ALICE FoCal

Tatsuya Chujo
Univ. of Tsukuba
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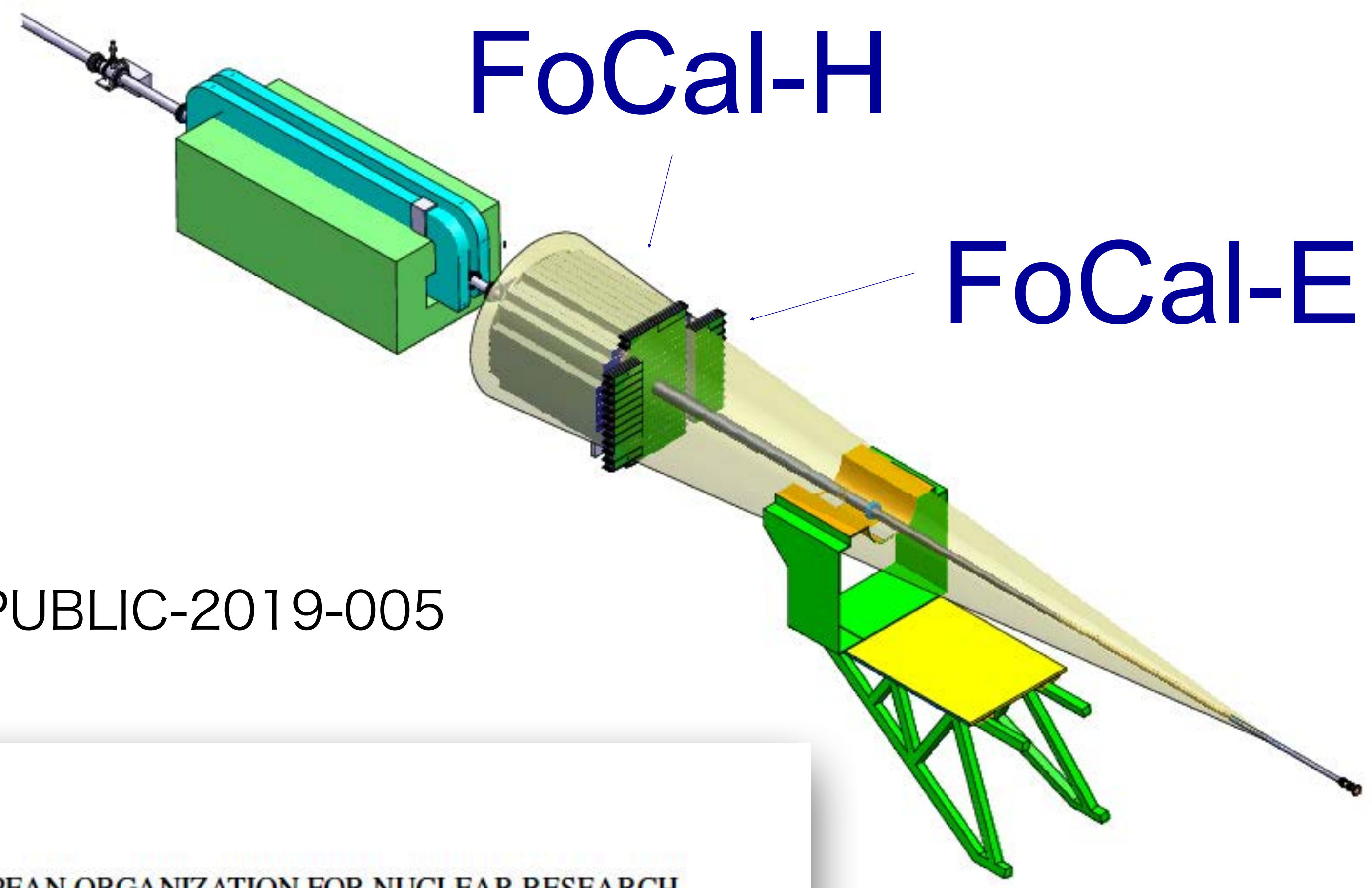
筑波大学
University of Tsukuba

ALICE FoCal status

- ALICE public note (~FoCal LoI) has been submitted to CDS, ALICE-PUBLIC-2019-005, on Nov. 1st, 2019
  - https://cds.cern.ch/record/2696471
- Discussed the ALICE FoCal at LHCC meeting on Nov. 2019.
- **ALICE internal review of FoCal: Jan. 15th, 2020**.
- Discussed LHCC meeting on Feb. 2020
- FoCal readout meeting in April 1-3.
- ALICE management approval on April 30.
- approval step by collaboration in May 15, and the official submission of LoI to LHCC, and will be discussed at LHCC in June.



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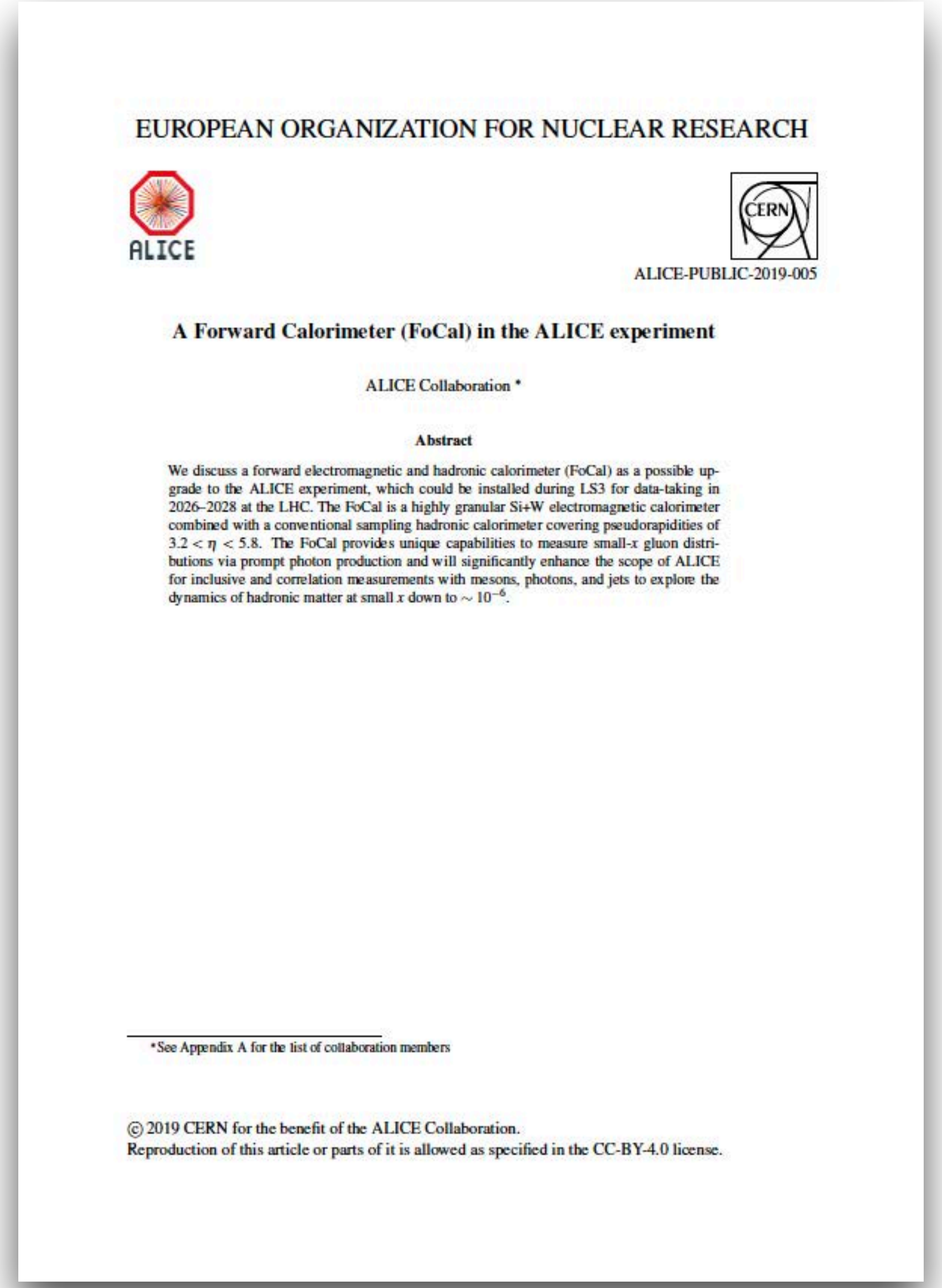


EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

ALICE-PUBLIC-2019-005

A Forward Calorimeter (FoCal) in the ALICE experiment

ALICE Collaboration *

Abstract

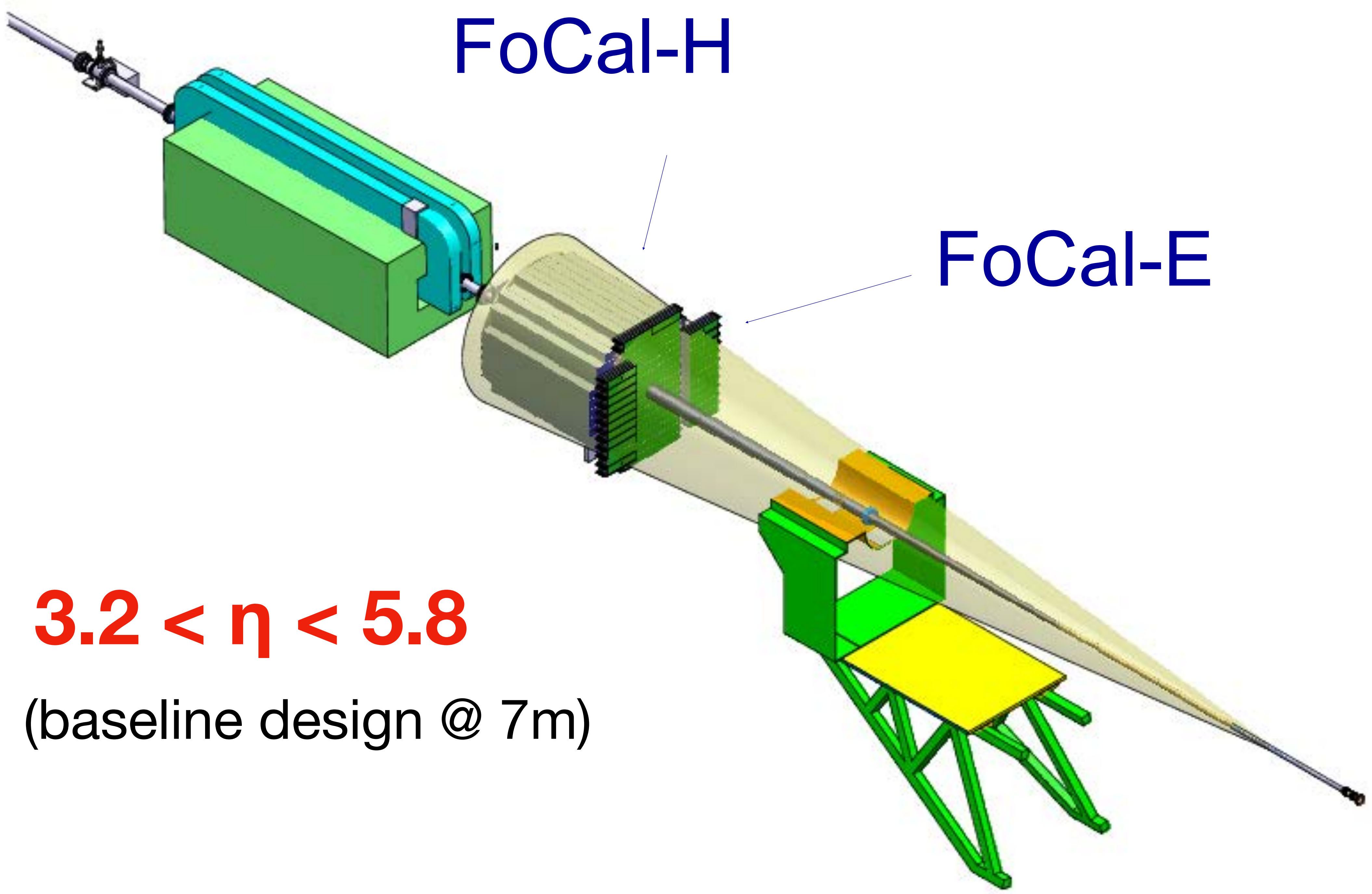
We discuss a forward electromagnetic and hadronic calorimeter (FoCal) as a possible upgrade to the ALICE experiment, which could be installed during LS3 for data-taking in 2026–2028 at the LHC. The FoCal is a highly granular Si+W electromagnetic calorimeter combined with a conventional sampling hadronic calorimeter covering pseudorapidities of $3.2 < \eta < 5.8$. The FoCal provides unique capabilities to measure small-x gluon distributions via prompt photon production and will significantly enhance the scope of ALICE for inclusive and correlation measurements with mesons, photons, and jets to explore the dynamics of hadronic matter at small x down to $\sim 10^{-6}$.

*See Appendix A for the list of collaboration members

The FoCal proposal

FoCal-E: high-granularity Si-W sampling calorimeter for photons and π^0

FoCal-H: conventional Cu-Sc sampling calorimeter for photon isolation and jets



$3.2 < \eta < 5.8$

(baseline design @ 7m)

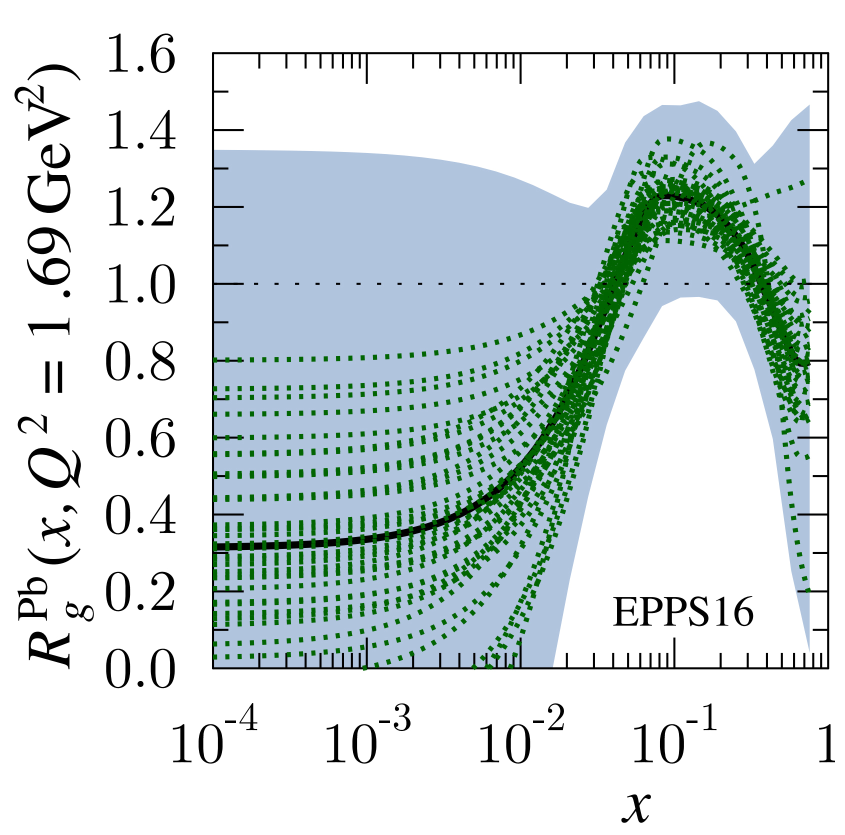
Observables:

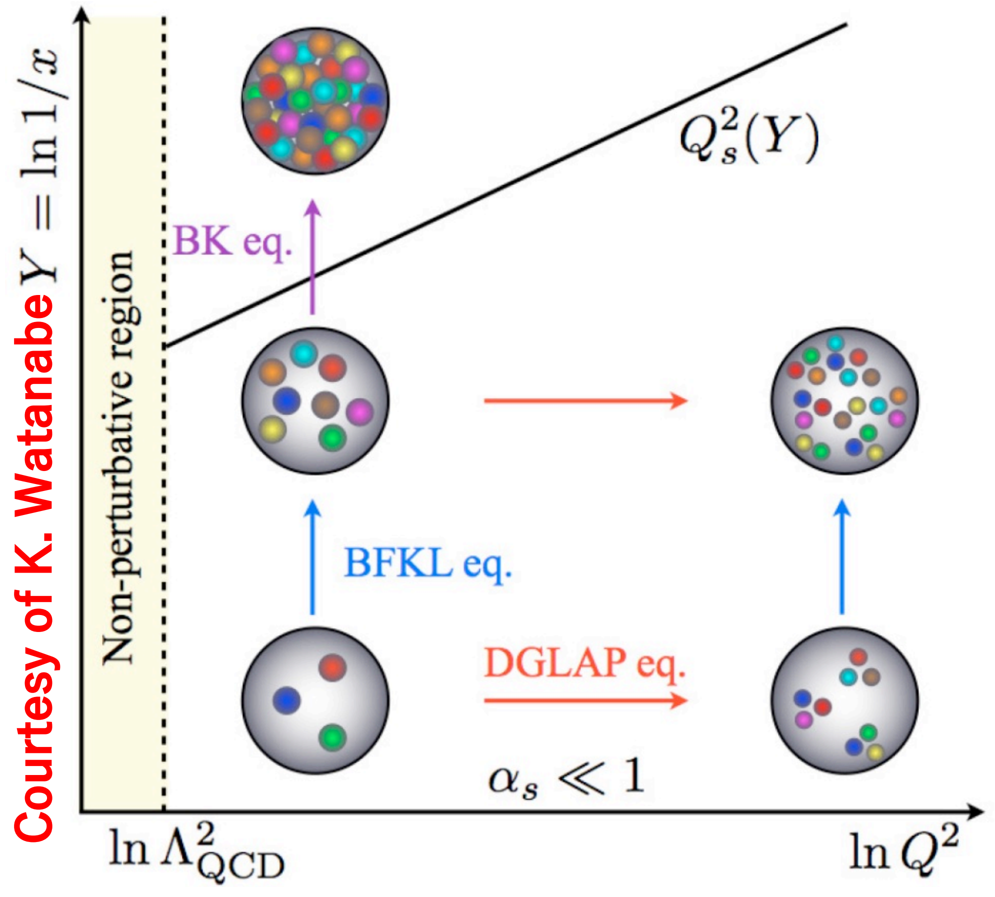
- π^0 (and other neutral mesons)
- Isolated photons
- Jets (and di-jets)
- J/ψ (Υ) in UPC
- W, Z maybe possible
- Event plane and centrality

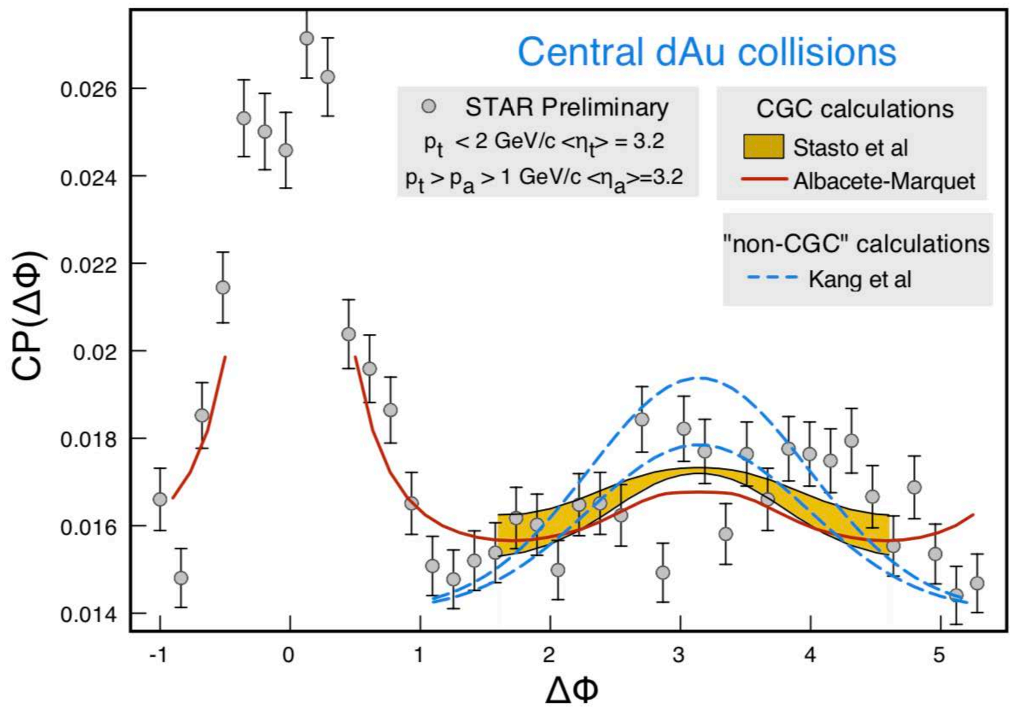
Advantage in ALICE:
forward region nearly not instrumented; 'unobstructed' view of interaction point

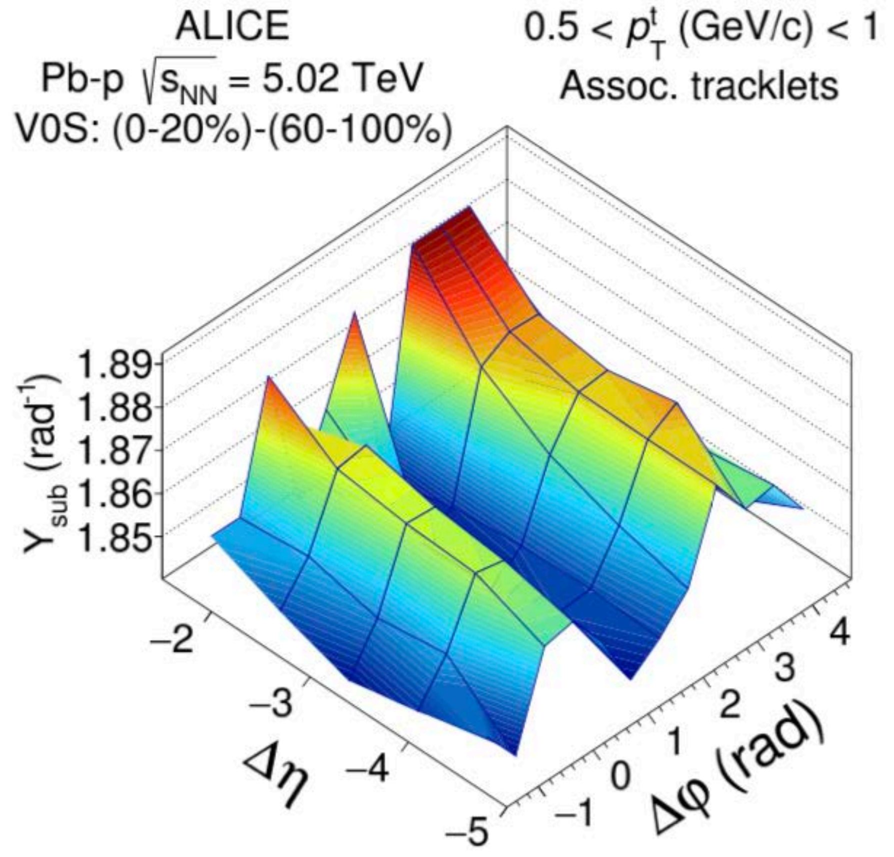
Physics goals

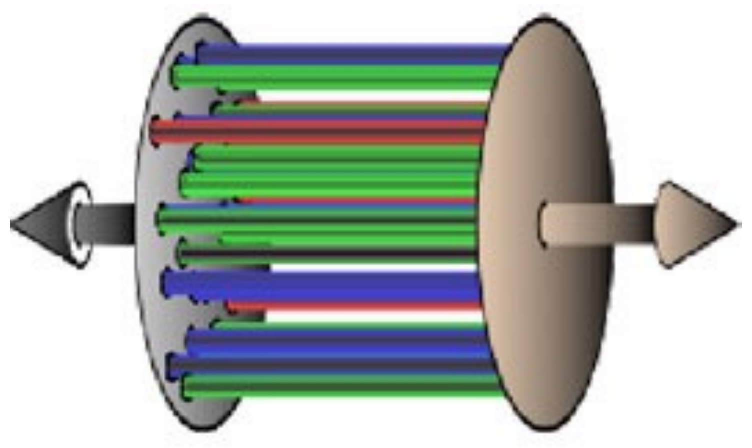
- **Quantify nuclear modification of the gluon density at small-x**
  - Isolated photons in pp and pPb collisions
- **Explore non-linear QCD evolution**
  - Azimuthal π^0-π^0 and isolated photon-π^0 (or jet) correlations in pp and pPb collisions
- **Investigate the origin of long range flow-like correlations**
  - Azimuthal π^0-h correlations using FoCal and central ALICE (and muon arm?) in pp and pPb collisions
- **Explore jet quenching at forward rapidity**
  - Measure high p_T neutral pion production in PbPb

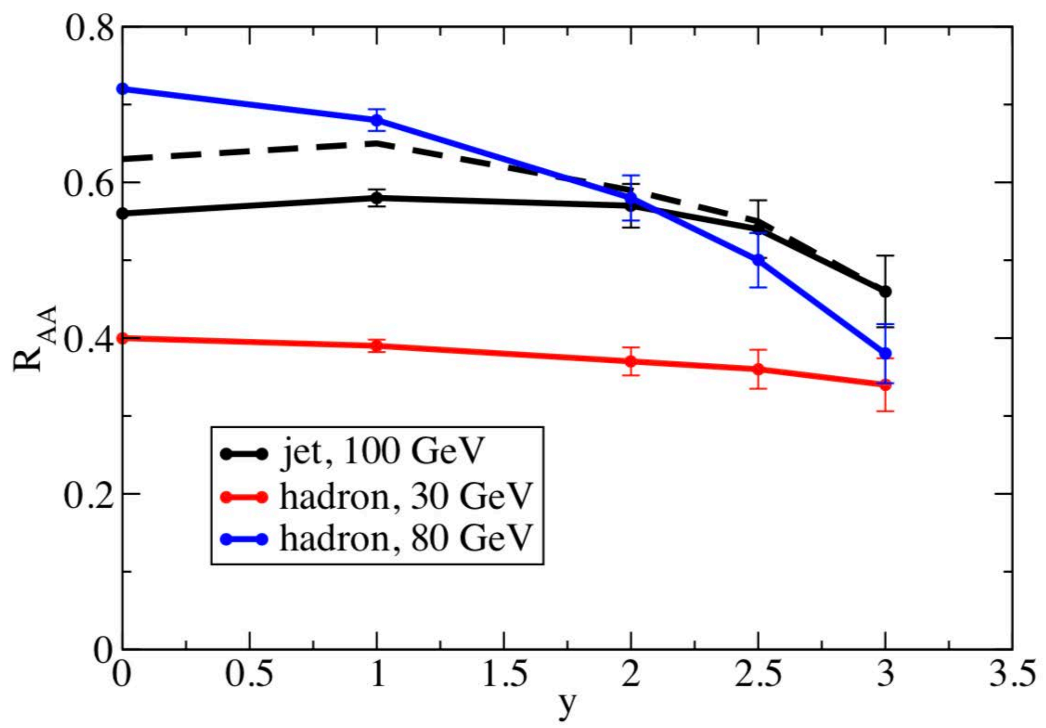








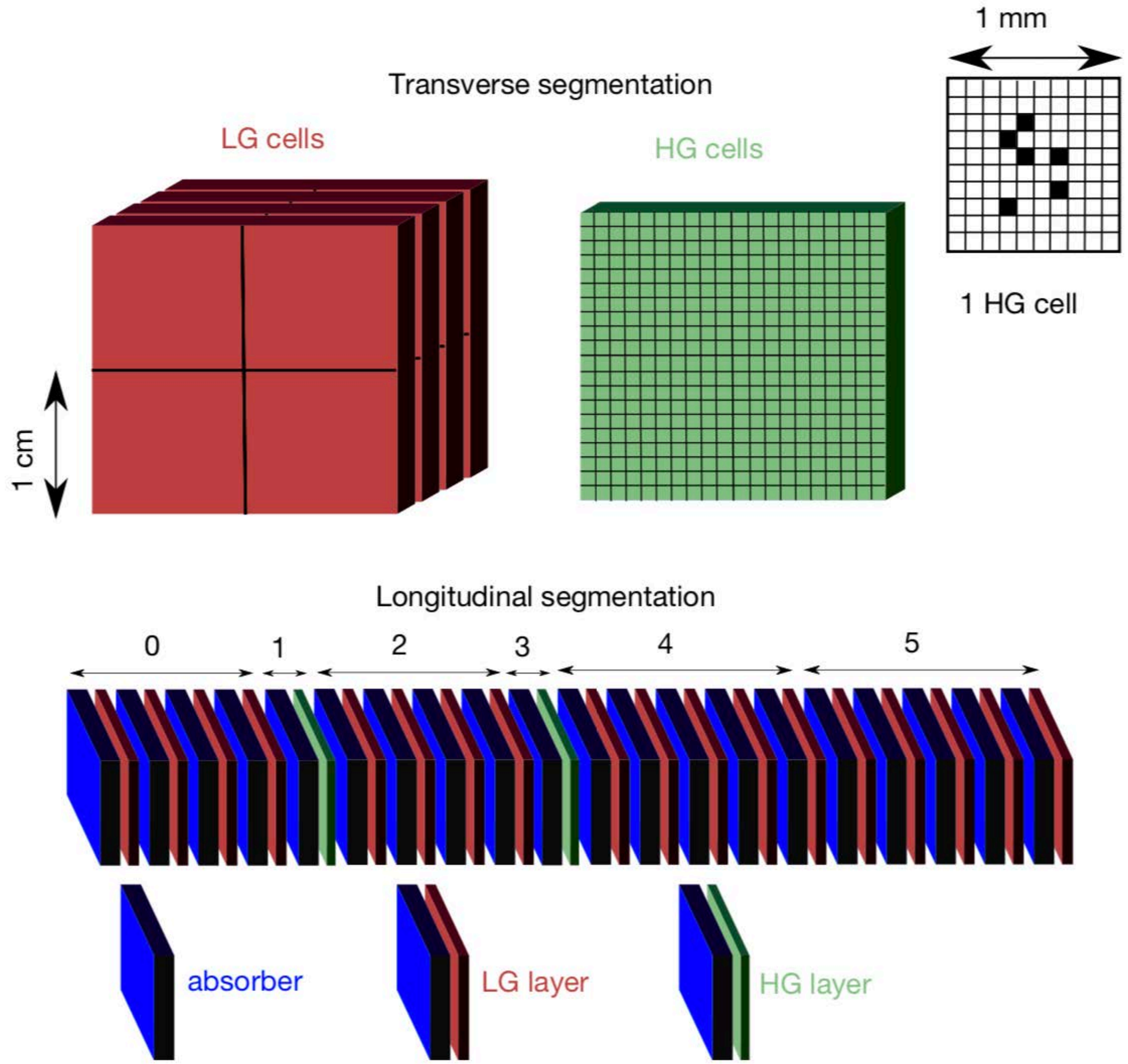




<u>**Key questions**</u>

* How QGP is created in heavy ion collisions and how thermalized?
* Is there any difference between QGP in the early universe and QGP produced in heavy ion collisions?

FoCal-E design



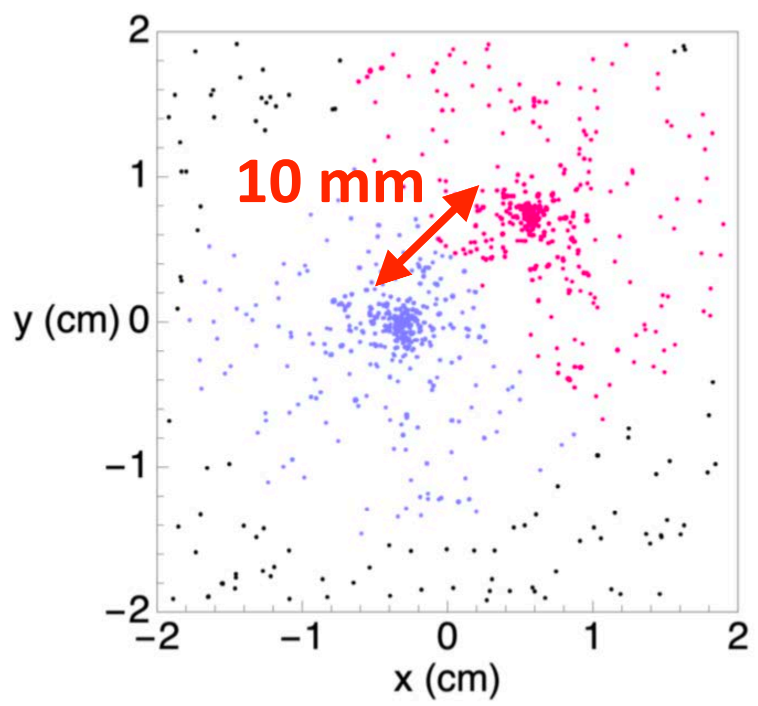
Studied in simulations 20 layers:
W(3.5 mm ≈ $1X_0$) + silicon sensors
Two types: Pads (LG) and Pixels (HG)

- Pad layers provide shower profile
- Pixel layers provide position resolution to resolve shower overlaps

Main optimization:

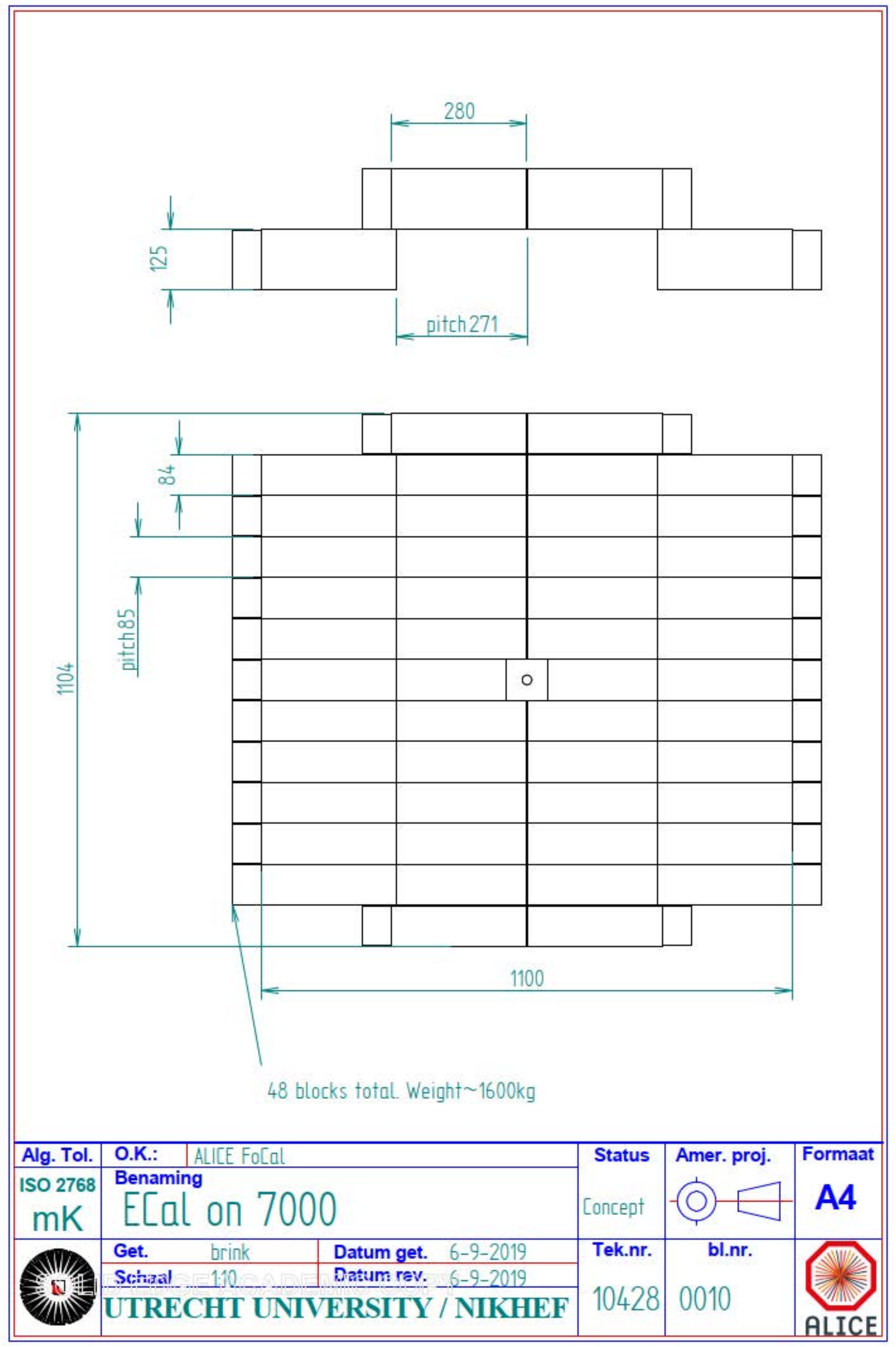
- Number of pixel layers and location
- Number of pad layers
- Maximum separation between layers

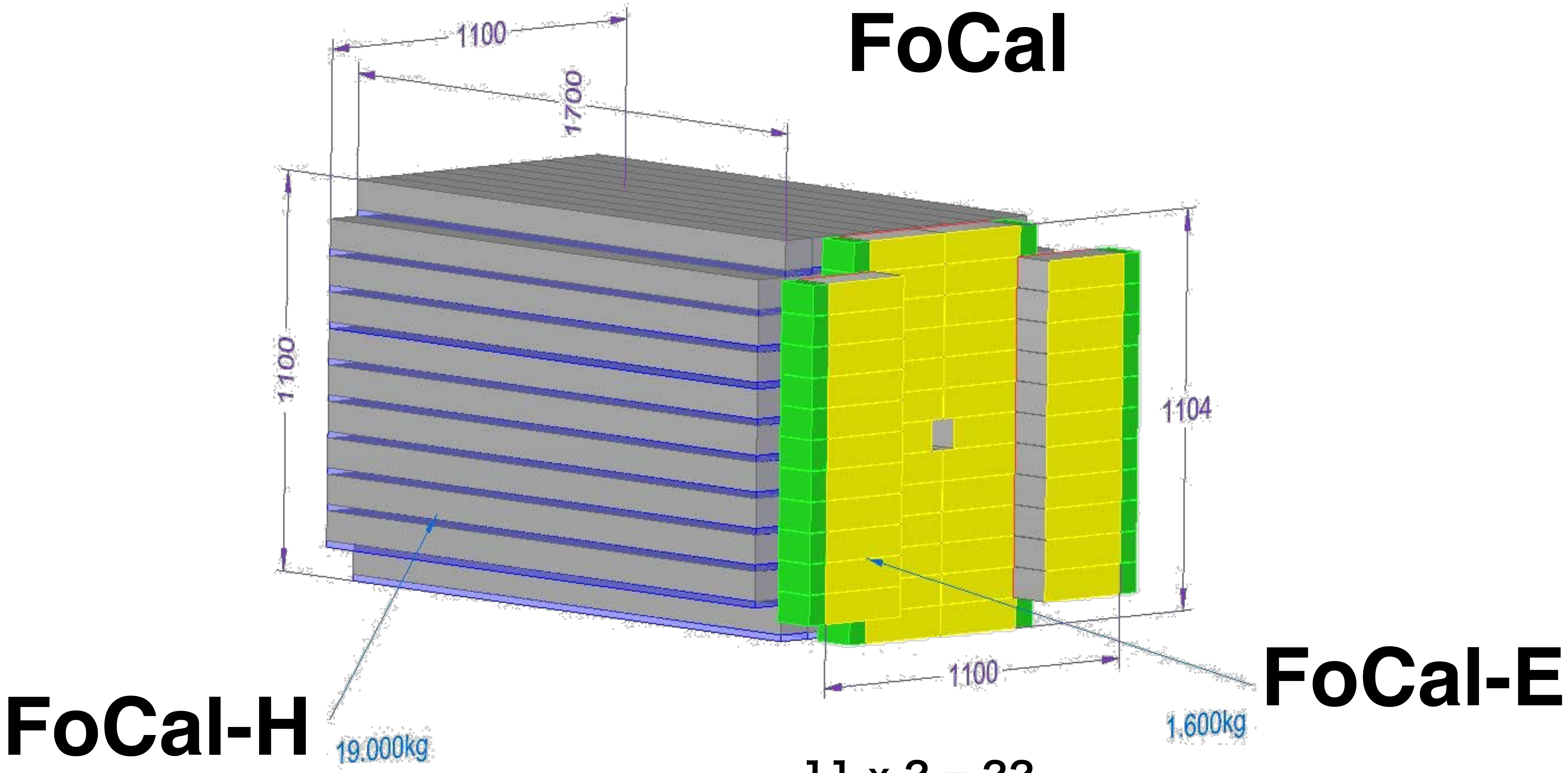
- Main challenge: Separate γ/π^0 at high energy
  - Two photon separation from π^0 decay (10 GeV, η=4.5) ~2mm
  - Needs small Molière radius and high granularity readout
  - Si-W calorimeter with effective granularity ≈ $1mm^2$



5.4 GeV electron, pileup event

FoCal in the final shape



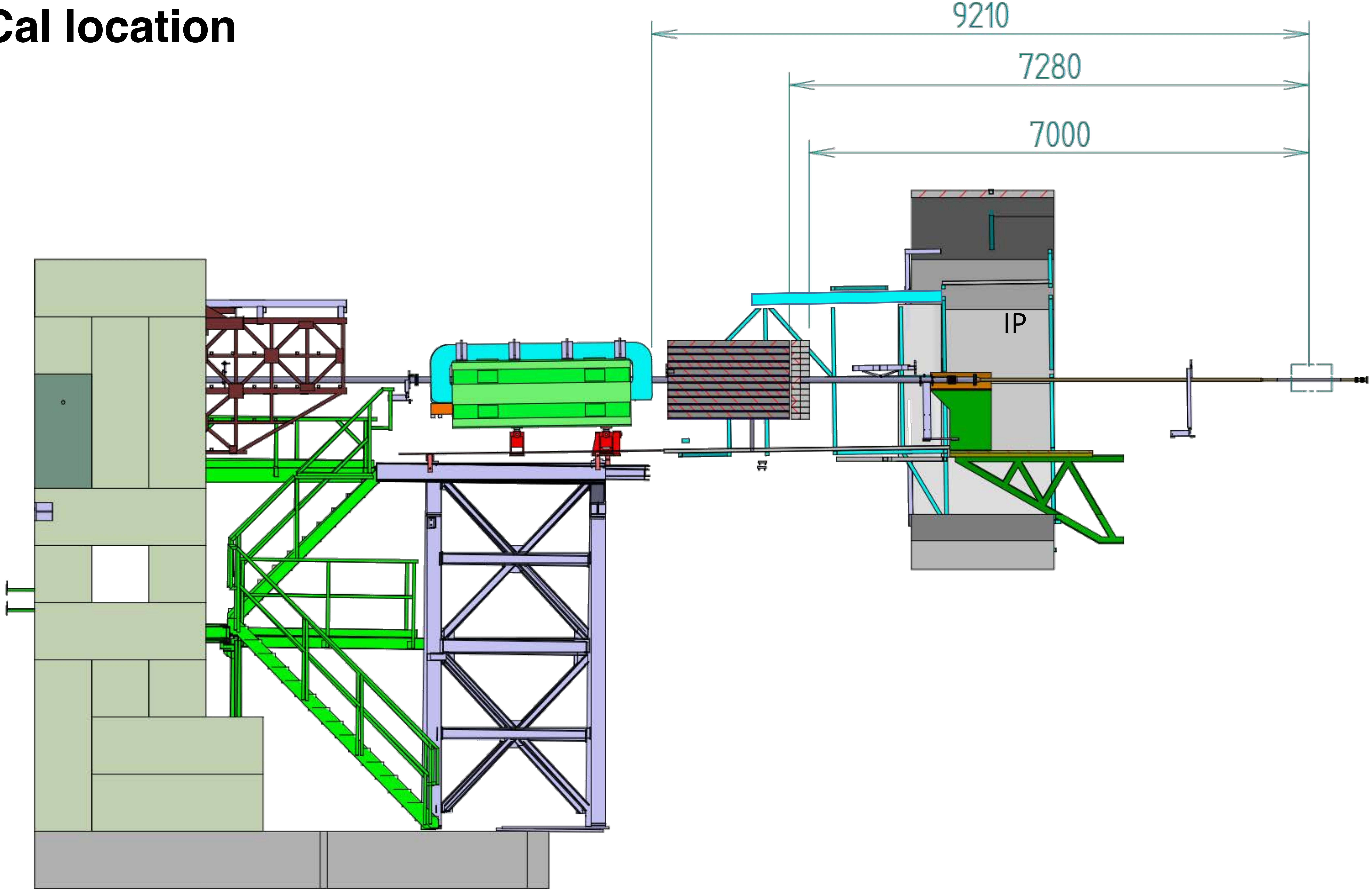


11 x 2 = 22
13 x 2 = 26
Total: 22 + 26 = 48 modules

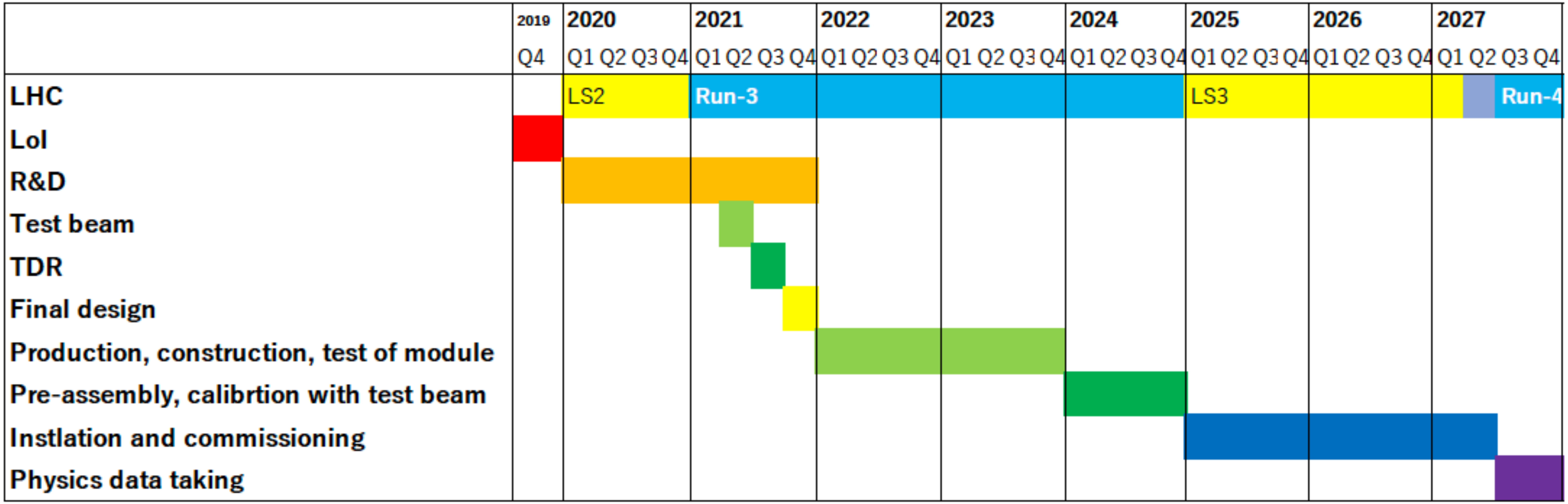
The HCal consists of lead sheets and scintillator plates.
The mix is 4.55:1 (more lead). The total weight by 1.7m long is about 20Tons.

The ECal is a mix of tungsten and several other materials. An ECal block contains 31kg Wo. The total weight of ECal is about 1.6Tons +0.4Tons for the construction, cooling etc. = about 2Tons.

FoCal location

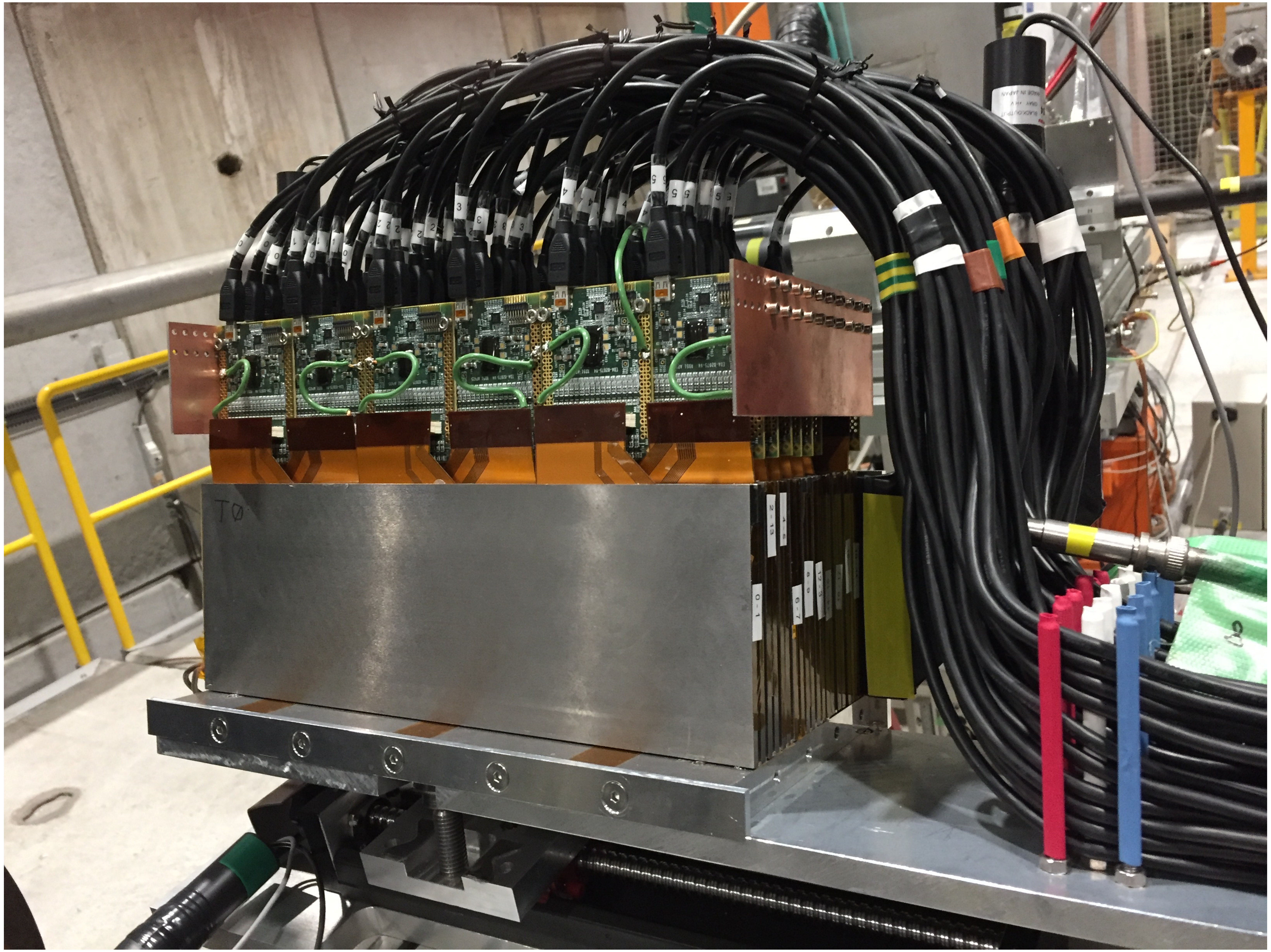


Timeline

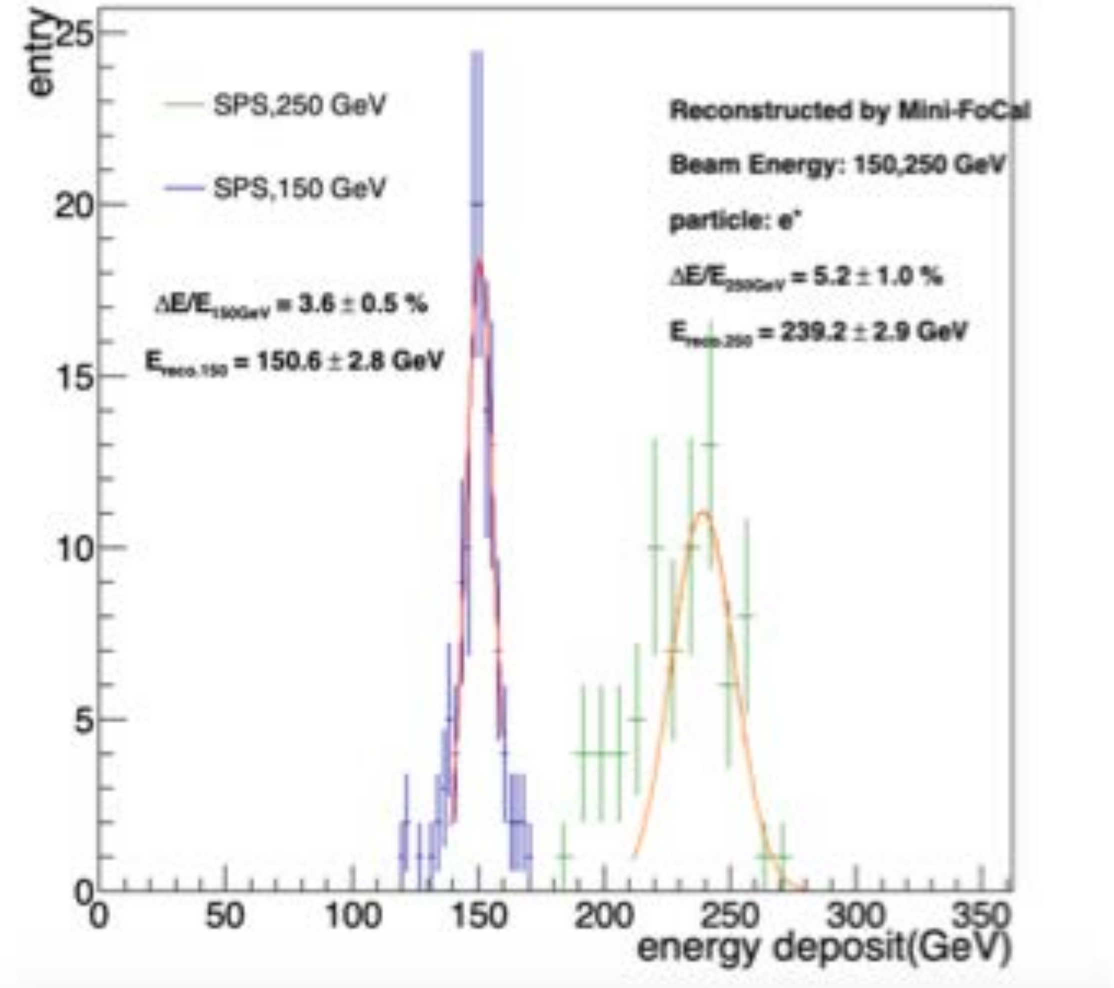


2019
Q4
2020
2021
2022
2023
2024
2025
2026
2027
Q1 Q2 Q3 Q4
LHC
LS2
Run-3
LS3
Run-4
LoI
R&D
Test beam
TDR
Final design
Production, construction, test of module
Pre-assembly, calibrtion with test beam
Instlation and commissioning
Physics data taking

mini-FoCal (FoCal-E, PAD only)

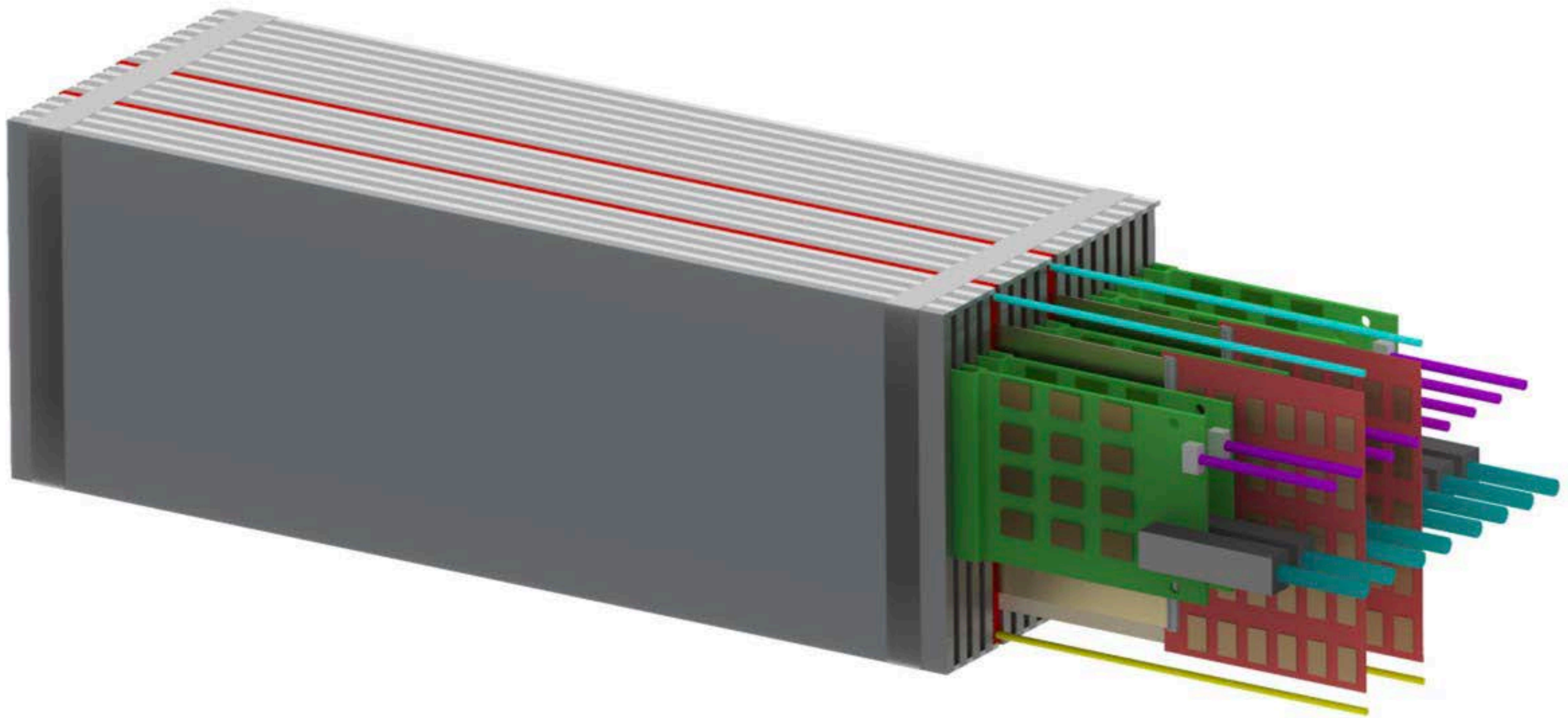


Y. Minato

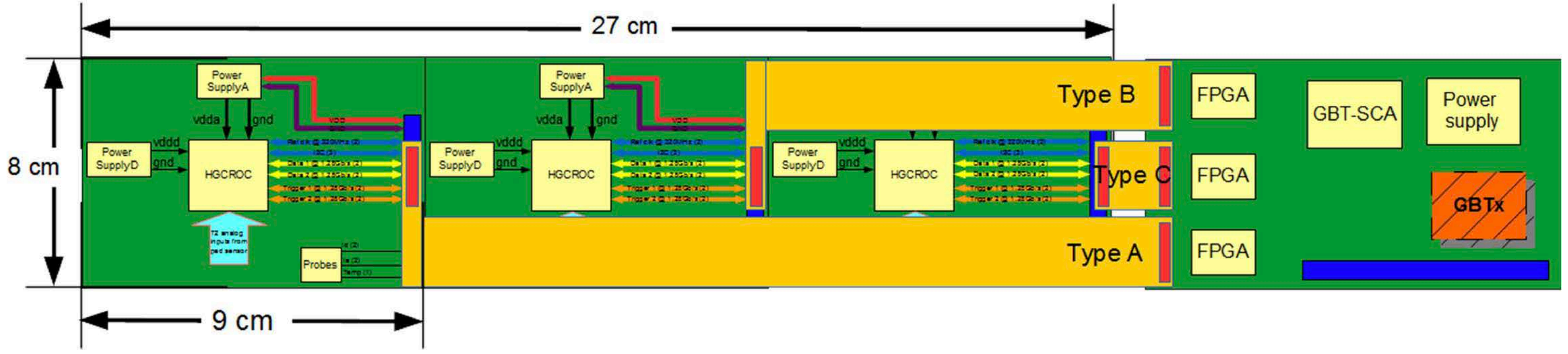


$\Delta E/E = 3.6$ %
@ 150 GeV/c , e^- (SPS)

- Built in Tsukuba, and shipped to CERN for test beam and ALICE test in 2018
- APV25 hybrid + SRS for readout

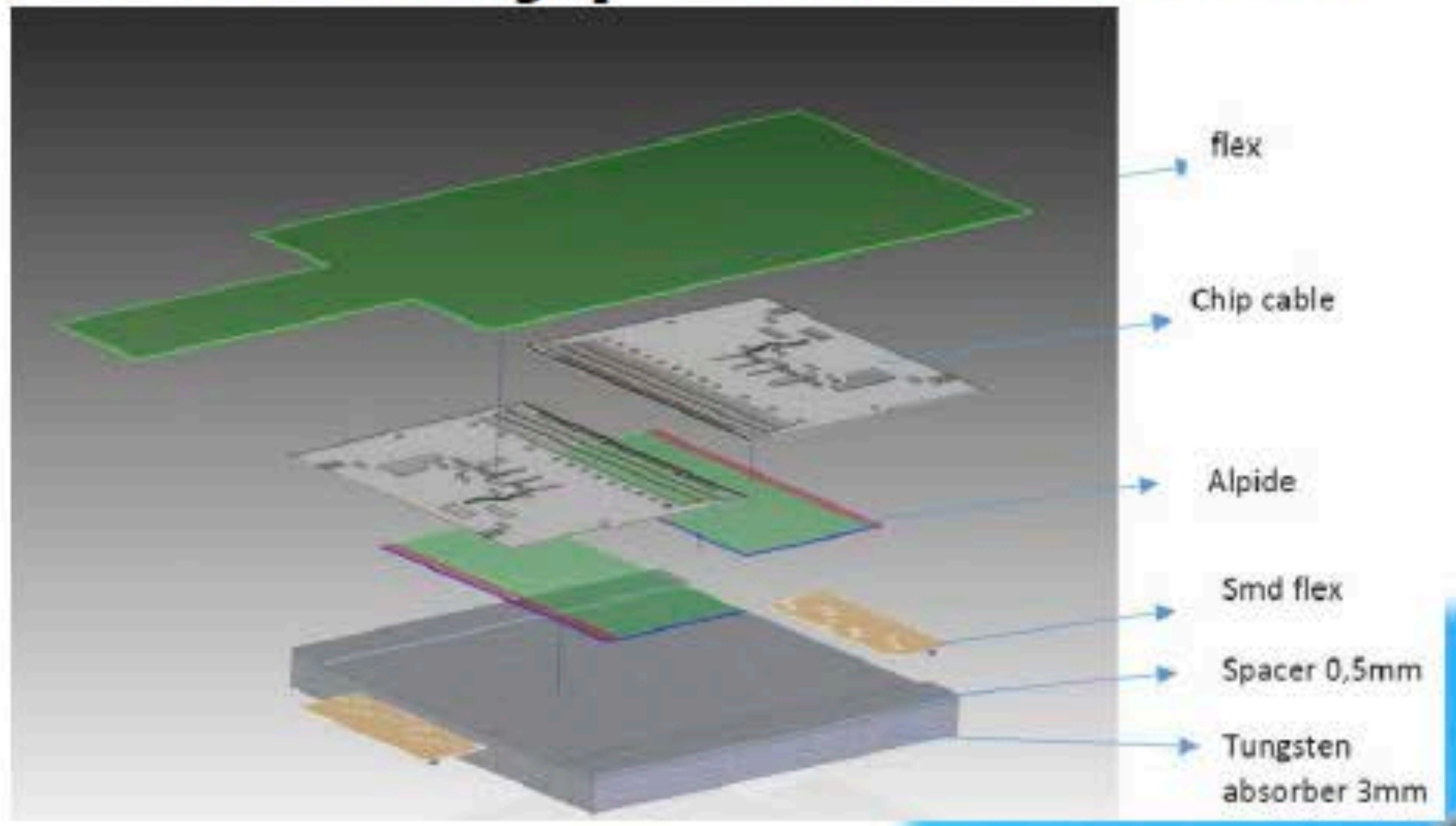


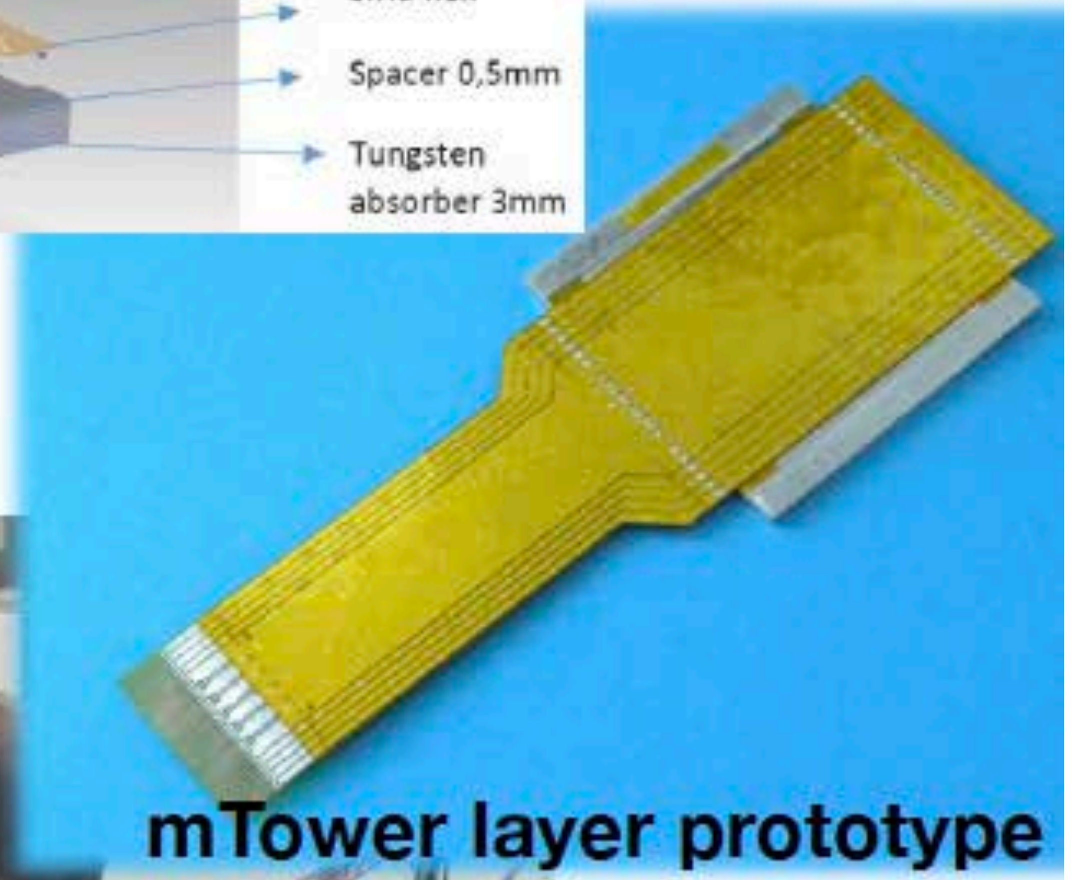
* this could be 9 x 5 = 45 cm (TBD)



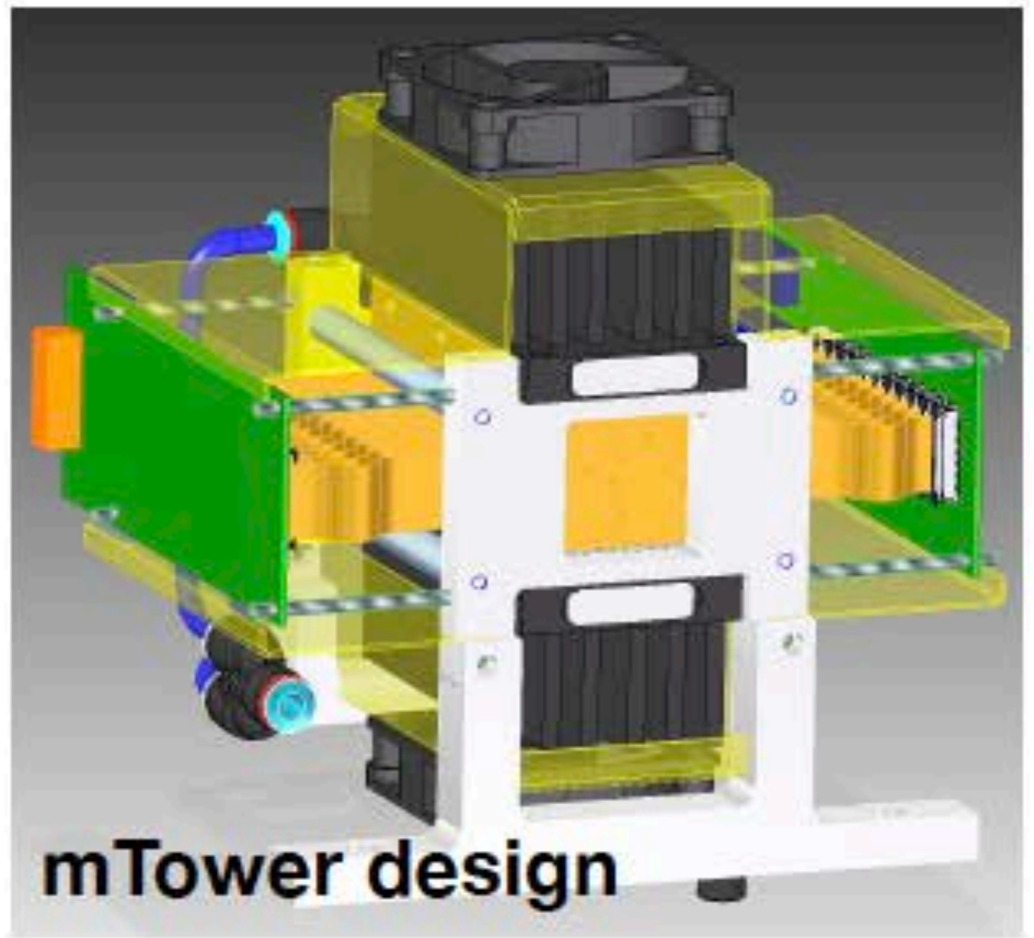
ALPIDE Calorimeter Prototype: mTower

- Small digital calorimeter (3x3 cm^2)
- designed for 24 layers
  - 2 ALPIDE sensors/3 mm W each
- 12 layer setup currently in DESY test
  - 1-5 GeV electron beams
- main goal:
  ALPIDE/system performance with high occupancy
  - also collect shower data,
    measure resolution, …

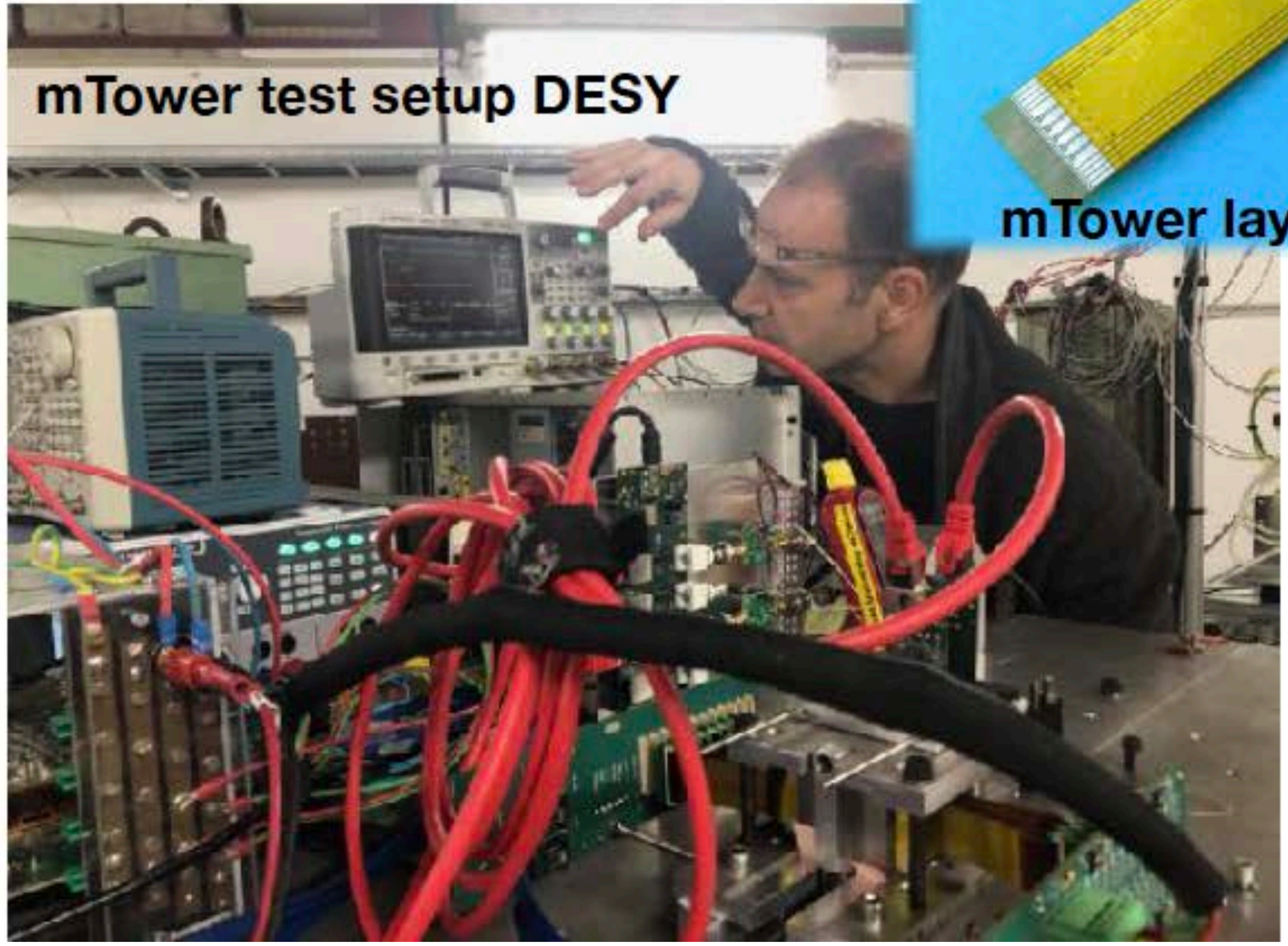




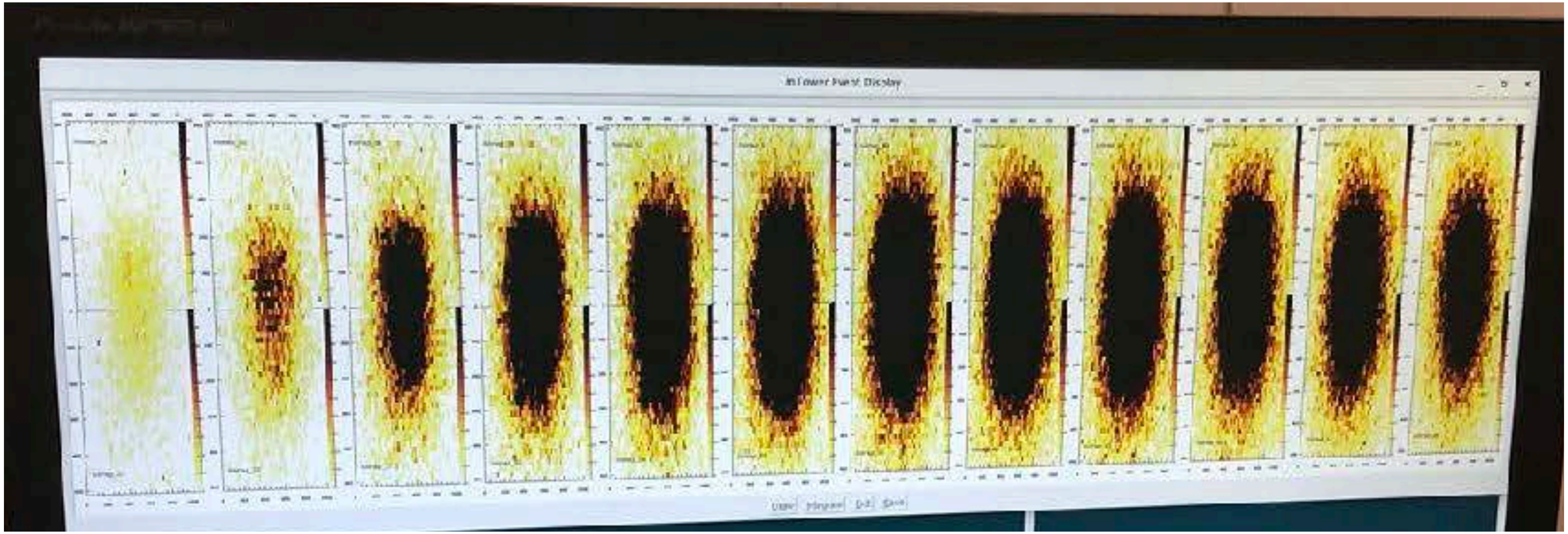
mTower layer prototype



mTower design



mTower test setup DESY



Event display @ DESY test beam, Nov. 2019

Thank you for your attentions!