Inclusive and VBS W+photon with the CMS detector

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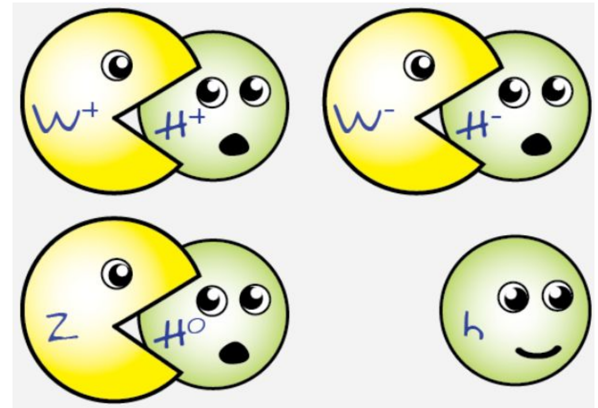
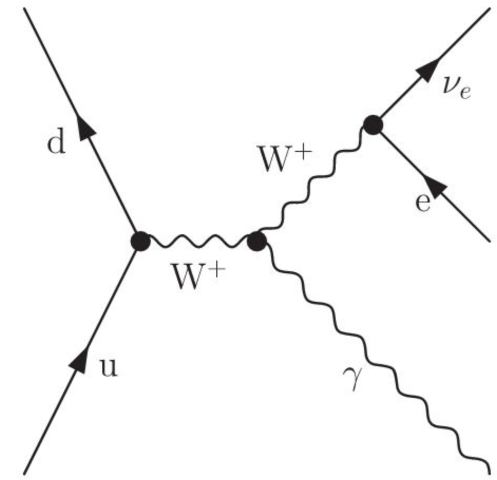
25 Nov 2021

Multi-boson process



Why is Multi-boson process interesting?

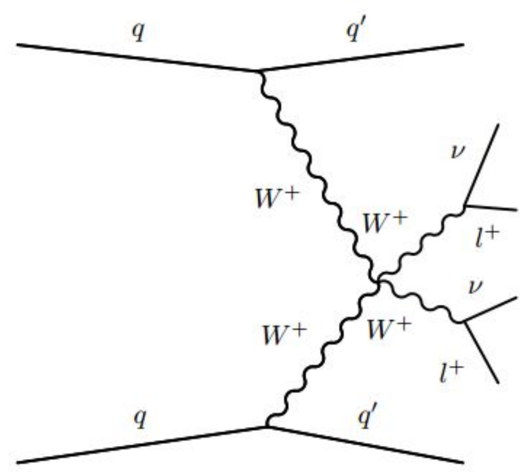
- Massive vector bosons directly couple to Higgs boson, provide probe to Higgs mechanism

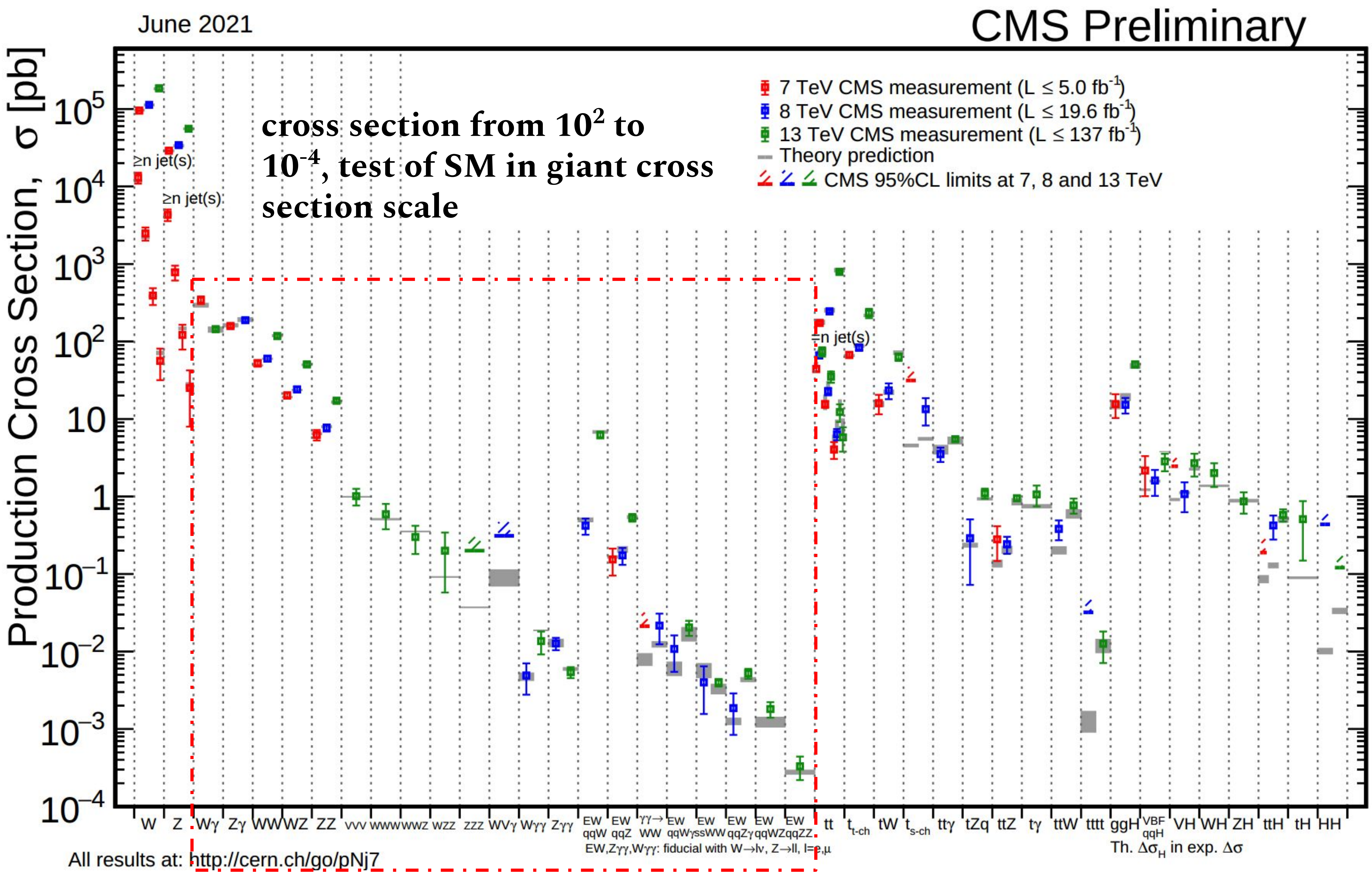


- Multi-boson process
  - ➢ Large cross section, precision test of SM
  - ➢ Multi-boson vertex sensitive to anomalous couplings

$$\mathcal{L}_{\mathrm{eff}} = \mathcal{L}_{\mathrm{SM}} + \sum_{n=5}^{\infty} \frac{f_n}{\Lambda^{n-4}} \mathcal{O}_n$$

- Vector boson scattering (VBS)
  - ➢ It's important that Higgs contribution preserve the unitarity within VBS
  - ➢ The longitudinal polarized part of massive vector boson is connected to the Higgs mechanism, help us have a better understanding on Higgs mechanism
  - ➢ Multi-boson vertex sensitive to anomalous couplings





cross section from 10^2 to 10^{-4}, test of SM in giant cross section scale

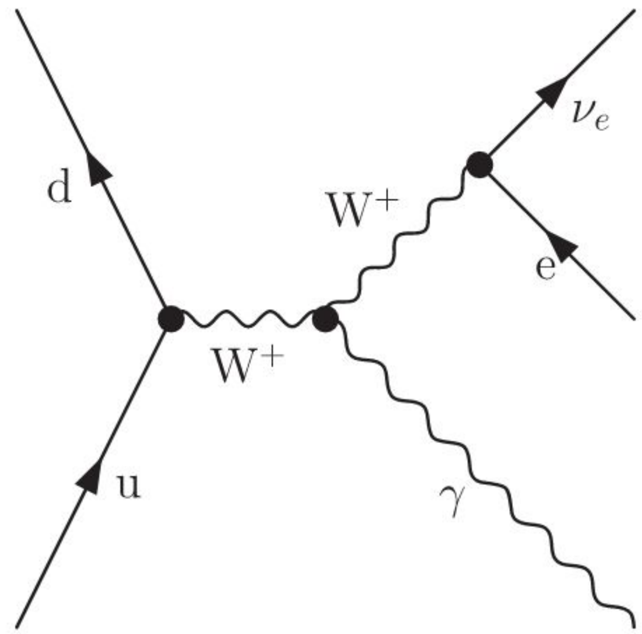
Topics in this talk

- Inclusive Wgamma: [PRL 126(2021) 252002]
    - Use 2016-2018 data @13 TeV
- VBS Wgamma: [PLB 811(2020) 135988]
    - Use 2016 data @13 TeV

inclusive Wγ

Final state: one lepton + one photon + MET

- ➢ Photon pt > 25 GeV (pass electron veto)
- ➢ Muon pt > 30 (26)GeV for 2017 (2016, 2018) data
- ➢ Electron pt > 30 (35) GeV for 2016 (2017, 2018) data
- ➢ MET > 40 GeV
- ➢ Extra muon or electron veto
- ➢ Two identification working points (WP) are defined, i.e., tight and loose for muons and electrons for fake lepton estimation

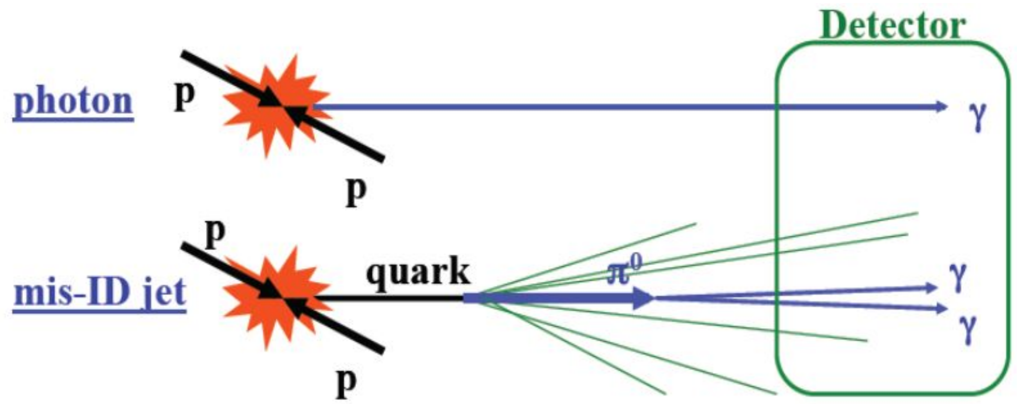


Backgrounds:

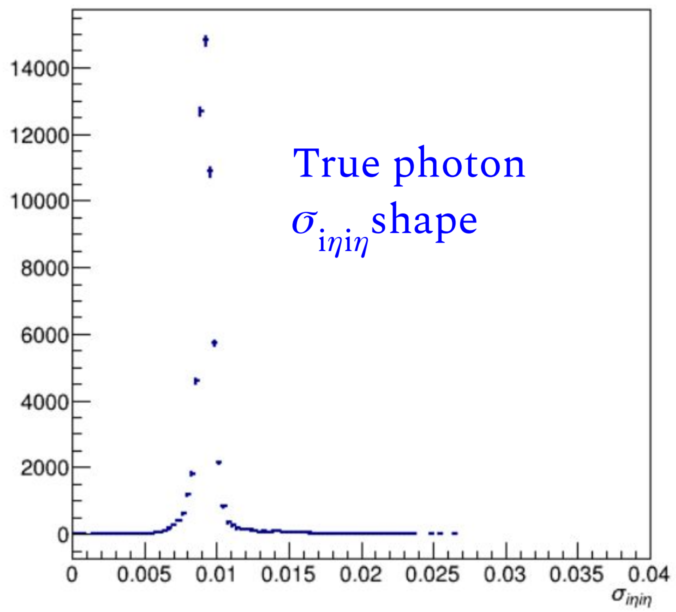
- Fake photon: photons from π^0 decay inside of jets
- Fake lepton: electrons and muons inside of jets
- Double fake: fake photon and fake lepton
- Electron-induced photon: track missed electron which pass the electron-veto selection
- Z+photon: one of the lepton does not pass the electron selection
- Pileup photons

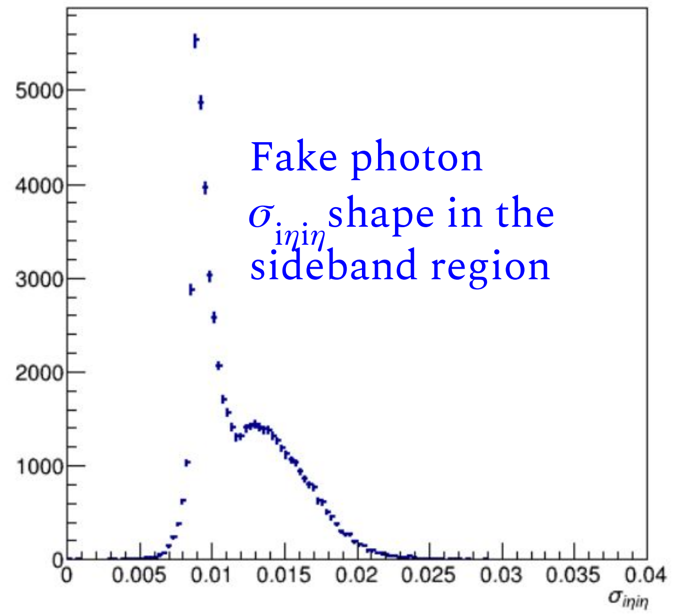
Fake photon estimation

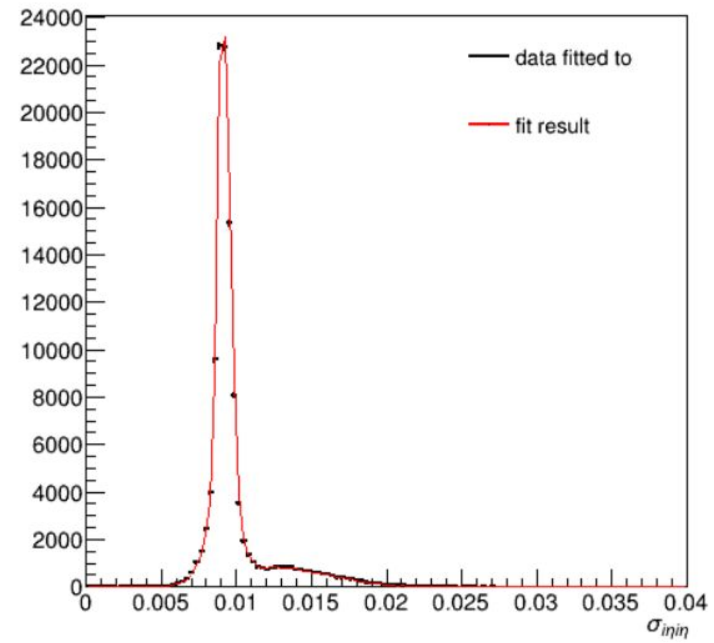
Neutral pion in the jets decays to two photons, they could be reconstructed as one single photon when the distance between them is small.



The shower shape $\sigma_{i\eta i\eta}$ (energy intensity) can be used to distinguish true and fake photons: true photon tend to have smaller $\sigma_{i\eta i\eta}$







Fit result will used to obtain the event weight of a control sample to get the fake photon contribution

Photon $\sigma_{i\eta i\eta}$ Shape after lepton selection

Fake lepton estimation

Leptons in the jets can pass the lepton selections, tight-to-loose method is used to estimate its contribution, event selections:

- Event passes trigger
- Exactly one muon or electron passing tight or loose WP
- MET < 20 GeV
- Transverse mass < 20 GeV
- One Jet with pt > 30 (20) GeV for muon (electron) channel with separation $\Delta R > 0.3$

Lepton fake rate: Numerator/Denominator

Denominator: #events passing selection above

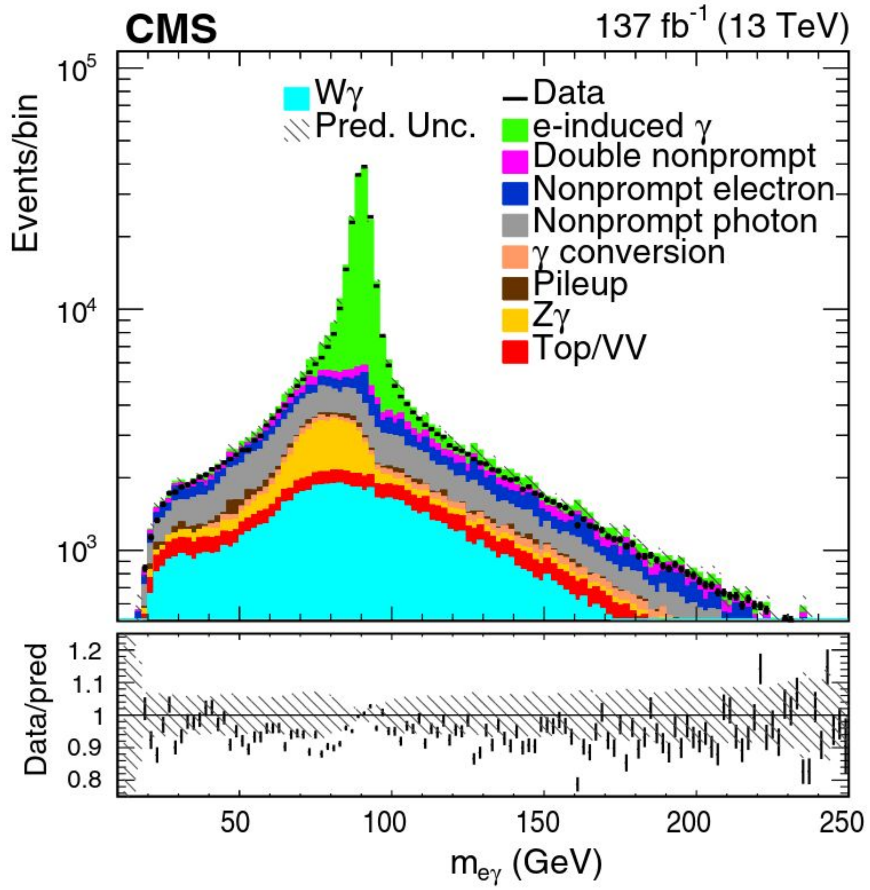
Numerator: #events passing tight lepton selection

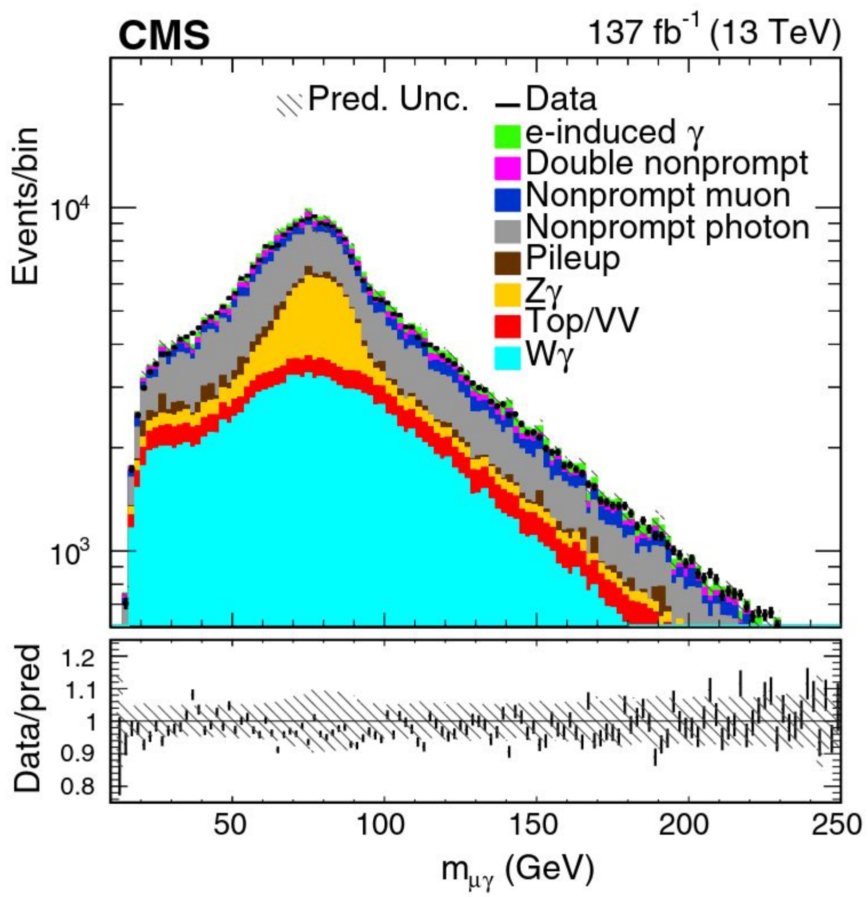
Fake rate is then applied on a fake-lepton enriched control sample

Other backgrounds estimation

- Double fake: the product of fake lepton and fake photon, apply them on a double fake control sample
- Electron-induced photon: mostly in electron channel, get the shape from MC (Z->ee), float it in the signal extraction fit
- Z+photon: estimate using MC
- Pileup photon: W boson event, and a photon from pileup event
  - Match the pileup true photon to the selection photon in the W+jets events
- Top and multi-boson contribution estimated using MC sample

Cross section measurement





Measured cross sections:

- Electron channel: 15.09 ± 0.09 (stat) ± 1.02 (exp) ± 0.32 (theory) pb
- Muon channel: 15.77 ± 0.06 (stat) ± 0.88 (exp) ± 0.12 (theory) pb
- Combined: 15.58 ± 0.05 (stat) ± 0.73 (exp) ± 0.15 (theory) pb = 15.58 ± 0.75 pb

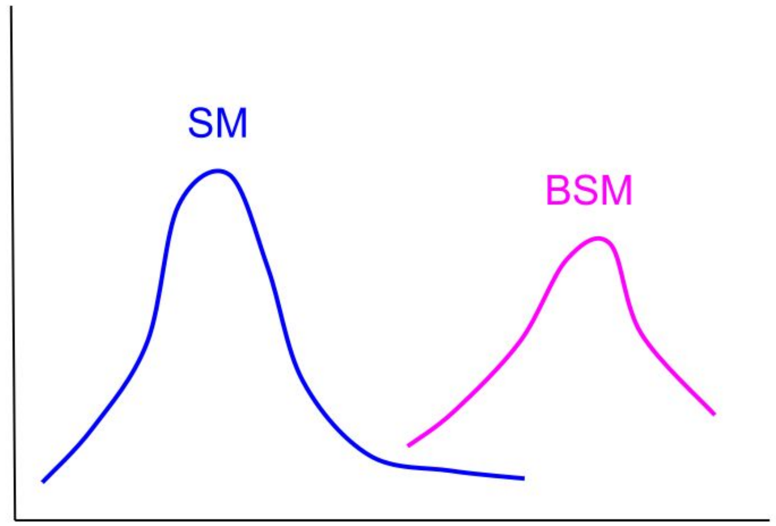
Theoretical cross section (MadGraph, 0+1 jet @NLO): 15.4 ± 1.2 (scale) ± 0.1 (PDF) pb

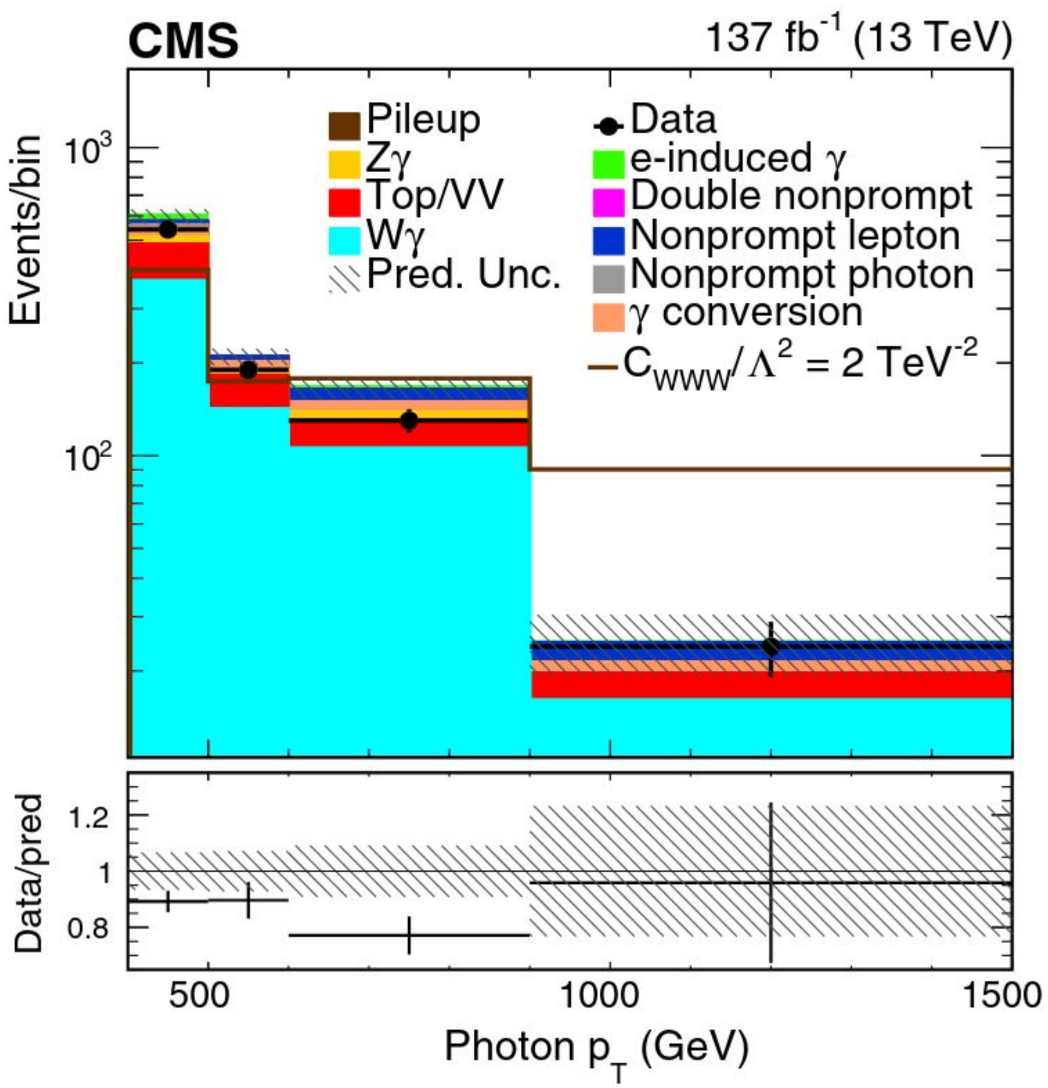
Perfect agreements:

- Between electron and muon channel
- Between measured and theoretical prediction

Anomalous coupling study

If physics Beyond SM exist in very high energy scale, it will promote the yields of SM, especially in the extreme phase space.





Photon pt is used for anomalous coupling study, four bins are used, no deviation is observed from SM.

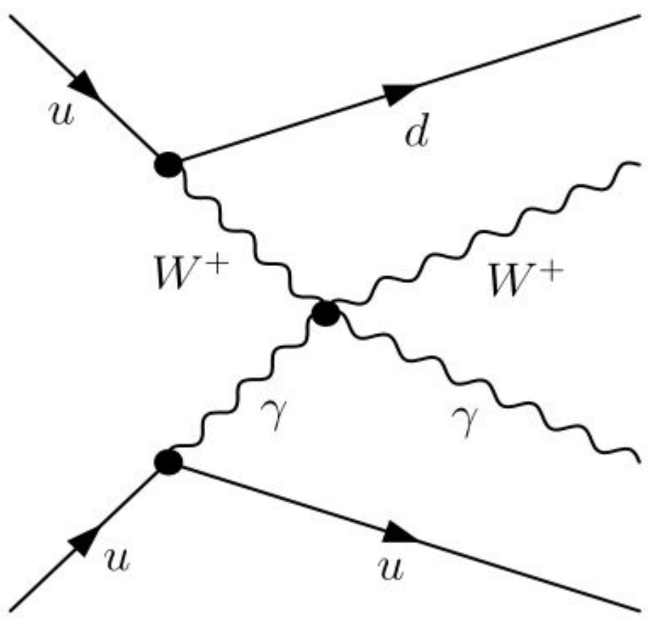
Coefficient	Exp. lower	Exp. upper	Obs. lower	Obs. upper
c_{WWW}/Λ^2	−0.85	0.87	−0.90	0.91
c_B/Λ^2	−46	45	−40	41
$c_{\bar{W}WW}/\Lambda^2$	−0.43	0.43	−0.45	0.45
$c_{\bar{W}}/\Lambda^2$	−23	22	−20	20

95% CL limits

Most stringent

VBS Wγ

VBS: scattering between two vector bosons radiated from incoming partons.
Unique topologies:
Two very forward jets, with large eta separation and invariant mass
Low hadronic activity in central region

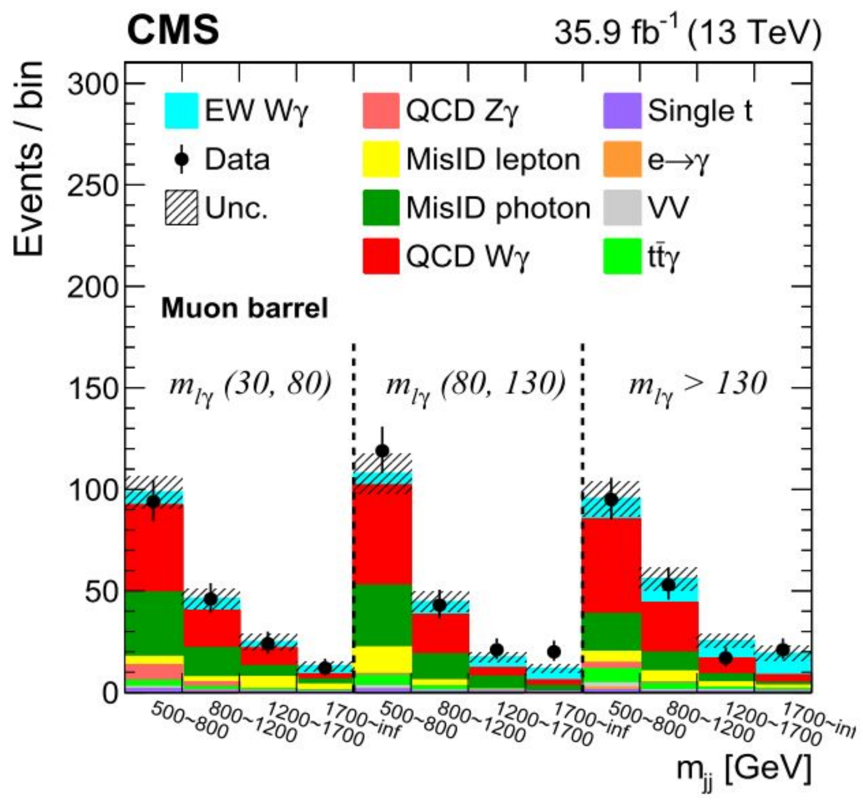


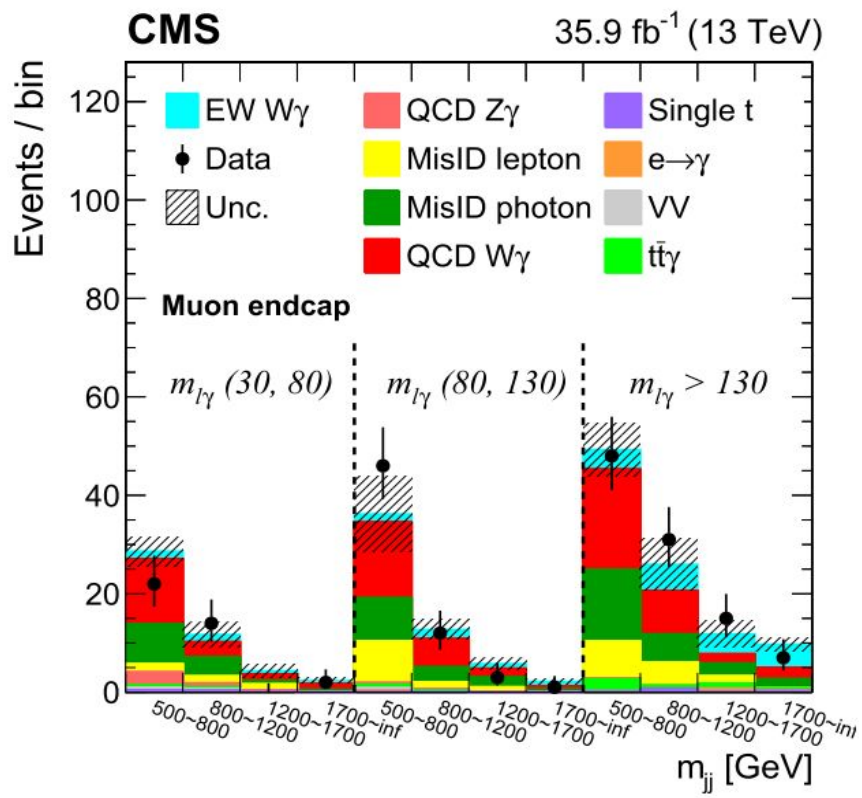
Because photon don't directly couple to Higgs boson, the main motivation of VBS Wγ is its sensitivity to aQGC.

Main backgrounds:

- ➢ QCD Wγ: estimated from MC, which is constrained by simultaneous fit
- ➢ fake photon, fake lepton, double fake, electron-induced photon: same with inclusive Wγ

- ➢ m_jj and mlγ are used to extract EW signal
- ➢ aQGC limits are set using m_Wγ

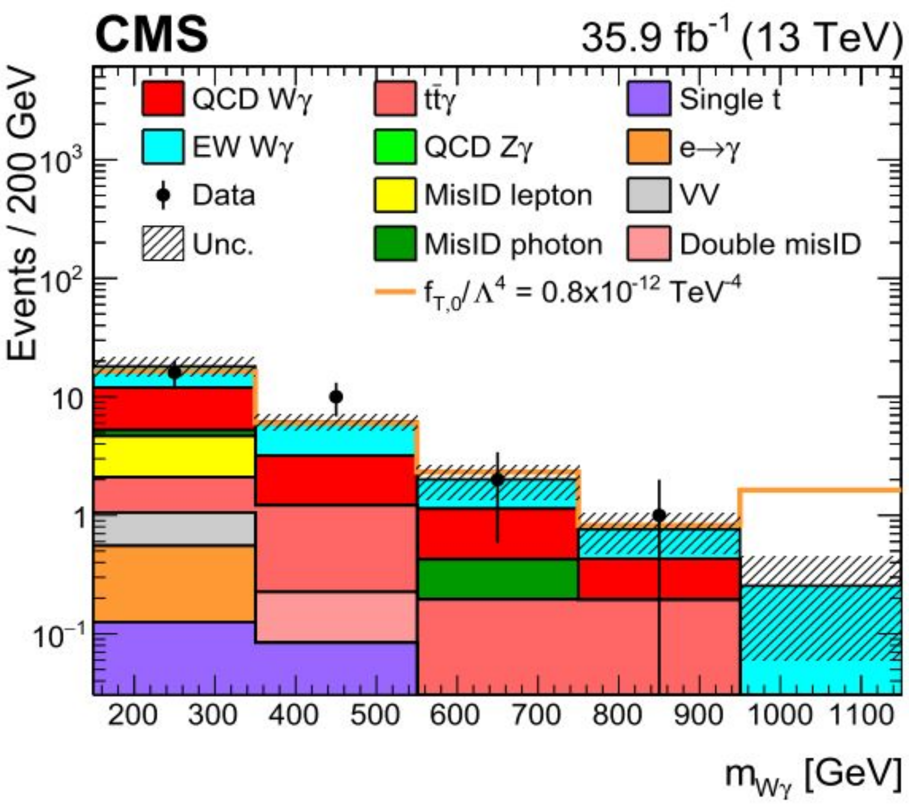




Results:

- Observed (expected) significance: 4.9σ (4.6σ) for 2016 data, 5.3σ (4.8σ) after combing with Run I data
- EW signal cross section: 20.4 ± 4.5 fb (corresponding signal strength: 1.20 +0.26-0.24)
- EW+QCD cross section: 108 ± 16 fb (corresponding signal strength: 1.21 +0.17-0.16)

Invariant mass of W and photon is used for aQGC study. No obvious deviation from SM prediction is observed.



Most stringent limits on fM2-5, fT6-7

Parameters	Obs. limit	Exp. limit	U_{bound}
$f_{M,0}/\Lambda^4$	[−8.1, 8.0]	[−7.7, 7.6]	1.0
$f_{M,1}/\Lambda^4$	[−12, 12]	[−11, 11]	1.2
$f_{M,2}/\Lambda^4$	[−2.8, 2.8]	[−2.7, 2.7]	1.3
$f_{M,3}/\Lambda^4$	[−4.4, 4.4]	[−4.0, 4.1]	1.5
$f_{M,4}/\Lambda^4$	[−5.0, 5.0]	[−4.7, 4.7]	1.5
$f_{M,5}/\Lambda^4$	[−8.3, 8.3]	[−7.9, 7.7]	1.8
$f_{M,6}/\Lambda^4$	[−16, 16]	[−15, 15]	1.0
$f_{M,7}/\Lambda^4$	[−21, 20]	[−19, 19]	1.3
$f_{T,0}/\Lambda^4$	[−0.6, 0.6]	[−0.6, 0.6]	1.4
$f_{T,1}/\Lambda^4$	[−0.4, 0.4]	[−0.3, 0.4]	1.5
$f_{T,2}/\Lambda^4$	[−1.0, 1.2]	[−1.0, 1.2]	1.5
$f_{T,5}/\Lambda^4$	[−0.5, 0.5]	[−0.4, 0.4]	1.8
$f_{T,6}/\Lambda^4$	[−0.4, 0.4]	[−0.3, 0.4]	1.7
$f_{T,7}/\Lambda^4$	[−0.9, 0.9]	[−0.8, 0.9]	1.8

Unitarity bound

Summary

- Cross section measurements are performed @5% in inclusive Wγ, good agreements are obtained between measured and theoretical prediction.
- First observation is obtained in VBS Wγ combining RunI and 2016 data, cross section measurements are performed in VBS Wγ.
- Anomalous coupling are measured in both inclusive and VBS Wγ, no deviation from SM is observed, limits are set, several of them are the most stringent.

Thanks!

Additional slides

Inclusive Wγ signal sample

MG 0+1 jet @NLO: 15.4 ± 1.2 (scale) ± 0.1 (PDF)

POWHEG 0+1 jet @NLO using C-NLO scheme: 22.4 ± 3.2 (scale) ± 0.1 (PDF)

Cuts	MCFM	POWHEG-NC	POWHEG-C-LO	POWHEG-C-NLO
Basic Photon	$12.92(3)^{+4\%}_{-6\%}$	$12.40(3)^{+8\%}_{-10\%}$	$12.95(3)^{+8\%}_{-11\%}$	$15.08(7)^{+2\%}_{-9\%}$
M_T cut	$2.625(1)^{+6\%}_{-6\%}$	$3.09(2)^{+10\%}_{-11\%}$	$3.20(2)^{+11\%}_{-11\%}$	$4.23(3)^{+10\%}_{-10\%}$
Lepton cuts	$1.077(1)^{+6\%}_{-6\%}$	$1.22(1)^{+8\%}_{-10\%}$	$1.31(1)^{+11\%}_{-11\%}$	$1.75(2)^{+7\%}_{-13\%}$

Link: https://arxiv.org/pdf/1408.5766.pdf

aTGC operators

C and P conserved operators:

$$
\begin{aligned}
\mathcal{O}_{WWW} &= \mathrm{Tr}[W_{\mu\nu}W^{\nu\rho}W_{\rho}^{\mu}] \\
\mathcal{O}_{W} &= (D_\mu\Phi)^\dagger W^{\mu\nu}(D_\nu\Phi) \\
\mathcal{O}_{B} &= (D_\mu\Phi)^\dagger B^{\mu\nu}(D_\nu\Phi)
\end{aligned}
$$

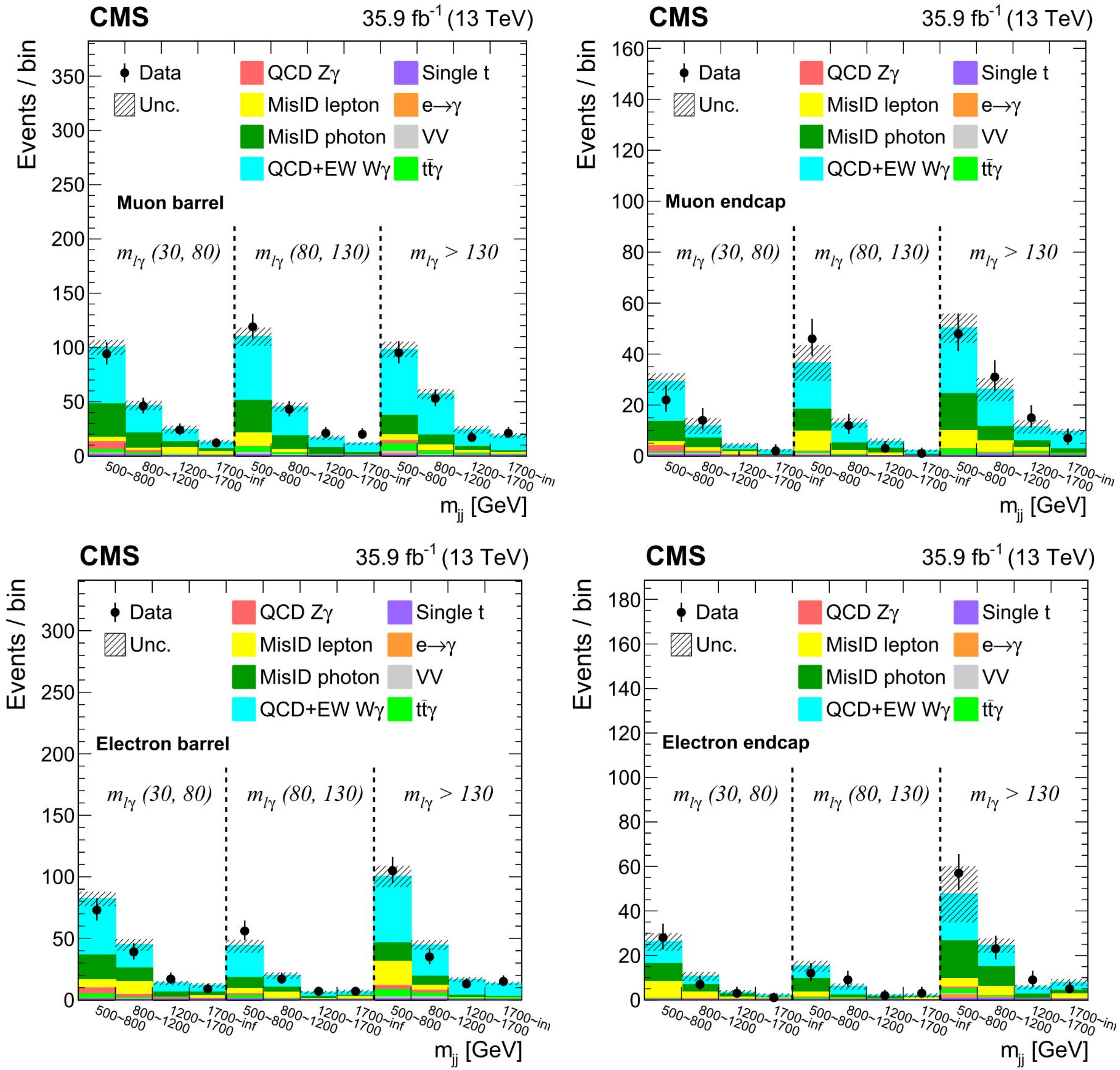
C and/or P violated operators:

$$
\begin{aligned}
\mathcal{O}_{\tilde{W}WW} &= \mathrm{Tr}[\tilde{W}_{\mu\nu}W^{\nu\rho}W_{\rho}^{\mu}] \\
\mathcal{O}_{\tilde{W}} &= (D_\mu\Phi)^\dagger \tilde{W}^{\mu\nu}(D_\nu\Phi)
\end{aligned}
$$

$$
\begin{aligned}
D_\mu &= \partial_\mu + \frac{i}{2}g\tau^I W_\mu^I + \frac{i}{2}g' B_\mu \\
W_{\mu\nu} &= \frac{i}{2}g\tau^I(\partial_\mu W_\nu^I - \partial_\nu W_\mu^I + g\epsilon_{IJK}W_\mu^J W_\nu^K) \\
B_{\mu\nu} &= \frac{i}{2}g'(\partial_\mu B_\nu - \partial_\nu B_\mu)
\end{aligned}
$$

Link: https://arxiv.org/pdf/1205.4231.pdf

VBS Wγ



QCD+EW:
comparison between
data and prediction

aQGC operators

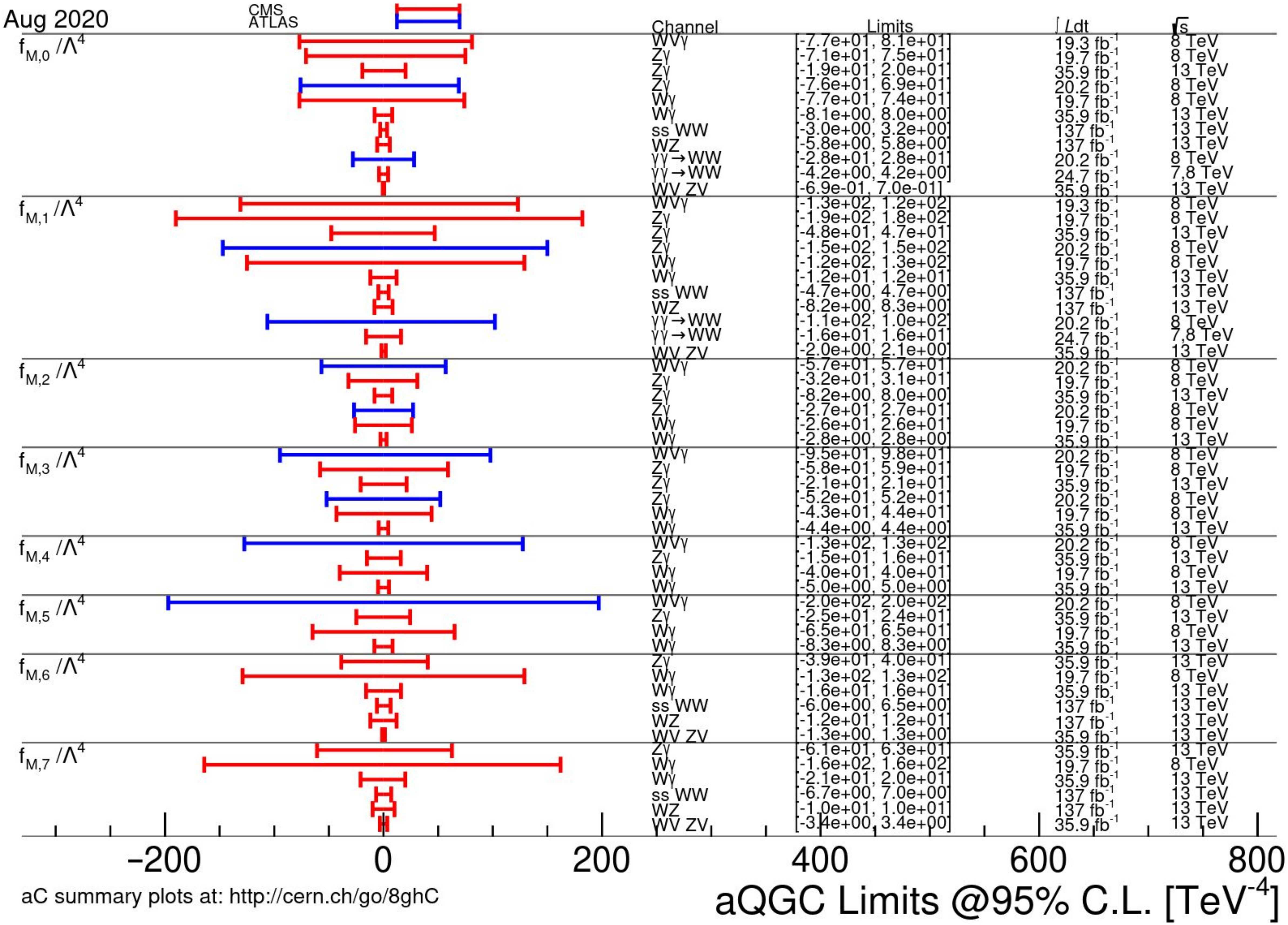
$$\mathcal{L}_{M,0} = \frac{f_{M0}}{\Lambda^4} \mathrm{Tr}\left[\hat{W}_{\mu\nu}\hat{W}^{\mu\nu}\right] \times \left[(D_\beta\Phi)^\dagger D^\beta\Phi\right],$$
$$\mathcal{L}_{M,1} = \frac{f_{M1}}{\Lambda^4} \mathrm{Tr}\left[\hat{W}_{\mu\nu}\hat{W}^{\nu\beta}\right] \times \left[(D_\beta\Phi)^\dagger D^\mu\Phi\right],$$
$$\mathcal{L}_{M,2} = \frac{f_{M2}}{\Lambda^4} \left[B_{\mu\nu}B^{\mu\nu}\right] \times \left[(D_\beta\Phi)^\dagger D^\beta\Phi\right],$$
$$\mathcal{L}_{M,3} = \frac{f_{M3}}{\Lambda^4} \left[B_{\mu\nu}B^{\nu\beta}\right] \times \left[(D_\beta\Phi)^\dagger D^\mu\Phi\right],$$
$$\mathcal{L}_{M,4} = \frac{f_{M4}}{\Lambda^4} \left[(D_\mu\Phi)^\dagger \hat{W}_{\beta\nu} D^\mu\Phi\right] \times B^{\beta\nu},$$
$$\mathcal{L}_{M,5} = \frac{f_{M5}}{\Lambda^4} \left[(D_\mu\Phi)^\dagger \hat{W}_{\beta\nu} D^\nu\Phi\right] \times B^{\beta\mu},$$
$$\mathcal{L}_{M,6} = \frac{f_{M6}}{\Lambda^4} \left[(D_\mu\Phi)^\dagger \hat{W}_{\beta\nu}\hat{W}^{\beta\nu} D^\mu\Phi\right],$$
$$\mathcal{L}_{M,7} = \frac{f_{M7}}{\Lambda^4} \left[(D_\mu\Phi)^\dagger \hat{W}_{\beta\nu}\hat{W}^{\beta\mu} D^\nu\Phi\right].$$

$$\mathcal{L}_{T,0} = \frac{f_{T0}}{\Lambda^4} Tr[\hat{W}_{\mu\nu}\hat{W}^{\mu\nu}] \times Tr[\hat{W}_{\alpha\beta}\hat{W}^{\alpha\beta}],$$
$$\mathcal{L}_{T,1} = \frac{f_{T1}}{\Lambda^4} Tr[\hat{W}_{\alpha\nu}\hat{W}^{\mu\beta}] \times Tr[\hat{W}_{\mu\beta}\hat{W}^{\alpha\nu}],$$
$$\mathcal{L}_{T,2} = \frac{f_{T2}}{\Lambda^4} Tr[\hat{W}_{\alpha\mu}\hat{W}^{\mu\beta}] \times Tr[\hat{W}_{\beta\nu}\hat{W}^{\nu\alpha}],$$
$$\mathcal{L}_{T,5} = \frac{f_{T5}}{\Lambda^4} Tr[\hat{W}_{\mu\nu}\hat{W}^{\mu\nu}] \times B_{\alpha\beta}B^{\alpha\beta},$$
$$\mathcal{L}_{T,6} = \frac{f_{T6}}{\Lambda^4} Tr[\hat{W}_{\alpha\nu}\hat{W}^{\mu\beta}] \times B_{\mu\beta}B^{\alpha\nu},$$
$$\mathcal{L}_{T,7} = \frac{f_{T7}}{\Lambda^4} Tr[\hat{W}_{\alpha\mu}\hat{W}^{\mu\beta}] \times B_{\beta\nu}B^{\nu\alpha},$$
$$\mathcal{L}_{T,8} = \frac{f_{T8}}{\Lambda^4} B_{\mu\nu}B^{\mu\nu}B_{\alpha\beta}B^{\alpha\beta},$$
$$\mathcal{L}_{T,9} = \frac{f_{T9}}{\Lambda^4} B_{\alpha\mu}B^{\mu\beta}B_{\beta\nu}B^{\nu\alpha}.$$

Φ为Higgs二重态, W$\mu\nu$ 和 B$\mu\nu$分别为SU(2)和U(1)的场强张量

Φ is Higgs doublet, W$\mu\nu$ and B$\mu\nu$ are field-strength tensors of SU(2) and U(1)

fM* limits



Aug 2020
CMS
ATLAS
Channel
Limits
∫Ldt
√s
$f_{M,0}/\Lambda^4$
Wγ [-7.7e+01, 8.1e+01] 19.3 fb⁻¹ 8 TeV
Zγ [-7.1e+01, 7.5e+01] 19.7 fb⁻¹ 8 TeV
Zγ [-1.9e+01, 2.0e+01] 35.9 fb⁻¹ 13 TeV
Zγ [-7.6e+01, 6.9e+01] 20.2 fb⁻¹ 8 TeV
Wγ [-7.7e+01, 7.4e+01] 19.7 fb⁻¹ 8 TeV
Wγ [-8.1e+00, 8.0e+00] 35.9 fb⁻¹ 13 TeV
ss WW [-3.0e+00, 3.2e+00] 137 fb⁻¹ 13 TeV
WZ [-5.8e+00, 5.8e+00] 137 fb⁻¹ 13 TeV
γγ→WW [-2.8e+01, 2.8e+01] 20.2 fb⁻¹ 8 TeV
γγ→WW [-4.2e+00, 4.2e+00] 24.7 fb⁻¹ 7,8 TeV
WV ZV [-6.9e-01, 7.0e-01] 35.9 fb⁻¹ 13 TeV
$f_{M,1}/\Lambda^4$
WVγ [-1.3e+02, 1.2e+02] 19.3 fb⁻¹ 8 TeV
Zγ [-1.9e+02, 1.8e+02] 19.7 fb⁻¹ 8 TeV
Zγ [-4.8e+01, 4.7e+01] 35.9 fb⁻¹ 13 TeV
Zγ [-1.5e+02, 1.5e+02] 20.2 fb⁻¹ 8 TeV
Wγ [-1.2e+02, 1.3e+02] 19.7 fb⁻¹ 8 TeV
Wγ [-1.2e+01, 1.2e+01] 35.9 fb⁻¹ 13 TeV
ss WW [-4.7e+00, 4.7e+00] 137 fb⁻¹ 13 TeV
WZ [-8.2e+00, 8.3e+00] 137 fb⁻¹ 13 TeV
γγ→WW [-1.1e+02, 1.0e+02] 20.2 fb⁻¹ 8 TeV
γγ→WW [-1.6e+01, 1.6e+01] 24.7 fb⁻¹ 7,8 TeV
WV ZV [-2.0e+00, 2.1e+00] 35.9 fb⁻¹ 13 TeV
$f_{M,2}/\Lambda^4$
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Zγ [-8.2e+00, 8.0e+00] 35.9 fb⁻¹ 13 TeV
Zγ [-2.7e+01, 2.7e+01] 20.2 fb⁻¹ 8 TeV
Wγ [-2.6e+01, 2.6e+01] 19.7 fb⁻¹ 8 TeV
Wγ [-2.8e+00, 2.8e+00] 35.9 fb⁻¹ 13 TeV
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Zγ [-2.1e+01, 2.1e+01] 35.9 fb⁻¹ 13 TeV
Zγ [-5.2e+01, 5.2e+01] 20.2 fb⁻¹ 8 TeV
Wγ [-4.3e+01, 4.4e+01] 19.7 fb⁻¹ 8 TeV
Wγ [-4.4e+00, 4.4e+00] 35.9 fb⁻¹ 13 TeV
$f_{M,4}/\Lambda^4$
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Zγ [-1.5e+01, 1.6e+01] 35.9 fb⁻¹ 13 TeV
Wγ [-4.0e+01, 4.0e+01] 19.7 fb⁻¹ 8 TeV
Wγ [-5.0e+00, 5.0e+00] 35.9 fb⁻¹ 13 TeV
$f_{M,5}/\Lambda^4$
WVγ [-2.0e+02, 2.0e+02] 20.2 fb⁻¹ 8 TeV
Zγ [-2.5e+01, 2.4e+01] 35.9 fb⁻¹ 13 TeV
Wγ [-6.5e+01, 6.5e+01] 19.7 fb⁻¹ 8 TeV
Wγ [-8.3e+00, 8.3e+00] 35.9 fb⁻¹ 13 TeV
$f_{M,6}/\Lambda^4$
Zγ [-3.9e+01, 4.0e+01] 35.9 fb⁻¹ 13 TeV
Wγ [-1.3e+02, 1.3e+02] 19.7 fb⁻¹ 8 TeV
Wγ [-1.6e+01, 1.6e+01] 35.9 fb⁻¹ 13 TeV
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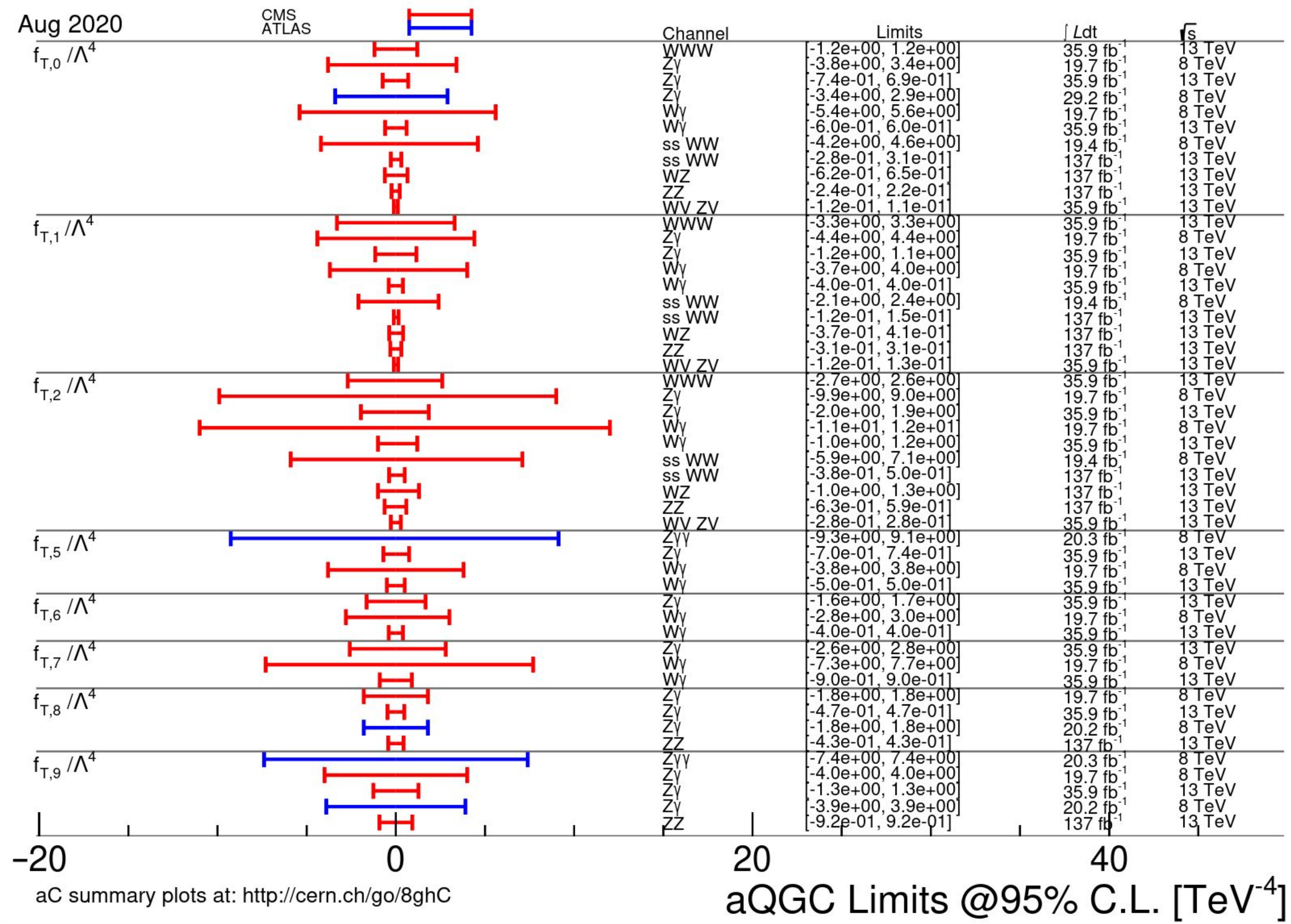
WZ [-1.0e+01, 1.0e+01] 137 fb⁻¹ 13 TeV
WV ZV [-3.4e+00, 3.4e+00] 35.9 fb⁻¹ 13 TeV
−200
0
200
400
600
800
aC summary plots at: http://cern.ch/go/8ghC
aQGC Limits @95% C.L. [TeV⁻⁴]

fT* limits


Aug 2020
CMS
ATLAS
Channel
Limits
∫Ldt
√s
f_T,0 /Λ^4
WWW [-1.2e+00, 1.2e+00] 35.9 fb-1 13 TeV
Zγ [-3.8e+00, 3.4e+00] 19.7 fb-1 8 TeV
Zγ [-7.4e-01, 6.9e-01] 35.9 fb-1 13 TeV
Zγ [-3.4e+00, 2.9e+00] 29.2 fb-1 8 TeV
Wγ [-5.4e+00, 5.6e+00] 19.7 fb-1 8 TeV
Wγ [-6.0e-01, 6.0e-01] 35.9 fb-1 13 TeV
ss WW [-4.2e+00, 4.6e+00] 19.4 fb-1 8 TeV
ss WW [-2.8e-01, 3.1e-01] 137 fb-1 13 TeV
WZ [-6.2e-01, 6.5e-01] 137 fb-1 13 TeV
ZZ [-2.4e-01, 2.2e-01] 137 fb-1 13 TeV
WV ZV [-1.2e-01, 1.1e-01] 35.9 fb-1 13 TeV
f_T,1 /Λ^4
WWW [-3.3e+00, 3.3e+00] 35.9 fb-1 13 TeV
Zγ [-4.4e+00, 4.4e+00] 19.7 fb-1 8 TeV
Zγ [-1.2e+00, 1.1e+00] 35.9 fb-1 13 TeV
Wγ [-3.7e+00, 4.0e+00] 19.7 fb-1 8 TeV
Wγ [-4.0e-01, 4.0e-01] 35.9 fb-1 13 TeV
ss WW [-2.1e+00, 2.4e+00] 19.4 fb-1 8 TeV
ss WW [-1.2e-01, 1.5e-01] 137 fb-1 13 TeV
WZ [-3.7e-01, 4.1e-01] 137 fb-1 13 TeV
ZZ [-3.1e-01, 3.1e-01] 137 fb-1 13 TeV
WV ZV [-1.2e-01, 1.3e-01] 35.9 fb-1 13 TeV
f_T,2 /Λ^4
WWW [-2.7e+00, 2.6e+00] 35.9 fb-1 13 TeV
Zγ [-9.9e+00, 9.0e+00] 19.7 fb-1 8 TeV
Zγ [-2.0e+00, 1.9e+00] 35.9 fb-1 13 TeV
Wγ [-1.1e+01, 1.2e+01] 19.7 fb-1 8 TeV
Wγ [-1.0e+00, 1.2e+00] 35.9 fb-1 13 TeV
ss WW [-5.9e+00, 7.1e+00] 19.4 fb-1 8 TeV
ss WW [-3.8e-01, 5.0e-01] 137 fb-1 13 TeV
WZ [-1.0e+00, 1.3e+00] 137 fb-1 13 TeV
ZZ [-6.3e-01, 5.9e-01] 137 fb-1 13 TeV
WV ZV [-2.8e-01, 2.8e-01] 35.9 fb-1 13 TeV
f_T,5 /Λ^4
Zγγ [-9.3e+00, 9.1e+00] 20.3 fb-1 8 TeV
Zγ [-7.0e-01, 7.4e-01] 35.9 fb-1 13 TeV
Wγ [-3.8e+00, 3.8e+00] 19.7 fb-1 8 TeV
Wγ [-5.0e-01, 5.0e-01] 35.9 fb-1 13 TeV
f_T,6 /Λ^4
Zγ [-1.6e+00, 1.7e+00] 35.9 fb-1 13 TeV
Wγ [-2.8e+00, 3.0e+00] 19.7 fb-1 8 TeV
Wγ [-4.0e-01, 4.0e-01] 35.9 fb-1 13 TeV
f_T,7 /Λ^4
Zγ [-2.6e+00, 2.8e+00] 35.9 fb-1 13 TeV
Wγ [-7.3e+00, 7.7e+00] 19.7 fb-1 8 TeV
Wγ [-9.0e-01, 9.0e-01] 35.9 fb-1 13 TeV
f_T,8 /Λ^4
Zγ [-1.8e+00, 1.8e+00] 19.7 fb-1 8 TeV
Zγ [-4.7e-01, 4.7e-01] 35.9 fb-1 13 TeV
Zγ [-1.8e+00, 1.8e+00] 20.2 fb-1 8 TeV
ZZ [-4.3e-01, 4.3e-01] 137 fb-1 13 TeV
f_T,9 /Λ^4
Zγγ [-7.4e+00, 7.4e+00] 20.3 fb-1 8 TeV
Zγ [-4.0e+00, 4.0e+00] 19.7 fb-1 8 TeV
Zγ [-1.3e+00, 1.3e+00] 35.9 fb-1 13 TeV
Zγ [-3.9e+00, 3.9e+00] 20.2 fb-1 8 TeV
ZZ [-9.2e-01, 9.2e-01] 137 fb-1 13 TeV
-20
0
20
40
aC summary plots at: http://cern.ch/go/8ghC
aQGC Limits @95% C.L. [TeV-4]