Results from the CERN TB Geant4 simulation

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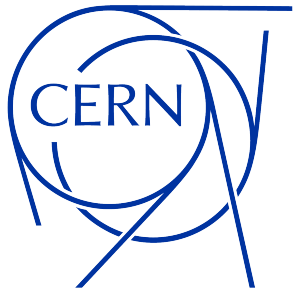
Dual-Readout Calorimetry bi-weekly meeting
17/11/2021



Geant4 validation on test beam data

The Geant4 Collaboration started in May 2021 a new validation program on test beam data targeting both hadronic and electromagnetic calorimeters.

- Lead by the EP-SFT Group under the supervision of Alberto Ribon.

- Four beam tests selected:
  - ATLAS Hadronic Endcap Calorimeter (HEC)  Completed.
  - ATLAS Tile Calorimeter (TileCal)  To be done.
  - The 2020 Dual-Readout fiber calorimeter (em-sized)  Ongoing, to be presented today.
  - Calice iron/scintillator hadronic technological prototype  To be done.

The G4 simulation of the CERN dual-readout TB

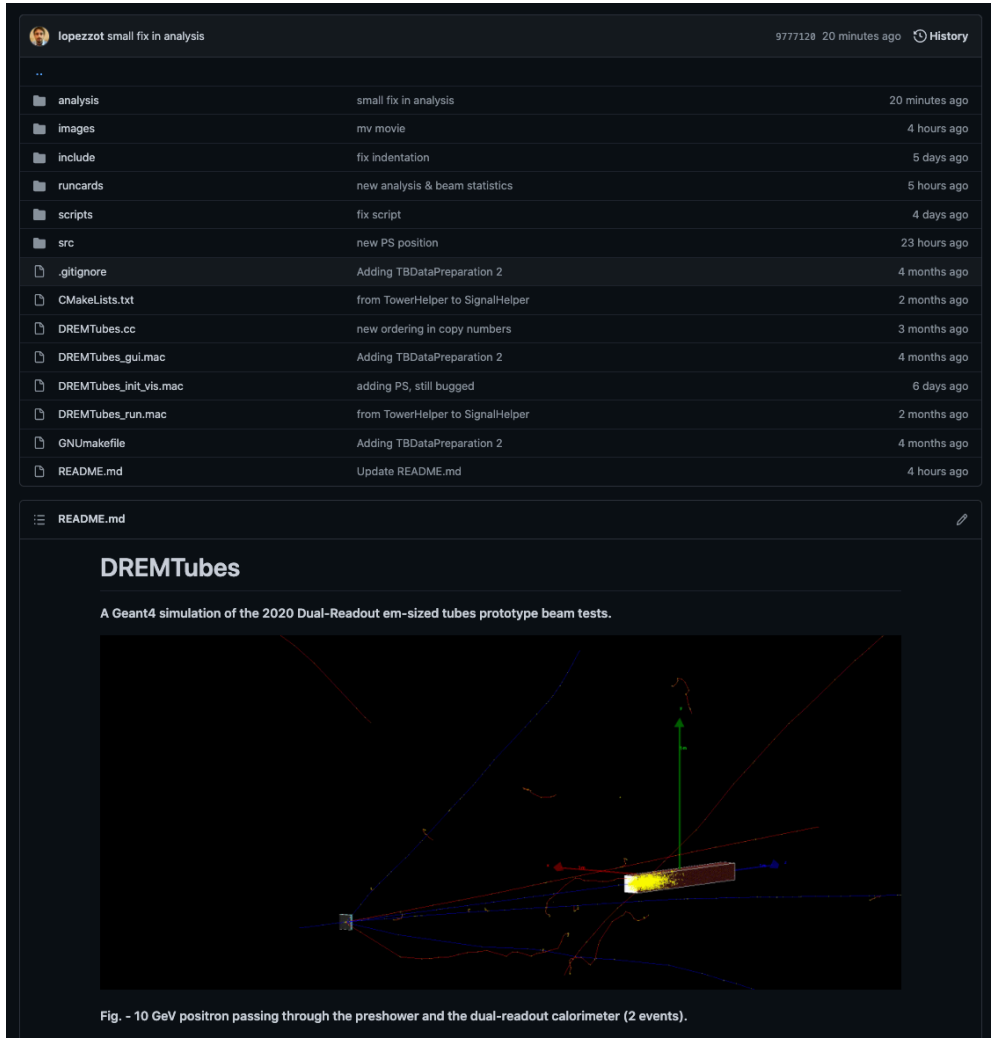
The Geant4 simulation code is located in the common TB software repository:

- [github] & [documentation]
- Already presented at this meeting as on *v1.1* [presentation],
- and as part of the whole test beam software as on *v1.2* [presentation].

Today's results obtained with *v1.3* to be released soon.

Updates since *v1.2*:

- Added the possibility to read out 9 towers independently, including the SiPM-readout tower.
- Updated the materials according to the 2020 prototype (Cu->CuZn(70/30)).
- Tuned the light yields on preliminary CERN TB data.
- Added the preshower description.

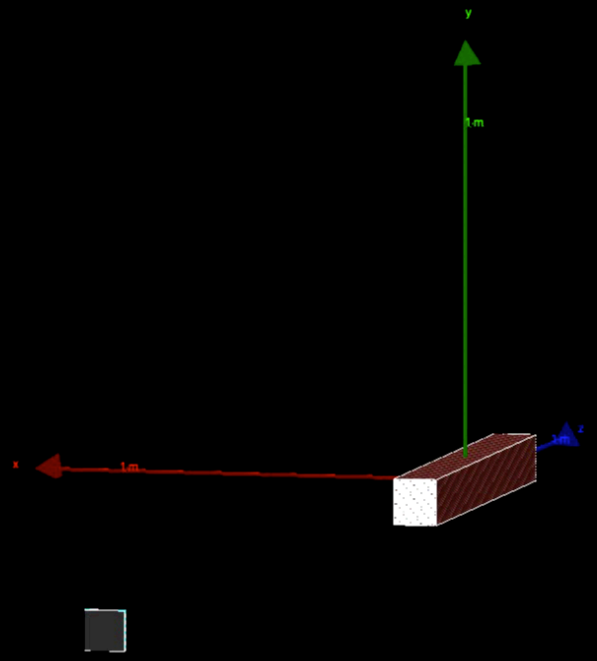


The Geant4 setup

Due to the large distance between the preshower and the calorimeter, it is mandatory to investigate the effect of the preshower on the detector performance. An example:

Geant4+Qt+ppmtompeg

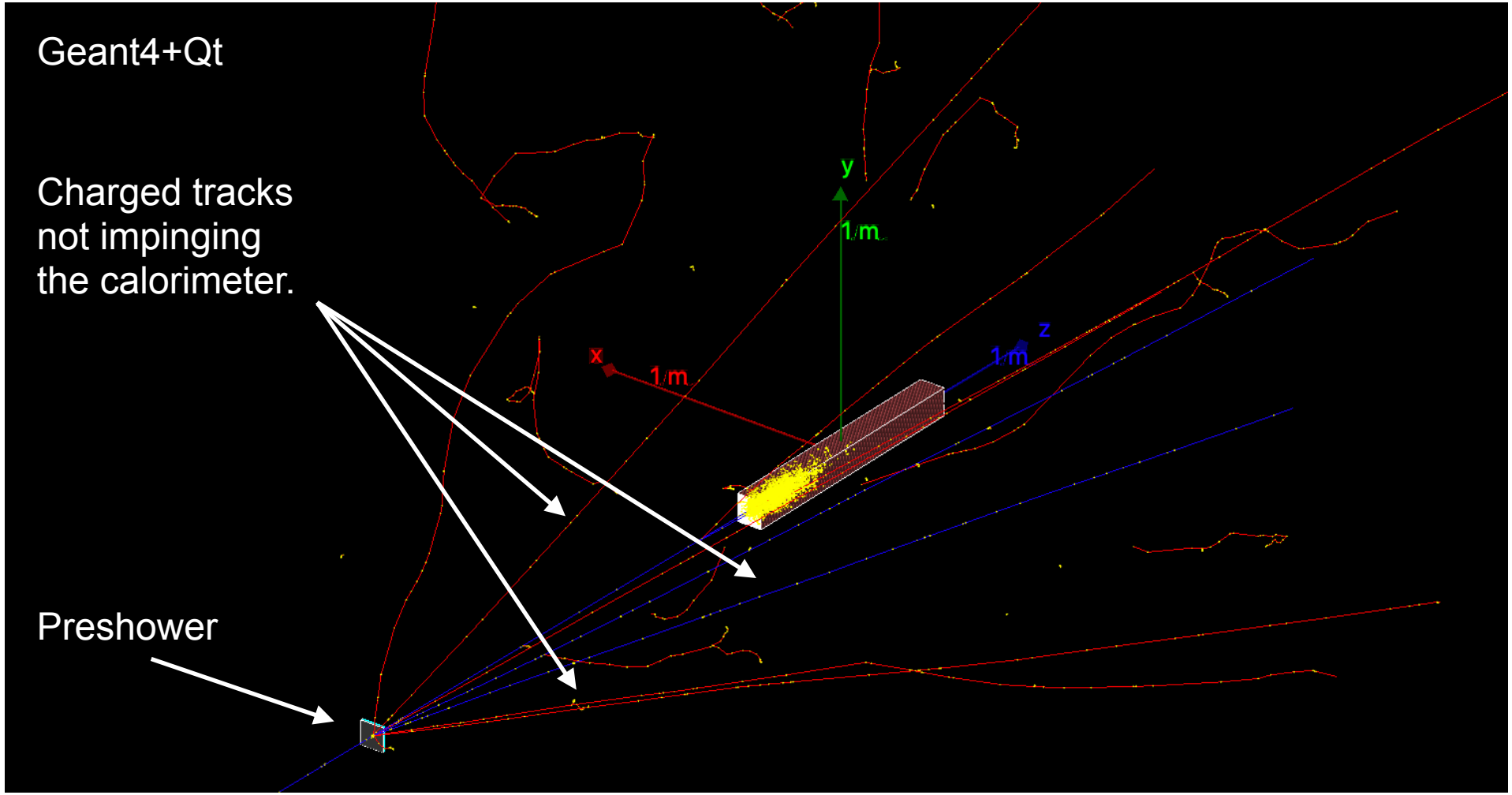
10 GeV e^+ impinging the preshower and the calorimeter.



For .pdf usage, this is a video!

The Geant4 setup

Due to the large distance between the preshower and the calorimeter, it is mandatory to investigate the effect of the preshower on the detector performance. An example:



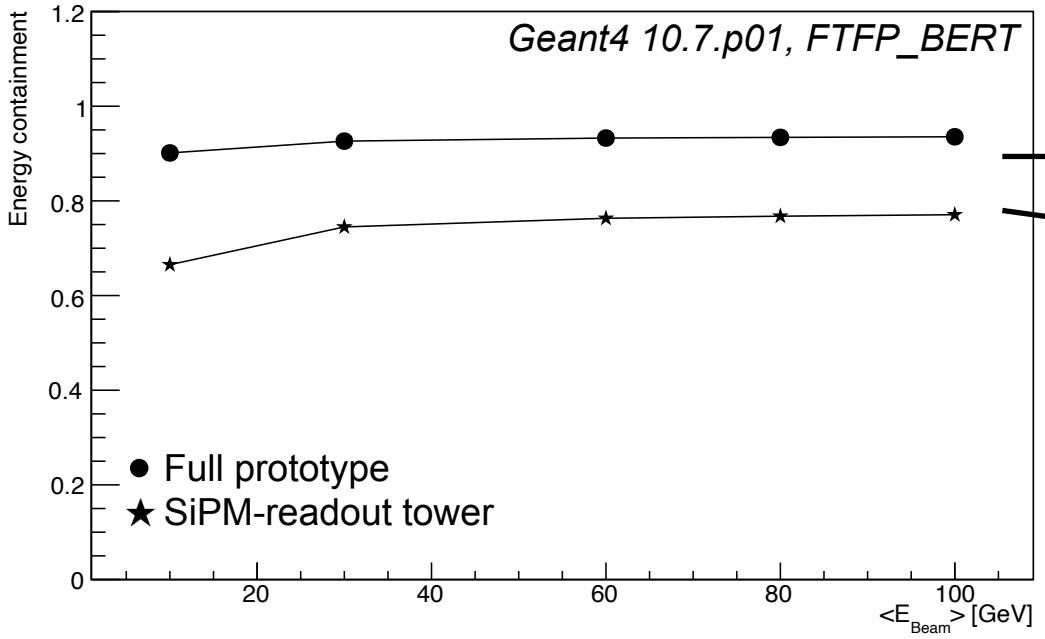
10 GeV e^+ impinging the preshower and the calorimeter.

Only charged tracks (e^+, e^-) displayed.

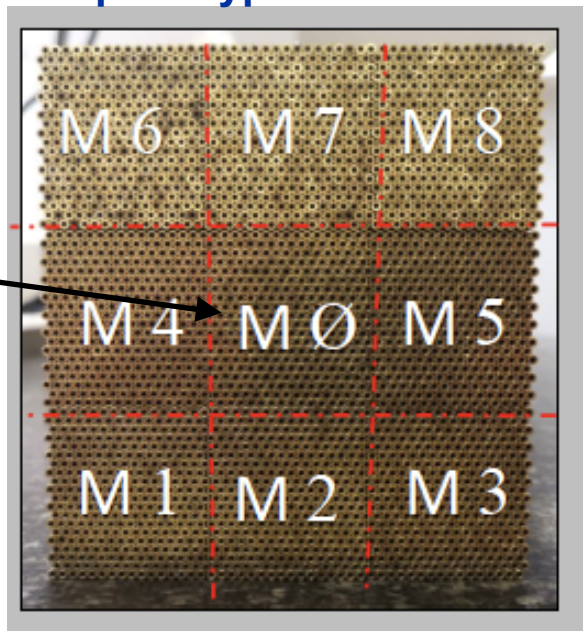
Results (e^+)

- Results for pure e^+ beams (10-100 GeV) shot at the M0 center, passing through the preshower. No event selection applied.

Average energy containment
Calculated as the average ionizing energy deposition by any track in the calorimeter, divided by the beam energy.



Full prototype - 9 towers

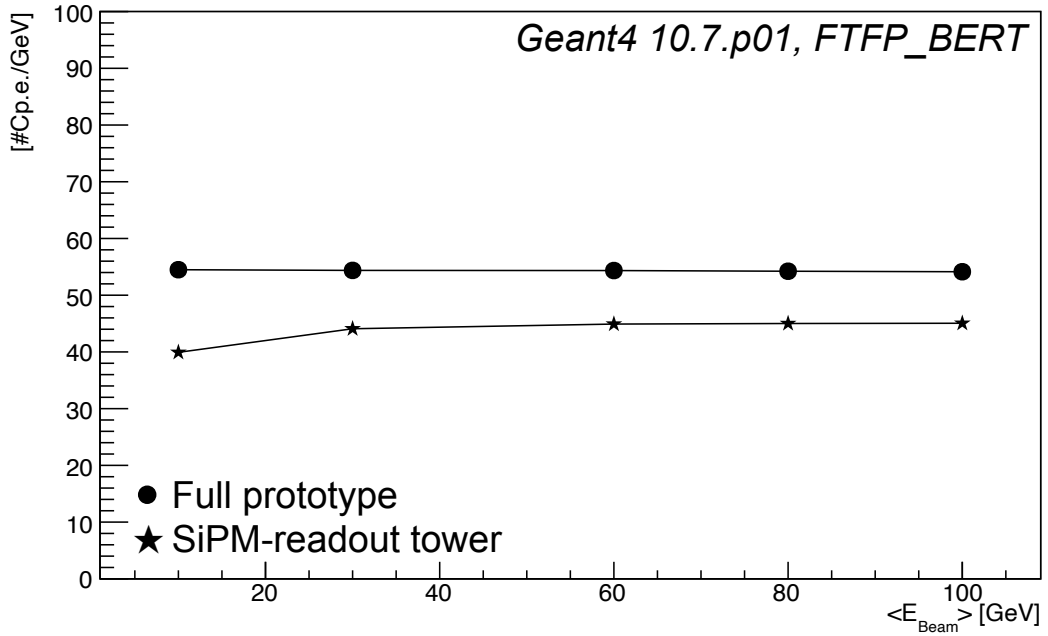


Results (e^+)

- Results for pure e^+ beams (10-100 GeV) shot at the M0 center, passing through the preshower. No event selection applied.

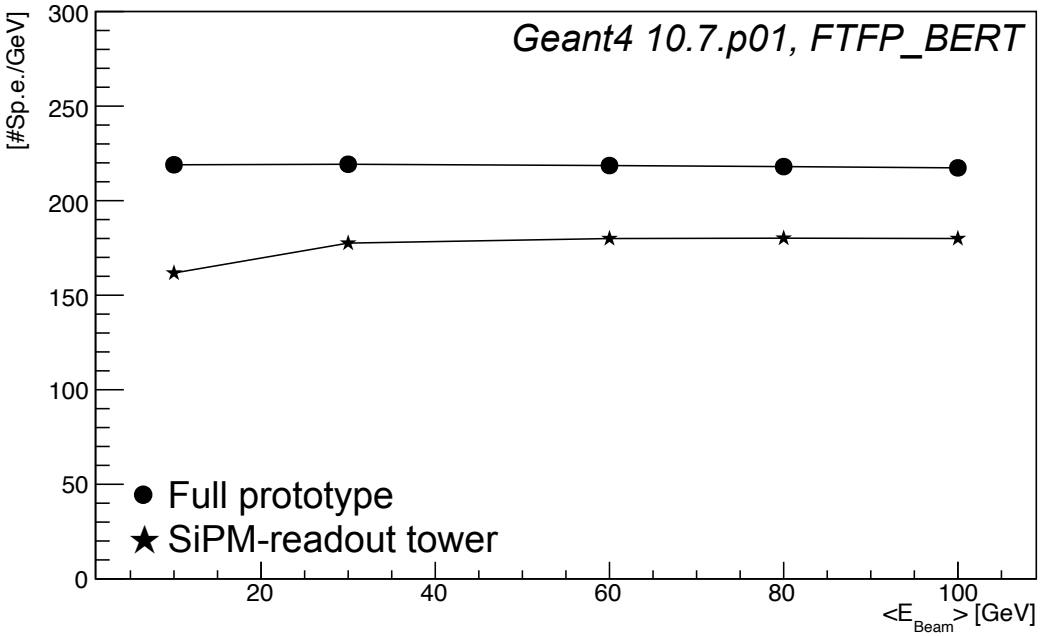
Cherenkov response

Calculated as the average Cherenkov signal (p.e.) per unit of deposited energy (GeV).



Scintillation response

Calculated as the average scintillation signal (p.e.) per unit of deposited energy (GeV).

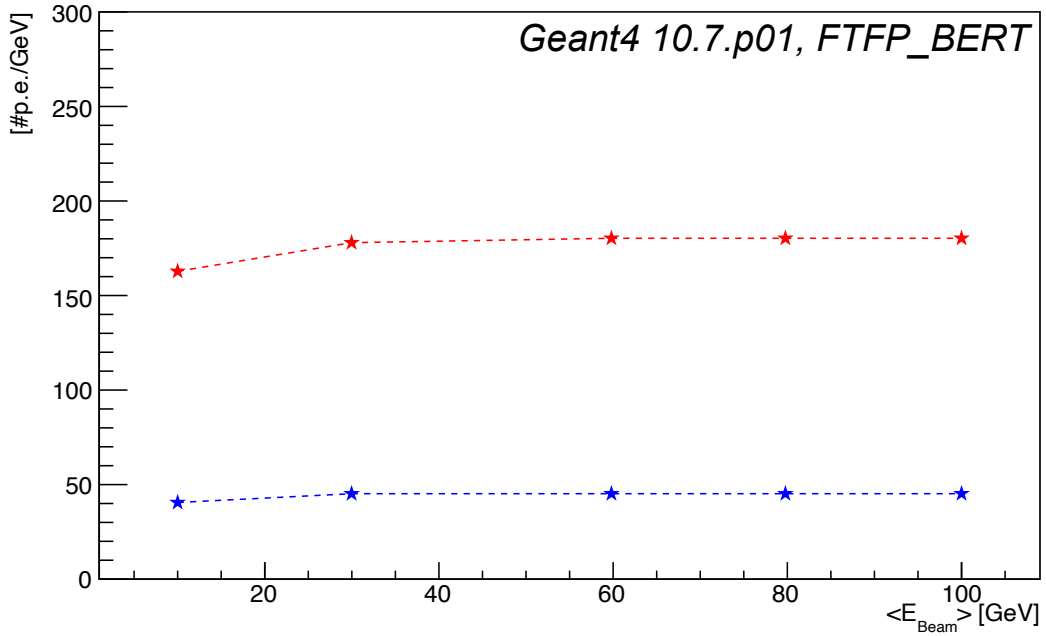


Results (e^+)

- Results for pure e^+ beams (10-100 GeV) shot at the M0 center, passing through the preshower.
  No event selection applied.

SiPM light yields

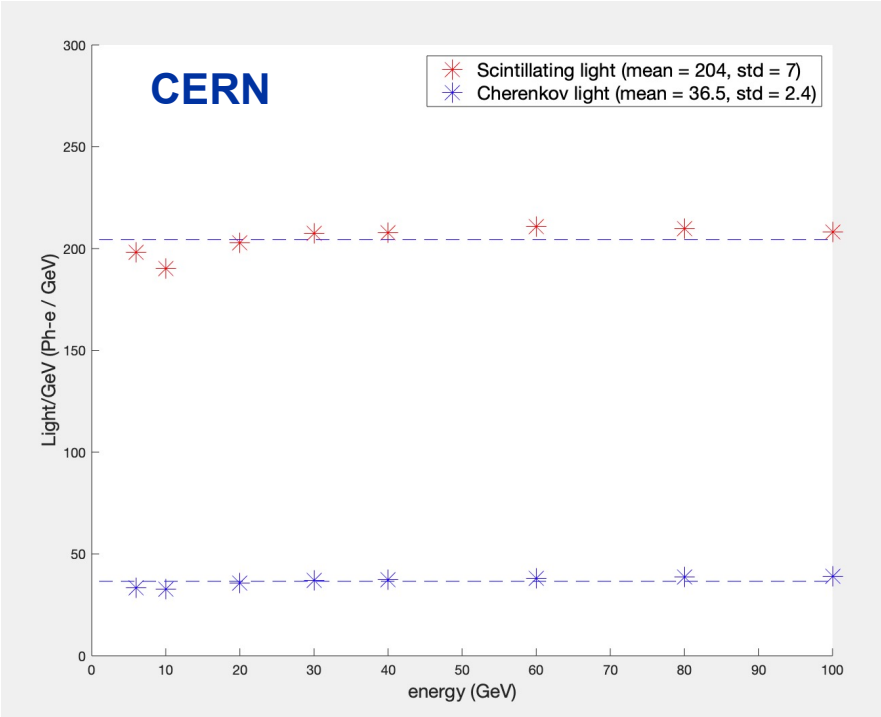
Calculated as the average signals (p.e.)
in the SiPM-readout tower,
per unit of deposited energy (GeV).



G4 to be retuned as soon as new light yields are computed.

CERN TB - Preliminary

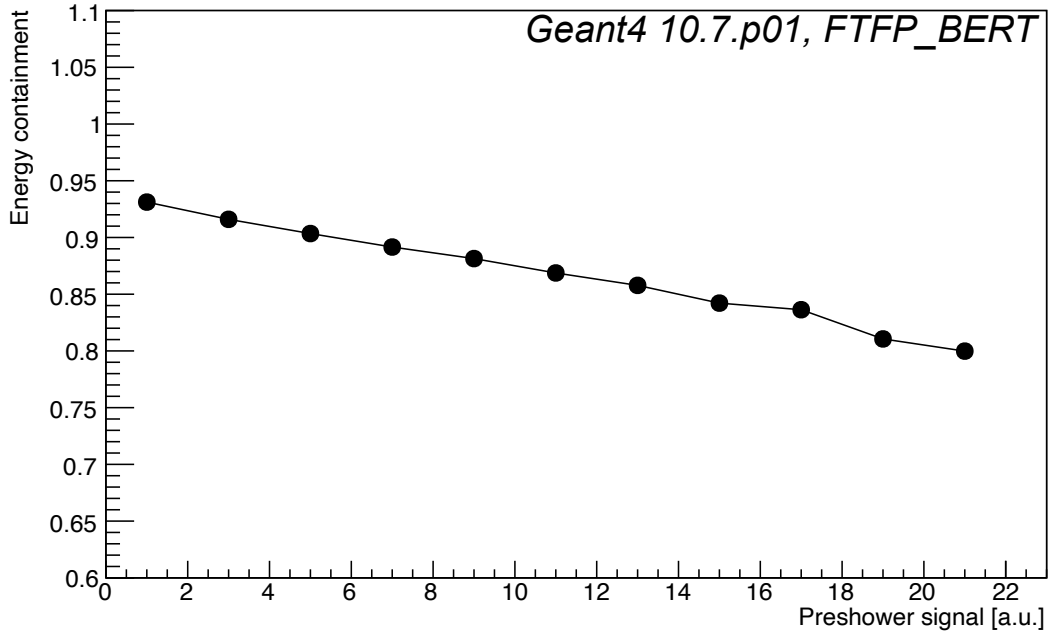
Courtesy of Romualdo.



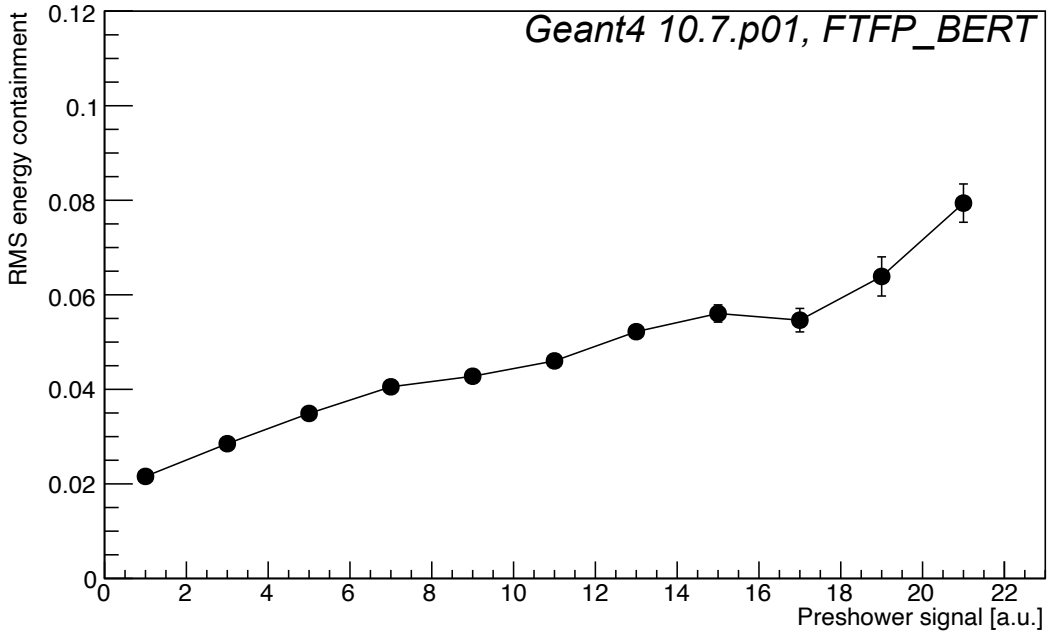
Preshower effect on e^+ performance

- Results for 10 GeV pure e^+ beam shot at the M0 center, passing through the preshower, as a function of the preshower signal.

Average energy containment
Calculated as the mean ionizing energy deposition from any track in the calorimeter, divided by the beam energy, as a function of the preshower signal.



Energy containment RMS
Calculated as the RMS of the energy containment distribution, as a function of the preshower signal.

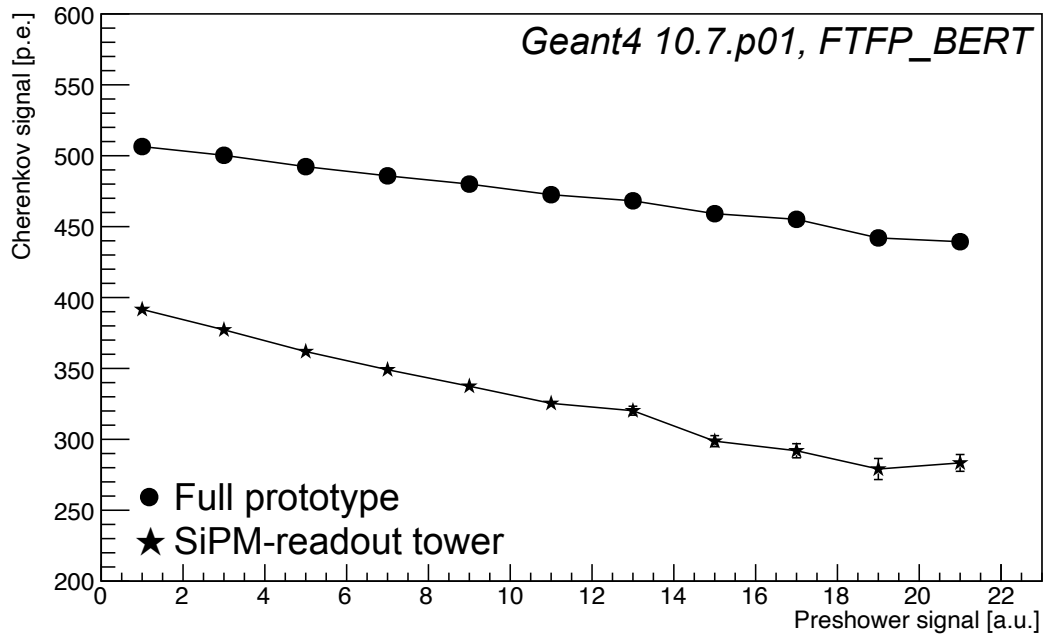


Non negligible effect of the preshower on energy fluctuations.

Preshower effect on e^+ performance

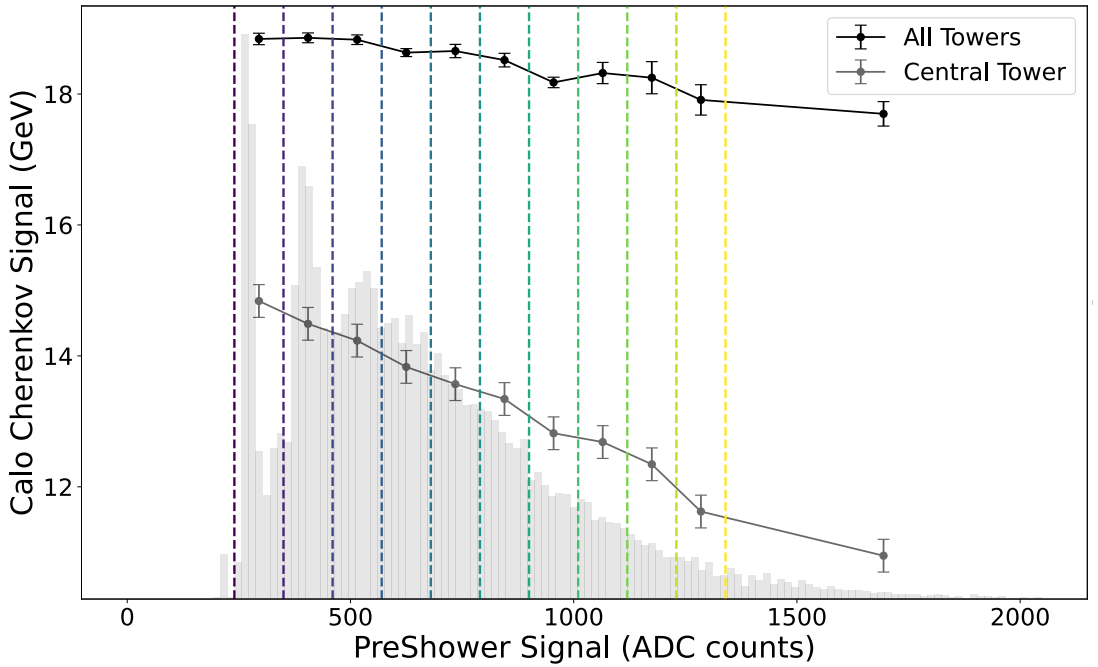
- Results for e^+ beam shot at the M0 center, passing through the preshower, as a function of the preshower signal.

Average Cherenkov signal
10 GeV e^+
Calculated as the mean Cherenkov signal,
as a function of the preshower signal.



CERN TB 20 GeV e^+ - Preliminary

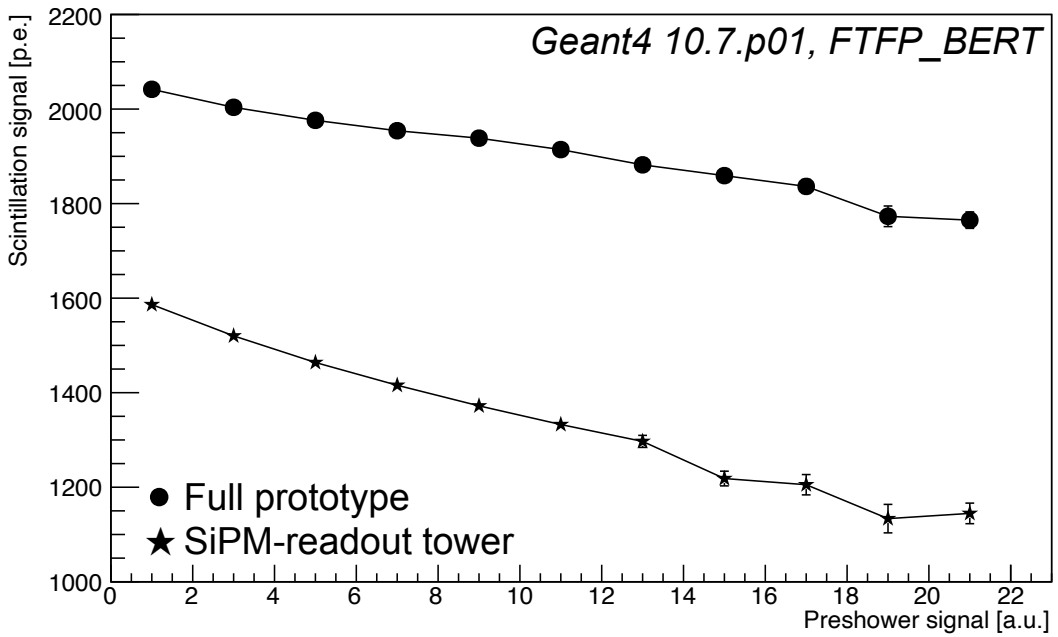
Courtesy of Andreas and Iacopo.



Preshower effect on e^+ performance

- Results for e^+ beam shot at the M0 center, passing through the preshower, as a function of the preshower signal.

Average scintillation signal
10 GeV e^+
Calculated as the mean scintillation signal,
as a function of the preshower signal.



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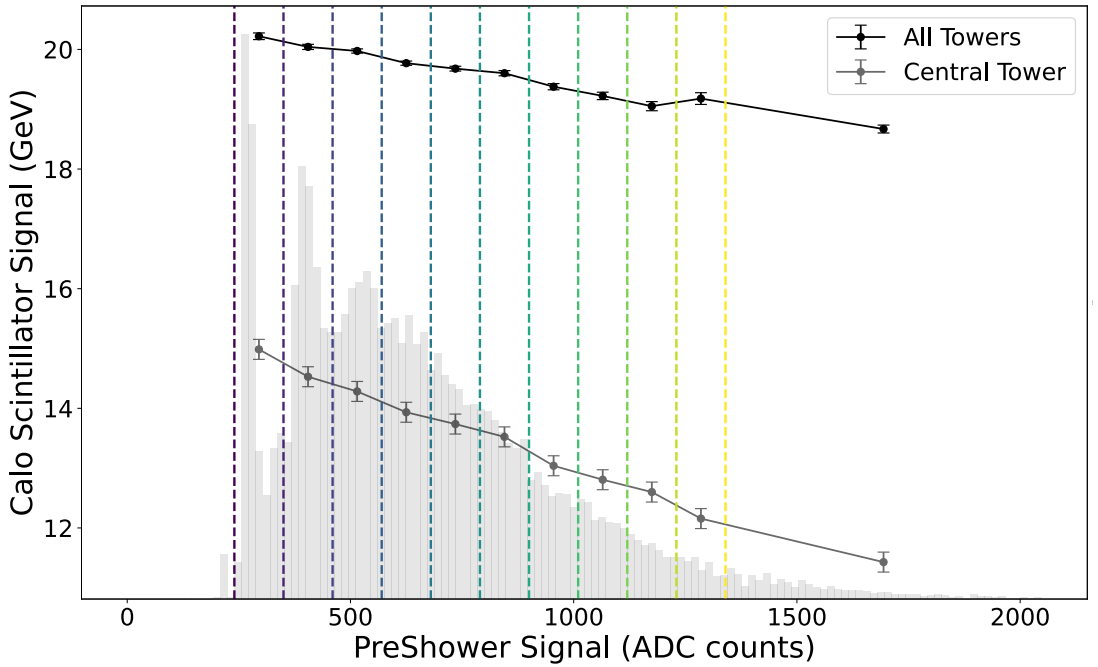

Conclusions and take home

- v1.3 of the dual-readout test beam sw is going to be released soon. Including:
  - Better SiPM data handling in ntuples calibration (pull request #28)
  - Adaptation of data merging and calibration for Desy test beam data (pull request #30)
  - Modifications of the Geant4 simulation discussed today (pull request to be drafted).
- The Geant4 simulation of the 2021 dual-readout beam tests is now ready for data production.
  - Need to start the data analysis and simulation interplay.
    - Simulation needs a new estimation of the light yields and the calibrated distributions for S/C signals (GeV).
    - Any other input from Geant4 for the analysis needed?
- The preshower effect of the detector performance is under investigation both with test beam data and simulations.
  - Do we all agree on how to handle it?