MonoHiggs to $b\bar{b}$ in Association with Dark Matter

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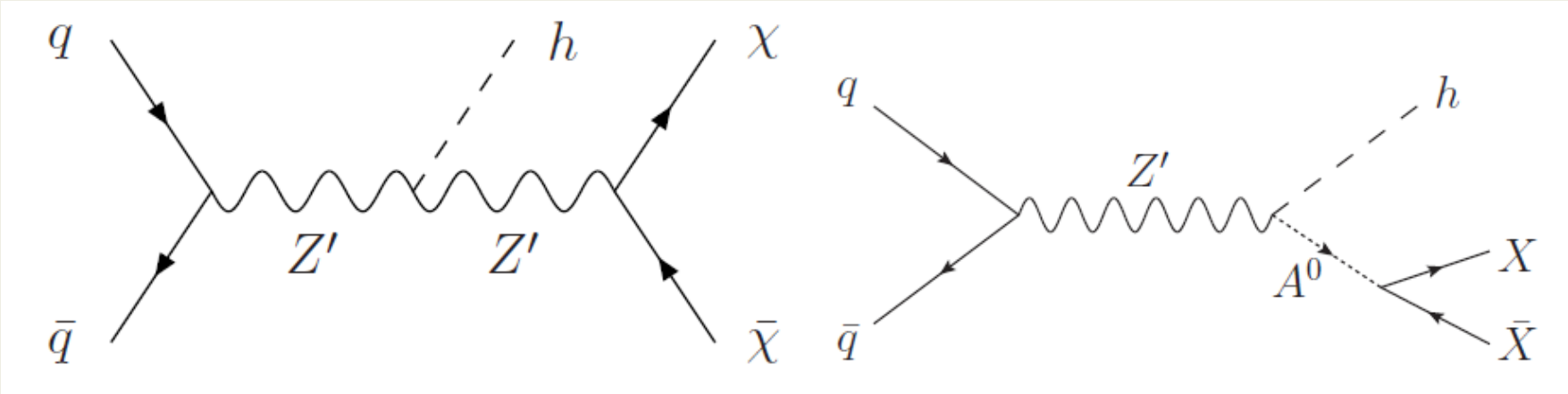
Summary of Signal

- What is a monoHiggs?
  - *Higgs boson produced by itself. Production and event topology separate Higgs from monoHiggs*
- Signal is associated production of a Higgs with a pair of Dark Matter candidates, where $H \rightarrow b\bar{b}$
- Require no leptons, large MET (dark matter candidates) and 2 b-tagged jets ($H \rightarrow b\bar{b}$)
- Background contributions come from $t\bar{t}$, W+jets and Z+jets
- W+jets and Z+jets control regions and signal region sidebands used to control the backgrounds

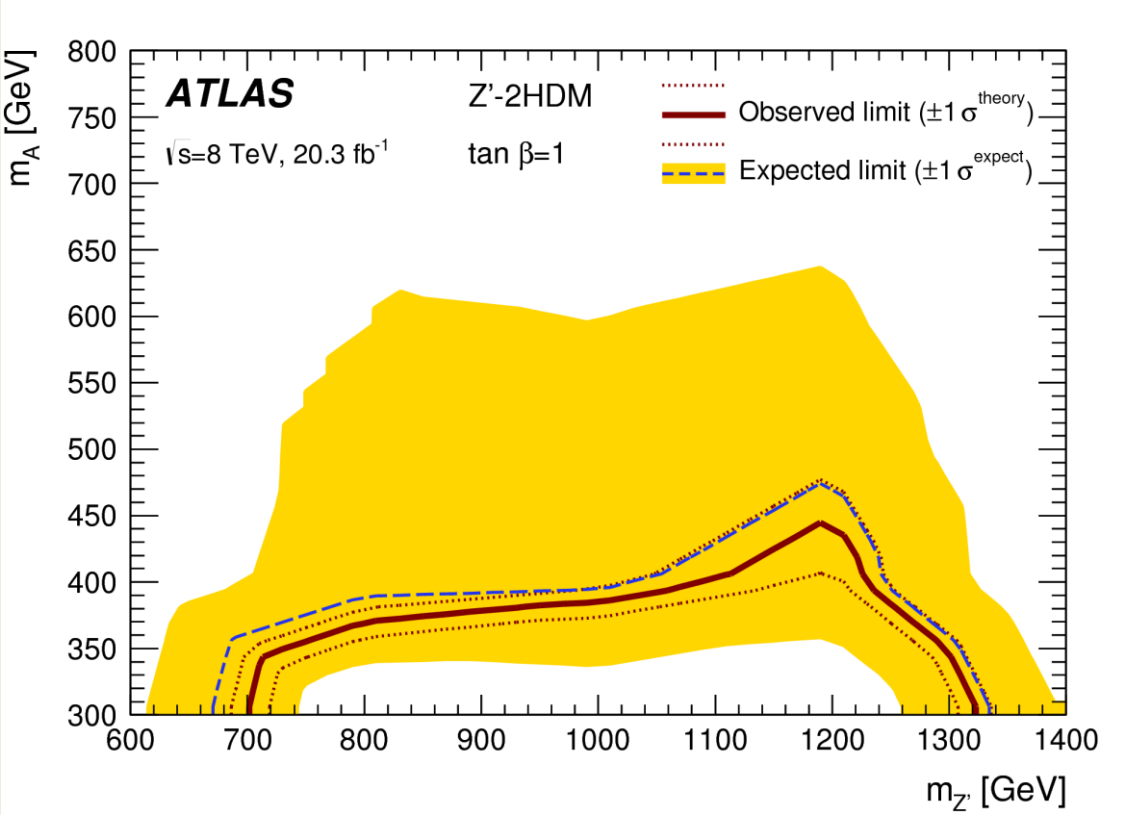
Models

- Simplified model
  - *Vector mediator (Z')*
  - *Vary Z' and dark matter mass*
- Z'-2HDM model
  - *Model predicts an additional heavy Higgs (A^0)*
  - *Vary Z' and A^0 mass*



Current Status of Limits

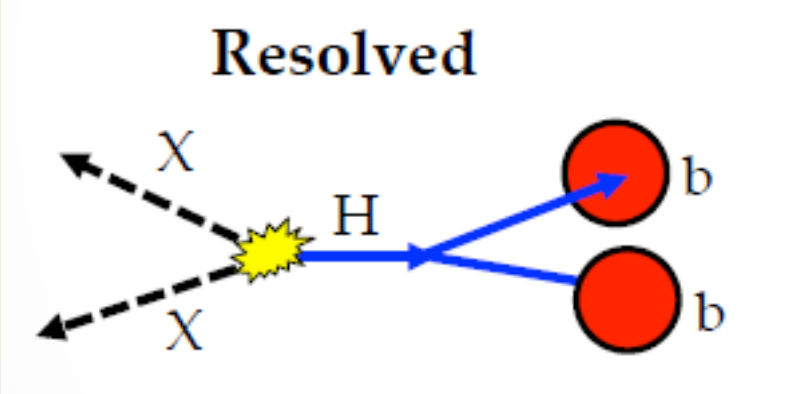
- Shown below: Mass exclusion plot for the Z'-2HDM model from Run 1 results
- We will extend the centre of mass energy with Run 2 results – this will give better sensitivity to dark matter
- There are no current limits on the simplified vector mediator model

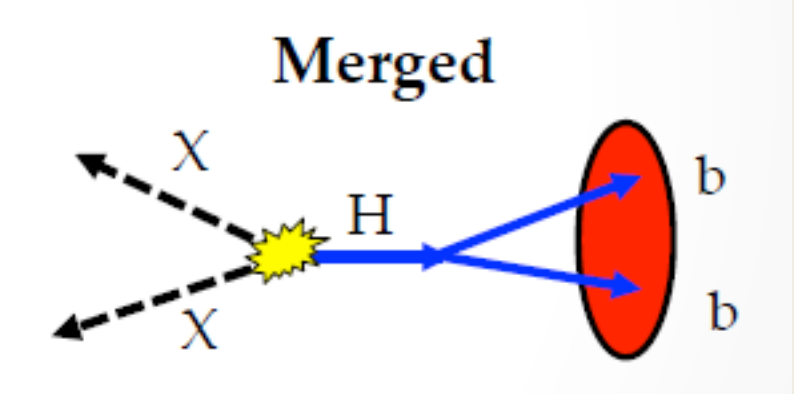


http://arxiv.org/abs/1510.06218

Resolved vs Merged Regions

- We combine results from a resolved (small R jet) and a merged (large R jet) region
- Large R jets are constructed from at least two track jets with anti-k_T R=0.2
- A b-tagging algorithm identified b-tagged jets (resolved) or b-tagged track jets (merged)
- Improve resolution of the jets used in Higgs reconstruction by adding back in muons





Signal Region Analysis Cuts

- Uses MET Trigger (with 100% efficiency at ~150 GeV)
- Leptons : Veto events with any loose electrons or muons
- MPT > 30 GeV
- Series of cuts applied to reduce QCD backgrounds:

Merged

- MET > 500 GeV
- N(fatjets)>=1
- Track jet b-tag counting on two leading subjets : exactly 0, 1, or 2

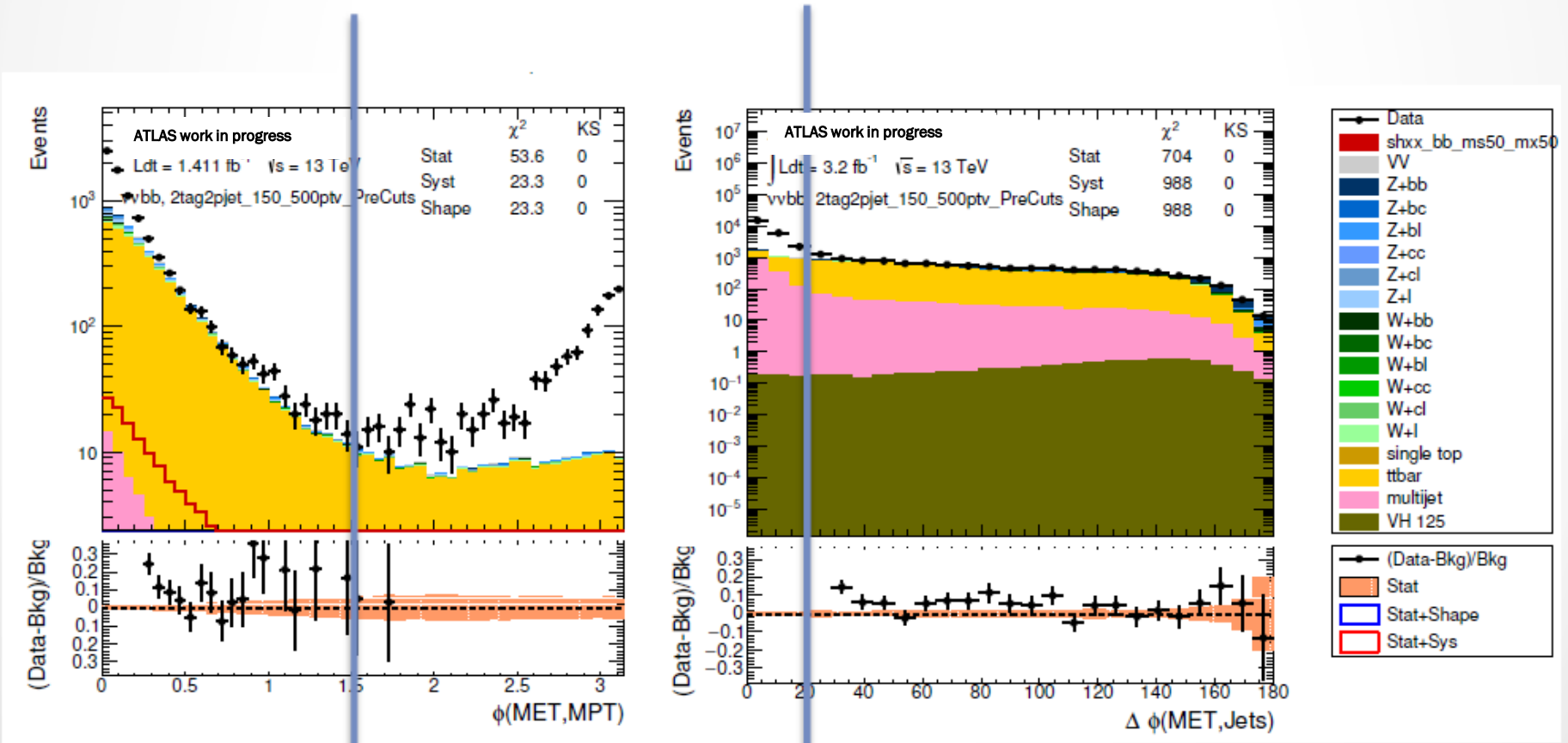
Resolved

- MET = 150-500 GeV
- Min[ΔΦ(MET, jets)] > 20^o
- ΔΦ(MET,MPT) < 90^o
- N(central jets) >= 2
- [pT(j1) or pT(j2)] > 45 GeV
  - *j1 and j2 are those used in Higgs reconstruction*
- HT(lead three jets)
  - *>120 GeV if N(central jets) == 2*
  - *>150 GeV if N(central jets) >=3*
- ΔΦ(j1, j2) < 140^o
- ΔΦ(MET, j1+ j2) > 120^o

QCD Background

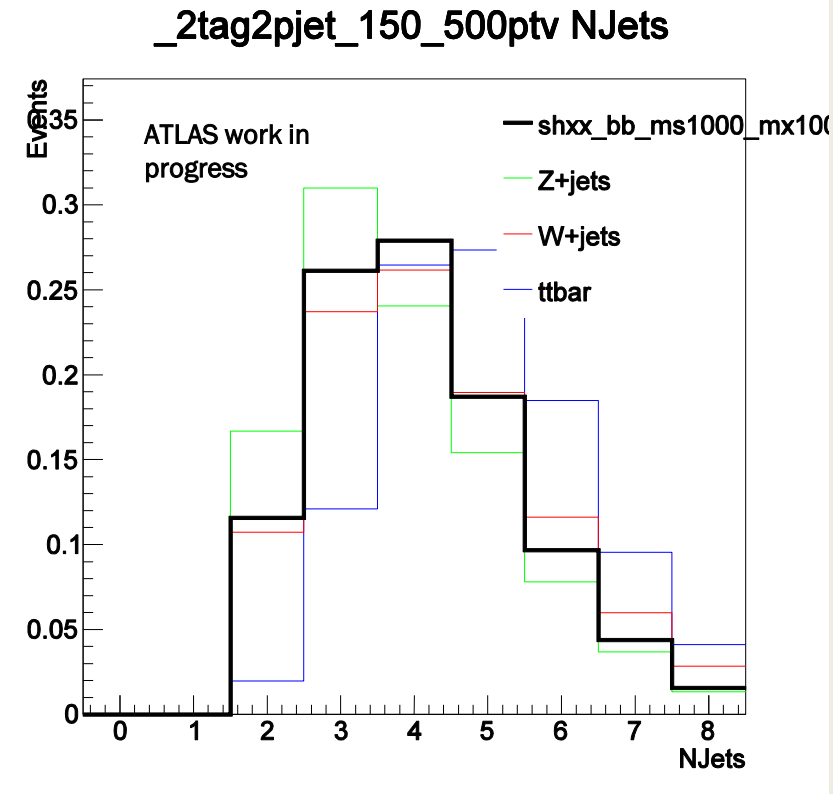
Cuts to suppress QCD background:

- Min[dϕ(MET,jets)] > 20° (Inverse of cut used for multijet background estimation) and dϕ(MET,MPT) < 90°
- Difference in MC/data is the multijet QCD background

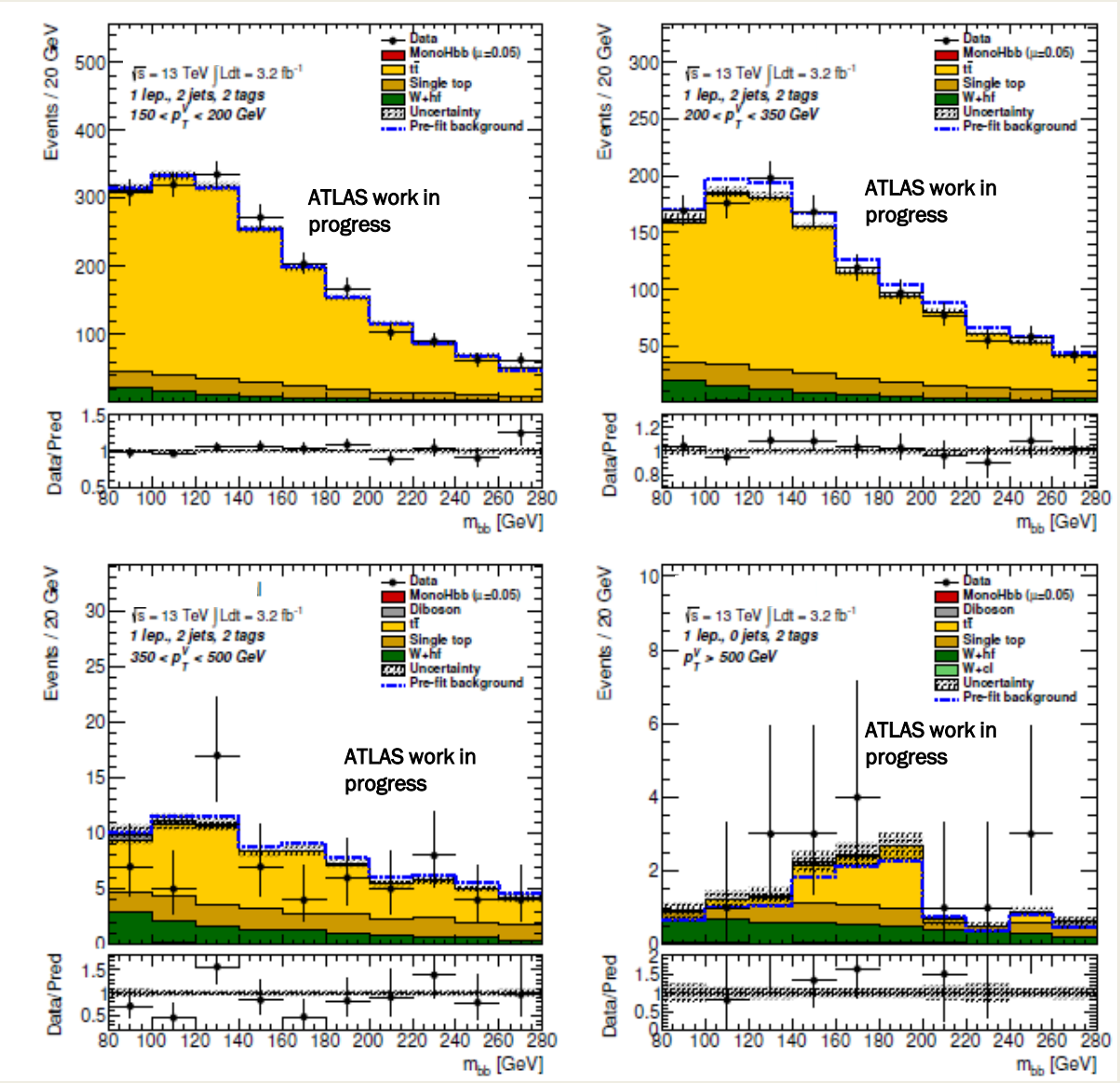


W+jets/$t\bar{t}$ Control Region

- We require exactly 1 muon in each event
- Apply the same analysis cuts as used on the signal region
  - *Look at the same phase space*
  - *MET needs to be substituted in all cuts with (MET+muon) – this is the proxy for the system which recoils from the Higgs*
- By looking at jet multiplicities, we can separate W+jets and $t\bar{t}$ events to some extent



Post-Fit Plots: W+jets/ $t\bar{t}$ Control Region

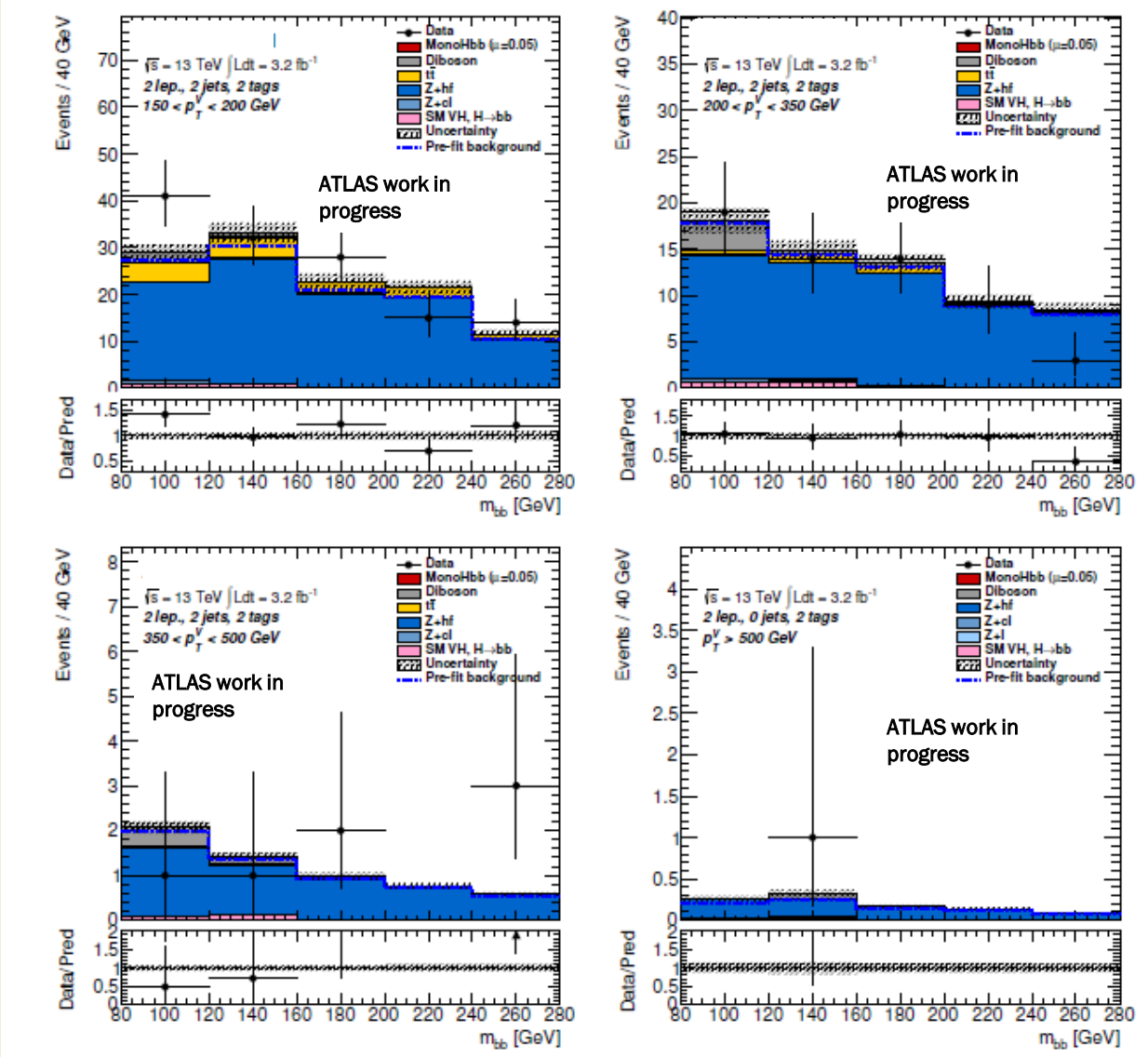


- m(BB) plots
- W+jets in green
- $t\bar{t}$ in yellow
- MET bins of:
  - *150-200GeV*
  - *200-350GeV*
  - *350-500GeV*
  - *>500GeV*

Z+jets Control Region

- Require exactly 2 electrons or 2 muons
- Use a range of lepton triggers in place of previously used MET trigger
- Apply same analysis cuts with following differences:
  - *MET is substituted in all cuts with (l+l), again as a proxy that recoils against the Higgs*
  - *Using pt(l+l) also reduces contributions from top backgrounds*
- We assume that the MC shape for Z+jets with 2 leptons in the event is the same as Z+jets with no leptons in the event

Post-Fit Plots: Z+jets Control Region

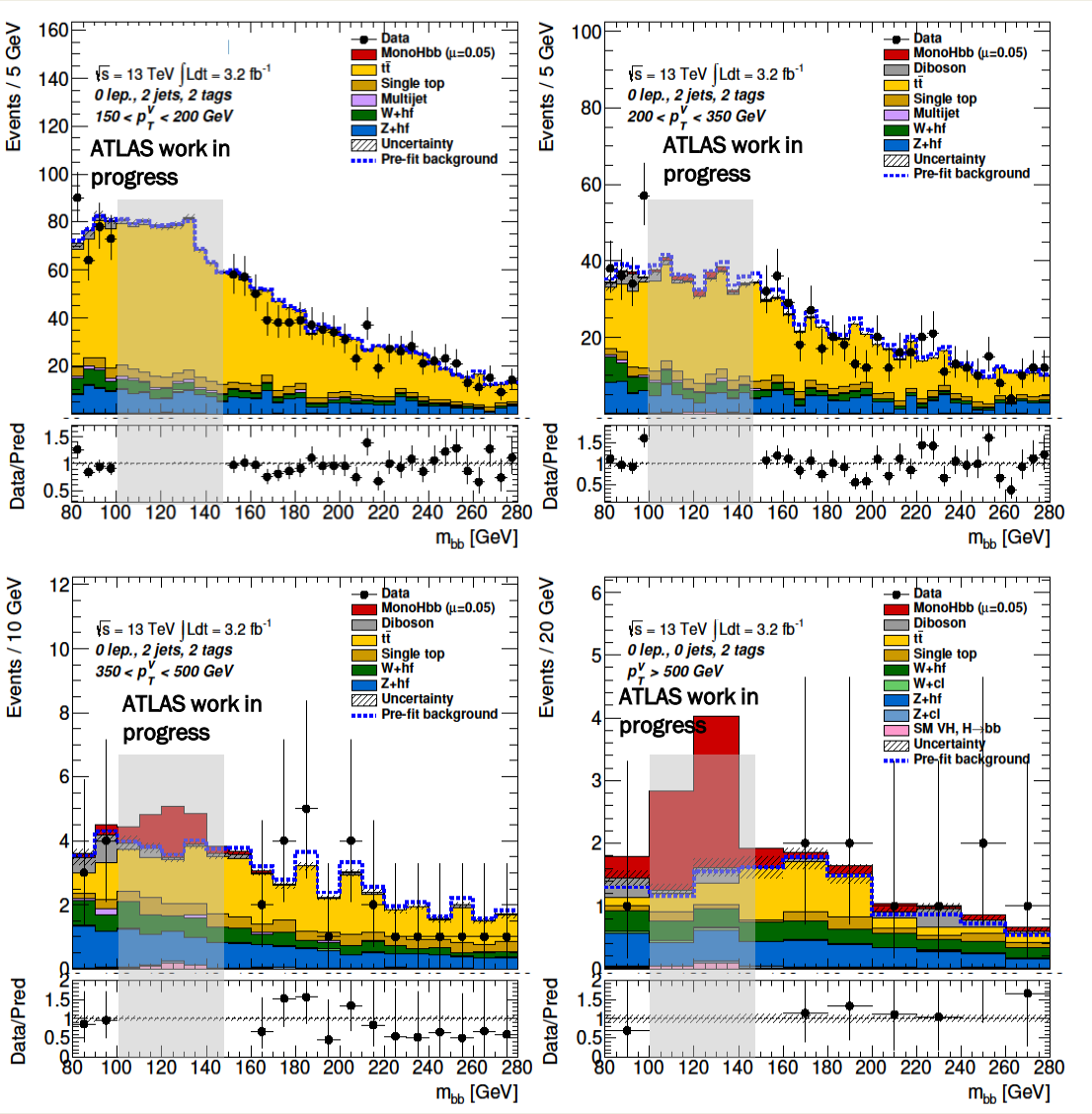


- m(BB) plots
- Z+jets in blue
- $t\bar{t}$ in yellow
- MET bins of:
  - *150-200GeV*
  - *200-350GeV*
  - *350-500GeV*
  - *>500GeV*

Fitting

- Combined profile likelihood fit to m(BB) distribution in control regions and signal region sidebands
- Fitting will be done to 3.2fb^{-1} of Run 2 data
- Regions split by:
  - *Signal and Control Regions*
  - *MET bins in order to improve sensitivity: 150-200GeV, 200-350GeV, 350-500GeV, 500+GeV*
  - *As mentioned previously, MET is defined as:*
    - MET for Signal Region
    - pT(MET+muon) for W+jets/$t\bar{t}$ Control Region
    - pT(ll) for Z+jets Control Region
- Fitting seeks to normalise the background processes ($t\bar{t}$, W+jets, Z+jets) – other backgrounds floated within uncertainties

Post-Fit Plots: Signal Region



- Blinding: m(BB)=[100,150] GeV.
- Black points show data, red bins show prefit signal model.
- Signal shown here is vector mediator simplified with m(DM) = 1 GeV and m(Z') = 2000 GeV
- The signals have arbitrary cross section before fit (here = 0.1fb)
- Different models have different normalisations and sensitivities. This one is angled toward high MET.

Summary and Conclusion

- Backgrounds fully modelled and understood
- Complete set of MC signals collected
- Background systematic uncertainties and scale factors accounted for
- Selections have been tried and tested, proved to give good convergence
- After unblinding, new limits can be produced including the first ever limits for the vector mediator simplified model