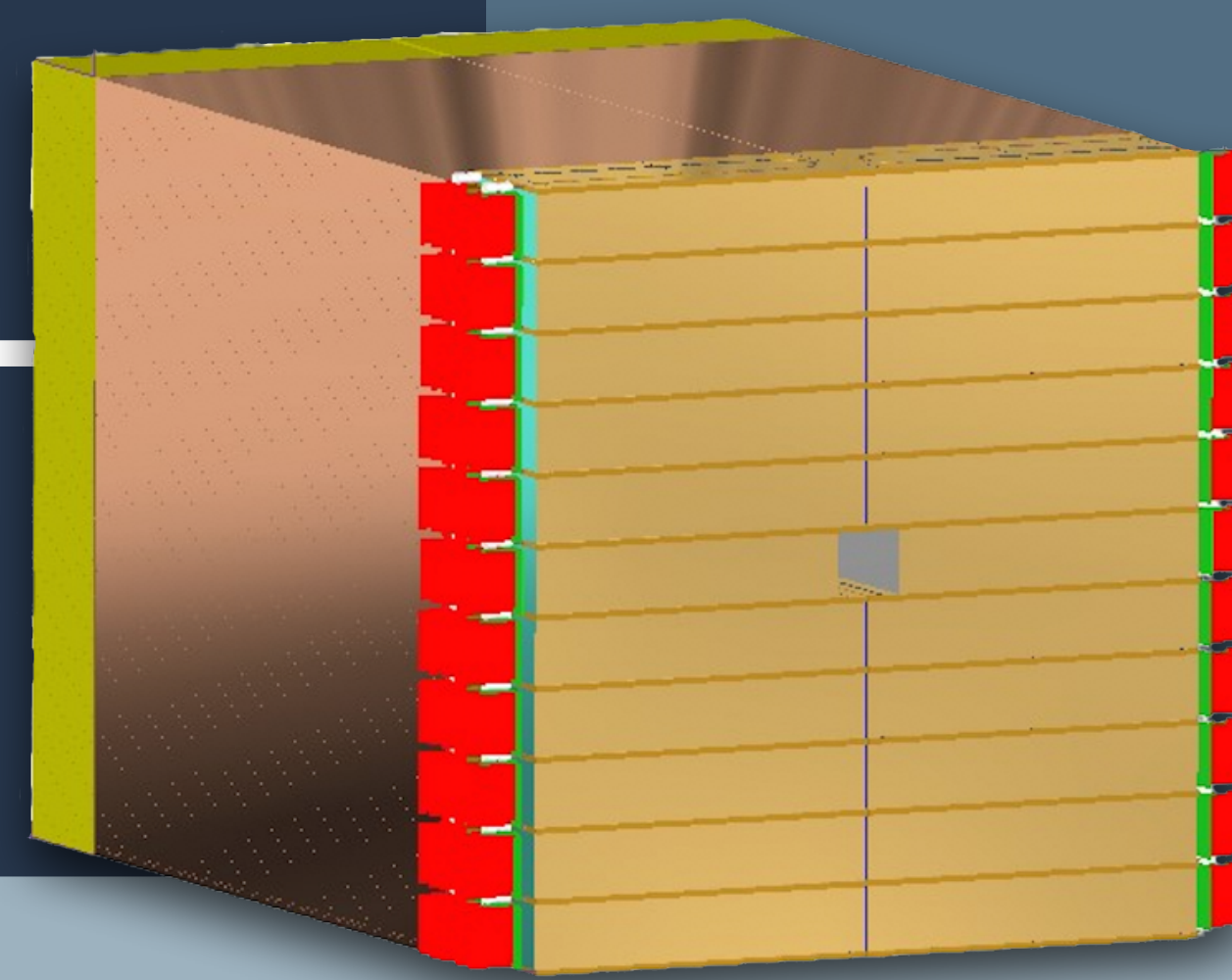# The ALICE Forward Calorimeter (FoCal) upgrade: physics program and prototype performance

Florian Jonas for the ALICE collaboration
(UC Berkeley / LBNL) | 156th LHCC Meeting

Summary:

- ⊚ FoCal is a planned calorimeter (installation in LS3) for the ALICE exp. covering forward rapidities $3.2 < \eta < 5.8$
- ⊚ **Physics goal:** explore gluon saturation & constrain nuclear Parton Distribution Functions (nPDFs)
- ⊚ The response of a FoCal prototype has been extensively tested in electron and hadron beams at the CERN PS and SPS, showcasing good performance that is well described by simulations

The FoCal detector

- ⊚ FoCal [1-3] is a calorimeter planned as an upgrade to the ALICE detector covering very forward rapidities $3.2 < \eta < 5.8$
- ⊚ Consists of electromagnetic and hadronic calorimeter (FoCal-E & FoCal-H)
- ⊚ FoCal-E is a highly granular Si-W calorimeter combining two sensor technologies: **18 silicon pad layers (1×1 cm^2)** and **two pixel layers (30×30 μm^2)**
- ⊚ FoCal-H uses scintillation fibres embedded into Cu tubes
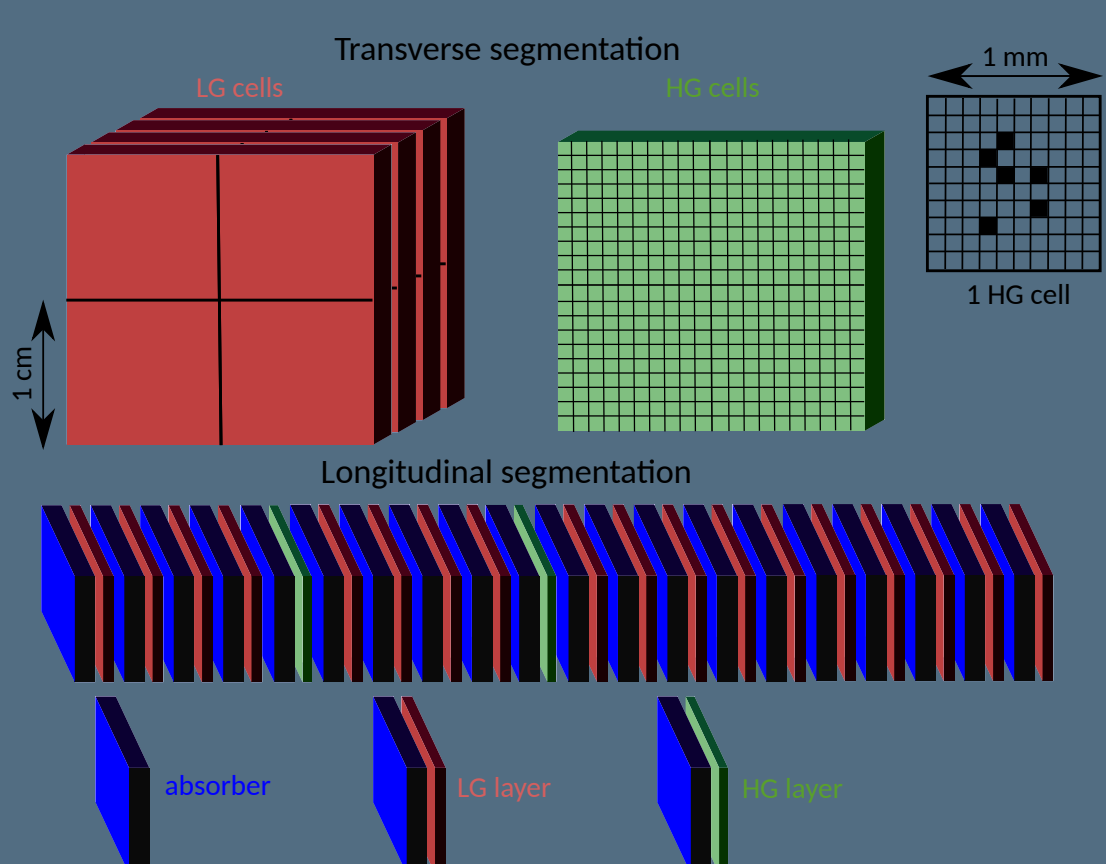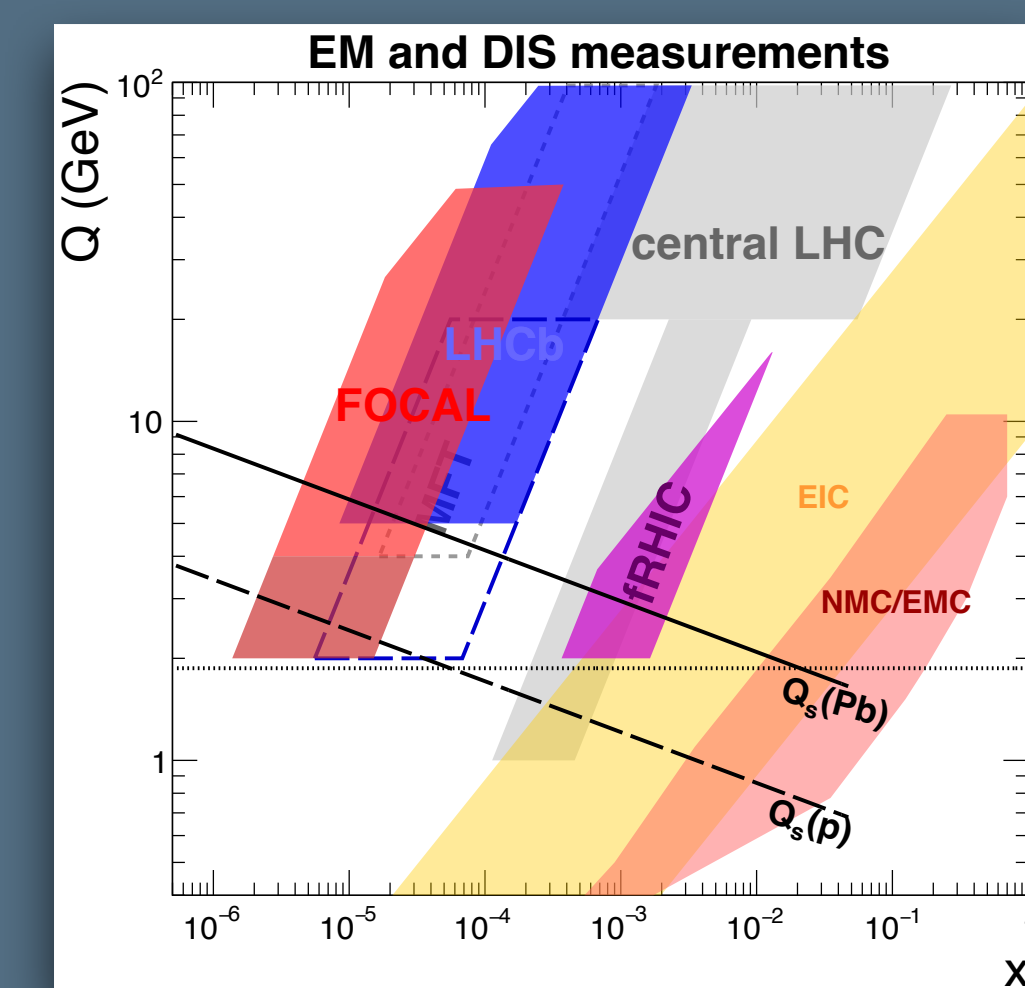

FoCal physics program

- **Physics goal:** explore gluon saturation & constrain nuclear Parton Distribution Functions (nPDFs) at $x \sim 10^{-6}$

Multi-messenger approach:
- ⊚ Prompt photon producion
- ⊚ γ-hadron correlation
- ⊚ Neutral meson production ($\pi^0, \eta, \omega, J/\psi, ...$)
- ⊚ Inclusive jet, dijet and γ-jet correlations
- ⊚ Vector meson photoproduction in Ultra-Peripheral Collisions (UPCs)

The FoCal prototype

FoCal-E prototype:
- ⊚ One tower ($9\times8\times17$cm) of 18 silicon pad and 2 silicon pixel layers
- ⊚ Pad layers: Si p-type sensors by Hamamatsu; readout using HGCROC developed for CMS HG-Cal
- ⊚ Pixel layers: ALICE PIxel DEtector (ALPIDE) sensors using both readout modes

FoCal-H prototype:
- ⊚ 9 modules arranged in 3×3 stack
- ⊚ Scintillation fibres insered into Cu tubes (668 per module) and readout using SiPMs
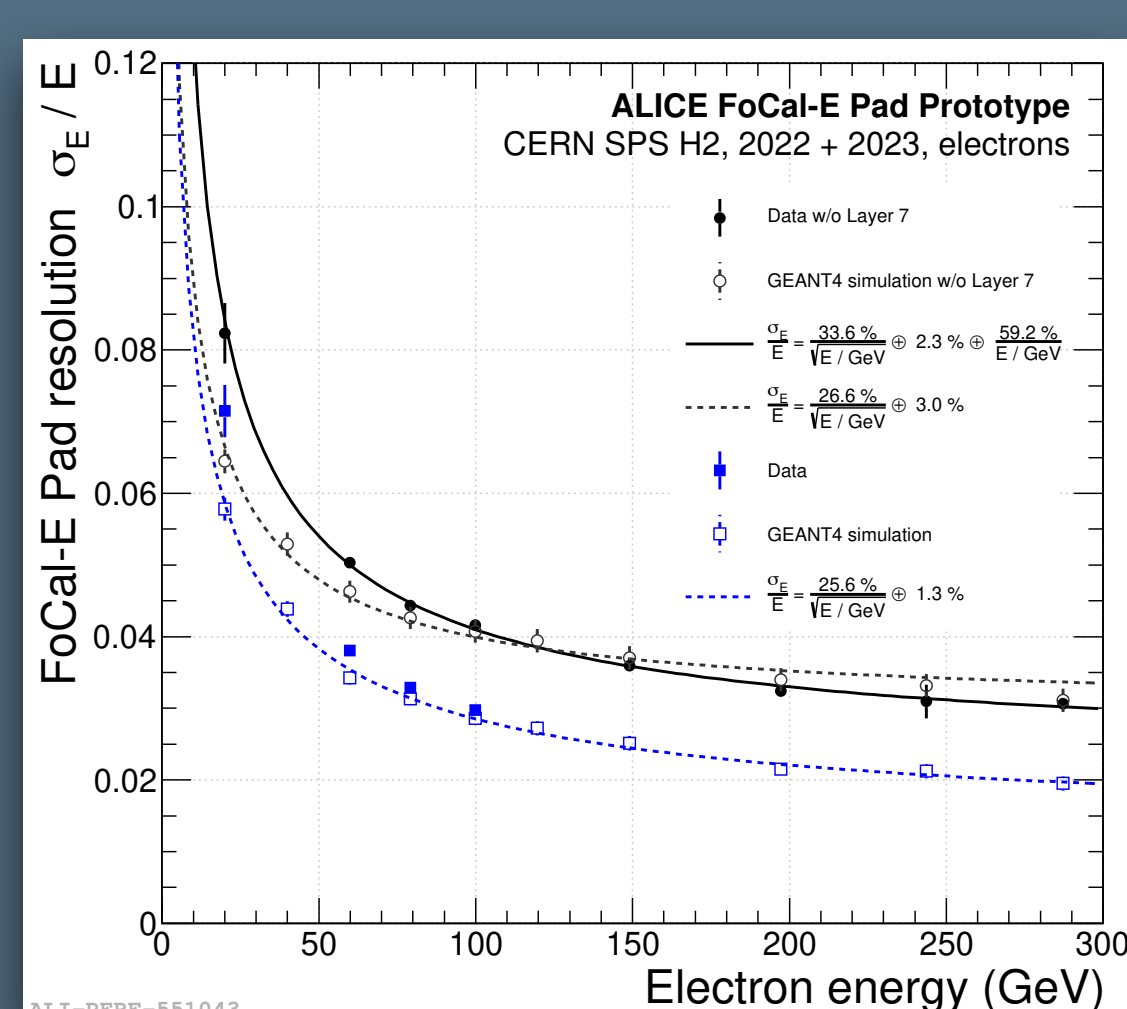
Testbeam Campaign:
- ⊚ Full-length prototype [4] of the FoCal detector tested in electron and hadron beams at the CERN PS and SPS in 2021-23
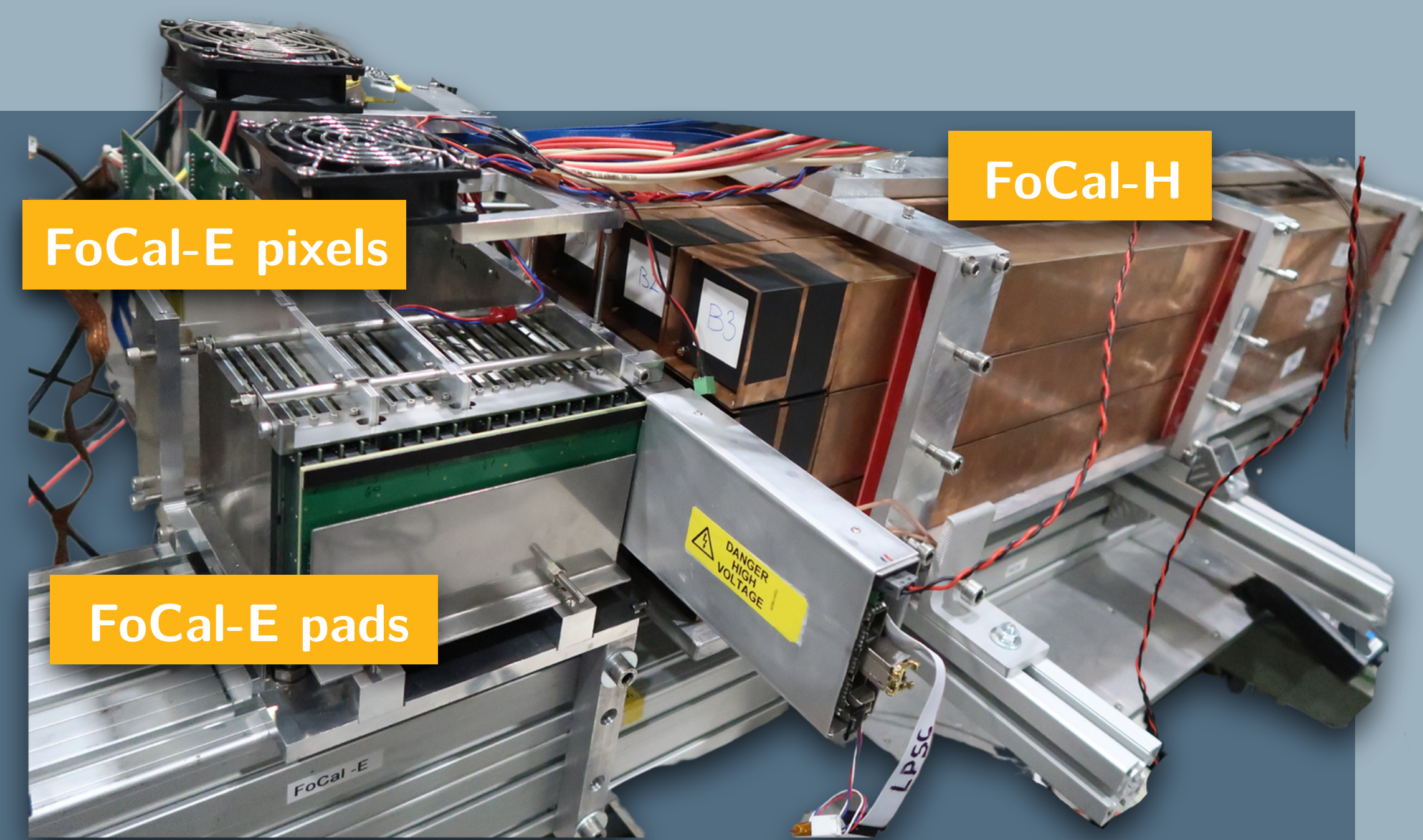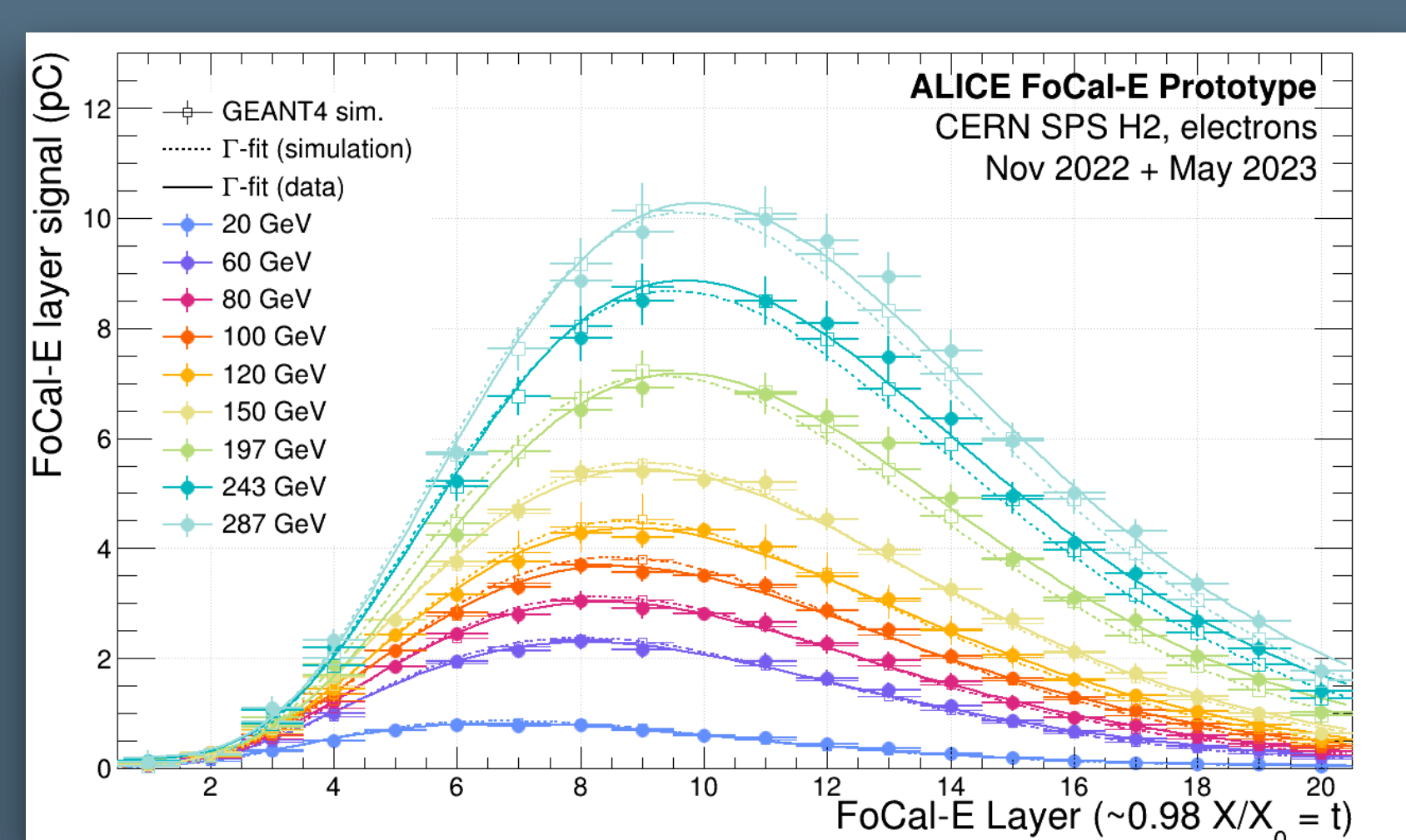

FoCal-E pads — Test beam CERN SPS 2022 & 2023

Energy Resolution

Longitudinal Shower Profile

- ⊚ Energy resolution for electrons $< 3\%$ for $E > 100$ GeV fulfills physics req.
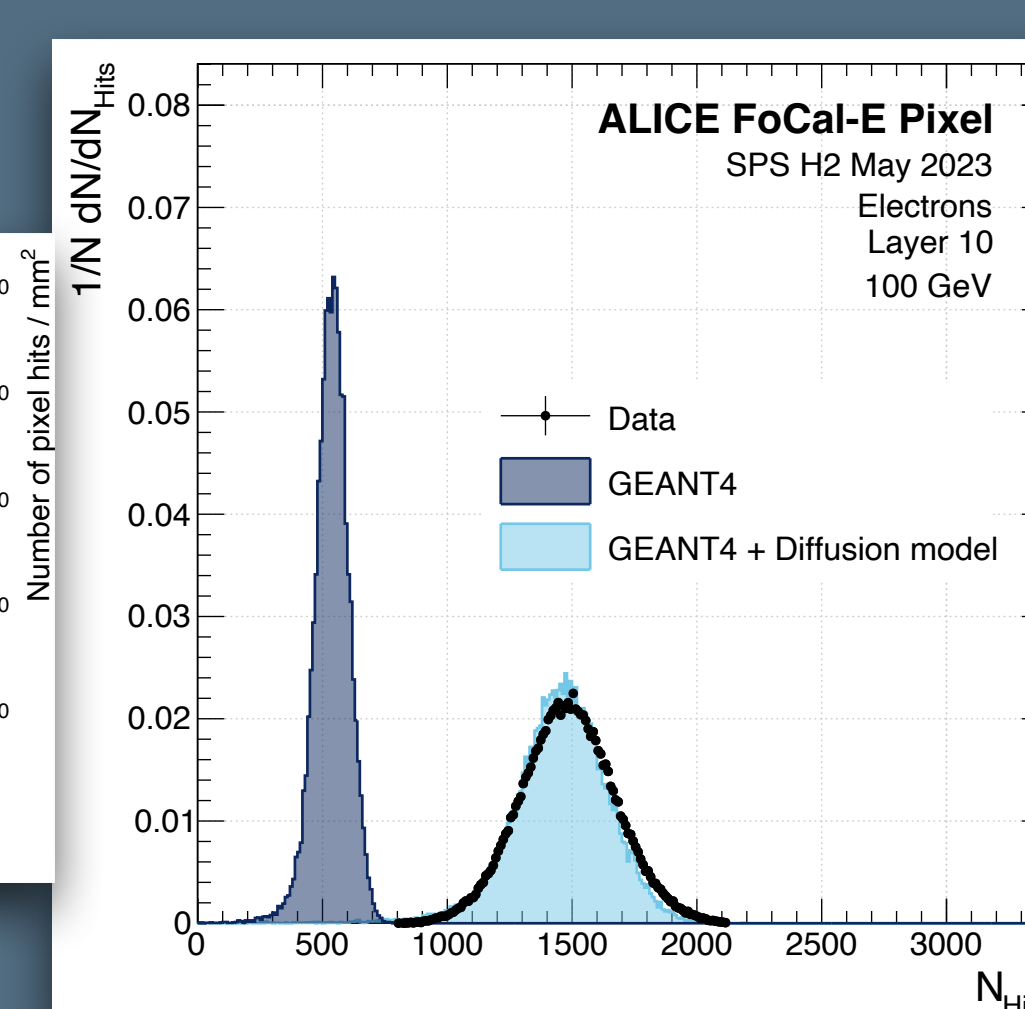
FoCal-E pixels — Test beam CERN SPS 2022 & 2023

Shower Profile
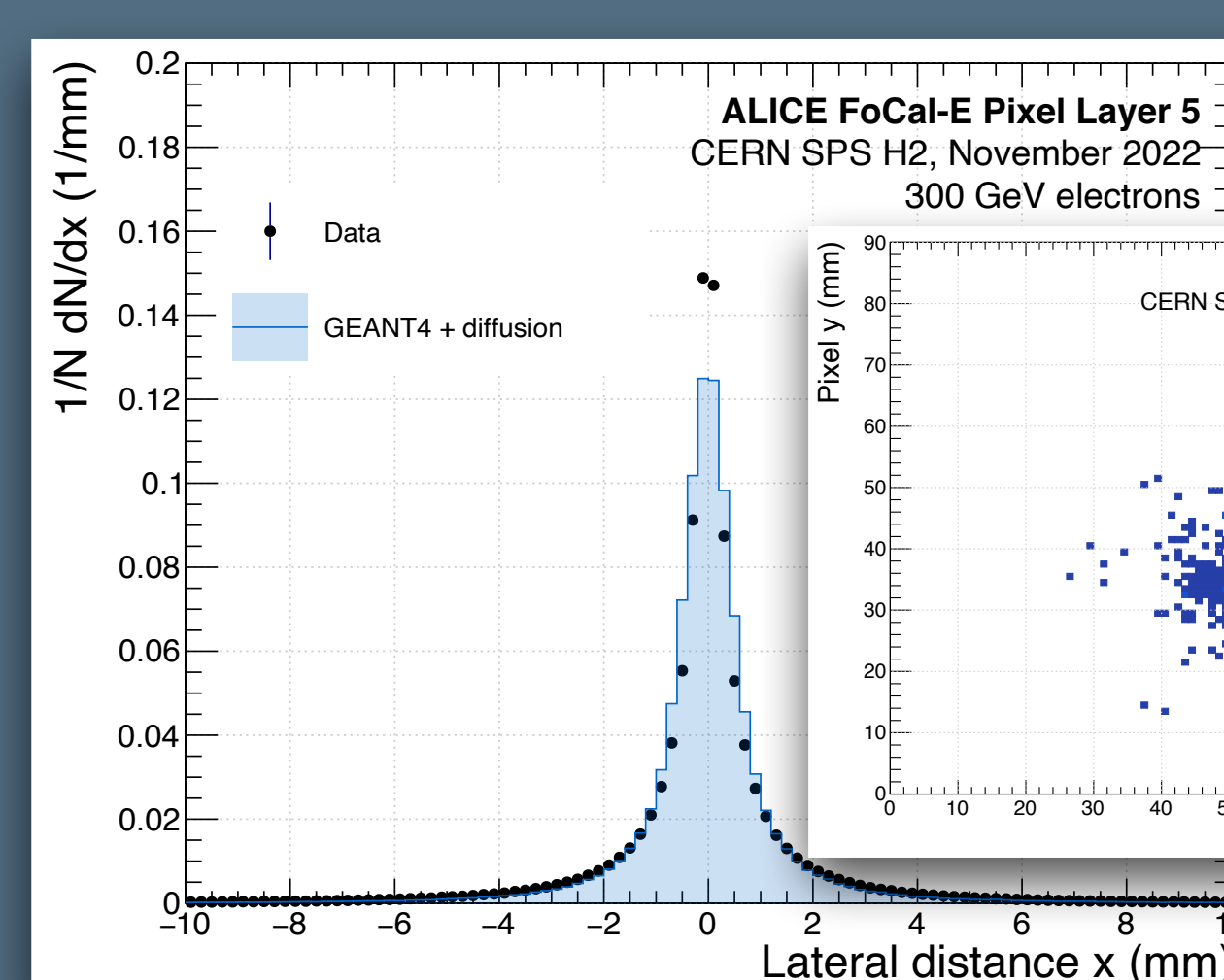
Number of hits

- ⊚ Transverse shower width ≈ 1.2mm enables excellent shower separation
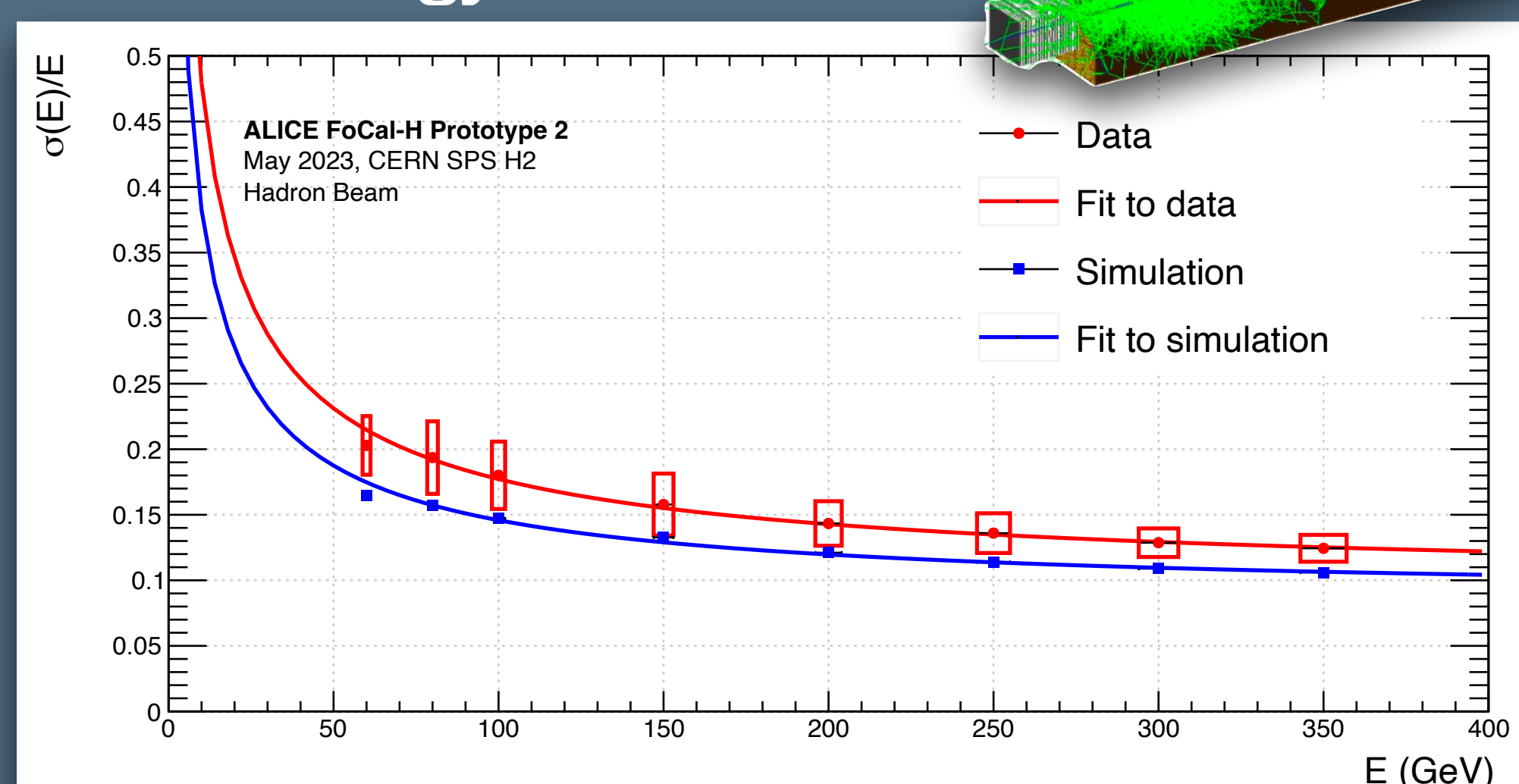
FoCal-H — Test beam CERN SPS 2023
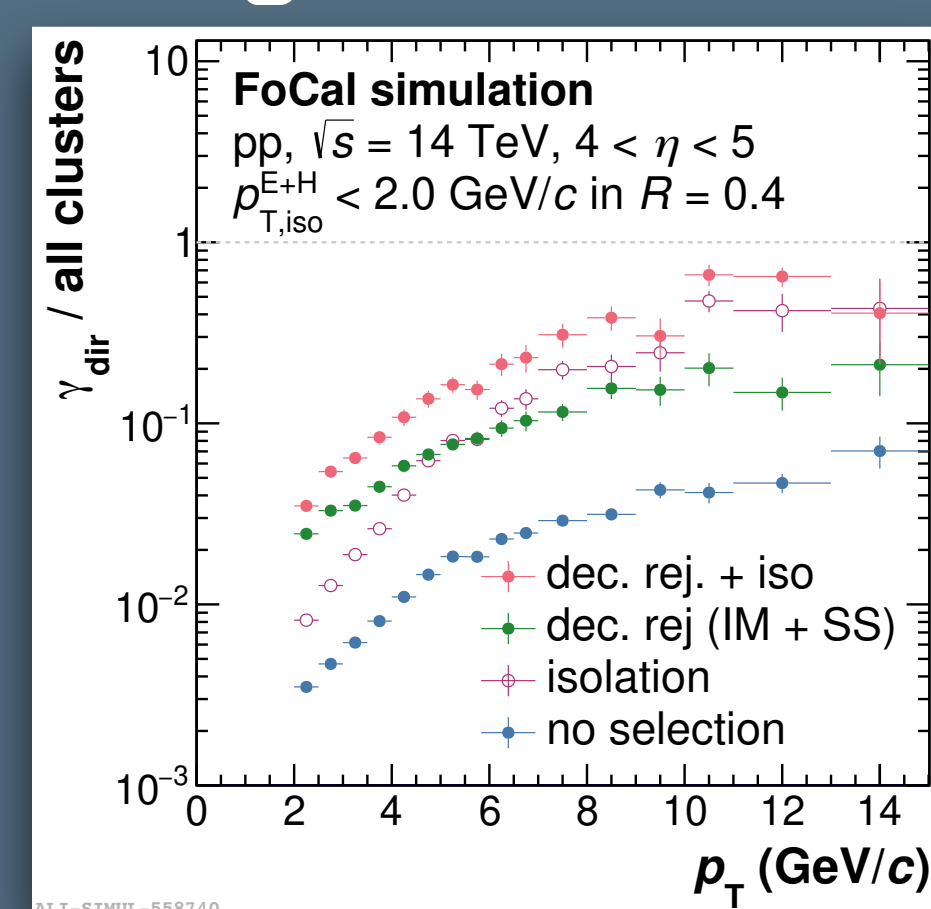
Energy Resolution

- ⊚ Energy resolution $\sim 10\%$ for hadrons at high energies

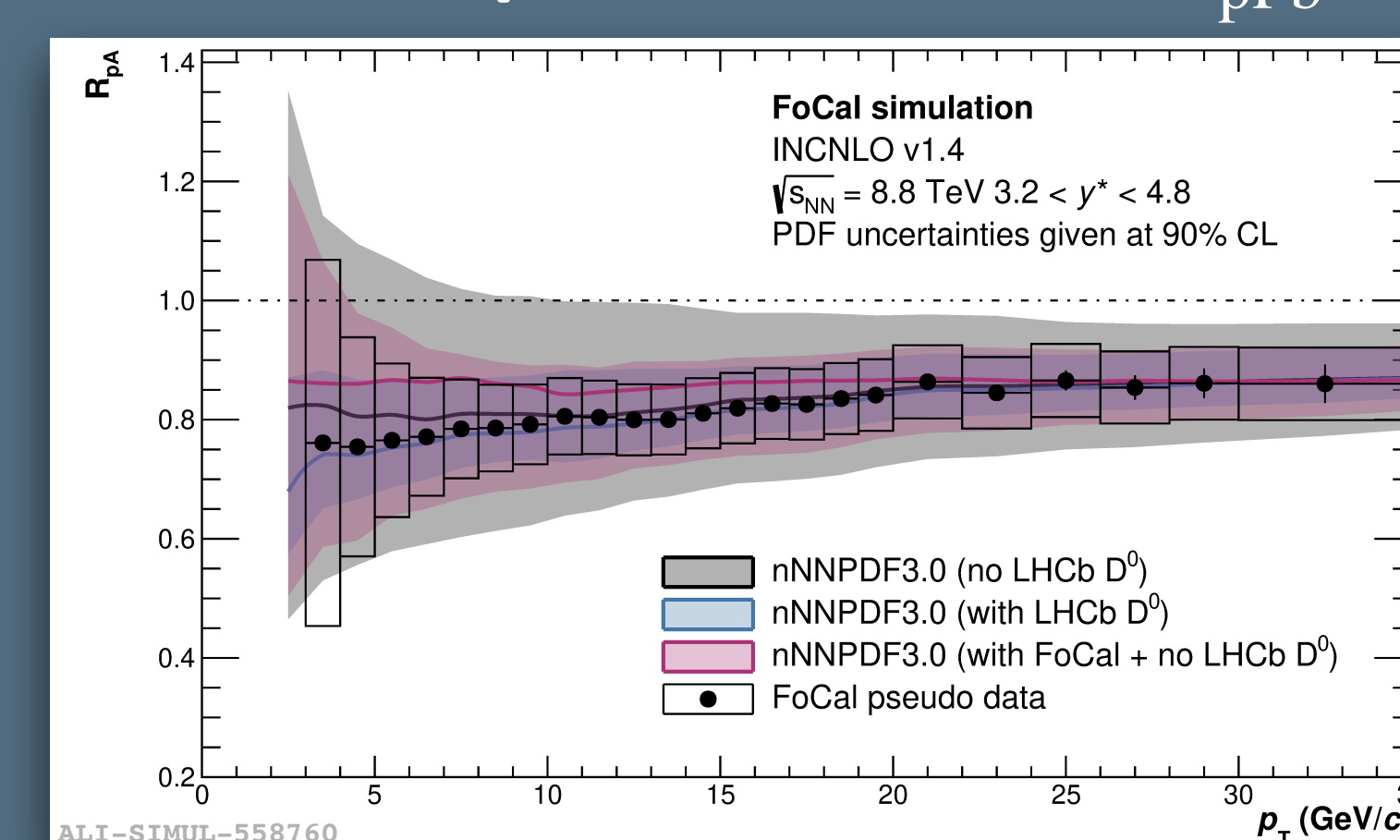## Physics impact — Simulations: Prompt photon production

Signal Fraction

FoCal pseudo-data of R_{pPb}

- ⊚ FoCal achieves high signal fraction and significant constrains of nPDFs [3]
- ⊚ Prompt γ are direct probe of nPDFs: no final state & hadronization effects

References

[1] ALICE Collaboration, Letter of Intent: A Forward Calorimeter (FoCal) in the ALICE experiment, CERN-LHCC-2020-009

[2] ALICE Collaboration, Physics of the ALICE Forward Calorimeter upgrade, ALICE-PUBLIC-2023-001

[3] ALICE Collaboration, Physics performance of the ALICE Forward Calorimeter upgrade, ALICE-PUBLIC-2023-004

[4] M. Aehle et al., Performance of the electromagnetic and hadronic prototype segments of the ALICE Forward Calorimeter. arXiv:2311.07413 **New Paper!**