ATLAS Performance in LHC Run-2

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On behalf of the ATLAS Collaboration
Overview

• ATLAS at a glance
• Upgrades during LS1
• Detector Performance
• Improvements/features for 2016
• Outlook
ATLAS at a glance
Overall Performance

- Upwards of 96% operational fraction across all detectors
- 92% Data taking efficiency while integrating new detector components

Run 2 Performance Results

ATLAS Detector Status

<table>
<thead>
<tr>
<th>Subdetector</th>
<th>Number of Channels</th>
<th>Approximate Operational Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pixels</td>
<td>92 M</td>
<td>98.2%</td>
</tr>
<tr>
<td>SCT Silicon Strips</td>
<td>6.3 M</td>
<td>98.6%</td>
</tr>
<tr>
<td>TRT Transition Radiation Tracker</td>
<td>350 k</td>
<td>97.3%</td>
</tr>
<tr>
<td>LAr EM Calorimeter</td>
<td>170 k</td>
<td>100%</td>
</tr>
<tr>
<td>Tile calorimeter</td>
<td>4900</td>
<td>99.2%</td>
</tr>
<tr>
<td>Hadronic endcap LAr calorimeter</td>
<td>5600</td>
<td>99.6%</td>
</tr>
<tr>
<td>Forward LAr calorimeter</td>
<td>3500</td>
<td>99.8%</td>
</tr>
<tr>
<td>LVL1 Calo trigger</td>
<td>7160</td>
<td>100%</td>
</tr>
<tr>
<td>LVL1 Muon RPC trigger</td>
<td>370 k</td>
<td>99.75%</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>357 k</td>
<td>99.7%</td>
</tr>
<tr>
<td>CSC Cathode Strip Chambers</td>
<td>31 k</td>
<td>98.4%</td>
</tr>
<tr>
<td>RPC Barrel Muon Chambers</td>
<td>370 k</td>
<td>96.6%</td>
</tr>
<tr>
<td>TGC Endcap Muon Chambers</td>
<td>320 k</td>
<td>96.6%</td>
</tr>
</tbody>
</table>

Run 1 | Run 2
---|---
Peak Luminosity (cm$^2$ s$^{-1}$) | $7.7 \times 10^{33}$ | $5.1 \times 10^{33}$
Pileup (mean) | 21 | 13.5
Integrated Luminosity | 22.8 | 4.2
Data taking efficiency (%) | 93 | 92
Overall Performance

• Pileup (num interactions per bunch crossing) did not reach Run 2 predictions in 2015

• Expect higher in 2016 with push for higher luminosity
Insertable B-Layer (IBL)

- New 4th layer for Pixel detector close to beam pipe (33.25 mm radius)
- Designed to improve tracking and vertex resolution
- Installed in 2014 and commissioned ahead of start of Run 2
Insertable B-Layer (IBL)

- Status – some startup issues
- Front-End current drift during runs, linked to irradiation of N-MOS transistors
  - Affected data taking from October 2015 onwards
  - Problem expected to stabilise in 2016 as integrated dose increases
  - Related temperature-dependent distortion of \(\sim 10\mu m/K\)
  - Corrected on run-by-run basis before reconstruction of data
- After alignment, no significant impact on tracking
Insertable B-Layer (IBL)

- Performance
  - Up to a factor of 2 improvement in impact parameter resolution for low $P_T$ tracks
  - Contributes to significant improvement in $b$-tagging efficiency for jets alongside move to offline-style tagging algorithms

![Impact Parameter Results](image1)

![b-tagging Results](image2)
Inner Detector Tracking Performance

• Semiconductor Tracker (SCT) and Transition Radiation Tracker (TRT) performed well in 2015 after maintenance during long shutdown

• TRT moved from Xe dominated gas mixture in all straws to Ar dominated mixture in some straws to mitigate cost of tubing leaks
Inner Detector Tracking Performance

• Tracking systematics
  • Loose selection: 0.4% for central barrel and 2.2% in endcap
  • Tight primary: 0.5% for central barrel and 2.6% in endcap

Tracking Results
Muon System Updates

- Installation of new chambers
- Improvements and overhaul of readout electronics
- New Thin Gap Chamber (TGC) coincidence layer added to minimise fakes at high pseudorapidity
- Extra coincidence with sections of tile calorimeter to be added in 2016

L1 Muon Trigger Results
Muon Trigger Status

- Significant improvements to muon full scan processing
- Low efficiency remaining in barrel due to geometrical constraints

Muon Trigger Results
Muon System Performance Status

- Full readout operational at 100kHz
- Alignment ~50µm for both barrel and endcap
- Reconstruction efficiency ~99% across whole pseudorapidity range
- Isolation efficiency > 93% ($p_T$ selection dependent)

<table>
<thead>
<tr>
<th></th>
<th>Barrel (%)</th>
<th>Endcap J/$\psi$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p_T$ resolution</td>
<td>1.7%</td>
<td>2.3</td>
</tr>
<tr>
<td>$p_T$ Scale uncertainty</td>
<td>0.05%</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Multiply by √2 for $p_T$ res
Calorimeter Status

- Hardware interventions
  - Front end power supplies repaired for Tile and Lar
  - Multiple readout fixes and improvements
  - Returned detectors to upwards of 99% operational state

- Software
  - Improvements to electron and photon ID algorithms

Jet Performance Results

ATLAS Preliminary

$\sqrt{s} = 13$ TeV, 3.3 fb$^{-1}$
$\gamma$+jet Events
anti-$k_T$, R = 0.4, EM+JES (in-situ)
$|\eta|^{\text{lead jet}} < 0.8$

 Photon ID Results

Pythia prompt photon MC
$|\eta| < 0.60$
$E_T^{\text{iso}} < 4$ GeV
- Converted
- Unconverted

The lower efficiency in data than in MC mostly arises from a known mismodelling of calorimetric shower shapes in the GEANT detector simulation.
Overall Trigger Status

• L1 rate limited in 2015 by need to protect IBL wire bonds from resonances
  • Problem diminishes as LHC bunch population increases
  • Doesn’t impair delivery of menu
• Dedicated B-physics triggers delivering good yields
L1 Topological Trigger

- New input to L1 trigger system
- Provides trigger with information on event topology
- Commissioning ongoing through early 2016
L1 Topological Trigger

• Expect significant improvements for B-physics performance
• More detail in Umberto De Sanctis’ poster in Tuesday session focussing on $B_S \rightarrow \mu\mu$
Fast TrackKer (FTK)

- New component for Run 2
- Will provide full scan tracking to High Level Trigger for events passing Level 1
- Important to keep pace with increasingly challenging LHC collision environment
Fast TracKer (FTK) Status

- Installation and commissioning throughout 2016
- Track quality similar to offline reconstruction for significantly reduced processing times

FTK Simulation Results
Overall Outlook for 2016

• LHC pushing to higher luminosity 13 TeV collisions
  • Aiming for 2700+ bunches in machine with 40cm $\beta^*$
    • Compared with max 1800 bunches and 80cm $\beta^*$ in 2015
    • Target of 152 days of proton physics to integrate 30fb$^{-1}$

• Improved trigger and tracking performance from L1Topo and FTK components coming fully online

• Data taking efficiency already comparable to Run 1
  • Improved stability expected for 2016
Missing ET and Tau Performance

• Good Data/MC agreement