Performance of the ATLAS first-level Trigger with first LHC Data

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on behalf of the ATLAS Collaboration

The 17th Full Time Conference, RT10 (IEEE-NPSS)
May 26 2010

First-level Trigger overview

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First level trigger latency $< 2.5\mu\text{s}$

First colliding beams in ATLAS

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First LHC beams “RF cogging”

ATLAS Beam Pickup
timing signals:

900 ps corresponds to a
vertex shift of 13.5 cm

after adjustment

Longitudinal track positions

Online Track Z_0 -

Before and after the adjustment by the
LHC RF team

...one of the first proofs of collisions in
ATLAS

Minimum bias trigger scintillators

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System summary

- Late add-on of 2x16 scintillator paddles installed in front of LAr cryostat, on both sides
- The most sensitive trigger detector. - Will be operational during initial running only $\sim 1/\text{fb}$

Colliding beams compared to single beams:

Requiring at least one hit on both sides reduces backgrounds.

Example event

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Run: 152845, Event: 3338173
Date: 2010-04-12 16:56:44 CEST

ATLAS EXPERIMENT

Minimum
bias trigger
scintillators
fired

Muon trigger:
TGC fired

Muon detector:
Muon Drift tubes

$p_T(\mu^-) = 40 \text{ GeV}$
 $\eta(\mu^-) = 2.0$
 $E_T^{\text{miss}} = 41 \text{ GeV}$
 $M_T = 83 \text{ GeV}$

Silicon and
TRT

Muon

Missing ET

**$W \rightarrow \mu \nu$ candidate
in 7 TeV collisions**

ATLAS First Level Central Trigger

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Central Trigger Processor (CTP)

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in a single
9U VME 64x chassis

40 MHz,
synchronized to the beams

CTPMI:
Machine interface and clocks

CTPCAL:
Calibration requests

CTPOUT:
Distribution of trigger results,
clock, detector veto, ...

ATLAS First Level Central Trigger

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The Bunch-Group mechanism:

Masking and selection of bunch-numbers (time within beam orbit) for trigger items

Example Bunch group configuration with 2 paired and 2 unpaired bunches

Bunch groups are updated at the press of a button - using ATLAS beam pickups

Activities and development during the commissioning phase

Developed and commissioned a Zero Bias trigger:

Fractional prescales

New firmware developed and commissioned

...for example 10,20,30 ... %

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Activities and development during the commissioning phase

Monitoring

trigger rates
timing,
dead-times

→ Online Plots/Tables

→ Databases → Automatic generation of status web-pages

First level calorimeter trigger - Overview

See also talk by David Hadley (next session LHC 2-1)
Digital Filtering Performance in the ATLAS Level-1 Calorimeter Trigger

- **PreProcessor:**

digitization and bunch-crossing id.

- **Cluster Processors:**

identifies electrons, photons, single hadrons

- **Jet/Energy processors:**

Jet finding and energy sums

Nearly 300 custom VME modules of 10 different types

17 crates @ ATLAS underground

Optical fibres
(Readout module)

LVDS cables and fibres
(PreProcessor module)

Trigger efficiency

The L1 Calorimeter trigger system has been commissioned successfully

The trigger performance is very good, about 99.8% of trigger towers fully operational.

Additionally ~1% affected by calorimeter problems.

About 95% timed in to within 5ns, only very few outside 10ns.

Activities and outlook:

- Continue improvements for timing and energy resolution.
- Optimizing noise suppression.
- Commissioning the last 0.2%

Trigger Rate (Hz)

EM2	1.282 ± 0.005
EM3	0.515 ± 0.003
EM4	0.252 ± 0.002
EM5	0.142 ± 0.002
EM10	0.021 ± 0.001
EM14	0.008 ± 0.001

Normalized to luminosity

$L=10^{27} \text{cm}^{-2} \text{s}^{-1}$ (~20% uncertainty)

First level muon triggers - Overview

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Muon trigger detectors:
Dedicated trigger detectors distinct from the measuring detectors.
- Triggers are faster/other detectors more precise.

Muon triggers provides trigger candidates for different momentum threshold, within $2 \mu\text{s}$.

ATLAS Toroidal magnetic field allows good muon energy measurement, also for muon triggers.

TGC detector coverage 99.2 %, RPC: 99.7%

*TGC is completely timed in $\sim 2-3$ ns.
Not yet enough muon data for complete timing in of RPC.*

With higher luminosity, more detailed timing and phase measurements will be possible

Summary and Conclusion

The ATLAS first level trigger has been fully commissioned.

The Beam Pickup and bunch group systems perform as expected. Beam phase measured to ~ 100 ps.

Calorimeter triggers are well timed in and operational to ~ 99 %.

Muon triggers are being timed in.

The Minimum bias trigger scintillator system is the main trigger so far.

ATLAS has recorded $\sim 8/\text{nb}$ of collision at 7 TeV.

(as of 20/5 2010)