Performance and calibration of CASTOR calorimeter at CMS

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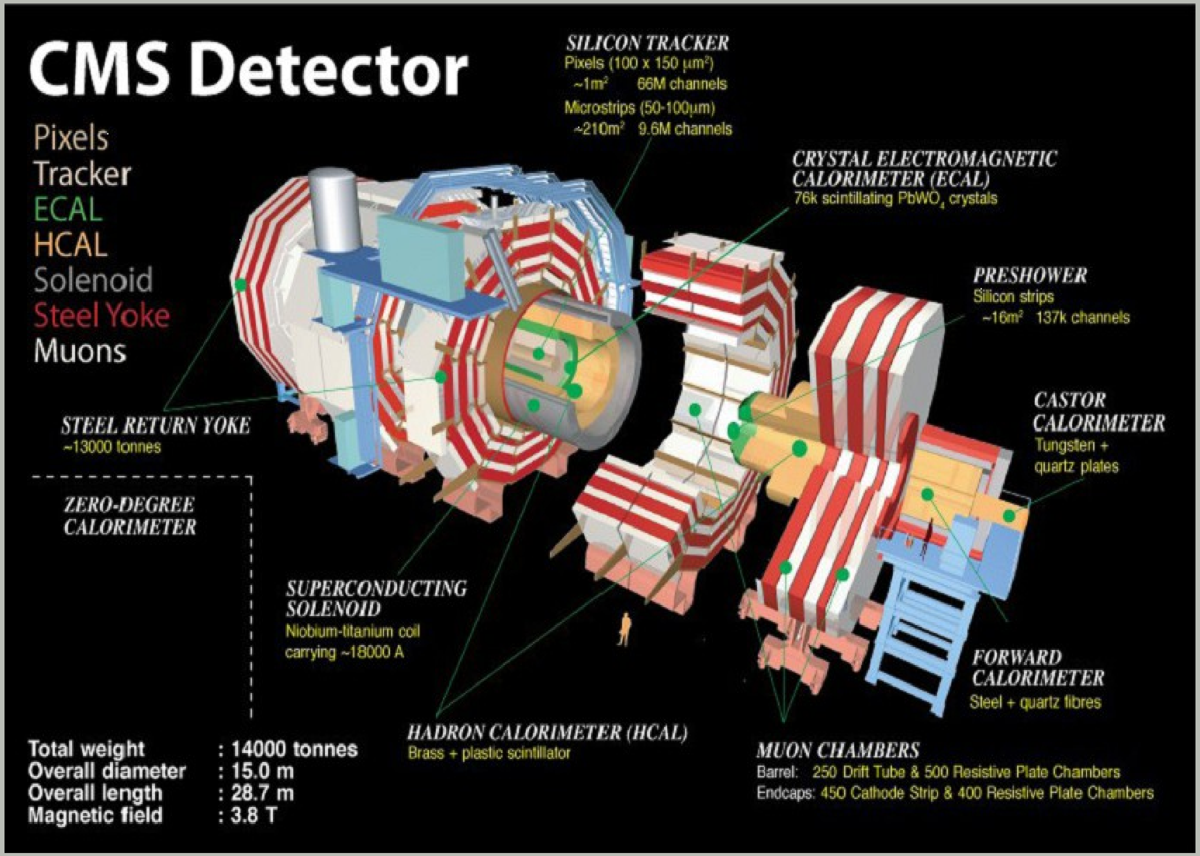
for CMS-CASTOR collaboration

TIPP 2011

CASTOR calorimeter at $-6.6 < \eta < -5.2$

- **Low-x dynamics**
  - proton structure, BFKL/CCFM/DGLAP dynamics
  - parton saturation
  - multi-parton scattering and underlying event
- **Diffraction**
- **Measurements for cosmic ray data analysis**
- **Forward energy and particle flows, minimum bias event Structure**



- **Forward physics in pA and AA collisions**
- **New forward physics phenomena**

CASTOR

- Čerenkov calorimeter
  with tungsten-quartz plates

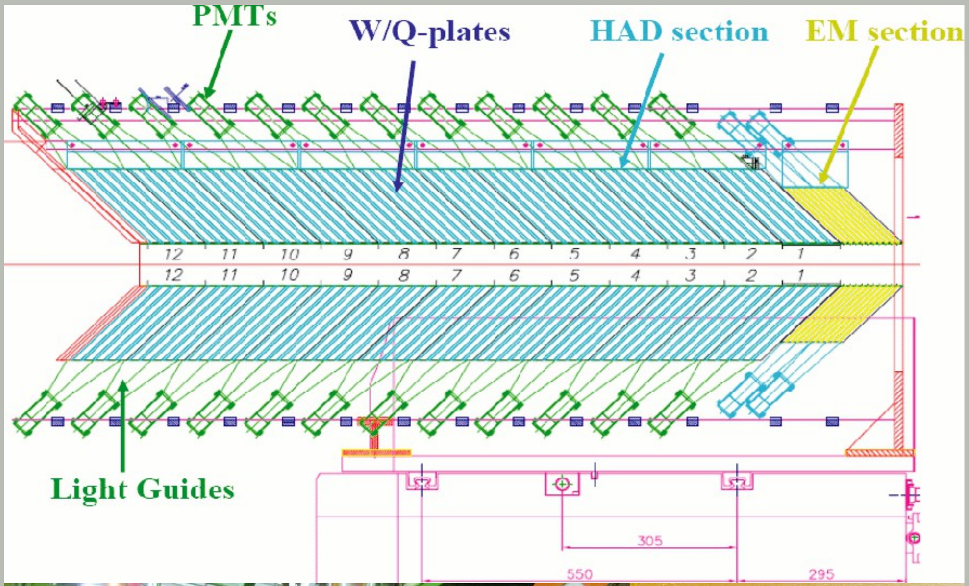
- Located at 14.4m from the
  interaction point

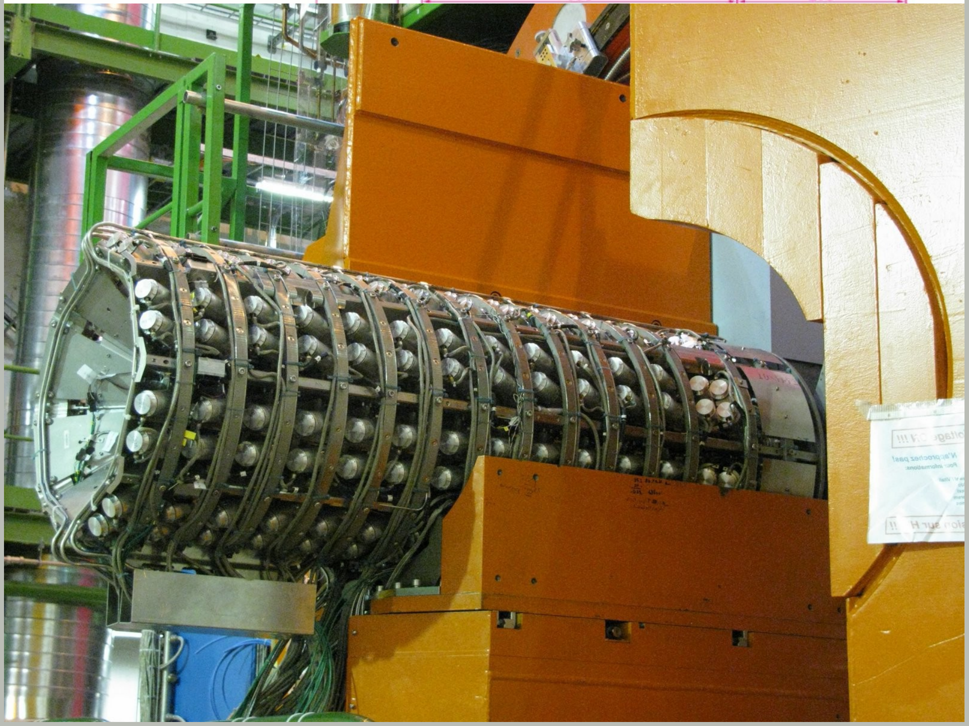
- Covering -6.6 < η < -5.2

- Longitudinal segmentation:
  electromagnetic(x2) and
  hadronic(x12) "modules"

- φ segmentation:
  16 "sectors"

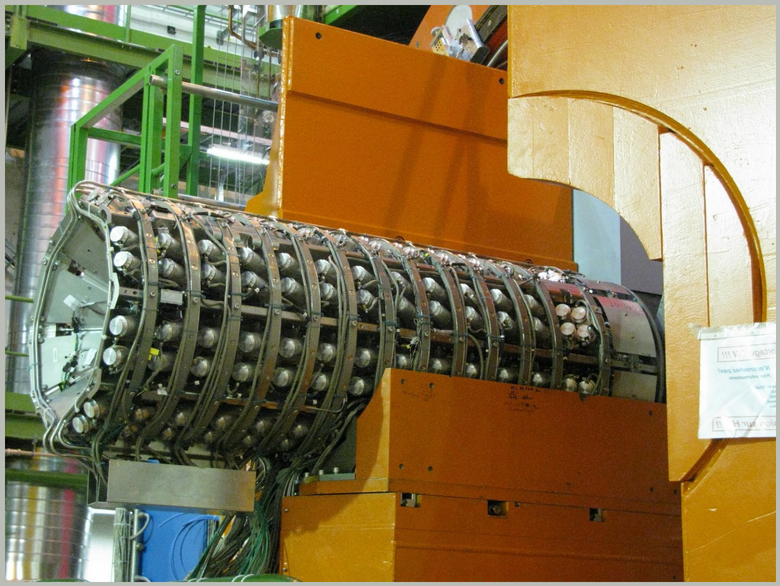
- Read-out: 224 channels with
  fine-mesh PMT (Hamamatsu R5505)



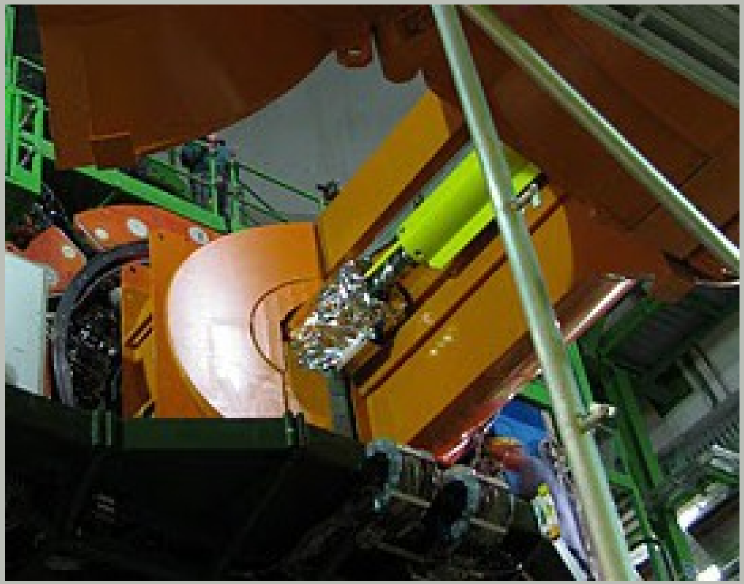


CASTOR shielding:

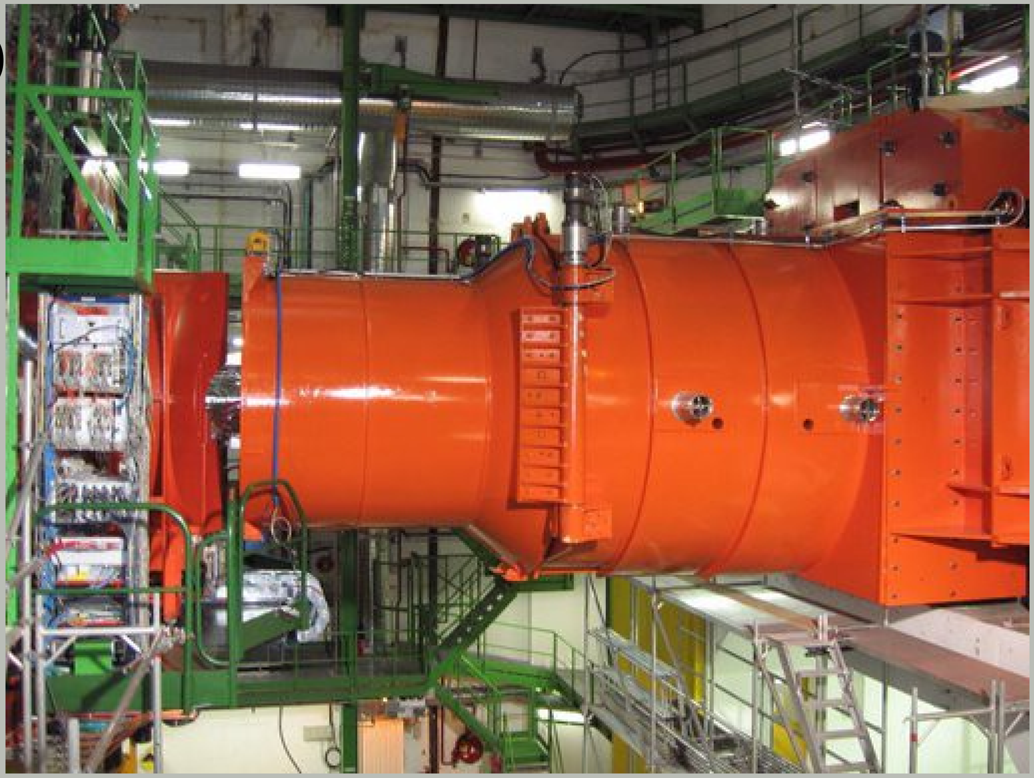
1)



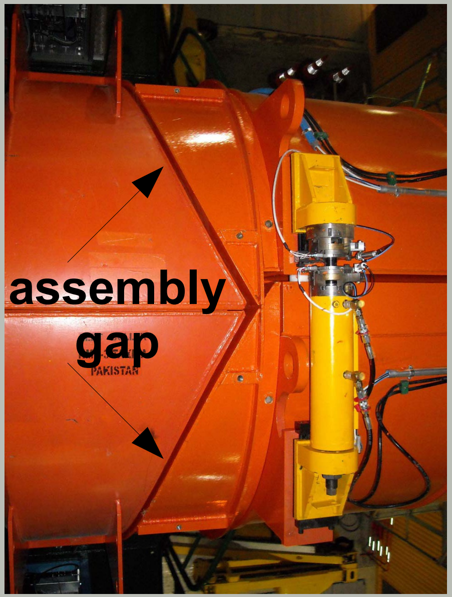
2)



3)



Top view final assembly:



Magnetic field influence:

In the gap region:

absolute value is less than 0.2T, but the angle is varying...

Minimum Bias data 2010 (pp collisions):

Signal(3.8T)/Signal(0T)

CMS preliminary

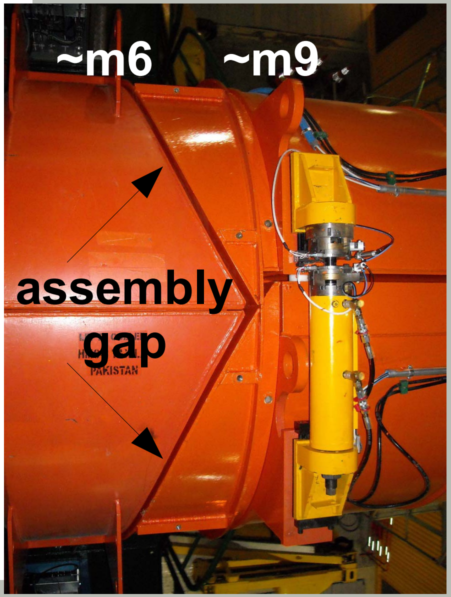
$Z \rightarrow$

$\uparrow \varphi$	1	2	3	4	5	6	7	8	9	10	11	12	13	14
16	0.85	0.91	0.92	0.98	1.31	0.33			0.68	0.81	0.91	1.01	0.99	0.97
15	0.98	0.91	0.94	1.01	1.27	1.32			0.79	0.93	0.92	0.97	1.06	1.00
14	0.84	0.92	0.94	0.97	1.20	0.42			0.65	0.81	0.96	1.02	1.15	1.30
13	0.89	0.93	0.96	1.04	1.34	0.11			X	0.73	0.94	1.02	X	1.07
12	0.94	0.94	0.98	0.98	1.03	0.10			0.46	0.74	0.94	1.03	1.10	1.13
11	0.96	0.94	0.93	1.00	1.21	0.24			0.68	0.84	0.93	0.97	1.08	1.03
10	0.97	0.89	0.88	0.93	0.96	0.27		0.43	0.87	0.94	0.95	0.88	0.91	1.18
9	0.92	0.88	0.89	0.99	0.92	0.29		0.62	0.70	0.85	0.89	0.91	0.97	0.93
8	0.95	0.69	0.83	0.90	0.86	1.09		0.41	0.66	0.82	0.76	0.79	0.85	0.85
7	0.95	0.81	0.83	0.90	0.87	0.12		0.27	0.71	0.71	0.71	X	0.81	0.94
6	X	1.03	0.81	0.75	1.07	0.29			0.30	0.71	0.69	0.57	0.80	0.76
5	X	0.89	0.81	0.84	1.06	0.49				X	0.68	0.50	0.97	0.88
4	0.84	0.91	0.84	0.88	0.79	0.60				0.59	0.80	0.84	0.83	0.96
3	0.89	0.88	0.85	0.81	0.98	0.50			0.16	0.62	0.76	0.83	0.99	0.84
2	0.84	0.76	0.90	0.86	1.01	1.35		0.08	0.73	0.72	0.80	0.84	0.88	0.85
1	1.02	0.86	0.89	0.96	0.92	2.15		0.49	0.69	0.81	0.85	0.85	0.92	0.94

Minimum bias data: run 133046 (Nominal B-field) / run 133239 (B = 0 T)

gray – no data
- dead channels (marked with cross)
- suppressed due to the magnetic field

Castor shielding:

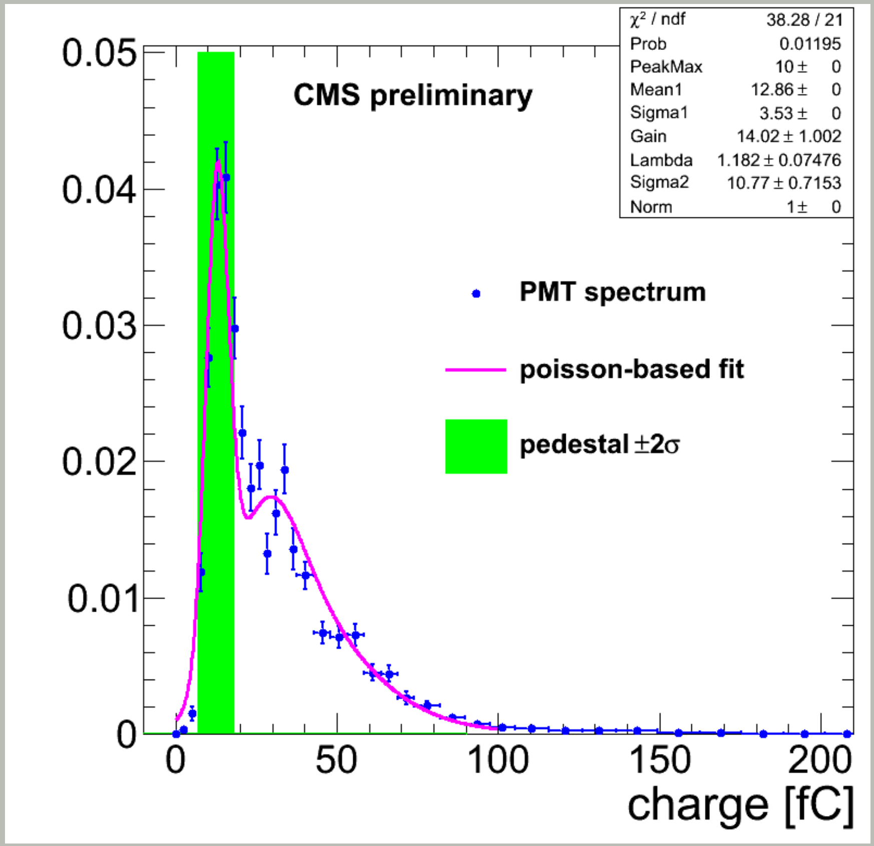


CASTOR intercalibration with halo muons:

- self-triggering during circulating, non-colliding beams
- trigger on an isolated penetrating particle
- offline selection:
  - isolated sector with at least N-3 modules with signal, N=f(φ) due to dead regions
  - to avoid bias: For each module in the sector: at least N-3 without this module
- Total statistics (2010, sept-nov): 2.3k-0.7k per sector (φ–dependent)
- Muon spectrum (example):
  - Low number of photoelectrons (1-4)
  - Average signal with mean of spectra
  - Mean from Poisson-based fit

    (simple approximation) as

    Poisson⊗Gauss (no tails)



- Fit and spectrum mean values are comparable => no long tails
- => muon showering is negligible

Intercalibration coefficents from halo muon runs:

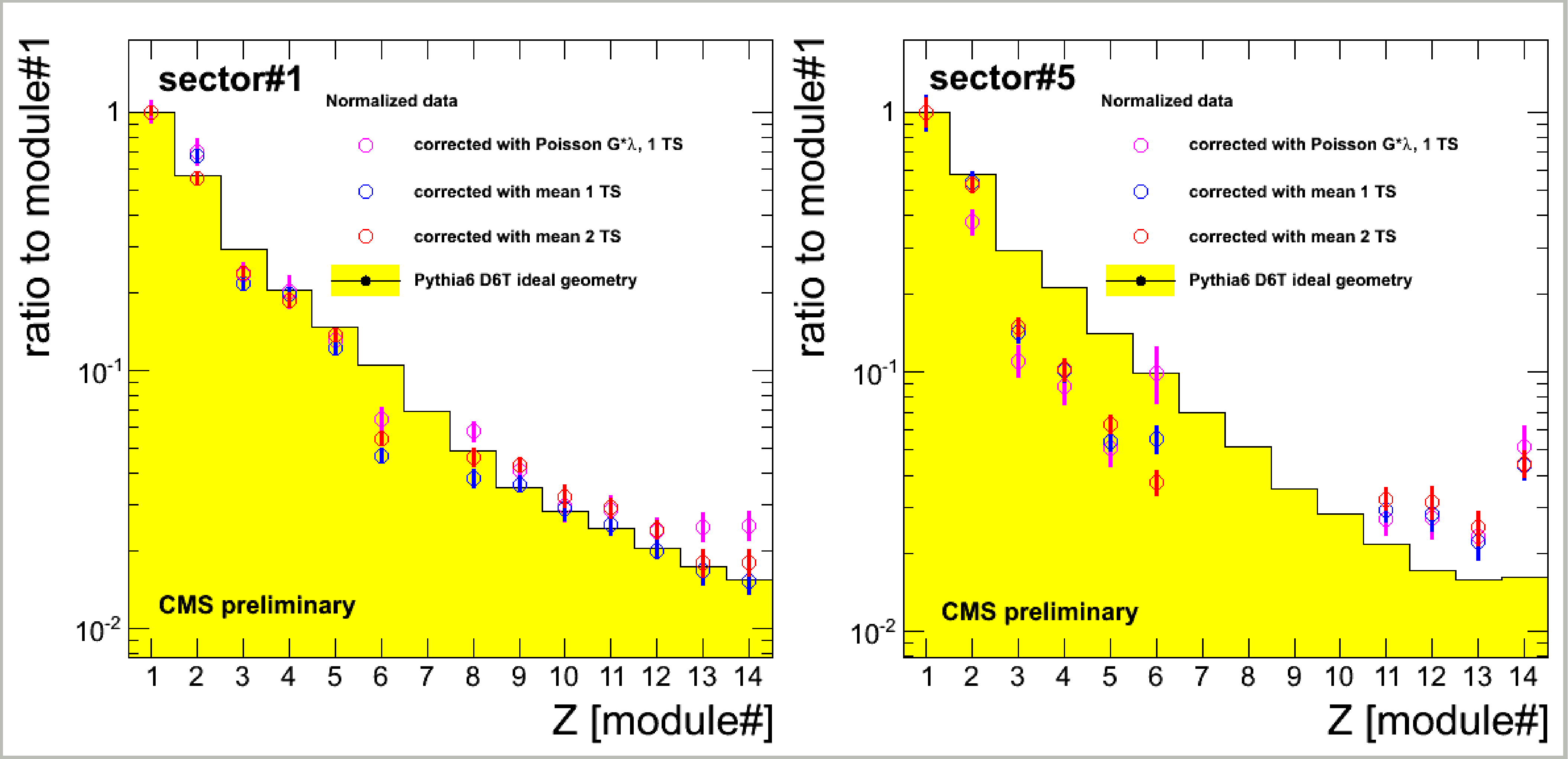
Minimum Bias data corrected with

mean from muon spectra fit (25ns integration = “1TS”)

mean from muon spectra (25ns integration = “1TS”)

mean from muon spectra (50ns integration = “2TS”) → **final choice**

compared to MC:



“SPLASH” run as a cross-check for halo muon results:

- **Beam 1 steered into collimator ~150 meters from CMS**
- **large amount of muons per one event**

- **φ-dependent => only longitudinal “intercalibration”**
- **small contribution from hadrons is possible**

  (larger signals in first CASTOR modules)

- **Still useful as qualitative cross-check for halo muon:**

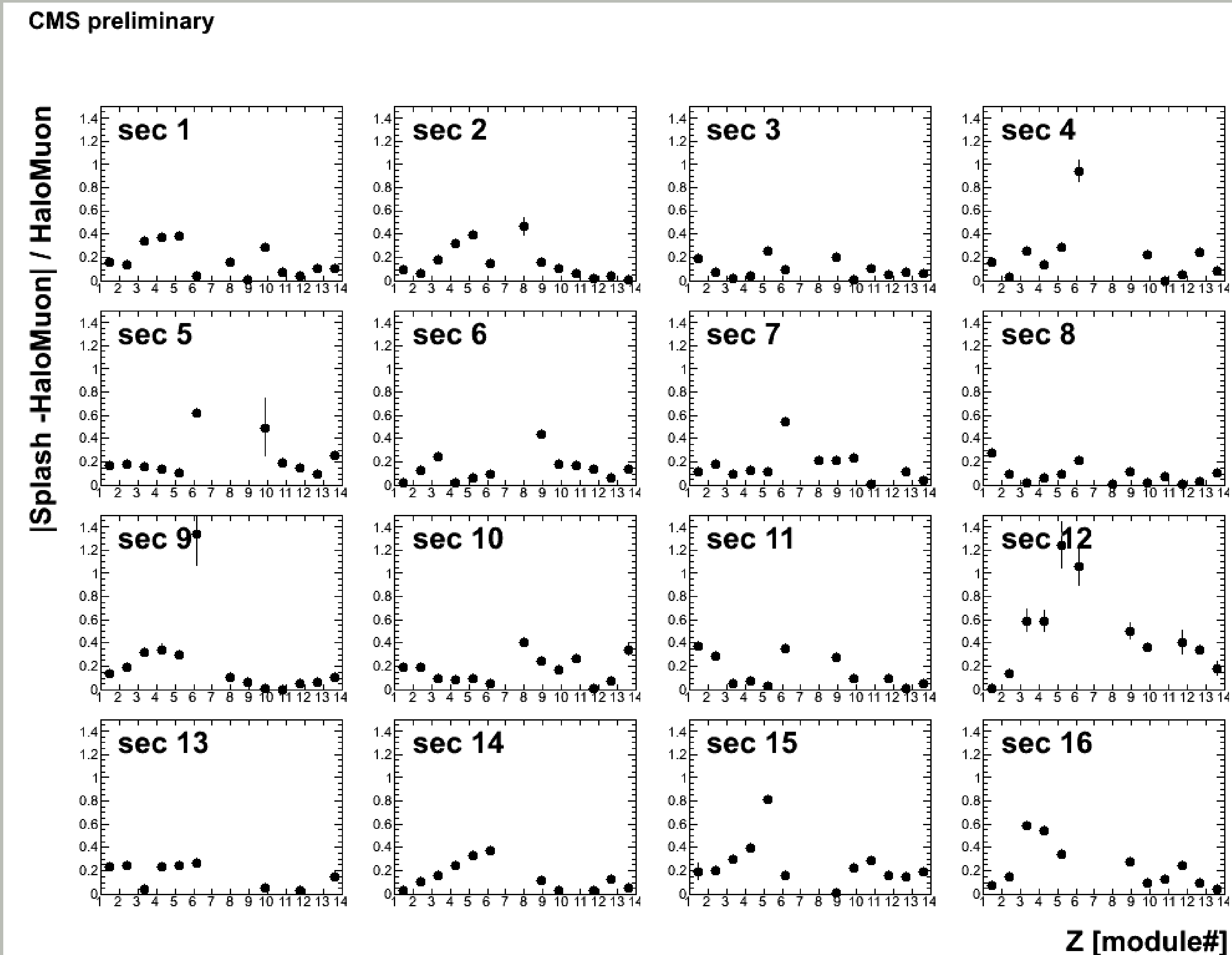
  Comparison of normalized mean signals -

  splash vs halo muon (sectorwise).

  The halo muon data are corrected for PMT gain difference in respect to the splash run.

- **Rough estimate of systematics for halo-muon mean signal values**

Rough estimate of the systematic errors |splash-HaloMuon|/HaloMuon



Intercalibration with muons for Minimum Bias data:

Minimum Bias data

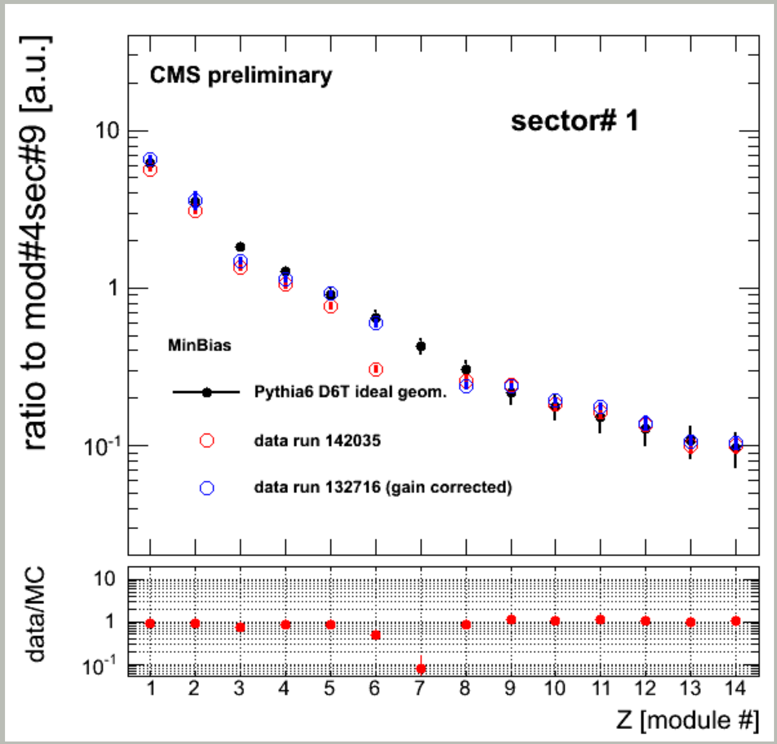
x

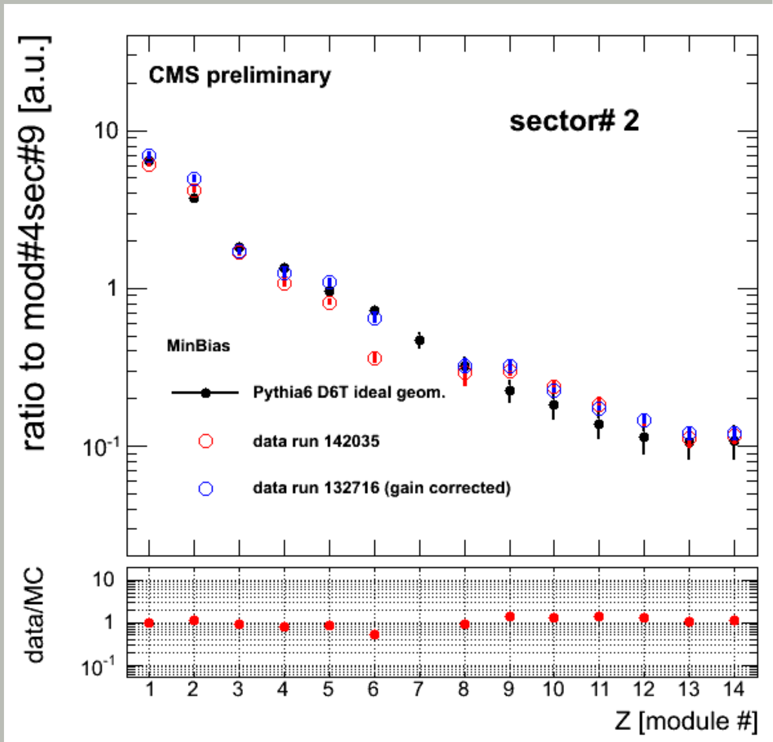
muon

intercalibration

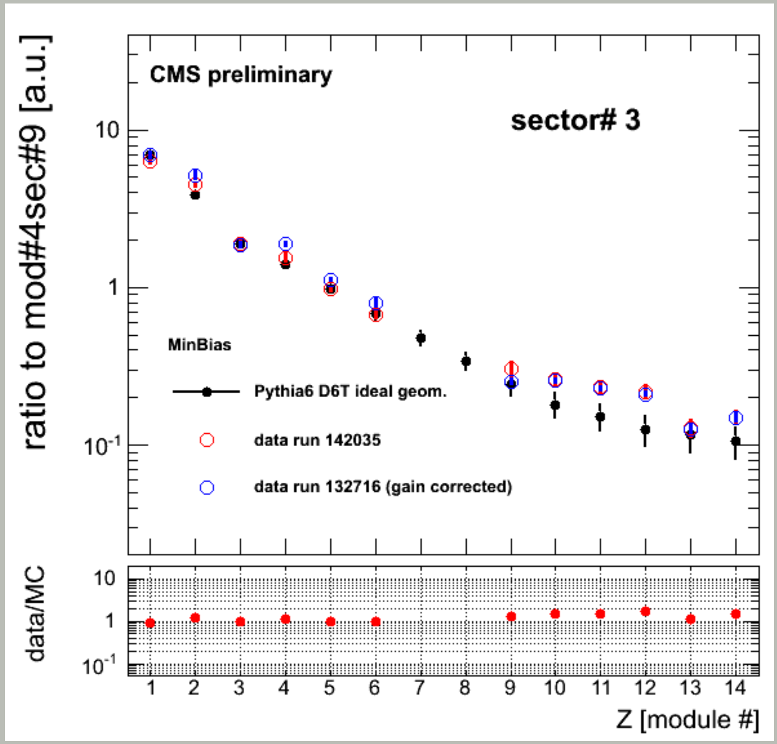
(in respect to

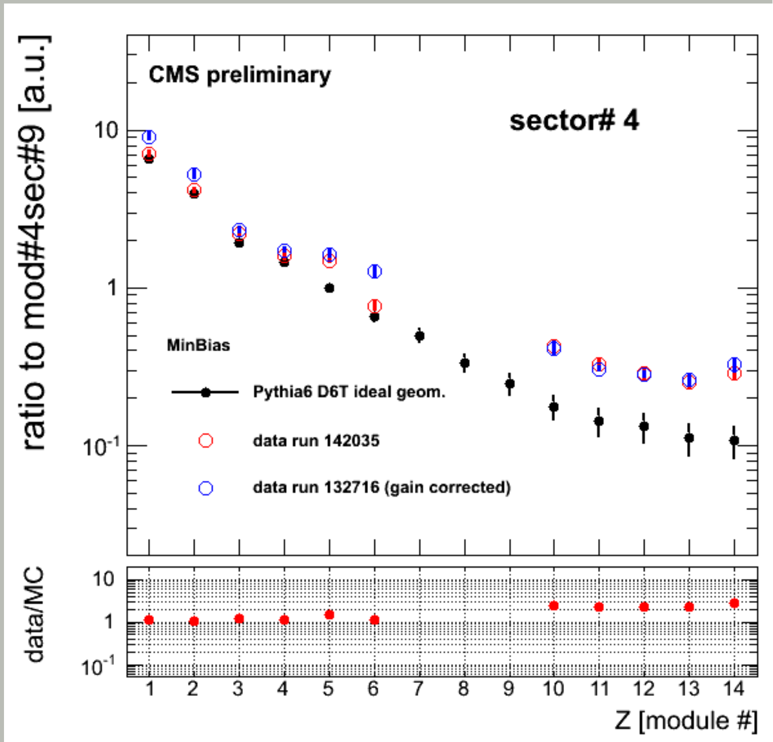
a fixed channel)



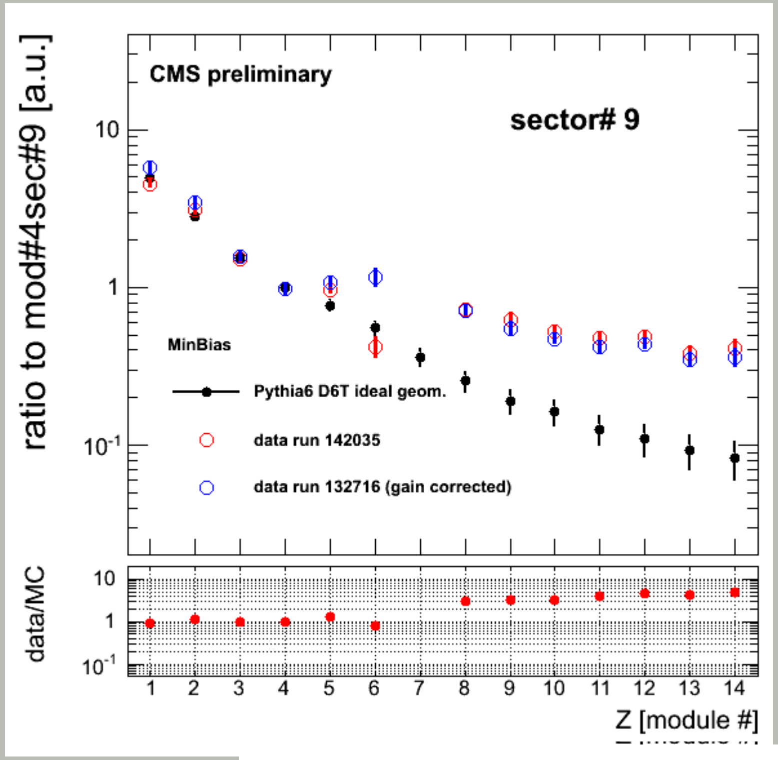


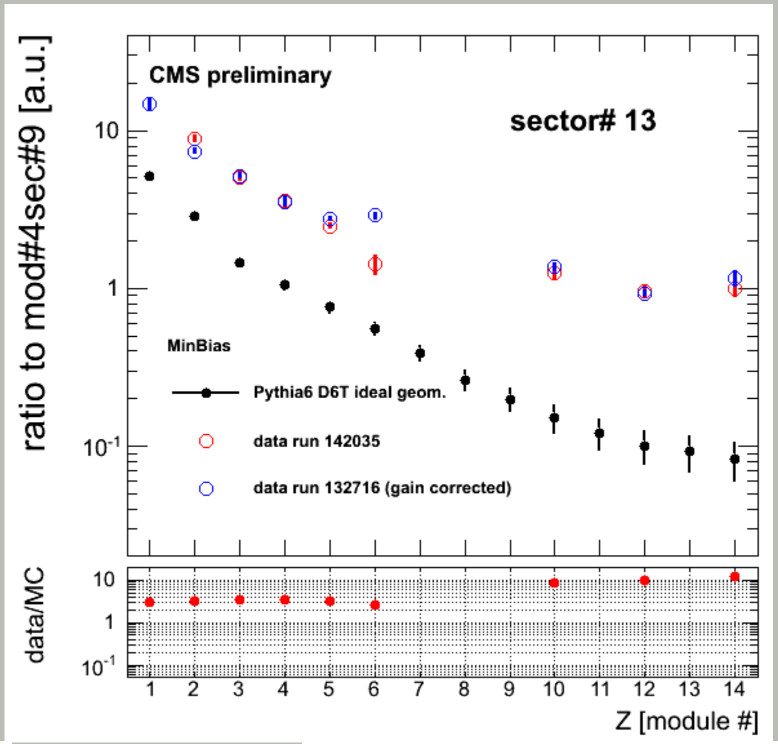
- Data taken with "muon" PMT gain
- Data taken with "physics" PMT gain with gain correction
- Monte Carlo (ideal CASTOR allignment)

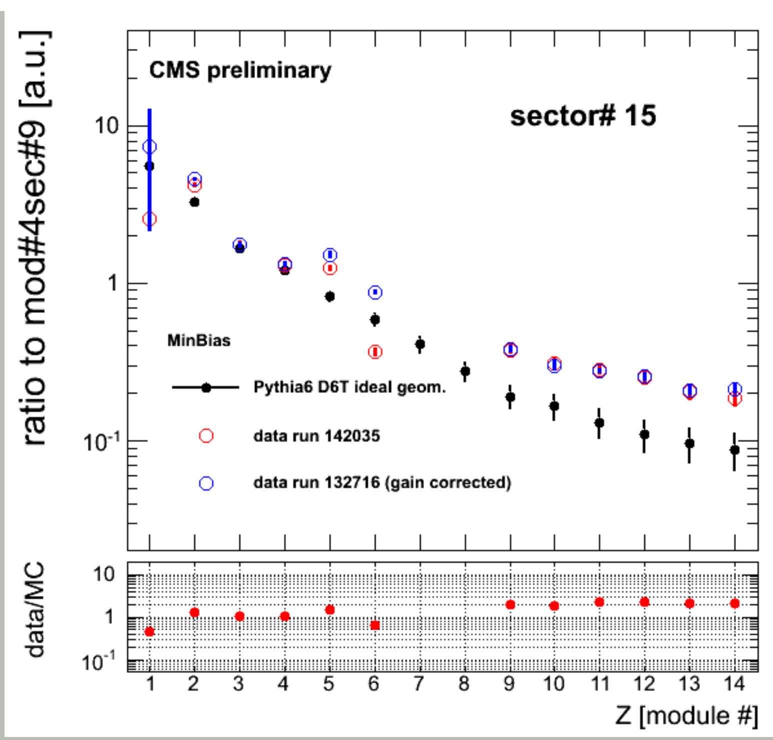


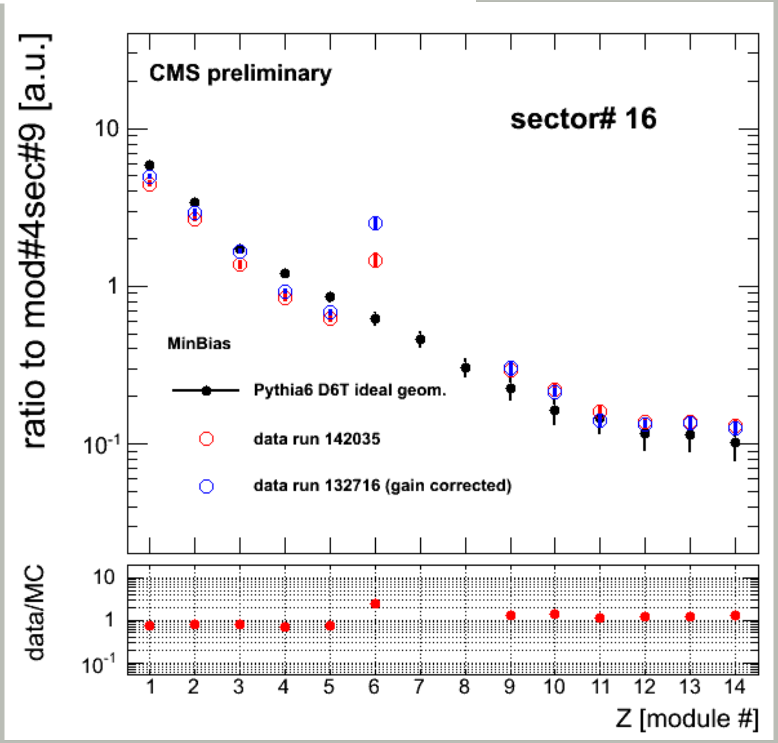


Intercalibration with muons for Minimum Bias data:



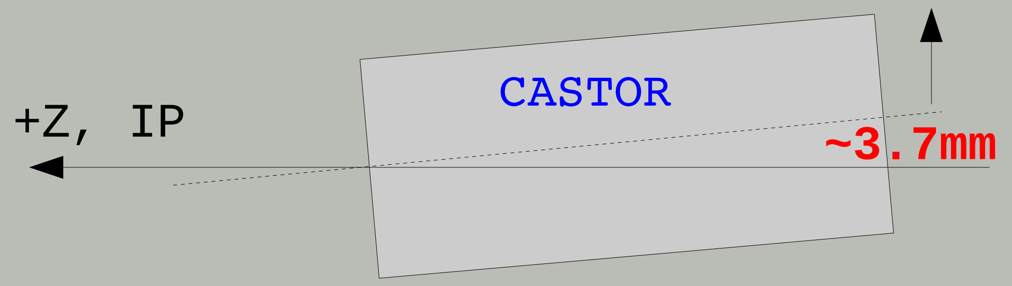






Discrepancy to MC:

? not perfectly aligned CASTOR ?



Influence of CASTOR position on MinBias data:

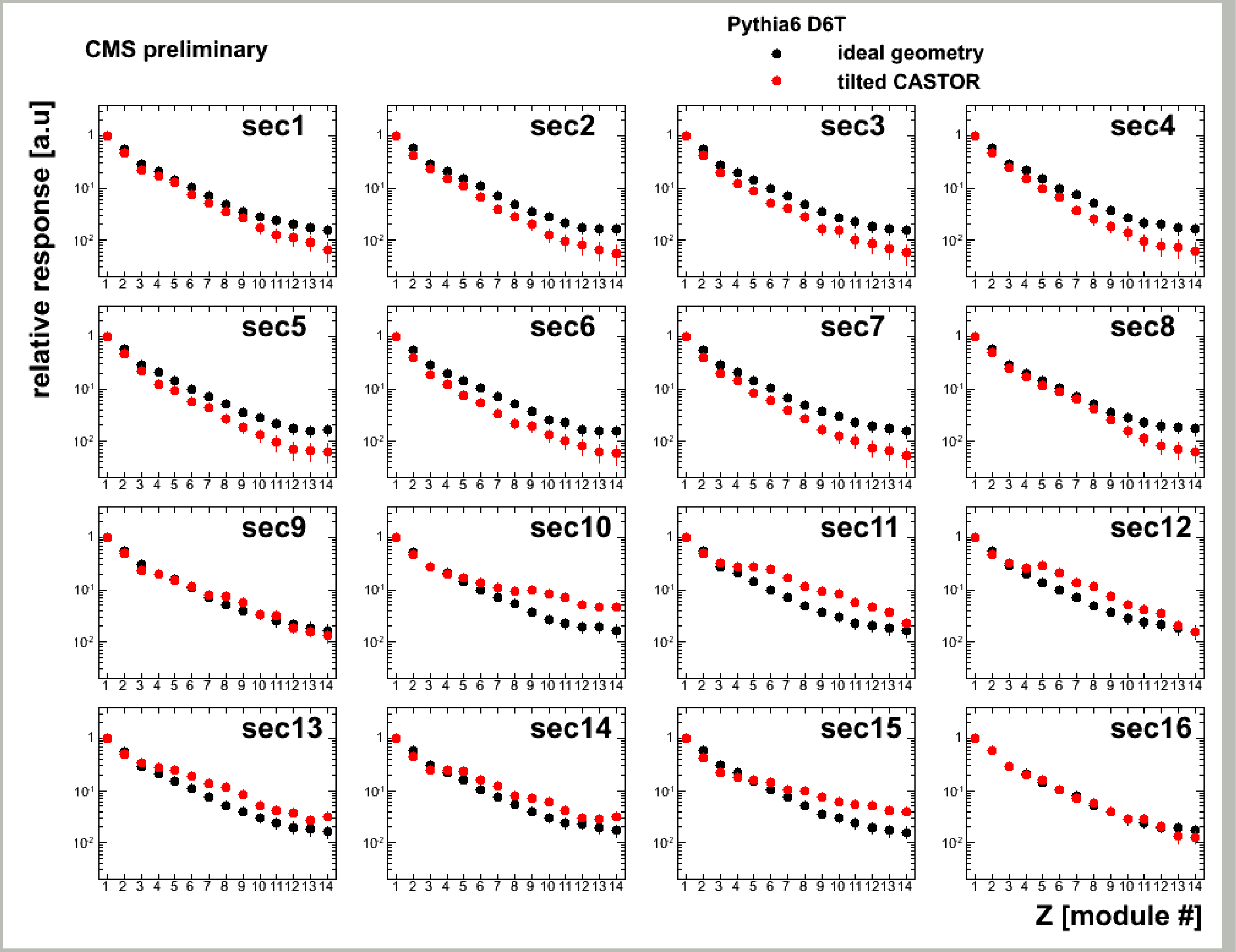
Monte-Carlo study:

rough tilt

(y direction only)

vs

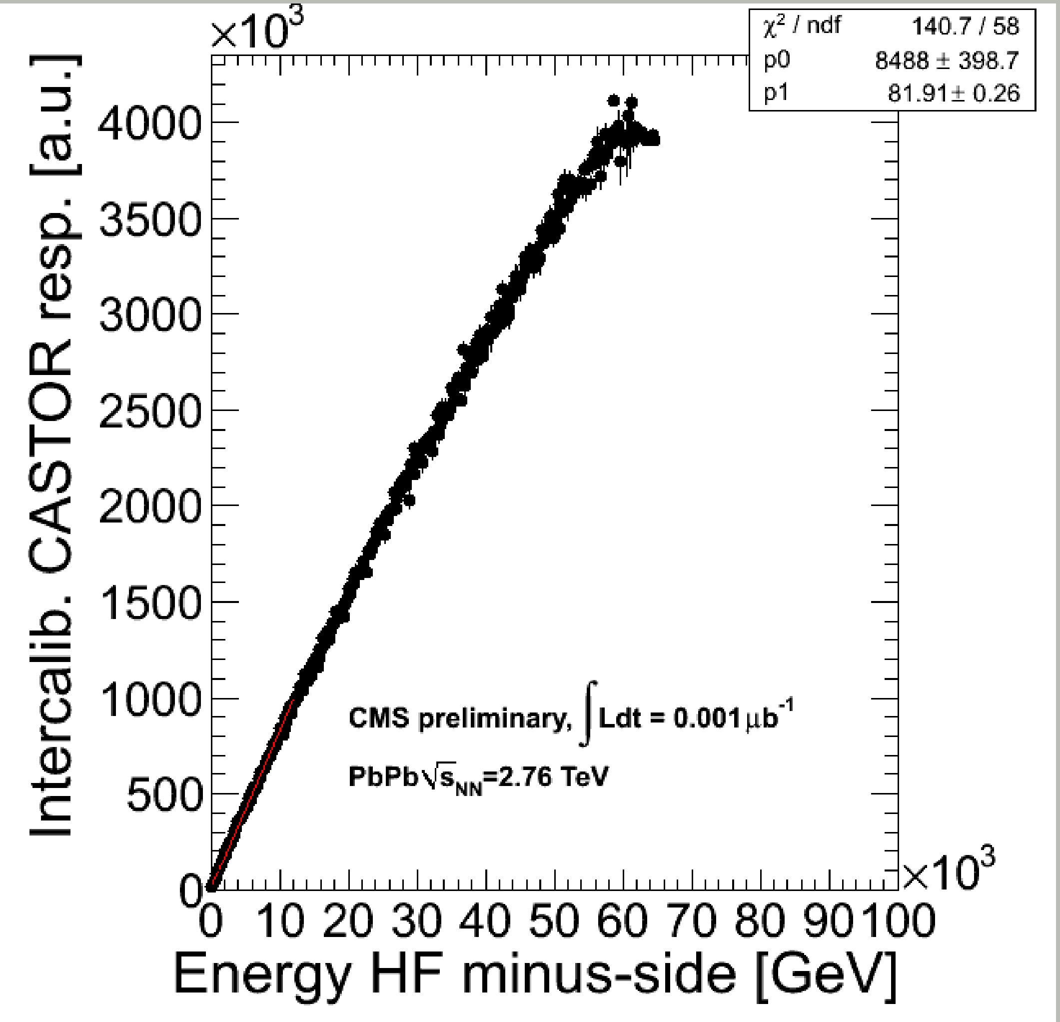
nominal position



=>

realistic CASTOR position to be implemented in MC

Performance at Heavy Ion collisions (Minimum Bias):

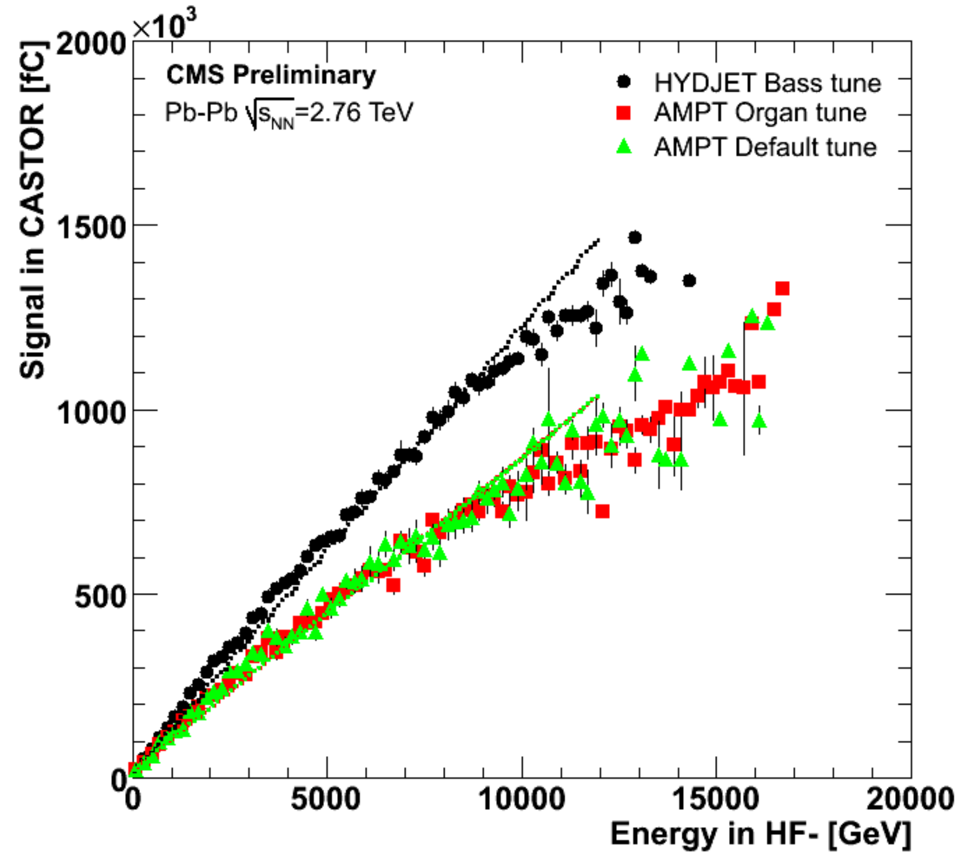


total CASTOR response

vs HF-minus enegry

<= HI data 2010

Monte-Carlo study:

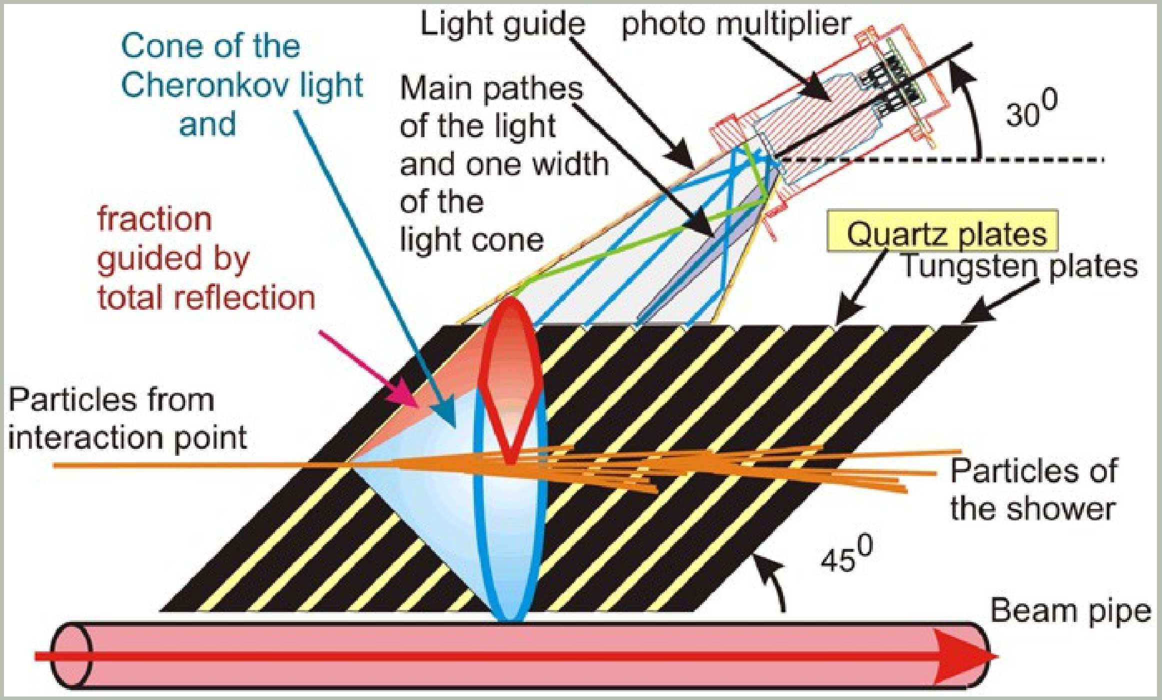


CONCLUSION

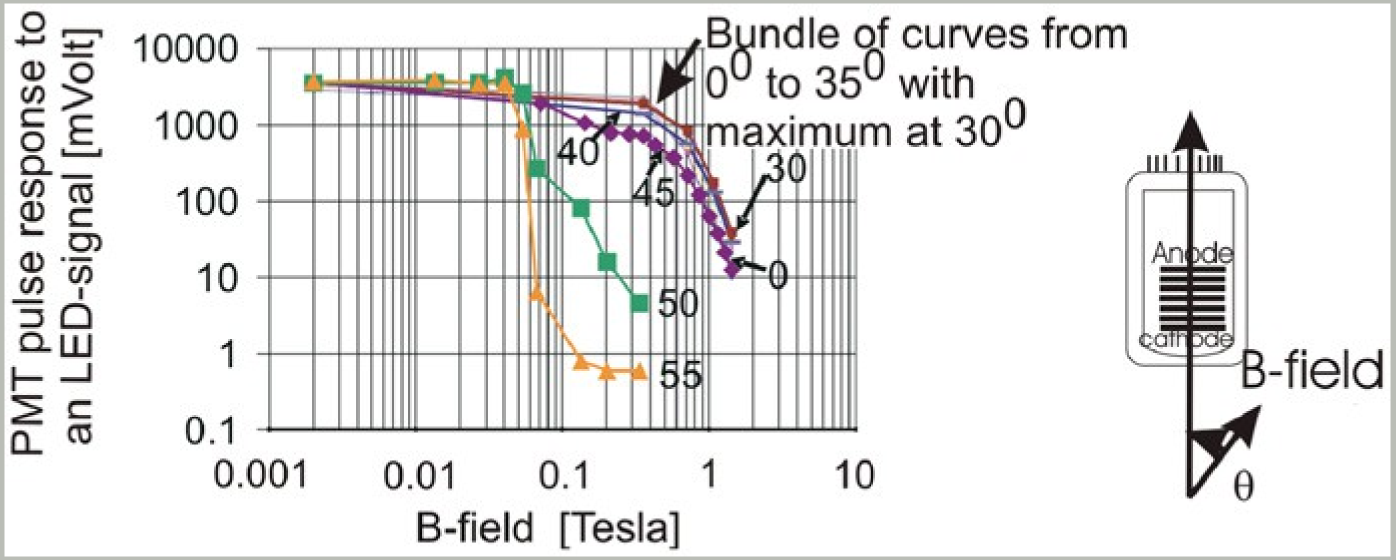
- CASTOR calorimeter has been designed, studied in beam tests, installed, commissioned and fully integrated into CMS in a record time. Detector took good quality pp-data at centre-of-mass energies 900, 2360 and 7000 GeV, heavy-ion data at 2.76 TeV per nucleon pair.
- Due to the location in the very forward region and nonuniform magnetic field, CASTOR calibration is challenging.
- Intercalibration with halo muons is the first step towards a full calibration of CASTOR.
- CASTOR response to halo muons also provides valuable input to understanding of the calorimeter performance.
- Further calibration studies are ongoing.

BCKUP

CASTOR construction

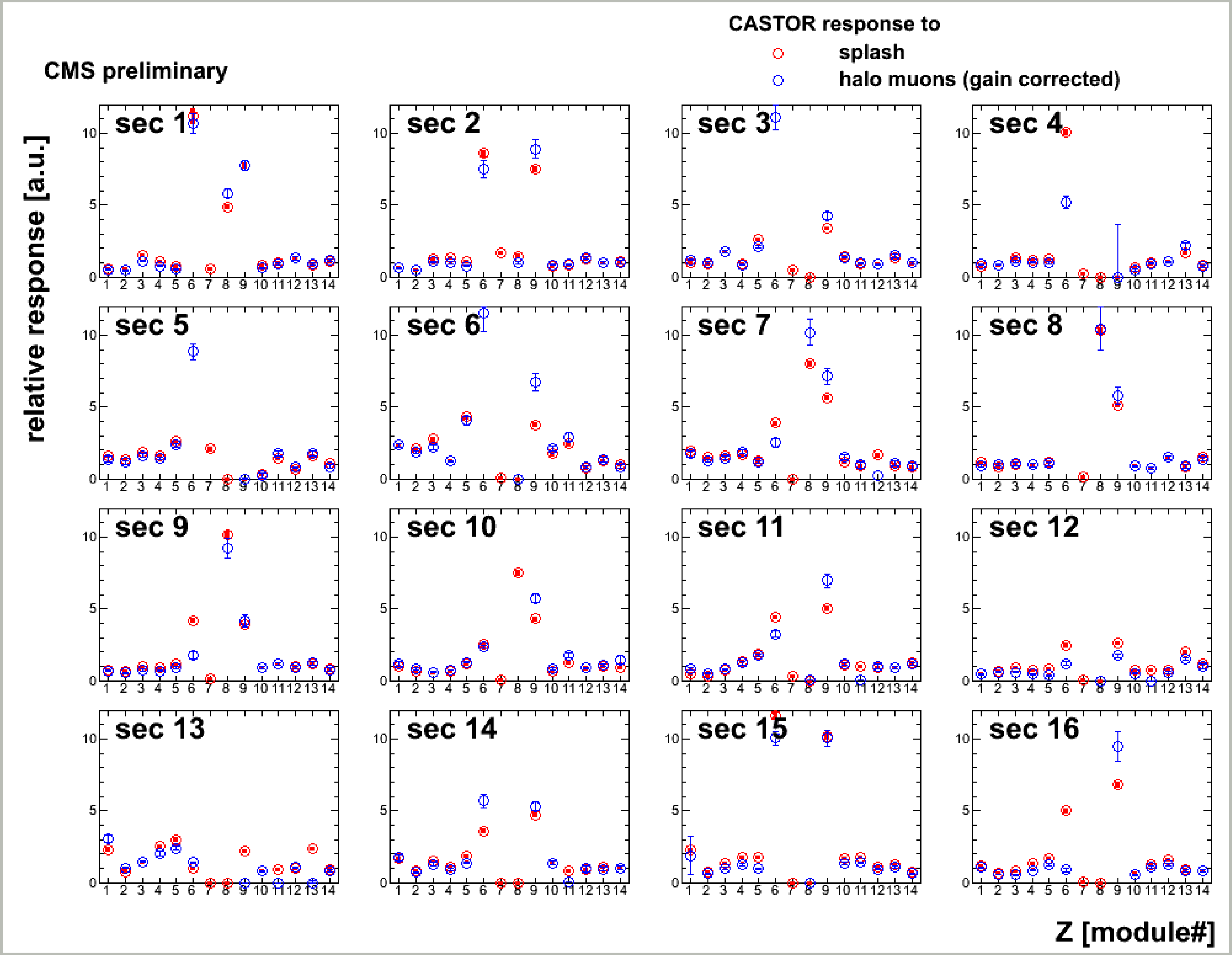


R5505 performance under magnetic field

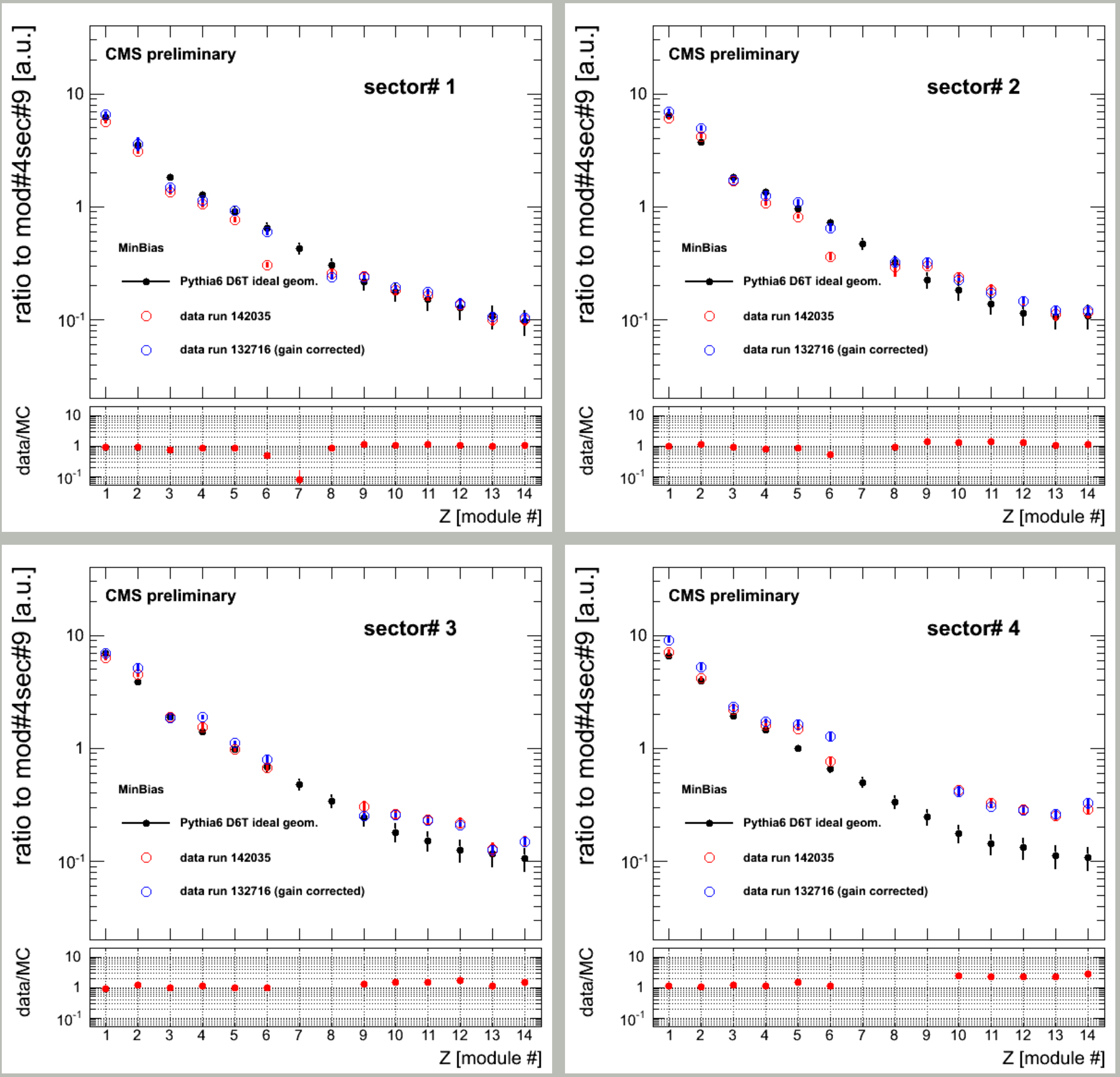


splash 2011 vs muons corrected for gain

(sectorwise, normalized to weighted mean of rear modules (10-14)):



Intercalibration with muon data:



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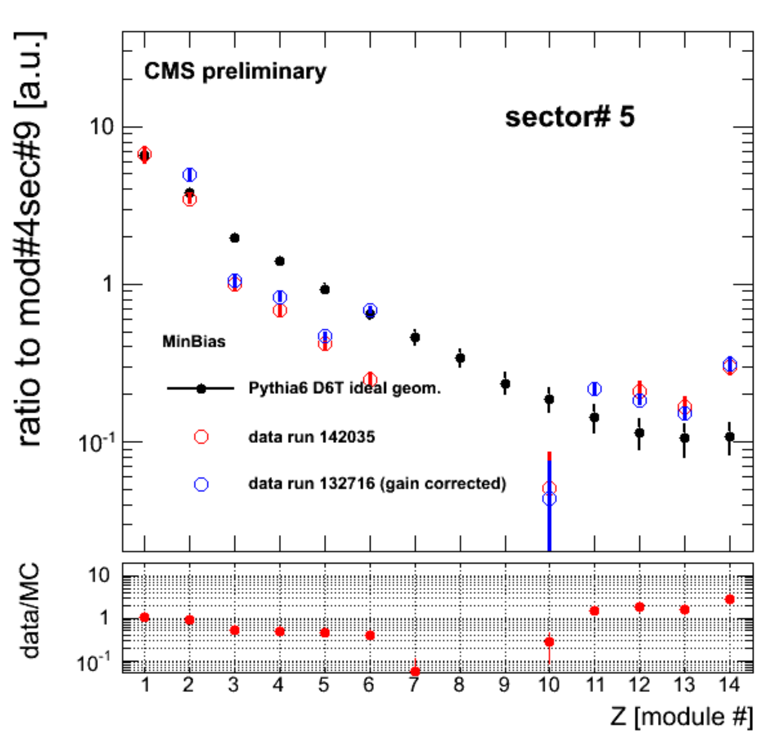

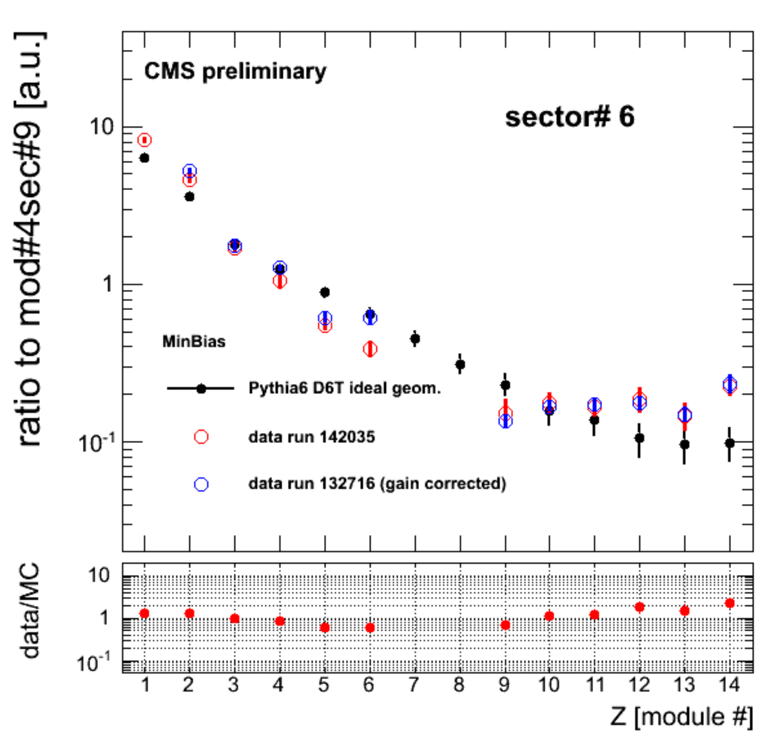

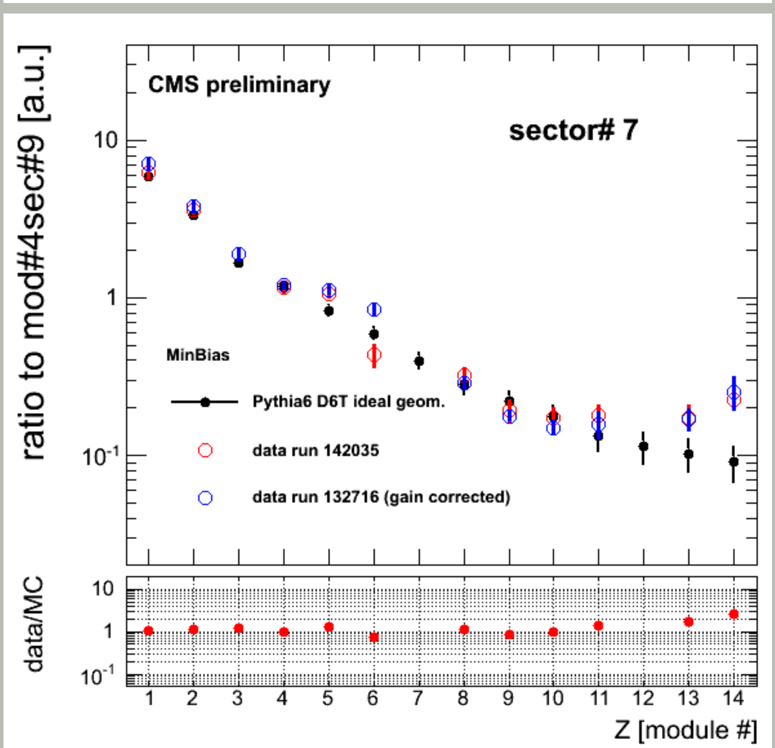

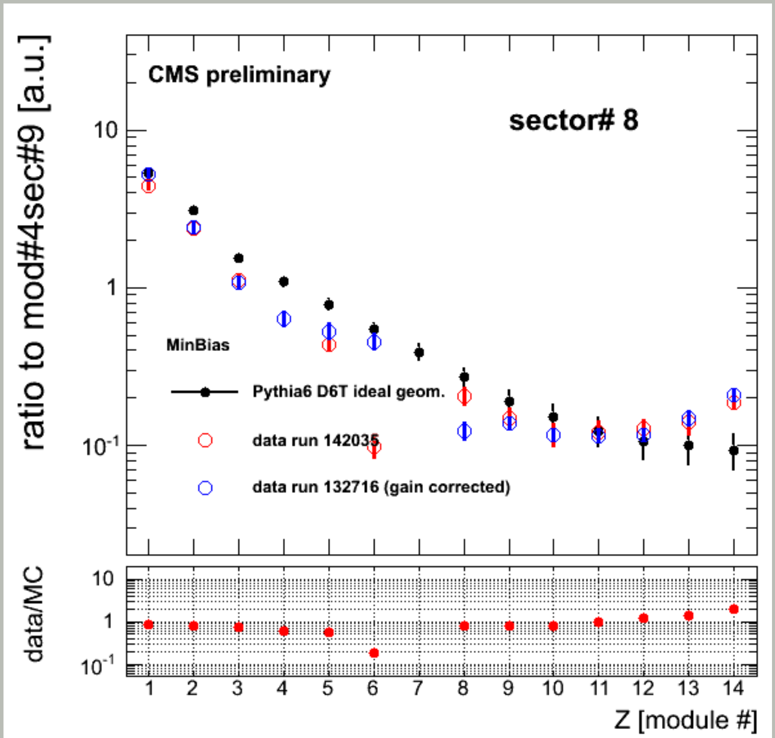

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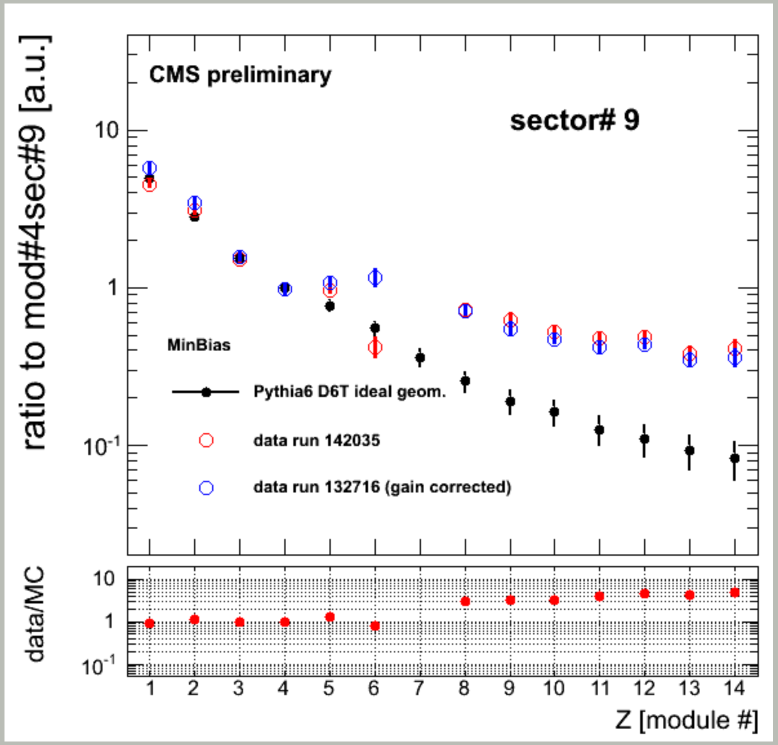

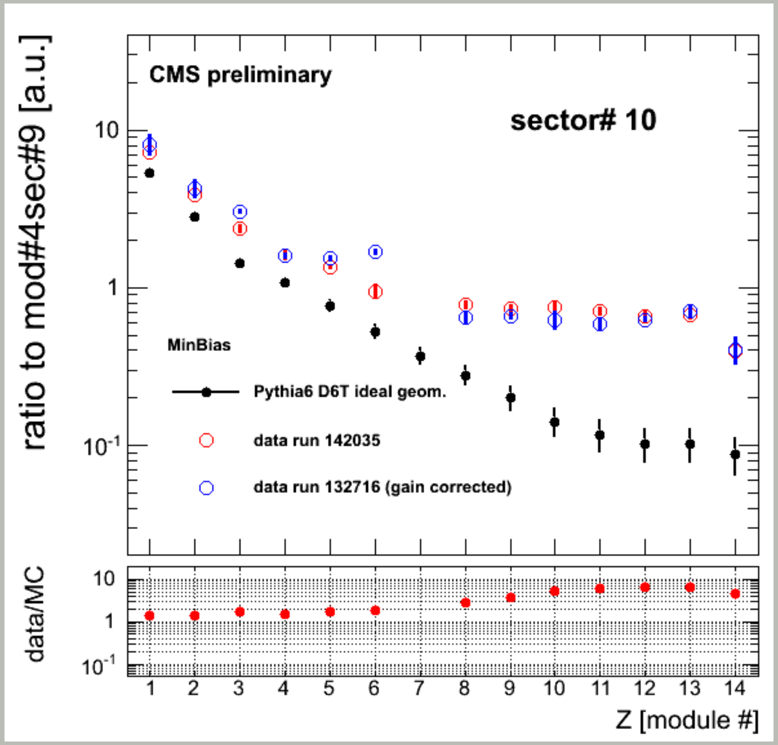

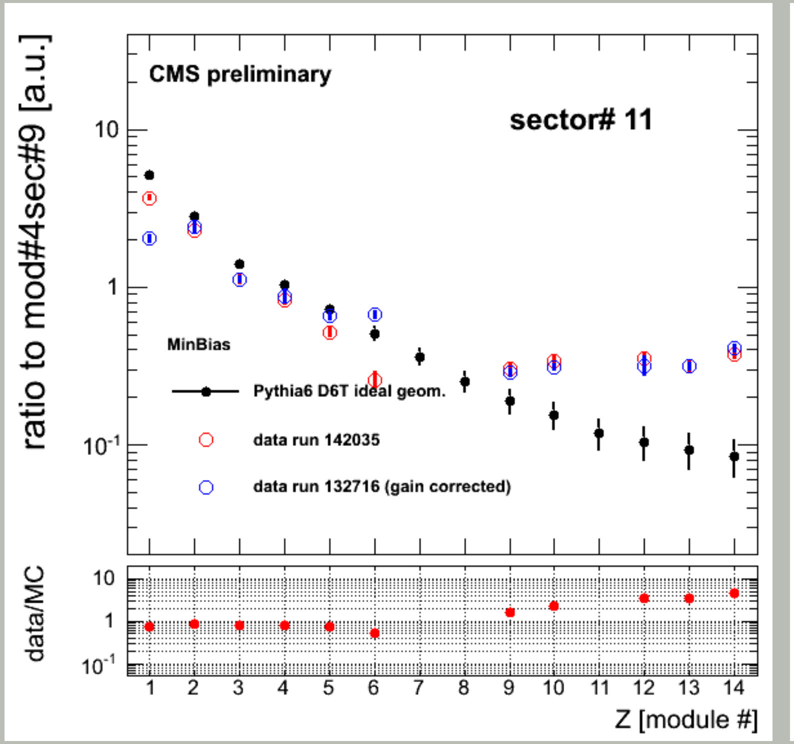

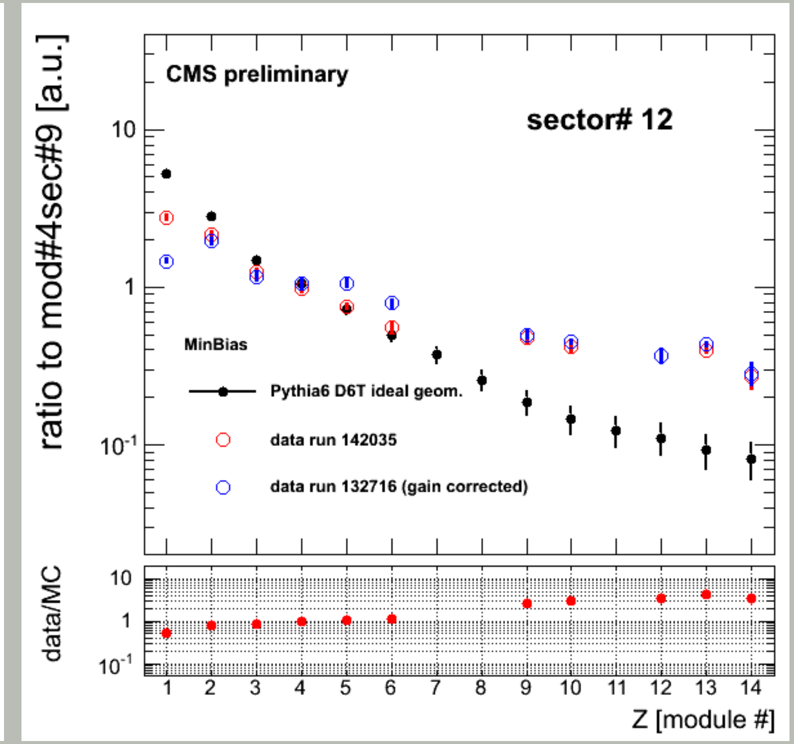

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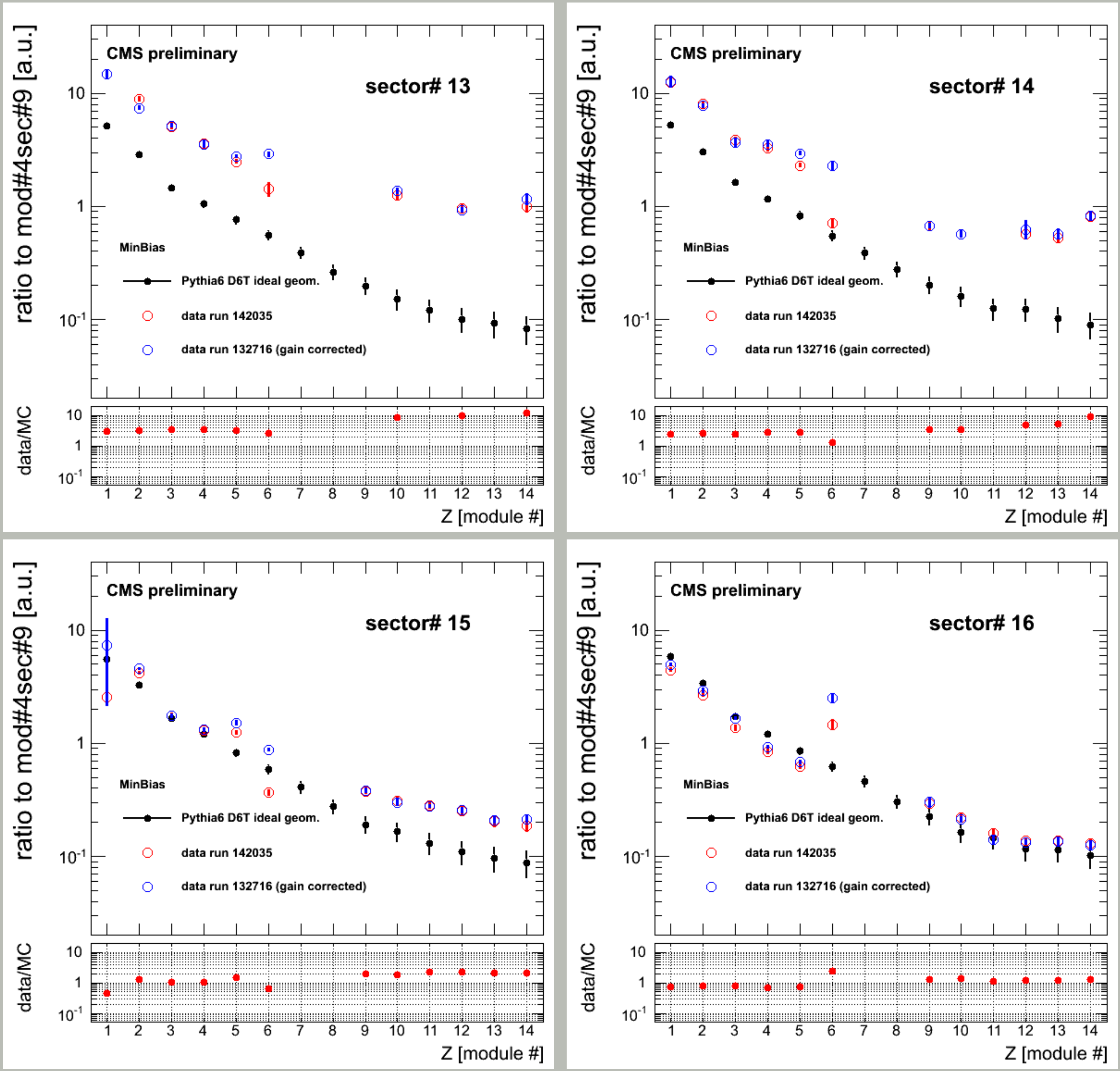

Performance at HI :