CONTINUOUS AND PROMPT MONITORING AND CALIBRATION OF THE CMS DETECTOR BEYOND RUN BOUNDARIES

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Beyond the run boundaries

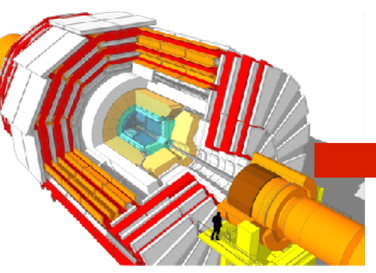
WHAT: continuous and unattended prompt calibration and Data Quality Monitoring workflows.

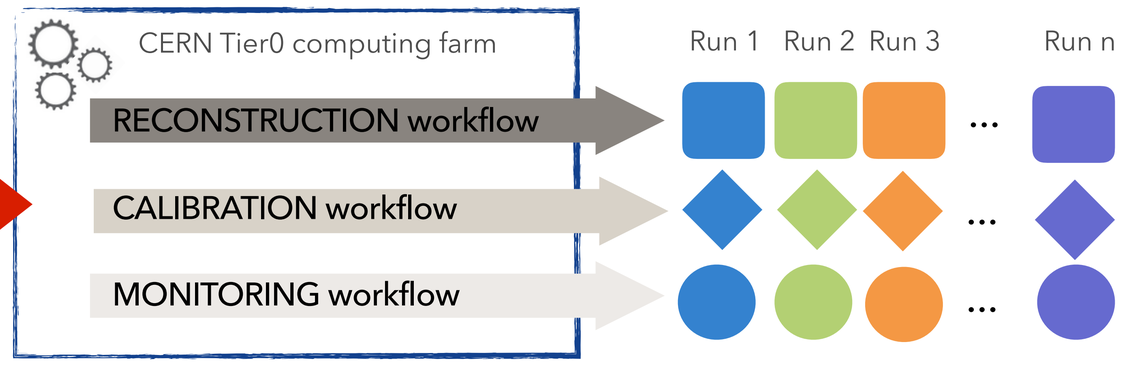
THE OLD PARADIGM: data processing is bound to the concept of acquisition run. As a consequence, the statistics available for the calibrations and monitoring workflows is limited. The computing infrastructure is agnostic to the physics content and detector conditions of each run.

GOAL: **increase statistics** available for Calibration and Monitoring workflows **aggregating multiple runs**.

HOW: configurable and **light-weight layer on top of Tier0 infrastructure** to:
- implement dataset-creation logic based on run/detector/reconstruction properties;
- execute calibration/monitoring jobs on quantities precomputed by Tier0;
- upload results to DQM and Condition infrastructure.

CHALLENGES:
- rely on Tier0 workflows for CPU intensive computation;
- maintain the additional infrastructure in sync with software and configuration s used by Tier0 ;
- run continuously and unattended.





Tier0 processing

EXPRESS PROCESSING: selection of data for low-latency workflows:
- reconstruction **latency 1-2 hours**
- ~50-100Hz bandwidth shared by:
  - calibrations
  - detector monitoring
  - physics monitoring

PROMPT PROCESSING:
bulk of the data (~1kHz) meant for physics analysis
- reconstruction **latency 48h to allow for prompt calibration**
- split into datasets according to physics content
- need monitoring of physics performance

AlCaRECO Datasets

Data skimmed **selecting events and customising event content** for each Alignment&Calibration (AlCa) workflow ⟶ **AlCaRECO datasets** are used as input to the automated calibrations.

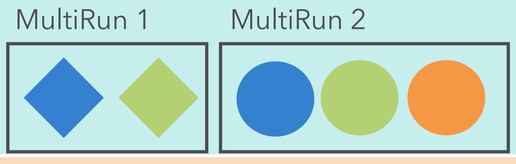
Data Quality Monitoring

Monitoring histograms are filled during reconstruction and stored in dedicated format allowing to aggregate the statistics across the single processing job. The resulting plots are browsed by sub-detector and physics object experts.

1. Data discovery & dataset creation

Aggregates information from different sources **deciding if runs can be merged in a Multi-Run Dataset** for a given workflow
Main criteria considered
- compatible trigger menus
- processed with compatible CMSSW release
- same B-field
- compatible calibrations
- Tier0 express processing completed

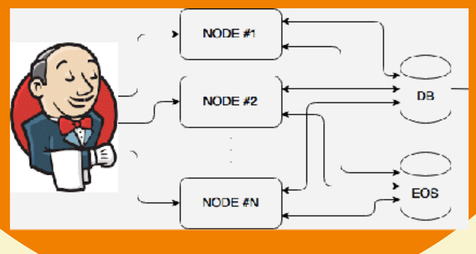
New Multi-Run Datasets created in dedicated DB tables
- input files (produced by Tier0 workflow)
- status of the processing
- other metadata (configuration parameters)



Jenkins: the "director"

Spawns jobs on dedicated batch resources (CMS Analysis Facilities)
- 4 jobs flavours → 4 tasks
- jobs read and write metadata to **DB**
- jobs read and write data to **EOS**

Handles job failures, notifications, resource management & credentials

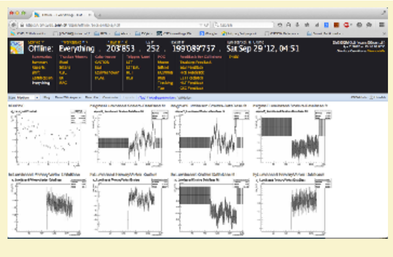


2. Multi-Run Harvesting

Run single CMSSW job with same configuration (& code) used @ Tier0
- **Input**: all PCL products produced @ Tier0 for all runs in a given Multi-Run Dataset
- **Output**: Data Quality Monitoring plots & DB payload for calibrations (if statistics allows)

3. DQM Upload

Quantities relevant for the given workflow are monitored in **plots aggregating the statistics across runs**.
Products are **uploaded on Graphical User Interface** for browsing by experts.



4. Condition DB Upload

Calibration **payloads** (temporarily stored in sqlite) are **uploaded to the Condition DB** (ORACLE) via a dedicated upload service.
The service **enforces reproducibility** policy avoiding to overwrite conditions already consumed by HLT or Prompt Reconstruction.

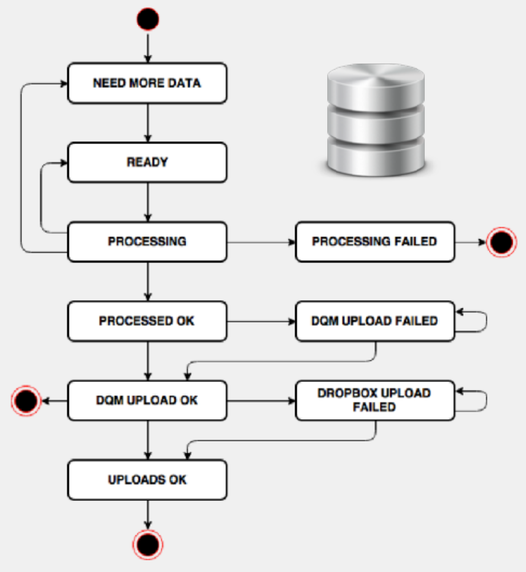
The **upload is steered by a metadata file** (**JSON dictionary format**) specifying:
- destination account
- target tag name
- Interval of Validity (IoV) of the new payload

These metadata can be configured at run time.

Multi-Run Dataset DB

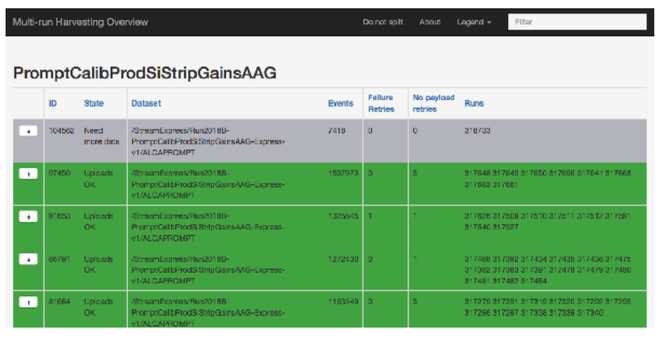
All information about Multi Run processing is stored in a DB (ORACLE):
- details about Multi-Run dataset;
- status of the processing.

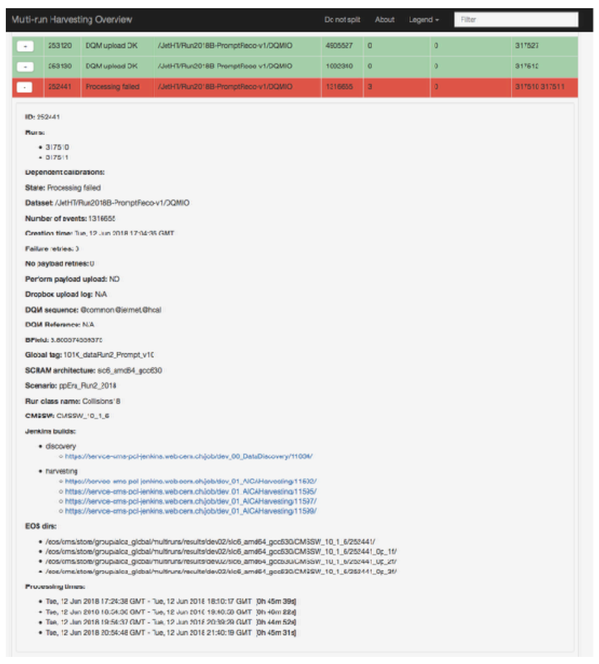
The status of the processing is tracked by a **state machine**: each task decide what to do on the basis of the status of the run and updates it consequently.
Simple and resilient system:
- easy monitoring of Multi-Run dataset;
- jenkins' tasks are independent and can run in parallel;
- failure sates are tracked and used to resubmit problematic jobs.



Monitoring Applications

Monitoring and alarm system crucial for reliable unattended operation.
Tier0 part of the workflow monitored by dedicated applications (**pclSpy**).
Multi-Run infrastructure monitored via:
- Jenkins notification system;
- dedicated Web-based application for browsing Multi-Run Database (state machine and metadata).



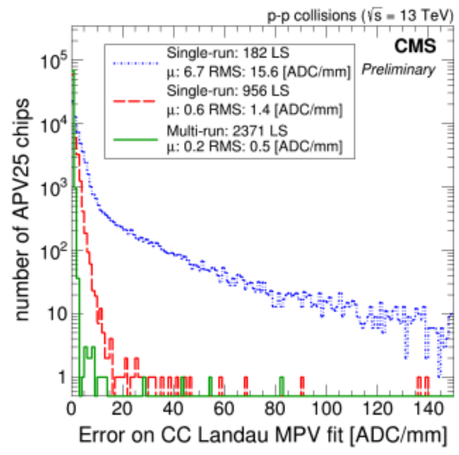


Multi-Run workflows

Workflows currently being commissioned or in production:
- Monitoring of L1 and HLT trigger efficiencies for low-rate triggers;
- Calibration of tracker Silicon Strip charge gains.

Si-Strip Gain calibration:
corrects the digitized charge of each Si-Strip cluster to account for differences in readout chains (due to operational temperature and radiation) and among the sensors (due to thickness and aging effects) which generate non uniform signal yield for a minimum ionizing particle (m.i.p.) across the detector.

The calibration procedure **requires** a **sizable amount of clusters on tracks** (~1B) in order to calibrate O(80,000) APV25 readout chips.



The error on the most probable ADC/mm value extracted from a fit of the cluster charge (CC) distribution to a Landau probability density function is shown in the picture for different statistics.
This demonstrates that the **target required accuracy of ~ 1% (3 ADC) can be achieved only when merging several runs.**

Outlook

The gain in statistics will open the door to new more accurate workflows without paying the price of additional processing or data bandwidth.

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