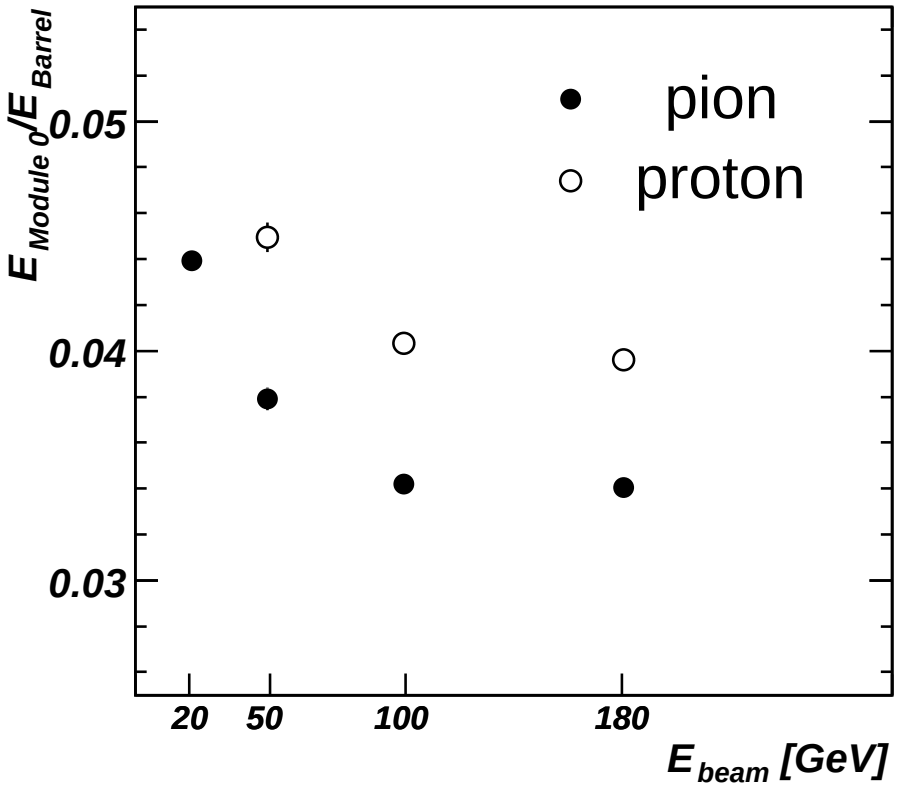


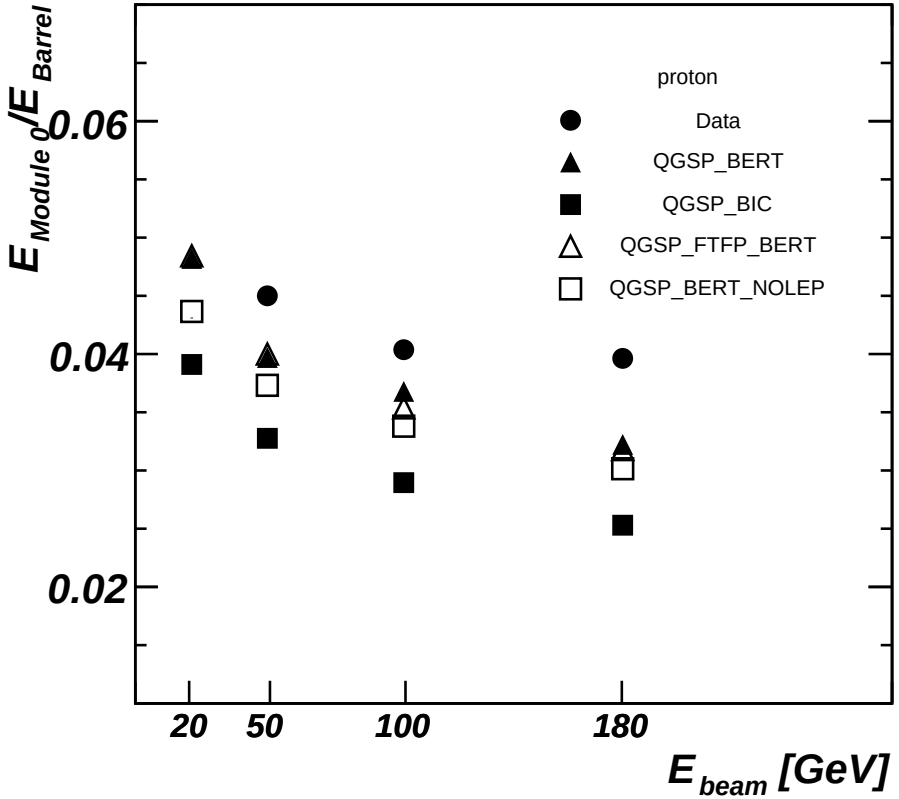


- Proton induced showers are wider than pion induced ones.
- All models predict narrow showers.
- QGSP_BERT is closer to data.

Lateral Spread

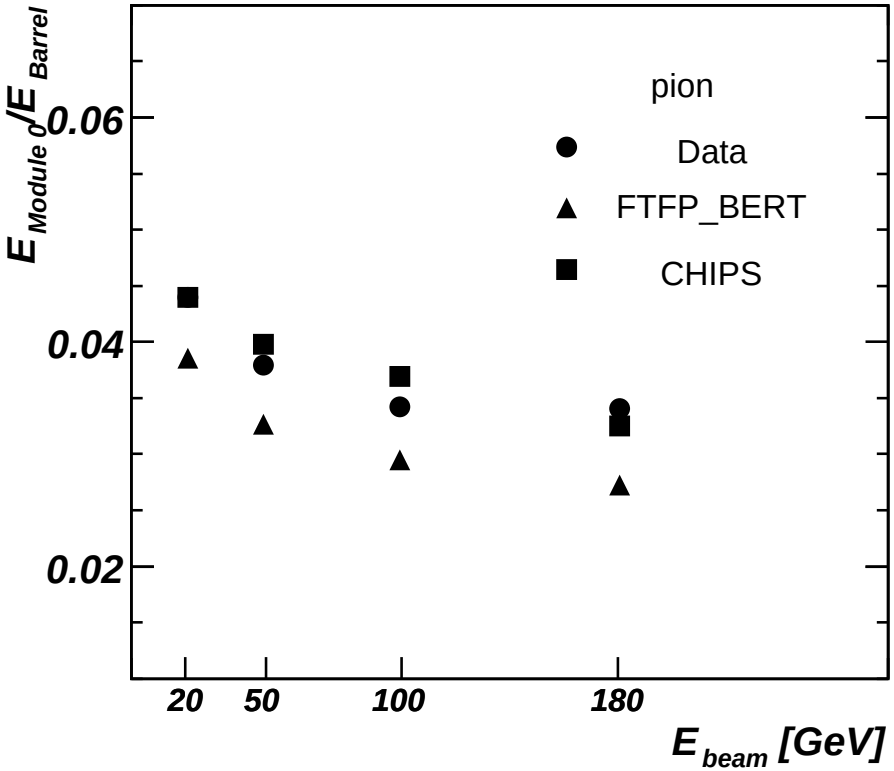
The ratio of energy measured in the bottom and central modules is an estimate of lateral spread.

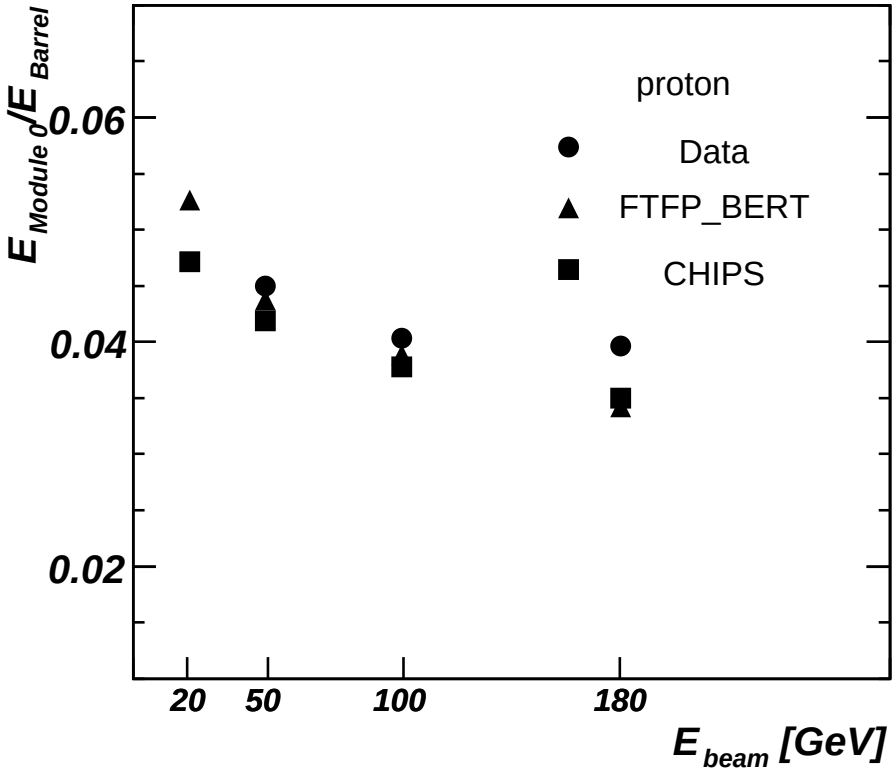




- Proton induced showers are wider than pion induced ones.
- All models predict narrow showers.
- QGSP_BERT is closer to data.

Lateral Spread

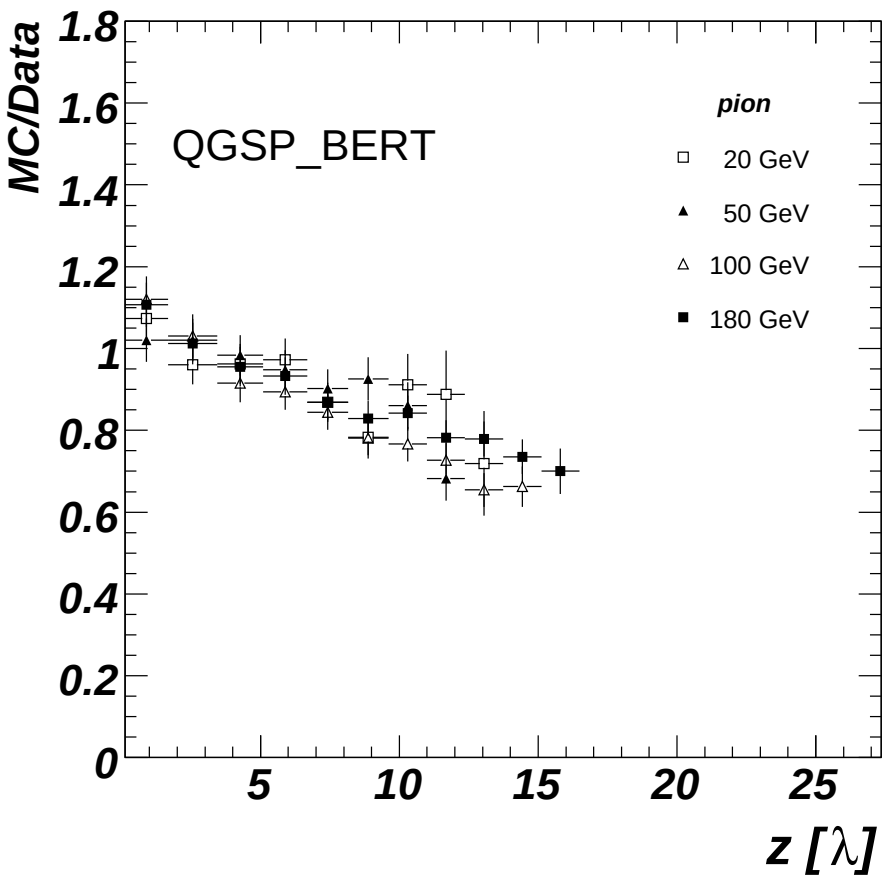


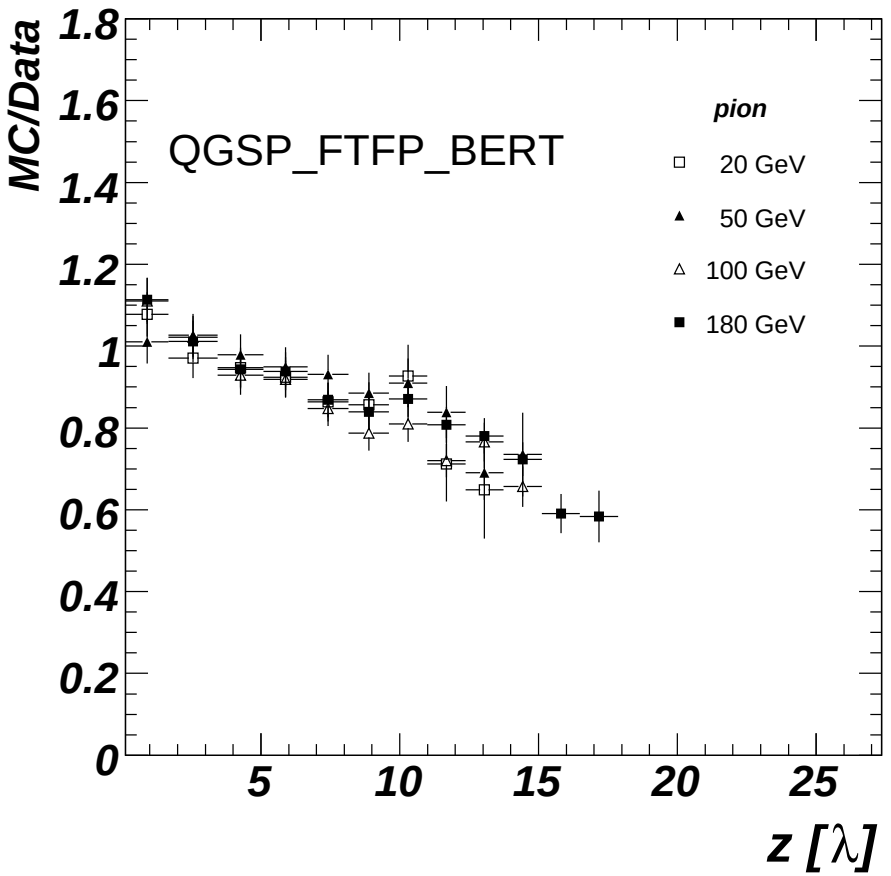


- CHIPS describes data well.
- Both CHIPS and FTFP_BERT describe data at the same level.

Longitudinal Profile

Pions

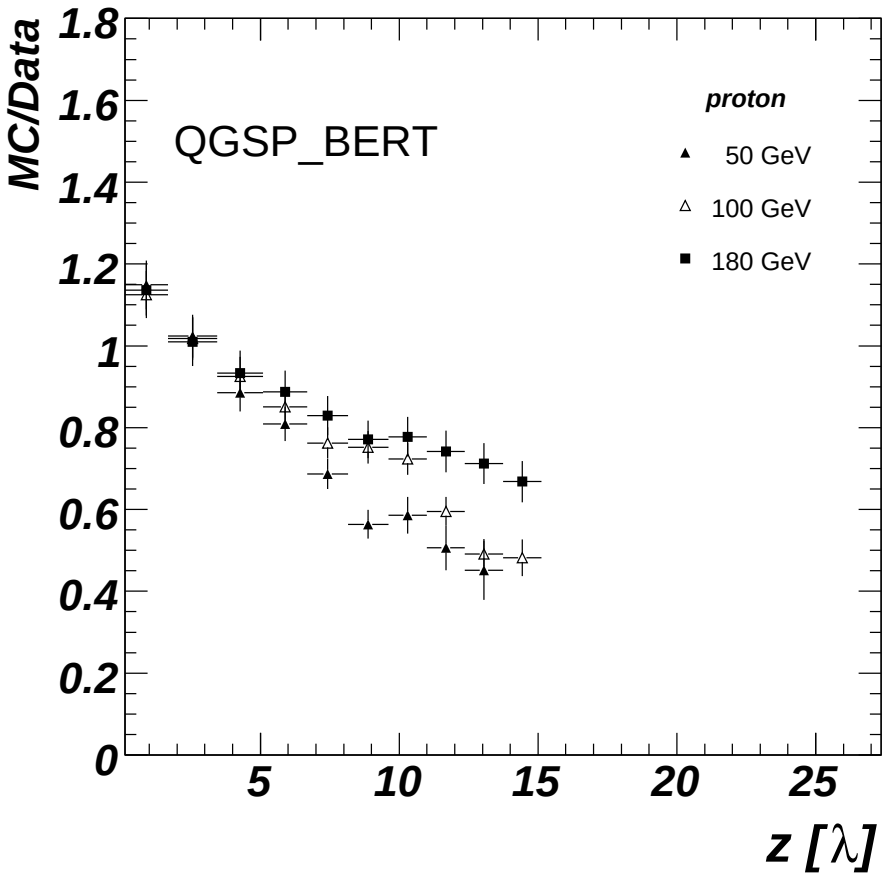


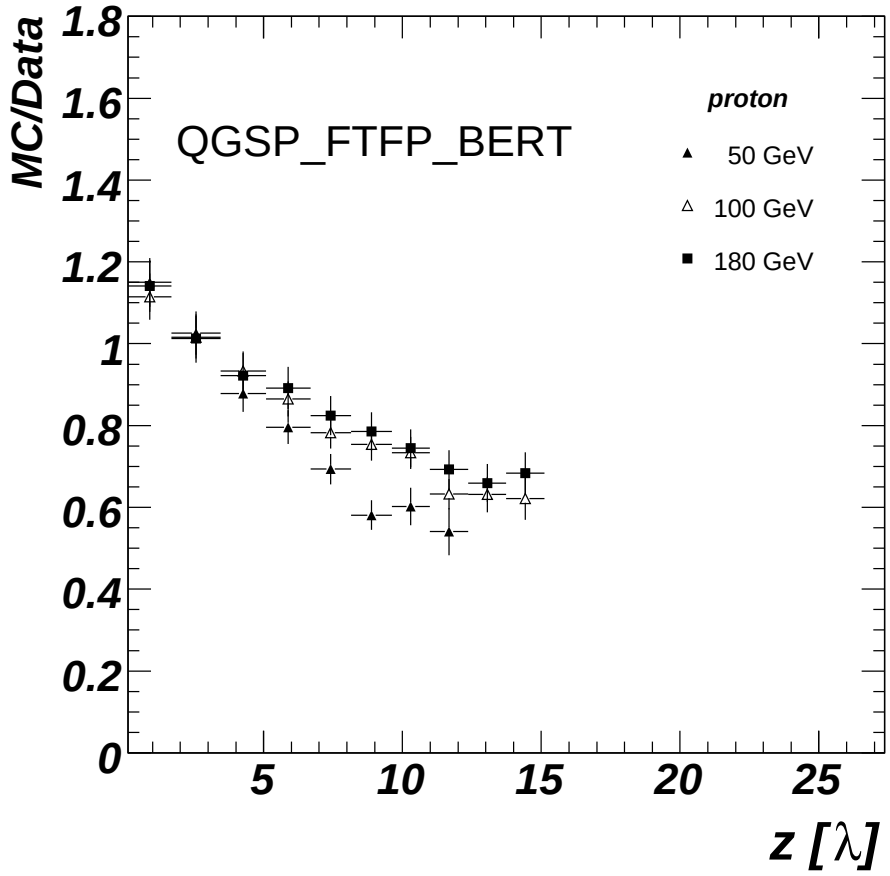


- Showers simulated with QGSP_BERT are short, 20% less energy at 10λ.
- Replacing LEP by FTFP does not change longitudinal shower profile.

Longitudinal Profile

Protons

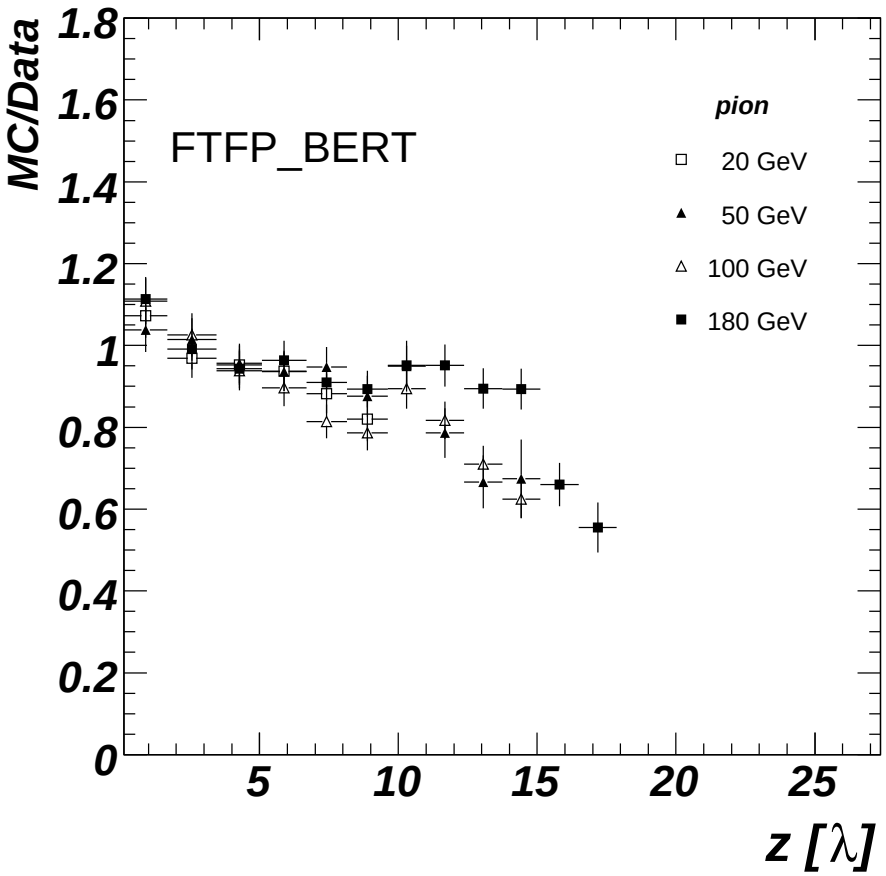


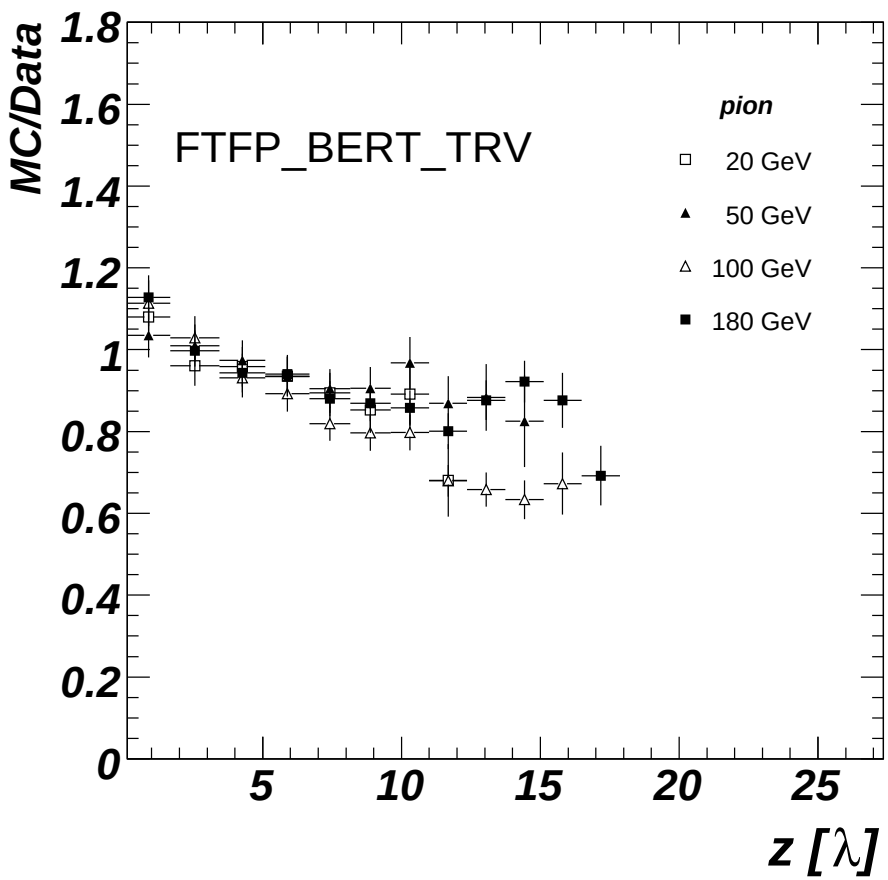


- Simulated showers are too short, at 10λ 30% less energy.
- Replacing LEP by FTFP does not change longitudinal shower profile.
- Protons are described worse than pions.

Longitudinal Profile

Pions

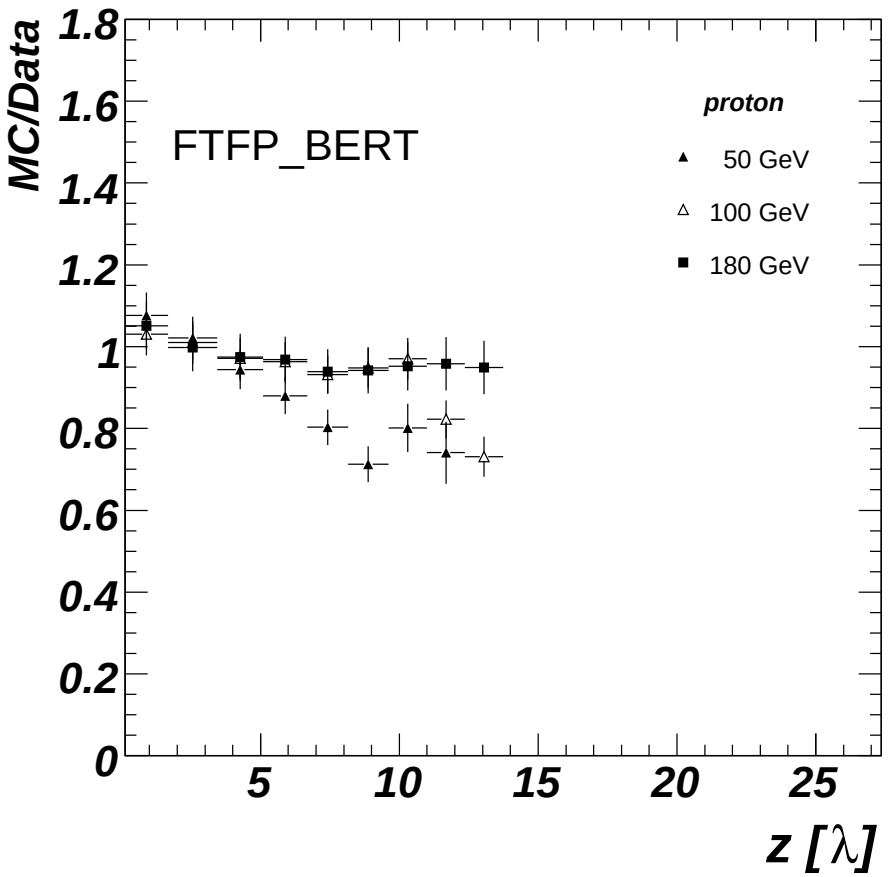


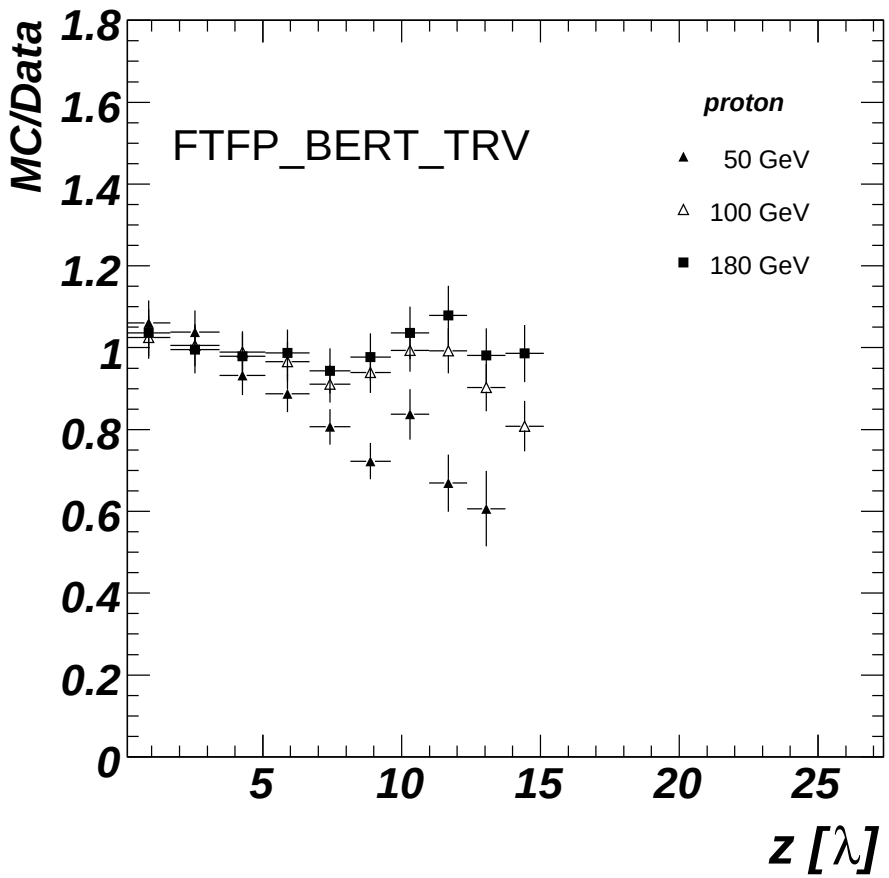


- With Fritiof model showers are a bit shorter, up to 10λ within $\pm$20%.
- Changing the Bertini applicability limit does not affect longitudinal shower development.

Longitudinal Profile

Protons

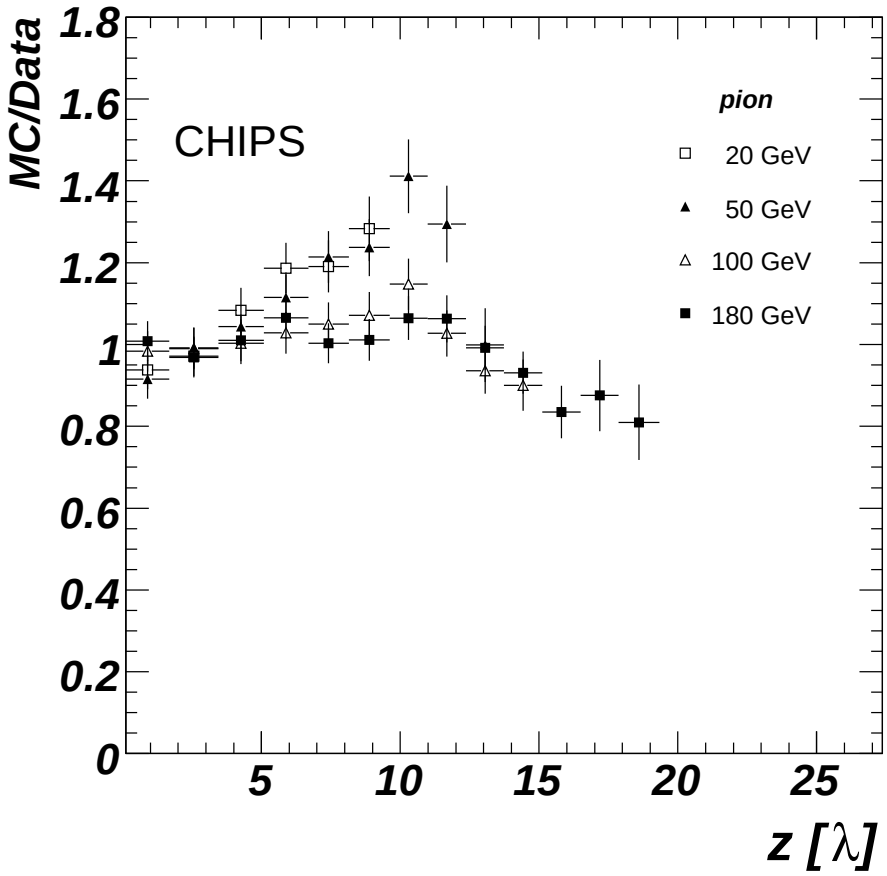


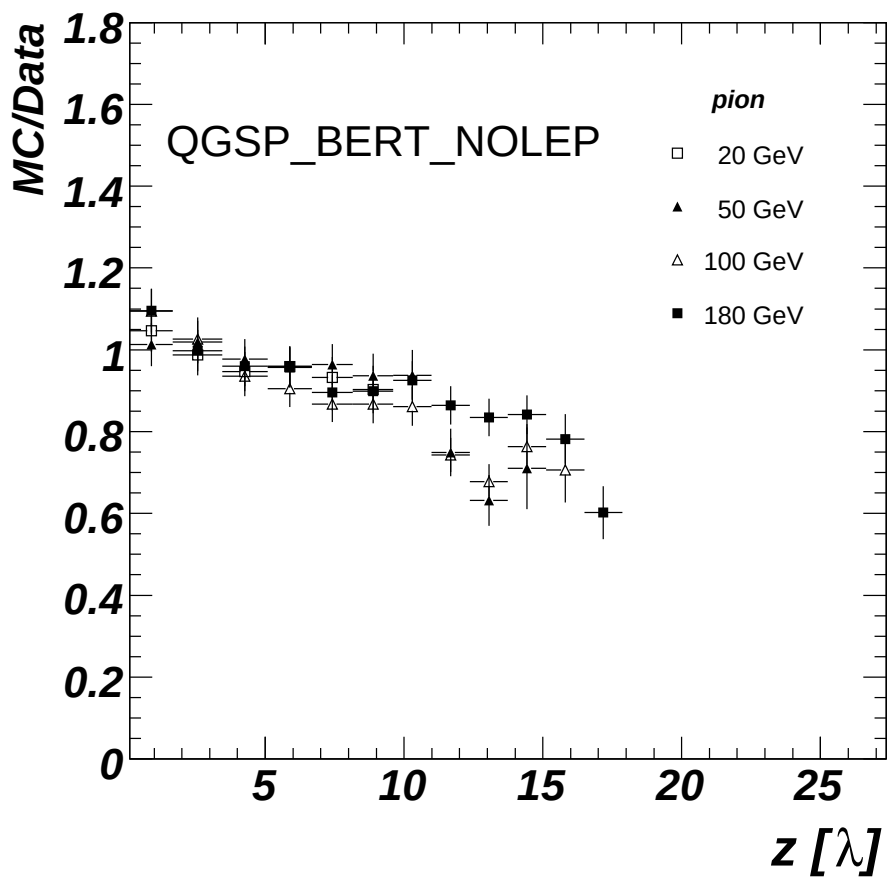


- Up to 10λ $\pm$20% agreement.
- Changing the Bertini applicability limit does not affect longitudinal shower development.

Longitudinal Profile

Pions

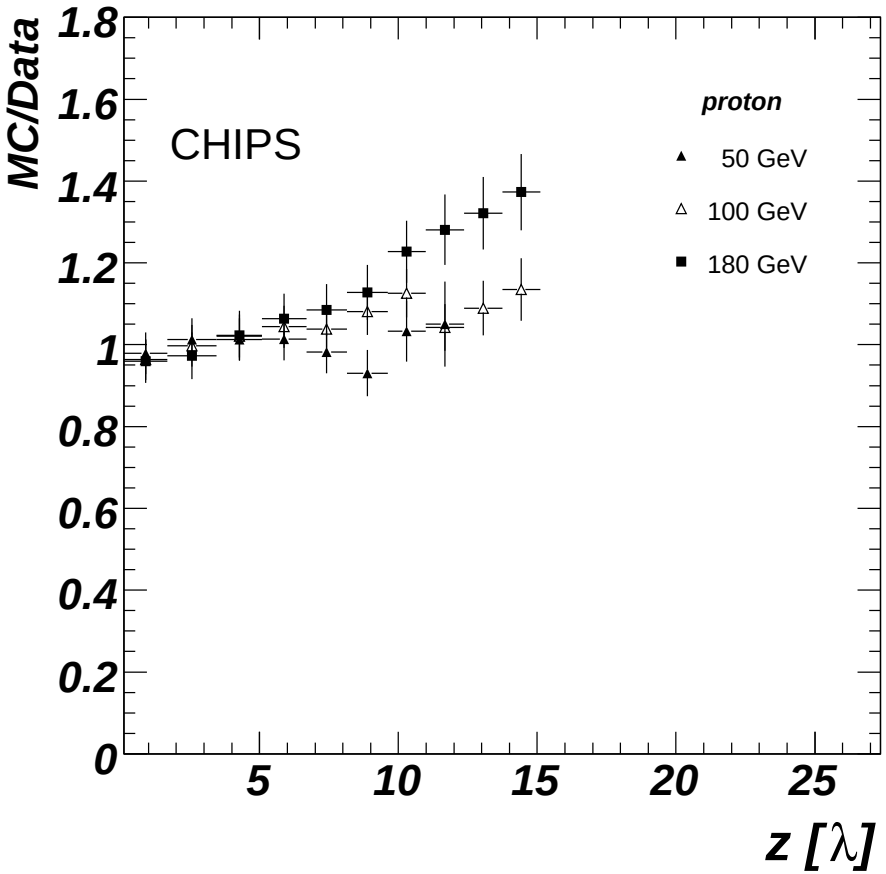


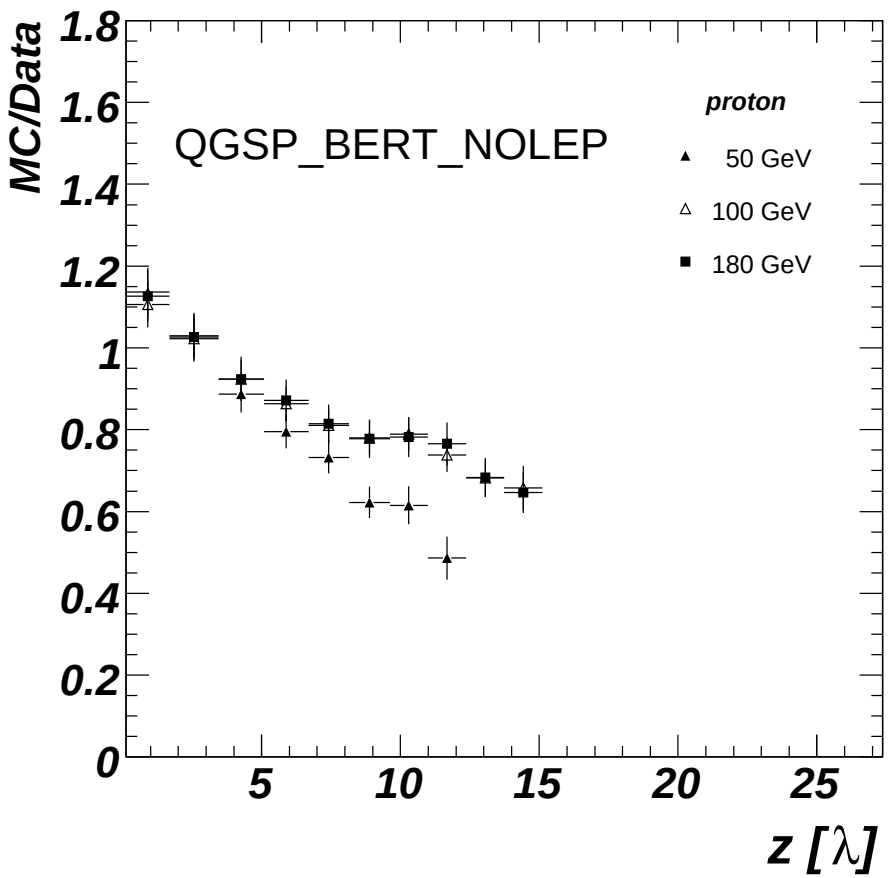


- CHIPS predict longer showers than in data, at 10λ 20% more energy.
- Up to 10λ within $\pm$10%.

Longitudinal Profile

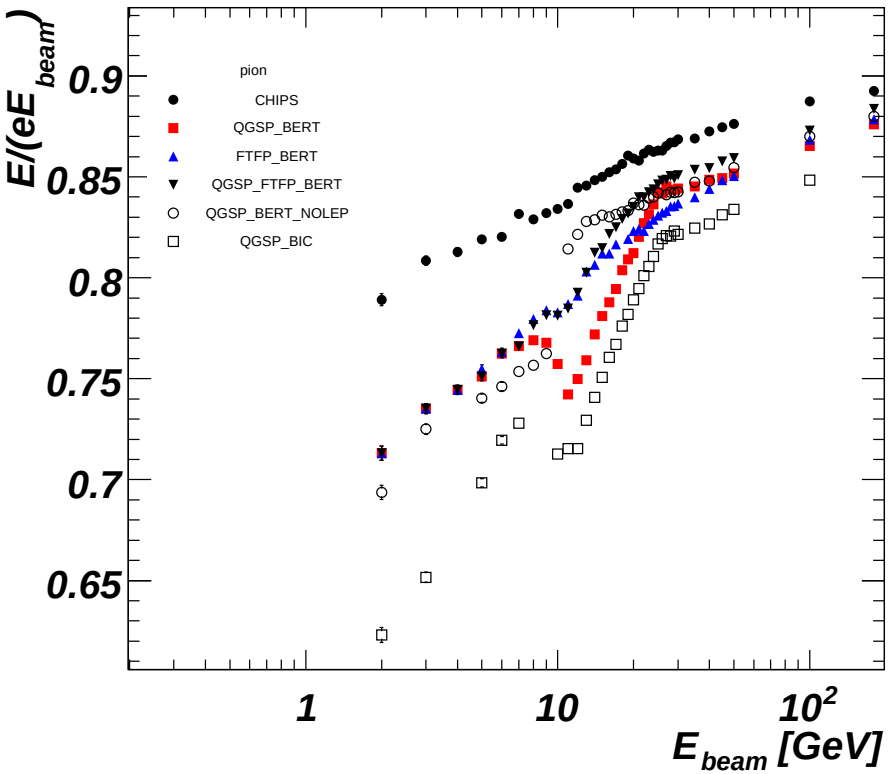
Protons

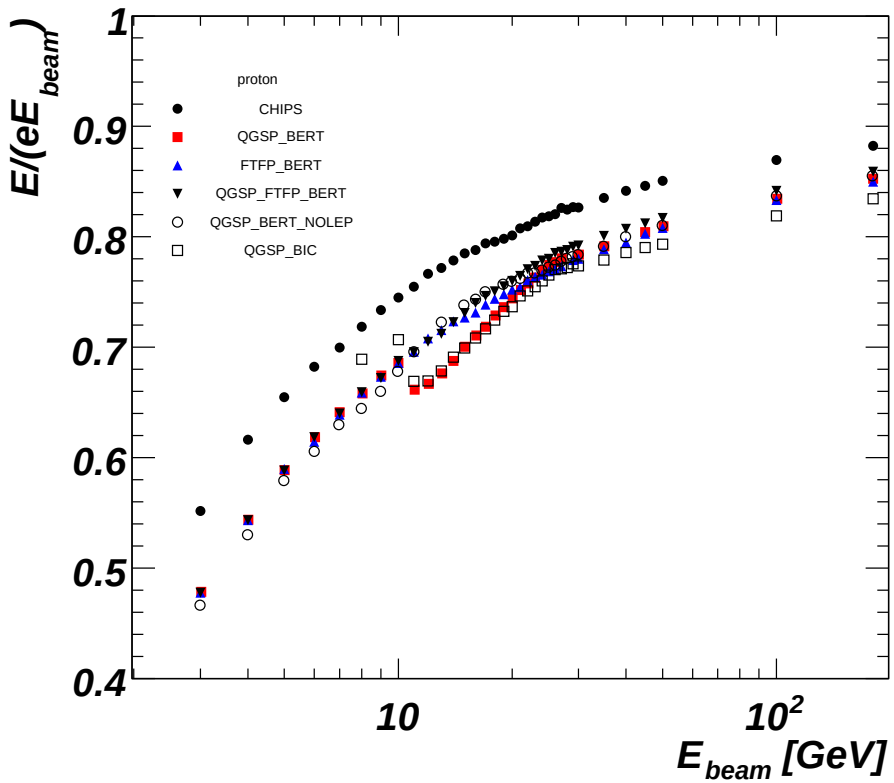




- Proton induced shower profiles are slightly longer with CHIPS.
- Showers are too short, at 10λ $20 - 40\%$ less energy.

Fine Energy Scan





- Unphysical energy dependence of response, the effect is larger in QGSP_BERT. For protons, QGSP_BIC has the largest discontinuity. CHIPS predict smooth response as function of beam energy.

Summary

- CHIPS predicts too high response and too good resolution, description of longitudinal and lateral profiles are acceptable.
- FTFP_BERT is becoming better and can be a good alternative to QGSP_BERT.
- Non-smooth energy response dependence on beam energy is observed in QGS based physics lists in the interaction model transition regions. FTF based lists predict smoother response. As expected, CHIPS physics list predicts smooth response.