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The commissioning and first results on the performance of the CMS Preshower detector

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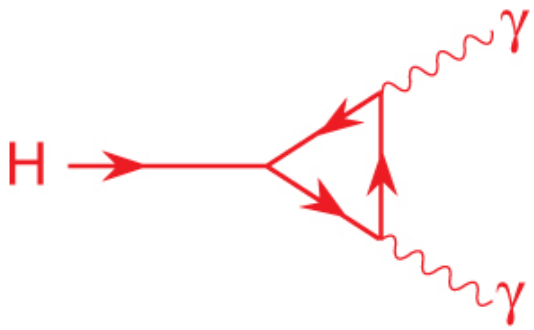
On behalf of CMS ECAL

Contents of presentation

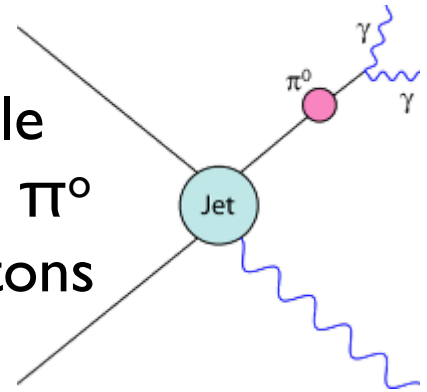
- CMS ECAL Preshower
  - Physics objective, location and structure
- Commissioning before collisions
- Results from beam splashes and collisions
- Summary

Physics Objective

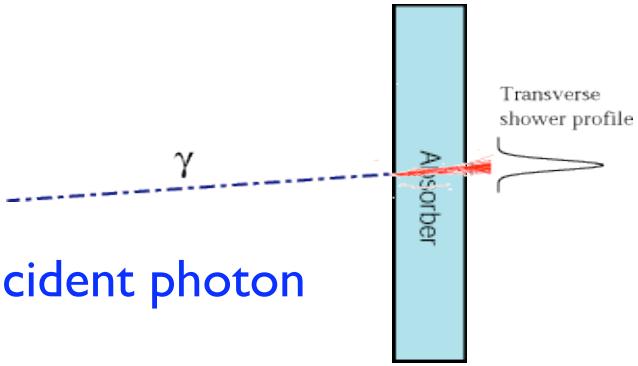
One of the main physics goals of CMS is search for SM Higgs
If m_H < 150 GeV best chance is through γγ decay



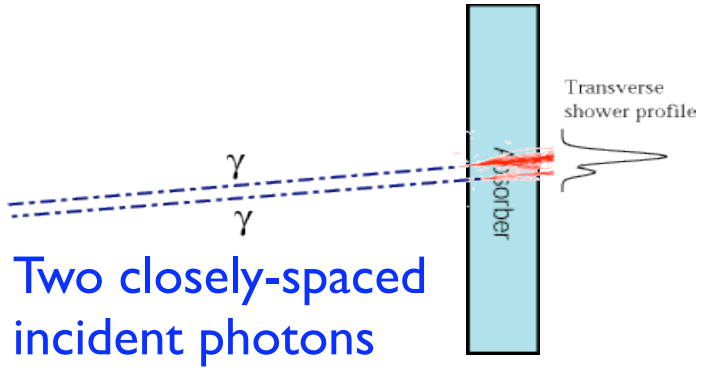
But large reducible background from π° faking single photons



Idea of Preshower:



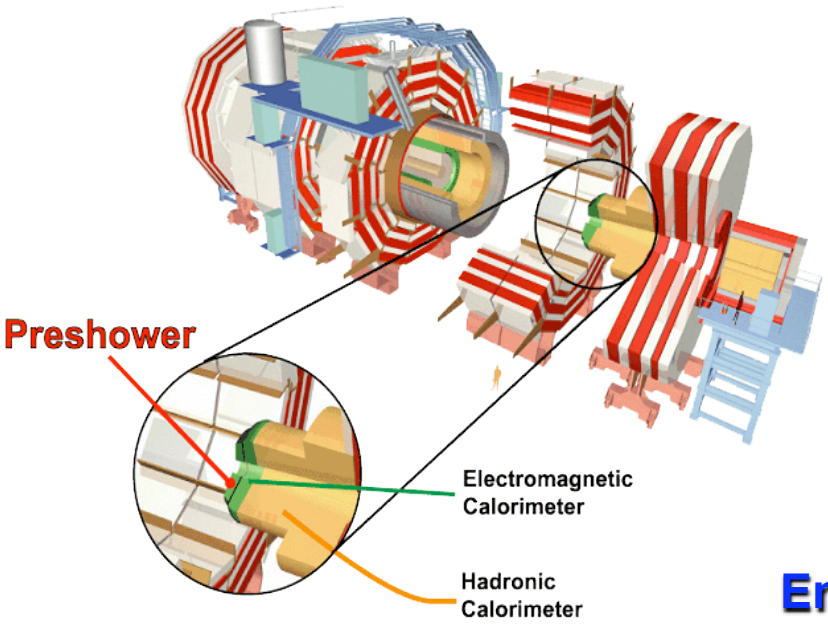
Single incident photon

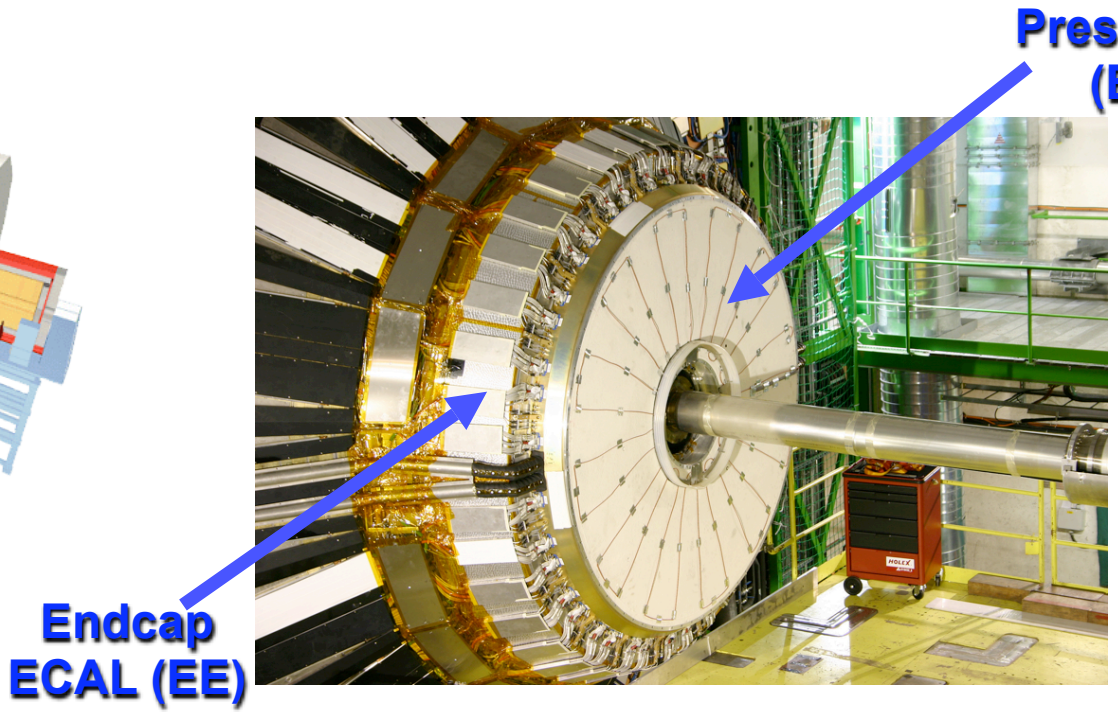


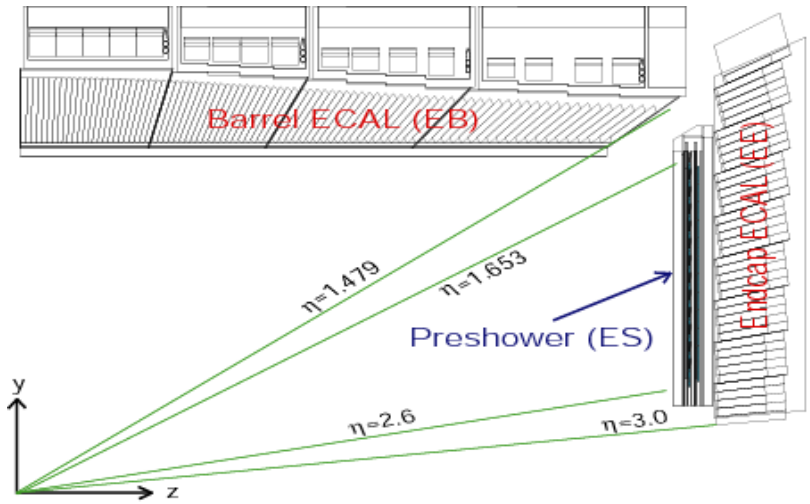
Two closely-spaced incident photons

- By adding a Preshower in front of endcap crystals, the reducible backgrounds to H→γγ search can be further reduced by about 50%

Physical Location



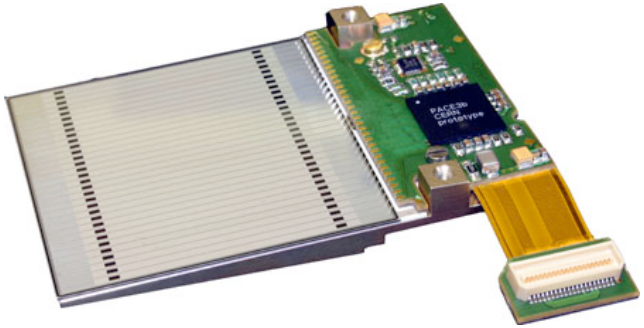




- 2.5m diameter discs, less than 20cm thick, containing 2 layers of:
  - lead absorber ($2X_0$ + $1X_0$)
  - silicon strip sensors + front-end electronics
  - mechanical supports, cooling etc.

Preshower assembly

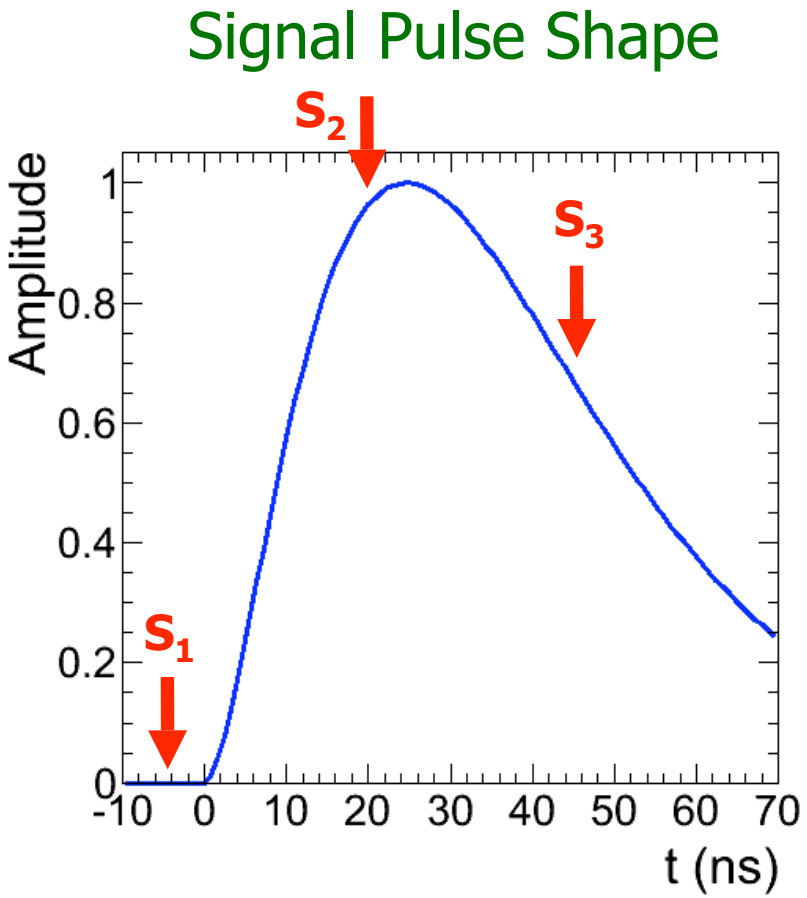
- The heart of CMS ECAL Preshower : 4288 silicon μ-modules
  - Silicon sensor : 6.3 x 6.3 cm^2, 310 μm thick, 32 strips
  - Custom front-end electronics



$17m^2$ of silicon sensors arranged in an X-Y grid

The largest EM sampling calorimeter based on silicon ever built !

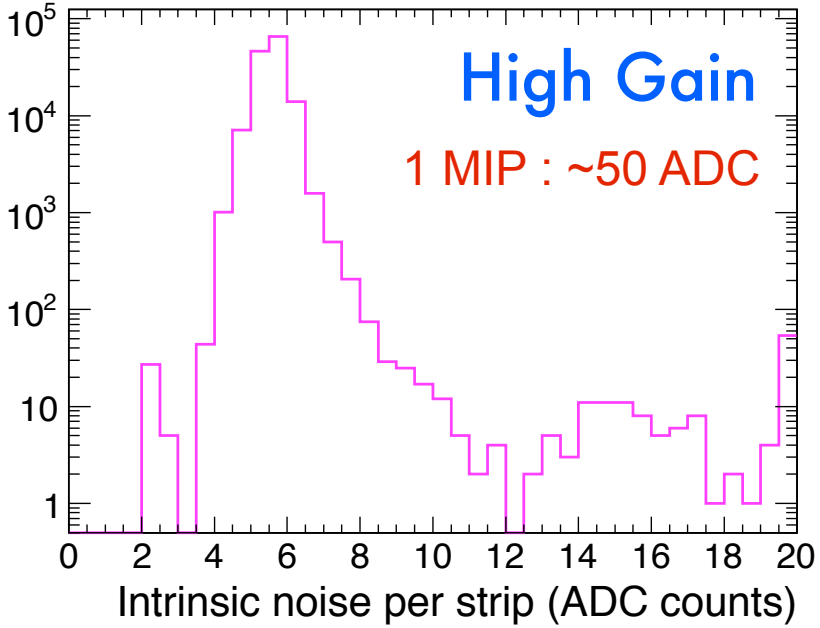
Readout electronics scheme

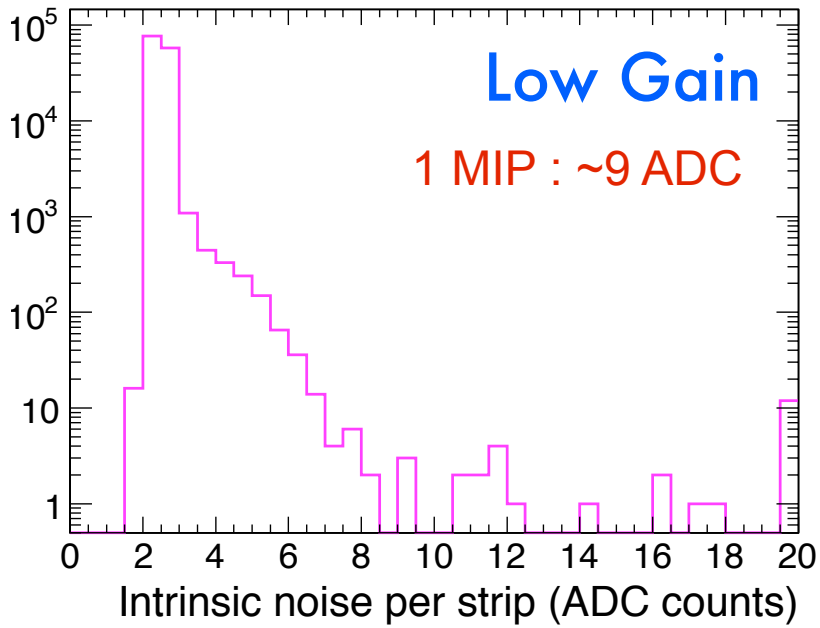


- Number of channels : **137216**
- amplified & shaped; sampled every 25 ns (S_1 for pedestal subtraction and S_2, S_3 for signal reconstruction)
- digitized by 12-bit ADCs
- Two switchable gains
  - **High gain** (0→70 MIPs) for absolute calibration and low energy LHC running. S/N is about **10** for a MIP.
  - **Low gain** (0→450 MIPs) for "high" energy running. S/N is about **3** for a MIP.

MIP : the energy deposited by a high energy charged particle traversing the 310μm silicon sensor.

First commissioning : Noise level





- > 99.88 % of channels functioning perfectly

(64 strips are not biased and 100 strips have intrinsic noise > 15 ADC counts in high gain so are masked from the readout)

- agrees with test beam performance (presented in Calor '08)

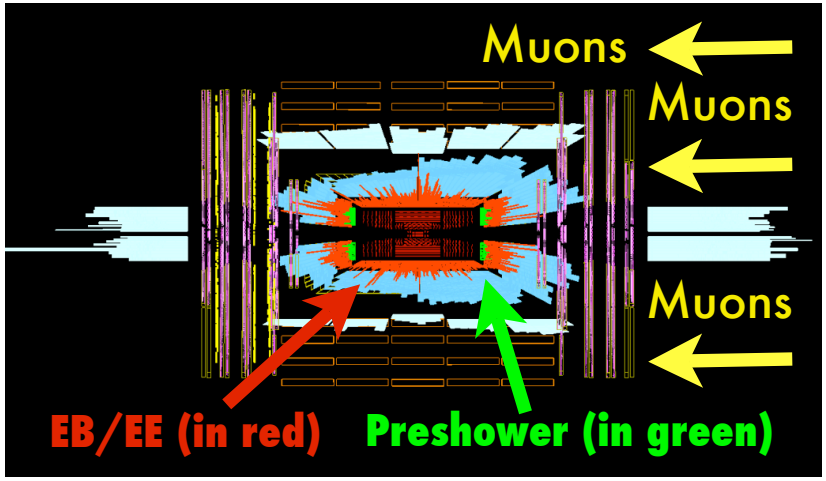
Response to Beam Splashes '09

- Beam splash : beam was deliberately dumped on collimators 150m away from CMS, producing spray of 2ndary particles

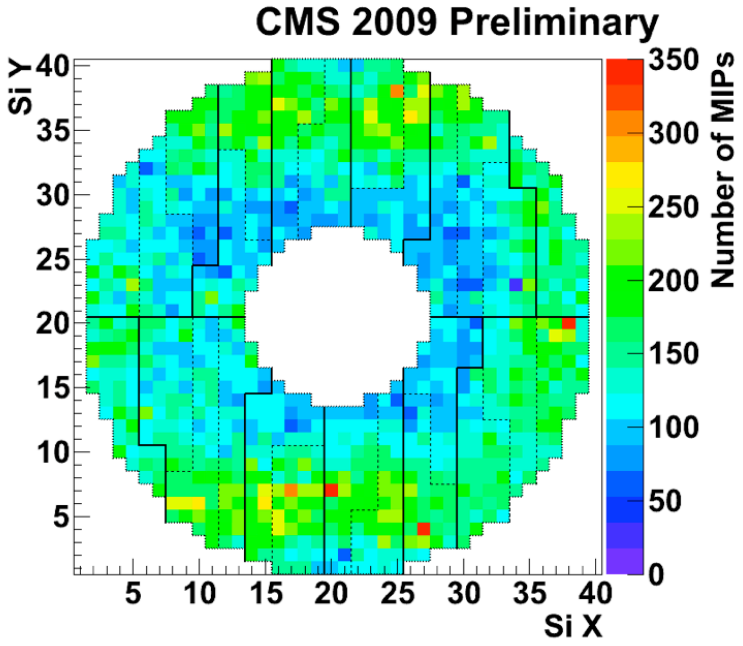
- average particle flux is about 5 muons per cm^2 for a "splash" event. Preshower signals
  - consistent with results from other detectors
  - isolated hot spots attributed to muon bremsstrahlung

- improve Preshower timing adjustment

- improve EE crystals inter-calibration

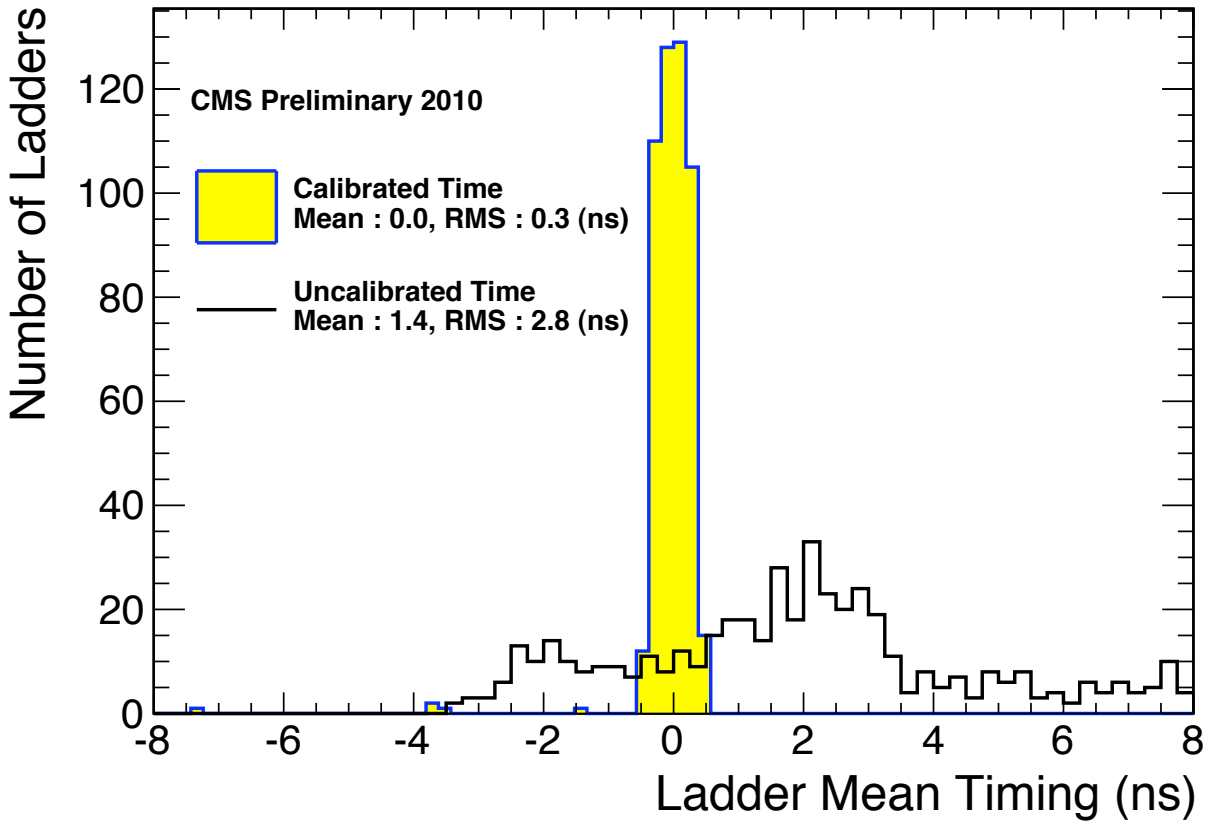


ES- Front



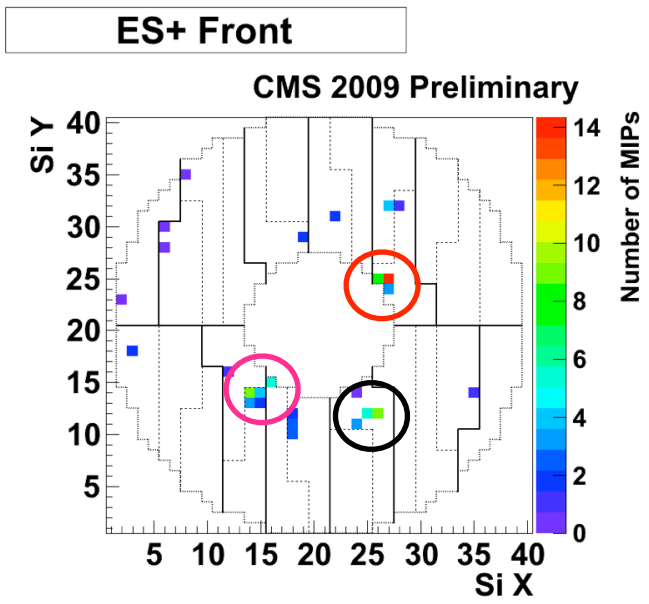
Timing Alignment

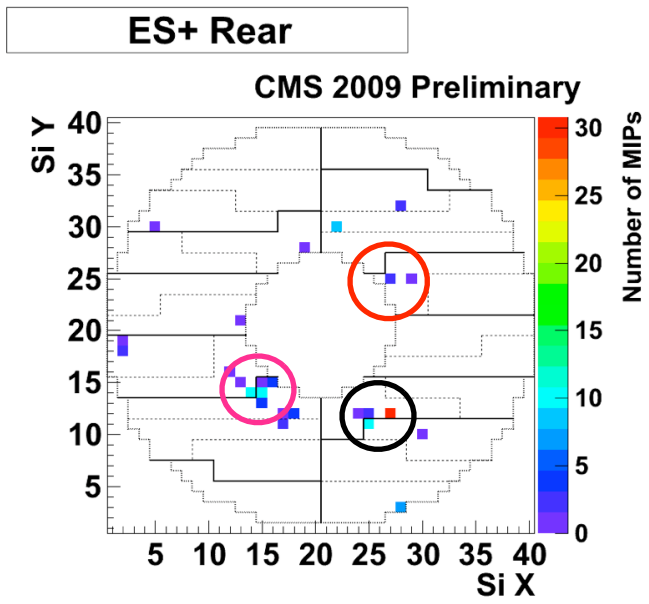
- Started with CMS cosmic ray data taking
- Beam splash data provided time synchronization of Preshower silicon sensors and used for LHC startup
- Improved with collision data

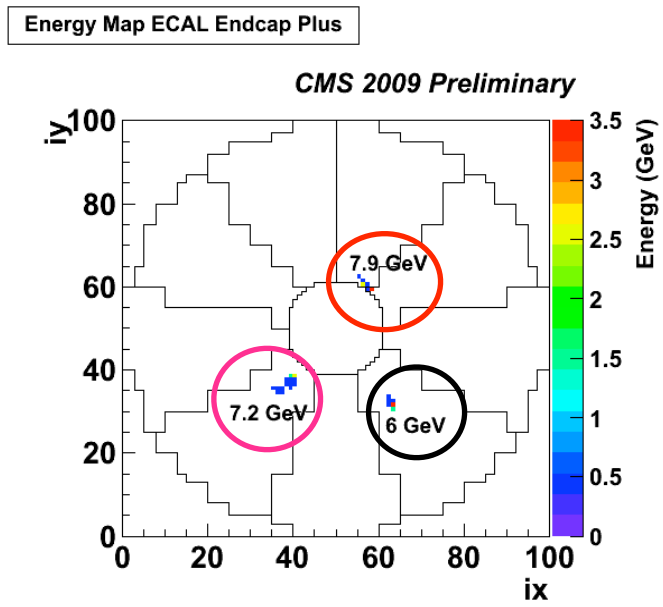


Nov 23rd, '09 : first 900GeV collisions

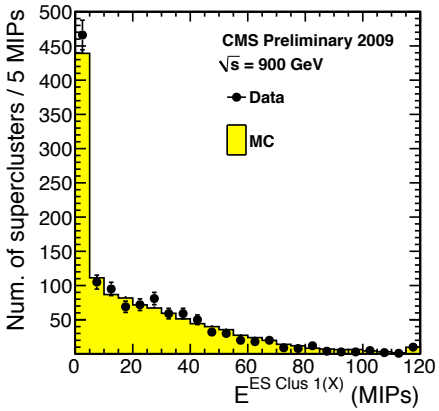
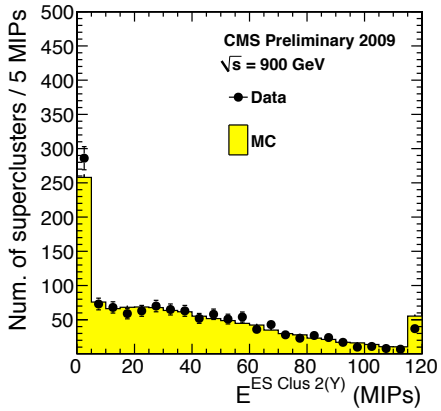
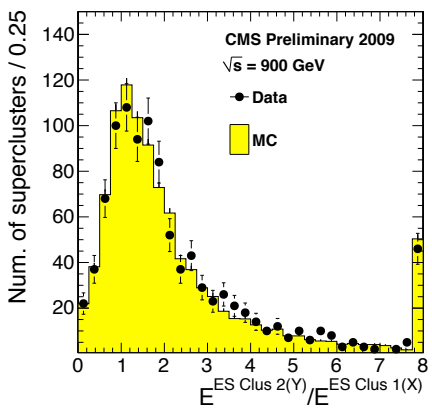
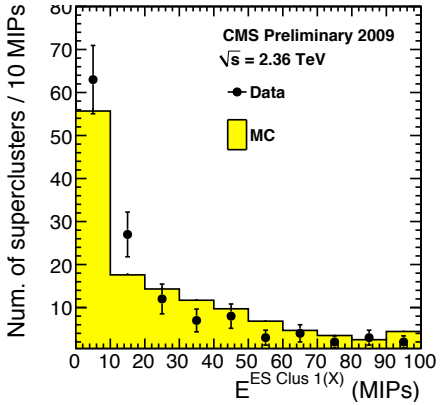
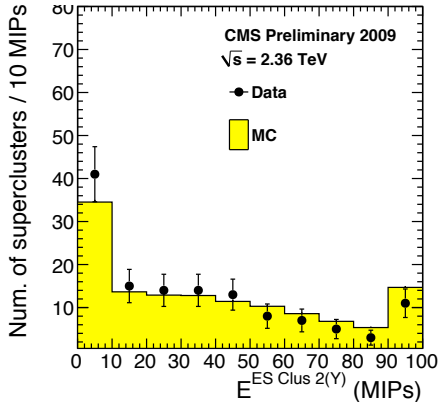
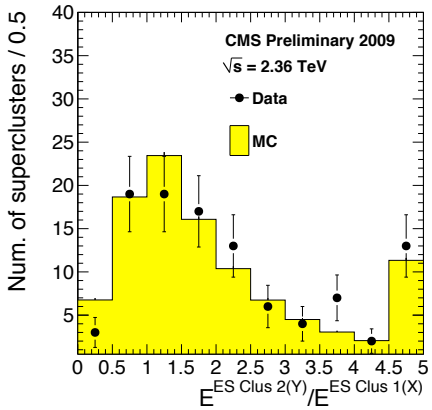
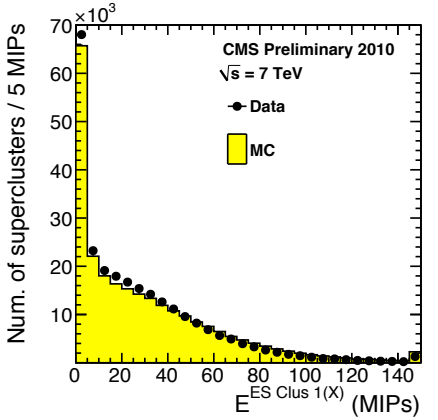
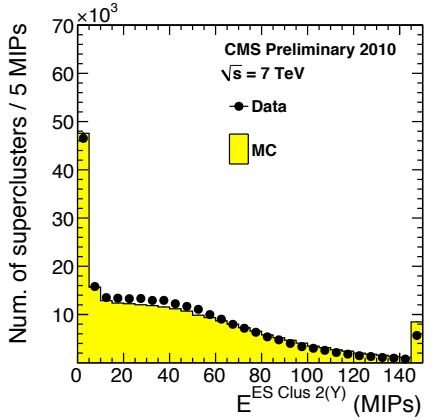
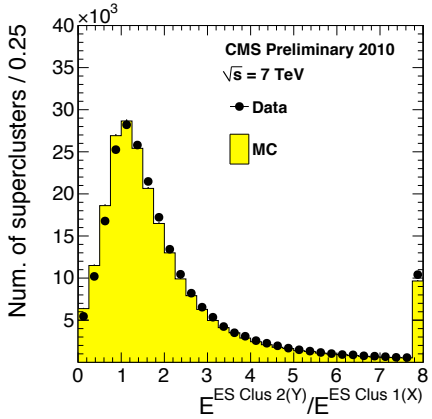
- Cluster matching between two Preshower planes and ECAL crystals
  - start from the significant amount of energy deposit in CMS EE crystals
  - extrapolate back to the origin and find the intersection on Preshower planes
  - open a search window and find the energy deposit within it





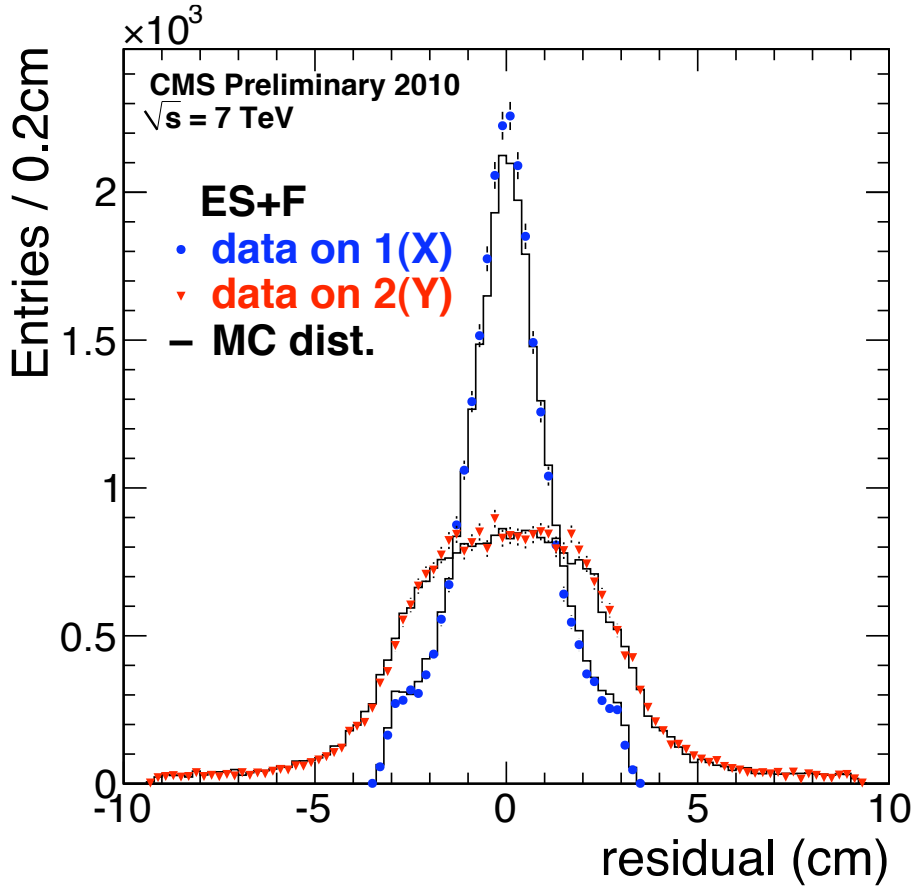


Energy deposit on Preshower planes

	Plane 1	Plane 2	Plane 2 / Plane 1
900 GeV			
2.36 TeV			
7 TeV			

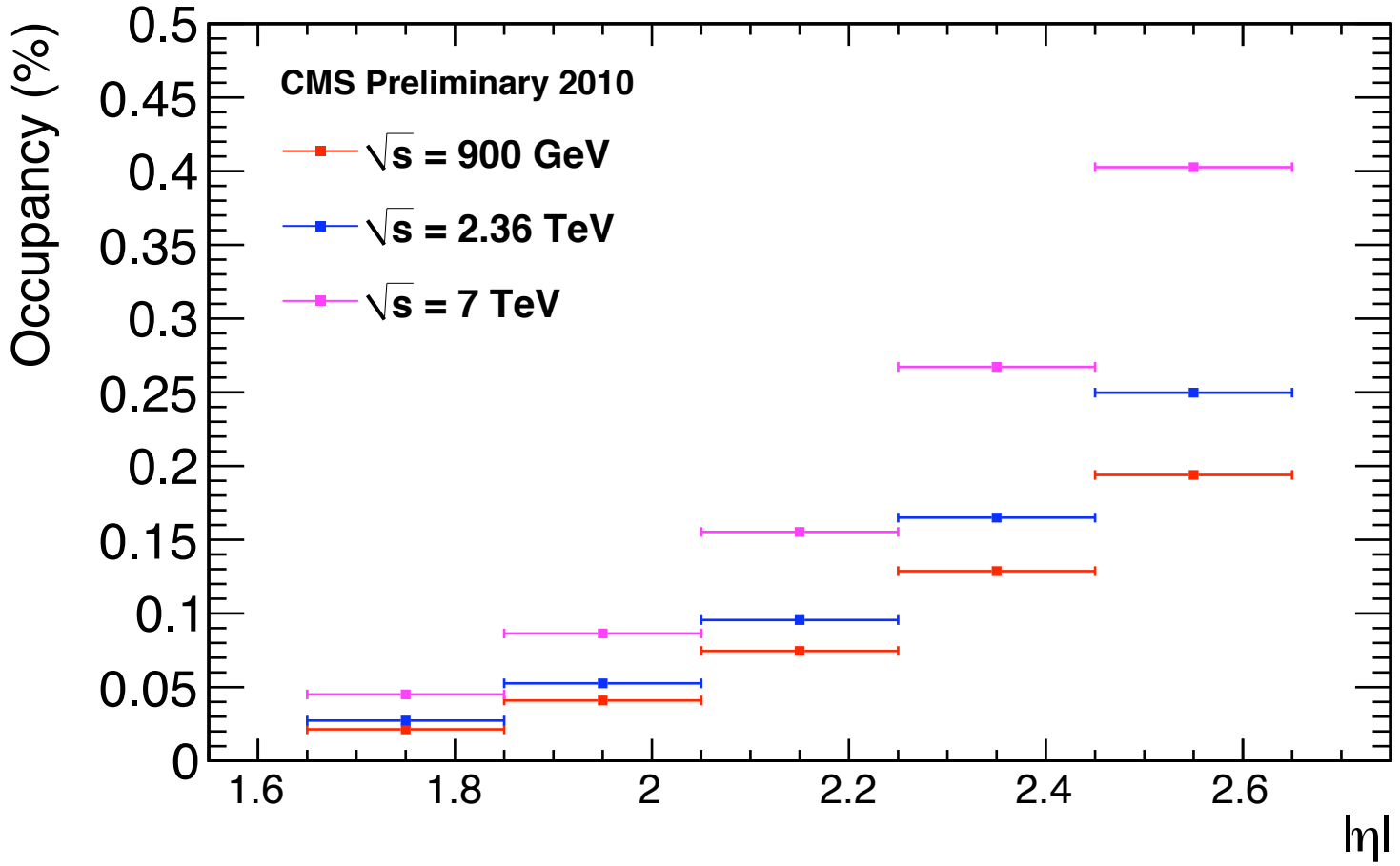
Position Correlation of EE-ES clusters

- Each ES plane measure X or Y with good resolution
- Residual distribution between most energetic Preshower (ES) cluster and seeded EE basic cluster shows alignment between EE and ES better than 2mm
- Residual widths dominated by low-energy particles in clusters - will decrease to less than 1mm when samples of high energy electrons/photons available



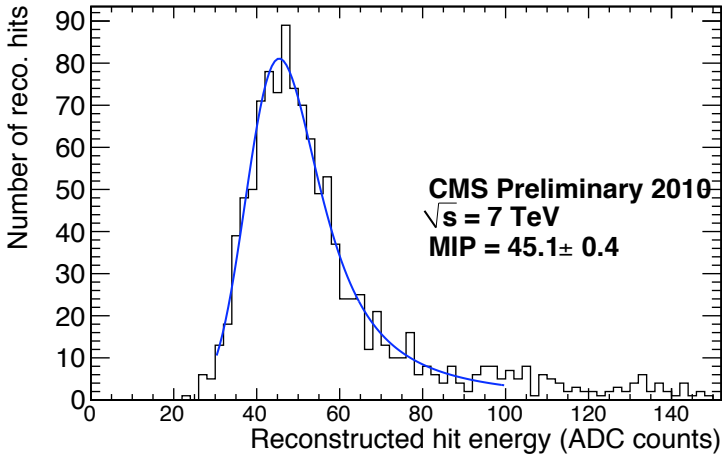
Occupancy for MinBias events

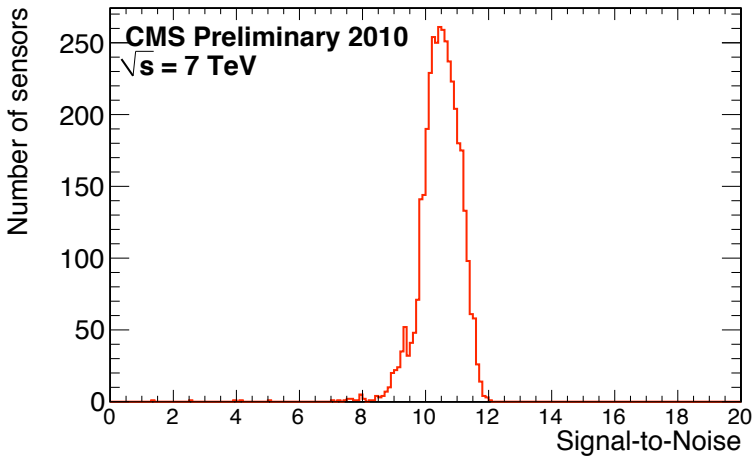
- The occupancy is defined as the percentage of strips with a signal at least $4\times\sigma^{noise}$
- The occupancy increases as a function of η and $\sqrt{s}$

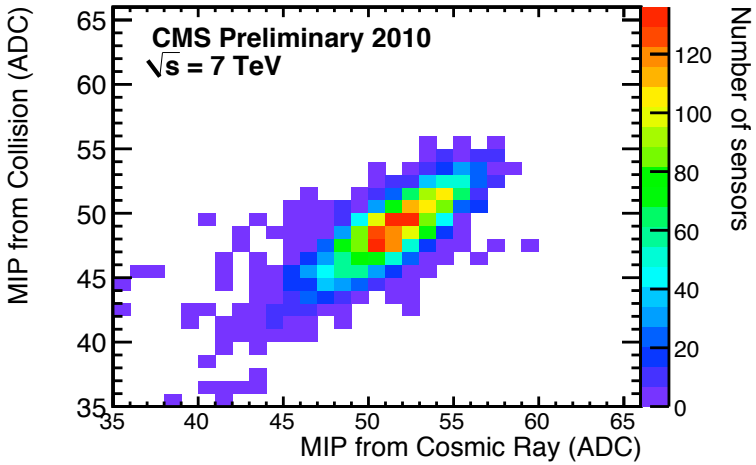


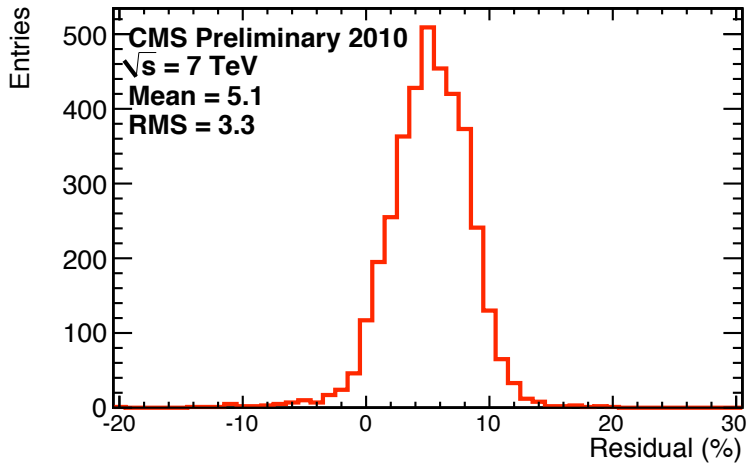
First in-situ MIP calibration

- The accuracy of MIP pre-calibration using cosmic rays : 2.5% (requirement : 5%)
- Use charged tracks with p > 1GeV to point to Preshower and find the associated hits
- Signals are corrected by the incidence angle
- Precision of first in-situ calibration is around 3.3% w.r.t. the pre-calibration









Summary

- CMS ECAL Preshower is fully operational at the CERN LHC
  - Installation and commissioning done in April 2009, according to schedule
  - 99.8% of channels are functioning perfectly
- Data recorded during cosmic ray data taking and beam splash used to provide initial time adjustment in preparation for LHC beam
  - Improved with LHC collisions
- Preshower successfully recorded collision events at LHC
  - Nice agreement between data and MC for energy deposit on Preshower planes and position correlation of Preshower-crystal
  - Occupancy grows as a function of η and $\sqrt{s}$, as expected
  - First in-situ MIP calibration has been carried-out, achieving required accuracy

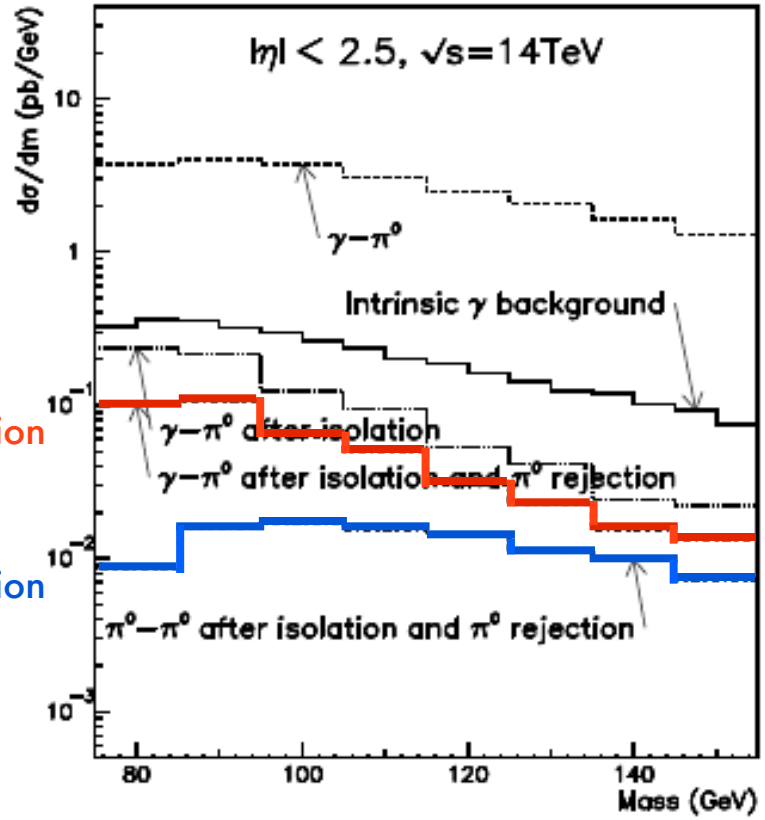
Supplement Materials

Physics Objective

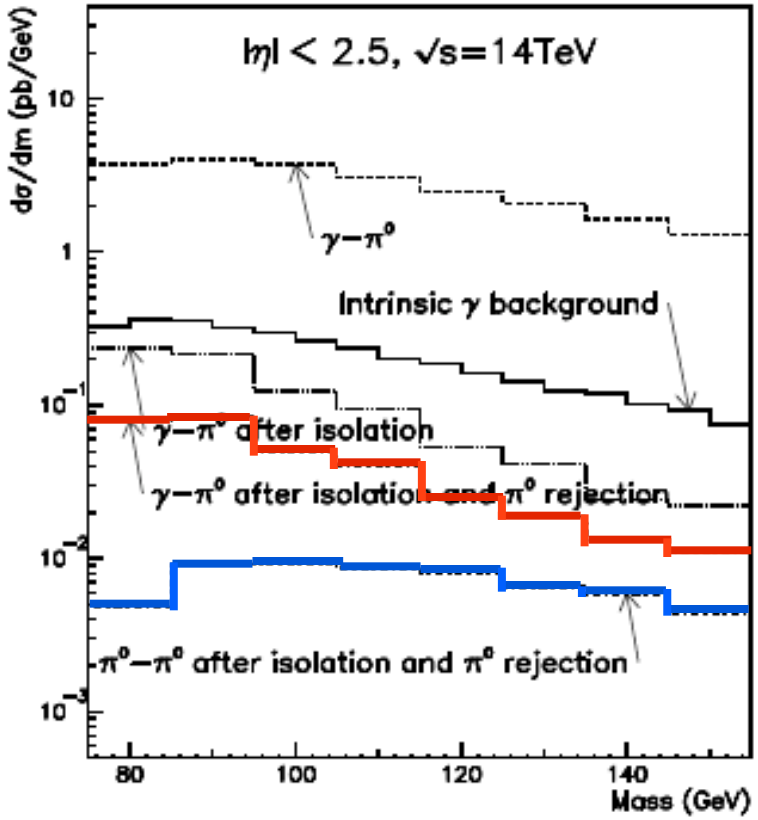
- By adding a Preshower in front of endcap crystals, the reducible backgrounds to H→γγ search can be further reduced by about 50%

γ-π°
isolation + π° rejection

π°-π°
isolation + π° rejection

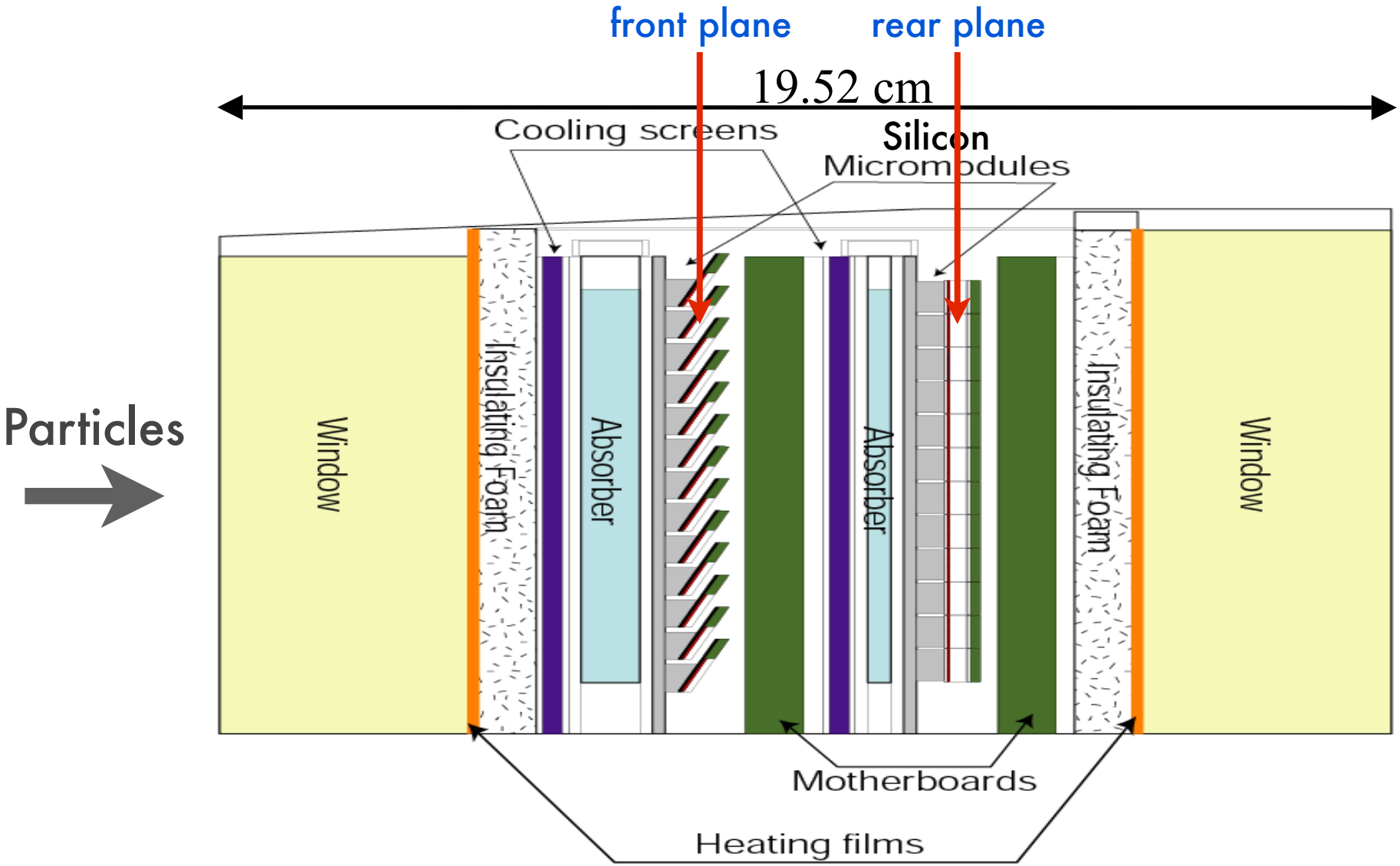


Crystals in endcap



Crystals + Preshower in endcap

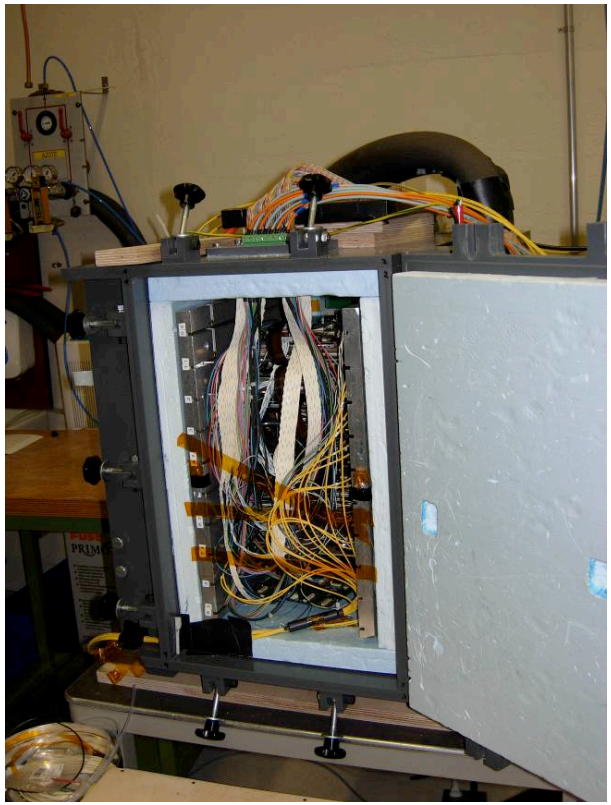
Internal Structure

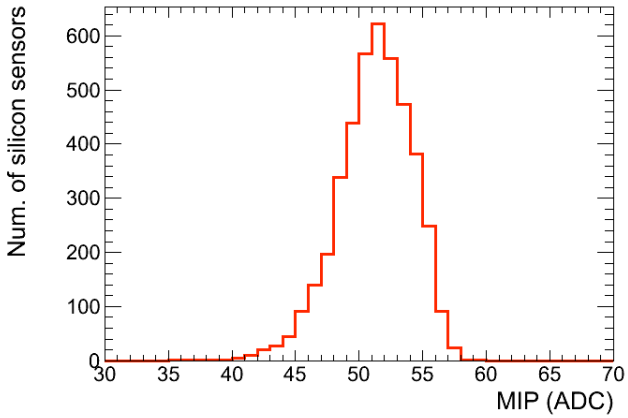


Total $3X_0$ for particles at $|\eta| = 1.7$

MIP Pre-calibration before installation

- MIP calibration requirement : **5%**
  - MIP varies from sensor to sensor and strip to strip due to silicon thickness, the particle incidence angle, the gain of electronics and the charge collection efficiency
- As part of our extensive testing procedure
  - Operating temperature : -15℃
- All silicon modules underwent "cosmic-ray calibration" for 24 hours (also serves as a first burn-in)
  - MIP calibration accuracy estimated to be **2.5%** for 24-hours of running





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