Searches for heavy resonances and new particles at ATLAS

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Why are we looking for Physics beyond the SM?²

The Standard Model of Particle Physics is a very successful theory, but cannot be the end of the story...

For example, it does not

- have a dark matter candidate**
- explain, why gravity is so weak compared to the other fundamental forces**

Also: Before we find the Higgs, we cannot be sure of how electroweak symmetry is broken

Final states (in this talk)

- two leptons
- two photons
- two jets
- two gauge bosons

Example models:

- Z'/W' bosons
- RS graviton
- Technicolor
- Excited quarks
- Color octet scalars

Advantages of signature searches:

- same final state can probe various models
- new physics can be found independently of exact model

SPOILER: No significant excess found in any of the shown analyses ---> 95% C.L. limits are set on a variety of models

Search for resonances in dilepton final states

4

Dilepton resonances could be a signature of

- new heavy gauge boson in the E6 model (Grand Unified Theory model)

$$E_6 \rightarrow SO(10) \times U(1) \rightarrow SU(5) \times U(1)_\chi \times U(1)_\psi$$
$$Z'(E_6) = Z'_\psi \cos(\theta_{E6}) + Z'_\chi \sin(\theta_{E6})$$

- Randall Sundrum graviton

1 warped extra dimension

Kaluza-Klein tower of massive graviton states

$k/\overline{M_{\text{Pl}}} = 1.0-0.01$

- technivector mesons in one of the Technicolor models

Low Scale Technicolor model (Lane, Eichten)

QCD-like spectrum

Benchmark model: Sequential Standard Model Z' (same couplings as Z boson), not theoretically motivated

Dileptons: Event selection

6

$\sim 5 \text{ fb}^{-1}$

Electrons

- shower shape, hadronic leakage, tracking quality
- leading electron isolated

Muons

- Inner Detector and Muon Spectrometer quality cuts
- impact parameter and distance from primary vertex
- opposite sign

	Electrons	Muons
Acceptance (2 TeV Z')	$\sim 70\%$	$\sim 45\%$
Resolution (object with $p_T = 1 \text{ TeV}$)	1-2%	10-25%

Dileptons: Limits

7

~5 fb⁻¹

Spin 1: new gauge boson Z'
(Sequential Standard Model
or E6 GUT)

Spin 2: RS gravitons
(different width, acceptance)

95% C.L. lower mass limits on reference models:

	Observed dilepton limit [TeV]
Sequential Standard Model Z'	2.21
RS graviton ($k/\bar{M}_{Pl} = 0.1$)	2.16

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**Low Scale technicolor
interpretation of CDF Wjj
excess
(Phys. Rev. Lett. 106 (2011) 171801)**

95% C.L. limits on reference model:

	Observed dilepton limit [TeV]
ρ_T/ω_T ($m(\rho_T/\omega_T) - m(\pi_T) = 100 \text{ GeV}$)	0.47

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RS graviton:

- diphoton branching fraction $\sim$ twice dielectron/dimuon
- limits ($k/\bar{M}_{\text{Pl}} = 0.1$) [TeV]: 1.85 (diphoton), 1.95 (diphoton+dilepton)

Searches in dijet final states

10

Resonances

- Excited quarks
 - possible if quarks are composite
- Color octet scalars
 - colored resonance decaying into two gluons

Deviation in mass spectrum/angular distributions

- Quantum black holes
 - extra dimensions (M_{Pl} reduces to M_D)
 - assume classical relativity for production
- Quark contact interaction
 - quark compositeness (visible above compositeness scale Λ)
 - interference with QCD (here: destructive)

Scale at which gravity becomes strong

- events with at least two jets (anti k_T , $R = 0.6$)
- $|y| < 2.8$, $p_T > 80 \text{ GeV}$
- $|y^*|$ in center of mass system must be small (jets from new physics are expected to be more isotropic than SM dijet production)
- fit dijet mass spectrum with a function to estimate SM background
- check fit quality and search for peak-like excesses
- also search in angular distributions

95% C.L. limits on reference models:

	Limit on	Observed limit [TeV]
Excited quarks q^*	mass	3.35
Color octet scalars s_8	mass	1.94
Mini Quantum Black Holes ($n = 6$)	Gravity scale	4.11
Quark contact interaction	Compositeness scale	7.8

Search for resonances in diboson final states

14

2 channels

(inv. masses of pairs close to Z mass)

IIII: 2 pairs of isolated electrons/muons

IIjj: exactly two isolated

electrons/muons, jet pair (anti kT, R = 0.4)

- RS graviton ($k/\bar{M}_{\text{Pl}} = 0.1$)

excluded for 325-845 GeV

- also limit on fiducial

cross section set for any new ZZ

physics (IIII)

Submitted to PLB

arXiv:1203.0718

- Z $\rightarrow$ ee, $\mu\mu$ and W $\rightarrow$ νe , $\nu\mu$
- > two oppositely charged,
same flavor leptons,
exactly one additional lepton, MET

- discriminating variable:

$$m_T^{WZ} = \sqrt{(E_T^Z + E_T^W)^2 - (p_x^Z + p_x^W)^2 - (p_y^Z + p_y^W)^2}$$

Lower mass limit on W'
in extended Gauge Model: 760 GeV

Limits on ρ_T in Low Scale Technicolor
($m(\rho_T) - m(\pi_T) = m(W)$)

- $m(a_T) = 1.1$
excluded $m(\rho_T) < 483 \text{ GeV}$
- $m(a_T) \gg m(\rho_T)$
excluded $m(\rho_T) < 469 \text{ GeV}$

Submitted to PRD
arXiv:1204:1648

**Presented results of resonance searches at ATLAS
in a variety of final states**

- no new physics found so far**
- extended exclusion ranges for many models**

Looking forward to 2012 results!

- resonance searches
benefit directly from
higher CM energy**

Simulated black hole event superimposed over
image of ATLAS detector

Limits on ρ_T in Low Scale Technicolor Model

- depend on $m(\pi_T)$ and $m(a_T)$,
and π_T mixing with EW gauge bosons
- assume $\sin(\chi) = 1/3$
- consider two scenarios: $m(a_T) = 1.1 m(\rho_T)$, $m(a_T) \gg m(\rho_T)$
- signal template modeled without spin correlations
---> affects acceptance, use W' acceptance as check

- depends on the achieved acceptance