

## New Developments in Web Based Monitoring at the CMS Experiment

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## CHEP 2012 Conference Proceedings

### New Developments in Web Based Monitoring at the CMS Experiment

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#### Abstract

The rate of performance improvements of the LHC at CERN has had a strong influence on the characteristics of the monitoring tools developed for the experiments. We present some of the latest additions to the suite of Web Based Monitoring services for the CMS experiment, and explore the aspects that address the roughly 20-fold increase in peak instantaneous luminosity over the course of 2011. One of these user-friendly tools allows collaborators to easily view, and make correlations among, accelerator configuration information such as bunch patterns, measured quantities such as intensities, vacuum pressures, and background conditions, as well as derived quantities such as luminosity and the number of simultaneous interactions per beam crossing. An additional tool summarizes the daily, weekly, and yearly luminosity and efficiency. Finally, we discuss a trigger cross section and rate fitting service that uses data from previous runs to validate current running conditions, as well as to serve as a predictive extrapolation tool for developing triggers for higher luminosity running.

#### Introduction

The Compact Muon Solenoid (CMS) [1] is a general purpose detector built at the Large Hadron Collider (LHC) [2] to study physics at the energies of the order of 14 TeV. The challenging experimental environment and extremely complex detector, trigger, and data acquisition (DAQ) systems impose the necessity of constant and close monitoring tools. Continuous monitoring of beam conditions, as well as detector hardware and software elements, is the key factor in the high quality data taking. The large geographical scale of the experiment, with over 3000 collaborators from over 40 countries, demands a common framework and remote accessibility of the monitoring tools.

Web Based Monitoring (WBM) was developed to address the monitoring needs and the security requirements of the experiment and has become one of the most important tools for the

Information about LHC and CMS status and performance are provided to WBM by specialized hardware via various messaging systems and the Oracle database:

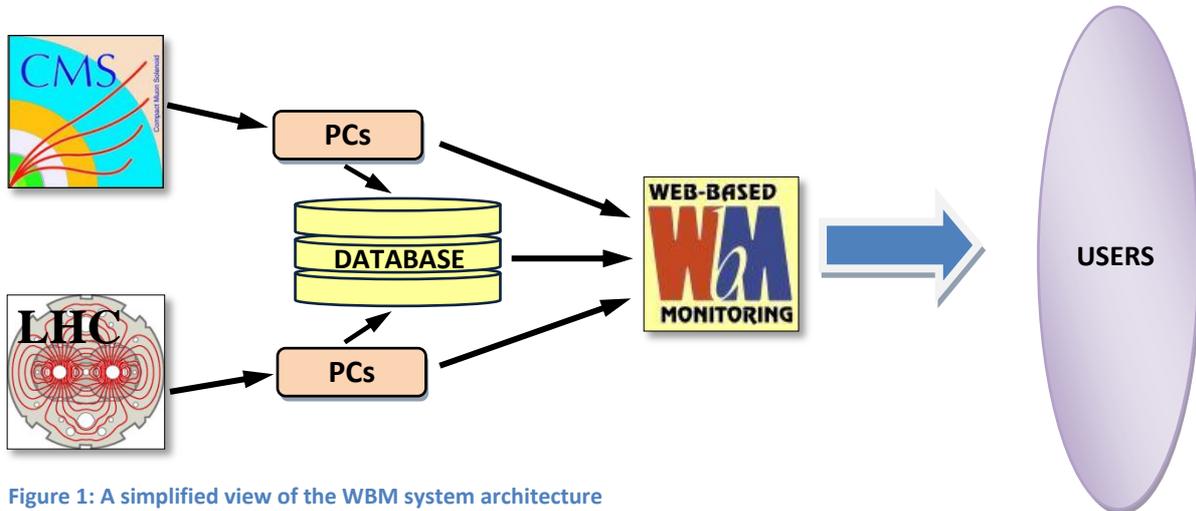


Figure 1: A simplified view of the WBM system architecture

Data from various heterogeneous sources are aggregated by WBM and translated into a user-friendly and convenient form. The fact that WBM provides online and archival monitoring capabilities, by obtaining the data from different sources, also makes it a perfect monitoring tool for correct and uninterrupted functioning of the primary data sources. Due to the summarizing nature of the resultant information (tables, plots, etc.), any unexpected behavior of the WBM monitoring tools can promptly indicate and identify a problem in the primary data-provider hardware or software.

### WBM Monitoring Tools

In the following we will describe latest WBM tools that provide users with the important information about LHC and CMS performance in a user-friendly fashion. Figure 2 shows the WBM main page with all its services.



## CMS Web Based Monitoring

*online*



<p><b>Subdetectors WBM</b></p> <ul style="list-style-type: none"> <li><a href="#">ECALSummary</a></li> <li><a href="#">DTSummary</a></li> <li><a href="#">RPCSummary</a></li> <li><a href="#">HCALHome</a></li> <li><a href="#">CSCSummary</a></li> <li><a href="#">BRMSnapshots</a></li> <li><a href="#">BCM1F Bunch Info</a></li> <li><a href="#">TriggerModes</a></li> <li><a href="#">TrackerTools</a></li> <li><a href="#">S<sup>3</sup> ScreenSnapShots</a></li> </ul>	<p><b>Core Services</b></p> <ul style="list-style-type: none"> <li><a href="#">RunSummary [24h] [24h&amp;1+trig]</a></li> <li><a href="#">RunTimeSummary [LHC Fills]</a></li> <li><a href="#">FillReport [Latest Fill] DataSummary <math>\beta</math></a></li> <li><a href="#">Automatic Fill eMails</a></li> <li><a href="#">DataQualityLogger <math>\alpha</math></a></li> <li><a href="#">LumiScalers</a></li> <li><a href="#">TriggerHistory   TriggerRunListing   TriggerRates</a></li> <li><a href="#">LastValue   ConditionBrowser [FPlot]</a></li> <li><a href="#">MagnetHistory   CurrentBunches   BunchFill</a></li> <li><a href="#">LhcMonitor   LHCStatusDisplay   BLM   BPM   DIP</a></li> <li><a href="#">LhcCollimators   AbortGaps</a></li> <li><a href="#">ShiftAccountingTool</a></li> <li><a href="#">PageZero   CMS Page 1</a></li> </ul>	<p><b>Links</b></p> <ul style="list-style-type: none"> <li><a href="#">DQM Run Registry</a></li> <li><a href="#">Online DQM GUI</a></li> <li><a href="#">FNAL ROC</a></li> <li><a href="#">Commissioning &amp; Run Coordination</a></li> <li><a href="#">CMS Twiki: OnlineWB TriDAS</a></li> <li><a href="#">CMS Online</a></li> <li><a href="#">Shift eLog</a></li> <li><a href="#">Snappy eLogViewer</a></li> <li><a href="#">LHC Page 1</a></li> </ul>
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[WBM Twiki Page](#) | [WBM Savannah](#) | [WBM Support & Contact](#)  
 Last modified 2012-05-11 16:06:06 UTC



Figure 2: WBM main page with the list of all the WBM services

**FillReport**

FillReport provides users with the online monitoring of the crucial components of the ongoing LHC fill, as well as archival information for all previous fills. The LHC fill is a period of time during which beams of given configuration circulate at LHC. At the front page (Fig. 3), a user can see the list of the latest fills along with summarized characteristics. The report page of each fill provides plots of important quantities (instantaneous and online measured integrated luminosity, background measurements, vacuum pressure, collimator position etc.). It also provides the summary table with the numerical values for those quantities. Plots are generated on the WBM server, using C++ code with ROOT [3] libraries, and provided to the user as .gif graphics files, thus eliminating the user side querying the database and optimizing the speed and performance of the web-service.

Specific Fill:  GO Begin: 2009 End: 2020 Stable:  Last n Fills: 20 Stable:  < 2027 |

Table shows 20 fills, 7 of which include stable beams. Tab-separated value file for Excel. Simple table for screen snapshot is here.

Fill	CreateTime	Duration Stable	PeakInstLumi	PeakPeak	PeakSpecLumi	DeliveredLumi	RecordedLumi	Eff
	LHC Fill Declared	IR/AMM	$10^{31} \text{ cm}^{-2} \text{ s}^{-1}$	$10^{31} \text{ cm}^{-2} \text{ s}^{-1}$	$10^{31} \text{ cm}^{-2} \text{ s}^{-1}$	$10^{31} \text{ pb}^{-1}$	$10^{31} \text{ pb}^{-1}$	%
2629	2012.05.14 11:42:43		0.000	0.000	0.000	0.000	0.000	
2627	2012.05.14 08:08:23	10:08	4190.032	19.399	354.193	102.805	99.084	
2626	2012.05.13 23:38:27		0.000	0.000	0.000	0.000	0.000	
2625	2012.05.13 22:11:27		0.000	0.000	0.000	0.000	0.000	
2624	2012.05.13 08:03:09	5:09	4369.948	20.232	1399.007	64.590	63.689	
2623	2012.05.12 23:44:57	5:25	4190.013	19.399	1421.456	64.208	63.785	
2622	2012.05.12 20:12:09		0.000	0.000	0.000	0.000	0.000	
2621	2012.05.12 05:20:12	13:17	4228.068	19.576	1467.963	124.546	121.191	
2620	2012.05.12 03:40:05		0.000	0.000	0.000	0.000	0.000	
2619	2012.05.12 03:18:16		0.000	0.000	0.000	0.000	0.000	
2618	2012.05.11 21:58:20		0.000	0.000	0.000	0.000	0.000	
2617	2012.05.11 14:04:27	0:25	4156.594	19.245	1448.574	6.085	5.876	
2616	2012.05.11 08:10:40	1:53	4379.739	20.278	1461.223	26.181	23.657	
2615	2012.05.11 06:16:47		0.000	0.000	0.000	0.000	0.000	
2614	2012.05.11 03:48:09		0.000	0.000	0.000	0.000	0.000	
2613	2012.05.11 03:23:34		0.000	0.000	0.000	0.000	0.000	
2612	2012.05.11 02:53:57		0.000	0.000	0.000	0.000	0.000	
2611	2012.05.11 02:09:27		0.000	0.000	0.000	0.000	0.000	
2610	2012.05.10 23:13:18		0.000	0.000	0.000	0.000	0.000	
2609	2012.05.10 16:13:28	4:23	3953.830	17.843	1692.986	43.434	35.613	
stable		40:40	4379.739	20.278	1692.986	431.989	409.794	

Figure 3: FillReport start page, showing the list of the latest fills with the characteristic information

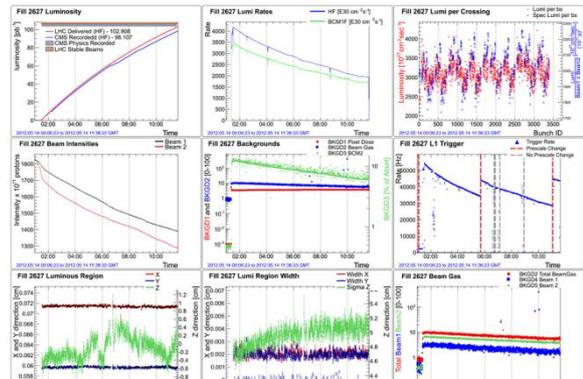


Figure 4: Few of the FillReport summary plots

Every quantity on the page is linked to the more detailed information regarding it. Therefore a user can easily drill down to this detailed information using convenient and clear links to WBM tools with more refined information. Due to the importance of information being promptly conveyed to the collaboration, this service is able to send emails to subscribed users with notifications of start and end of the fill and providing the concise summary.

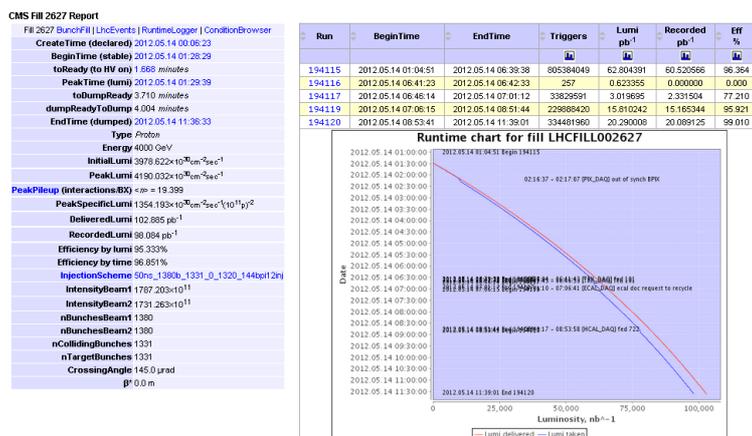


Figure 4: Summary tables with all the quantities and links (left) and runtime chart and table with data taking information during the fill (right)

FillReport contains the information regarding all previous fills, which can be useful to analyze the changes or debug the problems. The tool is important not only for online monitoring but also for data analysis. Besides summarizing the information, it keeps track of the most important values and updates the database with the important record value information, which is used for performance assessment and data analysis.

Efficient data taking on a longer time scale is very important in high energy experiments which are driven by the amount of quality data. WBM provides a very concise web-service called DataSummary, which shows progress of data collection, trend of instantaneous luminosity and efficiency of data taking on daily, weekly, and yearly basis. LHC is a complicated machine that can produce head-on collisions of both protons and heavy ions. DataSummary provides information for both types of collisions separately.

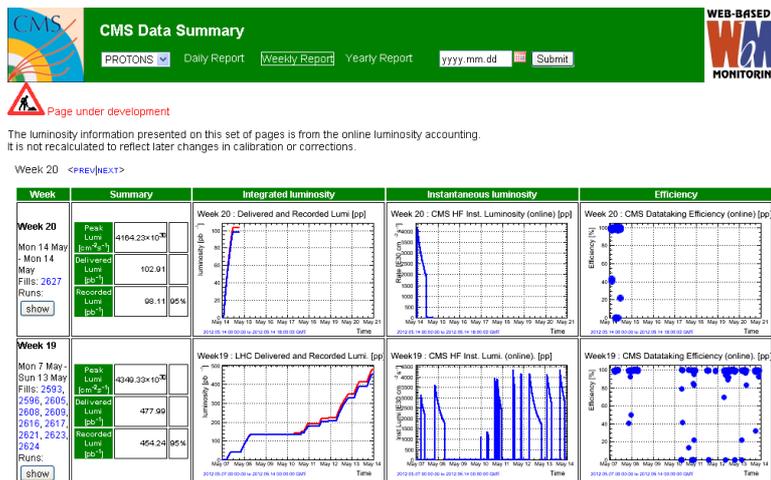


Figure 5: DataSummary page showing the summary plots of online measured integrated and instantaneous luminosity and data taking efficiency for last two weeks.

It also carries both archival and online-monitoring importance. Plots for current day, week, and year are updated frequently to achieve online monitoring capabilities. Like FillReport, DataSummary also tracks the shown quantities to provide the information about record values (highest instantaneous luminosity, most data collected during day, week or month, etc.). Users can drill to the details of every fill and CMS run of the time period shown using the clear links in the tables. A CMS run is the time period during which CMS takes data with a well defined configuration.

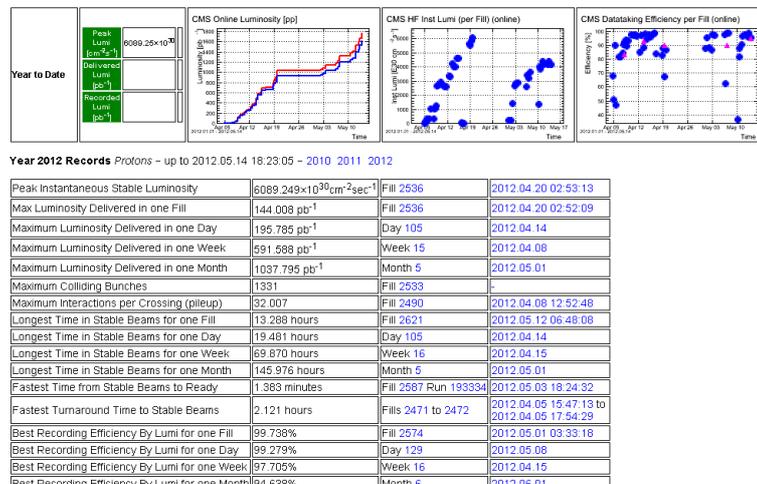


Figure 6: DataSummary records page, showing online measured integrated and instantaneous luminosity and data taking efficiency for year 2012, and table with all the record values for the same year

The LHC produces very high energy beams at very high luminosities leading to high rates of data production. Triggering is an extremely important and necessary part of the CMS experiment. Monitoring the complex CMS trigger system is a highly demanded WBM service.

TriggerHistory performs fitting for level one (hardware-based) and high level triggers (software-based) daily during collision runs. It provides a plot of the trigger cross section, which is defined as trigger rate divided by instantaneous luminosity. So trigger experts can monitor the trend of the trigger cross section.

The fit is performed to the recent collision runs, which are selected based on sub-detectors included in the data acquisition (DAQ) process, LHC energy, and recorded luminosity. The fit parameter values are periodically updated in the WBM database to be used for online trigger rate monitoring.

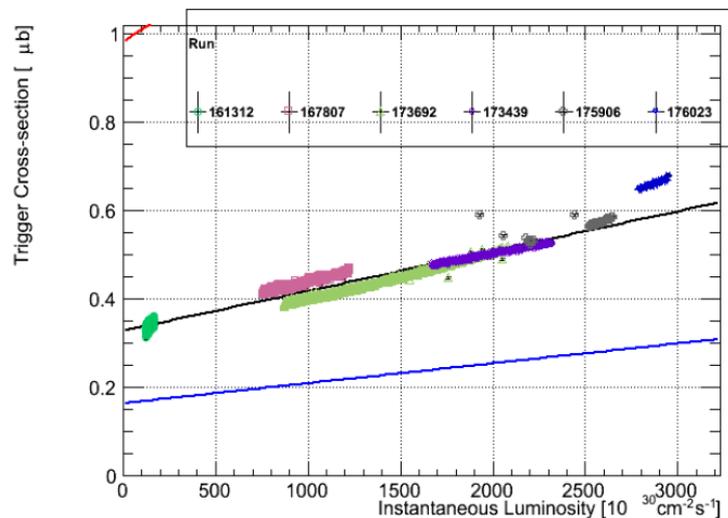


Figure 7: Level 1 algorithmic trigger bits for the p-p runs

Level one trigger rates are monitored online by checking against expected rates from the fit results of the TriggerHistory application.

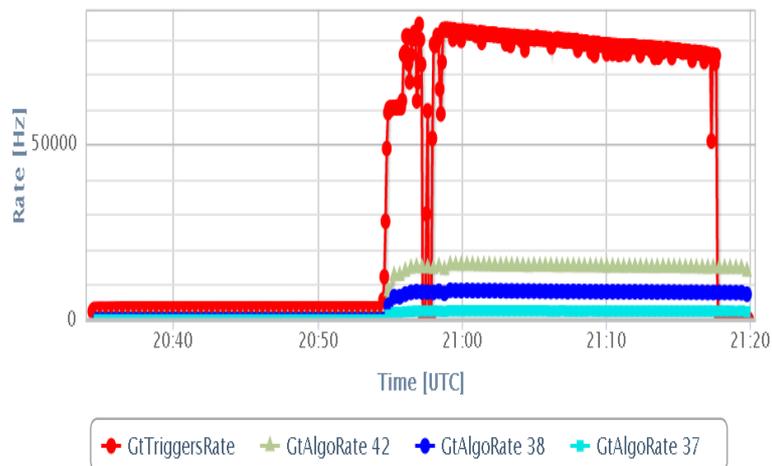


Figure 8: Level 1 trigger rate vs. time for selected p-p run

The fitter services can analyze runs with different trigger configuration, given the validity of the trigger path of interest. One of the goals of this service is to assist experts to understand instantaneous luminosity dependence for trigger menu design. In addition to trigger cross section, the rate and ratio of triggers can be plotted for level one trigger bits.

## Summary

In an experiment with challenging amount of information to be monitored and analyzed, WBM manages to receive, store and promptly deliver the crucial information to the CMS collaboration anytime and anywhere. Providing the online monitoring of correlated information of diverse sources is extremely important for efficient and high quality data taking. WBM proved to be one of the key elements of successful operation of the CMS experiment.

## Acknowledgements

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## References

- [1] Compact Muon Solenoid website: <http://cms.cern.ch>
- [2] Large Hadron Collider website: <http://lhc.web.cern.ch/lhc>
- [3] <http://root.cern.ch>