

New Developments in Web Based Monitoring at the CMS Experiment

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. Web-Based Monitoring is a suite of monitoring tools essential for efficient operations of the Compact Muon Solenoid (CMS) experiment. Information is provided to the WBM servers from the Large Hadron Collider (LHC) and CMS via specialized hardware using various messaging systems and Oracle database. Aggregated data is converted to user-friendly tables and plots of correlated information.

Left: WBM main page with all the services

Right: Simplified view of the WBM system architecture

FillReport

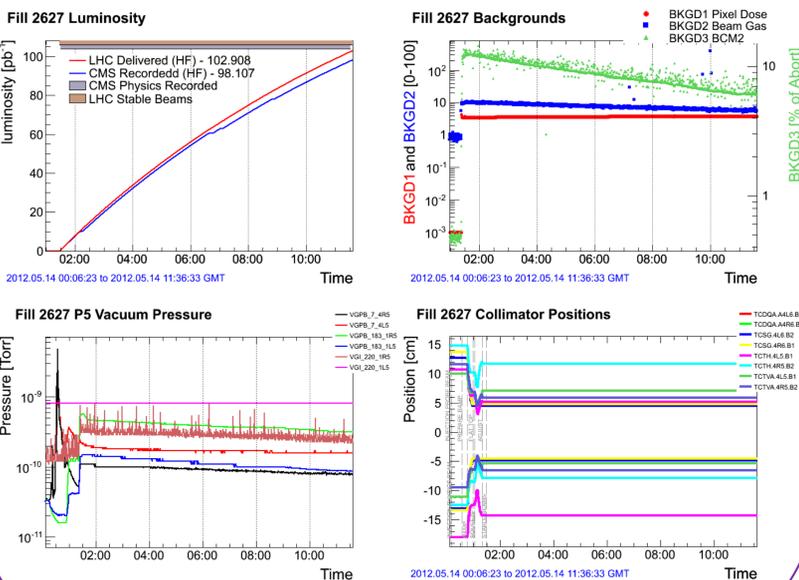
FillReport provides users with the online monitoring of the crucial components of the ongoing LHC fill, as well as archival information for all previous fills.

Specific Fill: GO Begin: 2590 End: 2630 Stable GO Last n Fills: 20 Stable GO < 2629 |

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

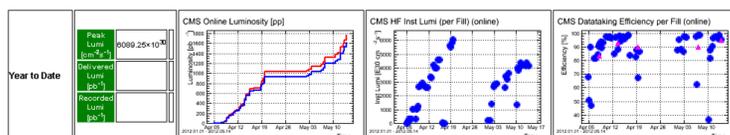
Fill	CreateTime	Duration Stable	PeakInstLumi	Peak Pileup	PeakSpecLumi	DeliveredLumi	RecordedLumi	Et
		#BMM	$\times 10^{31} \text{cm}^{-2} \text{s}^{-1}$	$\times 10^4$	$\times 10^{31} \text{cm}^{-2} \text{s}^{-1}$	$\text{pb}^{-1} \text{pp}$	$\text{pb}^{-1} \text{PbPb}$	
2630	2012.05.15 18:27:28	4.11	5526.735	25.588	1552.620	67.546	63.604	
2629	2012.05.15 04:19:38	5.52	4247.782	19.667	1338.069	71.352	68.651	
2628	2012.05.14 11:42:43	7.50	4877.818	22.584	1496.331	98.893	93.974	
2627	2012.05.14 00:06:23	10.08	4190.032	19.399	1354.193	102.885	98.084	
2624	2012.05.13 08:03:09	5.09	4369.848	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	61.685	
2621	2012.05.12 05:20:12	13.17	4228.068	19.576	1467.983	124.546	121.191	
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	1.63	4379.739	20.278	1461.223	26.181	23.657	(LHC Fill = 2617)
2609	2012.05.10 16:13:28	4.23	3853.830	17.843	1682.986	43.494	35.613	
2608	2012.05.10 13:53:32	0.30	3988.231	18.532	1656.710	6.963	6.120	
2605	2012.05.10 03:47:13	1.27	1355.608	17.706	4924.501	5.695	2.104	
2596	2012.05.07 16:18:15	10.43	3625.743	21.337	1917.586	93.985	92.774	
2593	2012.05.07 02:51:28	4.35	3190.189	18.808	1930.439	41.922	41.279	
2591	2012.05.06 17:20:24	1.19	3392.667	20.033	1986.072	14.695	9.152	
2590	2012.05.06 10:43:50	3.31	2586.257	19.785	2289.129	27.896	27.205	
2587	2012.05.05 15:55:48	7.11	2870.310	21.990	2417.683	54.764	53.200	
2584	2012.05.03 00:28:48	0.46	2797.878	21.456	2450.011	7.323	7.161	
2583	2012.05.02 19:08:33	3.51	2661.272	20.487	2326.057	30.367	26.261	
2580	2012.05.02 04:41:03	6.48	1426.487	18.843	5089.915	9.664	8.548	
stable		99.14	5526.735	25.588	5089.915	963.054	909.827	

The report page of each fill provides plots of important quantities (instantaneous and online measured integrated luminosity, background measurements, vacuum pressure, collimator position etc...). Summary Table provides the numerical values for those quantities. Plots are generated on the WBM server, using C++ code with ROOT 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.



DataSummary Continued

DataSummary, as well as FillReport, 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 for the particular time period or for the run with the record values.



Year 2012 Records Protons - up to 2012.05.14 23:44:46 - 2010 2011 2012

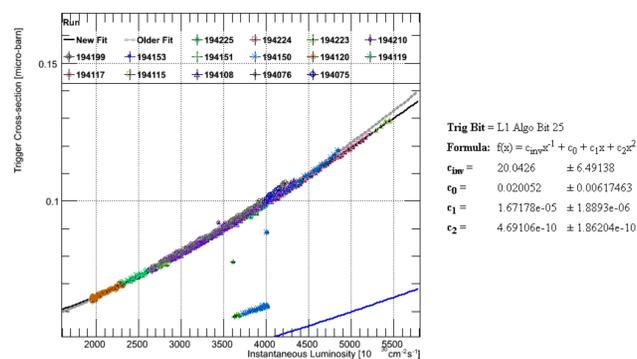
Peak Instantaneous Stable Luminosity	6089.249x10 ³⁰ cm ⁻² sec ⁻¹	Fill 2536	2012.04.20 02:53:13
Max Luminosity Delivered in one Fill	144.008 pb ⁻¹	Fill 2536	2012.04.20 02:52:09
Maximum Luminosity Delivered in one Day	195.785 pb ⁻¹	Day 105	2012.04.14
Maximum Luminosity Delivered in one Week	591.588 pb ⁻¹	Week 15	2012.04.08
Maximum Luminosity Delivered in one Month	1037.795 pb ⁻¹	Month 5	2012.05.01
Maximum Colliding Bunches	1331	Fill 2533	
Maximum Interactions per Crossing (pileup)	32.007	Fill 2490	2012.04.08 12:52:48
Longest Time in Stable Beams for one Fill	13.288 hours	Fill 2621	2012.05.12 06:48:08
Longest Time in Stable Beams for one Day	19.481 hours	Day 105	2012.04.14
Longest Time in Stable Beams for one Week	69.870 hours	Week 16	2012.04.15
Longest Time in Stable Beams for one Month	145.976 hours	Month 5	2012.05.01
Fastest Time from Stable Beams to Ready	1.383 minutes	Fill 2587 Run 193334	2012.05.03 18:24:32
Fastest Turnaround Time to Stable Beams	2.121 hours	Fills 2471 to 2472	2012.04.05 15:47:13 to 2012.04.05 17:54:29
Best Recording Efficiency By Lumi for one Fill	99.738%	Fill 2574	2012.05.01 03:33:18
Best Recording Efficiency By Lumi for one Day	99.279%	Day 129	2012.05.08
Best Recording Efficiency By Lumi for one Week	97.705%	Week 16	2012.04.15
Best Recording Efficiency By Lumi for one Month	94.638%	Month 6	2012.06.01

Figure shows the summary of data taking during year of 2012 and the table with the record values for this year.

Trigger Rates Monitoring

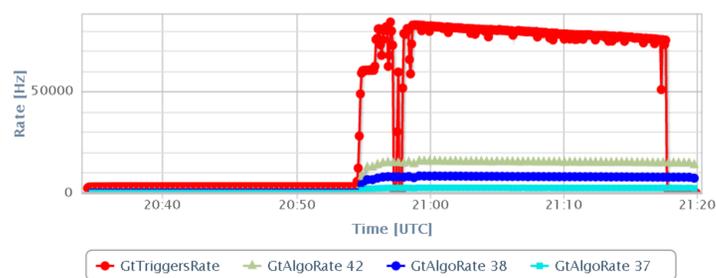
The LHC produces very high energy beams at very high luminosities leading to high rates of data production. Triggering is extremely important and necessary part of the CMS experiment. Monitoring the complex CMS trigger system is highly demanded WBM service. Trigger-History performs fitting for level 1 (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.

L1_DoubleMu5_EG5



Plot shows Level 1 trigger bits for p-p run.

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



Plot shows different L1 trigger rates for a particular CMS run

DataSummary

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 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.

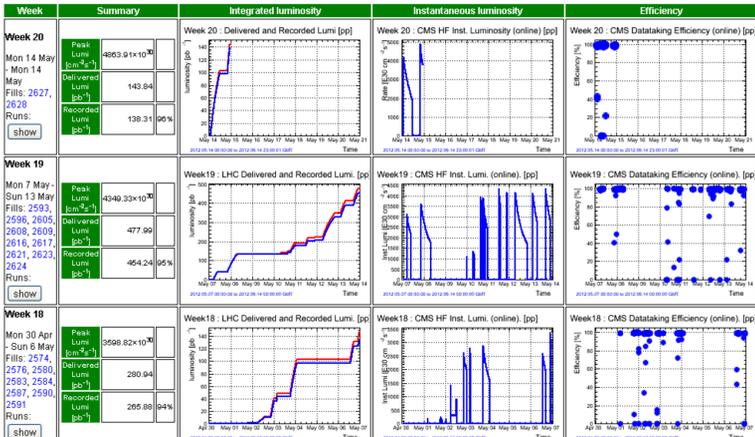


Figure shows summary of last three weeks of data taking with CMS detector.

Summary: In the 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 quality data taking. Developing new monitoring services to meet the demand of rapidly increasing instantaneous luminosity, WBM proved to be one of the key elements of successful operation of the CMS experiment.

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