Search for Wγ resonances using hadronic decay of Lorentz-boosted W bosons in *pp* collisions at $\sqrt{s}$ = 13 TeV on CMS

The CMS Collaboration

arXiv:2106.10509, submitted to *PLB*

Motivations

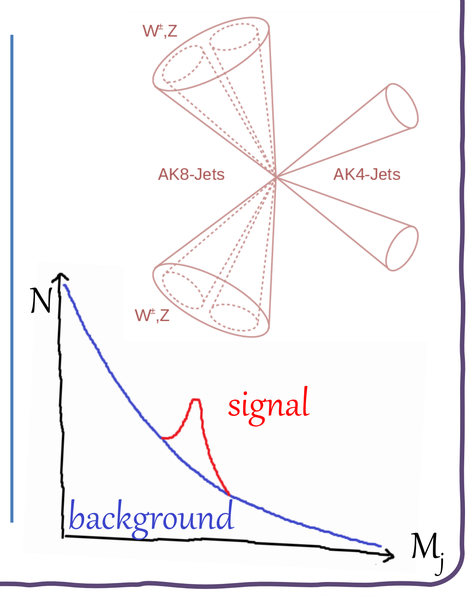
V/H + γ final states are commonly known as signatures of BSM theories[1][2].

Hγ[3] and Zγ[4] hadronic searches have been done on the CMS. Wγ channel is the missing part of a complete CMS V/H + γ search program.

ATLAS's newest results[5] on hadronic Wγ at 13 TeV give limits ranging from 0.14 - 12 fb for spin-1 resonances with mass between 1.0 – 6.8 TeV.

Strategies

- "Bump hunt" – resonance over a smooth falling background.
- Hadronic decay of the W boson – large radius PUPPI softdrop AK8 jets.
- W tagging - N-subjettiness τ_{21} variable.

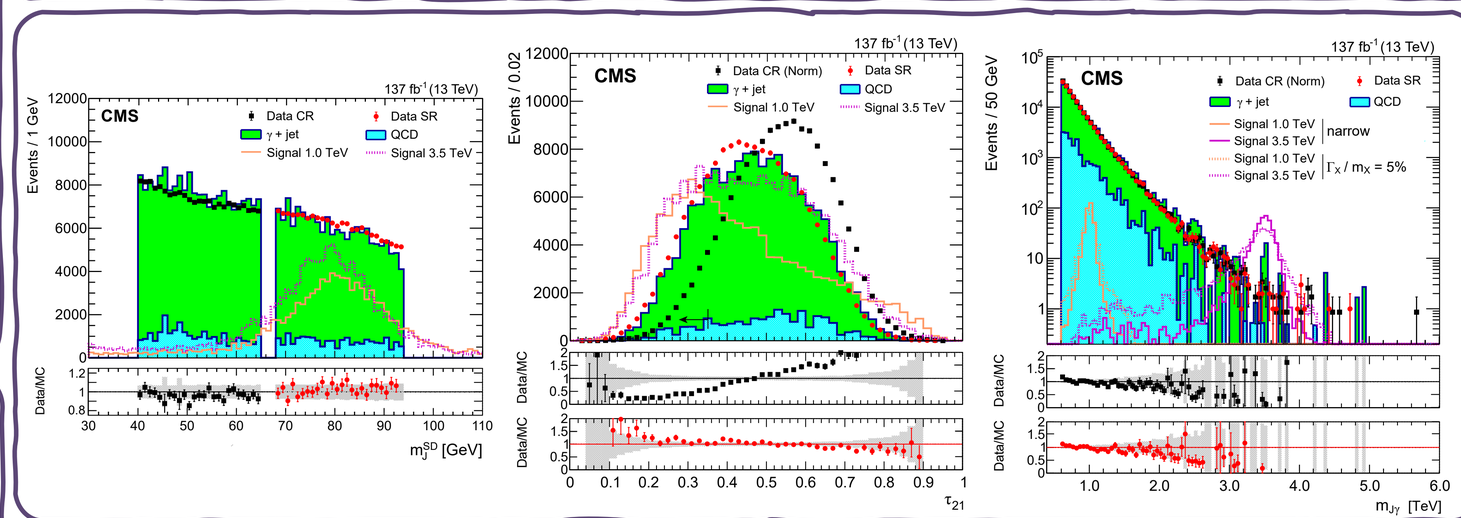


Trigger & datasets

- HLT_Photon165_HE10 || HLT_Photon175 (2016), HLT_Photon200 (2017,18)
- Primary dataset: SinglePhoton (2016,17), Egamma (2018)
- Signal MC: Spin-0[6, 7] and Spin-1[7] models with two width categories, narrow and broad (5%*m*).
- SM MC: γ + jet - dominating background; QCD MC – photon misidentification. Used for sanity checks only.

Optimization

- Blinding policy - use data sideband (CR) for the analysis optimization.
- Cut-based sequential selections on kinematic, angular and W tagging variables, maximize $S/\sqrt{B}$.



Event selection

Pre-selection & Analysis cuts	
HLT	HLT_Photon200 (HLT_Photon165_HE10 || HLT_Photon175)
Photon	p_T > 225 GeV, $\|\eta\|$ < 1.44, Cut-based loose ID, Electron veto
AK8 Jet	p_T > 225 GeV, TightLepVeto ID, $\|\eta\|$ < 2.0, τ_{21} < 0.35, 68 GeV < m_{sd} < 94 GeV
γ+jet system	$\Delta R_{\gamma,j}$ > 1.1, $p_{T\gamma}/m_{\gamma j}$ > 0.37, $\cos\theta^*$ < 0.60, $M_{\gamma j}$ > 0.6 TeV

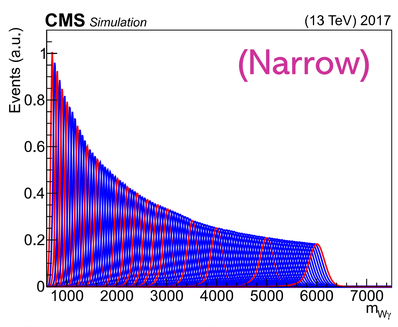
Signal and background modeling

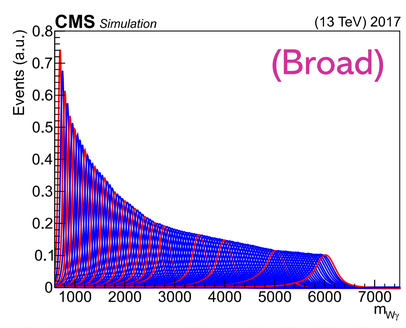
Signal

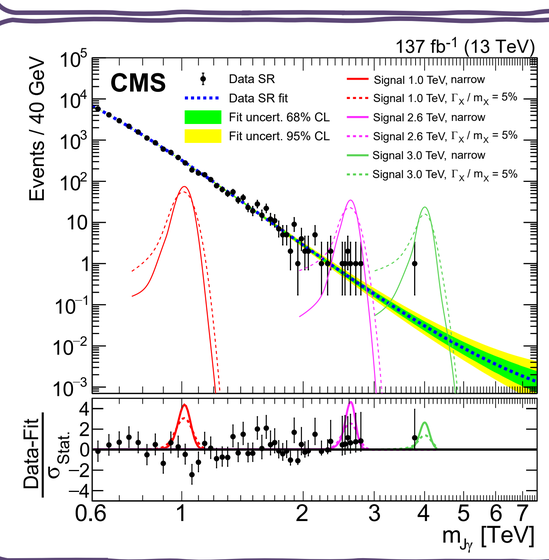
CB + Gaussian (Narrow) CB + 2 Gaussian (Broad)

Background

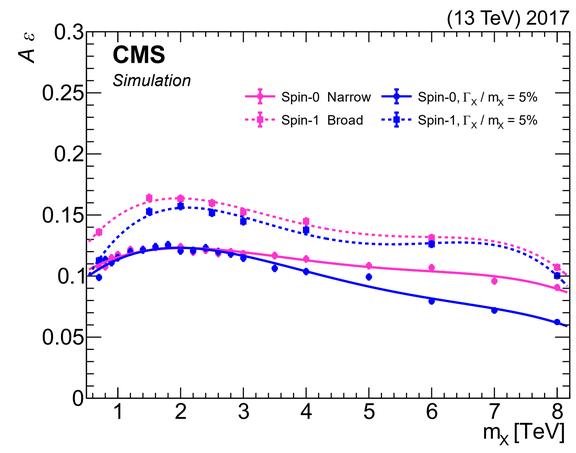
dijet-3 function: $\frac{dN}{dM} = P_0 \times \left(\frac{m}{\sqrt{s}}\right)^{P_1 + P_2 \times \ln\left(\frac{m}{\sqrt{s}}\right) + P_3 \times \ln^2\left(\frac{m}{\sqrt{s}}\right)}$





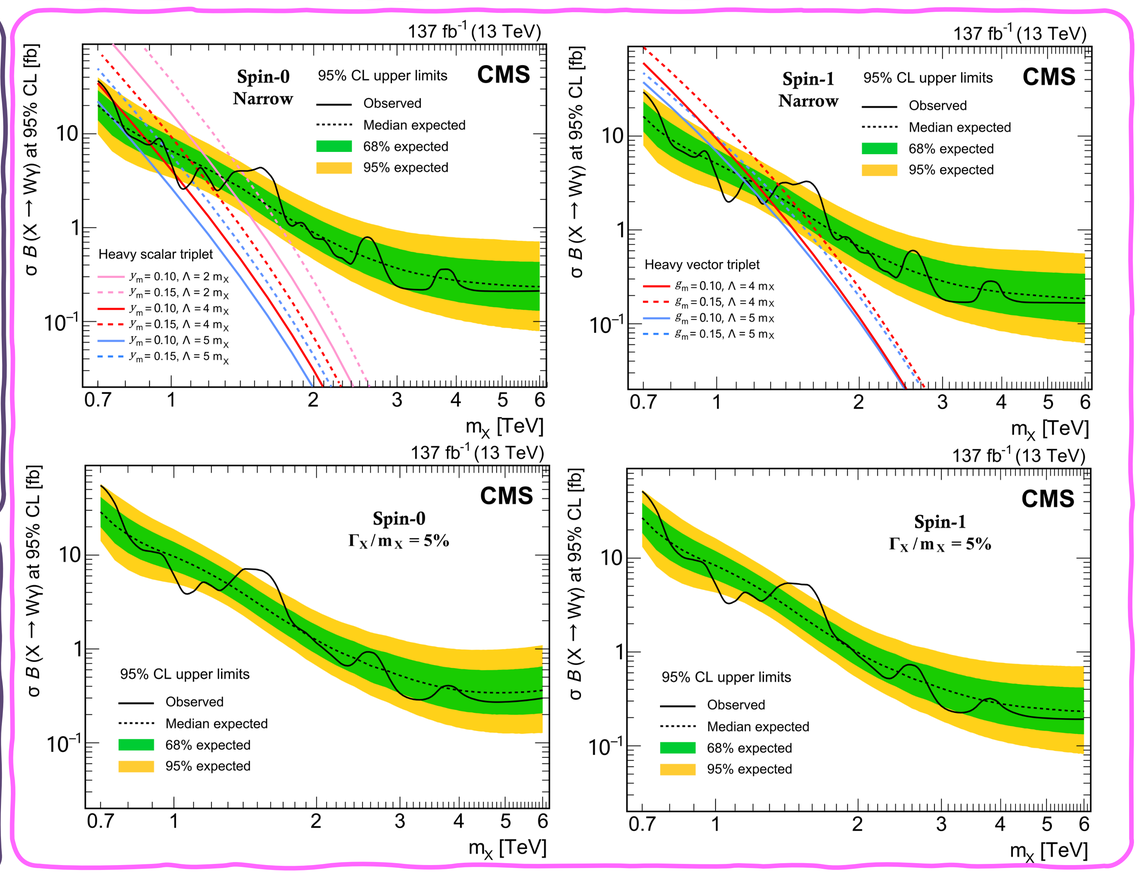


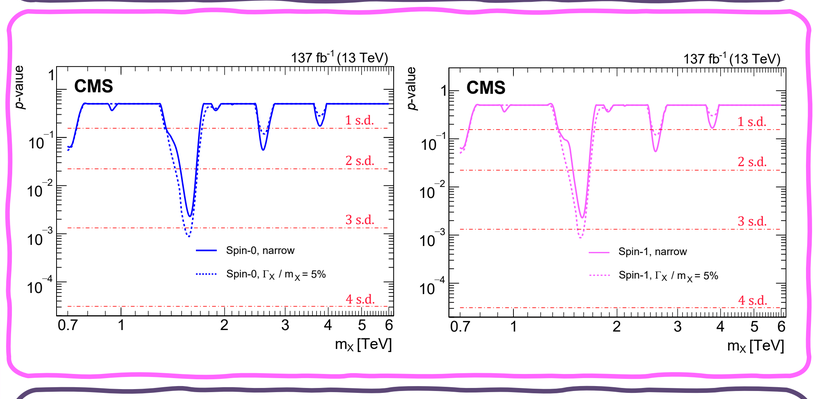
Signal total efficiencies



Systematics

Source	Effect on signal yield
Int. lumi	1.8%
Trigger eff.	0.9%
Photon ID	4.4%
W tagging	3.9%
Pile-up	1.3%
PDF	2.0%
JEC, JER	0.8%
PEC, PER	0.9%





Conclusions

- 95% CL upper limits are set for signals with mass ranging from 0.7 to 6 TeV.
  - Spin-0 narrow: 37 fb - 0.21 fb; broad: 55 fb - 0.30 fb
  - Spin-1 narrow: 29 fb - 0.17 fb; broad: 51 fb - 0.19 fb
- No significant excess is observed.
  - Minor excess Local significance: 2.7σ – 3.1σ
  - @1.58 TeV: Global significance: 1.0σ – 1.8σ

Reference

[1] G. Burdman et al., *Phys. Rev. D* **78** (2008) 075028.

[2] K. D. Lane and E. Eichten, *Phys. Lett. B* **222** (1989) 274.

[3] CMS Collaboration, *Phys. Rev. Lett.* ***122*** *(2019) 081804.*

[4] CMS Collaboration, *JHEP* **09** (2018) 148.

[5] ATLAS Collaboration, *Phys. Rev. D* **98** (2018) 032015.

[6] N. Arkani-Hamed et al., *JHEP* **11** (2016) 082.

[7] R. M. Capdevilla et al., *JHEP* **03** (2020) 117.