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# Advanced monitoring capabilities of the CMS Experiment for LHC Run3 and beyond

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#### On behalf of The CMS collaboration





### **CMS-monitoring-project**

#### CMS Monitoring & analytics

150+ Worldwide LHC Computing Grid sites (To, T1s, T2s and T3s) (Storage &Compute)

Services utilizing this infrastructure Statistics and metadata generated by these services

| CMSSDT CMSWEB CRAB                               | Jobs P&    |                                       |            | ch CMSMONIT JIRA DOCUMENTATION  | s Others |  |   |
|--|------------|---------------------------------------|------------|---|----------|--|---|
| Production Development Pl                        | ayground C | ontacts Meetings Migrations Data      | popularity | CRSG Plots Archive  |          |  |   |
| Tier0 ⓒ  |            | CRAB ()                               |            | Space Monitoring ③  |          | OpenSearch / ES endpoints  |   |
| CMS TIER0 Job Statistics<br>Production           | ☆          | CRAB ASOMetrics<br>Production         | ☆          | Rucio Used Space in Disk and Tape<br>Rucio File Deletions<br>Rucio Datasets Daily Stats     |          | monit-opensearch (new monit-kibana)<br>monit-opensearch-It (new monit-kibana-acc)<br>monit-timberprivate (cmsweb tenant) |   |
| CMS TIER0 Overview<br>Production                 | 合          | CRAB Metrics<br>Production            | 合          | Rucio Subscriptions<br>Rucio Account Monitoring<br>Rucio Account Activity Monitoring        |          | es-cms (Completed Condor jobs)   |   |
| CMS TIER0 Production<br>Production               | 合          | CRAB Alerts<br>Production             | 合          | Rucio Activity Monitoring<br>Rucio Quotas   |          |  |   |
| CMS TIER0 ReplayID Monitoring                    | ¢          | CRAB crabserver timber 🏠              |            | Rucio Fast Datasets Tables<br>EOS Quotas And Usage HTML Table<br>EOS Quotas And Usage Plots |          | StatusBoards ③   |   |
| EOS Control Tower ③<br>EOS Control Tower - CMS   |            | CRAB FE timber + pods<br>Production   | 合          | Rucio Rules Monitoring  |          | CMS Monitoring Data Source Status<br>Production  | ¢ |
|  |            | WMAgent ③                             |            | AAA Infrastructure ③  |          | CMS Monitoring K8S Clusters Status<br>Production   | ሰ |
| Jobs ③<br>CMS Job Monitoring - 12m<br>Production | ☆          | CMS WM Central Services<br>Production | 合          | CMS FTS metrics<br>Production   | 合        | Cmsmon k8s cron metrics<br>Production  | ☆ |
|  |            | CMS WMAgent Monitoring<br>Production  |            | Overview / Service Availability<br>Production   | 合        | Sqoop dumps statistics<br>Production   | 合 |
| CMS Job Monitoring - 12m (Bars)<br>Production    | Ω          | Production jobs exit code monitoring  |            | Site subscription   |          |  |   |

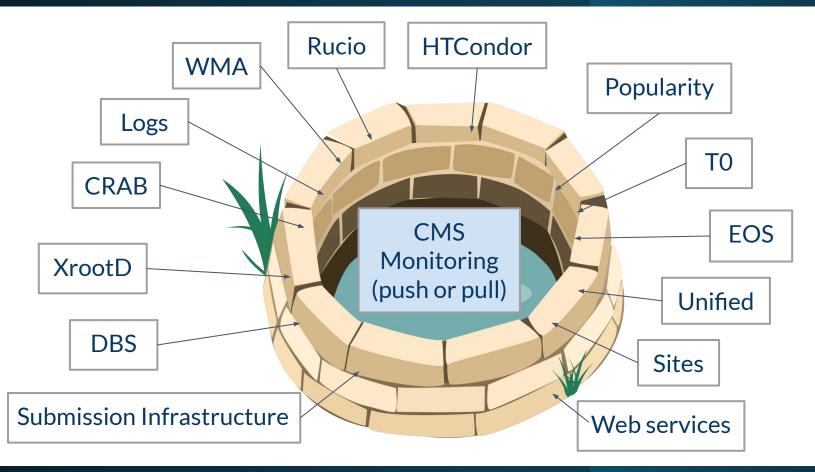
#### Baseline requirement

- Growing datasets and services
- Near real-time monitoring
- Metrics for general and detailed dashboards
- Smart alert system
- Store historical information

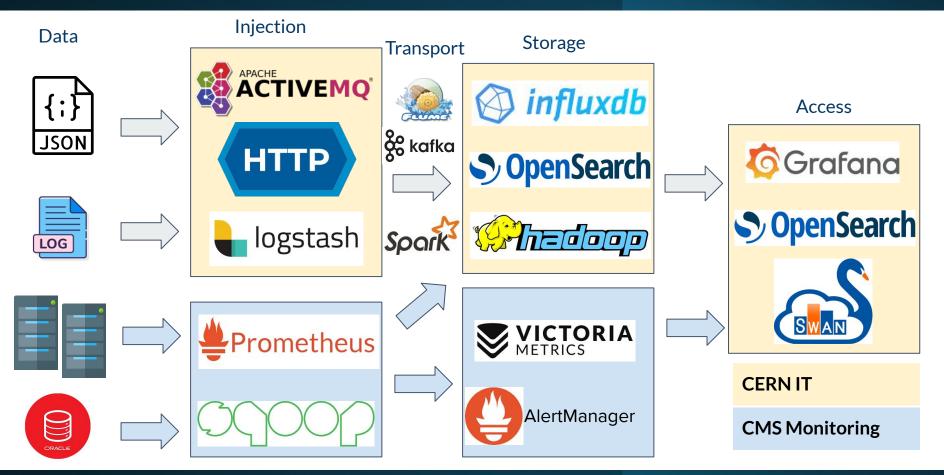
#### Infrastructure and services

- Leveraging open source tools
- Scalable microservices architectures
- CERN-Monit backend.

#### What do we monitor



#### Data-flow: or 'death by a thousand acronyms!'



## Infrastructure and services

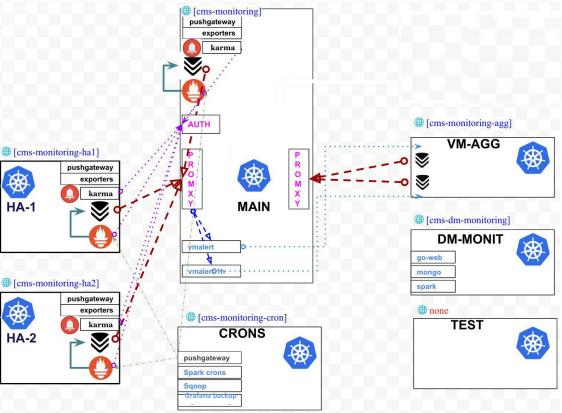
- We manage:
  - 6+1 kubernates (k8s) clusters
  - 150+ Grafana dashboards in production (>750 overall)
  - 3x60 Billion data points
  - $\circ$  10+ TB of data on OpenSearch
  - $\circ$  55+ TB of compressed data on HDFS
  - 4-5 M msg/hour to AMQ brokers with
    6.5 kHz
- We monitor:
  - 25+ k8s clusters
  - multiple services on VMs
  - $\circ$  100+ services on k8s
  - 150+ alert rules



### K8s Infrastructure

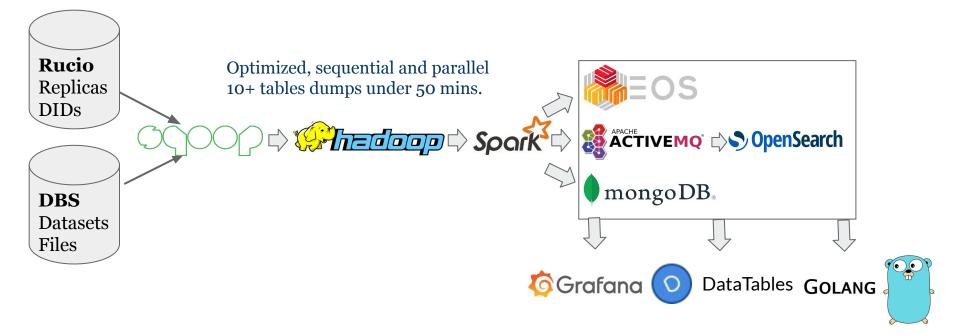
#### Robust infrastructure with zero downtime

- Prometheus (High Availability mode), VictoriaMetrics, AlertManager and Exporters: MAIN, HA-1, HA-2
- Single Grafana data-source to thousands metrics of Prometheus and VictoriaMetrics via Promxy
- Long-term time-series metrics storage for aggregated data: (2xVictoriaMetrics) VM-AGG
- Rucio dataset monitoring DM-MONIT
- Data aggregation/ETL batch jobs (Spark, Sqoop, etc.): CRONS



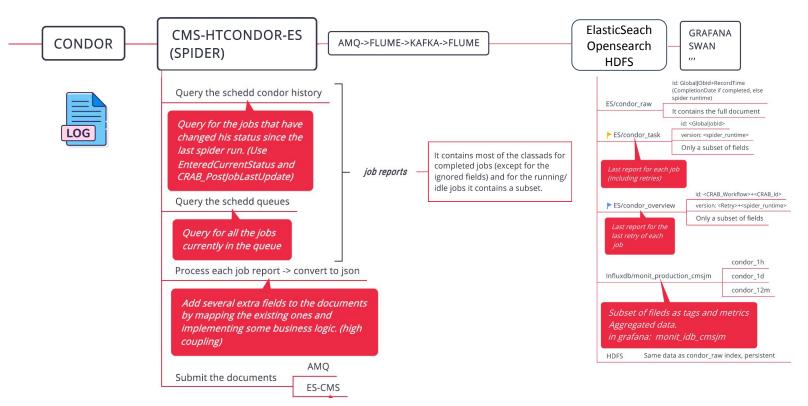
### **Rucio Dataset Monitoring**

- Detailed view (tables) of all datasets (Name, Size, RSE, Creation date, Last access)
- Time-series monitoring of dataset metrics

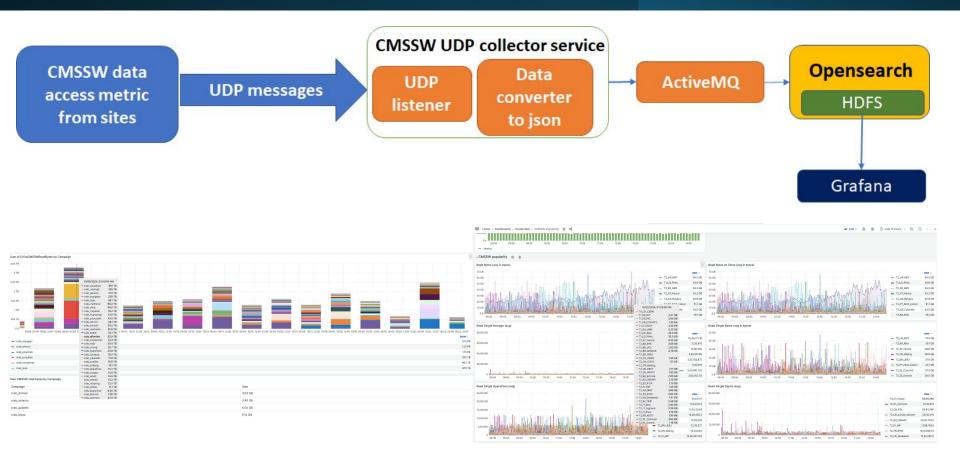


# HTCondor job monitoring

The <u>CMS htcondor ES</u> (or spider) is a set of scripts which consumes CMS HTCondor ClassAds (Job processing docs), converts them to JSON documents and feeds them via <u>CMSMonitoring/ActiveMQ</u> module to CERN MONIT infrastructure.



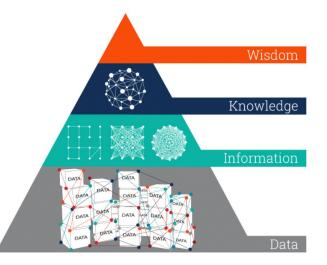
#### CMSSW popularity service



#### Infrastructure advancements

- Unified configuration management: Collected ownership of data pipelines from various users into a single service account, simplifying the system.
- Database Upgrade: Migrated from MongoDB to OpenSearch for improved data storage and query performance.
- Cronjobs Migration: Cronjobs (e.g sqoop jobs, spark jobs, backup jobs) from virtual machine to Kubernetes.
- Visualization Change: Transitioned from DataTables to Grafana for more advanced, user-friendly data visualization, allowing the creation of summarized charts.

- CMS Offline and Computing developed a comprehensive monitoring infrastructure
  - Use of common tools and technologies, keeping maintenance and operation tasks to minimal
  - Custom applications for specific use cases
  - System is performing well during Run-3 and evolvi for Run-4 and beyond.



### What gets monitored gets improved

# Thank you