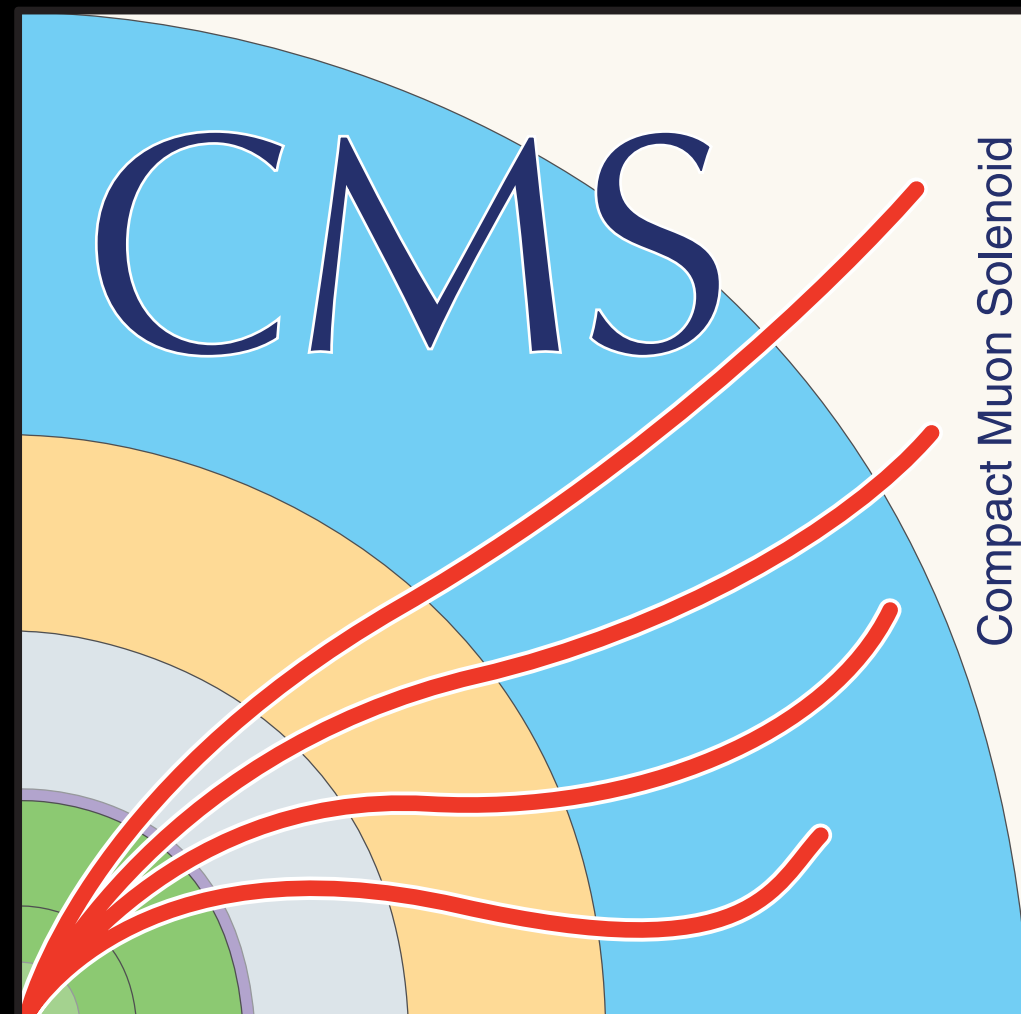


Searches for resonances in diboson final states



Andrea Malara

Université Libre de Bruxelles

November 2024

Cometa: WG1+WG3

- ▶ Predicted by several Beyond the Standard Model (BSM) theory models
 - ▶ Additional (heavy) Higgs bosons
 - ▶ Additional (pseudo) scalar/vector bosons

- ▶ Predicted with various properties:
 - ▶ Spin-0, Spin-1, Spin-2, pseudo-scalar, ...
 - ▶ High masses: $m(X) \sim \text{TeV}$
 - ▶ Off-shell production: ALPs

- ▶ Rich variety of final states to analyse
 - ▶ All-hadronic
 - ▶ Lepton(s)+jets
 - ▶ Multi-leptons

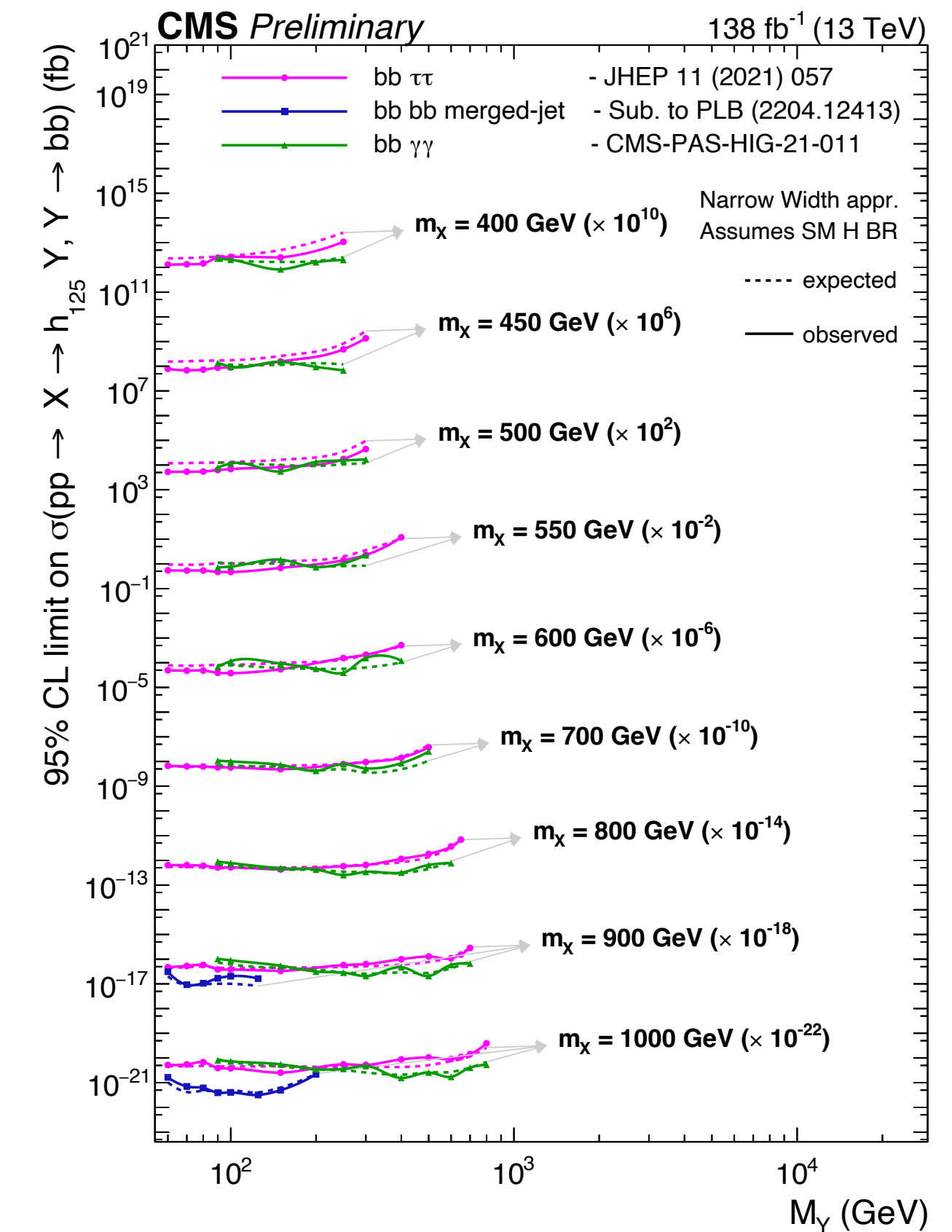
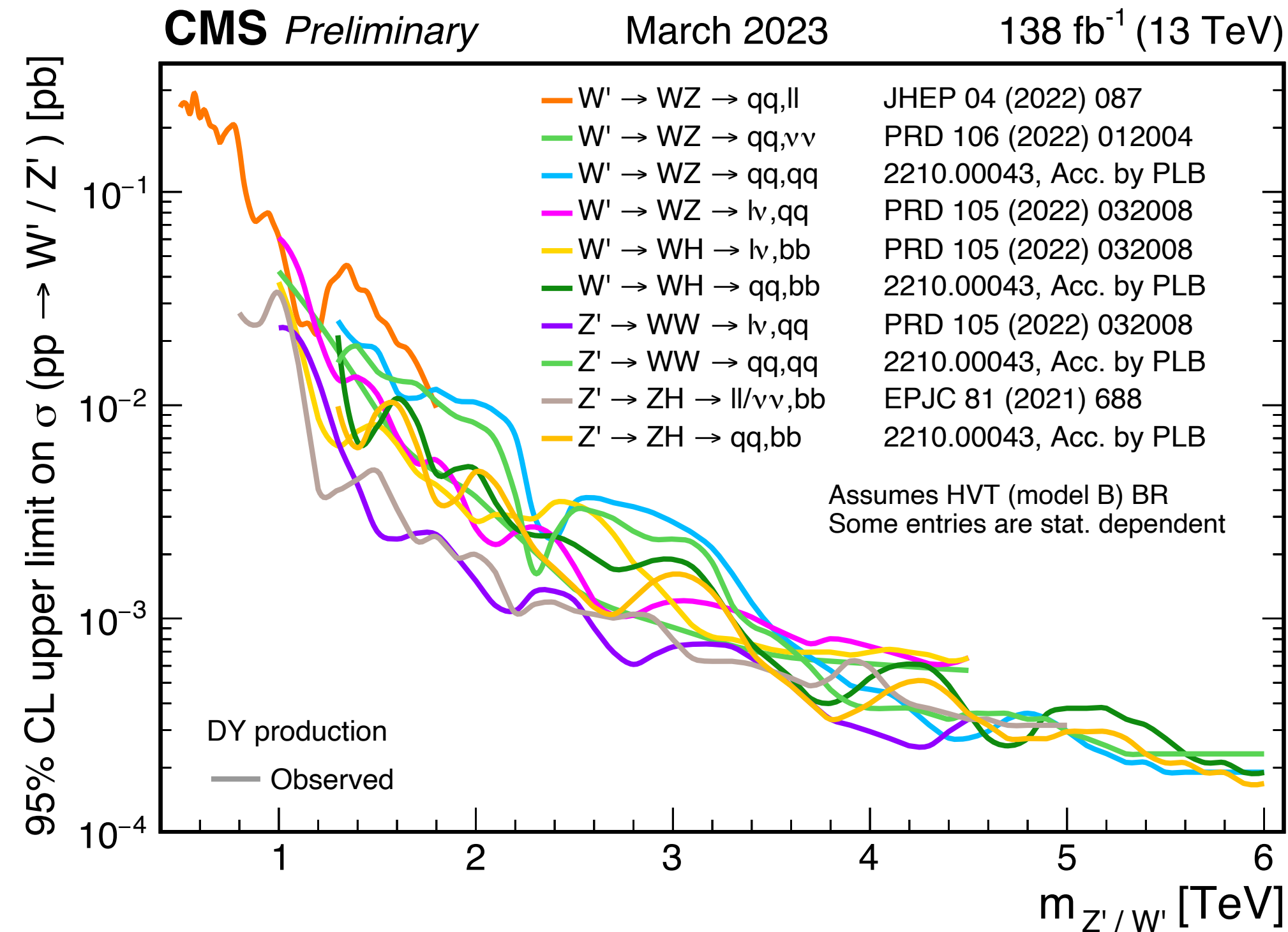
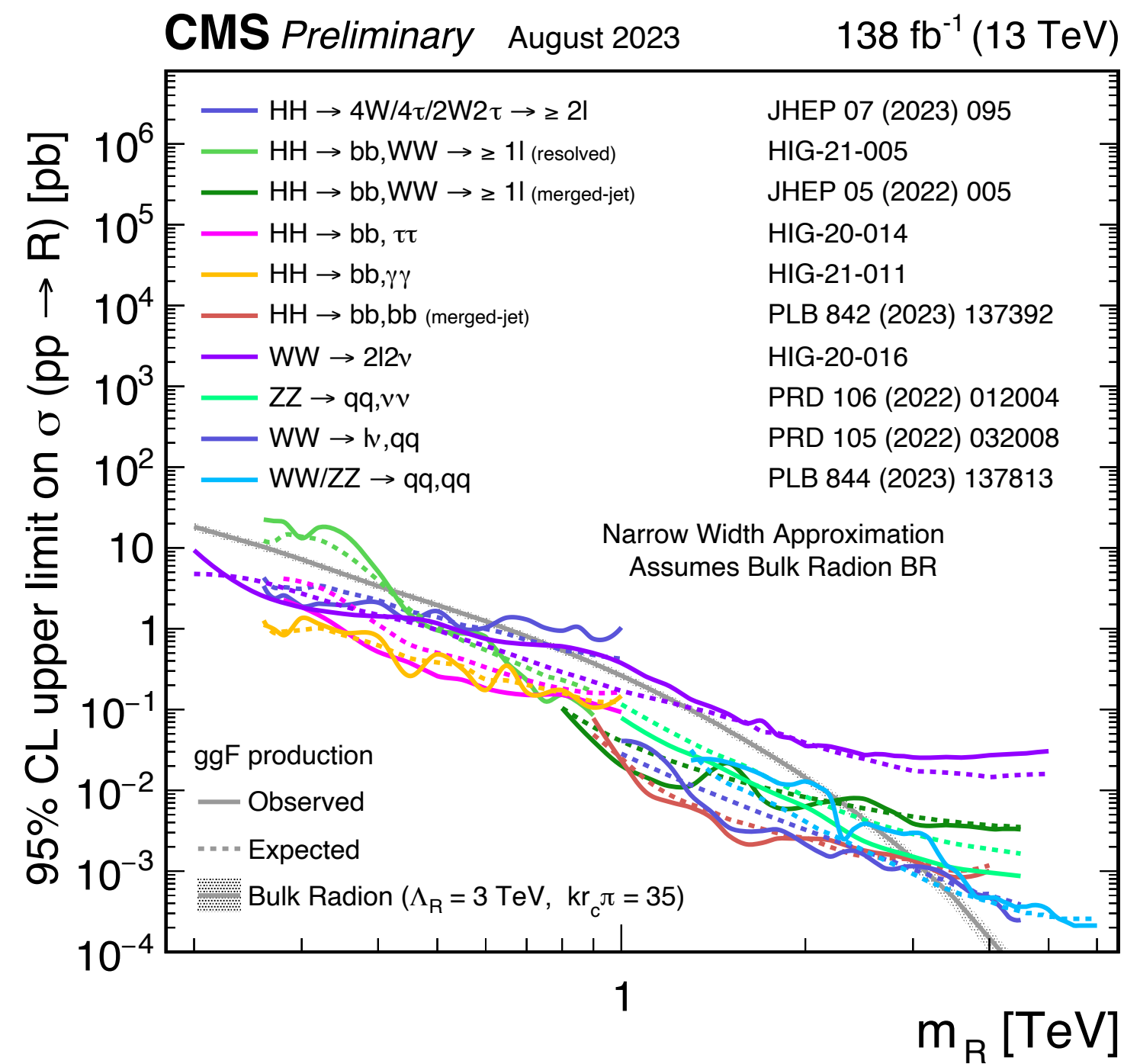
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- ▶ Rich variety of final states to analyse
 - ▶ All-hadronic
 - ▶ Lepton(s)+jets ← *This talk*
 - ▶ Multi-leptons

Overview of CMS results

More public results [here](#)



HH/VV resonances

- ▶ Multilepton (4W/4 τ /2W2 τ)
- ▶ bbWW
- ▶ bbVV, bb $\tau\tau$ boosted

WZ/WH/ZH

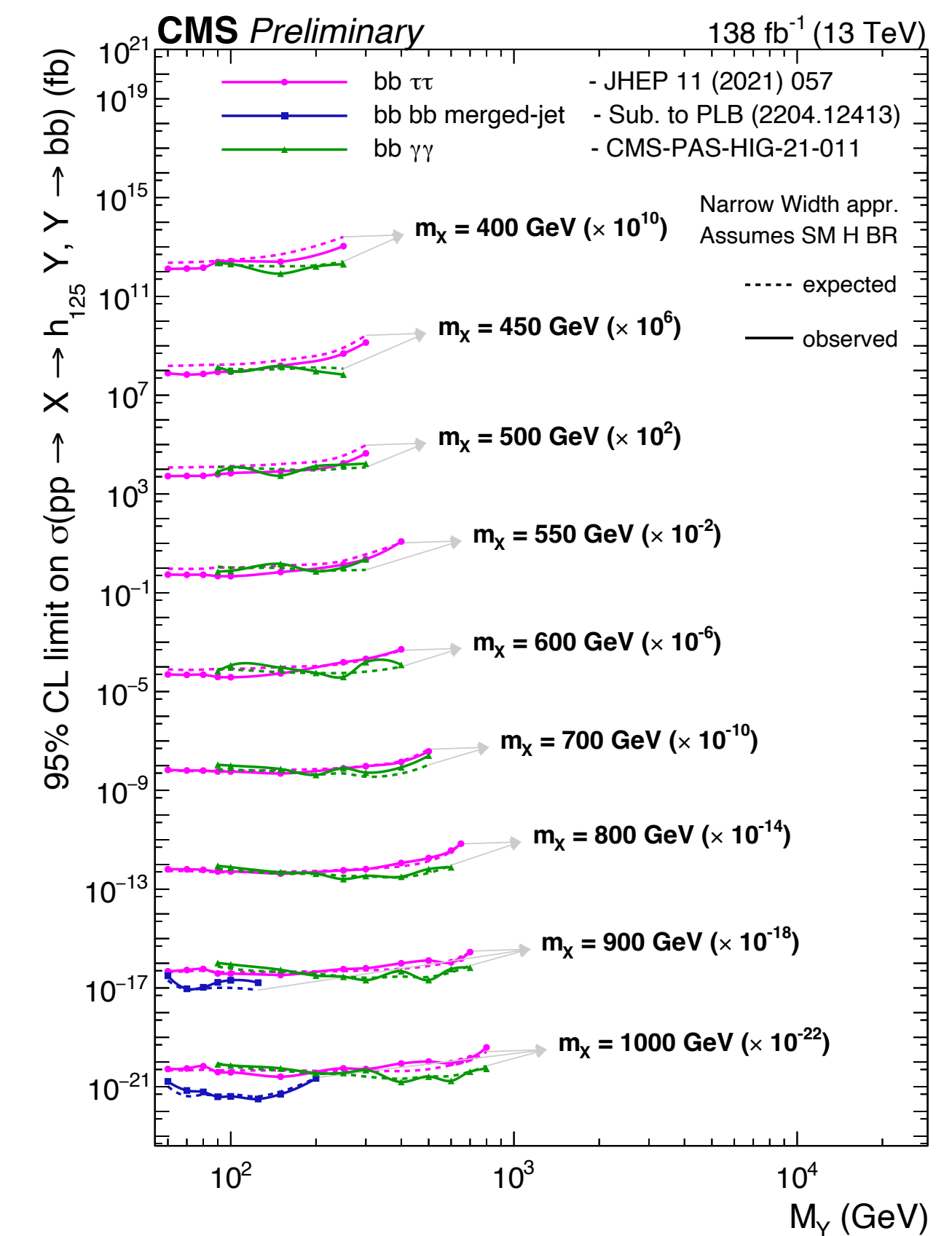
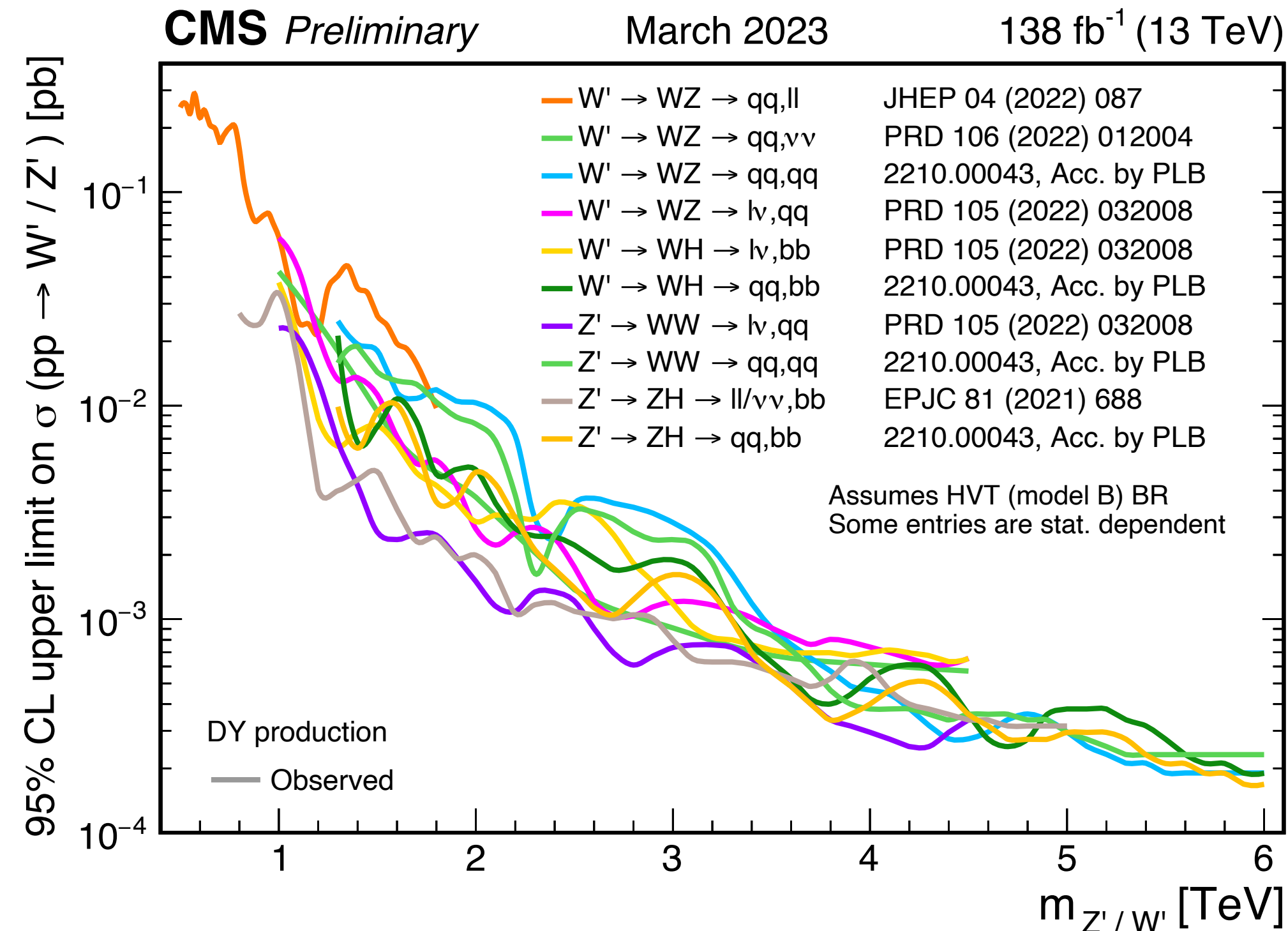
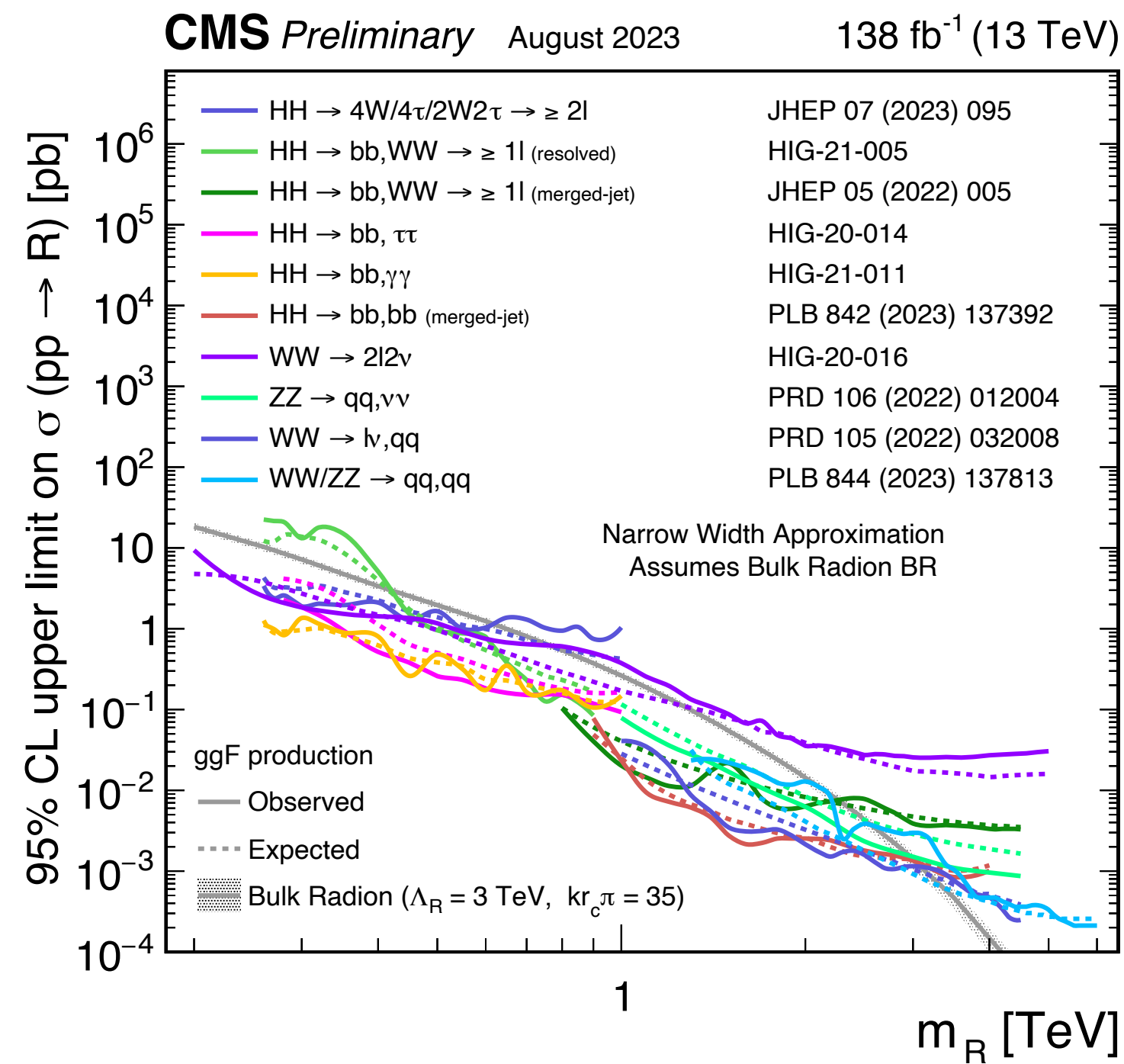
- ▶ Z(ll) V(qq)
- ▶ Z($\nu\nu$) V(qq)
- ▶ W(l ν) V(qq)

HY resonances

- ▶ H(bb)Y(bb)
- ▶ H($\gamma\gamma$)Y(bb)
- ▶ H($\tau\tau$) Υ (bb)

Overview of CMS results

More public results [here](#)



This talk

HH/VV resonances

- ▶ Multilepton (4W/4 τ /2W2 τ)
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WZ/WH/ZH

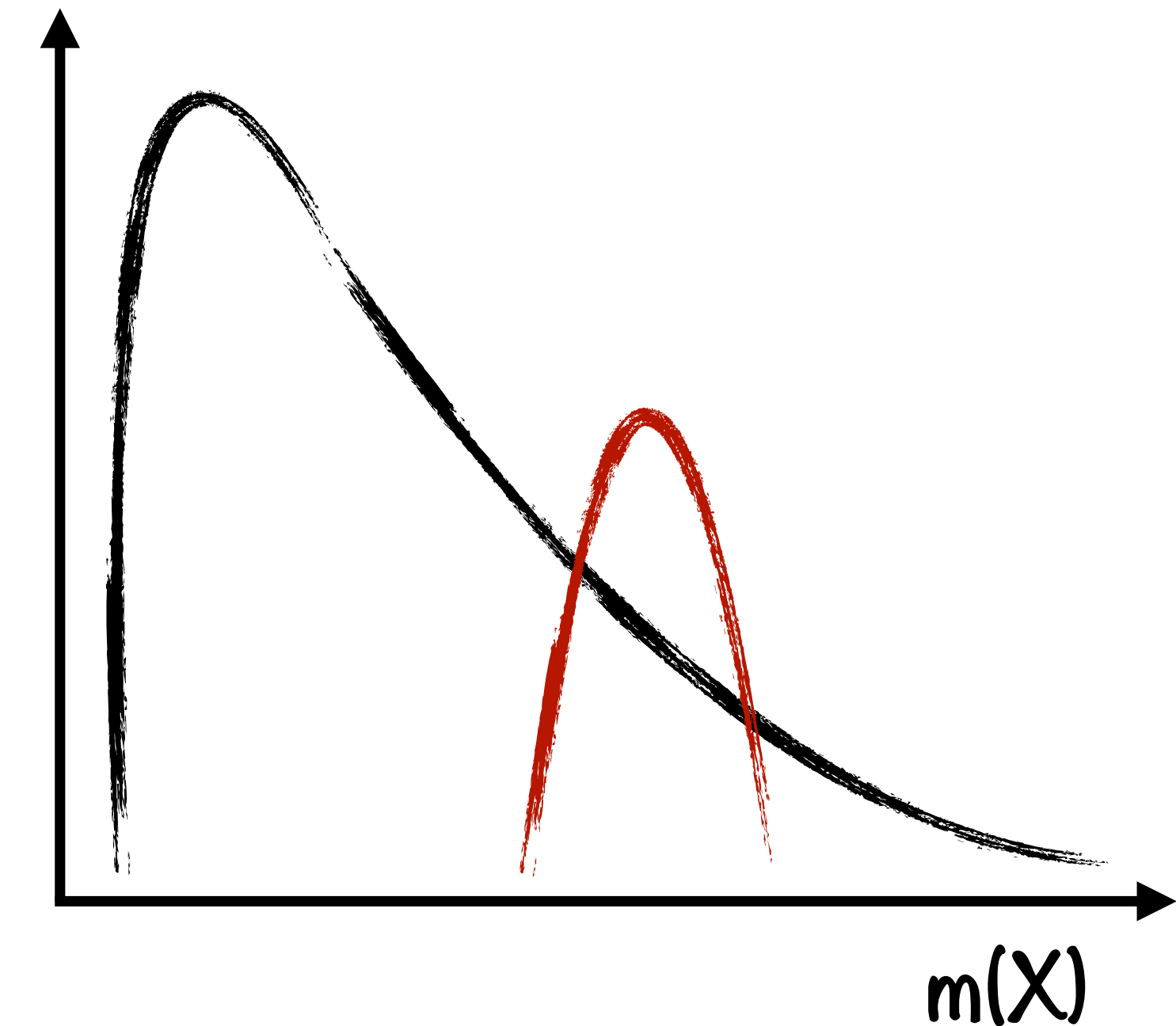
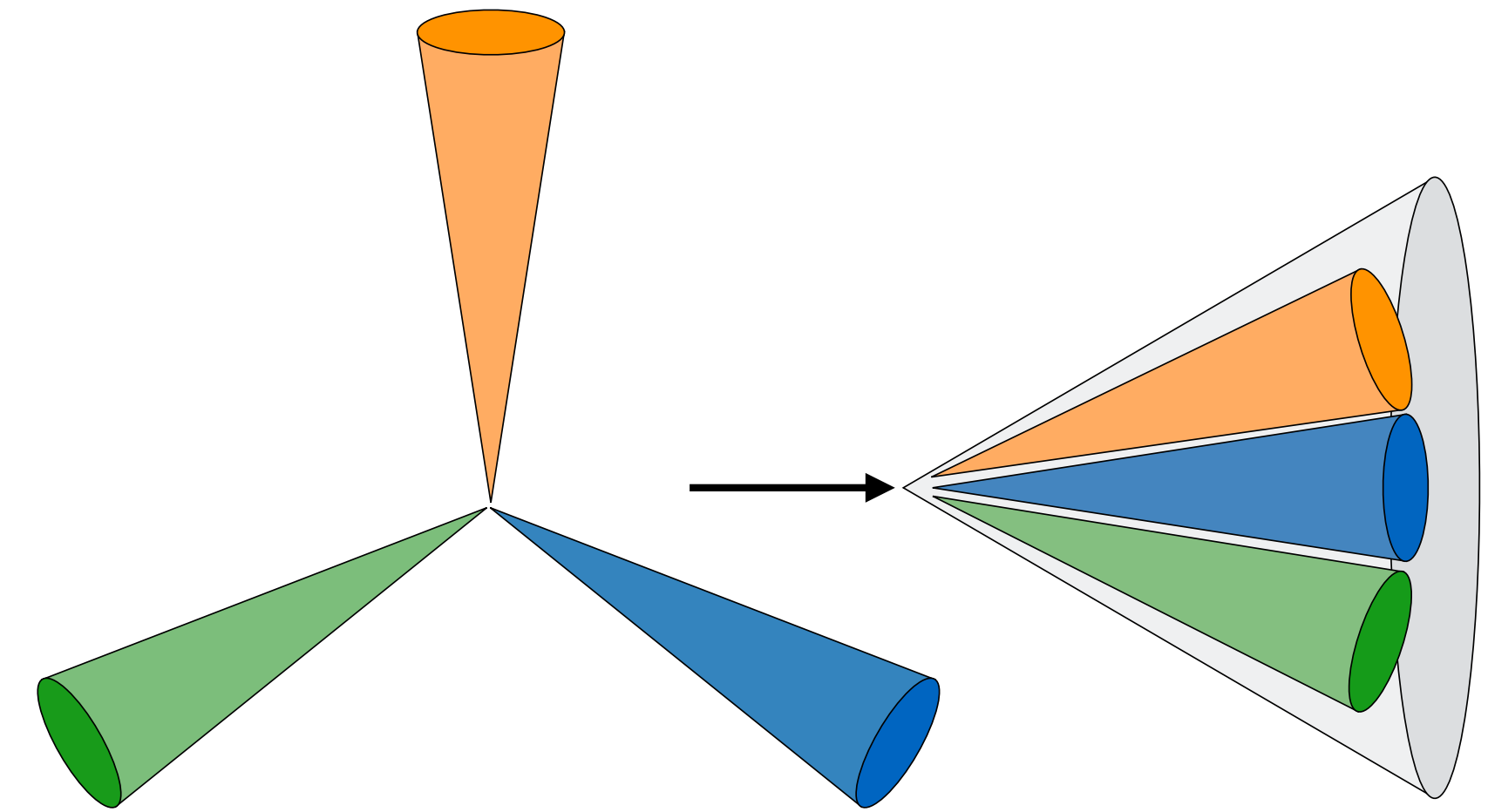
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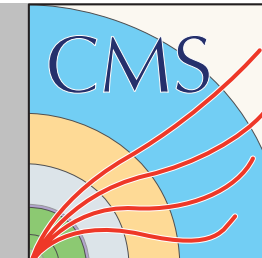
- ▶ Boosted vs resolved topology
 - ▶ Defined by the resonance's mass
 - ▶ Collimated decay products reconstructed as multi-prong objects
 - ▶ Less combinatoric, but overlapping
 - ▶ Usage of jet flavour and sub-structure:
 - pillars for BSM searches

- ▶ Search for localised excesses:
 - ▶ Tails of SM processes
 - ▶ Simple 1-D fit of $m(X)$, NN score, ...
 - ▶ 2-D/3-D fit when $M(V/H)$ known



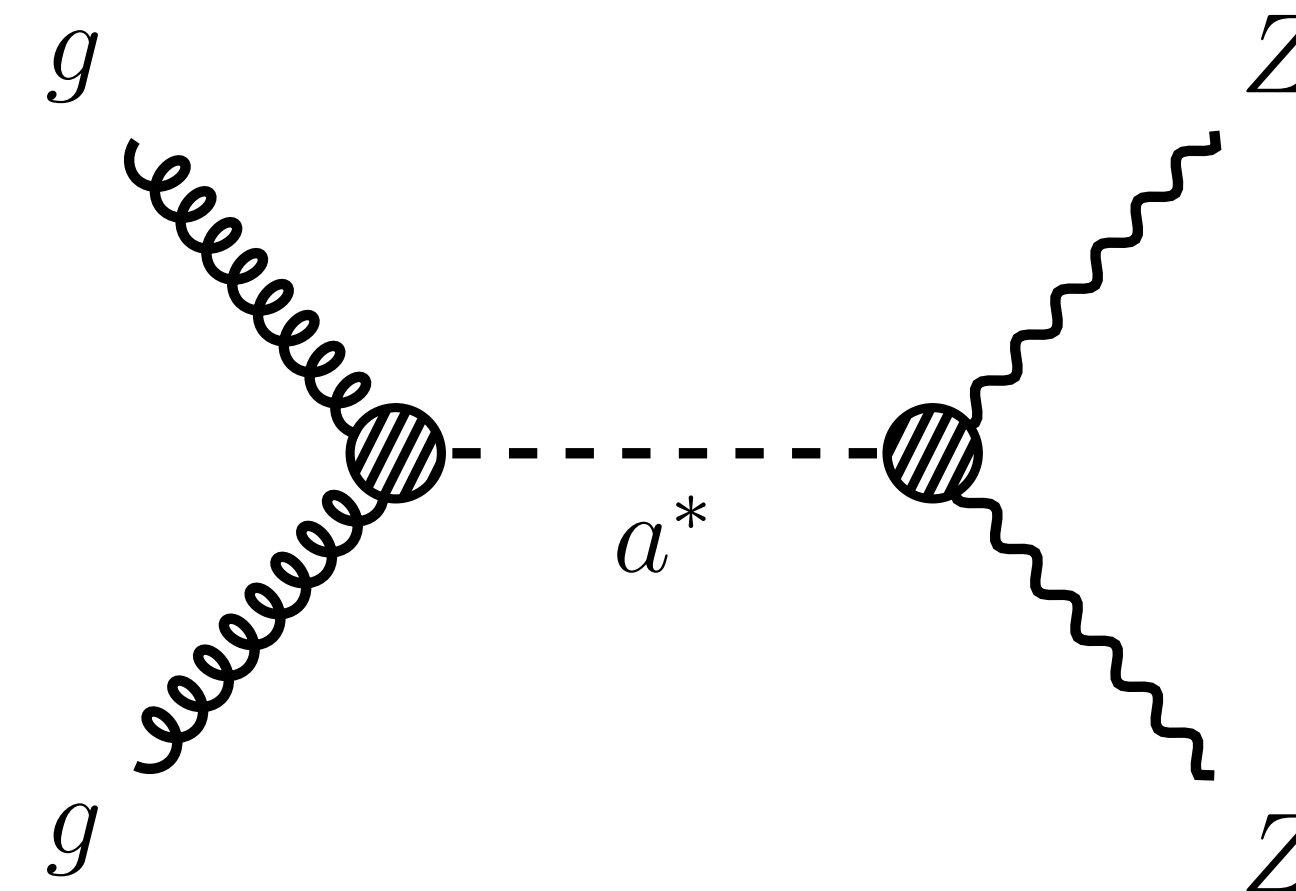
Search for ZV -- di-lepton channel

JHEP 04 (2022) 087



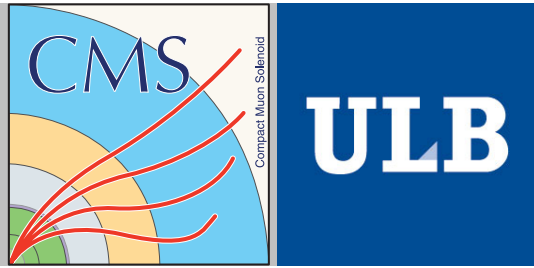
Analysis in a nutshell

- ▶ Reconstruction
 - ▶ 2 leptons (e/μ)
 - ▶ 1 large radius jet (W, Z, H)
 - or 2 small radius jets



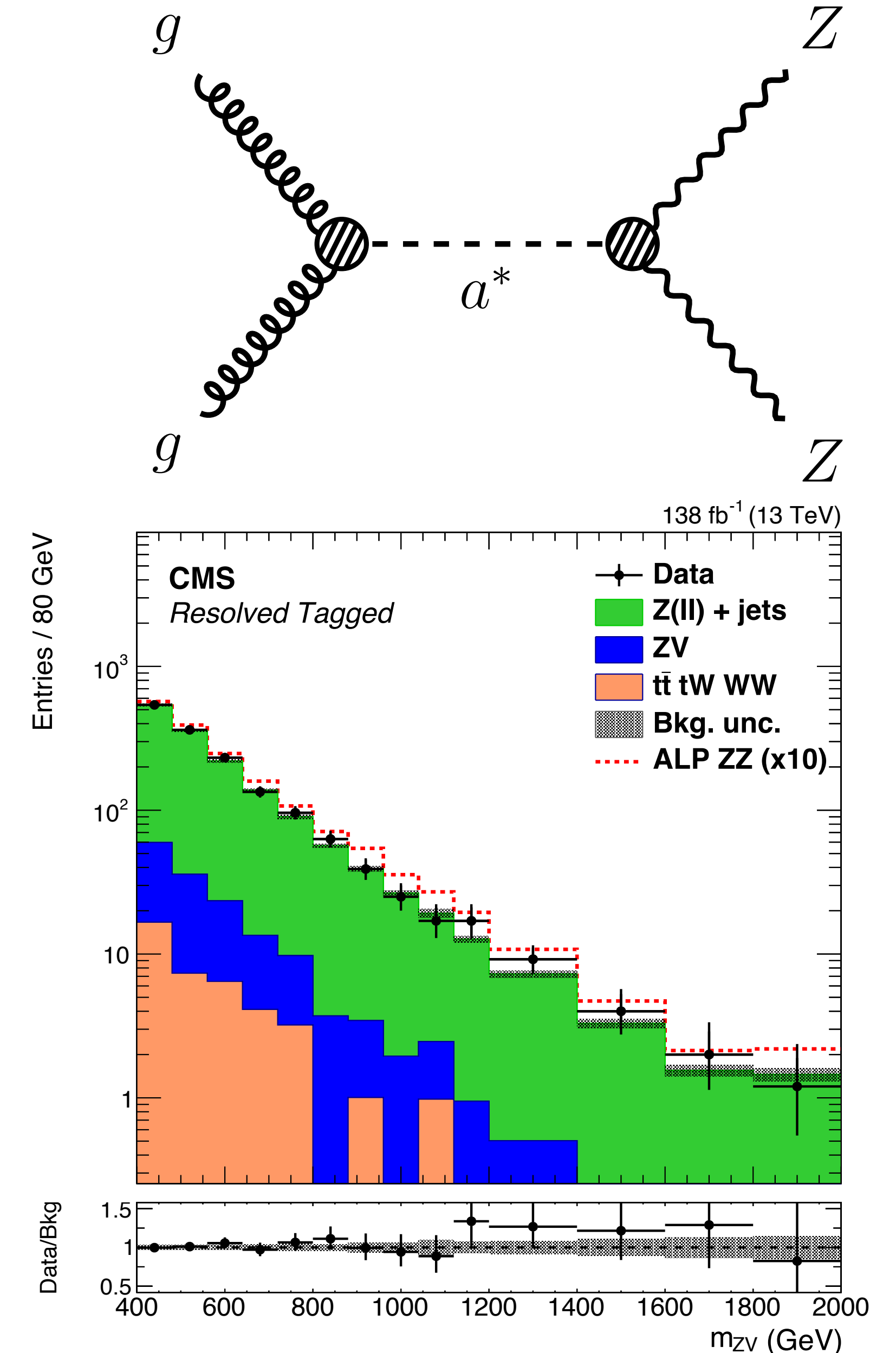
Search for ZV -- di-lepton channel

JHEP 04 (2022) 087



Analysis in a nutshell

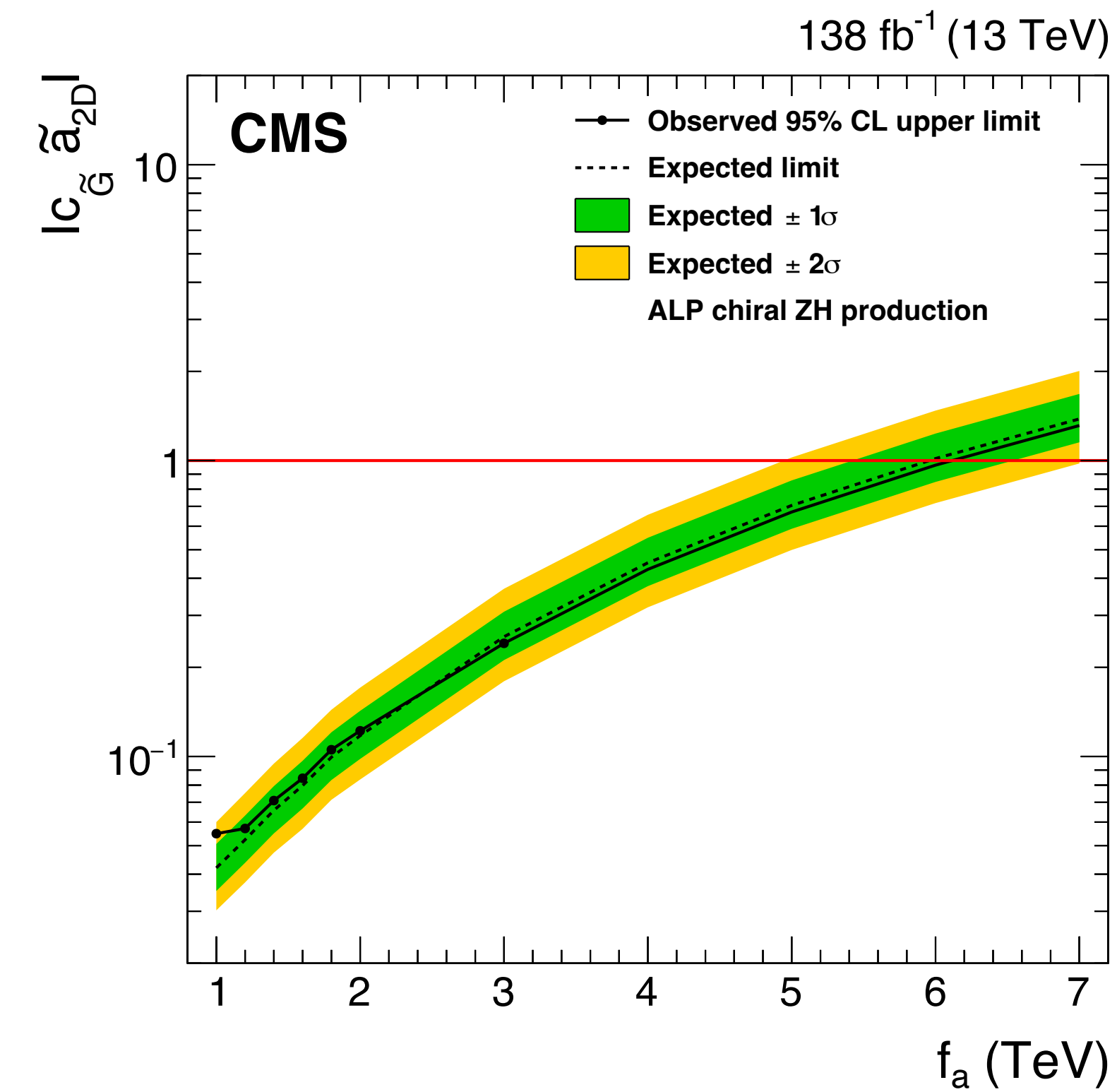
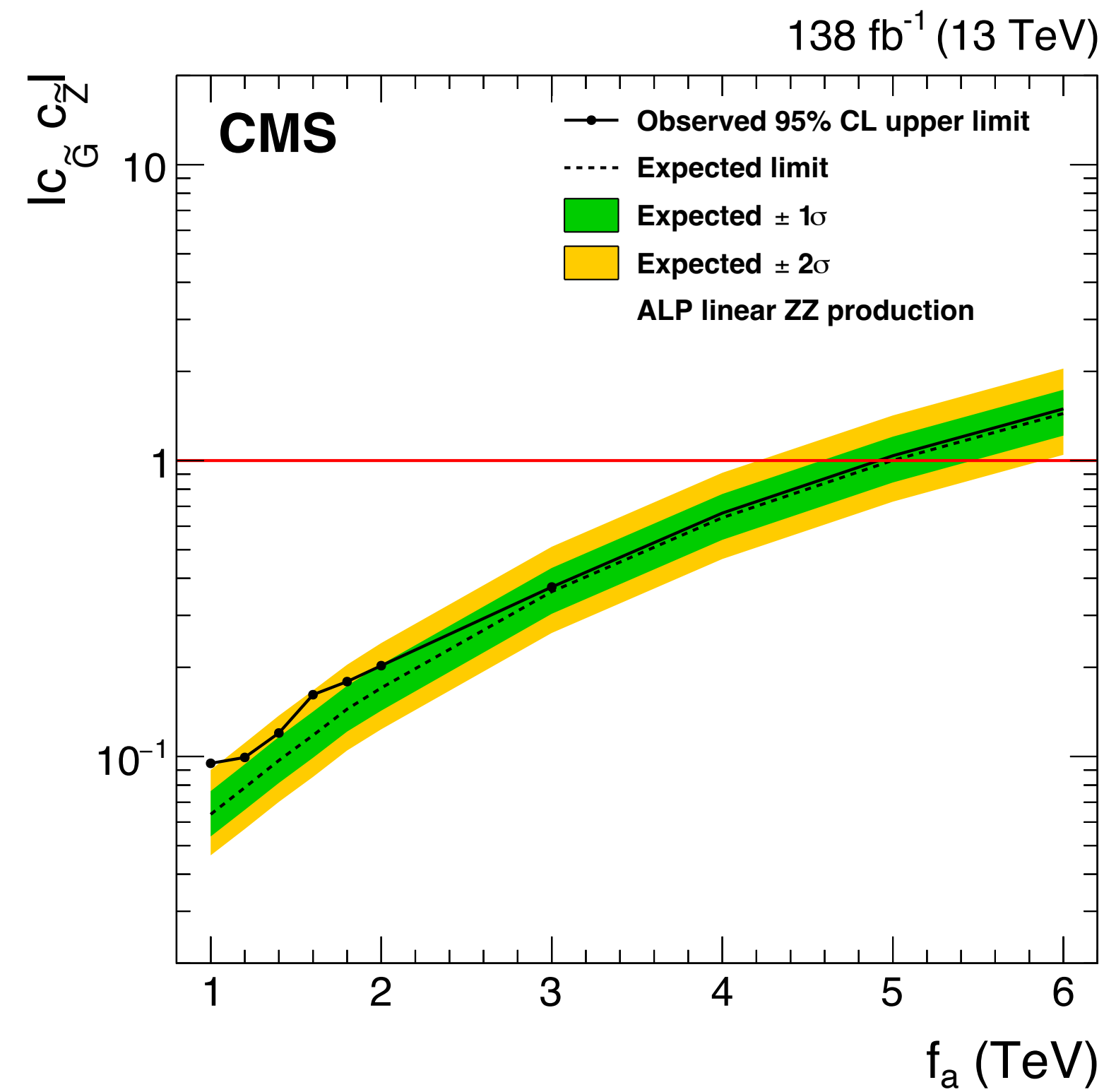
- Reconstruction
 - 2 leptons (e/μ)
 - 1 large radius jet (W, Z, H)
 - or 2 small radius jets
- Strategy
 - Categorisation:
 - Lepton flavour, Boosted/resolved
 - $bb/0b$ (based on subjet b-tagging)
 - V boson tagging with n-subjettines (τ_{21})
 - 1D fit of $m(ZV)$
 - $DY + jet$ as primary background
 - Subdominant contribution from diboson



Search for ZV -- di-lepton channel

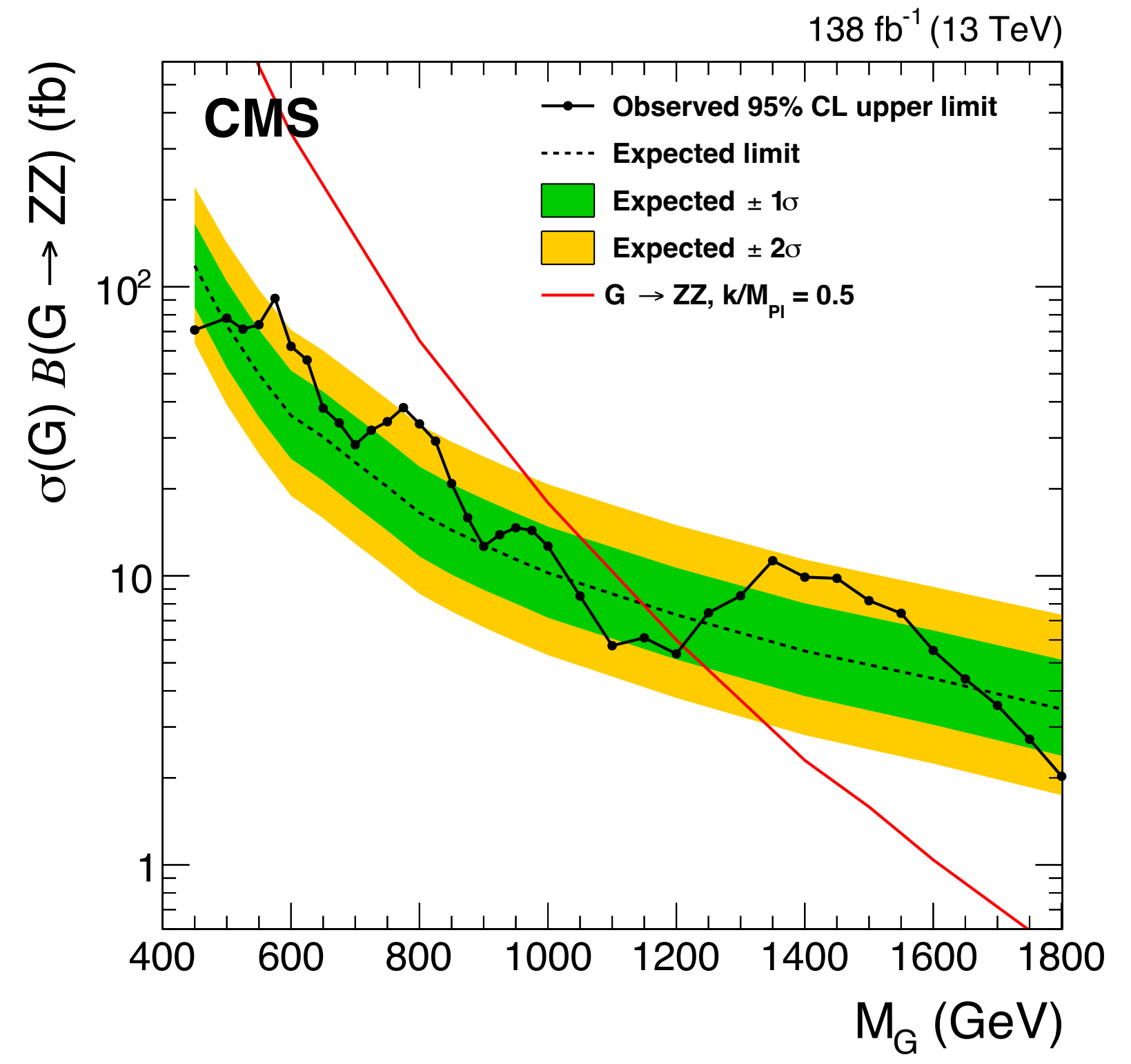
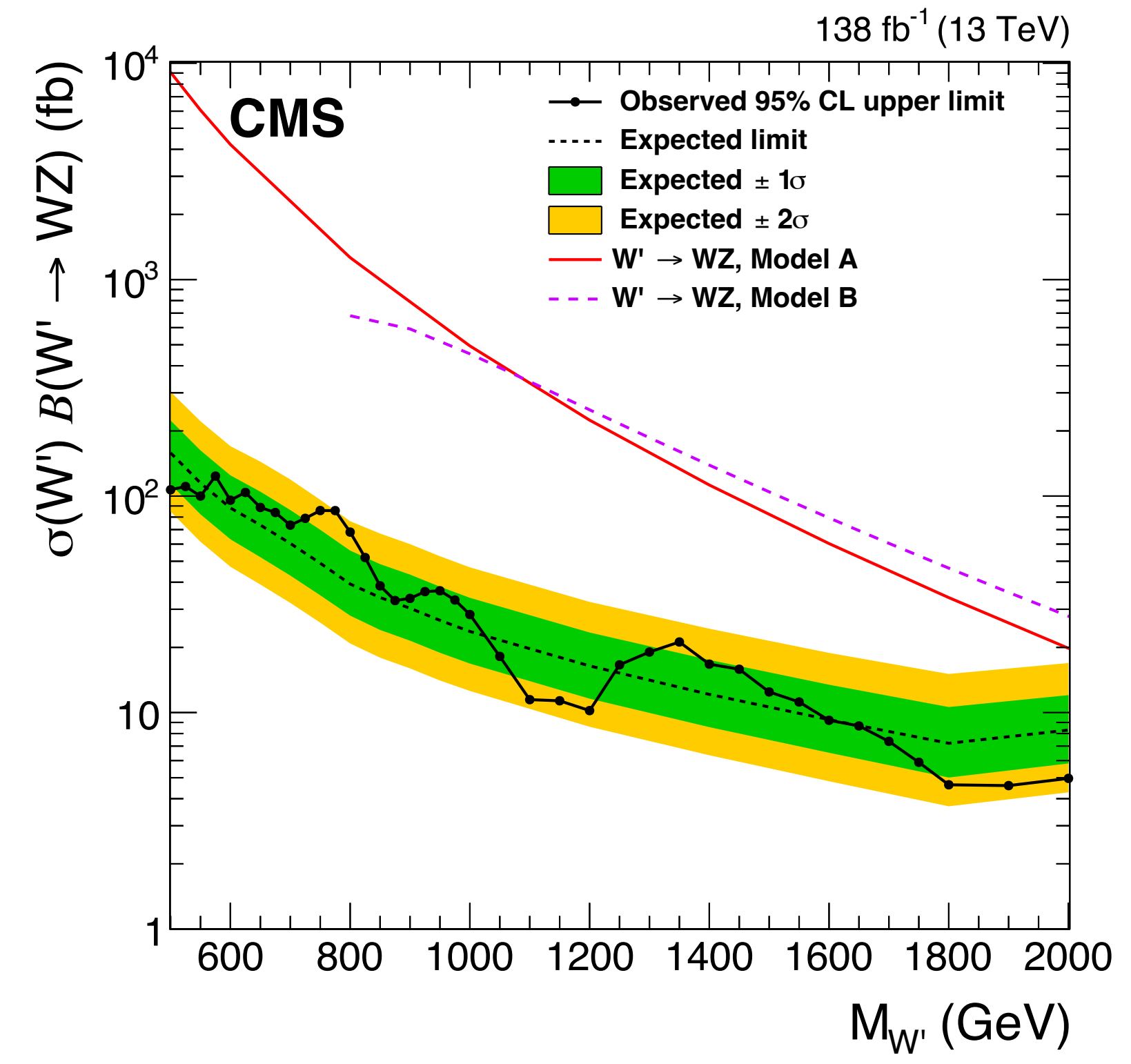
Results

► Upper limits on ALPs coupling



Results

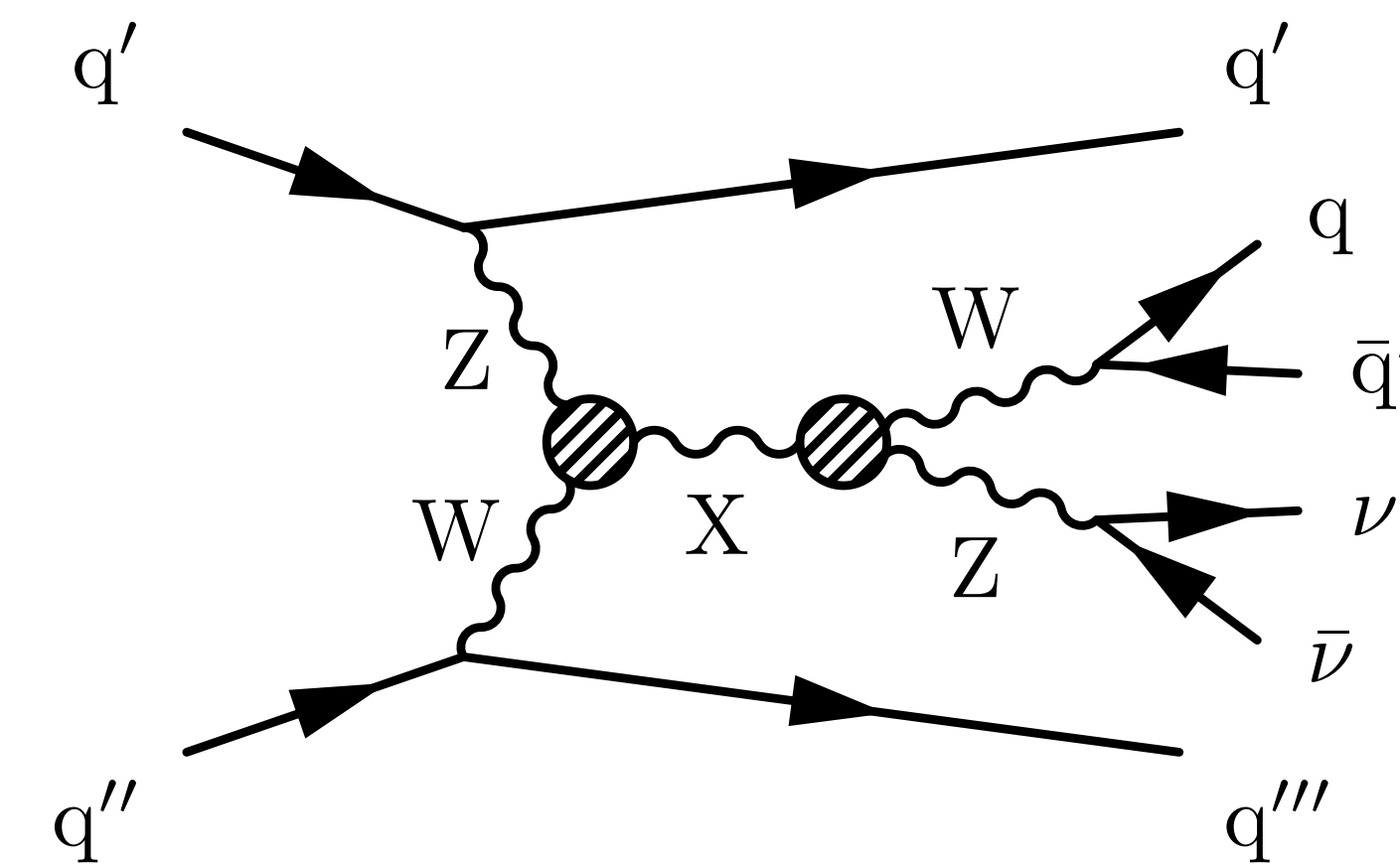
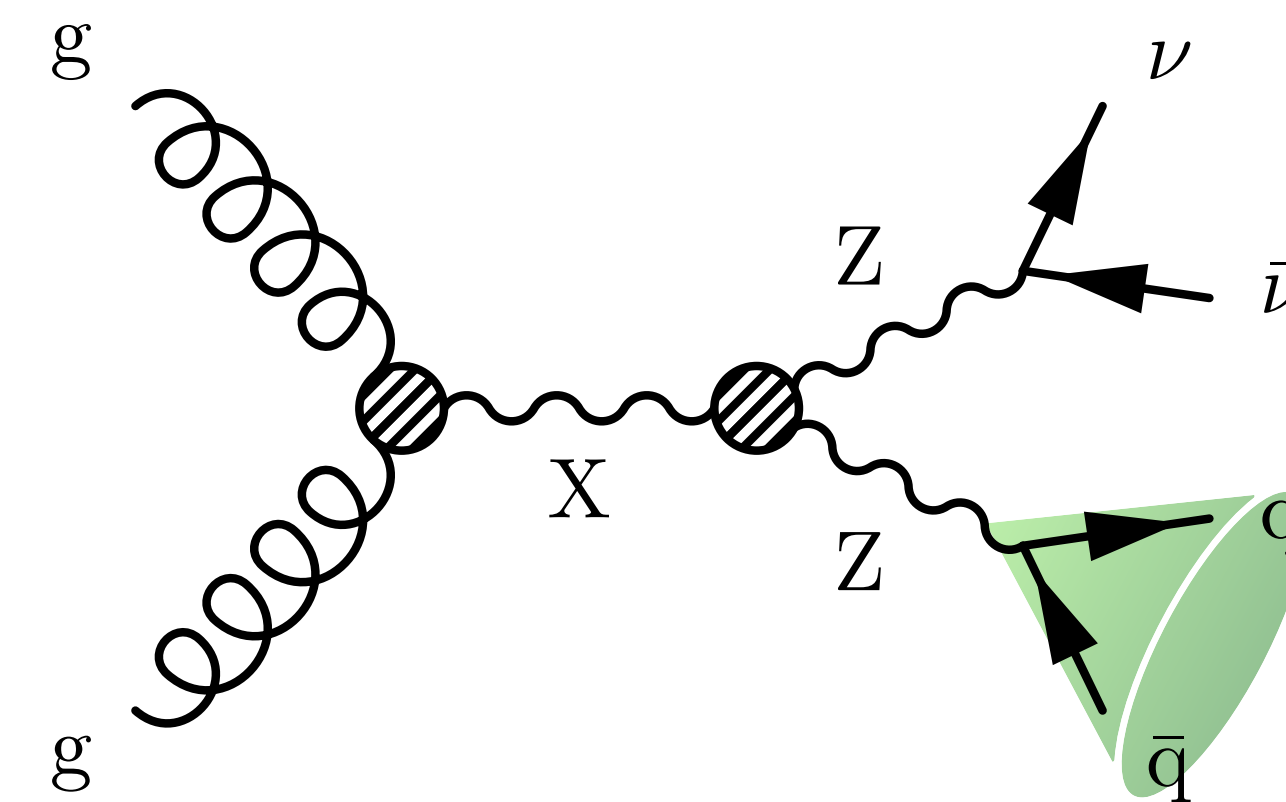
- ▶ Upper limits on ALPs coupling
- ▶ Upper limits on $X \rightarrow VV$
- ▶ Spin 1 and spin-2



Search for ZV -- 0-lepton channel

Analysis in a nutshell

- Reconstruction
 - 0 lepton (e/μ) + missing transverse energy ($\nu\nu$)
 - 1 large radius jet (W, Z, H)
 - Two additional forward jets in the VBF category



Analysis in a nutshell

► Reconstruction

- 0 lepton (e/μ) + missing transverse energy ($\nu\nu$)
- 1 large radius jet (W, Z, H)
- Two additional forward jets in the VBF category

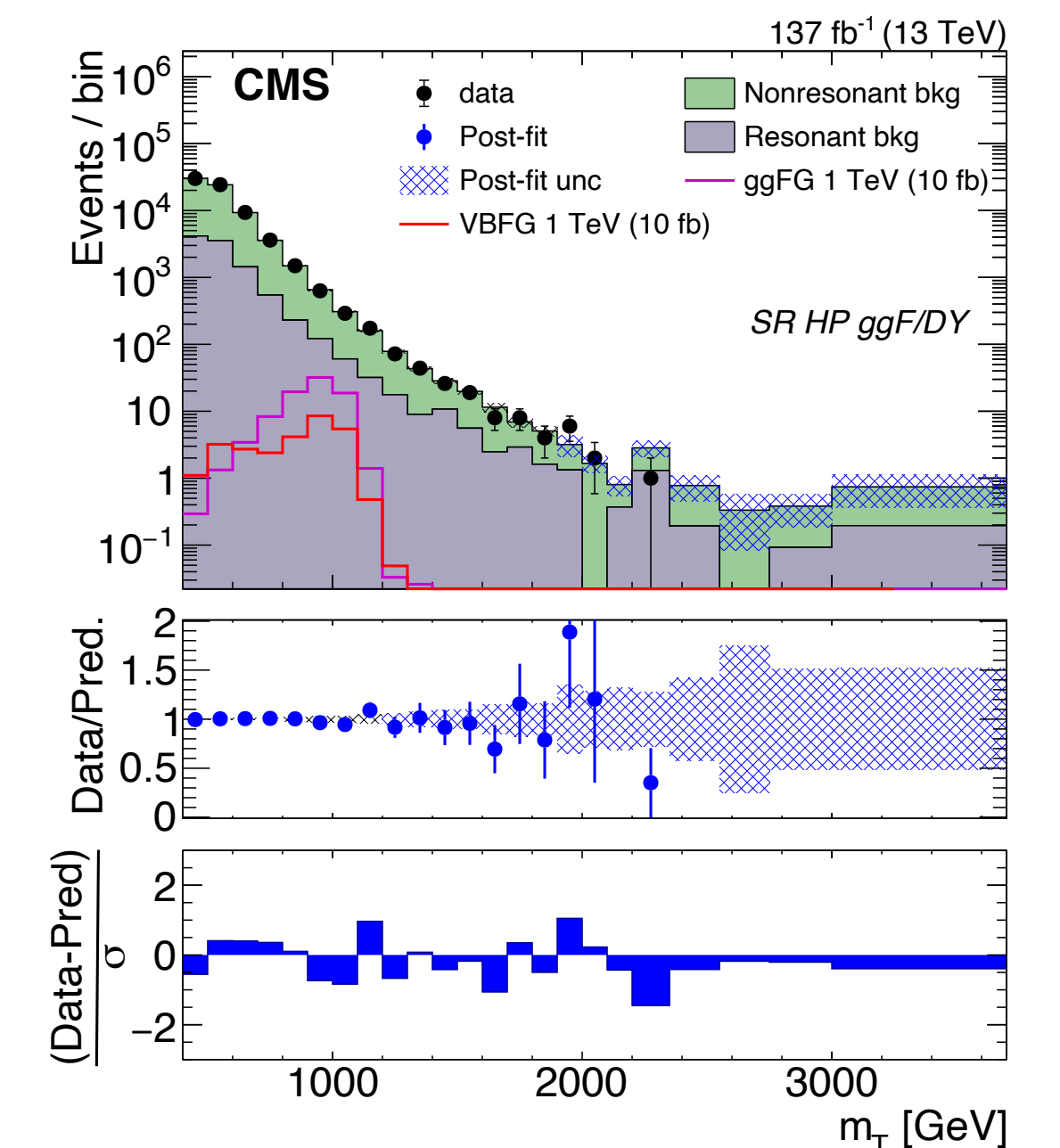
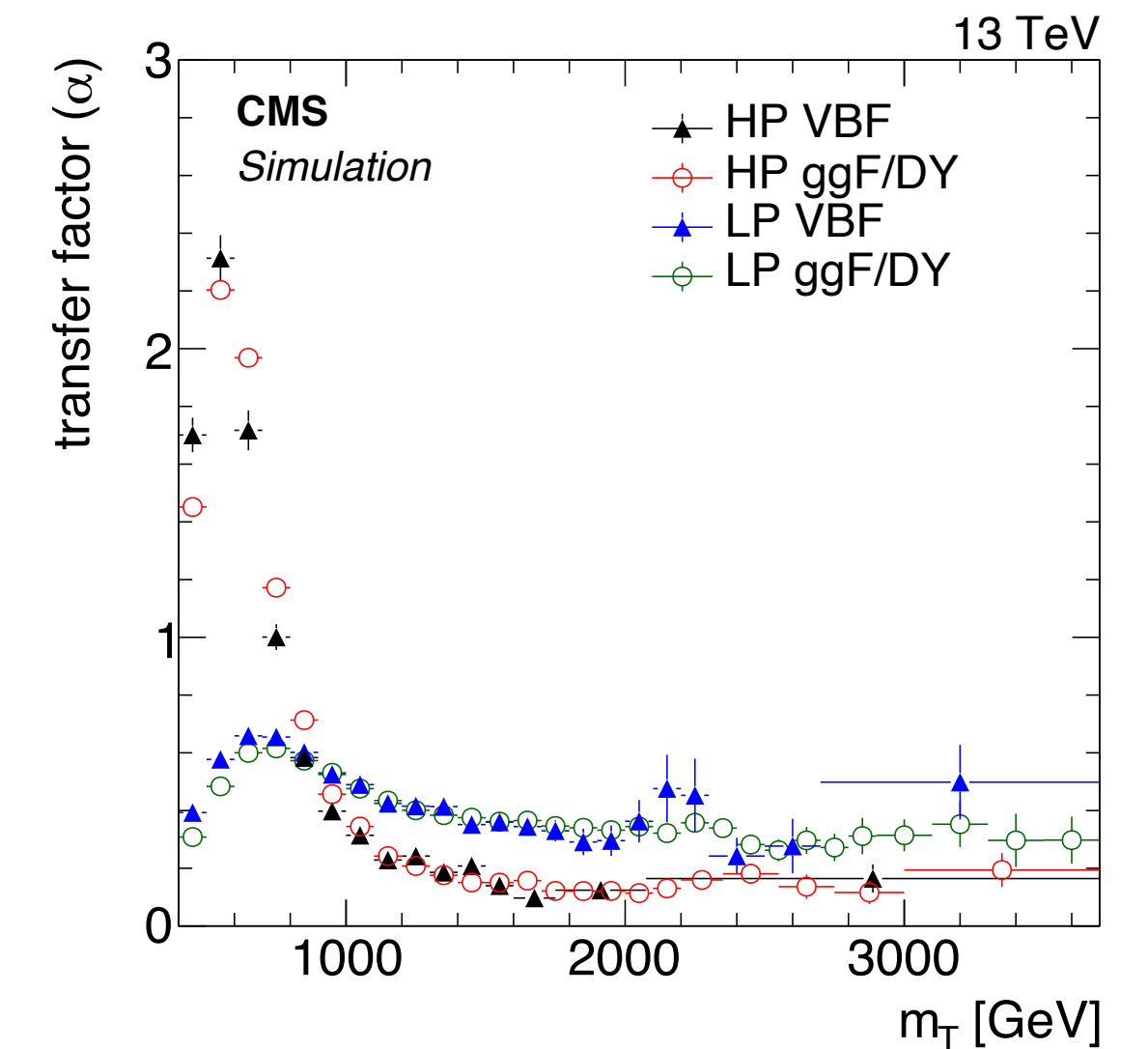
► Strategy

► Categorisation:

- ggF/VBF, bb/0b
- Purity based on n-subjettines (τ_{21})

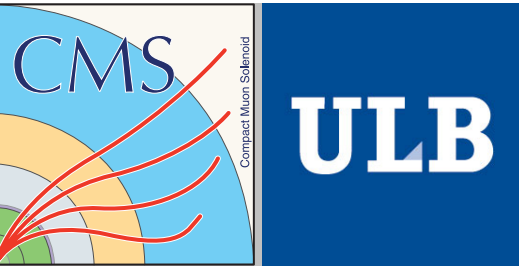
► 1D fit of $m_T(ZV)$

- $V + jet$ non-resonant background estimated from CR with transfer factors
- Resonant backgrounds ($t\bar{t}$, VV) from simulation



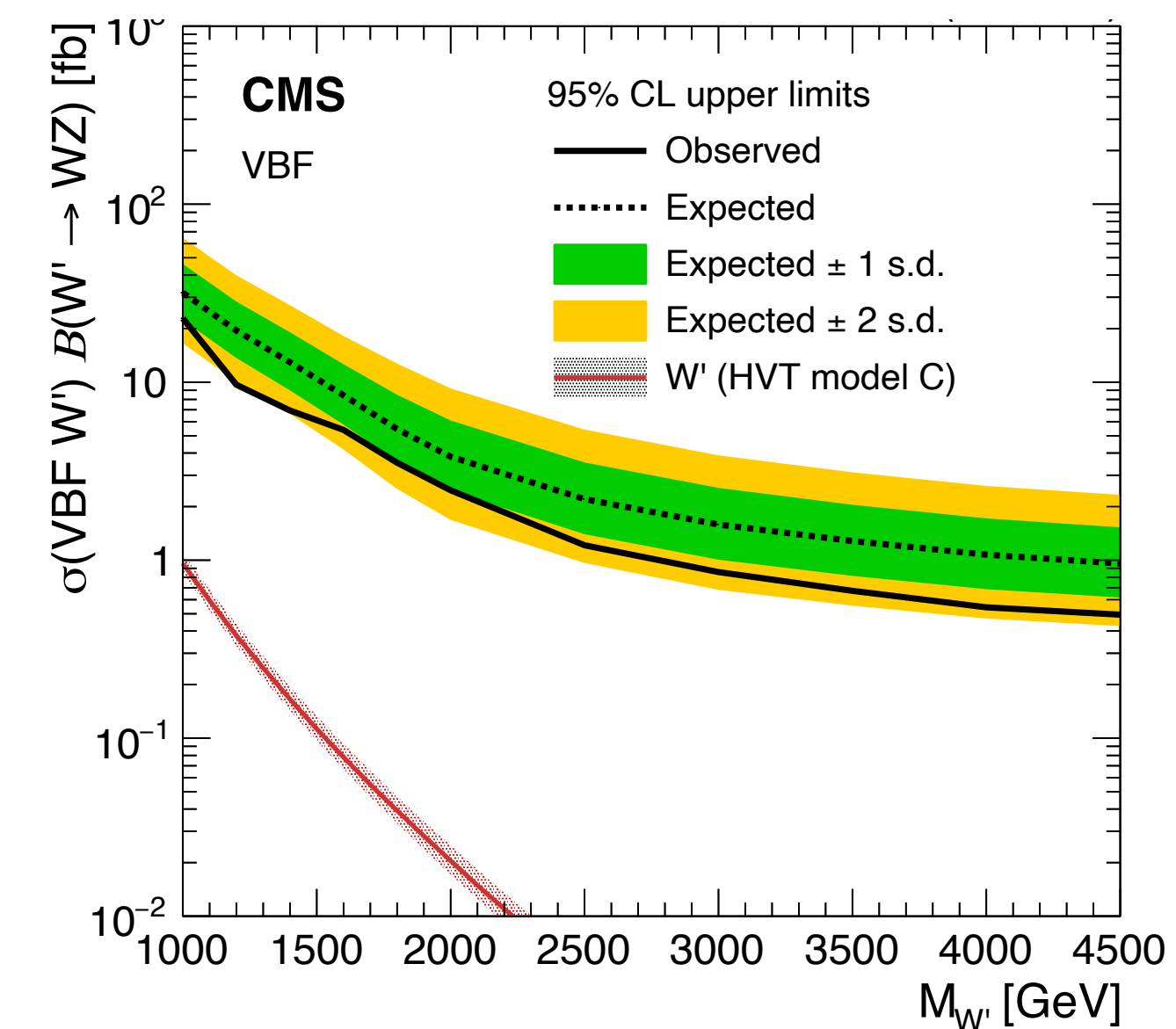
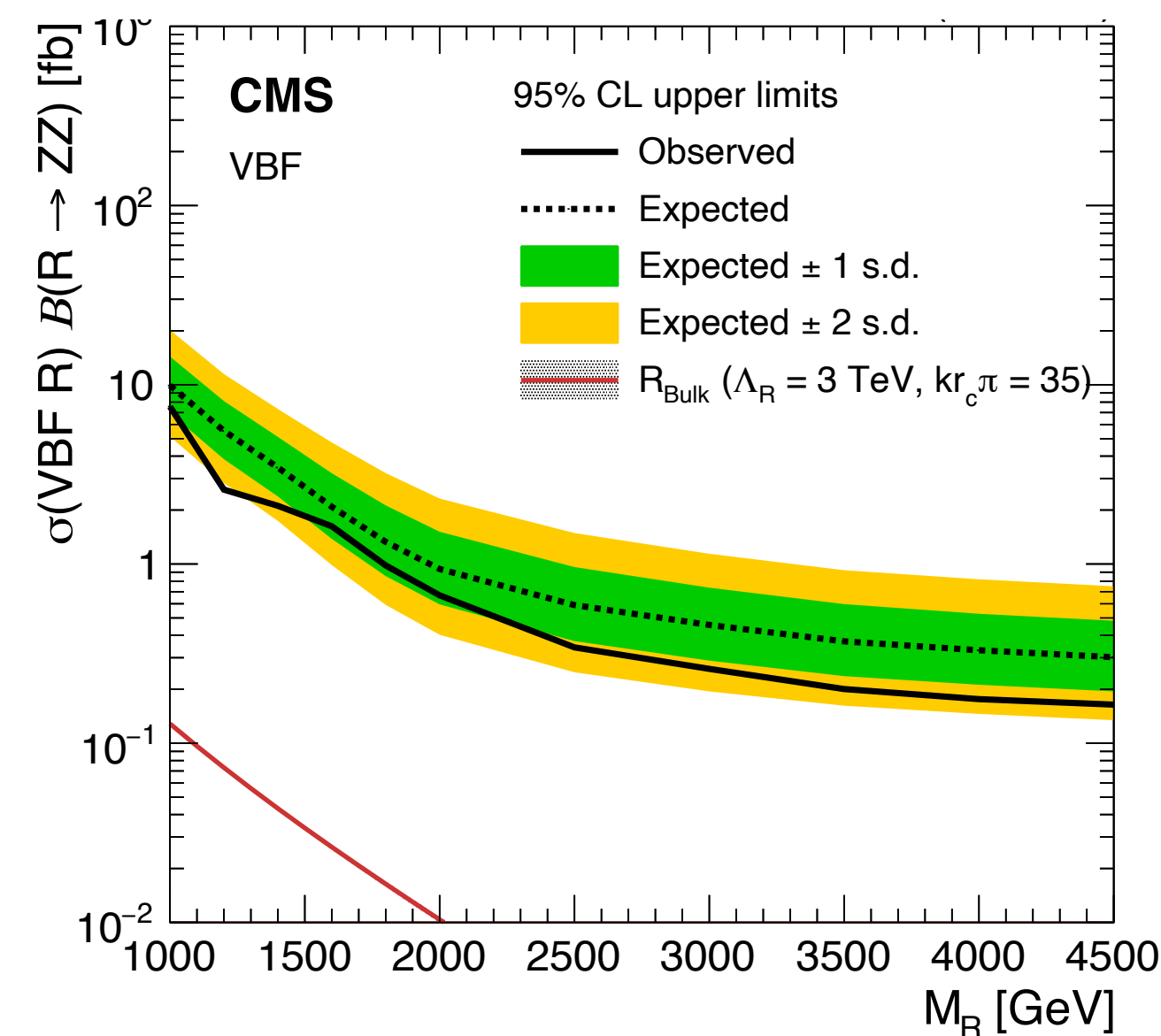
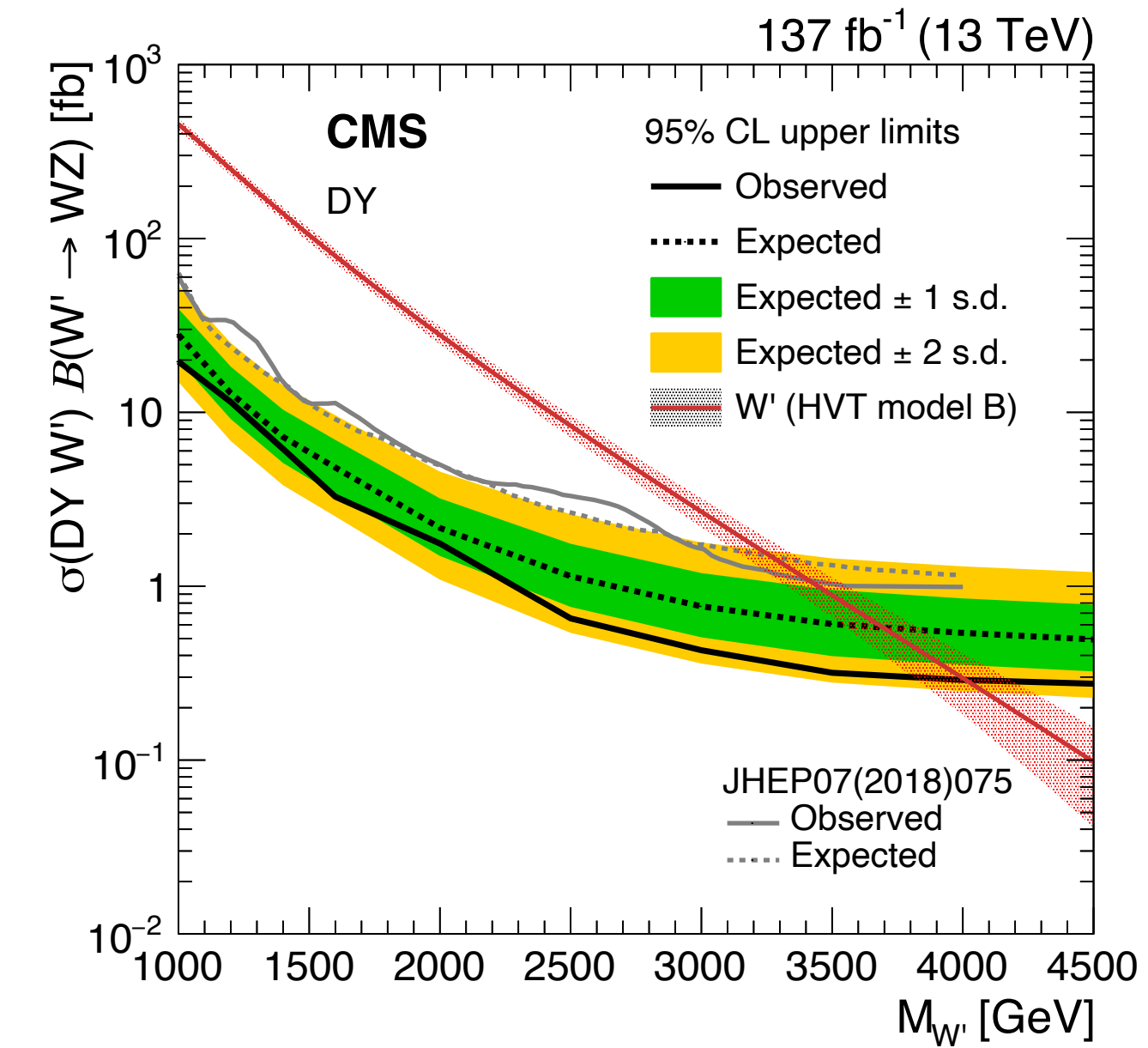
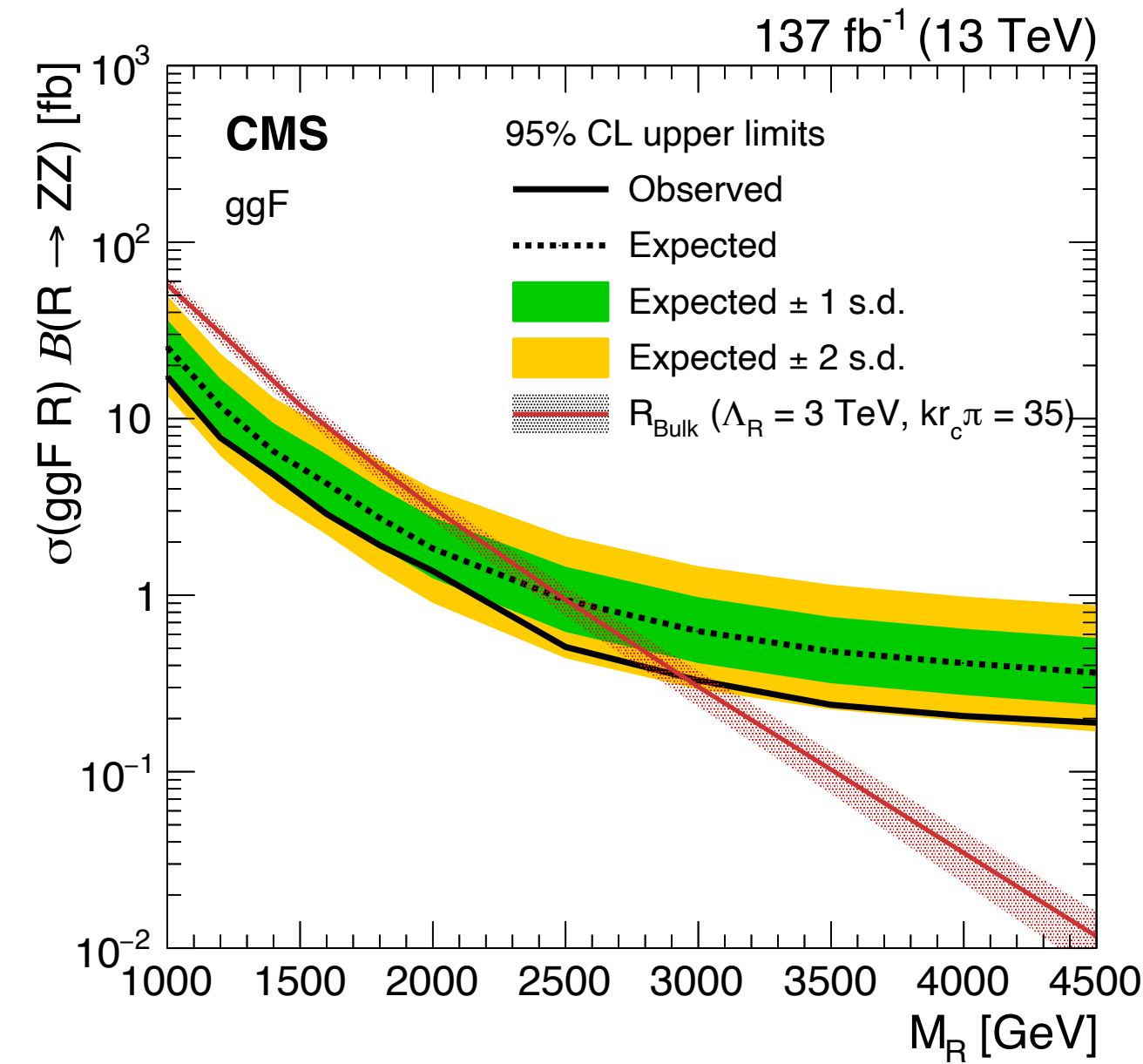
Search for ZV -- 0-lepton channel

PRD 106 (2022) 012004



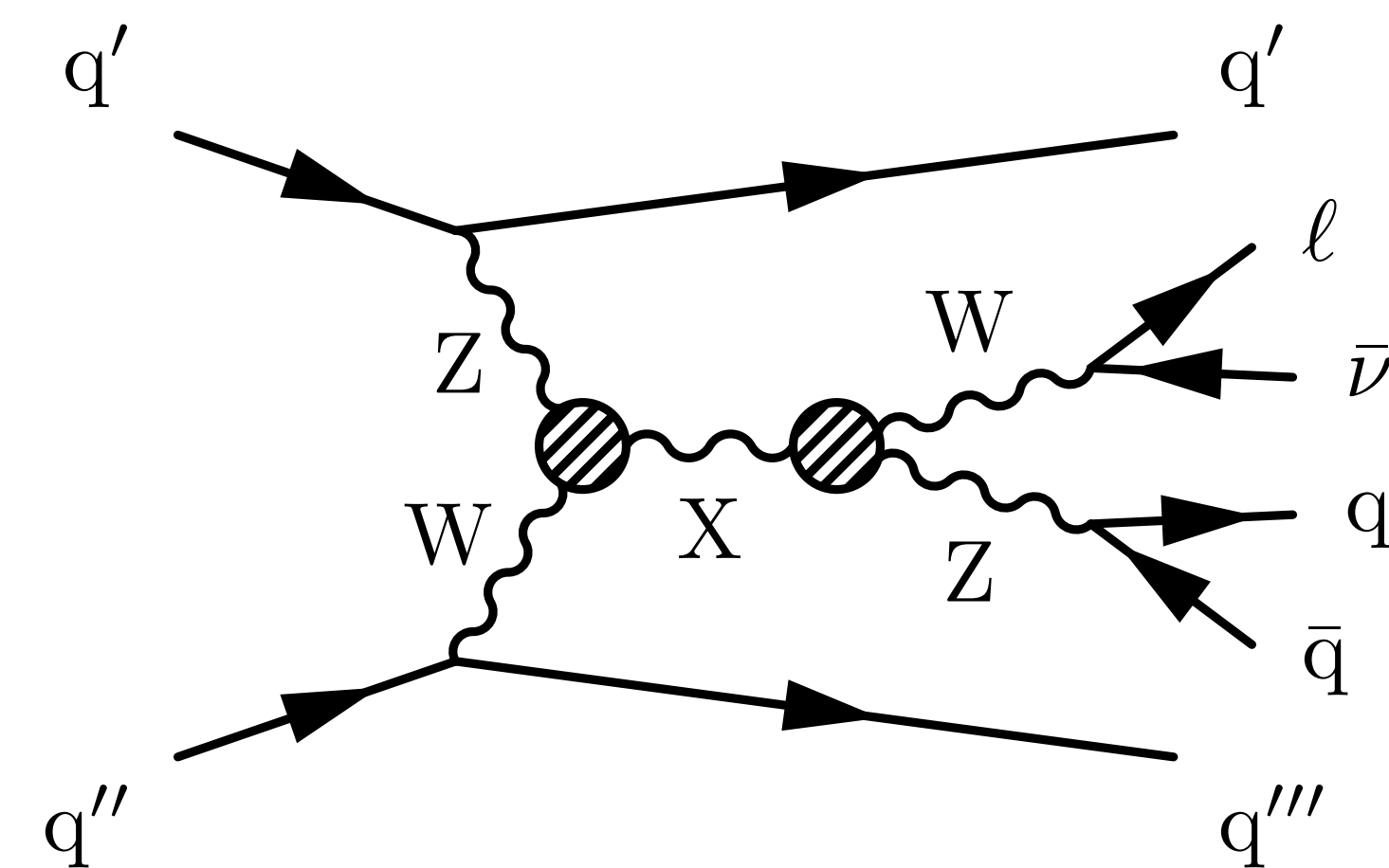
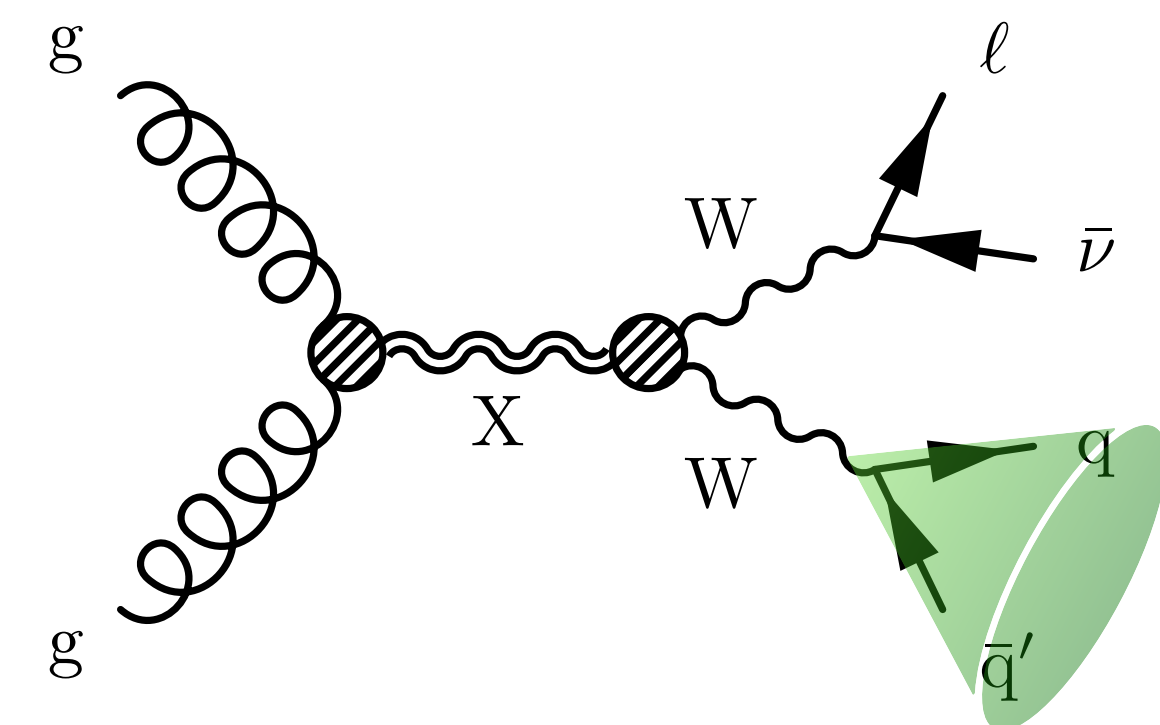
Results

- ▶ Upper limits on $X \rightarrow VV$
- ▶ Spin 0/1/2
- ▶ DY/ggF, VBF categories



Analysis in a nutshell

- Reconstruction
 - 1 lepton (e/μ) + missing transverse energy (ν)
 - 1 large radius jet (W, Z, H)
 - Two additional forward jets in the VBF category



Analysis in a nutshell

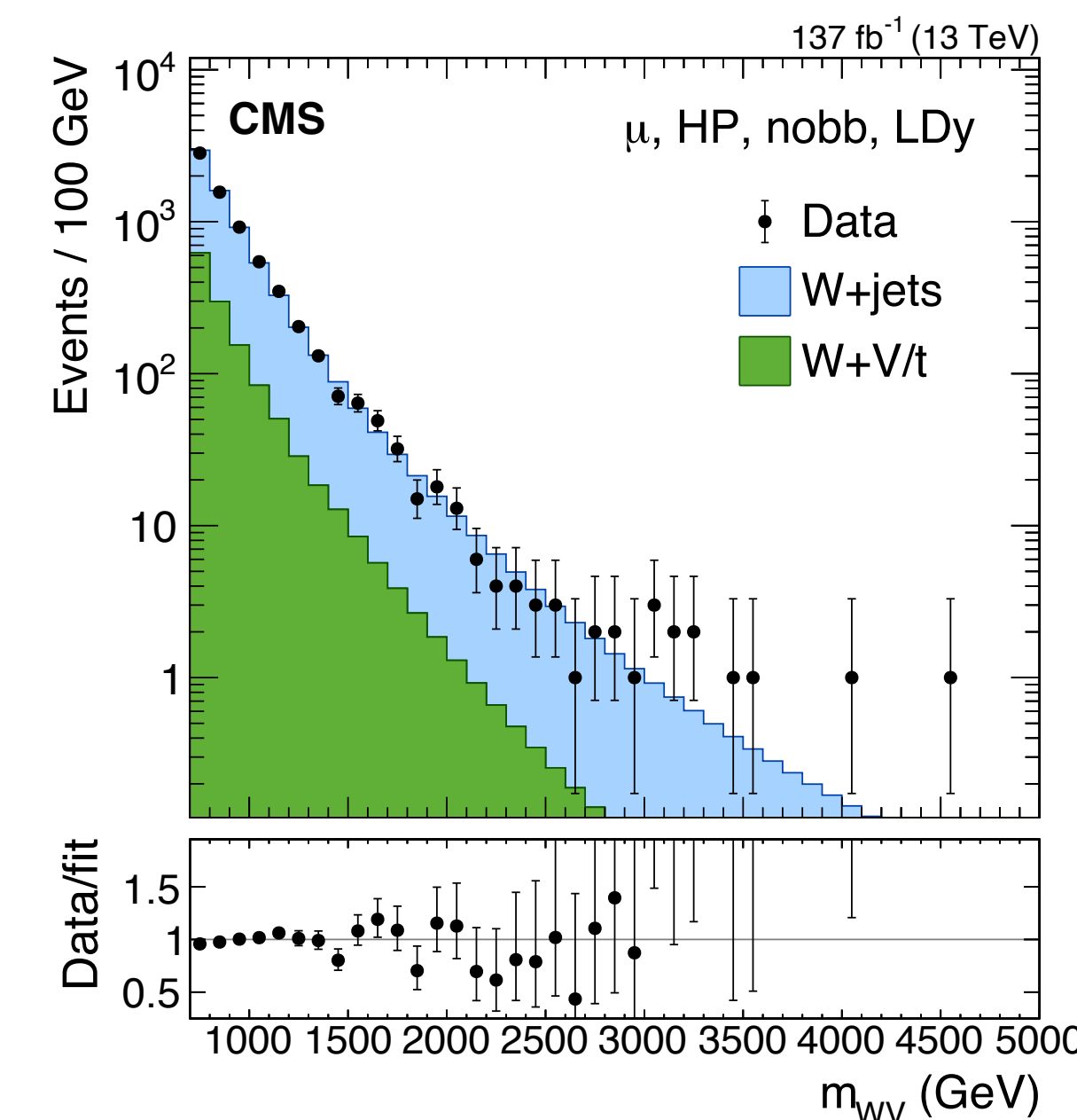
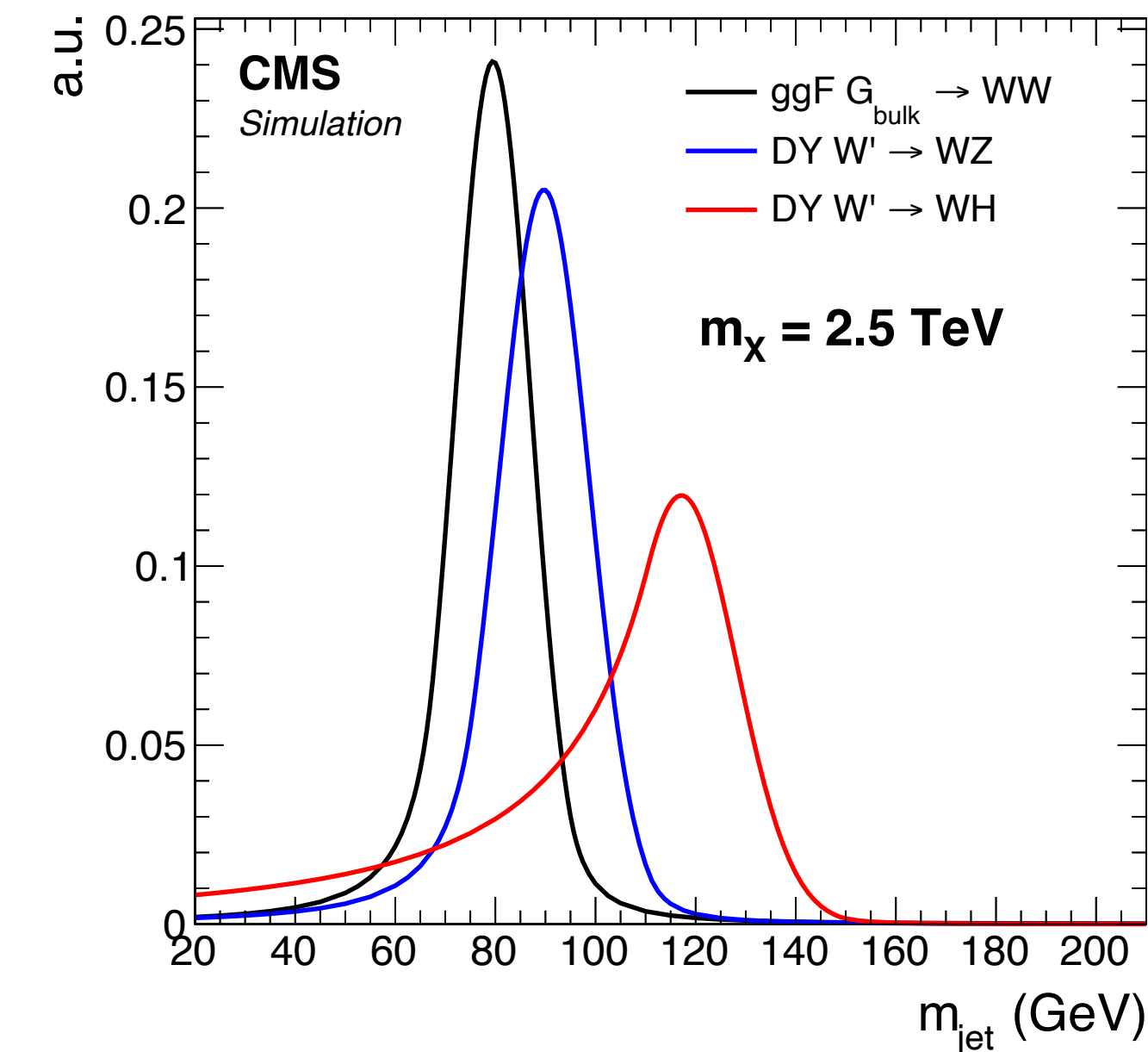
► Reconstruction

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- Two additional forward jets in the VBF category

► Strategy

► Categorisation:

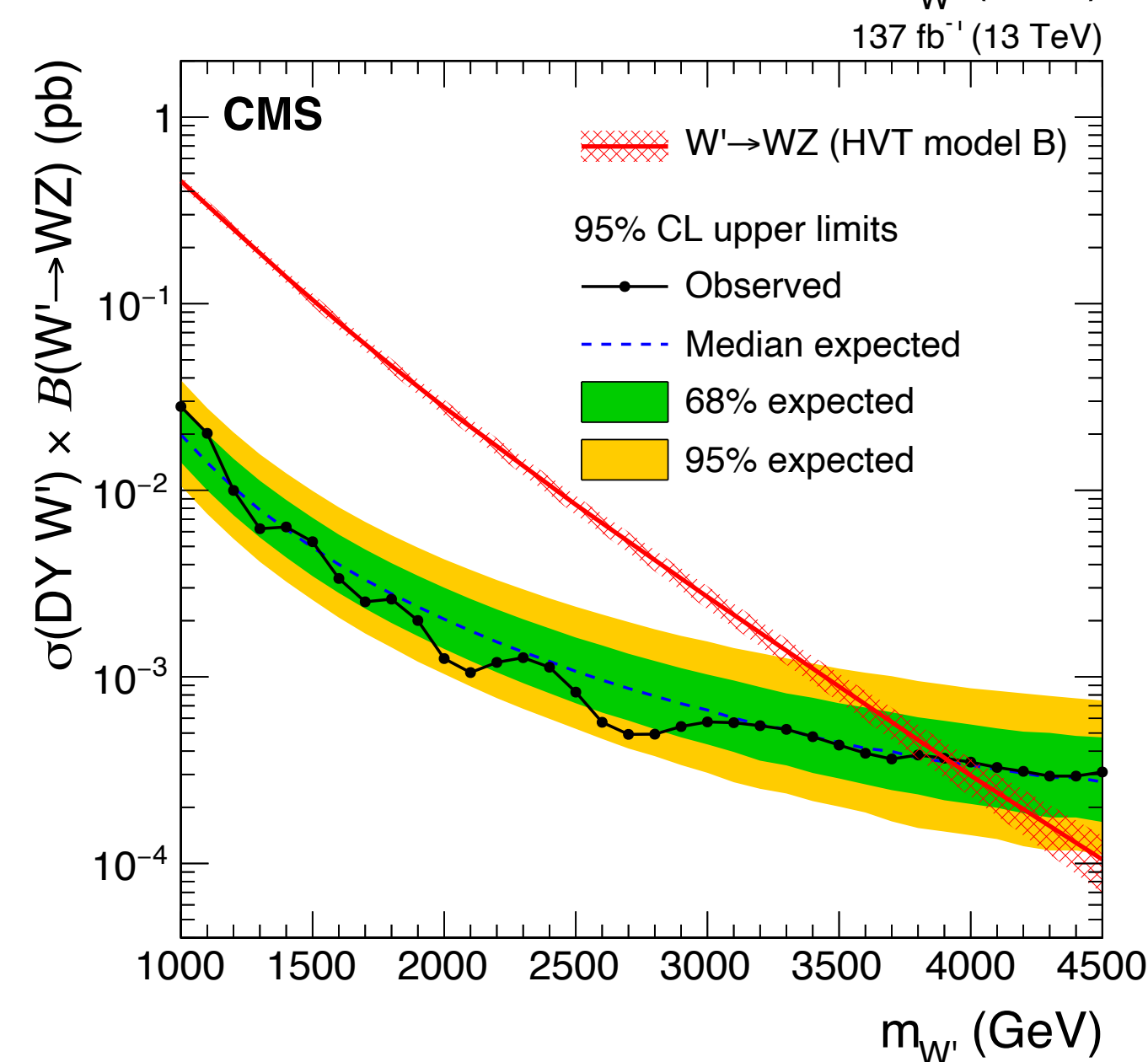
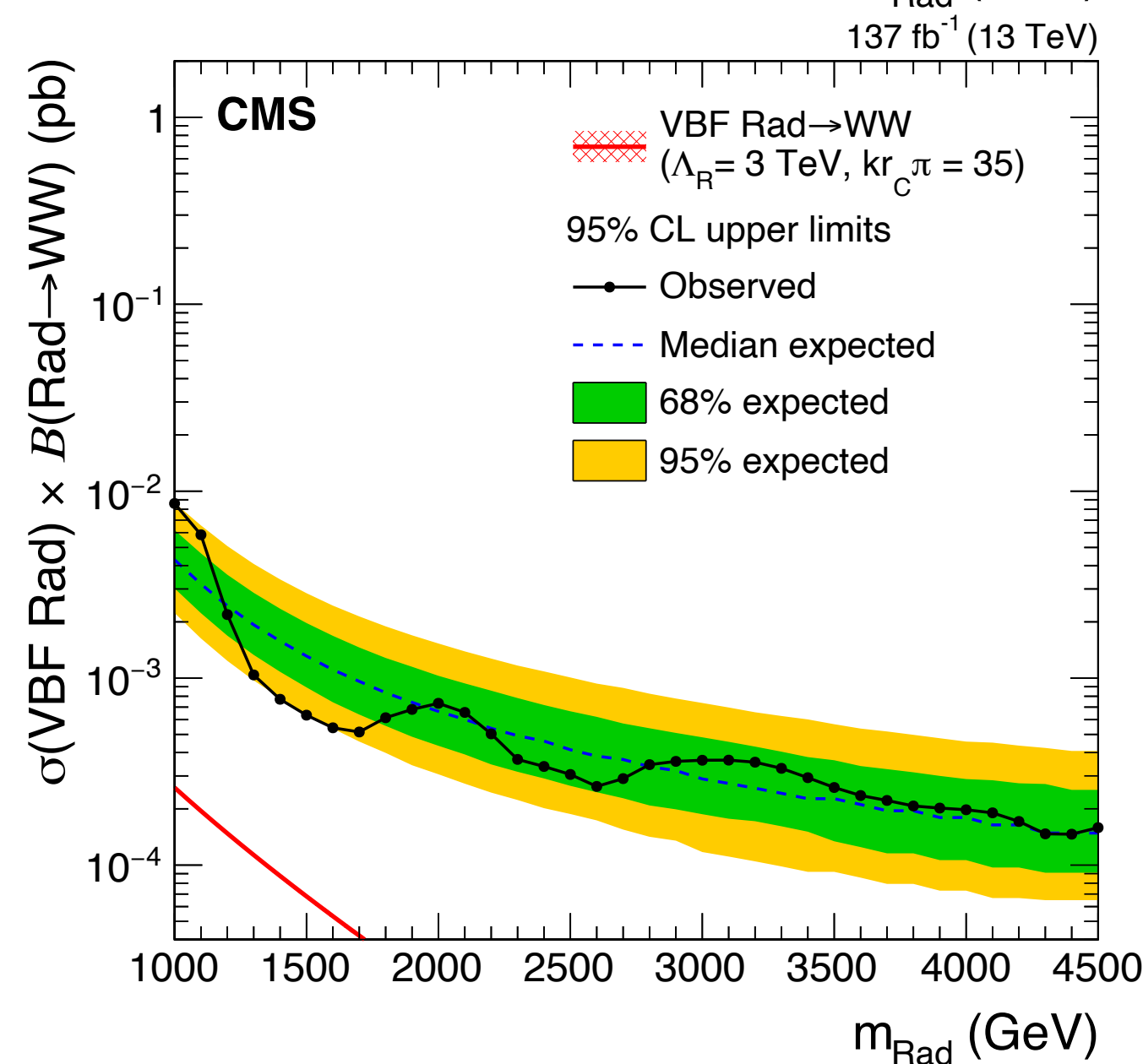
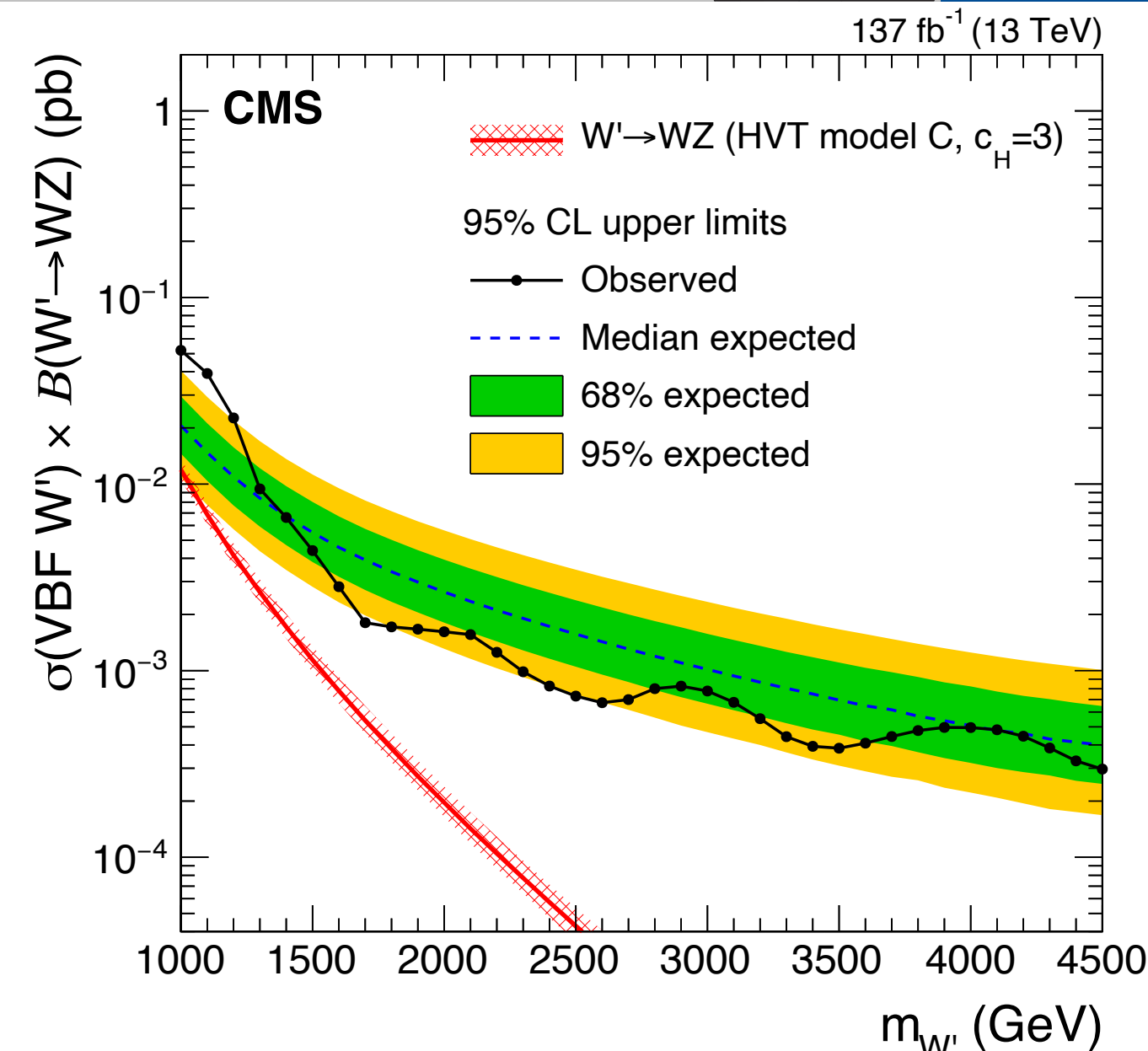
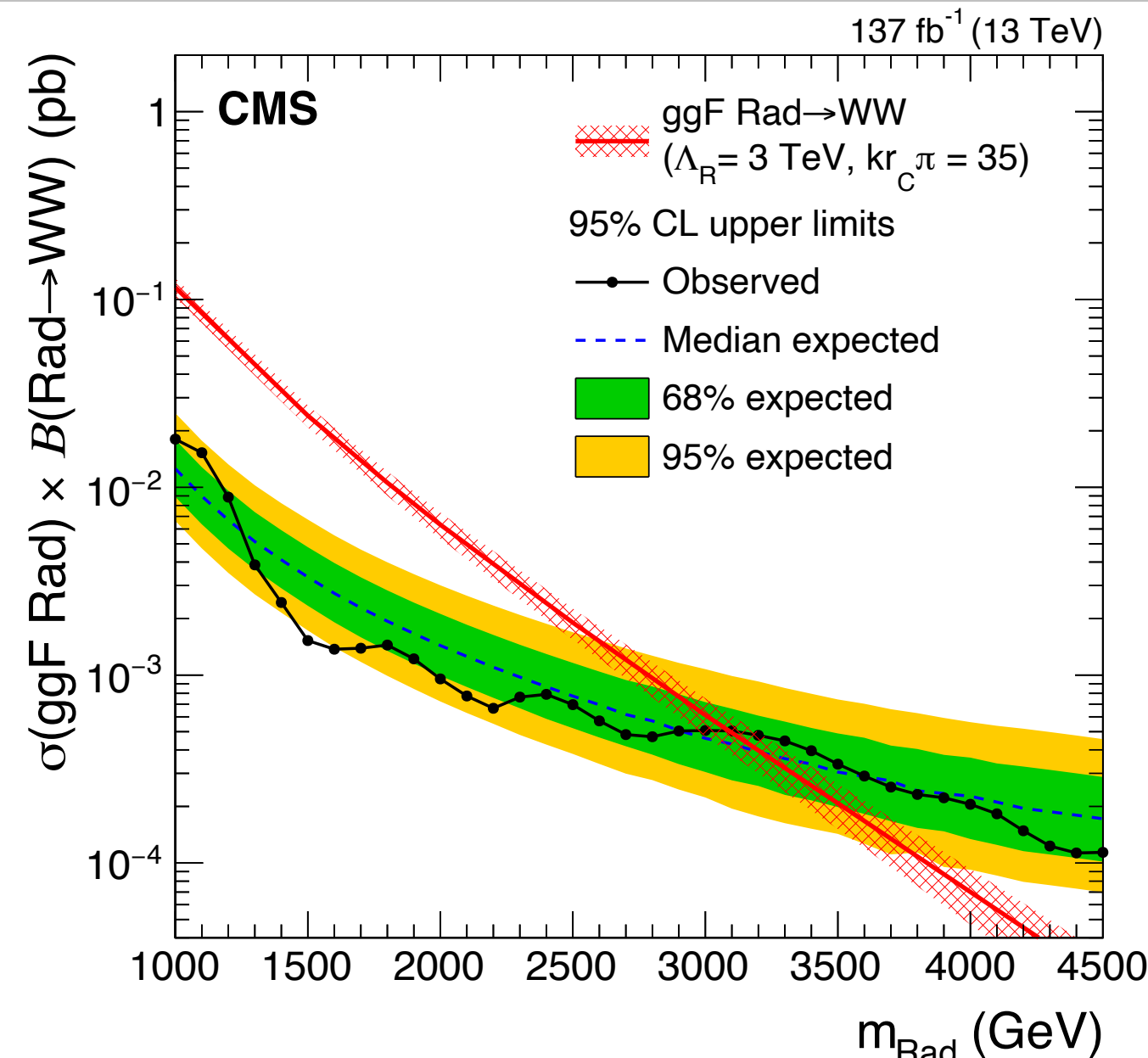
- Lepton flavour, ggF/VBF, bb/0b
- Purity based on decorrelated n-subjettines (τ_{21}^{DDT})
- Spin (rapidity separation)
- 2D fit of $m(WV)$ vs $m(j)$
 - $W + jet$ non-resonant in each dimension
 - Other backgrounds resonant in $m(j)$



Search for WV -- single-lepton channel

Results

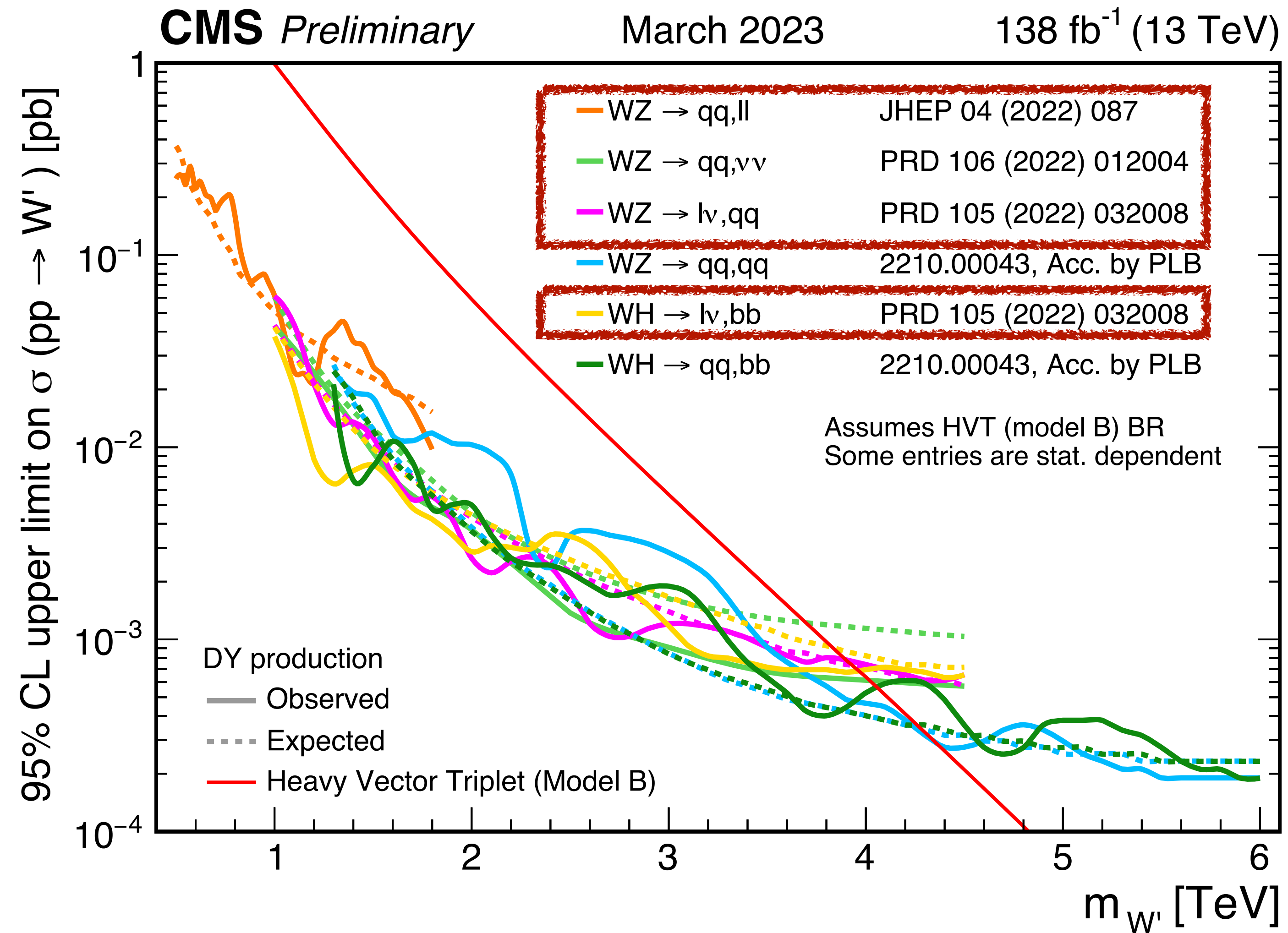
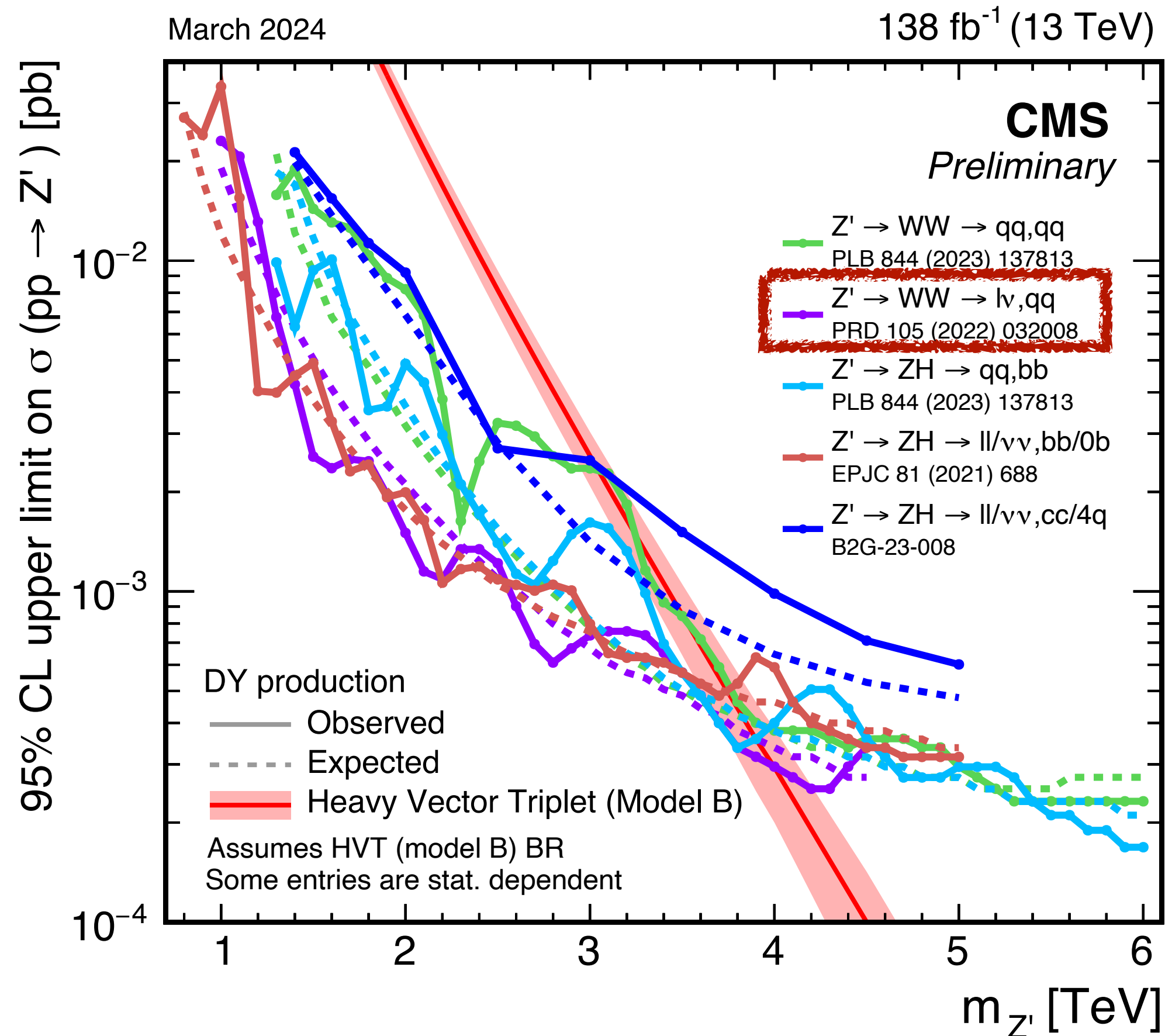
- ▶ Upper limits on $X \rightarrow VV$
- ▶ Spin 0/1/2
- ▶ DY/ggF, VBF categories



Search for diboson -- interpretations

Comparing channels

- Model-dependent limits:
- Production modes (ggF/DY, VBF)
- Theory parameters (spin, charge, coupling)

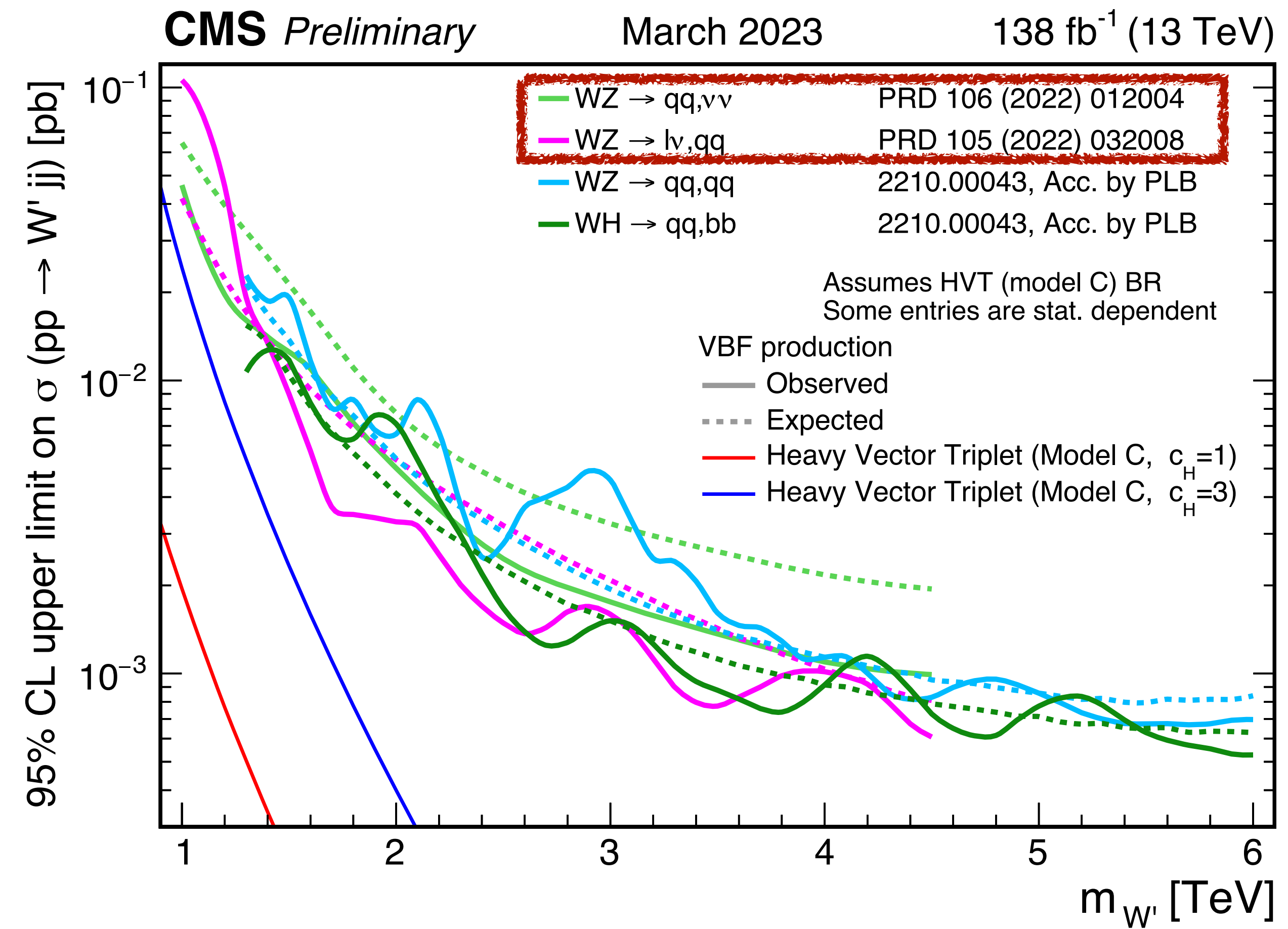
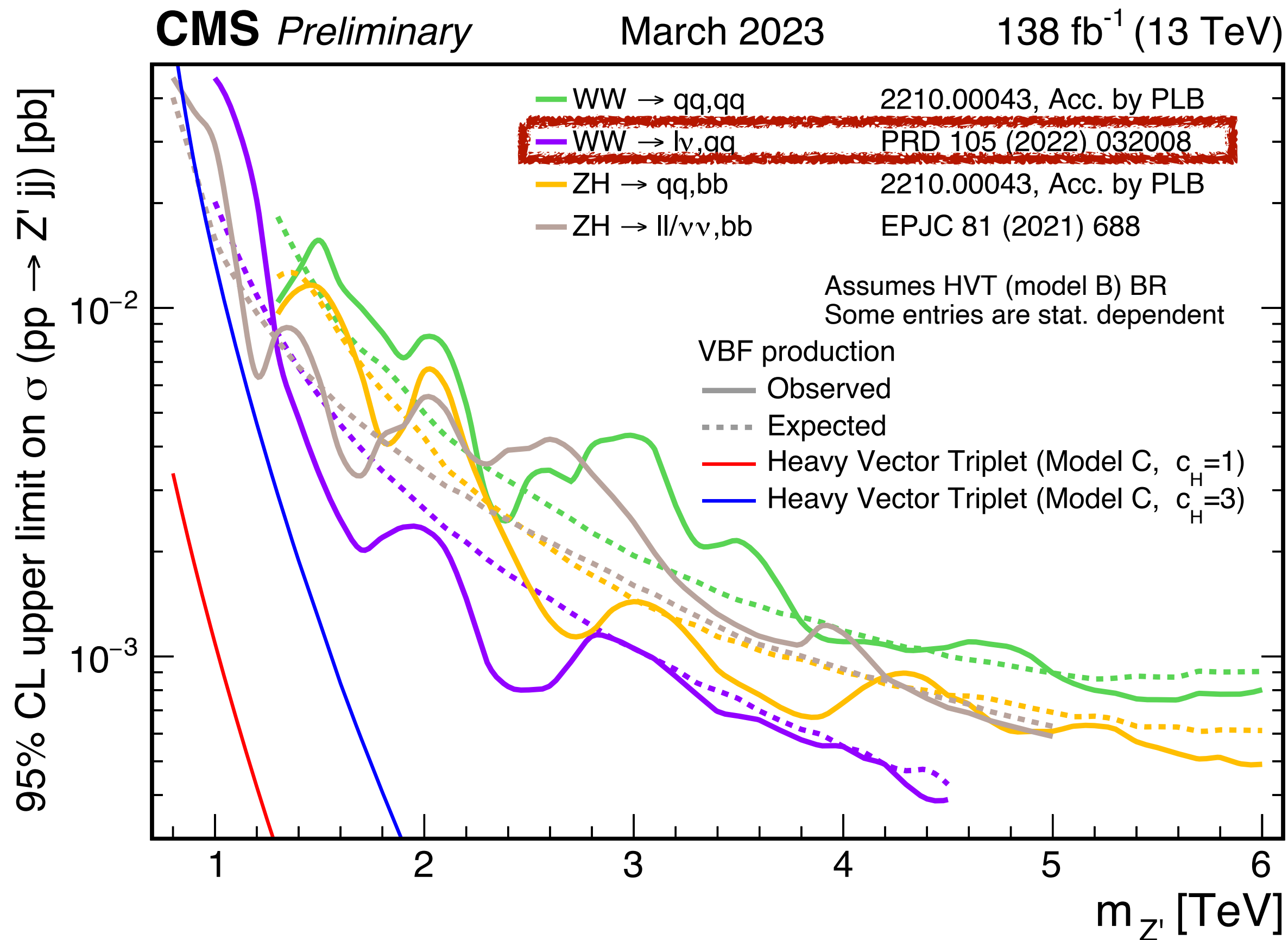


Search for diboson -- interpretations

More public results [here](#)

Comparing channels

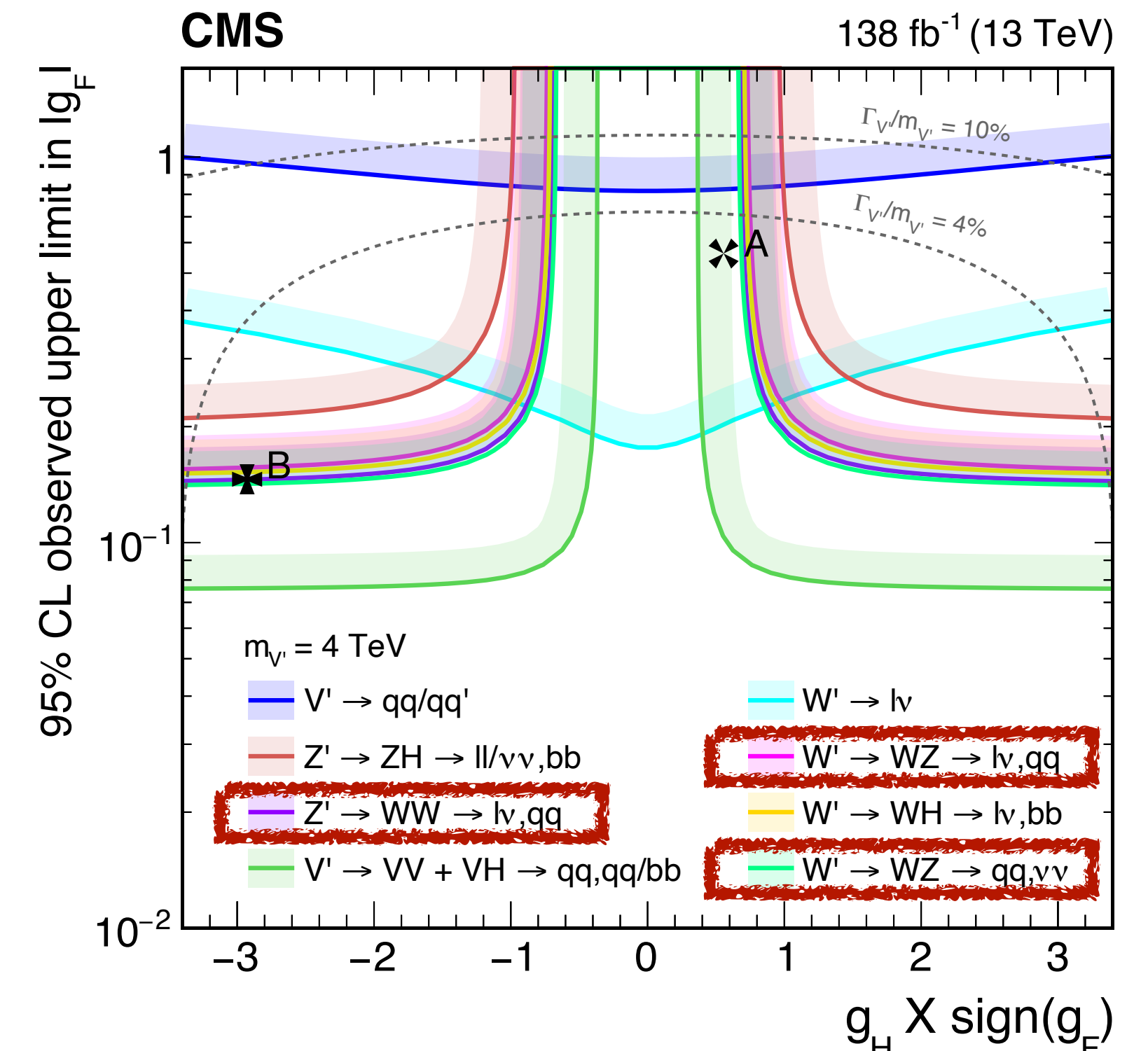
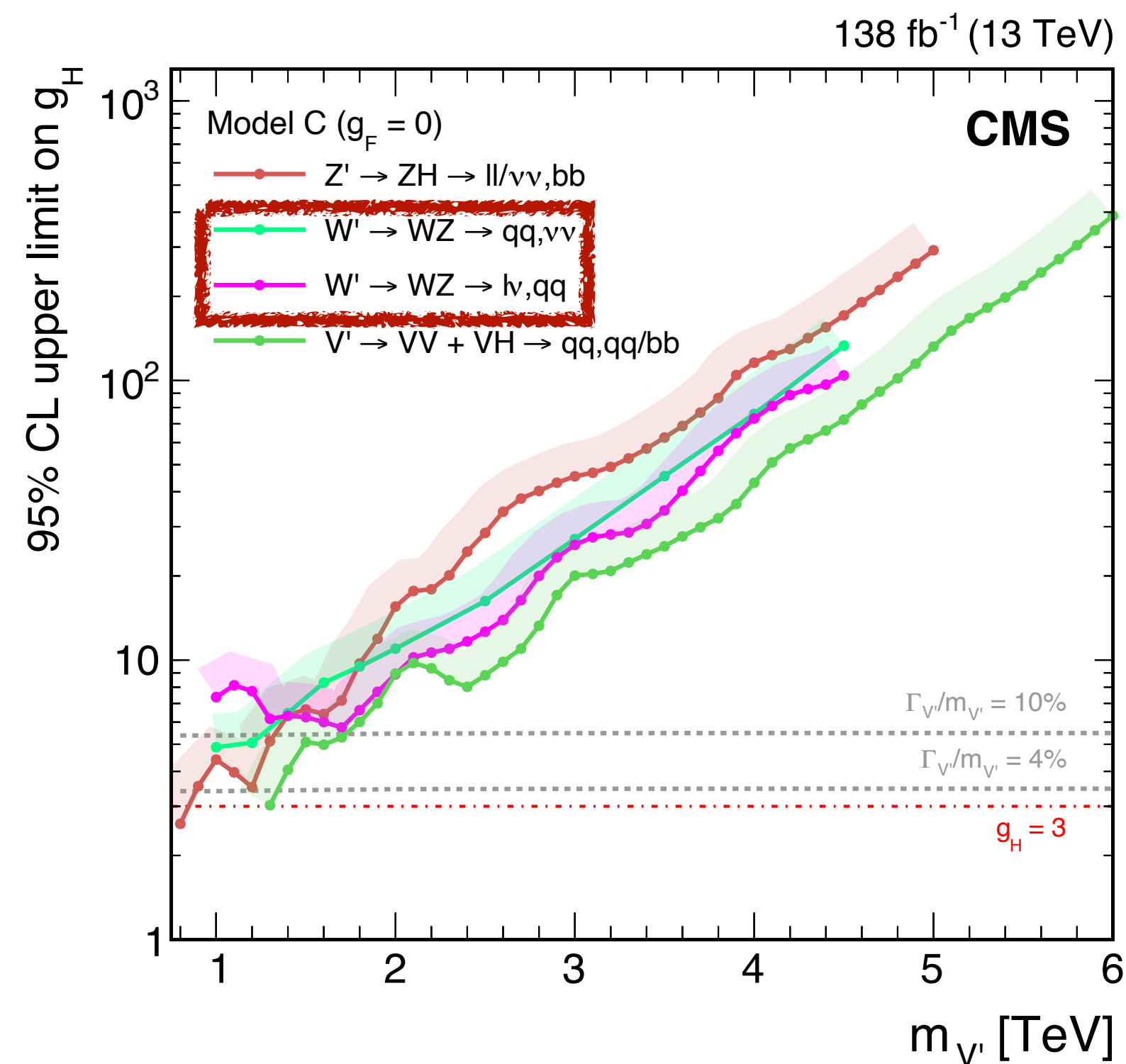
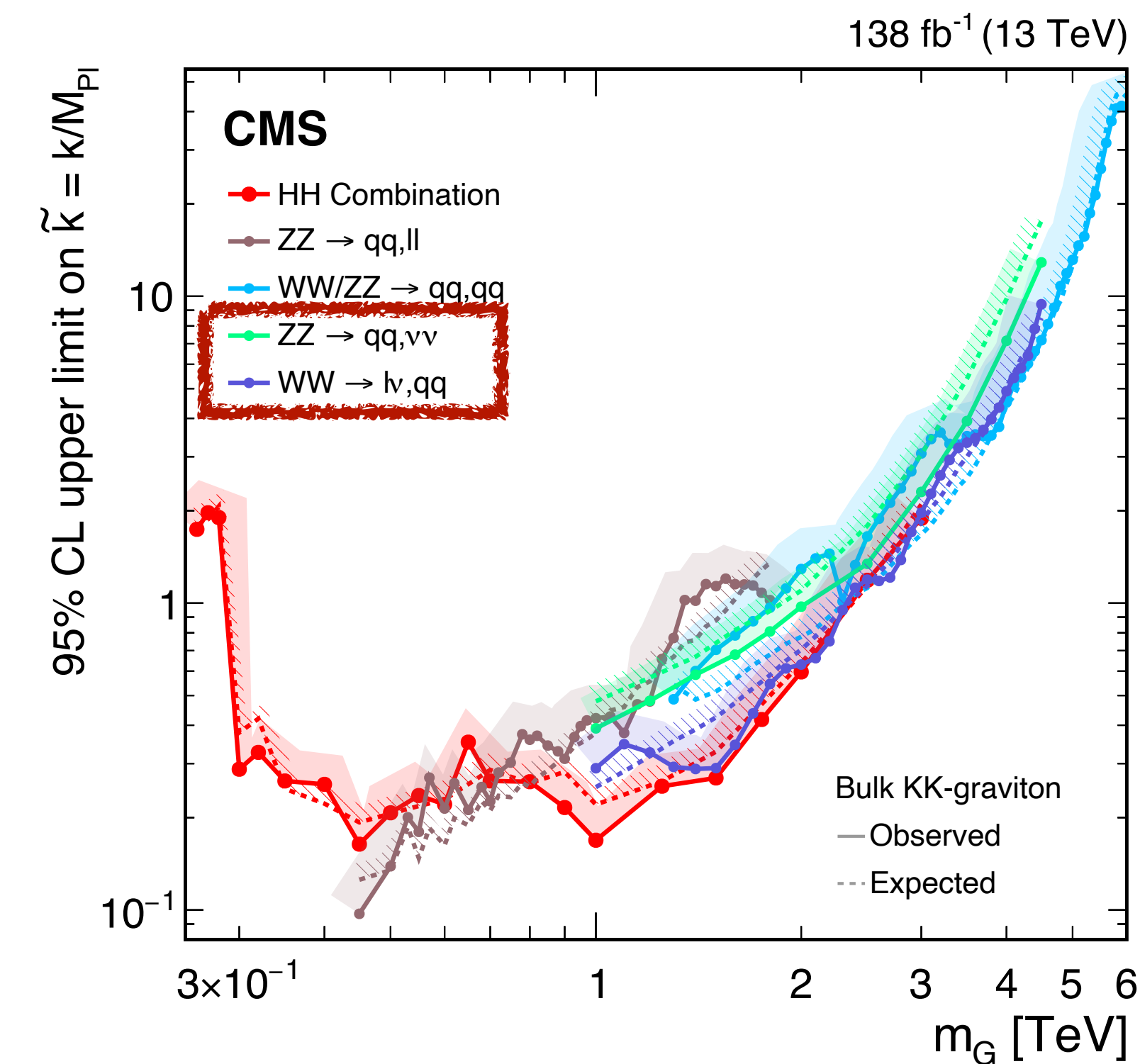
- ▶ Model-dependent limits:
- ▶ Production modes (ggF/DY, VBF)
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Search for diboson -- interpretations

Comparing channels

- ▶ Model-dependent limits:
- ▶ Production modes (ggF/DY, VBF)
- ▶ Theory parameters (spin, charge, coupling)



- ▶ Presented searches for diboson resonance
- ▶ 0/1/2 leptons final states
- ▶ Spin 0/1/2 hypotheses
- ▶ ggF/DY/VBF productions
- ▶ Several interpretations provided

- ▶ Stay tune for more results:
 - ▶ Legacy Run2 combination
 - ▶ new Run3 data to provide further insight

Thank you for your attention!

