Exotics Searches for New Physics with the ATLAS Detector

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Outline

- The LHC has reached a new milestone with more than 1.3 fb⁻¹ of deliver integrated luminosity

- As it is a “mission impossible” task to cover all the Exotics Searches in ATLAS in 15 min (over 19 CONF Notes and 11 Papers), I will give the headlines of the following analysis:
  - Monojet + missing Et
  - Dijet final states
  - Dilepton final states
  - Lepton and missing Et
  - Semileptonic ttbar
  - Diphoton final states

- **ATLAS Exotics public results web page**

Large diversity of theoretical models (Extra-Dimensions, Sequential SM, Lepto-Quark, ...) giving alternative solutions to the hierarchy problem, weakness of gravity dark matter, grand unification, etc.
pt=602 GeV; eta=-1; phi=2.6
Missing Et = 523 GeV
Monojet+MET final states

Physics Model: Arkani-Hamed, Dimopoulos, Dvali (ADD) Kaluza-Klein Graviton

- Observable
  - Large missing Et
  - High pt jet

- Event Selection
  - High pt jet and large MET
  - No second jet above threshold
  - No reconstructed lepton (e, μ)

- Main background
  - EW SM (Z/W+jets)

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No evidence for new physics signal found
Observed (Expected) 95% C.L. Limits (2011 data)
ADD graviton $M_D > 3.16$ to $1.99$ ($2.98$ to $1.92$) TeV for $n=2$ to $6$
Very high energy jet event
mjj = 4040 GeV
ptj1 = 1850 GeV
ptj2 = 1840 GeV
ATLAS-CONF-2011-081
Dijet final states: resonances

Physics Models:
- Excited quarks $q^*$
- Axigluons
- Color-octet scalars

- Observable
  - Dijet invariant mass

- Events Selection
  - Two highest pt jets with $|\eta|<2.5$ and $|\Delta \eta_{jj}|<1.3$

- Background
  - SM QCD parametrization
    $$f(x) = p_1 (1 - x)^{p_2} x^{p_3} + p_4 \ln x$$
Dijet final states: angular distribution

Physics Model:
- Quark contact interactions
- Randall-Meade QBH

$\chi$: Centrality in cm frame

Event Selection
- At least two jets with $p_{t_{j1}} > 60$ GeV and $p_{t_{j2}} > 30$ GeV

Observable
- Dijets angular distribution

Background
- SM QCD (NLO) prediction
Dijet final states: Limits

No evidence for new physics signal found

Observed (Expected) 95% C.L. Limits (2011 data)
- Excited quarks ($q^*$) $M > 2.77 \ (2.91)$ TeV
- Axigluons $M > 3.02 \ (3.21)$ TeV
- Color Octet Scalar $M > 1.71 \ (1.91)$ TeV

Observed (Expected) 95% C.L. Limits (2010 data)
- RMQ Black Hole (n=6) $M > 3.67 \ (3.64)$ TeV
- Contact interaction $\Lambda > 6.7 \ (5.7)$ TeV

ATLAS Preliminary

$\int L dt = 0.81 \text{ fb}^{-1}$
$\sqrt{s} = 7 \text{ TeV}$
Dilepton final states

$m_t = 959$ GeV
Physics Models:
- $Z'$ (SSM, E6)
- Randall-Sundrum Graviton
- Contact interactions

- Observable
  - Dilepton invariant mass

- Event Selection
  - Select events with two leptons (same flavor, e or $\mu$)

- Main background
  - SM EW background ($Z/\gamma^* \rightarrow \ell\ell$)
Dilepton final states

No evidence for new physics signal found

Observed (Expected) 95% C.L. Limits (2011 data)
E6 Z' bosons M in the range 1.50-1.64 (1.50-1.64) TeV
Z' SSM                      M>1.83 (1.83) TeV
RS G, k/M=0.1                M>1.63 (1.61) TeV
RS G, k/M=0.01               M>0.7  (0.7 )  TeV
(2010 data) Contact interaction Dimuon Λ> 4.9 (5.1) TeV
Lepton+MET final states

Physics Models:
- W' SSM
- W* Chiral boson

- Observable
  - Transverse mass
- Event Selection
  - Select events with just one high pt lepton (e, μ) and high MET
- Background
  - SM EW background (W)
  - QCD faking electron

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No evidence for new physics signal found

Observed (Expected) 95% C.L. Limits
(2011 data)

W' SSM \( M > 2.23 \) (2.15) TeV

(2010 data)

W* (chiral boson) \( M > 1.35 \) (1.31) TeV
Semileptonic ttbar final states

\[ m_{tt} = 1602 \text{ GeV} \]
Semileptonic tt\bar{b} final states

Search for tt\bar{b} resonances: Kaluza-Klein gluon Z' (TC2 leptophobic)

- Observable
  - Invariant mass of the jets, lepton and MET

- Selection
  - >=4 jets
  - >=1 b-jet
  - Just one lepton, pt > 20 GeV
  - Large MET

- Background
  - Main background SM tt\bar{b}
Semileptonic ttbar final states

No evidence for new physics signal found

Observed (Expected) 95% C.L. Limits
(2011 data)

KK-gluon $M > 650 \ (825) \ \text{GeV}$

No exclusion limits on $Z'$ TC2 Leptophobic

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Diphoton final states

m=679 GeV
Diphoton final states

Physics Model:
Randall-Sundrum Graviton

- Observable
  - Diphoton invariant mass
- Selection
  - Two photons with pT>25 GeV
- Background
  - SM diphoton production
  - fake photons from QCD

Dimensionless RS coupling
$k/M_{pl}$ (from 0.02 to 0.1)
Diphoton final states

No evidence for new physics signal found

Observed (Expected) 95% C.L. Limits (2010 data)

\( G \rightarrow \gamma\gamma, \ k/M=0.02 \quad M>545 \ (503) \, \text{GeV} \)

\( G \rightarrow \gamma\gamma, \ k/M=0.1 \quad M>920 \ (975) \, \text{GeV} \)
Summary

➢ Very good performance for the LHC in 2011.
➢ ATLAS data taking has been very efficient, recording up to 1.3 fb⁻¹.
➢ ATLAS Exotics searches for New Physics showed no significant excess beyond the Standard Model predictions.
➢ Most of the observed limits are already beyond Tevatron results, and some of them are world best records.
Backup slides
A Toroidal LHC Apparatus

**Inner Detector:**
- $|\eta| < 2.5$
- $\sigma/pT \sim 3.8 \times 10^{-4}$ $pT(\text{GeV}) \oplus 0.015$
- Precise tracking and vertexing

**Muon Spectrometer**
- $|\eta| < 2.7$
- $pT$ resolution $< 10\%$
- $E_\mu$ up to 1 TeV

**EM calorimeter:**
- $|\eta| < 3.2$
- Resolution $\sigma/E \sim 10\%/\sqrt{E}$

**HAD calorimeter**
- $|\eta| < 5$
- Central: $\sigma/E \sim 50\%/\sqrt{E} \oplus 0.03$
- Forward: $\sigma/E \sim 90\%/\sqrt{E} \oplus 0.07$

Length: 46m  
Diameter: 24m  
Weight: 7000 tons
LHC and ATLAS Operations

- Good performance in 2010
  (45 pb$^{-1}$ recorded)
- Remarkable increase of LHC performance in 2011; 1.3 fb$^{-1}$ delivered up to now
- Good data taking efficiency in ATLAS
- New results with ~1fb$^{-1}$

### Inner Tracking Detectors

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<th>Pixel</th>
<th>SCT</th>
<th>TRT</th>
<th>LAr</th>
<th>LAr</th>
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<td>99.8</td>
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<td>99.0</td>
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Luminosity weighted relative detector uptime and good quality data delivery during 2011 stable beams in pp collisions at $\sqrt{s}=7$ TeV between March 13$^{th}$ and June 29$^{th}$ (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.
Diphoton with Large Missing Et

Physics Model:
- GMSB with $\tilde{G}$ LSP ($\tilde{X}^0_1 \rightarrow \gamma \tilde{G}$)
- UED ($\gamma^* \rightarrow \gamma + G$)

- Observable
  - Diphoton invariant mass

- Event Selection
  - Two photons, $E_T > 30(20)$ GeV
  - Missing $E_T > 125$ GeV

- Background
  - Fake photons from QCD, $\gamma + \text{jet}$
  - $W + X$ and $t\bar{t}$ (electron and jet faking photons)

- No candidate events survive the selection

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Diphoton plus large missing \( E_T \)

No evidence for new physics signal found

Observed (Expected) 95\% C.L. Limits (2010 data)

UED: \( \frac{1}{R} > 961 \) (961) GeV

GMSB gluino: \( M > 560 \) (560) GeV
Dijet+lepton+MET final states

Physics Models: ??

- Observable
  - Dijet invariant mass

- Event Selection
  - Two jets with one lepton (e,μ) and MET

- Main backgrounds
  - EW background (W+jets)
  - Diboson (WW,WZ)
No significant excess beyond the SM expectation is observed.
Extra Spatial Dimensions

➢ Alternative to solve the hierarchy problem
➢ Extra spatial dimensions explain the apparent weakness of Gravity (relevant scale ~1 TeV)