Calorimeters' system
Status and Plans

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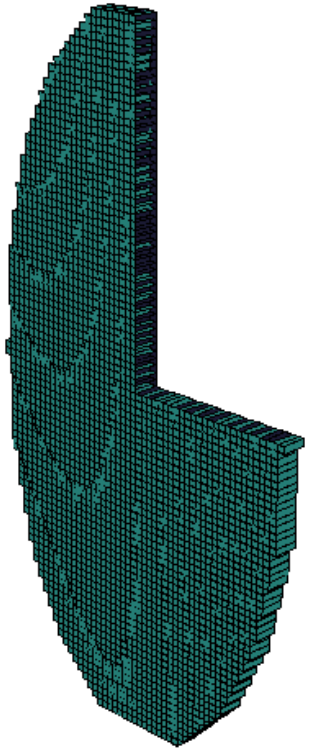
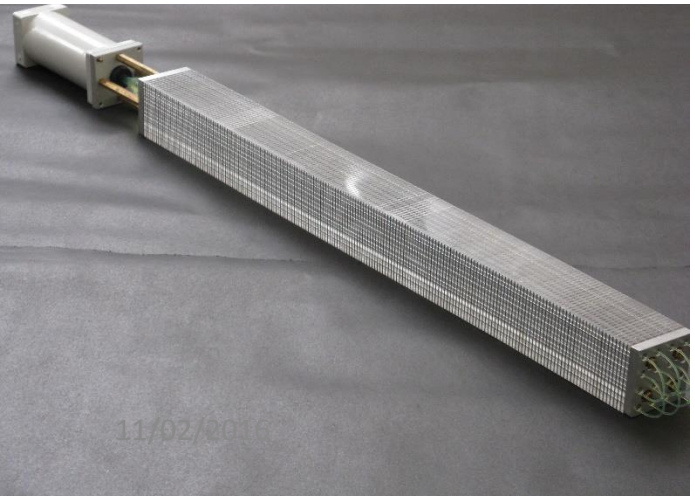
Outline

- Status
  - Quick review of current status of ECAL&HCAL
    - Design; software
  - Performances and costs
- Plans
  - Software updates
  - ECAL
    - Cost optimization;
    - Sensor tests
  - HCAL
    - Study of the structure, of the modules
  - Future Beam tests → see next talk; Ivan Korolko
  - Front-end and DAQ Electronics
  - Auxiliary electronics
  - Mechanics
- Summary

ECAL in TP

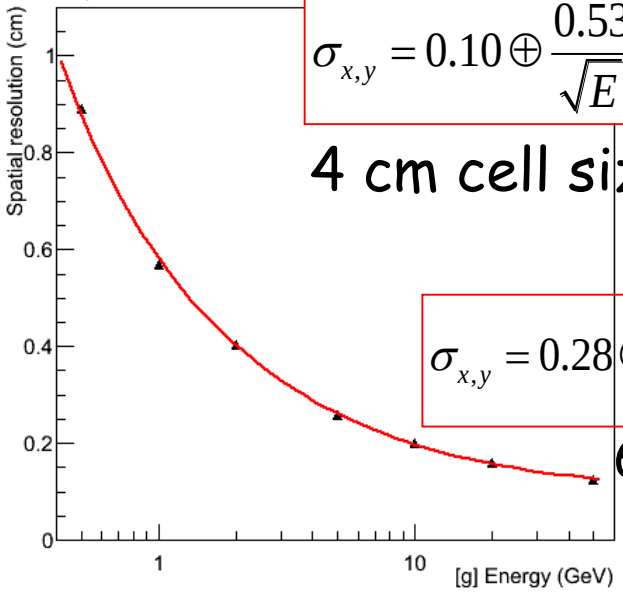


Almost elliptical shape
5 m x 10 m;
2876 Shashlik modules,
2x2 cells/modules, width=6 cm
11504 independent readout channels



- Dimensions 60x60 mm^2
- Radiation length 17 mm
- Moliere radius 36 mm
- Radiation thickness 25 X_0
- Scintillator thickness 1.5mm
- Lead thickness 0.8mm
- Energy resolution 6%/√E 1%

Spatial resolution



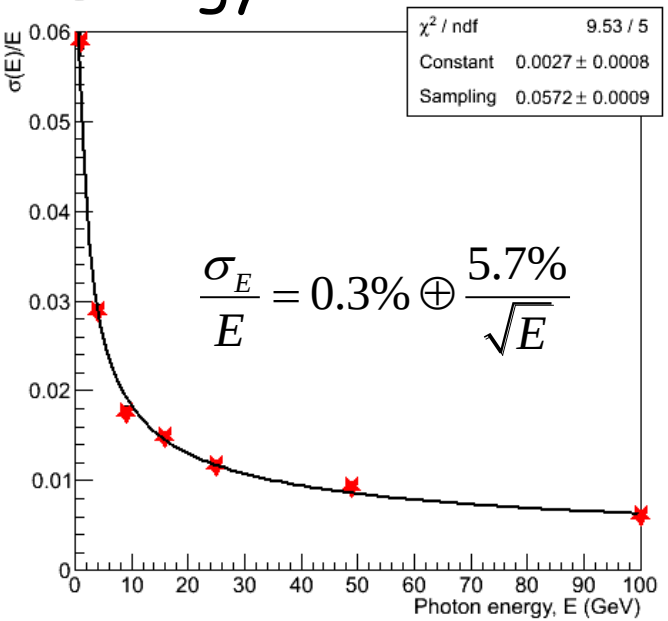
$$\sigma_{x,y} = 0.10 \oplus \frac{0.53}{\sqrt{E}} \oplus \frac{0.23}{E} \quad \text{(cm)}$$

4 cm cell size (3x3)

$$\sigma_{x,y} = 0.28 \oplus \frac{1.35}{\sqrt{E}} \quad \text{(cm)}$$

6 cm cells (2x2)

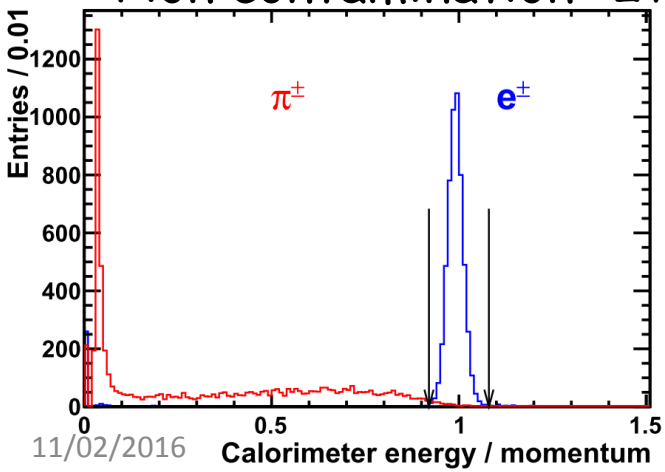
Energy resolution



$$\frac{\sigma_E}{E} = 0.3\% \oplus \frac{5.7\%}{\sqrt{E}}$$

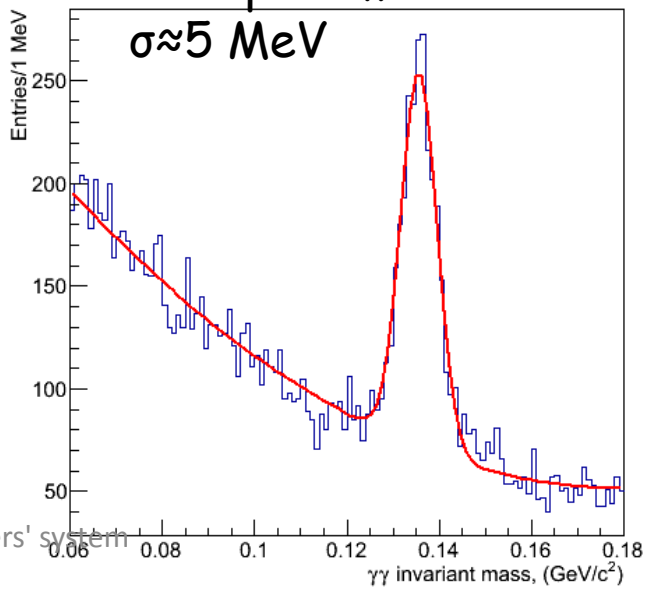
Electron efficiency: >98%

Pion contamination:<2%



Neutral pion mass resolution

σ≈5 MeV

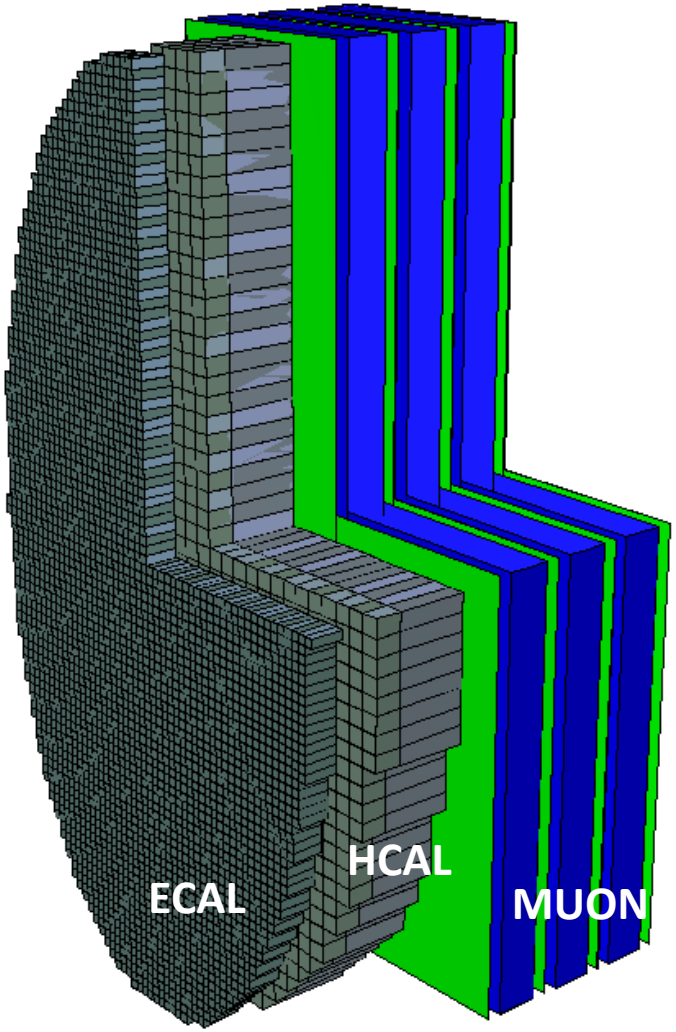


Breakdown of ECAL costs

- Driving numbers: 2876 Modules, 11504 cells
- Module cost 1500€/each 4.3 M€
- Infrastructure 0.2 M€
- Sensors (PMT) 3.0 M€
  - PMT+Base+CW/HV+cables 260€/each
  - SiPM+cables+LV embed 130 €/each
  - APD+cables+LV embed 130 €/each
- Readout electronics (90€/ch+4000€) 1.8 M€
- Racks and slow control 0.1 M€

Grand total 9.4M€

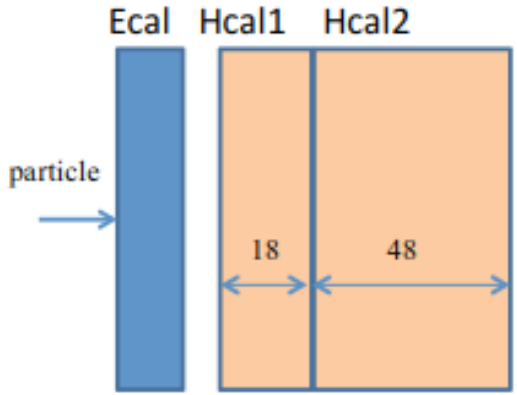
HCAL in TP



Matched with ECAL acceptance;
2 stations
5 m x 10 m;
1512 modules,
24x24 cm2 dimensions
Stratigraphy:
N x (1.5 cm steel+0.5 cm scint)
1512 independent readout channels

Technology:
- Availability of Shashlik MC description
- Two «thin» stations
  $1.7\ \lambda_I + 4.5\ \lambda_I$

HCAL performances



Rejection factor for ε_μ=95%

Energy, GeV	E+H1+H2
1.0	23
1.5	32
2.0	50
2.7	120
3.0	160
5.0	210
10.0	250

- ✓ Standard ECAL
- ✓ HCAL:18 (Hcal1) and 48 layers (Hcal2)
- ✓ The geometry maximise the capability for π/μ discrimination at low momentum
- ✓ Common likelihood based on information from Ecal, Hcal1 and Hcal2 (independent)
- ✓ Cut on likelihood to ensure 95% efficiency for muons

- ✓ Great for particles with E>2.5 GeV
- ✓ Still place for improvement

Breakdown of HCAL costs

- Driving numbers: 1512 Modules, 1512 cells
- Module cost 2000€/each 3.0 M€
- Infrastructure 0.7 M€
- Sensors (PMT) 0.4 M€
  - PMT+Base+CW/HV+cables 260€/each
  - SiPM+cables+LV embed 130 €/each
  - APD+cables+LV embed 130 €/each
- Readout electronics (90€/ch+4000€) 0.2 M€
- Racks and slow control 0.1 M€

Grand total 4.4M€

Plans

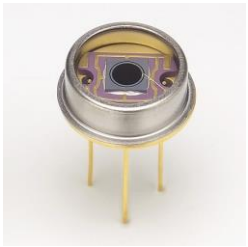
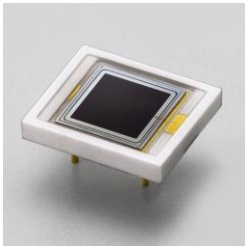
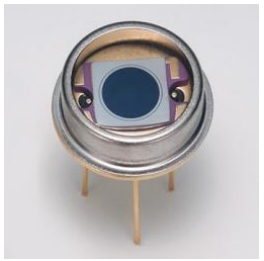
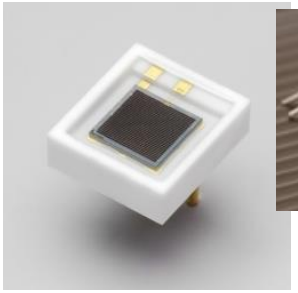
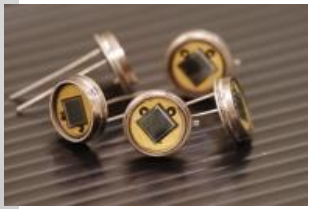
- Plans
  - Software updates
  - ECAL
    - Cost optimization
    - Sensor & RO tests
  - HCAL;
    - study of the structure of the modules
  - Future Beam tests → see next talk; Ivan
  - Front-end and DAQ Electronics
  - Auxiliary electronics
  - Mechanics/infrastructure

Plans for the software

- ECAL/HCAL Cluster reco in place;
- ECAL: **Finalise cluster feature extraction**
  - Zbest, Xbest, Ybest, Ecalib, Asymmetry
  - Add Neutral/Charged info;
  - Track Particle Identification likelihoods on ECAL
- HCAL: **study other options for geometry** (tile HCAL?)
  - Track Particle Identification likelihoods on HCAL (in place; to be tuned with MUON)
  - Optimize PID system (ECAL+HCAL+MUON)
- Physics studies with latest reco code

ECAL cost optimization

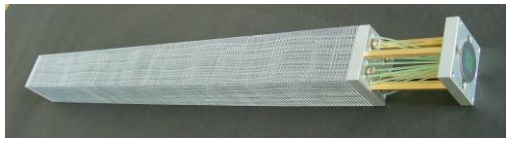
- Ecal costs already optimized for acceptance and granularity (at almost fixed performances)
- Studies are ongoing for **different sensors**
  - APDs under test:
  - MPPC & MAPD

3.0 M€→1.5 M€

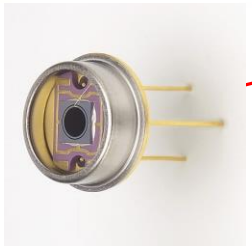
- Lower granularity will have an impact on performances→ **to be studied if needed**

Sensors and readout tests

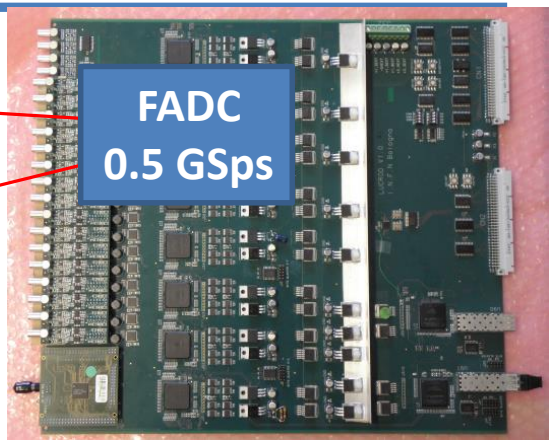


Shashlik module

PMT



APD



Processing board

- Sensors will be tested **on lab** mainly for linearity and dynamic range;

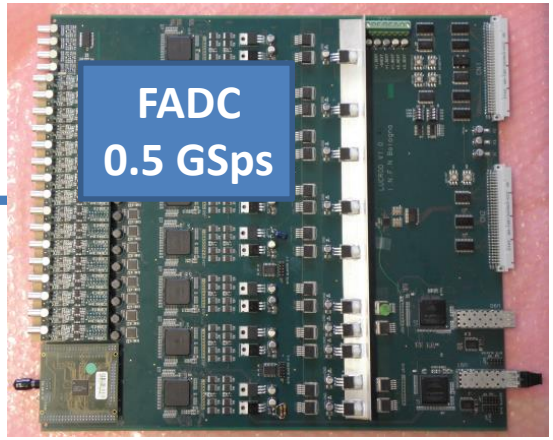
- ECAL Shashlik modules + sensors will be **tested on beams**

HCAL

- Which technology
  - **Shashlik**, Tile HCAL, or other
- Which geometry
  - One station, **two stations**, three stations?
  - **Widths? Granularities?**
  - Performances on muons with the MUON detector

- Beam tests → see Ivan

Front end and DAQ



Processing board

- Signals will be digitized by FADCs and locally processed by FPGA to provide:
  - Digitized energy information (amplitude, integral, ToT)
  - Signal time tagging (≈1 ns for event definition)
  - Digital signal shape analysis for noise/background rejection
- A single board equipped with FPGA, SoC will:
  - read 32/64 channels
  - perform monitoring functions on data
  - ship out event data
- Looking for a **low cost FADC solution** that will allow good signal timing and ease system integration;
- HCAL/ECAL **synergies looked for** to reduce costs

Auxiliary electronics ECAL/HCAL

- There will be a lot of auxiliary electronics whose details will not have impact on the performance:
  - Power supply for sensors (HV, LV or…)
  - Monitoring system for power supply
  - LED calibration systems
  - Clock, sync, beam, etc signal distribution (TTC?)
  - Data collection for DAQ/switches

- Details on these systems will be worked out at a later stage (exp-wide?) but are needed before the CDR
  - (several examples to look at in LHCb, Hera-B, ATLAS, CMS)

Infrastructure/mechanics

- Not seen as critical
  - But capability to build a 10 m high calo needs to be checked!

    (highest pressure 6 atm on lowest modules)

- Work is needed in this area, but can start once the geometry is almost frozen

Summary

- There are several areas to work for a "CDR" level of Calo descriptions.

- New collaborators wishing to contribute in any calo area are welcomed
  - Software/reconstruction
  - Detector design & further optimization
  - Electronics
  - Mechanics
  - Lab and beam tests

Please do not be shy!