WG3 Summary

EW & BSM

Sezen Sekmen & Eleni Vryonidou

DIS2024, Grenoble

12/4/2024

WG3 in a nutshell
Electroweak Physics & Beyond the SM

- 40 talks
- + joint session with WG6: 7 talks on future experiments
- Higgs measurements, EW measurements, Top measurements and their interpretations
- Searches for resonances, SUSY, DM, unconventional signatures
- Results from BELLE, NA62
- Just a fraction of results shown here due to time! Apologies to the speakers!

Couplings

Mass

Differential distributions

Width

Higgs

Rare decays

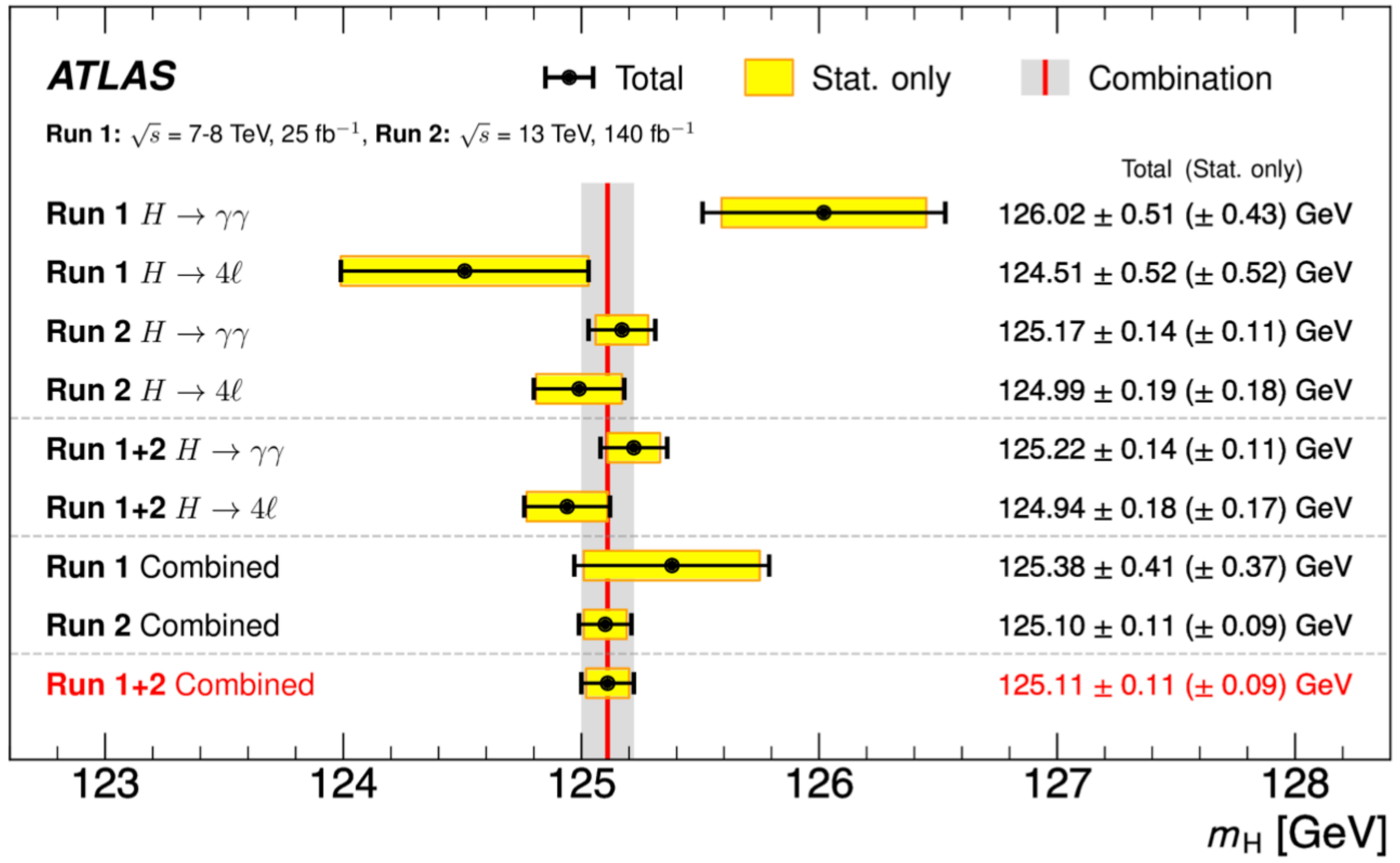
Heavy Higgs

LFV decays

HH production

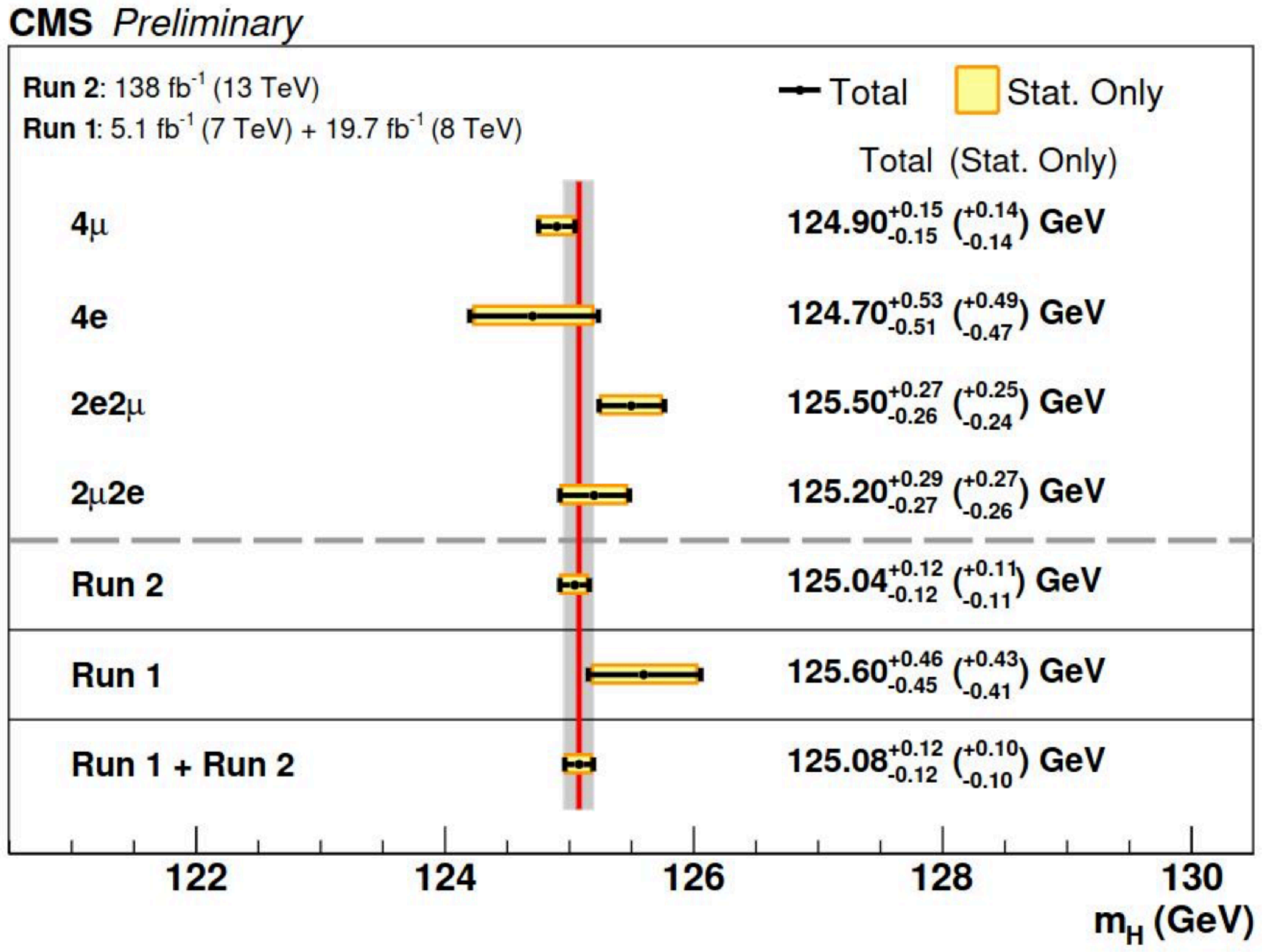
Higgs mass

ATLAS Leonardo Carminati



m_H = 125.11 ± 0.09 (stat.) ± 0.06 (syst.) = 125.11 ± 0.11 GeV

CMS Antonio Vagnerini



Impressive sub permille precision in the Higgs mass for the first time!

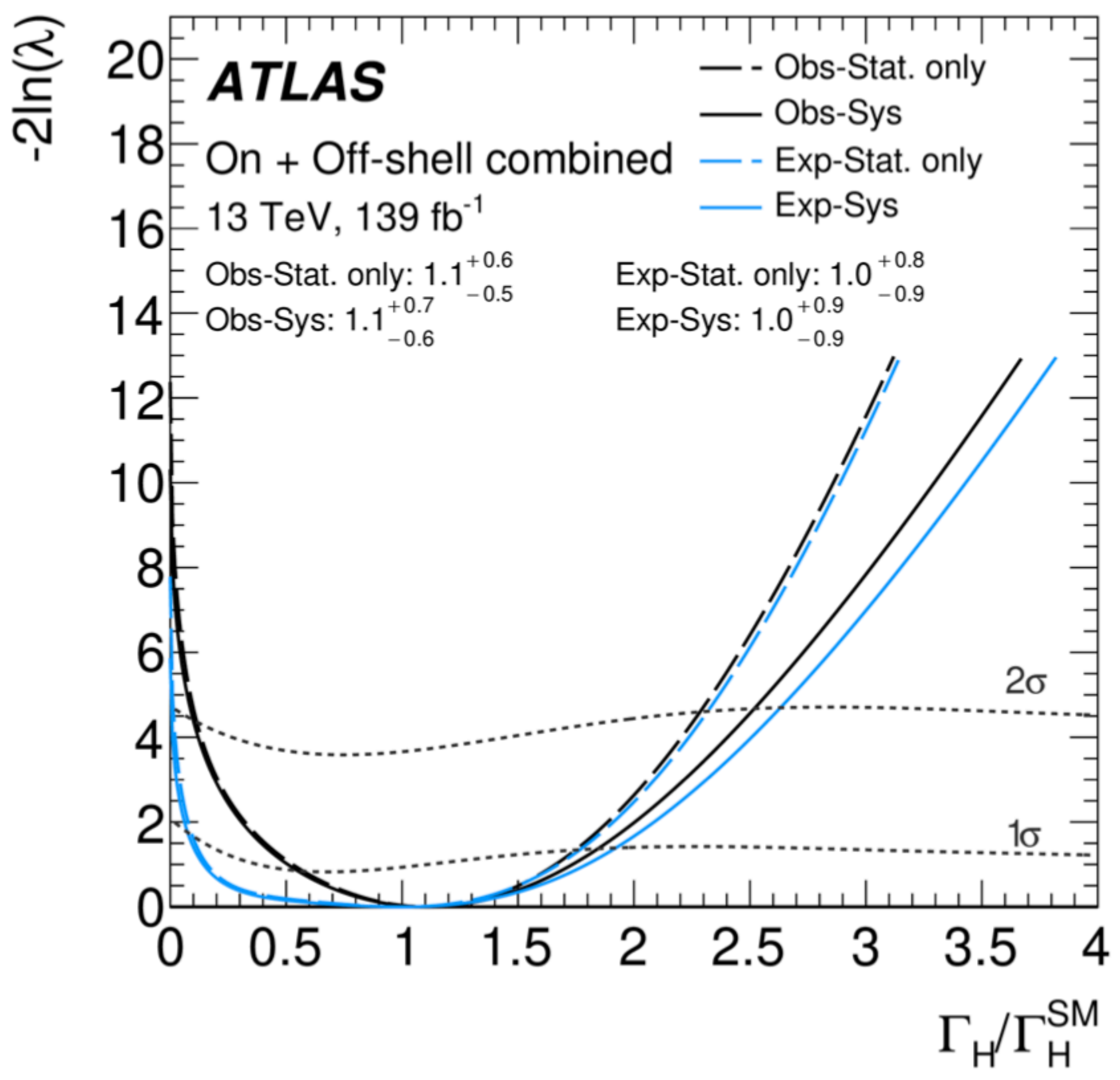
Higgs width

- Higgs width can be constrained using off-shell measurements

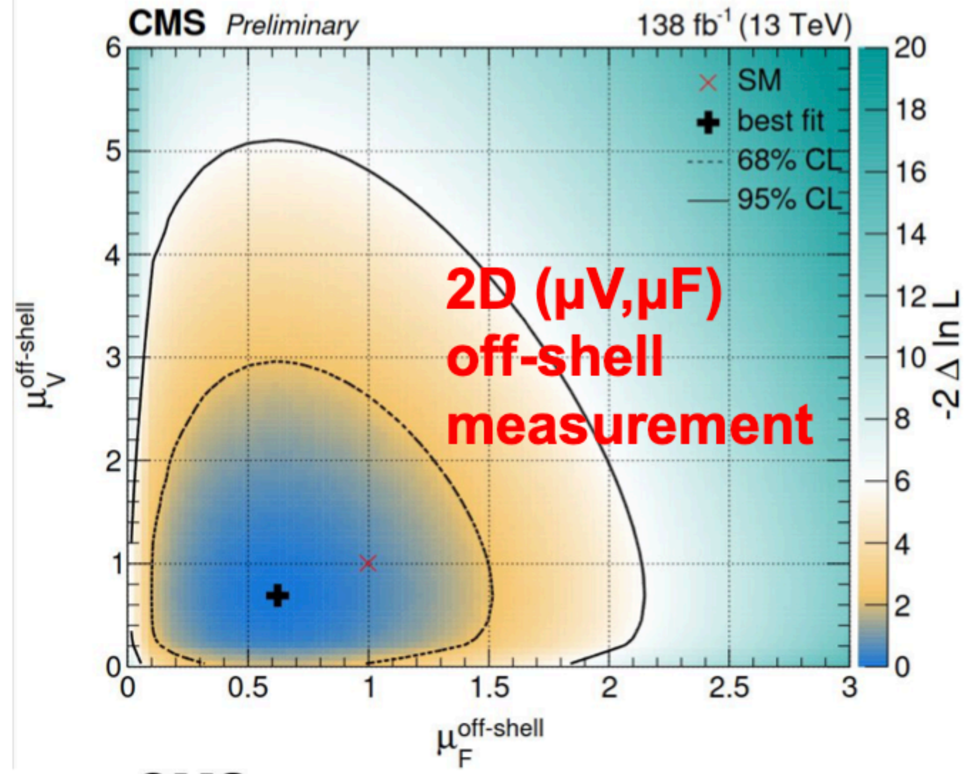
$$\sigma^{\text{onshell}}_{gg\to H\to VV} \sim \frac{c^2_{ggH}c^2_{VVH}}{m_H\Gamma_H}$$

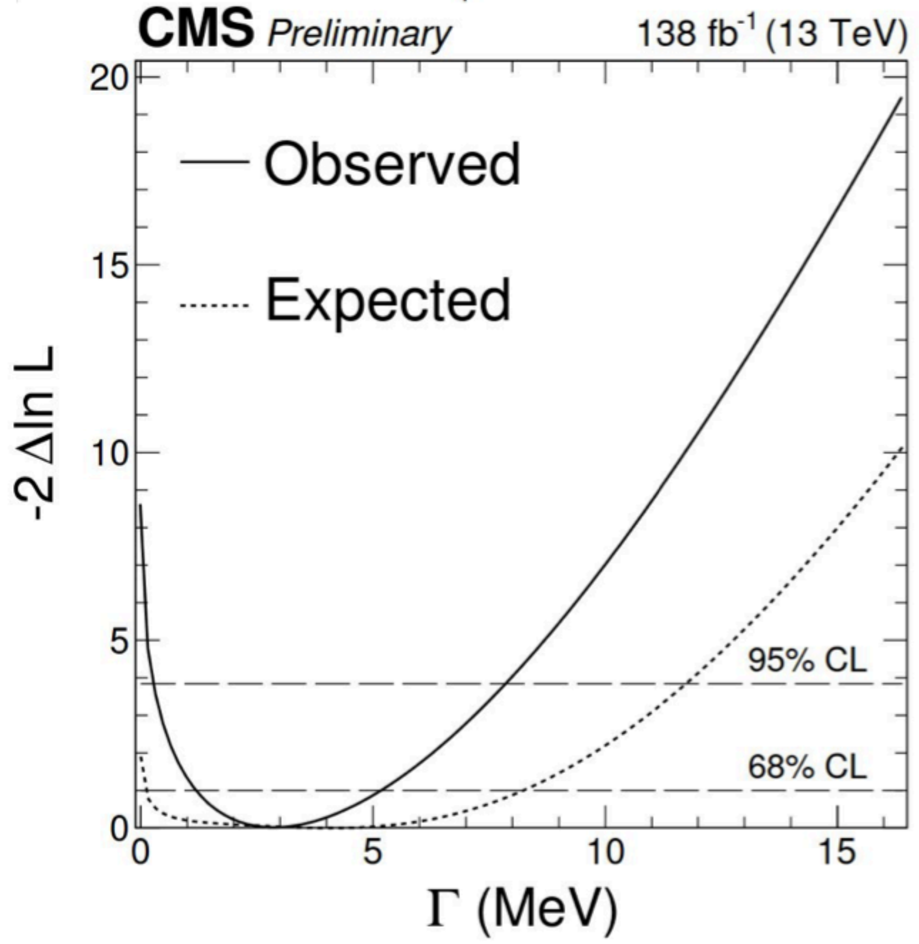
$$\sigma^{\text{offshell}}_{gg\to H\to VV} \sim \frac{c^2_{ggH}c^2_{VVH}}{m^2_{ZZ}}$$

$$\frac{\sigma^{\text{offshell}}}{\sigma^{\text{onshell}}} \sim \Gamma_H$$



Leonardo Carminati





Antonio Vagnerini

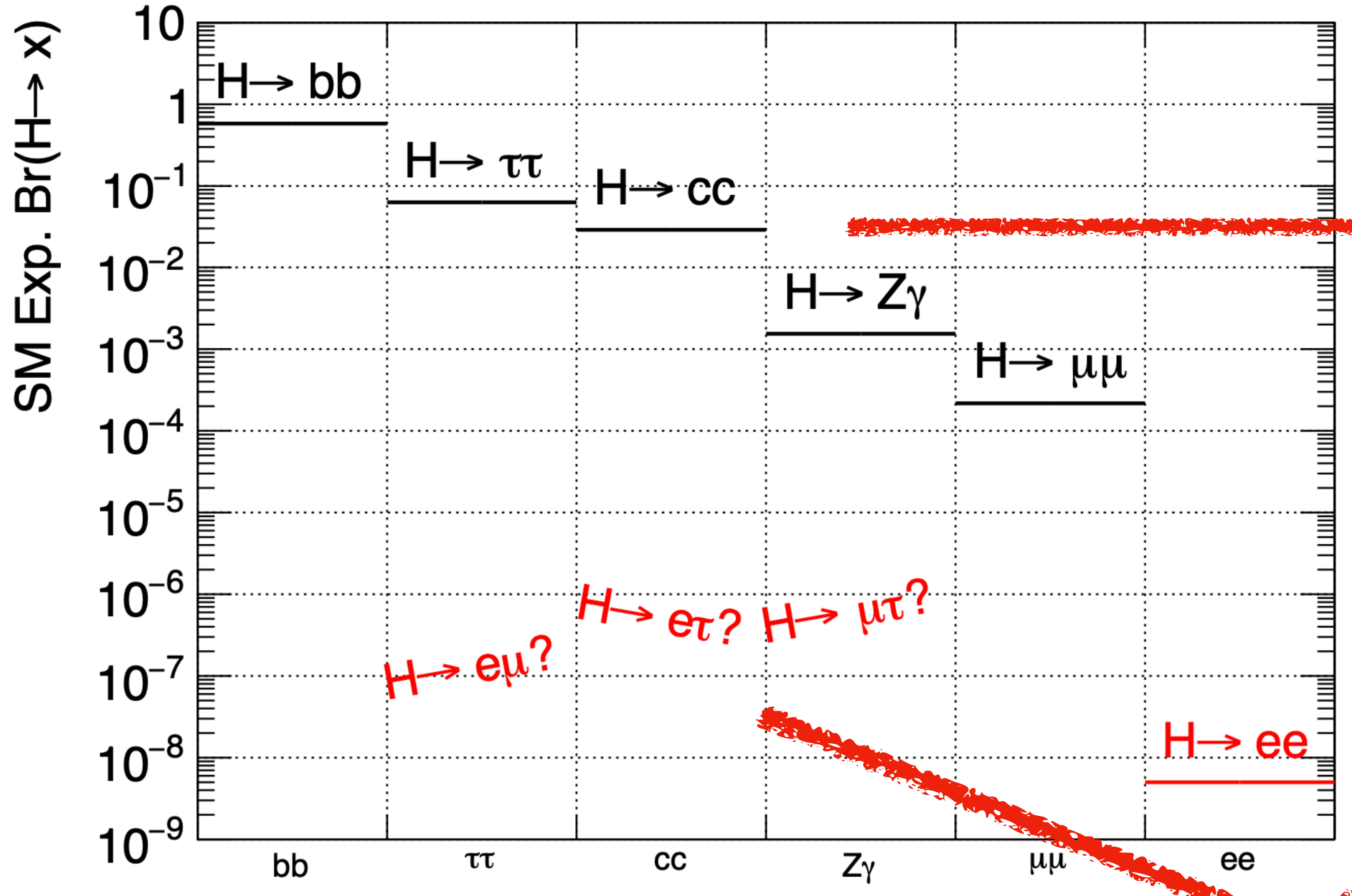
$\Gamma_H = 4.5^{+3.3}_{-2.5}$ MeV and 0.5 (0.1) < Γ_H < 10.5 (10.9) MeV at 95% CL

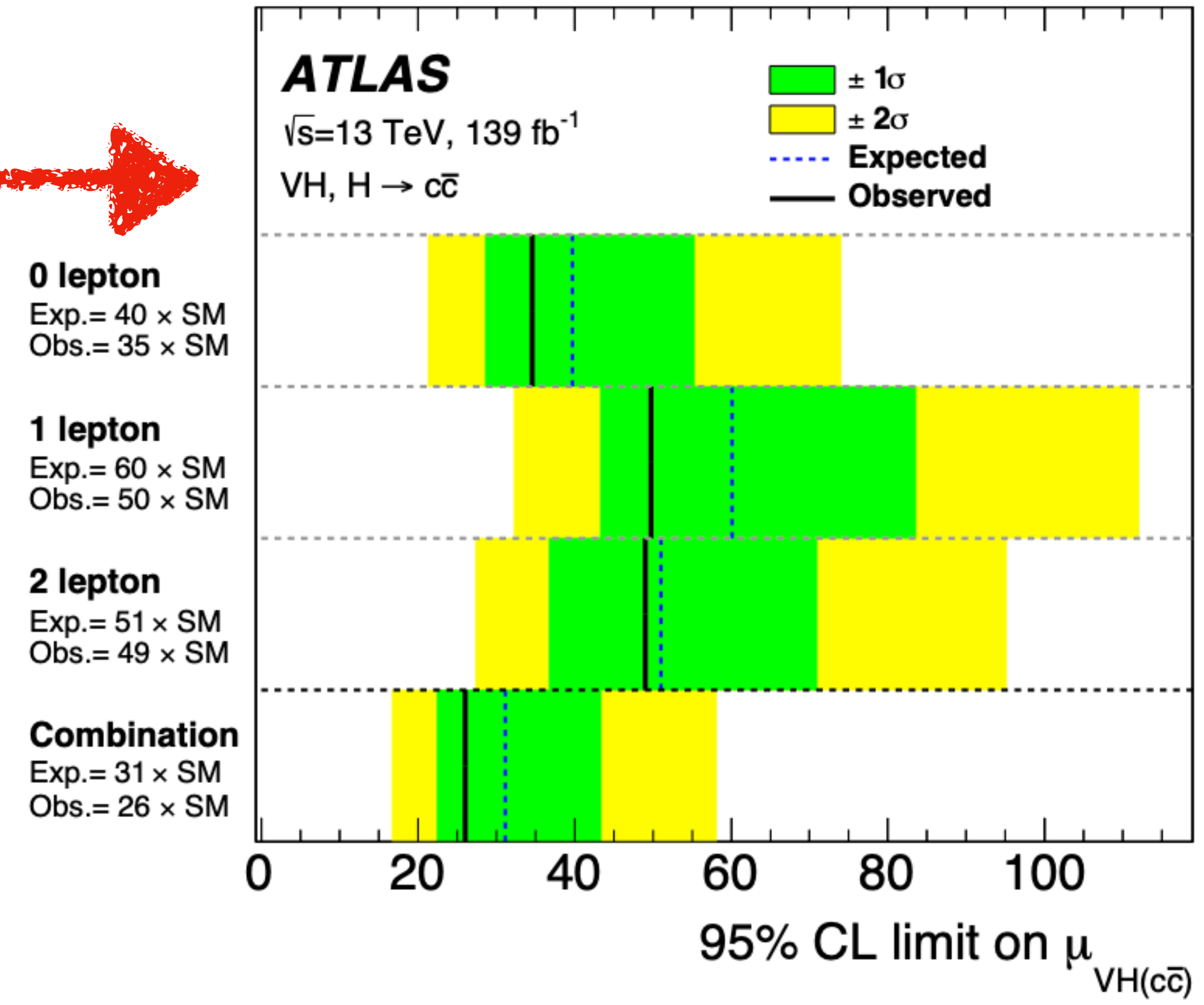
$\Gamma = 2.9^{+1.9}_{-1.4}$ MeV, $\in [0.6, 7.0]$ MeV @ 95 % CL

Higgs couplings to fermions

Search for rare/tough decay modes

Louis-Guillaume Gagnon





$V(\to qq)H(\to bb)$: 1.7σ excess over background

$V(\to ll')H(\to \tau\tau)$: 4.2$\sigma$ observation

$V(\to ll')H(\to cc)$: $\mu_{VHcc} < 26\times$ SM

$H \to Z\gamma$ ATLAS/CMS combination: 3.4σ observation

$H \to \mu^+\mu^-$: 2σ excess over background

$H \to ee$: $\mu < 3.6 \times 10^{-4}$

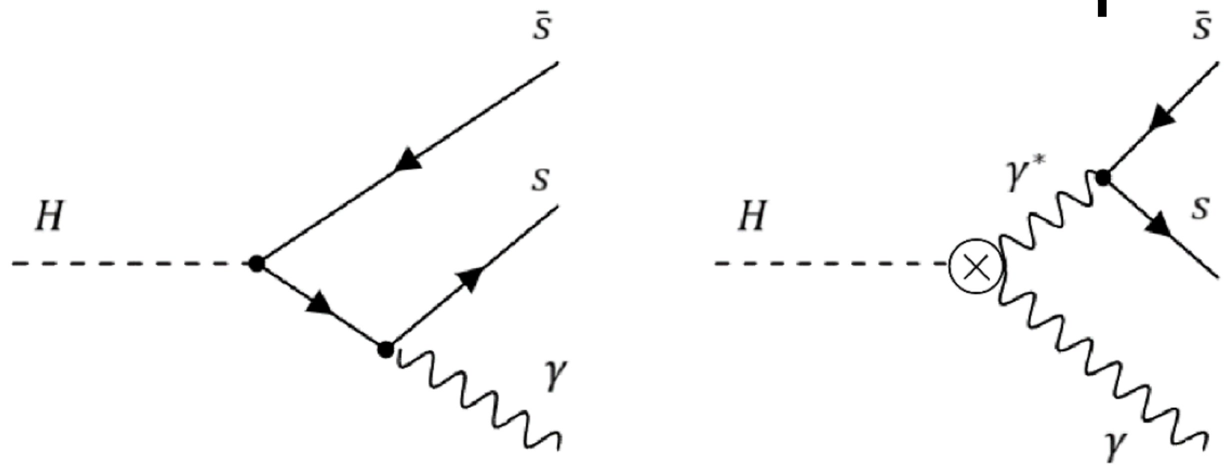
$H \to e\mu$: $\mu < 6.2 \times 10^{-5}$

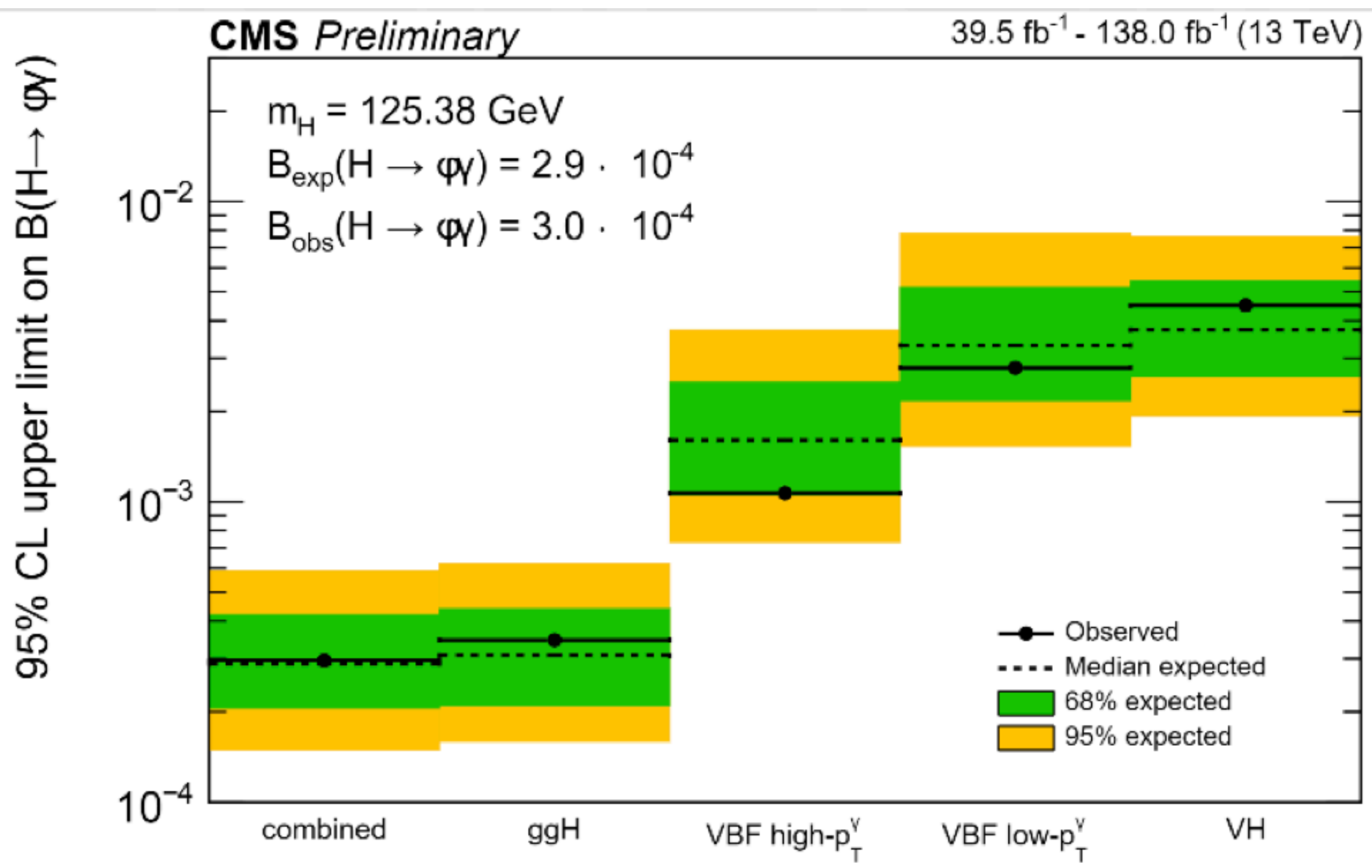
$H \to e\tau$: $\mu < 0.2\%$

$H \to \mu\tau$: $\mu < 0.18\%$

} Lepton Flavour violation

H → VECTOR MESON + γ

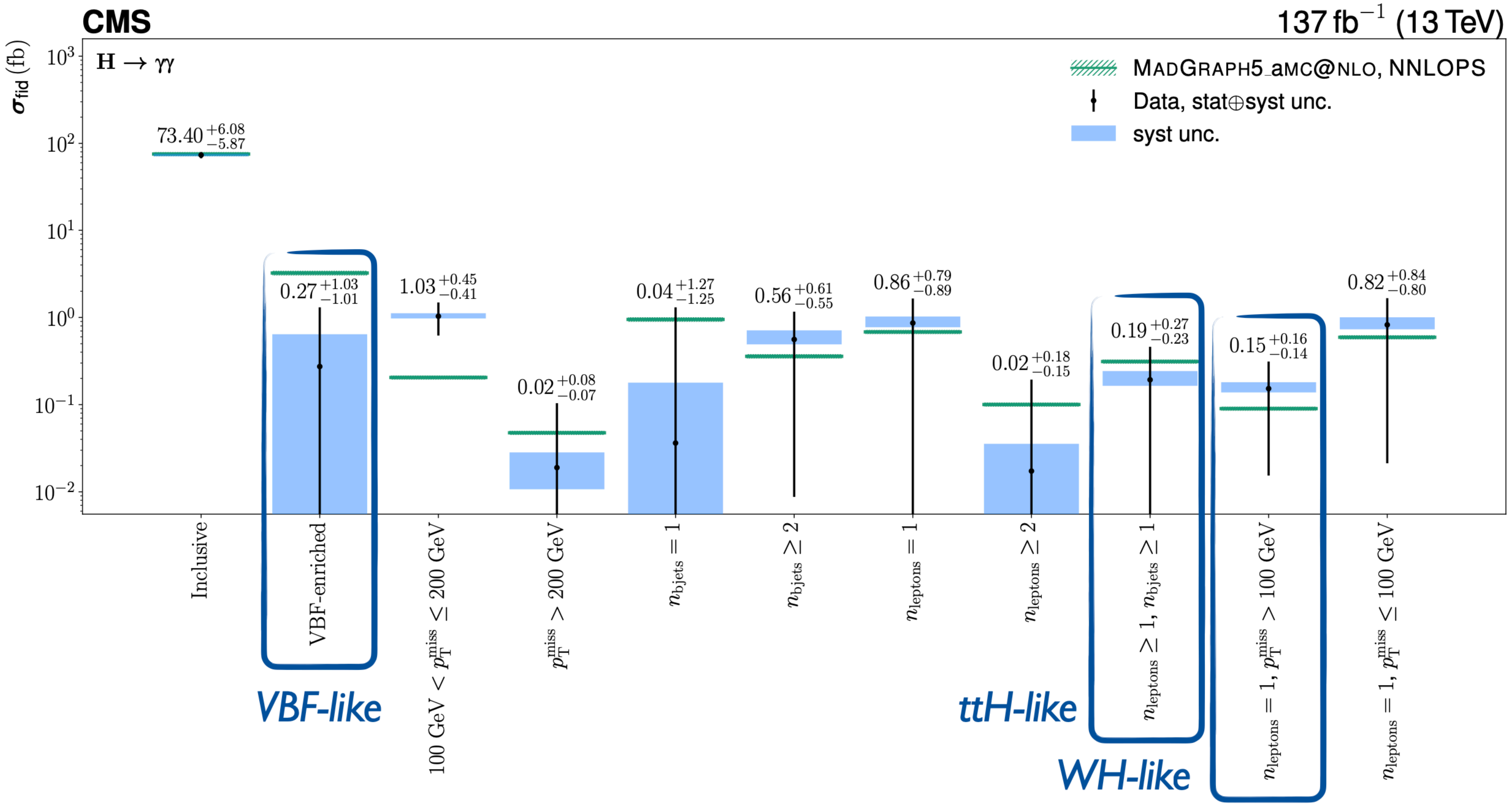


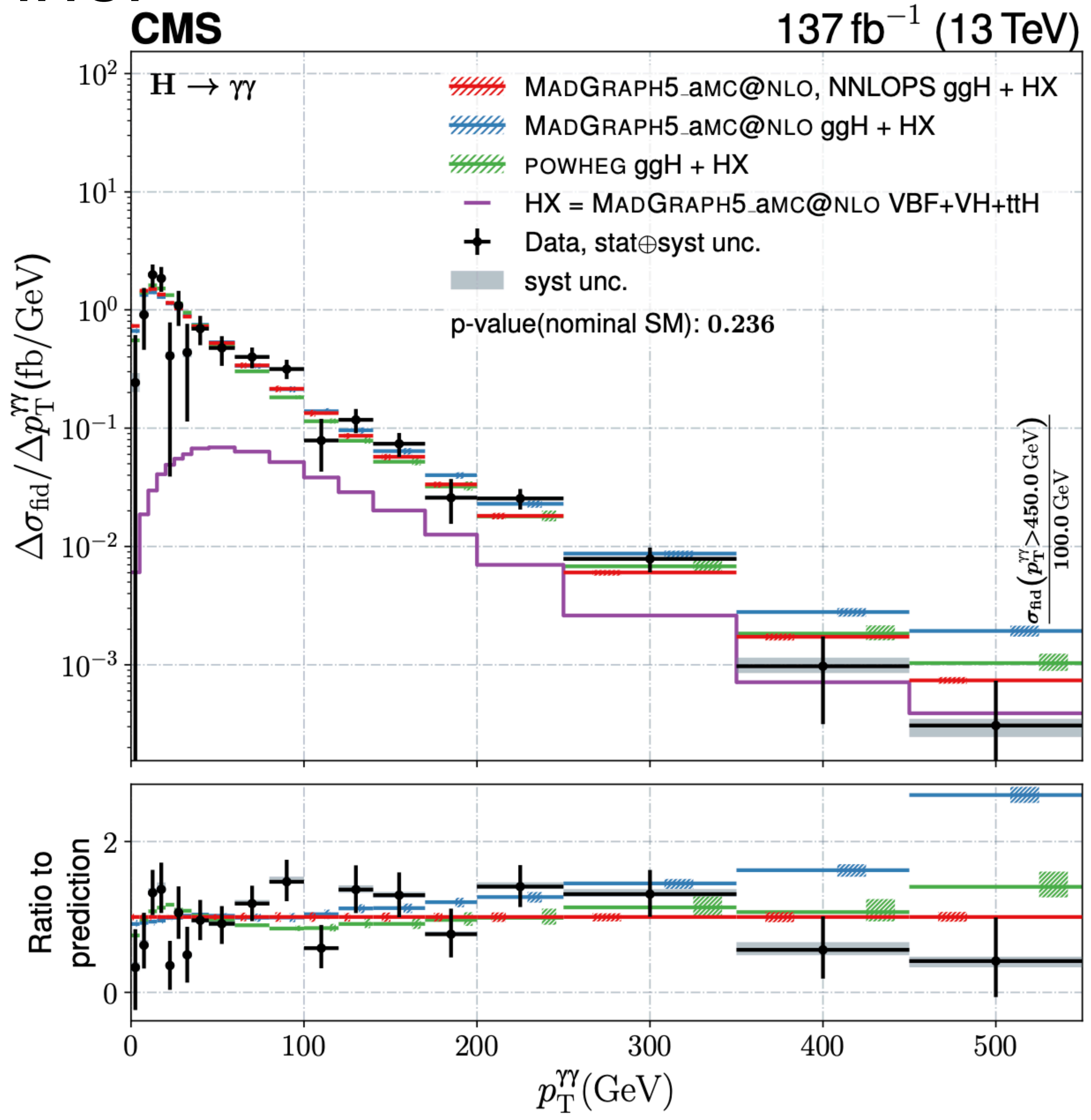


Roberto Covarelli

Going beyond Branching ratios

Fiducial measurements in the diphoton decay channel





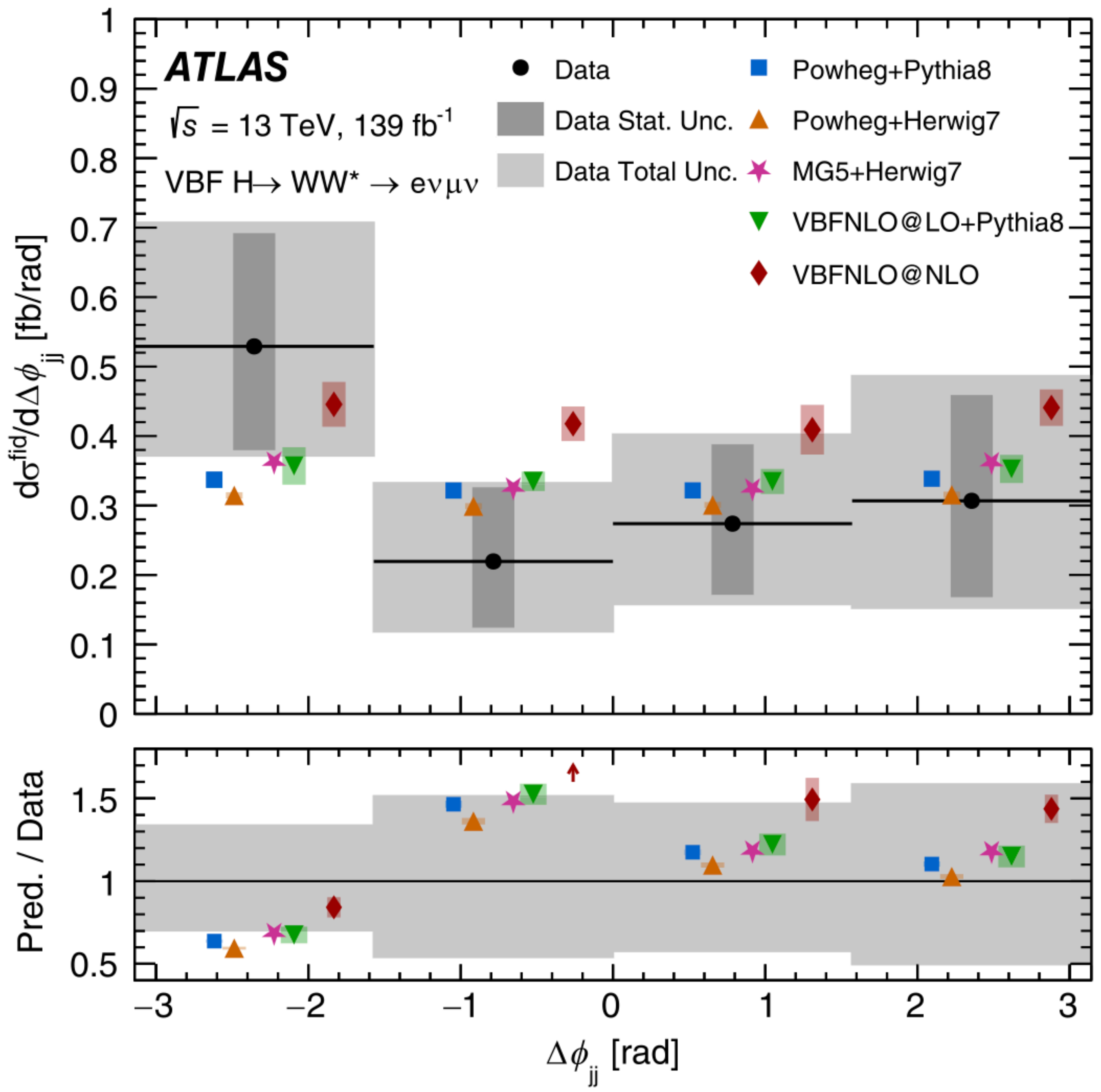
- Advanced morphing techniques
  - improving modelling of diphoton invariant mass resolution and photon identification

Johannes Erdmann

Higgs differential measurements

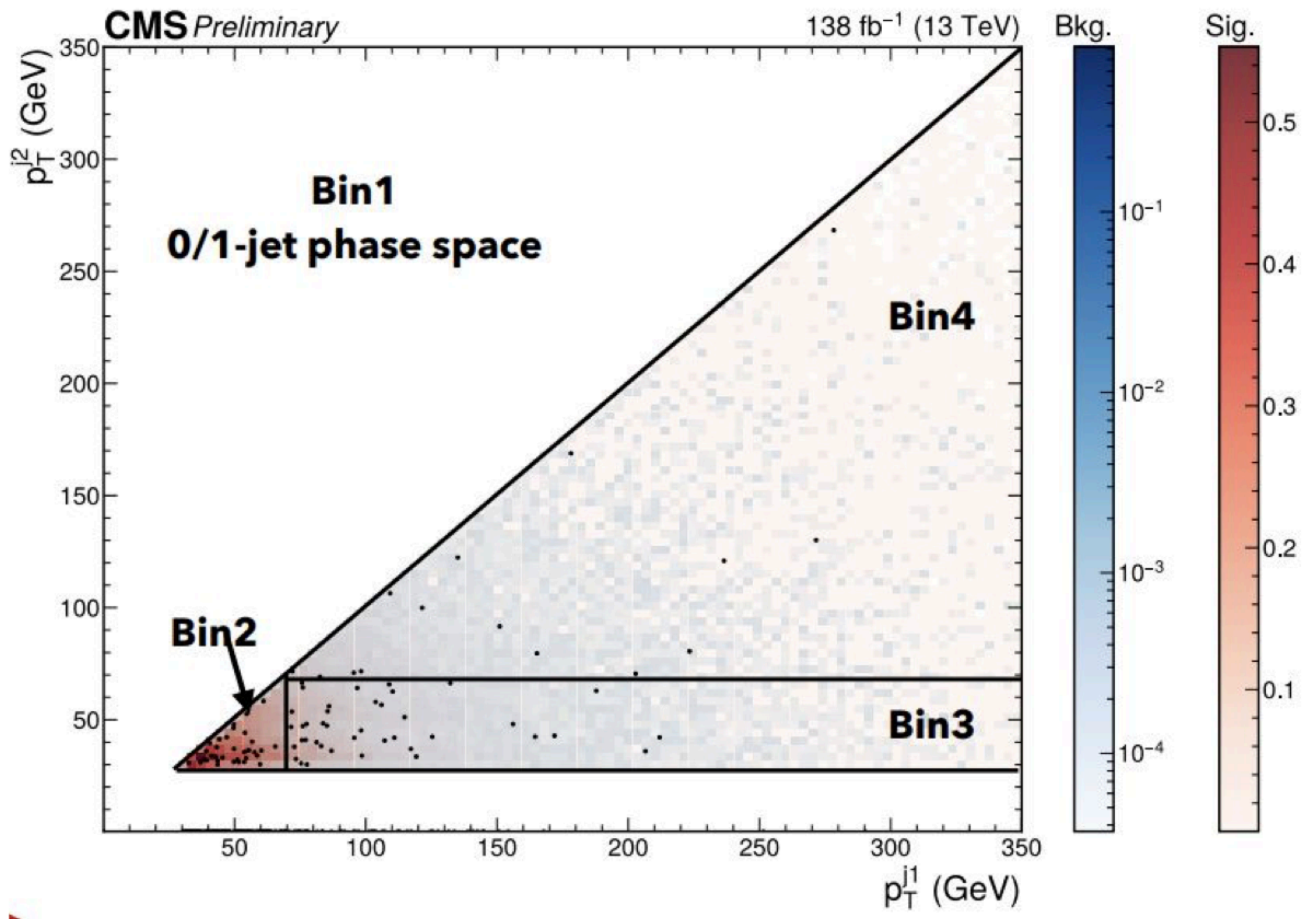
- Differential distributions available for various production and decay modes
- Covering both high energy tails, angular observables
- Double differential observables are also becoming available

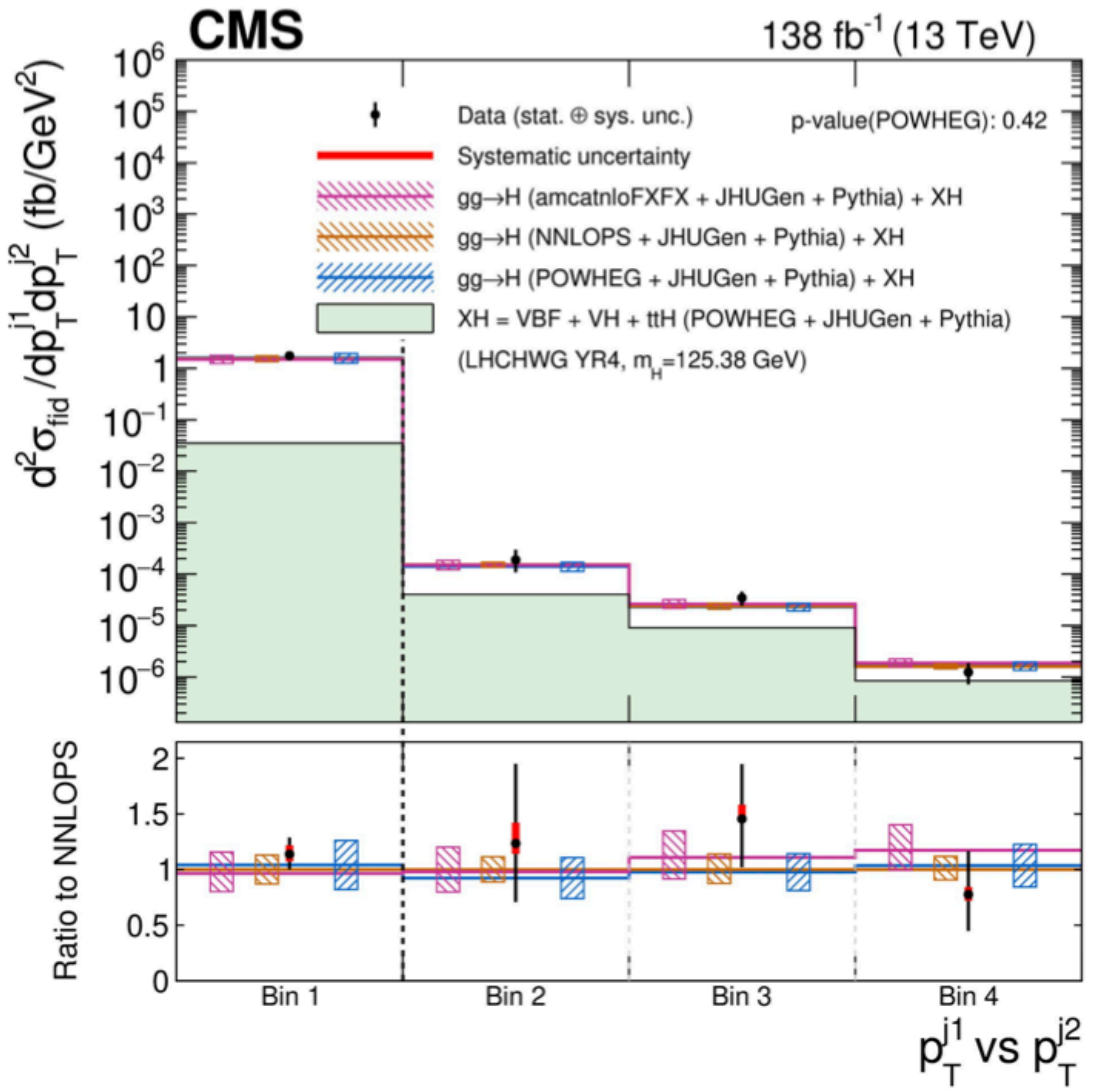
ATLAS Vector boson fusion



Benedict Winter

CMS Double differential observables



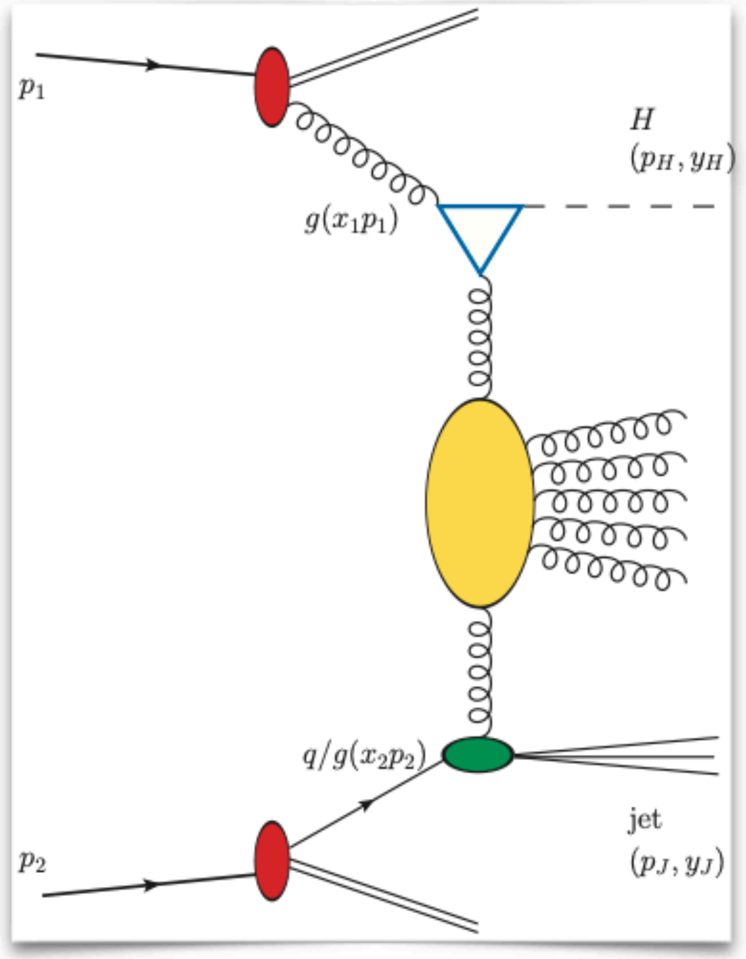


Alessandra Cappati

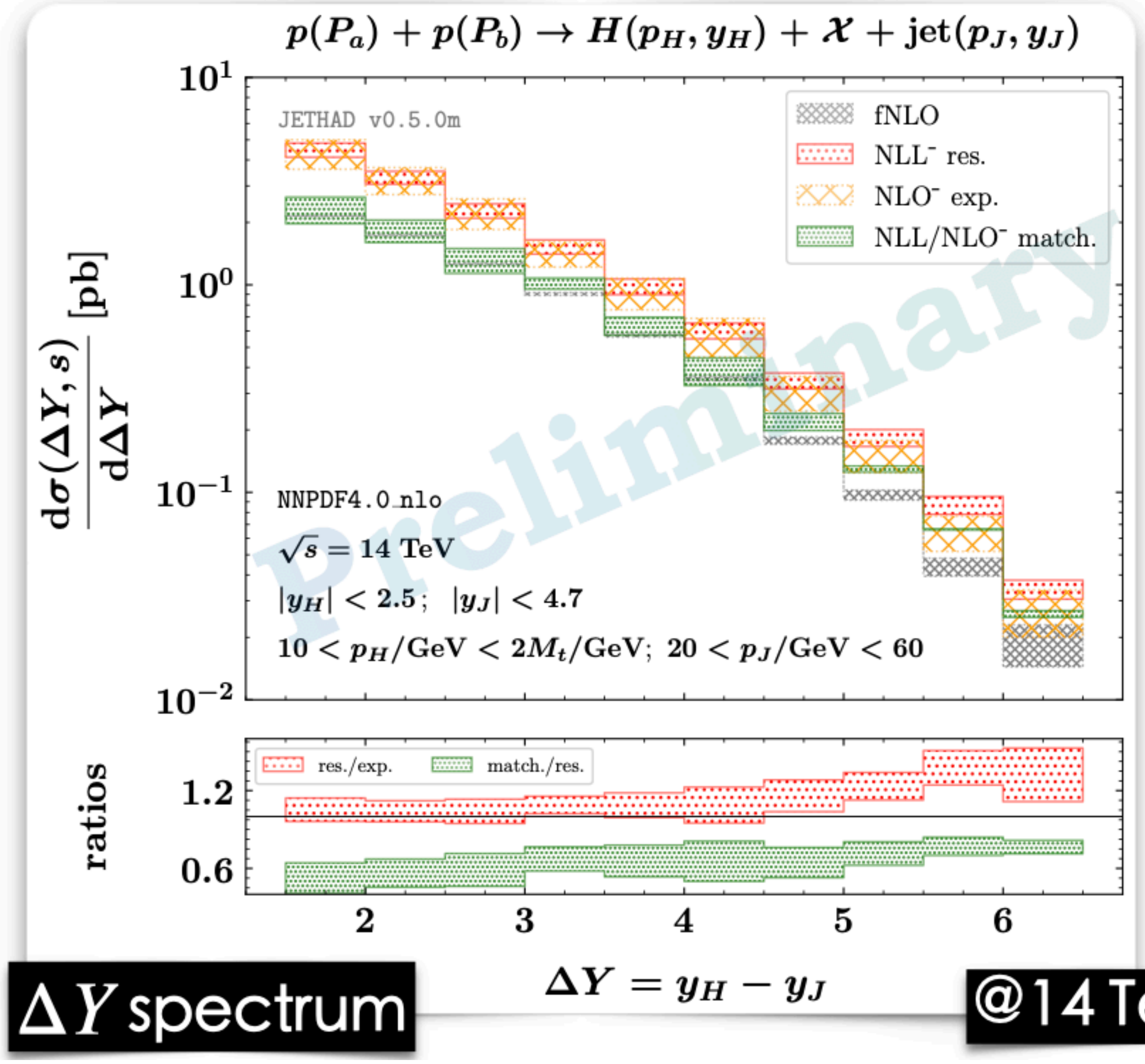
Progress in Theory

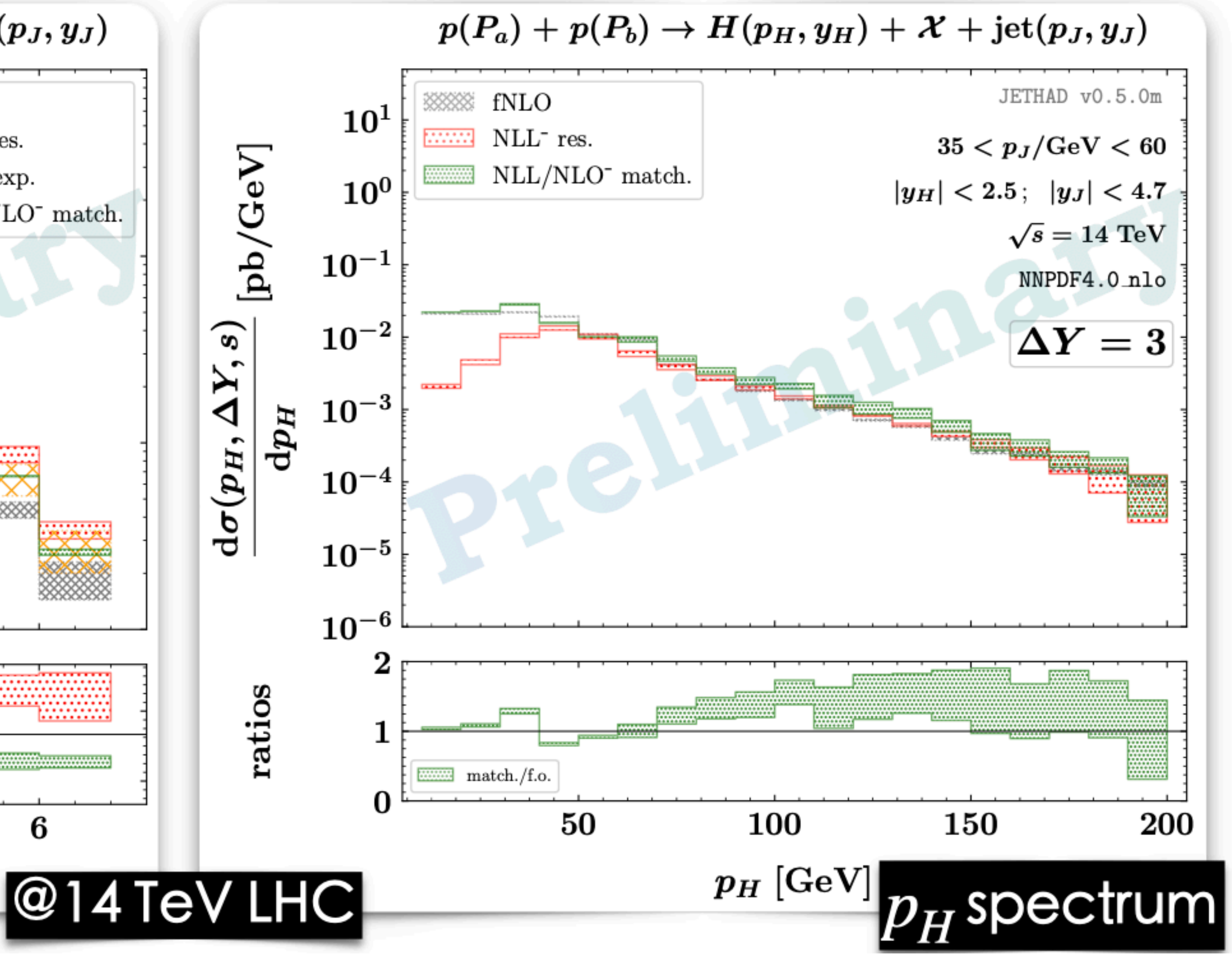
Higgs/Z+jet NLL/NLO+

- Resummed predictions NLL matched to Fixed Order



Francesco Celiberto





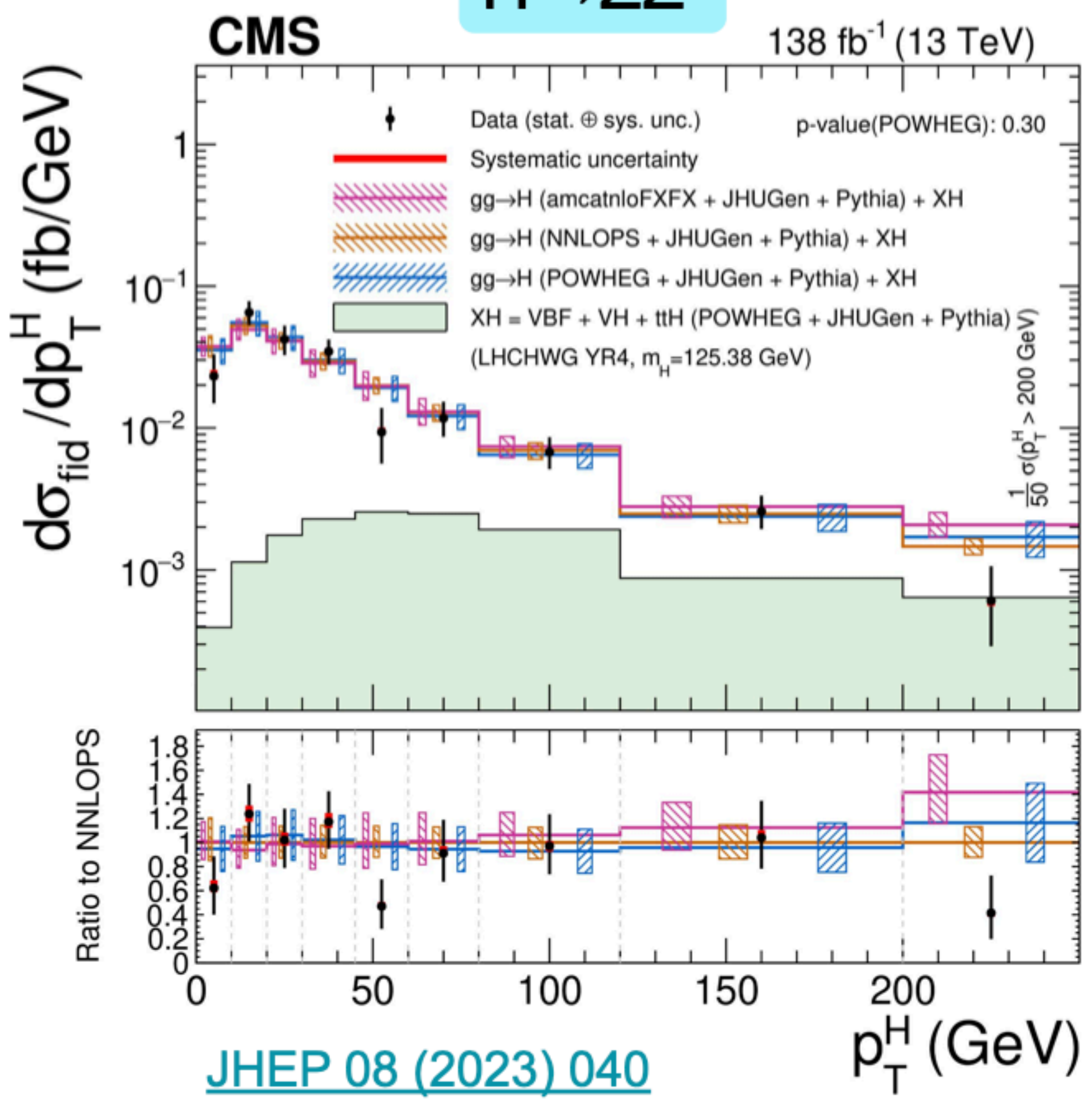
Better description for the semi-inclusive H+jet process

Interpretations of differential measurements

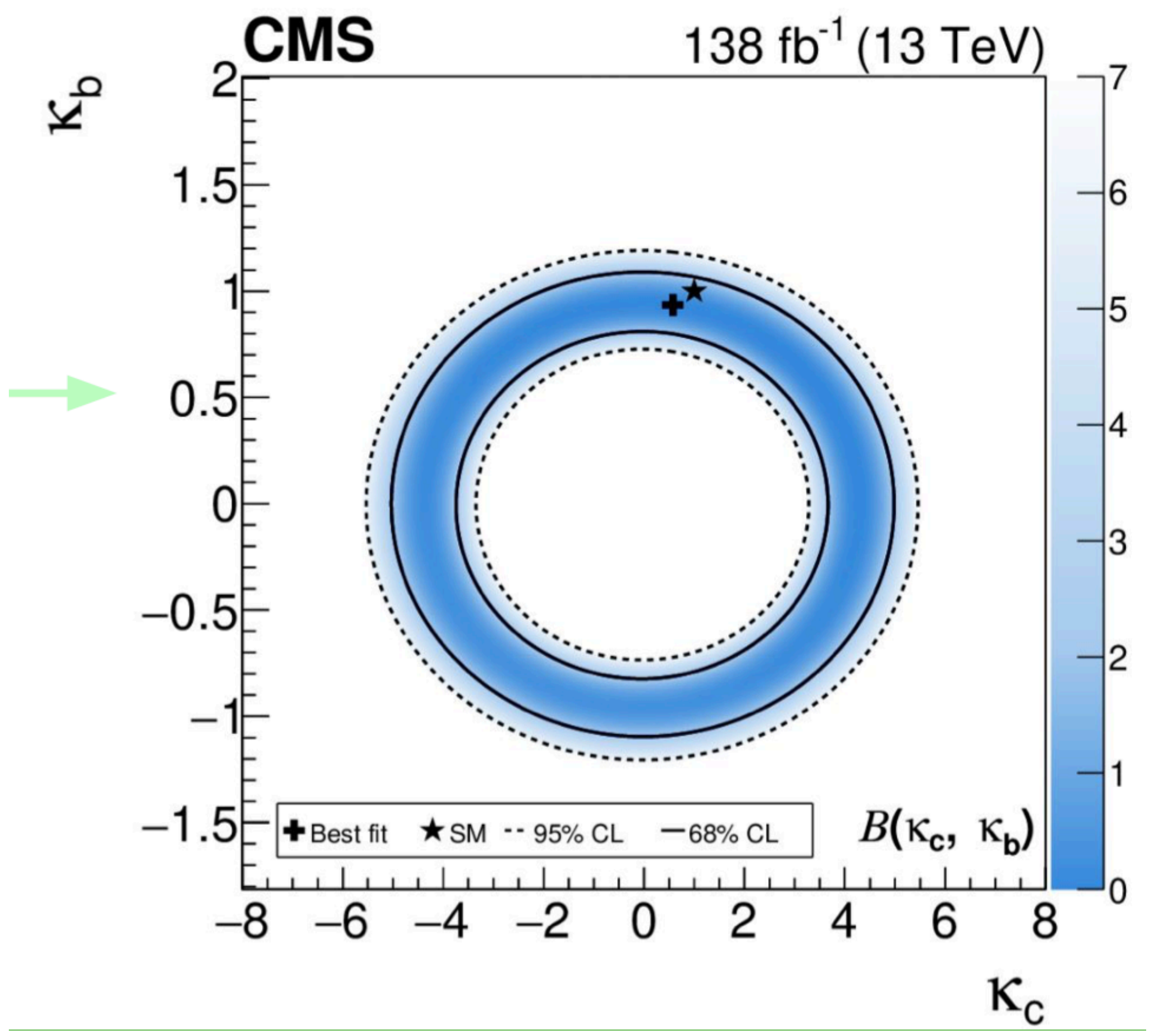
Increasing differential measurements can be used to constrain Higgs couplings:
Higgs Yukawa couplings

CMS Alessandra Cappati

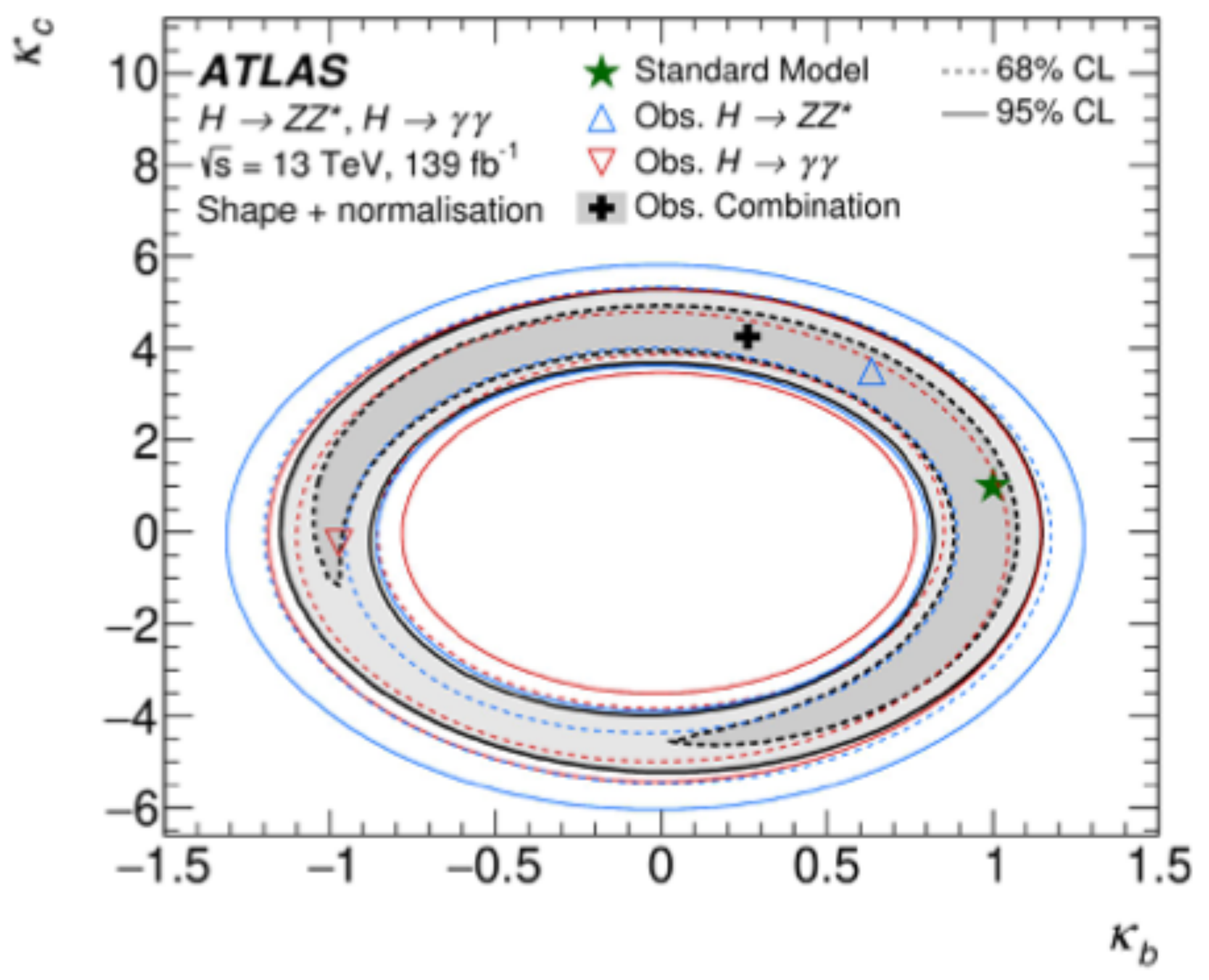
H→ZZ



JHEP 08 (2023) 040



ATLAS Benedict Winter



Higgs Transverse momentum distribution used to bound bottom and charm Yukawa

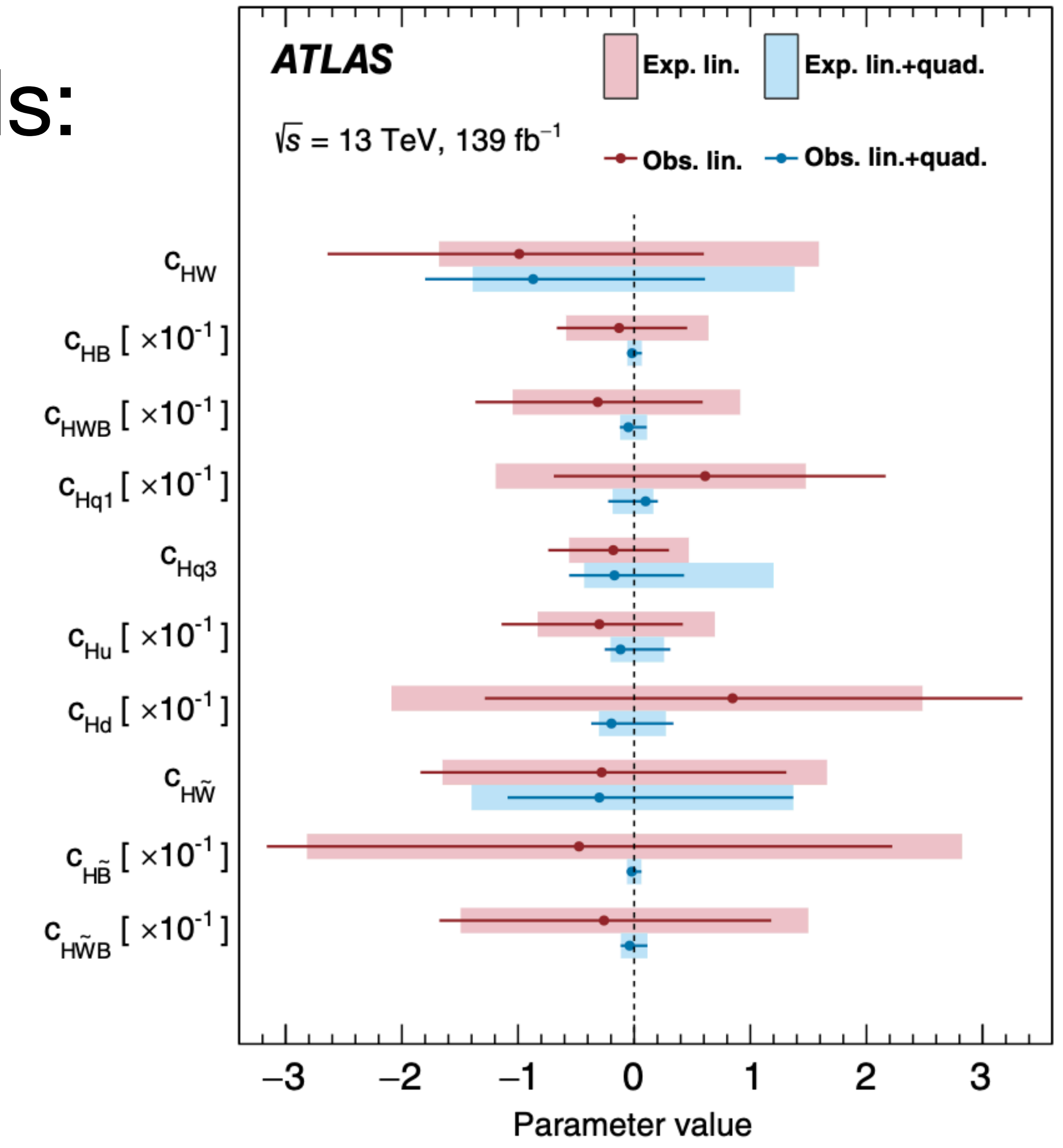
EFT interpretations of Higgs measurements

EFT → New Interactions of SM particles

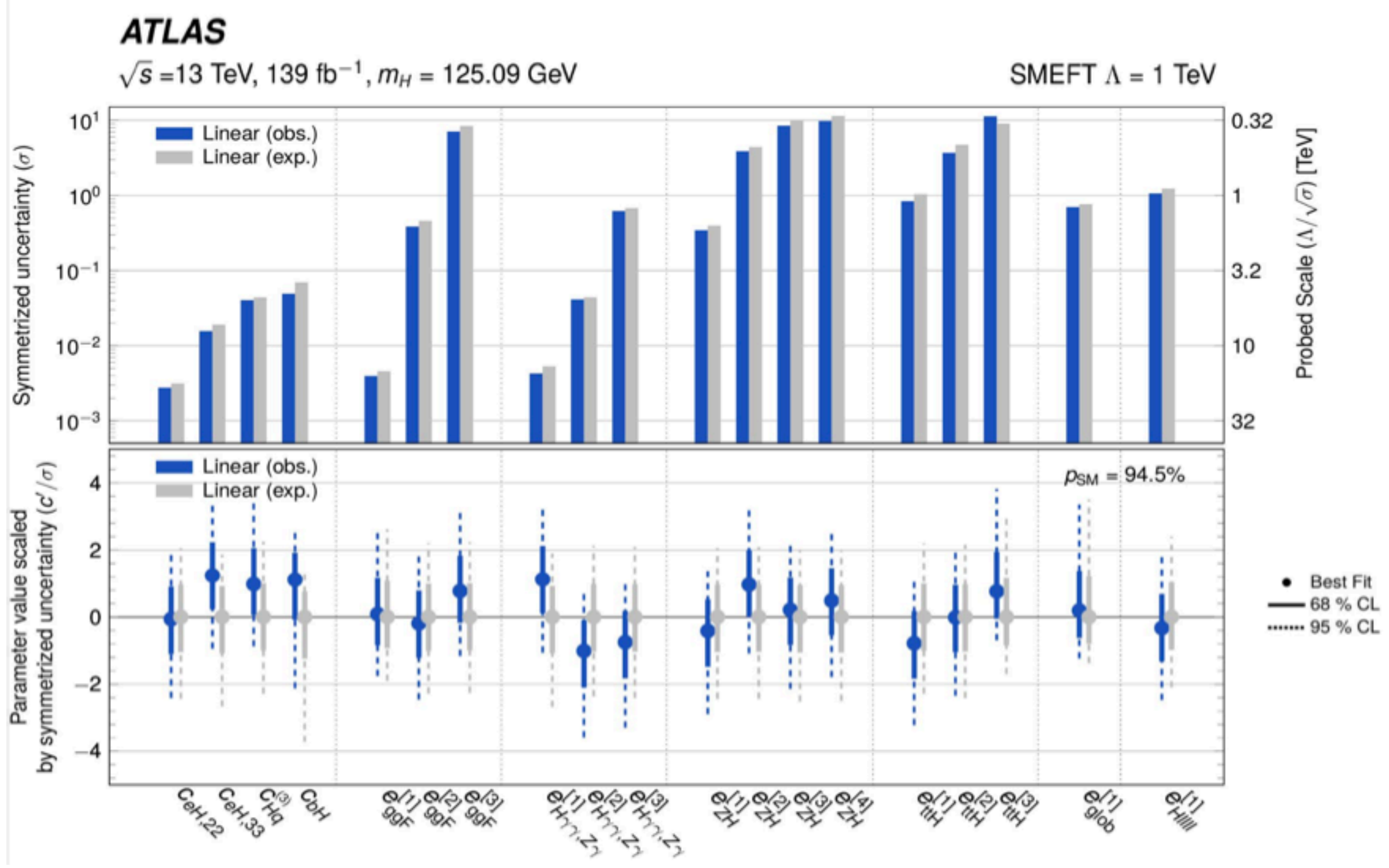
$$\mathcal{L}_{EFT} = \mathcal{L}_{SM} + \sum_i \frac{C_i^{(6)} O_i^{(6)}}{\Lambda^2} + \mathcal{O}(\Lambda^{-4})$$

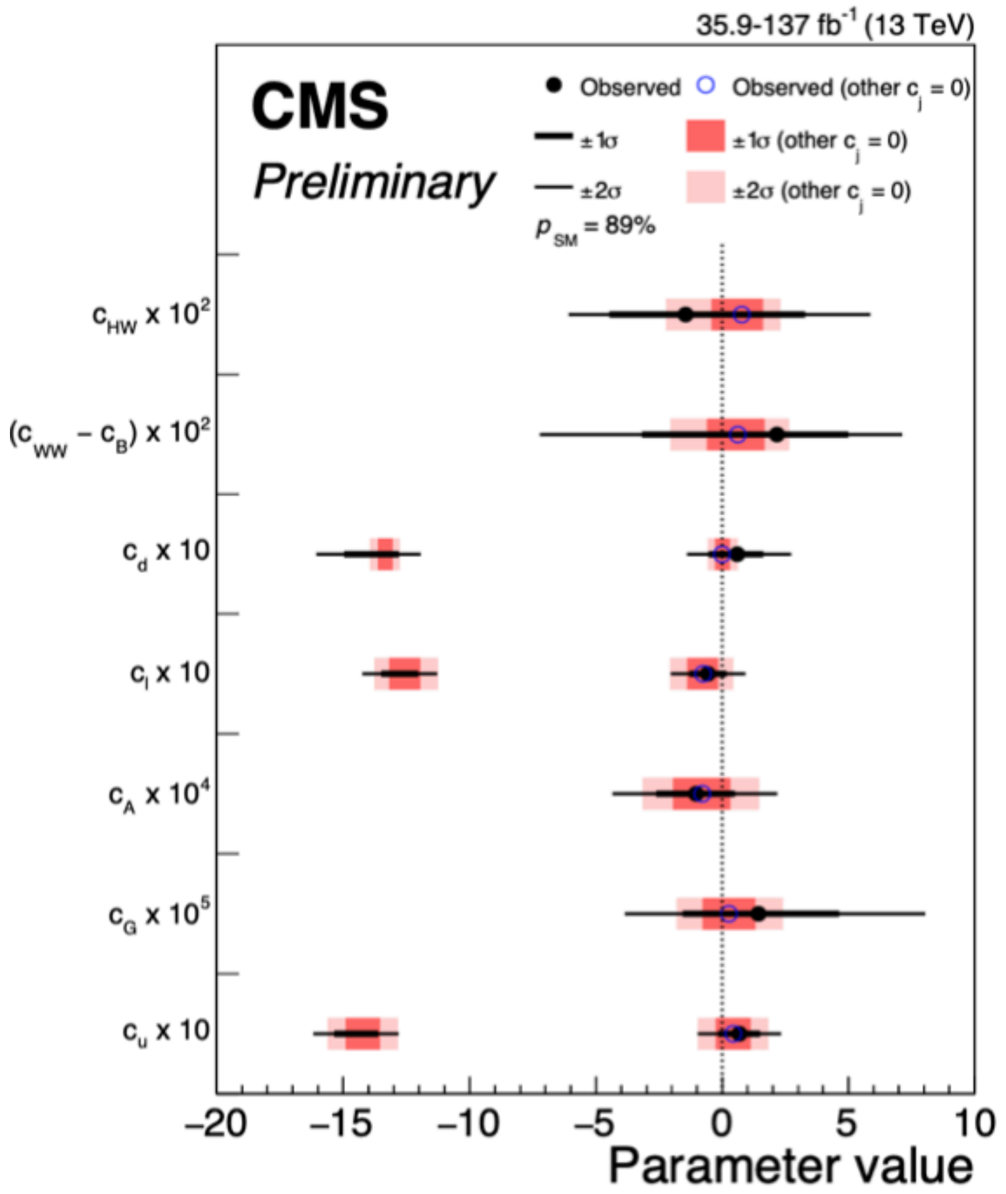
Individual channels:
e.g. VBF

ATLAS



Interpretation of STXS measurements:





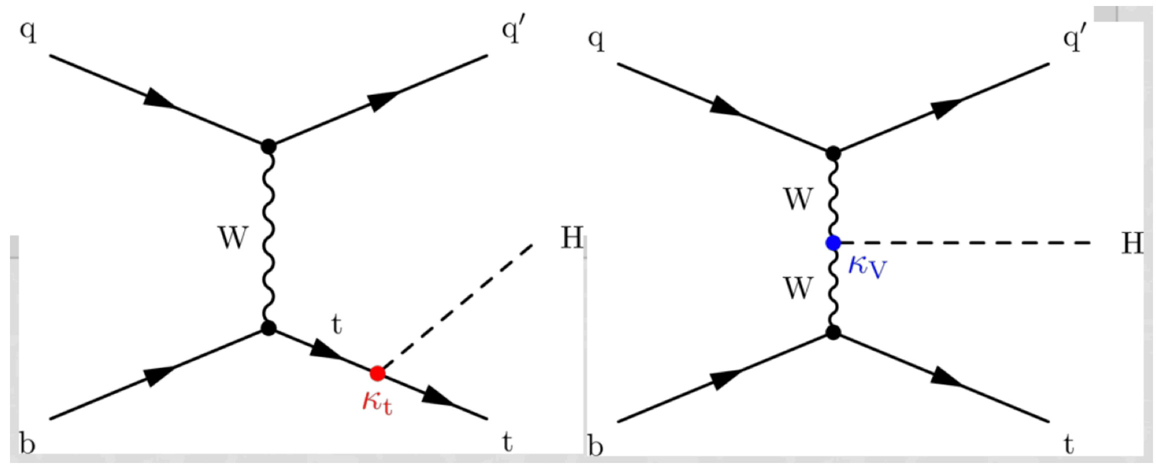
Benedict Winter

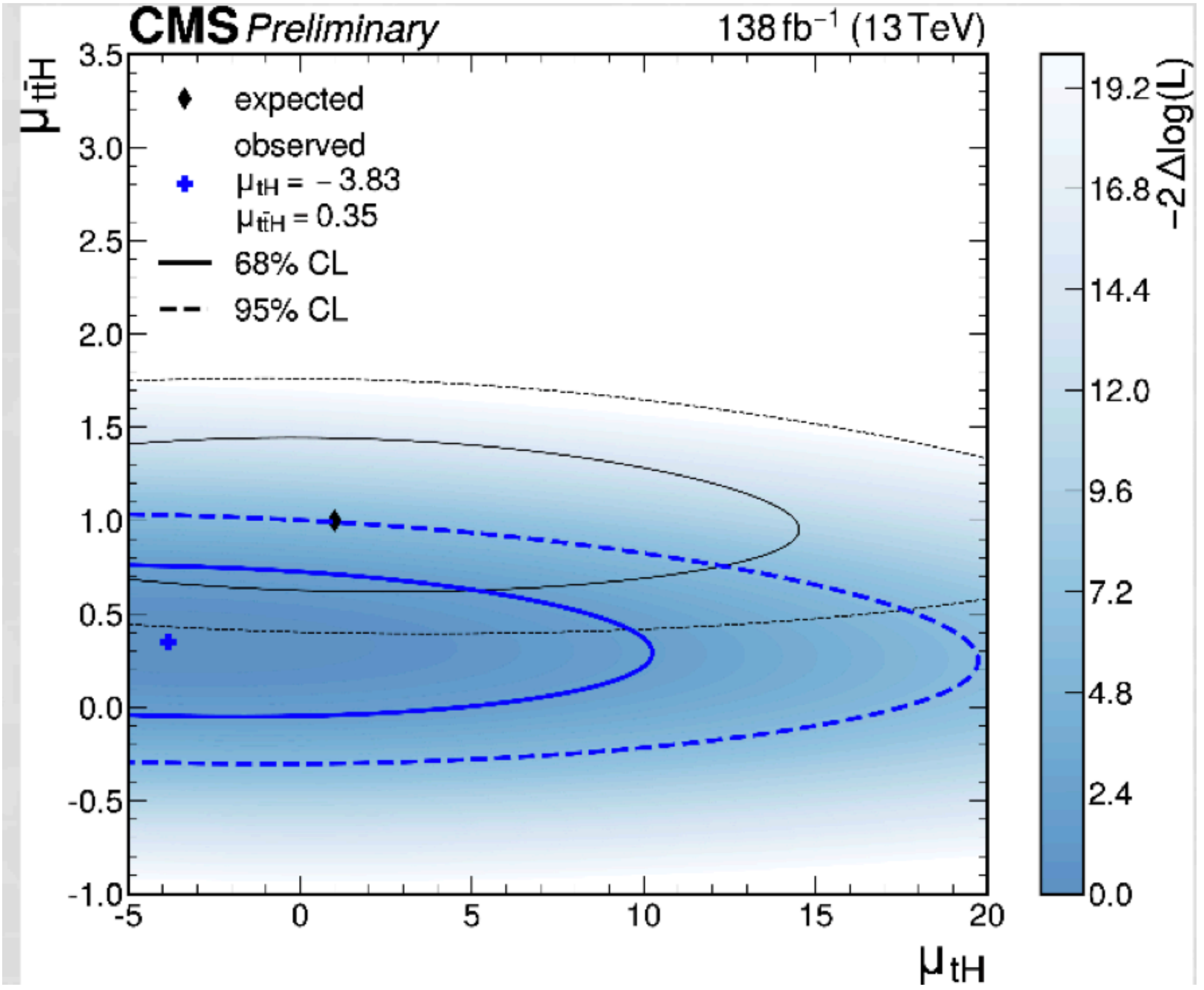
CMS Oguz Güzel

Rare Production modes

CMS   Roberto Covarelli

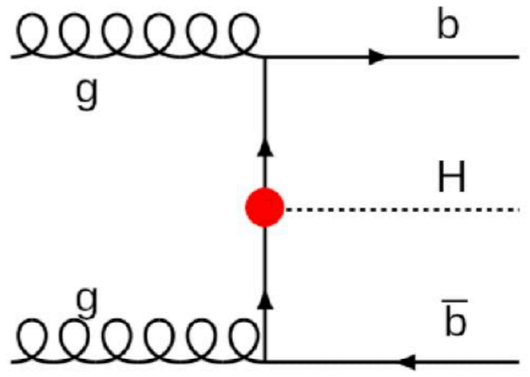
tHj



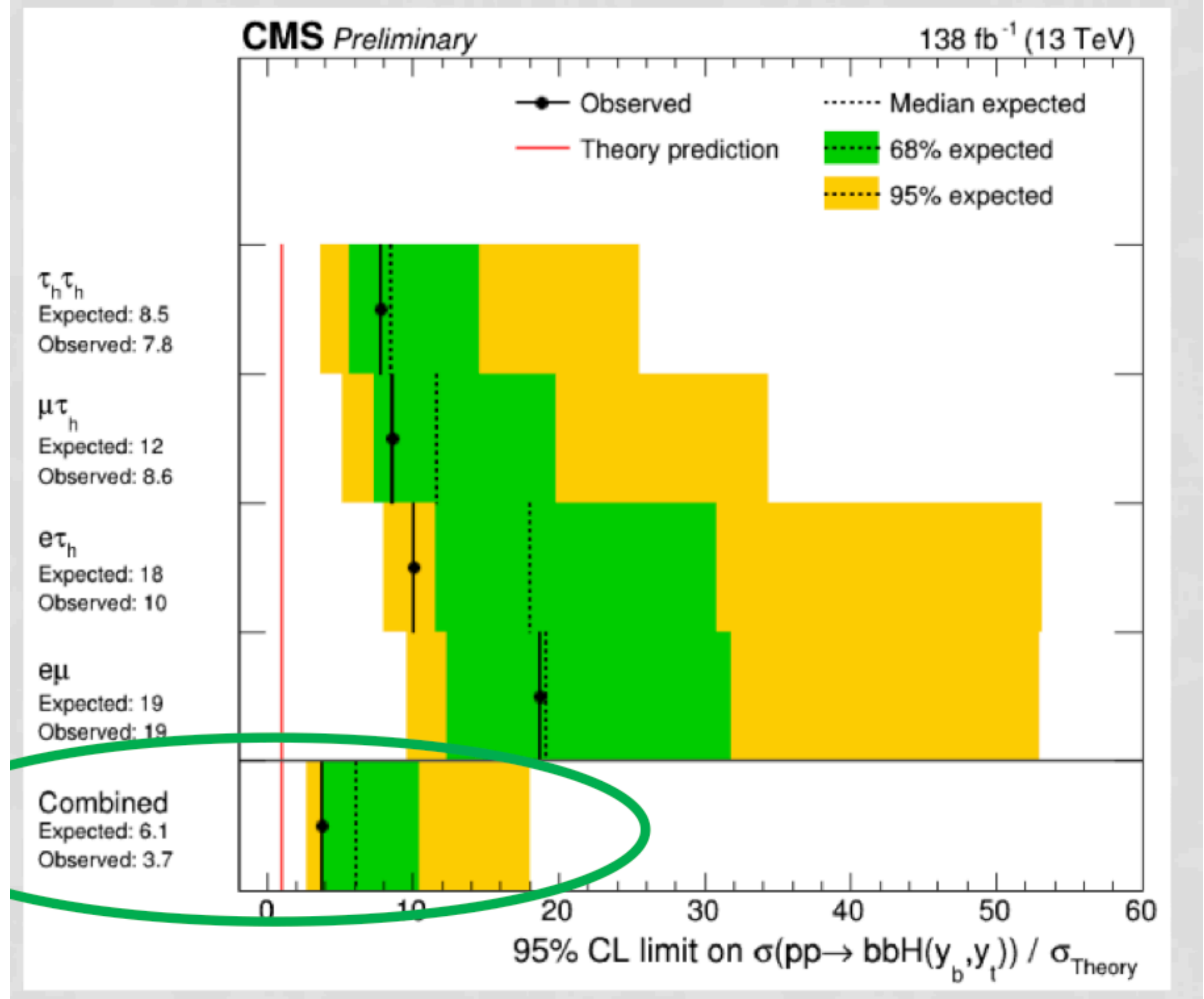


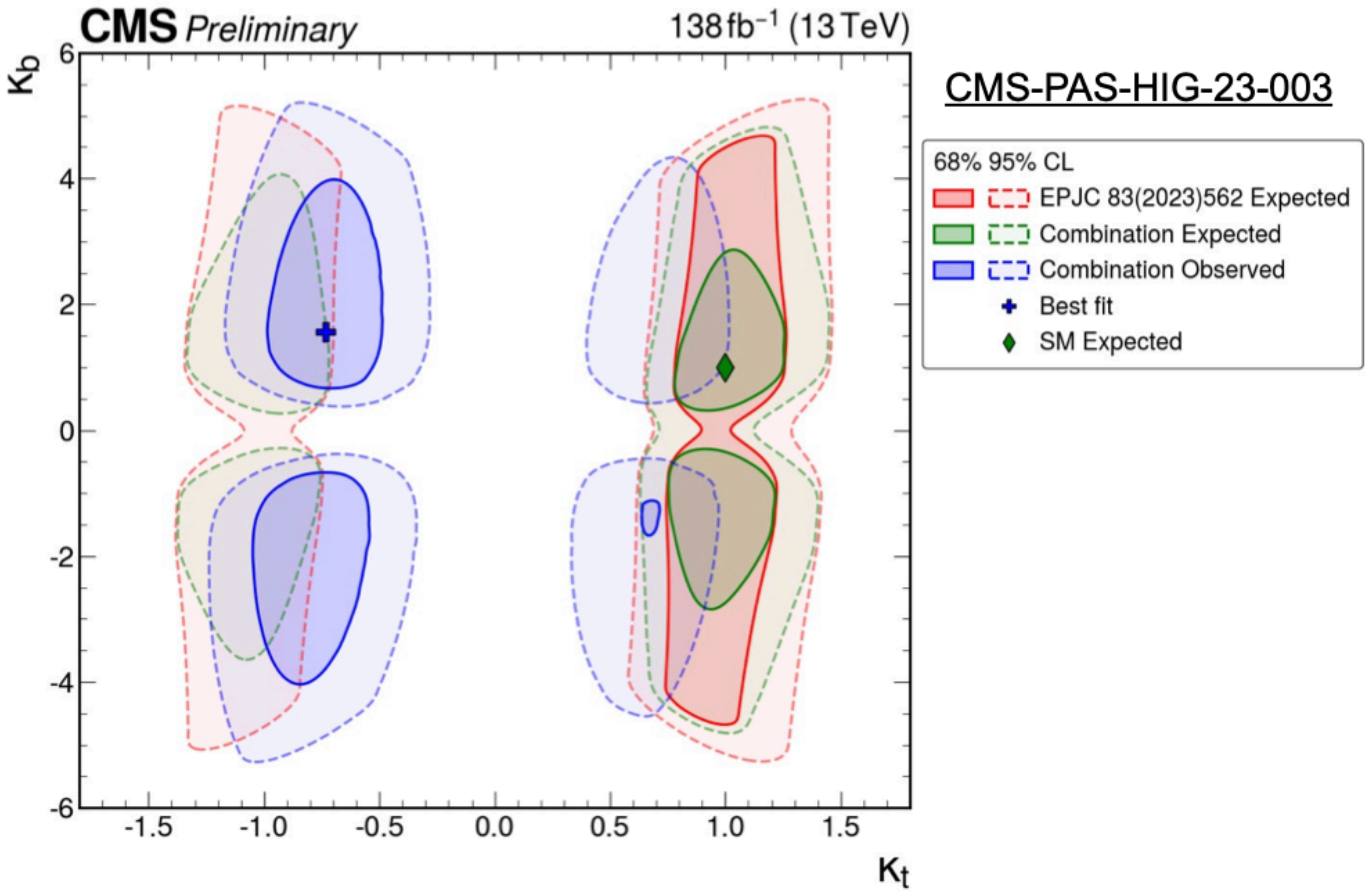
Bound for tHj ~15 times the SM prediction
Sensitive to both Htt and HWW couplings, cancellation between the two diagrams
Probe of coupling modifications

bbH



Mayam Makou





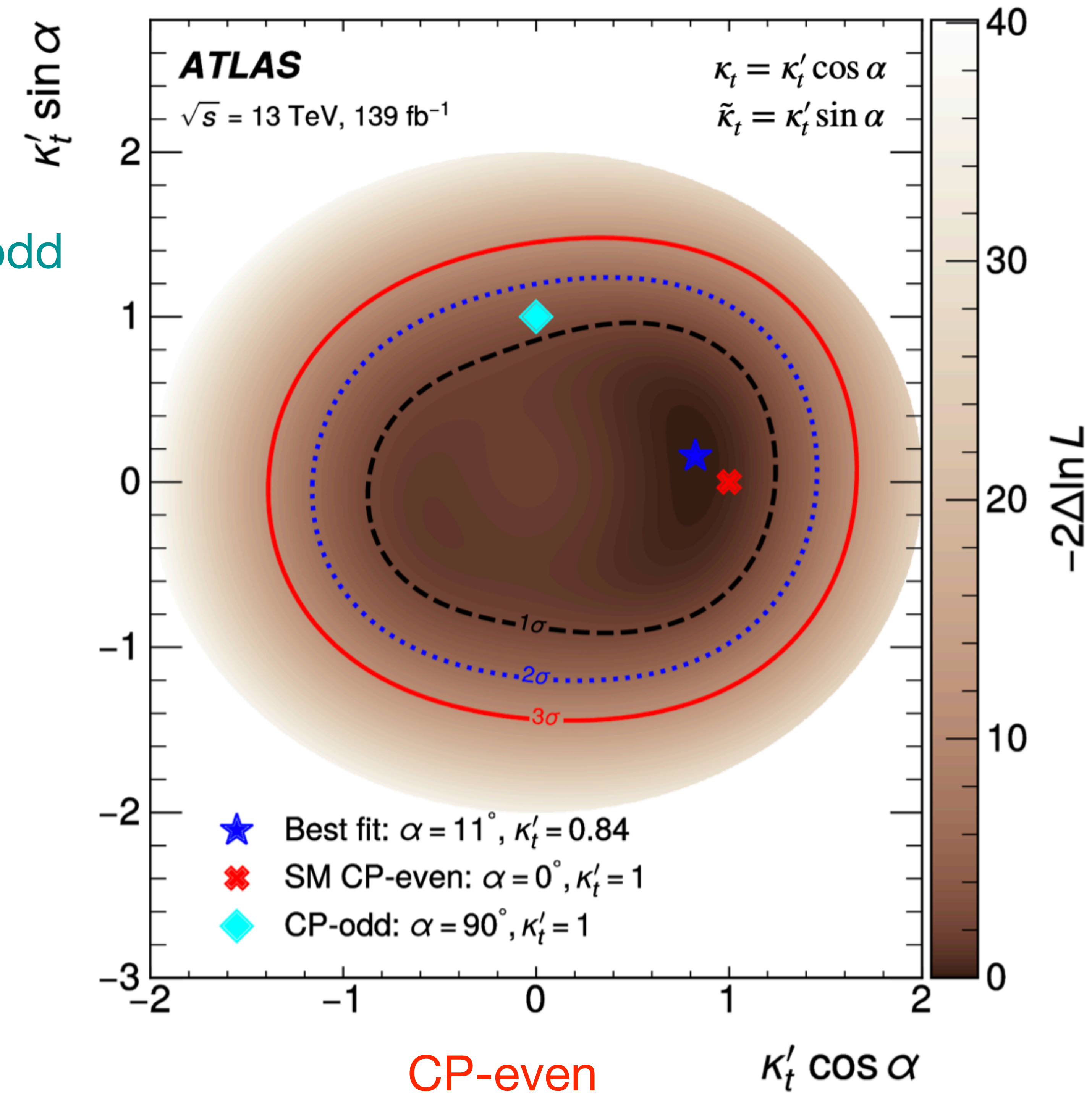
Bound for tHj ~6 times the SM prediction
Bounds on bottom Yukawa (and top)

CP odd couplings Higgs

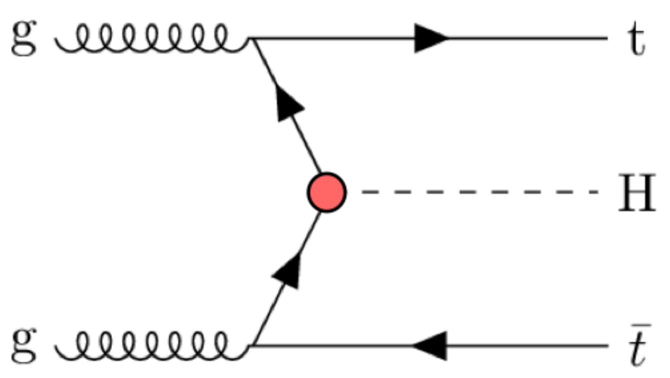
- The SM predicts a CP-even Higgs
- CP-violation needed to explain matter anti-matter asymmetry, motivates searches

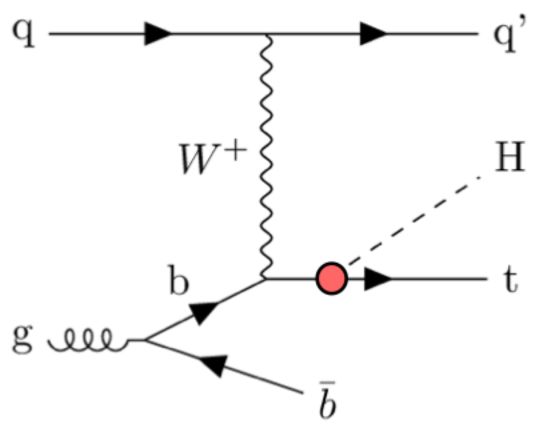
Fermionic couplings

CP-odd



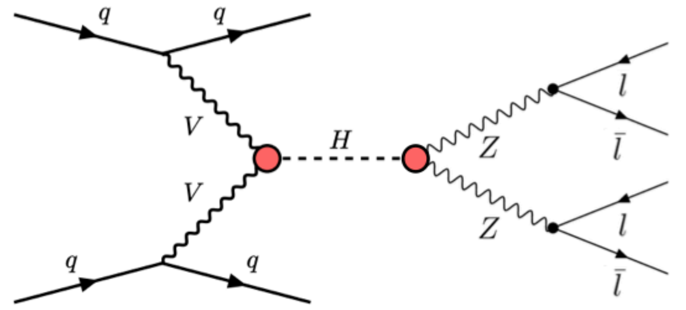
CP-even





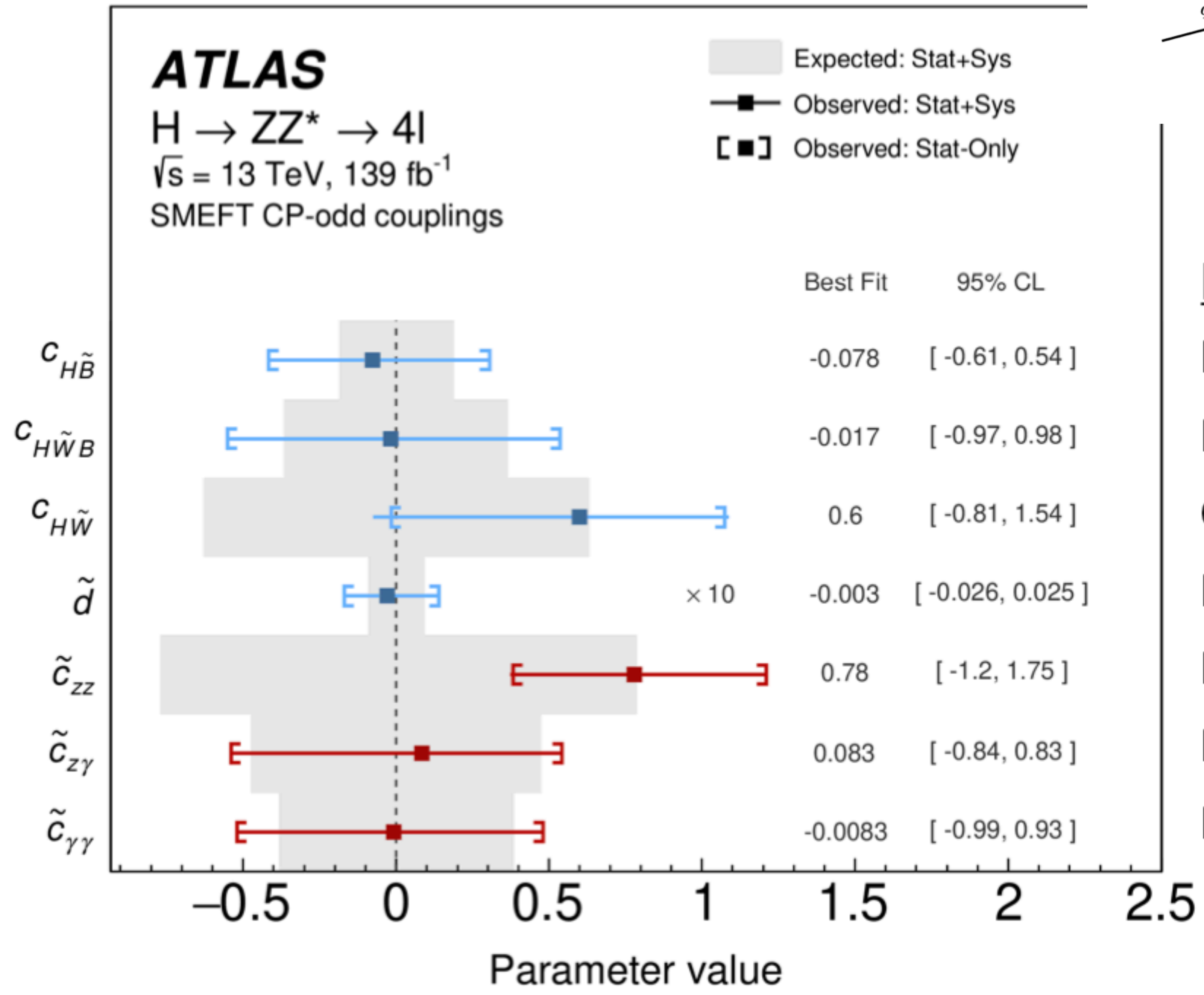
Ht, Htt̄ with H → bb̄

Bosonic couplings



H → ZZ^* → $4l$

SMEFT Coefficients



Fit Type
Decay
Decay
Combined
Decay
Production
Decay
Decay

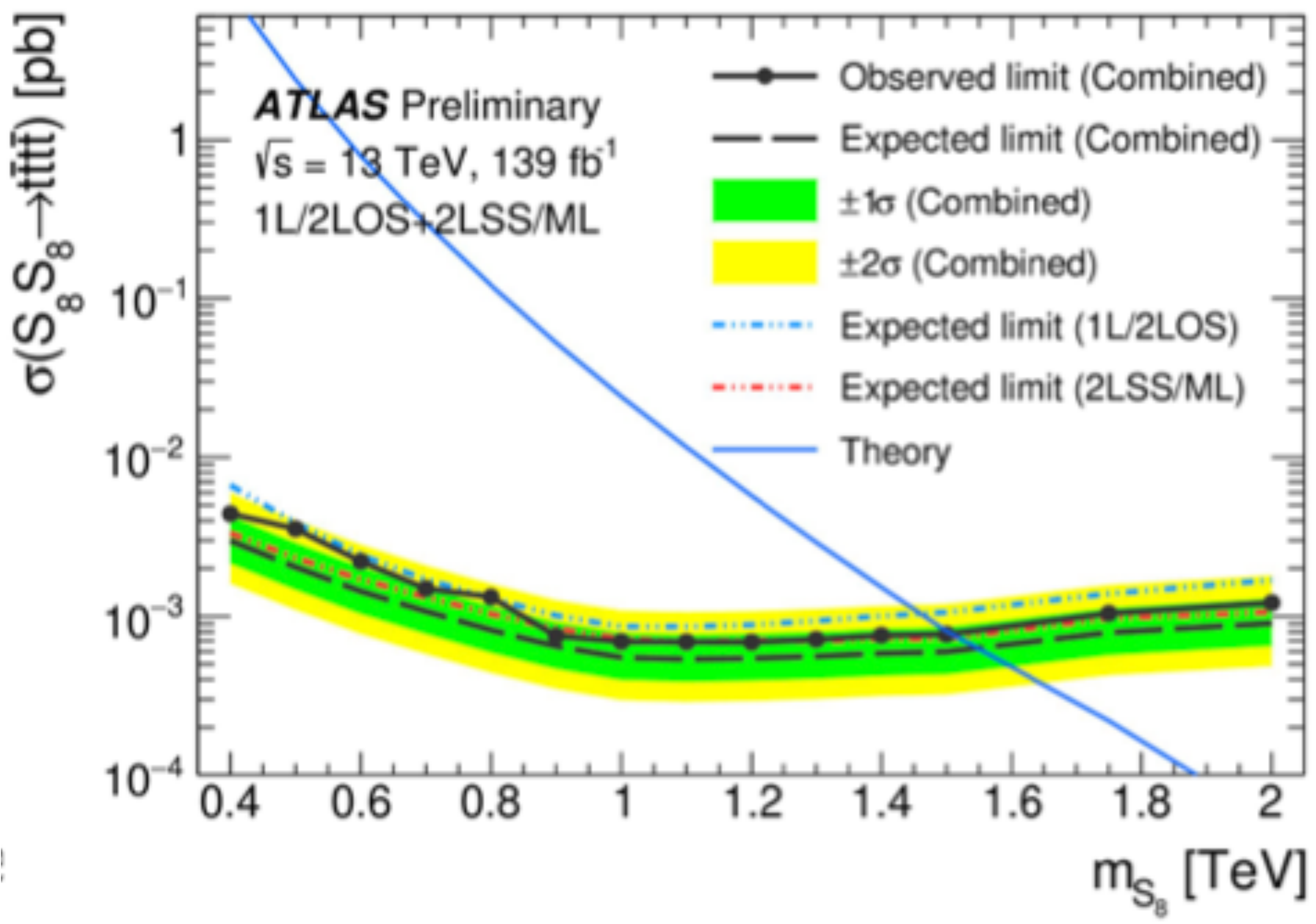
$H \rightarrow ZZ^* \rightarrow 4l$

ATLAS Simen Hellesund

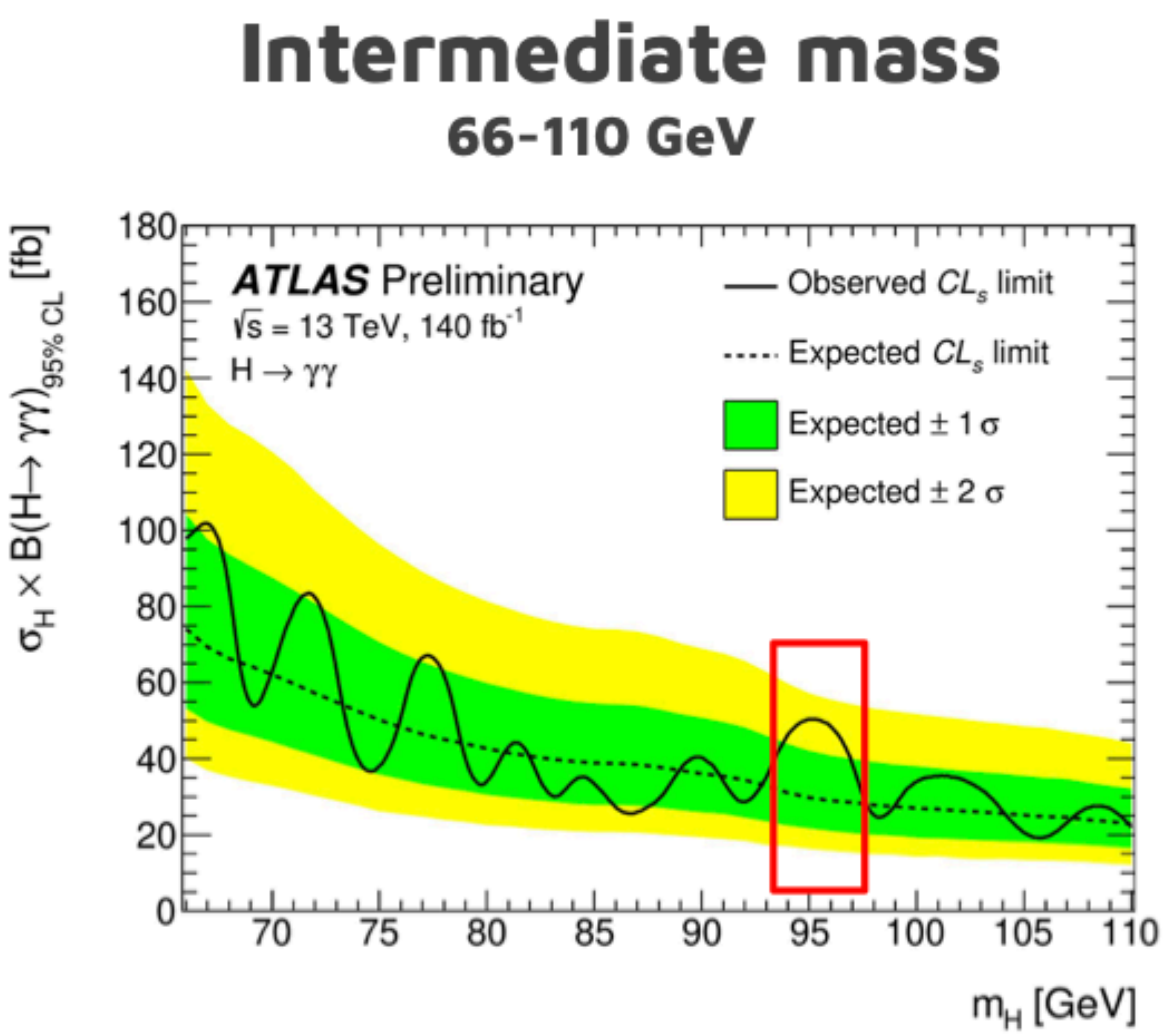
Searching for additional Higgses

- Resonance rearches motivated by various BSM models

Searches for scalar resonances with different masses & different decays



ttH/A to 4tops



Higgs to γγ

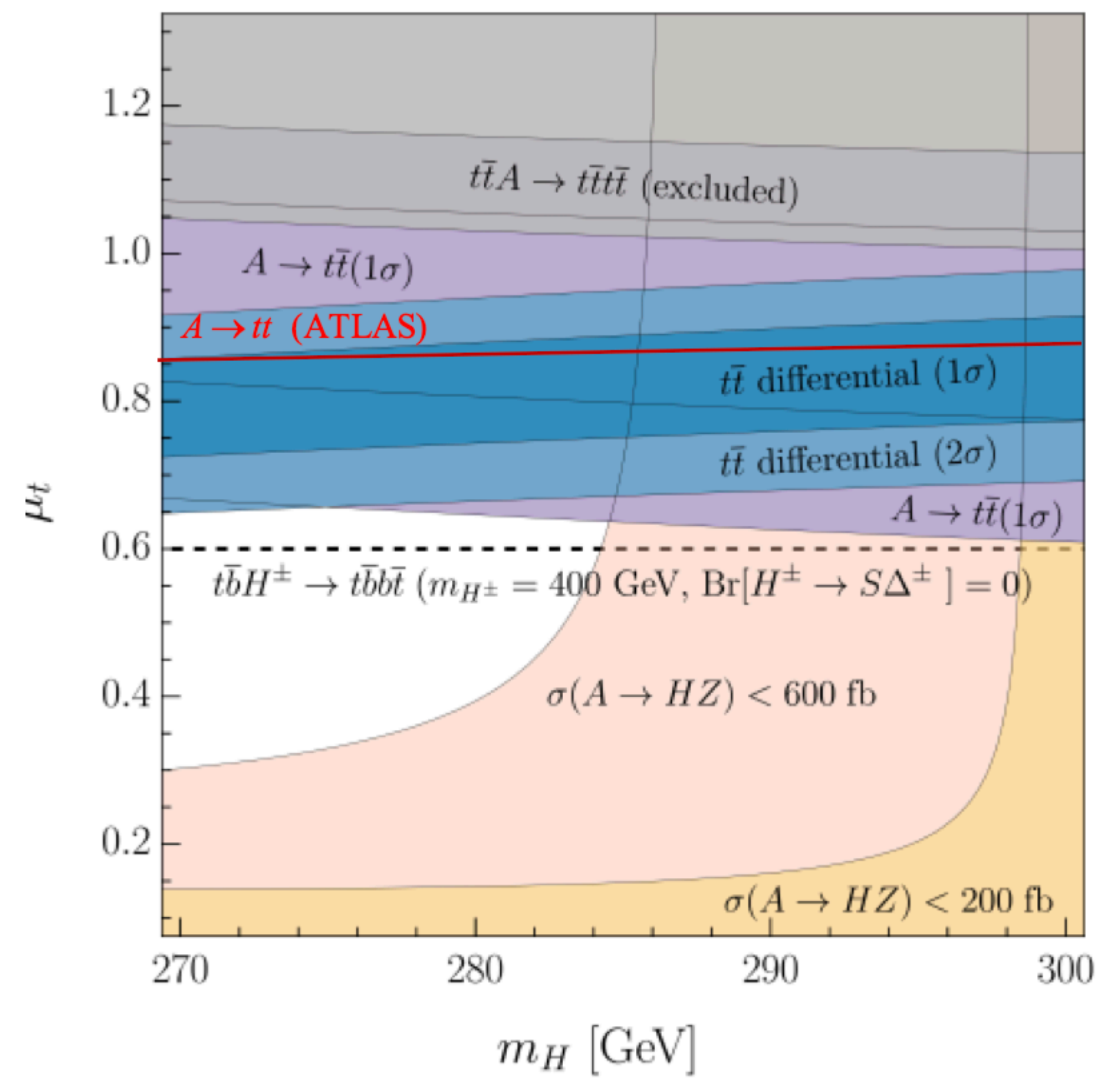
ATLAS Asma Hadel

Δ2HDMS

Field	$SU(2)_L$	$U(1)_Y$
ϕ_s	2	0
ϕ_2	2	1/2
ϕ_1	2	1/2
Δ	3	0

Andreas Crivellin

G. Coloretti, A.C. and B. Mellado, 2312.17314

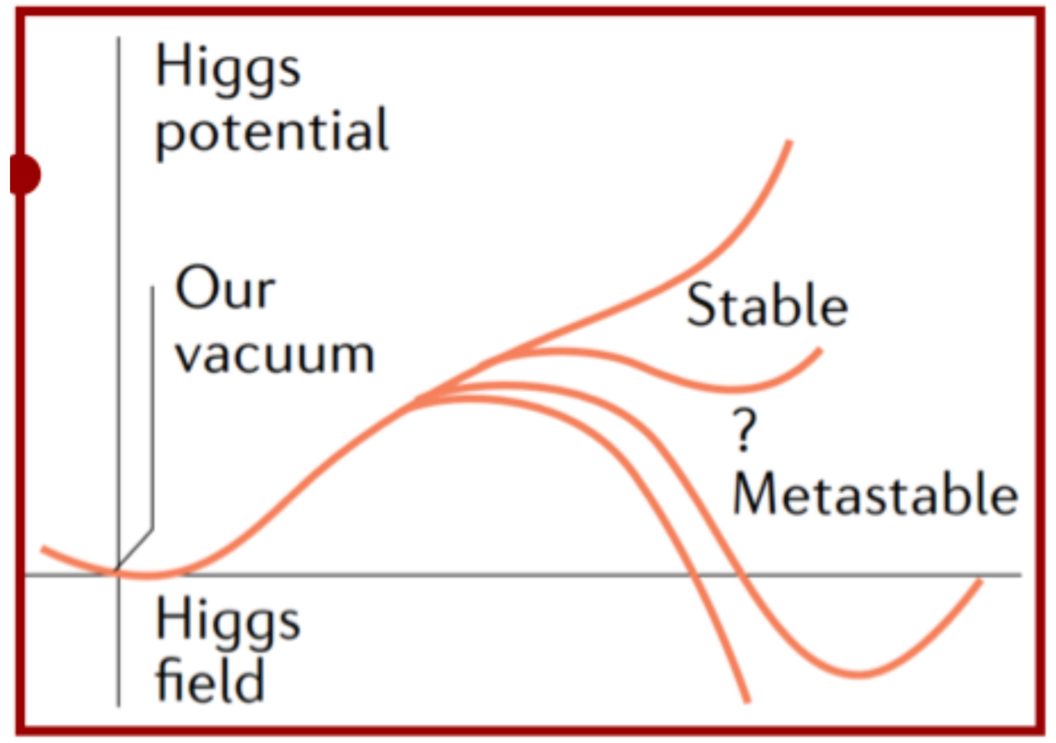


UV model suggested to explain various small excesses in various measurements

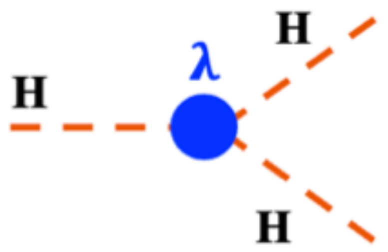
No significant excesses observed but sensitivity continuously improves

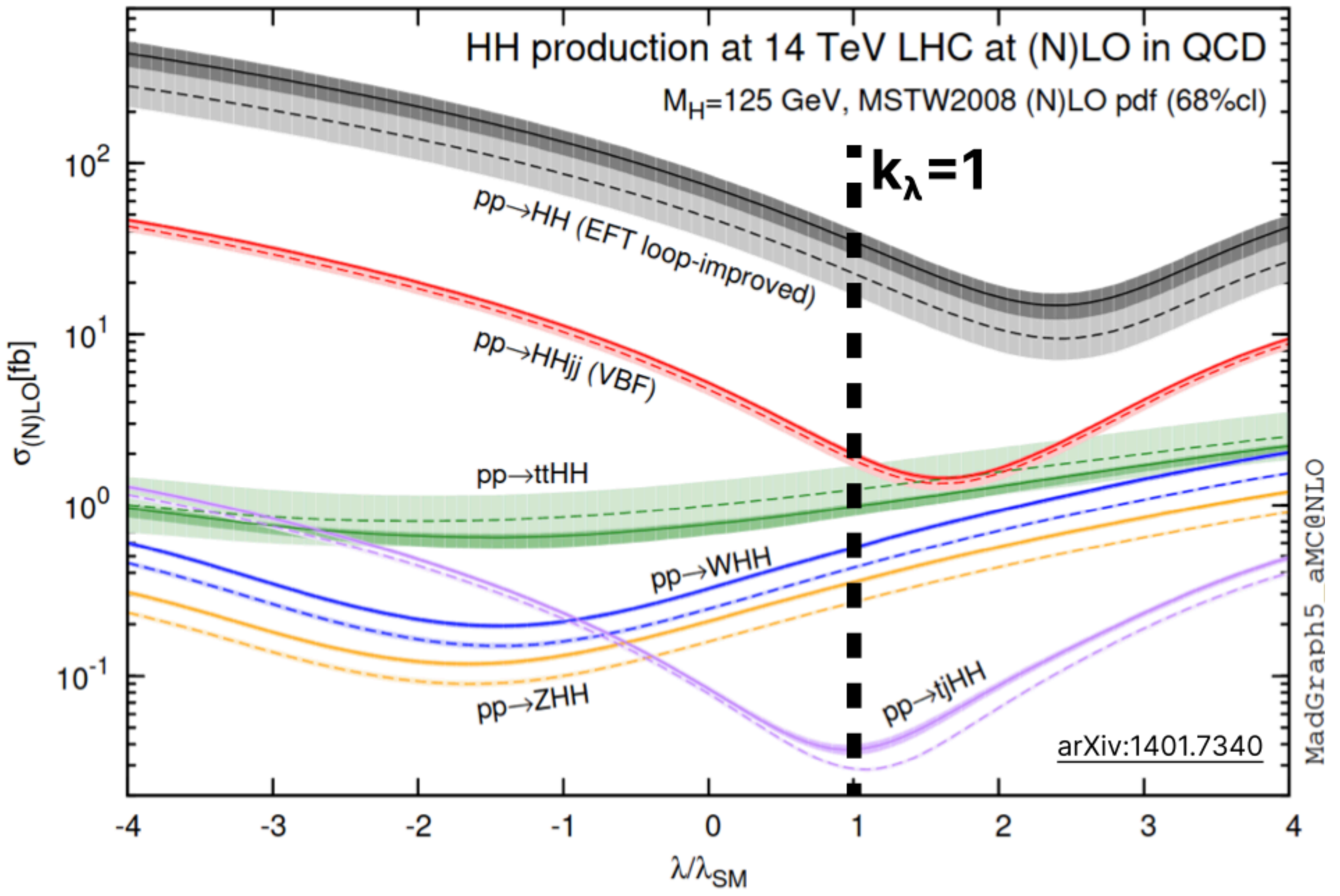
The Higgs potential: Di-Higgs searches

Nature Reviews Physics, volume 3, pages 608–624 (2021)



$$\lambda_{HHH} = \lambda_{HHHH} = \frac{m_H^2}{2v}$$

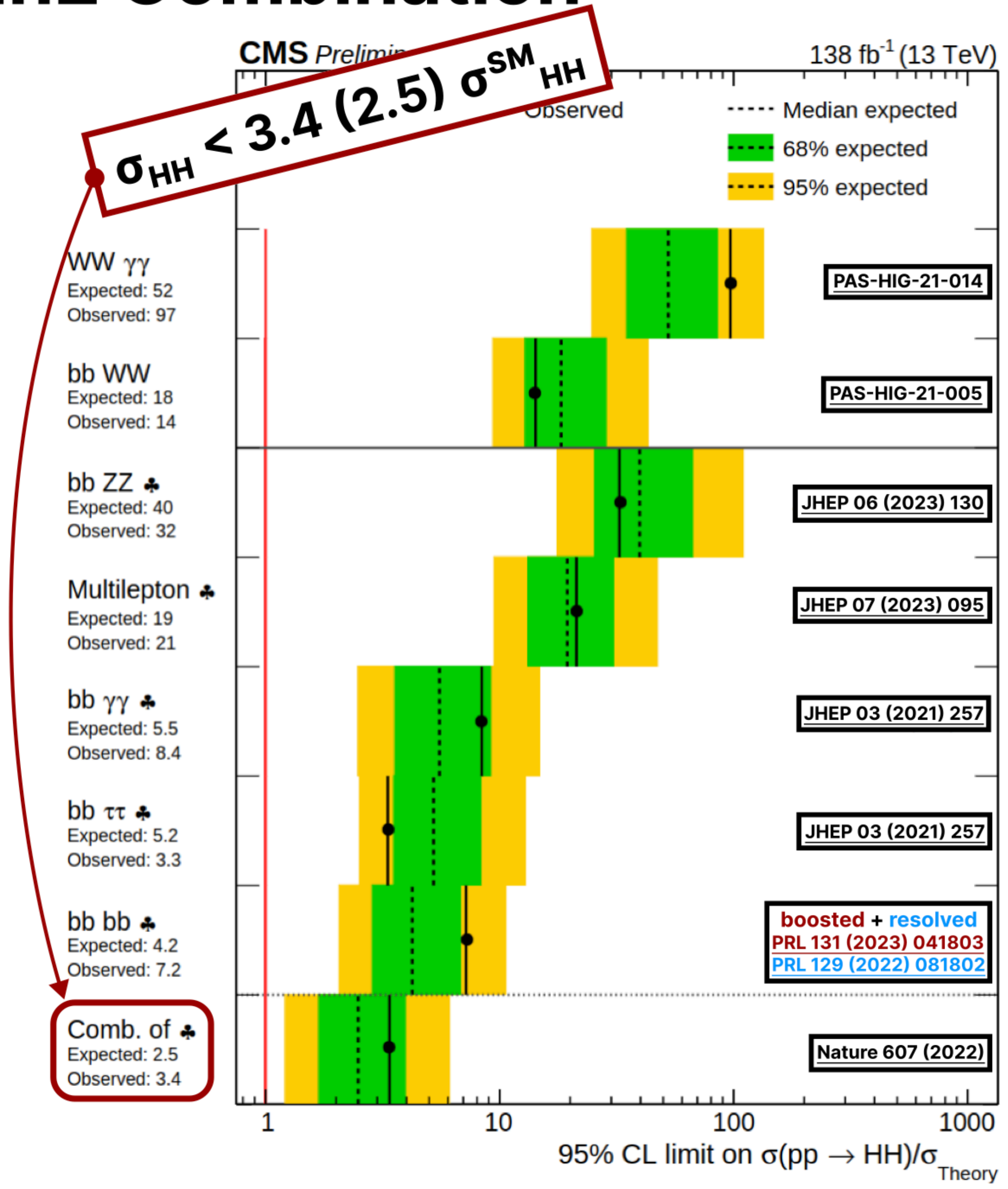




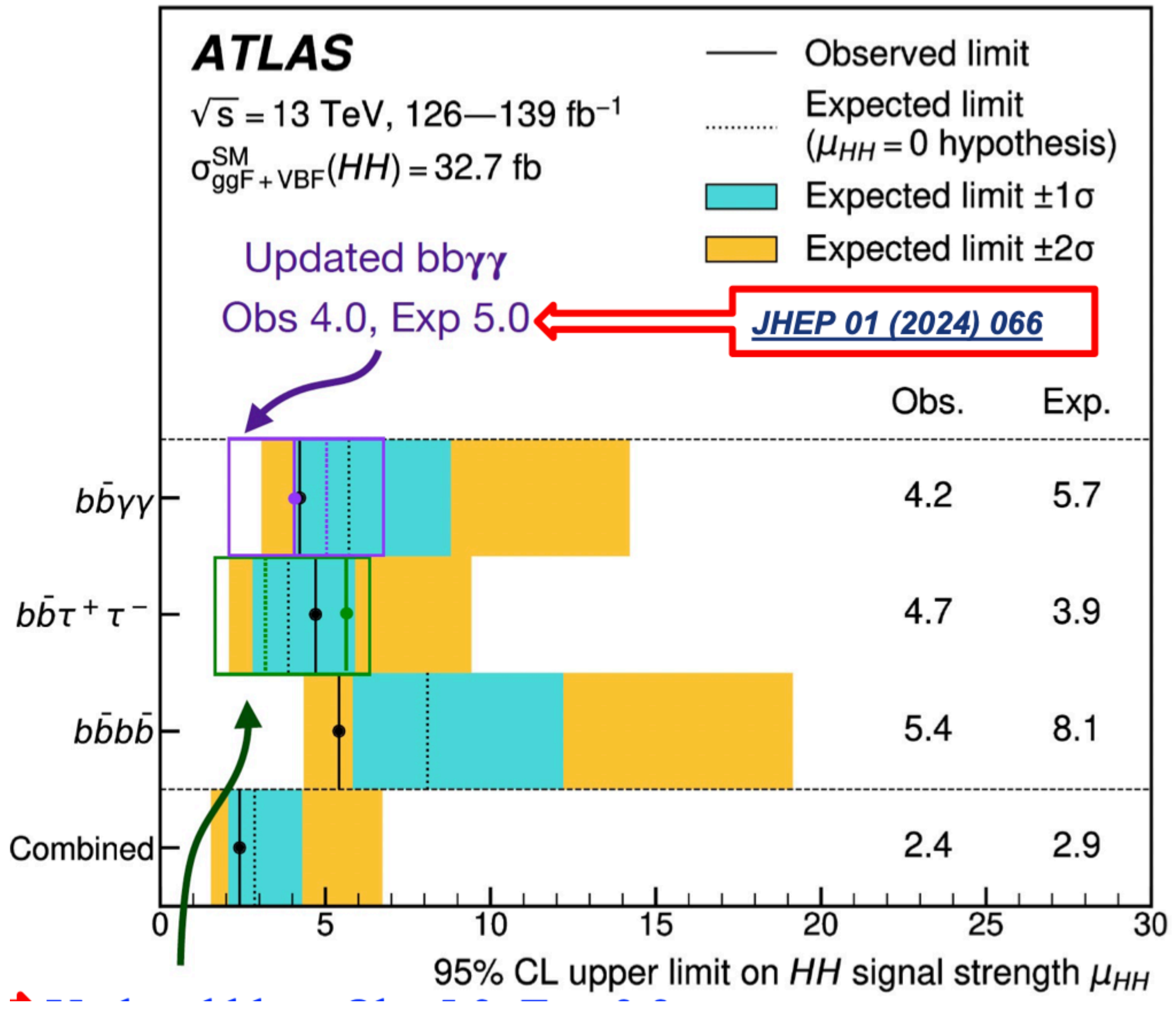
CMS Bruno Alves

ATLAS Ali Shahzad

Run2 Combination



Phys. Lett. B 843 (2023) 137745



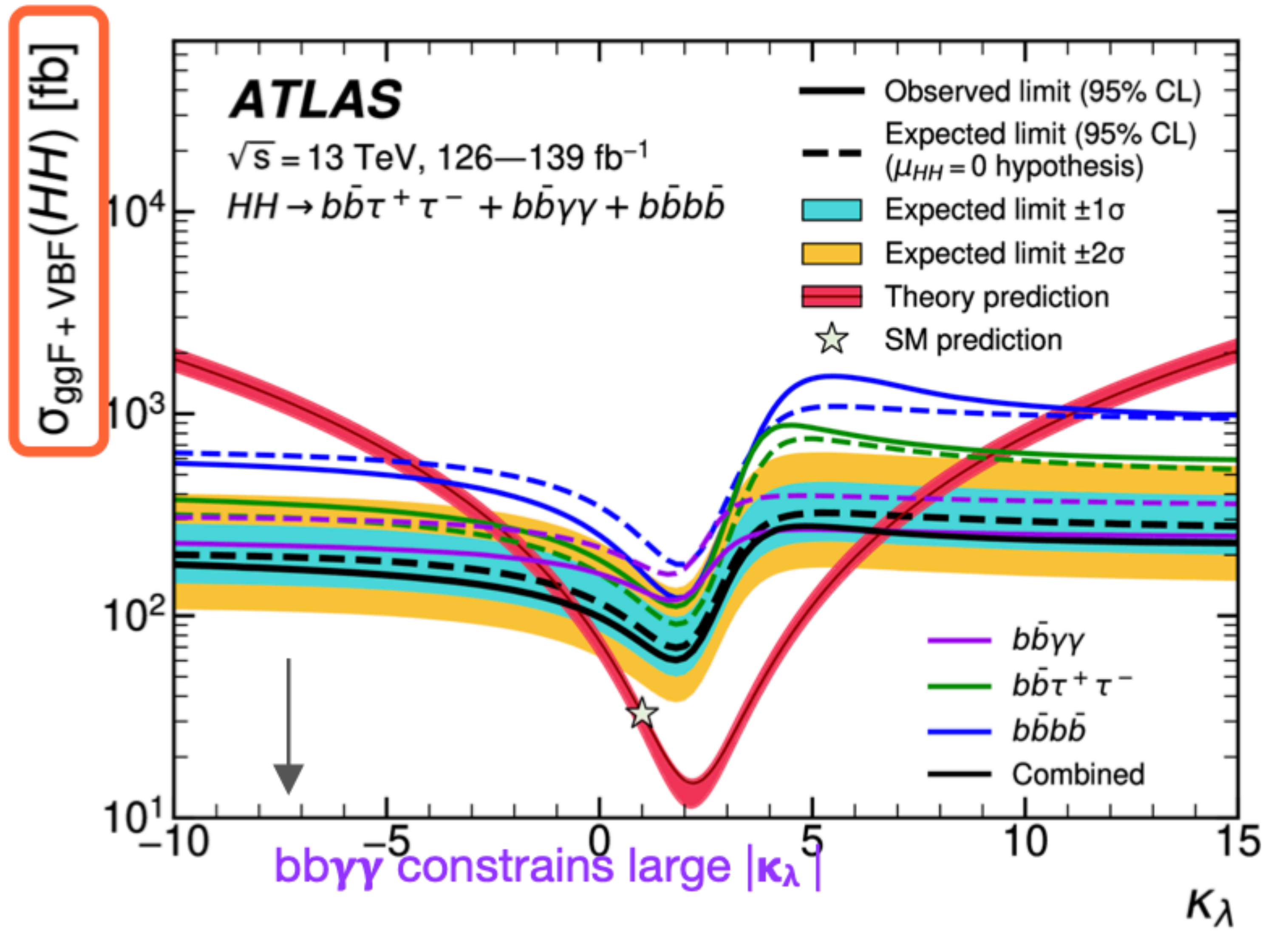
Huge progress in HH cross-section bounds: 2-3 x SM

Significant reduction of systematic uncertainties for 4b channel

HH interpretations

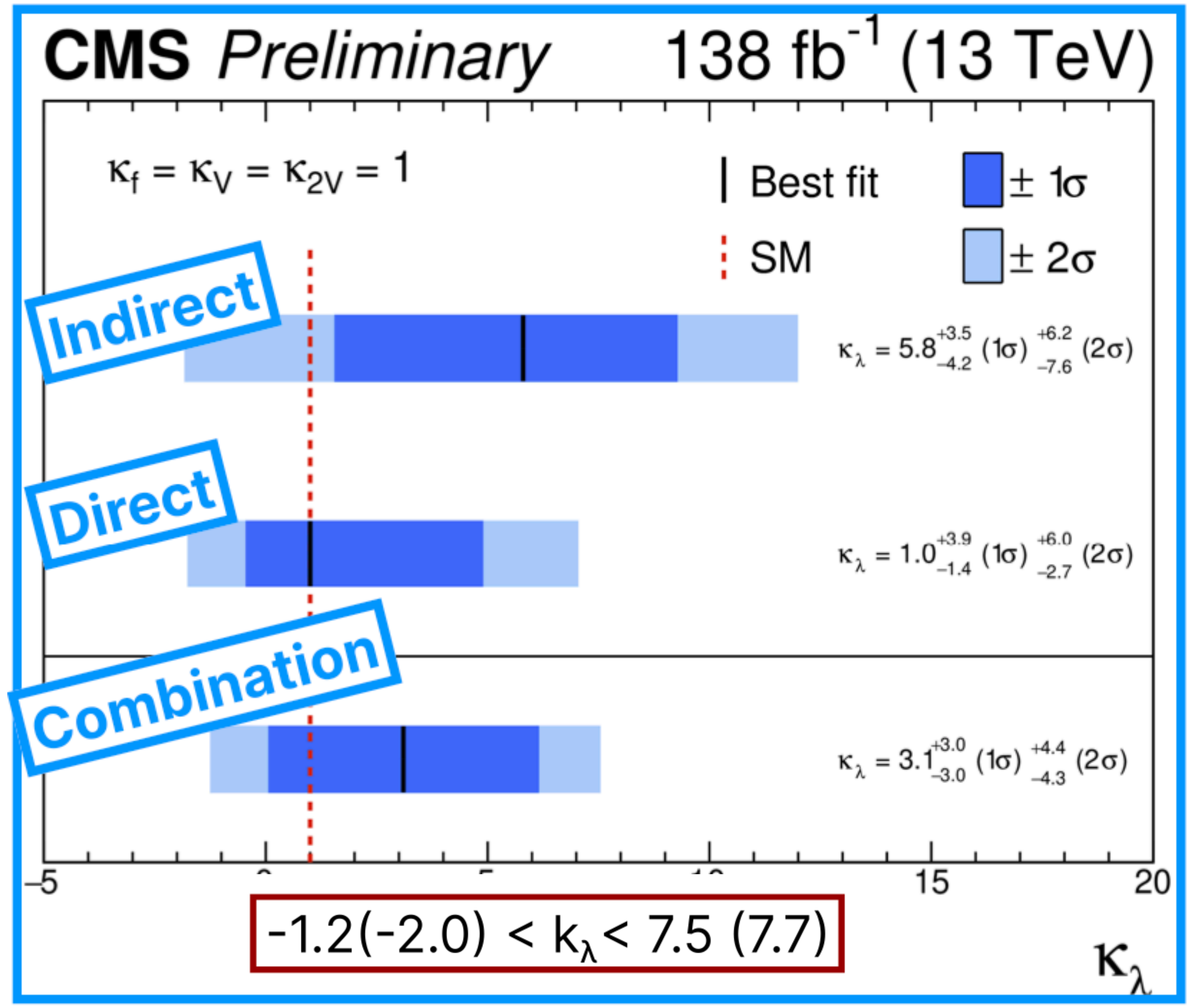
ATLAS Ali Shahzad

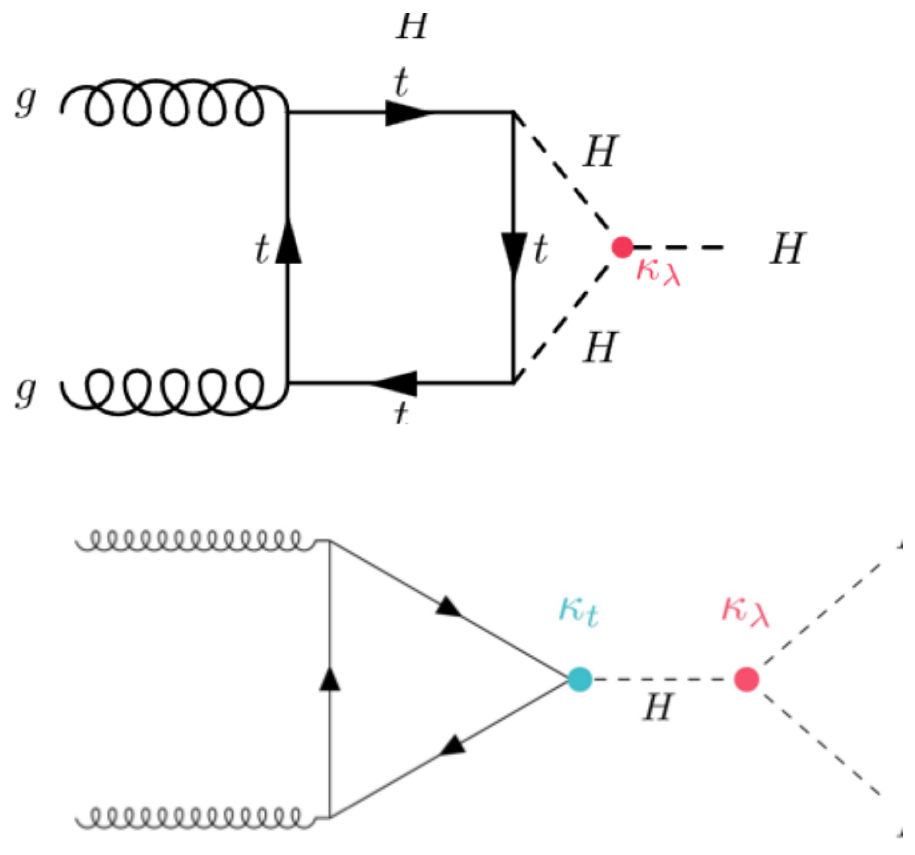
Phys. Lett. B 843 (2023) 137745



Final state	Obs. 95% CL	Exp. 95% CL	Obs. value$^{+1\sigma}_{-1\sigma}$
$HH \to b\bar{b}\gamma\gamma$	$-1.4 < \kappa_\lambda < 6.5$	$-3.2 < \kappa_\lambda < 8.1$	$\kappa_\lambda = 2.8^{+2.0}_{-2.2}$
$HH \to b\bar{b}\tau^+\tau^-$	$-2.7 < \kappa_\lambda < 9.5$	$-3.1 < \kappa_\lambda < 10.2$	$\kappa_\lambda = 1.5^{+5.9}_{-2.5}$
$HH \to b\bar{b}b\bar{b}$	$-3.3 < \kappa_\lambda < 11.4$	$-5.2 < \kappa_\lambda < 11.6$	$\kappa_\lambda = 6.2^{+3.0}_{-5.2}$
HH combination	$-0.6 < \kappa_\lambda < 6.6$	$-2.1 < \kappa_\lambda < 7.8$	$\kappa_\lambda = 3.1^{+1.9}_{-2.0}$

CMS Bruno Alves





HL-LHC

Uncertainty scenario	κ_λ 68% CI	κ_λ 95% CI
No syst. unc.	[0.7, 1.4]	[0.3, 1.9]
Baseline	[0.5, 1.6]	[0.0, 2.5]
Theoretical unc. halved	[0.3, 2.2]	[−0.3, 5.5]
Run 2 syst. unc.	[0.1, 2.4]	[−0.6, 5.6]

Pinning down κ_λ is tough, better prospects at HL-LHC:

Note: k_{2V} =0 excluded at more than 5σ by both experiments

No golden channel: Combinations are needed, significant efforts in all decay channels

$\sin\theta_W$

Diboson

Differential distributions

Triboson

EW physics

TGCs

VBS

Polarisation

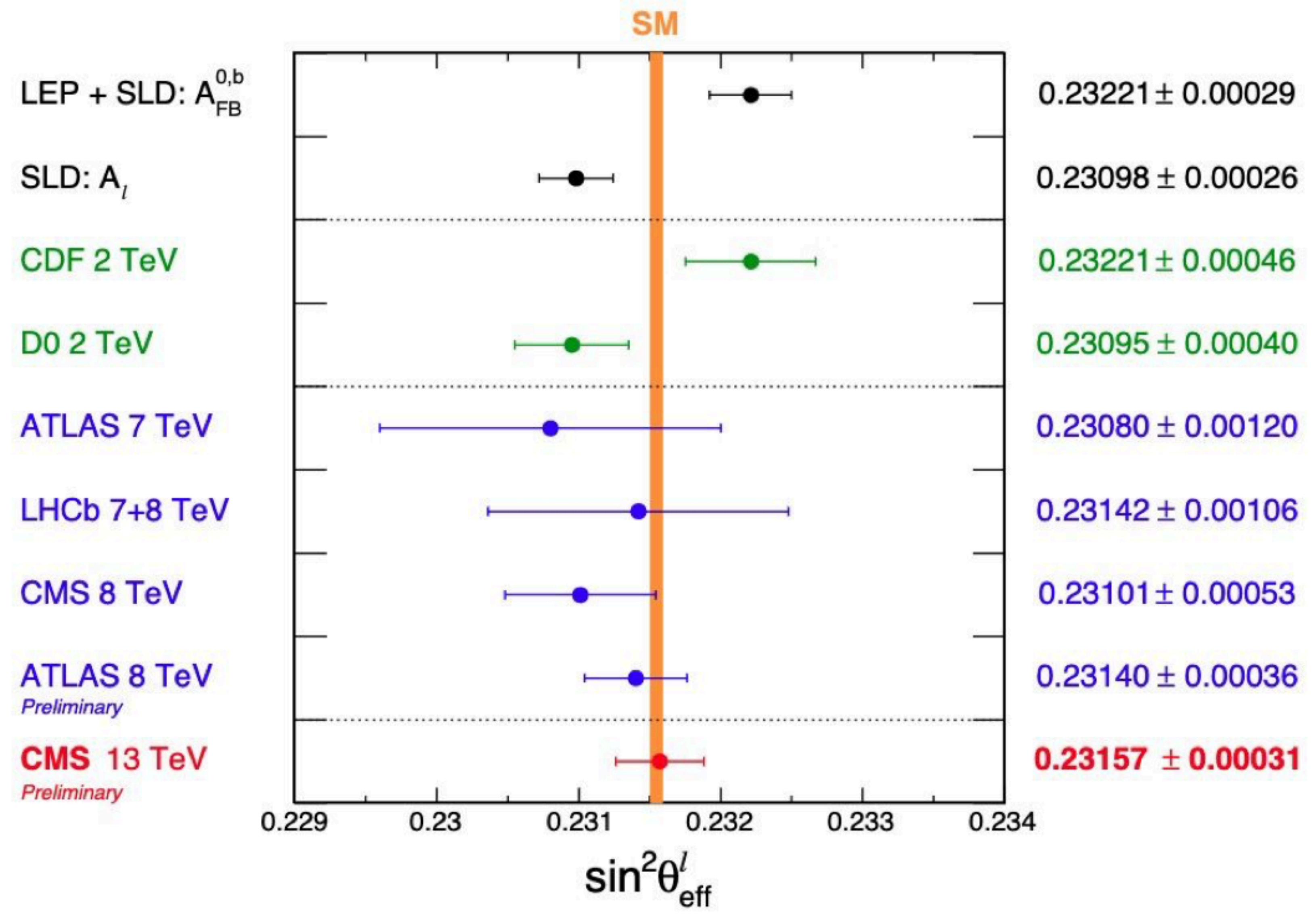
Peripheral collisions

EW precision measurements

The LHC as a precision machine!

Example1: $\sin^2\theta^l_{eff}$

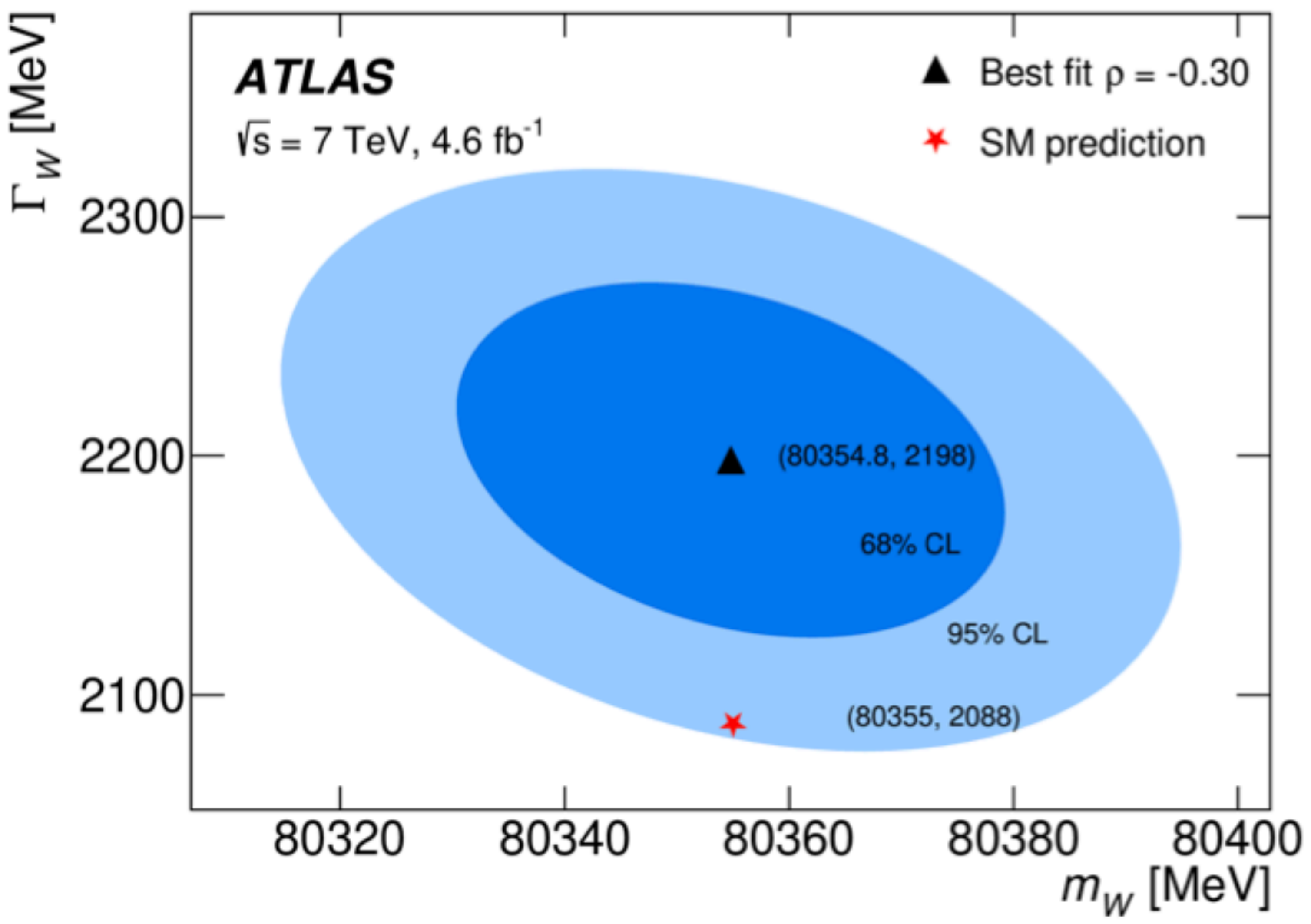
$$\frac{d\sigma}{d(\cos\theta^*)} \propto 1 + \cos^2\theta^* + A_4\cos\theta^* \quad \Rightarrow \quad A_{FB} = \frac{3}{8}A_4 = \frac{\sigma_F - \sigma_B}{\sigma_F + \sigma_B}$$

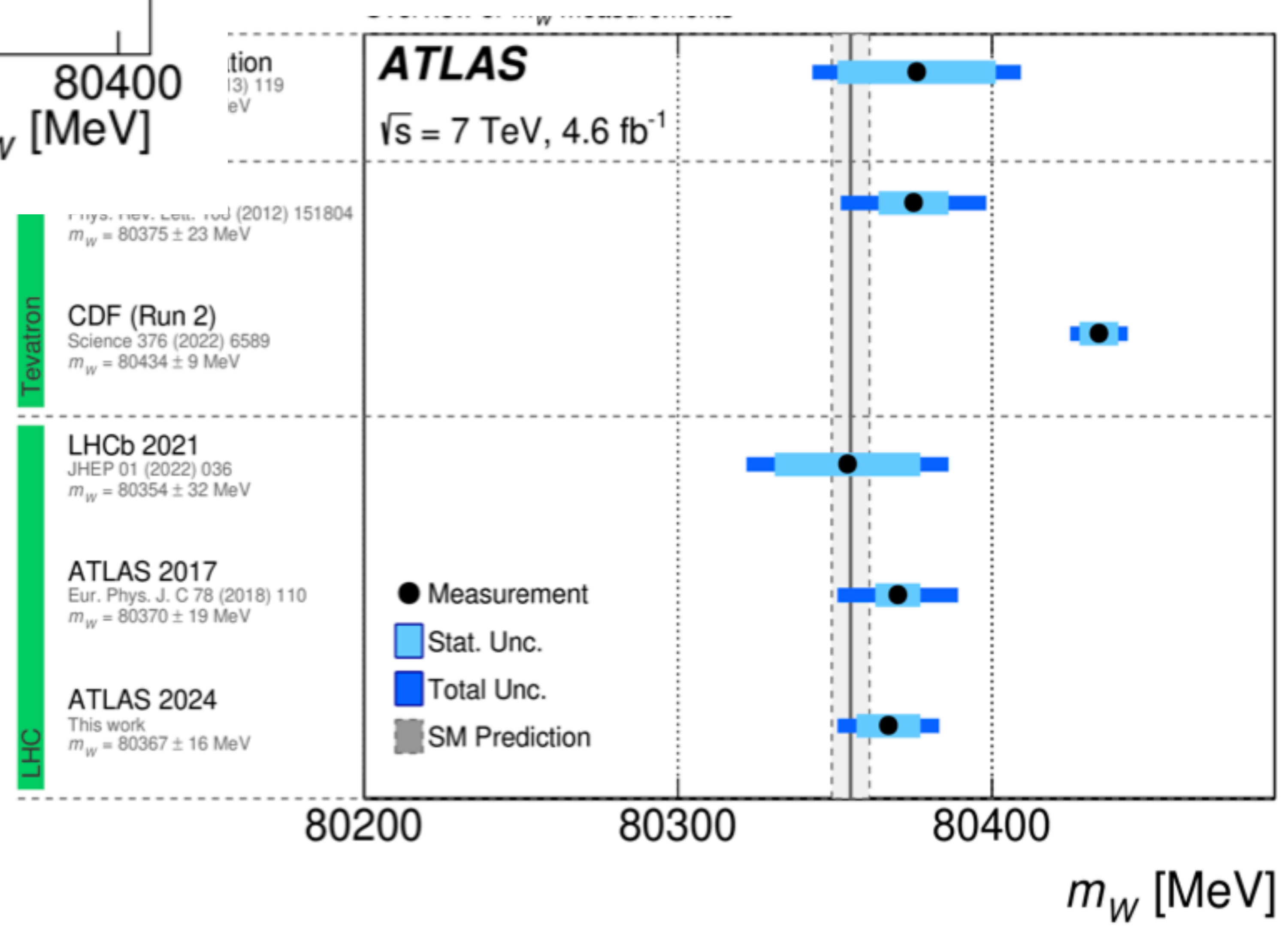


Good agreement with SM and previous measurement
Dominated by PDF uncertainties
Most precise measurement at hadron collider!

Mario Pelliccioni

Example2: m_W & Γ_W (first ATLAS measurement)



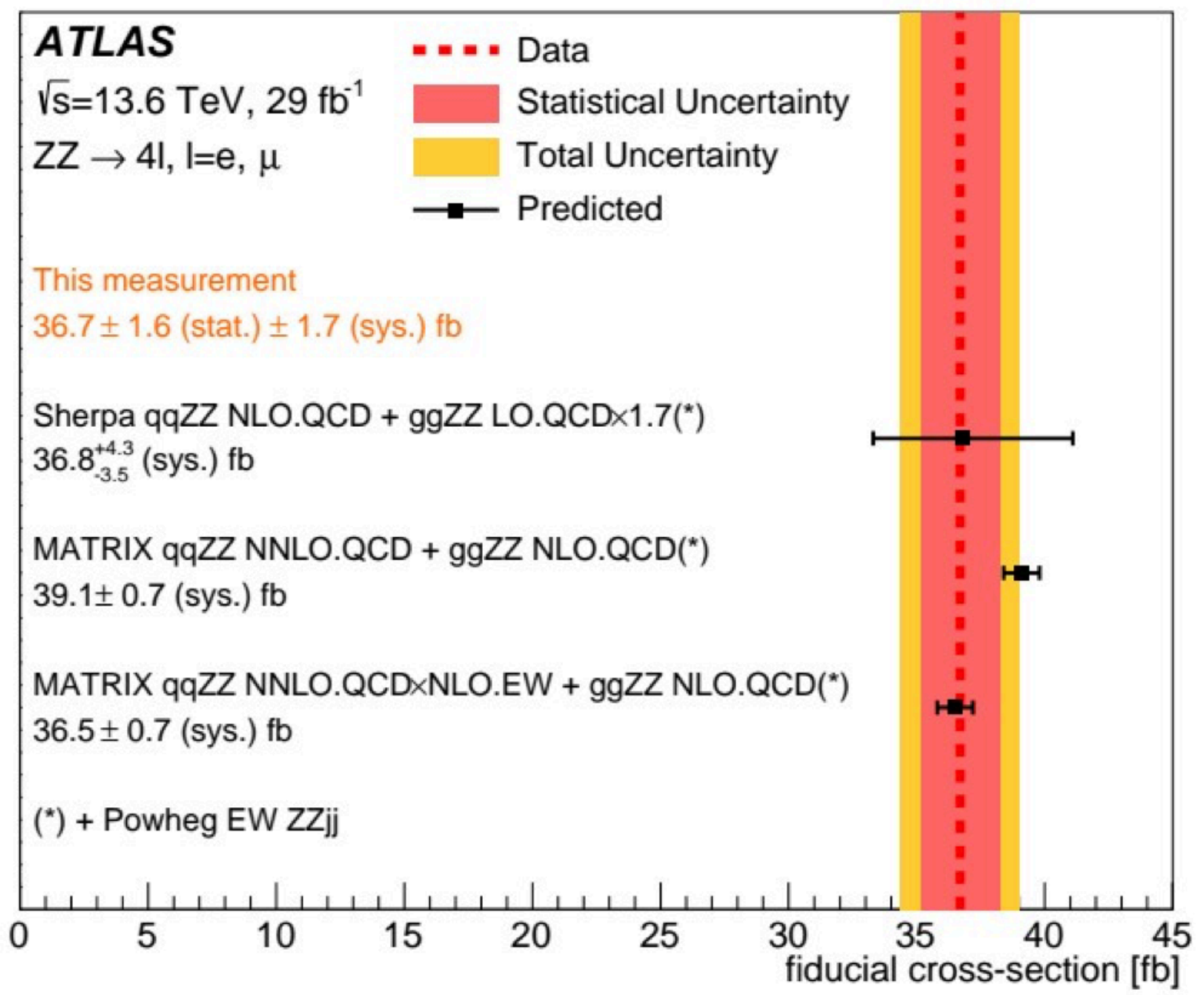


Andres Pinto

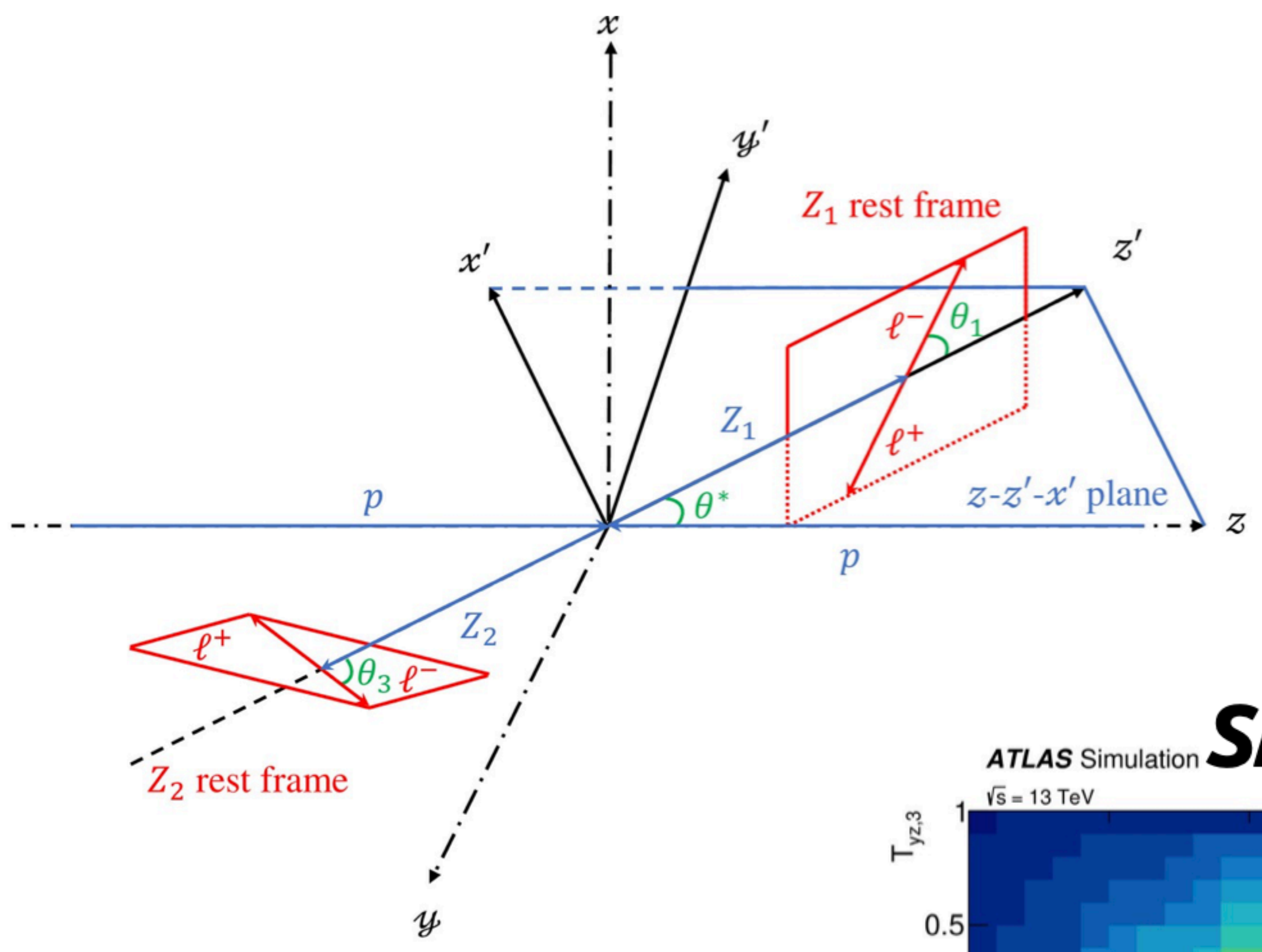
Diboson production and polarisation

ATLAS

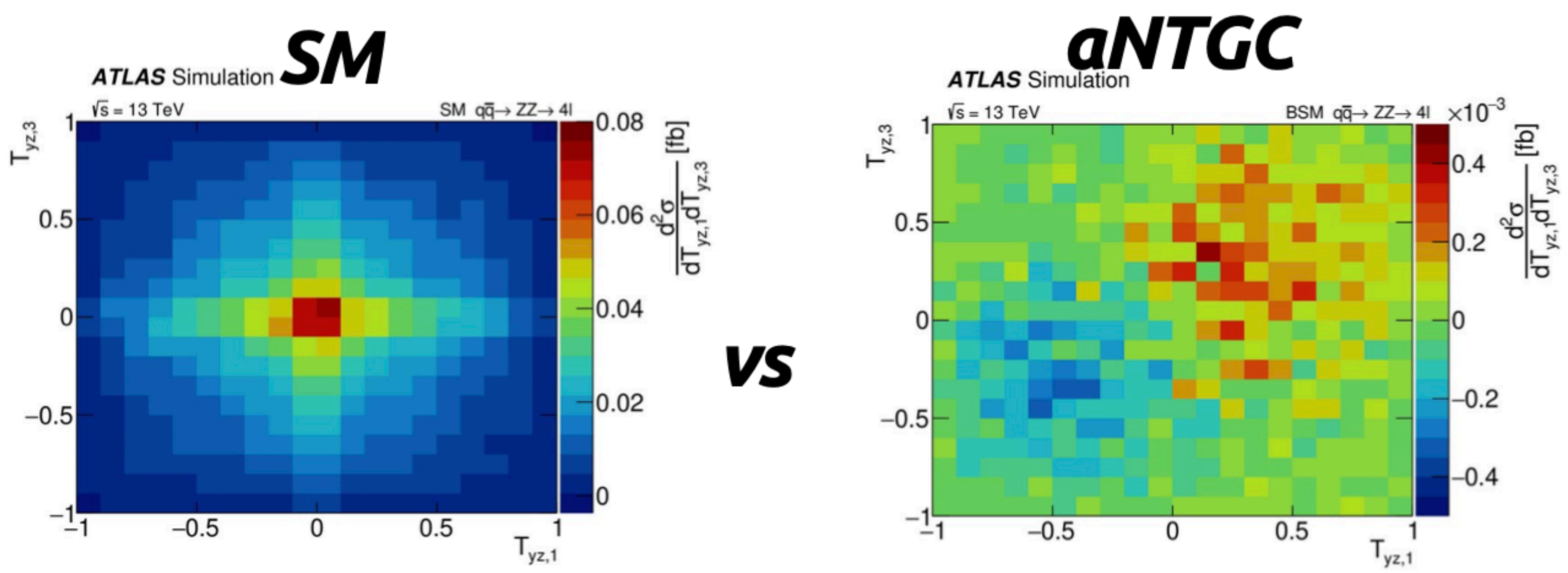
- Diboson measurements probe the EW structure of the SM
- Detailed studies of polarisation in ZZ and WZ final states also differentially



ZZ→ 4l decay channel
First Run 3 measurement
Agreement with higher order SM computations



	Measurement	
	$100 < p_T^Z \leq 200$ GeV	$p_T^Z > 200$ 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_{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_{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_{00} obs (exp) sig.	5.2 (4.3) σ	1.6 (2.5) σ



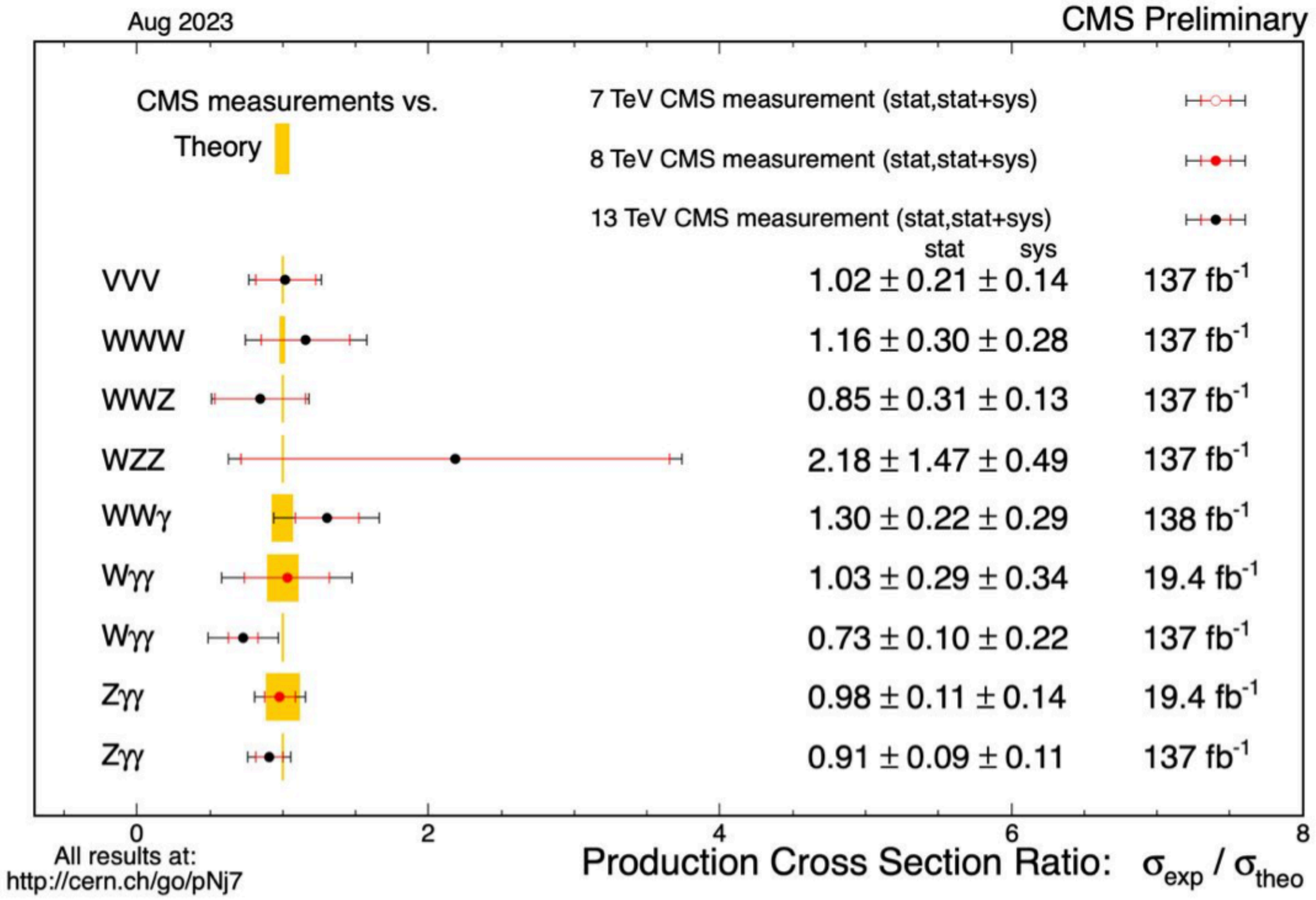
Luka Selem

Angular distributions also discriminating SM from aNTGC (CP-odd)

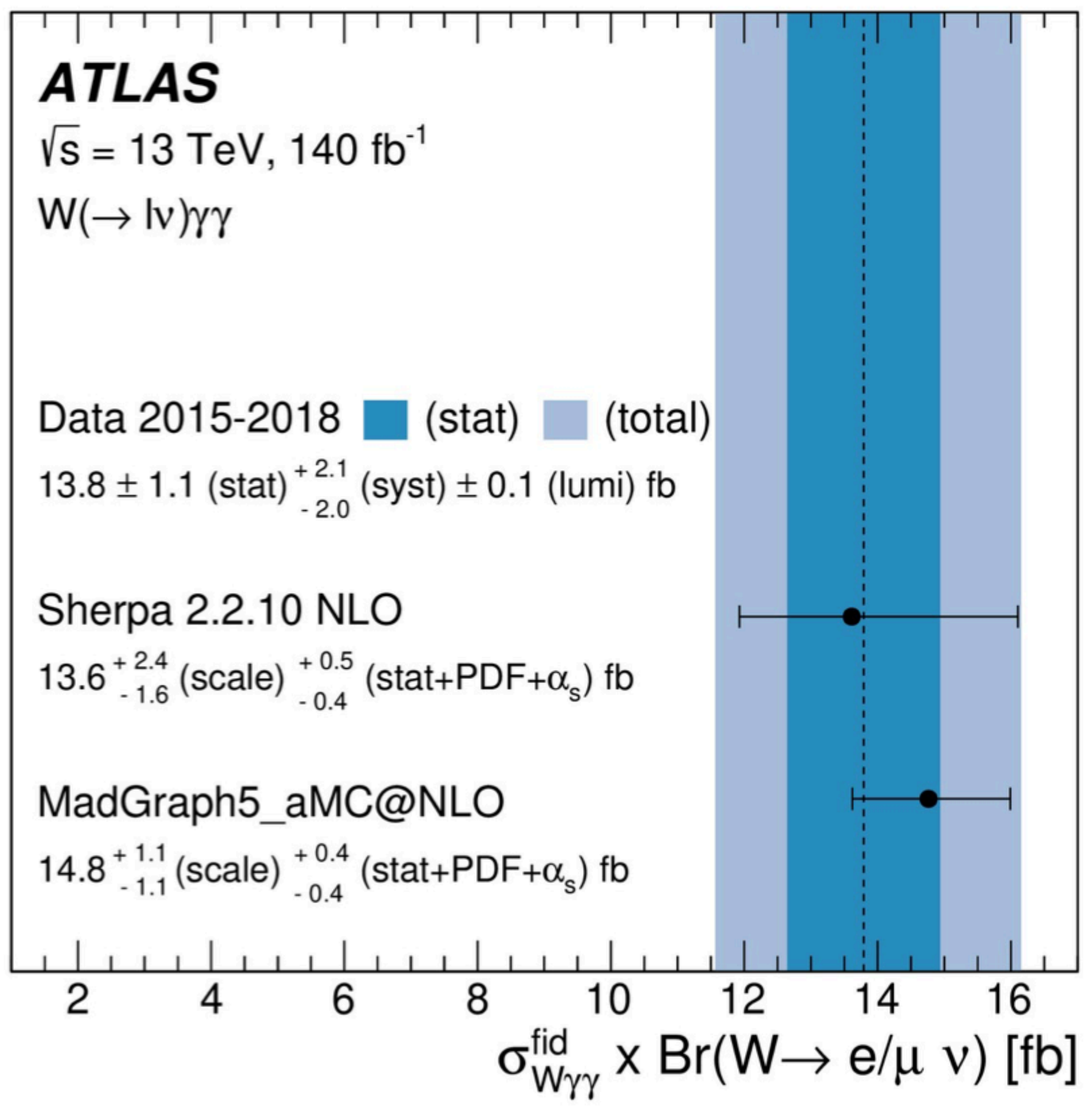
Triboson production at the LHC

- The more bosons the better!
- TGCs, QGCs, high threshold processes, great for BSM searches also
- Several processes measured, several channels will benefit from better statistics in Run III

CMS Tarricone Cristiano



ATLAS

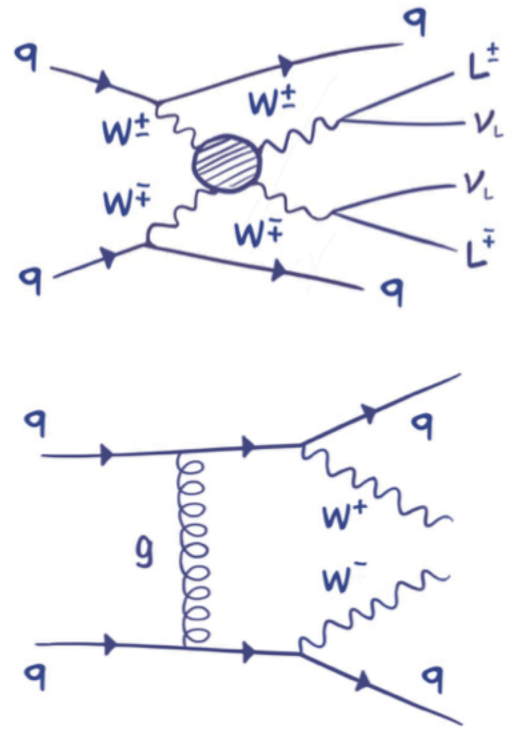


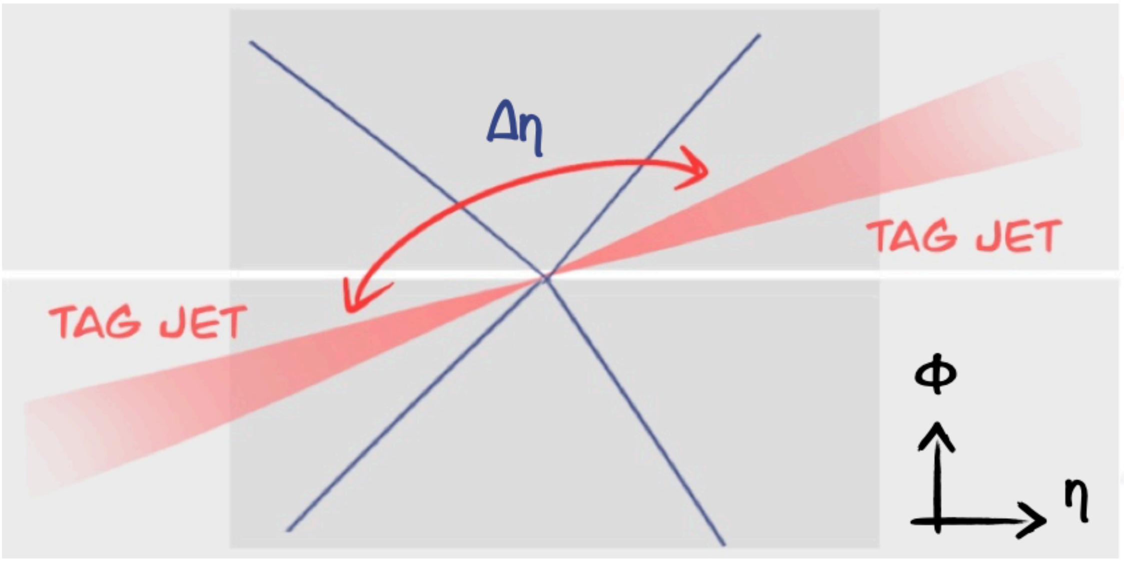
Luka Selem

WZγ observation $\sigma_{WZ\gamma}^{Fid} = 2.01 \pm 0.30$ (stat.) ± 0.16 (syst.)

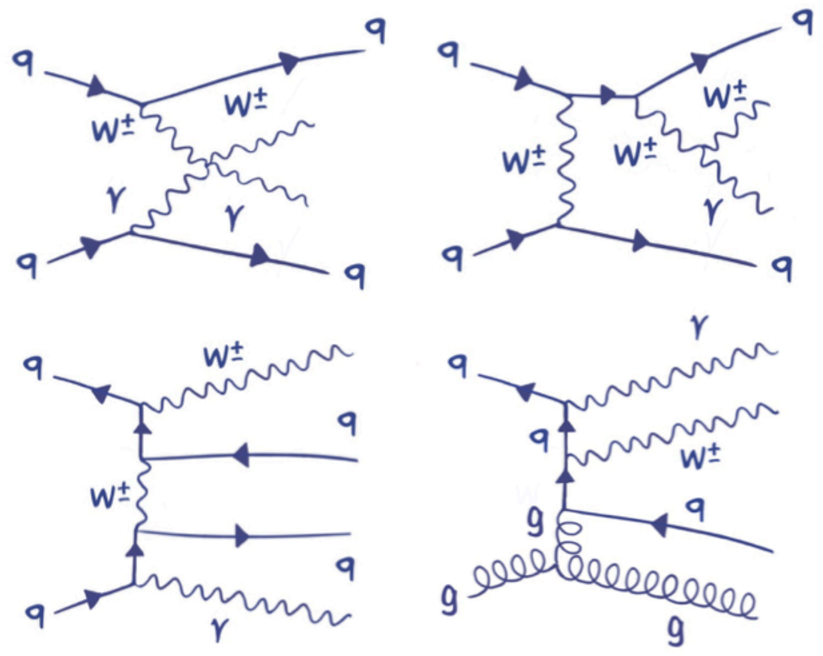
VBS@LHC

- VBS crucial for understanding EWSB
- Access to triple and quartic gauge couplings
- Tough processes to measure, but also lots of different channels





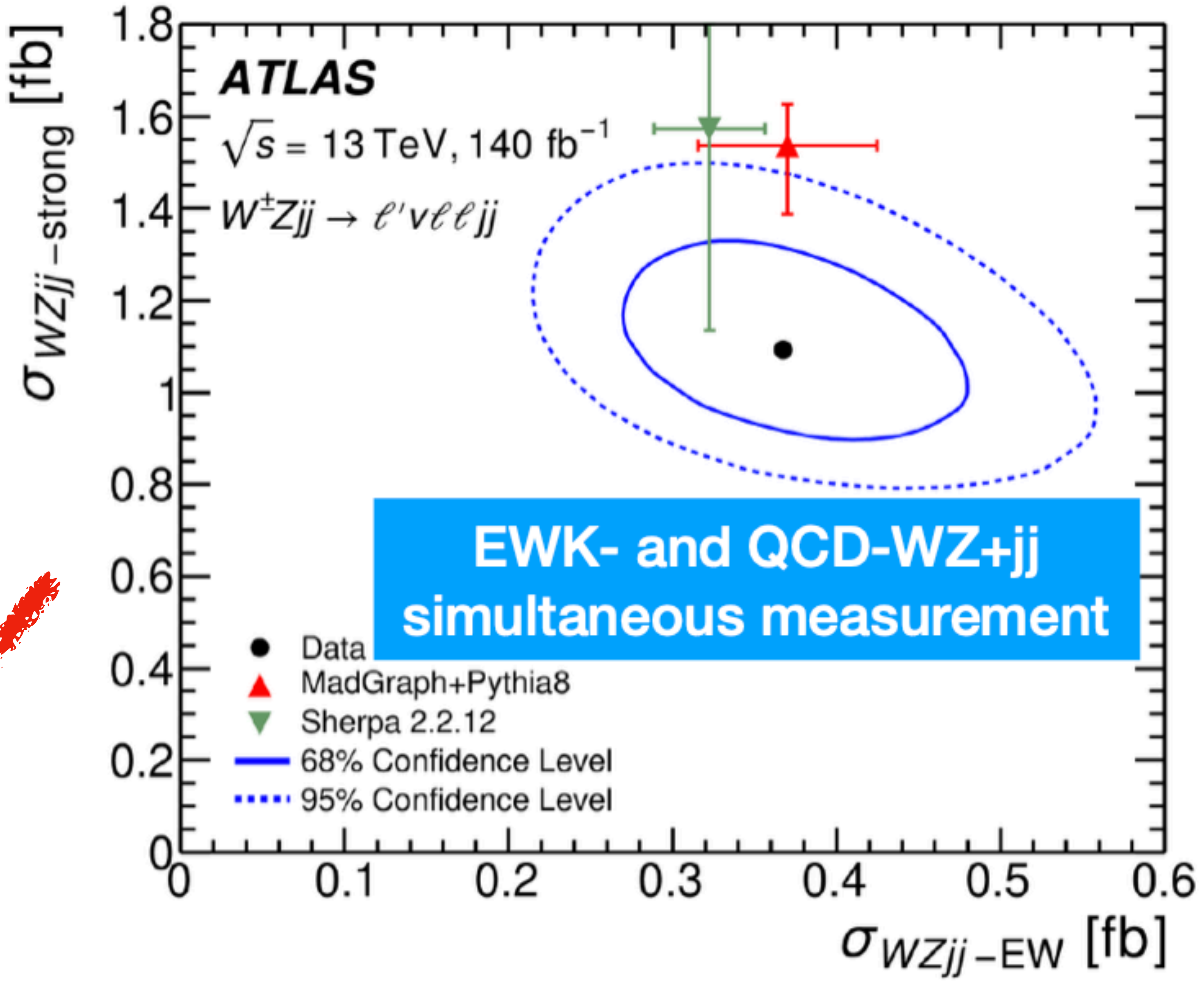
Opposite sign WW VBS: $\sigma_{obs} = 10.2 \pm 2.0$ **fb** $\sigma_{exp} = 9.1 \pm 0.6$ **(scale) fb**

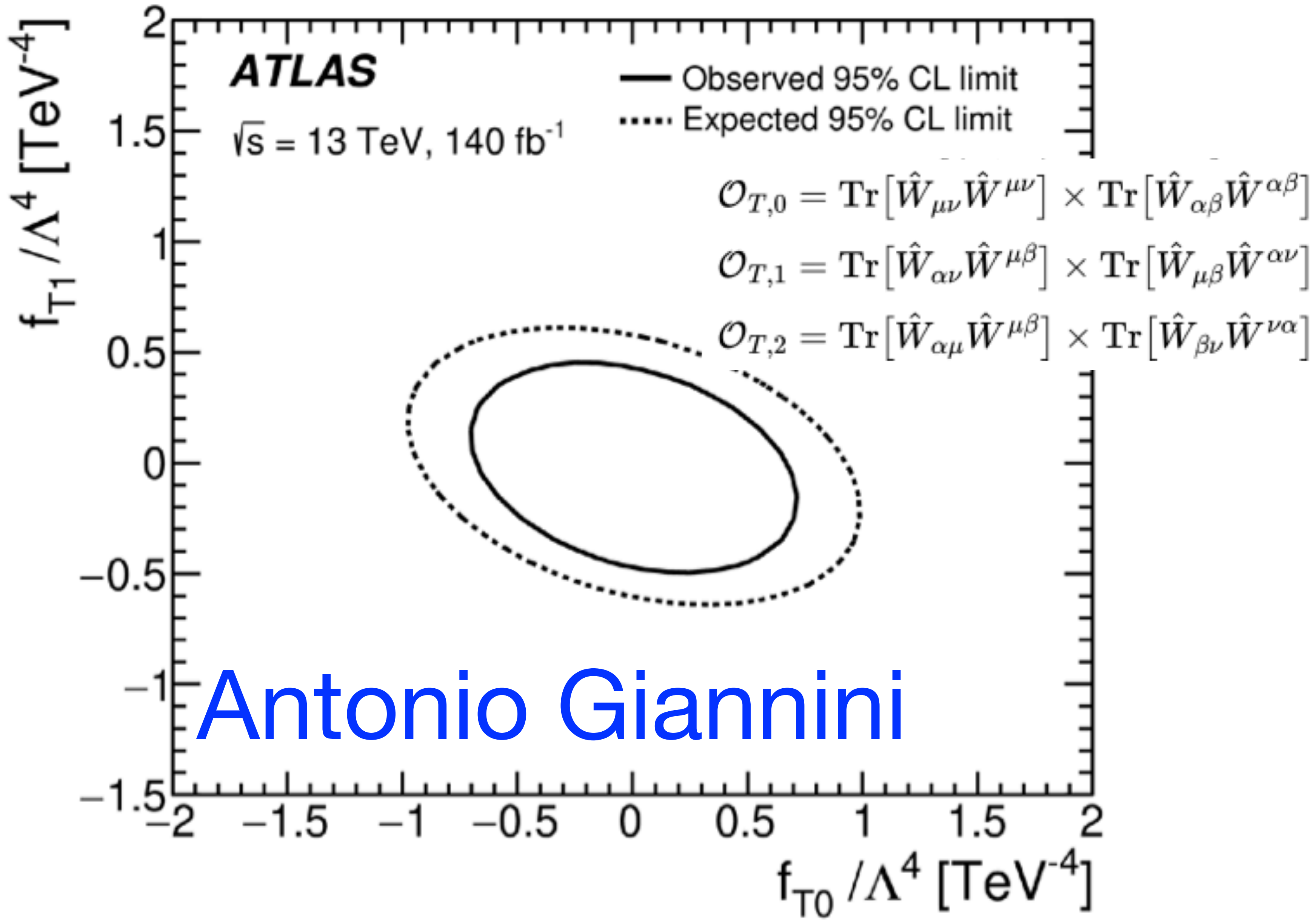


CMS

Signal	$\mu = \sigma_{OBS}/\sigma_{SM}$	Cross Section [fb]
EWK Wγ	$0.88^{+0.19}_{-0.18}$	$23.5 \pm 2.8(\text{stat})^{+1.9}_{-1.7}(\text{th})^{+3.5}_{-3.4}(\text{stat})$
EWK+QCD Wγ	$0.98^{+0.12}_{-0.11}$	$113 \pm 2.0(\text{stat})^{+2.5}_{-2.3}(\text{th})^{+13}_{-13}(\text{stat})$

Costanza Carrivale

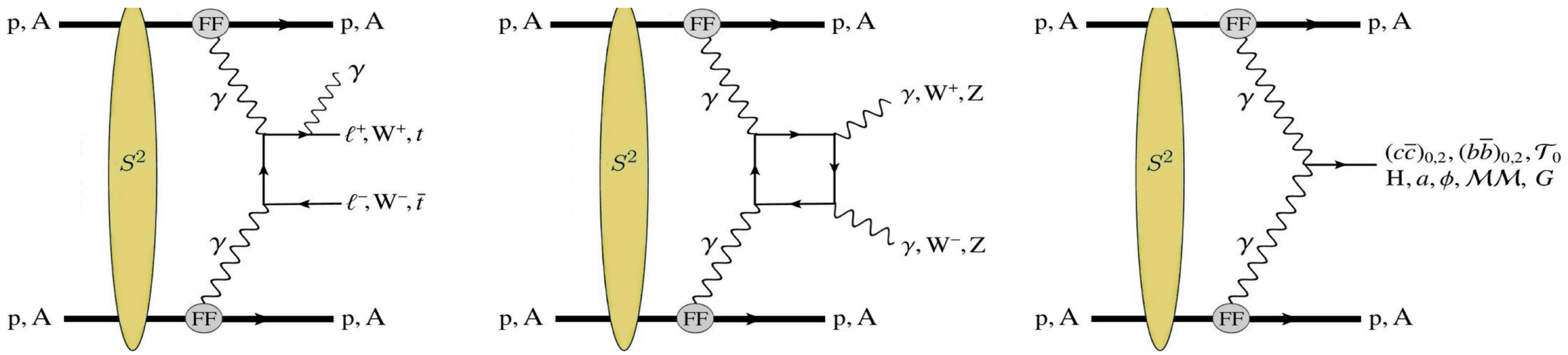




Antonio Giannini

Ultra Peripheral Collisions

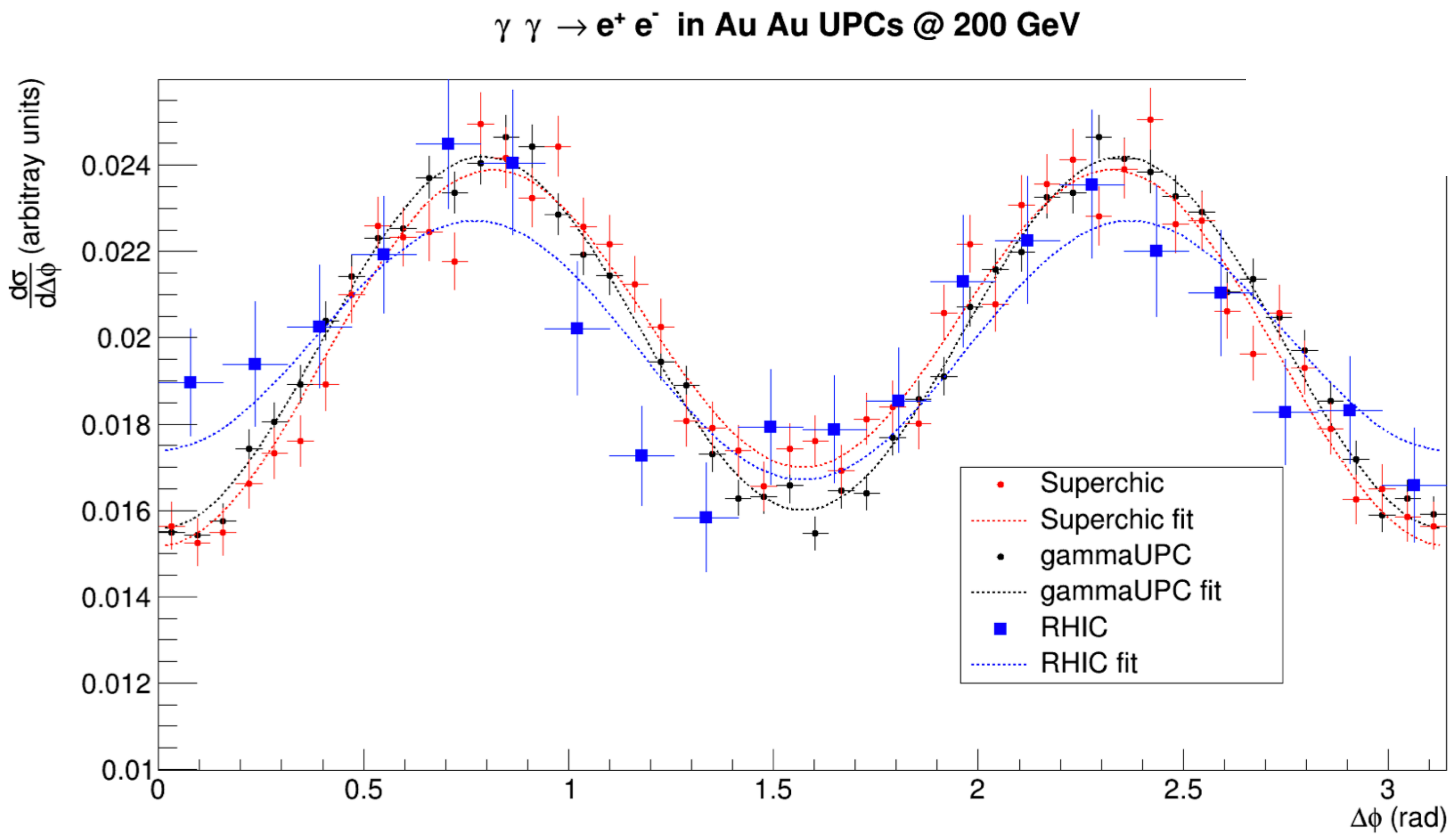
Unique (B)SM γγ physics with UPCs at the LHC



gamma-UPC is a new versatile code to generate any γγ process in UPCs with protons & ions. Interfaced to MG5_aMC@NLO & HelacOnia & custom codes.

New developments:

- Parametric uncertainties
- Δϕ distribution modulation for lepton pairs



Nicolas Crepet

FCNC

Spin correlations

Differential distributions

EFT

Top

Entanglement

Top mass

LFV

Single top

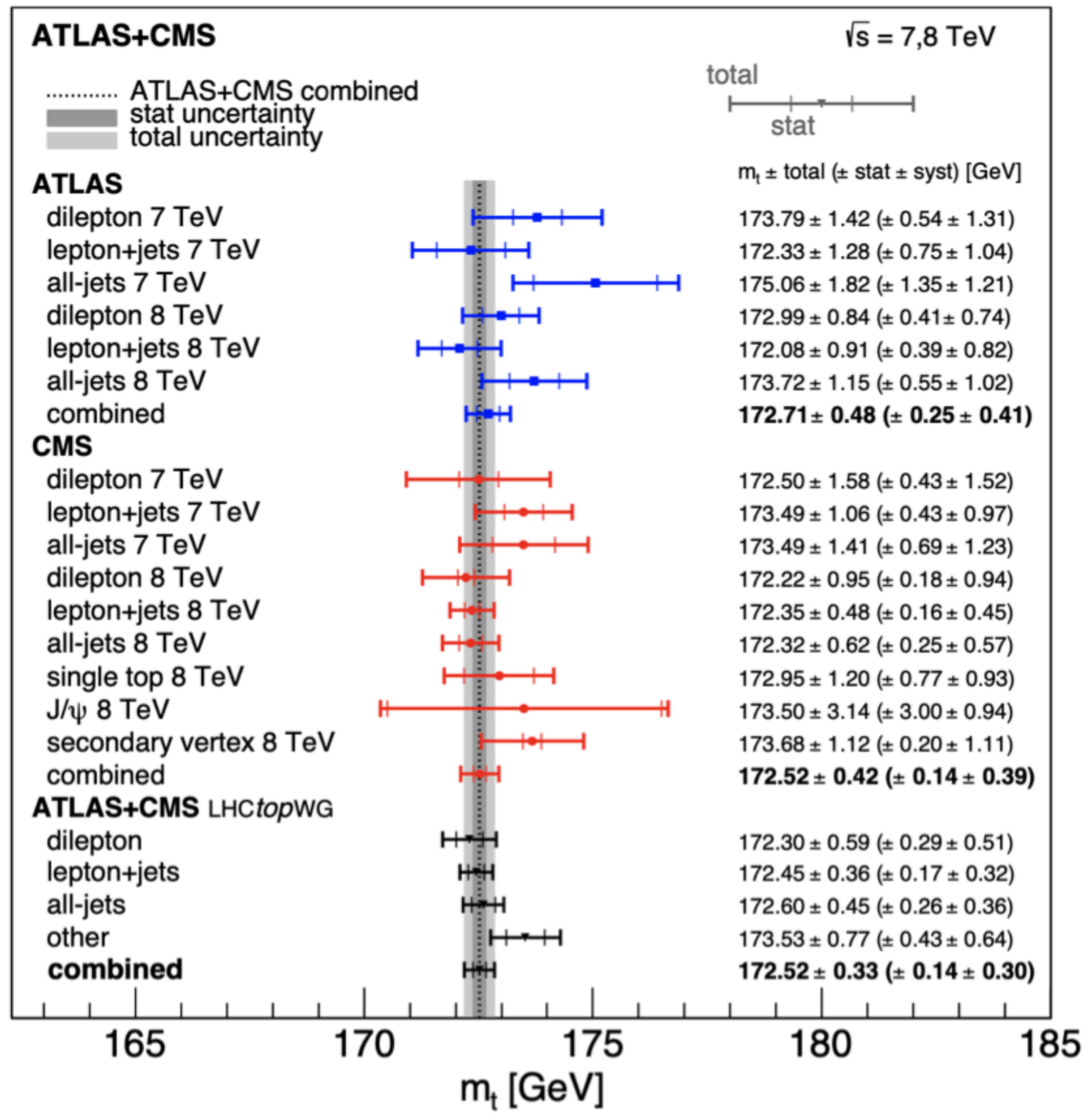
tt+X

Top properties

The heaviest quark, order~1 Yukawa coupling

Learning more about the top

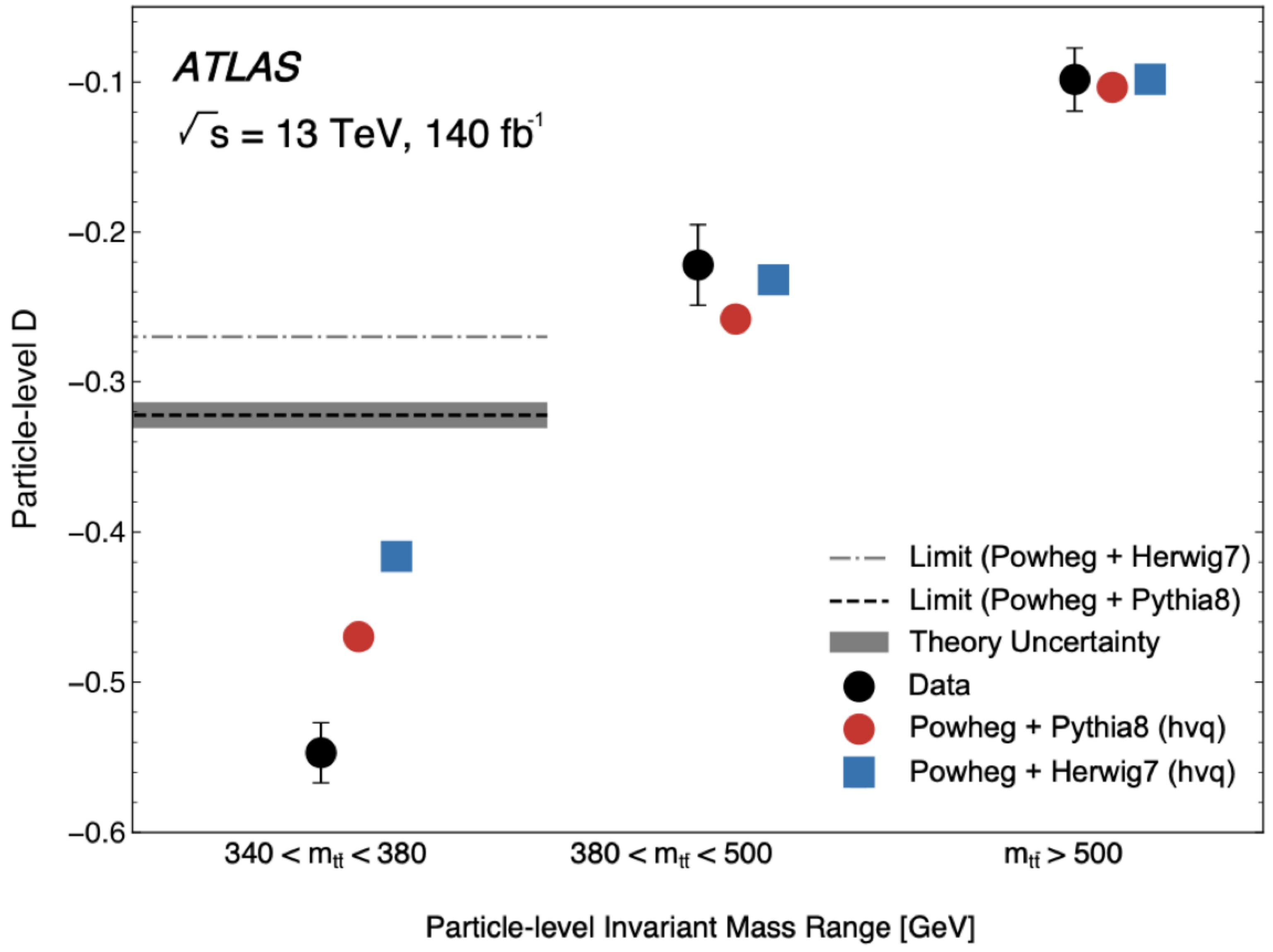
TOP MASS



Top-quark mass combination ATLAS/CMS run I

mt = 172.52 ± 0.14(stat) ± 0.30(syst) GeV (~ 0.2 % precision)

Quantum entanglement



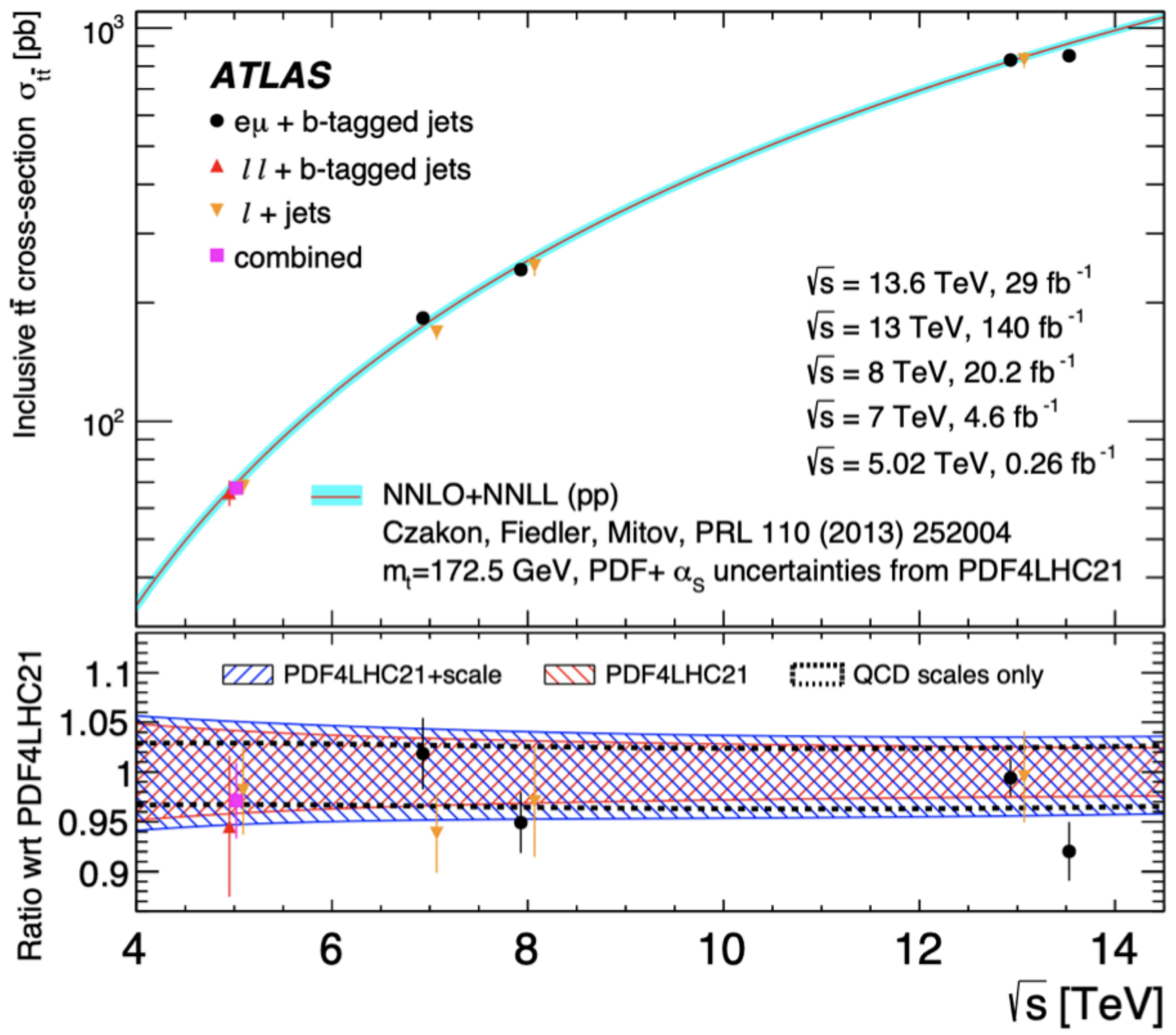
Entanglement: Top Spins are entangled
First observation of entanglement in events near the top-anti-top threshold

Luis Monsonis

Top measurements

Plethora of inclusive and differential measurements in all channels: pair production, tj, tW

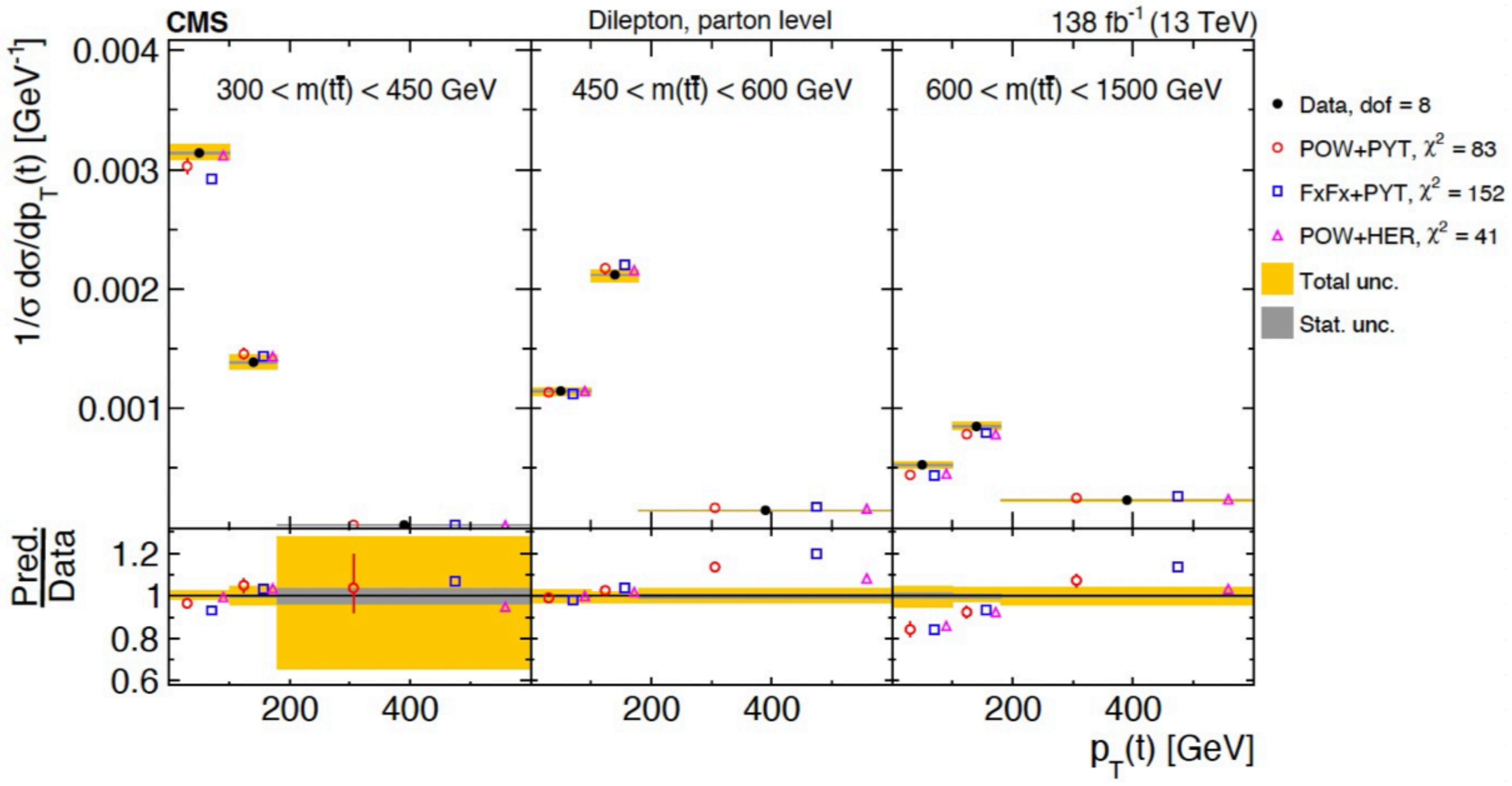
ATLAS



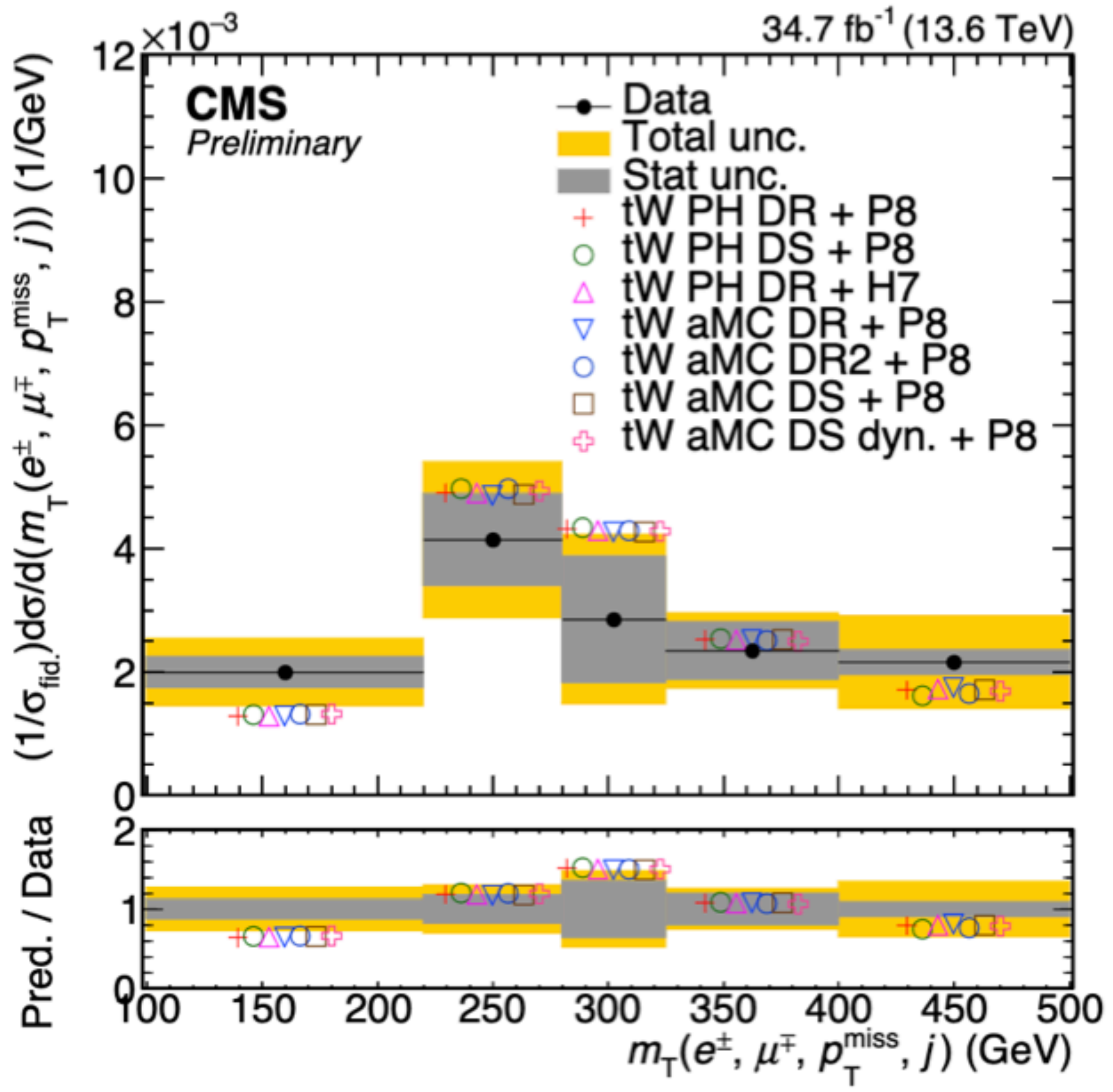
Inclusive results, at different CoM energies
Good agreement with NNLO+NNLL

Luis Monsonis

CMS



Differential measurements for tt, parton level

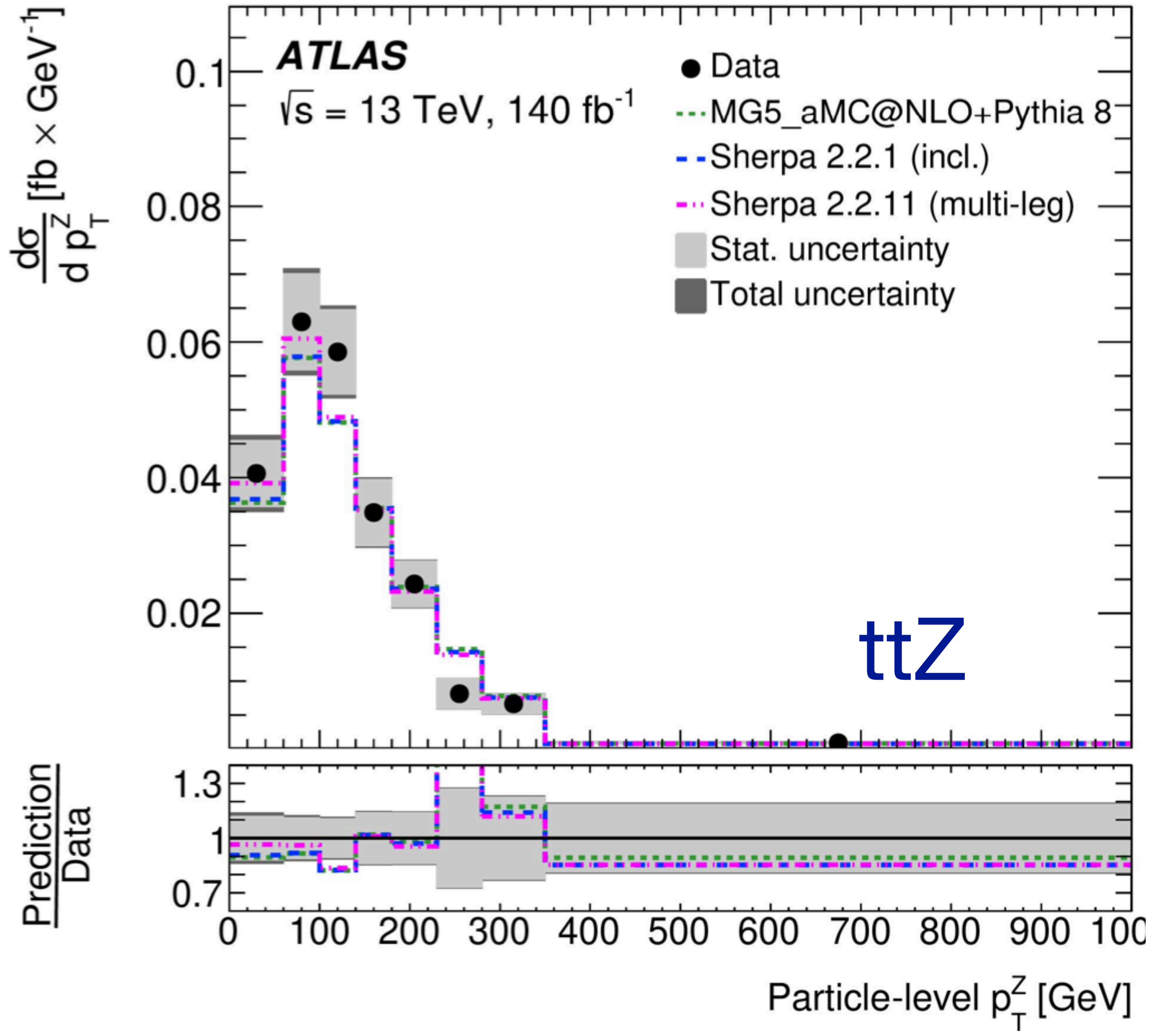


Differential measurements for tW

Jeremy Andrea

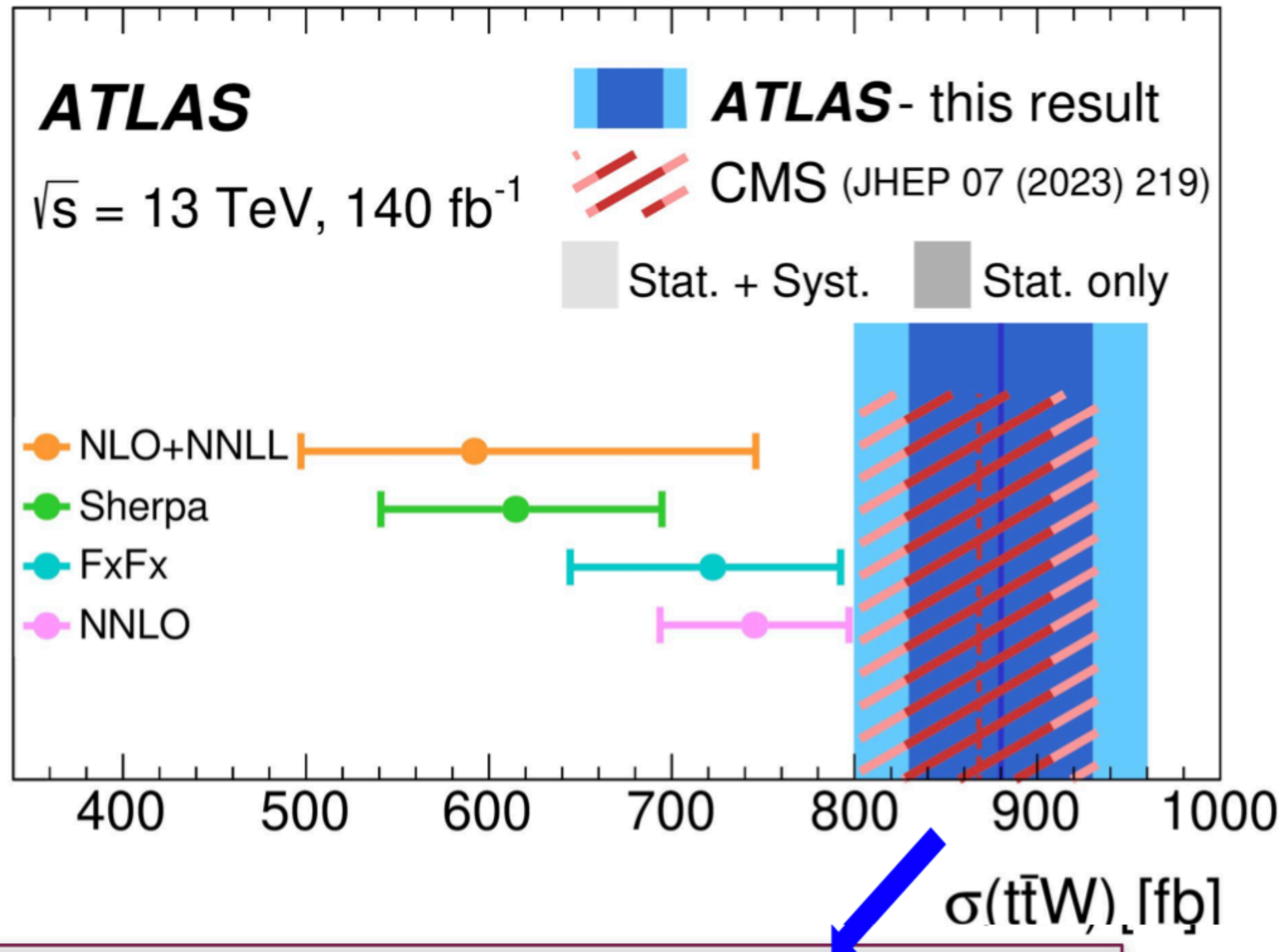
Top+X

- Leptonic final states for ttZ, ttW, ttγ, tZq
- For the first time measured at the LHC, now also differentially!



$$f_{SM}^{obs.} = 1.20 \pm 0.63\ (stat.) \pm 0.25\ (syst.) = 1.20 \pm 0.68\ (tot.)$$

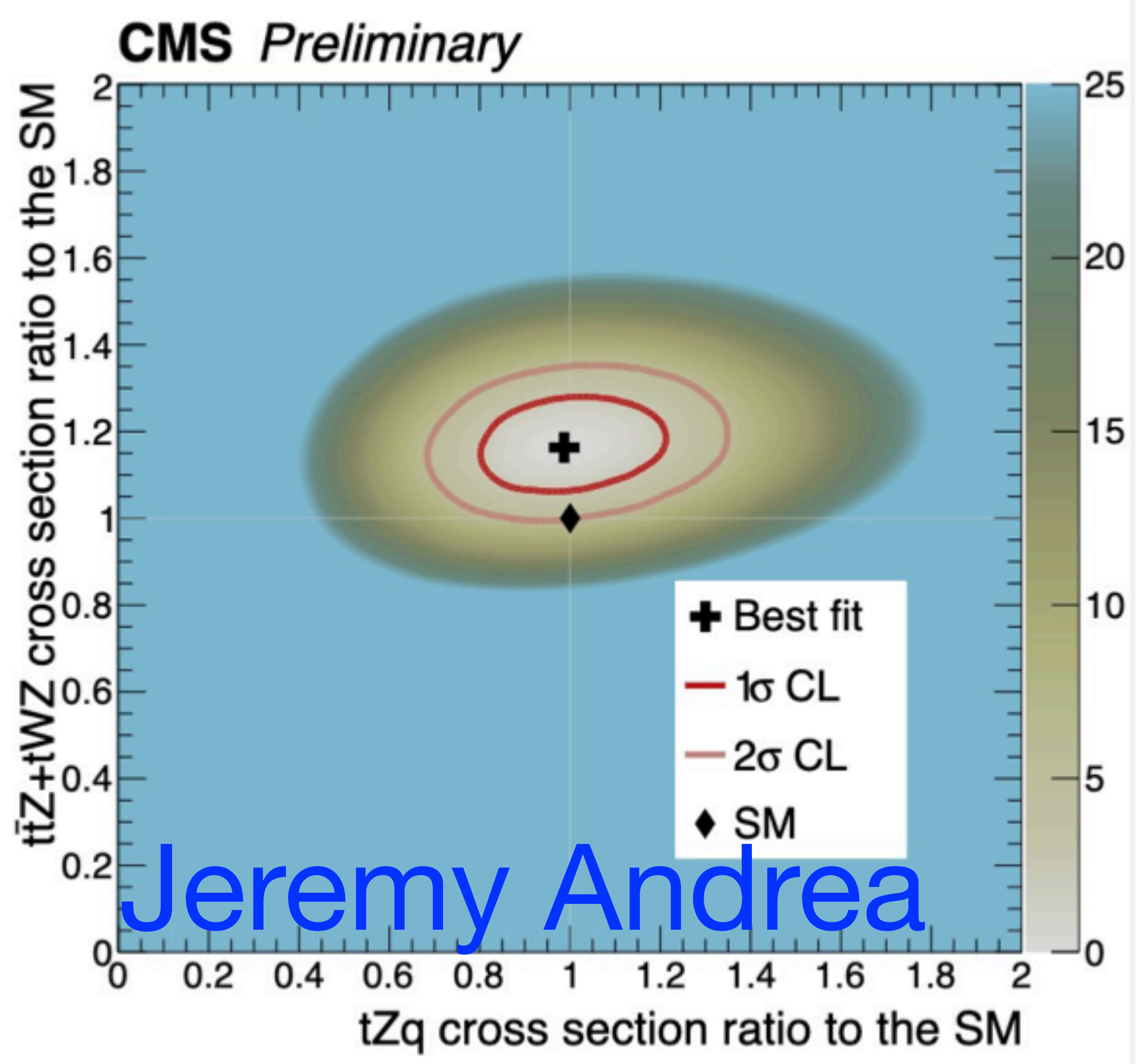
Spin Correlations in ttZ



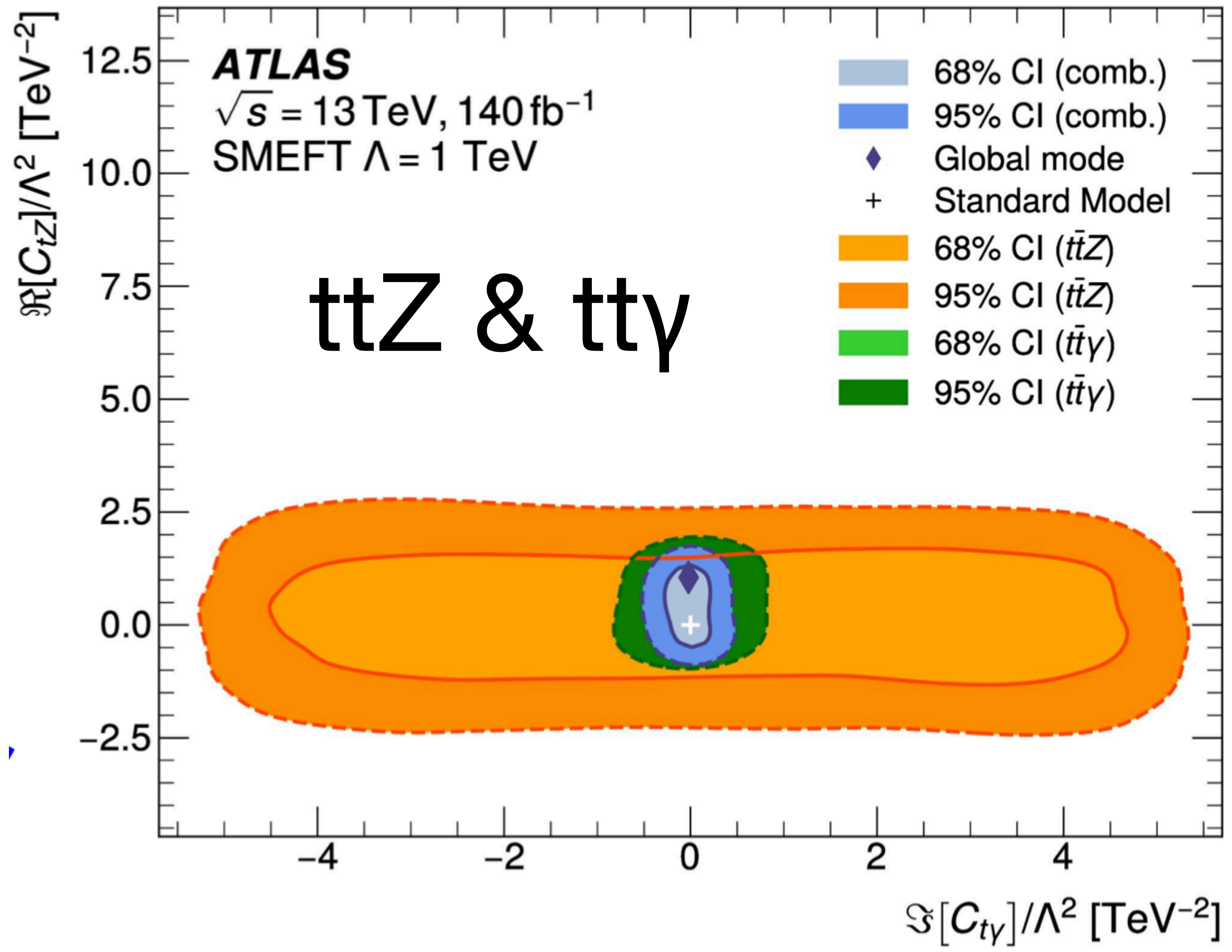
$$\sigma(t\bar{t}W) = 880 \pm 50\ (stat.) \pm 70\ (syst.) = 880 \pm 80\ fb$$

Improvement with NNLO computation

Harriet Watson

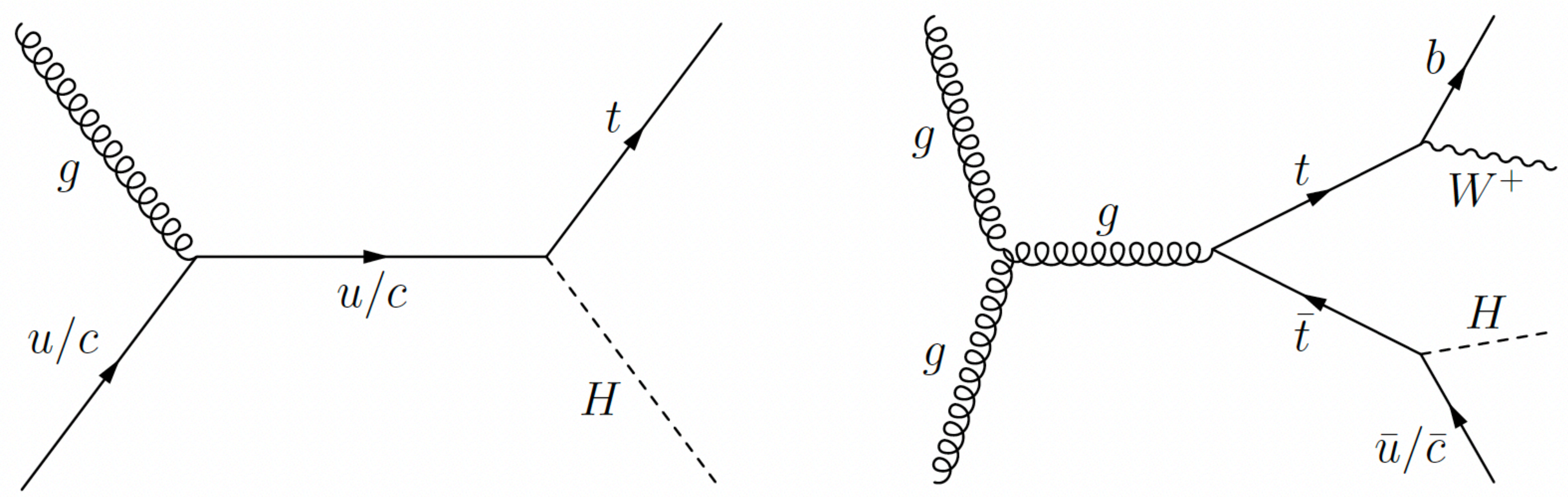


Jeremy Andrea



BSM top @ ATLAS and CMS

Example: FCNC tHq



Forbidden at tree level, highly suppressed at higher orders.

SM prediction BR(t ➔ Hu, Hc) < 10^{-15}, 10^{-17}.

Deviation would point to new physics

CMS: H➔WW, ZZ, ττ

>= 1 same sign dilepton pair, b-jets, jets

95% CL limits set using the CL_s criterion.

- Observed: $\text{Br}(t \to uH) < 0.072\%$, $\text{Br}(t \to cH) < 0.043\%$.
- Expected: $\text{Br}(t \to uH) < 0.059\%$, $\text{Br}(t \to cH) < 0.062\%$.

Olga Bessidskaia Bylund

ATLAS: H➔bb, γγ, ττ, VV*. Multilepton

Signal	Observed (expected) 95% CL upper limits $\mathcal{B}(t \to Hq)$	$\lvert C_{u\phi}^{qt,tq} \rvert$
tHu	$2.8\,(3.0) \times 10^{-4}$	0.71 (0.73)
tHc	$3.3\,(3.8) \times 10^{-4}$	0.76 (0.82)

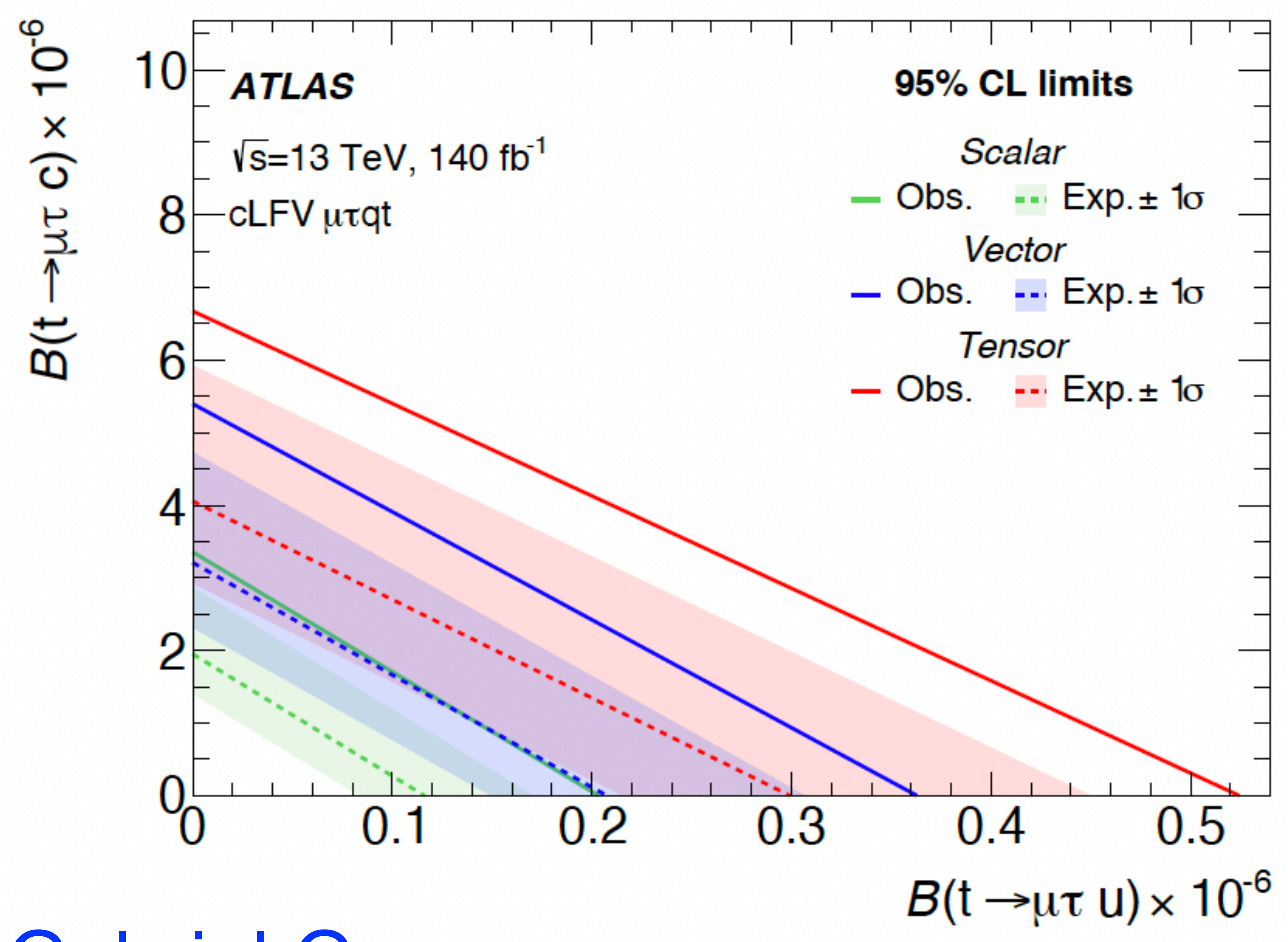
Gabriel Gomes

BSM top @ ATLAS and CMS

Charged LFV decays

No excess seen. EFT interpretation.
Limits improve by ~an order of magnitude.

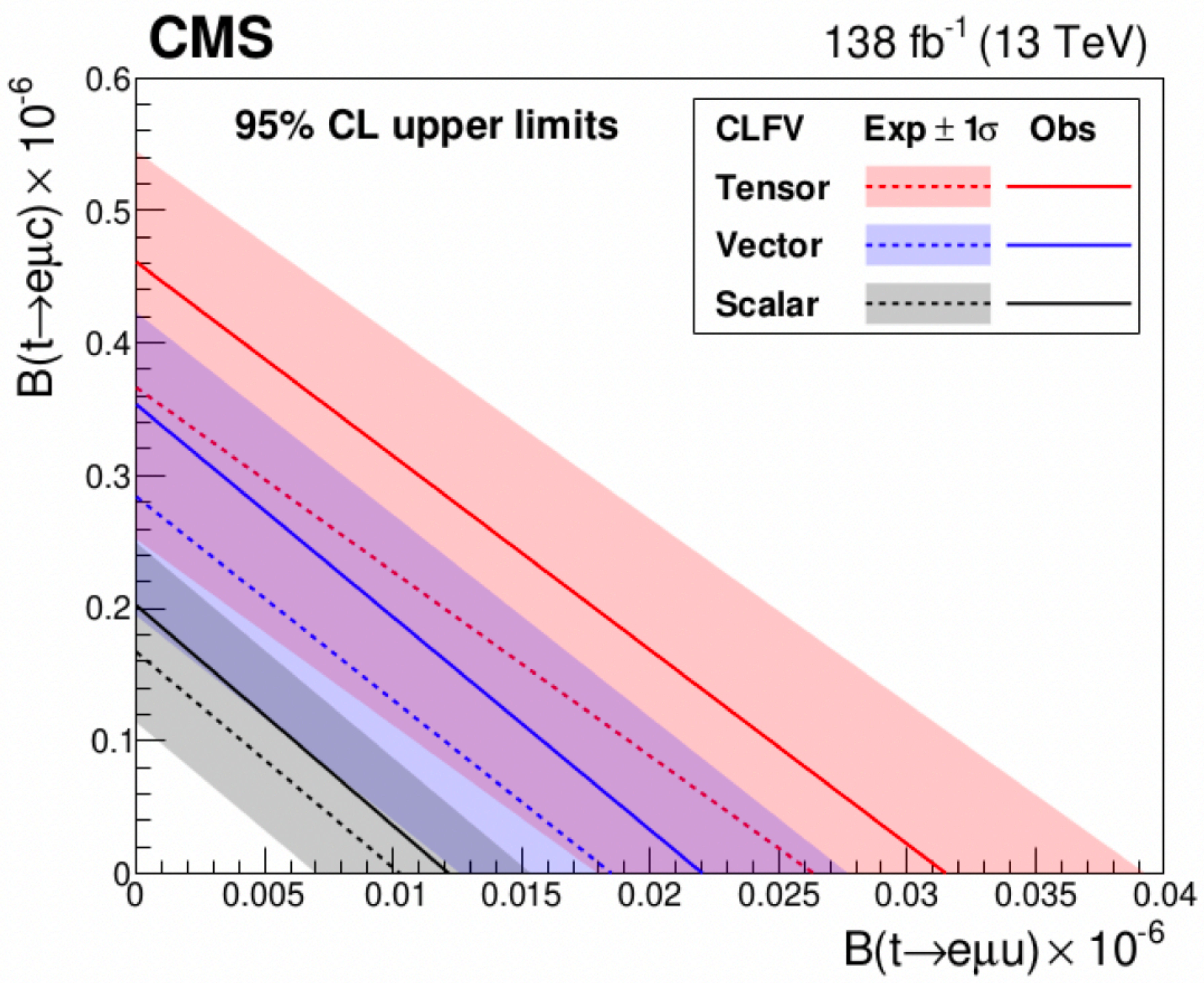
$\mathscr{B}(t \to \mu\tau q) < 8.7 \times 10^{-7}$



Gabriel Gomes

Olga Bessidskaia Bylund

	$\mathrm{Br}(t \to e\mu u)$	$\mathrm{Br}(t \to e\mu c)$
tensor	$0.032 \cdot 10^{-6}$	$0.498 \cdot 10^{-6}$
vector	$0.022 \cdot 10^{-6}$	$0.369 \cdot 10^{-6}$
scalar	$0.012 \cdot 10^{-6}$	$0.216 \cdot 10^{-6}$



Dark Matter

SUSY

Resonances

LQ

BSM

VLQ

LLPs

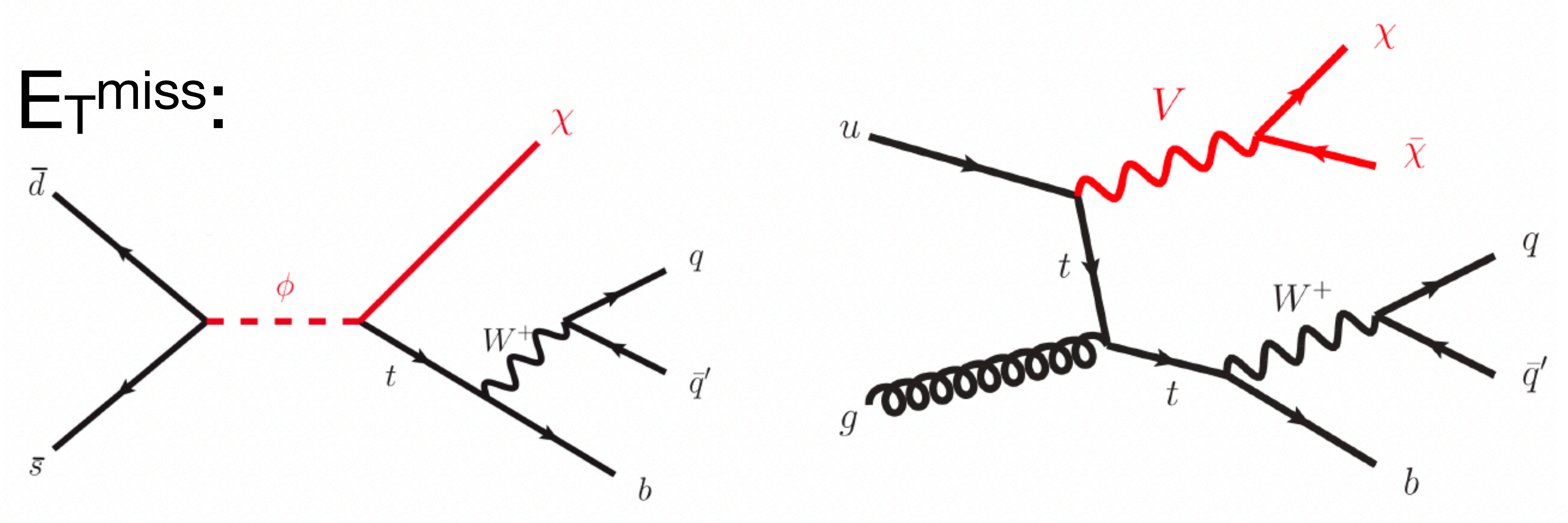
LFV

Unconventional signatures

DM searches @ ATLAS

Nikolai Fomin

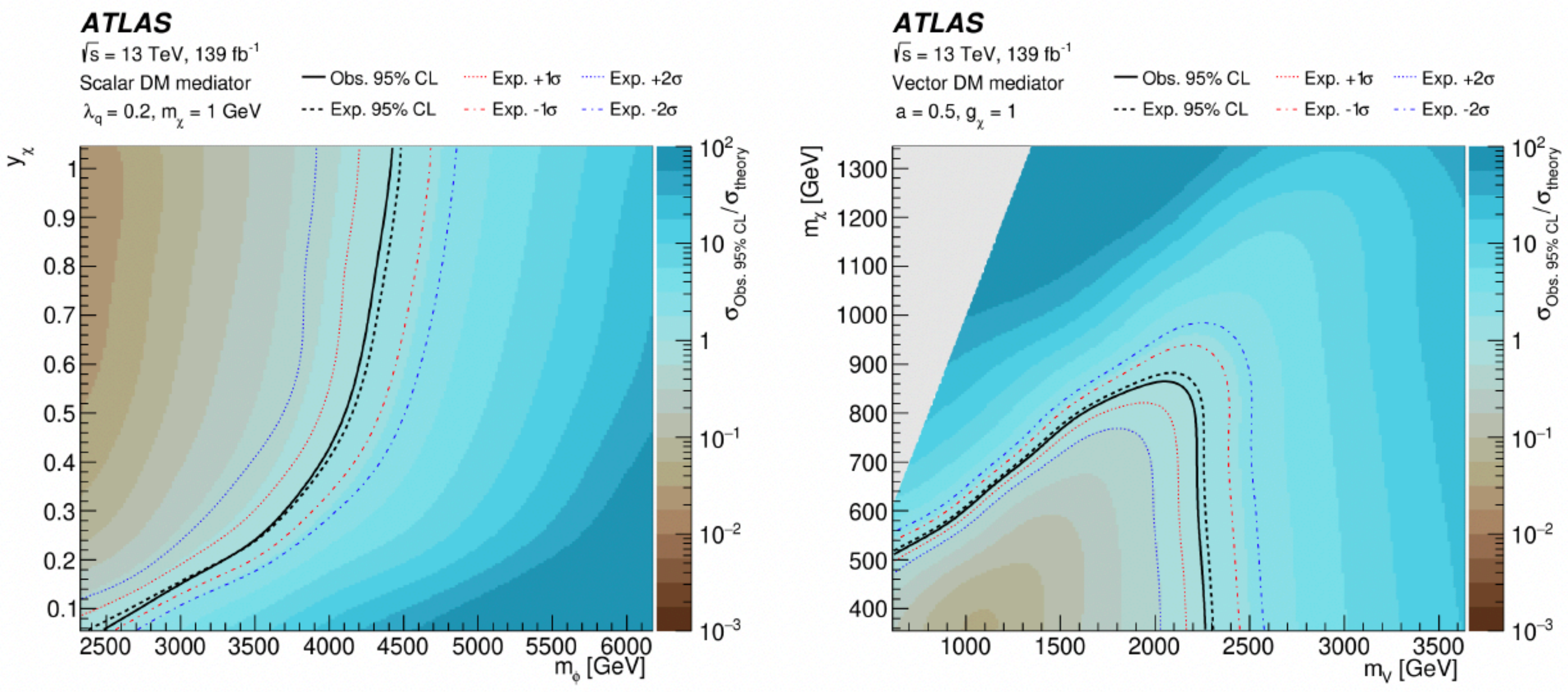
Monotop + E_T^{miss}:



Vigorously exploring complementary models / signatures:

- s-channel production (via mono-X + E_T^{miss})
- 2HDM + a
- Hidden/dark sectors (via LLPs).
- SUSY

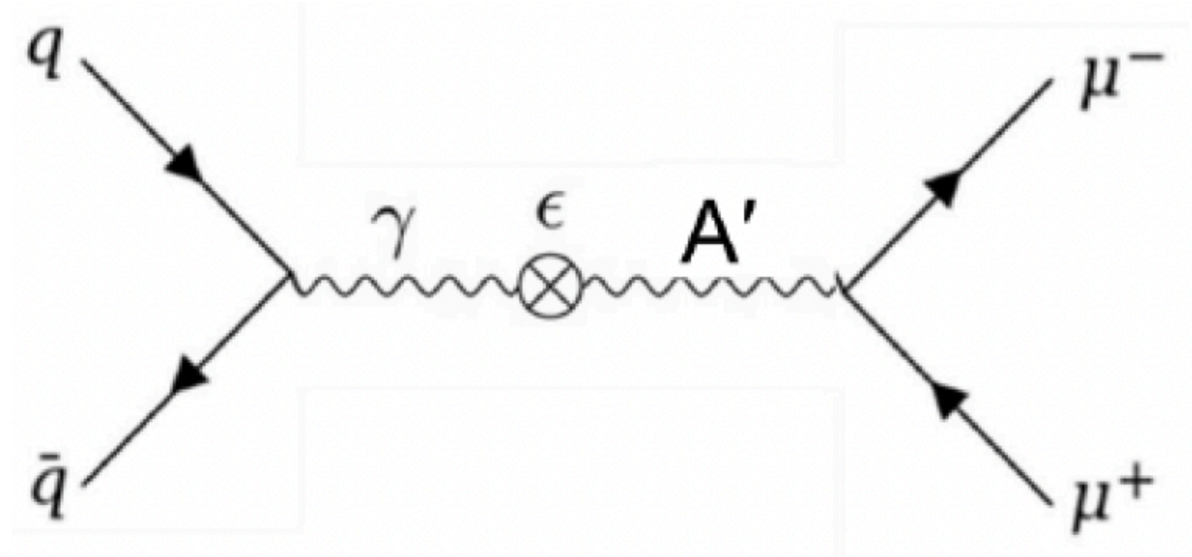
Scalar (vector) limits improved by 800 (300) GeV.

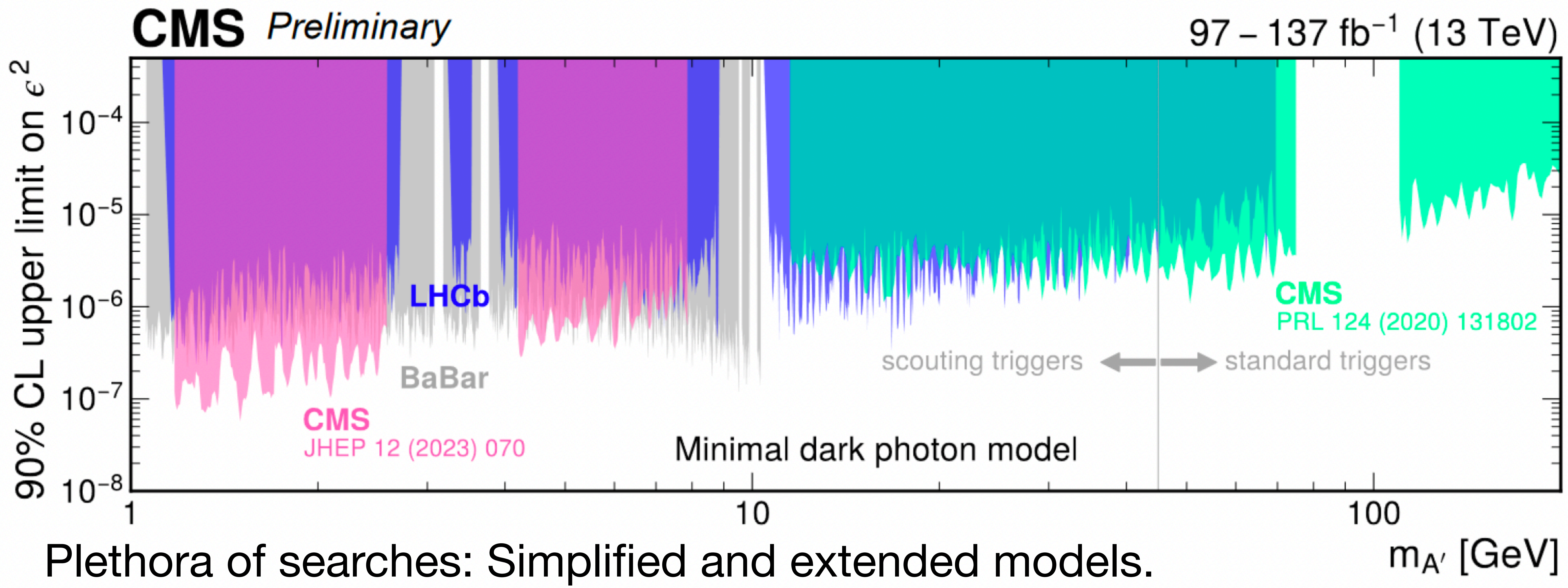


DM @ CMS

Dark photon: spin-1 mediator, mixing with SM photon.

Low mass resonance search using scouting triggers (store less content→reduce trigger thresholds).





Plethora of searches: Simplified and extended models.

Moving towards unconventional signatures.

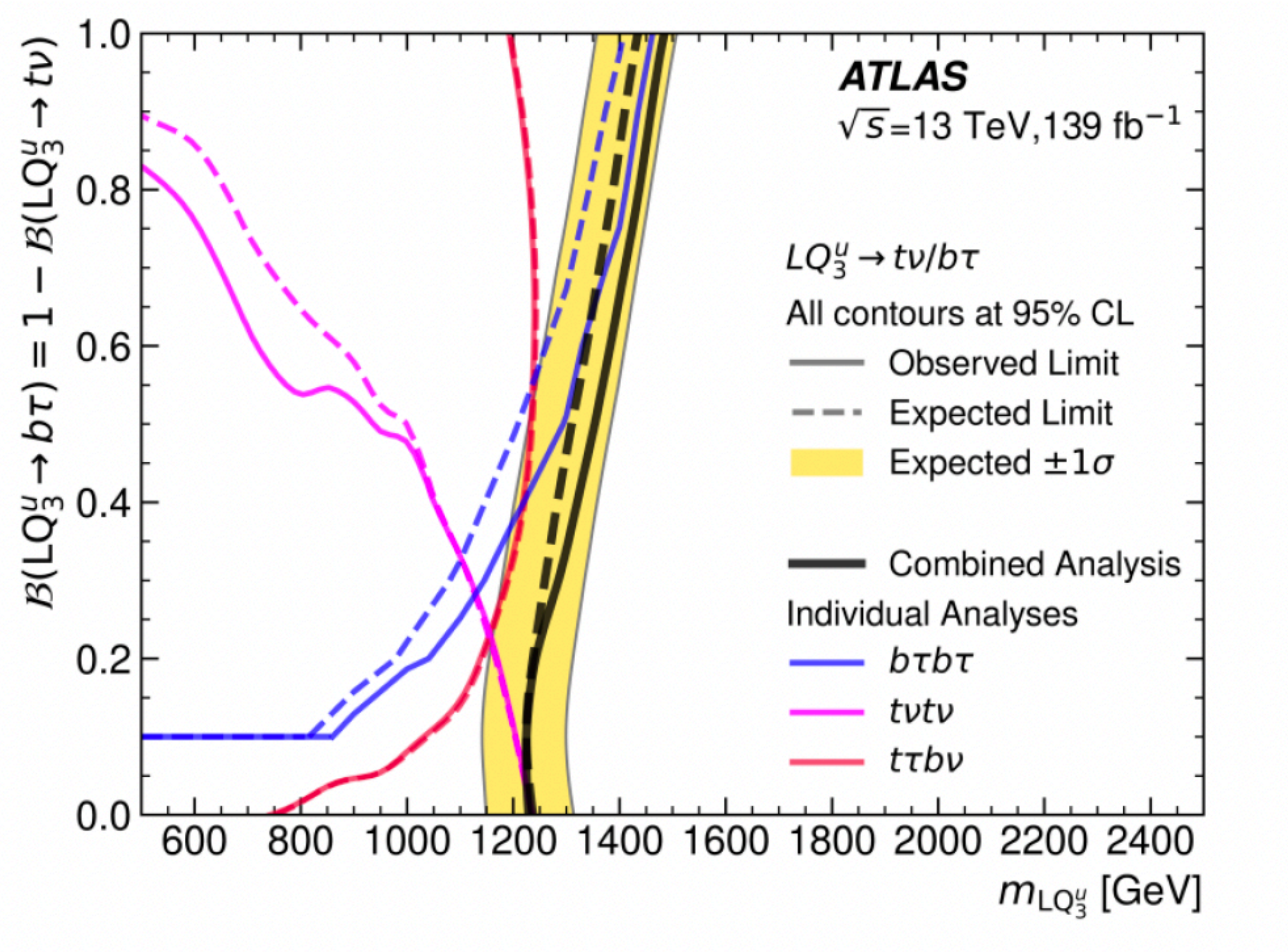
Jesus Manuel Vizan Garcia

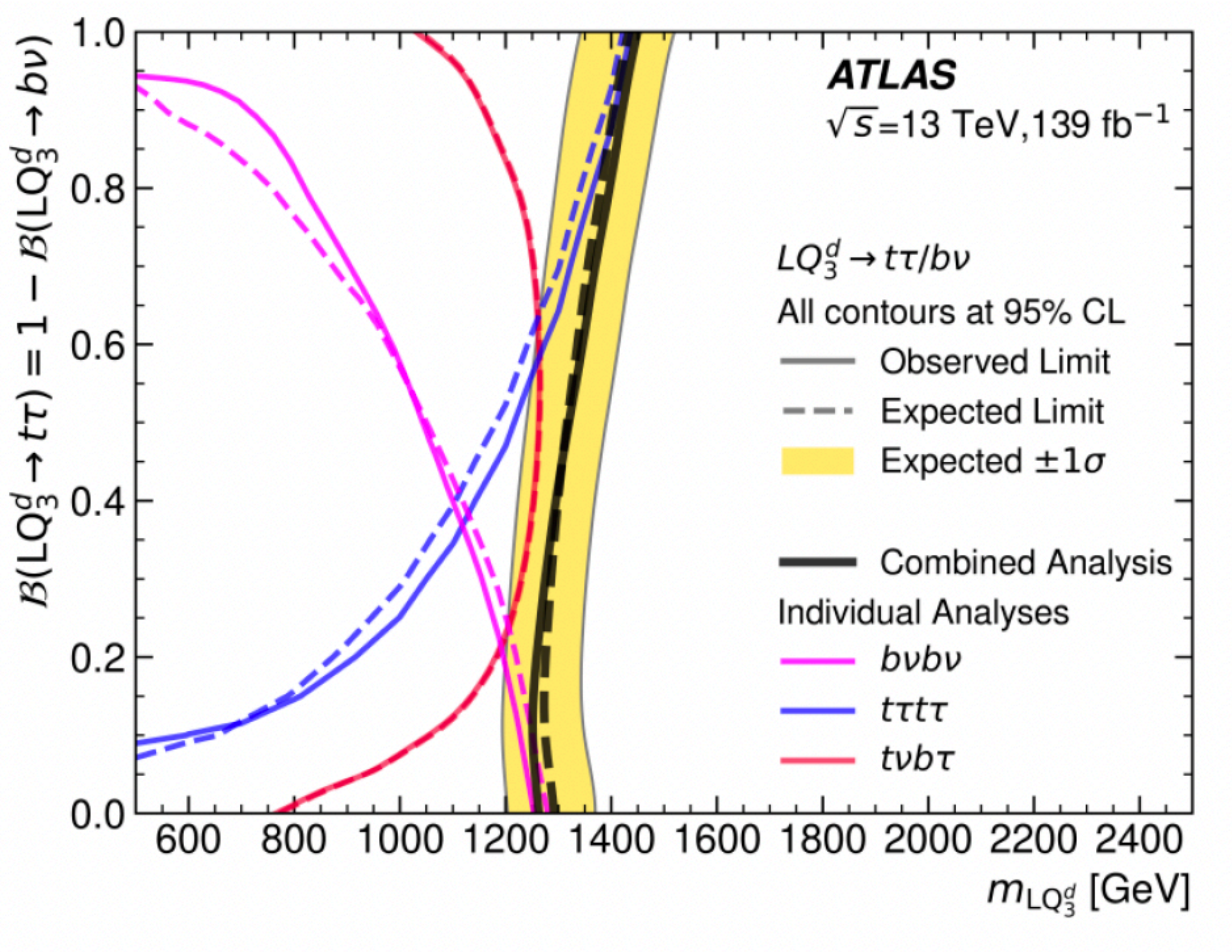
Leptoquarks & vector-like quarks @ ATLAS

Tomoya Iizawa

Lepton flavour universality violation in charged and neutral current processes in B physics can suggest a tree level mediator such as leptoquarks.

Pair production combination: increases lower bounds by ~100 GeV wrt individual analyses. Best limits to date.



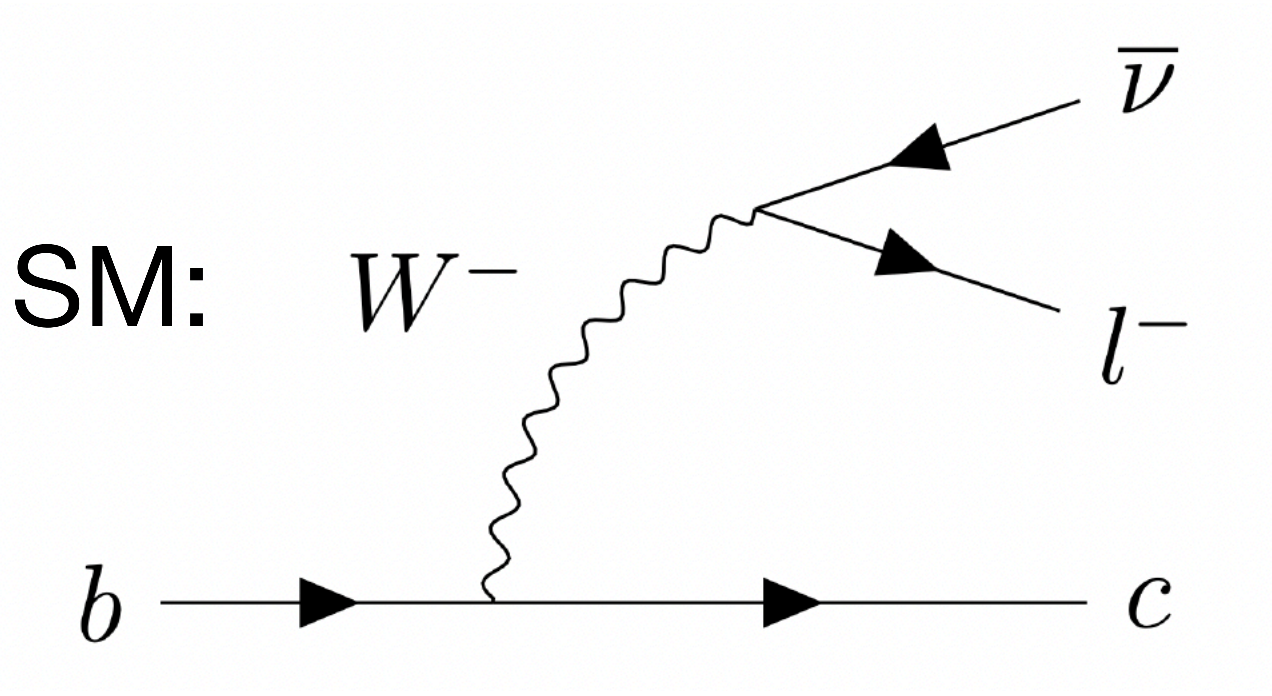


Vector-like quarks also searched for in both single and pair production

LFU in $b \to cl\bar{\nu}$ decays at LHCb

Chen Chen

SM:



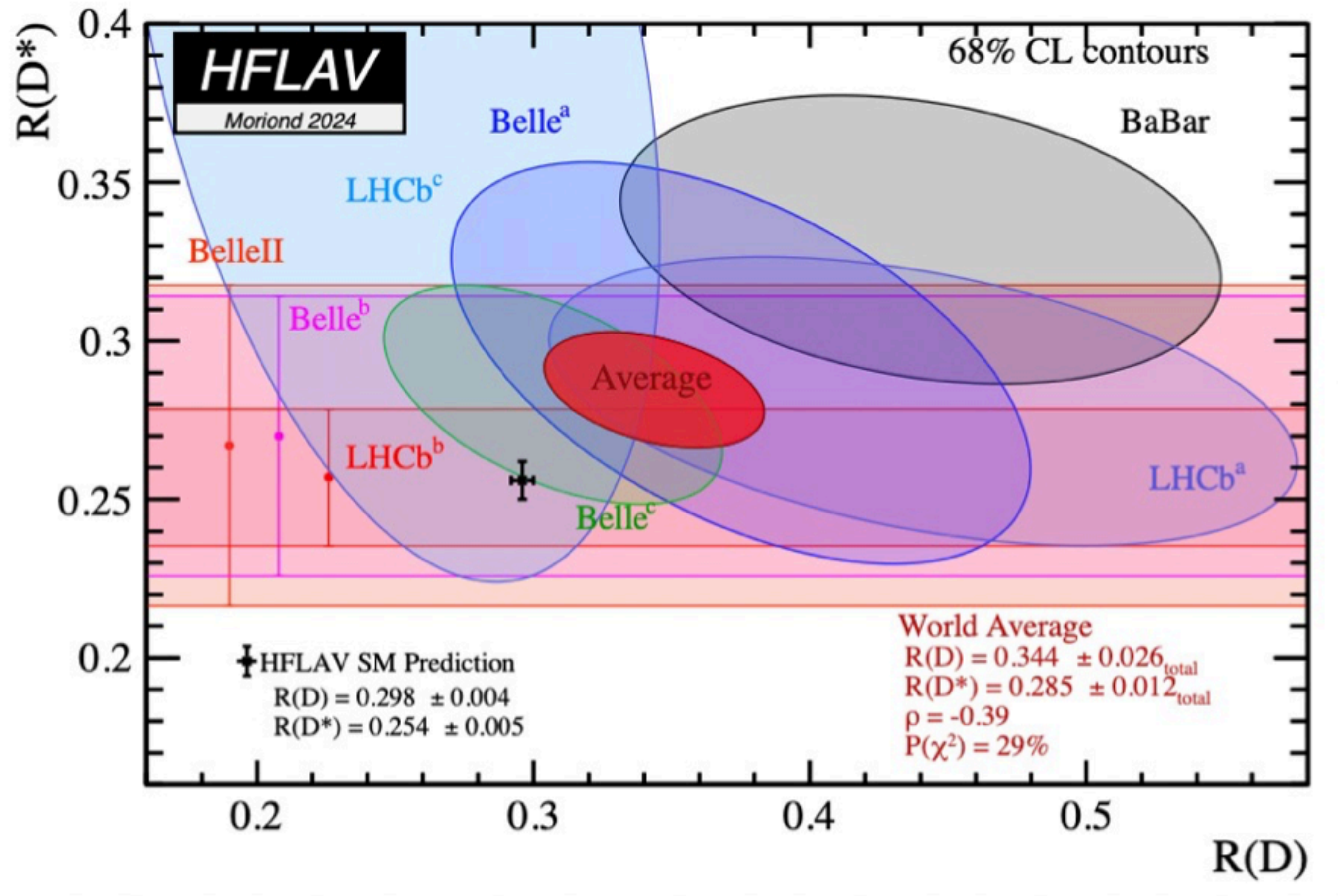
BSM: Replace W^- with e.g. H^- or LQ, or EFT operator.

First LHCb measurement using D+ meson:

$$R\left(D^{(*)+}\right) = \frac{\mathcal{B}(\bar{B}^0 \to D^{(*)+}\tau^-\nu_\tau)}{\mathcal{B}(\bar{B}^0 \to D^{(*)+}\mu^-\nu_\mu)}$$

$$R(D^+) = 0.249 \pm 0.043(\text{stat}) \pm 0.047(\text{syst})$$
$$R(D^{*+}) = 0.402 \pm 0.081(\text{stat}) \pm 0.085(\text{syst})$$

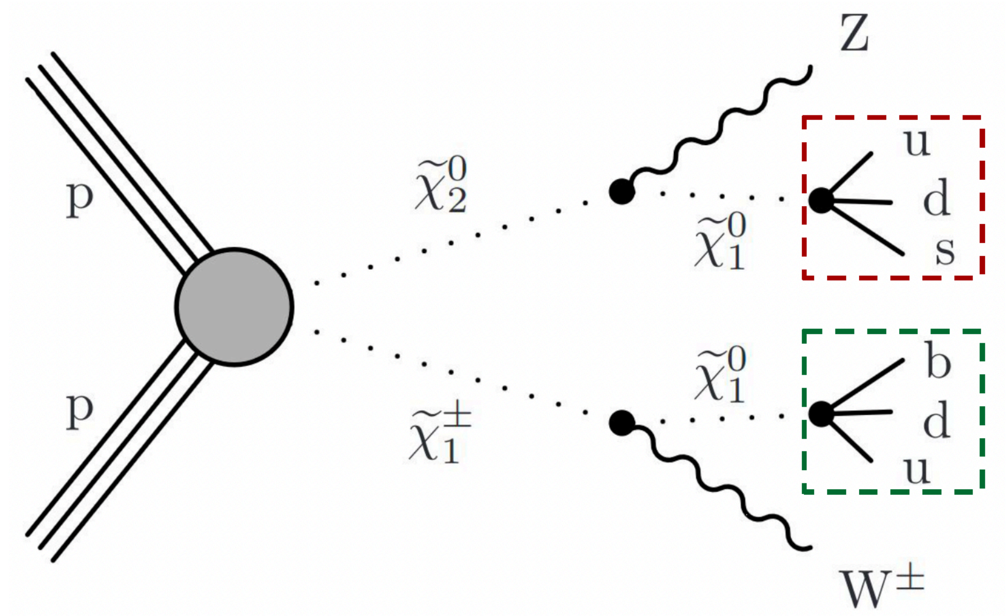
New R(D) & R(D*) world average:



Tension with SM: $3.34\sigma \to 3.17\sigma$

SUSY @ CMS

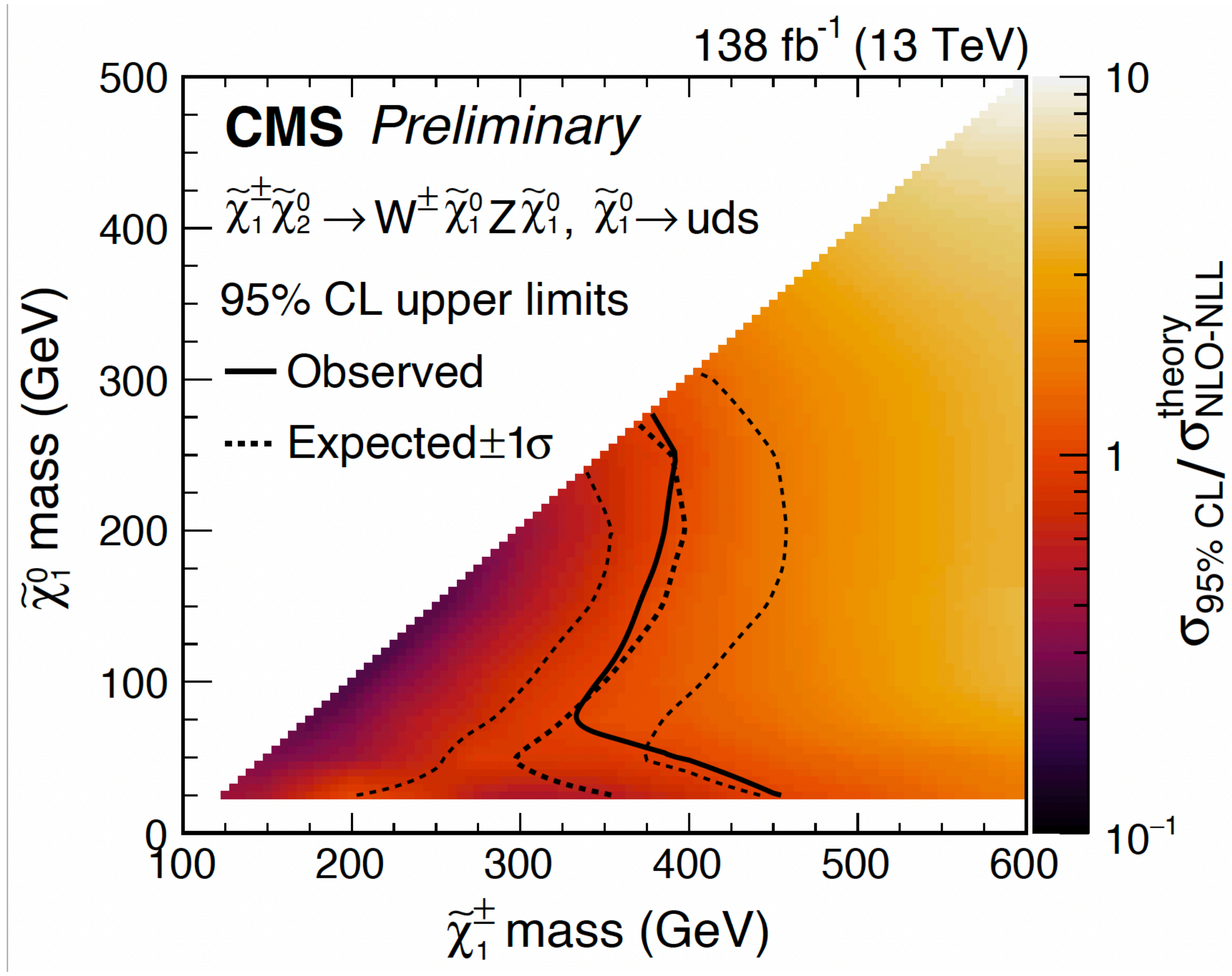
Pablo Matorras



R-parity violating neutralinos

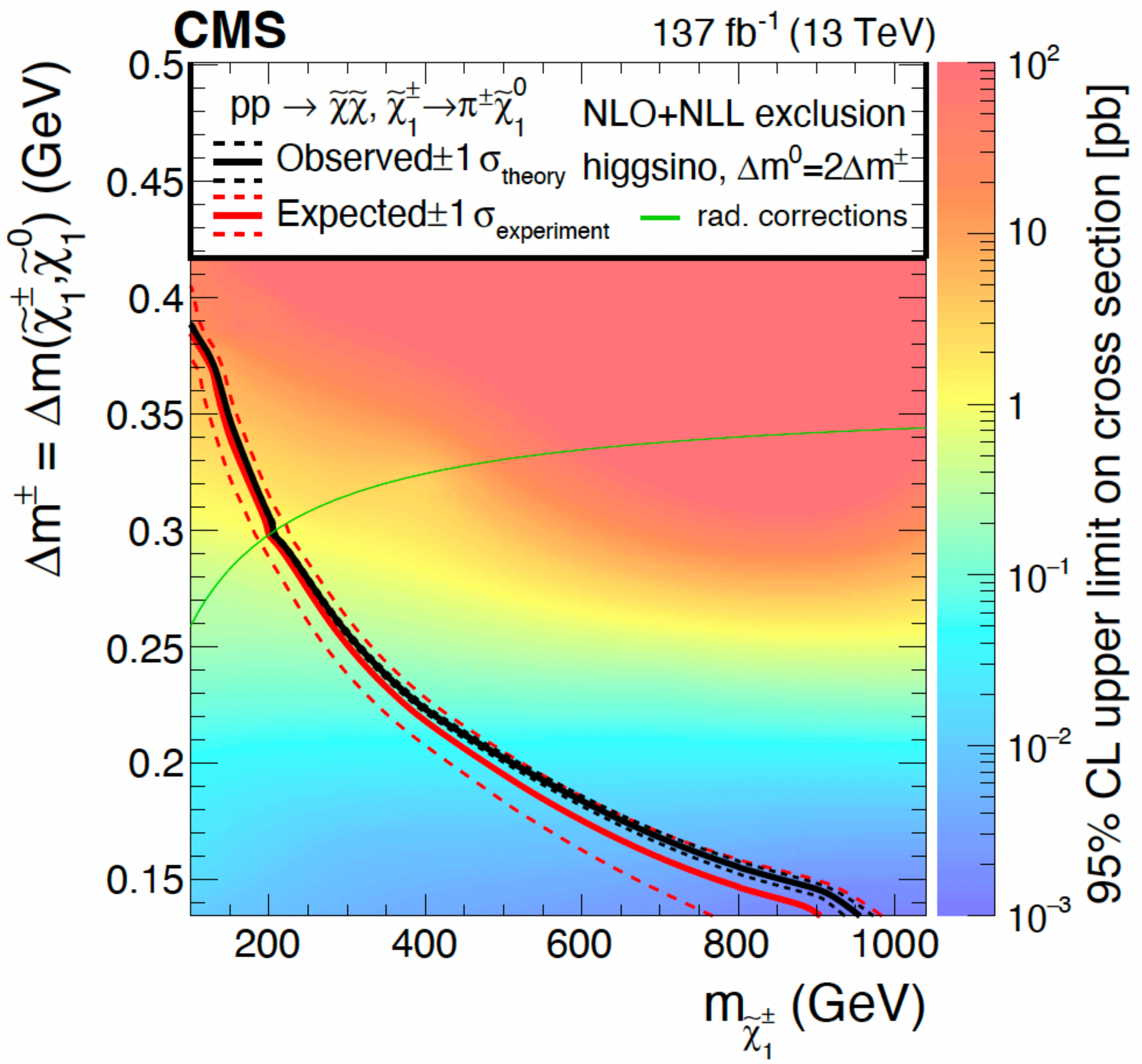
Moving toward unconventional and challenging signatures, combinations.

No excess, but still some hope.



Disappearing track search for long-lived charginos.

Stringent constraints on Higgsinos.



Higgs-like heavy resonances @ ATLAS

Jackson Barr

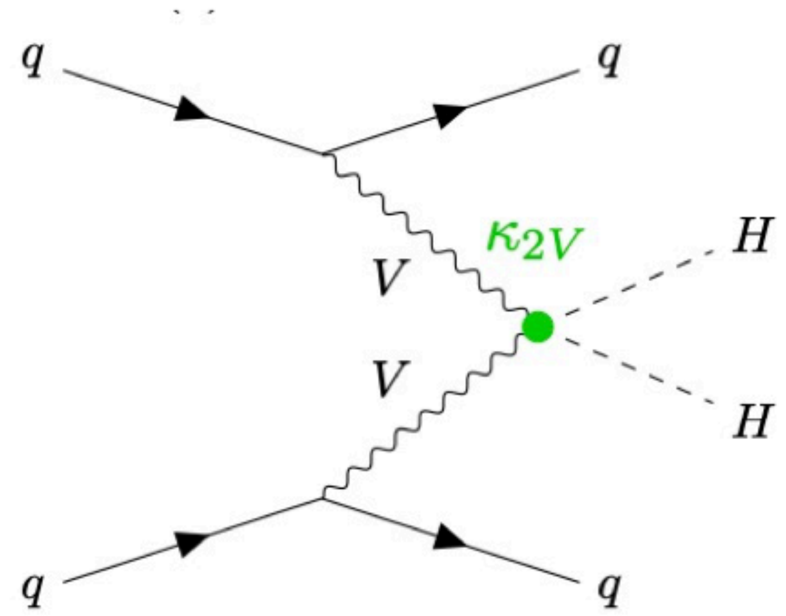
Dedicated search program: ML-based novel approaches in heavy object identification; anomaly detection studies, NN for boosted objects.

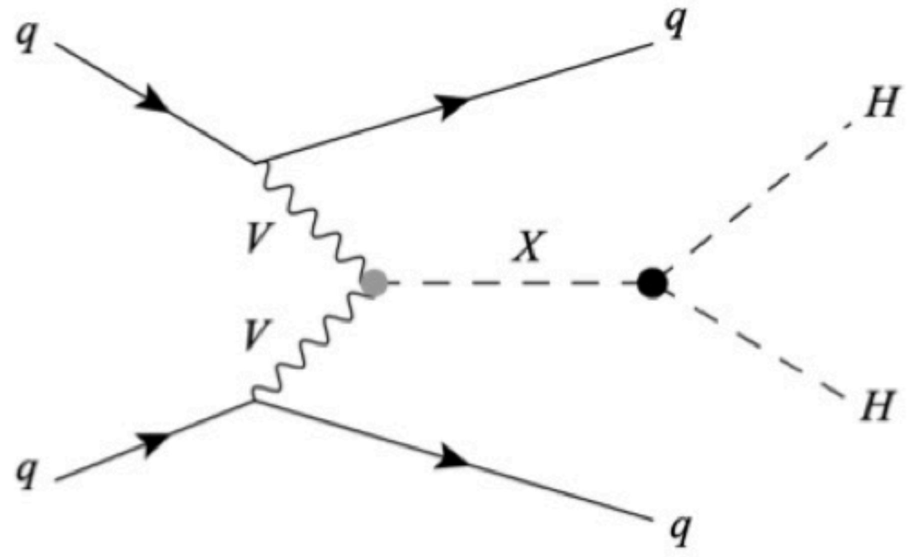
VBF HH ⟶ bbbb

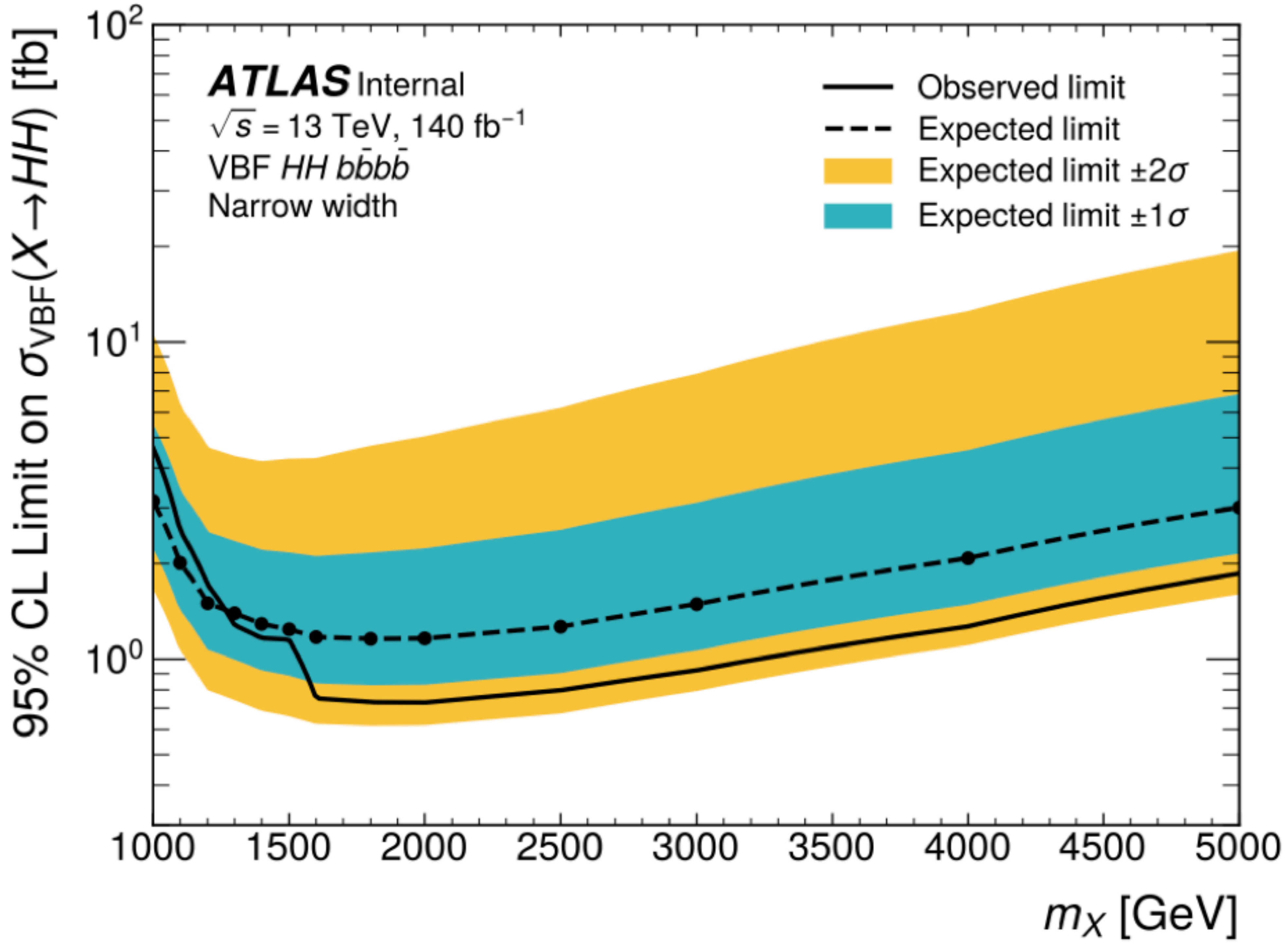
First ATLAS study in boosted channels with H ⟶ bb tagging.

Excludes $\kappa_{2V} = 0$ at 3.8σ.

Upper limits set for a the resonant case.





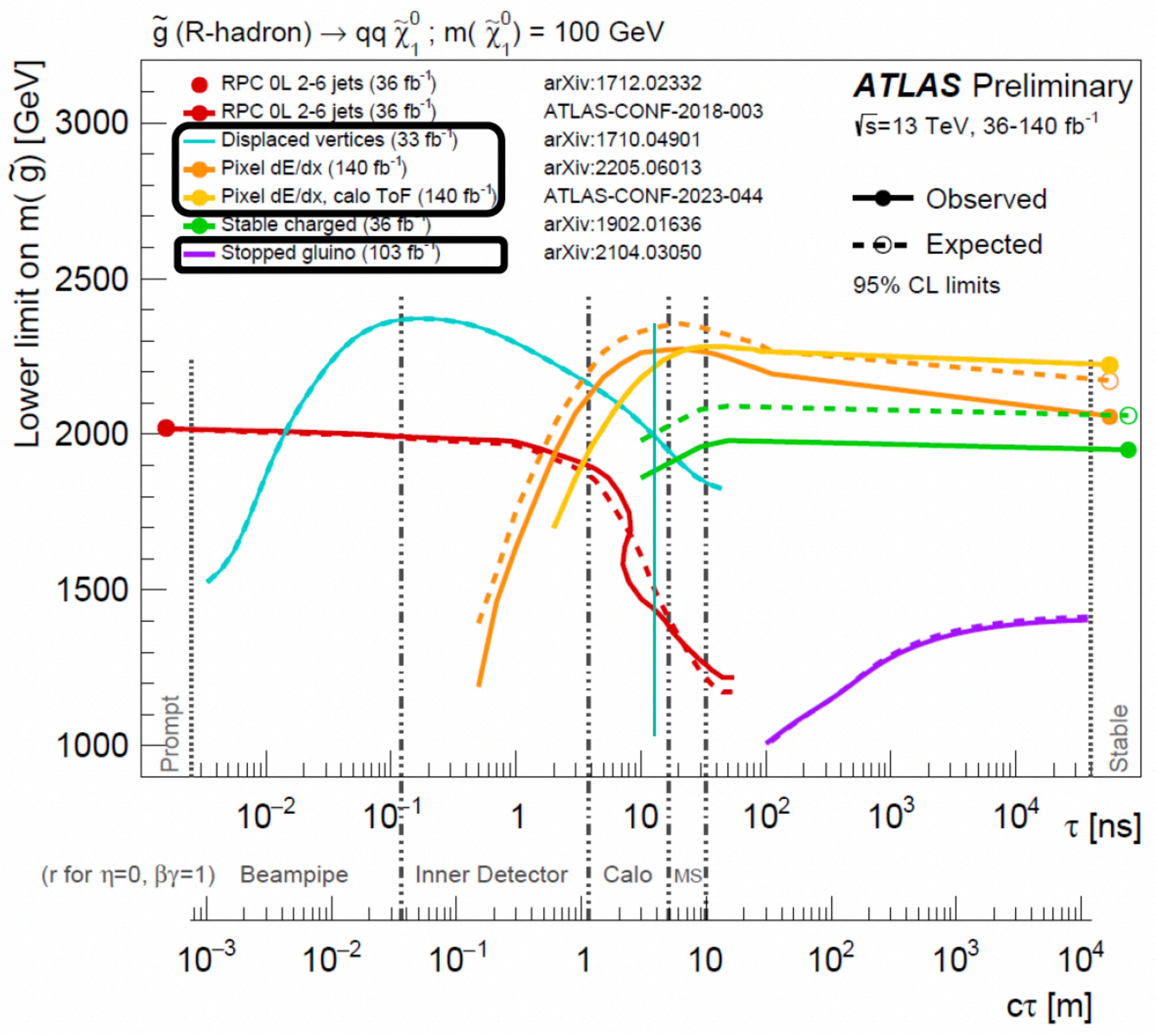


Unconventional signatures search @ ATLAS

Martina Ressegotti

Mainly targeting LLPs. Complementary searches based on different detector components.

- Inner detector: disappearing tracks, displaced vertices
- Calorimeter (and Transition Radiation Tracker): Highly Ionizing Particles (HIPs), Out-of-time energy deposits, non-pointing photons
- Pixel detector: high ionization energy loss (dE/dx).

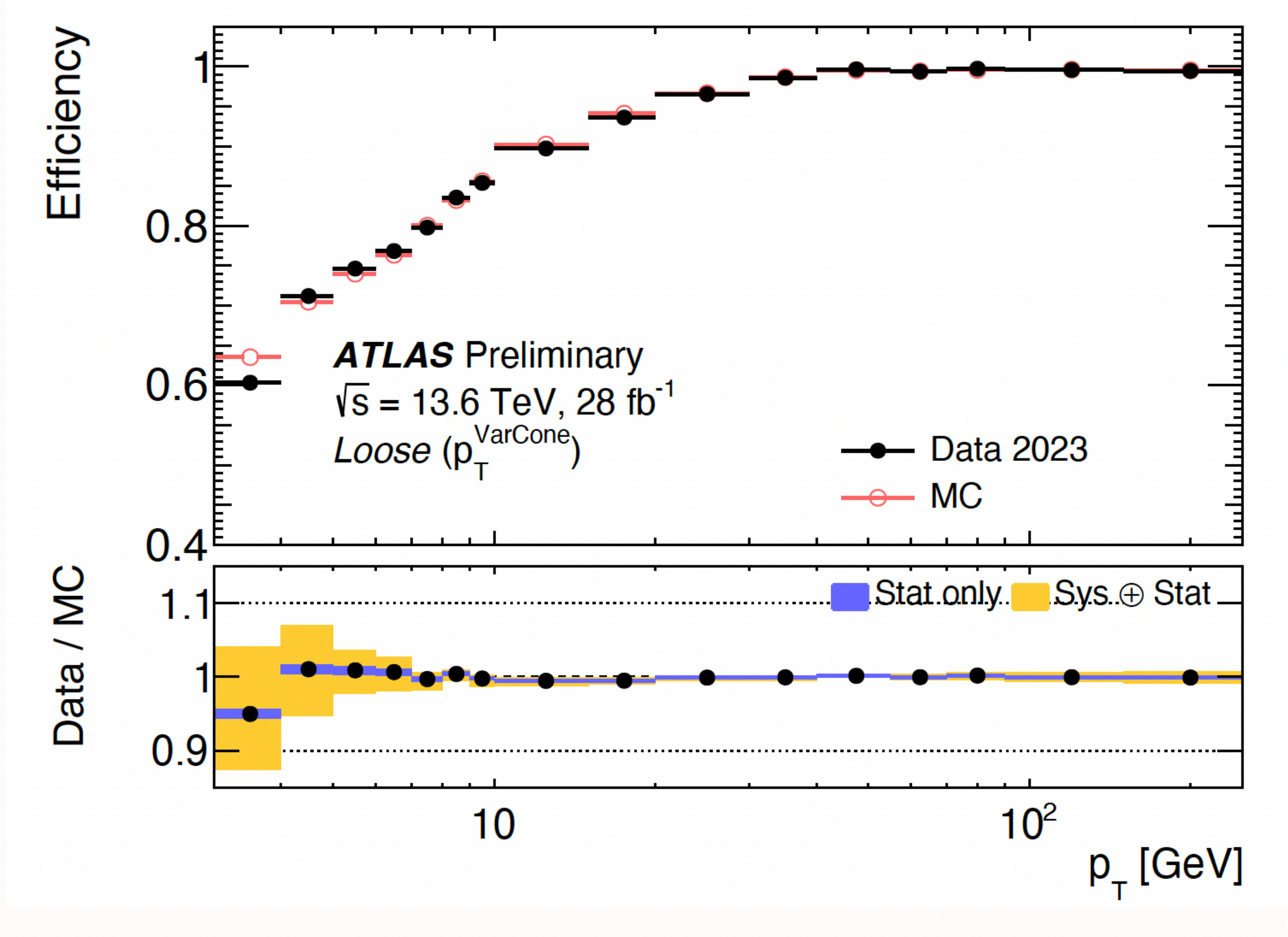


Complementarity in sensitivity to lifetime.

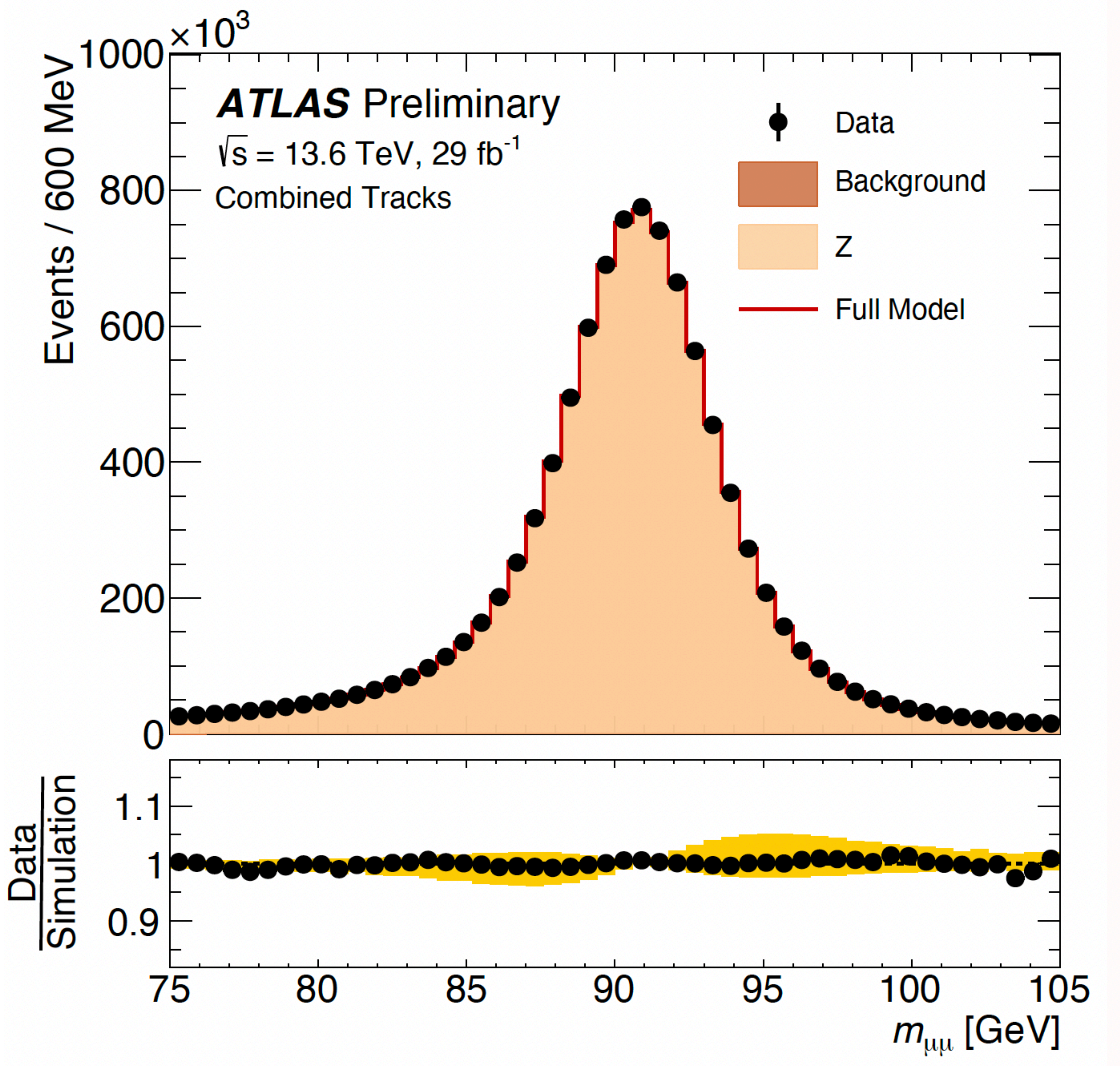
Run 3 muon Reconstruction @ ATLAS

Optimal object performance crucial for optimum performance in physics results.

Davide Cieri



Muon ID & isolation efficiencies performance almost at Run 2 level.



Calibration ongoing to achieve similar momentum resolution performance.

NA62

Belle

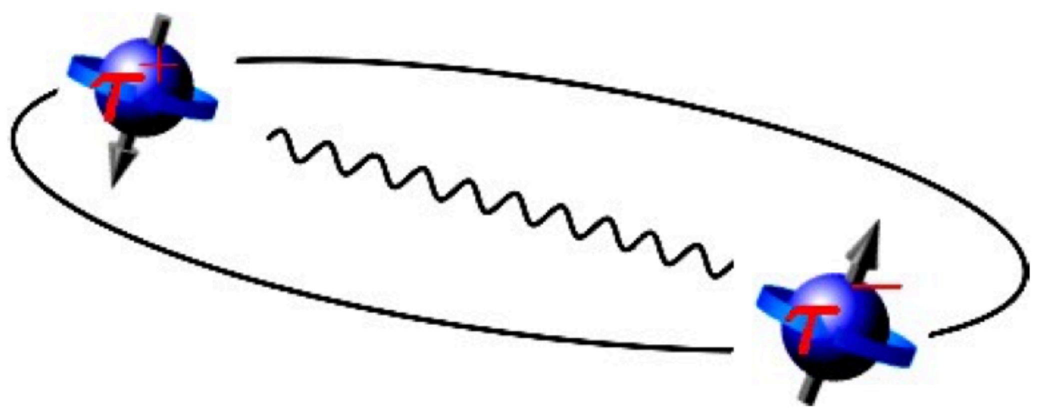
Beyond the LHC

LHeC

FCC-ee

Tauonium at colliders

David d'Enterria

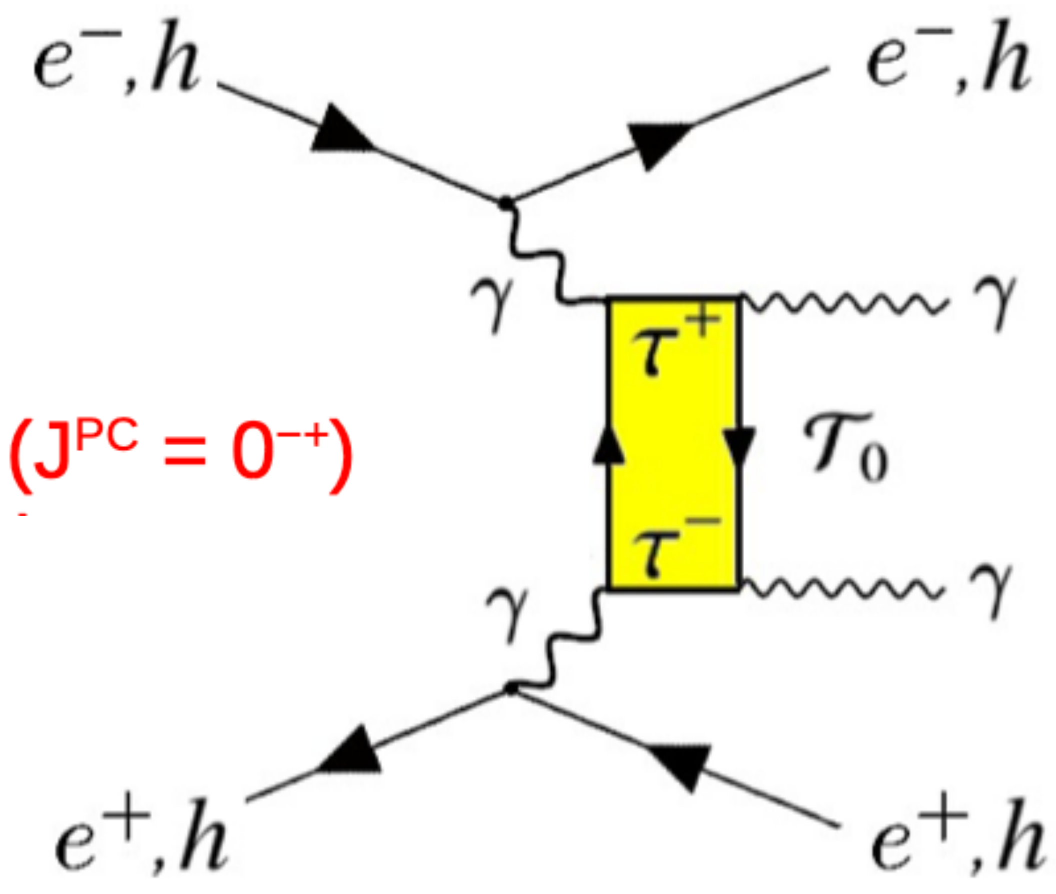


First comprehensive study of ditauoniom production in the lab.

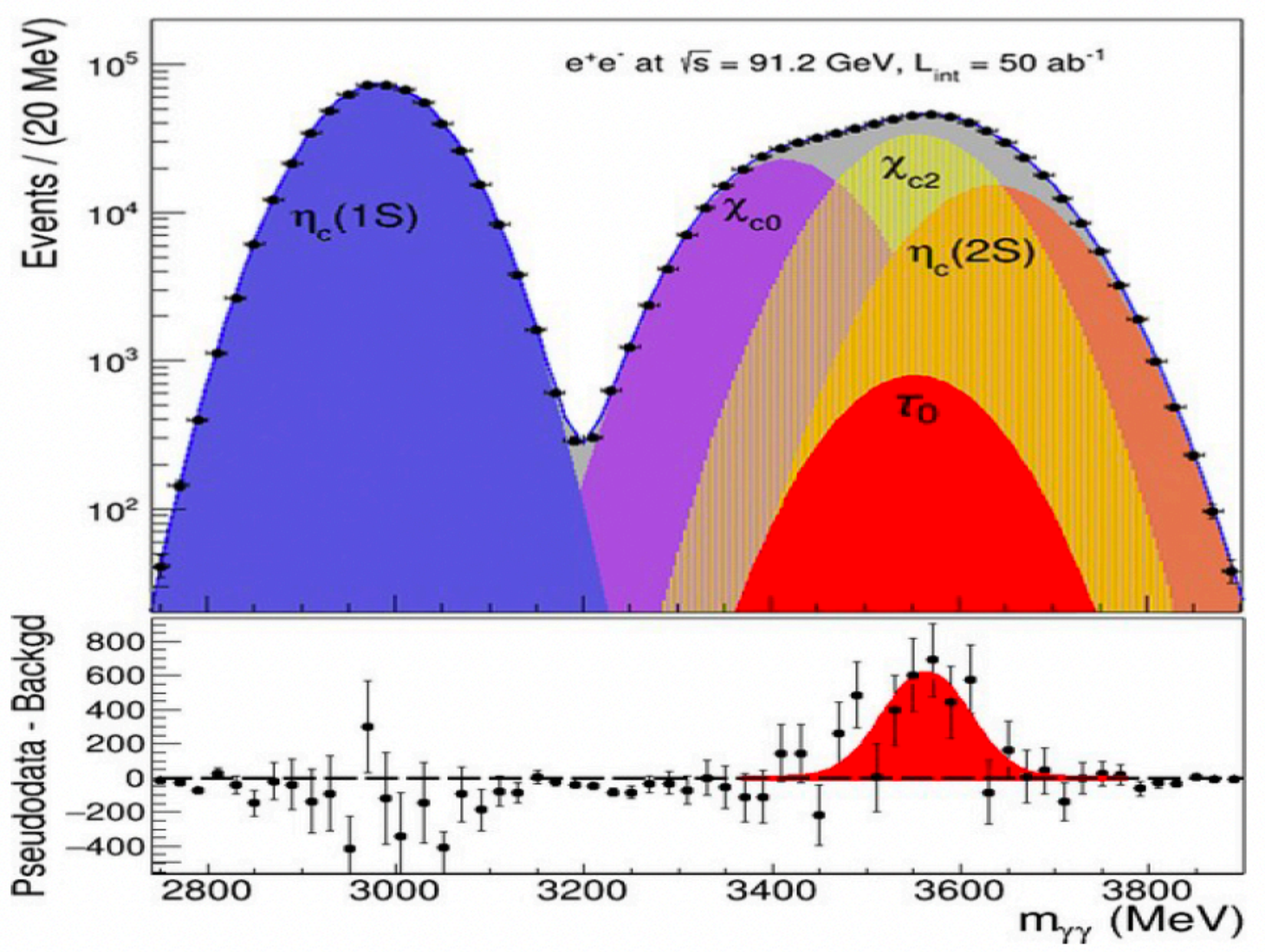
- Heaviest & most compact leptonic "atomic" system.
- Tests of bound QED & CPT symmetries at high mass.
- Ultra-precise τ mass extraction via $e^+e^- \rightarrow \tau_1\mu^+\mu^-$.

Para-ditauonim: Example observable via γγ fusion at high lumi e^+e^- colliders.

$m_{\gamma\gamma}$ fit stat. significance:
- Belle II, FCC-ee : 3σ , 5σ.

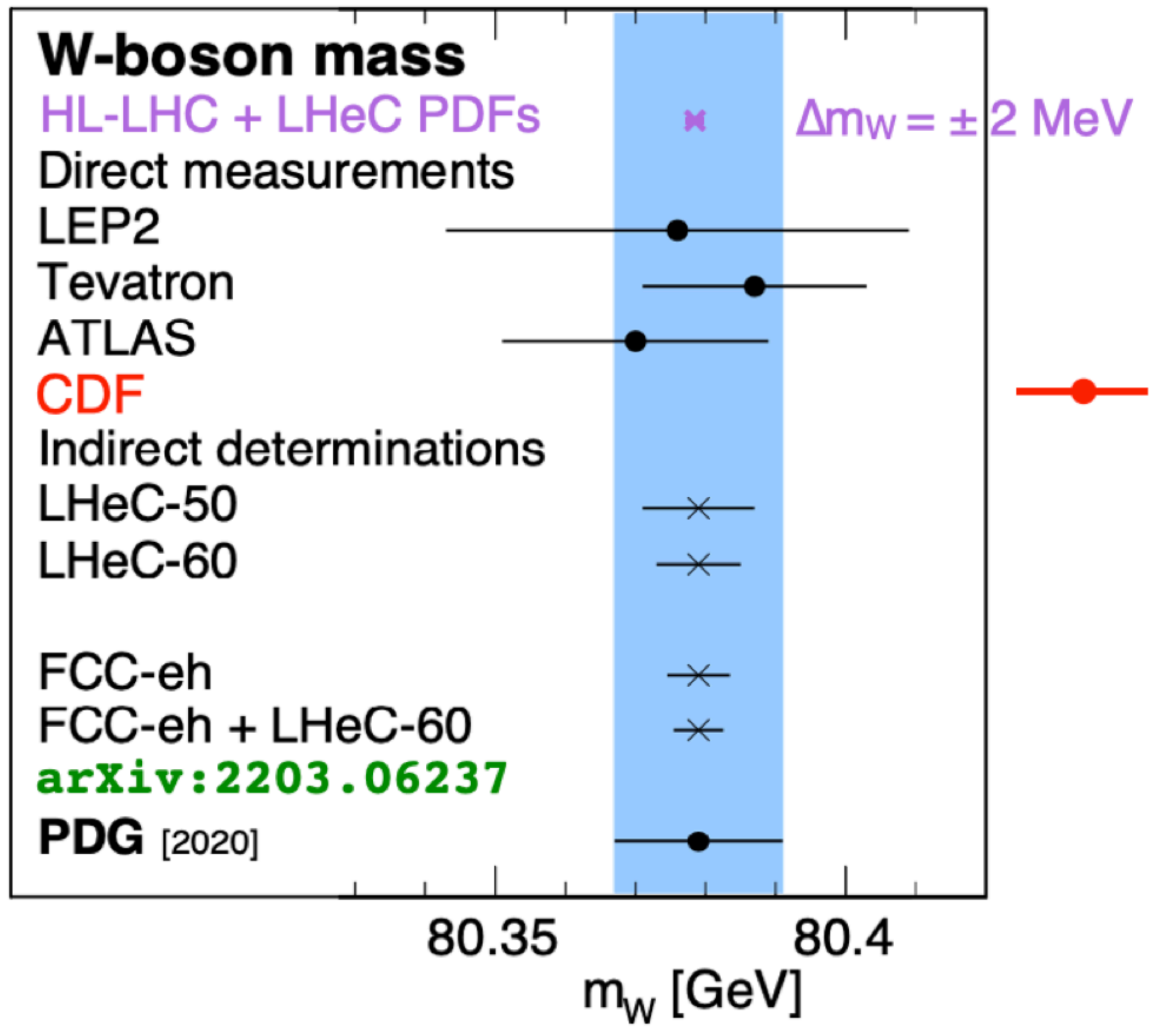


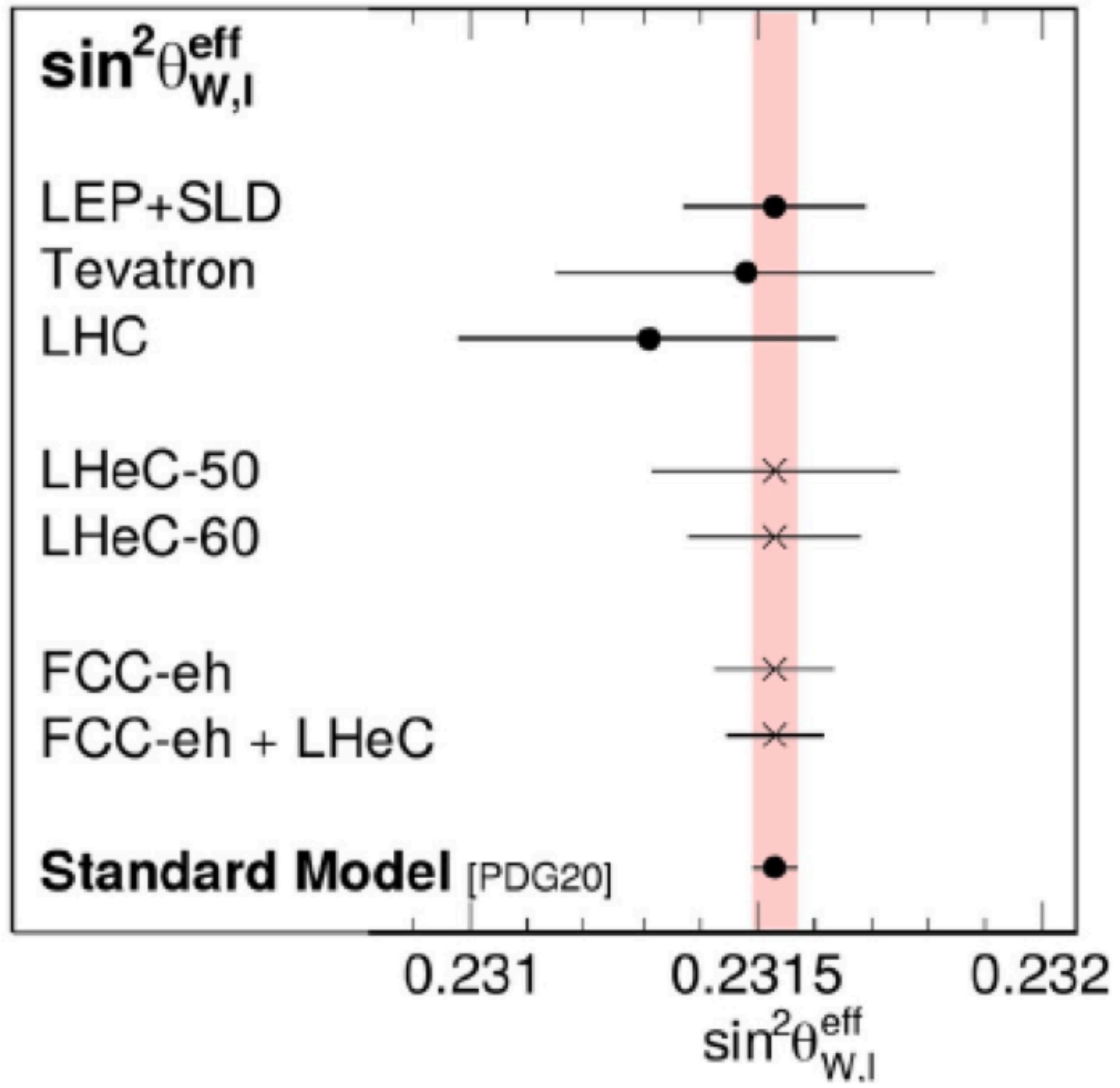
Para- ($J^{PC} = 0^{-+}$)



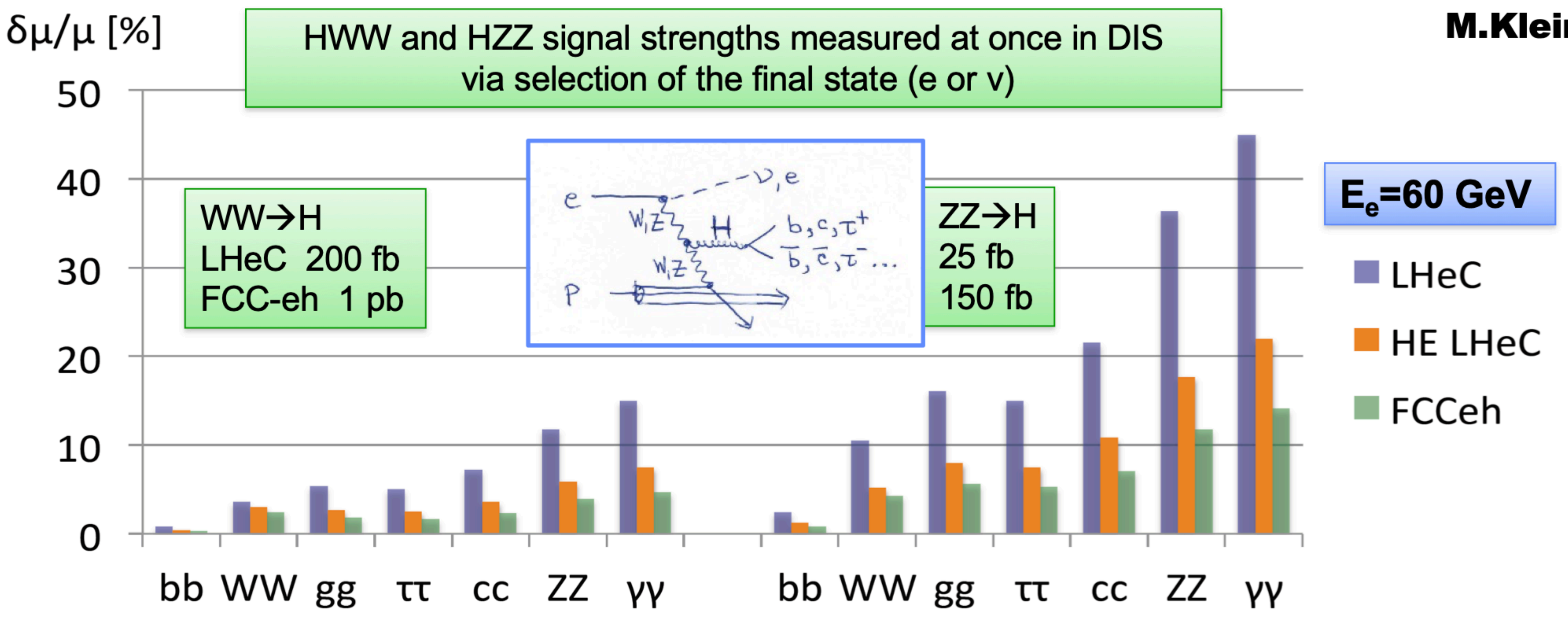
LHeC

Precision & BSM





M.Klein

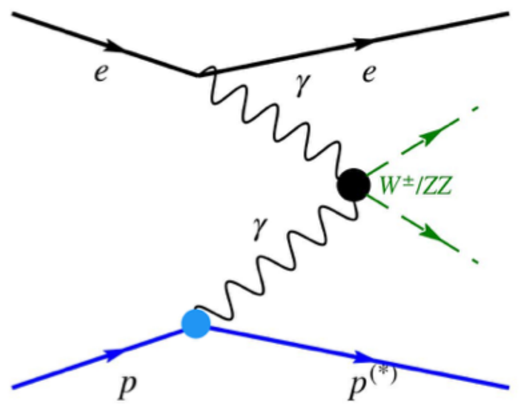


submitted to EU strategy CERN-ACC-Note-2018-0084

Bruce Mellado

Nestor Armesto

Also nice opportunities for γγ collisions

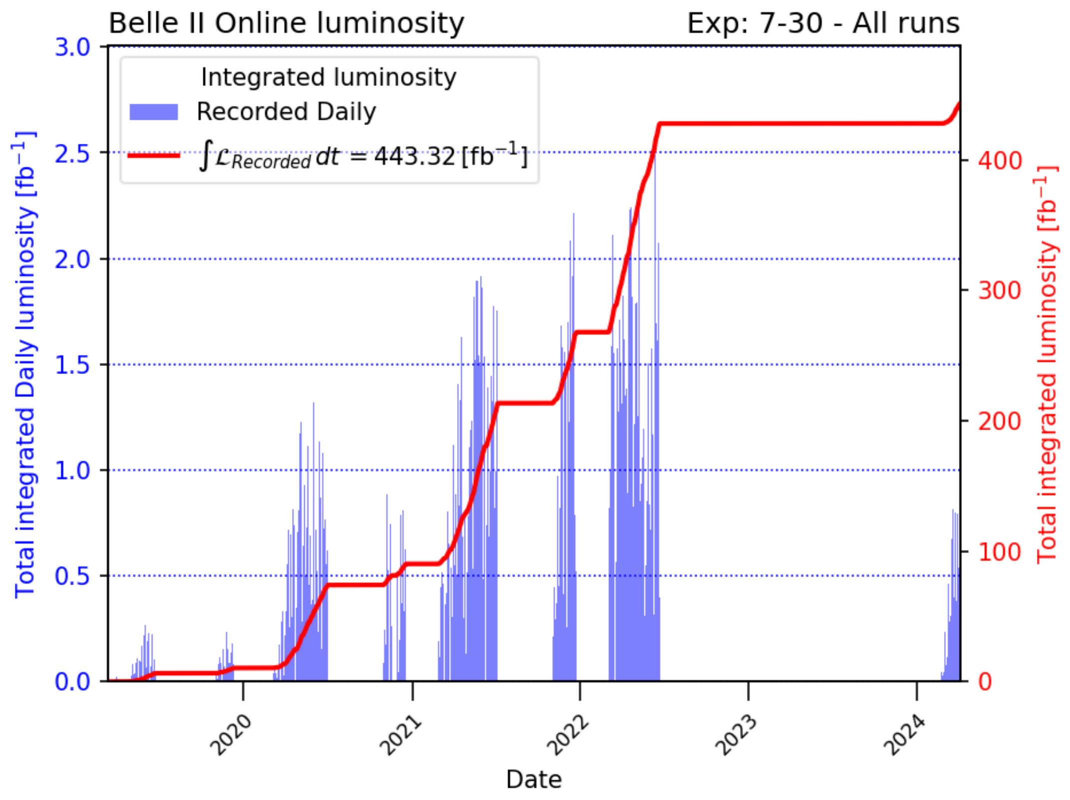


Hamzeh Khanpour

Rich Programme in precision physics, EW, top, Higgs and BSM physics

Belle II results Youngjoon Kwon

Belle II has collected over 0.4 ab^{-1} data sample in its first 3 years of operation before LS1, and started Run 2 data taking in Feb. this year.



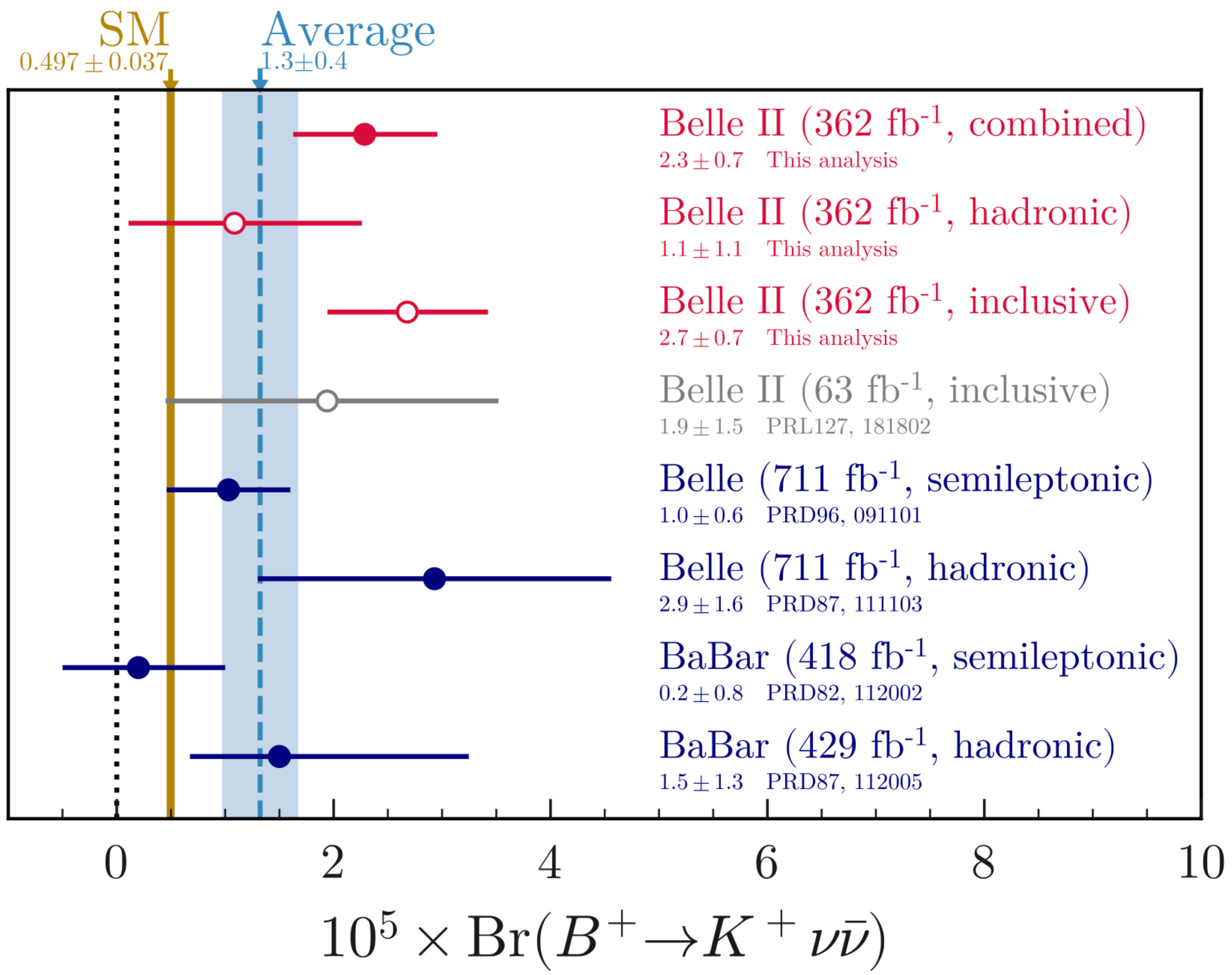
Inclusive test of LFU with B ➞ Xτν:

$$R(X_{\tau/\ell}) = \frac{\mathcal{B}(B \to X\tau\nu)}{\mathcal{B}(B \to X\ell\nu)}$$

$$R(X_{\tau/\ell}) = 0.228 \pm 0.016 \pm 0.036$$

Consistent with SM: 0.223 ± 0.005

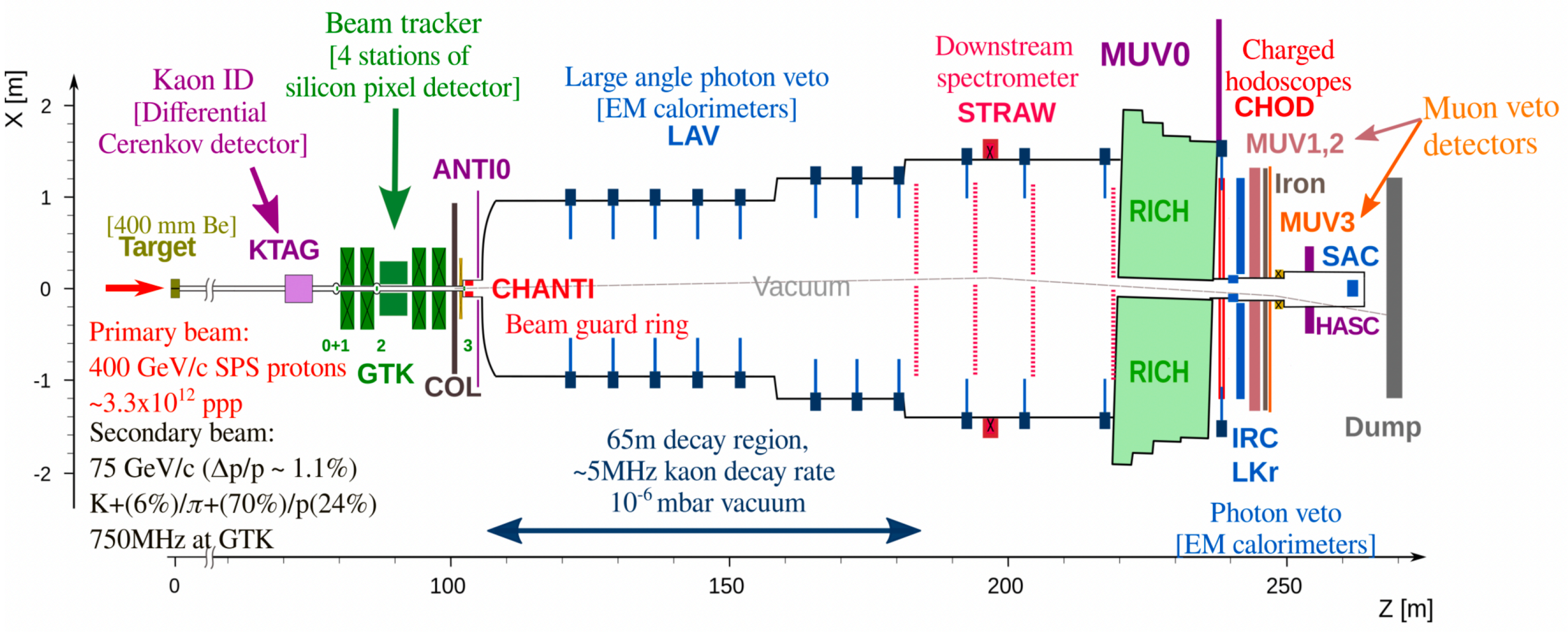
First evidence for $B^+ \to K^+ \nu\nu$:



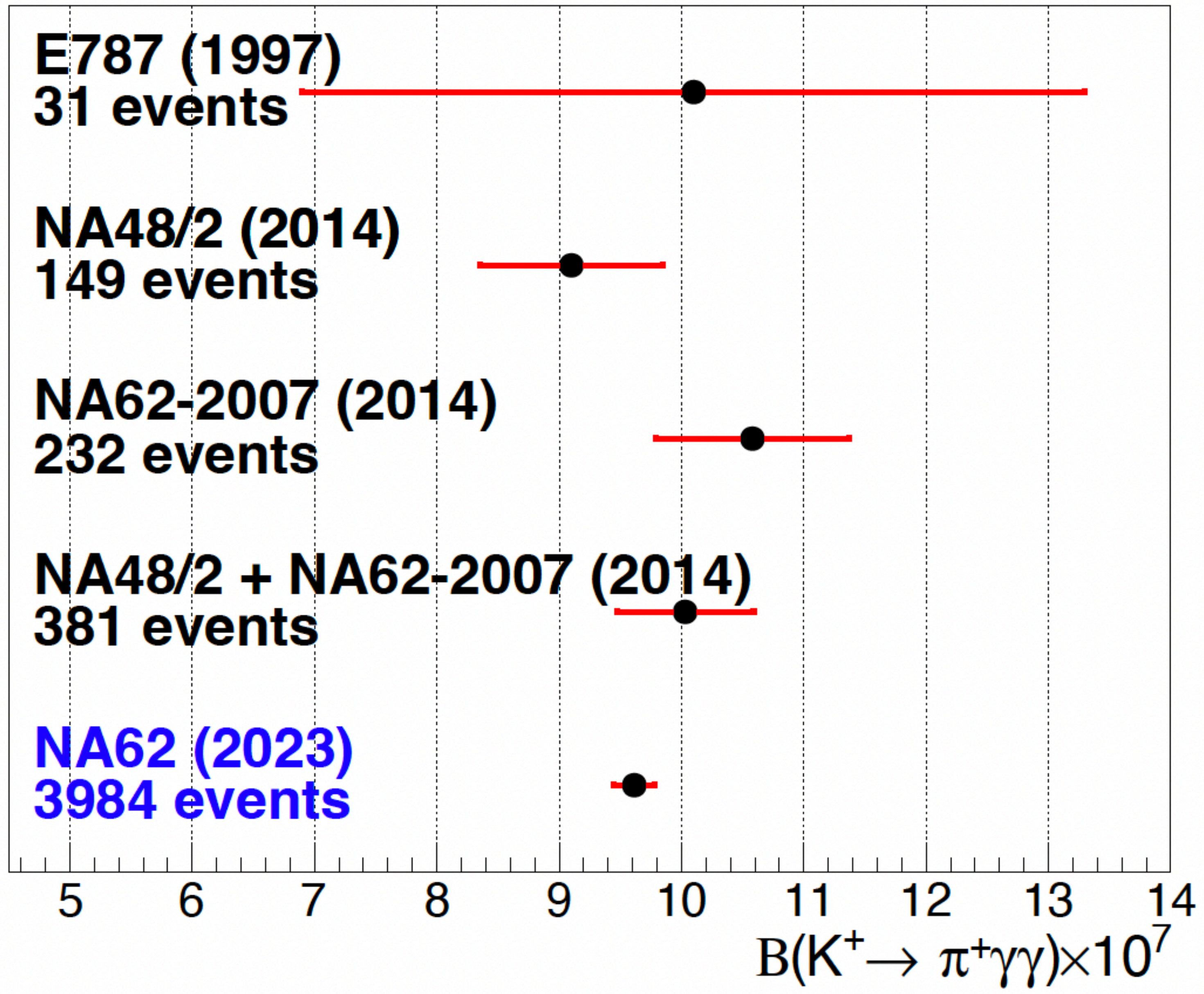
NA62 precision measurements

Petre Boboc

Fixed target experiment at CERN



$K^+ \rightarrow \pi^+\gamma\gamma$:



Also performed a peak search for ALPs: $K^+ \rightarrow \pi^+ a$, $a \rightarrow \gamma\gamma$

$\pi^0 \rightarrow e^+e^-$: New preliminary measurement.

$$\mathcal{B}_{\text{NA62}}(\pi^0 \to e^+e^-(\gamma), x > 0.95) = (5.86 \pm 0.30_{\text{stat}} \pm 0.11_{\text{syst}} \pm 0.19_{\text{ext}}) \times 10^{-8} = (5.86 \pm 0.37) \times 10^{-8}$$

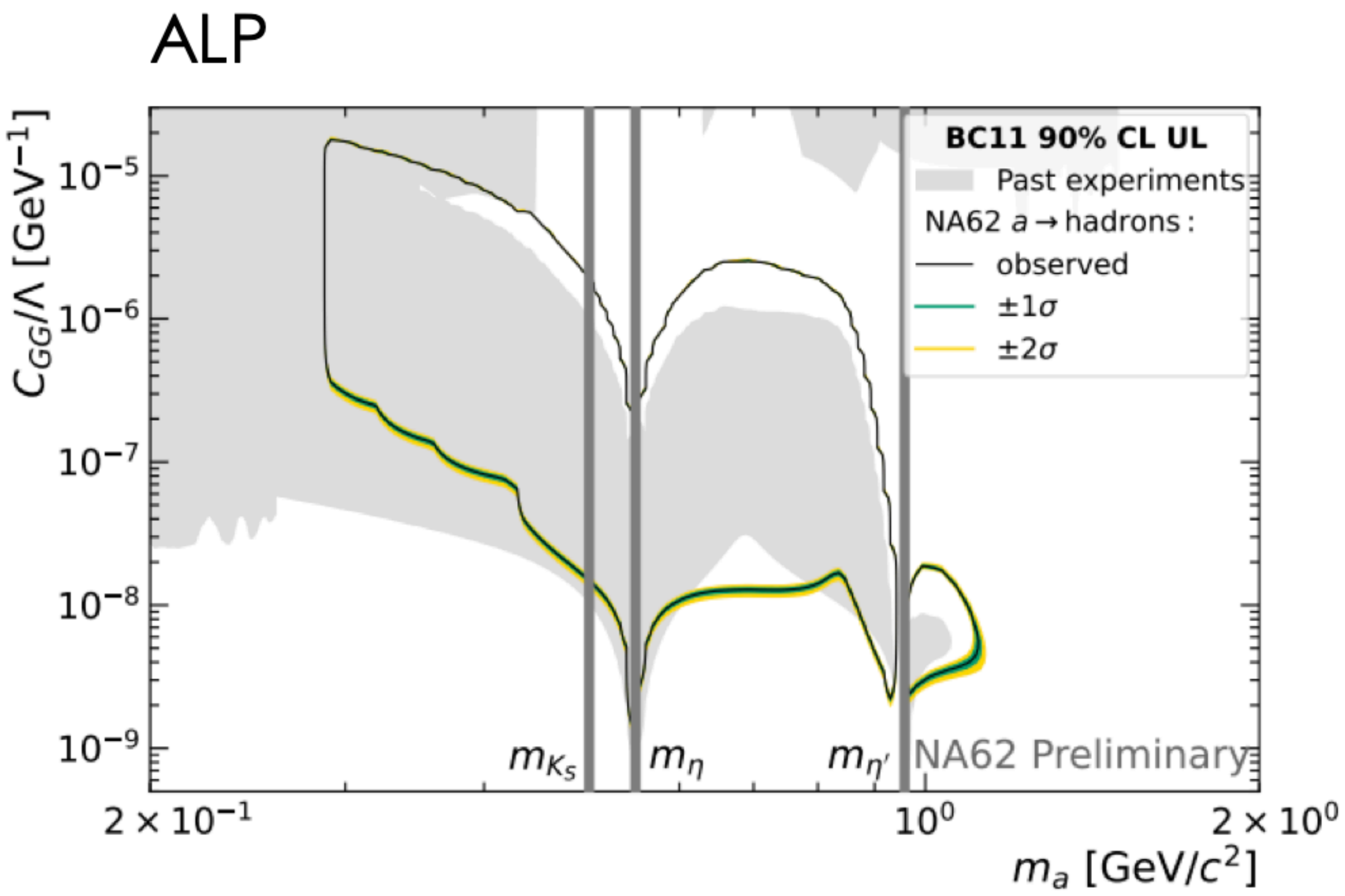
NA62: Exotic decays in beam dump mode

Alina Kleimenova

Search in hadronic final states:

Target is removed.

- Complementary to LHC and indirect searches.
- Smaller masses, lower couplings accessible.
- Models: ALPs, dark photons, dark Higgs.



Marco Ceoletta

NA62: LF/LN violation, hidden sectors

Marco Ceoletta

Powerful probe for BSM physics.

Rich rare and exotic decays program.

Type	Process	Prev. UL	NA62 UL	Improvement
LNV/LFV	$K^+ \to \mu^- \nu e^+ e^+$	$< 2.1 \times 10^{-8}$	$< 8.1 \times 10^{-11}$	$\mathcal{O}(10^2)$
LNV/LFV	$K^+ \to e^- \nu \mu^+ \mu^+$	—	$\sim 2 \times 10^{-11}$	—
LNV	$K^+ \to \pi^- \mu^+ \mu^+$	$< 8.6 \times 10^{-11}$	$< 4.2 \times 10^{-11}$	2 (w/30% Run1)
LNV	$K^+ \to \pi^- e^+ e^+$	$< 6.4 \times 10^{-10}$	$< 5.3 \times 10^{-11}$	$\mathcal{O}(10)$
LNV	$K^+ \to \pi^- \pi^0 e^+ e^+$	—	$< 8.5 \times 10^{-10}$	**FIRST SEARCH!**
LNV	$K^+ \to \pi^- \pi^0 \mu^+ e^+$	—	—	—
LNV	$K^+ \to \pi^- \mu^+ e^+$	$< 5.0 \times 10^{-10}$	$< 4.2 \times 10^{-11}$	$\mathcal{O}(10)$
LFV	$K^+ \to \pi^+ \mu^- e^+$	$< 5.2 \times 10^{-10}$	$< 6.6 \times 10^{-11}$	$\mathcal{O}(10)$
LFV	$\pi^0 \to \mu^- e^+$	$< 3.4 \times 10^{-9}$	$< 3.2 \times 10^{-10}$	$\mathcal{O}(10)$
LFV	$K^+ \to \pi^+ \pi^0 \mu^- e^+$	—	—	—
LFV	$K^+ \to \pi^+ \mu^+ e^-$	$< 1.3 \times 10^{-11}$	—	—
LFV	$\pi^0 \to e^- \mu^+$	$< 3.8 \times 10^{-10}$	—	—

- Thanks to all the speakers
- Thanks to everyone attending the session
- Thanks to the organisers