CSC Operations

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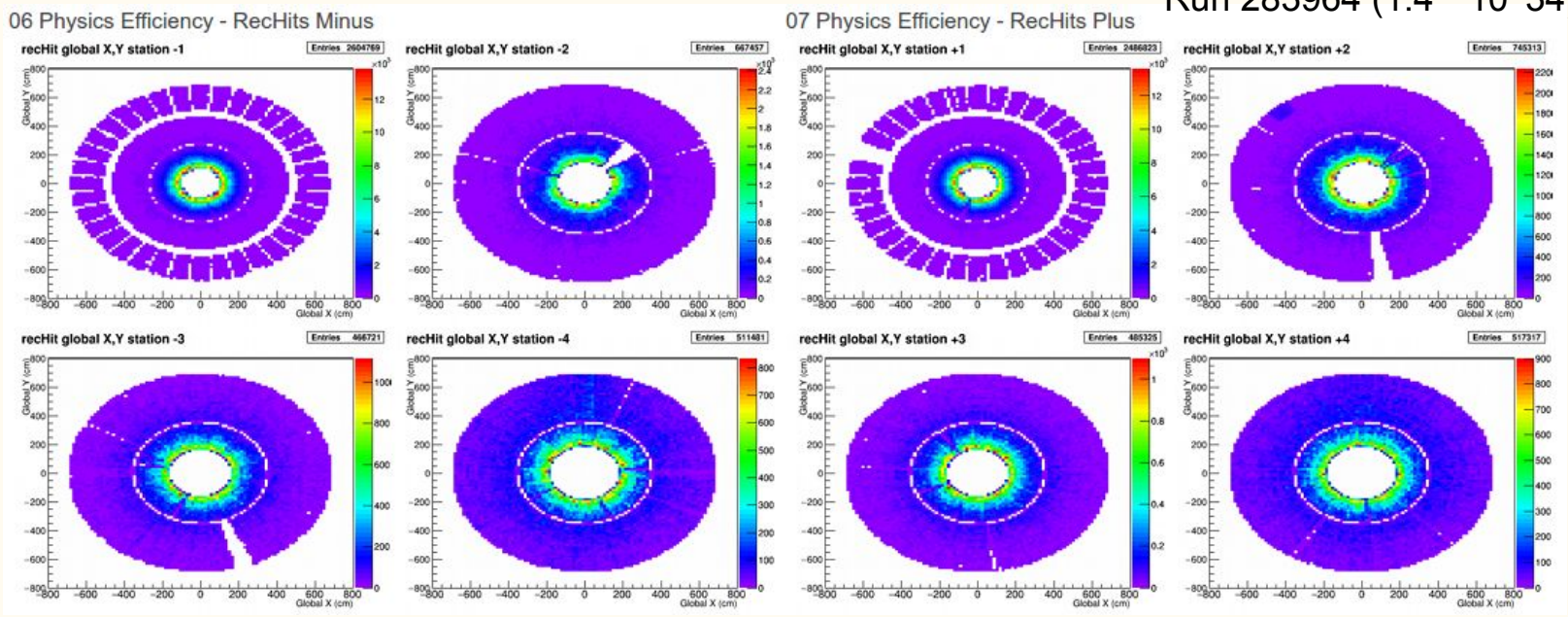
Overview

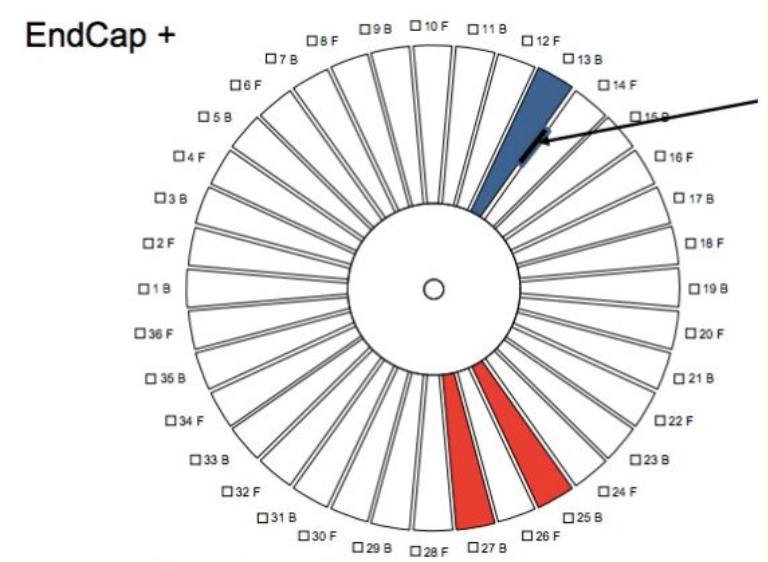
- ME1/1 water cooling
- General status and problems faced during 2016
- Backgrounds and HV stability
- System improvements
- Plans for EYETS

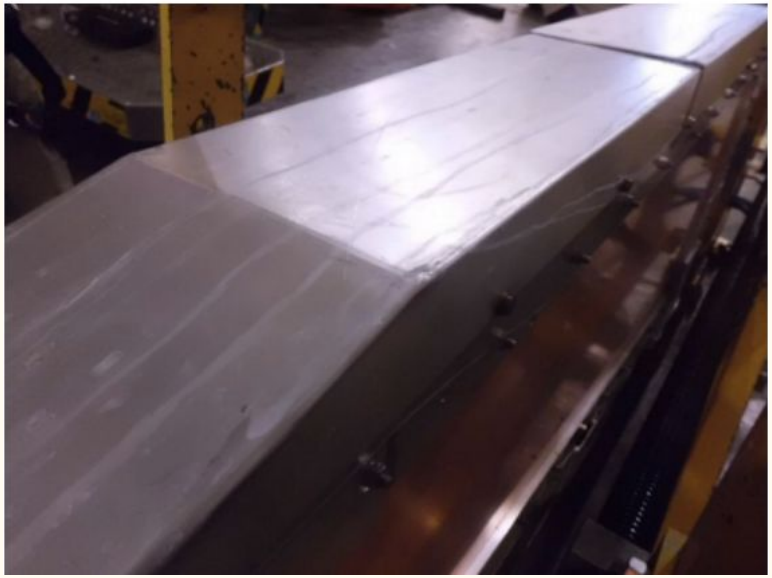
Run 283964 (1.4 * 10^34)



ME1/1 water leak in late 2015

- **Water leak detected during Heavy Ion run of 2015**
  - Leak traced to ME+1/1/13
  - 3 chambers extracted, brought to the surface, cleaned and repaired
- **Precautionary measures**
  - Enable water valve control of individual ME1/1 circuits when CMS is closed
  - Humidity sensors installed in vacuum tank
  - Water collectors installed to channel any water away from instrumented regions

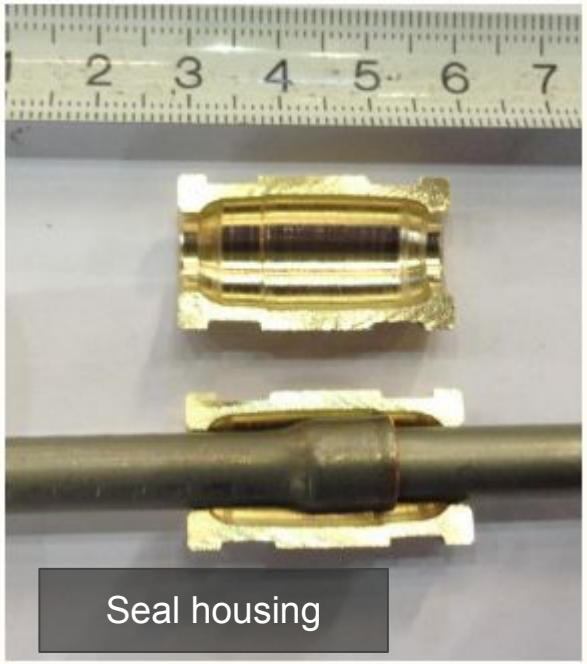




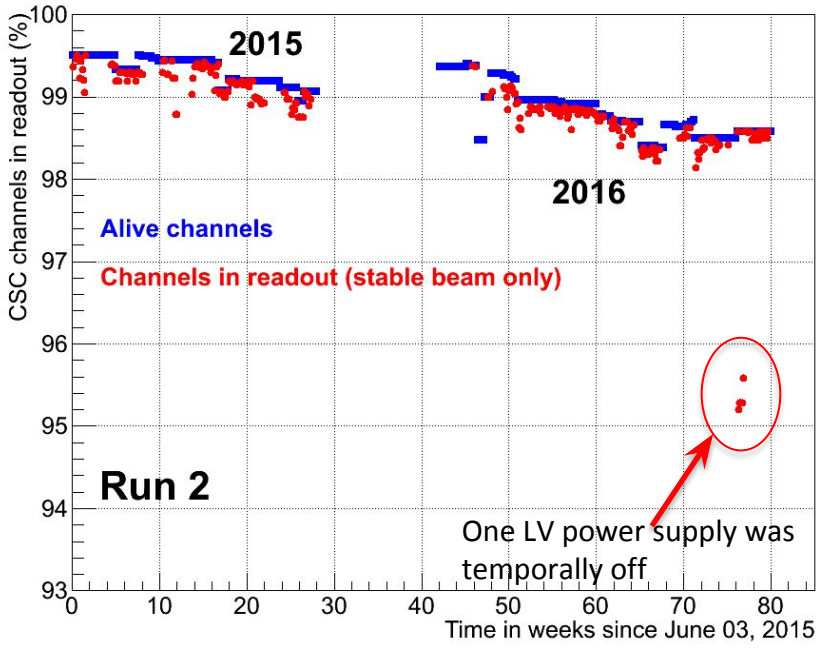
ME1/1 cooling circuit repair

- **The leak was caused by a faulty on-chamber cooling pipe joint**

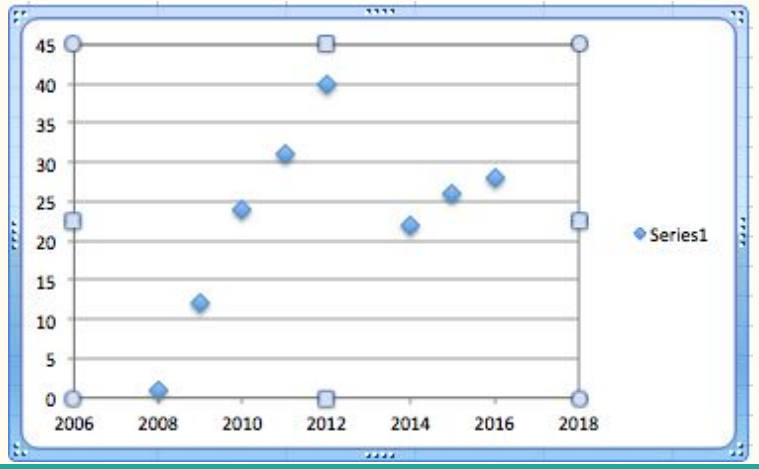
- **Reinforcing all ME1/1 cooling joints during this YETS**
  - High-performance rad-hard epoxy compound (Germetal)
  - Was shown to reliably seal the pipe joints even without any welding
  - Radiation tests at CHARM and CASTOR table showed no signs of degradation



Live channels



Number of dead CFEBs

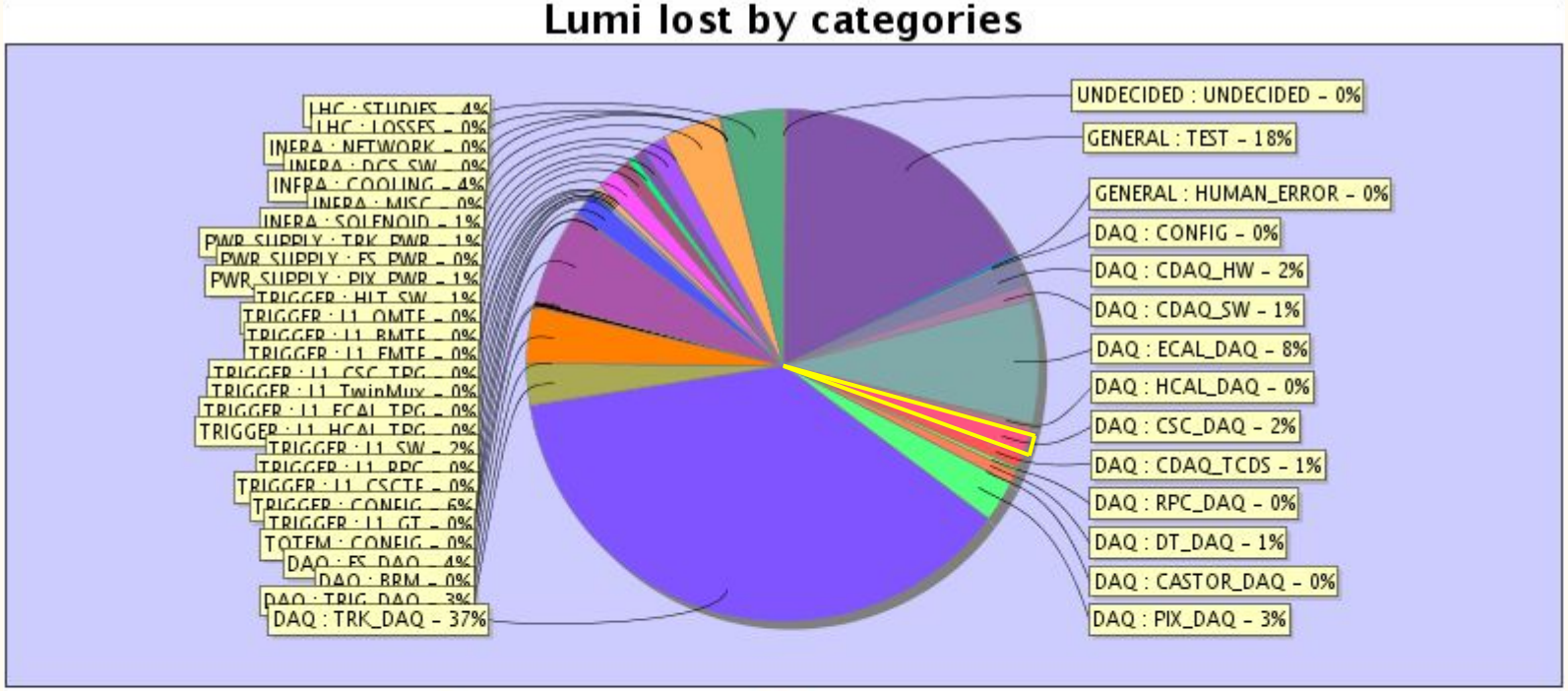


- **Readout efficiency > 98.5% at the end of 2016**
- **Main contributors to hardware problems**
  - 2 CSCs without LV
    - Faulty connectors
  - 2 CSCs with dead ALCT
  - 5 dead DCFEBs due to faulty EEPROMs
  - 5 DCFEBs with dead optical links
  - Only 2 dead CFEBs in 2016
- **Will recover what is accessible during this EYETS**

DCFEB problems

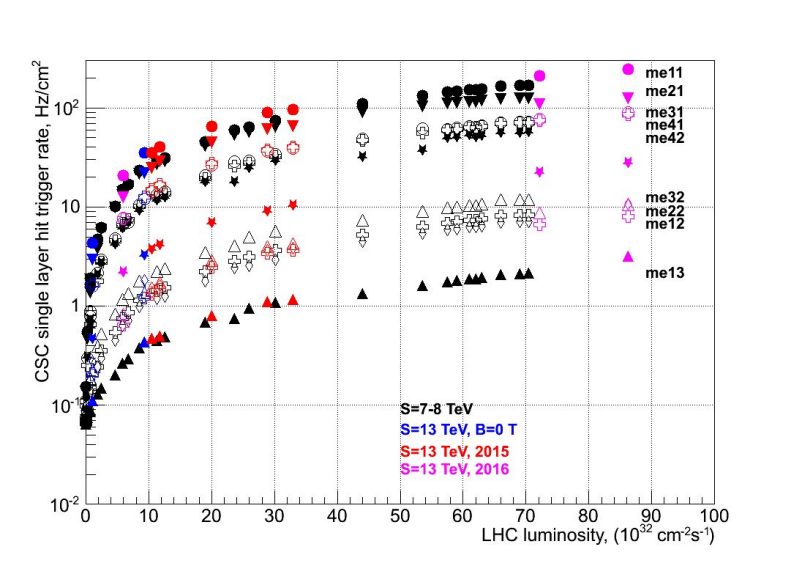
- **Occasional data corruption due to monitoring (over JTAG)**
  - Disabled some of the monitoring on these boards (fixed)
  - We have lots of redundancy in monitoring, so this is not a problem
- **Loosing optical link (sometimes stops the run)**
  - Turns out to be caused by SEU in the optical transceiver module
    - Transmitter is being turned off
    - SEU probably triggers the laser safety mechanism
  - Implemented firmware to reset the transceivers on hard-reset
    - But could not deploy because of the EEPROM problem (below)
- **EEPROM problem**
  - Discovered when trying to update firmware in July and August 2016
  - 5 boards stopped working (only tried downloading to 60 / 504 boards)
  - Reason: cannot erase or write EEPROM
    - After the first erase readback is always corrupted
  - Current hypothesis is that this is caused by radiation
  - Previous radiation tests didn't show problems, but we did not try erase
  - Repeated radiation testing at CHARM (20kRad)
    - After irradiation, cannot erase these PROMs (Xilinx XCF128x)
    - Studies ongoing, alternatives are being tested for future DCFEBs

Overview

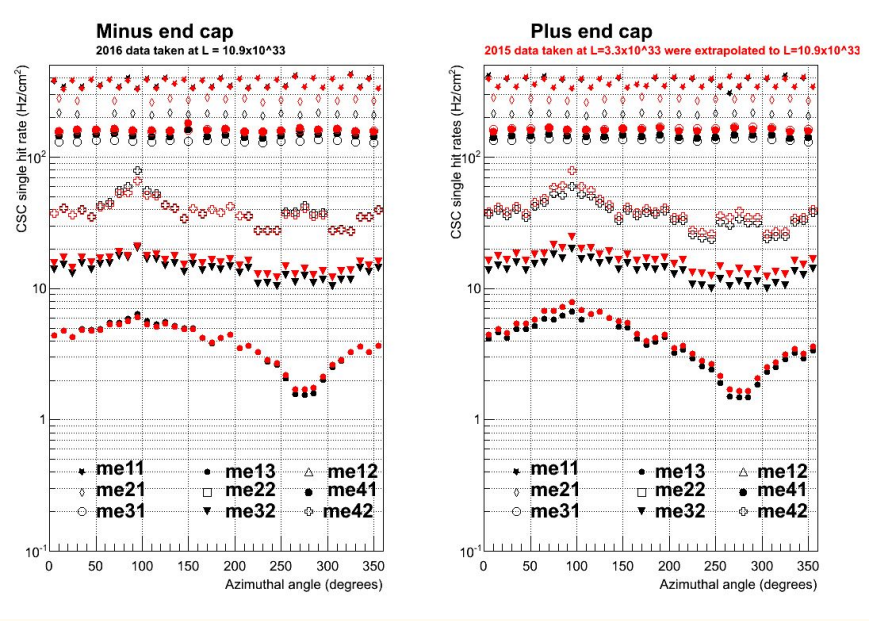


- **Downtime contribution = ~2%**
- **Main cause -- SEUs**
  - Corrupted data from the FPGAs
  - Some SEUs cause DCFEB optical transceivers to switch off
  - SEU mitigation
    - Hard-resets on-demand and periodically
    - Tripple modular redundancy in the firmware
    - Working on further improvements

Background



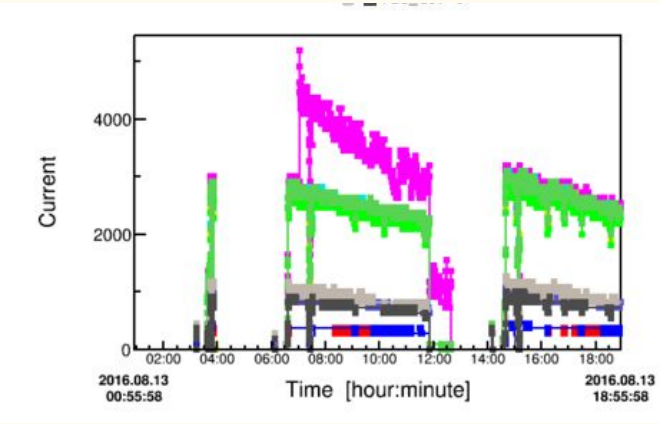
- CSC sees linear increase in background with increasing luminosity
- Small increase in background with 13TeV
- Magnetic field helps in inner rings
- During last EYETS rotating shielding was improved, but CSC doesn't see any noticeable effect in background rates



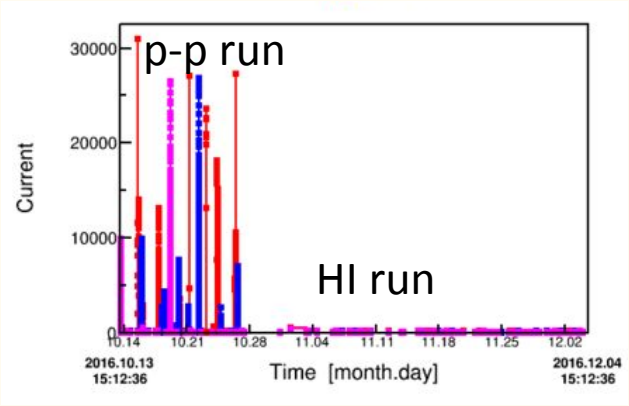
HV stability

- **Monitoring HV stability**
  - Paying special attention during high lumi running
  - So far very stable
  - A few channels stay at lower than nominal voltage since run 1
  - After lumi reached 10^34 we started seeing these effects:
    - HV current spikes in a few ME1/3 chambers
    - Occasional malter effect on a few other chambers
    - We think these chambers can be trained

Malter effect in me+2/1/07

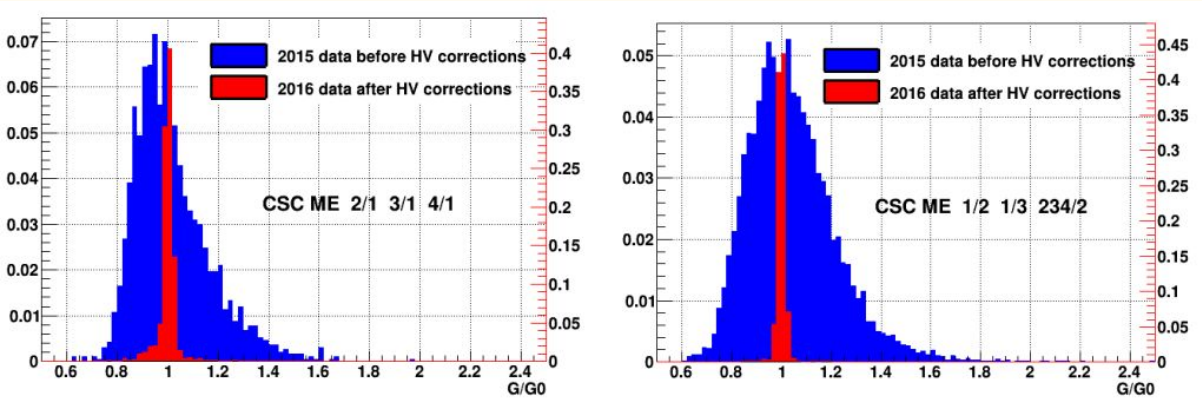


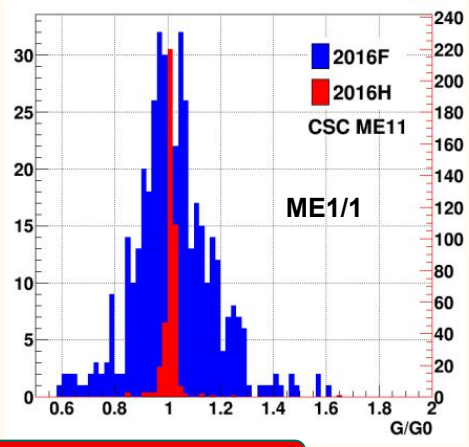
Spikes in HV currents of me-1/3/20



Gas gain equalization with HV tuning

- **Gas gain variation in CSC chambers was up to 3x**
  - Goal: equalize gas gains to achieve more uniform detector response
- **Tuned individual HV channel voltages to equalize gas gain**
  - The gas gain distribution now is impressively narrow
  - Note: this is average gas gain per sector, there is still variation within sectors
  - Recall: CSC has > 11000 HV channels/sectors
- **Next step: lower the gas gain on all chambers**
  - Maximize longevity
  - But preserve efficiency and good space resolution

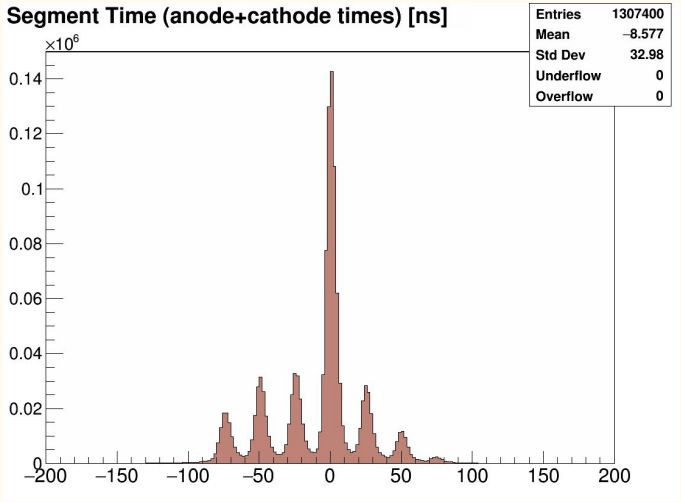


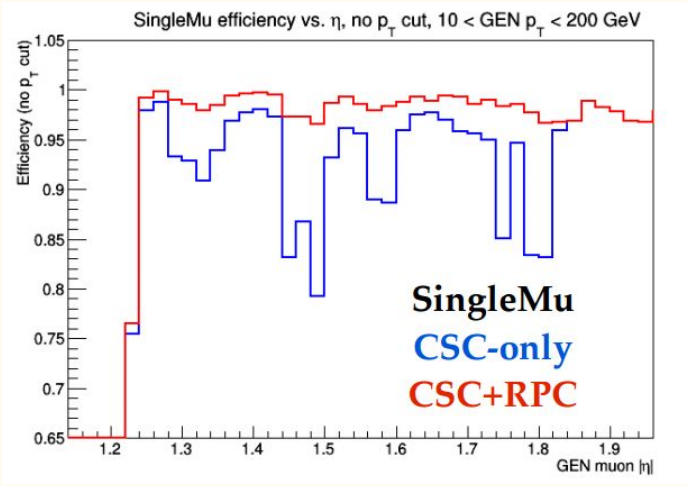


Before HV corrections **After HV corrections**

Trigger

- **EMTF has fully replaced CSCTF in 2016**
  - CSCTF was still in readout for offline cross-check studies
- **Chamber trigger timing is within a few ns**
- **Early EMTF firmware used the earliest LCT to form a trigger**
  - Later updated to choose the second earliest (like CSCTF)
  - This update reduced pre-firing rate from ~2% to ~0%
- **So far RPC hits were not yet included in track finding algorithm**
  - In 2017 RPC hits will be included -- shown to improve efficiency

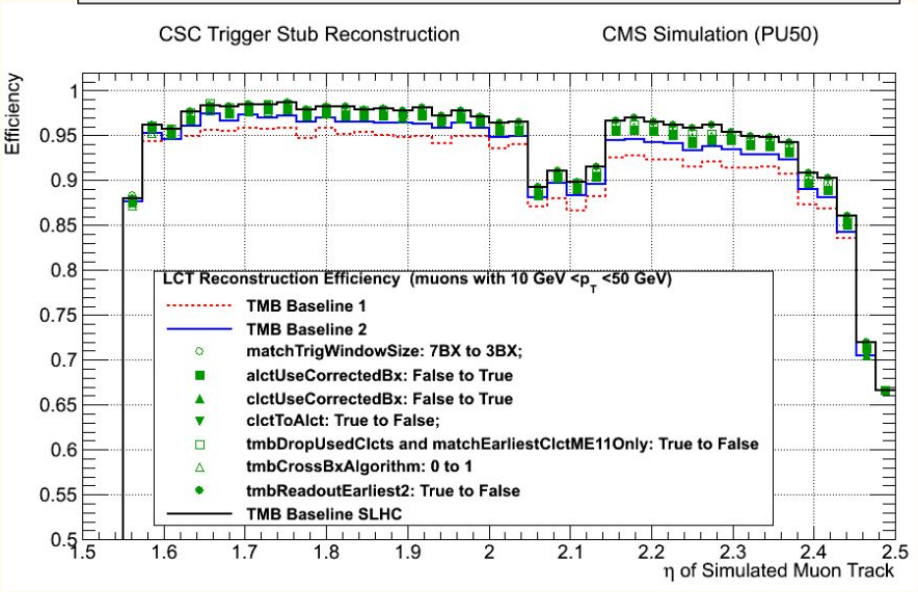




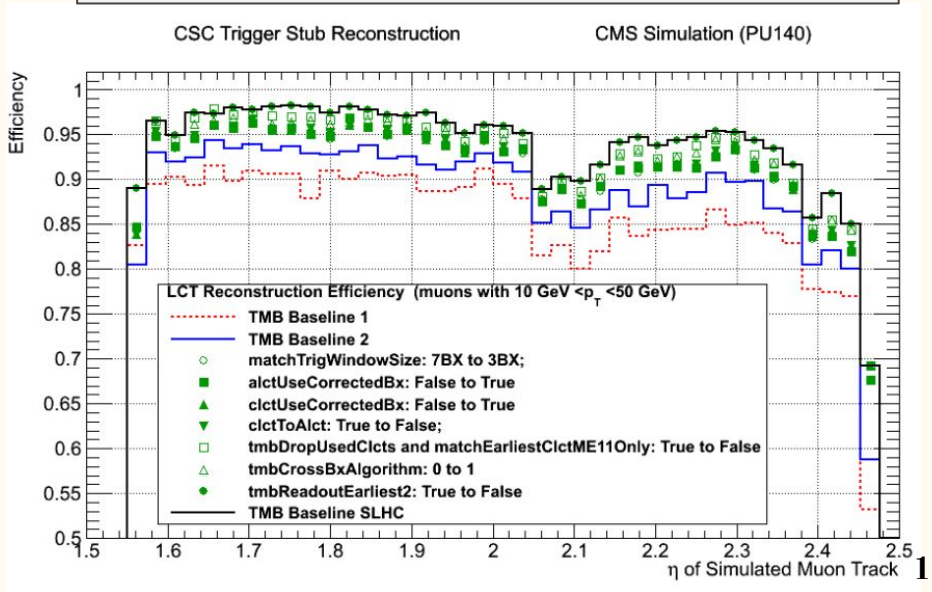
New OTMB firmware

- **Many developments for improving efficiency in high PU**
  - Individual improvements can be turned on/off in runtime
  - Extensively tested at GIF++
    - No problems seen, but improvements not visible due to small beam profile
  - Deployed at P5 on one chamber after pp run
    - No problems seen while running with or without algorithm improvements
  - Plan to deploy on a few crates during EYETS and later on the whole system
    - First run with the old algorithm and gradually turn on improvements

Simulation with PU = 50

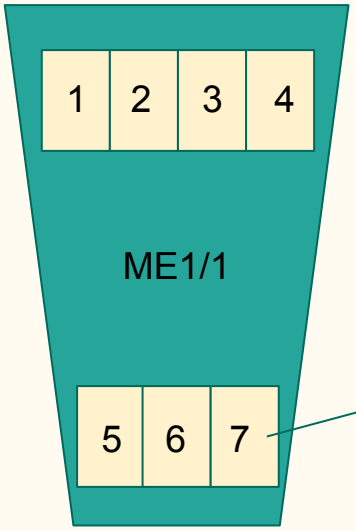


Simulation with PU = 140

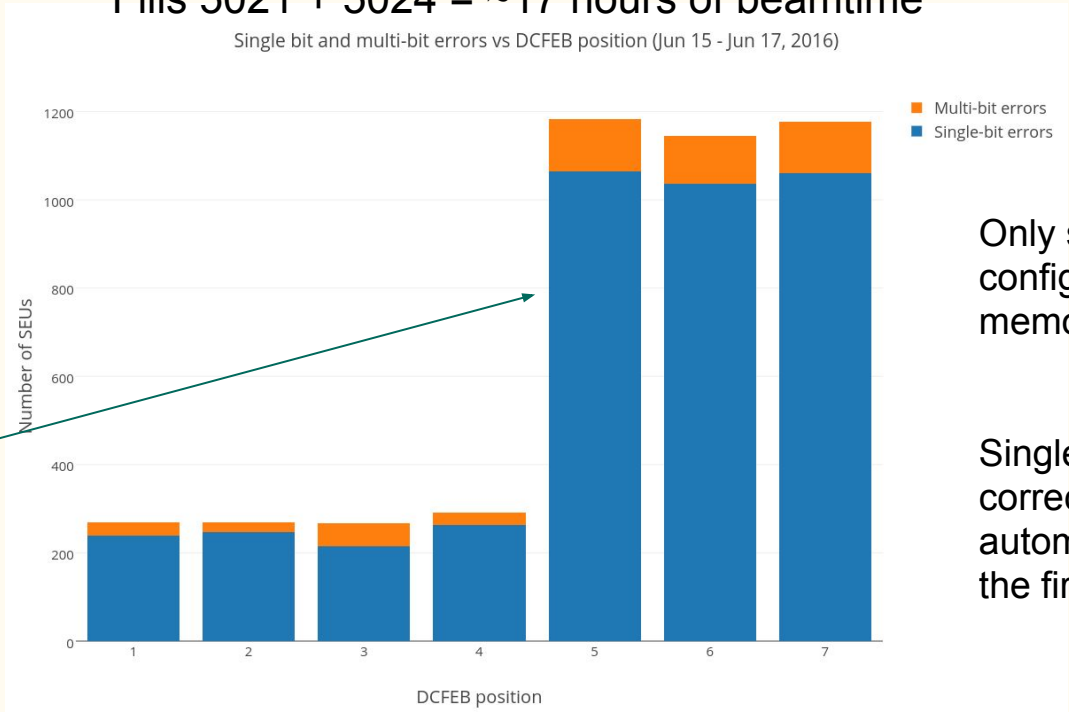


Online software

- SEU monitoring
  - Measurements saved to DB
- Improved firmware downloading stability
- EEPROM testing functions
- Support for new DCFEB and OTMB firmware functions



Total SEU count vs DCFEB position
Fills 5021 + 5024 = ~17 hours of beamtime



Only shows configuration memory SEUs

Single bit errors corrected automatically by the firmware

Plans for EYETS

- Reinforce ME1/1 water cooling joints
- Replace all dead DCFEBs
- DCFEB firmware update
  - Replace boards that show EEPROM problems during downloading
- Replace dead ALCTs
- Fix at least one broken LV connector (out of two)
  - May be possible to fix the second one as well
- Update ALCT slow control firmware
- Update OTMB firmware