Searches for BSM physics in ATLAS

Luis March (Université de Genève)
On behalf of the ATLAS Collaboration

CALOR 2016
Daegu (Republic of Korea), May 16th 2016
Outline

A Toroidal LHC ApparatuS (ATLAS) detector: Description and Run-2 (2015) data-taking

Searches for new (Beyond Standard Model) physics: Strategy and Run-1 data experience

SUperSYmmetry (SUSY): Production modes and searches with Run-2 data

$$0-\ell + \text{jets} \begin{cases} \text{ATLAS-CONF-2015-062} \\ \text{arXiv:1602.06194} \\ \text{arXiv:1604.07773} \end{cases} 1-\ell + \text{jets} \begin{cases} \text{ATLAS-CONF-2015-076} \\ \text{ATLAS-CONF-2016-007} \end{cases} 2-\ell \text{ or } 3-\ell \begin{cases} \text{ArXiv:1602.09058} \\ \text{ATLAS-CONF-2015-082} \end{cases}$$

Exotics searches with Run-2 data:

Fermionic final states

$$\begin{cases} \text{ATLAS-CONF-2015-063 (W' searches)} \\ \text{ATLAS-CONF-2015-070 (Z' searches)} \\ \text{ATLAS-CONF-2015-072 (Lepton Flavor Violation)} \end{cases}$$

Hadronic final states

$$\begin{cases} \text{ArXiv:1512.01530 (di-jet)} \end{cases}$$

VV

$$\begin{cases} \text{ATLAS-CONF-2015-068 (ZW/ZZ→vvqq)} \\ \text{ATLAS-CONF-2015-075 (WW/WZ→lνqq)} \\ \text{ATLAS-CONF-2015-071 (ZW→llqq)} \\ \text{ATLAS-CONF-2015-073 (ZZ/WW/WZ→qqqq)} \end{cases}$$

Vh

$$\begin{cases} \text{ATLAS-CONF-2015-074 (V→νν/νl/ll & h→bb)} \end{cases}$$

Zγ

$$\begin{cases} \text{ATLAS-CONF-2016-010 (Z→ll/qq)} \end{cases}$$

γγ

$$\begin{cases} \text{ATLAS-CONF-2016-018} \end{cases}$$

Conclusions

L. March
A Toroidal LHC ApparatuS (ATLAS) detector

**Structure:**

**Tracking:** Pixel, Silicon and Transition Radiation Tracker; In a solenoid magnetic field

**Calorimetry:**
- **Electromagnetic:** LAr in endcaps and barrel
- **Hadronic:** Scintillators in barrel

**Muon Spectrometer:** Drift Chambers, Resistive Plate Chambers; In a toroidal magnetic field

**Physics goals:**
Precision Electroweak measurements, Higgs and Physics Beyond Standard Model

**Run-2 2015**

\[ L_{\text{inst max}} = 5.1 \times 10^{33} \text{ cm}^{-2} \text{ s}^{-1} \]

Data-taking efficiency in Run-2 (2015): ~ 92%

New Insertable B-Layer (IBL): innermost layer of pixel

b-tagging improvement

ATLAS performance close to or exceeding design resolutions

This talk is focused on ATLAS results with Run-2 (2015) data
Searches for New Physics

Strategy for new physics searches:
- Define selection based on:
  Signal signatures and background (bkg) kinematics
- Compare data to:
  Standard Model (SM) bkg (Monte Carlo (MC) and data-drive)
  and MC signal predictions

No evidence for new physics: Limit settings
- Limits typically set on cross-section x Branching Ratio (σ x BR)
- Comparisons provided for specific models,
  but usually possible to constrain additional models

Large Hadron Collider (LHC) Run-1 data:
LHC Run-1 data allowed the Higgs discovery, precision measurements
and limit settings on other models Beyond the Standard Model (BSM)

But why looking for new (BSM) physics?
The SM does not provide answers to (e.g.): Gravity, Dark matter/energy and Hierarchy problem
Unanswered questions motivate further searches, either SUSY or Exotics

No other clear indications of new physics BSM with LHC Run-1 data

Run-1: results have been extremely useful to narrow down their allowed phase spaces
Run-2: Center of mass energy increased from 8 to 13 TeV → TeV scale searches for new physics
SuperSymmetry (SUSY): Production modes

Global symmetry between fermions and bosons:
All SM particles have SUSY partners (spin diff. of ±1/2)

Why SUSY?
- Solves the hierarchy problem
- Provides the dark matter candidate: If R-parity is conserved, lightest SUSY particle (neutralino) is stable
- Provides unification with gravity
- Required for the string theory
- And more others ...

SUSY production modes
- Electroweak: Searches for $\tilde{\chi}^0_1$ and $\tilde{\chi}^{\pm}_1$
  Low cross-section & multi-leptons final states with low SM bkg
- Strong:
  - Third generation: Dedicated searches for $\tilde{t}_1$ & $\tilde{b}_1$
    Final state similar to the SM bkg
  - gluinos/squarks: Inclusive searches for $\tilde{g}$ and $\tilde{g}$
    Large cross-section & Rich final states in case of $\tilde{g}$-$\tilde{g}$ production
SUSY searches

Large increase of SUSY cross-section from 8 to 13 TeV:
http://inspirehep.net/record/1326406

Sigma(\tilde{\chi}\tilde{\chi}) for m(\tilde{\chi}) = 0.5 TeV → Factor ~ 4 larger at 13 TeV
Sigma(\tilde{\chi}\tilde{\chi}) for m(\tilde{\chi}) = 0.7 TeV → Factor ~ 8 larger at 13 TeV
Sigma(\tilde{g}\tilde{g}) for m(\tilde{g}) = 1.4 TeV → Factor ~ 30 larger at 13 TeV

Focus on gluino and 3\textsuperscript{rd} generation squarks searches with 2015 data:
Discovery potential beyond Run-1 limits, even with 3 fb\(^{-1}\) of 13 TeV

Discovery potential of EW SUSY beyond Run-1 limits with 2016 data
0-\ell + 2-6 jets + E_T^{\text{miss}} analysis: Results

Search for gluino and squark pair production in final states with 0 lepton, jets and E_T^{\text{miss}}. ATLAS-CONF-2015-062

Selection cuts for 7 SRs: 2-6 jets & different cuts ($m_{\text{eff}}$ cut for different mass splittings)

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Signal Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E_T^{\text{miss}}$ [GeV] &gt;</td>
<td>2jl</td>
</tr>
<tr>
<td>$p_T(j_1)$ [GeV] &gt;</td>
<td>200</td>
</tr>
<tr>
<td>$p_T(j_2)$ [GeV] &gt;</td>
<td>200</td>
</tr>
<tr>
<td>$p_T(j_3)$ [GeV] &gt;</td>
<td>200</td>
</tr>
<tr>
<td>$p_T(j_4)$ [GeV] &gt;</td>
<td>200</td>
</tr>
<tr>
<td>$\Delta \phi (j_{1,2}(3), E_T^{\text{miss}})_\text{min}$ &gt;</td>
<td>0.4</td>
</tr>
<tr>
<td>$\Delta \phi (j_{1,2,3}, E_T^{\text{miss}})_\text{min}$ &gt;</td>
<td>0.2</td>
</tr>
<tr>
<td>$E_T^{\text{miss}}/\sqrt{H_T}$ [GeV^{1/2}] &gt;</td>
<td>15</td>
</tr>
<tr>
<td>Aplanarity &gt;</td>
<td>0.25</td>
</tr>
<tr>
<td>$m_{\text{eff}}(N_j)$ [GeV] &gt;</td>
<td>800</td>
</tr>
<tr>
<td>$m_{\text{eff}}$ (incl.) [GeV] &gt;</td>
<td>1200</td>
</tr>
</tbody>
</table>

Define HT, Aplanarity and meff

Main Backgrounds: \((Z \rightarrow \nu\nu)+jets, W+jets, t\bar{t}\) and single top events with hadronic taus (MC normalized in CRs)

Interpretation with squarks:
Exclude squark masses up to ~ 1 TeV

Interpretation with gluinos:
Exclude gluino masses up to ~ 1.5 TeV

No excess observed over SM bkg

L. March
0-\ell + 7-10 \text{ jets} + E_T^{\text{miss}} \text{ analysis: Results}

Search for gluino pair production with complex decay chains: arXiv:1602.06194

Selection cuts for 15 SRs: 7-10 jets & different cuts (no leptons with \(p_T > 10\ \text{GeV}\)):

<table>
<thead>
<tr>
<th>(n_{50})</th>
<th>(8\text{j50})</th>
<th>(8\text{j50}-1\text{b})</th>
<th>(8\text{j50}-2\text{b})</th>
<th>(9\text{j50})</th>
<th>(9\text{j50}-1\text{b})</th>
<th>(9\text{j50}-2\text{b})</th>
<th>(10\text{j50})</th>
<th>(10\text{j50}-1\text{b})</th>
<th>(10\text{j50}-2\text{b})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(n_{b-\text{jet}})</td>
<td>(\geq 8)</td>
<td>(\geq 9)</td>
<td>(\geq 10)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(E_T^{\text{miss}}/\sqrt{H_T})</td>
<td>(\geq 1)</td>
<td>(\geq 2)</td>
<td>(\geq 1)</td>
<td>(\geq 2)</td>
<td>(\geq 1)</td>
<td>(\geq 2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n_{80})</td>
<td>(\geq 7)</td>
<td>(\geq 8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n_{b-\text{jet}})</td>
<td>(\geq 1)</td>
<td>(\geq 2)</td>
<td>(\geq 1)</td>
<td>(\geq 2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(E_T^{\text{miss}}/\sqrt{H_T})</td>
<td>(\geq 4\ \text{GeV}^{1/2})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Main Backgrounds: Multijet (from CRs with 1 jet less), \(W+jets\) and \(t\bar{t}\) (from CRs with 1 lepton: \(p_T > 20\ \text{GeV}\))

\[
\tilde{g}, \tilde{g} \rightarrow q\bar{q}WZ\tilde{\chi}_1^0, m(\tilde{\chi}_1^0) = m(\tilde{g}) + m(\tilde{\chi}_1^0)/2, m(\tilde{\chi}_1^0) = m(\tilde{\chi}_1^0) + m(\tilde{\chi}_1^0)/2
\]

For \(m(\tilde{\chi}_1^0) < 500\ \text{GeV}\) and \(m(\tilde{g}) > 1200\ \text{GeV}\): Above decay chain is dominant

For \(m(\tilde{\chi}_1^0) > 500\ \text{GeV}\) and \(m(\tilde{g}) < 1200\ \text{GeV}\):
\[
\tilde{g} \rightarrow q\bar{q}\tilde{\chi}_1^0, \text{ decay chain is dominant}
\]

L. March
Energetic mono-jet + $E_T^{miss}$ analysis: Results

Search for gluino and squarks pair production with an energetic mono-jet and large $E_T^{miss}$: arXiv:1604.07773

Incomplete slide:
I need to add more info, sorry!
**1-\(\ell\) + jets + \(E_T^{\text{miss}}\) analysis: Results**

Search for gluino pair production in final states with 1 lepton, jets and \(E_T^{\text{miss}}\): ATLAS-CONF-2015-076

Selection cuts for Signal Regions (SRs):
- 4 hard-\(\ell\) SRs: \(p_T^{\ell} > 35\) GeV & 4-6 jets
- 2 soft-\(\ell\) SRs: 7(6) < \(p_T\) < 35 GeV for e(\(\mu\)) & 2 or 5 jets

Main Backgrounds:
\(t\bar{t}\) and \(W+jets\) events (suppressed with \(m_T\) cut)

Results:
Overall good agreement between expected bkg and observation
Largest deviation: 2\(\sigma\) observed in the SR with 1 hard-\(\ell\) + 6 jets

Add mass limits
1-\ell + 4 jets + $E_T^{\text{miss}}$ analysis: Results

Search for gluino and top squarks pair production with one isolated lepton, jets and $E_T^{\text{miss}}$: ATLAS-CONF-2016-007

**Selection cuts for 3 SRs:**

<table>
<thead>
<tr>
<th>Variable</th>
<th>SR1</th>
<th>TCR1 / WCR1</th>
<th>STCR1</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1\ell+4\text{jets}+E_T^{\text{miss}}$ trigger</td>
<td>exactly one signal lepton ($\ell$, $\mu$), no additional baseline leptons. at least four signal jets, and $</td>
<td>\Delta R(j_{\ell},p_{T}^{\text{miss}})</td>
<td>&gt; 0.4$ for $i \in {1, 2}$, veto events with a hadronic $\tau$ and $m_{\tau} &gt; 80$ GeV.</td>
</tr>
<tr>
<td>$E_T^{\text{miss}}$ [GeV]</td>
<td>$&gt;260$</td>
<td>$&gt;200$</td>
<td>$&gt;200$</td>
</tr>
<tr>
<td>$m_{\tau}$ [GeV]</td>
<td>$&gt;14$</td>
<td>$&gt;5$</td>
<td>$&gt;5$</td>
</tr>
<tr>
<td>number of b-tags</td>
<td>$\geq 1$</td>
<td>$\geq 1$</td>
<td>$\geq 2$</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Variable</th>
<th>SR2</th>
<th>TCR2 / WCR2</th>
<th>STCR2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1\ell+4\text{jets}+E_T^{\text{miss}}$ trigger</td>
<td>exactly one signal lepton ($\ell$, $\mu$), no additional baseline leptons. at least four signal jets, and $</td>
<td>\Delta R(j_{\ell},p_{T}^{\text{miss}})</td>
<td>&gt; 0.4$ for $i \in {1, 2}$, veto events with a hadronic $\tau$ and $m_{\tau} &gt; 80$ GeV.</td>
</tr>
<tr>
<td>$E_T^{\text{miss}}$ [GeV]</td>
<td>$&gt;350$</td>
<td>$&gt;250$</td>
<td>$&gt;200$</td>
</tr>
<tr>
<td>$m_{\tau}$ [GeV]</td>
<td>$&gt;20$</td>
<td>$&gt;15$</td>
<td>$&gt;5$</td>
</tr>
<tr>
<td>number of b-tags</td>
<td>$\geq 1$</td>
<td>$\geq 1$</td>
<td>$\geq 2$</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Variable</th>
<th>SR3</th>
<th>TCR3 / WCR3</th>
<th>STCR3</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1\ell+4\text{jets}+E_T^{\text{miss}}$ trigger</td>
<td>exactly one signal lepton ($\ell$, $\mu$), no additional baseline leptons. at least four signal jets, and $</td>
<td>\Delta R(j_{\ell},p_{T}^{\text{miss}})</td>
<td>&gt; 0.4$ for $i \in {1, 2}$, veto events with a hadronic $\tau$ and $m_{\tau} &gt; 80$ GeV.</td>
</tr>
<tr>
<td>$E_T^{\text{miss}}$ [GeV]</td>
<td>$&gt;480$</td>
<td>$&gt;280$</td>
<td>$&gt;200$</td>
</tr>
<tr>
<td>$m_{\tau}$ [GeV]</td>
<td>$&gt;14$</td>
<td>$&gt;8$</td>
<td>$&gt;5$</td>
</tr>
<tr>
<td>number of b-tags</td>
<td>$\geq 1$</td>
<td>$\geq 1$</td>
<td>$\geq 2$</td>
</tr>
</tbody>
</table>

Incomplete slide: I need to add more info, sorry!
Same-sign 2-$\ell$ or 3-$\ell$ analysis: Results

Search for gluino pair production with complex decay chains: arXiv:1602.09058

Selection cuts for 4 SRs: 2-3 leptons, 3-5 jets, b-jets & different cuts ($E_T^{\text{miss}}$ and $m_{\text{eff}}$):

<table>
<thead>
<tr>
<th>Signal region</th>
<th>$N_{\text{signal}}^{2\ell}$</th>
<th>$N_{\text{b-jets}}^{2\ell}$</th>
<th>$N_{\text{jets}}^{5\ell}$</th>
<th>$E_T^{\text{miss}}$ [GeV]</th>
<th>$m_{\text{eff}}$ [GeV]</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR0b3j</td>
<td>$\geq 3$</td>
<td>= 0</td>
<td>$\geq 3$</td>
<td>$&gt;200$</td>
<td>$&gt;550$</td>
</tr>
<tr>
<td>SR0b5j</td>
<td>$\geq 2$</td>
<td>= 0</td>
<td>$\geq 5$</td>
<td>$&gt;125$</td>
<td>$&gt;650$</td>
</tr>
<tr>
<td>SR1b</td>
<td>$\geq 2$</td>
<td>$\geq 1$</td>
<td>$\geq 4$</td>
<td>$&gt;150$</td>
<td>$&gt;550$</td>
</tr>
<tr>
<td>SR3b</td>
<td>$\geq 2$</td>
<td>$\geq 3$</td>
<td>-</td>
<td>$&gt;125$</td>
<td>$&gt;650$</td>
</tr>
</tbody>
</table>

Main Backgrounds: Multijet (from CRs with 1 jet less), $W$+jets and $t\bar{t}$ (from CRs with 1 lepton: $p_T > 20$ GeV)

Add mass limits
Z → ℓ⁺ℓ⁻ + E_T^miss analysis: Results

Search for gluino (or squark) pair production with Z in the decay chains: ATLAS-CONF-2015-082

Selection cuts for 1 SR

Main Backgrounds: ℓ⁺ℓ⁻ (CR with DF leptons) Z/γ* + jets

Results:

Observed events: 21 (10 ee + 11 μμ)
Expected bkg events: 10.3 ± 2.3 events

Excess of 2.2σ with 2015 data

Run-1 (8 TeV): 3(1.7)σ excess in the ee(μμ) channel

Add mass limits

L. March
Exotics searches

“Exotics” means direct searches for particles/phenomena:
- Beyond the Standard Model
- Not SUSY (nor BSM Higgs)

Leaves a huge range of hypotheses that explain one or more of the mysteries in the SM:

These searches benefit greatly from the increased LHC energy:
With ~ 3 fb\(^{-1}\) at 13 TeV, it has been already exceeded Run-1 sensitivity in many cases

---

**Fermionic final states:**
- ATLAS-CONF-2015-063 (W')
- ATLAS-CONF-2015-070 (Z')
- ATLAS-CONF-2015-072 (LFV)

**Hadronic final states:**
- ArXiv:1512.01530 (di-jet)

**Dibosons:**
- VV
- ATLAS-CONF-2015-068 (vvqq)
- ATLAS-CONF-2015-075 (lvqq)
- ATLAS-CONF-2015-071 (llqq)
- ATLAS-CONF-2015-073 (qqqq)

Vh (vv/lv/ll & h\rightarrow bb)
- ATLAS-CONF-2015-074

Z γ
- ATLAS-CONF-2016-010 (Zll/qq)

γ γ
- ATLAS-CONF-2016-018
Fermionic final states: Results

**W' searches:**
ATLAS-CONF-2015-063
Exactly 1-\(\ell = e(\mu)\) with \(p_T > 65\) (55) GeV
\(E_T^{\text{miss}} > 65\) (55) GeV
\(m_T > 100\) (130) GeV
Search for transverse mass (W') or invariant mass (Z') distributions

**Z' searches:**
ATLAS-CONF-2015-070
2-\(\ell = ee/\mu\mu\) with \(p_T > 30\) GeV
Opposite charge
\(m_\sigma > 120\) GeV

Lepton Flavor Violation (LFV) searches:
ATLAS-CONF-2015-072
Opposite flavour: \(e\mu\) with \(p_T > 65\) GeV
Back-to-back: \(\Delta \phi(e,\mu) > 2.7\)

SSM Z' and Quantum Black Holes (QBH) models can allow for LFV final states
**Hadronic final states: Results**

Search for central di-jet excesses among falling QCD background

\[ p_T^{j1(j2)} > 440 \, (50) \, \text{GeV} \]
\[ m_{jj} > 1.1 \, \text{TeV} \]
\[ |y_1 - y_2| < 1.2 \]

Di-jet mass & angular distributions:

[arXiv:1512.01530](http://arxiv.org/)

\[ \gamma = \ln \left( \frac{E + p_Z}{E - p_Z} \right) \quad \chi = e^{\lambda |\Delta y|} \]

Search for deviations from QCD in angular distribution of jets

\[ p_T^{j1(j2)} > 440 \, (50) \, \text{GeV} \]
\[ m_{jj} > 2.5 \, \text{TeV} \]
\[ |y_1 - y_2| < 3.4 \]
\[ |y_1 + y_2| < 2.2 \]

\[ m_{jj} > 5.4 \, \text{TeV} \] was not reachable for 8 TeV analysis

[Run-1 → Run-2](#)

8.1 → 12.0 TeV

12.0 → 17.5 TeV

m_{jj} > 3.4 \, \text{TeV}
**Di-bosons (VV) resonances: Results**

**VV → vvqq:**
- \( E_T^{\text{miss}} > 250 \text{ GeV} \)
- \( \Delta \phi(E_T^{\text{miss}}, J) < 0.6 \)
- \( \text{WZ/ZZ} \rightarrow \text{vvJ} \)

**VV → lvqq:**
- \( 1-\ell + E_T^{\text{miss}} > 250 \text{ GeV} \)
- \( p_T^{\ell/J}/m_{\ell/J} > 0.4 \)
- \( \text{WW/ZZ} \rightarrow \ell\nu J \)

**VV → llqq:**
- \( 2-\ell \) with \( m_{\ell\ell} \sim m_Z \)
- \( p_T^{\ell/J}/m_{\ell/J} > 0.4 \)
- \( \text{ZW/ZZ} \rightarrow \ell\nu J \)

**VV → qqqq:**
- All hadronic final state
- QCD multi-jet bkg dominant
- \( \text{WZ/ZZ/WW} \rightarrow JJ \)

---

2 boson tagged large-R jets with \( p_T^{J1(J2)} > 450 \) (200) GeV

**Add mass limits**

- **Exclusion limits for 4 di-boson resonances**
  - **Run-2:** No significant deviation from SM bkg
  - **VV → qqqq:**
    - **Run-1:** Excess at \( \sim 2 \text{ TeV} \)
    - **Run-2:** No significant deviation from SM bkg
**Di-bosons (VH) resonances: Results**

**VH: \(V \rightarrow vv/lv/ll\) and \(H \rightarrow bb\):**

ATLAS-CONF-2015-074

Large jet with \(p_T^J > 250\) GeV, \(m_J \sim m_H\)

1 or 2 b-tags and 0/1/2-l

0-l with \(E_T^{miss} > 200\) GeV

Main bkgs: Z+jets (0-l & 2-l) and W+jets/tt (1-l)

No significant deviation over the SM bkgs

Interpretations: HVT and A \(\rightarrow ZH\)

Add mass limits
**Di-bosons \((X \rightarrow Z \gamma)\) searches: Results**

\(X \rightarrow Z \gamma : Z \rightarrow \ell \ell / qq\)

ATLAS-CONF-2016-010

\(Z \gamma\) resonance search: Interesting in case of possible \(\gamma \gamma\) signal

- \(Z(\rightarrow \ell \ell)\) analysis: Search range \(m_X = 0.25\) to 1.5 TeV
  \(E_T^{\gamma} > 0.3m_X, p_T^{\ell} > 10\) GeV, \(m_\ell - m_Z < 15\) GeV

- \(Z(\rightarrow qq)\) analysis: Search range \(m_X = 0.72\) to 2.75 TeV
  \(E_T^{\gamma} > 250\) GeV, \(p_T^{J} > 200\) GeV, \(80 < m_J < 110\) GeV

Analytic background model similar to \(\gamma \gamma\)

No excess observed over the SM bkgs:
Limits set accordingly to heavy Higgs interpretation

Add mass limits:
Added in green color (text)
Di-bosons ($\gamma \gamma$) searches (1): Results

ATLAS-CONF-2016-018

Spin-0 analysis:
- Optimized for Higgs-like signal
  $E_{T,\gamma}^1 > 0.4 m_{\gamma \gamma}$, $E_{T,\gamma}^2 > 0.3 m_{\gamma \gamma}$
- As model-independent as possible
  Limit on fiducial cross-section
- Search range:
  $m_X = [200 \text{ GeV} - 2 \text{ TeV}]$
  $\Gamma_X / m_X = [0\% - 10\%]$

Spin-2 analysis:
- Loose selection
  $E_{T,\gamma}^{1,2} > 55 \text{ GeV}$
- Use RS graviton as benchmark
- Irreducible bkg ($\gamma \gamma$) from MC
- Search range:
  $m_X = [500 \text{ GeV} - 3 \text{ TeV}]$
  $k / M_{Pl} = [0.001 - 0.3]$
  $\Gamma_X / m_X \sim 1.44 (k / M_{Pl})^2 \sim [0\% - 10\%]$

Precision region of EM calorimeter: $|\eta| < 2.37$
(1.37 – 1.52 excluded)

Spin-0 analysis:
- Largest deviation from bkg-only hypothesis
  $m_X \sim 750 \text{ GeV}$, $\Gamma_X / m_X \sim 6\%$
  Global significance = 2.0 $\sigma$ (search range)

Spin-2 analysis:
- Largest deviation from bkg-only hypothesis
  $m_X \sim 750 \text{ GeV}$, $\Gamma_X / m_X \sim 6\%$ ($k / M_{Pl} \sim 0.2$)
  Global significance = 1.8 $\sigma$ (search range)
Di-bosons ($\gamma \gamma$) searches (2): Results

ATLAS-CONF-2016-018

Re-analysis of Run-1 (8 TeV) data

Spin-0 analysis:
1.9 $\sigma$ at $m_X = 750$ GeV, $\Gamma_X / m_X = 6\%$
8 TeV (re-analyzed) data compatibility with 13 TeV:
1.2 $\sigma$ (gg) – 2.1 $\sigma$ (qq)

Spin-2 analysis:
No significant excess
8 TeV (re-analyzed) data compatibility with 13 TeV:
2.7 $\sigma$ (gg) – 3.3 $\sigma$ (qq)

---

![Spin-0 Selection](ATLAS Preliminary)

$\sqrt{s} = 8$ TeV, 20.3 fb$^{-1}$

![Spin-2 Selection](ATLAS Preliminary)

$\sqrt{s} = 8$ TeV, 20.3 fb$^{-1}$
Conclusions

ATLAS shows a successful commissioning of the detector upgrade for Run-2

ATLAS has performed a wide range of searches:

Early SUSY searches performed with $\sim 3.2 \text{ fb}^{-1}$ of data at 13 TeV
- Exclude up to 1.8 TeV
- Exclude up to $\sim 1$ TeV
- Exclude up to $\sim 0.84$ TeV

Significant improvement of exclusion limits from Run-1
Excess of $2.2\sigma$ in the $Z+E_T^{\text{miss}}$ analysis, after $3.0\sigma$ in Run-1

Early Exotics searches performed with $\sim 3.2 \text{ fb}^{-1}$ of data at 13 TeV
- The sensitivity of all searches already exceeds Run-1 results and new mass regions have been explored
- Most searches do not see significant excesses, but larger exclusion limits are set for various models Beyond Standard Model
- Largest excess observed in $\gamma \gamma$ resonance search around $m_x = 750$ GeV
  * Global significance: $2.0\sigma$ ($1.8\sigma$) for the spin-0 (spin-2) analysis
- 8 TeV $\gamma \gamma$ data re-analyzed, compatibility with 13 TeV results assessed:
  * gg: $1.2\sigma$ ($2.7\sigma$), qq: $2.1\sigma$ ($3.3\sigma$) for the spin-0 (spin-2) analysis

The expected higher luminosity in 2016 ($\sim 10$ times larger than 2015) will allow a deeper exploration of the 13 TeV regime
Back-up Slides

Add back-up slides: Support info
Such as other plots for the notes shown
ATLAS Performance
Object definition, etc