

Dan Tovey, University of Sheffield, on behalf of the ATLAS Collaboration

- Overview of the ATLAS detector
- Status of the experiment
- Performance and physics results from 2010
- Prospects for 2011/12



>3000 physicists38 countries175 institutes

ATLAS Collaboration

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~300 UK 14 institutes

The ATLAS Detector



Construction

Barrel Toroid Magnets



Liquid Argon Calorimeter

Endcap muon detectors

- Coloreste

8.10

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Cosmics Commissioning



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... Countdown ...

!!! BEAM AT ATLAS !! 20-11-09 20:47 !!

- 20 Nov 23 Dec 2009:
 - First pp physics run at \sqrt{s} = 900 GeV (few hours \sqrt{s} = 2.36 TeV)
- 30 March 4 Nov 2010:
 - LHC pp running at $\sqrt{s} = 7$ TeV
- 4 Nov 2010 6 Dec 2020:
 - LHC Pb+Pb running at $\sqrt{s} = 2.76$ TeV/nucleon
- Now: Technical stop restart pp physics mid-March \sqrt{s} = 7 TeV

. Lift-off



Detector Status

Inner Tracking Detectors			Calorimeters				Muon Detectors			
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	CSC	TGC
99.1	99.9	100	90.7	96.6	97.8	100	99.9	99.8	96.2	99.8
Luminosity weighted relative detector uptime and good quality data delivery during 2010 stable beams in pp collisions at √s=7 TeV between March 30 th and October 31 st (in %). The inefficiencies in the LAr calorimeter will partially be recovered in the future.										

- 2% average DAQ inefficiency due to 'warm start' not included
- LAr inefficiency mostly due to isolated HV trips and noise bursts
- CSC inefficiency due to 6/16 problematic chambers in one 3 day period

Trigger Performance

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- L~10²⁷ cm⁻²s⁻¹ run without prescales
- L>10²⁷ cm⁻²s⁻¹ prescale (only) minbias triggers
- L>10²⁹ cm⁻²s⁻¹ activate HLT (L2 and EF)
- 300 Hz bandwidth split between physics
- Challenging in 2010, even more so in 2011...



Grid Data Processing



- Data distributed and processed via the Grid.
- Large peaks exceeding design limit
- Progress (performance, reliability) has been rapid



Why LHC?



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Minimum Bias with Tracks

- Inclusive, model-independent measurement from inelastic events:
- Most recent results benefit from work to reduce track p_T threshold
 - Greatly improves acceptance
- Vital for understanding soft backgrounds to New Physics



Underlying Event

- Measurement of charged particle activity with respect to leading hard track in event
- Transverse region provides measure of underlying event activity
- Current models under-estimate







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$J/\psi \rightarrow \mu^{+}\mu^{-}$

- J/ψ → μ⁺μ⁻ key milestone for commissioning and physics
- Mass consistent with PDG, width well modelled by simulation
- Use reconstructed decays as input to more complex states e.g. B[±]→J/ψ K[±]



ATLAS-CONF-2010-062



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Eight Jets with $p_T > 60 \text{ GeV}$



Inclusive Jet Distributions

- Jets reconstructed with Anti-kT algorithm, calibrated with simple η/p_Tdependent corrections from test-beam, track E/p, MC → ~6-10% JES uncertainty
- Good agreement w/ NLO predictions
- Further improvements in JES to come





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Missing Transverse Energy

- Evolution of calibration schemes
- Clean and stable





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

TI

Muon: 3 Pixel hits, 8 SCT hits, 17 TRT hits, 14 MDT hits, Z~0.1 mm from vertex, ID-MS matching within 1 GeV, E_T^{miss} (calorimeter only) ~ 3 GeV

> $p_{T}(\mu) = 40 \text{ GeV}$ $\eta(\mu) = 2.0$ $E_{T}^{miss} = 41 \text{ GeV}$ $M_{T} = 83 \text{ GeV}$

W→µv candidate in 7 TeV collisions



Leptonic W Cross-Section

- W decays isolated from QCD jet (fake) backgrounds with cuts on lepton isolation, E_T^{miss} and transverse mass of lepton-E_T^{miss} system
- Fitted cross-section in good agreement with NNLO prediction
- W charge asymmetries constrain PDFs





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JHEP12 (2010) 060



Run: 154822, Event: 14321500 Date: 2010-05-10 02:07:22 CEST

 $p_{T}(\mu^{-}) = 27 \text{ GeV } \eta(\mu^{-}) = 0.7$ $p_{T}(\mu^{+}) = 45 \text{ GeV } \eta(\mu^{+}) = 2.2$ $M_{\mu\mu} = 87 \text{ GeV}$

> Z+μμ candidate in 7 TeV collisions



Leptonic Z Cross-Section

- Good agreement with NNLO
 prediction
- W/Z cross-section ratio also agrees well
- Analysis of full 2010 dataset in progress – cross-section results to be updated for winter confs





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W/Z+Jets

- Jet production in association with W/Z bosons
- Anti-K_T R=0.4 jets with p_T>20 GeV in |η|<2.8
- MC normalised to inclusive data sample (>=1 jet for jet p_T distributions)
- Good agreement so far using ALPGEN+herwig LO+PS signal MC

arXiv:1012.5382 [hep-ex] (1.3pb-1)





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Top Quark Candidate in the Semi-Leptonic Channel



Top Quark Candidate in the Fully Leptonic Channel

Top Pair Cross-Section

arXiv:1012.1792 [hep-ex] Events Events / 40 GeV Two complementary strategies all channels tagged e/µ+≥4-jets ATLAS 25 ATLAS data data Semi-leptonic decay mode: $L = 2.9 \text{ pb}^{-1}$ $L = 2.9 \text{ pb}^{-1}$ single top One lepton with $p_T > 20 \text{ GeV}$ single top Z + jets Z + jets At least 4 jets with p_T>20 GeV W + jets diboson 15 in $|\eta| < 2.5$, at least one bfake leptons QCD 🕅 uncertainty /// uncertainty tagged 10 E_{τ}^{miss} > 20 GeV Fully leptonic decay mode: 5ŀ Two leptons with p_T>20 GeV At least 2 jets with $p_T > 20 \text{ GeV}$ 0 2 1 400 500 600 0 100 200 300 Number of b-tagged jets in $|\eta| < 2.5$, no b-tag m_{iii}[GeV] requirement σ_{*tī*} [pb] ----- NLO QCD (pp) ATLAS E_{T}^{miss} > 30(40) GeV and $|m_{II}$ -(2.9 pb Approx. NNLO (pp) m_z|<10(5) GeV in μμ(ee) NLO QCD (pp) ▼ CMS 10^{2} $(3.1 \text{ pb}^{-1}) \xrightarrow{\bullet} \text{Approx. NNLO } (p \overline{p})$ channel CDF ▲ D0 $H_{T}>150 \text{ GeV}$ (eµ channel) 300 250 37(9) candidates in Ij (II) 200 10 channels in 2.9 pb⁻¹ 150 **Data-driven background** 100 estimation techniques used for 6.5 7.5 QCD and W+jet backgrounds 5 6 7 2 3 4 √*s* [TeV]

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Run 166466 Event 26227945 Time 2010-10-07 22:16:39 UTC

 μ^+

WZ→evµµ Candidate

MET

μ

SUSY Searches

- First ATLAS SUSY search results
- Data consistent with background expectation in jets + E_T^{miss} + 1-lepton channel
- Sets world's best limits on mSUGRA models
- O-lepton, 2-lepton (OS/SS) and b-jet channel results available soon
- HIP search results also just released
 - arXiv:1102.0459 [hep-ex]





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Excited Quark Search

• Search for new particles decaying to dijets

PRL105 161801, arXiv:1008.2461[hep-ex]

- First published LHC search paper
- Limits set on excited quarks (compositeness) decaying to dijet resonance:
 - 0.40 TeV < m(q*) < 1.26 TeV excluded at 95% CL for SM-like couplings
 - Extends excluded region beyond previous experiments



• Also search for contact interactions in dijet angular distributions

PLB694 (2011) 327-345

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Heavy Ion Results

- Some of the most exciting results of 2010 came in flurry of activity during / after the HI run
- First observation of a centrality dependent dijet energy asymmetry and J/ψ suppression
- Evidence for strong jet energy loss in a 'hot dense medium'





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Prospects for 2011/12

- Best guess post-Chamonix
 - 2011: 2-3 fb⁻¹ (x50) at 7 TeV
 - 2012: ~10 fb⁻¹? (x200) at ≥7 TeV
- 2011: Should be able to:
 - exclude SM Higgs to 95% ATLAS+CMS `
 - Make 5σ SUSY discovery to ~0.8 TeV
- 2012: Should be able to:
 - Observe SM Higgs ~ 5σ ATLAS+CMS

- Make 5σ SUSY discovery to ~1.2 TeV







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Summary

- First year of high energy LHC data surpassed expectations
- Remarkably smooth start-up of experiment and machine testament to years of hard work
 - Profound thanks to the machine for such rapid progress
- Agreement between data and MC predictions astounding
 - Result of hard work by theoretical community and developers of simulation tools
- First SM results published and showing good agreement with latest theoretical N(N)LO predictions
- First searches show no signs of new physics (yet) limits already outstripping earlier expts
- Next 2 years promise to revolutionise physics ...



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BACK-UP



Semi-Conductor Tracker (SCT)

Flavour Tagging

- Track counting: simple, robust
- Jet probability tagger:
 - **Construct combined probability of** tracks to be associated with PV
- Secondary vertex tagger:
 - **Reconstruct SVX and cut on decay** length significance
- Data/MC agreement very encouraging at such an early stage: bodes well for bjet physics



10'

10⁶ •

s= 7 TeV

: light jets

Data 2010

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ATLAS-CONF-2010-041

ATLAS-CONF-2010-042

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 $L \sim 1 \text{ nb}^{-1}$

Hadron Spectroscopy



$\pi^0 \rightarrow \gamma \gamma$ Reconstruction

- Key benchmark for EM reconstruction
- Tool for measuring calorimeter scale and uniformity
- Energy scale measured to ~2%



Systematics: m: 1%; σ~ 10%



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D(*) Meson Reconstruction



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Primary Vertex Reconstruction



- ~ 10-45 tracks with $p_T > 150$ MeV per vertex
- Vertex z-positions : -3.2, -2.3, 0.5, 1.9 cm (vertex z-resolution better than ~200 μm)
- Expect handful of 4-vertex events in this run

 $Y \rightarrow \mu^+ \mu^-$



W→ev Cross-Section

Event Selection

- Level 1 EM trigger (~ 5 GeV E_T threshold)
- One PV with 3 tracks, consistent with beam spot
- One loose electron with: ID track matching EM calo cluster, selection on the shower shape in the 2nd calo layer, energy in 1st had layer, cluster E_T >20 GeV
- Any jets must pass quality cuts
- Tight selection
 - Full electron ID with TRT HT hits,
 - Conversion veto, detailed shower shape, impact parameter requirements





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$W \rightarrow \mu \nu \ Cross-Section$

- Event Selection
 - Level 1 muon trigger (no explicit p_T threshold)
 - One PV with 3 tracks, consistent with BS
 - 1 combined MS+ID muon, p_T(combined)> 15 GeV, p_T(MS)>10 GeV
 - |p_T(combined)-p_T(MS)|< 15 GeV</p>
 - $|z_{\mu}-z_{PV}| < 1 \text{ cm}, |\eta| < 2.4$
 - Any jets must pass quality cuts
- Tight selection

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- p_T >20 GeV and relative track isolation<0.2 in ΔR =0.4

 E_{T}^{miss} > 25 GeV, m_T > 40 GeV



Preselected sample Ge⁄ Normalized to data Data 2010 (Vs = 7 TeV) Stat errors only Entries / 5 (0 $W \rightarrow \mu \nu$ QCD $Z \rightarrow \mu\mu$ $W\to\tau\nu$ ATLAS Preliminary L=16.6 nb⁻¹ 10 20 80 100 40 60 120 0

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Z⁰→II Cross-Section

ATLAS-CONF-2010-076

- Similar event selection to W analysis
- Mass window cut: 66 GeV < m_{II} < 116 GeV
- Good agreement with
 NNLO prediction





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Contact Interactions



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 $W \rightarrow \tau v$





Electric charge



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Hideriai

ID Material Mapping



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