HCAL nel 2017

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CMS Italia a Spoleto

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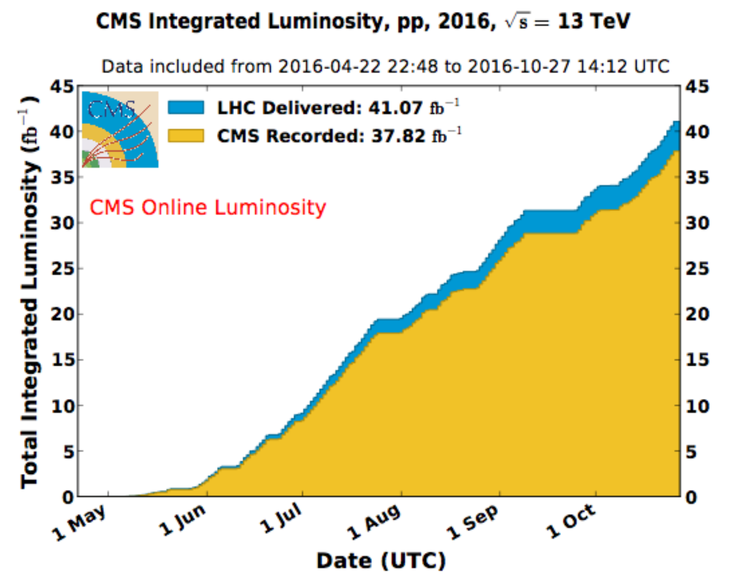
Outline

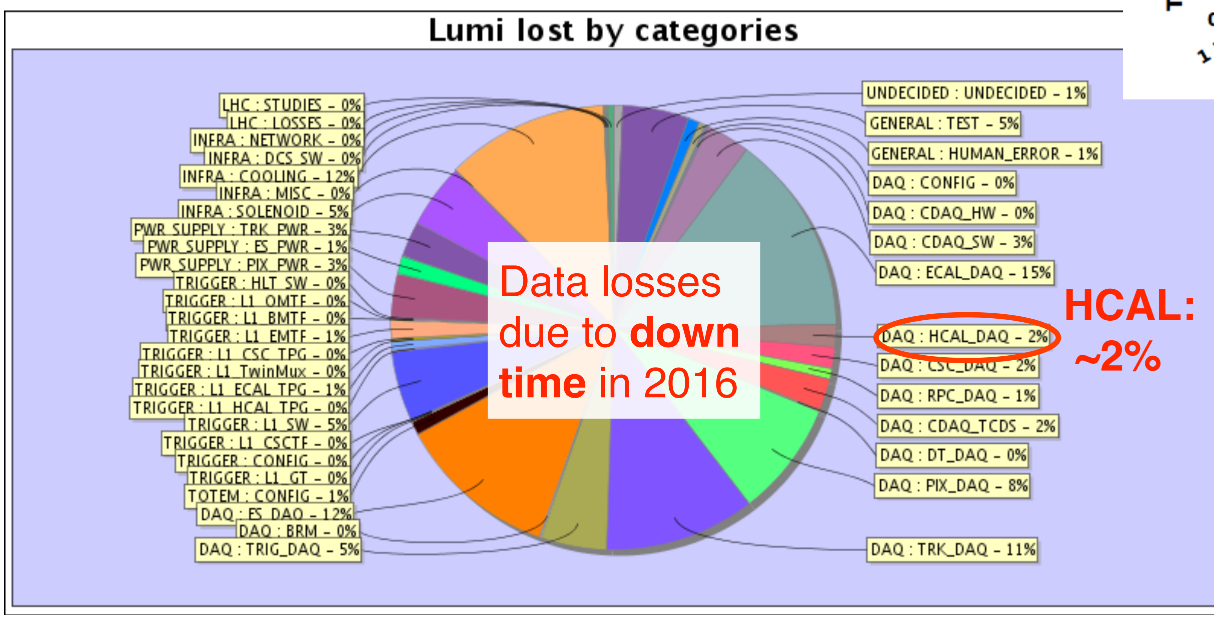
- Brief summary of 2016 data taking
- Plans for 2017, the HE and HF Phase-I upgrades
  - Overview and motivation
  - HF and HE phase-I pilot systems in P5
  - Status of HF and HE Phase-I hardware and firmware
  - Phase-I reconstruction software
  - Installation plans (and actual readiness for installation)
- Summary and Conclusions

Brief Summary of 2016 Data Taking

HCAL Data Taking Efficiency in 2016

- Global CMS data taking efficiency in 2016 pp run was ~92% (41.07 fb^{-1} delivered, 37.82 fb^{-1} recorded)
  - data loss at down time is ~1.6 fb^{-1} (~4% of the total delivered luminosity)
- HCAL has generally behaved very stably during pp data taking in 2016
  - has been responsible for only ~2% of the total lumi loss at down time (~26 pb^{-1})
- Similar performance during HI running

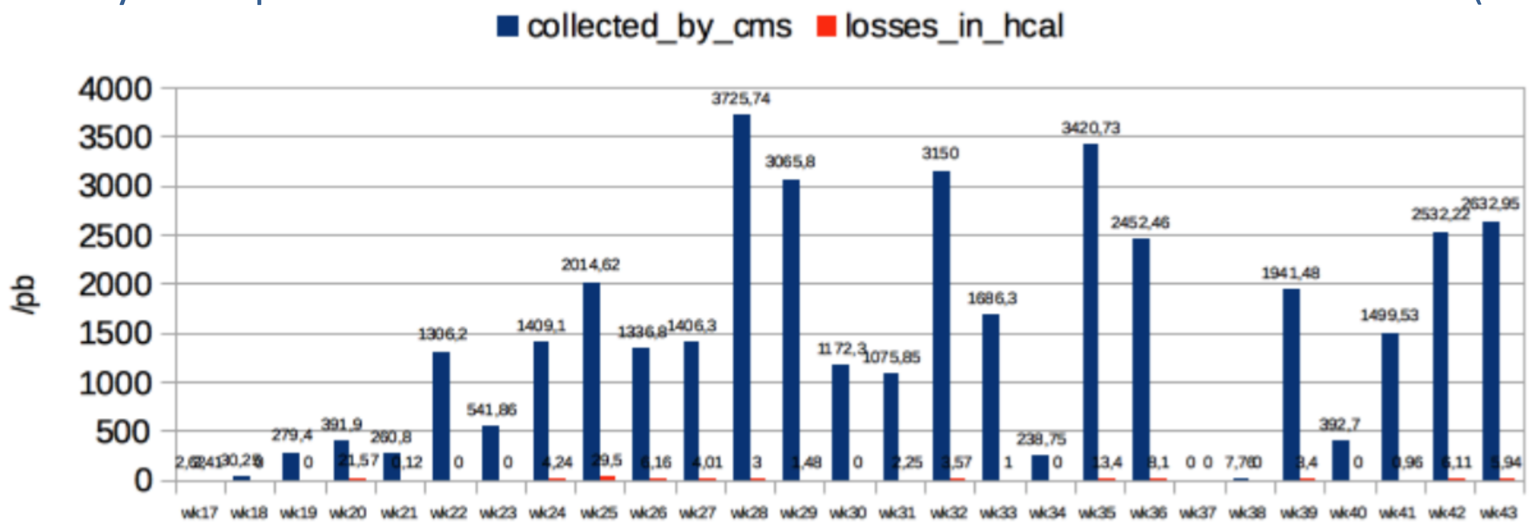




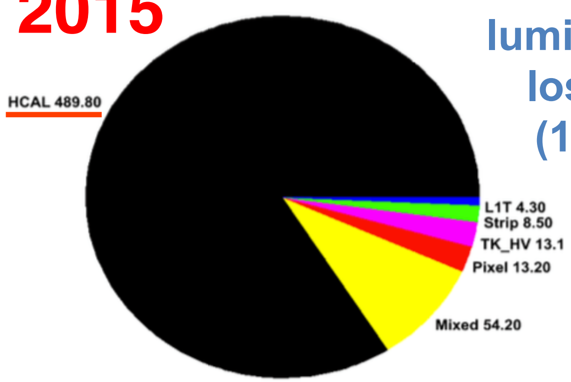
- No general recurring issues, downtime losses mainly due to few isolated incidents

HCAL Data Quality in 2016

- HCAL has performed very well in terms of data certification:
  - only ~126 pb^{-1} out of 37.4 fb^{-1} certified are marked bad because of HCAL (~0.3%)

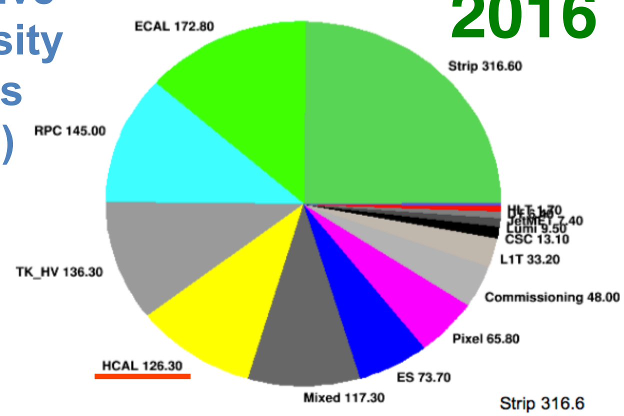


2015



Exclusive luminosity losses (1/pb)

2016



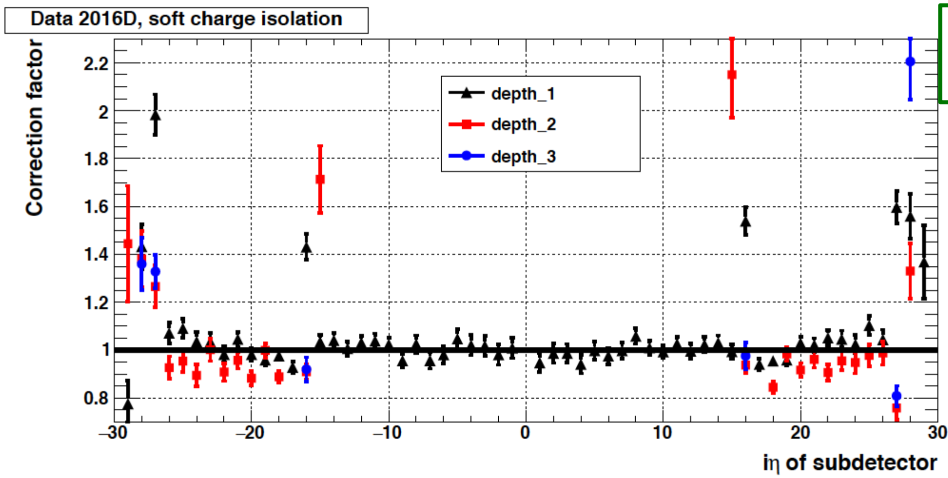
- Much better figures in 2016 than last year!
- Key ingredients:
  - Having addressed firmware issues
  - Much improved online monitoring (alarms/DQM)

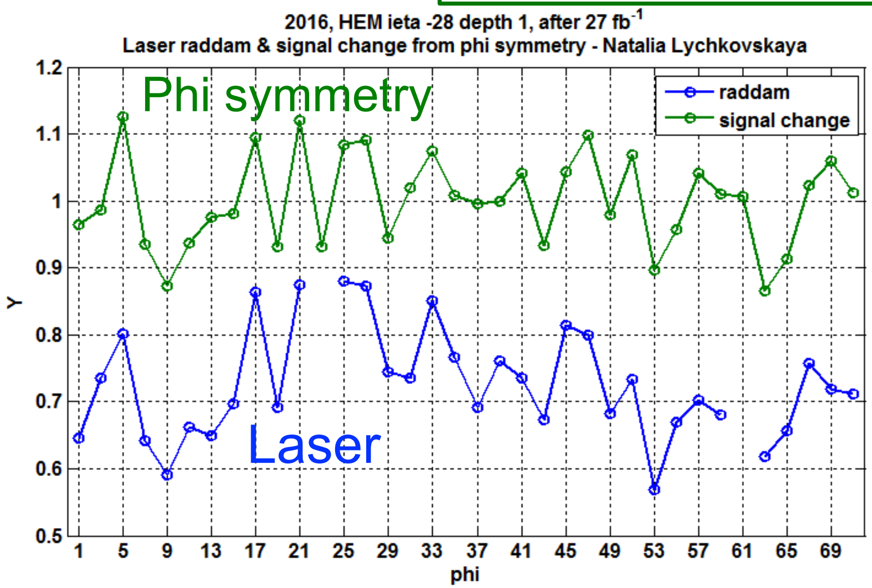
Calibration

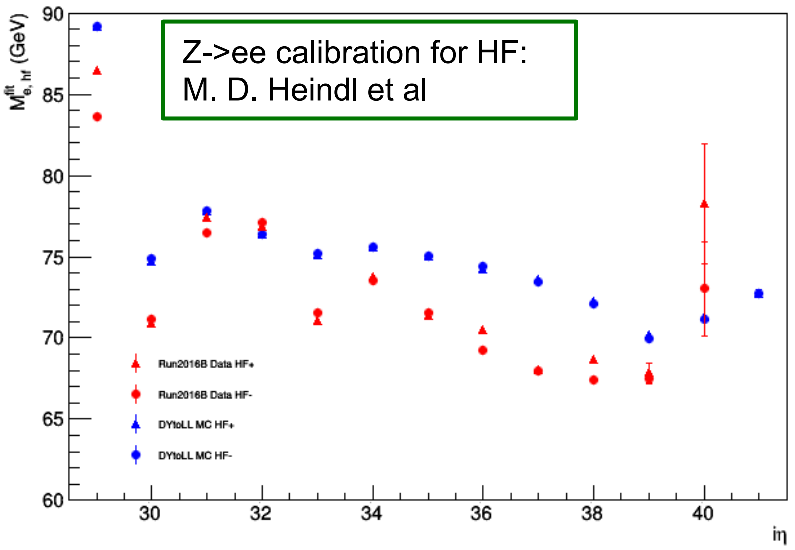
- No major issues with calibration in 2016

Phi symmetry Calibration team: N. Lychkovskaya, S. Nandan, S. Banerjee, O. Kodolova, V. Epshteyn

Single track for HB/HE: M. Chadeeva, S. Banerjee et al







Overall good data-MC agreement: up to 10% differences at some ieta

Phi dependence of radiation damage captured by phi symmetry corrections

HF and HE Phase-I Upgrades (EYETS 2016/17)

HE and HF Phase-I Upgrades in 1 Slide

New, improved photo-detectors

- HE: Hybrid Photo-Detectors (HPD) → Silicon Photo-Multipliers (SiPM)
  - To eliminate high amplitude noise and drifting response of HPDs
  - To mitigate effects of radiation damage to scintillators and WLS fibers
  - To allow increasing the longitudinal segmentation of readout (pile-up suppression and recalibration of depth-dependent aging)
- HF: single-anode readout of PMTs → dual-anode readout and addition of TDC
  - improve discrimination of anomalous signals

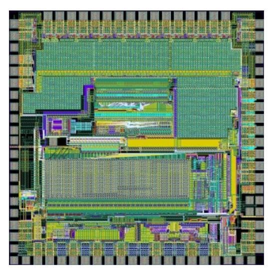
New front-end electronics – support of increased number of channels and new photosensors
– QIE8 (7bit ADC) ➔ QIE10/QIE11 HF/HBHE (8bit ADC, embedded TDC)

New back-end electronics (μTCA) – supports larger data volumes, new trigger primitives

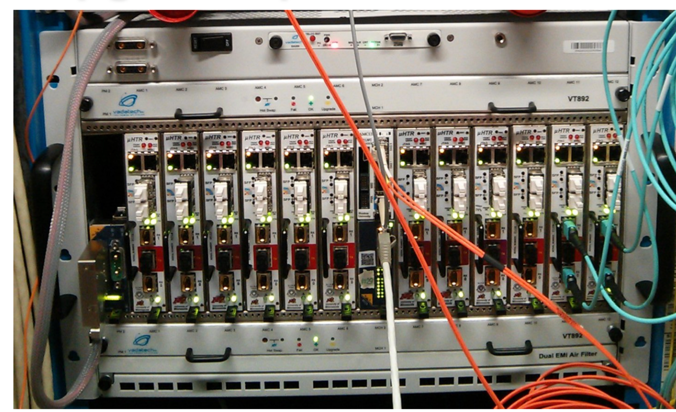
HE/HB: improved photosensors

HF: single to dual readout PMTs

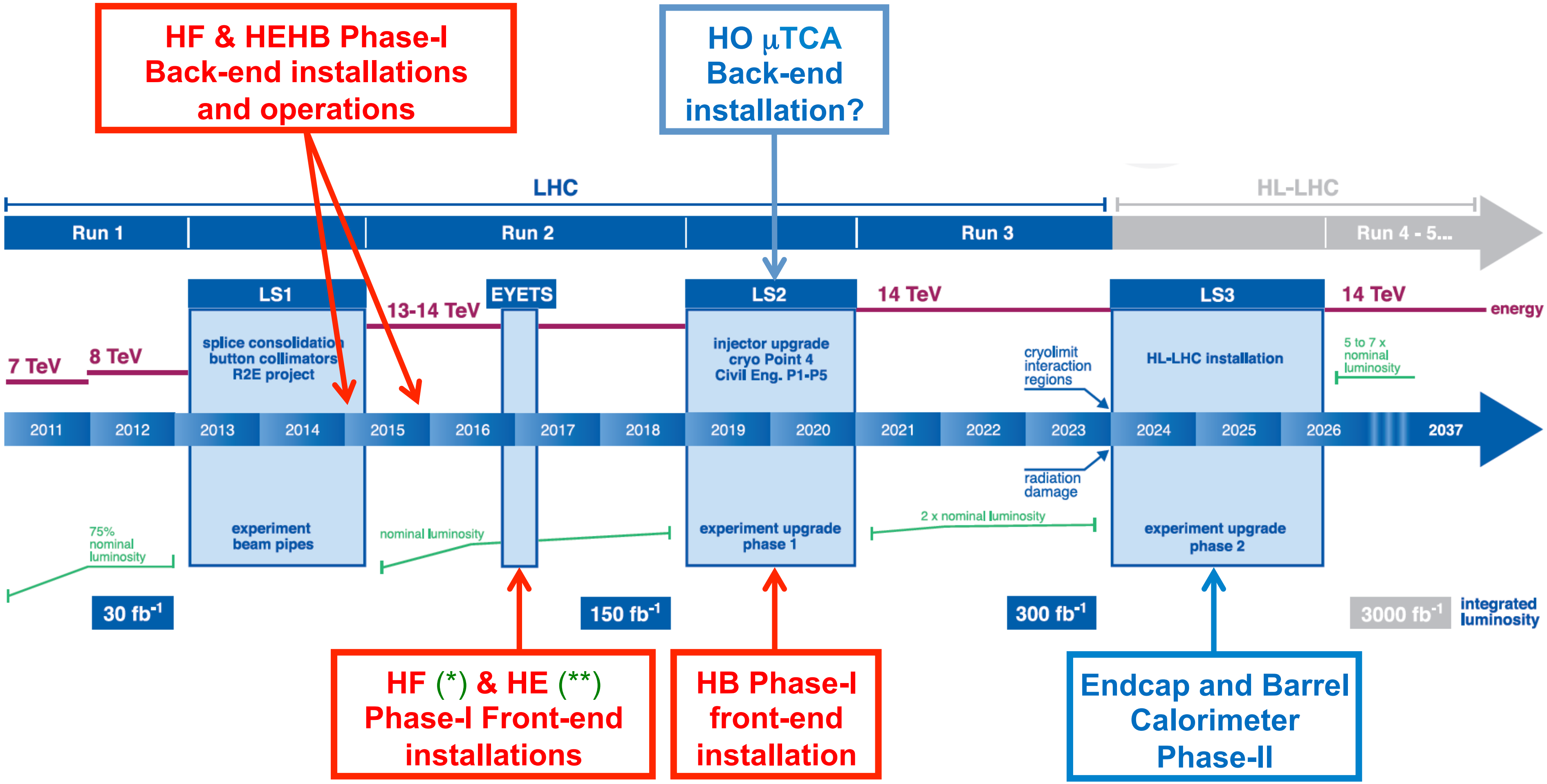
QIE10 (HF)
QIE11 (HBHE)



Upgraded μTCA Back-end



HCAL Phase-I Timeline



(*) Postponed from YETS 15/16 (benefit: it allowed installing improved QIE10 chips on HF front-end cards)
(**) Accelerated from LS2 (to ameliorate effects of faster-than-foreseen radiation damage)

HF Phase-I Upgrade

HF Upgrade Motivation

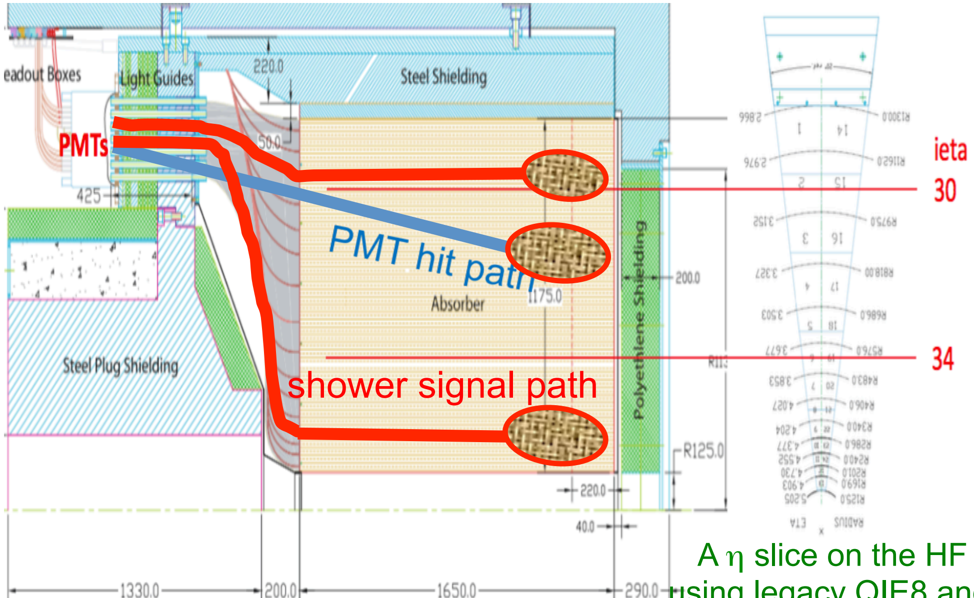
To further discriminate physics signals from 'PMT hits'

- Beam-induced anomalous signals were discovered during test beams prior to the LHC Run-1, and were due to particles directly hitting PMT windows.
- New, thin-window PMTs (installed during LS1) are less sensitive to anomalous hits

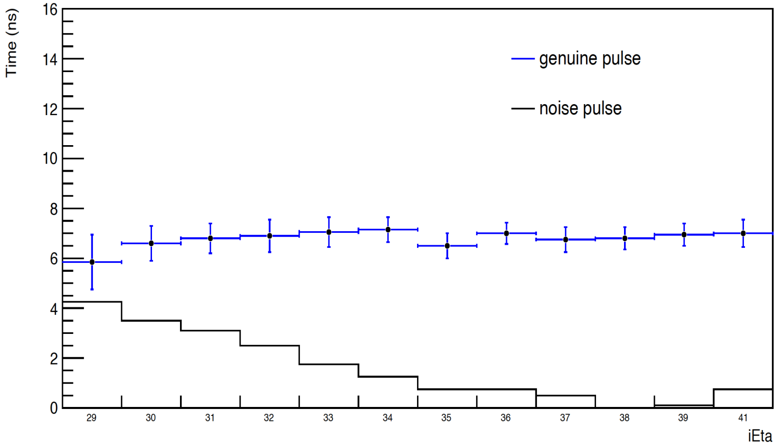
Phase-I upgrade in EYETS 16/17:

- Add TDC to improve noise vs physics signal discrimination (spurious signals arise 2-7 ns earlier)
  - HF pulse shape is short, fully contained in 1 time slice, no timing info at all without a TDC
- Dual-anode readout as further discrimination for spurious signals affecting one anode, with the ability to recover energy measurement from the other anode

Signal paths for **PMT hits** and **normal shower** signals



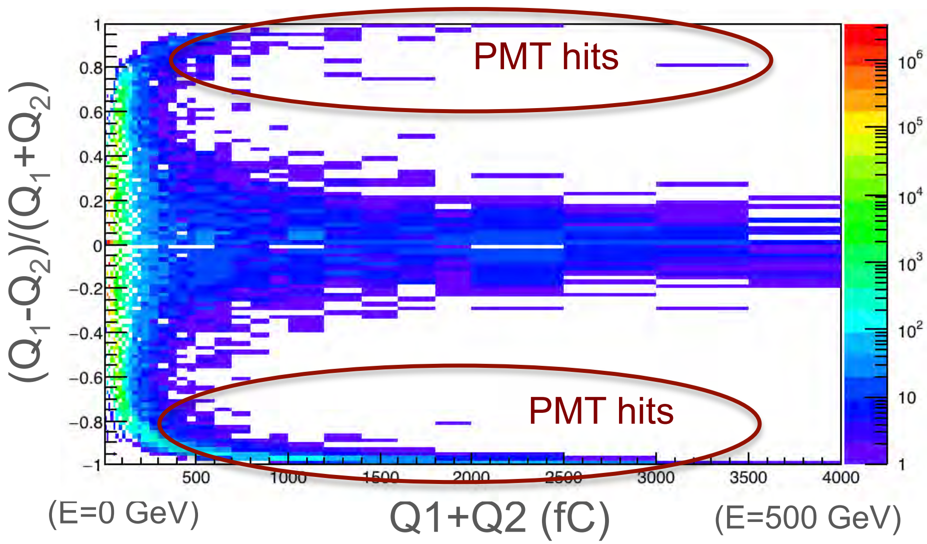
2016 QIE10 pilot system data

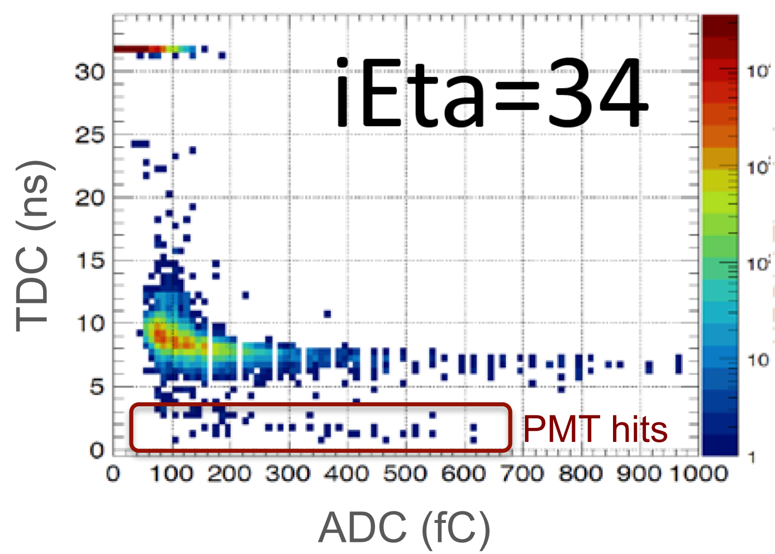


A η slice on the HF detector has been instrumented with dual anode readout using legacy QIE8 and Phase1 QIE10 (iη 30 and 34 use QIE10 for both anodes)

HF QIE10 Pilot Installation

- A dual-anode PMT readout box was reworked in HF+ to commission a pilot system of the new QIE10 front-end electronics in parallel with normal data readout for CMS with QIE8
  - 22 PMTs have their outputs split 50%-50% between QIE8 (for CMS data taking) and QIE10, spanning a full η sector
  - 2 PMTs have their outputs split into two QIE10 channels
  - HF front-end cards with the new (2016) QIE10 chips were installed in July
- The plots below are from collision runs for a PMT split between 2 QIE10 chips
  - Good symmetry between anode-A (Q_1) and anode-B (Q_2) measurement for physics signals
  - Asymmetric hits due to PMT hits are seen
  - TDC measurement working reliably, providing ability to discriminate early hits based on timing

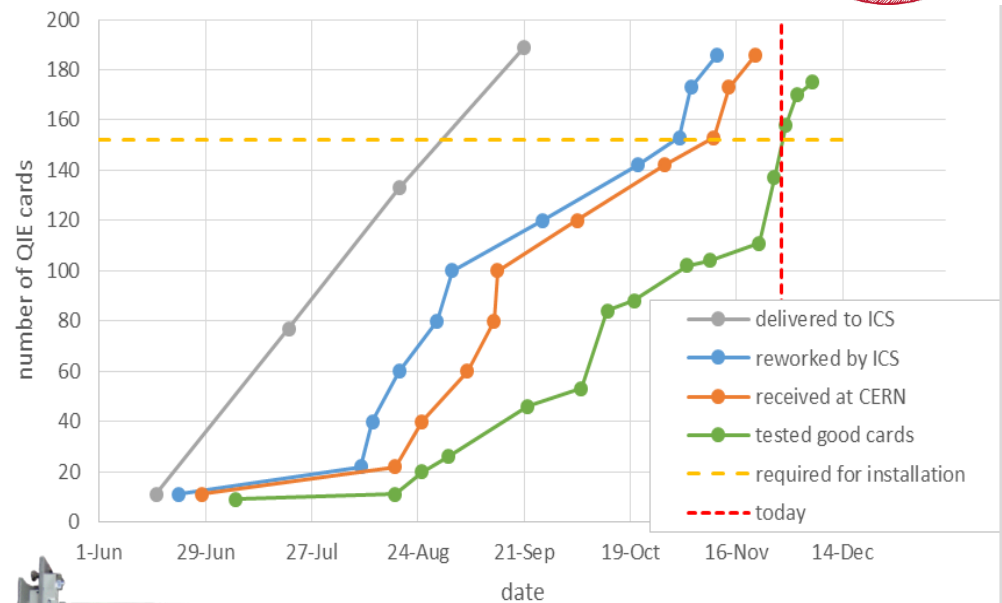




HF Hardware Status

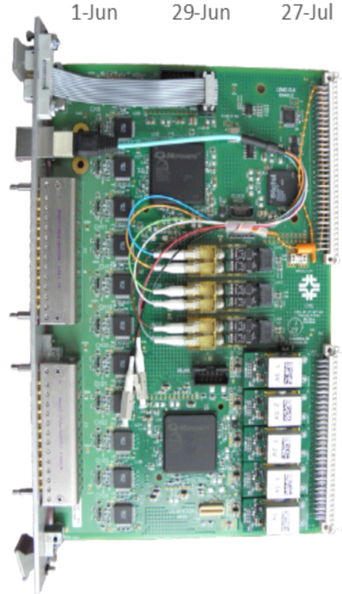
Status of QIE card rework

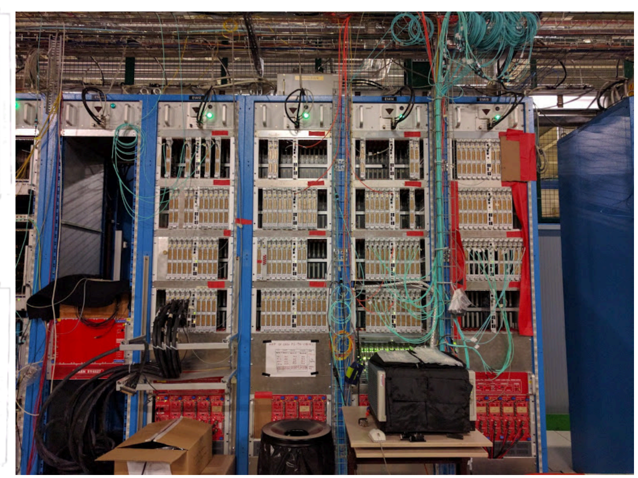
- All 189 cards sent to vendor have been reworked and returned to CERN
- Percolating through testing sequence
- Permanent failure rate small (≈6%)
- ➢ Have now enough good cards for installation (152) plus spares



Overall readiness of HF front-end system

- Final version of channel alignment in the QIE card IGLOO2 FPGA firmware implemented
- HF front-end electronics at the burn-in station is being operated stably and reliably – no failures during burn-in
- HF pilot system in P5 has been operated successfully for several months





HE Phase-I Upgrade

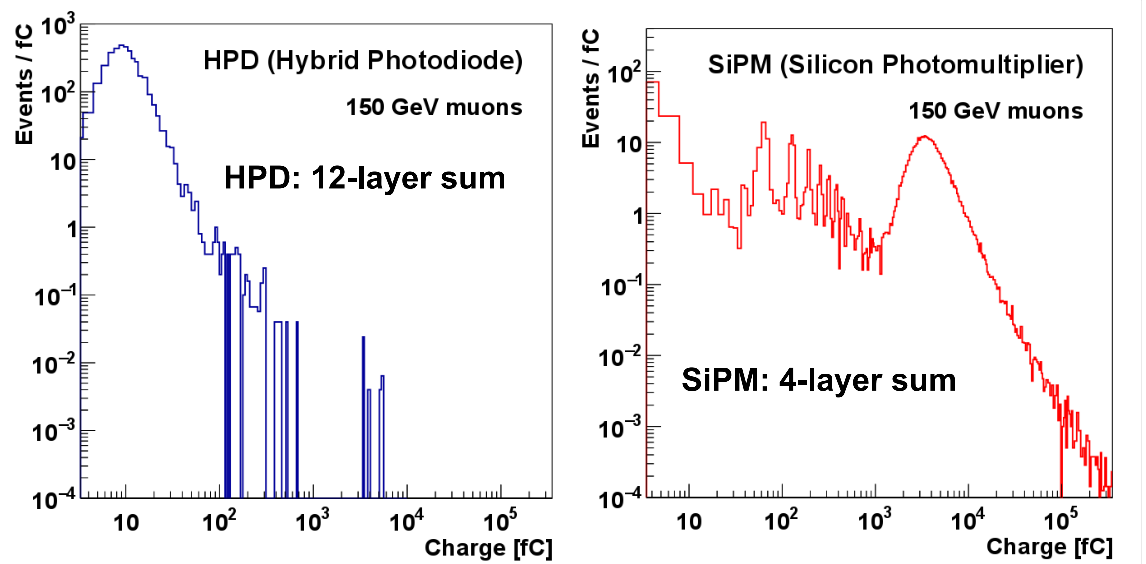
Motivation for HE acceleration

Observed HE signal reduction largely exceeds expectations based on pre-construction studies

- Dose rate effects were not accounted for (more on next slide)

The HE upgrade was originally scheduled in LS2. HCAL has put a considerable effort to allow an earlier installation of the HE Phase-I front-end in EYETS 2016/17.

- To counteract radiation damage with the 3x higher SiPM photo-detection efficiency (w.r.t. HPDs) even before LS2
- The radiation damage to HE scintillators has a strong gradient across detector volume
  - New SiPM+QIE11 readout supports up to 7 depth segmentation, allowing fine-grained calibration corrections vs depth, alleviating worsening of jet energy resolution



J. Pastika, test beam 2015

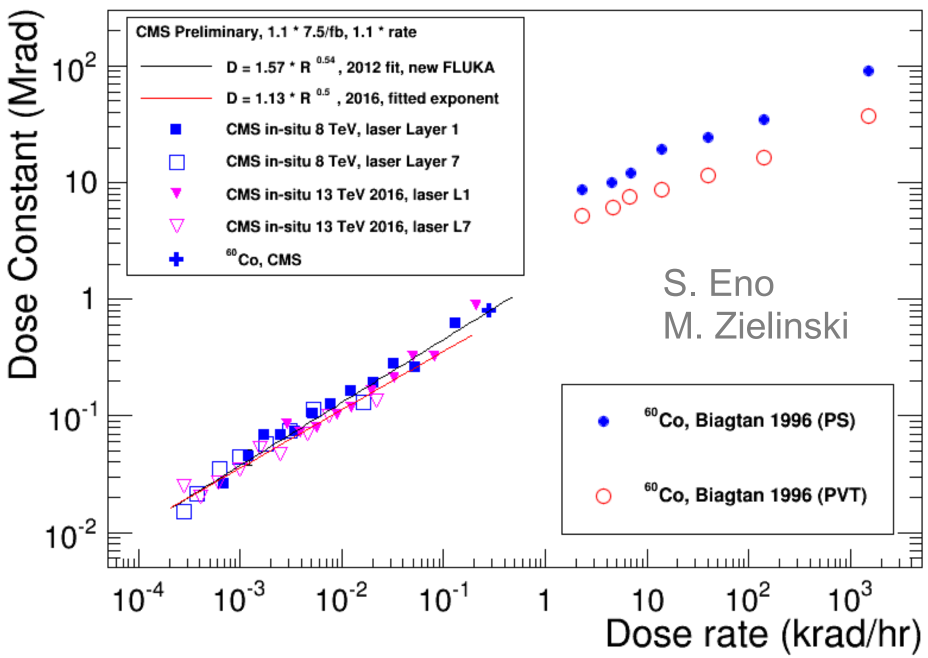
HE signal loss, and dose-rate dependency of damage

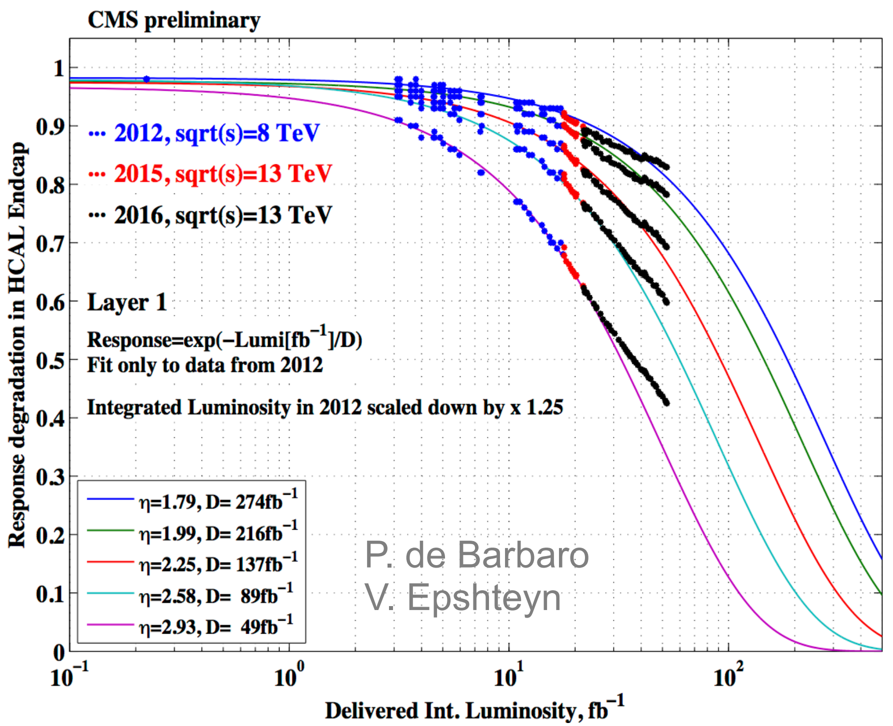
The dependency of the radiation damage on the rate at which the radiation dose is delivered is well established

- Damage per unit of delivered dose is lower for higher dose rate
- Also confirmed by in-situ data using HCAL laser monitoring system

The plot below shows the increasing HCAL signal loss at various eta values as a function of integrated luminosity

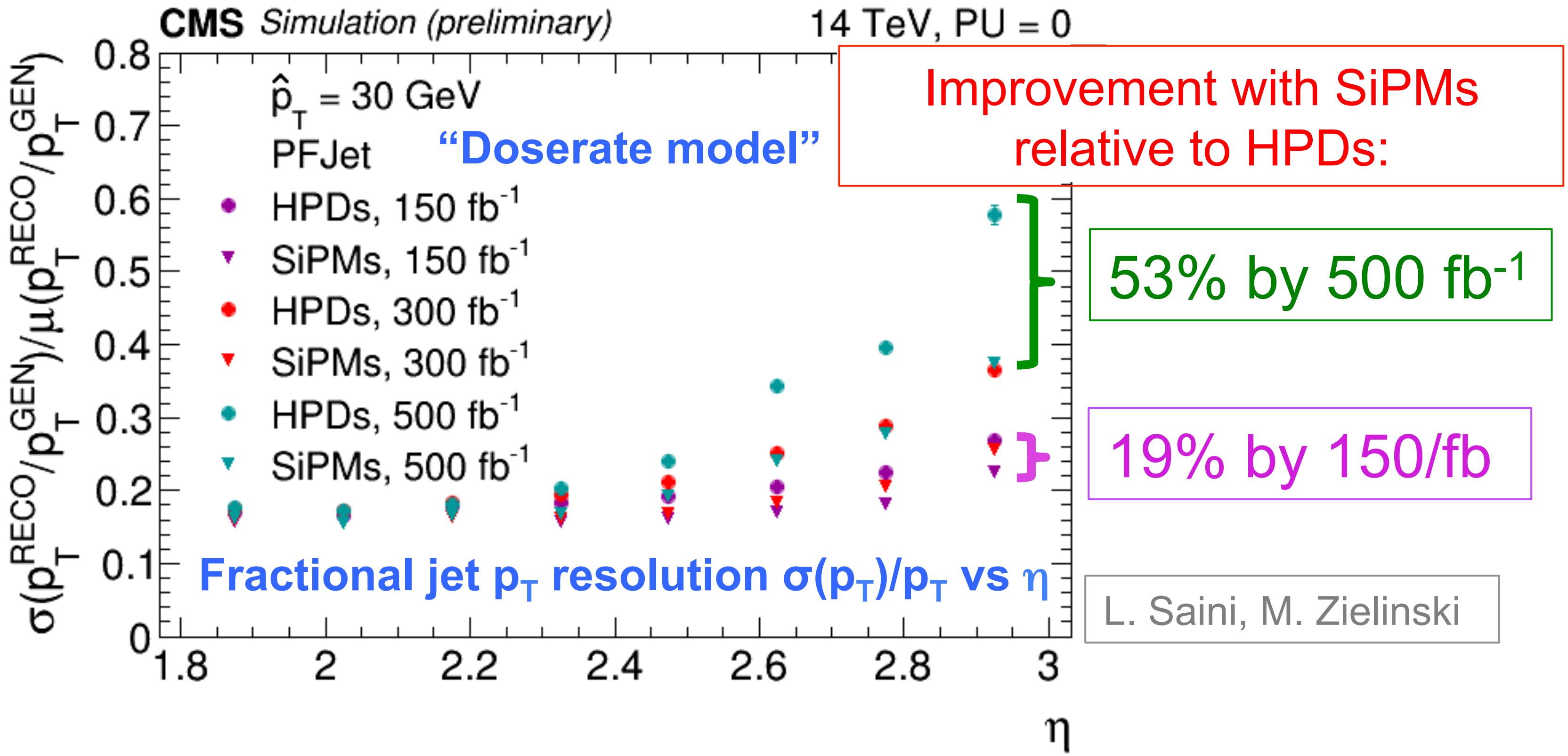
- measured with HCAL Laser system in layer-1 in 2012, 2015, 2016 (layer-7 shows a similar trend)
- Fits are made to 2012 data only
- Signal loss due to radiation damage has slowed down (per unit of integrated luminosity) in 2016 wrt fit to 2012 data





Impact on jet resolutions

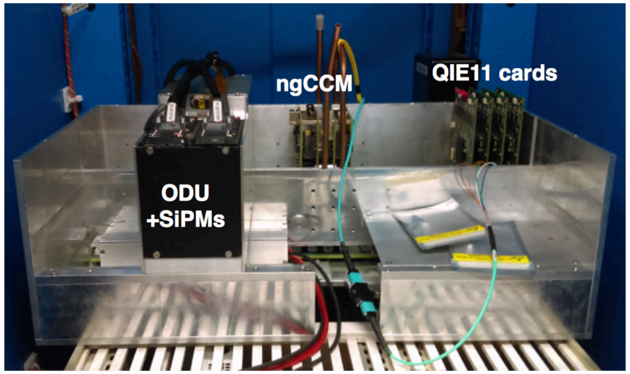
- The 3x higher SiPM photon detection efficiency (PDE) and finer re-calibration for depth-dependent radiation damage allows to reduce the degradation of jet resolution with respect to HPDs



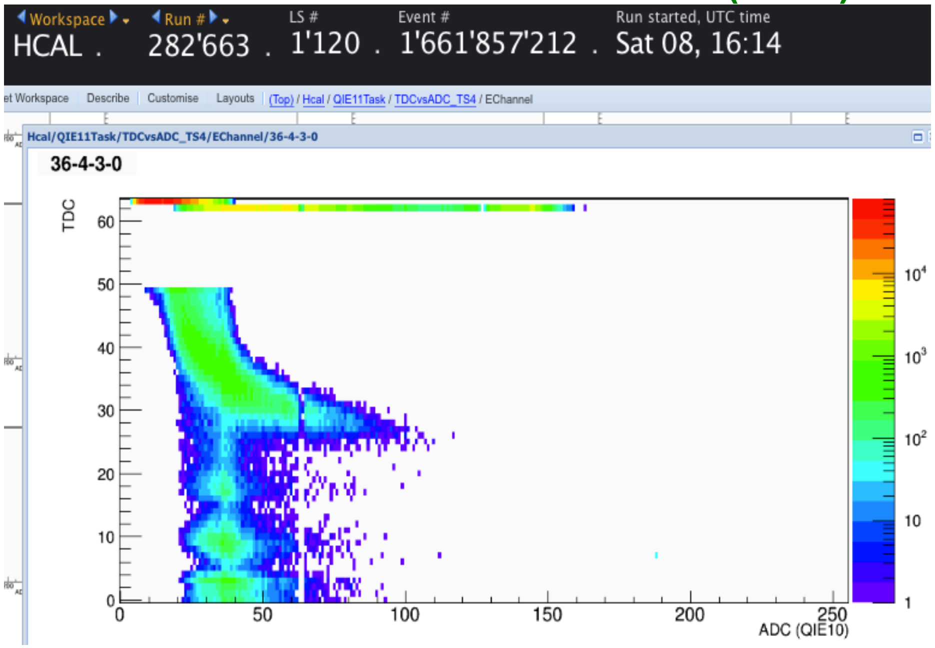
- Any additional luminosity delivered before LS2, either due to high performance of the LHC or delays in the LS2 start, would increase the benefits of the EYETS-16/17 installation of HE

HE Pilot System in P5: AKA Castor Radiation Facility (CRF)

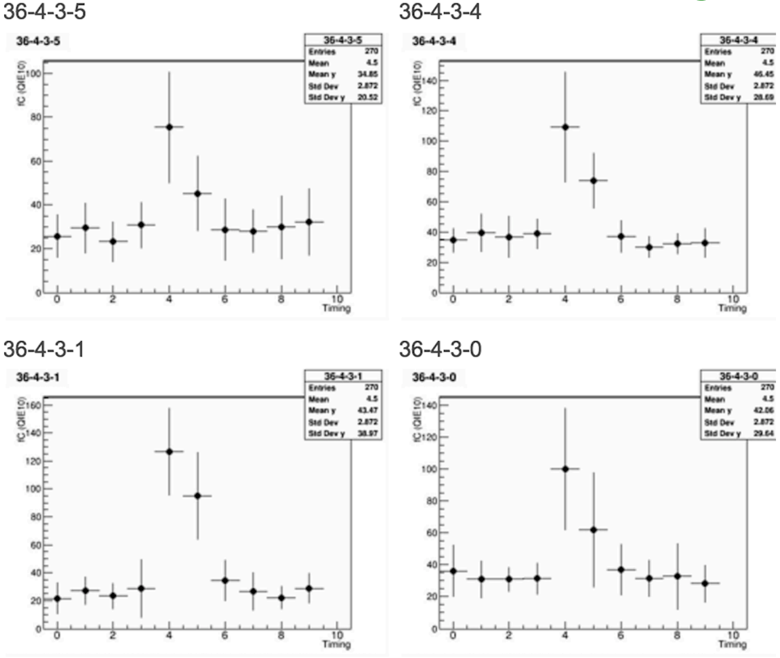
- CRF consists of set of scintillators/WLS fibers connected to HCAL laser injection system, read out by production grade HE Phase-I Front-End (SiPM+ QIE11 boards), feeding to uHTR in USC.
- The CRF has shown that the new HE front-end works as expected, and provided feedback on software and firmware commissioning
  - FE-BE data links stable, signals timed in (both physics and LASER in orbit gap), full HE Phase-I readout chain works in P5
  - Very high occupancy given location close to beam pipe, TDC info may already be providing new information



TDC vs ADC from Collisions run (DQM)



Event shapes of Laser-in-abort-gap

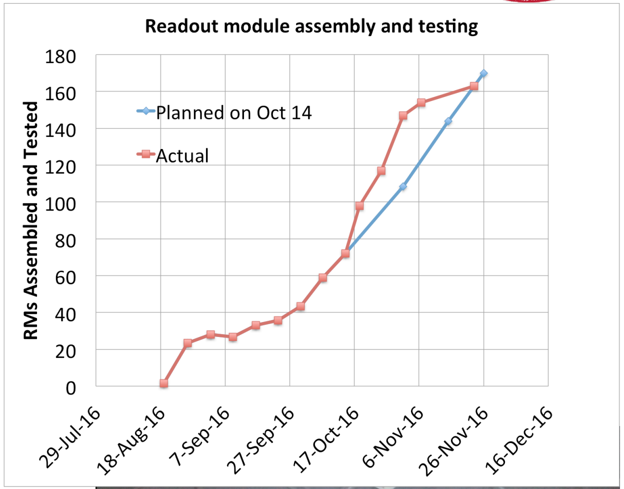


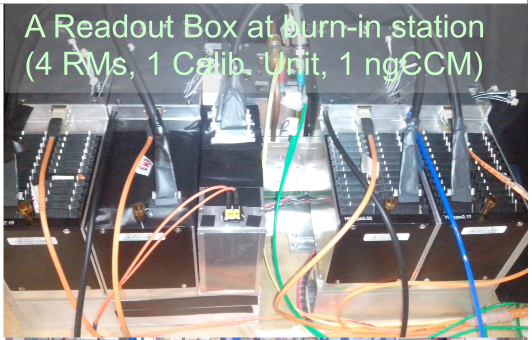
HE Front-end Hardware Status

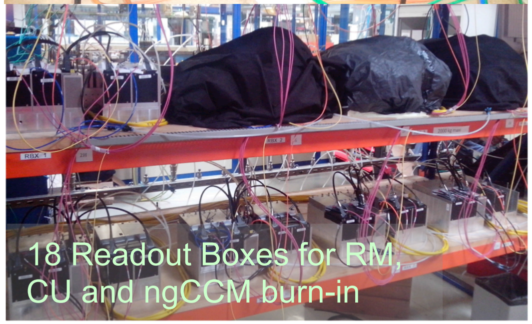
- Hardware production completed
  - However, a PCB manufacturing problem affected the control boards of the ngCCM (new gen. Clock and Control Module)
    - ➢ a new production is ongoing (next slides)

- Readout Module (RM) assembly and burn-in
  - Completed assembly of 144 RMs for detector plus spares
  - Burn-in of first 72 RMs completed
    - No failures observed
    - Operated at 19 deg (3 weeks) and 5 deg (2 weeks)
    - Typically ~2 power on/off cycles per day
    - Regularly taken pedestal and LED runs
    - SiPM gains have been equalized, QIE pedestals adjusted, established stable Peltier cooler operation even at 5 deg
    - Mean of SiPM gain unchanged over time
  - Started burn-in of next 72 RMs
    - No failures observed so far

- Extended burn-in of 1 RBX ongoing in parallel
  - Operated at 19 deg, ~1 power cycle per day, all OK

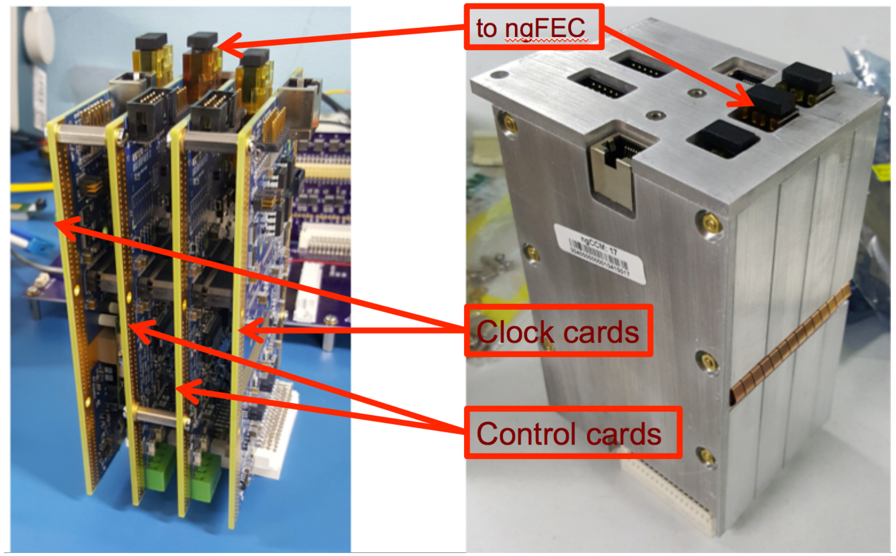






new generation Clock and Control Module (ngCCM) Hardware Problem with Production-1

- Require 36 ngCCM modules for HE, plus spares
  - One ngCCM module consists of 4 cards
    - 2 clock and 2 control cards
- The production of 110 control cards for 55 HE modules was defective (prod-1)
  - 20% failure rate, plus 3 cards failing after a few weeks of operation
  - Problem in the PCB production
    - now fully understood
    - all cards will likely eventually fail
    - currently working prod-1 cards can be (and are being) used to perform burn-in of readout modules only, or to temporarily support/commission RM installation in HE
- After verifying that there was no problem with the board design, a second production was immediately launched
  - Different PCB vendor, same assembly vendor
  - Components were readily available as already procured for the (identical) HB ngCCM

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Prod-1 PCB manufacturing problem:
First PCB vendor cross-sectioned the
failed boards and identified the
problem to be with the desmear process,
which is used to clean out drilled
holes prior to plating. Organic
material was inadvertently left in the
holes and plated over. This material
outgasses with temperature, which
damages plating and the traces near the
holes. All boards are expected to be
affected and to fail eventually.
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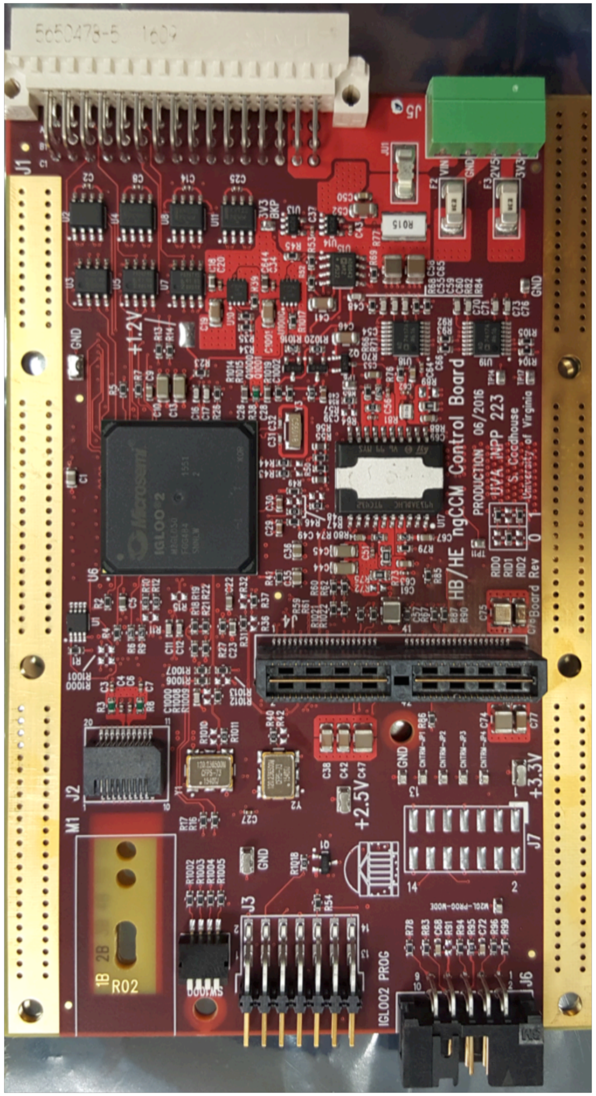
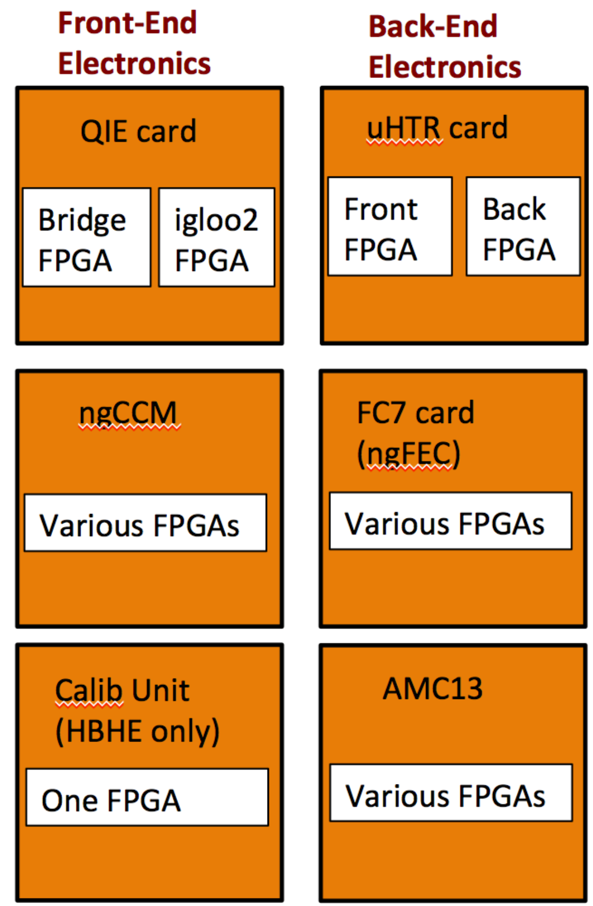
ngCCM Production-2

- New ngCCM production (prod-2) ongoing
  - 1st batch of 30 assembled cards received at CERN Monday Nov 21
  - 2nd batch (30 cards) arrived and being tested
  - 3rd (25) and 4th (25) batches expected at CERN on Dec 19 and in early January
- Prod-2 assembly and testing
  - All 30 prod-2 control cards passed single-board tests (where 20% of prod-1 cards had failed)
  - 14 fully assembled ngCCM modules, 9 in burn-in, 5 used for firmware work
- Currently foreseen schedule
  - Burn-in of first 18 ngCCM prod-2 modules through Jan 10
    - Ready to be used for installation, which starts mid-Jan
  - Burn-in of 2nd set of 18 ngCCM prod-2 modules Jan 10 - Feb 10
    - Some prod-1 modules could temporarily be used on detector to support RM installation and commissioning, to be replaced by prod-2 as burn-in is completed



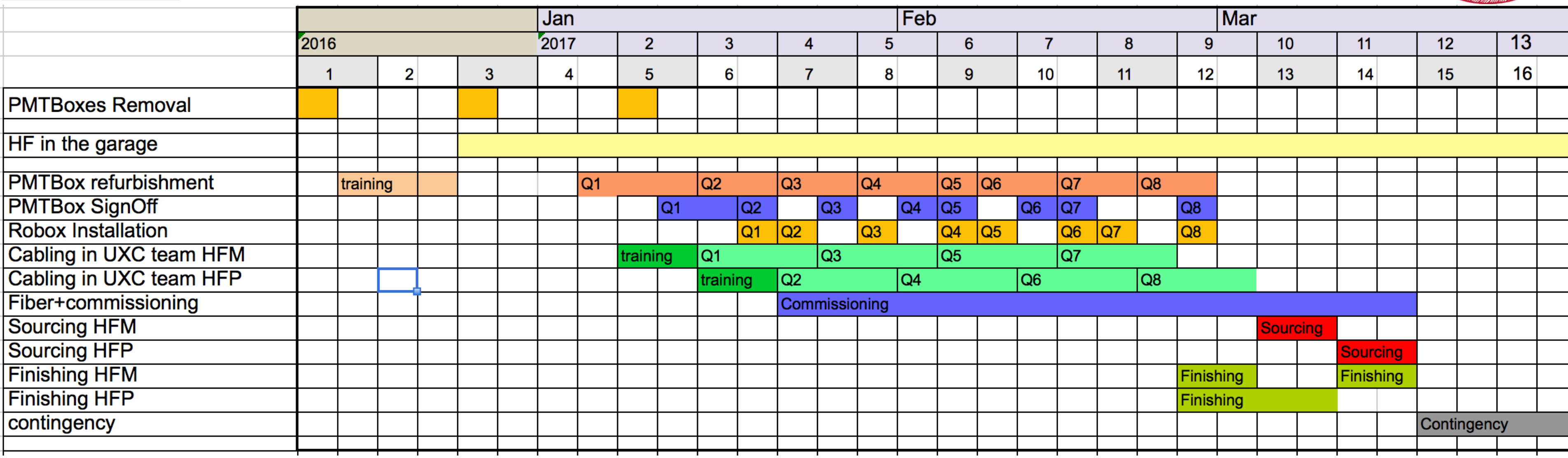
Firmware and other tasks

- The following firmware functionalities are being completed or commissioned, and are critical for installation
  - Channel alignment algorithm in FE Igloo2 FPGA:
    - Two complementary methods have been tested successfully
  - Achieve universal FW build for HE ngCCM:
    - In progress; have recruited additional experienced engineer to assess status and facilitate convergence
  - Finalize stable remote QIE card Igloo2 reprogramming:
    - Achieved, but not extensively tested yet
  - Finalize stable remote ngCCM Igloo2 reprogramming:
    - Universal FW build is prerequisite
- Other required items
  - Understand and improve stability of HE ngCCM⇔ngFEC link, almost done
  - Dual AMC13 -> central DAQ readout: deployed and used in HF during p-Pb run (HB/HE to be done during EYETS)



HF and HE Phase-I Installations and Commissioning

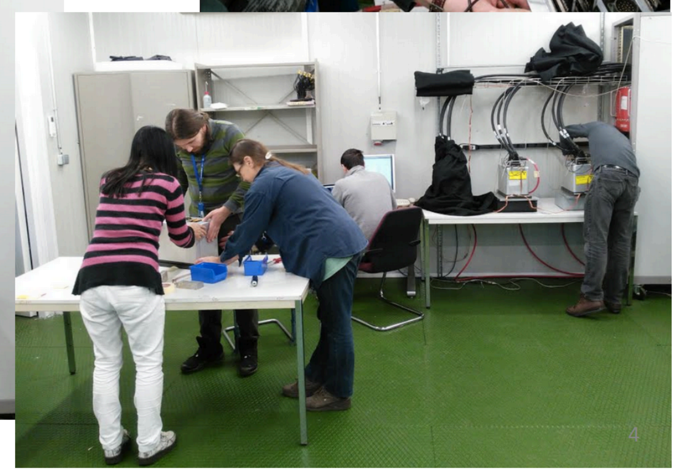
HF Installation Schedule



- We need to replace legacy front-end electronics (crates and boards) located on racks next to HF detector with upgraded electronics – re-cabling and rack reorganization necessary
- To implement PMT dual-anode readout, we need to remove the PMT boxes, take them to SX5, open them and replace an adapter board, re-QC them, and re-install them in UXC
  - ➢ Installation and commissioning in a 21 week EYETS is doable with 2 week contingency
- Co-60 wire-sourcing campaigns are crucial to validate the end-to-end mapping and connection
  - – two, one-week-long campaigns for HF are necessary

HF PMT Box Rework

- The rework of the HF PMT boxes has started in SX5
  - To implement the dual anode readout
  - 21 of 144 PMT Boxes have been removed from HF detector, 5 already reworked



Location of HE Front-end Readout Boxes

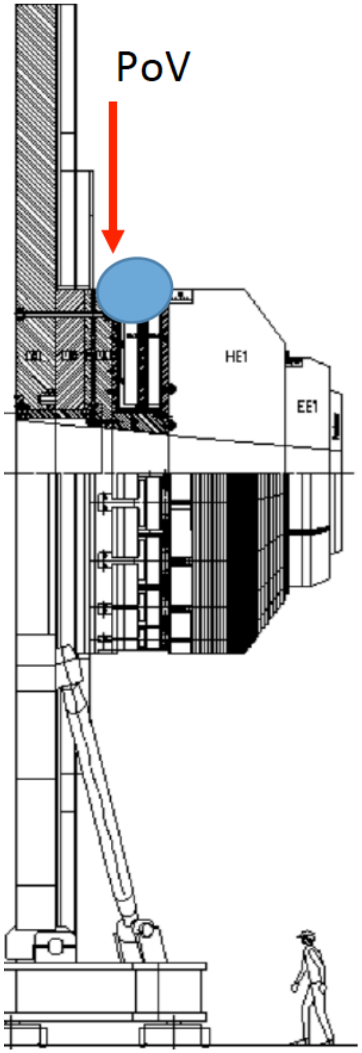
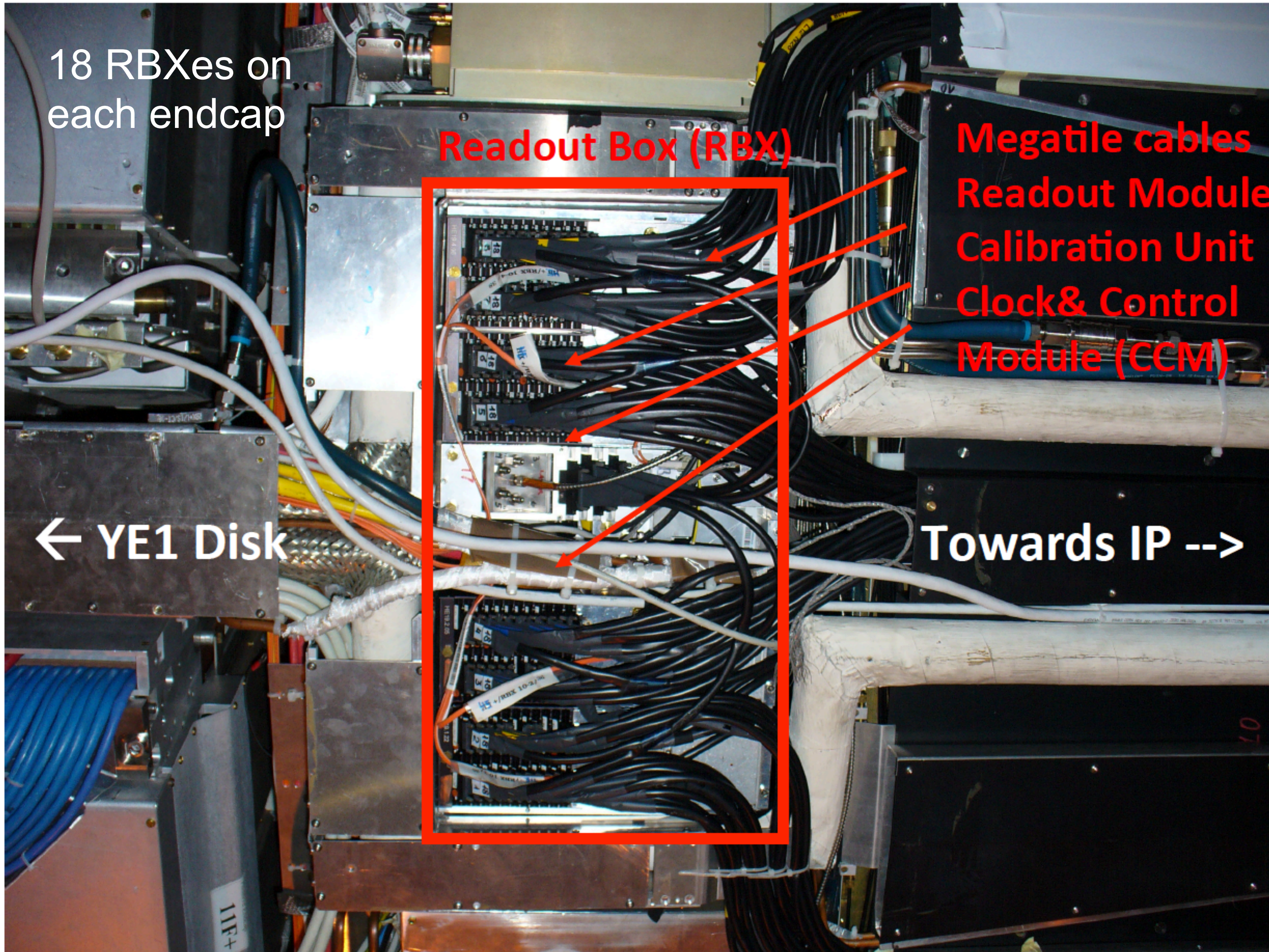
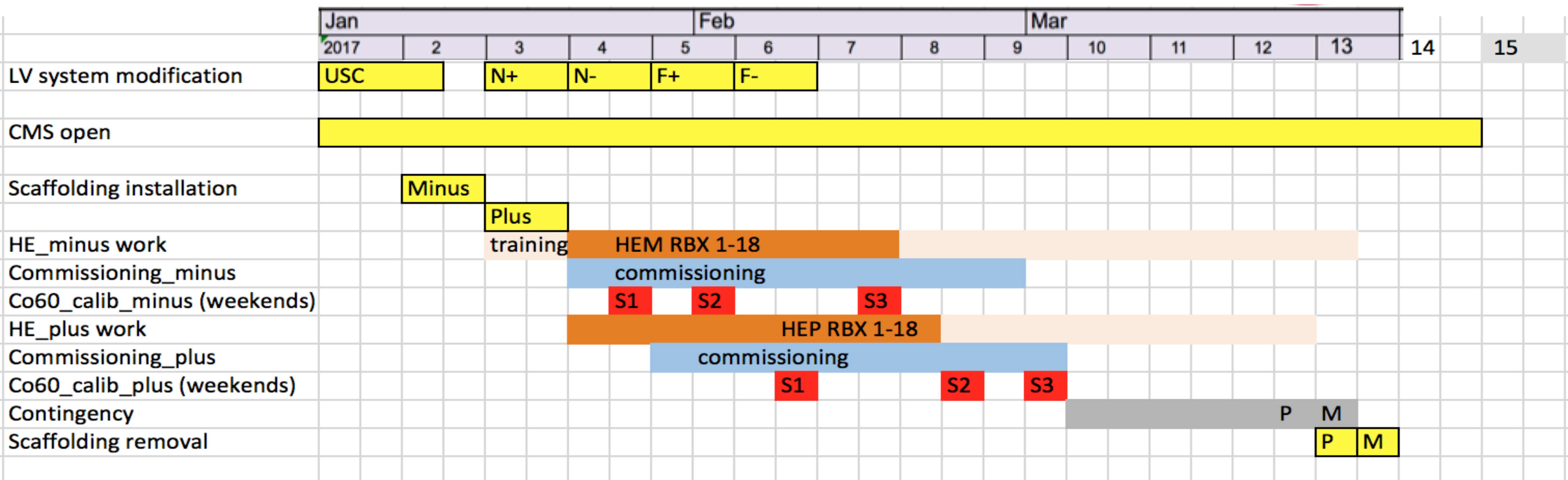


Fig. 3.60: Assembled unit.



HE Installation Schedule

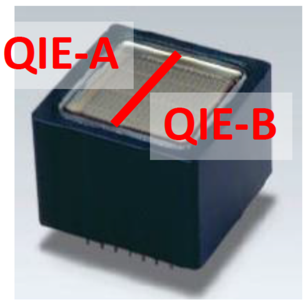


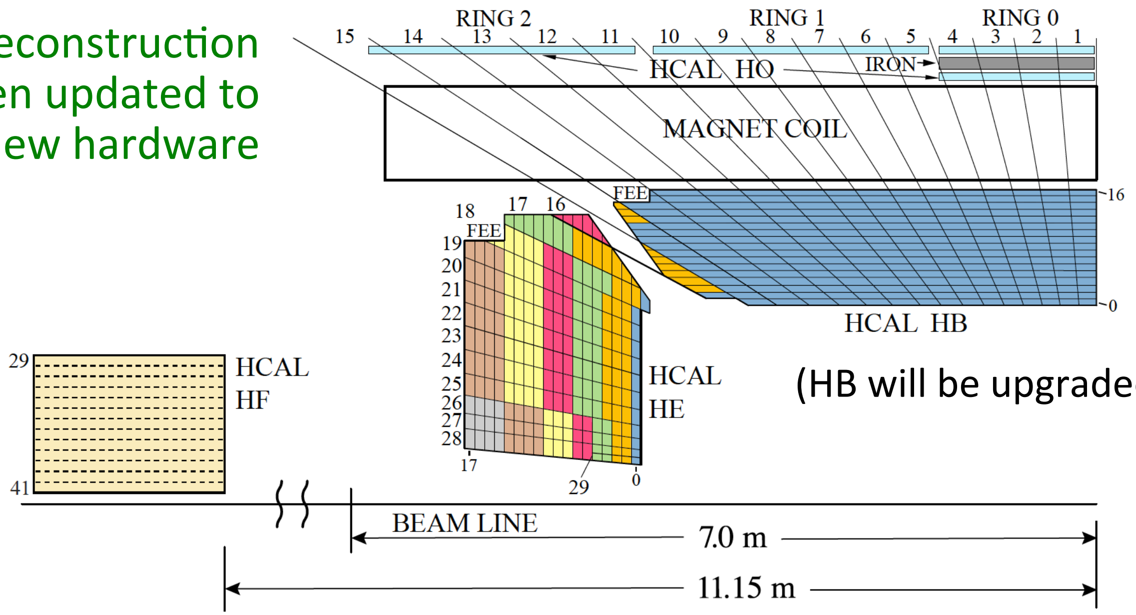
- We need to disconnect, replace, reconnect and recommission the content of 36 RBXes
  - 144 Readout Modules, 36 Calibration Units, 36 ngCCMs
  - Current plan foresees to work HEM and HEP in parallel
  - ➢ Installation and commissioning in a 21 week EYETS (14 weeks of CMS open) is doable with 3 week contingency
- Co-60 wire-sourcing campaigns are crucial to validate the end-to-end mapping and connection
  - six weekend campaigns are scheduled

Reco Software

2017 HCAL Configuration

Simulation &reconstruction have been updated to support new hardware





(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)

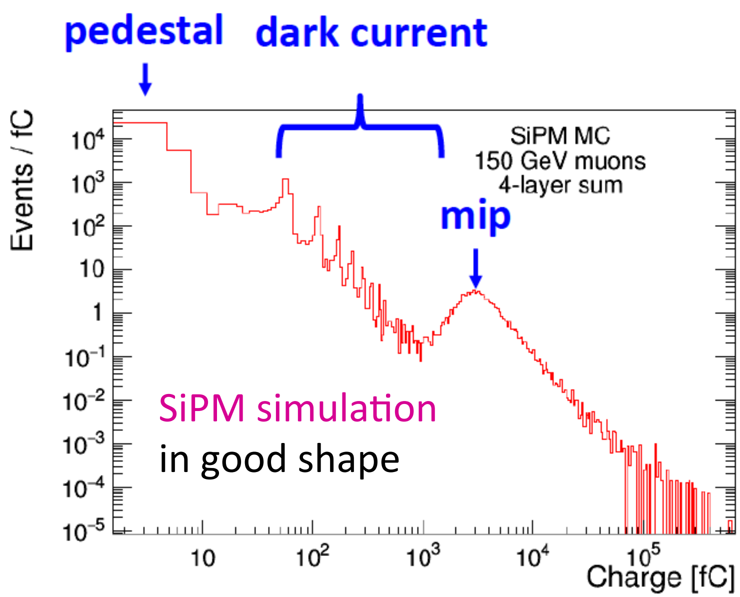
HE:

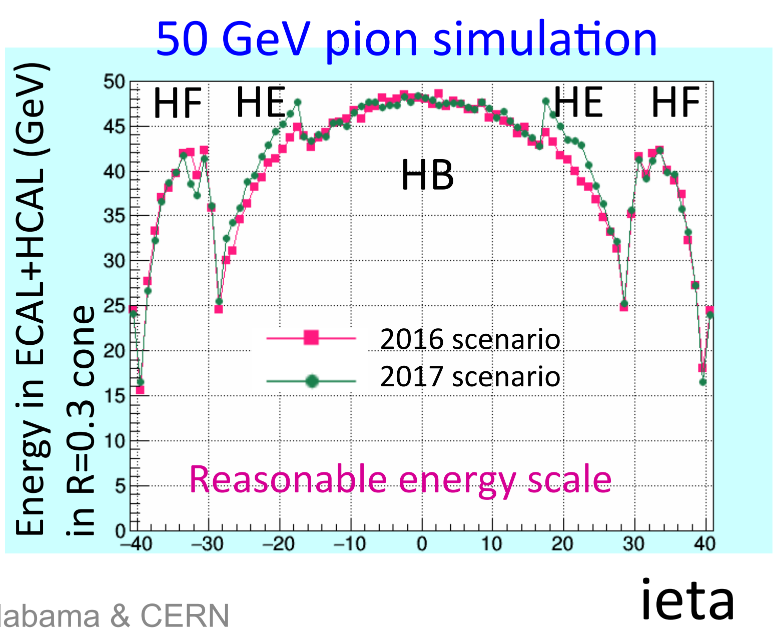
- ✓ 2-3 → 6-7 readout depths
- ✓ HPD → SiPM, QIE8 → QIE11

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

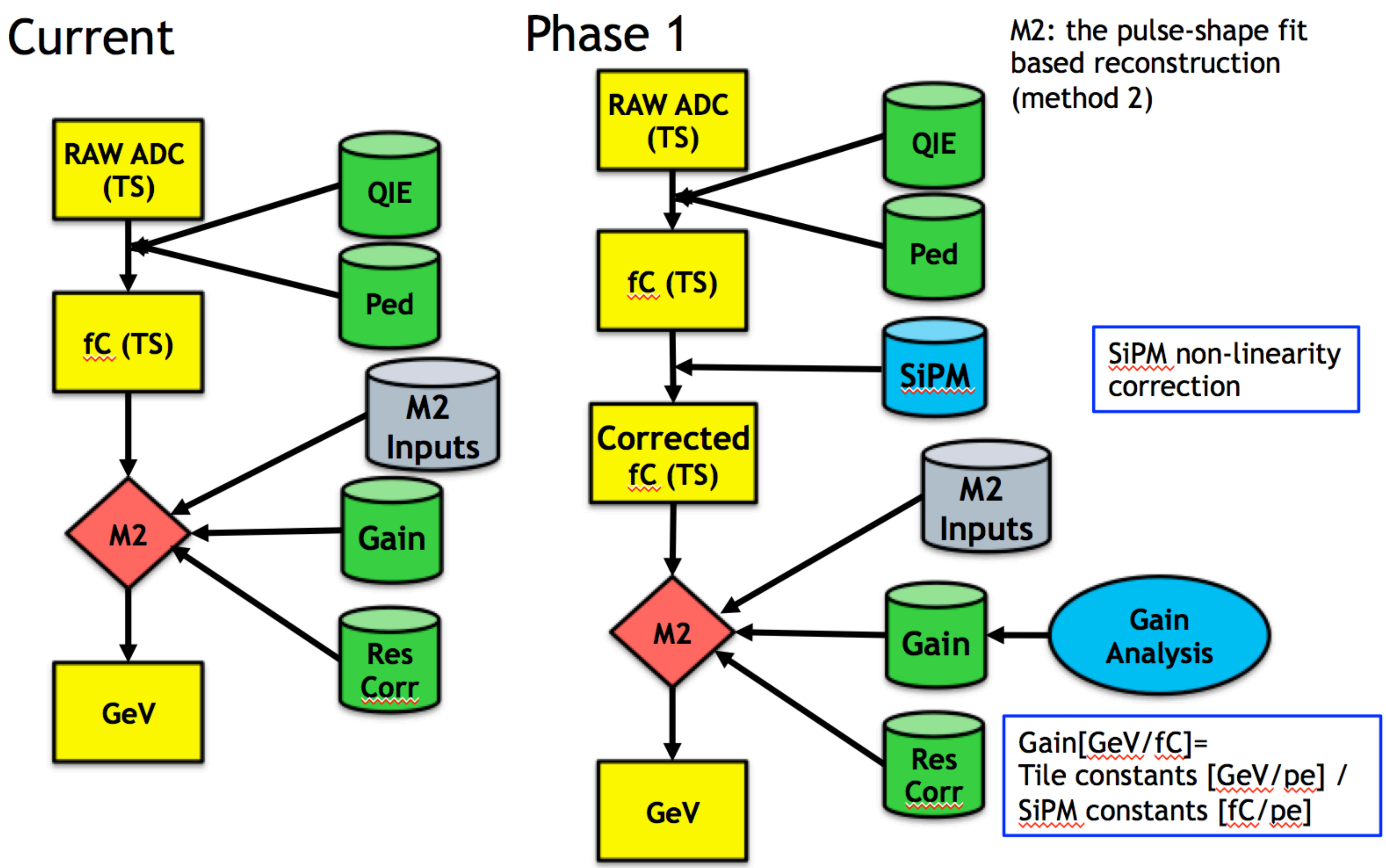
Software Development for 2017

- There was a major effort to prepare the updated HCAL software to accommodate the planned upgraded HE/HF configuration in 2017
  - We've made a major revision of the simulation, digitization, reconstruction, monitoring, and trigger emulator software
  - Also we've updated numbers of existing conditions in the database, and added SiPM-related conditions
  - The task force was formed to coordinate and monitor the progress weekly
  - Very close to have a MC workflow ready for higher-level object tuning

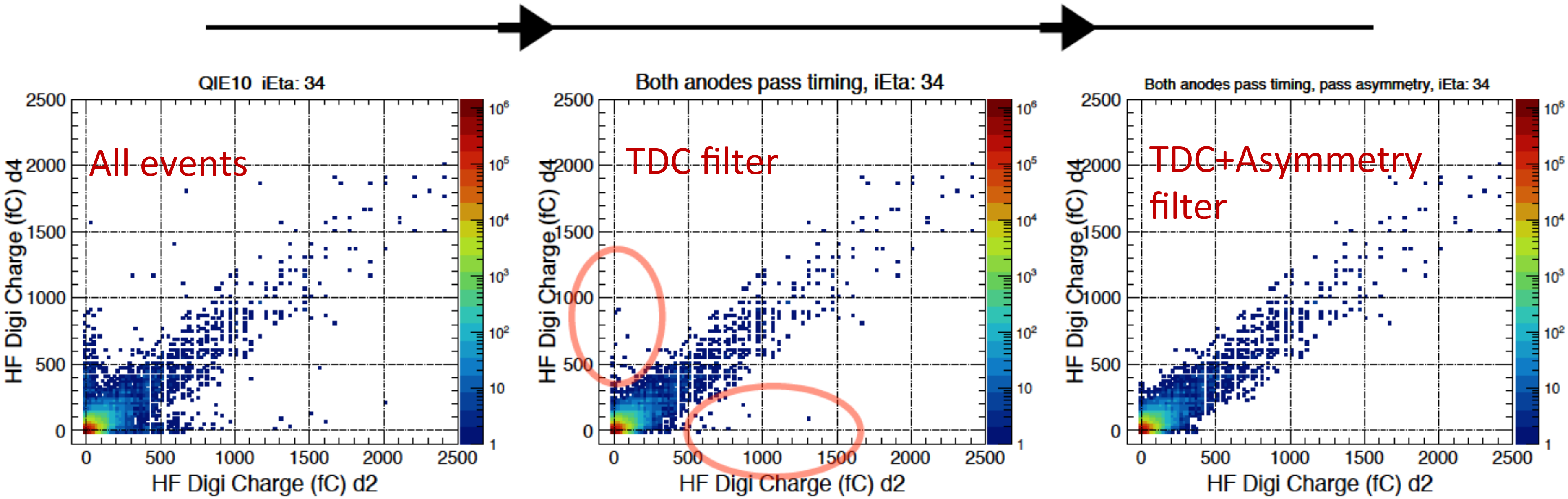




HE Reconstruction Workflow

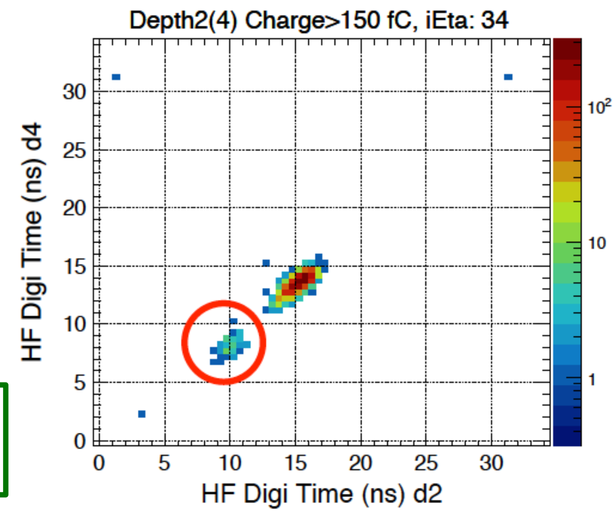


HF: Noise Filter



- ✓ Cut on the TDC time to reduce noise hits
- ✓ Cut on the dual-anode asymmetry to further clean noise hits.
  - There are some simultaneous early anomalous hits – symmetric in both anodes
- ✓ The HF noise rejection algorithm is tested and optimized using the pilot system data.

Collision plots are from a pilot HF Phase 1 setup at P5



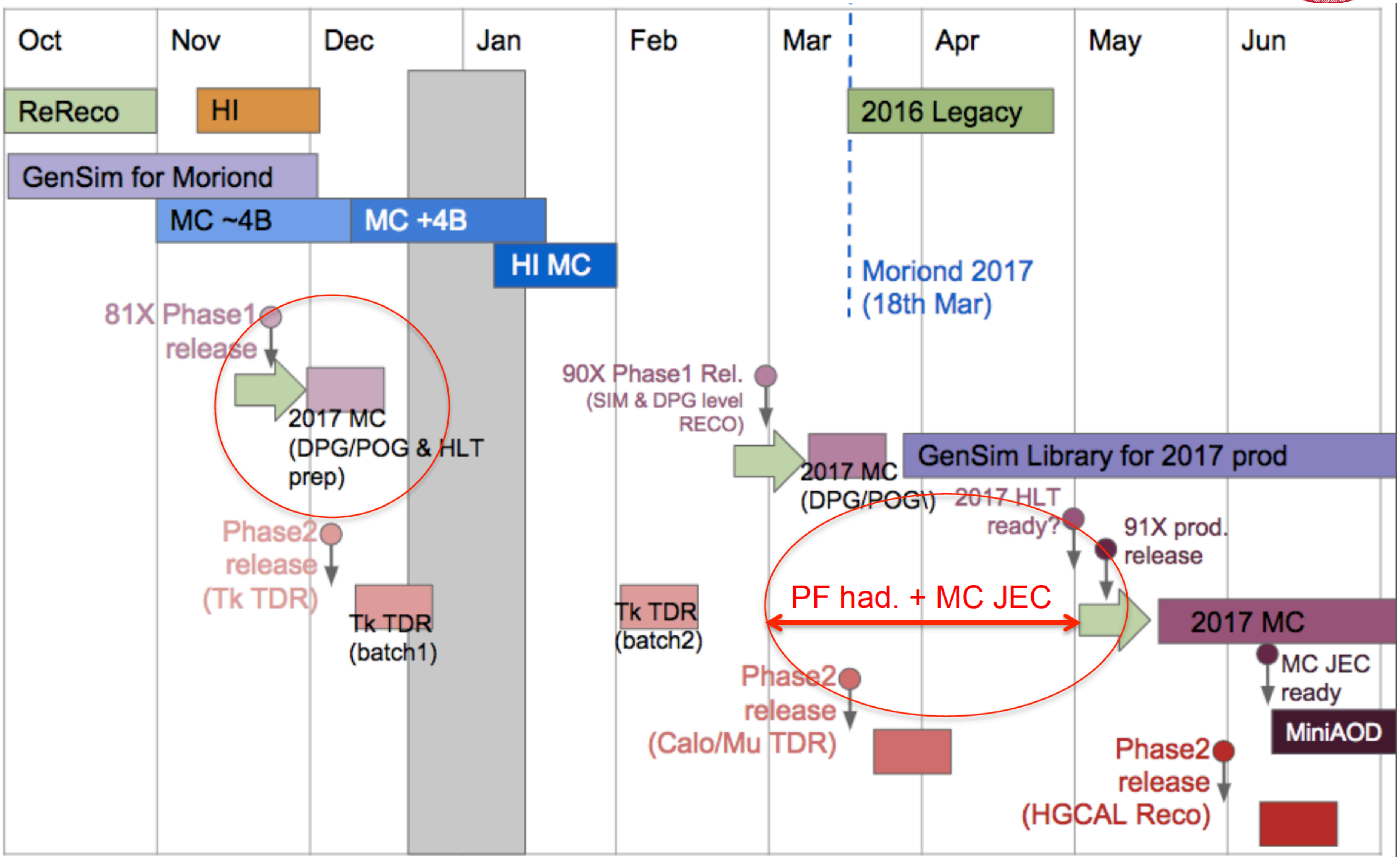
Beyond HCAL Local Reco

- The HCAL Phase 1 software Task Force was established (within the HCAL DPG) to facilitate the development of the HCAL software needed for the HCAL phase-I hardware upgrade
  - While the task force team will continue to provide support as needed, its charge is almost completed
- Downstream software development (beyond the RecHit) for both the HF and HE is mainly the responsibility of existing groups:
  - operations / DPG / JetMET / XPOG / POG
  - Started to make a list of the remaining tuning and calibration tasks in order to understand the requirements and dependencies
  - Further discussion and coordination of the down stream tasks is happening in the XPOG forum

CMSSW Release Plan

- CMSSW_8_1_0 was released on Dec 2 and includes the HCAL Phase 1 HE/HF workflow.
  - This release can be used for the GEN-SIM MC production
  - Can be used to develop and validate calibration workflows
- Further tuning of (local) reconstruction will be included in the 90x release.
  - Will address known issues with high chi2 in Method 2
  - Used for “final” POG tuning → to be included in 91x
- 91x will be used for production release (DIGI-RECO)

Production schedule



Summary (I)

- A very successful 2016 data taking was just completed
  - High HCAL data taking efficiency and quality both during pp and HI running
- HF and HE Phase-I, readiness for installation:
  - HF:
    - The rework of HF QIE cards, while it slipped w.r.t. milestones, has converged
    - We have started the HF upgrade work
  - HE:
    - ngCCM: prod-2 is progressing well, no indications of hardware problem so far in this new production
    - Work on firmware is still ongoing, especially ngCCM area
      - Progress has continued, but have not yet reached all functionalities and stability required for installation – additional resources in place
    - A further assessment on the readiness to install the HE upgrade this EYETS will be made tomorrow with the Installation and Commissioning Review panel and CMS management
      - the actual start of removing legacy front-end is mid-January

Summary (II)

- The HCAL simulation, digitization, reconstruction, monitoring, and trigger software went through a major update to accommodate the 2017 HE/HF configuration
  - Very close to have a MC workflow ready for higher-level object tuning
  - Started planning the remaining tasks for the higher level object tuning and calibration
  - Existing groups do the work, have discussions in the XPOG forum

- The noise rejection algorithm for HF utilizing the TDC time and dual-anode charge asymmetry is well studied using the pilot system in 2016
  - In HE, HPDs are replaced with SiPMS → anomalous signal characteristics will change or possibly be eliminated. Need to be monitored during the commissioning period

- We have a plan to set the calibration of HF and HE for the start-up of 2017 data taking and further refine it after the collision data arrive (end of backup slides)
  - For HF, the simple sum of the dual-anode charge is demonstrated to work well for the startup
  - For HE, we will determine the initial set of gains using Co^{60} source data
  - The in-situ calibration technique will be re-established using upgrade MC samples well before the collision data taking starts

BACKUP

Italians in HCAL

Although there are no Italian institutes that formally participate in HCAL, there are several Italians working on HCAL through foreign institutions and holding key responsibilities:

- Alberto Belloni
  - Prof. at U. of Maryland, HCAL Phase-I and Phase-II
- Tullio Grassi
  - engineer at U. of Maryland, HCAL electronics coordinator
- Aldo Penzo
  - Senior Researcher, HF expert
- Mario Galanti
  - postdoc at U. of Rochester, former HCAL operations coordinator
- Andrea Benaglia
  - postdoc at Princeton U., current HCAL operations co-coordinator
- Federico De Guio
  - postdoc at Texas Tech U., new HCAL DPG co-convener
- Mariarosaria d'Alfonso
  - postdoc at MIT, HCAL DPG, local reconstruction
- Francesco Costanza
  - (postdoc at DESY, firmware developer)
- P.R.
  - Prof. at U. of Alabama, HCAL Project Manager

(I hope I am not forgetting anyone)

More on 2016 Run

Key Ingredients: online alarms and DQM

- HCAL Alarmer: our primary tool for detecting hardware issues
  - monitor the status of RBXs, FE-to-BE links, BE (μHTRs+AMC13s), laser, etc.
  - trigger a prompt reaction in case of problems (mail, SMS, RunningDegraded)
- HCAL DQM rewritten from scratch during 2015, new version put in production in 2016
  - lumi-section-based status computation to better catch transient problems
  - monitoring of global and local runs
  - continues to expand to meet our needs (e.g. upgrade pilot systems)
- All the (few) problems we have had were caught by DQM

ROC this and next year

Expanding the ROC responsibilities

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

This year

- Check prompt reconstruction [offline workflow, 48h delay]
  - inspect continuously collision runs in offline GUI instead of once a week, and help run certification process
  - pre-fill the offline RR (prompt reco dataset)
  - Certification contact signs off once per week

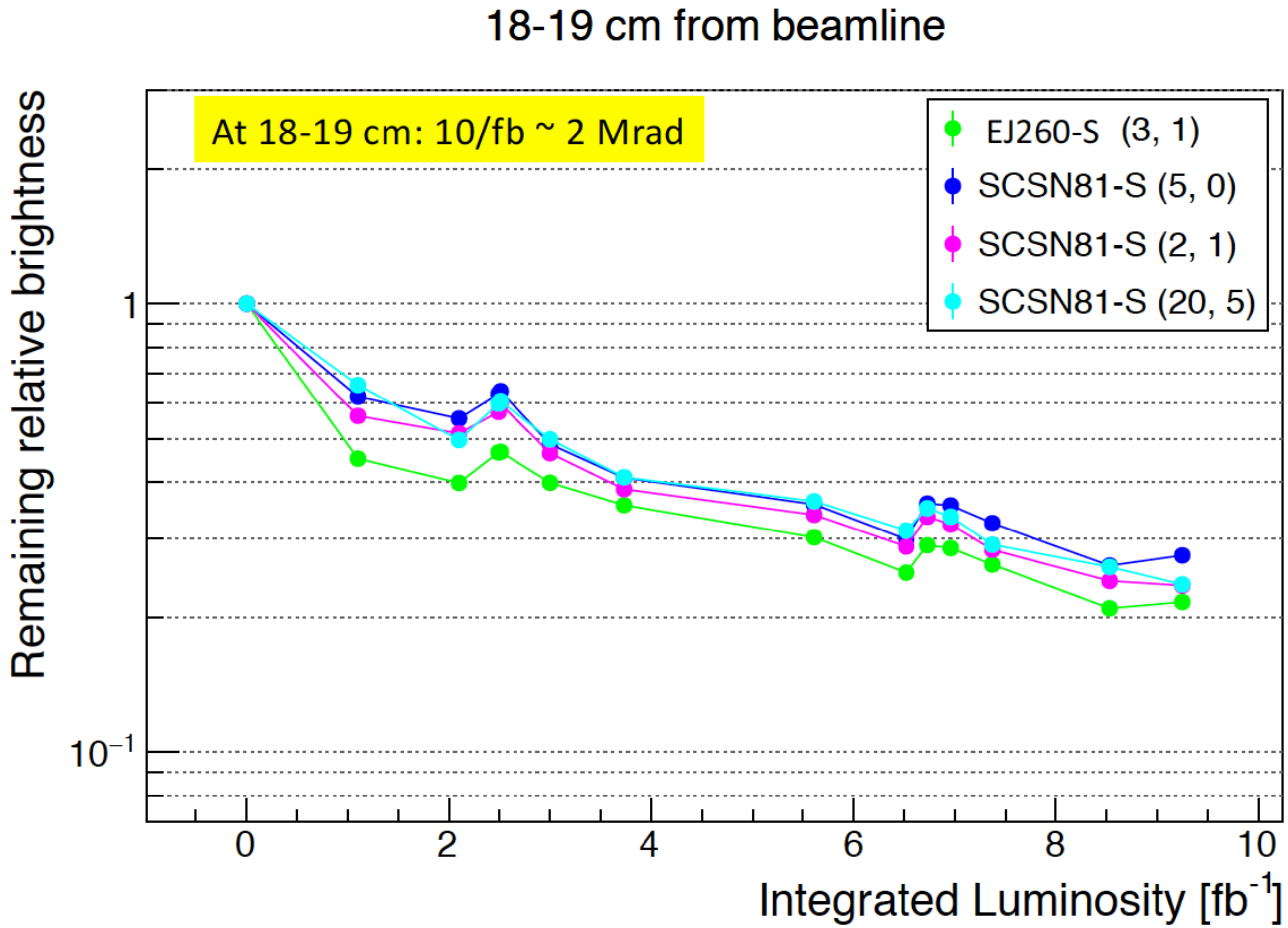
New in 2017

- Check health check runs [once a day]
  - inspect health check runs in hcal local GUI
  - Local run DQM GUI became accessible from outside P5 without tunneling recently

New in 2017

CRF - Radiation Damage Results

Radiation damage of SCSN-81 vs EJ260



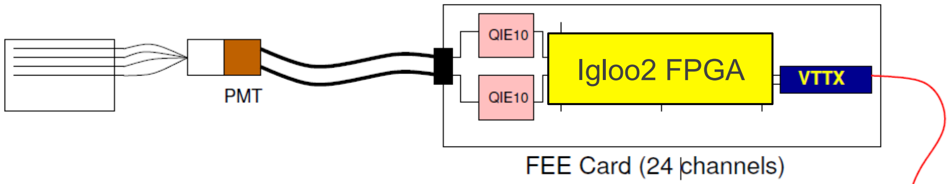
R. Heller

More on Phase-I

HCAL Phase-I Electronics

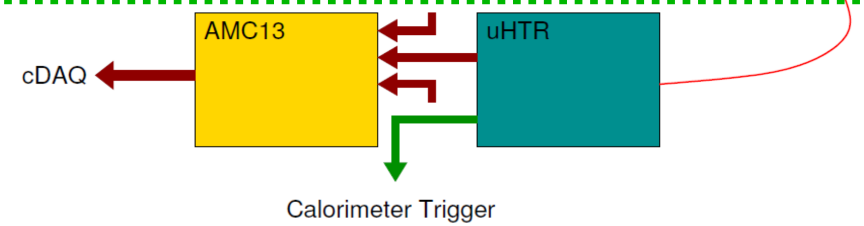
HF

PMT rework + Front-end Electronics: EYETS 2016/17



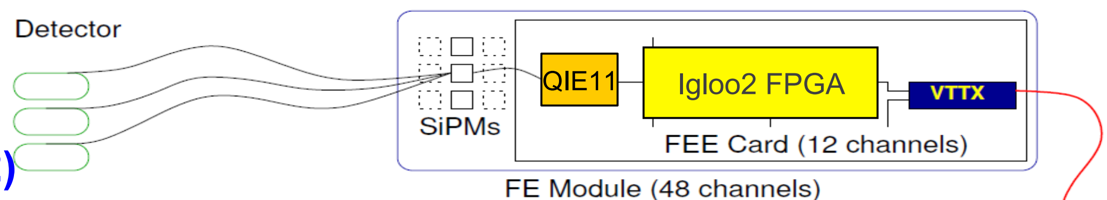
Back-end Electronics

In operation since early 2015



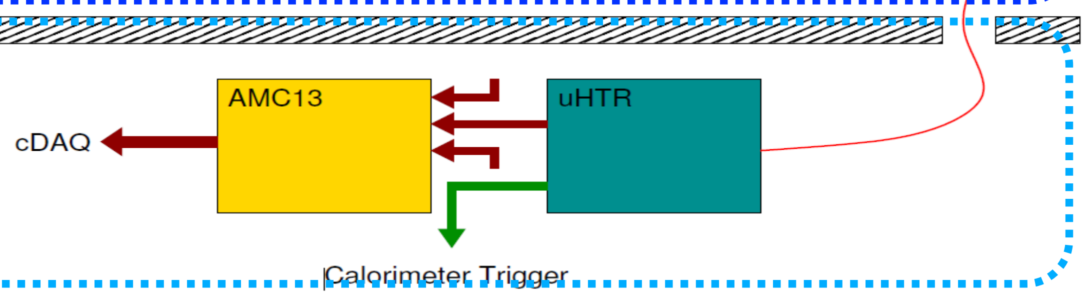
HB HE

SiPMs + Front-end electronics:
HE: EYETS 2016/17
HB: 2018-2019 (LS2)



Back-end electronics:

In operations since early 2016



Online SW and DAQ

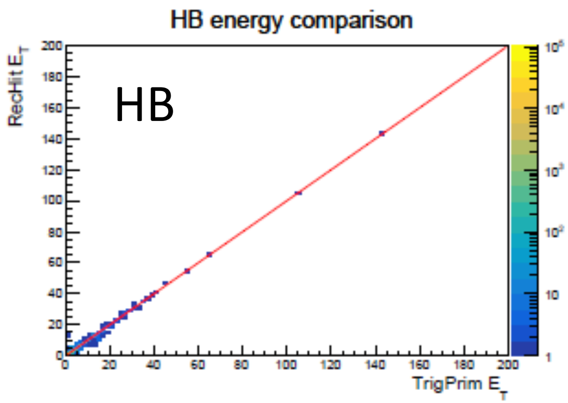
- All necessary software to control the upgrade front-end is in place and running in Prevessin/B904 and at p5.
  - All the basic functionality needed to configure and take a run with the upgrade front-end is available.
- Software development is ongoing to improve the ngCCMServer
  - The scalability to the full system is closely watched, but no problems are expected
  - Work ongoing to improve communication to uTCA crate, with participation of Ipbus (the protocol being used) experts.
  - Some functionality still needs to be added, but no major tasks remain.
- Monitoring is implemented, the work on including all necessary monitorable variables and alarms is ongoing and will continue throughout installation.
- The back-end readout is already upgraded and the commissioned. The development of the new uHTR firmware is almost complete, and validation is progressing.

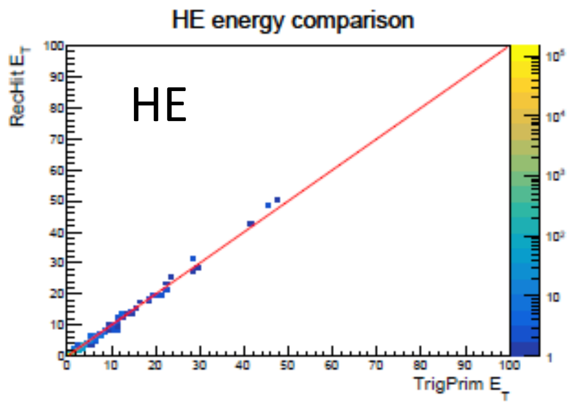
Trigger Primitive Changes (in the uHTR firmware)

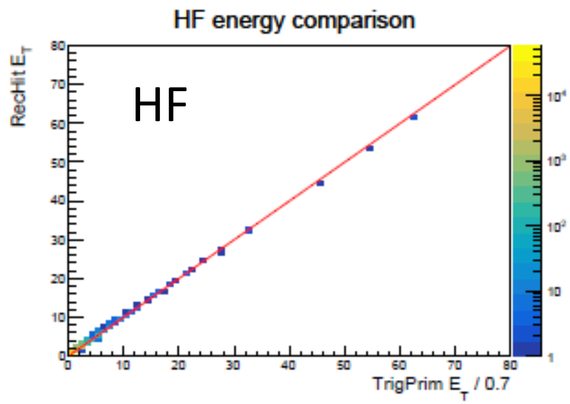
- HF
  - Additional FE channels
  - Bigger dynamic range of ADC (7b vs. 8b)
  - New logic required for combination with suppression of out-of-time bad data
  - ➢ Status: fully implemented and validated for regular TPs, work remaining on fine-grain bits (not priority)
- HE
  - Additional depths
  - Bigger dynamic range of ADC (7b vs. 8b)
  - Two firmwares (one for combining legacy HB and upgraded HE in the overlap region, and one for HE-only)
  - New capabilities for fine-grain bits
  - ➢ Status: firmware implemented. Validation using patterns done for the HE-only case. HE and HB overlap region is more complex, and hardware setup to test it is ready

Trigger Emulation

Good agreement between the energy calculated for the trigger primitives and offline reconstructed hits in the 2017 MC workflow.

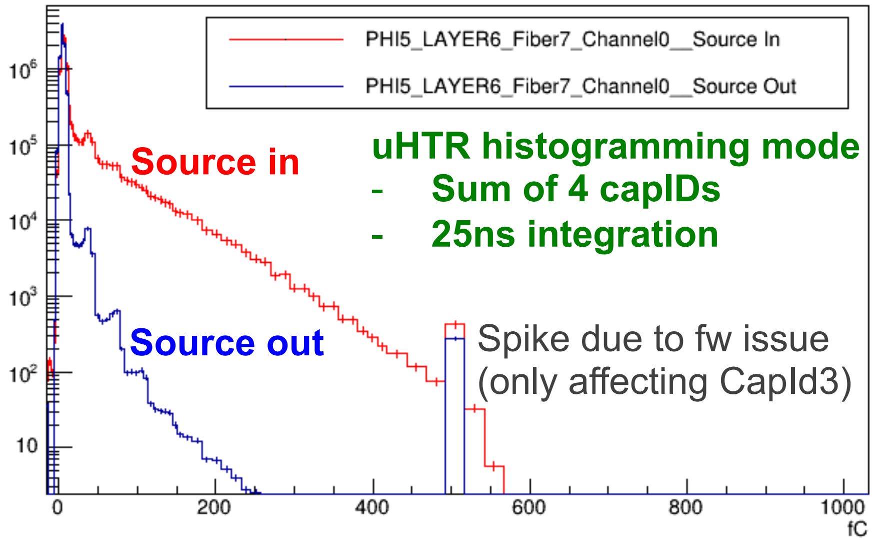


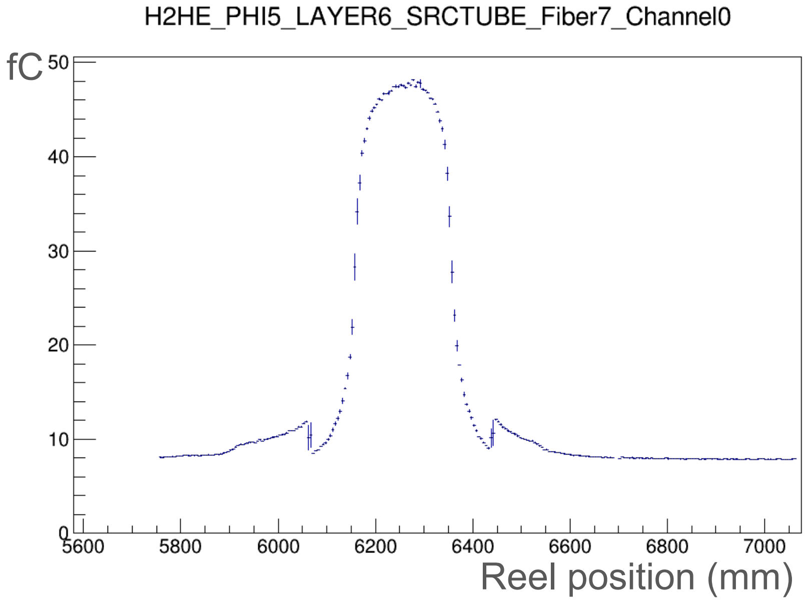




First Co60 Wire-Source Exercise with SiPM/QIE11 in H2

- Performed in H2 on Oct 20, more info at https://twiki.cern.ch/twiki/bin/viewauth/CMS/HCALSourcing
- Much improved resolution w.r.t. HDPs

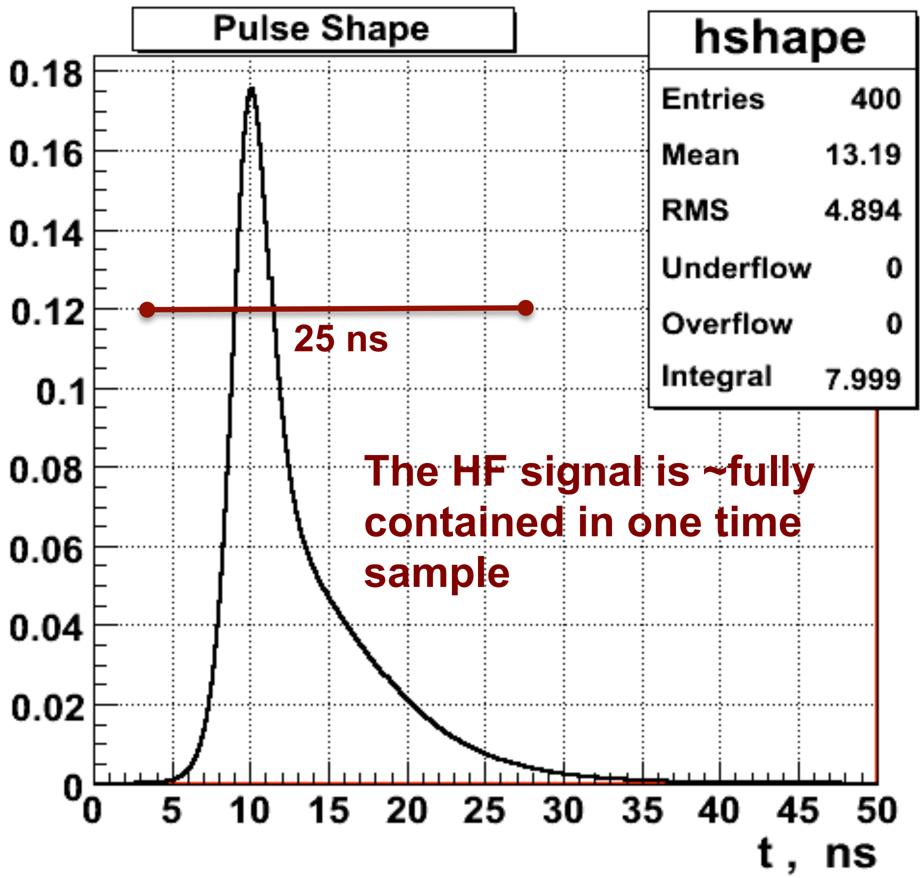




- Two independent analysis ongoing

➢ Thanks Sasha K., Ianos S., Burak B., David S., Joe P., Caleb S., Ted L., Pavel P., Stepan O., Alexey K., Seth C., Elena P., Pawel de B., et al

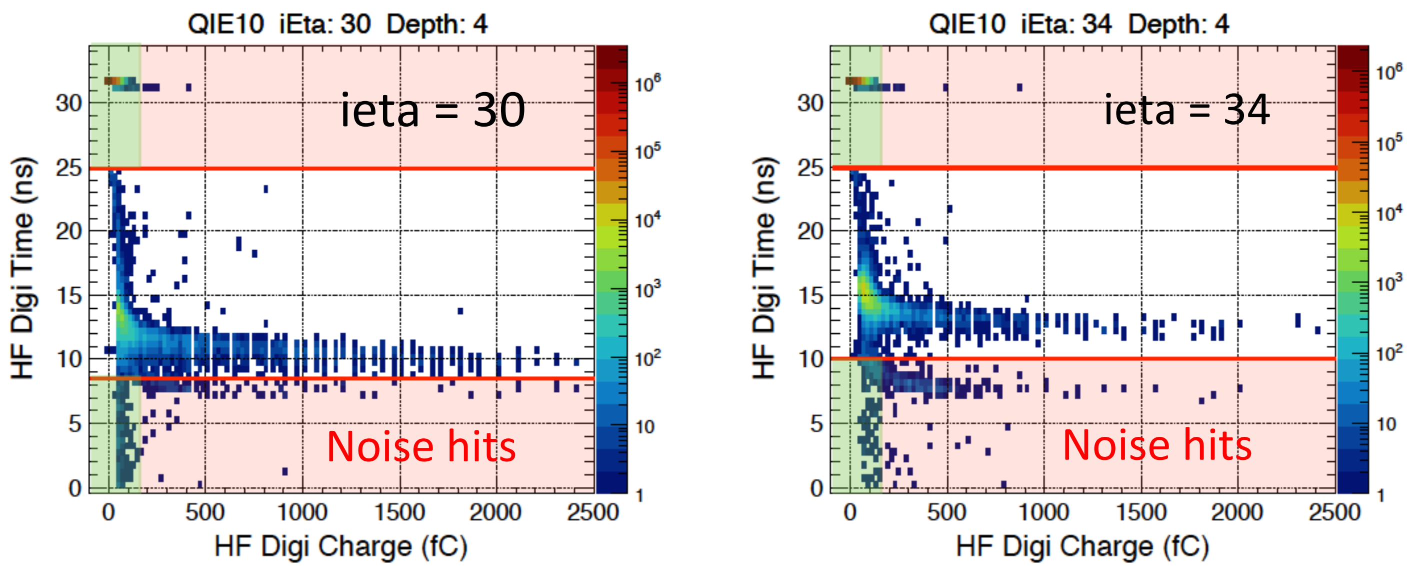
HF Signal Shape



HF Noise Filter

- Noise in HF: particles from IP or showers hit directly the HF PMT windows and produce photoelectrons.
  - Because of path length differences, anomalous signals arrive 2-7(ns) early.
  - For anomalous signals in the PMT window, charge measured in two channels of the dual-anode PMT is expected to be imbalanced in many cases

Collision plots are from a pilot HF Phase 1 setup at P5



Cut on the TDC time to reduce noise hits. The separation is smaller for lower ieta's, as the path length difference of PMT hits and real showers is smaller.

HF QIE card rework process

- The HF Front-end QIE cards have been reworked to replace the 2015 version of the QIE10 chips with the improved 2016 version

189 cards

ICS (Decatur, IL)
Replace 24 QIE chips
Install header+jumpers
Clean and inspect boards

overnight
189 cards

Fermilab
Visual inspection

1 wk
186 cards

CERN
Visual inspection & assembly
- DC/DC converters, VTTx, front panel, fibers

Acceptance tests
- Pedestals and internal charge injection

Install Winchester connectors
LED tests
- LED pulses via externally connected PMTs

Calibration of QIE response
- External charge injection board

11 cards

Typical failure modes/recovery
Poor soldering
- Rework at ICS or CERN

Individual faulty channels
- Replace QIE chip at CERN

8 cards

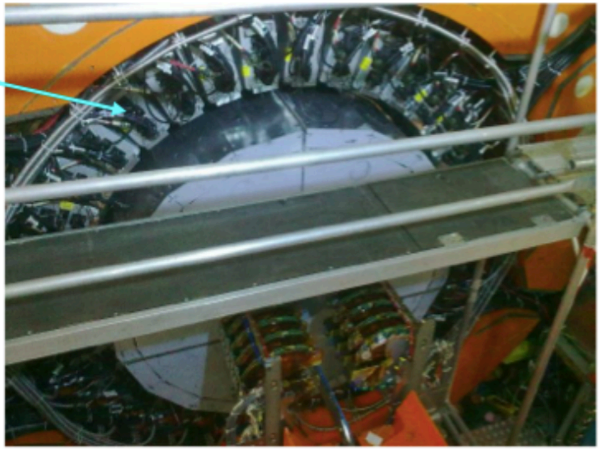
Bad cards
Some may still be recoverable but not a priority right now

137 cards

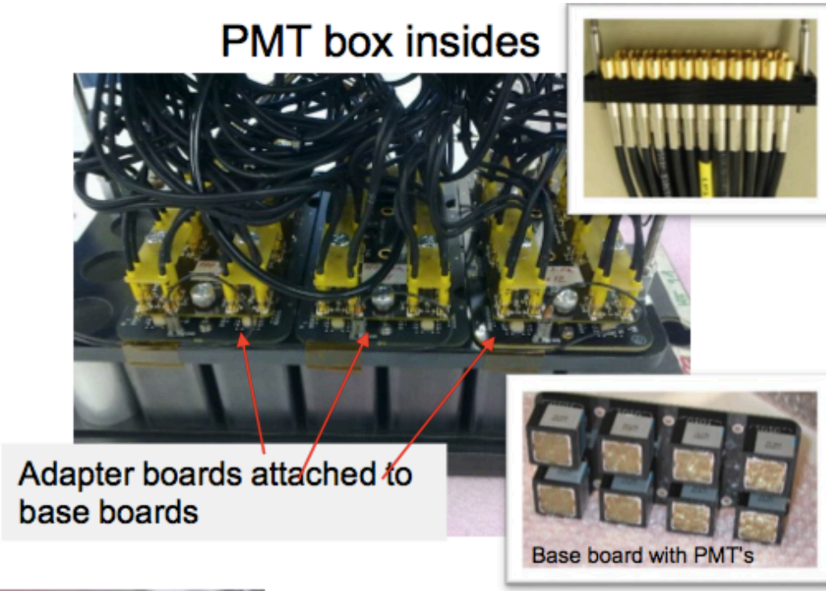
Good cards → Burn-in
- Operate under power, power cycle

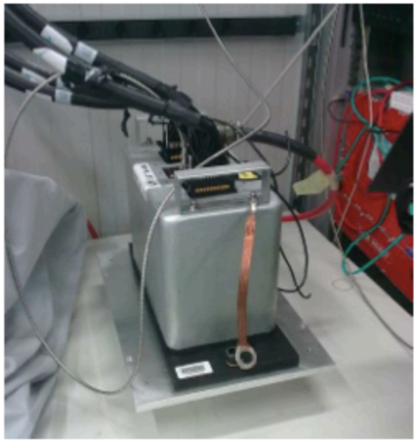
HF PMT Box rework

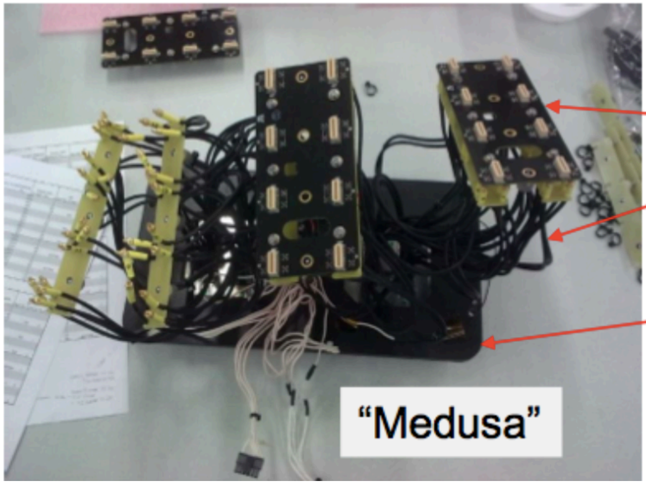
36 PMT
boxes
each end



PMT box insides







Adapter board, gangs anodes

Winchester to MMCX coax
cables (96 per box)

"plate 3" holding connectors

2

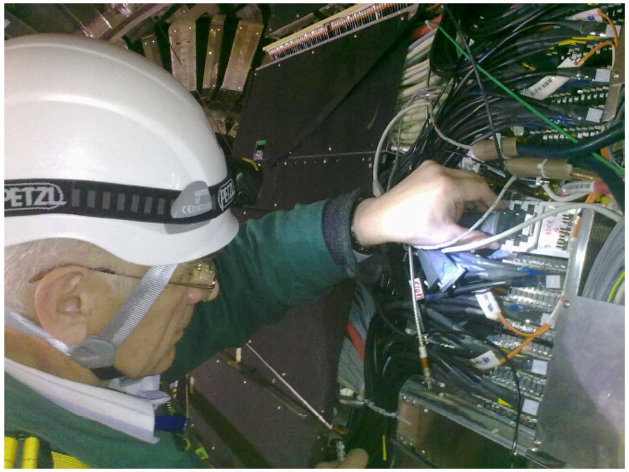
HE Front-end replacement

Major steps:

1. Remove RBX covers
2. Disconnect digital optical/laser cables, roll them with protection
3. Disconnect megatile cables (4*19 per 20 deg wedge) (3h)
4. Remove 4 RMs, CCM and CalUnit and back-plane per RBX
5. Remove HV and reinstall LV module per RBX. Make a LV test.
6. Install Back-plane, ngCCM. Make thermal, communication tests.
7. Install 4 RMs and ngCalUnit per RBX
8. Connect CalUnit to RMs, connect digital cables
9. Initial tests of RMs (pedestal and LED runs)
10. Connect megatile cables (4h)
11. Re-install RBX covers
12. Perform Co-60 validation

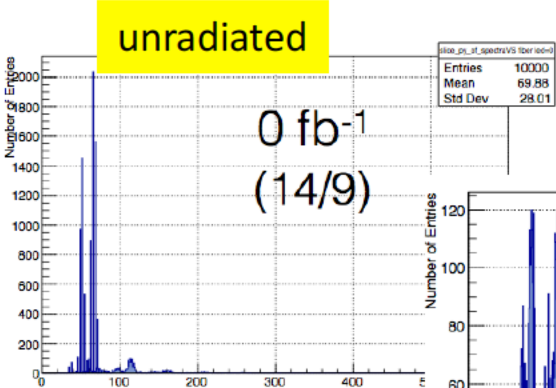
Key personnel present during initial FE installation and commissioning in 2003-07 will not be present.

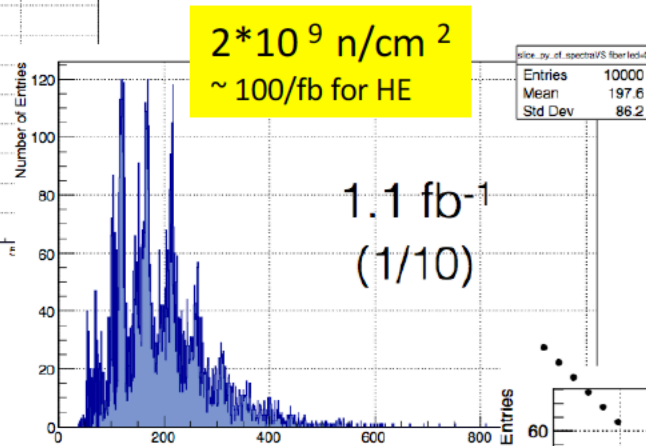
A new team, which has an experience during FE reworking in LS1 2013-2014, will be involved in process.



Rate:
1 RBX per 2 days per 1 team
3 RBX per 2 days per 3 teams = 18 RBX per 12 working days per 3 teams

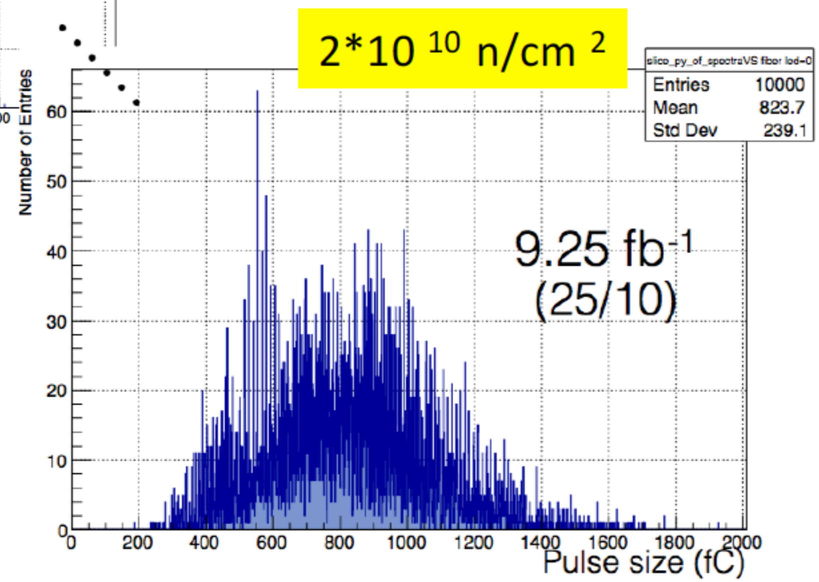
Effects of Neutron Radiation on SiPMs





F. Ricci-Tam

Operating temp = 20 deg C



12.1 Radiation and Experimental Environment

The HB and HE Front-End Electronics (FEE) are inside the CMS solenoid, exposed to a 3.8-Tesla magnetic field and to radiation. The upgraded FEE must survive an integrated luminosity of 3000 fb^{-1} [5]. We have calculated the irradiation using the CMS Dose-Fluence Calculator, [11] assuming energy deposit on silicon. The results are in Table 12.1.

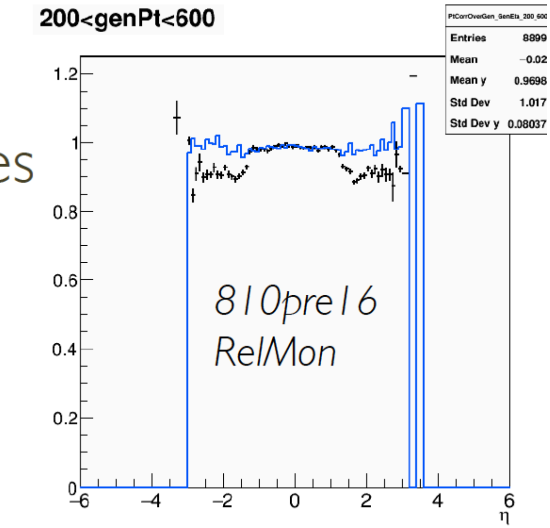
Table 12.1: HCAL FEE radiation levels (total ionizing dose (TID) and neutron and high-momentum-hadron fluence) for an integrated luminosity of 3000 fb^{-1}.

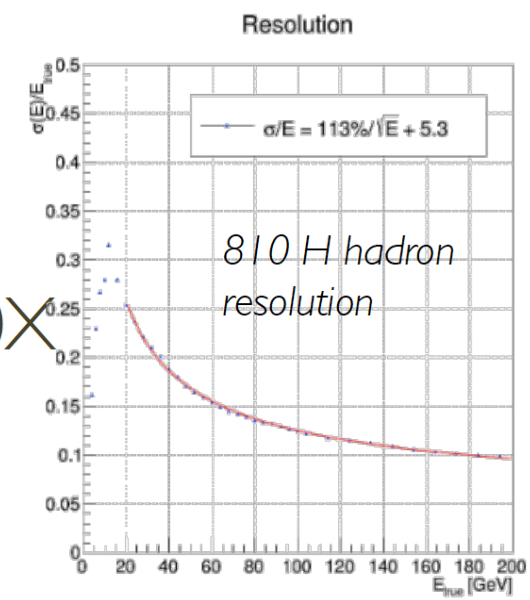
FEE type	Position [cm]	TID [Gy]	TID [rads]	1 MeV-equivalent neutron fluence [cm^{-2}]	fluence for hadrons with E>20 MeV [cm^{-2}]
HB	R=279, Z=429	31	3100	1×10^{12}	1.7×10^{11}
HE	R=261, Z=548	0.9	90	6×10^{10}	1.6×10^{9}
HF	R=300; Z=1200	20	2000	2×10^{11}	1.1×10^{11}

JME calibration for Phase 1

From Robert Schoefbeck (JetMET)

- 810 integration (ongoing)
  - DQM: follow pre-releases and monitor changes in HCAL local reco (HE readout, SiPMs, M2)
  - pre16 seems to improve HE response
  - currently exercise PF hadron calibration in HB
    - on-the-fly single-pion event generation works
    - calibration workflow under control
  - in parallel, prepare now for R&D exploiting depth info for calibration
- expect changes to HCAL reco 81X → 90X
  - details of M2 matter! (→ backup)
  - 90X→ 91X JME timescale driven by PFhad calib + JEC





JME calibration in 90X

From Robert Schoefbeck (JetMET)

- step 1: PF hadron calibration
  - when local reco (HCAL, ECAL) is ready
  - JME manpower: Shubham, Seema, (Matthieu Marionneau)
  - O(10M) pion gun
  - well established, some transition, studies have started on HB
- step 2: MC based JEC
  - needs PF hadron calibration
  - well established and exercised
  - 10M QCD with and without PU
- both items together doable on the 2M timescale

outlook

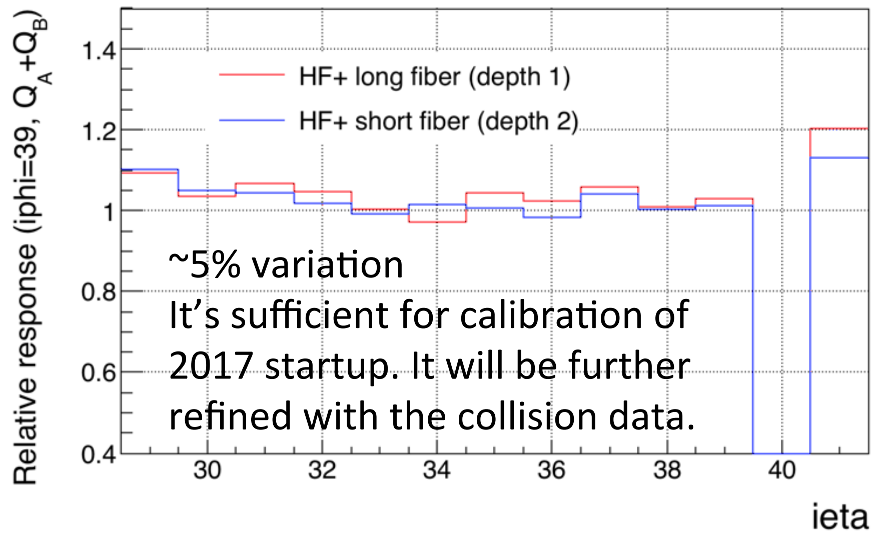
From Robert Schoefbeck (JetMET)

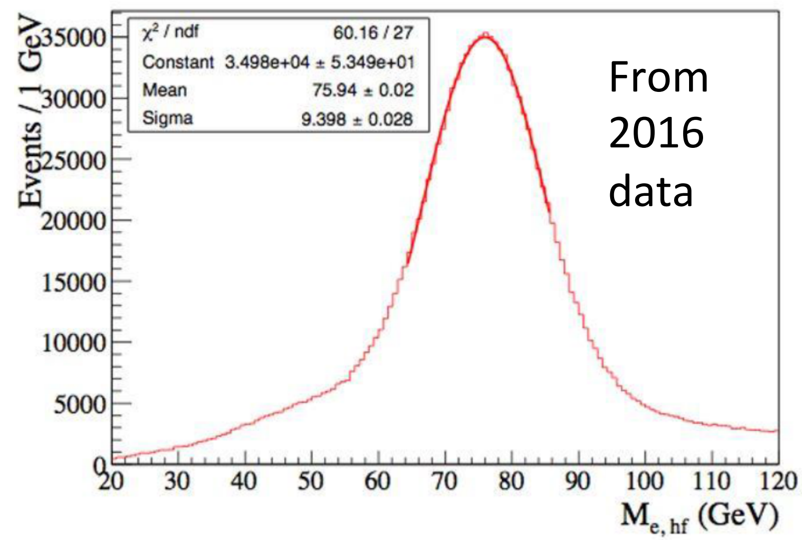
- in 810 we follow incrementally the patch releases
  - few things to take offline (backup)
- exercising PF hadron calibration in 81X
  - to be delivered using 90X
  - together with JEC, will go into 91X DR release
- JME performance depends on details of M2
- most deliverables depend on PF hadron calibration

2017 Calibration Plans

HF Calibration

- From charge to energy measurement:
  - 2016: E(rechit)[GeV] = Q[fc] * Gains * RespCorr
  - 2017: E(rechit)[GeV] = $(Q_1 + Q_2)$[fc] * Gains * RespCorr
- PMTs and operation voltage will stay unchanged
- We need to update ADC->fC constants for QIE10, but can keep the absolute Gain & RespCorr the same as in 2016 for the 2017 startup
- HF calibration with collision data will be done in the same way as now
  - Phi symmetry for relative calibration
  - Z->ee (one electron in the barrel or endcap, another in the HF) for the absolute scale





HE: Calibration

- 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)

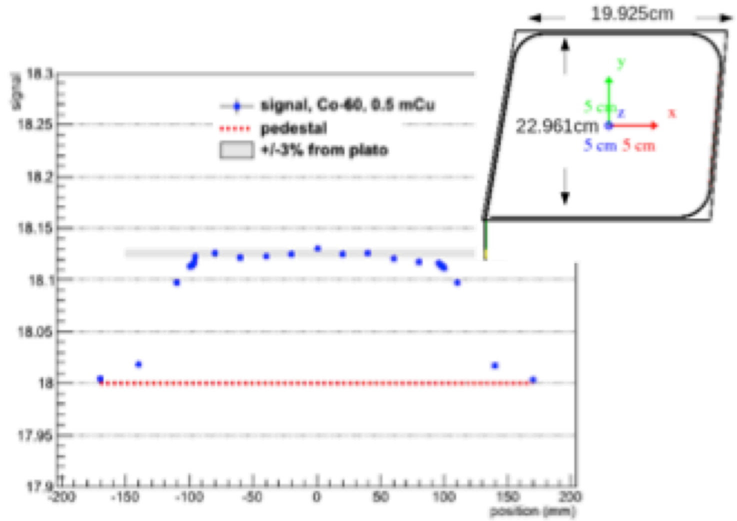
- Use 2017 Gains [GeV/fc] and SiPM constants [fC/pe] to derive "Tile constants" [GeV/pe] for several phi

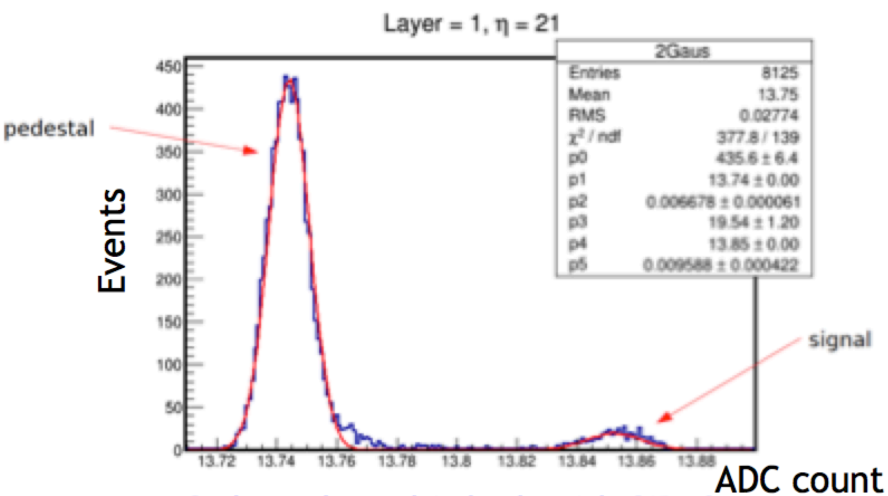
Gains[GeV/fC] = Tile constant [GeV/pe]
/ SiPM constant [fC/pe]

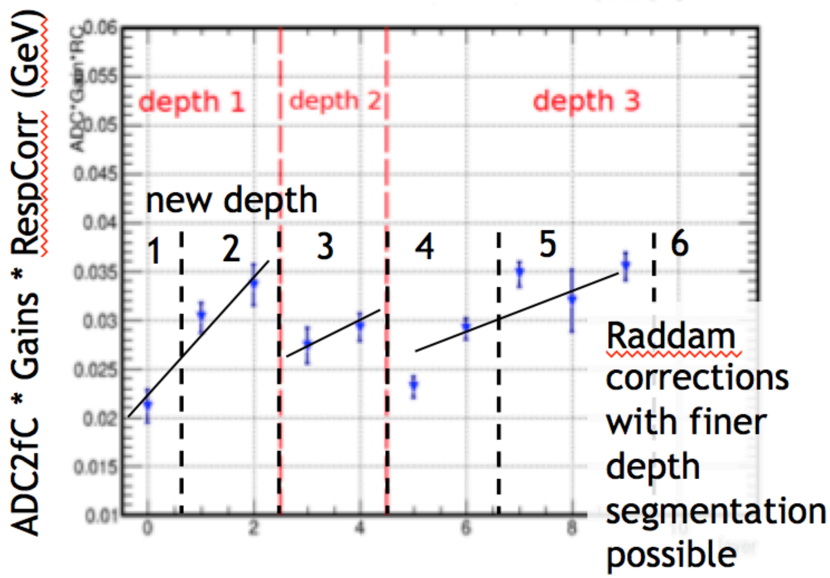
- Assuming that "Tile constants" depends on eta but not on phi, calculate Gains for all HE channels using mean values of "Tile constant" for the same eta & SiPM constant for a particular channel

HE Gains from Source Data

- Source data can provide layer-by-layer information, helping to calibrate increased number of depths
- Use the 2013 Co^{60} source data as a reference



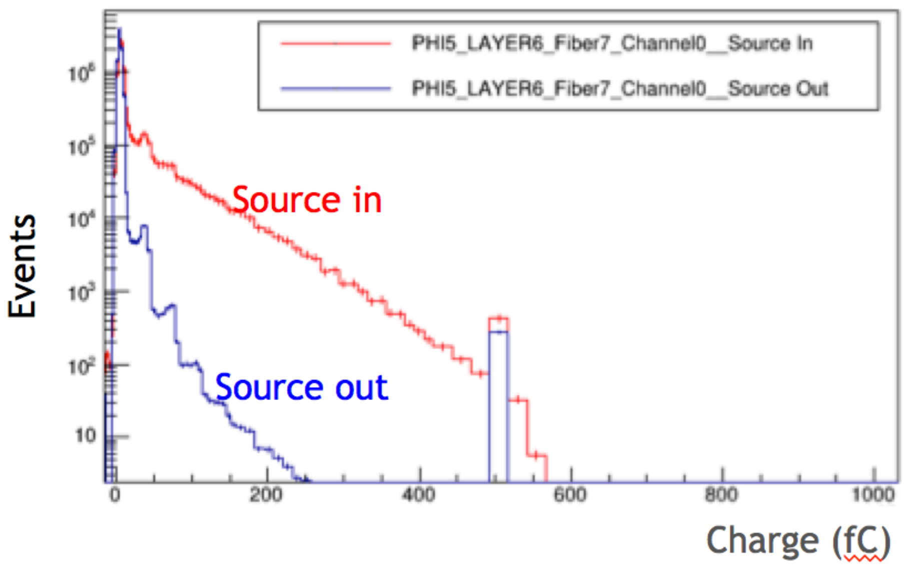




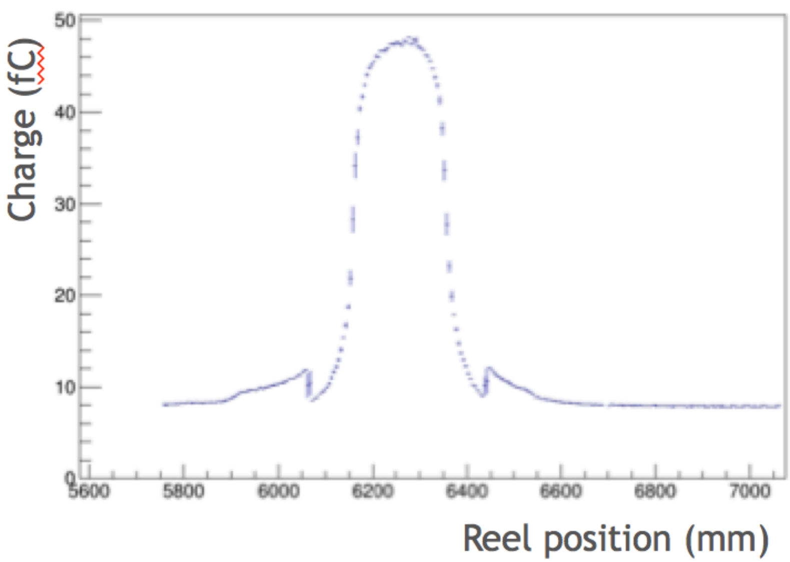
Q: how does this look with SiPM?

HE Gains from Source Data

- Co^{60} source testing was performed with SiPM & QIE11 in H2 in October 2016
  - Preparation of major source campaign scheduled from the end of January to early March for HE (and mid March for HF, more details in Paolo's talk)



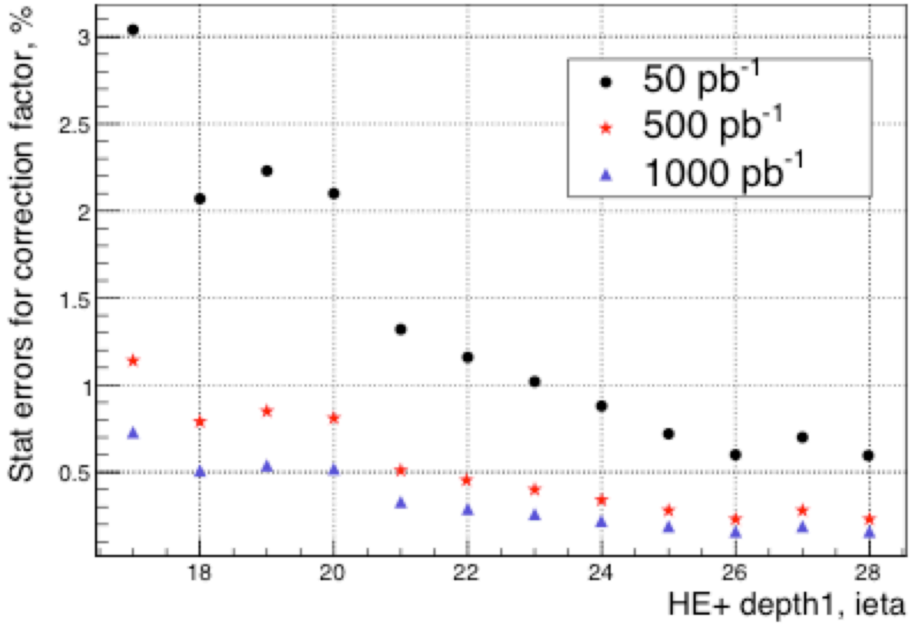
Commissioning of the Co^{60} source system with SiPM and QIE11



HE inter-Calibration with Collisions

- Use phi symmetry method for inter-calibration of channels with the same eta and depth
  - With 50/pb, we can obtain <0.5% stat precision for HF and 1-3% for HE.
- Study a possibility of using muon MIP signals for inter-calibration
- Aim to (re-)establish these calibration methods over the coming months using the phase1 MC samples

Phi symmetry calibration, HE



HE Absolute Calibration with Collisions

- The Z->ee calibration will provide ~1% precision in most of HF channels with ~70/pb of data
- The single track calibration will provide 5-10% precision with ~75/pb
- Aim to re-establish these calibration methods over the coming months using the phase1 MC samples

Single track analysis