Search for resonant top-antitop production in lepton+jet channel

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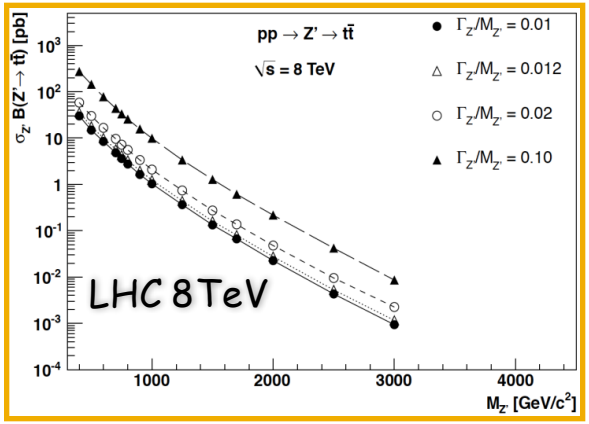
New Physics at top sector...

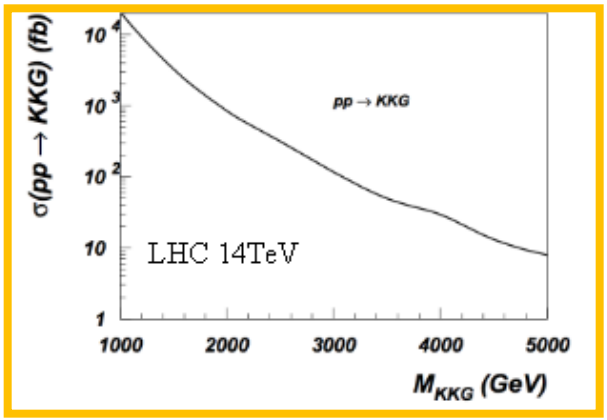
- Top quark provides various handles on new physics
  - Many are covered by precisely measuring top quark, others require dedicated studies
- After the discovery of a particle consistent with a 126 GeV Higgs boson, the hierarchy problem remains a puzzling question
- With a mass close to EWSB scale top may be a privileged probe to study the emergence of new physics at TeV scale

Numerous Beyond the Standard Model (SM) theories predict New phenomena at the TeV scale that are accessible at the LHC

arXiv:1112.4928



arXiv:hep-ph/0612015

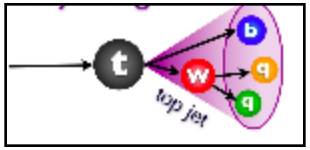


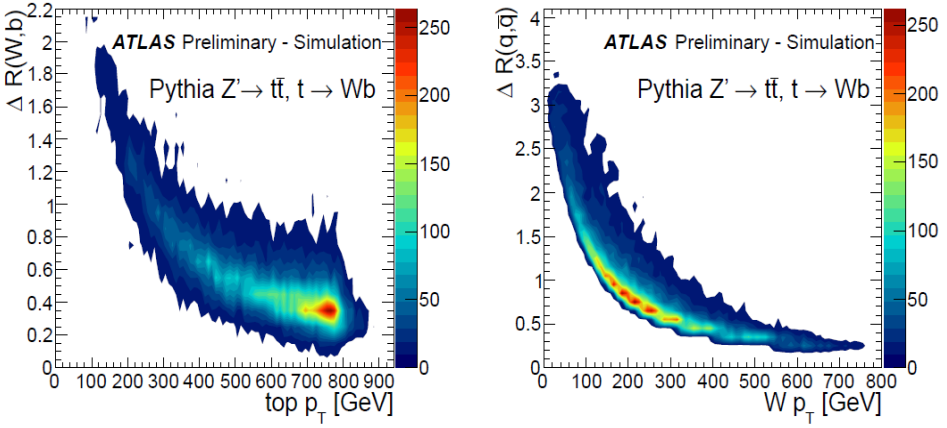
Focus on this talk

- Present search for ttbar resonances on smooth SM backgrounds
  - Heavy bosons decaying into ttbar pair in the lepton + jets channel
- **Benchmark models is used to interprete the results:**
  - **Topcolor models**
  - **Randall-Sundrum models KK graviton**
    - KK gluon: validation at generation level on-going
  - **Scalar/Pseudoscalar from 2HDMmodel**
    - Problem is that interference with SM $gg \rightarrow tt$ is huge (signal is non-resonant) and it is prohibitive to generate the full grid of signal points
    - Solution is to reweight of SMtt at parton level analytically using Madgraph
- **Search strategy:**
  - Setup model-independent analyses
  - Interpret results using benchmarks

ttbar resonances & boosted object

- With the increase of energy and luminosity at the LHC, decay of heavy resonances associated with new physics is in the multi-TeV mass range
- Result in highly boosted very massive objects such as Top
  - Decay products of Boosted Tops collimated in direction of pT
  - Separation can be described according to $\Delta R \sim m/pT$





(a) $t \to Wb$ ATLAS-CONF-2012-065 (b) $W \to q\bar{q}$

Standard reconstruction methods are no longer sufficient for boosted top quarks

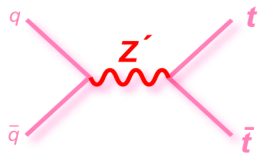
Many new techniques are developed to reconstruct and identify boosted tops

- Jet substructure → **fatjet**
- Less-isolated leptons

ttbar resonances: Analysis strategy

Benchmark models to quantify sensitivity:

- Topcolour assisted technicolour leptophobic Z'
  - Narrow resonance (width ~1% of the mass, Spin 1)



- Randall-Sundrum Kaluza-Klein gluons, g_{KK}
  - Broad resonances (width ~10-15% of the mass, Spin 1)
  - Present a challenge for detector resolution

- **Analysis strategy**
- Top quark signature is difficult to reconstruct efficiently → Many objects
  - Adapt the event selection and reconstruction to the final configuration
    - **Event selections:**
      - **Resolved**: standard top reconstruction with narrow jets
      - **Boosted**: using large-cone "fatjet to reconstruct the hadronic top
    - **Event reconstruction:**
      - Combined limit of boosted and resolved selection:
        - Resolved selection mainly relevant at low mtt
        - Boosted selection relevant at high mtt

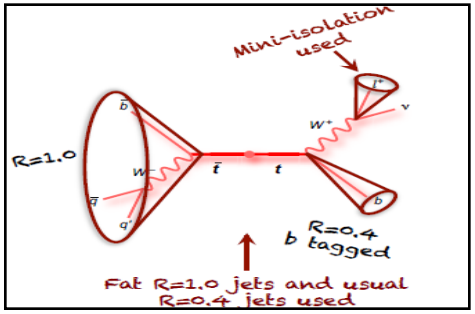
Event selection (1/2)

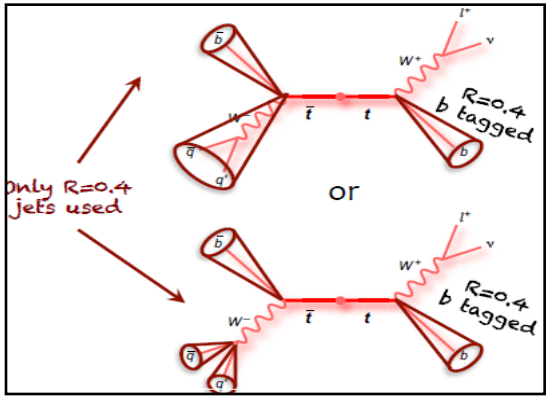
Common selection

- Exactly one isolated lepton with p_T > 25 GeV and MI10/p_T < 0.05
- **e+jet channel**: $E_T$miss > 30 GeV and transverse mass m_T > 30 GeV
- **mu+jet channel**: $E_T$miss > 20 GeV and m_T + $E_T$miss > 60 GeV

The boosted and resolved selections diverge

- Events are placed into either the boosted or resolved selection samples:





Check for boosted selection

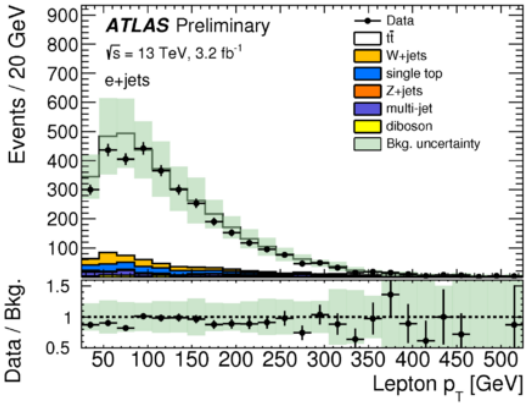
- One small-radius jet, p_T > 25 GeV DR(l,j) < 1.5
- One large-radius jet, p_T > 350 GeV,
- m > 100 GeV and first kt splitting scale
- $\sqrt{d12}$ > 40 GeV, at least one b-jet

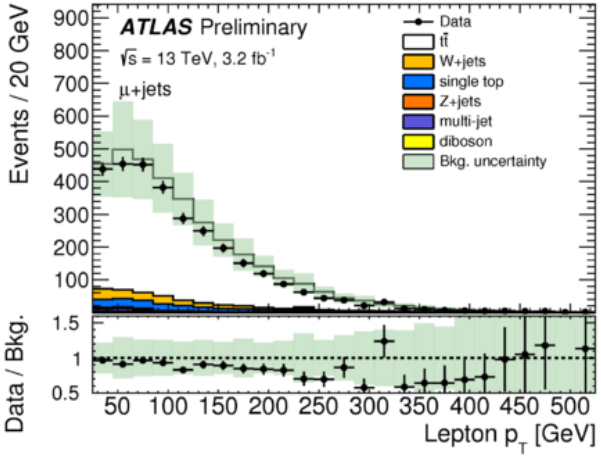
Check for resolved selection

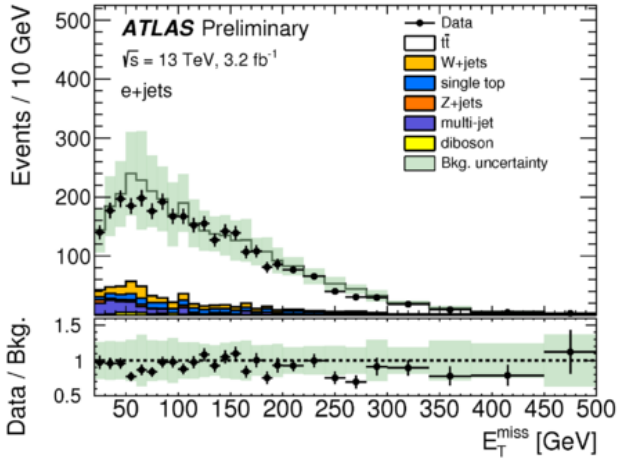
- Four small-radius jets or
- three if one has m > 60 GeV
- At least one small-radius b-tagged jet

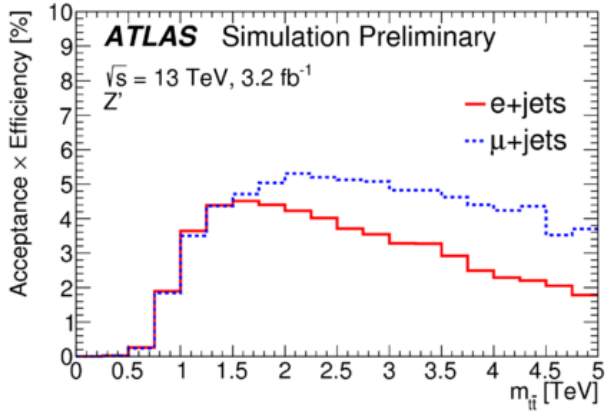
Control plots (only Boosted)

- *Data-MC disagreements covered by systematic uncertainties*









Systematics & Backgrounds

- Experimental sources (objects reconstruction)
  - Jet Energy Resolution (JER), jet recon. efficiency, jet energy scale (JES)
  - Jet mass scale (JMR) and JES for fatjets
  - missing ET resolution
  - uncertainties on the lepton reconstruction
  - b-tagging efficiency & Luminosity
- Theoretical sources +further experimental
  - uncertainties in the background estimates
  - Cross section uncertainties on backgrounds
  - W normalization and heavy flavour modelling
  - QCD normalisation PDF, MC scale uncertainty, parton shower

Main systematic

- PDF (50% for high masses)
- W+jets & SM ttbar normalization
- b-tagging, MC Modeling
- JES/JER for small R-jet
- JES/JMR for large R-jet

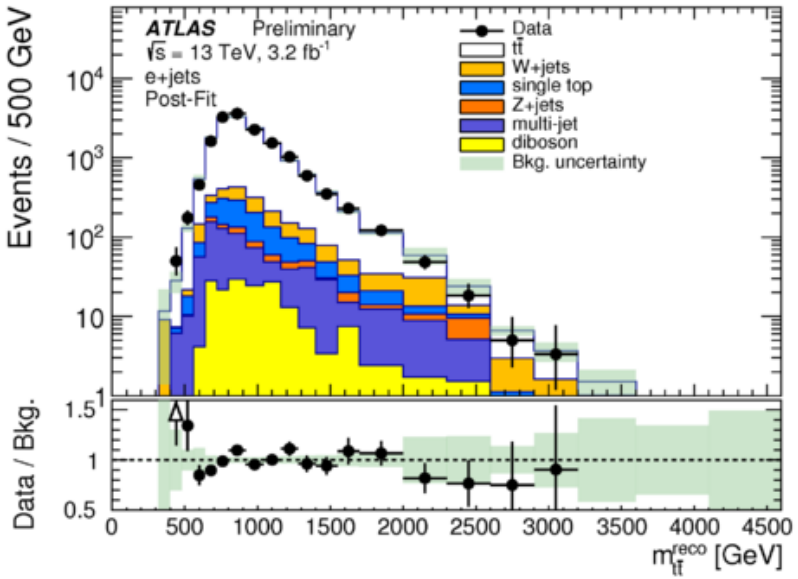
Main Backgrounds

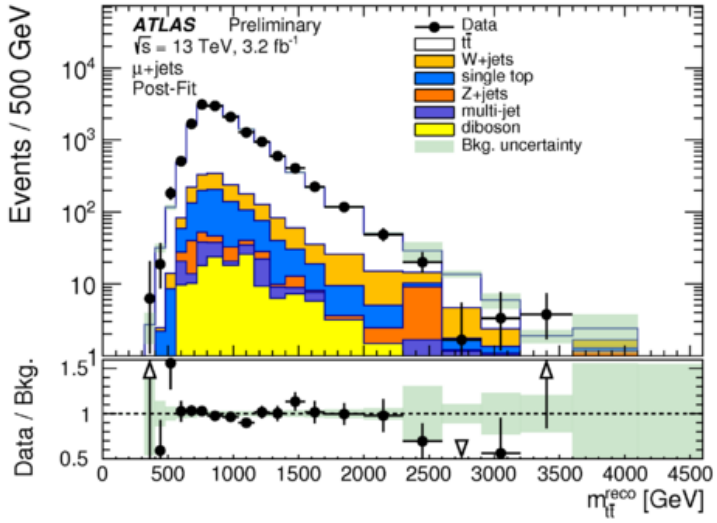
- SM ttbar → largest background estimated using MC@NLO.
- W+jets → use data-driven techniques.
- Multi-jets → small background estimated from data-driven methods.
- **Single top, Z+jets, Diboson** (small backgroubd).

ttbar mass recontruction (boosted regime)

- Discriminate observable: reconstructed ttbar mass (m_{ttbar})
- Longitudinal component pz of neutrino momentum computed by W mass contraint on lepton + E_T system

Boosted scenario: **m_{ttbar} is built from th fatjet, b-jet, lepton and neutrino**





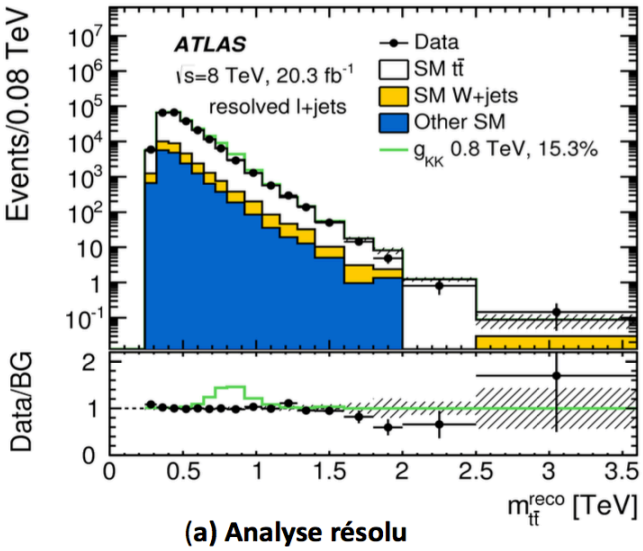
Data consistent with prediction

ttbar mass recontruction (resolved regime)

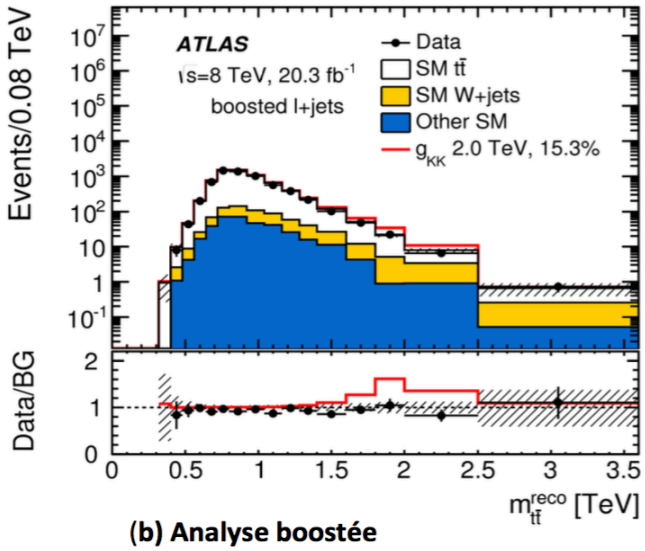
- Resolved scenario: χ^2 sorting method
- select the combination which minimizes the chi2 function and performing the best jet assignment to the top quarks

$$\chi^2 = \left[\frac{m_{jj} - m_W}{\sigma_W}\right]^2 + \left[\frac{m_{jjb} - m_{jj} - m_{t_h - W}}{\sigma_{t_h - W}}\right]^2 + \left[\frac{m_{j\ell\nu} - m_{t_\ell}}{\sigma_{t_\ell}}\right]^2 + \left[\frac{(p_{T,jjb} - p_{T,j\ell\nu}) - (p_{T,t_h} - p_{T,t_\ell})}{\sigma_{\mathrm{diff}\,p_T}}\right]^2$$

W mass; Hadronic top; leptonic top; p_T difference



(a) Analyse résolu

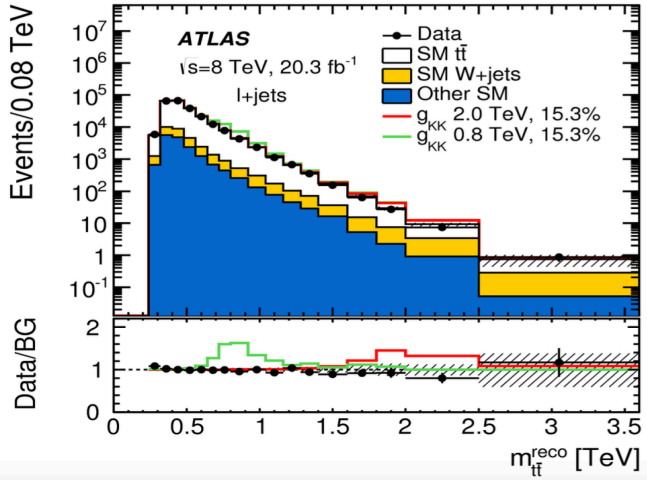


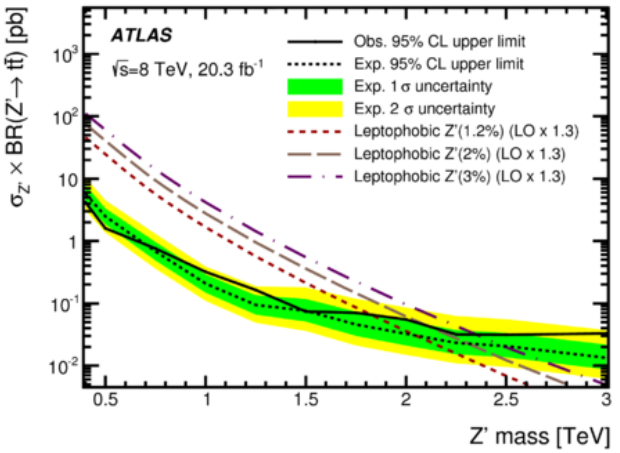
(b) Analyse boostée

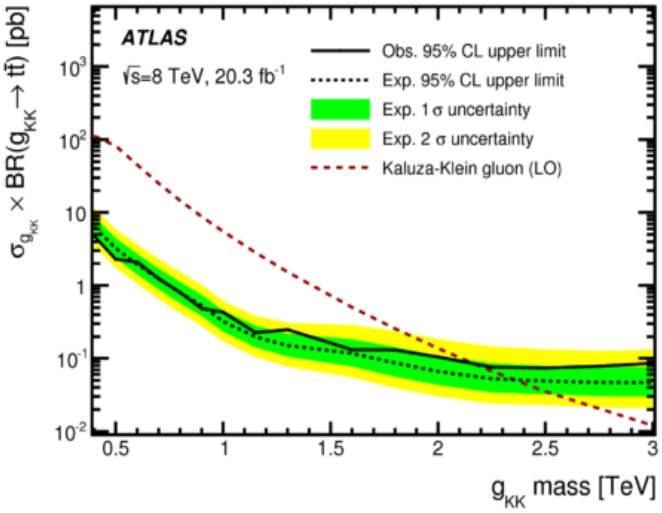
Data consistent with prediction

Results: 20.3fb^{-1}, 8TeV

- Focus on invariant mass spectrum, m_{tt}
- Good Data/Prediction agreement, within systematic uncertainties and statistical errors







- **No significant deviations from the SM**

- **Exlusion @95% CL limit** (Bayesian)
  - **0.4TeV < $m_{Z'}$ < 1.8TeV**
  - **0.4TeV < mg_{KK} < 2.3 TeV**

Summary & outlook

- *No hints of new physics yet!!*
- *Results using boosted regime*

- *combning both resolved and boosted topologies*
- *Goal: paper with full datasets and improved/more complete analysis*

BACKUP