TRIGGER STATUS AND MENU OPTIMIZATION

LHCC Referee Meeting with ATLAS – 7th July 2009

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Outline

- Recent activity
- Highlights from recent results
- Planning for 2009/10 run
- Online and offline monitoring
- Trigger menus for the coming run
- Conclusions

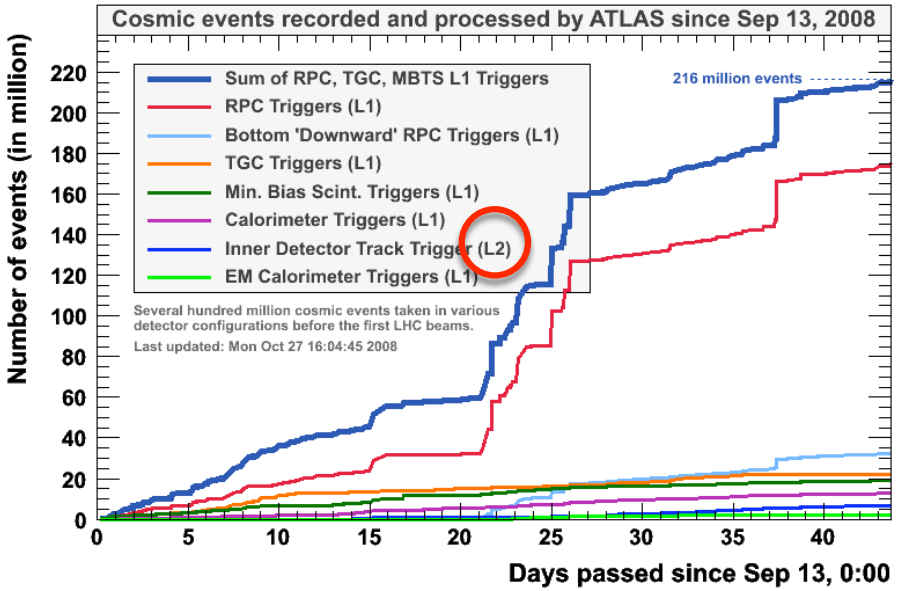
Recent activity

- Much has happened since the last Trigger report at this meeting:
  - See talk by Nick Ellis in September 22nd LHCC review: http://indico.cern.ch/conferenceDisplay.py?confId=26620
- The short single-beam run and the cosmics runs in 2008/09 provided a good stress test of the Trigger/DAQ system
  - The trigger successfully worked with LHC beams for the first time!
  - Excellent progress was made on timing-in the various detectors in late 2008 and 2009
  - Trigger successfully selected events for detector and trigger commissioning
- Since then the collected data were thoroughly analyzed:
  - Residual problems were identified and fixed
  - Lessons from the operational experience have led to new tools and improved procedures

Oscilloscope traces from beam pickup (yellow) and min.bias scintillators for single injected bunch

Single-beam and cosmic runs

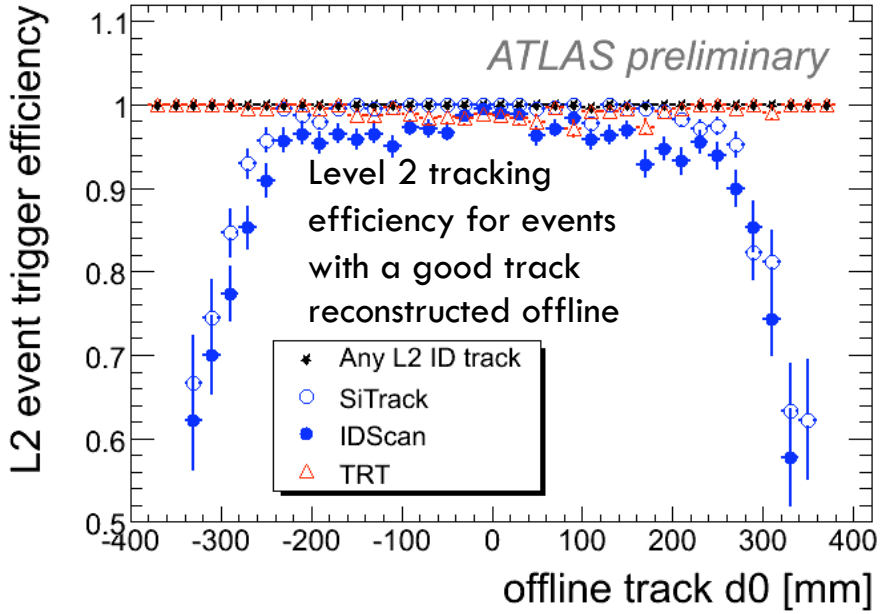
- Single-beam events were selected with various triggers: beam pickups, minimum-bias trigger scintillators, calorimeters and forward muon detectors
- Data streaming done by the **H**igh-**L**evel **T**rigger (HLT) based on Level 1 trigger type and on Level 2 tracking (see figure)
- HLT algorithms exercised online to reconstruct trigger data
  - Running in parasitic mode without rejecting events
  - Contributed much to weeding out problems in real environment
  - Monitoring benefited much from exercise
- Heavy use of CAF for testing bug fixes and new menus before deployment
- Menus updated almost daily, responding to feedback from data analysis and to needs from commissioning of detector systems
- Menu configuration machinery responded fast and well to new demands

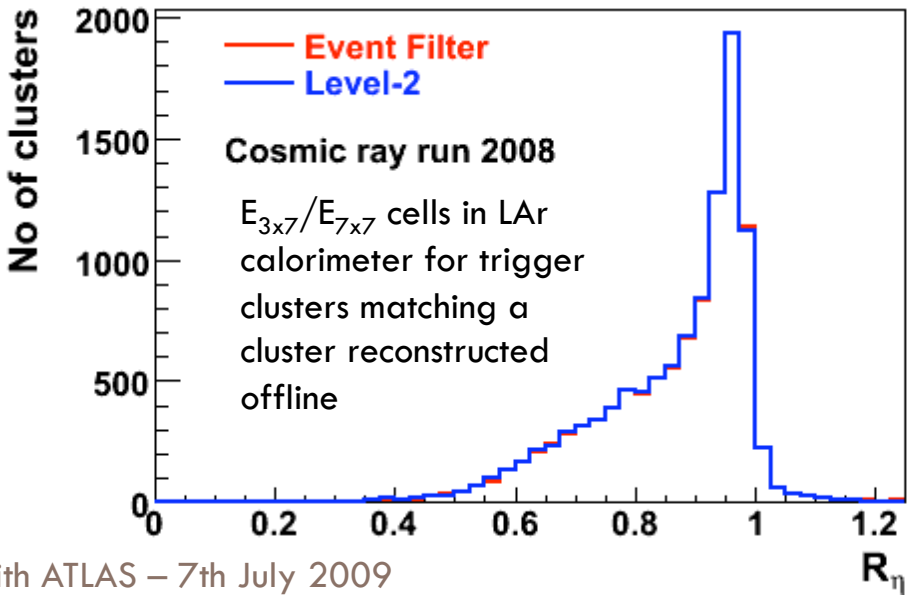


Number of events recorded into each stream in 2008

Highlights from cosmic runs

- Complete HLT infrastructure was tested
  - Including the algorithm steering and configuration
  - Also the online and offline monitoring
  - Weak points were identified and were/are being addressed – e.g. new trigger rate display
- Level 2 inner detector tracking algorithms were useful to select events with track candidates (top figure)
  - Modified algorithms to accept tracks not coming from nominal IP
  - Used to create stream enriched in good track candidates for inner detector and offline tracking commissioning
- Many HLT algorithms were exercised with cosmics by relaxing selection thresholds and requirements (bottom figure)…many other examples would be possible…

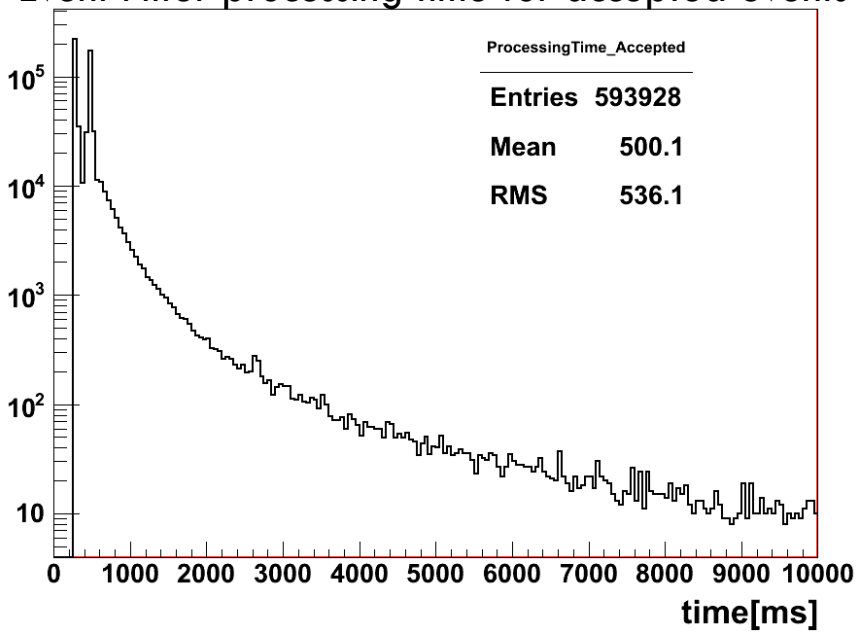


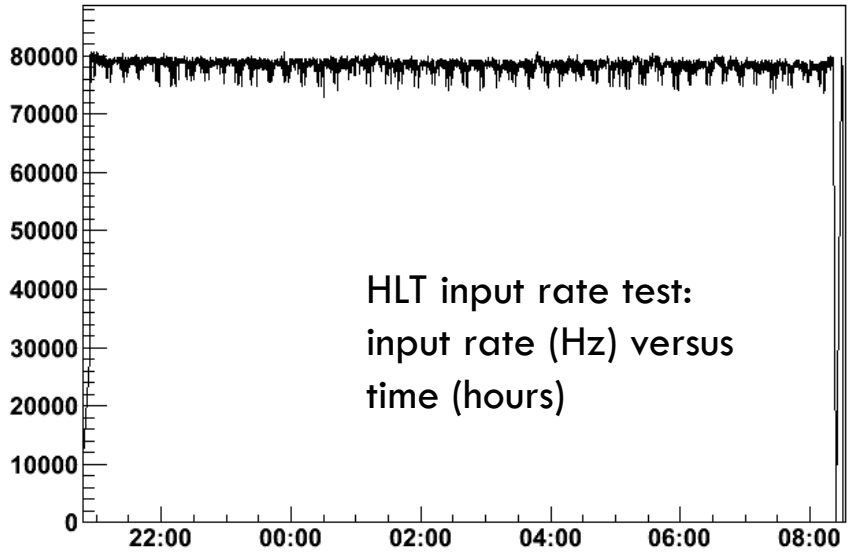


Technical runs

- Playback of simulated collision data through the DAQ system
- Performed regularly to integrate new software releases in online environment
  - Allows to test new DAQ and HLT software in real system
- Allows to test the system with collision-type data: enhanced bias, physics channels
- Preparation before running detectors on cosmics
- Estimate system performance:
  - Estimated processing time compatible with design goals (top figure); mean HLT average should be ~ 40ms at Level 2 and ~ 4s at the Event Filter or less
  - Throughput rate: tested up to ~78-90kHz input to Level 2 (bottom figure; 50-75kHz expected)
  - Event building rate of ~5kHz starts to compete with Level 2 data requests (~2kHz event building rate expected); E.B. design rate is 3.5kHz
  - Note: processing time is strongly dependent on event topology and on trigger menu

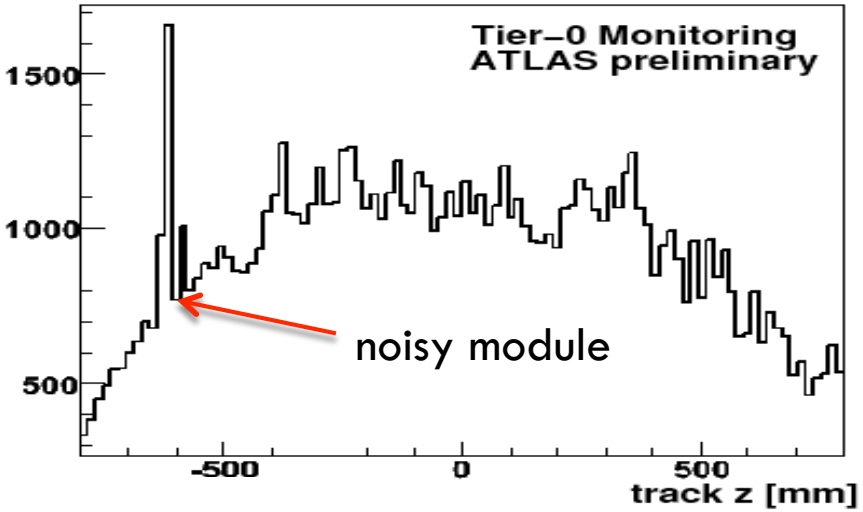
Event Filter processing time for accepted events

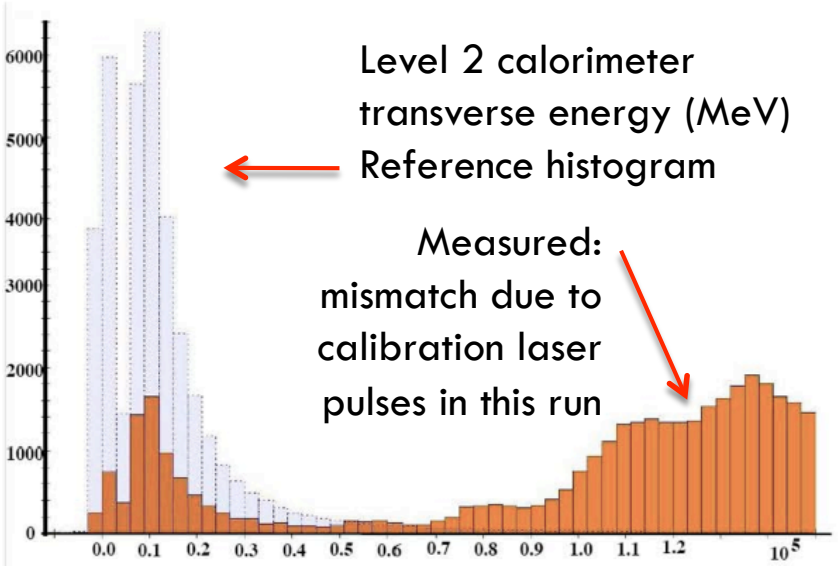




Monitoring and diagnosing problems

- Monitoring essential to quickly spot and diagnose problems
- Both online – in control room – and offline, trigger monitoring was exercised in the cosmics and technical runs
- Online monitoring based on histograms of:
  - Trigger rates
  - Overlap between trigger streams
  - Characteristic event quantities for each selection
- Offline monitoring based on:
  - Histograms produced during Tier0 event reconstruction
  - Re-processing and error analysis of events from the debug stream
- Improved trigger monitoring currently being tested with cosmic events





Offline testing and monitoring

- As learned from the 2008 run, it is essential to thoroughly test new menus and HLT algorithms with real data before online deployment
- Also, it is important to be able to react quickly to new problems – or risk wasting bandwidth collecting bad data
- The CAF is an essential part of the trigger strategy for this:
  - Used for automatic re-processing events from the debug stream, where an error condition occurred online – e.g. a time-out during a Level 2 data request
  - Used to test new menus once they are loaded to the trigger configuration database and before they are deployed online
  - Needs to provide access to RAW data from a small number of runs where a problem was identified until the debugging is completed
    - This is essential and allows us to study problematic events offline, correct weaknesses in the software and test the fixes – it minimizes lost time and disruption to online running
- Other debugging tools are provided by:
  - The monitoring histograms produced during event reconstruction at Tier 0
  - The production of commissioning ntuples at Tier 1 for fast analysis of problems (and Tier 0 for time-critical needs)
  - The "Preseries" subfarm: a set of HLT nodes serving as a test platform and not used for normal trigger processing

Planning for the 2009/10 run

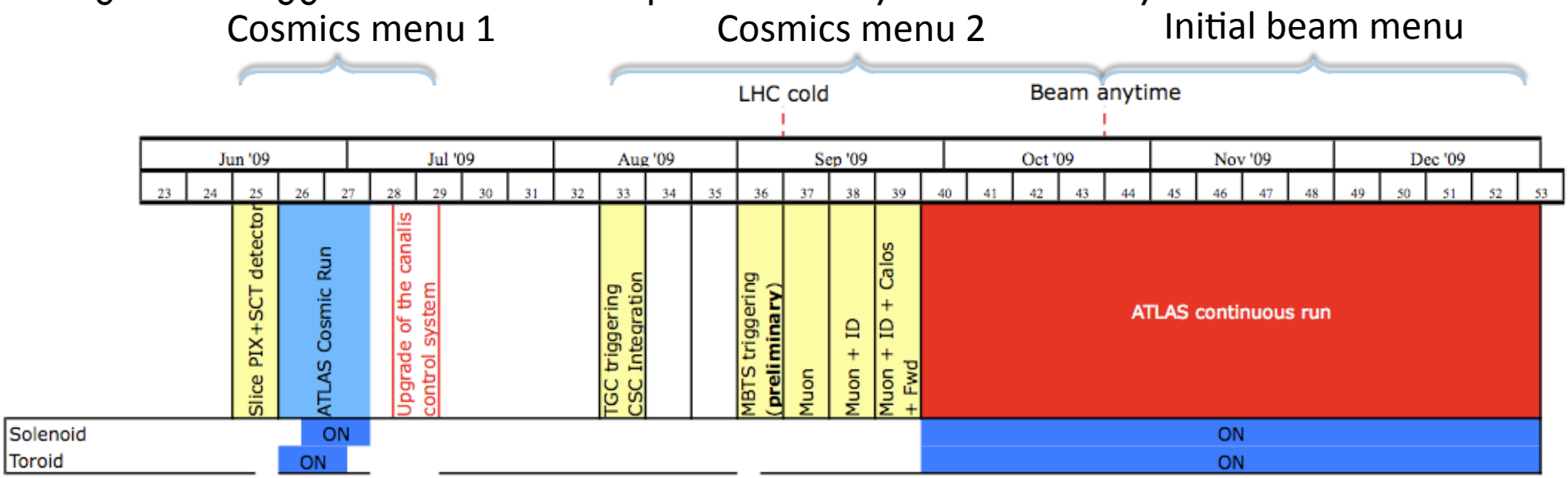
- A set of reviews was done after last year's run to examine critically what had been done
  - Touched the following subjects: offline monitoring infrastructure, tools for online monitoring and debugging, shift crew operation and tools, information flow, timing measurements, configuration and streaming
- The trigger workshop in February 2009 was an important milestone:
  - Reviewed the trigger activity in the 2008 single-beam and cosmics run and establish plans to prepare for the 2009 run
    - https://twiki.cern.ch/twiki/bin/view/Atlas/TriggerWorkshop2009
  - Led by panel from broader ATLAS community and with experience from other experiments
  - Raised interest and involved people from detector, physics, combined performance, data preparation, etc
  - Resulted in a report and ~80 identified action items with responsible people's names attached
    - Touching on all areas from trigger menus to monitoring, documentation, configuration etc
    - We have been following up on these for the last five months in the various trigger domains
    - Many translated into agreed procedures, software deliverables or tools

Commissioning plans

- Combined ATLAS cosmic run will start at T0 – 4 weeks with all systems and 24h coverage
  - The trigger will start with the already familiar Level 1 selection for cosmic events
    - Menu will be ready at T0 – 10 weeks, to be deployed at T0 – 8 weeks for runs with some systems
  - Have the HLT in passthrough mode – exercise the algorithms, event data, monitoring etc without rejecting events
  - Data streaming by the HLT based on Level 1 trigger type and on tracking/cosmic event algorithms
  - Exercise HLT algorithms with loose event selection to accept and process cosmic events
- Single-beam events to be selected with dedicated menu
  - Based on use of beam pickup and minimum bias scintillators
  - Refine timing of signals from various detector systems
  - Continue to exercise HLT algorithms in passthrough mode using beam-gas events and halo muons
- Initial collisions triggered with Level 1 only
  - Significant amount of work on e.g. Level 1 calibration needs to be done with initial collisions
  - This data will be essential for commissioning of detectors, Level 1trigger, HLT selections
- HLT deployed to reject events only when needed to keep event rate within budget
  - Both Level 1 and HLT trigger prescales can now be updated during the run to increase operational flexibility – prescale factors constant within luminosity blocks
- Now creating conditions to have fast feedback from the trigger on the collected samples
  - Using Tier 1 and/or CAF to process events and create monitoring histograms and dedicated ntuples (root) with fast turnaroun

Menus for initial data

- Cosmics menus have been thoroughly exercised in recent runs in May and June
  - Level 1 calorimeter and muon trigger have been reliably providing triggers for cosmics runs this year
  - Evolution of cosmics menu will contain some muon triggers in physics configuration
- The initial-beam menu will be used for single-beam running and first collisions
  - It will need to be able to handle different LHC scenarios and be resilient to a badly timed-in detectors
  - Rely on beam pickup to identify filled bunches
  - Experience from single-beam running in 2008 used in the design of this menu
- Bunch-group mechanism will be commissioned carefully to replace beam pickups
- High-Level trigger will be used to reject events only when necessary



Menu evolution

- The evolution of the trigger menu is very much tied to the evolution of the LHC luminosity (and to the beam energy)
  - Several commissioning menus are being put in place for the initial beam period with detector and trigger commissioning as the highest priority
  - Procedures for menu evolution agreed but still need to be tested in real life
- Menus exist or are being developed in Monte Carlo simulation for average luminosities of $10^{31}cm^{-2}s^{-1}$ and $10^{32}cm^{-2}s^{-1}$
  - These are possible scenarios for the coming run
  - Depending on the detailed bunch spacing scenario, this could mean up to 5 overlapping events per bunch crossing, on average – might require changes to the menu, in order to keep the rate manageable
  - These menus provide a reference for planning and evolving the online trigger menu as the LHC luminosity grows
  - Some high-p_T physics triggers, needed for analysis in channels with low cross section, are "un-prescalable"
- Some practical questions remain on what menus should be used in Monte-Carlo production
  - Can have impact on the analysis of initial data
  - It must be possible to simulate the response of menus/algorithms used in online event selection

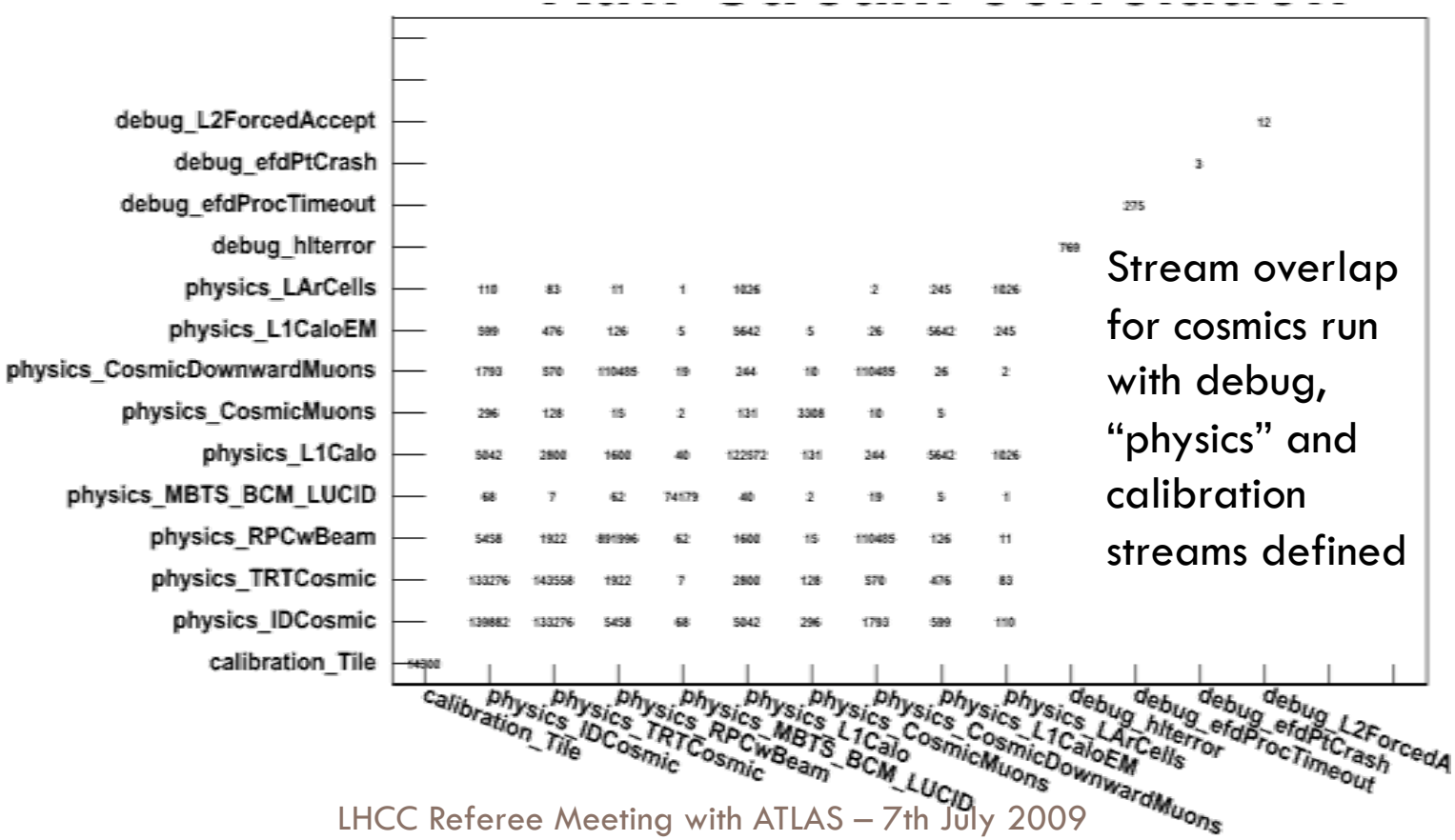
Conclusions

- The trigger was ready for beam in 2008 and a lot was achieved from the single-beam and 2008/09 cosmics runs
  - The HLT was successfully used to stream single-beam events and to select and stream cosmic events for detector commissioning
  - The cosmics runs provided vital experience from prolonged stable running (>200 million cosmics recorded)
  - Level 1 (muon, calorimeter) triggers were selecting events from the start and reliably providing events for detector commissioning since then
- The lessons learned from this initial running period were extremely important in planning for this year's activities
  - Addressing weak areas, improving robustness, preparing for the unexpected
- As a result we are even better prepared for running in 2009

Backup slides

Trigger stream overlap

- Data streams determined by the high-level trigger
- ATLAS inclusive streaming model relies on small overlap between streams
- Exclusive debug streams for events with online error conditions



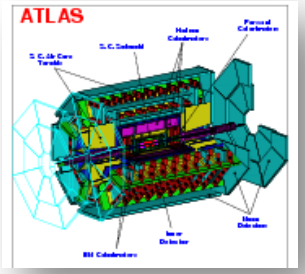
Trigger information for physics analysis

Preparation

Data taking

Reconstruction

Trigger aware analysis



TriggerDB
All configuration data

Configures

Stores decoded Trigger Menu

Online Conditions Database COOL

Encoded trigger result from all 3 levels

Decoded trigger menu

Trigger Result

- passed?, passed through?, prescaled?, last successful step in trigger execution?

Trigger EDM (Features)

- Trigger objects for trigger selection & studies

Trigger Configuration

- Trigger names, prescales, pass throughs

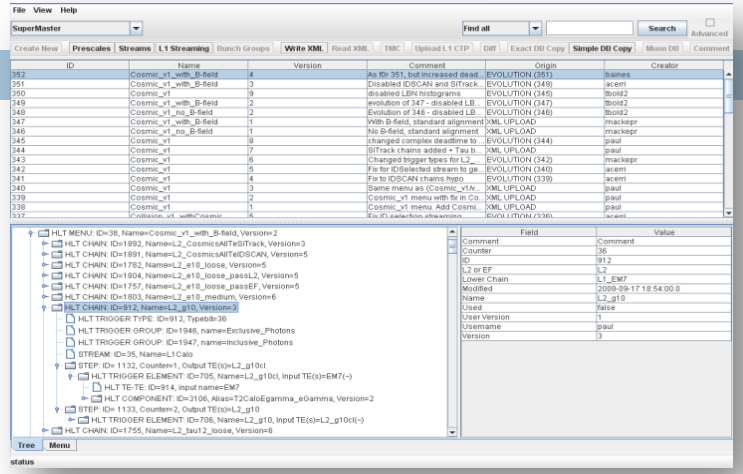
access through TrigDecisionTool

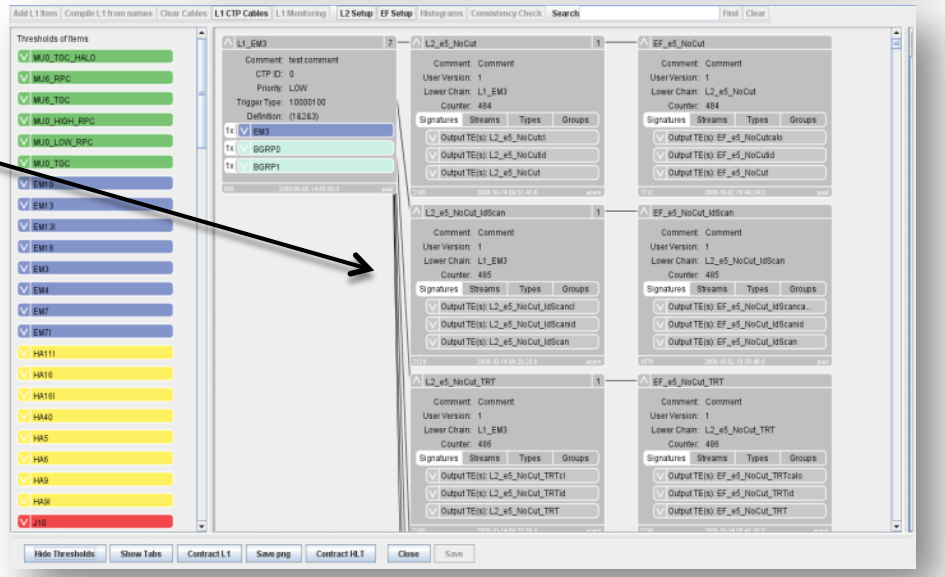
ESD
AOD
DPD
TAG

With decreasing amount of detail

Trigger menu configuration

- Java based front end to TriggerDB, launch from the web (Java web-start): http://www.cern.ch/triggertool
  - Overview of all trigger configurations
  - Detailed and convenient investigation of trigger menus
    - Trigger definition L1->L2->EF: prescales, threshold algorithms, selection criteria, streaming information, etc.

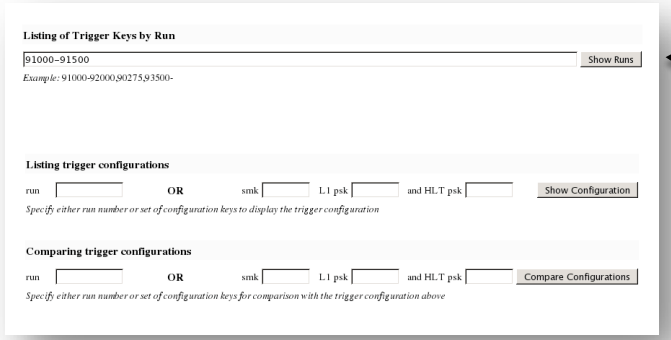




- Possibility to compare different trigger configurations

Web-based access to trigger configuration

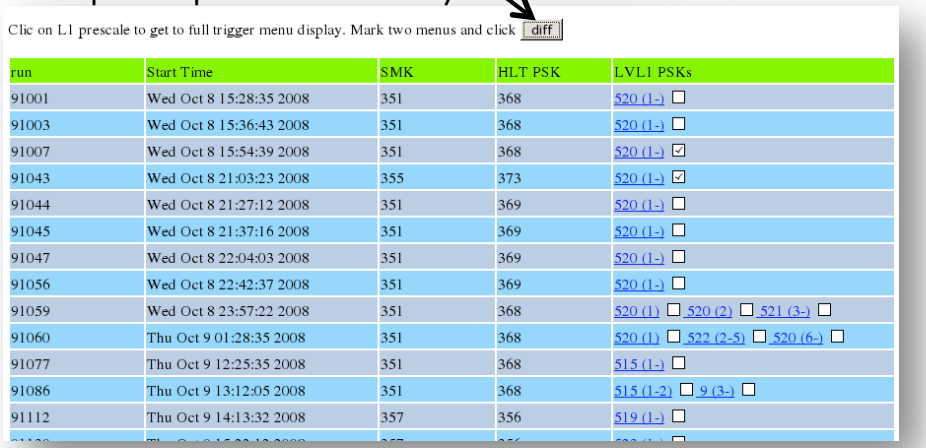
- Web interface http://trigconf.cern.ch
  - Runs TriggerTool on the server, result presented as dynamic html pages



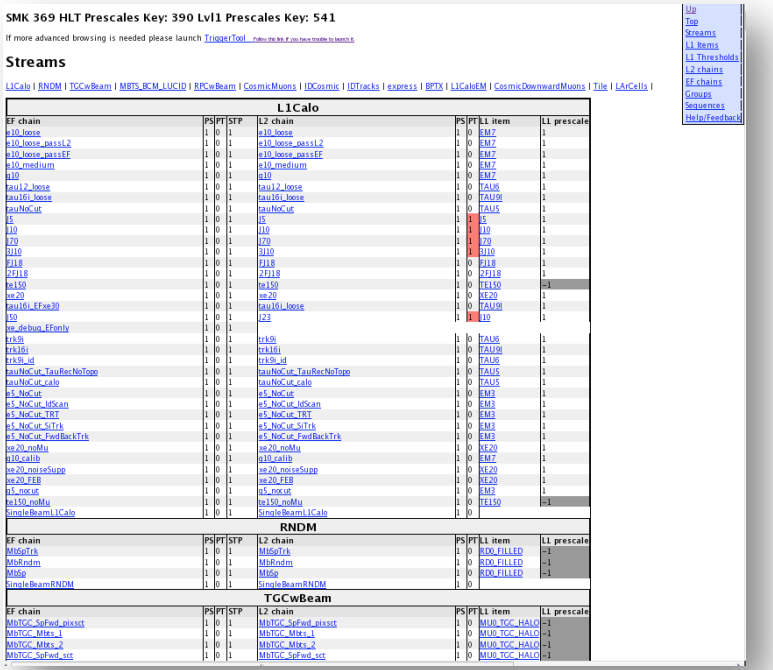
1. Search run-range

2. Run list

Also with simple comparison functionality

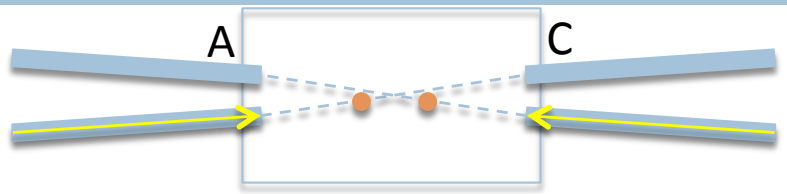


3. Trigger configuration (browsable) (definition, algorithms, selection cuts)

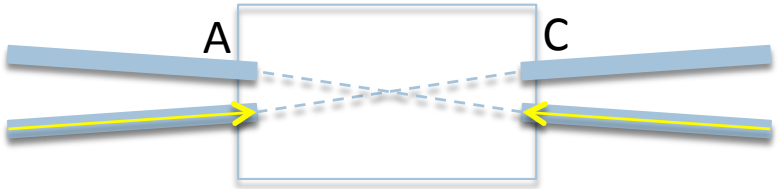


Types of bunch crossings

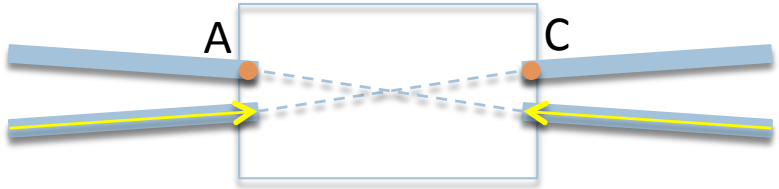
Both bunches filled:



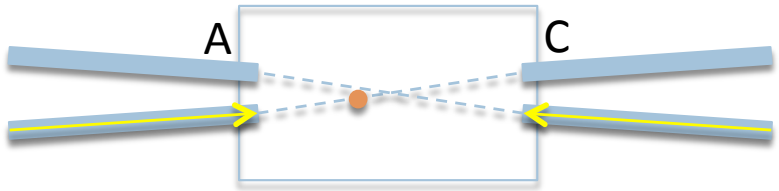
Both bunches empty:



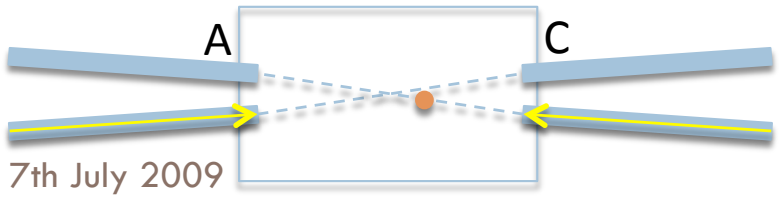
Empty bunch crossing after filled:



A-side filled:



C-side filled:



Bunch groups

- All bunch crossings are numbered with Bunch-Crossing IDentifiers (BCID)
- A set of BCIDs falling into one category is called a *bunch group*.

BGRP0	Not in BCR veto
BGRP1	Filled
BGRP2	Empty reserved for calibration
BGRP3	Empty
BGRP4	Unpaired beam1
BGRP5	Unpaired beam2
BGRP6	Empty after filled

Beam:

L1_EM3 = EM3 & BGRP0 & BGRP1

Cosmic:

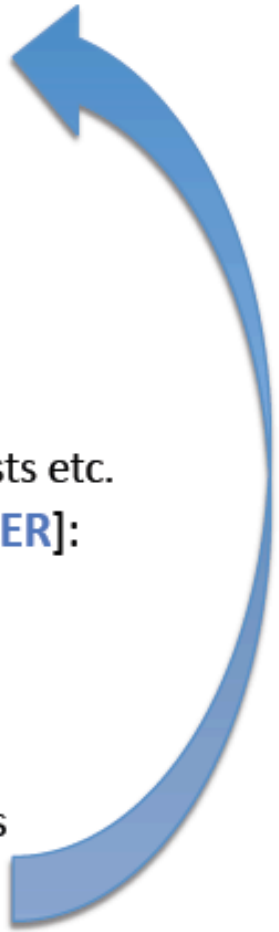
L1_EM3_EMPTY = EM3 & BGRP0 & BGRP3

Makes a well-defined cosmic slice possible in a physics menu!

- Bunch groups are realised as 7 lists of numbers that set internal thresholds in the Central Trigger Processor (CTP)
- Relying on the bunch group mechanism means relying on the clocks
- This requires well timed-in detectors and is not feasible with initial beams

Typical trigger operations pipeline

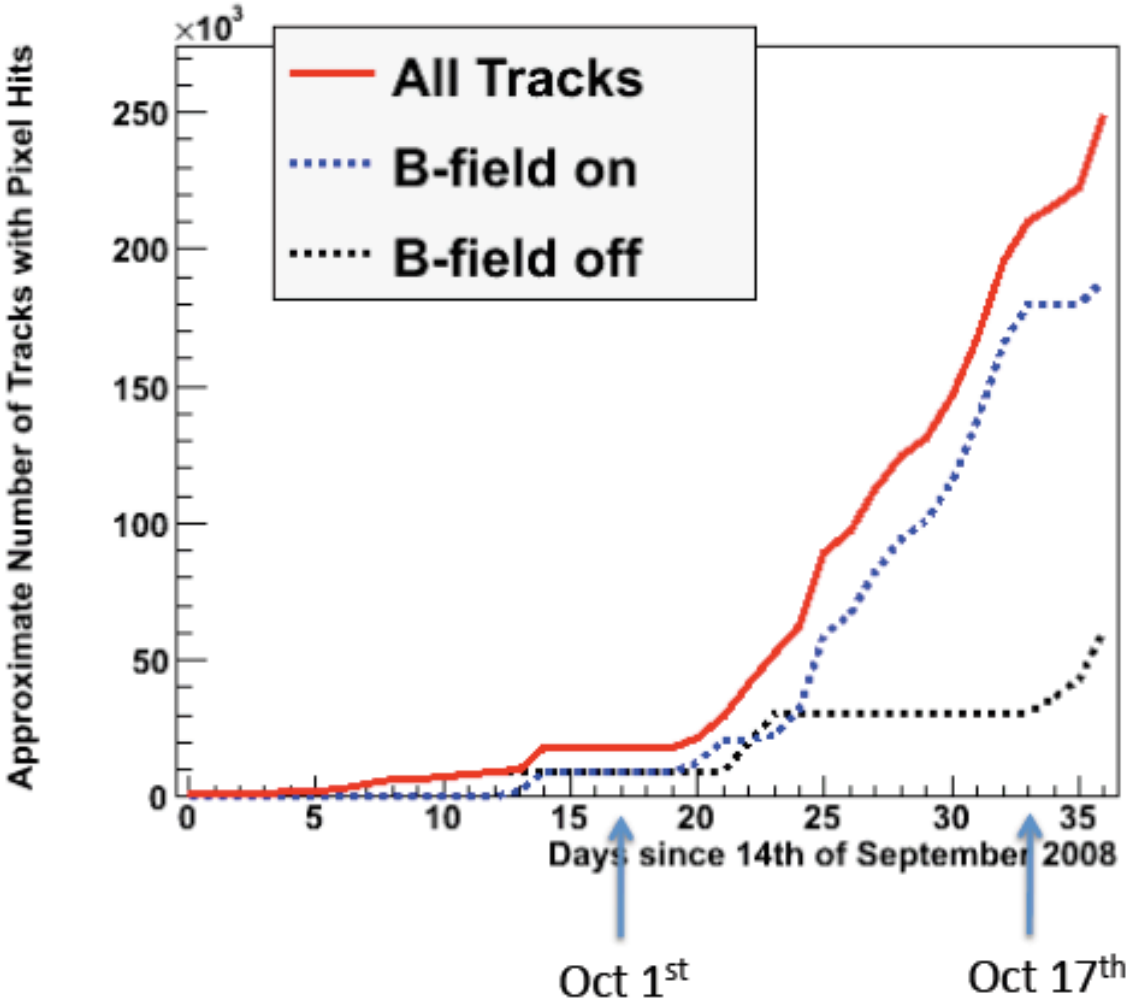
- 9 AM (trigger operations) [OMSCR]:
  - Overnight run status/problems
  - Overnight CAF tests
  - Decide improvements & CAF tests for the day
- 9:30 AM (ATLAS daily run meeting) [S]:
  - Report status
  - Feedback from subsystems
  - Request time to apply improvements/perform tests etc.
- 3:15 PM (trigops meets with slices & menus) [SCER]:
  - Discuss algorithm specific needs/performances
  - New batch of CAF tests
- 4 PM (DQ meeting) [C]:
  - Report on DQ
  - additional feedback from specific detector studies
- Overnight run



Main characters
(highlited initials used here and in the next slides):
- On call expert
- Release coordin.
- Menu operator
- Trigger Shifter
- Slice Experts
- Offline (CAF) operators

Let's see how this worked on the specific case of implementing an effective ID-tracks selection!

An application: ID tracks collection



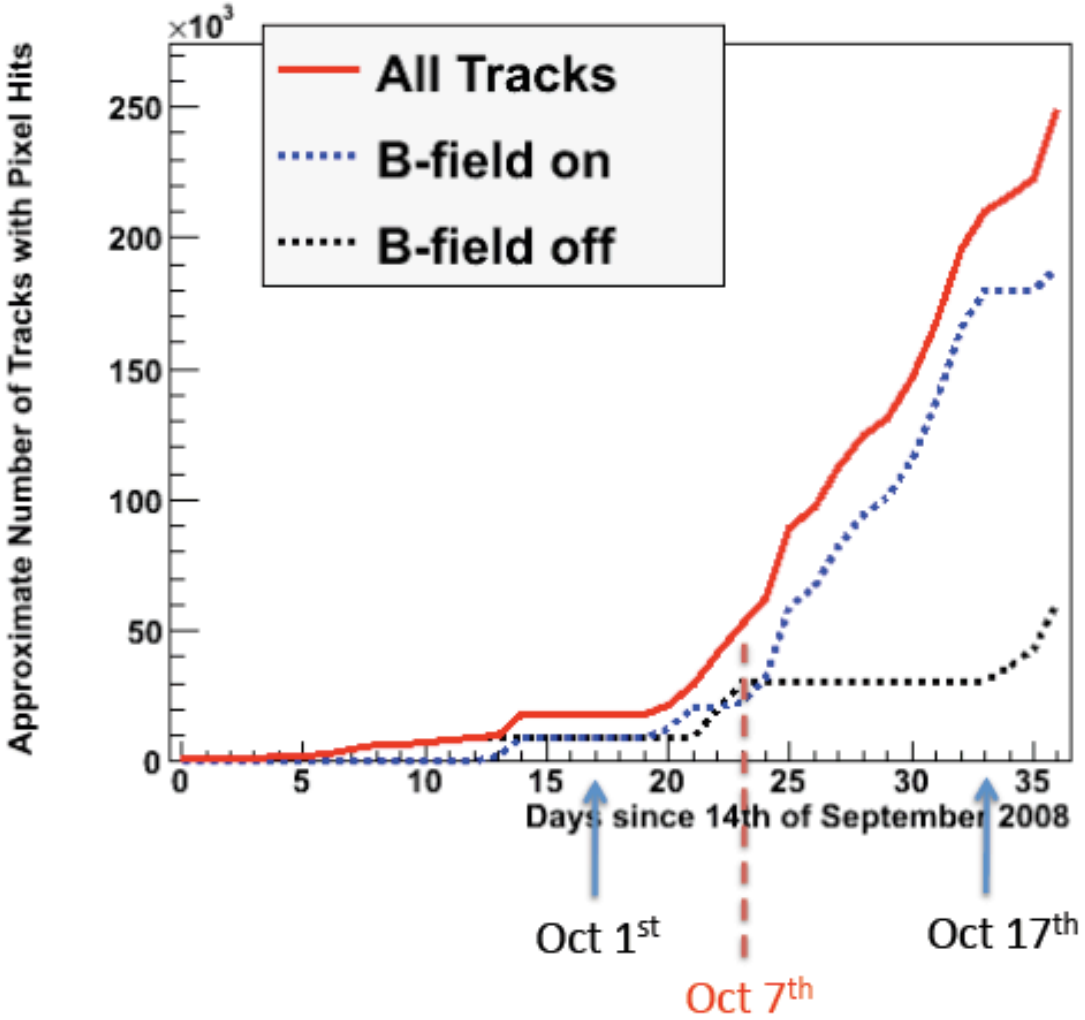
Status:

- O(300Hz) L1 rate from cosmic triggers (RPC+TGC mostly)
- Est. O(<1Hz) 'golden' tracks going through all ID components

Aim:

- Provide efficient and unbiased selection stream
- Reject triggers in order to cope with BW, processing time etc. restrictions
- Produce a first-guess menu (MOESC)

ID tracks collection



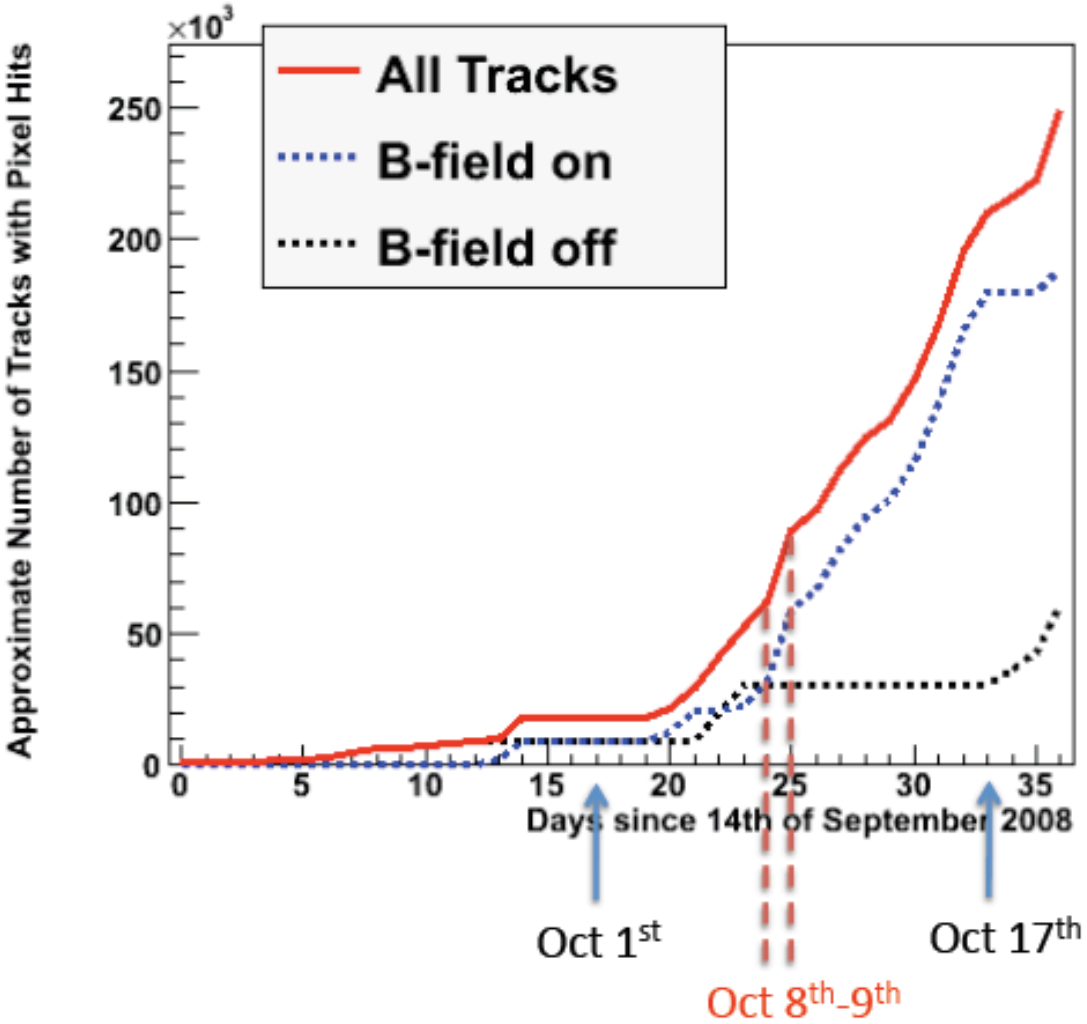
Status:

- Brought L1 prescale for RPC triggers down to 1 (**OS**)
- Raised L2 prescale for pass-thru HLT chains (**OS**)
- First rough guess for 'selective' chains (**MOS**)
- Si-tracks selection made noise-immune with hard cuts (**MOESR**)

Actions:

- Improve prescales (**OS**)
- Investigate selection efficiency (**E**)
- Loosen Si selection (**MOER**)
- Test on CAF (**C**)

ID tracks collection



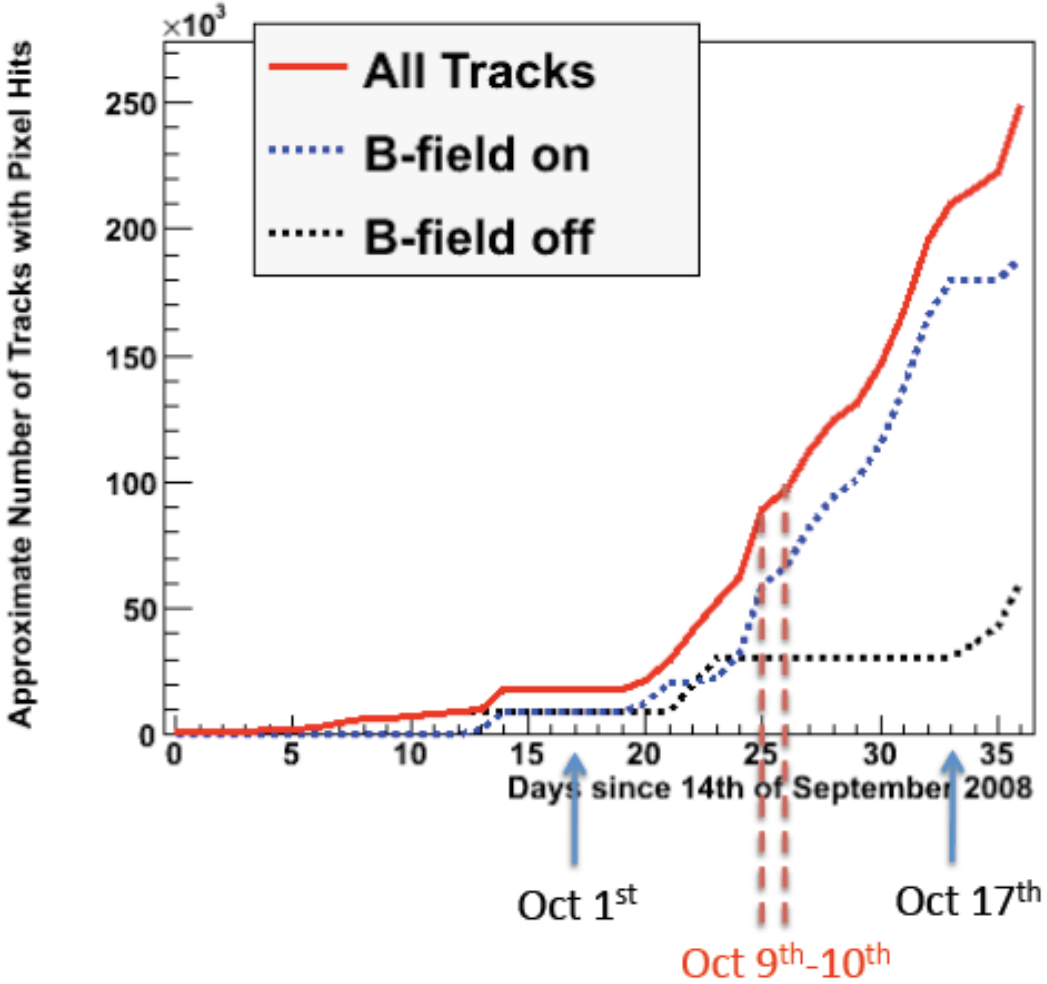
Status:

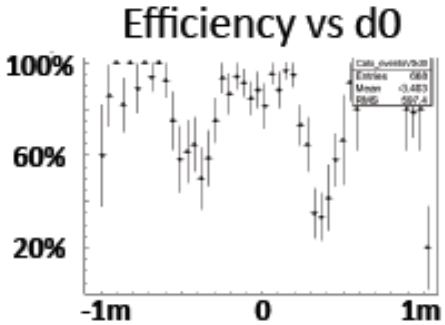
- Efficiency:
  - 96%
  - Flat in d0 and Pt
- B field on, algos assume it's off
- Old ID alignment constants
- Tough Si selection, to be noise immune

Actions:

- Switch to correct B field configuration (**MOS**)
- New alignment constants (**MOS**)
- Loosen Si selection (**MOSR**)
- Test on CAF (**C**)

ID tracks collection





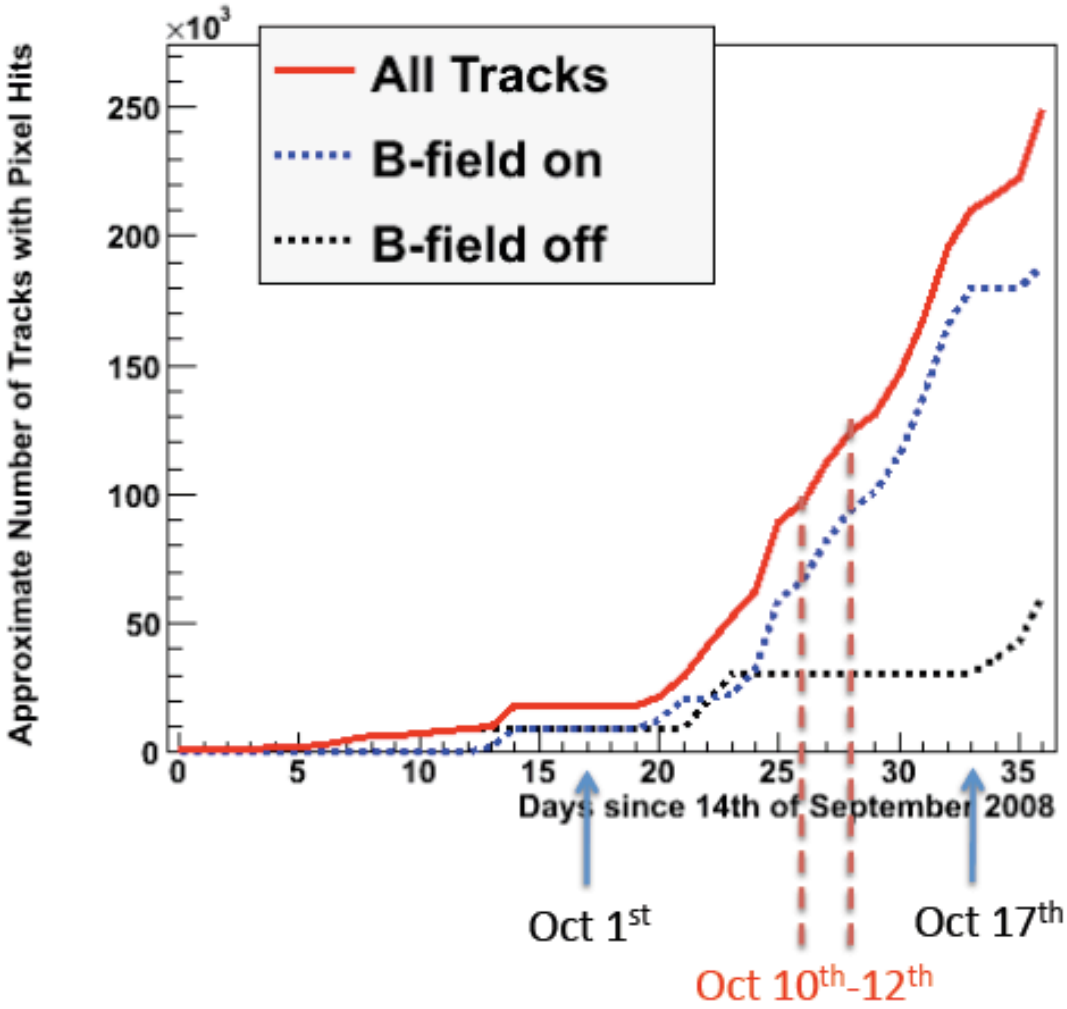
Status:

- Efficiency:
  - 94.2%
  - Bias in d0
- B field on
- New ID alignment constants
- Looser (noise-robust) Si selection: non optimal

Actions:

- Understand & correct bias (**ER**)
- Loosen Si selection (**MOER**)
- Test on CAF (**CR**)
- Propose new fixes

ID tracks collection



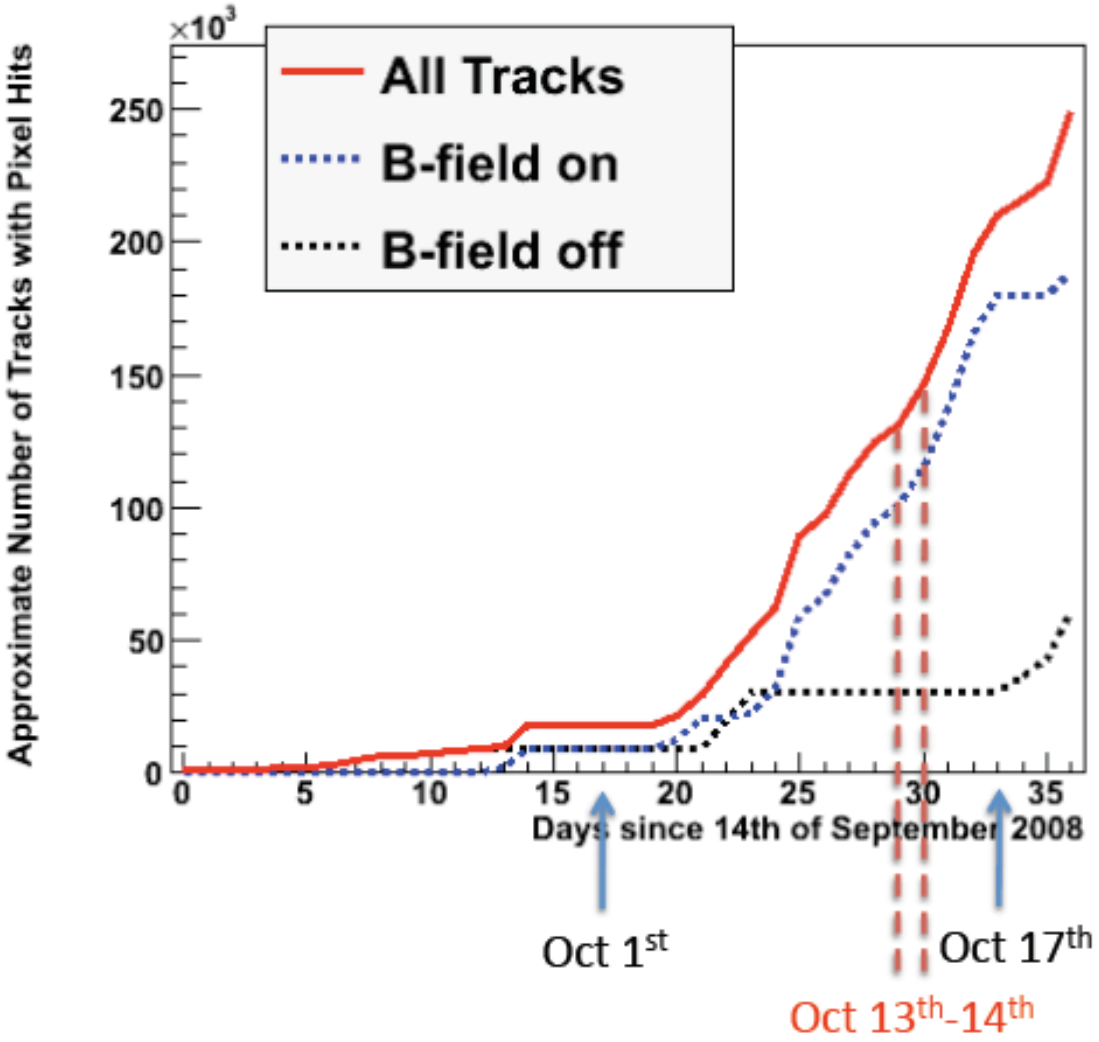
Status:

- Efficiency:
  - 94-95%
  - Bias in d0
- Stable weekend running
- TRT selection too tight (Pt and number of DriftCircles)!

Actions:

- Prepare fixed menu (OER)
- Run Tests on CAF (C)

ID tracks collection



Status:

- Efficiency:
  - 98.1%
  - No bias in d0 and Pt
- Improved Si selection
- Improved TRT selection

Actions:

- Freeze and go!
- Parasitically study other selections (EOSR)
  - EF-ID reco
  - Muon ROI based etc.