VBF produced Higgs decays to invisible final states at CMS

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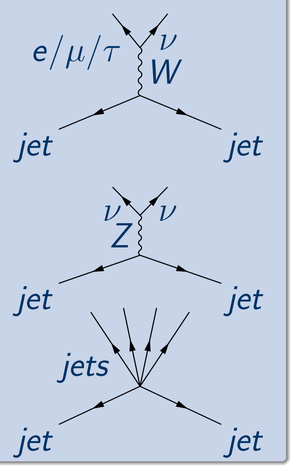
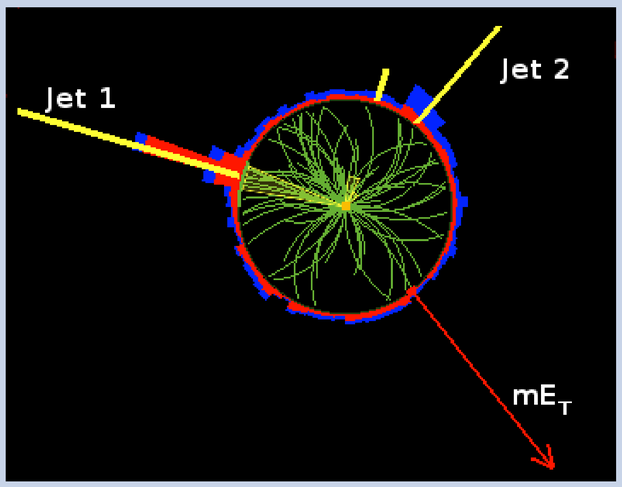
Why VBF Higgs to invisible?

- Many beyond the Standard Model theories predict significant invisible branching fractions, BF(inv), for the Higgs boson:
  - SUSY, extra dimensions, dark matter, etc.
- The only signature is the other particles produced with the Higgs, so associated production is necessary.
- Vector Boson Fusion (VBF) production's distinctive topology makes it the most promising channel:
  - the expected limit on BF(inv) is 53% compared to 84% (ATLAS) and 91% (CMS) from ZH.

Main backgrounds

- Leptonic W + jets:
  - reduced by lepton veto,
  - remaining contribution where lepton is missed,
- $Z \to \nu\nu$ + jets:
  - irreducible.
- QCD multijets:
  - reduced by central jet veto and jet topology cuts.





Measurement strategy

- Perform a counting experiment.
- Select distinctive VBF topology:
  - 2 jets with a large pseudorapidity separation,
  - veto events with central jets or any leptons.
- Require missing transverse energy, which is expected due to the invisible final state.
- Use hard cuts to restrict backgrounds.
- Use data driven methods to estimate remaining backgrounds:
  - MC yields cannot be trusted due to hard cuts.

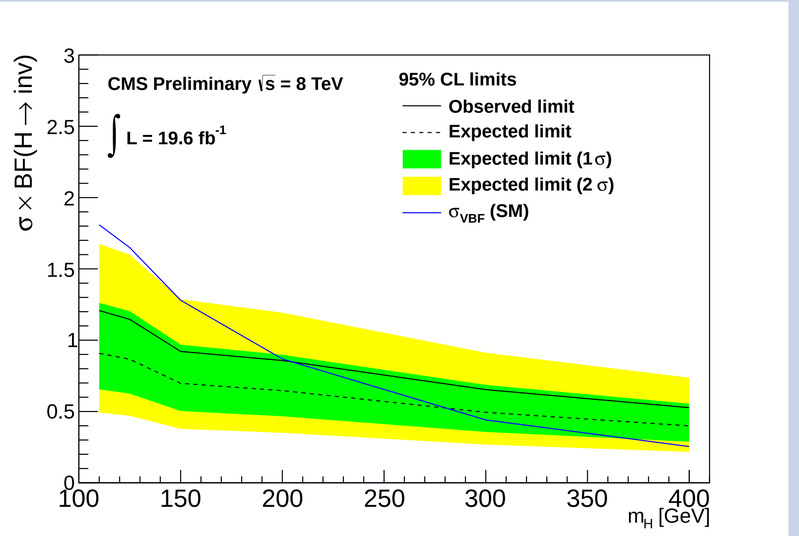
Leptonic W+jets background estimation

- We use a data driven method:
  - A control region enriched in W+jets events is chosen
  - The MC ratio between the signal and control regions is used to extrapolate to the signal region:

$$N^{signal}_{W\to l\nu} = (N^{control}_{obs} - N^{control}_{bkg}) \cdot \frac{N^{signal}_{W_{MC}}}{N^{control}_{W_{MC}}}$$

- For $W \to e/\mu\nu$ the control region is the signal region with the lepton veto reversed.
- For $W \to \tau\nu$ the control region is the signal region without the central jet veto and with a hadronic tau requirement.

Results



- We predict 339 $\pm$ 36 (stat.)$\pm$50 (syst.) events and we observe 390:
  - this corresponds to a 69% limit on BF(inv) for a 125 GeV Higgs boson at 95% C.L.

Conclusion and future work

- First ever limit on invisible branching fraction of VBF produced Higgs boson:
  - compatible with the standard model.
- We have additional 'parked' data with lower trigger thresholds that is yet to be analysed:
  - this should give more events in our control regions and thus reduce the errors on our background estimation.

- I would like to thank my supervisors David Colling and Gavin Davies and the members of my analysis group, particularly Anne-Marie Magnan and Andrew Gilbert, for the help they have given me, and the STFC for funding my work.
- More information can be found in CMS PAS HIG-13-013.