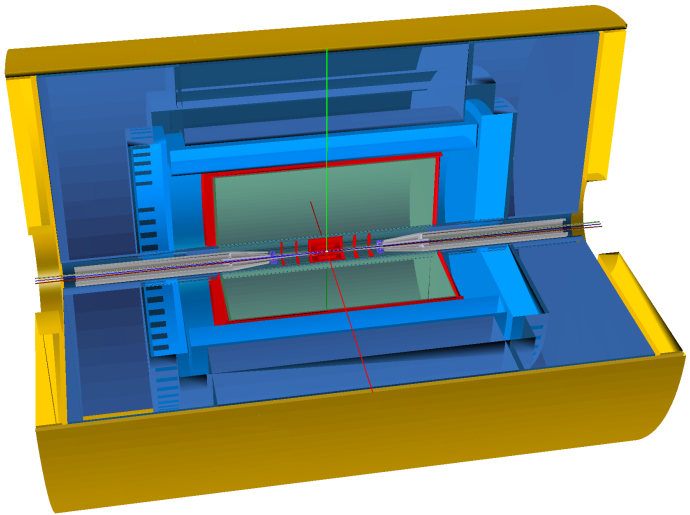
EOI ALLEGRO

Prospectives R&D détecteurs LAPP



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31/3/2025

ALLEGRO: a noble liquid calorimeter *and* an FCC detector

Expression of Interest for a Noble Liquid Electromagnetic Calorimeter for the ALLEGRO Detector Concept

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- *ALLEGRO calorimeter R&D in WP2 of DRD6 (which LAPP is officially a member of)*
- *Activity already existing at LAPP since ~2 years*
- *EOI already signed by LAPP members and validated by LAPP Directions*

Expression of Interest for the ALLEGRO Full-Detector Concept for FCC-ee

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ALLEGRO: high granularity noble liquid calorimeter for FCC-ee

Baseline design

1536 straight inclined (50.4°) 1.8mm Pb absorber plates

Multi-layer PCBs as readout electrodes

1.2 – 2.4 mm LAr gaps

40 cm deep (≈ 22 X_0)

Segmentation:

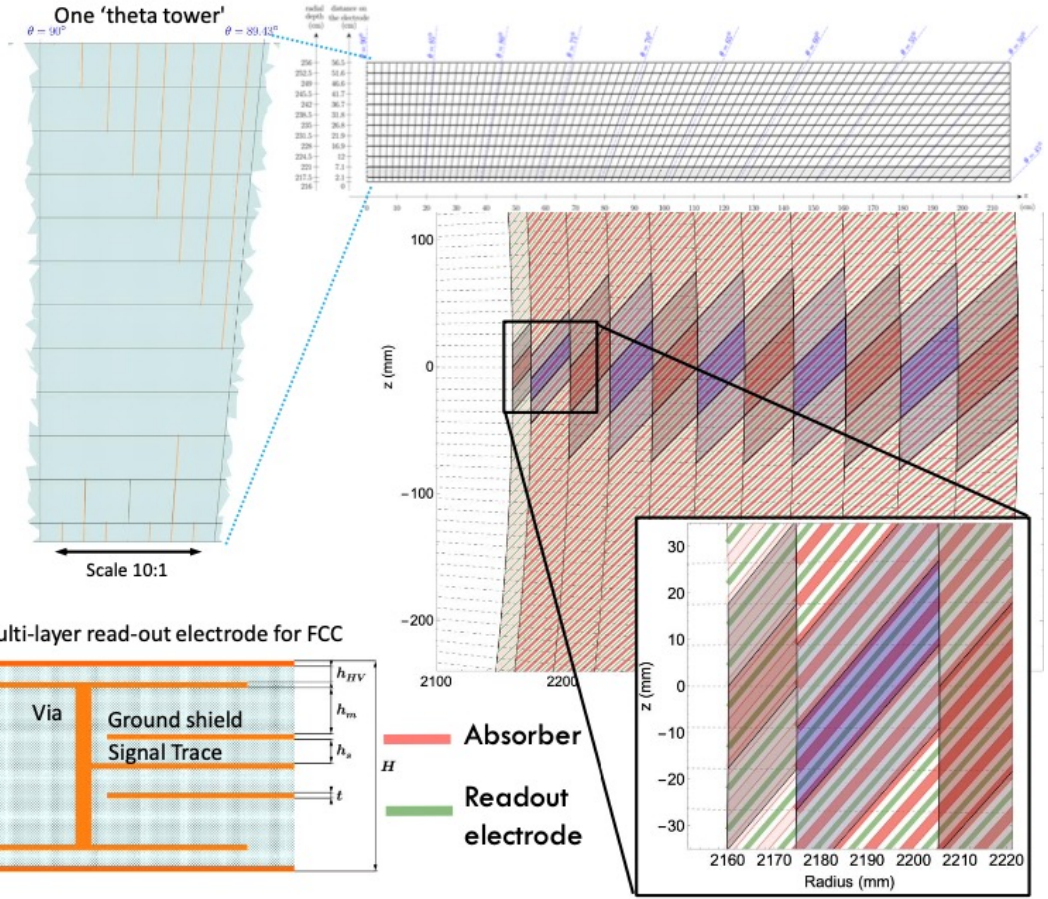
- $\Delta\theta$ = 10 (2.5) mrad for regular (1st comp. strip) cells,
- $\Delta\phi$ = 8 mrad
- → cell size in strips: 5.4mm x 17.8mm x 30mm

12 layers

Implemented in FCC-SW Fullsim

Possible Options

- LKr or LAr, W or Pb absorbers,
- Absorbers with growing thickness
- Granularity optimization
- Al or carbon fiber cryostat
- Warm or cold electronics



ALLEGRO: a full detector concept for FCC-ee

Vertex Detector:
- MAPS or DMAPS possibly with timing layer (LGAD)
- Possibly ALICE 3 like?

Drift Chamber (±2.5m active)

Silicon Wrapper + ToF:
- MAPS or DMAPS possibly with timing layer (LGAD)

High Granularity ECAL:
- Noble liquid + Pb or W
- Particle Flow reconstruction

Solenoid B=2T, sharing cryostat with ECAL, outside ECAL
- Light solenoid coil ≈ 0.76 X_0 (see back-up)
- Low-material cryostat < 0.1 X_0 (see back-up)

High Granularity HCAL / Iron Yoke:
- Scintillator + Iron (particle flow reconstruction)
  - SiPMs directly on Scintillator or
  - TileCal: WS fibres, SiPMs outside

Muon Tagger:
- Drift chambers, RPC, MicroMegas

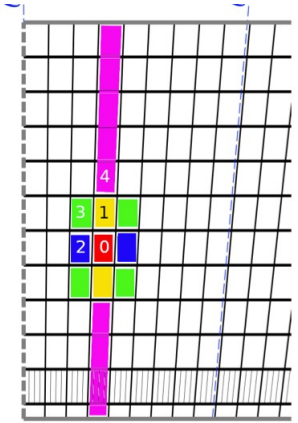
ALLEGRO calorimetry: already a (proto) collaboration

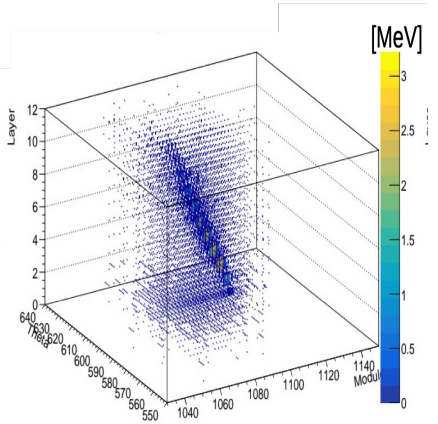
- Several IN2P3 institutes, a clear interest at French level
  - ✓ APC, IJCLAB, CPPM, Omega
- CERN
- Various "friendly" institutes we have already collaborated with (e.g. in ATLAS LAr)

ALLEGRO: what is LAPP already contributing to?

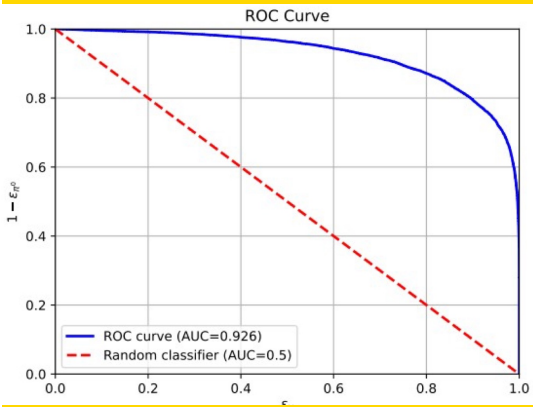
Zhibo

- ALLEGRO calorimeter simulation
  - ✓ Cross-talk and noise simulation in ALLEGRO ECAL
  - ✓ ALLEGRO electrode geometry optimization for optimal reconstruction of electromagnetic showers and particle identification
    - *Talk @ ICHEP 2024: Z. Wu, "R&D studies of the noble liquid calorimeter for ALLEGRO FCC-ee detector concept"*
  - ✓ Pion-photon separation for tau reconstruction (e.g. Z→tautau polarization studies)

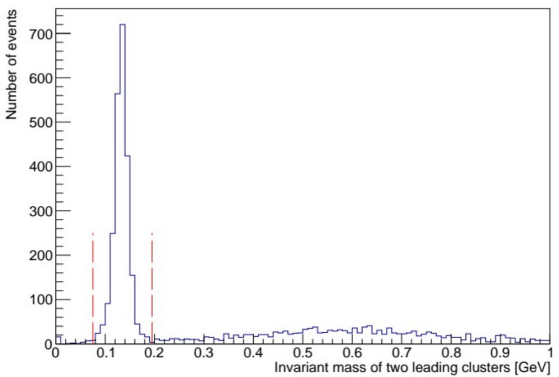




From cross-talk measurment on electrode prototype at CERN to cross-talk emulation in simulation (LAPP)



Pion/photon separation with ALLEGRO shoer shapes



Pion reconstruction from ALLEGRO topoclusters

ALLEGRO ECAL R&D: electrodes

Continue lab tests with small-scale electrode PCB and first large-scale prototype

- Measurements of x-talk and other cell properties
  - Promising to reach <1% x-talk target
  - Minimize noise aiming for photons down to 300 MeV and S/N>5 for MIPs
- Comparing lab results with Finite Element simulations

Develop endcap design

- Depends on geometry
- Optimize granularity

Finalize barrel design and produce prototype

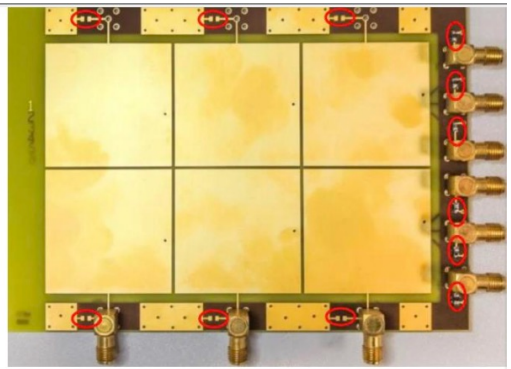
- Readout signals at the back → chose connectors

Happening now: excellent opportunity to contribute!

Manufacture test-module electrodes by 2027

- Potentially foresee half of module read-out by cold electronics, other half send signals outside of cryostat with coax

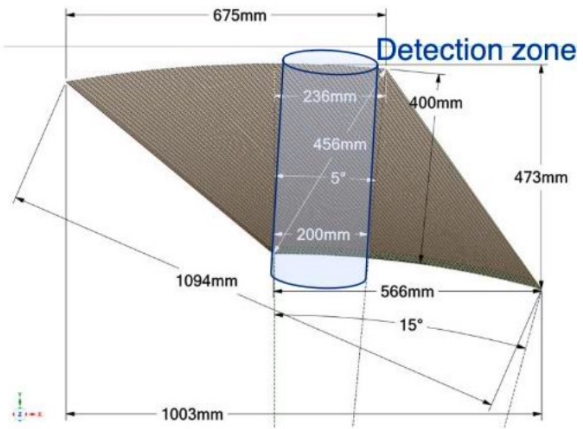
Testbeam opportunity of small-scale prototype in a O(3) years!



Small-scale PCB prototype at IJCLAB

58 cm x 44 cm x 1.2 mm electrode prototype at CERN

ALLEGRO ECAL R&D: test module



Mechanical design of testbeam module (64 absorbers) has started

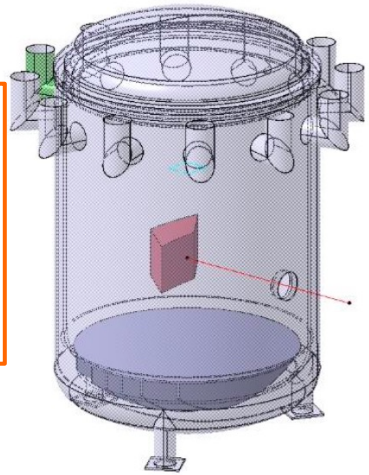
Finite element calculations including

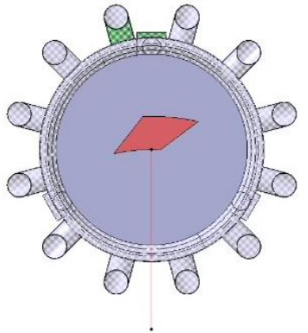
- Rings and G10 bars
- Absorbers and electrodes as shell (2D) elements using layers
- Distance pins
- Six M5 beams join electrodes and absorbers in each side (inner-outer)

Plan to place module into cryostat available at CERN

- But looking into thin carbon-fiber cryostats

Assembly and first tests at warm ~2027, cold tests and test-beam in 2028





ALLEGRO ECAL R&D @ LAPP | Electrode geometry

Renaud

- Decrease electrode capacitance (i.e. noise and crosstalk) by geometrical optimization
  - ✓hatched shielding ground planes
  - ✓hatched pickup electrode
  - ✓decrease pickup electrode size with respect to electrode size

- Try other materials to decrease relative permittivity (polyimide ?) → reduce cross talk

- Must perform simulations to check if useful or not
  - ✓Ansys licences available → do we want to gain expertise ?

Already in contact with IJCLAB colleagues to mutualize/ learn simulation expertise

ALLEGRO ECAL R&D @ LAPP | Resistive coating?

Renaud

- Resistive coating may be used to distribute HV on electrodes.
- DLC sputtering allows a wider range and more controlled resistivity, a more robust coating and more controlled thicknesses than historical resistive ink serigraphy.
- Some values commercially available, CERN workshop is able to produce etchable sheets compatible with PCB process.

ALLEGRO ECAL R&D @ LAPP | Push electronic limits?

Renaud

- Technological interest in putting electronic inside the PCB (like a CB)
  - ✓ at least shapers?
  - ✓ lower constraints on crosstalk and on cryostat feedthrough: worth prototyping !

- Use LAPP expertise in flexible printed circuit to design end-of-electrode flex circuit adapter