ATLAS Status Report
133rd LHCC Meeting
28-FEB-18

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on behalf of the
ATLAS Collaboration

W mass measurement published in EPJC on 12th Feb 2018

ttH evidence paper accepted by PRD 16th Feb 2018
Outline

- Detector Status and Performance
- Recent Physics Results
- Upgrade Status
Access to cavern on 21\textsuperscript{st} December, 3 weeks after start of YETS.

**Status of interventions:**
- Maintenance of major infrastructure **finished**.
- All planned detector interventions **completed**.
- **First re-commissioning week** accomplished, detector re-commissioning **on track**.
- Closing process has started, 2 days contingency.
- **On track to be closed 27\textsuperscript{th} of March.**
• **Pixel**
  – Upgrade of read-out system on B-Layer and Disks installed, **commissioning ongoing**.
• **Semiconductor Tracker**: Standard maintenance.
• **Transition Radiation Tracker**
  – Developed a leak of cooling liquid (C$_6$F$_{14}$) in the front end cooling system.
  – Mitigation by regulating the flow, leak rate reduced **8l/day -> 2l/day**
  – Leak located inside the ID Volume, decision not to open the ID end plate.
Status Calorimeters

- **Liquid Argon Calorimeter**
  - March 2017 *lost redundancy* of one power supply of the Hadronic-Endcap, failure mode understood.
  - All 8 hadronic end-cap low voltage power supplies *refurbished*:
    - Damaged capacitors exchanged.
    - Corroded cooling circuit connectors replaced.

- **Tile Calorimeter**:
  - Two modules *repaired* that failed in the beginning of the 2017 run.
  - **Minimum Bias Trigger Scintillator** try to recover detection efficiency (lost due to radiation damage of scintillators) with additional read-out fibers.
Status Muon Detectors

- **CSC**: Two chambers brought to surface to repair and reinstalled.
- **RPC**: Leak search and repair ongoing.
- **MDT+TGC**: Standard maintenance.

**RPC: Gas leak rate**

Δ~300l/h

Repairs in YETS2017

28.02.18 LHCC meeting
FTK is designed to reconstruct tracks with $p_T > 1\text{GeV}$, $|\eta| < 2.5$ with Pixel & SCT data for L1 triggers.

**Hardware Status:**
- SSB production and testing ongoing.
- AUX being installed based on AMB availability.
- All other boards ready.
Commissioning and installation in progress.

**FTK Objectives for 2018:**
- 12-layer track (SliceA) integration by March.
- Commission with beam Slice2 in high pileup conditions.
- Scale-up FTK data flow.
- 12 layer track processing when firmware stabilizes, expected for autumn.
- Continue firmware development and aim for deployment of full system.

Simultaneous debugging of Slice2, SliceA and Hemisphere!
Systems in commissioning:
ATLAS Forward Proton project (AFP)

• **AFP fully integrated** in ATLAS data taking.
• **Took data with Silicon Tracker** (29.6 fb^{-1}), used also in the ATLAS trigger.
• **ToF system** showed low efficiency, mostly under commissioning in 2017.
• During YETS four Silicon modules with issues were replaced.
• The “near stations” have been re-installed, “far station” silicon tracker will be re-installed this week.
• **Aim to install ToF system during the first technical stop.**
ATLAS data taking in 2017

Delivered 50.2 fb\(^{-1}\), recorded 46.8 fb\(^{-1}\) with 93.3\% data taking efficiency.

Preliminary “Good for Physics” integrated luminosity 93.6\% i.e. 43.6 fb\(^{-1}\) (±2.4\%).
ATLAS Operation

- **Re-commissioning week 1 (M1) successful:**
  - Re-integration of detector systems.
  - Cosmic data taking.
  - High Rate tests.
  - 24/7 control room shifts, full on-call coverage.

- **Re-commissioning week 2 (M2):**
  Final consolidation and transition to continuous operation.

- **2018 Operation:**
  - HLT nominal size, 20% capacity increase wrt to 2017.
  - Aim to maintain primary trigger thresholds of 2017.
  - Level at $L \sim 2 \times 10^{34}$, $\mu \sim 60$ with 25ns 2556b BCMS beam.
Electron Identification with 2017 data.

- Good understanding of data in high pile-up condition.
- Lower efficiency in data than in MC due to known mis-modeling of calorimeter shower shapes in the GEANT4 detector simulation.

For comparison 2016 data (30% less pile-up).
Reconstruction Performance

- Missing Transverse Energy "track soft term" distribution with 2017 data.
  - The longitudinal component recoiling against the Z-boson transverse moment ($p_T^{\text{hard}}$) is well modeled by the simulation, despite high pile-up environment.
Outline

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- Recent Physics Results
- Upgrade status
Recent Physics Results

- Highlighting results published since November LHCC meeting.
- All results use full 2015+2016 data set.
- 135 publications with run-2 data set.

W mass measurement published in EPJC on 12th Feb 2018

tZ evidence submitted to PLB, 4.2σ (5.4σ) evidence observed (expected).
arXiv:1710.03659

ttH evidence paper accepted by PRD 16th Feb 2018
4.2σ (3.8σ) evidence observed (expected).
arXiv:1712.08891
Recent Physics Results

- **SM Higgs**
  - $H \rightarrow \gamma\gamma$
  - $H \rightarrow cc$

- **BSM**
  - $W' \rightarrow \tau\nu$
  - $W' \rightarrow tb$

- **SUSY**
  - electroweak production with compressed mass states
SM Higgs Properties in $\gamma\gamma$ channel

Very comprehensive analysis and paper (120 pages).

- **Production mode cross sections and signal strengths.**
  - $ggH$, VBF, VH, $ttH$, $tHq$

- **Simplified template cross sections (STXS).**
  - SM production modes as “templates” in simplified fiducial regions

- **Integrated and differential cross sections**
  - 5 fiducial cross sections.
  - 18 differential variables

Data driven determination of event yield

Di-photon invariant mass spectrum
SM Higgs Properties in $\gamma\gamma$ channel

Results:
Signal strength*
*ratio of measured cross section to SM prediction

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Exp. $Z_0$</th>
<th>Obs. $Z_0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mu_{VBF}$</td>
<td>2.6 $\sigma$</td>
<td>4.9 $\sigma$</td>
</tr>
<tr>
<td>$\mu_{VH}$</td>
<td>1.4 $\sigma$</td>
<td>0.8 $\sigma$</td>
</tr>
<tr>
<td>$\mu_{top}$</td>
<td>1.8 $\sigma$</td>
<td>1.0 $\sigma$</td>
</tr>
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Precision on global signal strength improved by factor 2 compared to 7 and 8 TeV measurement.
• Integrated cross section
  - Matching experimental acceptance.

• $p_T^{\gamma\gamma}$ differential cross section
  - Probes perturbative QCD modeling of $ggH$ production.

Compared to several predictions. Generally, in agreement with latest QCD expectation.
SM Higgs Properties in $\gamma\gamma$ channel

Results: Simplified Template Cross Sections (STXS)

Example: ggF STXS definitions

STXS aim to maximize sensitivity and minimize theoretical dependence:
- Define “bins” of STXS by production mode and non-overlapping kinematic regions.
- STXS provides common framework for combination of channels and experiments.

Measured nine different STXS
Search for H->cc

- Set **direct limits** on Z(\(\Upsilon\))H(cc).
- Uses new run-2 c tagging algorithm.
- ZV measurement as cross check:
  - Observed significance of ZV(c[c]) peak 1.4\(\sigma\) (2.2\(\sigma\) expected).
- **Upper limit signal strength for pp->ZH(cc) \(\mu=107\).**
- Significant improvement over previous indirect measurement.
Recent Physics Results

- **SM Higgs**
  - $H \rightarrow \gamma\gamma$
  - $H \rightarrow cc$

- **BSM**
  - $W' \rightarrow \tau v$
  - $W' \rightarrow tb$

- **SUSY**
  - Electroweak production with compressed mass states
Search for $W'\rightarrow \tau\nu$ in the hadronic decay channel

- Sensitive to models where $W'$ couples preferentially to 3rd generation fermions.
- **Strategy**: Count events above a transverse mass threshold.
- Extract **visible cross section limits** and **model dependent limits**.

**First publication** from ATLAS in this channel.
**Extends mass reach** over existing searches.
**Complementary** to other channels.

$W'\rightarrow (e,\mu)\nu$ arXiv:1706.04786
$ee,\mu\mu$ arXiv:1707.02424
$\tau\tau$ arXiv:1709.07242
Motivated by scenarios where $W'$ couples preferentially to quarks.

Look for decay signature of boosted $t$ and $b$ quarks.

First search to use “shower deconstruction top tagger”.

No significant excess observed.

Observed (expected) mass exclusion above $2.98$ (2.99) TeV and $2.85$ (2.76) TeV for right- and left-handed couplings, respectively.
Recent Physics Results

- **SM Higgs**
  - $H \rightarrow \gamma\gamma$
  - $H \rightarrow cc$

- **BSM**
  - $W' \rightarrow \tau\nu$
  - $W' \rightarrow tb$

- **SUSY**
  - electroweak production with compressed mass states
Search for electroweak SUSY production with compressed mass states

Naturalness argues Higgsinos should be near weak scale. Higgsinos realised as multiplet of neutralinos and charginos:

\[ \Delta M \sim 1 \text{ to } 10 \text{ s GeV} \]

\[ \tilde{\chi}_2^0 \rightarrow (Z^* \rightarrow \ell^+\ell^-) \]

\[ \tilde{\chi}_1^\pm \rightarrow (W^* \rightarrow \text{soft objects}) \]

Trigger on missing \( E_T \) by boosting LSPs

Soft dileptons allow signal-background discrimination e.g. m(\( \ell\ell \)), mT2

Hadronic recoil from initial-state radiation (ISR)

Efficiency vs. Lepton \( p_T \) for\( \sqrt{s} = 13 \text{ TeV} \):

- Muon
- Electron

ATLAS Simulation

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Higgsino

- No significant excess observed, set limits on masses and mass splitting.
- First ATLAS results on direct Higgsinos.
- Pushing past LEP limits.
- Splitting limits $O(1\text{GeV})$. 

Search for electroweak SUSY production with compressed mass states

Disappearing tracks now published, arXiv:1712.02118
Search for electroweak SUSY production with compressed mass states

Sleptons

Hadron Collider sensitivity beyond LEP in Δm<55GeV mass gap.
Compressed mass spectrum, mass difference reach ~ 1 GeV.
Slepton mass excluded up to ~190 GeV.

28.02.18
LHCC meeting
Outline

• Detector Status and Performance

• Recent Physics Results

• Upgrade Status
Upgrade Phase-I: New Small Wheel

- **New Small Wheel (NSW):**
  - Replacement of innermost station of Muon Endcap Spectrometer.
  - **Technologies:** Micromegas (MM) and small-strip thin gap chambers (sTGC).
  - Both technologies provide tracking and triggering information.
  - Complete new detector (chambers + electronics).
Upgrade Phase-I: New Small Wheel

- **Mechanics**
  - Several components delivered or assembled (NJD, hub) or expected soon (copper disk, NSW structure).

- **Read-out electronics**
  - Four ASICs produced with engineering run, two validated, two will undergo final tests.
Upgrade Phase-I : New Small Wheel

- MicroMegas
  - Production has started at all sites.
  - Some batches of PCB for strip electrodes had cut strips (getting back on track again).
  - New cleaning protocol (due to HV problems) to be deployed at production sites.
  - Resume chamber assembly in 1-2 months, panel production continues uninterrupted.

- sTGC
  - Moved forward towards series production.
  - Production schedule very tight.
  - First module fully closed and completed.

In parallel, getting ready for wedge integration @ CERN
**Upgrade Phase-I:**

**Brief Updates**

**Liquid Argon Calorimeter Electronic Upgrade**

- **L1 trigger upgrade to cope with increasing pile-up.**
- **ASICS in packaging & testing stage.**
- **Firmware developments and testing ongoing.**
- **Production Readiness Reviews in Spring 2018.**
- **Pre-production hardware components will be tested with beam in 2018 parasitically.**
- **All project activities are on track.**
Trigger/DAQ Upgrade

- **New hardware components**
  - L1 Calorimeter,
  - L1 Muon,
  - L1 Topological Processor,
  - L1 Central Processor,
  - DAQ.

- **All projects make good progress, despite some delays.**

- **Outstanding Final Design Reviews and Production Readiness Reviews scheduled for 2018.**

- **Production of all modules will be finished by early 2019.**

Upgrade Phase-I:
Brief Updates
Upgrade: Phase-II

• Status of TDR’s:
  – ITk strip detector approved LHCC, UCG, CERN RB (Jun 2017)
  – Muon system upgrade approved LHCC, UCG, CERN RB (Dec 2017)
  – Liquid Argon calorimeter approved by LHCC, UCG.
    CERN RB discussion Mar 2018
  – Tile calorimeter approved by LHCC, UCG.
    CERN RB discussion Mar 2018
  – ITk Pixel detector submitted Dec 2017
  – TDAQ submitted Dec 2017

Preparation and CERN approval of TDRs and reviews on track for RRB meeting in April 2018
Upgrade
Studies for **LS2** and **LS3** services during YETS

- Last chance before LS2 to **survey** and **reverse engineer** layout of services in ATLAS
  - For Phase-I:
    Review information of
    **Muon New Small Wheel** cabling
    **Liquid Argon Calorimeter** trigger fiber cables
  - For Phase-II:
    **All upgrade detector systems** study service routings and available space.

Example: Cable tray mismatch.
Summary

• ATLAS achieved its goals of the YETS.
• Exploitation of Run-2 data-set yields exiting new results, and many more to come.
• Understanding of 2017 data performance well advanced.
• The upgrade effort for Phase-I and Phase-II is progressing well.

• ATLAS is well prepared to take data in 2018 at high luminosity and high efficiency.
YETS closing plan

- YETS extended by 4 days, but only 2 days are available for ATLAS
  -> kept as contingency
  - Last detector movement = Big Wheel A, 8th March
  - 7 days dedicated to EOL gas leak repair
  - Cavern cleaning on 20th March
  - BME to Run position on 21st March
  - Patrol on 23rd March
  - UX15 closed on the evening of 27th March
Studies for LS3 services

- Requests from ITk, Muons, LAr, Tile, HGTD
  - Study the feasibility of removing cables and cable trays, rearrange cables into flexible chains
  - Route a significant amount of new cables
  - Study the availability of enough space to displace power supplies
  - Understand and solve the problem of sharing available space among sub-detectors services

- During YETS 2017-2018:
  meetings, surveys, reverse engineering, mock-up installation
  - Obtaining requirements from sub-detectors (meetings, surveys, etc.)
  - Acquiring information: photo survey, measurements
  - Updating 3D models adding envelopes for current services
  - Building mock-up for flexible chain to study the feasibility of re-arranging cables with limited access
ALFA

**ALFA improvements:**
One trigger channel recovered.
Minor leak in secondary vacuum fixed.

**Movement system:**
- FESA server upgraded to fix memory leak (that caused the system to crash every few months).
- Automatic recovery (of PXI) after power cycle implemented.

Problem with BUSY signal in standalone DAQ system traced and fixed.

**ALFA routine maintenance:**
Secondary vacuum pumps replaced
Fan filters replaced
TLD (passive radiation sensors) replaced and readout
Un-cabled RadMon read out
• MBTS counters are used during low-mu runs like VdM and in Heavy Ion
• After the replacement of the scintillator in 2015, the signal degraded by 97% in the inner counters and by 80% in the outer counters by the end of 2017
• In the past, only half of the fibers from the outer counters were read out, and the signal from two adjacent counters in phi was summed together to save the number of PMTs
• In the last YETS, the light from all fibers of the outer counters was routed to the PMTs, and the signal from individual counters is now going to separate PMTs, to increase the amount of light and increase the trigger efficiency
Cathode Strip Chambers

- 2 CSC (1 broken layer each) removed from cavern, opened, repaired, re-installed
  - 1 with a broken wire
  - 1 with poorly glued loose wire end causing a spurious HV short
  - all layers of both chambers cleaned
  - after re-installation, one new layer (Co3 layer 1) seems broken, reason unclear
- HV is at nominal voltages except Co3 layer 1
  - Trips at 1690 V,
  - 1MOhm short,
  - no broken wire or dangling ends
- Reconnected a disconnected cooling line that had prevented powering the FE electronics of chambers C14/C15 in 2017
- A01 and A11: Fibers on the detector cleaned. This may solve G-Link locking issues.
- Modification of gas system ongoing, humidity can be added to the gas starting March 15
Status

• TILE:
  – Two modules **repaired** that failed in beginning of 2017 (0.6% of dead channels).

![Graph showing evolution of masked channels and cells](image-url)
HEC LV Boxes – Refurbishment

- 8 HEC LV Boxes (LVPS) supply LAr HEC cold preamps
- Reminder: Failure of one HEC LVPS on Oct. 29, 2016, other three lost redundancy
- 4 HEC LVPS were exchanged during EYETS
- Post-mortem analysis shows a 470 µF electrolyte capacitor broke.
  - Such electrolyte (ELCO) capacitors are known for their limited lifetime
- During ATLAS closing (March 2017), noticed that temperatures of regulator boards in 3 of new boxes were 50°C (instead of 20-30°C).
  - One fixed by higher water flow, decision to take other two out and fix the problem (stopped ATLAS closing A-side, re-opening small wheel on C-side)
- Careful inspection in the lab:
  - Shows strong corrosion in one of the metal pieces of the circuit
- During 2017 all HEC LVPS working fine (one has lost redundancy again)
- Refurbishment campaign done at company that produced converters (Wiener) and at MPI Munich:
  - Exchange ELCO capacitors with higher temperature-grade ones (9 power boards for 9 LVPSs already received)
  - Exchange corroded metal pieces of into plastic connections
  - All 9 HEC LVPS burnt in at MPI.
  - Installation on the detector took place in the week of Jan 8., 2018. All 8 boxes work as expected since then.
LAR status

- HV currently ramped to 50V. It will be **ramped up to nominal** in the second week of March.
- Exchange of 4 HV modules.
  - HV2: EMEC C M132/133 SN: 790210->790100
  - HV3: EMB A M310/M311 SN: 473100->734310
  - HV5: EMB C M244/245 SN: 710620->710600
  - HV5: EMB C M258/M259 SN: 710510->710590
- Exchange of 8 HEC LV PS boxes.
  - During the HI run in 2015 we lost one HEC LV power supply (≈ 1 quadrant) due to a double failure of the DC/DC converter system (inaccessible) on repowering due to **aging capacitors**. It was found that we had lost redundancy on three more power supplies.
  - Before closure of ATLAS in 2017 it was found that the temperatures of regulator boards in 3 of new boxes had increased.
    - One board was fixed by increasing the water flow, the other two were taken out. Inspection revealed strong corrosion of one of the pieces of the **cooling loop**.
  - To **restore full redundancy** all HEC LV boxes were refurbished (**capacitors exchanged** and corroded pieces of water circuit replaced with **plastic connectors**) and installed in the first week of January.