Status Report from ATLAS to the LHCC

David Strom, University of Oregon
Topics in this talk

• Operations and data quality in proton runs
• Trigger in the proton run
• Effects of pileup on the trigger
• Effects of pileup on the reconstruction
• Status of ALFA (elastic proton-proton scattering)
• Operation and trigger in the Pb-Pb run
• Performance in the Pb-Pb run
• New physics since the last LHCC:
  • SM
  • top
  • SUSY
  • Exotics
• Shutdowns and upgrade
2011 Data Taking Conditions  Proton Run 5.2 fb$^{-1}$

ATLAS Online Luminosity  $\sqrt{s} = 7$ TeV

Peak Luminosity per Fill [$10^{33}$ cm$^2$ s$^{-1}$]

- LHC Stable Beams
- Peak Lumi: $3.65 \times 10^{33}$ cm$^2$ s$^{-1}$

Recorded Luminosity [pb$^{-1}$]

- $\beta^* = 1.0$ m, $\langle n \rangle = 11.6$
- $\beta^* = 1.5$ m, $\langle n \rangle = 6.3$

Mean Number of Interactions per Crossing
Overall data taking efficiency 93.5% (94.7% w/o warm-start)

<table>
<thead>
<tr>
<th>Cause</th>
<th>Inefficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dead time</td>
<td>1.0</td>
</tr>
<tr>
<td>Warm-start</td>
<td>1.2</td>
</tr>
<tr>
<td>DAQ Actions</td>
<td>1.2</td>
</tr>
<tr>
<td>Equipment Failure (incl. Human Resp.)</td>
<td>2.8</td>
</tr>
</tbody>
</table>

Luminosity weighted relative detector uptime and good quality data delivery during 2011 stable beams in pp collisions at $\sqrt{s}=7$ TeV between March 13th and October 30th (in %), after the summer 2011 reprocessing campaign.

DQ efficiency for physics analysis $\geq 90%$
Trigger Overview

Calo, Muon, Specialized Detectors

- L1
  Fast Custom Electronics
  t<2.5μs

- L2
  X racks
  <t> ~ 60ms (40 ms)

- EF
  Y racks
  <t>~0.6s (4s)

Requested Data in RoI

- Tracking
  Front End Pipelines
  < 75kHz

Access to full event

- Readout Buffers
  <6kHz (3kHz)

- Event Builder
  Full Event Buffers

~500MB/s (300MB/s)

~400 Hz (200Hz)

Storage & Offline Processing

ATLAS 2011 Trigger, end of run (ATLAS Design)

Limits

- DAQ readout rate significantly beyond design (lower thresholds)
- Sophisticated tools in place to predict resource usage throughout system
- Expect that current system is adequate for 2012 run
- Can complete CPU system during the 2012 run if necessary

Menus and Algos

- ~200 Level 1 items
- ~500 Level 2 chains
- ~500 EF chains

Menu complexity mainly for supporting items

arXiv:1110.1530
Add Hadronic Core Veto for EM
Raise electron thr. to 22 GeV
Single electron thr. 20 GeV
Single muon thr. 18 GeV
Comb. $\tau$ (e, $\tau$) (15,16), (µ, $\tau$) (15,16), ($\tau$, $\tau$) (29,20)
Comb. $\tau$ (e, $\tau$) (15,20), (µ, $\tau$) (15,20), ($\tau$, $\tau$) (29,20)

<table>
<thead>
<tr>
<th>L1</th>
<th>HLT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muon</td>
<td>electron</td>
</tr>
<tr>
<td></td>
<td>photon</td>
</tr>
<tr>
<td></td>
<td>muon</td>
</tr>
<tr>
<td></td>
<td>tau</td>
</tr>
<tr>
<td></td>
<td>jet</td>
</tr>
<tr>
<td></td>
<td>b-jet</td>
</tr>
<tr>
<td></td>
<td>missing $E_T$</td>
</tr>
<tr>
<td>99.0</td>
<td>99.3</td>
</tr>
<tr>
<td>100</td>
<td>99.3</td>
</tr>
<tr>
<td>99.8</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>99.9</td>
</tr>
<tr>
<td></td>
<td>98.6</td>
</tr>
<tr>
<td></td>
<td>99.9</td>
</tr>
<tr>
<td></td>
<td>99.3</td>
</tr>
</tbody>
</table>

Luminosity weighted relative trigger quality delivery during 2011 stable beams in pp collisions at $\sqrt{s}=7$ TeV between 13 March and 31 October (in %).
Trigger rates and timing at high pileup

Most Trigger cross sections are flat with $\mu$.

ATLAS Trigger Operations (Oct. 22 & 25, 2011)

| L1 rate (kHz) at $L = 10^{34} \text{cm}^{-2}\text{s}^{-1}$ |
|-----------------|-----------------|
| $\mu$           | 0               |
| 0               | 10              |
| 10              | 20              |
| 20              | 30              |
| 30              | 40              |

- 12 trains, 50ns, 1332 bunches
- no trains, 10 bunches

Single-objects triggers

L2 Electrons

L2 taus

L2 CPU time linear with pileup for key algorithms
Mulit-jet Rates and Missing E\textsubscript{t} are especially sensitive to pileup

Many knobs to turn to reduce rate:
- Increase noise threshold
- Reduce angular coverage of lowest threshold
- Raise thresholds

• Standard noise threshold is 1 GeV
• Loose noise thresholds in FCAL <6.5 GeV
• Tight noise thresholds in FCAL <7.5 GeV
Muon trigger efficiency versus pileup

Little dependence of muon trigger with respect to muon efficiency on mean number of interactions per event

ATLAS Preliminary
2011 Data $\sqrt{s} = 7$ TeV

**Barrel**

- mu18 2-station level1 seed
- mu18 3-station level1 seed

| $|\eta_{\muon}| < 1.05$ |
|-----------------------|
| Trigger efficiency w.r.t. offline |
| interactions per bunch crossing |

| $|\eta_{\muon}| > 1.05$ |
|-----------------------|
| Trigger efficiency w.r.t. offline |
| interactions per bunch crossing |

- 2 station level 1 seed used in barrel for $\beta^*=1.5$ m
- 3 station level 1 seed used in barrel for $\beta^*=1.0$ m
Electron efficiency versus number of interactions

Efficiency relative to offline

\[
\begin{align*}
\text{ATLAS Preliminary} \\
\int Ldt = 2.8 \text{ fb}^{-1} \\
2011 \text{ p-p Collision Data } \sqrt{s} = 7 \text{ TeV}
\end{align*}
\]

Small dependence of trigger efficiency with respect to offline selection
Data is has \( \beta^* = 1.0 \text{m} \)
### 2011 Physics Proton Trigger Menu (end of run $L = 3.3 \times 10^{33} \text{ cm}^{-2}\text{s}^{-1}$)

<table>
<thead>
<tr>
<th>Offline Selection</th>
<th>Trigger Selection</th>
<th>L1 Rate (kHz) at 3e33</th>
<th>EF Rate (Hz) at 3e33</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Single leptons</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single muon &gt; 20 GeV</td>
<td>11 GeV</td>
<td>18 GeV</td>
<td>8</td>
</tr>
<tr>
<td>Single electron &gt; 25 GeV</td>
<td>16 GeV</td>
<td>22 GeV</td>
<td>9</td>
</tr>
<tr>
<td><strong>Two leptons</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 muons &gt; 17, 12 GeV</td>
<td>11 GeV</td>
<td>15,10 GeV</td>
<td>8</td>
</tr>
<tr>
<td>2 electrons, each &gt; 15 GeV</td>
<td>2x10 GeV</td>
<td>2x12 GeV</td>
<td>2</td>
</tr>
<tr>
<td>2 taus &gt; 45, 30 GeV</td>
<td>15,11 GeV</td>
<td>29,20 GeV</td>
<td>7.5</td>
</tr>
<tr>
<td><strong>Two photons</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 photons, each &gt; 25 GeV</td>
<td>2x12 GeV</td>
<td>20 GeV</td>
<td>3.5</td>
</tr>
<tr>
<td><strong>Single jet plus MET</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jet $p_T$ &gt; 130 GeV &amp; MET &gt; 140 GeV</td>
<td>50 GeV &amp; 35 GeV</td>
<td>75 GeV &amp; 55 GeV</td>
<td>0.8</td>
</tr>
<tr>
<td><strong>MET</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MET &gt; 170 GeV</td>
<td>50 GeV</td>
<td>70 GeV</td>
<td>0.6</td>
</tr>
<tr>
<td><strong>Multi-jets</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 jets, each $p_T$ &gt; 55 GeV</td>
<td>5x10 GeV</td>
<td>5x30 GeV</td>
<td>0.2</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>&lt;75</td>
<td>~400 (mean)</td>
</tr>
</tbody>
</table>

- Some increase in L1 thresholds needed in 2012 (other measures need upgrade)
- Many triggers have rate $\sim E_t^{-3}$, raising thr. 20% gives 50% rate reduction
- Isolated single lepton triggers ready in 2011, but not yet used in physics
  - Factor of 2 to 3 available from tracking isolation alone at EF
- Expect to keep 25 GeV single lepton offline thresholds in 2012
Continuing code optimization is underway

Expect 6000 cores in 2012

Tier0 jobs
Tracking at high pile up ($\mu \sim 30$)

Comparison of tracks in random events between normal running and high mu run

Hits on tracks are constant even at pileup of 30

Fakes will increase

Comparison of tracks in random events between normal running and high mu run

Fakes will increase
• Significant impact of pileup on electron ID well described by MC
• *Will optimize electron ID for 2012 further*
No evidence of degradation of electron mass resolution with high $\mu$ in 2011

<table>
<thead>
<tr>
<th>$\eta$ coverage</th>
<th>2011 resolution (GeV)</th>
<th>2010 resolution (GeV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$</td>
<td>\eta</td>
<td>&lt; 2.47$</td>
</tr>
<tr>
<td>$</td>
<td>\eta</td>
<td>&lt; 1.37$</td>
</tr>
<tr>
<td>$2.47 &lt;</td>
<td>\eta</td>
<td>&lt; 1.37$</td>
</tr>
</tbody>
</table>
Muon Performance

Mass resolution and isolation is well described by the Monte Carlo

Isolation efficiency

Tracks: $\sum 0.2 p_{t}^{trk}/p_{t}^{\mu} < 0.15$

Calo: $\sum 0.2 E_{t}/p_{t}^{\mu} < 0.3$
ALFA: goal to measure precisely luminosity and total cross section

- probe $|t|$ in range 0.01 to 0.2-0.4GeV$^2$
- measure $\sigma_{\text{tot}}$ via optical theorem (using vdM lumi)
- 100M events in total, 1.5M elastic and 2M diffractive events

**2011 run $\beta^* = 90$ m, detectors at 6.5$\sigma$ (~5mm):**

- Potential to reach Coulomb-Nuclear Interference (CNI) region
- Push $\beta^*$ to 500 - 1000m
- Move detector close to the beam to touch CNI region
- Measure $\sigma_{\text{tot}}$ and luminosity simultaneously

**2012 program**

Angular correlation of protons on left & right indicating elastic scattering
HI OPERATIONS in 2011

Stream | Events Taken | Reco CPU/evt [s]
--- | --- | ---
Min Bias | 60M | 70
Hard Probes | 54M | 140
UPC | 6.6M | 30

CPU carefully optimized for the HI run

15 times more data than last year

ATLAS Online Luminosity $\sqrt{s_{\text{NN}}} = 2.76$ TeV

Total Integrated Luminosity [ub$^{-1}$]

Tier0 jobs – up to 5000 CPUs used

HI Tier0 backlog about 2 weeks
Triggers for heavy ions

Peak luminosity $5.1 \times 10^{26} \text{cm}^{-2}\text{s}^{-1}$, gives 6 kHz of min-bias rate at L1:

- In 2011 High Level Trigger (HLT) essential to bring output rate down to 500MB/s (200Hz for HI events)
- Two approaches used:
  - Full scan reconstruction at EF on all min-bias events triggered by L1 (jets, muons),
  - Region-Of-Interest (RoI)-based reconstruction seeded off the lowest-$p_T$ threshold at L1 (muons, photons, electrons),

<table>
<thead>
<tr>
<th>Signature</th>
<th>Trigger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jets</td>
<td>single jet $p_T &gt; 20 \text{GeV}$</td>
</tr>
<tr>
<td>Muons</td>
<td>single muon $p_T &gt; 4 \text{GeV}$</td>
</tr>
<tr>
<td></td>
<td>di-muon $p_T &gt; 2 \text{GeV}$</td>
</tr>
<tr>
<td>Electron/photon</td>
<td>single egamma $p_T &gt; 14 \text{GeV}$</td>
</tr>
<tr>
<td></td>
<td>di-egamma $p_T &gt; 5 \text{GeV}$</td>
</tr>
<tr>
<td>UPC</td>
<td>low track multiplicity cut</td>
</tr>
</tbody>
</table>
Number of tracks as a function of centrality

ATLAS preliminary

Pb+Pb $\sqrt{s_{NN}} = 2.76$ TeV, data 2011

runs 193211-193321

Increasing overlap

ATLAS Preliminary

Pb+Pb $\sqrt{s_{NN}} = 2.76$ TeV

$\langle \Delta E, E \rangle = 200$ mb

FCal $\Sigma E_T$ [TeV]
Muon spectra from hard probes stream

$\sqrt{s_{NN}} = 2.76$ TeV

$\int Ldt \approx 40 \mu b^{-1}$

$p_T^{\mu^+,\mu^-} > 3$ GeV

$\text{ATLAS Preliminary}$

$\text{Dimuon trigger}$

$\text{Pb+Pb data 2011}$

$dN/dm_{\mu\mu}$ [GeV$^{-1}$]

$m_{\mu\mu}$ [GeV]
Symmetric dijet event

Track jet, $R = 0.4$
Calorimeter jet, $R = 0.4$

track $p_T > 2$ GeV
muon $p_T > 2$ GeV

Jet 1, $p_T = 416$ GeV
Jet 2, $p_T = 380$ GeV

$A_J = 0.05$
Track jet, $R = 0.4$
Calorimeter jet, $R = 0.4$
  track $p_T > 2$ GeV
  muon $p_T > 2$ GeV

Jet 1, $p_T = 206$ GeV
Jet 2, $p_T = 63$ GeV
Jet 3, $p_T = 39$ GeV

$A_J = 0.5$
Jet finding in HI Events

Trigger algorithm finds jets independently of centrality

ATLAS Preliminary
Pb+Pb $\sqrt{s_{NN}} = 2.76$ TeV

20 GeV $E_T$ threshold
anti-$k_T$ R=0.2

Centrality
- 0-10%
- 10-20%
- 20-40%
- 40-60%
- 60-100%

Offline Jet $E_T$ [GeV]
Physics -- publications

- 88 papers submitted on collision data
- 261 public conf notes

---

Bar chart showing the number of searches, measurements, and performance papers submitted each month.
Standard Model (including top)

Concentrate on dibosons and new constraints on couplings

\[ \int \, \text{L dt} = 0.035 \, - \, 1.04 \, \text{fb}^{-1} \]

\[ \sqrt{s} = 7 \, \text{TeV} \]

- Theory
- Data 2010 (~35 pb\(^{-1}\))
- Data 2011
ZZ production (electron and muon decays)

\[ \sigma_{ZZ}^{tot} = 8.5^{+2.7}_{-2.3} \text{ (stat.)} +0.4_{-0.3} \text{ (syst.)} \pm 0.3 \text{ (lumi.) pb} \]

\[ \sigma_{SM} = 6.5^{+0.3}_{-0.2} \text{ pb} \]

arXiv:1110.5016
$\sigma_{WZ}^{tot} = 20.5^{+3.1}_{-2.8} \text{ (stat.)}^{+1.4}_{-1.3} \text{ (syst.)}^{+0.9}_{-0.8} \text{ pb}$

$\sigma_{SM} = 17.3^{+1.3}_{-0.8} \text{ pb}$

arXiv:1111.5570
Is the top quark special?

$\sqrt{s} = 7$ TeV

$\ttbar\gamma$

$\mathbf{p}_t$ photon $> 8$ GeV

Uses energy in cone to identify signal:

$\sigma \cdot BR = 2.0 \pm 0.5^{(\text{stat.})} \pm 0.7^{(\text{syst.})} \pm 0.08^{(\text{lumi.})}$ pb

$\sigma_{SM} \cdot BR = 2.1 \pm 0.4$ pb

ATLAS-CONF-2011-153
Analysis is based on an analysis of \( t \bar{t} \rightarrow WqZq' \rightarrow \ell \nu q \ell^+ \ell^- q' \)

**Data compatible with b.g.**

- ZZ and WZ MC: \( 2.4 \pm 0.3 \)
- Fake leptons: \( 0.0^{+1.8}_{-0.0} \)
- Expected background: \( 2.4^{+1.8}_{-0.3} \)
- Data observed: 2

**ATLAS Result**

\[ BF(t \rightarrow qZ) < 1.1\% \]

at 95% C.L.

**ATLAS-CONF-2011-154**

**D0 result:**

\[ BF(t \rightarrow \gamma q) < 3.2\% \]
Double differential di-jet cross sections now measured over a very large range of $m_{12}$ and rapidity ($y$)
Squark versus gluino masses limits with non-zero LSP masses
sbottom production

In many SUSY models stop and sbottom are the lightest squarks, look for:

\[ \tilde{b}_1 \rightarrow b \chi_1^0 \]

- Triggered by j70 xe45
- Require events with 2 tagged b-jets
- Expect large missing energy and contransverse invariant mass
Diphoton SUSY and UED

GMSB models have: \( \tilde{\chi}^0_1 \rightarrow \gamma \tilde{G} \)

UED Models have: \( \gamma^* \rightarrow \gamma G \)

Search for two photons and missing energy

http://arxiv.org/abs/1111.4116
ATLAS Exotics Searches - 95% CL Lower Limits (Status: Dec. 2011)

- Large ED (ADD): monojet
- Large ED (ADD): diphoton
- UED: $\gamma + E_{T,miss}^*$
- RS with $k/M_p = 0.1$: $\gamma\gamma$, ee, $\mu\mu$ combined, $m_T$
- RS with $k/M_p = 0.1$: ZZ resonance, $m_{ll}^T$
- RS with $g_{qgK}/g_s = -0.20$: $H_T + E_{T,miss}^*$
- Quantum black hole (QBH): $m_{dijet}$, $F(\chi)$
- QBH: High-mass $\sigma_{_{\text{prod}}}$
- ADD BH ($M_{TH}/M_D = 3$): multijet, $\Sigma p_T$, $N_{jets}$
- ADD BH ($M_{TH}/M_D = 3$): SS dimuon, $N_{\text{pairs}}$
- ADD BH ($M_{TH}/M_D = 3$): leptons + jets, $\Sigma p_T$
- $qqll$ contact interaction: $F_q(m_{dijet})$

**Scalar LQ pairs ($\beta = 1$):**
- kin. vars. in eejj, eejj
- kin. vars. in $\mu\mu jj$, $\mu\mu jj$

**4th generation (d, $d'$):**
- Coll. mass in QCD $q$ gluon
- $\Sigma$ quark contact interaction: $m_{ee/\mu\mu}$

**Major neutrals:**
- (LRSM, no mixing): 2-leptons + 2 jets
- Major neutrals (LRSM, no mixing): 2-leptons + 2 jets
- Higgs (DY decay, BR(Higgs-$\mu\mu$-$\mu\mu$): $m_{\mu\mu}$ (like-sign)
- Excited quarks: $\gamma$-jet resonance, $m_{\gamma^*}$
- Excited quarks: dijet resonance, $m_{dijet}$

- Axigluons: $m_{dijet}$
- Color octet scalar: $m_{dijet}$
- Vector-like quark: $CC, m_{dijet}$
- Vector-like quark: $NC, m_{dijet}$

**Other:**

**37**

**Only a selection of the available results leading to mass limits shown**
3 or more leptons – e.g. H^{++}

- Reject events with leptons from Z bosons
- No cut on MET, use it to check agreement with SM

Four charged leptons – RS Graviton decay

Limit on 4 lepton fiducial cross section (veto events with z’s)

\[ \sigma_{4\ell} \text{ fid} < 4.7 \, \text{fb} \]

Fiducial def:

\[ p_t > 15 \text{ GeV} \]
\[ |\eta| < 2.5 \]
\[ m_{\ell^+\ell^-} \text{ not in } [66, 116] \text{GeV} \]

Limit on graviton

\[ \sigma(pp \rightarrow G) \times BF(G \rightarrow ZZ) < 2.6 - 3.3\text{pb} \]
Leptonic Contact Interactions

First gen. leptoquark pair production

### Table: Expected limits on $\Lambda$

<table>
<thead>
<tr>
<th>Channel</th>
<th>Prior Expected limit (TeV)</th>
<th>Observed limit (TeV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$e^+e^-$</td>
<td>$1/\Lambda^2$</td>
<td>9.6</td>
</tr>
<tr>
<td></td>
<td>$1/\Lambda^4$</td>
<td>8.9</td>
</tr>
<tr>
<td>$\mu^+\mu^-$</td>
<td>$1/\Lambda^2$</td>
<td>8.9</td>
</tr>
<tr>
<td></td>
<td>$1/\Lambda^4$</td>
<td>8.3</td>
</tr>
<tr>
<td>Combined</td>
<td>$1/\Lambda^2$</td>
<td>10.4</td>
</tr>
<tr>
<td></td>
<td>$1/\Lambda^4$</td>
<td>9.6</td>
</tr>
</tbody>
</table>

95% C.L. on $\Lambda$
Photon + Jet

Generic search for photon + jet resonances

Di-photon

Limits on Excited quarks

Limits on gravitons in RS models
Expect ATLAS Higgs results next week with up to 5 fb$^{-1}$
Higgs Updates since last LHCC

\[ H \rightarrow ZZ \rightarrow \ell^+\ell^- \nu\bar{\nu} \]

\[ H \rightarrow ZZ \rightarrow \ell^+\ell^- q\bar{q} \]

\[ \int L dt=2.05fb^{-1}, \sqrt{s}=7TeV \]

\[ \int L dt=2.05fb^{-1}, \sqrt{s}=7TeV \]

95\% CL limit on \( \alpha_{SM} \)

ATLAS-CONF-2011-148

ATLAS-CONF-2011-150
- Fix some calorimeters readout problems
- Install staged EE chambers on one side (C), remaining ones in the next shutdown
- Yearly maintenance of the infrastructure
LHC Schedule Assumptions

- LHC start-up $\sqrt{s} = 900\text{GeV}$
- $\sqrt{s} = 7\text{TeV}$ rising to 8TeV, $\mathcal{L} = 6 \times 10^{33}\text{cm}^{-2}\text{s}^{-1}$, bunch spacing 50ns
- Go to design energy and nominal luminosity
- $\sqrt{s} = 13-14\text{TeV}$, $\mathcal{L} = 1 \times 10^{34}\text{cm}^{-2}\text{s}^{-1}$, bunch spacing 25ns
- Injector and LHC Phase-I upgrade to full design luminosity
- $\sqrt{s} = 14\text{TeV}$, $\mathcal{L} = 2-3 \times 10^{34}\text{cm}^{-2}\text{s}^{-1}$, bunch spacing 25ns
- HL-LHC Phase-II upgrade, crab cavities, new IR, ...
- $\sqrt{s} = 14\text{TeV}$, $\mathcal{L} = 5 \times 10^{34}\text{cm}^{-2}\text{s}^{-1}$ (luminosity levelling) 25ns

- $\sim 25\text{fb}^{-1}$
- $\geq 50\text{fb}^{-1}$
- $\geq 300\text{fb}^{-1}$
- $\sim 3000\text{ fb}^{-1}$
Phase-0 (installation 2013-14)

Major Improvements to Physics Capabilities

• New insertable pixel b-layer (IBL) (drives shutdown schedule)
• Finish the installation of the EE muon chambers staged in 2003 +additional chambers in the feet (new electronics) and elevators region
• New small Be pipe

Consolidation and maintenance to preserve present performance

- New Aluminum beam pipes to prevent activation problem and reduce BG
- New pixel services (nSQP) (.pending decision by mid 2012)
- New evaporative cooling plant for Pixel and SCT + IBL CO₂ cooling plant
- Replace all calorimeter Low Voltage Power Supplies
- Exchange all broken TGCs where possible
- Consolidate part of the LUCID system
- Upgrade the magnets cryogenics with a new spare main compressor and decouple toroid and solenoid cryogenics
- Add specific neutron shielding (behind end-cap toroid, USA15)
- Revisit the entire electricity supply network (UPS,…)
- Repairs and maintenance work in general !!!
- Preparations for Phase I upgrade (moveable b-pipe, AFP prototypes,…
- MBTS removal and possible replacement
Phase-I (installation in or before 2018)

### Major Projects

1. New muon small wheels with more trigger granularity and trigger track vector information
2. Fast track processor (FTK) using SCT and pixel hits (input to LVL2) expected installation before 2018
3. Higher-granularity calorimeter LVL1 trigger and associated front-end electronic
4. New forward physics detection station at 220 m for new diffractive physics (full 3D edgeless and timing detectors, target 2017)
5. Topological trigger processors combining LVL1 information from different regions of interest (improvements starting well before 2018)

### Supporting Projects

1. Adapt central LVL1 trigger electronics to new needs
2. New Tiles crack-gap scintillators and some new trigger electronics
3. Adapt if proven necessary HLT (in particular network) to the new needs/conditions
Phase-II (installation 2022-23)

1. New Inner Detector (strips and pixels)
   *Very substantial progress in many R&D areas*
2. New LAr front-end and back-end electronics
3. New Tiles front-end and back-end electronics
4. TDAQ upgrade
5. TAS and shielding upgrade
6. Various infrastructure upgrades
7. Common activities (installation, safety, ...)

Under study:

1. LAr new FCAL
2. LAr HEC cold electronics consolidation
3. Muon Barrel and Large Wheel system upgrade
4. L1 track trigger
5. LUCID upgrade
**Conclusion**

- *Thanks to the LHC* for excellent performance in 2011 allowed ATLAS to collect a very substantial data set.
- Hard work of ATLAS collaborators resulted in high data quality and high efficiency.
- Trigger, Reconstruction, Computing and Analysis are meeting the challenge of increased pileup.
- Physics results from the 2011 run are very promising.
- Preparations for a very ambitious work plan in the 2011-2012 technical stop and LS1 are underway; the LoI for Phase I upgrade should be submitted early in the new year and work on Phase II is progressing.
Backup
Four lepton limits on RS gravitons decaying to ZZ

\[ \int L \, dt = 1.02 \, fb^{-1} \sqrt{s} = 7\, TeV \]

\[ \sigma(pp \rightarrow G) \times BR(G \rightarrow ZZ) [pb] \]

ATLAS Preliminary

- Expected limit at 95% CL
- Observed limit
- Expected limit ± 1 \( \sigma \)
- Expected limit ± 2 \( \sigma \)
- RS Graviton
Jet Finding in heavy ion events is challenging