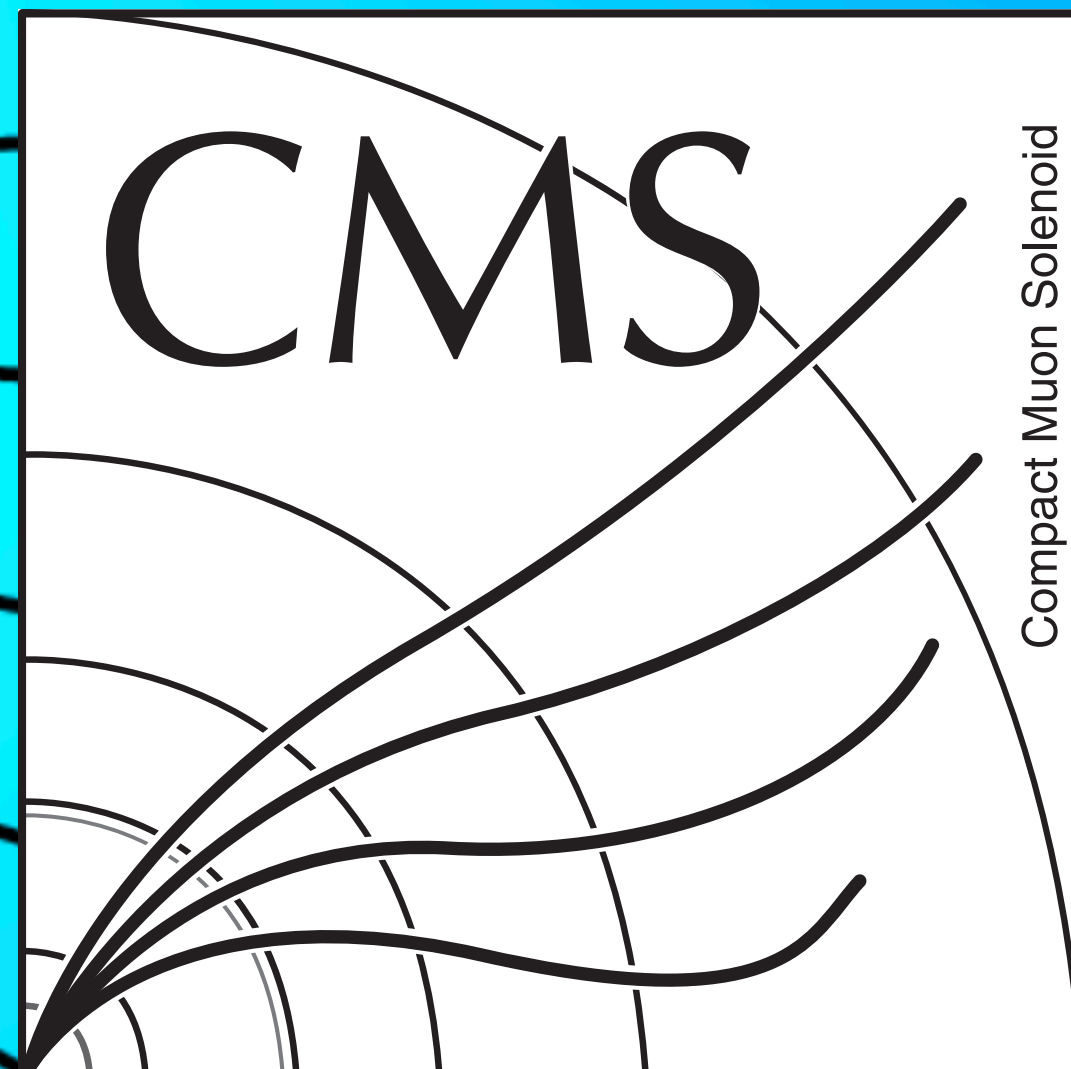
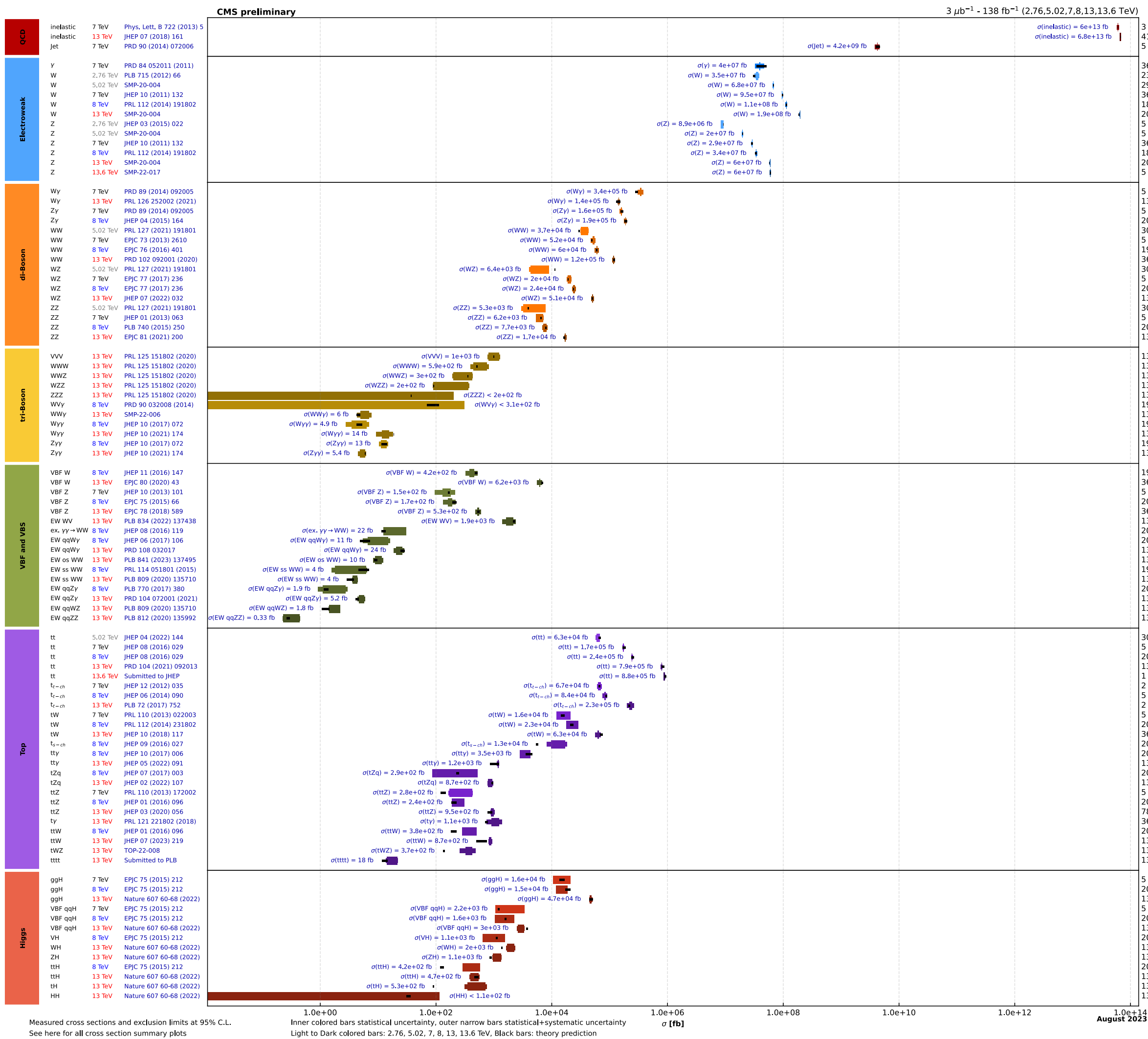


# Higgs and Electroweak highlights

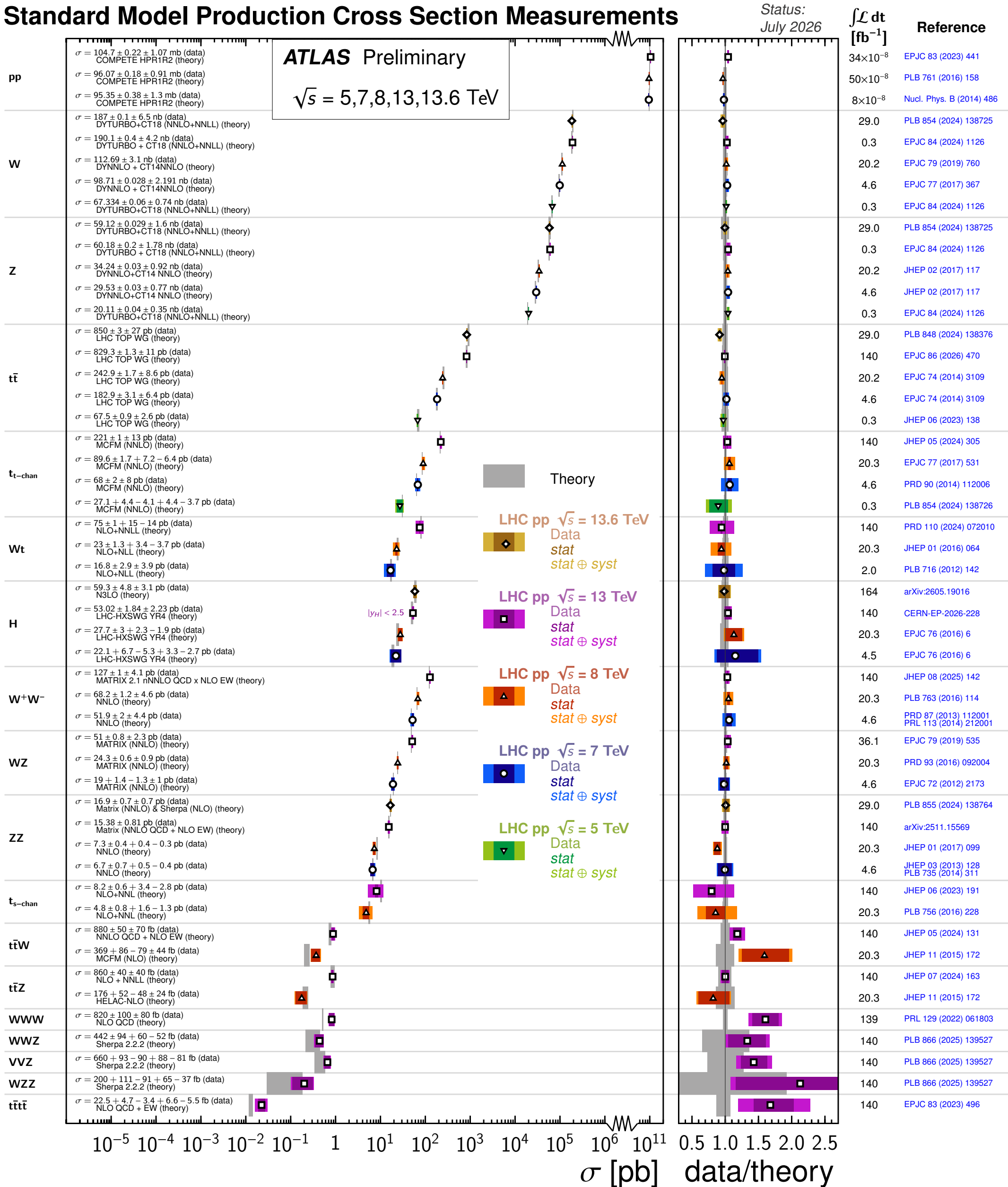
Chris Pollard  
Warwick

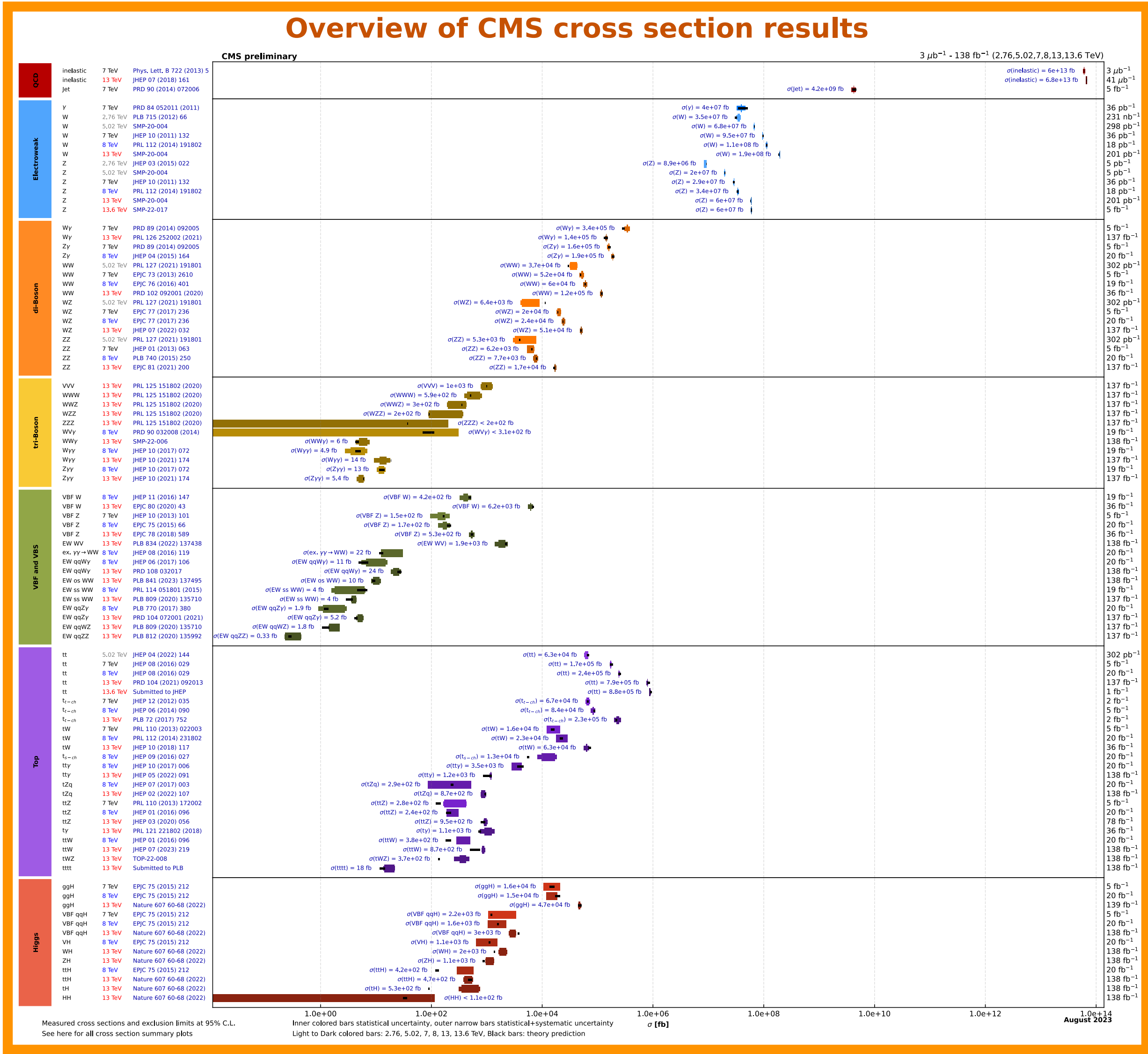


# Overview of CMS cross section results



## Standard Model Production Cross Section Measurements





huge breadth/depth of the LHC physics program

covers enormous dynamic range: milli-  $\rightarrow$  femtobarn

focus here on selected, recent experimental results

complete public results: ATLAS, CMS, LHCb

(notably: I'm not going to attempt to cover the wealth of LHC searches)

these results enabled by  
excellent operation of the  
LHC and detectors.

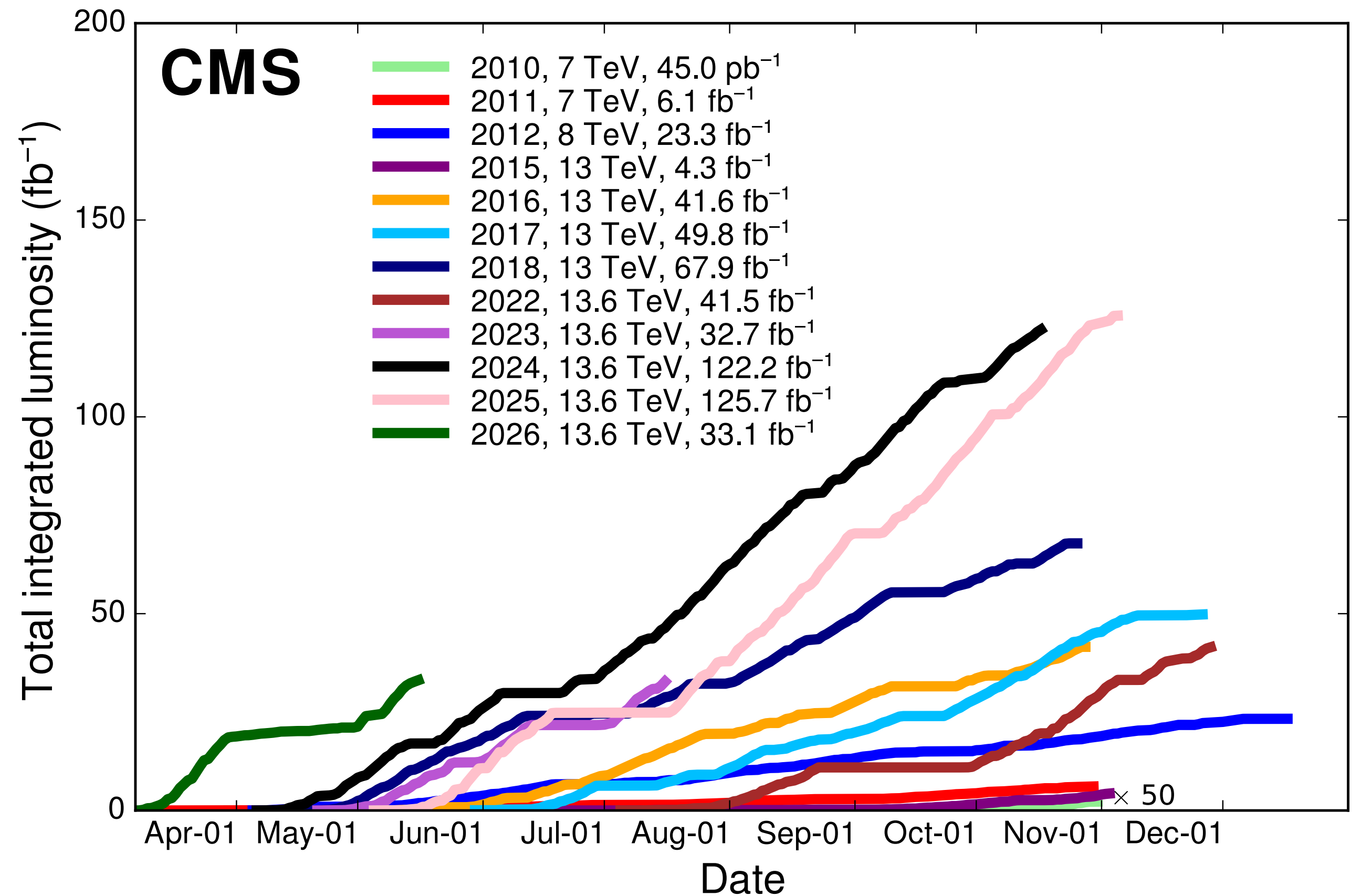
much of what I will discuss  
is from the Run 2 dataset

these results enabled by  
excellent operation of the  
LHC and detectors.

much of what I will discuss  
is from the Run 2 dataset

Run 3 is an incredible  
“harvest”: being analyzed  
as we speak

looking forward to what we  
will learn with these new  
data + the HL-LHC!



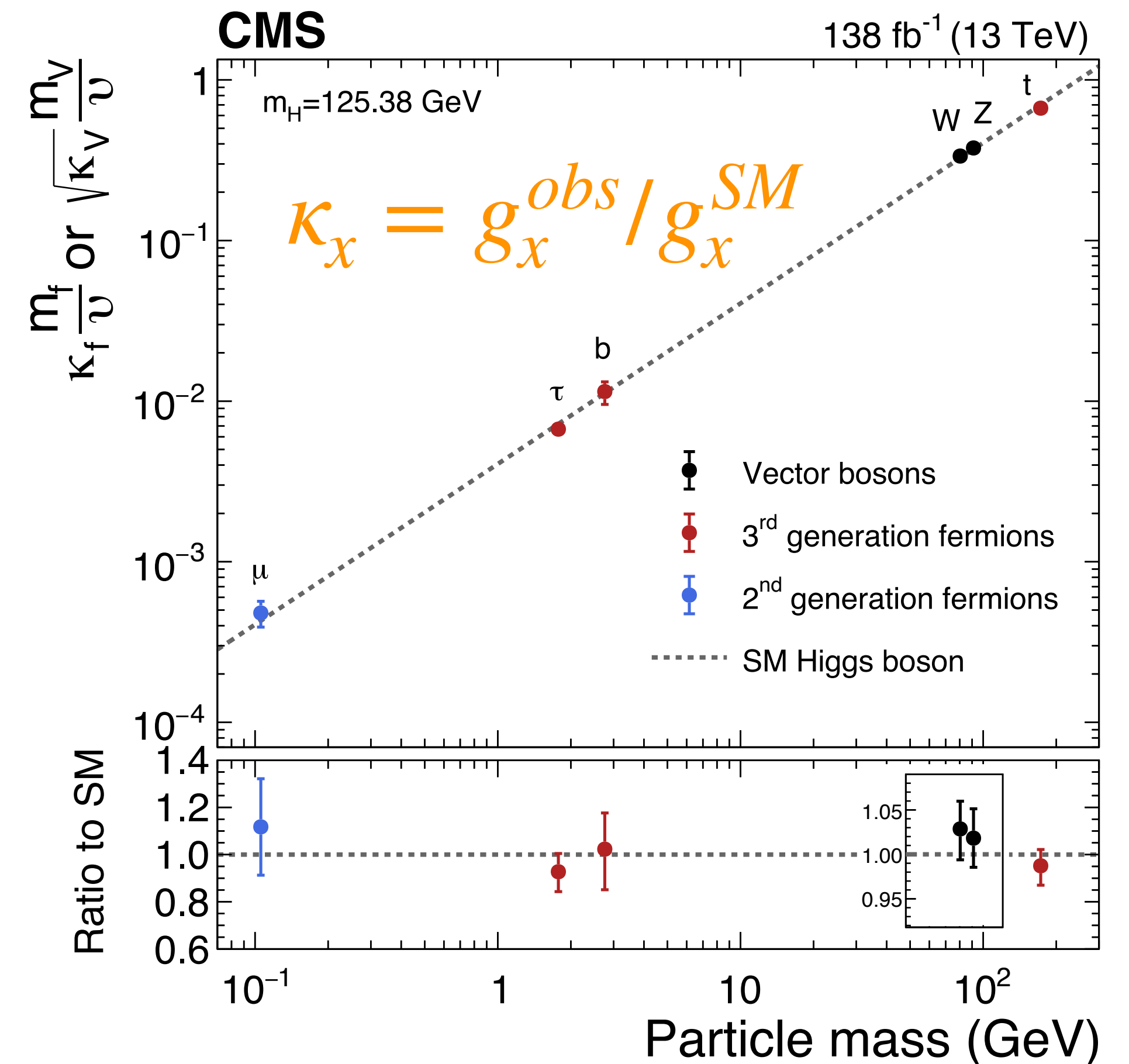
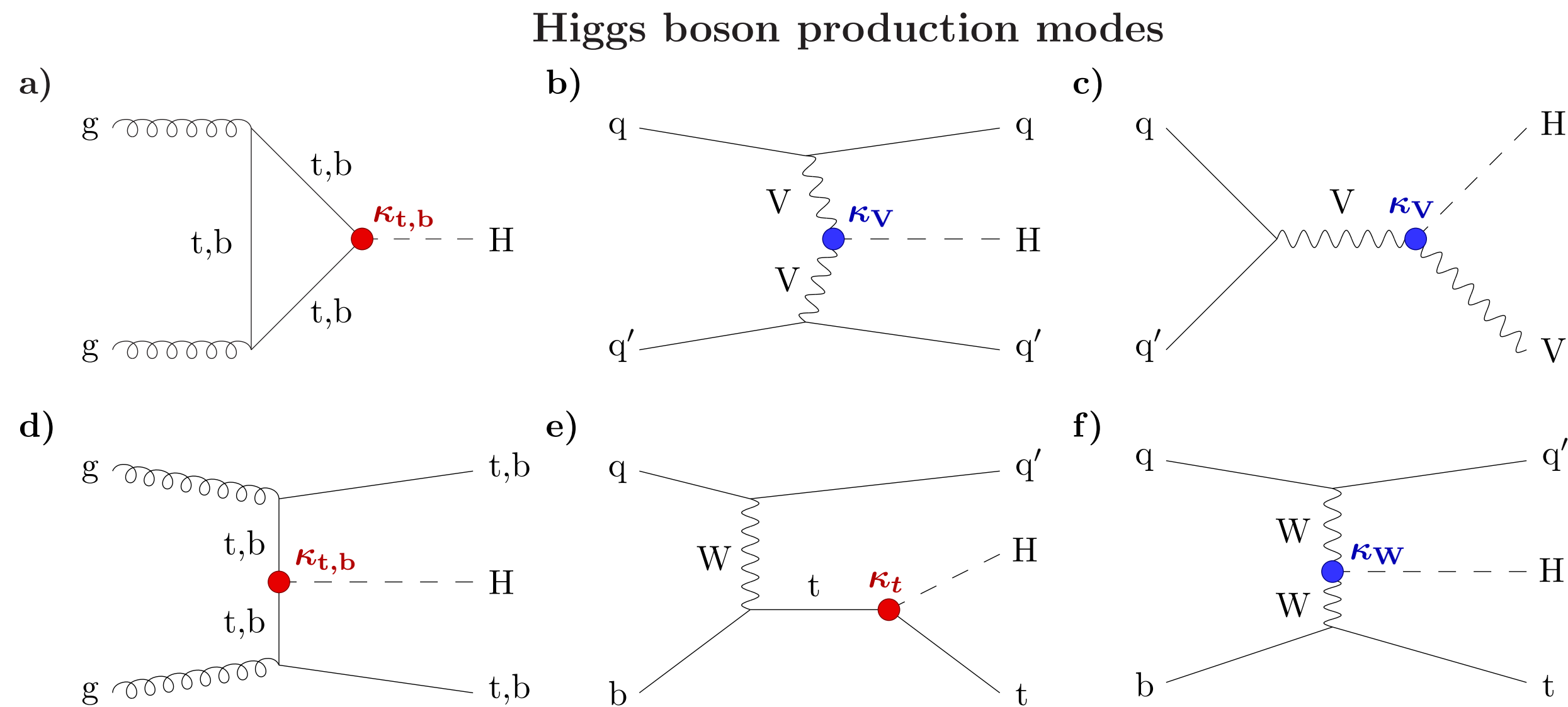
hang on tight...



# Higgs Physics

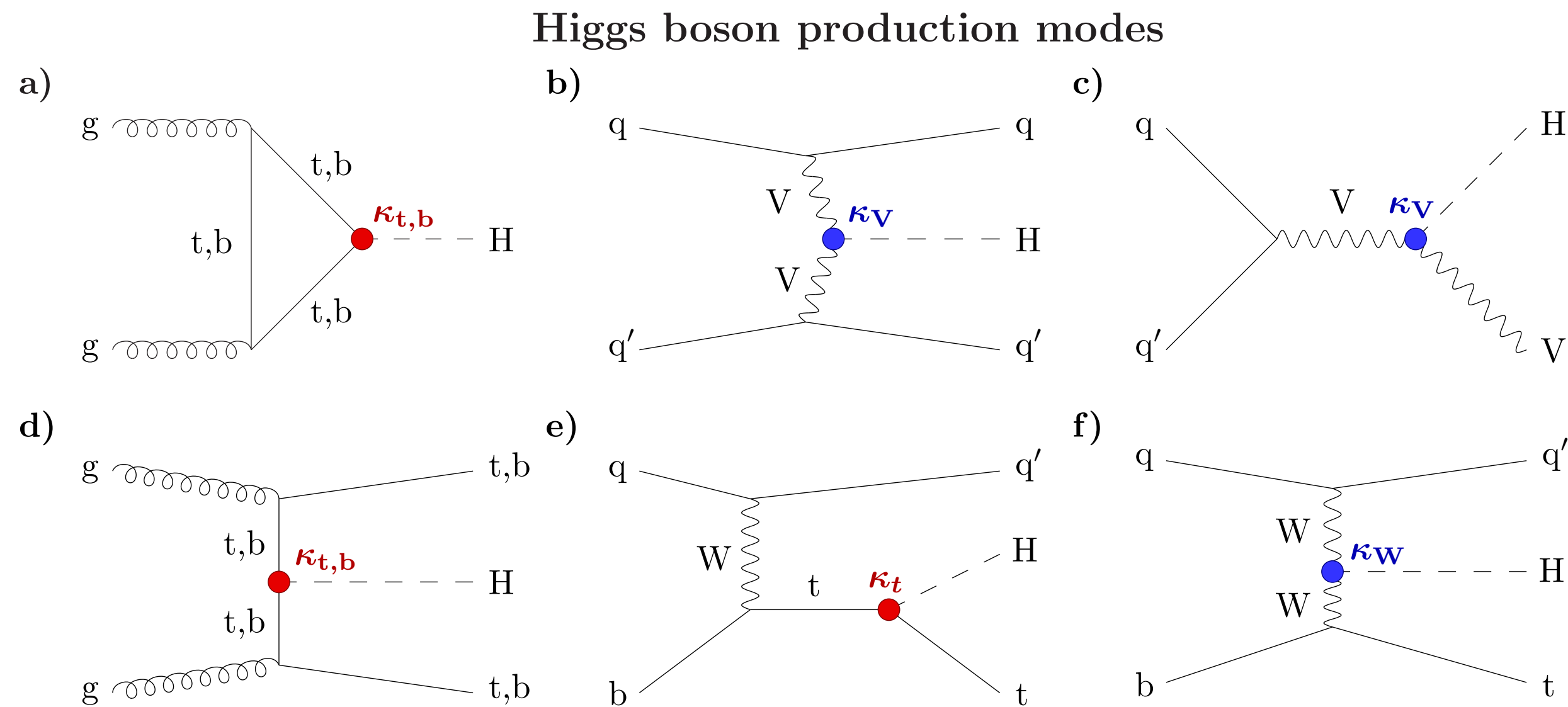
# State of the Higgs: 2022

comprehensive Nature summaries released by ATLAS and CMS  
cover couplings, cross-sections, mass, etc: CMS, ATLAS

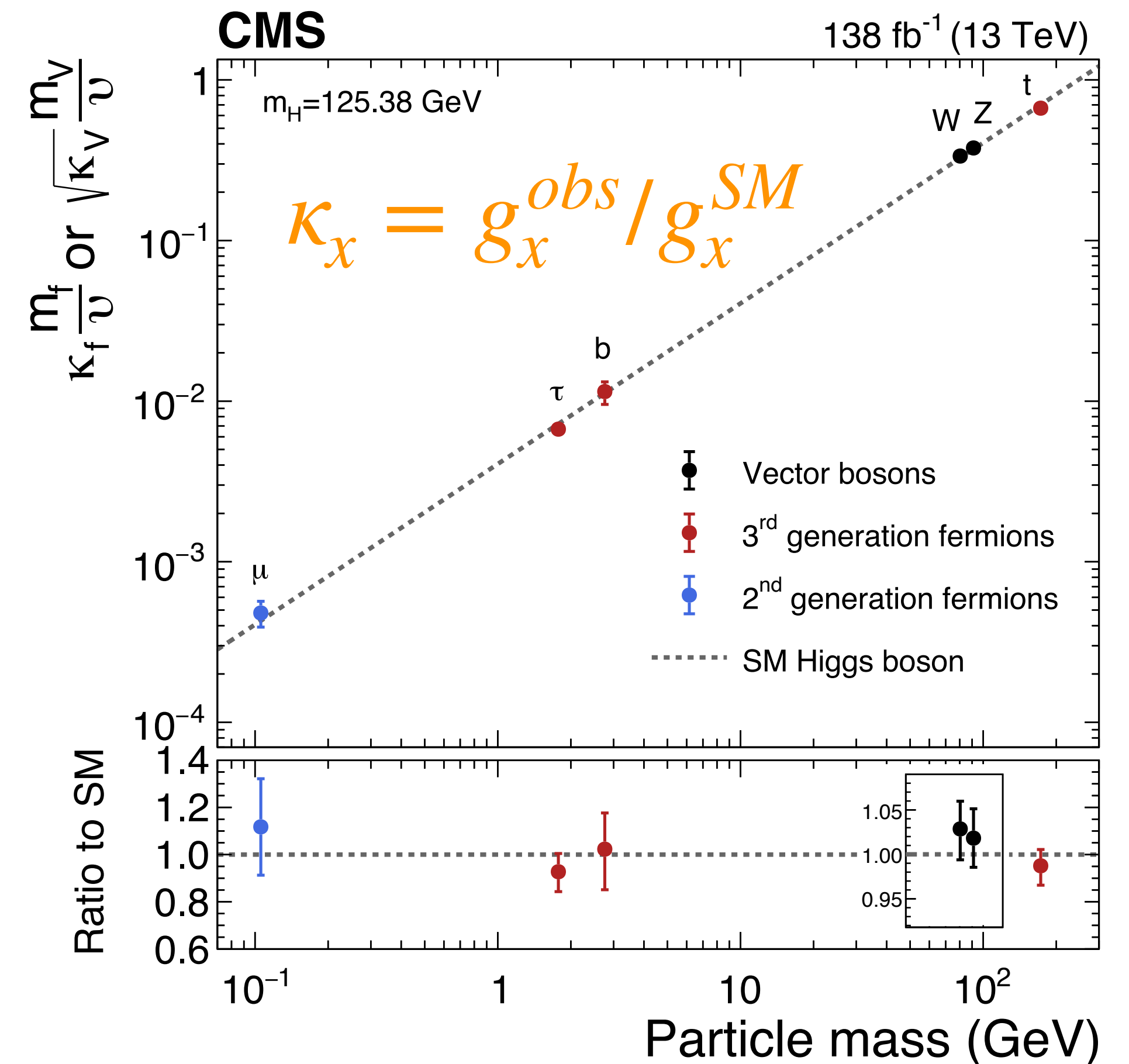


# State of the Higgs: 2022

comprehensive Nature summaries released by ATLAS and CMS  
cover couplings, cross-sections, mass, etc: CMS, ATLAS



summary: the Higgs behaves as predicted, but there has been substantial progress since.

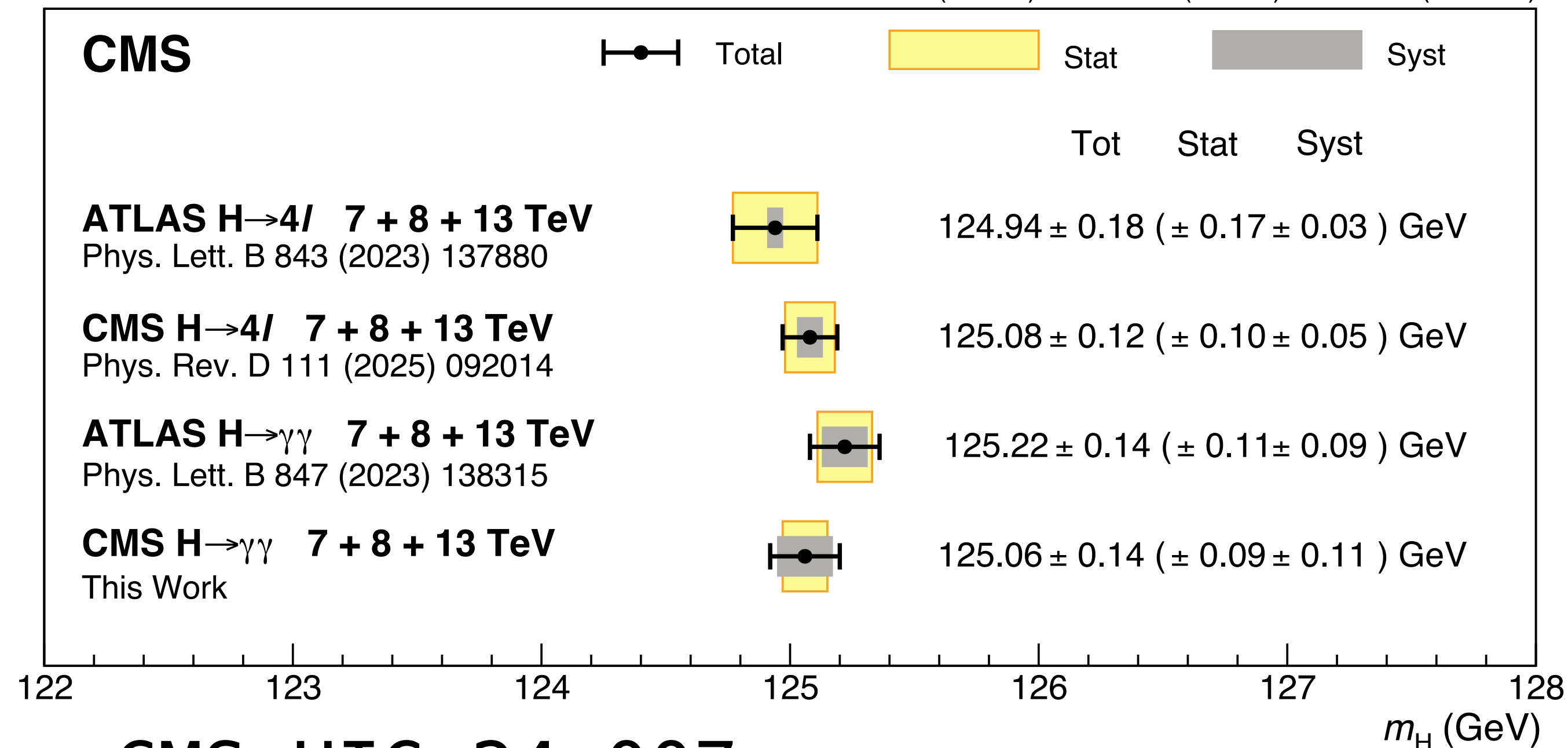


# Higgs mass measurements

important SM consistency check together with  $m_t$  and  $m_W$

currently  $\sim 100$  MeV precision per experiment,  
consistent with  $m_H = 125$  GeV

5.1 fb<sup>-1</sup> (7 TeV) + 19.7 fb<sup>-1</sup> (8 TeV) + 138 fb<sup>-1</sup> (13 TeV)



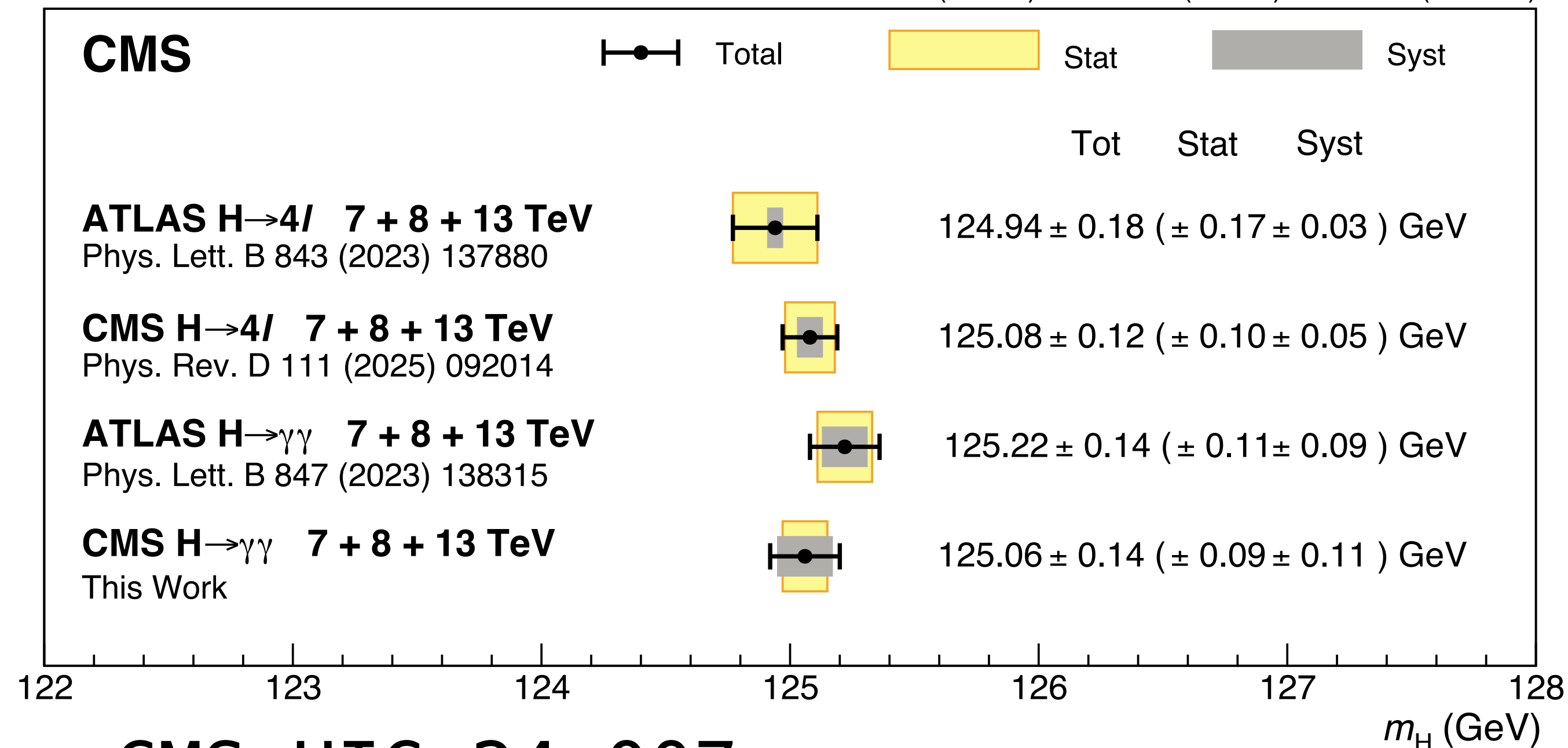
CMS-HIG-24-007

ATLAS Run 2 combination  
(2023) :  $m_H = 125.00 \pm 0.11$  GeV

# Higgs mass measurements

expect  $< 100$  MeV precision from LHC combination  
 $< 50$  MeV from HL-LHC  
 $\sim 10$  MeV from FCC-ee [[source](#)]

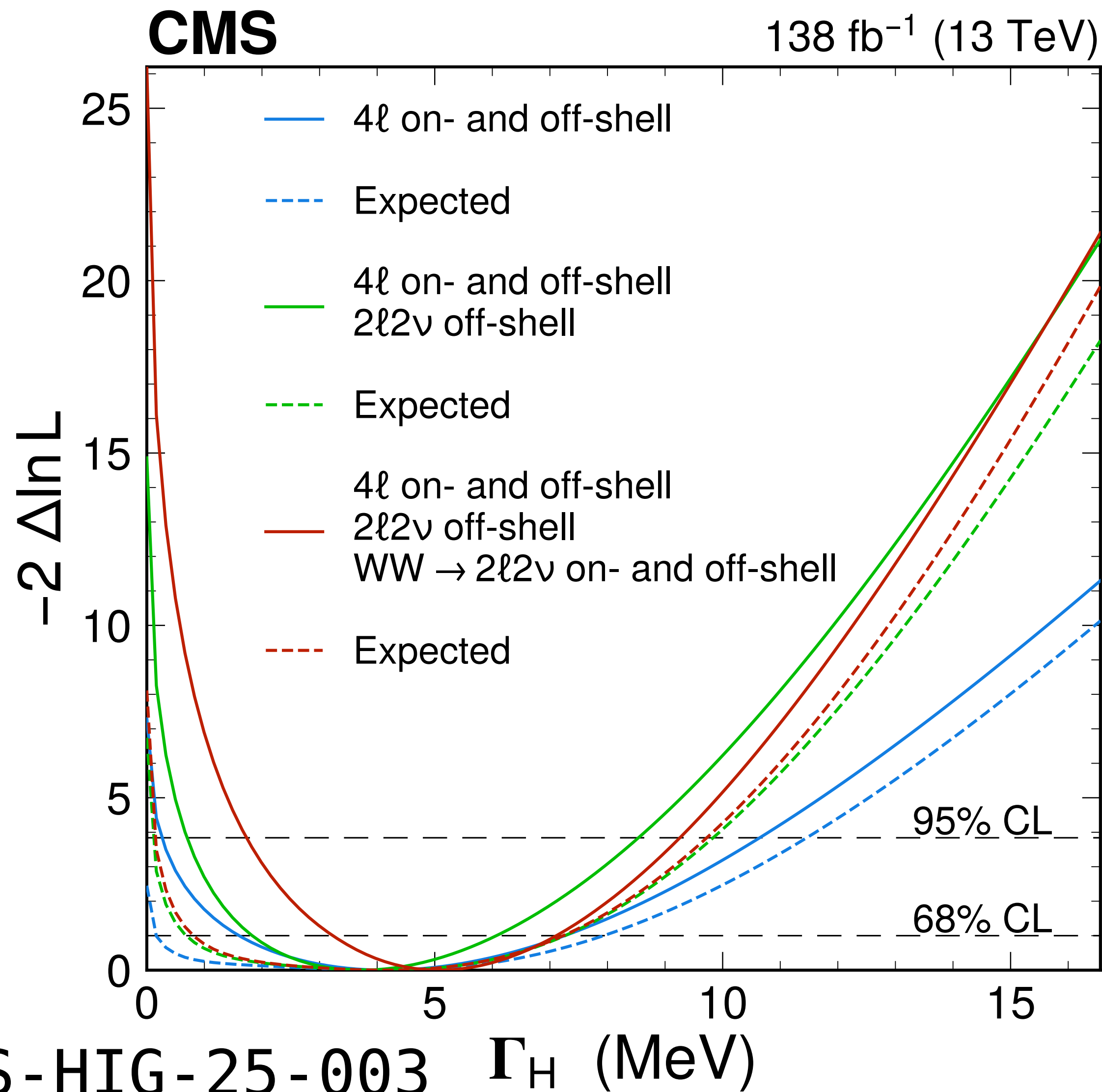
5.1 fb<sup>-1</sup> (7 TeV) + 19.7 fb<sup>-1</sup> (8 TeV) + 138 fb<sup>-1</sup> (13 TeV)



ATLAS Run 2 combination  
(2023) :  $m_H = 125.00 \pm 0.11$  GeV

CMS-HIG-24-007

# Higgs width measurements



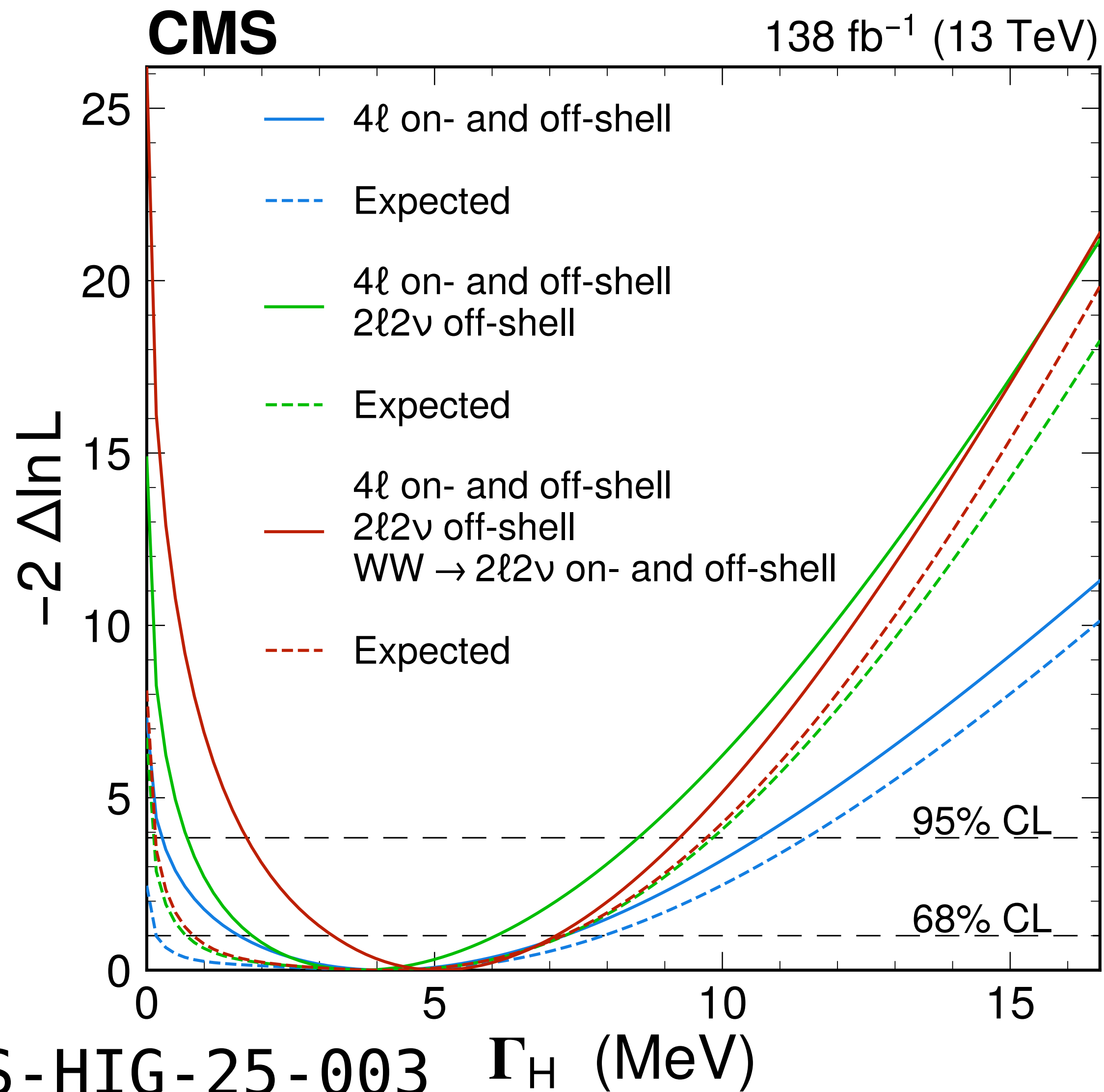
$\Gamma_H \sim 4$  MeV in the SM

measurements via off-shell  
production sensitive to BSM  
effects and can break  
degeneracies e.g.  $k_t \leftrightarrow k_g$ .

< 2 MeV precision on  $\Gamma_H$

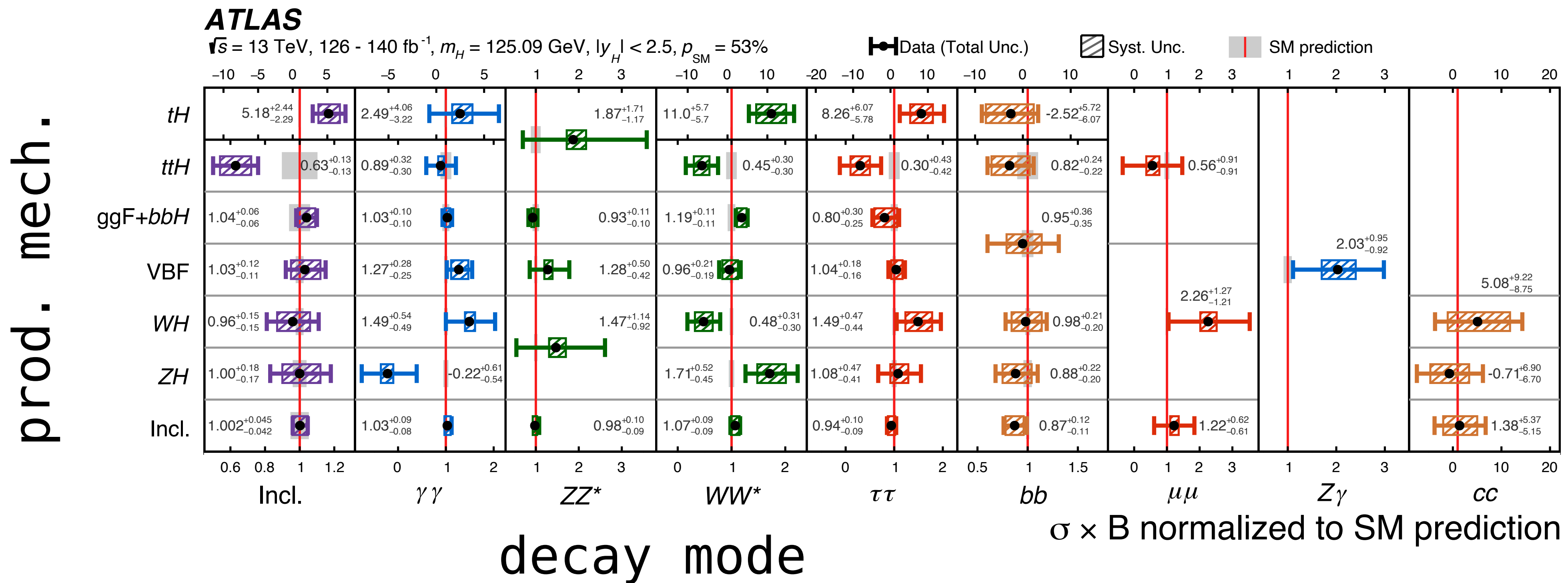
measurements via on-shell line  
shape result in ~30 MeV  
precision.

# Higgs width measurements



✦ dominant uncertainty from  
 $qq \rightarrow 4\ell$  background prediction

# Higgs cross sections



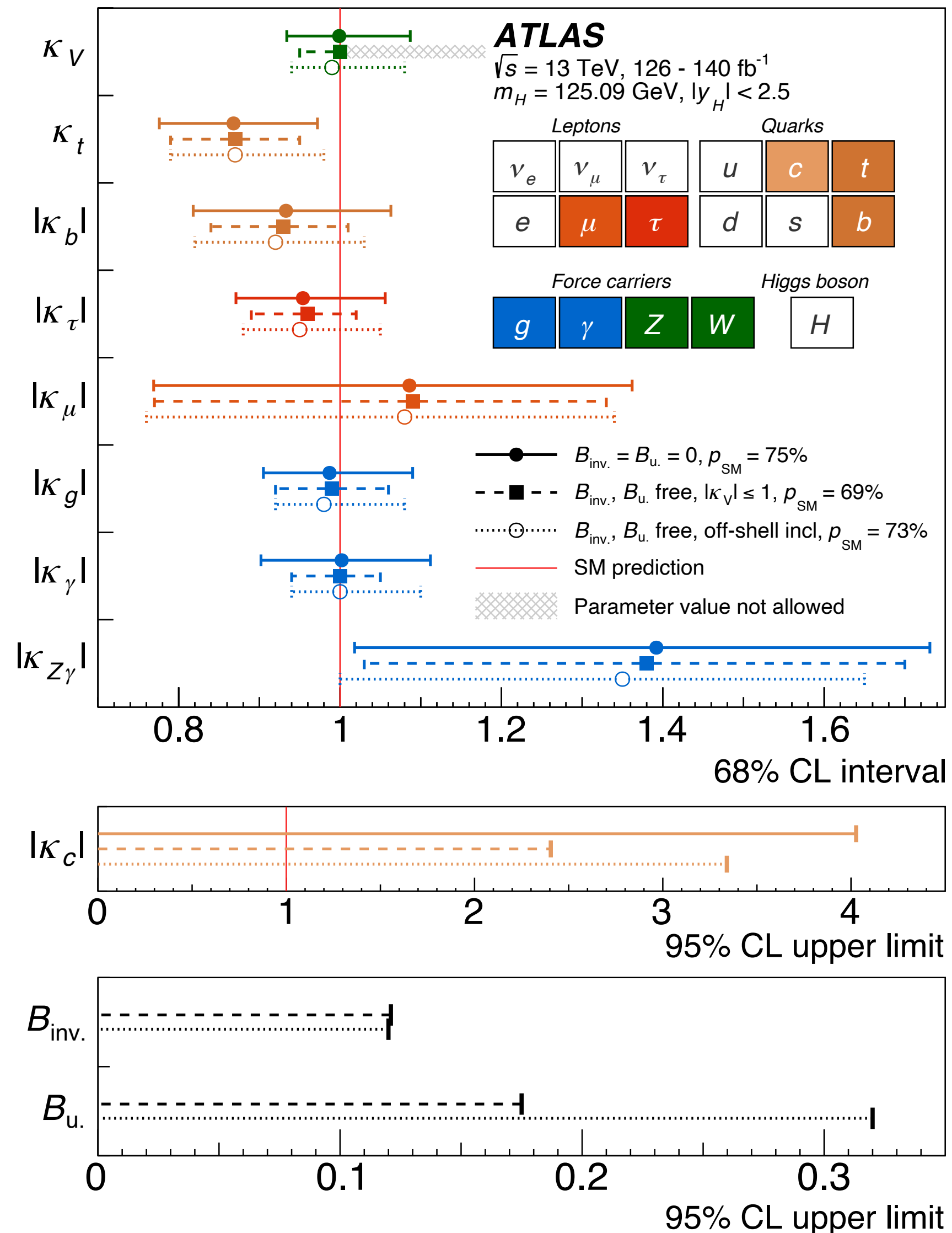
HIGP-2025-16

10-20% precision on main prod. modes, ~10% on BRs

broadly in line with the SM

# Higgs couplings: kappas

HIGP-2025-16



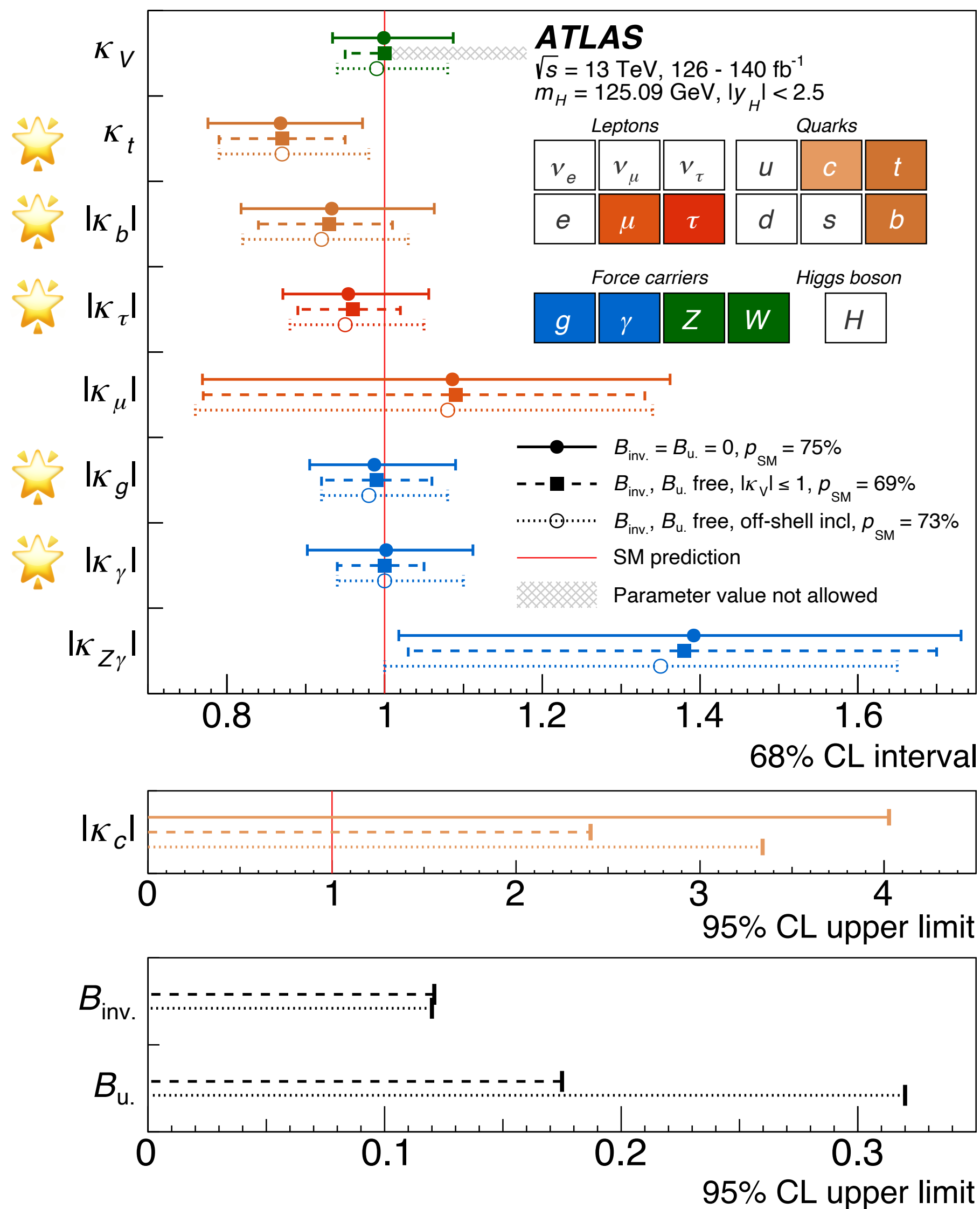
interpretations via coupling modifiers are in agreement with the SM

~10% precision in a fairly model-independent fit

$BR(\text{invis})$  now also at  $< 10\%$

# Higgs couplings: kappas

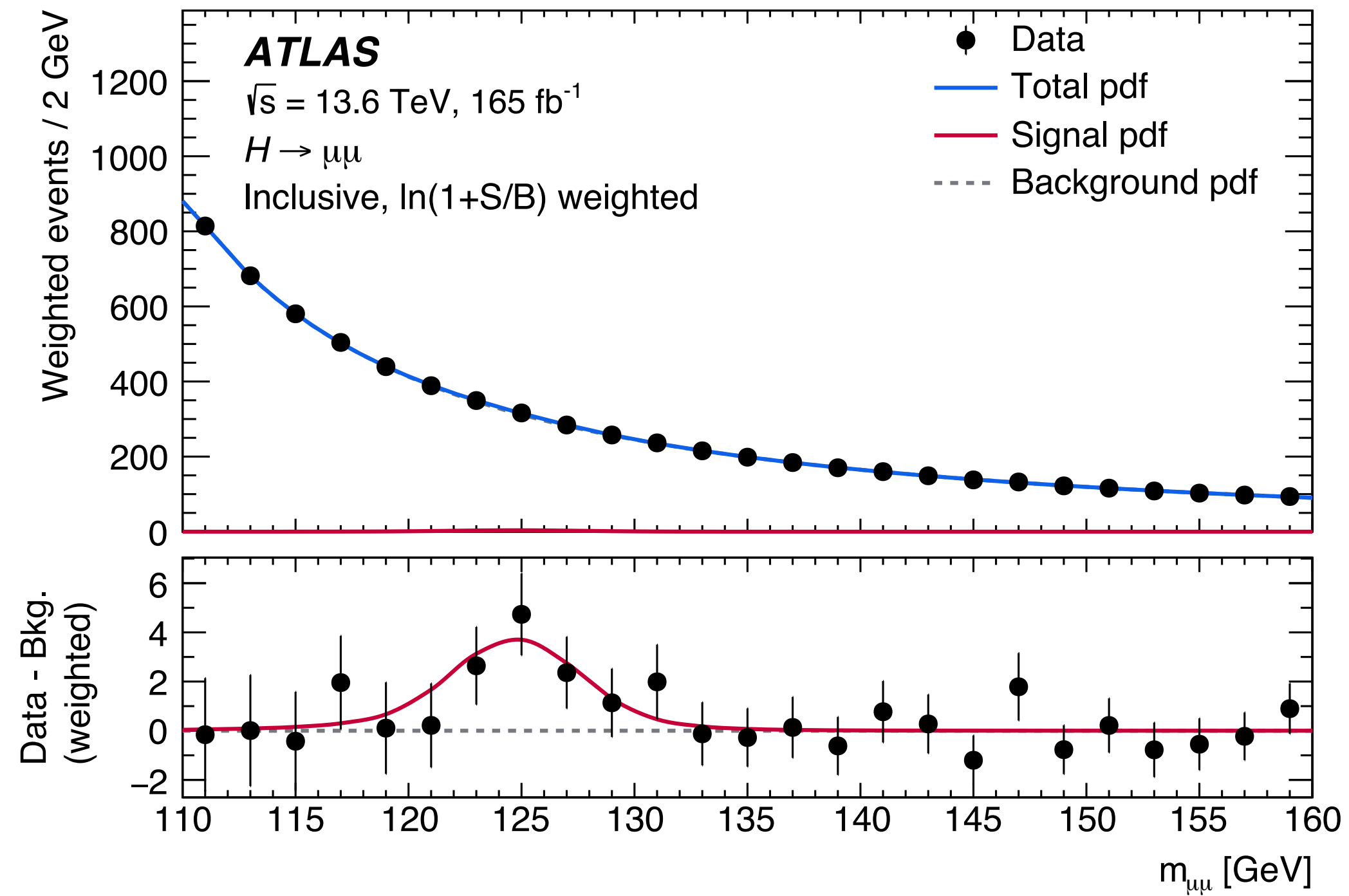
HIGP-2025-16



★ substantial uncertainty  
theory predictions

# Rare / 2nd gen decays

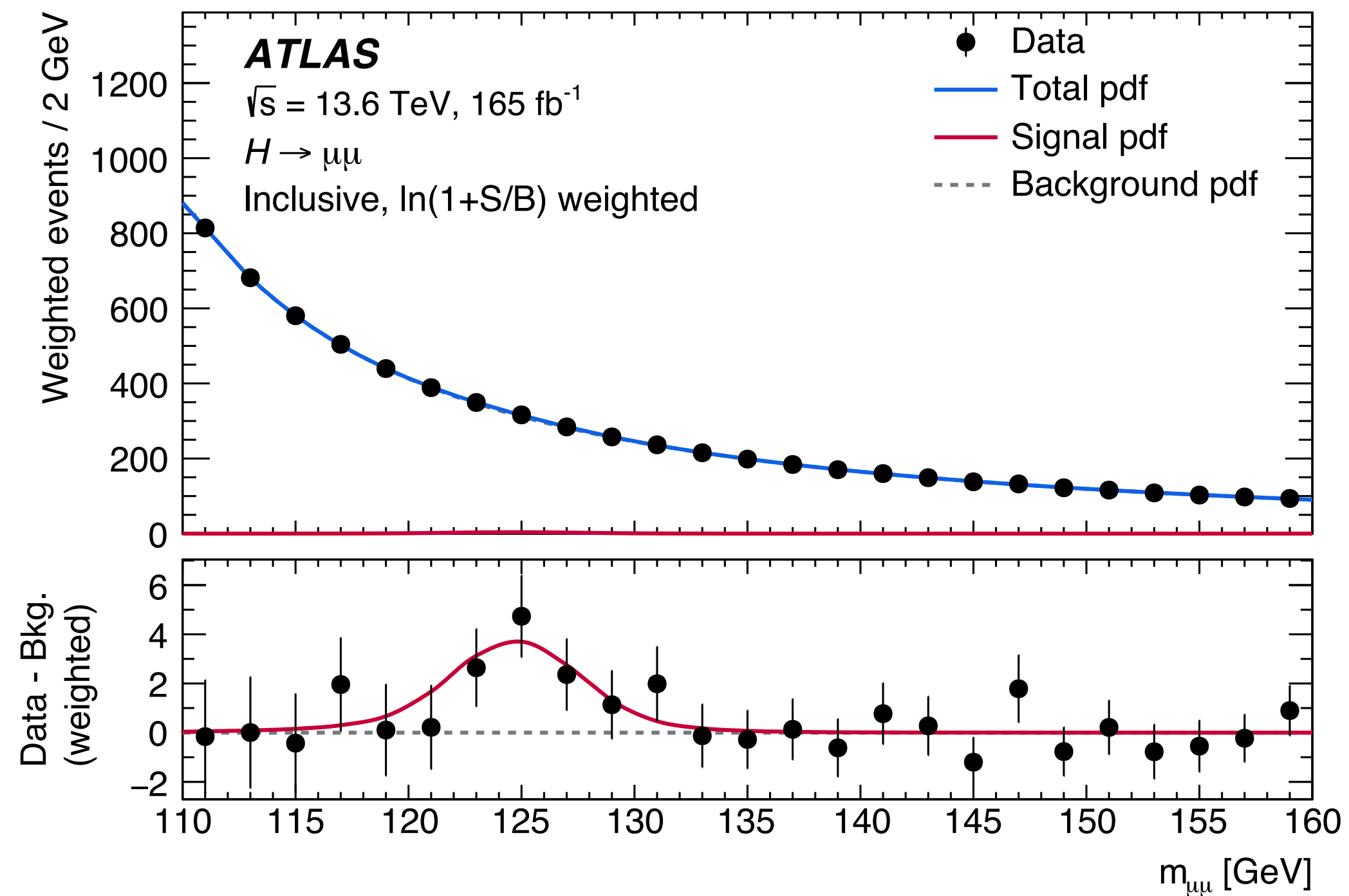
PRL 135 (2025) 231802



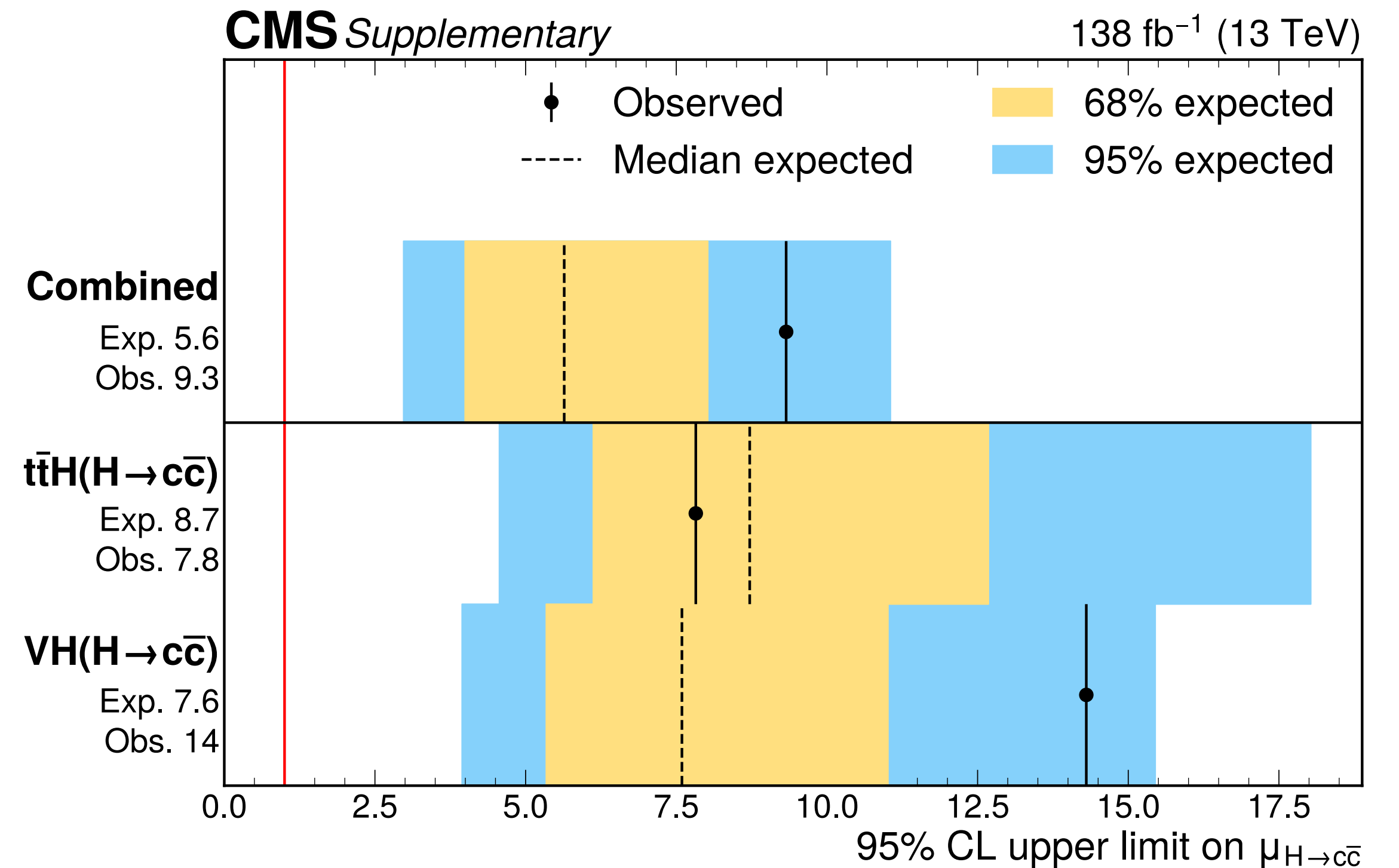
rapidly closing in on decays to  $\mu\mu$  and  $Z\gamma$  (evidence)

# Rare / 2nd gen decays

PRL 135 (2025) 231802



PRL 136 (2026) 011801



rapidly closing in on decays to  $\mu\mu$  and  $Z\gamma$  (evidence)

$\kappa_c < 3$  driven by impressive growth of jet flavor identification:  
we've already surpassed HL-LHC projection from 2022

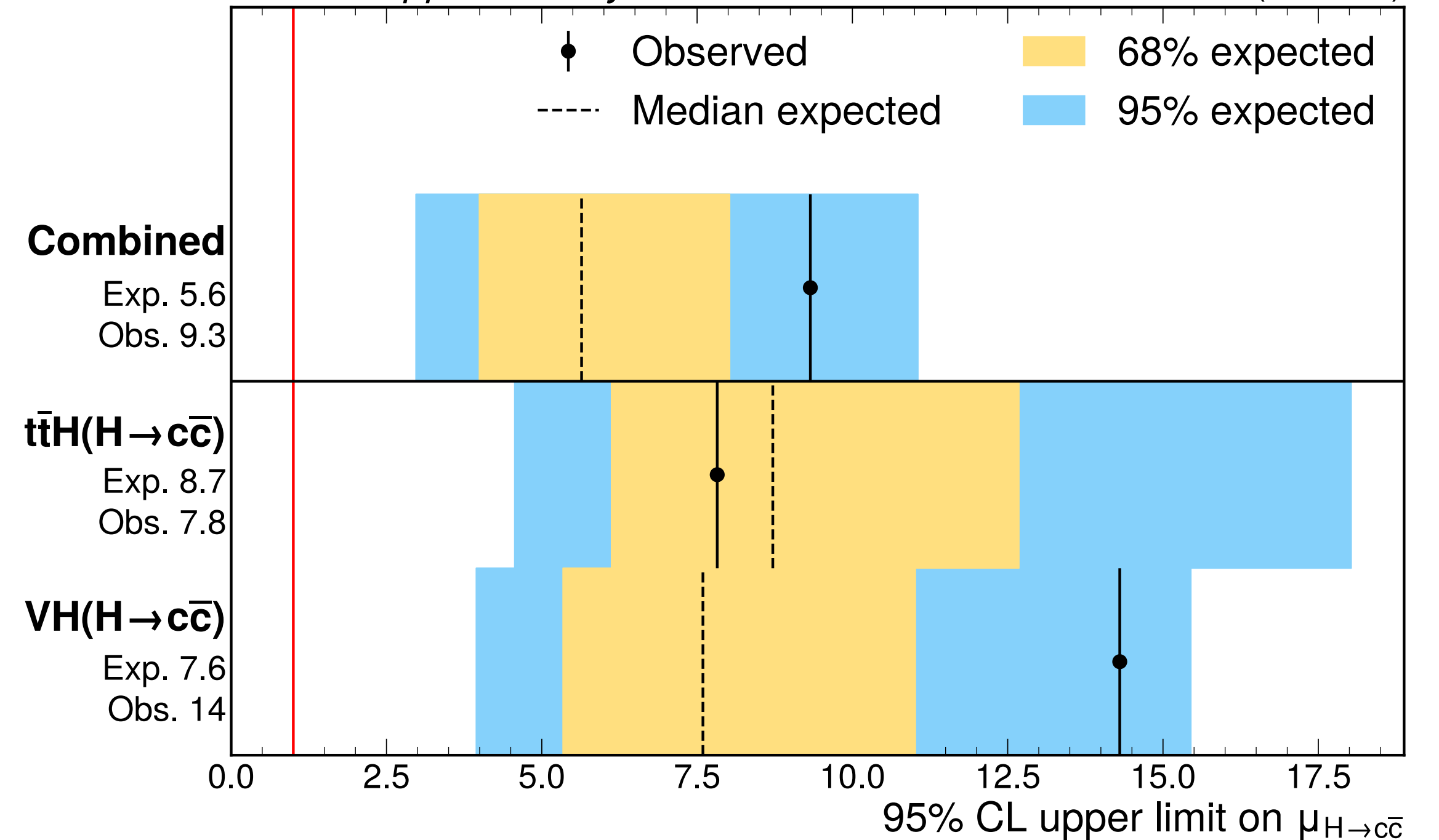
# Rare / 2nd gen decays

PRL 136 (2026) 011801

**CMS** *Supplementary*

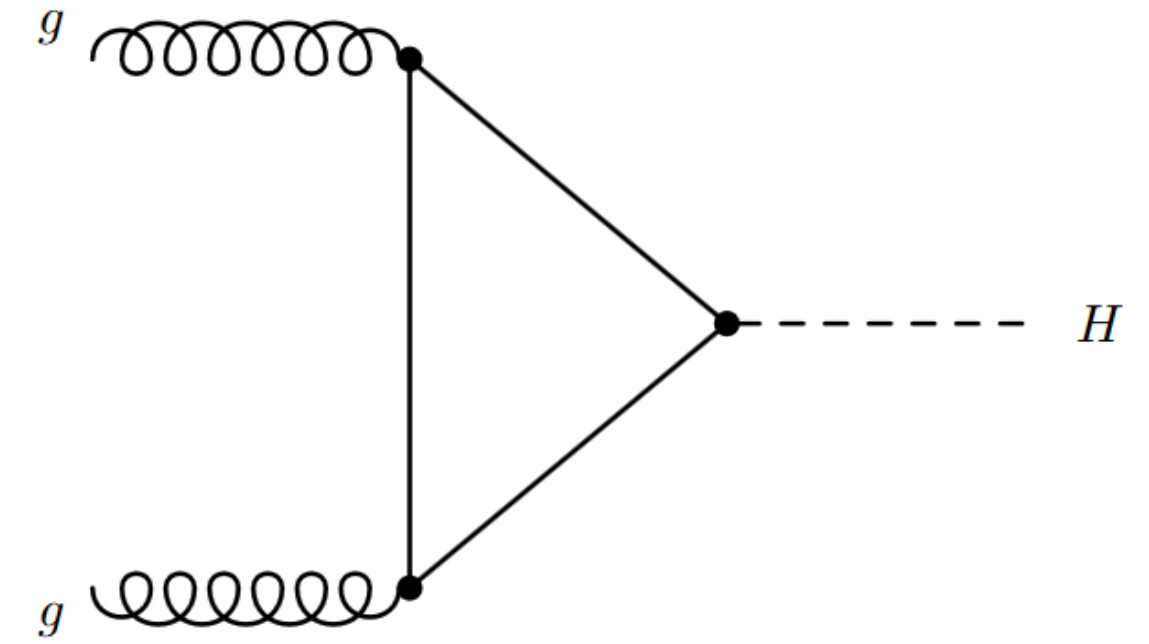
138 fb<sup>-1</sup> (13 TeV)

✦ efficient charm-jet  
identification depends  
critically on correct  
simulation of QCD-induced  
background jets



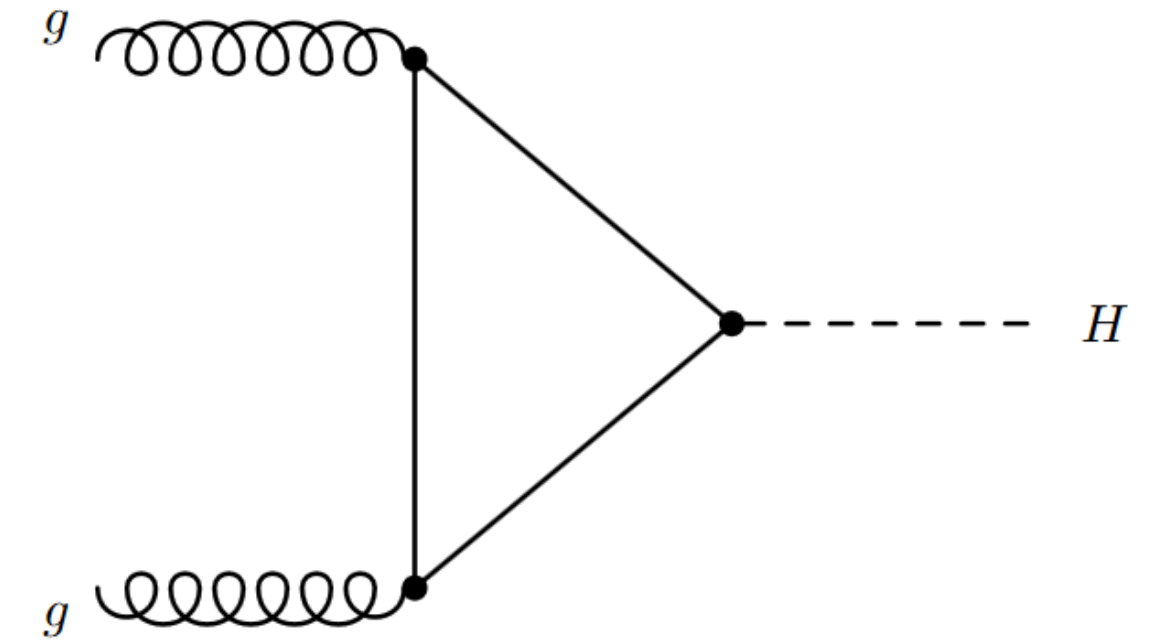
# High- $p_T$ cross sections

Higgs production at high  $p_T$  very sensitive to non-SM contributions to the gg-H loop.

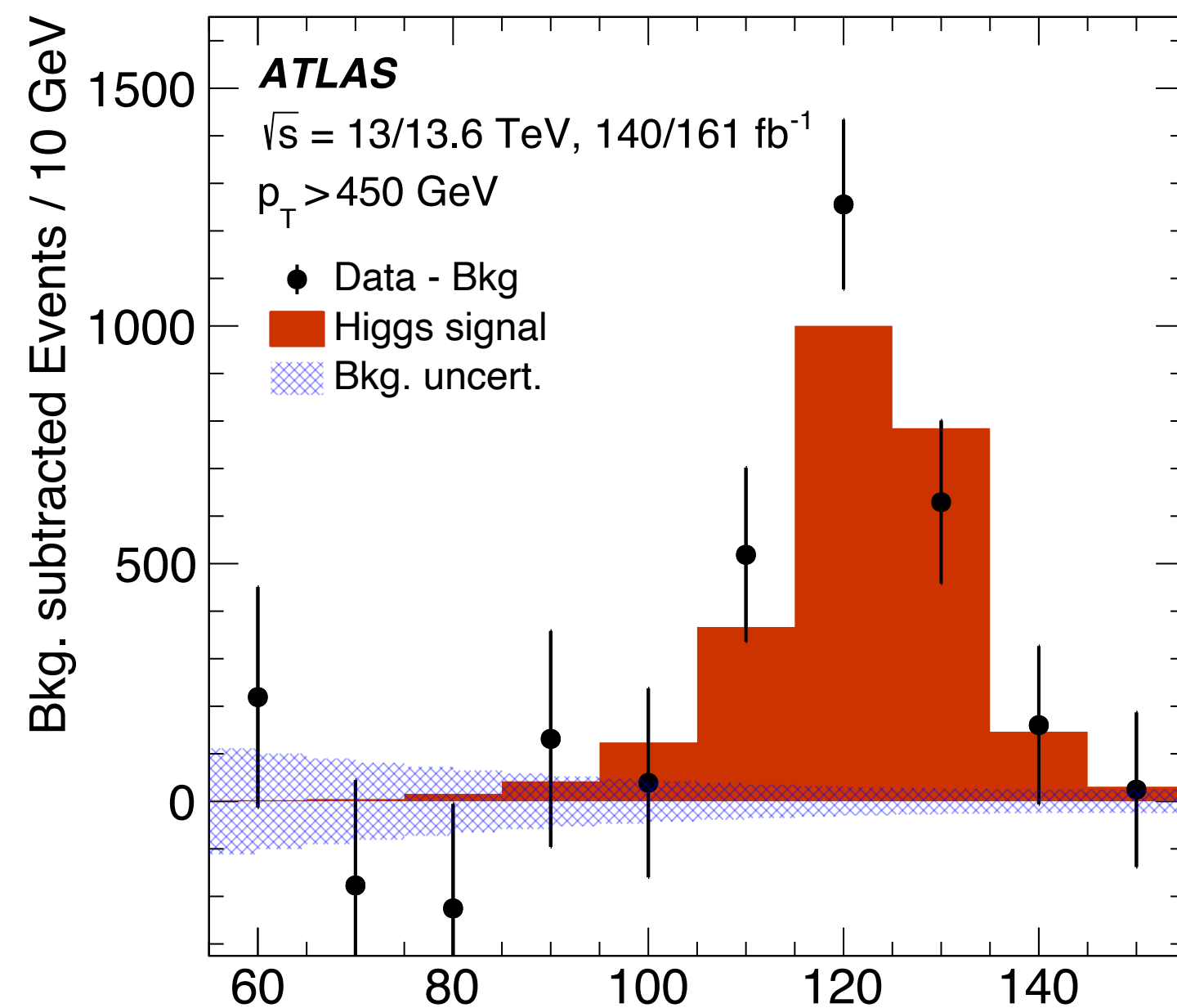


# High- $p_T$ cross sections

Higgs production at high  $p_T$  very sensitive to non-SM contributions to the gg-H loop.



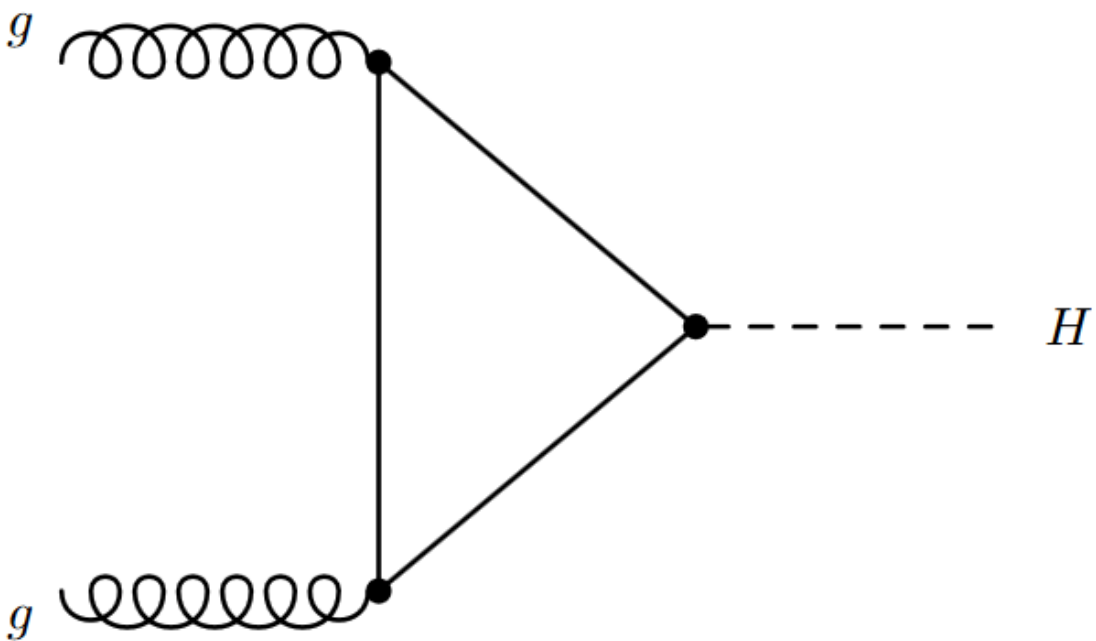
PRL 137 (2026) 7, 071801



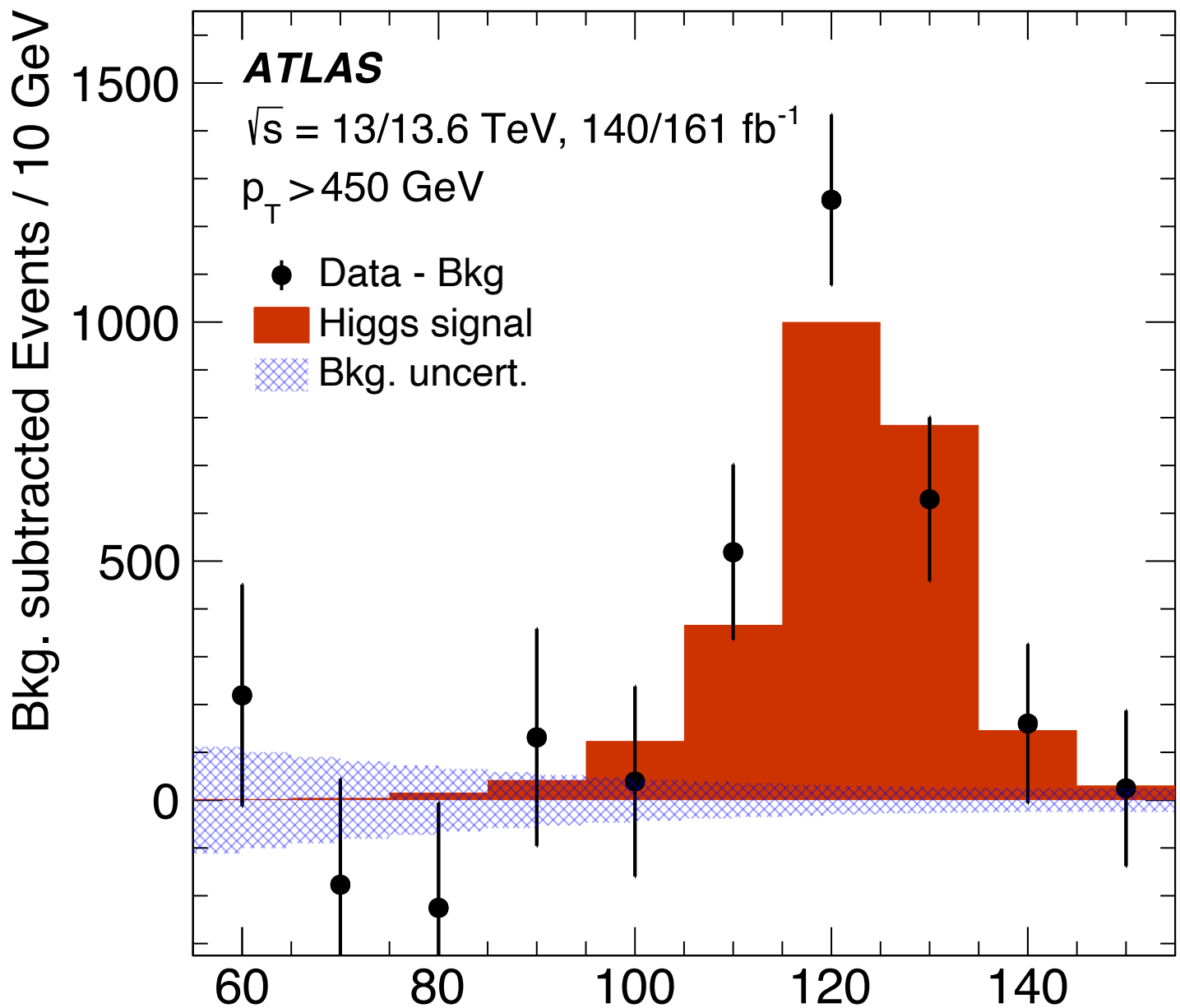
first evidence of “inclusive”  
 $H \rightarrow b\bar{b}$  production and of  
 $p_T^H > 450$  GeV!

# High- $p_T$ cross sections

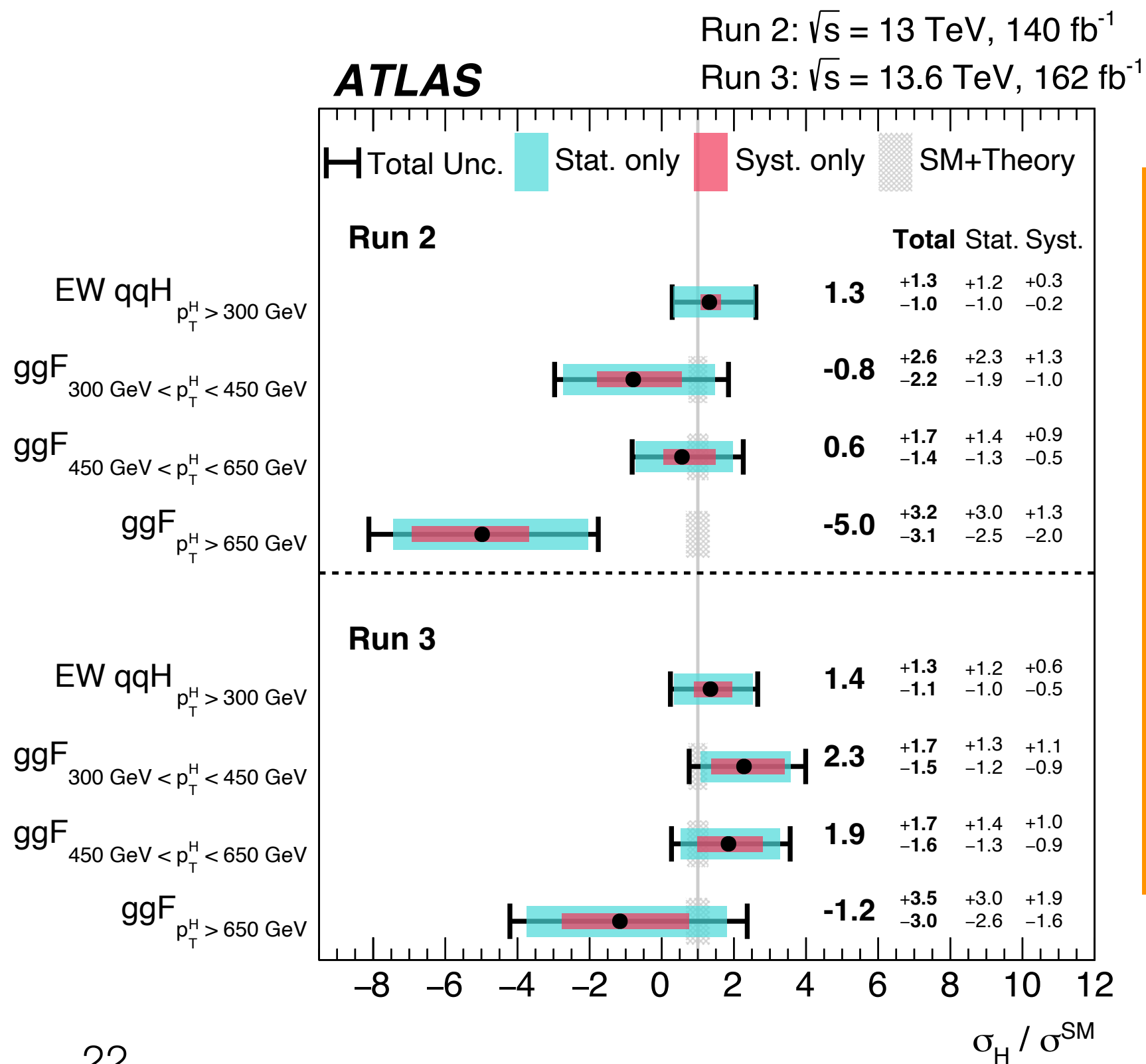
Higgs production at high  $p_T$  very sensitive to non-SM contributions to the gg-H loop.



PRL 137 (2026) 7, 071801



first evidence of “inclusive”  
 $H \rightarrow b\bar{b}$  production and of  
 $p_T^H > 450$  GeV!

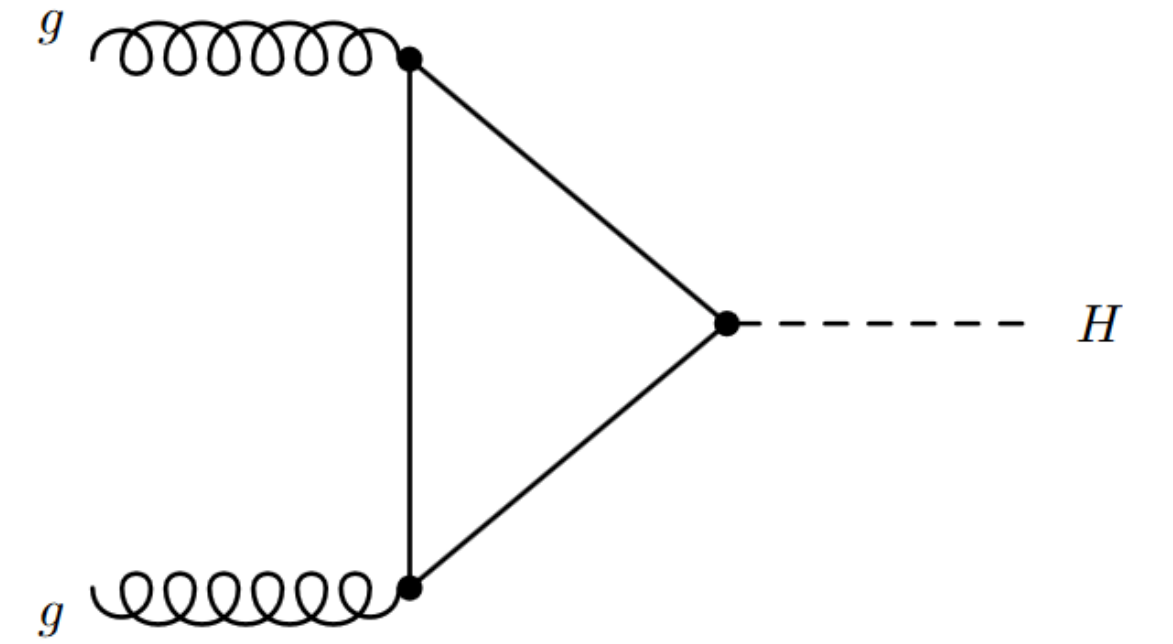


new  
measurement  
of  $H \rightarrow \tau\tau$   
focusing on  
high  $p_T^H$

ATL-HIGP-2024-49

# High- $p_T$ cross sections

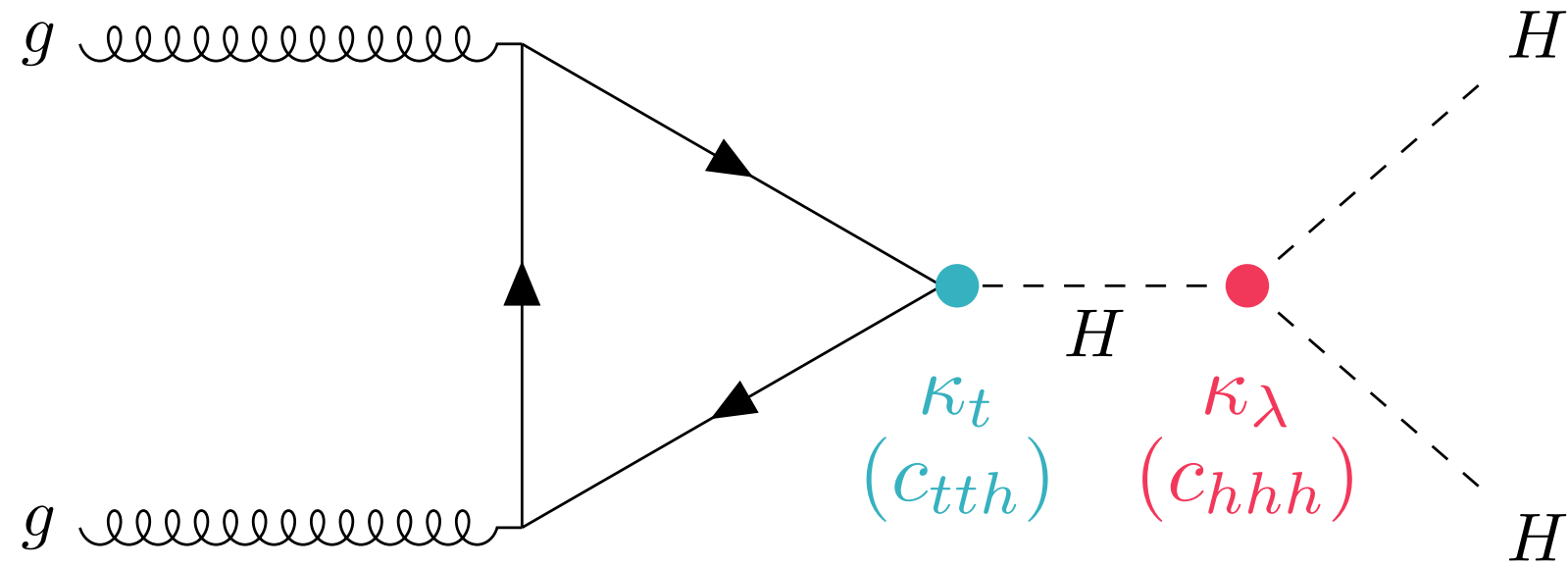
Higgs production at high  $p_T$  very sensitive to non-SM contributions to the gg-H loop.



✴ driven by improvements in boosted  $H$  identification, which crucially relies on QCD predictions, for backgrounds in particular.

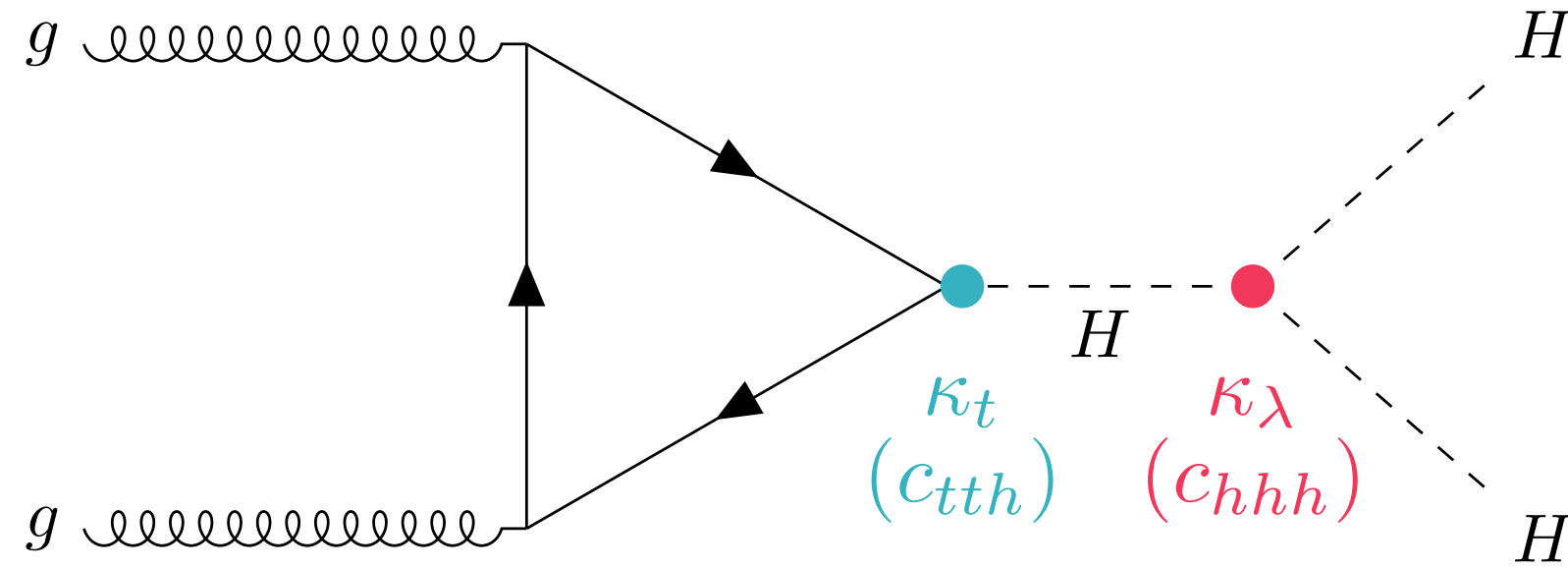
# The Higgs potential

$HH$  production is uniquely sensitive to Higgs self-interaction and the shape of the Higgs potential.

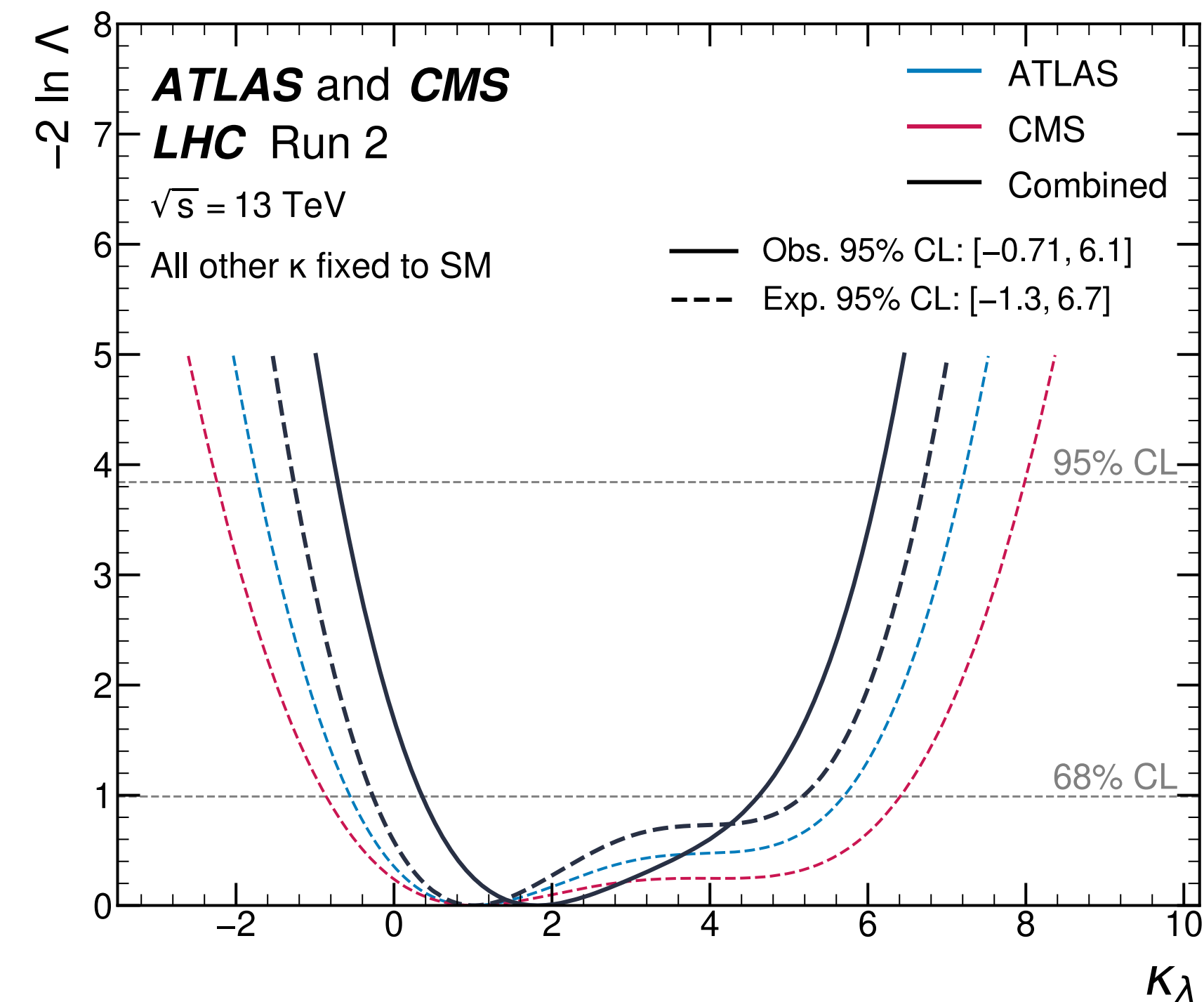


# The Higgs potential

$HH$  production is uniquely sensitive to Higgs self-interaction and the shape of the Higgs potential.



PRL 137 (2026) 131803

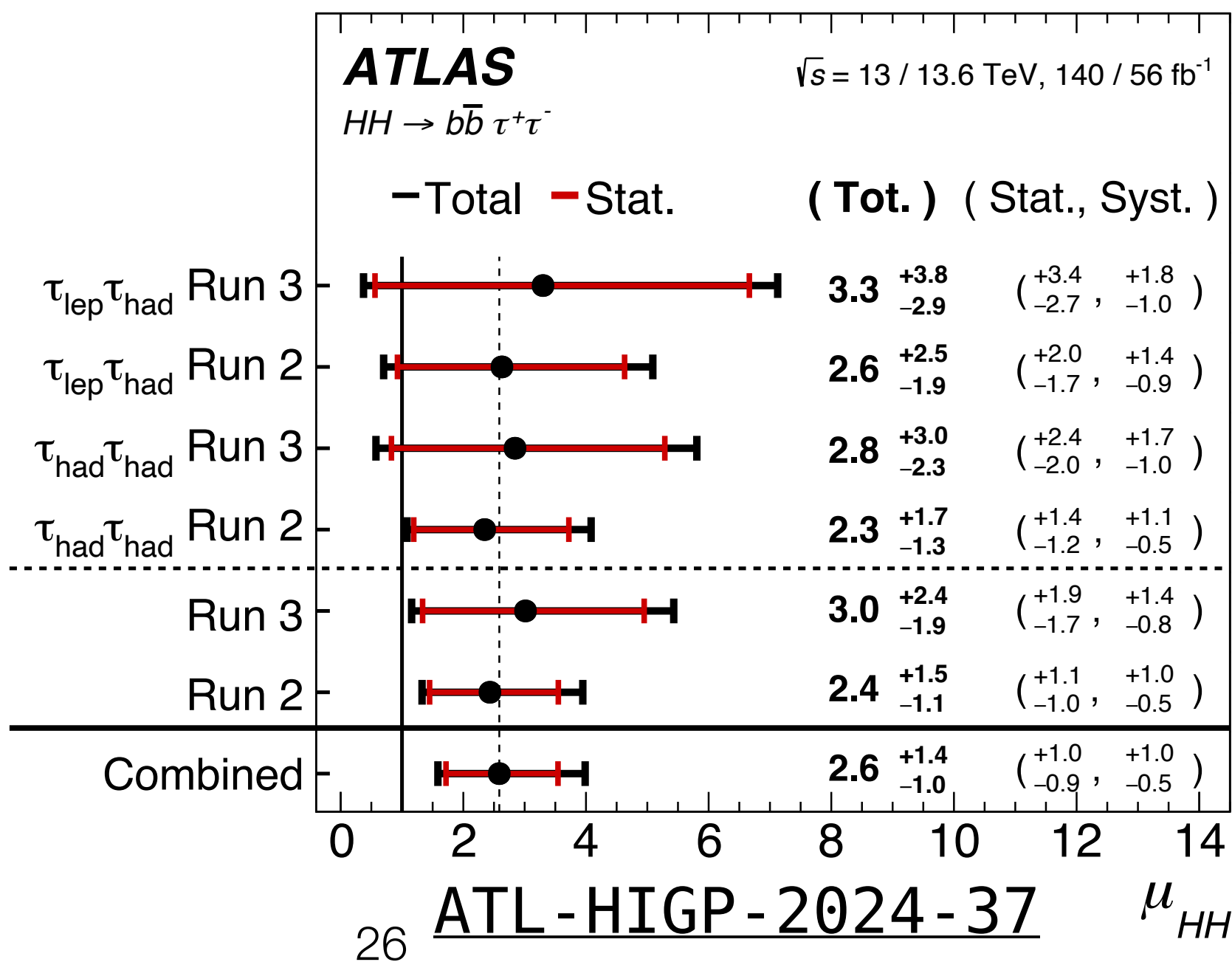
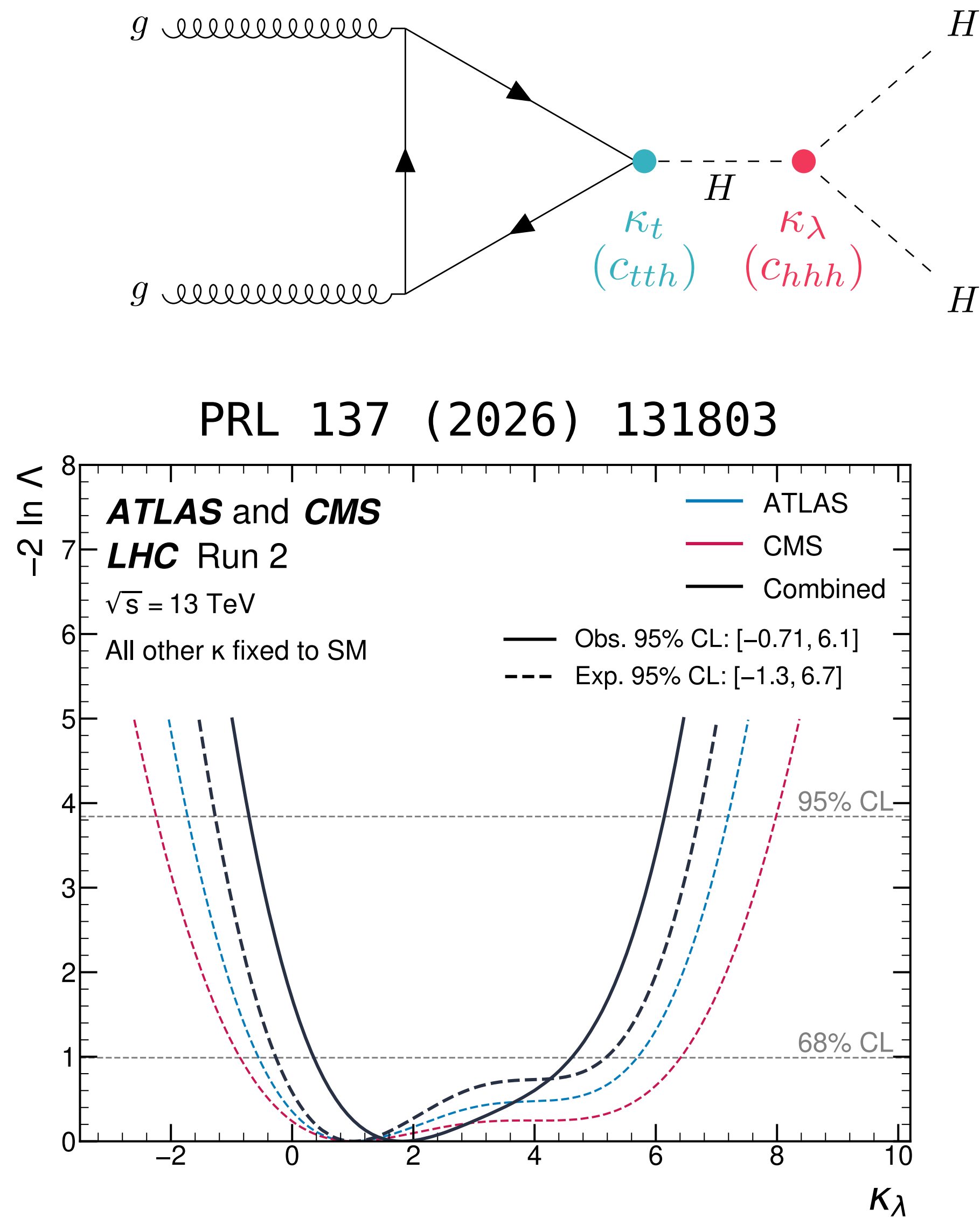


“Legacy” Run 2 LHC  
 $HH$  combination is  
now complete.

# The Higgs potential

$HH$  production is uniquely sensitive to Higgs self-interaction and the shape of the Higgs potential.

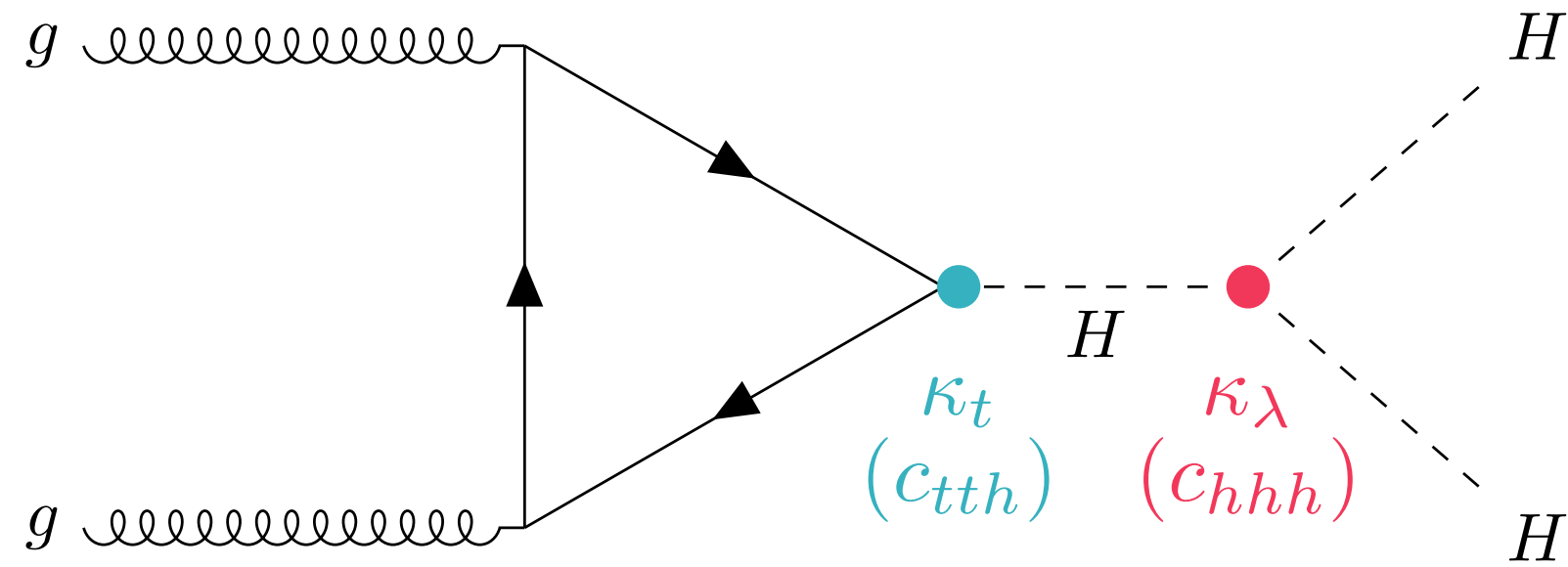
LHC experiments closing in on  $HH$  evidence



ATLAS  $HH \rightarrow b\bar{b} \tau\tau$   
2.5 $\sigma$  obs.  
(1.2 $\sigma$  exp.)

CMS  $HH \rightarrow b\bar{b} \tau\tau$   
1.5 $\sigma$  obs.  
(0.7 $\sigma$  exp.)

# The Higgs potential



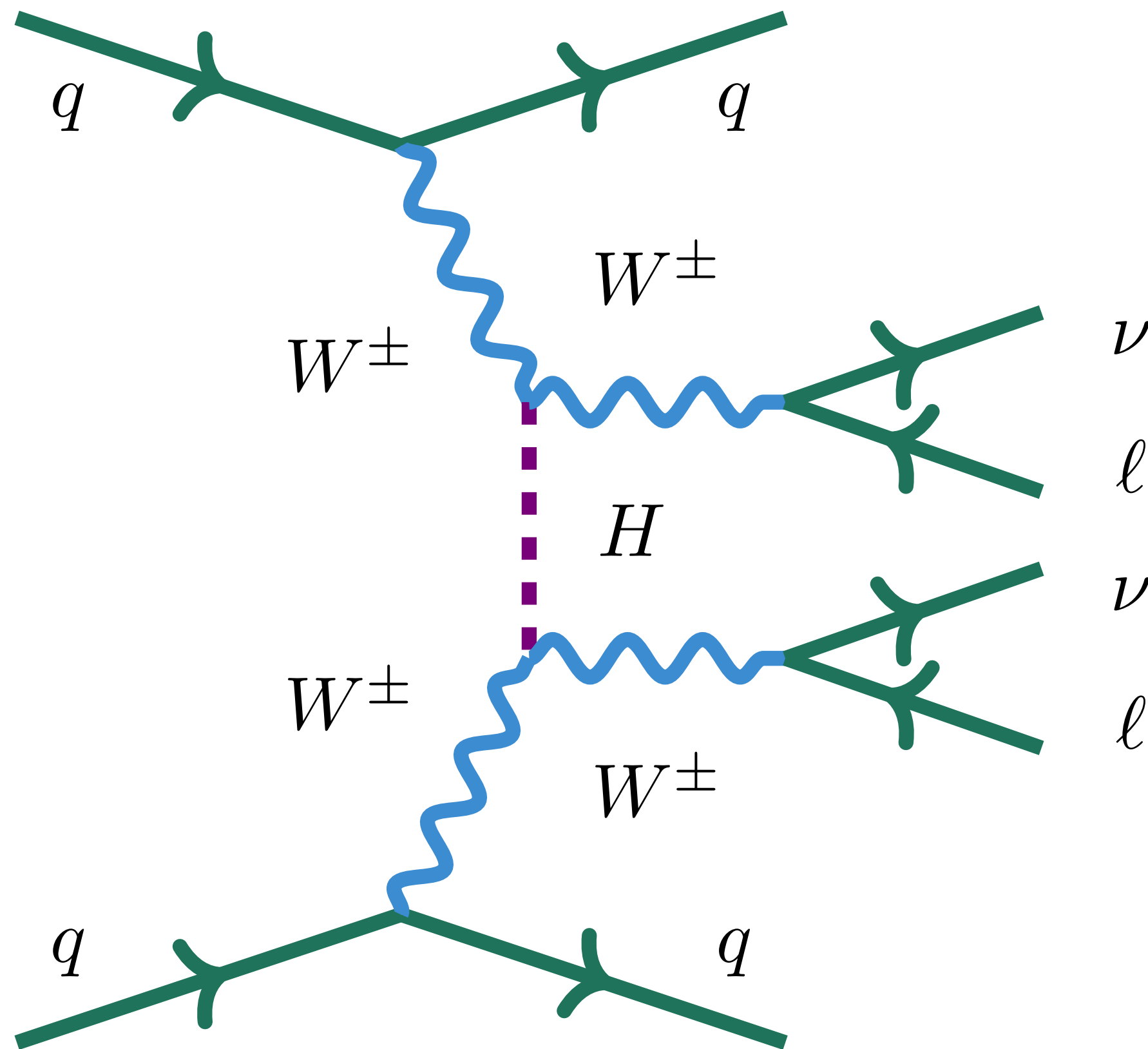
$HH$  production is uniquely sensitive to Higgs self-interaction and the shape of the Higgs potential.

LHC experiments closing in on  $HH$  evidence

★ important theoretical uncertainties coming from  $H + b(b)$  production cross sections

# Electroweak Sector and Beyond

# vector boson scattering

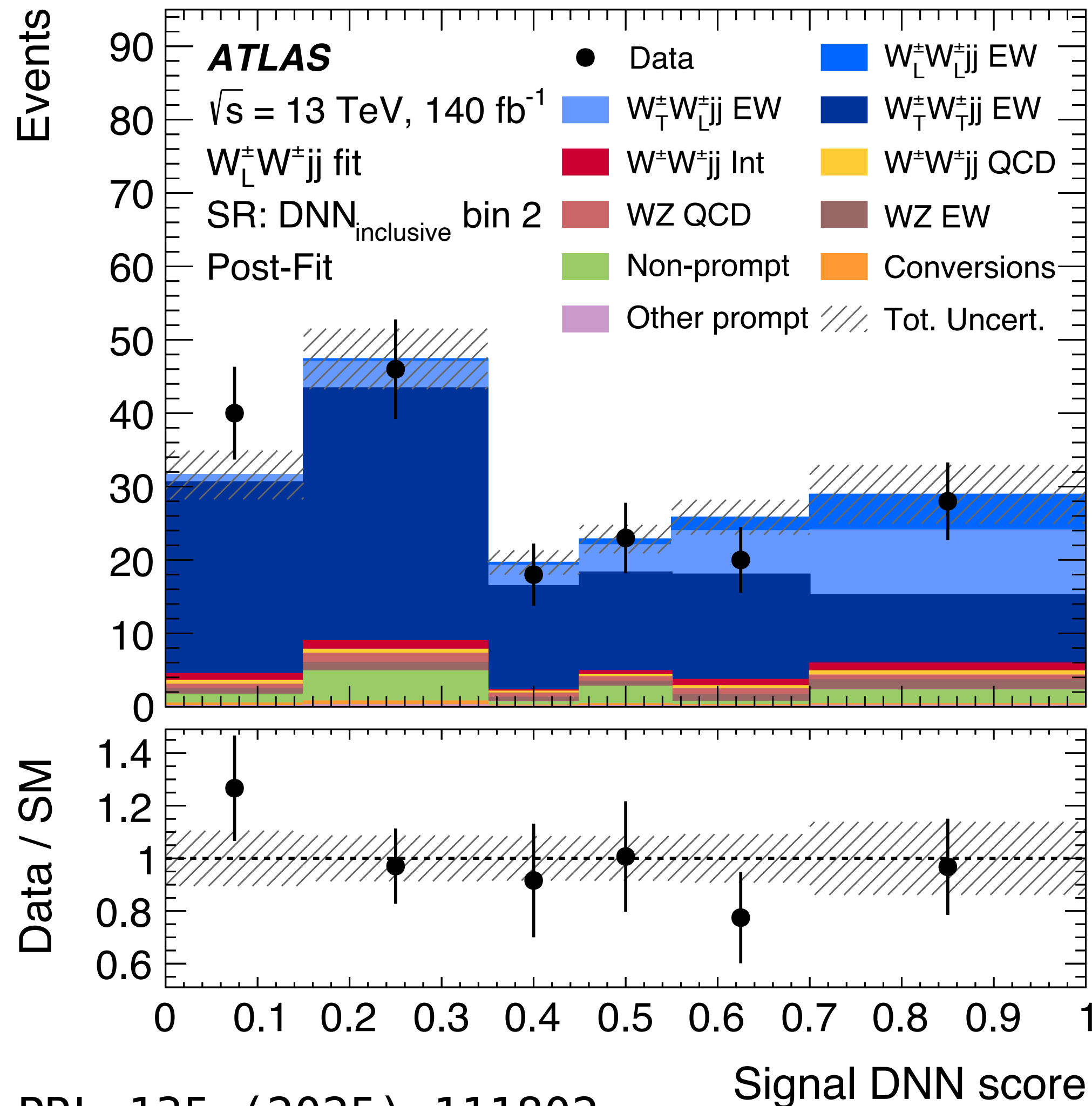


without the Higgs, the VBS cross section diverges at high mass

the coupling of longitudinally-polarized  $V$  bosons to the Higgs prevents this divergence

CMS and ATLAS have been searching for  $V_L$  production in this process

# vector boson scattering



PRL 135 (2025) 111802

without the Higgs, the VBS cross section diverges at high mass

the coupling of longitudinally-polarized  $V$  bosons to the Higgs prevents this divergence

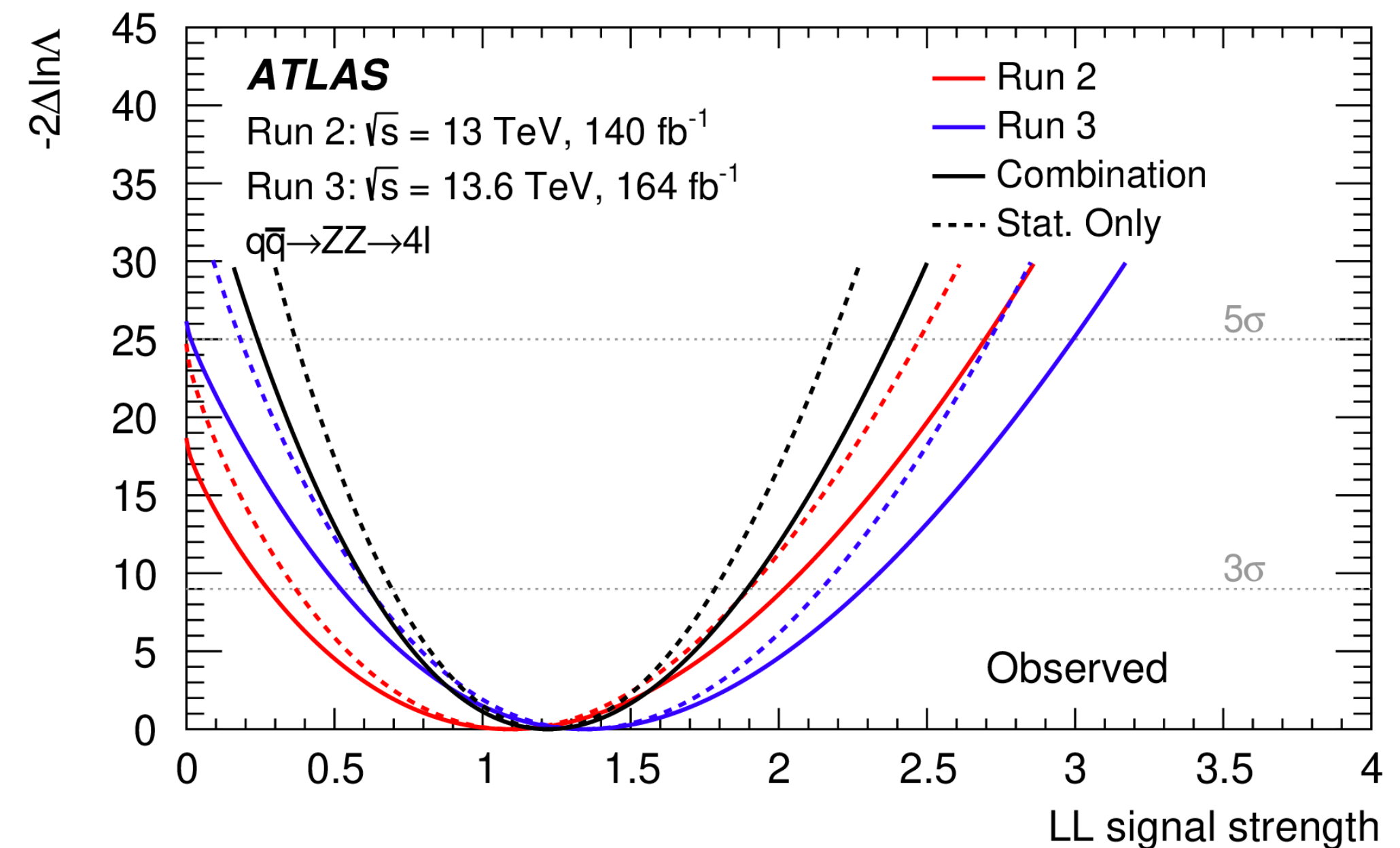
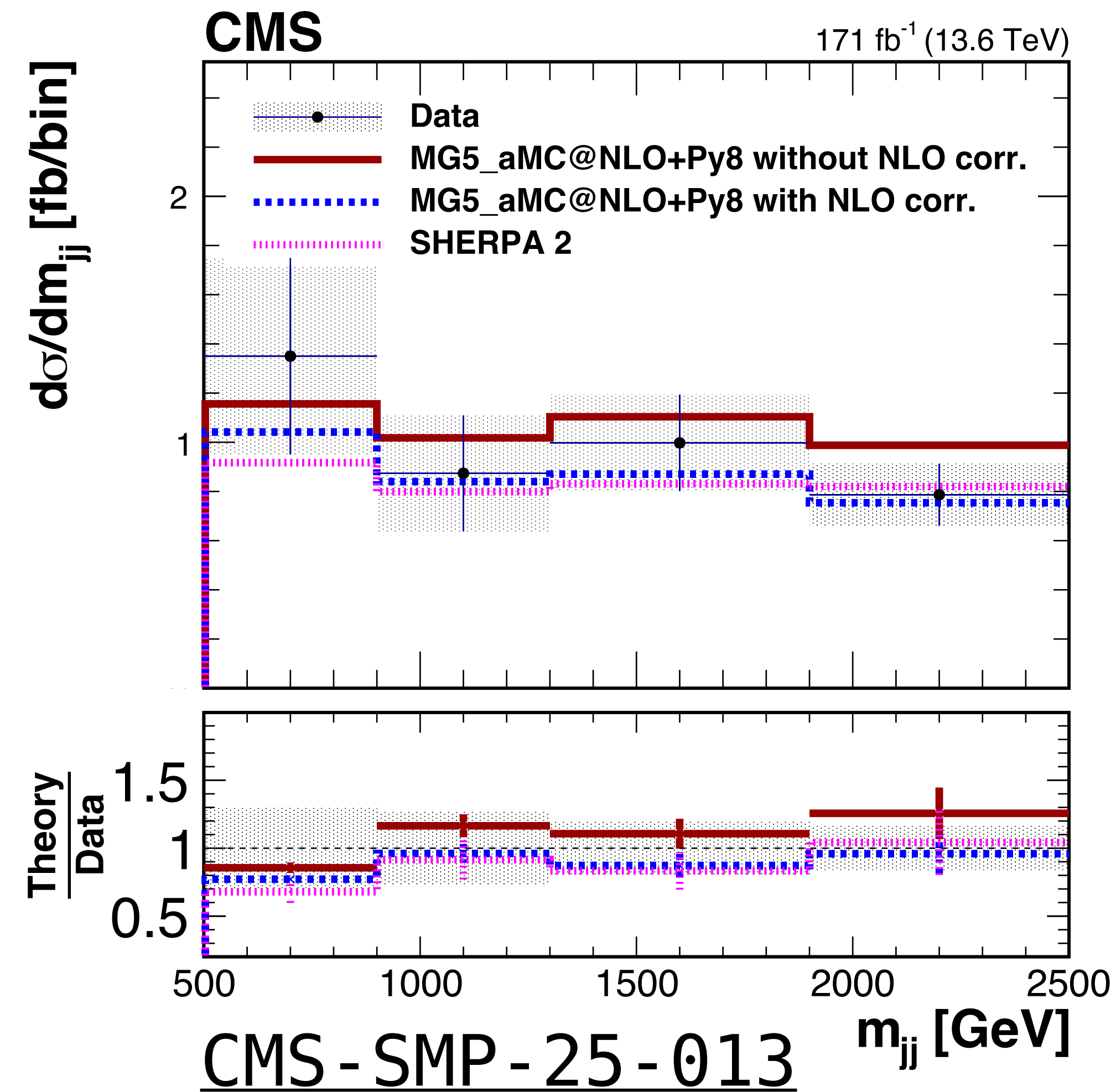
CMS and ATLAS have been searching for  $V_L$  production in this process

ATLAS recently showed first evidence of one  $V_L$  in VBS events

# vector boson scattering

impressive program of electroweak  
 $W^\pm W^\pm$ ,  $W^\pm Z$ ,  $ZZ$  measurements since:

differential cross sections,  
observation of longitudinally-  
polarized Z-boson pairs



ATL-STD-2024-01

# lepton universality

the LHC has produced millions  
of  $V$ -bosons and top-quarks:

ideal testbed for precision  
tests in the lepton sector

broad program searching for  
lepton universality violation  
and lepton flavor violation

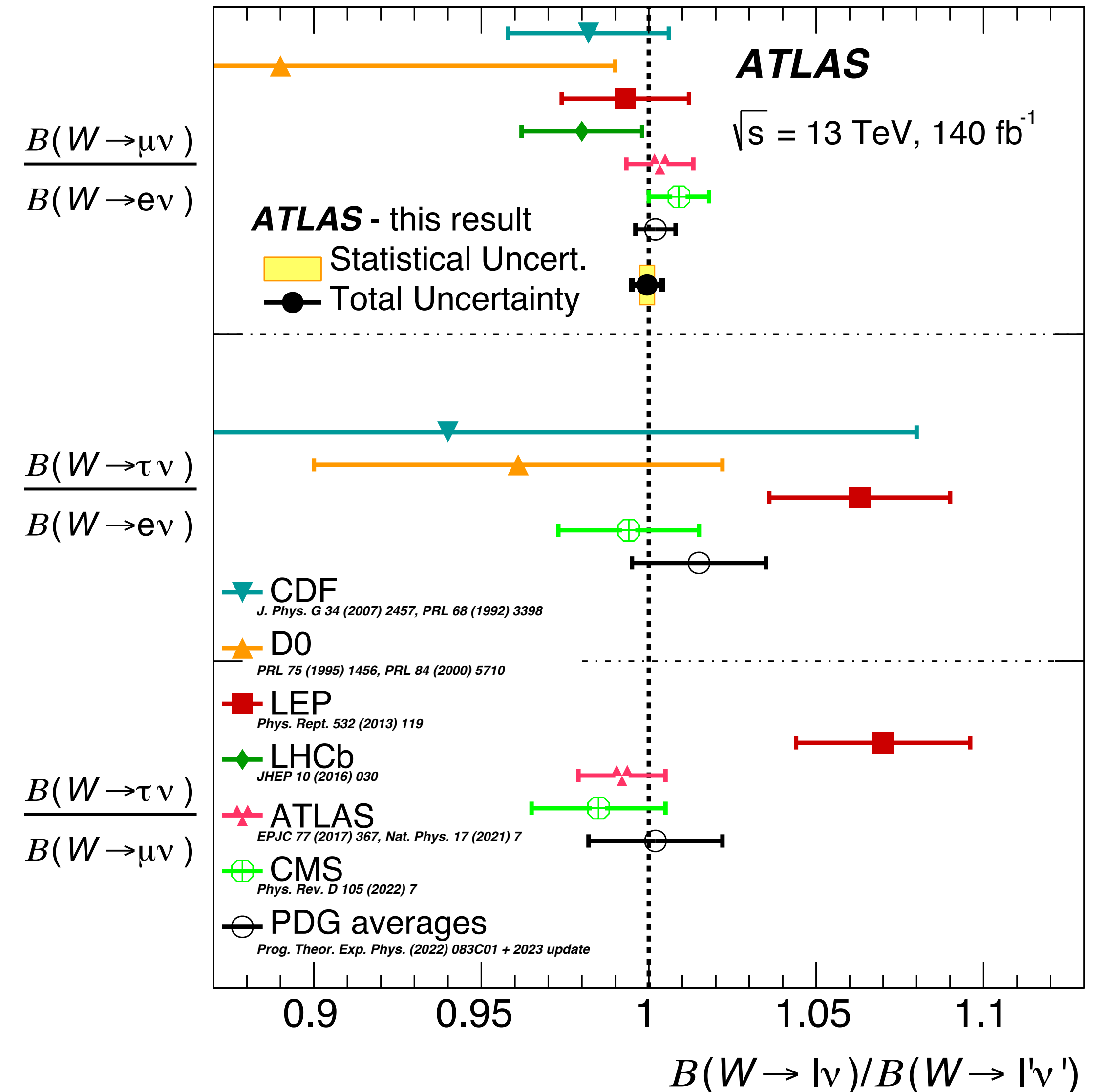
# lepton universality

the LHC has produced millions of  $V$ -bosons and top-quarks:

ideal testbed for precision tests in the lepton sector

broad program searching for  
lepton universality violation  
and lepton flavor violation

in  $W$  decays,  $\mathcal{O}(\%)$  uncertainties  
for all charged leptons  
(sub-percent for the  $e/\mu$  ratio)



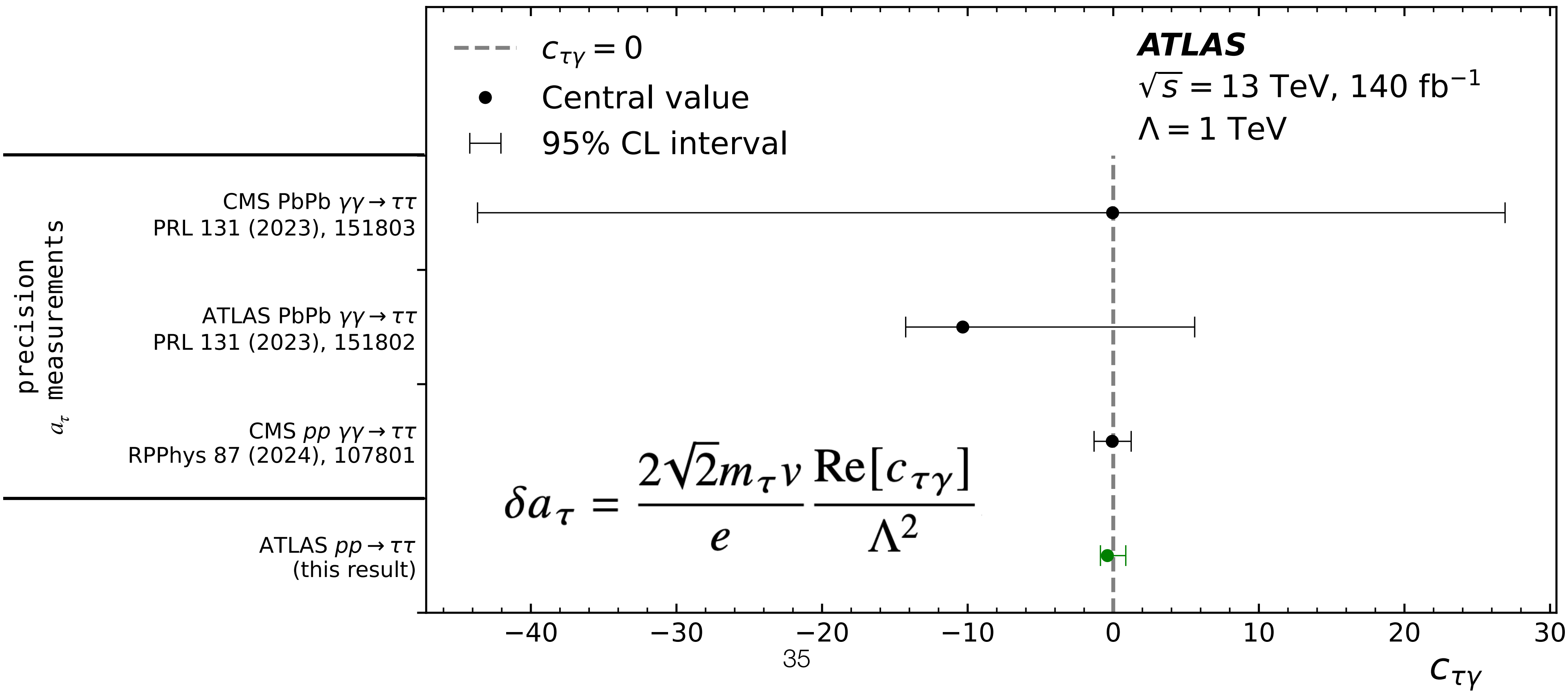
# anomalous EM couplings

lepton anomalous electromagnetic moments are a hot topic:  
the LHC is uniquely sensitive to the  $\tau$ -lepton  $g-2$

# anomalous EM couplings

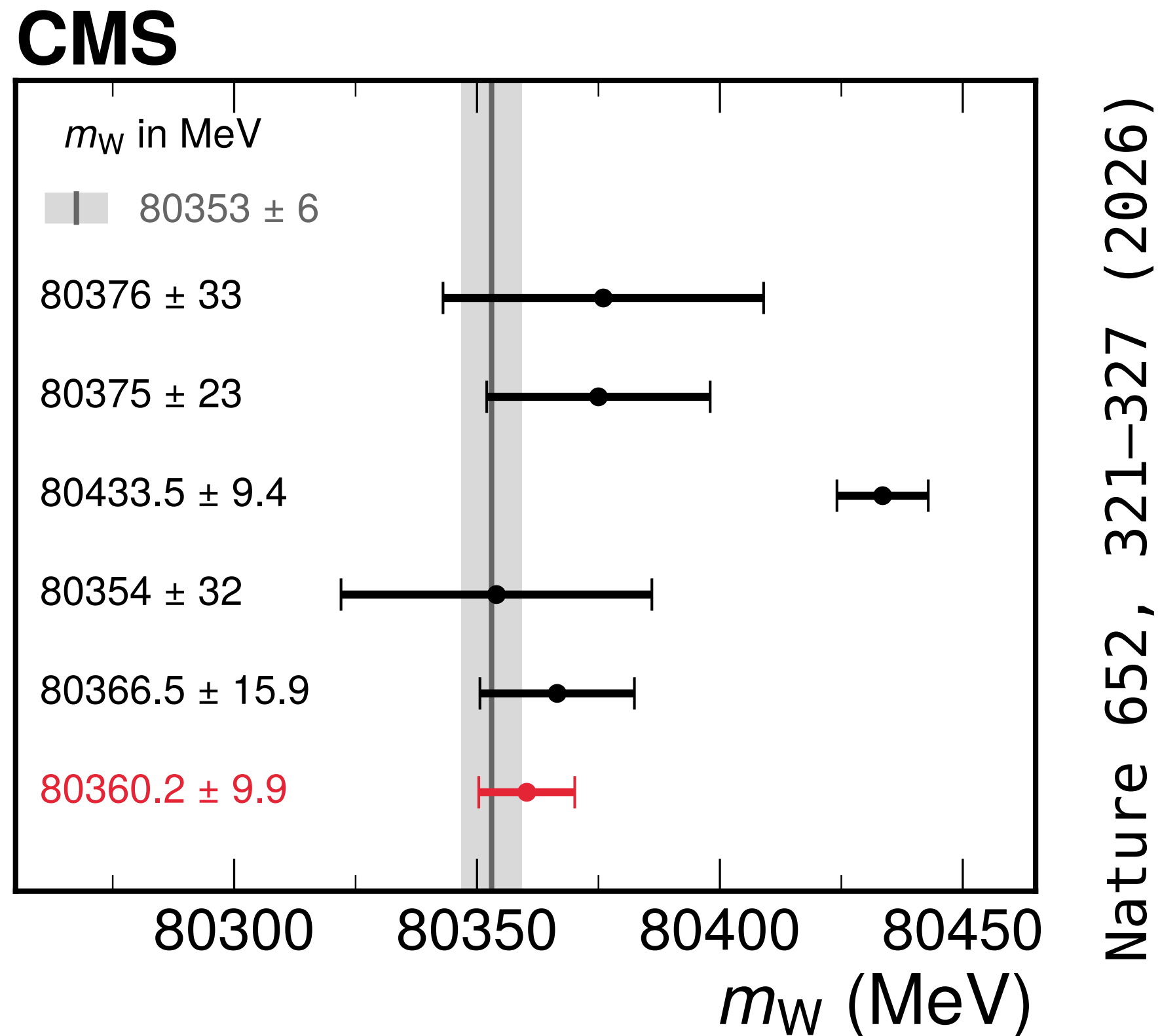
lepton anomalous electromagnetic moments are a hot topic:  
the LHC is uniquely sensitive to the  $\tau$ -lepton  $g-2$

rapid progress constraining  $a_\tau$  using a variety of strategies



# measurements of $m_W$

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  
**CMS**  
*This work*

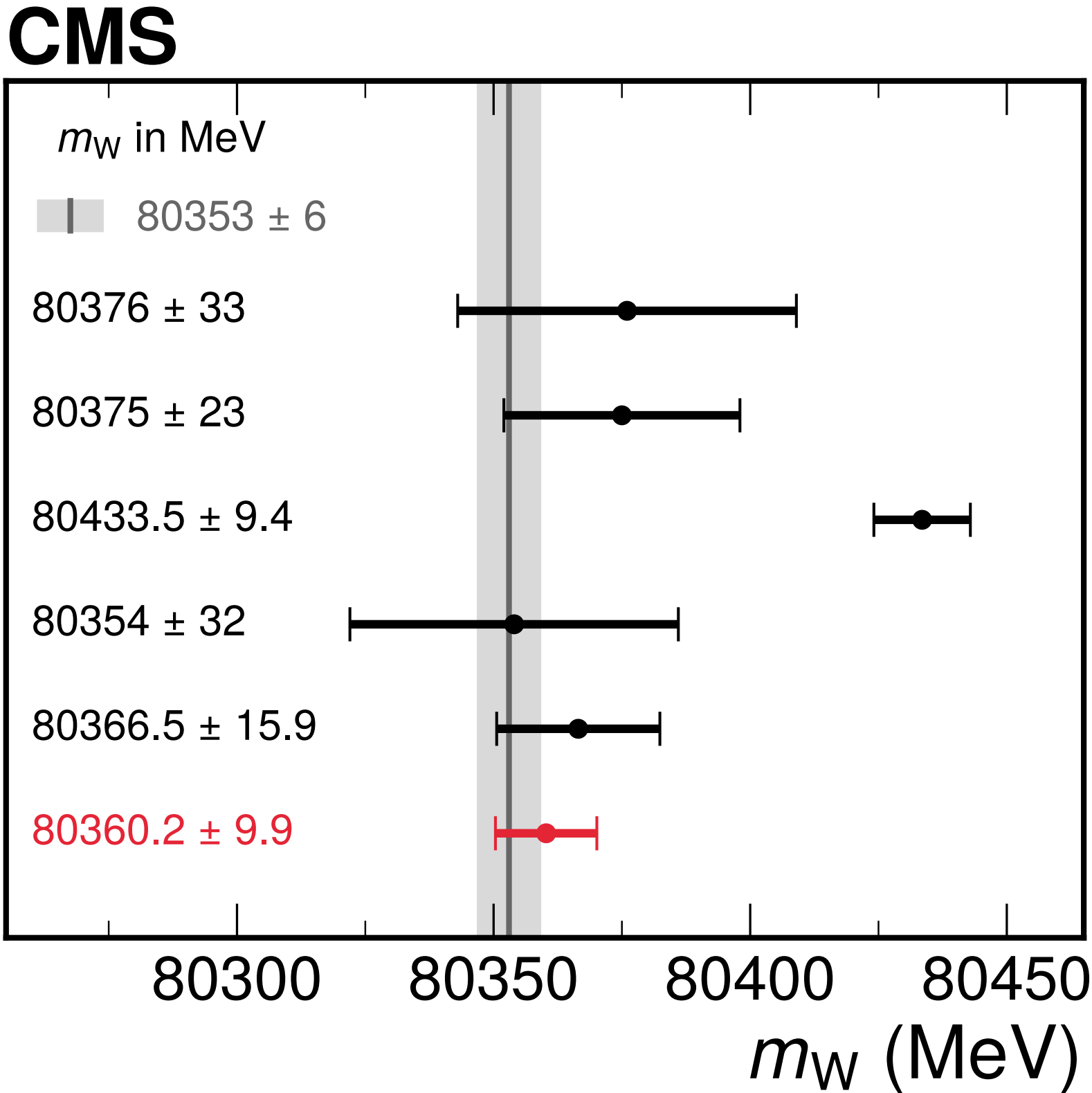


LHC experiments are leading measurements of  $m_W$

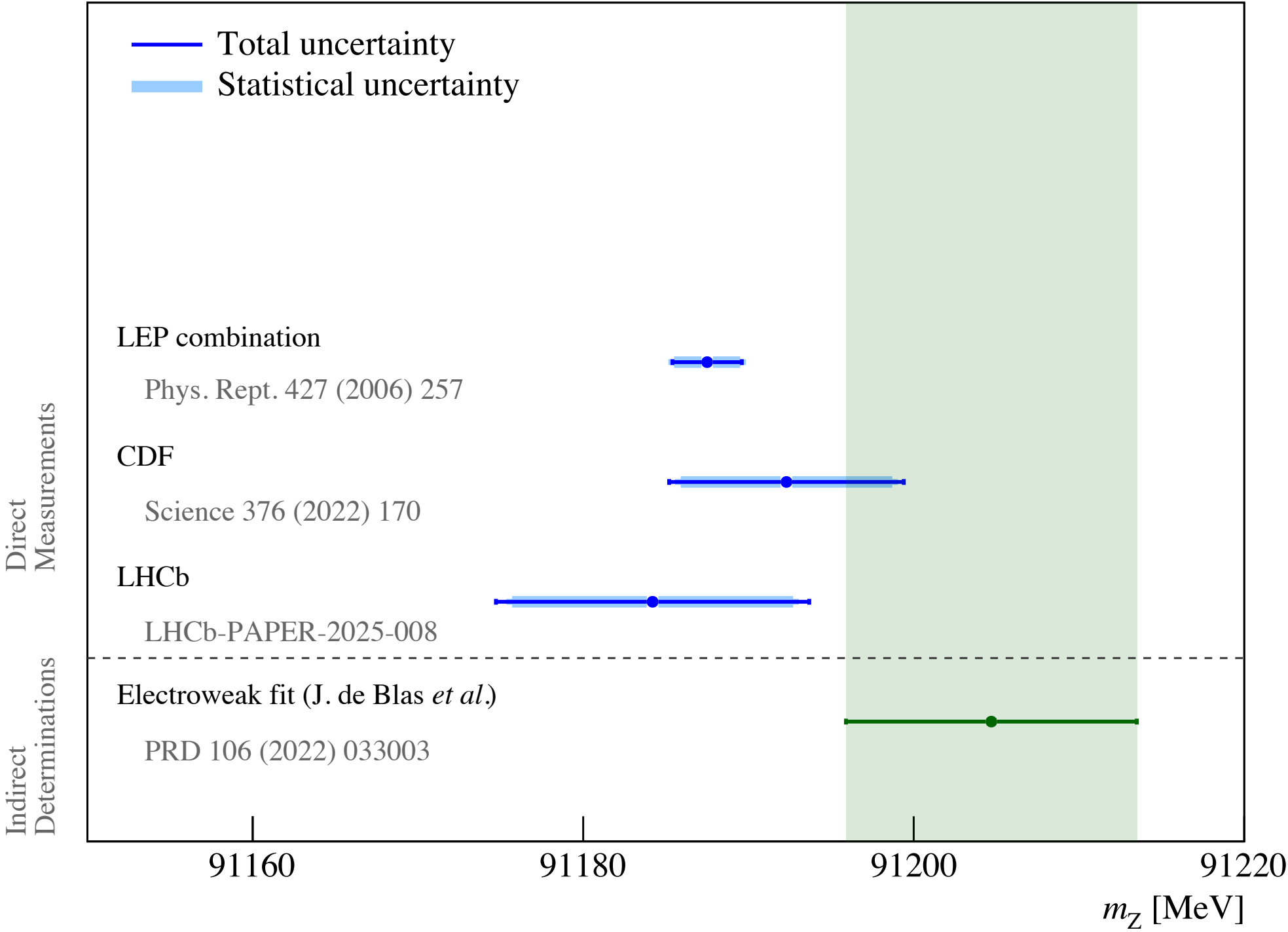
< 10 MeV uncertainties and impressive scaling with  $L$ .

# measurements of $m_V$

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  
**CMS**  
*This work*



Nature 652, 321–327 (2026)



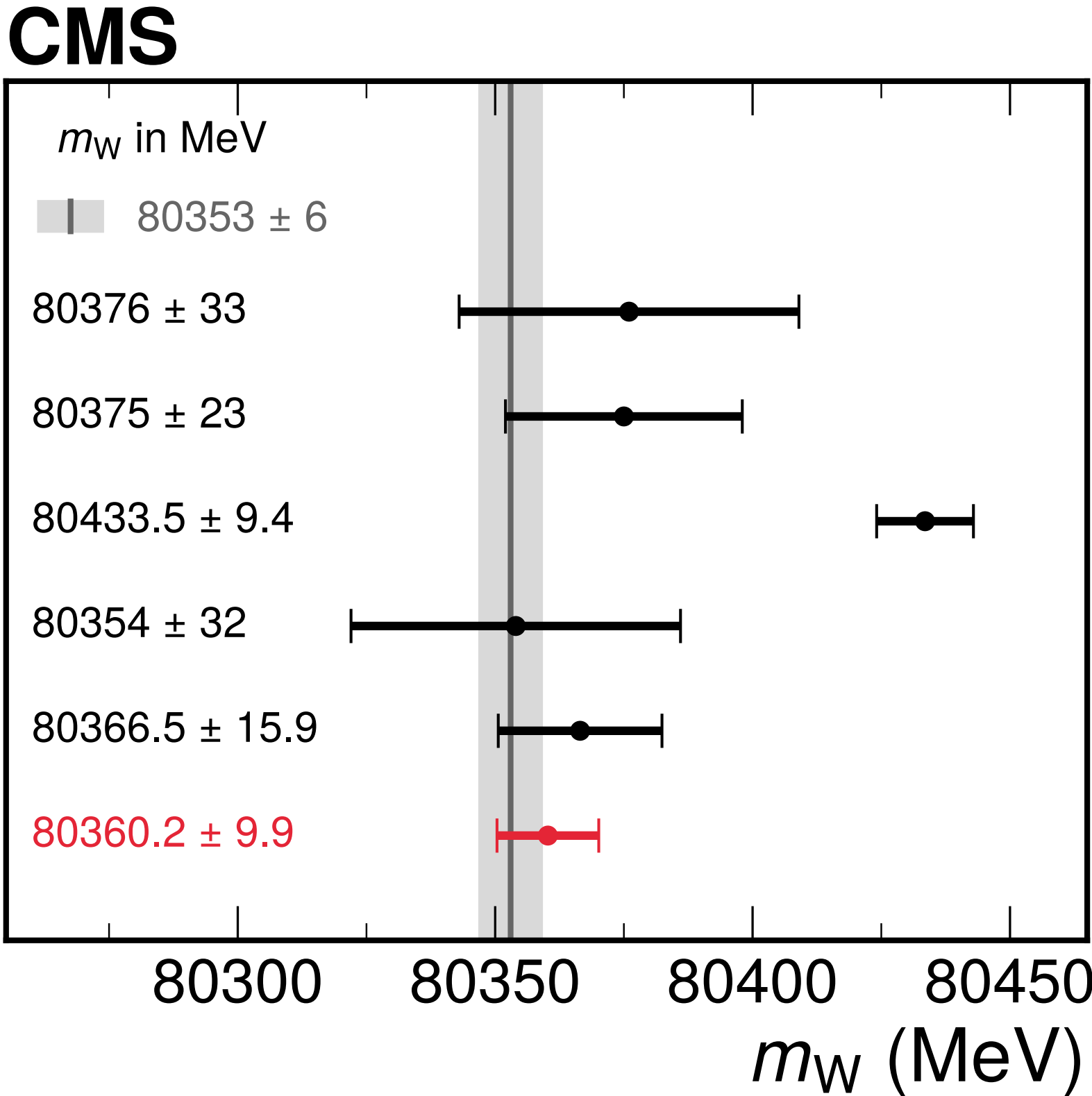
PRL 135 (2025) 161802

LHC experiments are leading measurements of  $m_W$   
and may compete with LEP  $m_Z$  in the near future

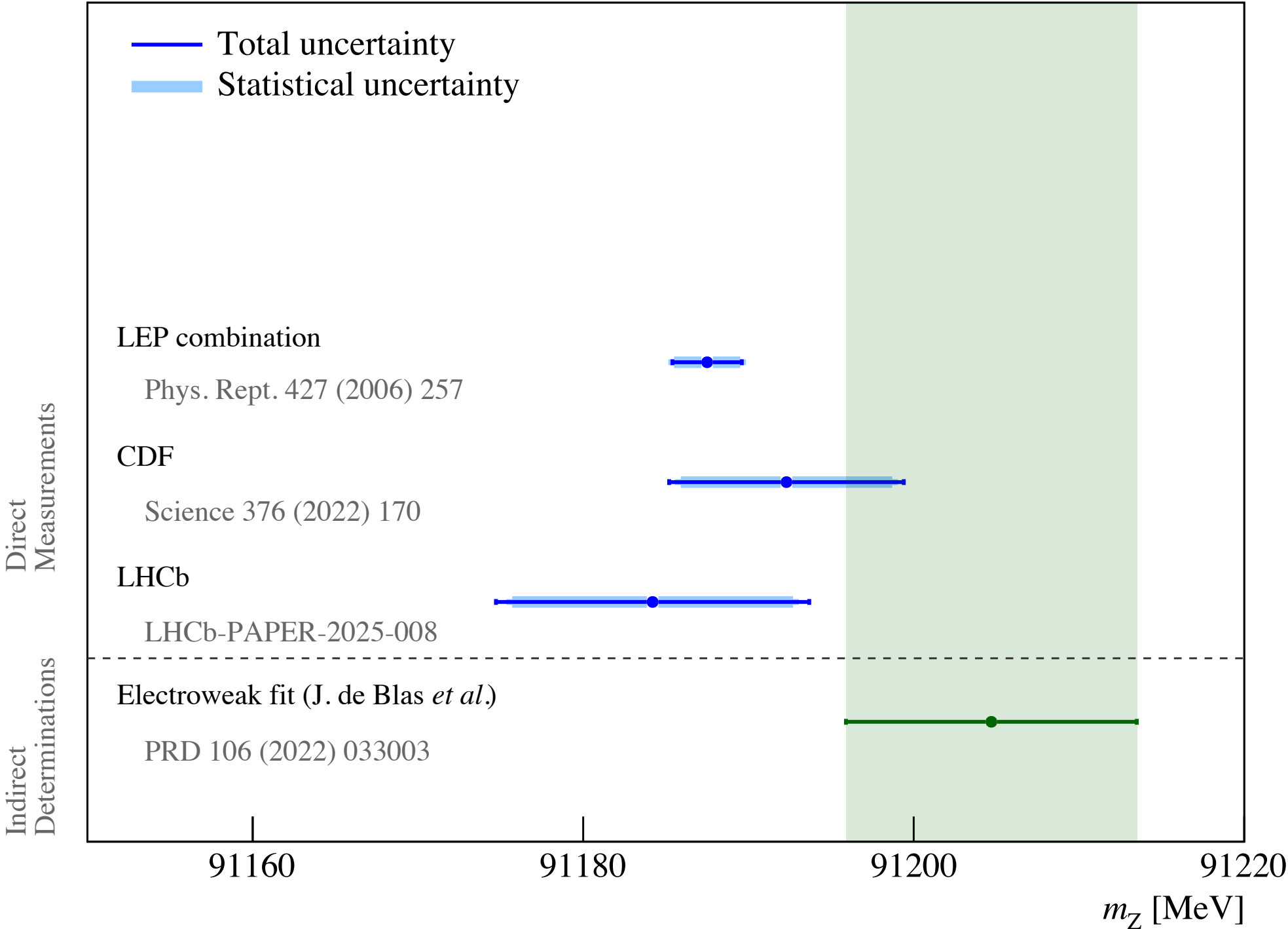
< 10 MeV uncertainties and impressive scaling with  $L$ .

# measurements of $m_V$

Electroweak fit  
PRD 110 (2024) 030001  
LEP combination  
Phys. Rep. 532 (2013) 119  
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arXiv:2403.15085  
**CMS**  
*This work*



Nature 652, 321–327 (2026)



PRL 135 (2025) 161802

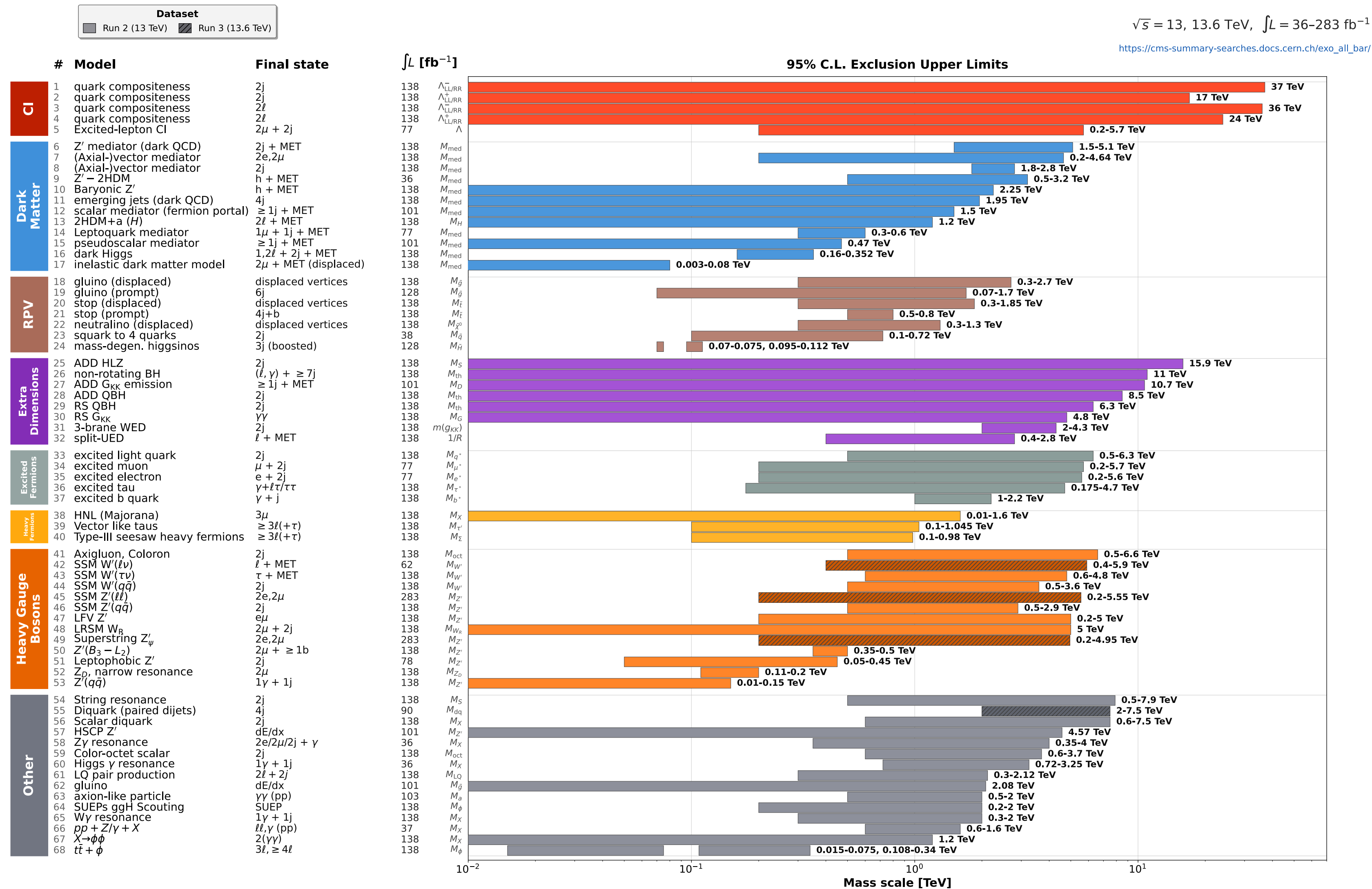
✨ important theoretical uncertainties from PDFs, hadronic recoil, angular coefficients.

# BSM exclusions

**CMS** Preliminary

## Overview of CMS EXO Results

**July 2026**



enormous breadth  
of searches for  
BSM physics...

mass-scales probed  
up to  $\sim 30$  TeV

no stone unturned,  
but so far no  
surprises

# EFT constraints

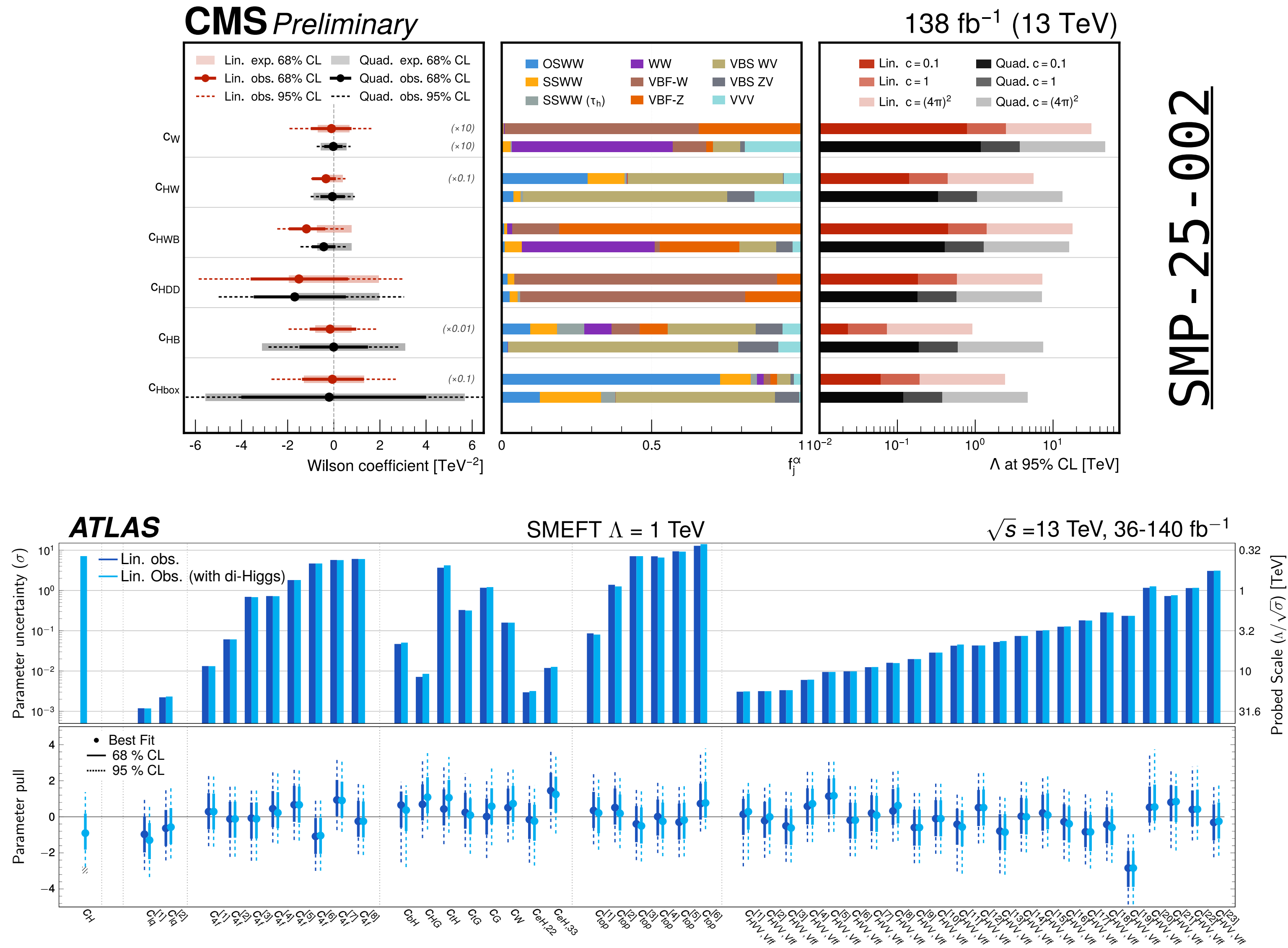
in the absence of  
“striking” new physics  
(so far),

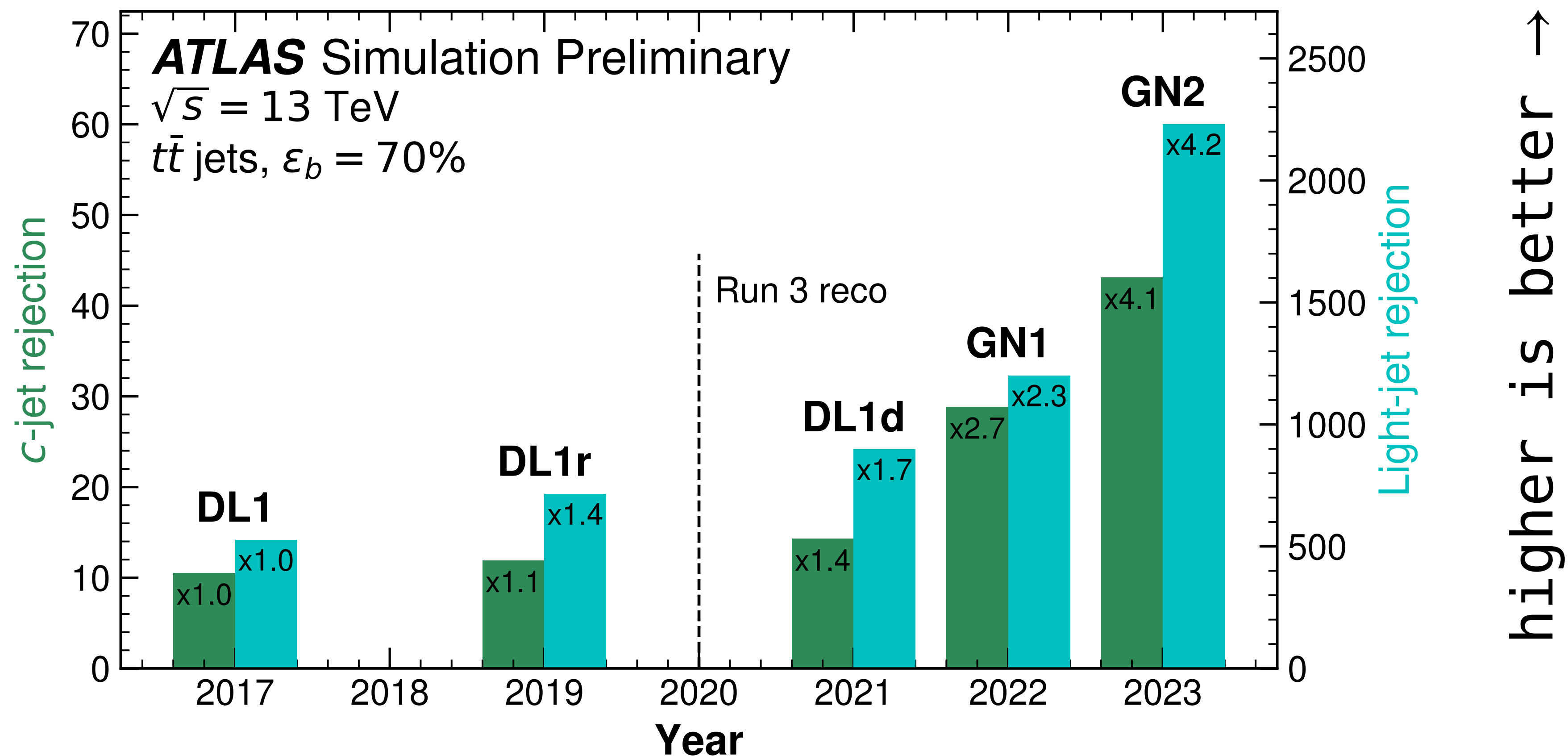
both experiments are  
providing  
comprehensive  
constraints on dim 6  
EFT operator  
coefficients.

# EFT constraints

in the absence of “striking” new physics (so far), both experiments are providing comprehensive constraints on dim 6 EFT operator coefficients.

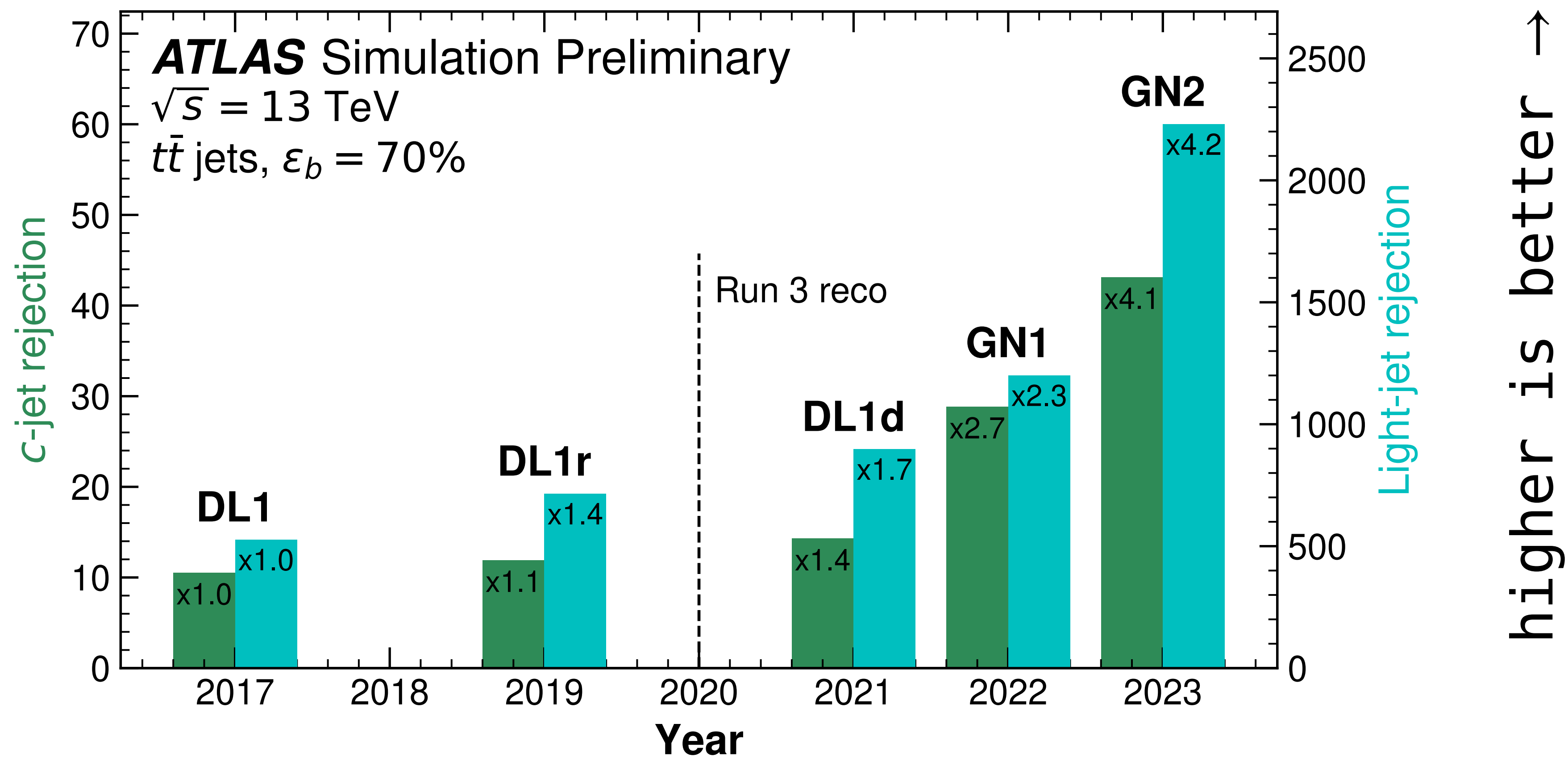
scales probed range from 0.1-30 TeV





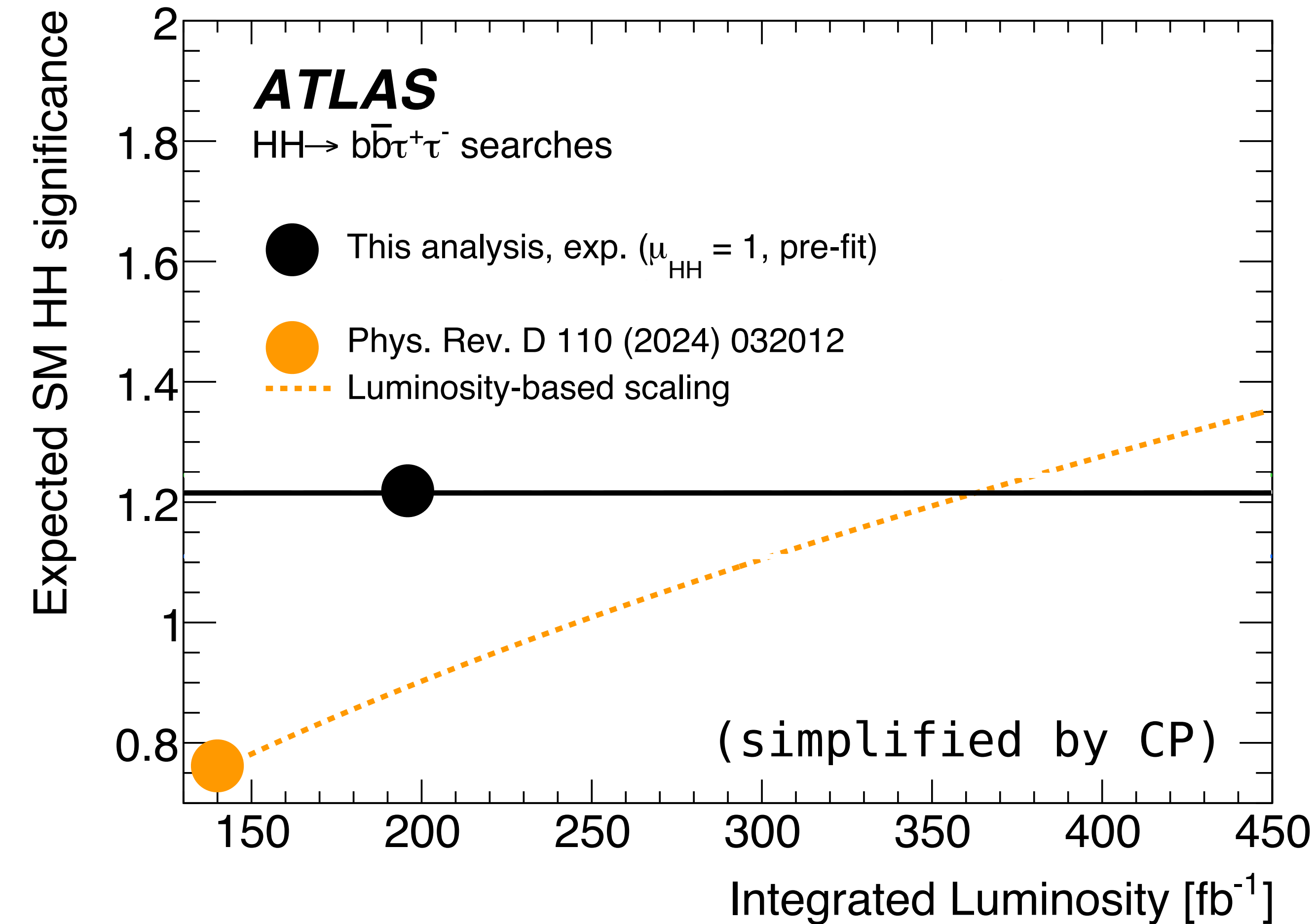
the strength of many results go well beyond our projections:

driven by important improvements in computing, triggering,  
 reconstruction algorithms, calibrations, theory calculations,  
 etc.



🌟 in the majority of cases, ML advances are enabled by excellent simulation.

# Growth with luminosity



astonishing scaling of  
experimental sensitivity  
over the past few years:

far beyond  $\sqrt{L}$  would  
predict.

creativity still has a  
large part to play in  
the LHC program.

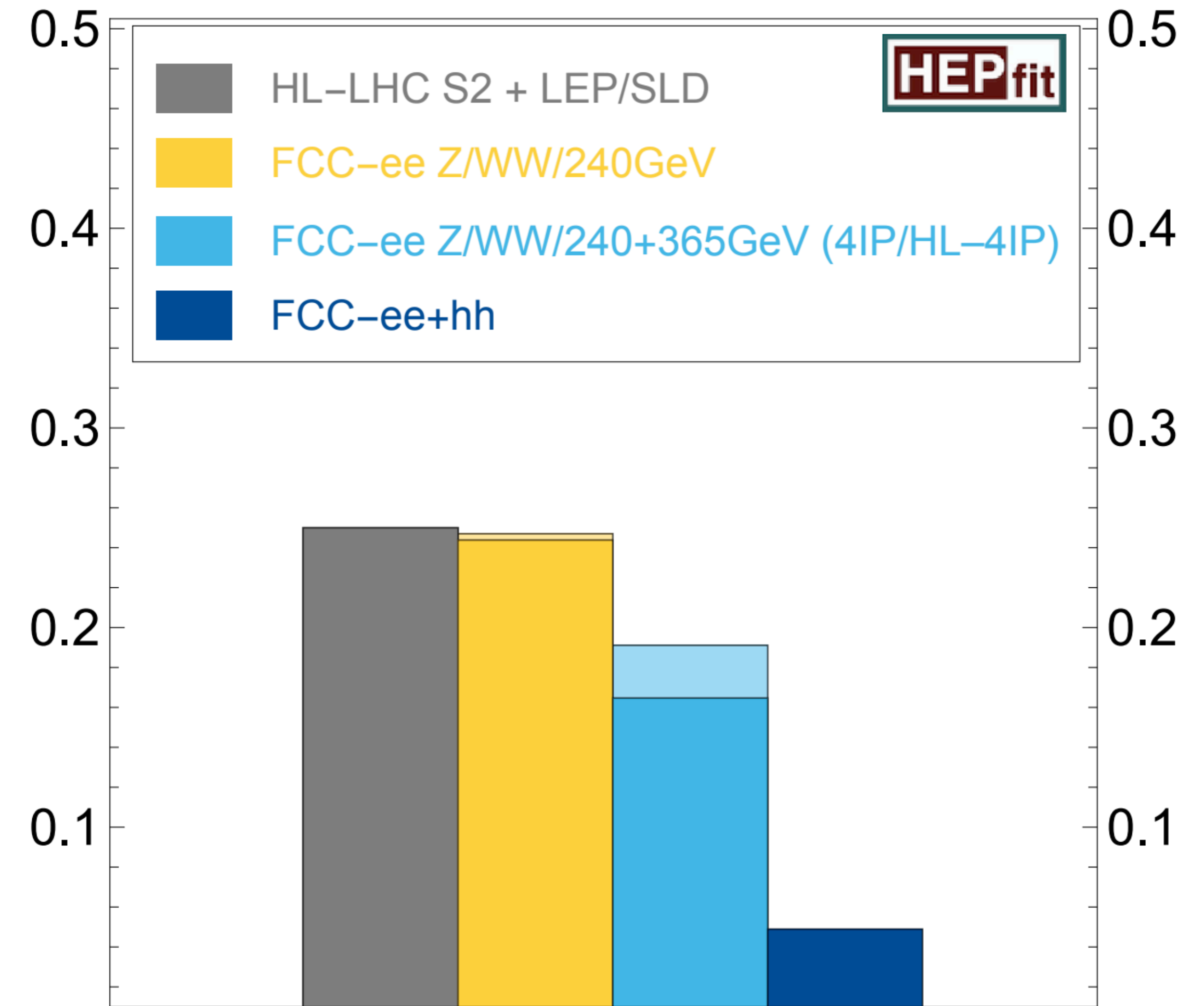
incredibly strong EW-scale program at the LHC:

- ⦿ the Higgs continues to be probed with higher and higher precision
- ⦿ several EW measurements are world-leading or on the cusp of being so
- ⦿ sensitivity scaling well beyond projections in ~all cases
- ⦿ clear gains on the horizon from Run 3 and the HL-LHC

thanks for your attention!

# Bonus

# Higgs potential: future



# Higgs couplings : future

s on coupling modifiers

| Coupling                                        | HL-LHC                 | FCC-ee               | FCC-ee + FCC-hh      |
|-------------------------------------------------|------------------------|----------------------|----------------------|
| $\kappa_Z$ (%)                                  | 1.3*                   | 0.10                 | 0.10                 |
| $\kappa_W$ (%)                                  | 1.5*                   | 0.29                 | 0.25                 |
| $\kappa_b$ (%)                                  | 2.5*                   | 0.38 / 0.49          | 0.33 / 0.45          |
| $\kappa_g$ (%)                                  | 2*                     | 0.49 / 0.54          | 0.41 / 0.44          |
| $\kappa_\tau$ (%)                               | 1.6*                   | 0.46                 | 0.40                 |
| $\kappa_c$ (%)                                  | —                      | 0.70 / 0.87          | 0.68 / 0.85          |
| $\kappa_\gamma$ (%)                             | 1.6*                   | 1.1                  | 0.30                 |
| $\kappa_{Z\gamma}$ (%)                          | 10*                    | 4.3                  | 0.67                 |
| $\kappa_t$ (%)                                  | 3.2*                   | 3.1                  | 0.75                 |
| $\kappa_\mu$ (%)                                | 4.4*                   | 3.3                  | 0.42                 |
| $ \kappa_s $ (%)                                | —                      | $^{+29}_{-67}$       | $^{+29}_{-67}$       |
| $\Gamma_H$ (%)                                  | —                      | 0.78                 | 0.69                 |
| $\mathcal{B}_{\text{inv}} (<, 95\% \text{ CL})$ | $1.9 \times 10^{-2} *$ | $5 \times 10^{-4}$   | $2.3 \times 10^{-4}$ |
| $\mathcal{B}_{\text{unt}} (<, 95\% \text{ CL})$ | $4 \times 10^{-2} *$   | $6.8 \times 10^{-3}$ | $6.7 \times 10^{-3}$ |

HL-LHC:  $\mathcal{O}(\%)$   
uncertainties on  
Higgs couplings

FCC-ee: factor 2-10  
improvement

FCC-hh: additional  
factor ~3 for rare  
decays

source