Muon small wheel - new for Run 3

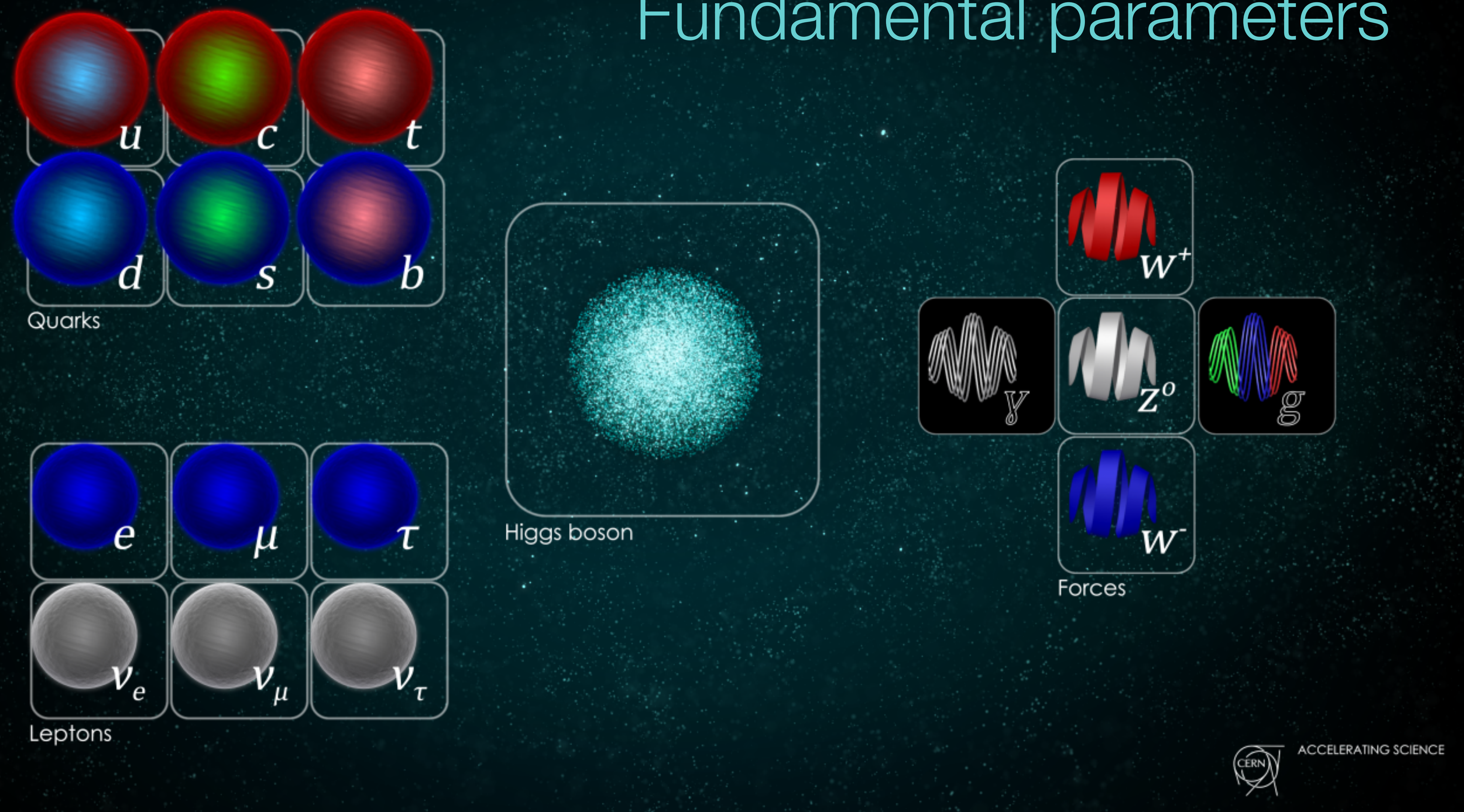
ATLAS EXPERIMENT

ATLAS Highlights

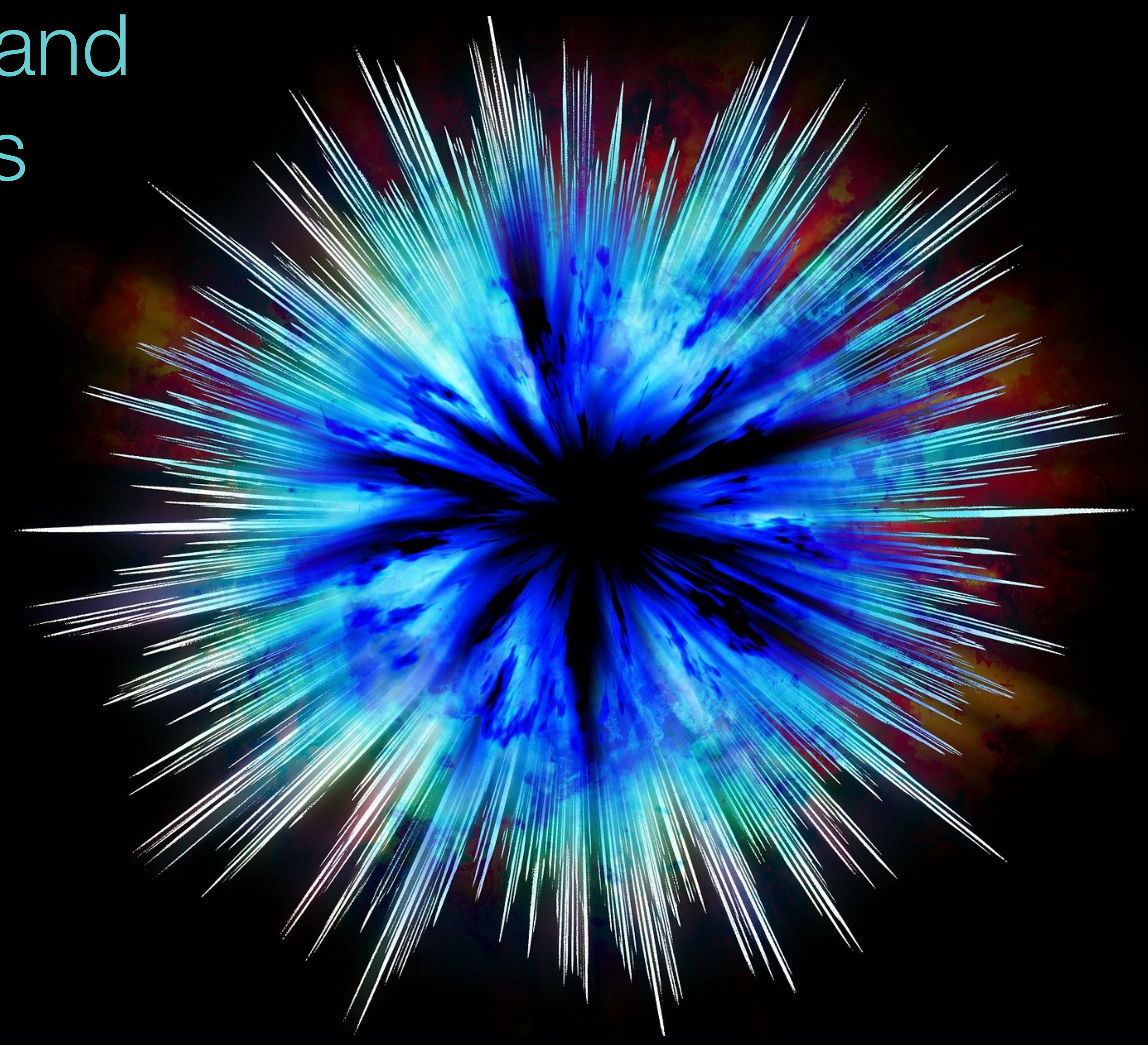
ICHEP 2024

Monica Dunford, Heidelberg University
On behalf of the ATLAS collaboration

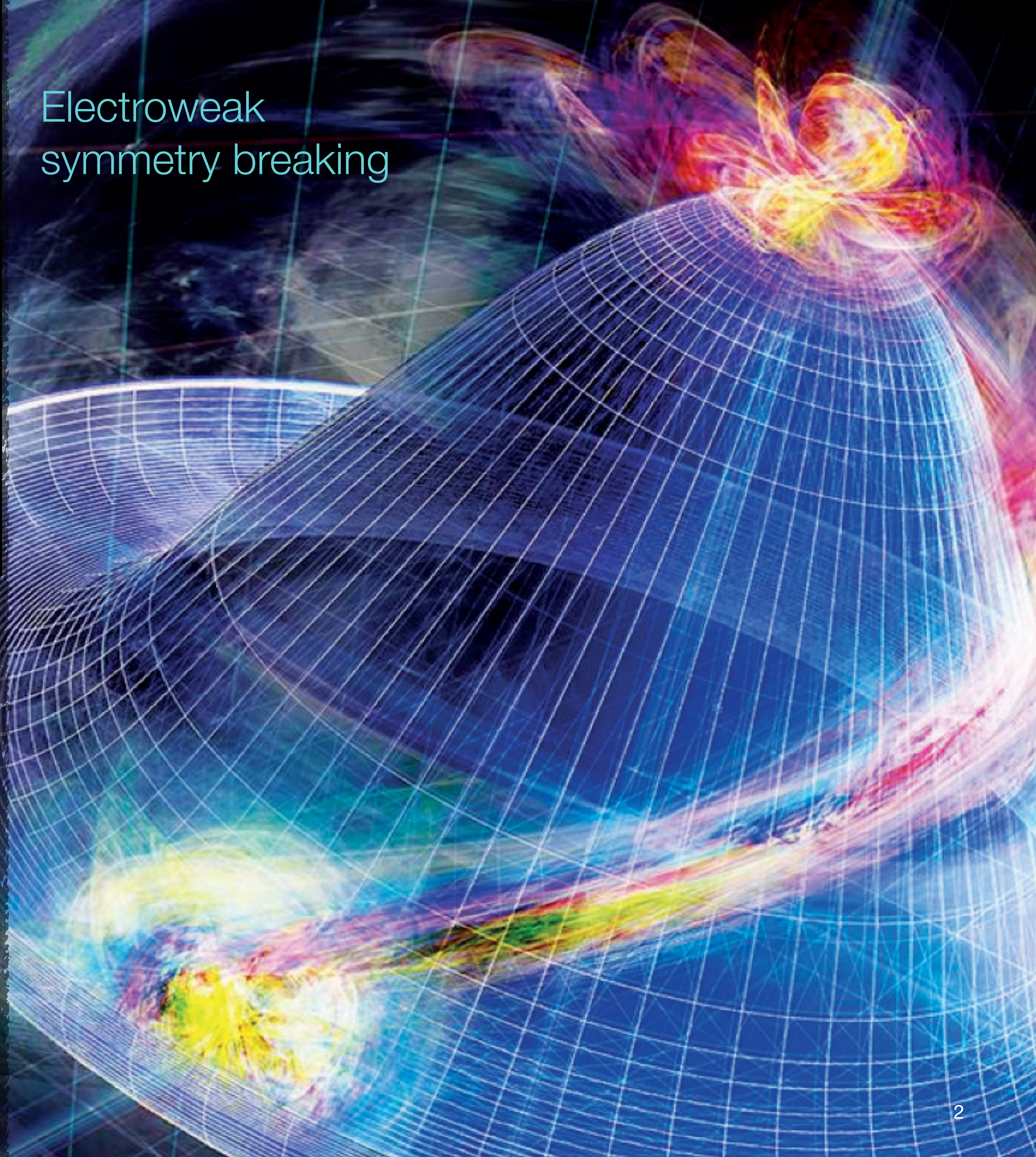
Fundamental parameters

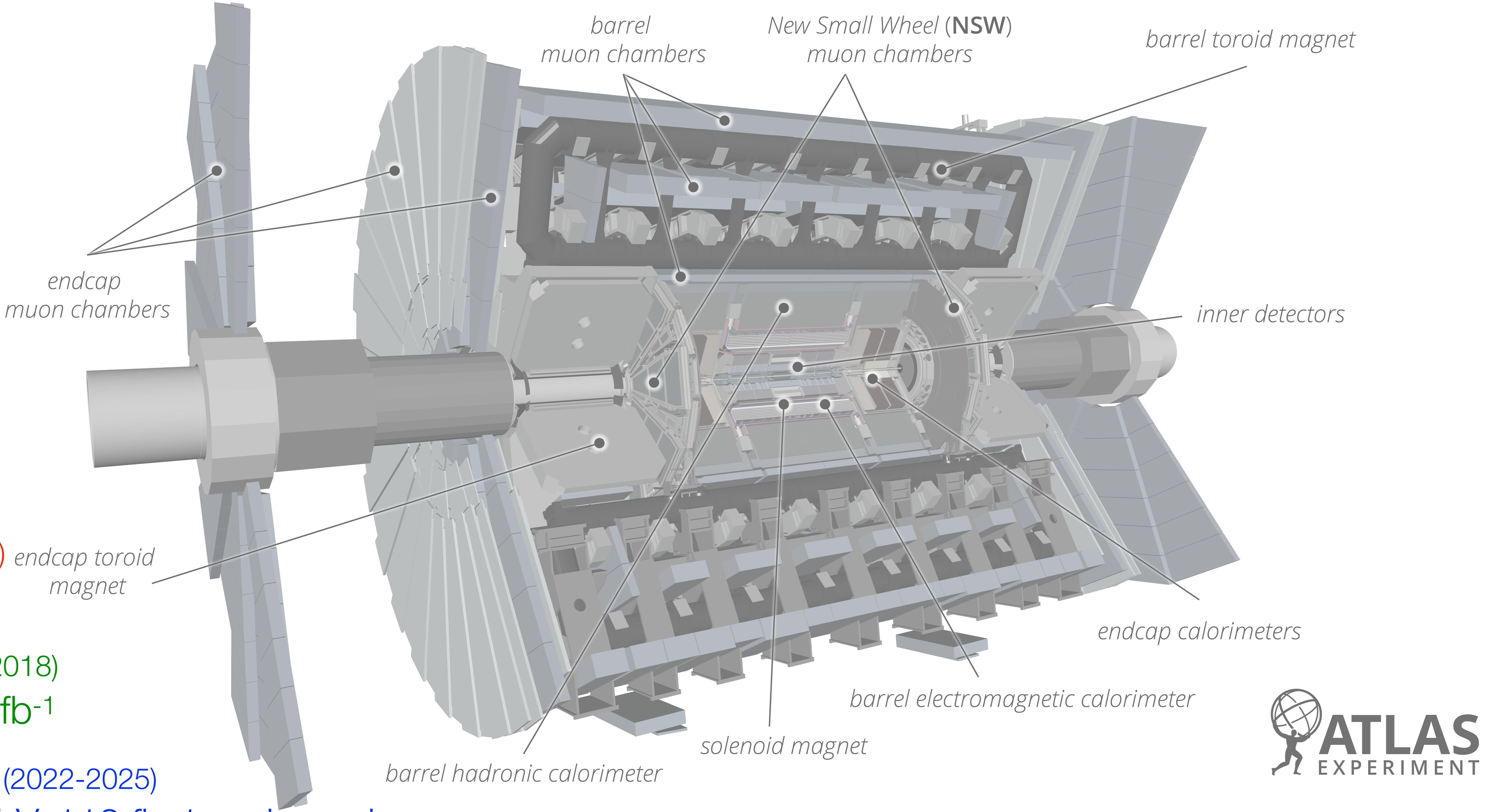


Dynamics and symmetries



Electroweak symmetry breaking





Run 1 (2011-2012)
7/8 TeV, 40 fb^{-1}

Run 2 (2015-2018)
13 TeV, 140 fb^{-1}

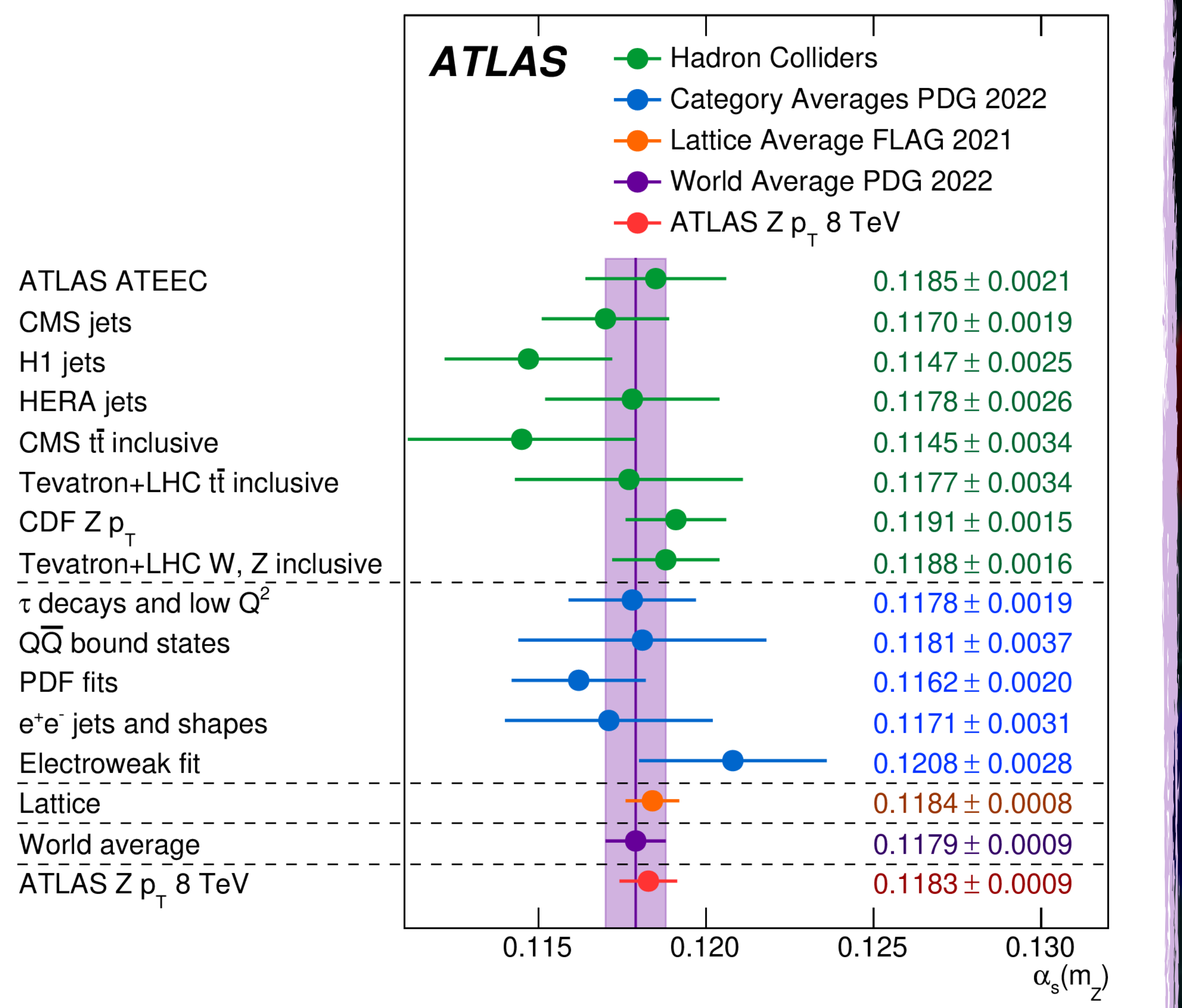
Run 3 (2022-2025)
13.6 TeV, 113 fb-1 and growing

We are here

HL-LHC (2029-2041)
14 TeV, 3000 fb-1 total

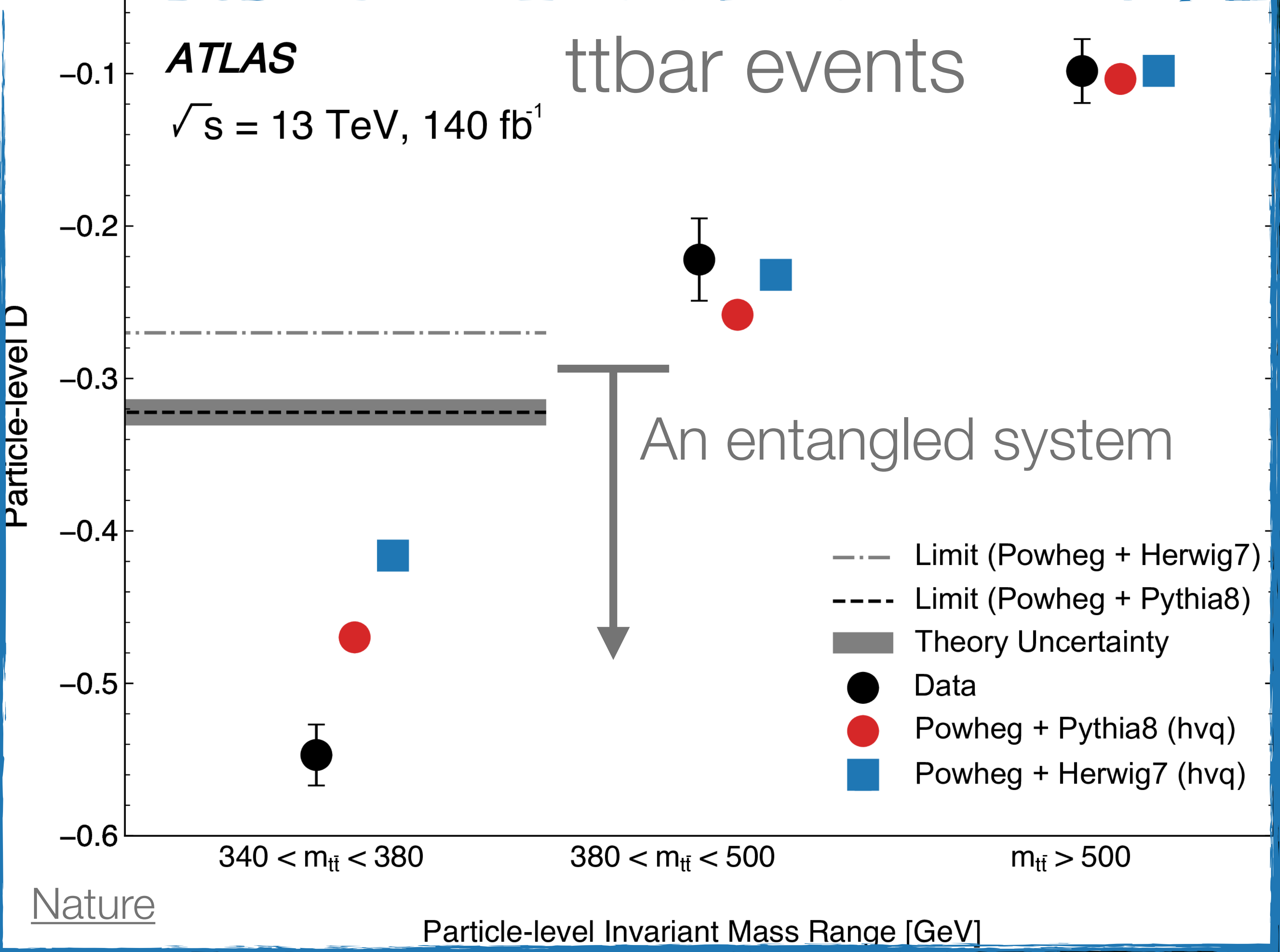
Understanding fundamental parameters

Where we stand - a few examples



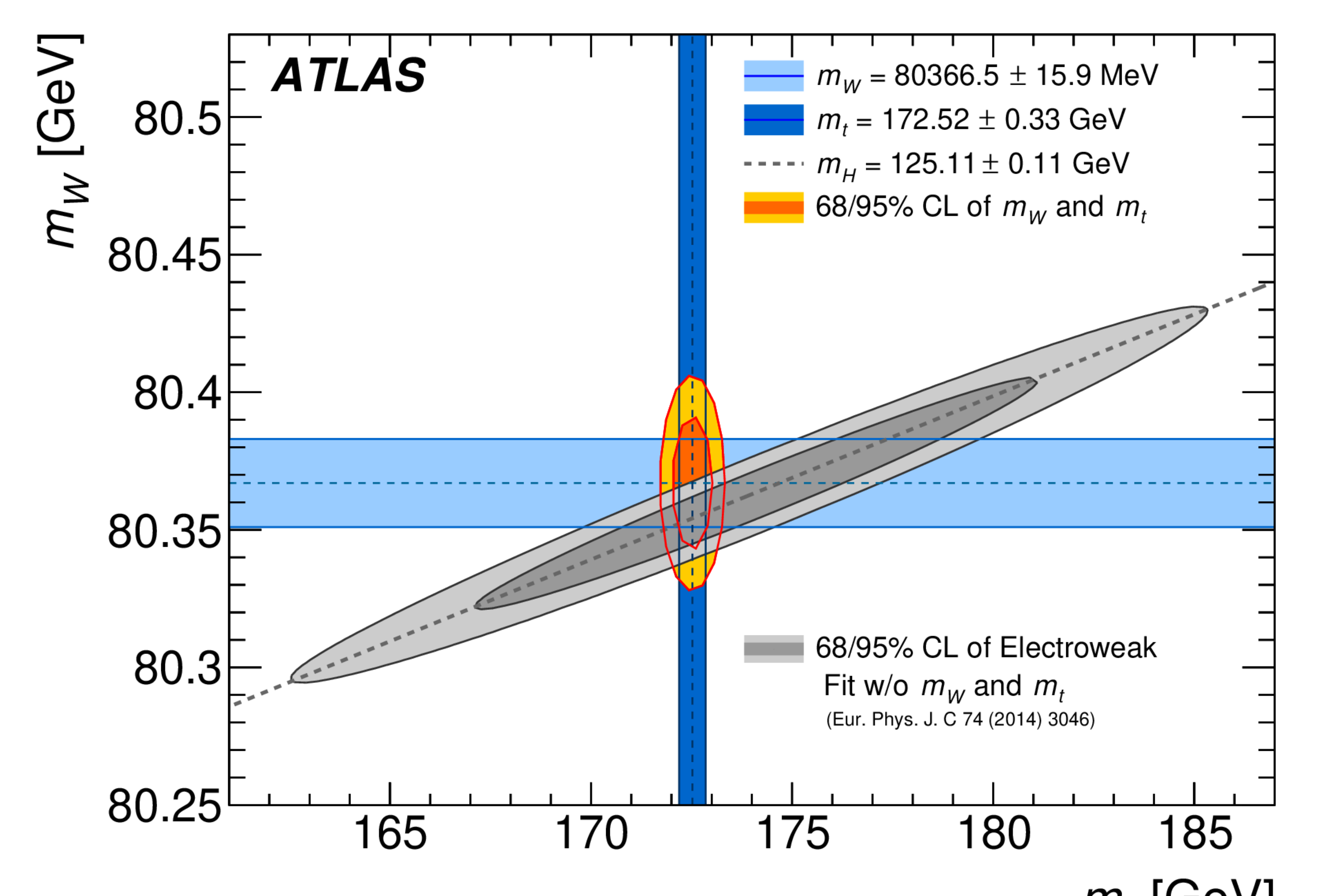
arXiv:2402.08713

0.8% precision on strong force couplings at Z mass



Nature

First observation of quantum entanglement at high-energy and among quarks



arXiv:2403.15085

0.02% precision on W mass

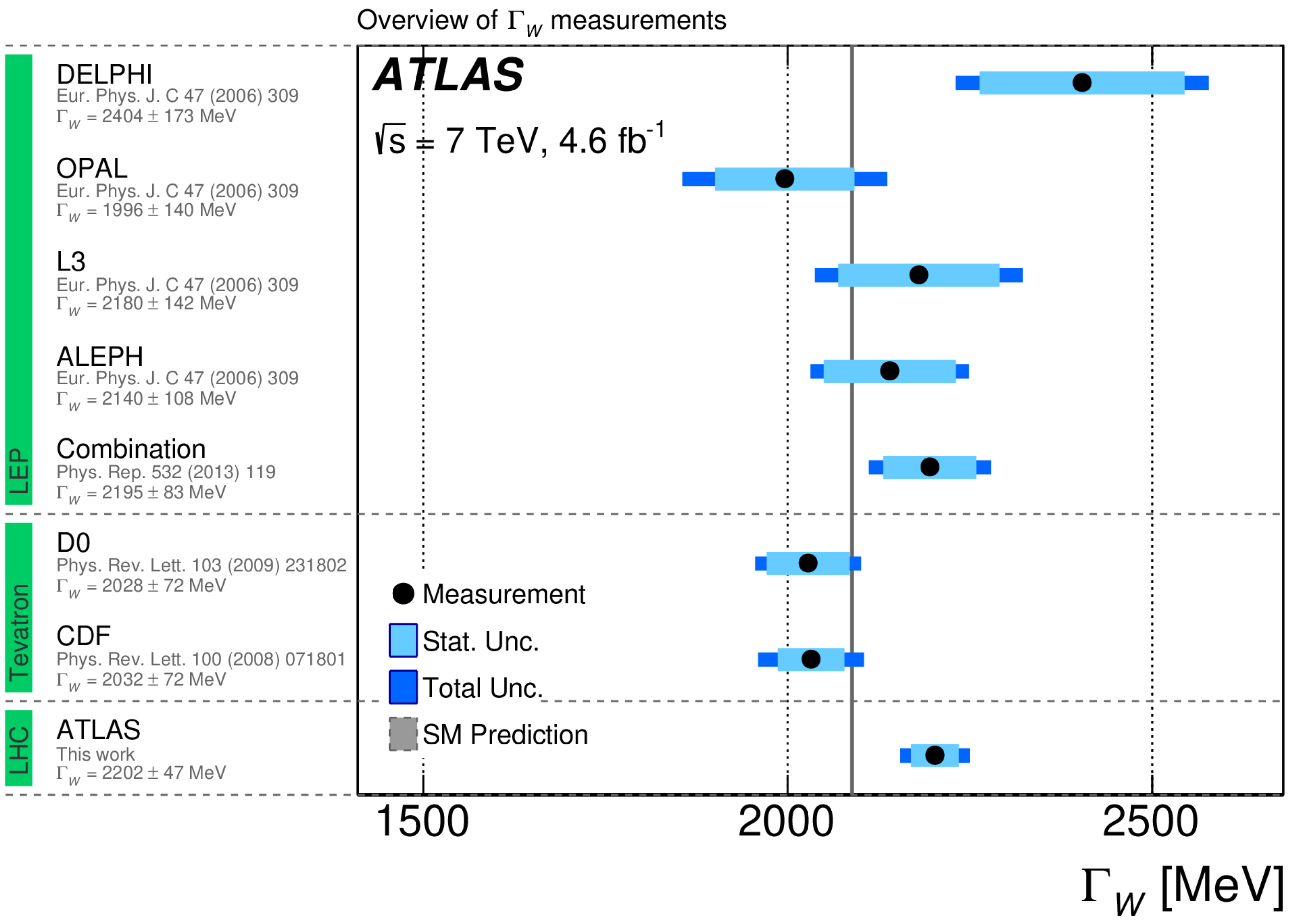
0.2% on top mass arXiv:2308.04775

0.09% on Higgs mass arXiv:2309.12986

Properties of the W boson

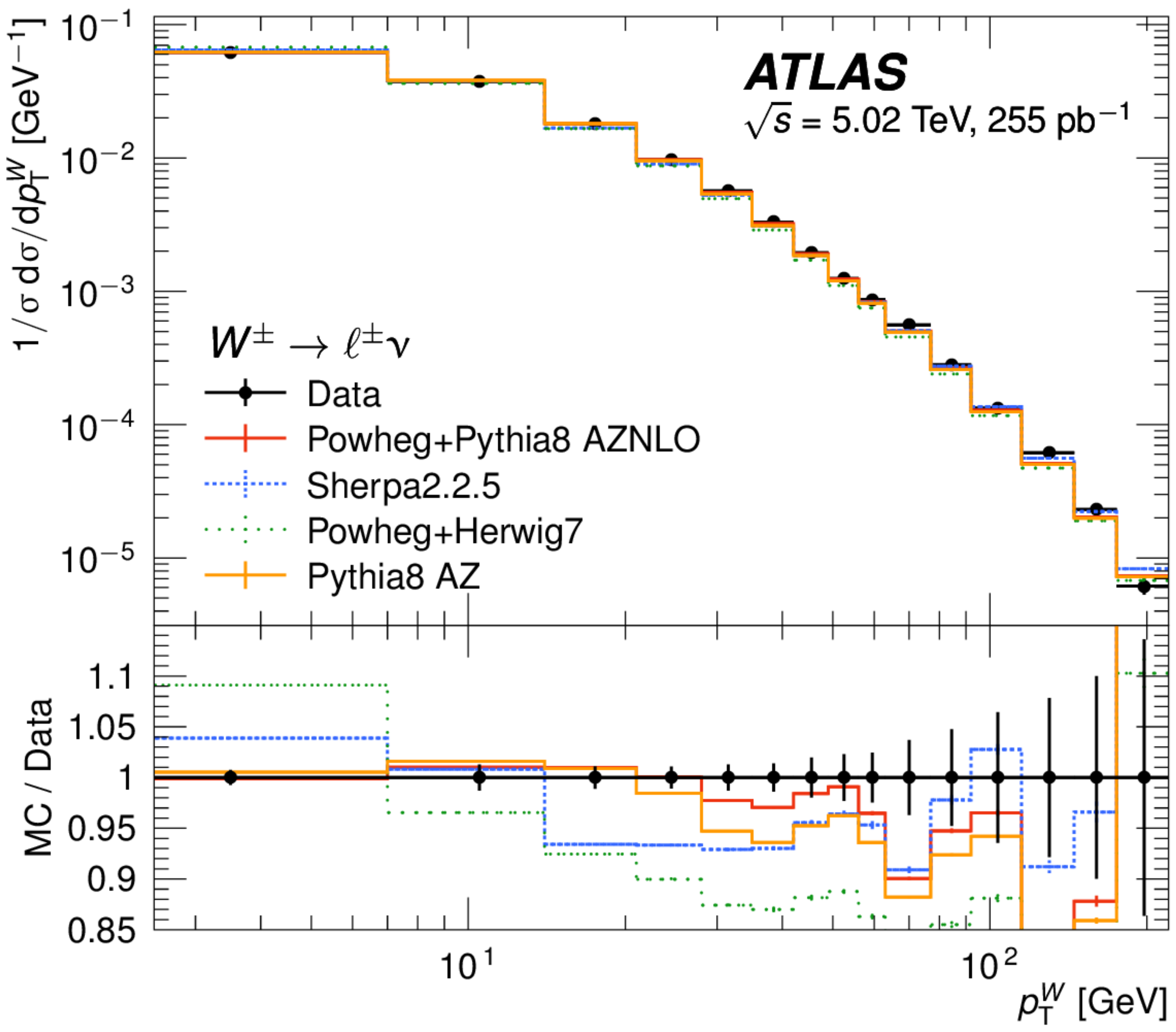
- First measurement of the W width at the LHC, together with an improved W mass

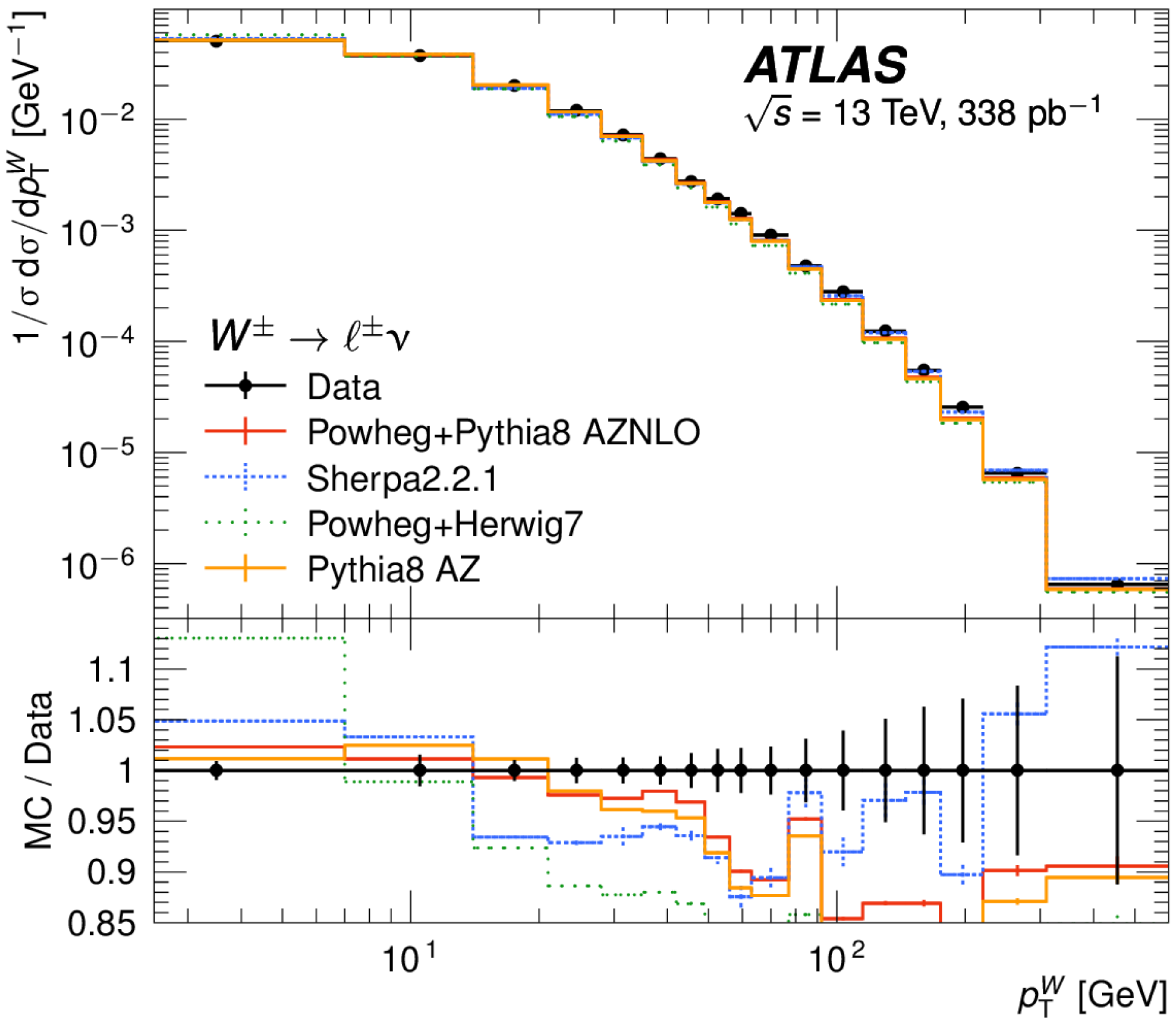
- Largest systematics from the calibration, the theoretical modeling and the parton density functions



Where can we go - improved modeling

- Dedicated measurements under optimal running conditions can play a key role to improve these limitations



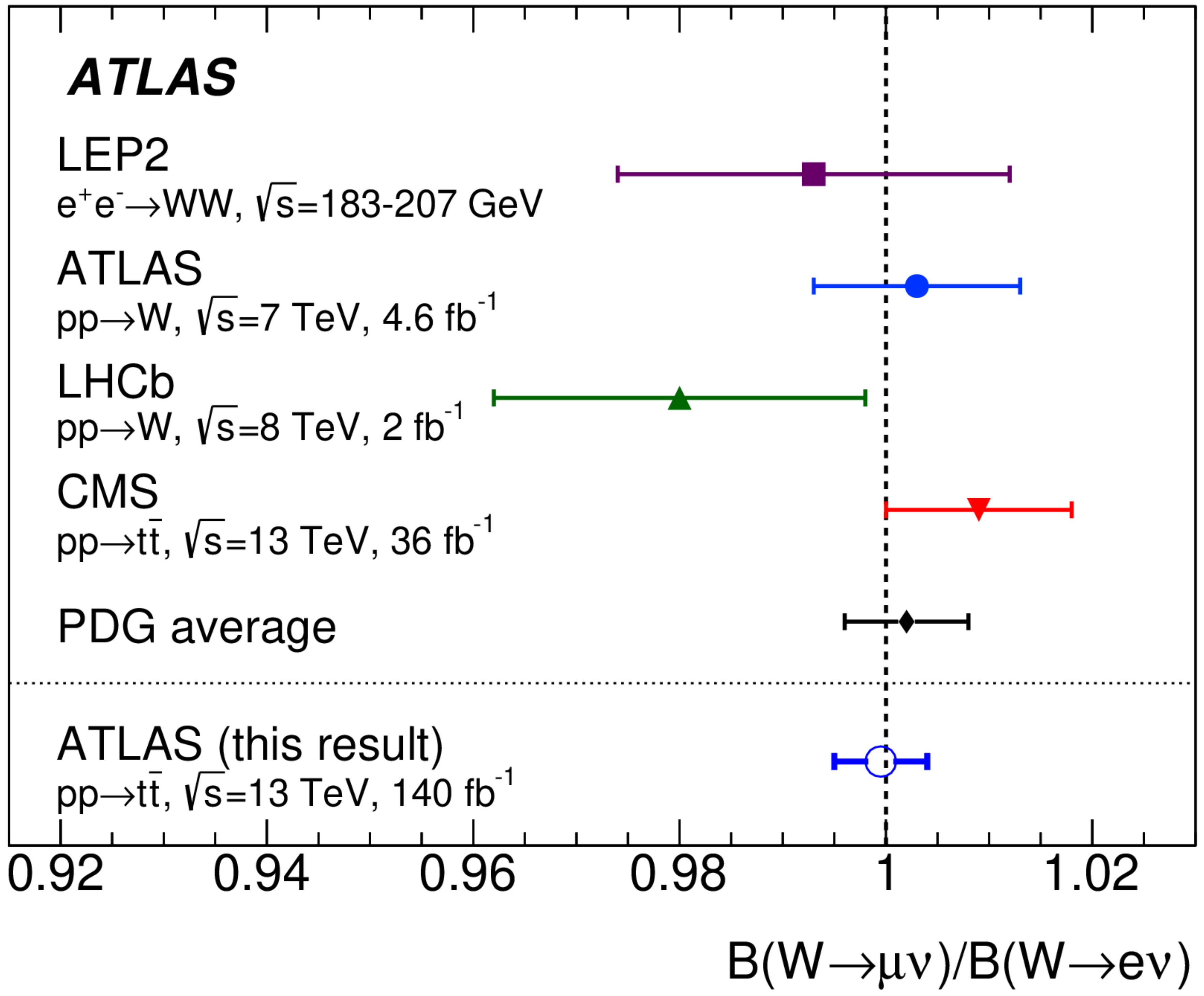


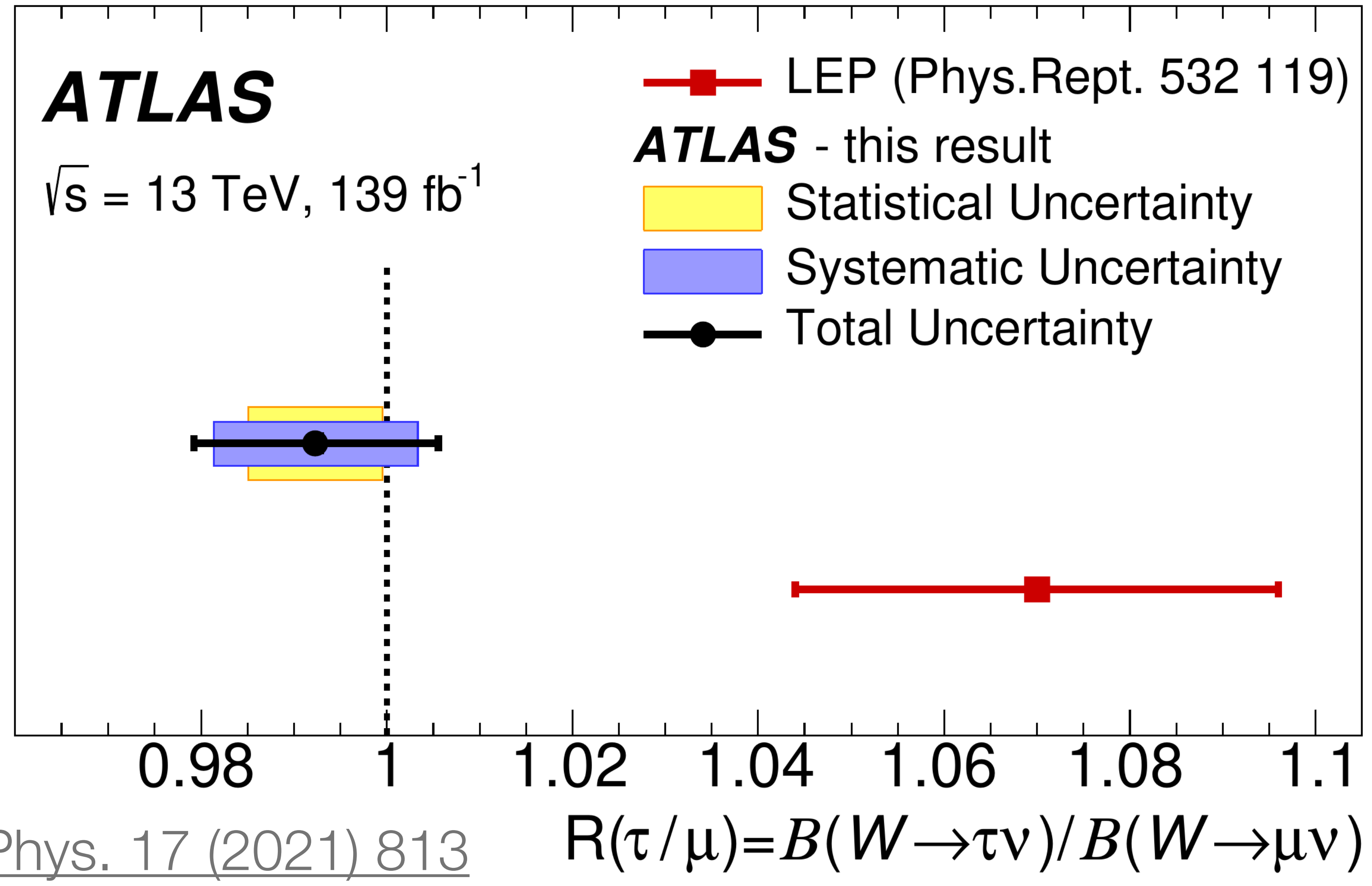
Lepton universality in W decays

- Exploits clean W bosons from top-pair decays
- Higher precision than current world average

$$R_W^{\mu/e} = 0.9995 \pm 0.0045$$

- This adds to a previous result with taus, solving a decade old puzzle from LEP





Nature Phys. 17 (2021) 813

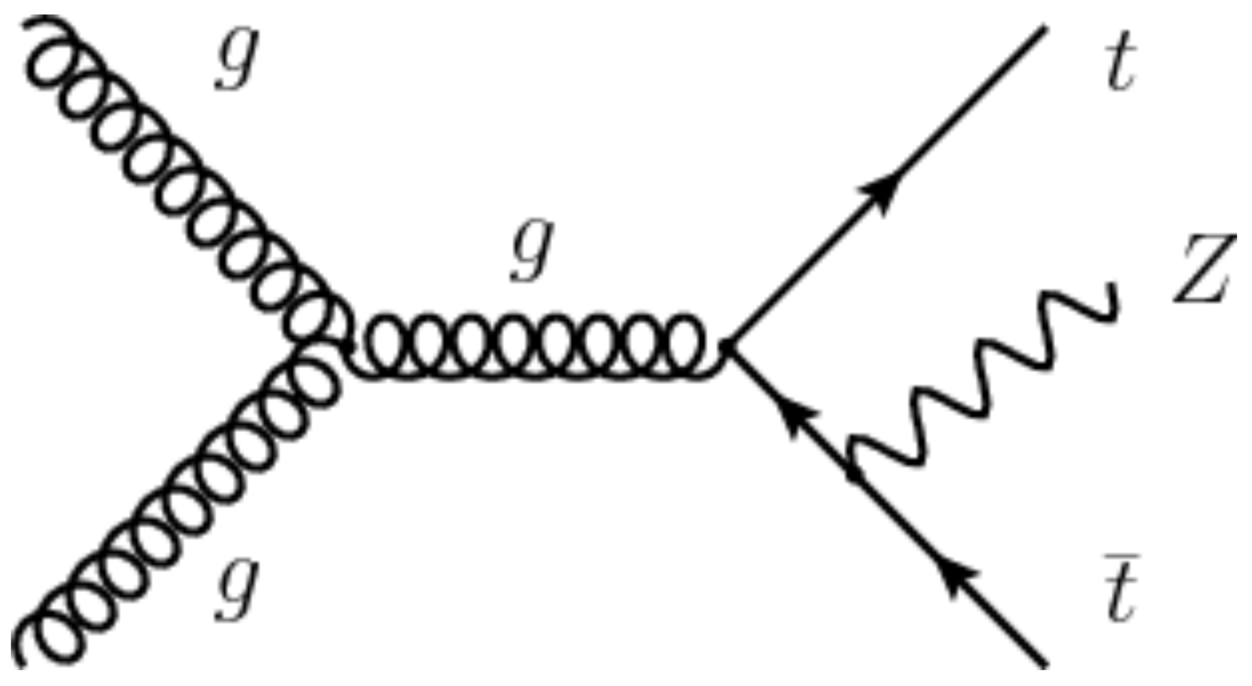
Z boson and top quark couplings

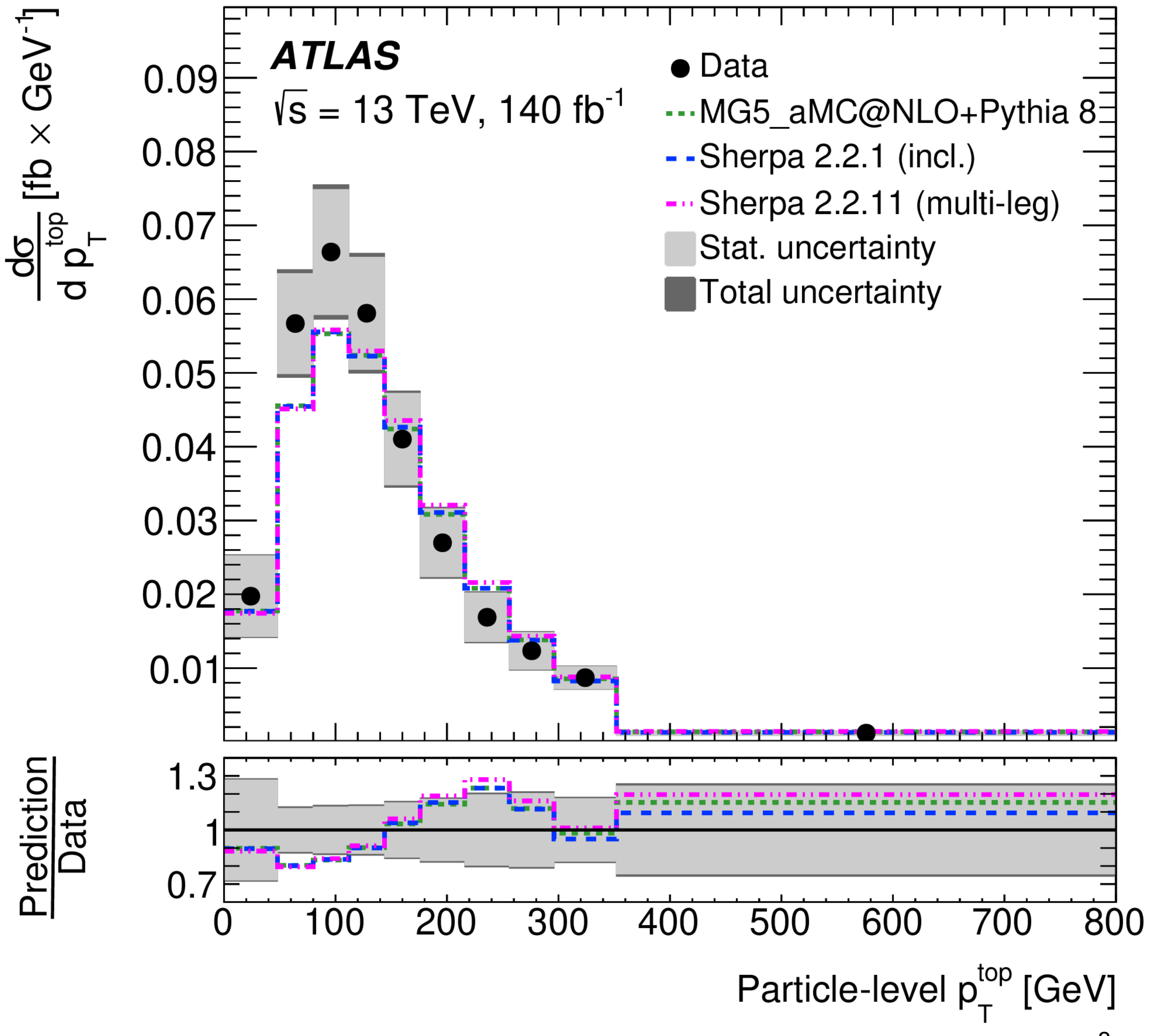
- Measurements of ttbar + Z provide important test of top-Z couplings, which are not well constrained

Measured $\sigma_{t\bar{t}Z} = 0.86 \pm 0.04\ (\mathrm{stat.}) \pm 0.04\ (\mathrm{syst.})\ \mathrm{pb}$

Prediction $\sigma_{t\bar{t}Z} = 0.863^{+0.073}_{-0.085}\ (\mathrm{scale}) \pm 0.028\ (\mathrm{PDF} \oplus \alpha_\mathrm{s})\ \mathrm{pb}$

- A factor of two improvement in systematic uncertainties

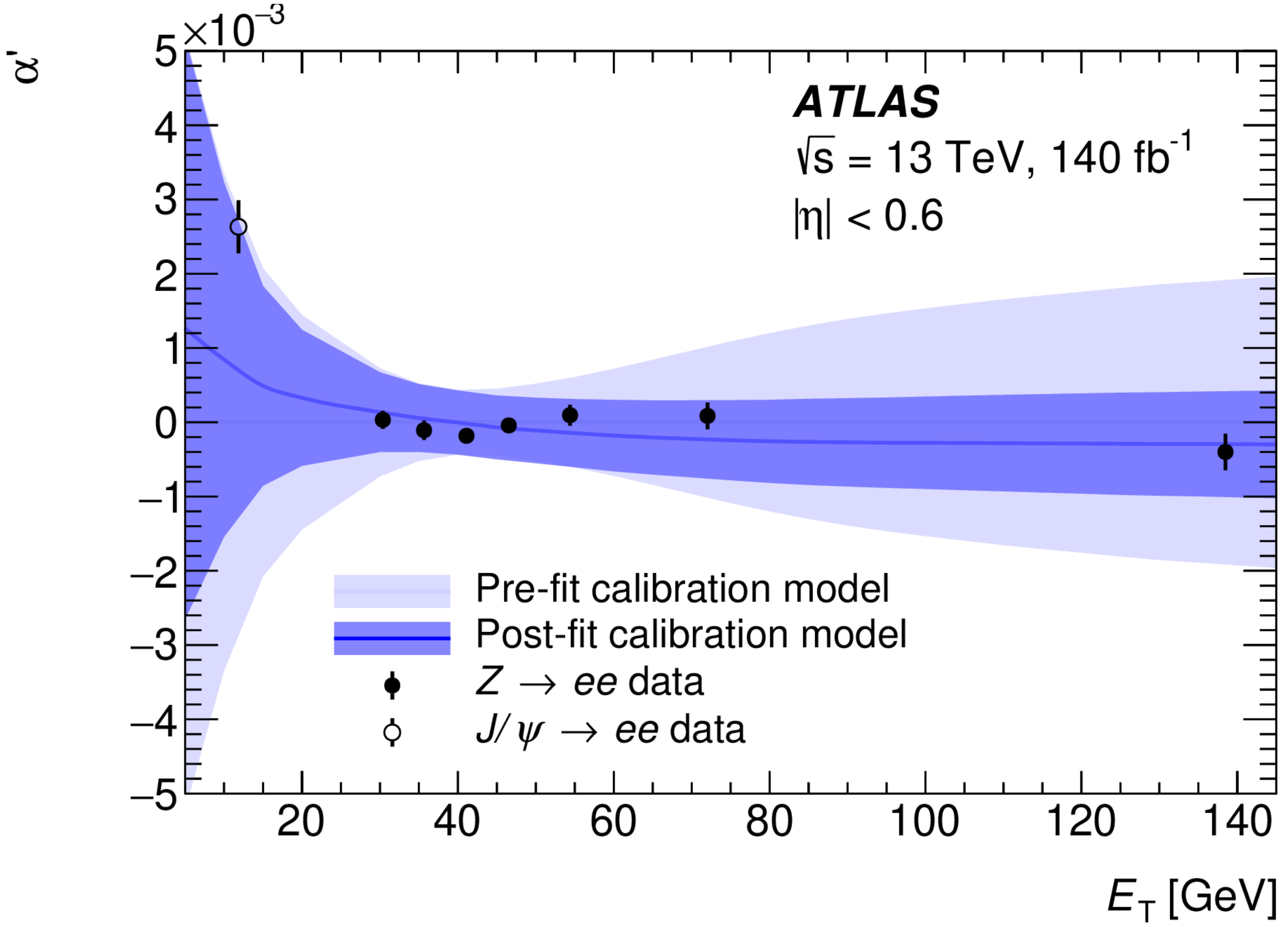




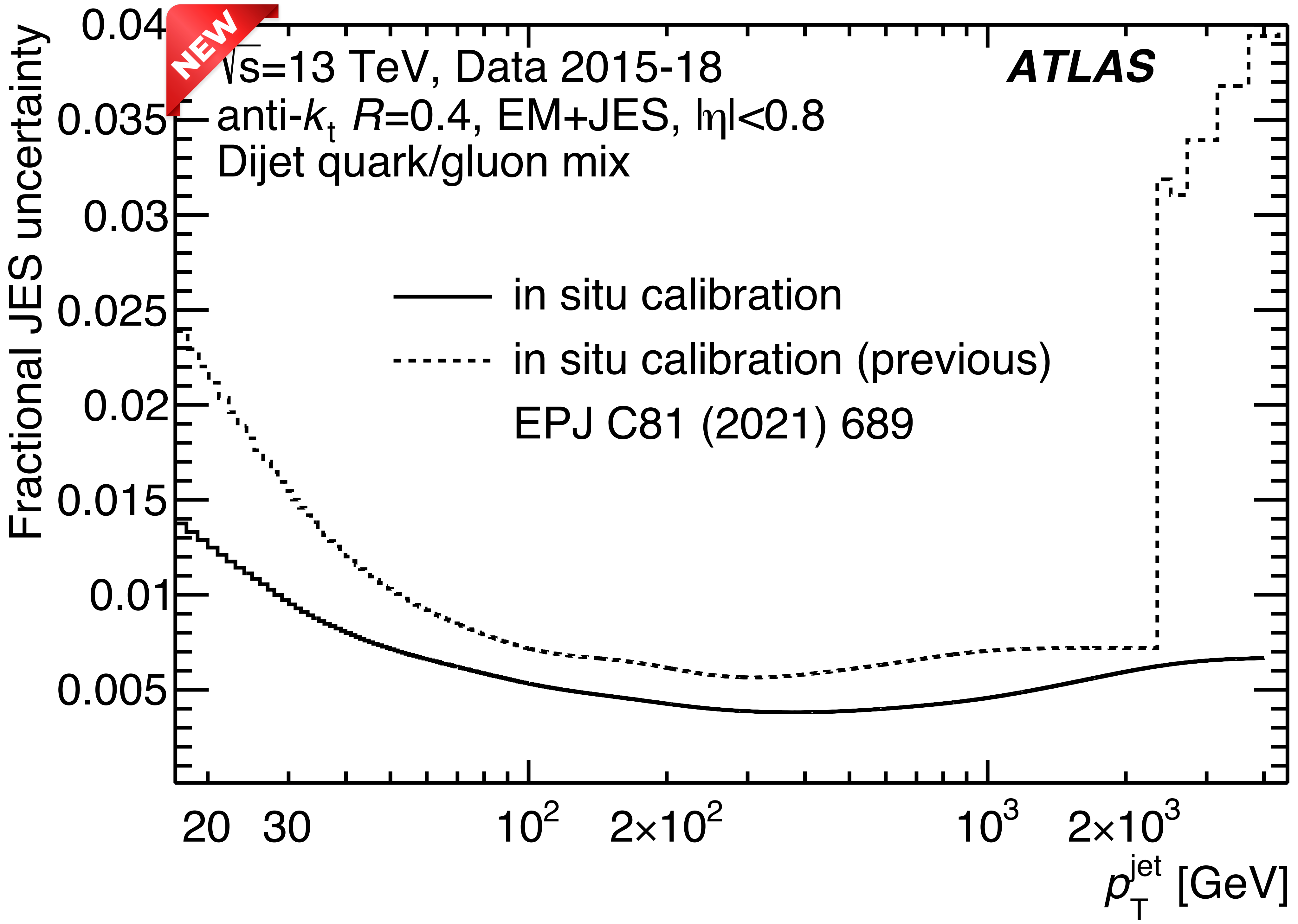
JINST 19 (2024) P02009
CERN-EP-2024-195

Where can we go - precision calibration

- Precision of our object reconstruction much beyond the design goals



Improved photon calibration - Higgs mass precision of 0.09% from di-photon decays

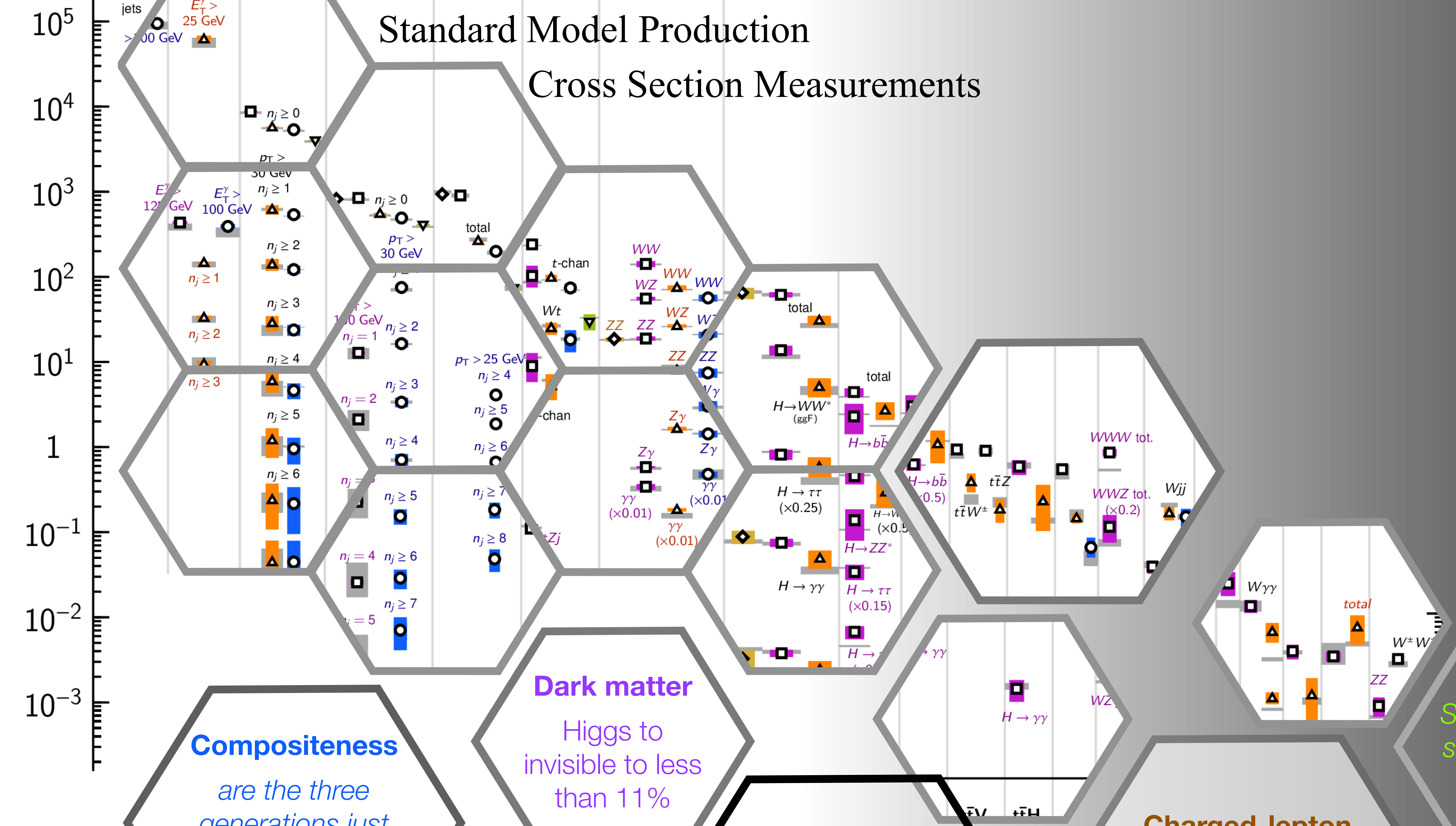


Single pions for tau decays, 0.4% jet energy scale accuracy at 300 GeV

See also new methodology with pile-up jets reconstruction

Dynamics and symmetries

Standard Model Production Cross Section Measurements



SUSY

Symmetry connecting fermions and bosons

Strong to 2.45 TeV
EW to 1 TeV

Extra dimensions, gravitons, quantum black holes

Explaining gravity's 'weakness'

Extra dimensions mass to 5.9 TeV

Monopoles and co.

Multi-charged particles to 1 TeV

Additional leptons

Seesaw mechanism and small neutrino couplings

Type III seesaw heavy leptons to 790 GeV

Compositeness

are the three generations just smaller constituents

q* to 6.7 TeV

Dark matter

Higgs to invisible to less than 11%

Leptoquarks

A symmetry connecting the lepton/quark sectors

Scalar leptoquarks to 1.2 TeV

Charged-lepton flavour violation

What forbids it

e-mu BR < 10^{-7}

Additional vector bosons

Extended gauge sectors

Z' to 5.1 TeV

Axions

Why does QCD preserve CP

BR to 10^{-5}

Dark sector portals

Hidden sectors and long lived particles

Dark photon lifetimes to 1000mm

Vector-like leptons and quarks

Solving higgs radiative corrections

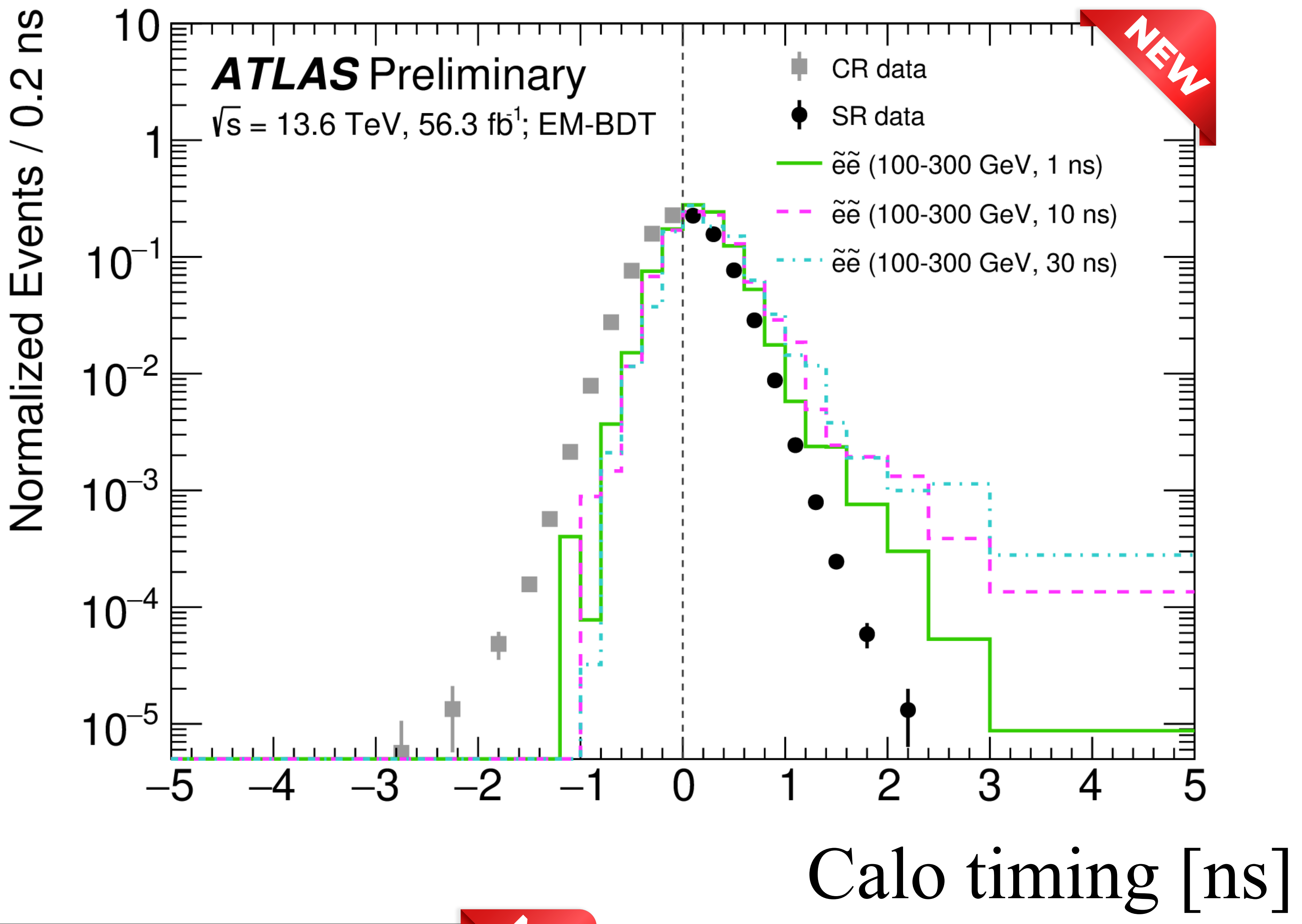
VLQ T m to 1.27 TeV, VLL tau (4321 model) to 910 GeV

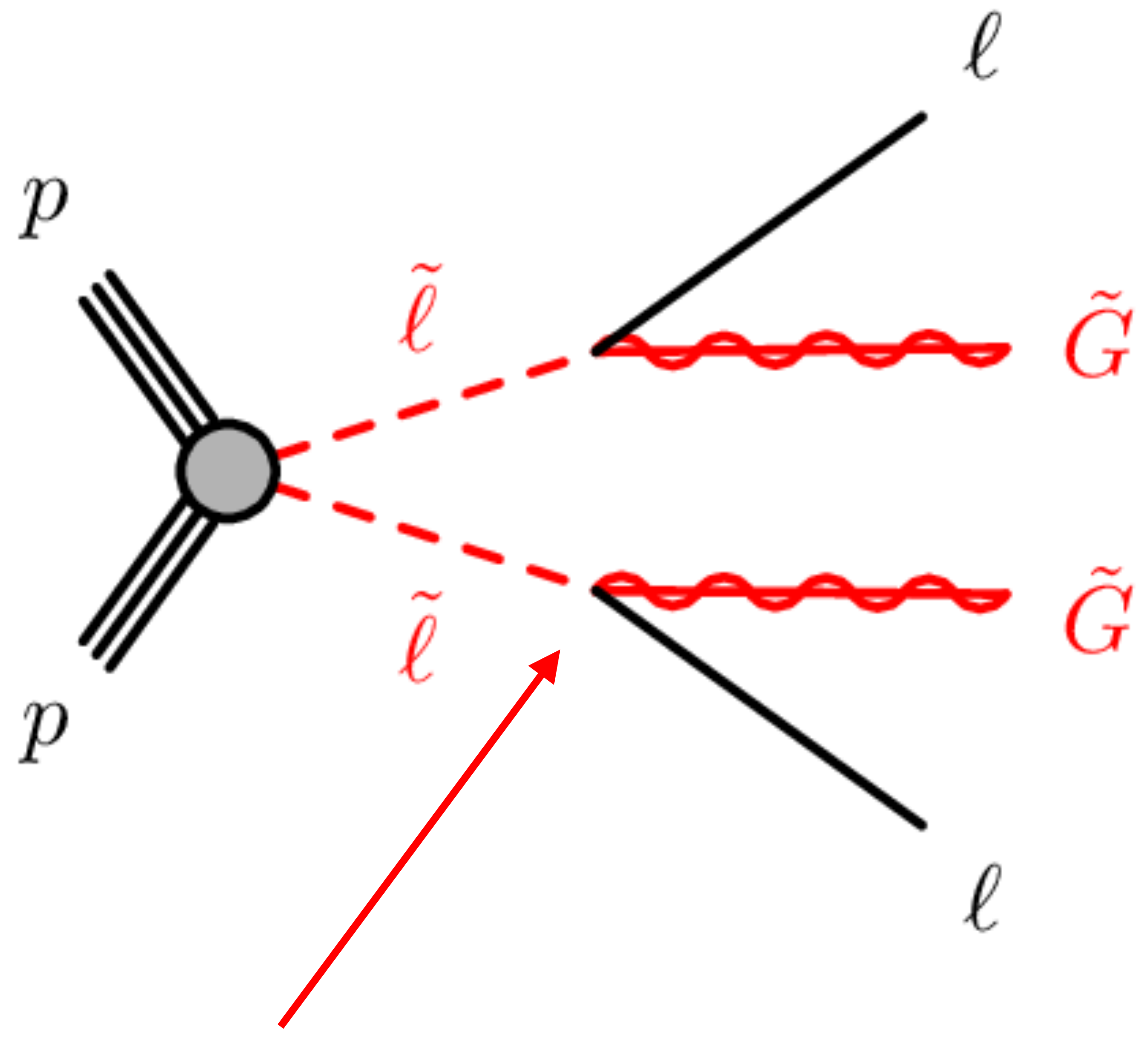
Inspired from ATLAS Exotics, SUSY, extended Higgs physics reports

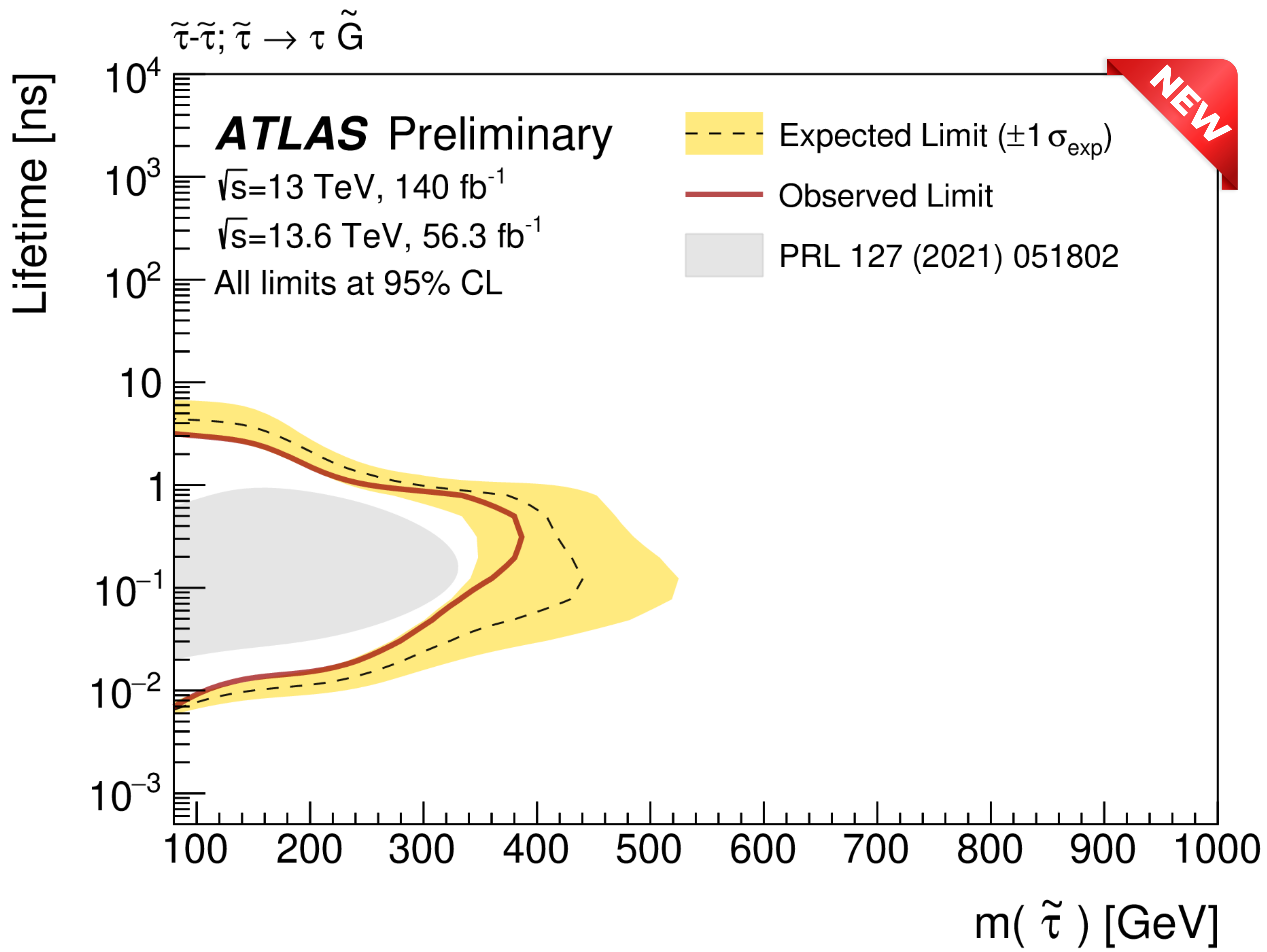
ATLAS-CONF-2024-011

Supersymmetry and small couplings

- New Run 3! Triggering with large impact parameters tracks
- Precision timing information from calorimeter to compliment tracking



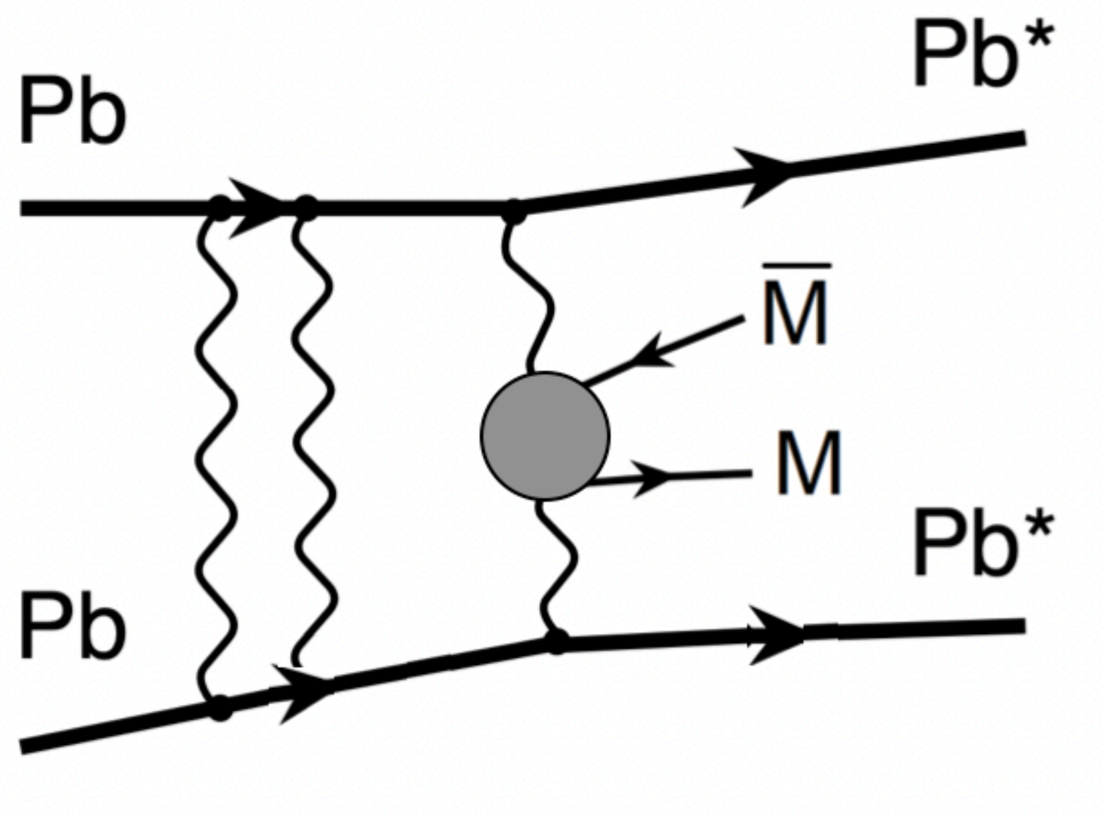


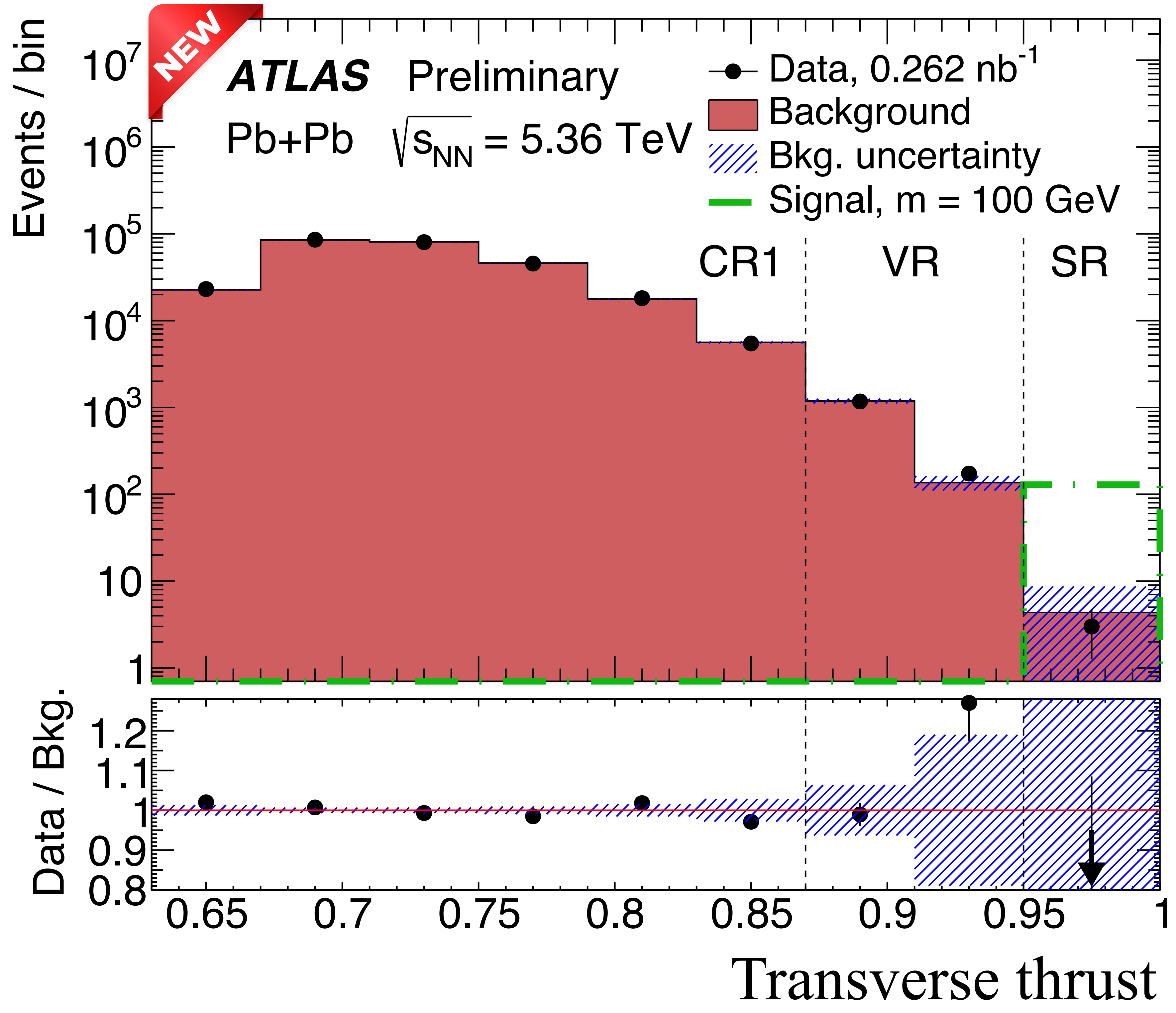


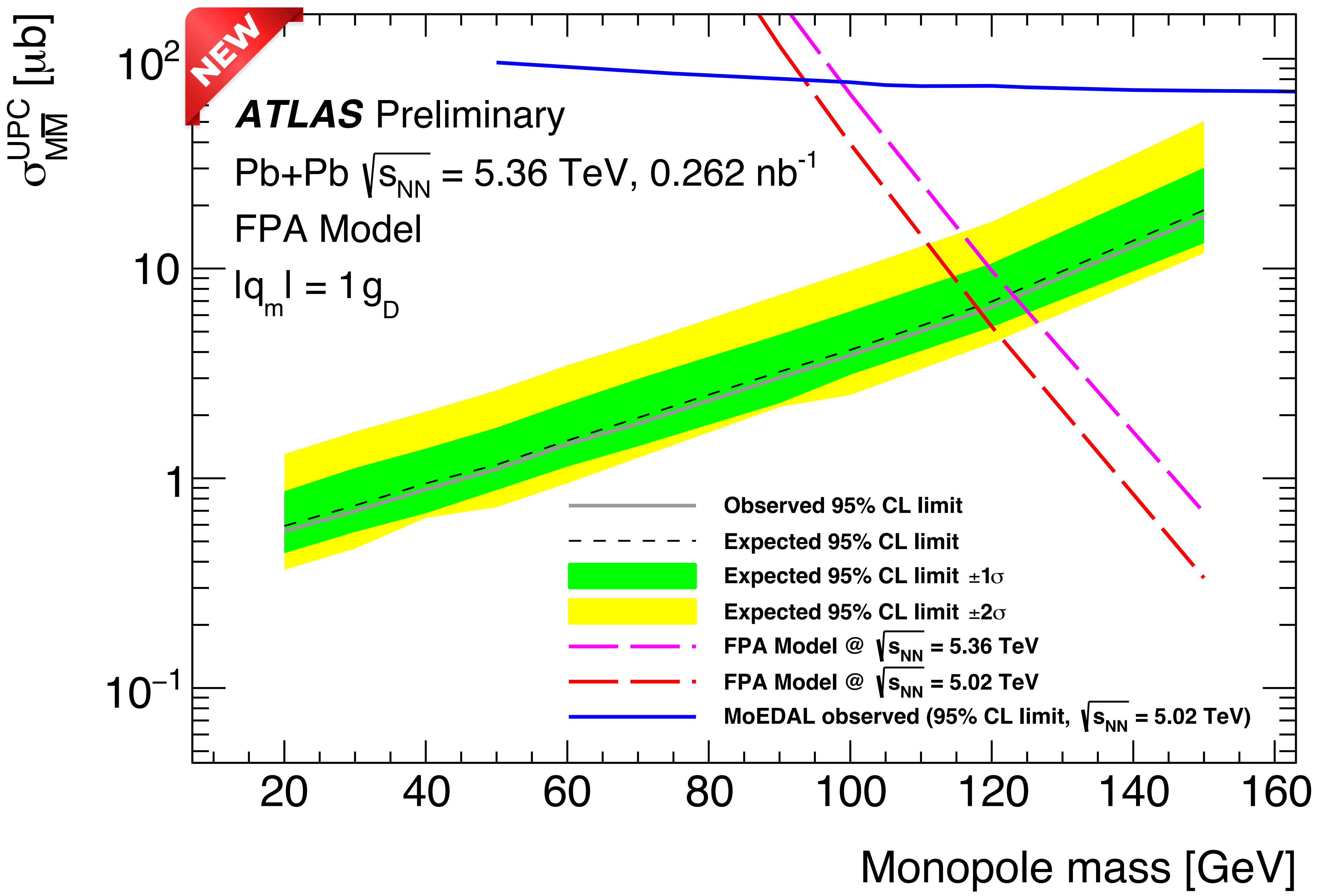
Small couplings leading to long $\tilde{\ell}$ lifetimes

Magnetic monopoles in ultraperipheral lead collisions

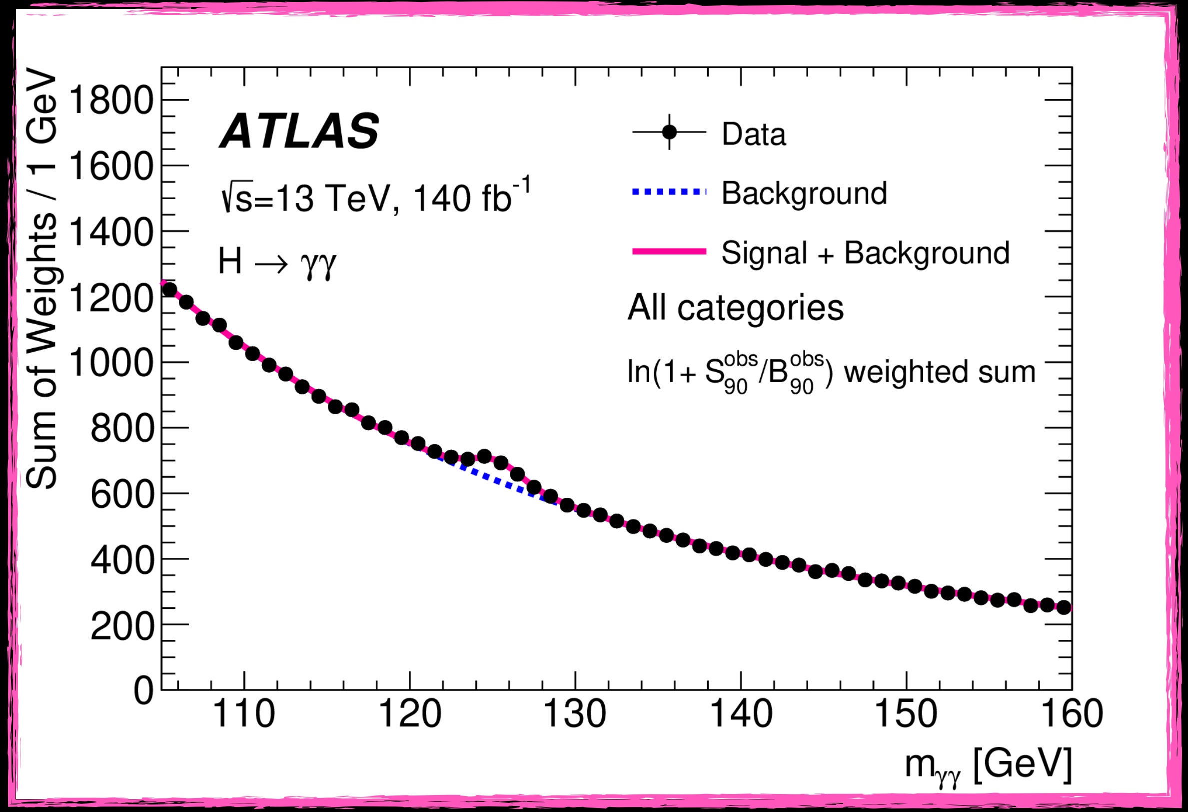
- New data from 2023! New triggers, new methodology
- Achieve up to x8 improvement at masses below 120 GeV



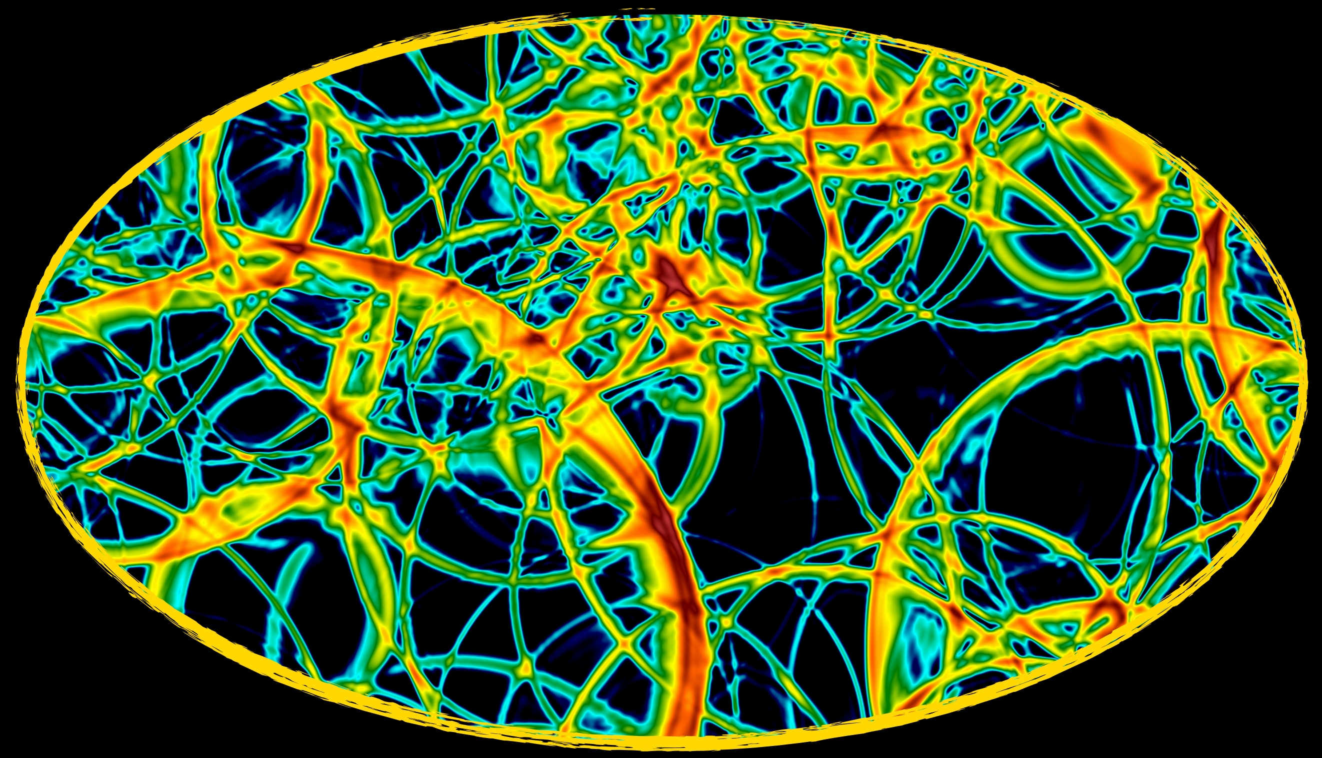




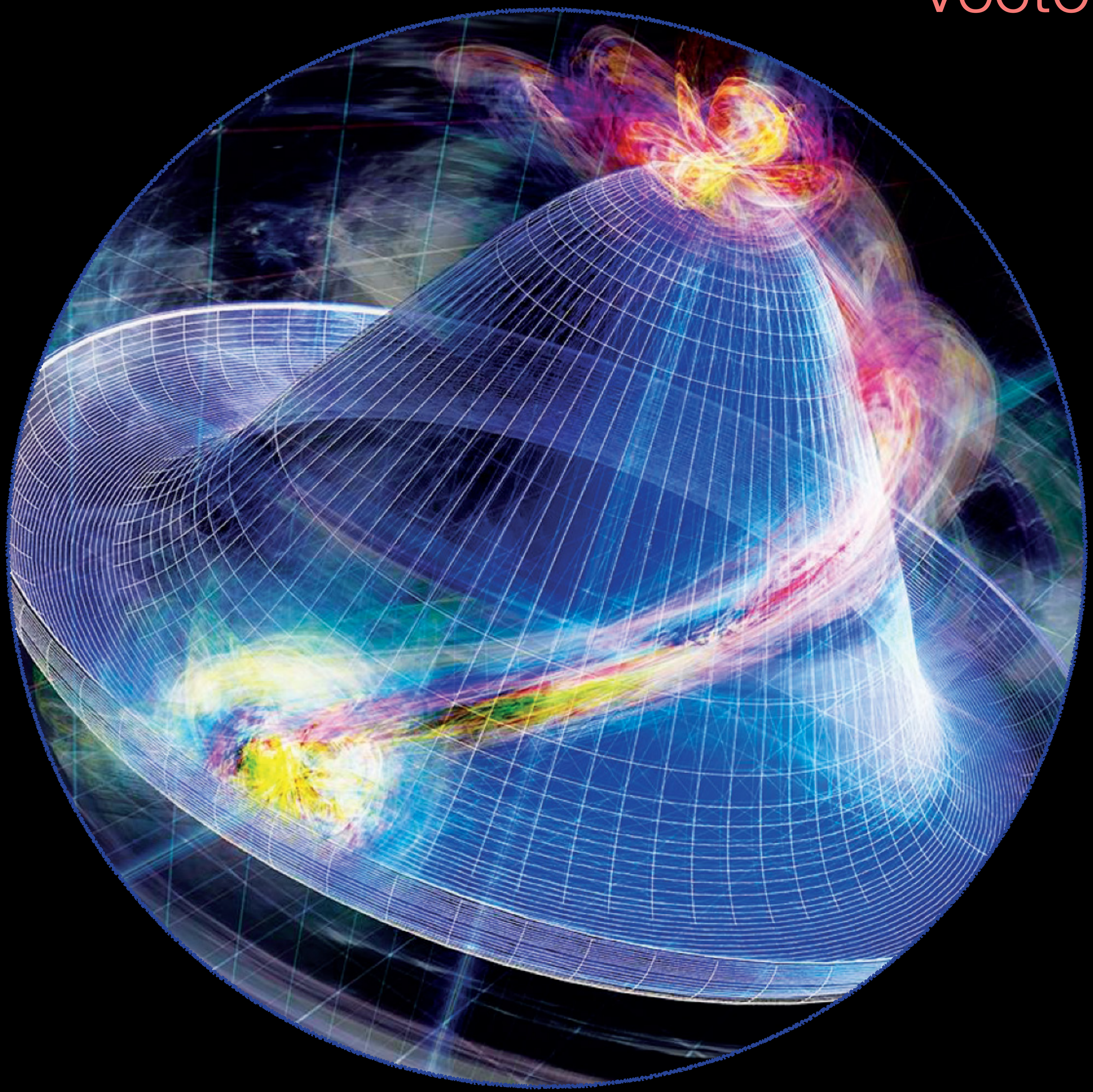
Breaking Electroweak symmetry



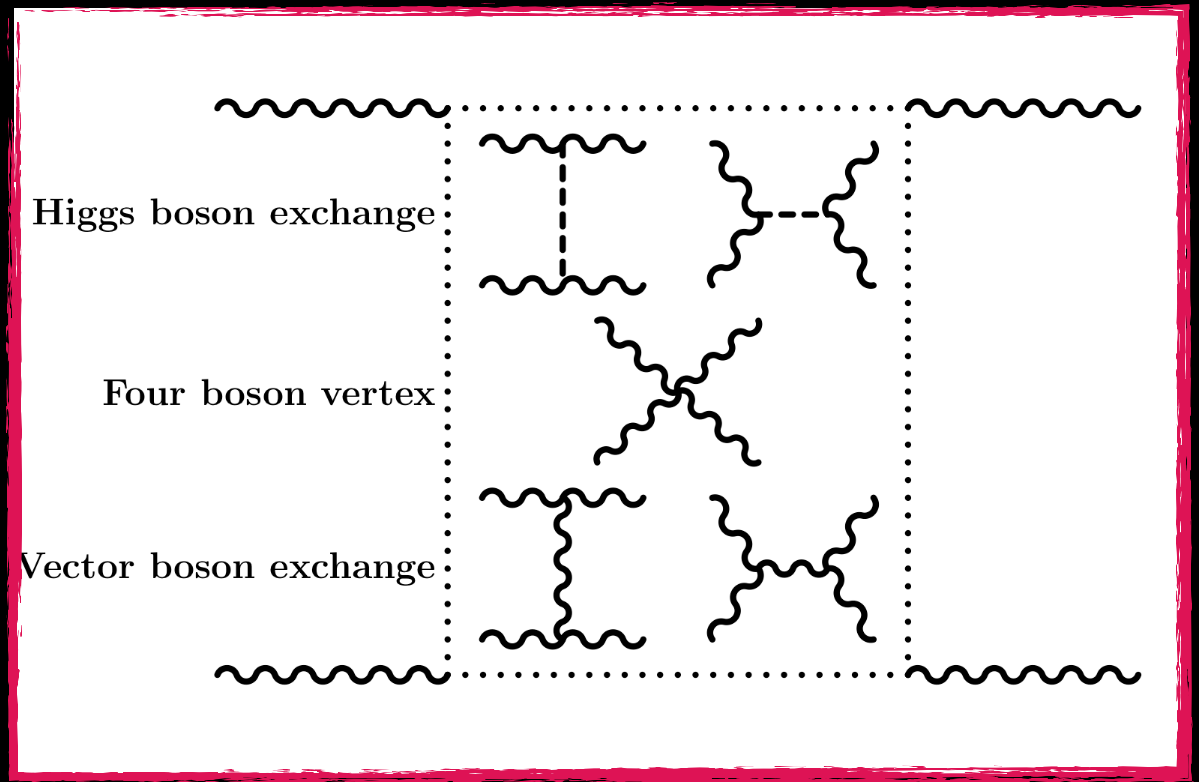
Precision Higgs

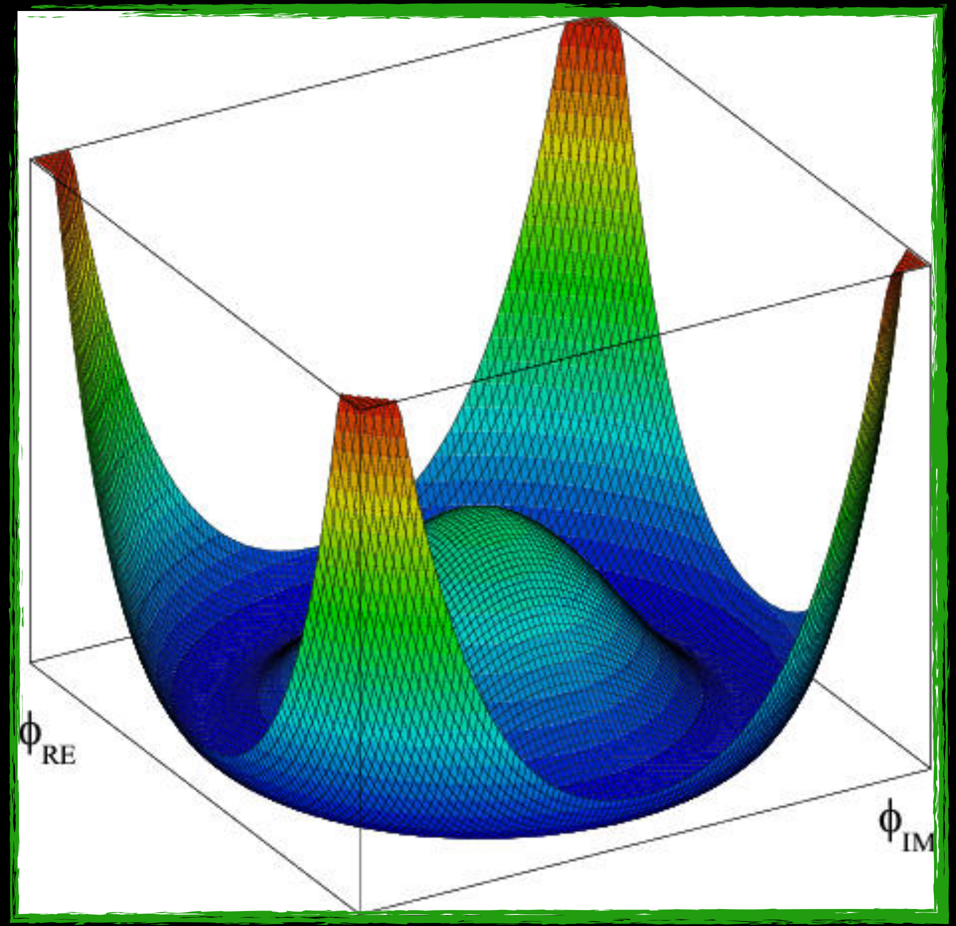


Extended Higgs sector



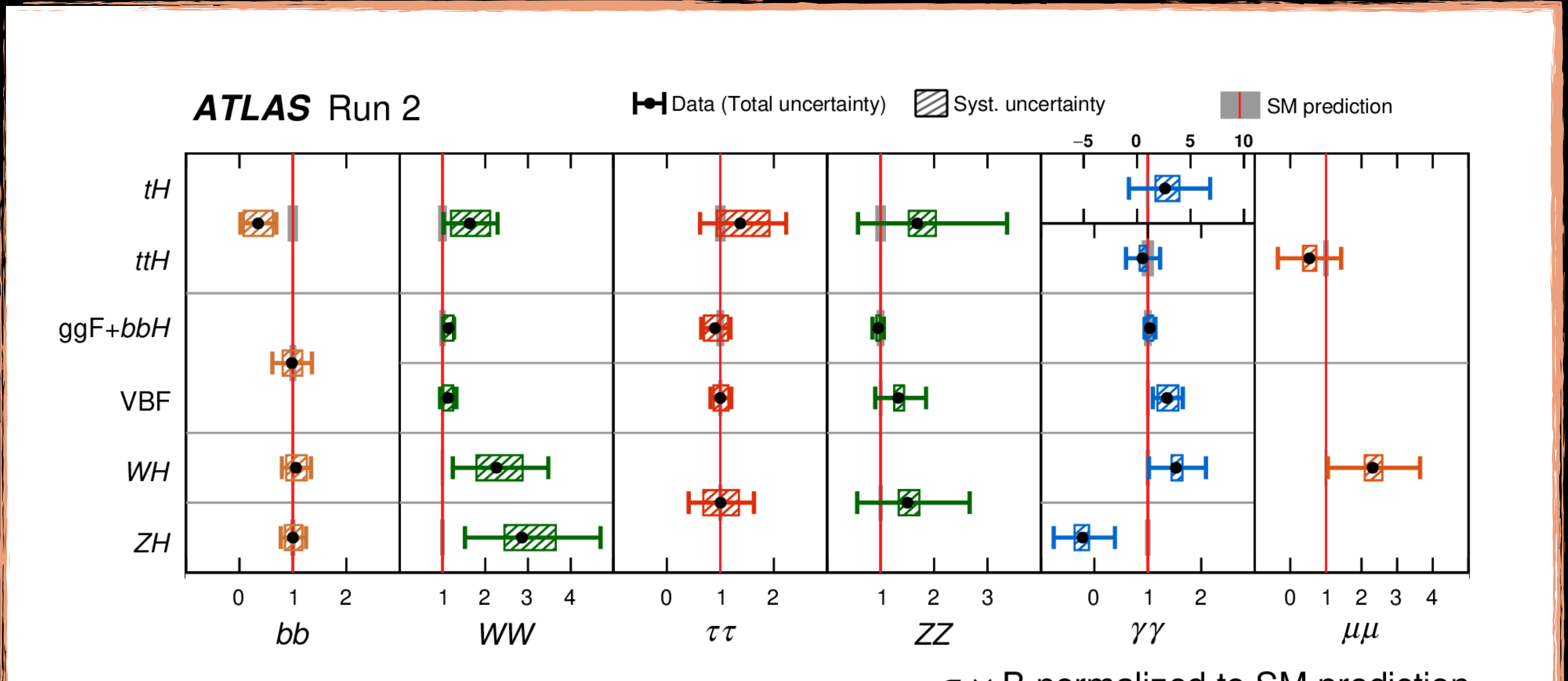
Vector boson polarisation





Higgs self-coupling

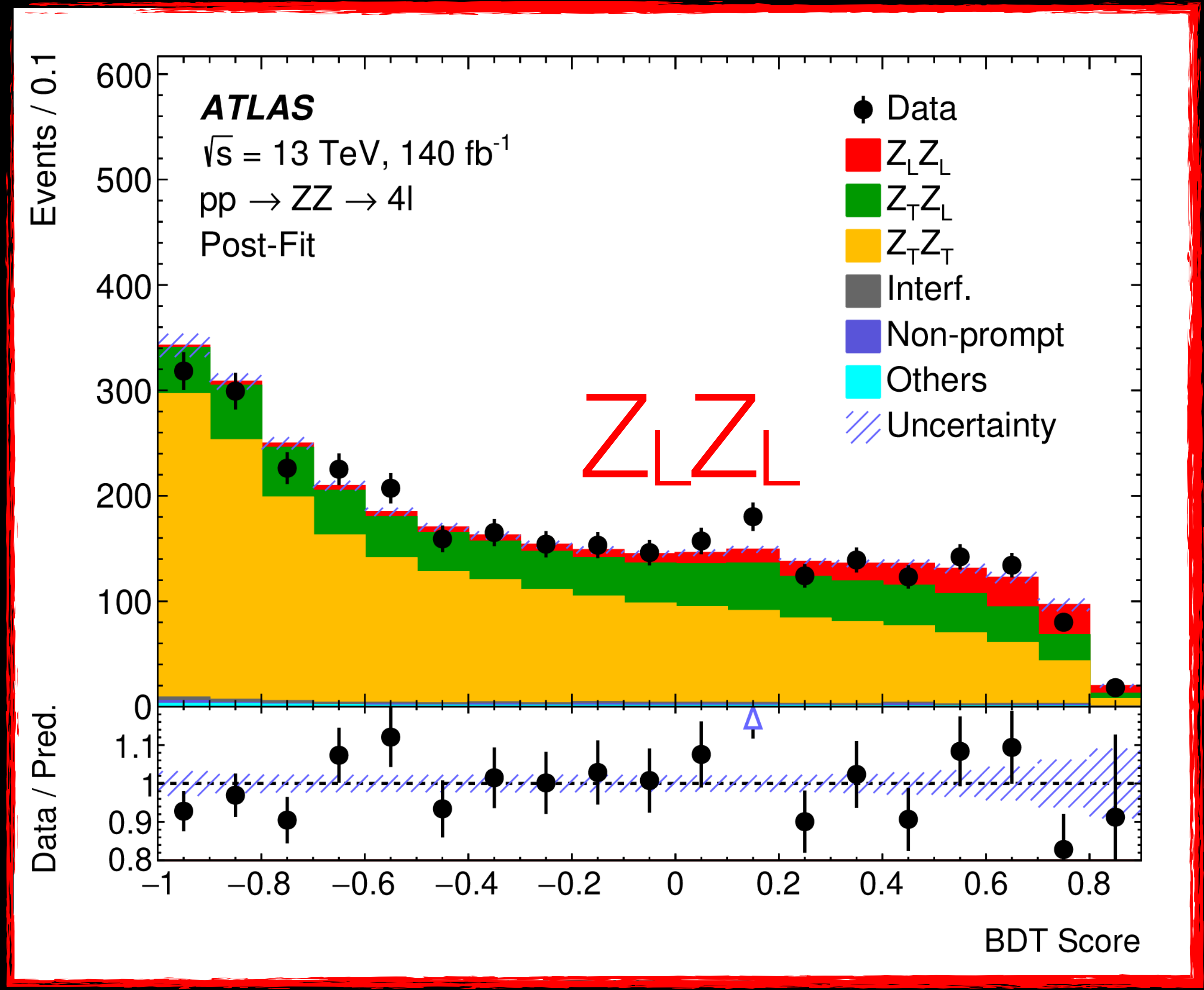
Where we stand - a few examples



Nature 607, 52 (2022)

Approaching 5% level in Higgs couplings, targeting second generation

Observation/evidence of longitudinal WZ/ZZ polarisation



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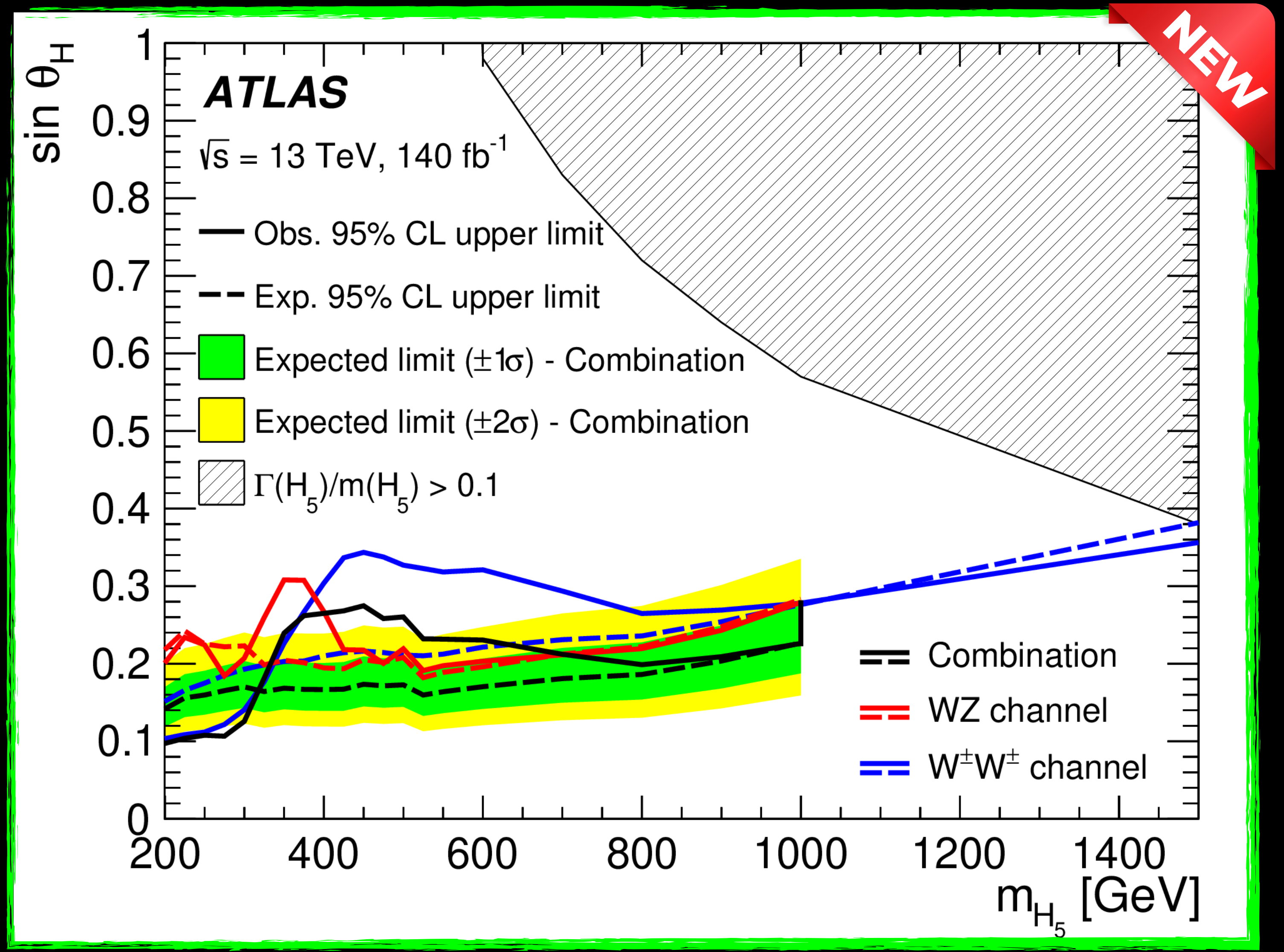
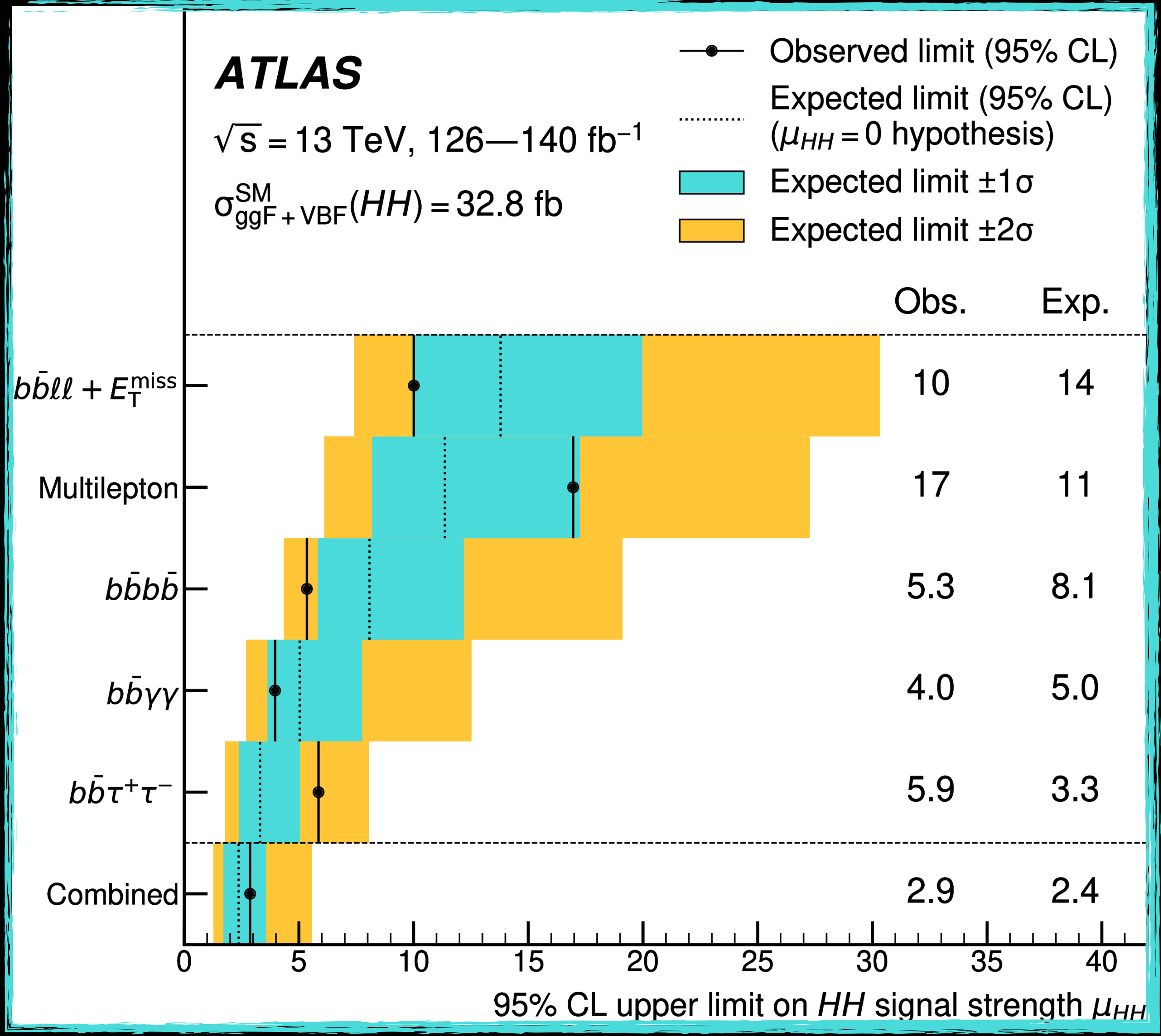
Extensive search for extended Higgs sectors



arXiv:2407.10798

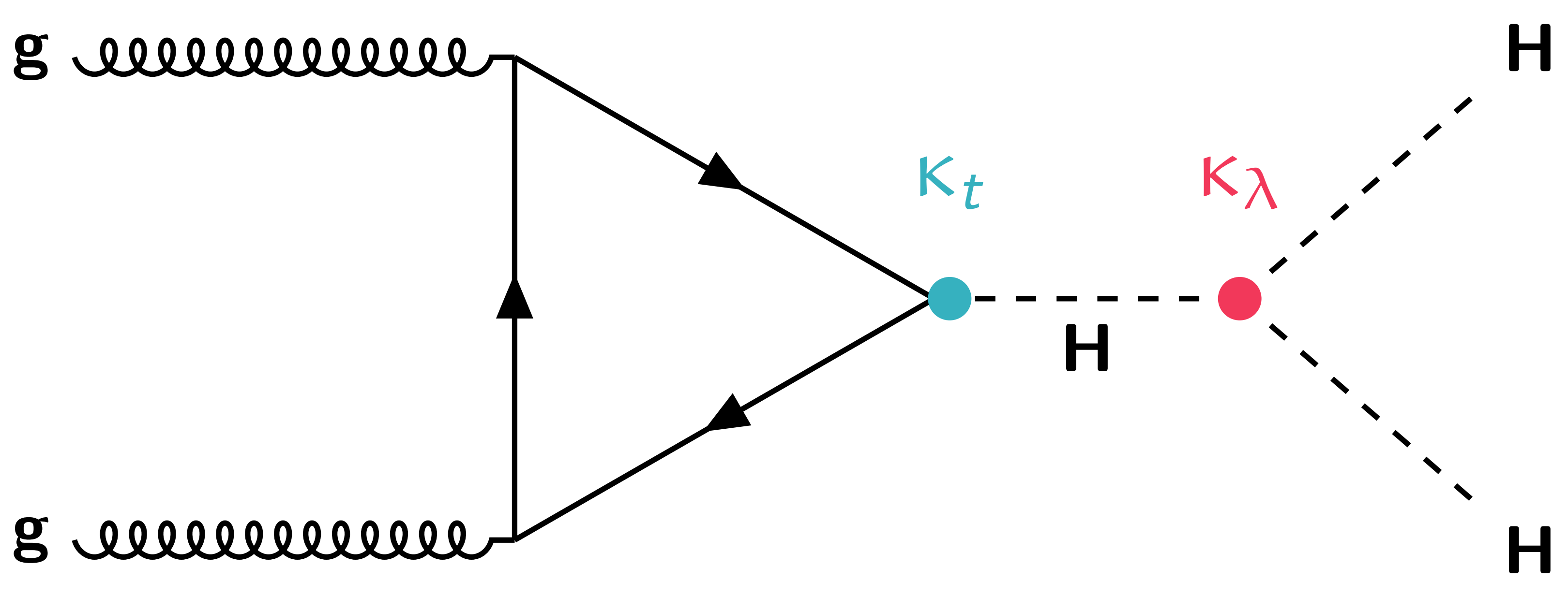


	Obs.	Exp.
$b\bar{b}\ell\ell + E_T^{miss}$	10	14
Multilepton	17	11
$b\bar{b}b\bar{b}$	5.3	8.1
$b\bar{b}\gamma\gamma$	4.0	5.0
$b\bar{b}\tau^+\tau^-$	5.9	3.3
Combined	2.9	2.4

Approaching SM prediction for HH cross section

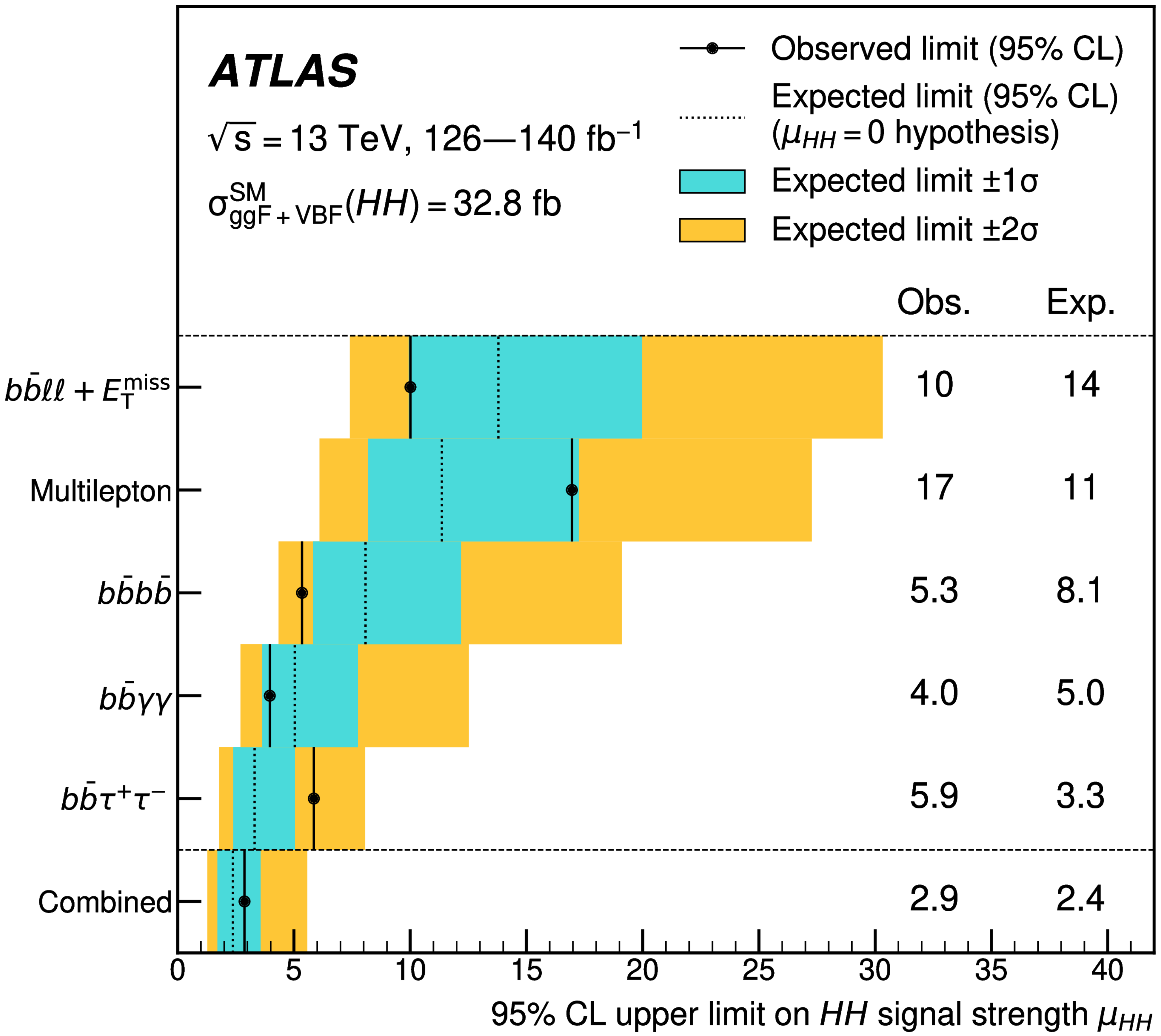
arXiv:2406.09971

Di-higgs production



Best expected sensitivity on HH cross section, self-coupling, κ_λ

$$\mu_{HH} = 0.5^{+0.9}_{-0.8}(\text{stat.})^{+0.7}_{-0.6}(\text{syst.})$$



New

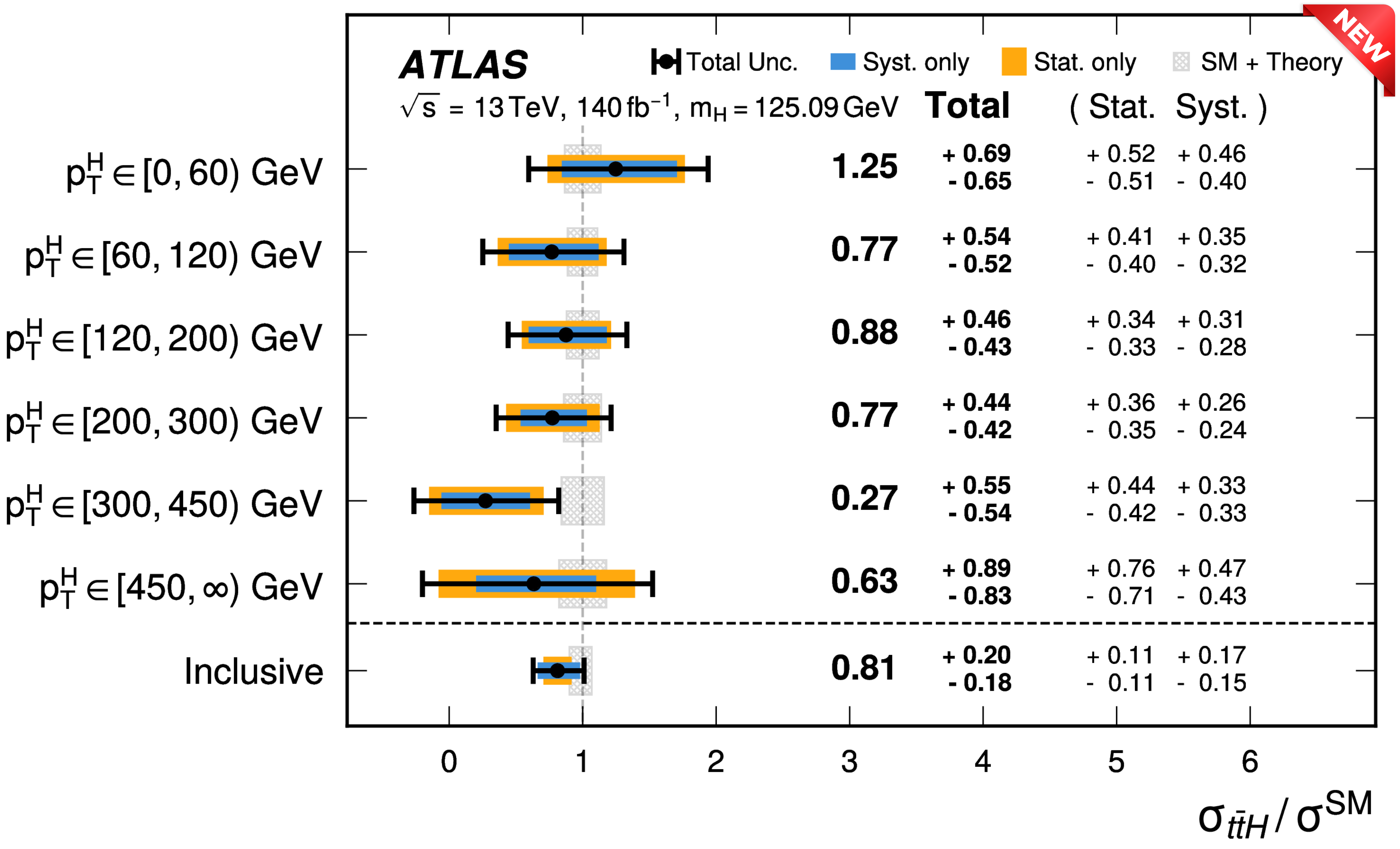
New

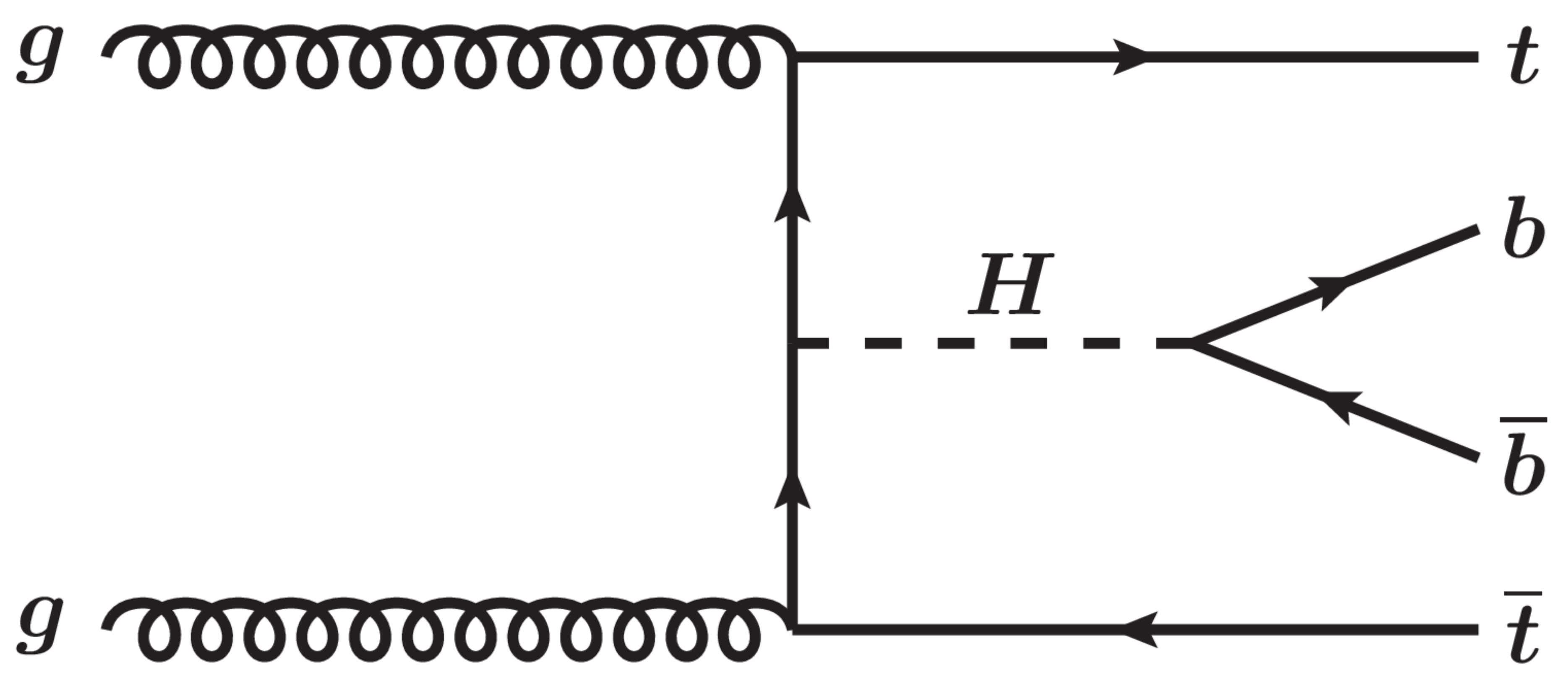
New boosted part

Improved

Improved

Precision Higgs - ttH to bb



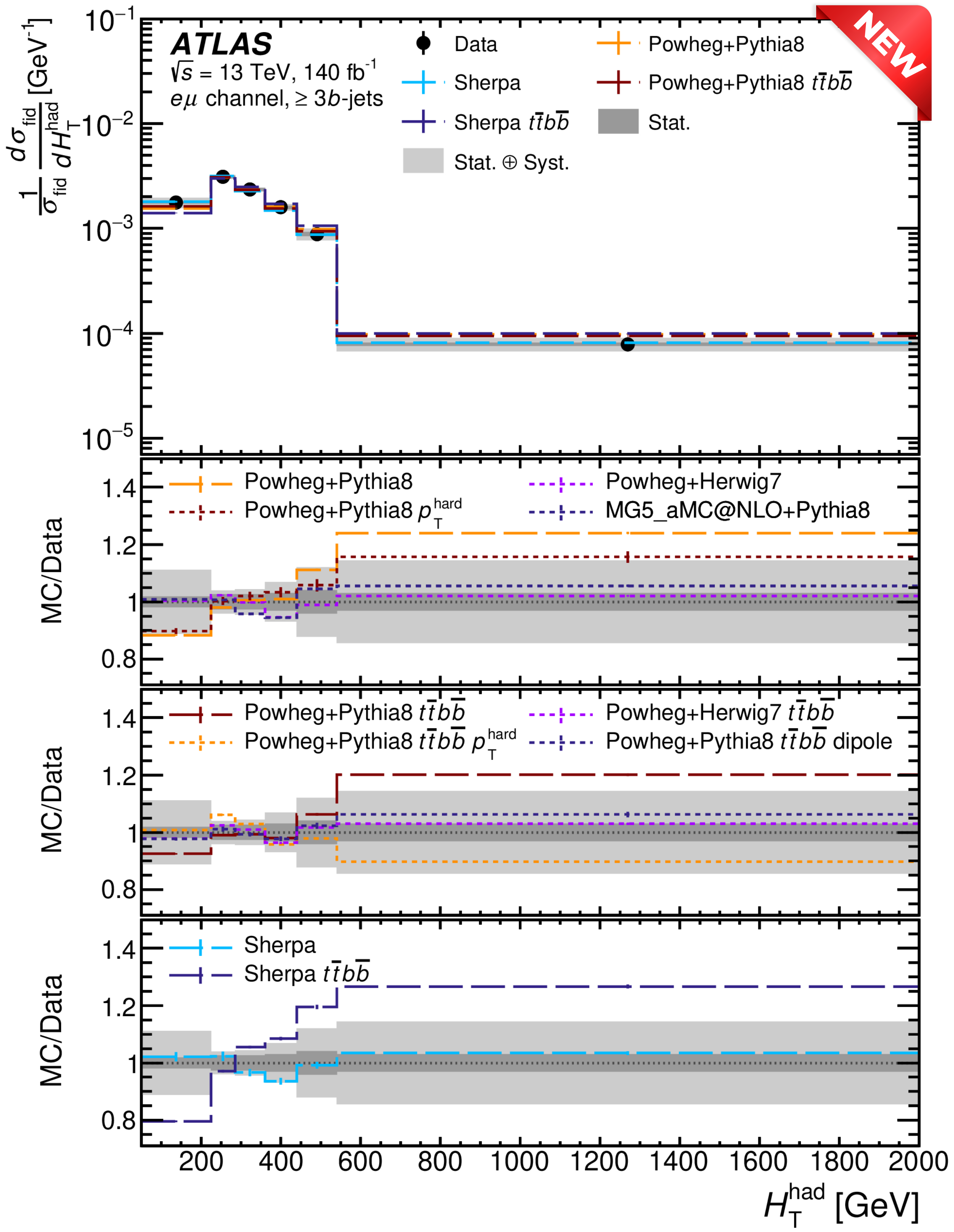


Total uncertainty reduced by factor of ~2, 4.6 σ observed

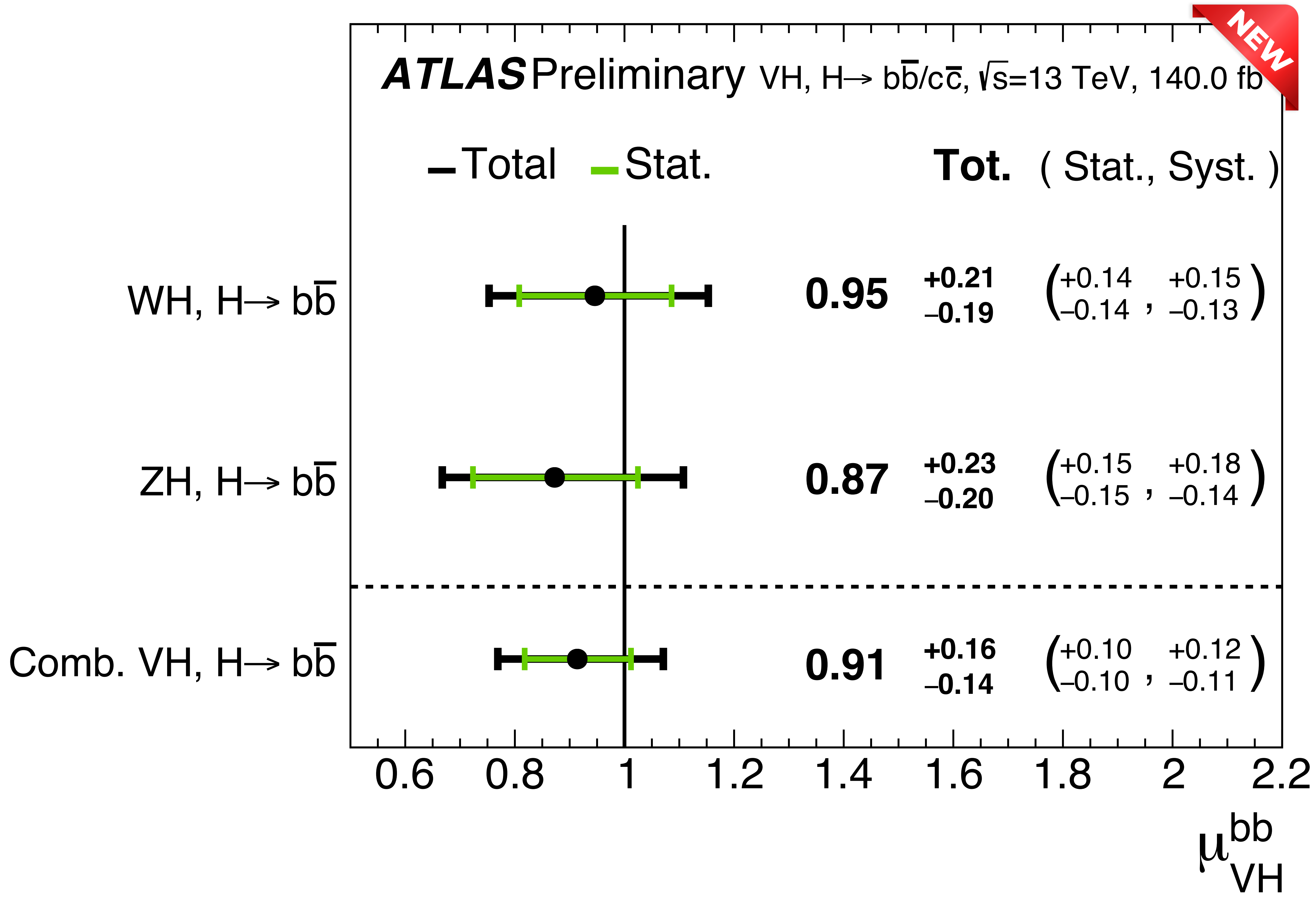
Where can we go - Precision Top for precision Higgs

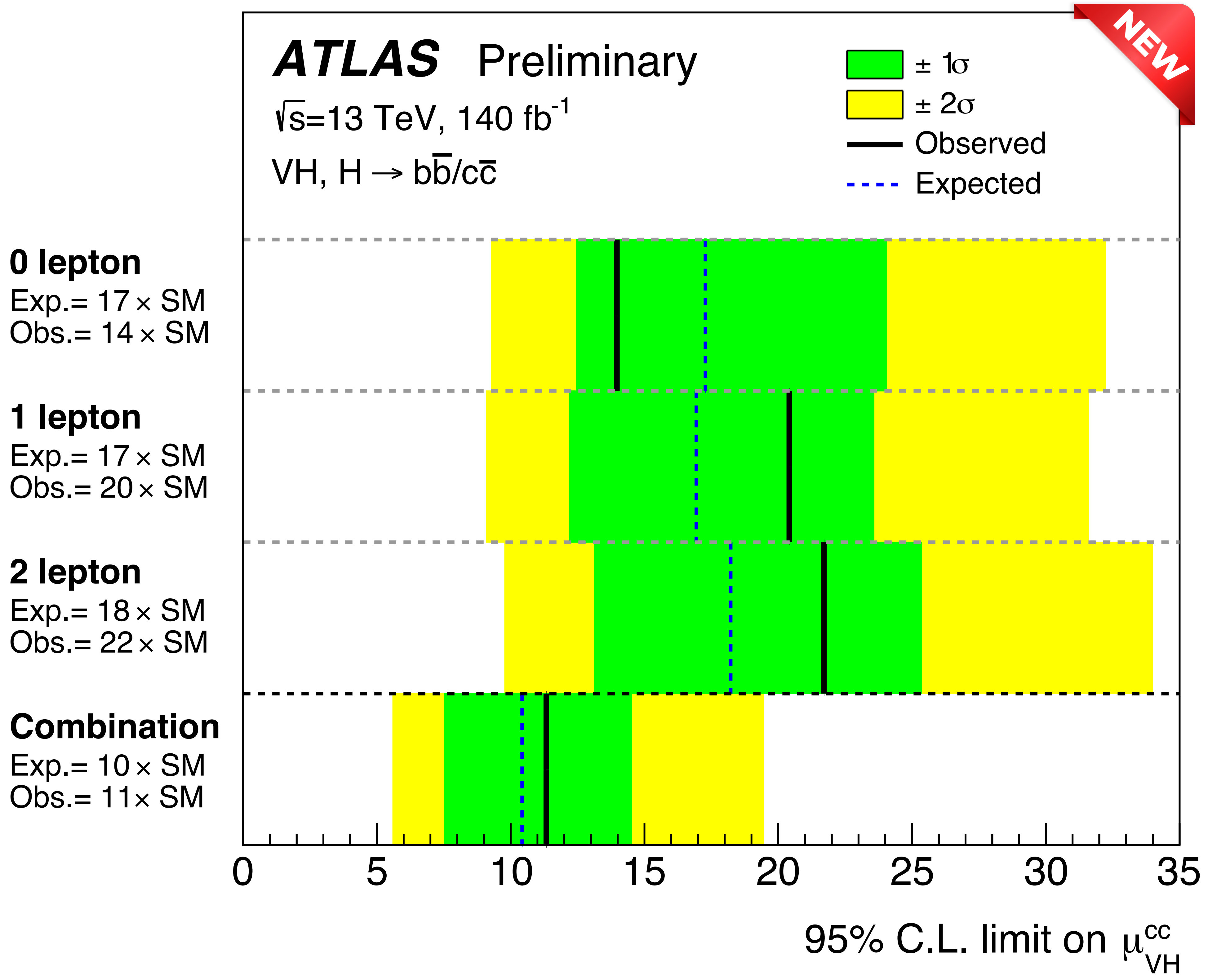
- Measurement of ttbar + heavy flavor: extensive measurement for improved theory modeling
- Important result to help further improve measurement like ttH

Other recent comprehensive results like ttW and Z+heavy flavour



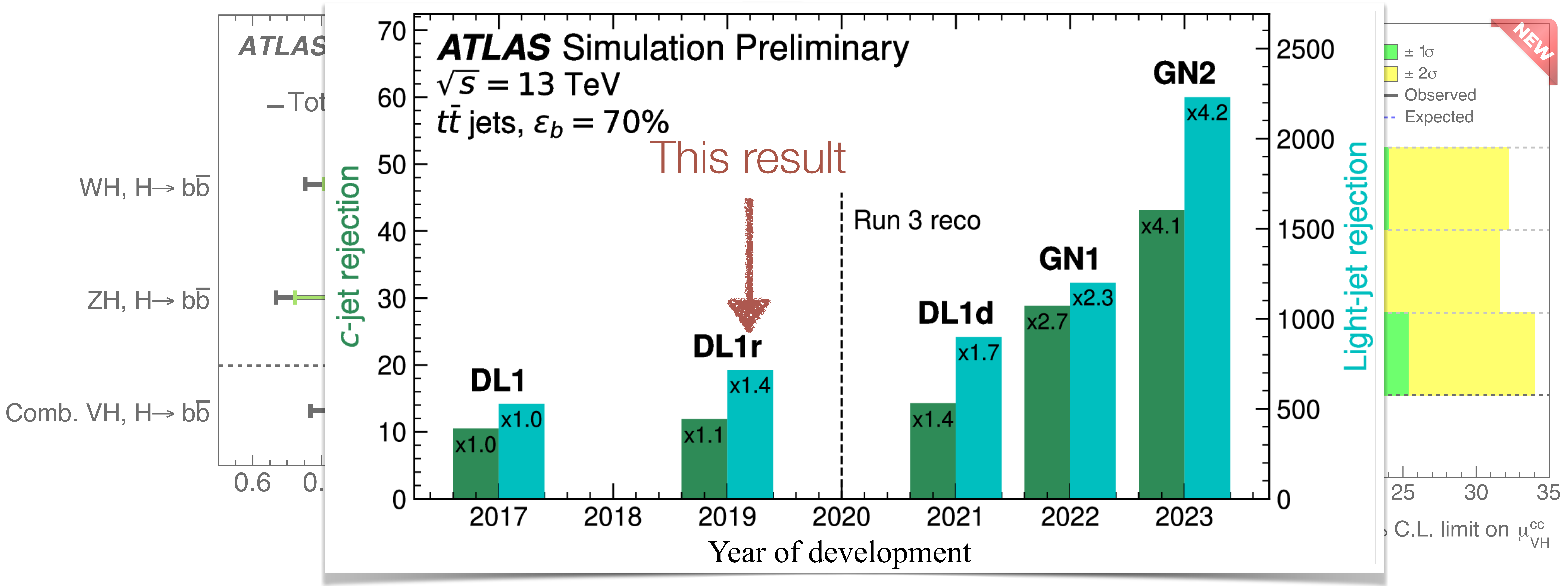
Precision Higgs - VH to bb/cc





Improvement of 15% for VHbb and a factor of x3 for VHcc

Where can we go - improved identification



Improvements to identification yielding impressive gains

Where can we go ATLAS and the HL-LHC

A Higgs factory:

400M Higgs bosons in ATLAS & CMS for precise Higgs coupling measurements, access to Higgs self interaction and longitudinal vector boson scattering

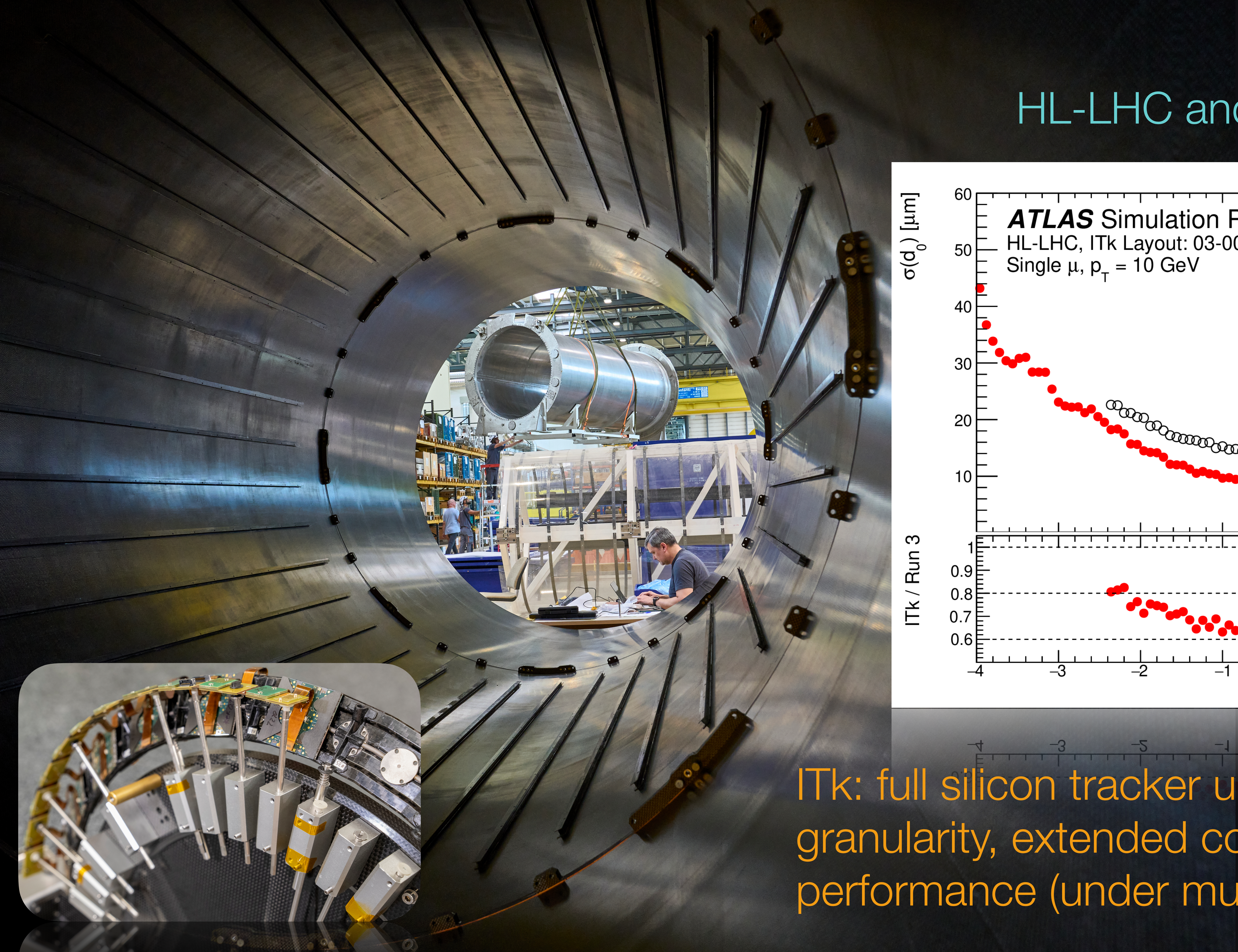
Plus significantly increased overall rare & new physics sensitivity

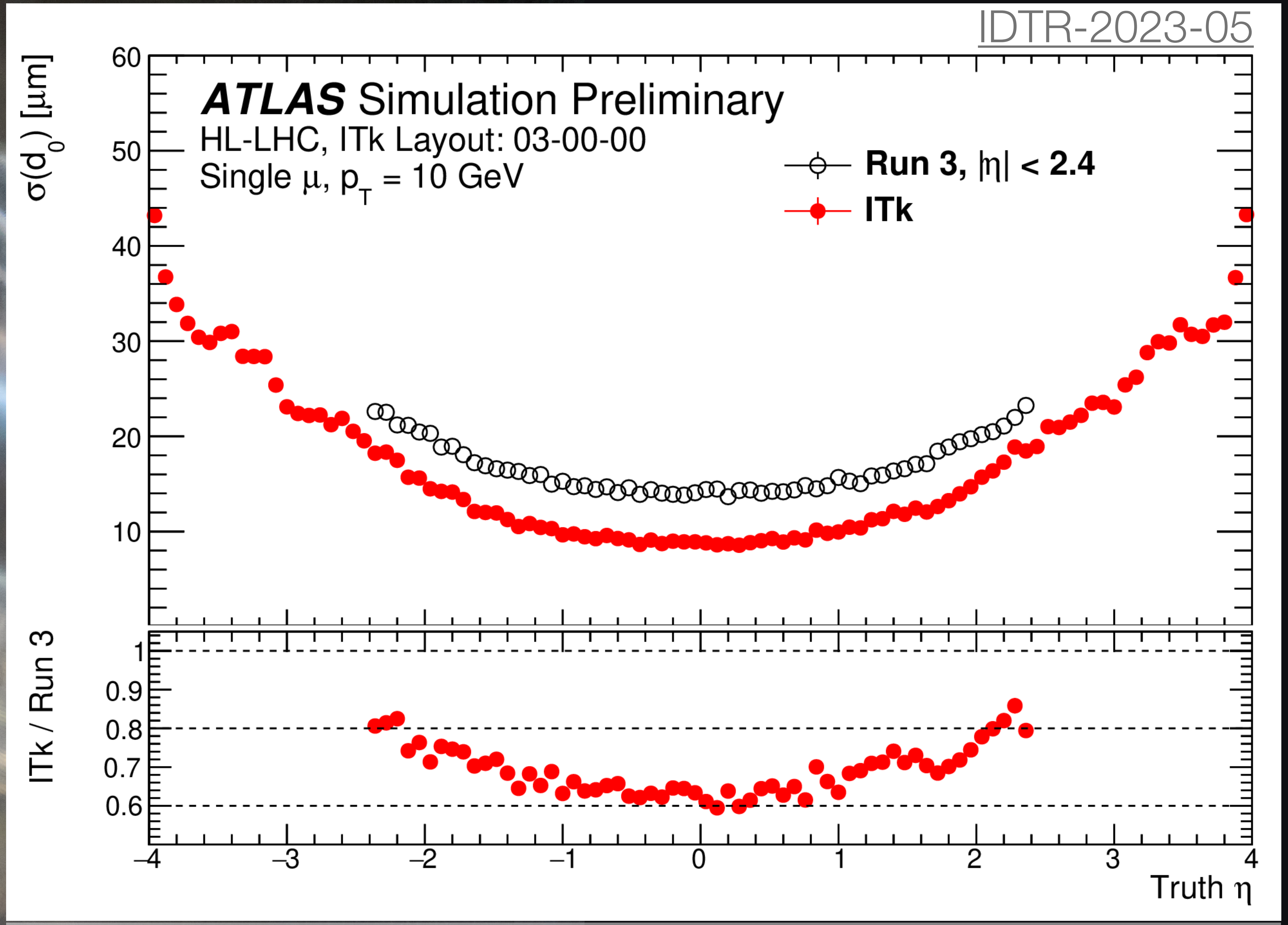
An upgraded ATLAS:

New detectors: high-granularity, high-coverage tracker, high-granularity timing detector, muon chambers

Improved trigger, high-performance software & computing, deeply embedded machine learning

Where can we go -
HL-LHC and the power of tracking





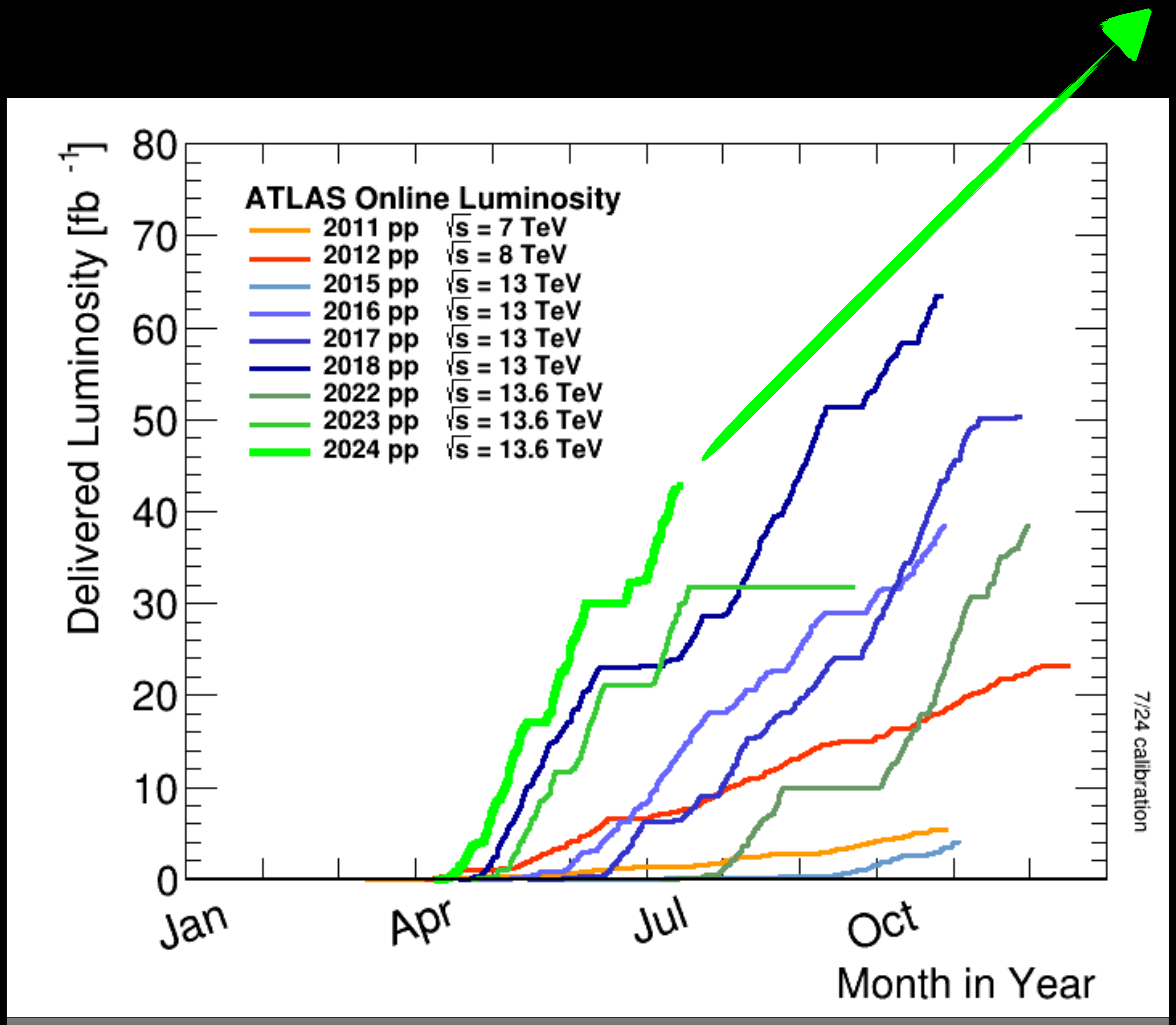
ITk: full silicon tracker upgrade with improved granularity, extended coverage, better performance (under much harsher conditions)

Where can we go
HL-LHC and the
future of triggering

New trigger system for HL-LHC -
faster, digital, higher rate capacity and more

New digital global, high granular trigger
Level 1 rate: 100 kHz to 1 MHz
Output rate: 1-2 kHz to 10 kHz

Where can we go - more data



1+ years of data taking to go

See many more results in the talks of Nicolas Berger, Philip Sommer, Didar Dobur, Livia Soffi, Josu Cantero and Kai Schweda

ATLAS ICHEP summary page

- pT fluctuations in Pb+Pb and Xe+Xe
- Constituent-based top tagging
- Dijet asymmetry vs jet radius
- 3D pixels sensor response
- Lund Plane in ttbar events
- pile-up jets reconstruction
- Jet energy scale E/P
- ttbar+heavy flavour
- tW cross section
- Higgs to tautau
- VH to bb/cc
- Higgs width
- ttH to bb
- Hyy+c
- H to aa to bbtautau search
- ssWW+WZ combination
- SUSY displaced leptons
- SUSY RPV top squarks
- prompt lepton-jets
- UPC monopoles
- CalRatio+X
- VLL 4321
- H+ to cs

ATLAS results premiering at ICHEP

Extras

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