Recent Results from ATLAS

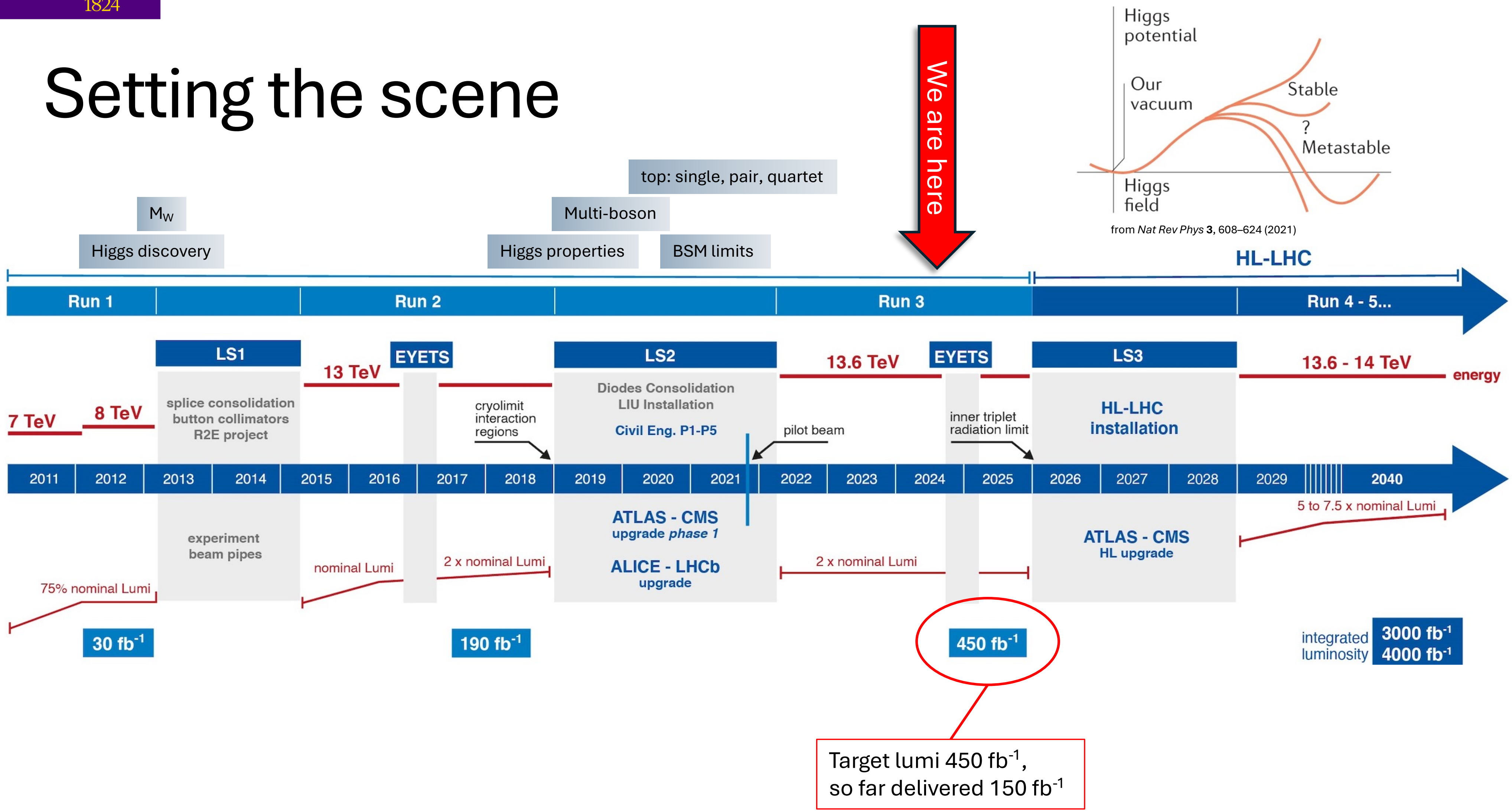
V2.1

Alexander Oh
on behalf of the
ATLAS Collaboration

Corfu 2024

The University of Manchester

Setting the scene



Content

- ATLAS in run-3
- EW Precision measurements
- Multi-boson
- Higgs
- Top
- Searches for physics beyond the SM
- Heavy Ion
- Summary

W mass talk Thursday noon

CMS + ATLAS Higgs talk tomorrow at 10am

long lived particle review Wednesday morning
SUSY & BSM talks Wednesday afternoon
Dark Matter on Saturday morning

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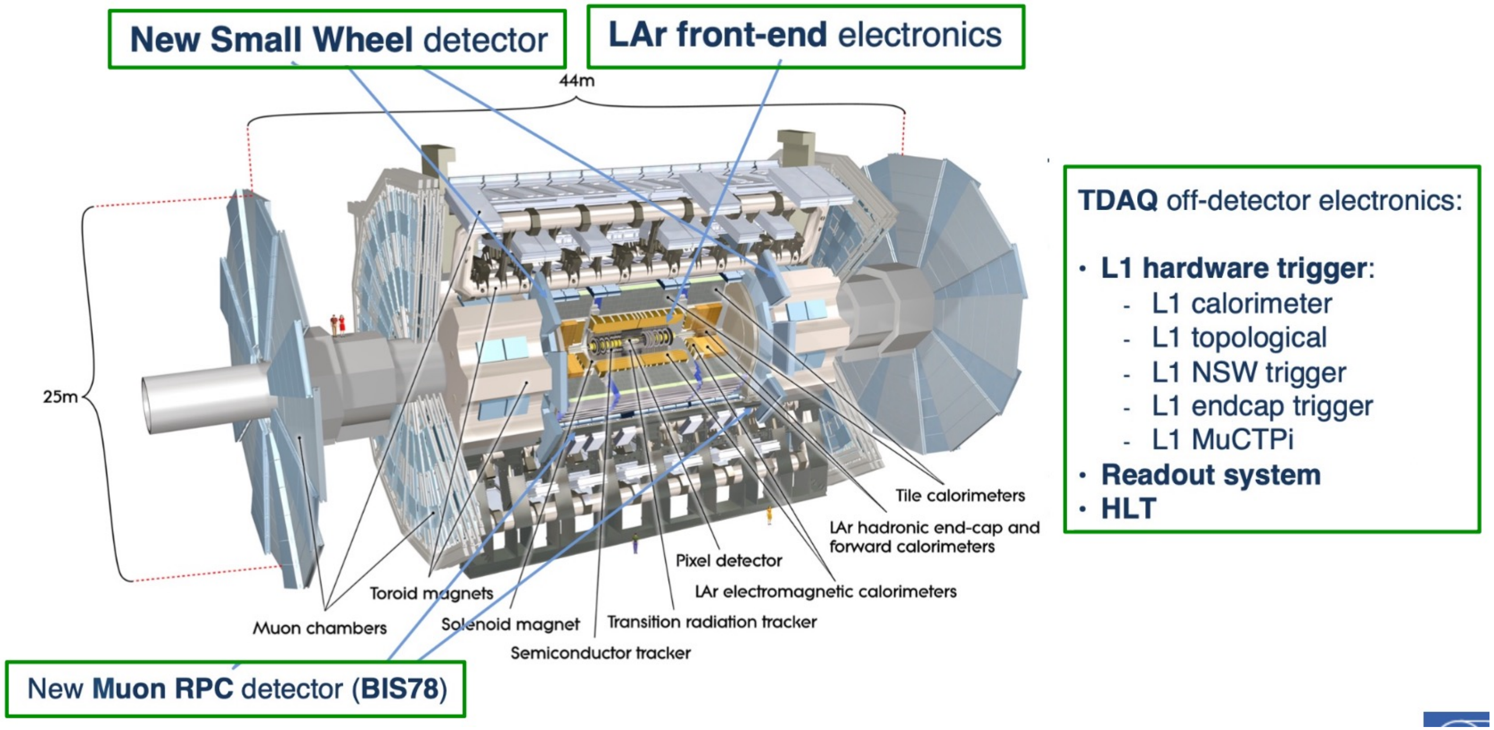
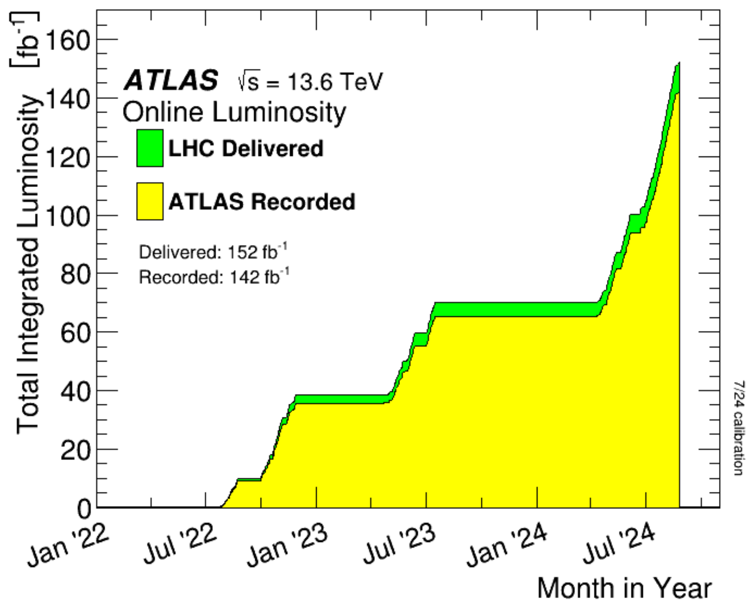
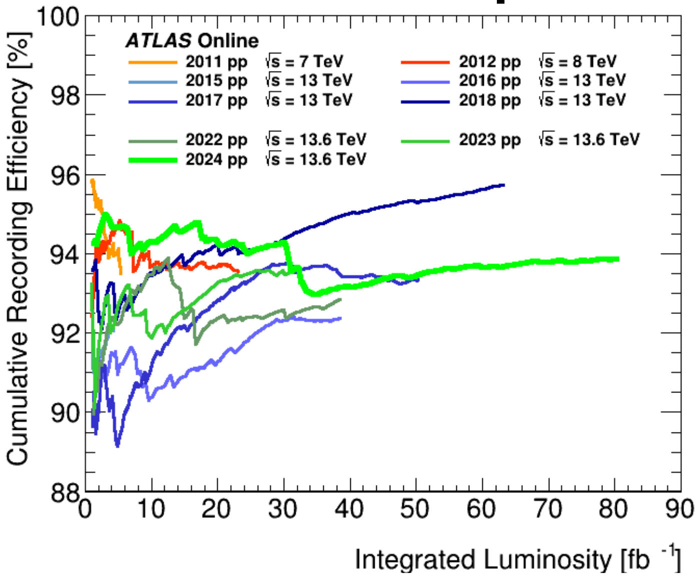


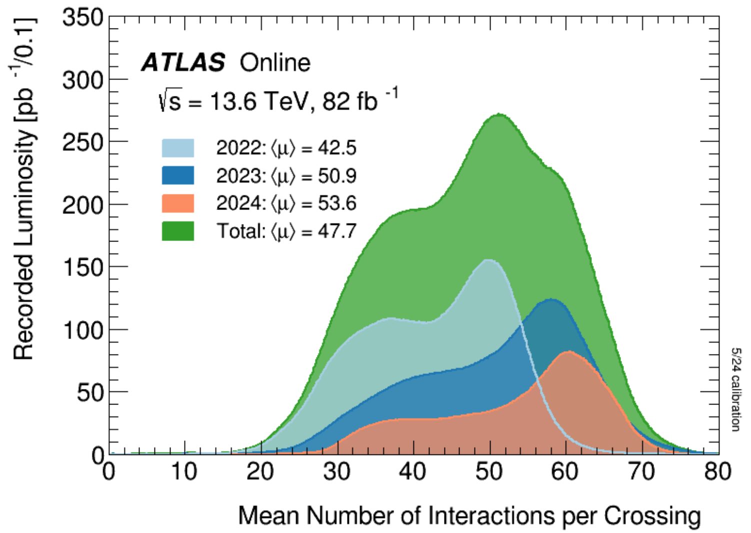
ATLAS in run-3

- **Collected 142 fb^{-1}** of proton-proton collisions at 13.6 TeV
  - Increased pile-up of μ=53.6 with levelling at 63.
  - Data taking efficiency 94%
- **Improvements of detector and reconstruction push the physics potential.**

Already seven **run-3** physics papers published.



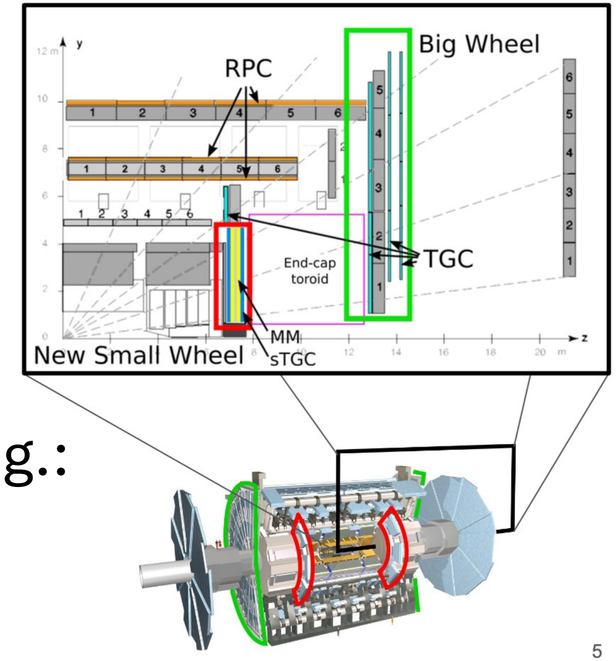


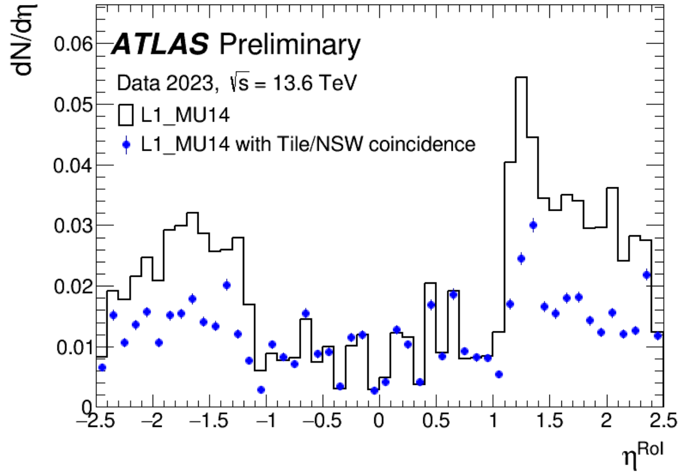


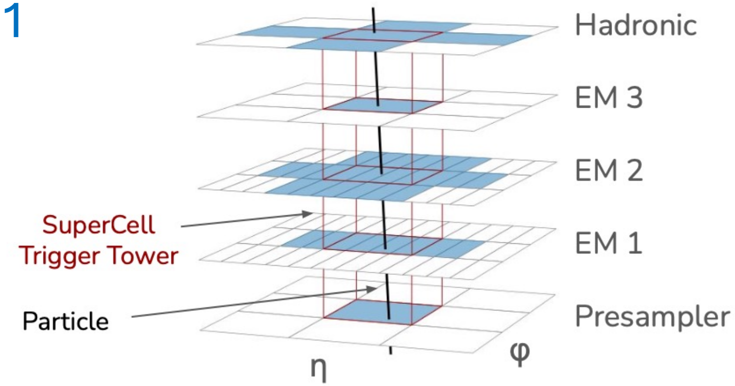
ATLAS in run-3

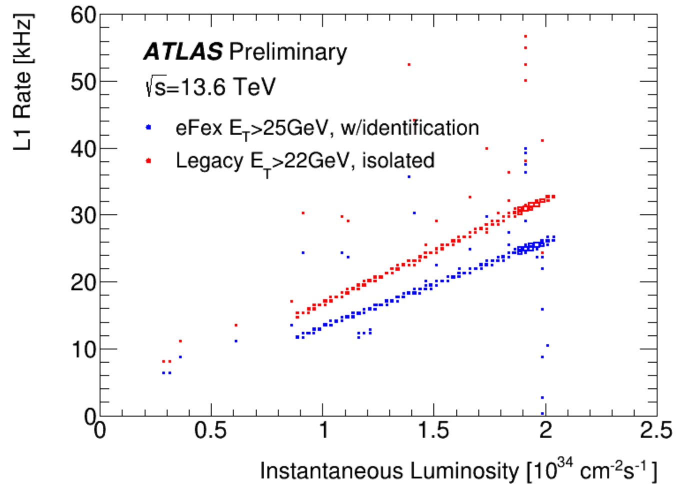
- Several detector improvements over run-2, eg.:
  - New Small Wheel detector (muons)
  - Higher granularity of L1 Calorimeter trigger

=> Significant L1 rate reduction!









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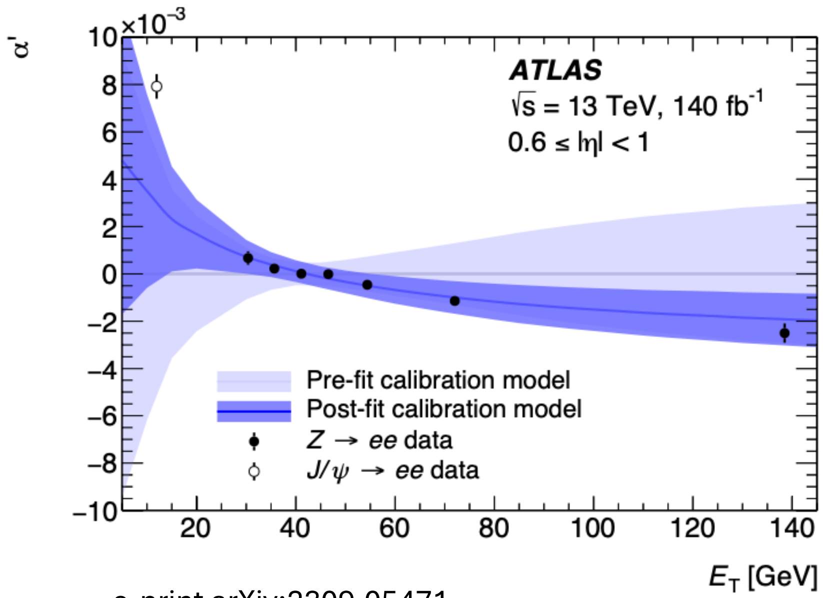
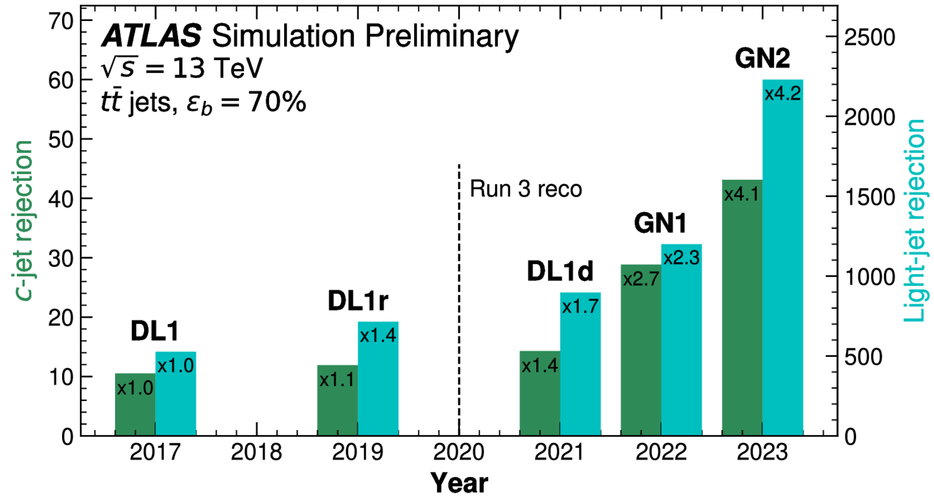
ATLAS in run-3

- Several reconstruction improvements, e.g.
  - Improvement of EM energy calibration by >2
    ~0.05% for Z → e+e−
    ~0.2% for $E_T(\gamma)$ = 60 GeV
  - Flavor tagging performance enhancement with advanced AI/ML techniques
    4x background rejection improvement with **graph neural network** tagger (GN2) compared to early Run-2
  - Improved understanding of EM reconstruction efficiencies lowering uncertainties by **30-50%**. (arXiv:2308.13362)



e-print arXiv:2309.05471



e-print arXiv:2405.03253, FTAG-2023-01

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- **EW Precision measurements**
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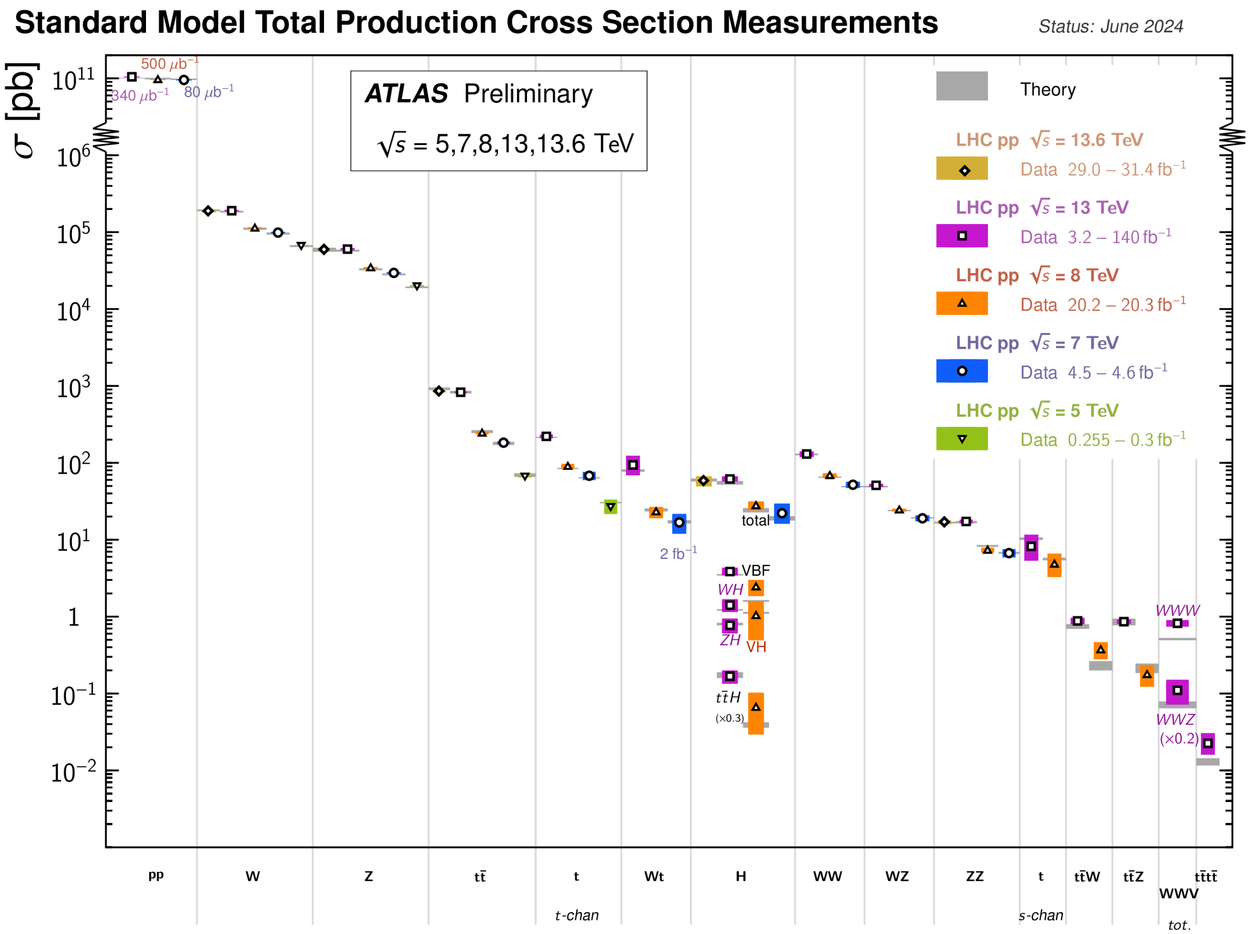
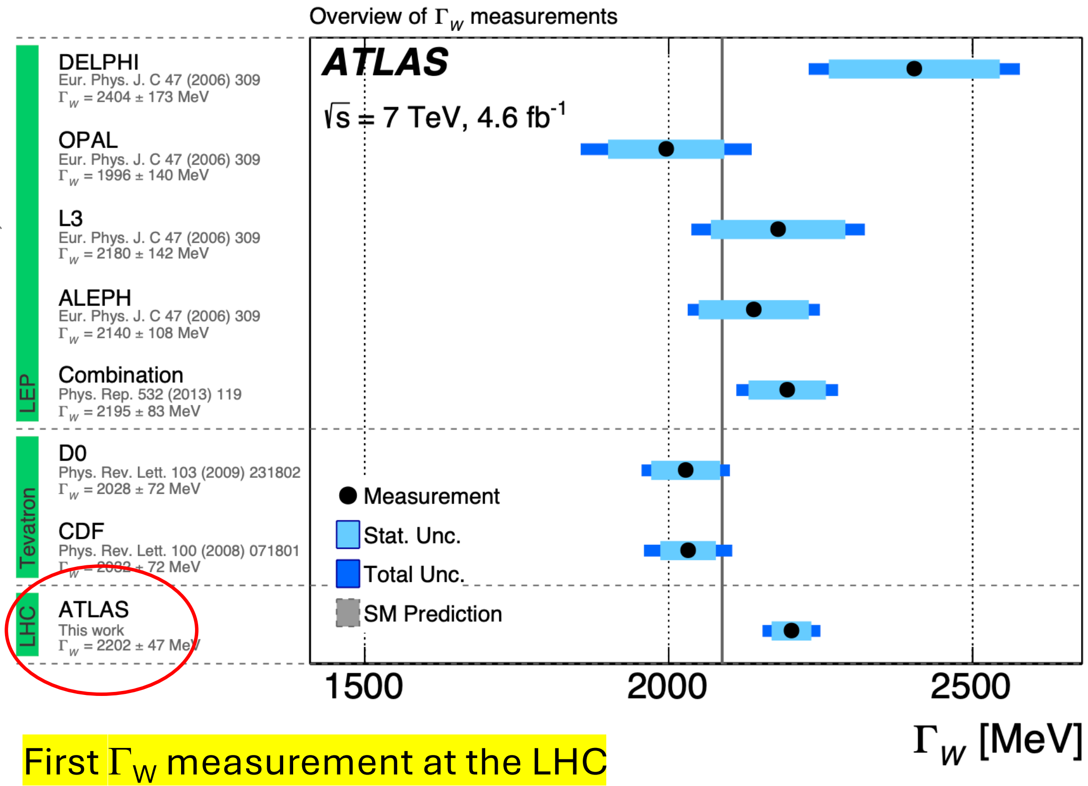


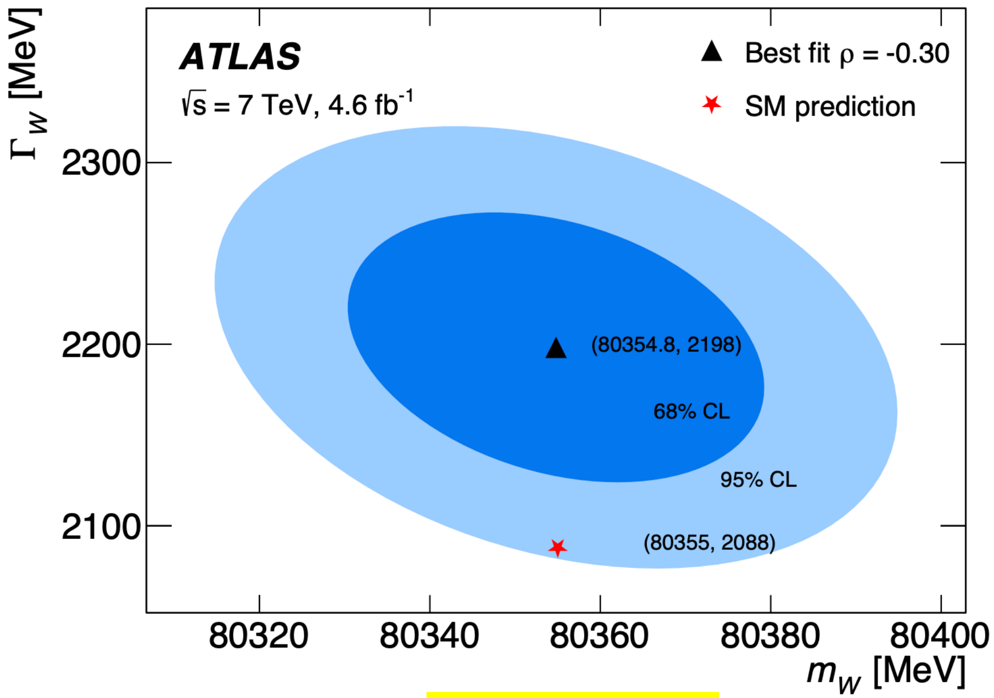
e-print arXiv:2403.15085

W mass and width

- See talk from Maarten Boonekamp on 4pm today.



First Γ_W measurement at the LHC

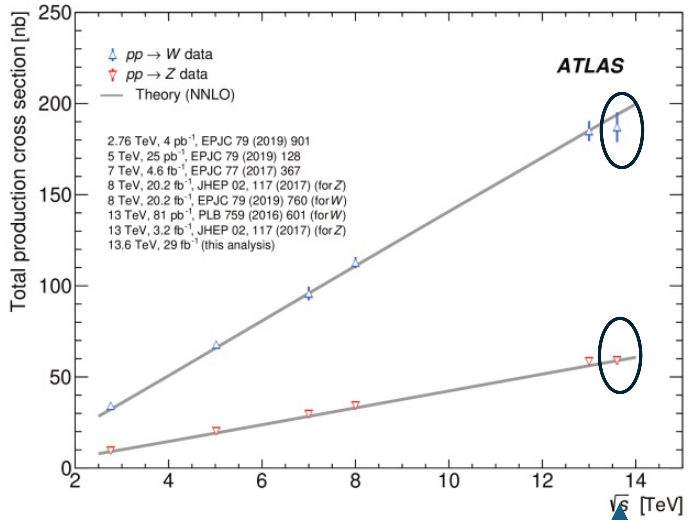


W mass vs width

e-print arXiv:2403.12902

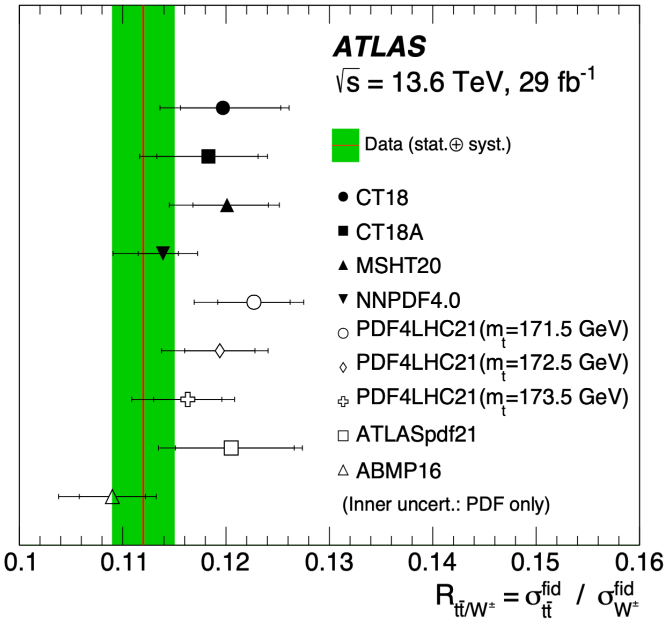
Run-3: W / Z production

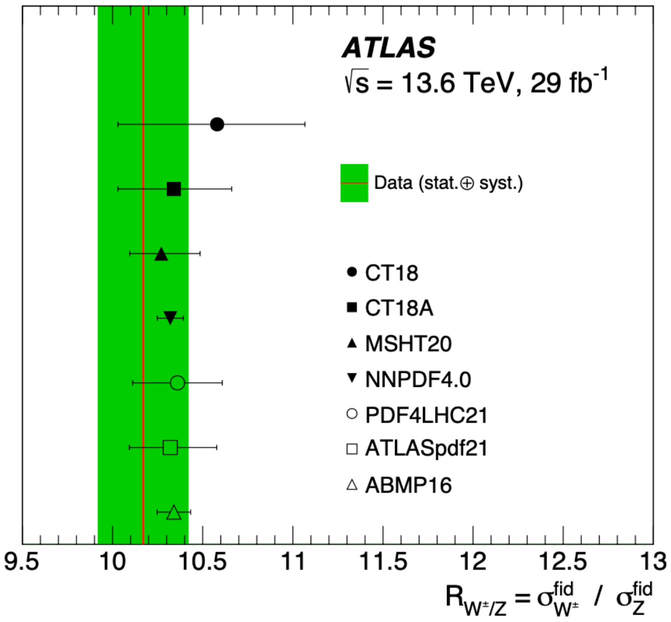
- First run-3 W/Z measurement, added **13.6 TeV data point**.
- Fiducial cross section ratios for precise theory comparison.



tt/W ratio slightly lower the predicted.

W/Z ratio in good agreement.





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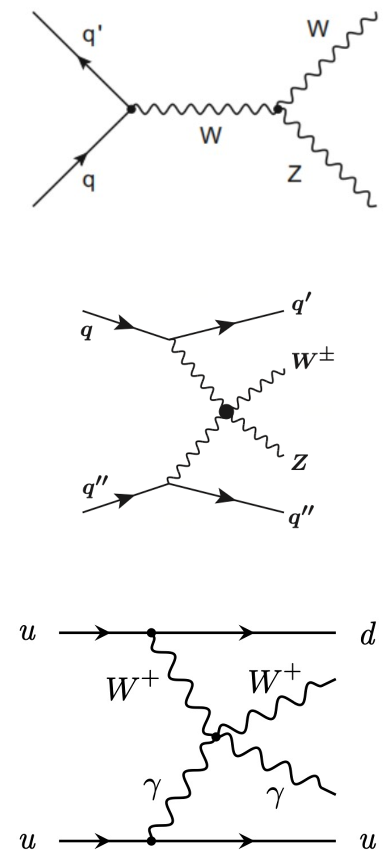

e-print arXiv:2402.16365

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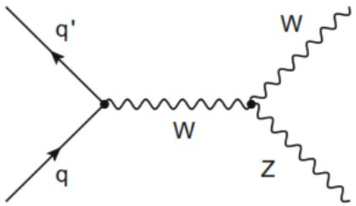
WZ polarization at high p_T

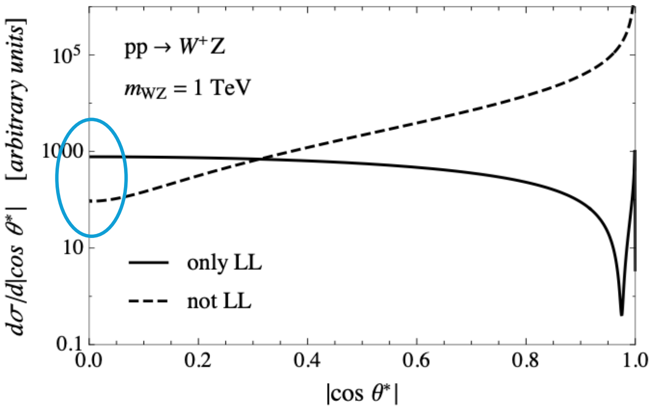
- Measure **polarisation fractions** of vector bosons.
- $V_L V_L$ shows quadratic sensitivity to new physics in interference regime.
- Previous measurement f_{00} = (6.71±1)%, not optimised for $V_L V_L$.
- Chose phase space to maximise contribution from $V_L V_L$.

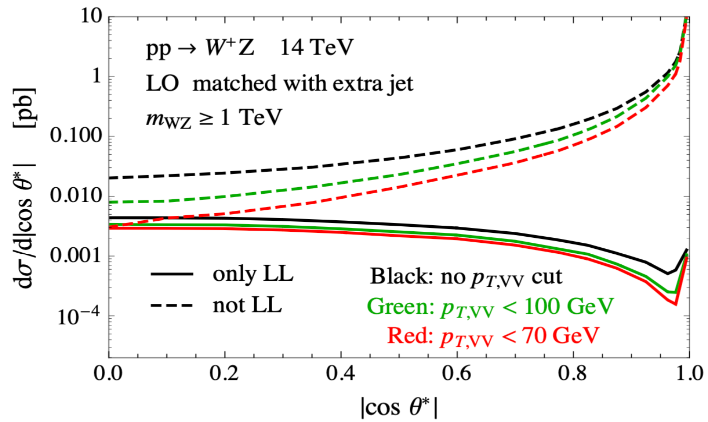


	SM	BSM
$q_{L,R}\bar{q}_{L,R} \to V_L V_L(h)$	~ 1	$\sim E^2/M^2$
$q_{L,R}\bar{q}_{L,R} \to V_\pm V_L(h)$	$\sim m_W/E$	$\sim m_W E/M^2$
$q_{L,R}\bar{q}_{L,R} \to V_\pm V_\pm$	$\sim m_W^2/E^2$	$\sim E^2/M^2$
$q_{L,R}\bar{q}_{L,R} \to V_\pm V_\mp$	~ 1	~ 1

from arXiv:1712.01310

from arXiv:1712:01310





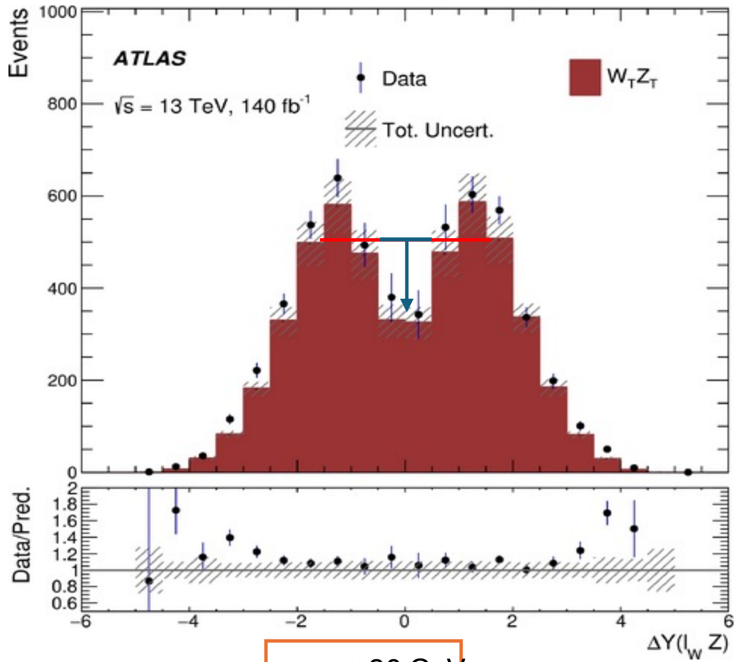
Cancellation at Born-level leads to "radiation-zero" (RAZ) dip in angular distribution. Sensitivity enhanced for $V_L V_L$.

Additional jets dilute cancellation. Restricting $p_{T,VV}$ help to restore the "RAZ".

e-print arXiv:2402.16365

WZ polarization at high p_T

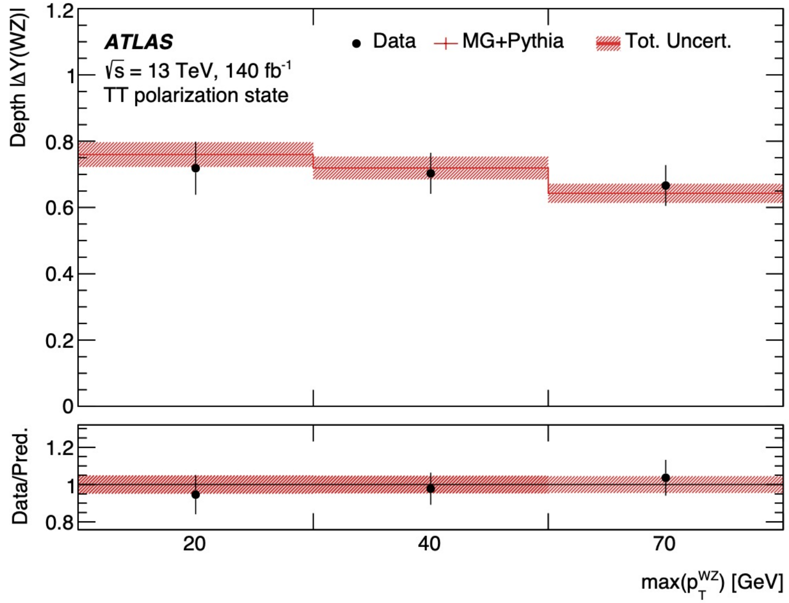
- Observable rapidity difference between l_W and Z: $\Delta Y(l_W, Z)$.



$p_{T,VV}$ < 20 GeV

Define depth variable to quantify dip:

$$\mathcal{D} = 1 - 2 \times N^{unf}_{central} / N^{unf}_{sides}$$



First observation of "RAZ" in WZ events!

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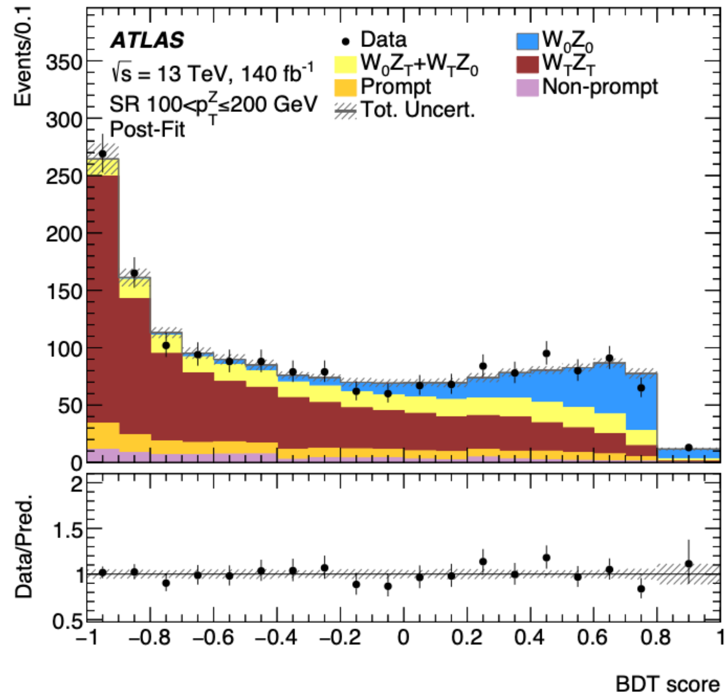
e-print arXiv:2402.16365

WZ polarization at high p_T

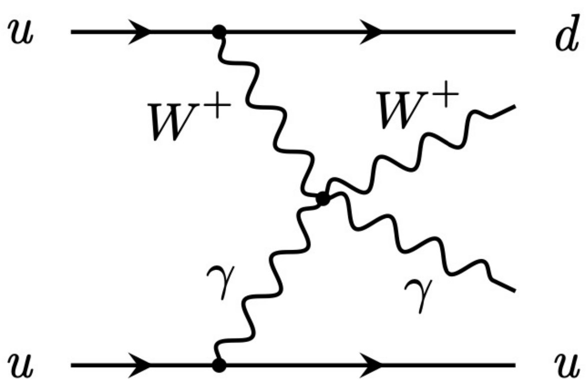
- Measure polarisation fractions.
- Use boosted decision tree (BDT) to separate longitudinal and transverse polarisation components.
- Improved fraction of f_{00} over previous analysis
  - inclusive $f_{00} \approx 7\%$ (PLB 843 (2023) 137895)
  - **high p_T $f_{00} \approx$ 16-17%** (this analysis)



	Measurement $100 < p_T^Z \leq 200$ GeV	Measurement $p_T^Z > 200$ GeV		Prediction $100 < p_T^Z \leq 200$ GeV	Prediction $p_T^Z > 200$ GeV
f_{00}	$0.19 \pm^{0.03}_{0.03}$ (stat) $\pm^{0.02}_{0.02}$ (syst)	$0.13 \pm^{0.09}_{0.08}$ (stat) $\pm^{0.02}_{0.02}$ (syst)	f_{00}	0.152 ± 0.006	0.234 ± 0.007
f_{0T+T0}	$0.18 \pm^{0.07}_{0.08}$ (stat) $\pm^{0.05}_{0.06}$ (syst)	$0.23 \pm^{0.17}_{0.18}$ (stat) $\pm^{0.06}_{0.10}$ (syst)	f_{0T}	0.120 ± 0.002	0.062 ± 0.002
f_{TT}	$0.63 \pm^{0.05}_{0.05}$ (stat) $\pm^{0.04}_{0.04}$ (syst)	$0.64 \pm^{0.12}_{0.12}$ (stat) $\pm^{0.06}_{0.06}$ (syst)	f_{T0}	0.109 ± 0.001	0.058 ± 0.001
f_{00} obs (exp) sig.	5.2 (4.3) σ	1.6 (2.5) σ	f_{TT}	0.619 ± 0.007	0.646 ± 0.008

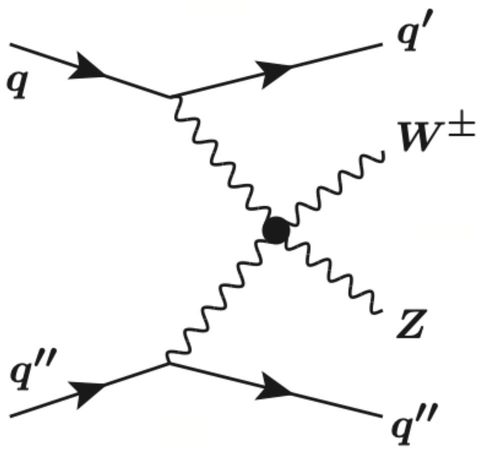
VBS: Wγ WZjj

- Vector boson scattering probes **quartic gauge boson vertex**.
- Differential measurements provide powerful probe of SM.
- **Effective field theory** dim 8 operators can be constrained.
- **ATLAS measured all VVjj processes** (V=W,Z,γ), focussing on two recent results:



VBS Wγ

e-print **arXiv:2403.02809**



VBS WZ

e-print **arXiv:2403.15296**

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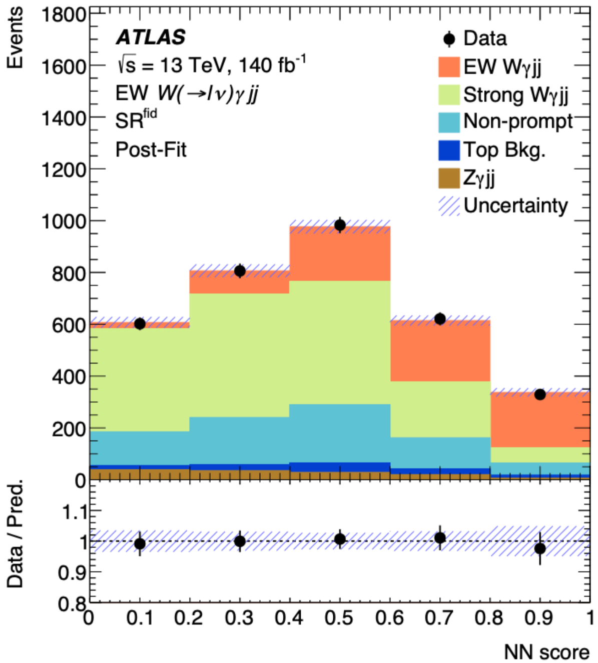
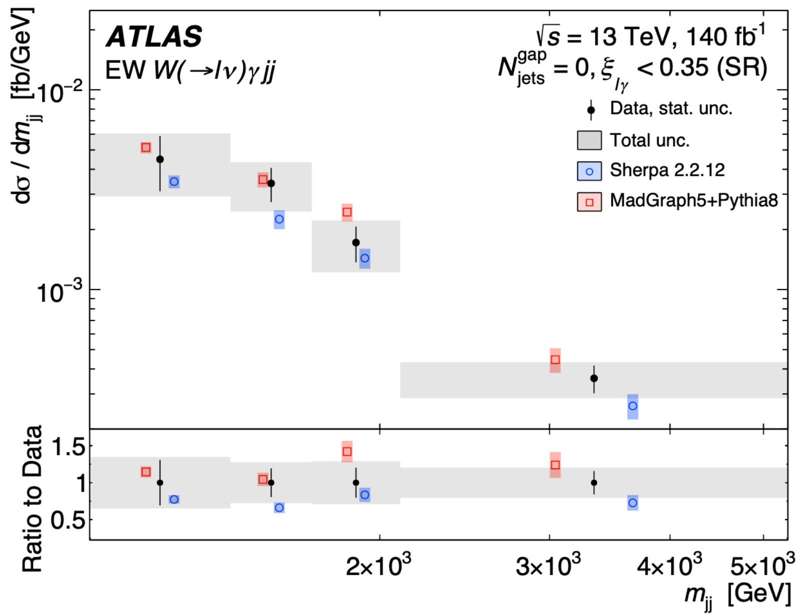
e-print arXiv:2403.02809

VBS: Wγ

- NN trained for **EW signal** separtion, highest ranking variables:
  - lepton-photon centrality
  - pseudo-rapidity difference of jets
  - Angular distance of jj and lγ system.





- Measured fiducial cross section **σ_{EW}=13.2±2.5 fb** signal strengt **μ_{EW}=1.5±0.5**
- Unfolded differential measurement at m_{jj}>1TeV

Alexander Oh, Corfu 2024

26.8.24

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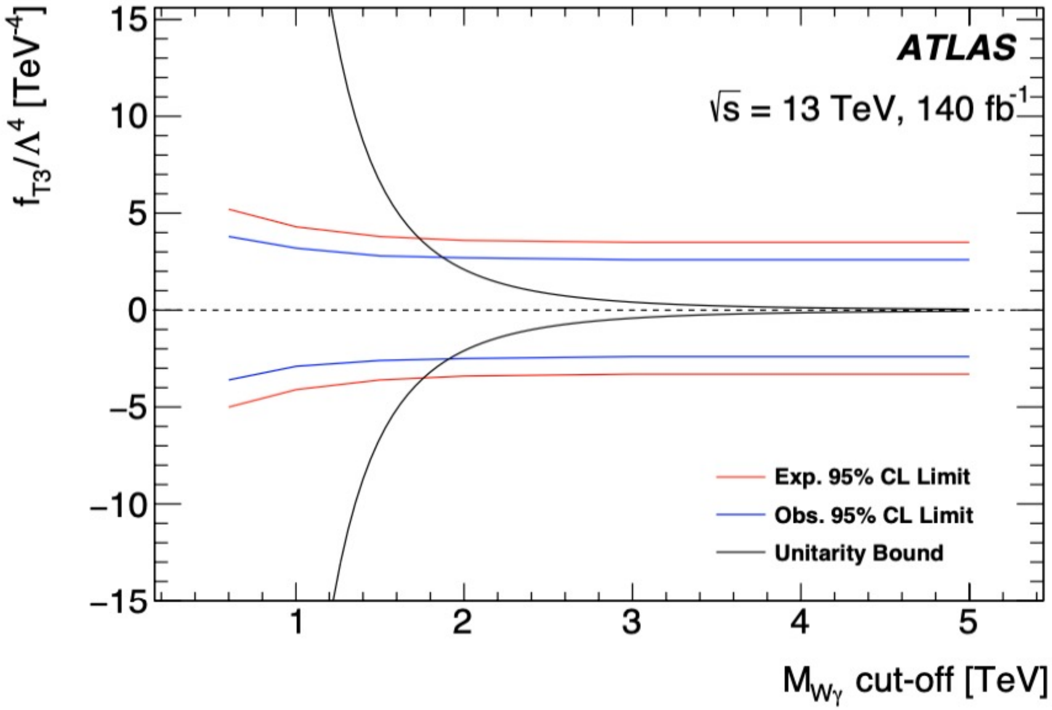
e-print arXiv:2403.02809

VBS: Wγ

- EFT interpretation using the Eboli basis dimension-8 operators:

$$\mathcal{L}_{\text{eff}} = \mathcal{L}_{\text{SM}} + \sum_j \frac{f_j^{(8)}}{\Lambda^4} O_j^{(8)}$$

- Use $p_T(jj)$ and $p_T(l)$ to constrain tensor type (T) and mixed scalar (M) coefficients.
- Added constrains on Wilson coefficients f_{T3} and f_{T4}.

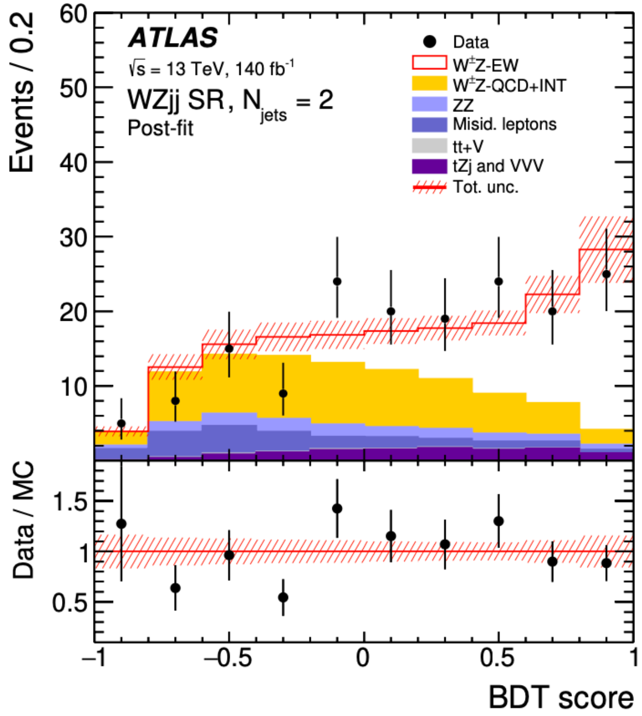


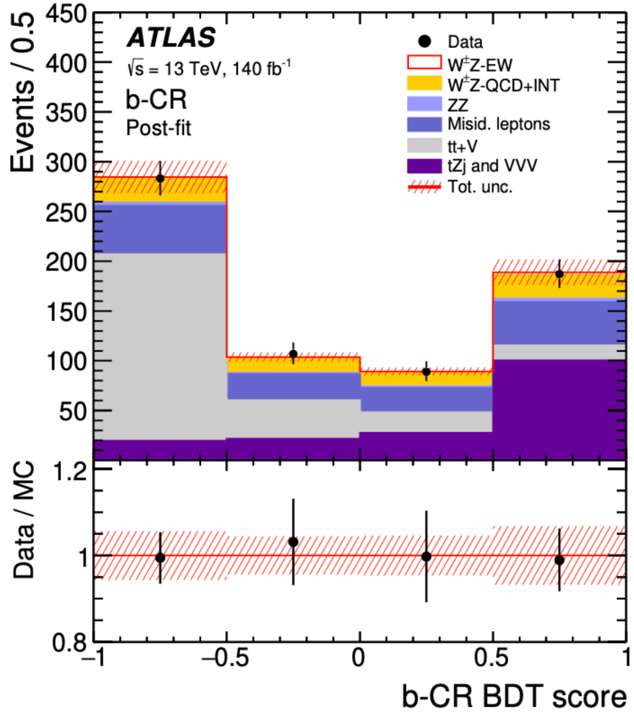
Cofficients [TeV^{-4}]	Observable	$M_{W\gamma}$ cut-off [TeV]	Expected [TeV^{-4}]	Observed [TeV^{-4}]
f_{T0}/Λ^4	p_T^{jj}	1.4	[-2.5, 2.6]	[-1.9, 1.9]
f_{T1}/Λ^4	p_T^{jj}	1.9	[-1.6, 1.6]	[-1.1, 1.2]
f_{T2}/Λ^4	p_T^{jj}	1.6	[-4.9, 5.3]	[-3.6, 4.0]
f_{T3}/Λ^4	p_T^{jj}	1.9	[-3.4, 3.6]	[-2.5, 2.7]
f_{T4}/Λ^4	p_T^{jj}	2.2	[-3.1, 3.1]	[-2.2, 2.3]
f_{T5}/Λ^4	p_T^{jj}	1.8	[-1.8, 1.8]	[-1.3, 1.3]
f_{T6}/Λ^4	p_T^{jj}	2.1	[-1.5, 1.5]	[-1.1, 1.1]
f_{T7}/Λ^4	p_T^{jj}	2.1	[-4.0, 4.1]	[-2.9, 3.0]

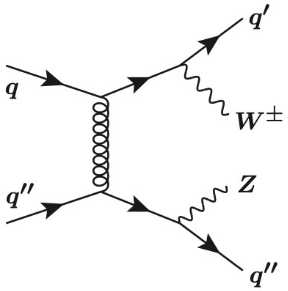
e-print [arXiv:2403.15296](https://arxiv.org/abs/2403.15296)

VBS: WZ

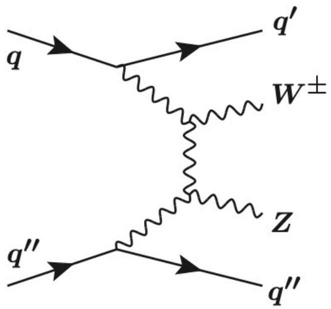
- Measure inclusive, EW, and strong production of WZjj
- Main backgrounds
  - QCD WZ+jj
  - ZZ (CR with 4 leptons)
  - tt+V (CR with b-jets)







strong production



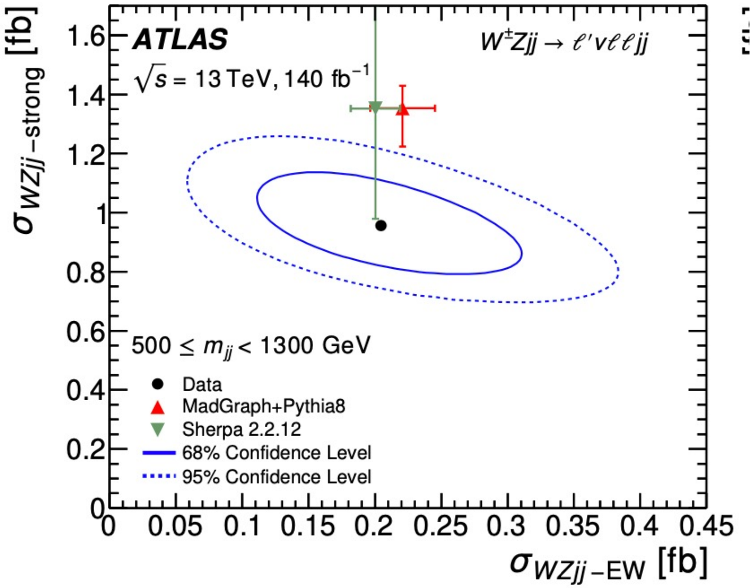
EW production

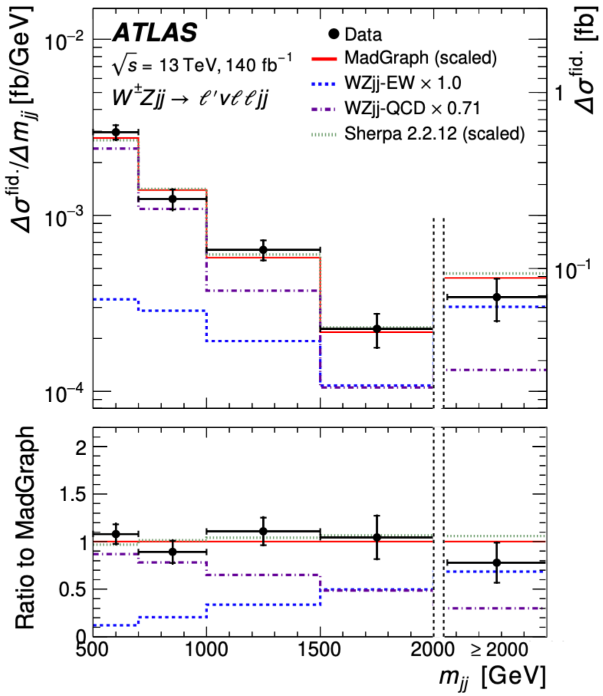
- BDT for SR and CR
  - Adversarial network to distringuish EW and strong production

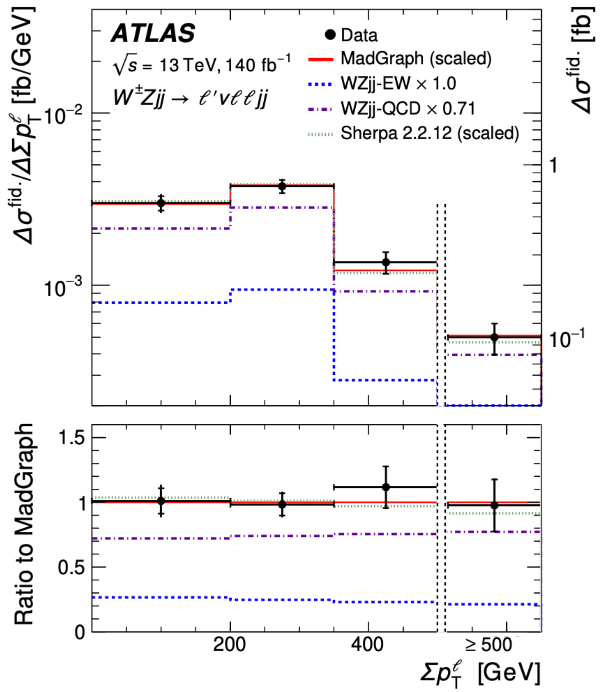
e-print [arXiv:2403.15296]

VBS: WZ

- Simultaneous measurements of EW, and strong production of WZjj in bins of $\mathbf{m_{jj}}$ and $\mathbf{n_{jets}}$.
- WZjj differential cross sections







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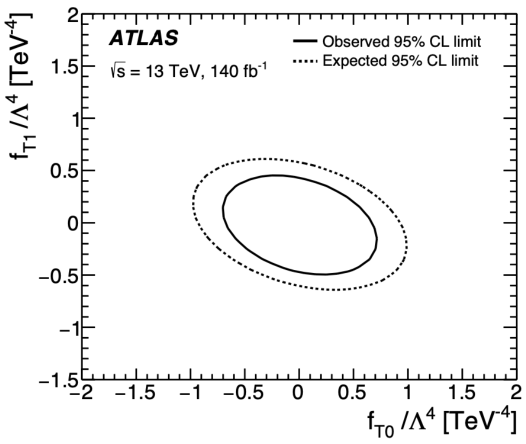
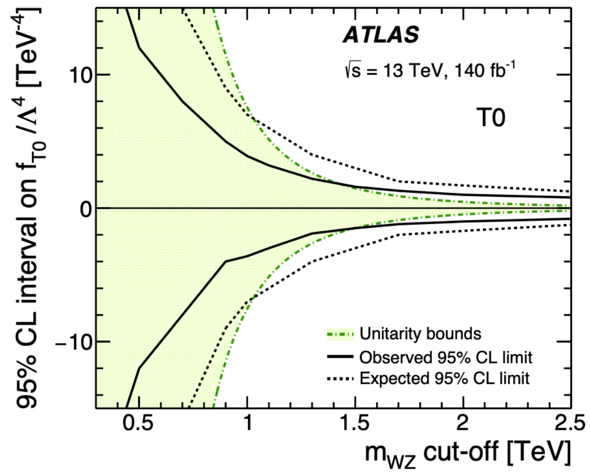
e-print arXiv:2403.15296

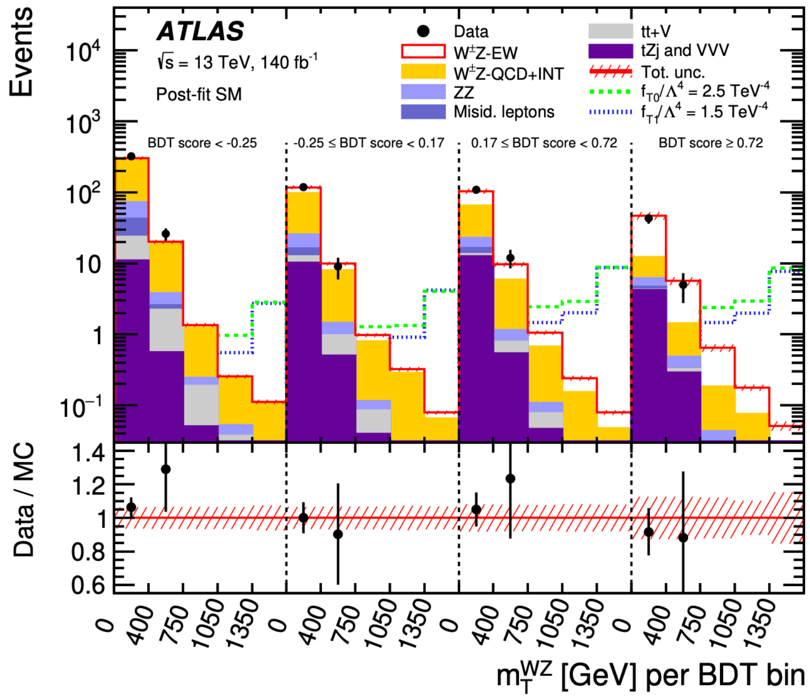
VBS: WZ

- **EFT limits** derived by 2D fit on m^{WZ}_T and BDT.
- First time unitarised limits on S-type operators (f_S) acting on Higgs doublet.

	Expected [TeV $^{-4}$]	Observed [TeV $^{-4}$]
f_{T0}/Λ^4	[-7.0, 7.0]	[-1.5, 1.6]
f_{T1}/Λ^4	[-1.1, 1.0]	[-0.7, 0.6]
f_{T2}/Λ^4	[-12, 6]	[-2.4, 1.8]
f_{M0}/Λ^4	[-60, 60]	[-12, 12]
f_{M1}/Λ^4	[-32, 32]	[-15, 15]
f_{M7}/Λ^4	[-30, 30]	[-15, 15]
f_{S02}/Λ^4	[-41, 41]	[-18, 18]
f_{S1}/Λ^4	—	—







Limits also derived as function of cut-off scale.

see also CMS + ATLAS Higgs talk tomorrow at 10am
Sandra Kortner

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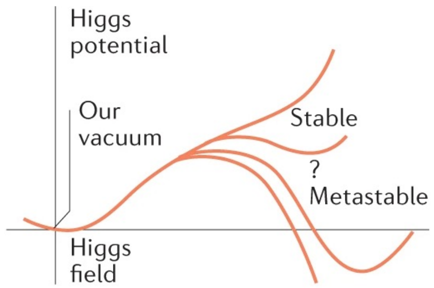

e-print arXiv:2407.10904

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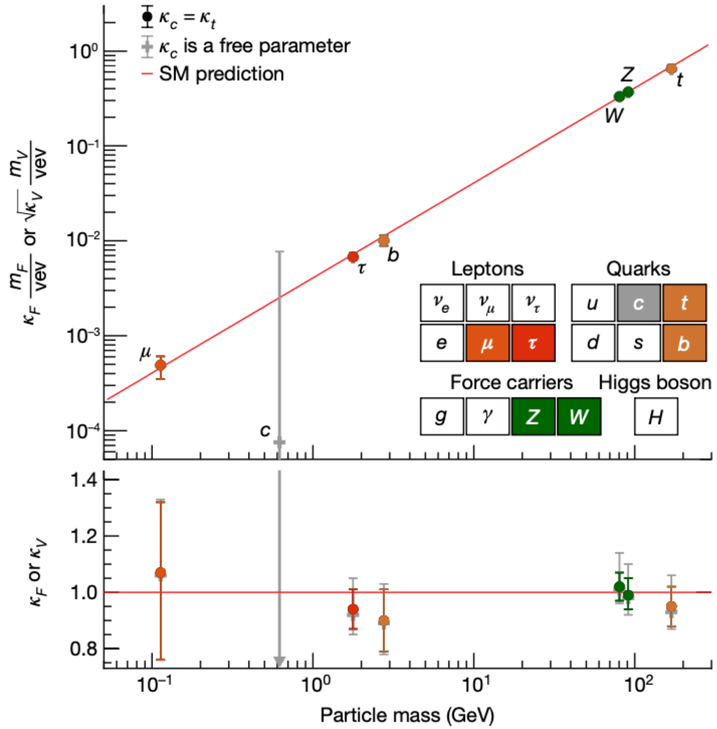
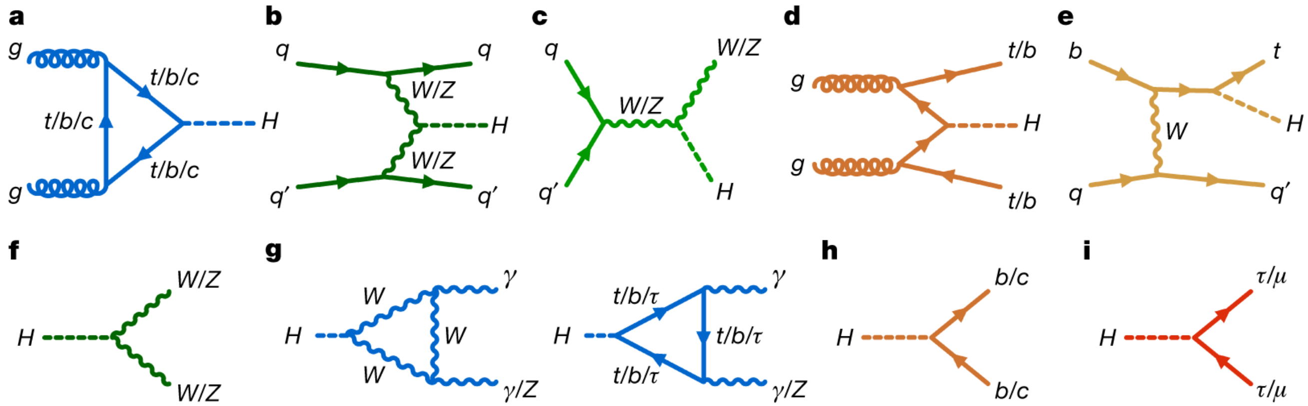
Higgs Physics

- Moved to precision Higgs physics after discovery at the LHC.
  - **Spin, CP**
  - **Yukawa couplings**
  - **Higgs self-couplings**



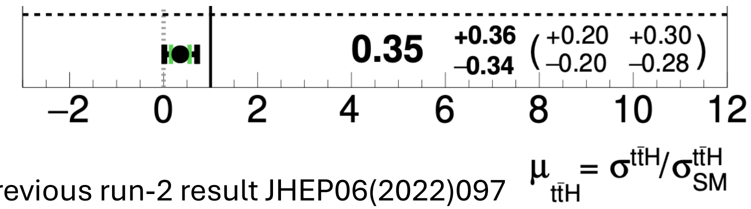


Nature volume 607, pages 52–59 (2022)

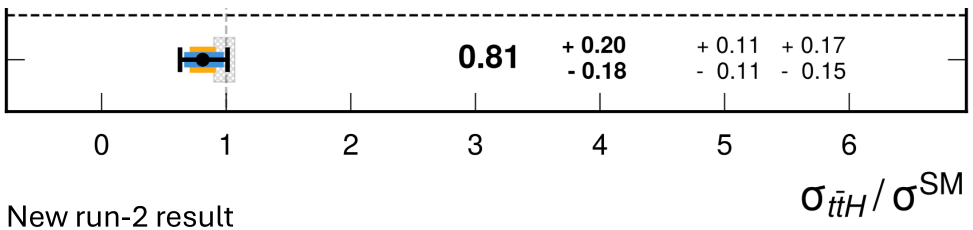
MANCHESTER 1824 e-print arXiv:2407.10904

Precision Higgs Physics:
top Yukawa couplings

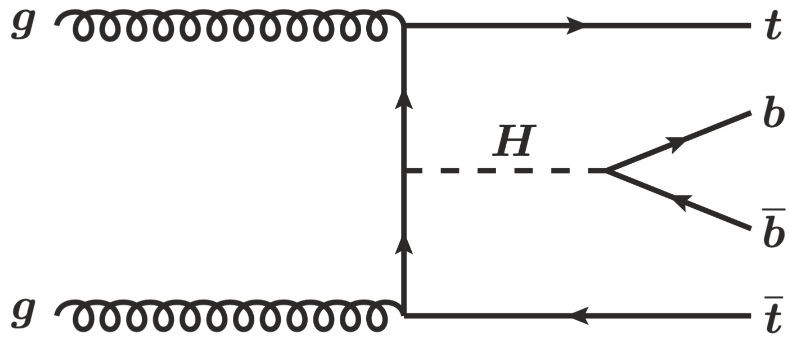
- New precise direct measurement of top Yukawa coupling.
  - ttH(bb) channel.
  - Main challenge tt+bb backgrounds

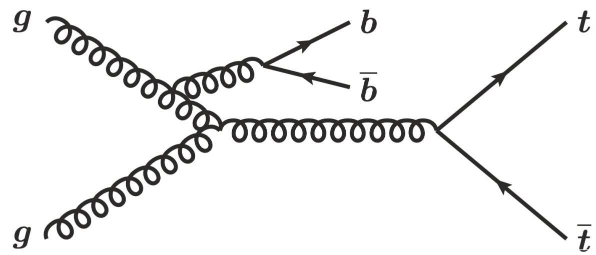


Previous run-2 result JHEP06(2022)097



New run-2 result

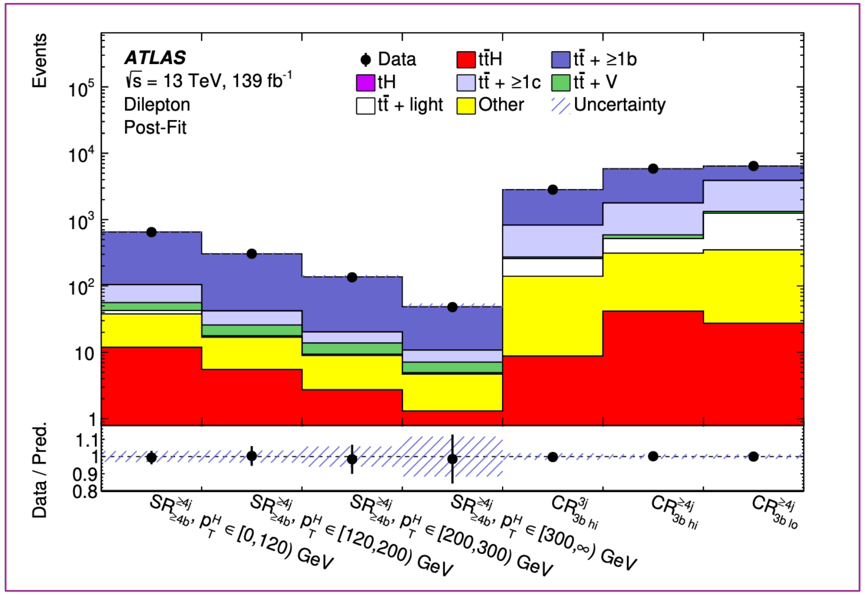




e-print arXiv:2407.10904

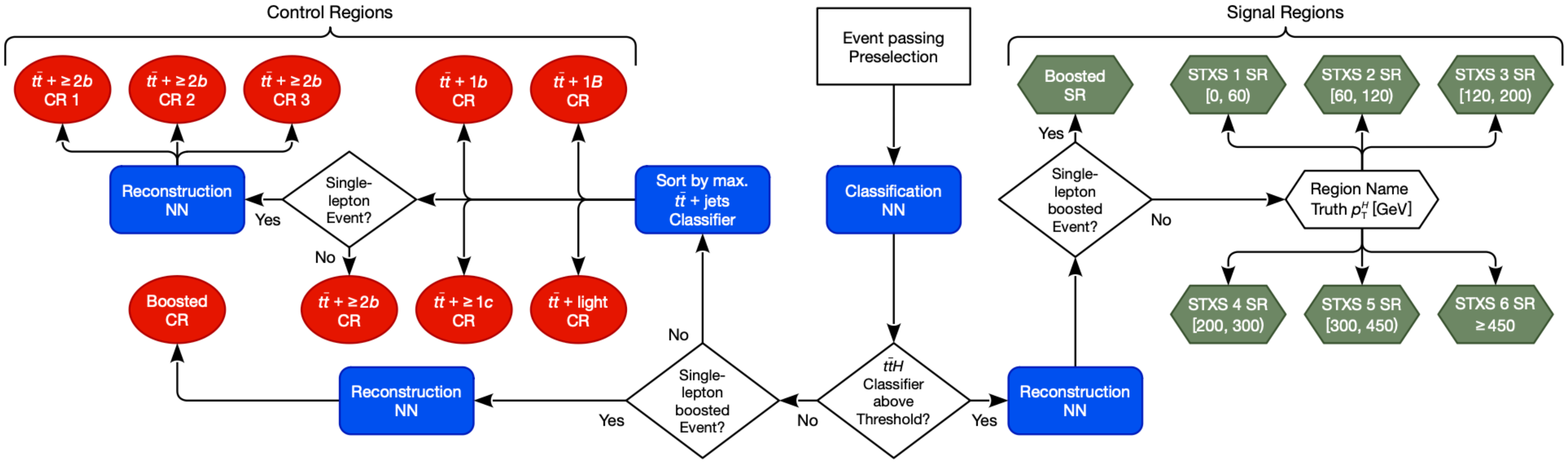
Improvements in:

- Reconstruction and particle identification.
  - Flavour tagging, particle flow jets.
- Machine learning technique
- Background modelling
  - understanding $t\bar{t}\, b\bar{b}$ production
- Achieved major improvement of exp. sensitivity from **2.7σ to 5.4σ!**



SR and CR in di-lepton channel, post-fit

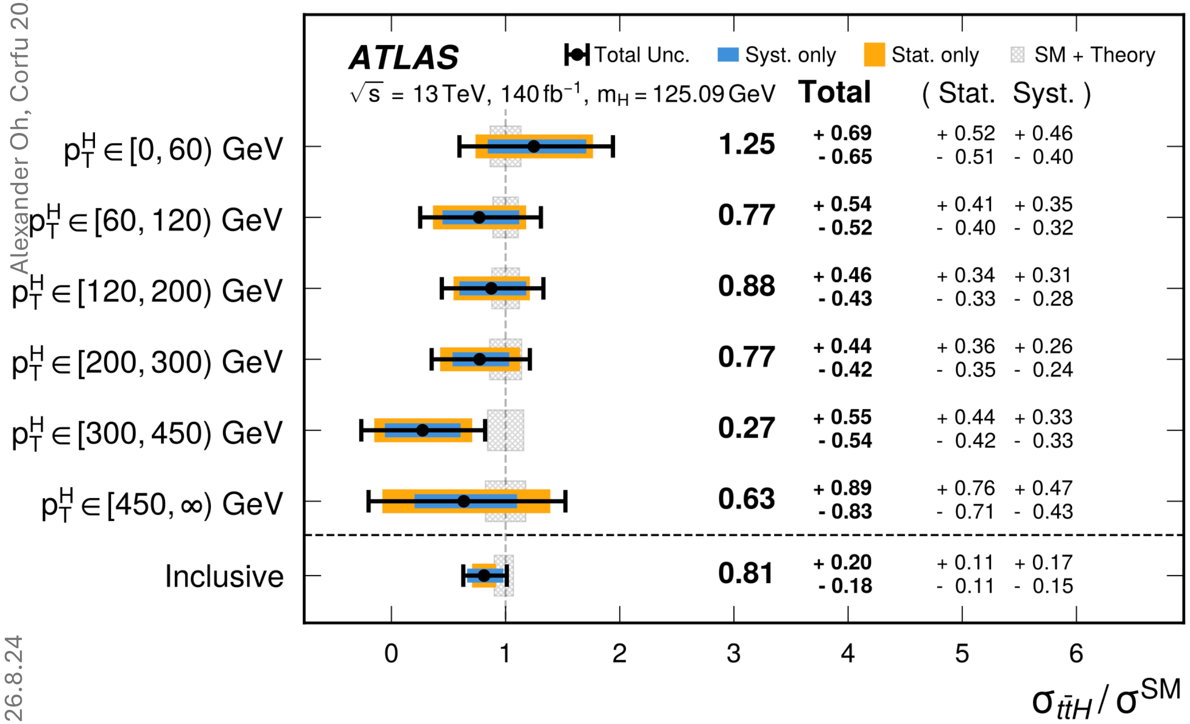
Classification transformer with SR and CR.

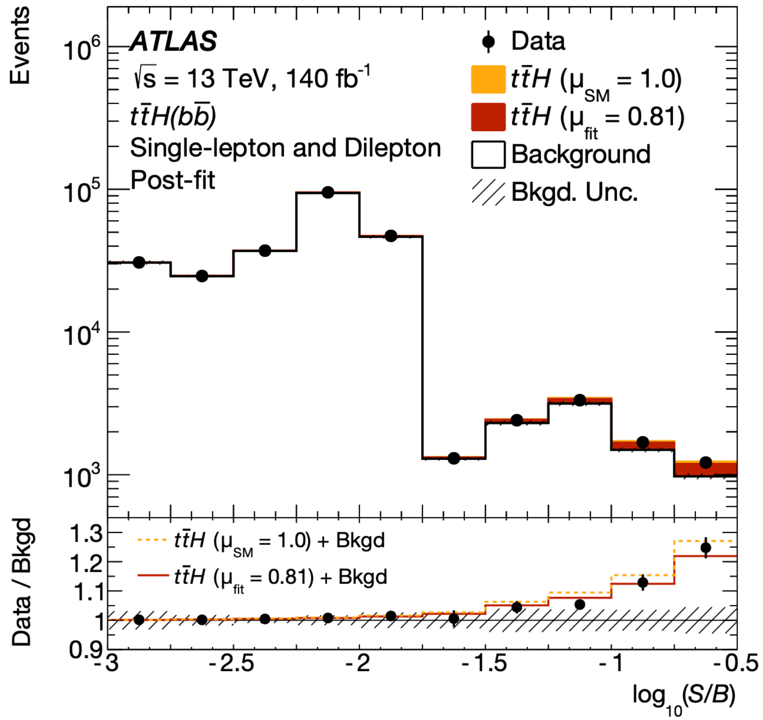


e-print arXiv:2407.10904

Results

- Excess of $\bar{t}tH(bb)$ events: observed (expected) significance **4.6** (5.4) std dev
- Signal strength: $\mu_{t\bar{t}H} = 0.81^{+0.22}_{-0.19} = 0.81 \pm 0.11(\text{stat.})\ ^{+0.20}_{-0.16}(\text{syst.})$.
- Differential cross section in STXS bins

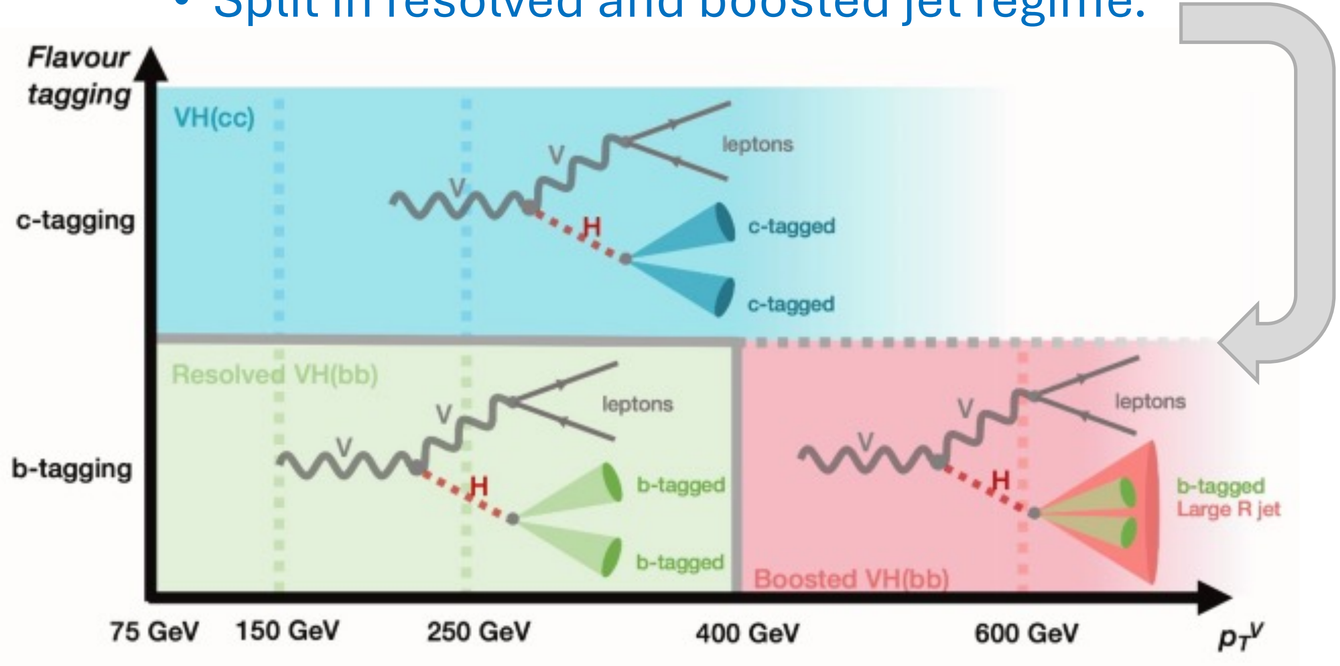




Precision Higgs Physics:

b and *c* Yukawa couplings in *HV* production

- New precise direct measurement of ***b*** and ***c*** Yukawa couplings.
  - New result re-analysis of *VH(bb)* and *VH(cc)* analysis.
  - Cover *V=Z/W*, *l*=e,μ,τ
  - Split in resolved and boosted jet regime.



Improvements over previous analysis:

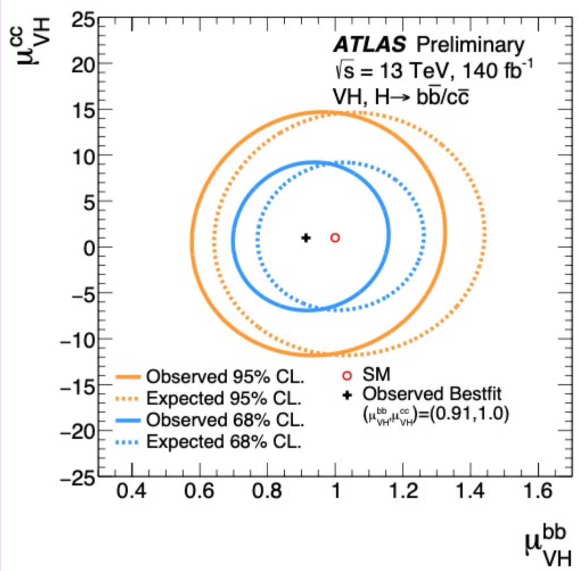
- Improved charm tagger.
- Use BDT classifier in boosted topologies.
- Overall improved sensitivities by
  ***H → bb* by 15%**
  ***H → cc* by factor 3**

MANCHESTER 1824 e-print ATLAS-CONF-2024-010

Precision Higgs Physics:

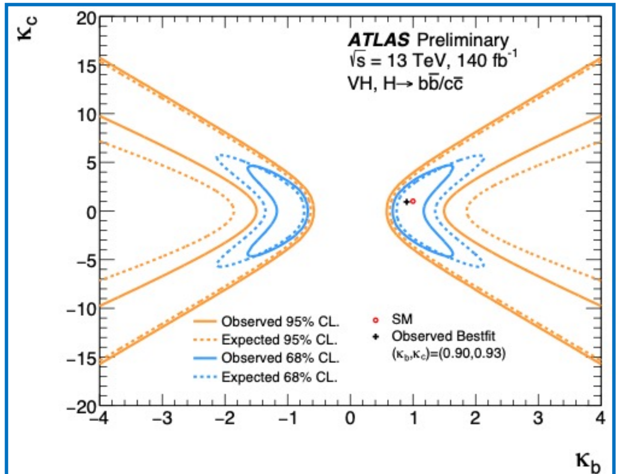
b and *c* Yukawa couplings in *HV* production

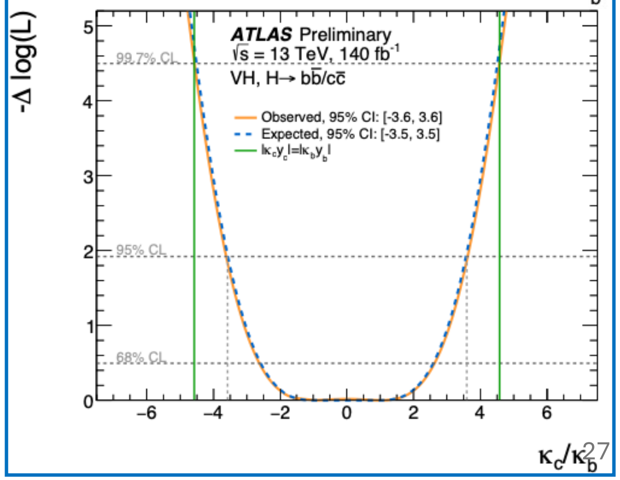
- Simultaneous extraction of Yukawa couplings to *b* and *c* quarks.
  - Sensitivities obs. (exp.) : WH(bb) 5.3 (5.5), ZH: 4.9 (5.7) σ
  - VH(cc) upper limits at 95% CL 11.2 (10.4) **best observed limits to date**
- Also provide
  - differential measurements (STXS)
  - Coupling modifiers in **κ–framework**



$$\mu^{bb}_{VH} = 0.91^{+0.16}_{-0.14}$$

$$\mu^{cc}_{VH} = 1.0^{+5.4}_{-5.2}$$

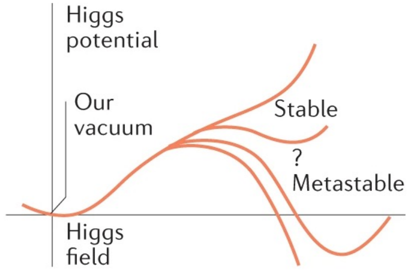




e-print [arXiv:2406.09971]

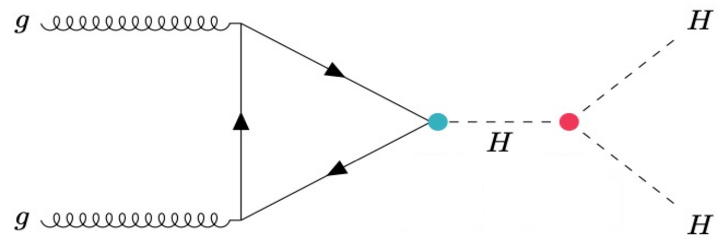
Di-Higgs physics

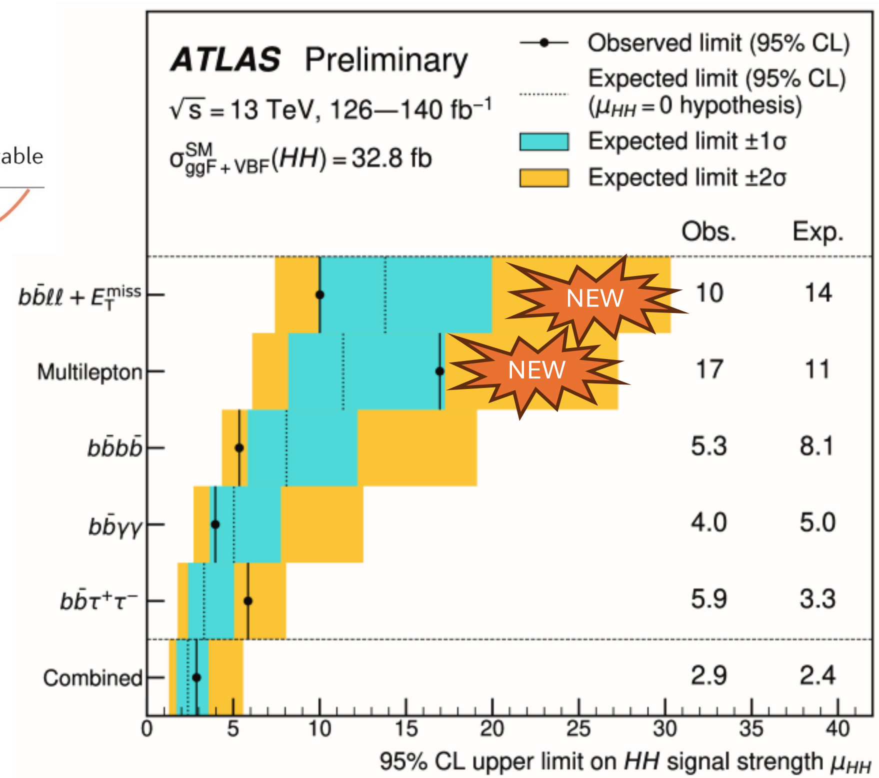
- Measure self-coupling of Higgs boson with di-Higgs production.
  - Sensitive to shape of Higgs potential



- Extremely rare process, expected production cross section ~33fb.
- Merged five analyses to achieve the **most sensitive probe** yet of di-Higgs production and the Higgs self-coupling.
- New combination includes **multi-lepton** and **bbll+ET$_{miss}$** decay channels.
- Measured signal strength:

$$\mu_{HH} = 0.5^{+1.2}_{-1.0}$$





Extract upper 95% CL upper limit on HH signal strength

e-print arXiv:2406.09971

Di-Higgs physics

- Coupling strength parameters in κ framework (and HEFT):

κ_λ (c_{hhh}): HHH

κ_V (c_{VVh}): VVH

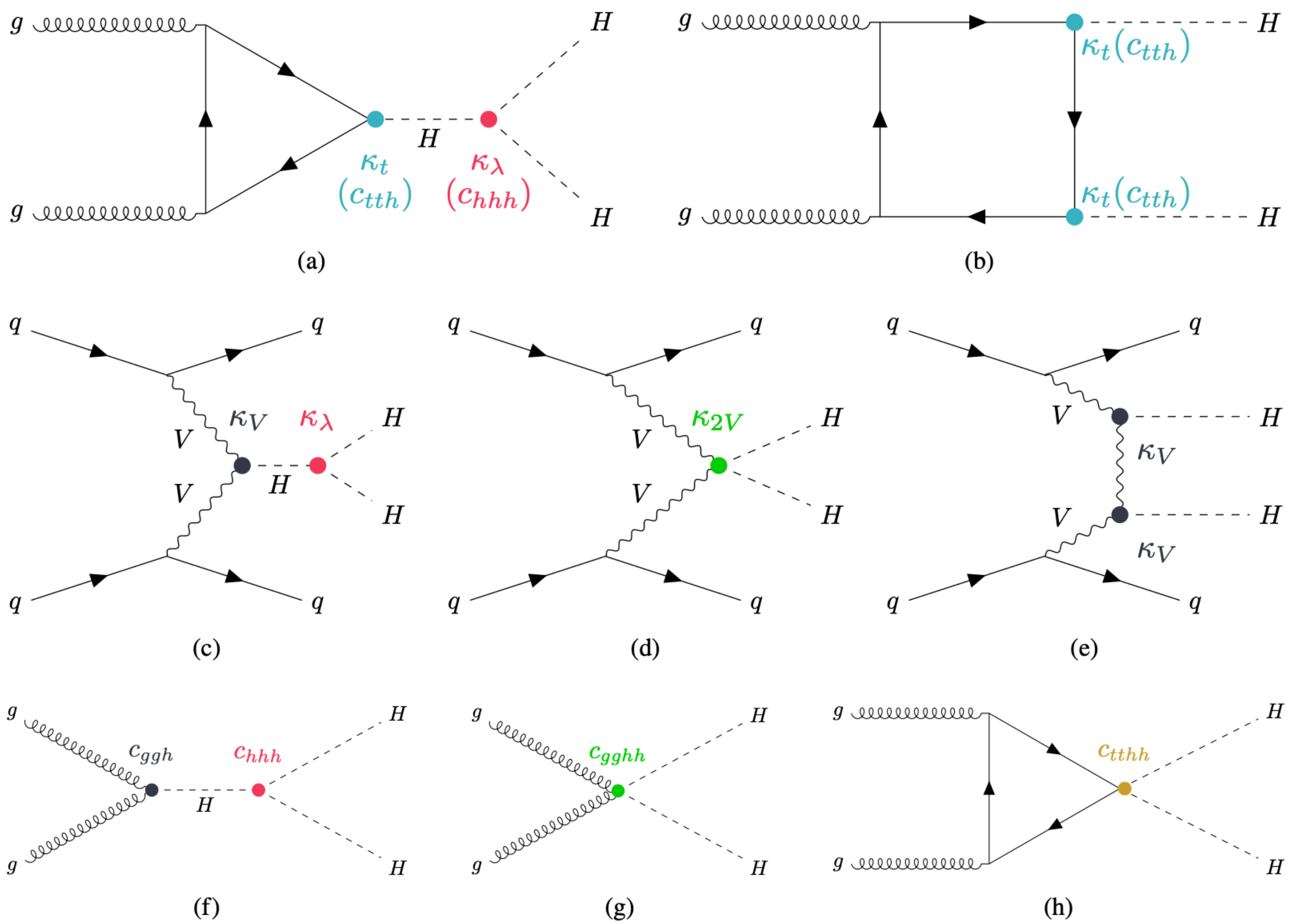
κ_{2V} (c_{VVhh}): VVHH

κ_t (c_{tth}): ttH

(c_{gghh}) : ggHH

(c_{tthh}) : ttHH

} not in SM



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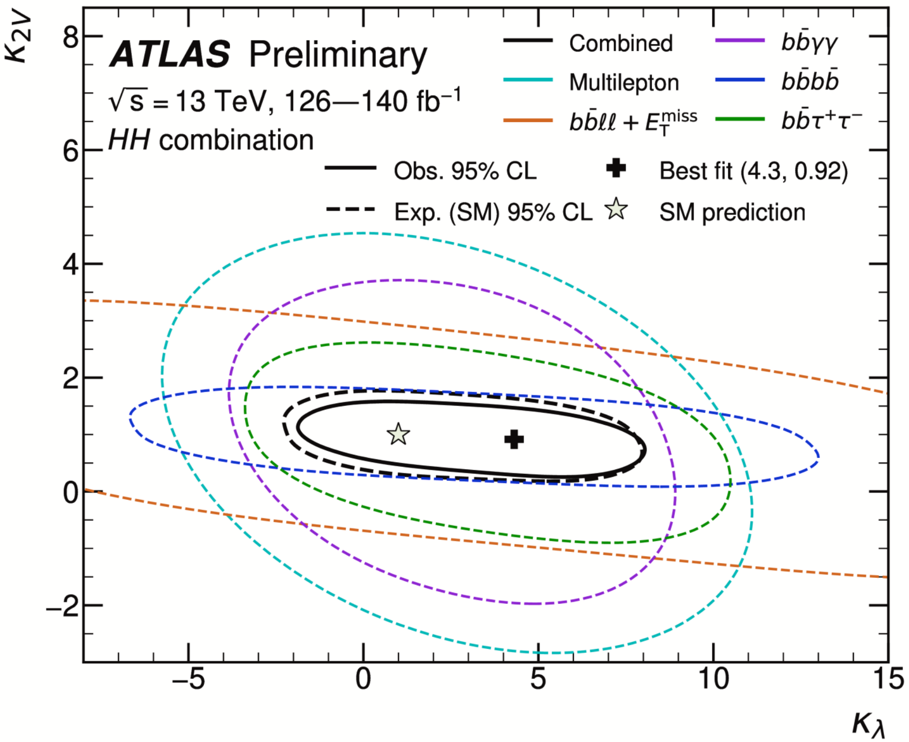
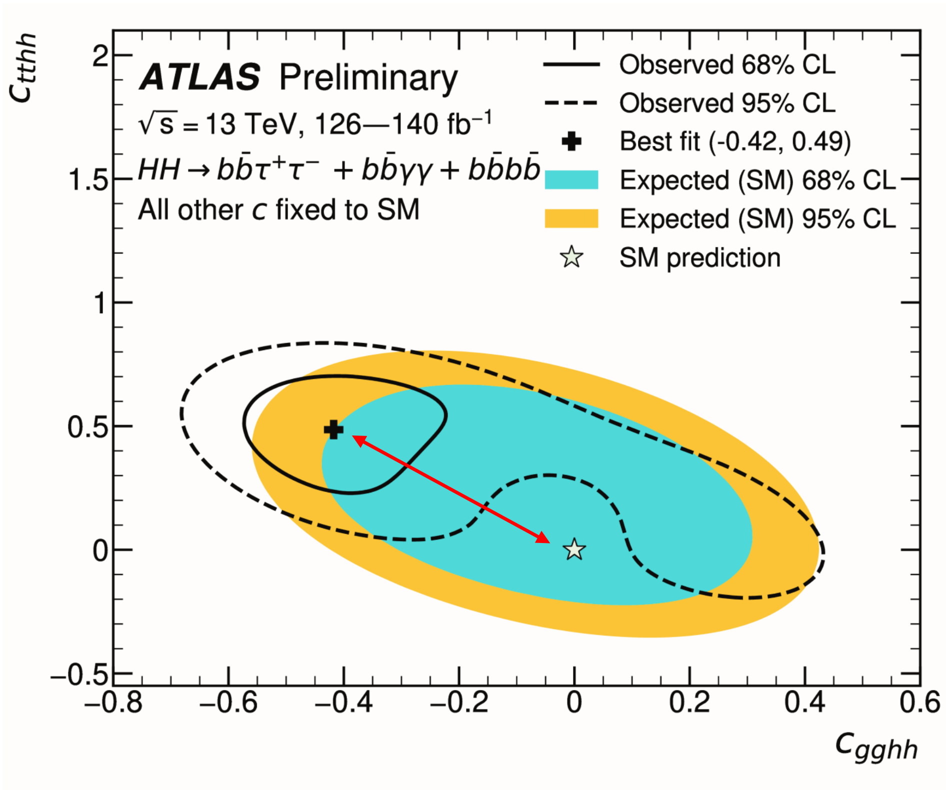
e-print arXiv:2406.09971

Di-Higgs physics

- k values in agreement with SM
- HEFT show slight tension with SM (p-value 3.1%).





e-print arXiv:2405.20040

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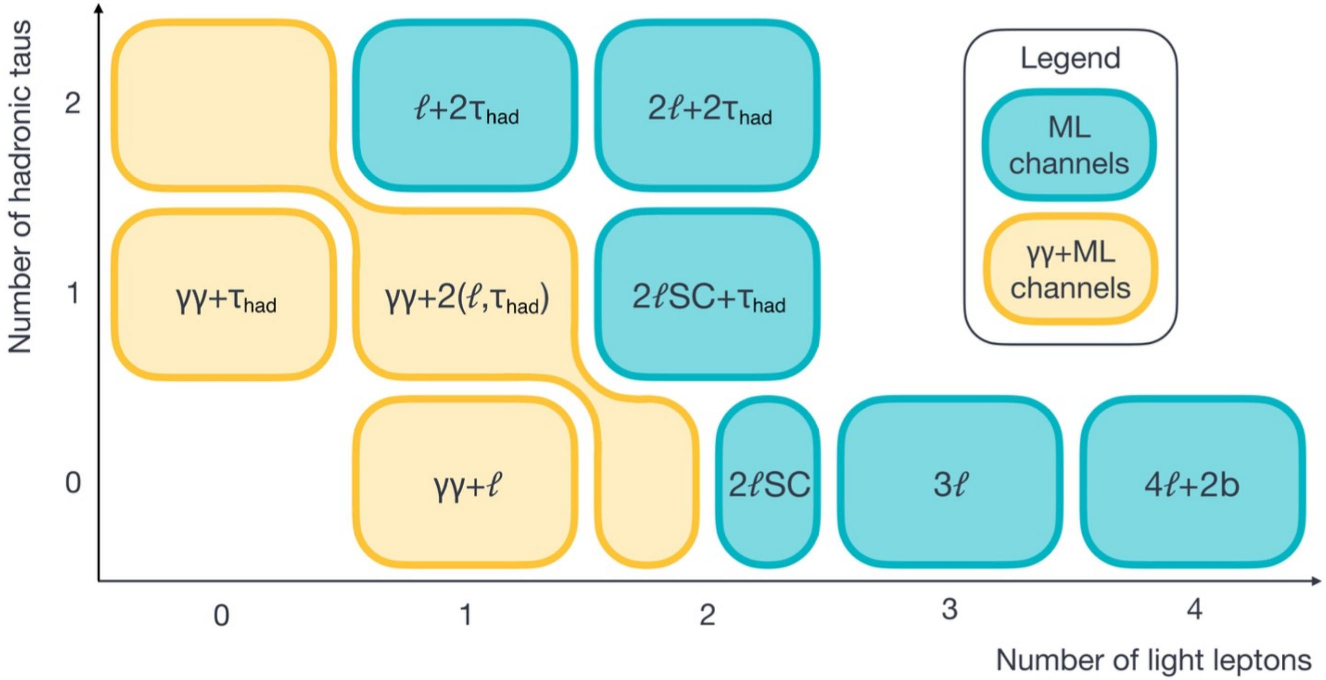
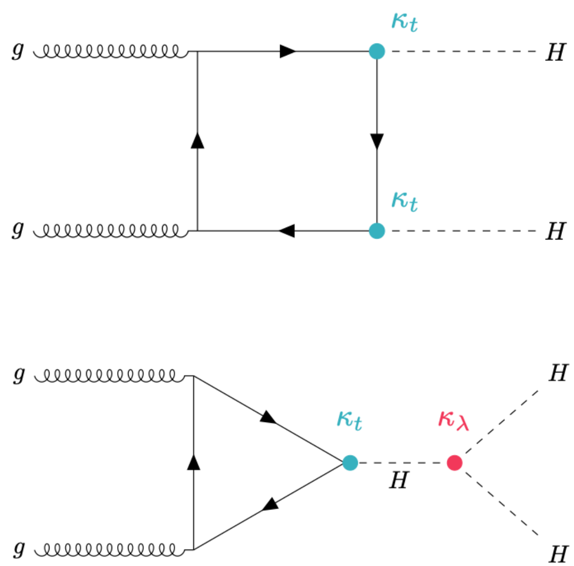
Looking for Higgs pair with multi-lepton and $\gamma\gamma$

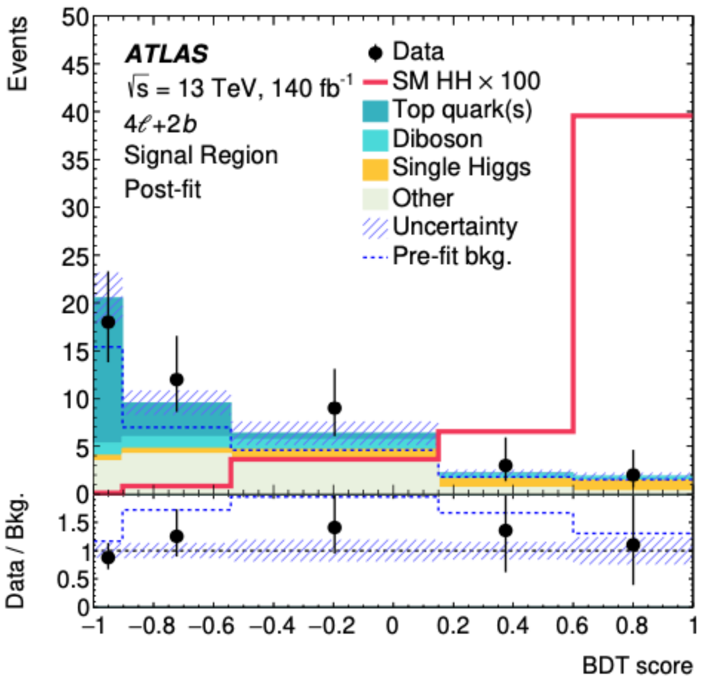
- Target multiple final states of **HH decays** in a **non-resonant search** with BDTs combining multi-lepton (ML) and $\gamma\gamma$ signatures.

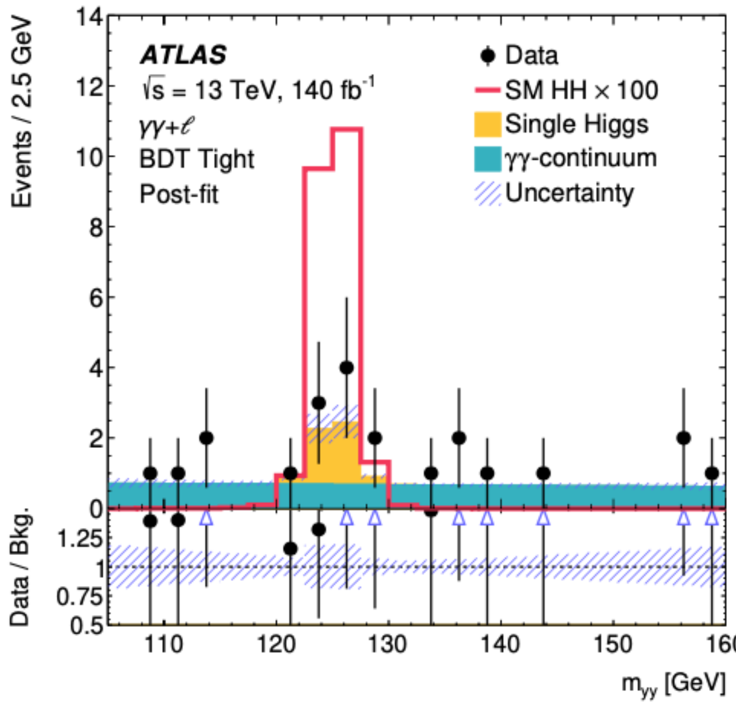




Looking for Higgs pair with multi-lepton and γγ

- **ML**: cut based categorisation and BDT fit
- **γγ:** BDT based categorisation and fit to $m_{\gamma\gamma}$.

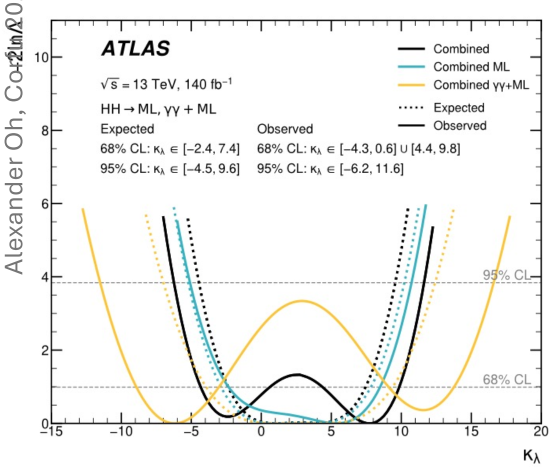




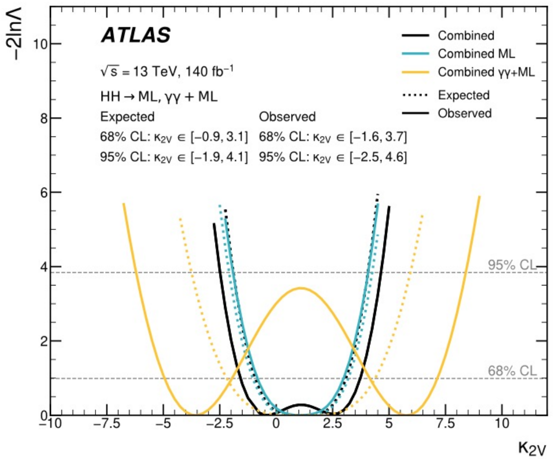
e-print arXiv:2405.20040

Looking for Higgs pair with multi-lepton and $\gamma\gamma$

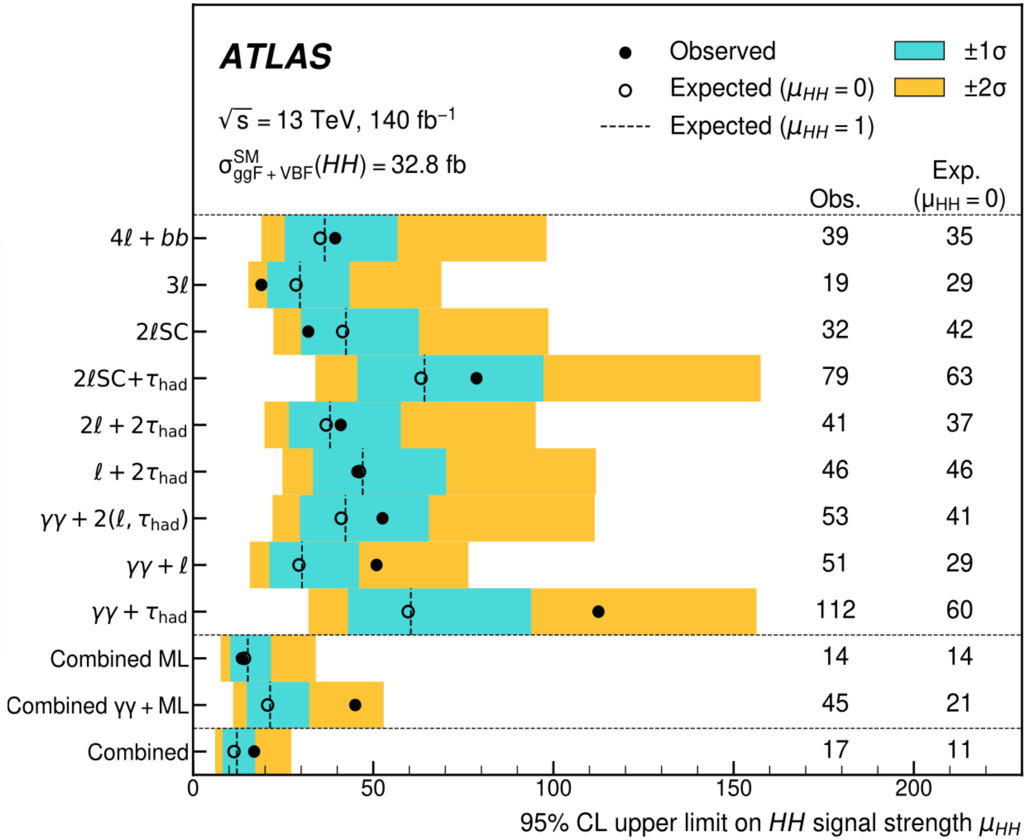
- Combined result on signal strength μ_{HH} and HH coupling strength κ_λ and κ_{2V}.



κ_λ



κ_{2V}



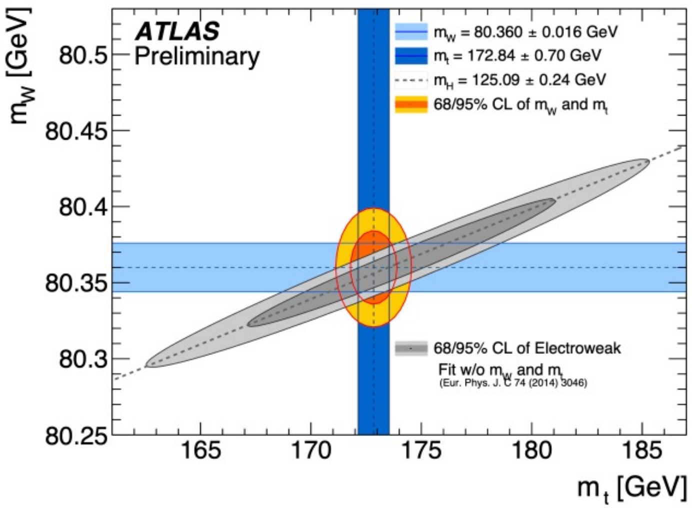
-6.2 (-4.5)< κ_λ < 11.6 (9.6) obs. (exp.) at 95% CL.

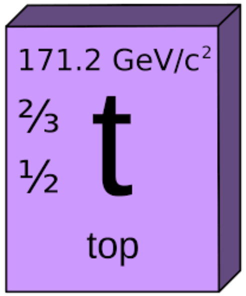
-2.5 (-1.9)< κ_{2V} < 4.6 (4.1) obs. (exp.) at 95% CL.

μ_{HH} <17 obs. and 11 exp. at 95% CL.

Content

- ATLAS in run-3
- EW Precision measurements
- Multi-boson
- Higgs
- Top
- Searches for physics beyond the SM
- Heavy Ion
- Summary





MANCHESTER 1824 e-print arXiv:2407.13473

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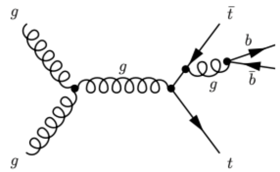
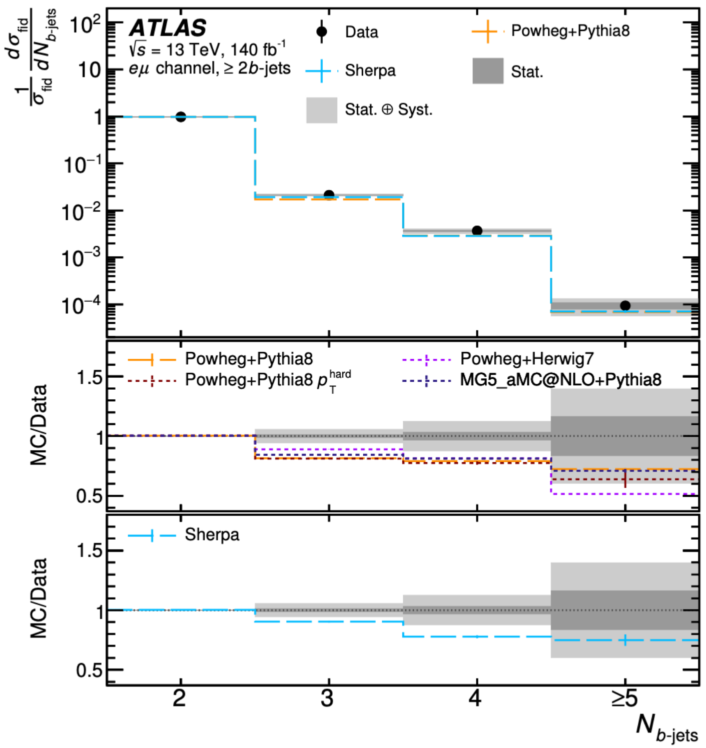
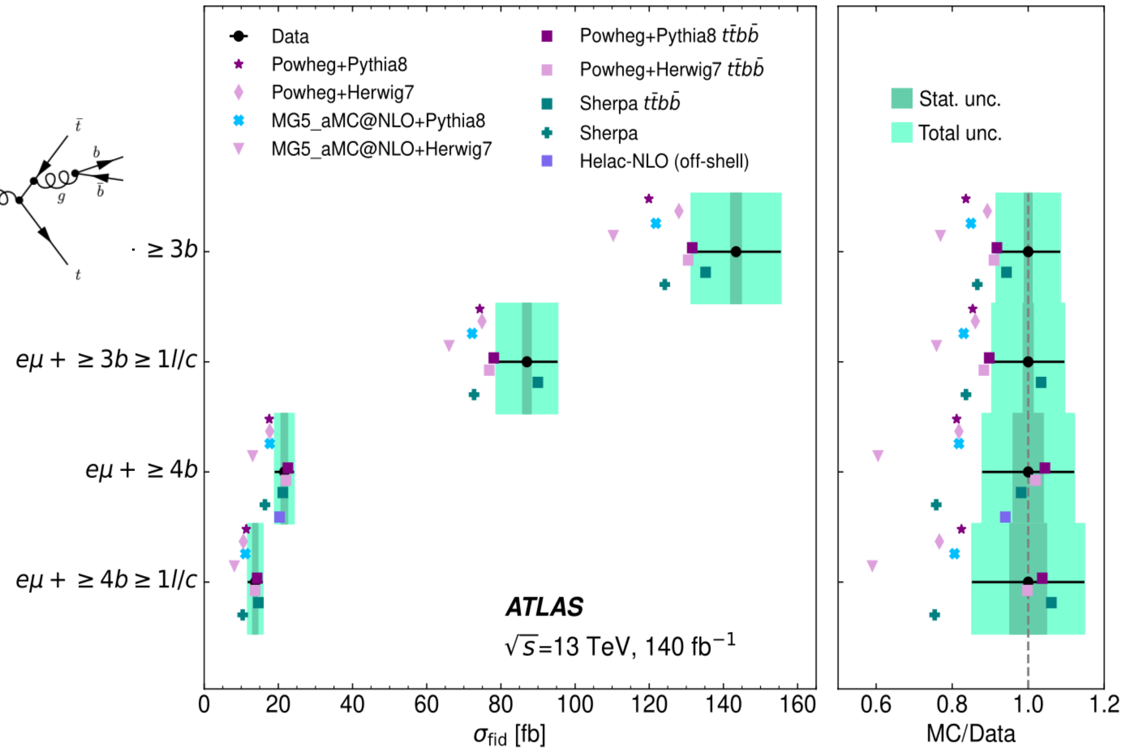
Precision top physics

$t\bar{t}$ + heavy flavour



- Comprehensive measurement to **improve theory modeling.**
- **Important input also for di-Higgs!**

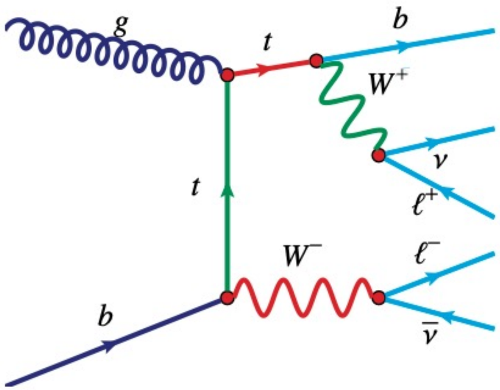


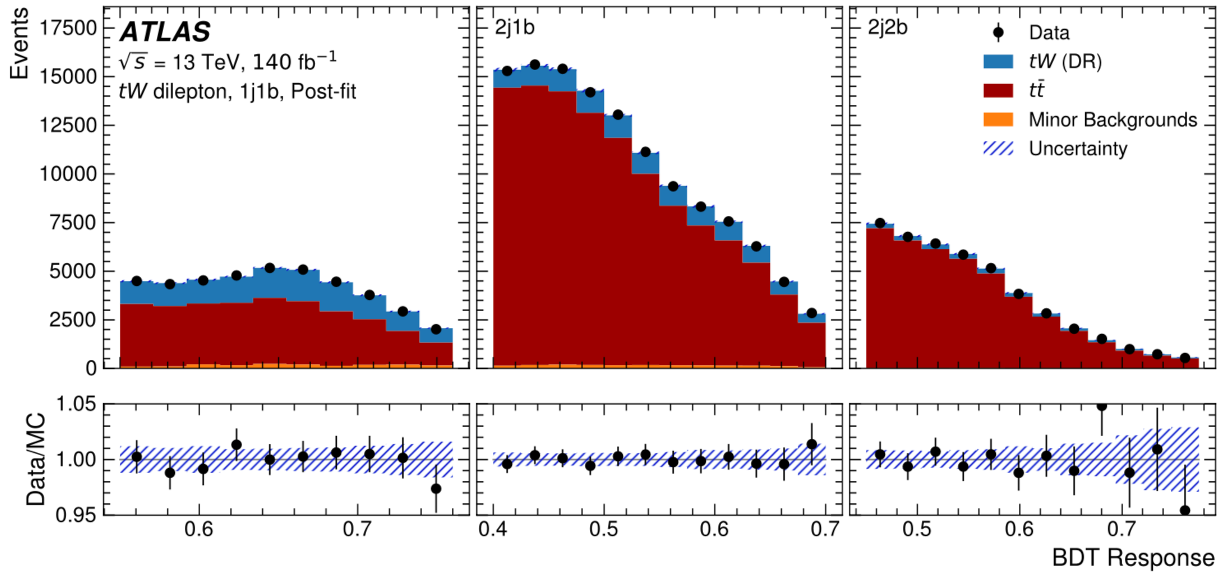


- **Fiducial and normalised differential cross section** in single lepton (e and μ) channel with 3 or 4 b-jets.
  - **Precision best to date** in e μ channel with **4%-20%.**
  - Particle level observables compared to various predictions.

tW production

- Single top production in association with a W boson: **Updated result with full run-2 data-set.**
- Important test of *Wtb* vertex and complementary to *qq'→ tb* channel.
- *tW* measured in relatively clean **di-lepton channel.**
- Use BDT
  - Trained for three signal categories (1j1b, 2j,1b, 2j2b).
  - Main background $t\bar{t}$ events.





e-print arXiv:2407.15594

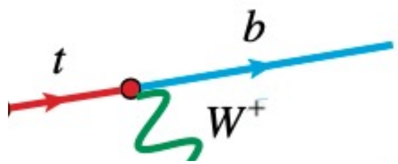
tW production

- Measured cross section in good agreement with expectation.
  - Systematic limited.
  - Leading systematic uncertainties (13-11%) : $t\bar{t}$ modelling, jet energy scale, missing transverse energy reconstruction.
- Set contraints on $|f_{LV}V_{tb}|$
  - f_{LV} left handed form factor, unity in SM.
  - **Measurement consistent with SM.**

$$\sigma_{tW} = 75\,^{+15}_{-14}\text{ pb} = 75 \pm 1\text{ (stat.)}\,^{+15}_{-14}\text{ (syst.)} \pm 1\text{ (lumi.) pb}$$

$$\sigma_{tW}^{\text{theory}} = 79.3\,^{+1.9}_{-1.8}\text{ (scale)} \pm 2.2\text{ (PDF) pb.}$$

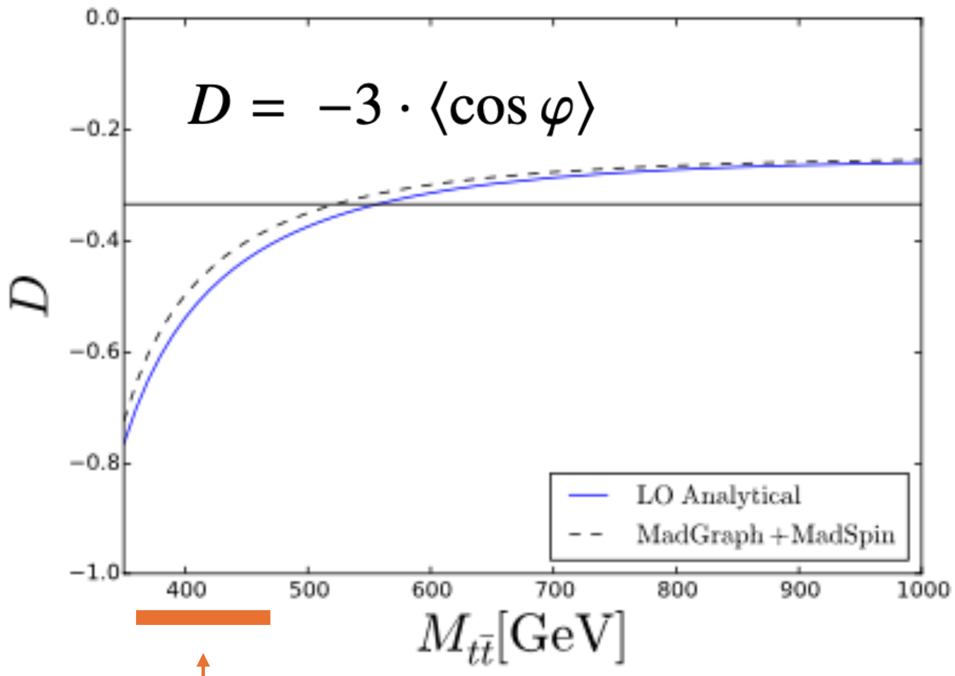
$$|f_{LV}V_{tb}| = 0.97 \pm 0.10$$



MANCHESTER 1824 e-print arXiv:2311.07288

Quantum entanglement with top quarks

- Measure the **spin correlation** in $t\bar{t}$ system (dilepton channel).
- Entanglement enhances the **spin correlation**.
- Entanglement marker characterises spin-entanglement (**D < -0.3**), with **<cos ϕ>** the average separation of the two lepton in the $t\bar{t}$ rest-frame.
- Close to threshold 80% of $t\bar{t}$ from spin-singlet state, maximum of entanglement

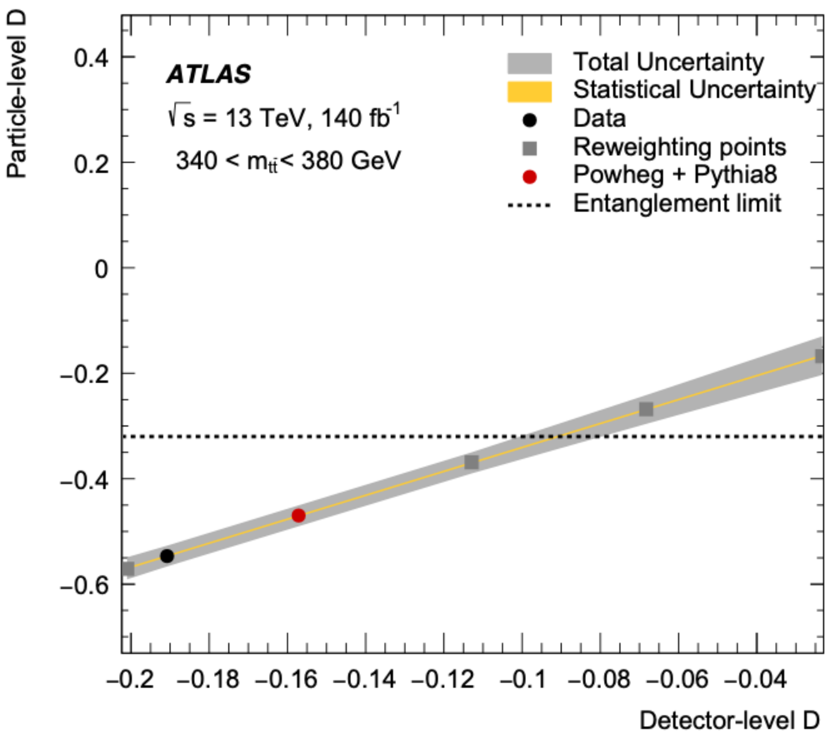


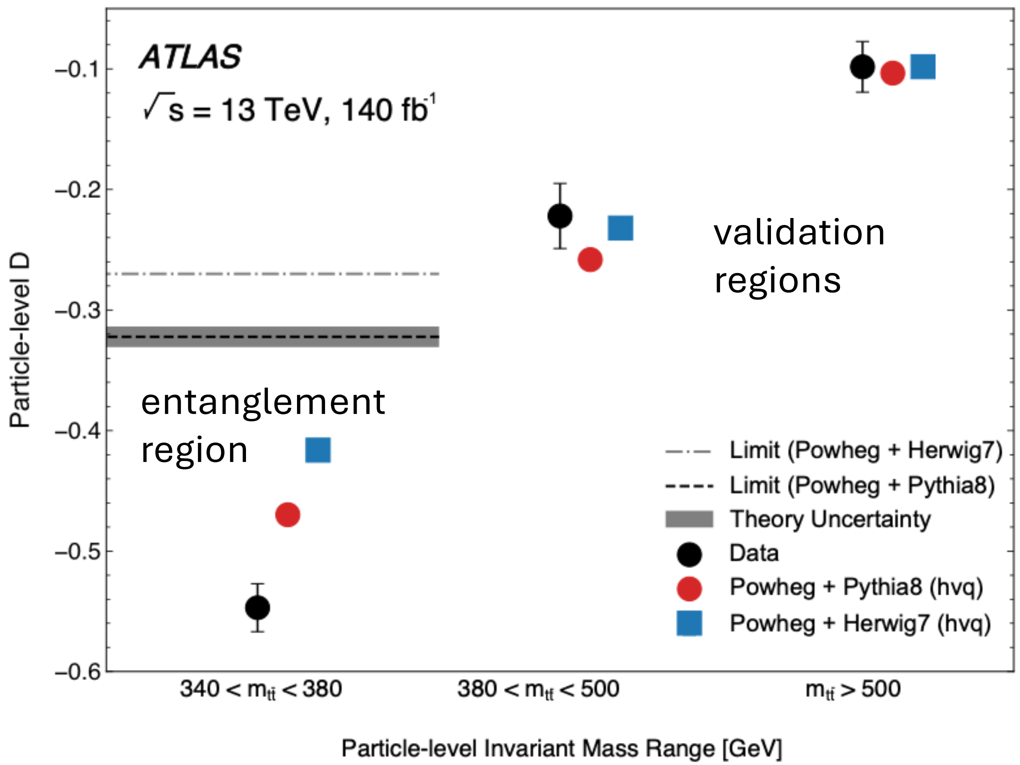
Entanglement expected at threshold $t\bar{t}$ production.

e-print arXiv:2311.07288

Quantum entanglement with top quarks

- Observed entanglement in di-leptonic $t\bar{t}$ events:
  D = -0.547 ± 0.002 (stat.) ± 0.021 (syst.) , exp.: D = -0.470 ± 0.002 (stat.) ± 0.018 (syst.)





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- **Searches for physics beyond the SM**
- Top
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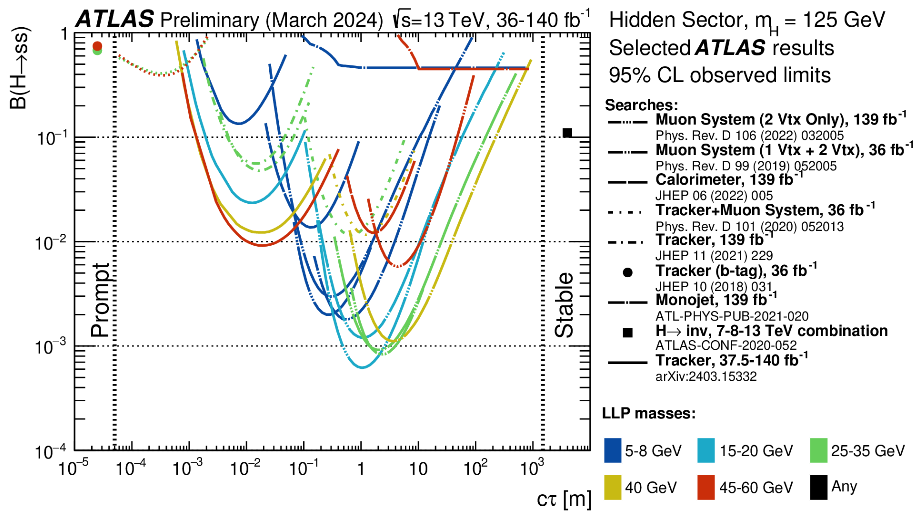
- Summary

long lived particles Wednesday morning
Albert de Roeck

SUSY & BSM talks Wednesday afternoon
YuyaMino(SUSY),AndreaPerrotta(BSM)

Dark Matter on Saturday morning
Xinhui Huang

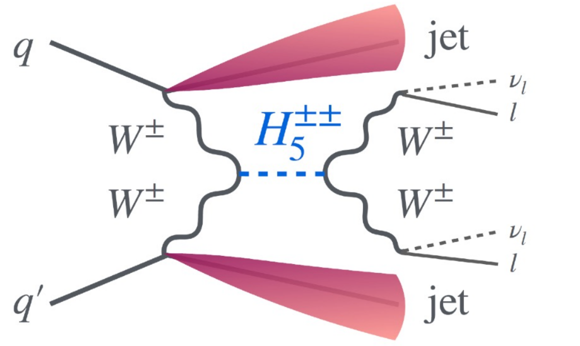


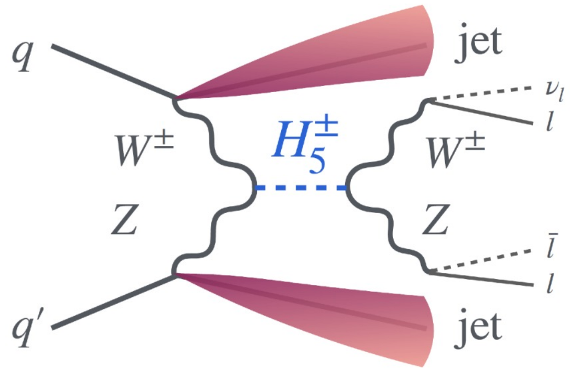
e-print arXiv:2407.10798

Exotic Higgs searches

- Combination of two searches for singly and doubly charged Higgs bosons within the Georgi-Machacek (GM) model:
  - Predicts neutral, singly and doubly charge Higgs bosons.
  - Fermiophobic charged states, **VBF production**.
  - **Degenerate mass states**, parameterised by mass m_{H5} and $\sin(\theta_H)$ mixing parameter.
  - Combination of $H^{\pm\pm} \rightarrow W^{\pm}W^{\pm}$ and $H^{\pm} \rightarrow W^{\pm}Z$ Run 2 analyses results

JHEP 04 (2024) 026 $H^{\pm\pm}$
Eur. Phys. J. C 83 (2023) 633 $H^{\pm}$





e-print arXiv:2407.10798

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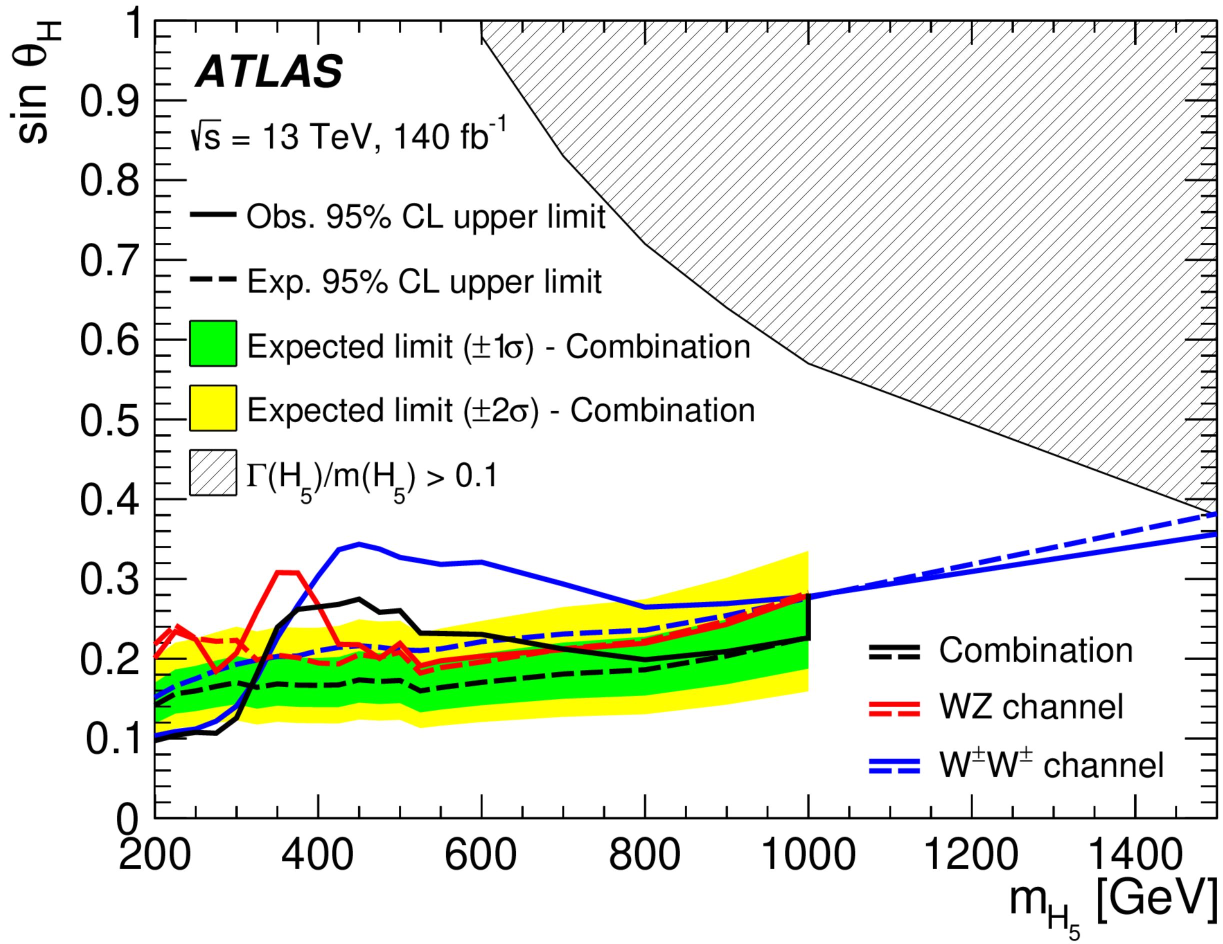
Exotic Higgs searches

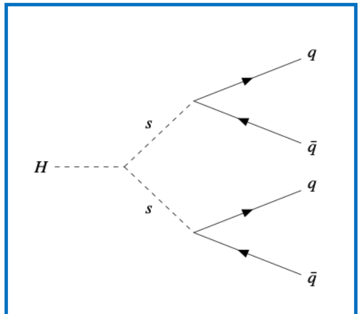
- Georgi-Machacek exclusion limits
  - Range covered: 200 < m_{H5} < 1500 GeV
  - Excluding sin(θ_H) > 0.10 – 0.36
  - Excess around m_{H5} = 375 GeV with 2.5 (3.3) sigma global (local) significance.
  - **Improved GM limits by 9% - 25%** comparing to previous ATLAS results.



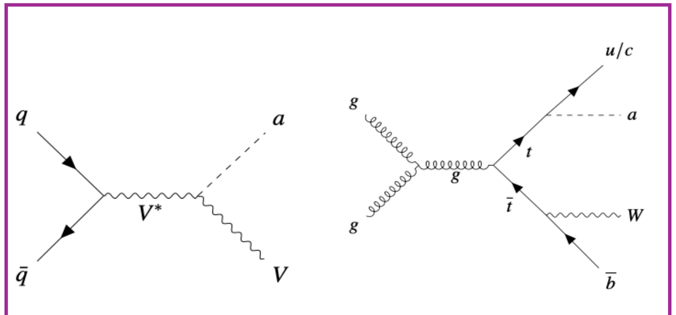
e-print arXiv:2403.15332

Higgs as a portal

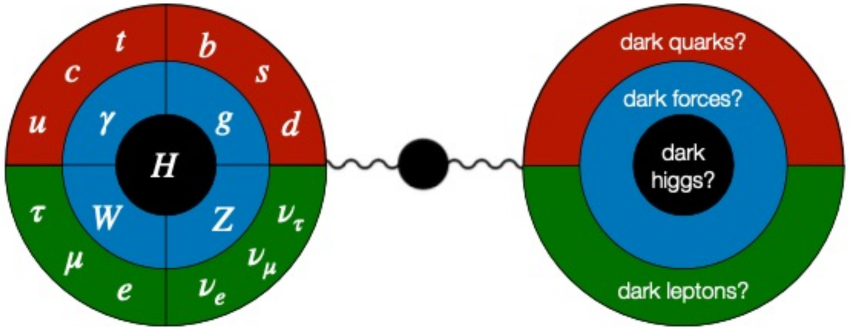
- Updated search for **long lived particles (LLP)**
  - Dark sector coupling to Higgs.
  - ALP coupling to vector bosons
  - First time top quark to ALP and *u/c* quark

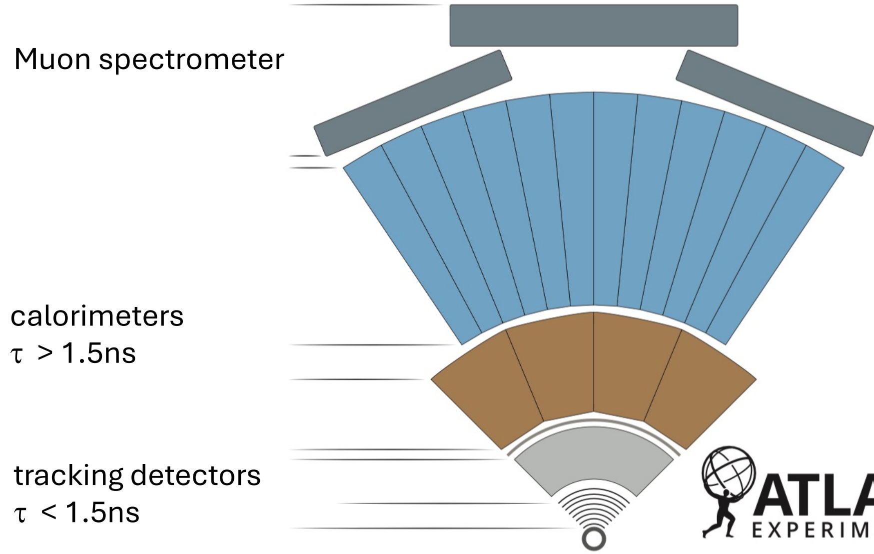


Higgs



ALP





- Improves bounds by a factor of **10 - 40** compared to previous search (same dataset) thanks to new tracking algorithms.

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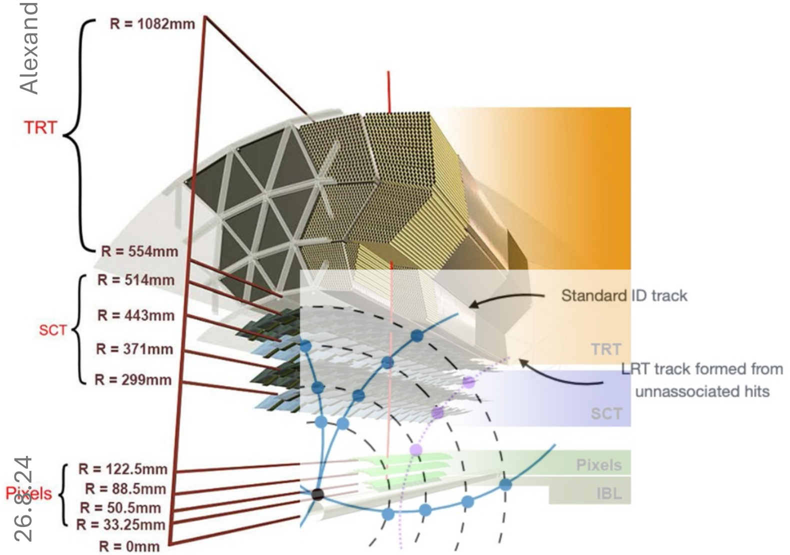
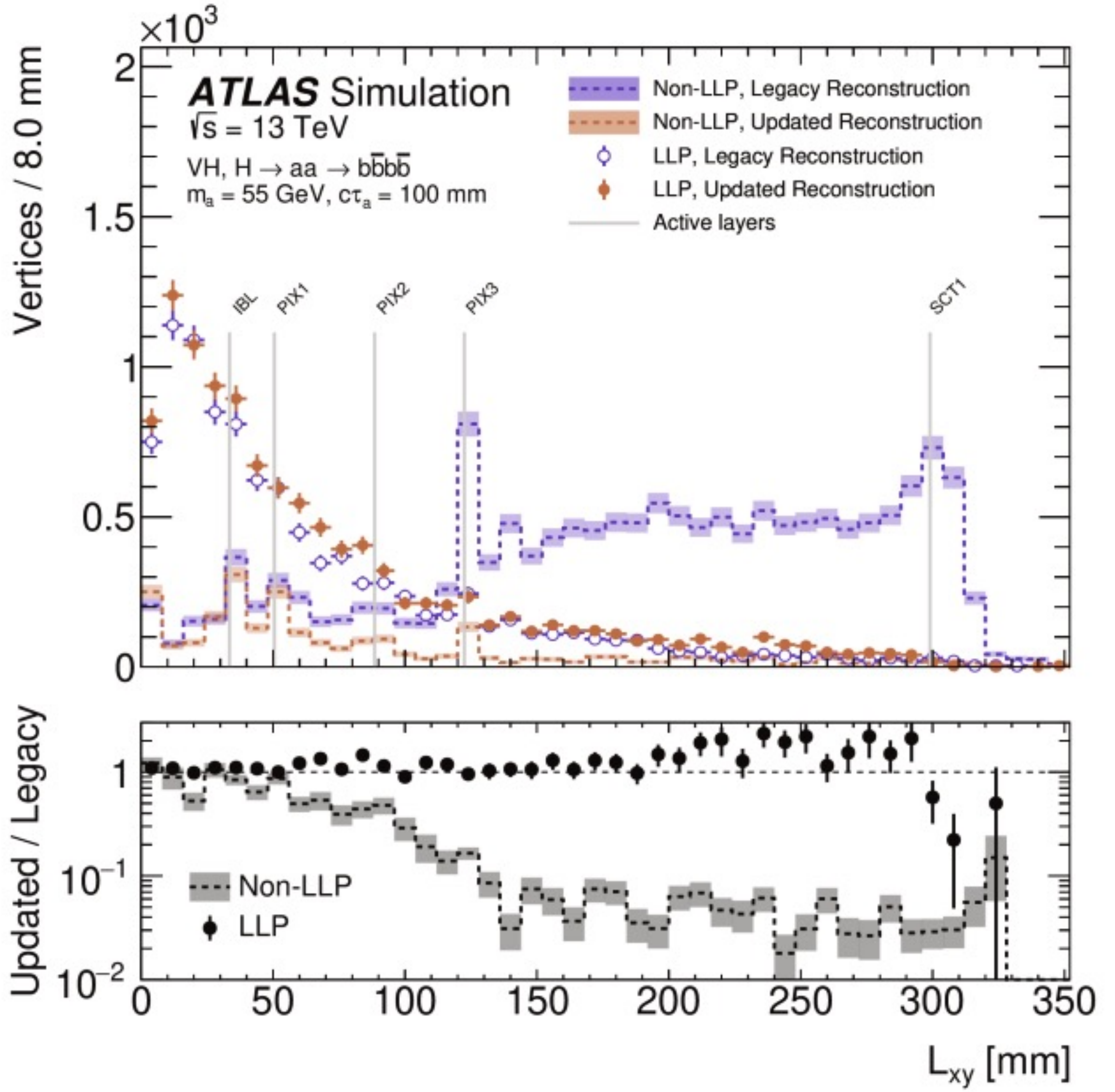
Alexander Oh, Corfu 2024

e-print arXiv:2403.15332

Higgs as a portal

- Use of dedicated and improved tracking algorithm (**Large Radius Tracking**).
  - Runs on all events (previously only on 10%, CPU limited).

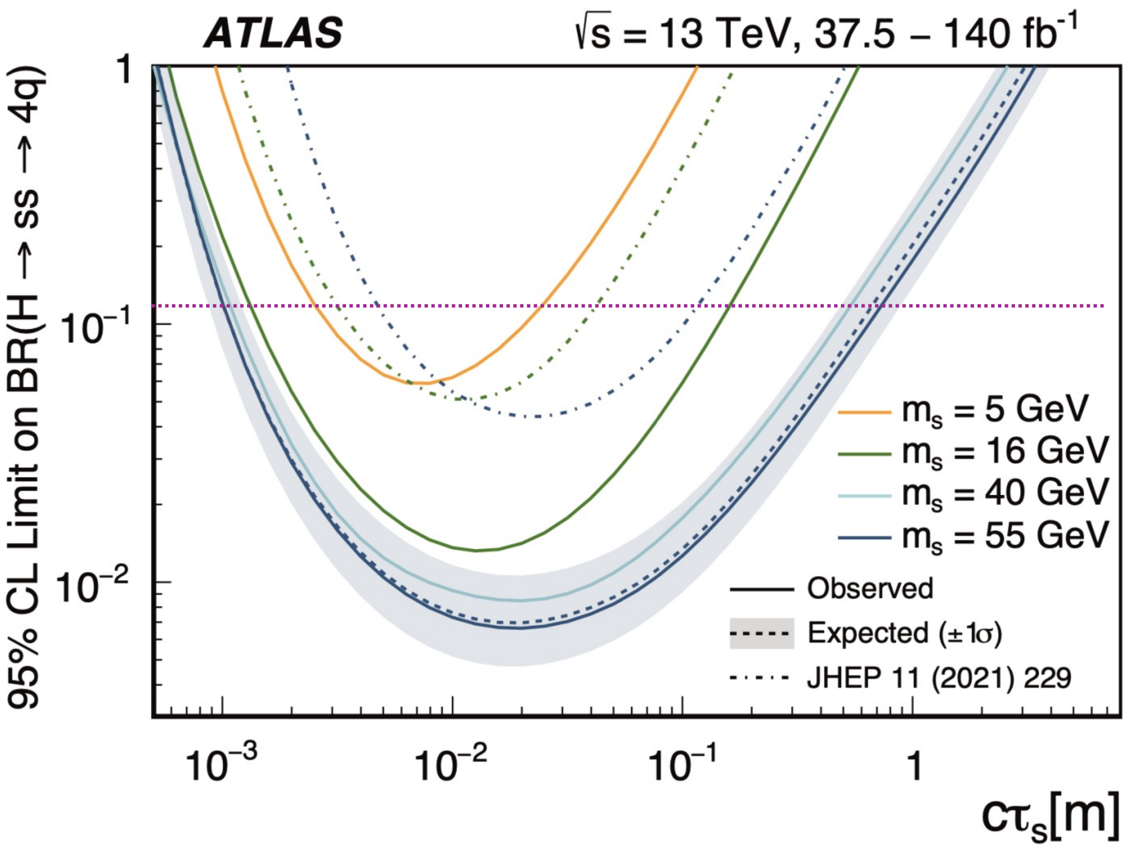




https://doi.org/10.1140/epjc/s10052-023-12024-6

Higgs as a portal

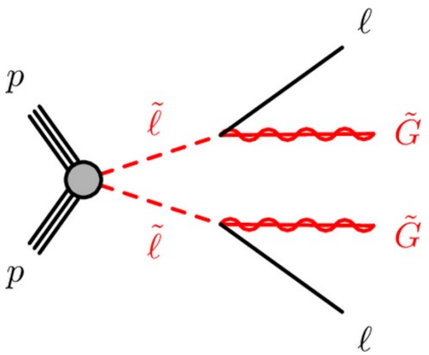
- No LLP's discovered, but bounds **improved by factor 10-40** compared to previous result using the same data.
- First time bounds for low LLP masses (less than 16 GeV) **surpassed** bounds from direct searches for exotic Higgs-boson decays to undetected states*.



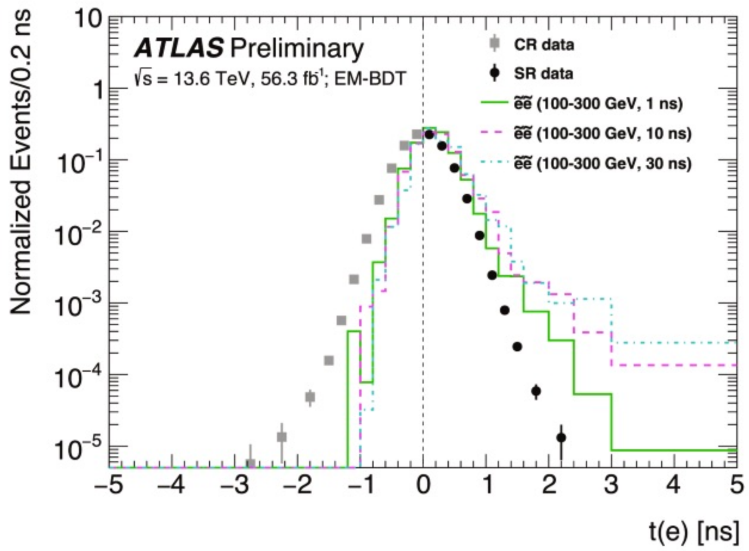
*Nature 607, 52–59 (2022)

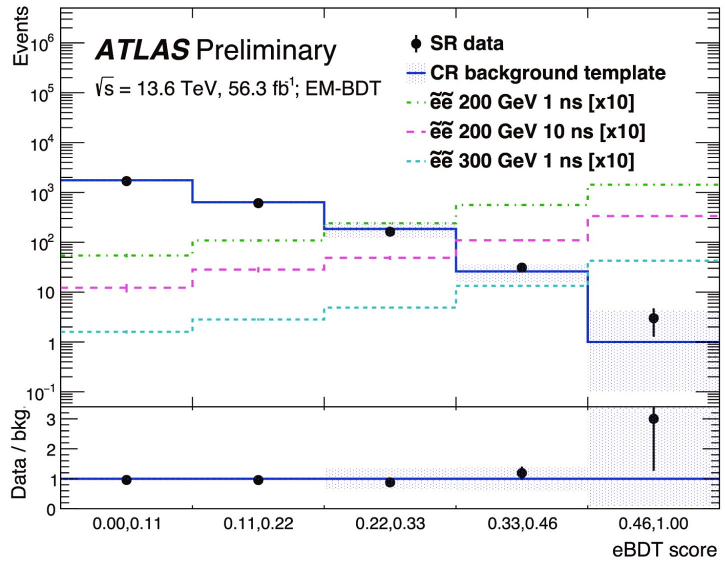
e-print ATLAS-CONF-2024-011

LLP: Displaced leptons run-2+3 analysis



- LLP flight time can **delay** decay leptons.
- Calorimeter **precision timing** used to search for LLPs.
- **O(200ps)** resolution for e/γ.
- BDT defines discriminant (exploit timing asymmetry).
  - Train on data with $ToF_{cal} < 0$, signal $ToF_{cal} > 0$ to predict scores in $ToF_{cal} > 0$ data.
  - BDT validated with SM W/Z events.





MANCHESTER 1824 e-print ATLAS-CONF-2024-011

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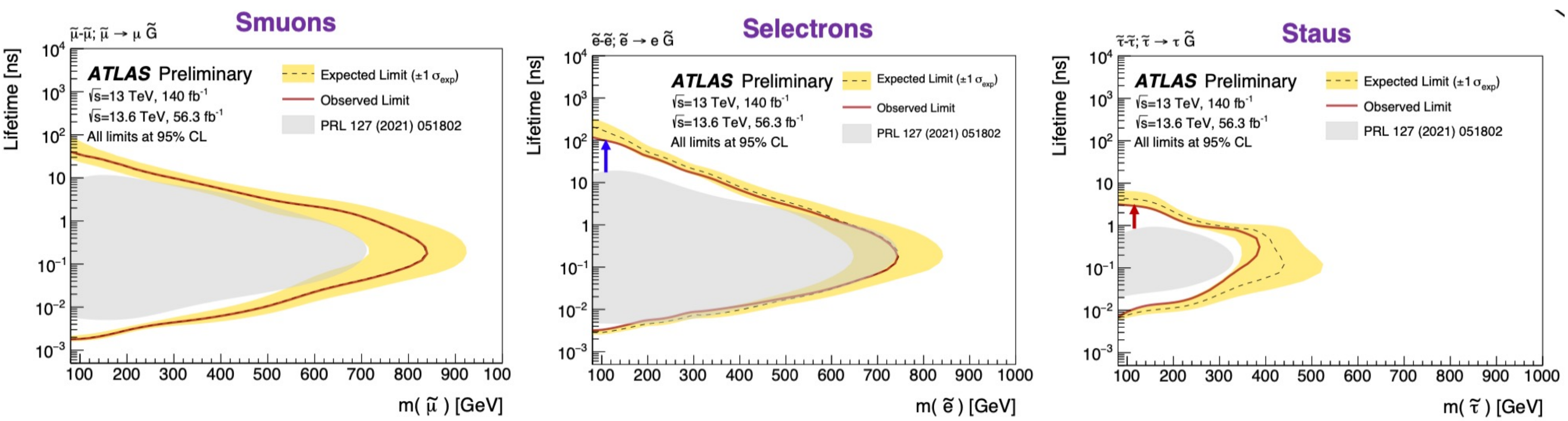
LLP: Displaced leptons run-2+3 analysis

Calorimeter timing

Large Radius Tracking

Increased statistics

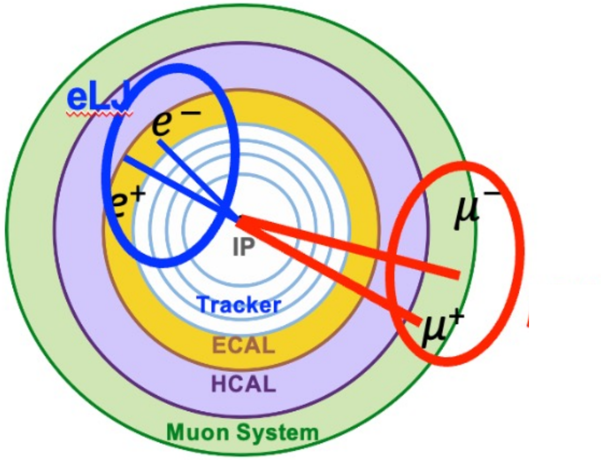
- Combined run-2 and run-3 results
- **Improved sensitivities** for long-lived particle decays:
  ~3x for smuons
  ~5x for selectrons
  ~3x for staus



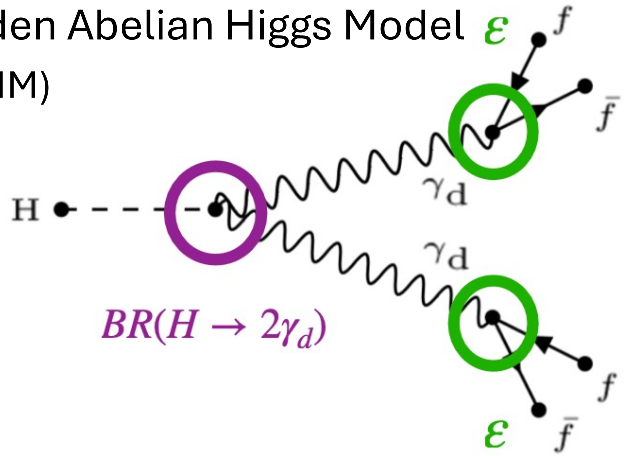
e-print arXiv:2407.09168

Dark Photons

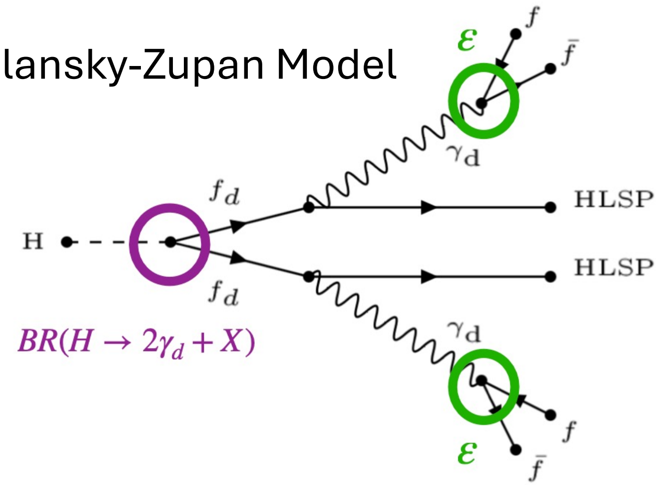
- Search dark photons promptly decaying into lepton jets.
- Target intermediate mass range O(10MeV)- O(10GeV).
- Signature: Narrow jets of electrons or muons.
- Consider two models:



Hidden Abelian Higgs Model (HAHM)



Falkowski-Ruderman-Volansky-Zupan Model (FRVZ)

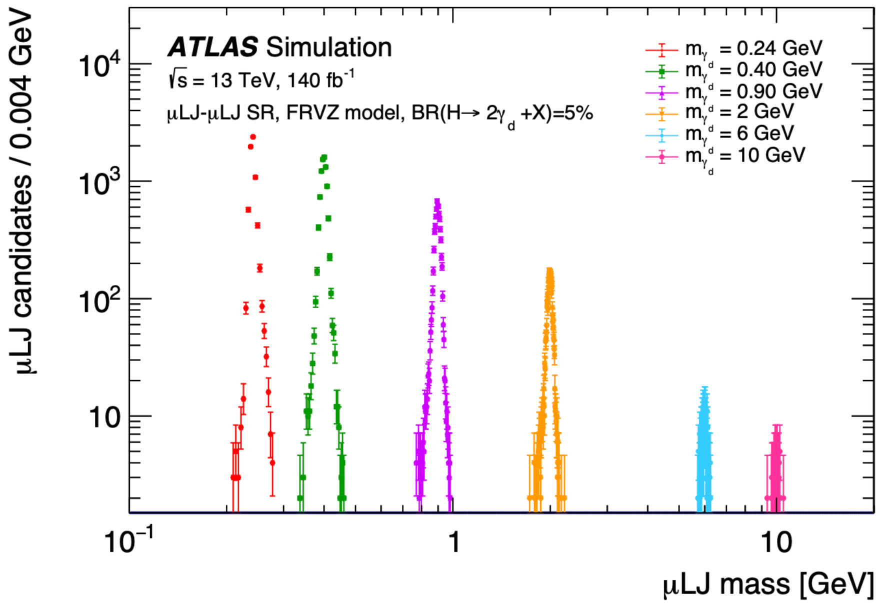


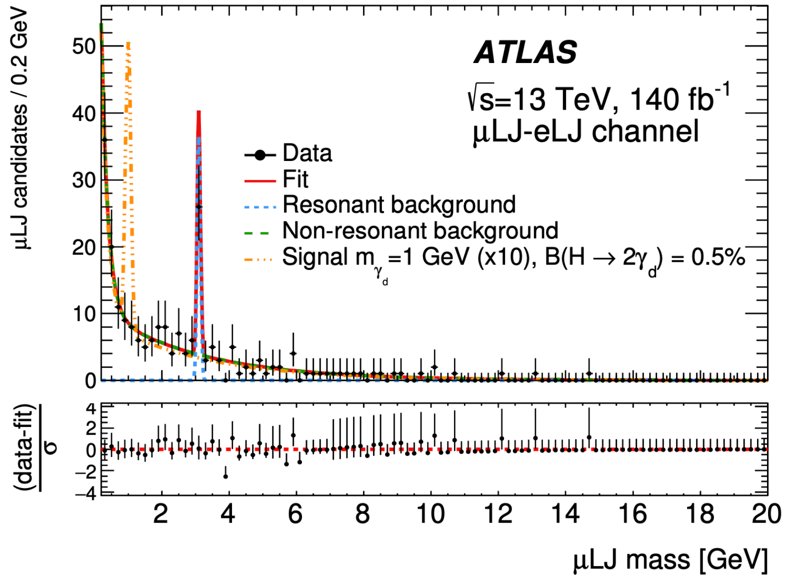
MANCHESTER 1824 e-print arXiv:2407.09168

The University of Manchester

Dark Photons

- Improvements of run-2 analysis over previous run-1
  - More data (20.3 fb^{-1} vs 140 fb^{-1})
  - Extended mass range up to 10 GeV.
  - Better constraint on $B(H \rightarrow 2\gamma_D + X)$ with analytical background description.

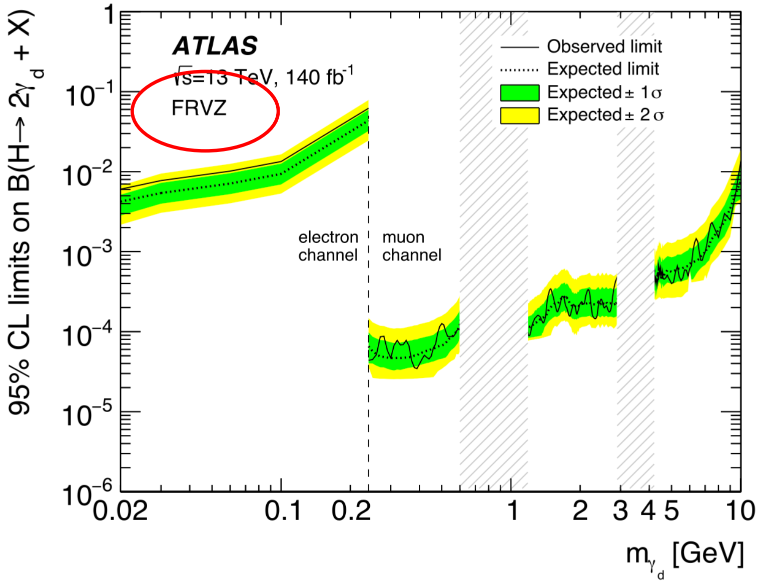


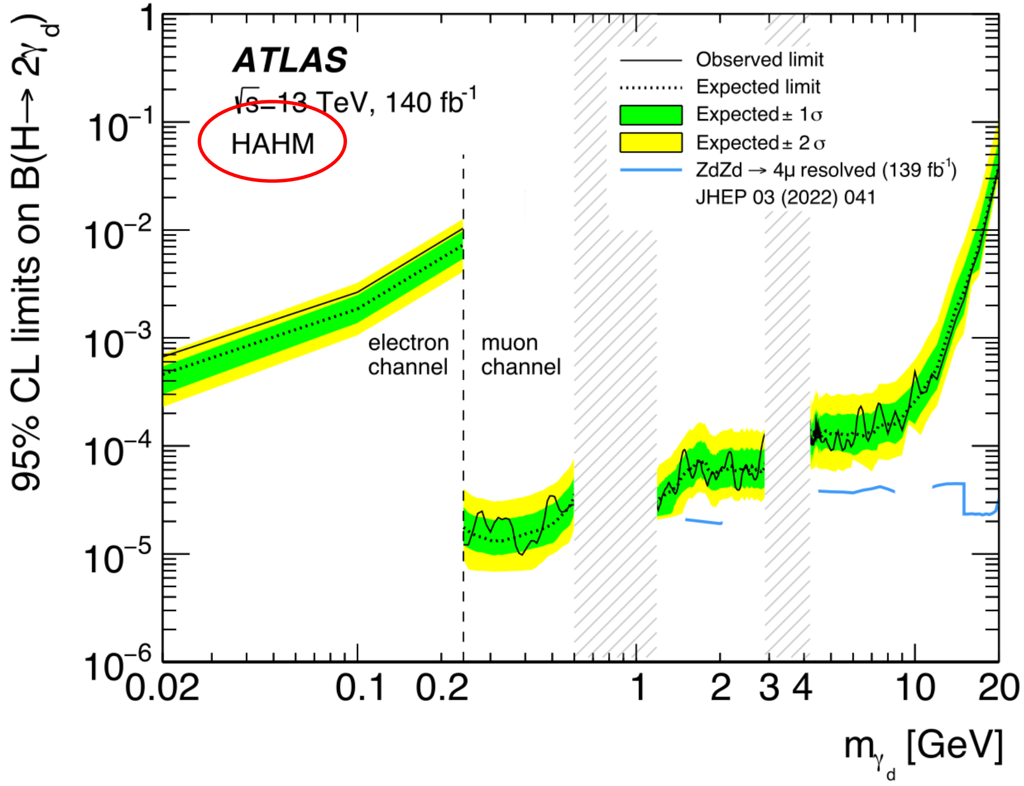


e-print arXiv:2407.09168

Dark Photons

- No significant deviation from SM expectation observed.
- 95% CL limits on Higgs decay to dark photons are derived.

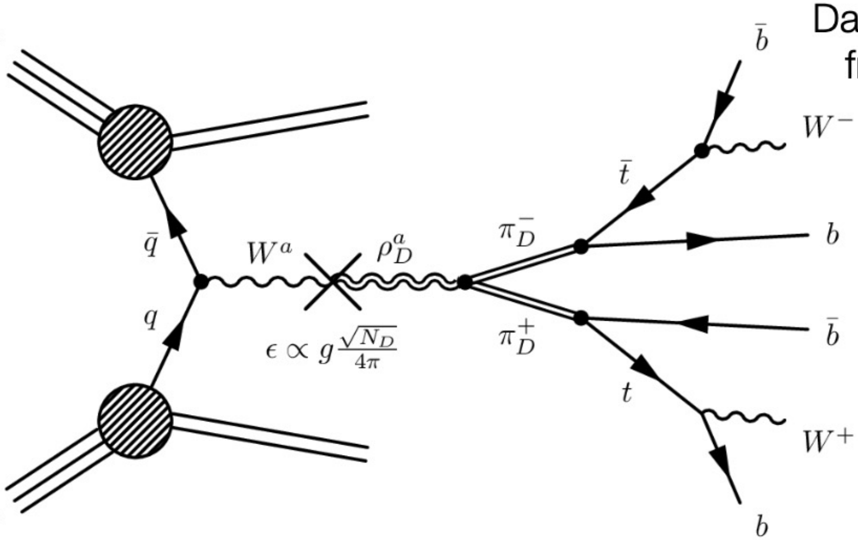




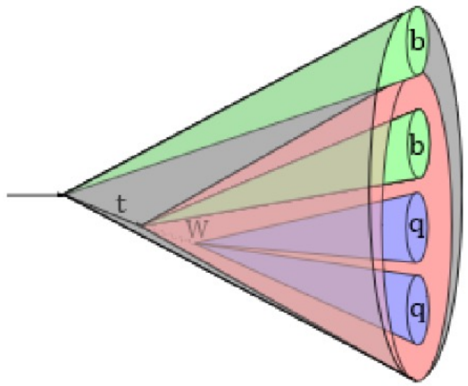
- Known resonance regions are masked out (J/Ψ, $\psi(2D)$, $\varphi(1020)$, ρ)

Dark mesons decaying to top and bottom quarks

- **First search of this kind at the LHC.**
- Simplified Stealth Dark Matter model
- Search for **dark pions π_D** from dark rhos ρ_D
- Decay parametrised with $\eta = m(\pi_D) / m(\rho_D)$



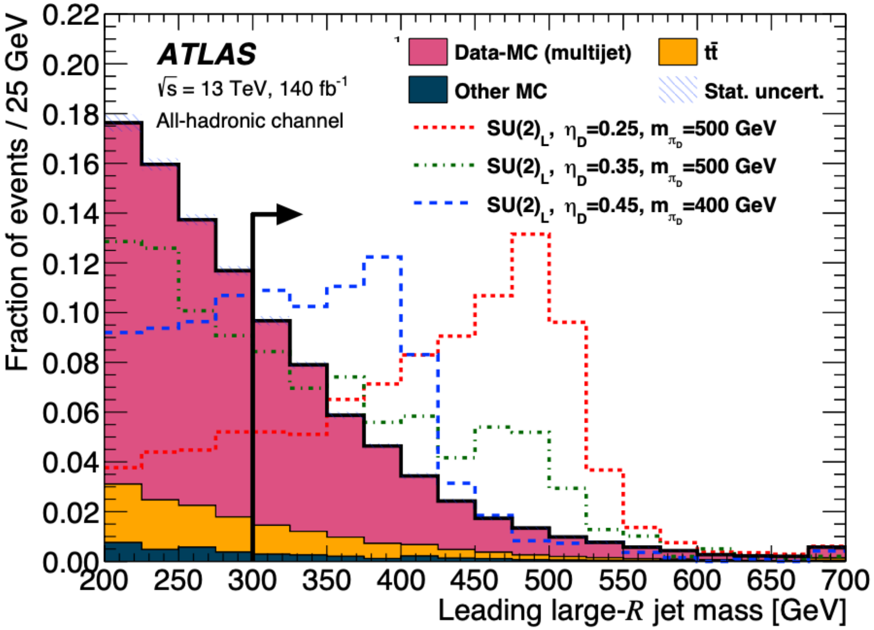
Dark pions: large-R jets (R=1.2) from R=0.4 jets reclustering



e-print arXiv:2405.20061

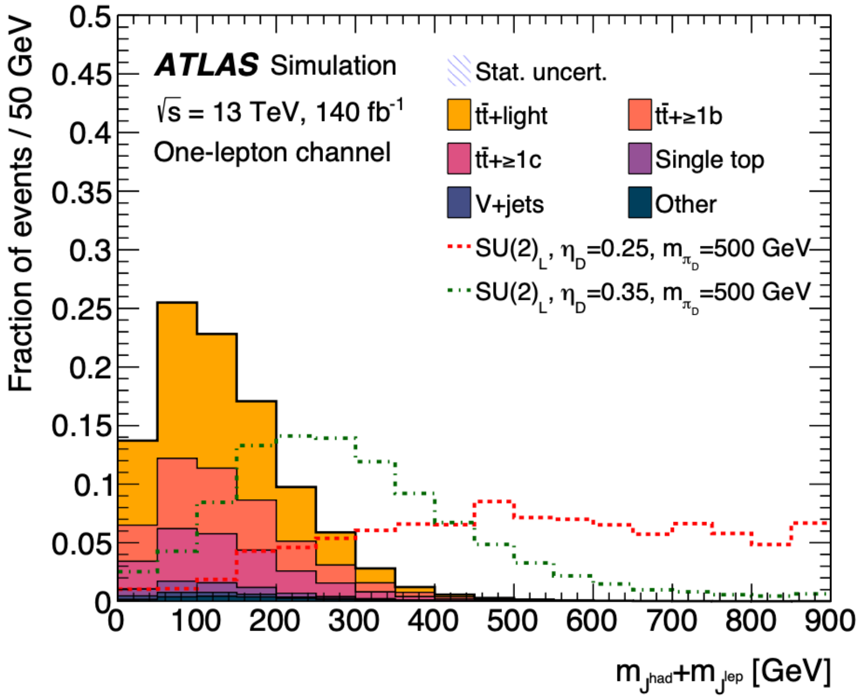
Dark mesons decaying to top and bottom quarks

Hadronic channel



Fit on 9 SR's , defined by leading and sub-leading large-R jet mass

Leptonic channel

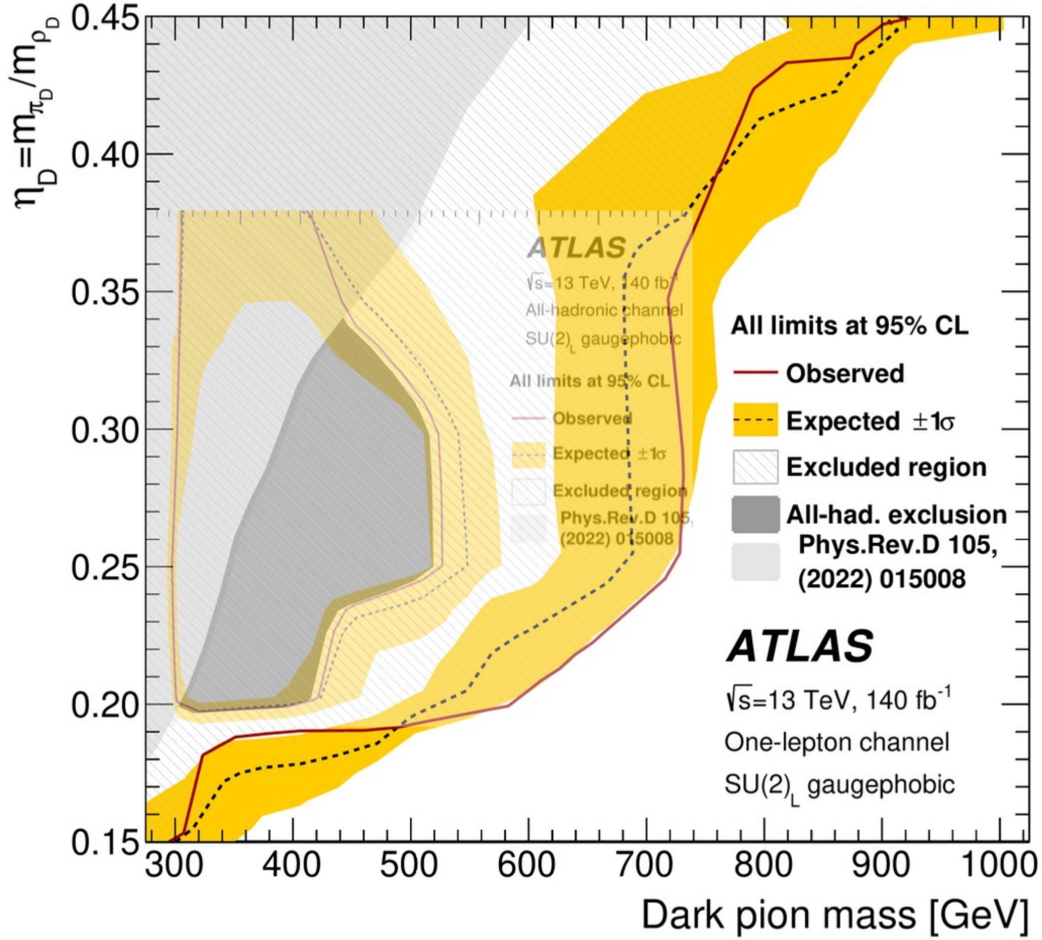


Fit in bins of (b-)jet multiplicities on sum of jet and jet+lepton mass.

e-print arXiv:2405.20061

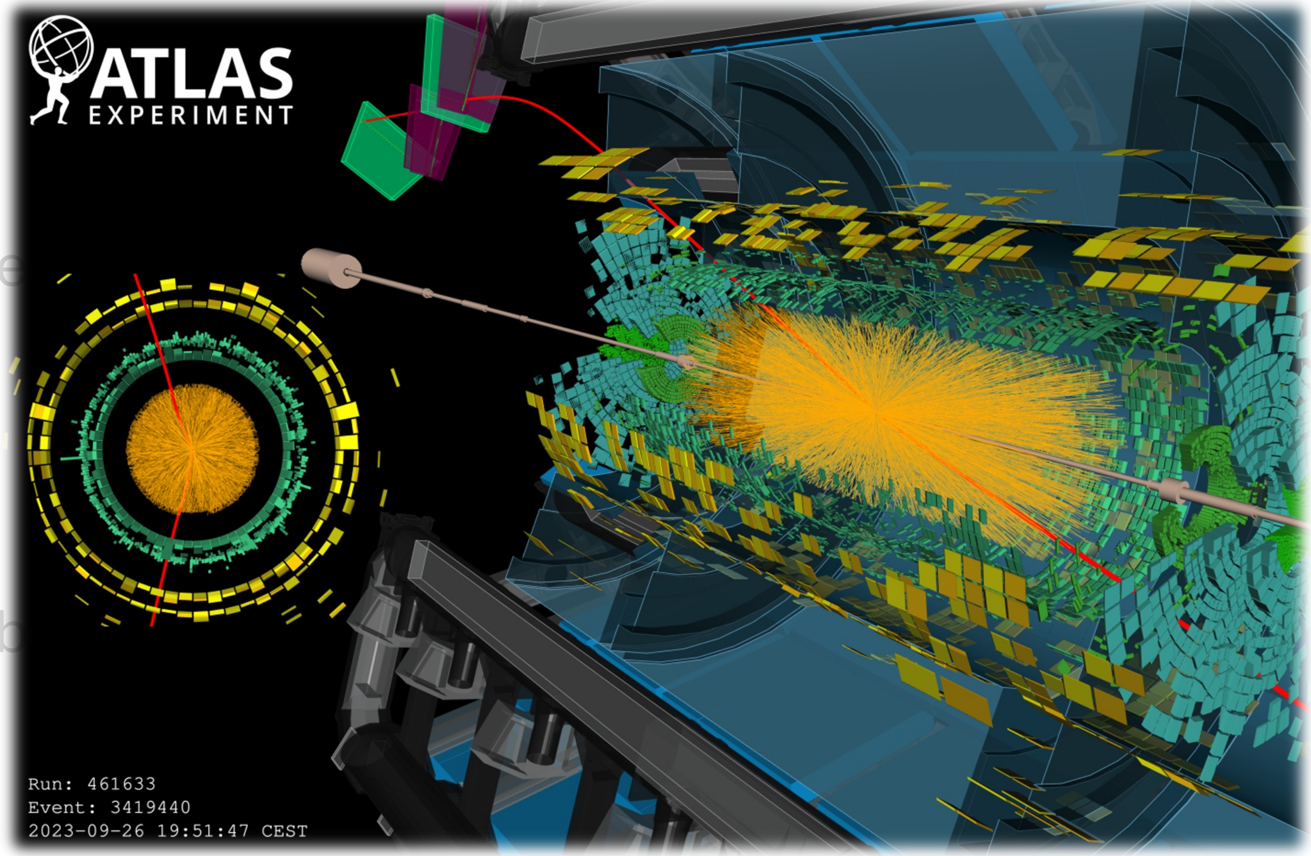
Dark mesons decaying to top and bottom quarks

- Hadronic channel less sensitive than leptonic channel.
- No excess observed, thus exclusion limits set in the plane η–m(π_D)
- **Most stringent limits at LHC todate.**



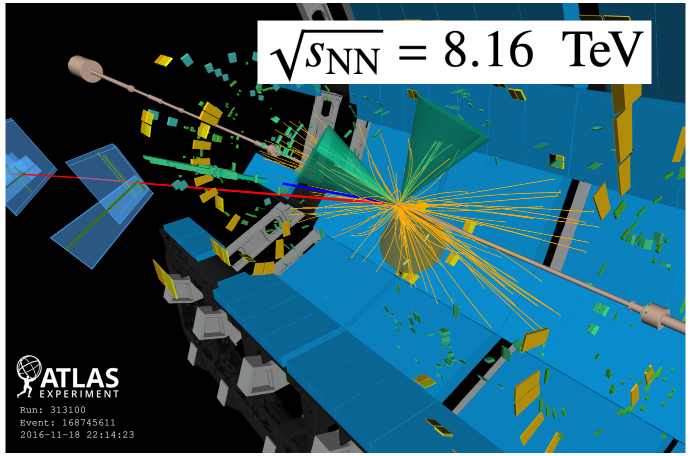
Content

- ATLAS in run-3
- EW Precision measure
- Multi-boson
- Higgs
- Top
- Searches for physics b
- **Heavy Ion**
- Summary

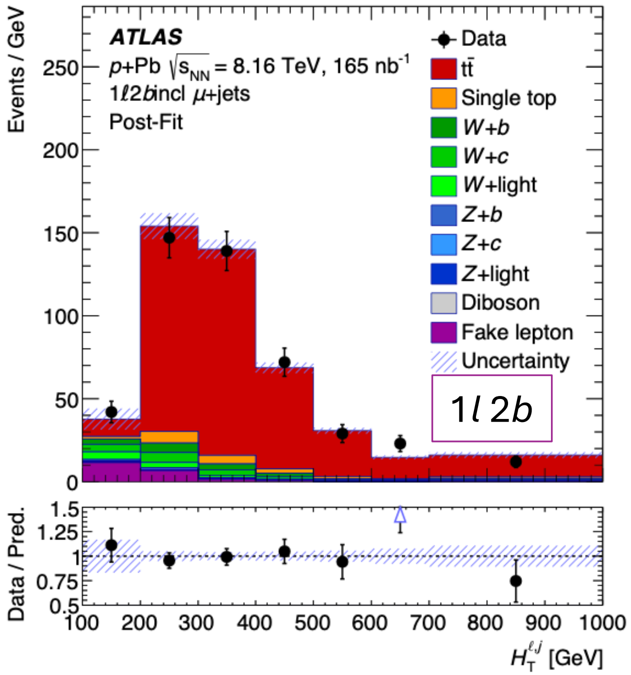


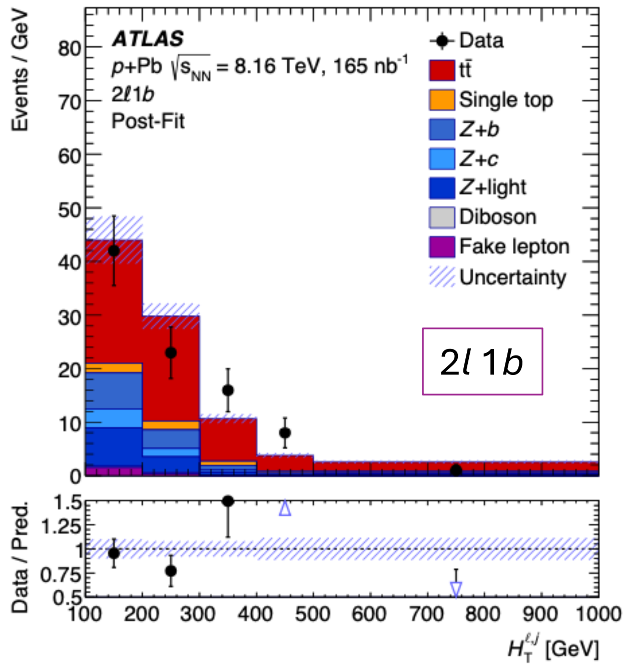
MANCHESTER 1824 e-print arXiv:2405.05078

$t\bar{t}$ production in p+Pb



- top quarks probe the **nPDF** (nuclear parton distribution function).
- Important input for extracting **QGP properties** from Pb+Pb data.
- Combination of single and di-lepton (new!) channel.





MANCHESTER 1824 e-print arXiv:2405.05078

$\sqrt{s_{\mathrm{NN}}} = 8.16$ TeV

$t\bar{t}$ production in p+Pb

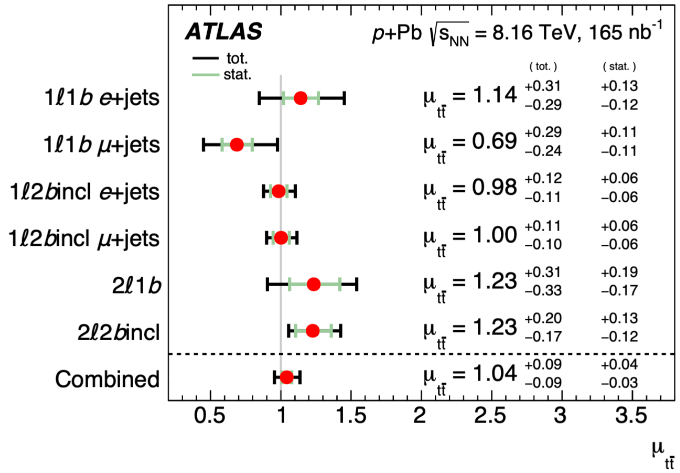
- First observation of $t\bar{t}$ production in di-lepton channel in p+Pb.
- Measured combined cross section:

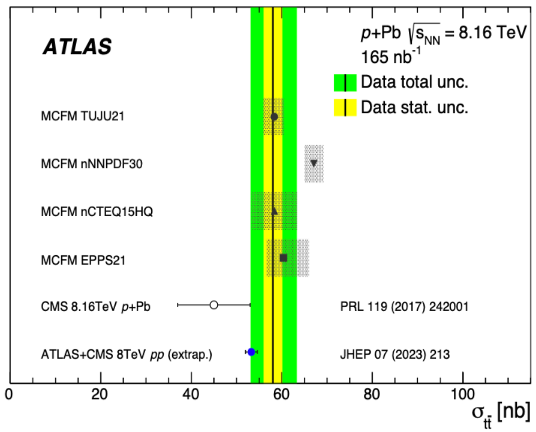
$$\sigma_{t\bar{t}} = 58.1 \pm 2.0\ (\text{stat.})\ ^{+4.8}_{-4.4}\ (\text{syst.})\ \text{nb}$$

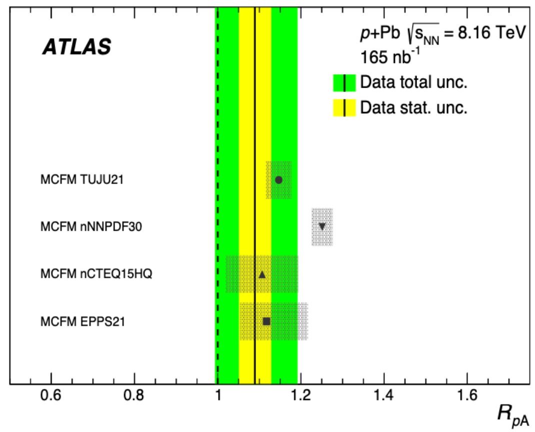
- Nuclear modification:

$$R_{p\mathrm{A}} = 1.090 \pm 0.039\ (\text{stat.})\ ^{+0.094}_{-0.087}\ (\text{syst.})$$

- Good agreement with SM expectation for different PDFs.
- Limited by systematics.



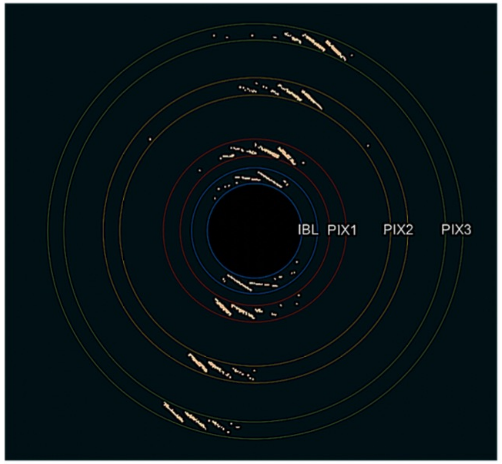




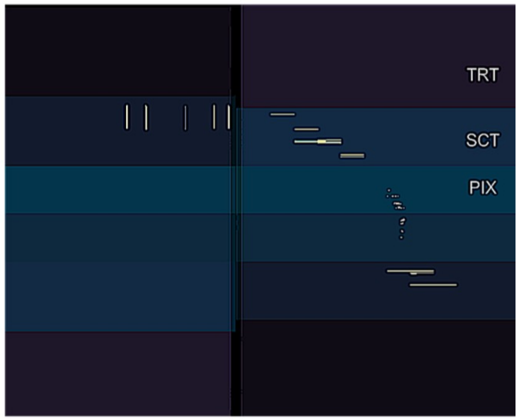
e-print ATLAS-CONF-2024-009

Heavy ion physics: monopoles

- **Ultraperipheral** (UPC) **Pb+Pb** collisions provide **quasi-real photons**, flux scaling with Z^2
  - High luminosity photon-photon collider.
- Use UPC to search for magnetic monopole (MM) pair production
  - Occurs in strong magnetic fields via the Schwinger mechanism
  - MM track is parabolic in r-Z and a straight line in r-ϕ, creates high ionisation density.
  - Look for high pixel activity without associated reconstructed tracks.



r-ϕ view



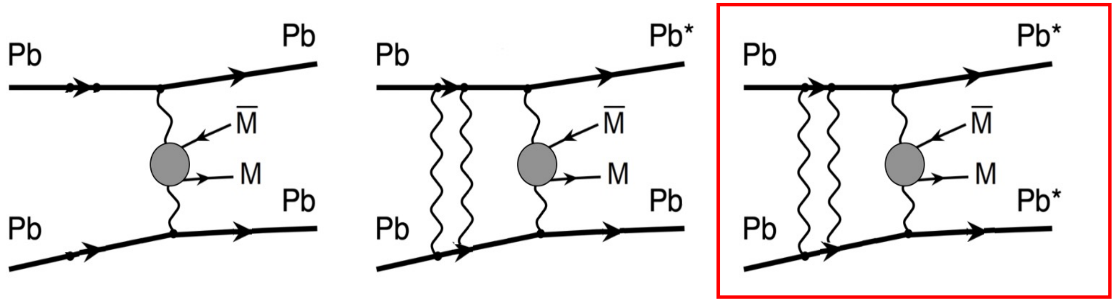
r-Z view

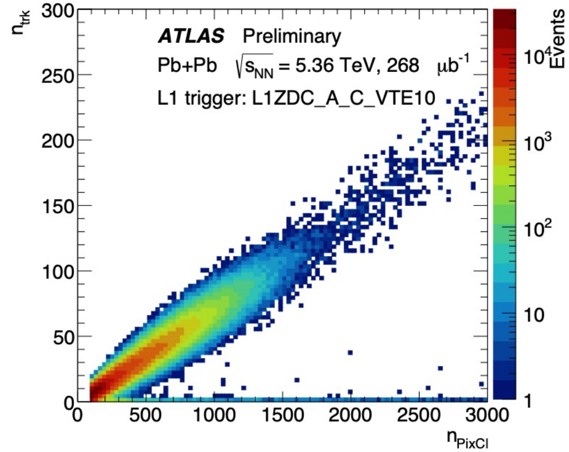
e-print ATLAS-CONF-2024-009

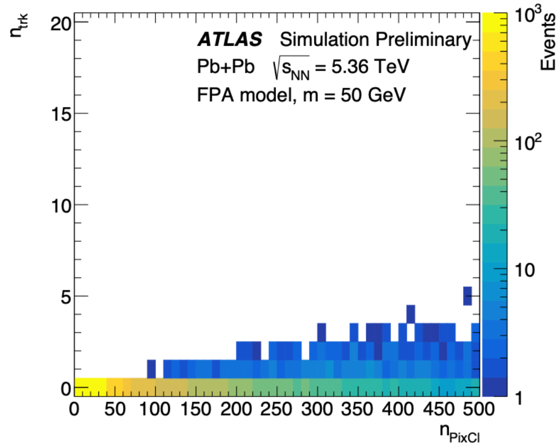
Heavy ion physics: monopoles

2023 Pb+Pb data-set at
sqrt(s_{NN}) = 5.36 TeV, 1.6 nb^{-1}
First ATLAS study using run-3 Pb+Pb data

- Difficult to trigger on MM signature.
- Use Zero Degree Calorimeter to trigger on events with neutrons in both arms of the calorimeter from EM breakup of both Pb.
  - High trigger rate, need to pre-scale by factor 6.

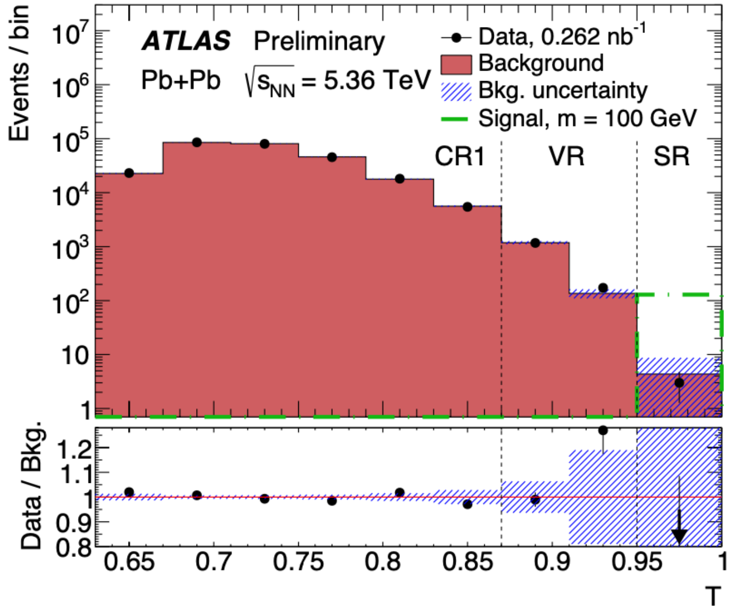


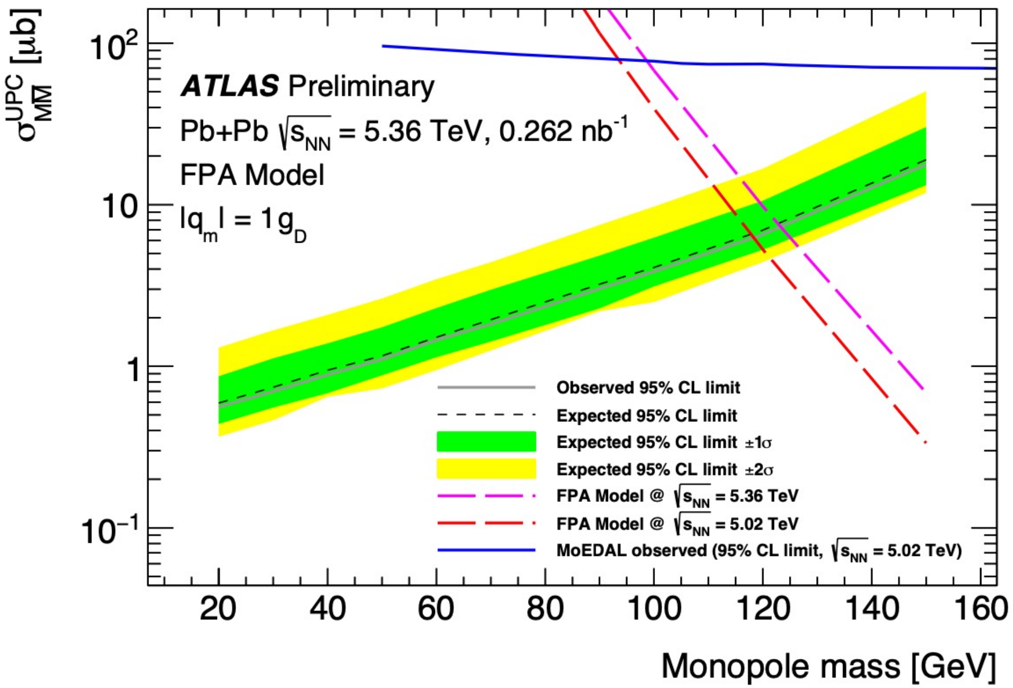




e-print ATLAS-CONF-2024-009

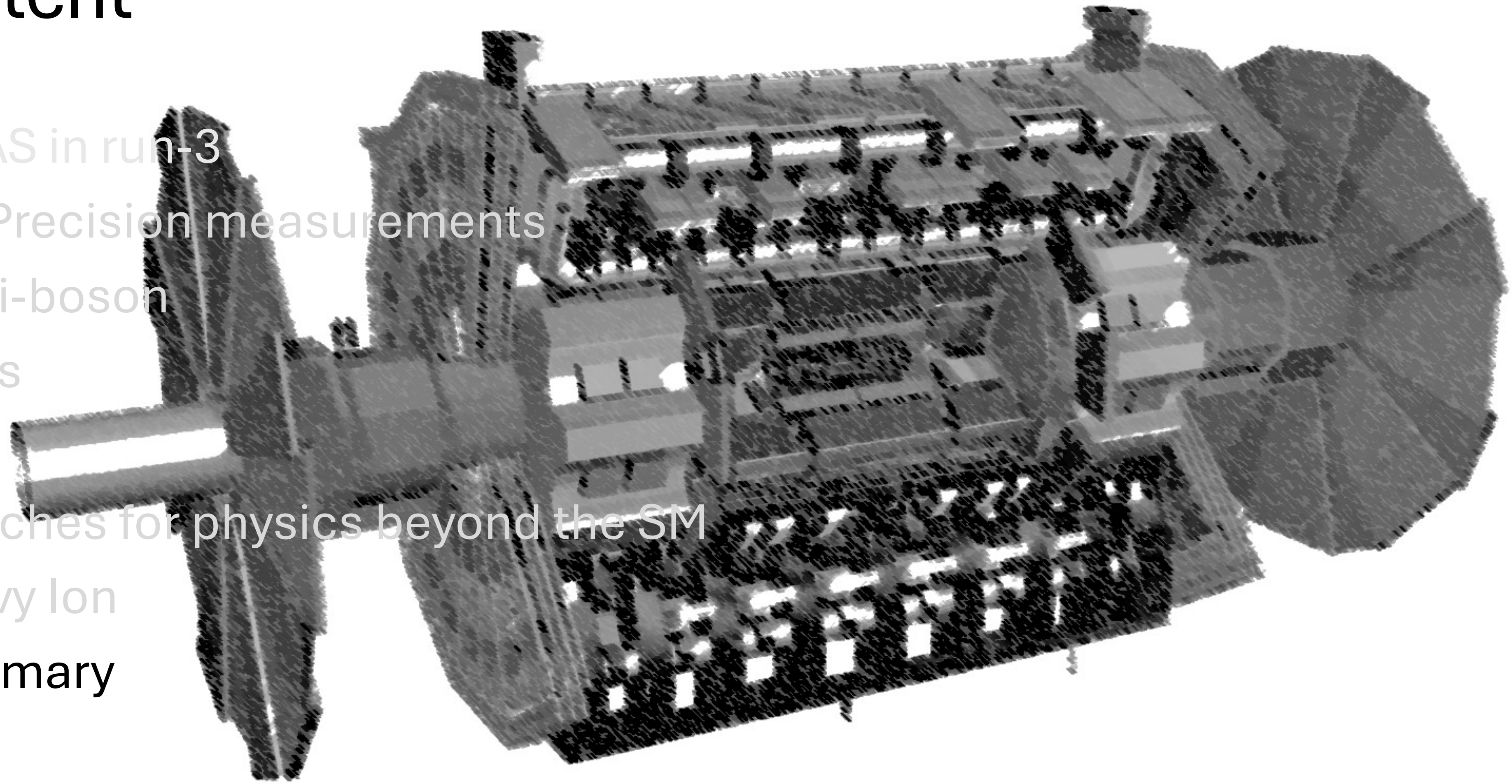
- **Observed 3 events**, consistent with background estimate of 4 ± 4 events.
- Better sensitivity compared to recent MoEDAL measurement.
- **Excluded** magnetic monopoles with **mass < 120 GeV**





$$T = \frac{1}{n_{PixCL}} \sum_{i=i}^{n_{PixCL}} |\hat{r}_i \cdot \hat{n}|$$

Content



- ATLAS in run-3
- EW Precision measurements
- Multi-boson
- Higgs
- Top
- Searches for physics beyond the SM
- Heavy Ion
- Summary

Summary

- Presented a few recent results of ATLAS
  - Corfu 2024 has more detailed talks on ATLAS results (see next slide).
  - Could only select a few of the 126 publications since Corfu 2023.
- Run-2 analysis are wrapping up.
  - Re-visiting data with improvements in analysis techniques.
  - Still a lot to gain from run-2 data.
- **First Run-3 analysis results**
- **ATLAS has achieved great improvements in performance of detector and trigger, reconstruction, and analysis techniques.**
- Data taking in full swing, stay tuned.

Some ATLAS related talks

- 12. Recent Higgs results from ATLAS and CMS
  Sandra Kortner (Max Planck Society (DE))
  27/08/2024, 09:00
- 60. W mass measurements and prospects
  Maarten Boonekamp (Université Paris-Saclay (FR))
  29/08/2024, 12:00
- 86. SUSY in ATLAS and CMS
  Yuya Mino (Kyoto University (JP))
  28/08/2024, 12:30
- 93. Dark matter in ATLAS and CMS
  Xinhui Huang (Chinese Academy of Sciences (CN))
  31/08/2024, 09:00
- 97. Exotics and BSM (non SUSY, non DM) in ATLAS and CMS
  Andrea Perrotta (INFN Bologna)
  28/08/2024, 13:00

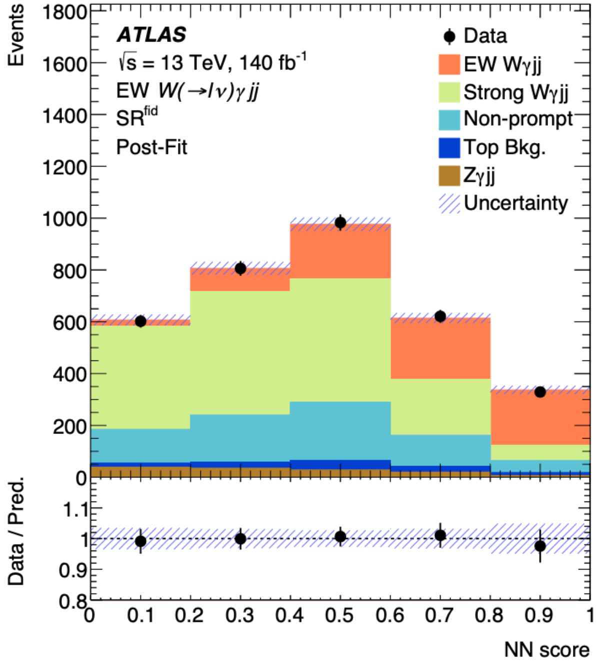
EXTRA

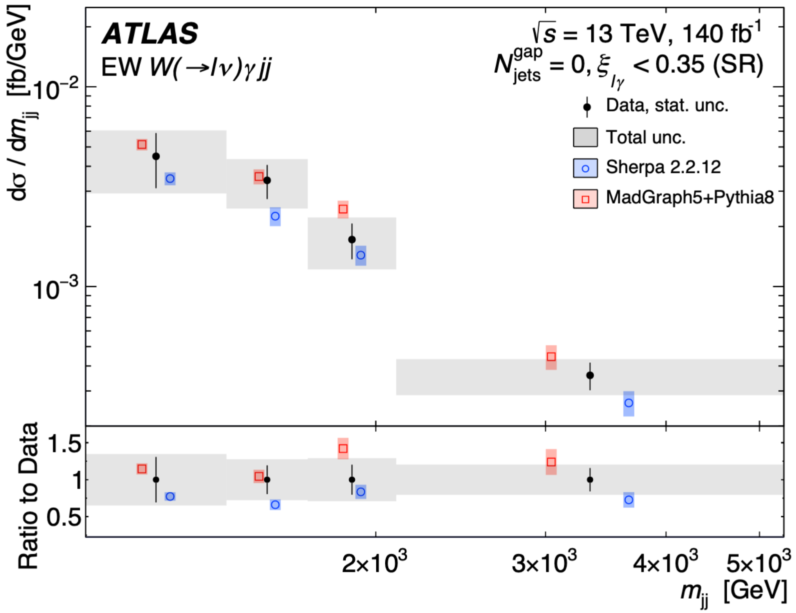
The University of Manchester

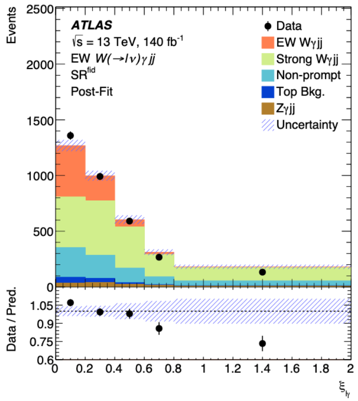
e-print arXiv:2403.02809

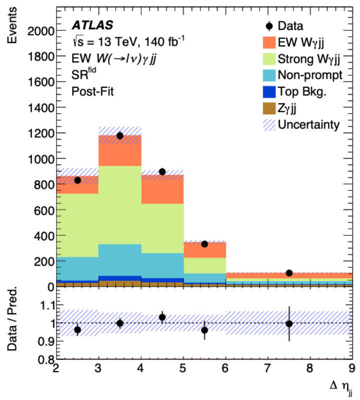
VBS: Wγ

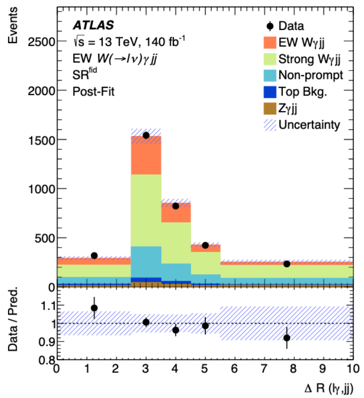
- NN trained for **EW signal** separtion, highest ranking variables:
  - lepton-photon centrality
  - pseudo-rapidity difference of jets
  - Angular distance of jj and lγ system.











- Measured fiducial cross section σ_{EW}**=13.2±2.5 fb** signal strengt μ_{EW}**=1.5±0.5**
- Unfolded differential measurement at m_{jj}>1TeV

MANCHESTER 1824 e-print [arXiv:2403.15332](https://arxiv.org/abs/2403.15332)

Higgs as a portal

- No LLP's discovered, but bounds **improved by factor 10-40** compared to previous result using the same data.
- First time bounds for low LLP masses (less than 16 GeV) **surpassed** bounds from direct searches for exotic Higgs-boson decays to undetected states.

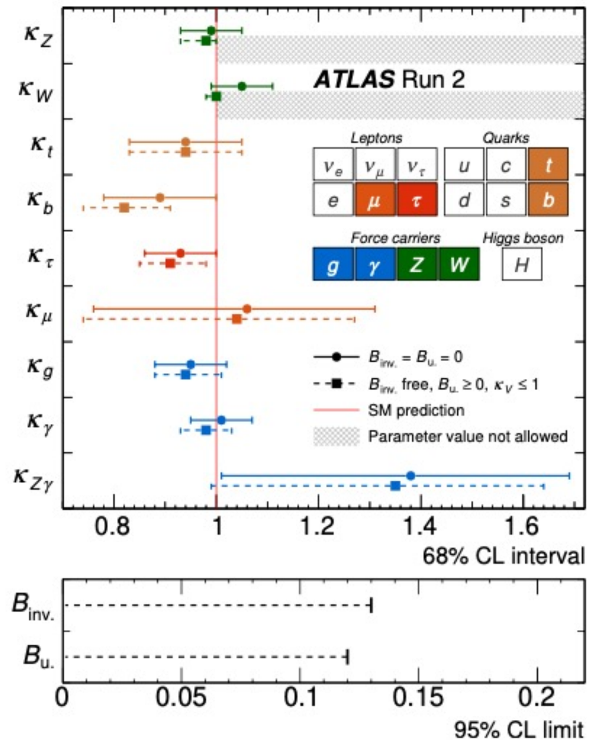
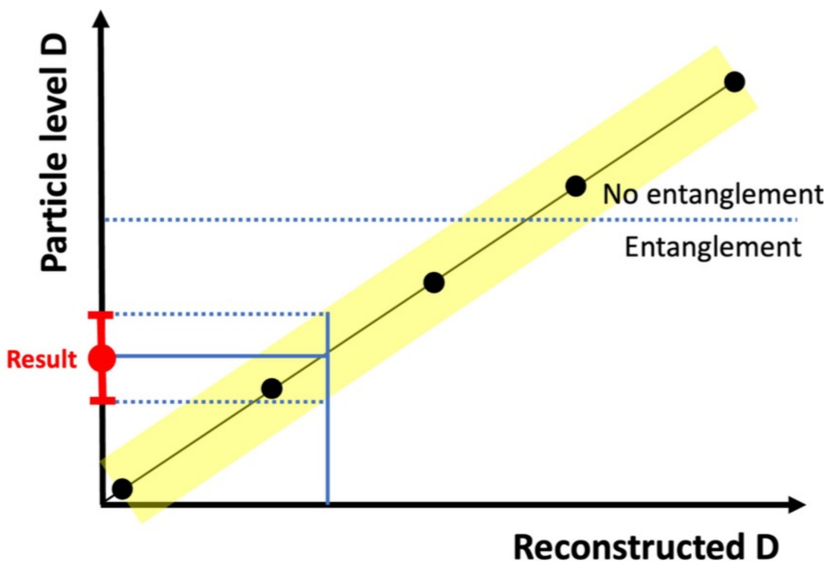
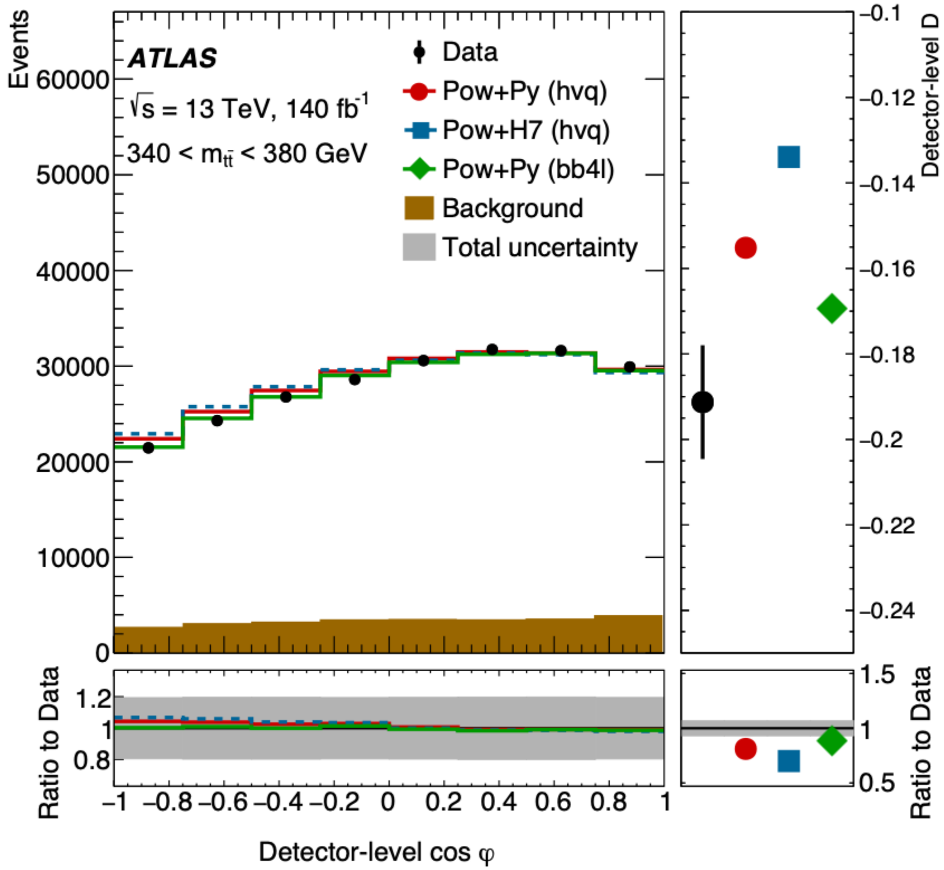


Figure 6: **Reduced coupling strength modifiers and their uncertainties per particle type with effective photon, $Z\gamma$ and gluon couplings.** The horizontal bars on each point denote the 68% confidence interval. The scenario where $B_{inv.} = B_{u.} = 0$ is assumed is shown as solid lines with circle markers. The p-value for compatibility with the SM prediction is 61% in this case. The scenario where $B_{inv.}$ and $B_{u.}$ are allowed to contribute to the total Higgs boson decay width while assuming that $\kappa_V \leq 1$ and $B_{u.} \geq 0$ is shown as dashed lines with square markers. The lower panel shows the 95% CL upper limits on $B_{inv.}$ and $B_{u.}$.

Quantum entanglement with top quarks

- Map fiducial particle level D values from detector level via Monte Carlo calibration curve.





e-print arXiv:2405.05078

$\sqrt{s_{NN}} = 8.16$ TeV

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- First observation of $t\bar{t}$ production in di-lepton channel in p+Pb.
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$$\sigma_{t\bar{t}} = 58.1 \pm 2.0 \text{ (stat.) } {}^{+4.8}_{-4.4} \text{ (syst.) nb}$$

- Nuclear modification:

$$R_{pA} = 1.090 \pm 0.039 \text{ (stat.) } {}^{+0.094}_{-0.087} \text{ (syst.)}$$

- Good agreement with SM expectation for different PDFs.
- Limited by systematics.

Source	$\Delta\sigma_{t\bar{t}}/\sigma_{t\bar{t}}$ unc. up [%]	unc. dow
Jet energy scale	+4.6	-4.1
$t\bar{t}$ generator	+4.5	-4.0
Fake-lepton background	+3.1	-2.8
Background	+3.1	-2.6
Luminosity	+2.8	-2.5
Muon uncertainties	+2.3	-2.0
W+jets	+2.2	-2.0
b-tagging	+2.1	-1.9
Electron uncertainties	+1.8	-1.5
MC statistical uncertainties	+1.1	-1.0
Jet energy resolution	+0.4	-0.4
$t\bar{t}$ PDF	+0.1	-0.1
Systematic uncertainty	+8.3	-7.6