Operation of the ATLAS Detector with First 7 TeV Collisions

Peter Onyisi

for the ATLAS Collaboration

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Topics

- Luminosity
- Online monitoring
- Reconstruction (Tier-0)
- Offline monitoring
- Calibration
- Analysis

Operation of the ATLAS Detector
24 July 2010
Not shown: forward detectors (see later)
As of July 19:

- 357 nb$^{-1}$ stable beam delivered
- 338 nb$^{-1}$ recorded in full configuration
- Peak lumi $1.6 \times 10^{30}$ cm$^{-2}$ s$^{-1}$
Subdetectors Used For Luminosity

- scintillator disks
- forward LAr calorimeter
- zero degree calorimeter
- gas Cherenkov tubes
- track/vertex counting
- beam conditions monitor
Luminosity Normalization — Monte Carlo

- For 900 GeV runs and early 7 TeV data used cross-sections and normalization from Monte Carlo
- Uncertainty 20% dominated by MC cross-section

Independent normalizations from MC

Normalized to MBTS

ATLAS Preliminary
LHC fill 1022; \(\sqrt{s}=7\) TeV

\[
\int L^{\text{MBTS}} \, dt = 75.6 \pm 15.1 \text{ (stat} \oplus \text{syst) } \mu \text{ b}^{-1}
\]
Luminosity Normalization — van der Meer scans

- LHC provided three van der Meer scans
  - beams separated by known distances & interaction rate measured
  - measured transverse beam profile gives normalization from geometry

- Luminosity normalization now known to 11%
  - Largest uncertainty from LHC beam current measurement (5% per beam)

\[ \mathcal{L} = \frac{n_b f_r I_{1} I_{2}}{2\pi \Sigma_x \Sigma_y} \]

- \( n_b \): number of bunches
- \( f_r \): revolution frequency
- \( I_{(1,2)} \): particles per bunch in beams 1, 2
- \( \Sigma_{(x,y)} \): effective convolved width in \( x \), \( y \)
  \[ = \int R(X) \, dX / (\sqrt{2\pi} R_{\text{peak}}) \]
## Detector Operational Channels

<table>
<thead>
<tr>
<th>Subdetector</th>
<th># of Channels</th>
<th>Fraction operational</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pixels</td>
<td>80 M</td>
<td>97.4%</td>
</tr>
<tr>
<td>SCT Silicon Strips</td>
<td>6.3 M</td>
<td>99.2%</td>
</tr>
<tr>
<td>TRT Transition Radiation Tracker</td>
<td>350 k</td>
<td>98.0%</td>
</tr>
<tr>
<td>LAr EM Calorimeter</td>
<td>170 k</td>
<td>98.5%</td>
</tr>
<tr>
<td>Tile calorimeter</td>
<td>9800</td>
<td>97.3%</td>
</tr>
<tr>
<td>Hadronic endcap LAr calorimeter</td>
<td>5600</td>
<td>99.9%</td>
</tr>
<tr>
<td>Forward LAr calorimeter</td>
<td>3500</td>
<td>100%</td>
</tr>
<tr>
<td>LVL1 Calo trigger</td>
<td>7160</td>
<td>99.9%</td>
</tr>
<tr>
<td>LVL1 Muon RPC trigger</td>
<td>370 k</td>
<td>99.5%</td>
</tr>
<tr>
<td>LVL1 Muon TGC trigger</td>
<td>320 k</td>
<td>100%</td>
</tr>
<tr>
<td>MDT Muon Drift Tubes</td>
<td>350 k</td>
<td>99.7%</td>
</tr>
<tr>
<td>CSC Cathode Strip Chambers</td>
<td>31 k</td>
<td>98.5%</td>
</tr>
<tr>
<td>RPC Barrel Muon Chambers</td>
<td>370 k</td>
<td>97.0%</td>
</tr>
<tr>
<td>TGC Endcap Muon Chambers</td>
<td>320 k</td>
<td>98.6%</td>
</tr>
</tbody>
</table>

> 97% of channels operational for all subdetectors
1/3 of final L2+EF farm capacity installed

**Rates**

<table>
<thead>
<tr>
<th>Eventual</th>
<th>Typical*</th>
</tr>
</thead>
<tbody>
<tr>
<td>75 kHz</td>
<td>2-3 kHz</td>
</tr>
<tr>
<td>(~ 3 kHz)</td>
<td>0.7–1 kHz</td>
</tr>
<tr>
<td>200 Hz</td>
<td>200 Hz</td>
</tr>
</tbody>
</table>

* = Physics menu, highest \(\mathcal{L}\) run

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Operation of the ATLAS Detector

24 July 2010
DAQ In An Example (Recent) Run

LHC declares stable beam; ATLAS still in STANDBY

ATLAS READY after warm start

End of fill; ATLAS to STANDBY

Luminosity-weighted DAQ efficiency for 7 TeV data: 97.2%

ATLAS Online Luminosity

- LHC Delivered
- LHC Stable Beams
- ATLAS Recorded

LHC Fill 1225
14 July, 2010

LHC Stable Beams

1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0

02h 04h 06h 08h 10h 12h 14h 16h 18h

CEST Time

Total Delivered: 60.0 nb
Total Recorded: 59.5 nb

beam separation removed

ATLAS run begins at 22:39

ATLAS run ends at 17:14

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Operation of the ATLAS Detector

24 July 2010 10
• Event size is at target \( \sim 1.6 \text{ MB/event} \)
• Level 2 output is near design output rate (reached 2.5 kHz, design \( > 3 \text{ kHz} \) — full set of computing nodes not yet deployed)
• Event Filter (final trigger output) has surpassed design output rate (200 Hz)
  • The Tier-0 reconstruction farm processes 200 Hz successfully
• Techniques implemented to maintain high efficiency
  • “Stopless” removal/recovery: parts of readout can be dropped during run if causing problems, and reincluded when fixed
  • Automatic resynchronization to LHC clock
  • Silicon and muon detectors kept in intermediate standby state until stable beams declared (“warm start”): shortens ramp time without compromising safety
  • “Expert system” recognizes error/configuration conditions and takes appropriate action
ATLAS separates Level 1 trigger (hardware) from High Level Trigger (software).

HLT operation was phased in:
- For brief initial period HLT did not run any algorithms on events
- Very quickly HLT algorithms began to run, but did not reject any events (events were just tagged with whether they passed triggers or not). Minimum bias rate handled via prescales.
- For recent higher luminosity ($\geq 10^{29}$) some HLT triggers are now in rejection mode
- Physics menu was deployed at $1.6 \times 10^{30}$ cm$^{-2}$ s$^{-1}$
Trigger configuration change after stable beams visible

L1 EM rates would saturate recorded bandwidth; therefore improve rejection by using EF algorithms
Monitoring in HLT

Trigger monitoring is important part of monitoring chain
  - e.g. can determine beamspot parameters online in high level trigger — will feed this back to displaced vertex triggers
Online Monitoring

Many tools for online monitoring:

- Detector Control System and LHC interface tools
- An extensive suite of trigger rate monitoring tools
- Several event analysis frameworks provide histograms
  - Raw data fragments
  - HLT monitoring
  - Full event reconstruction (also feeds event displays)
- Selected histograms are analyzed and flagged good/caution/bad automatically
- Histograms archived at end of run

Systems are distributed programs, makes overall system more robust

Developing/improving remote monitoring tools
Full cycle (first reconstruction pass, calibration, second reconstruction pass, data quality assessment) generally complete in 3–4 days
Calibration Loop

- Calibration occurs immediately after prompt reconstruction of express data (finished within hours after a run ends) and before “bulk” reconstruction of all events (~ 36 hours after run ends)
- Typical updates:
  - Beamspot (determined on ~ 10 minute intervals)
  - Calorimeter hot channels, noise distributions
  - Straw tube $t_0$ and distance-time relations
  - Silicon noise masks
- Muon detectors will join at higher luminosity
Impact of Calibration Loop

Before

DCA vs Phi wrt Beamspot

After

DCA vs Phi wrt Beamspot

Hit Map of clusters with $E_{clus} > 2.5$ GeV

Hit Map of clusters with $E_{clus} > 2.5$ GeV

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Data Quality

- Input to data quality decisions comes from shifters, slow control information, and automated tests on distributions.
- Preliminary DQ decision within 36 hours, finalization of decisions for initial Tier-0 processing within 92 hours of data taking.
- Good interaction with calibration loop.

<table>
<thead>
<tr>
<th>Inner Tracking Detectors</th>
<th>Calorimeters</th>
<th>Muon Detectors</th>
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</thead>
<tbody>
<tr>
<td>Pixel</td>
<td>SCT</td>
<td>TRT</td>
</tr>
<tr>
<td>97.1</td>
<td>98.2</td>
<td>100</td>
</tr>
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</table>

Luminosity weighted relative detector uptime and good quality data delivery during 2010 stable beams at $\sqrt{s}=7$ TeV between March 30th and July 16th (in %).

Poster: Peter Waller
Quality of ATLAS data can change significantly during a run...

- Standby/Ready transition
- Power supply trips
- Coherent noise bursts
- Removal/readdition of fractions of the detector

DQ evaluated with luminosity block granularity (~ 2 minutes)
ATLAS has begun its 7 TeV data taking very successfully
  - During LHC stable beams, DAQ efficiency of ~ 97% and good data efficiency of ~ 94%

Commissioning of all essential data-taking systems proceeding well

Fast monitoring and calibration provides high-quality data for analysis