RECENT RESULTS ON ASSOCIATED TOP QUARK PRODUCTION AND SEARCHES FOR NEW TOP-QUARK PHENOMENA WITH THE ATLAS DETECTOR

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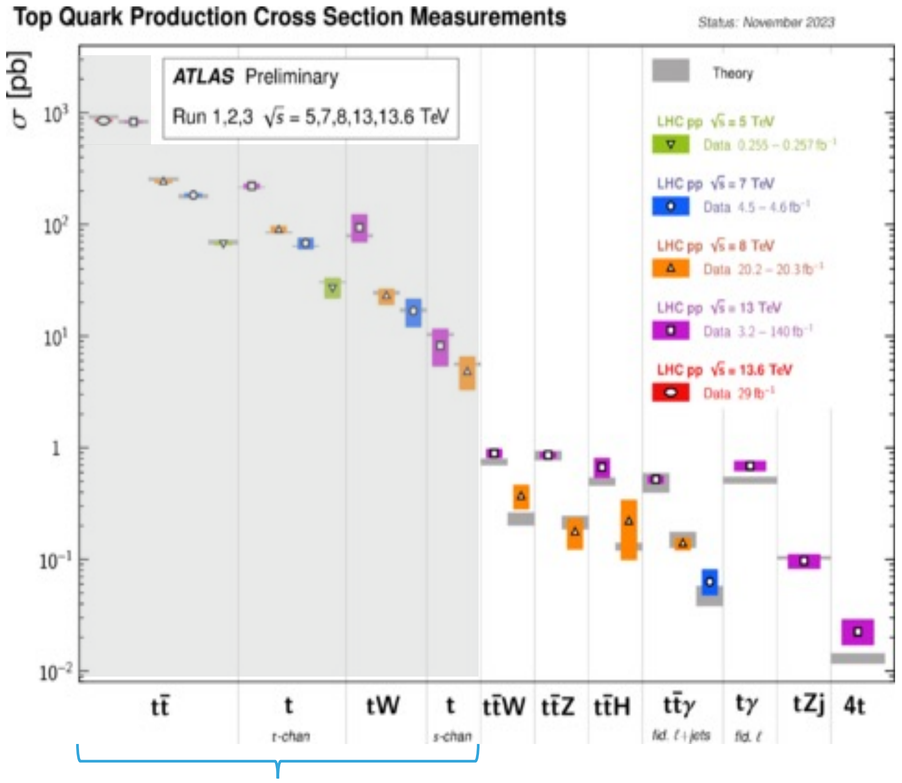
On behalf of the ATLAS Collaboration

Associated Top Quark Production

Results from 140 fb^{-1} pp collision as $\sqrt{s}$ = 13 TeV

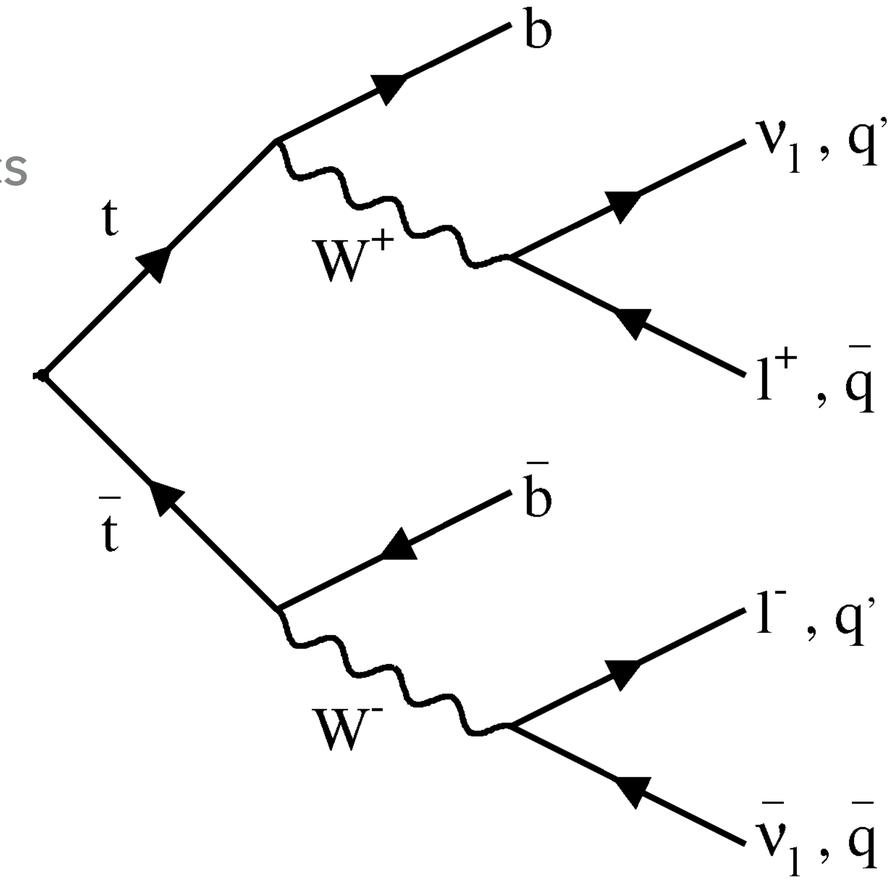
- ttW and ttZ inclusive and differential cross-section
- 4 tops observation and cross-section
- t ɣ cross-section
- Search for FCNC's in t→μτq
- Search for tq(H → ɣɣ) (including limits on FCNC's)



Thanks Stefan!

Associated Top Quark Production

- Rare SM processes sensitive to BSM Physics
  - t + *X* is often a background to BSM searches
- Top quark reconstruction:
  - t decays before hadronization: t → bW (> 99%)
    - W decays leptonically (lν) or to jets



ATLAS EXPERIMENT

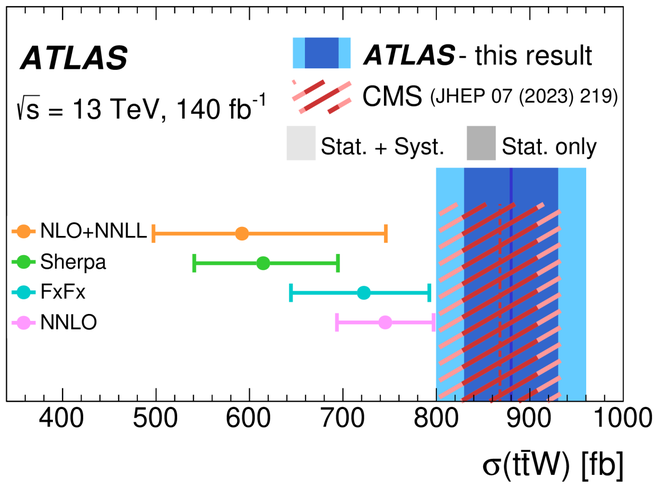
ttW Inclusive Cross Section and Charge Asymmetry

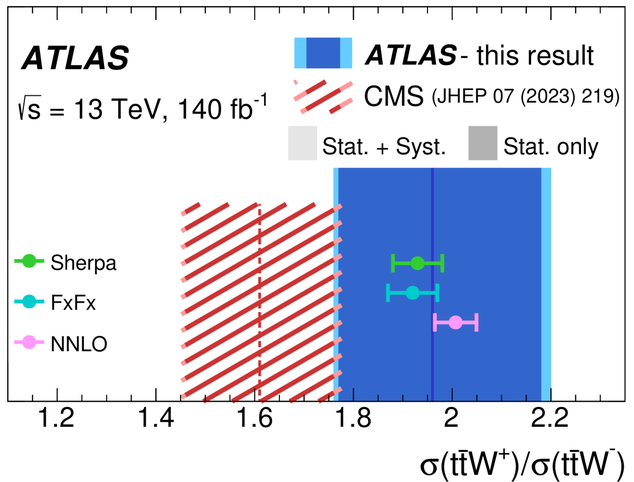
arXiv:2401.05299

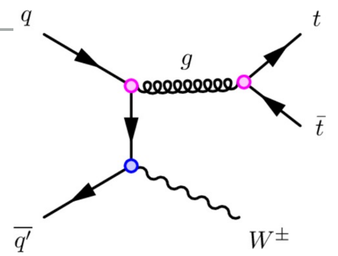
- Rare SM process subject to complex higher-order QCD and EWK corrections
- Dominant background in tt$H$ and tttt studies, irreducible background for many searches exploiting same-sign or multi-lepton signatures
- ttZ/γ*, VV, and ttH are the dominant backgrounds
  - VV MC has a data-driven jet multiplicity correction applied
- Dominant uncertainty from ttW ME models
- 56 (8) Signal regions for inclusive (differential) cross-sections
- σ_{ttW}= 880 ± 50 (stat) ± 70 (syst) fb, A_C^{rel} = 0.33 ± 0.05 (stat) ± 0.02 (syst)

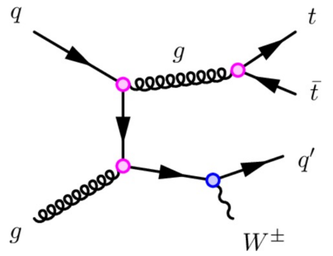
Normalised from control region

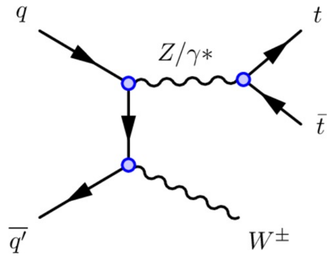
$$A_C^{rel} = \frac{\sigma(ttW^+) - \sigma(ttW^-)}{\sigma(ttW^+) + \sigma(ttW^-)}$$

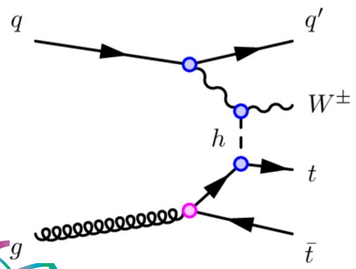










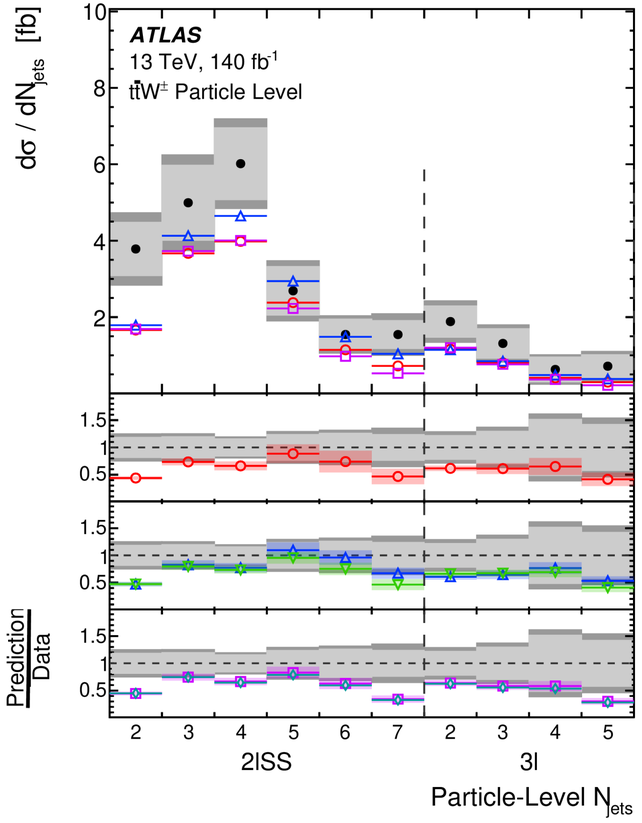


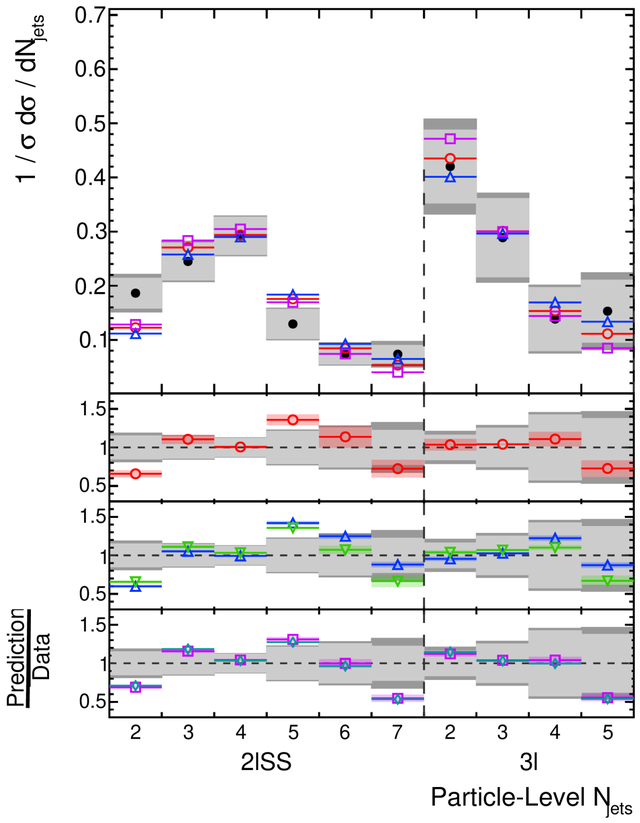
ATLAS EXPERIMENT

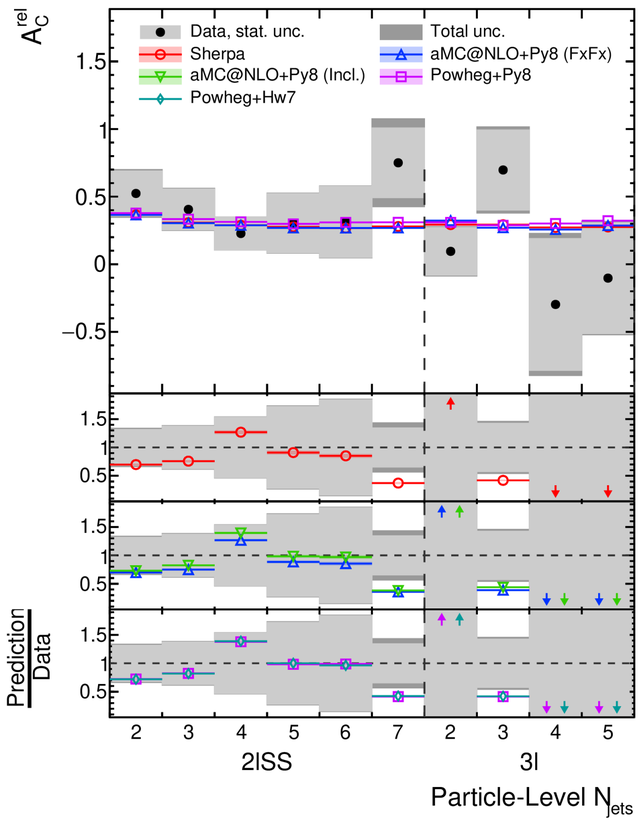
ttW Differential Cross Section

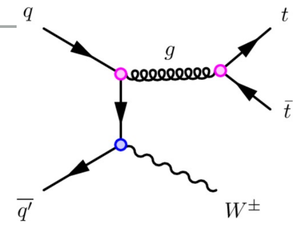
arXiv:2401.05299

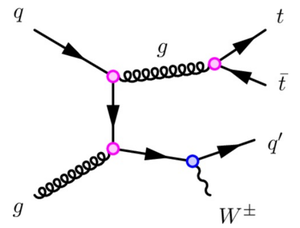
Differential in 6 variables: **jet multiplicity**, H_T(leptons,jets), $\Delta R_{lb,lead}$ $|\Delta\varphi_{ll,ss}|$, $|\Delta\eta_{ll,ss}|$ at particle level

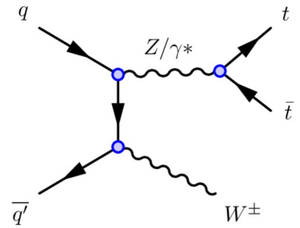


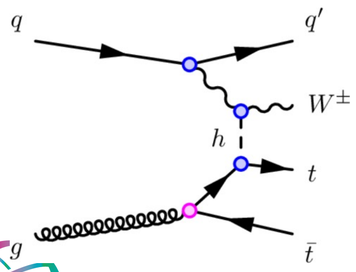










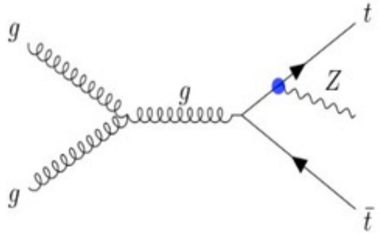


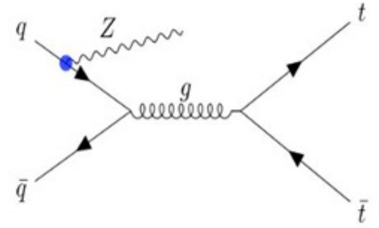
ATLAS EXPERIMENT

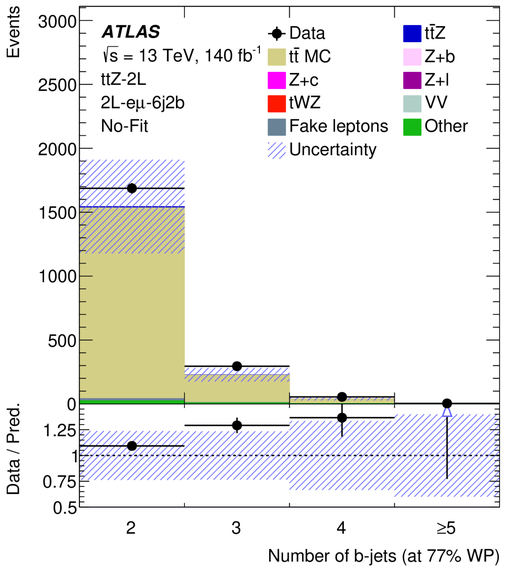
ttZ Cross Section

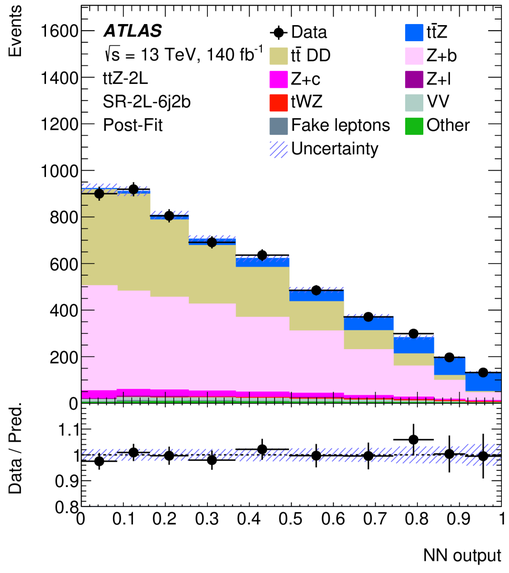
arXiv:2312.04450

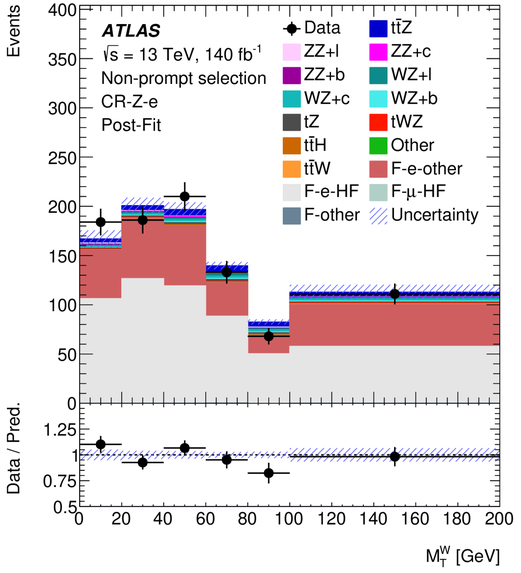
- Fully reconstructed Z in e and μ channels
  - 2, 3, and 4 lepton signal regions
- Use DNN for signal classification
- Data-driven fake lepton estimation in 2/3 lepton signal regions
- Data-driven tt background for 2-lepton signal region from opposite flavor events

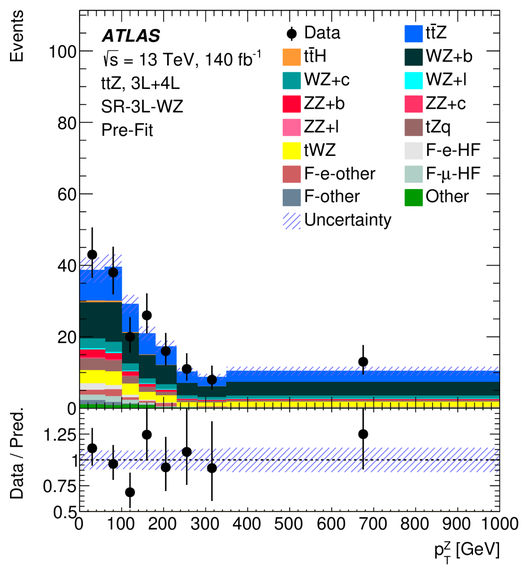








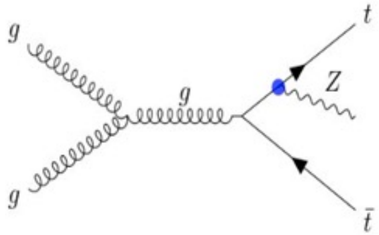


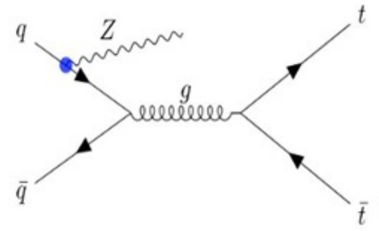


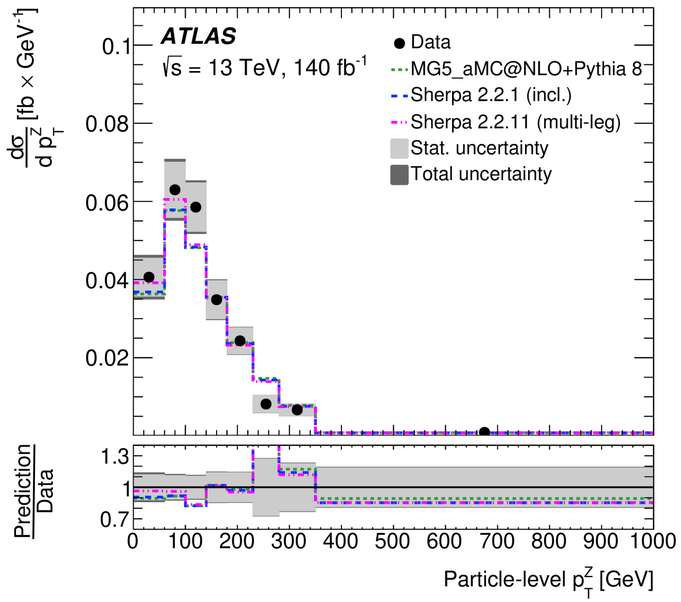
ttZ Cross Section

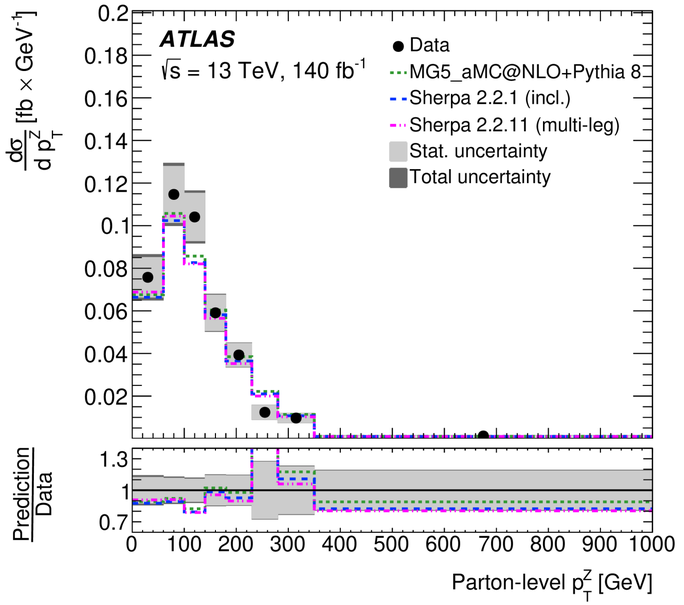
arXiv:2312.04450

- σ_{ttZ}= 0.86 ± 0.04 (stat) ± 0.04 (syst) pb
- $\sigma_{SM}^{NLO+NNLL} = 0.86^{+0.08}_{-0.09}$ pb
- 17 differential cross section variables at parton and particle level
- Spin correlations observed with 1.8σ significance
- Limits set of top-boson and 4 quark EFT parameters



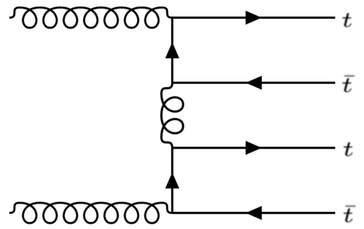




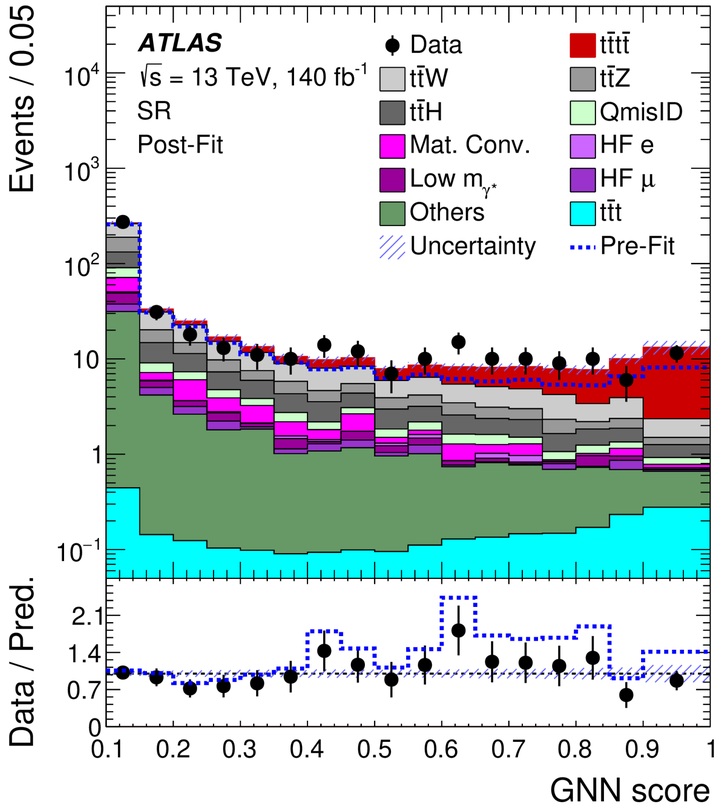


ATLAS EXPERIMENT

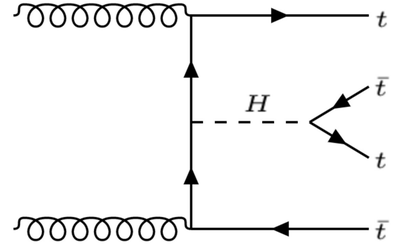
Observation of 4 tops Production [Eur. Phys. J. C83 (2023) 496]



- Used 2 lepton same-sign (2LSS) (7%) and 3 lepton (3L) (5%) topologies
- Fit GNN discriminant score in SR and CR distributions to extract signal
  - GNN Nodes: Jet,e,μ, MET
  - GNN Edges: information about angular separation



- Signal Strength μ = $\frac{\sigma_{data}}{\sigma_{SM}} = 1.9 \pm 0.4(stat)^{+0.7}_{-0.4}\ (syst)$
- Cross Section $\sigma = 22.5^{+4.7}_{-4.3}(stat)^{+4.3}_{-3.4}(syst)$ fb

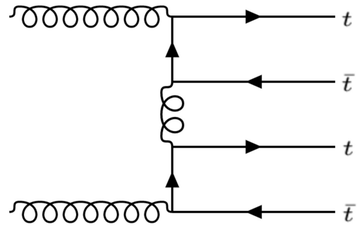


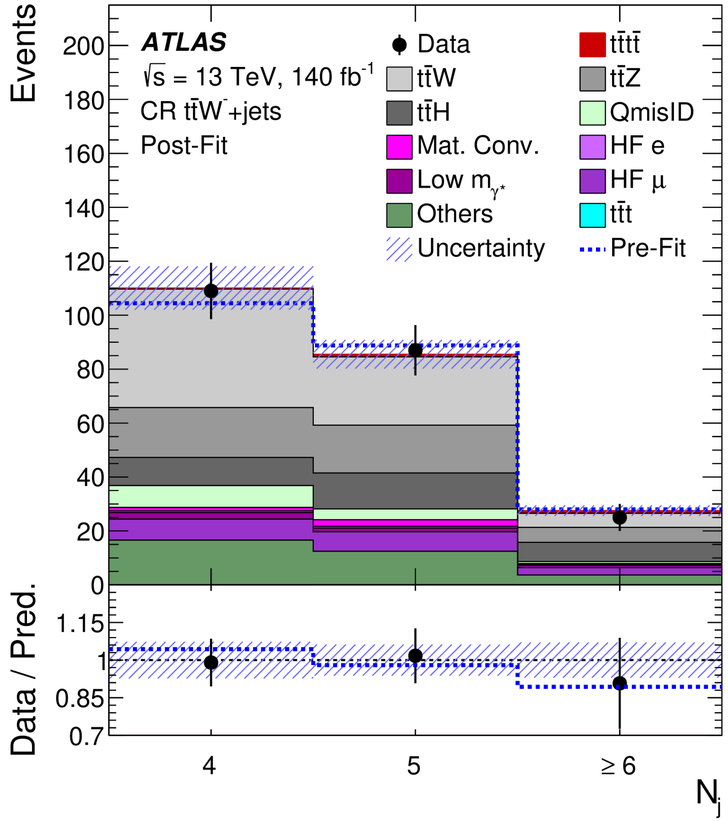
ATLAS EXPERIMENT

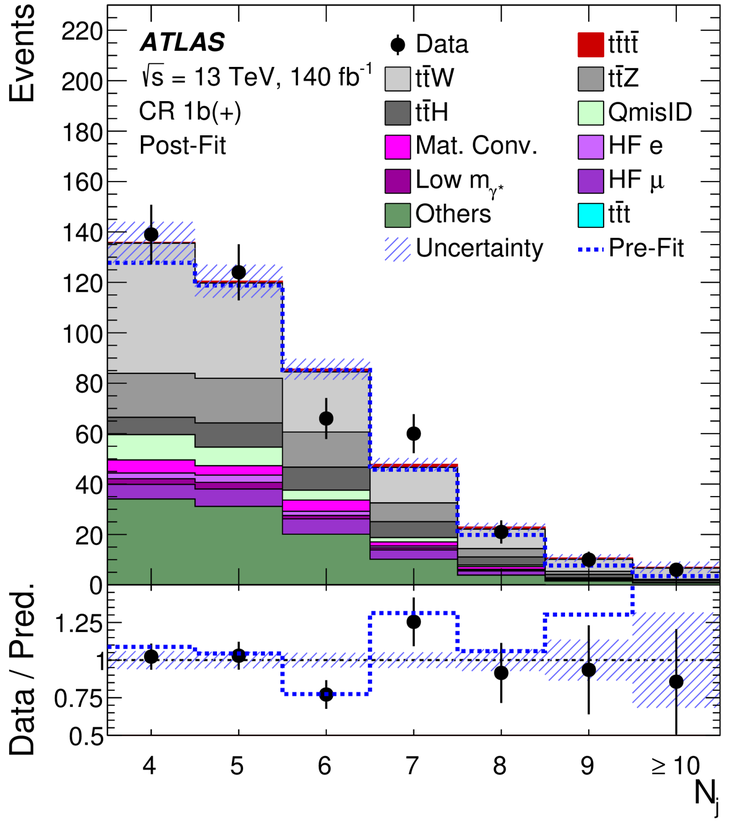
Observation of 4 tops Production

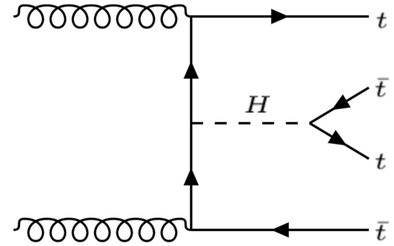
Eur. Phys. J. C83 92023) 496

Data-driven ttW jet multiplicity spectrum and normalization





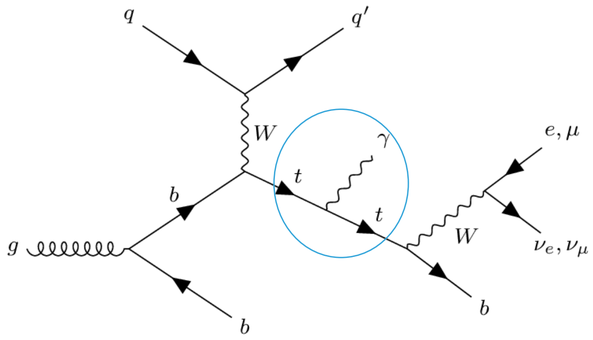




ATLAS EXPERIMENT

OBSERVATION OF SINGLE TOP PRODUCTION WITH AN ASSOCIATED γ

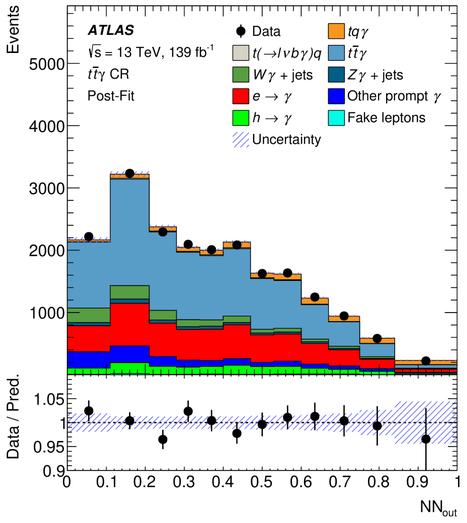
PHYS. REV. LETT. 131, (2023) 181901

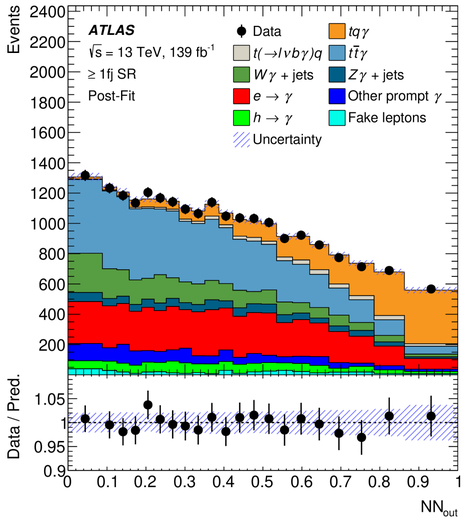


- Search for direct t-γ coupling
  - Separated from FSR by kinematic information
  - Dominant backgrounds (ttγ and Wγ + jets) are normalized from control regions
  - MC fake γ estimates from e are corrected comparing Z → ee MC and data
  - Compatible with SM at 2.1 σ

ATLAS: $\sigma_{tq\gamma} \times \mathcal{B}(t \to lvb) = 688 \pm 23\,(stat)^{+33}_{-32}$ fb

SM: $\sigma_{tq\gamma} \times \mathcal{B}(t \to lvb) = 515^{+36}_{-42}$ fb



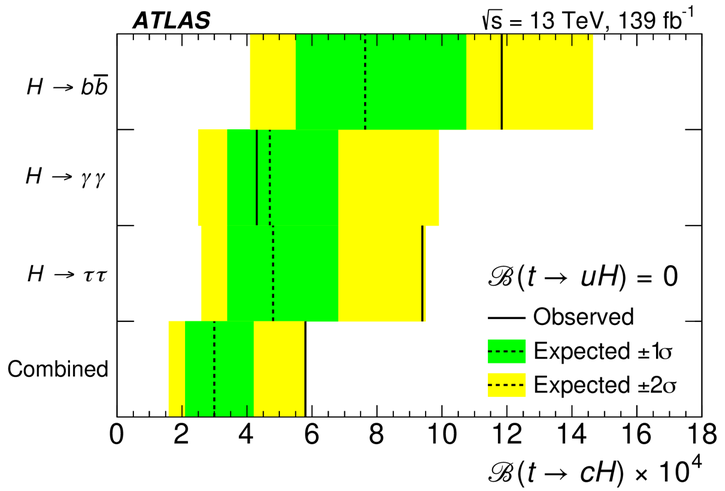


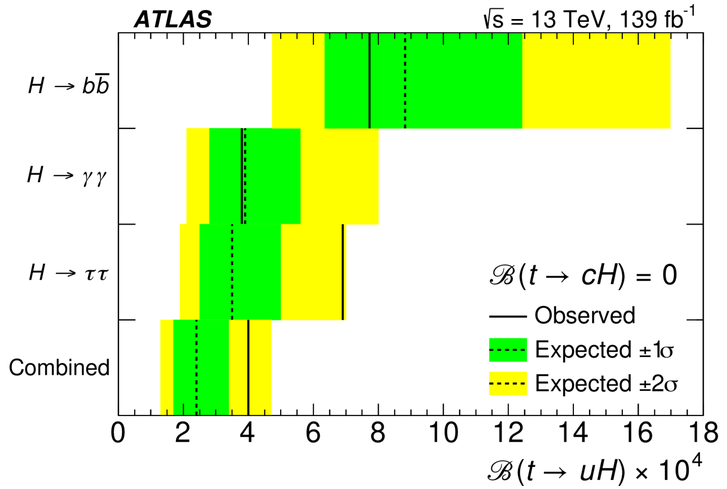
ATLAS EXPERIMENT

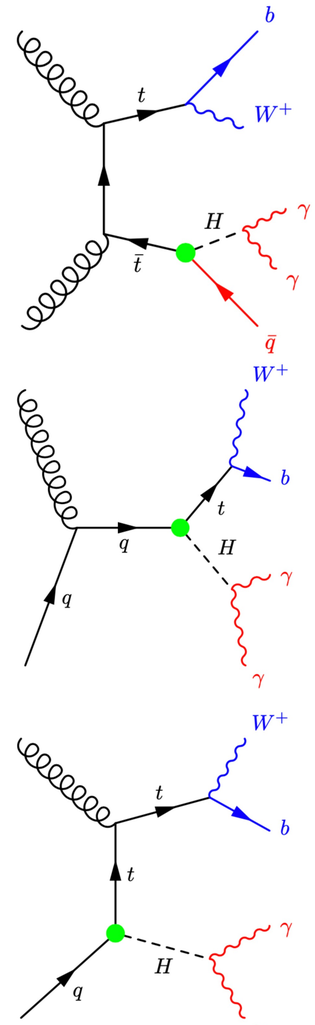
Searching for FCNC's in tqH → γγ

JHEP 12 (2023) 195

- Flavor Changing Neutral Currents (FCNC's) in tqH are forbidden at tree level and suppressed at higher orders
- BDT used to discriminate signal from background
- Limits on BR's from in tqH → γγ
  - BR (t → cH) < 4.3 X 10^{-4} (4.7 X 10^{-4})
  - BR (t → uH) < 3.8 X 10^{-4} (3.9 X 10^{-4})
- Combined Result (with H → bb and H→ **τ τ**) :
  - BR (t → cH) < 5.8 X 10^{-4} (3.0 X 10^{-4})
    - $C_{\mu\varphi}^{23,32} < 1.07$ ($C_{\mu\varphi}^{13,31} = 0, \Lambda = 1\ TeV$)
  - BR (t → uH) < 4.0 X 10^{-4} (2.4 X 10^{-4})
    - $C_{\mu\varphi}^{32,23} < 1.07$ ($C_{\mu\varphi}^{31,13} = 0, \Lambda = 1\ TeV$)





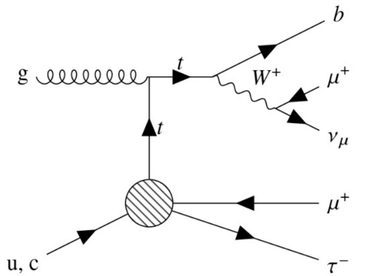


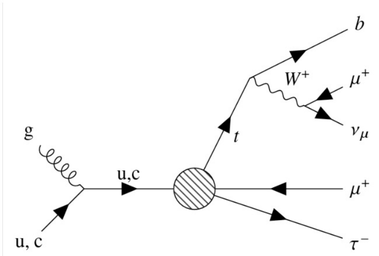
ATLAS EXPERIMENT

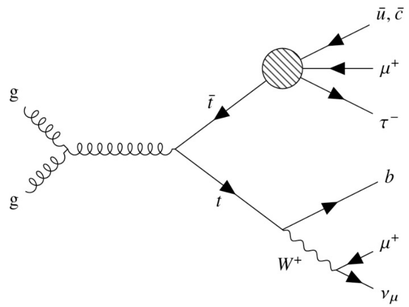
Search for l± flavour violating interactions

ATLAS-CONF-2023-001

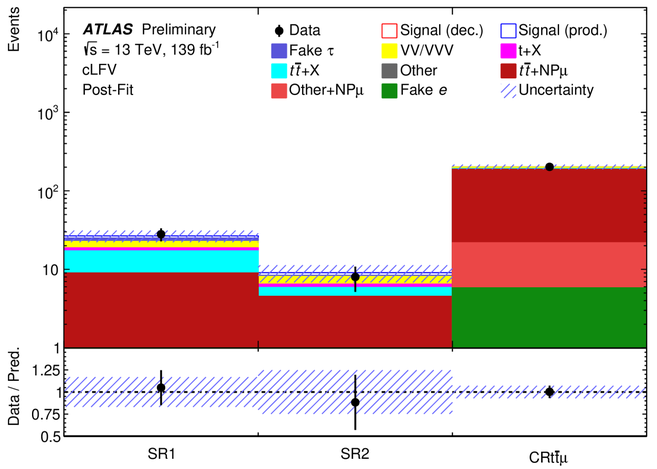
- Search μτqt interaction, considering both in top-quark production and decay
  - Sensitive to leptoquark, supersymmetric, and technicolor BSM's
- t decays leptonically, τ decays hadronically
- Data-driven scale factor estimation of fake τ's, and normalization of NP muon background
- Results agree with SM expectation
- Limits on Wilson Coefficients set







	95% CL upper limits on Wilson coefficients c/Λ^2 [TeV^{-2}]							
	$c_{lq}^{-(ijk3)}$	$c_{eq}^{(ijk3)}$	$c_{lu}^{(ijk3)}$	$c_{eu}^{(ijk3)}$	$c_{lequ}^{1(ijk3)}$	$c_{lequ}^{1(ijk3)}$	$c_{lequ}^{3(ijk3)}$	$c_{lequ}^{3(ijk3)}$
Previous (u) [22]	12	12	12	12	26	26	3.4	3.4
Expected (u)	0.47	0.44	0.43	0.46	0.49	0.49	0.11	0.11
Observed (u)	0.49	0.47	0.46	0.48	0.51	0.51	0.11	0.11
Previous (c) [22]	14	14	14	14	29	29	3.7	3.7
Expected (c)	1.6	1.6	1.5	1.6	1.8	1.8	0.35	0.35
Observed (c)	1.7	1.6	1.6	1.6	1.9	1.9	0.37	0.37



Thank you for your attention

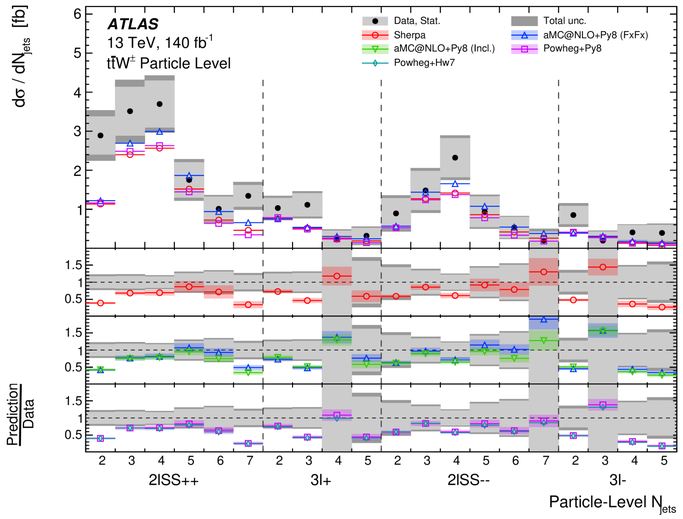
- ATLAS continues to take advantage of the LHC as top factory
- Significance of results is being boosted by development of analysis techniques and the increase in statistics
- We expect this to continue as we collect more data

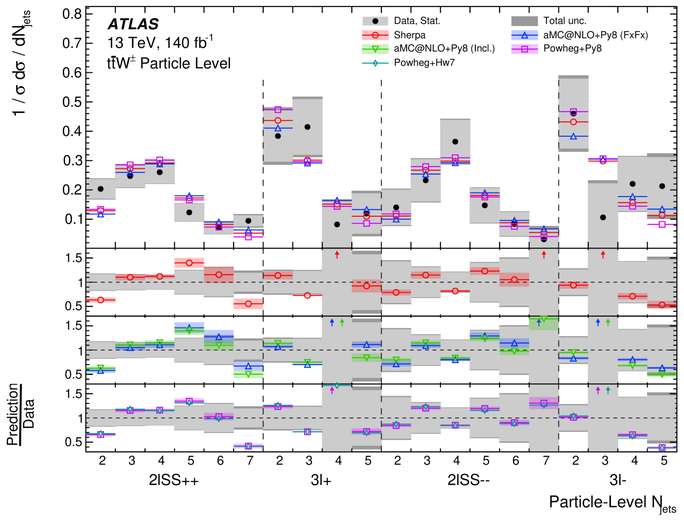
ATLAS EXPERIMENT

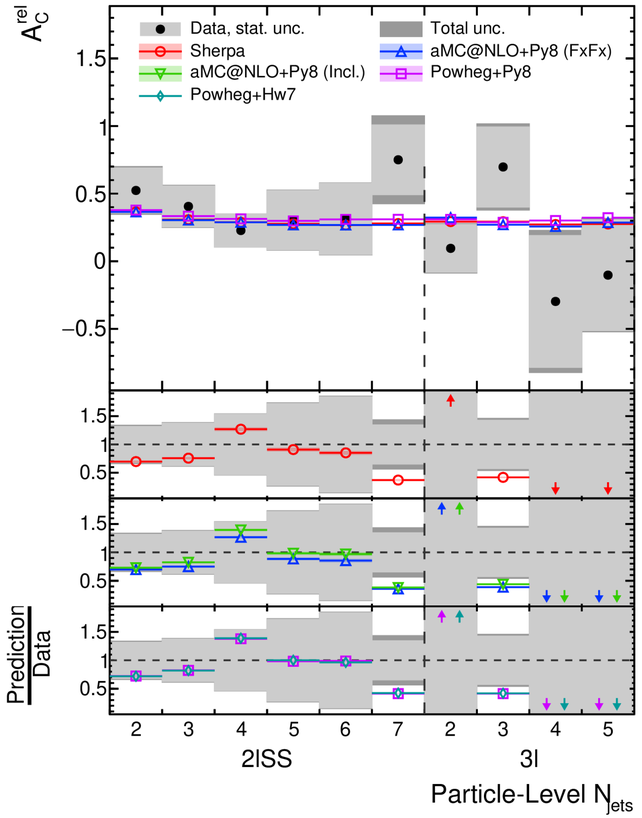
ttW Differential Cross Section

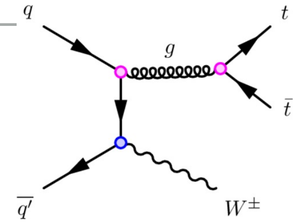
arXiv:2401.05299

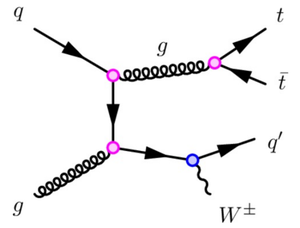
Differential in 6 variables: **jet multiplicity**, H_T(leptons,jets), $\Delta R_{lb,lead}$ $|\Delta\varphi_{ll,ss}|$, $|\Delta\eta_{ll,ss}|$ at particle level

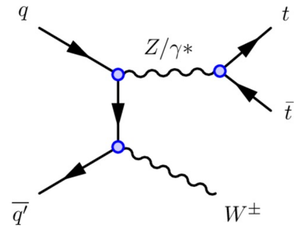


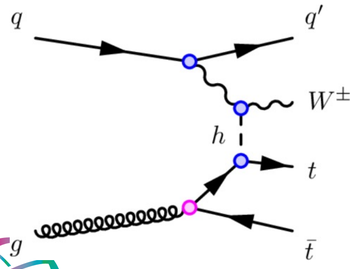






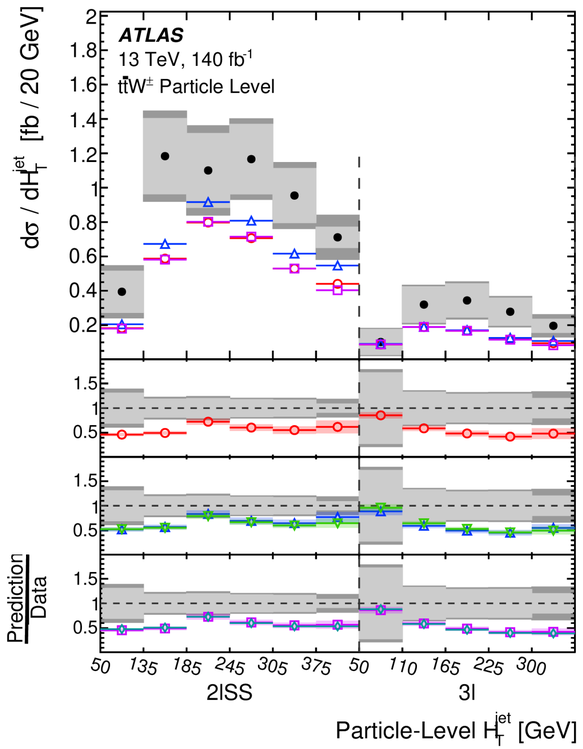


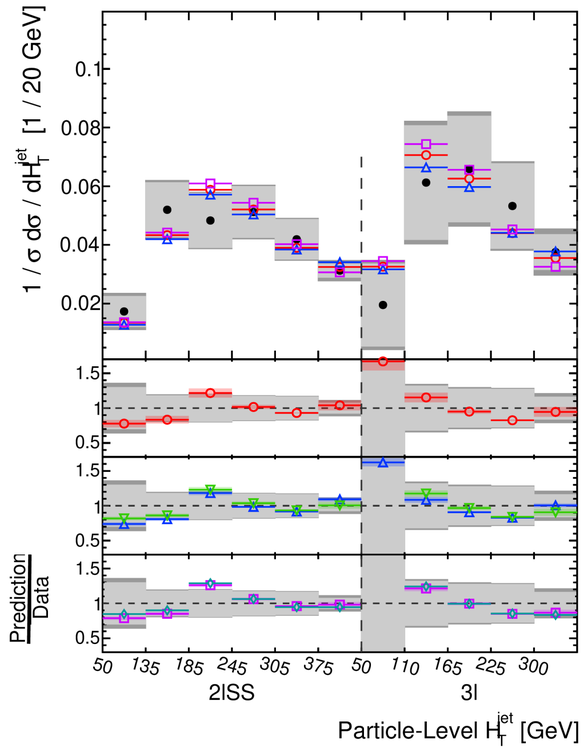


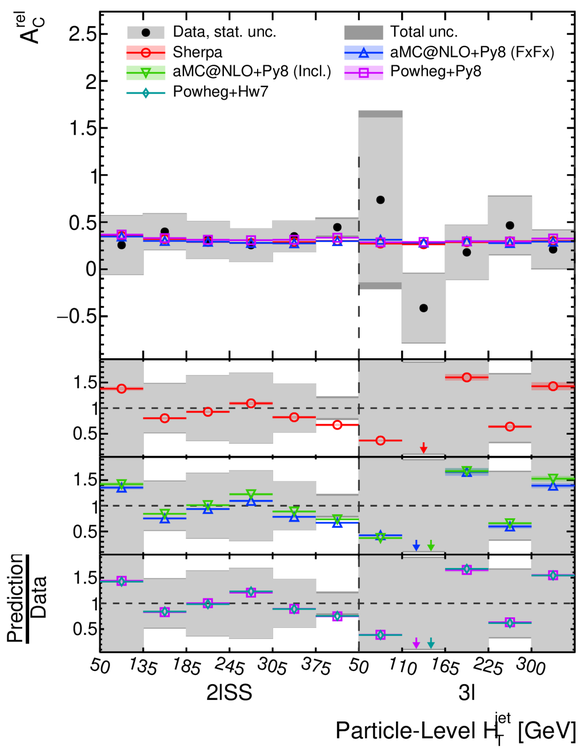


ATLAS EXPERIMENT

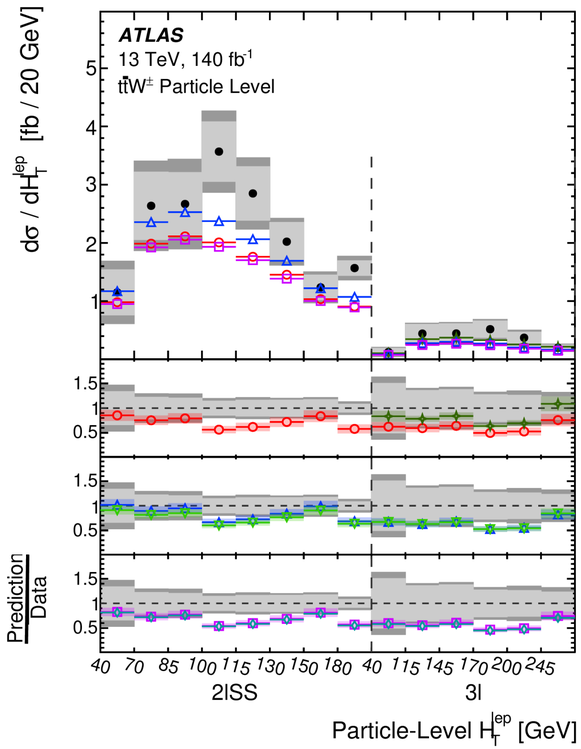
ttW Cross Sections and Charge Asymmetry in H_T(jet)

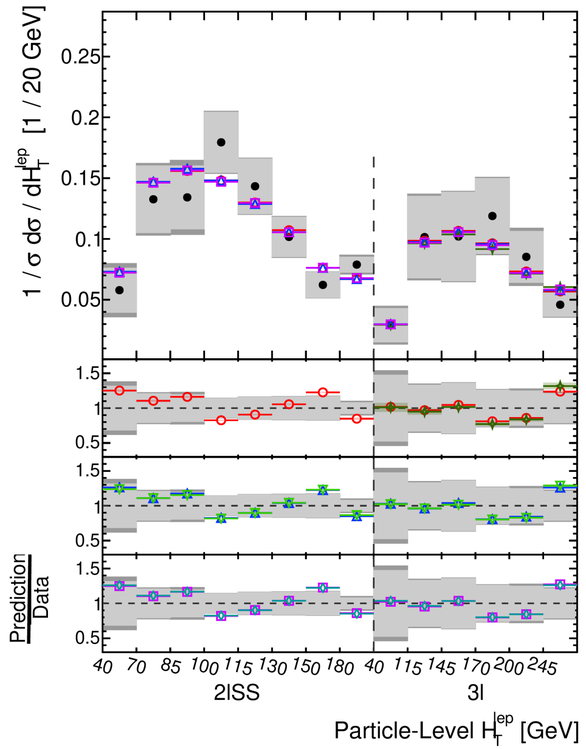


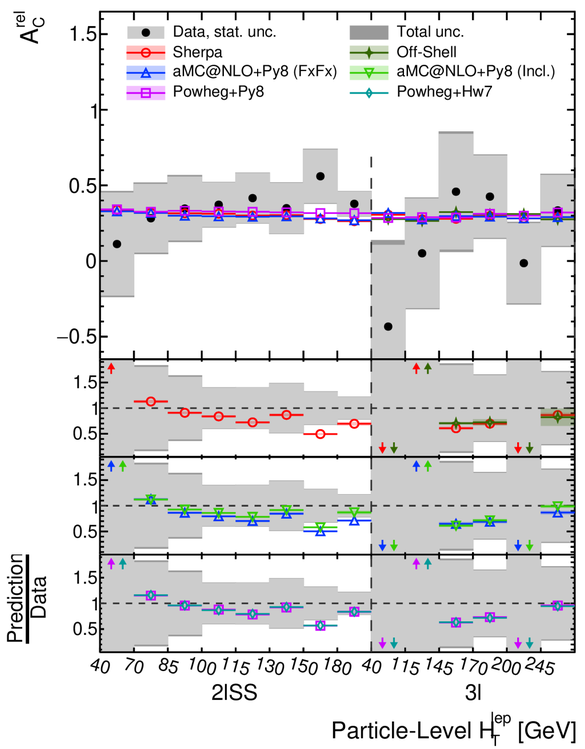




ttW Cross Sections and Charge Asymmetry in H_T(lep)

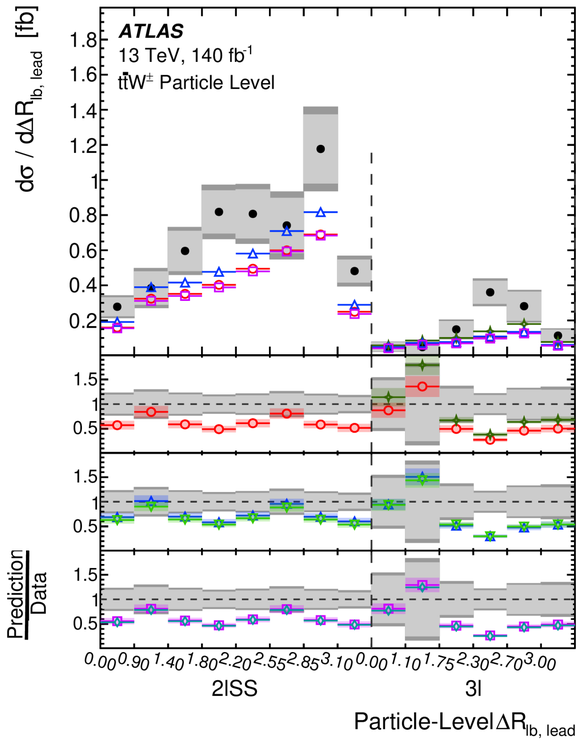


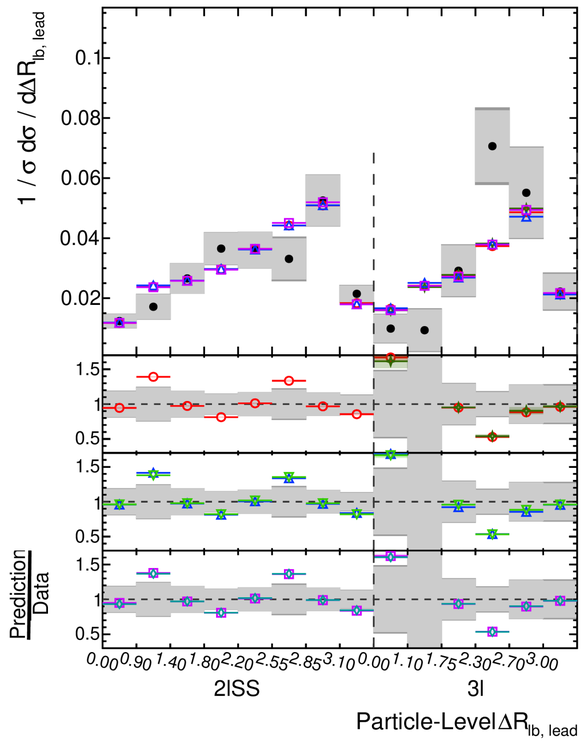


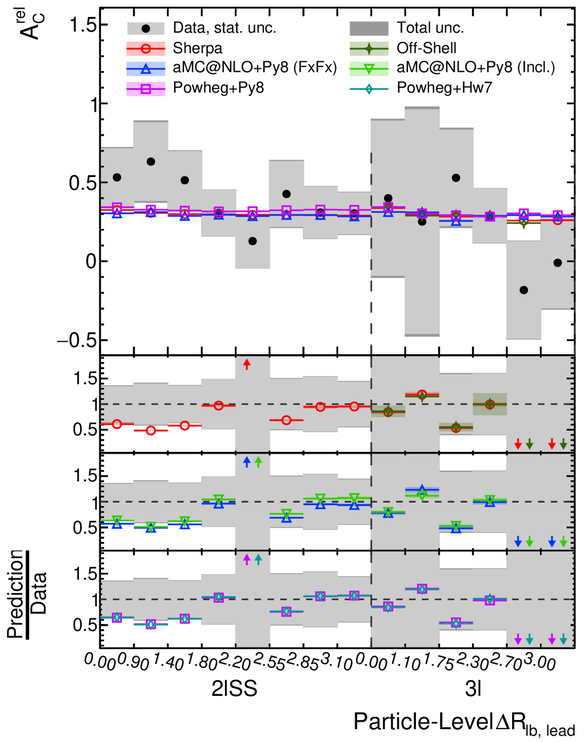


ATLAS EXPERIMENT

ttW Cross Sections and Charge Asymmetry in $\Delta R_{lb,lead}$

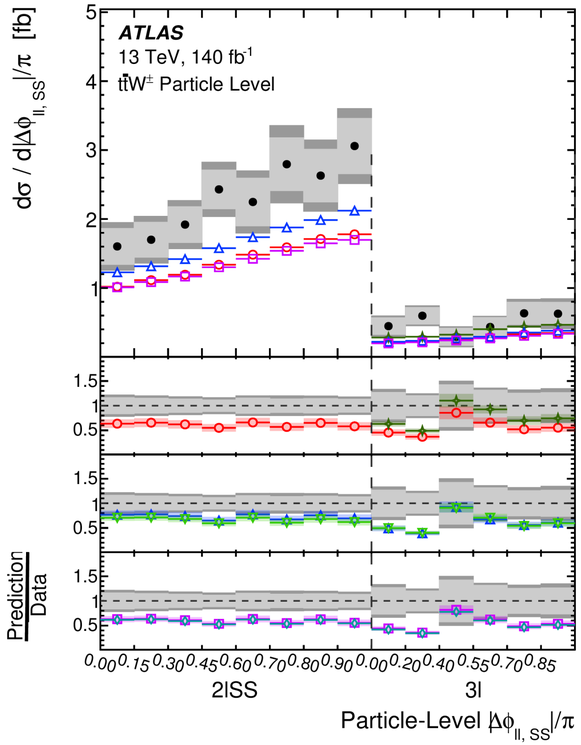


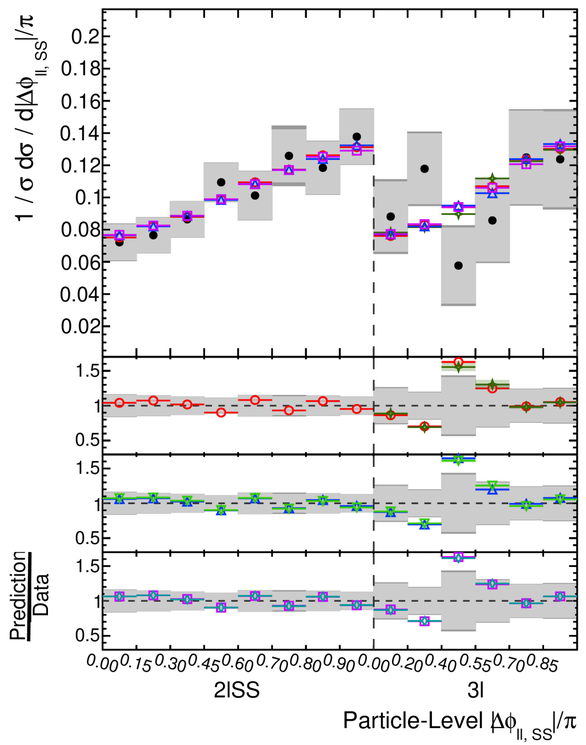


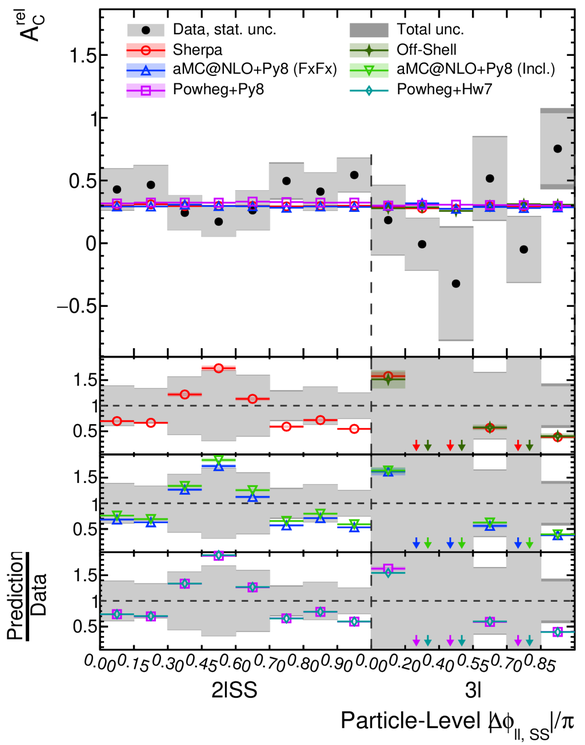


ATLAS EXPERIMENT

ttW Cross Sections and Charge Asymmetry in $|\Delta\phi_{ll,ss}|$

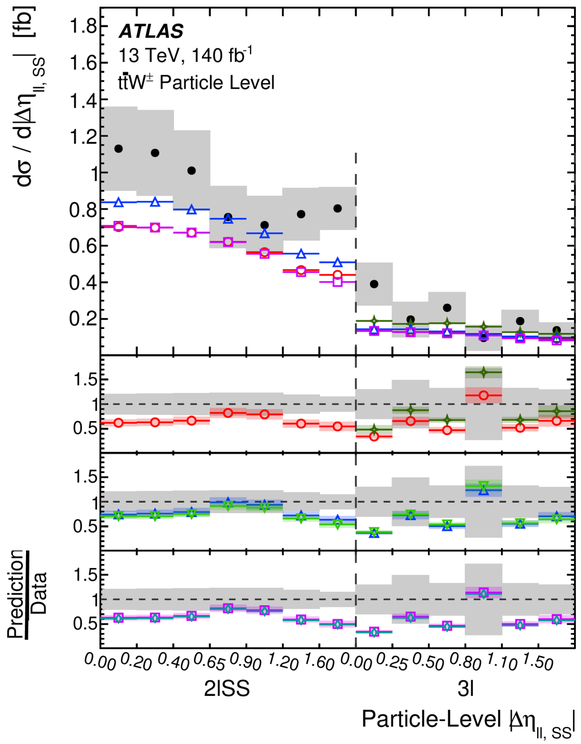


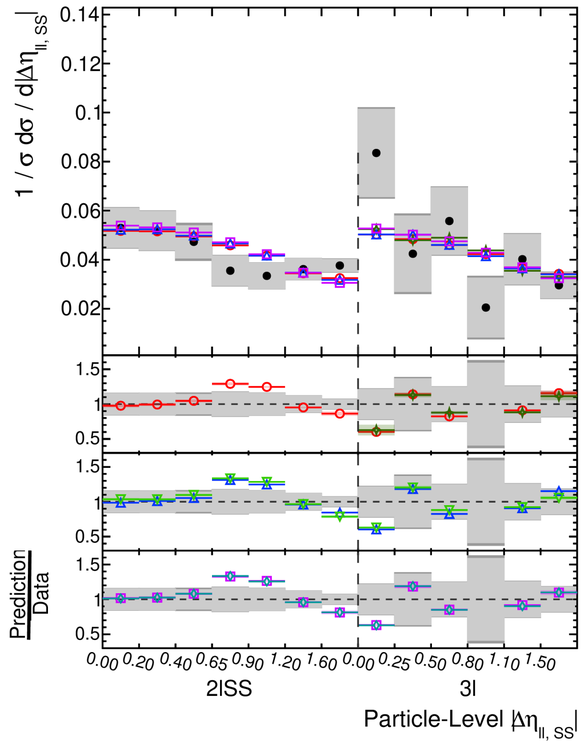


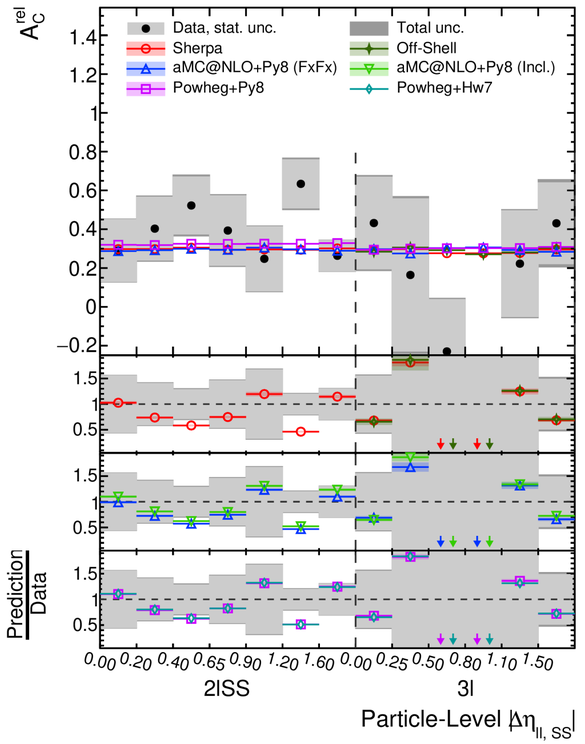


ATLAS EXPERIMENT

ttW Cross Sections and Charge Asymmetry in $|\Delta\eta_{ll,ss}|$







ATLAS EXPERIMENT

ttZ Cross Section by Channel

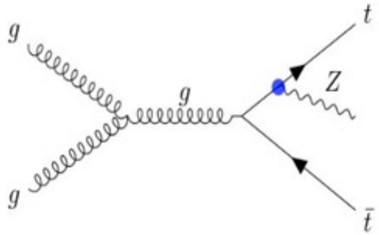
Channel	$\sigma_{t\bar{t}Z}$
Dilepton	0.84 ± 0.11 pb $= 0.84 \pm 0.06$ (stat.) ± 0.09 (syst.) pb
Trilepton	0.84 ± 0.07 pb $= 0.84 \pm 0.05$ (stat.) ± 0.05 (syst.) pb
Tetralepton	$0.97^{+0.13}_{-0.12}$ pb $= 0.97 \pm 0.11$ (stat.) ± 0.05 (syst.) pb
Combination (2ℓ, 3ℓ & 4ℓ)	0.86 ± 0.05 pb $= 0.86 \pm 0.04$ (stat.) ± 0.04 (syst.) pb

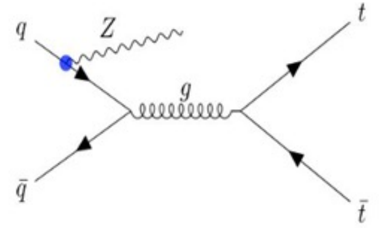
ATLAS EXPERIMENT

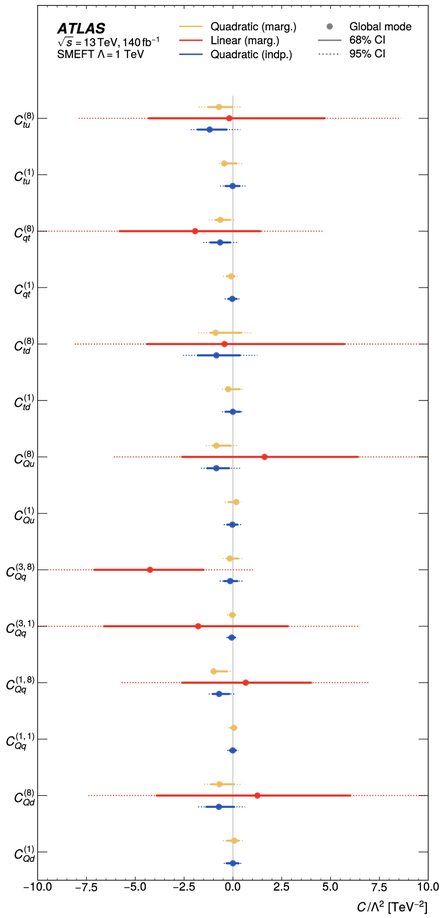
ttZ Cross Section

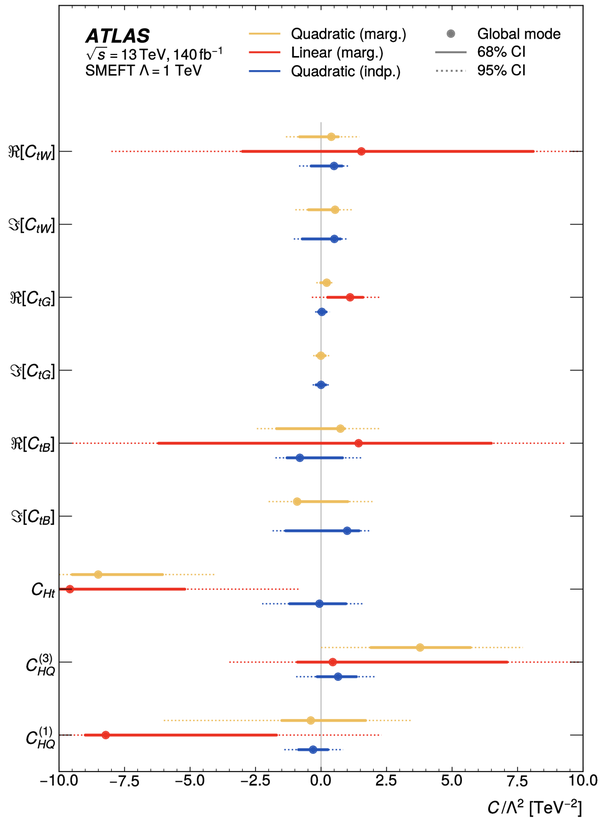
arXiv:2312.04450

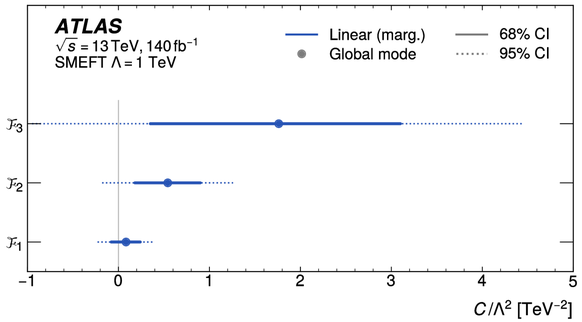
- Constraints on top boson and four-quark EFT Wilson Coefficients







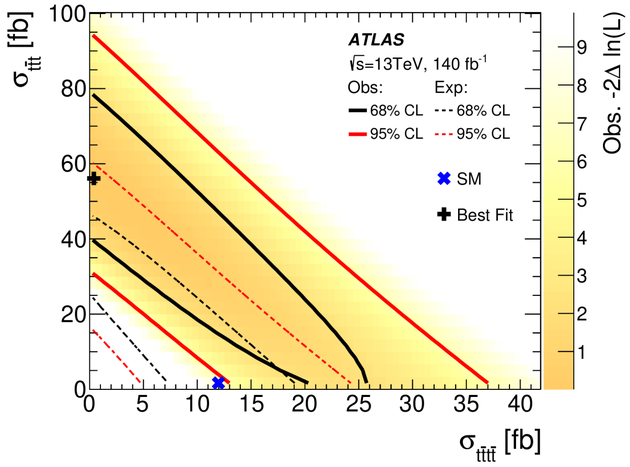


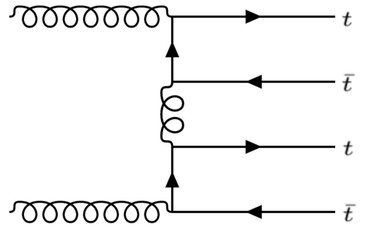


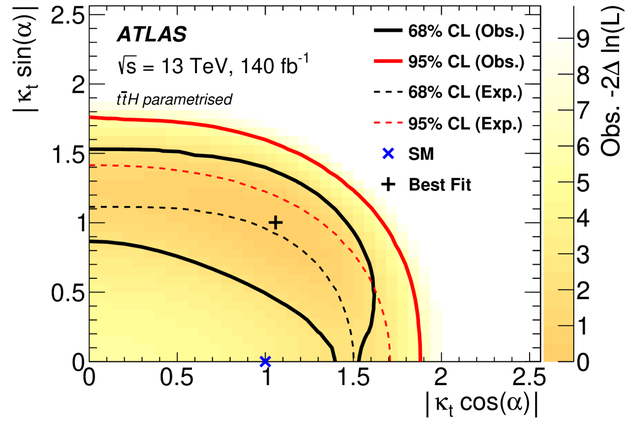
4 tops Production Cross Section [Eur. Phys. J. C83 92023) 496]

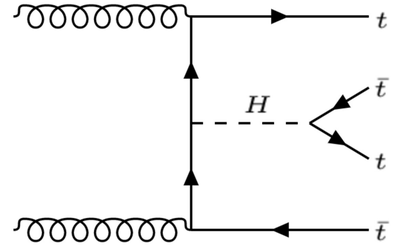
- Signal Strength μ = $\frac{\sigma_{data}}{\sigma_{SM}} = 1.9 \pm 0.4(stat)^{+0.7}_{-0.4}\ (syst)$
- Cross Section $\sigma = 22.5^{+4.7}_{-4.3}(stat)^{+4.3}_{-3.4}(syst)$ fb
- Top Yukawa Coupling κ_τ<1.8 (1.6 expected)
- Higgs Oblique Parameter $\widehat{H} < 0.20$ (0.12 expected)
  - Preserves unitarity
- EFT Operator Limits:

Operators	Expected C_i/Λ^2 [TeV $^{-2}$]	Observed C_i/Λ^2 [TeV $^{-2}$]
O^1_{QQ}	[-2.4, 3.0]	[-3.5, 4.1]
O^1_{Qt}	[-2.5, 2.0]	[-3.5, 3.0]
O^1_{tt}	[-1.1, 1.3]	[-1.7, 1.9]
O^8_{Qt}	[-4.2, 4.8]	[-6.2, 6.9]









ATLAS EXPERIMENT