Trigger Algorithms for Alignment and Calibration at CMS

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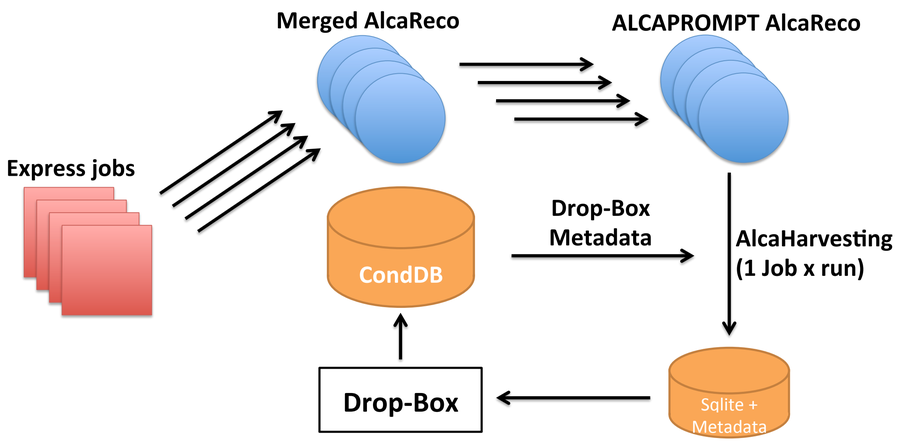
Overview

The CMS online event selection system is implemented in two steps. The Level-1 Trigger is implemented on custom-made electronics and dedicated to analyse the detector information at a coarse-grained scale, while the High Level Trigger (HLT) is implemented as a series of software algorithms, running in a computing farm, that have access to the full detector information. A dedicated set of HLT algorithms are used to meet the data needs of the Alignment and Calibration group at CMS. We describe here that set of algorithms, how it fits in the general infrastructure of the HLT, and how it feeds the Prompt Calibration Loop (PCL), allowing for a fast turnaround for the calibration constants.

Prompt Calibration Loop – PCL

The PCL is embedded in the overall CMS data-taking workflow. Compact datasets named **AlcaReco** are produced automatically, with reduced event content, for input to the alignment and calibration algorithms. The resulting calibration conditions are transferred to the online environment of the CMS detector site via a database system.



- **Express Processing**:
  - parallel jobs on Express Stream
  - very short latency (maximum of a couple of hours)
  - output: merged AlCaReco datasets
- **AlCaReco splitting**:
  - parallel jobs on merged AlCaReco
  - CPU intensive computations to produce calibrations
  - aggregated products: ALCAPROMPT dataset
  - 1 job per N luminosity sections
- **AlCaHarvesting**:
  - 1 job per run for all the ALCAPROMPT files
  - output: calibrations in a (transient) SQlite file
  - framework job-report to the offline drop-box metadata
- **conditionsUpload**:
  - ordered upload of the SQlite files to conditions database
  - at least 1 file per PCL workflow

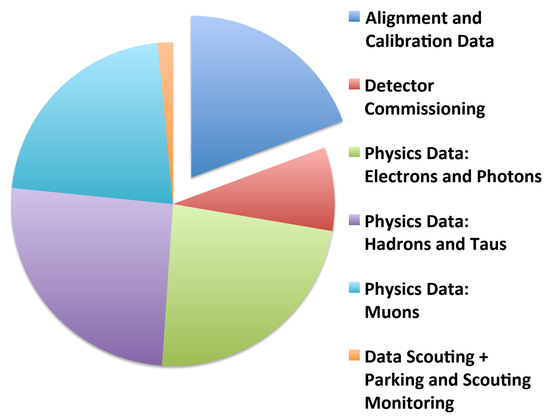
Alignment and Calibration in PCL

- Fit of the luminous region 3D position and widths as function of time. At most 1 fit every luminosity section (= 23.31 s).
- Identification of Silicon Strip Tracker problematic channels. At most 1 set identified per run.
- Determination of Silicon Strip Tracker gains. At most 1 set determined per run.
- Track based alignment of Silicon Pixel Tracker large structures. At most 1 geometry alignment per run.

Additionally, monitoring of the ECAL crystal radiation damage runs on dedicated online resources. One measurement every $\sim$ 30 minutes.

Thanks to the PCL, the best calibrations are available in 1–2h for prompt data reconstruction. With the current data volumes, and re-reconstruction campaigns limited to no more than once a year, CMS physics performance depends on it.

Alignment and Calibration Triggers

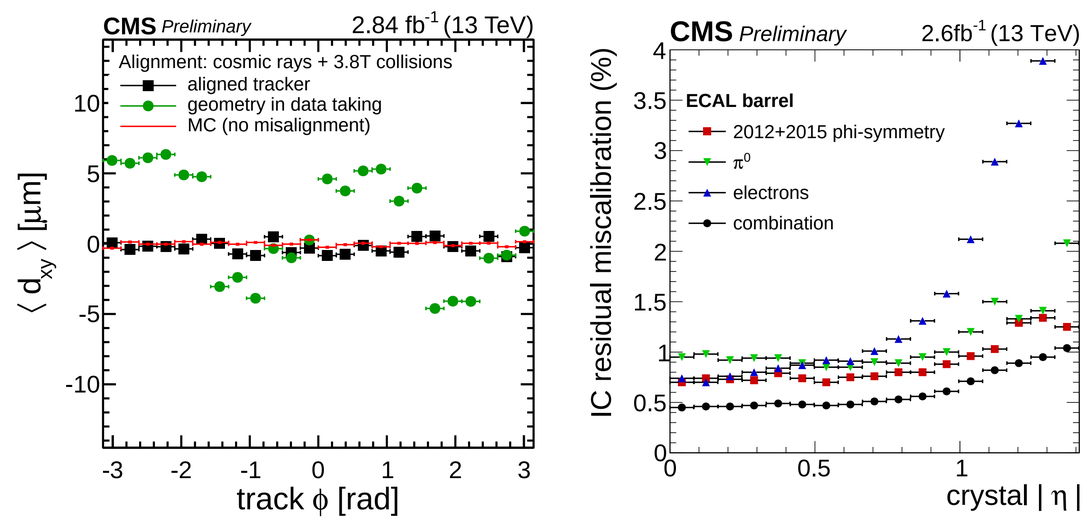


HLT algorithms for subdetectors	
TRACKER	ECAL
Random triggers	η, π^0 triggers
Zero bias	ϕ-symmetry
Isolated / leading bunch	Single, double e
HCAL	MUON
Non-zero suppressed	RPC monitoring
ϕ-symmetry	Single, double μ
Isolated tracks	Cosmic ray triggers

Collected data are grouped in streams, with dedicated streams for alignment and calibration needs, and streams for physics data, commissioning and monitoring (chart). The needs of the subsystems are addressed through different HLT algorithms (table).

- Three classes of triggers
  - **Express Stream**: low rate ($\sim$ 50 Hz out of 1 kHz) stream with trigger paths for the Prompt Calibration Loop
  - **AlCA Streams**: triggers for stream populated with reduced event content $\rightarrow$ smaller size $\rightarrow$ higher rate allowed
  - **Physics Streams:** selected trigger paths used for alignment and calibration purposes

Results



Alignment and calibration results: distance in the transverse plane of the track at its closest approach to a refit unbiased primary vertex (left) and residual miscalibration of the ECAL barrel (EB) channel inter-calibration (right).

Analyses presented at this ICHEP were able to use the 12.9 fb^{-1} dataset collected until July 15th with the latest calibrations, thanks to the Prompt Calibration Loop. Detector Performance Groups collected a significant number of events for alignment and calibration that will be used to deliver the ultimate conditions for 2016 data.

Acknowledgements

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References

[1] CMS Collaboration, "The CMS experiment at the CERN LHC", *JINST* **3** (2008) S08004.
[2] G. Cerminara and B. van Besien, "Automated workflows for critical time-dependent calibrations at the CMS experiment", J. Phys. Conf. Ser. **664**, no. 7, 072009 (2015).