Data Quality: Online Luminosity Monitoring Overview

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Luminosity Taskforce

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Outline

- Luminosity Basics
- Online Luminosity Responsibilities
- Online Luminosity Infrastructure
- Short-Term Goals

Actual shifter instructions: DQ session tomorrow!

What All Analysts Learn About Luminosity

From an arbitrary process $pp_{\text{inel}} \to Y$ at the LHC:

How many $pp_{\text{inel}} \to Y$ events were produced during a run of duration T?

$$N_{pp_{\text{inel}} \to Y} = \int_0^T \mathcal{L}(t)\,dt \times \sigma_{pp_{\text{inel}} \to Y}$$

where the instantaneous luminosity ($\mathcal{L}$) is time-dependent, accounting for the varying LHC conditions during the run (proton burn-off, etc.).

- Fundamental for cross-section measurements ($pp \to W/Z$, $pp \to t\bar{t}$, $pp \to H$, ...)
- Crucial for estimating sensitivity of model-dependent searches.
- Needed to normalize MC samples.

Other Uses for Luminosity Information

- LHC operators use $\mathcal{L}(t)$ measured by the experiments to optimize collisions at the interaction points.
- The luminosity signals (along with other indicators) when LHC conditions are adequate for physics data-taking.
- Forms the basis for the adjustment of the triggers during data-taking (prescales, etc.).
- The time-evolution of the luminosity together with the beam-spot parameters provide accelerator diagnostics that cannot be obtained by any other means:
  - Often needed during LHC development even if no ATLAS data is taken.

Online Luminosity Monitoring Responsibilities

- **Detector Desks**:
  - Monitor the performance of the detectors up to and including the raw luminosity data they publish on the Information Service (IS).
    - Calorimeters Desk: LUCID, FCal, Tile, EMEC.
    - Inner Detector Desk: BCM, DBM, (Pixel, SCT and IBL for offline).
    - Trigger Desk: MBTS.
- **Run Control Desk**:
  - Monitors the luminosity infrastructure:
    - Luminosity data flow from detectors to luminosity online tools (OLC).
    - Archiving in COOL database for offline use (OLC2COOL).
- **Data Quality Desk**:
  - Monitors the content of the luminosity publications from the luminosity infrastructure and their internal consistency.

Luminosity: Which One?

- **Instantaneous Luminosity**:
  - $\mathcal{L}$ as previously defined.
  - Calculated by the Online Luminosity Calculator (OLC) for the shortest time interval possible for a particular detector.
  - Updates typically every 1-2 seconds for BCM and LUCID.
- **Luminosity Block (LB)**:
  - A short time period (Δt_{LB}, order ~ 1 min) defined by TDAQ during which LHC and ATLAS conditions are assumed constant, for which the average luminosity is calculated.
  - Smallest time granularity with which luminosity data is stored in COOL.
- **LB-averaged Instantaneous Luminosity**:
  - Instantaneous luminosity averaged over the duration of a LB ($\mathcal{L}_{\mathrm{LB}}$).
  - ***_all:** summed over all Bunch-Crossing IDentifiers (BCIDs).
  - ***_phys:** restricted to colliding bunches used for physics.
- **Integrated Luminosity**:

$$\int \mathcal{L} dt = \sum_{i}^{N} \mathcal{L}_{\mathrm{LB}_i} \Delta t_{\mathrm{LB}_i}, \qquad i \in \{\mathrm{run/fill}\}$$

Online Luminosity Monitoring Infrastructure

- **Online Luminosity Calculator (OLC)**:
  - Software that lives in the TDAQ online environment under the partition called OLC which hosts the OLC Application.
  - Collects raw data from the ATLAS sub-detectors (via IS) and LHC beam instrumentation (via the Data Interchange Protocol (DIP)).
  - Calculates calibrated instantaneous and integrated luminosities.
  - Publishes the information for online usage and permanent storage.

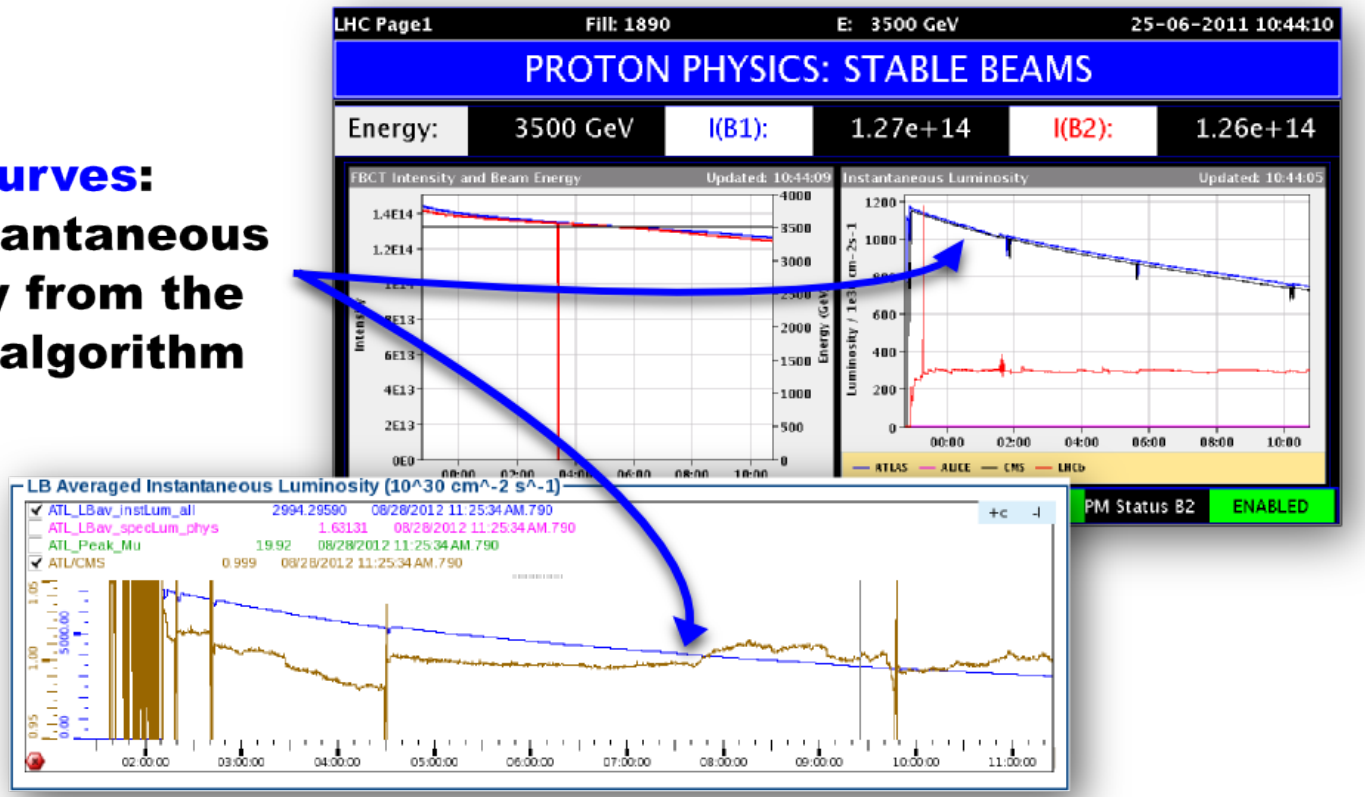
- **OLC2COOL**:
  - Archives the online luminosity values from OLC in the COOL database for offline use.

- **Luminosity diagnostics**:
  - **Data Quality Desk:**
    - DCS displays: time histories of $\mathcal{L}$ or ratios of $\mathcal{L}$.
    - OHP: bunch-by-bunch luminosities (for experts only).
  - **Run Control Desk:**
    - Shifter Assistant rules.

- **Preferred Algorithm: The one luminosity value that is:**
  - distributed to ATLAS as a whole (public plots, trigger prescales, etc.),
  - sent to LHC page 1,
  - Typically used for a first pass of physics analysis,
  - The focus of the DQ shifter.

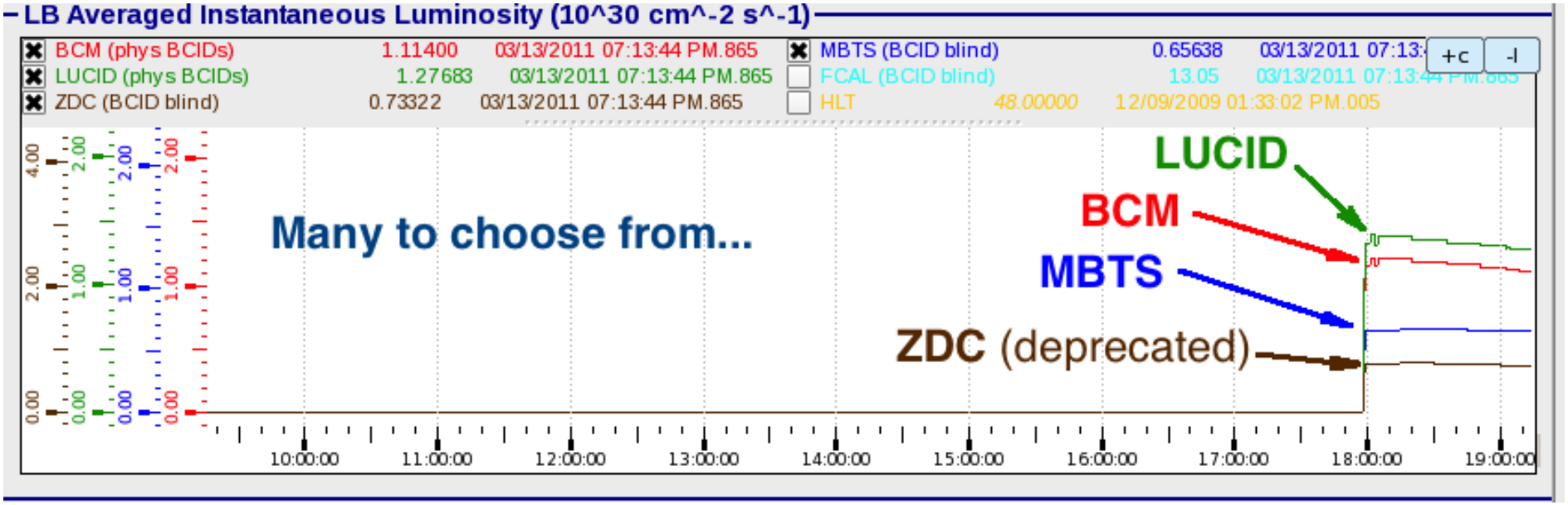
LHC Page 1

Blue curves:
ATLAS instantaneous luminosity from the preferred algorithm



ATLAS DCS Display

Preferred Algorithm for Run II start



- **The current preferred algorithm is BCMTOR.**
  - It's an OR of all 8 BCM sensors.
  - Maximizing acceptance for first collisions.

- **Right now:**
  - The BCM publishes what it currently measures.
  - The absolute scale may be off, but relative changes are meaningful.

Current Luminosity Monitoring Goals

- **Exercise the online $\mathcal{L}$: stability? problems?**
  - The software in the OLC partition is constantly evolving: testing stability is always a concern.
  - Some Luminosity DCS panels are also evolving: make sure the correct data make it to the displays.
- **Develop/exercise the DQ shifter tasks:**
  - Find out how to make you guys more effective shifters: expand documentation, render instructions unambiguous.
  - Currently in the process of updating ALL luminosity online monitoring documentation, all of which will become gradually accessible through the new Luminosity and Beam Conditions Whiteboard.

What We Want From the DQ Shifters

- Keep an eye on the **luminosity values coming from the preferred algorithm**.
- Keep an eye on the **luminosity infrastructure monitoring plots**.
- Keep an eye on **luminosity FSM alarms**.
- **Be aware of interventions by experts:** elogs, phone calls, drop-in visits in the control room, etc.
- DQ shifters: attend tomorrow's dedicated DQ session at the filtration plant.