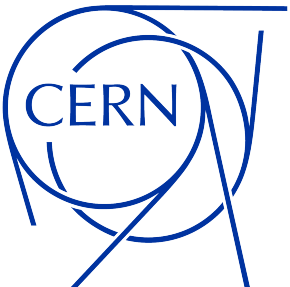


Physics lists' comparison and regression testing on CALICE SiW data

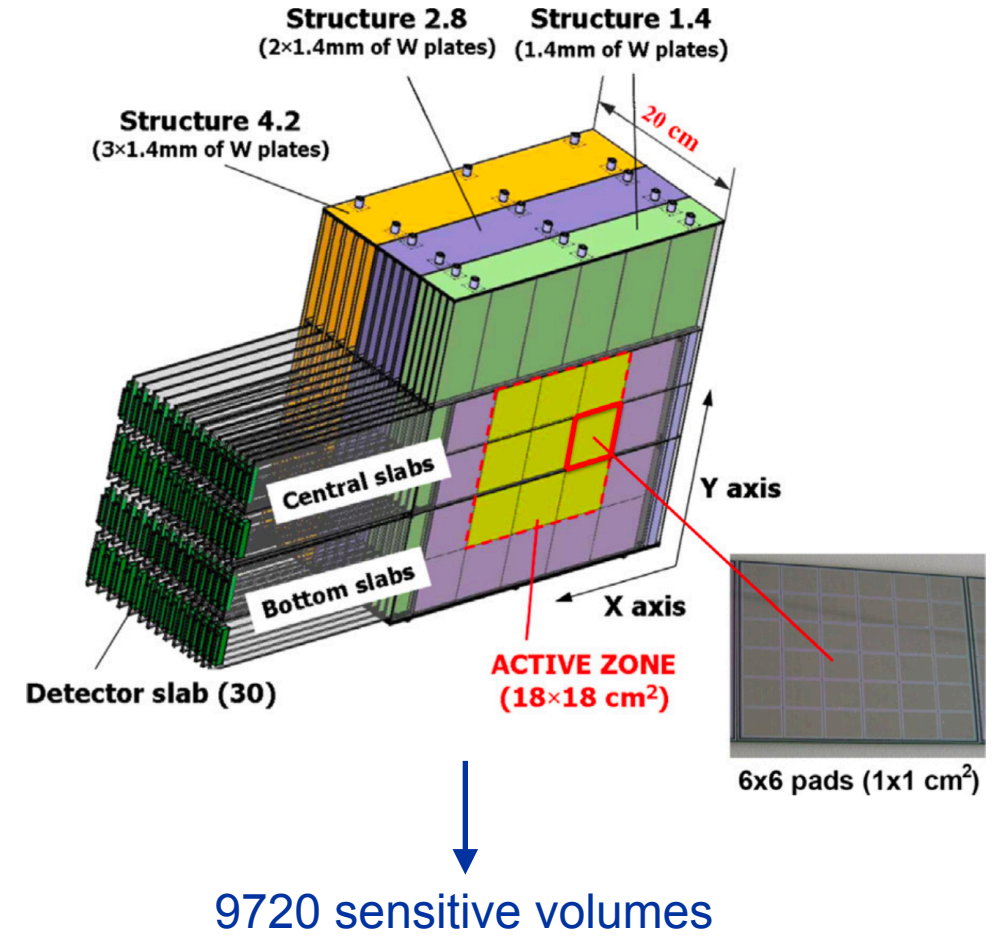
Lorenzo Pezzotti, Alberto Ribon and Dmitri Konstantinov
CERN EP-SFT

Simulation bi-weekly meeting
26/04/2022



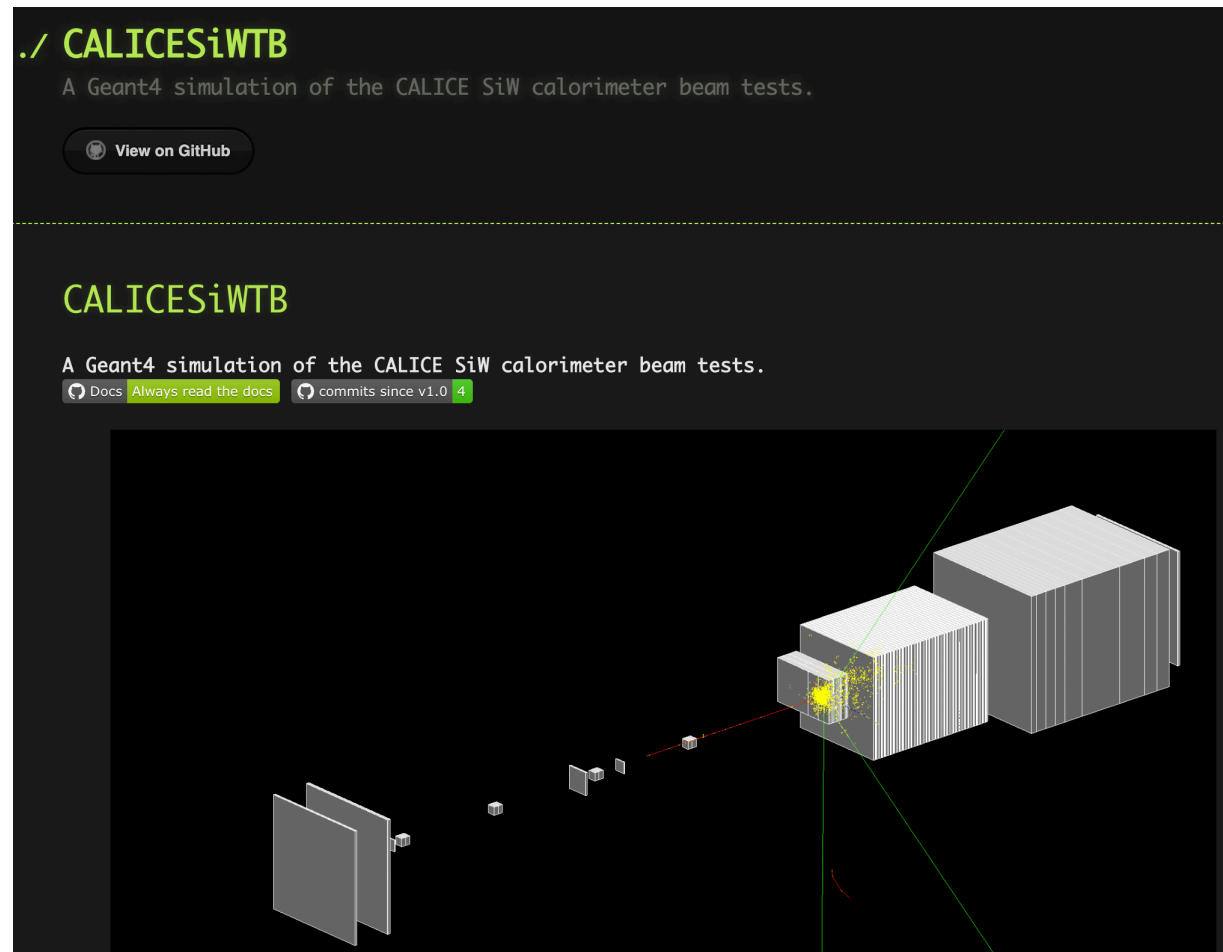
The CALICE SiW 2008 test beam

- ◆ **Beam tests** performed in 2008 at the FNAL beam line, involving 2, 4, 6, 8 and 10 GeV π^- .
- ◆ **The CALICE SiW prototype** is ECAL-sized. It features:
 - ❖ 30 longitudinal layers,
 - ❖ each layer readout by 36x9 Si cells. Active area is 18x18 cm², thickness is 24 X_0 ($\simeq 1\lambda$).
 - ❖ Tungsten slabs used as absorbers with different thicknesses (1.4, 2.8 and 4.2 mm). Sampling fraction decreasing with shower depth.
- ◆ **Reference paper** from 2015: NIM A 794 (2015) [[link](#)].



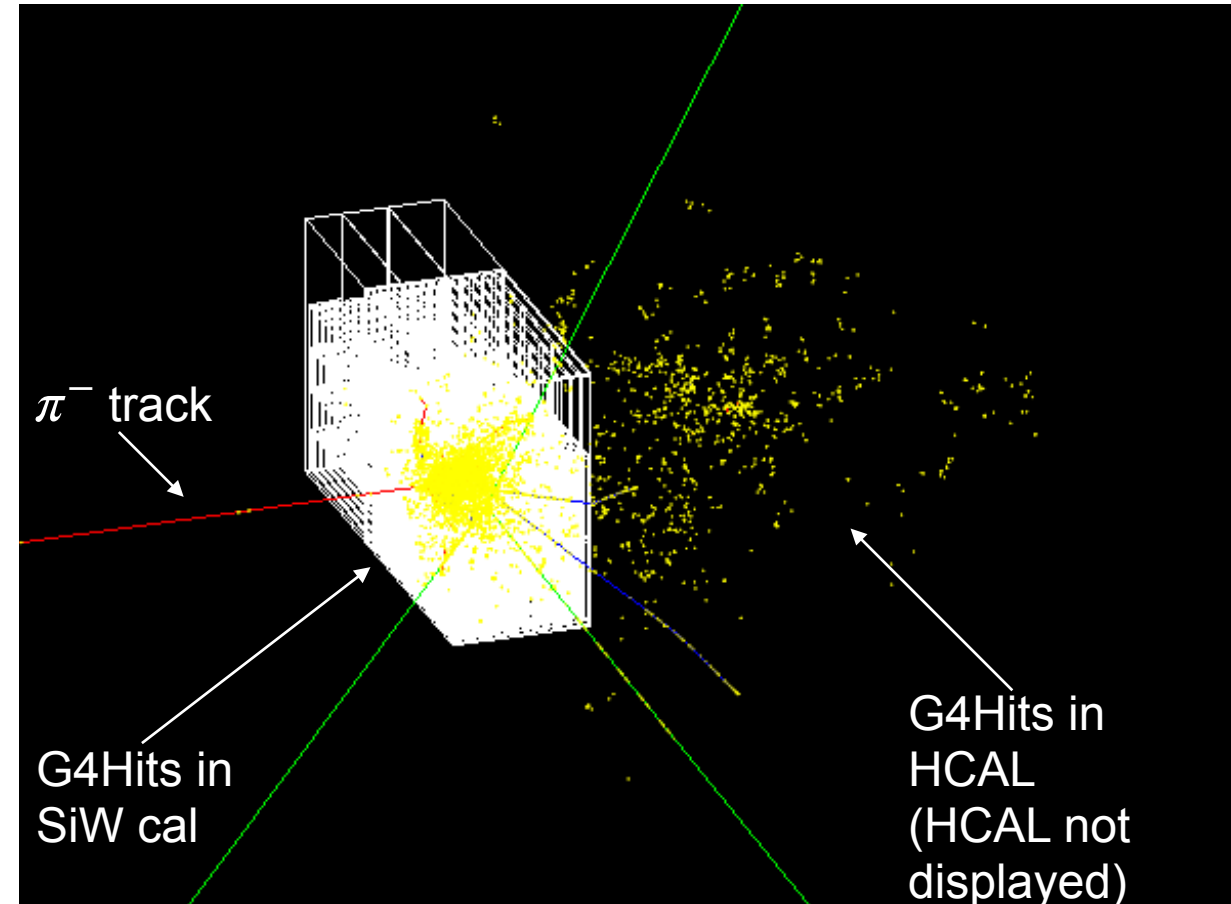
CALICESiWTB

- ◆ A standalone Geant4 simulation of the CALICE SiW 2008 beam test.
 - ❖ Based on the Geant4 env. Works easily on lxplus+HTCondor.
 - ❖ Geometry and sensitive detectors extracted from a GDML file from a previous attempt around 2018. Remaining parts rewritten as an advanced Geant4 example.
 - ❖ Open code [[Github](#)]
 - ❖ [[Documentation](#)]
 - ❖ **First CALICE simulation within Geant-val.** From v1.0 it can be used with Geant-val and (some) results are already available on the Geant-val website.



Selecting events

- ◆ Only π^- events with a nuclear breakup are considered in the analysis.
- ◆ Each cell is calibrated with MIPs: energy deposits are expressed in MIP units. Each Si-cell is associated to a single hit (G4VHit).
- ◆ First interaction layer (i) is selected if:
 - ♣ three consecutive layers have an energy > 8 MIPS, or,
 - ♣ $\frac{E_i + E_{i+1}}{E_{i-1} + E_{i-2}} > 6$ and, $\frac{E_{i+1} + E_{i+2}}{E_{i-1} + E_{i-2}} > 6$
- ◆ Setting the interaction layer as layer 0, it is possible to extract the longitudinal energy distribution (in MIPS) as a function of the beam energy, regardless of the depth of the first interaction.





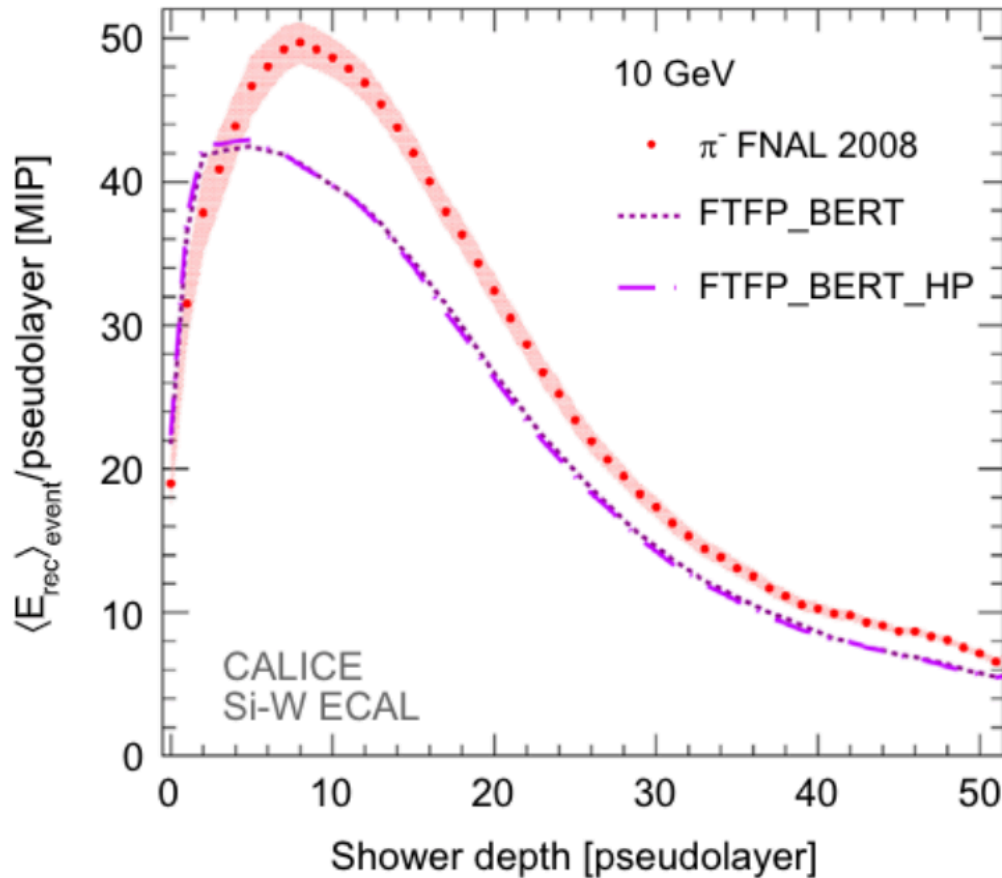
Longitudinal energy distributions

Geant4 regression testing and physics lists comparison

Longitudinal energy distribution - regression testing

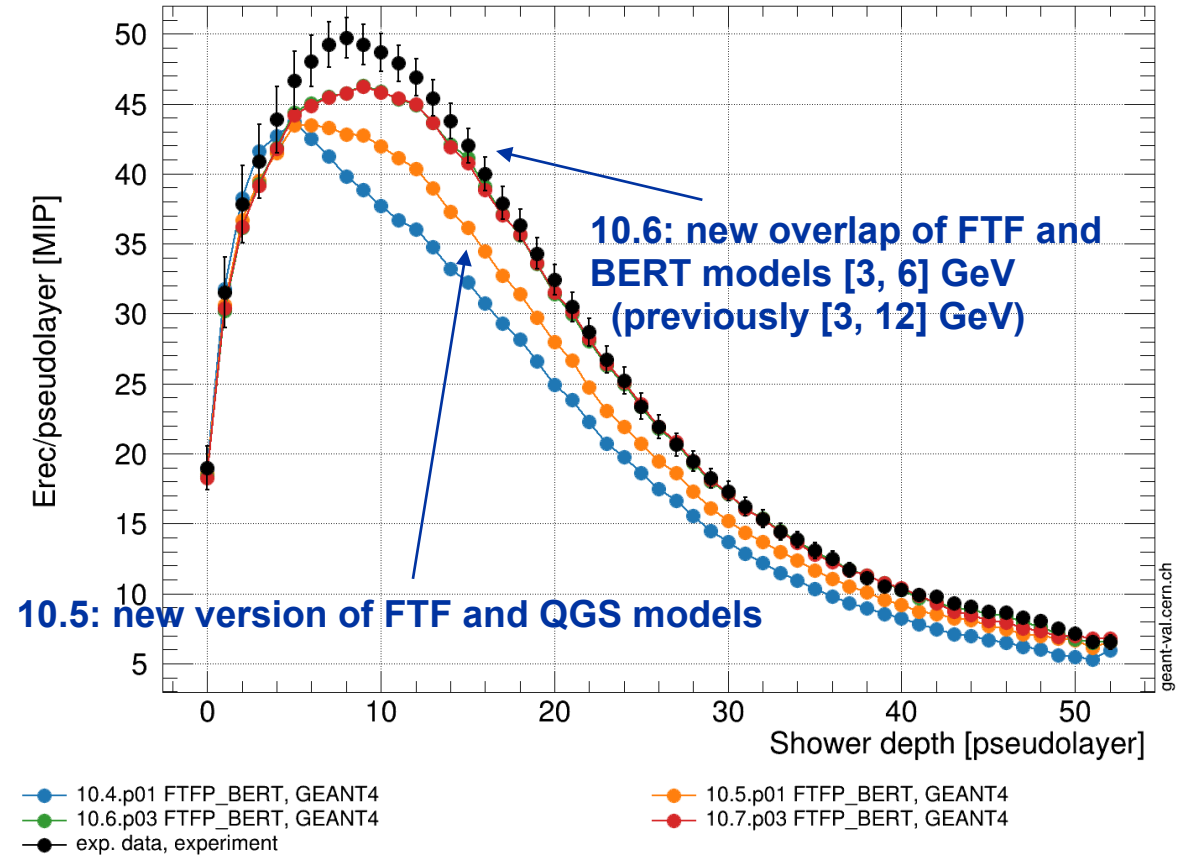
10 GeV π^-

CALICE 2015 - Geant4.9.6 NIMA794



Geant4 Collaboration 2022

Energy per layer | Beam: pi- | Energy: 10 | Target: CALICE-SiW



From 2017 to 2021

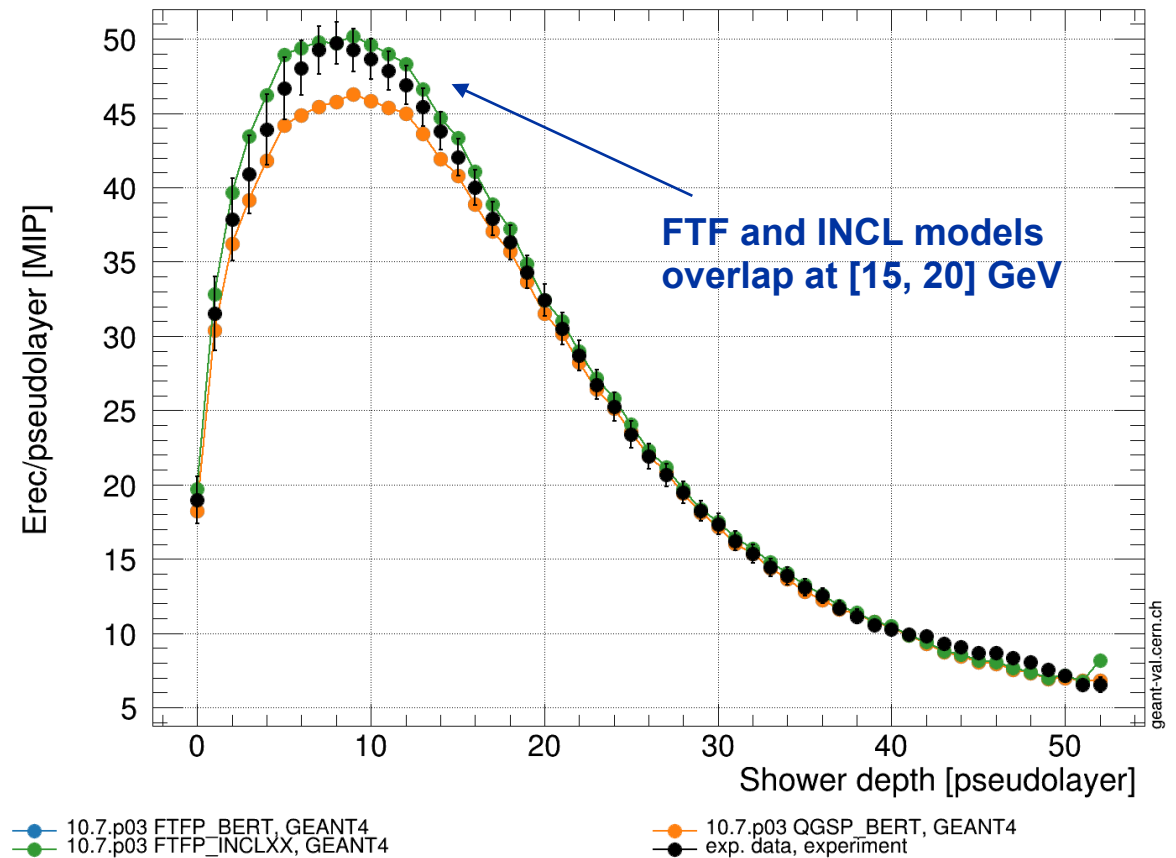
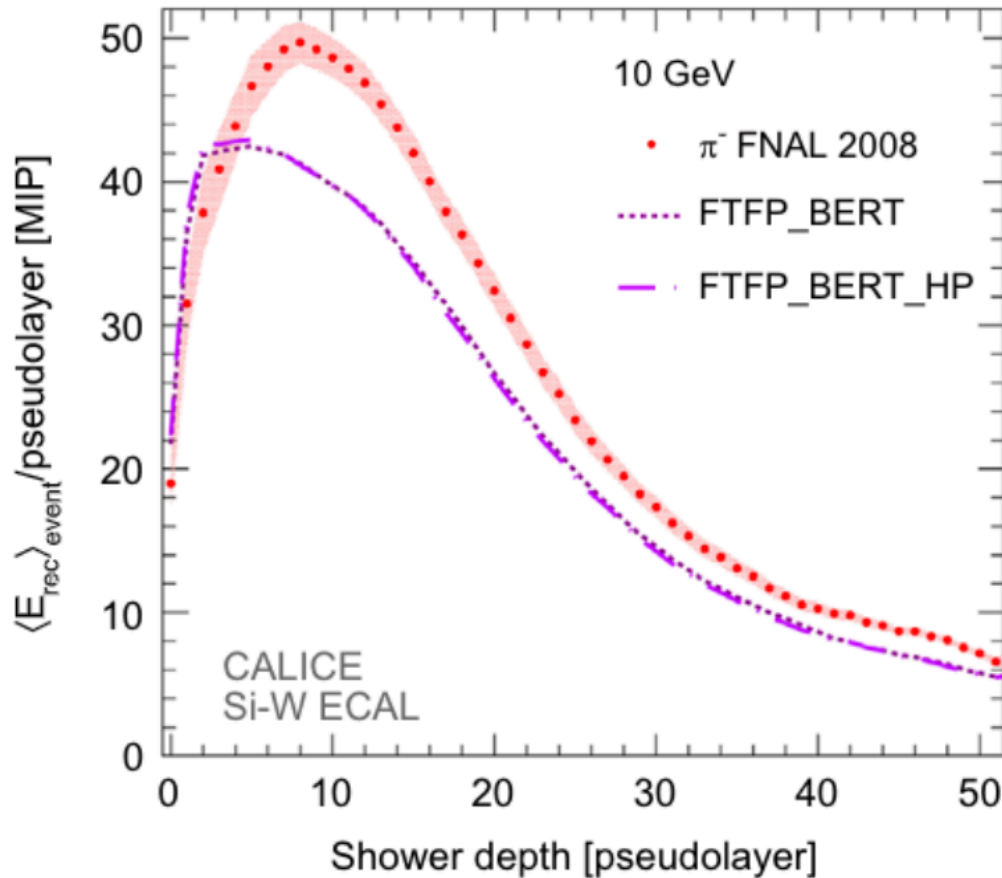
Longitudinal energy distribution - PL comparison

10 GeV π^-

CALICE 2015 - Geant4.9.6 NIMA794

Geant4 Collaboration 2022 - Geant4.10.7.p03

Energy per layer | Beam: pi- | Energy: 10 | Target: CALICE-SiW

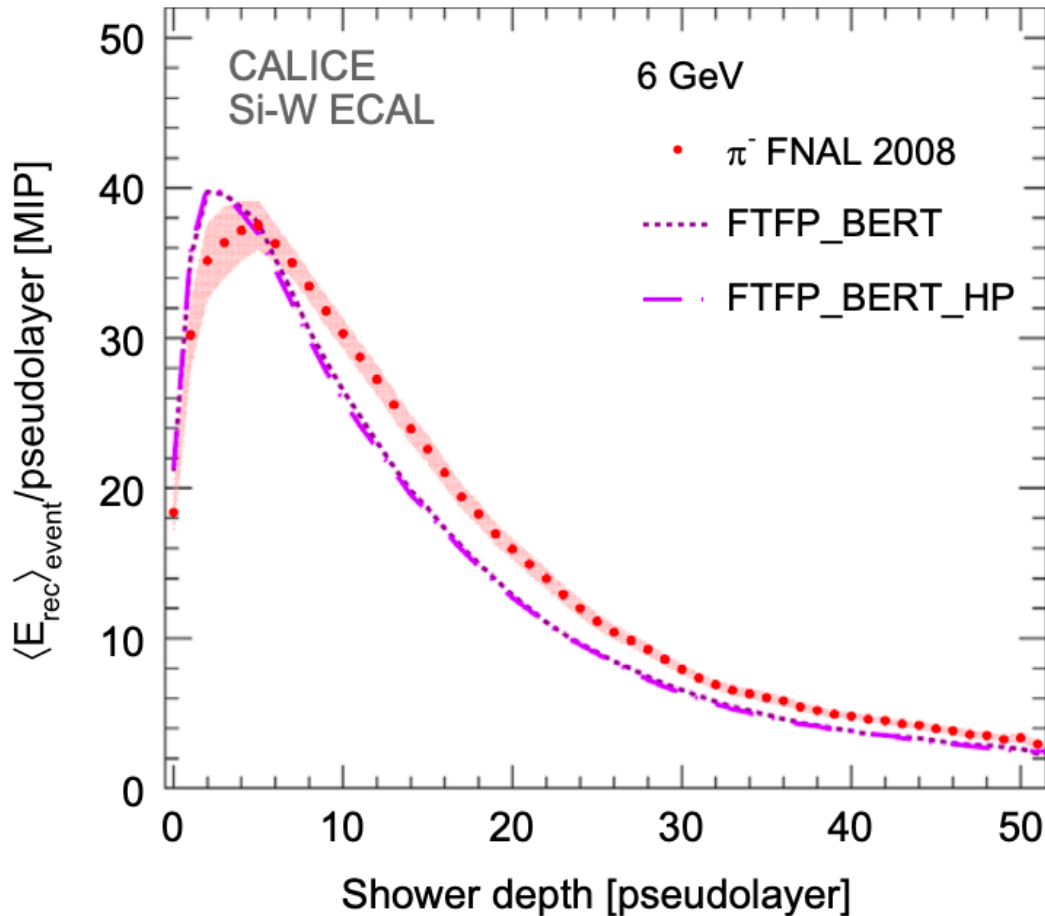


Below 12 GeV FTFP_BERT and QGSP_BERT are identical

Longitudinal energy distribution - regression testing

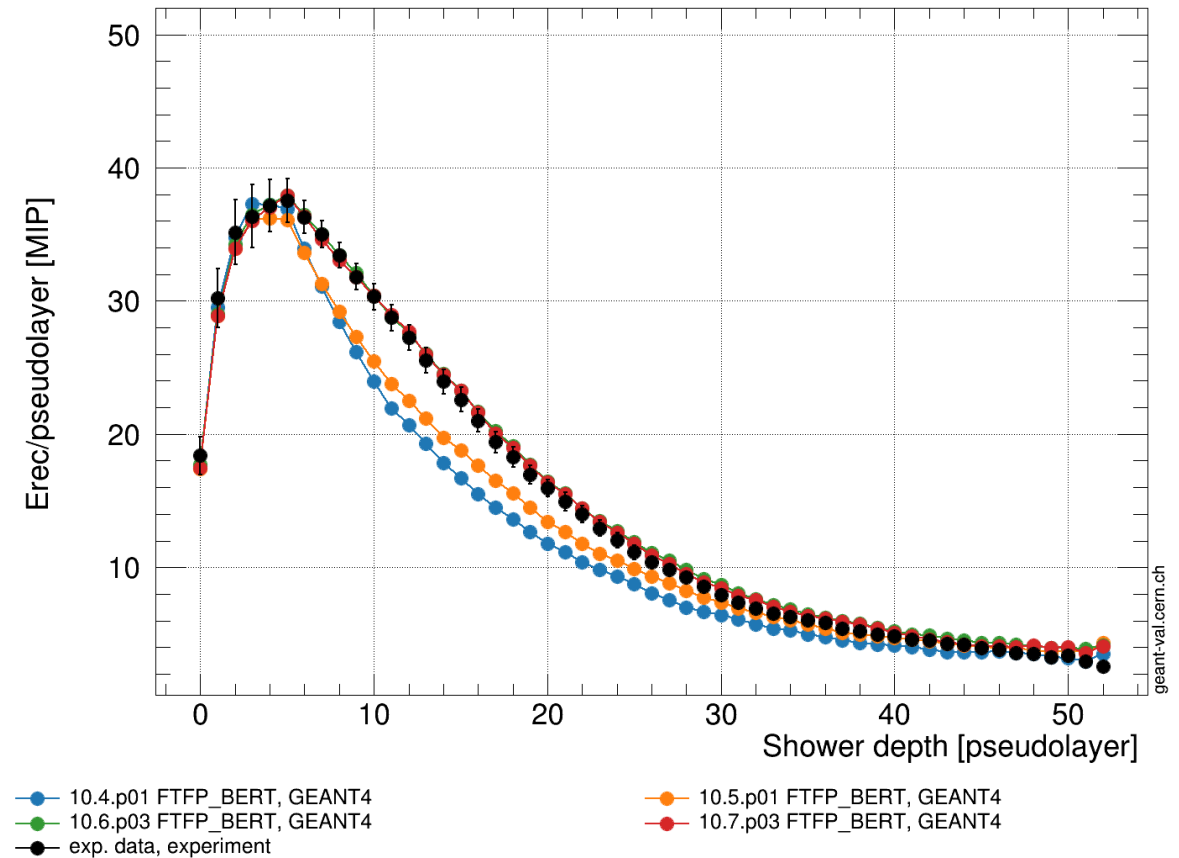
6 GeV π^-

CALICE 2015 - Geant4.9.6 NIMA794



Geant4 Collaboration 2022

Energy per layer | Beam: pi- | Energy: 6 | Target: CALICE-SiW

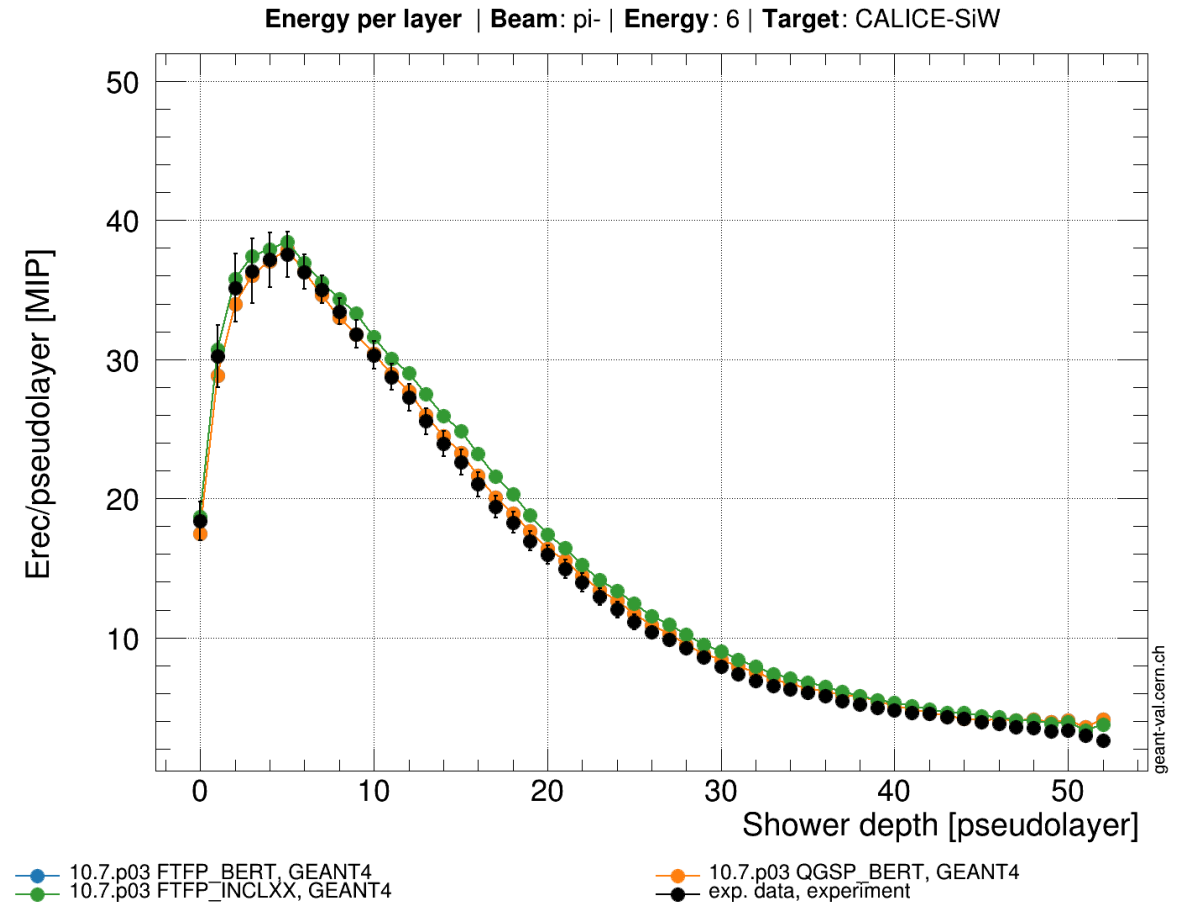
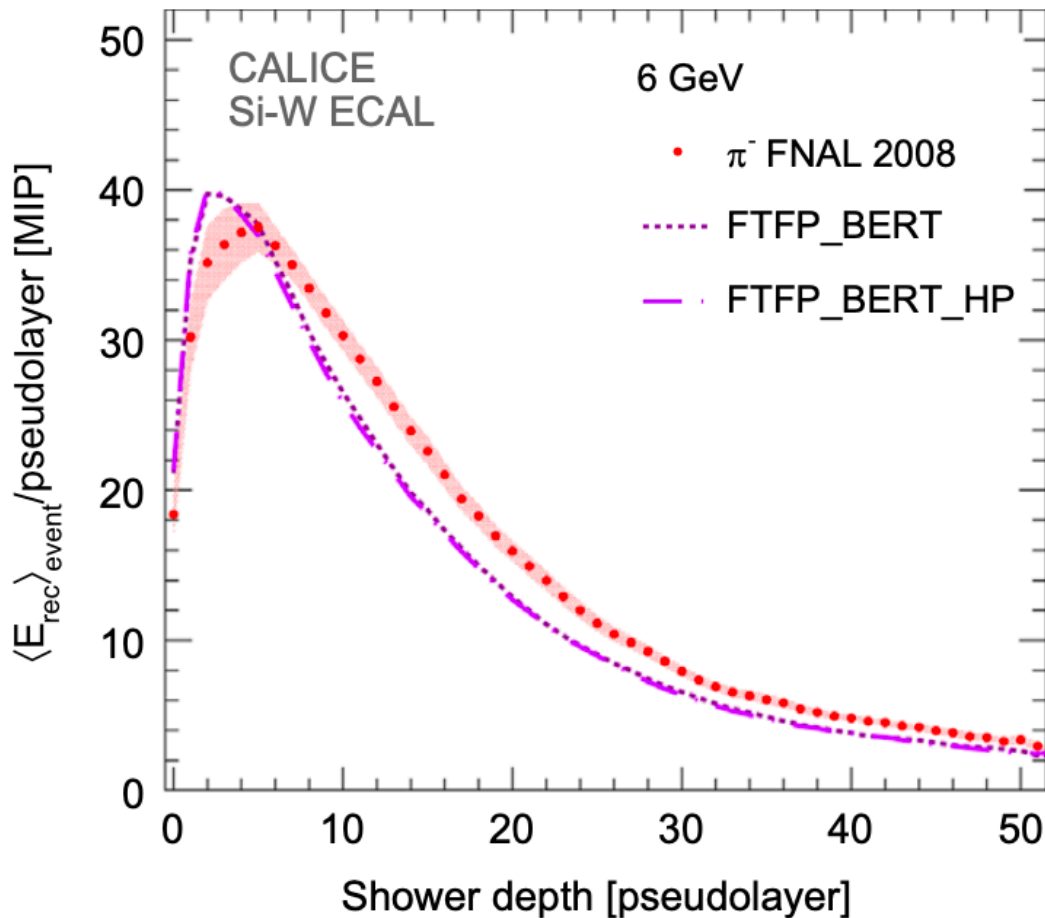


Longitudinal energy distribution - PL comparison

6 GeV π^-

CALICE 2015 - Geant4.9.6 NIMA794

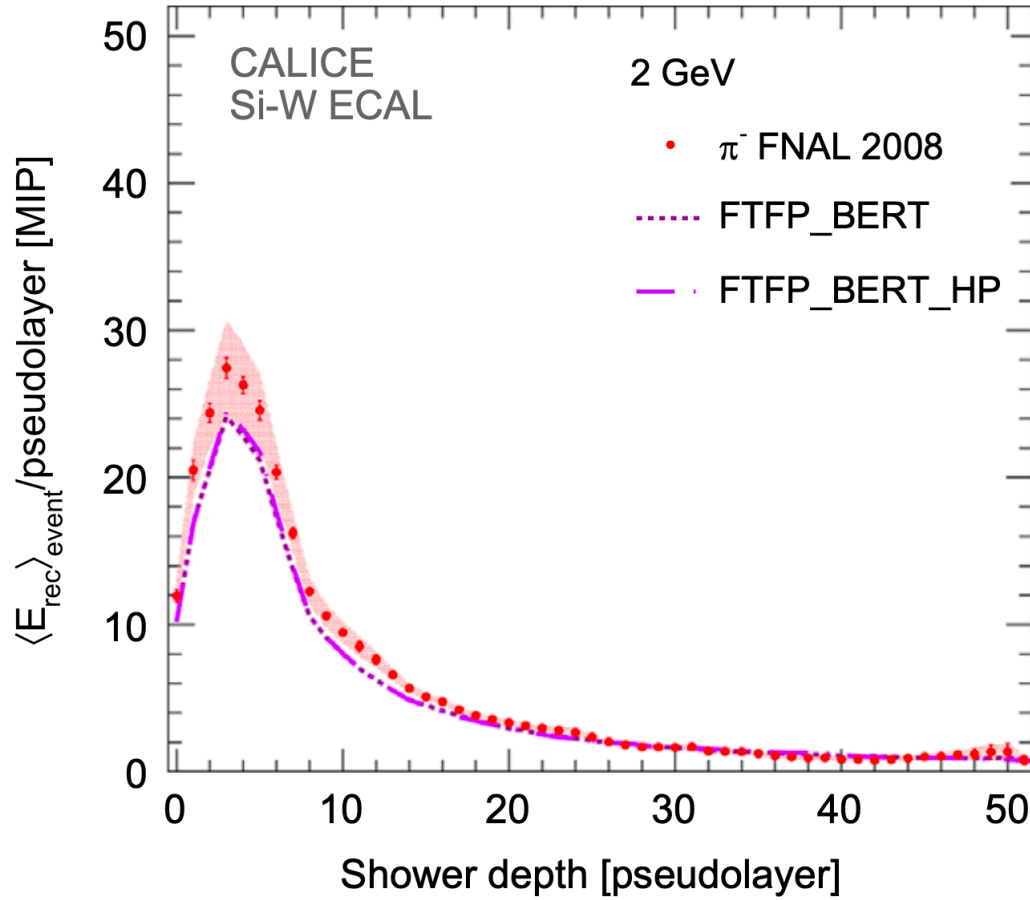
Geant4 Collaboration 2022 - Geant4.10.7.p03



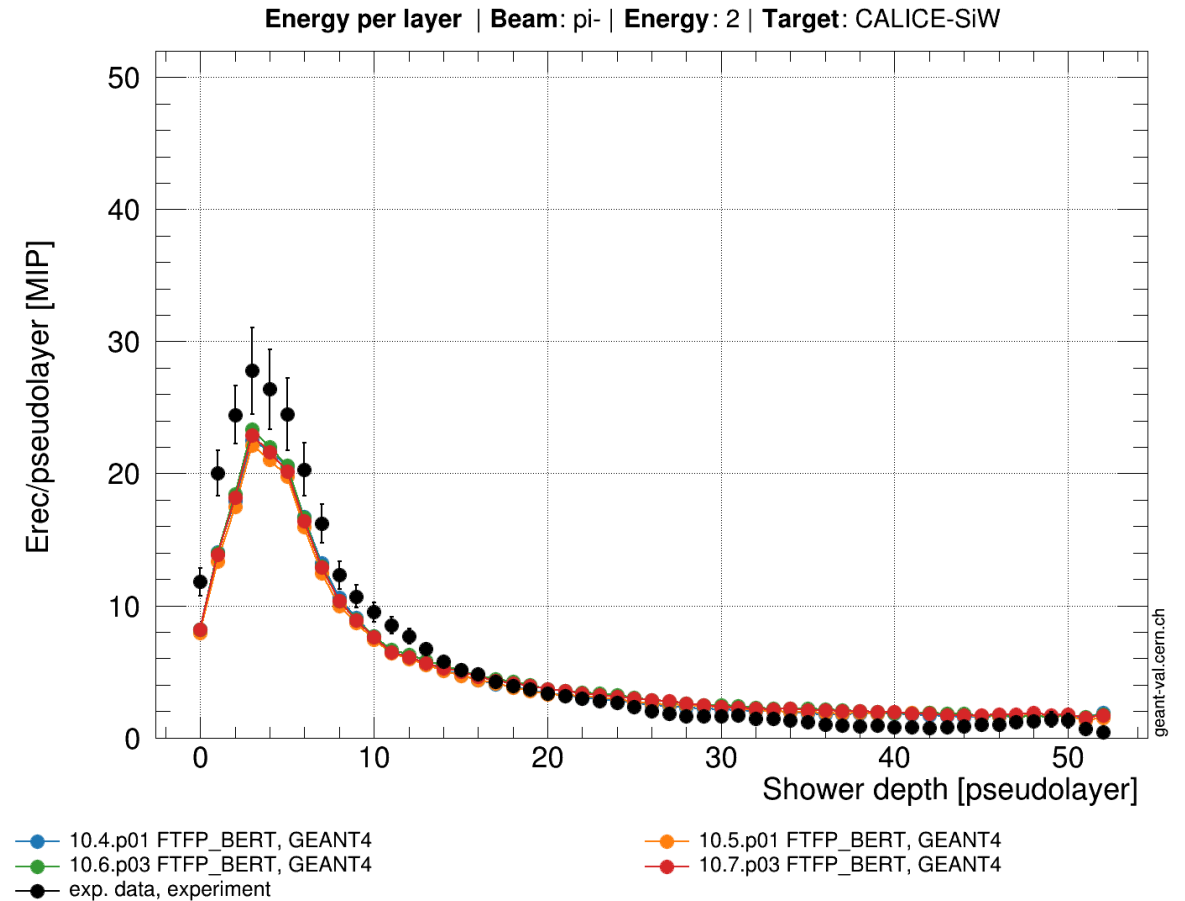
Longitudinal energy distribution - regression testing

2 GeV π^-

CALICE 2015 - Geant4.9.6 NIMA794



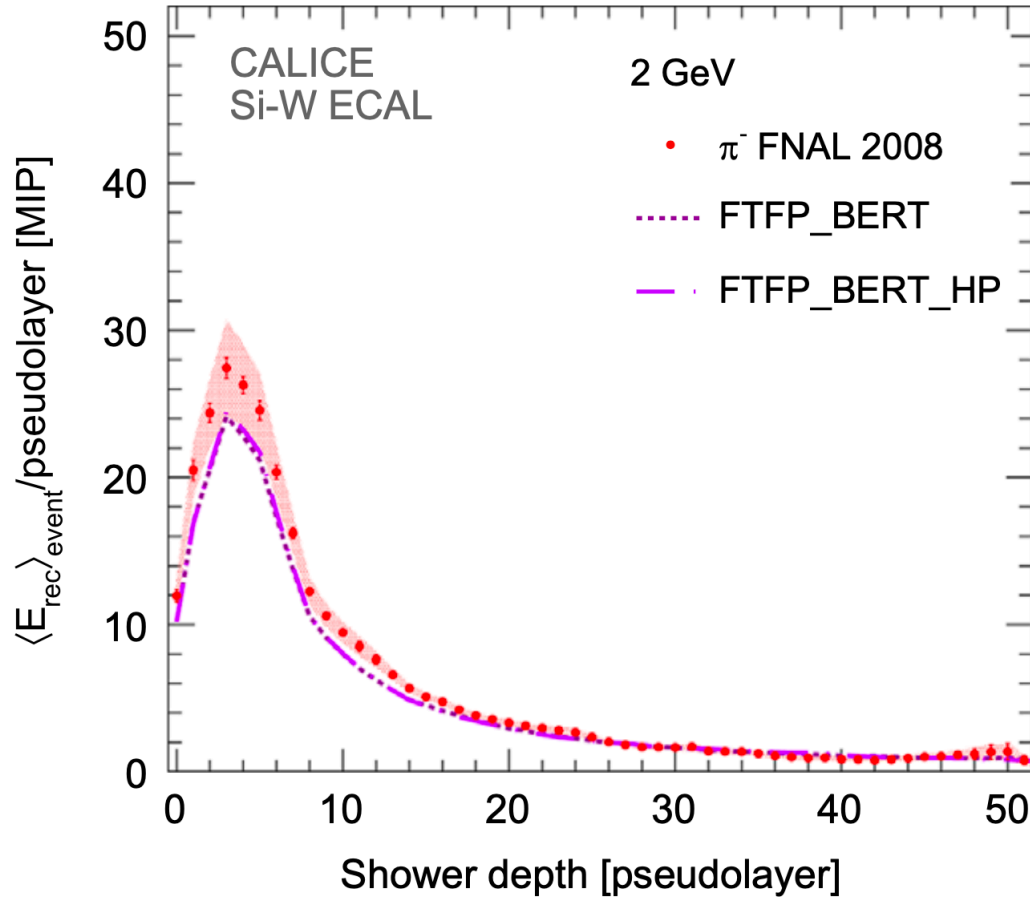
Geant4 Collaboration 2022



Longitudinal energy distribution - PL comparison

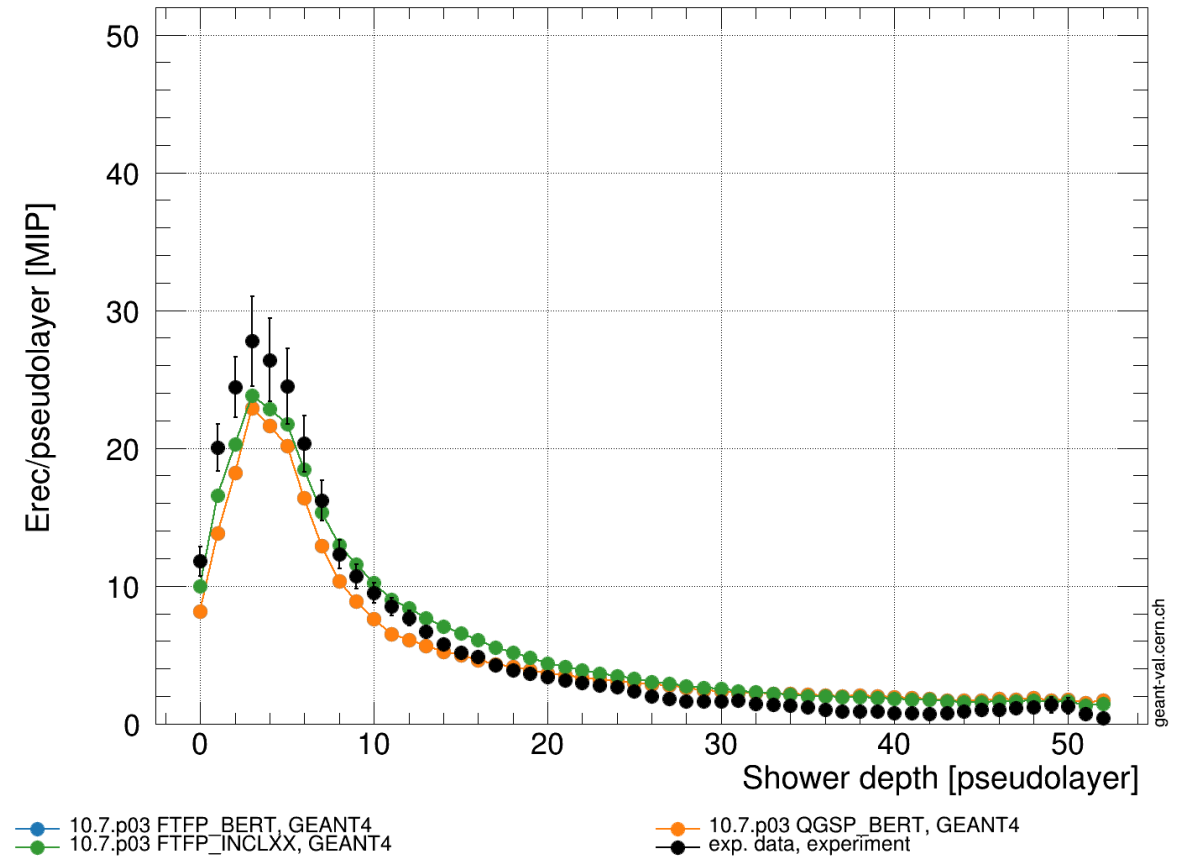
2 GeV π^-

CALICE 2015 - Geant4.9.6 NIMA794



Geant4 Collaboration 2022 - Geant4.10.7.p03

Energy per layer | Beam: pi- | Energy: 2 | Target: CALICE-SiW





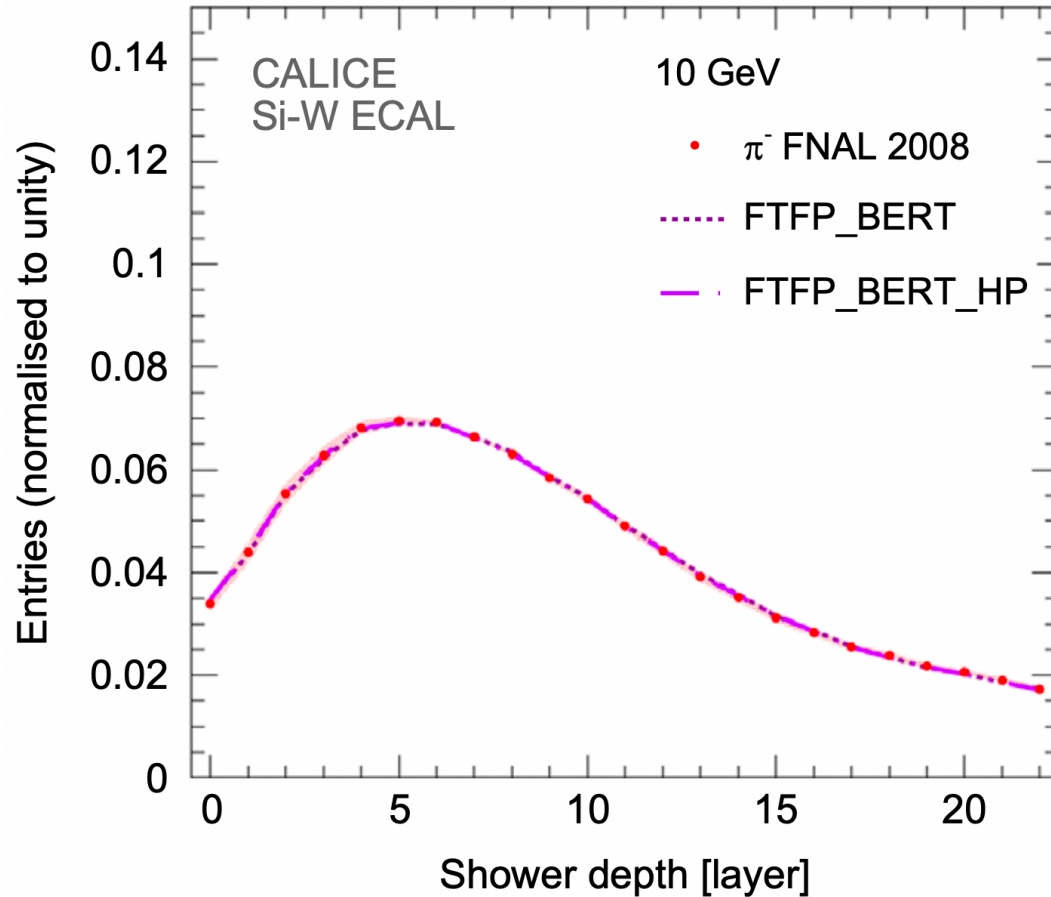
Longitudinal hit distributions

Geant4 regression testing and physics lists comparison

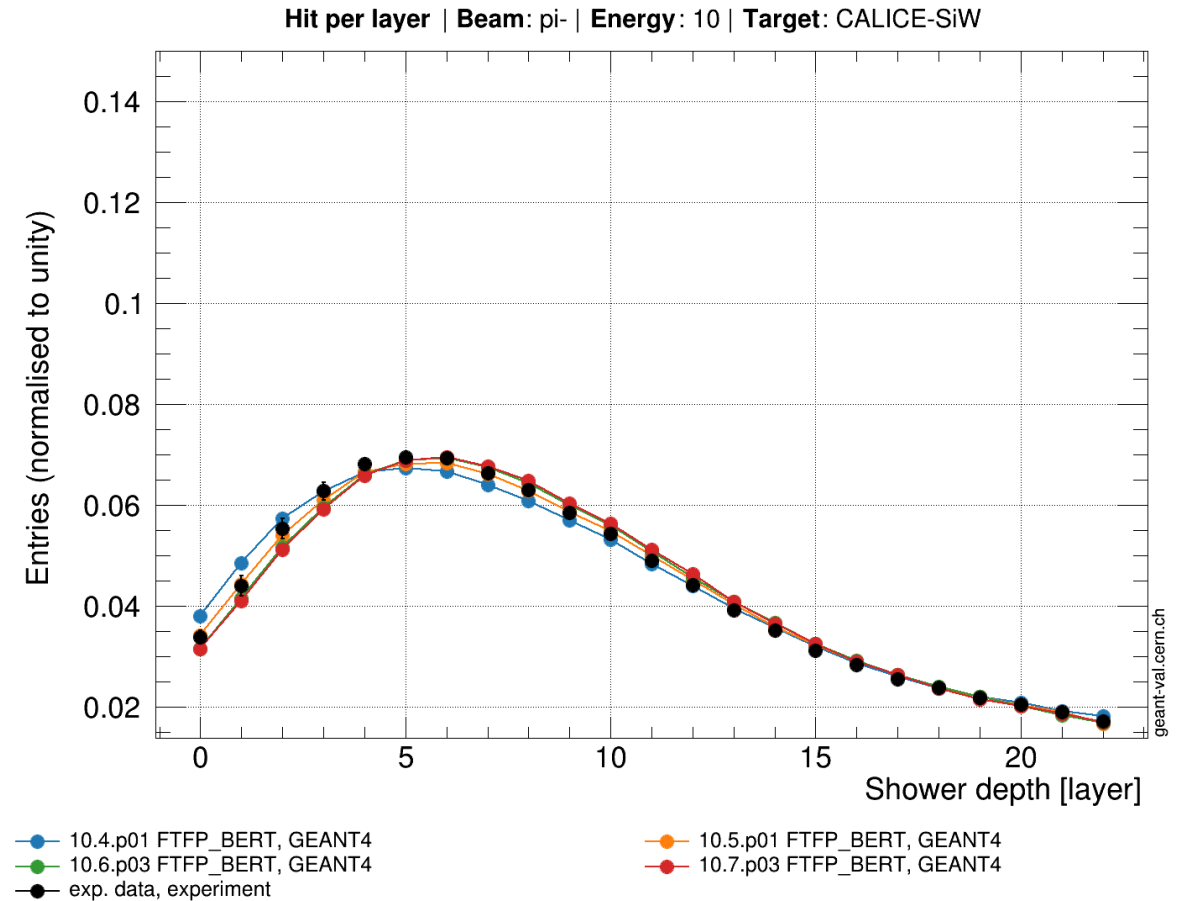
Longitudinal hit distribution - regression testing

10 GeV π^-

CALICE 2015 - Geant4.9.6 NIMA794



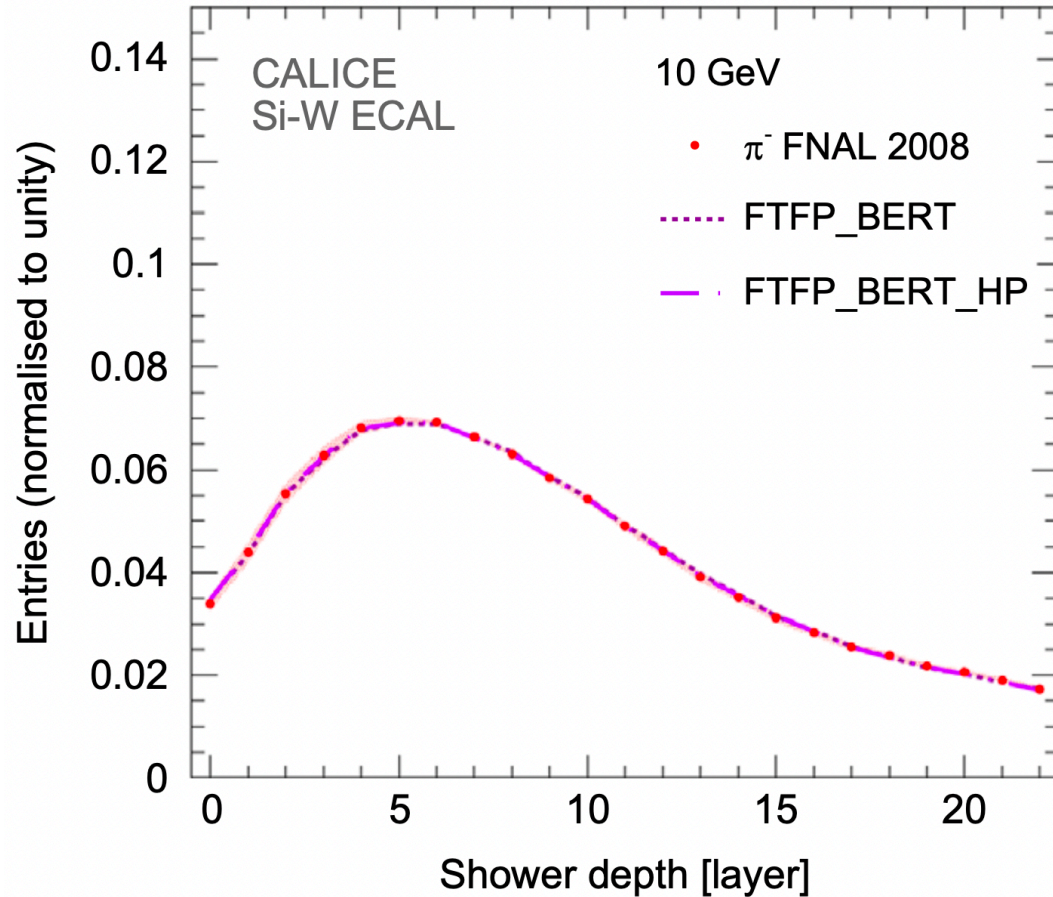
Geant4 Collaboration 2022



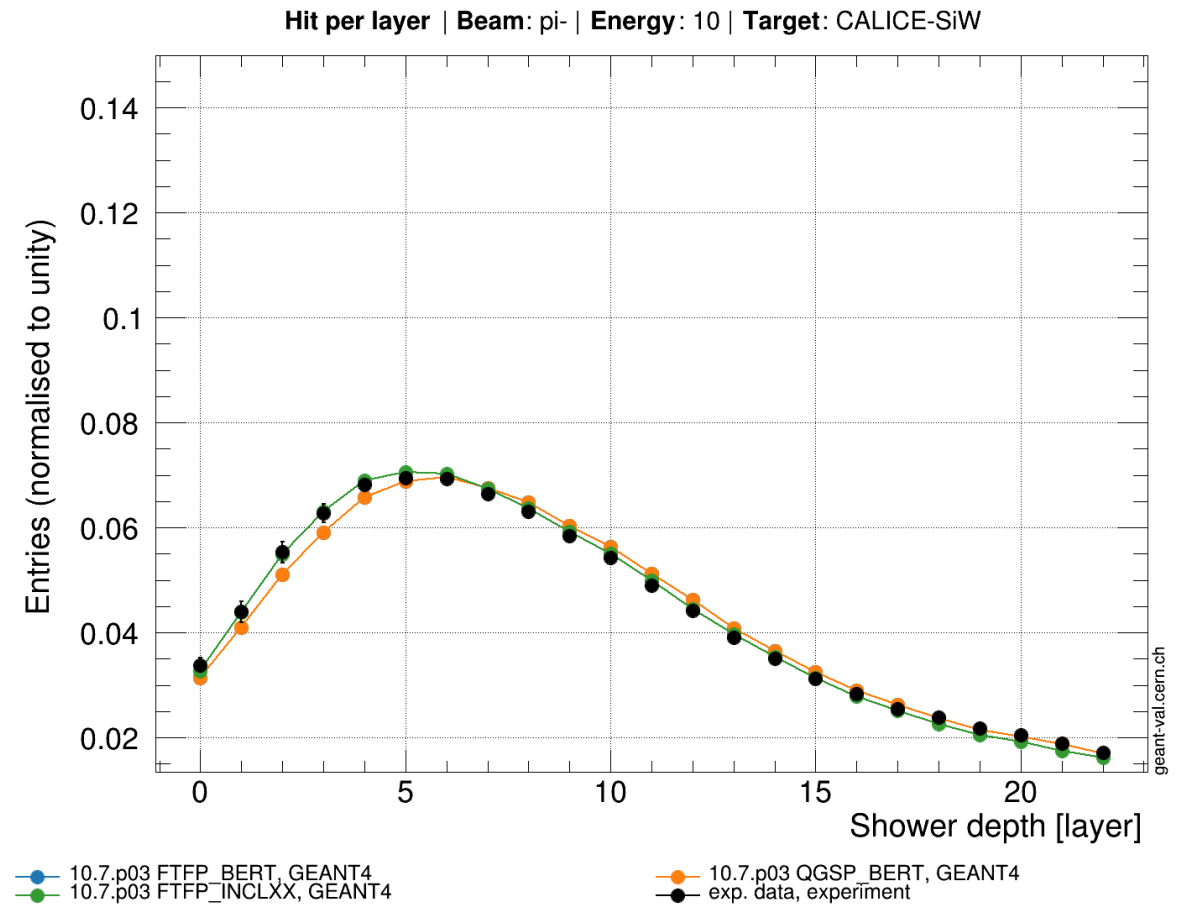
Longitudinal hit distribution - PL comparison

10 GeV π^-

CALICE 2015 - Geant4.9.6 NIMA794



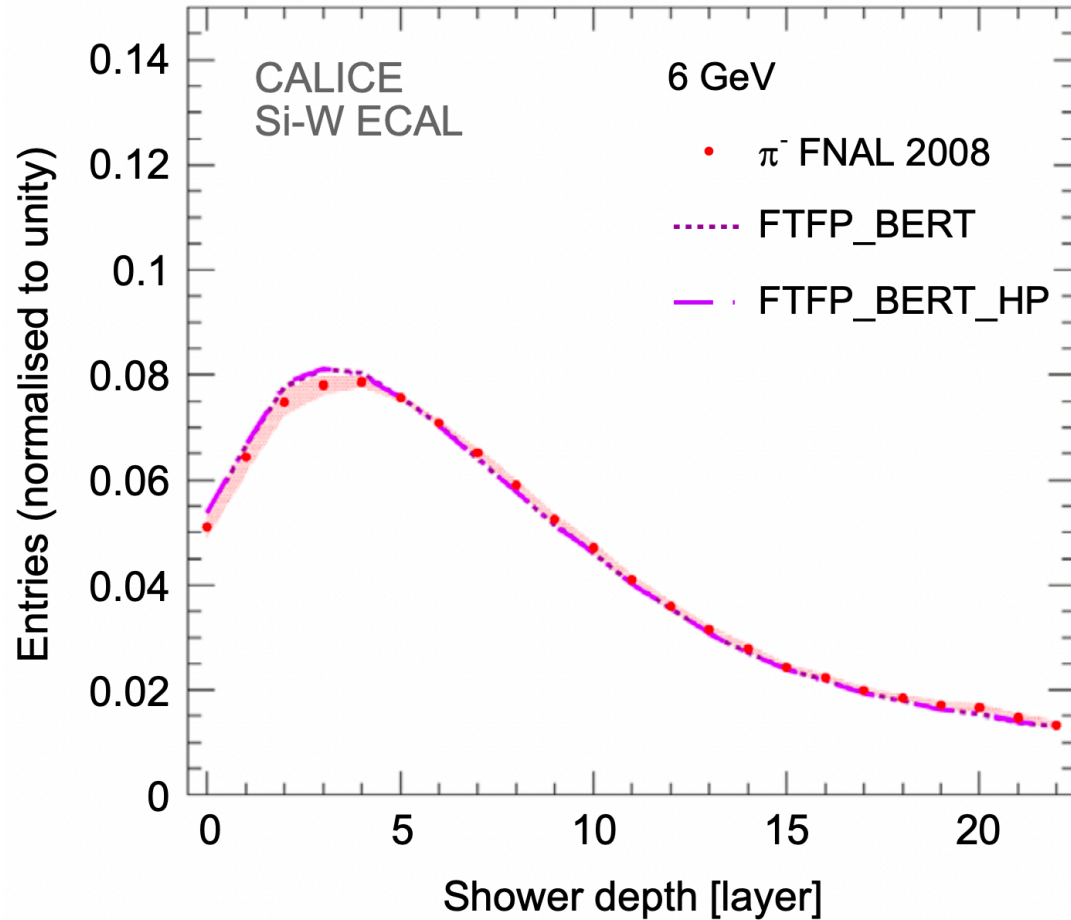
Geant4 Collaboration 2022 - Geant4.10.7.p03



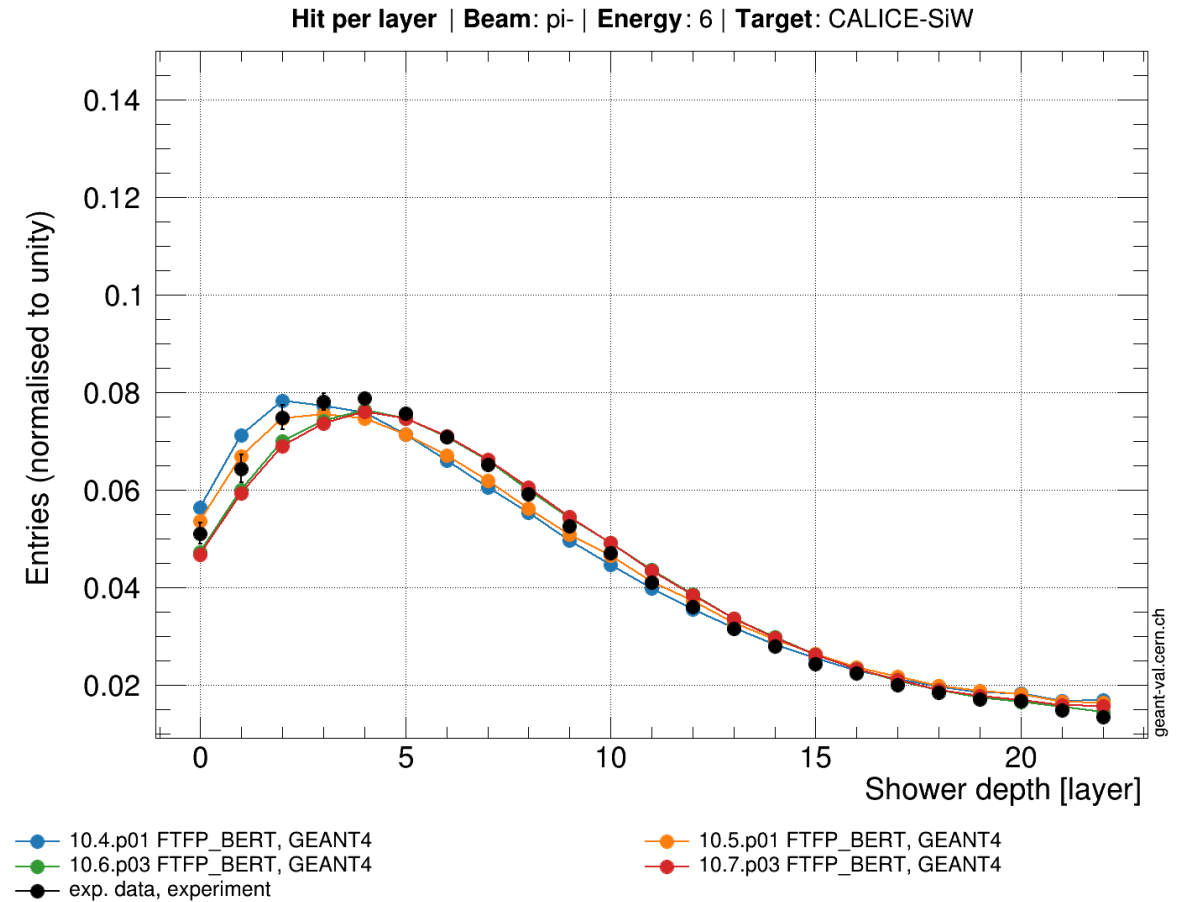
Longitudinal hit distribution - regression testing

6 GeV π^-

CALICE 2015 - Geant4.9.6 NIMA794



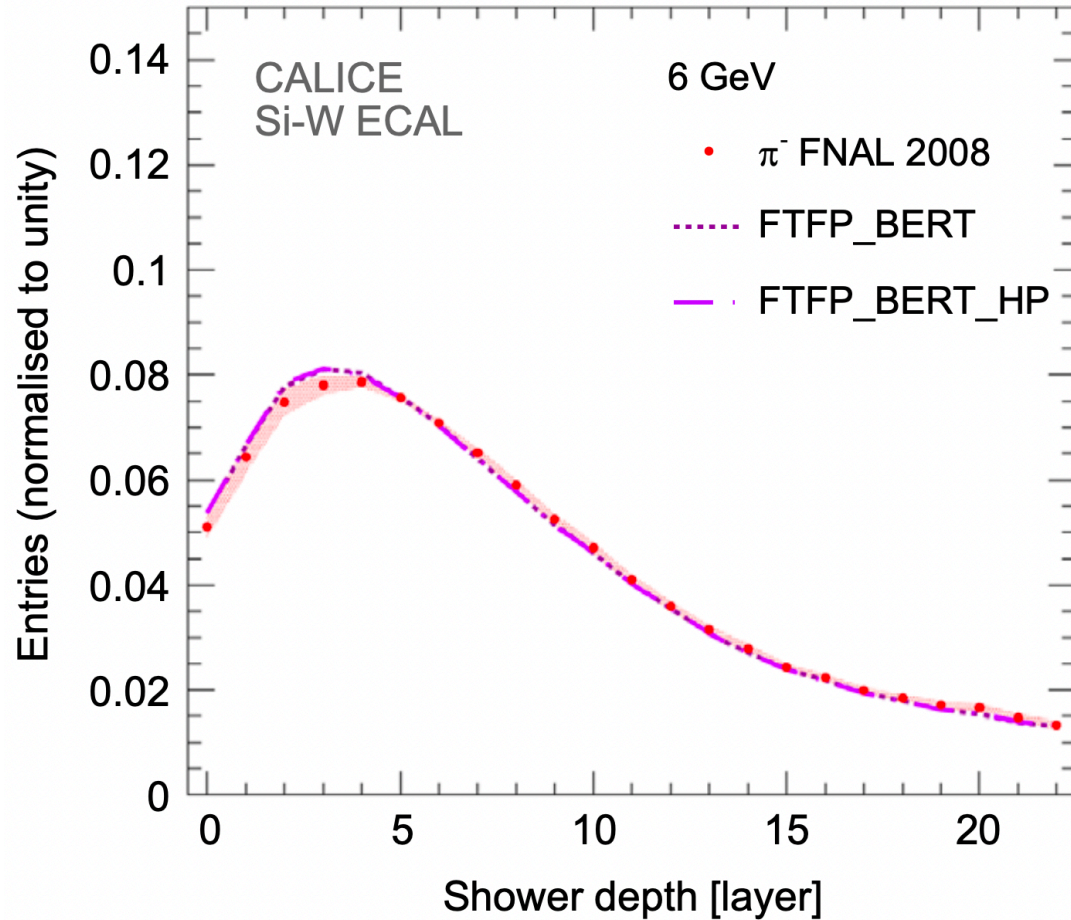
Geant4 Collaboration 2022



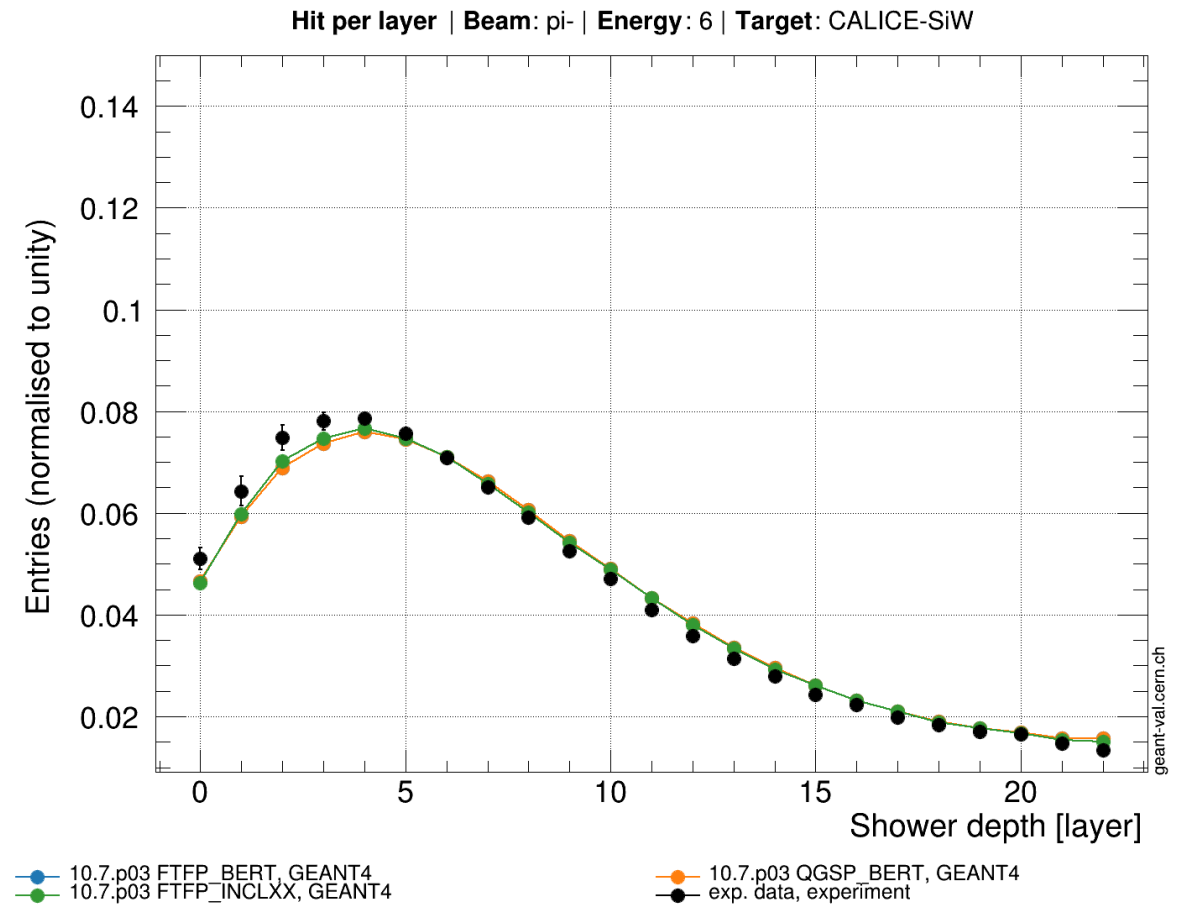
Longitudinal hit distribution - PL comparison

6 GeV π^-

CALICE 2015 - Geant4.9.6 NIMA794



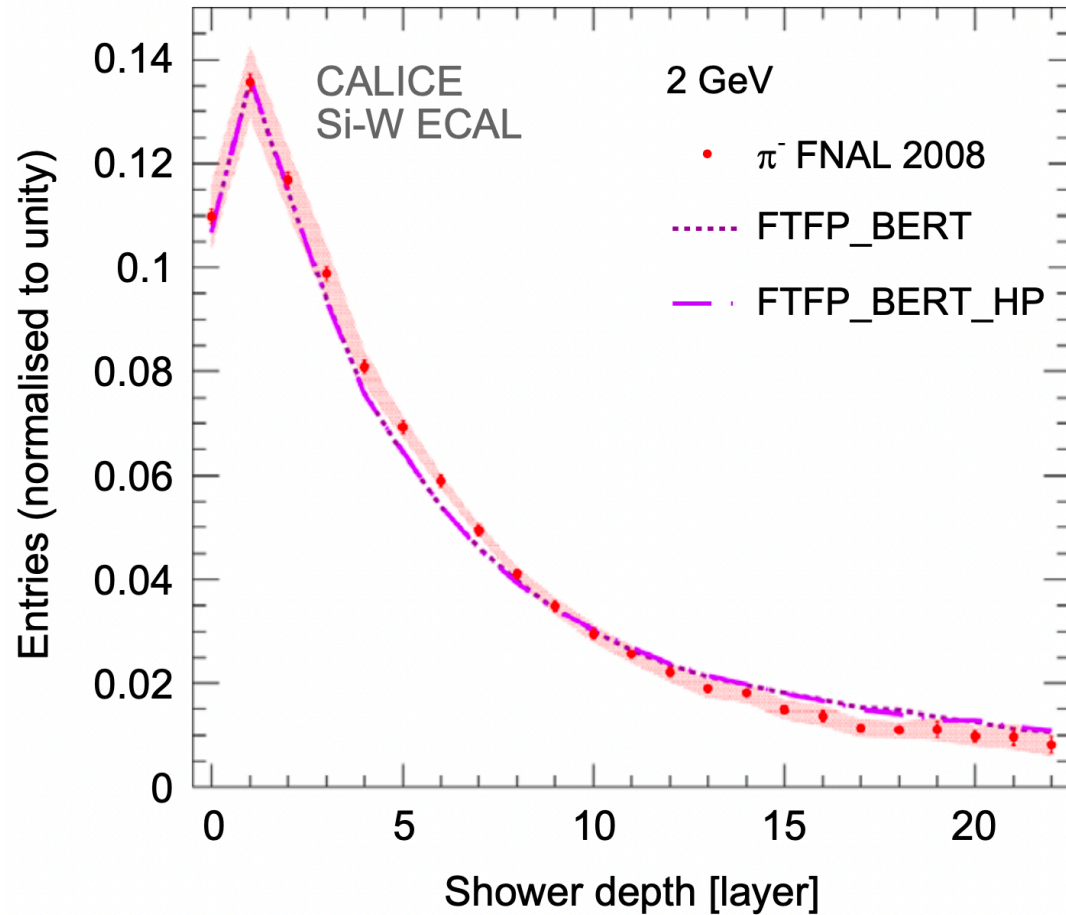
Geant4 Collaboration 2022 - Geant4.10.7.p03



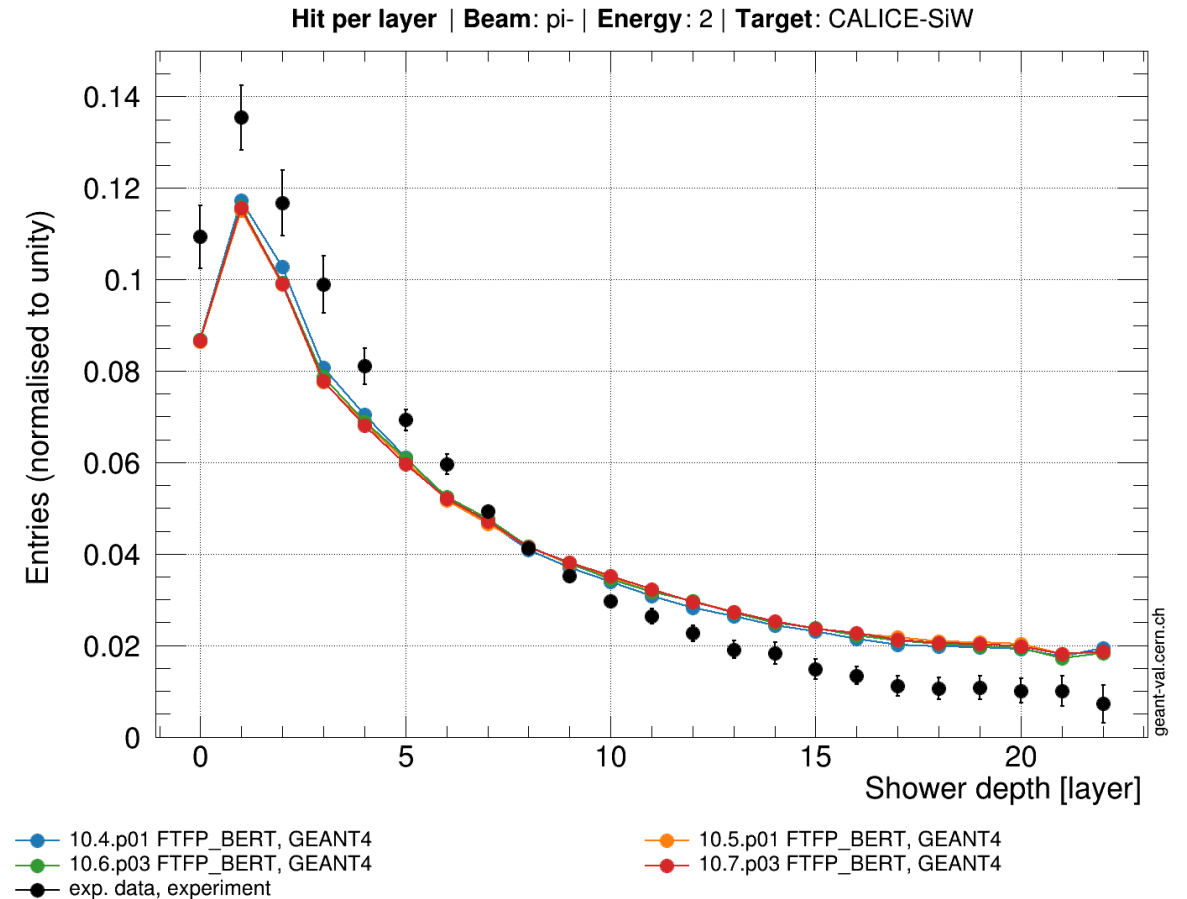
Longitudinal hit distribution - regression testing

2 GeV π^-

CALICE 2015 - Geant4.9.6 NIMA794



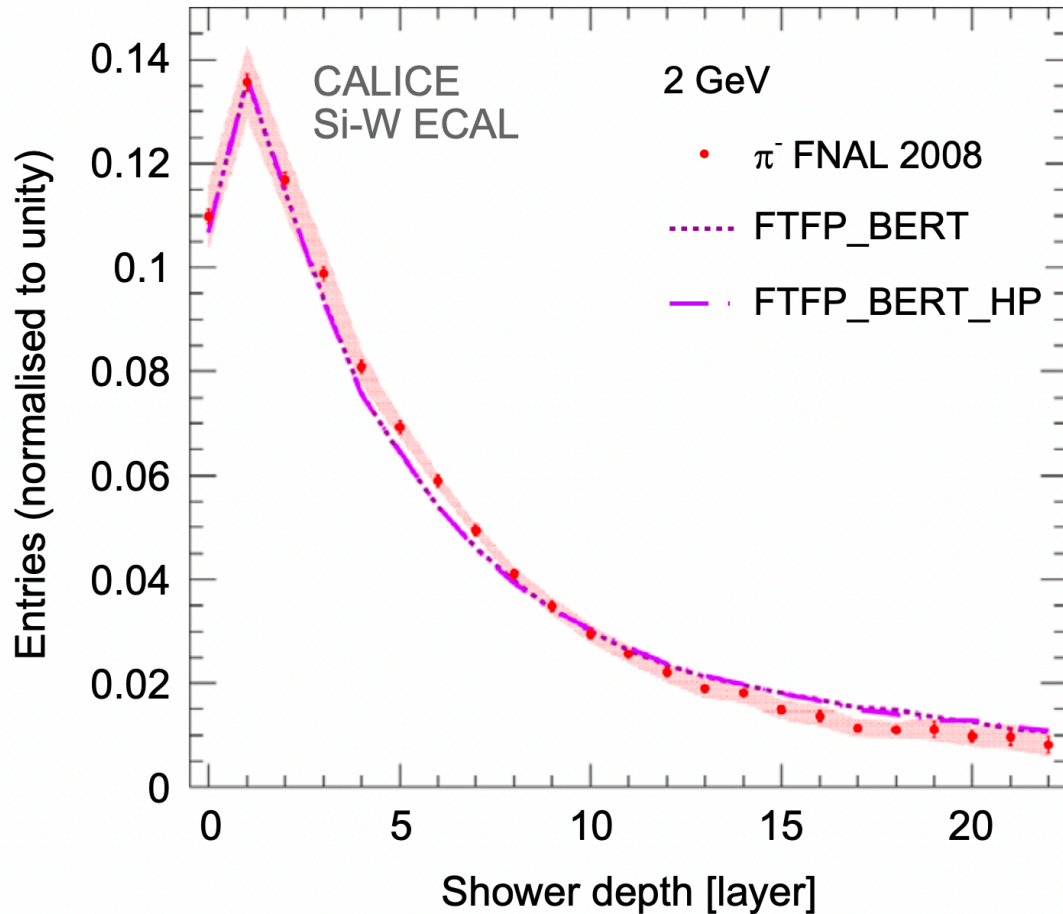
Geant4 Collaboration 2022



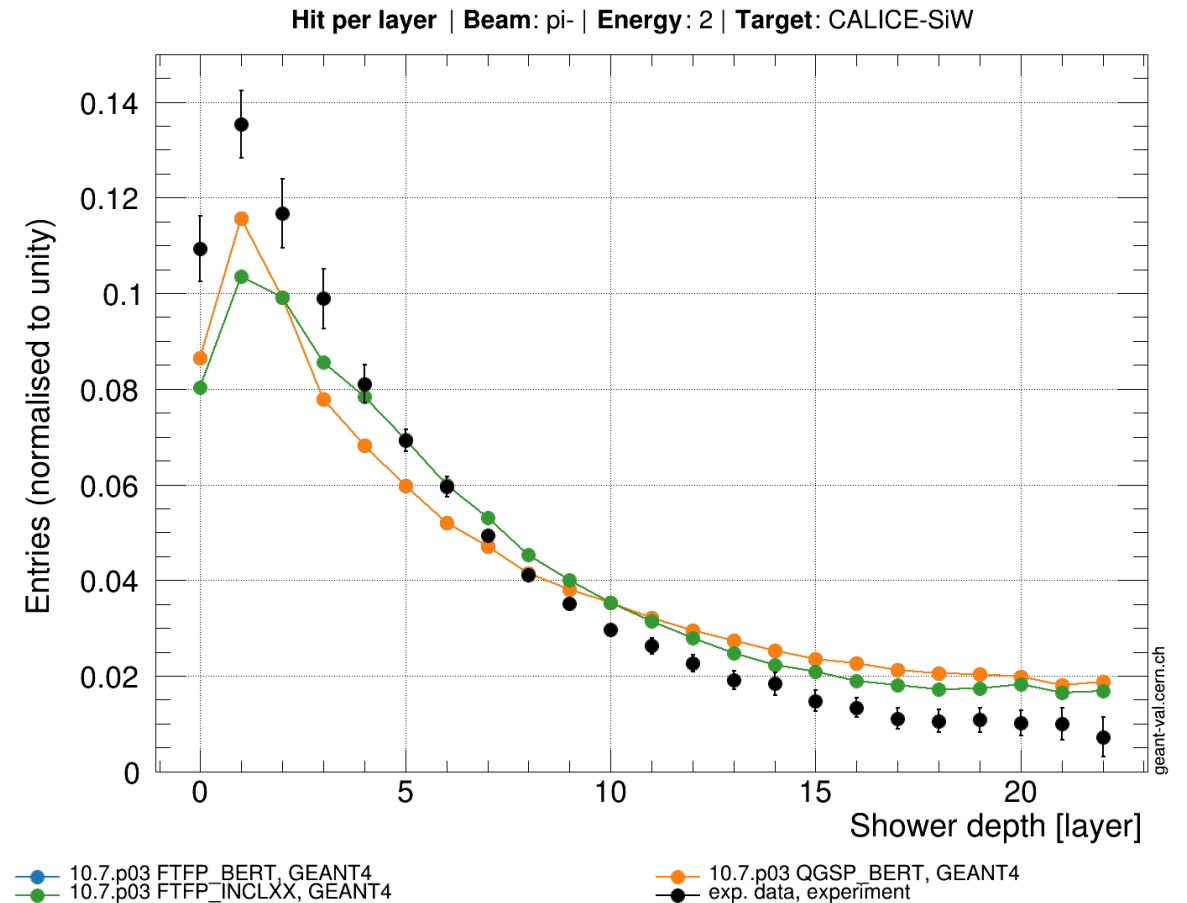
Longitudinal hit distribution - PL comparison

2 GeV π^-

CALICE 2015 - Geant4.9.6 NIMA794



Geant4 Collaboration 2022 - Geant4.10.7.p03





Conclusion and take home

- ◆ A new Geant4 standalone simulation of the CALICE SiW 2008 test beam is available on GitHub and first results are deployed on geant-val.
- ◆ It shows good improvement in the longitudinal energy distributions for the FTF model from Geant4.10.4 to Geant4.10.7.
- ◆ The INCL model shows a better MC-to-data agreement w.r.t. the FTF model for 10 GeV π^- .
- ◆ The CALICE Collaboration was pleased to see these improvements and invited us to actively collaborate on the upcoming SiW+AHCAL test-beam in June at the SPS.
- ◆ It is possible to expand the analysis on radial distributions.