

Comparison of ATLAS and CMS Luminosities

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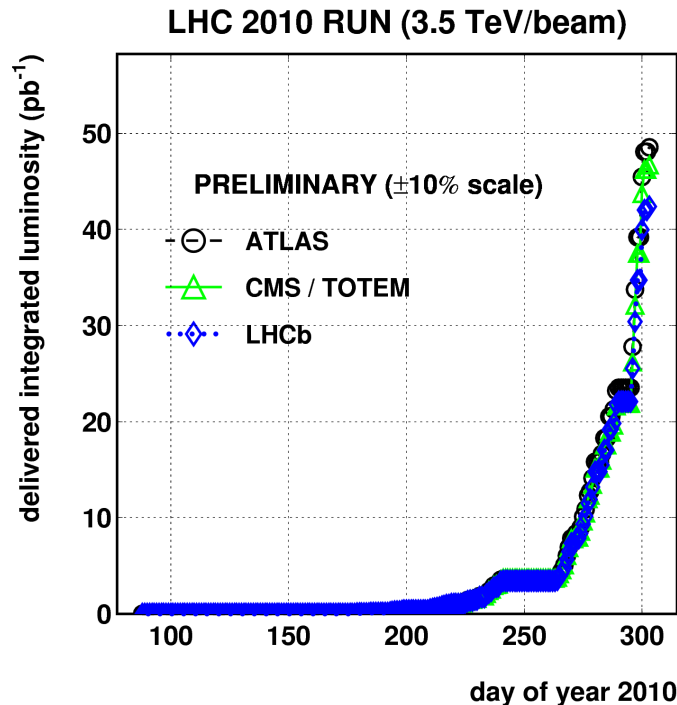
UC Berkeley and LBNL

on behalf of ATLAS and CMS

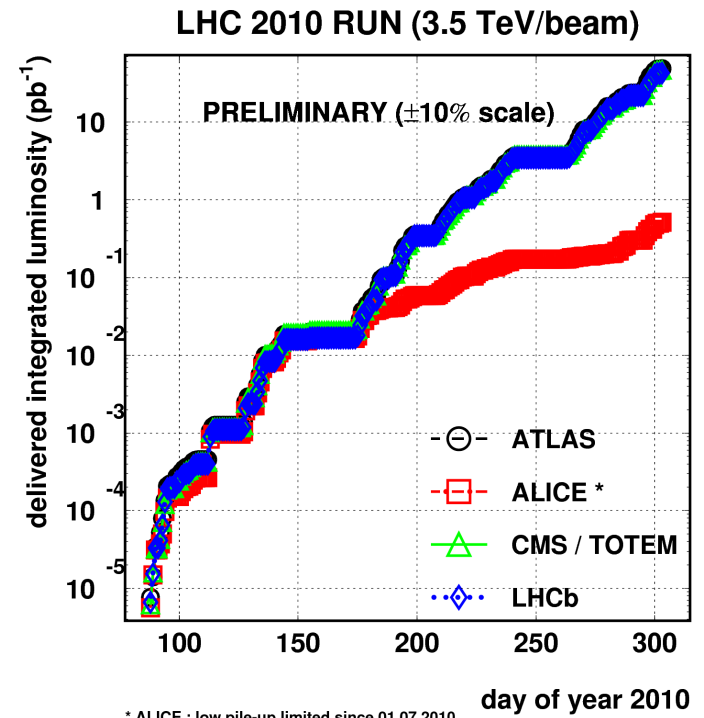
Lumi days, CERN, January 13th 2011

Delivered Luminosity in 2010

2010/11/05 08.33



2010/11/05 08.34



- ATLAS: 48.9 pb^{-1}
 - 48.1 pb^{-1} during stable beam until end-of-fill handshake
 - 0.8 pb^{-1} delivered after handshake with stable beam flag set
- CMS: 47.0 pb^{-1}
 - During stable beams
- 4% more luminosity reported by ATLAS
 - May also be partially due to detector downtime etc.

Luminosity Determination: ATLAS vs CMS

- Both experiments use the Van-der-Meer scans from April and May 2010 (see previous talks)
- *ATLAS uses event counting*
 - main method counts events with at least one hit on either side of LUCID (LUCID EVENT OR)
 - Many other methods studied and yield consistent results to within <2%
 - This is sensitive to pileup but corrected for
 - E.g. at $\mu=3.0$ the correction is 54%
 - Residual non-linearity is <0.5%
- *CMS uses hit counting*
 - Main method counts total number of channels with 0-hits in HF (on either side)
 - This is also sensitive to pileup and corrected for
 - Residual non-linearity <1%

Systematic Uncertainties from Spring scans

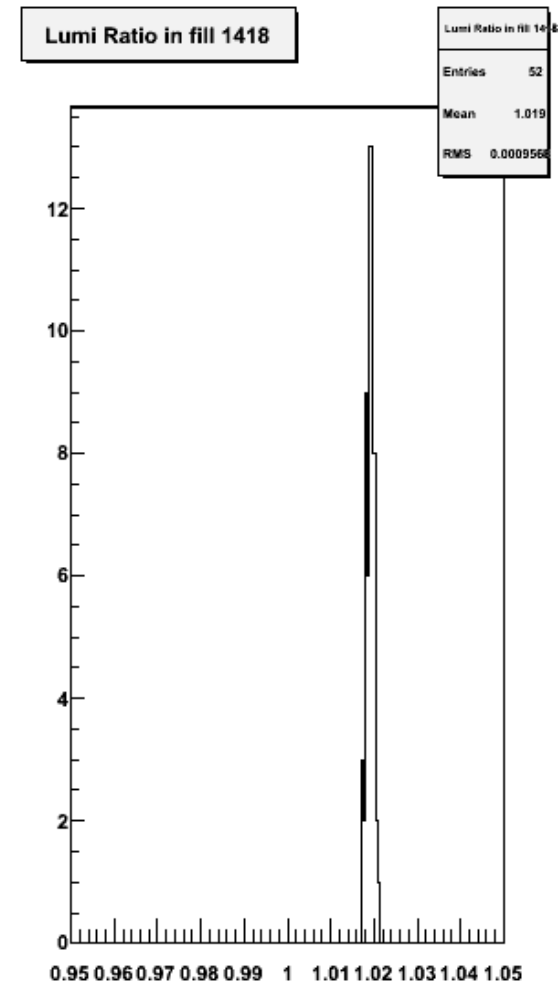
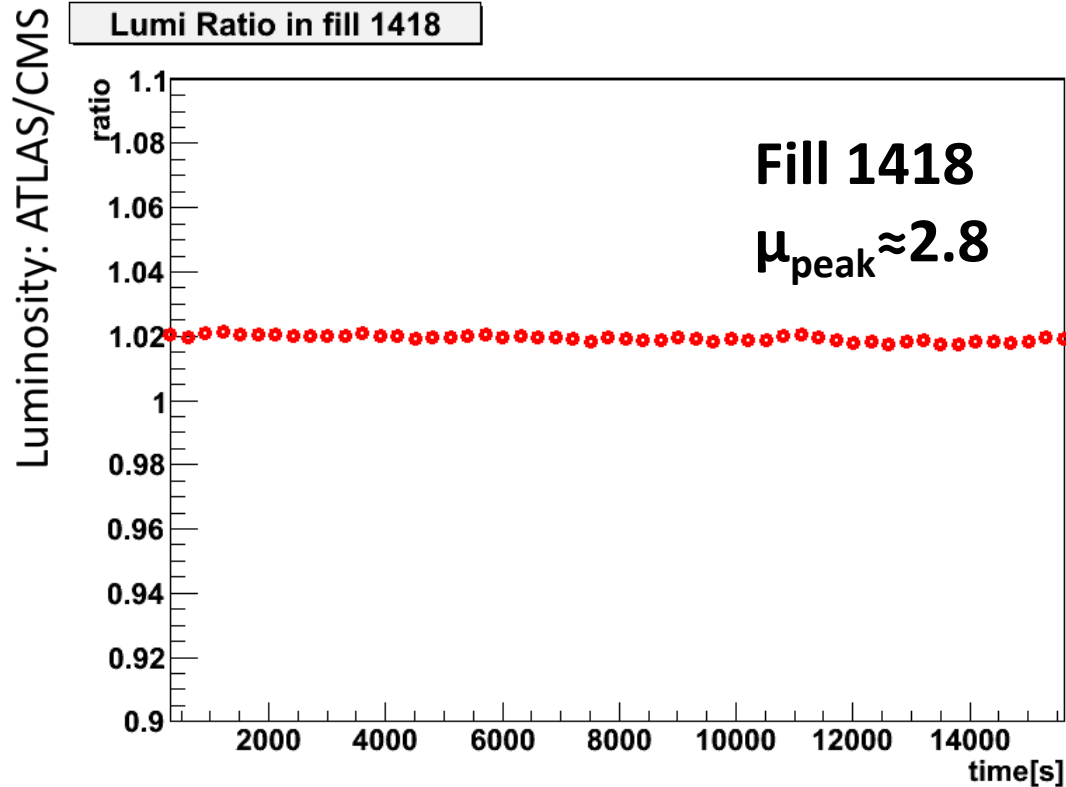
	ATLAS	CMS	Uncorrelated part per experiment
Beam current	10%	10%	0%
Length scale	2%	2%	2%
Beam centering	2%	2%	2%
Background	negligible	0.1%	0.1%
μ dependence	2%	n.a.	2%
reproducibility	3%	3%	3%
Fit model	1%	1%	1%
total	11%	11%	CMS: 4.2%, ATLAS: 4.7%

- The uncorrelated systematic uncertainty on ratio of ATLAS to CMS luminosity is 6.3%
 - This does not change with new beam current uncertainty
- Deviations of $\sim 6\%$ are thus easily expected on the ratio of ATLAS to CMS luminosity

Comparison of Luminosity for typical fills

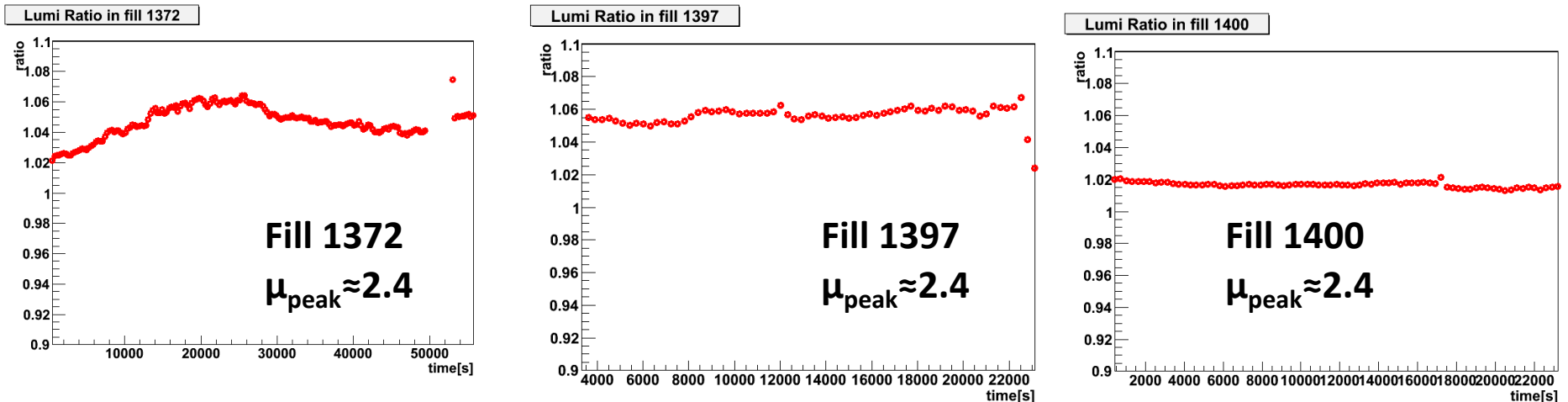
- CMS and ATLAS provide luminosity online to Massi Ferro-Luzzi via ascii files
- Available at <https://lpc-afs.web.cern.ch/lpc-afs/cgi-bin/webpage.sh>
- Comparison made of ATLAS vs CMS values by both experiments
 - Will show here just some example fills

Comparison per Fill: e.g. 1418



- 2% higher luminosity for ATLAS
- Ratio constant in time in this fill

More LHC fills: ratio of ATLAS to CMS



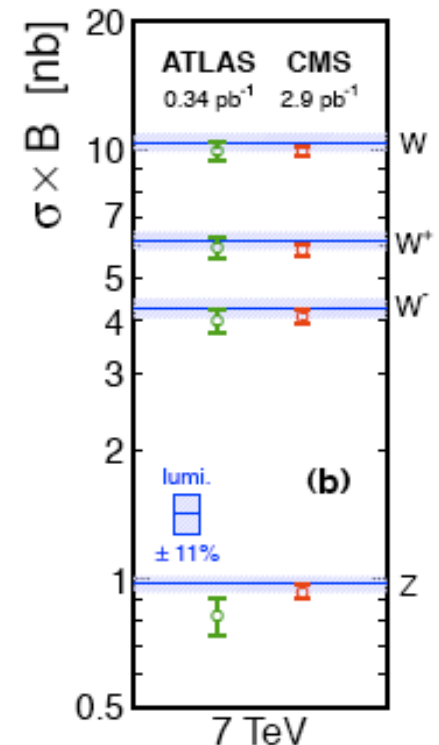
- Some observations:
 - ATLAS Luminosity generally $\sim 2\%$ larger than CMS luminosity
 - Usually 2% but sometimes up to 6%
 - Sometimes strong time-dependence within fill
- 2% difference well within uncertainty of ATLAS and CMS luminosity measurements
- Would be nice to understand why sometimes difference larger
 - Not obviously correlated with anything (e.g. not with peak luminosity or bunch setup)

Physics Rates and Cross Sections

- Luminosity delivered by LHC to ATLAS and CMS may of course be different
 - Although ATLAS and CMS reported values agree usually to within uncorrelated experimental uncertainty on luminosity measurement
- Physics cross section should, however, be the same
 - => compare
 - W and Z Cross Sections
 - Rate of MinBias events in common acceptance region

W and Z cross section

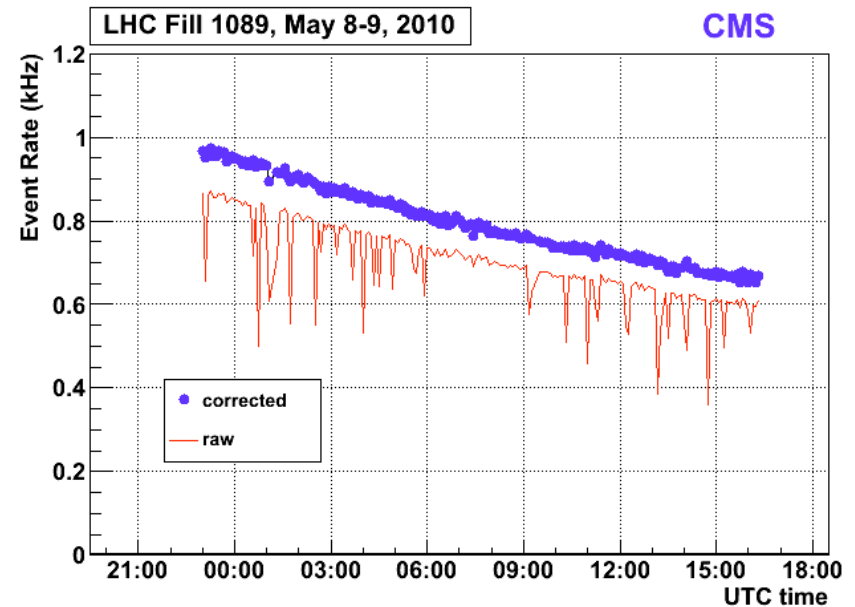
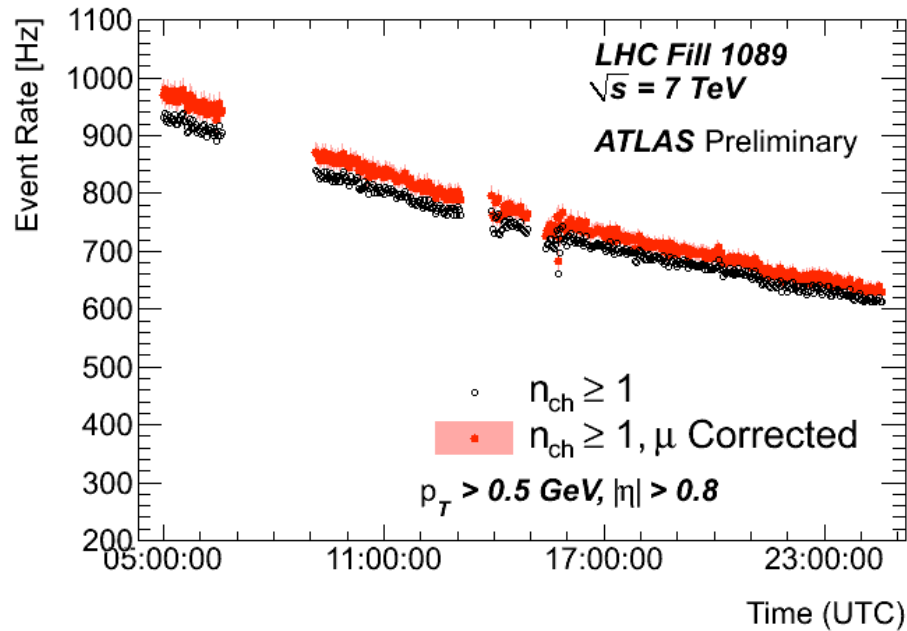
- ATLAS and CMS have both measured the W and Z boson cross sections in e and μ decay channels
- CMS (arXiv: 1012.2466) using 2.9 pb^{-1}
 - **W: 9.95 ± 0.29 (stat.+syst.) ± 1.09 (lumi) nb**
 - **Z: 0.931 ± 0.035 (stat.+syst.) ± 0.102 (lumi) nb**
- ATLAS (arXiv: 1010.2130) using 0.3 pb^{-1}
 - **W: 9.96 ± 0.55 (stat.+syst.) ± 1.10 (lumi) nb**
 - **Z: 0.82 ± 0.08 (stat.+syst.) ± 0.09 (lumi) nb**
- W cross section ratio ATLAS/CMS:
 - **1.00 ± 0.06 (stat.+syst.) ± 0.06 (unc. Lumi)**
- Excellent agreement between experiments
 - Indicates that luminosity is the same within uncorrelated errors
 - Will be very interesting with full data statistics (40 pb^{-1})



Event Rate in MinBias Events

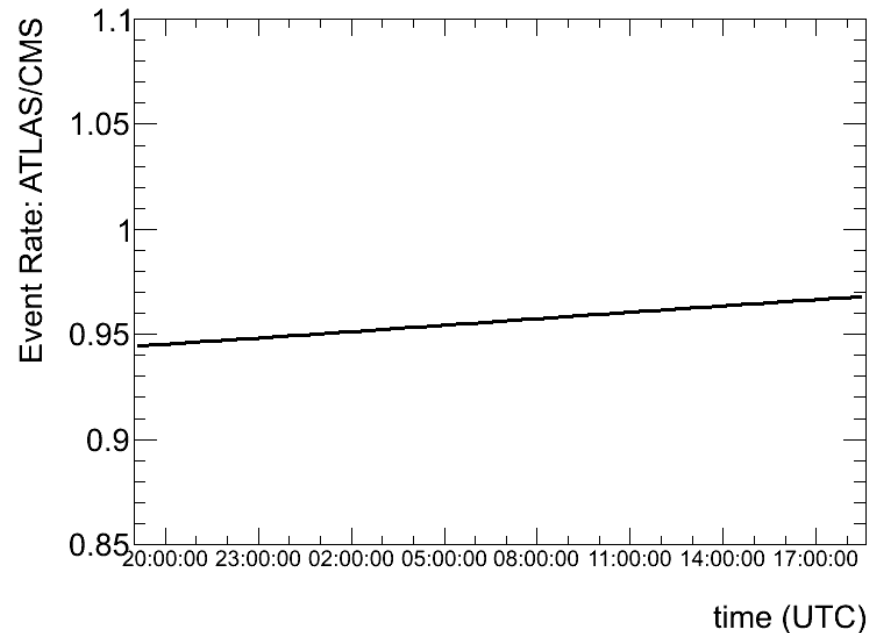
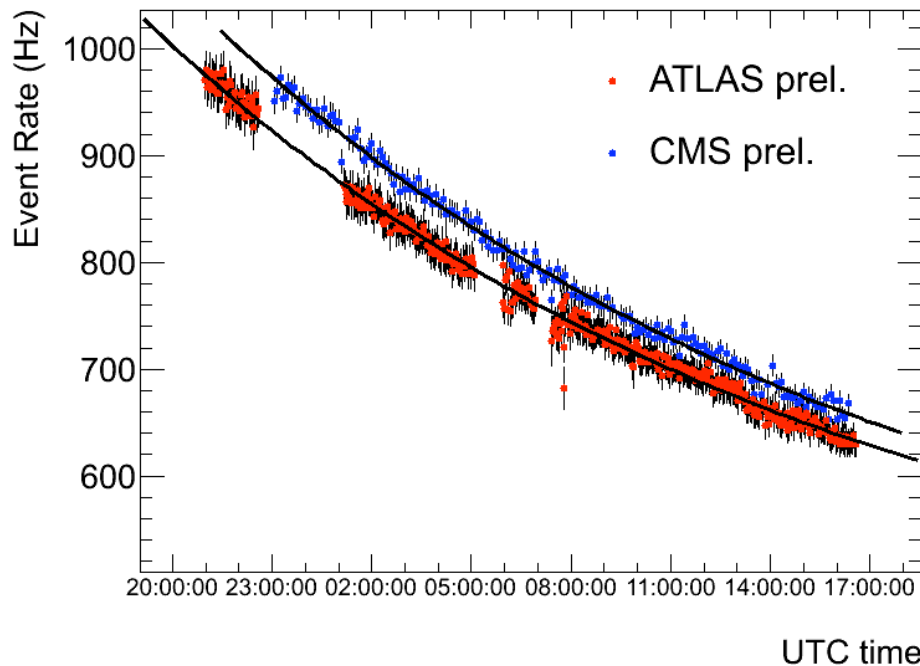
- Selected common acceptance region:
 - Events with at least one prompt charged particle with $p_T > 0.5$ GeV and $|\eta| < 0.8$ for ATLAS, CMS and ALICE
 - Spin-off of Minimum Bias analysis
- Measure cross section for such events
 - Corrected for any experimental effects
 - Tracking efficiency, fake tracks, vertex efficiency, trigger, deadtime, pileup,....
- Compare between experiments for one LHC fill
 - Rate of these events versus time
 - Cross section of these events versus time
- Comparison done for fill 1089
 - This is the May van-der-Meer-scan fill where both ATLAS and CMS scans took place
 - Can hopefully be extended to more fills (maybe even all)
 - E.g. for other VdM scan fills or for e.g. 1397 where 6% difference between CMS and ATLAS lumi is seen

Charged Particle Event Rate for Fill 1089



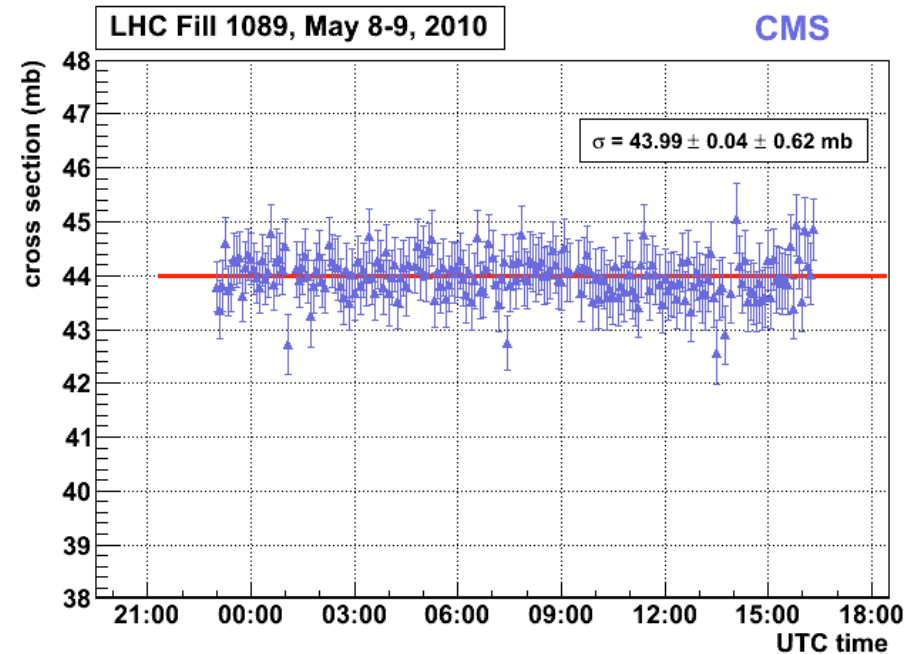
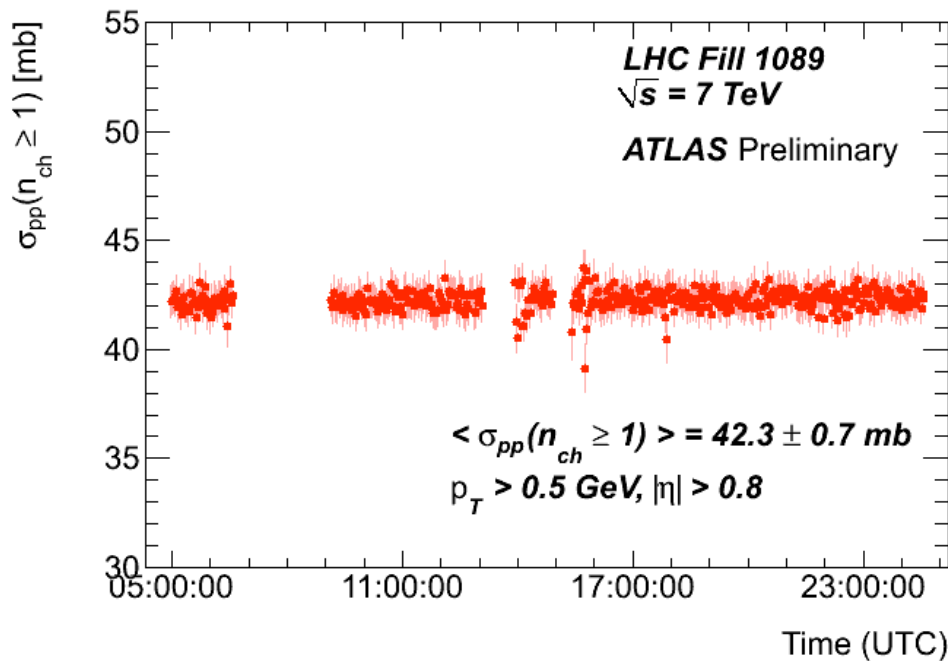
- Gaps in rate due to ongoing VdM scan or due to interruptions in data taking
- Overall analysis corrections about 10%
 - About 5% due to reconstruction, trigger etc.
 - About 5% at start and 3% at end due to pileup

Rate Comparison: ATLAS/CMS



- Rates are nicely fit by exponential + constant
- Ratio of ATLAS over CMS rate:
 - Differs by $\sim 5\%$ at start and $\sim 3\%$ at end of fill
- This should correlate with luminosity \Rightarrow check cross section

Charged Particle Cross Section for fill 1089



- ATLAS: $42.3 \pm 0.7 \text{ mb}$, CMS: $43.99 \pm 0.62 \text{ mb}$
 - Systematic errors quoted do not include luminosity uncertainty
- $\sigma_{\text{CMS}}/\sigma_{\text{ATLAS}} = 1.040 \pm 0.022 \text{ (stat+sys)} \pm 0.063 \text{ (unc. lumi)}$
 - Difference corresponds to 1.8σ (stat.+syst) and 0.6σ (stat+syst+lumi)

Conclusions and Outlook

- ATLAS than CMS luminosities usually differ by 2%
 - Sometimes bigger differences reason not yet understood
 - Integrated luminosity in all of 2010 differs by 4%
- The observed differences are within the experimental systematic associated to the analyses of the spring VdM scans
 - Uncertainties will get reduced with new scan => check again
- Physics cross sections comparable within uncorrelated systematic uncertainties (stat.+syst. And luminosity):
 - W cross section: ratio (CMS/ATLAS)= $1.00 \pm 0.06 \pm 0.06$
 - Charged particle event cross section: ratio(CMS/ATLAS)= $1.040 \pm 0.022 \pm 0.063$
- Higher precision statements soon possible
 - W cross sections with full 2010 dataset
 - New VdM scan from October will have much smaller uncertainty
 - Charged particle event rate can be compared in more fills and also with new luminosity normalization from new scans