Top tagging in Run 1 and early Run 2 commissioning with the ATLAS detector

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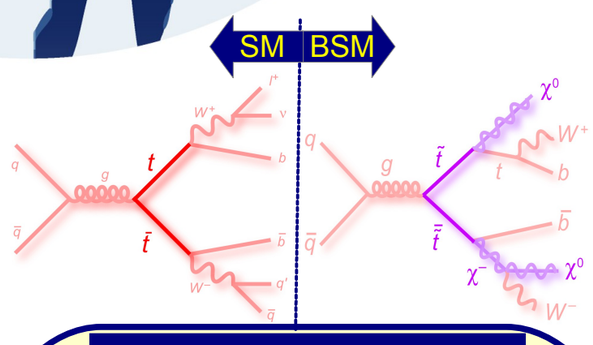
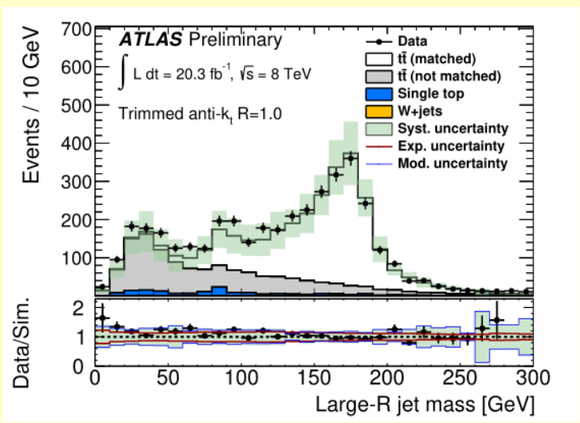


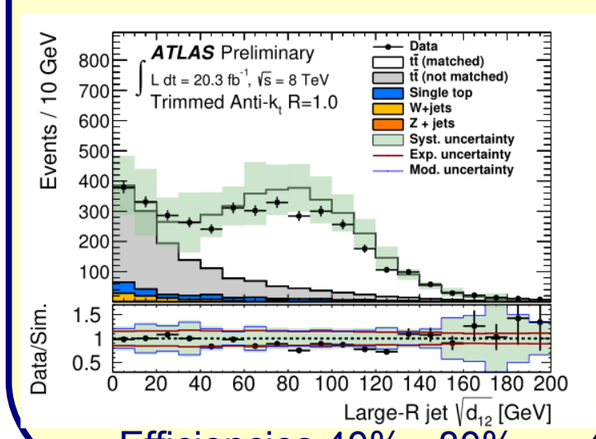
Introduction

- Conventional top quark reconstruction usually done with a small jet radius R=0.4 or 0.5 is limited at higher energies of the top quarks produced at the LHC
  - Decay products will be colimated, thus the probability for resolving separate small-R jets will be reduced => top quarks with high transverse momentum (p_T) are reconstructed with a jet with large radius parameter R > 0.8, and jet substructure is explored
- Both SM processes, like tt and ttH, or BSM, like resonant tt production or other signatures with top quarks in the final states can largely benefit from large-R jets with substructure
- Large-R jets reconstructed with different algorithms and different R are used for top tagging
  - Efficiencies (fake rates) are measured in a ttbar (multijet) sample in data.

Single variable tagger

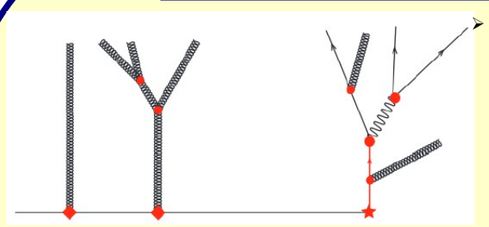
- Jets
  - anti kT, R=1, p_T>350 GeV
- Variables :
  - trimmed jet mass m
  - $\sqrt{d_{12}} = min(p_{Ti}, p_{Tj}) \times \Delta R_{ij}$
  - N subjetiness τ
- Taggers
  - I: $\sqrt{d_{12}} > 40\,GeV$
  - II: $m > 100\,GeV$
  - III: $m > 100\,GeV$, $\sqrt{d_{12}} > 40\,GeV$
  - IV: $m > 100\,GeV$, $\sqrt{d_{12}} > 40\,GeV$, $\sqrt{d_{23}} > 10\,GeV$
  - V: $m > 100\,GeV$, $\sqrt{d_{12}} > 40\,GeV$, $\sqrt{d_{23}} > 20\,GeV$
  - ATLAS W': $\sqrt{d_{12}} > 40\,GeV$, $0.4 < \tau_{21} < 0.9$, $\tau_{32} < 0.65$



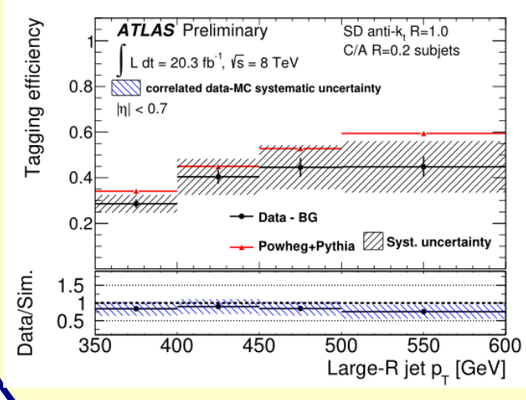


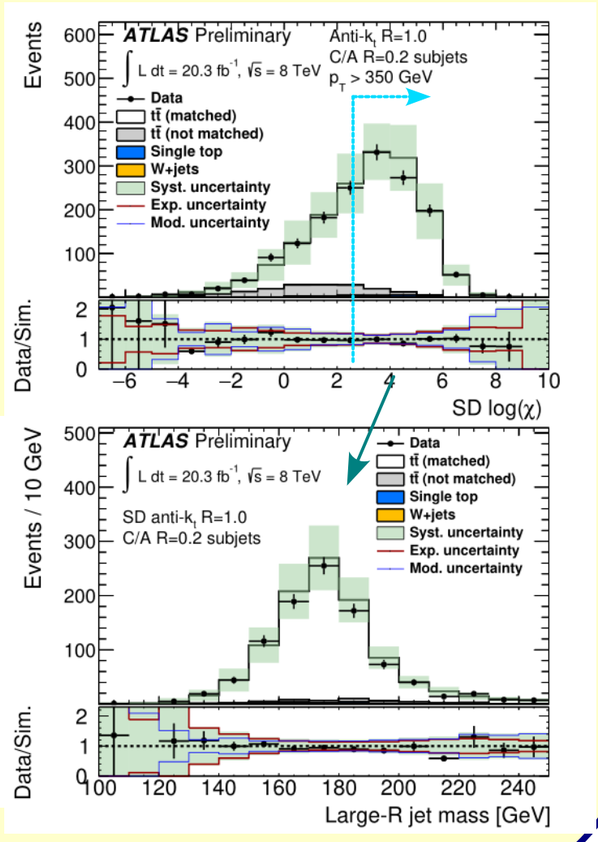
Efficiencies 40% - 80%

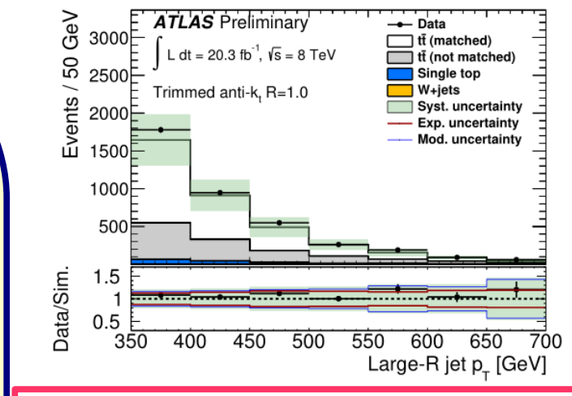
Shower deconstruction

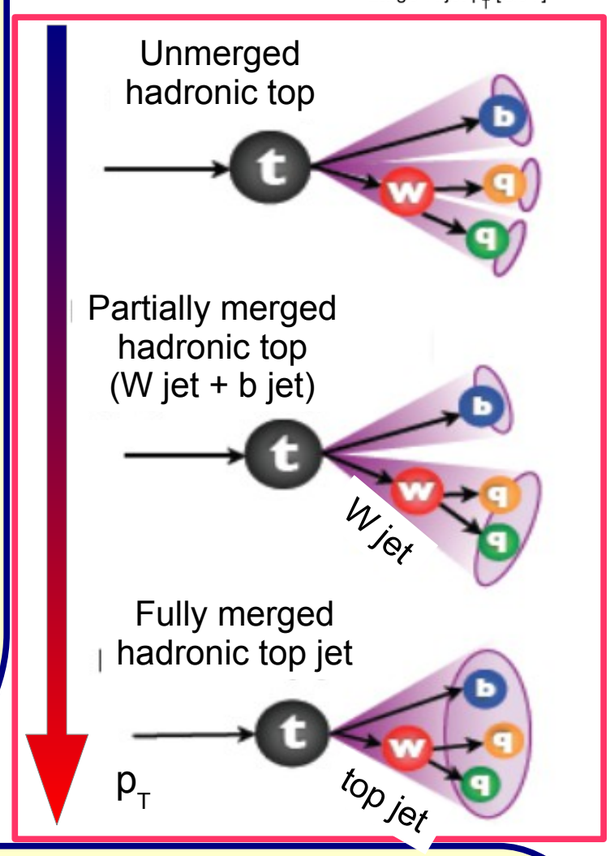


- Use simplified model of shower coming from hadronically decaying top quark or from light parton
  - Define ratio of probablilities between the two as a discriminant
- Jets
  - anti kT, R=1, p_T>350 GeV
  - No grooming is needed, there is an internal pile-up supression
  - Between three and nine hardest C/A jets with R=0.2 and p_T>20 GeV are used



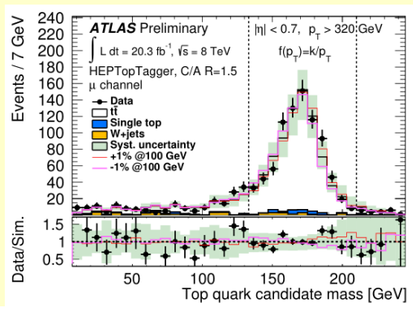


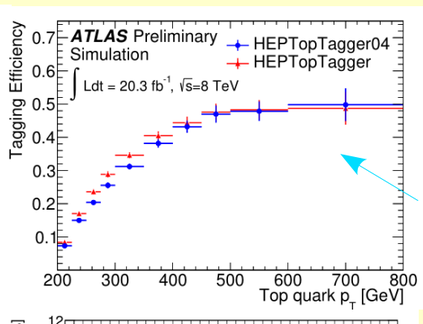


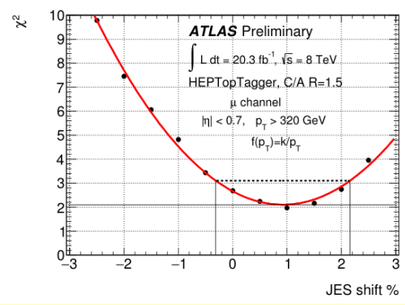


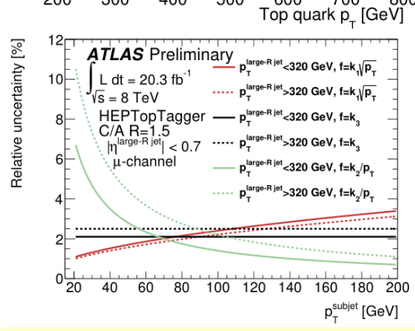
HEPTopTagger

- Apply mass drop process to C/A, R=1.5 jets until all remaning subjets have m>50 GeV
- Apply filtering to remove underlying events and pile-up
- Keep combinations consistent with W boson (m_W) and top quark (m_t)
- In-situ subjet JES determination





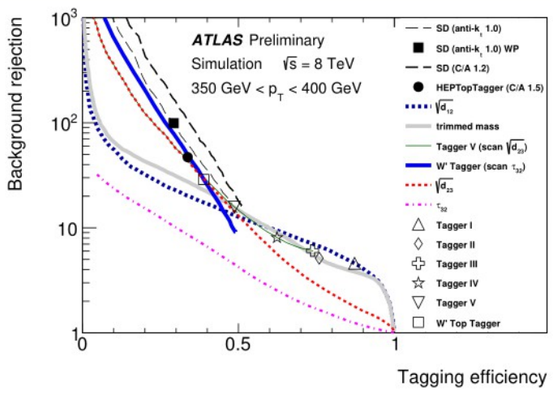


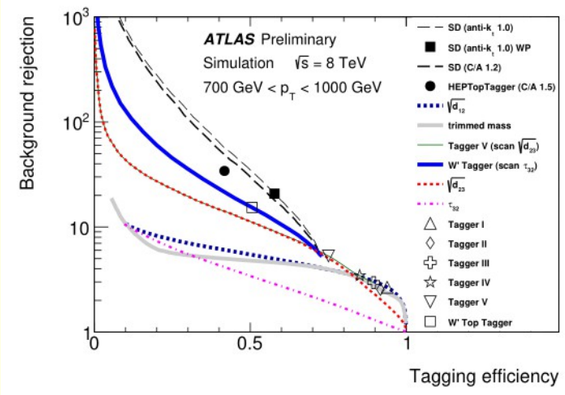


Variant of HTT with R=0.4 jets as inputs
Advantages in highly populated multijet events, $H^+t(b) \rightarrow tbt(b)$

Performance

- The best performing variables: high eff: $\sqrt{d_{12}}$; low eff: $\sqrt{d_{23}}$

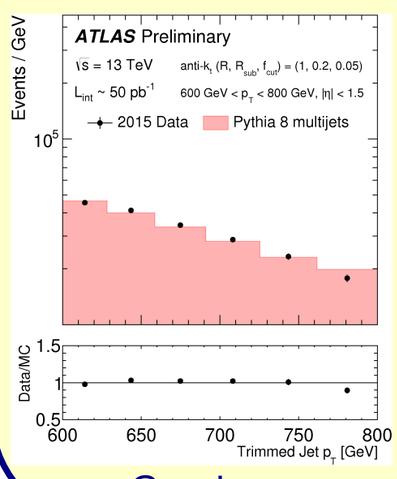


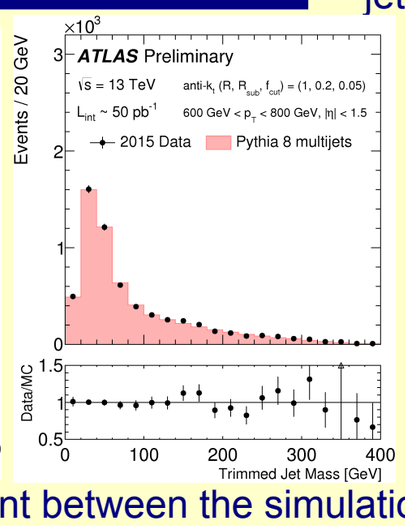


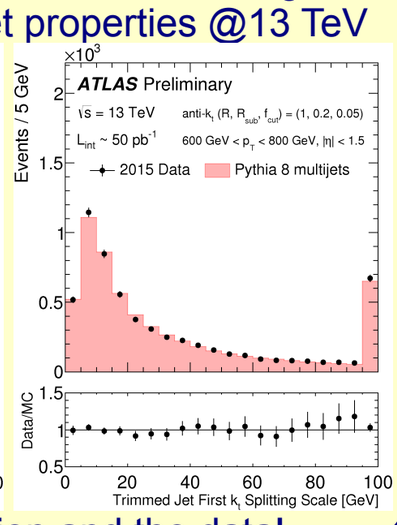
- For 350<p_T<1000 GeV SD performs the best up to eff of 50%
- HepTopTagger is superior above 1 TeV

Run 2 jet substructure

- First studies of large-R jet properties @13 TeV







- Good agreement between the simulation and the data!

1. ATLAS-CONF-2015-036 https://twiki.cern.ch/twiki/bin/view/AtlasPublic/JetEtmissPublicResults 2. ATLAS-CONF-2015-035