

Detector Upgrades and plans for the High-Luminosity LHC

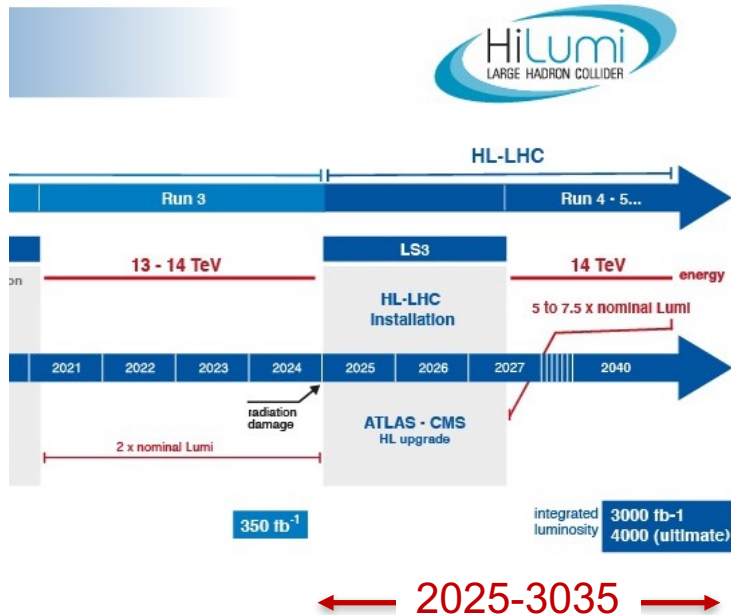


J. Varela, LIP Lisbon
CMS Day @ IST
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The High-Luminosity LHC

HL-LHC is the next big thing in Particle Physics!

It will provide **20 times more data** than available today



- Major upgrade upgrade of the accelerator
- Major upgrade of the detectors
 - Cost is 50% of the original CMS detector

New colliders are necessary

- **New colliders are necessary to address several of the major, fundamental open questions of particle physics**
 - possible composite nature of the Higgs
 - solutions to the hierarchy problem
 - baryogenesis and the electroweak phase transition
 - the nature of dark matter
 - the origin of neutrino mass
- **Many of the open questions beyond the Standard Model are related to the Higgs scalar sector.**

The Higgs boson is special

Higgs field = forces of very different nature than the other interactions

The precise knowledge of the **Higgs properties** is essential to our understanding of the deep structure of matter

**Higgs precision program is very much needed
to probe physics beyond the SM**

CMS experiment upgrade

New paradigms in an HEP experiment to fully exploit HL-LHC luminosity

LIP contributions to Calorimeter Endcap

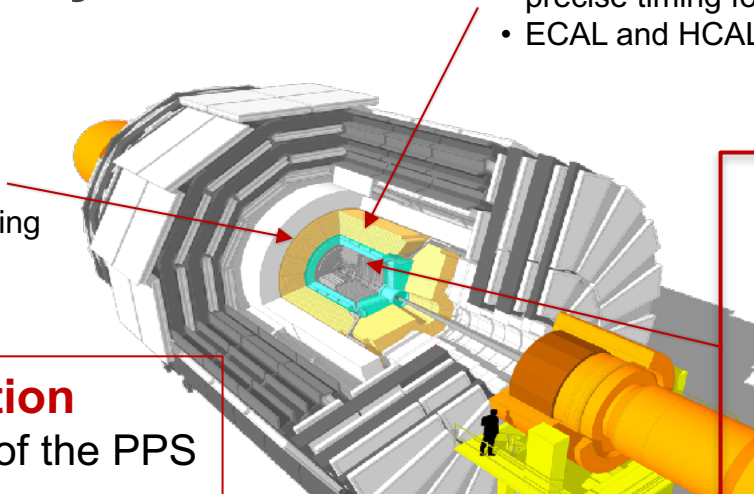
- 3D showers and precise timing
- Si, Scint+SiPM in Pb/W-SS

LIP main contribution

Proposal for upgrade of the PPS proton spectrometer

LIP contributions to Barrel Calorimeters

- ECAL crystal granularity readout at 40 MHz with precise timing for e/γ at 30 GeV
- ECAL and HCAL new Back-End boards



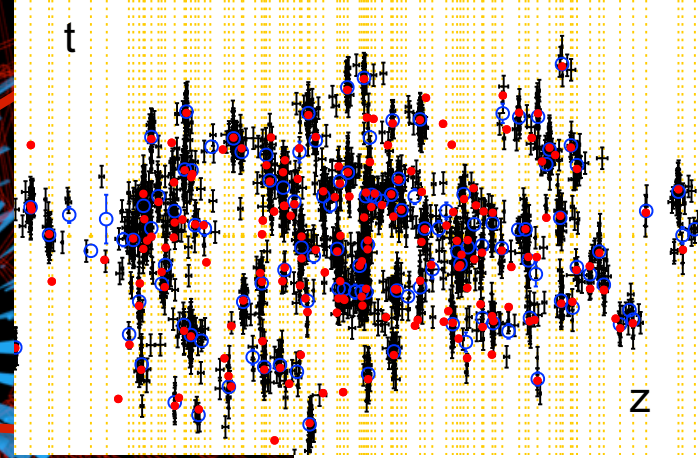
LIP main contribution MIP Timing Detector

Precision timing with:

- Barrel layer: Crystals + SiPMs
- Endcap layer: Low Gain Avalanche Diodes

Huge experimental challenge

High luminosity requires very intense beams
About 200 collisions when beams cross each other, 40 million time per second



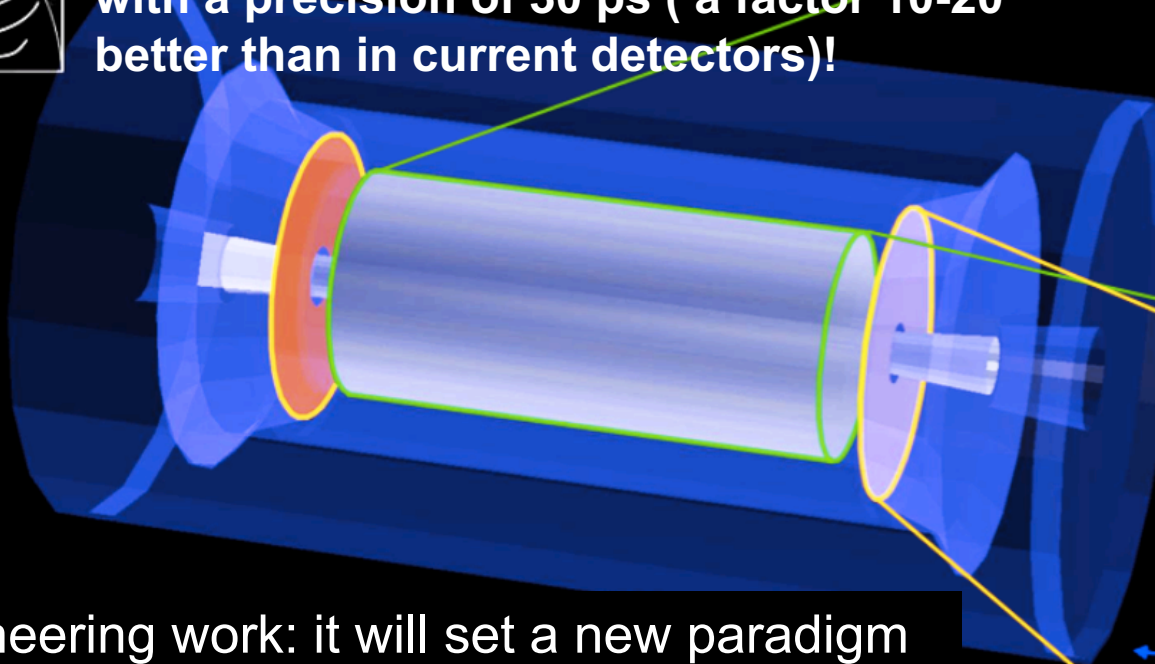
Luminous region

- $t_{\text{RMS}} \sim 180 \text{ ps}$
- $z_{\text{RMS}} \sim 4.6 \text{ cm}$

New timing detector

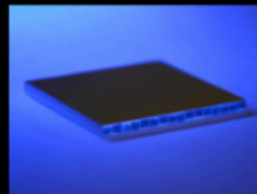
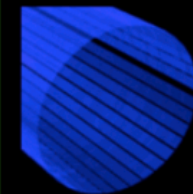


Measurement of time of charge particles
with a precision of 30 ps (a factor 10-20
better than in current detectors)!



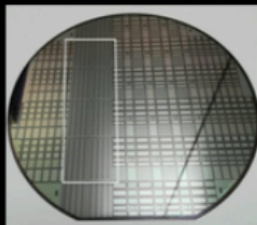
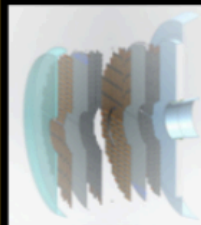
BARREL

Surface $\sim 40 \text{ m}^2$
Number of channels $\sim 332\text{k}$
Radiation level $\sim 2 \times 10^{14} \text{ n}_{\text{eq}}/\text{cm}^2$
Sensors: LYSO crystals + SiPMs



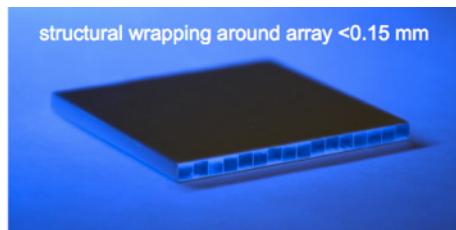
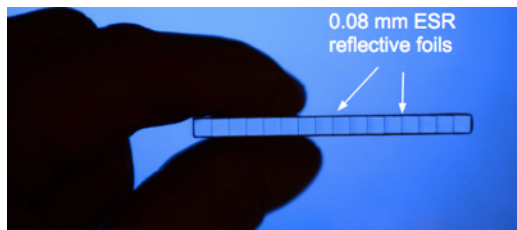
ENDCAPS

Surface $\sim 15 \text{ m}^2$
Number of channels $\sim 8000\text{k}$
Radiation level $\sim 2 \times 10^{15} \text{ n}_{\text{eq}}/\text{cm}^2$
Sensors: Low gain avalanche diodes

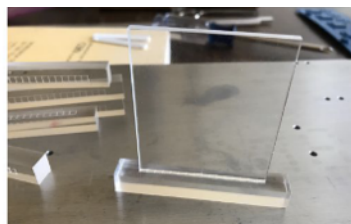
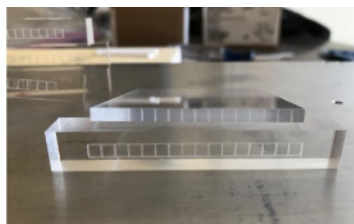
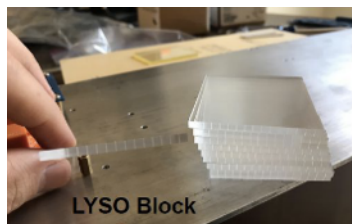


Pioneering work: it will set a new paradigm
in HEP experiments

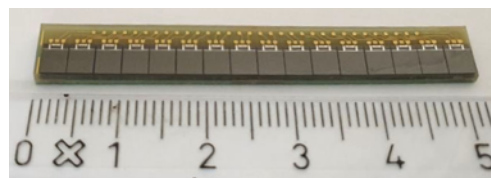
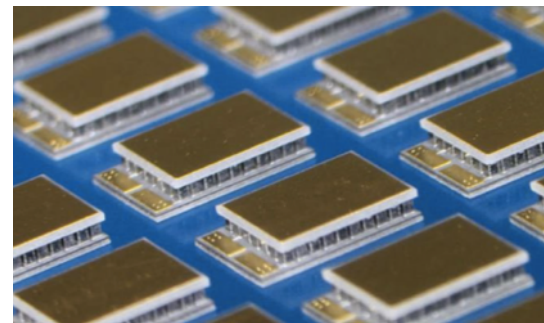
R&D on different technologies



LYSO scintillating crystals



Thermo electric coolers

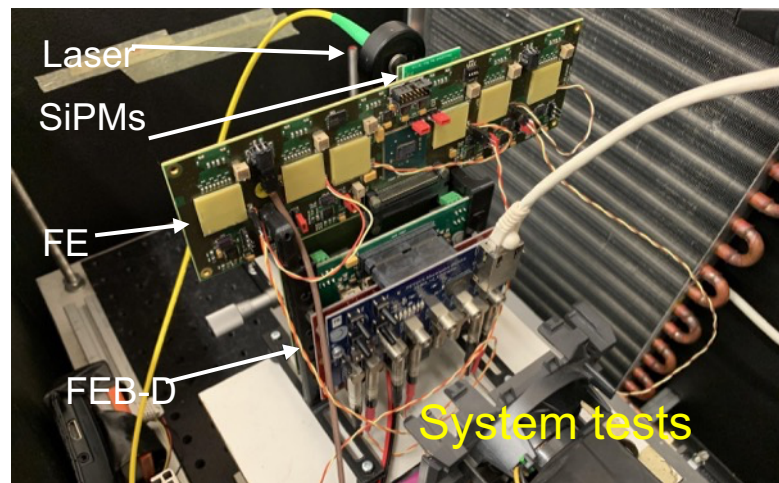
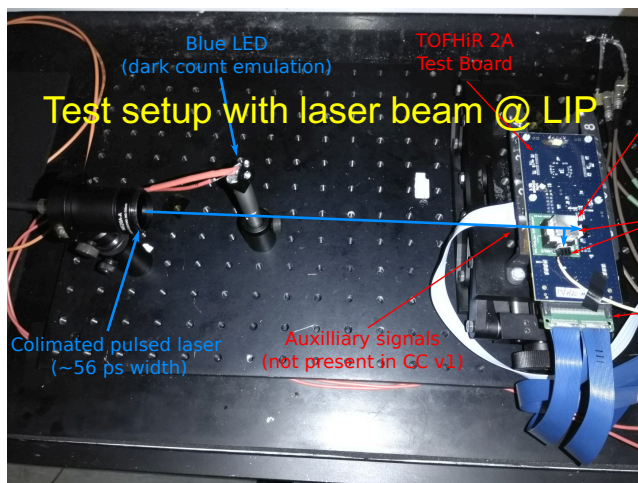
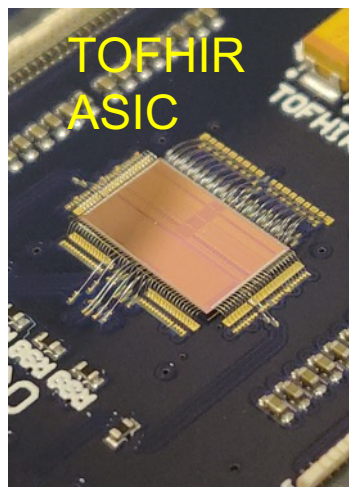


Silicon photomultipliers

TOFHIR ASIC and readout system

TOFHIR ASIC developed by LIP in collaboration with Portuguese start-up PETsys

LIP is responsible for the readout system of the Timing Detector



Unique opportunity to participate in challenging high-tech detector development

Thank you for your attention