On-beam system test of the new readout electronics for the CMS Electromagnetic Calorimeter upgrade

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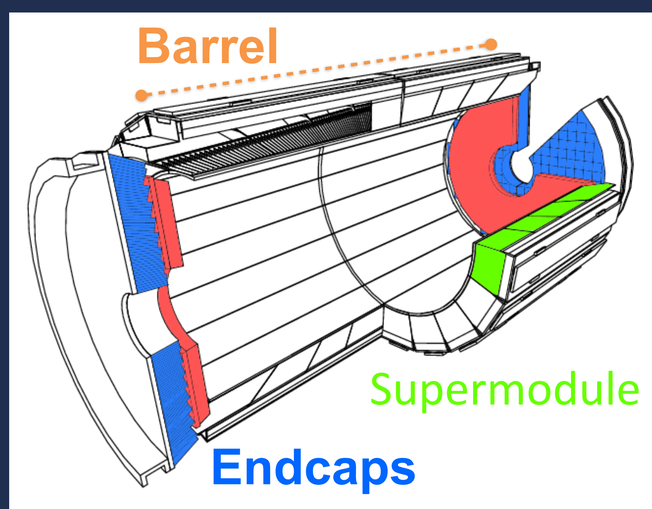
On behalf of the CMS Collaboration

ECAL : the CMS electromagnetic calorimeter

ECAL is an homogeneous calorimeter and is made of **75848 lead tungstate ($PbWO_4$)** scintillating crystals, placed around the beam line with a cylindrical symmetry and oriented towards the nominal interaction point. ECAL is divided into two regions:

- **Barrel:** covering the central region of the cylinder
  - ➡ **36 Supermodules (1700 crystals each)**
  - ➡2448 **5x5 crystal matrices,** each one equipped with a front end read out board
- Endcap: the lateral faces of the cylinder

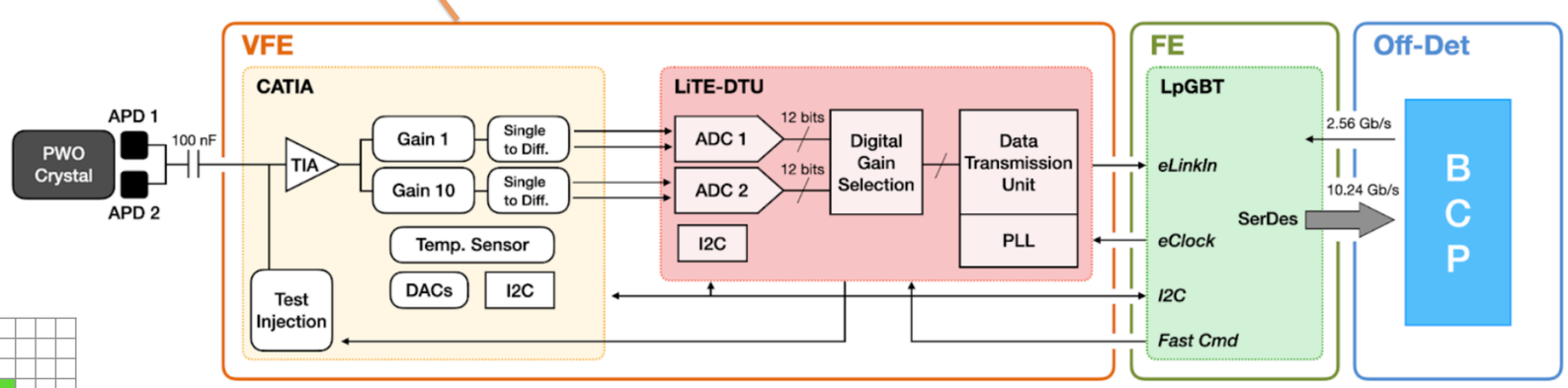


High Luminosity LHC

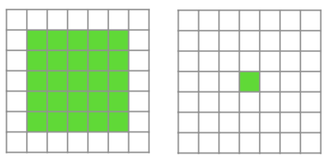
To cope with HL-LHC operations challenges (**140-200 interactions per collision -** compared to the current 50 of Run2) the ECAL electronics will be upgraded, while the scintillating crystals and their associated avalanche photodiodes (APDs) will be retained.

Temperature: $18°C \rightarrow 9°C$
➡ APDs dark current mitigation

faster electronics, oversampling and data streaming towards off-detector electronics (40 MHz→ 160 MHz)
➡Reduces signal from direct ionisations of APDs (spikes)
➡Improves time resolution for primary vertex identification
➡Reduces impact of pileup & noise

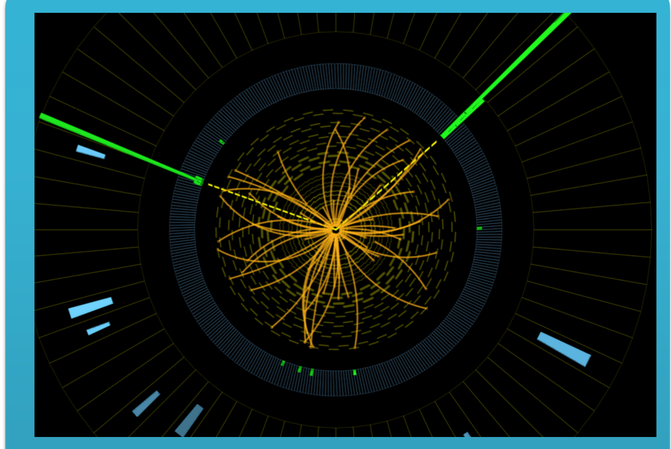


Trigger:
Matrix 5x5
→ 1 crystal



➡better trigger performance and spike rejection

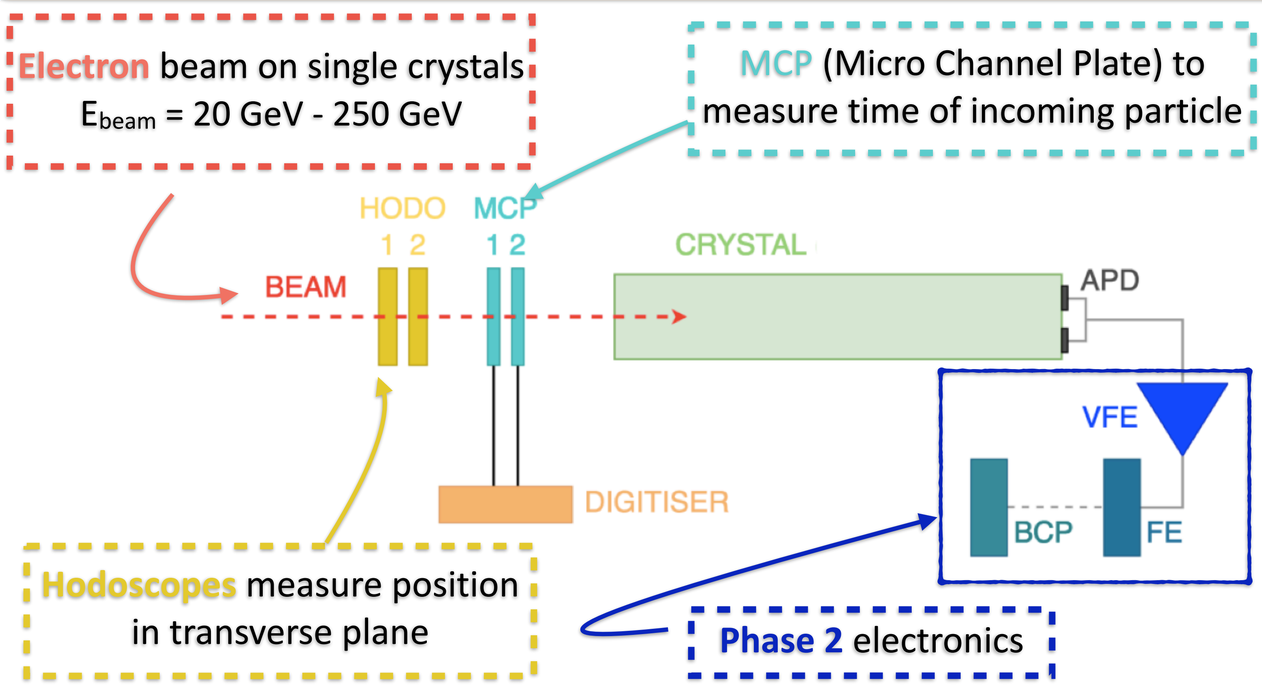
Trigger acquisition:
➡ Increase rate (100 kHz → 750 kHz) & latency (4 μs → 12 μs)



Phase 1: ECAL excellent energy resolution crucial to observe and study H→γγ.

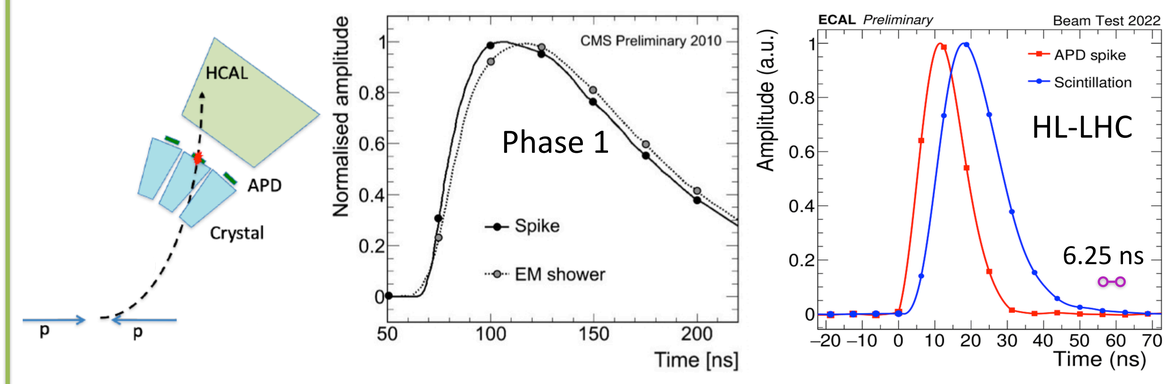
HL-LHC: The upgraded electronics design targets to maintain the current energy resolution performance, preserve the physics potential and obtain a time resolution of **30 ps for E>50 GeV**

Electron test beam



Spike suppression

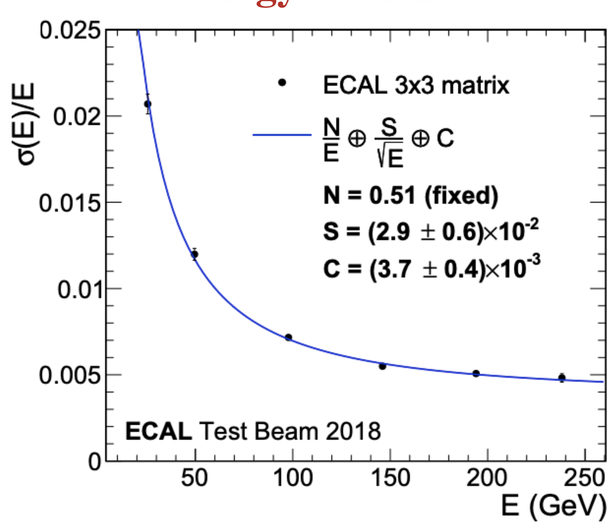
Spikes are unwanted signals generated by direct ionisation with energy deposition in the depleted silicon bulk of the APDs



The **narrower pulse shape** and the **single crystal** info at trigger level will provide much better spike rejection than in Phase-1 via shape discrimination

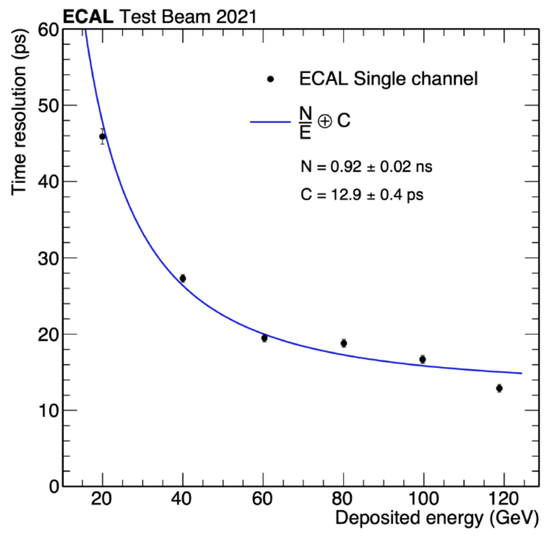
Test beams results

Energy Resolution



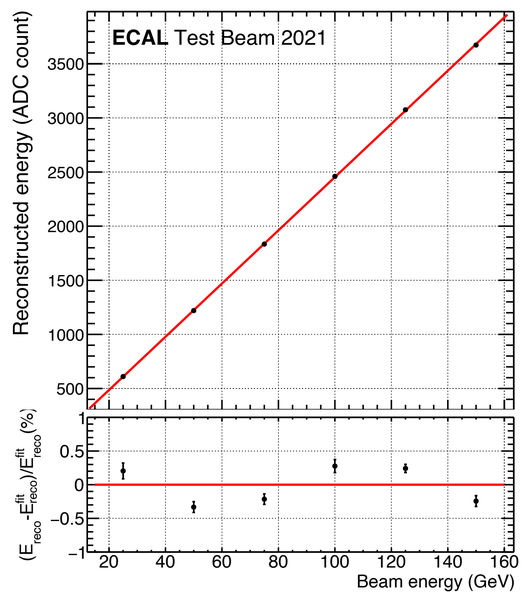
~1% @ H→γγ photon energy, matching current resolution

Time Resolution



matching design expectation of **30 ps for E > 50 GeV**

Energy linearity



Signal amplitude **linearity** with respect to the energy of the incident particle

✦**deviation < 0.3%**

References
[1] *The Phase-2 Upgrade of the CMS Barrel Calorimeters (CMS-TDR-015)*

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view poster here