Preliminary

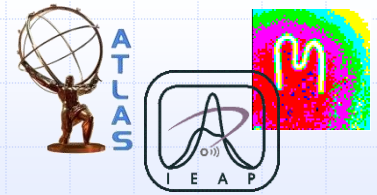# Luminosity Monitoring in ATLAS with MPX Detectors

André Sopczak (IEAP CTU in Prague)

on behalf of the ATLAS and Medipix2 Collaborations
ATLAS conference note ATLAS-CONF-2013-103

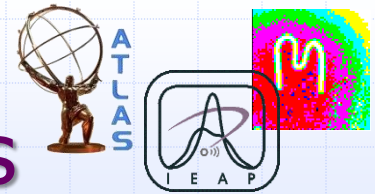**13th Topical Seminar on Innovative Particle and Radiation Detectors (IPRD13) Siena, Italy**
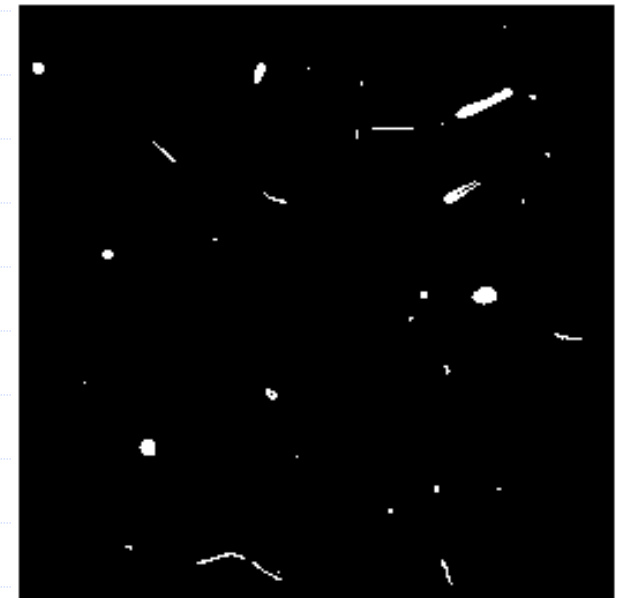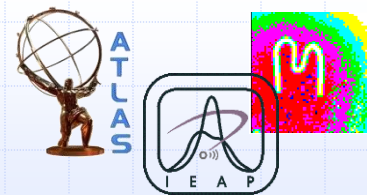
9 October 2013

Outline

- Introduction

- Luminosity from Hit Counting

- Luminosity from Thermal Neutron Counting

- van der Meer Scans

- Conclusions

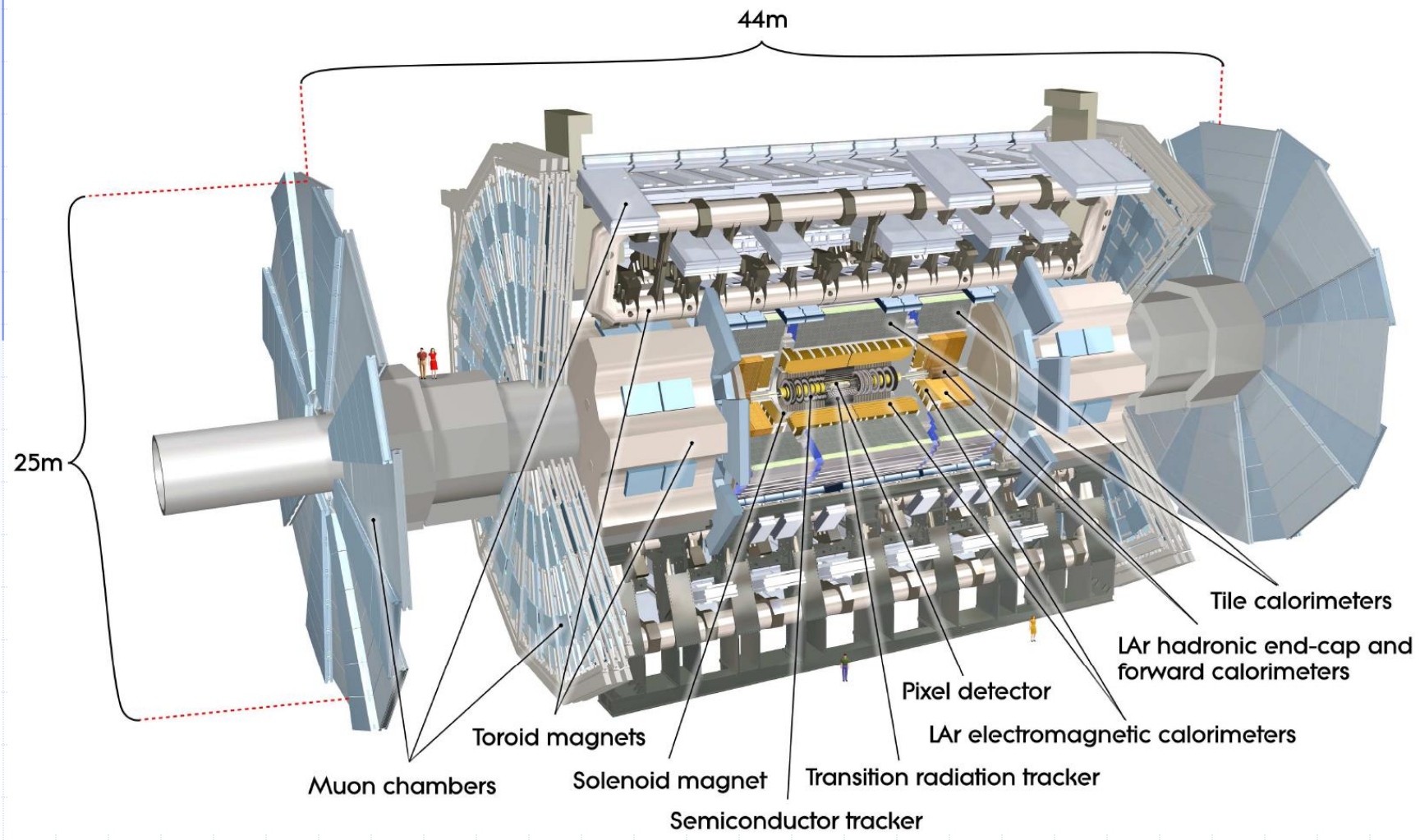# Focus on MPX network 2012 data from 8 TeV proton-proton collisions

- 16 Medipix2 (MPX) pixel detectors operating in ATLAS from 2008 to Feb. 2013, acquisition time 0.1ms-600s.

- For luminosity measurements usage as 65536 (256x256) independent counting detectors.

- Measure the particle fluxes originating from the LHC proton-proton collisions.
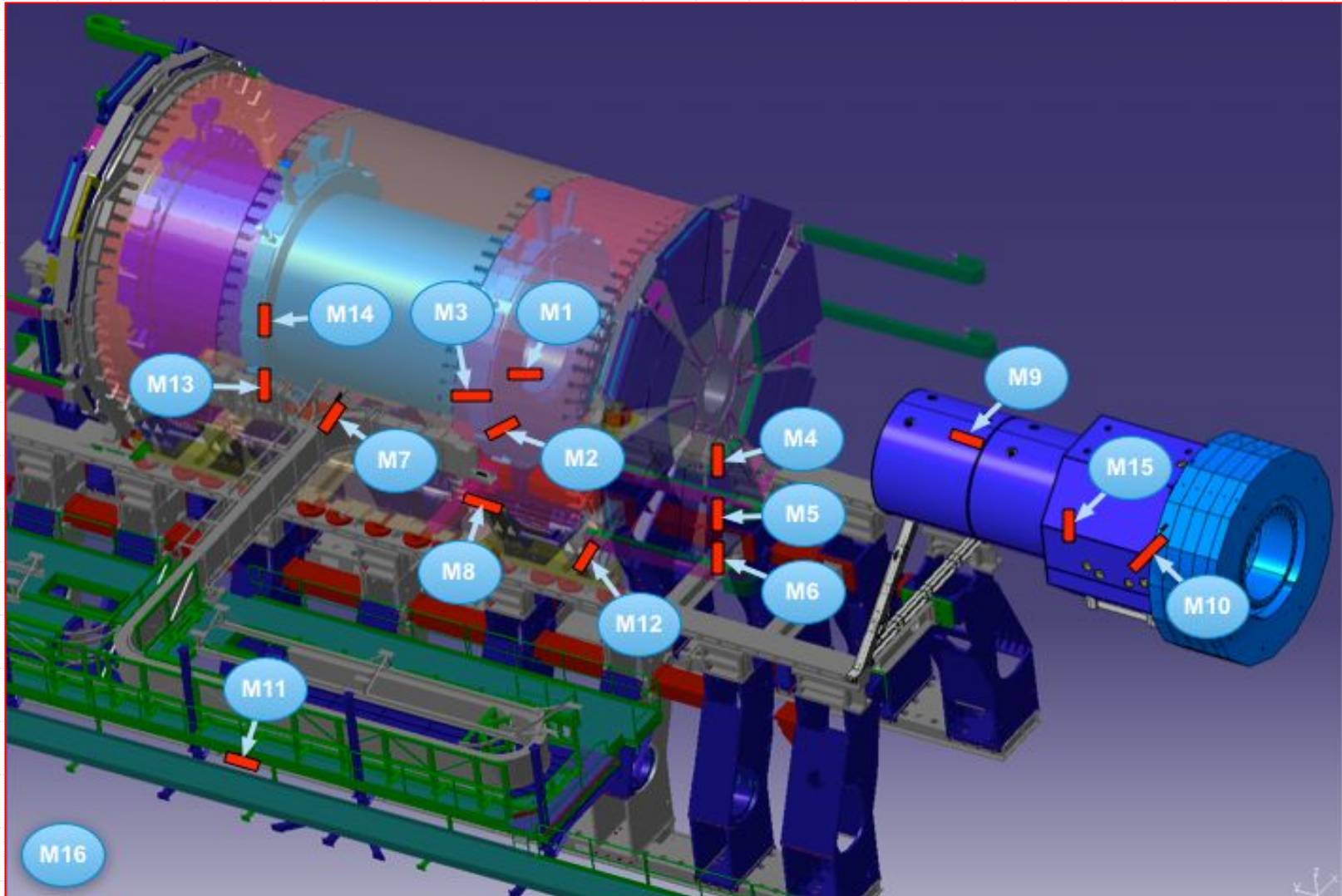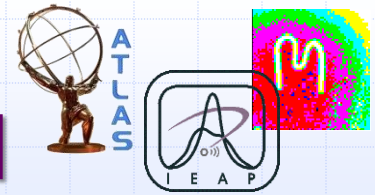
The ATLAS detector

44m

25m

Tile calorimeters

LAr hadronic end-cap and forward calorimeters

Pixel detector

LAr electromagnetic calorimeters

Toroid magnets

Solenoid magnet

Transition radiation tracker

Muon chambers

Semiconductor tracker

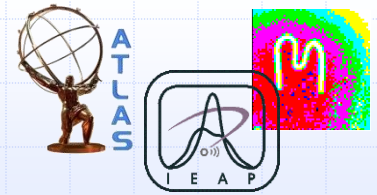# MPX detectors for luminosity determination: MPX01-MPX13 used

MPX locations and particle (cluster) fluences in the ATLAS detector
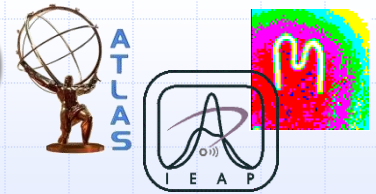
| Device	Z [m]	R [m]	Measured MPX clusters per sensor area and per unit luminosity [cm^{-2}/nb^{-1}]	Used for neutron counting
MPX01	3.42	0.77	55000	No
MPX13	−3.42	2.44	380	No
MPX02	3.42	2.50	230	No
MPX03	2.94	3.57	31	No
MPX06	7.20	3.36	20	Yes
MPX05	7.20	2.36	47	No
MPX08	4.02	4.40	1.2	Yes
MPX07	0.35	4.59	0.45	Yes
MPX04	7.12	1.30	110	No
MPX09	15.39	1.56	5.8	Yes
MPX12	7.23	6.25	3.9	Yes
MPX10	22.88	5.19	1.0	Yes
MPX11	4.86	16.69	0.30	Yes

Institute of Experimental and Applied Physics Czech Technical University in Prague

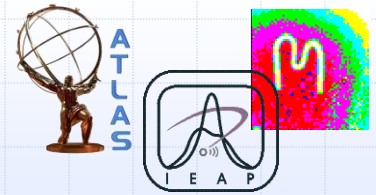# Method of luminosity monitoring with hit counting

- Measure number of counts by 13 independent MPX devices during collision periods.

- Apply three different methods to remove noisy pixels from the hit counting.

- Normalize MPX hit rate/luminosity with the ATLAS BCM luminosity detector for the data taking on 21 May 2012.

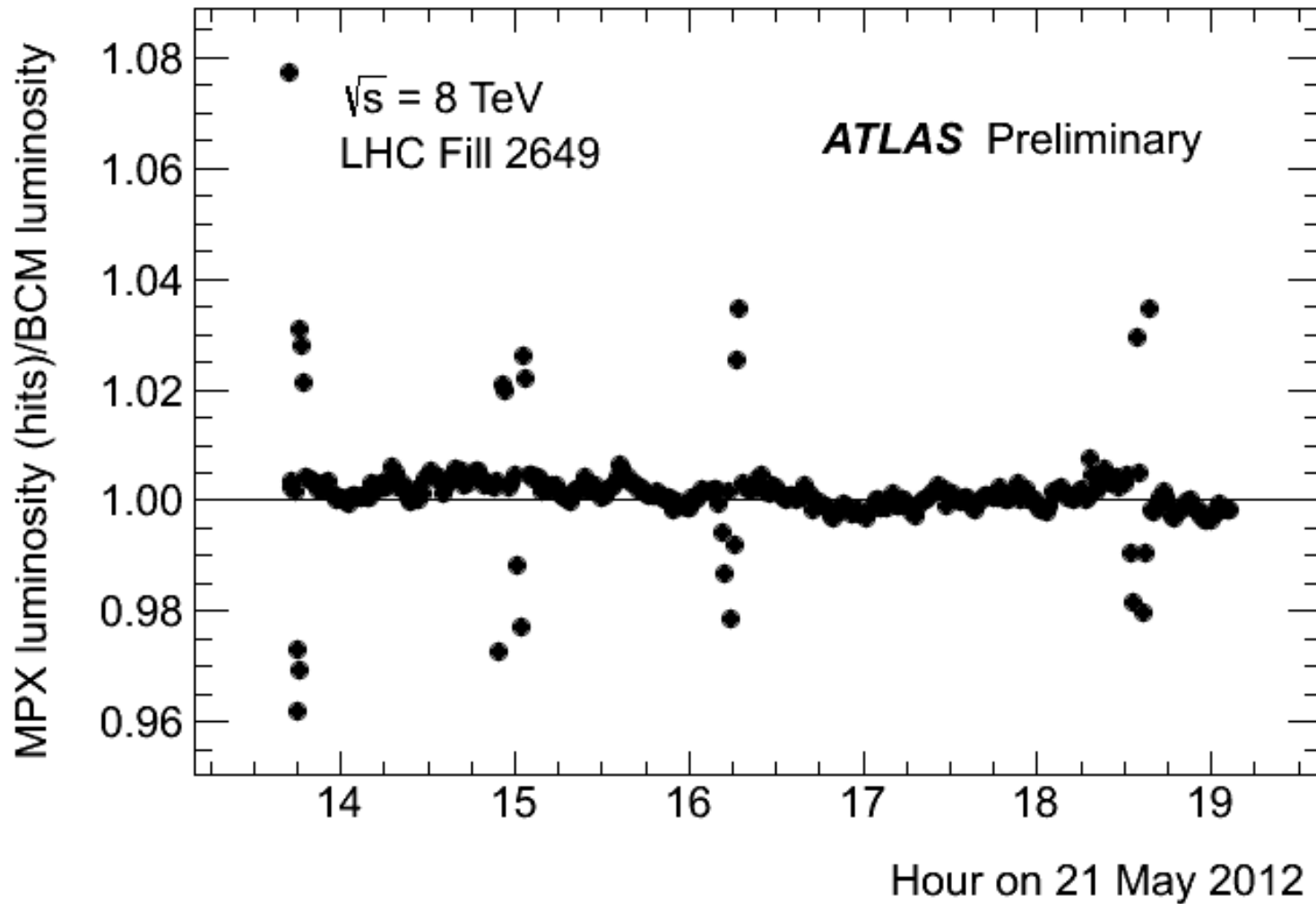- Study the MPX/BCM luminosity ratio as a function of time for all 2012 data.
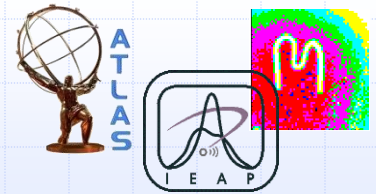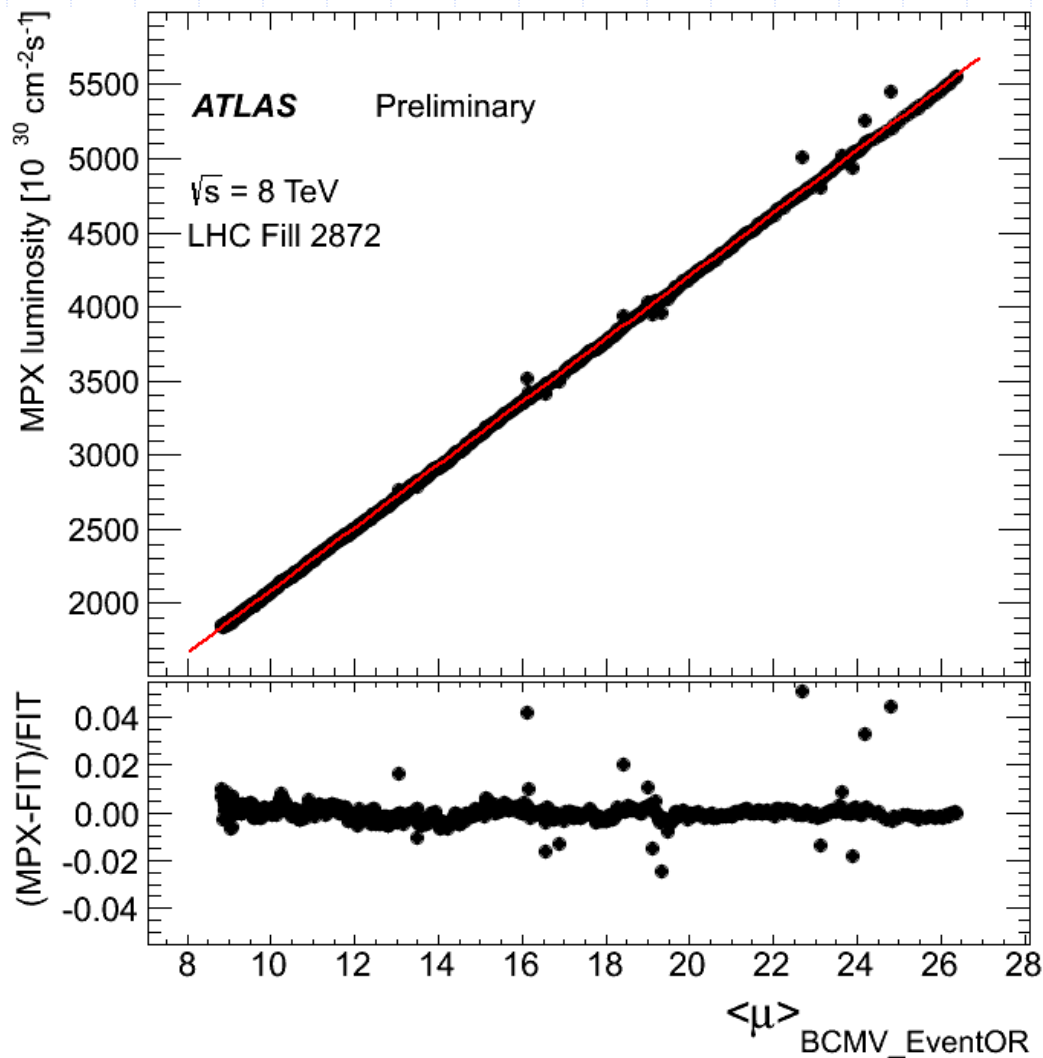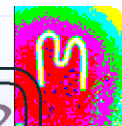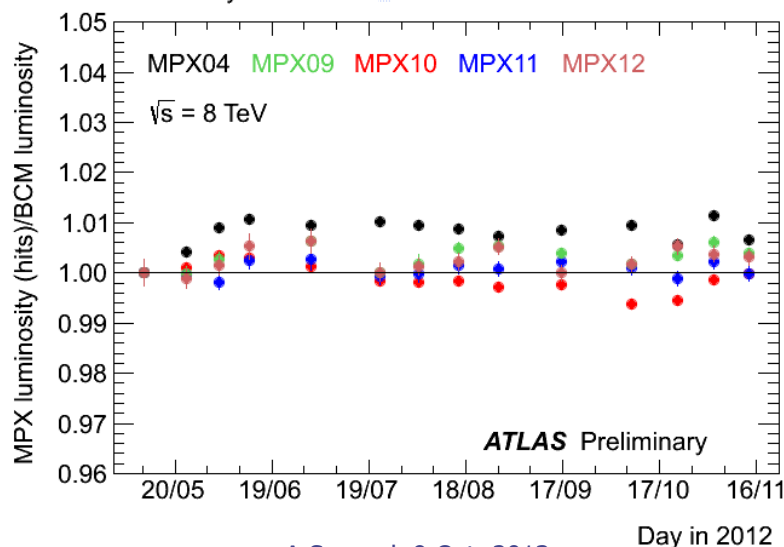
MPX luminosity

MPX/BCM luminosity ratio

√s = 8 TeV
LHC Fill 2649

ATLAS Preliminary

MPX luminosity (hits)/BCM luminosity

Hour on 21 May 2012
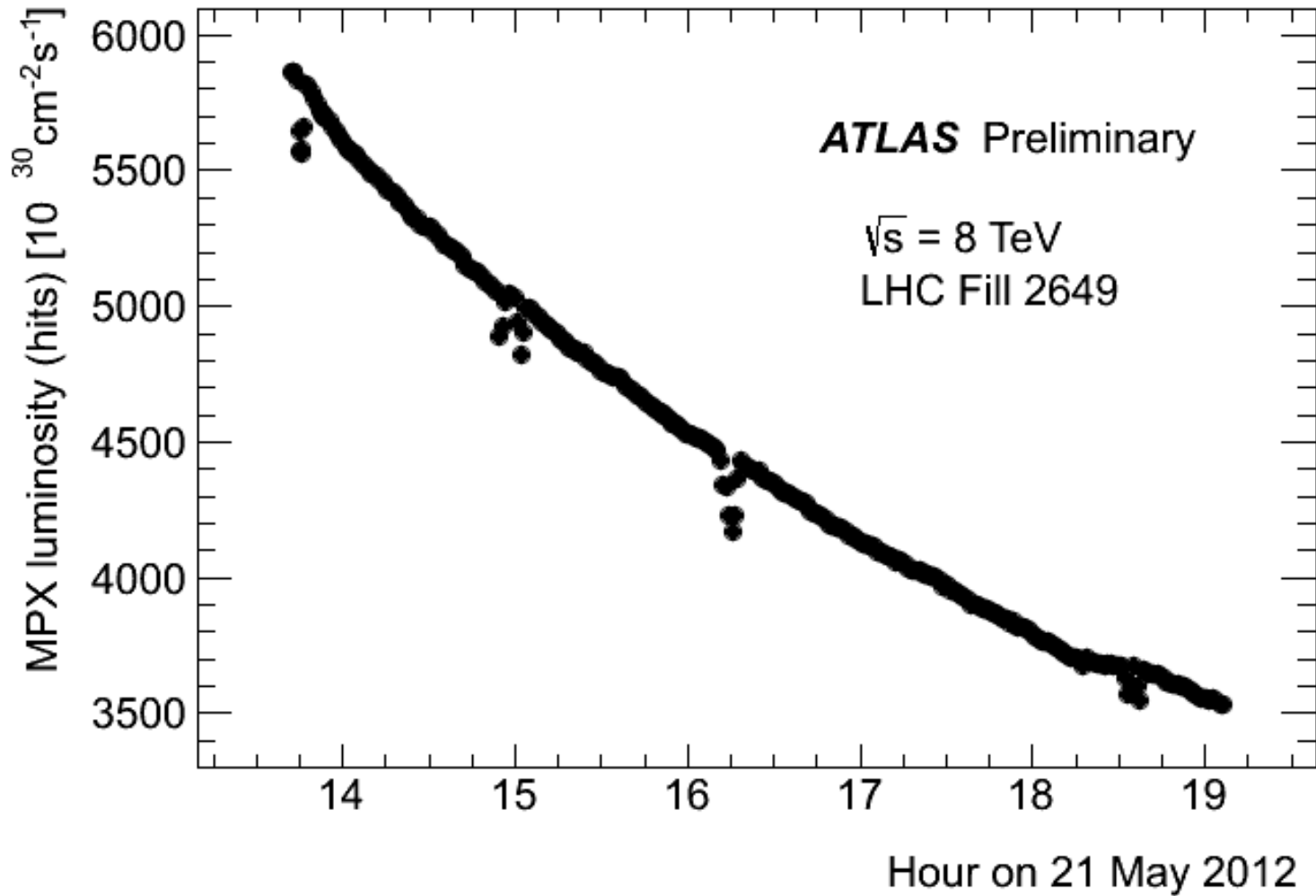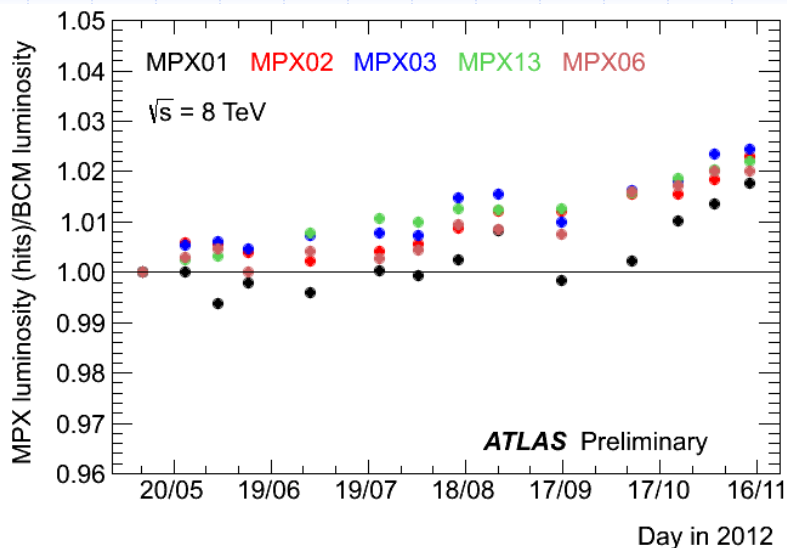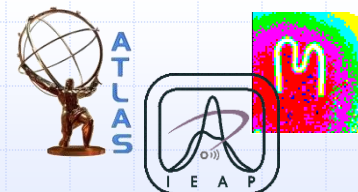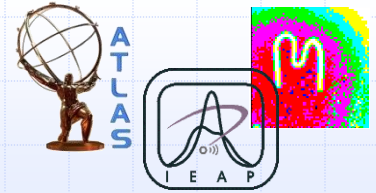
MPX01 hit luminosity vs. bunch-averaged interactions per crossing
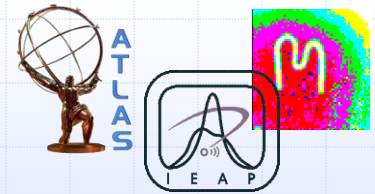
Fractional deviation in luminosity (hit counting mode)
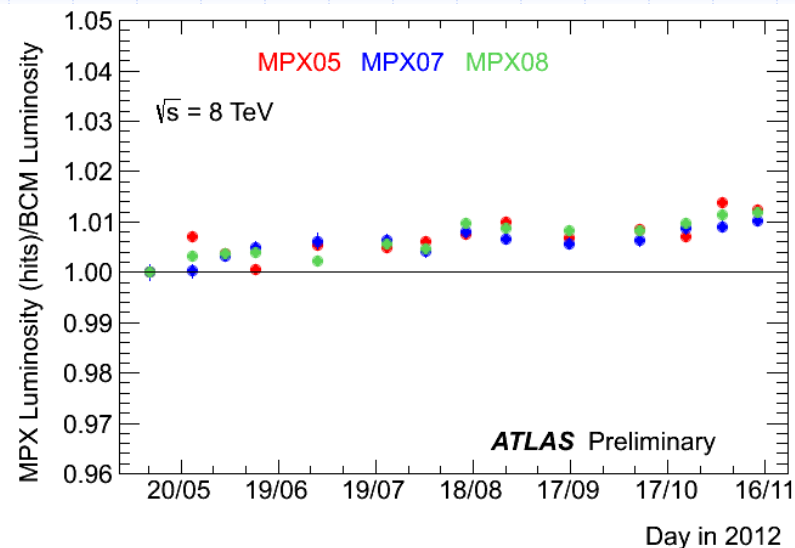
$$\frac{L_{MPX}}{L_{BCM}}$$

# Method of luminosity monitoring with thermal neutron counting

- Thermal neutrons detected by MPX devices via $^6Li(n,\alpha)^3H$ reactions in a ^6LiF converter layer.

- Resulting tritons and alpha particles are registered as "heavy blobs" (large round-shaped pixel clusters).

- Typical detection efficiency of thermal neutrons 1%.

- Normalize MPX thermal neutron rate/luminosity with the BCM ATLAS luminosity detector for the data taking on 21 May 2012.

- Study the MPX/BCM luminosity ratio as a function of time for 2012 data.
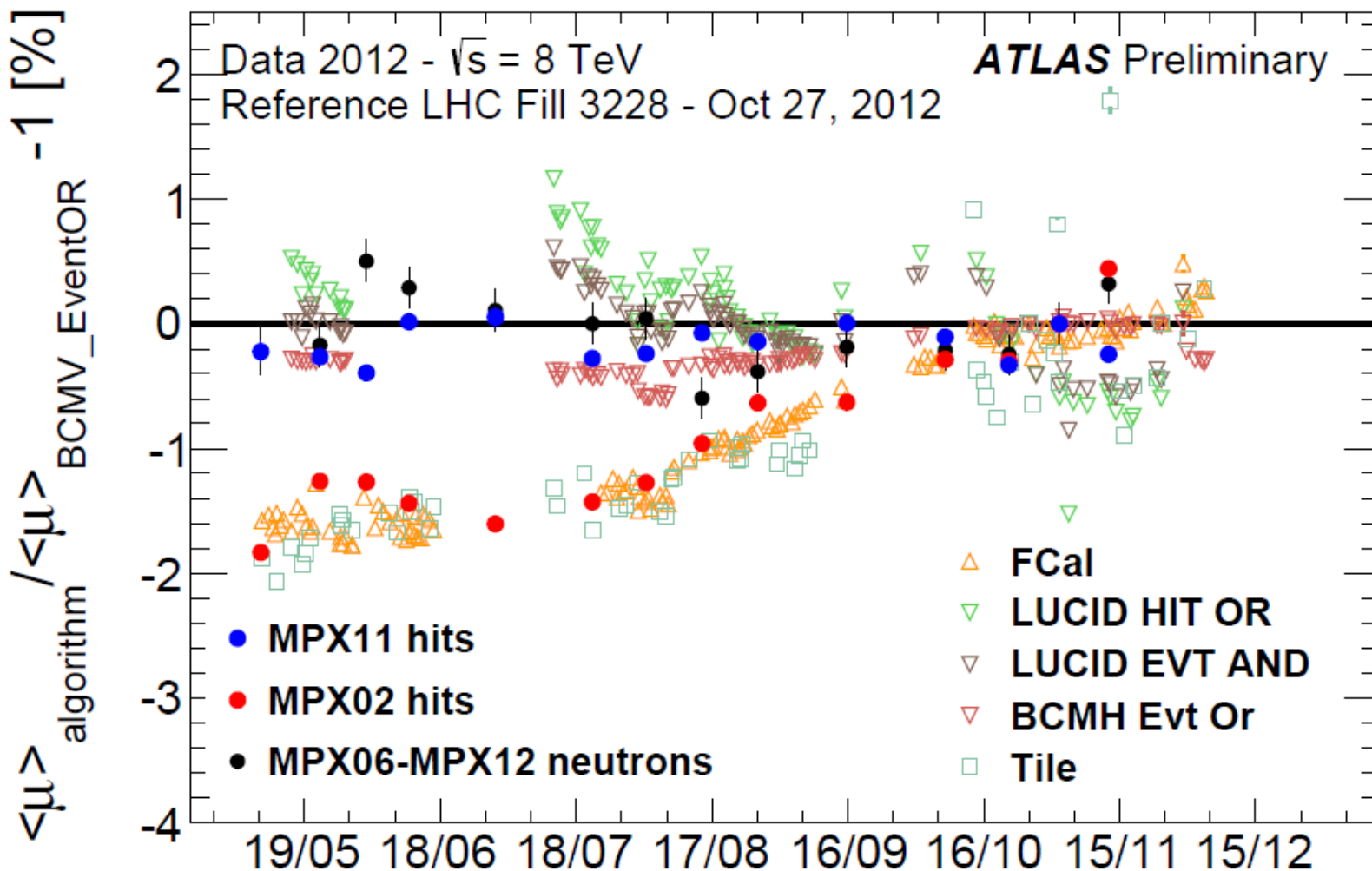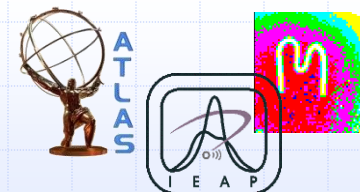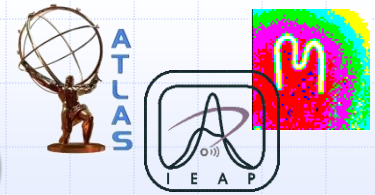
Number of heavy blobs per frame

MPX12 number of heavy blobs (thermal neutrons) per frame
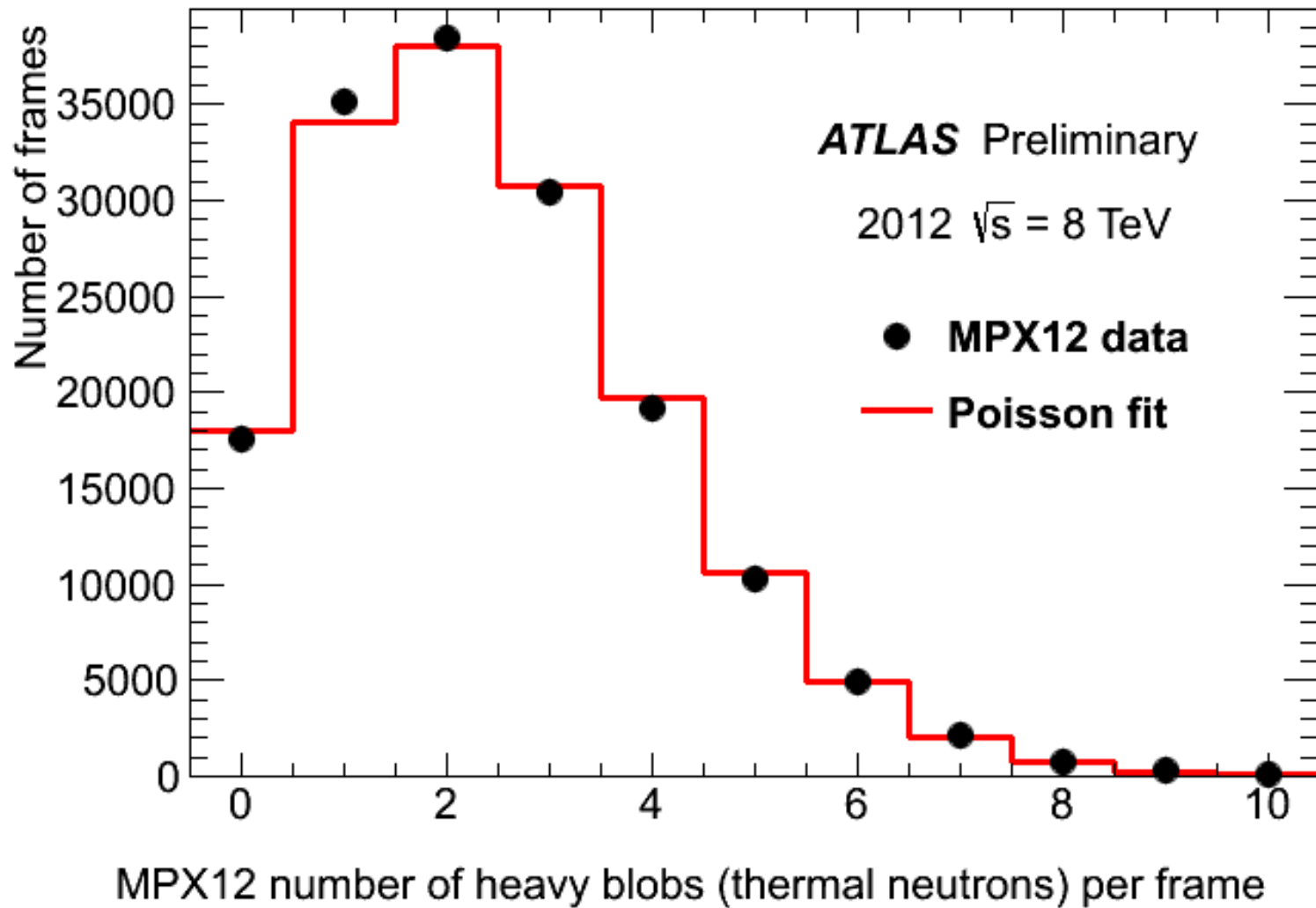
Fractional deviation in luminosity (thermal neutron counting mode)
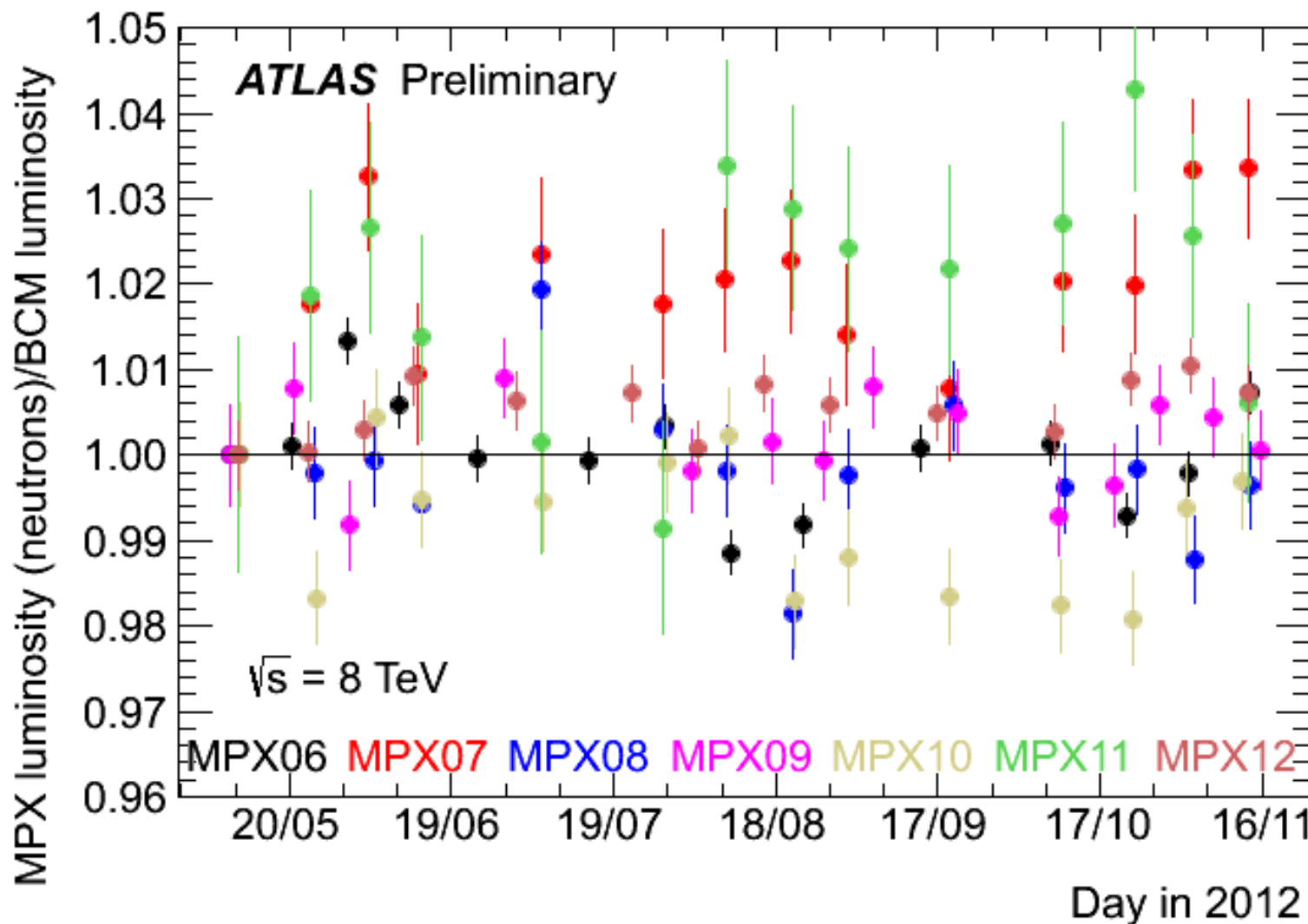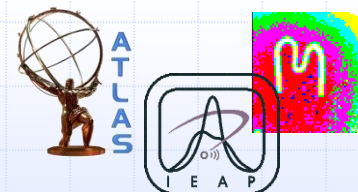
# Fractional deviation in the number of interactions per bunch crossing

van der Meer scan peak
(last horizontal scan in November 2012)

- At LHC, van der Meer scans (vdM) are used for absolute luminosity calibration.
- This study focuses on comparisons of the ratio of MPX versus the BCM luminosity measurements in order to quantify the relative stability of the BCM and MPX luminosity calibrations.
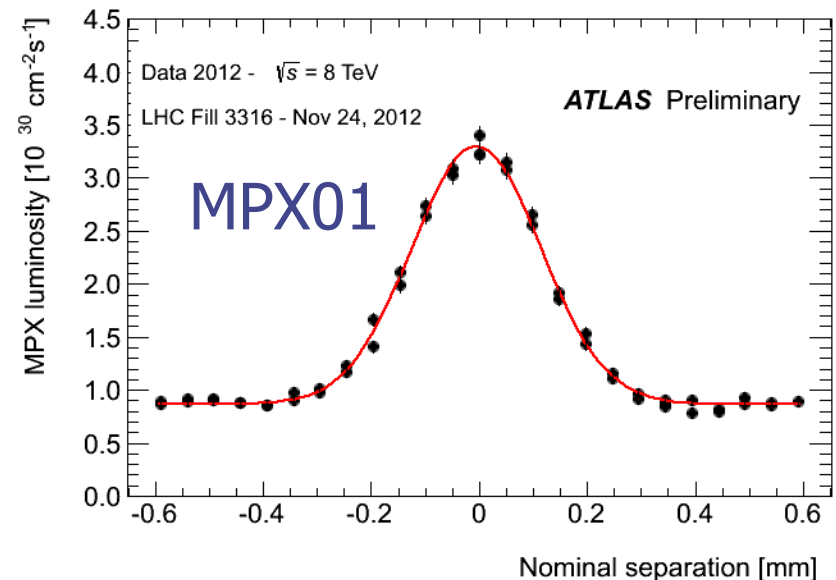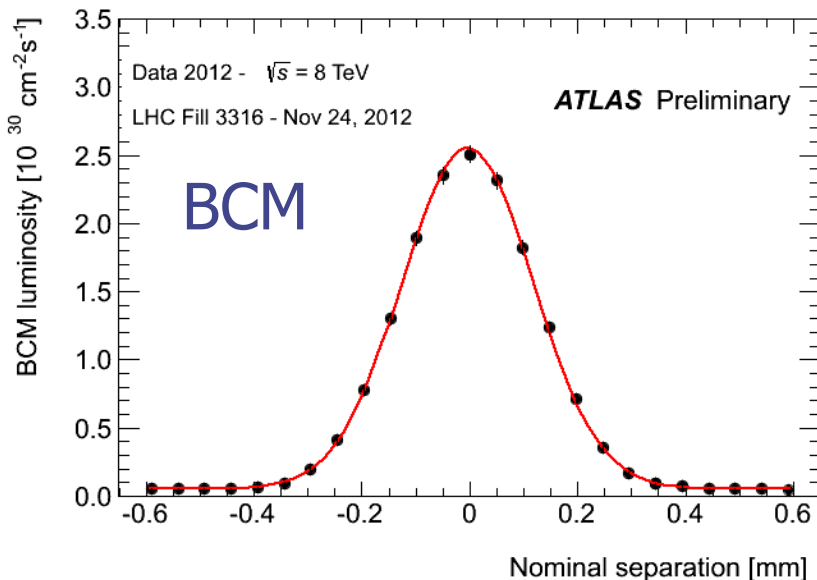
van der Meer scan: linearity MPX01 hit vs. BCM luminosities

Conclusions

- MPX network successful data-taking 2008 to 2013.

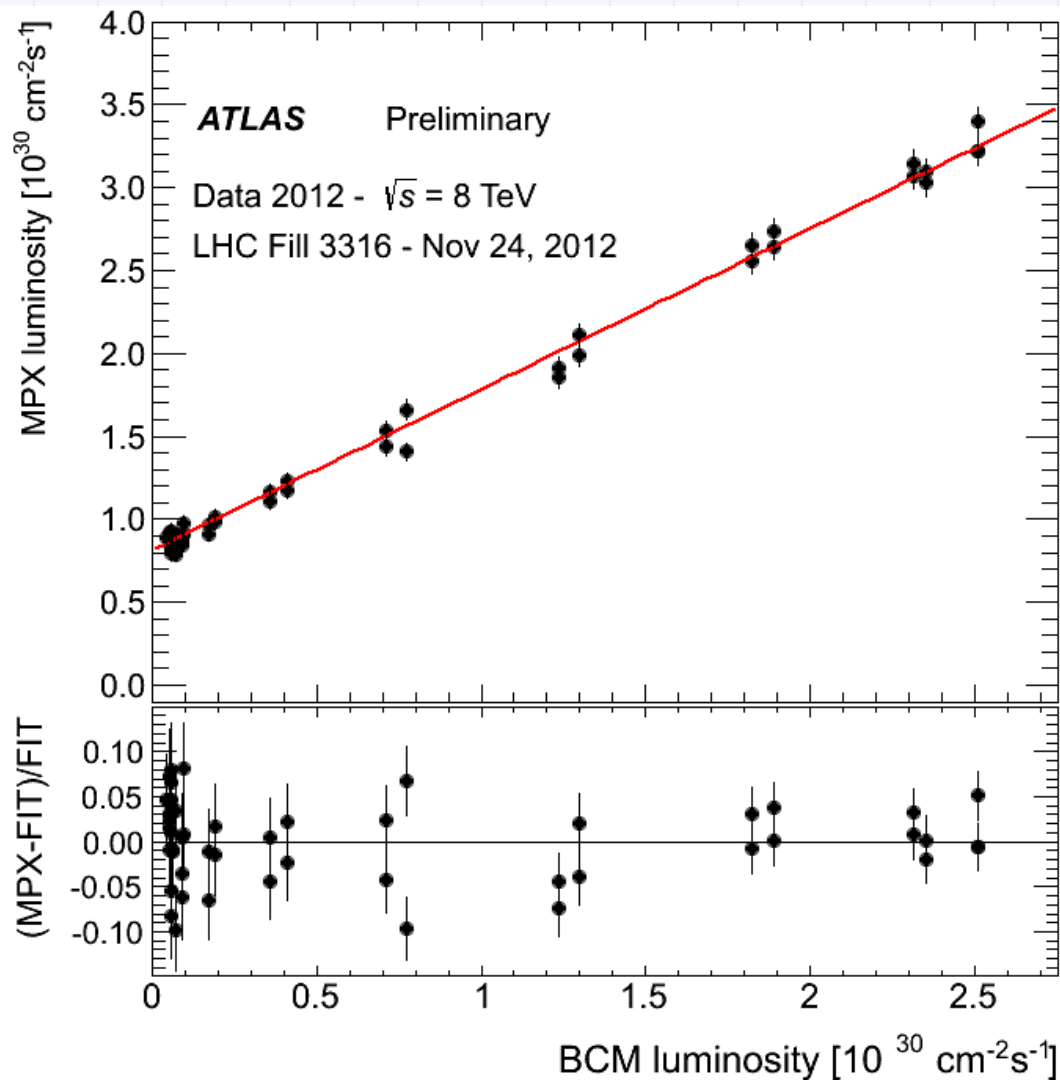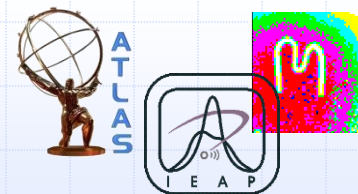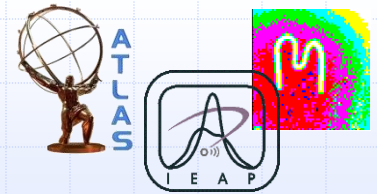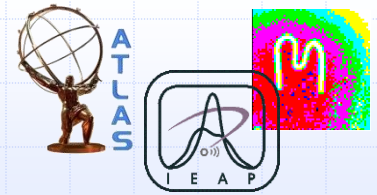- Sufficiently radiation hard for the 2012 high-luminosity.

- MPX network has an internal consistency of about 2% using different detectors and techniques for hit counting and heavy blob (thermal neutron) counting as measures of luminosity.

- This precision is comparable to other luminosity detectors in ATLAS in the same 2012 time period.

- MPX 2012 van der Meer scan luminosity four orders of magnitude lower than routine physics data-taking: MPX has wide dynamic range $\sim$0.5-7000$\cdot$10^{30} cm^{-2}s^{-1}.

Institute of Experimental and Applied Physics
Czech Technical University in Prague

References

[1] Medipix2 Collaboration, 2013. `http://medipix.web.cern.ch/medipix`.

[2] M. Campbell, C. Leroy, S. Pospisil, and M. Suk, *Measurement of Spectral Characteristics and Composition of Radiation in ATLAS by MEDIPIX2-USB Devices*, Project proposal, 2006. `https://edms.cern.ch/document/815615`.

[3] The ATLAS Collaboration, *The ATLAS Experiment at the CERN Large Hadron Collider*, JINST **3** (2008) S08003.

[4] M. Campbell et al., *Analysis of Radiation Field in ATLAS Using 2008-2011 Data from the ATLAS-MPX Network*, ATL-GEN-PUB-2013-001. `https://cds.cern.ch/record/1544435`.

[5] The ATLAS Collaboration, *Improved luminosity determination in pp collisions at $\sqrt{s} = 7\,TeV$ using the ATLAS detector at the LHC*, EPJC **73** (2013) 2518.

[6] V. Cindro et al., *The ATLAS Beam Conditions Monitor*, JINST **3** (2008) P02004.