Invisible Higgs Decays

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US LHC Users' Association Lightning Round
Nov. 4th, 2016

What we know about the Higgs

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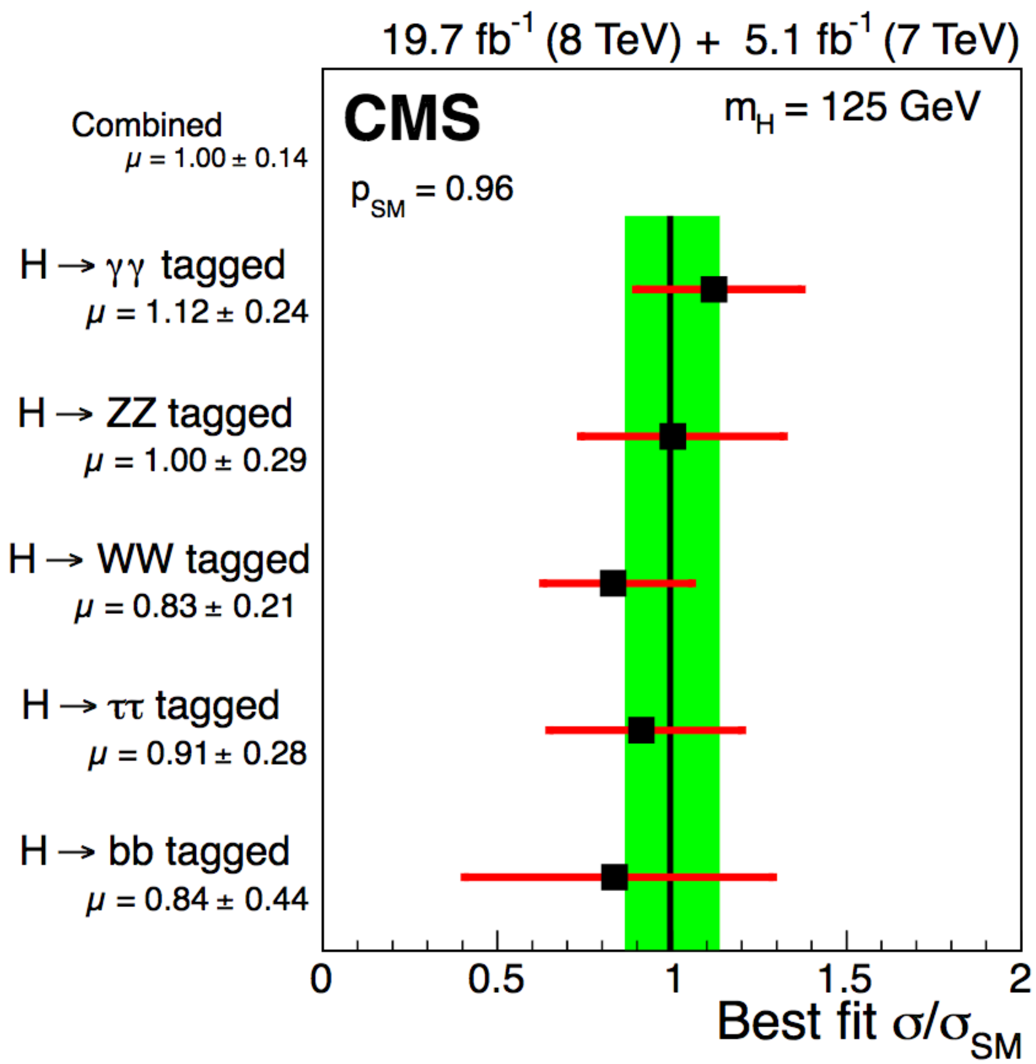
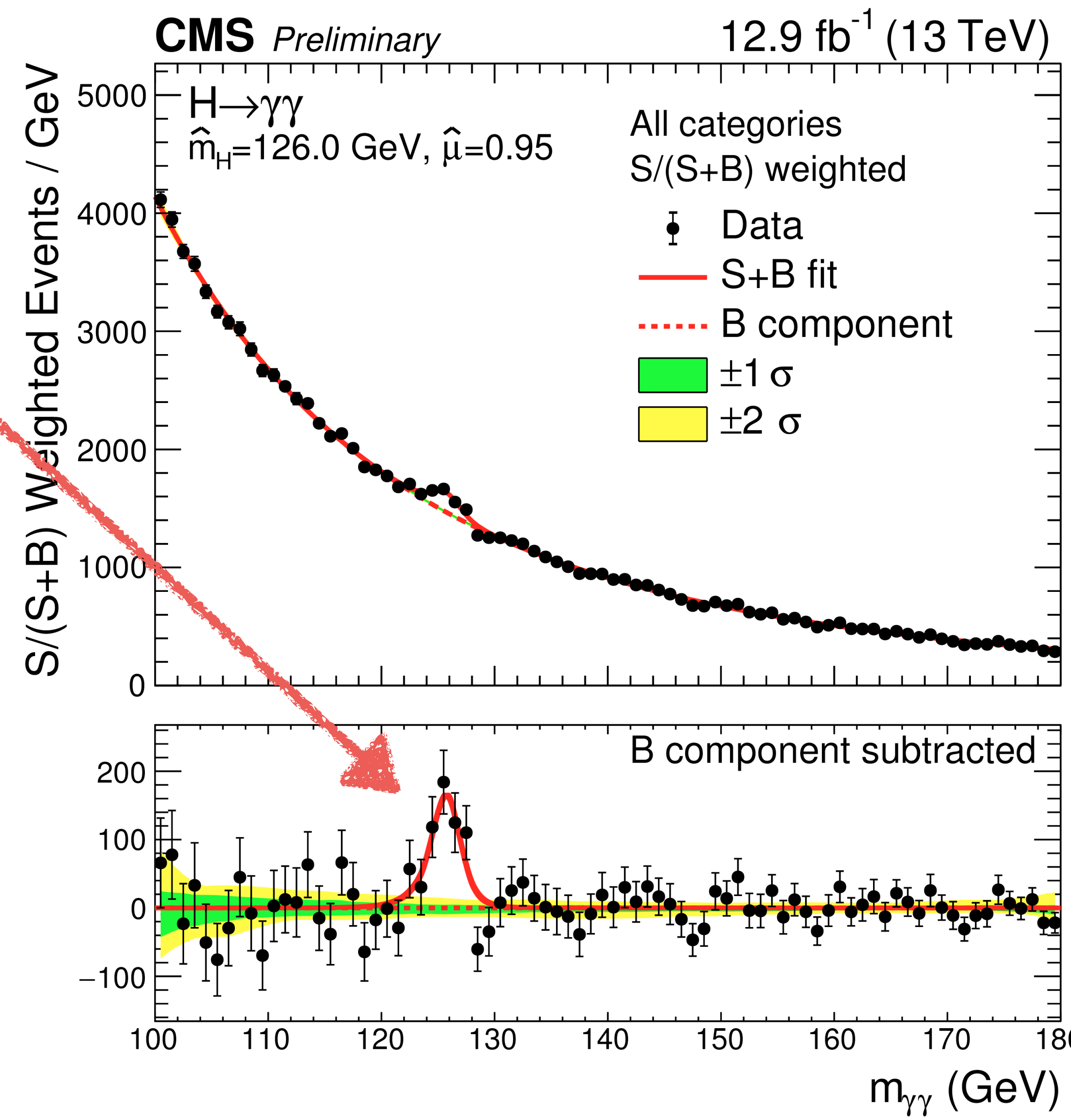
- Discovered in 2012
- Re-discovered* in 2016!
- Appears 'standard'
  - Large uncertainties remain



arXiv:1412.8662



CMS-PAS-HIG-16-020

* ICHEP result: ZZ & γγ channels both >6σ

What the Higgs can tell us

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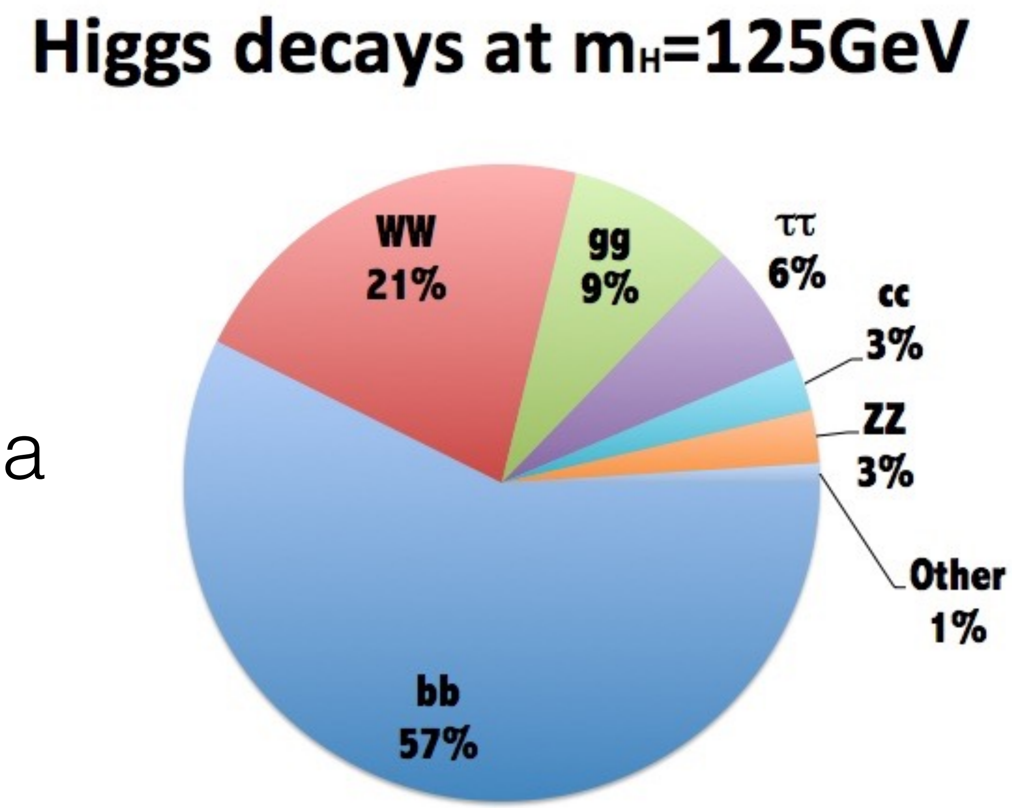
Standard Model Higgs couplings predict:

- Higgs Production Modes
- Higgs Decays

Combined predictions <u>strengthen</u> belief that a SM Higgs boson was discovered



But are the SM Higgs couplings the only ones?

Investigate by looking for:

- Anomalous SM couplings
- Invisible Higgs decays

+  ?

Use the Higgs boson as a new tool for discovery

The Higgs as a Dark Matter Portal

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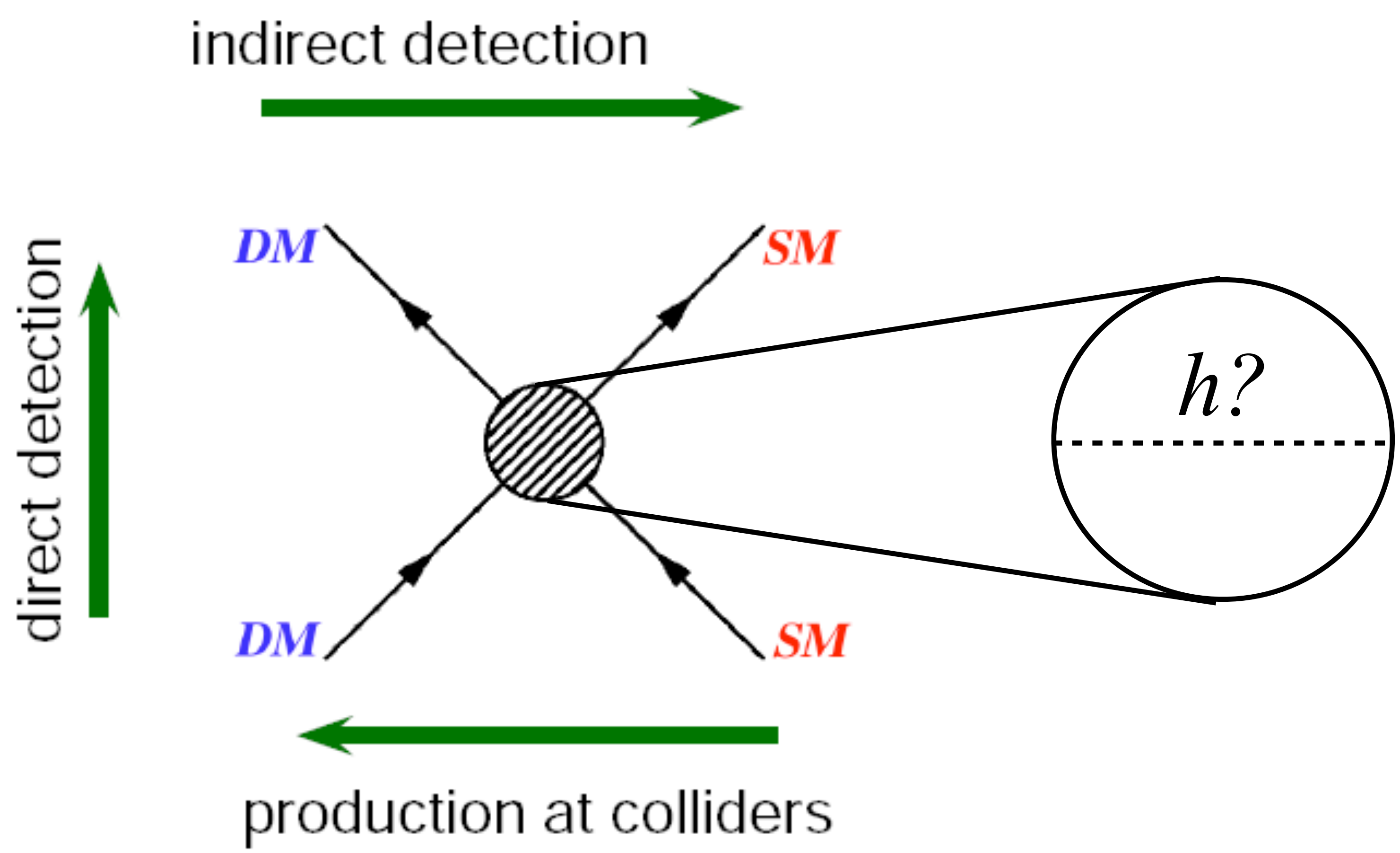
Special case BSM prediction:

Does the Higgs connect the Standard Model to dark matter?



http://rejuvenatte.blogspot.com

Identify the new physics of dark matter

Seeing Invisible Higgs Decays

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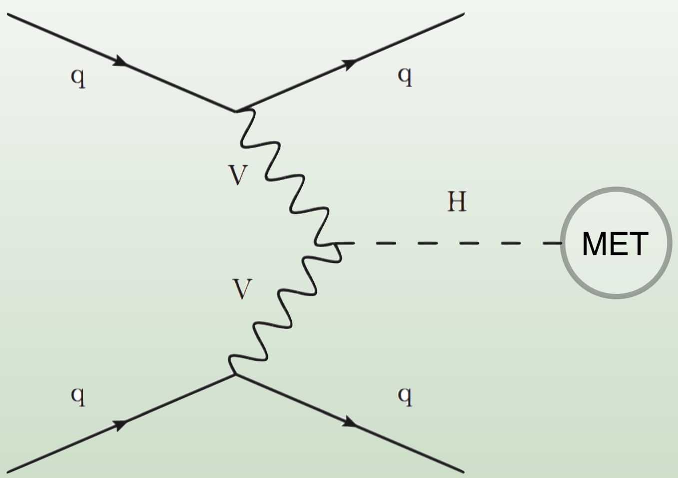
Invisible Higgs decay → missing energy (MET)

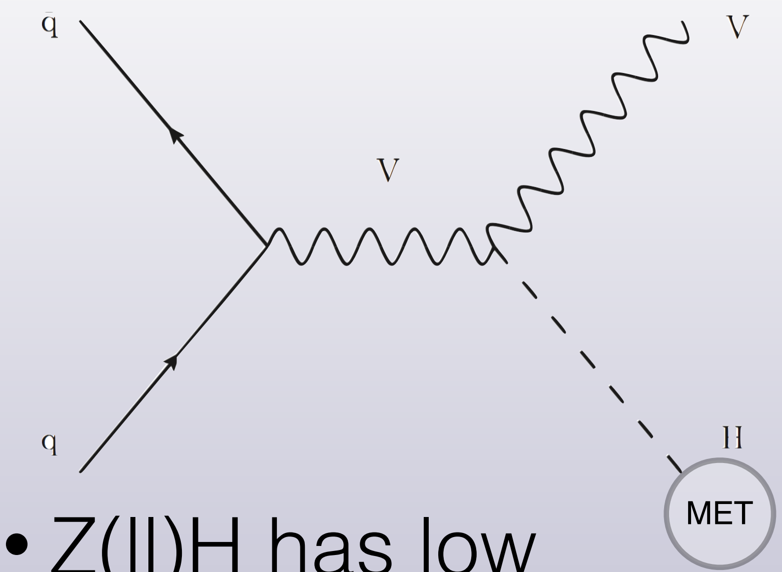
Tag SM Higgs production mode with recoil topology

qqH



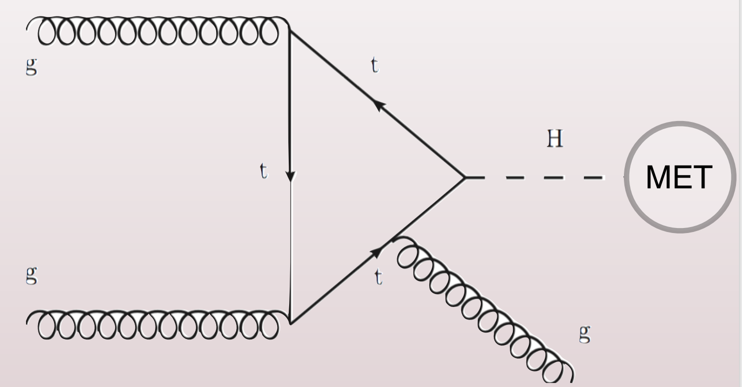
- Most sensitive
- VBF signature: two well-separated jets

VH



- Z(ll)H has low background
- V(qq)H uses jet substructure techniques

gH



- Mono-Jet reinterpretation

qqH Highlights

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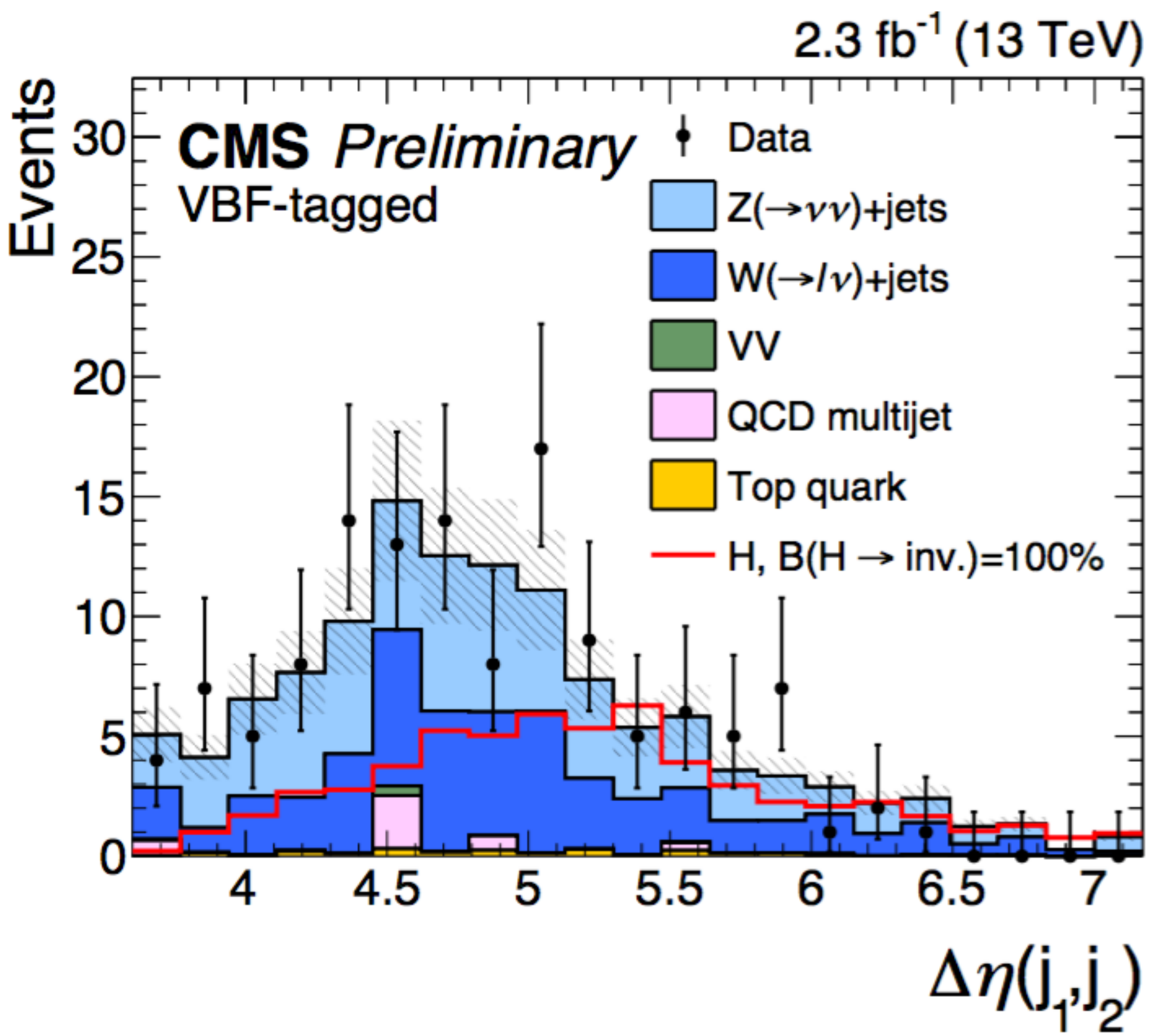
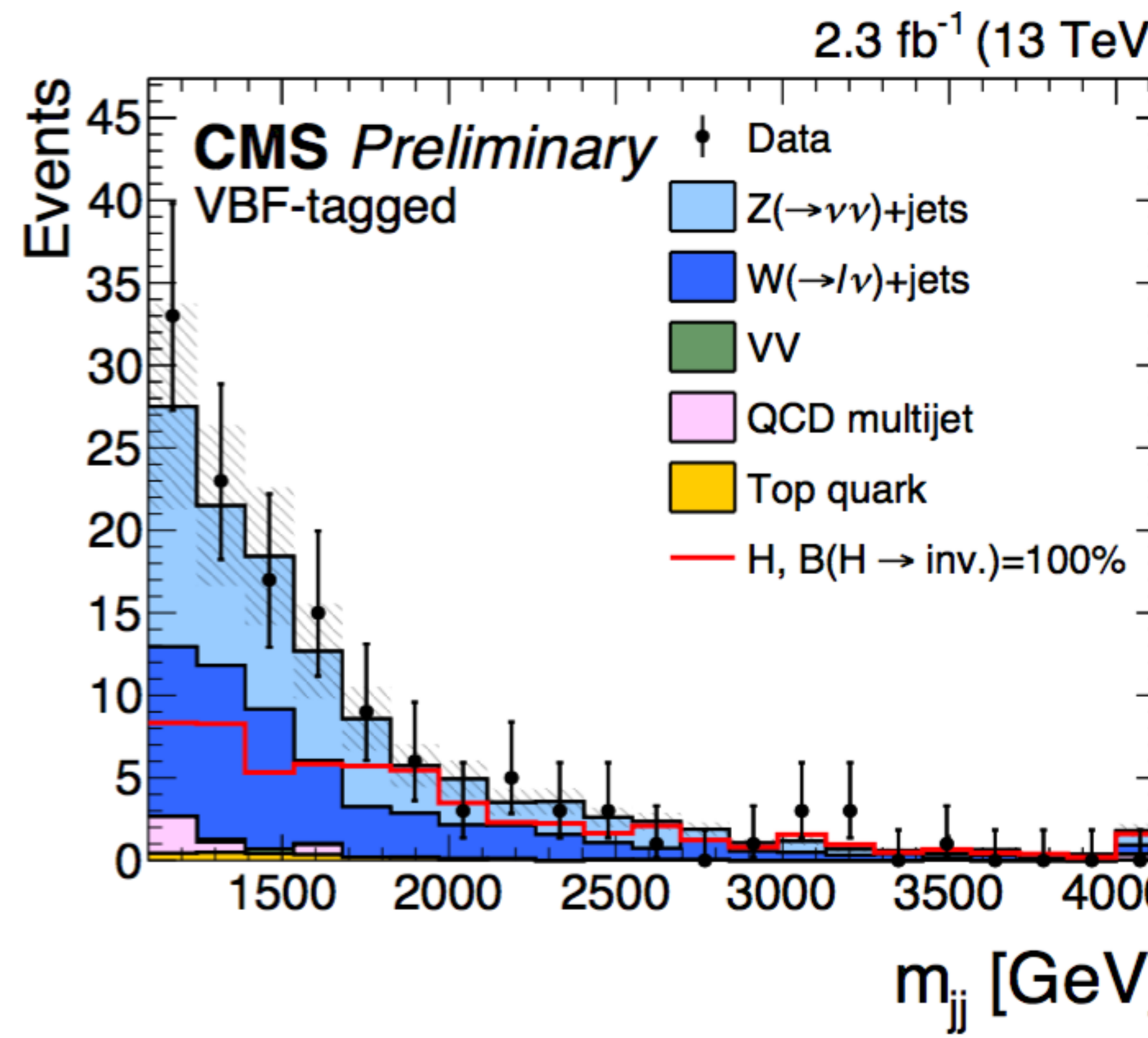
- Dedicated VBF+MET trigger
- High S/B ratio
- Challenge: theory uncertainty in background control regions





arXiv:1610.09218

Z(ll)H Highlights

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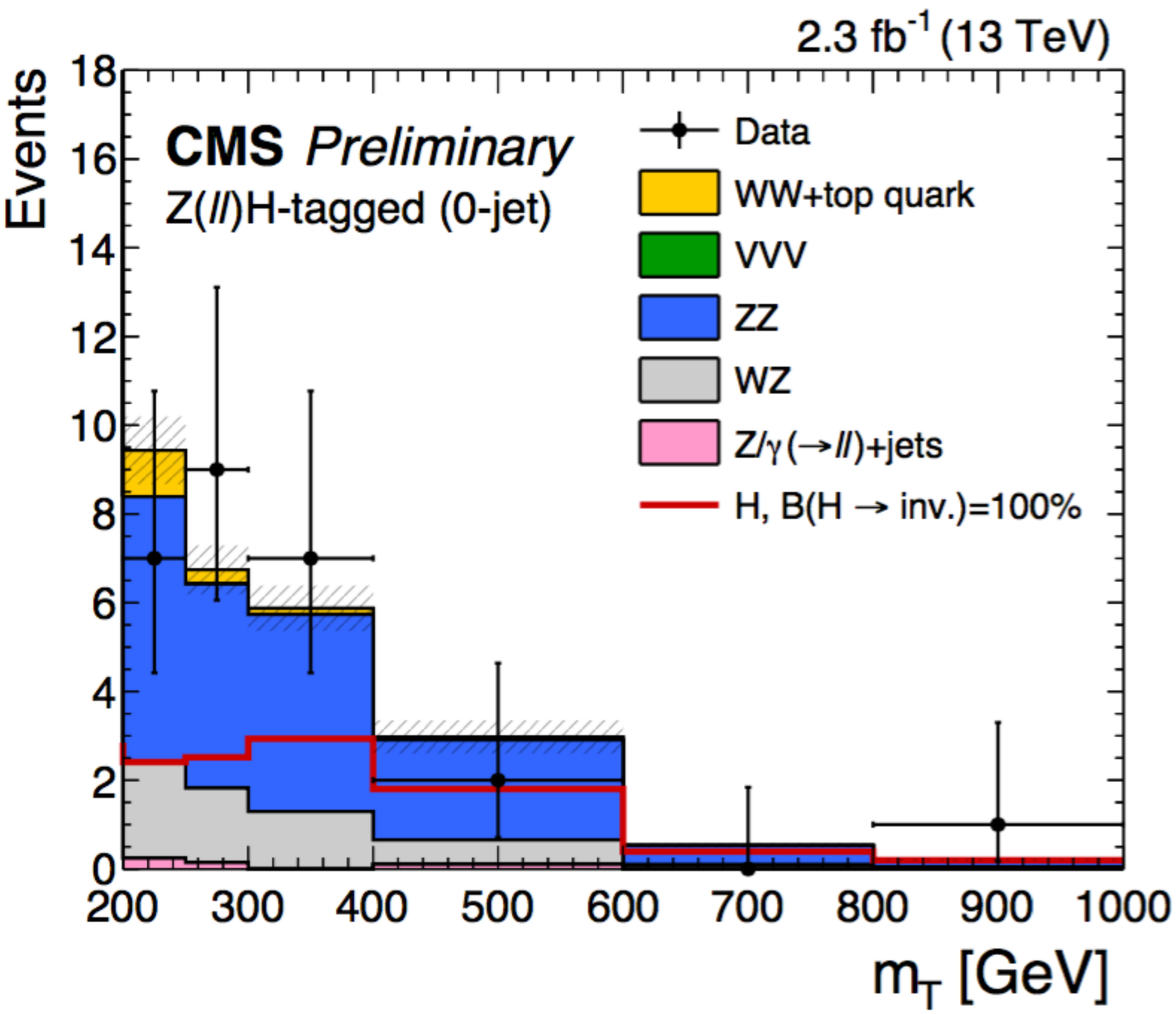
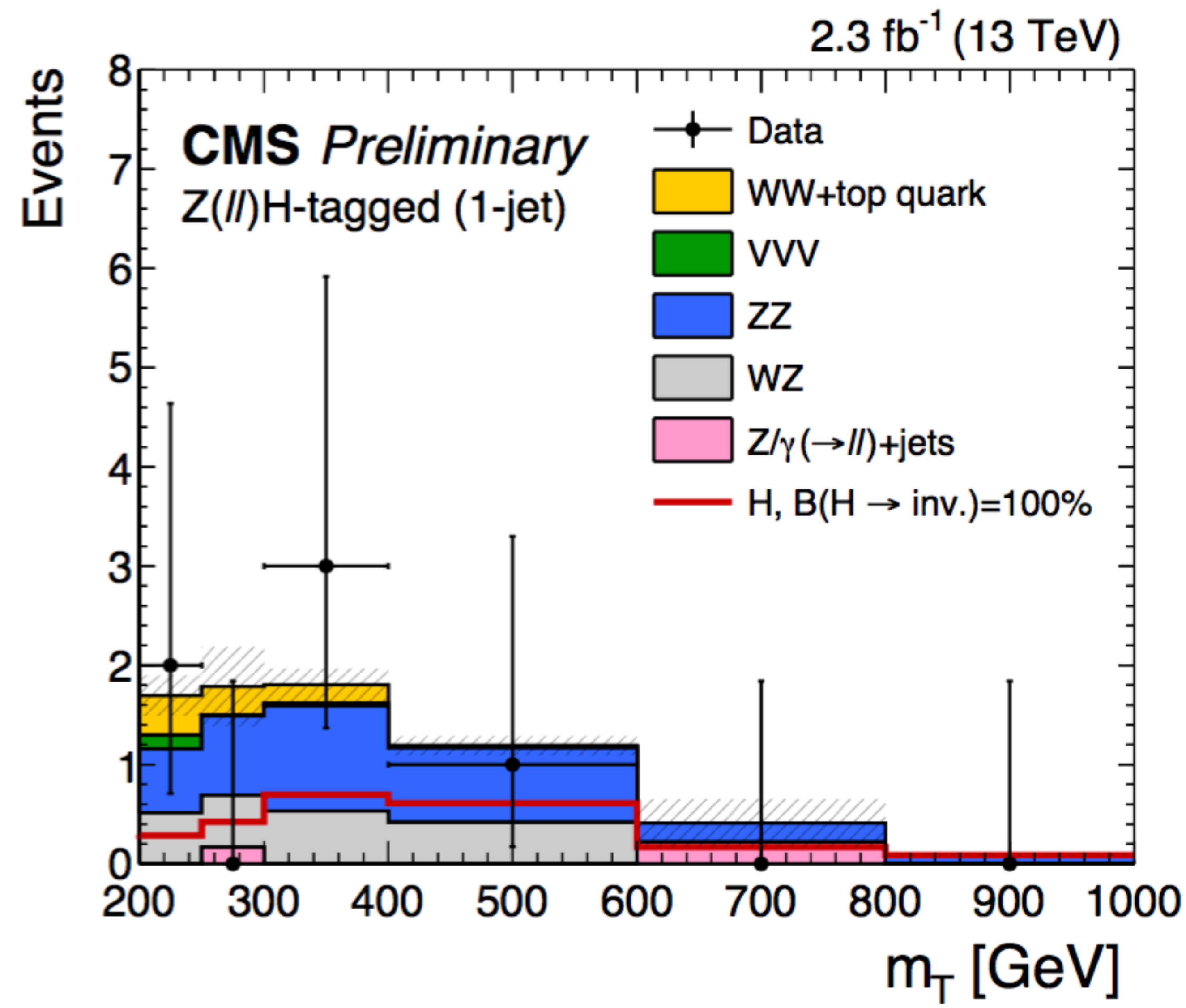
- Fully reconstructed final state
- Challenge: irreducible Z(ll)Z(νν) background





(g/V)H Highlights

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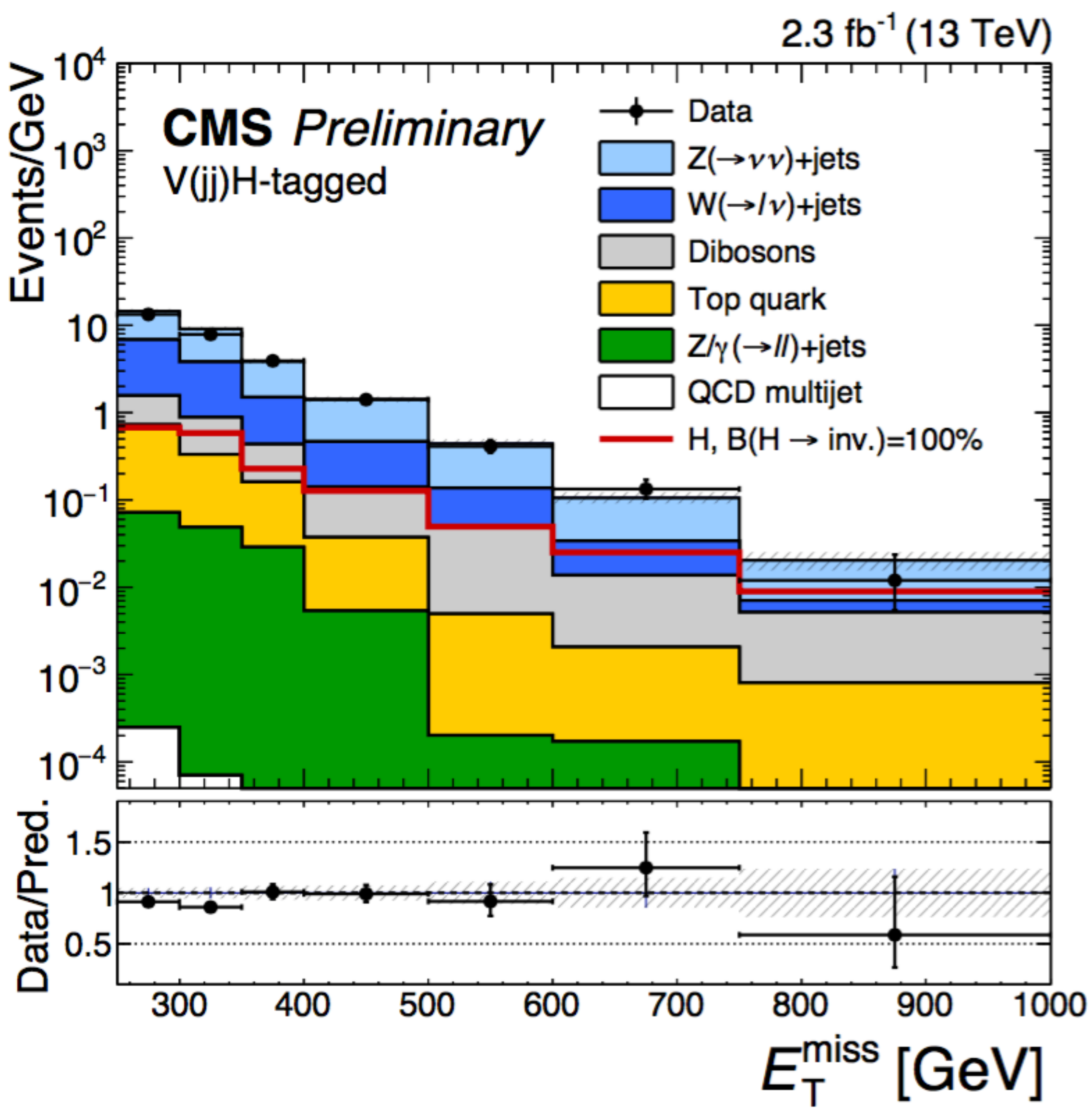
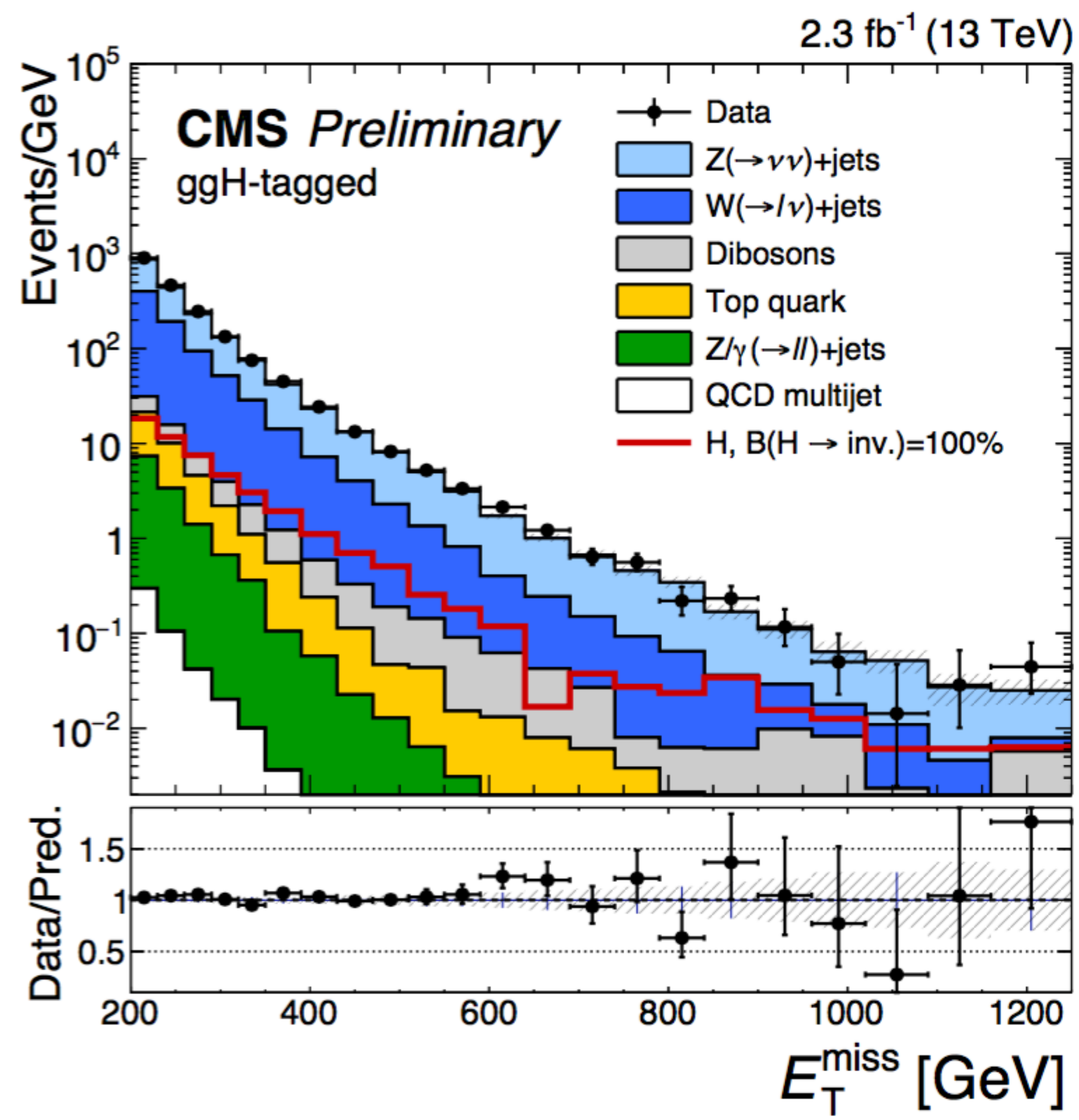
- V(qq)H exploits jet substructure
- Challenge: large backgrounds





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The Combination

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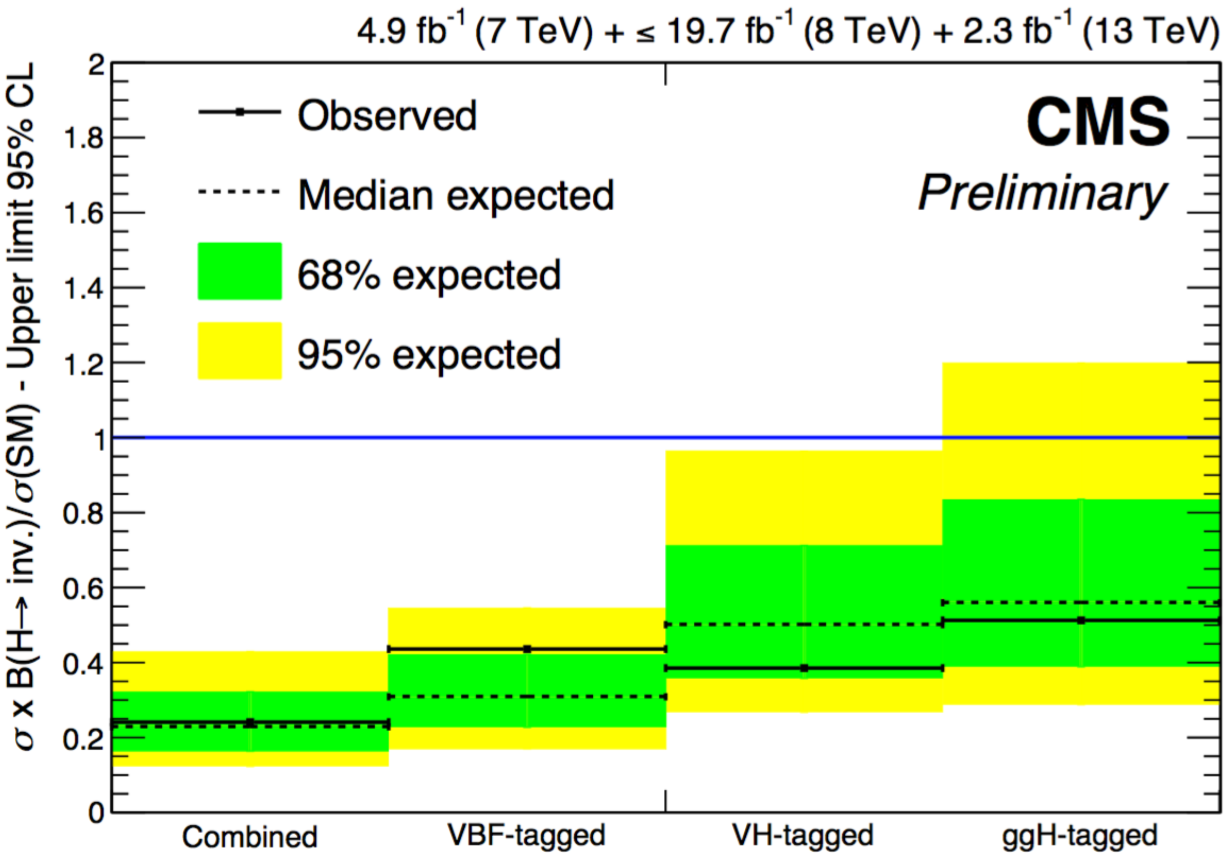
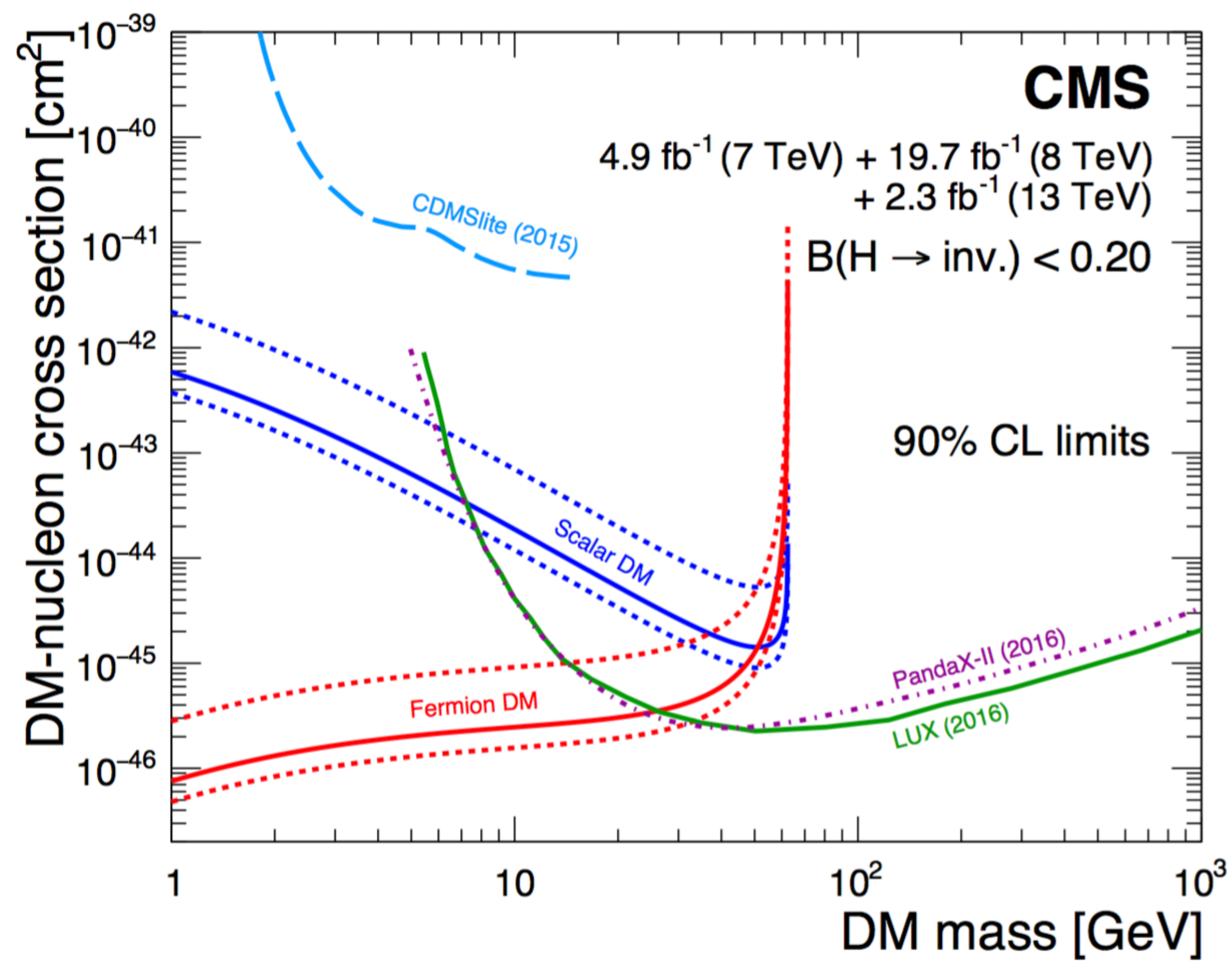


- Leverage statistical power
- No excess → set upper limits

- Translation to dark matter direct detection limits
- Complementary phase space



Outlook

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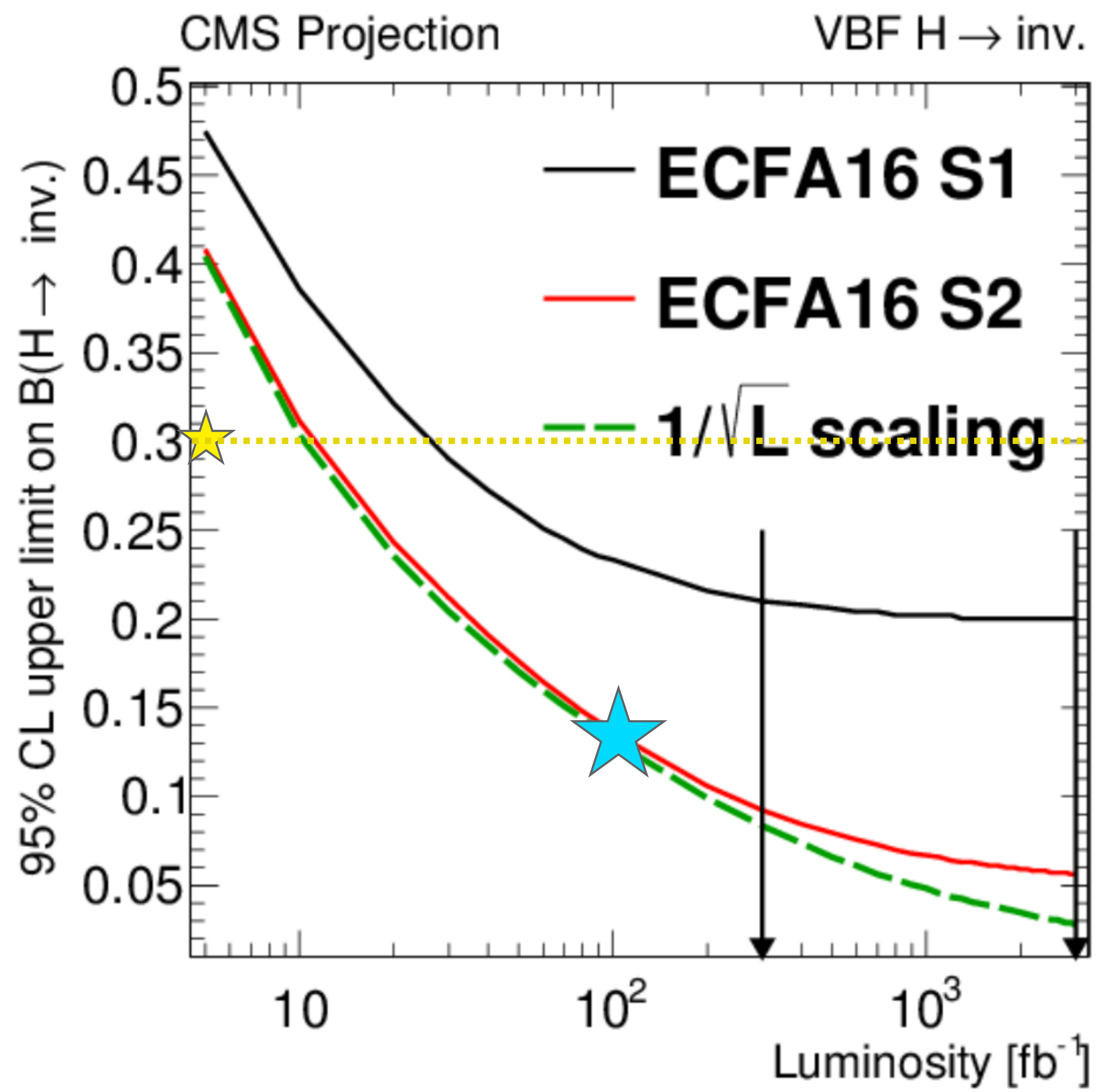
Will CMS see Higgs Invisible Signal?

- SM predicts BR(H→inv.) = 0.001
  - H→ZZ*→4ν
- BSM could be around the corner

Future Collider Workshop study:

- Extrapolate result under different assumptions about uncertainties
- ★ arXiv:1610.09218
- ★ Projected limit by 2018



CMS-DP-2016-064

Backup

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Extrapolation strategy for ECFA16 projections

Public results are extrapolated to larger data sets 300 and 3000 fb^{-1}. In order to summarize the future physics potential of the CMS detector at the HL-LHC, extrapolations are presented under different uncertainty scenarios:

S1 All systematic uncertainties are kept constant with integrated luminosity. The performance of the CMS detector is assumed to be unchanged with respect to the reference analysis.

S1+ All systematic uncertainties are kept constant with integrated luminosity. The effects of higher pileup conditions and detector upgrades on the future performance of CMS are taken into account.

S2 Theoretical uncertainties scaled down by a factor 1/2, while experimental systematic uncertainties are scaled down by the square root of the integrated luminosity until they reach a defined lower limit based on estimates of the achievable accuracy with the upgraded detector. The performance of the CMS detector is assumed to be unchanged with respect to the reference analysis.

S2+ Theoretical uncertainties scaled down by a factor 1/2, while experimental systematic uncertainties are scaled down by the square root of the integrated luminosity until they reach a defined lower limit based on estimates of the achievable accuracy with the upgraded detector. The effects of higher pileup conditions and detector upgrades on the future performance of CMS are taken into account.

Theoretical uncertainties follow the prescriptions of the LHC Yellow Report 4 (in preparation).