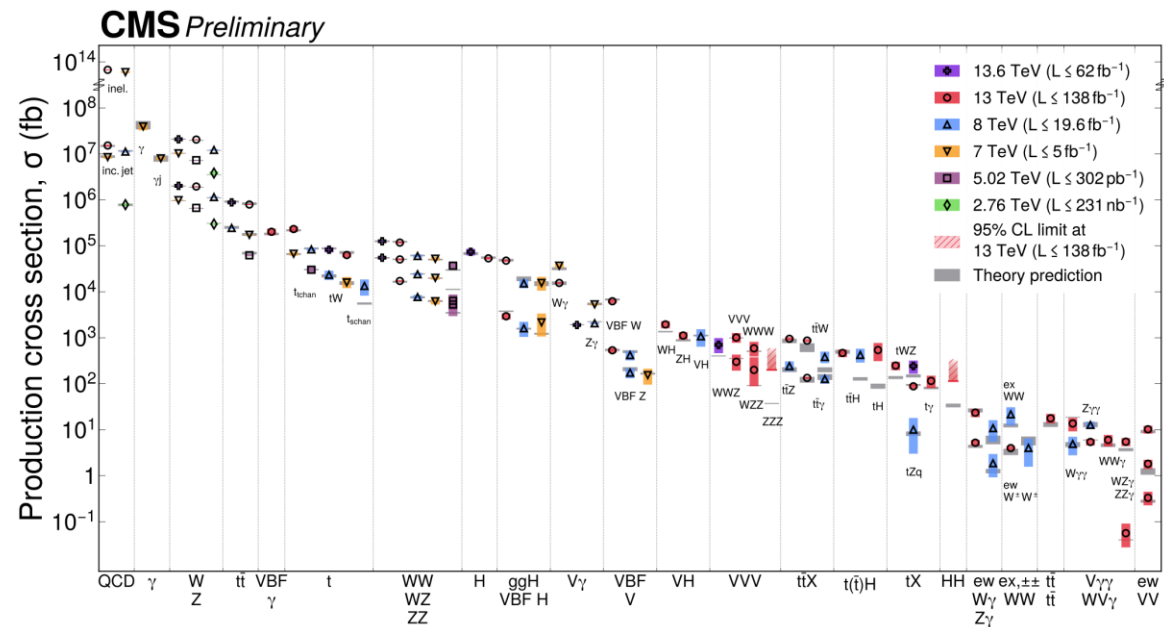
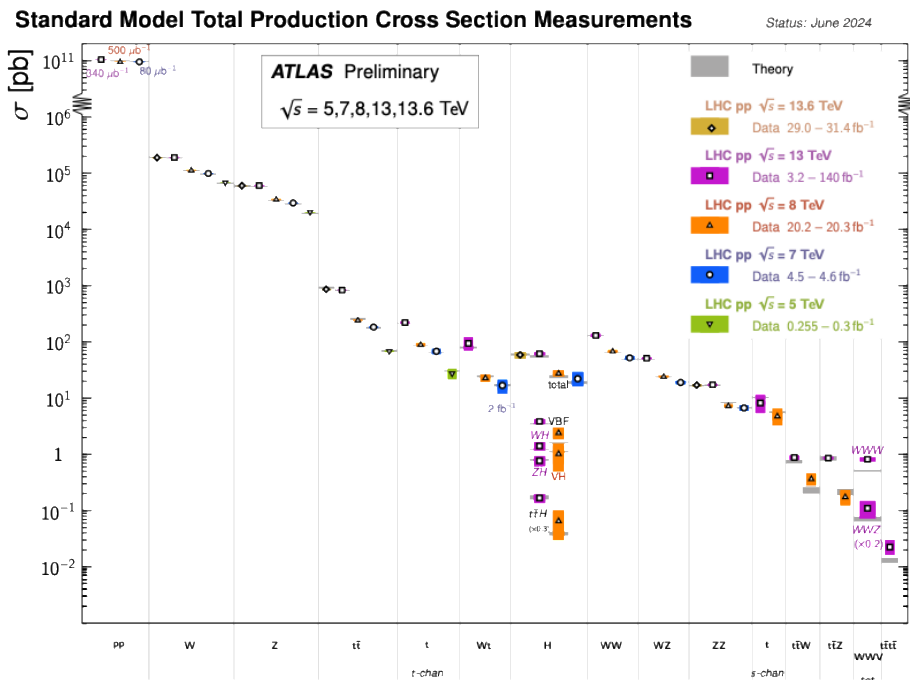


Highlights on EW and SM results at ATLAS and CMS

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CLHCP2025
2025.10.31, Xinxiang

Introduction

- ❑ **The LHC has become a precision factory for SM parameters (e.g., $\sin^2\theta_{\text{eff}}^\ell$, W/Z spectra) while pushing to multi-TeV tails that stress-test theory.**
 - Precision W/Z and W+jets results improve background modelling and systematic controls across measurements.
 - Inclusive and differential gauge bosons measurements validate NNLO (+EW) predictions and constrain PDFs that are crucial for Higgs, top, and BSM analyses.

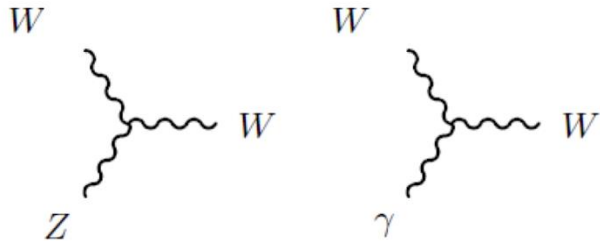


Introduction

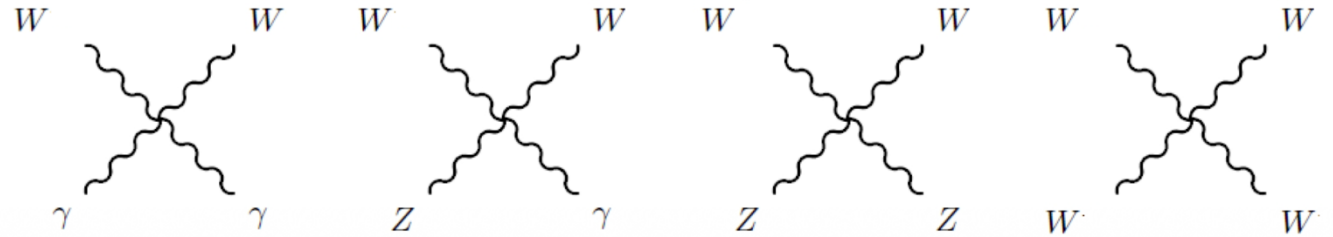
❑ Multi-boson production and vector-boson scattering (VBS) provide direct access to gauge self-interactions and longitudinal modes.

- These channels allow for the exploration of triple- and quartic-gauge couplings and the W/Z longitudinal components associated with electroweak symmetry breaking, utilizing characteristic dijet topologies.
- Presence of new physics can significantly deviate the SM prediction of gauge couplings.

- **Triple gauge couplings (TGC)**



- **Quartic gauge couplings (QGC)**



❑ Higgs unitarization stands as a central conceptual test.

- In purely bosonic $VV \rightarrow VV$ scattering, the amplitude increases as $\sim E^2$, but the SM Higgs exchange cancels this growth precisely, restoring unitarity.
- This is a very delicate equilibrium: if H boson is not the SM one, cancellation is only partial.
- Consequently, the observed high-energy behavior of VBS directly validates the Higgs mechanism.

Selected highlights: Single vector boson studies

Topics	References
$B(W \rightarrow cq)/B(W \rightarrow q^- q')$ measurement	CMS, Phys. Lett. B 868 (2025) 139754
Drell–Yan forward–backward asymmetry and effective leptonic weak mixing angle	CMS, Phys. Lett. B 866 (2025) 139526
W angular coefficients in low pileup data	ATLAS, arXiv:2509.13759
W high transverse mass spectrum	ATLAS, JHEP 07 (2025) 026
W cross section with low pileup	ATLAS, Eur. Phys. J. C 85 (2025) 729
W + jets cross section	ATLAS, Eur. Phys. J. C 85 (2025) 738

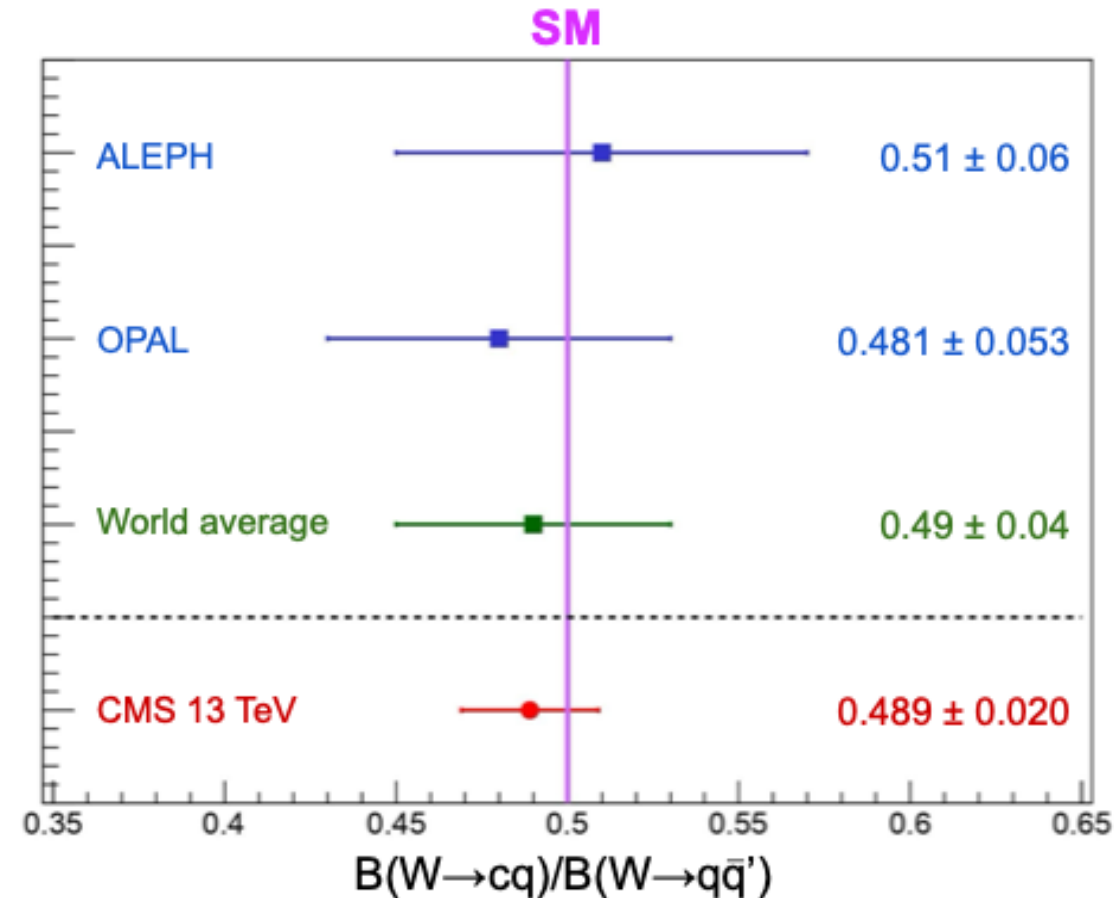
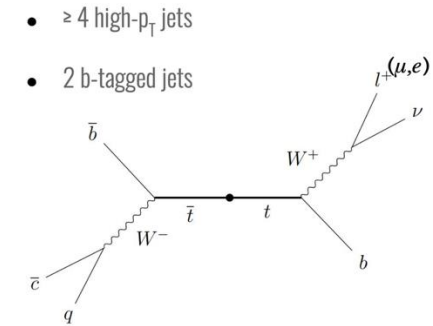
$B(W \rightarrow cq)/B(W \rightarrow q^- q')$ measurement

- ❑ High-purity sample of W bosons from $t\bar{t}$ production.
- ❑ Semi-leptonic $t\bar{t}$ decay channel.
- ❑ Tagging of charm jets: identification of a muon inside a jet stemming from the semi-leptonic decay of the charm hadron.

- ❑ Target measurement:

$$R_c^W = \frac{\mathcal{B}(W \rightarrow cq)}{\mathcal{B}(W \rightarrow cq) + \mathcal{B}(W \rightarrow uq)}$$

- ❑ The result 0.489 ± 0.020 , is consistent with the standard model prediction and is twice as precise as the current world-average value.

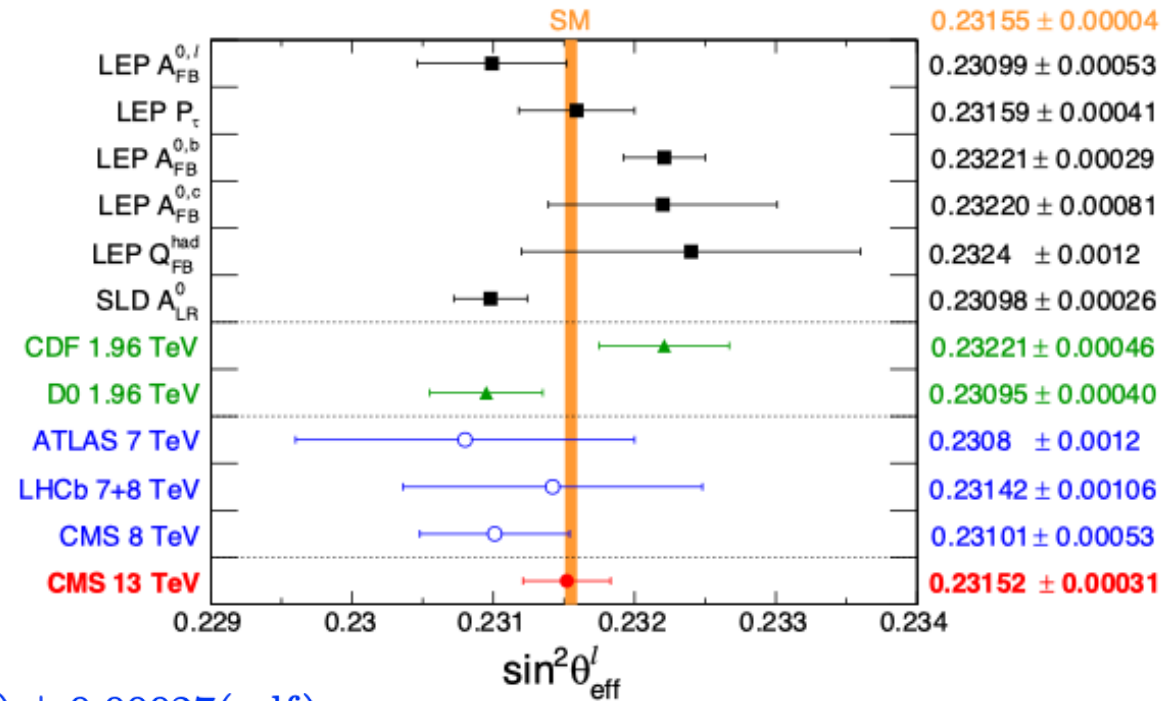
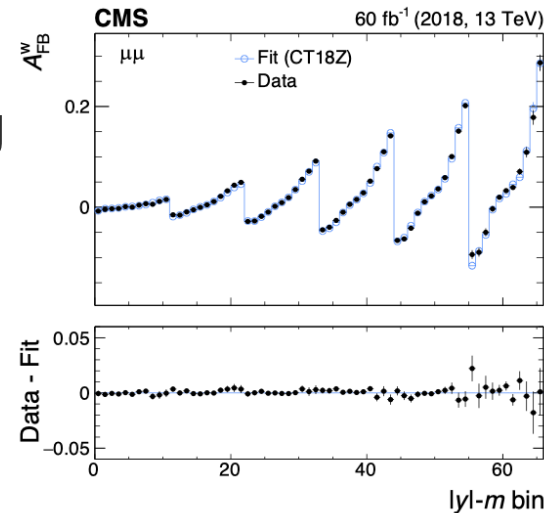


$\sin^2 \theta_{eff}^\ell$ from DY forward–backward asymmetry

□ Leptonic effective mixing angle $\sin^2 \theta_{eff}^\ell = (1 - m_W^2/m_Z^2)\kappa^\ell$ is a key SM parameter

□ Asymmetry in lepton decay angle distribution:
 $\sim 1 + \cos^2 \theta + 0.5A_0 (1 - 3 \cos^2 \theta) + A_4 \cos \theta$
 $\rightarrow A_{FB} = 3/8 A_4$

□ Extracted from fitting reconstructed weighted $A_{FB}(y,m)$



$$\sin^2 \theta_{eff}^\ell = 0.23157 \pm 0.00010(\text{stat}) \pm 0.00015(\text{syst}) \pm 0.00009(\text{theo}) \pm 0.00027(\text{pdf})$$

□ Precision comparable with LEP and SLD measurements

□ PDF is the dominant uncertainty

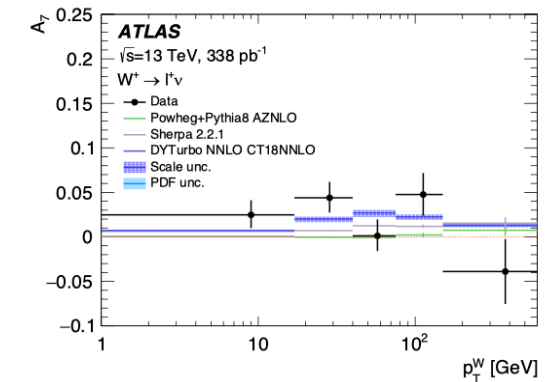
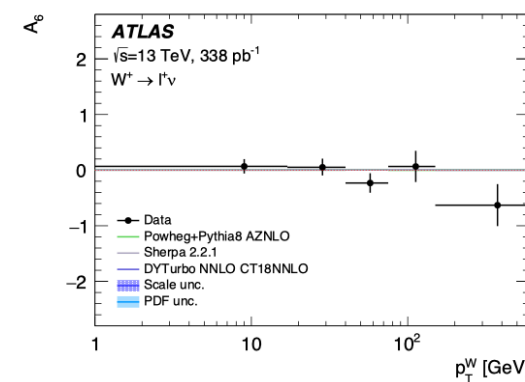
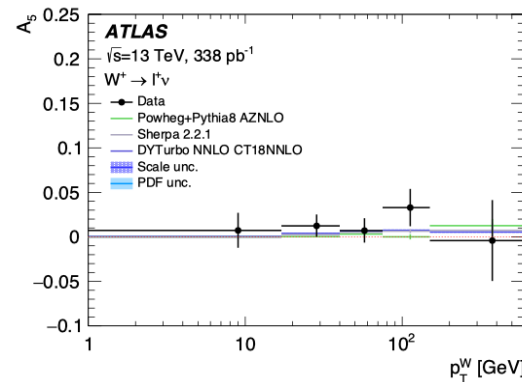
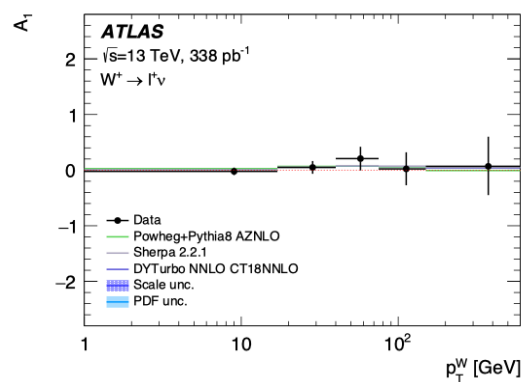
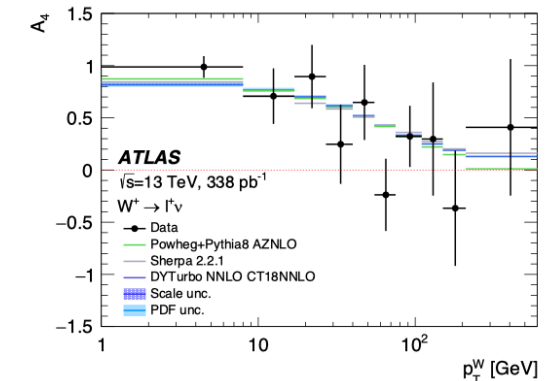
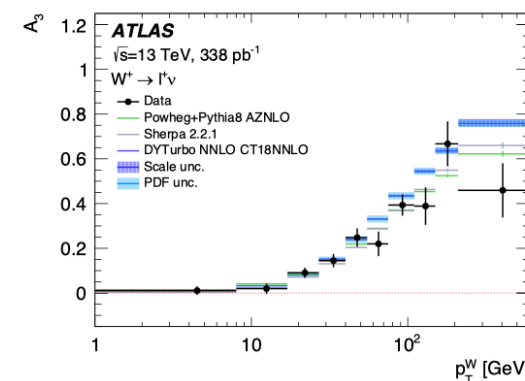
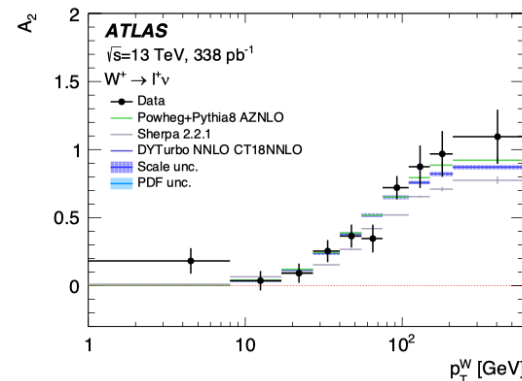
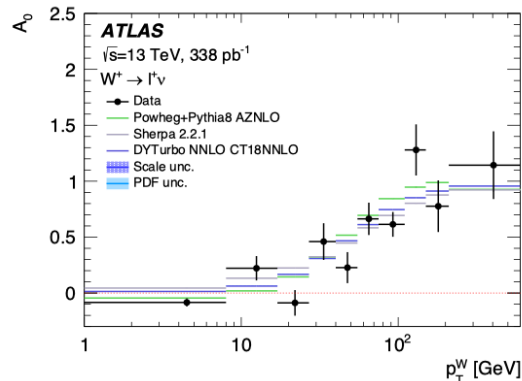
$W^\pm$ angular coefficients in low pileup data

□ Sensitive probe of the underlying dynamics of QCD effects in vector-boson production.

□ Low pile-up enables optimized reconstruction of the W boson transverse momentum.

□ First time measurements of the full set of W angular coefficients.

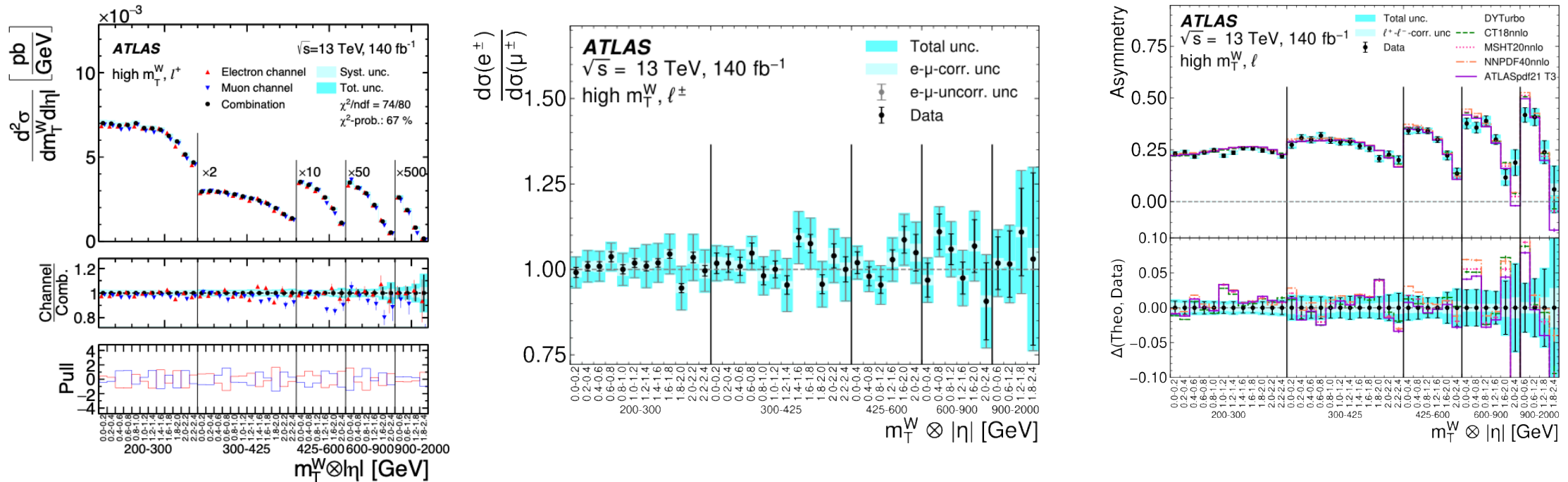
$$\frac{d\sigma}{dp_T^W dy^W dm^W d\cos\theta d\phi} = \frac{3}{16\pi} \frac{d\sigma^{U+L}}{dp_T^W dy^W dm^W} \left\{ (1 + \cos^2\theta) + \frac{1}{2} A_0 (1 - 3\cos^2\theta) + A_1 \sin 2\theta \cos\phi + \frac{1}{2} A_2 \sin^2\theta \cos 2\phi + A_3 \sin\theta \cos\phi + A_4 \cos\theta + A_5 \sin^2\theta \sin 2\phi + A_6 \sin 2\theta \sin\phi + A_7 \sin\theta \sin\phi \right\}.$$



W high transverse mass spectrum

□ First measurement of the charged-current DY process above the resonance region.

- Powerful tool in understanding partonic interactions and testing the NNLO p-QCD predictions
- Measured region sensitive to large Q and provides new constraints on high-x anti-quark PDFs

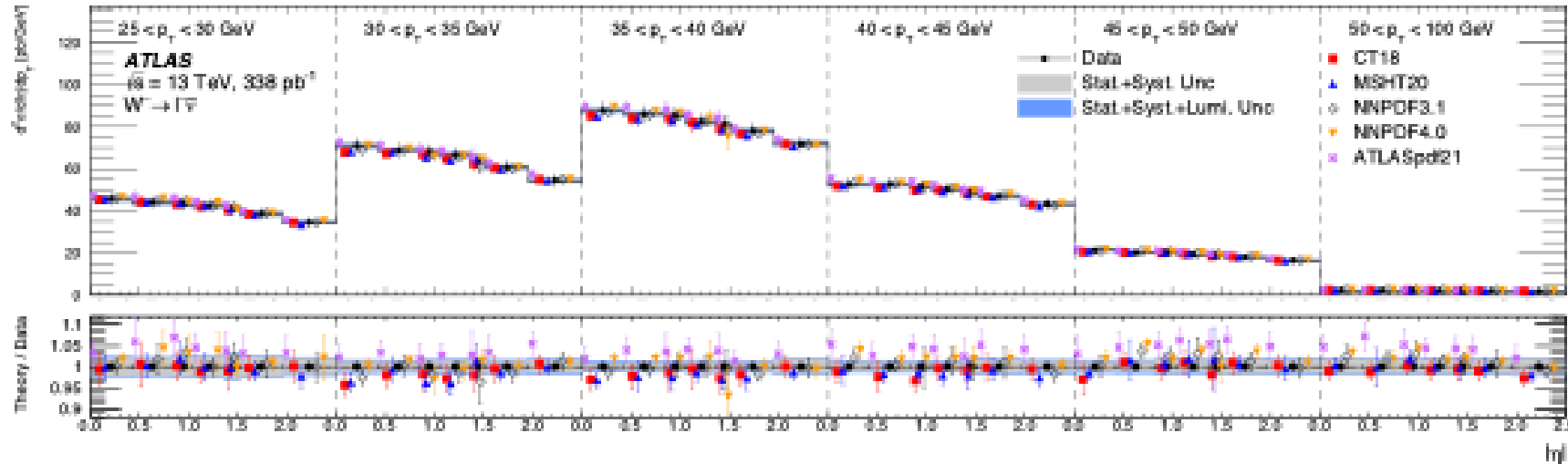


□ The double-differential (W m_T and lepton η) and charge asymmetry are reported.

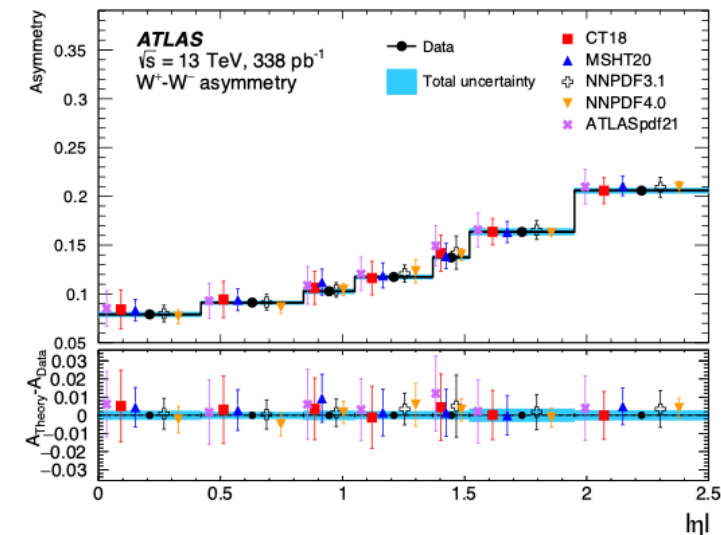
□ Test of lepton flavor universality shows no significant deviations from the SM.

W cross section with low pileup data

- double-differential cross section reported as a function of lepton p_T and η .

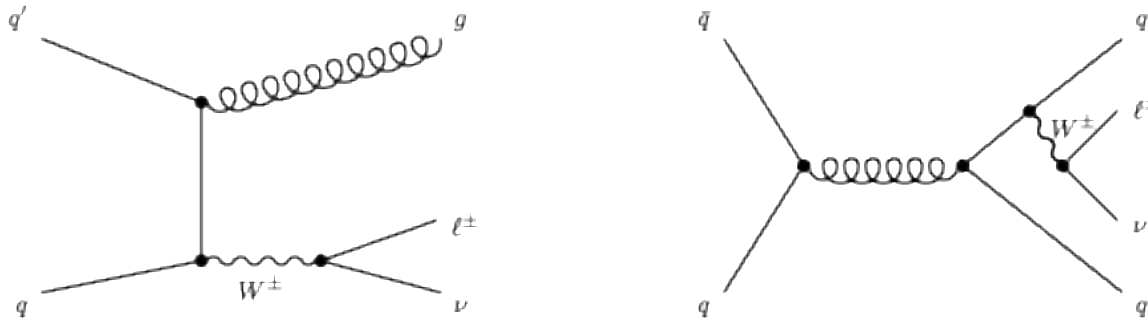


- The W-boson charge asymmetry as a function of lepton η is also measured.
- The measurements align with SM predictions at N3LO in α_s , including transverse momentum resummation at N3LL accuracy, using various PDFs.

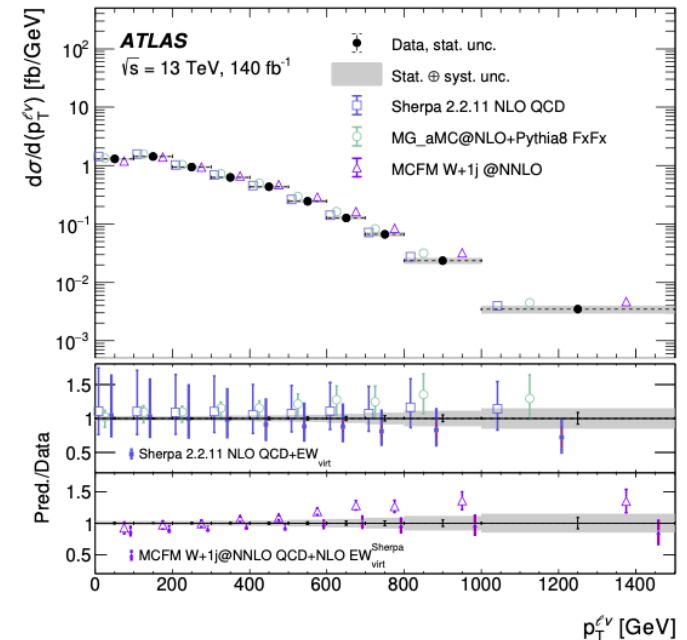
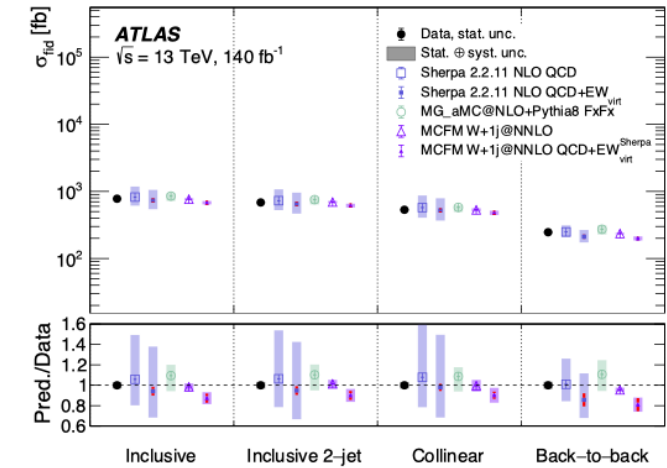


W + jets cross section

- W+jets process is a significant irreducible background to many analyses.
- W-boson production in association with high p_T jets is measured in leptonic final state.



- NLO multi-leg merged generators describe the data well.
- NNLO W+1-jet (MCFM) gives good overall agreement and precision comparable to data.
- Including NLO EW virtual corrections in Sherpa improves agreement for highly boosted W bosons.

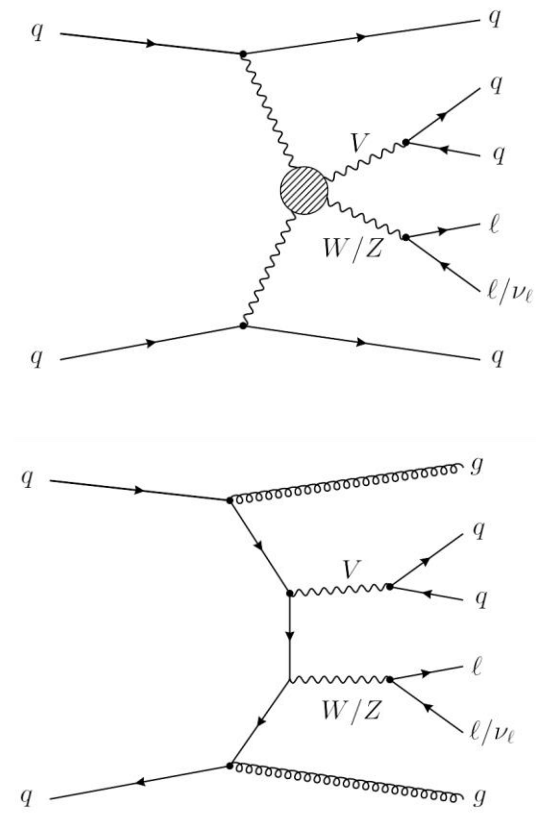
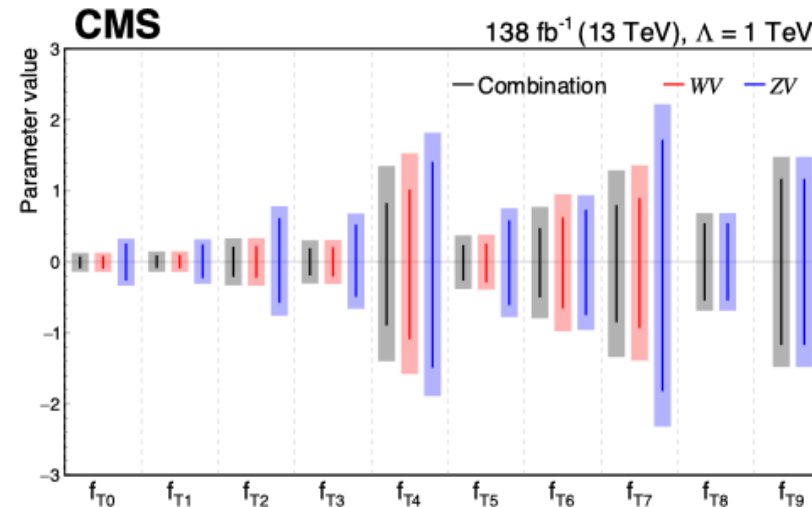
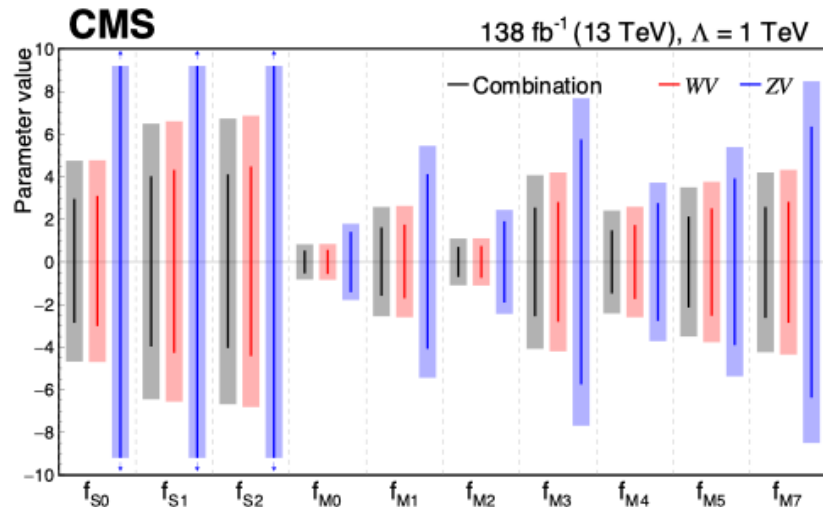


Selected highlights: Multi-Boson & VBS studies

Topics	References
VBS $\rightarrow$ ZV $\rightarrow$ llqq/lnuqq	CMS, arXiv:2510.00118
WWZ and ZH cross section	CMS, Phys. Rev. Lett. 135 (2025) 091802
W boson pair production in photon fusion	CMS, CMS-PAS-SMP-24-019
Same-sign W boson scattering in one tau final state	CMS, arXiv:2410.04210
Observation of $W^+W^-\gamma$	ATLAS, arXiv:2509.14070
$W^\pm Z$ production cross section	ATLAS, arXiv:2507.03500
W^+W^- production cross sections	ATLAS, JHEP 08 (2025) 142
Observation of double parton scattering in same-sign W boson pair production	ATLAS, arXiv:2505.08313
Observation of WW/WZ/ZZ in association with a high-mass dijet system	ATLAS, arXiv:2503.17461
Evidence for same-sign WW polarization	ATLAS, Phys. Rev. Lett. 135 (2025) 111802
Observation of VVZ production	ATLAS, Phys. Lett. B 866 (2025) 139527

Measuring EW production of ZV via VBS

- Focus on final states where one boson decays to leptons ($Z \rightarrow \ell^+ \ell^-$) and the other decays hadronically ($V \rightarrow qq'$) + two forward jets.
- Measured with an observed (expected) significance of 1.3 (1.8) σ .



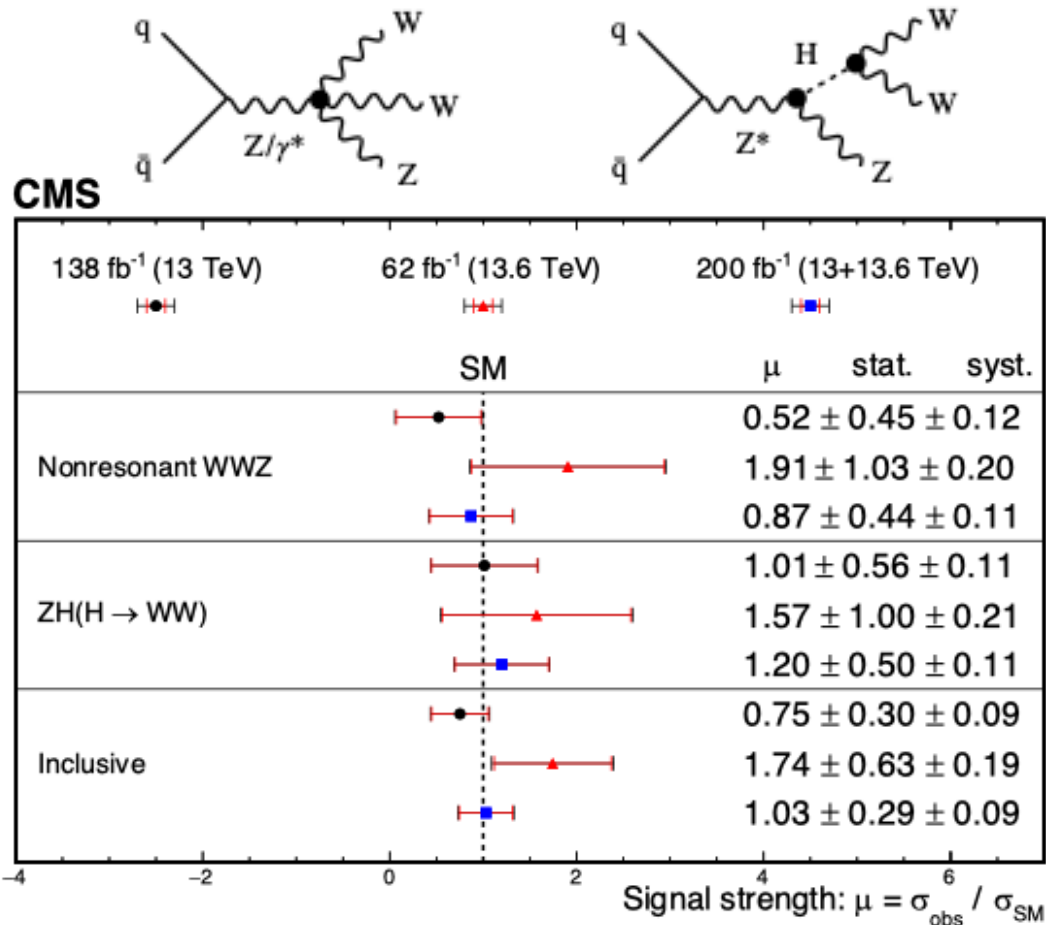
- Combined with the previously published WV channel in the lepton plus jets final state to test aQGC and SMEFT.
 - sets world-best limits on a selection of dimension-8 effective operators.

WWZ and ZH production cross sections

- ❑ Measured the WWZ and ZH signal strengths at 13 TeV and 13.6 TeV in the 4-lepton final state and compare with SM prediction
- ❑ A simultaneous fit that separates non-resonant WWZ production from ZH (H → WW) production for the first time.

Era	Total	WWZ	ZH
Run 2	2.9 (4.4)	1.3 (3.1)	2.0 (2.6)
Run 3	3.8 (2.5)	2.5 (1.3)	2.5 (1.7)
Total	4.5 (5.0)	2.4 (3.3)	3.1 (3.1)

- ❑ First evidence for a triboson production process at 13.6 TeV.
- ❑ Results agree with SM predictions.



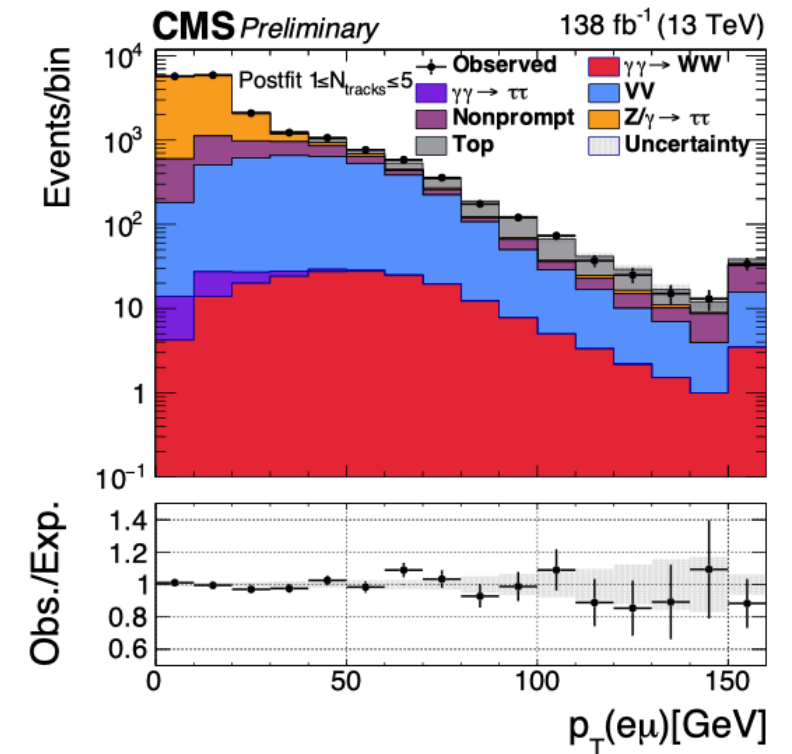
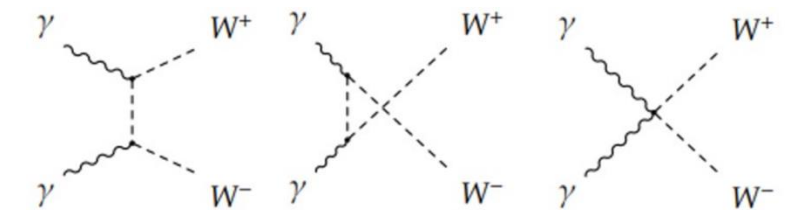
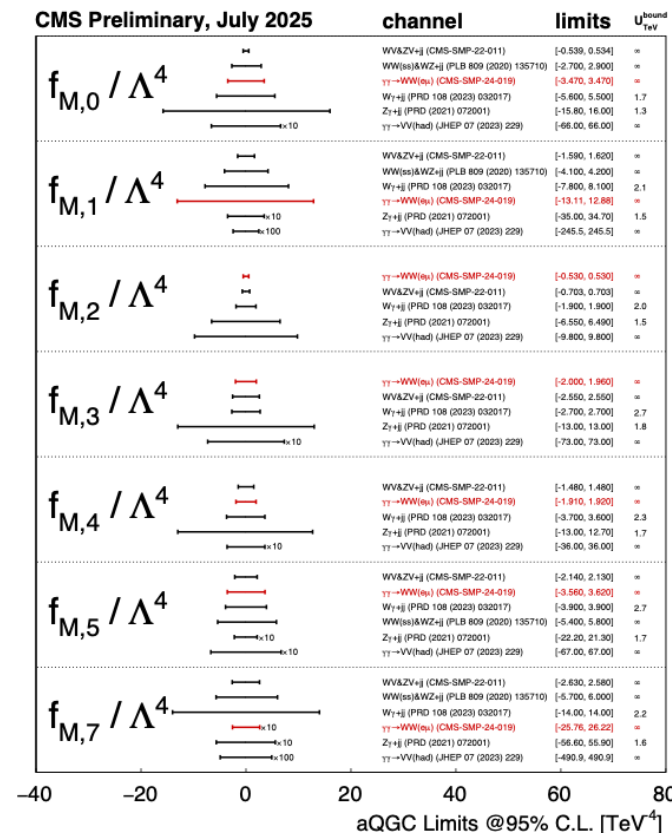
W boson pair production in photon fusion

PKU

- Pure electroweak environment, sensitive to trilinear and quartic gauge couplings.
- Exclusive $e\mu$ final state.

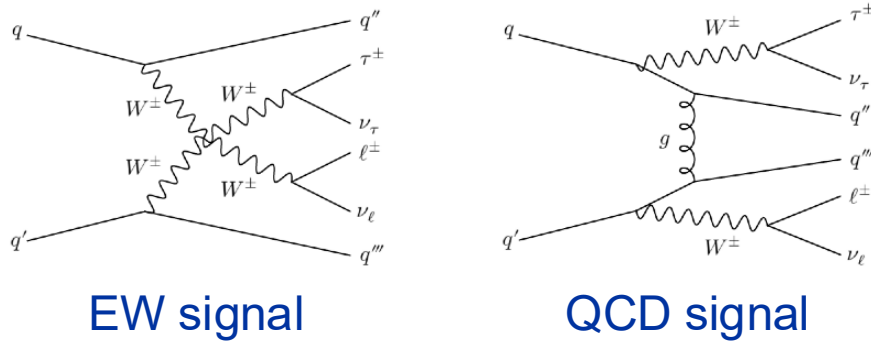
- Measured total cross section 659^{+82}_{-78} fb.
- Fiducial 4.1 ± 0.5 fb.

- Interpreted in dimension-8 EFT.

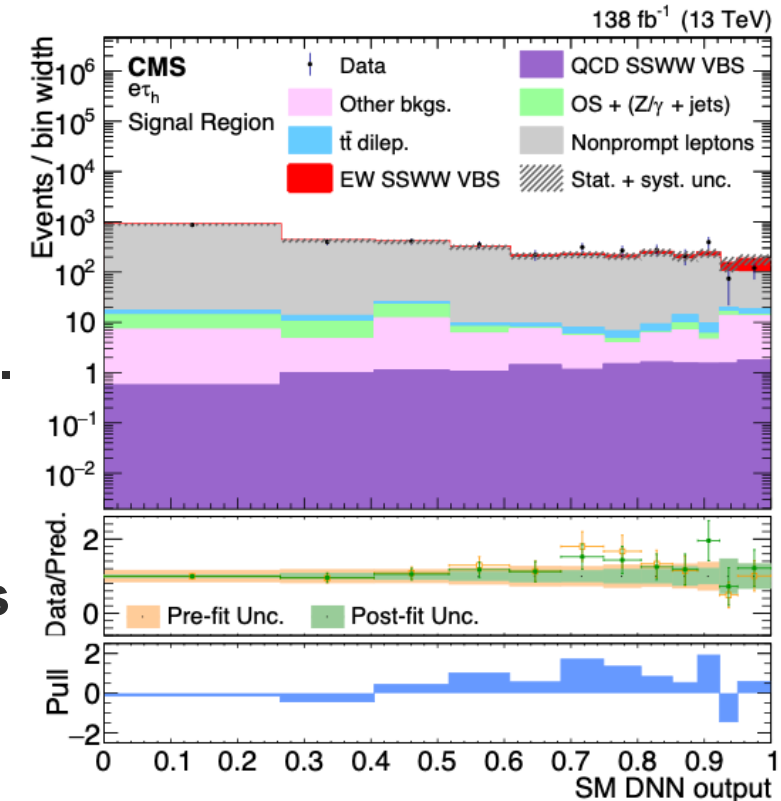


Same-sign W boson scattering in one tau final state

- SSWW process previously observed by [CMS](#) and [ATLAS](#).
- This search focuses on final states with one hadronically decaying tau lepton.

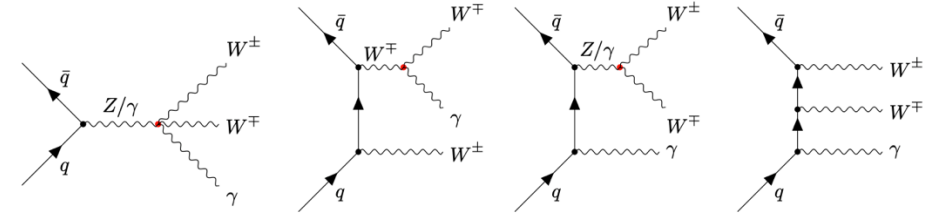


- DNN used to significantly boost the sensitivity of the search.
- The observed (expected) significance of the EW signal is 2.7 (1.9) σ .
- The combined EW and residual QCD-mediated contributions yields an observed (expected) significance of 2.9 (2.0) σ .
- Results also interpreted in SMEFT, setting limits on several dimension-6 and dimension-8 operators.

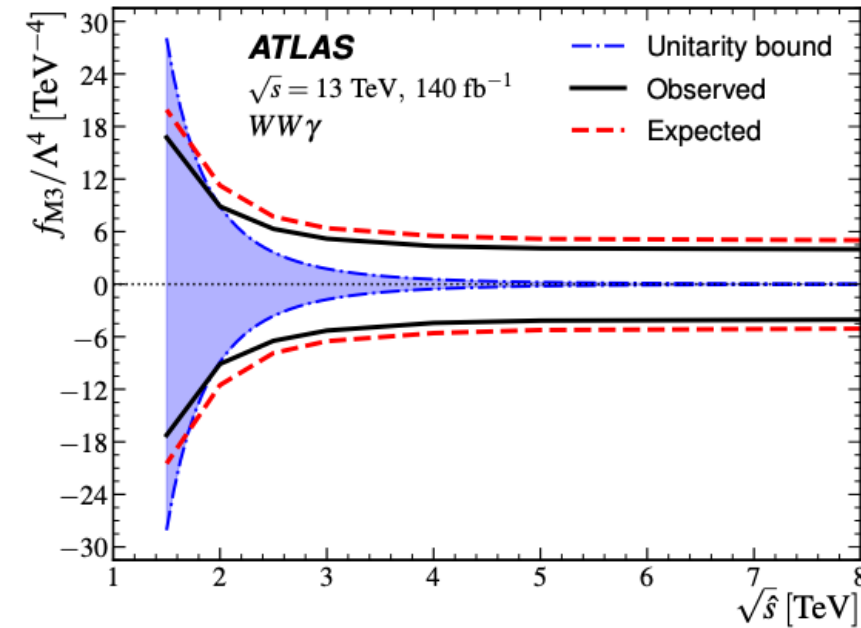
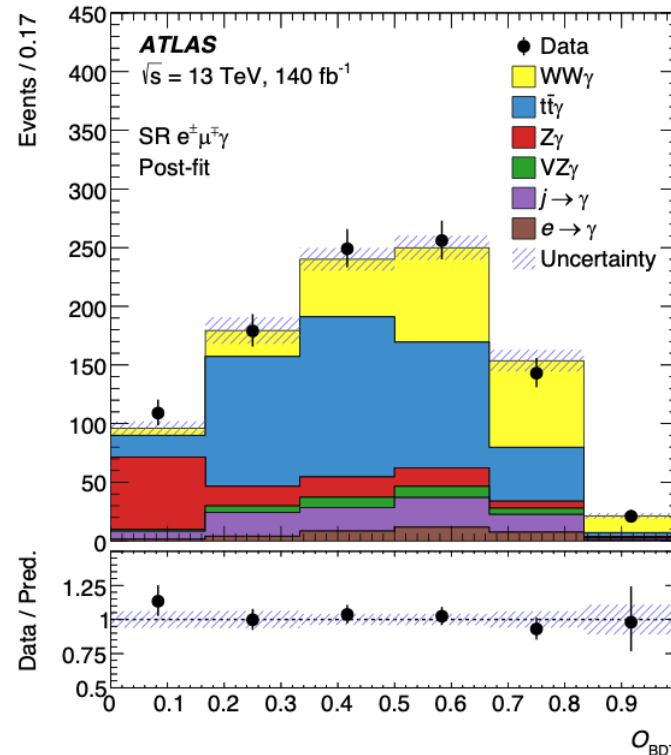


Observation of $W^+W^-\gamma$

- Sensitive to both QGC and TGC vertex.
- Focus on events with an opposite-charge $e\mu$ pair.
- Multivariate analysis method.



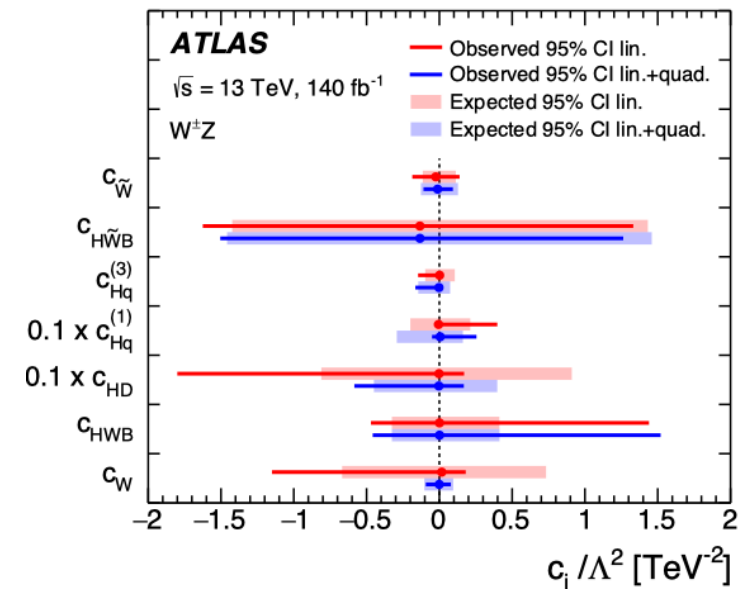
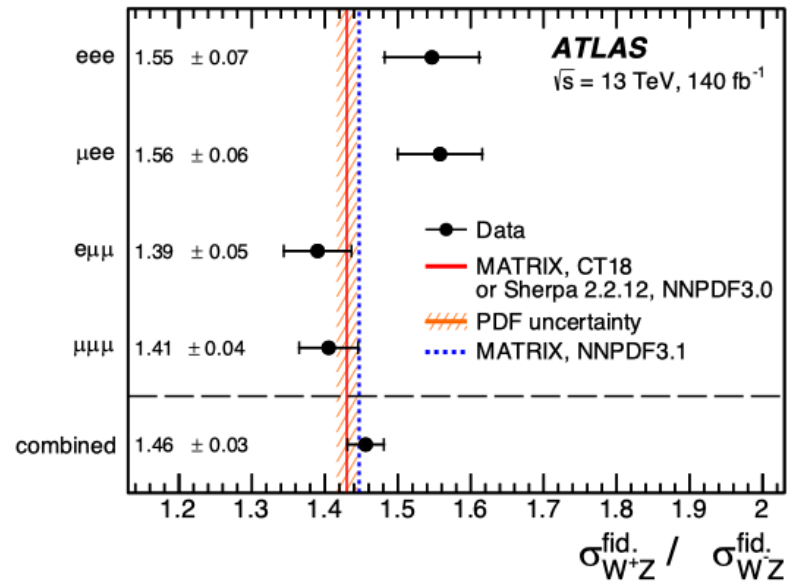
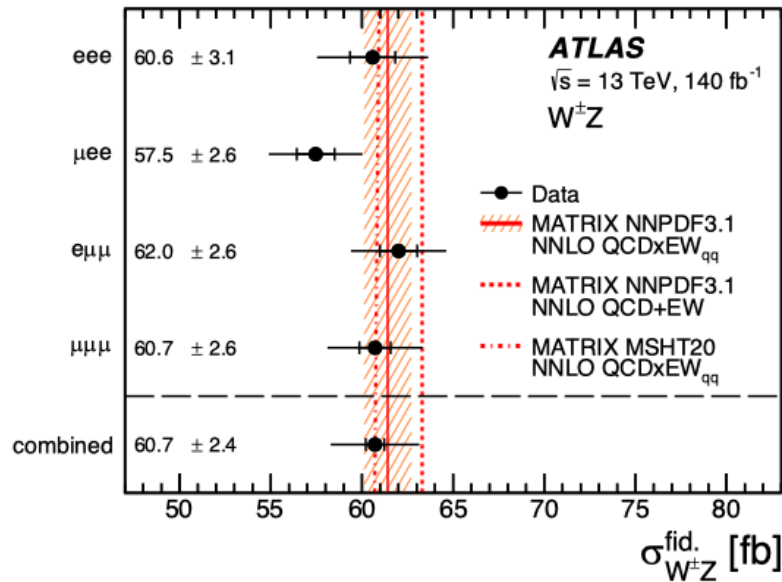
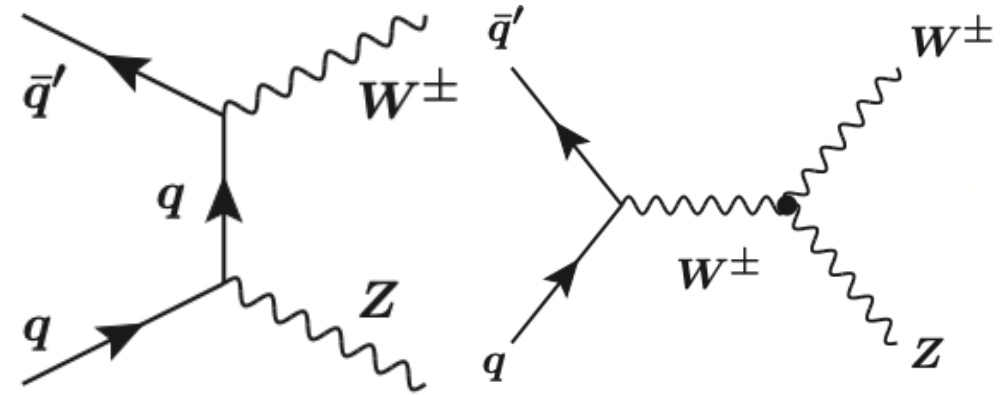
- The observed (expected) significance of the signal is 5.9 (6.0) σ .
- Measured $WW\gamma$ fiducial production cross-section $=6.2 \pm 1.0$ fb.



- Constraints at the 95% CL are set on 13 dimension-8 EFT Wilson coefficients within SMEFT.

$W^\pm Z$ production cross section

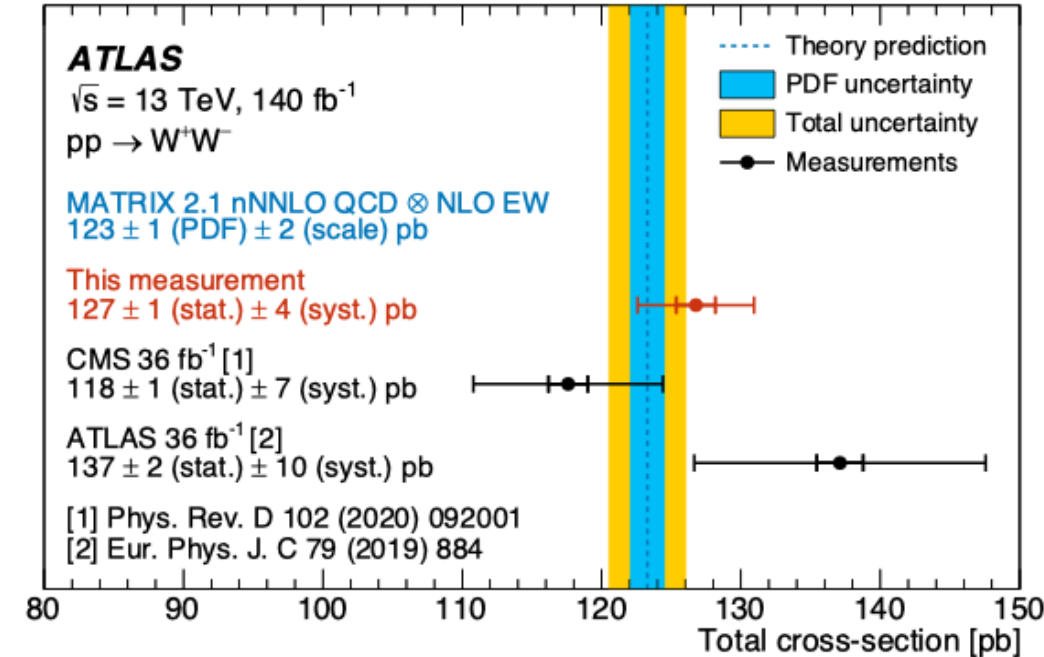
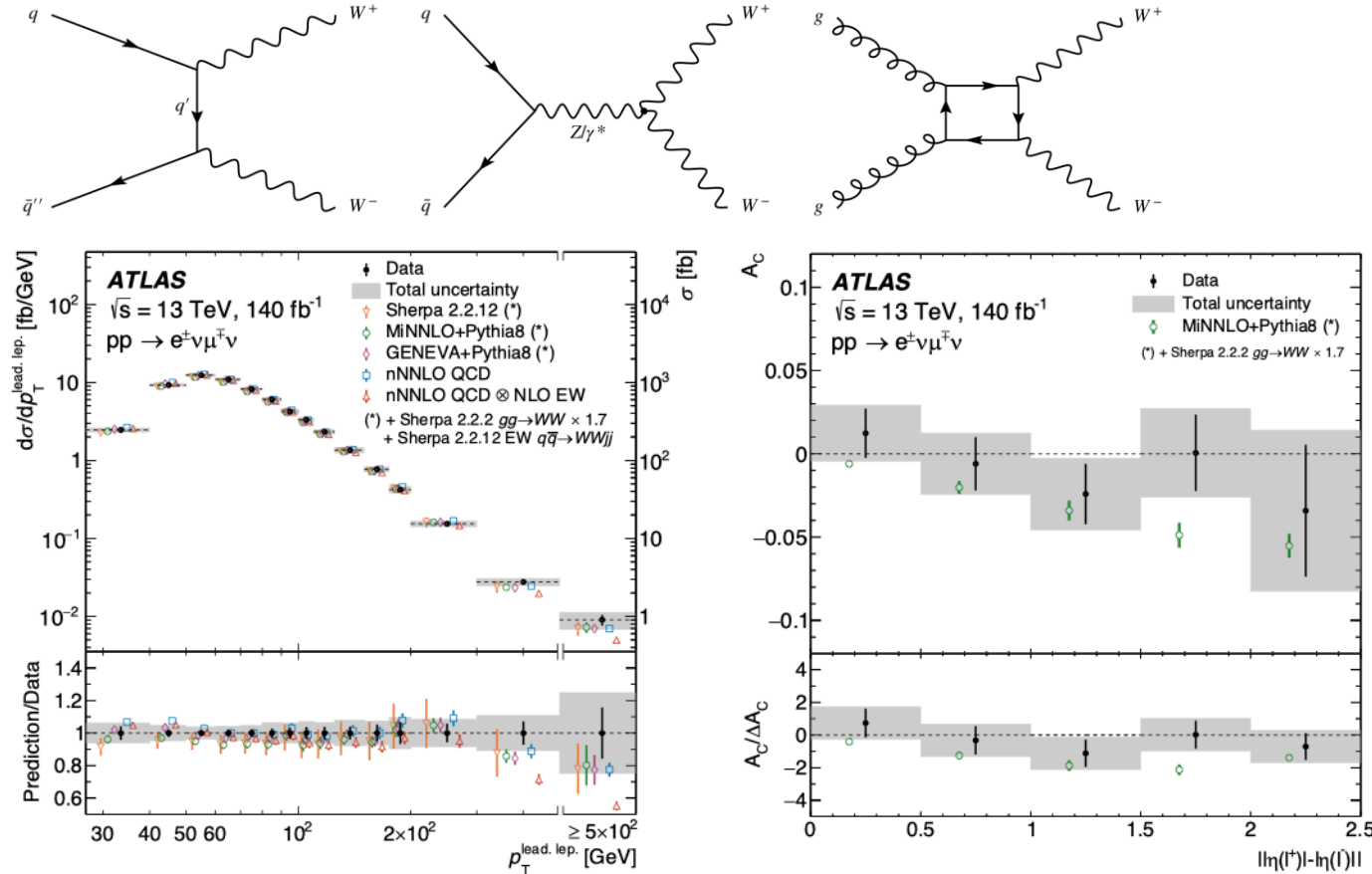
- Directly probes TGC, specifically WWZ.
- Measured both integrated and differential cross sections for $W^\pm Z$ in fully leptonic final state.



- Result matches NNLO QCD + NLO EW prediction.
- Interpreted to test the CP violation effects in the SMEFT framework.

W^+W^- production cross sections

Measured in final state $W^+W^- \rightarrow e^\pm \nu \mu^\mp \bar{\nu}$ differentially, extrapolated to full phase space.

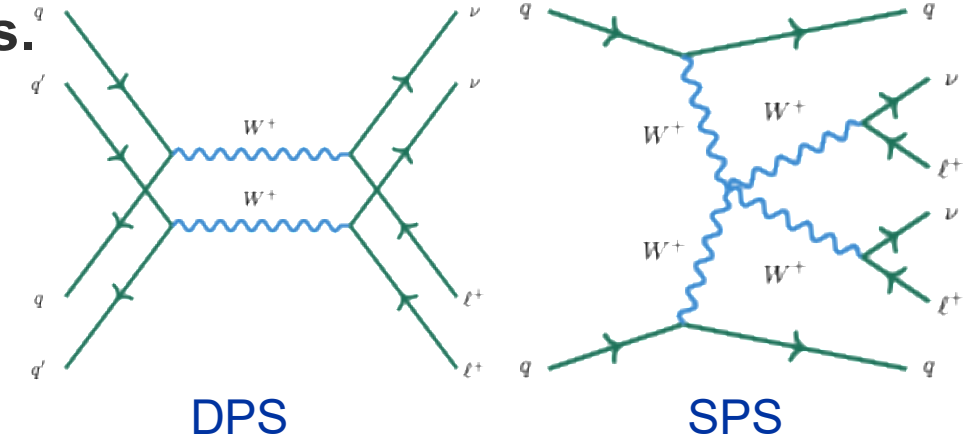
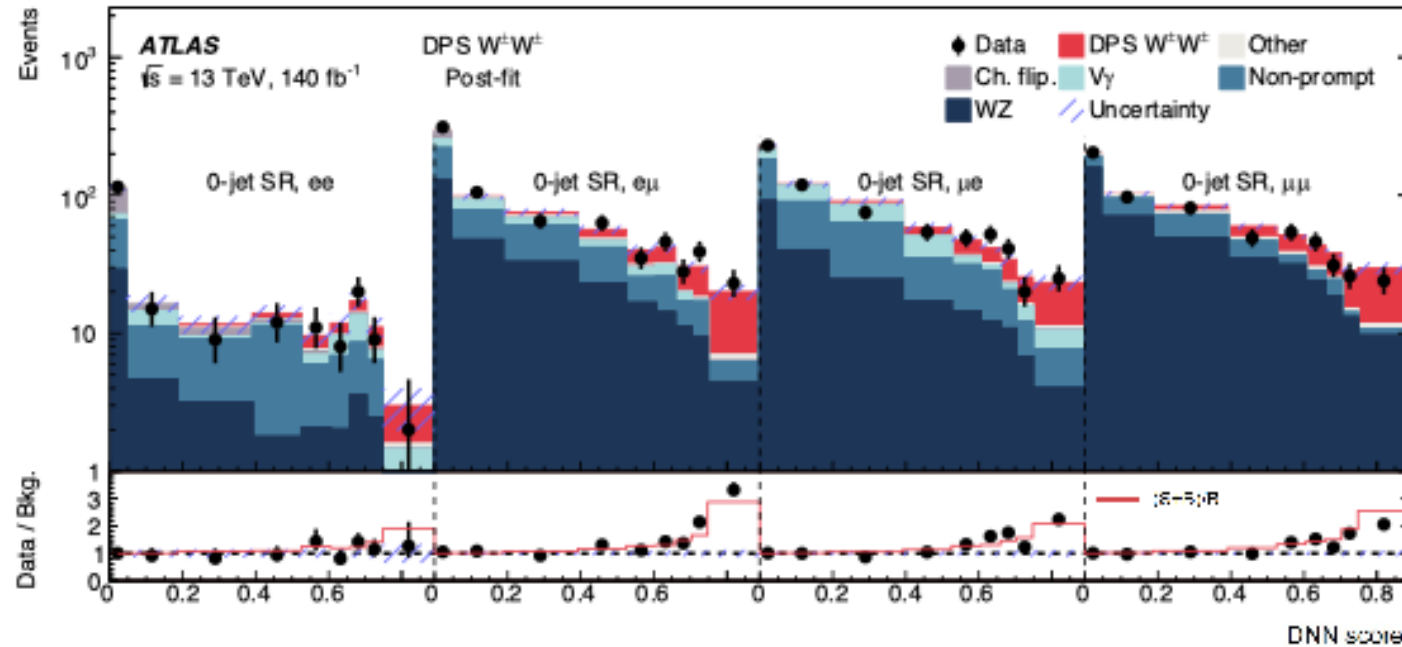


Charge asymmetry in agreement with the SM expectation.

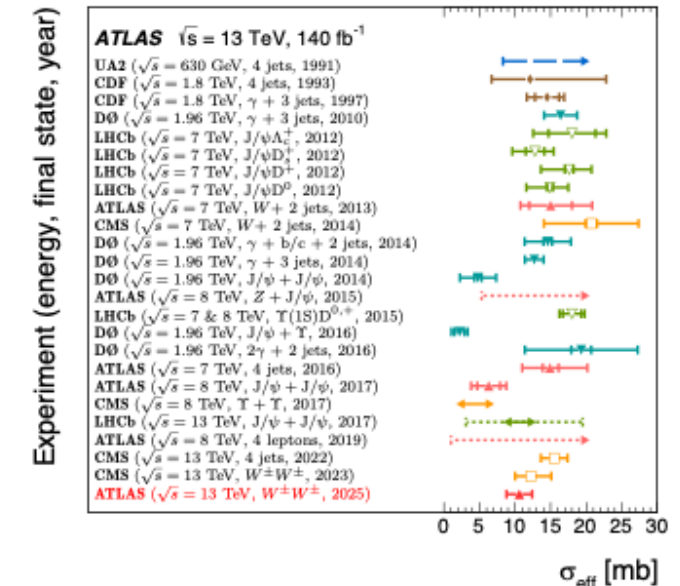
$A_{CP} = 0.014 \pm 0.008 \text{ (stat.)} \pm 0.008 \text{ (syst.)}$, consistent with no CP violation.

SSWW production from double parton scattering

- ❑ DPS studies are crucial for understanding the internal structure of colliding hadrons.
- ❑ Measurement performed with $W^\pm W^\pm \rightarrow l^\pm \nu l^\pm \nu$ events.



- ❑ Observation with a significance of 8.8σ .
- ❑ Measured DPS effective cross section of $10.6 \pm 1.8 \text{ mb}$.



Observation of WW/WZ/ZZ + high-mass dijet

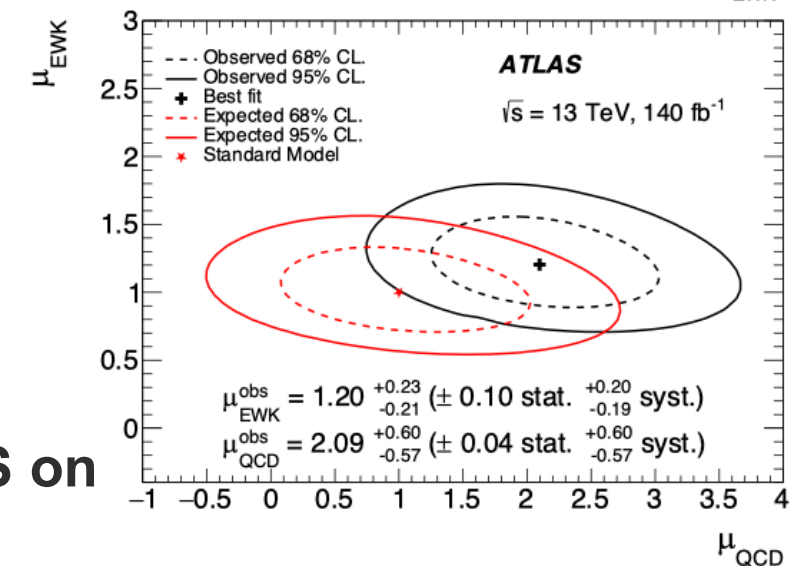
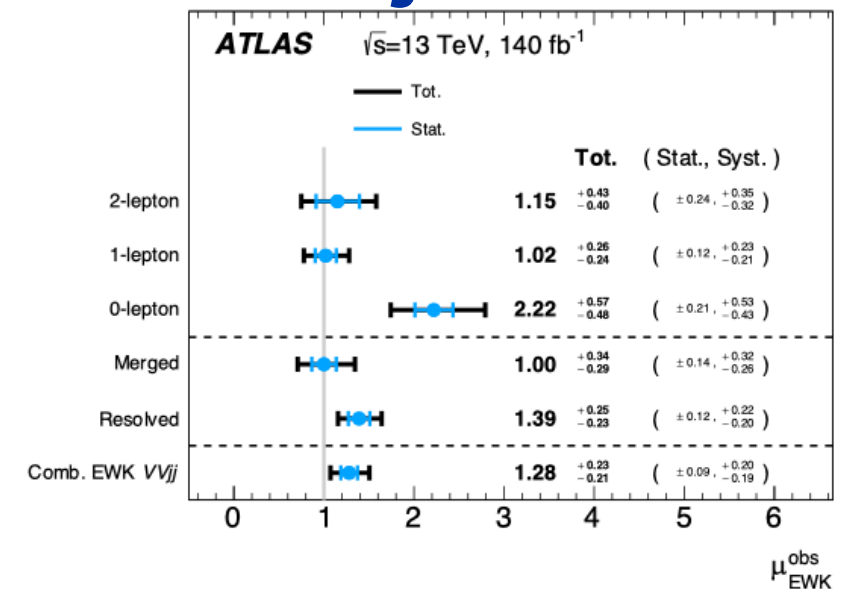
□ Final states with one boson decaying leptonically and the other boson decaying hadronically are studied.

□ EWK VVjj observed with 7.4σ (expected 6.1σ).

□ EKW signal strength measured to be $1.28^{+0.23}_{-0.21}$

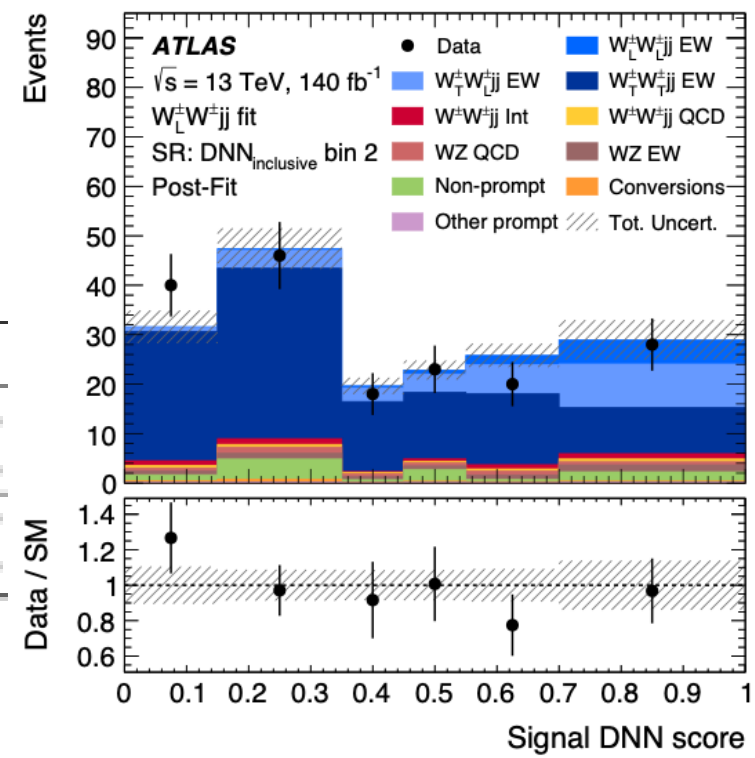
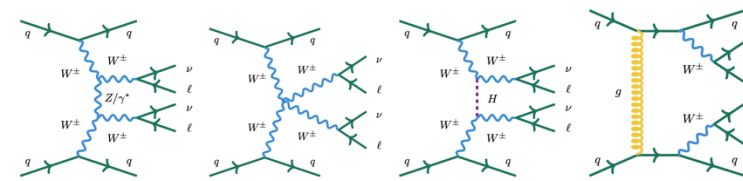
Wilson coefficient	Expected limit [TeV^{-4}]	Observed limit [TeV^{-4}]	Expected limit unitarized [TeV^{-4}]	Observed limit unitarized [TeV^{-4}]
f_{T1}/Λ^4	[-0.20, 0.18]	[-0.25, 0.22]	[-0.79, 0.47] at [1.76, 1.96] TeV	[-0.85, 0.47] at [1.73, 2.00] TeV
f_{T2}/Λ^4	[-0.19, 0.19]	[-0.24, 0.24]	[-0.34, 0.34] at [2.59, 2.59] TeV	[-0.43, 0.43] at [2.43, 2.43] TeV
f_{T3}/Λ^4	[-0.44, 0.44]	[-0.55, 0.55]	[-0.95, 0.96] at [2.22, 2.22] TeV	[-1.16, 1.17] at [2.12, 2.11] TeV
f_{T4}/Λ^4	[-0.38, 0.38]	[-0.48, 0.48]	[-0.62, 0.62] at [2.71, 2.71] TeV	[-0.88, 0.88] at [2.49, 2.48] TeV
f_{T5}/Λ^4	[-1.46, 1.32]	[-1.51, 1.37]	[-3.03, 2.60] at [2.02, 2.09] TeV	[-3.03, 2.60] at [2.02, 2.10] TeV
f_{T6}/Λ^4	[-0.57, 0.53]	[-0.64, 0.58]	-	[-2.65, 2.57] at [1.53, 1.54] TeV
f_{T7}/Λ^4	[-0.76, 0.72]	[-0.74, 0.71]	[-2.82, 2.01] at [1.66, 1.73] TeV	[-2.98, 2.62] at [1.64, 1.69] TeV
f_{T8}/Λ^4	[-1.78, 1.52]	[-1.94, 1.70]	[-7.88, 4.29] at [1.65, 1.90] TeV	[-6.70, 4.11] at [1.72, 1.91] TeV
f_{T9}/Λ^4	[-0.59, 0.59]	[-0.48, 0.48]	-	-
f_{T10}/Λ^4	[-1.22, 1.22]	[-1.02, 1.03]	-	-
f_{S1}/Λ^4	[-3.22, 3.22]	[-3.96, 3.96]	[-5.53, 5.54] at [2.07, 2.67] TeV	[-6.16, 6.17] at [2.01, 2.01] TeV
f_{S2}/Λ^4	[-6.84, 6.86]	[-8.06, 8.06]	-	-
f_{S3}/Λ^4	[-1.13, 1.12]	[-1.26, 1.25]	[-2.61, 2.58] at [2.00, 2.00] TeV	[-2.71, 2.65] at [1.97, 1.98] TeV
f_{S4}/Λ^4	[-3.23, 3.24]	[-3.95, 3.95]	[-6.22, 6.22] at [2.27, 2.27] TeV	[-7.42, 7.43] at [2.17, 2.17] TeV
f_{S5}/Λ^4	[-1.66, 1.67]	[-1.85, 1.85]	-	-
f_{S6}/Λ^4	[-5.29, 5.29]	[-5.68, 5.71]	[-23.69, 23.39] at [1.57, 1.57] TeV	[-18.62, 19.10] at [1.66, 1.65] TeV
f_{S7}/Λ^4	[-2.62, 2.62]	[-2.96, 2.97]	-	-
f_{S8}/Λ^4	[-3.81, 3.82]	[-4.41, 4.44]	[-6.80, 6.80] at [2.33, 2.33] TeV	[-7.28, 7.30] at [2.29, 2.29] TeV
f_{S9}/Λ^4	[-5.32, 5.20]	[-6.60, 6.43]	[-9.47, 9.38] at [2.43, 2.43] TeV	[-11.91, 11.11] at [2.29, 2.33] TeV

□ First set of limits in this semi-leptonic channel by ATLAS on dimension-8 SMEFT operator coefficients.



Same-sign WW polarization USTC

- ❑ Polarized WW/ZZ from VBS provides sensitive test to EWSB.
- ❑ Theory predictions challenging beyond LO.
- ❑ Dedicated DNNs trained to separate $W_L^+ W^\pm jj$ from $W_T^+ W_T^\pm jj$ and $W_L^+ W_L^\pm jj$ from $W_T^+ W^\pm jj$ for two independent fits.

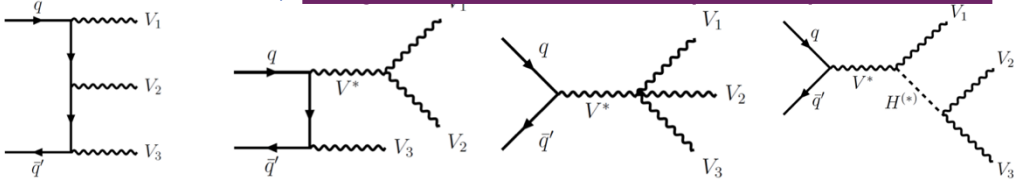


- ❑ Observed (expected) significance of at least one longitudinally polarized W boson is 3.3 (4.0) σ .
- ❑ Most stringent limits to date on the production of two longitudinally polarized same-sign W bosons set to be 0.45 (0.70) fb at 95% CL.

Observation of VVZ production

Channels categorized by N leptons:

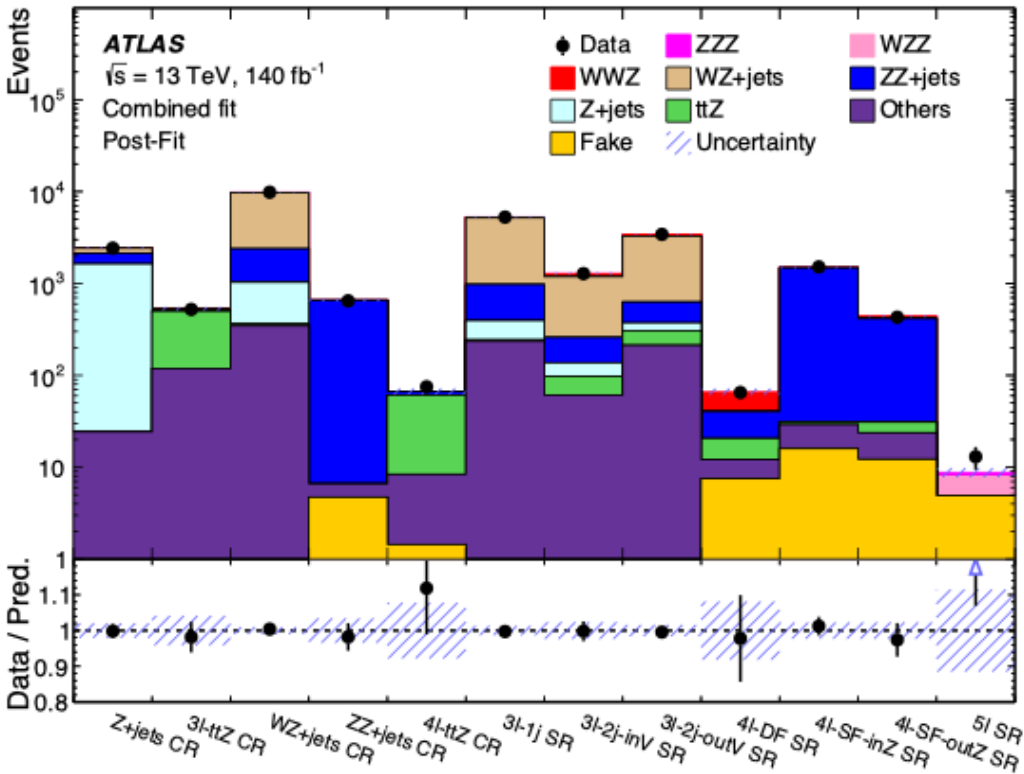
- $WWZ \rightarrow qqlvll, WZZ \rightarrow lvqqll.$
- $WWZ \rightarrow lvlvll.$
- $WZZ \rightarrow lvlvll, ZZZ \rightarrow llllll.$



A combined signal strength for VVZ is measured:

Table 1: Measured signal strengths and inclusive cross sections and observed (expected) sensitivities for WWZ, WZZ, and VVZ production. The uncertainties listed are statistical and systematic.

Process	Signal strength	Cross section (fb)	Observed (expected) sensitivity
VVZ	$1.43 \pm 0.20(\text{stat.})^{+0.21}_{-0.19}(\text{syst.})$	$660^{+93}_{-90}(\text{stat.})^{+88}_{-81}(\text{syst.})$	6.4 (4.7) σ
WWZ	$1.33 \pm 0.28(\text{stat.})^{+0.21}_{-0.17}(\text{syst.})$	$442 \pm 94(\text{stat.})^{+60}_{-52}(\text{syst.})$	4.4 (3.6) σ
WZZ	$2.13^{+1.18}_{-0.96}(\text{stat.})^{+0.76}_{-0.41}(\text{syst.})$	$200^{+111}_{-91}(\text{stat.})^{+65}_{-37}(\text{syst.})$	2.8 (1.6) σ



VVZ production observed with a significance of 6.4 σ (expected 4.7 σ).

WWZ production shows a significance of 4.4 σ (expected 3.6 σ).

Interpreted in SMEFT for dim-8 operators.

Selected highlights: Other SM/QCD measurements

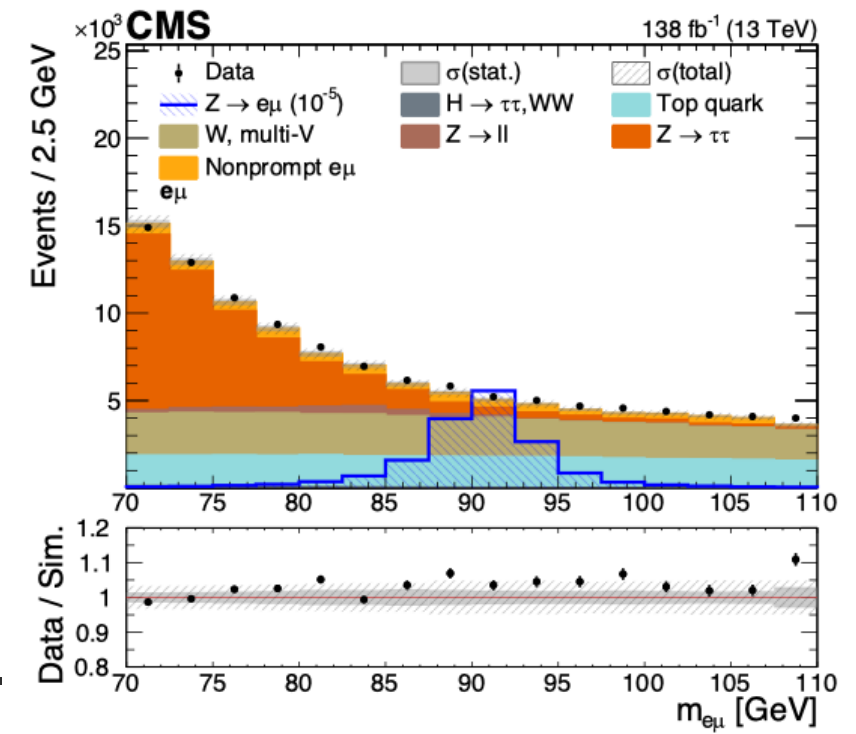
Topics	References
Charged lepton flavor violating Z decay	CMS, arXiv:2508.07512
Rare decays of Z and H to J/ψ or $J/\psi(2S)+\gamma$	CMS, Phys. Lett. B 865 (2025) 139462

Charged lepton flavor violating Z decay

- Family number violation seen in quark sectors via weak decays and neutral leptons via neutrino oscillations.
- Lepton flavor violation suppressed ($\sim 10^{-60}$) for charged leptons (via neutrino induced loops).

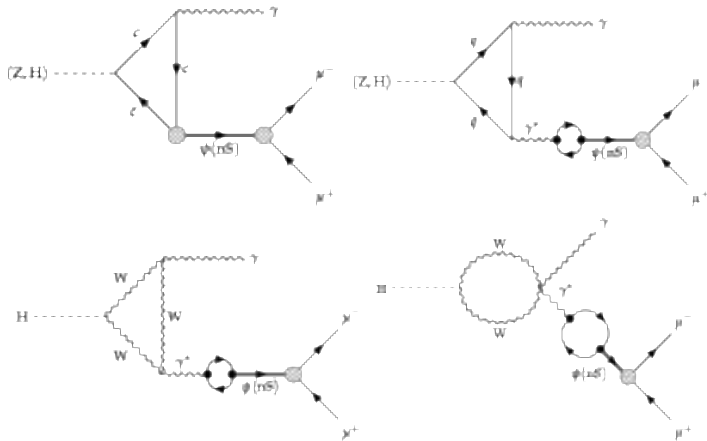
Channel	Branching fraction	Signif. [σ]	Observed (expected) limit	Prior (expected) limit
$Z \rightarrow e\mu$	$-0.1^{+1.0}_{-1.0} \times 10^{-7}$	-0.1	$1.9 (2.0^{+0.8}_{-0.6}) \times 10^{-7}$	$2.6 (2.4) \times 10^{-7}$ [22]
$0.3 < \text{BDT} < 0.7$	$-3.4^{+2.8}_{-2.6} \times 10^{-7}$	-1.2	$5.7 (8.2^{+2.5}_{-2.0}) \times 10^{-7}$	—
$0.7 < \text{BDT} < 0.9$	$0.4^{+1.5}_{-1.4} \times 10^{-7}$	+0.3	$3.2 (2.9^{+1.2}_{-0.8}) \times 10^{-7}$	—
$0.9 < \text{BDT} < 1.0$	$0.0^{+1.5}_{-2.0} \times 10^{-7}$	+0.0	$3.0 (3.0^{+1.2}_{-0.8}) \times 10^{-7}$	—
$Z \rightarrow e\tau$	$3.2^{+6.1}_{-6.0} \times 10^{-6}$	+0.5	$13.8 (11.4^{+4.7}_{-3.2}) \times 10^{-6}$	$5.0 (6.0) \times 10^{-6}$ [21]
$Z \rightarrow e\tau_h$	$6.3^{+8.4}_{-8.2} \times 10^{-6}$	+0.8	$21.3 (16.1^{+6.7}_{-4.6}) \times 10^{-6}$	$8.1 (8.1) \times 10^{-6}$ [21]
$Z \rightarrow e\tau_\mu$	$1.2^{+7.9}_{-8.1} \times 10^{-6}$	+0.2	$16.2 (15.3^{+6.1}_{-4.2}) \times 10^{-6}$	$7.0 (8.9) \times 10^{-6}$ [21]
$Z \rightarrow \mu\tau$	$7.5^{+2.7}_{-2.7} \times 10^{-6}$	+2.7	$12.0 (5.3^{+2.1}_{-1.5}) \times 10^{-6}$	$6.5 (5.3) \times 10^{-6}$ [21]
$Z \rightarrow \mu\tau_h$	$7.2^{+2.8}_{-2.8} \times 10^{-6}$	+2.5	$11.9 (5.6^{+2.2}_{-1.6}) \times 10^{-6}$	$9.5 (6.1) \times 10^{-6}$ [21]
$Z \rightarrow \mu\tau_e$	$7.5^{+7.1}_{-7.9} \times 10^{-6}$	+1.0	$19.5 (14.4^{+5.1}_{-3.8}) \times 10^{-6}$	$7.2 (10.0) \times 10^{-6}$ [21]

- Most stringent limit to date on $Z \rightarrow e\mu$ with 1.9×10^{-7} .
- Comparable results to ATLAS on $Z \rightarrow e\tau$ and $Z \rightarrow \mu\tau$ limits.



Rare decays of Z and H to J/ψ or ψ(2S) + γ

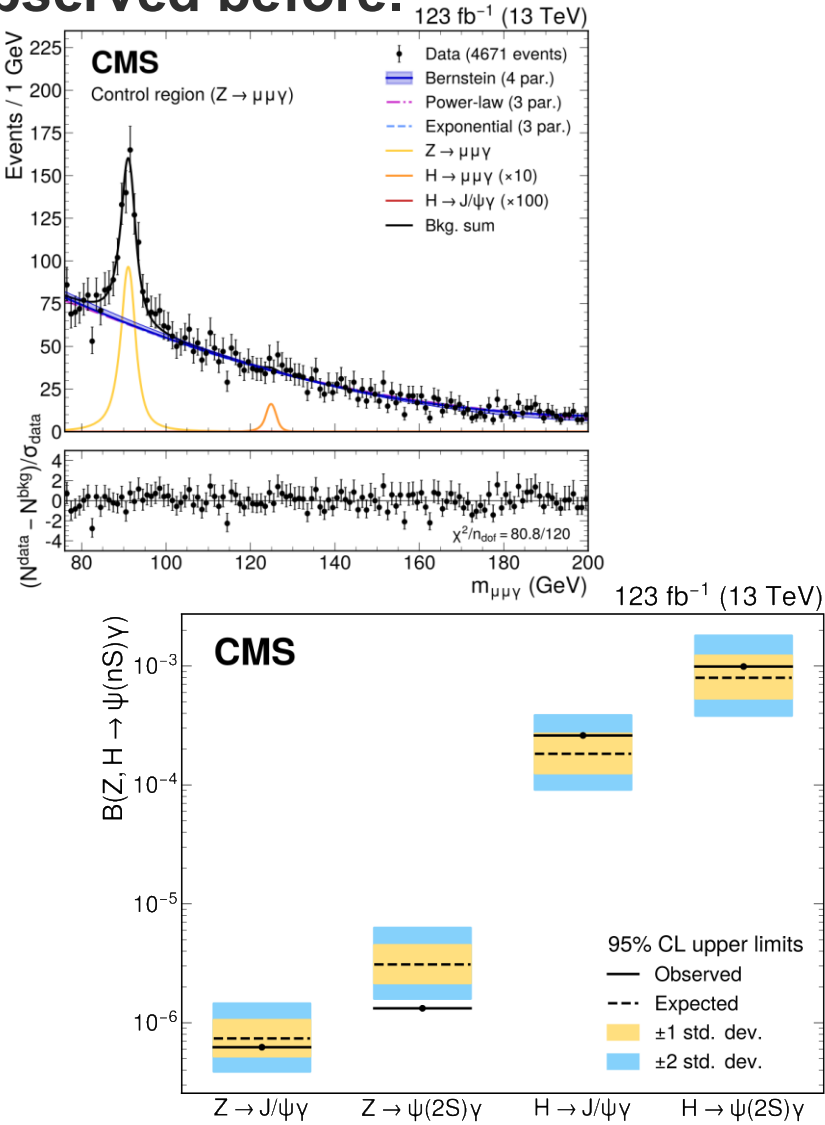
❑ SM predicted rate decay Z/H→ ψ(nS)γ, n=1 or 2, never observed before.



Process	This work (123 fb ⁻¹)			CMS (36 fb ⁻¹) [24]	ATLAS (139 fb ⁻¹) [26]
	$\mu_{\text{obs}}(\mu_{\text{exp}})$	$\sigma B_{\text{obs}}(\sigma B_{\text{exp}})$ [pb]	$B_{\text{obs}}(B_{\text{exp}})$	$B_{\text{obs}}(B_{\text{exp}})$	$B_{\text{obs}}(B_{\text{exp}})$
Z → J/ψγ	7.2 (8.6 ^{+4.1} _{-2.7})	3.8 (4.4 ^{+1.8} _{-1.3}) × 10 ⁻²	0.6 (0.7 ^{+0.3} _{-0.2}) × 10 ⁻⁶	1.5 (1.7 ^{+0.7} _{-0.5}) × 10 ⁻⁶	1.2 (0.7 ^{+0.3} _{-0.2}) × 10 ⁻⁶
Z → ψ(2S)γ	29 (68 ⁺³⁶ ₋₂₂)	8 (19 ⁺⁸ ₋₆) × 10 ⁻²	1.3 (3.1 ^{+1.4} _{-0.9}) × 10 ⁻⁶	—	2.4 (3.0 ^{+1.3} _{-0.8}) × 10 ⁻⁶
H → J/ψγ	88 (62 ⁺³⁰ ₋₁₉)	1.4 (1.0 ^{+0.5} _{-0.3}) × 10 ⁻²	2.6 (1.8 ^{+0.9} _{-0.6}) × 10 ⁻⁴	7.6 (5.2 ^{+2.4} _{-1.6}) × 10 ⁻⁴	2.0 (1.8 ^{+0.8} _{-0.5}) × 10 ⁻⁴
H → ψ(2S)γ	970 (780 ⁺⁴²⁰ ₋₂₆₀)	5.5 (4.4 ^{+2.3} _{-1.5}) × 10 ⁻²	9.9 (8.0 ^{+4.2} _{-2.6}) × 10 ⁻⁴	—	10.5 (8.1 ^{+3.6} _{-2.3}) × 10 ⁻⁴

❑ Upper limits at 95% confidence level are set on the branching fractions.

❑ Limits comparable with the previous ATLAS results.



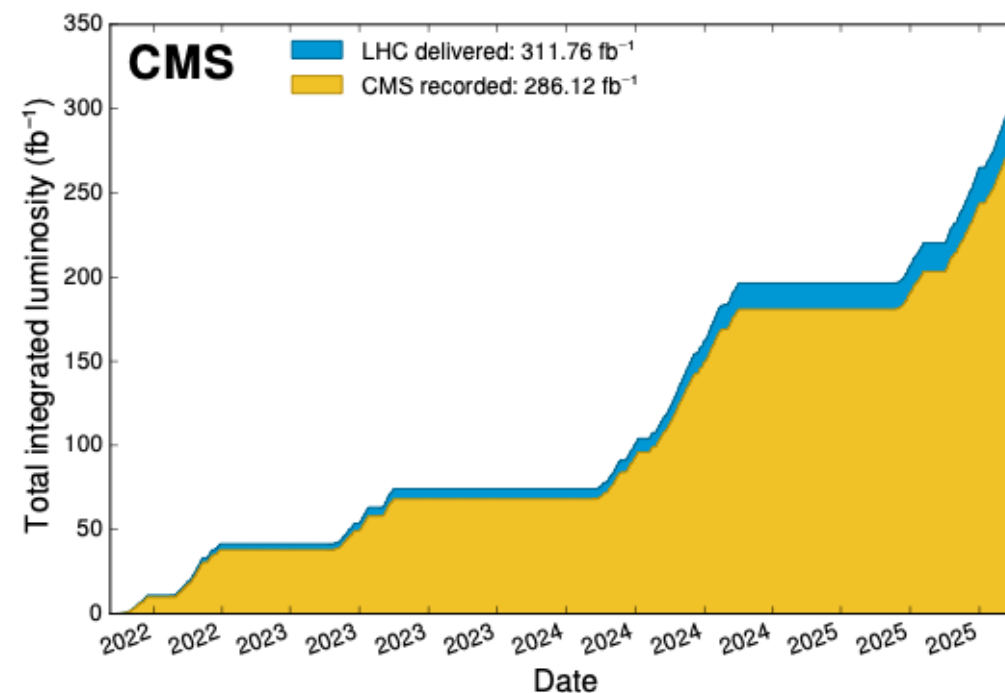
Summary

❑ The LHC's Run2 precision program has matured and is bearing fruit

- More precision measurements on vector bosons spectra.
- More observations and evidences on multi-bosons/VBS production.
- Increased sensitivity to diboson polarization.
- Stringent constraints on aTGC/aQGC and SMEFT.
- Rare SM decays setting new limits.

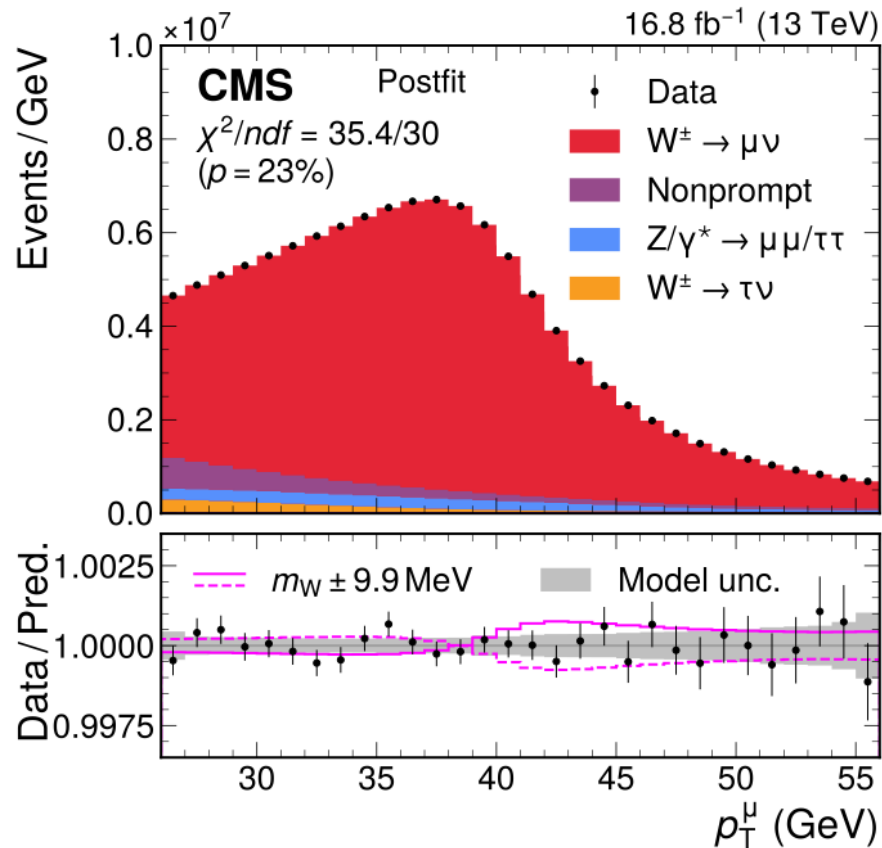
❑ Looking at Run3 and beyond

- LHC has delivered >300/fb of pp collision at 13.6 TeV.
- Run3 precision physics at EWK is producing results.
- Multi-boson physics progressing from observation to precise measurement.
- Expecting more individual and combined new measurements soon.

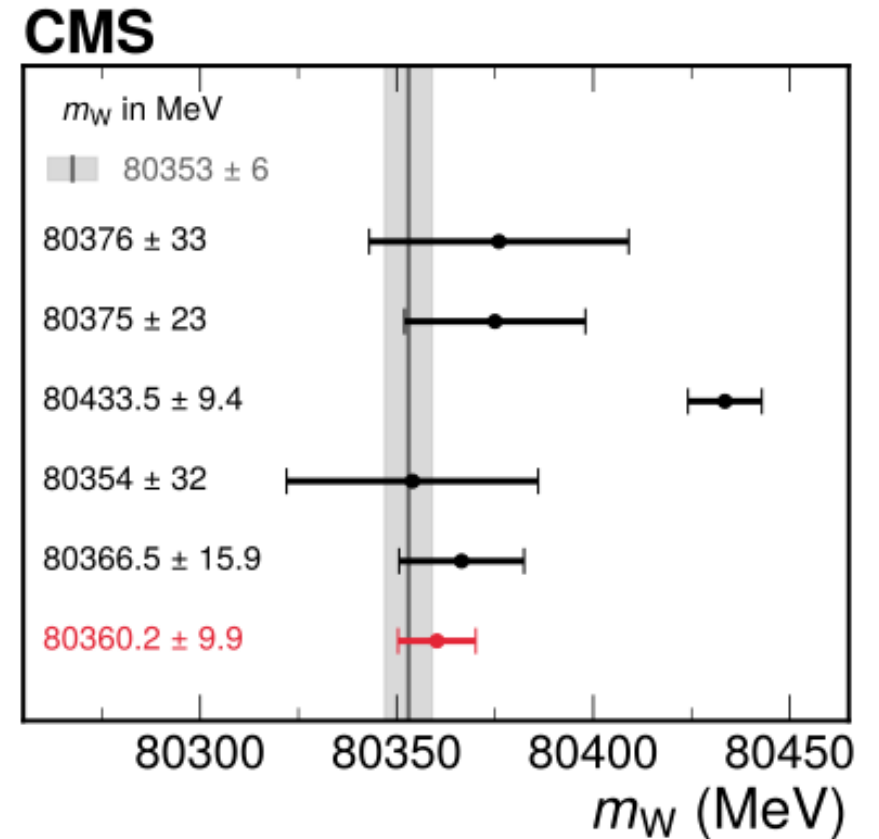


Backups

SMP-23-002 CMS W mass submitted to Nature



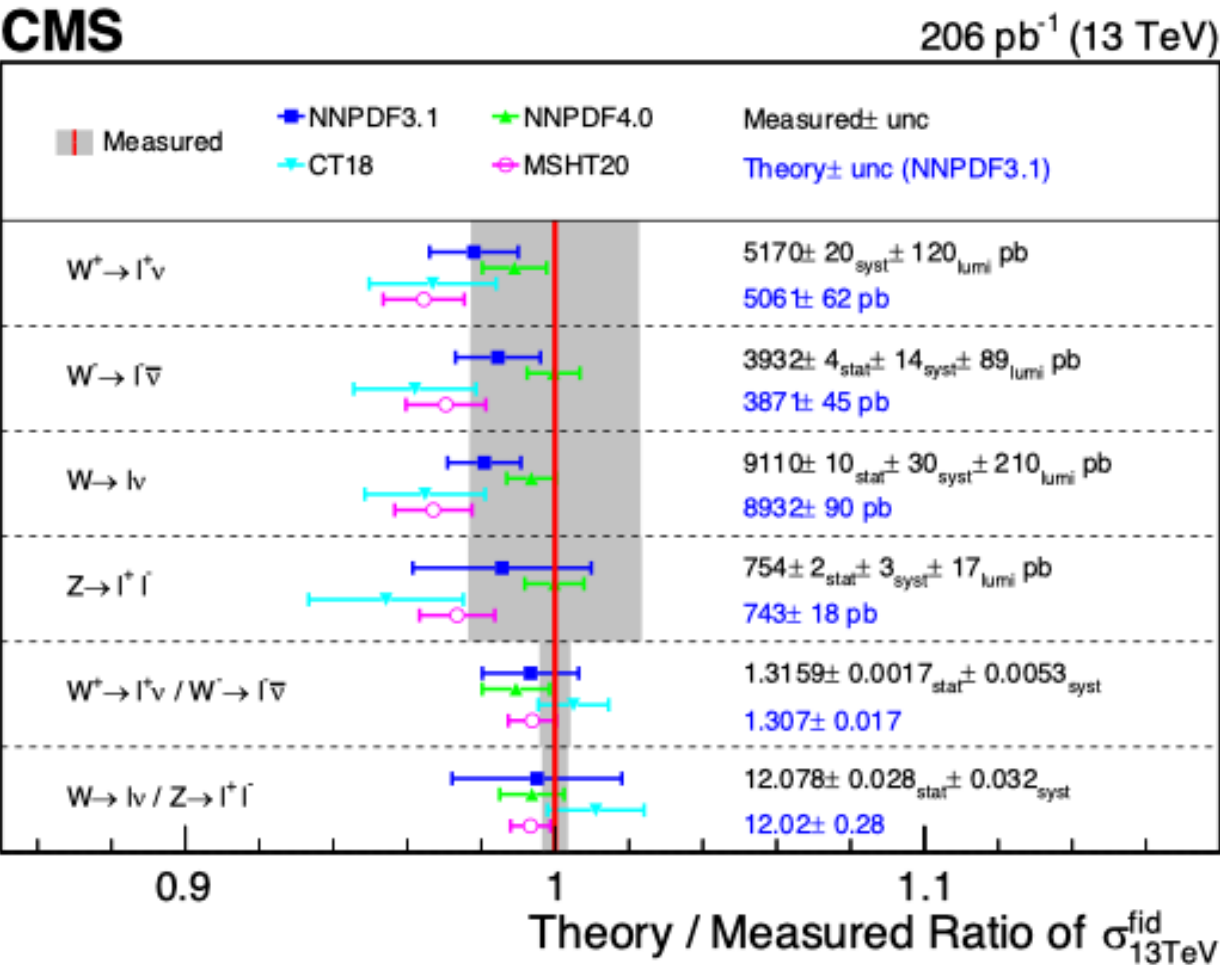
Electroweak fit
 PRD 110 (2024) 030001
LEP combination
 Phys. Rep. 532 (2013) 119
D0
 PRL 108 (2012) 151804
CDF
 Science 376 (2022) 6589
LHCb
 JHEP 01 (2022) 036
ATLAS
 arXiv:2403.15085
b**CMS**
 This work



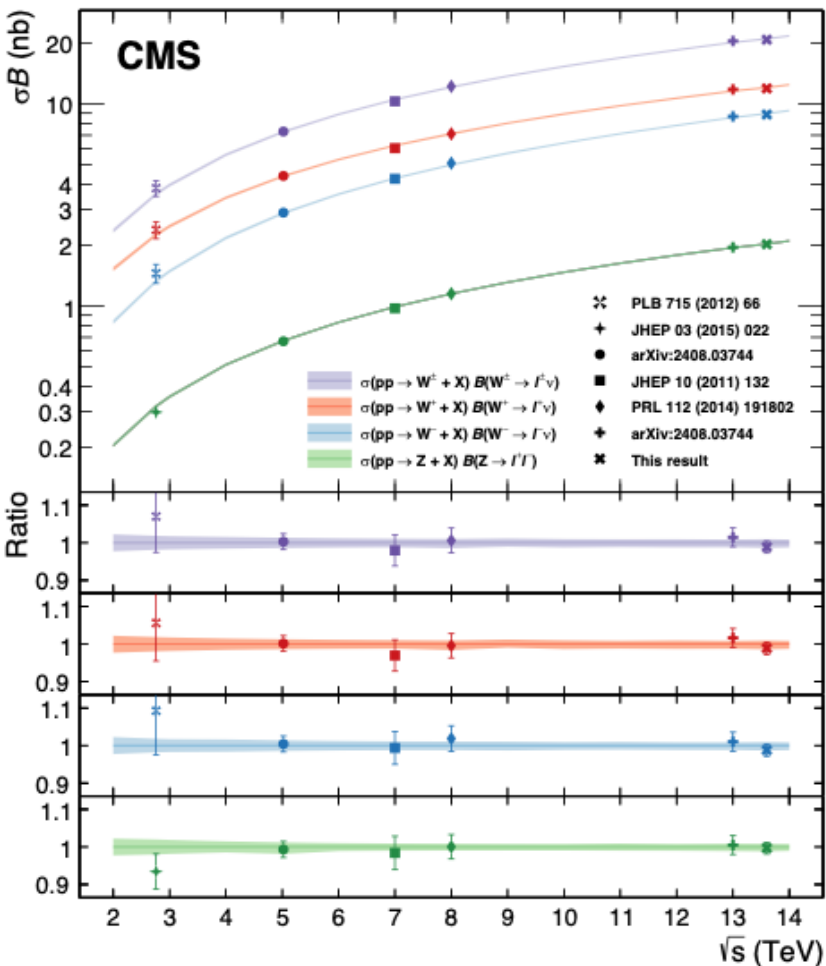
arXiv:2412.13872, submitted to Nature

SMP-20-004 & SMP-22-017

W/Z cross section measurements are finally published



JHEP 04 (2025) 162

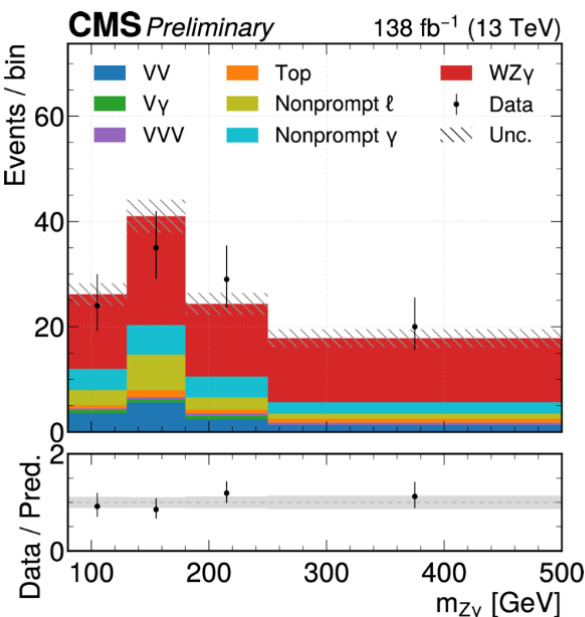


arXiv:2503.09742, Submitted to JHEP

CMS $WZ\gamma$ observation

CMS, SMP-22-018

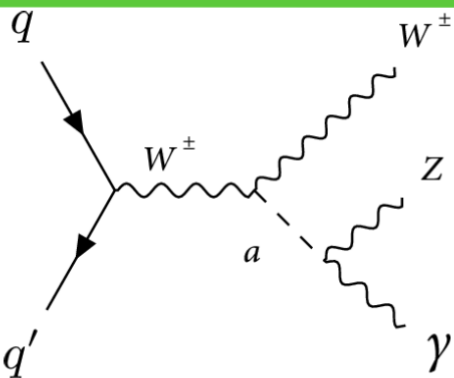
- Simultaneous production of three different gauge bosons



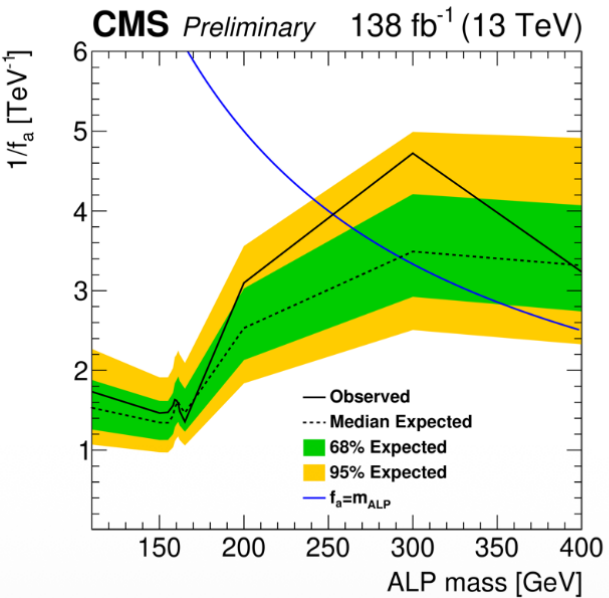
Observed (expected) significance: $5.4(3.8)\sigma$

Constraints on aQGC

Operators	Observed limits [TeV^{-4}]	Expected limits [TeV^{-4}]	Unitarity bound [TeV]
$F_{T,0}/\Lambda^4$	[-2.60, 2.60]	[-2.52, 2.52]	1.32
$F_{T,1}/\Lambda^4$	[-3.28, 3.24]	[-3.18, 3.14]	1.48
$F_{T,2}/\Lambda^4$	[-7.15, 7.05]	[-6.95, 6.85]	1.35
$F_{T,5}/\Lambda^4$	[-2.54, 2.56]	[-2.46, 2.50]	1.55
$F_{T,6}/\Lambda^4$	[-3.18, 3.22]	[-3.08, 3.14]	1.61
$F_{T,7}/\Lambda^4$	[-6.85, 7.05]	[-6.65, 6.85]	1.71



Search for axion-like particles
(photophobic ALPs $a \rightarrow Z\gamma$)



PKU

11/15/2024

Lailin Xu