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# **ECAL Performance and calibration: plans for 2017 commissioning**

24<sup>th</sup> January 2017

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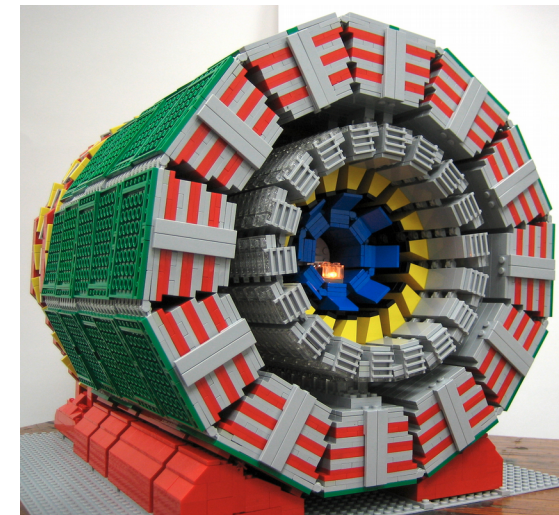
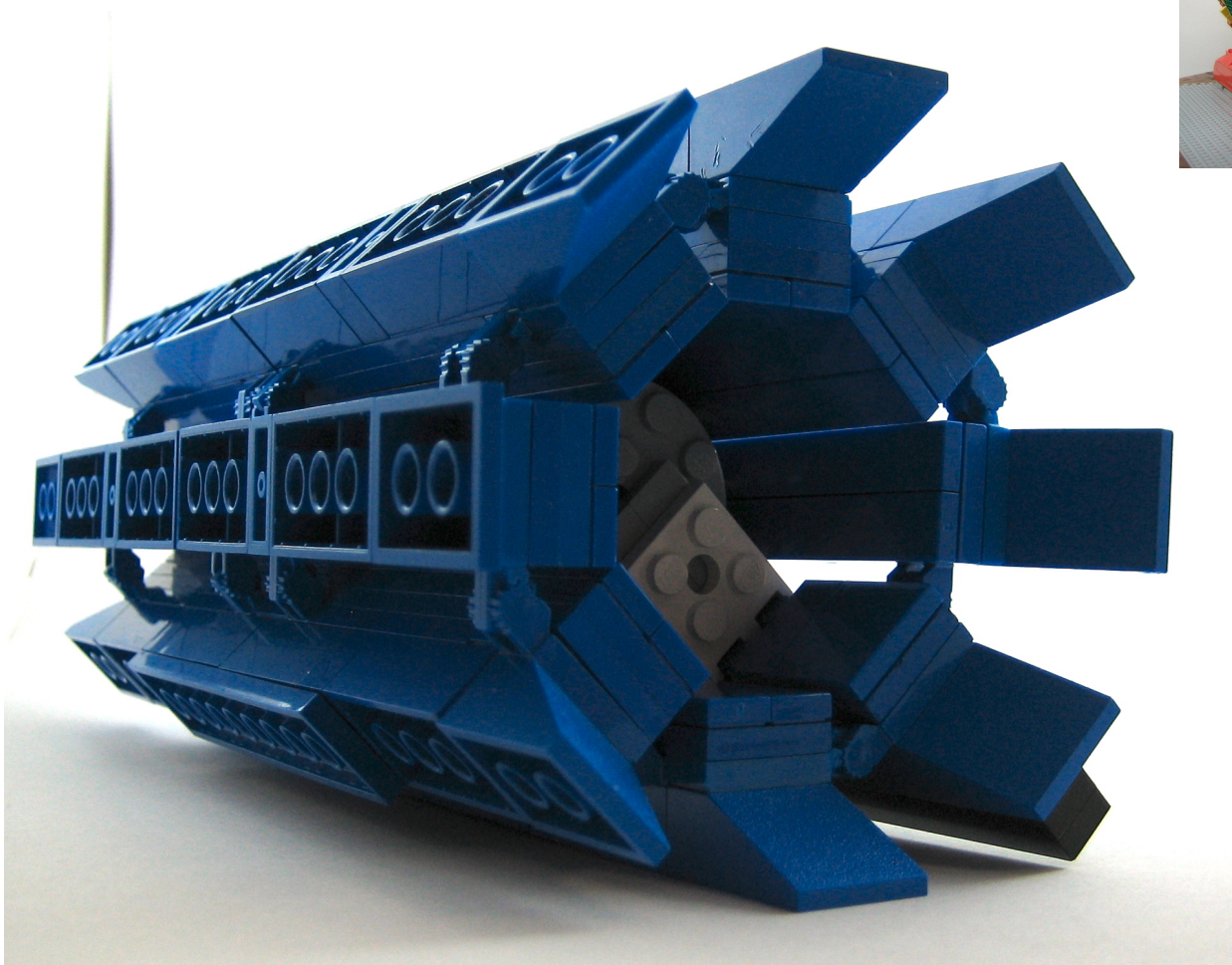
**CMS Run & DPG Commissioning Workshop**  
**<https://agenda.infn.it/conferenceDisplay.py?ovw=True&confId=12412>**

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# ECAL: 2016 and beyond

- 2016 summary
- Conditions and Legacy ReReco
- Preparation for 2017

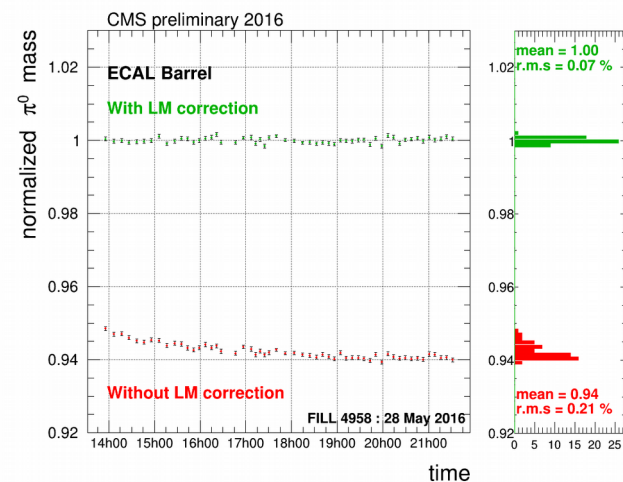
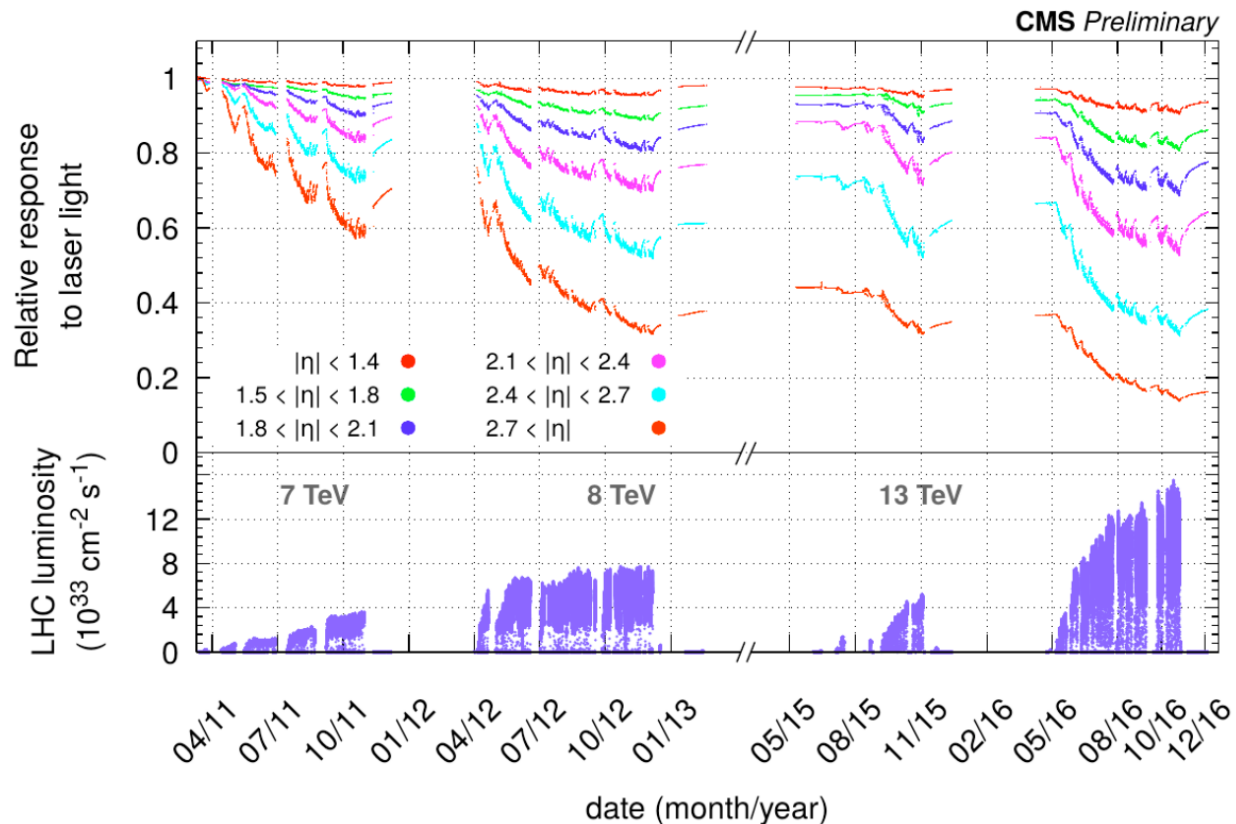
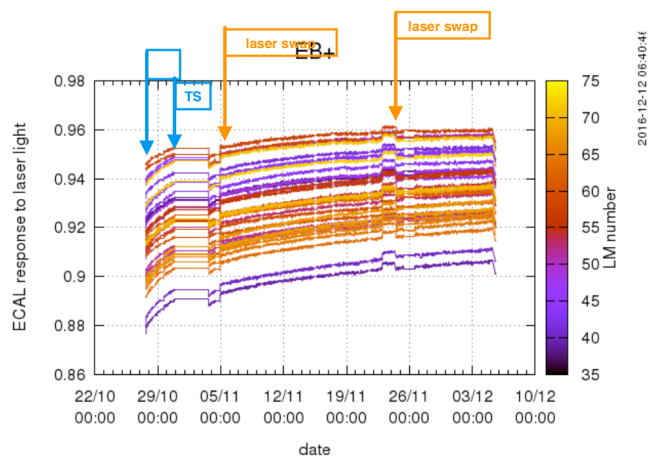




# 2016 running from ECAL DPG perspective

- **Prompt Calibration Loop (PCL):** transparency correction
  - Need of (thanks to) continuous monitor by the operators
  - We are able to detect problems and intervene within 48 hours
  - Possible pause of prompt reco in case of issues (it happened in 2016)
  - A protocol with AICa is defined in case of stop of prompt-reco
- [https://indico.cern.ch/event/546412/contributions/2216814/attachments/1298779/1938097/160627\\_AICaDB.pdf](https://indico.cern.ch/event/546412/contributions/2216814/attachments/1298779/1938097/160627_AICaDB.pdf)

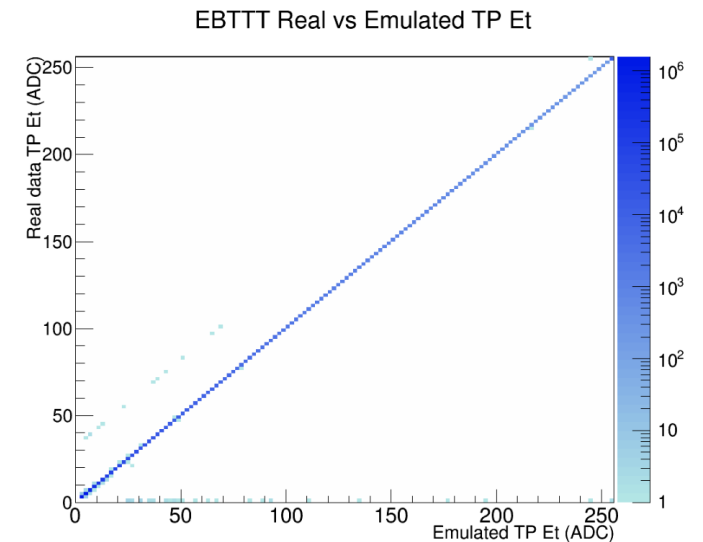
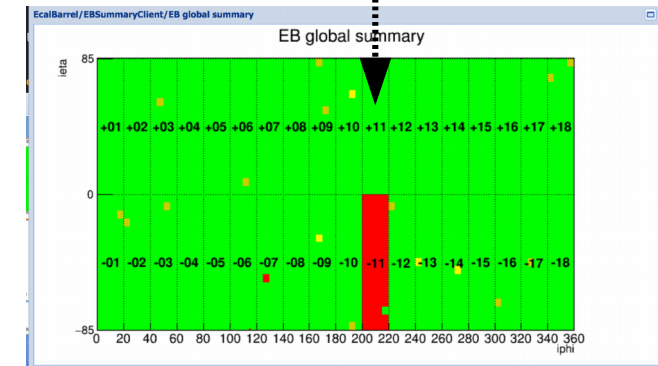
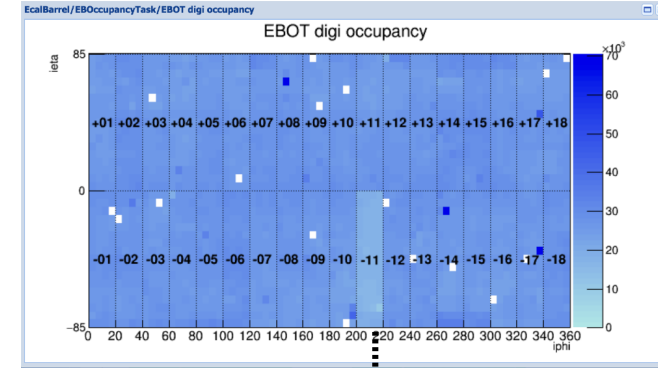
- Corrections monitored also with  $\pi^0$  and E/p
- PN Test Pulse drift observed in July  $\rightarrow$  corrected in 23Sep ReReco





# DQM status and improvements

- Introduced **new alarms** to **alert DQM shifter** immediately if an entire supermodule starts to produce invalid data.
- Added plots to monitor the behaviour of the **Trigger Primitives**
  - TT Flag plots as requested by the trigger team, who used these plots in the **commissioning** of a new feature that enables ECAL to mask noisy towers 'on-the-fly' (i.e. without having to reconfigure)
  - Plot of correlation between **emulated** and **observed** trigger primitives Et. A mismatch might signify problems in the trigger timing.
- Added plots to monitor **changes vs LumiSections**
  - Plots of the fraction of channels in each supermodule that are bad, as a function of the lumisection
  - Duplicates of a few key plots that refresh their contents by lumisection rather than accumulating statistics. This helps experts by providing a snapshot of the latest condition of the detector rather than waiting until the next reset
- Added plot of correlation between rechit occupancy in the **positive side** and rechit occupancy in the **negative side** of EB, and in the near and far side of EE. A discrepancy in this plot could indicate potential problems, including, for example, voltage issues in one of the endcaps.
- **For 2017, work in progress:**
  - **Timing** plot vs **BX** and vs **LS**, to monitor changes and check LHC time







# Failure scenarios

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- Lesson learned from failure scenarios and actions taken
  - Study back in 2010, still valid: <https://twiki.cern.ch/twiki/bin/view/CMS/EcalFailureScenarios2010>
  - In **2016**: < 1% of Lumi lost ([https://docs.google.com/document/d/12G7zoRu0brNdm\\_Odl1OxD4CUHEwGe\\_D9R1QWNanFLPM/edit](https://docs.google.com/document/d/12G7zoRu0brNdm_Odl1OxD4CUHEwGe_D9R1QWNanFLPM/edit))
    - Main failure mode is one or more EB/EE FEDs **out of the run**
      - Run is BAD
      - One run with missing **Trigger Primitives** from a single EB FED
        - was considered “good” by L1 DPG, but should be detected quickly and run stopped if it occurs again.
        - Should not keep running in this state
      - We invalidate LS with ~8 **Trigger Towers** that have data integrity issues due to SEU
        - Ok, if rate remains low
      - **ES FED** issues (few FEDs kept out of the run):
        - Run is GOOD, but careful off-line treatment of ES planes energy → ECAL DPG/EGamma

new



# 2016 update of conditions

## Regular updates of the conditions:

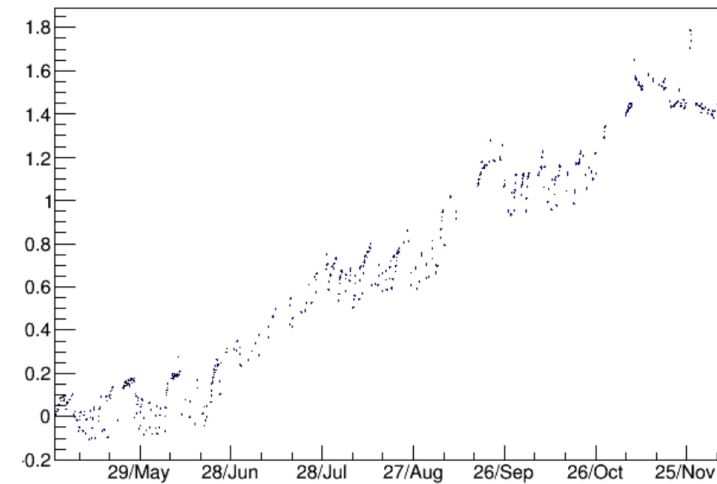
### Pedestals

- Dedicated runs to monitor the pedestals in different gains
- Pedestals has been seen drifting during time: fast drift during LHC fill and slow drift in the long period

### Pulse shapes

- Use of both lone bunch and normal LHC train to extract the pulse shape needed by local reconstruction

EB Pedestal variation

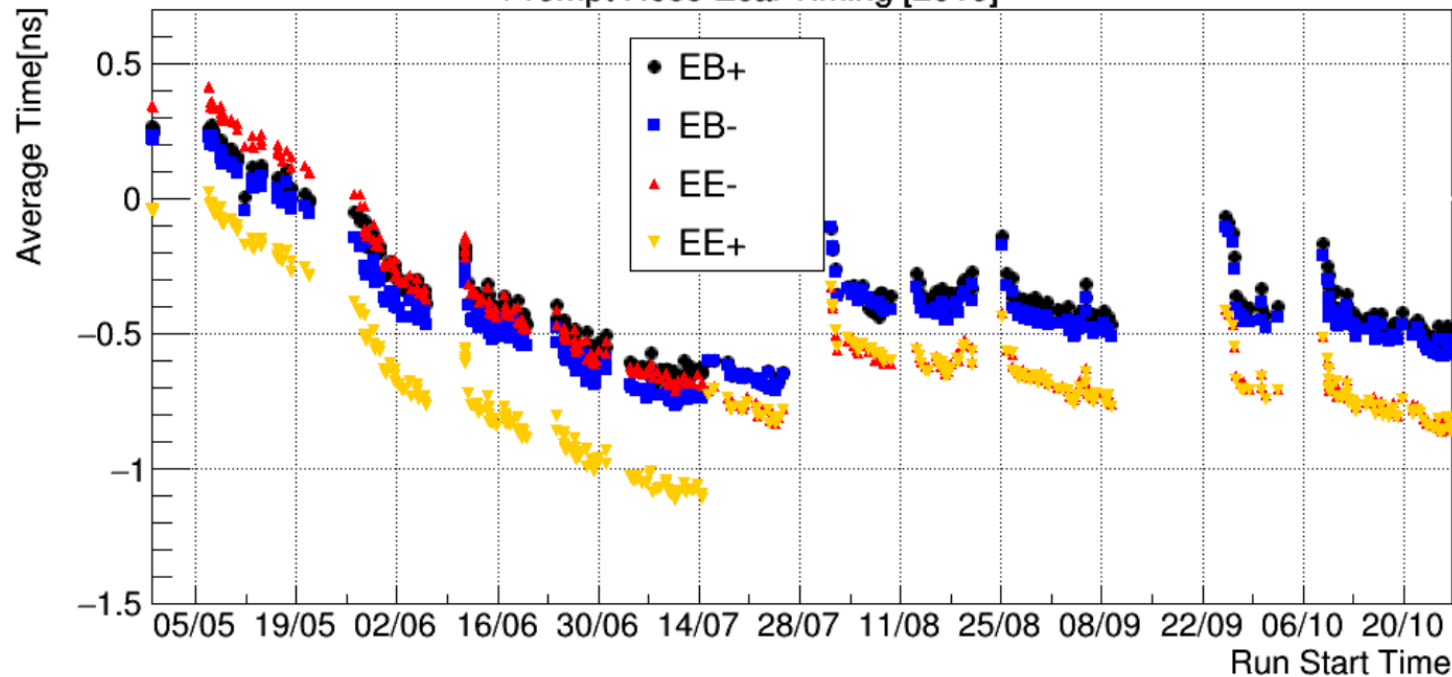


## Milestones updates:

### Timing

- Time drift observed in data → time drift gives energy shift: new pulse shapes calculated
- Time tag updated for specific analyses strongly depending on it

Prompt Reco Ecal Timing [2016]





# 2016 update of conditions (cont)

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- Milestones updates:

- **Alignment: ECAL and ES**

- Very important at the beginning of data taking, since we “open” the endcaps during YETS → electron ID/trigger
    - Continuous validation during the year to check the stability

- **Channel status**

- New problematic channels are removed: less than 0.03 % change compared to 2015

- **ES channel status**

- **ADC2GeV**

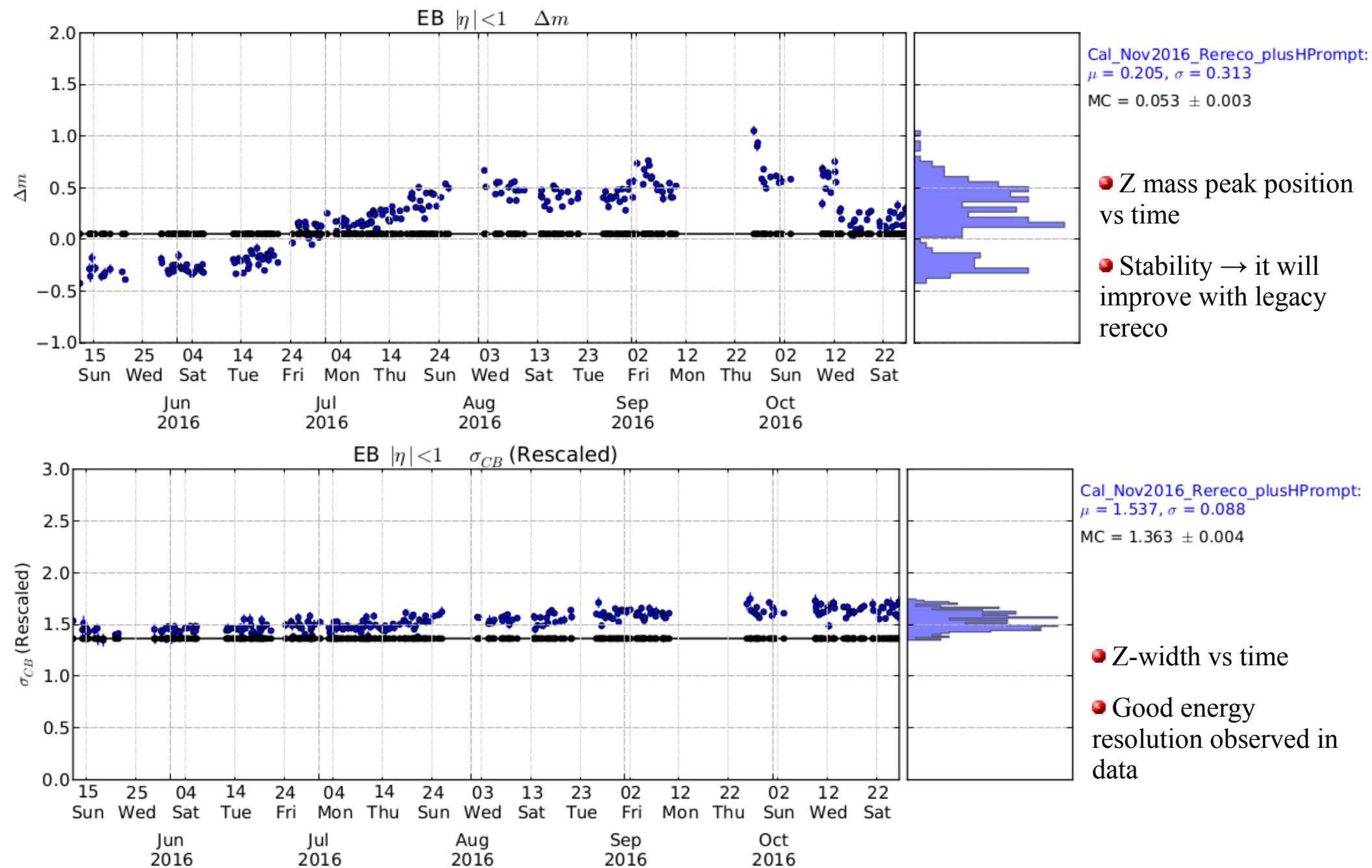
- Updated in September

- **InterCalibrations (IC)**

- Already very good performances from 2015 IC
    - No update in IC for the prompt
    - They will be updated for Legacy ReReco



# Resolution and Stability

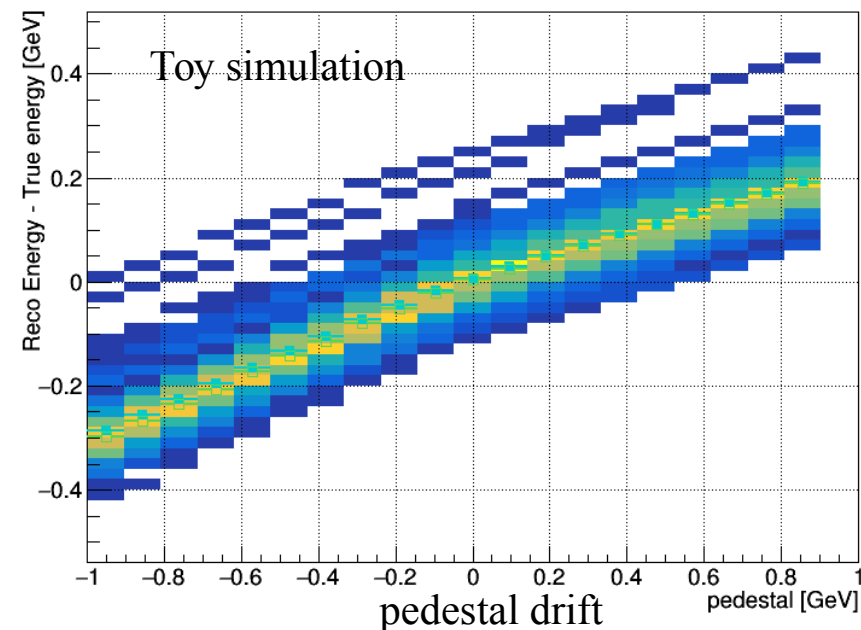
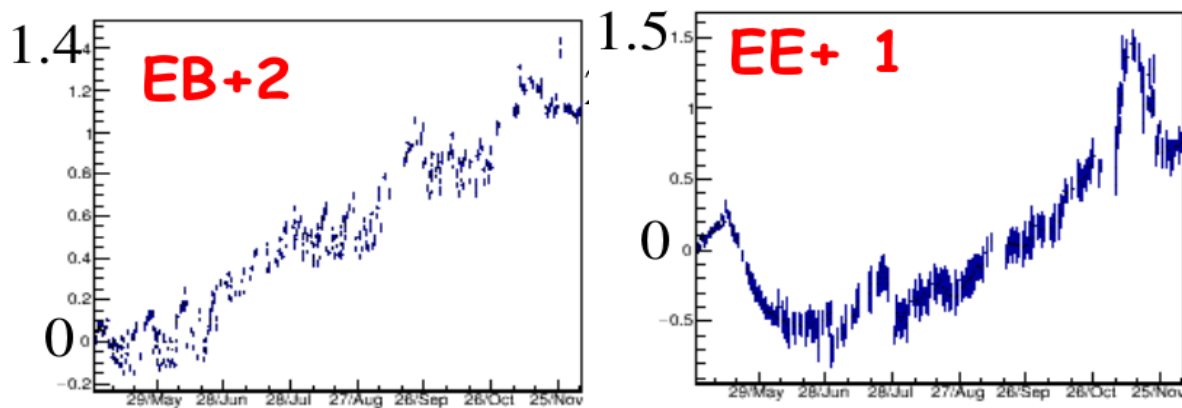






# Pedestals

- Current **local reconstruction** (multifit) assumes knowledge of the pedestal:
  - Fit 10 possible energy deposit, one every 25 ns
- Pedestal **drift** observed in data → impact on **energy reconstruction**: bias in energy
  - In 2016 prompt we corrected for that by means of special runs to measure pedestals
  - For legacy rereco we use pedestal values measured during data-taking
- Studies ongoing for modification of local reconstruction to be less sensitive to pedestal drifts in 2017
  - Different possibilities under investigation
  - CMSSW implementation ready and under validation in terms of performances and robustness



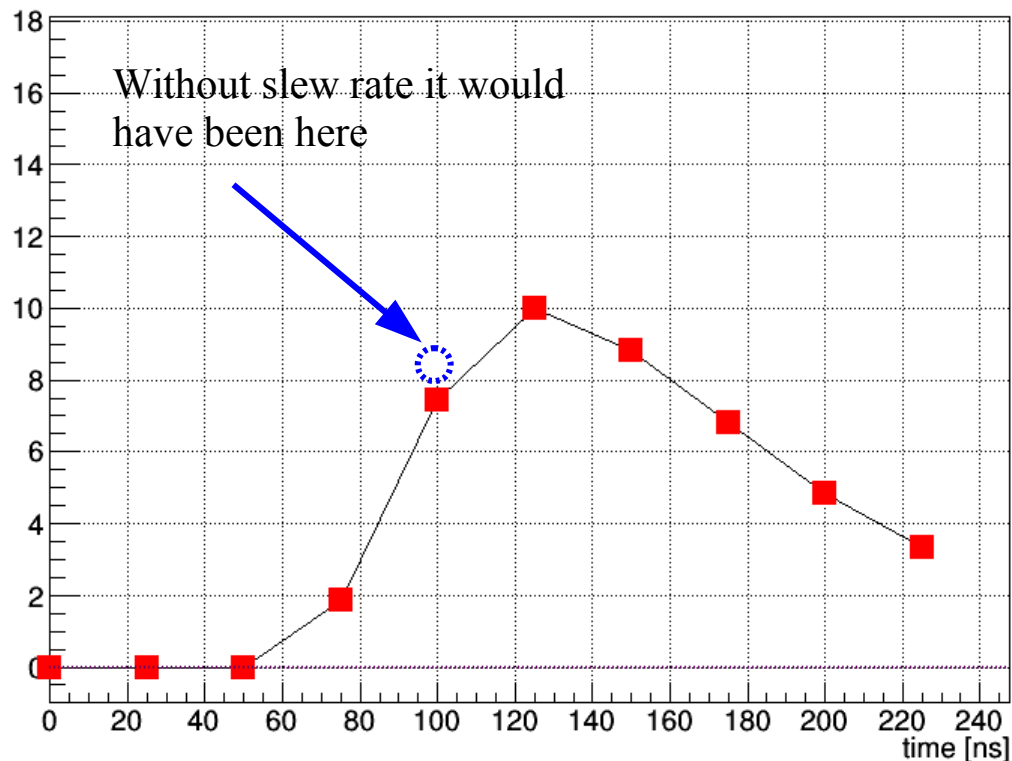


# Slew rate / Gain switch

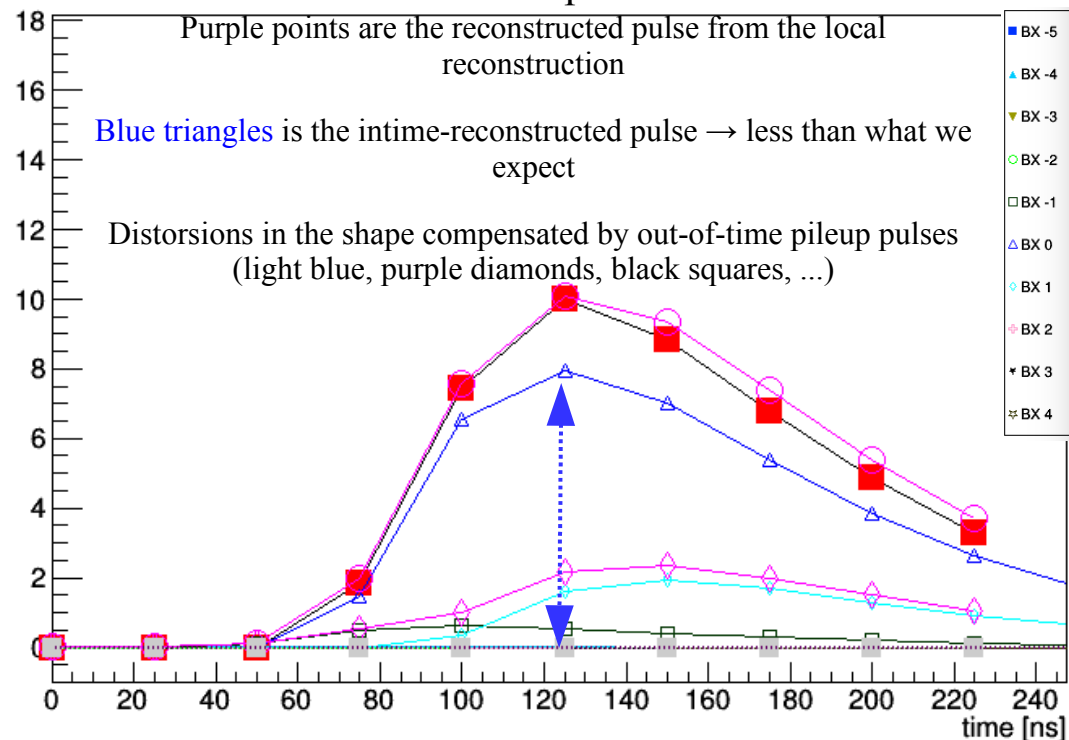
## Gain-switch / slew rate

- Non linearity of pre-amp if  $\Delta V/\Delta t$  is large, it depends on the shape of the pulse
- Effect: The pulse is distorted  $\rightarrow$  local reconstruction fits distortions as out-of-time pileup  $\rightarrow$  in-time energy reconstructed is reduced  $\rightarrow$  bias in energy
- **Fix:** different **local reconstruction** when gain-switch happens (as in Run I, max-amplitude method)
- Partial fix for re-miniaod, fix available for legacy rereco and for 2017 data-taking
- Additional changes in local reconstruction are under investigation for 2017

Pulse affected by slew rate



Fitted pulse





# Legacy ReReco

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- Status and plan for legacy rereco
  - **Pedestals drift** corrected with multiple IOV → more stable energy reconstruction
    - Time-dependent pedestals or run-dependent pedestals
  - Minor fixes in **laser** corrections
    - Removed quality cut on response ( $< 0.1$ ), affecting only high  $\eta$  region in EE
  - **Channel status** update in EE ( $\sim 10$  channels)
  - New **pulse shapes** with multiple IOV
  - New **ADC2GeV** to fix data/MC discrepancies in scale
  - New **ES Intercalibration** Constants
- New **InterCalibrations (IC)** and  **$\eta$  scale** under validation (should improve ECAL energy resolution)
  - IC depends on all aforementioned tags
  - The different workflows started:  $\phi$ -symmetry,  $\pi^0/\eta$ , electrons
  - Validations are ongoing: comparison of IC constants and optimal combination in Feb prior to AlCa sign off



# 2017 (a.k.a. now) from ECAL DPG perspective

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- **Local reconstruction** updates:
  - Improved multifit to cope with **pedestal** drift
    - Different options under evaluation in terms of performance and stability
    - Increase of pedestal uncertainty in the fit
    - Dynamic pedestal measurement
  - Fix of **slew rate** effect on local reconstruction for EB (EE is un-effected)
    - Different options under evaluation
      - Max-amplitude method
      - Ignore slew-rate affected sample in multifit
    - Technical implementation ready and pull request under validation
- **ES** software update in case of a dead layer
  - Energy shared in reconstruction between the two layers → close contact with EGamma on energy reconstruction
  - Pull request under validation





# In preparation for 2017 in P5

- Optimization of **Zero Suppression (ZS)** and **Selective Readout (SR)** thresholds

- Limitation of payload  $\sim 2\text{ kB/event/DCC}$   $\rightarrow$  limit reached in high PU in 2016

- The thresholds will change and will **increase** w.r.t. 2016

- *2016* Zero Suppression settings:

- EB = 4.5 ADC  $\sim 157.5$  MeV

- EE = 6.5 ADC  $\sim 390$  MeV

- *2016* Selective Readout settings:

- High-interest tower = 2.5 GeV

- Low-interest tower = 1.5 GeV

- Different ZS thresholds option is under study: **2 thresholds logic**

- It should allow to keep reasonably low thresholds without an increase of payload. First studies are promising and we will soon converge on a set of thresholds

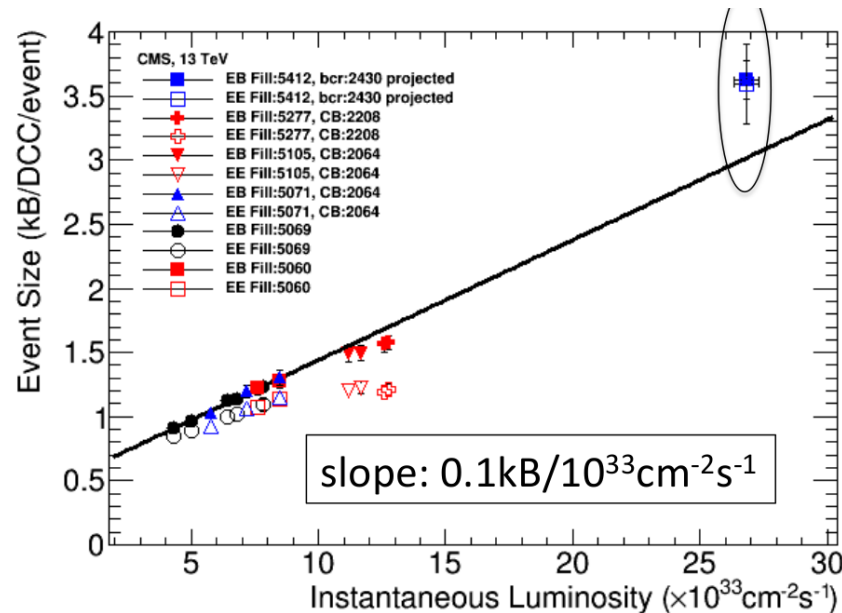
- CMSSW implementation SR logic in **PF**

- Currently offline PF rechits thresholds (ZS everywhere) are lower than online ZS

- Online ZS thresholds are defined in ADC counts  $\rightarrow$  sensitive to  $\eta$ /time variation due to transparency loss

- Currently variation vs time and  $\eta$  **not** propagated to MC (unless run dependent MC is done)!

- SR in PF will allow to raise PF ZS threshold to be tighter than online, without paying in energy resolution and isolation





# What will happen in 2017

- With first hundreds of  $\text{pb}^{-1}$

- **Alignment**

- Important for Endcap, since it open now during EYETS
- Electron ID ( $\Delta\eta$  and  $\Delta\phi$  tracker-matching identification cuts need to be relaxed at the beginning)

- **IC** will be **transported** with laser corrections

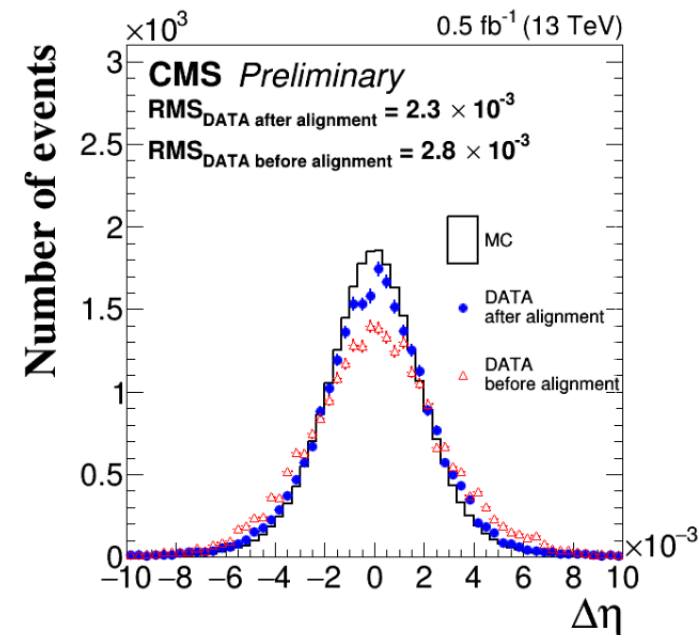
- It will be cross checked with first data:

- $\pi^0/\eta$

- $\Phi$ -symmetry (interplay with new material upstream, possible changes expected)

- We don't expect huge updates before the end of 2017

- to be checked the impact of the new material in front of ECAL: new pixels!





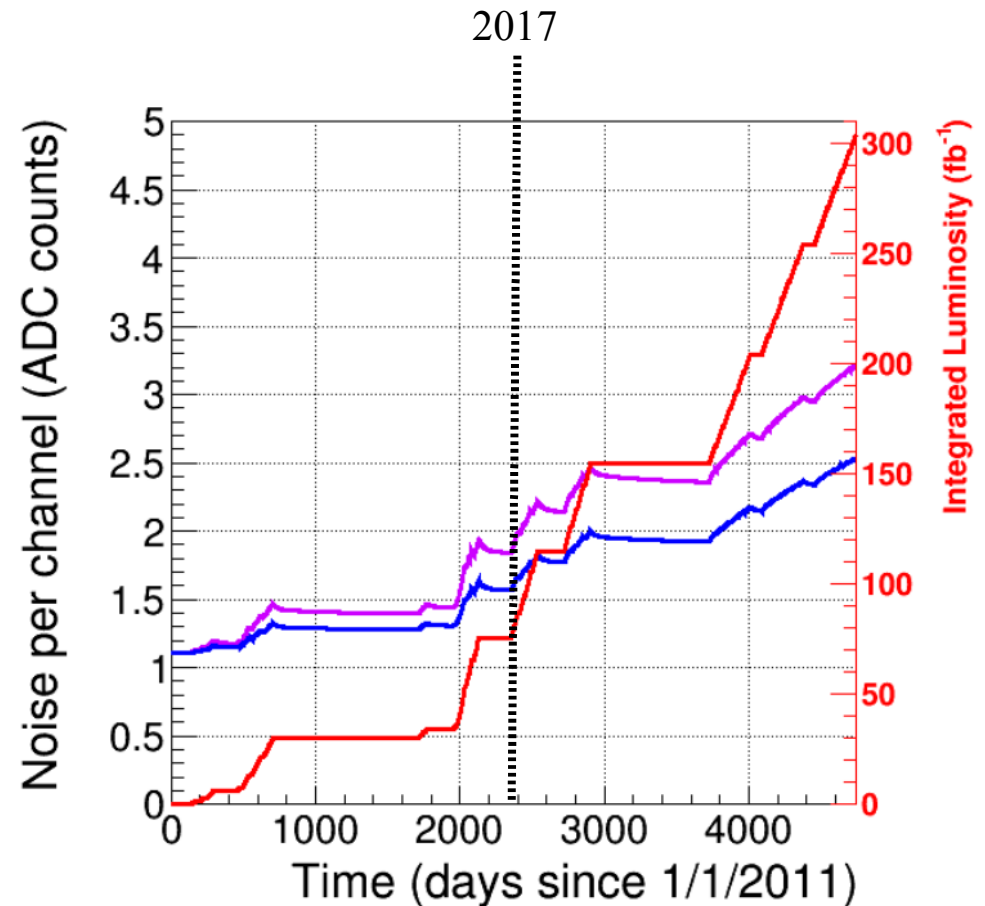
# MonteCarlo

- MC samples needed for 2017
  - $\pi^0$  for containment corrections with new material budget  $\rightarrow \sim 10\text{M}$  evts
  - Special MC sample of **photon gun** and **electron gun** with *ideal* ECAL conditions to train regression  $\rightarrow \sim 20\text{M}$  evts
  - **Minimum bias** for  $\pi^0$  selection tuning to improve stream efficiency  $\rightarrow \sim 50\text{M}$  evts

- For official MC 2017:

- We will provide tags representative of the average ECAL conditions (noise and transparency) expected during 2017

- $\eta = 0$
    - $\eta = 1.45$





# Possible improvements in 2017 data taking

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- Prompt Calibration Loop (PCL):
  - Possibility of PCL for **pedestal** update (interplay with decision on/performance of local reconstruction)
  
- Plans for updating **L1/HLT conditions**
  - Currently L1/HLT transparency corrections are updated weekly, with a delay of 1 week, with the latest transparency measured
  - Studies ongoing on more **frequent** update and on **extrapolations** (useful in case of long periods without beam to avoid increase in rate at the beginning of data-taking)
    - Automatic-validation may be rediscussed in order to keep the process fast
  - **Pedestals**
    - In 2016 update of HLT conditions typically synchronous with offline
    - With possibility of de-couple them due to additional check on changes in rate required for HLT conditions
    - For 2017, possible weekly update or in synchronous with transparency





# Recommissioning

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- Calibration **streams** and **rates**
  - **Beginning** of data-taking
    - Increased rate for  $\pi^0$  and  $\Phi$ -symmetry
      - $\Phi$ -symmetry  $\rightarrow$  10 kHz
      - $\pi^0 \rightarrow$  optimization ongoing,  $\sim$ 15 kHz
    - **Steady-state** running condition
      - $\Phi$ -symmetry  $\rightarrow$  3 kHz
      - $\pi^0 \rightarrow$  7 kHz
    - Re-tuning of thresholds of  $\pi^0$  to be more efficient
    - Work ongoing on E/ $\gamma$  isolation and ID at L1, different for physics and calibration purposes
  - **Tier** requirements
    - RAWRECO of double electron Zee particularly useful at the beginning of data-taking
    - RAW Data of calibration stream available on disk in T2
  - **Prompt and ReReco updates:**
    - Lesson from 2016: IC are good from previous year, can be improved only at the end of data-taking
    - Legacy ReReco of 2017 should happen at the end of 2017, to fully exploit the ECAL performance



# Summary

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- The **2016** has been an exciting year
- We had to face some **unexpected challenges**
  - ECAL is a living and evolving detector
  - Most of them have been coped with, thanks to excellent team of people online and offline!
    - **Thanks** to everyone! PM, TC, RC, Shifters, DQM, DAQ, PFG, MoCa, DPG, ...
- Many lessons learned from 2016
- The final “exam” and the ultimate performances will be delivered in the **Legacy ReReco**
- **2017** is now:
  - We fixed/are fixing what we have learned from 2016
  - Re-tuning and improvement of online conditions, streams, ... ongoing
- ECAL will continue to successfully produce good data to perform good analyses

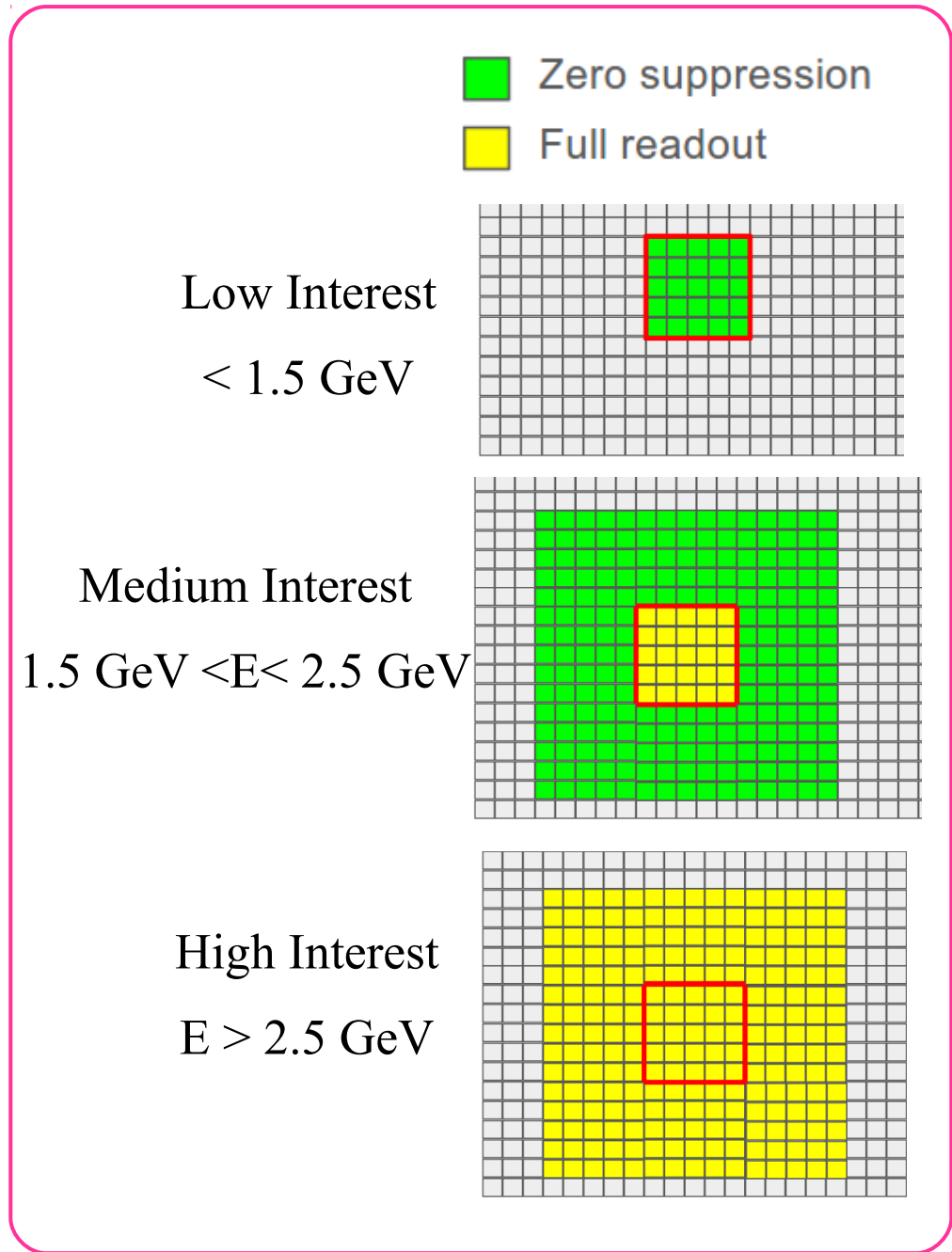




# Selective Readout and Zero Suppression

- **Tune** of online thresholds

- 75k crystals  $\rightarrow$  we cannot save/read all crystals (**Full readout**)
- Limit in payload  $\sim$  2kB/event/DCC
- **Selective Readout (SR)** logic  $\longrightarrow$
- **Zero suppression**: save the crystal if above a threshold (in ADC, 4.5 in EB, 6.5 in EE in 2016)





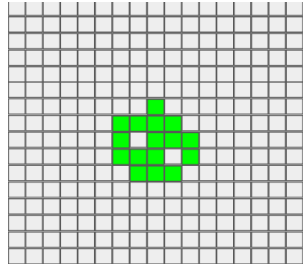


# SR and ZS for 2017

- Zero suppression with lower threshold
- Zero suppression
- Full readout

Legend: each point is a crystal

Low Interest  
 $< 1.5 \text{ GeV}$

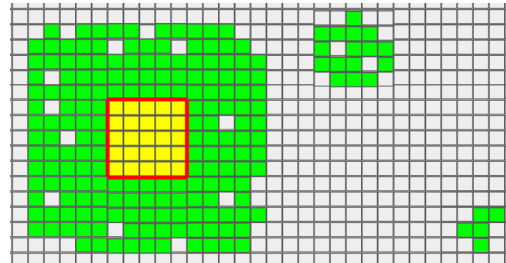


With ZS Threshold 2 set to 2/3 ADC counts, we can gain the payload reduction needed for readout

Tuning ongoing

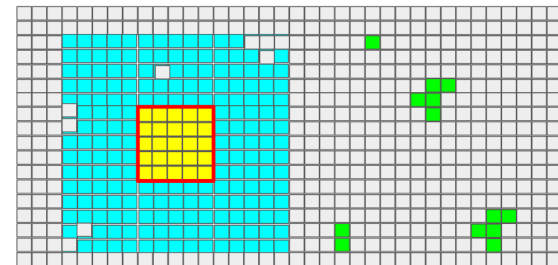
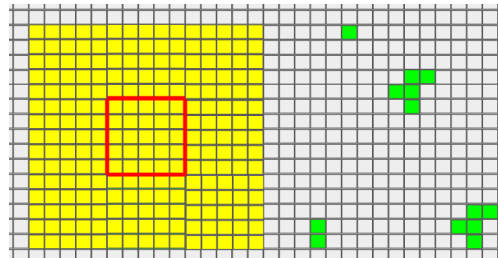
Medium Interest

$1.5 \text{ GeV} < E < 2.5 \text{ GeV}$



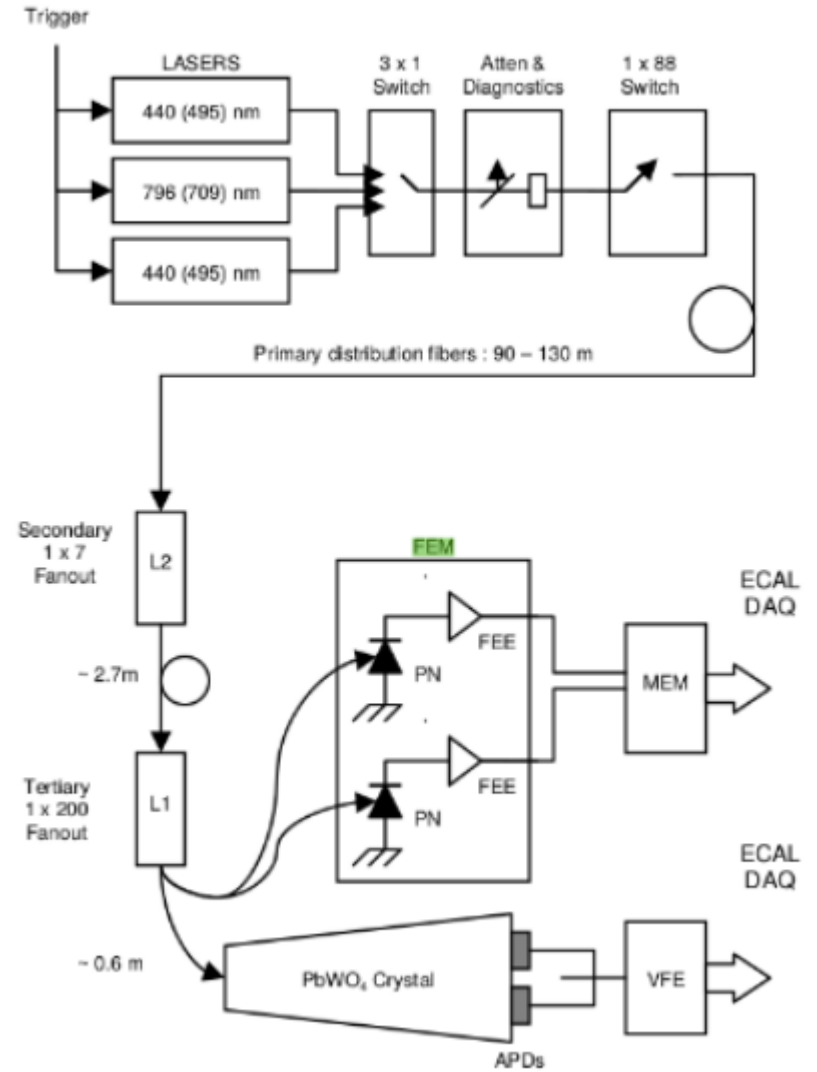
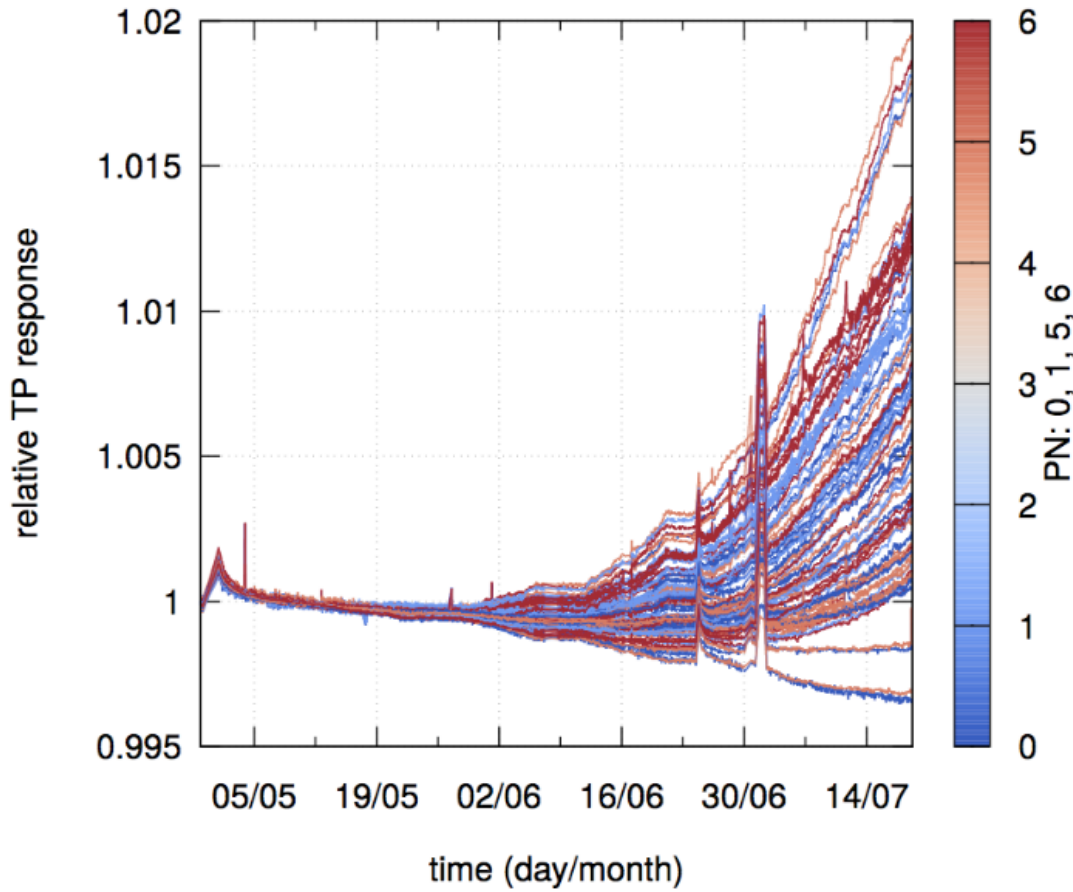
2 thresholds system, for 2017

High Interest  
 $E > 2.5 \text{ GeV}$





# Laser and PN





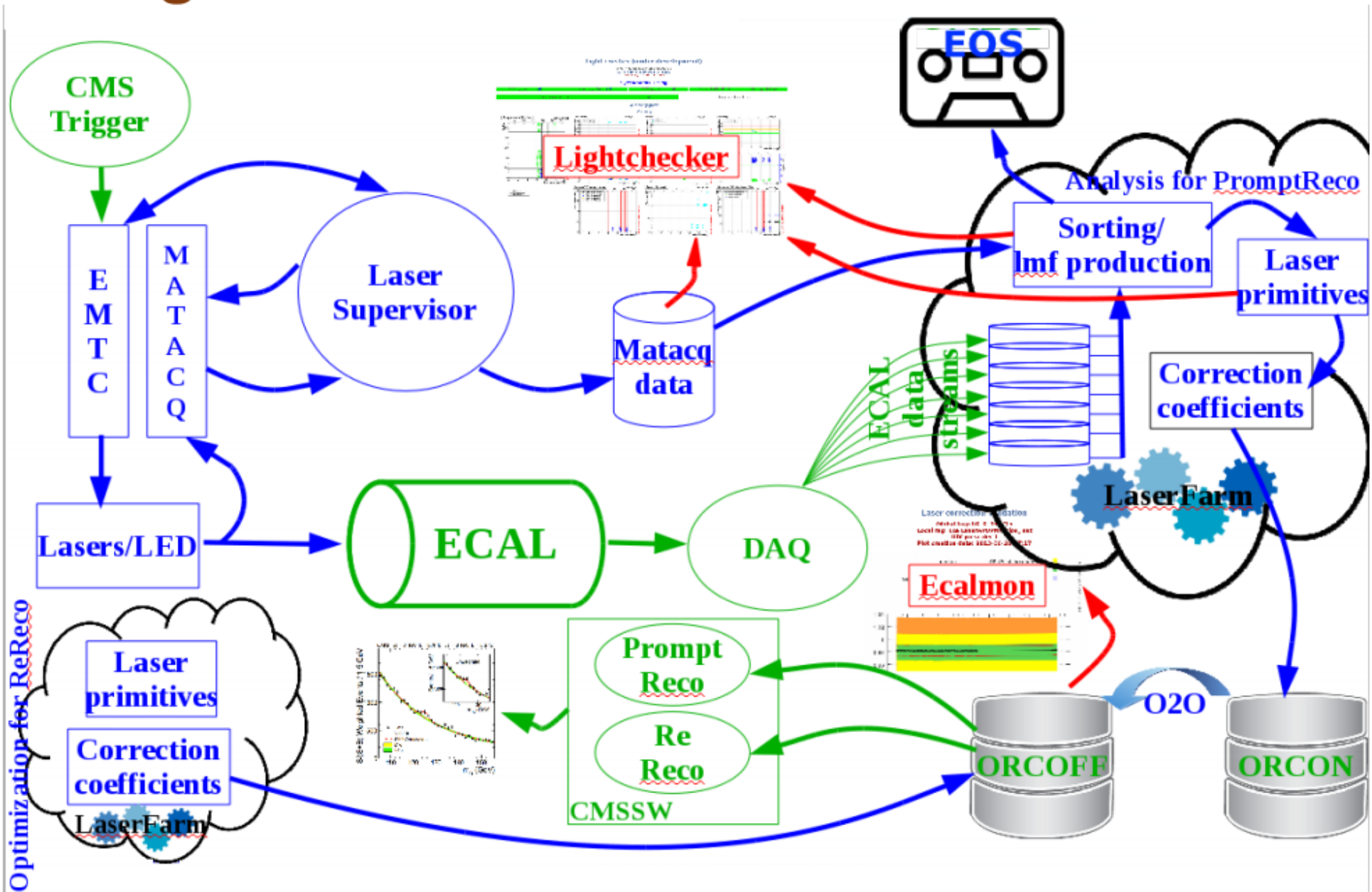
# Laser response matrix

Incident/Time	Laser Farm issue Notified by	Who should be notified	What action should be taken	Phone numbers and emails
<b>&lt;30 hours</b>	ECAL DOC(online) PFG shifter (offline) ->	<b>Laser experts-&gt;</b> ->O2O	Stop DB Filling (FillCorr) Stop O2O  Provide a fix to OMDS	Write to: <a href="mailto:cms-saclay-laser-monitoring@cern.ch">cms-saclay-laser-monitoring@cern.ch</a> And/or call:77800
<b>30 hours &lt; t &lt; 48hours+rl</b>	<b>Laser experts-&gt;</b>	->ECAL DPG ->O2O ->Prompt_reco experts	Stop Db Filling Stop O2O Stop prompt_reco Provide a fix to prompt_v2	Write to CMS ORM And CMS DB on call?
<b>&gt;48 hours +runLength</b>	<b>Laser experts-&gt;</b> Should never happen but if...	-> ECAL DPG	New corrections in the offline_tag for Re-reco	



# Laser data workflow

## Processing the data





# Crystal response monitoring

## ECAL Crystals response monitoring

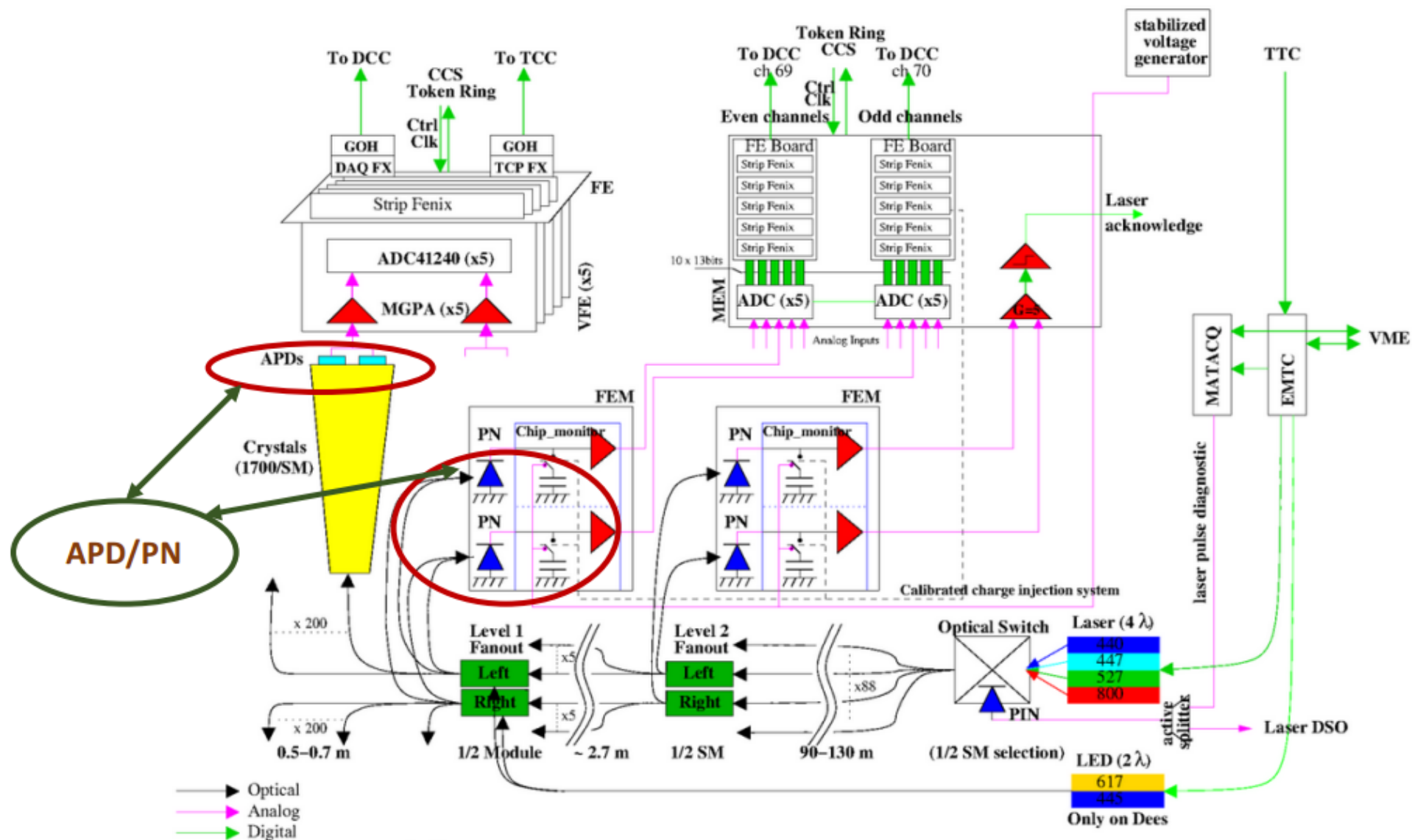


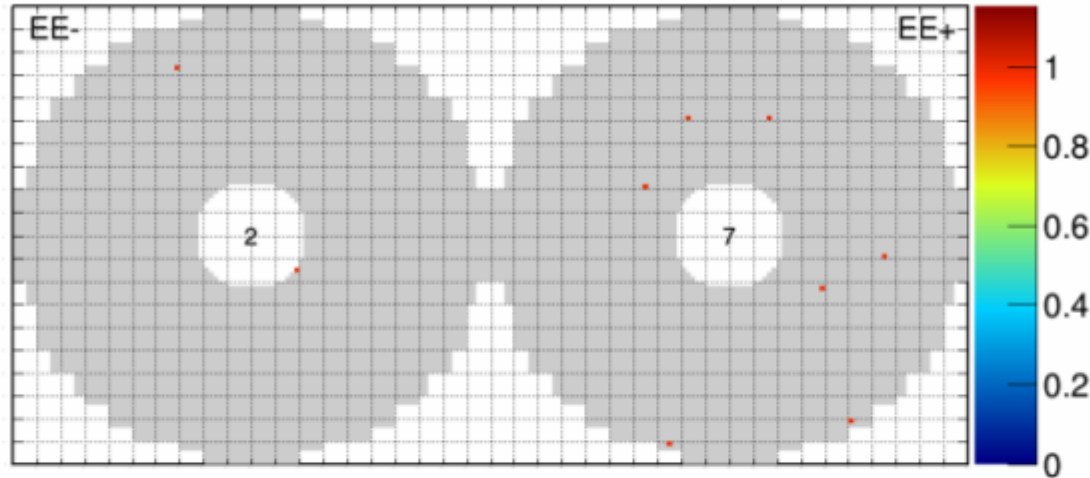
Figure 1: Schematic view of the monitoring system in CMS-ECAL



# Channel status update for Legacy ReReco

EE Channel Status Mask (Diff), RERECO : 2016\_272760 vs 2015\_263256

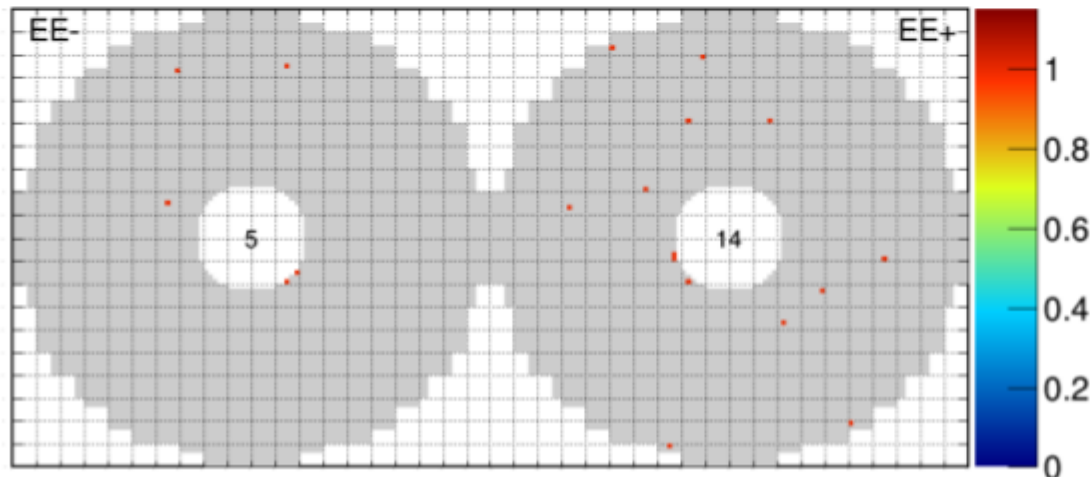
Net difference: 9 channel(s)



23Sep Rereco

EE Channel Status Mask (Diff), LEGACY RERECO : IOV 272760 vs 263256

Net difference: 19 channel(s)



Legacy2016





# Changes in Legacy ReReco

• See details in Shervin's presentation at AICa:

<https://indico.cern.ch/event/586738/contributions/2397212/attachments/1389985/2117199/AICaDB-v18.pdf>

Record	Tag	Comment
E{B,E,S}AlignmentRcd	NO UPDATE	Up-to-date
EcalTimeCalibConstantsRcd	EcalTimeCalibConstants_Legacy2016_v1	multiple IOVs
EcalLaserAPDPNRatiosRcd	EcalLaserAPDPNRatios_offline_2016pp_legacy	
EcalLaserAlphasRcd	some values being updated	
EcalIntercalibConstantsRcd		in Feb
EcalADCToGeVConstantRcd		in Feb
ESIntercalibConstantsRcd		in Jan
ESEIntercalibConstantsRcd		in Jan
EcalChannelStatusRcd	EcalChannelStatus_v10_offline	
ESChannelStatusRcd	ESChannelStatus_V03_offline	
EcalPedestalsRcd	currently in PREP being copied to PROD	multi IOV
EcalPulseShapesRcd	EcalPulseShapes_Legacy2016_v1	multi IOV
EcalPulseCovariancesRcd	NO UPDATE	



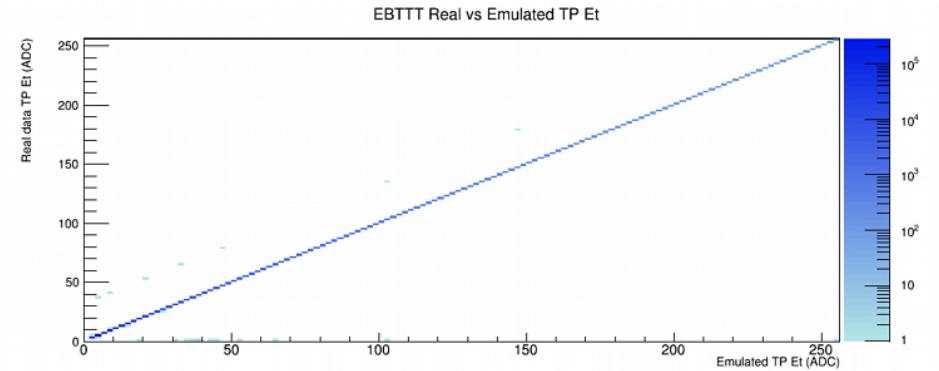


# New plots in DQM

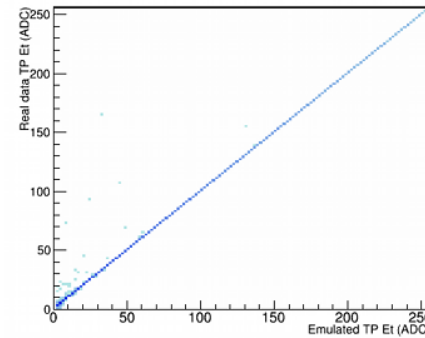
Values for Ecal.EventInfo.reportSummaryContents.Ecal\_EB-02



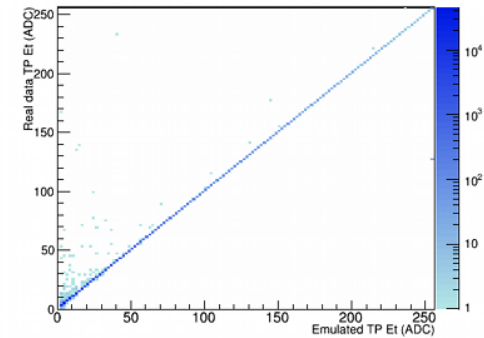
13 Real vs Emulated TP Et



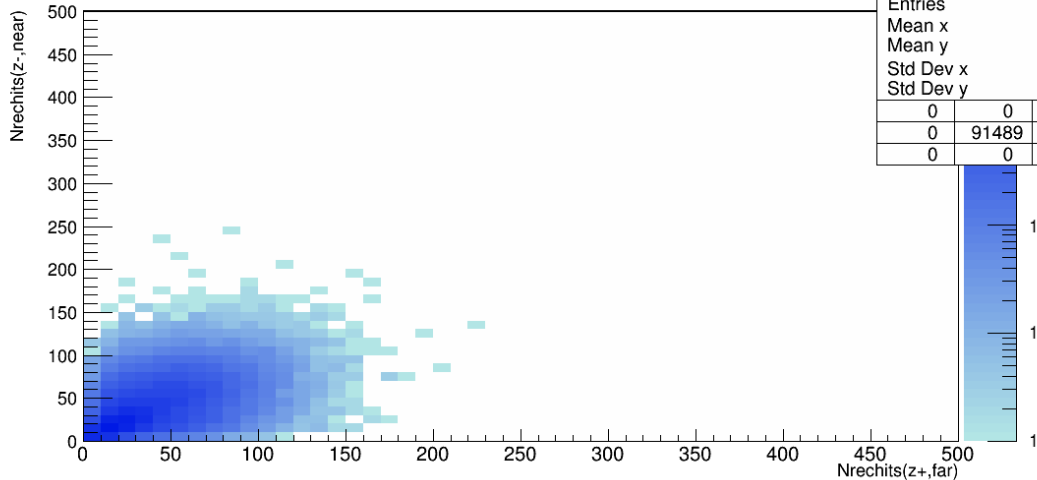
EETTT Real vs Emulated TP Et EE -



EETTT Real vs Emulated TP Et EE +

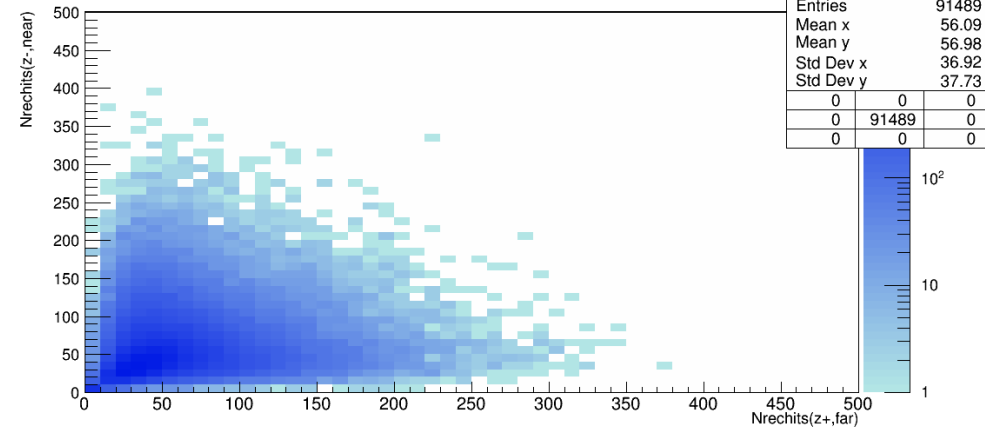


EBOT rec hit thr occupancy correlation



Entries	9
Mean x	233.33
Mean y	133.33
Std Dev x	233.33
Std Dev y	233.33
0	0
0	91489
0	0

EEOT rec hit thr occupancy correlation



Entries	91489
Mean x	56.09
Mean y	56.98
Std Dev x	36.92
Std Dev y	37.73
0	0
0	91489
0	0



# In the rare case you forgot how CMS/ECAL is

## CMS DETECTOR

Total weight : 14,000 tonnes  
Overall diameter : 15.0 m  
Overall length : 28.7 m  
Magnetic field : 3.8 T

STEEL RETURN YOKE  
12,500 tonnes

SILICON TRACKERS  
Pixel ( $100 \times 150 \mu\text{m}$ )  $\sim 16\text{m}^2 \sim 66\text{M}$  channels  
Microstrips ( $80 \times 180 \mu\text{m}$ )  $\sim 200\text{m}^2 \sim 9.6\text{M}$  channels

SUPERCONDUCTING SOLENOID  
Niobium titanium coil carrying  $\sim 18,000\text{A}$

MUON CHAMBERS  
Barrel: 250 Drift Tube, 480 Resistive Plate Chambers  
Endcaps: 468 Cathode Strip, 432 Resistive Plate Chambers

PRESHOWER  
Silicon strips  $\sim 16\text{m}^2 \sim 137,000$  channels

FORWARD CALORIMETER  
Steel + Quartz fibres  $\sim 2,000$  Channels

CRYSTAL  
ELECTROMAGNETIC  
CALORIMETER (ECAL)  
 $\sim 76,000$  scintillating  $\text{PbWO}_4$  crystals

HADRON CALORIMETER (HCAL)  
Brass + Plastic scintillator  $\sim 7,000$  channels

