OMS Data Aggregation and Management in the CMS Experiment

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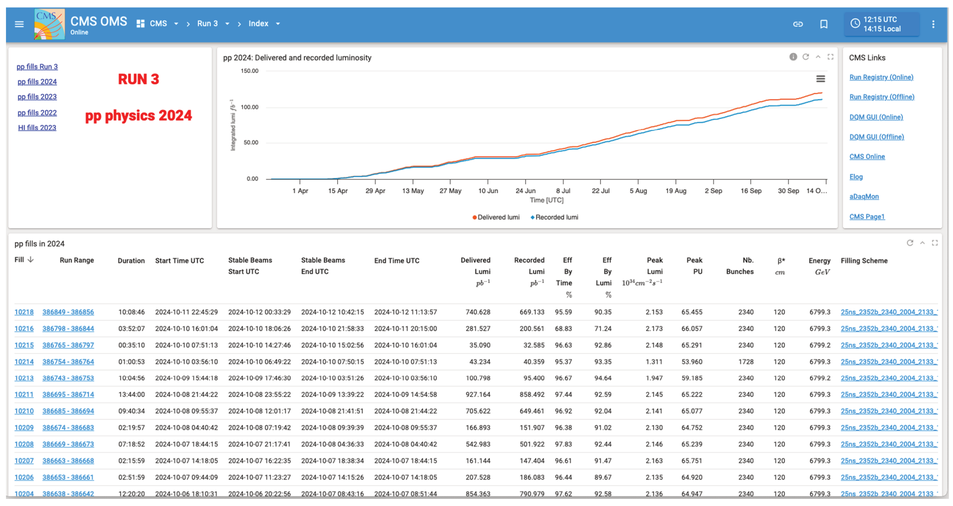
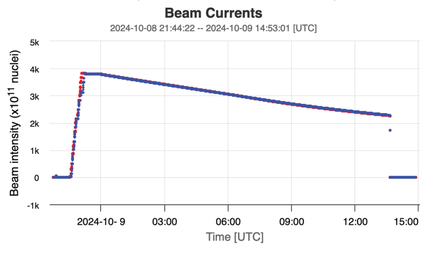
CMS Online Monitoring System

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.

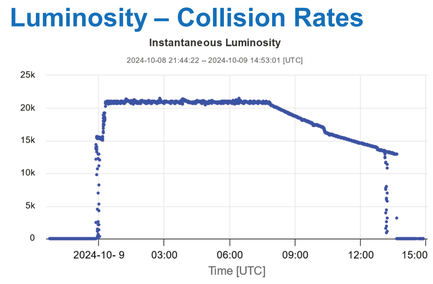


The OMS contains **information** about the following **categories**:

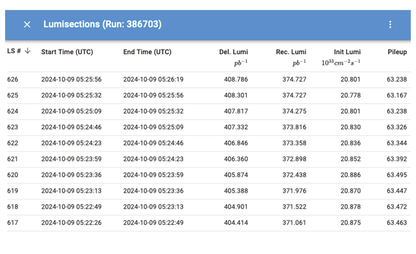
LHC – Fill, Beam currents, status



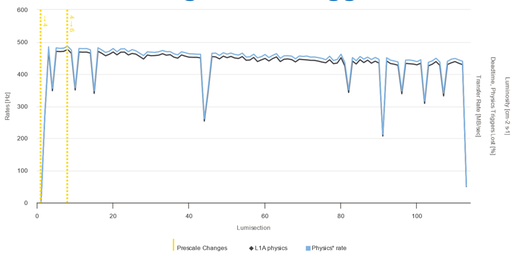
Luminosity – Collision Rates



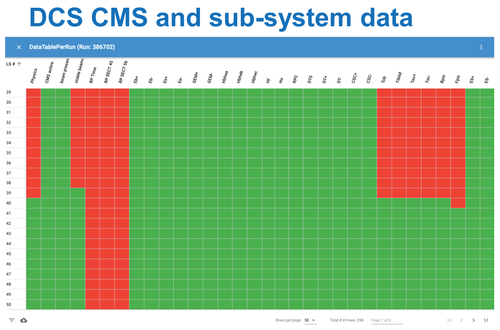
CMS Runs and lumisections



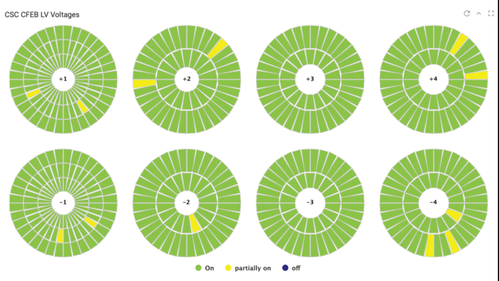
Level 1/ High Level Triggers



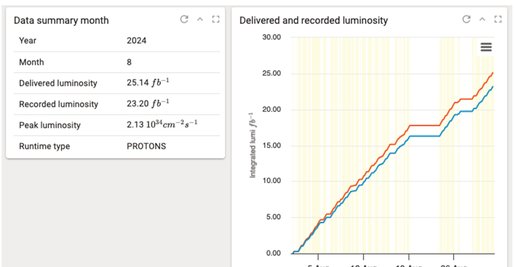
DCS CMS and sub-system data



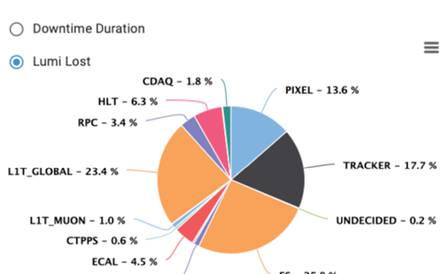
Sub-system specific information



Luminosity Data Summary

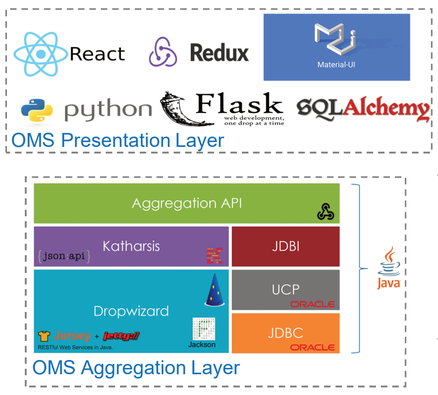


Downtimes bookkeeping and reports

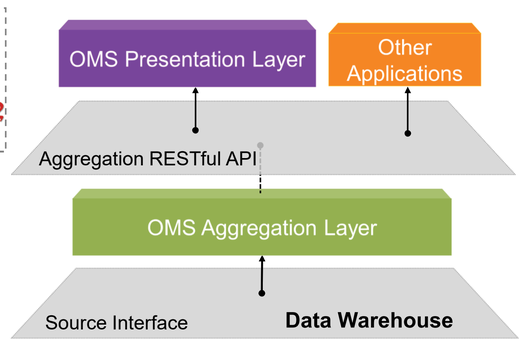


The **primary objective** of OMS is to offer an interactive suite of tools that support centralized data taking with **ease** of use, **security**, **flexibility**, and **maintainability** as key priorities. The tool is used by **run coordinators**, **trigger experts, shift crews, offline & computing 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.

Technologies

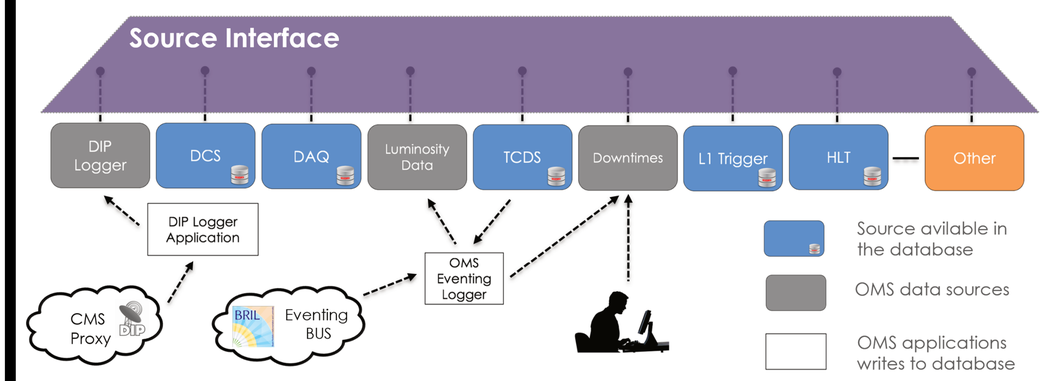


Architecture



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.



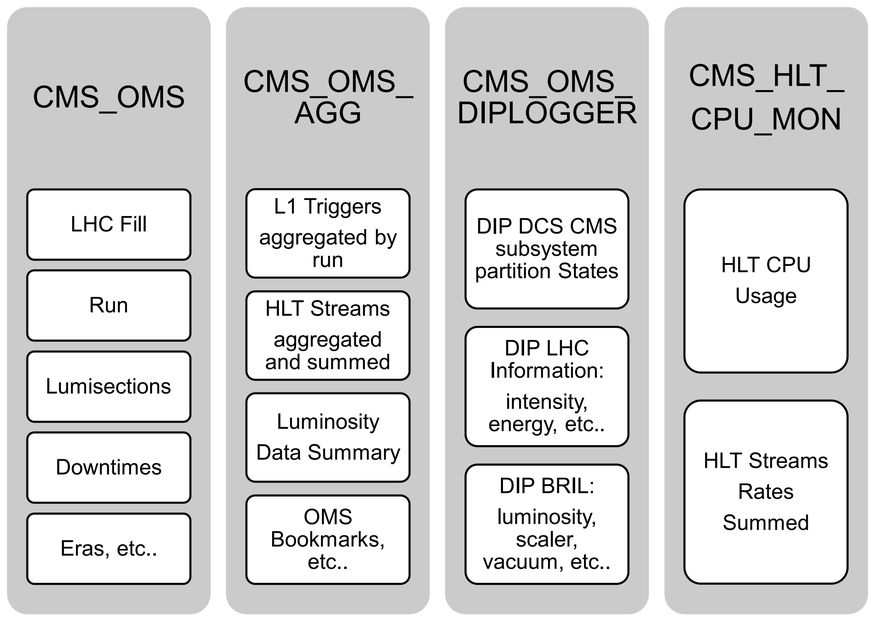
The **OMS data sources** are two distinct types:

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.

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 procedures**. These 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:

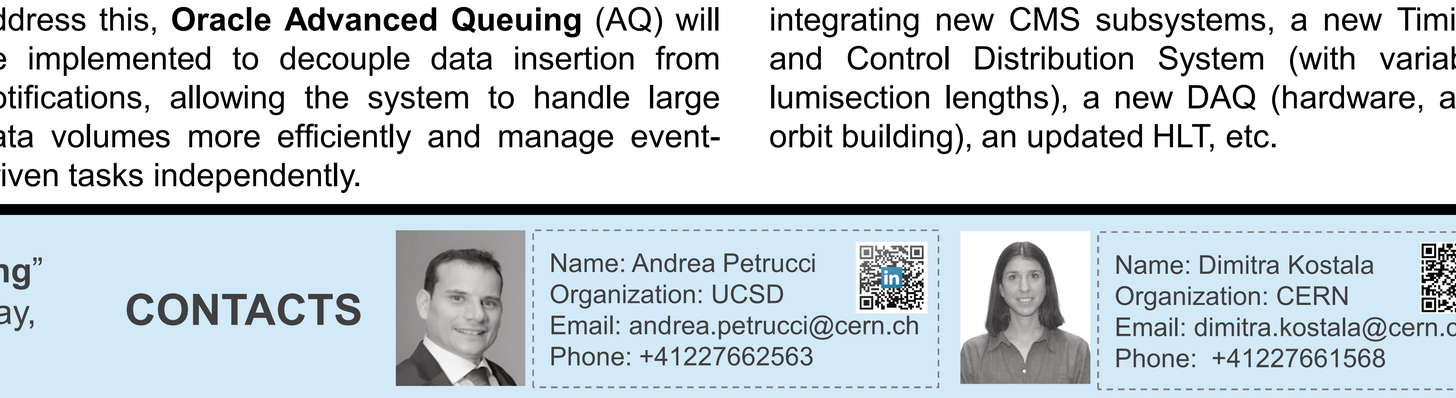
- Management of Logs, Errors, Partitions, Events, Objects, History and Space;
- Notifications of events (report, error, etc..) by email or TXT message.

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

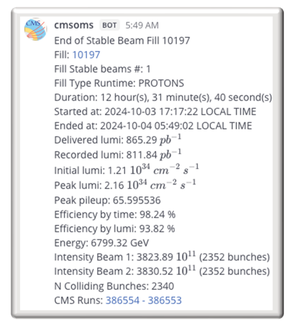
Note *: The BE Common4Oracle library is installed in the CMS_OMS, CMS_OMS_AGG and CMS_OMS_DIPLOGGER schemas. The number of tables used by the library is 16, and the lines of PL/SQL code are 16557.

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



End of stable beam Mattermost post



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 event-driven 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.

October 19 - 25, 2024
CHEP 2024

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

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