

Comparison of Geant4 9.4 results to ATLAS TileCal test-beam data

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LCG Physics Validation meeting

1 Introduction

- ATLAS Tile Calorimeter
- Test Beam Setup

2 Data vs. G4.9.4

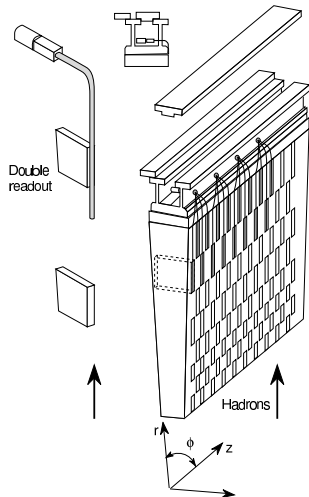
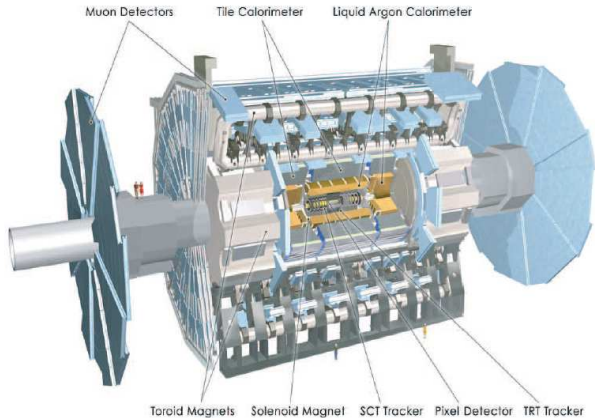
- Pion and Proton Response
- Shower Lateral Spread
- Longitudinal Shower Profile

3 Fine Energy Scan

4 Summary

ATLAS Tile Calorimeter

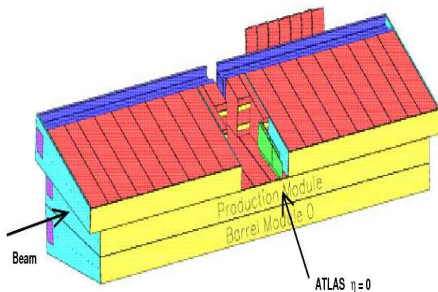
- Iron-scintillator hadronic calorimeter located in the central region of the ATLAS detector.
- Scintillating tiles are placed perpendicularly to the LHC colliding beams.



Test Beam Setup

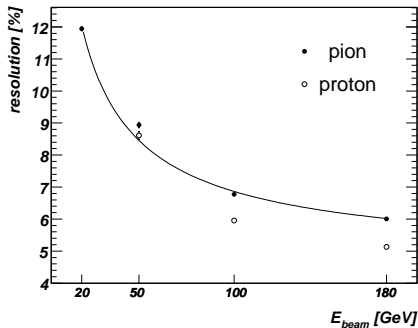
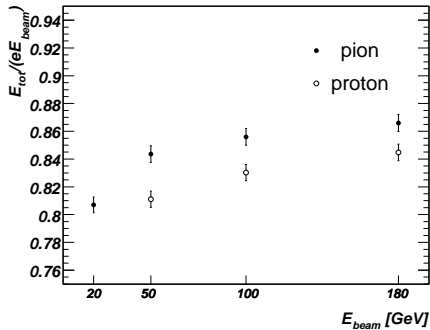
Special Runs

- 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.



Response and Resolution

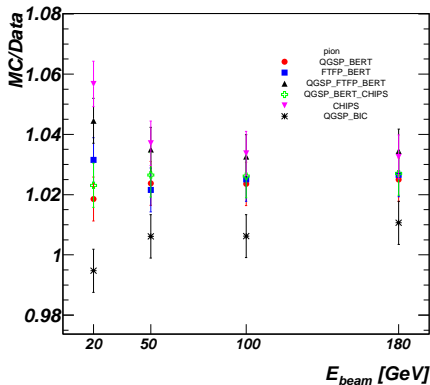
EM-scale from electron response.



- Pions have larger response, but worse resolution.

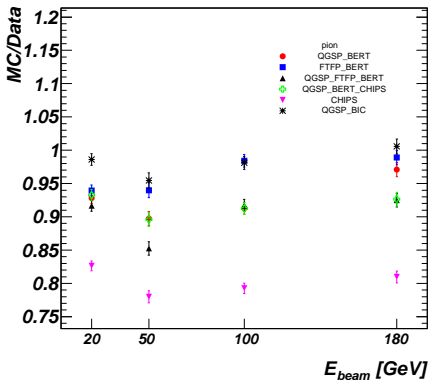
Pion Response and Resolution

Response



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

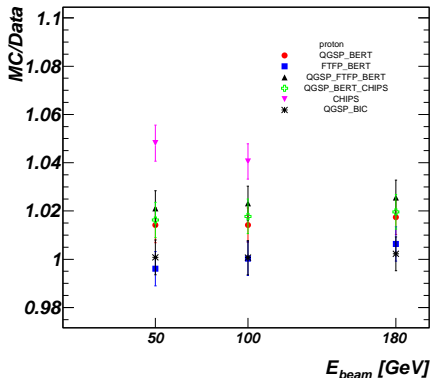
Resolution



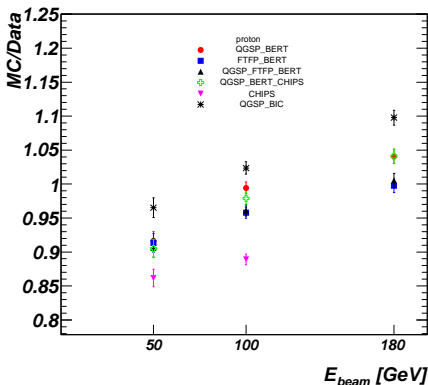
- Too good resolution with CHIPS, within $\pm 10\%$ with cascade models.

Proton Response and Resolution

Response



Resolution

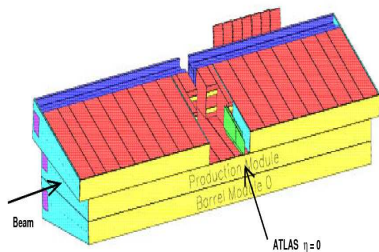
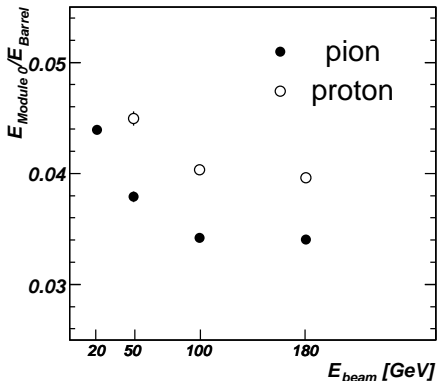


- The response is too high with CHIPS. Best description by QGSP_BIC.

- Too good resolution with CHIPS.

Lateral Spread

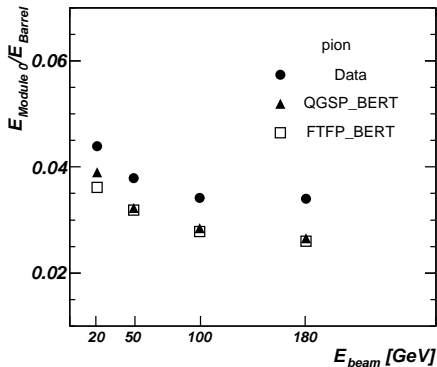
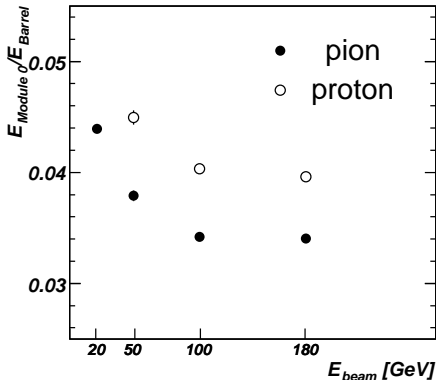
The ratio of energy measured in the bottom and central modules is an estimate of lateral spread.



- Proton induced showers are wider than pion induced ones.

Lateral Spread

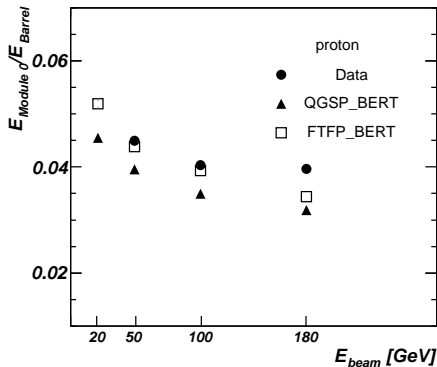
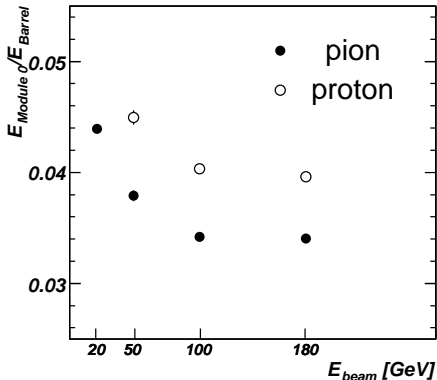
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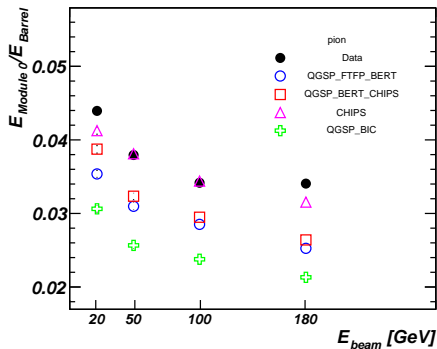
Lateral Spread

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

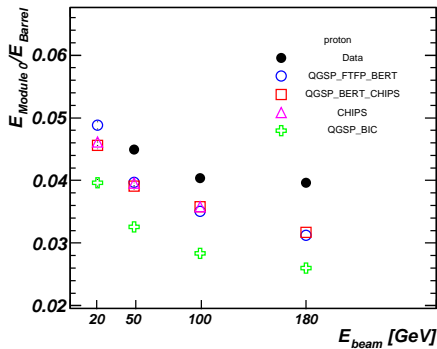


- Proton induced showers are wider than pion induced ones.

Lateral Spread



● CHIPS describes data well.

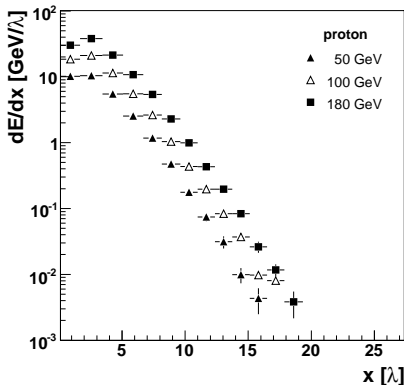
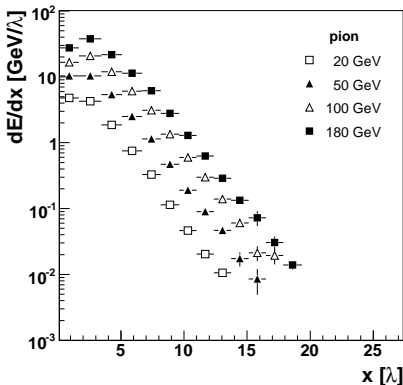


● QGSP_BIC predicts too narrow showers.

Longitudinal Profile

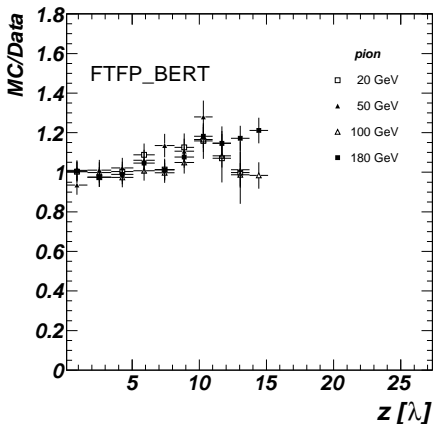
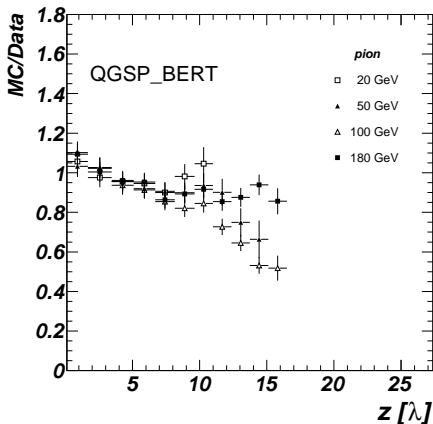
Measurement

- Measured longitudinal profile of pion and proton induced showers.



Longitudinal Profile

Pions

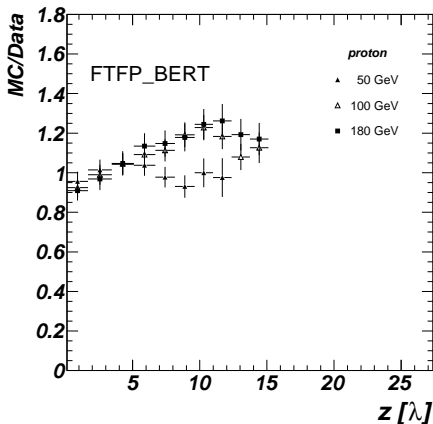
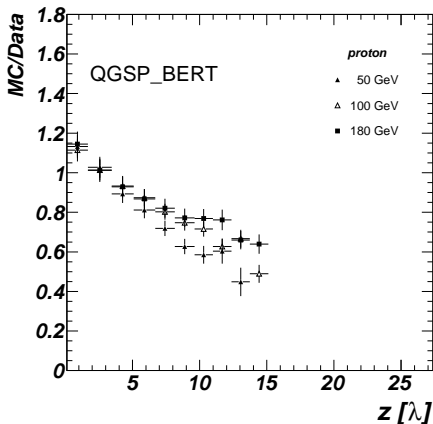


- Showers simulated with QGSP_BERT are short, 10% less energy at 10λ .

- FTFP_BERT tends to predict longer showers.

Longitudinal Profile

Protons



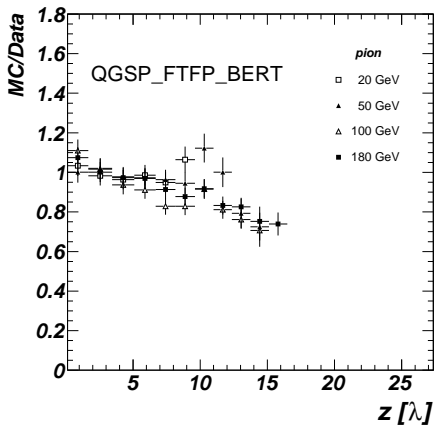
- Simulated showers are **too short**, at 10λ 30% less energy.

- FTFP_BERT tends to predict longer showers.

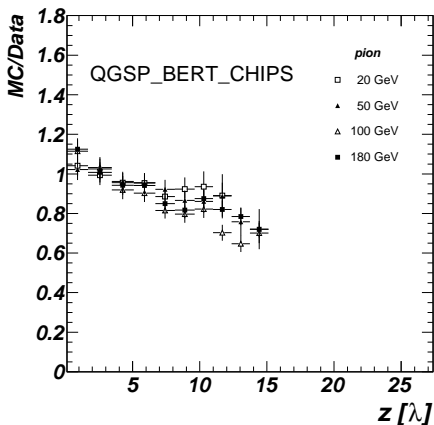
- Protons are described worse than pions.

Longitudinal Profile

Pions



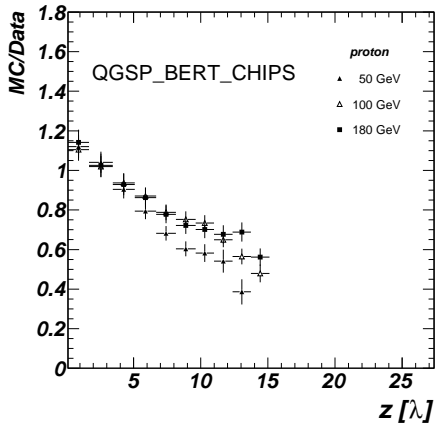
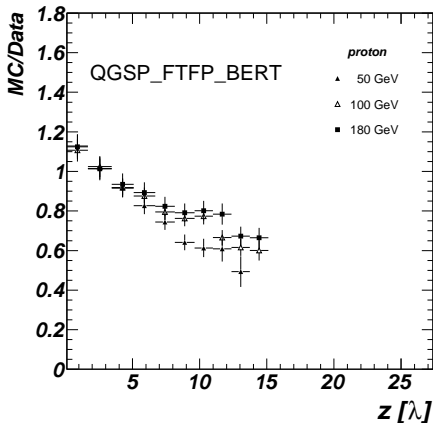
- Similar to QGSP_BERT.



- Shorter showers are predicted.

Longitudinal Profile

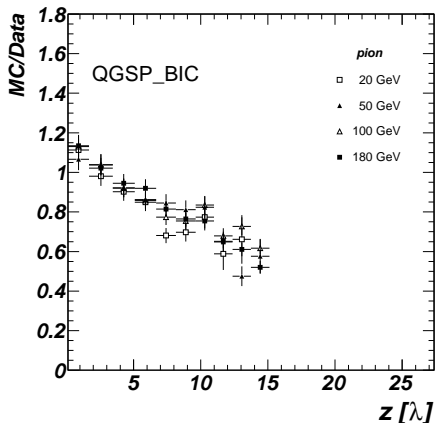
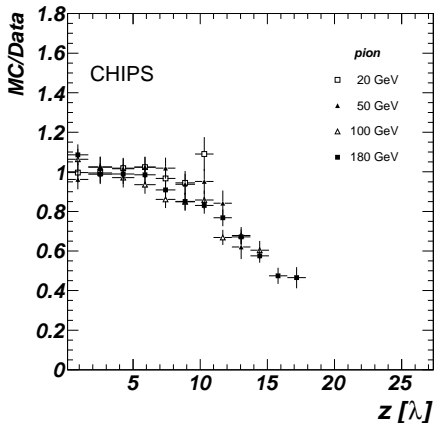
Protons



- Too short showers.

Longitudinal Profile

Pions

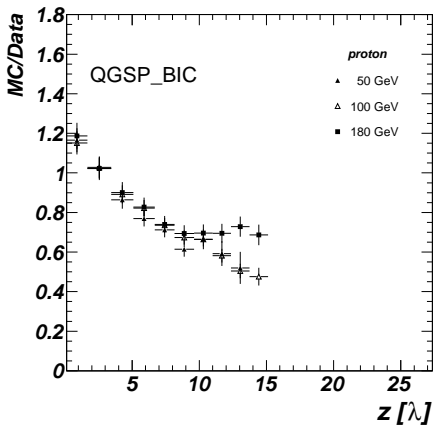
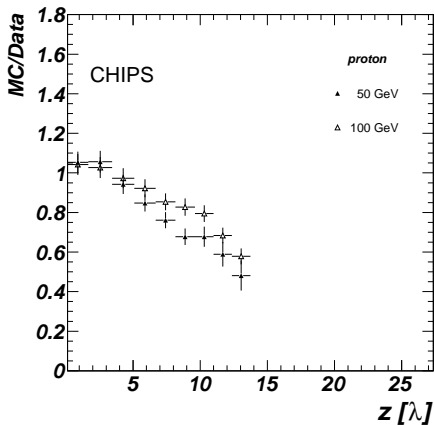


● Satisfactory description up to 10λ .

● Too short showers.

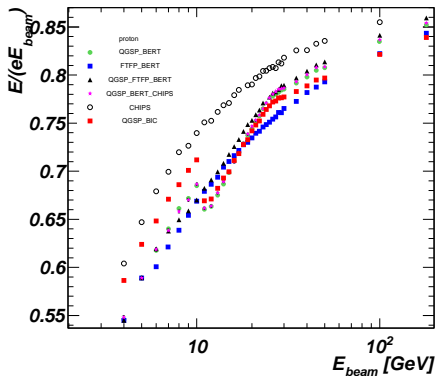
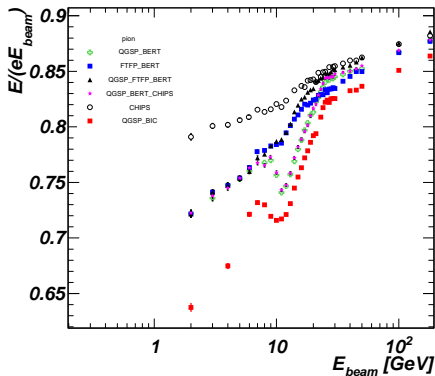
Longitudinal Profile

Protons



- Too short showers.

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, but too high.