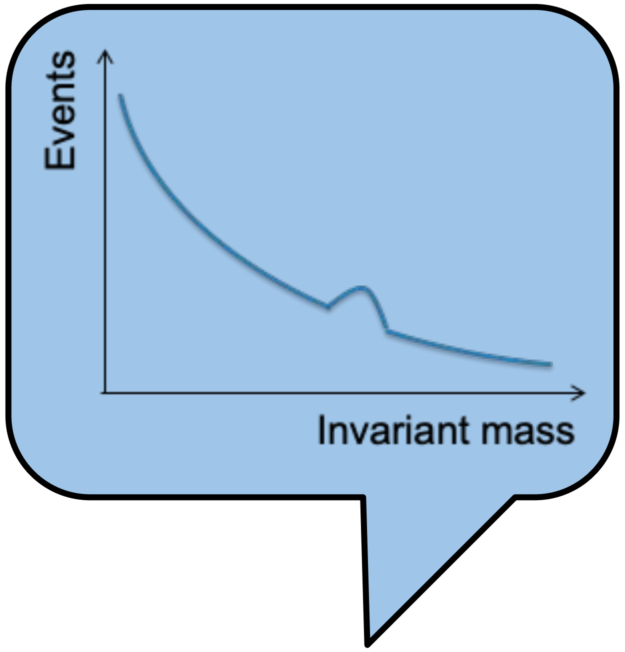
Search for new resonances decaying into ttbar in the hadronic final state with the ATLAS detector

Trine Poulsen

January 3rd 2020



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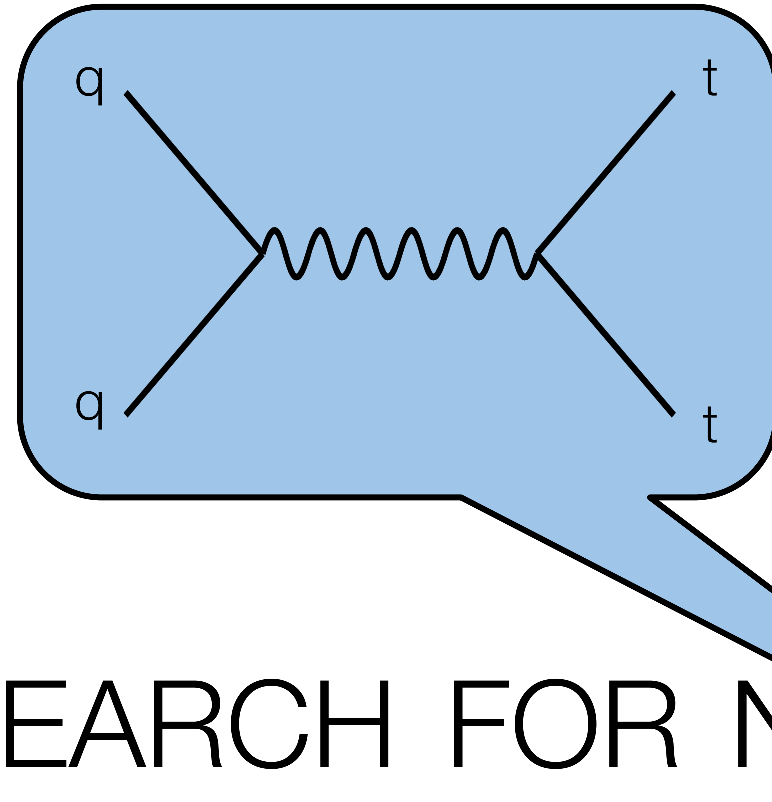

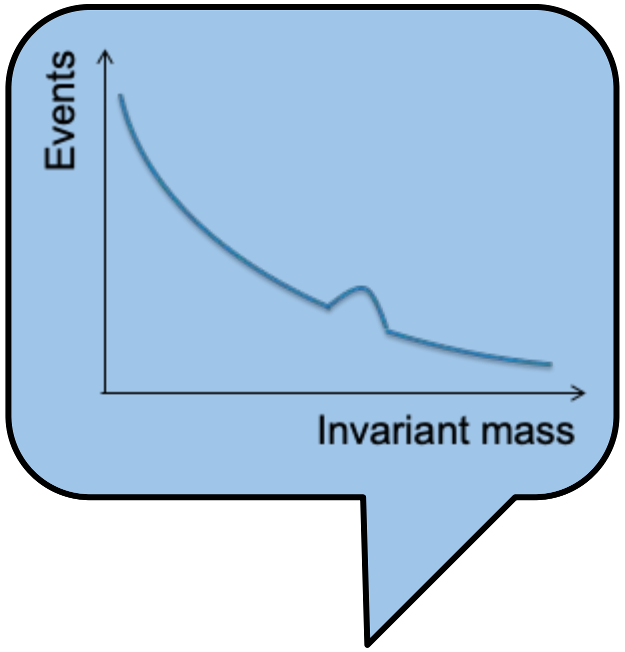

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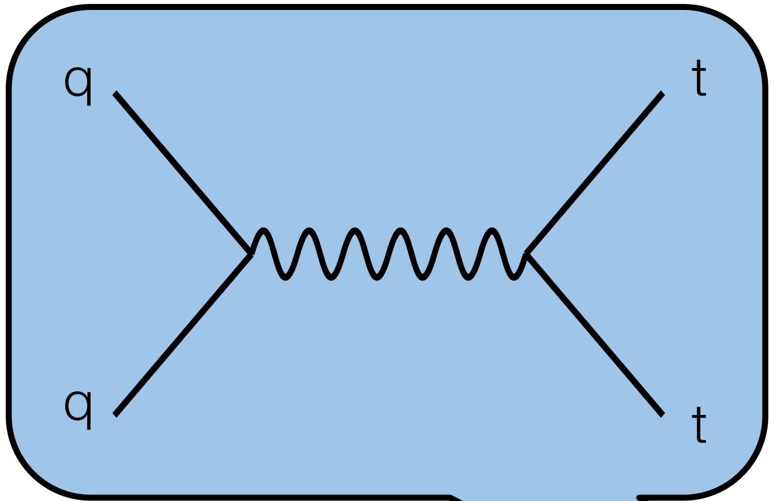

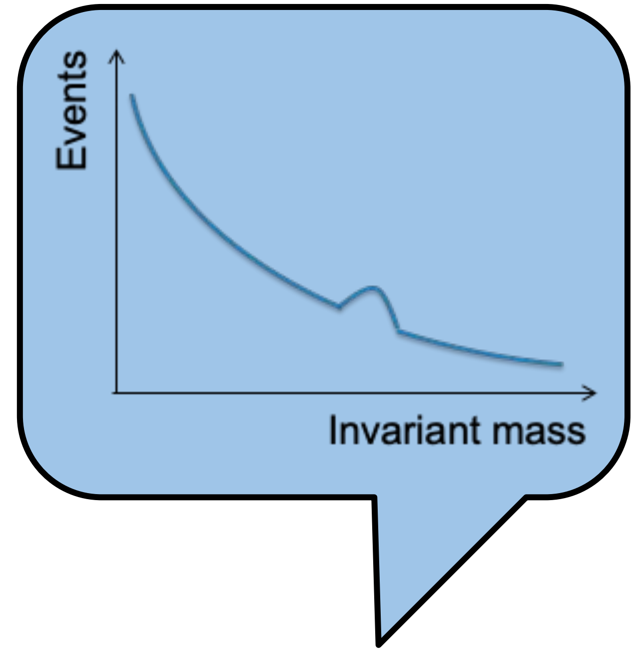

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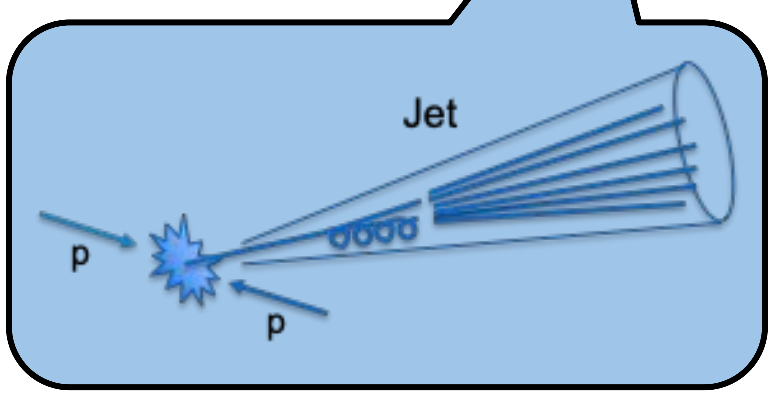

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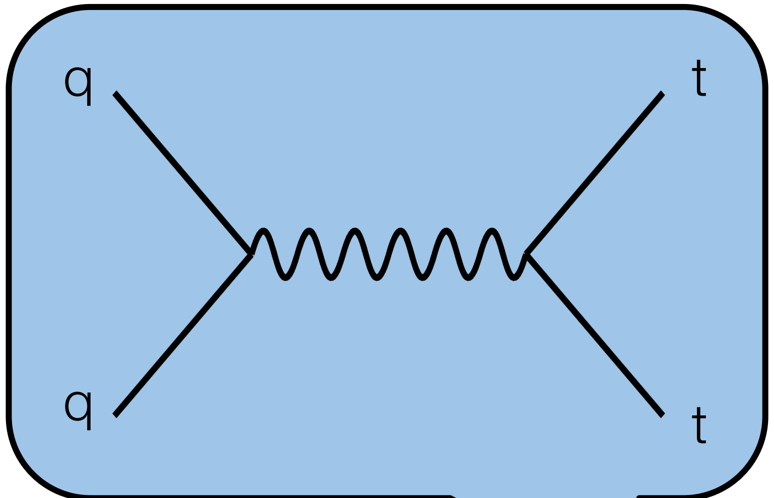

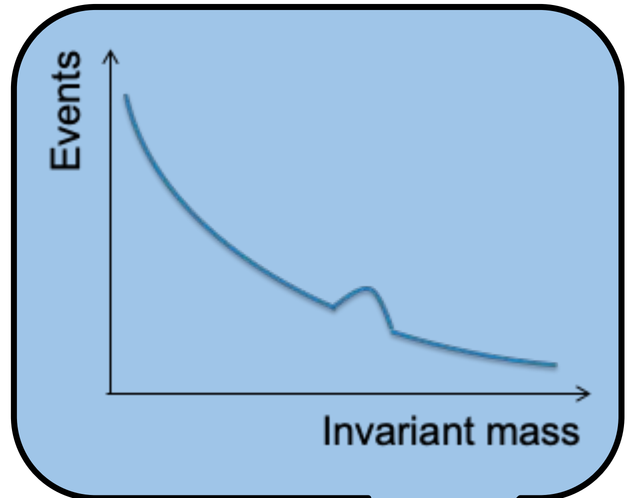

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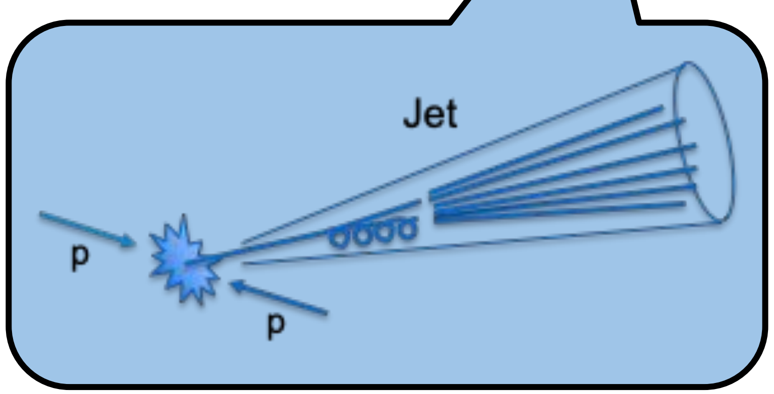

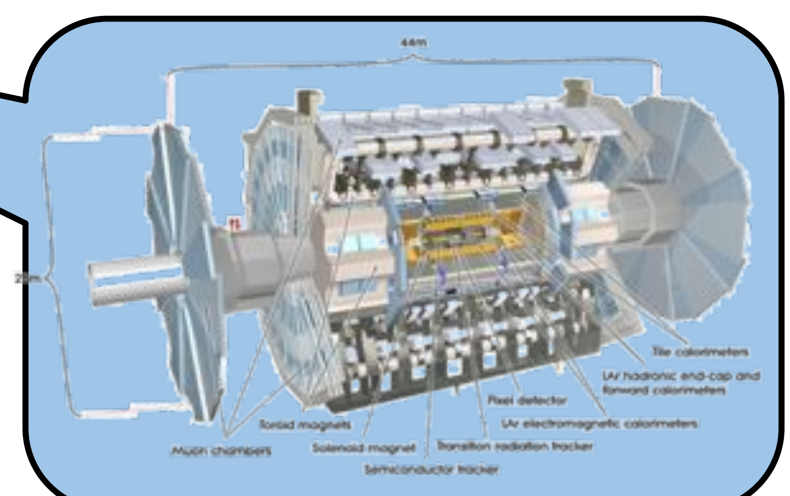

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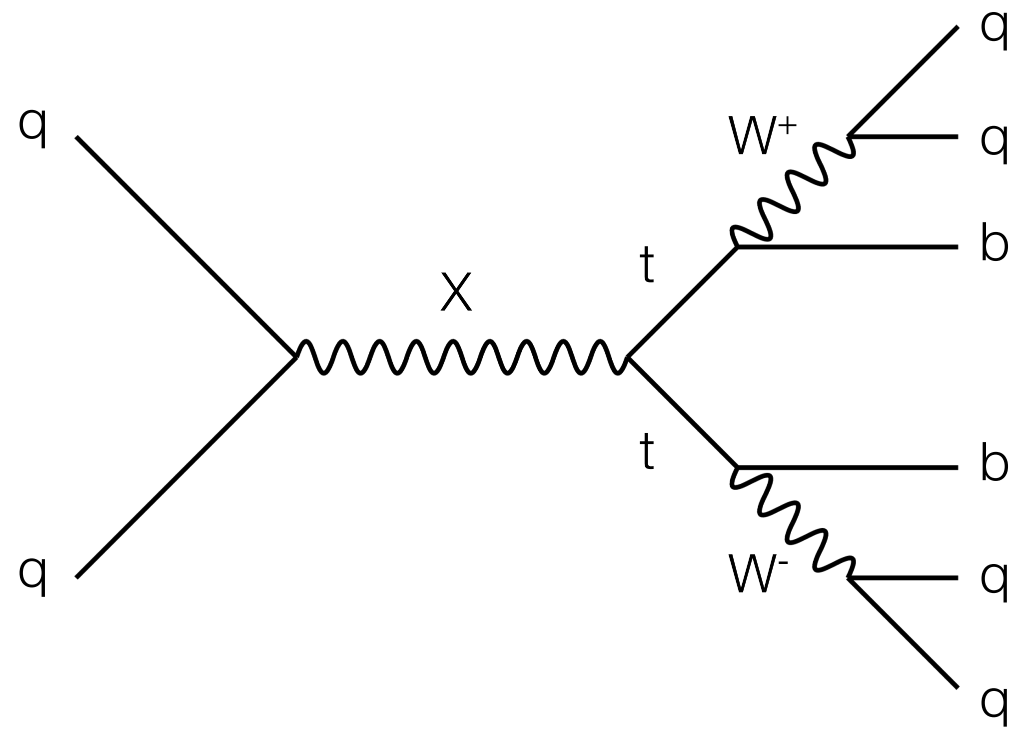
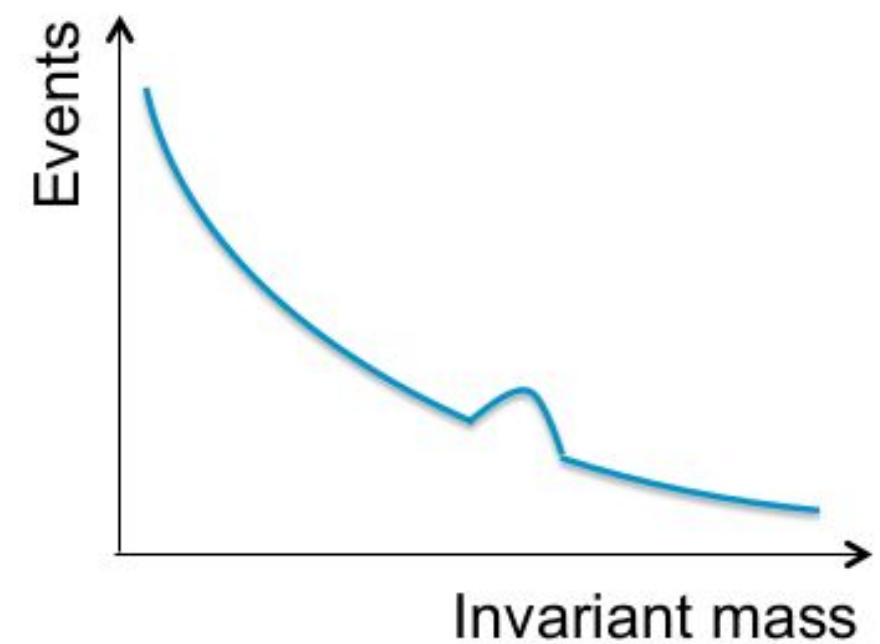
Beyond Standard Model Physics

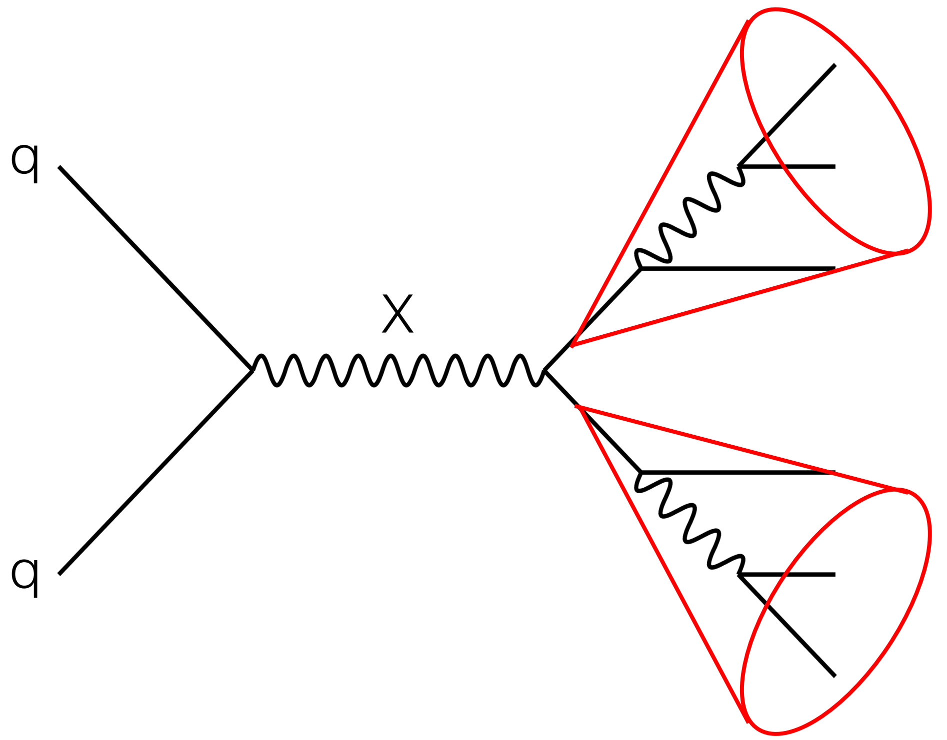
- Looking for a particle decaying into two **top quarks** in the hadronic final state
  - $X \rightarrow tt \rightarrow bqq+bqq$
- E.g. Z' mediator
  - Arise from **extensions** of the **electroweak symmetry** in many different models
  - [Topcolor assisted technicolor]
- Looking for a **bump** in the invariant mass spectrum of the decay products of the two top quark candidates

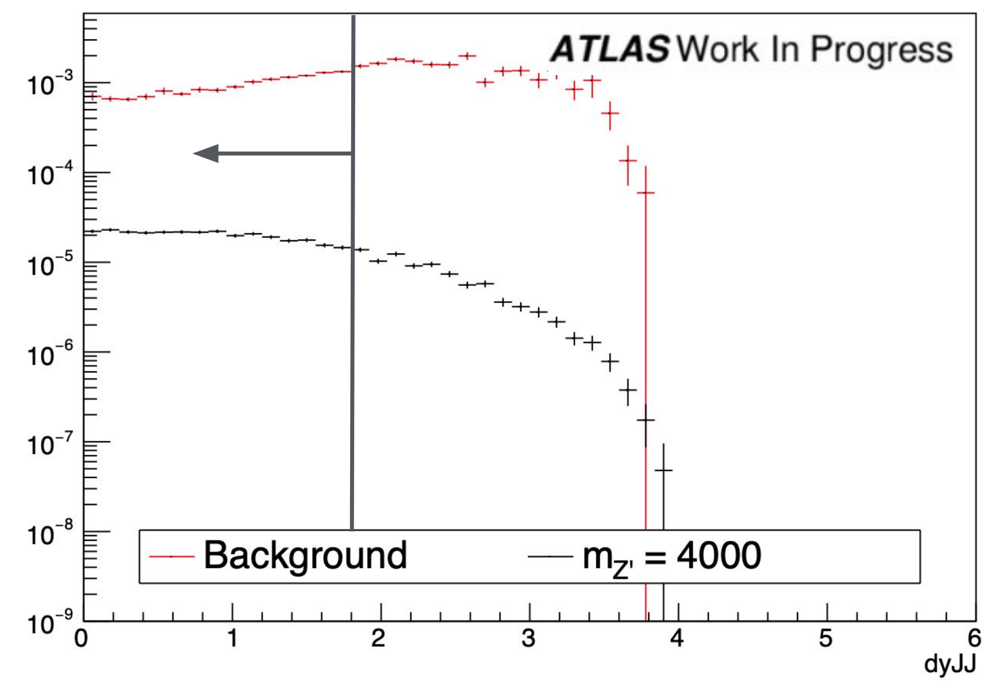




OBJECT AND EVENT SELECTION

- Single jet trigger with $p_T > 460$ GeV
- Two large radius anti-kt jets (R=1) with
  - **$p_{T,J1}$ > 500 GeV** and **$p_{T,J2}$ > 350 GeV**
  - **dphi(J1,J2) > 1.6** (back-to-back)
  - **dy(J1,J2) < 1.8** (remove SM t-channel)
- Leading and subleading large radius jets are top-tagged (**DNN top-tagger 80% WP**)
- One or both of the leading large radius jets should be matched to a b-tagged variable radius track jet (**DL1 77% WP**)
  - 1b and 2b signal region





Top Tagging

- Deep Neural Network (DNN) with input variables
  - Jet kinematics: m^{comb}, p_T
  - Energy corr. ratios: e_3, C_2, D_2
  - N-subjettiness: τ_1, τ_2, τ_3, τ_{21}, τ_{32}
  - Splitting measures: $\sqrt{d_{12}}$, $\sqrt{d_{23}}$
  - Minimum pairwise invariant mass: Q_w

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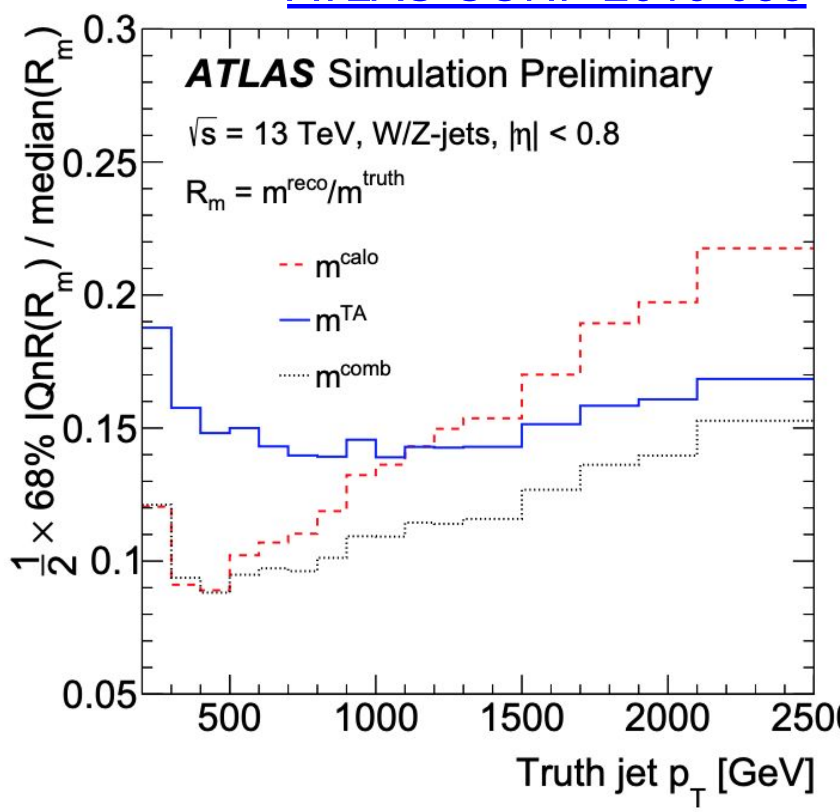
- $m^{comb} = a \cdot m^{calo} + b \cdot m^{TA}$
  - Combined jet mass

ATLAS-CONF-2016-035



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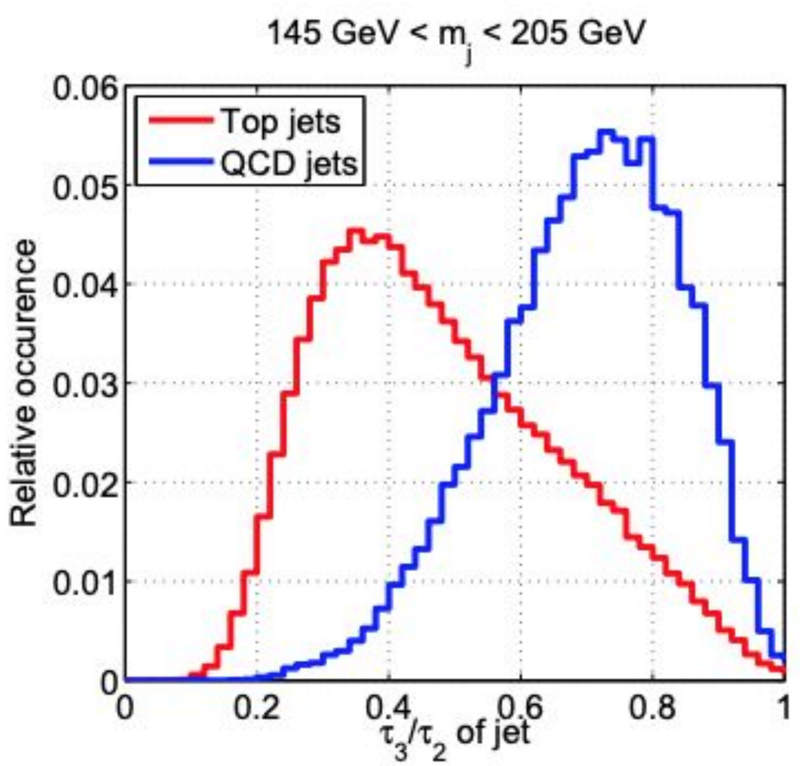
arXiv:1011.2268v3



- $m^{comb} = a \cdot m^{calo} + b \cdot m^{TA}$
  - Combined jet mass

- $\tau_{32} = \tau_3/\tau_2$
  - How likely is the jet to have three prongs compared to two

Top Tagging

- Discriminant cut varied as a function of p_T to always have a **signal efficiency of 80%**
- The DNN tagger is **2x better** than the simple tagger based on m^{comb} and τ_{32} cuts
- BDT tagger perform similarly as expected
- This analysis is one of the **first** to use the DNN top tagger
    - Training DNN at high p_T
    - Deriving uncertainty

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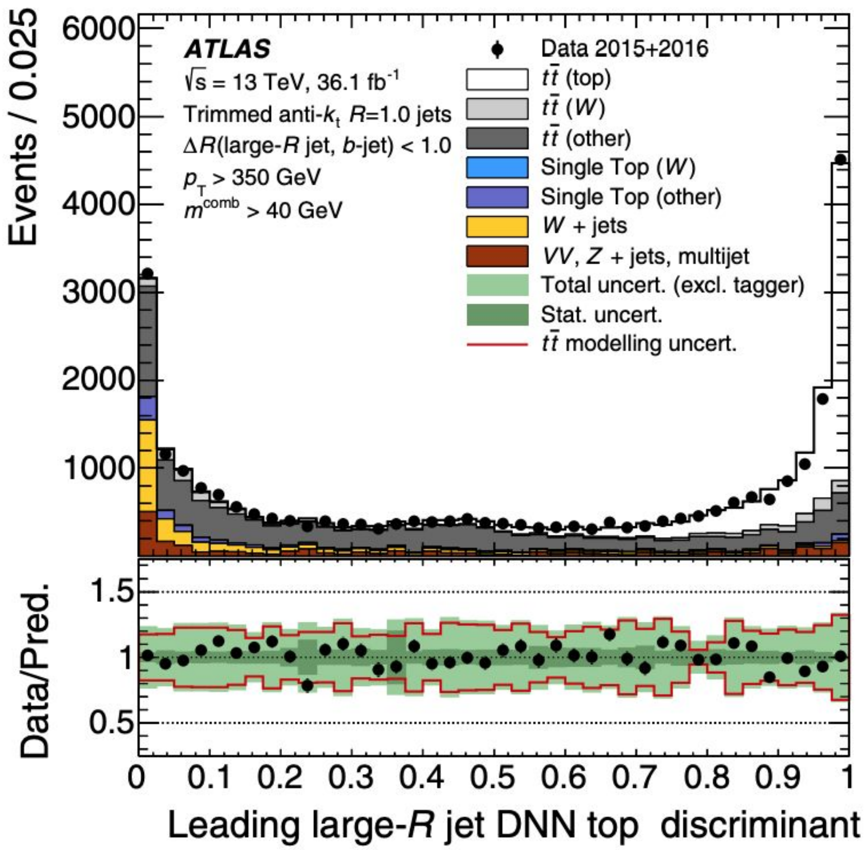
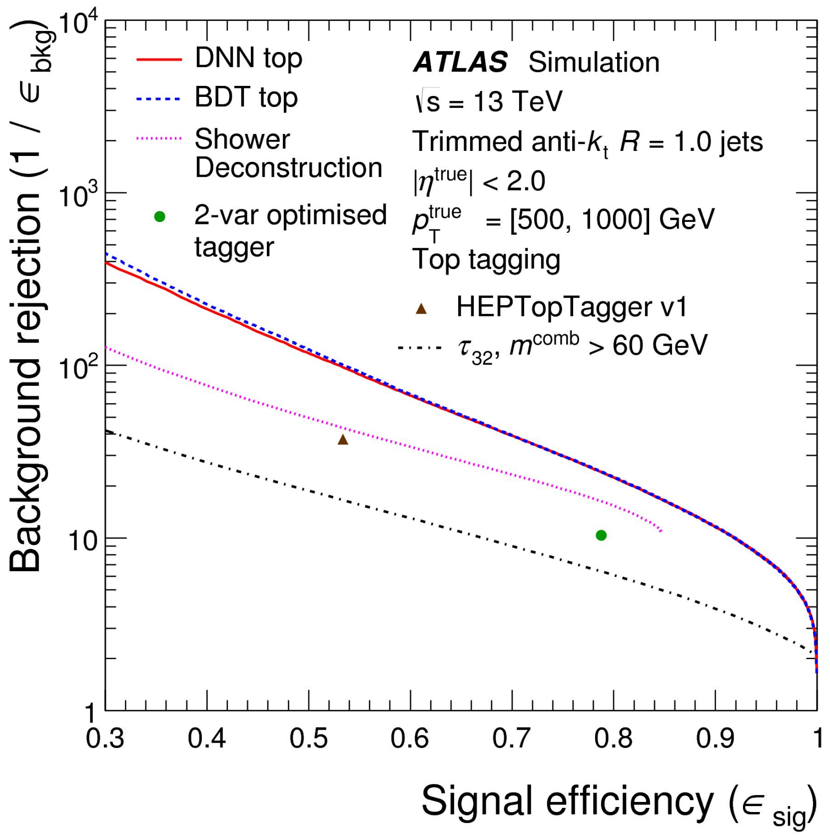
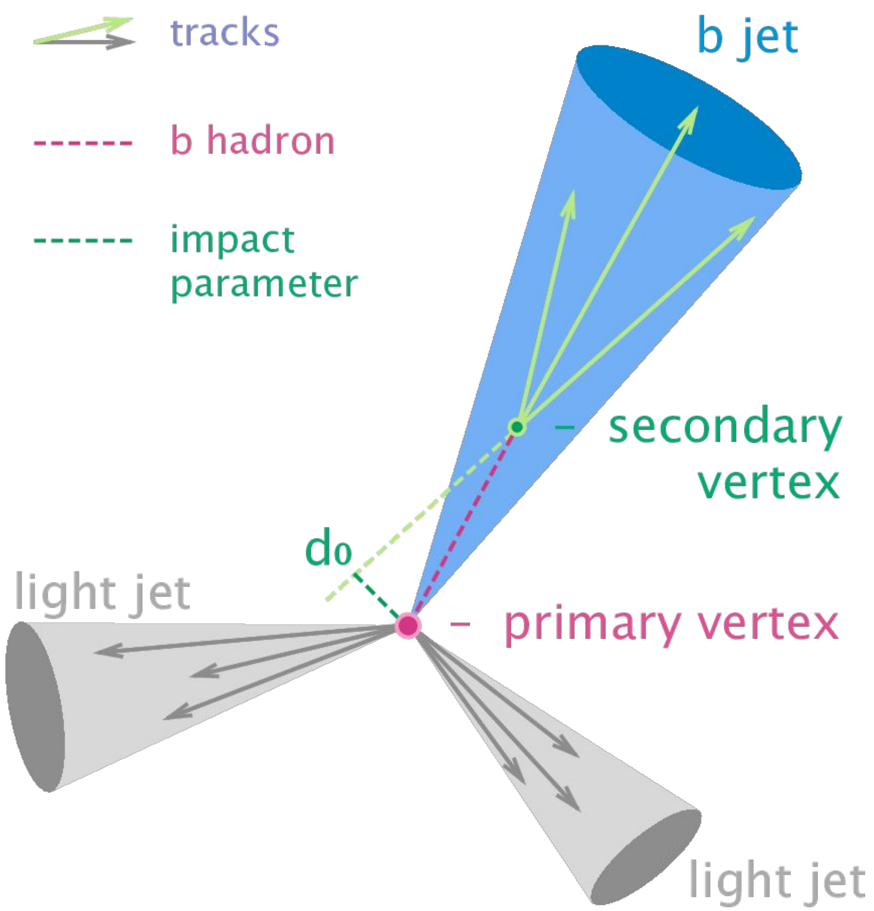




B TAGGING

- B-hadrons have certain **characteristics** which can be used to tag a jet as coming from a b-quark
  - **Impact parameter** of tracks
  - **Displaced vertices** reconstructed in the inner detector
- DL1
  - Deep learning **neural network** based on distinctive features of b-hadrons



Background Estimation

- Fit smoothly falling m_{tt} background with **function**:

$$f(x) = p_0(1-x)^{p_1} x^{p_2 + p_3 \log x + p_4 (\log x)^2 + \ldots}$$

- Tests were done on **asimov dataset** and pseudo-experiments
- Method used in several Exotics searches in ATLAS
- Pros
  - Does not need huge amount of Monte Carlo simulations
  - Smaller systematic uncertainties
- Cons
  - Is the expected background completely smooth?
    - **Spurious signal test**
  - Is it affected by a potential signal?
    - **Signal injection test**
    - Not possible to discover a broad signal

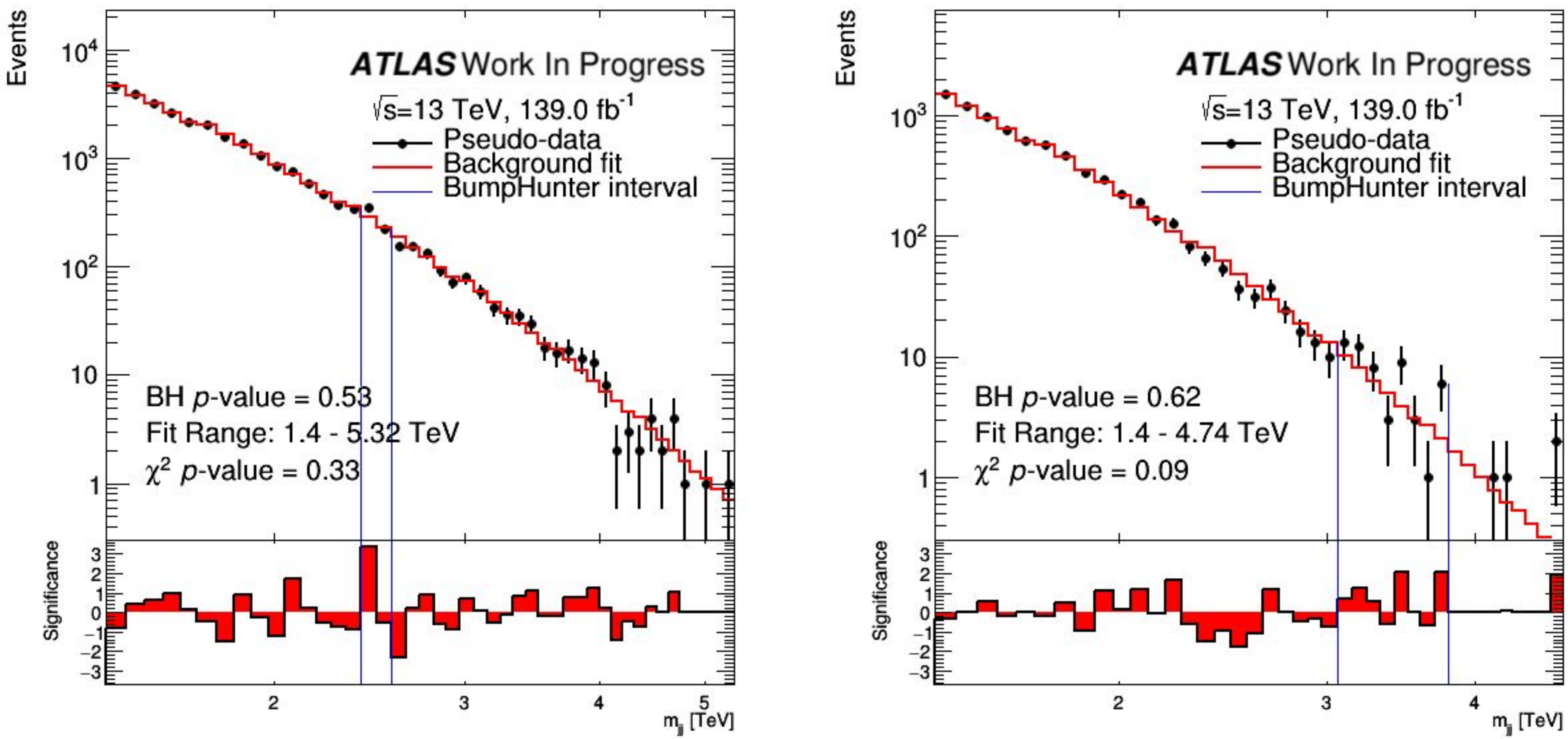
ASIMOV SAMPLE

- **Dijet** samples
  - MC: Pythia8 pT-sliced samples
    - Good statistics at high m_{tt}
  - Data-driven (DD): ABCD method based on b- and top-tagging
    - Better description of dijet and good statistics at low m_{tt}
  - **Combined**: DD at low m_{tt} and corrected MC at high m_{tt}
    - Good statistics over full m_{tt} range
    - Stitch at 2410 GeV for 1bSR and 2730 GeV for 2bSR
- **Ttbar** samples
  - **MC**: All-hadronic tt and non-all-hadronic tt

Fitting Pseudo-Data

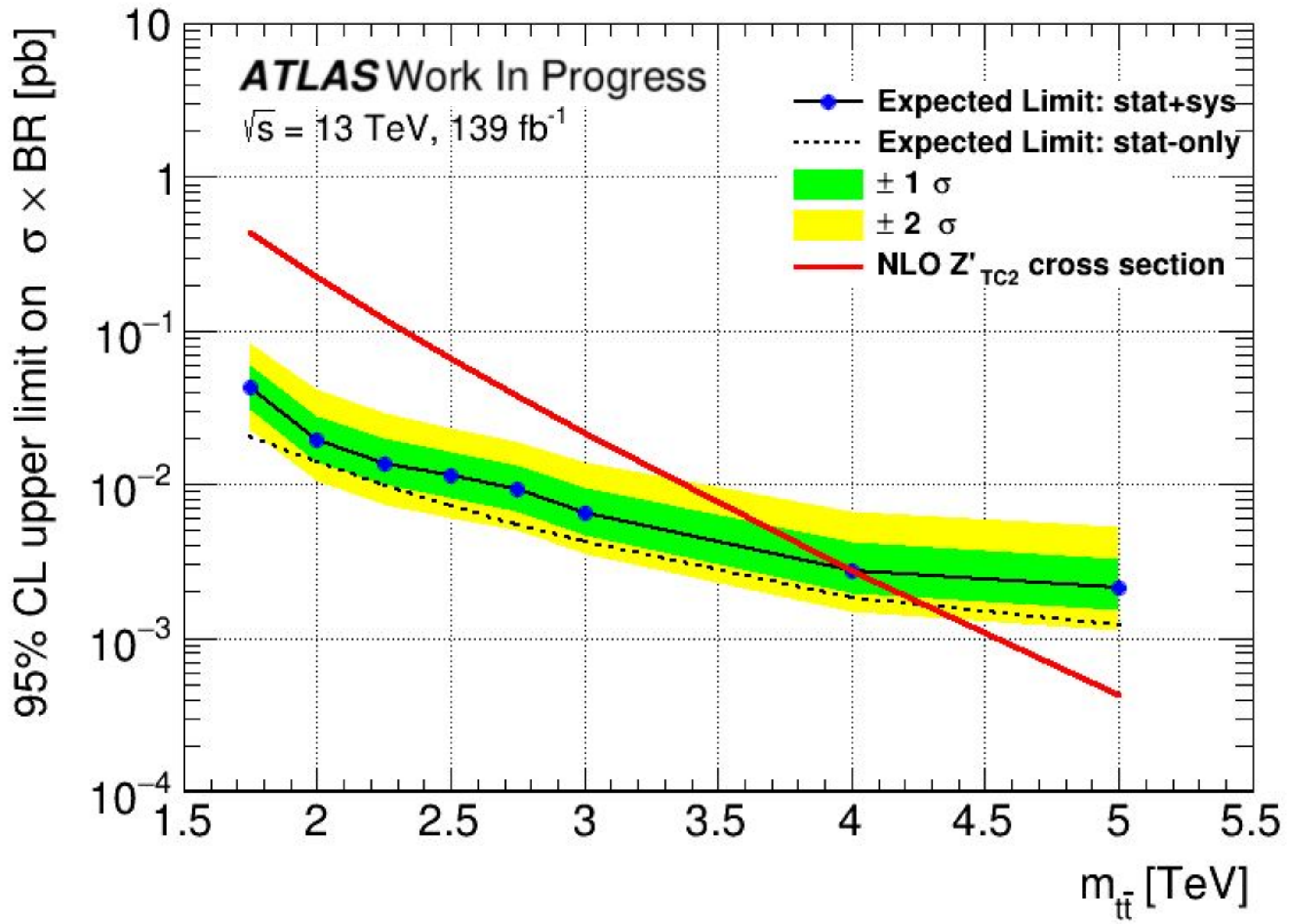
4 parameters

1b signal region   2b signal region



LIMIT SETTING

- Limit setting machinery in place
  - Expected limit on Z' → tt is 4 TeV
  - Calculated with asimov sample



Conclusion And Outlook

- Improvements
  - **Better** top- and b-**tagging**
  - **Fit** instead of MC used for background estimation
  - Compared to previous ttbar analysis the **limit improves** from 3 TeV to 3.4 TeV when scaled to same integrated luminosity (36.1 fb^{-1})
- Plans
  - Result will be included in Heavy Resonance combination in ATLAS

Back up

arXiv:1011.2268v3

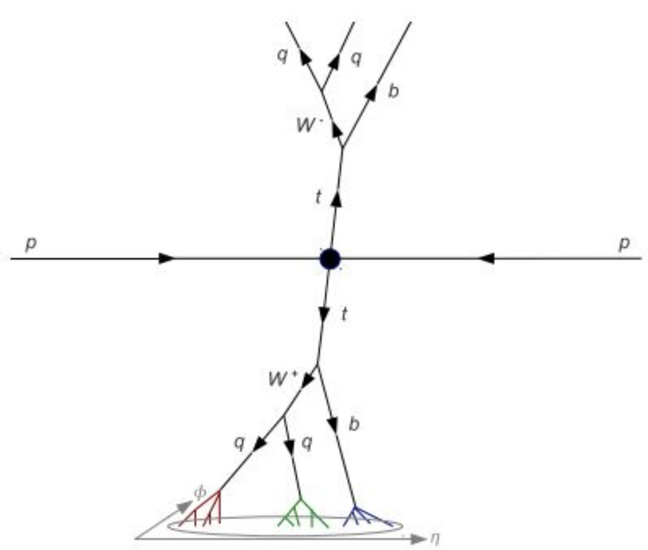
N-SUBJETTINESS

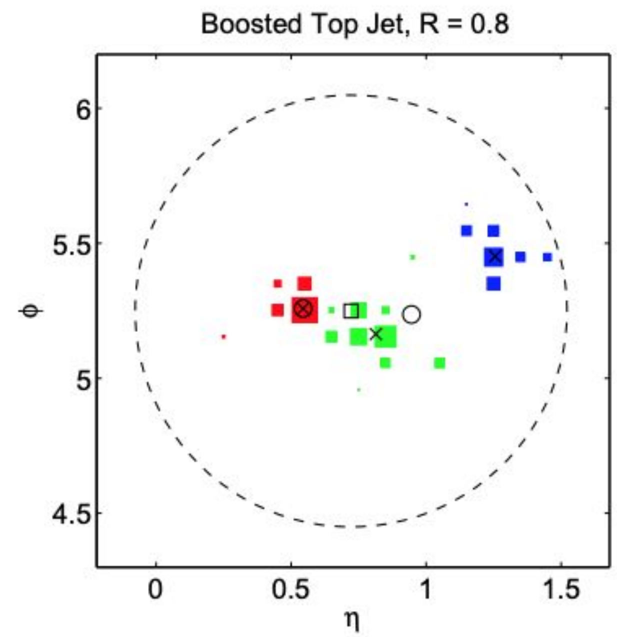
$$\tau_N = \frac{1}{d_0} \sum_k p_{T,k} \min \{\Delta R_{1,k}, \Delta R_{2,k}, \cdots, \Delta R_{N,k}\} . \quad (2.1)$$

Here, k runs over the constituent particles in a given jet, $p_{T,k}$ are their transverse momenta, and $\Delta R_{J,k} = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$ is the distance in the rapidity-azimuth plane between a candidate subjet J and a constituent particle k. The normalization factor d_0 is taken as

$$d_0 = \sum_k p_{T,k} R_0, \quad (2.2)$$

where R_0 is the characteristic jet radius used in the original jet clustering algorithm.





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