Prospects for $H \rightarrow$ Invisible with VBF+MET for Snowmass

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On behalf of the analysis team

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VBF+MET: Analysis overview

VBF signal selection

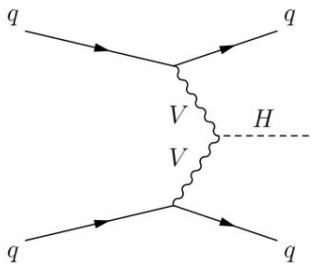
- Two jets with $p_T(j_1/j_2) > 80/50$ GeV.
- Small add. jet activity: $p_T(j_3) < 25$ GeV.
- Jets in opposite hemispheres.
- $\Delta\eta_{jj} > 3.8$.
- $m_{jj} > 0.8$ TeV

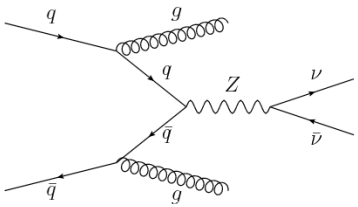
EWK veto

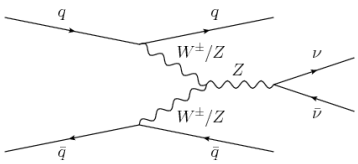
- Veto on $e^{\pm}$ and $\mu^{\pm}$

Multijets supression

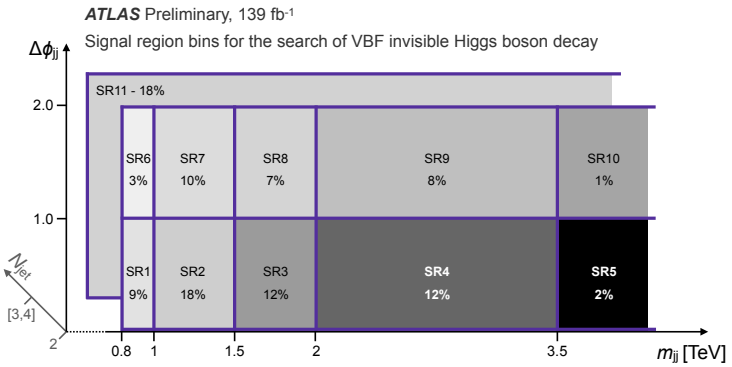
- $MET > 200$ GeV.
- $\Delta\phi_{jj} < 2.0$.

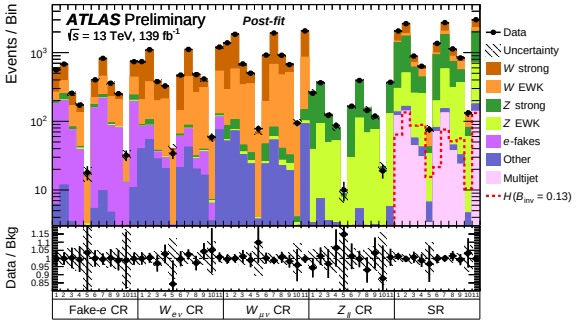






Run 2 results





Process	SR	$Z_{\ell\ell}$	$W_{e\nu}$	$W_{\mu\nu}$	$W_{\ell\nu}$	Fake-e CR
Tot. bg.	15 490 ± 130	2 065 ± 44	6 288 ± 75	11 130 ± 110	17 420 ± 150	4 300 ± 66
H (VBF)	647 ± 52	Predicted signal for $\mathcal{B}_{\text{inv}} = 13\%$ (observed limit)				
H (ggF)	90 ± 43					
H (VH)	0.81 ± 0.14					
Data	15 511	2 050	6 323	11 095	17 418	4 293

- Best observed (expected) limit 95% CL on branching ratio to invisible final states: 0.13 (0.13).
- Paper- draft https://cds.cern.ch/record/2789616/

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

Table 1: Expected and observed limits on $\mathcal{B}_{\text{inv}}$ for H=125 GeV at 95% CL with 139 fb^{-1}.

Study goal for Snowmass

Goal

- Projection of the current analysis in the LHC High Lumi (HL) condition.
- This required:
  - A better understanding of signal and background.
  - Good estimation of the systematics.

Ongoing Activities for HL-Projection study

- Smearing study.
- Limit projection.
- Multijet background estimate.

- The multijet backgrounds projection study is completed.
- The results have been already presented to the Physics Upgrade meeting: https://indico.cern.ch/event/1051932/.

Smearing study

Strategy

- Conduct a series of truth smearing to depict the detector in the HL-LHC condition.
- Truth level information is fed through a simulation of the upgraded detector.
  - → By making use of the performance function for high pileup conditions: https://twiki.cern.ch/twiki/bin/viewauth/AtlasProtected/UpgradePerformanceFunctions
- Objects that are smeared:
  - → $e^{\pm}$, γ, $\mu^{\pm}$, ν, $jets$.

Smearing validation

- For validation we compare:
  1. Smeared and reconstructed variables.
  2. Smeared and reconstructed cut-flow.
- After validation $\Rightarrow$ reweighting to 14 TeV.
- The smearing validation for VBF125 signal samples has been presented also to the physics upgrade meeting: https://indico.cern.ch/event/1093739/.

Systematic uncertainties projection to HL/LHC conditions

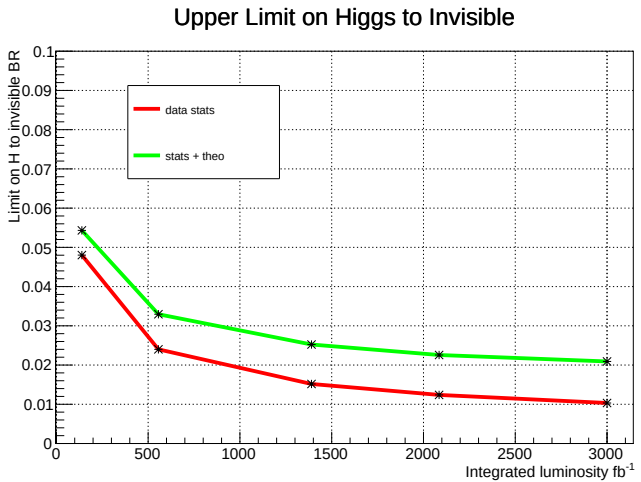
- Expected uncertainty on the integrated luminosity in Full HL-LHC ~ 1 %.
- Expected up to $\sim 2\%$ on the systematics uncertainty.
- Fit to data control region and signal region by scaling down with the projected systematics uncertainties.
- The projection of the systematics uncertainty can be fond in here: https://twiki.cern.ch/twiki/bin/viewauth/AtlasProtected/HighLumiLhcSystematics2018

Limit projection to HL-LHC conditions

Approach

- Scaled background and signal prediction as a function of luminosity.
- Estimate the sensitivity at higher luminosity conditions.
- Two different cases are considered for now:
  - data Stats only.
  - data statistics + 0.5*theo systematics.

- For the 3000 fb^{-1}.
  - With correlated theory + MJ: 1.9% mjj shape fit $\Rightarrow$ 2.1%, with reco systematics in the optimistic scenario.
  - For the non-shape fit (bin-by-bin NFs), the 2.8% $\Rightarrow$ 3.1% with reco systematics.



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