Imperial College London

Latest results on invisibly decaying Higgs bosons

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on behalf of the ATLAS and CMS Collaborations
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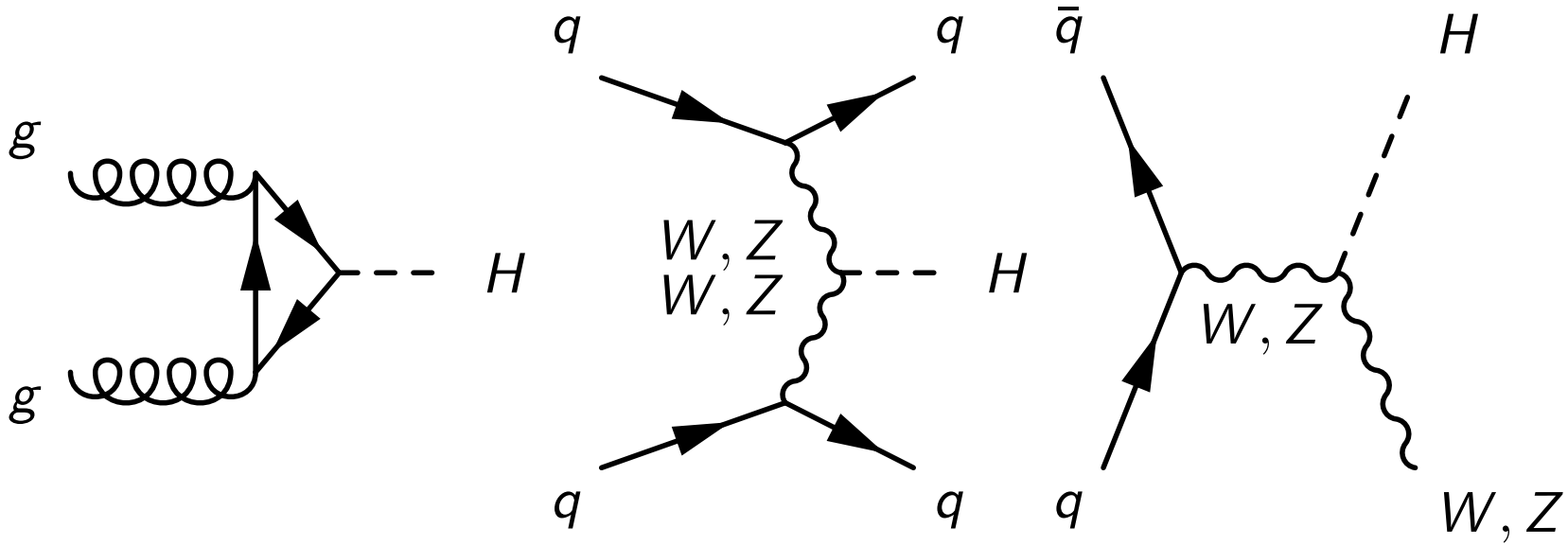


Outline

- How to search for invisibly decaying Higgs bosons:
  - direct and indirect searches
- Run 1 results from ATLAS and CMS
- Run 2 results from CMS
- Projections of future sensitivity

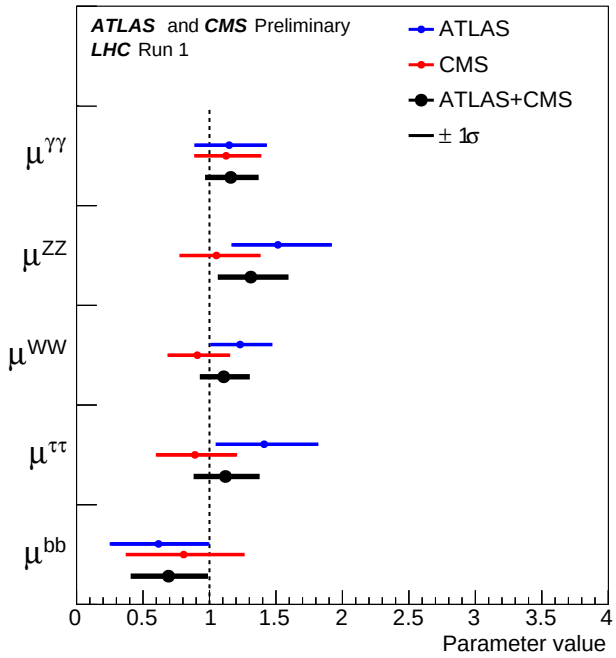
Why look for invisibly decaying Higgs bosons?

Theoretical Motivations

- All SM massive particles get their mass through Higgs boson couplings
- Why not dark matter?

Experimental motivation

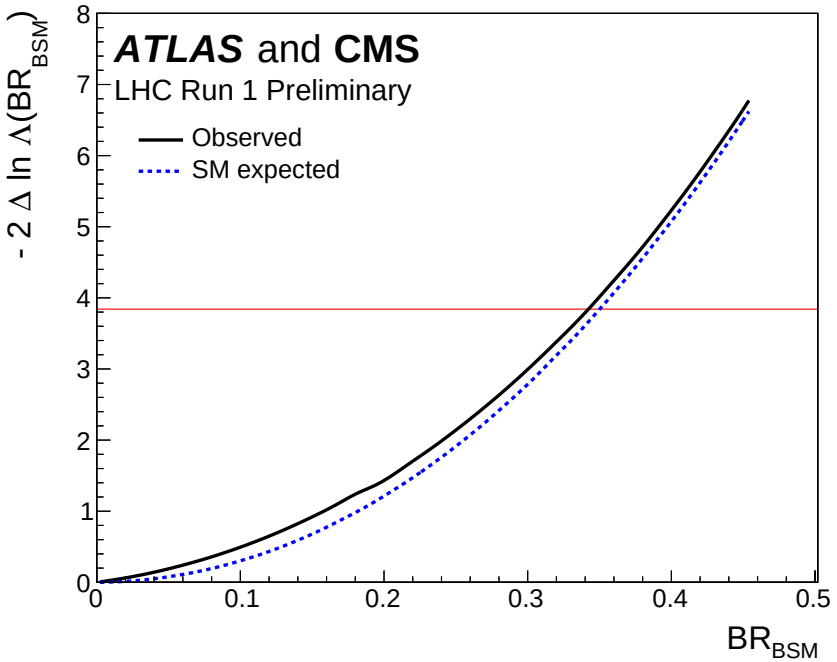
- Measurements of the Higgs boson made so far are impressive:
  - Mass measured with 0.2% error
- A lot of parameters are still relatively unconstrained:
  - Limit on width is $\sim 4\Gamma_{SM}$
- Plenty of room for Higgs boson couplings to dark matter



How to search for invisibly decaying Higgs bosons

Indirect searches

- Compare visible width to total width:
  - $\mathrm{BR_{BSM}} = \frac{\Gamma_H - \Gamma_{vis}}{\Gamma_H}$
- No measurement of Γ_H, need to make an assumption
  - Usually assume SM width
- ATLAS+CMS combination gives an observed (expected) limit on $\mathrm{BR_{BSM}}$ of 0.34 (0.35) at 95% CL



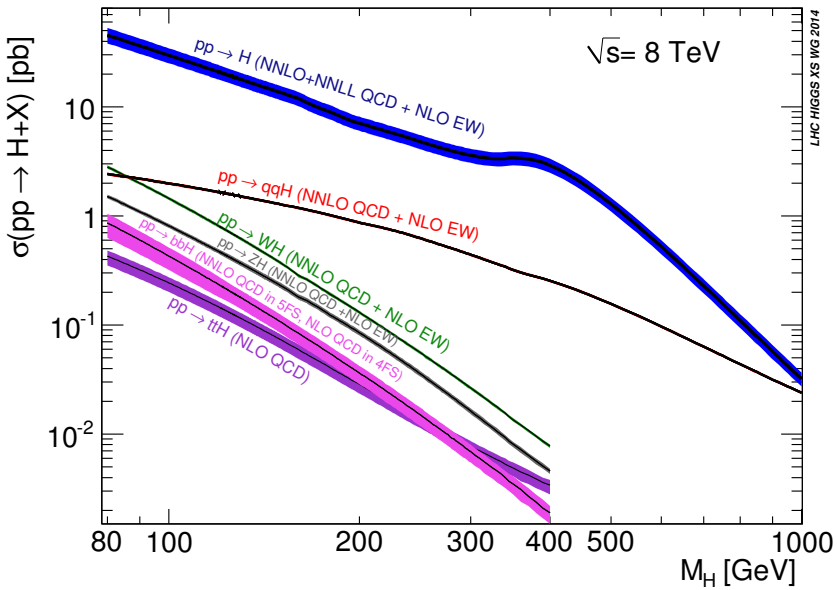
CMS-PAS-HIG-15-002
ATLAS-CONF-2015-044

How to search for invisibly decaying Higgs bosons

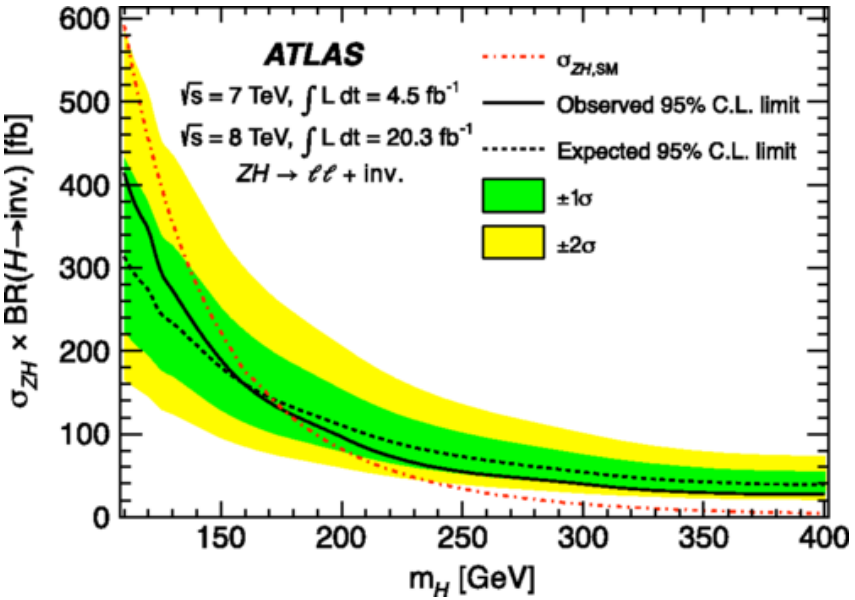
- Look for associated Higgs boson products plus E_T^{miss}

Production channels

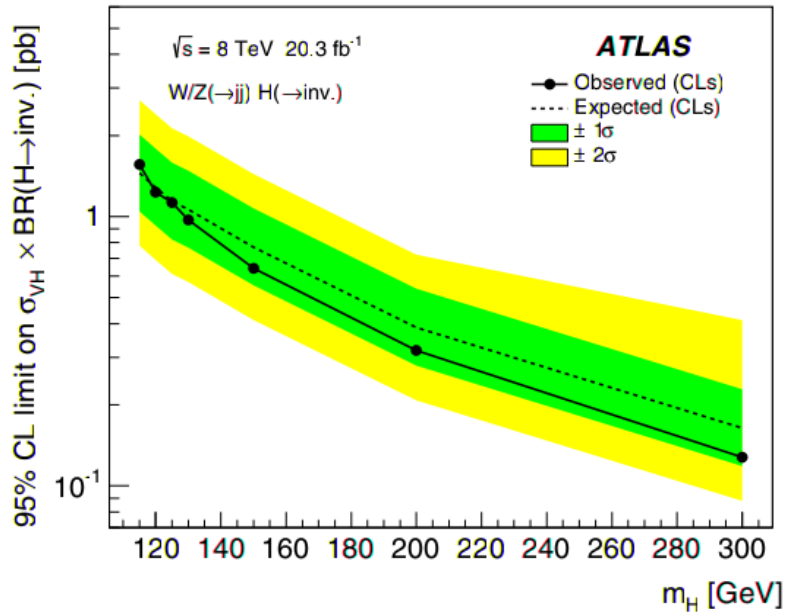
- VBF mode is most sensitive
  - Second highest rate and distinctive topology
- Gluon fusion has no visible products, needs ISR
  - High rate, difficult final state
- VH has clean final states but low rate



Run 1 ATLAS direct searches - ZH



Run 1 ATLAS direct searches - V(had)H



Run 1 ATLAS direct searches - VBF

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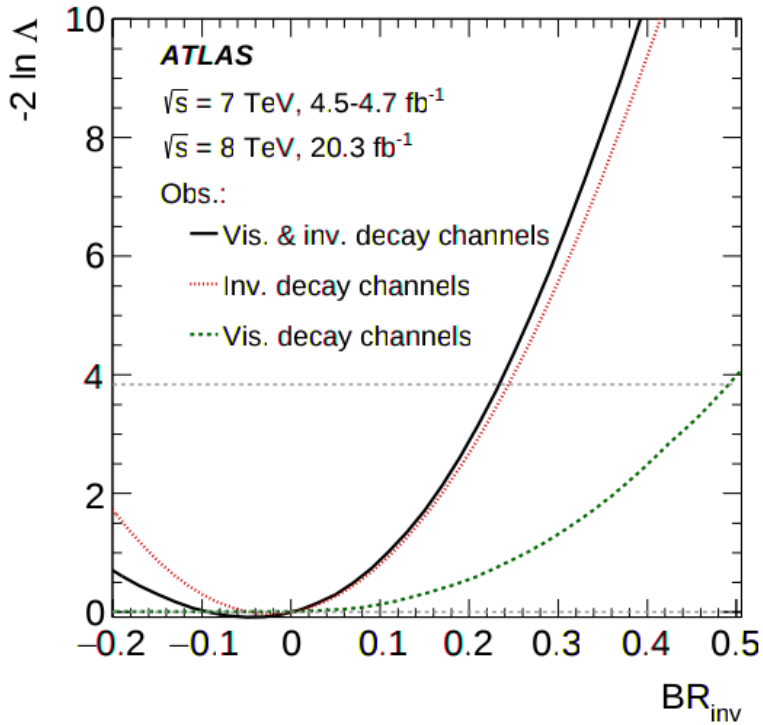
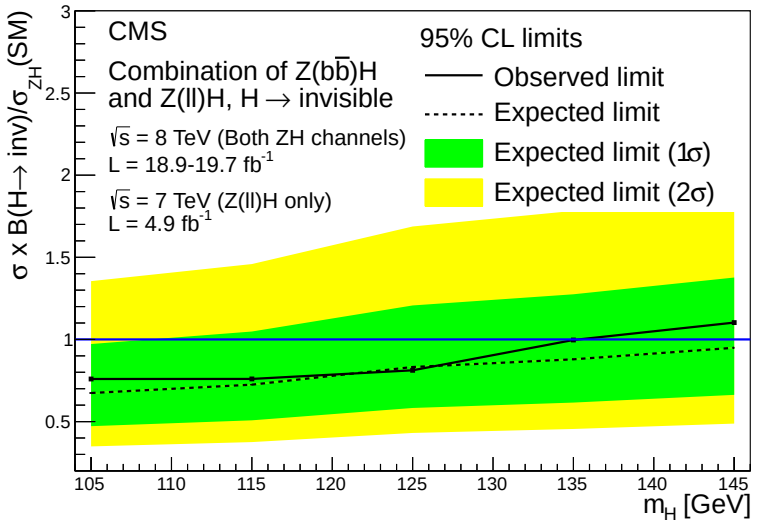
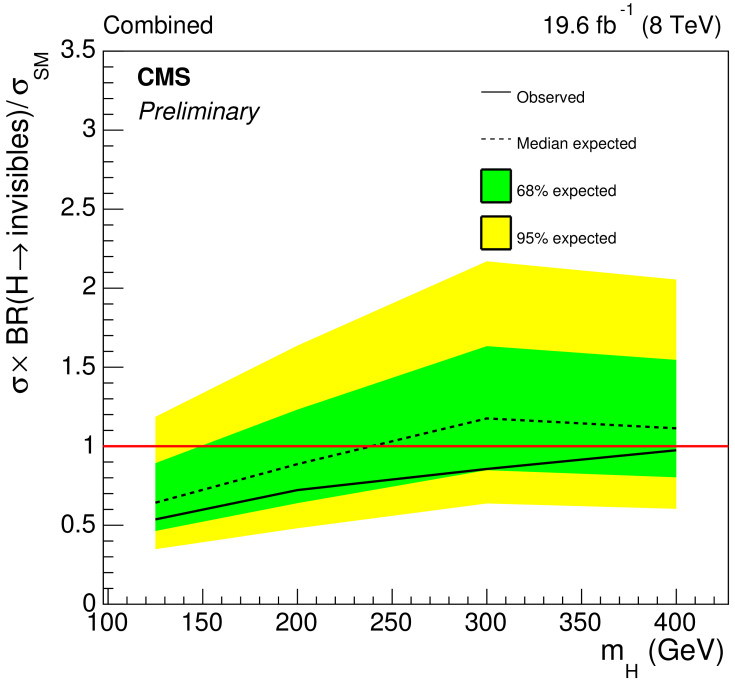
Run 1 ATLAS direct searches - Combination



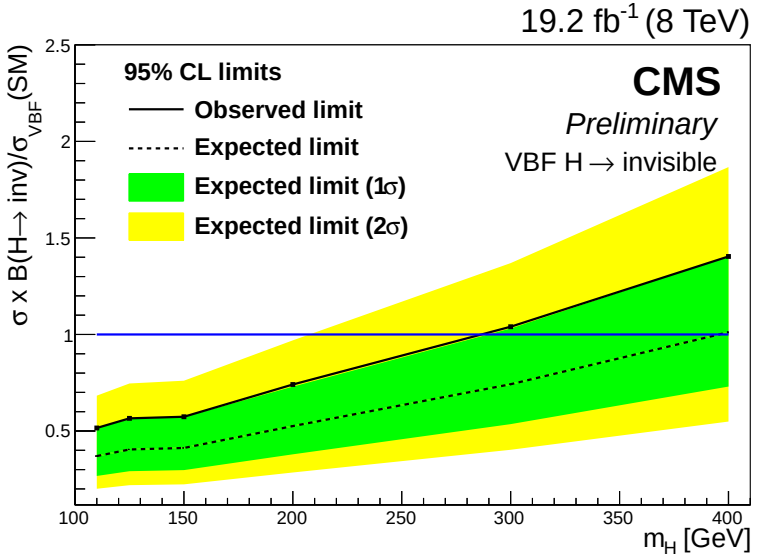
Run 1 CMS direct searches - ZH



Run 1 CMS direct searches - Monojet+V(had)H



Run 1 CMS direct searches - VBF



Run 1 CMS direct searches - Combination

- Combine by production mode as well as full combination
  - ggH-tagged is monojet, VH-tagged is Z($\ell\ell$)H+Z(bb)H+V(had)H, VBF-tagged is VBF
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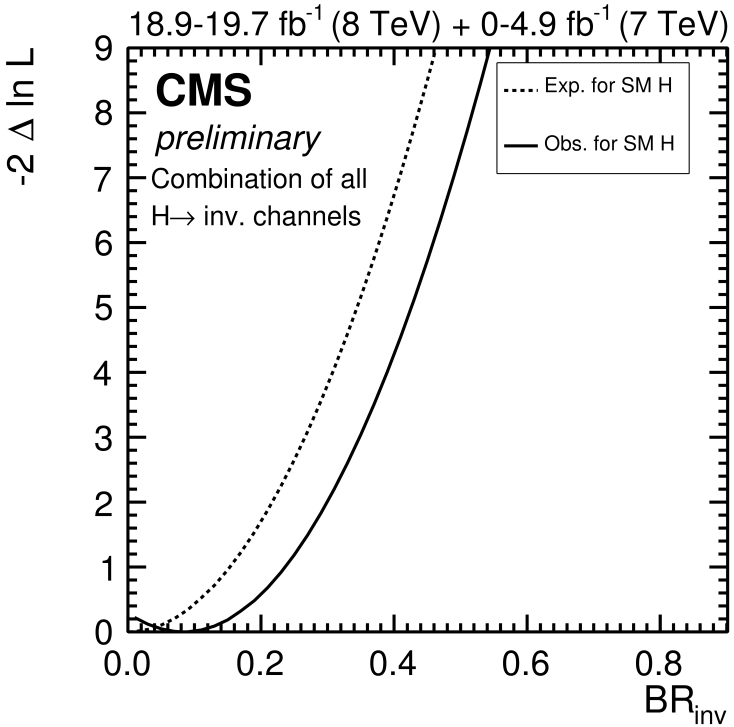
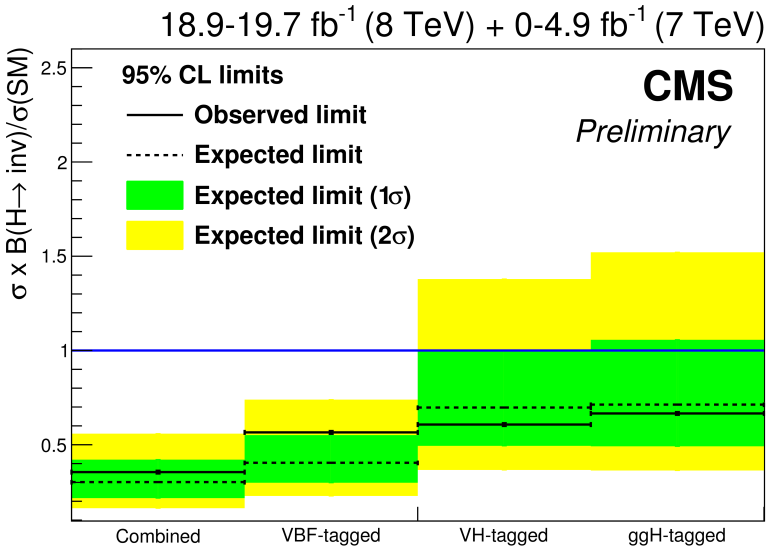
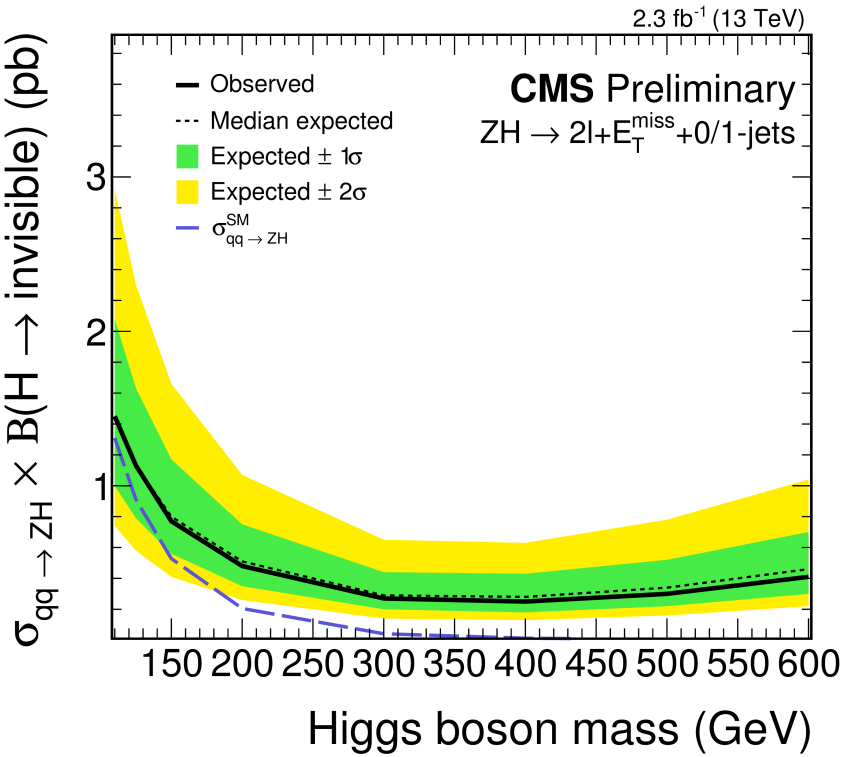




Run 2 CMS direct searches - ZH



Run 2 CMS direct searches - VBF

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Run 2 CMS direct searches - Combination

Projections

- CMS VBF analysis projected to increased luminosity at 13 TeV
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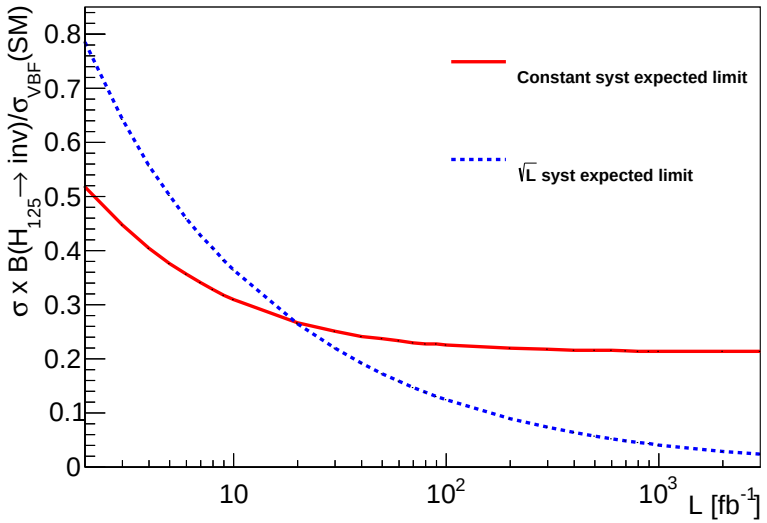
- If systematics scale as $\sqrt{\mathcal{L}}$ can exclude $\mathcal{B}(H \to inv.) = 5\%$ with full LHC dataset



Dark matter interpretations

Summary

- Both collaborations are sensitive to $\mathcal{B}(H \to inv.) \sim 25\%$ with current datasets
- Current 95% CL upper observed (expected) limits are CMS: , ATLAS:
- Combinations of channels allow sensitivity to be greatly improved
- Projected limit on $\mathcal{B}(H \to inv.)$ ~10-20% from VBF alone by the end of LHC Run 2 and 5% by end of LHC running