Flash talk: A Forward Hadronic Calorimeter for ALICE at the LHC

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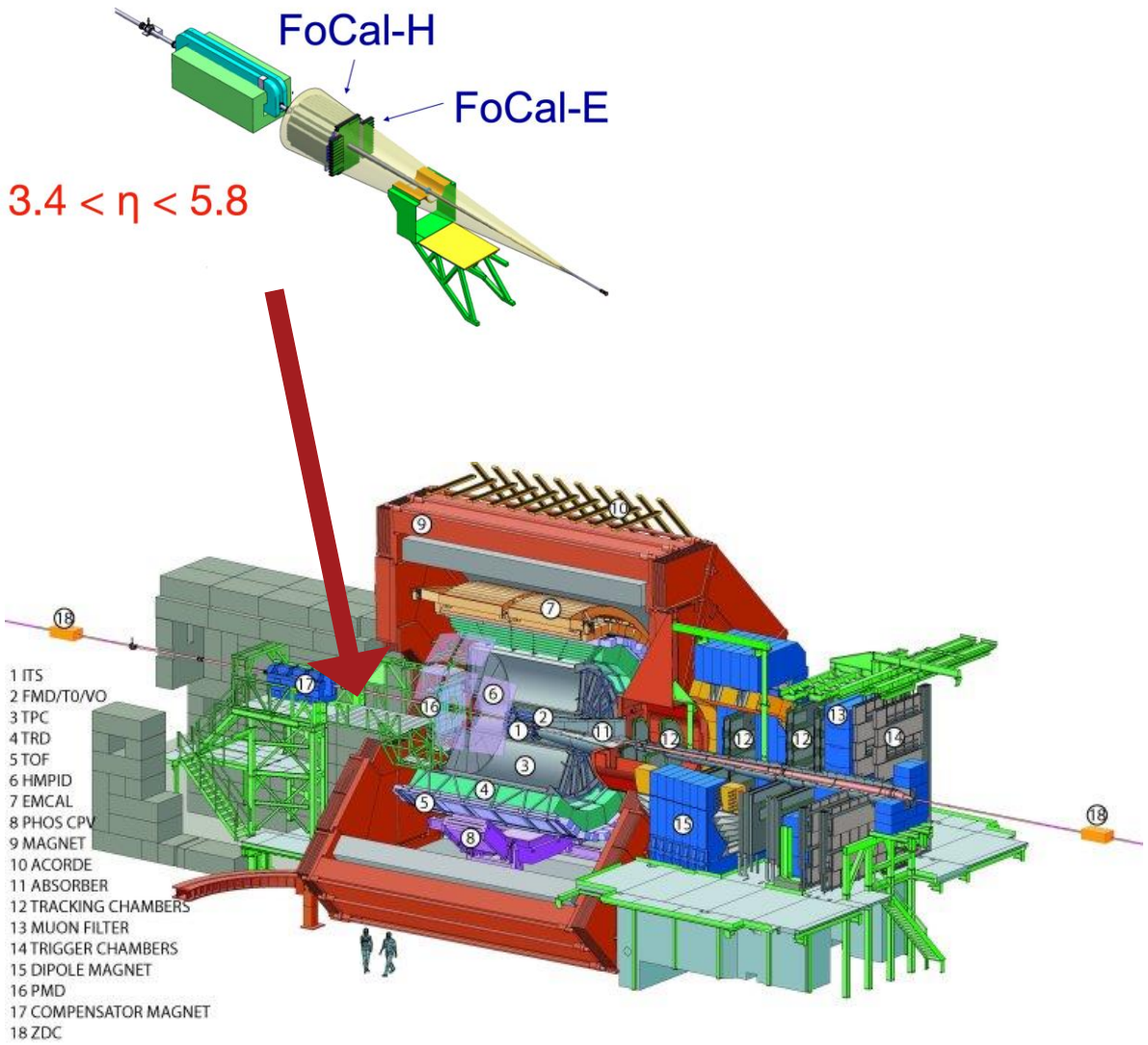
What is the project about?

- New particle detector (FoCal) for the ALICE experiment.

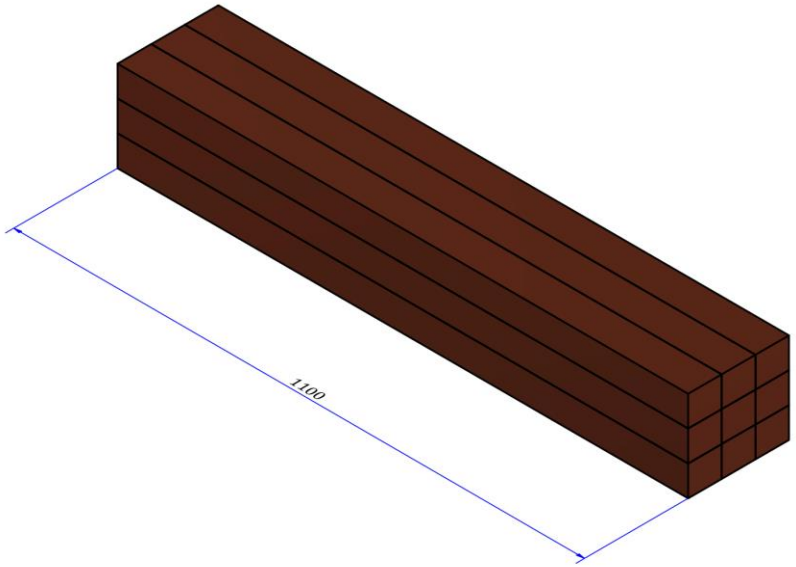
- FoCal consists of two parts, an Electromagnetic calorimeter (FoCal-E) and a Hadronic calorimeter (FoCal-H).

- FoCal physics goals:
  - *Measure the gluon density in protons and lead nuclei and quantify its nuclear modification at small x and Q^2.*
  - *Explore the physical origin of shadowing effects*
  - *Jet quenching at forward rapidity in Pb–Pb collisions.*
  - *Origin of long-range flow-like correlations in p-p and p–Pb collisions*

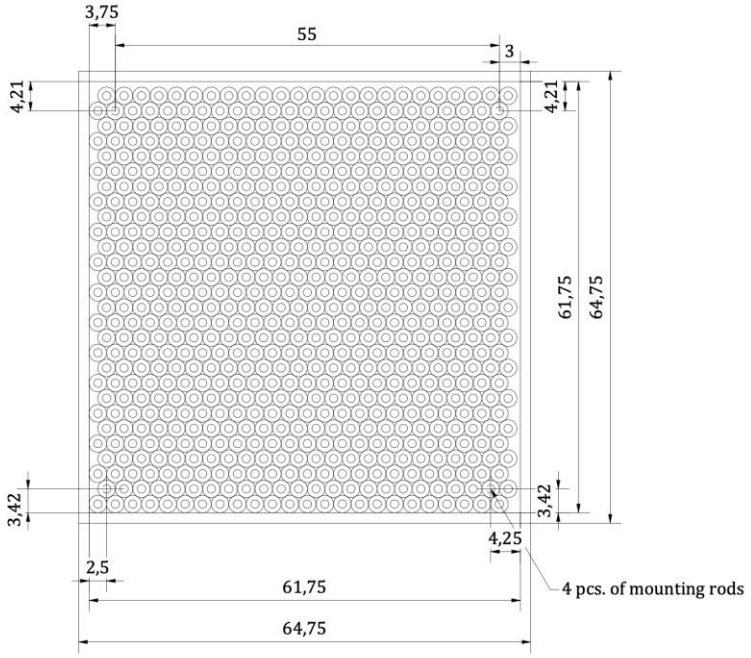
- FoCal is at the end of the prototyping phase, and aims for the TDR by end of 2023. Installation is foreseen for 2028.

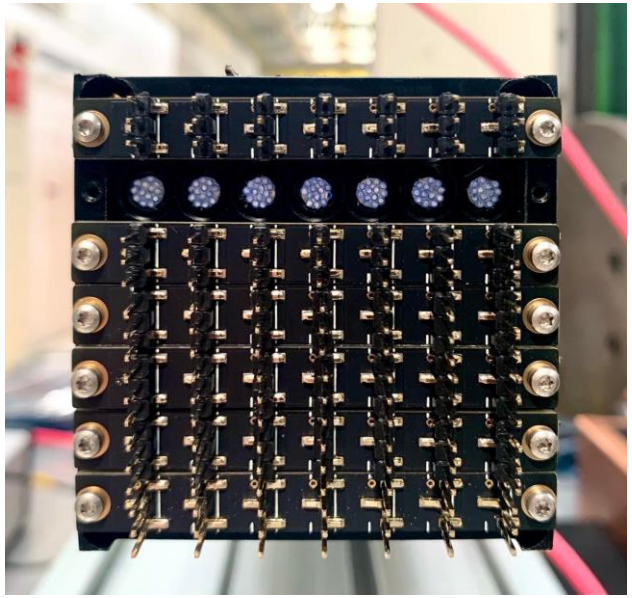


Forward Hadronic Calorimeter (FoCal-H)



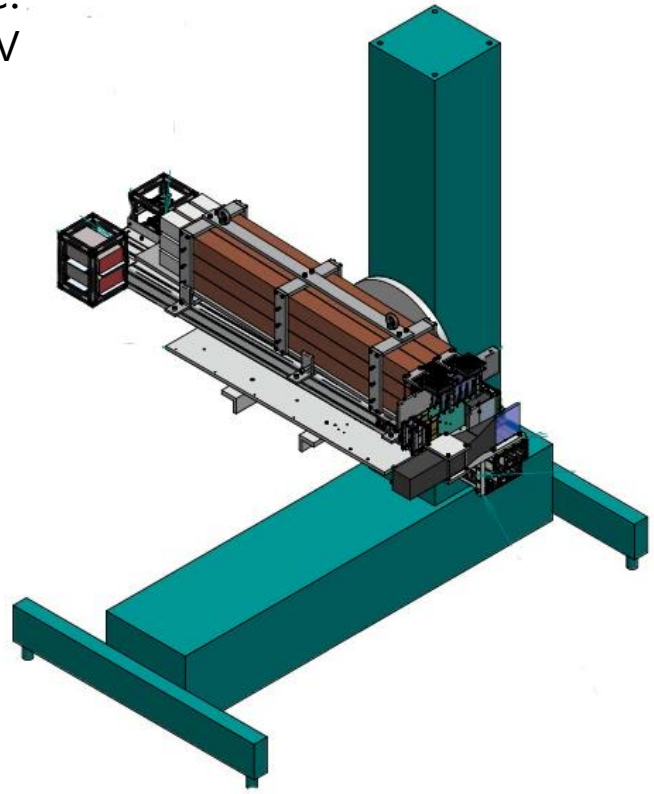
- FoCal-H second prototype.
  - Different shapes and stacking methods of the calorimeter modules was considered → Square modules were chosen.
  - Each module consist of 668 copper-tubes with a scintillating fiber (BCF12) inside.
  - Central module: Scintillating fibers are grouped in 49 bundles with ~14 fibers per bundle.
  - Outer modules: Scintillating fibers are grouped in 25 bundles with ~ 27 fibers per bundle.
  - SiPM: S13360-6025PE from Hamamatsu
    - Read out by CAEN DT5202

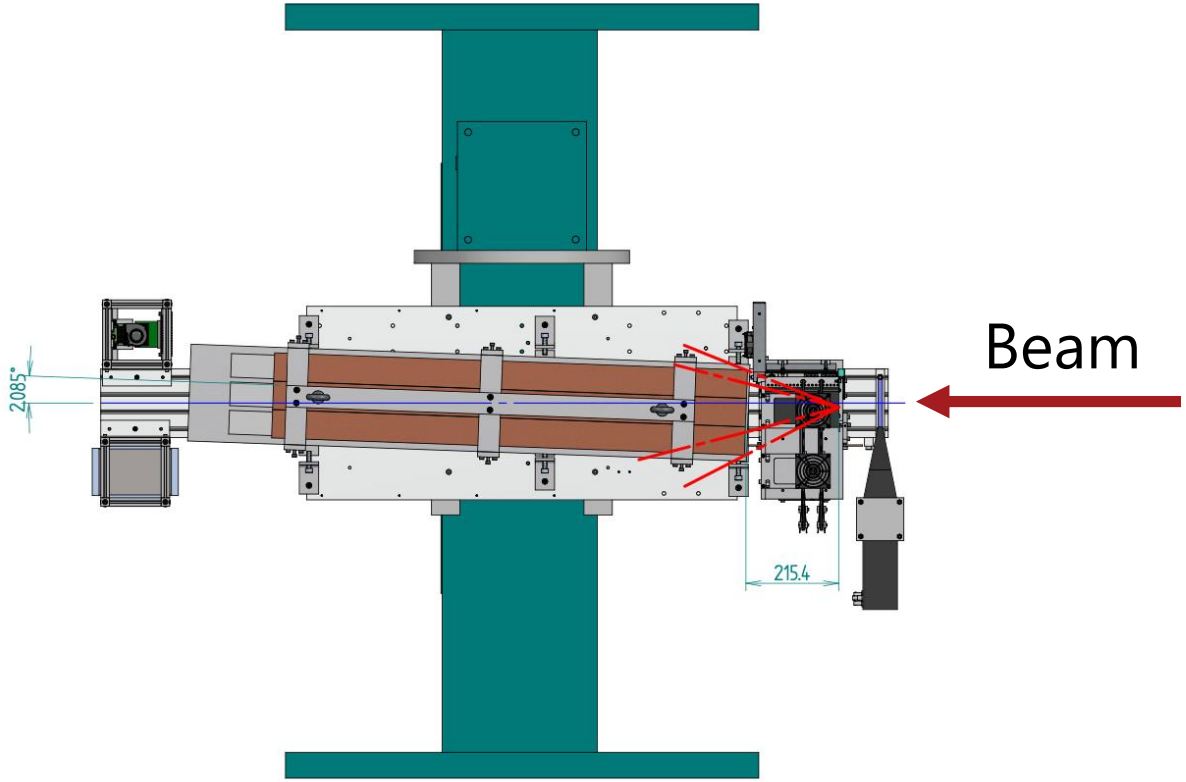




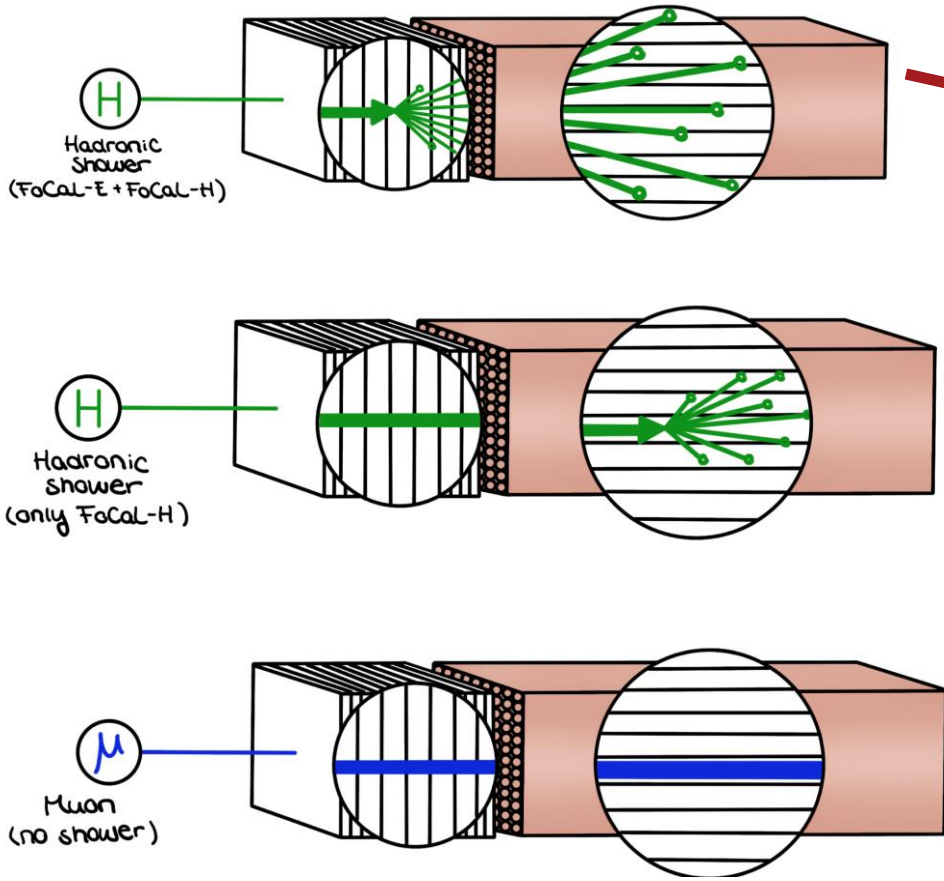
FoCal-H SPS H2 testbeam setup

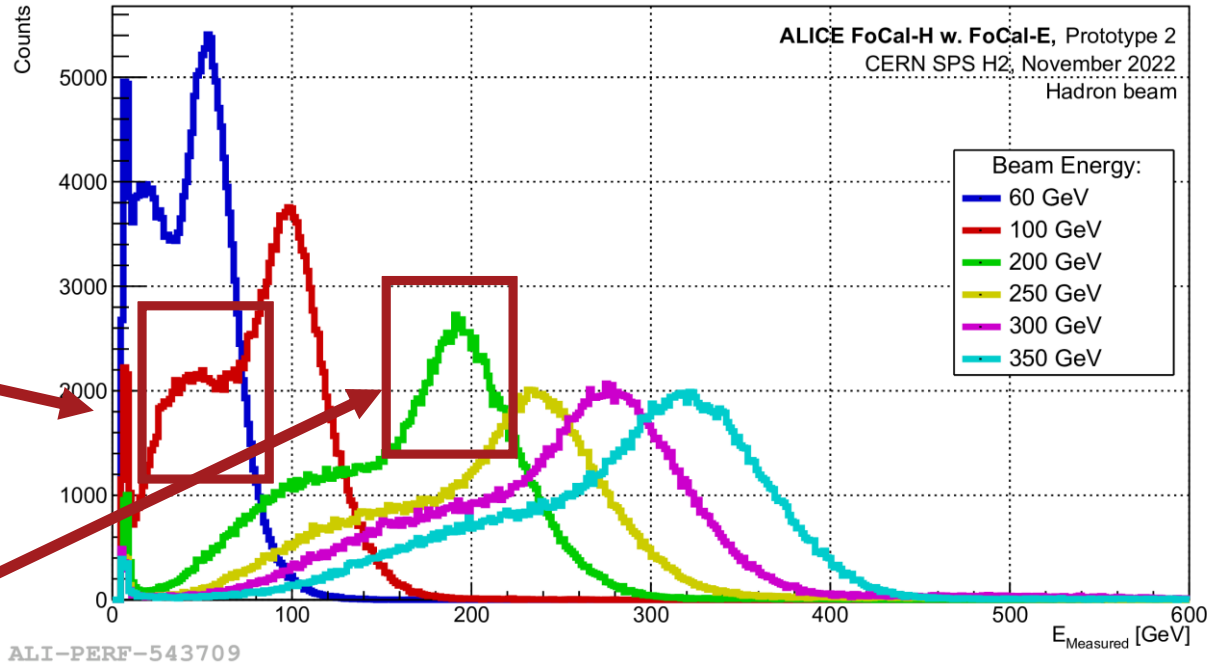
- FoCal-H setup:
  - Prototype 2: 9 calorimeter modules of 668 copper-tubes with a scintillating fiber inside.
- SPS H2 Energy range:
  - 60 GeV to 350 GeV

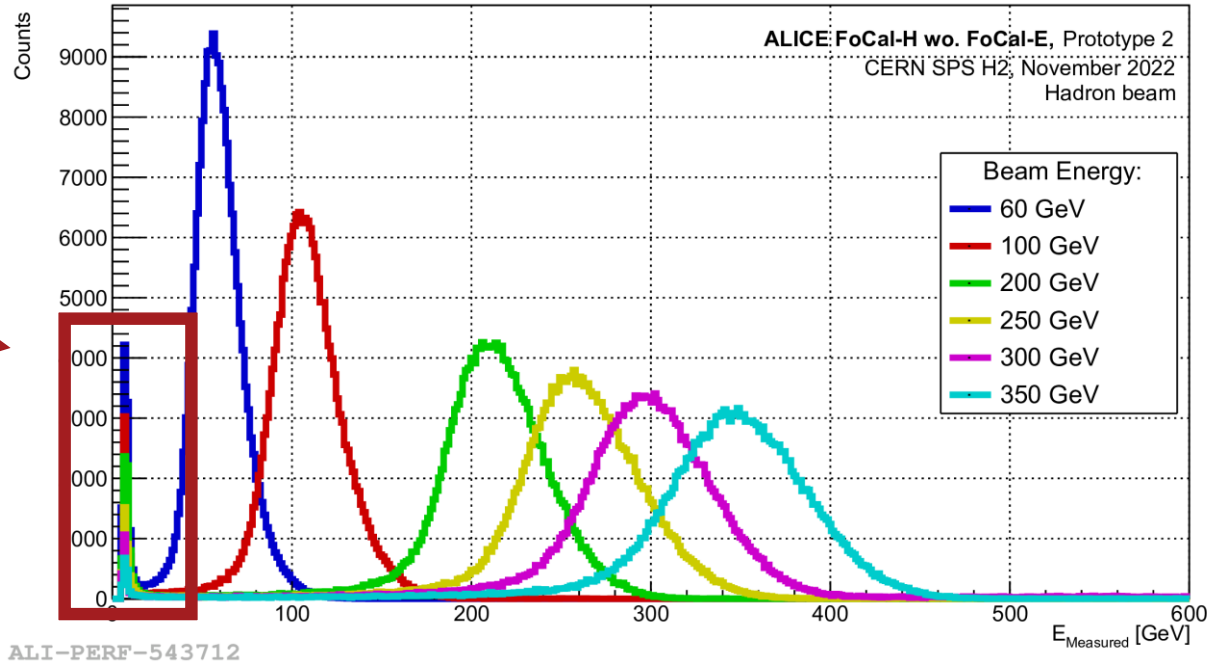




Testbeam data

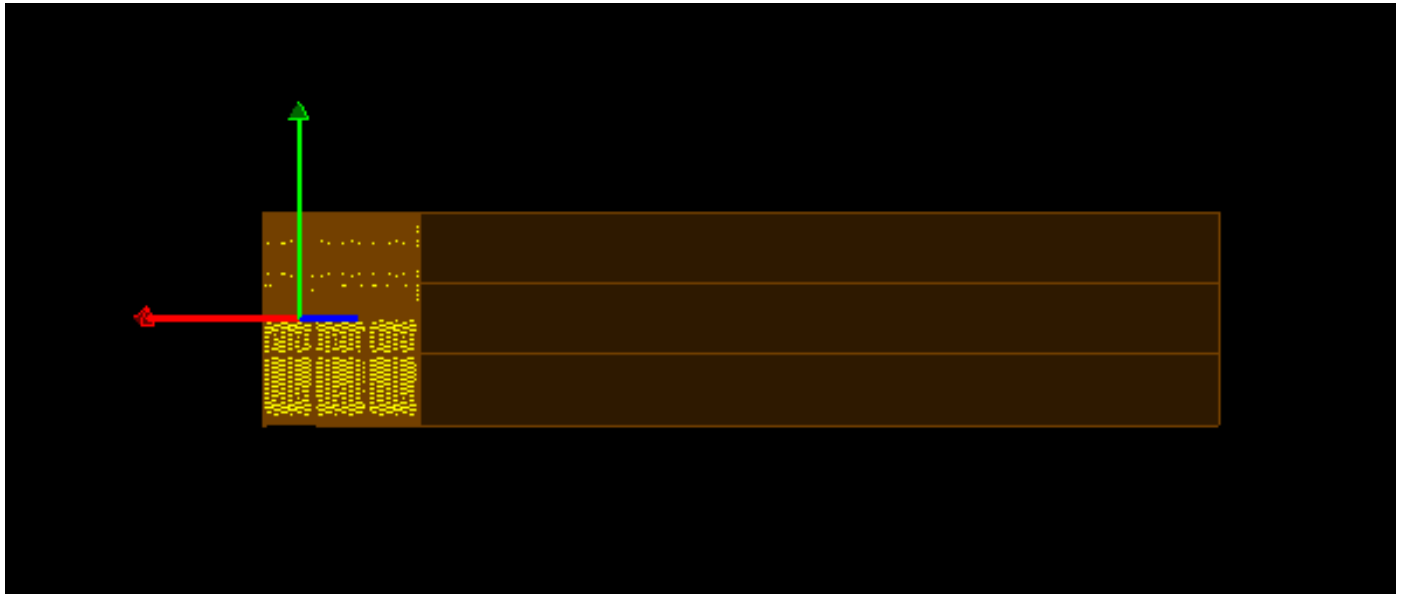




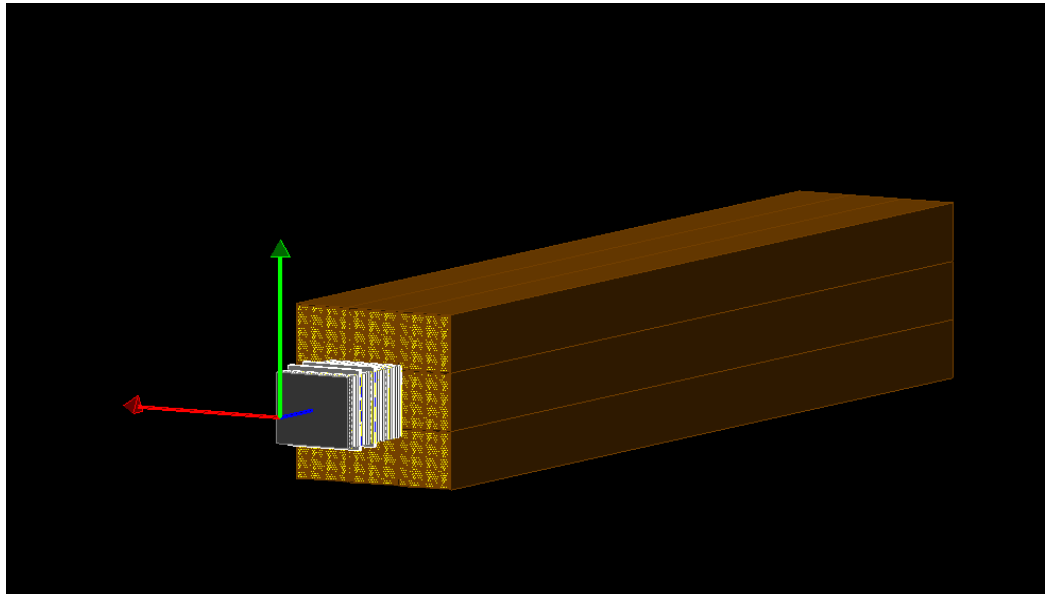


Simulation setup

Prototype 2 excluding FoCal-E.

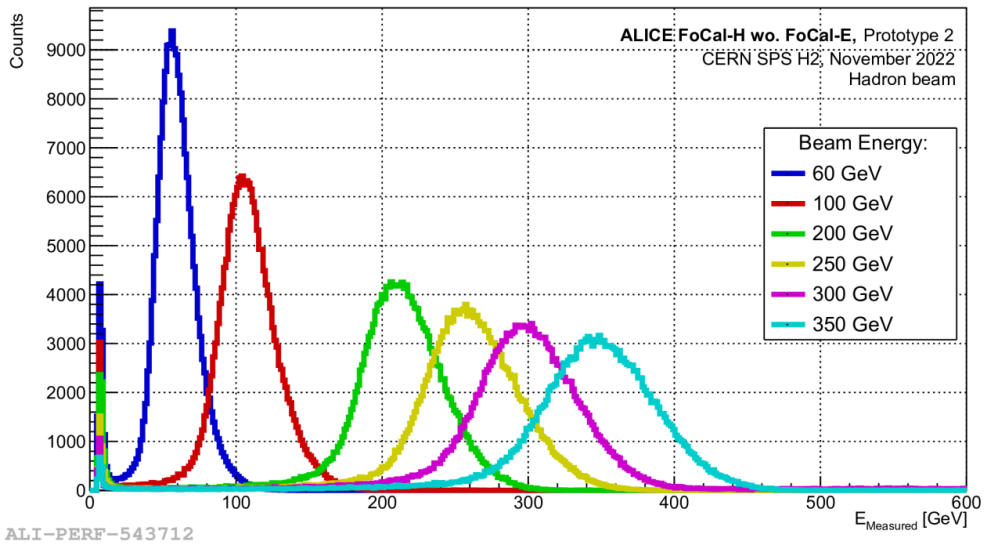


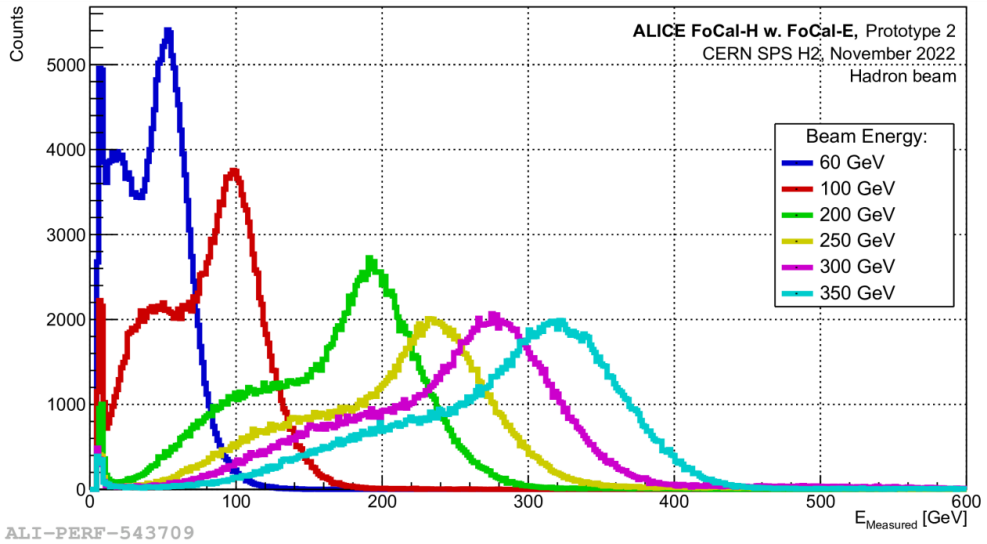
Prototype 2 including FoCal-E.



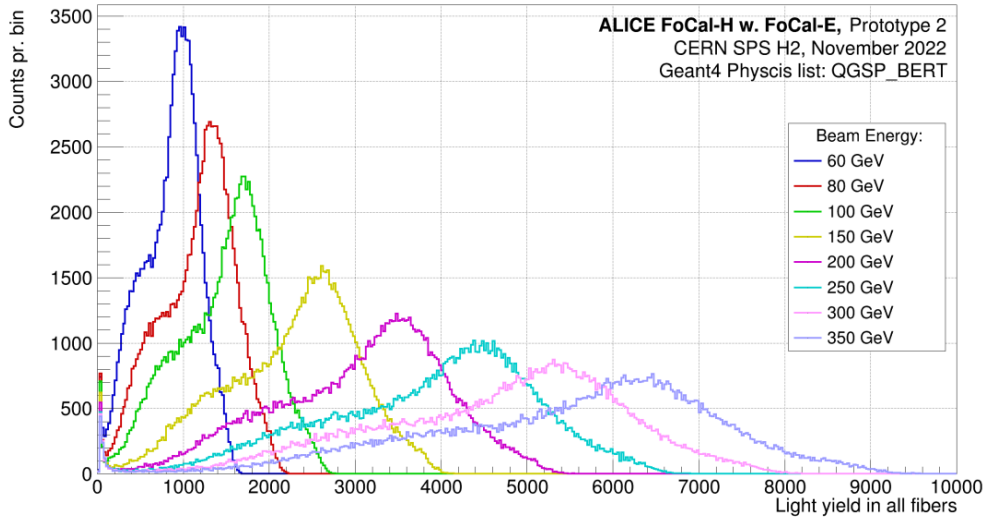
Testbeam data and simulation

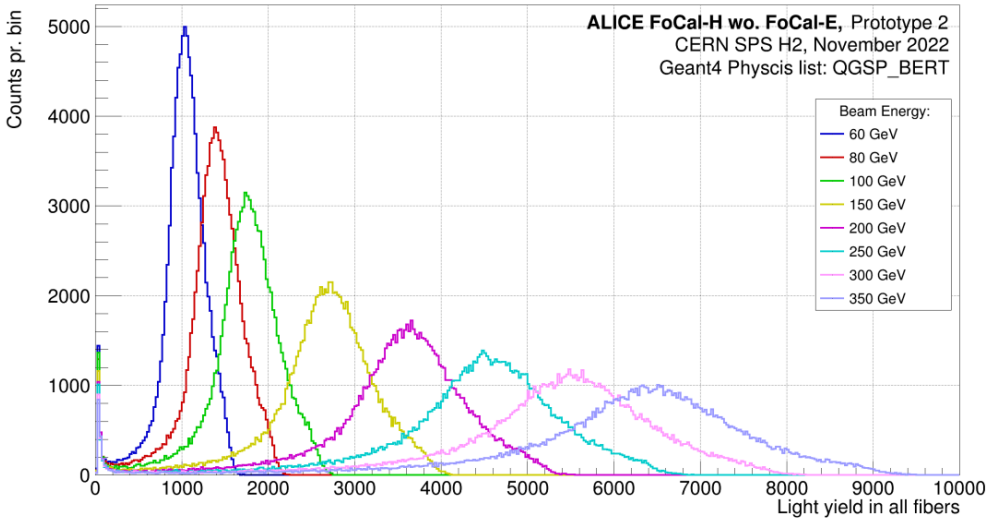
Testbeam



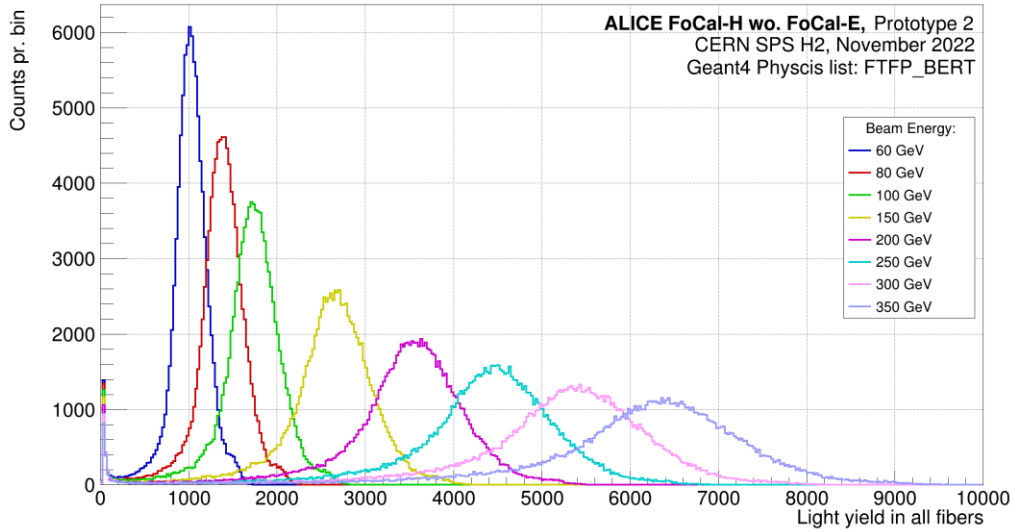


Simulations

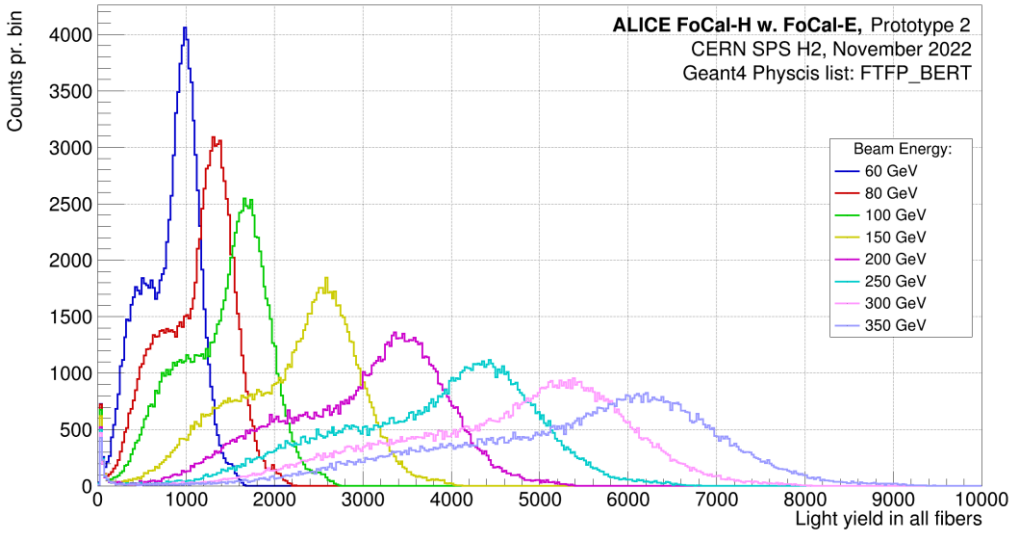


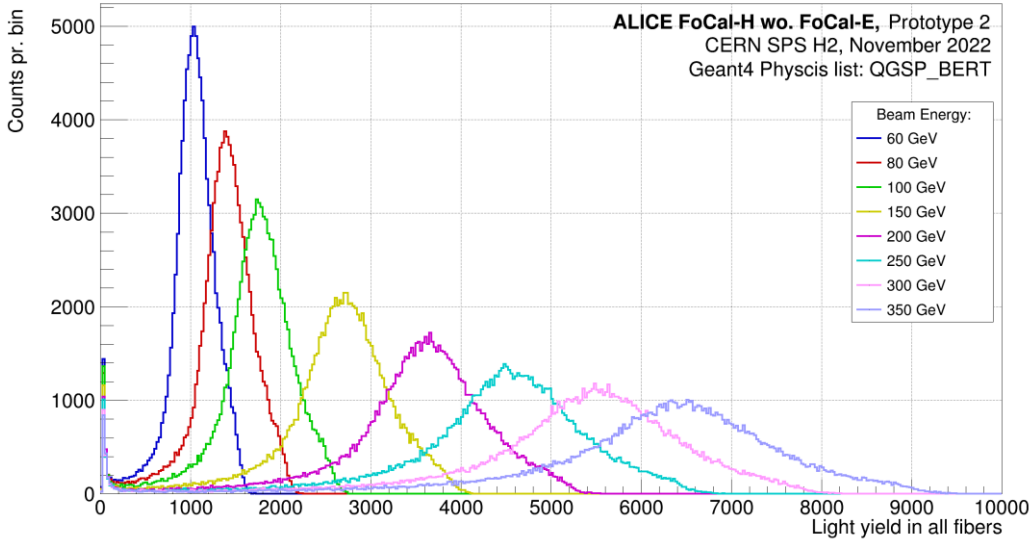


FoCal Setup response and Geant4 Physics lists

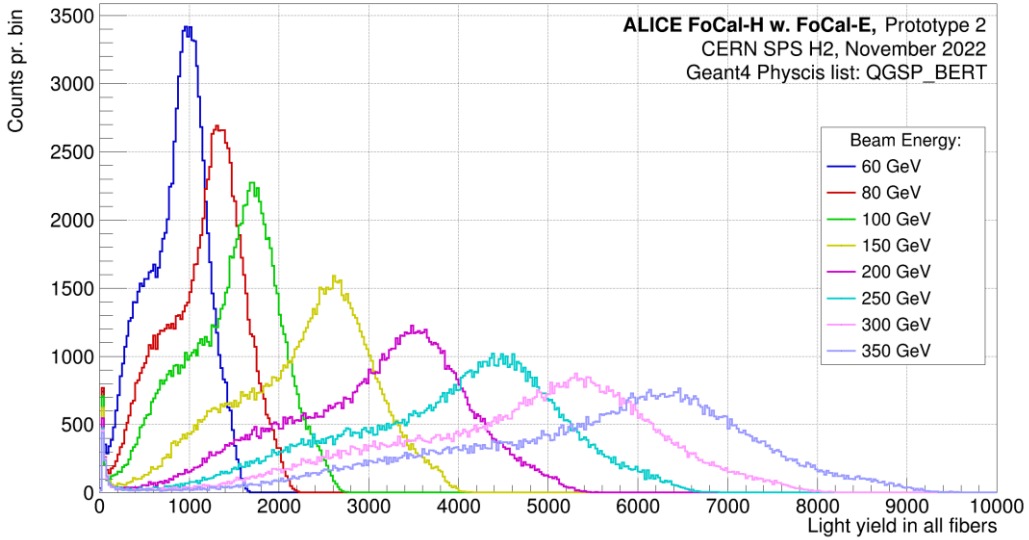


FTFP_BERT





QGSP_BERT

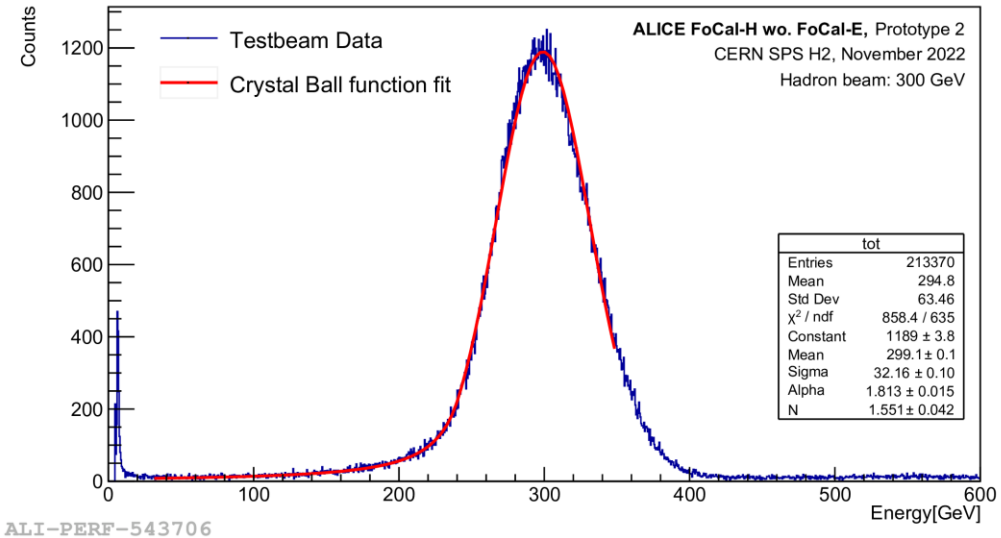


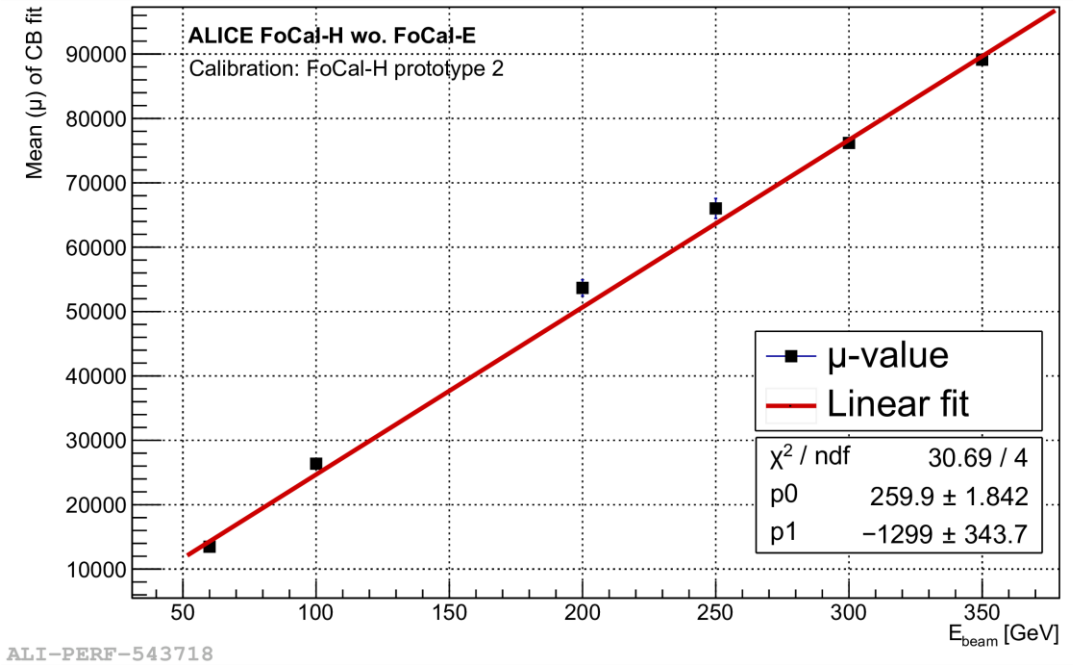
Energy calibration

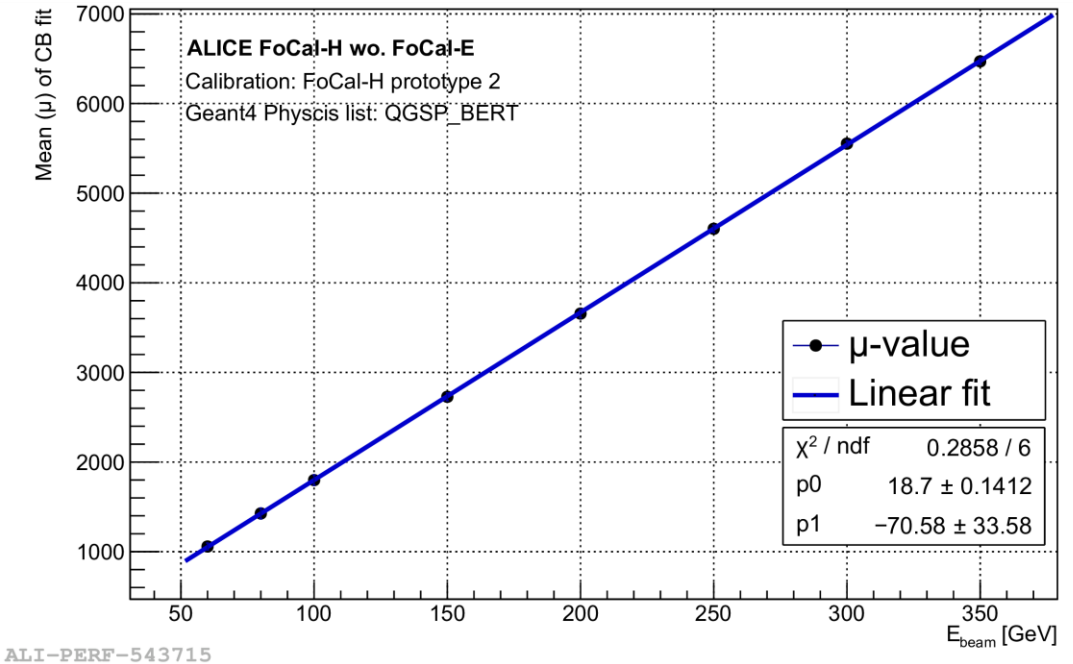
- The testbeam data and simulation are calibrated in order to be compared to each other.

- Calibration Method:
  - Crystal Ball function is fitted to each of the response curves.
  - Mean and sigma is extracted.

- Error bars are very small → Needs to be investigated (Alexander Buhl is making a study on this).







Energy resolution

- Energy resolution is measured to determine how well the calorimeter determined the energy of particles:
  - $\frac{\sigma}{E} \approx \frac{\sigma}{\mu} = \sqrt{\left(\frac{a}{\sqrt{E}}\right)^2 + \left(\frac{b}{E}\right)^2 + c^2}$
- Error propagation:
  - The errors have a contribution from statistical and estimated error, due to small statistical uncertainty.
  - $Error = \sqrt{\left(\frac{1}{\mu}\right) \cdot \sigma_{error}^2 + \left(\frac{\sigma}{\mu^2}\right)^2 \cdot \left(\frac{\mu_{error}^{estimated} \cdot \mu_{error}}{100}\right)^2}$
- Saturation of either electronics or the SiPMs could fool us into thinking the resolution is better than it really is?
- Energy resolution result from May 2023 is performed by Radoslav Simeonov and Florian Jonas