The response of the ATLAS Tile Calorimter to pions and protons in the test beam and Geant4 simulation

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Outline

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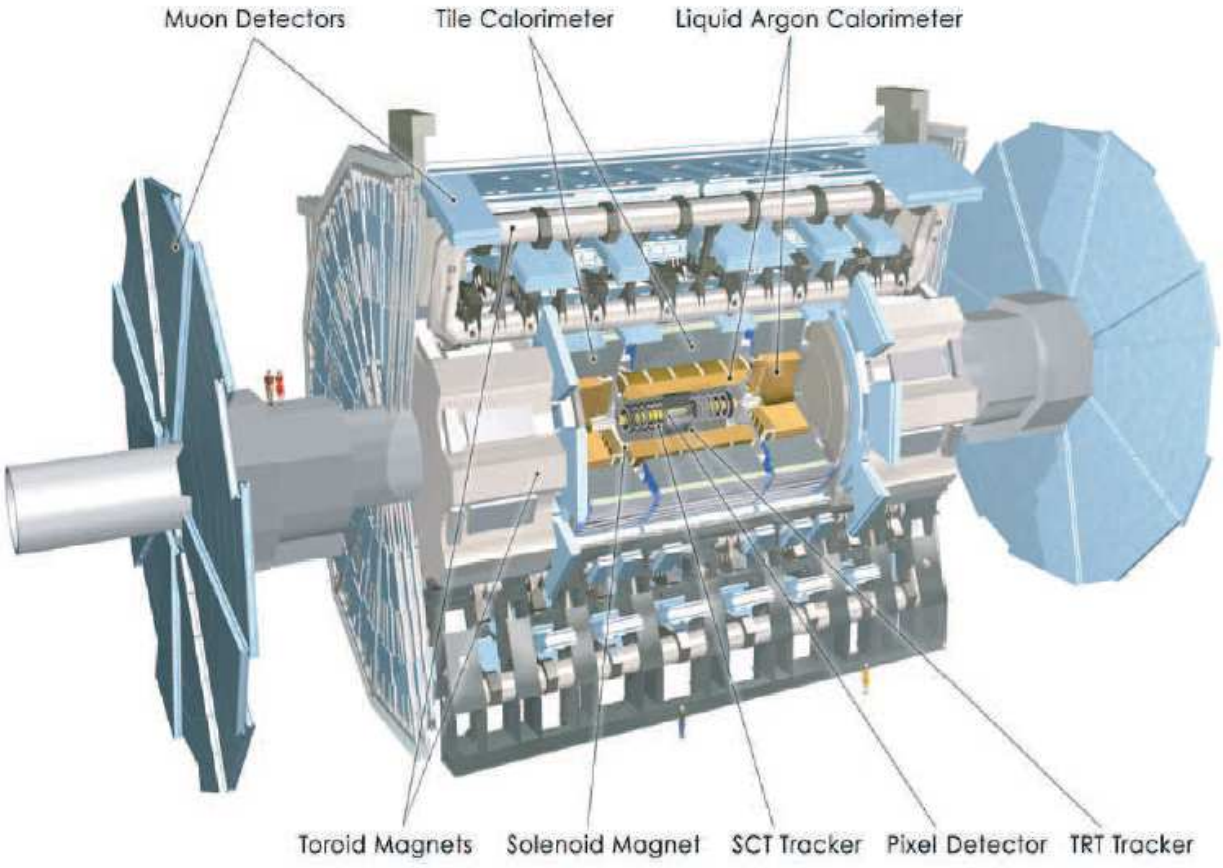
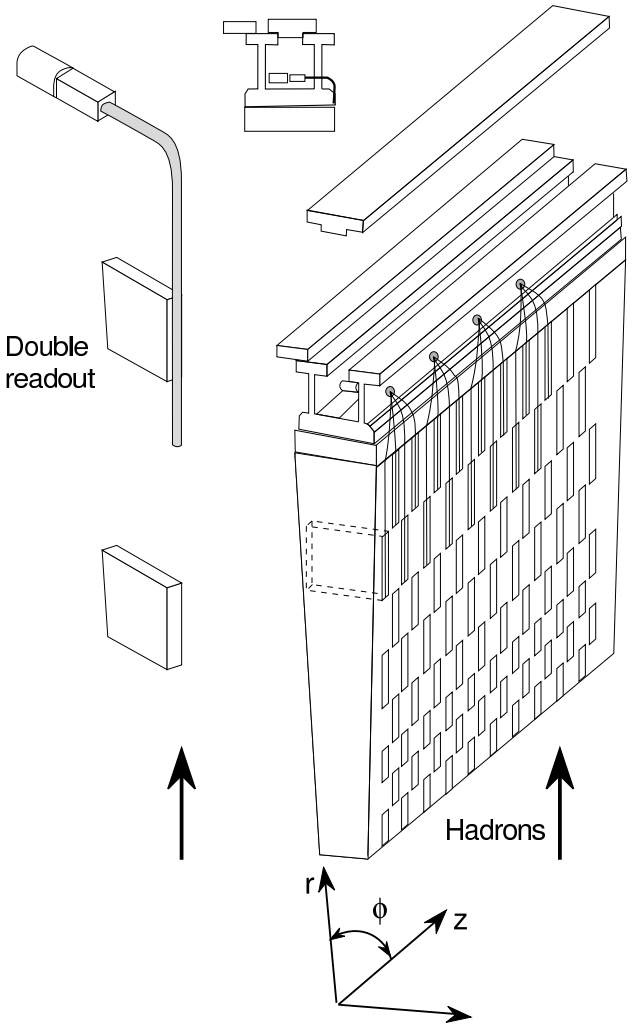
ATLAS Tile Calorimeter

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

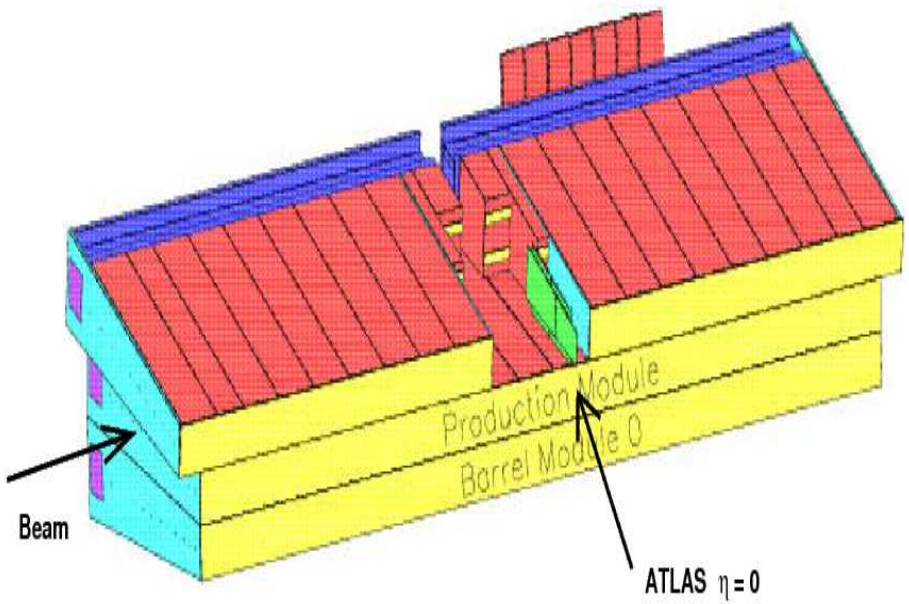




Test Beam Setup

Special Runs

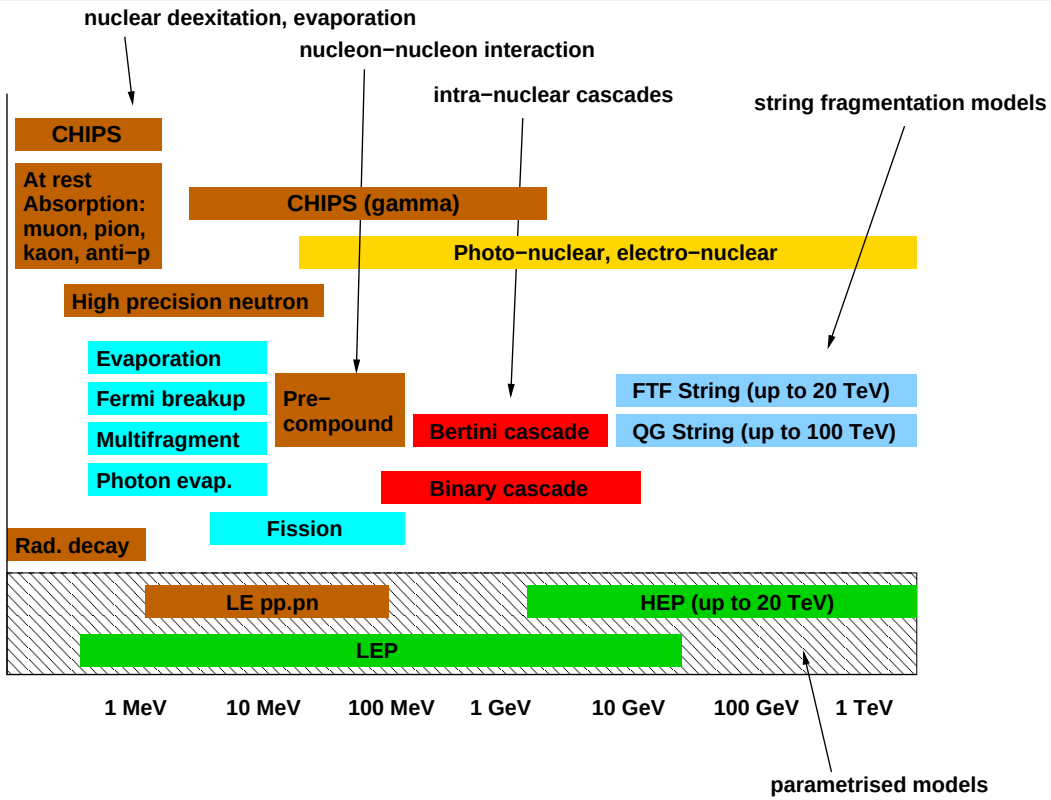
- Beam impinging the detector from the side.
- The depth is more than 25 nuclear interaction lengths (λ).
- Longitudinally showers are fully contained.
- Lateral containment of showers is more than 99%.
- Pion/proton separation is done by Cherenkov detector.



Simulation

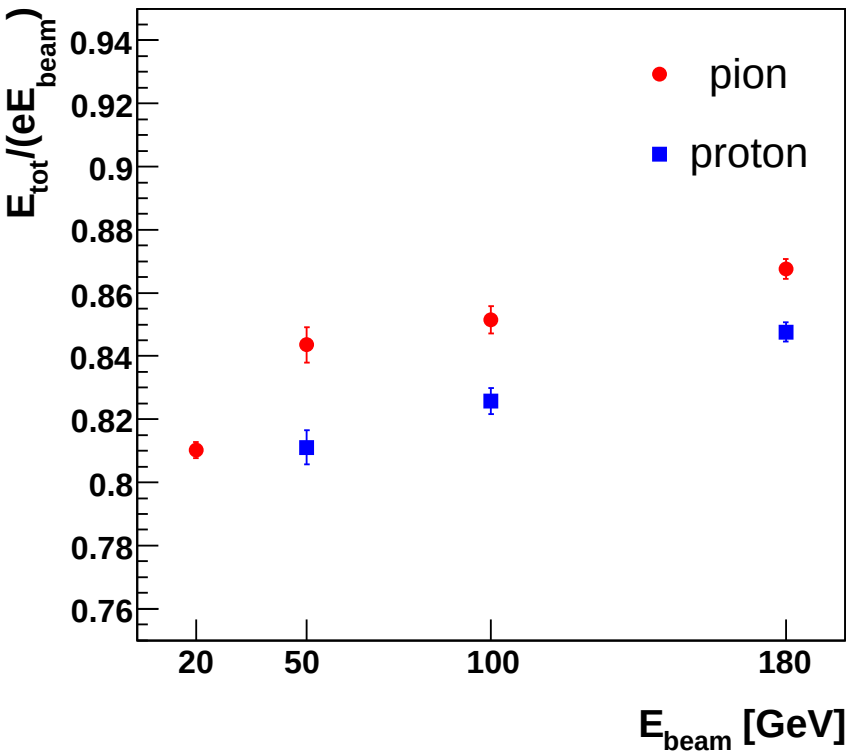
Geant4

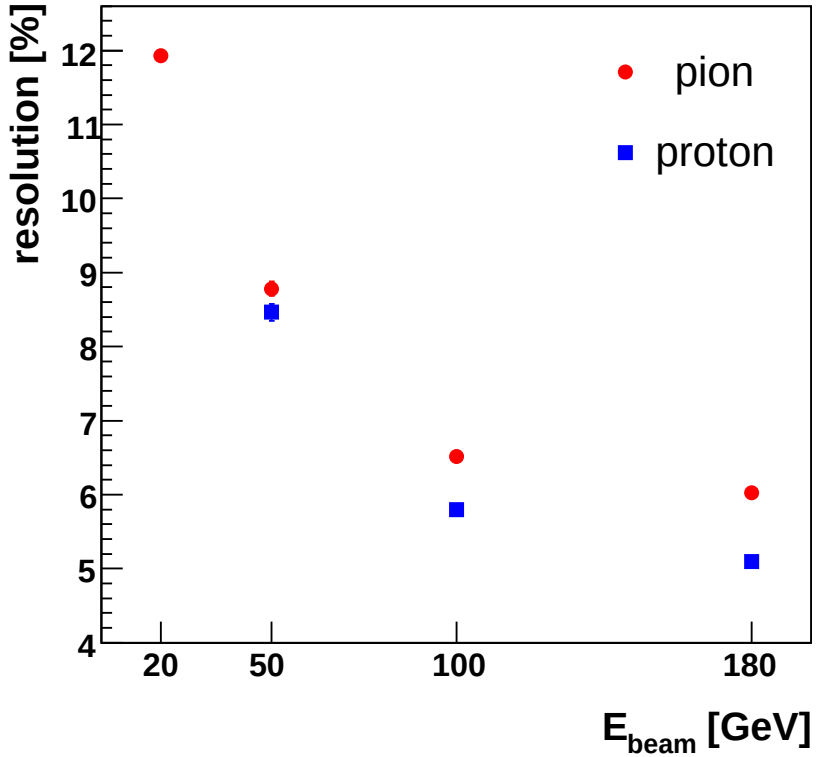
- version 9.1.
- Quark-Gluon String (QGS) and Fritiof (FTF) fragmentation models.
- Binary and Bertini cascade models.



Pion and Proton Response

EM-scale from electron response.

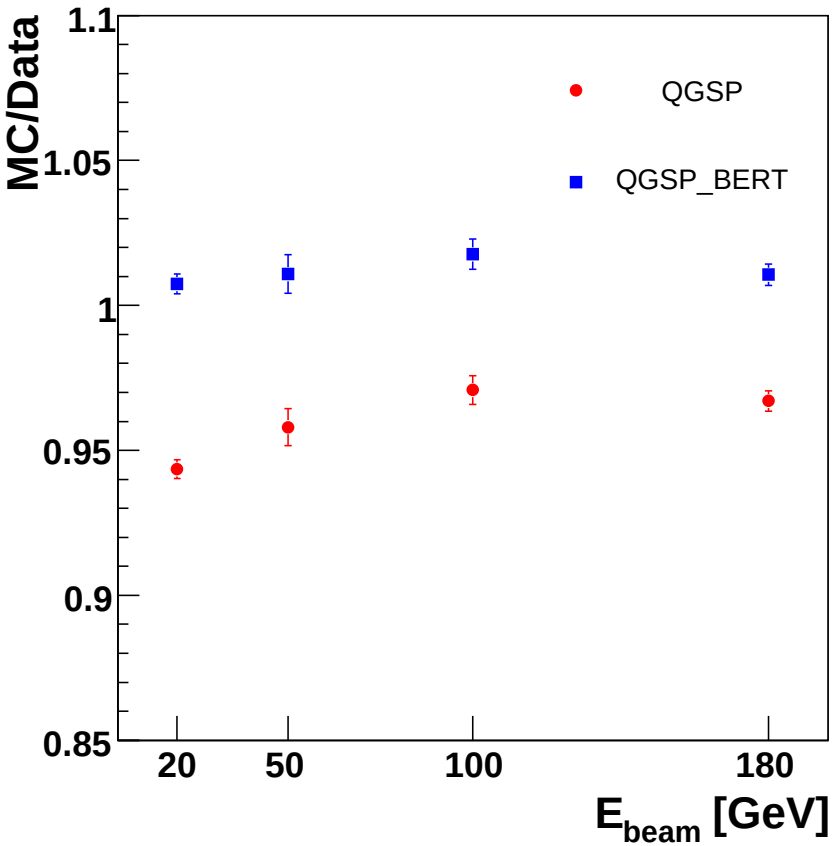




- Pions have larger response, but worse resolution.

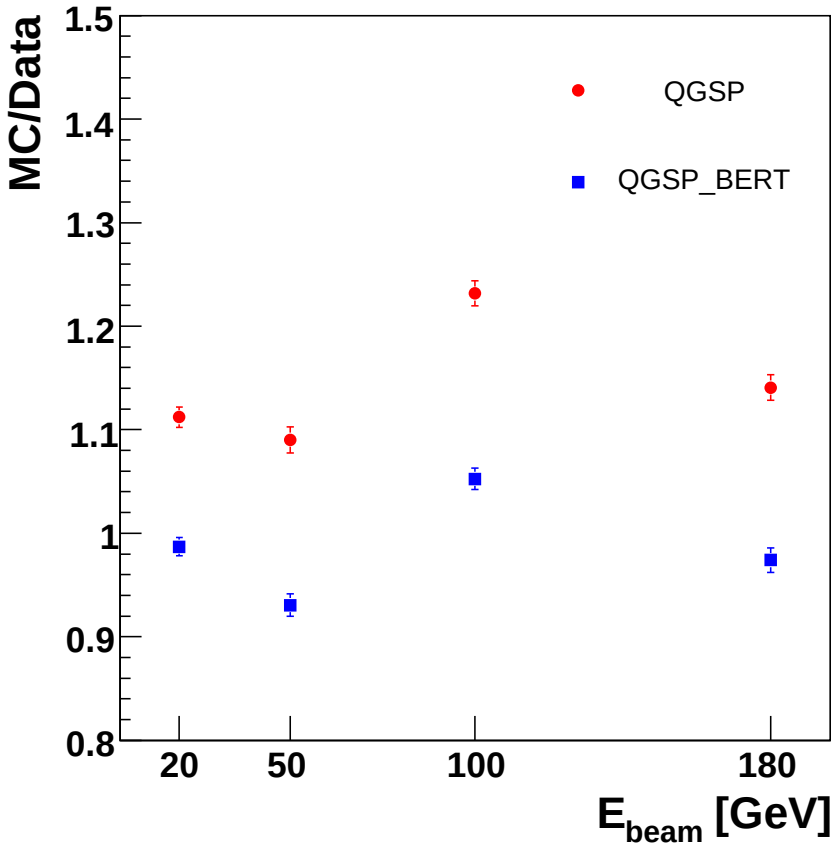
Pion Response

Response



- Bertini cascade increases response, describes data within 2%.

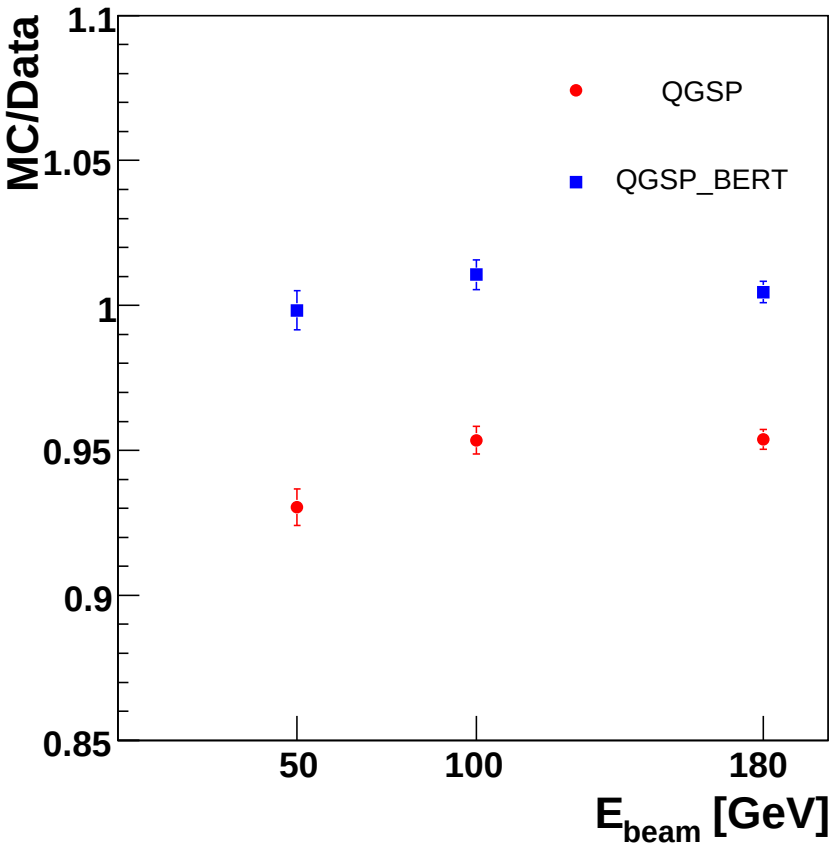
Resolution



- 10-25% worse resolution with QGSP, within $\pm$ 10% with cascade model (BERT).

Proton Response

Response



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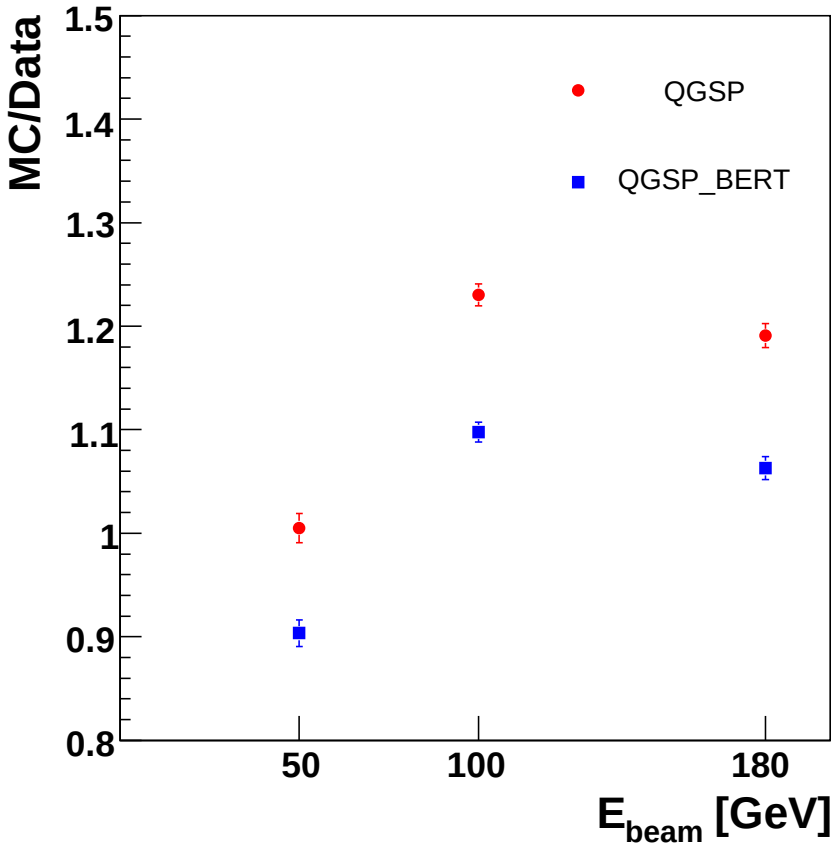

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Lateral Spread

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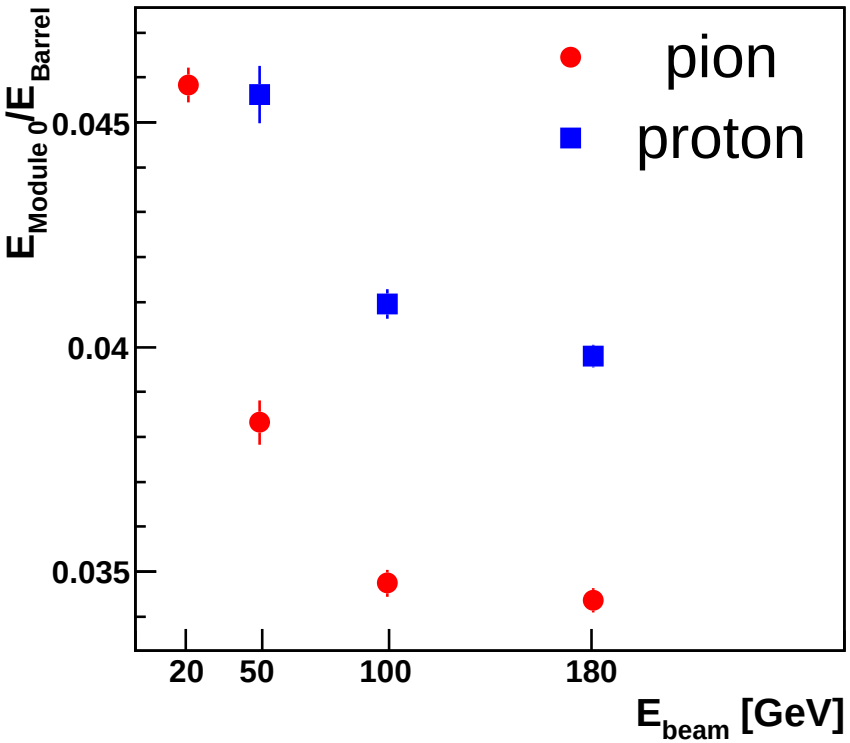

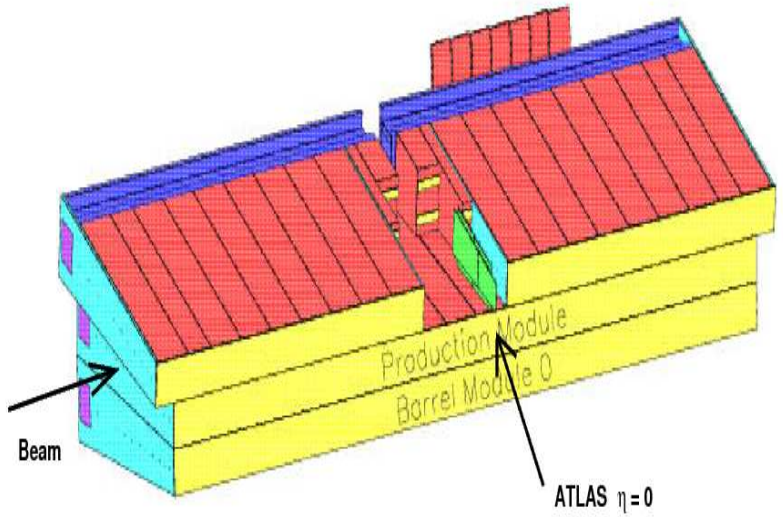

- Proton induced showers are wider than pion induced ones.
- Showers simulated using QGSP and FTFP are too narrow.
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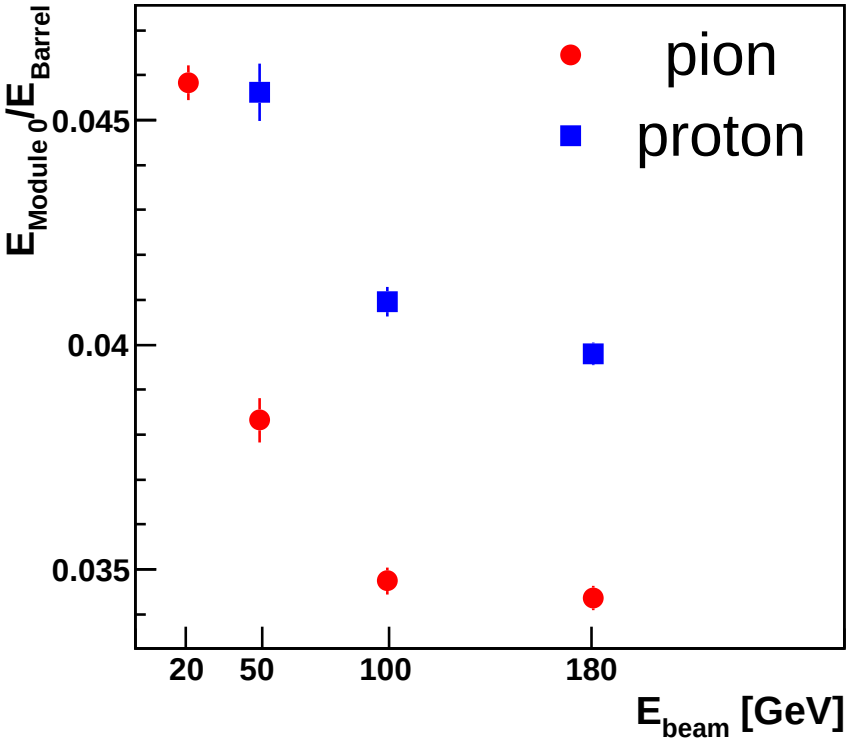

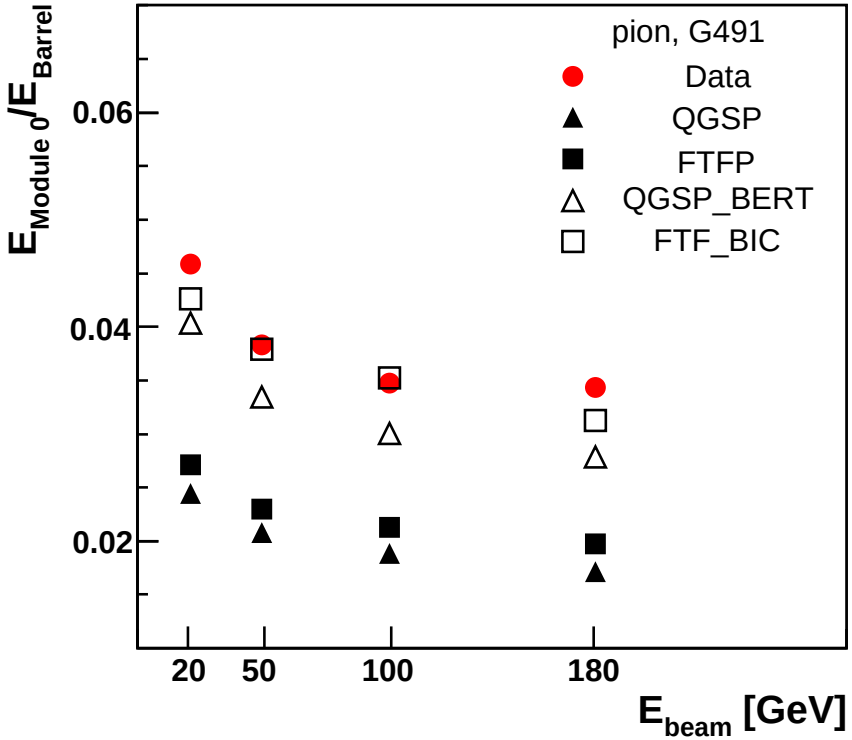

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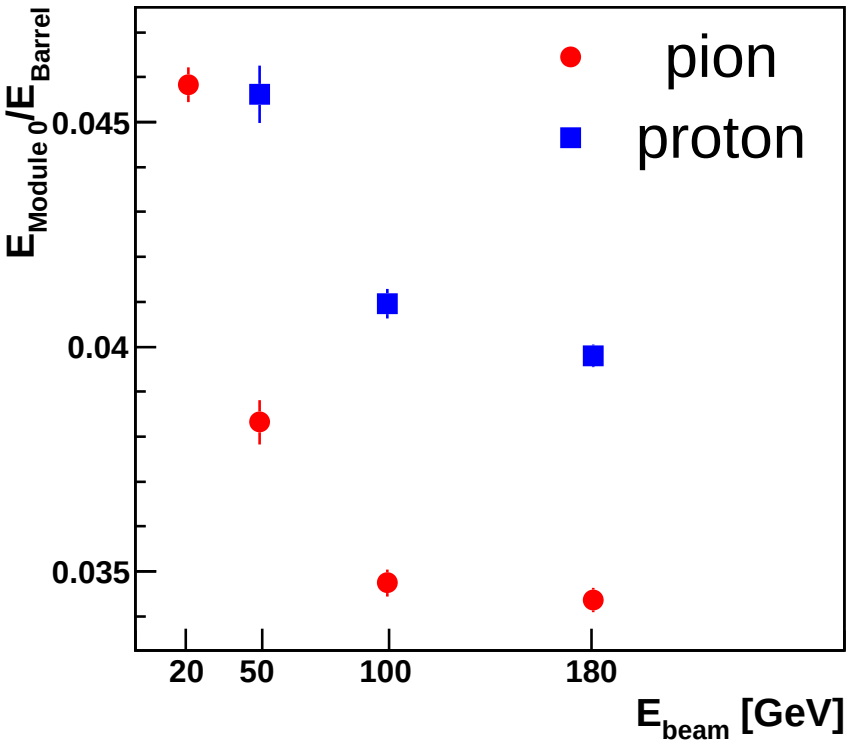

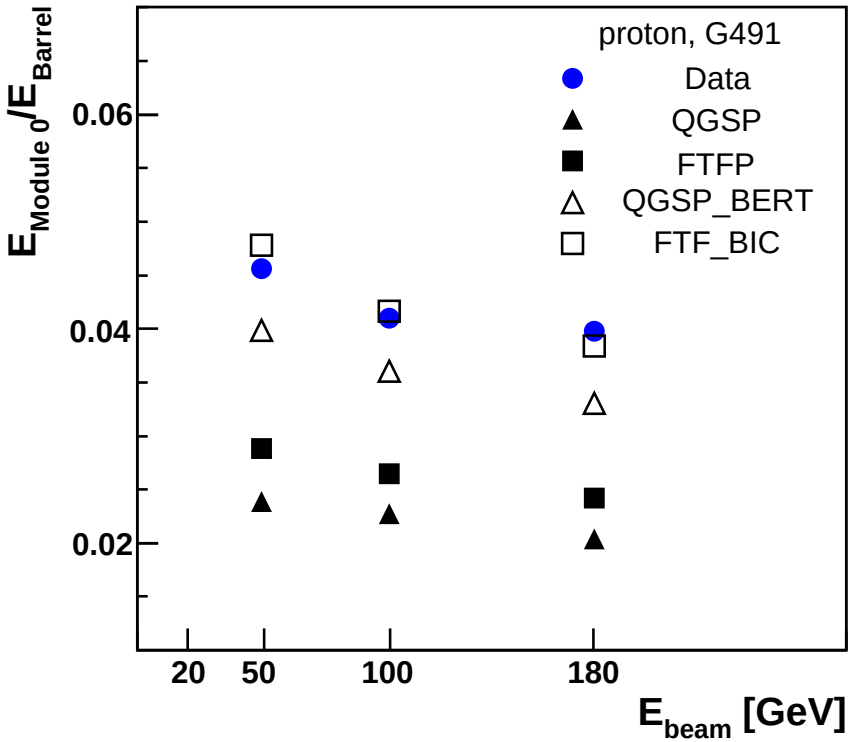

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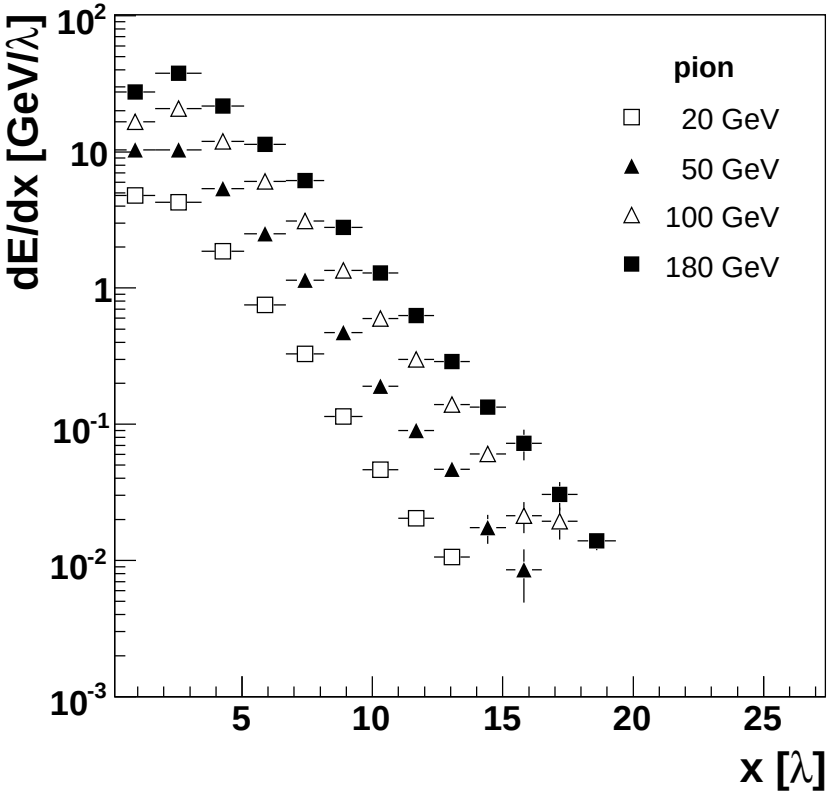
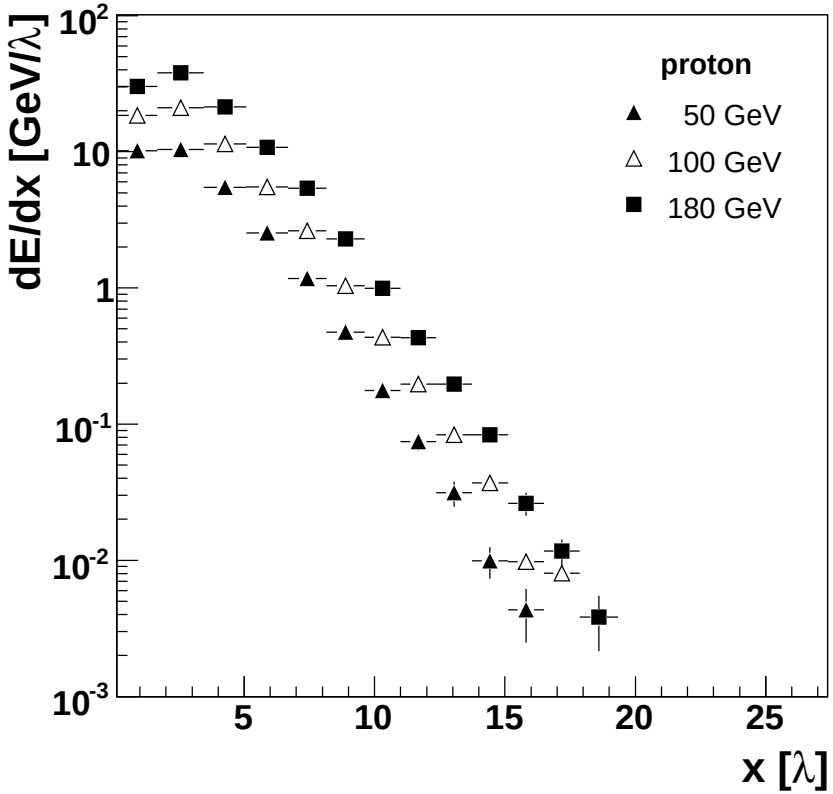
Longitudinal Profile

Pions and Protons

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





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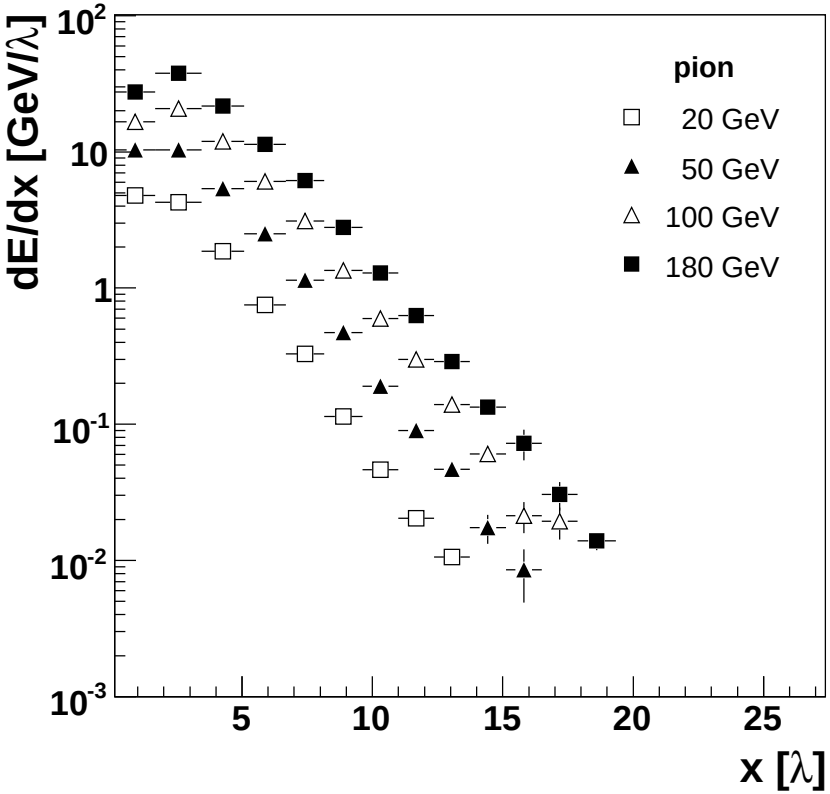

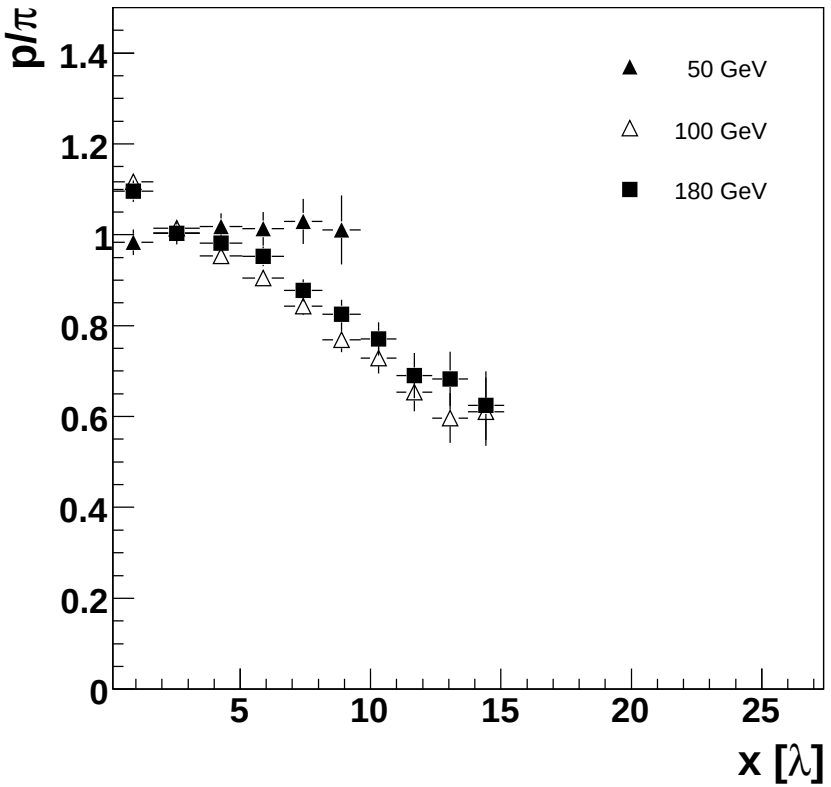

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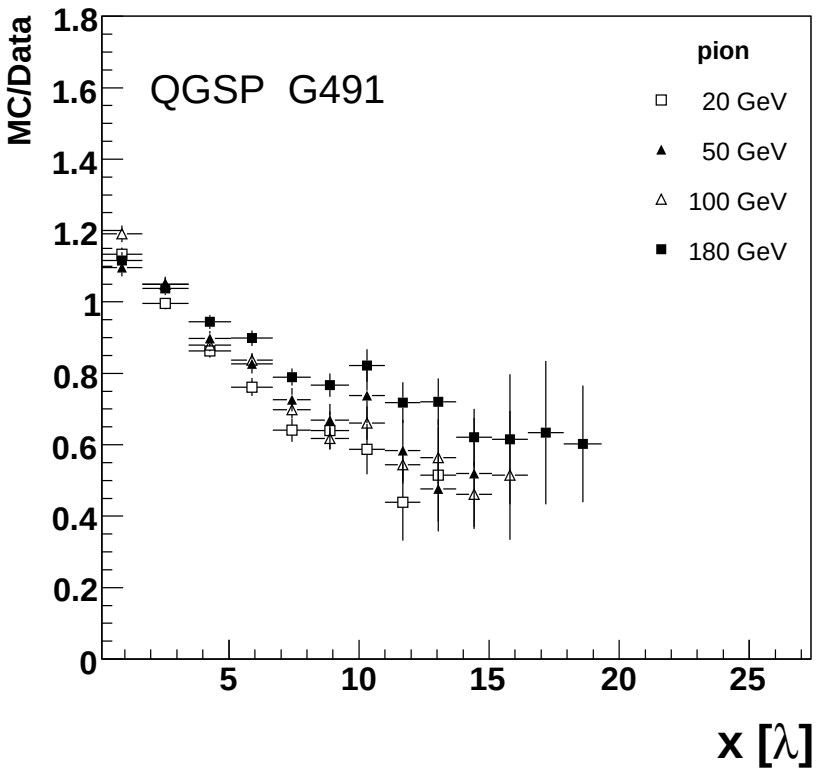
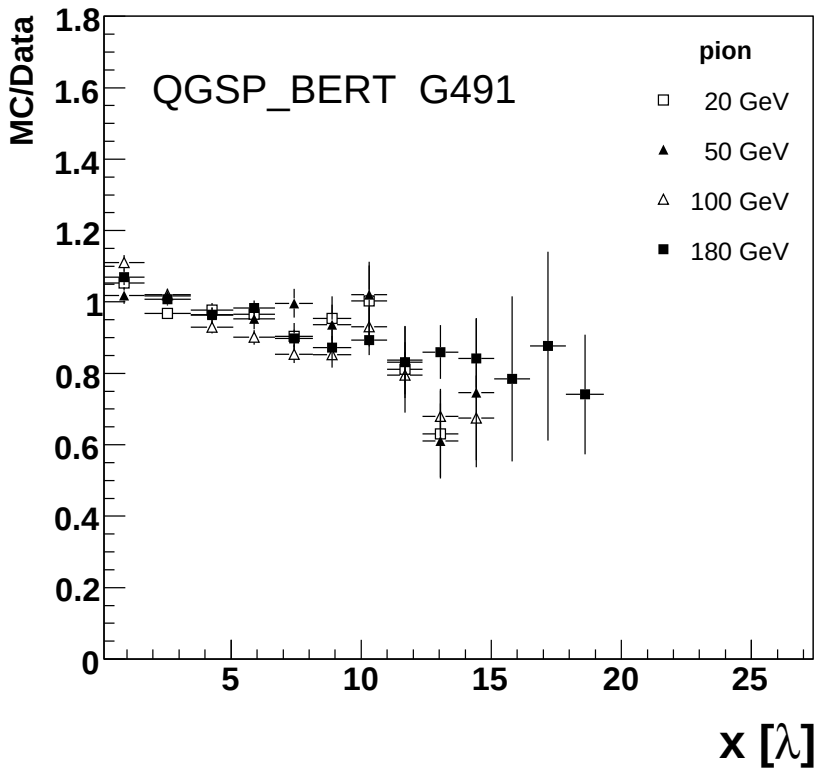
Longitudinal Profile

Pions

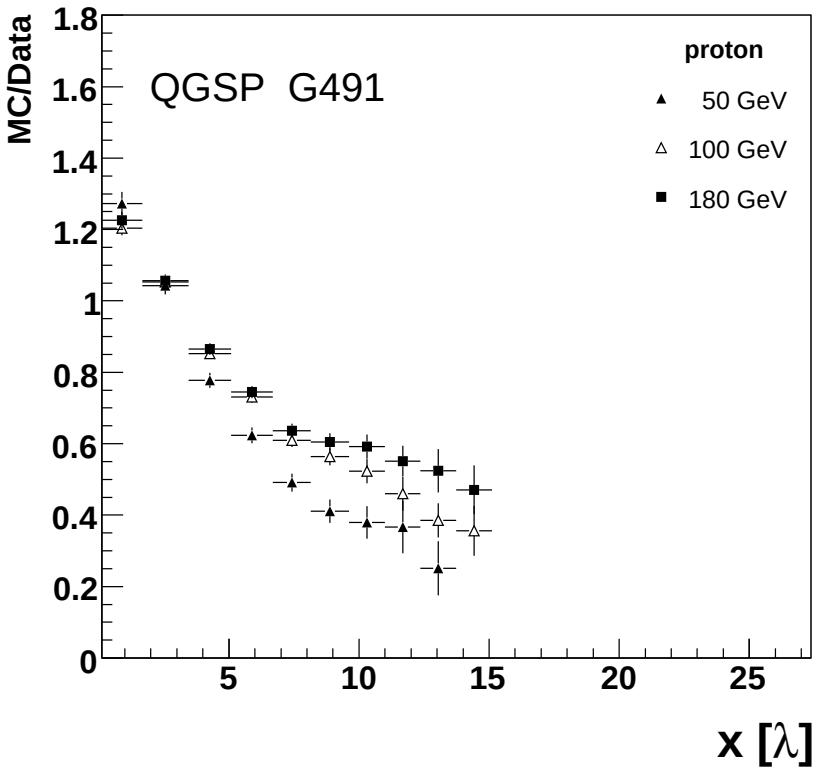


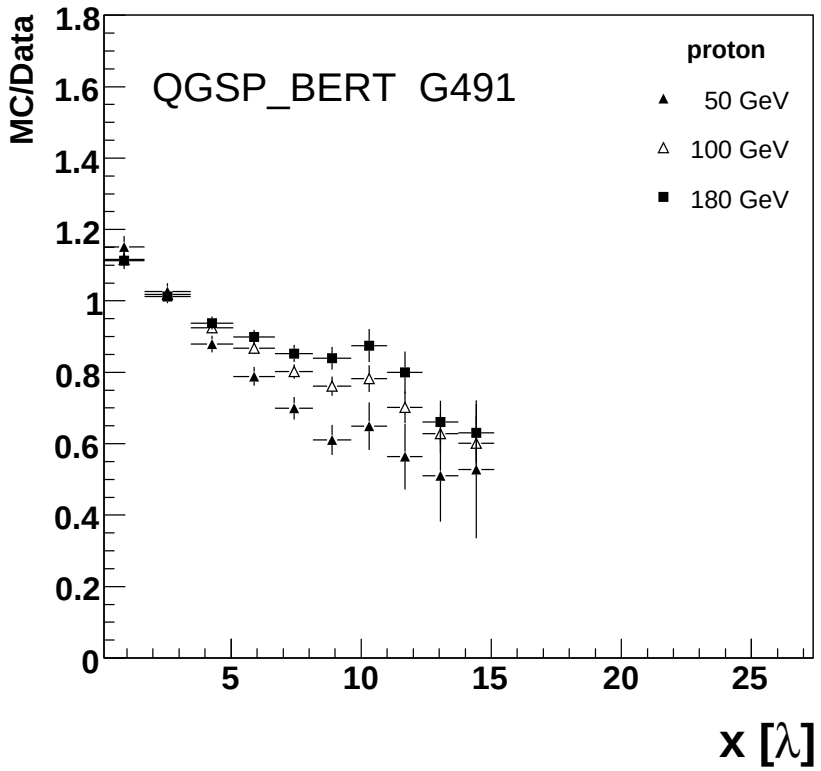


- Showers simulated with QGSP are too short, 20 – 40% less energy at 10λ.
- Adding Bertini makes showers longer, up to 10λ within $\pm$15%.

Longitudinal Profile

Protons

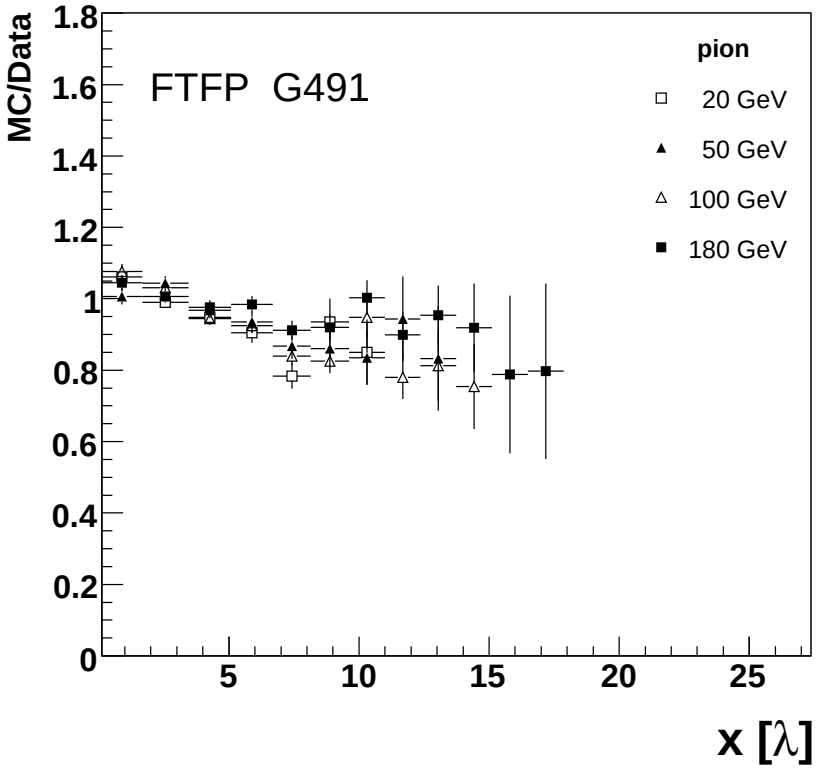


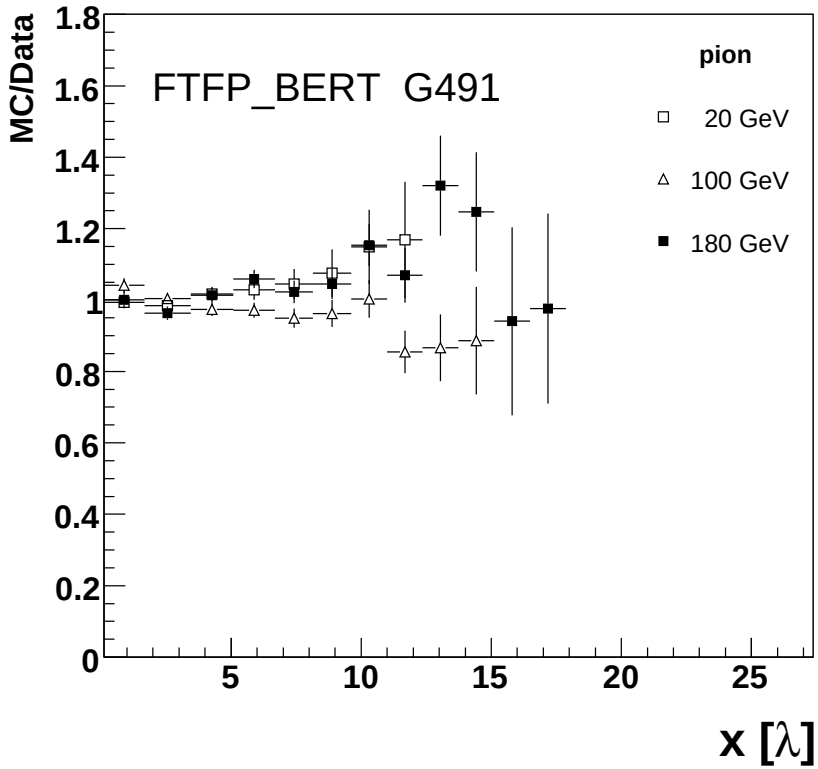


- Simulated showers are too short, at 10λ $40 - 60\%$ less energy.
- Adding Bertini makes showers longer, at 10λ 10-40% less energy.
- Protons are described worse than pions.

Longitudinal Profile

Pions

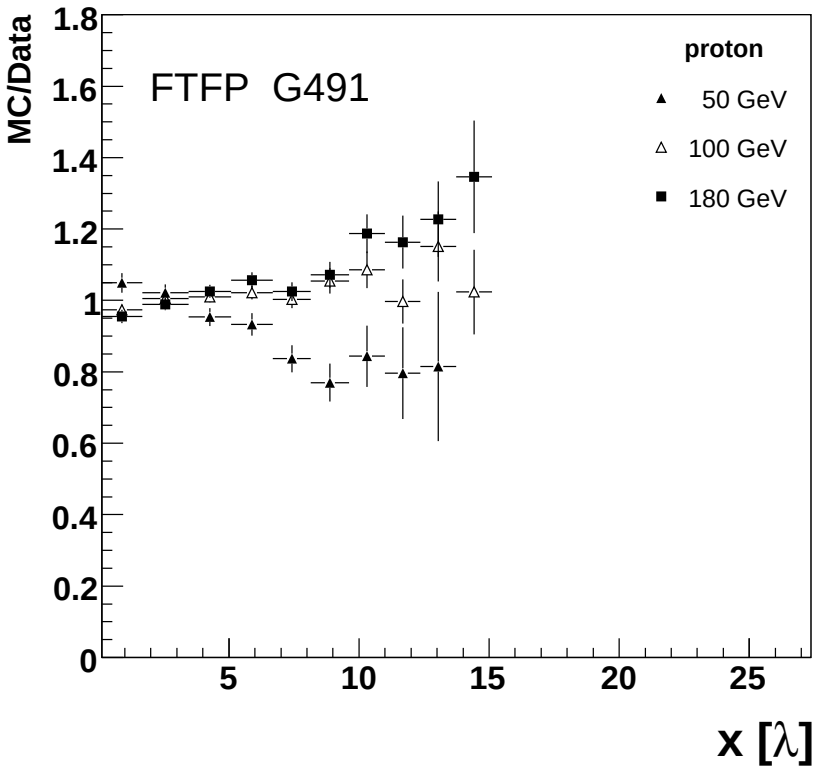


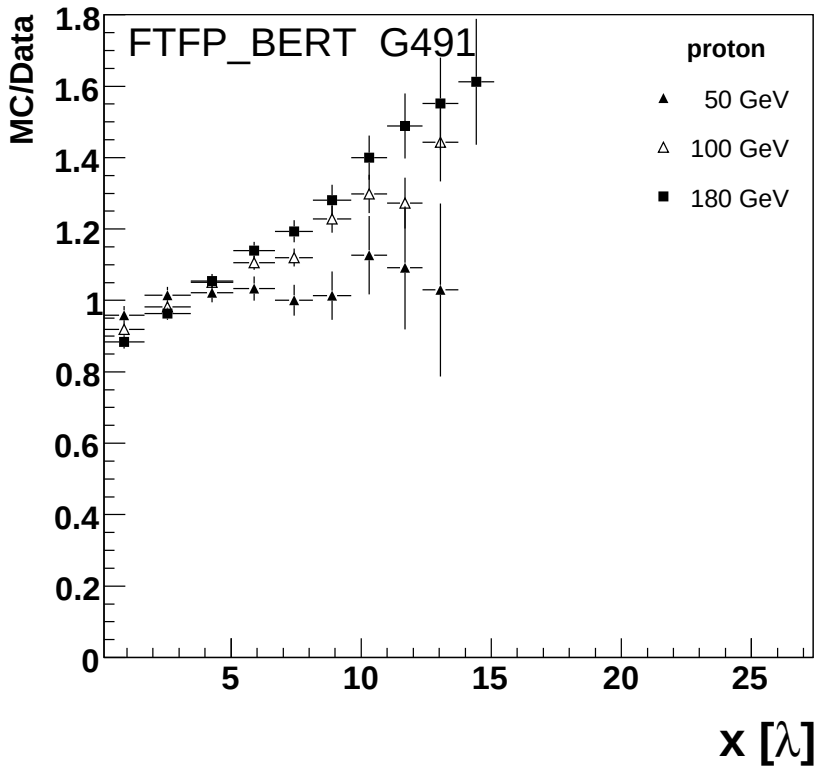


- With Fritiof model showers are a bit shorter, up to 10λ within $\pm$20%.
- With Bertini cascade MC describes data up to 10λ within $\pm$10%.

Longitudinal Profile

Protons

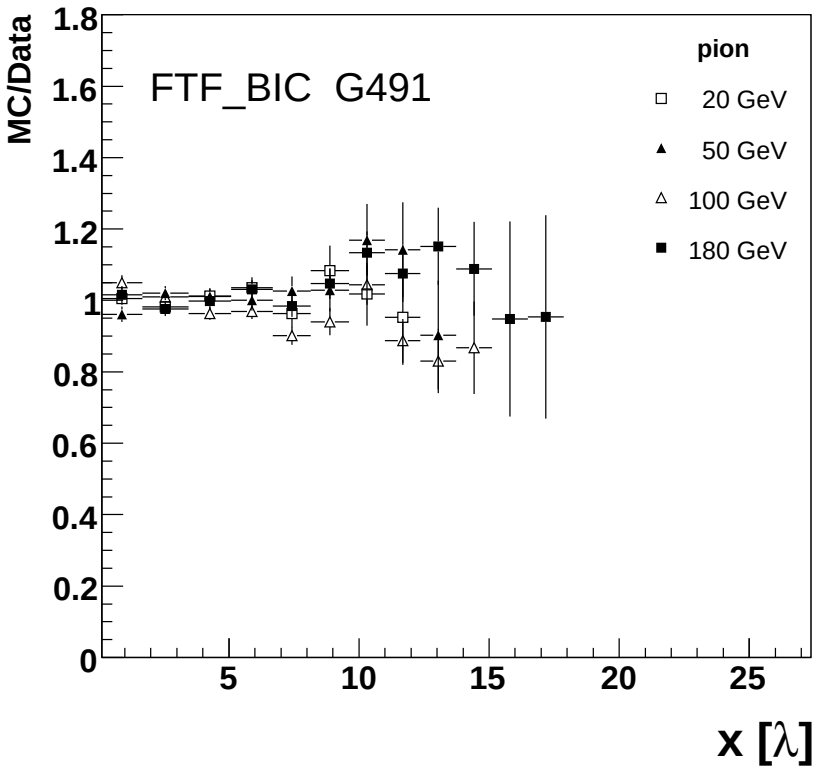


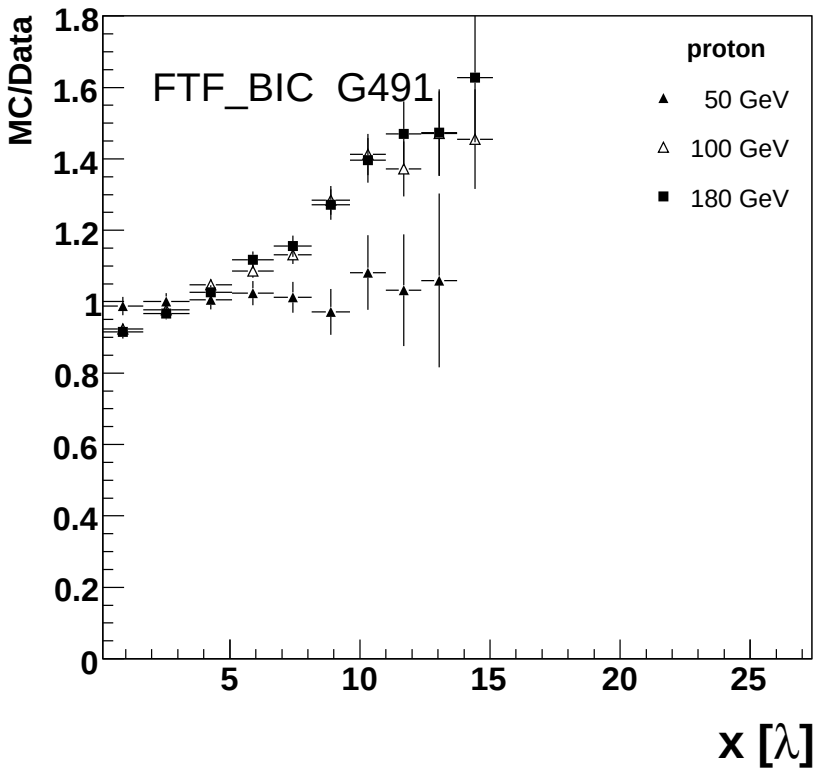


- Up to 10λ $\pm$20% agreement.
- Too long showers at high energies, MC higher by 25% at 10λ.

Longitudinal Profile

Pions and Protons





- With Binary cascade the agreement is within $\pm 10\%$ up to 10λ.
- Long showers at higher energies, MC higher by 30% at 10λ.

Summary

- Pions have larger response but worse resolution as compared to protons.
- Proton induced showers are shorter than pion induced ones, but they are laterally wider.
- Hadronic showers simulated by QGSP are too short and too narrow.
- FTFP predicts too narrow showers, 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.

$\Rightarrow$ ATLAS has recently changed the default physics list from QGSP to QGSP_BERT, which will be used for simulation of the first LHC collisions.

Backup

More information about the analysis can be found in the ATL-TILECAL-PUB-2007-008 note.
`http://cdsweb.cern.ch/record/1004188`