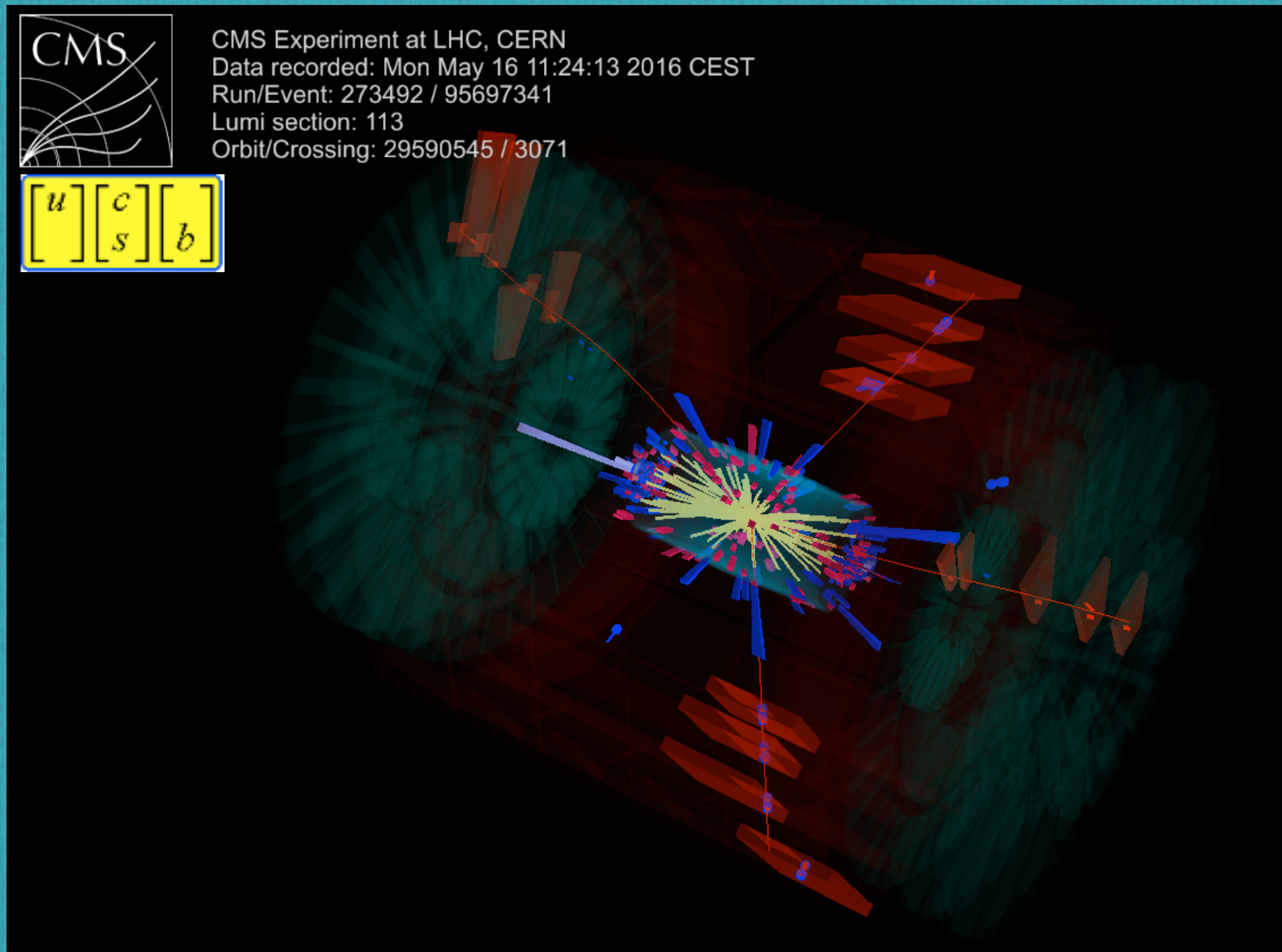

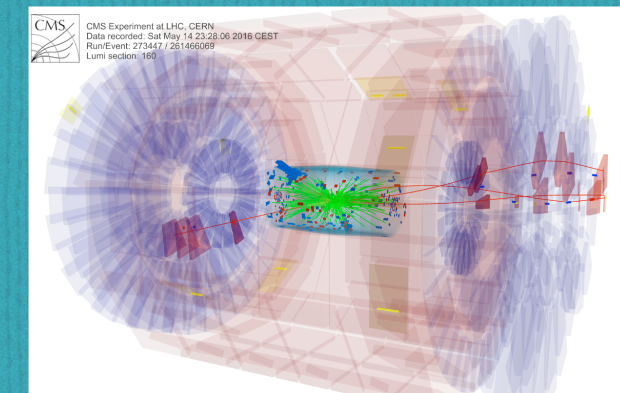

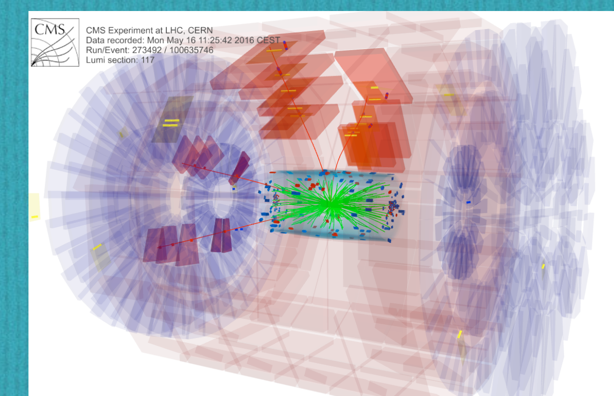

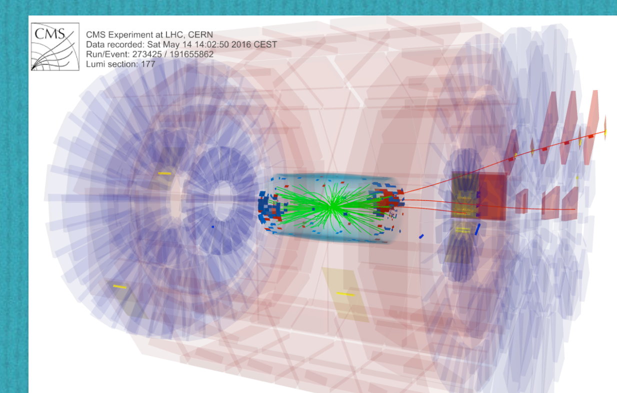

CSC Performance and Calibration

Indara Suarez (UCSB)

CMS Run & DPG Commissioning Workshop

24 January, 2017

Performance of the CSC Muon Subsystem

Data Quality
- Prompt Feedback
- Data Monitoring & Certification

Timing Performance
- CSC Rechit & Segment Timing

Trigger Performance
- CSC Trigger Primitives Eff.

Offline Reconstruction
- Spatial Resolution
- Offline CSC Segment Reconstruction Efficiency

- Overview of 2016 Results
- Preparation for 2017 Commissioning
- Studies for HL-LHC Scenarios

Prompt Feedback

- Daily Feedback based on Express data streams (high stats)
- Provided by subsystem shifters on data availability, quality, and detector performance
- Great way to communicate with Run Coordination @ P5

CMS DQM Run Registry (CSC)

Offline Application (3.5.0)

Offline | Datasets Show Waiting list — Refresh | Configure | Export — 5,090 items. Show 20 fro

Run Number	Run Class Name	Dataset Name	Dataset State	Dataset Created	Csc	Occupancy	Integrity	Strips	Timing	Efficiency
275376	Collisions16	/Express/Collisions2016/DQM	OPEN	Mon 20-06-16 16:05:34	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD
275375	Collisions16	/Express/Collisions2016/DQM	OPEN	Mon 20-06-16 07:53:30	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD
275371	Collisions16	/Express/Collisions2016/DQM	OPEN	Sun 19-06-16 23:03:22	GOOD	GOOD	GOOD!	GOOD	GOOD	GOOD
275370	Collisions16	/Express/Collisions2016/DQM	OPEN	Sun 19-06-16 22:43:26	GOOD	GOOD	GOOD!	GOOD	GOOD	GOOD

Certification of Collision runs recorded in the last 5 days
(Last update on Wed Jun 1 18:01:47 2016)

Run	B-field	Events	L1T calo	L1T muon	CSC	DT	RPC	ECAL	ES	HCAL	PIX	STRIP	TRACKING
274314	3.8 T	1035284120	WAIT	WAIT	WAIT	WAIT	WAIT	WAIT	WAIT	WAIT	WAIT	WAIT	WAIT
274172	3.8 T	847893400	GOOD	GOOD	GOOD	To be checked	GOOD	GOOD	GOOD	GOOD	GOOD [...]	GOOD [...]	GOOD [...]
274161	3.8 T	4400000410	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD [...]	GOOD [...]	GOOD	GOOD [...]	GOOD [...]	GOOD [...]

Data Certification & Validation

- Procedures
  - Offline DQM & validation tools to monitor & evaluate each run

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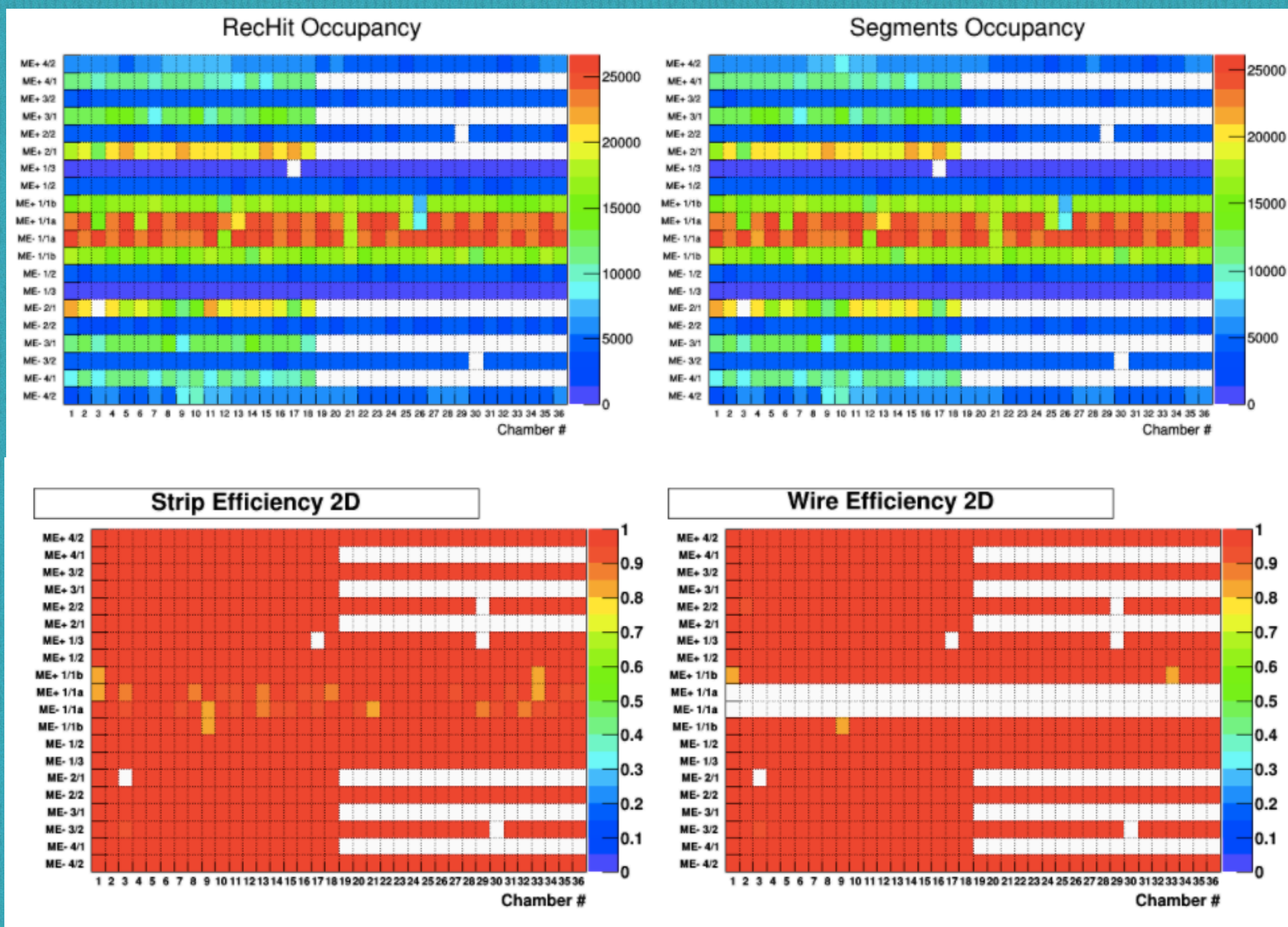


- rechit and segment occupancies & efficiencies (based on extrapolated segments)

Data Certification & Validation

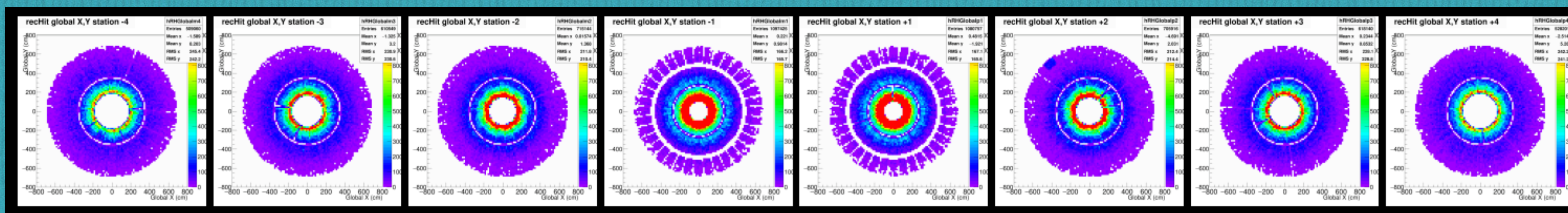
- Procedures
  - Offline DQM & validation tools to monitor & evaluate each run
    - Data Integrity
    - Timing & Resolution
    - Hit & Segment Occupancies & Efficiencies
    - HV/Gas Gain
    - Trigger (efficiency & quality)
    - Noise/Pedestals

Data Certification & Validation

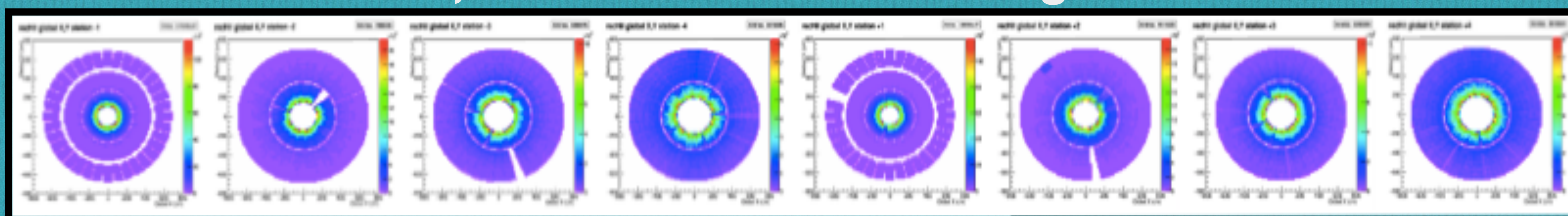
- Procedures
  - Offline DQM & validation tools to monitor & evaluate each run
  - Criteria for final certification
    - Specific working points, e.g. “> 95% of CSC system in operation” are not useful criterion. BAD data if >5% of CSCs in a contiguous region are not providing rechits.
    - Dedicated people responsible for monitoring the data quality on daily basis (DOC2) and for data validation (Validation expert)
- Proven to be robust and will continue to implement during 2017 data taking

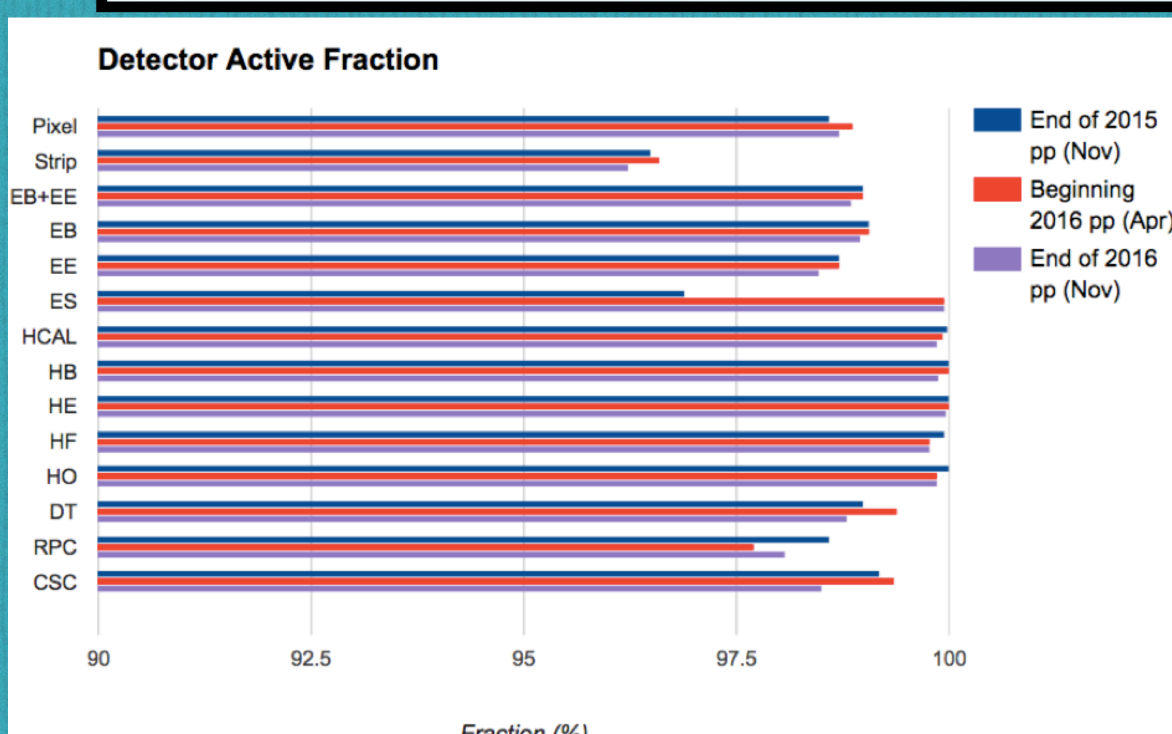
Status of System

- Started Run 2 with 99.4% of good channels in CSCs and no holes!



- At the end of 2016, we are left with 98.6% good channels

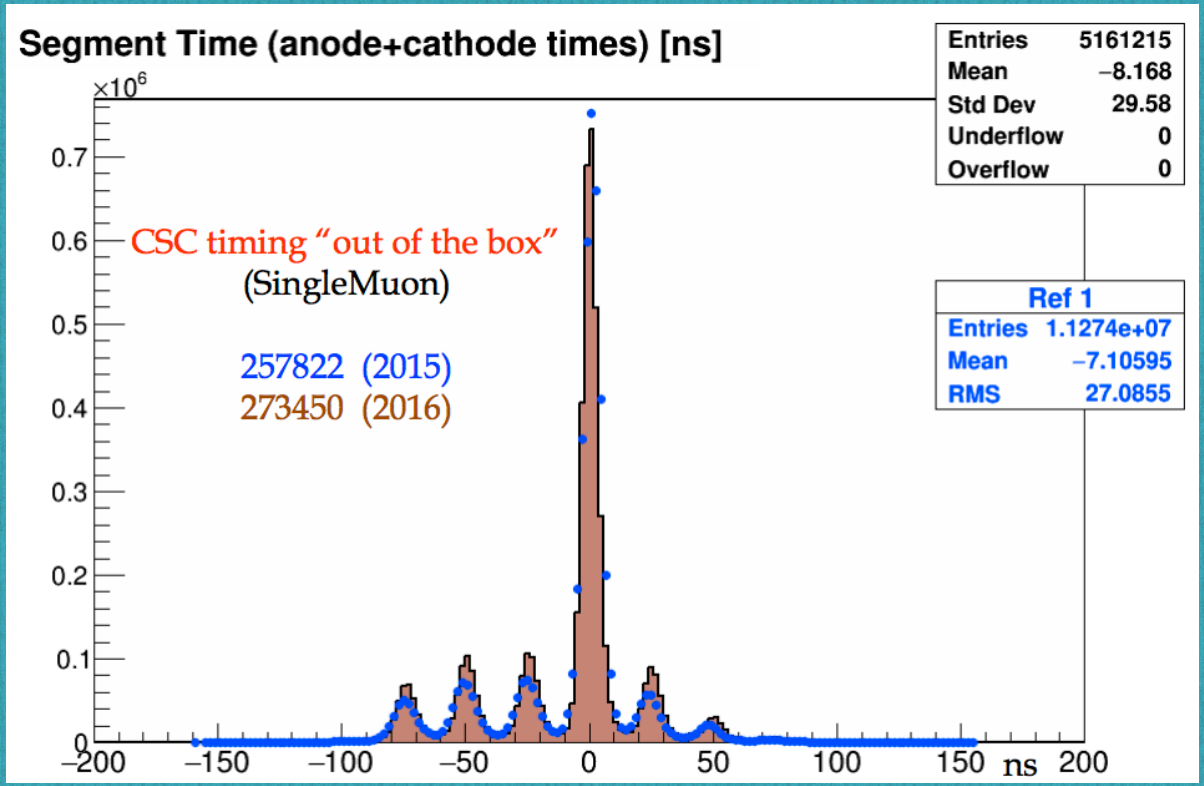




- Various problems with chamber electronics
- Will try to recover
  - Short time to fix problems and limited accessibility
- More details in tomorrow's CSC Ops talk

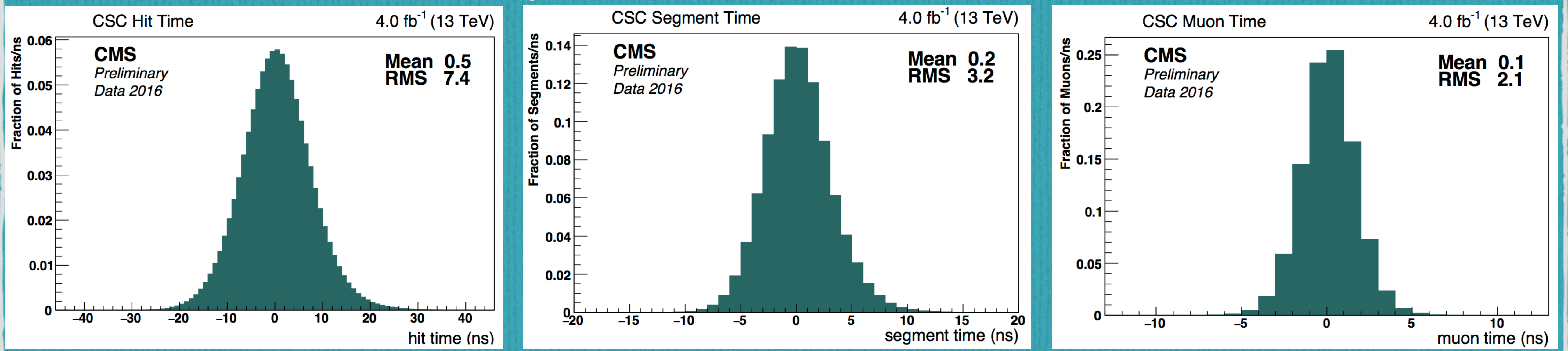
Timing Calibration

- Calibrate the offline reconstruction of the μ-time at the PV so that its distribution for prompt muons is centered at 0.
  - Timing calibration was performed using 2015 data.
  - The same timing calibration values remained appropriate for 2016 data, and a new calibration did not seem required.
  - We have no reason to expect any difference in (future) 2017 data.



Timing Performance

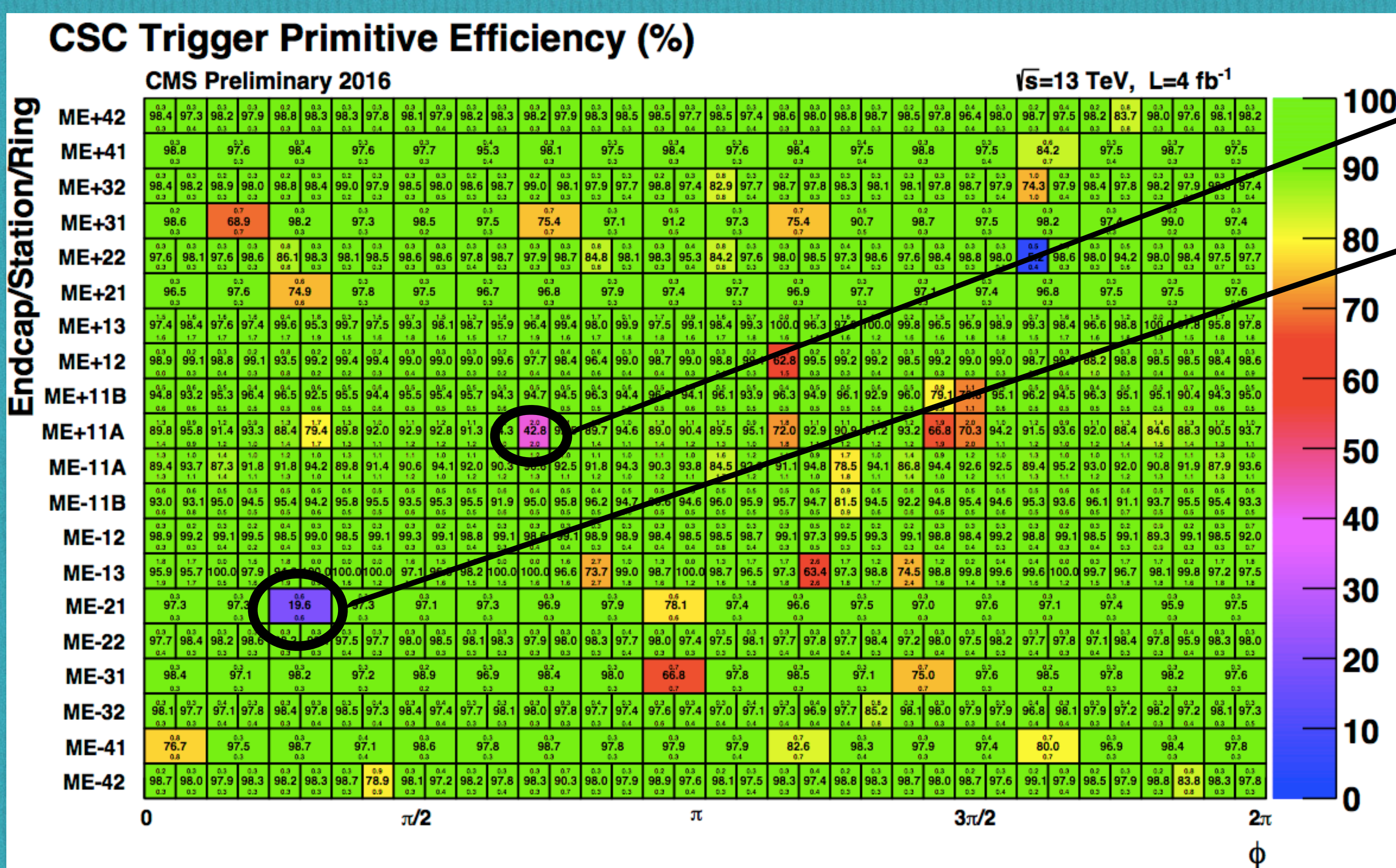
- Muon timing performance is determined by measuring time resolution for CSC rechits and segments
  - choose high quality segment and perform fit
    - template fit to the digitized cathode strip pulse height distributions to determine the timing of each rechit.   Segment timing = cathode + anode hits timing



    - 2015 and early 2016 results similar, results with full 2016 dataset underway
    - Rerun with 2017 data but don't expect changes in resolution for 2017

Local Trigger Performance

- Local trigger performance is measured by determining CSC trigger primitive efficiency by using tag & probe method and fitting to the Z-mass window
  - Inefficiencies found in 2016 data due to known chamber problems and some sporadic ones



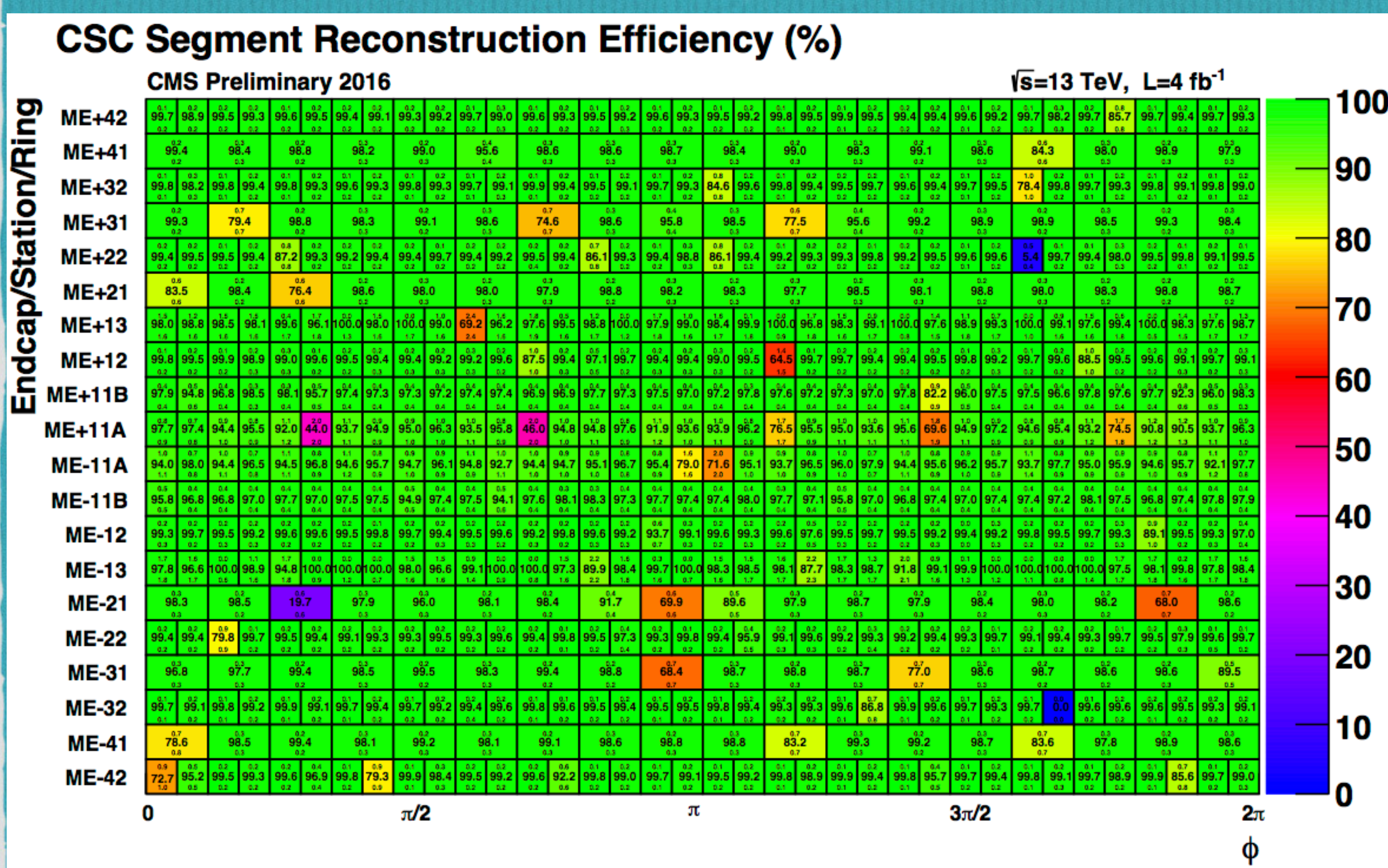
DCFEB issue, to be fixed

low Voltage problem

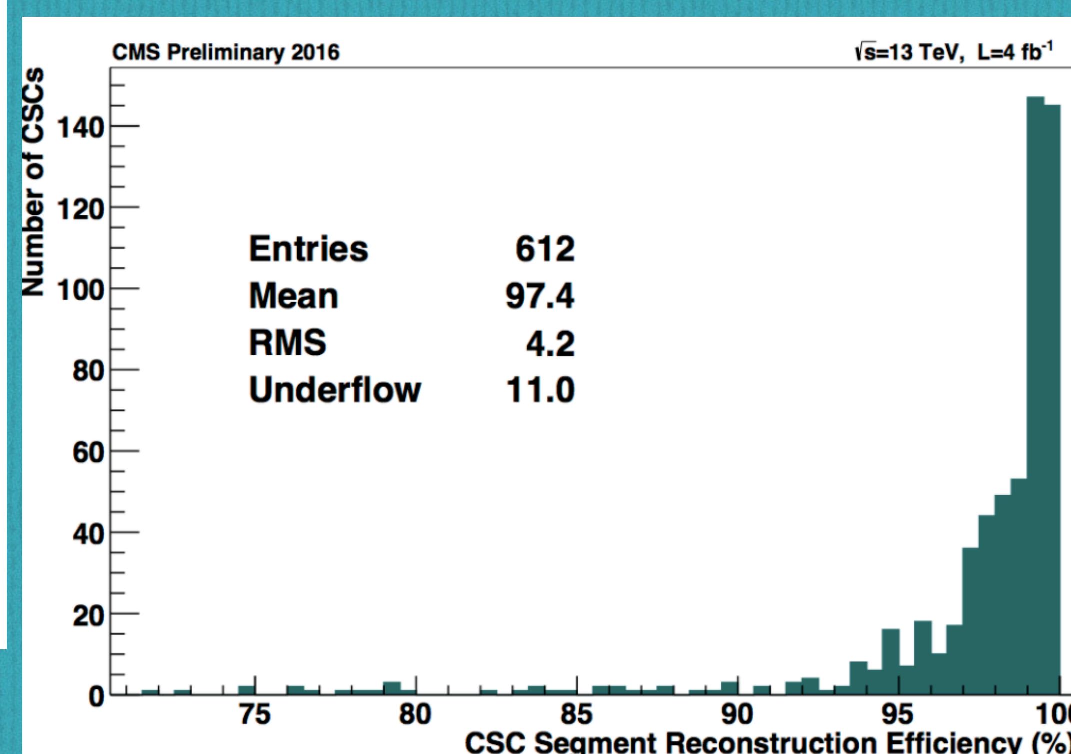
With ongoing work during EYETS we can recover some of these inefficiencies

Offline Reconstruction Efficiency

- Offline efficiency is determined by CSC Segment Reconstruction efficiencies using tag & probe method and fitting to the Z-mass window (same analysis as used in Local Trigger Performance)
  - inefficiencies found in chambers with known problems

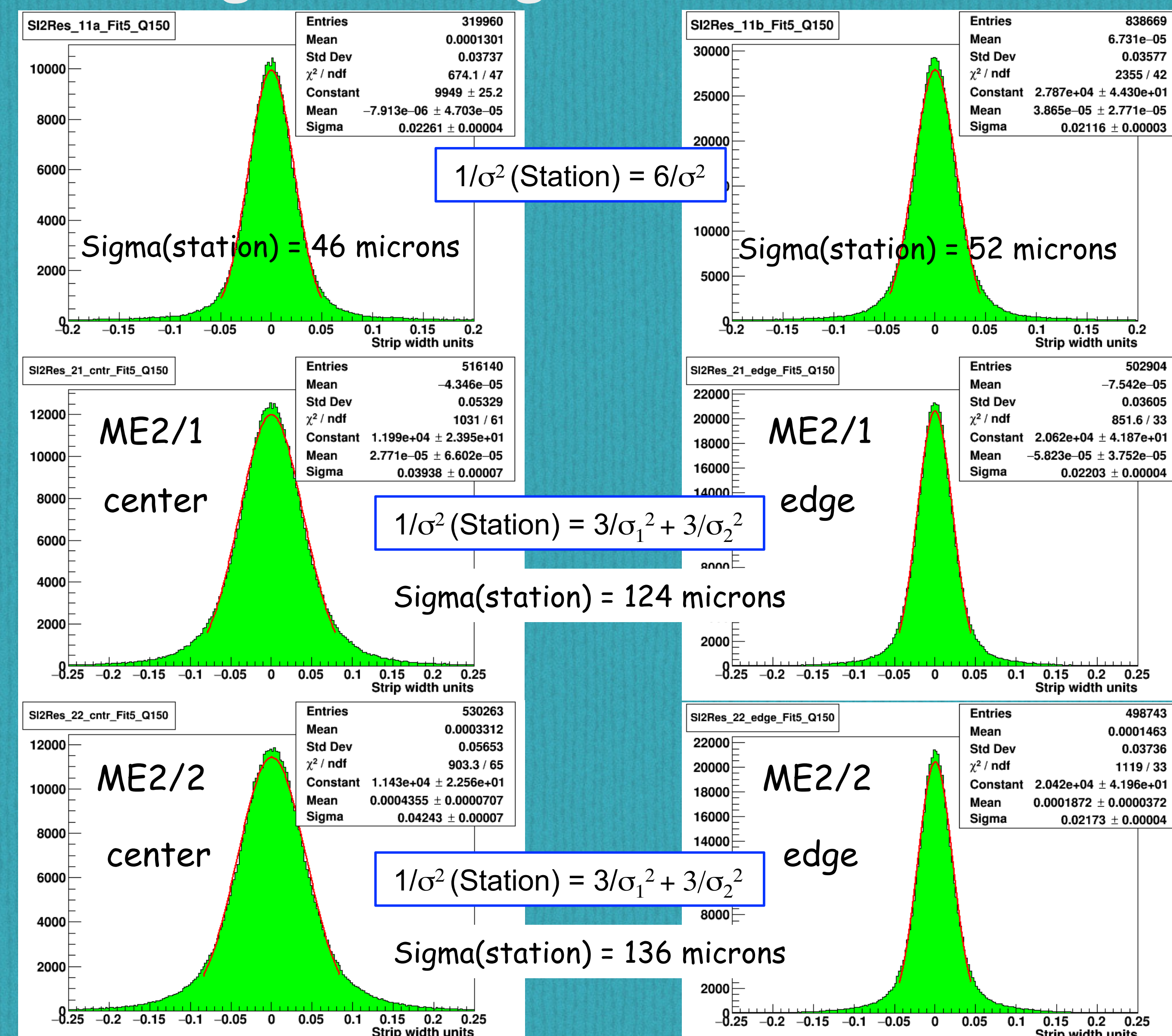


- but overall good performance of system



Spatial Resolution

- Spatial resolution is determined from the distribution of hit residuals with respect to the muon trajectory
  - Hit residuals are computed using reco-segments with a straight line fit
  - spatial resolutions are calculated per each station
  - resolutions sensitive to:
    - atmospheric pressure
    - angle of incidence of muons
    - event selections used for studies



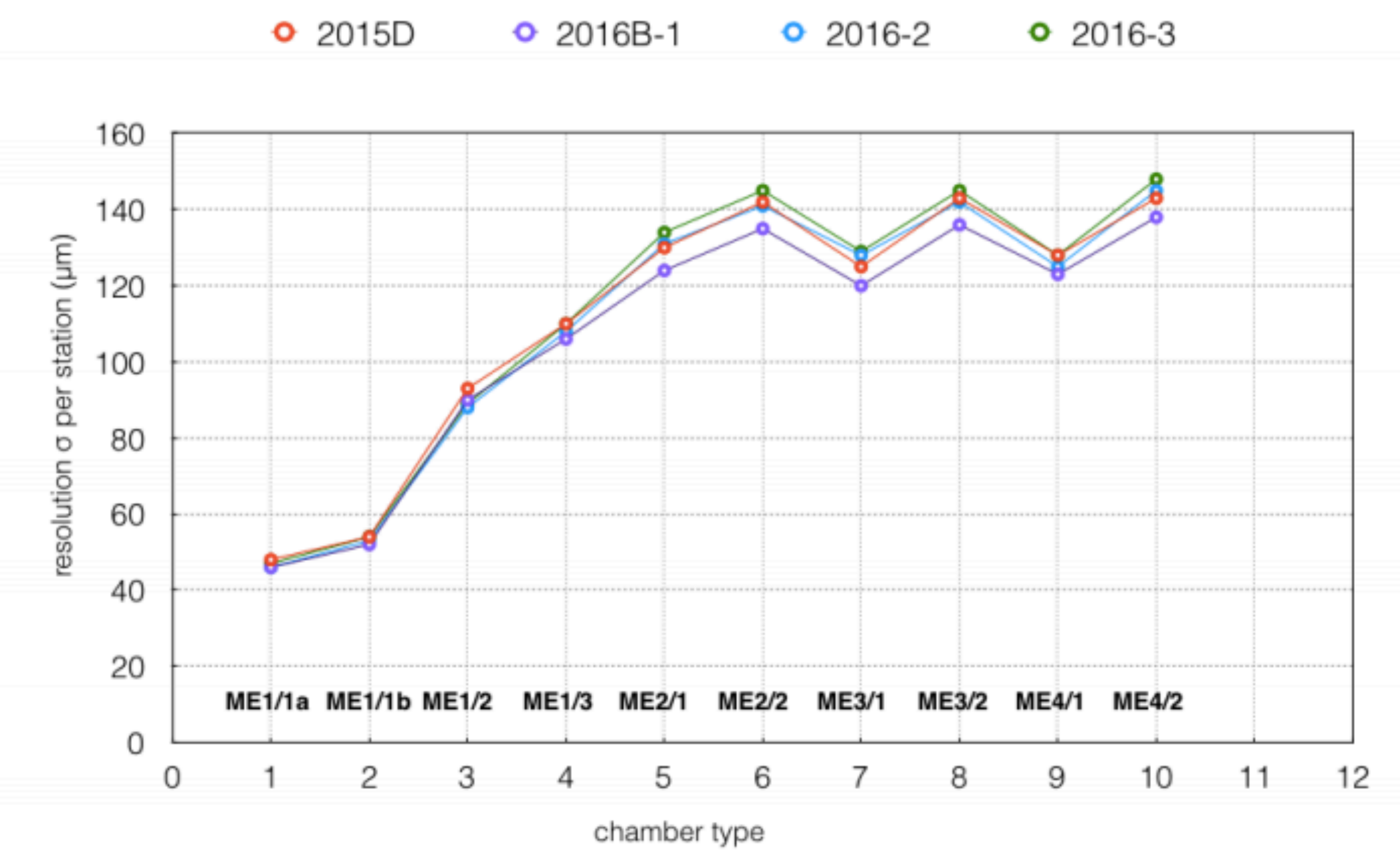
Spatial Resolution in 2016

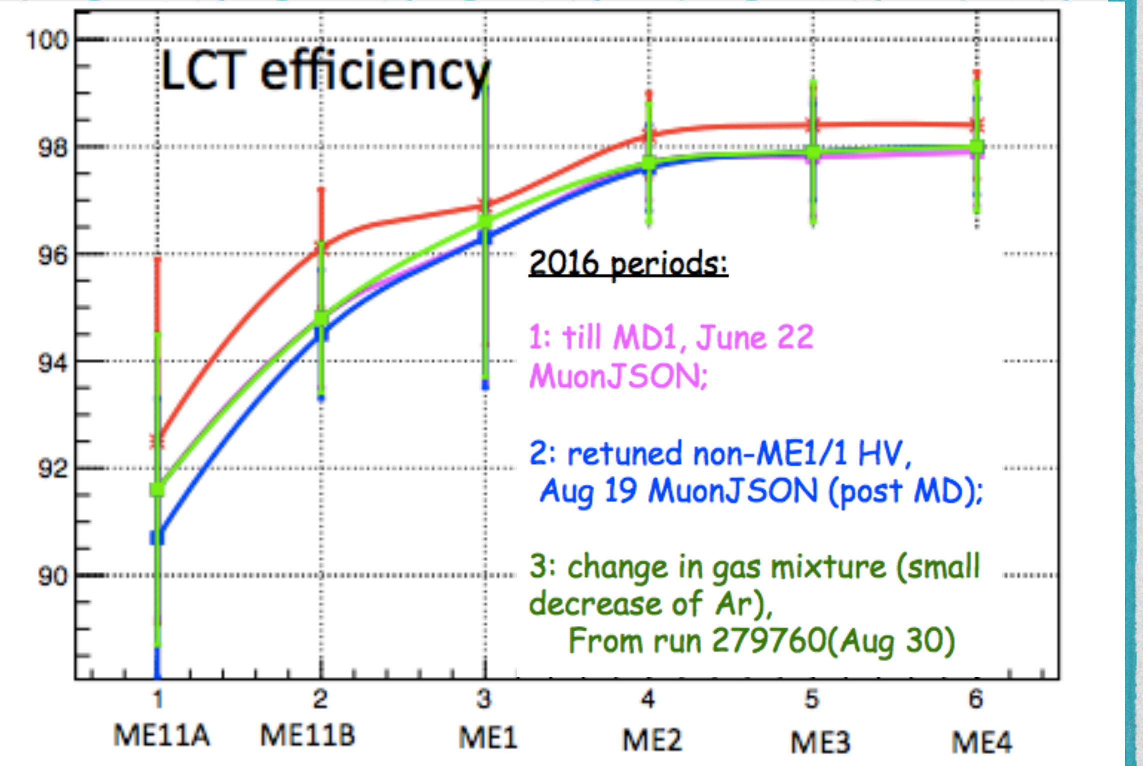
Spatial resolution per station (µm):

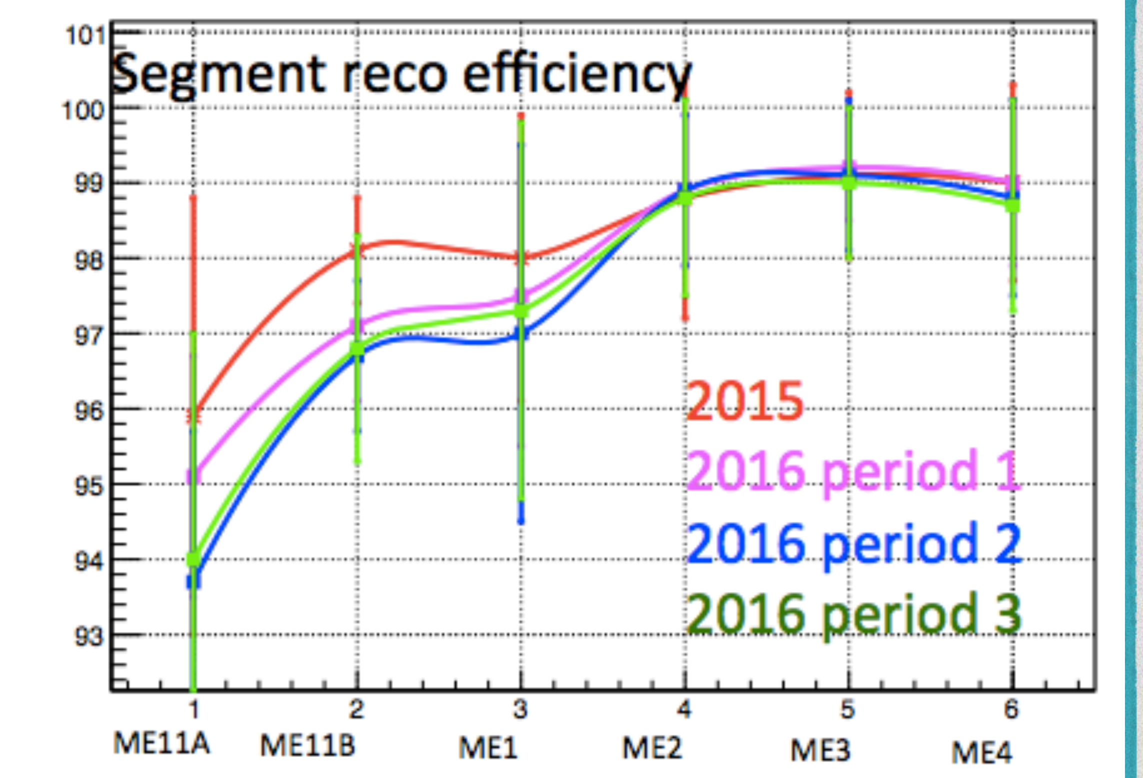
Station	Collision dataset			
	Run1	Run2		
	2012	2015B	2015D	2016B
ME1/1a	66	51	50	46
ME1/1b	57	54	55	52
ME1/2	93	94	95	91
ME1/3	108	114	112	107
ME2/1	132	132	133	124
ME2/2	140	149	145	136
ME3/1	125	128	128	120
ME3/2	142	150	147	138
ME4/1	127	131	130	123
ME4/2	147	149	146	139

- Understand improvement in resolution from 2012 to 2015B
  - triple ganging removed
  - CFEB to DCFEB
- 5-8% improvement in spatial resolution between 2015D and 2016B
  - originally thought it was atmospheric pressure

Source of Resolution Improvement



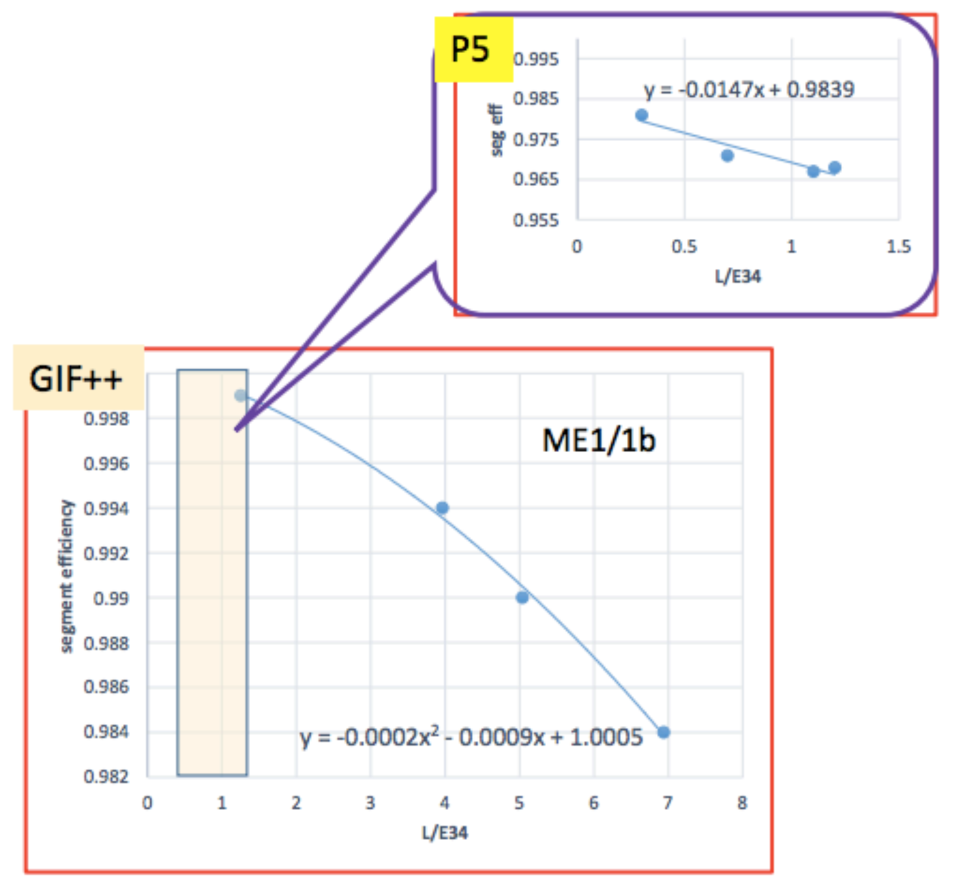




- **differences between 2015D and 2016B due to changes in gas mixture:**
  - **a 1% higher Ar fraction (40.4% instead of 40%). This causes a 10% increase in gas gain and ~8% improvement in spatial resolution**
- **differences between 2016B-1and 2016B-2: HV tuning of non-ME1/1s**

Performance v. Luminosity

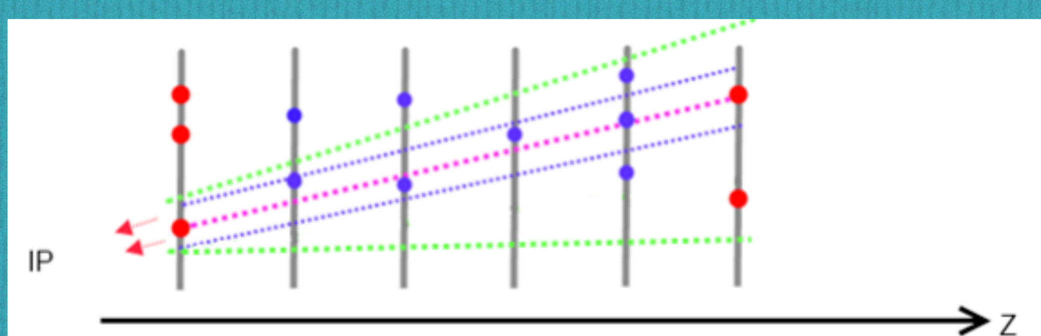
- Would like to understand performance as a function of luminosity
  - Important not only for HL-LHC but also to anticipate issues with electronics and aging of chambers
  - Studies of trigger and segment reconstruction efficiency and spatial resolution as a function of lumi
    - 2016H data,
    - 2016 high lumi run, GIF++ data
    - For 2017: working together with other muon subsystems (DPGO) to develop trend monitoring tools using the DB

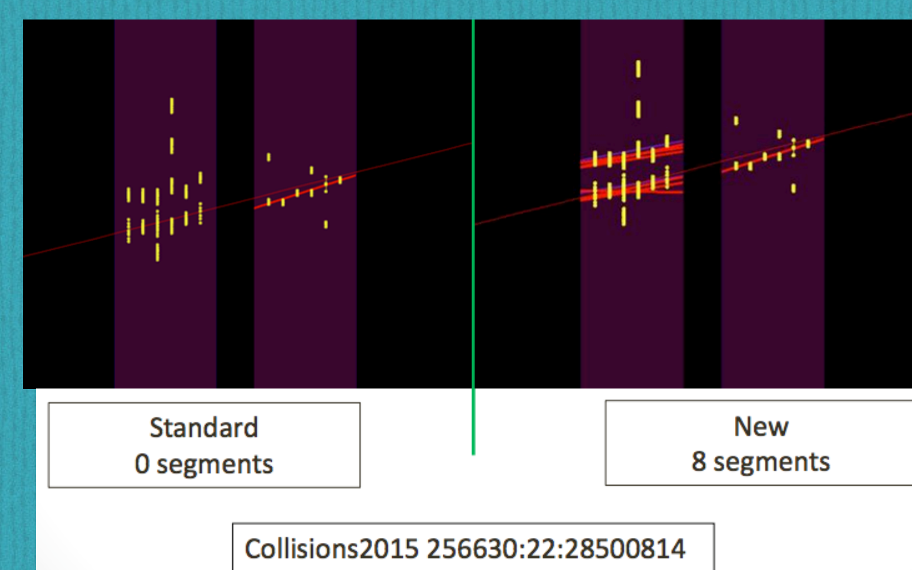


- with GIF++ data: 2% degradation
- with p5 data (long extrapolation): up to 10%

Improving Reconstruction Algorithms

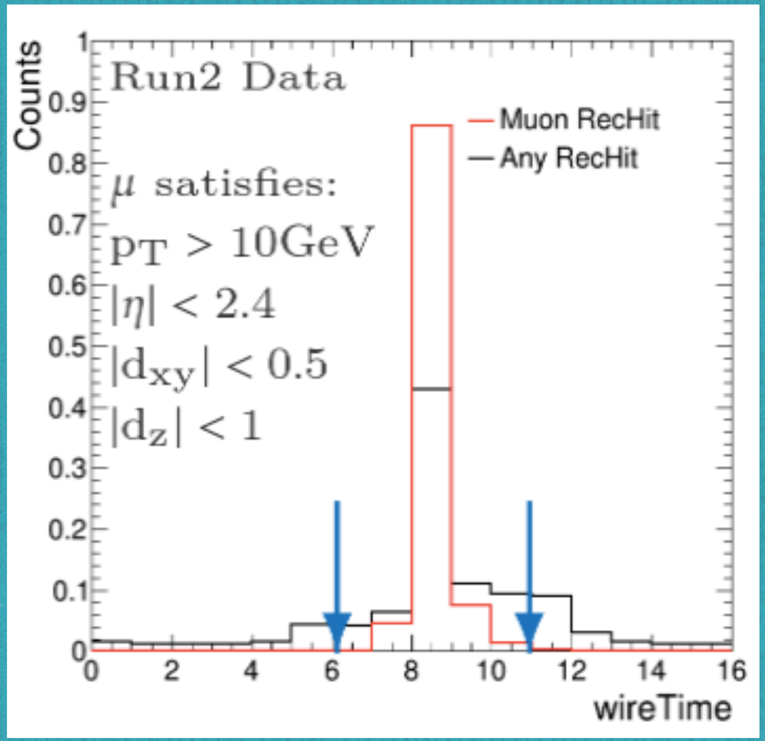
- Development of a new segment builder that is more robust against backgrounds and showering. Achieves better hit association, and resolution, with fewer fake segments.
  - LHC luminosity may increase much more dramatically than expected - be ready to use if necessary in 2017
- Use the IP as a constraint while choosing the base hits in terms of WG for the future segment:
  - A straight line is traced through the base hits
  - In the road formed along this line new hits from the inner layers are added to the segment



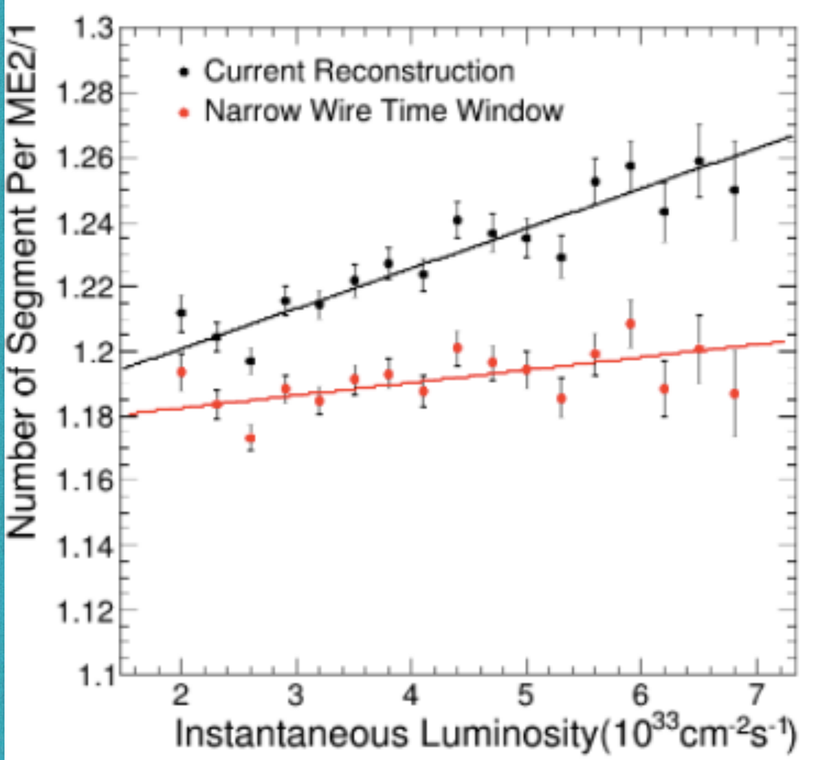


Improving Reconstruction Algorithms

- Narrow the wire time window to reduce the number of combinatorial fake RecHits (which grows with luminosity)
  - currently, we take the full 0-16 25ns time window



  - by restricting the time window to the BX-range 6-11, we can reduce the number of fake segments by a factor of 2



code implemented in CMSSW and ready to use

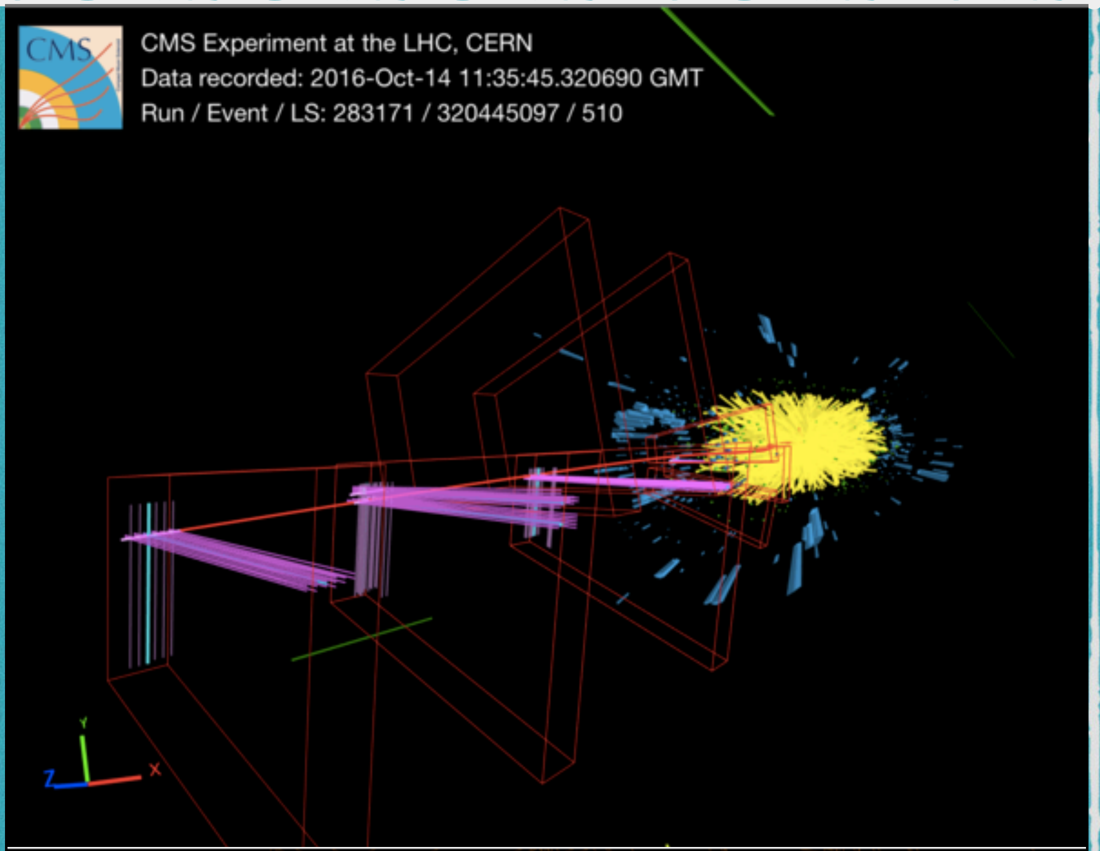
CSC Aging Studies

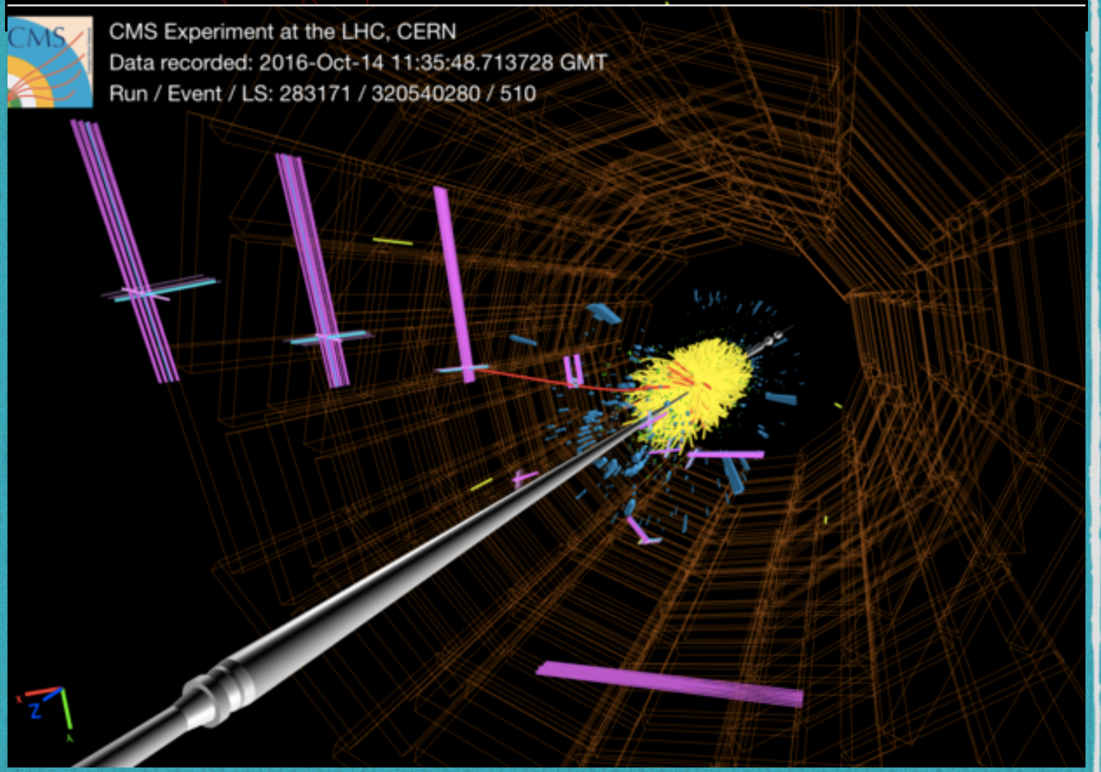
- Developing tools to model different aging scenarios for Phase II simulation
- Existing DT aging software package
    - Drops digis from a set of inefficient chambers listed in conditions data
    - Inefficiency is used to control the probability with which a digi in such a chamber is kept or dropped.
    - Can be applied at various parts of the CMSSW data flow

- CSC needs finer granularity - typically at the level of a Front End Board
    - Implement loses in terms of sets of dead strips and wire channels
    - Try to extend the DT software - short timeline!
- Working together with technical coordination to determine which aging scenarios need to be investigated.
    - best, worst, and realistic case scenarios → simulate the realistic scenario
- Studies to be included in the Muon TDR.

CSC DPG Plans for 2017

- Finalize all studies using 2016 Data
- Determine if any changes in conditions data are needed for 2017 Data taking
    - do not expect major changes
- New performance plots with 2017 data
    - Expect some regain of efficiencies after EYETS work completed
- Deliver to CMSSW and enable an improved rechit and segment reconstruction code
- Work on aging studies to provide results for Phase II Upgrade Muon TDR





Not a Small Effort

CSC Detector Performance Group

Conveners: Tim Cox (UCD), Indara Suarez (UCSB)

Data Monitoring & Performance (L3 Convener: Senka Duric, Wisconsin)

- DQM Infrastructure & Content — V. Barashko, T. Cox
- CSC Validation & Prompt Feedback — D. Taylor
- Data Certification — K. Long
- MC-Data Comparison & Release Validation — T. Cox
- Producing Conditions Data — A. Hortiangtham
- Performance Measurements Spatial Resolution — V. Palchik
- Performance Measurements Time Resolution — F. Golf
- Performance Measurements LCT & Segment Efficiencies — S. Duric
- Performance Measurements CSC Aging Studies — L. Shchutska + UF

Senka

Local Reconstruction (L3 Convener: Mirena Paneva, UCR)

- Geometry(strips & wires) — T. Cox
- Data Structures (Digis, Rechits, Segments, Conditions Data) — T. Cox
- Data Structures (Trigger Primitives) — TAMU
- Unpacker (Raw - Digi) — V. Barashko
- Rechit & Segment Building (Maintenance) — T. Cox
- Rechit & Segment Building (Development) — N. Voytishin, V. Palchik, UF

Mirena

Simulation

- Geometry(strips & wires) — T. Cox
- Digitizer (Simhits - Digis) — T. Cox
- LCT Emulator (Digis - LCTs) — TAMU
- Packer (Digis - Raw) — V. Barashko
- Neutron Backgrounds/Phase 2 Studies — UCLA, I. Suarez