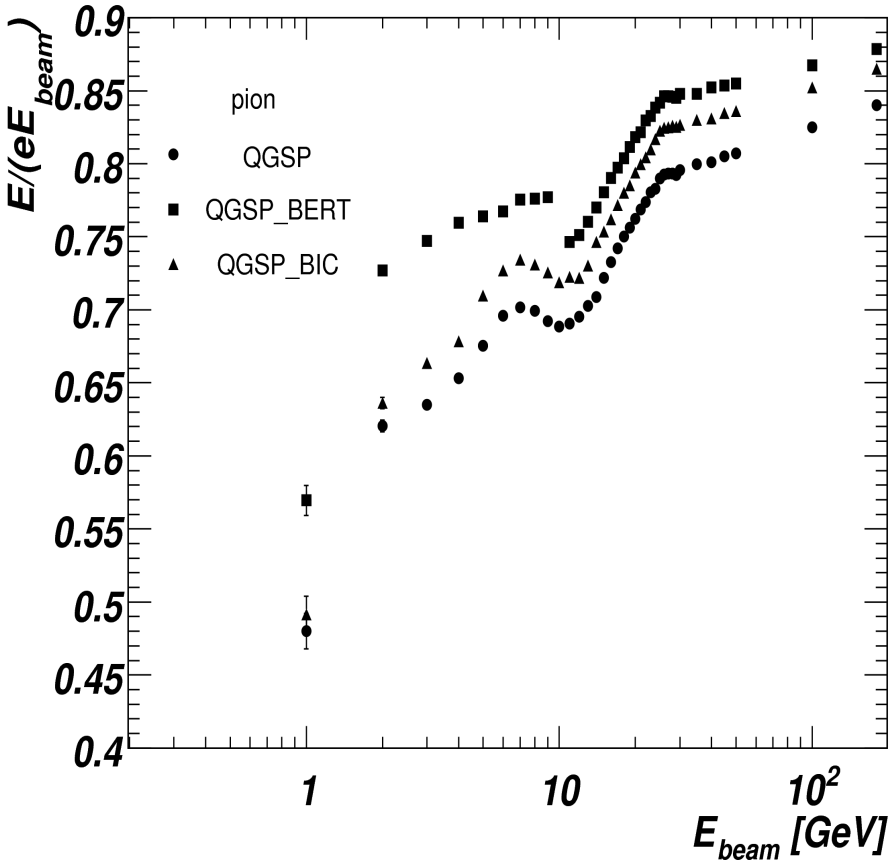
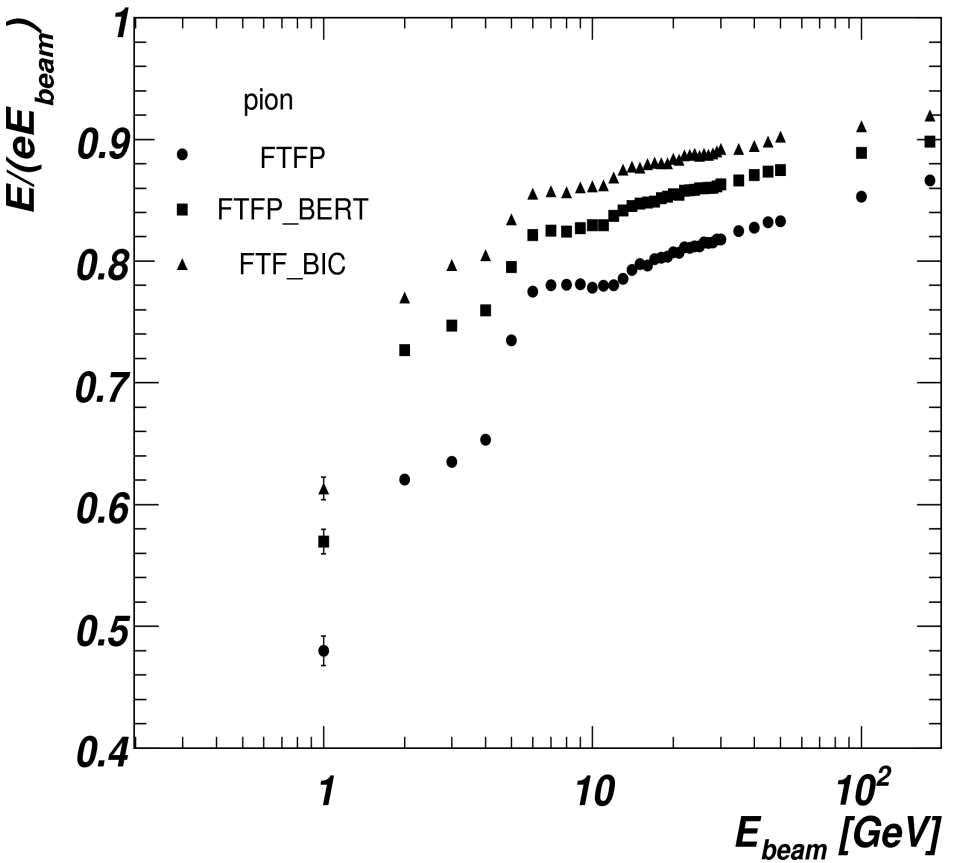
New GEANT4 Physics Lists

Tancredi Carli
(CERN)
Margar Simonyan
(LAPP)

Usual Physics List

TileCal response, G492

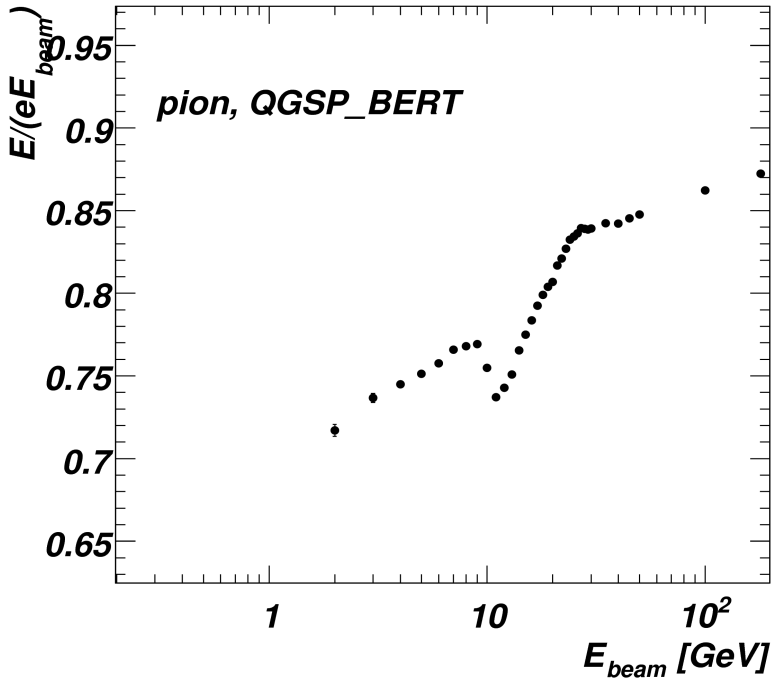


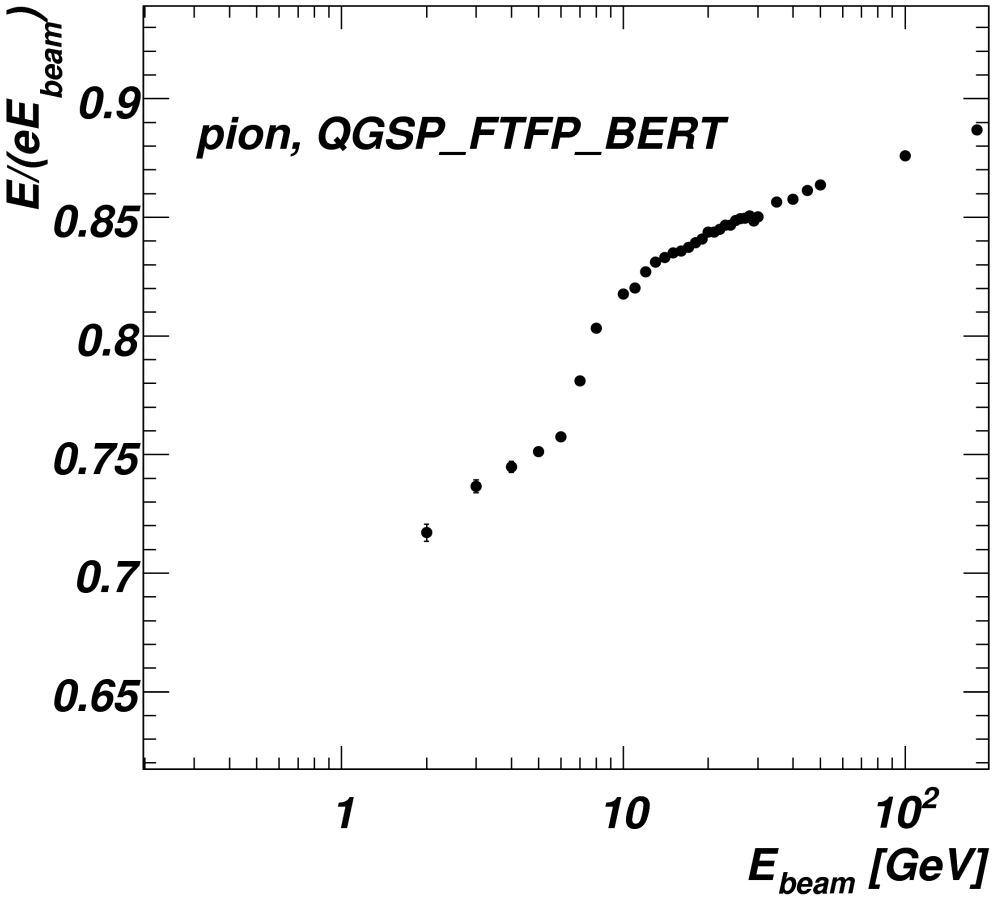


Unphysical energy dependence of the calorimeter response on beam energy. Other observables (shower depth, core, EM fraction) also have discontinuities.

New Physics Lists

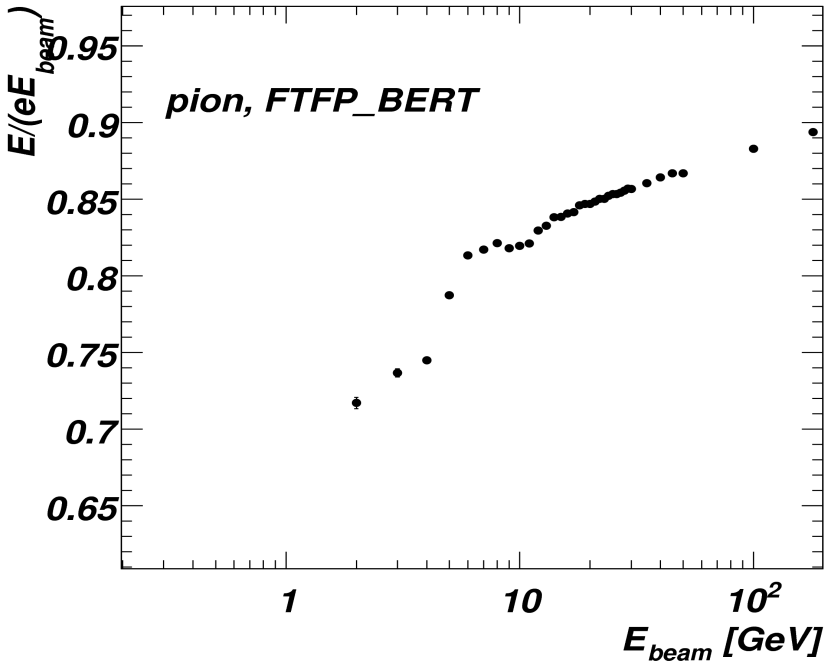
- In QGSP_FTFP_BERT the LEP model is replaced by FTF. The transition from BERT to FTF is 7-9 GeV.

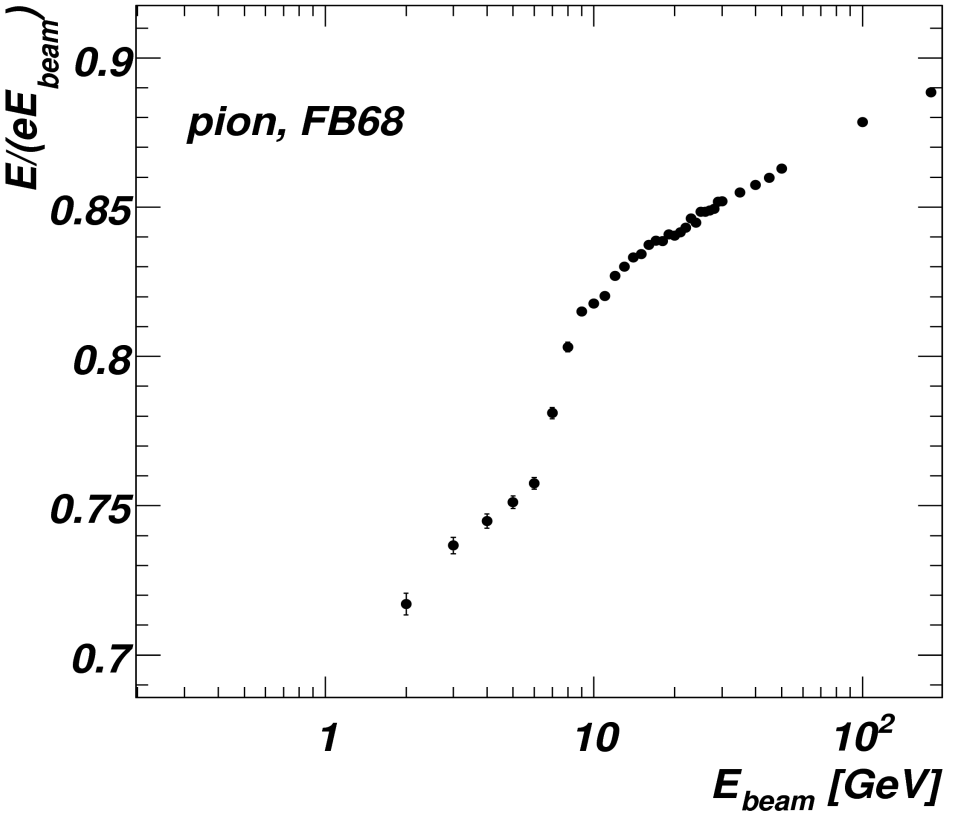




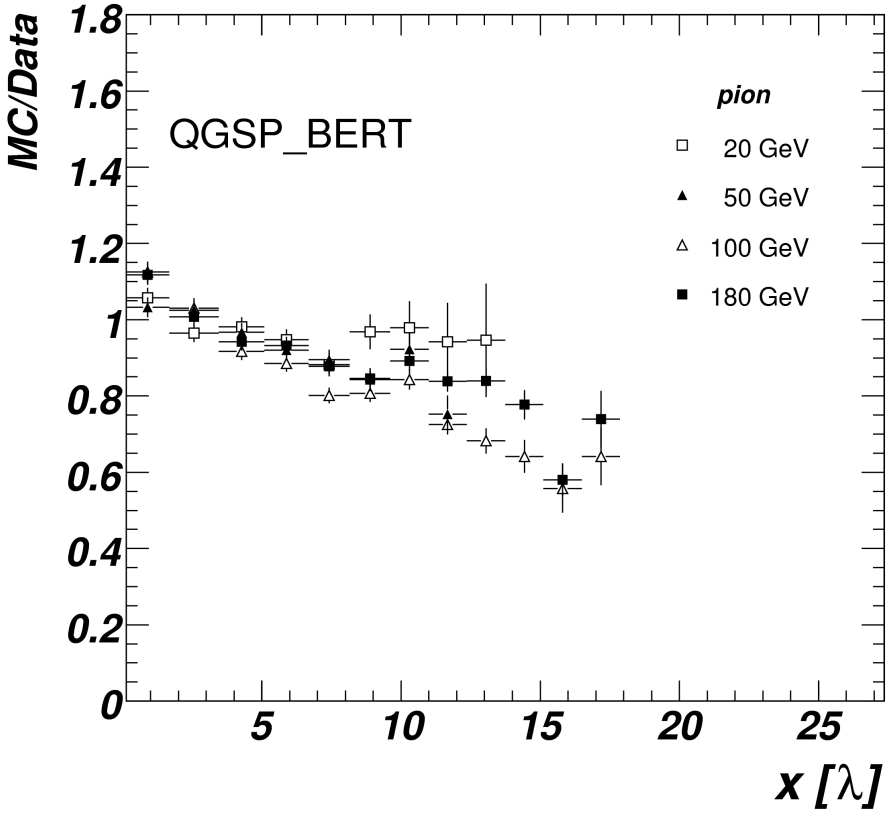
New Physics Lists

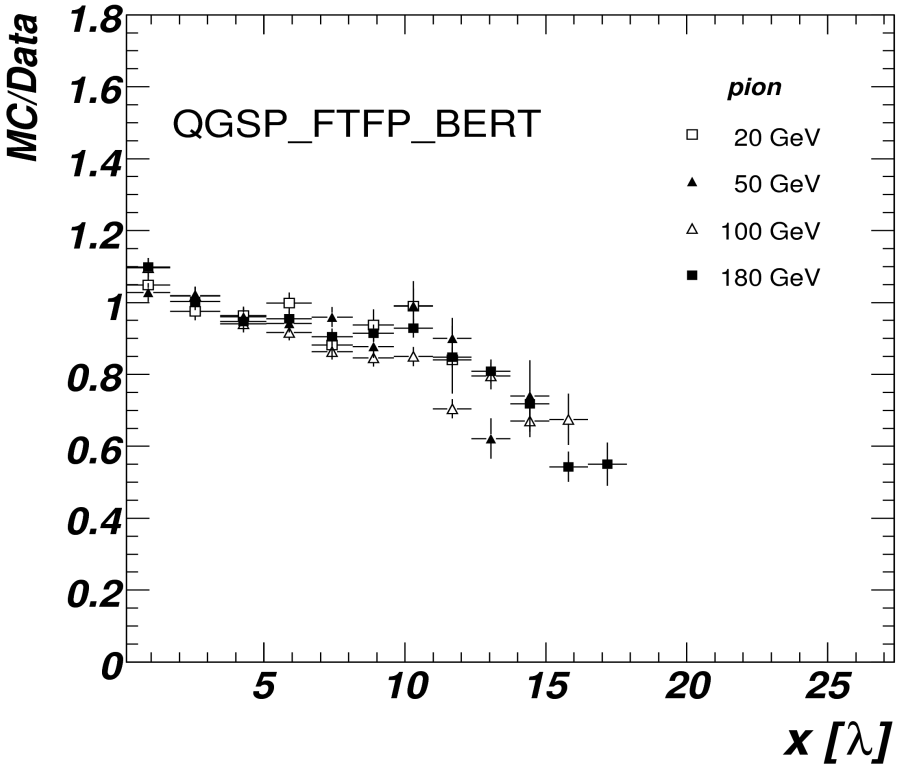
- FB68 is essentially FTFP_BERT with transition from BERT to FTF moved from 3 – 4 GeV to 6 – 8 GeV.





Shower profiles





- No change in longitudinal shower profiles, as well as in lateral spread.

Conclusions

- The calorimeter response becomes smoother with modified physics list.
- Longitudinal shower profiles, lateral spread and resolution are not changed noticeably.
- Looking forward to test QGSC_CHIPS physics list.

Backup

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

Tancredi Carli
CERN
Margar Simonyan
LAPP

LCG Physics Validation meeting

Outline

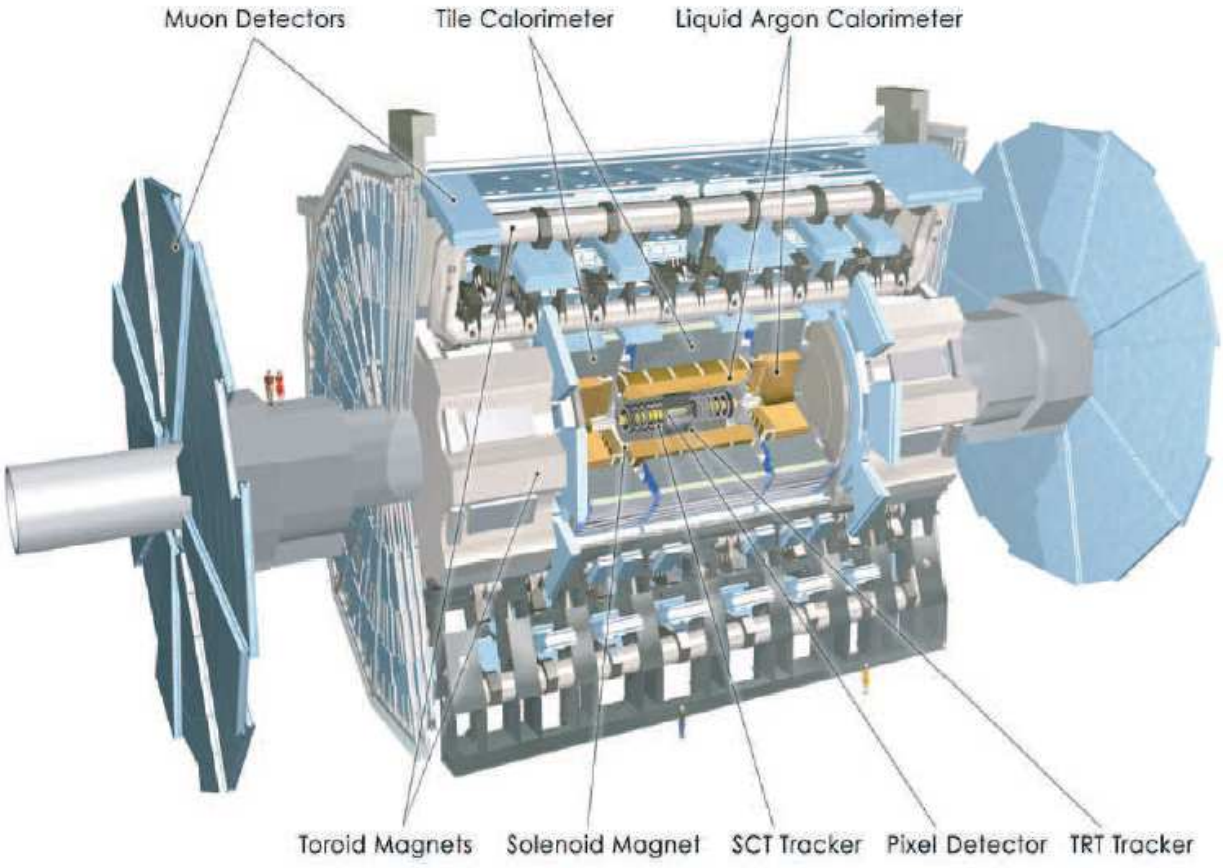
Outline

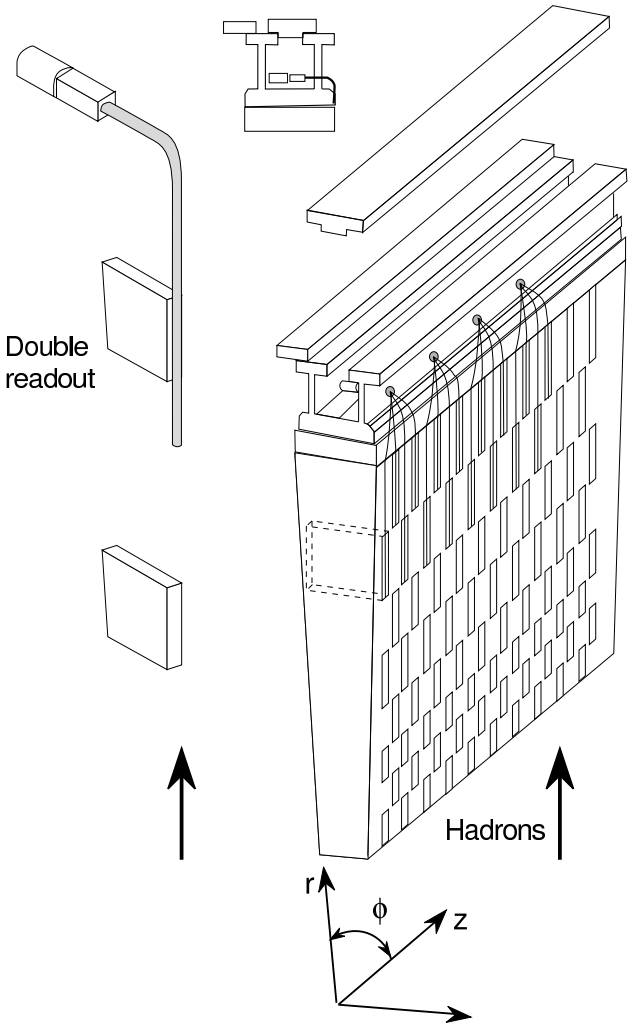
Outline

Outline

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.

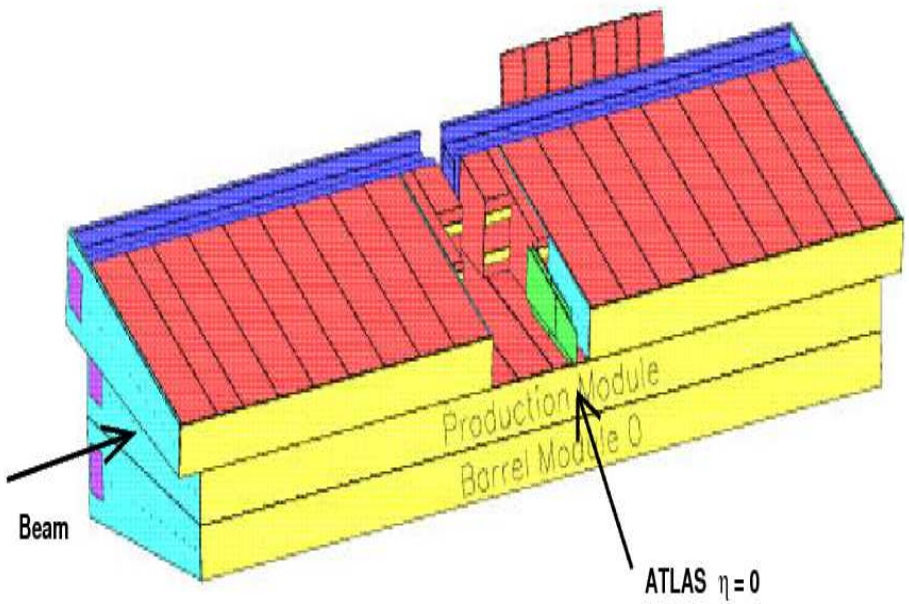




Test Beam Setup

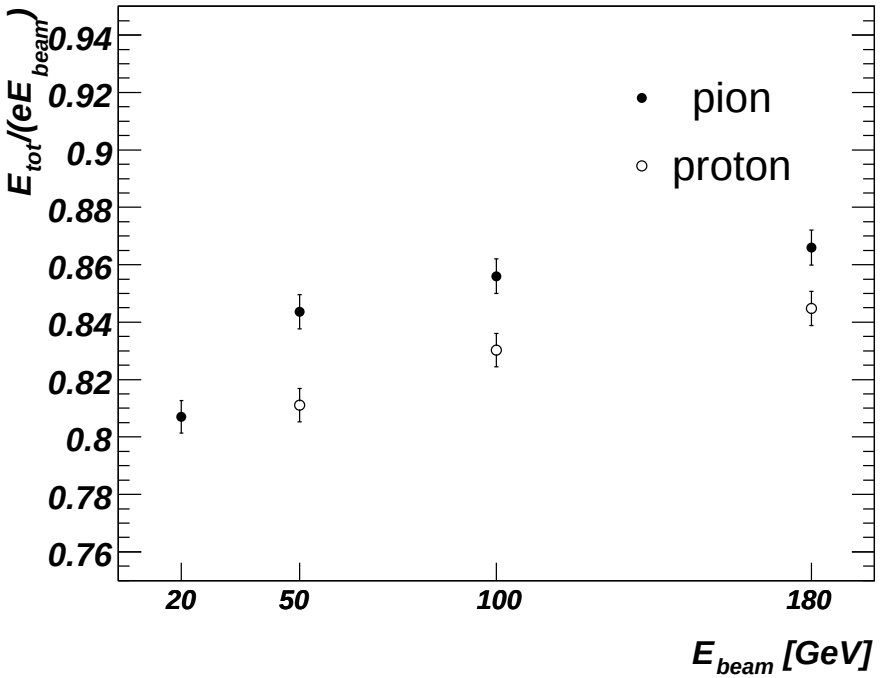
Special Runs

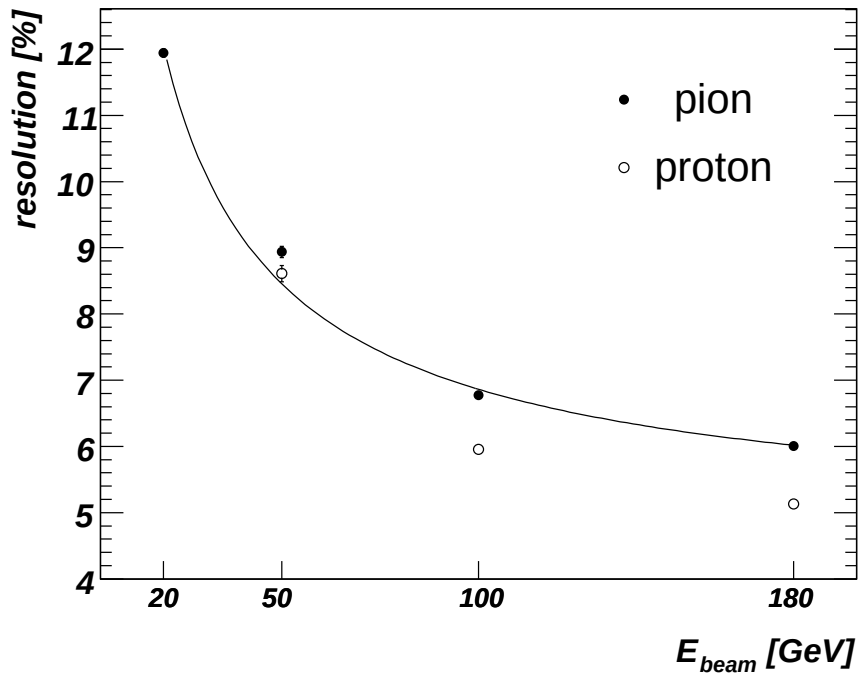
- Beam impinging the detector from the side.
- The depth is more than 25 nuclear interaction lengths (λ).
- Longitudinally showers are fully contained.
- Lateral containment of showers is more than 99%.
- Pion/proton separation is done by Cherenkov detector.



Pion and Proton Response

EM-scale from electron response.

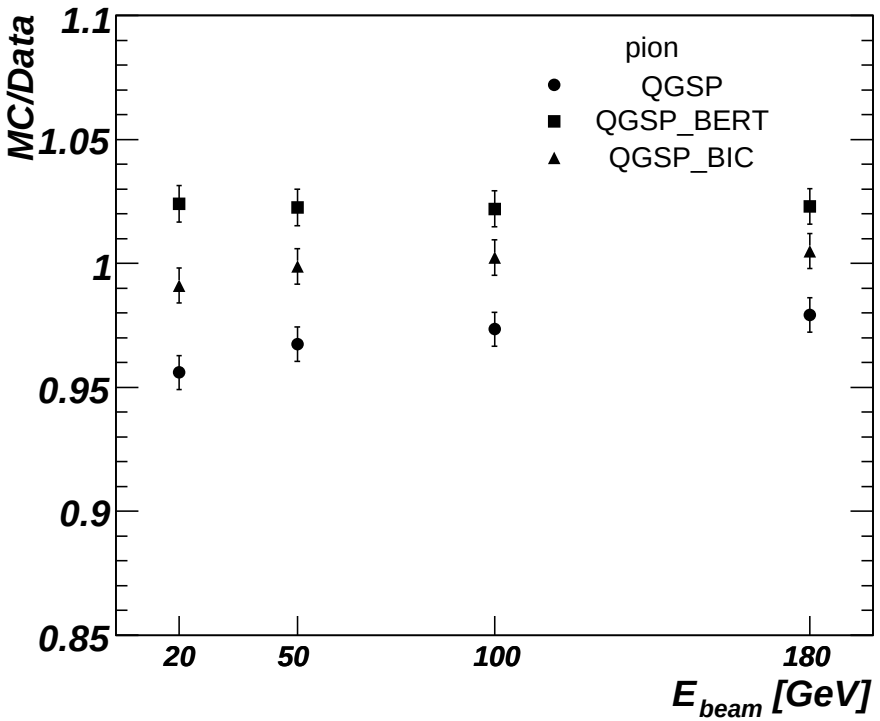




- Pions have larger response, but worse resolution.

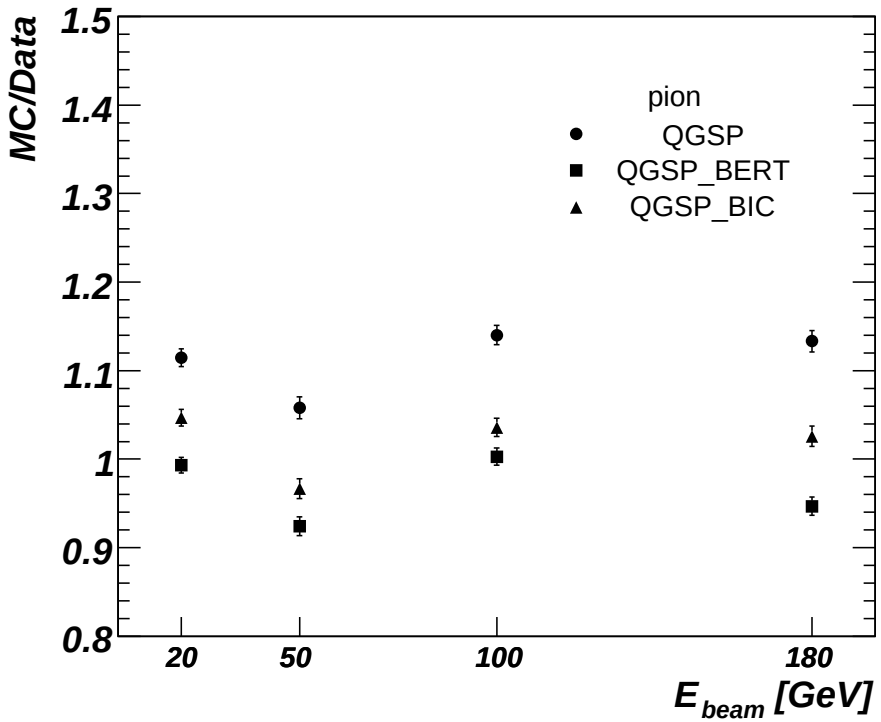
Pion Response and Resolution

Response



- Cascade models increase the response. QGSP_BIC describes data better.

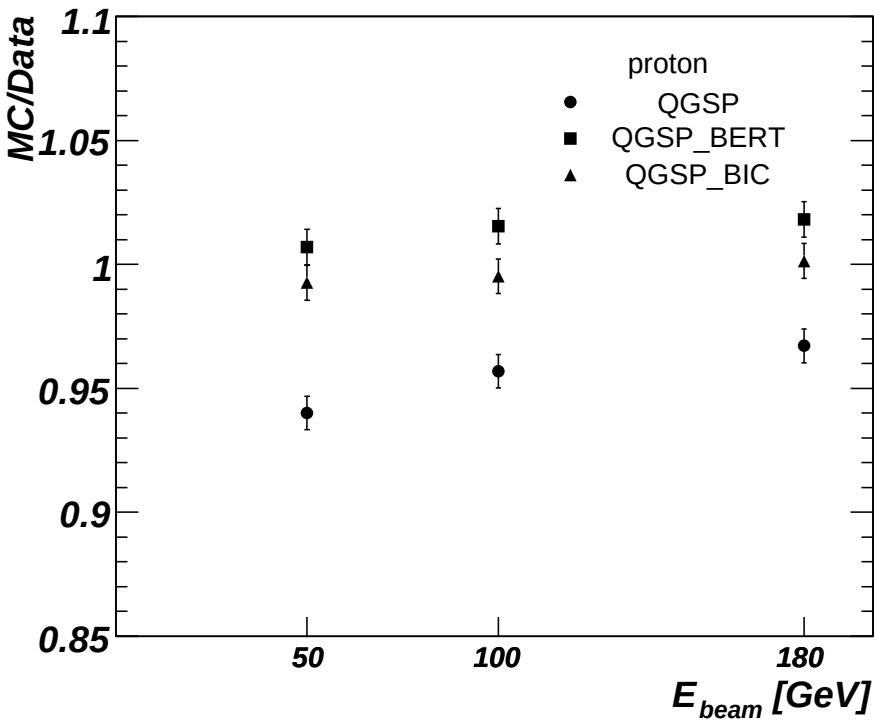
Resolution



- 10% worse resolution with QGSP, within $\pm$ 10% with cascade models.

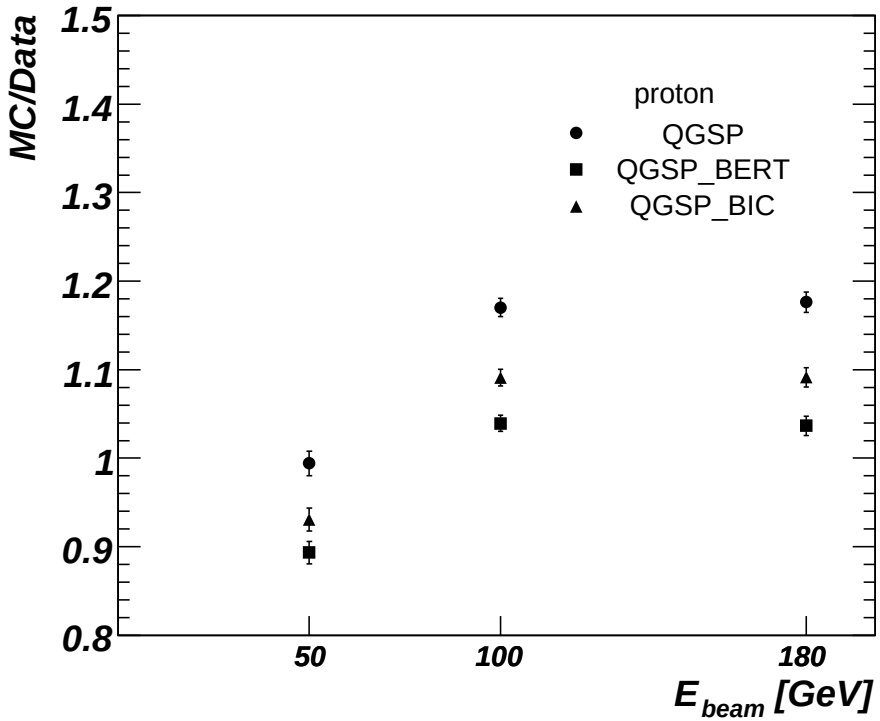
Proton Response and Resolution

Response



- Cascade models describe proton response, QGSP is too low.

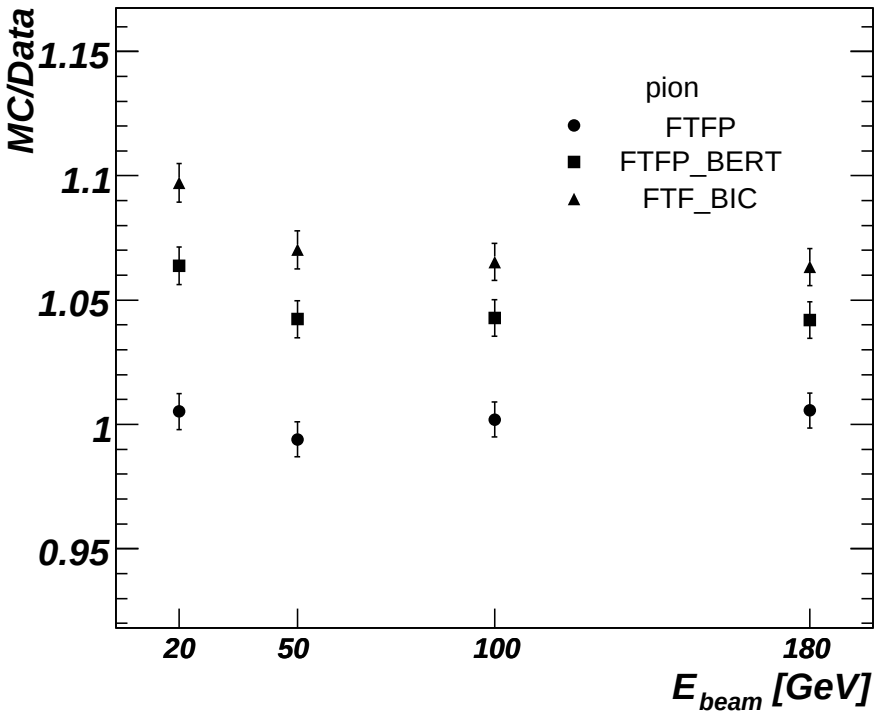
Resolution



- QGSP alone gives worse resolution.

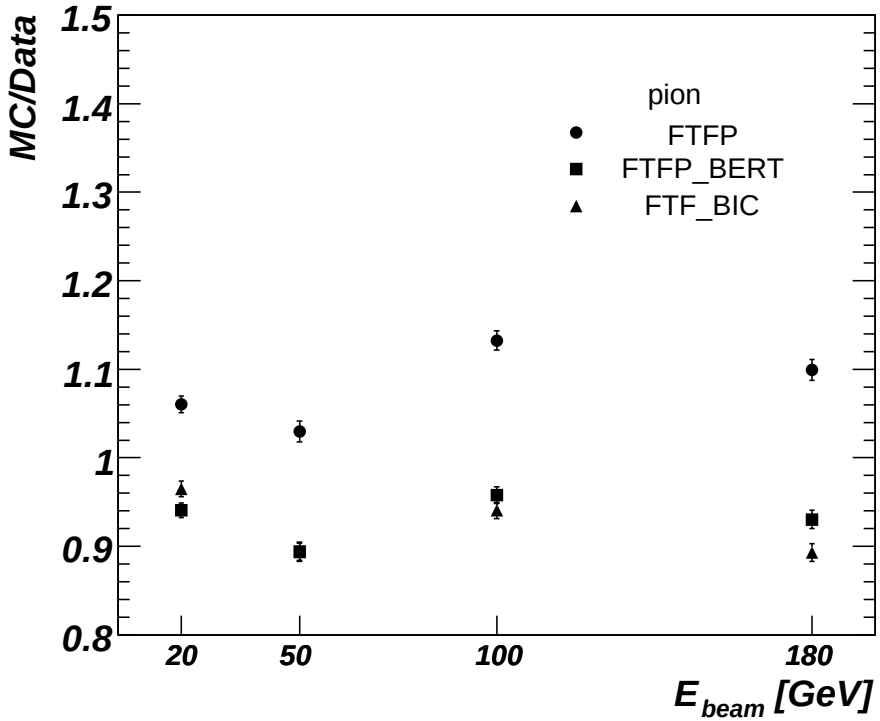
Pion Response and Resolution

Response



- The response is too high with cascade models. Binary cascade predicts a higher response than Bertini.

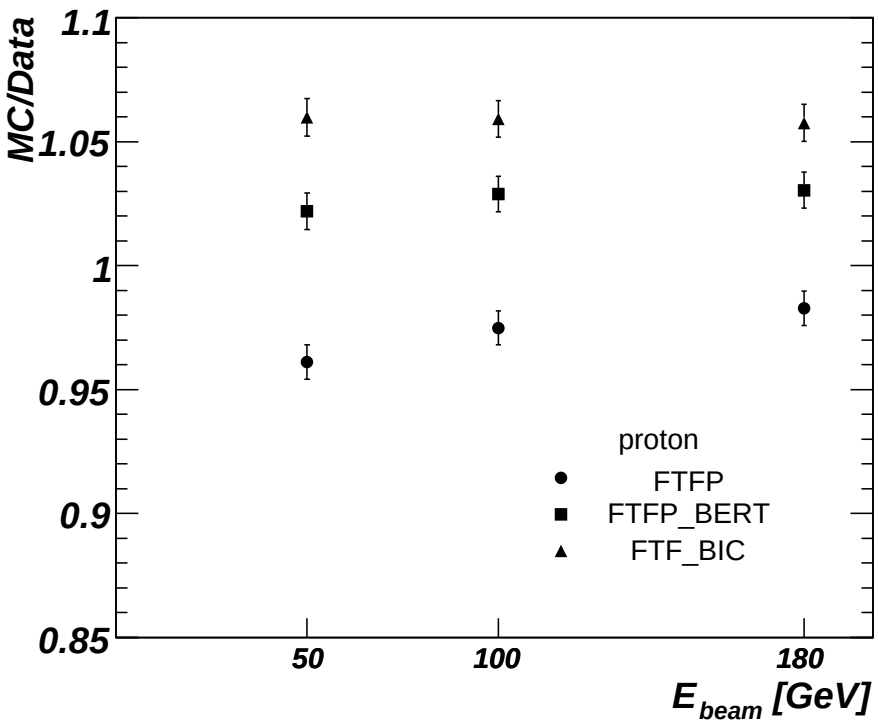
Resolution



- Without cascade models the resolution is worse.

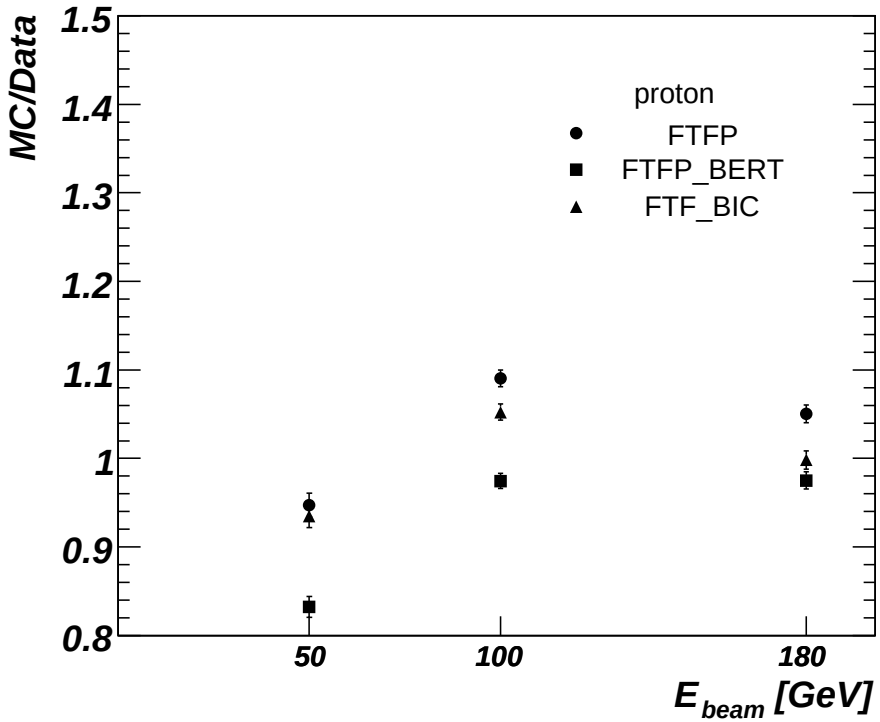
Proton Response and Resolution

Response



- FTFP_BERT is in better agreement with data. Binary cascade predicts a higher response than Bertini.

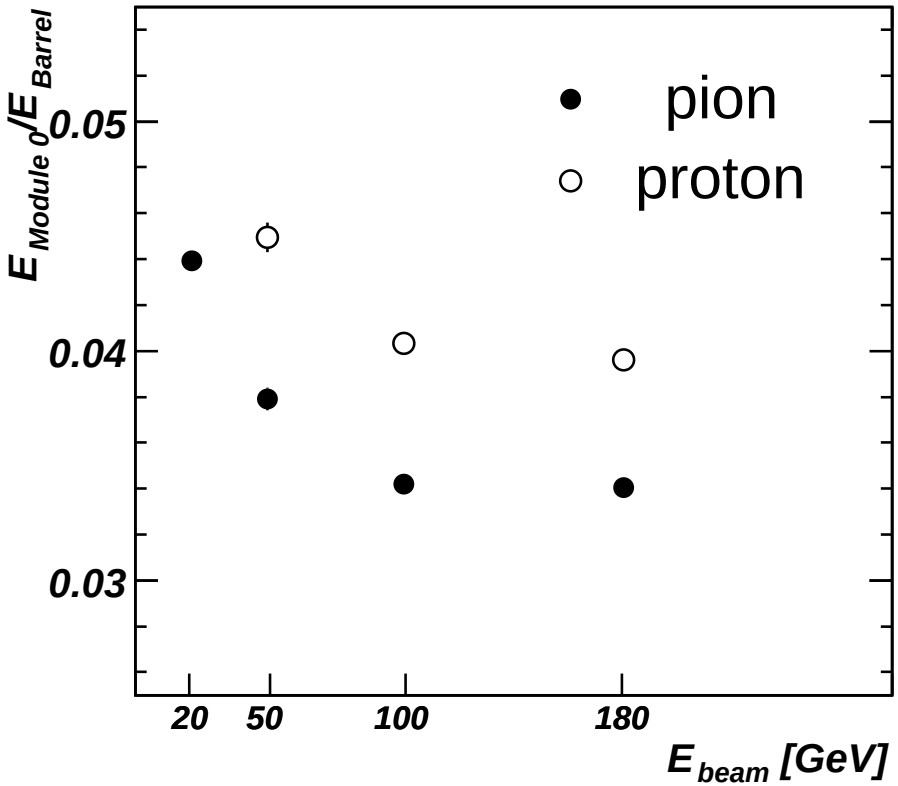
Resolution

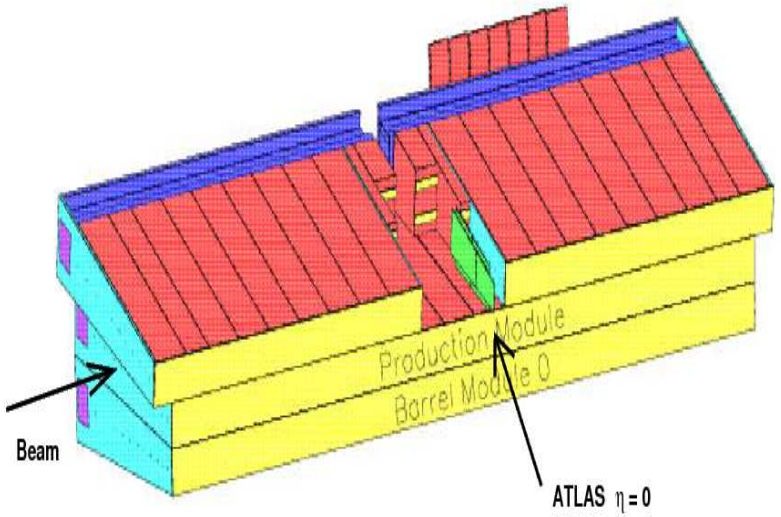


- Within $\pm$ 10% with cascade models.

Lateral Spread

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

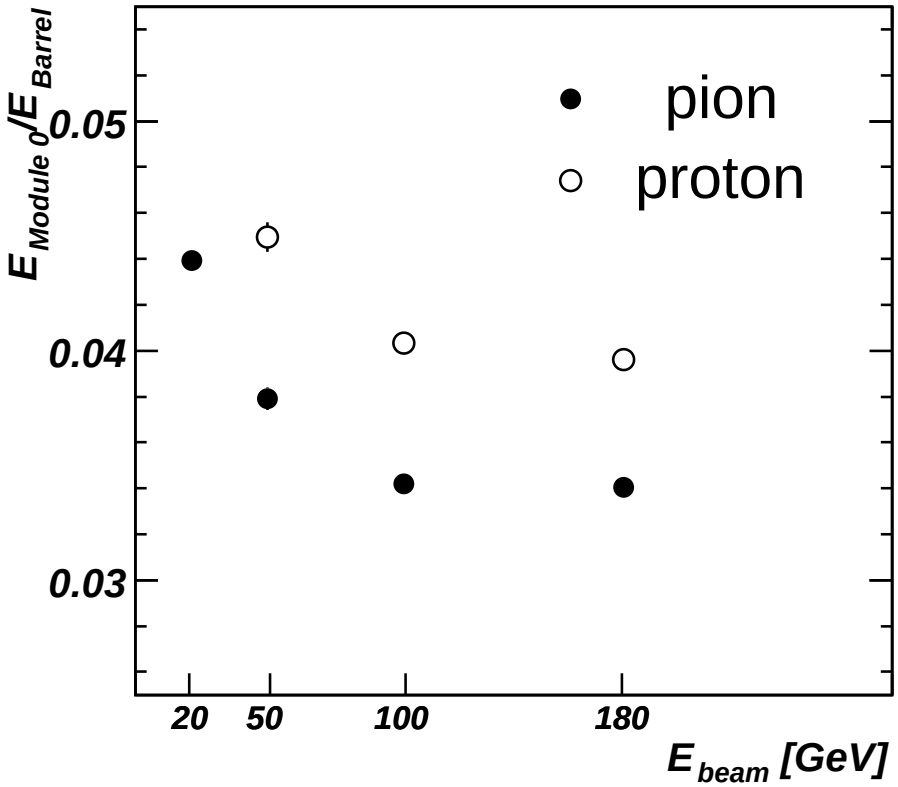


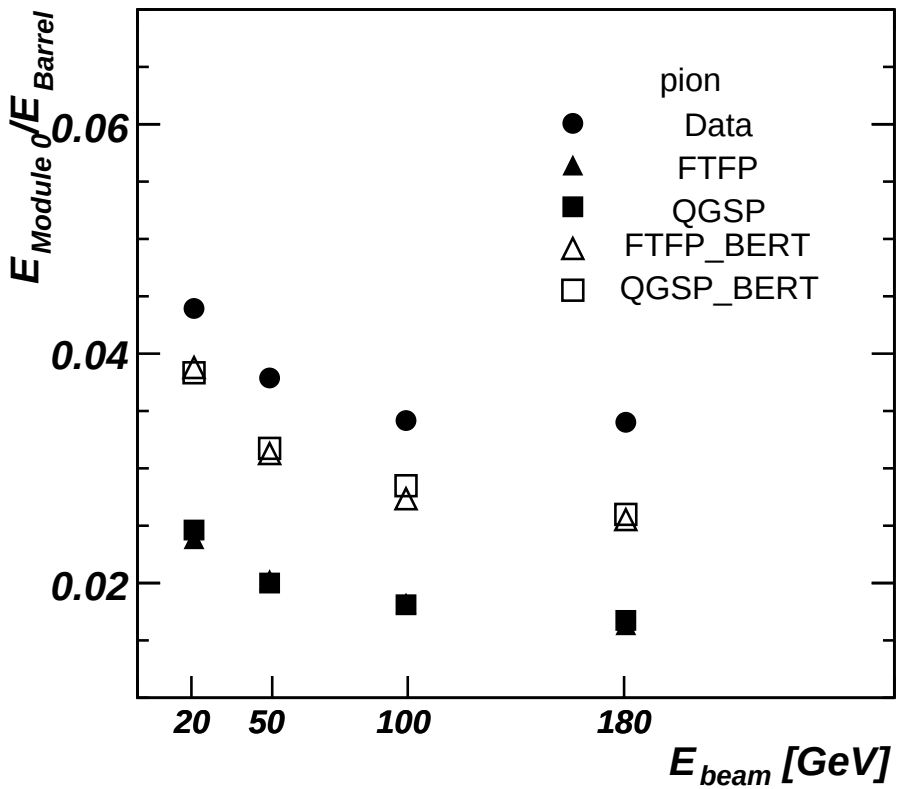


- Proton induced showers are wider than pion induced ones.
- Showers simulated using QGSP and FTFP are too narrow.
- Better description with cascade models.

Lateral Spread

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

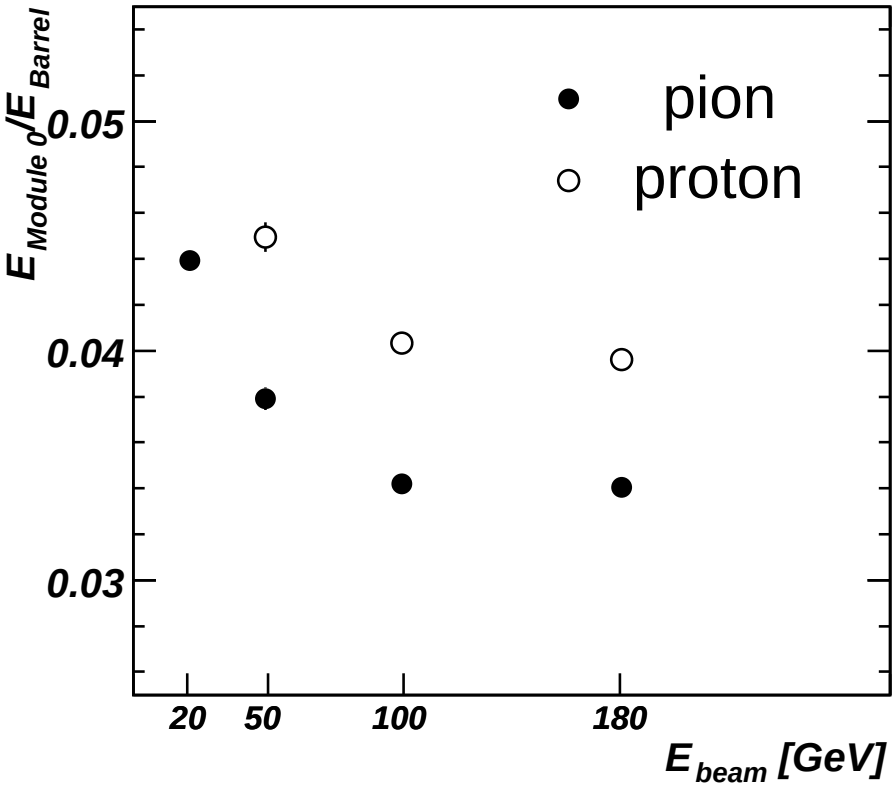


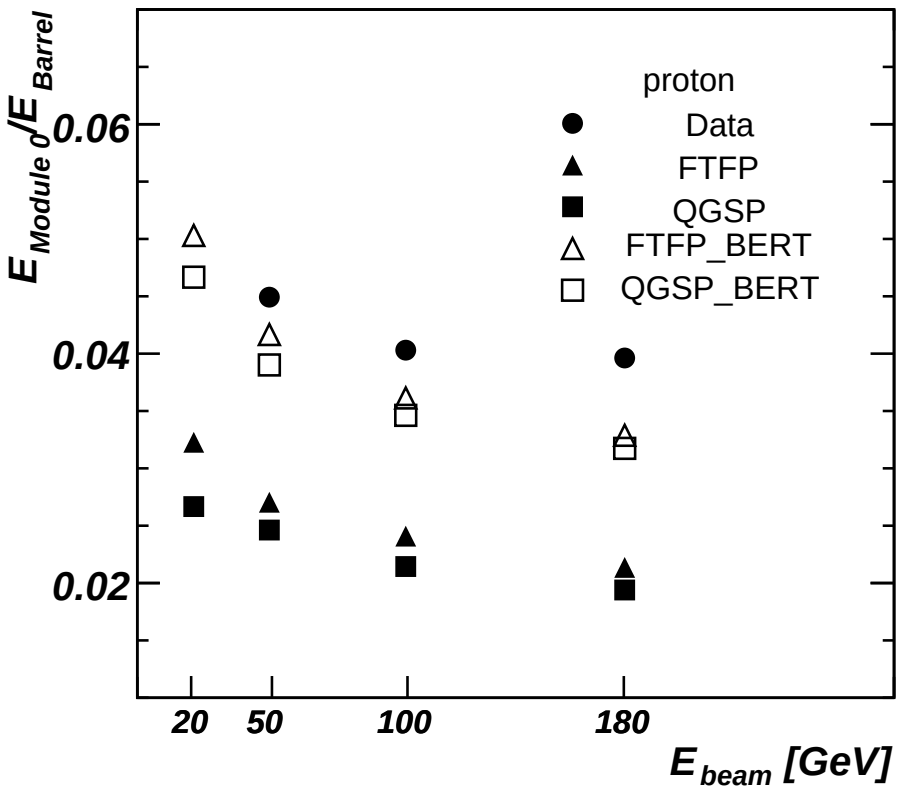


- Proton induced showers are wider than pion induced ones.
- Showers simulated using QGSP and FTFP are too narrow.
- Better description with cascade models.

Lateral Spread

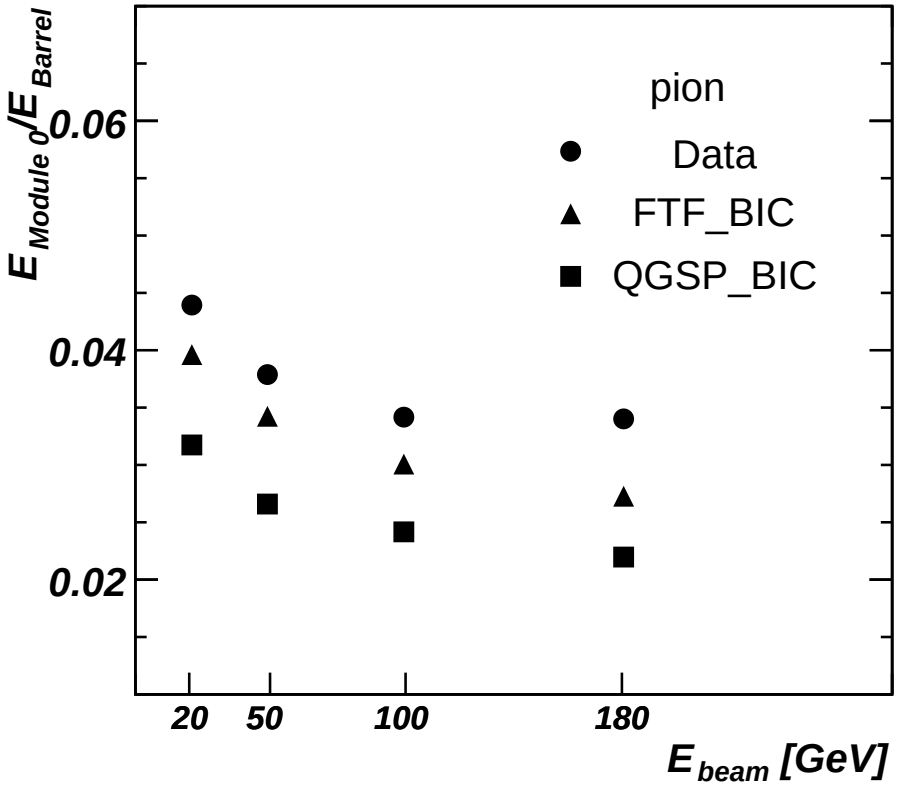
The ratio of energy measured in the bottom and central modules is an estimate of lateral spread.

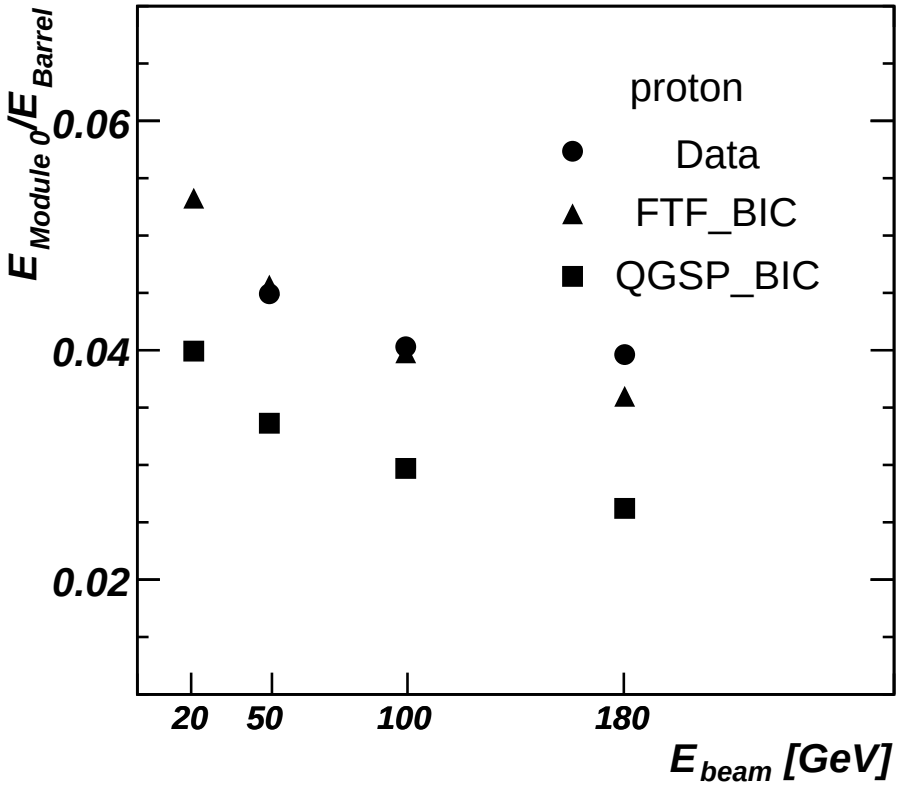




- Proton induced showers are wider than pion induced ones.
- Showers simulated using QGSP and FTFP are too narrow.
- Better description with cascade models.

Lateral Spread

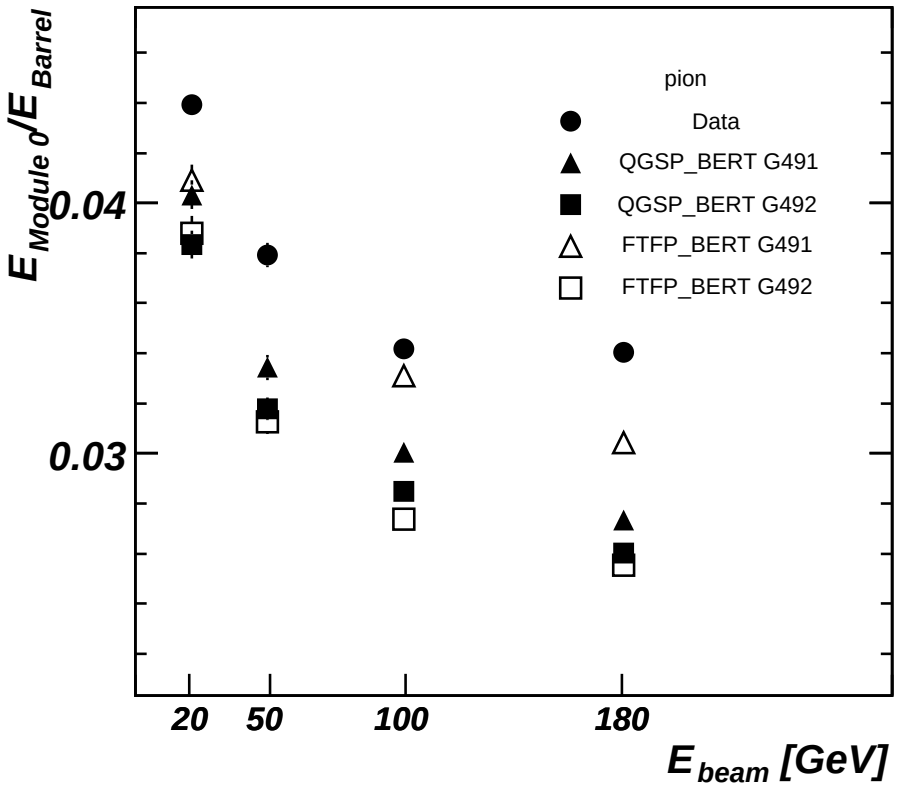


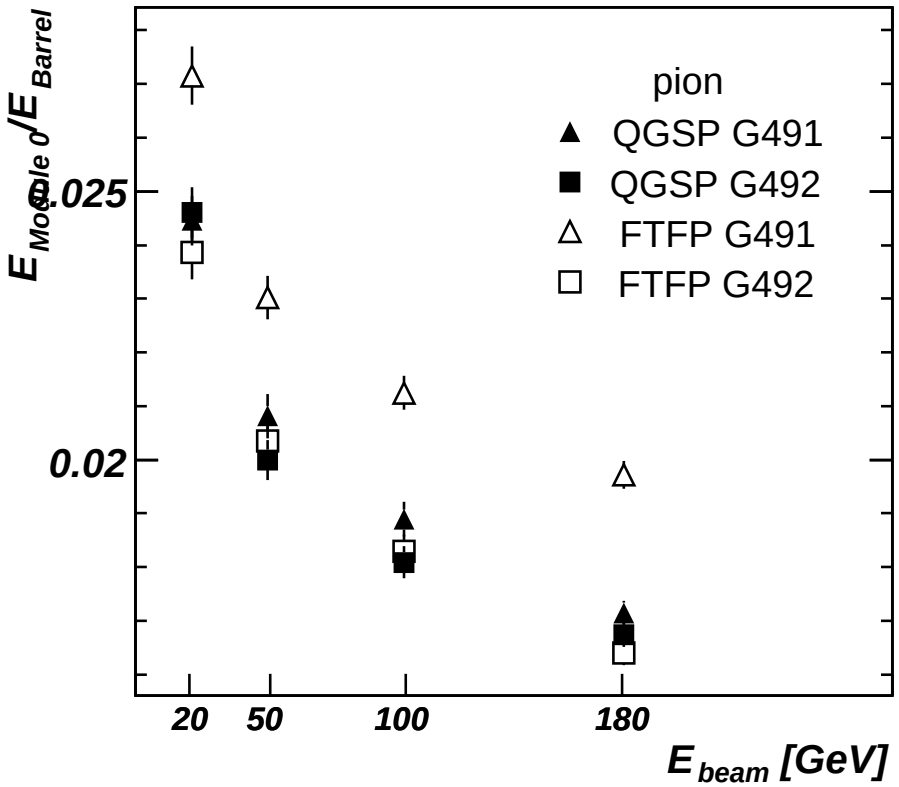


- Too narrow showers with QGSP_BIC.
- Good description with FTF_BIC.

Lateral Spread

G4.9.2 vs. G4.9.1



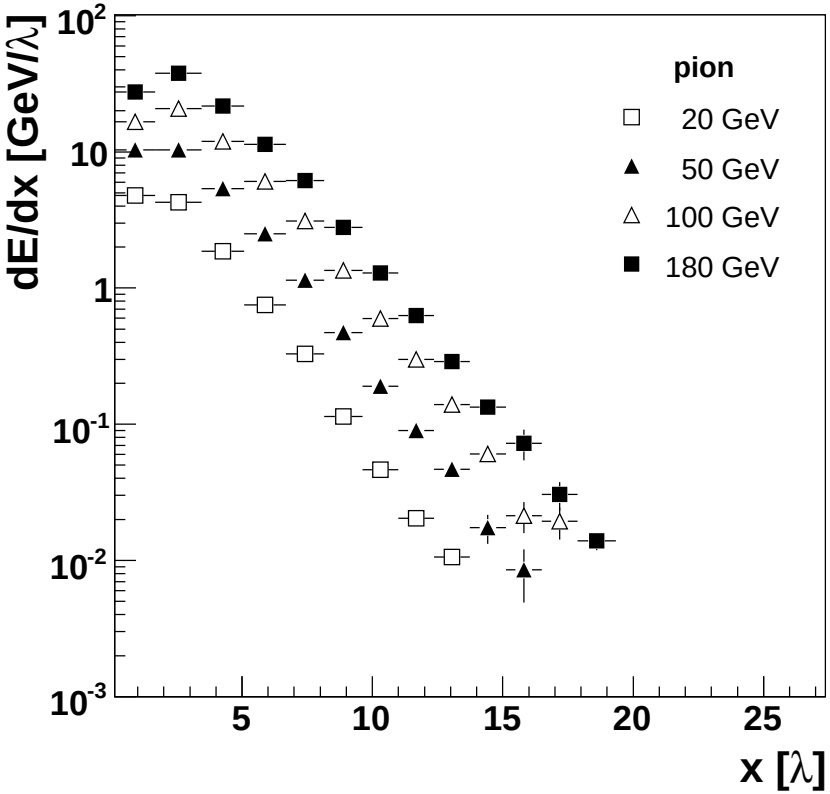


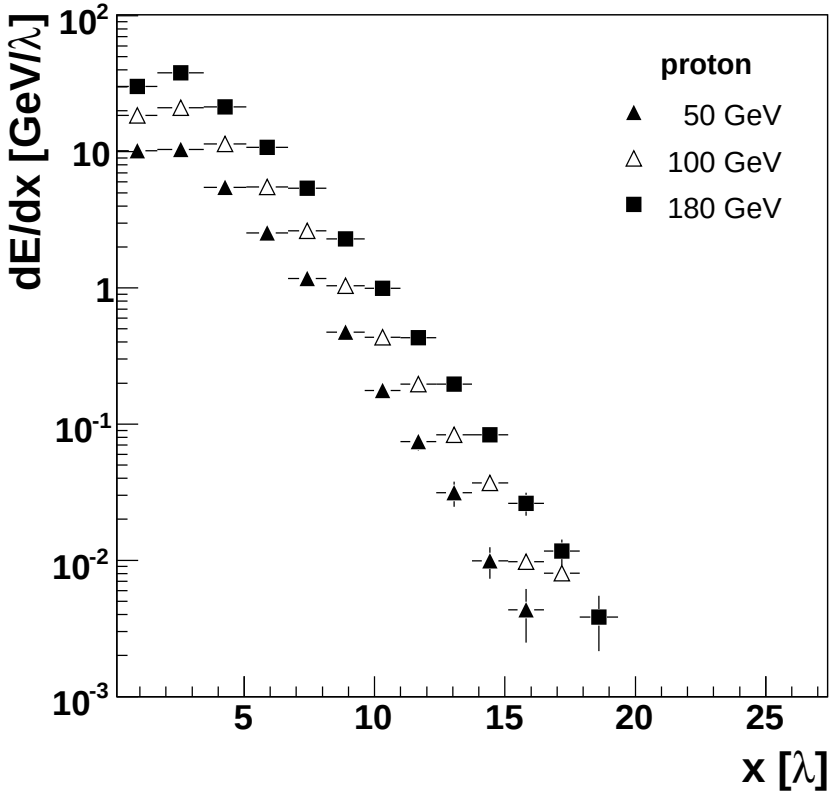
- Large change of lateral spread in FTFP based lists between G4.9.1 and G4.9.2. Data description became worse.

Longitudinal Profile

Pions and Protons

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



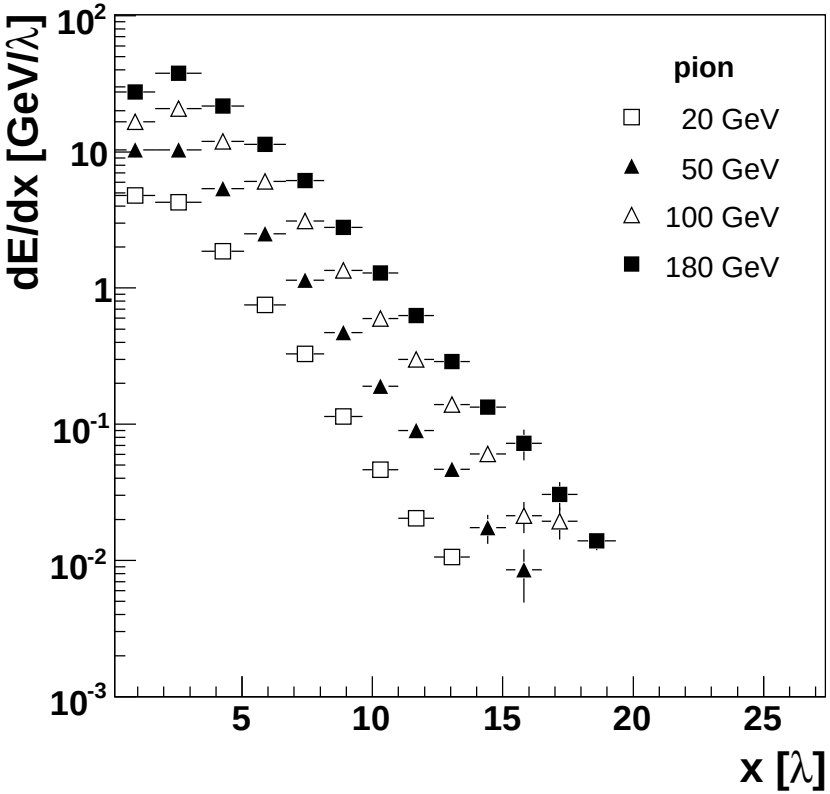


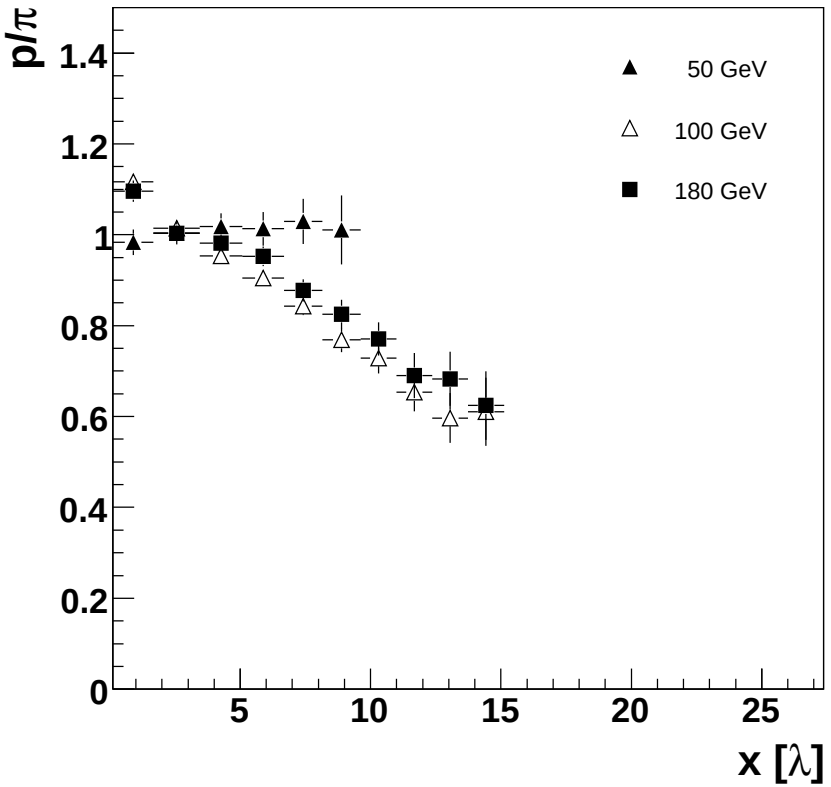
- Pion induced showers are longer at high energies.

Longitudinal Profile

Pions and Protons

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

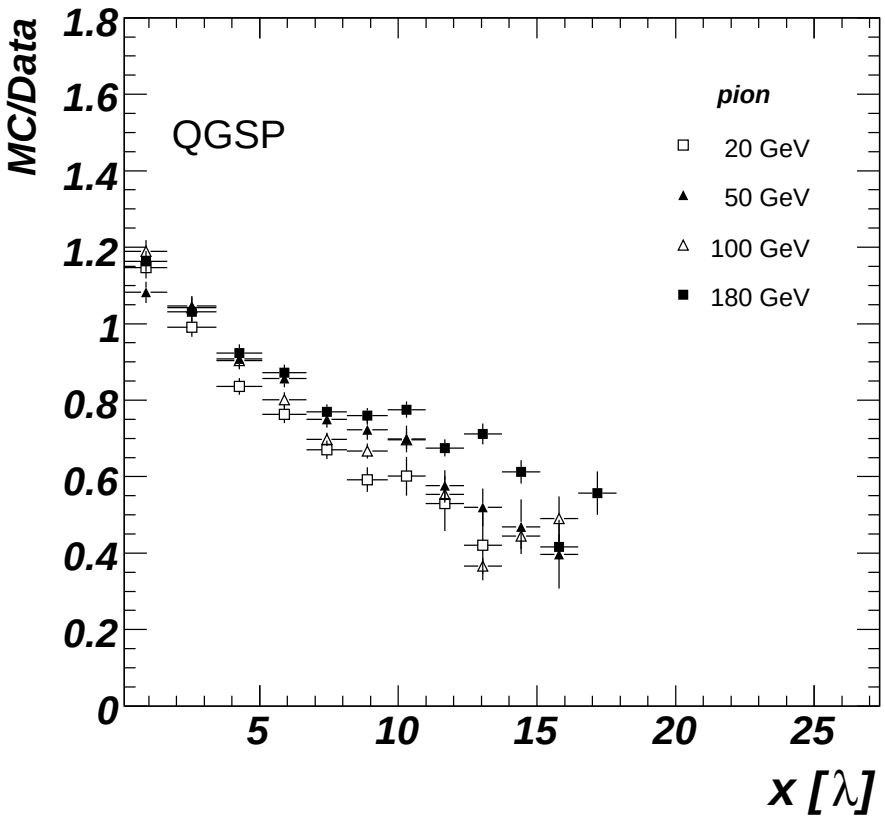


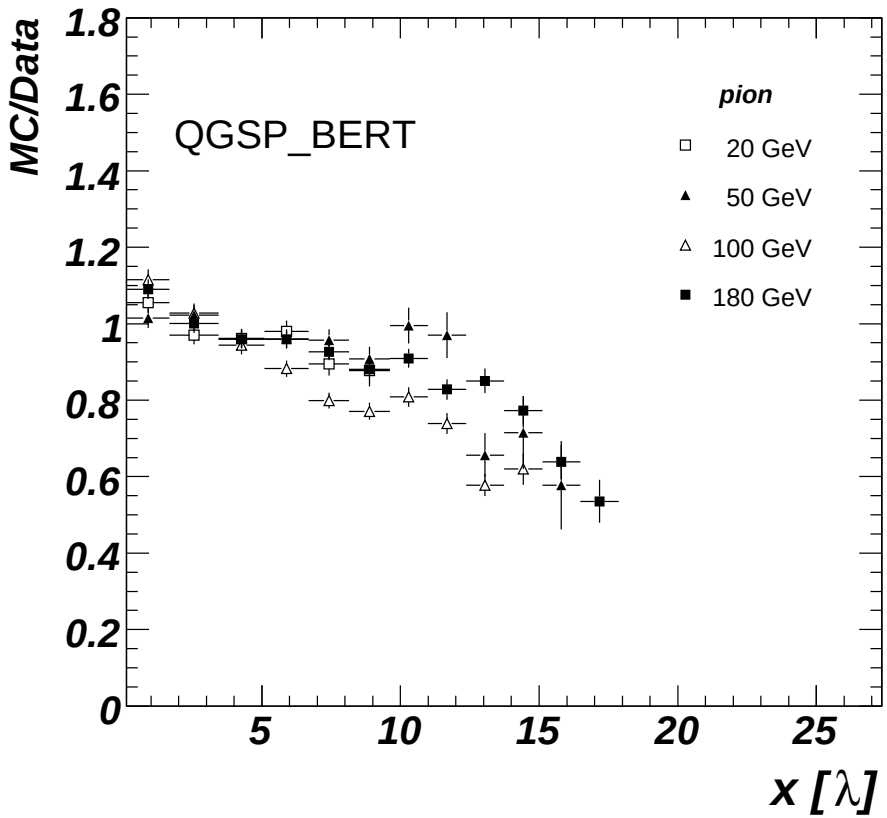


- Pion induced showers are longer at high energies.

Longitudinal Profile

Pions

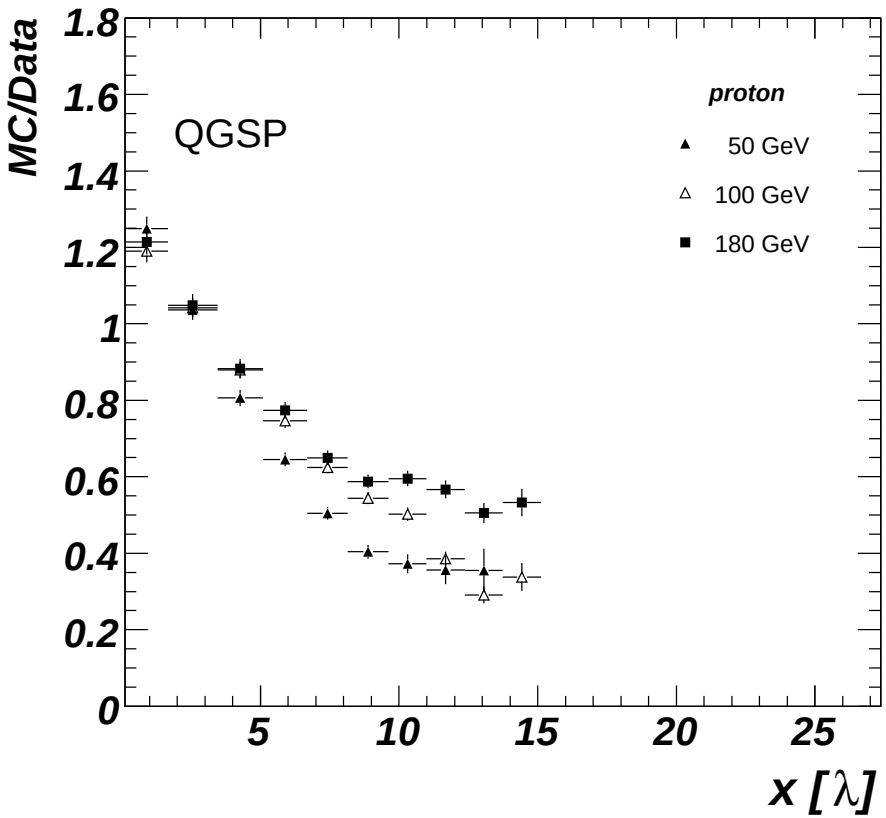


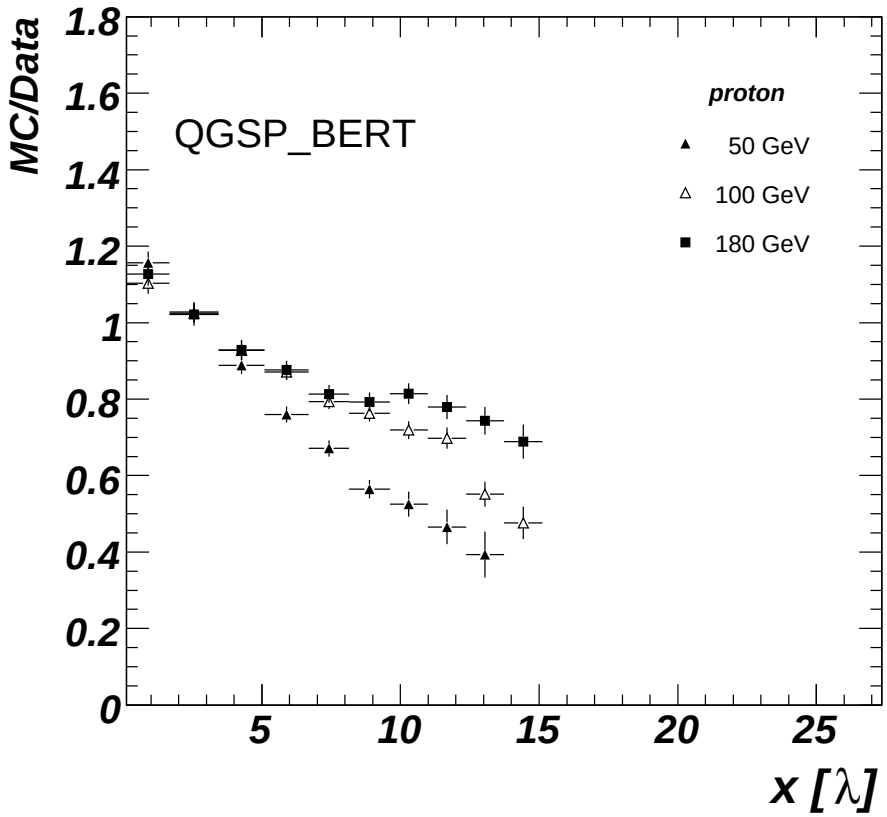


- Showers simulated with QGSP are too short, 20 – 40% less energy at 10λ.
- Adding Bertini makes showers longer, up to 10λ within $\pm$15%.

Longitudinal Profile

Protons

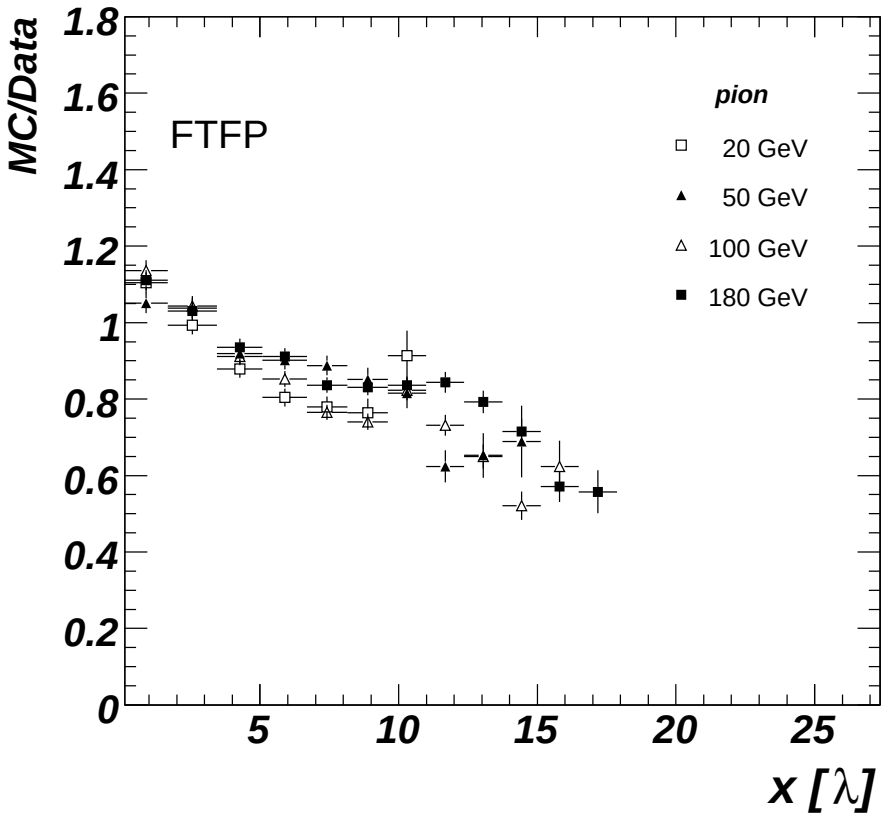


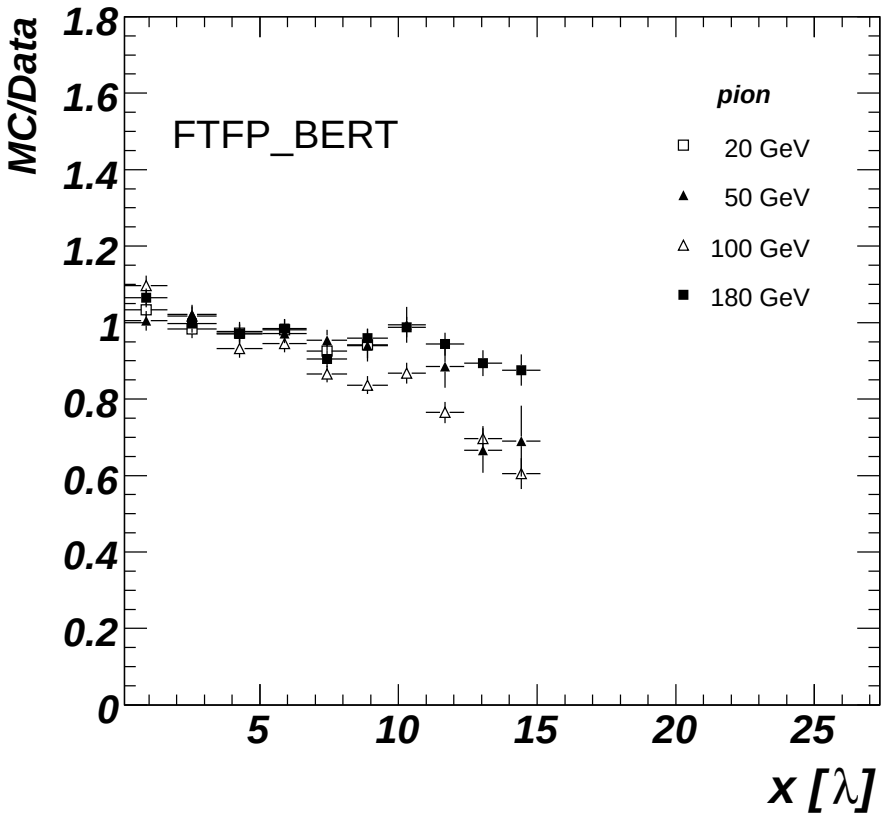


- Simulated showers are too short, at 10λ 40 – 60% less energy.
- With Bertini at 10λ 20-40% less energy.
- Protons are described worse than pions.

Longitudinal Profile

Pions

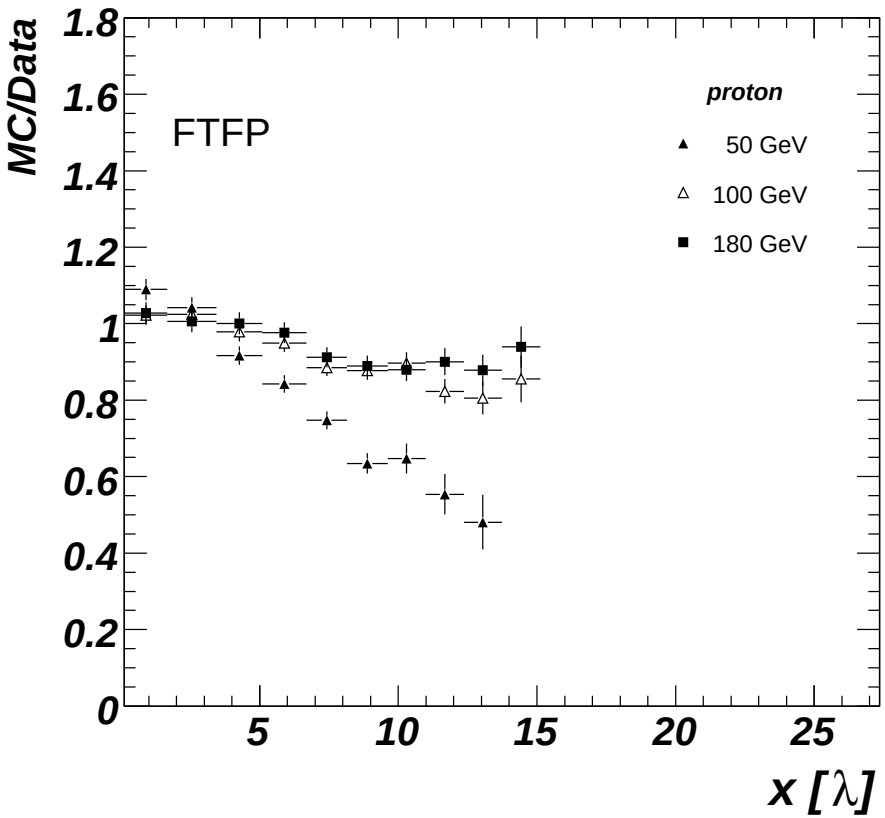




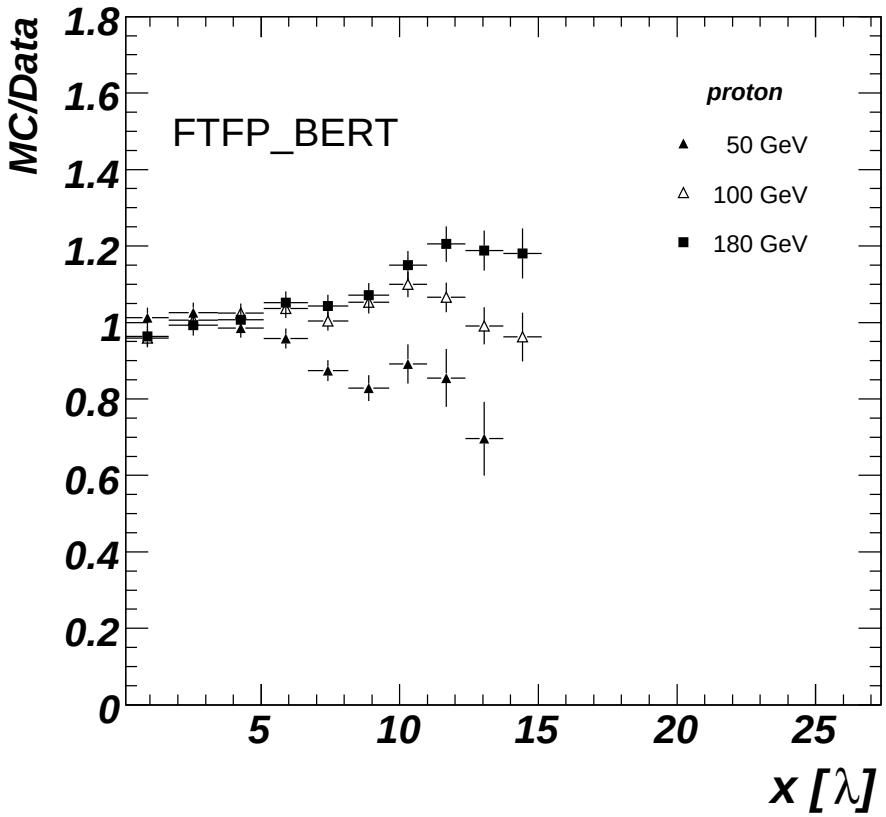
- With Fritiof model showers are a bit shorter, up to 10λ within $\pm$20%.
- With Bertini cascade MC describes data up to 10λ within $\pm$10%.

Longitudinal Profile

Protons



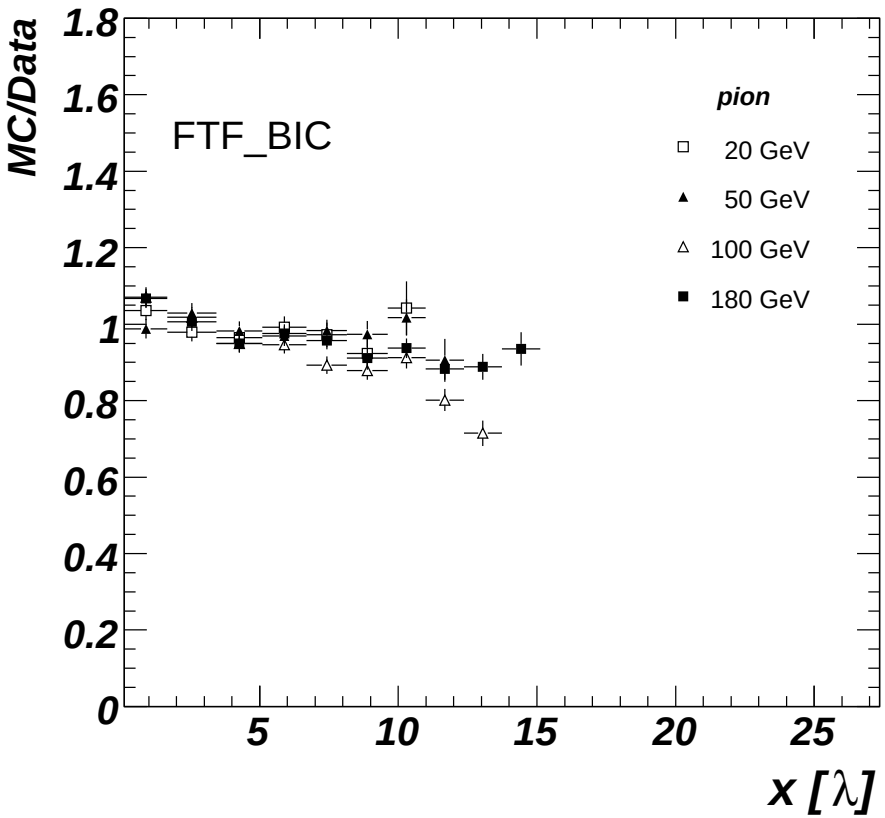
- Up to 10λ $\pm$20% agreement.

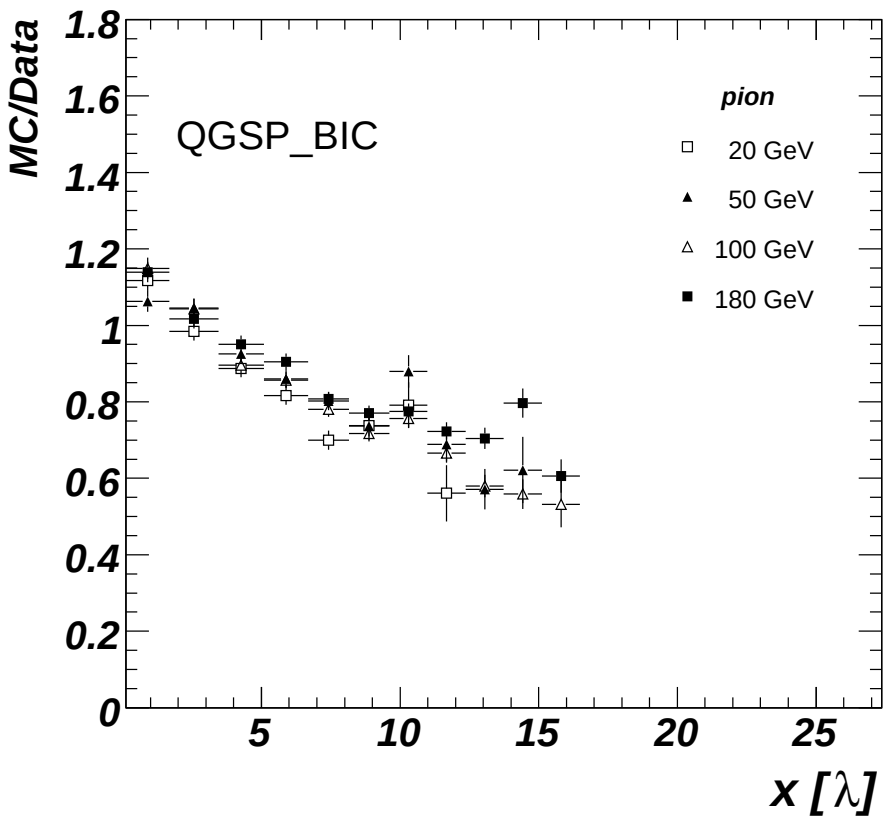


- Quite good description.

Longitudinal Profile

Pions

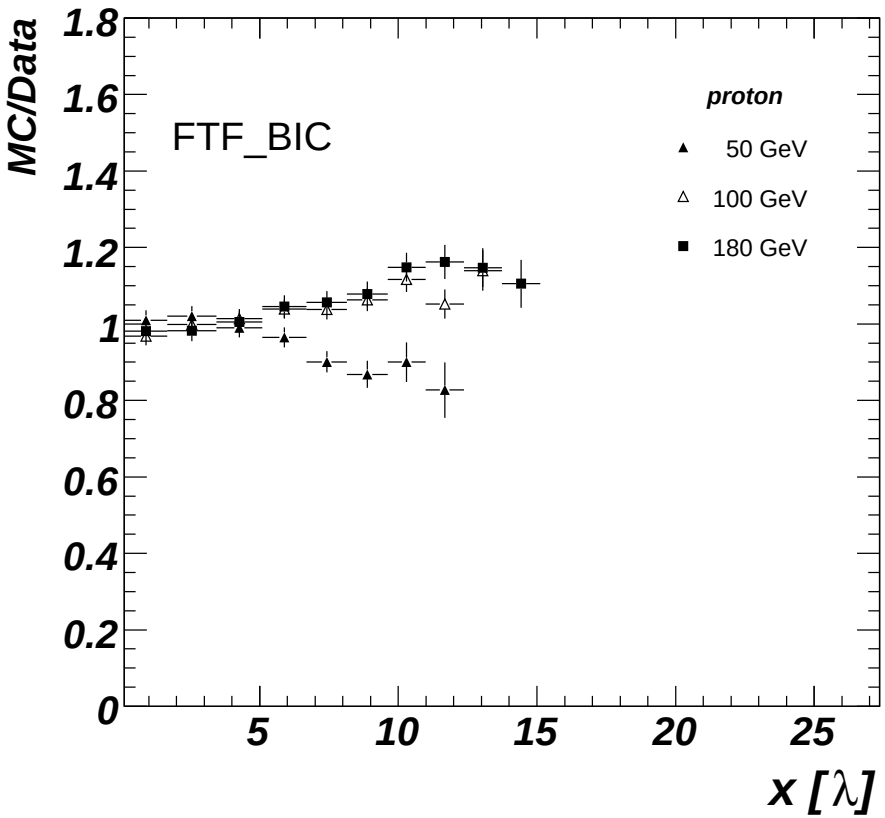




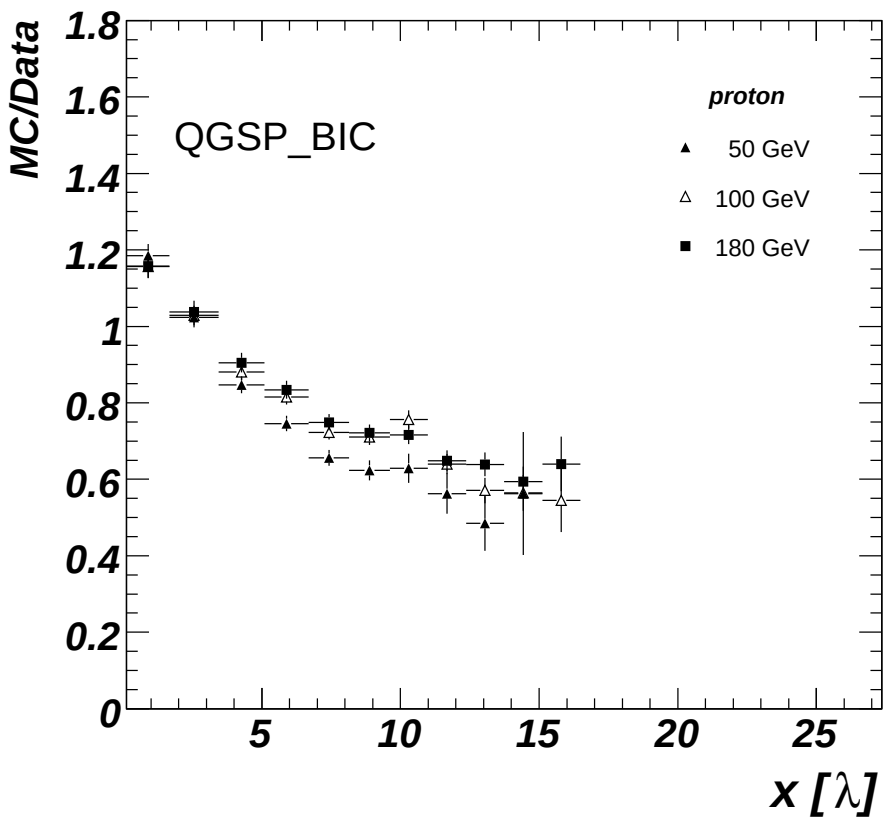
- With Fritiof model showers are a bit shorter, up to 10λ within $\pm$10%.
- At 10λ 20% less energy is predicted.

Longitudinal Profile

Protons



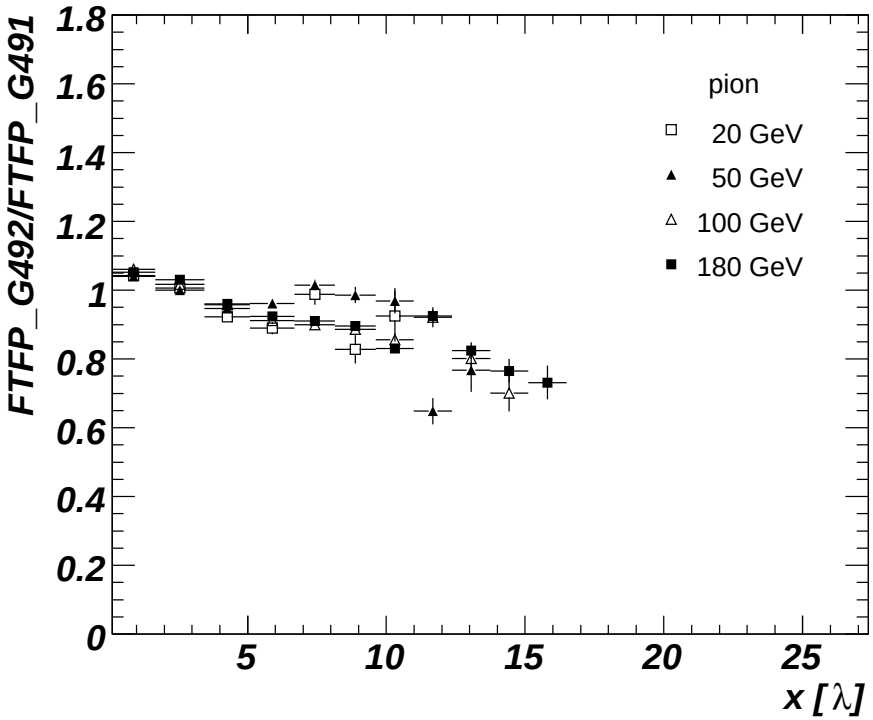
- Good description of shower development.

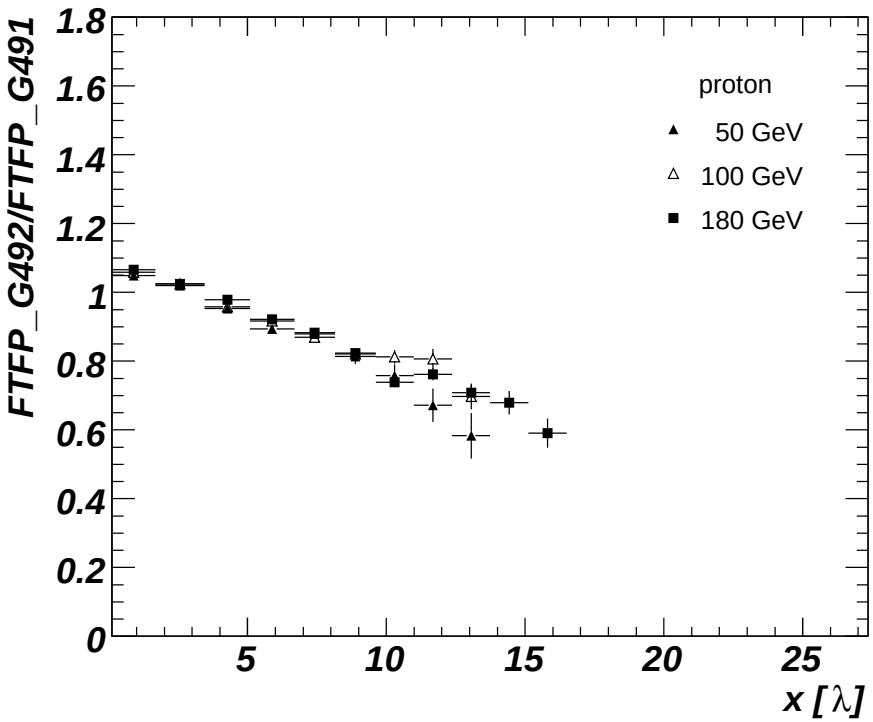


- Showers are too short.

Longitudinal Profile

G4.9.2 vs. G4.9.1

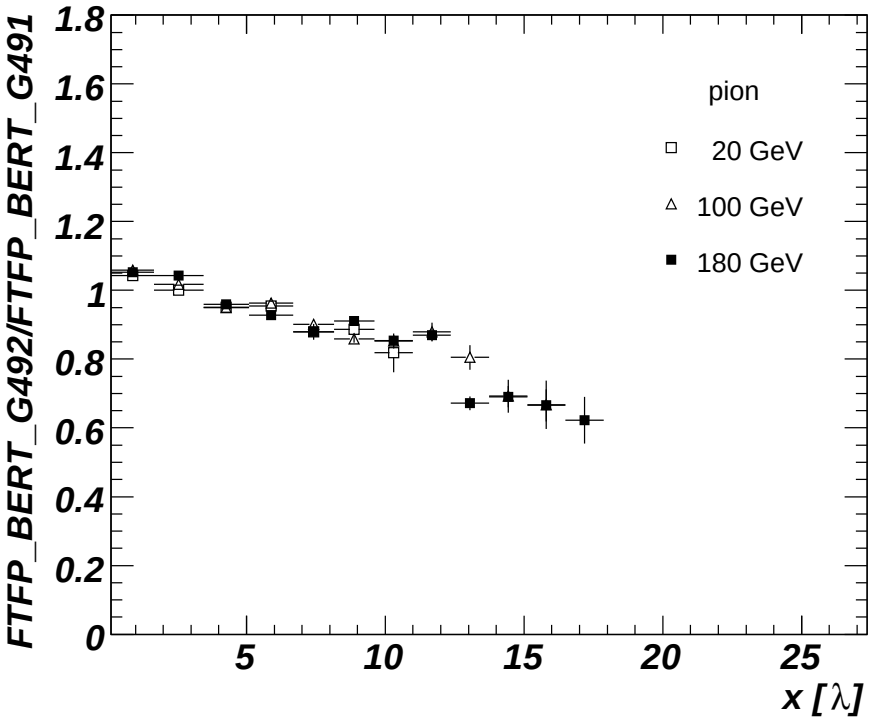


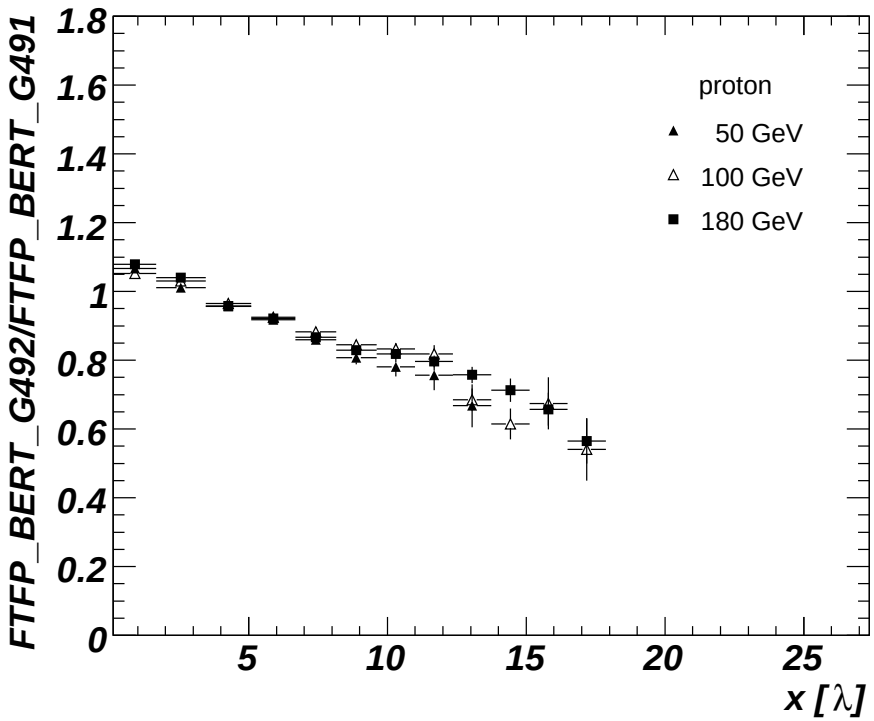


- Showers became shorter in G4.9.2 with respect to G4.9.1 in FTFP based physics lists. Worsening data description.

Longitudinal Profile

G4.9.2 vs. G4.9.1

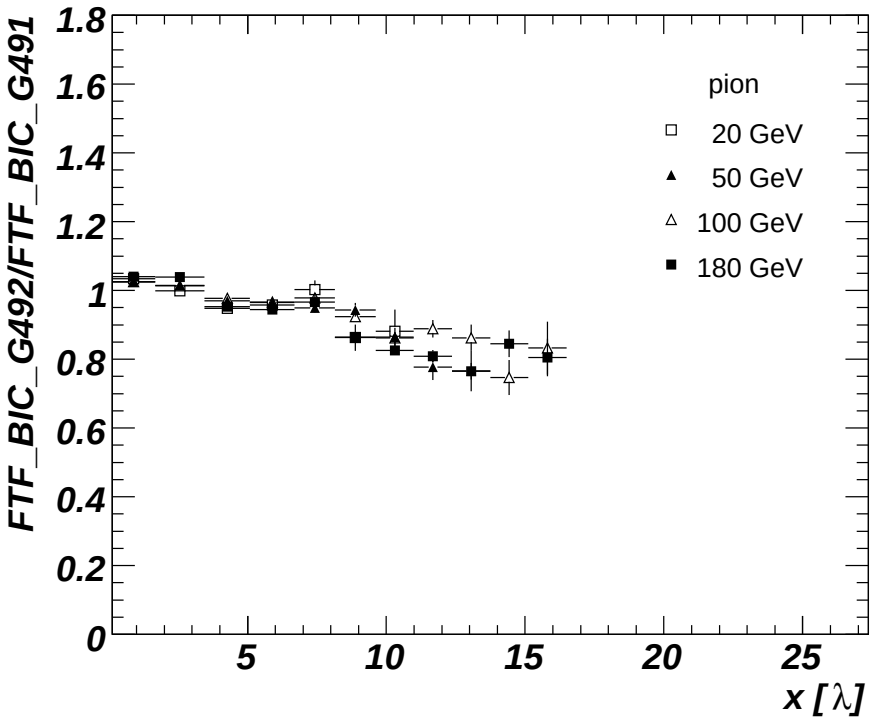


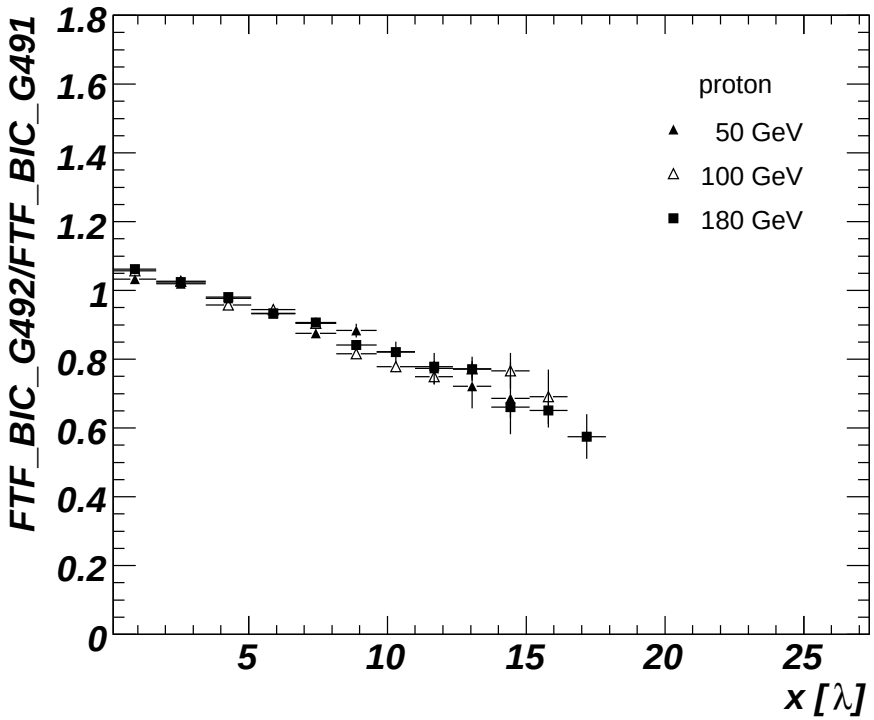


- Showers became shorter in G4.9.2 with respect to G4.9.1 in FTFP based physics lists.

Longitudinal Profile

G4.9.2 vs. G4.9.1

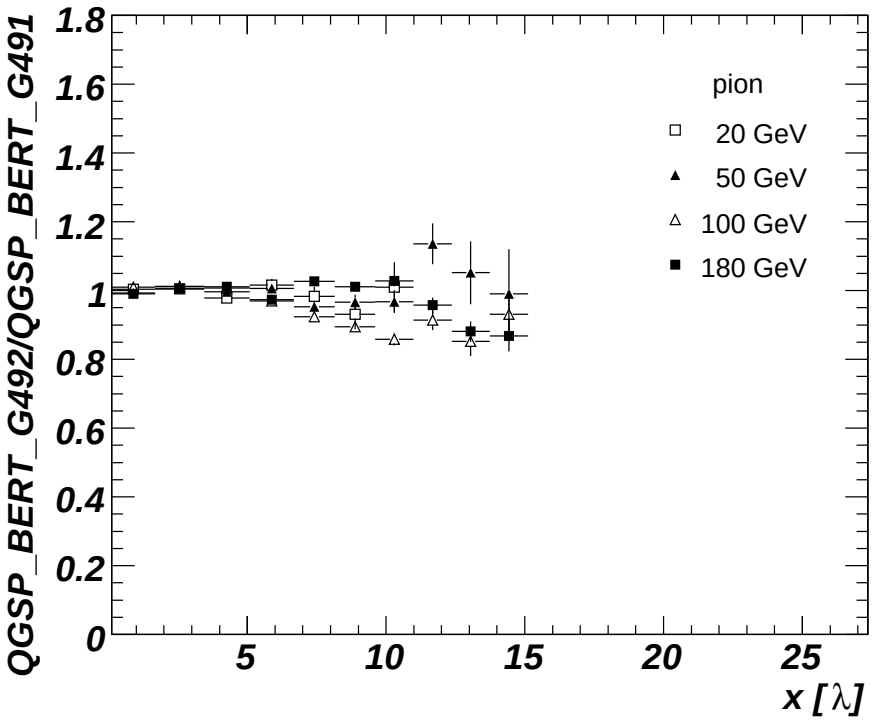


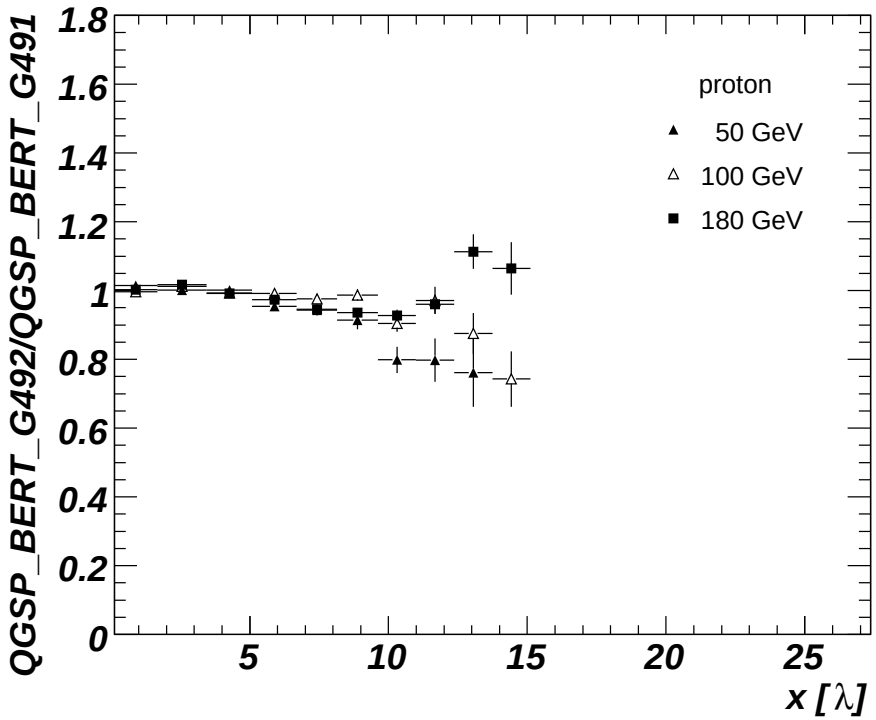


- Showers became shorter in G4.9.2 with respect to G4.9.1 in FTFP based physics lists.

Longitudinal Profile

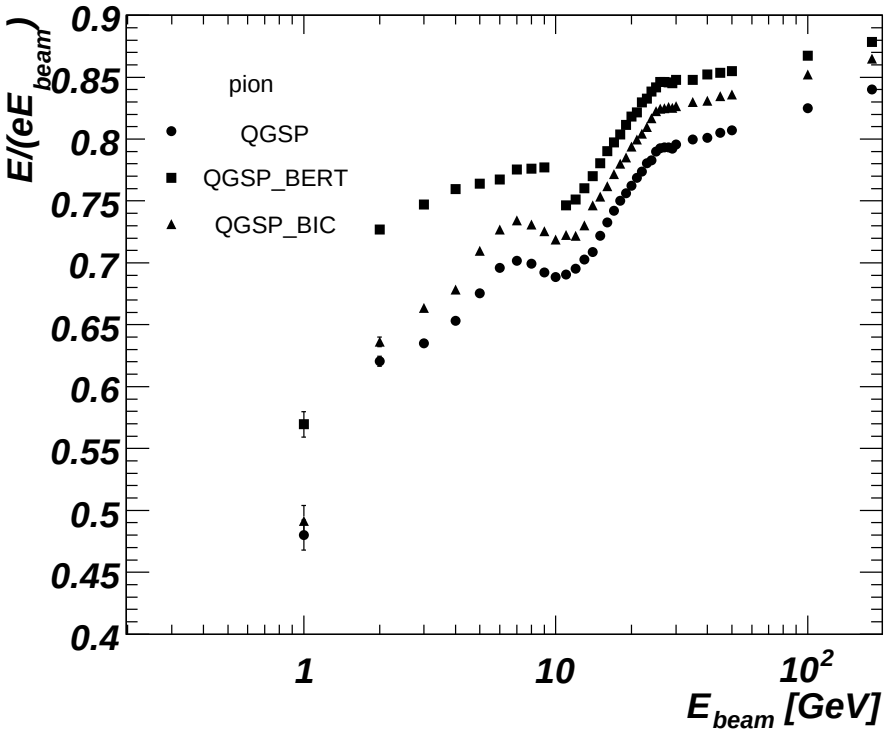
Pions

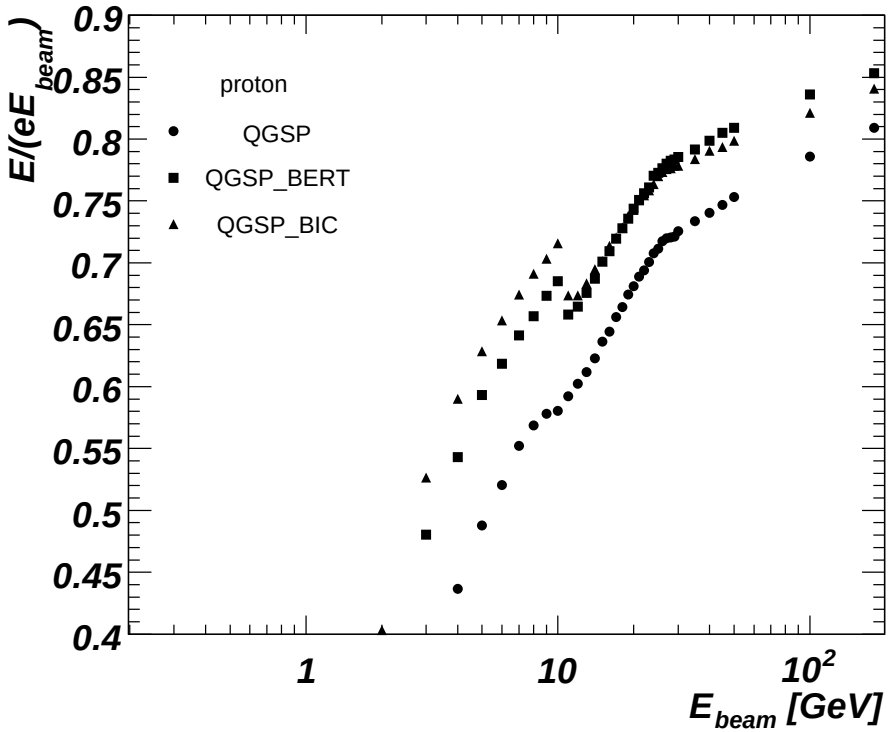




- No change across versions in QGSP based physics lists.

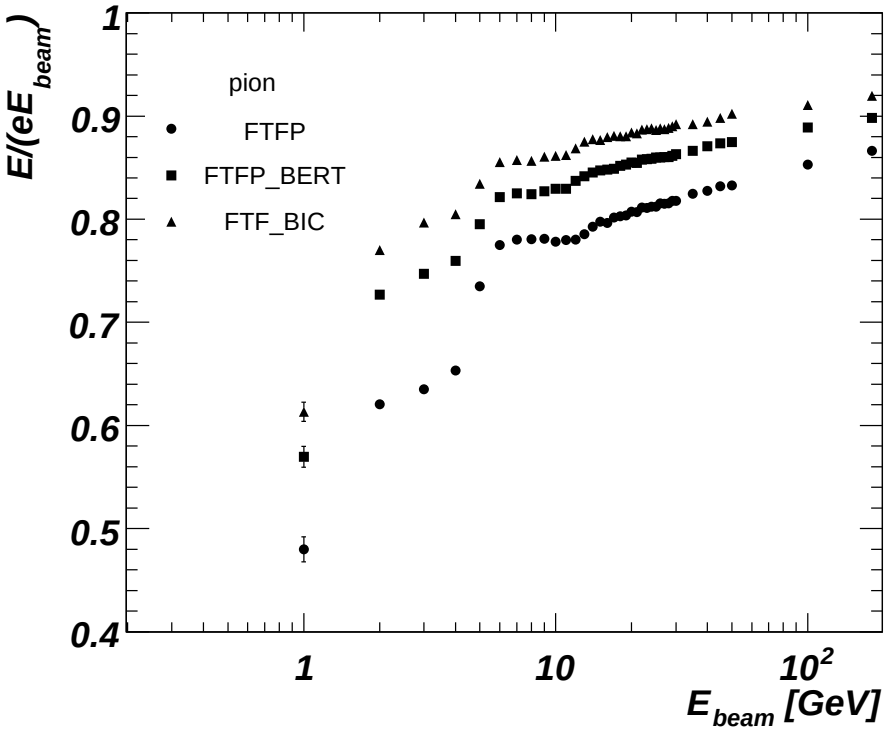
Fine Energy Scan



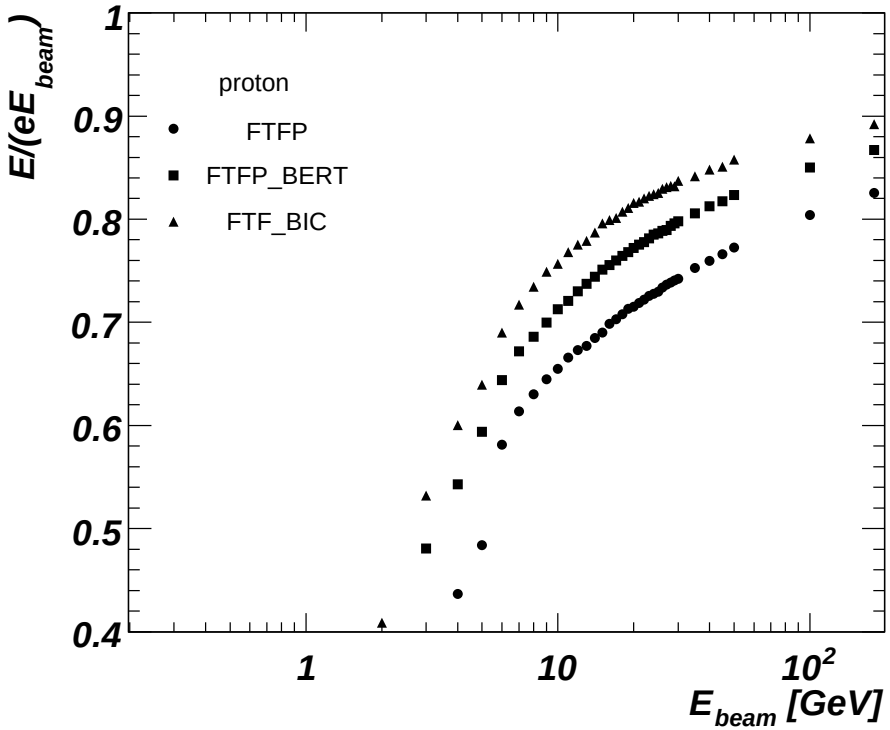


- Unphysical energy dependence of response, the effect is larger in QGSP_BERT. For protons, QGSP_BIC has the largest discontinuity.

Fine Energy Scan



- FTF(P) is smoother than QGSP.



- Smooth energy dependence as expected.

Summary

physics list	response	resolution	longitudinal	radial
QGSP	low	worse	too short	too narrow
QGSP_BERT	ok	ok	short	narrow
QGSP_BIC	ok	ok	short	too narrow
FTFP	ok	worse	short	too narrow
FTFP_BERT	high	low	short	narrow
FTF_BIC	too high	low	ok	narrow

Table: Pion observable description by G4.9.2.

physics list	response	resolution	longitudinal	radial
QGSP	low	worse	too short	too narrow
QGSP_BERT	ok	ok	too short	narrow
QGSP_BIC	ok	ok	too short	too narrow
FTFP	low	worse	short	too narrow
FTFP_BERT	ok	ok	ok	narrow
FTF_BIC	high	ok	ok	ok

Table: Proton observable description by G4.9.2.

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 shorter in G4.9.2. No change in QGS based physics lists.
- 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.