# *Calorimeter R&D for future hadron colliders*

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LAPP

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# FCC-hh: reference detector

FCC-hh:
- 100 TeV
- pileup 1000
- high radiation level (~10×HL-LHC)

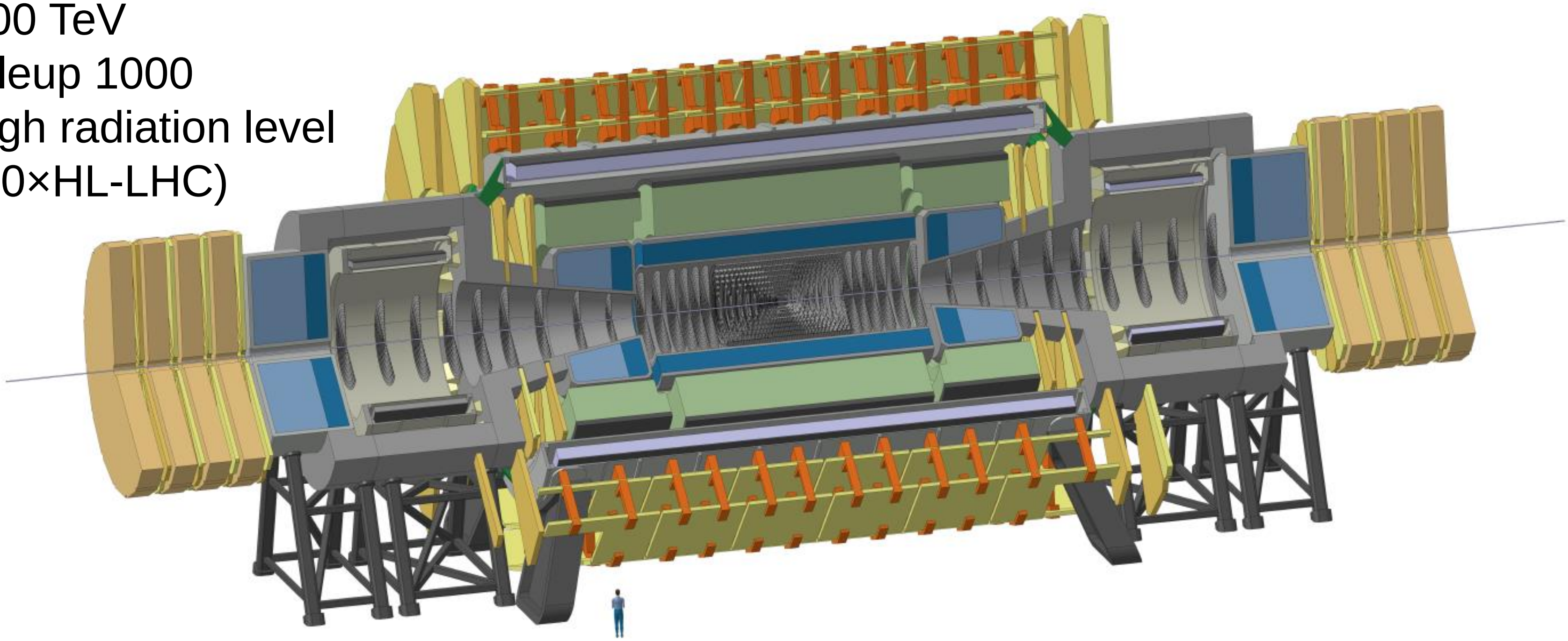

Figure 7.1: The FCC-hh reference detector with an overall length of 50 m and a diameter of 20 m. A central solenoid with 10 m diameter bore and two forward solenoids with 5 m diameter bores provide a 4 T field for momentum spectroscopy in the entire tracking volume.

Calorimeter up to $\eta = 6$

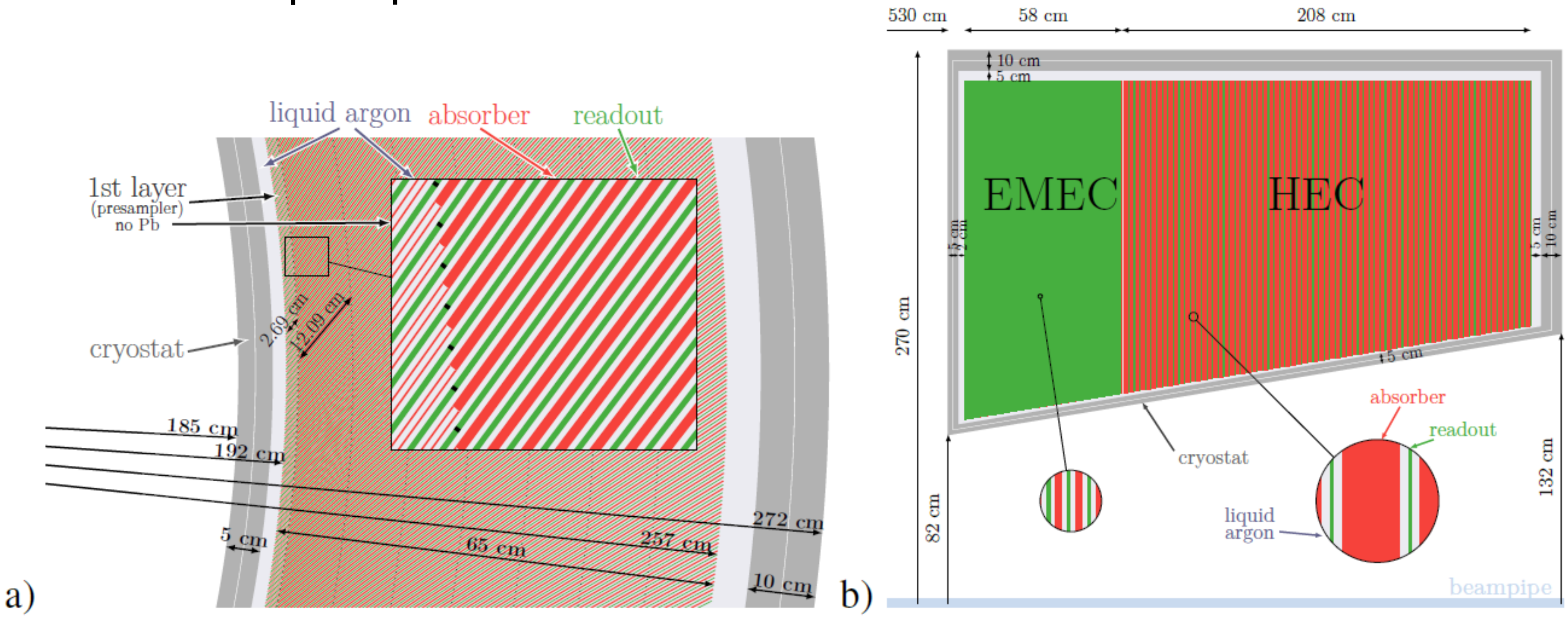


Figure 7.16: a) LAr barrel ECAL geometry and b) LAr endcap calorimeter geometry.

Figure 7.16a shows a geometry using straight inclined plates as assumed for this study. It allows highly granular readout by use of multilayer printed circuit boards. The 2 mm steel plated lead absorber plates are inclined at 50° and 8 layers are assumed in the radial direction. The LAr gap increases from 1.15 mm at the inner radius to 3.09 mm at the outer radius, which results in a variation of the sampling fraction in radial direction. The ECAL therefore has to be calibrated separately for each of the 8 layers.

# The CERN 2020-2025 R&D program

Report: https://cds.cern.ch/record/2649646

## 6 Calorimetry and light based detectors

### 6.1 RD1: R&D for future high-granularity noble liquid calorimetry (towards FCC-hh)

High granularity noble liquid calorimetry will be essential for future accelerator experiments, due to its radiation hardness, stability, high resolution energy measurement, high position resolution, timing resolution and high granularity, for 3D imaging, pile-up suppression, particle ID, jet substructure and more. It is part of the reference design of an FCC-hh experiment presented in the FCC CDR [1]. Due to the high radiation environment a fully passive calorimeter with read-out electronics sitting behind the calorimeter outside the cryostat is the preferred choice, leading, however, to long transmission lines of the signals.

# The CERN 2020-2025 R&D program (2/2)

### 6.1.1 Activity A: PCB development and test-beam module

The granularity of noble liquid calorimeters can easily be adjusted to the needs by finely segmented read-out electrodes (multi-layer PCBs). Such electrode PCBs need to be designed, simulated, produced and tested. Special focus has to be given to the resulting electronics noise of the full system including read-out electronics. The idea is to exclusively rely on warm electronics that can be maintained/ refurbished during shut-downs, although this leads to long transmission lines and a large number of signal feedthroughs. It is planned to also study the feasibility of such an approach with a test-beam program (including signal attenuation along the transmission lines). As a fall-back solution, cold electronics inside the cryostat (preamplifiers) could be envisaged later on. The final granularity needed will be defined by performance requirements, which will be simulated using FCC software. For this purpose, the FCC software will need some further developments such as the implementation of particle flow or other novel reconstruction techniques. Based on the obtained results a small test module will be designed, produced and tested at the test-beam (in 2023). LAr is the baseline choice for the moment, but other liquids (e.g. LKr) will be studied with simulation.

# ANR

Pre-proposal of a JCJC ANR project submitted in October:
***DEciPhering The Higgs potential at FCC-hh (DEPTH)***

Results for the 2nd step mid-February

Participation to the Activitiy A (discussions with Martin Aleksa)

Content:
WP1: A fast highly granular electromagnetic calorimeter
The work will focus on the development of an as granular as possible electrode for a noble liquid sampling calorimeter, to reach the best possible performance. Many aspects will have to be considered : geometry (including absorber geometry), uniformity, high voltage distribution, number of layers, cell capacitance, etc. A particular attention will also be drawn on timing aspects (mainly driven by the signal rise time and the signal amplitude). SPICE simulation of the electrode will be needed.

WP2: Calorimeter reconstruction techniques
Energy reconstruction, clustering algorithms and particle flow

WP3: Higgs self-coupling sensitivity study
Establish the feasability to measure the Higgs self-coupling at the % accuracy in the golden $HH \rightarrow \gamma\gamma bb$ channel