Calibration and Performance of the CMS Electromagnetic Calorimeter in LHC Run2

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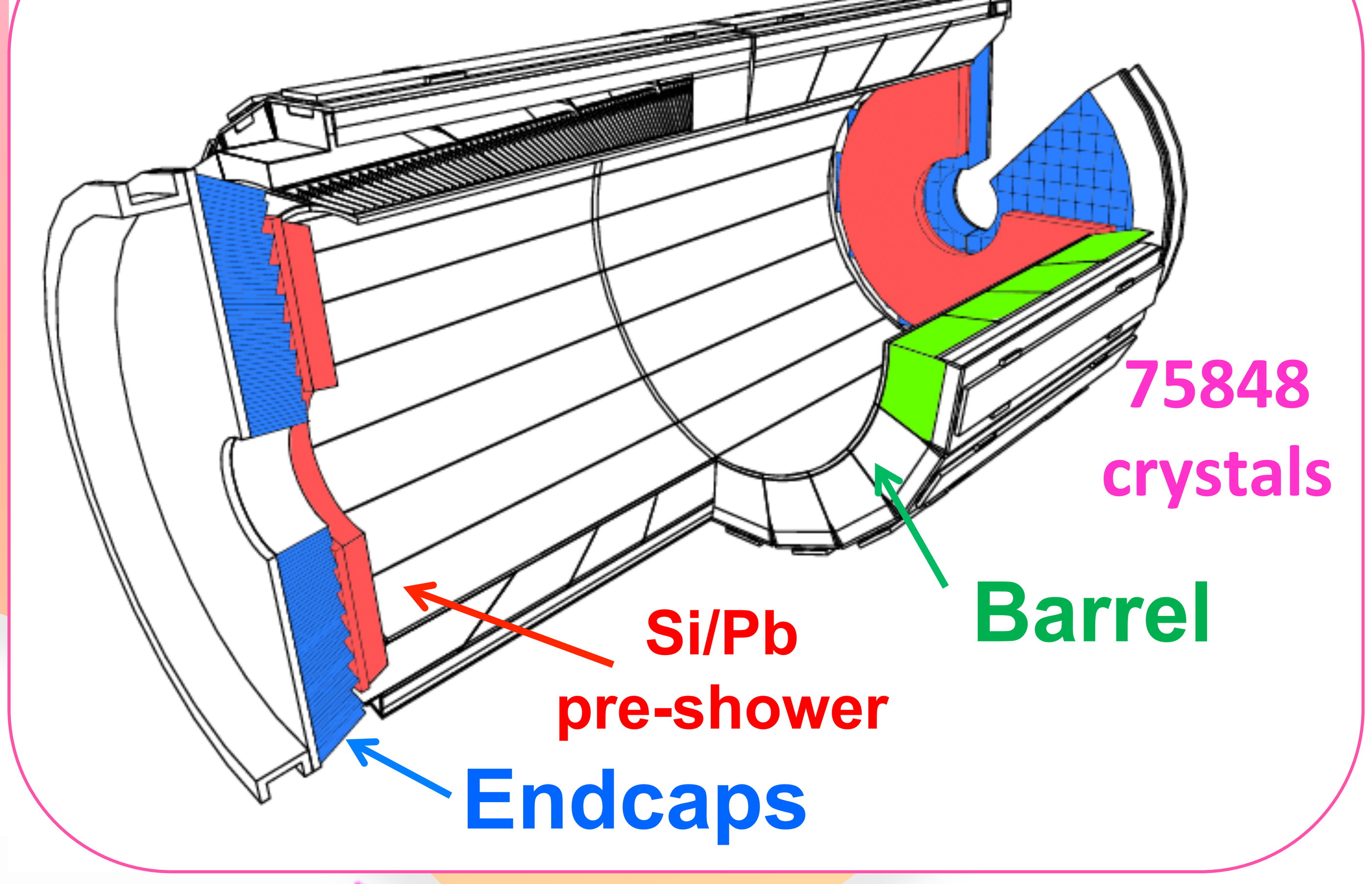
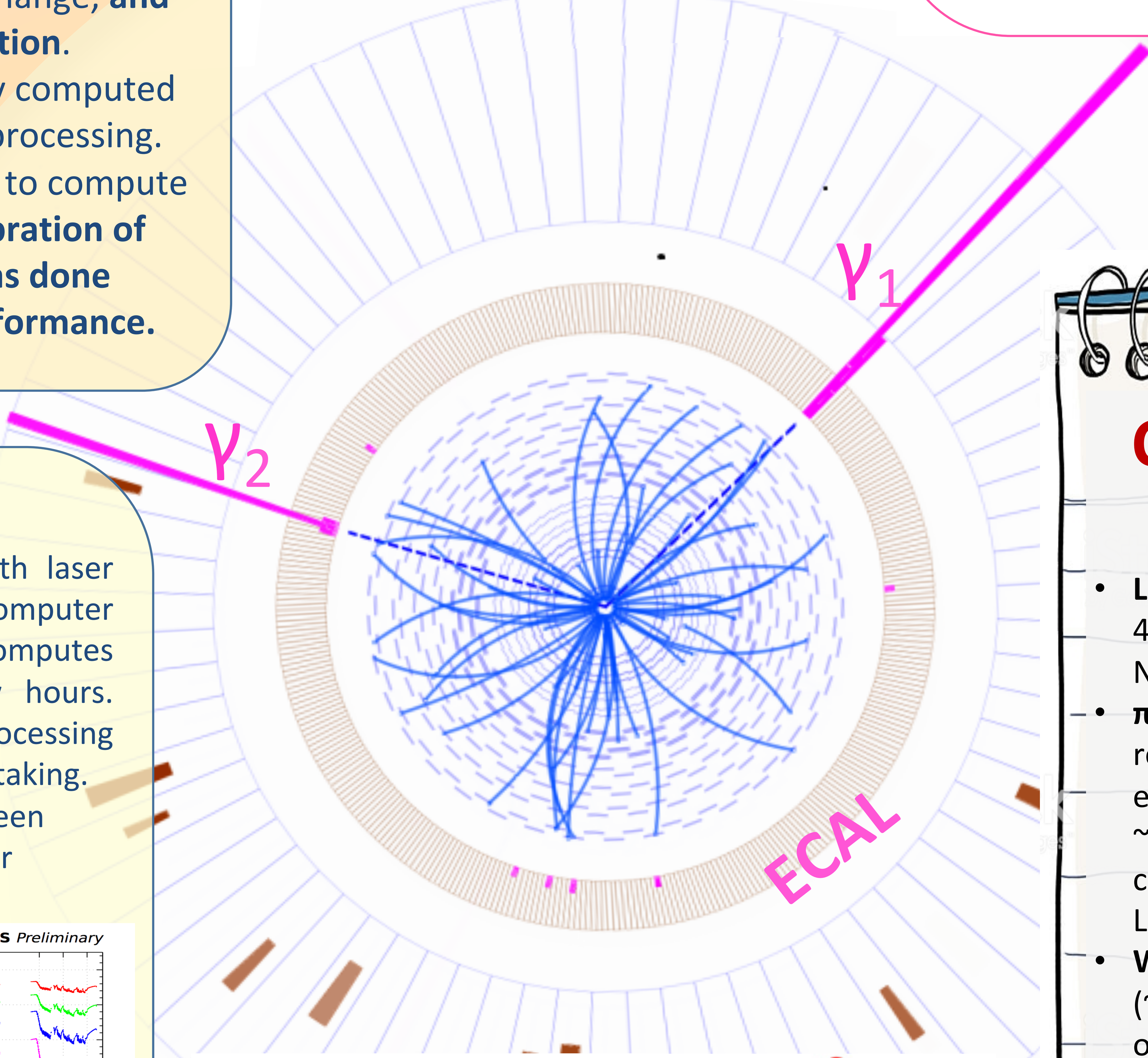
Introduction

The CMS experiment at the LHC is equipped with a scintillating crystal calorimeter, made of about 75000 crystals. It is the largest crystal calorimeter ever built for a high energy physics experiment. The energy resolution is fundamental for many physics analyses, in particular for the Higgs boson decay in two photons (see one candidate event below).

CMS ECAL

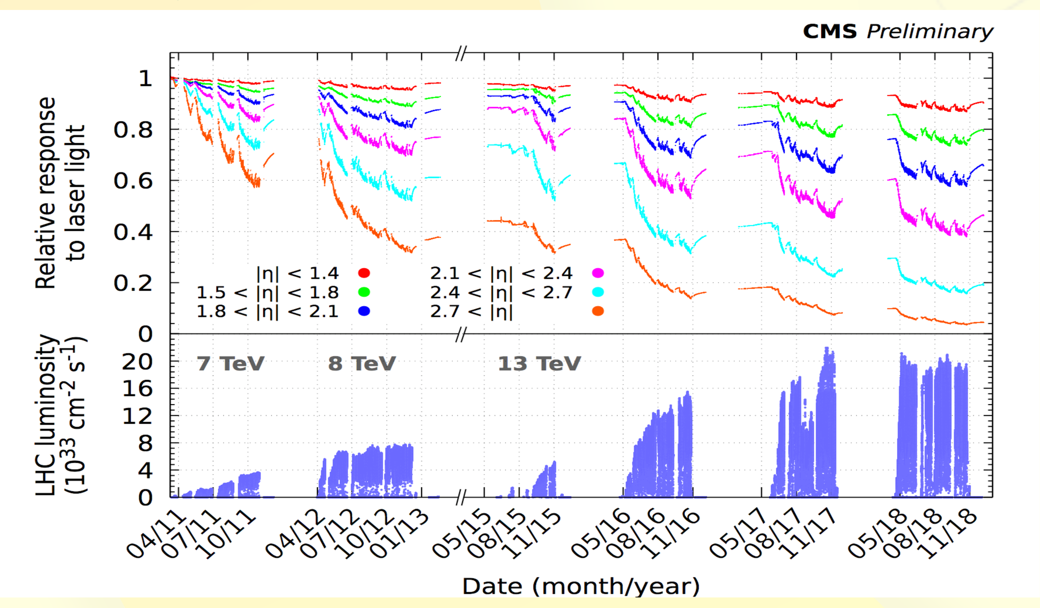


Crystal calorimeters require constant monitoring to correct for environment effects and radiation induced light output change, **and periodic channel-to-channel calibration**. Monitoring corrections are promptly computed and are available for prompt event processing. The full statistics of one year is used to compute the calibrations. **A full detector calibration of the Run2 data (2016-2017-2018) was done during 2019 to achieve optimal performance.**

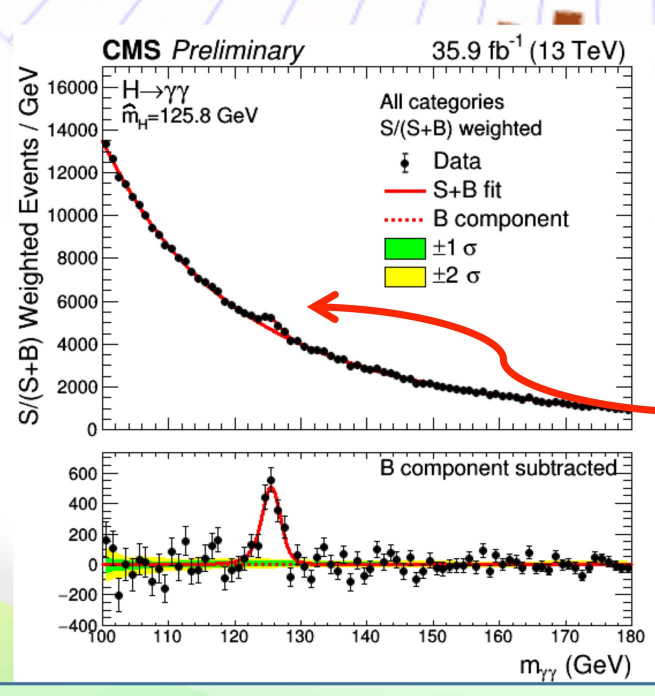


Monitoring

Crystal transparency is monitored with laser light during data taking. A dedicated computer farm processes the laser data and computes the transparency corrections in few hours. These are then used for the prompt processing of the CMS events, 48 hours after data taking. During 2019 the whole laser data has been reanalysed to achieve excellent detector stability.



The Figure shows the evolution of the laser signal response during the years.



The H→γγ analysis requires excellent energy resolution to observe a small mass peak over a large background.

Computing aspects of the calibration

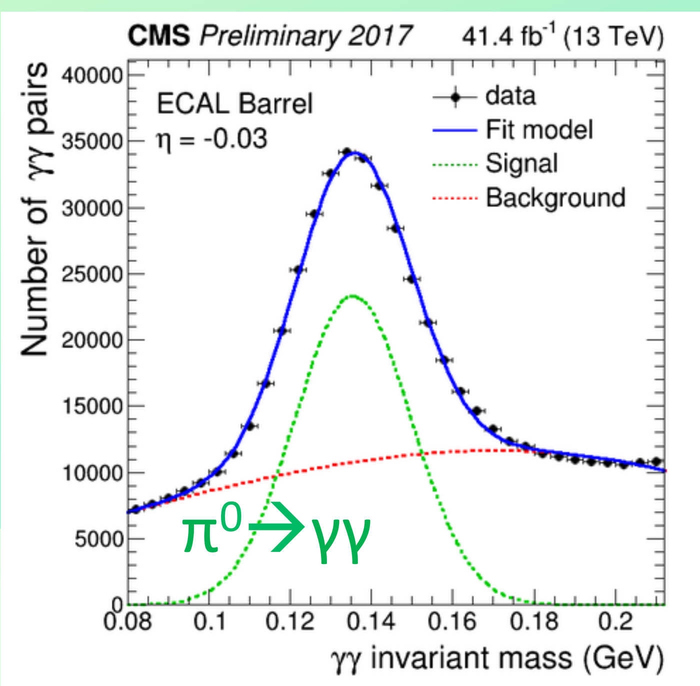
- **Laser** data are taken at 100 Hz, they occupy 40TB per year, reduced format makes 200GB. No reprocessing of the raw data was needed.
- **π^0** data are taken at ~ 7 kHz, data are saved in a reduced data format with only the ECAL hits. 1 event occupies 2kB (average CMS event size ~1MB). One year of π^0 occupies ~30 TB. The calibration takes about 2 weeks for one year on LSF or condor.
- **W/Z electrons** are saved in a reduced format (~50 TB per year). A dedicated minimal ECAL-only reprocessing is done when testing calibrations (it takes 3-4 days to reprocess 1 year on LSF or HT condor). Common root files are used by W and Z analyses (~800 GB per year).
- **It takes about 2 months per year to calculate the final calibrations and combine them.**

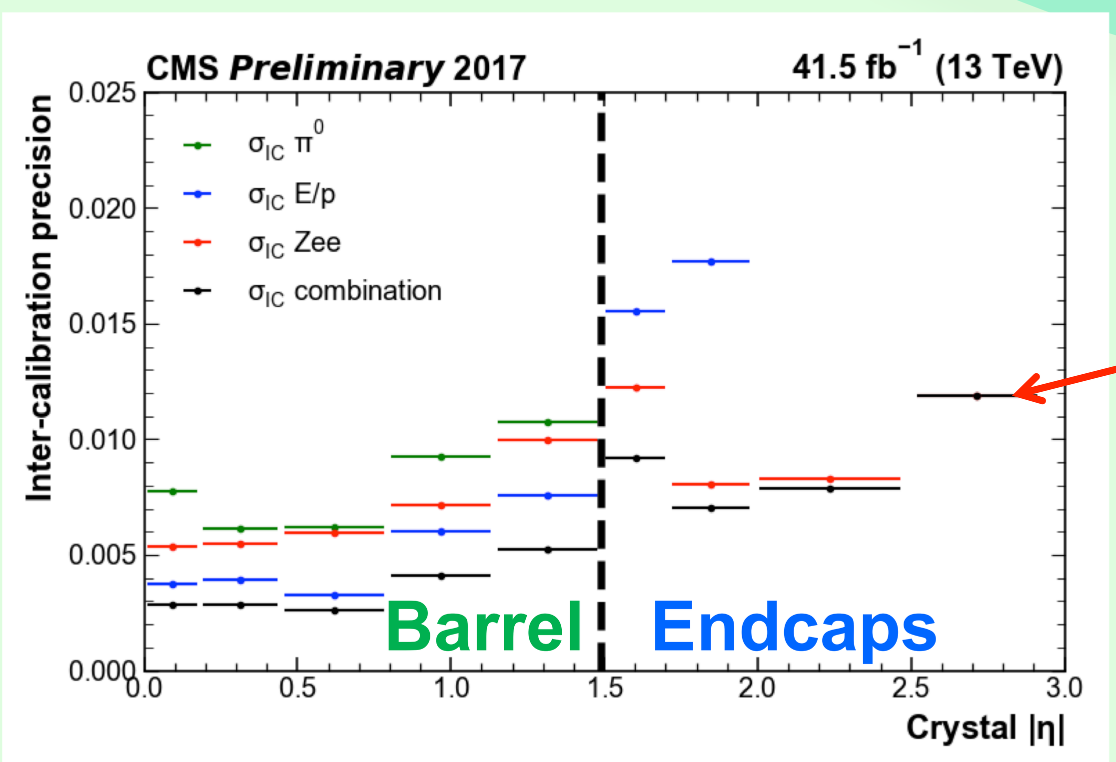
Calibration

Channel-to-channel calibration exploits physics signals:

- photons from π^0 decay using the Mass(γγ)
- electrons from W boson decay using E/p
- electrons from Z boson decays using the Mass(ee)
- azimuthal symmetry of minimum bias events

Dedicated reduced data sets are saved for each stream.

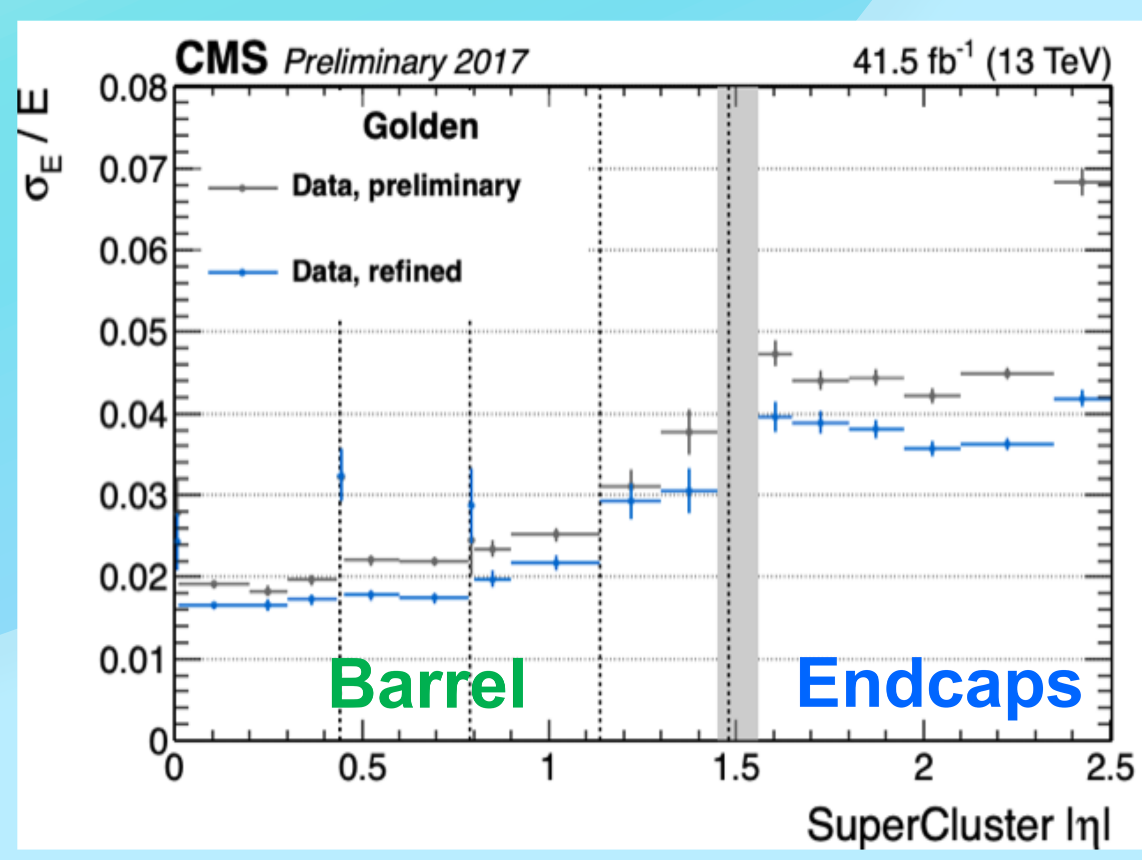




All methods are combined with a weighted mean to account for each method precision. The Figure shows the precision of the various methods and of the combination.

Finally Z→ ee events are used to set the absolute energy scale.

Results



The Figure shows the achieved energy resolution for electrons versus the position in the detector. A large improvement is observed between **prompt processing** performance and **new refined recalibration**. The effect is particularly evident for the forward region, where an excellent response stability has been restored.

view the poster here

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