$M_{jj} \approx 4$ TeV

Beate Heinemann
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on behalf of the ATLAS Collaboration
LHCC, CERN, June 15th
2011 Luminosity and Data Taking

- ATLAS is recording the amazing amount of LHC data efficiently: **1.0 fb⁻¹ delivered by LHC**
  - 95.8% data-taking efficiency
  - Inefficiency due to:
    - Turn-on at start of stable beams: 1.6%
    - Deadtime: 2.6%
  - Uncertainty on luminosity: 4.5%
    - Will improve with recent vdM scan data
- Quality of data generally very high
  - LAr calorimeter DataQuality inefficiency will largely be recovered in reprocessing by Fall 2011

### Inner Tracking Detectors vs. Calorimeters vs. Muon Detectors vs. Magnets

<table>
<thead>
<tr>
<th>Inner Tracking Detectors</th>
<th>Calorimeters</th>
<th>Muon Detectors</th>
<th>Magnets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pixel</td>
<td>SCT</td>
<td>TRT</td>
<td>LAr EM</td>
</tr>
<tr>
<td>99.8</td>
<td>99.5</td>
<td>100</td>
<td>89.3</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 June 6th (in %). The inefficiencies in the LAr calorimeter will partially be recovered in the future. The magnets were not operational for a 3-day period at the start of the data taking.
### ATLAS Subdetectors

- All ATLAS subdetectors work well
  - Coverage 96.9-100%
    - On April 30th lost 0.4% of LAr barrel EM: hope to recover during technical stop in early July
- ALFA roman pot detector commissioning progressing well
  - Tracks observed regularly in garage position
  - Recent scraping run successful
    - All RP stations moved to 5σ from beam (1.5-2.0mm)

### ATLAS Subdetectors Performance Summary

<table>
<thead>
<tr>
<th>Subdetector</th>
<th>Number of Channels</th>
<th>Approximate Operational Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pixels</td>
<td>80 M</td>
<td>96.9%</td>
</tr>
<tr>
<td>SCT Silicon Strips</td>
<td>6.3 M</td>
<td>99.1%</td>
</tr>
<tr>
<td>TRT Transition Radiation Tracker</td>
<td>350 k</td>
<td>97.5%</td>
</tr>
<tr>
<td>LAr EM Calorimeter</td>
<td>170 k</td>
<td>98.5%</td>
</tr>
<tr>
<td>Tile calorimeter</td>
<td>9800</td>
<td>97.8%</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>99.8%</td>
</tr>
<tr>
<td>LVL1 Muon RPC trigger</td>
<td>370 k</td>
<td>99.5%</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>350 k</td>
<td>99.6%</td>
</tr>
<tr>
<td>CSC Cathode Strip Chambers</td>
<td>31 k</td>
<td>98.5%</td>
</tr>
<tr>
<td>RPC Barrel Muon Chambers</td>
<td>370 k</td>
<td>97.0%</td>
</tr>
<tr>
<td>TGC Endcap Muon Chambers</td>
<td>320 k</td>
<td>98.4%</td>
</tr>
</tbody>
</table>
The pileup in 2011 is on average $\langle \mu \rangle = 6$ interactions per crossing

- Significantly higher than 2010
  - And than originally anticipated in early LHC running
- Tails up to 14 interactions per crossing
  - Due to some bunches with much higher currents

Causes challenge for physics analyses and software

- Detailed simulation models both the $\langle \mu \rangle$ and the bunch train structure
  - Reweighted according to data $\langle \mu \rangle$ distribution
- Software performance significantly improved to accommodate Tier0 resources (reco time 11-13s/event)
- Physics performance reasonably unaffected
  - Jet energy scale uncertainty temporarily increased for low $p_T$ jets
Trigger Menu in 2011

- Trigger menu kept stable for primary triggers
  - Primary triggers are never prescaled
  - Supplement by supporting and monitoring triggers
    - Increased fraction in early 2011 runs and at end of runs
- Typical Rates:
  - L1: 60 kHz, L2: 5 kHz, EF: 300-400 Hz
    - EF output rate constrained by offline resources
  - Can predict rates with ~20% accuracy
- Performance of trigger well understood
  - Detailed paper on 2010 data in preparation

Unprescaled trigger rates at $L=1\times10^{33}$ cm$^{-2}$s$^{-1}$

<table>
<thead>
<tr>
<th>trigger</th>
<th>L1 item</th>
<th>L1 Rate (Hz)</th>
<th>EF Rate (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E20_medium</td>
<td>EM14</td>
<td>8500</td>
<td>50</td>
</tr>
<tr>
<td>2e12_medium</td>
<td>2EM7</td>
<td>5700</td>
<td>1</td>
</tr>
<tr>
<td>g80_loose</td>
<td>EM30</td>
<td>700</td>
<td>3</td>
</tr>
<tr>
<td>2g20_loose</td>
<td>2EM14</td>
<td>750</td>
<td>2</td>
</tr>
<tr>
<td>mu18</td>
<td>MU10</td>
<td>5300</td>
<td>40</td>
</tr>
<tr>
<td>2mu10</td>
<td>2MU10</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>xe60</td>
<td>XE40</td>
<td>300</td>
<td>4</td>
</tr>
<tr>
<td>J180</td>
<td>J75</td>
<td>200</td>
<td>6</td>
</tr>
<tr>
<td>Tau29medium_xe35</td>
<td>TAU11_XE20</td>
<td>3800</td>
<td>6</td>
</tr>
<tr>
<td>Tau16_e15</td>
<td>TAU6_EM10</td>
<td>7500</td>
<td>6</td>
</tr>
<tr>
<td>J75_xe45</td>
<td>J50_XE20</td>
<td>500</td>
<td>10</td>
</tr>
</tbody>
</table>
Data Processing

Tier0 capacities sufficient to cope with current data volume
- At current values of pileup

Tier1 and Tier2 centres process ~70k jobs per day
- Includes centralized analysis ntuple production
Physics Results

• Public results:
  • **Submitted papers** on collision data: **38**
    • About 20 drafts in final review stage
  • **Conference notes** provide thorough documentation of preliminary results: **192**
    • 102 in 2010
    • 90 in 2011

• Today will focus on selected results primarily obtained since the last LHCC meeting
  • Will highlight results obtained with early 2011 data
Pb-Pb Collisions

ATLAS-CONF-2011-079
ATLAS-CONF-2011-078
ATLAS-CONF-2011-075
ATLAS-CONF-2011-074
Some Highlights from Quark Matter 2011

- First steps towards probing nuclear pdf’s via $W^\pm$ production
  - Observe $399^{+36}_{-38} W^\pm$ candidates
- More in-depth studies of jet quenching
  - Ratio of jet rate in central vs peripheral collisions $\sim 0.5$ independent of leading jet $E_T$
- Detailed studies of coefficients of elliptic and higher order flow
The Strong Interaction
Inelastic pp Cross Section

- Hot topic at hadron colliders since the 1960’s
- Inelastic cross section at 7 TeV measured using just 20 \(\mu\)b\(^{-1}\) of data (2\(^{nd}\) run recorded in 2010)
  - Uses MBTS detector to detect events: defines acceptance (\(\xi > 5 \times 10^{-6}\))
- Precision 3.5% for \(\xi = M_X^2/s > 5 \times 10^{16}\)
  - Dominated by uncertainty on luminosity measurement (3.4% in 2010)
  - Larger uncertainty on full cross section due to model-dependence of extrapolation (use Donnachie-Landshoff model for \(d\sigma/d\xi\))
- ALFA will provide complementary measurement
Multi-Jet Production

- Require at least 2 jets:
  - Leading jet $P_T > 80$ GeV, all others require $P_T > 60$ GeV
- Cross section measured up to 6 hard jets
  - Observe good agreement with ME and PS MC’s (amazingly!)
- Excellent news for multi-jet searches for new physics (e.g. SUSY)
Heavy Quarks
Tracking and b-tagging

- B-tagging performance measured with 3 complementary methods for several taggers:
  - $p_T^{rel}(\mu)$, $D^+ + \mu$, top
  - Consistent results
- Mistag rate also well controlled
- Understanding and calibration of advanced taggers in progress

- Tracking $p_T$ cut was increased to 400 MeV in 2011
  - Mainly affects vertexing but well understood
Charm and Bottom Meson Production

**D* and D± meson cross sections measured in minimum bias events**
- Typical exp. uncertainty 10%
- Agreement with theory reasonable within large theory errors

**Production of Υ(1S) mesons measured in restricted kinematic range**
- $p_T(μ)>4$ GeV, $|η(μ)|<2.5$
- Reasonable agreement with NRQCD (Pythia8)
- CSM NLO falls short by ~factor 10

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**J/ψ cross section shown previously**
b-jet Production Cross Section

- $\sigma$ measured with two methods:
  - Secondary vertex mass
  - $p_T^{\text{rel}}$ of muon
- Results compare well with predictions

$\sigma$ measured with two methods:
- Secondary vertex mass
- $p_T^{\text{rel}}$ of muon
- Results compare well with predictions
Top Quark Pair Production

Lepton+jets:

- Cross section measured in variety of channels with different techniques
  - Lepton+jets: with and w/o b-tagging
  - Dileptons: with and w/o b-tagging
- Result: $\sigma_{tt} = 180 \pm 18$ pb
  - 10% precision similar to theoretical precision

Dilepton

- ATLAS Preliminary
- $L = 35$ pb$^{-1}$
- Data
- $t\bar{t}$
- $W +$ jets
- Other Bkgd
- QCD
- Uncertainty

Events vs. Number of jets

Events vs. Number of b-tags

$\sqrt{s}$ [TeV] vs. $\sigma_{tt}$ [pb]

ATLAS-CONF-2011-023
ATLAS-CONF-2011-034
ATLAS-CONF-2011-035
ATLAS-CONF-2011-066
Top Quark Mass

Via explicit reconstruction (2010 data):
\[ \Delta m_{\text{top}}/m_{\text{top}} = 3.7\% \]
not yet competitive with Tevatron (but consistent)

- \( \sigma_{tt} \) also constrains top mass
  - Directly sensitive to the pole mass
  - Uncertainty: \( \Delta m_{\text{top}}/m_{\text{top}} = 4.5\% \)
Single Top Quark Production

- **Selection:**
  - 1 lepton, $E_T^{miss}$, 1 $b$-jet, 1 other jet
  - Two analyses
    - Cut-based analysis using 6 variables
    - Neural network

- **Signal significance:** $6.3\sigma$
  - Observe 134 events
  - Expect $124.4\pm23.7$ ($66.4\pm19.6$ signal)

- **Cross section:**
  \[ \sigma_t = 76^{+41}_{-21} \text{ pb} \]

Consistent result obtained with cut-based measurement

*ATLAS-CONF-2011-088*
Electroweak Bosons
• Uses both converted and unconverted photons
  • Main background are $\pi^0$’s and $\eta$’s:
  • Photon purity is 88% (98%) at $E_T^\gamma=50$ (100) GeV
• Data agree well with predictions over 5 orders of magnitude
Understanding of Leptons

- Electrons, muons and τ’s well understood
  - Improvements due to ID and LAr alignments
  - Expect further improvements in Inner Detector and Muon Spectrometer alignment for upcoming reprocessing
W and Z Boson Cross Sections

- Inclusive \( \sigma(W) \) and \( \sigma(Z) \) measurements achieved precision of 5%
  - Dominated by uncertainties on luminosity and acceptance (pdf’s)
- \( Z\rightarrow\tau\tau \) cross section measured with 11% uncertainty
- New measurement of differential \( Z \) \( p_T \) spectrum up to 350 GeV
  - Falls by 3.5 orders of magnitude
  - Data impressively well described by most MC generators
- \( W \) and \( Z + \text{jet} \) production also impressively well described by predictions
WZ→lllv Production

- Event selection
  - 3 leptons $p_T>15$ GeV
    - Leading $e$ ($\mu$) $p_T>25$ (20) GeV
  - $E_T^{miss}>25$ GeV
  - Dilepton mass consistent with Z
  - $m_T(l_3,E_T^{miss})>20$ GeV
- Very pure signal: $S/B=4.8$

\[
\sigma_{WZ}^{tot} = 18^{+7}_{-6}^{(stat)} +^{3}_{-3}^{(syst)} +^{1}_{-1}^{(lumi)} \text{ pb}
\]

Consistent with Prediction of

\[
16.9^{+1.2}_{-0.8} \text{ pb}
\]

2011 data

# of events

<table>
<thead>
<tr>
<th></th>
<th># of events</th>
</tr>
</thead>
<tbody>
<tr>
<td>expected background</td>
<td>2.0 ± 0.7</td>
</tr>
<tr>
<td>expected WZ signal</td>
<td>9.1 ± 1.3</td>
</tr>
<tr>
<td>observed</td>
<td>12</td>
</tr>
</tbody>
</table>

ATLAS-CONF-2011-084
Summary of Electroweak Boson and Top Quark Cross Sections

- All measurements agree with SM expectation (so far)
- Measuring cross sections of ~10 pb
Searching for the Higgs Boson
2010 Higgs Search Results

- 2010 data analyses complete
  - $H\rightarrow\gamma\gamma$
  - $H\rightarrow WW$: both $lvlv$ and $lvjj$
  - $H\rightarrow ZZ$: $llll$, $ll\nu\nu$ and $lljj$
- All analyses simple/cut-based
  - Room for improvement!
Combined Limit for 2010 Data on SM Higgs Cross Section

- **Sensitivity to SM Higgs:**
  - $m_H = 120$ GeV: expected limit $11.4 \times \sigma_{SM}$
  - $m_H = 160$ GeV: expected limit $2.3 \times \sigma_{SM}$
  - $m_H = 300$ GeV: expected limit $7.2 \times \sigma_{SM}$

- **Exclude $140 < m_H < 185$ GeV in models with 4$^{th}$ generation**
  - Assuming no other new physics is present
  - Expected exclusion $136 < m_H < 208$ GeV

arXiv:1106.2748
Di-photon events selected
- $E_T(\gamma_1) > 40$ GeV, $E_T(\gamma_2) > 25$ GeV, isolation cut <5 GeV
- Background normalized from a-priori MC estimates (cross-checked in data)

No significant peak observed in mass spectrum
- Limit obtained by fitting for peak + exponential
  - independent of background estimate

Expected constraint on the Higgs cross section <7x SM expectation
- Observed constraint varies between 5x and 17x the SM cross section
- Even with no improvements to analysis expect to reach $\sim 1.6 \times \sigma_{SM}$ with 4 fb$^{-1}$
Physics Beyond the Standard Model

ATLAS Searches - 95% CL Lower Limits (June 6, 2011)

- ATLAS Preliminary

- $\int L dt = (31 - 236) \text{ pb}^{-1}$

- Mass scale [TeV]

- Only a selection of the available results shown
Physics Beyond the Standard Model

New results with 2011 data

ATLAS Searches* - 95% CL Lower Limits (June 6, 2011)

*Only a selection of the available results shown
SUSY: $E_T^{\text{miss}} + \text{jets} + 0 \text{ or } 1 \text{ lepton}$

- Classic searches for events with multi-jets and $E_T^{\text{miss}}$
  - Various jet multiplicities
  - 0 vs 1 lepton selection

**Data vs Background Expectation**

<table>
<thead>
<tr>
<th>Analysis channel</th>
<th>expected</th>
<th>observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\geq 2$ jets + 0 leptons</td>
<td>$12.1\pm2.8$</td>
<td>10</td>
</tr>
<tr>
<td>$\geq 3$ jets + 0 leptons</td>
<td>$10.1\pm2.4$</td>
<td>8</td>
</tr>
<tr>
<td>$\geq 4$ jets + 0 leptons</td>
<td>$7.3\pm1.7$</td>
<td>7</td>
</tr>
<tr>
<td>$\geq 3$ jets + 1$\mu$</td>
<td>$12.2\pm3.8$</td>
<td>12</td>
</tr>
<tr>
<td>$\geq 3$ jets + 1$e$</td>
<td>$14.5\pm5.2$</td>
<td>10</td>
</tr>
</tbody>
</table>
Data probe squark/gluino cross sections of about 0.1 pb

Data challenge squark and gluino masses of ~1 TeV

- 725 GeV for gluino regardless of squark mass
- 1025 GeV for m(\tilde{g})=m(\tilde{q}) in simplified model [m(\tilde{\chi}_1^0)=0]
- 950 GeV in mSugra/CMSSM model [m(\tilde{\chi}_1^0)\approx m(\tilde{g})/6\approx160 GeV]
W' searches

- Selection of lepton $p_T > 25$ GeV, $E_T^{\text{miss}} > 25$ GeV
- For each W' mass require $m_T > M(W')/2$

Data consistent with background expectation
- Use data to constrain W' bosons
- Exclude $m(W') < 1.7$ TeV for SM couplings
  - combining ev and $\mu\nu$ decay modes
Z’ Searches in Dilepton Decay

- Search for peak in invariant mass of high $P_T$ dilepton pairs

\[ \int L \, dt = 167 \, \text{pb}^{-1} \]
\[ \sqrt{s} = 7 \, \text{TeV} \]

\[ \int L \, dt = 236 \, \text{pb}^{-1} \]
\[ \sqrt{s} = 7 \, \text{TeV} \]

- Data in good agreement with SM expectation
  - No evidence for any peak structure
  - Use data to derive limits on Z’ in various models

- **Exclude $m(Z’) < 1.44$ TeV with SM couplings** (ee and $\mu\mu$ combined)
  - Now clearly beyond Tevatron limits
  - Limits range between 1.15 and 1.29 TeV for E6 inspired models
Dijet Resonance

- Dijet resonance search with 2011 data
  - No bump-like structure found
  - Excludes excited quarks with \(0.8<M(q^*)<2.5\) TeV and axigluons with \(0.8<M(A)<2.67\) TeV
Resonant Top Pair Production

- Same base event selection as cross section measurement in lepton+jets channel
- Data consistent with SM expectation
- **Sensitive to cross sections of about 10 pb**
  - Exclude Kaluza-Klein (KK) gluon with $M(g_{KK})<680$ GeV
  - Not yet sensitive to leptophobic $Z'$ model

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**ATLAS Preliminary**

- $\int Ldt=200\,\text{pb}^{-1}$
- $\sqrt{s}=7$ TeV

**ATLAS Preliminary**

- $\int Ldt = 200 \, \text{pb}^{-1}$
- $dR_{\text{min}}$, Syst.+stat.
- Obs. 95% CL upper limit
- Exp. 95% CL upper limit
- Exp. 1\,\sigma uncertainty
- Exp. 2\,\sigma uncertainty
- Kaluza-Klein gluon

**ATLAS-CONF-2011-087**
Concluding Remarks

- ATLAS is operating very well: collects, triggers, processes and analyses data delivered by LHC efficiently
  - 1 fb\(^{-1}\) of data collected (\(\varepsilon = 95.8\%\))
  - Many analyses already available with early 2011 dataset
    - Best demonstration of excellent performance of detector calibration, software, computing and fast analysis turnaround time
    - Excellent progress being made on understanding large pileup in 2011
- Many new physics results since March 2011
  - Continue to probe (ever more deeply) the strong and electroweak sectors of the Standard Model in new energy regime
  - New in-depth studies of the hot medium in Pb-Pb collisions
  - Closing in on the Standard Model Higgs boson
  - Searches for new physics truly probe TeV scale in many signatures
    - No deviation from SM found yet though => hope for this to change!
- Looking forward to multi-fb\(^{-1}\) dataset this year

The ATLAS collaboration deeply thanks the LHC for the outstanding accelerator performance!!
Backup Slides
6 Frontend Boards and one calibration board lost TTC signal on 30.04.2011
4 FEBs Layer 2 (~20X₀),
2 FEBs Layer 3 (a few X₀)
-0.84<φ<-0.64 - 0<η<1.4
Failure probably due to a burnt fuse on the controller board
Preparation of the repair during beg. of July
Technical Stop ongoing
Review of controller board spec. ongoing

Impact on analyses mitigated by usage of tracking and other calorimeter layers
**Impact of Pileup on Reconstruction**

- **Significant impact on calorimeter reconstruction since LAr drift time is 400 ns**
  - Thus LAr calorimeter “sees” the previous 8 interactions (at 50ns bunch spacing)
    - Signal shape is bipolar to cancel on average for 25ns running
    - We call these previous interactions “out-of-time pileup noise”
  - **Impact on physics**
    - Depends on $<\mu>$ and position in bunch train
    - Increase in systematic uncertainty for low $p_T$ jets w.r.t. 2010
      - Up to 7% at $p_T<$50 GeV in forward region
      - No impact for $p_T>$100 GeV

- **No appreciable impact on physics performance of ID tracking or muon reconstruction**
New: Missing Et Significance Trigger

- L1 rates of SumET and MET triggers grows non-linearly with Luminosity
  - Sensitive to pileup
- Developed new trigger “Missing ET significance”
  - \( \text{MEtSig} = \text{MET} / \sqrt{\text{SumEt}} \)
  - Insensitive to pileup

Adds flexibility particularly for tau and SUSY triggers
• Z mass resolution ~20% worse in data compared to ideal alignment
• Expect improvements for reprocessing campaign
  • Available for analyses in Fall 2011
Inner Detector Alignment

- Movements of up to 8 μm during interventions
  - Otherwise stable
- Recently corrected observed tilt between solenoid and ID
Understanding of τ-leptons

- Tau energy scale understood to within ~2-4%
- Efficiency understood to within 6-10%
• No significant dependence of shape on centrality
• Appears to scale at fixed centrality
• No significant dependence versus $|\eta|$
Elliptic and Higher Order Flow

\[ dN/d\phi \propto 1 + 2 \sum_{n=1}^{\infty} v_n(p_T) \cos (n(\phi - \Psi_n)) \]

- \( v_2 \) depends on centrality
- Higher order coefficients nearly independent of centrality
Two-Particle Correlations

- Detailed measurements of 2-particle correlations
- For most central events data consistent with $v_3 > v_2$
Centrality dependence of high $p_T$ probes

- Indication of J/psi suppression for central events
- W and Z bosons consistent with no suppression
Jet cross sections measured in Pb-Pb collisions for
  - Different centrality bins
  - Various $p_T$ bins

Relatively less jets observed in central events
  - Qualitatively consistent with jet quenching
Jets in Pb-Pb Collisions

- Evaluating jet suppression in more details since initial observation end of 2010

\[ R_{CP} = \frac{1}{N_{coll}^{cent}} \frac{E \frac{d^3N^{cent}}{dp^3}}{1 \frac{1}{N_{coll}^{periph}} \frac{E \frac{d^3N^{periph}}{dp^3}}{dp^3}} \]

- Data tend to \( R_{CP} = 0.5 \) in most central events
  - Effect \( \sim \) independent of \( E_T \) (jet)
- Consistent results with cone sizes of 0.2 and 0.4 obtained
Inclusive Jet Production

Impressive achievement of both Data and Theory!
Search for strong gravity effects in several channels

- $\mu^+\mu^+ + 10$ tracks with $p_T > 8$ GeV
- $\geq 5$ high $p_T$ jets

Data consistent with background

- Place limits in parameter space, probe
  - $M_D$ up to 3 TeV
  - $M_{TH}$ up to 4.5 TeV

ATLAS-CONF-2011-065
Di-Jets

- Previously reported inclusive jet cross section based on full 2010 dataset
- More exclusive jet measurements now available
  - Dijets separated by a rapidity gap
  - $\Delta \phi$ between jets
- MC generators reproduce data quite well
  - NLO calculation also where available

**Graphs and Diagrams**

- Graph showing gap fraction with different generator predictions.
- Graph comparing MC/Data for $Q_0 = 20$ GeV, $90 < p_T < 120$ GeV.
- Graphs illustrating $p_T$ distributions for different rapidity intervals.

*ATLAS* $\sqrt{s}=7$ TeV

*MC* generators reproduce data quite well.

NLO calculation also available where available.
Summary of $\sigma(t\bar{t})$ Measurements

- Cross sections consistent among different techniques and decay modes

$$\Delta \sigma_{t\bar{t}} / \sigma_{t\bar{t}} = 10\%$$
• Low mass: $H \rightarrow \gamma\gamma$ and $H \rightarrow WW \rightarrow lvlv$ contribute most
• High mass: strongest constraints from $H \rightarrow WW \rightarrow lvjj$, $H \rightarrow ZZ \rightarrow vvll$ and $H \rightarrow ZZ \rightarrow lljj$
  • $H \rightarrow ZZ \rightarrow 4$ leptons will improve most as nearly background free: sensitivity $\sim L$ and not $\sqrt{L}$ as for most others
Combined Limit: $4^{\text{th}}$ generation model

- Exclude Higgs in models with $4^{\text{th}}$ generation for $140 < m_H < 185$ GeV
  - Expected exclusion $136-208$ GeV
  - Similar to exclusions achieved by Tevatron and CMS
  - Assumes that no other new physics is present
Luminosity Required for Higgs Boson Discovery

- 95% exclusion with 5 fb\(^{-1}\) for full mass range
- 3σ evidence possible for most of the mass range with 5 fb\(^{-1}\)
Higgs in Supersymmetry (MSSM)

- **Parameter** $\tan\beta = \langle H_u \rangle / \langle H_d \rangle$
  - 3 Neutral Higgs Bosons: $A$, $H$, $h$
    - At high $\tan\beta$: $\text{BR}(A \to \tau\tau) \approx 10\%$
    - At least 2 of neutral states degenerate
  - Cross section: $\sigma(A) \tan^2\beta$

- Analyse di-tau decays using 3 channels: $\tau_h + \mu$, $\tau_h + e$, $\mu + e$
  - Identification efficiency for $\tau$ checked with data-embedding technique
- Data agree well with background estimate
  - Exclude $\tan\beta > 30$ for $m_A \approx 150$ GeV
Exclusion from SUSY 1-lepton analysis

MSUGRA/CMSSM: \( \tan \beta = 10, A_0 = 0, \mu > 0 \)

ATLAS Preliminary

1 lepton, \( \geq 3 \) jets

\( L^{\text{int}} = 165 \, \text{pb}^{-1}, \sqrt{s} = 7 \, \text{TeV} \)

- Observed PCL 95% CL
- Expected PCL
- Observed CL\(_S\)
- Expected CL\(_S\)

\( \tilde{g} (800 \, \text{GeV}) \)
\( \tilde{q} (700 \, \text{GeV}) \)
\( \tilde{q} (800 \, \text{GeV}) \)
\( \tilde{q} (600 \, \text{GeV}) \)
\( \tilde{q} (500 \, \text{GeV}) \)
\( \tilde{q} (400 \, \text{GeV}) \)

\( \tilde{g} (400 \, \text{GeV}) \)

- LEP2 \( \tilde{\chi}_1^\pm \)
- D0 \( \tilde{g}, \tilde{q}, \tan \beta = 3, \mu < 0, 2.1 \, \text{fb}^{-1} \)
- CDF \( \tilde{g}, \tilde{q}, \tan \beta = 5, \mu < 0, 2 \, \text{fb}^{-1} \)

\( m_{1/2} [\text{GeV}] \)

\( m_0 [\text{GeV}] \)
Limit on $W'$ bosons

- Exclude $W'$ bosons with SM coupling up to $1.70 \text{ TeV}$ at 95% CL
Limits on $Z'$ Bosons

$\sqrt{s} = 7$ TeV

$Z' \rightarrow ll$

**95% exclusion on $Z'$ in SSM [TeV]**

<table>
<thead>
<tr>
<th>$ee$</th>
<th>1.275</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mu\mu$</td>
<td>1.222</td>
</tr>
<tr>
<td>$ee+\mu\mu$</td>
<td>1.442</td>
</tr>
</tbody>
</table>

- With first 2011 data limits now approach 1.5 TeV

*ATLAS Preliminary*
SUSY: $E_T^{\text{miss}}$ and $\geq 2$ jets Search

Selection cuts for 0-lepton analysis

<table>
<thead>
<tr>
<th>Signal Region</th>
<th>$\geq 2$ jets</th>
<th>$\geq 3$ jets</th>
<th>$\geq 4$ jets</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E_T^{\text{miss}}$ [GeV]</td>
<td>$&gt; 130$</td>
<td>$&gt; 130$</td>
<td>$&gt; 130$</td>
</tr>
<tr>
<td>Leading jet $p_T$ [GeV]</td>
<td>$&gt; 130$</td>
<td>$&gt; 130$</td>
<td>$&gt; 130$</td>
</tr>
<tr>
<td>Second jet $p_T$ [GeV]</td>
<td>$&gt; 40$</td>
<td>$&gt; 40$</td>
<td>$&gt; 40$</td>
</tr>
<tr>
<td>Third jet $p_T$ [GeV]</td>
<td>–</td>
<td>$&gt; 40$</td>
<td>$&gt; 40$</td>
</tr>
<tr>
<td>Fourth jet $p_T$ [GeV]</td>
<td>–</td>
<td>–</td>
<td>$&gt; 40$</td>
</tr>
<tr>
<td>$\Delta \phi$ (jet, $E_T^{\text{miss}}$)$_{\text{min}}$ ($i = 1, 2, 3$)</td>
<td>$&gt; 0.4$</td>
<td>$&gt; 0.4$</td>
<td>$&gt; 0.4$</td>
</tr>
<tr>
<td>$E_T^{\text{miss}}/m_{\text{eff}}$</td>
<td>$&gt; 0.3$</td>
<td>$&gt; 0.25$</td>
<td>$&gt; 0.25$</td>
</tr>
<tr>
<td>$m_{\text{eff}}$ [GeV]</td>
<td>$&gt; 1000$</td>
<td>$&gt; 1000$</td>
<td>$&gt; 1000$</td>
</tr>
</tbody>
</table>

• Separate analysis performed with 1 lepton + $\geq 3$ jets
  • $e$ or $\mu$ with $p_T > 25$ GeV
  • 3 jets with $p_T > 60, 25, 25$ GeV
  • $E_T^{\text{miss}} > 125$ GeV
  • $m_T > 100$ GeV
  • $m_{\text{eff}} > 500$ GeV

$m(\tilde{q}) << m(\tilde{g})$: 2 jets + $E_T^{\text{miss}}$

$m(\tilde{q}) \approx m(\tilde{g})$: 3 jets + $E_T^{\text{miss}}$

$m(\tilde{q}) >> m(\tilde{g})$: 4 jets + $E_T^{\text{miss}}$