HCAL Performance and calibration: plans for 2017 commissioning

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for the HCAL DPG

Outline

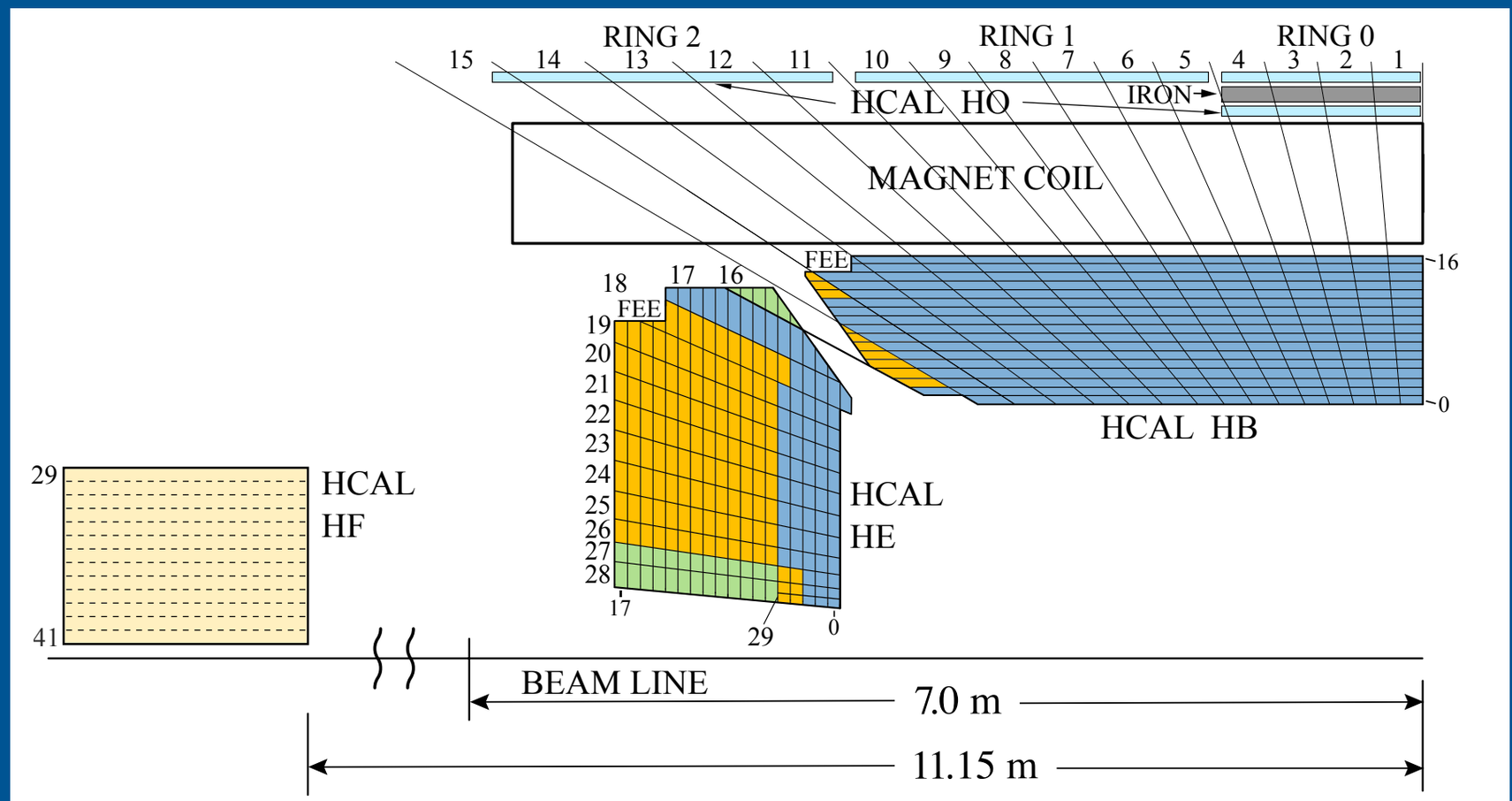
- HCAL in 2016:
  - pp and HI data taking summary
  - performance in 2016 and conditions for legacy ReReco

- HCAL in 2017
  - open possibilities for detector layouts
  - workflow availability
  - calibration plans
  - reconstruction readiness

- Summary

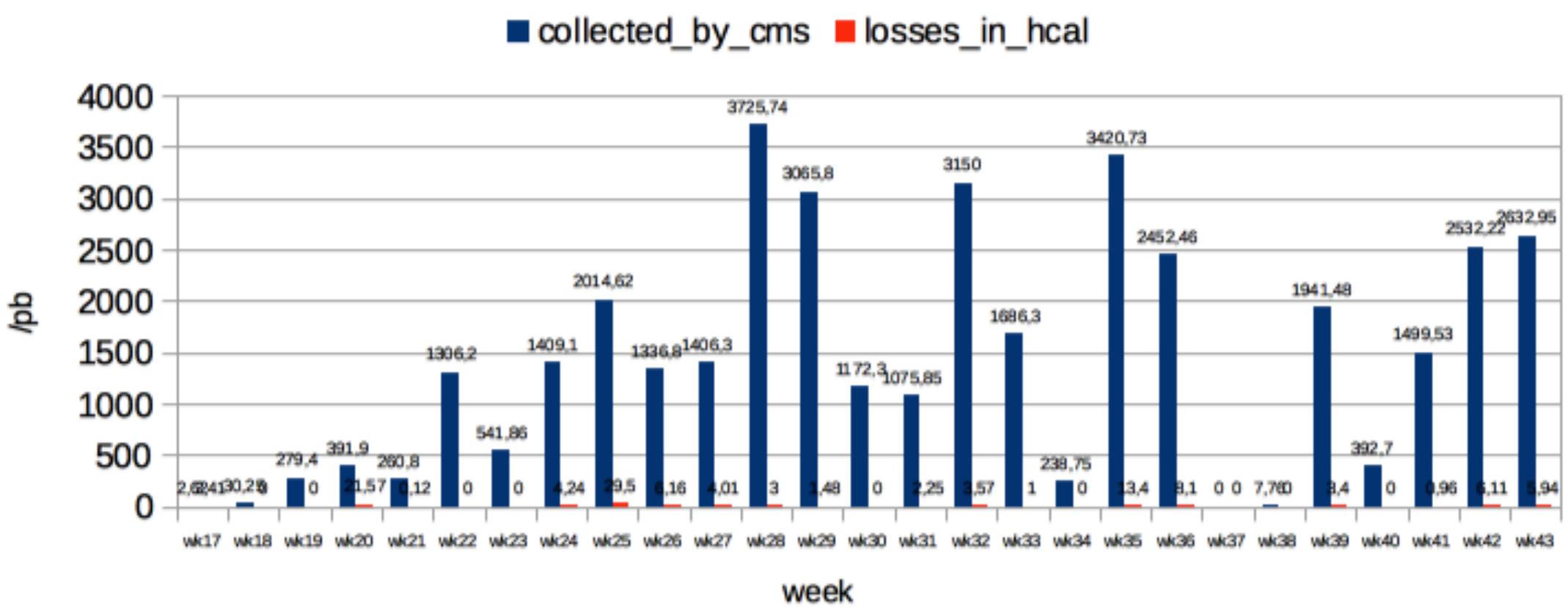
HCAL in 2016

- Hybrid Photo Detector in HB and HE
- PMT in HF
- 2-3 depths, QIE8
- Pilot systems for both HF (QIE10) and HE (QIE11)



Summary of 2016 data taking: a golden year for HCAL

- Loss due to downtime during pp: **~2%**
  - few isolated events, more in Andrea's talk
- Loss due to bad quality:
  - pp data taking: ~126 pb^{-1} out of 37.8 fb^{-1} **(~0.3%)**
  - HI data taking: ~0,1 nb^{-1} out of ~90 nb^{-1} **(~0.1%)**

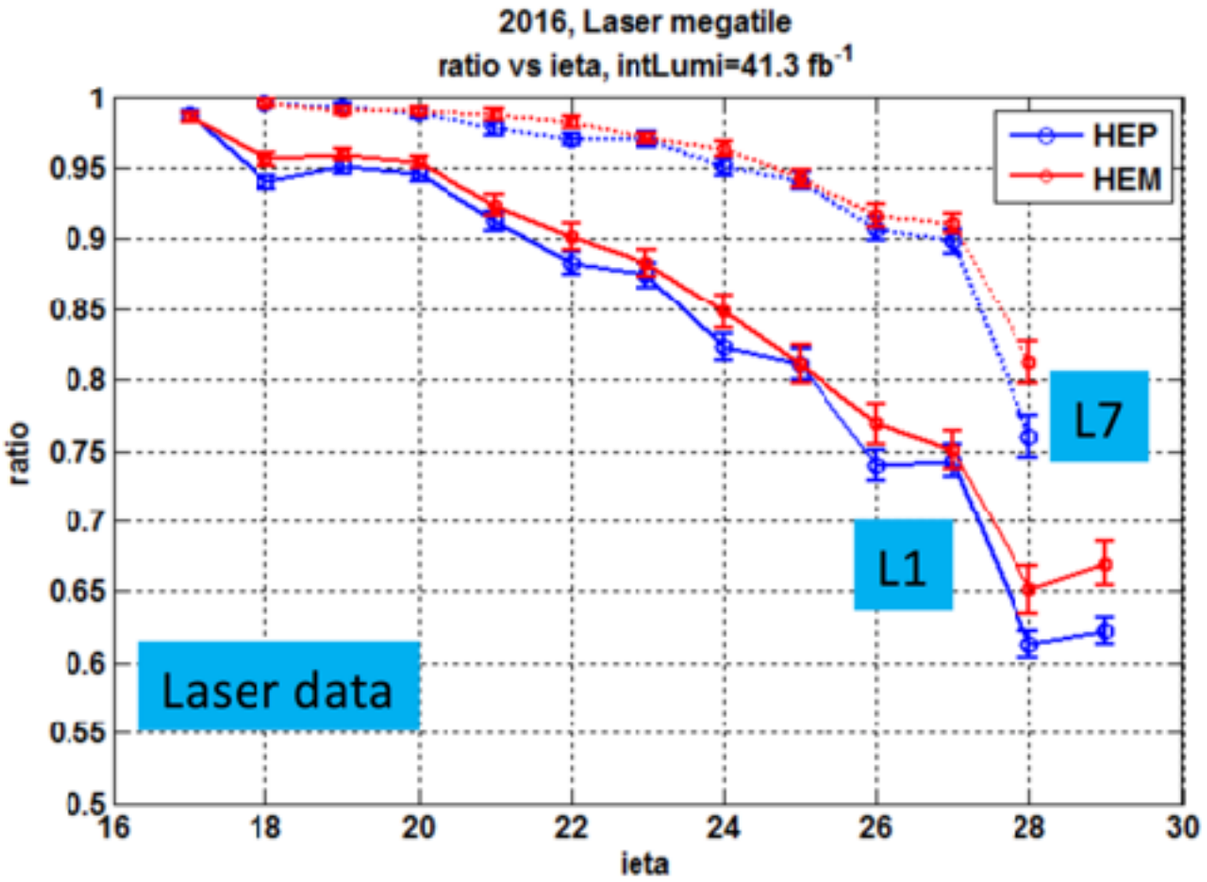


Detector calibration: reminder of methods

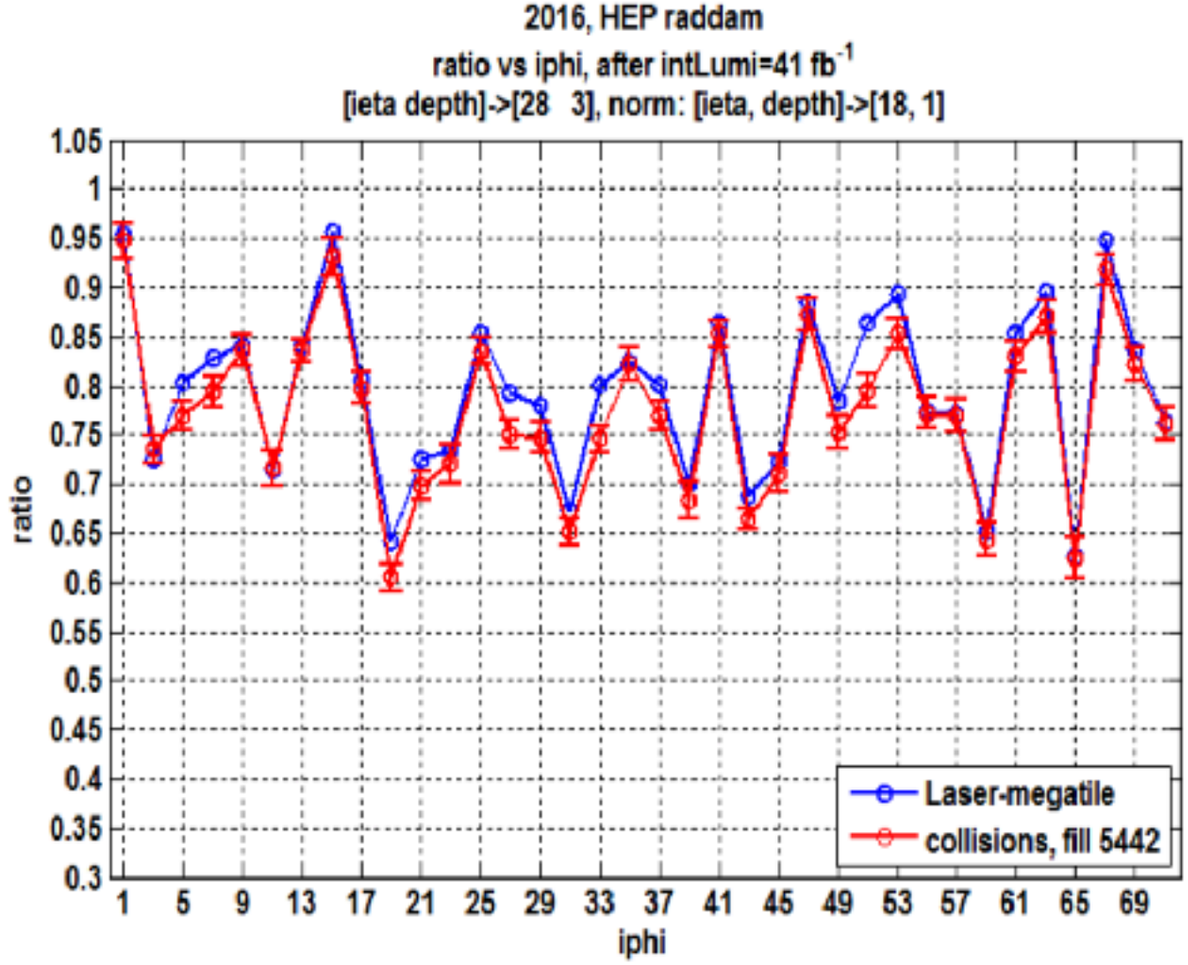
- **RadDam corrections** from laser and collision data
- Channels **inter-calibration** at the same eta/depth: **Phi Simmetry**
  - equalizes the channels response wrt each other
  - works for HB, HE, HF
- Absolute scale in HB, HE: **Iso Track method**
  - uses 50 GeV pions momentum as a reference
- Absolute scale in HF: **Z—> ee mass**
  - one electron in ECAL, the other in HF
  - check calibration of the response of the deposit in HF

RadDam corrections full 2016

- **Measured dependence** of the radiation damage **with Eta**



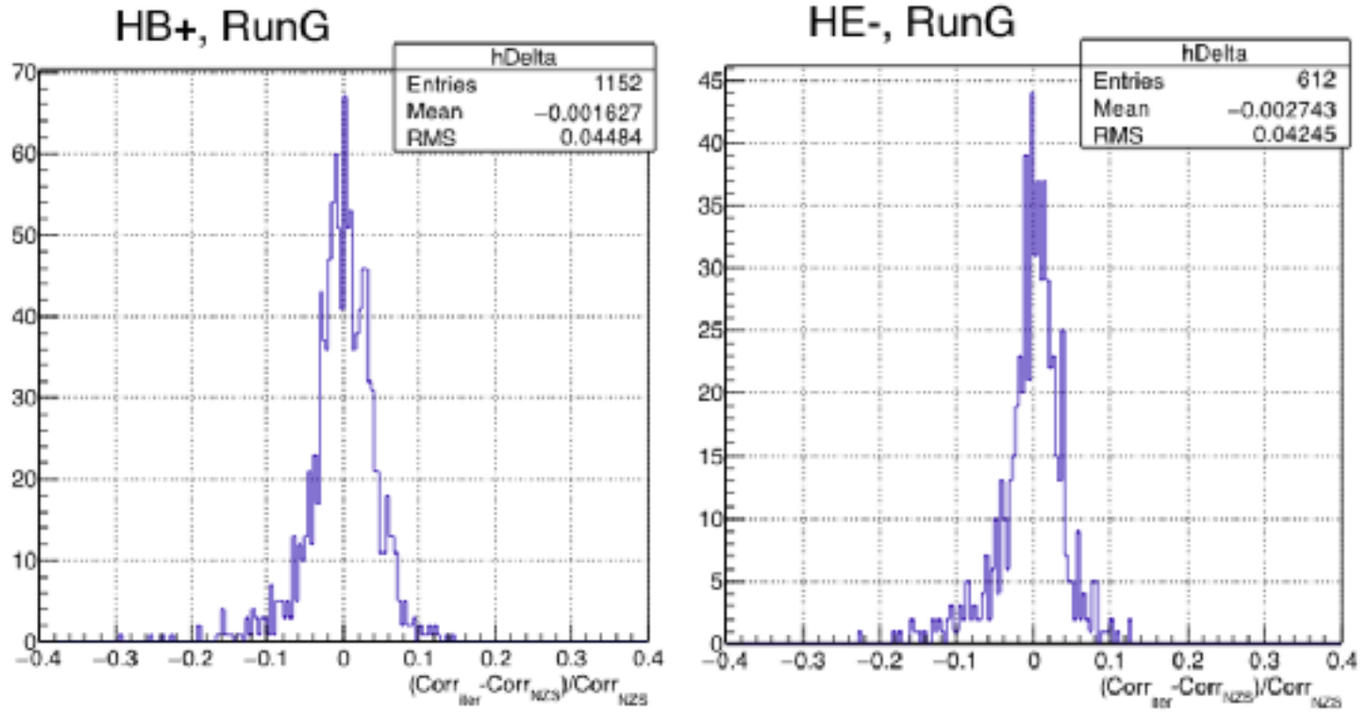
- **Large fluctuation** of the measured damage **vs phi**
  - phi dependence in conditions for the first time
  - possible explanation: HPD to HPD variation of the photo detection efficiency



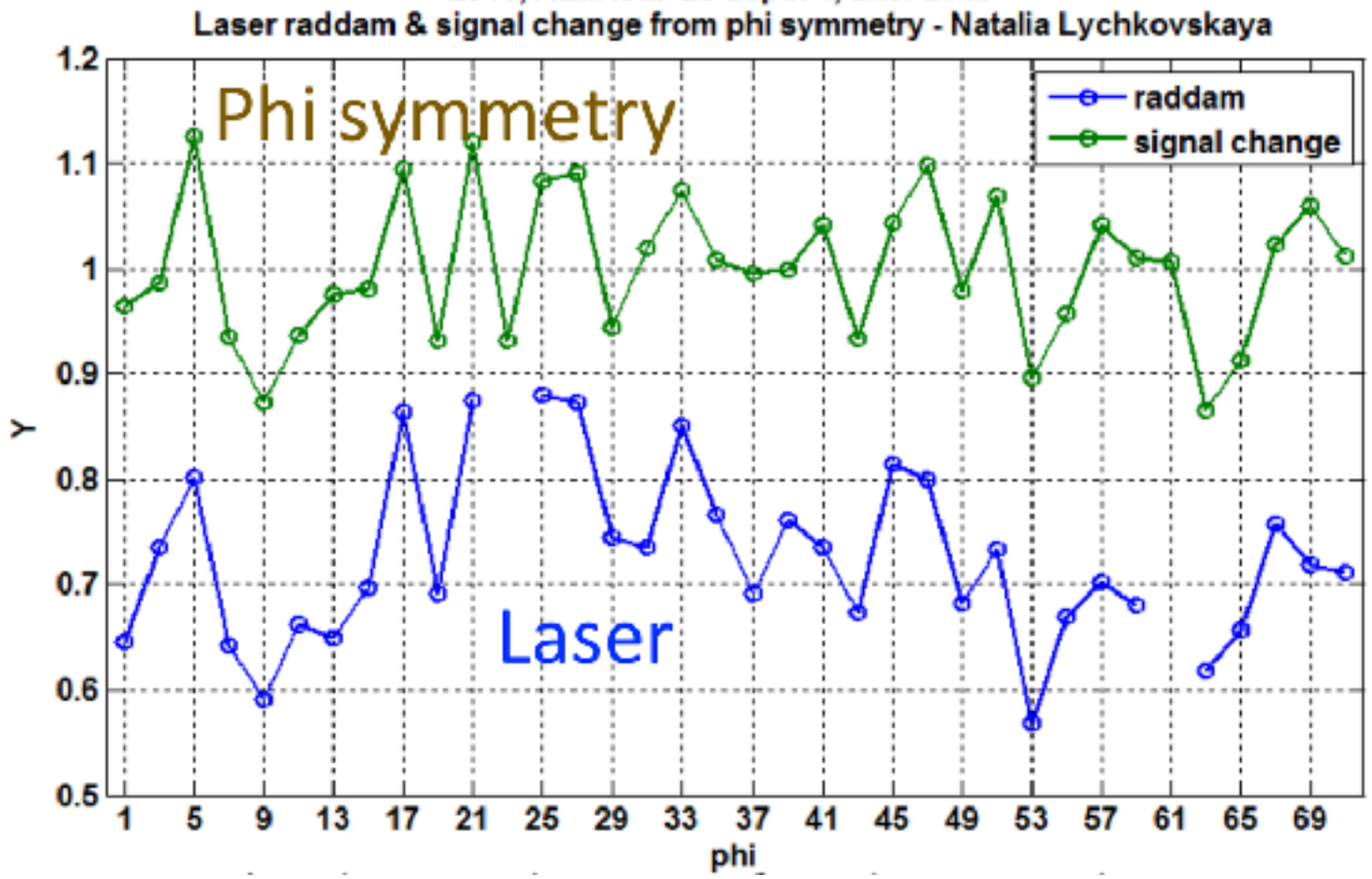
Phi symmetry inter-calibration

- Two methods available
  - method of moments
  - iterative method

- **~4% precision** (stat+syst) achieved from the comparison of the two methods

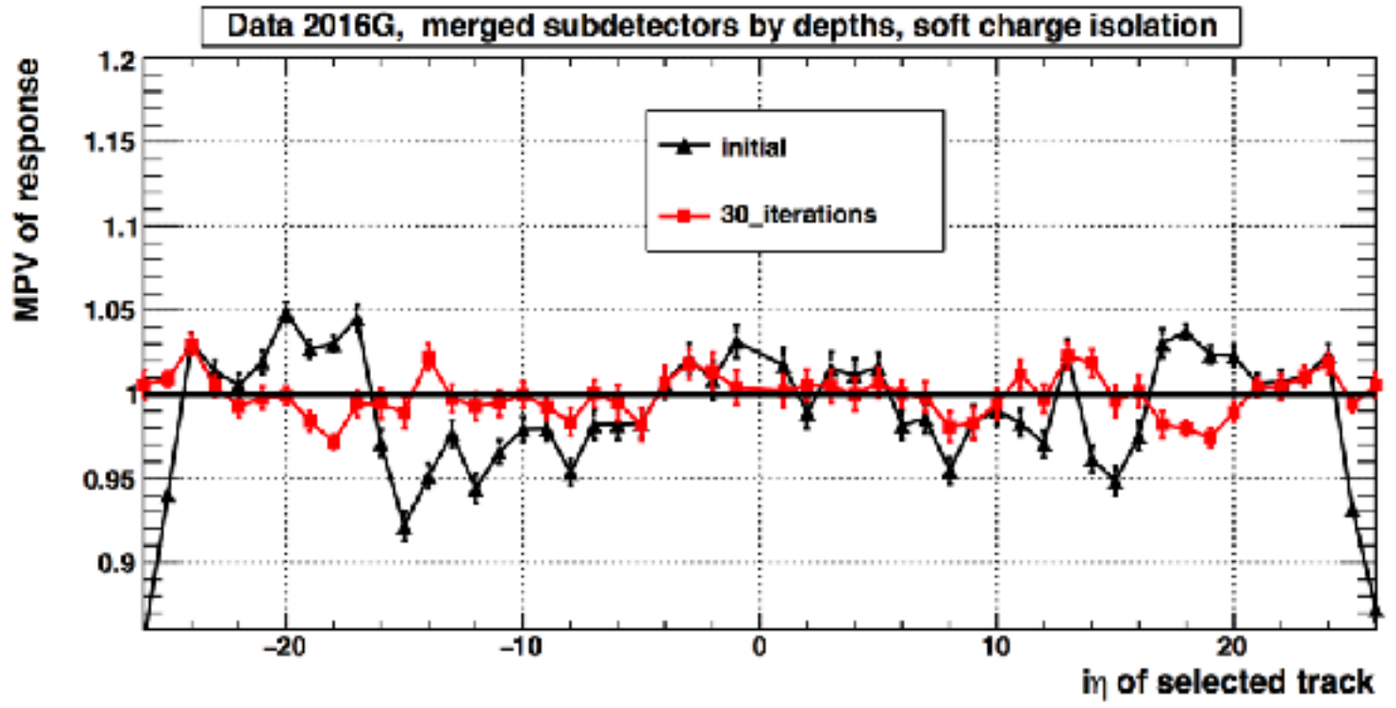


- Phi dependence of the radiation damage visible with Phi symmetry

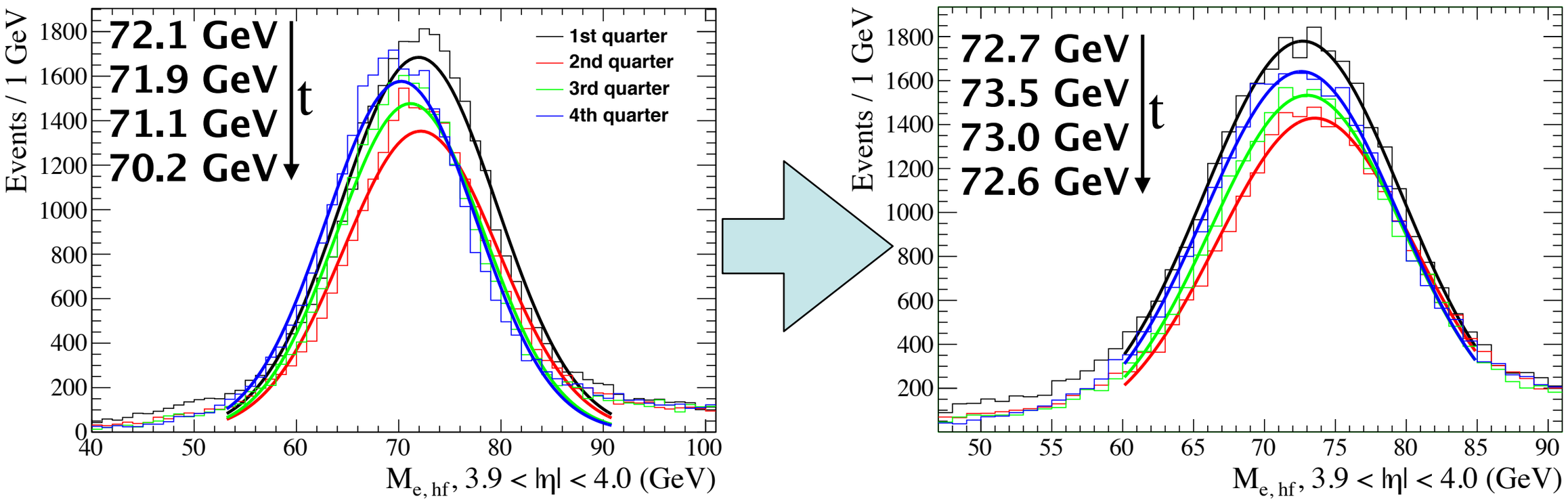


Energy scale calibration and validation

- Isotrack method in HBHE:
  - improvement after 30 itr
  - residual structures at few% level



- Zee method in HF:
  - the gradual shift of the peak position with time gets levelled after raddam are applied



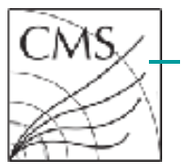
Summary of conditions for legacy re-reco

- All calibration methods updated with the full 2016 statistics

- Condition tags submitted before Christmas
  - **~4%** uniformity achieved
  - **~2%** on absolute scale achieved

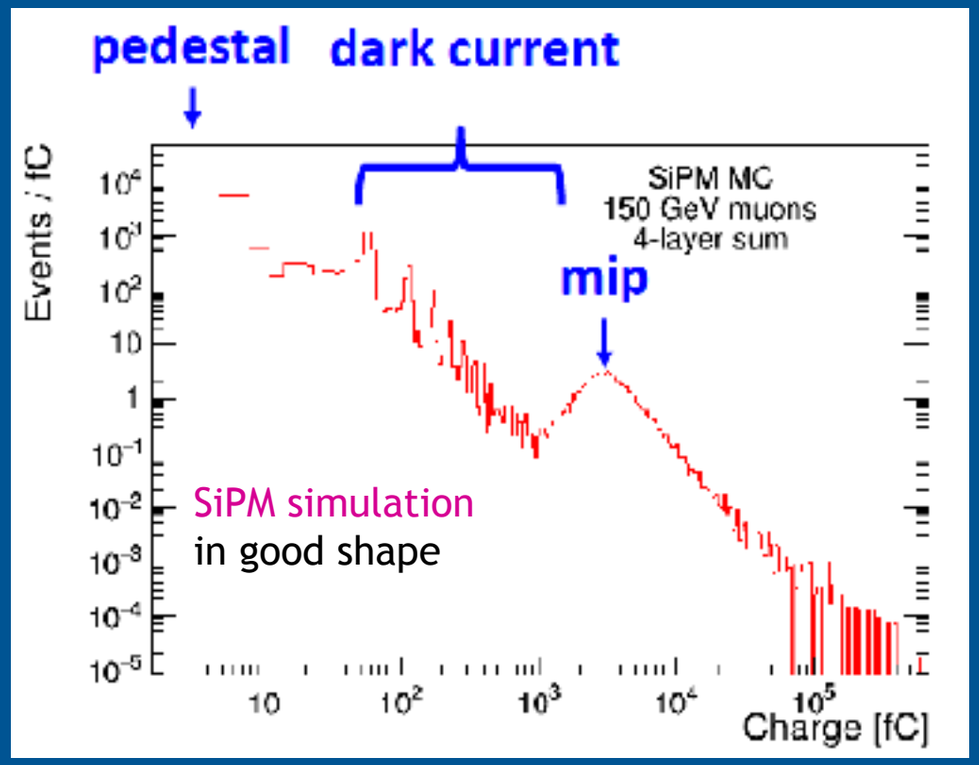
- Documentation being finalized:
  - https://twiki.cern.ch/twiki/bin/viewauth/CMS/HcalCalibrationGroupRun2
    - Raddam: DN-17-007
    - IsoTrack: DN-16-029
    - PhiSymm: DN-17-006
    - HF calibration: DN-16-026, DN-2017-004
    - HO calibration: DN-16-023

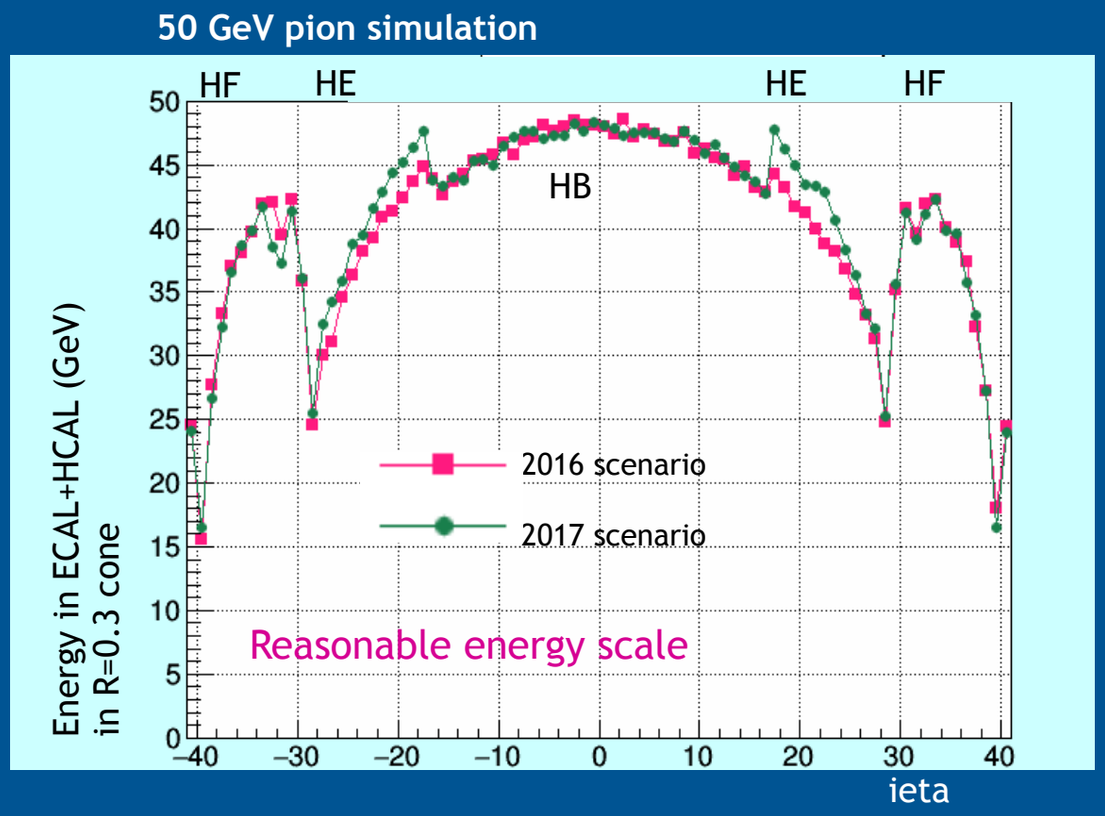
- Last iterations with AlCa ongoing:
  - provided a comparison of the latest conditions with Prompt



HCAL in 2017: goodbye Plan36

- The full HE upgraded has been postponed
- In 2016 a heroic effort has been made to make geometry, reco algos, trigger, monitoring ready for the full upgraded scenario
- All the work will be incorporated in a scenario to be used in the future (2018 Era)

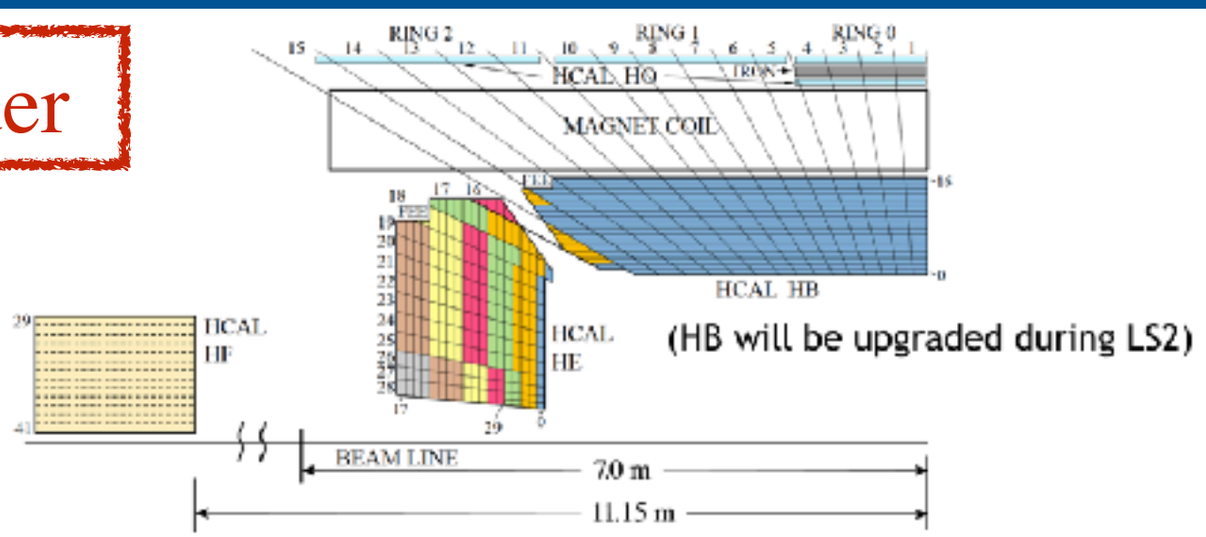




HCAL in 2017
open possibilities for Phase1 upgrade

- **Plan0**:
  - upgraded HF
  - 2016 configuration for HE
- **Plan1** where 1 indicates a small integer:
  - upgraded HF
  - upgrade one or more HE RBX
  - profit from reduced scale pilot system in 2017 in view of the full upgrade in 2018

Reminder



(HB will be upgraded during LS2)

HF:

✓ Dual-anode readouts

✓ QIE8 → QIE10

Identify anomalous signals with timing information (QIE10) and redundant energy (charge) measurements (dual-anode PMT)

HE:

✓ 2-3 → 6-7 depths

✓ HPD → SiPM, QIE8 → QIE11

Mitigate radiation damage with increased depth segmentation and photon detection efficiency (SiPM photosensor + QIE11 readout)

HCAL in 2017
open possibilities for Phase1 upgrade

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  - upgraded HF
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Both have parts in common with the available scenarios, but require extra effort that wasn't foreseen

Plan0 workflow
Status: ~ready

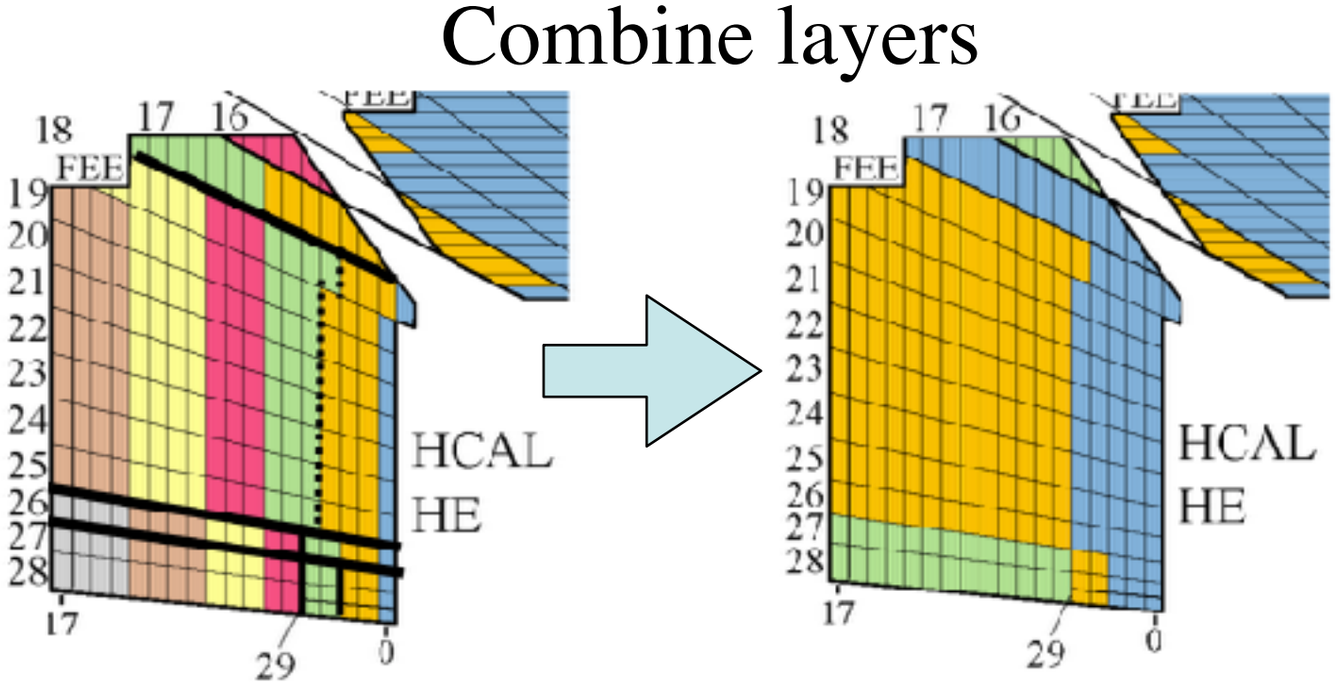
- **Geometry**: available with upgraded HF, 2016 HE
- **Sequences and Configuration**: code ready, PR submitted
- **Conditions**: ready and available —> GT should be produced today

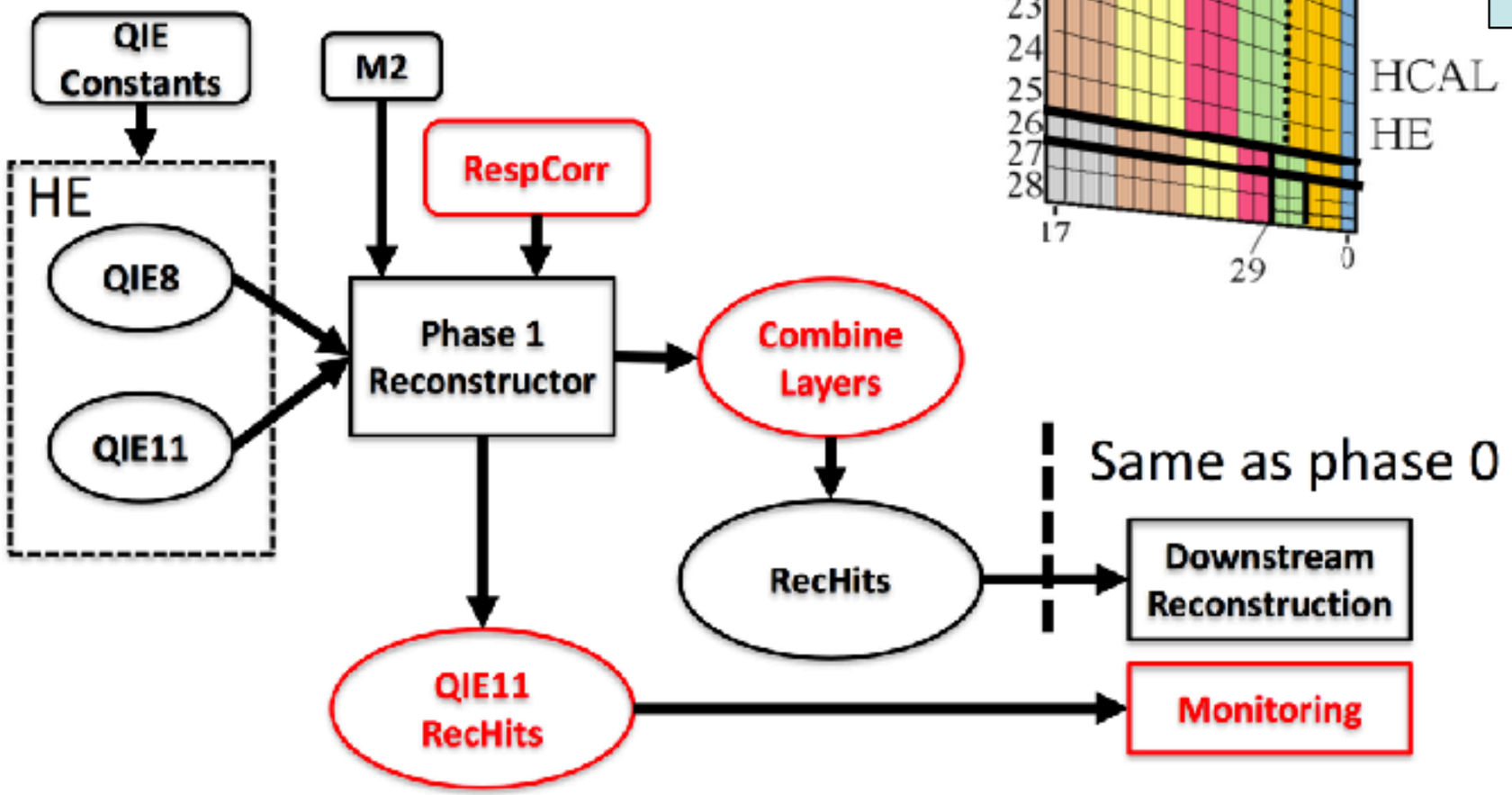
- Can proceed with the integration in 900_pre3
- Backport to 80x also needed

- **Allows the first injection of MC samples with a possible 2017 scenario**

Plan1 workflow:
a mixed configuration to deal with

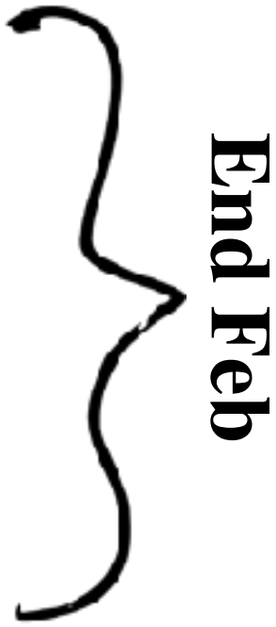
- Update the reco and make the **upgraded wedges look like the rest of the detector**
- Save **extra RecHit** collection for **monitoring** and **studies**





Plan1 workflow: status of implementation and timescale

- **Geometry**: code available. can be validated by end of the week
- **Reco**: need to collapse depths from new wedge into Run2 like layout. ~1 week. needs input from Geometry
- **Conditions implementation**: ~2 weeks
- **Workflow implementation**: ~1 week
- **TP emulation tested/verified**: ~1 week
- **MC calibration study of the HE wedge**: ~1 week



- Want to produce private samples asap to enable downstream consumer to test/study/develop:
  - noise filters
  - calibration methods
  - JetMET performance
  - physics objects
  - monitoring/validation

Effort shared between Phase1 task force and DPG

Plan1 workflow: outside HCAL

- **Main concern: introducing phi-dependent features may impact calibration methods and JetMET (and other high-level objects) performance**

- Need to understand the **level of tolerance** for physics objects when introducing inhomogeneities
  - to be done **in parallel to the Plan1 scenario implementation** as much as possible
  - use the existing Run2 MC and full upgrade HE MC samples to assess tolerance on **energy scale shift and response non-linearity**

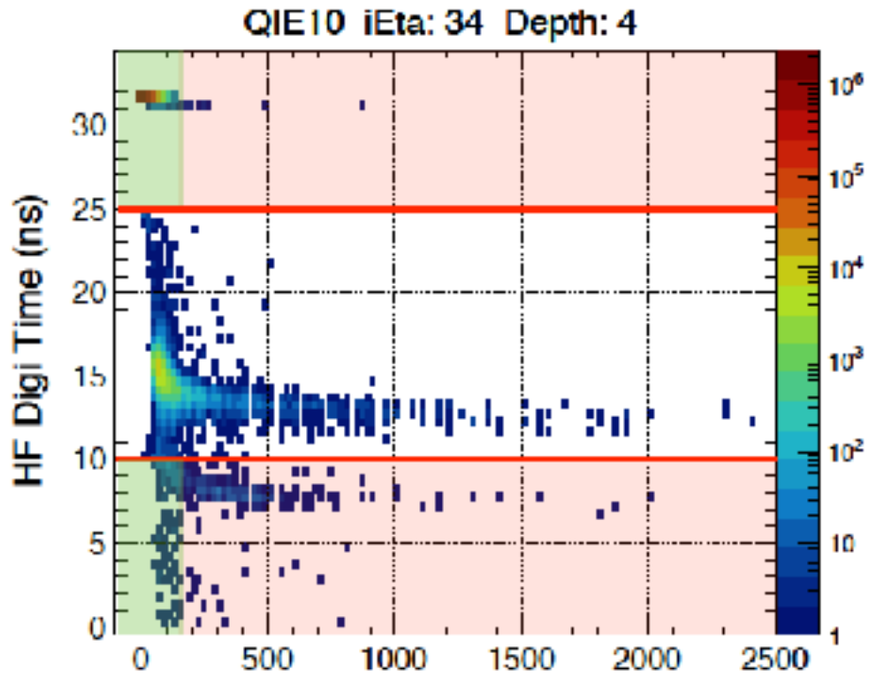
HF noise filtering: cleaning implemented and tested

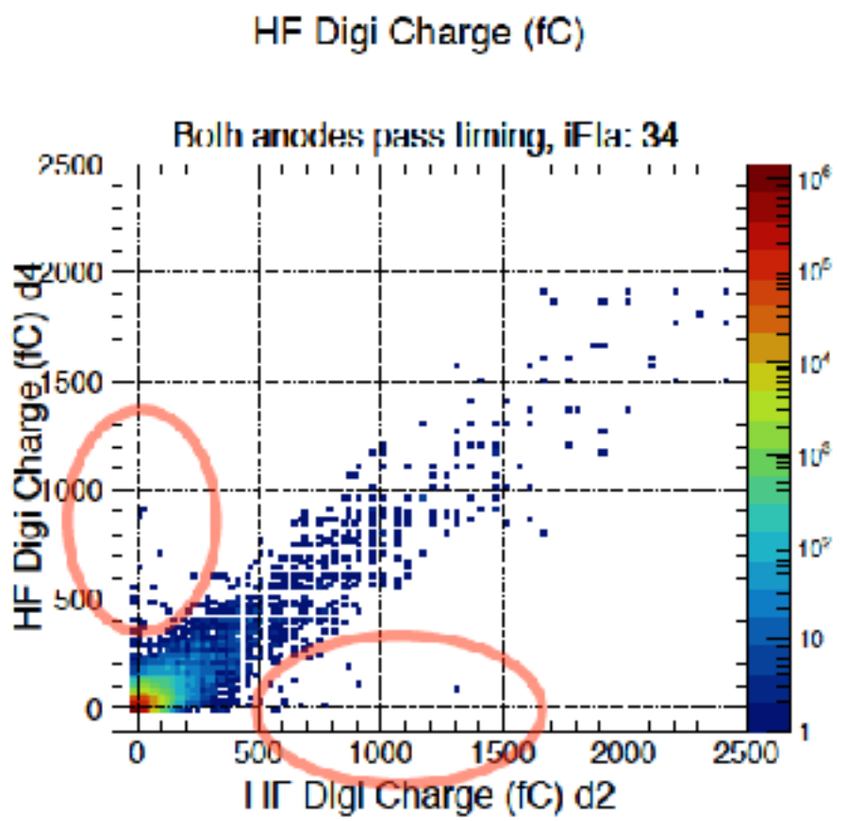
Real Data

- Noise due to **PMT hits**
- Anomalous signals are **2-7 ns early** and local to a **single anode**

- Two handles to reject those:
  - **TDC time information**
  - **Dual anode response asymmetry**

- Strategy implemented thanks to the **HF Pilot system**





HF calibration:
ready for startup, same calib strategy

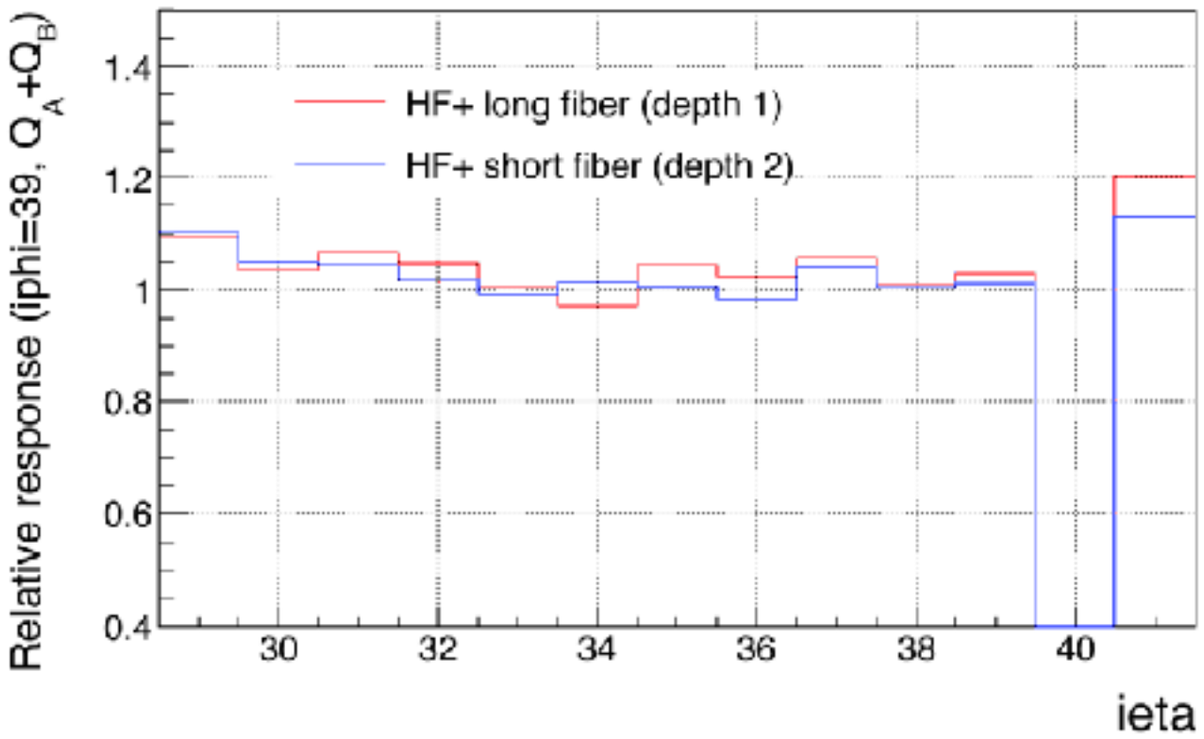
$$E(\text{rechit})[\text{GeV}] = (Q1 + Q2)[\text{fc}] * \text{Gains} * \text{RespCorr}$$

- Geometry, reco algos, configuration are all available

- Can **keep the same Gain and RespCorr** for startup: expect 5% variation
  - Further refinement with collision data

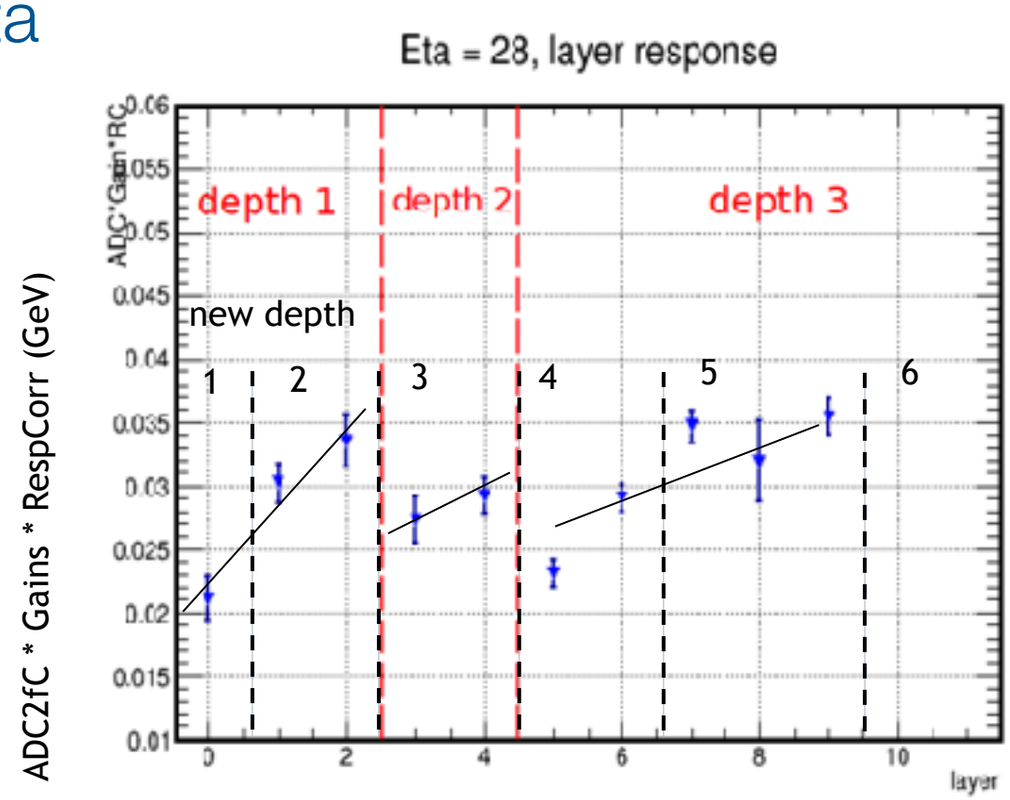
- **Same calibration strategy** as in 2016:
  - PhiSimmetry for inter-calibration
  - Zee events for abs scale
    - one e in ECAL

Response of HF+ pilot system channels without in-situ calibration

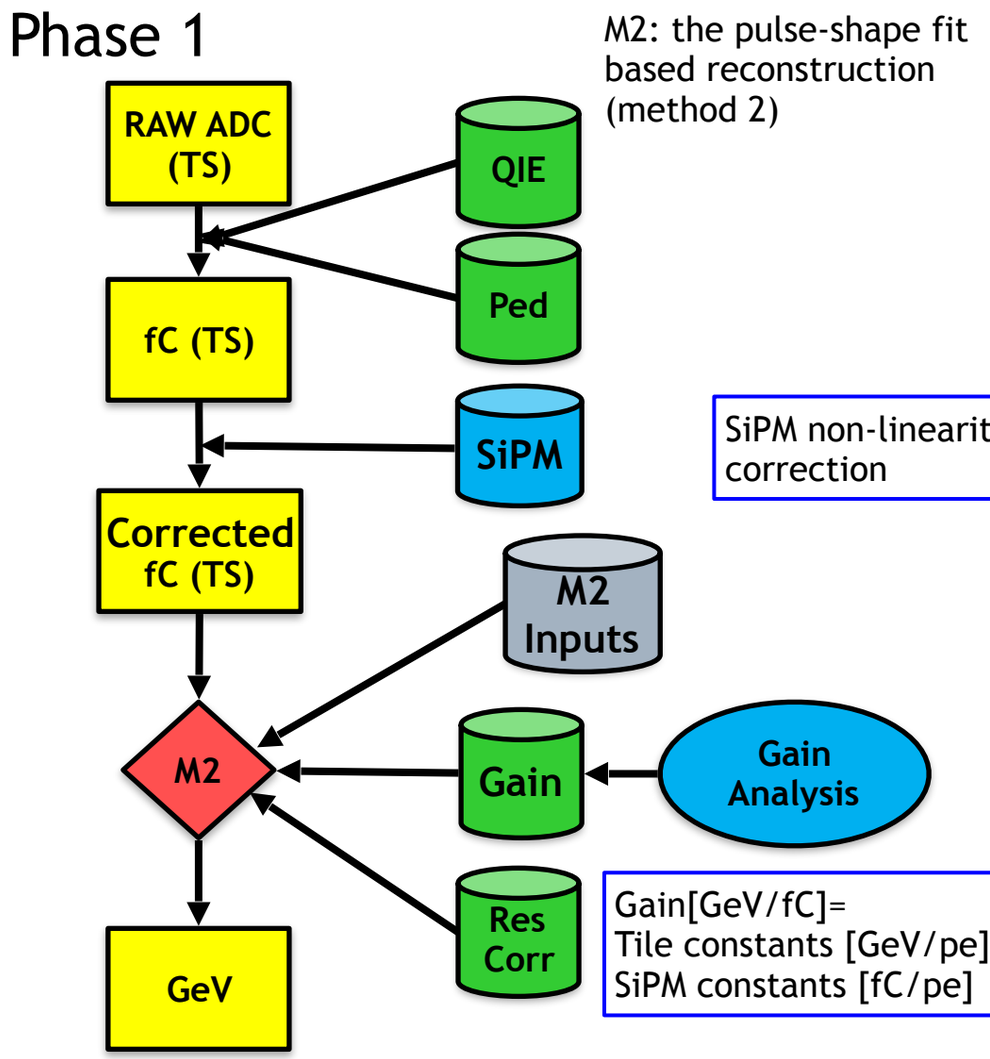


HE calibration: gain measurement from source campaign

- Major **source campaign** for HE: end Jan - begin March
  - Co60 source testing with SiPM & QIE11 done in H2 in October 2016
- Layer-by-layer measurement to calibrate increased number of depths if needed
- Compare the 2013 and 2017 sourcing data

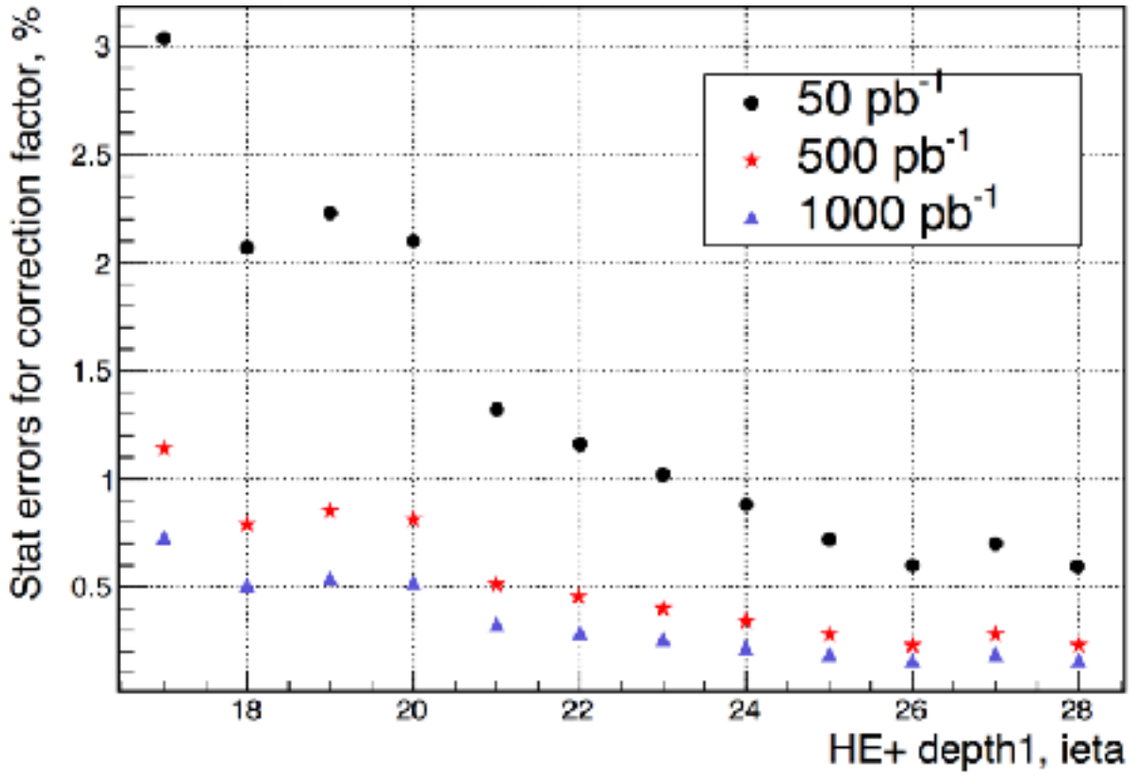


Applies to the upgraded detector



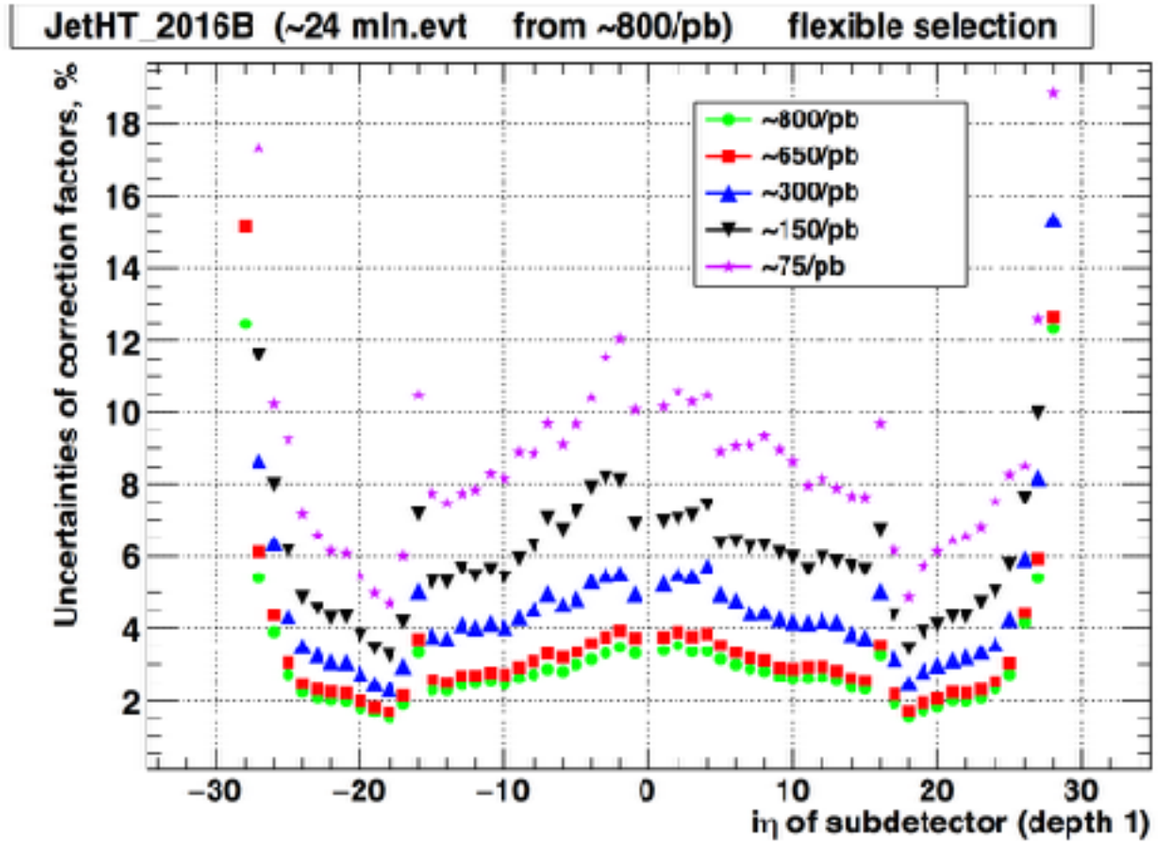
Calibration with first collision data

- Phi symmetry: **~50/pb**
  - < 0.5% stat precision for HF
  - 1-3% stat precision for HE



- Single track calibration: **~75/pb**
  - 5-10% stat precision

- Z—>ee: **~70/pb**
  - 1% stat precision in most of HF



Readiness and plans for reconstruction: Method 2 improvements

$$\chi^2 = \sum_{i}^{10TS} \frac{(TS_i - A_i)^2}{\sigma_p^2} + \sum_{j}^{Pulses} \frac{(t_j - \langle t \rangle)^2}{\sigma_t^2} + \frac{(ped - \langle ped \rangle)^2}{\sigma_{ped}^2}$$

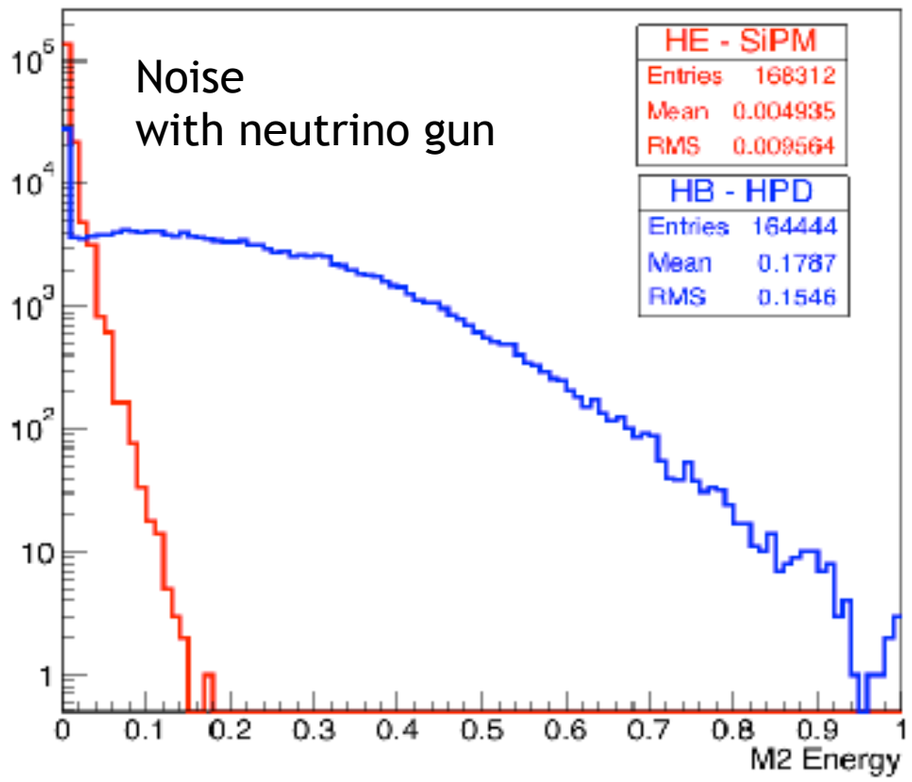
Electronic noise:
HPD, **siPM**
Dark Current:
only for siPM
ADC granularity:
QIE8 for HPD
QIE11 for siPM

Time resolution
HPD 5ns
SiPM 2.5 ns

Electronic noise term for HPD and siPM

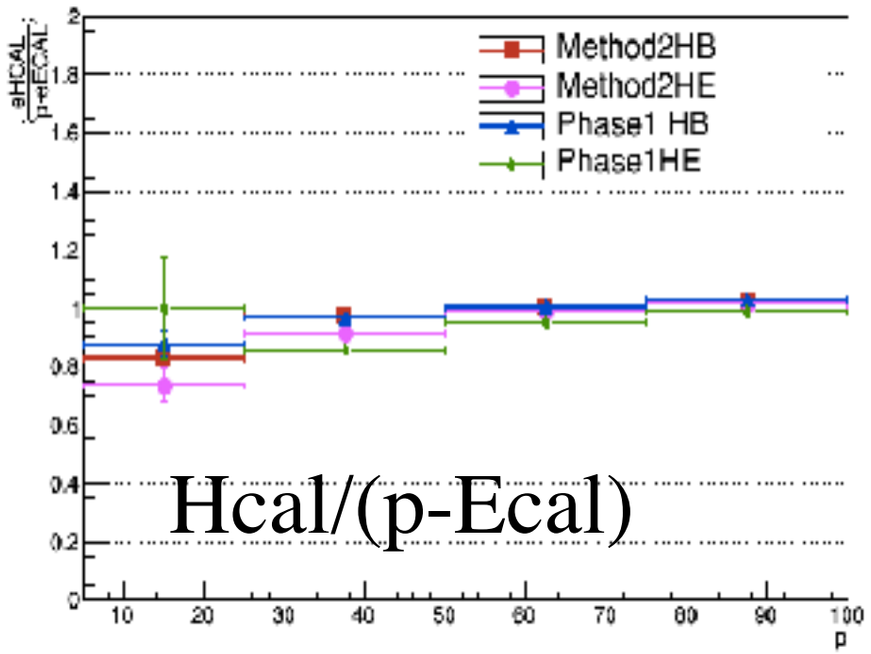
- SiPMs not only **eliminate anomalous signals**, but also **reduce the electronics noise**

- With a reduced noise it is crucial to:
  - better **understand and implement the contributions to the amplitude**
  - improve the **pulse description**



Readiness and plans for reconstruction: energy scale and resolution

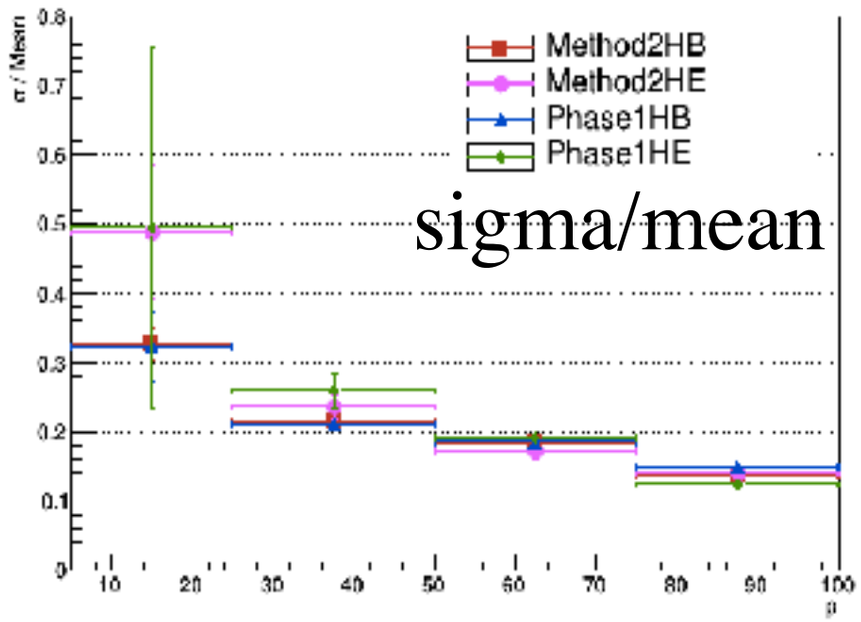
- MC single **pion gun** used (no PU)
- Use **isolated track** selections to compare the energy scale against the momentum



- **Scale under control** in SiPM simulation
  - pulse description improved
  - bias eliminated

- **Comparable SiPM/HPD resolution**

- **Data/MC** improvements from introducing dedicated MC templates
  - ongoing - short term



Monitoring and certification

- **Non-disruptive updates** will be submitted in order to:
  - monitor the **final implementation** of the detector
  - monitor additional collection from **pilot systems**

- **ROC scope expanded** (bridge between online and offline)
  - Express+Offline+local runs monitoring
  - feedback to P5 and input for final certification
  - new tools for ROC shifters available

Will get central credits (TBC)

- Working on:
  - expanding **trend analysis** for stability monitoring across runs
  - improve **instructions/training material**

In summary

- HCAL performed great in 2016 thanks to the effort of many from the DPG and Ops teams

- A challenging period ahead of us
  - a new detector (HF) to be recommissioned
  - potentially a mixed detector configuration for HE to deal with

Backup

Needs for the commissioning of the calibration workflows: MC samples

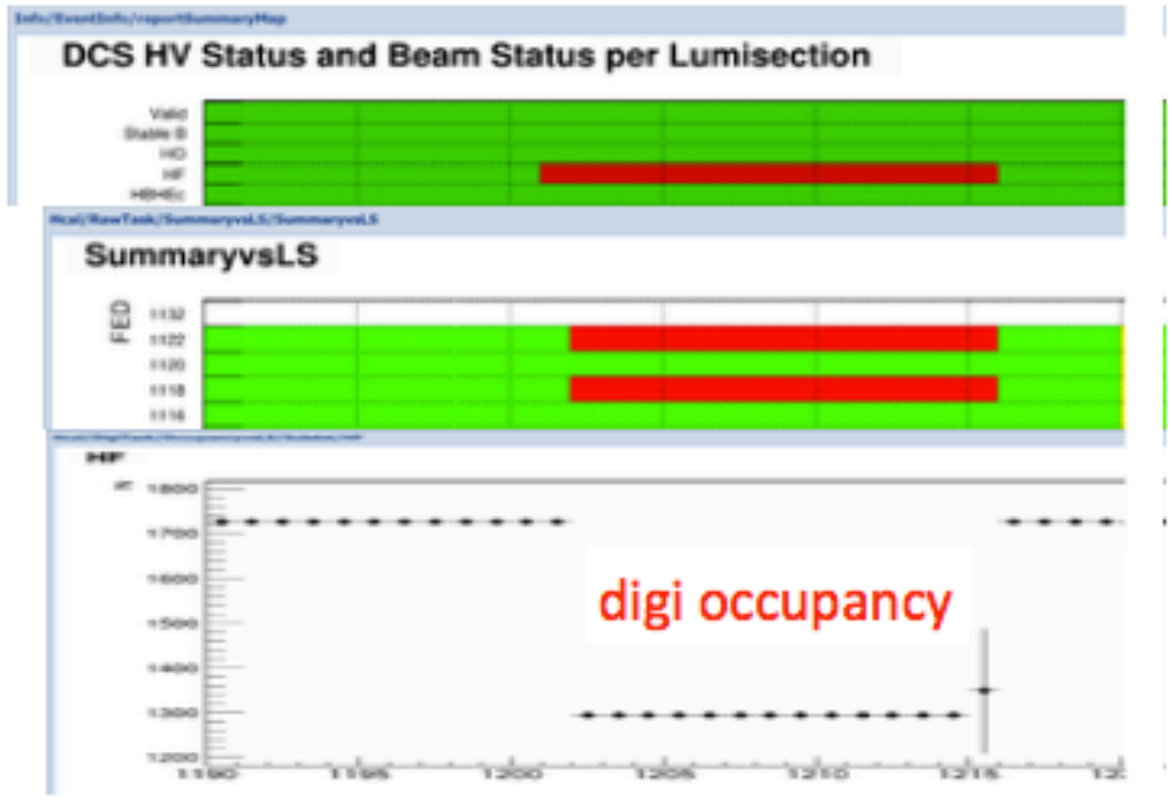
- First round of samples submitted early this year with full Phase1 scenario
  - Single Pi gun 50, 100 GeV
  - QCD MC: standard samples + with isotrack filter
  - Single Nu gun
  - DYtoMuMu

- Will be used together with 2016 MC for Plan1 studies

- Will be resubmitted with the final scenario

Recurring Issues

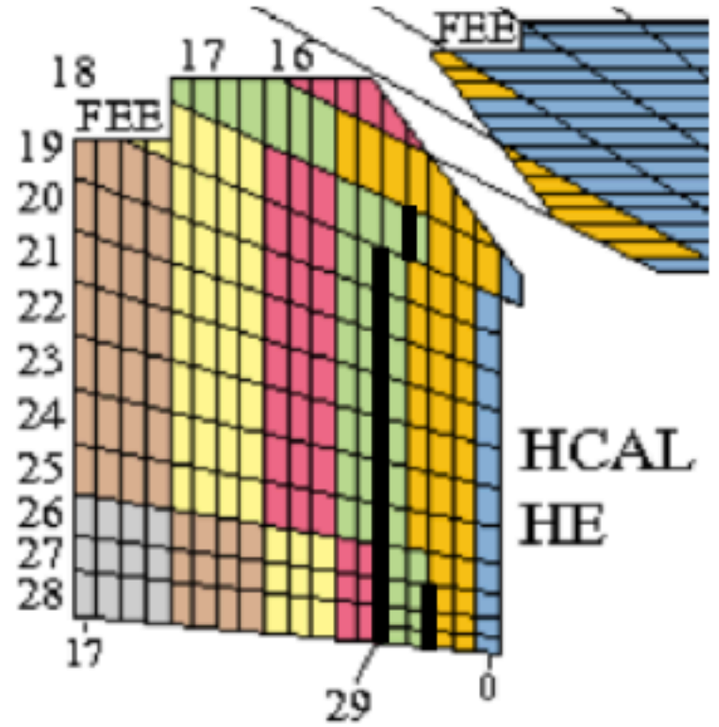
- HF LV communication errors:
  - We experience single event upsets (SEUs) in the HF LV modules. This causes a module to lose communication and go into error (only when there is beam in the machine).
  - There were 14 instances this year.
  - The LV may or may not stay on
  - The fix is typically quick (< ~20 LS): try restoring communication with the module, if it doesn't work power cycle the AC/DC
  - We're studying the correlation of these events with activity in the cavern, and will continue to discuss with CAEN personnel



- μHTR fragility in case of power cycles / shutdowns
  - ~1–2% probability of firmware corruption after a power cycle (we have 144 μHTRs)
  - a few hours time is needed to put the system back in a healthy state after a major intervention
  - will further iterate with μTCA and firmware experts

Calibration of New Depths

We have to provide a response correction for the summed depth but will have finer depth segmentation



$d1 = c1 + c2;\ d2 = c3 + c4 + c5 + c6$

$E_{QIE11} = r1' \times c1 + r2' \times c2$

$E_{QIE8} = r1 \times d1$

Calibration procedure would have to determine *r1'* and *r2'* such that $E_{QIE11} = E_{QIE8}$

We could start with r1' = r2' = r3'....

Compartment 1 (c1) may age faster than compartment 2 (c2)

Need to use the new calibration procedure

Key ingredients: Online alarms and DQM

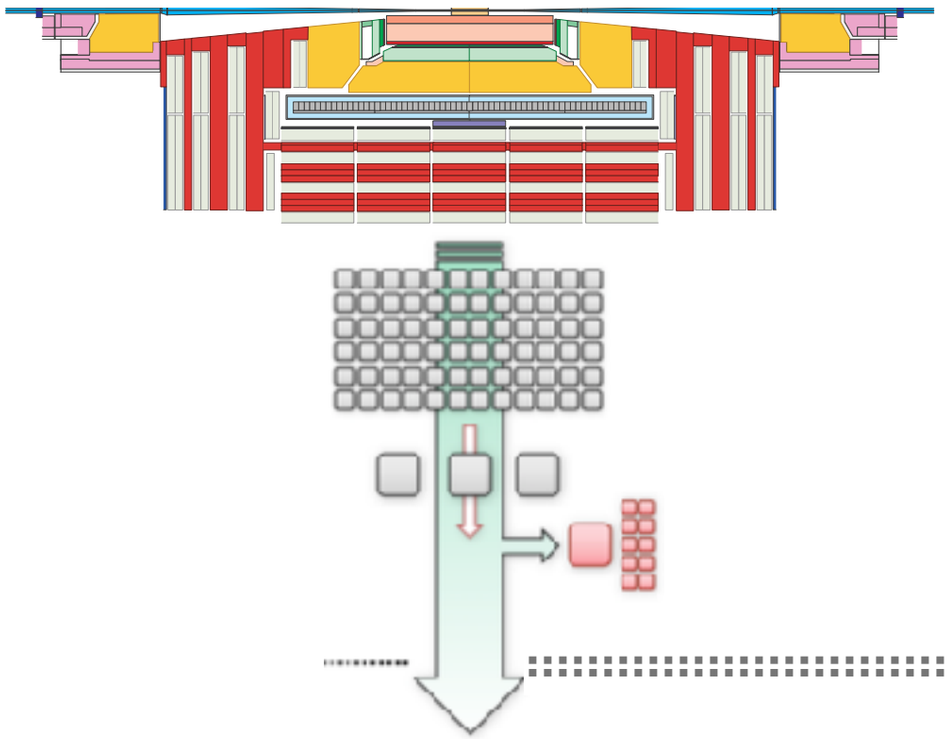
- HCAL DQM completely rewritten for 2016 data taking
  - global+local runs monitoring
  - quality monitoring by LS

- The new system demonstrated to be very effective in spotting problems right away

- Framework written having in mind Phase1 upgrade
  - flexible design
  - easy to adapt to different detector layouts
  - different set of coordinates for monitoring
    - detector coordinates, electronics coordinates, etc

Data flow and data quality monitoring

proposal



- 1/10 of full stats
- Central shifters 24/7:
  - check ongoing data taking (coll+calib)
  - fill Online RR
- Hcal DoC+experts monitoring:
  - take+check local runs
  - follow up on problems w/ PFG

Online

Once a day

PFG

Input

ROC shifter:
- Health Check Runs → Once a day
- Online/Express → Quasi online
- Prompt → 48h delay

Offline RR

Daily summary
Daily feedback to RC
Input to Data Cert

Offline

Weekly

- Instructions
- Access to local GUI
- Easy choice of Dataset+Reference
- Access to Offline RR

Cert Responsible
double checks data quality
CMT analysis on demand
→ JSON

In summary the ROC should:

- Check ongoing data taking **[quasi online wf, ~2h delay]**
  - inspect collision runs (collision+abort gap events) in online GUI
  - fill the offline RR (express dataset)

- Check prompt reconstruction **[offline wf, 48h delay]**
  - inspect **continuously** collision runs in offline GUI instead of once a week
  - pre-fill the offline RR (prompt reco dataset)
    - pavel signs off once per week

- Check health check runs **[once a day]**
  - inspect health check runs in hcal local GUI

HE Gain Calibration Concept

[*] Vladimir Gavrilov

- Compare the 2013 and 2017 sourcing data to obtain 2017 Gains

2013 sourcing	⟷	2017 sourcing
ADC2fC(QIE8) x Gains(2013)[GeV/fC] x RespCorr(2013)	exp [-3years /5.3 years] (Co^{60} halflife: 5.3 years)	ADC2fC(QIE11) x Gains(2017) [GeV/fC] x RespCorr(2017)

- Use 2017 Gains [GeV/fc] and SiPM constants [fC/pe] to derive "Tile constants" [GeV/pe] for several phi

Gains[GeV/fC] = Tile constant [GeV/pe] / SiPM constant [fC/pe]

- Assuming that "Tile constants" depends on eta but not on phi, calculate Gains for all HE channels using mean values of "Tile constant" for the same eta & SiPM constant for a particular channel

[*] e,g, https://indico.cern.ch/event/530726/contributions/2195668/attachments/1294215/1929007/HCAL_calib_stat_plans_190616.pdf