The ATLAS High Level Trigger Configuration and Steering Software: Experience with 7 TeV Collisions

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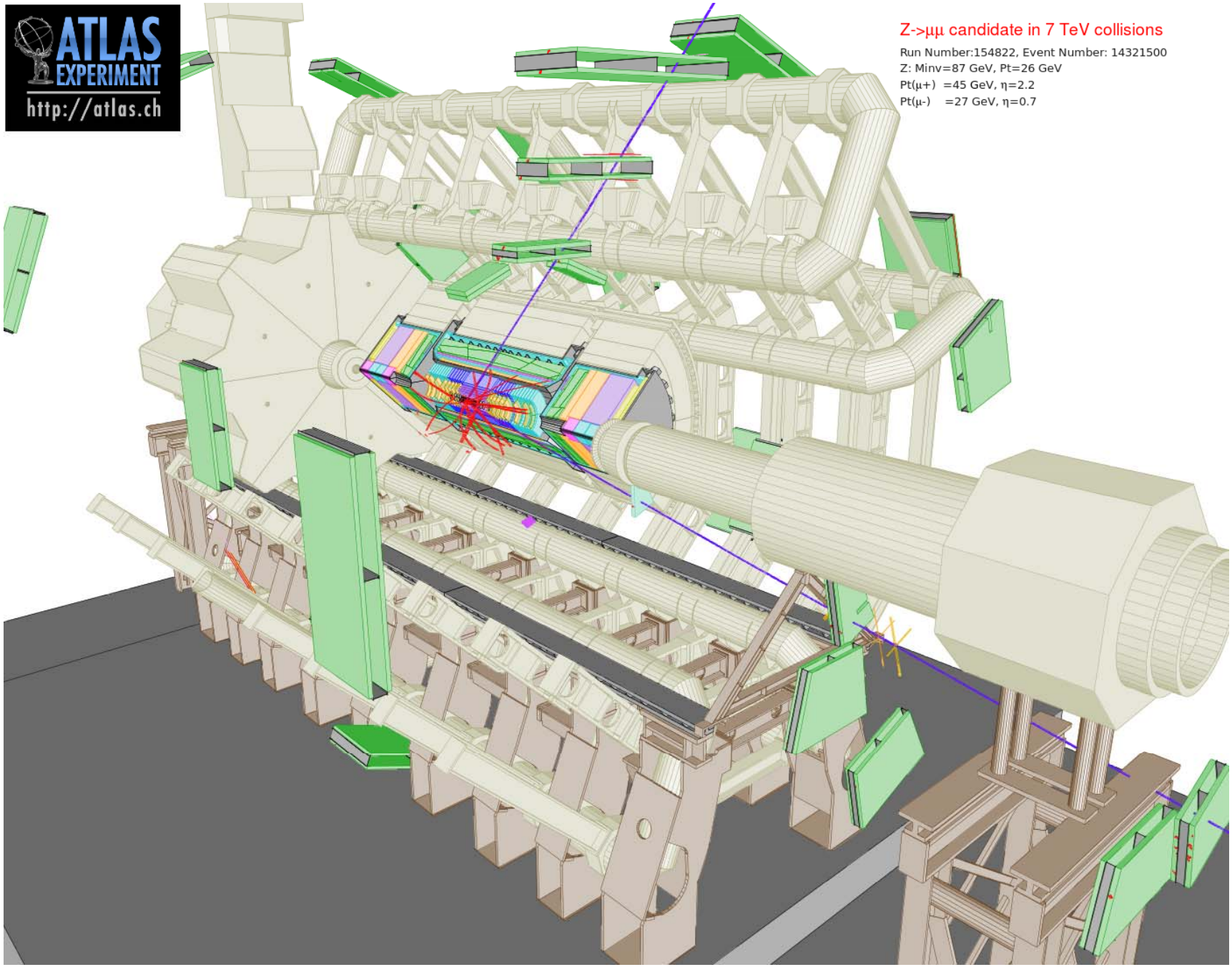
ICHEP
PARIS 2010

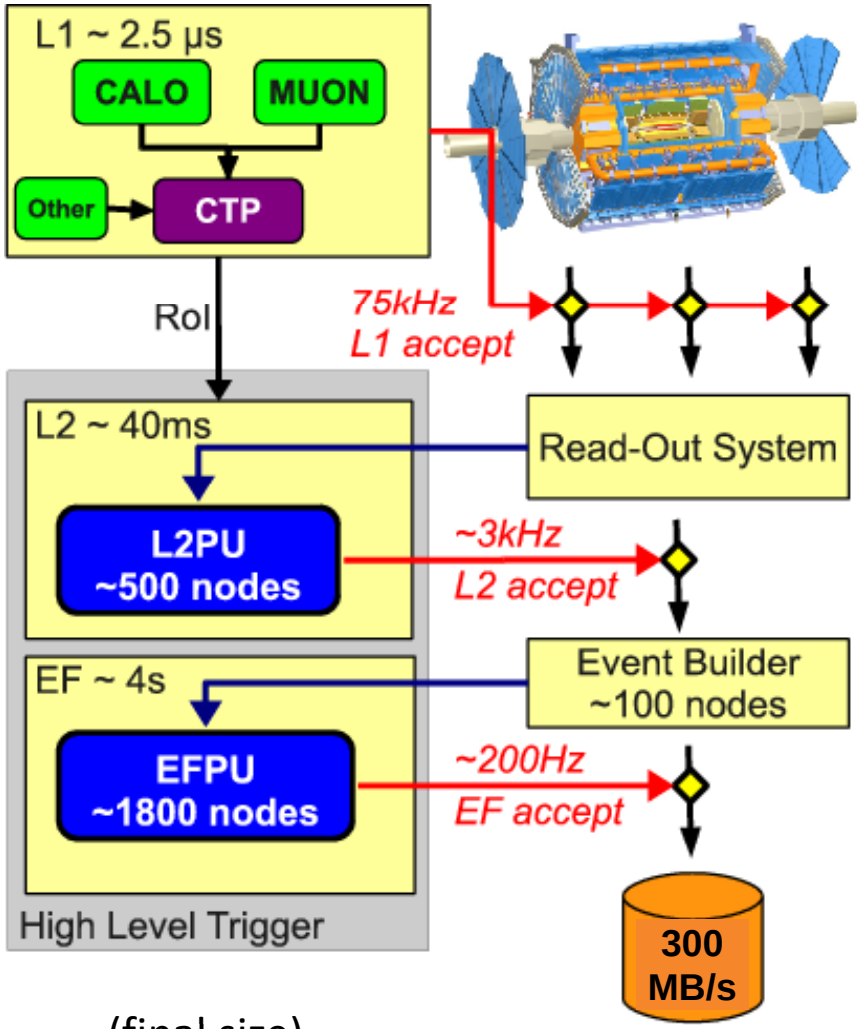

ATLAS
EXPERIMENT
http://atlas.ch
Z->μμ candidate in 7 TeV collisions
Run Number:154822, Event Number: 14321500
Z: Minv=87 GeV, Pt=26 GeV
Pt(μ+) =45 GeV, η=2.2
Pt(μ-) =27 GeV, η=0.7

Contents of talk

- Introduction to ATLAS and its trigger
- Focus on some of the new features introduced in the last year, to maximise data taking efficiency:
  - HLT prescale updates
  - Trigger configuration tools
  - Performance monitoring

For an overview of ATLAS trigger performance and specific examples of algorithms:
J. Baines, “Performance of the ATLAS Trigger with Proton Collisions at the LHC” (Track 1)

The ATLAS Trigger



(final size)

Level 1

- Analyses data from CALO, MUON and Other (Minbias) detectors
- Central Trigger Processor (CTP) combines triggers
- Identifies Region of Interest (RoI) used to seed Level 2

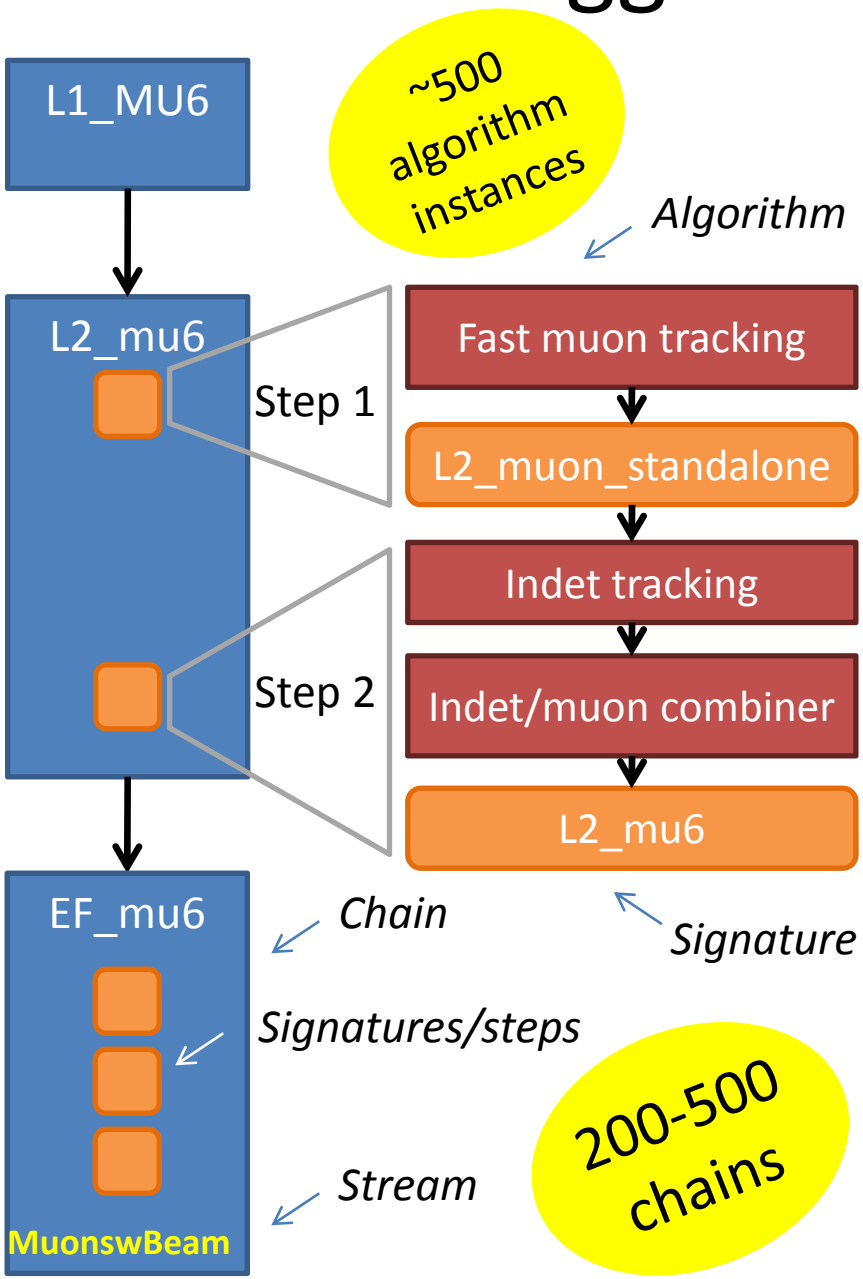
Level 2 (L2)

- Mainly partial event reconstruction in RoI
- Event fragments requested from Read-Out System
- Specialized algorithms optimized for fast, early rejection

Event Filter (EF)

- Full event merged together by Event Builder
- Mainly RoI reconstruction seeded by L2
- Offline reconstruction tools in custom wrappers & configurations

Trigger Configuration

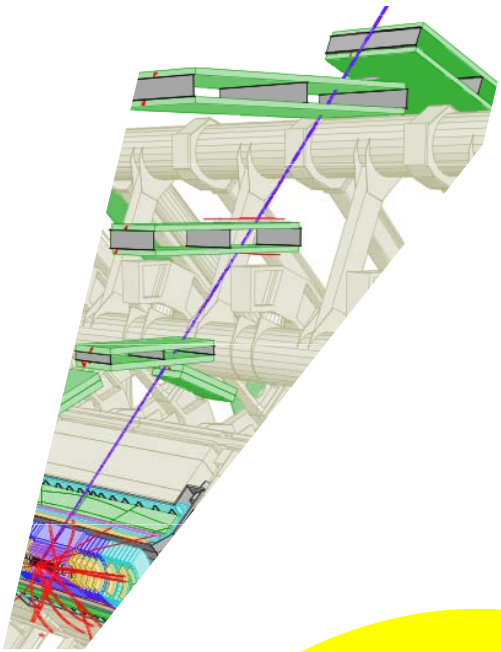


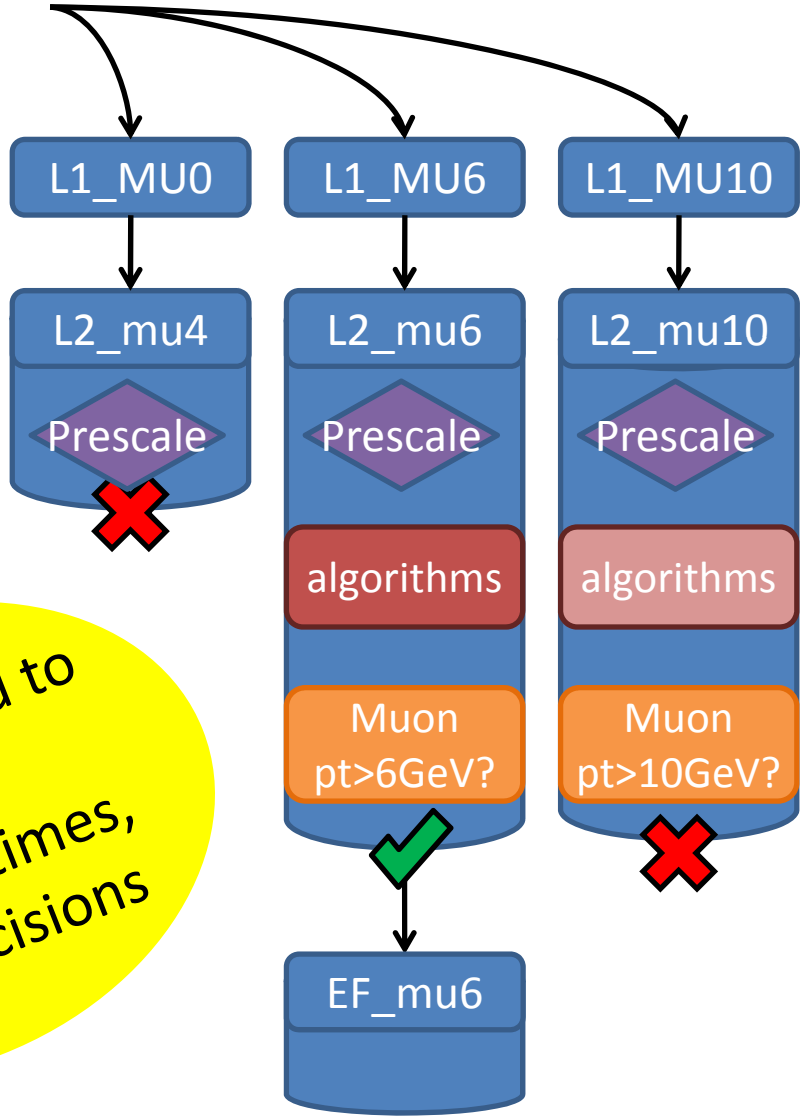
- **Menu** - list of **chains**: physics-like objects with thresholds, e.g. mu6, 2e5, e10, j20
- Each **chain** seeded by previous trigger level
- **Chain** built up from intermediate steps, each characterised by a **signature**
- Each step contains one or more **algorithms**
- Same **algorithms/signatures** may be used by multiple chains
- **Chains** are assigned to output **streams**
- Also special monitoring & calibration **chains**
- **Prescale** value for every **chain**

- Configuration stored in database
- Identified by three integer keys: Menu, L1 prescale set, HLT prescale set
- **Prescales** also used to enable/disable chains

High Level Trigger Steering

A muon triggers at Level 1 … three level 1 thresholds fired





Instrumented to monitor algorithm times, rates, decisions

Data driven:

Each L1 threshold seeds L2 chains

Enable related L2 chains

Apply L2 disable/prescale

Run algorithms. Same algorithm & data? Only run once.

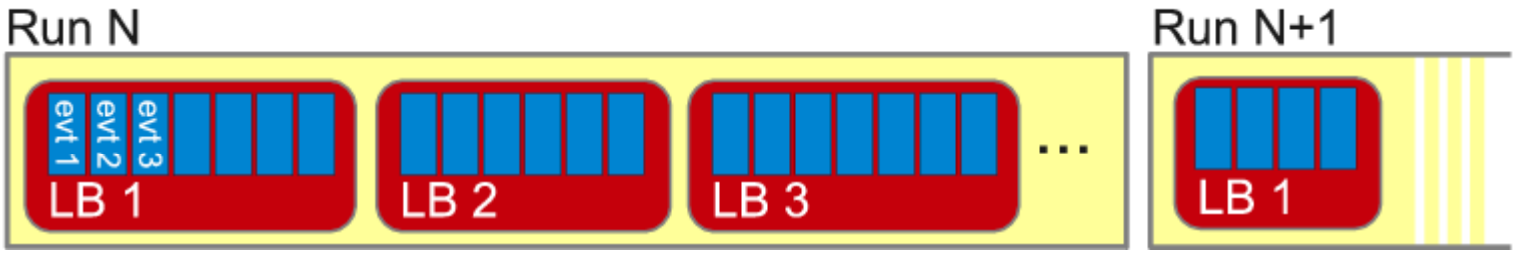
Signature confirmed?

De-activate chain if not

Active chains carried on to EF

Reject when no chains remain, otherwise accept when event processing complete.

ATLAS Run structure

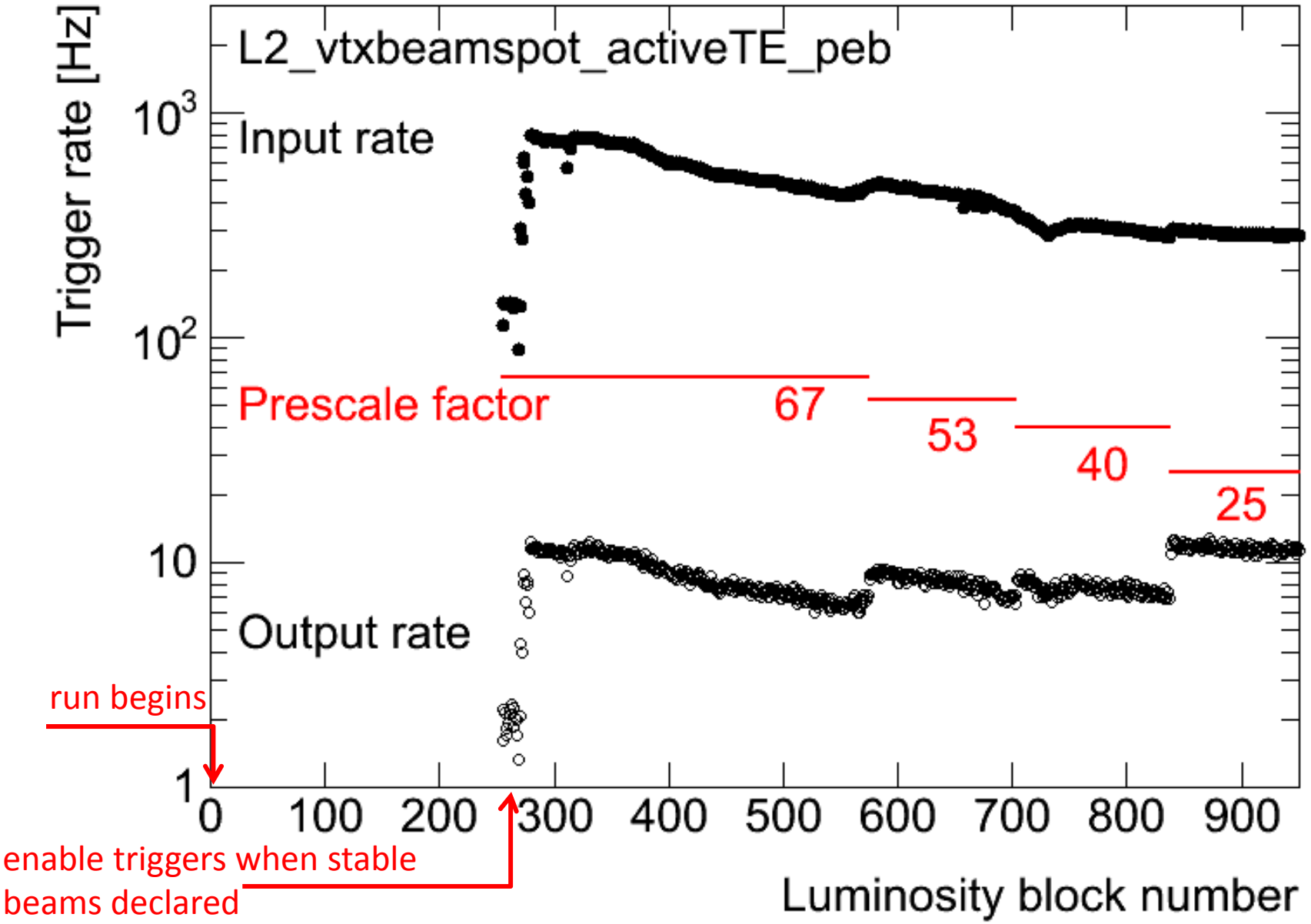


- Run
  - Period of data taking with a fixed trigger configuration and stable detector conditions
  - Typically lasts hours, usually corresponds to LHC fill
- Luminosity Block (LB)
  - Time interval (~2 min) within a run
  - Luminosity and conditions are considered to be approximately constant
  - Smallest unit of data considered by data quality

HLT prescale changes during a run

- Motivation
  - Already used for Level 1
  - Can be used to enable/disable HLT chains
  - Can be used to adjust prescales
    - to optimise bandwidth use as luminosity falls during fill
  - Need to do these things without restarting run (takes minutes)
- Requirements
  - Change only on luminosity block (LB) boundary
  - Apply consistently across all HLT nodes
  - Reproducible offline
  - No reduction in data taking efficiency
- Solution
  - Use Level 1 Central Trigger Processor (CTP) to flag change
    - part of event data always loaded in HLT
  - Map of luminosity blocks (LB) to prescales (PS) recorded in trigger database
  - HLT apps extend their cache to include new prescale set
  - Always check which set is needed whenever LB changes
    - events not guaranteed to be in LB order
  - Archive LB/PS mapping to conditions database for use in offline analysis
- Other conditions updates (e.g. transverse beam spot) handled similarly

Example of Level 2 trigger prescale changes during a run

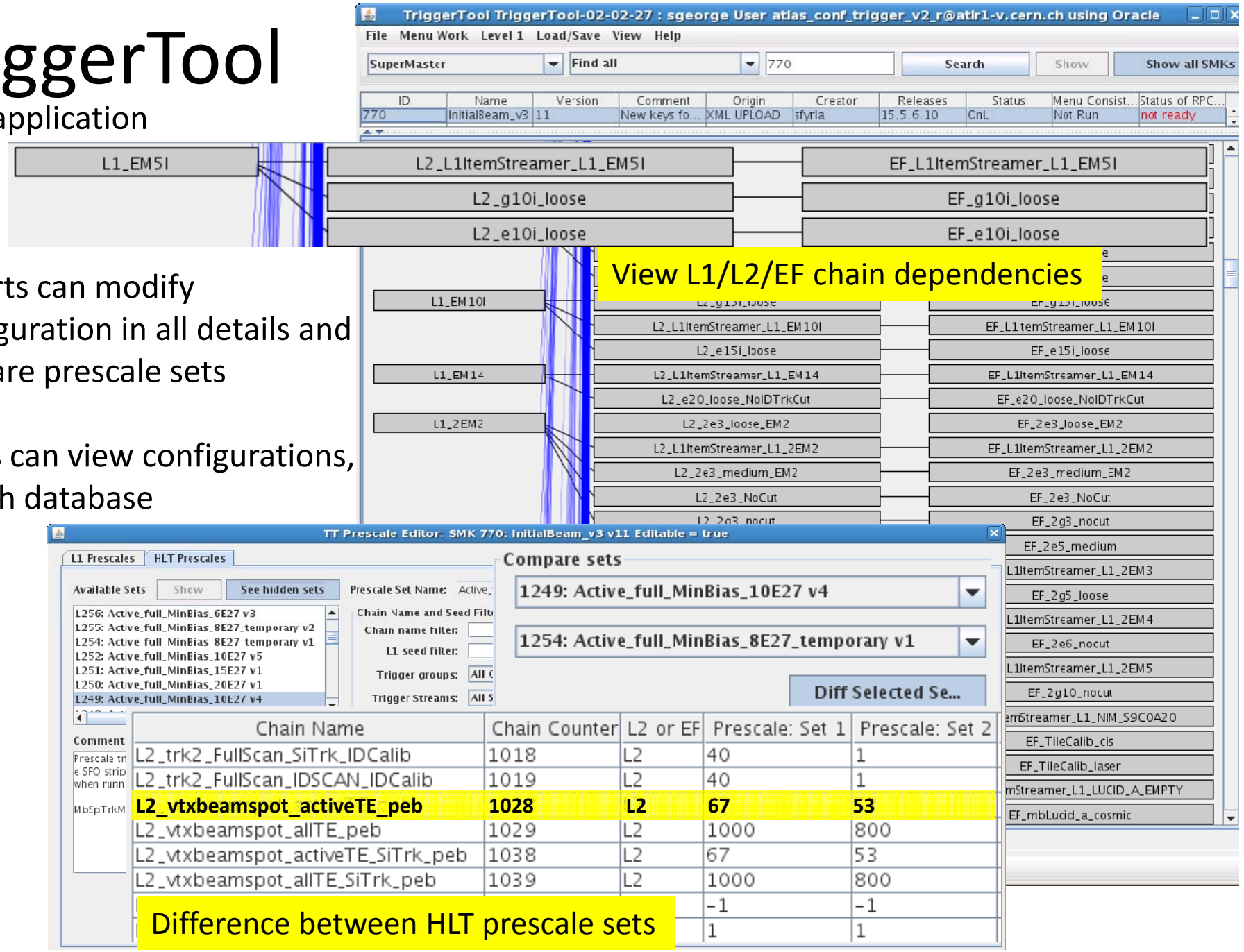


TriggerTool

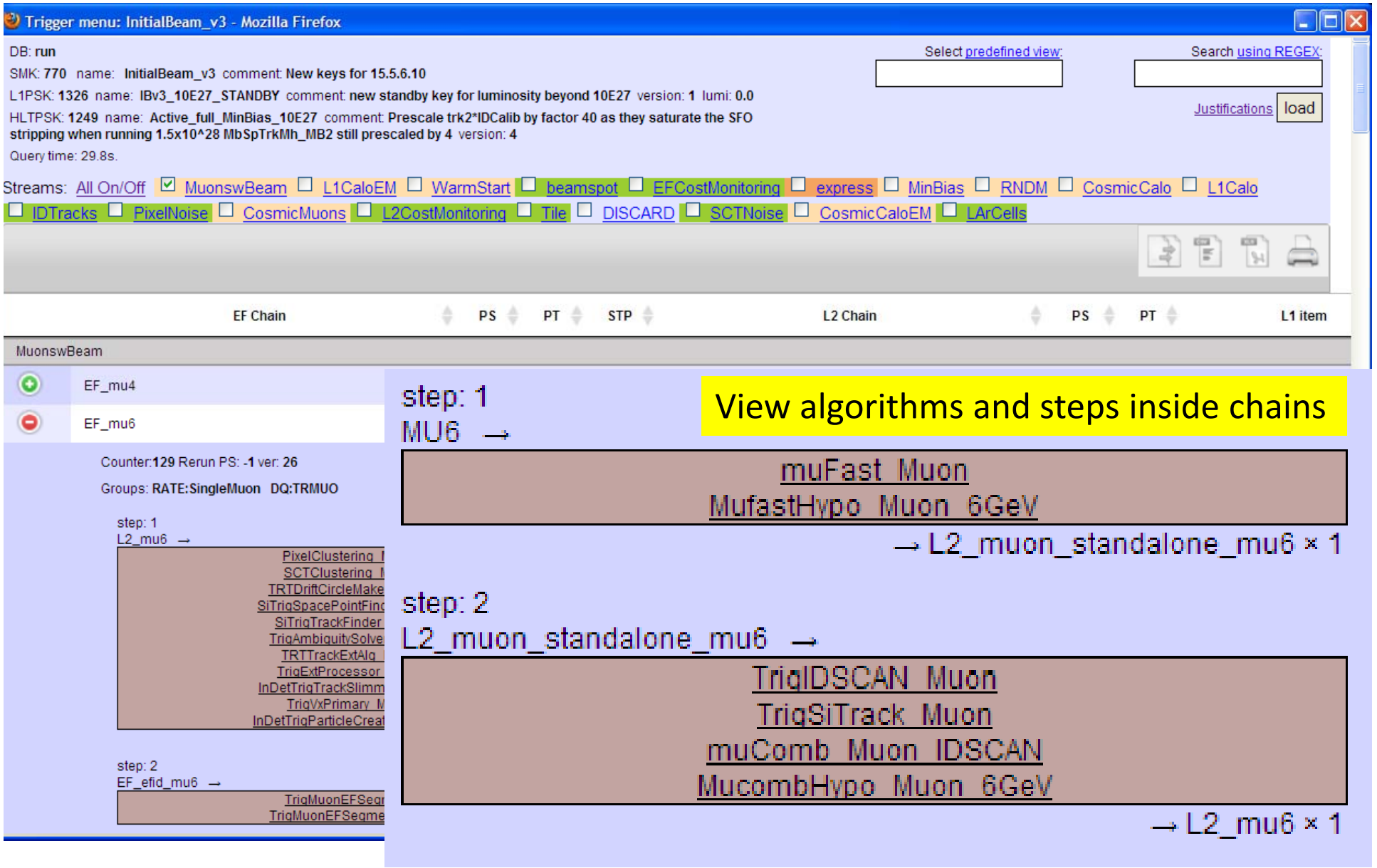
Java application

Experts can modify configuration in all details and prepare prescale sets

Users can view configurations, search database



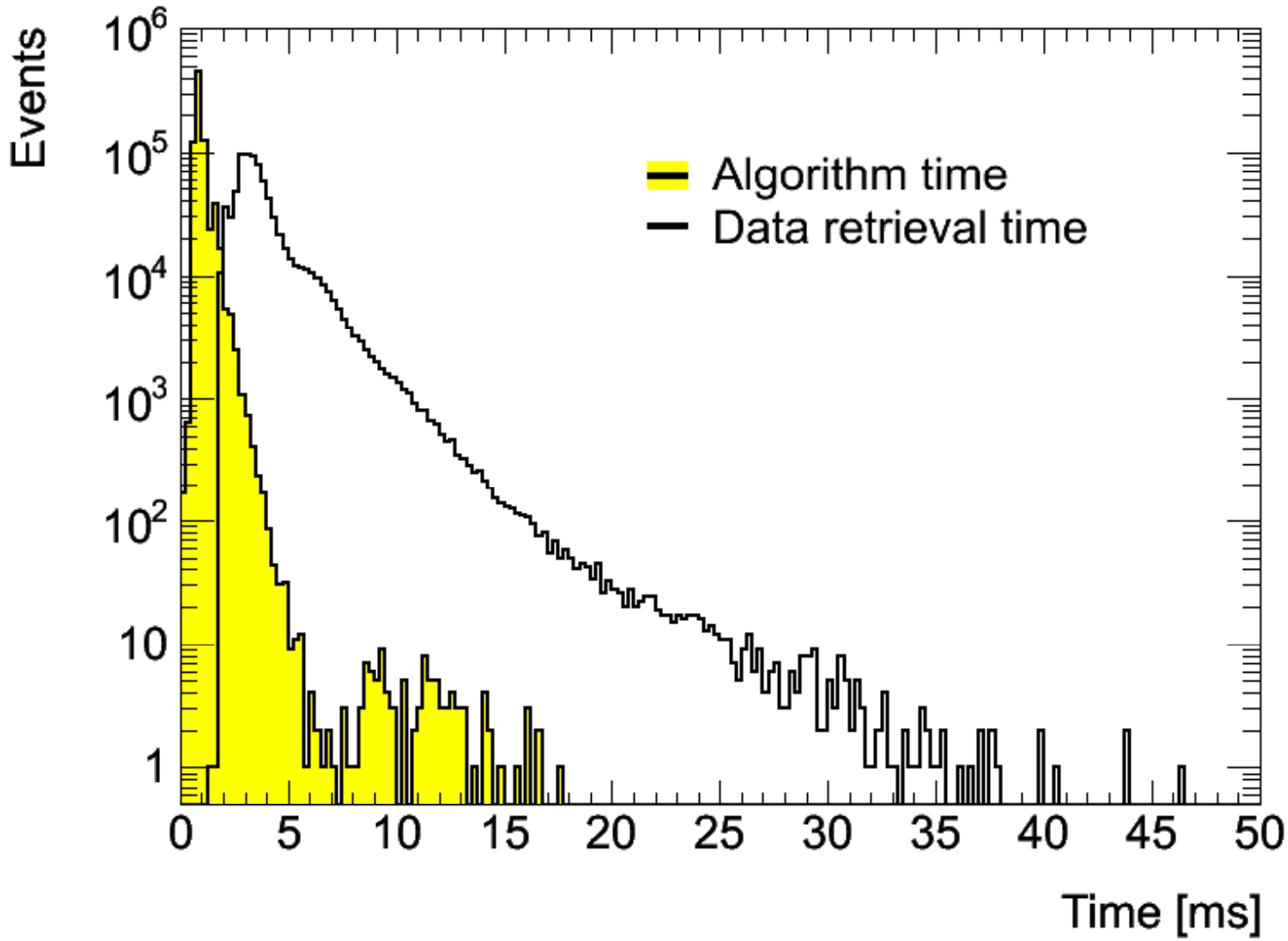
Web-based trigger menu display



HLT resource monitoring

- Motivation
  - Monitor online **CPU usage and rates**, **including rejected events**
  - Identify cause of any resource problems
  - Compare to offline measurements – is online performance reproducible?
  - Provide detailed input to predict rates at higher luminosity
- Requirements
  - Minimal overhead/impact on T/DAQ system
  - Handle large number of events, chains, algorithms and HLT applications – not trivial!
- Solution
  - For every event, store L1 accept time stamp, L1 & HLT decisions
  - Sample detailed timing data from the instrumented HLT steering
  - Data from multiple events are buffered and written out at low rate
  - Unlike other online monitoring, data written like calibration events in event data stream

Example: time taken by trigger algorithm



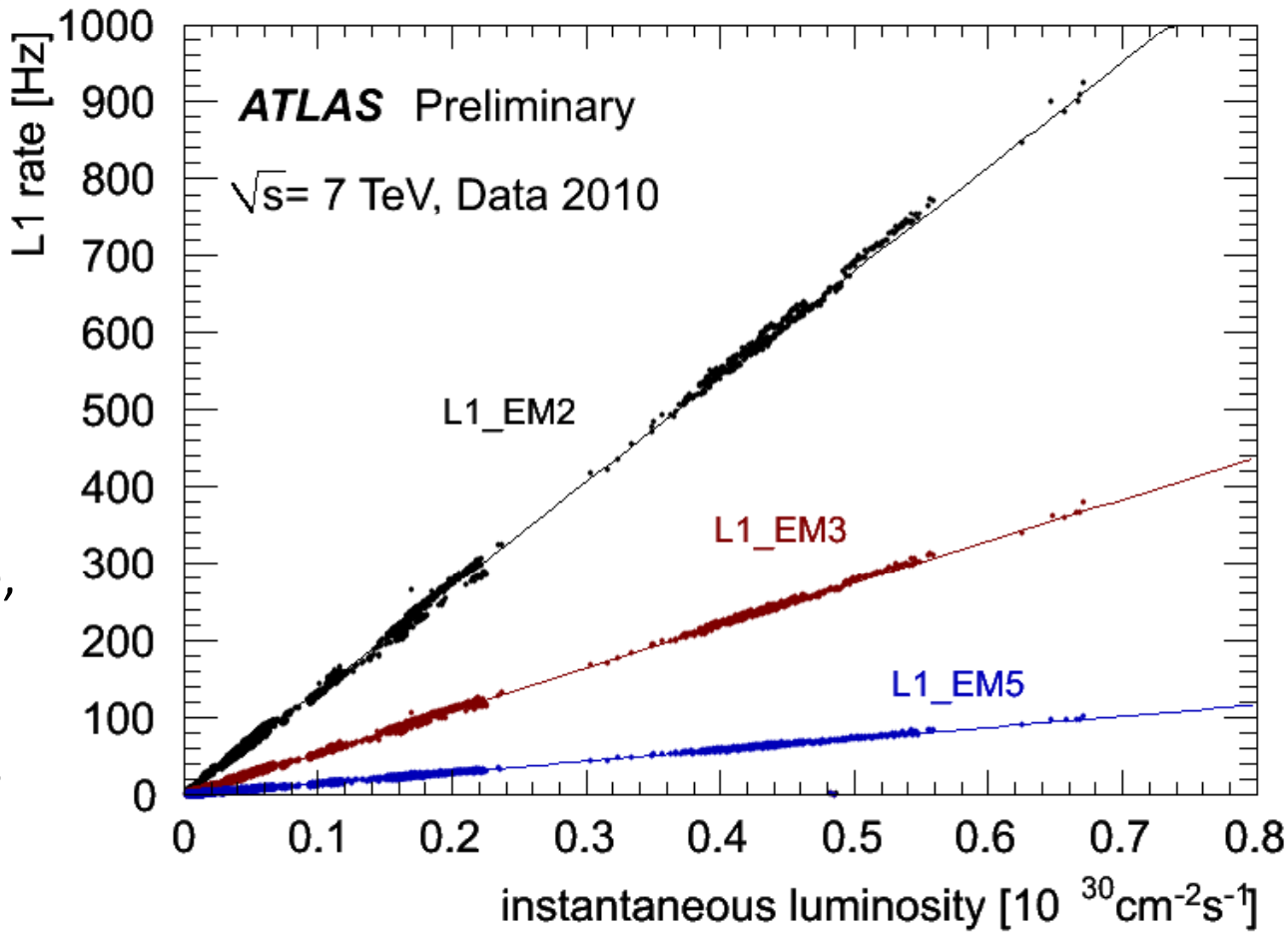
HLT resource monitoring tool samples times provided by HLT steering framework.
Top CPU lists and graphs like this are produced automatically for every run.

Trigger rates scaling with luminosity

From data, HLT rates at higher luminosities are predicted.

- Take data triggered by L1 minimum bias
- Re-run HLT offline
- Software tools handle complexity of menu size, overlaps and prescales.
- Also used to check rates with new menu or software version

Measured Level 1 EM trigger rates



Conclusions

ATLAS has a reliable and flexible trigger that has proved successful in taking 7 TeV LHC data.

Trigger configuration tools allow easy checking and comparison of configurations used online

- Helps experts prepare and verify configuration before online use
- Same database schema and tools used for simulation too.

HLT prescales can be changed during a run

- Enable/disable triggers and adjust prescale factors to compensate for luminosiity falling
- Avoids the need for run restarts and resulting loss of data taking efficiency

HLT resource monitoring gives a detailed picture of CPU usage and rates

- Quickly pinpoint any unusual behaviour that could cause timeouts
- Tools help to predict rates for new menus or software, and higher luminosities
- Menus and prescale sets can be better prepared in advance

ATLAS recorded about 95% of the luminosity delivered by the LHC. The HLT is an extremely reliable and robust factor in this.

Thanks to the dedication of all those who help run the Trigger/DAQ system and detectors, and the trigger software experts who developed the features described in this talk.