Search for Invisibly Decaying Vector Boson Fusion Produced Higgs Bosons with 139 fb^{-1} of *pp* collisions with the ATLAS Detector

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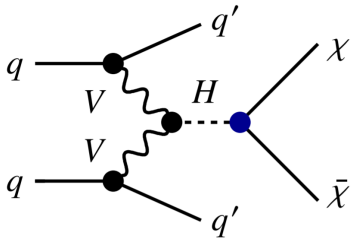
Motivation



- Distinctive topology: VBF jets and E_T^{miss}
- Direct probe of $\mathcal{B}_{H\to\text{inv.}}$
  - $\mathcal{B}_{H\to\text{inv.}}$ SM prediction: 0.13%
  - After considering Higgs couplings to SM particles,
    $\mathcal{B}_{\text{undet.}} < 0.12$ (0.31) obs (exp) [1]
    $\Rightarrow$ Room for BSM to hide

Previous results

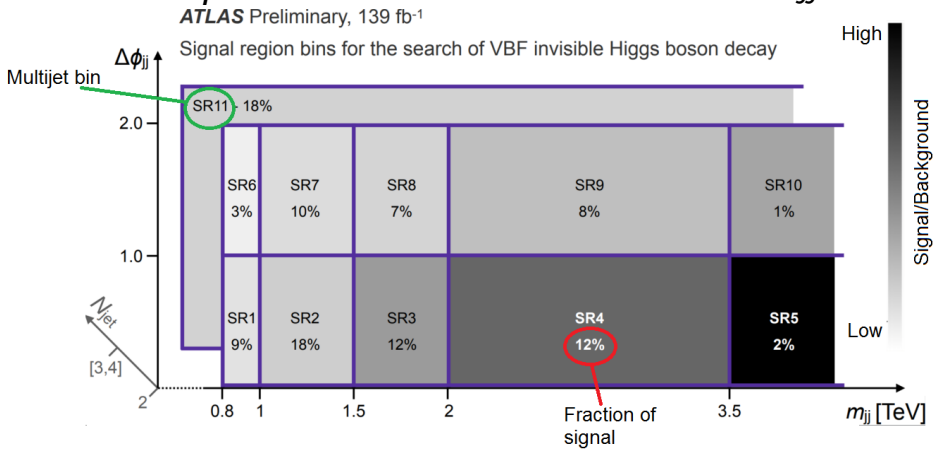
- **DM search**: Higgs portal dark matter
- 36 fb^{-1} VBF
  $\mathcal{B}_{H\to\text{inv.}} < 0.37$ (0.28) obs (exp) [2]
- VBF channel drives $\mathcal{B}_{H\to\text{inv.}}$ combination
  $\mathcal{B}_{H\to\text{inv.}} < 0.26$ (0.17) obs (exp) [3]

Analysis Improvements

- Improved lepton veto reducing W+jets
- Pileup discrimination with vertex tagging, jet timing
- Optimized binning, enhanced QCD multijet estimation
- Looser kinematic requirements

Some important selections:

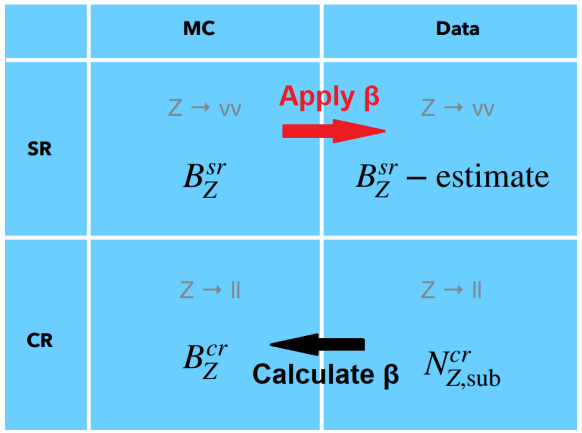
- MET triggered
- Large $E_T^{miss} > 200$ GeV
- Veto ℓ, γ
- Large $\Delta\eta_{jj} > 3.8$



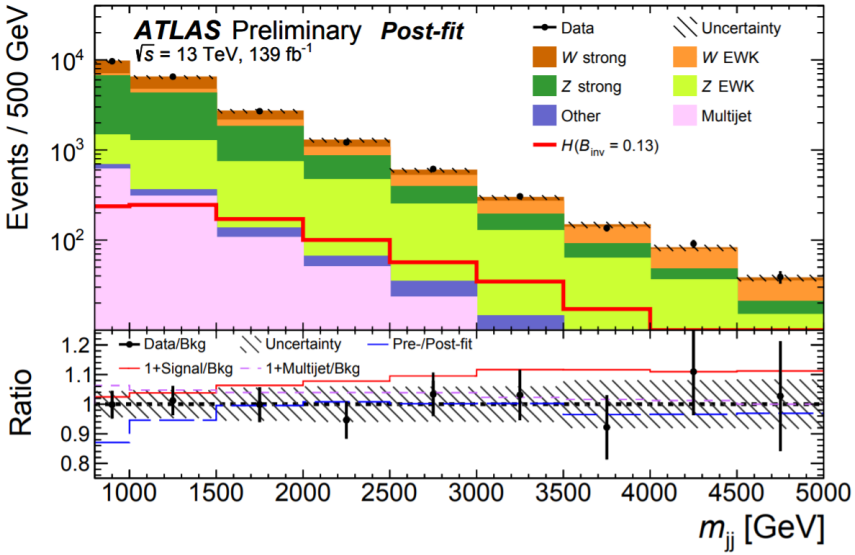
Backgrounds and Fit

- Dominant background = V+jets ($\sim 95\%$)
- Estimated in each bin with normalization factors from Z and W + jets control regions with detected lepton

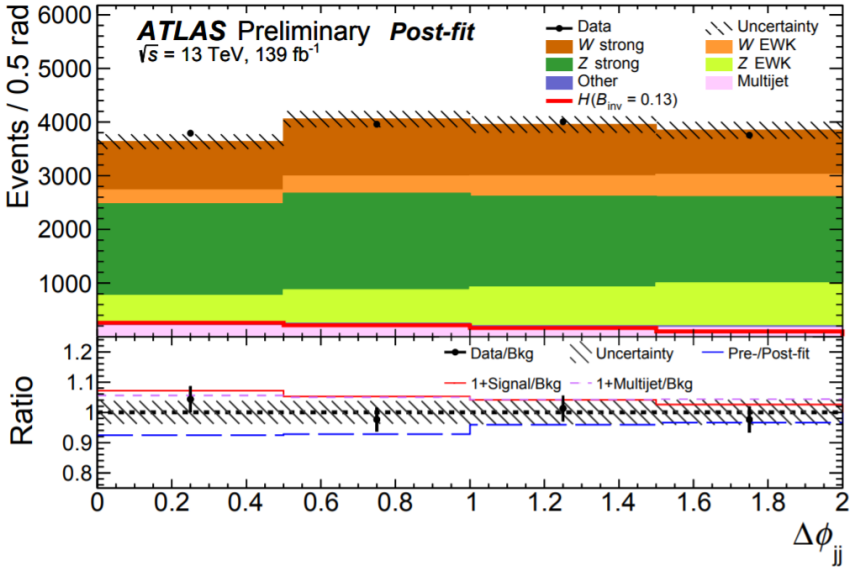
$$B^{\mathrm{SR}}_{Z,i} = B^{\mathrm{SR,MC}}_{Z,i} \cdot \underbrace{\frac{N^{\mathrm{ZCR}}_{i} - B^{\mathrm{ZCR}}_{\mathrm{non}\text{-}Z,i}}{B^{\mathrm{ZCR,\,MC}}_{Z,i}}}_{\beta_{Z,i}}$$



- Data-driven estimation techniques: QCD Multijet, $W \to e\nu$ (e fakes)
- Direct MC estimation: multiboson, $t\bar{t}$



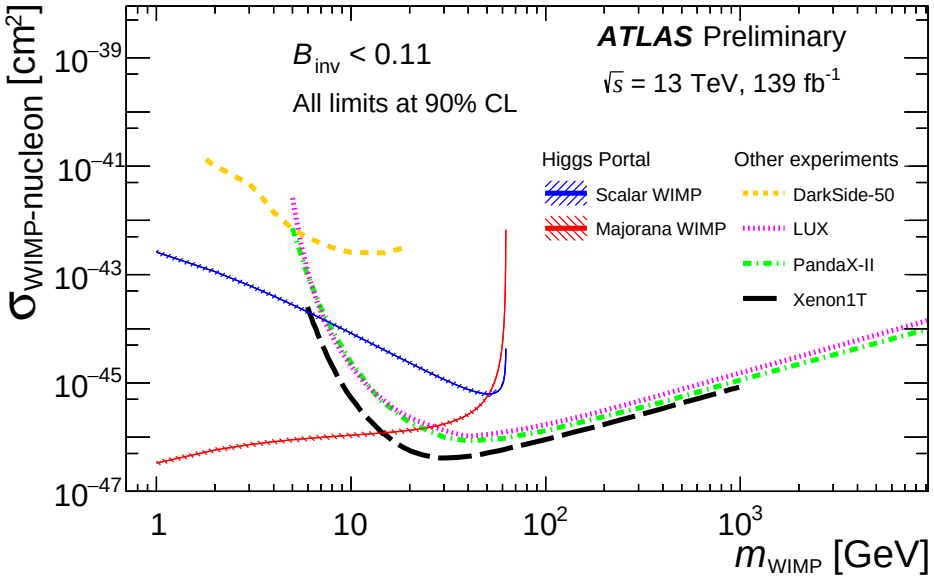
(Red) S/B increases with m_{jj} and at low $\Delta\phi_{jj}$



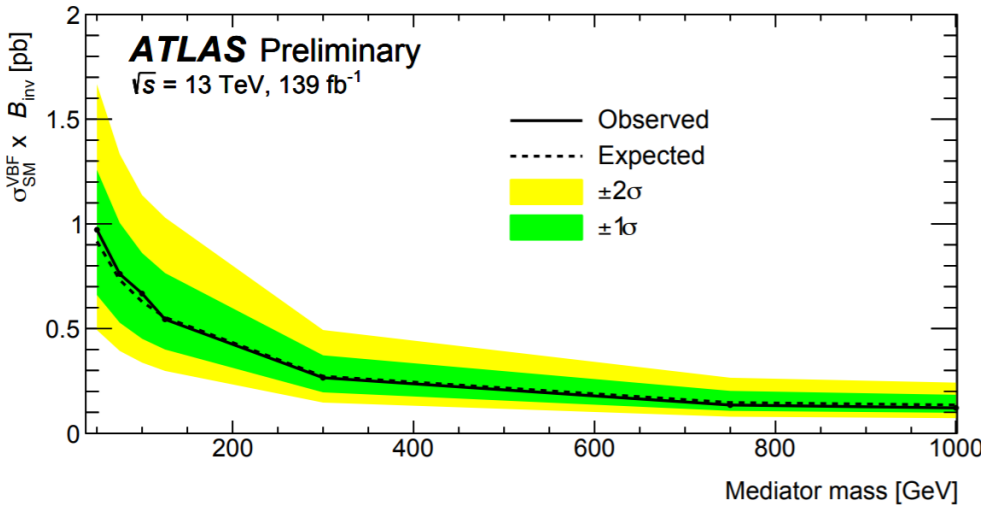
Results

$\mathcal{B}_{H\to\text{inv.}}$ Upper Limit at 95% CL

Observed	Expected	$+1\sigma$	-1σ	$+2\sigma$	-2σ
0.132	0.132	0.183	0.095	0.248	0.071



Analysis complementary to direct detection DM experiments



Consider $\sigma^{VBF} \times \mathcal{B}_{H\to\text{inv.}}$ with new heavy scalar mediator rather than SM Higgs

See additionally Searches for invisible Higgs boson decays at the ATLAS experiment talk today at 19:36