The performance of the ATLAS Inner Detector Trigger Algorithms in pp collisions at the LHC

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on behalf of the
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Preface

- LHC took its first 900 GeV collisions in November 2009
 - $L \sim 9 \mu\text{b}^{-1}$ at $\sim 5 \times 10^{26} \text{cm}^{-2}\text{s}^{-1}$
- Since March 2010, 7 TeV collisions
 - $L \sim 15 \text{nb}^{-1}$ at $\sim 2 \times 10^{29} \text{cm}^{-2}\text{s}^{-1}$
- Bunch crossing every 25 ns – 40 MHz rate
 - Data storage capability $\sim 200 \text{Hz}$
 - Reduction of around 200000 to 1 required
- Eventually expect up to ~ 25 (soft) pp interactions per bunch crossing
 - Interesting high p_T interactions complicated by “pile-up”
- Essentially all interesting signatures contain leptons or high momentum tracks

The ATLAS Detector

The Inner Detector

- Transition Radiation Tracker (TRT)
 - Radius 2 mm straw tubes
- Semiconductor Tracker (SCT)
 - 80 μm pitch Silicon strip detectors, double layered, 40 mrad stereo
- Pixel Detector
 - Silicon pixel detector 50 $\times$ 400 μm pixels

The ATLAS Semiconductor Tracker

The ATLAS Trigger System

- Level 1
 - Hardware based, pipelined trigger, coarse granularity, largely Calorimeter and Muon system based.
 - 2.5 microsecond latency
- High Level Trigger - Level 2 and Event Filter
 - Software based, farms of commodity CPU's and ethernet
- Level 2
 - Seeded by Level 1 in Regions of Interest
 - Full detector granularity, all detector subsystems
- Event Filter
 - Seeded by Level 2
 - Access to complete event, reconstruction similar to Offline

Collected data at 7TeV

- LHC provided the first collisions at 7 TeV at the end of March 2010
 - So far, over 800 million events written to tape with stable beams

Tracking through the Silicon detectors

Track Selection

Collision Event at 7 TeV with 2 Pile Up Vertices

- Good Offline tracks were selected from 900GeV or 7TeV collisions
 - $|\eta| < 2.5$, $p_T > 1\text{GeV}$ (no p_T cut for distributions versus p_T)
 - Number of pixel hits > 0 , Number of SCT clusters > 5
 - consistent with Offline vertex
- The performance of the HLT Level 2 and EventFilter tracking was evaluated by matching with these selected Offline tracks.

Run Number: 152166, Event Number: 467774

Date: 2010-03-30 13:31:46 CEST

Efficiency versus Offline track p_T

- Efficiencies with algorithms “out of the box”
- Good performance considering no additional tuning for data
- Excellent agreement with Monte Carlo
- EventFilter plateaus near 100%

Efficiency versus Offline track η

- Well reproduced by the Monte Carlo, except at very large $|\eta|$
- Essentially flat efficiency versus η
 - for EventFilter $\sim 100\%$ for $p_T > 1.2\text{ GeV}$
- Higher efficiency for 7 TeV due to harder track p_T spectrum

Efficiency vs time

- Good stability of trigger over time with changing beam conditions

Transverse beam position

- Accurate online measurement of the luminous region
- Available both to the HLT algorithms and the LHC machine
- Easily see reduced size of luminous region for 7 TeV collisions

Pixel hit multiplicities

- Mean number of SCT and Pixel clusters on tracks versus offline track η
- Data well described by the Monte Carlo, including small number of dead Pixel modules
- Offline tracks reproduced by EventFilter reconstruction extremely well

Resolution with respect to Offline track impact parameter

- EventFilter reconstruction within about $20\mu\text{m}$ of the Offline and around $5\mu\text{m}$ at high p_T
- Level 2 around $30\mu\text{m}$ for high p_T tracks

Muon Trigger Efficiency

- Efficiency for reconstructing offline Muons with $p_T > 4$ GeV with the Inner Detector Trigger in the Region of Interest identified by the L2 Muon algorithm
- Efficiency better than 99% for both Level 2 and the EventFilter

Summary and Outlook

- The LHC is routinely providing collisions at 7 TeV
- The HLT tracking is essential for the identification of physics objects with high transverse energy
- The ATLAS HLT tracking has been running successfully during data taking since December 2009, and also providing accurate online determination of the vertex
- Recently (since 23rd May) started running the HLT in rejection mode for the electron triggers.
- The HLT performance accurately reproduces that of the Offline algorithms and is remarkably well described by the Monte Carlo.
- The future will be an interesting time for us all.