Atlas Status and Perspectives

Bruno Mansoulié (IRFU-Saclay)

On behalf of the ATLAS Experiment
• **The hot news: Heavy Ion analysis**

• **Data taking in 2010**
  – Luminosity, Data taking & quality, trigger

• **Detector performance**
  – e, γ, µ, τ, jets, E_{T}-miss, b-tag…

• **Physics analyses and results**
  – Jets, W, Z, γ, top

• **Prospects for Higgs search**
Muon Spectrometer ($|\eta|<2.7$): air-core toroids with gas-based muon chambers
Muon trigger and measurement with momentum resolution < 10% up to $E_\mu \sim 1$ TeV

Length : ~ 46 m
Radius : ~ 12 m
Weight : ~ 7000 tons
~10^8 electronic channels
3000 km of cables

3-level trigger reducing the LVL1 rate to ~200 Hz

Inner Detector ($|\eta|<2.5$, $B=2T$):
Si Pixels, Si strips, TRT
Precise tracking and vertexing,
$\sigma/p_T \sim 3.8 \times 10^{-4}$ $p_T$ (GeV) $\oplus 0.015$

EM calorimeter: Pb-LAr Accordion
e/$\gamma$ trigger, identification and measurement
E-resolution: $\sigma/E \sim 10%/\sqrt{E} \oplus 0.007$
granularity : .025 x .025 $\oplus$ strips

HAD calorimetry ($|\eta|<3$): segmentation 0.1 x 0.1
Fe/scintillator Tiles (central), Cu/W-LAr (fwd)
E-resolution: $\sigma/E \sim 50%/\sqrt{E} \oplus 0.03$
FWD calorimetry: W/LAr $\sigma/E \sim 90%/\sqrt{E} \oplus 0.07$
Heavy Ions

- Observation of a Centrality-Dependent Dijet Asymmetry in Lead-Lead Collisions at $\sqrt{s(\text{NN})} = 2.76$ TeV

- Use of the excellent jet and hadron calorimetry
Luminosity

- Measured by several different detectors and methods, consistency to \(~2\%\).

- Present uncertainty on absolute luminosity determination (p-p): 11\% limited by the measurement of beam current.

- Prospects to reduce strongly soon (5 to 6 \%)
Data taking and data quality

- Very good recording efficiency
  - Stable beams to disk (includes ID voltages rise, dead time, etc.)
- And data quality
  - Disk to physics analysis
  - Latest reprocessing even better

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<tr>
<th>Inner Tracking Detectors</th>
<th>Calorimeters</th>
<th>Muon Detectors</th>
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<tbody>
<tr>
<td>Pixel</td>
<td>LAr EM</td>
<td>MDT</td>
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<td>SCT</td>
<td>LAr HAD</td>
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<td>TRT</td>
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Luminosity weighted relative detector uptime and good quality data delivery during 2010 stable beams in pp collisions at $\sqrt{s}=7$ TeV between March 30th and October 31st (in %). The inefficiencies in the calorimeters will largely be recovered in a future data reprocessing.

- Operational channels: 97 to 100 % depending on system
**Trigger**

- **Good understanding of trigger primitives, thresholds…**
  - EM
  - level 1 calorimeter
  - Trigger vs Readout
  - Muon
  - level 2
  - Trigger threshold (4 GeV)

- **Good control of rates, evolution with luminosity…**

  **3 level trigger**
  - L1
  - L2
  - Event Filter

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Understanding the Detector: a few examples

- Pixel detector alignment
  (transverse plane, autumn reprocessing)

- Transition Radiation threshold

- EM calorimeter: timing
Electrons and photons

- Inclusive electron spectrum

- All 2010 data
  - First processing
  - Several triggers according to luminosity, rescaled
**Di-electron mass**

- **5 GeV di-electron trigger**
  - prescaled in later data
  - produces shoulder at 15 GeV

- **Z peak with full 2010 data**
  - All EM calorimeter
  - Autumn reprocessing
  - Fit : Breit-Wigner \( \otimes \) Crystal Ball
  - \( \sigma \) quoted : Crystal Ball right

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Direct photons

• Data: photon / $\pi^0$

Very fine granularity
first compartment
in EM calorimeter

(This 21 GeV $E_T\pi^0$
would pass cuts in S2!)

• Preliminary analysis of direct photons
  Isolated
  Background: fake photons ($\pi^0,\eta$), QED radiation
  Purity reaches ~70% at 25 GeV $E_T$

• Just released: cross-section on 880 nb$^{-1}$
  see F Bucci’s Talk at Ann Arbor Dec 14th

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• **Di-muon mass spectrum**
  - Heavily used in resolution studies

• **Z peak**
  - Quite close to ultimate (expected) performance
Taus

- **Tau-Identification**
  - Tracking
  - fine grained calo
  - Very good simulation

- Observation of $W \rightarrow \tau \nu$
  (small statistics)

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$Z \rightarrow \tau \tau$

$\mathbf{ATLAS}$

EXPERIMENT

$p_T(\mu) = 18$ GeV
$p_T^{\text{vis}}(\tau_H) = 26$ GeV
$m_{\text{vis}}(\mu, \tau_H) = 47$ GeV
$m_T(\mu, E_T^{\text{miss}}) = 8$ GeV
$E_T^{\text{miss}} = 7$ GeV

Run Number: 160613, Event Number: 9209492
Date: 2010-08-03 02:12:37 CEST

$Z \rightarrow \tau \tau$
Candidate in 7 TeV Collisions

3-prong hadronic tau decay

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Jets

- Jet Energy Scale
  - Initial uncertainty < 10%
  - From test-beam, M-C

- In-situ studies
  - Jet balance
  - Single hadron p/E

in reach soon: 3-4%
missing $E_T$

- Excellent control of tails

- Very good resolution (as expected)
B-tagging

- Algorithms already quite under control
  - Good pixel alignment
  - Calibration with data (jets with muons)
    (Simplest algorithm, better ones being calibrated on data…)

Detail
top→ e-μ
candidate

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Jets

- Early measurement of jet cross-section (published)
  - Up to 500 GeV
  - Excellent agreement with NLO QCD

- All 2010 stats
  - Dijet masses up to 3.7 TeV!
    (MC is LO Pythia, normalized to data)
Jets: search for new phenomena

- Strongly coupled new physics: accessible with few data

Published

Resonance search

\[ 0.50 < m(q^*) < 1.53 \text{ TeV} @ 95\% \text{ CL} \]

- Exceed TeVatron limits

Contact interaction (angular dist)

\[ \Lambda < 3.4 \text{ TeV} @ 95\% \text{ CL} \]
• Published cross-section on early data (with Z cross-section)
  – limited by luminosity uncertainty
  – Excellent agreement with NNLO QCD

• Full data 2010
  
  \( e \) or \( \mu \ p_T > 20 \text{ GeV} \), \( E_T^{\text{miss}} > 25 \text{GeV} \)
  
  119k electron
  135k muon candidates

  Stat errors only
  MC normalized to data
Jet multiplicity
Stat error only
MC normalized to data

W \ p_T
• Final state includes several ingredients of analyses: $e, \mu, E_T^{\text{miss}}, b$-tag

• Sizeable backgrounds from QCD and $W + \text{jet}$
  $\Rightarrow$ (mostly) data-driven estimates

• Cross-section from combined likelihood fit on 3 pb$^{-1}$ data
Top: 1 lepton + jets

- 1 e or \( \mu \) \( p_T > 20 \) GeV, \( E_T^{\text{miss}} > 20 \) GeV, \( E_T^{\text{miss}} + m_T(W) > 60 \) GeV

- **Signal**: 4-jets + 1 b-tag; 3-jets used as cross-check.

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Top: 2 leptons + jets

- $\nu e$ or $\nu \mu \mu \mu \mu \mu \mu \mu \mu > 20$ GeV, $E_{T\text{miss}} > 40$ (resp 30) GeV, exclude M(Z) region

- $e \mu$: $p_T > 20$ GeV, Total $E_T$ (scalar) > 150 GeV
Top cross-section (combined)

\[ \sigma_{\bar{t}t} = 145 \pm 31^{+42}_{-27} \text{ pb} \]

- Significance \( \sim 4.8 \sigma \) (with respect to background only hypothesis).

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Di-bosons

Other event displays on Atlas public web page: WW => ee, µµ, eµ candidates

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Prospects for Higgs search

- Recently updated sensitivity at 7, 8, 9 TeV for strategy evaluation
  - New cross-sections (ex $gg \rightarrow H : + 30\% \ [\text{NNLO} + \text{NNLL}]$)
  - New modes studied and/or added to combination

- Median exclusion region at 7 TeV for 1 fb$^{-1}$: 129-460 GeV

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At 7 TeV c.o.m., 5 fb\(^{-1}\) allows to "close the gap" with LEP limit.

+ 1 TeV => equivalent to + 20% luminosity for Higgs sensitivity.
Conclusion

• Powerful detector, excellent status

• Published results with limited statistics
  – Jets cross-section
  – W, Z cross-section

• Many preliminary results to be published soon
  – Direct photon cross-section, Top cross-section…

• Large scope of results with 2010 data

• Also extensive work on backgrounds, min bias, underlying event, pileup

=> Entering discovery range, but also precision measurements!

• All results available on https://twiki.cern.ch/twiki/bin/view/AtlasPublic
Additional slides
Direct photon measurement

- Photons selected and isolated ($E_T [\Delta R < 0.4] < 3$ GeV)
- Good agreement with Jetphox (NLO QCD) above 25 GeV $E_T$
- More systematics below (data and prediction)
- Cross-section 30 times higher than TeVatron.
Minimum Bias, Underlying event

- charged particle multiplicity in Min Bias events: higher than expected

Same is true for the underlying event

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