First year of experience with the new operational monitoring tool for data taking in CMS during Run 3



UC San Diego

Presenter: Andrea Petrucci (UCSD) on behalf of the CMS DAQ group Primary authors: Ulf Behrens (RICE) and Andrea Petrucci (UCSD)

**26th International Computing in High Energy & Nuclear Physics Conference** Hampton Roads II (Norfolk Waterside Marriott), 235 East Main Street, Norfolk, Virginia, USA - 9<sup>th</sup> of May 2023





# CMS Experiment & Operation

CMS Online Monitoring System
 Timeline of monitoring tool for data taking

# OMS: Architecture and Technologies

- Architecture
- Data Warehouse
- OMS Aggregation API Layer
- Presentation Layer
- Infrastracture

■ First year of experience with Online Monitoring System

# CMS Experiment & Operation

# CMS experiment at CERN



- The Compact Muon Solenoid (CMS) detector has an approximately cylindric shape with a diameter of 15 m and a length of 21 m, and weighs approximately 14,000 t
  - All inner detectors are immersed in a magnetic field of 3.8 T produced by a superconducting solenoid
  - It is designed to optimally detect all kinds of particles and especially muons with the Muon Chambers located in the return yoke of the magnet
- CMS is a complex system which needs fast and reliable monitoring
- Quick feedback is needed for efficient data taking



## CMS Collaboration – People statistics



247

INSTITUTES

COUNTRIES & REGIONS

5/

6288

ACTIVE PEOPLE (PHYSICISTS, ENGINEERS, TECHNICAL, ADMINISTRATIVE, STUDENTS, ETC.)

Of these members there are about:

2166 PHD PHYSICISTS

(1769 MEN, 397 WOMEN)

1228 Physics doctoral

PHYSICS DOCTORAL STUDENTS (919 MEN, 309 WOMEN) ENGINEERS (951 MEN, 151 WOMEN)

1102

3B

1388 undergraduates

(995 MEN, 393 WOMEN)

A typical CMS physics paper will be signed by the PhD physicists and a significant fraction of the doctoral students

meaning it will typically have about 2100 signatures.

# CMS Operation during Long Shut down 2 and LHC RUN 3





CMS **semi-remote** control room:

- Shift leader and technical shift at CMS experiment (P5)
- DAQ Shifter should be at P5 during Physics data taking and in other time could be remote
- Trigger and DQM shifter preferibly at P5 otherwise remote
- Remote sub-system shifters oncall 24/7
- Requirement for Tools used during data taking:
  - Tools needed for remote status display
  - Must be easy to use, flexible, drillable
  - **Security** is an important topic
  - Must survive world-wide operation

 World wide possible location for remote CMS shifters from their home institutes

# CMS Online Monitoring System







other more specific monitoring tools are used by all collaboration and







system

口 〇 18:39 UTC 20:39 Local

information

Level Triggers

CMS OMS 🔡 CMS + > Runs + > Run Report + > 🏟 Run: 361974

Luminos Collisio Rate

lumisections

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	Run	361974	Trigger	Rate Hz	Name		%	Stream $\downarrow$			DQM GUI (Online)		
	Fill	8387	L1A calibration	95.16	Total		6.10			_	DOM GUI (Offline)		
Luminosity –	Stable Beams	False	L1A physics	72528.65	TTS	:	3.05	ScoutingPF		1173	Pup Pagieter (Opli		ninositv
	Fill Type	PROTONS	L1A random	374.94	Trigger Rules	1	0.58	RPCMON		16	<u>Run Registry (Onin</u>		
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Rates	Lumisections	192	PhysicsGeneratedFD	L GT 76668.25	ReTri		0	PhysicsMuon		7		Sui	mmary
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	End Time (UTC)	2022-11-13 11:02:47	Total before deadtim	e 76766.46	Calibration		0.10	PhysicsEGamma		11			
	Delivered Lumi	$35.679 \ pb^{-1}$	Trigger physics beam	n active 72181.76	Software Pause		1.24	PhysicsDispJetBTag	MuEGTau				
	Recorded Lumi	33.706 $pb^{-1}$	Trigger physics beam	n inactive 346.89	Firmware Pause		0.09	PhysicsCommission	ing	10			
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	End Lumi	0 $10^{33} cm^{-2} s^{-1}$						HLTMonitor			/cdaq/physics/Ru	n2022/2e3	
	BField	3.8 T						Express		é			
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	Clock	LHC	Downtimes									G ^ []	
	Sequence	GLOBAL-RUN	Start Time $\downarrow$	End Time	Duration	Lost Group	Cate	gory	Subsystem	Details			
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Beam	Initial Prescale	<u>15</u>	2022-11-13 11:01:51	2022-11-13 11:02:04	00:00:13	0 DAQ	HV_F	RAMP	Other	Not sure which subsystem c	aused this downtime		desse
currents	Tier0 Transfer	True	2022-11-13 10:20:25	2022-11-13 10:20:37	00:00:12	0.105 DAQ	SOF	ERROR_RECOVERY	ES	ECAL Preshower subsystem	soft_error recovery		keeping
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# CMS Online Monitoring System (OMS)





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639640.9

False

L1\_SingleMu3

PIL

Rate vs Pile-up Plot









2023-04-30 10:18:56 2023-04-30 10:27:17

8690

00:08:20

1.708 DAQ

FED





TRG/UGT/1404 is stuck in TTS state WARNING

L1T\_GLOBAL

# Timeline of monitoring tool for data taking





# OMS: Architecture and Technologies

## OMS Architecture

### **OMS Aggregation Layer**

- Aggregation RESTFul API
  - Fetch data from database and expose it via Representational State Transfer (RESTful)

### Data Warehouse

 Responsible to aggregate and collect non-event data from heterogeneous sources, with different data formats and changing context

### **OMS Presentation Layer**

 Fetch data from multiple sources and display it via web interface (datatables, interactive charts, images, ...)

### **Other Applications**

 Any CMS project can use the Aggregation RETSFUL API for online or offline processes.



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## The RESTFul Aggregation API is a Java web application used to retrieve the OMS data from database:

### □ JSON:API specification

QueryBuilder library generates a dynamical SQL query based on the REST request

### **Scalable**:

- Request connection pools
- Database connection pools
- Support of multiple database instances
- Available the Python REST Client for automation scripts:
  - Used by other applications





## OMS Data Warehouse

- □ The OMS Data Warehouse is based on PL/SQL running on ORACLE database
- The main goal was to re-design the PL/SQL of the WBM project:
  - Design new Aggregation tables (Lumisections, Run, Fill, etc.)
  - Use **name** and **code convention** for PL/SQL development
  - Setup development environment for PL/SQL
  - Define a workflow for **continuous integration** for PL/SQL
  - Management of Oracle schemas for OMS project
  - Select PL/SQL common libraries:
    - CERN BE Commons4Oracle project took all common functionality from all BE databases and combine into a common code set for use everywhere:
      - Logging, Event Management, Error Management, Notifications, Job Surveillance / Reporting, Partition Management and Data History Mechanism







## OMS: Presentation Layer





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# OMS: Presentation Layer - Content organisation



- Workspace top-level container defines organizational unit, sub-detector, etc.
  - **Folder** lower-level container contains Pages organized by context.
  - Page lowest-level content container contains of one or more Portlets.
  - **Controller** (optional) component allows user to filter result set.



**Portlet** - a content presentation component.





- The portlet is a **reusable** content presentation component.
- Displays **single** well-defined aspect of information: chart, datatable, text, etc.



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## OMS Infrastracture



- The OMS Infrastructure is based on the OMS applications, virtual machines and proxies running at the CMS experiment (LHC P5) or CERN IT infrastructure:
  - Stable and settled
  - P5 (main services) and IT (external access)
  - CentOS 7.9 (moving to RHEL 8), java 8, python 3, ES6 Javascript
  - Deployed with puppet at P5 using dropbox
  - Single sign-on authentication using OAUTH2 (openidc):
    - no private passwords, certificates needed

## System of Reverse Proxies



### Authentication required. CMS membership required. Exceptions for LHC coordinators.

First year of experience with Online Monitoring System



- The OMS is an essential tool for CMS data taking, commissiong, online/offline data quality and physics analysis
  - Non-event data must be monitored efficiently or data taken might not be useful for physics
  - Experts from different systems need to correlate information to identify the cause of problems
  - It is used by all the CMS community and it keeps historical information about the past data taking (example: LHC RUN 1 and 2)



CMS experiment: Run 3 started First proton collisions at 13.6 TeV – 05/07/2022

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## Questions?



#### Authors:

- Behrens, Ulf (RICE)
- Petrucci, Andrea (UCSD)

#### **Co-Authors:**

Amoiridis, Vassileios (CERN); Bocci, Andrea (CERN); Branson, James (UCSD); Brummer, Philipp (CERN); Cano, Eric (CERN); Cittolin, Sergio (UCSD); Da Silva Almeida Da Quintanilha, Joao (CERN); Darlea, Georgiana-Lavinia (MIT); Deldicque, Christian (CERN); Dobson, Marc (CERN); Gigi, Dominique (CERN); Glege, Frank (CERN); Gomez-Ceballos, Guillelmo (MIT); Gutic, Neven (CERN); Hegeman, Jeroen (CERN); Izquierdo Moreno, Guillermo (CERN); Kartalas, Miltiadis (CERN); Krawczyk, Rafal (RICE); Li, Wei (RICE); Long, Kenneth (MIT); Meijers, Frans (CERN); Meschi, Emilio (CERN); Morovic, Srecko (UCSD); Orsini, Luciano (CERN); Paus, Christoph (MIT); Pieri, Marco (UCSD); Rabady, Dinyar Sebastian (CERN); Racz, Attila (CERN); Sakulin, Hannes (CERN); Schwick, Christoph (CERN); Simelevicius, Dainius (Vilnius University); Vazquez Velez, Cristina (CERN); Zejdl, Petr (CERN); Zogatova, Dominika (CERN); Zhana, Yousen (RICE)

Presentations at CHEP2023

- CMS Data Acquisition
  - May 9, 11:30 AM Track 2 Andrea Petrucci
    - First year of experience with the new operational monitoring tool for data taking in CMS during Run 3
  - May 9, 4:30 PM Track 2 Rafal Krawczyk
    - Event Building studies for CMS Phase-2 at CERN
  - May 11, 12:00 PM Track 2 Dainius Simelevicius
    - Towards a container-based architecture for CMS data acquisition
  - May 11, 12:15 PM Track 2 Philipp Brummer
    - MiniDAQ-3: providing concurrent independent subdetector datataking on CMS production DAQ resources

#### CMS High Level Trigger

- Poster Session Abdulla Mohamed
  - Optimising the configuration of the CMS GPU reconstruction
- May 9, 2:30 PM Track X Ganesh Parida
  - Run-3 Commissioning of CMS Online HLT reconstruction using GPUs
- May 9, 5:00 PM Track 2 Andrea Bocci
  - Adoption of the alpaka performance portability library in the CMS software

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# OMS: Presentation Layer - Content organisation



Solution Workspace – top-level container defines organizational unit, sub-detector, etc.

Folder – lower-level container contains Pages organized by context. Page – lowest-level content container contains of one or more Portlets.



**Portlet** - a content presentation component.



### **Controller**:

- Controller is a reusable filtering component.
- User selected filter is applied to all Portlets within the Page.

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# OMS: Presentation Layer - Portlet

- Portlet is a reusable content presentation component.
- Displays single well-defined aspect of information: chart, datatable, text, etc.
- Similar to Master-Detail, but it is Many-to-Many relationship.:
- Portlets can be assigned into groups. Multiple groups can be within a Page.
- Portlets communicate with each other only within a group scope.
- Action in one Portlet causes other Portlets update accordingly

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<u>318876</u>	01:03:28 2018-06-28 19:44:2	4 2018-06-28 20:47:52	47.401	44.185	233883654	collisions2018	"l1_triggers_counter":
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{ "label "props "hre "/cms/r "par "typ }	": "Run", e": "run_number", s": { ef": runs/report?cms_rur rams": ["run_numbe pe": "link"	<pre>{     "label": "     "name": "     "props": "     "type":     "r"], }</pre>	<pre>{     "Duration",     ": "duration",     ": {     e": "duration"</pre>			Aggregation API	
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