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Combination of Higgs to Invisible Direct Measurements

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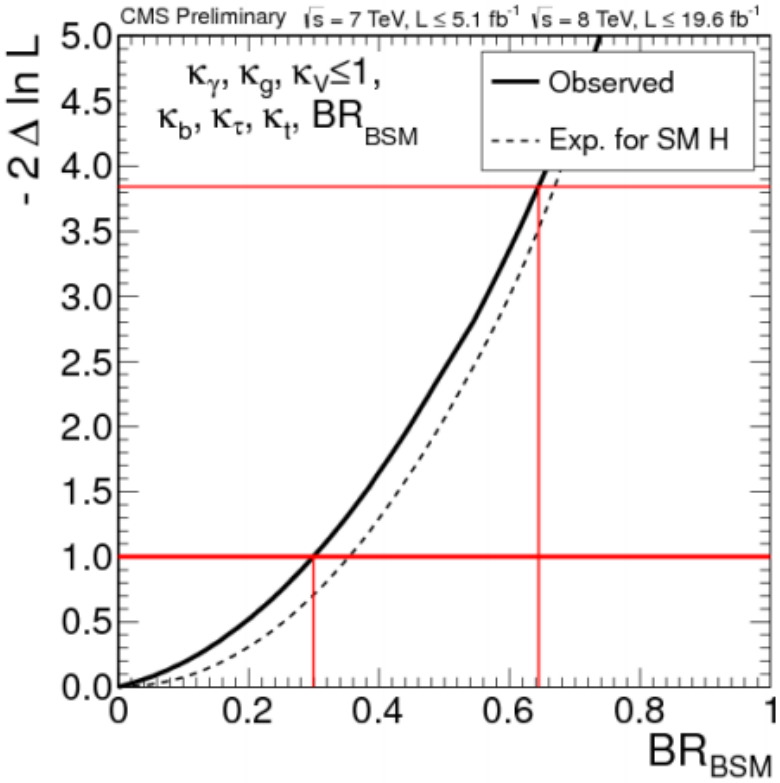
Introduction

- Decays of the Higgs boson to invisible final states are a strong indication of BSM physics
  - SUSY, graviscalars, etc.
- Because the final state is invisible the search must be carried out in the associated production channels:
  - Search for large missing transverse energy plus associated production

Analyses

- There are two currently approved CMS analyses searching for invisible final states of the Higgs boson.
  - HIG-13-013, VBF production
  - HIG-13-018, ZH channel where the Z decays to 2 leptons
- A further analysis, HIG-13-028, in the ZH channel where the Z decays to 2 b quarks is in progress
- An indirect limit can also be placed using the signal strength of the visible channels
  - Combination between direct and indirect methods is being investigated e.g. talk by M. Zanetti

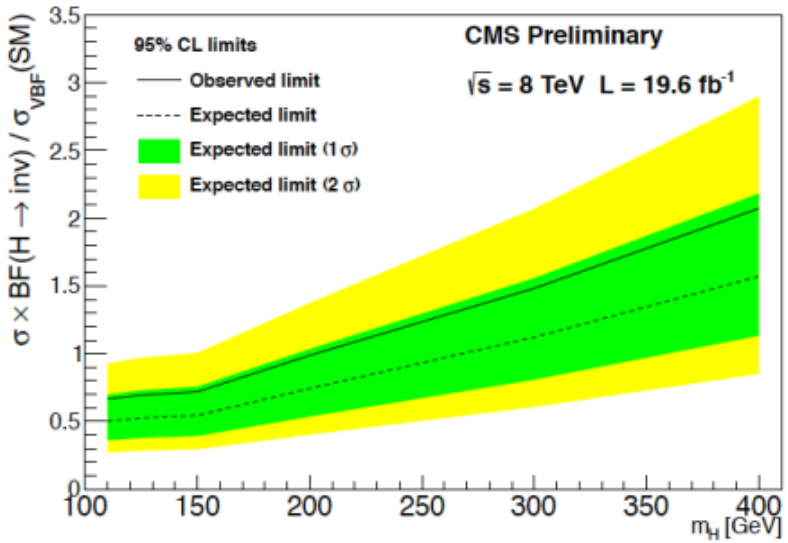
Current Indirect Result



- observed (expected) limit of 64% (67%) at 95% C.L. on BR_{inv} for a 125 GeV Higgs

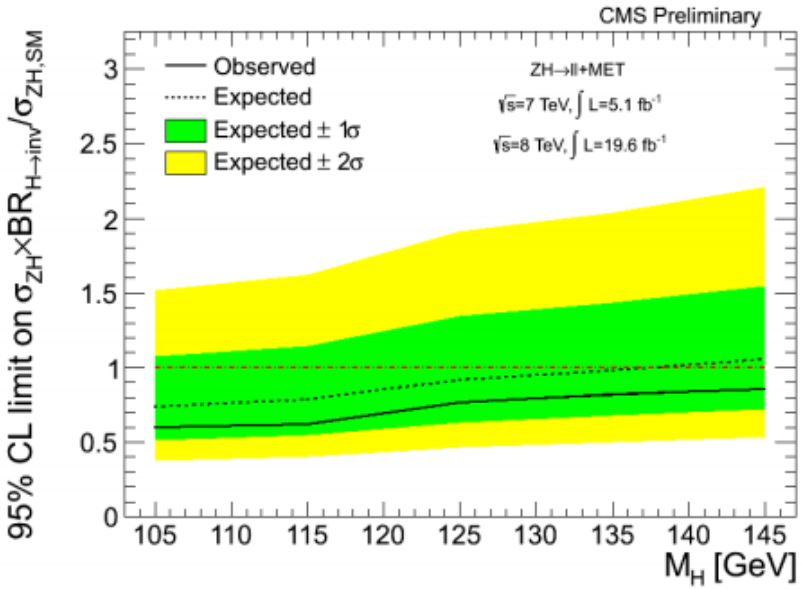
Individual Results: Direct

- VBF



- observed (expected) limit of 69% (53%) at 95% C.L. on BR_{inv} for a 125 GeV Higgs

- ZH



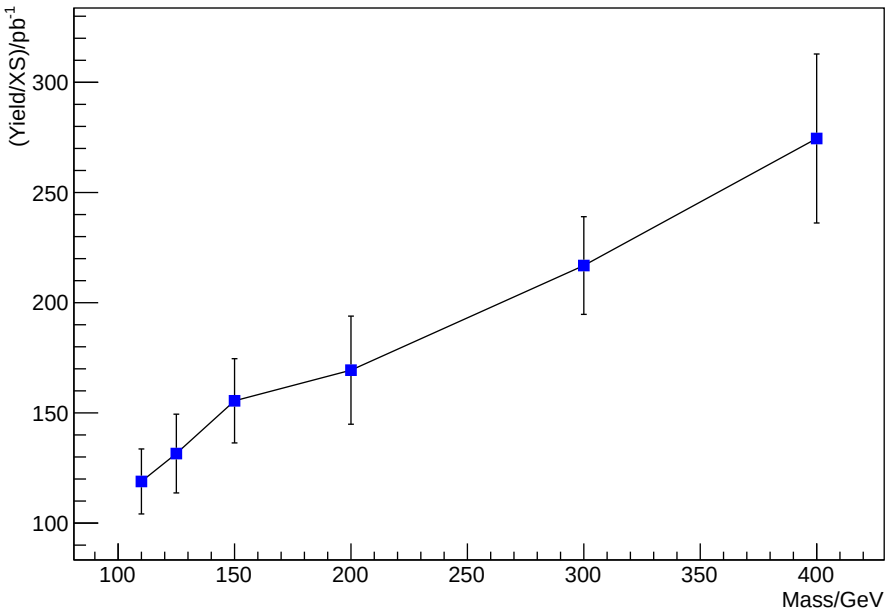
- observed (expected) limit of 75% (91%) at 95% C.L. on BR_{inv} for a 125 GeV Higgs

Datacards

- ZH analysis (cards from M. Zanetti) has datacards for 105,115,125,135 and 145 GeV
- VBF analysis has datacards for 110,125,150,200,300 and 400 GeV
- The signal yield is the only Higgs mass dependent part of the datacard
- New VBF datacards were produced for 115,135 and 145 GeV, with signal yields caluclated using method on the next slide

Signal Yield interpolation

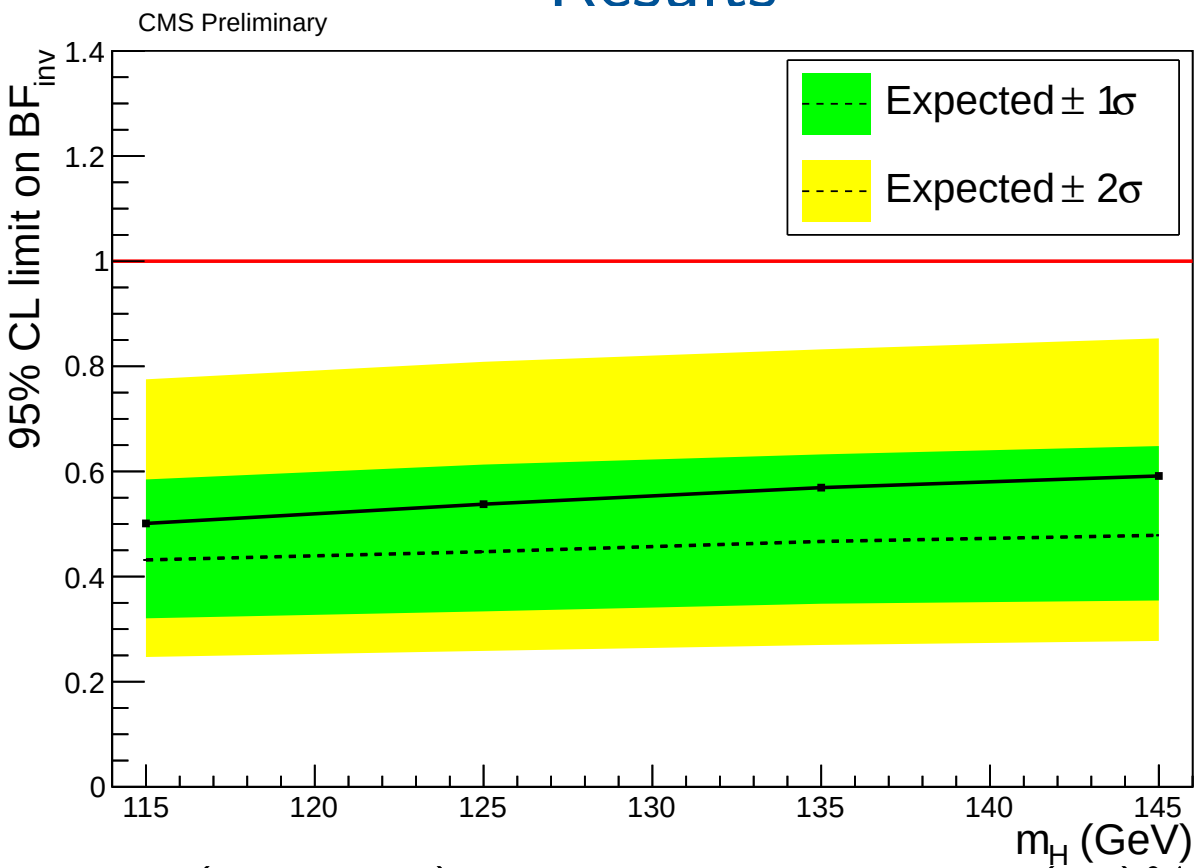
- $N_{Signal} = eff. \times acc. \times \mathcal{L}\sigma$
- Luminosity is constant
- Yield over cross-section is thus proportional to efficiency times acceptance
- Signal yields were produced at 115, 125(to cross-check), 135 and 145 GeV for the VBF channel
  - Cross-sections from LHC-HXSWG were used



Combination Method

- The cards for the two approved analyses were combined using the standard Higgs combination tool
- The luminosity uncertainties were considered correlated between the analyses
- All other uncertainties were considered not to be correlated between analyses
- The VBF analysis datacard does not separate out individual sources of error so JES/R correlations cannot be taken into account without more information

Results



- Observed (expected) limit at 125 GeV is 54(45)%
- Consistent with number from M. Zanetti's talk 56(47)%

Conclusions

- The results of HIG-13-013 and HIG-13-018 have been combined using the standard Higgs combination tool
- The result is compatible with the SM at the 1σ level
- The combined result gives strongest direct limit on the invisible branching fraction of the SM Higgs
  - Values at 125 GeV in agreement with that shown by M. Zanetti

Backup

Previous Limits

- Current CMS limits on BR_{inv} for a 125 GeV Higgs boson are:
  - VBF: observed (expected) limit of 69% (53%) at 95% C.L.
  - ZH: observed (expected) limit of 75% (91%) at 95% C.L.
  - CMS indirect limit, from visible channels: observed (expected) limit of 64% (67%) at 95% C.L.
- ATLAS also produce an indirect limit and a limit in the ZH channel:
  - Indirect limit 60% (no expected limit given)
  - ZH: observed (expected) 65% (84%)

VBF Cross-sections

Mass/GeV	σ/pb
110	1.809 ± 0.048
115	1.729 ± 0.046
125	1.578 ± 0.042
135	1.448 ± 0.038
145	1.333 ± 0.035
150	1.280 ± 0.033
200	0.869 ± 0.023
300	0.441 ± 0.011
400	0.254 ± 0.007