Testing alternative FTF tunes on calorimeters

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Alternative FTF tunes

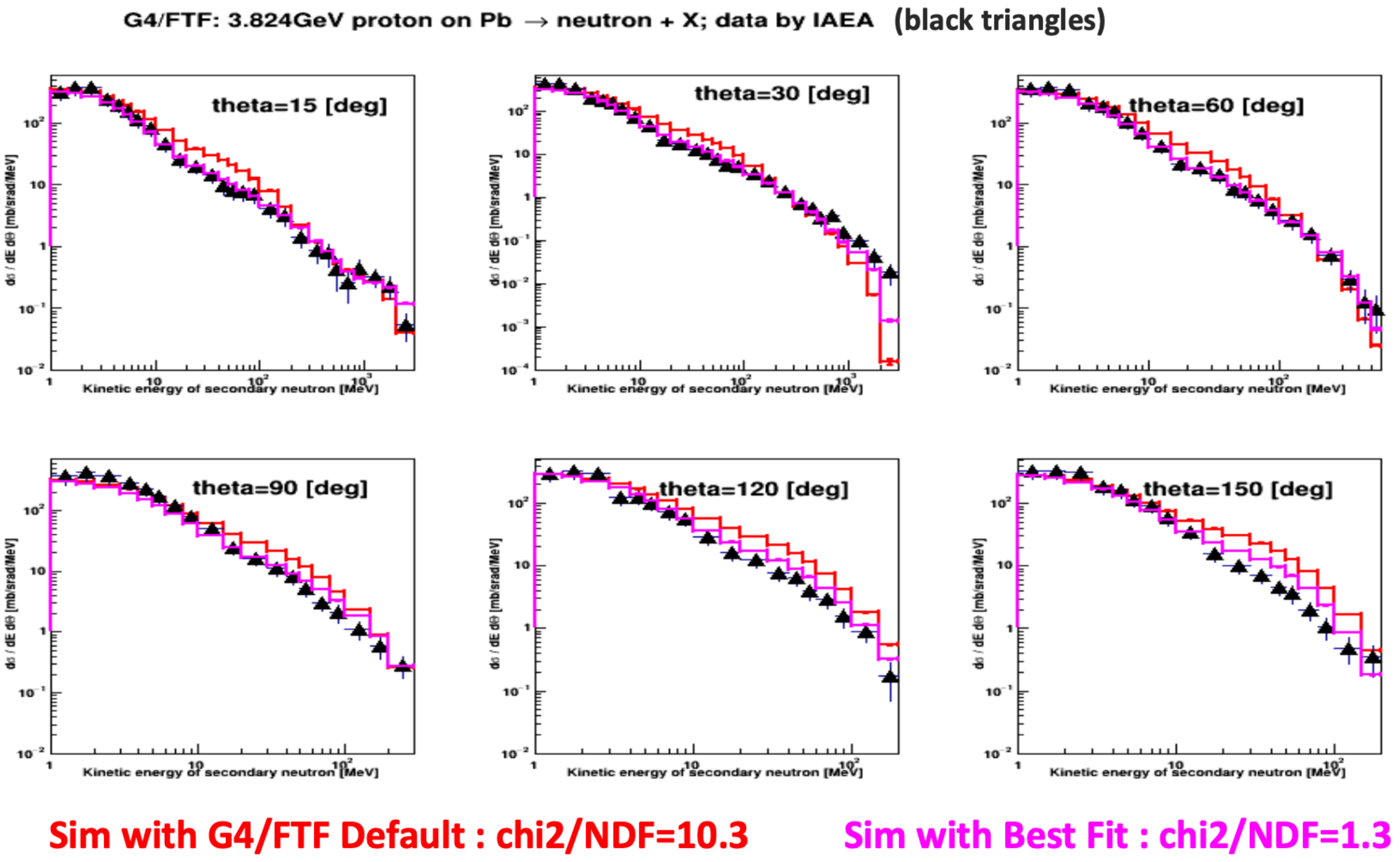
Geant4-11.1 introduces alternative FTF-model tunes selectable via the `G4FTFTunings` singleton

- FTF tunes extracted by J. Yarba, several examples reported at her presentation at latest HSF Detector Simulation WG Meeting
- Currently, 4 tunes are available: default (index=0), baryon-tune2022-v0 (index=1), pion-tune2022-v0 (index=2), combined-tune2022-v0 (index=3)
- From the release notes:
  Currently, the feature is mostly meant for use in internal tests, further study and development

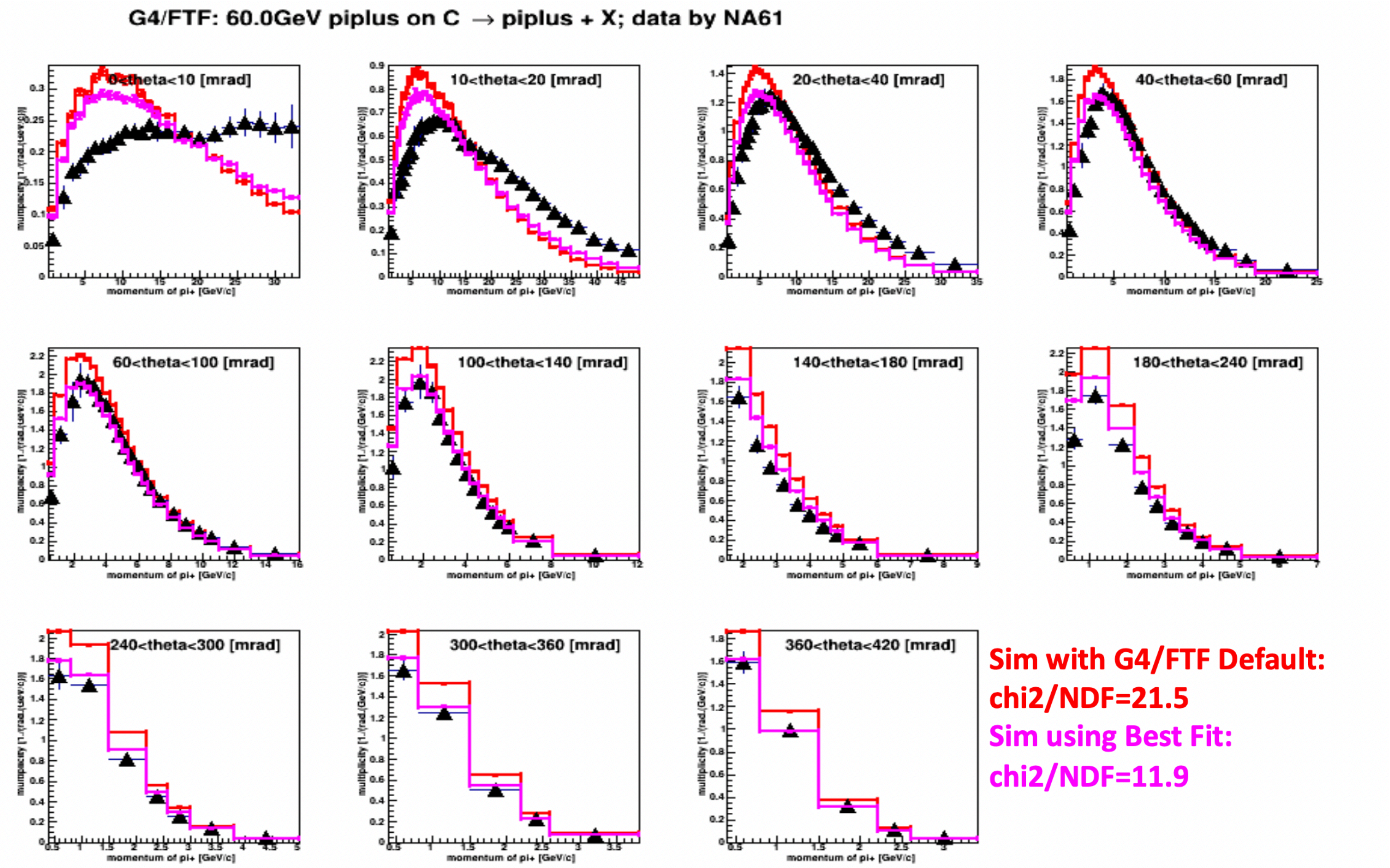
Two tasks reported today:

- Alternative tunes are obtained as best parameters to maximize the MC agreement with thin target experimental data (see next slides)
  - We need to address their impact on thick targets (*i.e.* calorimeters)
- Need to update *geant-val* in order to house results obtained with alternative FTF tunes

FTF tunes: proton projectile (examples)



FTF tunes: pion projectile (examples)



Sim with G4/FTF Default: chi2/NDF=21.5

Sim using Best Fit: chi2/NDF=11.9

FTF tunes and *geant-val*

At the moment, *geant-val* knows nothing about FTF tunes:

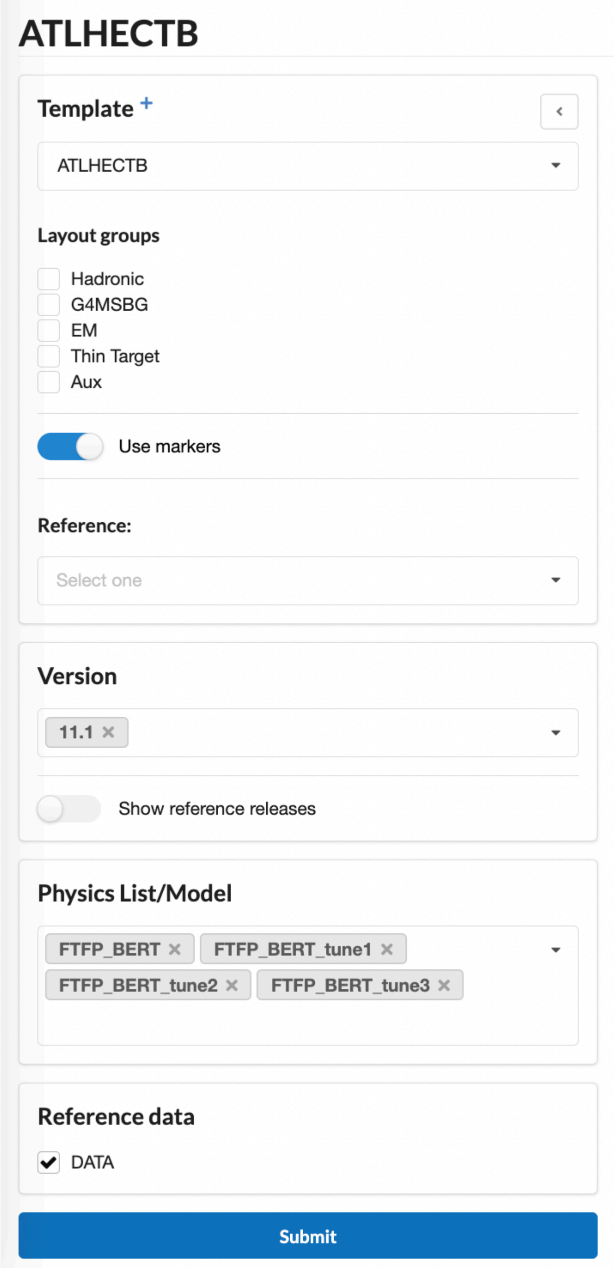
- they are not selectable as parameters in configuration files (`params.conf`)
- they are not selectable via the web interface

We suggest the following:

- `params.conf` files allow PLnames such *FTFP_BERT_tuneID*
  - Tests internally split string into PL_name and tune_ID
- Web interface compares *FTFP_BERT* with *FTFP_BERT_tuneID*
  - no changes required on *geant-val* side

params.conf

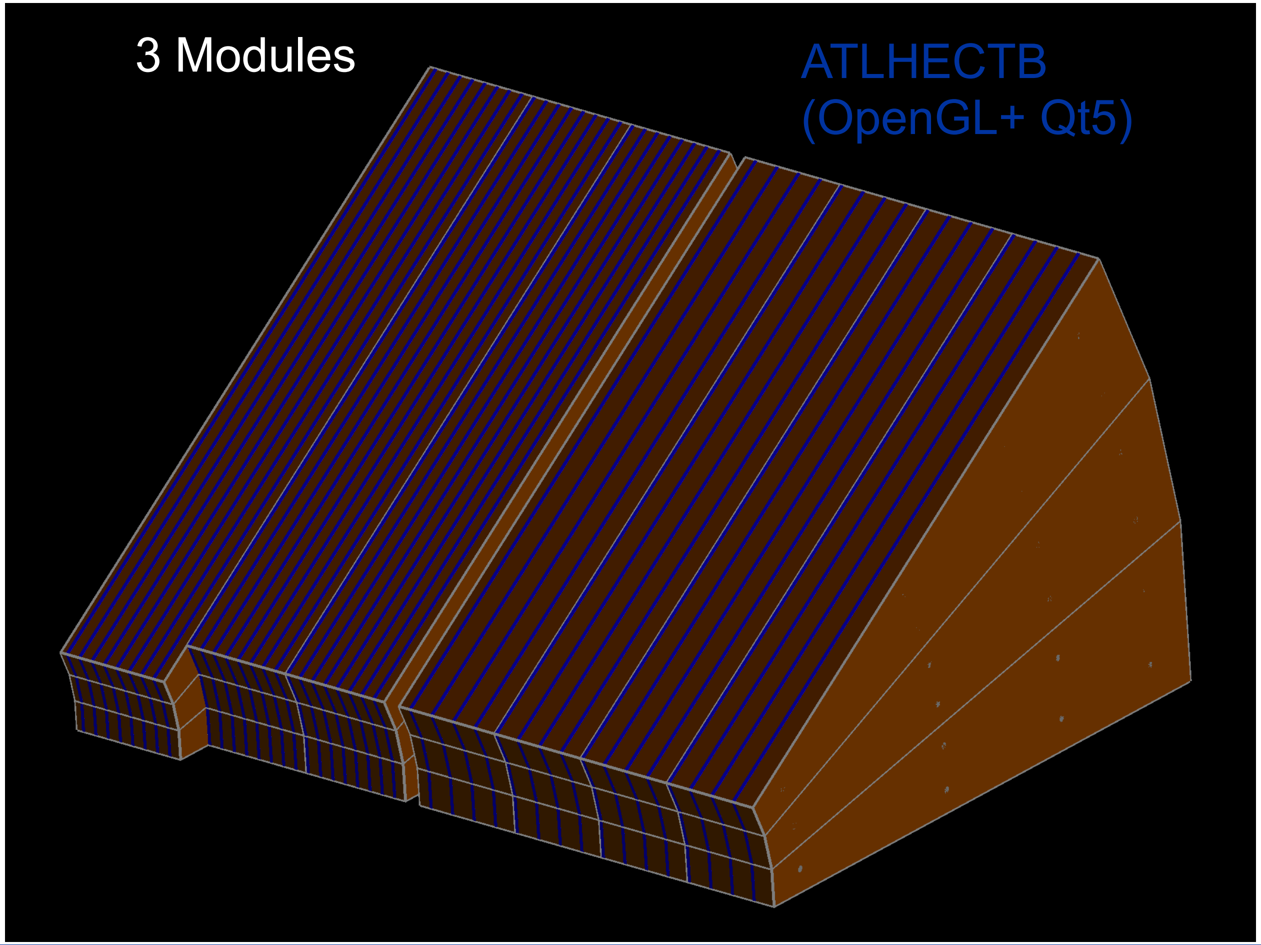
```
!PHYSLIST=FTFP_BERT, QGSP_BERT,
FTFP_BERT_ATL, FTFP_INCLXX,
FTFP_BERT_tune1, FTFP_BERT_tune2,
FTFP_BERT_tune3

!CONST:ENERGY_UNIT=GeV
PARTICLE | ENERGY | PHYSLIST | NEVENTS
pi- | 20. | PHYSLIST | 50000
pi- | 30. | PHYSLIST | 50000
pi- | 40. | PHYSLIST | 50000
pi- | 50. | PHYSLIST | 50000
pi- | 60. | PHYSLIST | 50000
pi- | 80. | PHYSLIST | 50000
pi- | 100. | PHYSLIST | 50000
pi- | 120. | PHYSLIST | 50000
pi- | 150. | PHYSLIST | 50000
```



Results from the ATLAS HEC validation test

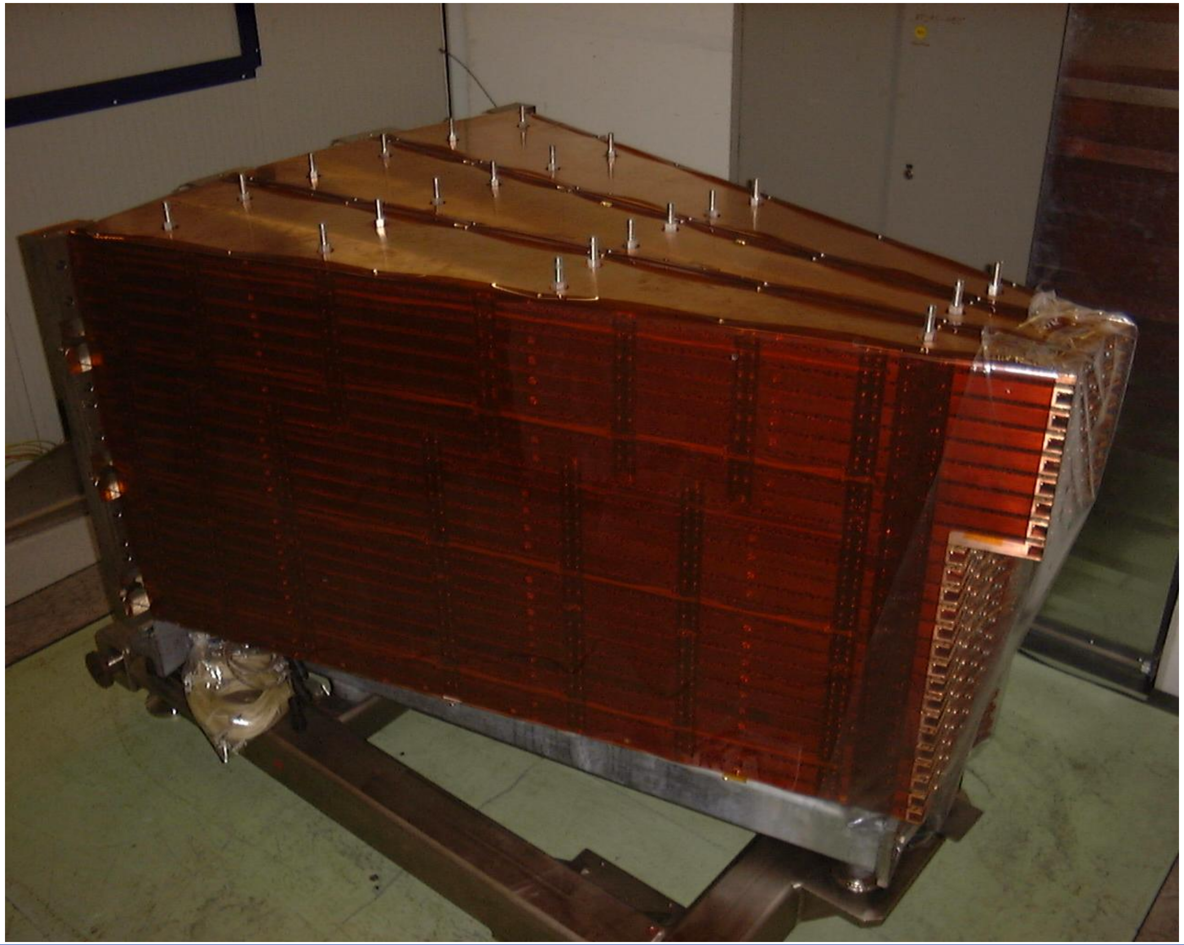
Default ATLHECTB geometry

Detailed geometry description at presentation



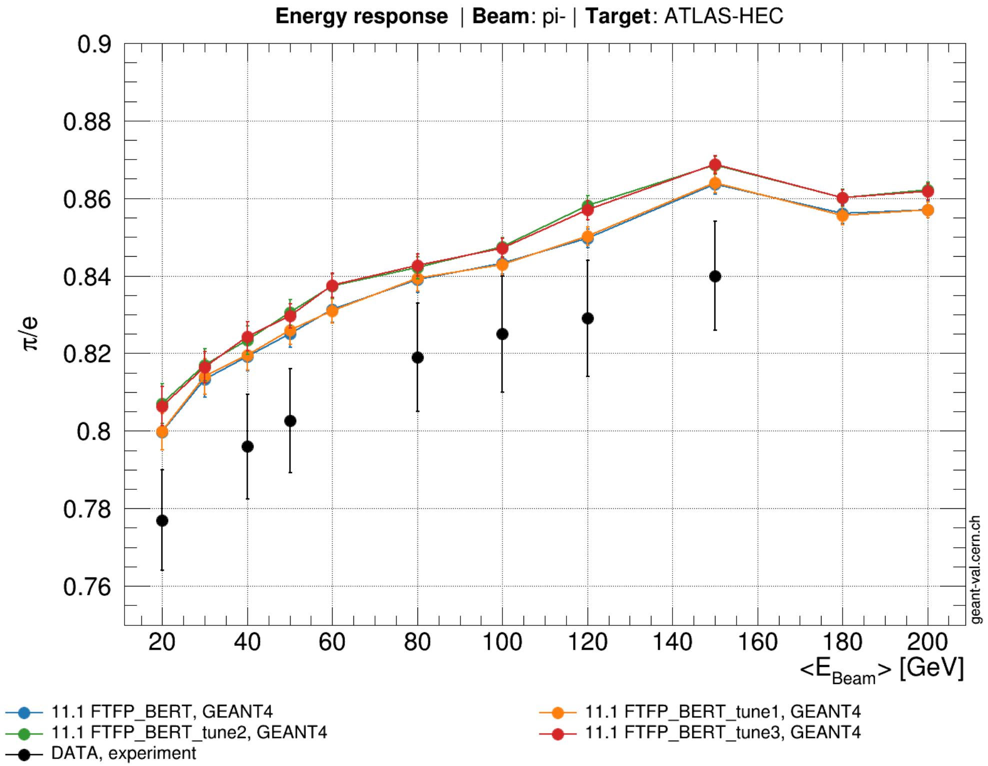
Picture from ATLAS HEC test beam (2000/2001)

Some pictures from ATLAS at link



Energy response (π^-)

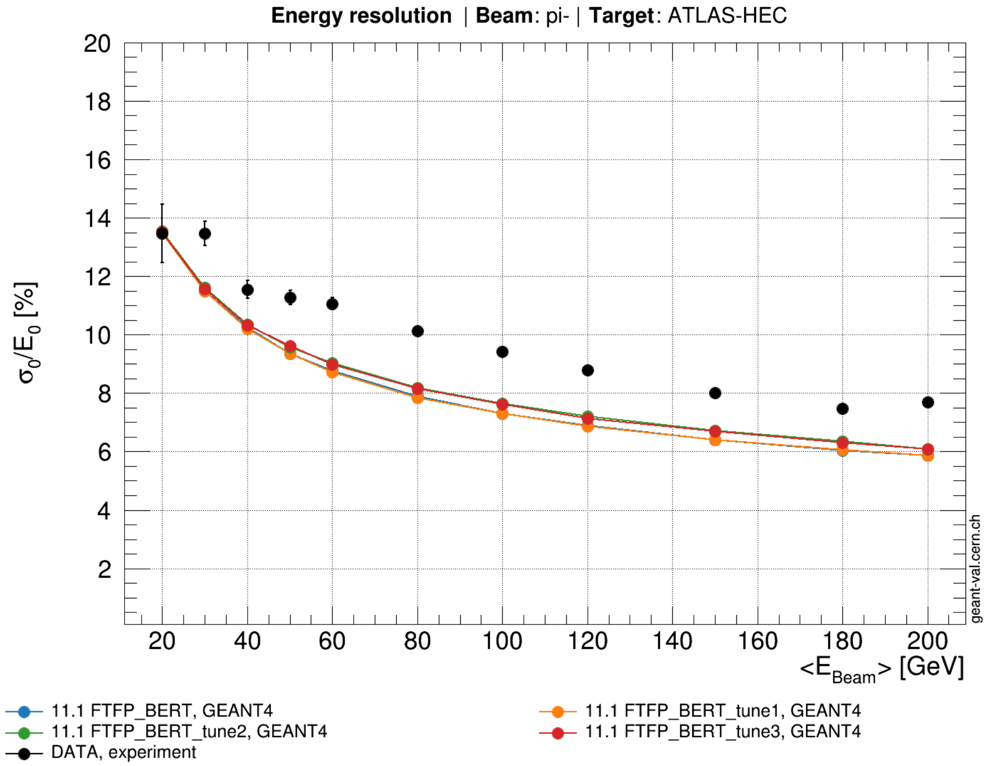
- π/e is extracted from the average π^- reconstructed energy (peak position), using the calibration at the electromagnetic scale, divided by average e^- reconstructed energy (peak position) at close beam energies.
- Results:
  - FTFP_BERT overestimates π/e by $\simeq 2\,\%$
  - tune_1 identical to FTFP_BERT (sub per-mille differences)
  - tune_2 leads to slightly higher response w.r.t. default, and $\simeq 3\,\%$ higher than data
    - tune_2 relates to π beams (makes sense to expect bigger changes from it)
  - tune_3 identical to tune_2 (sub per-mille differences)



Energy resolution (π^-)

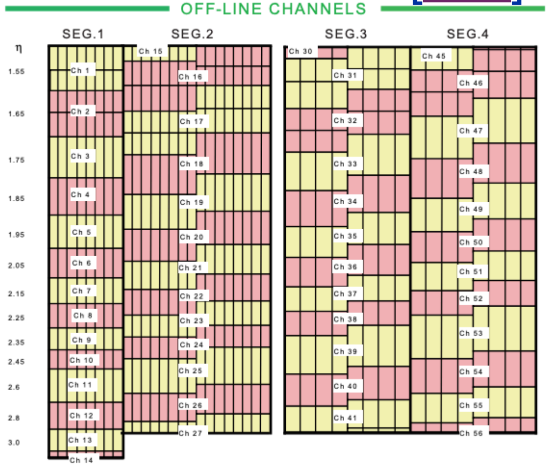
- Energy resolution is obtained as σ/E from a Gaussian fit to the π^-energy distributions.

- Results:
  - FTFP_BERT still underestimating energy fluctuations up to $\simeq 20\,\%$
    - tune_1 identical to default (sub per-mille agreement)
    - tune_2 predicts energy fluctuations $\simeq 2-3\,\%$ higher than default
      - Still very far from ATLAS data
    - tune_3 identical to tune_2 (sub per-mille agreement)

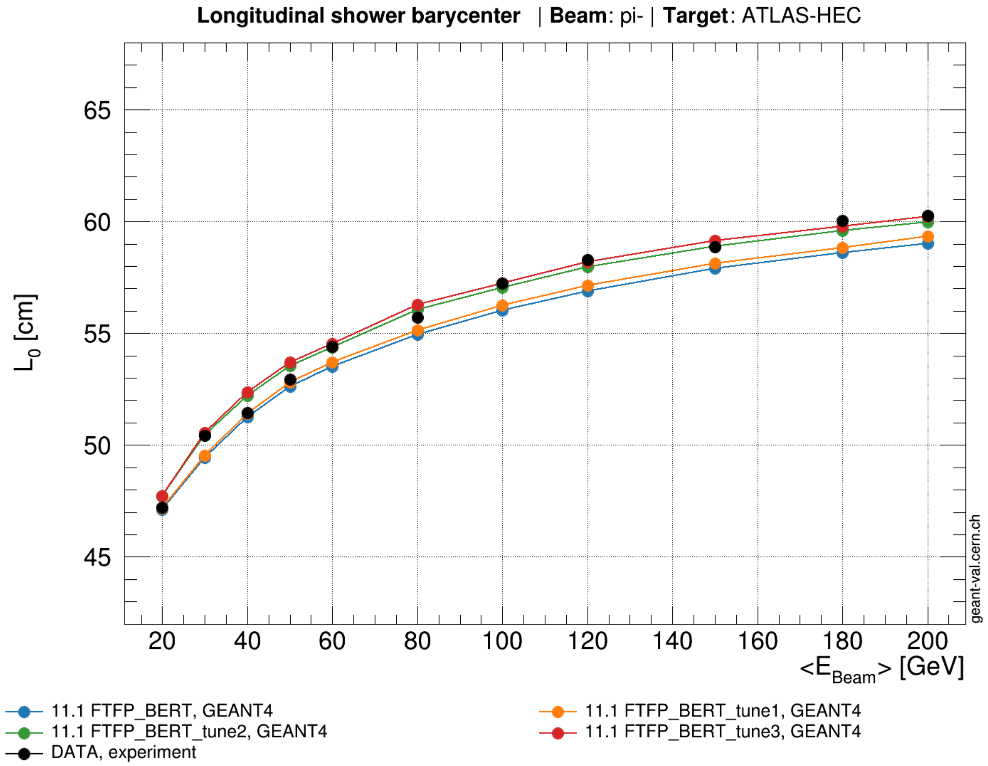


Found at [Link]

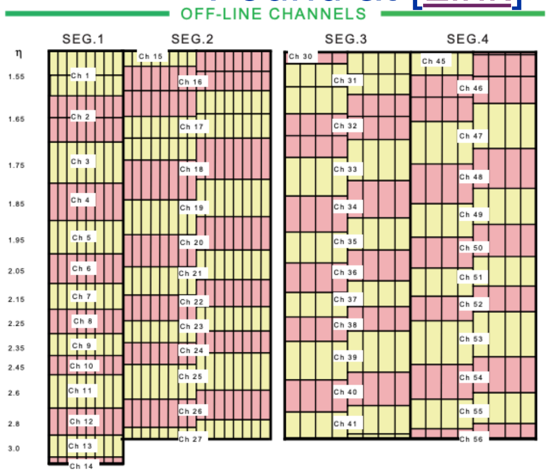
Longitudinal shower barycenter (π^-)



- It is possible to study the fraction of energy (signal) deposited in each layer: $F_i = < E_i > / E_{sum}, E_{sum} = \Sigma < E_i >$
- The mean of the profile (L_0) is a direct measurement of the hadronic shower average depth (barycenter)
- Results:
  - FTFP_BERT predicts shower longitudinal barycenter $\simeq 2\,\%$ shorter than ATLAS data
  - tune_1 identical to default (sub per-mille agreement)
  - tune_2 predicts better shower longitudinal barycenter with sub-percent agreement with ATLAS data
  - tune_3 identical to tune_2 (sub per-mille agreement)

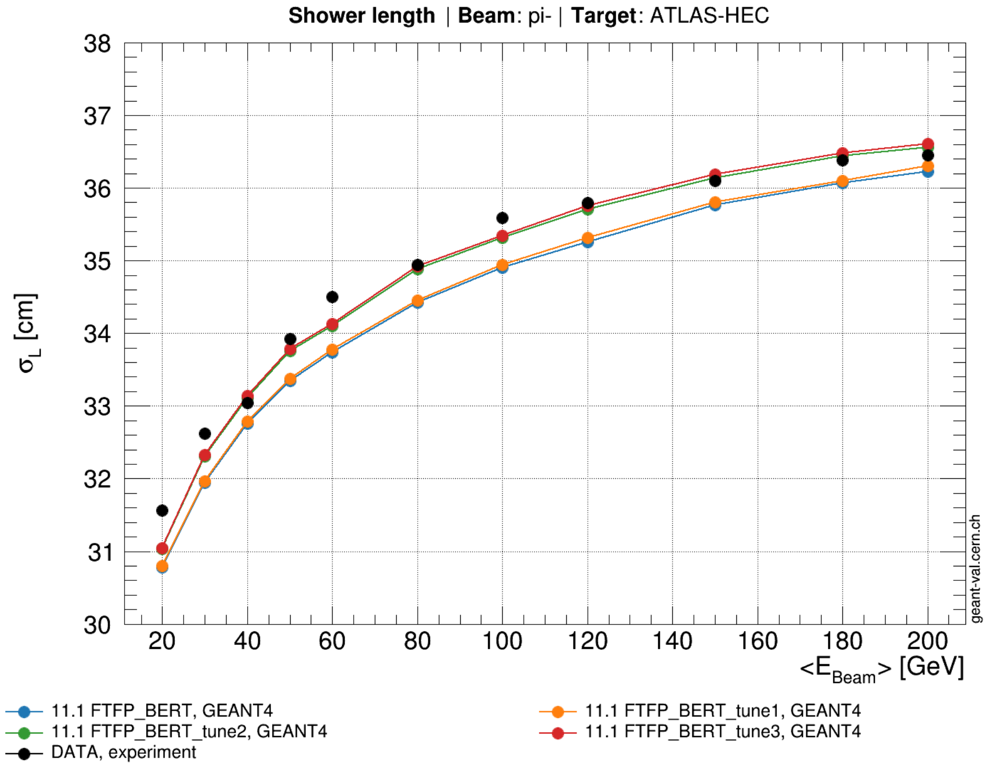


Found at [Link]



Shower length (π^-)

- It is possible to study the fraction of energy (signal) deposited in each layer:
  $F_i = < E_i > / E_{sum}, E_{sum} = \Sigma < E_i >$
- The RMS of the profile (σ_L) is an indirect measurement of the hadronic shower length.
- Results:
  - FTFP_BERT predicts shower $\simeq 2\,\%$ shorter w.r.t. ATLAS data
  - tune_1 is identical to default (sub per-mille agreement)
  - tune_2 predicts shower in better agreement w.r.t. ATLAS data (especially above 40 GeV)
  - tune_3 is identical to tune_2 (sub per-mille agreement)



Conclusions on FTF tunes

- Geant4-11.1 introduces alternative FTF-model tunes based on baryon, pion and combined parameterizations on thin target data.
- We suggest to include related results in *geant-val* as PLname_tuneID (*do not be confused by _tuneID, these are not real physics lists!*)
- When tested on the ATLAS HEC test-beam data obtained with π^- beams, we found that:
    - Only tunes obtained with π data introduces significant changes in the shower description
        - π/e is up to $\simeq 1\,\%$ higher than default (usually not a good sign)
        - σ/E is $\simeq 2-3\,\%$ than default, but still far from ATLAS data
        - The shower barycenter is $\simeq 2\,\%$ higher than default and in better agreement with ATLAS data
        - The shower length is $\simeq 2\,\%$ higher than default and in better agreement with ATLAS data

Update on ATLHECTB

Notes on changes applied to the Geant4 ATLAS HEC test beam simulation in v2.4

Update on ATLHECTB

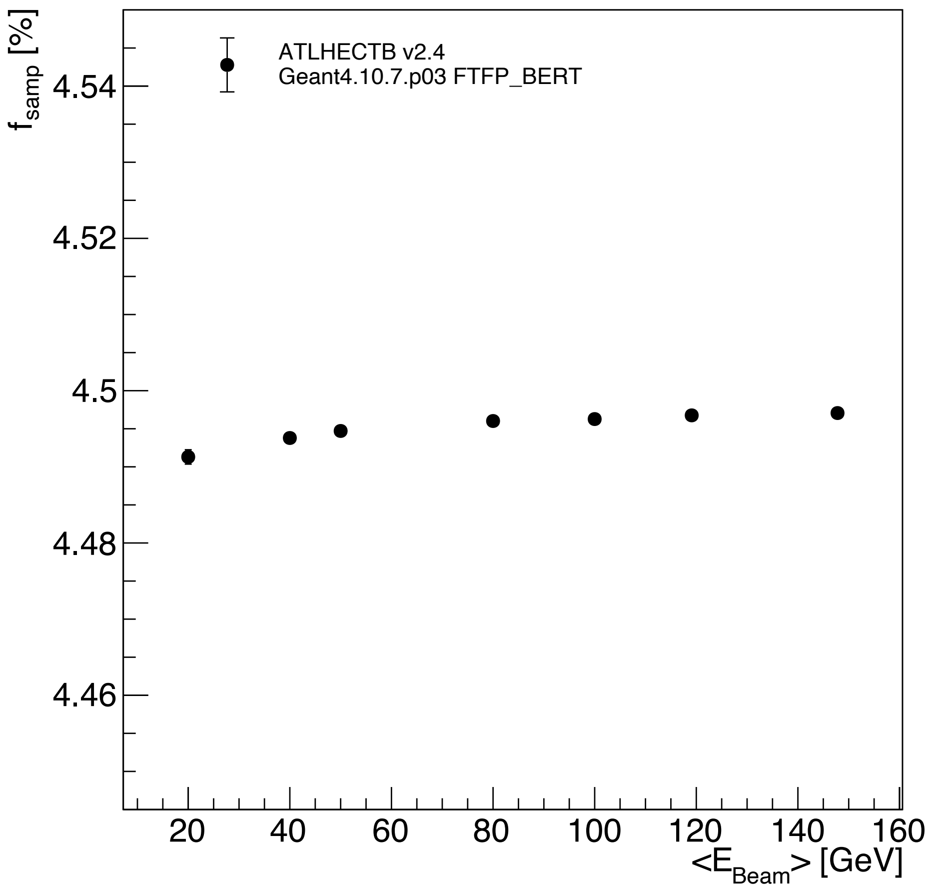
The Geant4-based simulation of the 2000/2001 ATLAS HEC test-beam was updated to v2.4 as recommended by Andrey Kiryunin.

Changes included:

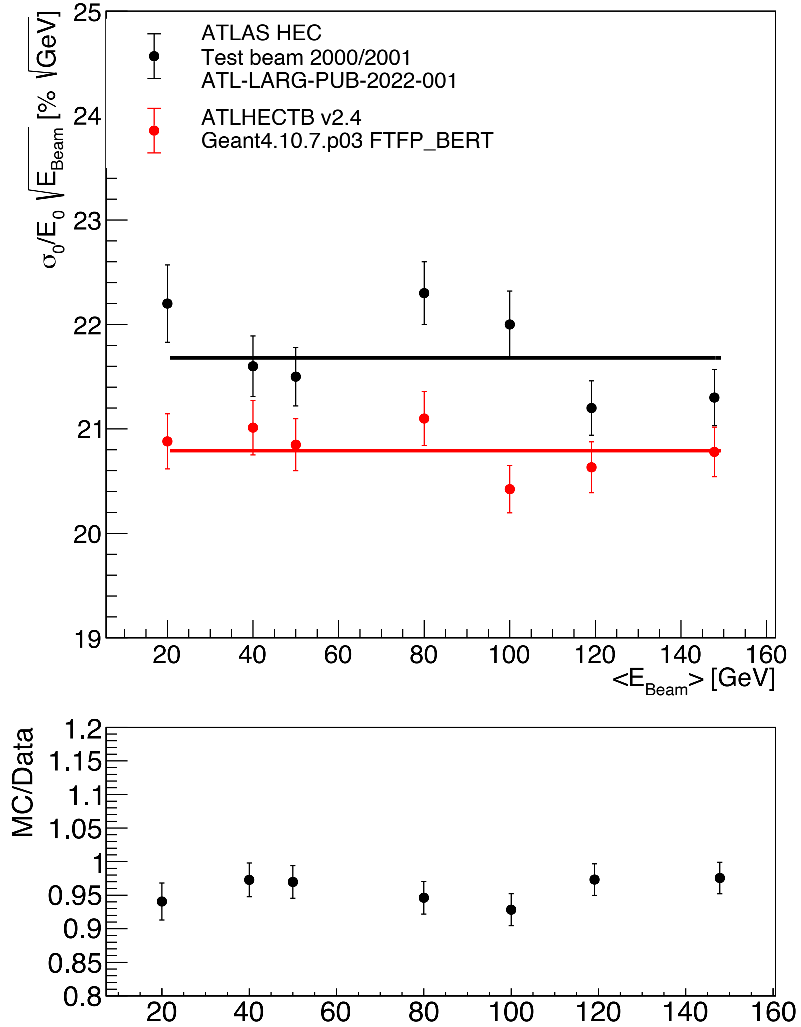
- Added two passive scintillators (F1 and F2) with no sensitive detectors and no hits associated. Material is C9H10 (density 1.032 g/cm^3). F1 is located at 200 cm from the HEC front face.
- π/e measurements are now done as ratio of response to π^- and e^- beams even if the energy of beams is slightly different (e.g. π/e measurement at 150 π^- beam is obtained with beams of 150 GeV π^- and 147.8 GeV e^-).
  - Response to π^- and e^- is defined as the peak position of Gaussian fit to energy distributions.
  - For π^- beams at 30, 60, 180 and 200 GeV no e^- beams with close energies are available → I consider for them 0.99*beam_energy. Note that no experimental data are available for such points anyways.
- Fractions of energies deposited in the 4 longitudinal layers are now computed as $F_i = < E_i > / E_{sum}$ with $E_{sum} = \Sigma < E_i >$.

e^- results

Sampling fraction

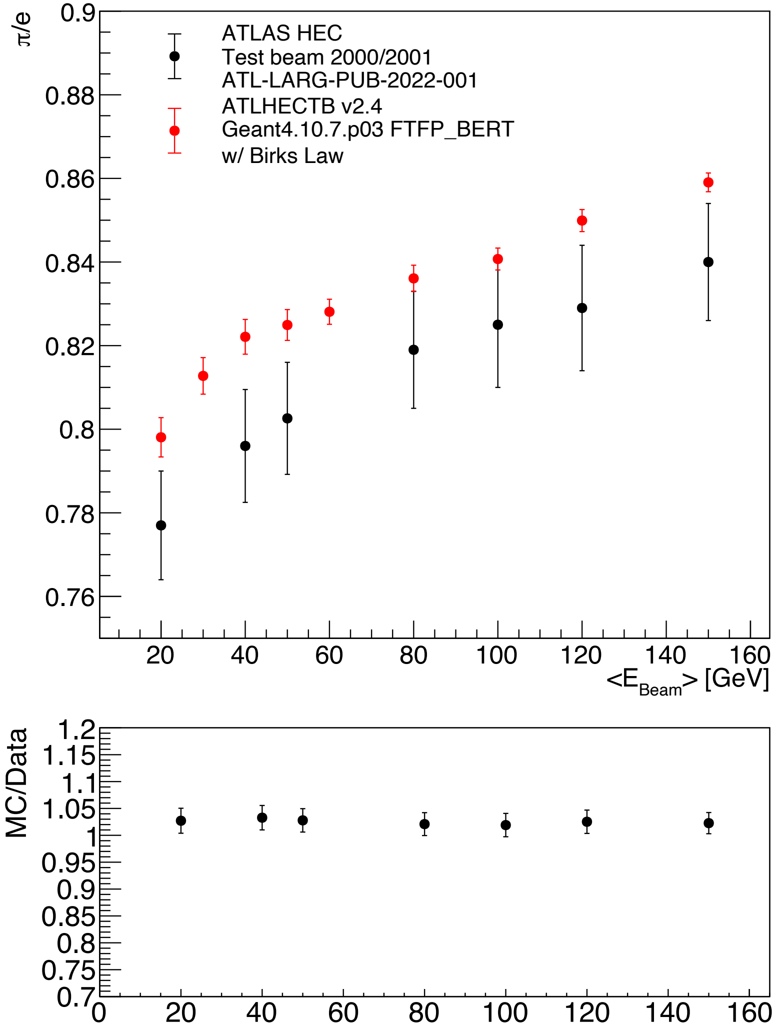


Energy resolution

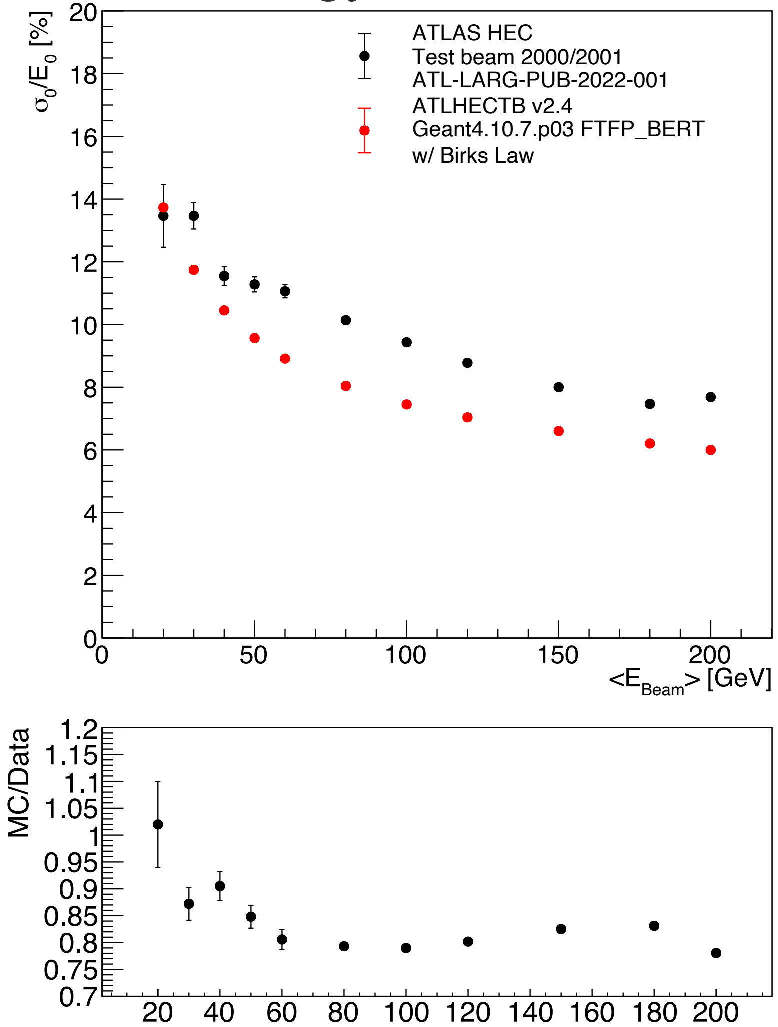


π^- results (1/4)

π/e

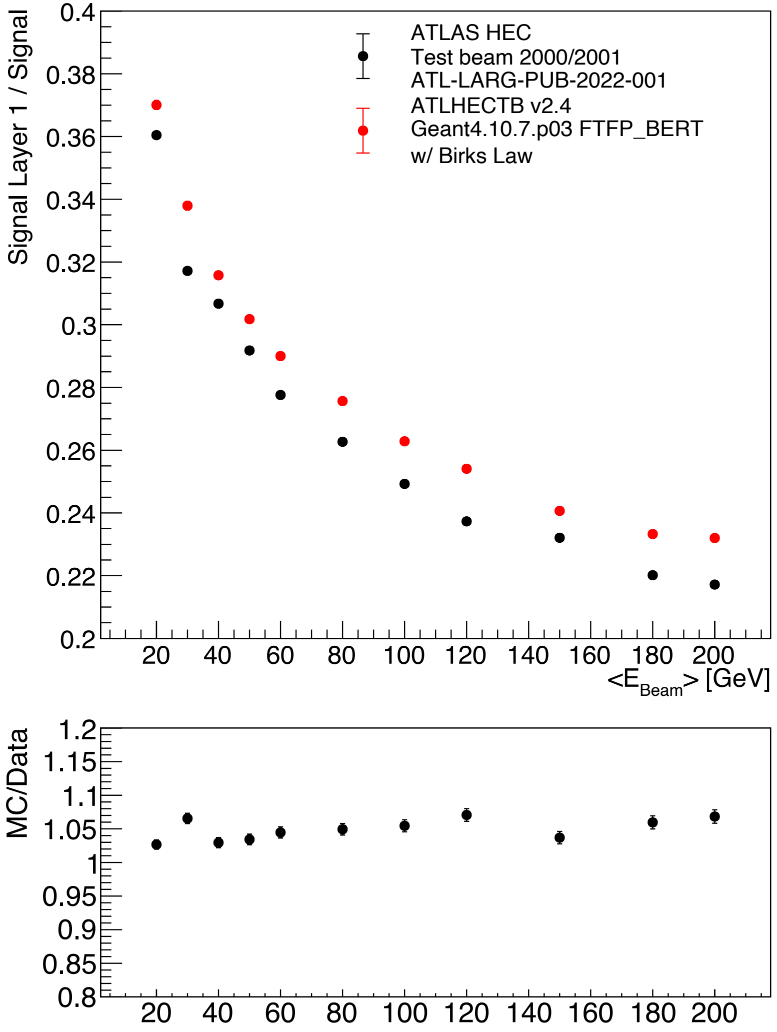


Energy resolution

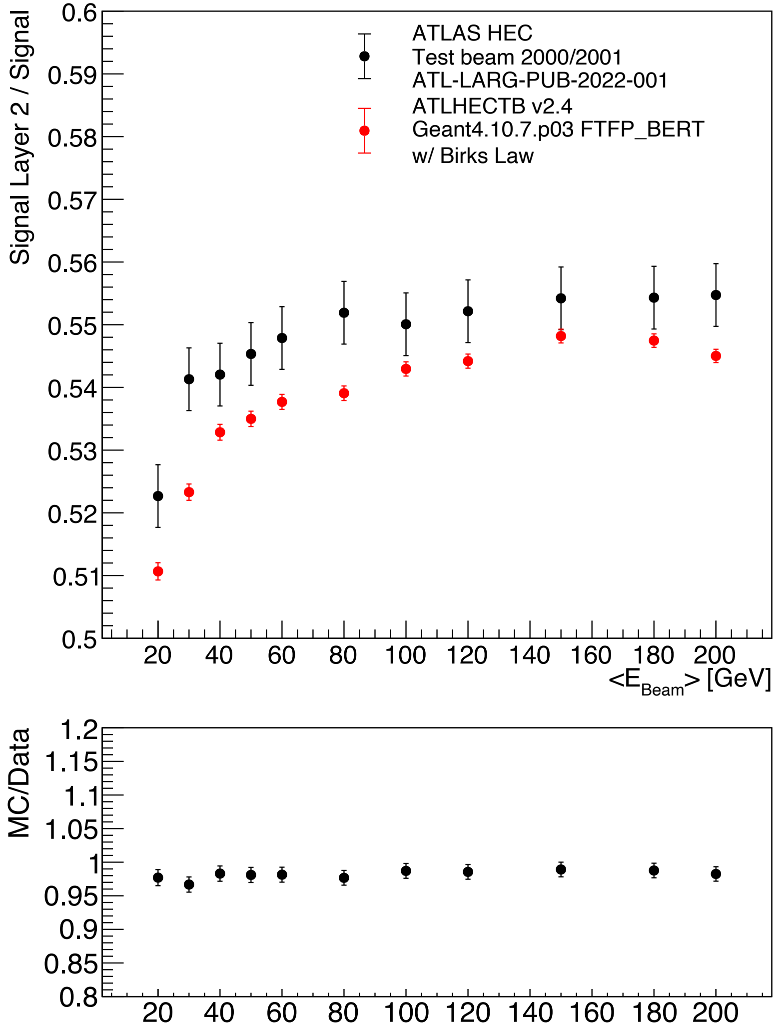


π^- **results** (2/4): energy fraction per layer

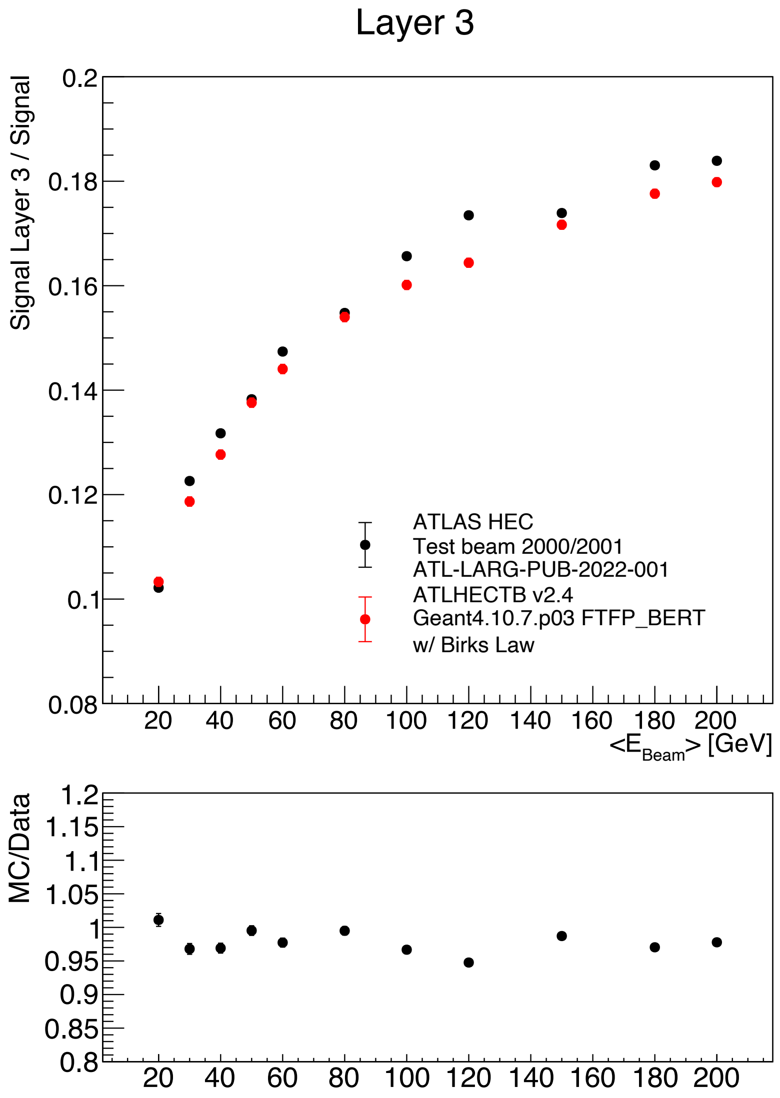
Layer 1

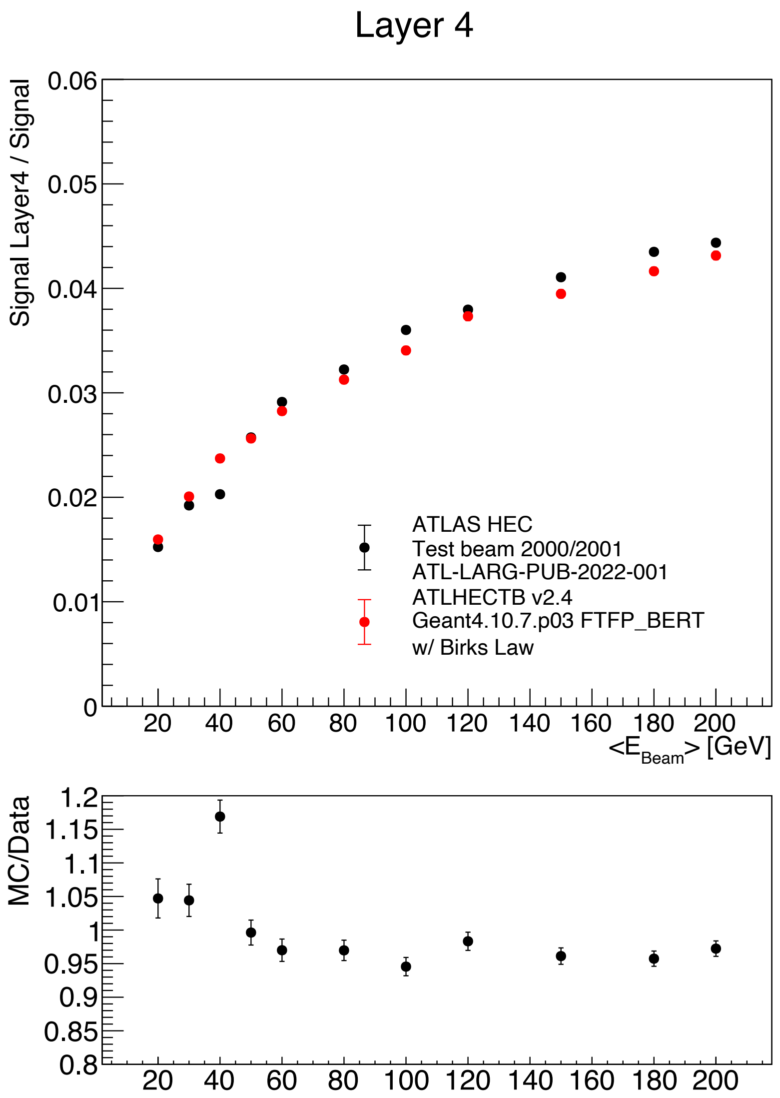


Layer 2



π^- **results** (3/4): energy fraction per layer





π^- results (4/4)