Measurement of differential cross sections in the process $pp \to W^+W^-b\bar{b}$

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ATLAS EXPERIMENT

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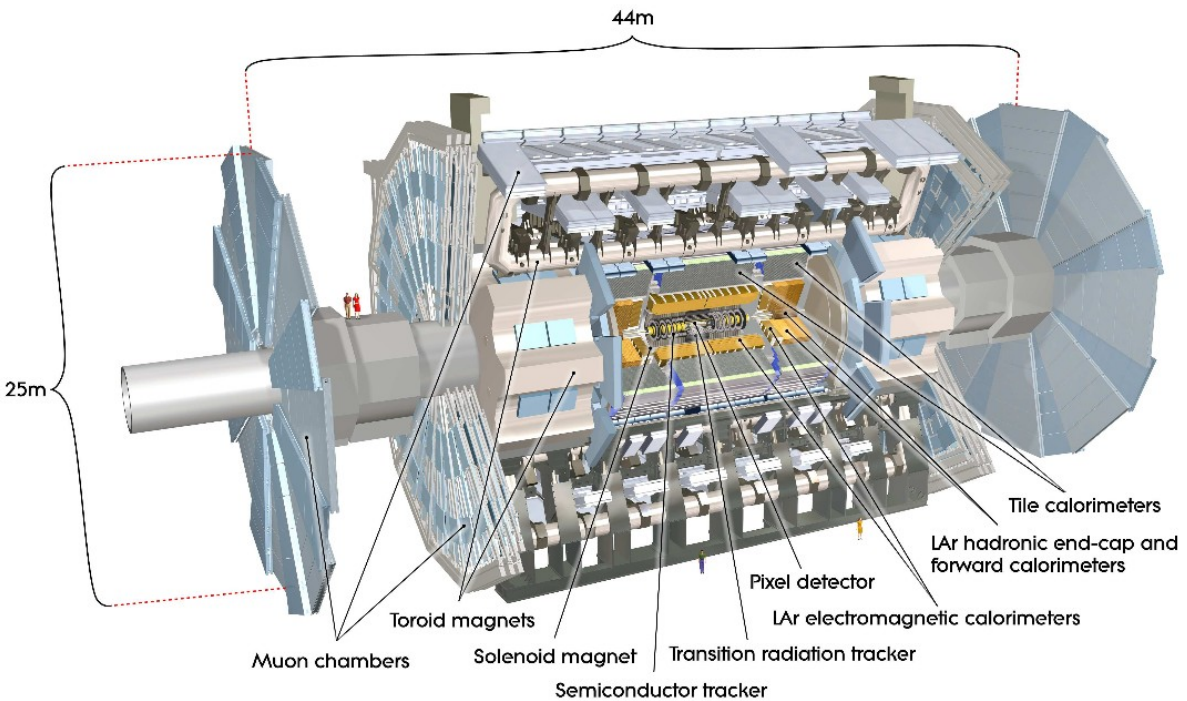
ATLAS Experiment

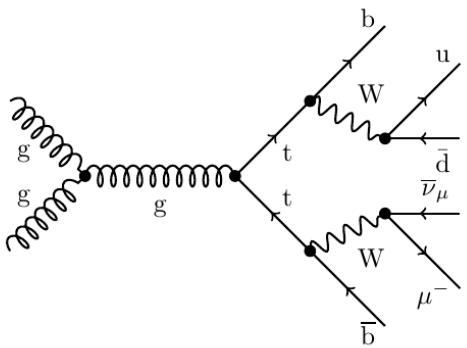
- Collider experiment @LHC
- Many-layered design with tracking detectors, calorimeteres, muon chambers, …
- Run 2 data
  → L = 140 fb^{-1}
  → $\sqrt{s}$ = 13 TeV



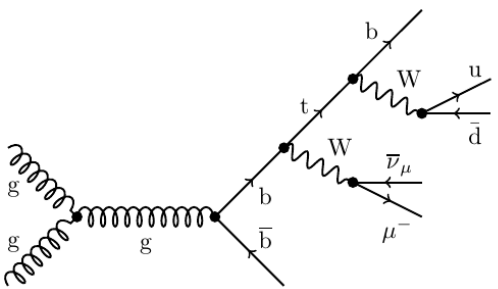
Measurements of $pp \rightarrow WWbb$

WWbb is not just top-quark pair production, but it is much more extensive ...

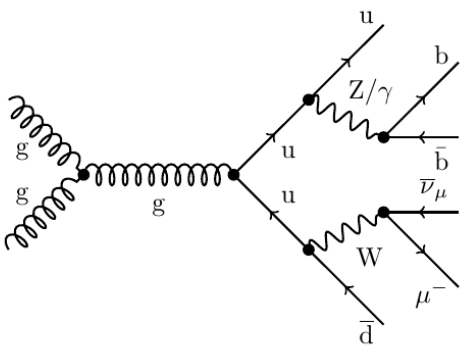
tt-production



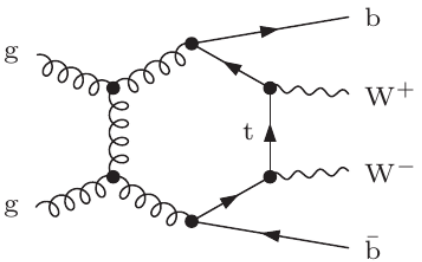
Non-resonant diagram



EW processes



Hexagon diagrams



Two main physics objectives

- Details on *WWbb* modelling are very relevant for *tt* & top-quark mass analyses, *SUSY* searches, etc..
- *WWbb* is an important process on its own
  - fixed order predictions, etc...
  - sensitivity to m_t, top-quark width Γ_t, α_s, PDFs, ...

WWbb in lepton+jets final state

Analysis strategy

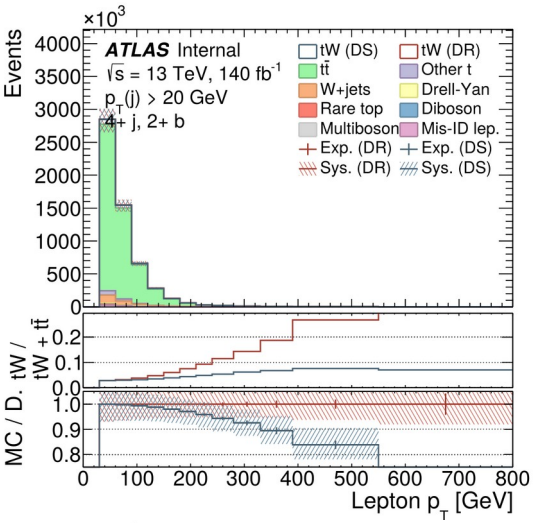
- Trigger and identify exactly one lepton (e or μ)
- Require Missing E_T > 30 GeV
- Identify b-tagged jets

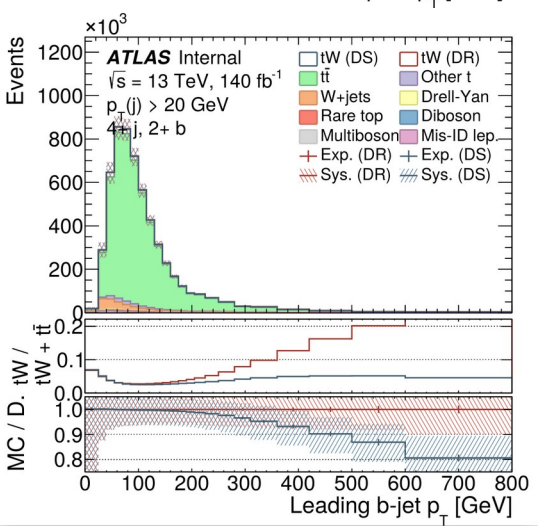
  → Sufficient to identify WWbb events

  → Sizeable amount of data + large cross section

  → Very clean signal region
- For precision measurements:

  → Require W_{had} reconstructed from light jets

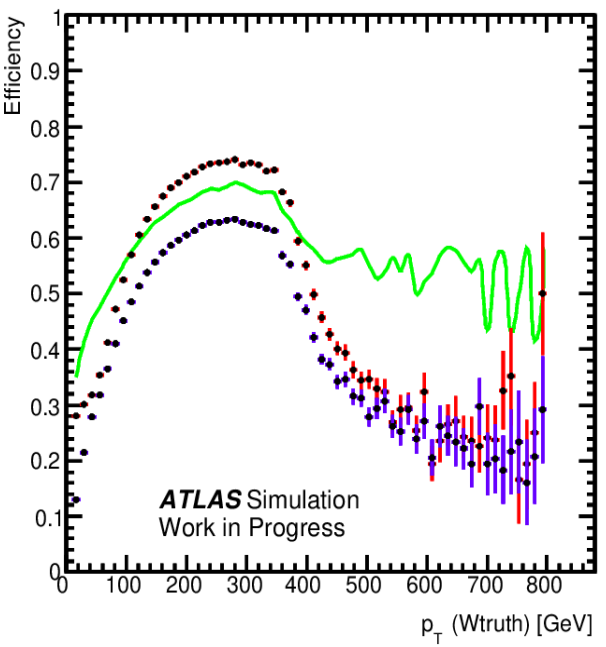




Hadronic W-boson

- Hadronic W-boson is reconstructed from (light) jets
- No 1-to-1 correspondence between various levels (ME-level, particle-level, or reco-level)
- Consider W-boson matched when
  $\Delta R = \sqrt{\Delta\phi^2 + \Delta\eta^2} < 0.5$
- W-candidate efficiencies:
  - Reco-level with ME (truth)
  - Particle-level with ME (truth)
  - Reco-level with Particle-level

Select 2-jet candidate closest to M(W_{had})

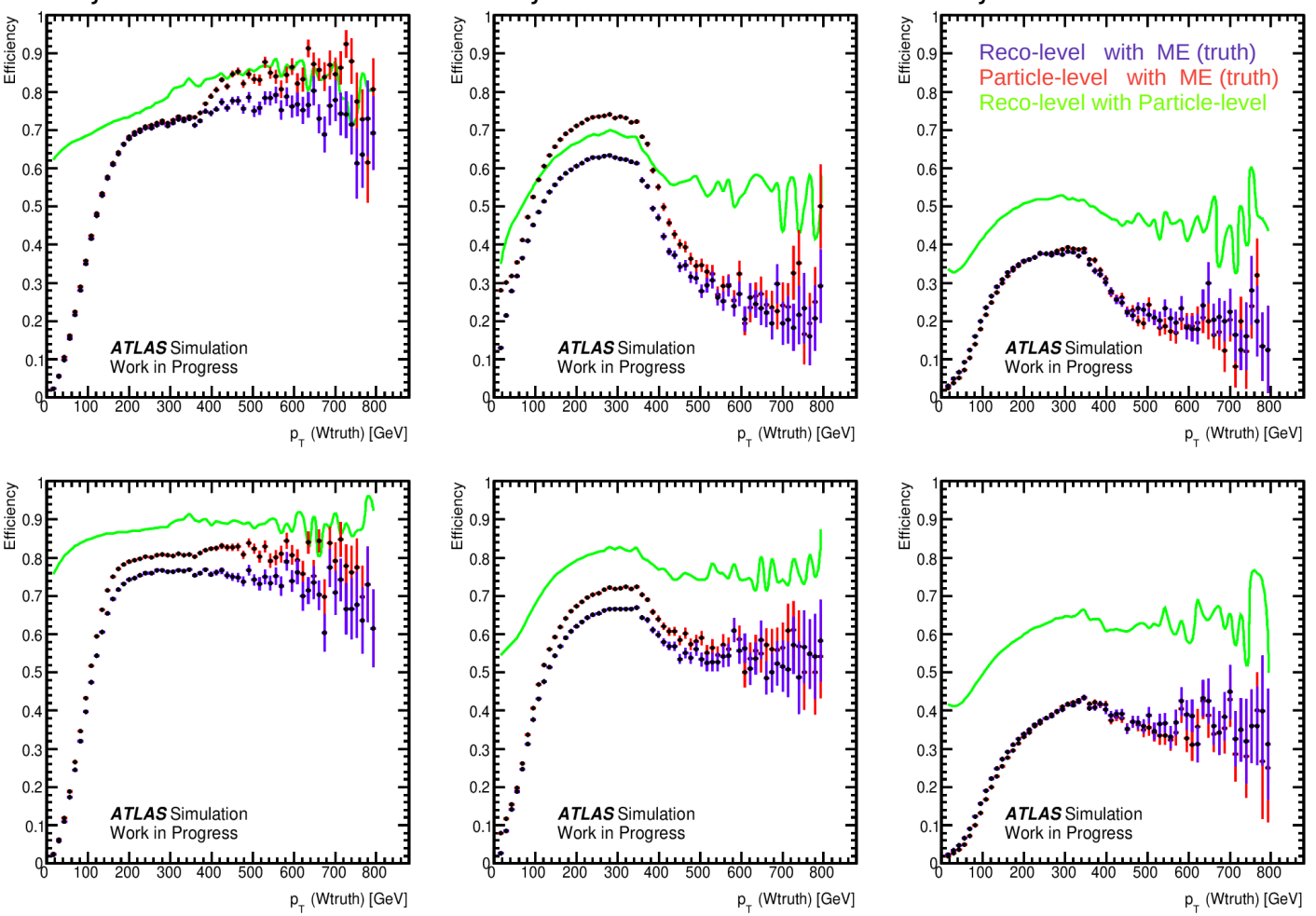


W_{had} – Naive reconstruction

Select the candidate with the mass closest to $M(W_{had})$

Select the hardest candidate (highest p_T)

1-jet candidates | 2-jet candidates | 3-jet candidates



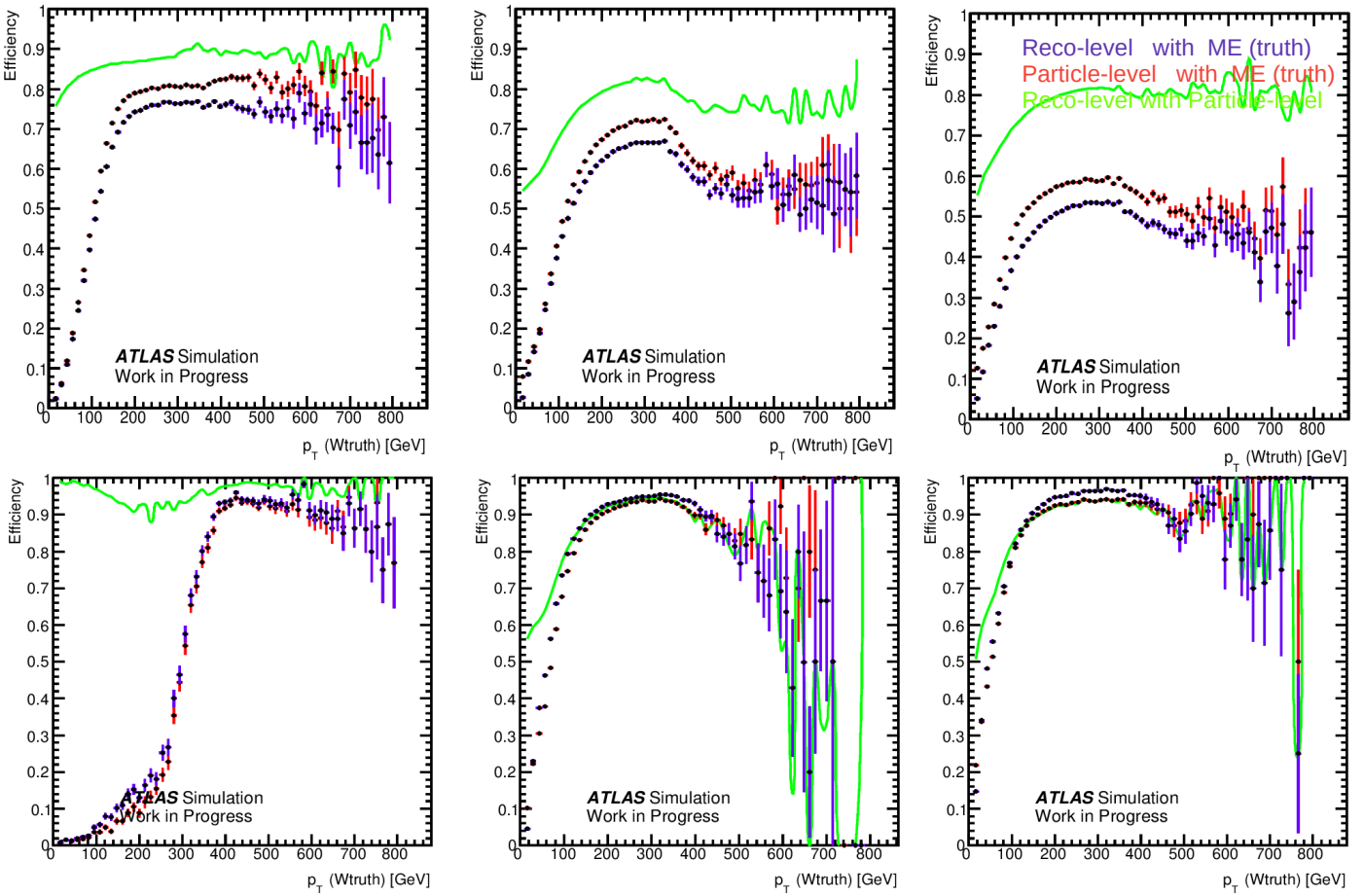
→ p_T ordering preferred over mass ordering
→ Select from hardest 1-jet, 2-jet and 3-jet candidates

W_{had} – Improved reconstruction

No constraints on the properties of the reconstructed W_{had}

Add a cut on the mass:
$60 < M(W_{had}) < 100$ GeV

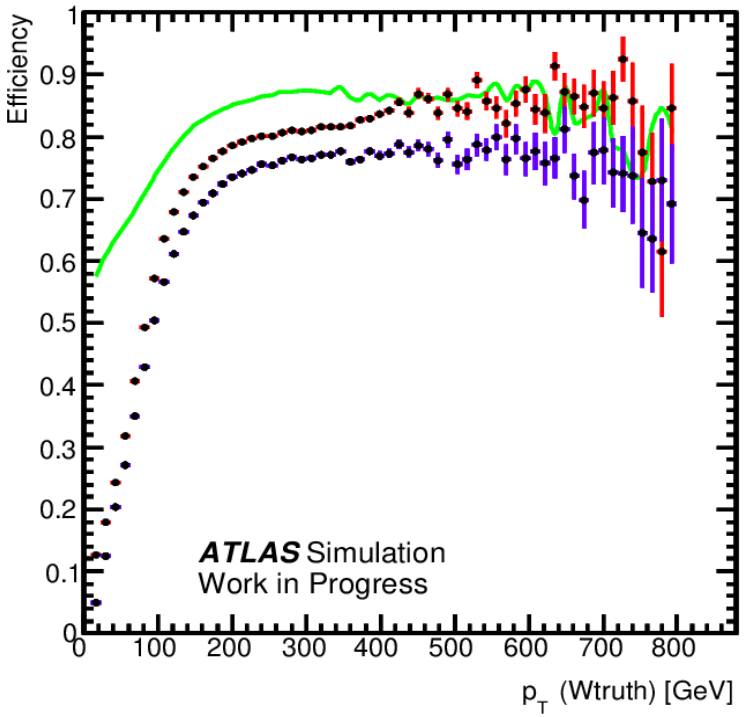
Leading jet | Hardest 2-jet cand. | Leading+subleading jet



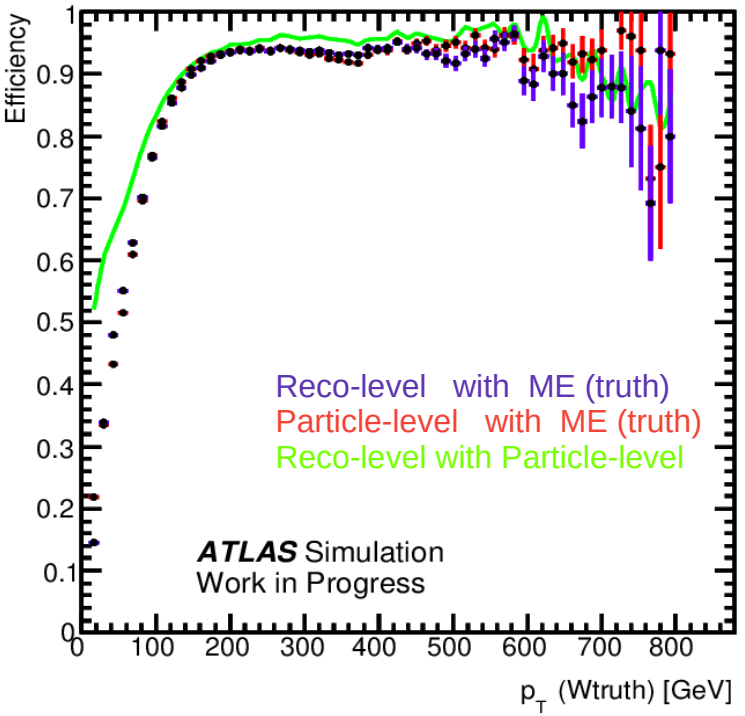
→ Applying a cut on the W-mass increases reconstruction efficiency
→ Combine 1- and 2-jet candidates for optimal reconstruction over entire p_T range

W_{had} - Optimized reconstruction

No mass constraint



60 < M(W_{had})< 100 GeV



Select from 5 candidates:

- Leading jet, subleading jet
- Sum of leading and subleading jet
- Hardest 2-jet and hardest 3-jet candidate
  → Select candidate with mass closest to M(W)

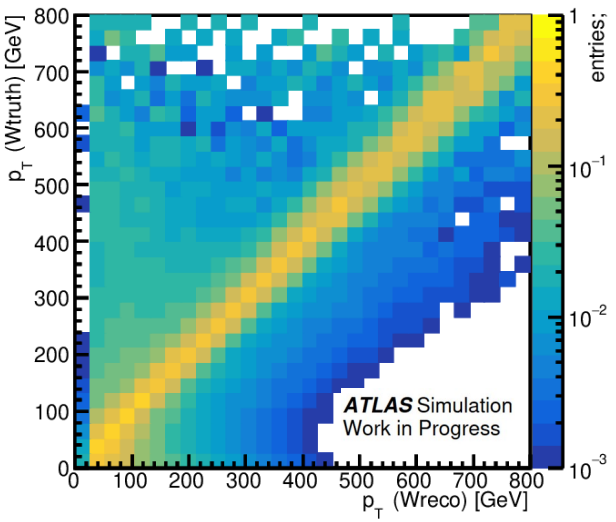
Select from 3 candidates:

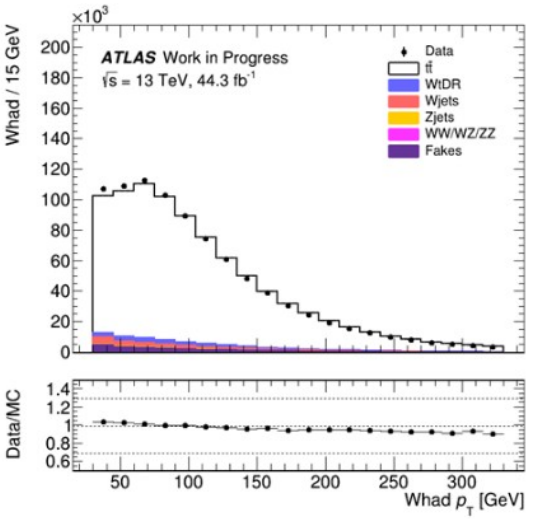
- Leading jet, subleading jet
- Sum of leading and subleading jet
  → Select candidate with mass closest to M(W)

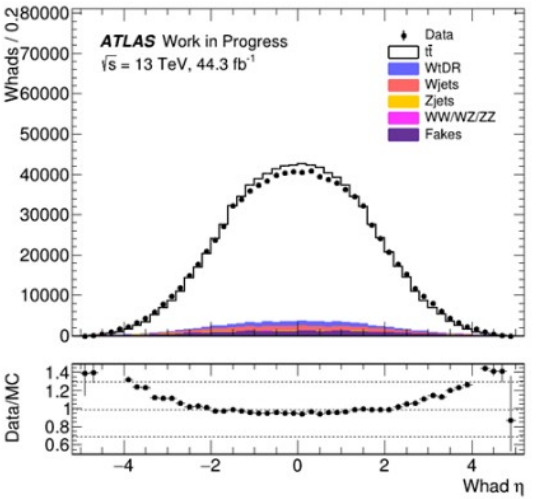
W_{had} - Control plots

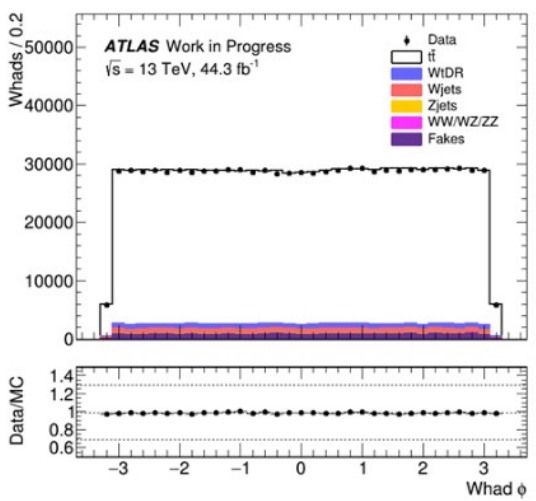
5-candidate-reconstruction (see previous slide, no mass cut)

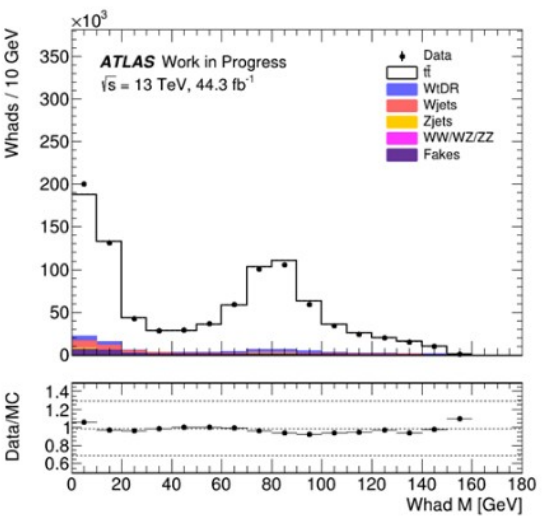
- W-boson can be well reconstructed
- All properties of WWbb kinematics can be measured
- Good agreement with data











Summary

- Study process pp → $W^+W^-b\bar{b}$ with lepton + jets final state
- Accurate W_{had} reconstruction important for precision measurements
- Presented optimized reconstruction algorithm for W_{had}
- High reconstruction efficiency over entire p_T range