LHCC Poster Session - CERN, 5 March 2014

A Search for Resonant Higgs-Pair Production in the $b\bar{b}b\bar{b}$ Final State with ATLAS

Introduction

- Searching for TeV-scale resonances that decay via two SM Higgs to 4 b-jets

$$X \rightarrow HH \rightarrow b\bar{b}b\bar{b}$$

- This final state is promising for higher mass resonance searches due to:
  - Large expected branching ratio of $H \rightarrow b\bar{b}$
  - High p_T with which the b-quarks are produced
- Backgrounds: multijet events (90%) and $t\bar{t}$ events (10%)

Event Selection

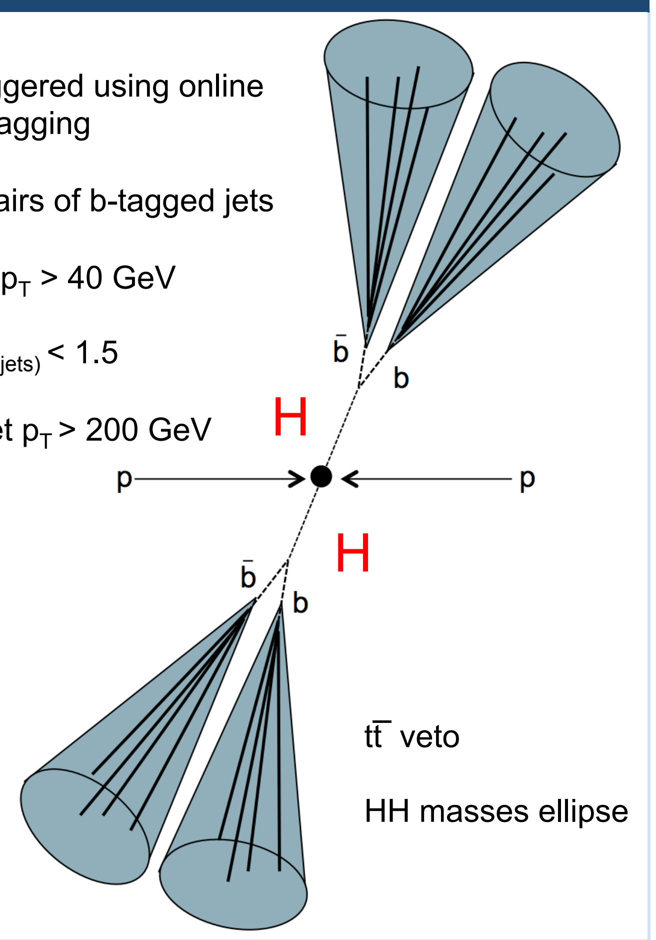
Triggered using online b-tagging

2 pairs of b-tagged jets

Jet p_T > 40 GeV

$\Delta R_{(jets)}$ < 1.5

Dijet p_T > 200 GeV



$t\bar{t}$ veto:
Applied to events with an extra jet close to a dijet

$$X_{tt} = \sqrt{\left(\frac{m_W - 80.4}{0.1 m_W}\right)^2 + \left(\frac{m_t - 172.5}{0.1 m_t}\right)^2} > 3.2$$

m_W is the mass of the extra jet and the jet in the dijet with the lowest probability of being a b-jet
m_t is the mass of the dijet + extra jet

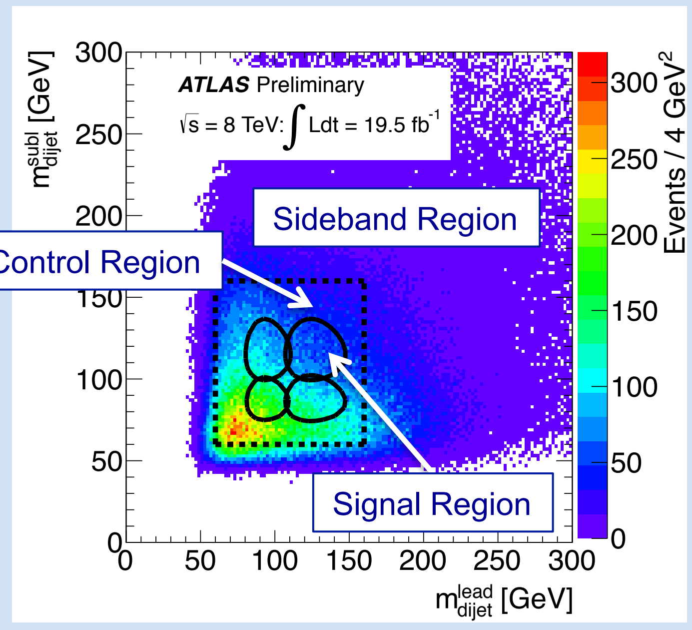
HH Masses ellipse:

$$X_{HH} = \sqrt{\left(\frac{m_1 - 124}{0.1 m_1}\right)^2 + \left(\frac{m_2 - 115}{0.1 m_2}\right)^2} < 1.6$$

$m_{1(2)}$ is the leading (sub-leading) dijet

Multijet Background

- The multijet background is modelled using data that pass a modified "2-tag" selection
- The 2-tag sample is 98% multijet events
- This is the same selection as in the signal region except only one of the dijets has to be b-tagged
- Regions in the dijet mass plane are defined to normalise, reweight, and test this model
- The Control Region is used for testing the m_{4j} shape and estimating the uncertainty on the multijet background in the signal region



Kinematic Reweighting

- The data sample in the Sideband Region was used to reweight the kinematics of the multijet background prediction
- This was done to remove biases introduced from the loosened b-tagging requirements

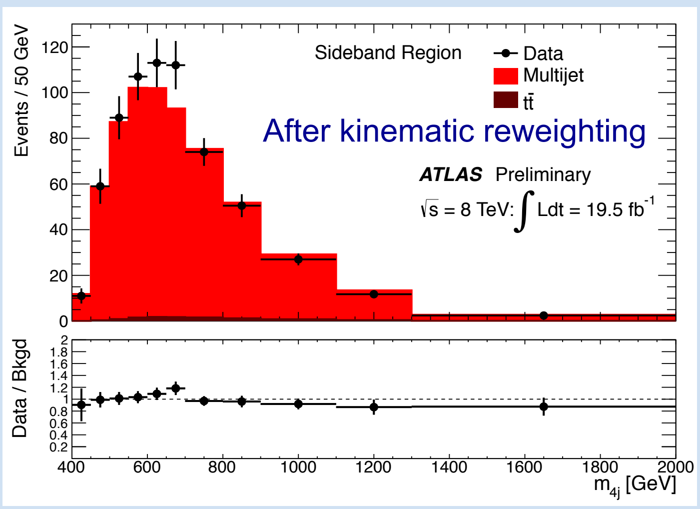
Normalisation

- The Sideband Region of the data sample is 97% pure in multijet events so it can be used for the normalisation
- The event yield in the 2-tag sample is scaled using $\mu_{multijet}$:

$$\mu_{multijet} = \frac{N^{Sideband}_{4tag} - N^{Sideband}_{tt,4tag} - N^{Sideband}_{Z+j,4tag}}{N^{Sideband}_{2tag}}$$

Where N_{sample} is the number of events in the sideband region of that sample, "4-tag" refers to the usual event selection of 4 b-tagged jets

- From this scaling of the multijet prediction, in the Sideband Region the total number of background events exactly equals the number of events in the data sample



Signal Model

- The baseline signal model used is a first Kaluza Klein excitation of the graviton (G*) in a Randall-Sundrum model, with $k/\overline{M}_{pl} = 1.0$
- The RS model features a warped extra dimension
- The G* decays to a pair of Higgs bosons with a branching fraction of ~7%
- 11 MC samples spaced 100 GeV apart from 500 GeV – 1.5 TeV were used

$t\bar{t}$ Background

Normalisation

- "$t\bar{t}$ Control Region" defined as data which pass the 4-tag selection but either one or both dijets fail the $t\bar{t}$ veto
- Multijet contribution in this region is modelled by a 2-tag sample that also fails the $t\bar{t}$ veto, scaled by $\mu_{multijet}$
- The yield in the tt-bar Signal Region is extrapolated from:

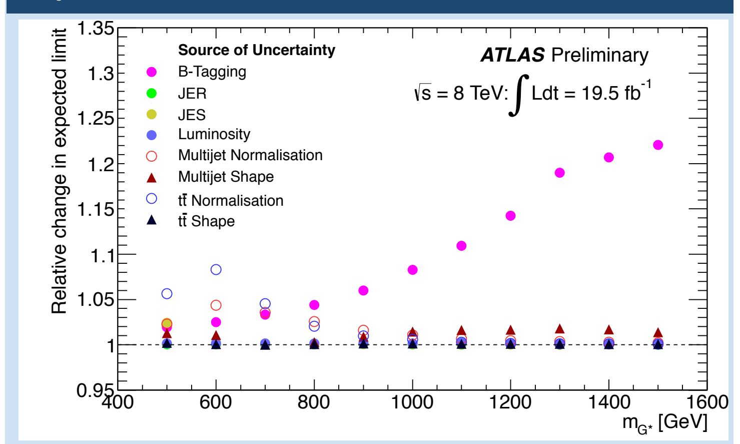
$$N^{Bkg}_{t\bar{t}} = \frac{\varepsilon^2_{t\bar{t}}}{1 - \varepsilon^2_{t\bar{t}}} \times N^{CR}_{t\bar{t}}$$

Where ε_{tt} is the efficiency for a dijet in tt-bar event to pass the $t\bar{t}$ veto, measured from a "lepton+jets $t\bar{t}$" data sample.

M_{4j} Shape

- Derived from MC simulation using the "2-tag" selection
- Systematic uncertainty is derived by comparing the 2-tag and 4-tag m_{4j} distributions in MC

Systematic Uncertainties

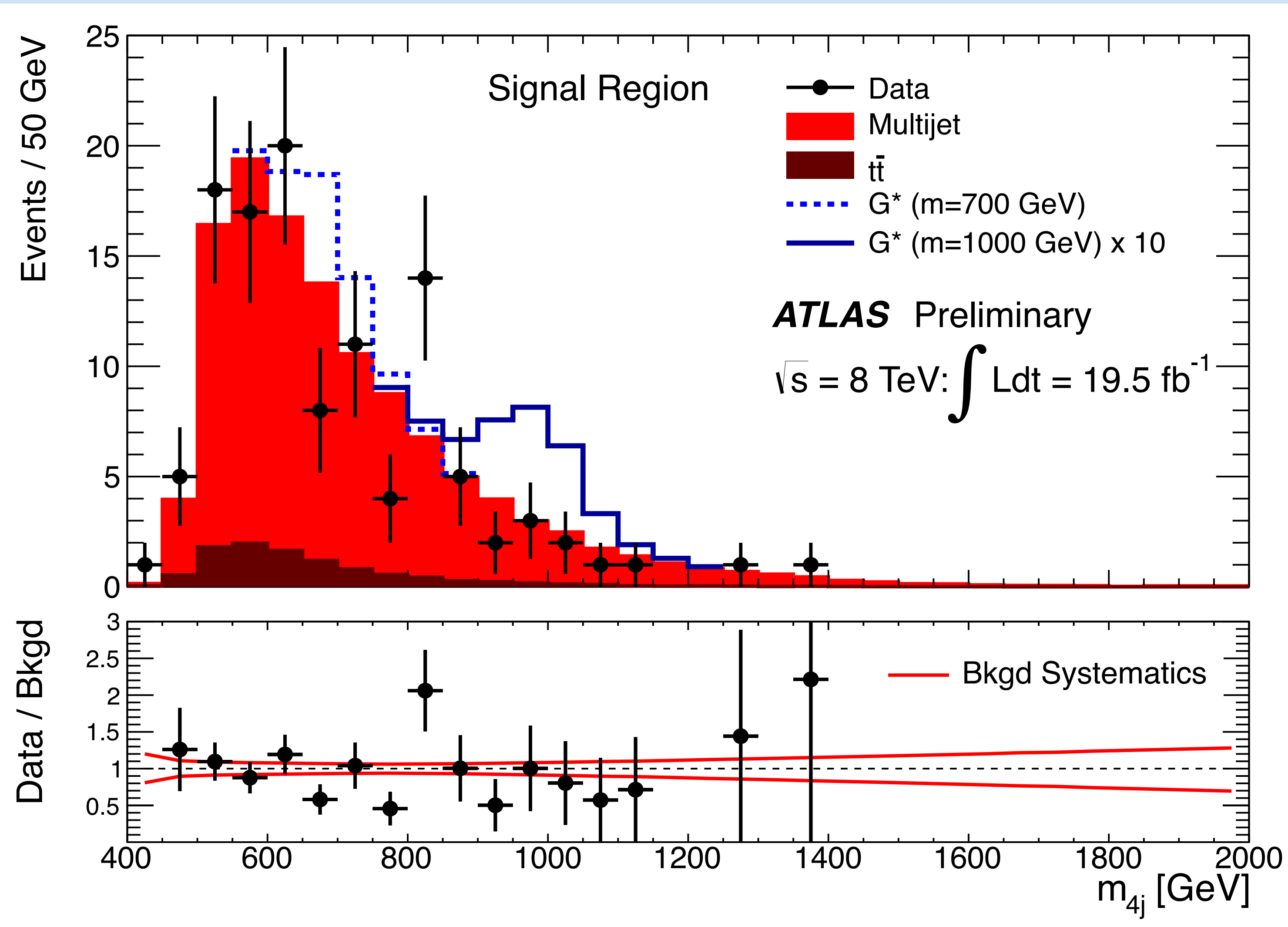


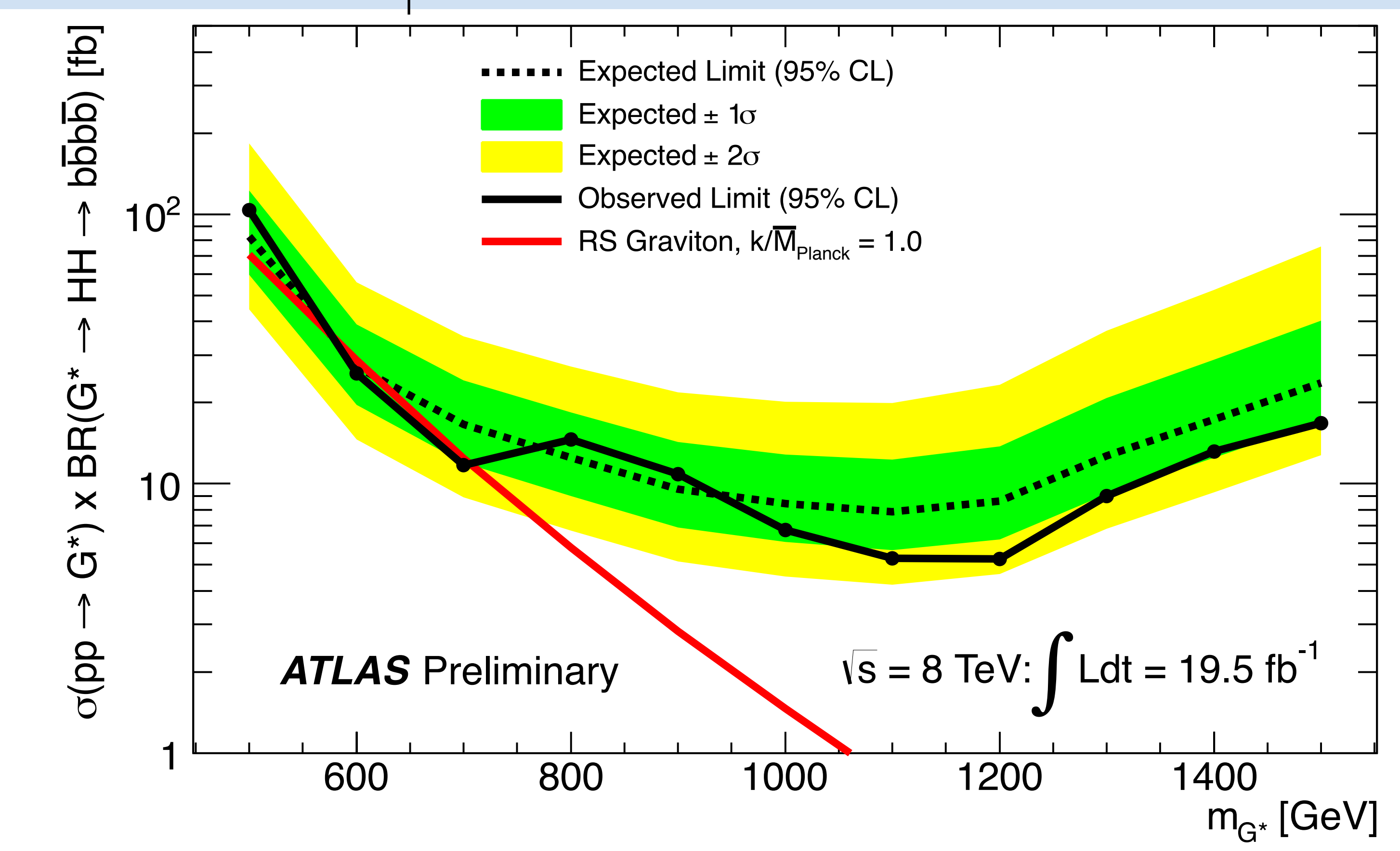
Results

The data are compatible with the background only hypothesis
The model is excluded for m_{G^*} between 590 GeV and 710 GeV

Sample	Signal Region
Multijet	109 ± 5
$t\bar{t}$	10 ± 6
Z + jets	0.7 ± 0.2
Total Background	120 ± 8
Data	114

For local p_0, maximum significance of 1σ at m_{G^*} = 500 GeV and m_{G^*} = 800 GeV





Conclusions

- Searching for TeV-scale resonances that decay via two SM-like Higgs to four b-jets, $X \rightarrow HH \rightarrow b\bar{b}b\bar{b}$, in the mass range 500 GeV – 1.5 TeV
- Used spin-2 KK graviton decaying this way in the bulk RS model, with $k/\overline{M}_{pl} = 1.0$ as benchmark signal model
- The observed data is compatible with the background only hypothesis
- The model is excluded for m_G* between 590 GeV and 710 GeV

For more information, see the conference note:

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ATLAS EXPERIMENT