OMS Data Aggregation and Management in the CMS Experiment



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CMS Online Monitoring System

The Online Monitoring System (OMS) at the Compact Muon Solenoid experiment (CMS) at CERN aggregates and integrates different non-event data sources of information into a central place and allows users to view, compare and correlate real-time and historical information. User interface of OMS is the browser and this screenshot shows the first page of the OMS.



OMS Data Management

Data management in the OMS involves handling both raw, pre-summarized and aggregated non-event data, each serving specific purposes in the context of the experiment. This drawing represents the OMS data sources.



The OMS data sources are two distinct types:

- 1. Standard: those accessible at the database level
- **2.** Custom: those are not directly available in the database

The CMS proxy DIP and the BRIL (Beam Radiation, Instrumentation, and Luminosity) eventing BUS are two distinct sources that are not available in the database.

				1	Apr 15 Apr 2	29 Apr 13 May 2	• Delivered	24 Jun Time [l	8 Jul UTC] orded lumi	22 Jul	5 Aug 19	9 Aug 2 S	Sep 16 Sep	30 Sep 14	0	<u>aDaqMon</u> <u>CMS Page1</u>
pp fills	up fills in 2024											G ~ 13				
Fill ↓	Run Range	Duration	Start Time UTC	Stable Beams Start UTC	Stable Beams End UTC	End Time UTC	Delivered Lumi pb^{-1}	Recorded Lumi pb^{-1}	Eff By Time %	Eff By Lumi %	Peak Lumi $10^{34}cm^{-2}s^{-1}$	Peak PU	Nb. Bunches	β* E	nergy GeV	Filling Scheme
<u>10218</u>	<u> 386849 - 386856</u>	10:08:46	2024-10-11 22:45:29	2024-10-12 00:33:29	2024-10-12 10:42:15	2024-10-12 11:13:57	740.628	669.133	95.59	90.35	2.153	65.455	2340	120 6	799.3	25ns_2352b_2340_2004_2133_1
<u>10216</u>	<u>386798 - 386844</u>	03:52:07	2024-10-10 16:01:04	2024-10-10 18:06:26	2024-10-10 21:58:33	2024-10-11 20:15:00	281.527	200.561	68.83	71.24	2.173	66.057	2340	120 6	799.3	25ns_2352b_2340_2004_2133_
<u>10215</u>	<u>386765 - 386797</u>	00:35:10	2024-10-10 07:51:13	2024-10-10 14:27:46	2024-10-10 15:02:56	2024-10-10 16:01:04	35.090	32.585	96.63	92.86	2.148	65.291	2340	120 6	799.2	25ns_2352b_2340_2004_2133_
<u>10214</u>	<u> 386754 - 386764</u>	01:00:53	2024-10-10 03:56:10	2024-10-10 06:49:22	2024-10-10 07:50:15	2024-10-10 07:51:13	43.234	40.359	95.37	93.35	1.311	53.960	1728	120 6	799.3	25ns_2352b_2340_2004_2133_1
<u>10213</u>	<u> 386743 - 386753</u>	10:04:56	2024-10-09 15:44:18	2024-10-09 17:46:30	2024-10-10 03:51:26	2024-10-10 03:56:10	100.798	95.400	96.67	94.64	1.947	59.185	2340	120 6	799.2	25ns_2352b_2340_2004_2133_
<u>10211</u>	<u> 386695 - 386714</u>	13:44:00	2024-10-08 21:44:22	2024-10-08 23:55:22	2024-10-09 13:39:22	2024-10-09 14:54:58	927.164	858.492	97.44	92.59	2.145	65.222	2340	120 6	799.3	25ns_2352b_2340_2004_2133_
<u>10210</u>	<u>386685 - 386694</u>	09:40:34	2024-10-08 09:55:37	2024-10-08 12:01:17	2024-10-08 21:41:51	2024-10-08 21:44:22	705.622	649.461	96.92	92.04	2.141	65.077	2340	120 6	799.3	25ns_2352b_2340_2004_2133_
10209	<u> 386674 - 386683</u>	02:19:57	2024-10-08 04:40:42	2024-10-08 07:19:42	2024-10-08 09:39:39	2024-10-08 09:55:37	166.893	151.907	96.38	91.02	2.130	64.752	2340	120 6	799.3	25ns_2352b_2340_2004_2133_
10208	<u> 386669 - 386673</u>	07:18:52	2024-10-07 18:44:15	2024-10-07 21:17:41	2024-10-08 04:36:33	2024-10-08 04:40:42	542.983	501.922	97.83	92.44	2.146	65.239	2340	120 6	799.3	25ns_2352b_2340_2004_2133_
<u>10207</u>	<u>386663 - 386668</u>	02:15:59	2024-10-07 14:18:05	2024-10-07 16:22:35	2024-10-07 18:38:34	2024-10-07 18:44:15	161.144	147.404	96.61	91.47	2.163	65.751	2340	120 6	799.3	25ns_2352b_2340_2004_2133_
10206	<u>386653 - 386661</u>	02:51:59	2024-10-07 09:44:09	2024-10-07 11:23:27	2024-10-07 14:15:26	2024-10-07 14:18:05	207.528	186.083	96.44	89.67	2.135	64.920	2340	120 6	799.3	25ns_2352b_2340_2004_2133_
10204	386638 - 386642	12:20:20	2024-10-06 18:10:31	2024-10-06 20:22:56	2024-10-07 08:43:16	2024-10-07 08:51:44	854.363	790.979	97.62	92.58	2.136	64.947	2340	120 6	799.3	25ns 2352b 2340 2004 2133

The OMS contains **information** about the following **categories**:







writes to database

OMS Data Warehouse

The CMS experiment chose the **Oracle database** as persistent storage for information to operate the experiment. Most of the non-event data sources in OMS are available in the Oracle database, hence during the design of OMS, Oracle and all its functionalities were chosen to build the OMS Data Warehouse. The OMS requires a data warehouse since retrieving data through regular SQL queries would take an unacceptably long time for users. As a result, this type of data needs to be pre-summarized or aggregated. This diagram represents the 4 schemas in the OMS project and their contents.



The pre-summarized or aggregated data by the system is generated using Oracle database scheduled jobs and PL/SQL These procedures procedures. are designed in such a way that if the raw data changes, the procedures can be re-run, ensuring that the aggregated or summed data remains up-to-date and reflects any modifications to the original data.

The CERN BE Common4Oracle library was chosen because it offers a collection of common functionalities:

Management of Logs, Errors, Partitions,

DCS CMS and sub-system data





Luminosity Data Summary

Downtimes bookkeeping and reports



The **primary objective** of OMS is to offer an interactive suite of tools that support centralized data taking with ease of use, security, flexibility, and maintainability as key priorities. The tool is used by run coordinators, trigger experts, shift crews, offline **& computing experts** and **CMS members**, to ensure the quality and efficiency of data taking. The OMS complements other data quality monitoring tools that rely on event data.

Events, Objects, History and Space;

Notifications of events (report, error, etc..) by email or TXT message.

Schema	Tables	Views	Triggers	Sequences	Jobs	Schema Size GB	Lines of PL/SQL Code *
CMS_OMS	53	5	42	33	23	35	28847
CMS_OMS_AGG	68	19	8	17	18	250	27022
CMS_OMS_DIPLOGGER	105	0	146	87	8	2753	23603
CMS_HLT_CPU_MON	12	0	5	1	0	126	36

Note *: The BE Common4Oracle library is installed in the CMS_OMS, CMS_OMS_AGG and CMS_OMS_DIPLOGGER schemas. The number of tables used by the library is 16, and the lines of PL/SQL code are 16557.

Over the past 5 years, **1.4 FTE** has focused on revamping inherited code from the previous project (Web-Based Monitoring) to meet evolving requirements by updating PL/SQL, creating new aggregation tables, and enhancing development workflows, naming conventions, and continuous integration strategies.

Additional Helpful Features



Technologies



Future Work

In LHC Run 3 (2022-2026), the main goal is to resolve long data insertion times caused by **slow** triggers linked to certain event notifications. To address this, **Oracle Advanced Queuing** (AQ) will be implemented to decouple data insertion from notifications, allowing the system to handle large data volumes more efficiently and manage eventdriven tasks independently.

Looking ahead to LHC Phase-2 (starting 2030), the focus will be on **adapting** the system to the **CMS experiment upgrade**. This includes integrating new CMS subsystems, a new Timing and Control Distribution System (with variable lumisection lengths), a new DAQ (hardware, and orbit building), an updated HLT, etc.



"Track 2 - Online and real-time computing" as Poster 28 in session "Poster" on Tuesday, the 22nd of October 2024

Architecture



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