ATLAS tt̄ resonance searches
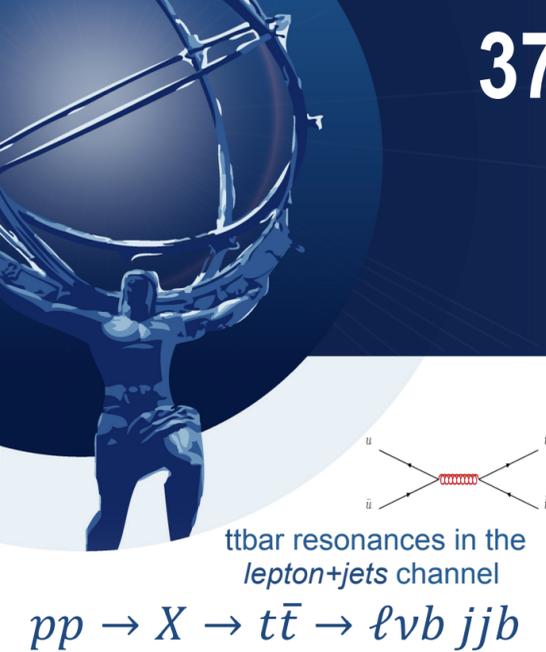
ttbar resonances in the *lepton+jets* channel

$$pp \rightarrow X \rightarrow t\bar{t} \rightarrow \ell\nu b\, jjb$$

Benchmark models

Models that produce the signature of high-mass ttbar system clustered about a particular mass are:

- Topcolor-assisted technicolor (TC2): produces a top-philic **Z'**-like particle → quantifies sensitivity to narrow resonances (relative to detector resolution).
- Randall-Sundrum warped extra-dimension: results in a Kaluza-Klein gluon (**g_KK**). → used as proxy for wide.

Data & MC Samples

Data:
- 14fb⁻¹ of ATLAS 2012 data @8TeV.
- Trigger on a single lepton+jets topologies.

SM expectation based on the following processes:
- ttbar.
- W+jet
- Z+jets
- Single top
- Diboson
- Multi-jet production estimated with data-drive methods

Data & expected background

Data and expected background event yields after the *resolved* and *boosted* selections ± normalization uncertainty.

Type	Resolved	Boosted
$t\bar{t}$	211000 ± 33000	4900 ± 1100
Single top	15200 ± 1900	176 ± 34
Multi-jet	14000 ± 6000	71 ± 25
W+jets	39000 ± 10000	480 ± 140
Z+jets	3600 ± 800	52 ± 15
Di-bosons	550 ± 100	3.5 ± 1.8
Total	283000 ± 39000	5600 ± 1200
Data	280251	5122

Systematic uncertainties

Impact of the various systematic effects on the total MC background (shift given in % of the nominal value):

- The effect on the Jet Energy Scale and the ttbar normalization are the largest.

Systematic Uncertainties	Resolved selection yield impact [%] total bkg.	[%] Z'	Boosted selection yield impact [%] total bkg.	[%] Z'
Luminosity	2.9	4	3.3	4
PDF	2.9	5	6	2.9
ISR/FSR	0.2	–	0.7	–
Parton shower and fragm.	5	–	4	–
$t\bar{t}$ normalization	8	–	9	–
$t\bar{t}$ EW virtual correction	2.2	–	4	–
$t\bar{t}$ Generator	1.5	–	1.6	–
W+jets $b\bar{b}+c\bar{c}+c$ vs. light	0.8	–	1.0	–
W+jets $b\bar{b}$ variation	0.2	–	0.4	–
W+jets c variation	1.1	–	0.6	–
W+jets normalization	2.1	–	1.0	–
Multi-Jet norm, e+jets	0.6	–	0.3	–
Multi-Jet norm, μ+jets	1.8	–	0.3	–
JES, small-radius jets	6	2.2	0.7	0.5
JES+JMS, large-radius jets	0.3	4	17	3.3
Jet energy resolution	1.6	0.4	0.6	0.7
Jet vertex fraction	1.7	2.3	2.1	2.4
b-tag efficiency	4	1.8	3.4	6
c-tag efficiency	1.4	0.3	0.7	0.9
Mistag rate	0.7	0.3	0.7	0.1
Electron efficiency	1.0	1.1	1.0	1.0
Muon efficiency	1.5	1.5	1.6	1.6
All systematic uncertainties	14	9	22	9

Motivation & Introduction

- The top quark mass is close to the electroweak symmetry breaking (EWSB) scale; an indication of a special role in BSM physics.
- Several new physics scenarios give rise to **heavy particles** that couple strongly to **ttbar pairs**.

- A search for new particles that decay into ttbar pairs is performed with the ATLAS experiment at the LHC using an integrated luminosity of **14fb⁻¹** of pp collision data collected at √**s=8TeV**.
- The analysis is designed to deal both with *boosted* and *resolved* topologies in two channels (*el* and *mu*).
  - *Boosted* configuration: the top decay products overlap in the detector.
  - *Resolved* configuration: the top decay products are all well separated in the detector.
- Backgrounds are estimated using a mixture of **MC** and **data-driven** methods.

- The mass of the ttbar candidate system is reconstructed and searched for a local excess or deficit. If no significant deviation → limits are set on **CrossSection x BR**

Boosted Event

Resolved Event
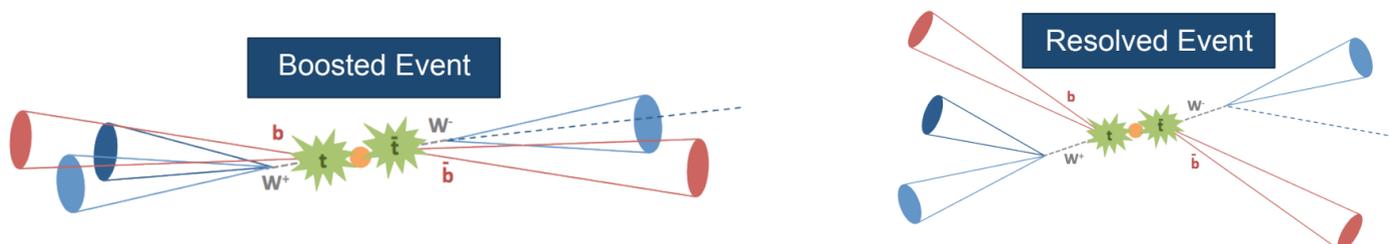
Event selection: 4 different categories of events

1. (data) Use data run with all subsystems operational.
2. Pass the trigger (electron, muon or fat-jet).
3. Primary vertex has >4 tracks with p_T>400MeV
4. Exactly one electron or one muon.
5. The offline lepton must match trigger candidate.
6. No bad small-R jets.
7. E_T^{miss}>20GeV
8. E_T^{miss}+m_T>60GeV

Resolved
9. At least four small-R jets satisfying p_T>25GeV; |η|<2.5; JVF>0.5;
10. An event which fails step 9 is selected if it contains three small-R jets with one m_{jet}>60GeV.
11. At least one small-R jet b-tagged.
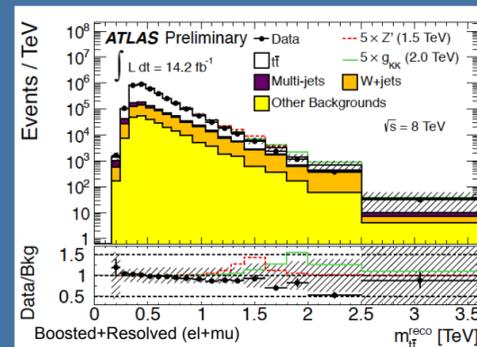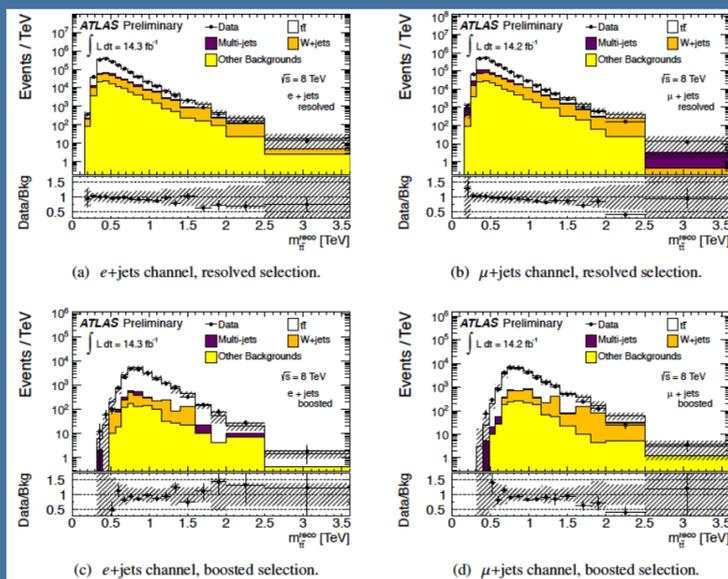
$$\Delta R = \sqrt{\Delta\eta^2 + \Delta\phi^2}$$

Boosted
9. At least one small-R jet with ΔR(ℓ,j)<1.5
10. At least one large-R jet with p_T>300GeV; |η|<2.0; m_{jet}>100GeV; √d_{12}>40GeV; ΔR(j, j_sel)>1.5; Δφ(j,ℓ)>2.3
11. At least one small-R jet b-tagged.

$$\chi^2 = \left[\frac{m_{jj}-m_W}{\sigma_W}\right]^2 + \left[\frac{m_{jjb}-m_{jj}-m_{th-W}}{\sigma_{th-W}}\right]^2 + \left[\frac{m_{j\ell\nu}-m_{tl}}{\sigma_{t\ell}}\right]^2 + \left[\frac{(p_{T,jjb}-p_{T,j\ell\nu})-(p_{T,th}-p_{T,t\ell})}{\sigma_{diff\,pT}}\right]^2$$

large-R jets
R=1.0
akt10

small-R jets
R=0.4
akt4

After the data event selection…
280,251 passed the Resolved selection
**5,122 passed the Boosted selection**

Results

After the reconstruction of the ttbar mass spectrum, the data is compared to the SM expectation. We search for hints of new physics in the form of bumps or dips in the spectrum.

No significant deviation from the SM is found!

(a) e+jets channel, resolved selection.

(b) μ+jets channel, resolved selection.

(c) e+jets channel, boosted selection.

(d) μ+jets channel, boosted selection.

Expected and observed upper cross section limits times the ttbar BR on: (a) Z' bosons, (b) Kaluza Klein gluons considering systematic and statistical uncertainties.

(a) Z' upper cross section limits.

(b) g_{KK} upper cross section limits.
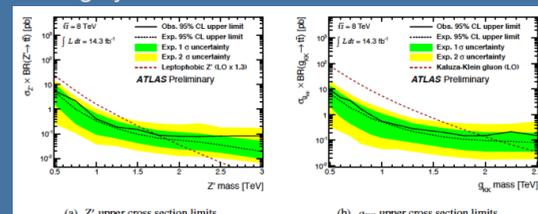
Summary & Conclusion

- A search has been performed for production of a new particle decaying to ttbar.
- Limits on the possible CrossSection X BR have been determined. These limits translate to observed bounds on the allowed mass of the new particle in the benchmark scenarios of **0.5 TeV < m(Z') < 1.8 TeV** and **0.5 TeV < m(g_KK)< 2.0 TeV**, both ranges excluded at 95% CL.
- No significant deviation from the SM is found.

Victoria Sánchez Martínez, for the ATLAS Collaboration   victoria.sanchez.martinez@cern.ch