Search for rare processes and lepton-flavor-violating decays of Higgs boson at the ATLAS experiment

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on behalf of the ATLAS Collaboration

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Introduction

- Since the Higgs discovery in 2012 at the LHC, a new era began for testing the Standard Model (SM) and its limits.
- **Rare decays**, such as H → μμ/ee and H → Zγ, offer sensitive tests of the Higgs couplings.
- **Lepton-flavor-violating (LFV)** Higgs decays are forbidden in the SM, but suggested by neutrino oscillations and predicted by several **BSM models**.
  - Can these decays **reveal signs of new physics**?
  - What do **precision measurements** tell us about **Yukawa couplings** and **loop-level processes**?

What answers can Higgs decays to 1st and 2nd generation leptons provide?

Can we confirm Standard Model (SM) couplings?

- Higgs decays to muons offer a direct probe of the muon Yukawa coupling
- $BR(H \rightarrow \mu^+\mu^-) \approx 2.18 \times 10^{-4}$
  → Most promising 2nd-generation decay channel at the LHC
- $BR(H \rightarrow e^+e^-) \approx 5.0 \times 10^{-9}$ (challenging at current luminosity)
- Couplings to 3rd-generation fermions are established; 2nd-generation Yukawa couplings not yet conclusively measured
- Precise measurement of $H \rightarrow \mu^+\mu^-$ tests SM prediction.

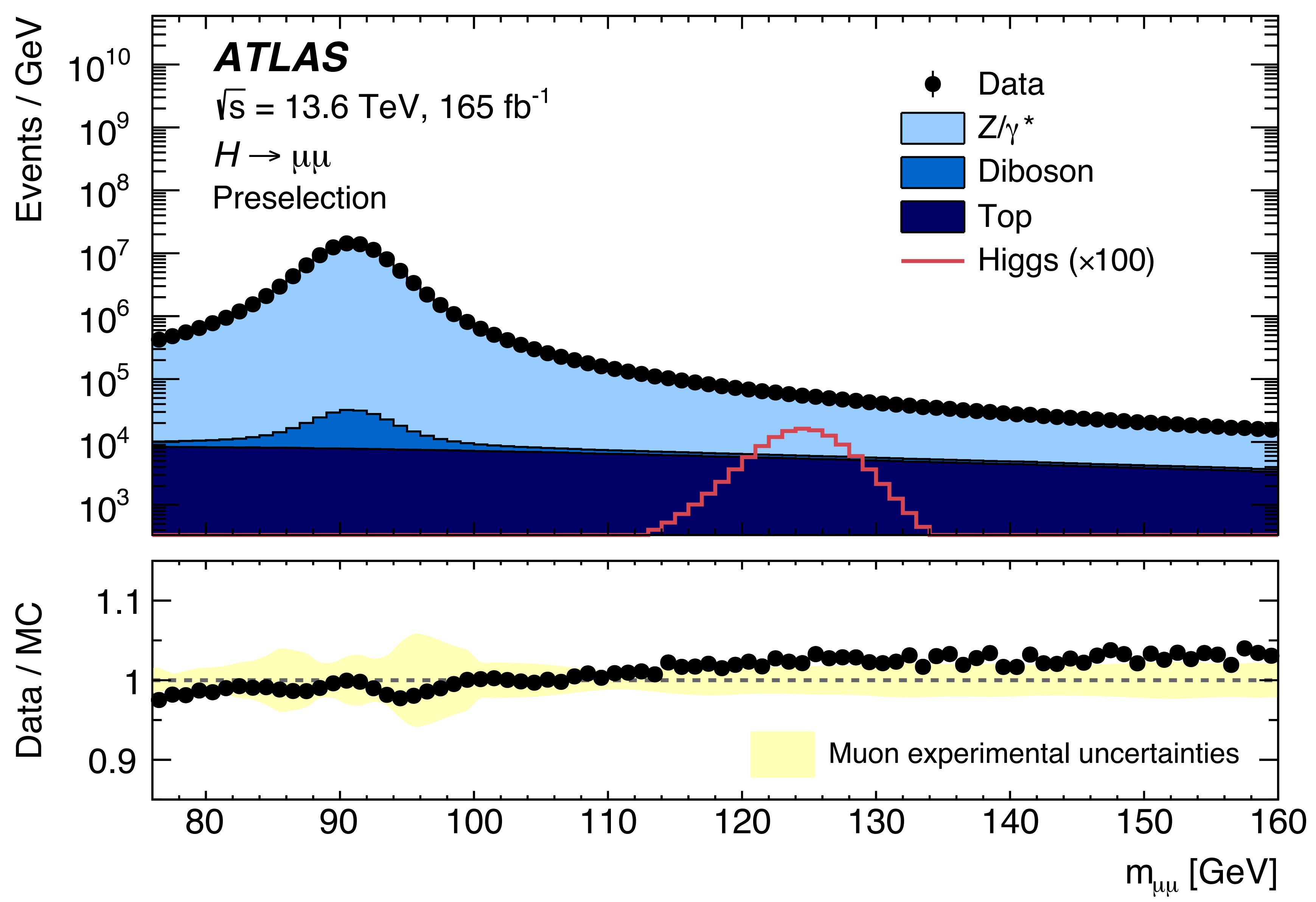
Any indication of Beyond Standard Model (BSM)?

- Are measured rates consistent with SM expectations?
- Enhanced or suppressed $BR(H \rightarrow \mu\mu)$ can arise from loop-level effects or new particles?
- **Precision measurements** can help constrain BSM parameter space

H → μ⁺μ⁻: ATLAS Run 2 + Run 3 NEW!

Status with Run 2 data for H → $\mu^+\mu^-$:

- **ATLAS**: observed (expected) significance **2.0σ** (1.7σ)
- **CMS**: observed (expected) significance **3.0σ** (2.5σ)



Challenge: Rare signal and huge background — signal to background ratio ~ 0.2%

Refined Strategy:

✓ Improved muon reconstruction & mass resolution

✓ Stronger signal–background separation

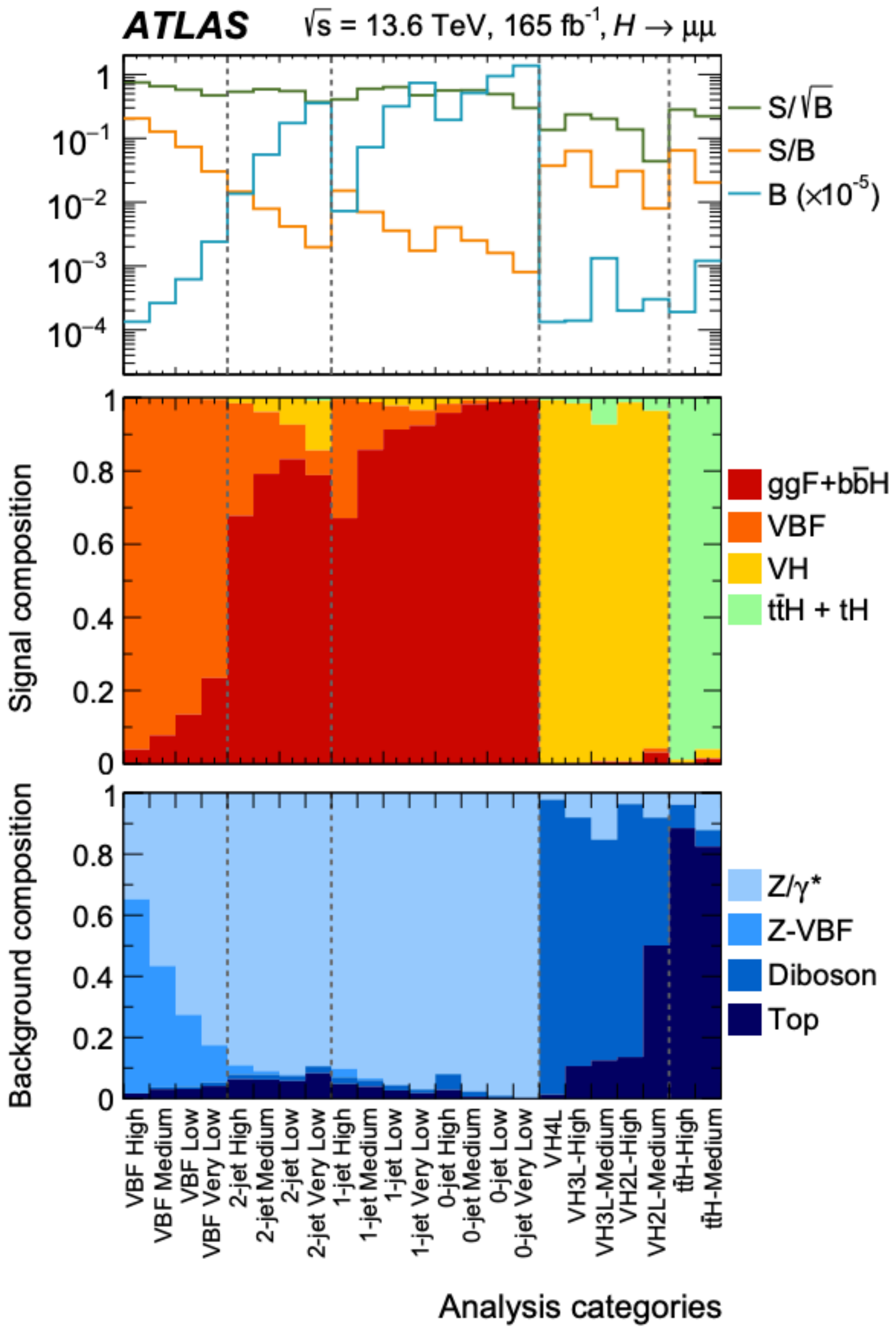
✓ More robust background modelling: 5B fully simulated events

✓ Expanded phase space coverage (including VH-2ℓ and ttH fully hadronic categories)

Key Enhancements:

- Increased statistics in data
- High-statistics NLO Drell–Yan simulation
- New event categories & better categorization with ML
- Refitting H → $\mu^+\mu^-$ primary vertex:
  - More precise d_0 reduces its correlation impact with $m_{\mu\mu}$
  - 1.8% improvement on mass resolution - NEW in Run3
- Including radiation from muons - improvement on mass resolution!

H → μ⁺μ⁻: ATLAS Run 2 + Run 3 NEW!



Event Categorization Strategy

- Events are split into **23 exclusive categories** optimized for different Higgs production modes: **ggF, VBF, VH, ttH**
- Categorization exploits **topology and kinematics** using ML tools:
  - – **BDTs** (XGBoost)
  - – **NNs** (Keras/TensorFlow) for *ttH*
  - – **TMVA** for *4ℓ VH* category
- Training uses **final-state kinematics** and object relationships
- Category boundaries optimized for **maximum signal sensitivity**

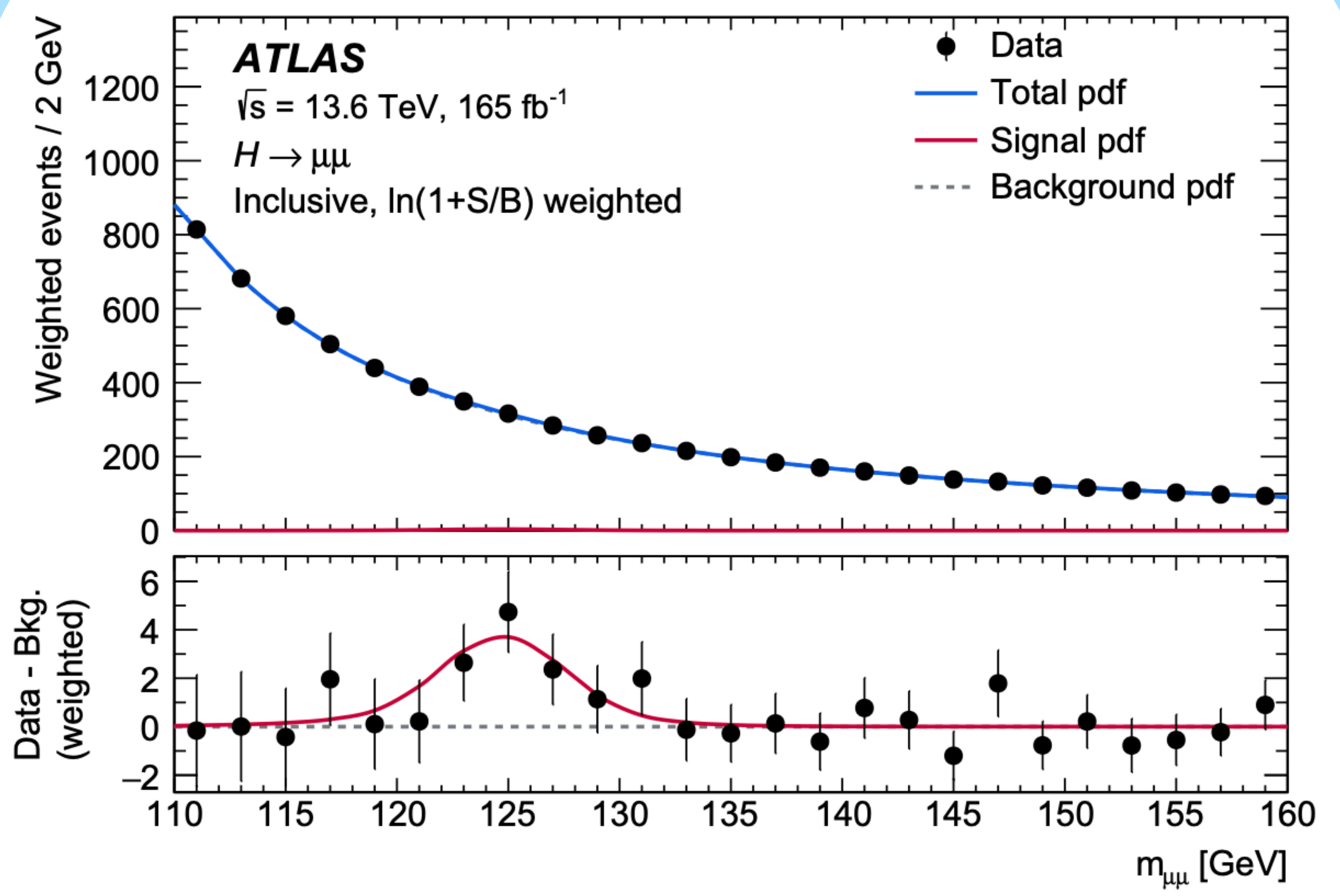
A **simultaneous signal+background fit on the $m_{\mu+\mu-}$** spectrum with analytic function among all categories:

- **Signal:** double-sided Crystal Ball function.
- **Background:** Core × empirical function:
  - Smeared with detector resolution
  - Used full-simulated NLO samples
  - Improved core function with accurate dimuon resolution

$H \to \mu^+\mu^-$: results

NEW!

Run 3



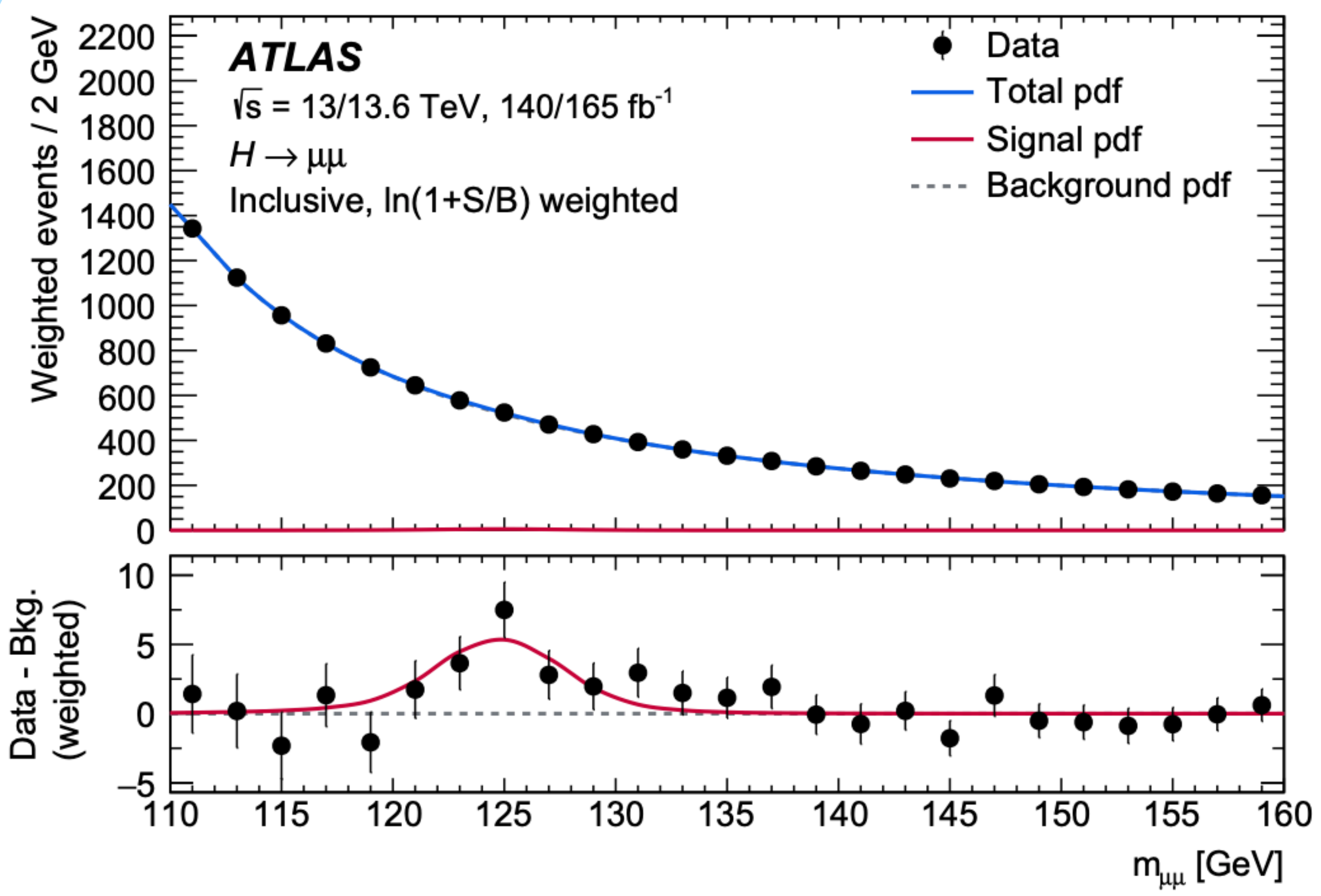
μ **= 1.6 ± 0.6** $= 1.6^{+0.6}_{-0.5}$ (stat) ± 0.2 (syst)

Observed (expected) **significance 2.8σ (1.8σ)**

Compatibility between Run2 and Run3: 68%

Sensitivity improvement mostly driven by Increased statistics.

Run 2 + Run 3



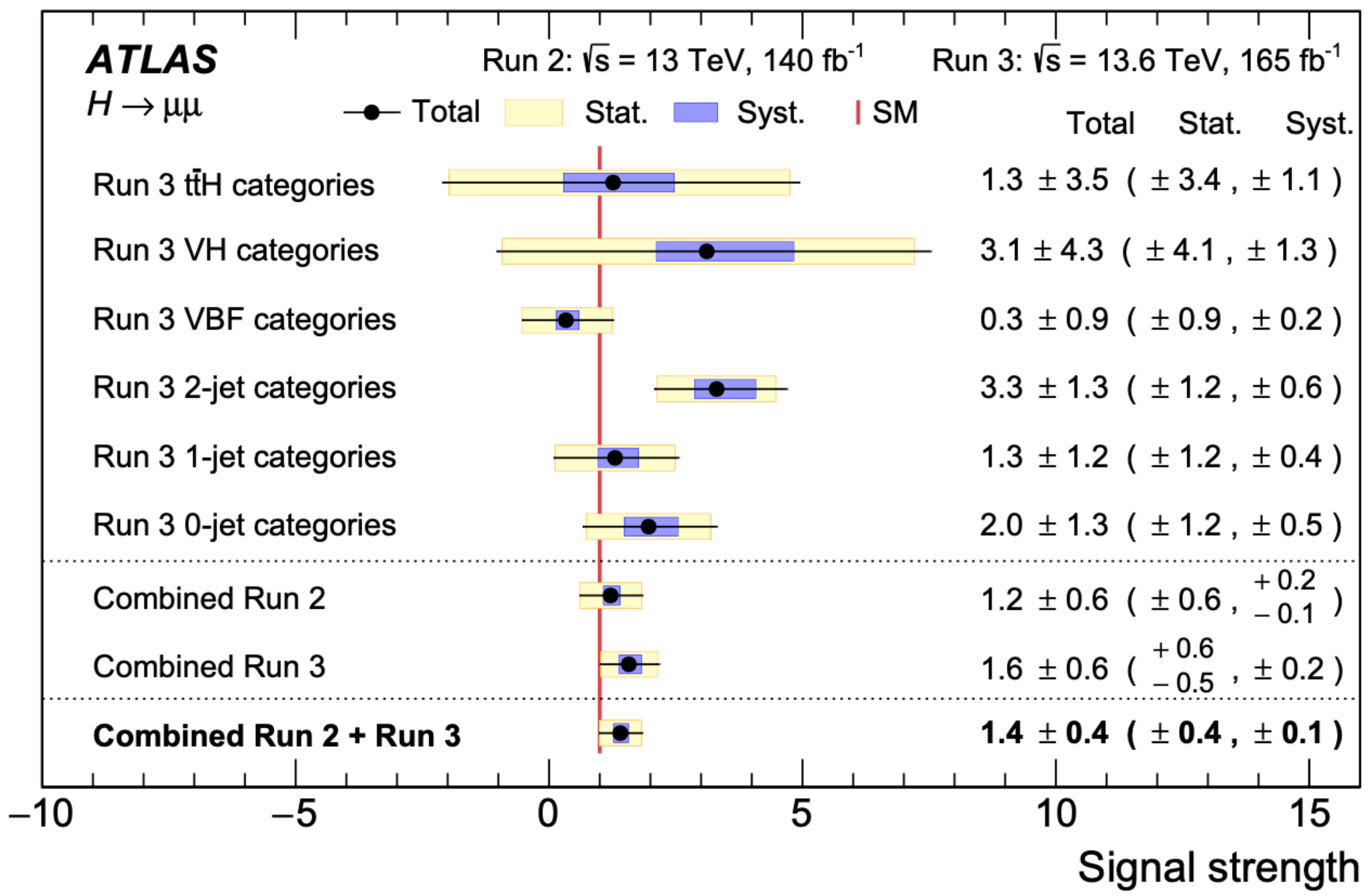
μ **= 1.4 ± 0.4** = 1.6 ± 0.4 (stat) ± 0.1 (syst)

Observed (expected) **significance 3.4σ (2.5σ)**

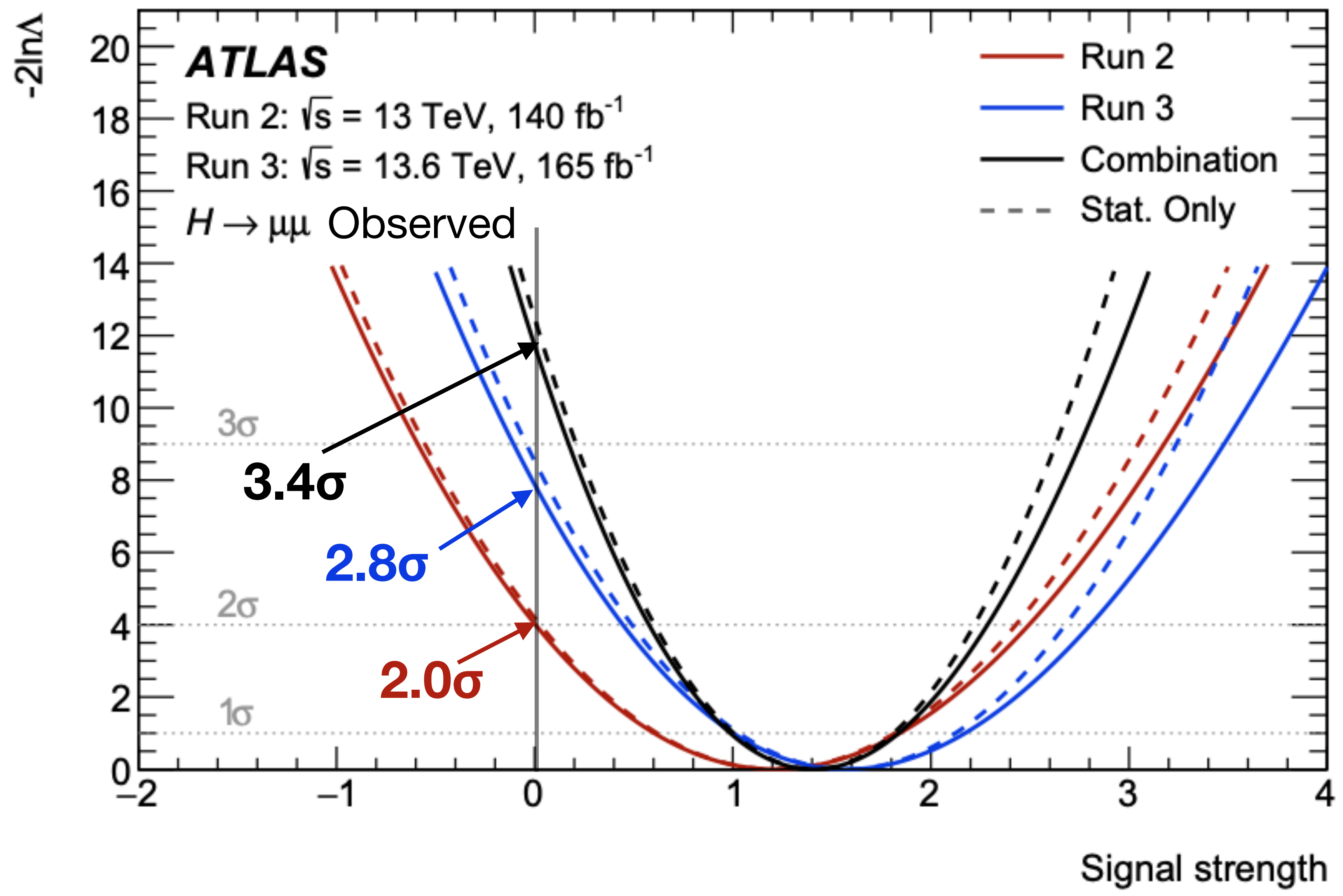
Sensitivity improves by ~50% w.r.t Run 2 results.

Evidence of $H \to \mu^+\mu^-$ decay!

Observed



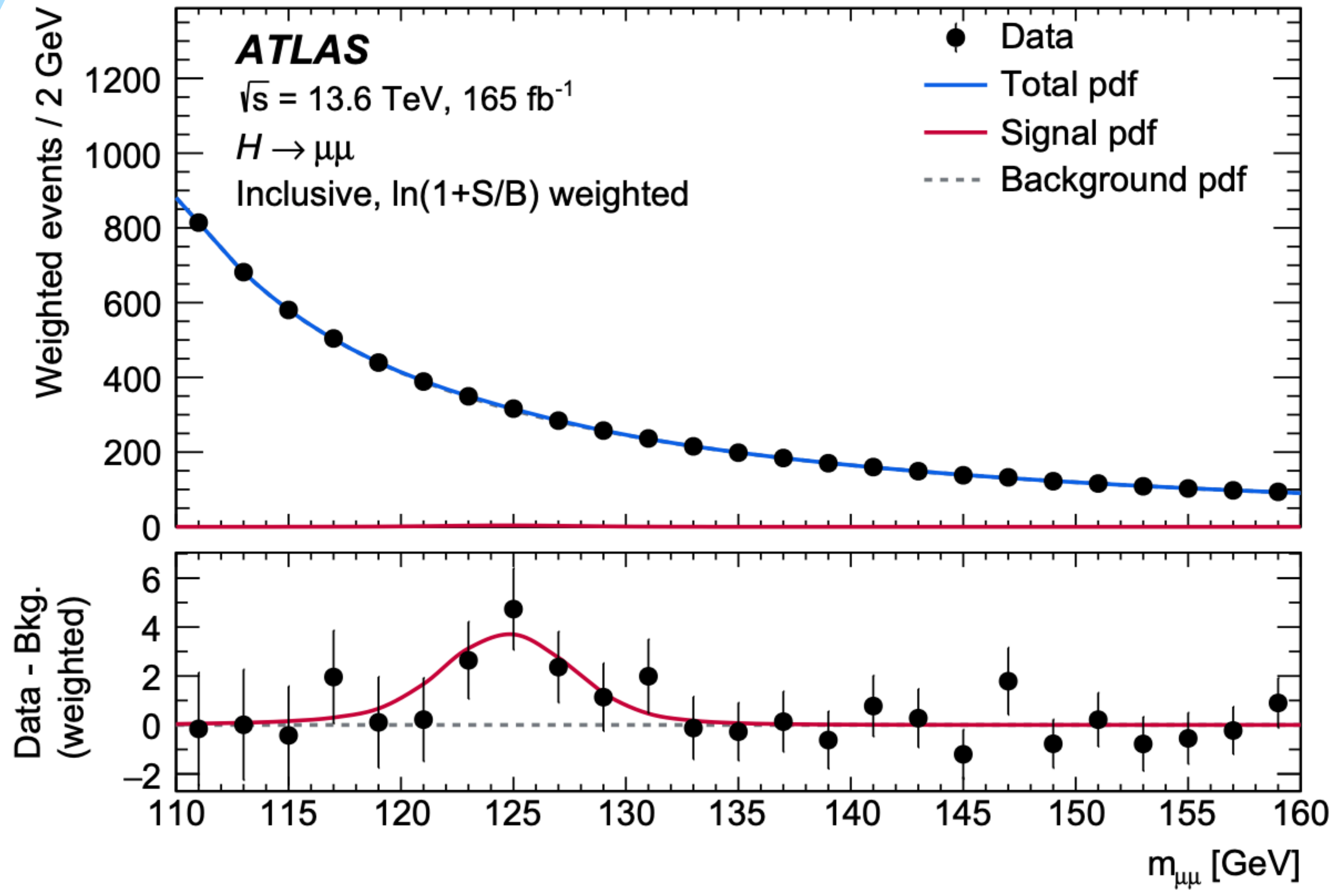
Profile likelihood scan of signal strength



H → μ⁺μ⁻: results

NEW!

Run 3



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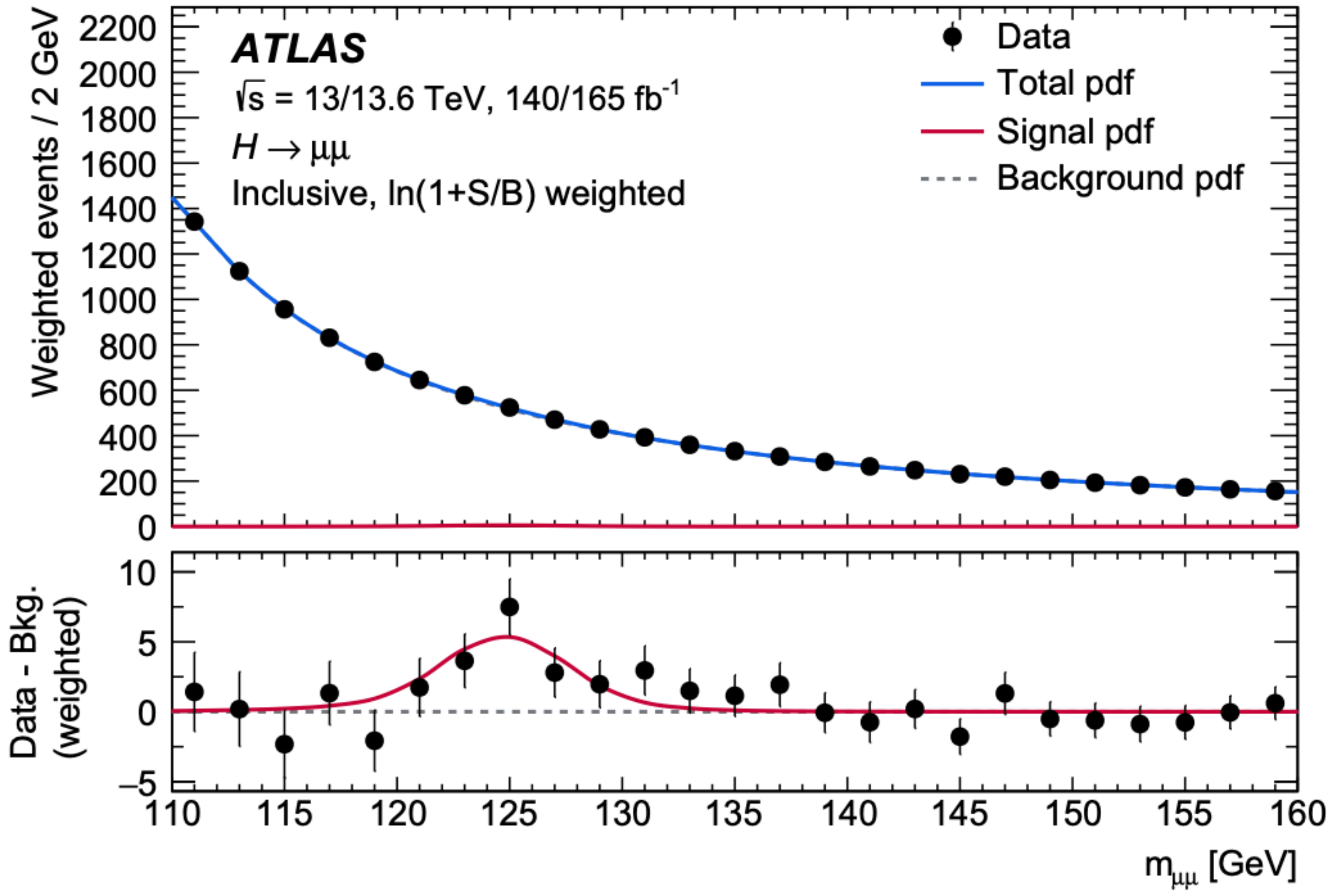

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Evidence of H → μ⁺μ⁻ decay!

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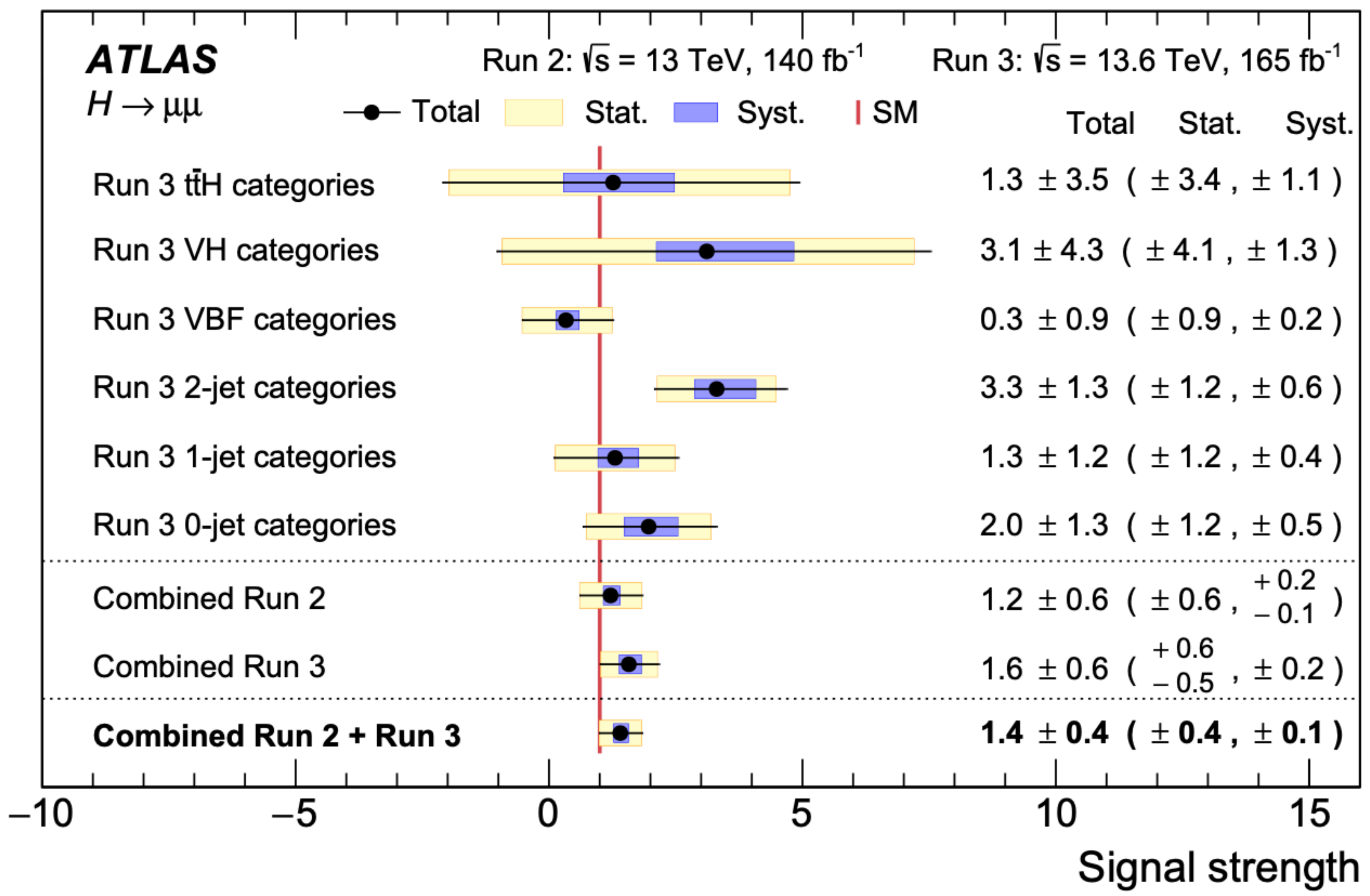

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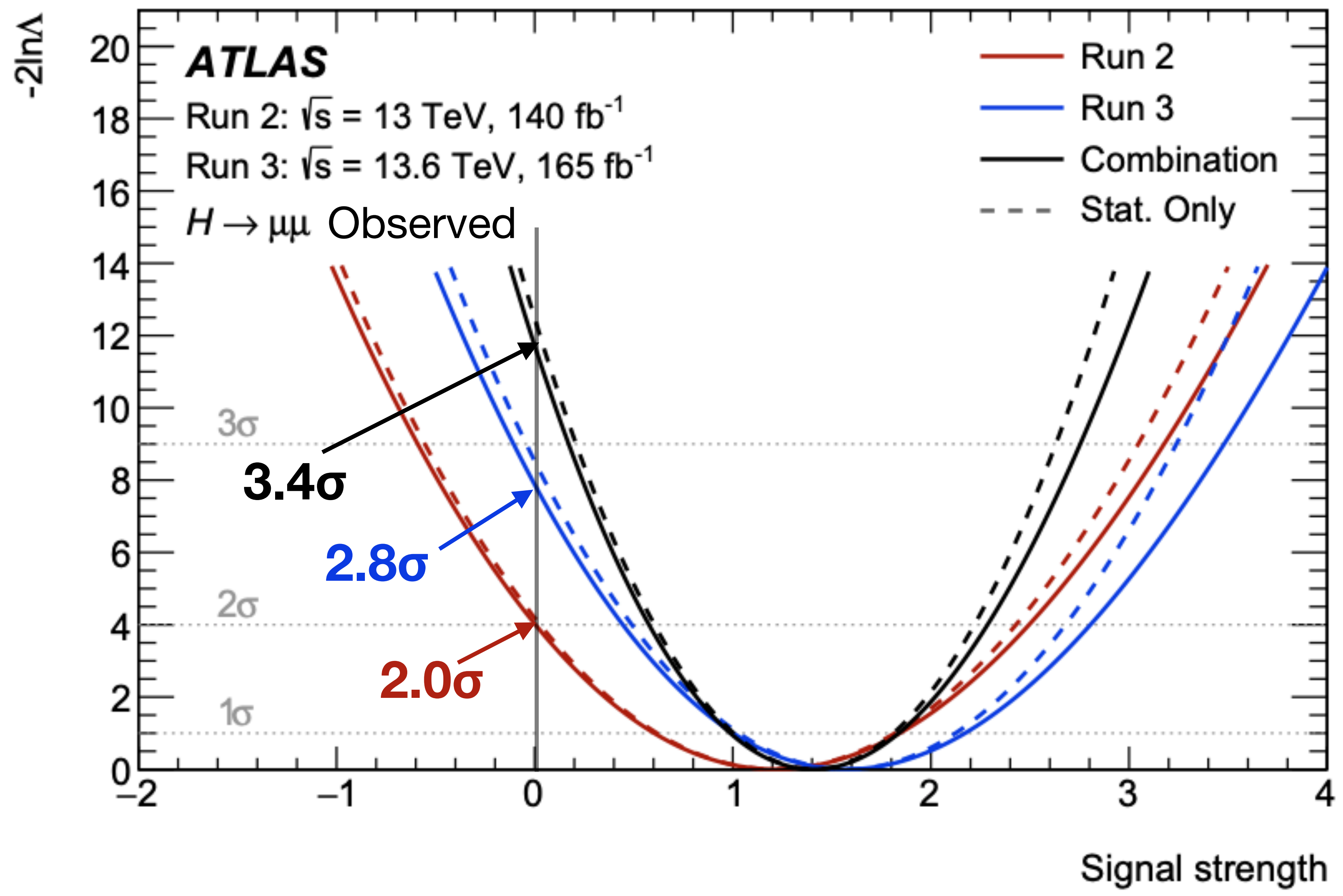


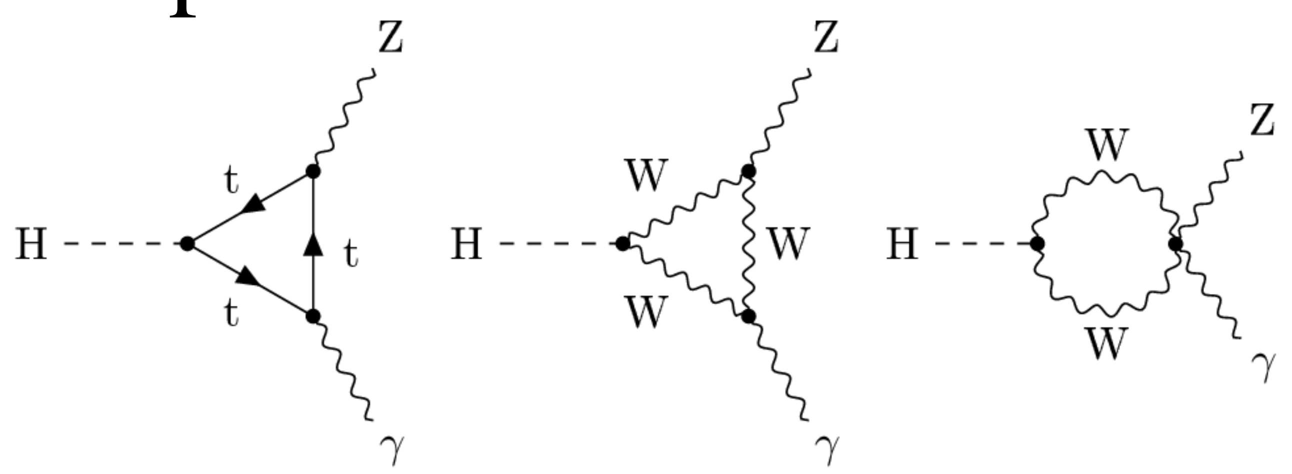

ATLAS
EXPERIMENT
Run: 484466
Event: 3913031636
2024-09-13 05:46:24 CEST
μ
μ
Event candidate:
$H \rightarrow \mu^+\mu^-$

Link

What can the rare H → Zγ decay tell us?

Within the Standard Model:

- Is the observed rate consistent with SM expectations?
- SM predicts BR(H → Zγ) = $(1.54 \pm 0.09) \times 10^{-3}$
  - Similar in size to H → γγ $(2.27 \pm 0.07) \times 10^{-3}$
- Can we observe this rare loop-induced decay and complete the picture of Higgs decays to electroweak bosons (γγ, ZZ*, WW*)?
- How precise can we measure this decay to test the SM loop structure?



Beyond the Standard Model:

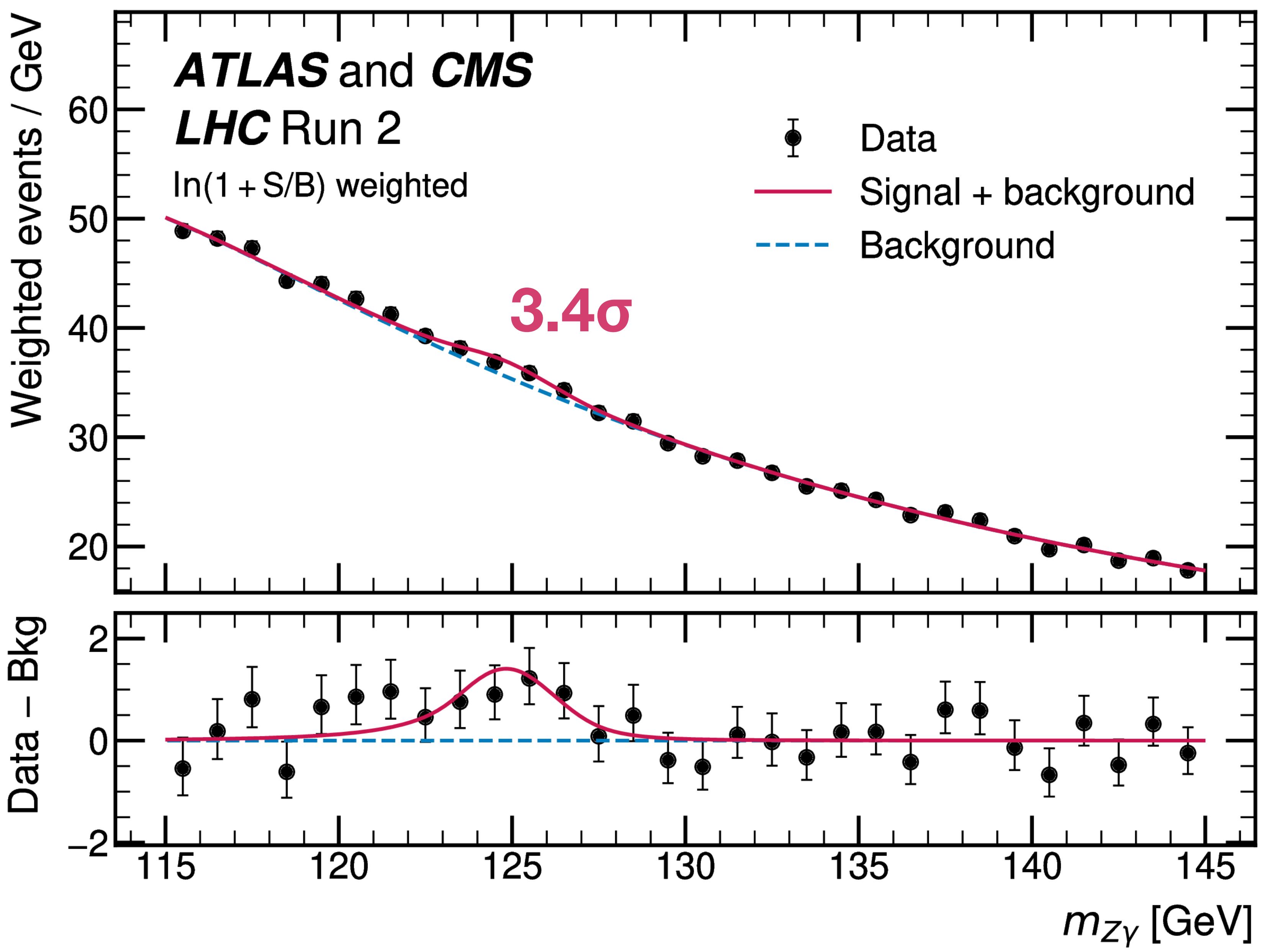
- Are there deviations from the SM prediction in BR(H → Zγ)?
- Could new particles (charged scalars, fermions, vector bosons) be running in the loop and modifying the decay rate?
- Does the ratio BR(H → Zγ) / BR(H → γγ) show anomalous behaviour?
- Could this point to composite Higgs scenarios or alternative symmetry-breaking mechanisms?

$H \to Z\gamma$: ATLAS + CMS - Run 2

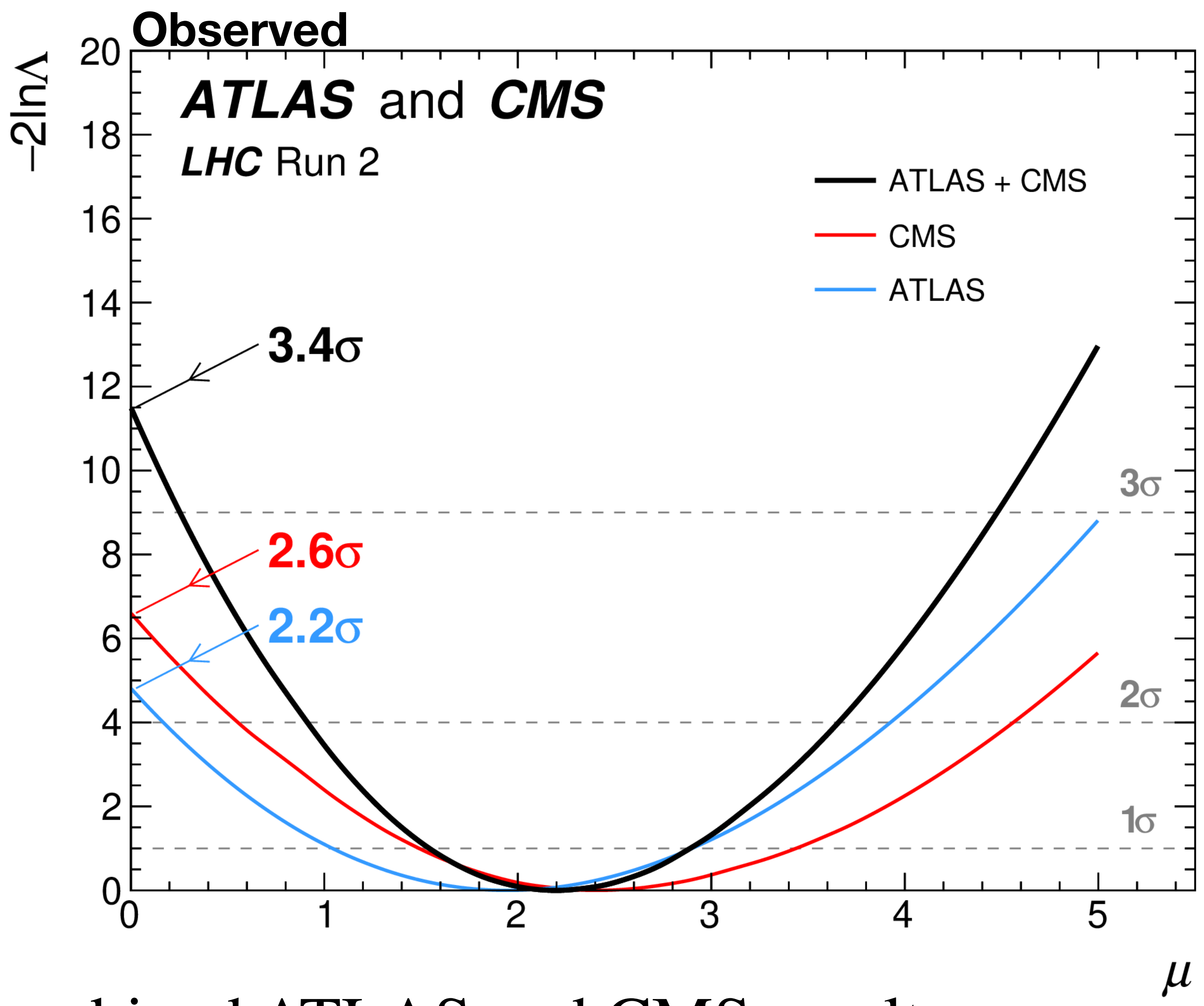
Status with Run 2 data for $H \to Z\gamma$: **Evidence** - combining ATLAS and CMS results!

Event Selection & Categorization:

- Focus on $Z \to e^+e^-/\mu^+\mu^-$ decays - good mass resolution & background rejection, but small BR (6.7%).
- **ATLAS**: 6 categories, including a VBF-enriched one using a BDT and others split by lepton type & $Z\gamma$ kinematics.



- **CMS**: 8 categories, with BDTs targeting VBF, associated production, and signal–background separation.
- Experimental uncertainties from ATLAS and CMS are treated as uncorrelated; theory (QCD & BR) uncertainties as correlated.



Combined ATLAS and CMS results:

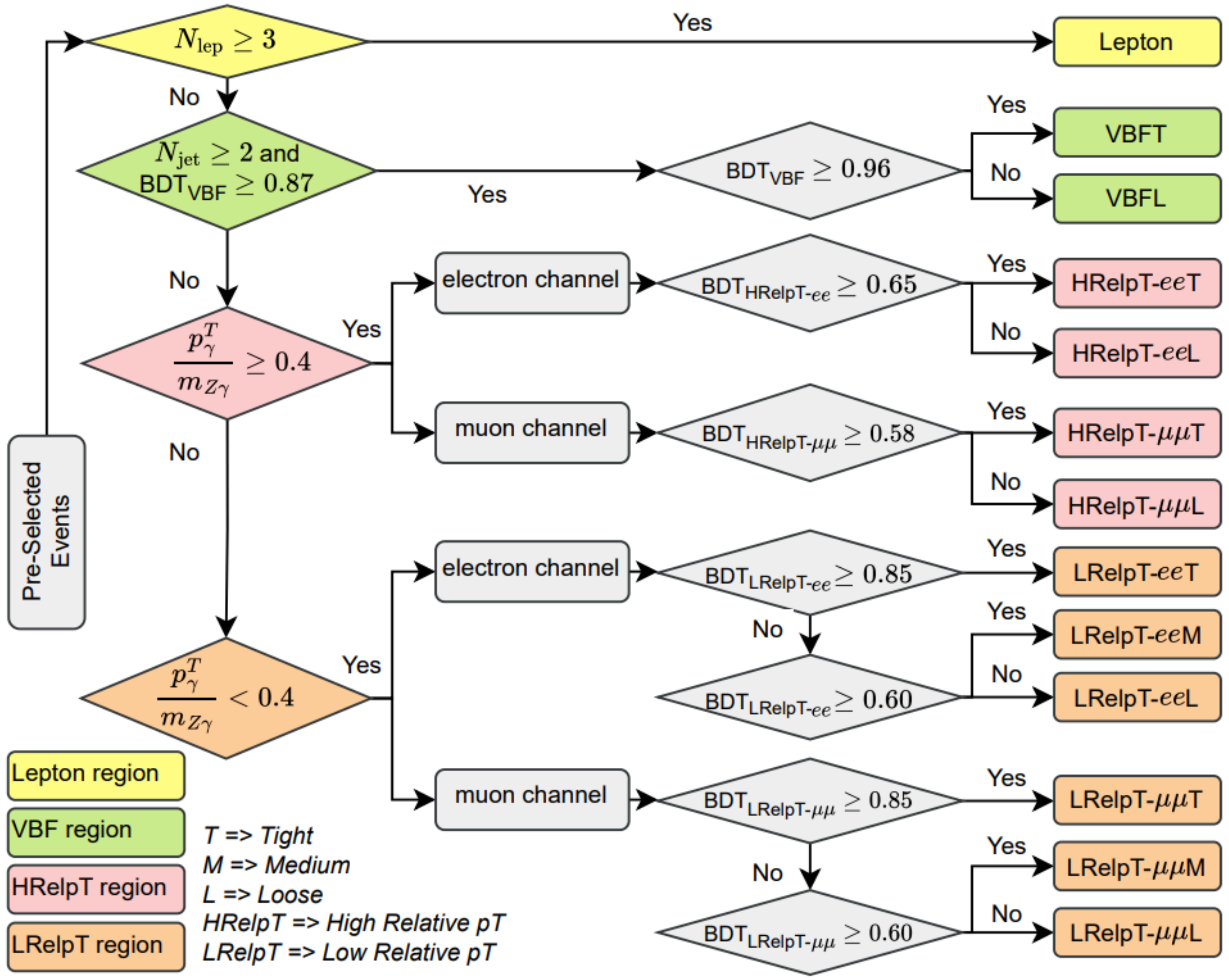
$\boldsymbol{\mu = 2.2 \pm 0.7} = 2.2 \pm 0.6\ (\text{stat})^{+0.3}_{-0.2}\ (\text{syst})$

Observed (expected) **significance 3.4σ (1.6σ)**

- ⋆ **ATLAS -** Observed (expected) significance 2.2σ (1.2σ)
- ⋆ **CMS -** Observed (expected) significance 2.6σ (1.1σ)

$H \rightarrow Z\gamma$: ATLAS - Run 2 + Run 3

NEW!



~15% sensitivity improvement

A **simultaneous signal+background fit on the** $ll\gamma$ mass spectrum with analytic function among all categories:

- **Signal:** double-sided Crystal Ball function.
- **Background:** function and fit range chosen to minimize spurious signal.

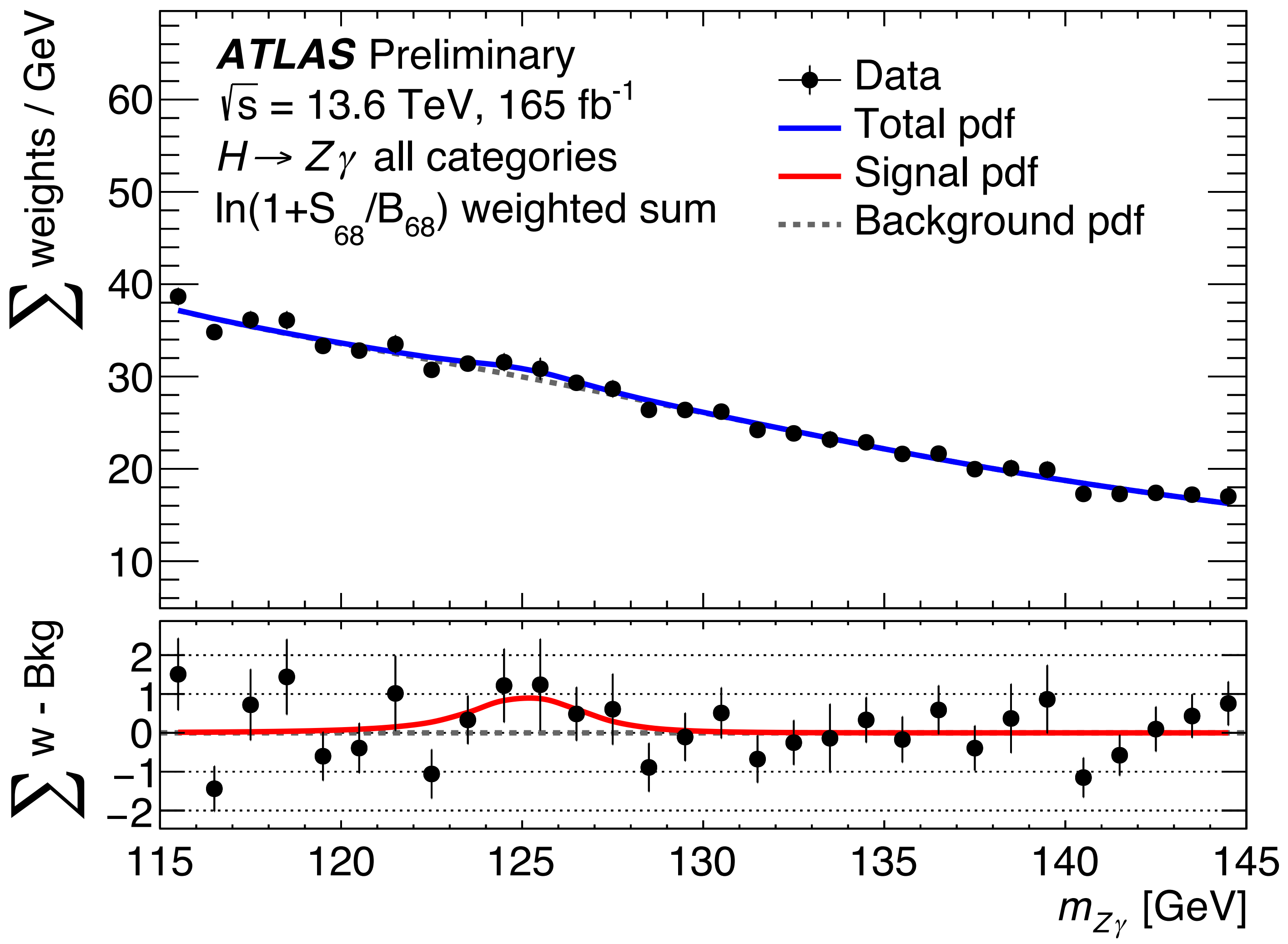
Main changes w.r.t. previous ATLAS Run2 search:

- Object threshold **selection optimization** - improve the signal efficiency
- Split into different regions for categorization **-** targeting all major production modes: ggF, VBF, VH, ttH.
- **Categorization** optimization: new lepton category, VBF re-optimization, MVA optimization with low-relative pT and high relative pT separation (in total: 13 categories).
- Including partial ATLAS Run3 data (2022+2023+2024) of $165 fb^{-1}$

~30% sensitivity improvement

$H \to Z\gamma$: ATLAS - Run 2 + Run 3 NEW!

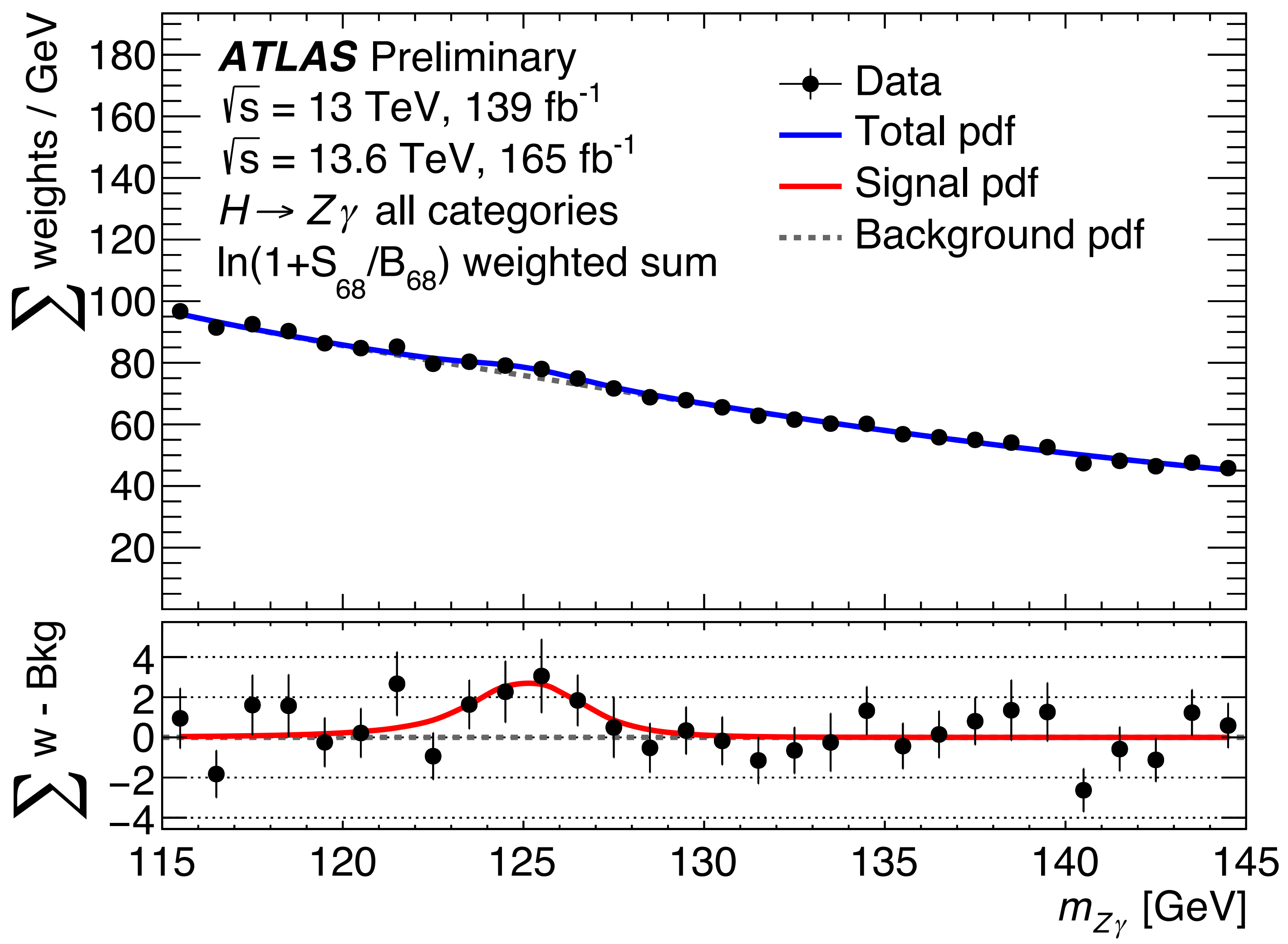
Run 3 ⟵ Compatibility: 33% ⟶ Run 2 + Run 3



$\boldsymbol{\mu = 0.9^{+0.7}_{-0.6}} = 0.9 \pm 0.6\ (\text{stat})^{+0.2}_{-0.1}\ (\text{syst})$

Observed (expected) **significance 1.4σ (1.5σ)**

Sensitivity improves by ~30% w.r.t Run 2 results - driven by:
- enhanced event selection/categorization strategies;
- larger data set/Signal cross-section

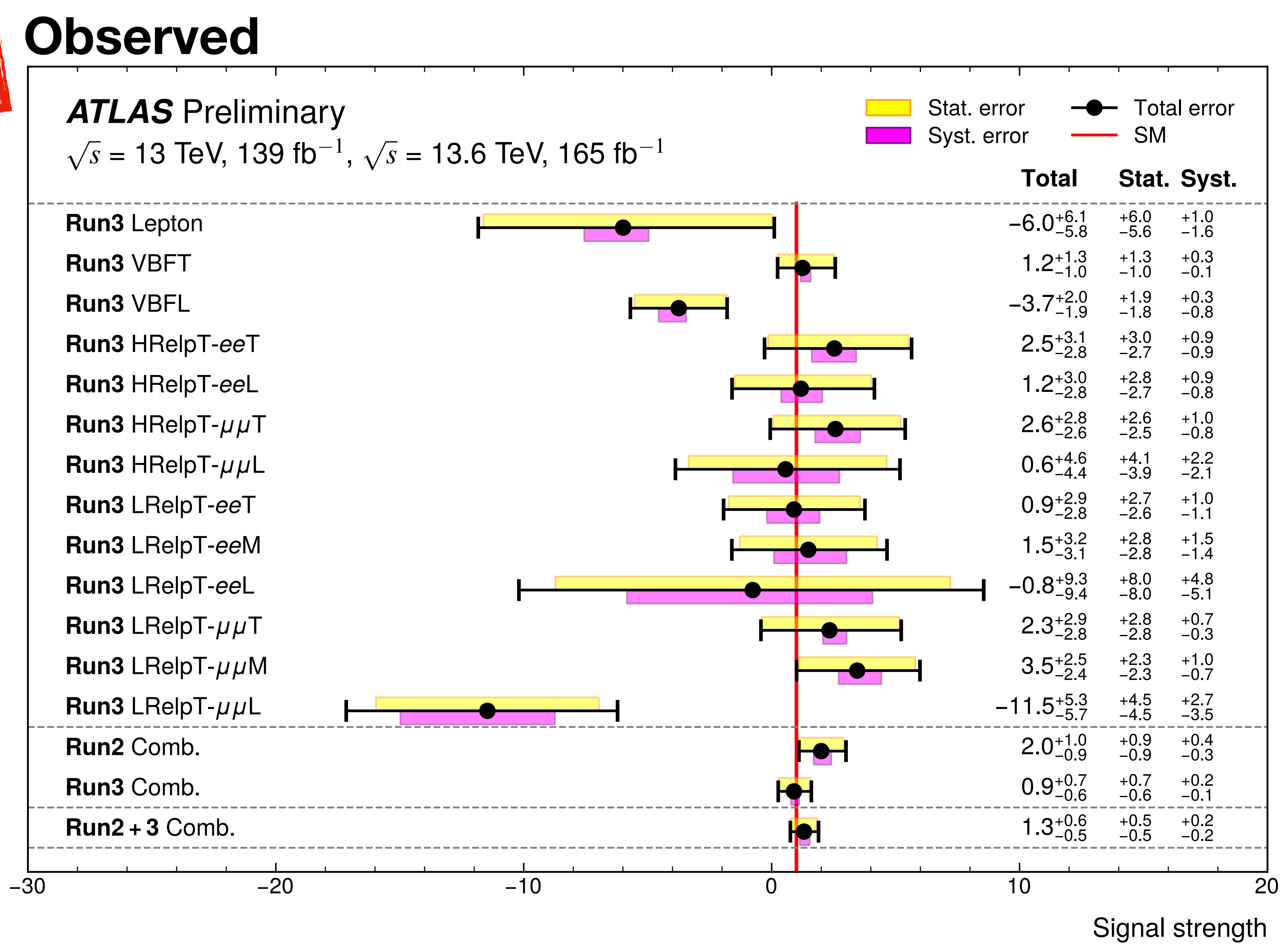


$\boldsymbol{\mu = 1.3^{+0.6}_{-0.5}} = 1.3 \pm 0.5\ (\text{stat}) \pm 0.2\ (\text{syst})$

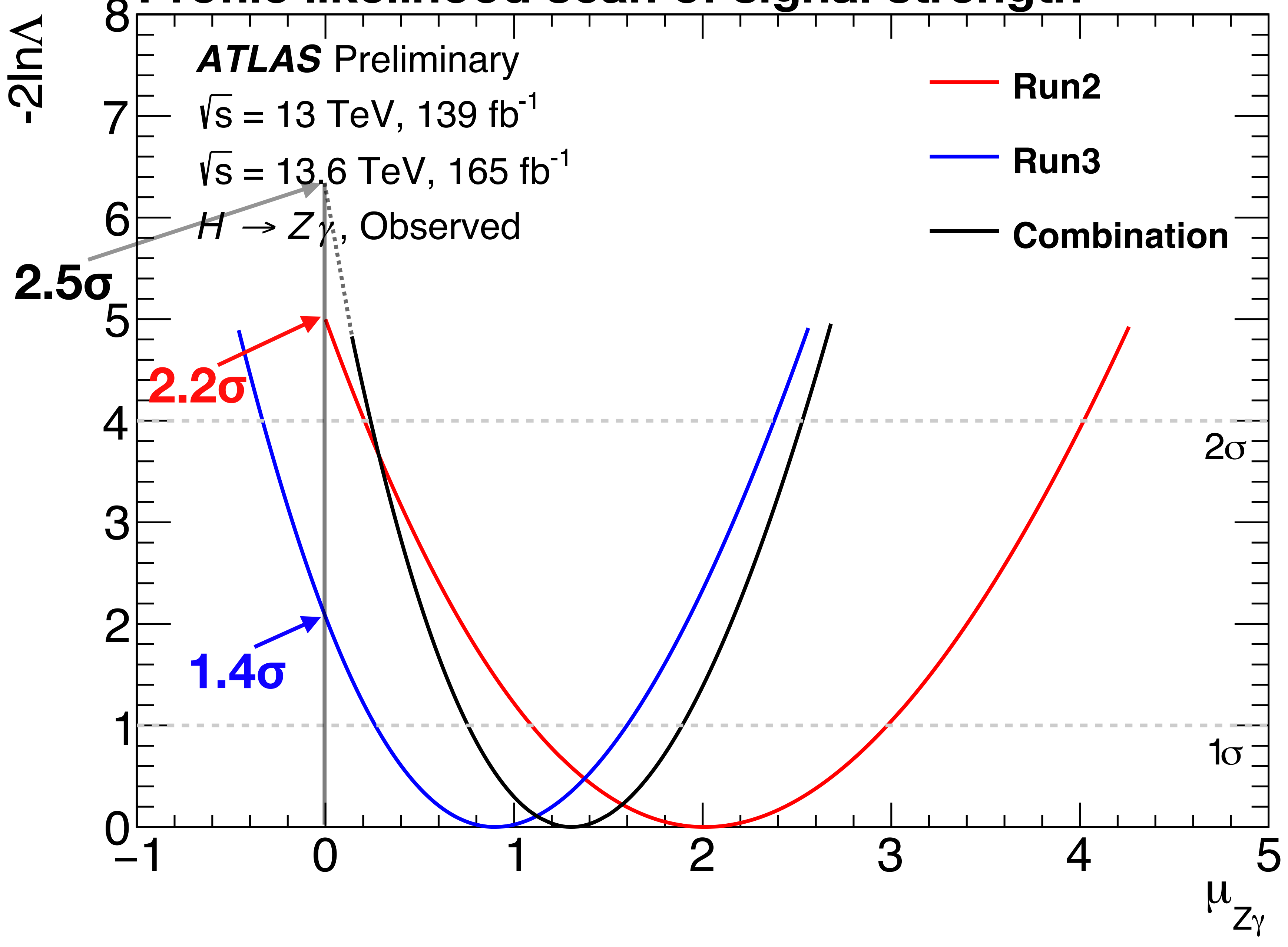
Observed (expected) **significance 2.5σ (1.9σ)**

Sensitivity improves by ~60% w.r.t Run 2 results.

The most stringent expected sensitivity to date!



Profile likelihood scan of signal strength




ATLAS
EXPERIMENT
Event candidate:
H → Z(→μ+μ-)γ
Run: 486179
Event: 3284045424
2024-10-05 19:38:01 CEST
μ
μ
γ
Link

Lepton Flavour Violation in the Higgs sector?

Not in Standard Model but nature hints otherwise - neutrino oscillations!

What are the possible LFV Higgs decays?

- $H \rightarrow \tau\mu$
- $H \rightarrow \tau e$
- $H \rightarrow e\mu$*

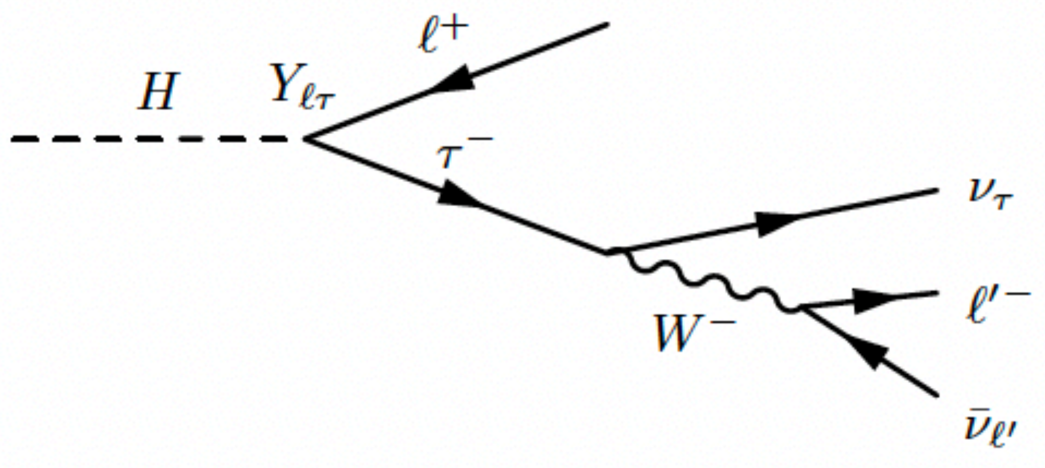
LFV Higgs decays can probe off-diagonal Yukawa couplings.

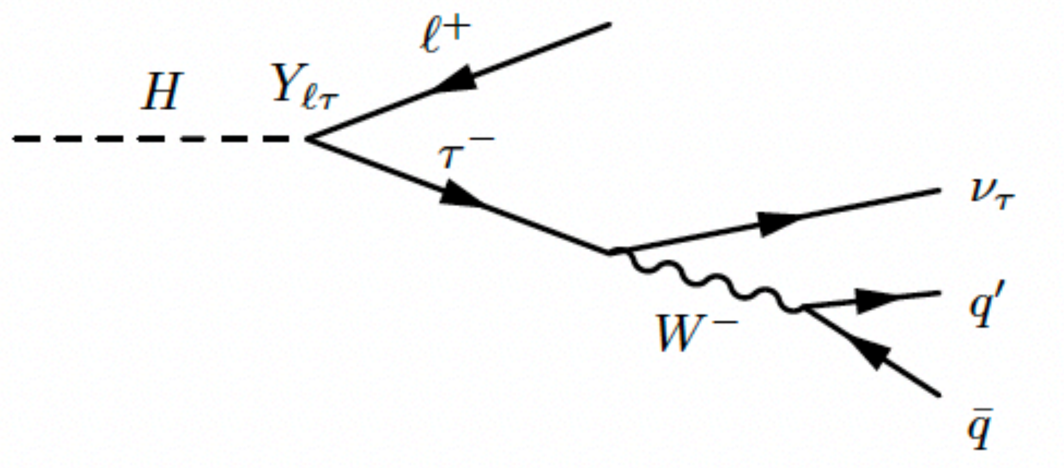
Beyond Standard Models predict Higgs LFV decays:

- Supersymmetry (SUSY)
- Two-Higgs-doublet models (2HDM)
- Composite Higgs models
- Randall–Sundrum models
- Other scenarios with extended Higgs sectors

JHEP 07 (2023) 166

Higgs LFV decay





Status with Run 2 data for Higgs LFV decay

Two independent searches: H→eτ and H→μτ

Two categories: VBF and Non-VBF

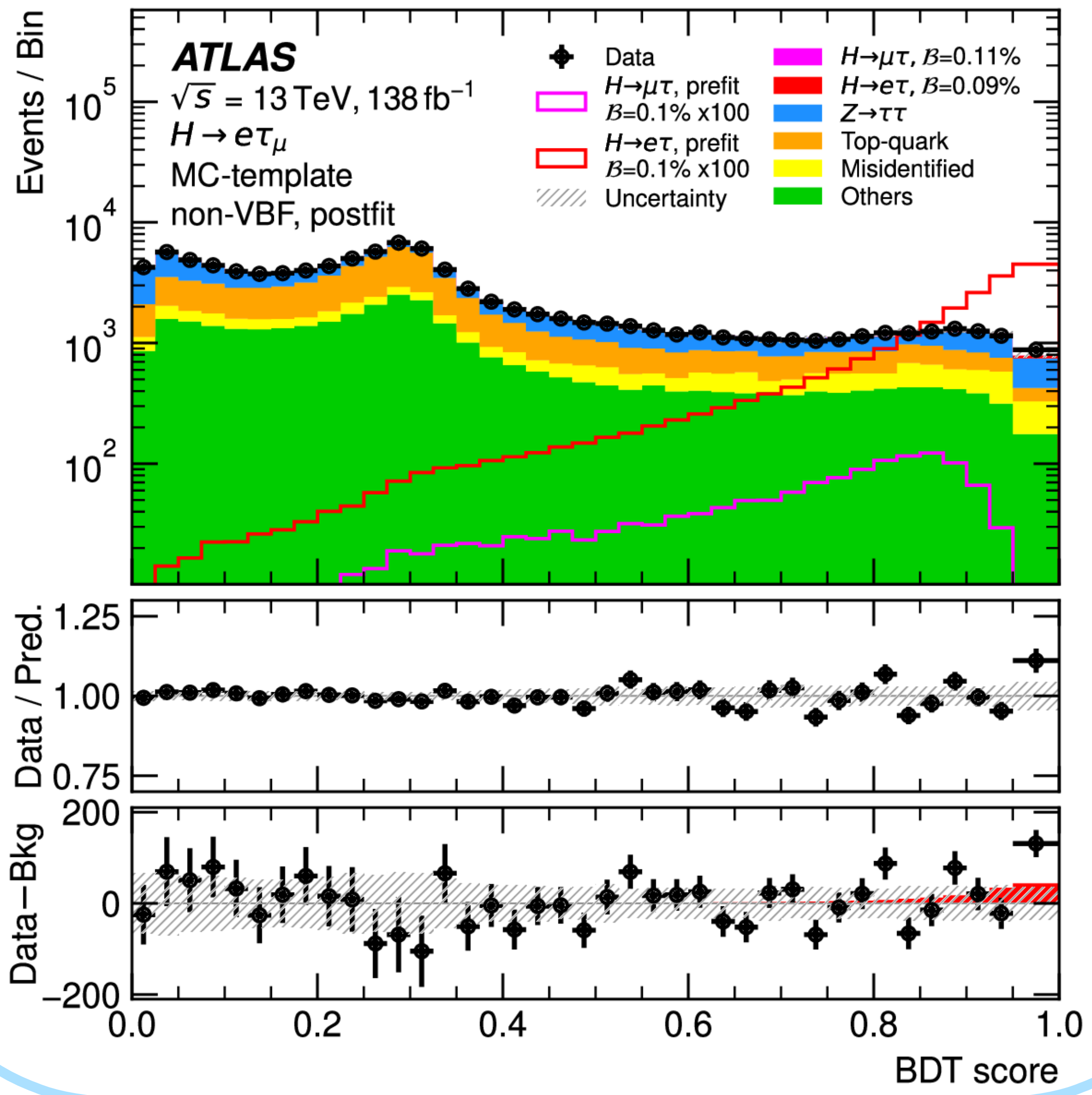
Two independent background methods:

- MC-template (for leptonic and hadronic decays)
- Symmetry method (for leptonic decays)

BDT (MC-template $\ell\tau_\ell$)

Background estimation:

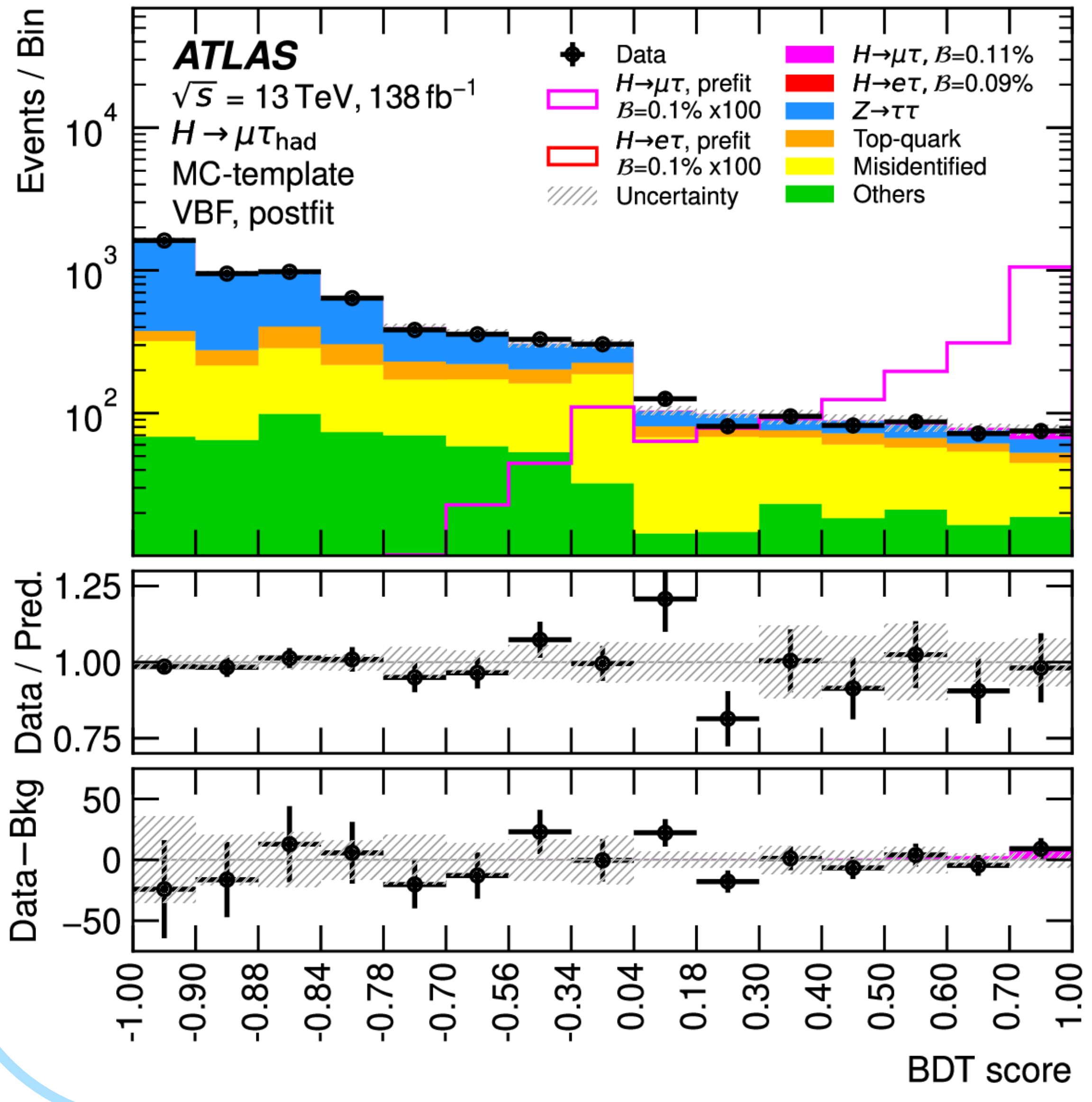
- Fake background data-driven.
- Other backgrounds — MC templates.



BDT (MC-template $\ell\tau_{had}$)

Background estimation:

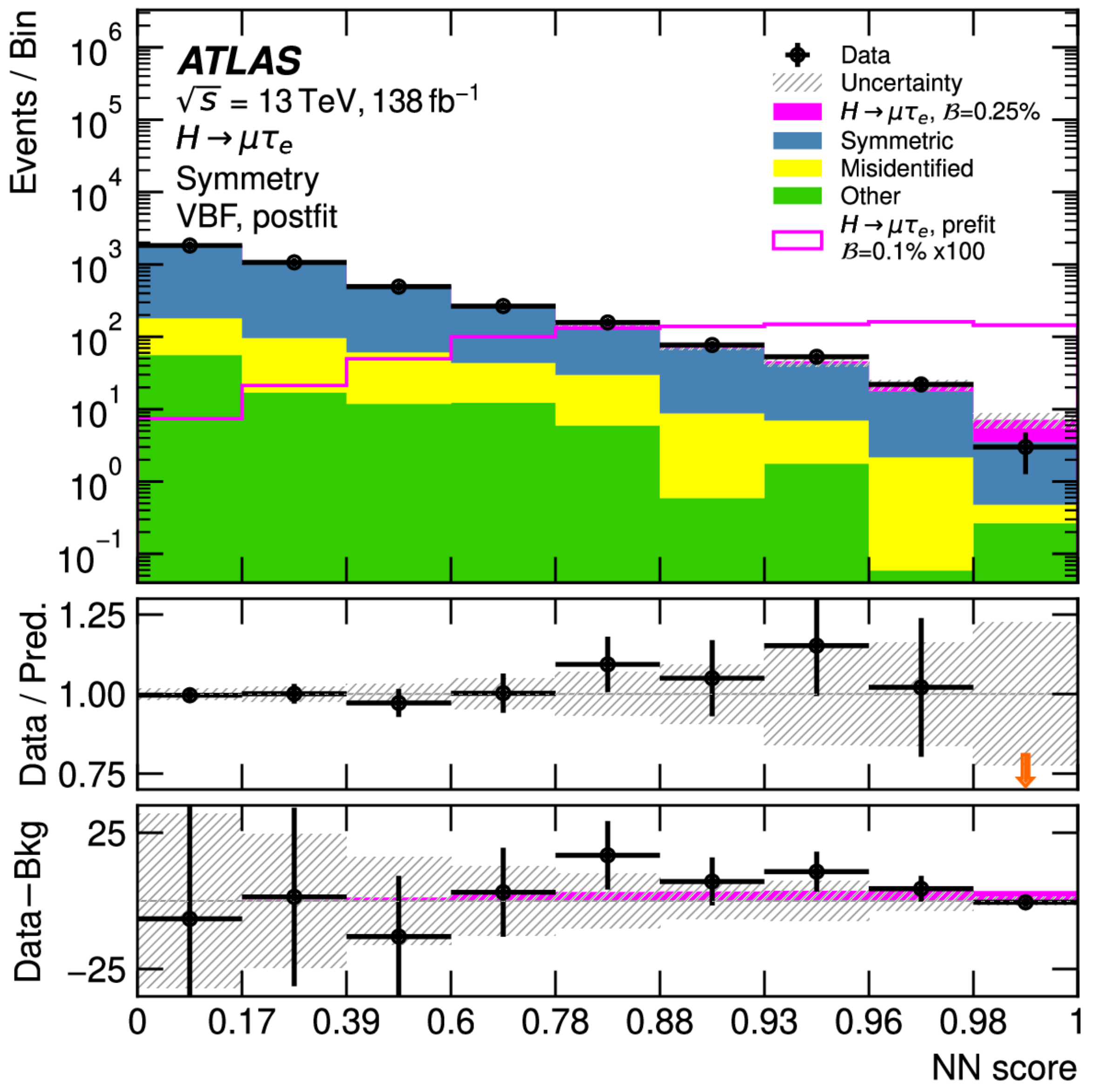
- Fake background data-driven.
- Other backgrounds — MC templates.



NN (Symmetry based $\ell\tau_\ell$)

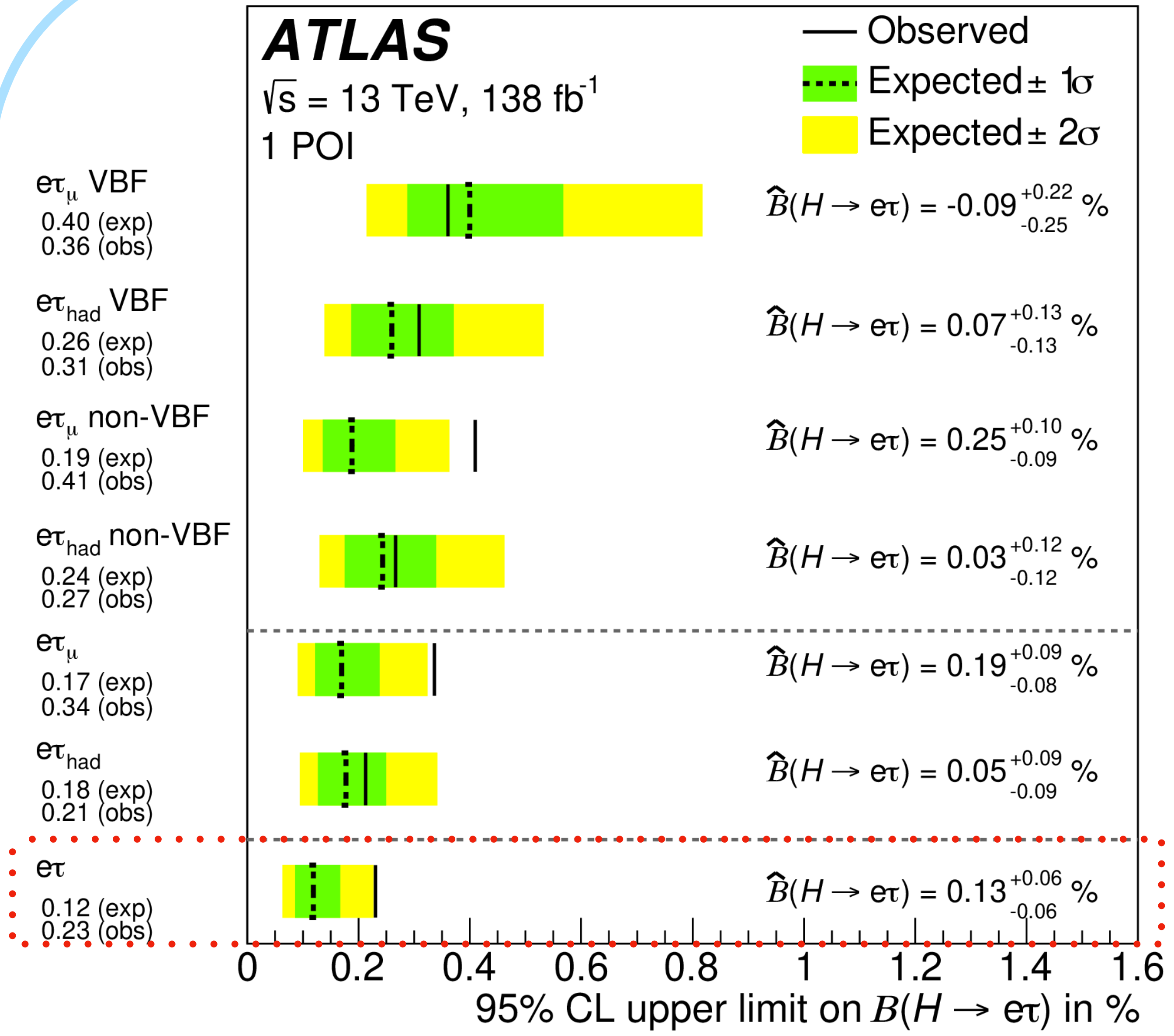
Background estimation:

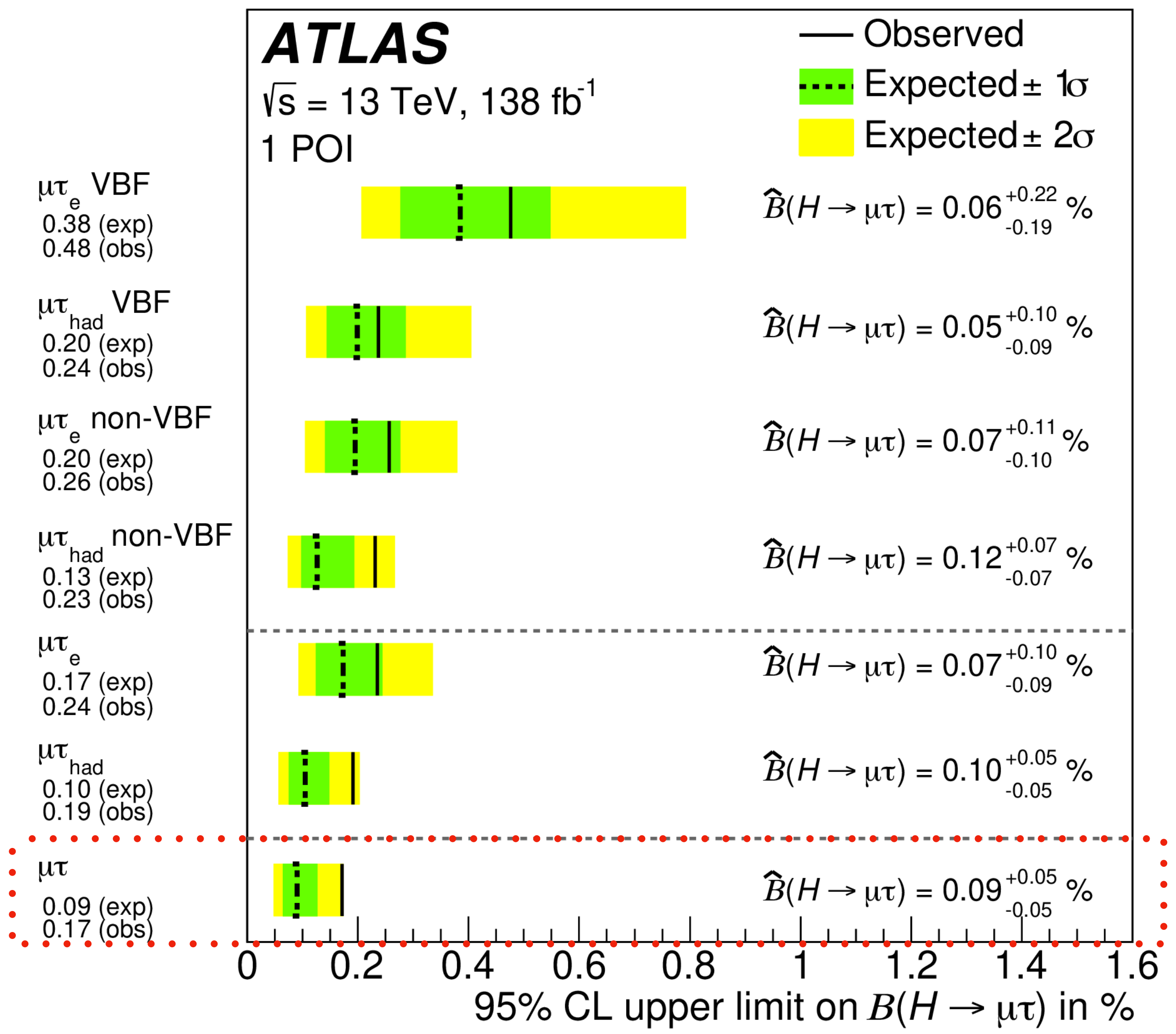
- Fake background data-driven.
- Other backgrounds — data-driven symmetry method (eτ ↔ μτ).



Higgs LFV decay: ATLAS Run2 results

1 POI: Independent fits in eτ and μτ channels

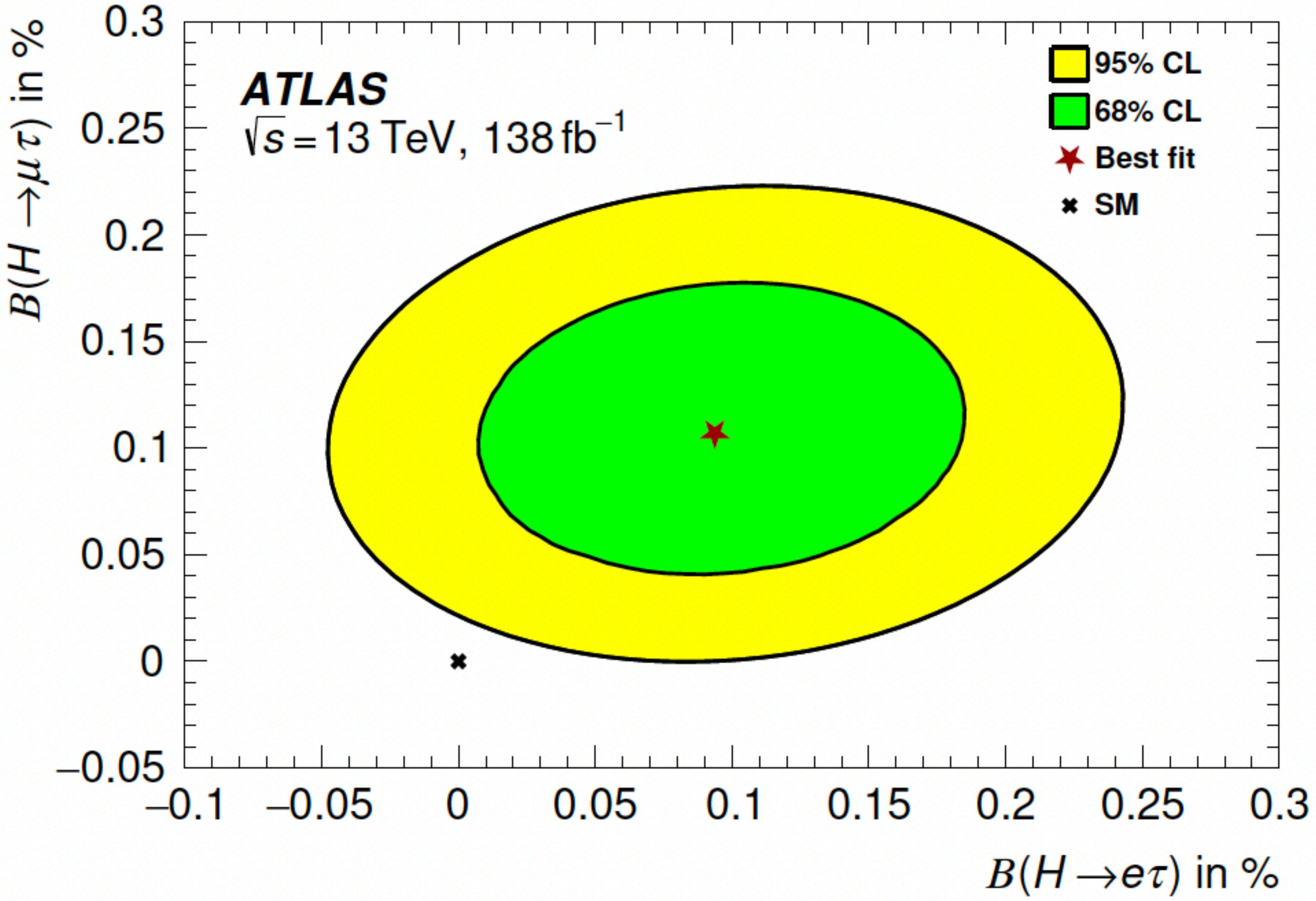




- Combination of the three analysis approach with a 1 POI fit setup:
  - Observed limits are above expected ones for both signals.
  - 2.2σ excess seen for $\mathcal{B}$(H→eτ) and 1.9σ for $\mathcal{B}$(H→μτ).
- 1 POI setup also used to extract branching ratio difference with Symmetry analysis:

$$\mathcal{B}(H \to \mu\tau) - \mathcal{B}(H \to e\tau) = (0.25 \pm 0.10)\%$$

2 POI: Simultaneous fit of H→eτ and H→μτ



Observed limits are above expected ones, in line with 1 POI fits.

- 1.6σ excess seen for $\mathcal{B}$(H→eτ) and 2.4σ for $\mathcal{B}$(H→μτ).
- A slight upward deviation.
- Global compatibility with SM within 2.1σ.


ATLAS
EXPERIMENT
Event candidate:
H → μτ$_e$
MET
e
μ
$p_{T,e}$ = 46 GeV
$p_{T,\mu}$ = 75 GeV
E_T^{miss} = 26 GeV
m_{MMC} = 124 GeV
Run: 363979
Event: 1287452799
2018-10-19 18:39:50 CEST
Link

Summary

- ❖ **H → μμ:** Evidence at 3.4σ!

- ❖ **H → Zγ:** Reaching most stringent expected sensitivity to date!
- ❖ **H → τμ, τe:** Small excesses in Run 2 — consistent with SM within 2.1σ.

Improved sensitivity achieved through:

- Enhanced **event reconstruction & categorization**
- **Machine Learning techniques** (BDTs, NNs)
- Larger datasets and **Run 3 inclusion**

Outlook: Great potential to observe rare Higgs boson decay modes to probe new physics with:

- Improved analysis techniques
- Increased integrated luminosity in Run 3
- And not in very far future: High Luminosity LHC

Stay tuned!

Thank you!

Backup

$H \rightarrow \mu^+\mu^-$

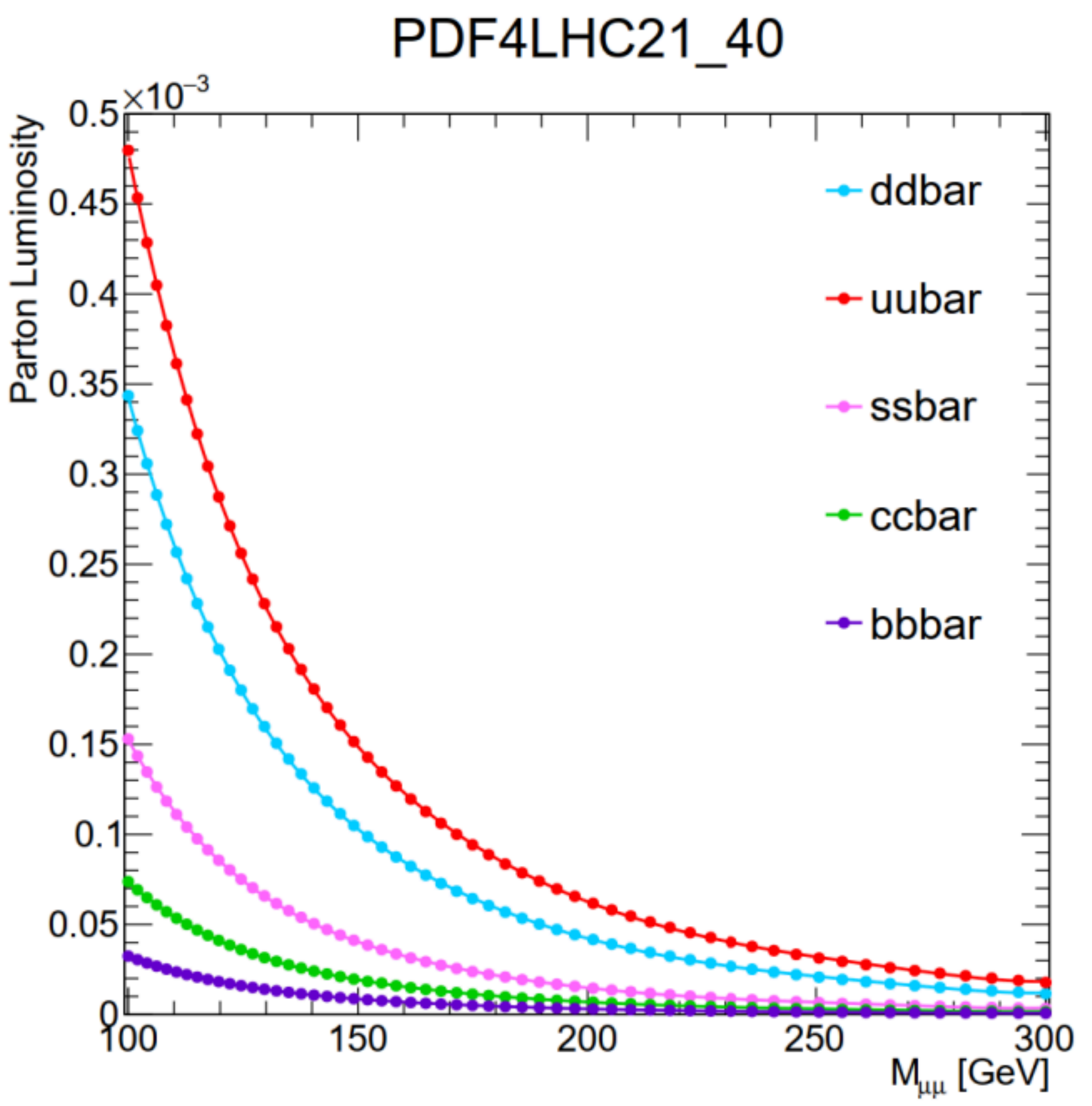
Background Modelling

- **Analytic function used for background modelling:**
  - Core × empirical function

$$F(m_{\mu\mu}, a_i)^{cat} = \mathrm{Core}(m_{\mu\mu}) \times \mathrm{Empirical}(m_{\mu\mu}, a_i)^{cat}$$

- **Core: Same DY lineshape for all categorize**
  - Rigid function without DOF
  - Calculated with parton luminosity and LO DY cross section
  - **New $c\bar{c}$ and $b\bar{b}$ contribution in Run3**
  - Smeared with detector resolution from FullSim samples

$$DY_{LS}(m_{\mu\mu}) = \sum_q \mathcal{L}_{q\bar{q}} \cdot \sigma_{q\bar{q}} \cdot m_{\mu\mu}\ ,\ q = u,\ s,\ d,\ c,\ b$$



Slides link

Selection of Empirical Function

- **Empirical function used to account for the remaining bias**
  - Determined by spurious signal test
- S+B fit on B–only template (from FullSim MC)
- $S \pm 1\sigma / \delta S < 20\%$
  - 1σ: the MC statistical uncertainty on the fitted signal
  - δS : statistical uncertainty assuming 165/fb error
- X^2 **probability of b–only fit better than 1%**
- If multiple functions pass selection:
  - Choose the one with smallest NDOF
  - Then, least spurious signal
- **The final spurious signal will be taken as additional systematic for bkg bias**

List of functions for testing

Function	Expression	nPar
Epoly1	$\exp(a_1 m_{\mu\mu})$	1
Epoly2	$\exp(a_1 m_{\mu\mu} + a_2 m_{\mu\mu}^2)$	2
Epoly3	$\exp(a_1 m_{\mu\mu} + a_2 m_{\mu\mu}^2 + a_3 m_{\mu\mu}^3)$	3
Epoly4	$\exp(a_1 m_{\mu\mu} + a_2 m_{\mu\mu}^2 + a_3 m_{\mu\mu}^3 + a_4 m_{\mu\mu}^4)$	4
Power0	$pow(m_{\mu\mu}, a_0)$	1
Power1	$pow(m_{\mu\mu}, a_0 + a_1 m_{\mu\mu})$	2
Power2	$pow(m_{\mu\mu}, a_0 + a_1 m_{\mu\mu} + a_2 m_{\mu\mu}^2)$	3
Power3	$pow(m_{\mu\mu}, a_0 + a_1 m_{\mu\mu} + a_2 m_{\mu\mu}^2 + a_3 m_{\mu\mu}^3)$	4

Slides link

Run3 Categorization

$H \rightarrow \mu^+\mu^-$

Category	$ggF + b\bar{b}H$	VBF	WH	ZH	$t\bar{t}H + tH$
$t\bar{t}H$-High	0.1%	0.0%	0.5%	0.5%	98.9%
$t\bar{t}H$-Medium	1.4%	0.1%	1.2%	1.3%	96.0%
VH4L	0.0%	0.0%	0.0%	99.3%	0.7%
VH3L-High	0.1%	0.0%	95.1%	3.3%	1.5%
VH3L-Medium	0.5%	0.2%	83.7%	8.3%	7.3%
VH2L-High	0.4%	0.1%	26.1%	72.0%	1.3%
VH2L-Medium	3.1%	1.1%	29.7%	62.5%	3.5%
VBF High	3.9%	96.1%	0.0%	0.0%	0.0%
VBF Medium	7.7%	92.2%	0.0%	0.0%	0.0%
VBF Low	13.4%	86.4%	0.0%	0.1%	0.1%
VBF Very Low	23.4%	76.2%	0.1%	0.1%	0.2%
2-jet High	67.8%	30.7%	0.7%	0.6%	0.2%
2-jet Medium	79.2%	16.9%	2.2%	1.5%	0.2%
2-jet Low	83.2%	9.4%	4.4%	2.7%	0.3%
2-jet Very Low	78.9%	6.7%	8.4%	5.2%	0.8%
1-jet High	67.1%	32.5%	0.2%	0.2%	0.0%
1-jet Medium	85.8%	13.0%	0.7%	0.5%	0.0%
1-jet Low	91.3%	6.5%	1.4%	0.8%	0.0%
1-jet Very Low	92.4%	4.2%	2.2%	1.1%	0.0%
0-jet High	95.9%	2.5%	0.7%	0.9%	0.0%
0-jet Medium	98.3%	1.1%	0.3%	0.3%	0.0%
0-jet Low	98.8%	0.7%	0.2%	0.3%	0.0%
0-jet Very Low	99.5%	0.3%	0.1%	0.1%	0.0%

Signal composition per category

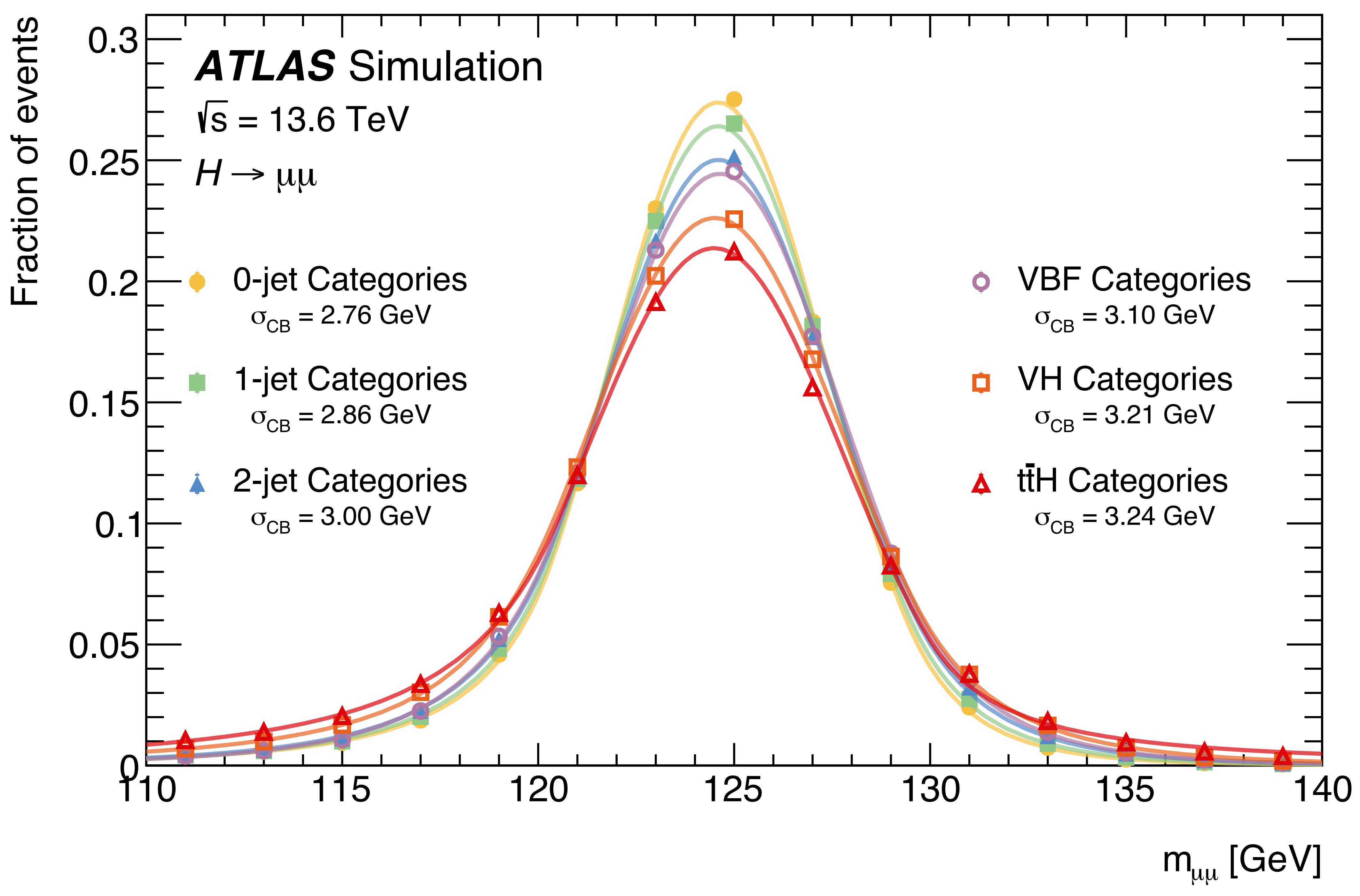
Category	Data	S	B	$S/\sqrt{B}$	S/B [%]
$t\bar{t}H$-High	12	1.9 ± 0.7	15.5 ± 2.3	0.49	12.5
$t\bar{t}H$-Medium	117	3.9 ± 1.4	115 ± 7	0.36	3.4
VH4L	11	0.78 ± 0.29	12.2 ± 1.8	0.22	6.4
VH3L-High	25	1.4 ± 0.5	17.4 ± 2.9	0.33	8.0
VH3L-Medium	143	3.7 ± 1.4	136 ± 10	0.31	2.7
VH2L-High	19	1.0 ± 0.4	18.3 ± 2.9	0.23	5.3
VH2L-Medium	30	0.38 ± 0.14	31.7 ± 3.1	0.07	1.2
VBF High	9	4.3 ± 1.6	10.5 ± 1.8	1.34	41.2
VBF Medium	28	5.3 ± 2.0	25.8 ± 2.7	1.04	20.5
VBF Low	69	7.2 ± 2.7	62 ± 4	0.91	11.6
VBF Very Low	217	11 ± 4	225 ± 8	0.76	5.1
2-jet High	1 399	31 ± 12	$1\,367 \pm 25$	0.84	2.3
2-jet Medium	5 657	69 ± 26	$5\,560 \pm 50$	0.92	1.2
2-jet Low	17 684	110 ± 40	$17\,300 \pm 70$	0.87	0.7
2-jet Very Low	35 147	110 ± 40	$35\,160 \pm 140$	0.59	0.3
1-jet High	708	17 ± 6	710 ± 16	0.65	2.4
1-jet Medium	7 166	80 ± 30	$7\,140 \pm 70$	0.95	1.1
1-jet Low	31 761	180 ± 70	$31\,510 \pm 120$	1.00	0.6
1-jet Very Low	73 578	200 ± 80	$73\,330 \pm 200$	0.75	0.3
0-jet High	19 445	120 ± 50	$19\,260 \pm 90$	0.89	0.6
0-jet Medium	50 742	200 ± 80	$50\,830 \pm 190$	0.90	0.4
0-jet Low	94 032	240 ± 90	$93\,770 \pm 210$	0.78	0.3
0-jet Very Low	136 762	170 ± 60	$136\,510 \pm 290$	0.47	0.1

The number of observed events and the fitted number of signal (S) and background (B) events from the combined fit to 165 fb^{-1} of Run-3 data

Signal Modelling

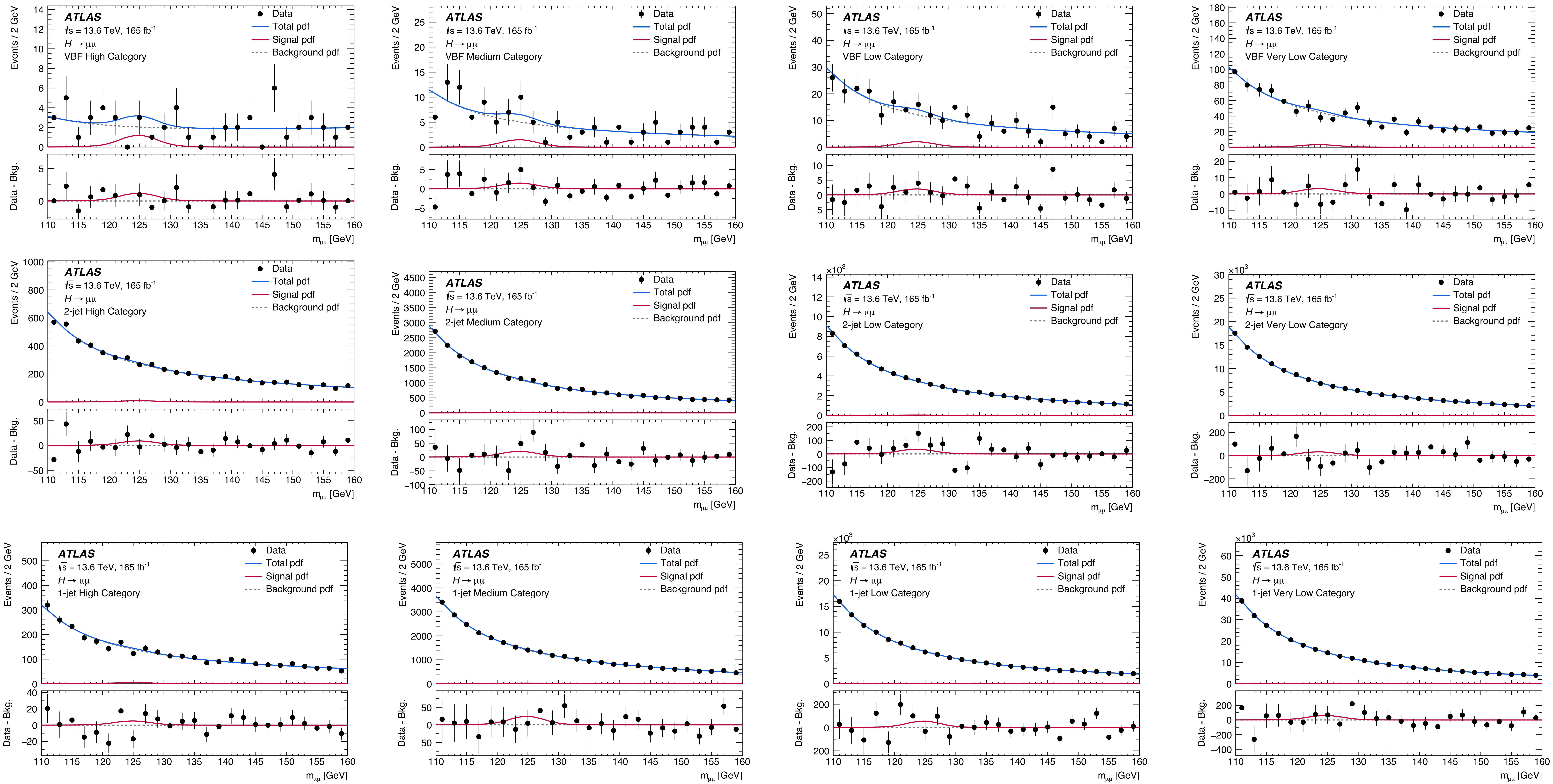
- **Parametrise Higgs peak with Double-Sided Crystal Ball function**
  - 2% improvement on resolution mc23a/d
  - Benefit from reprocessed data
  - New MS alignment
  - Similar to Run2 after including mc23e
- **Resolution: 2.6GeV to 3.5GeV**

	mc23a/d	mc23e	Run3 inclusive	Run2 inclusive
M_{CB} [GeV]	124.60	124.58	124.58	124.64
σ_{CB}[GeV]	2.71	2.80	2.77	2.74



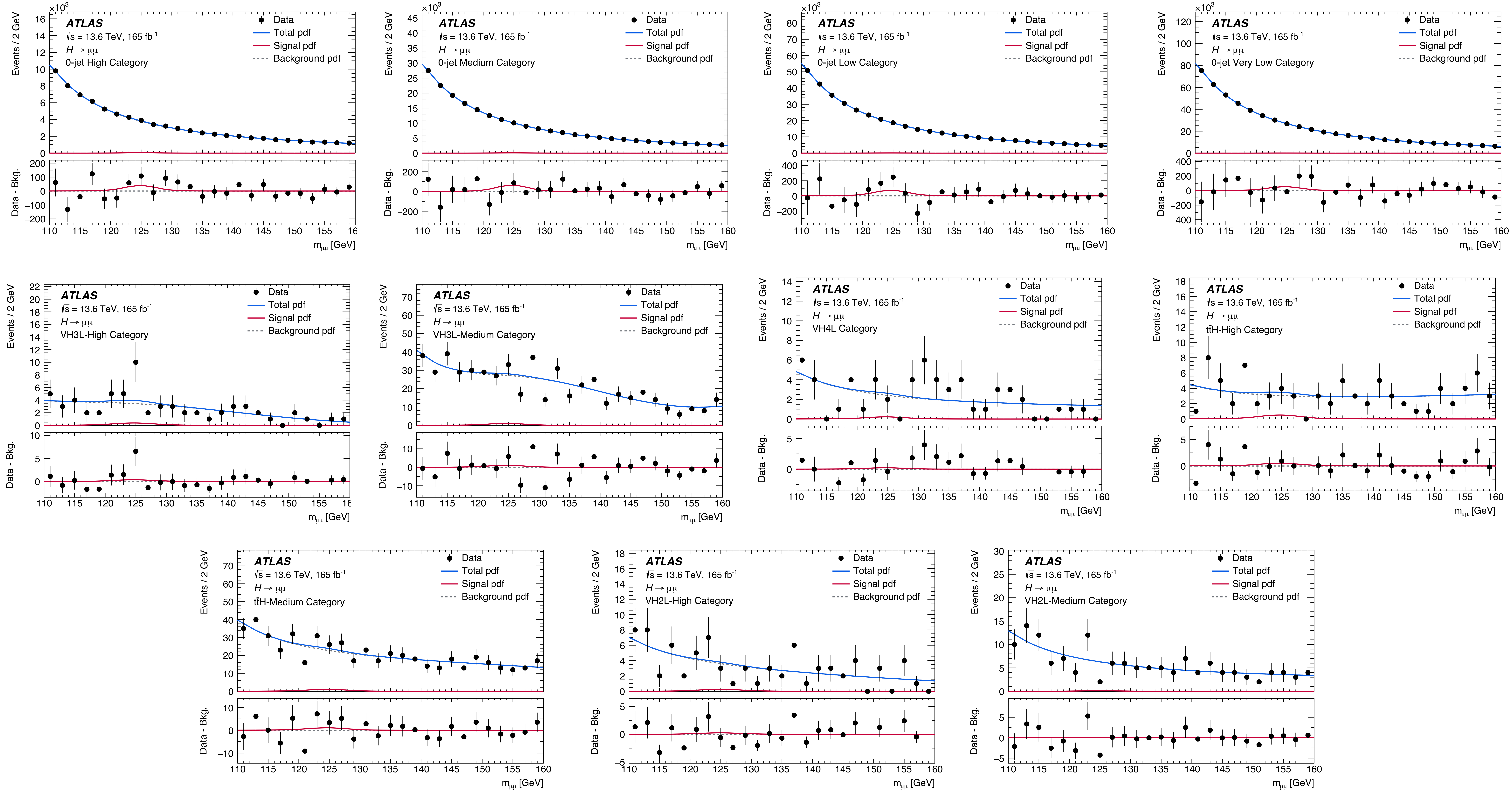
Individual categories in the H → μ+μ- analyses

H → μ+μ-



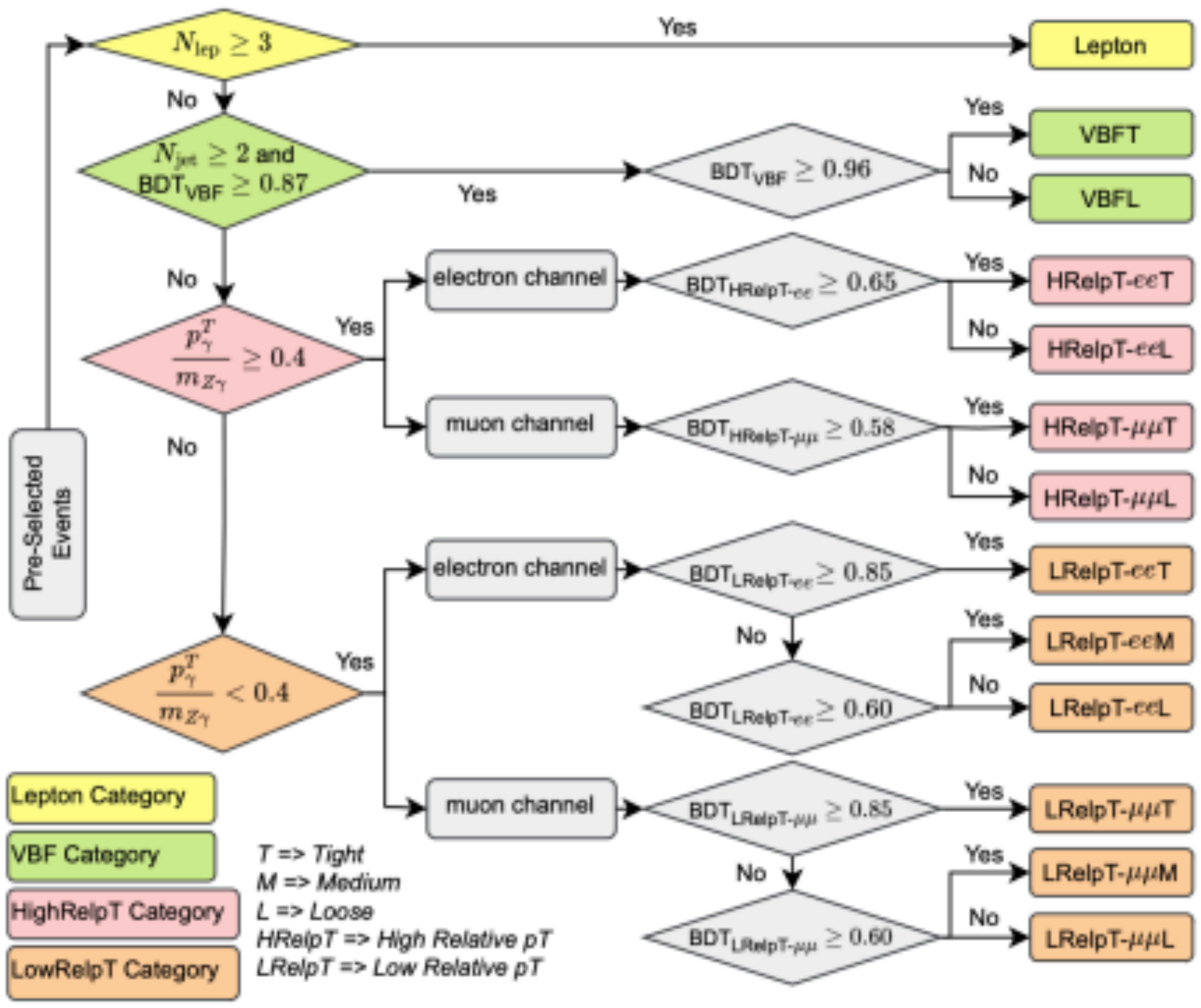
Individual categories in the H → $\mu^+\mu^-$ analyses

H → $\mu^+\mu^-$



Categorization

$H \to Z\gamma$

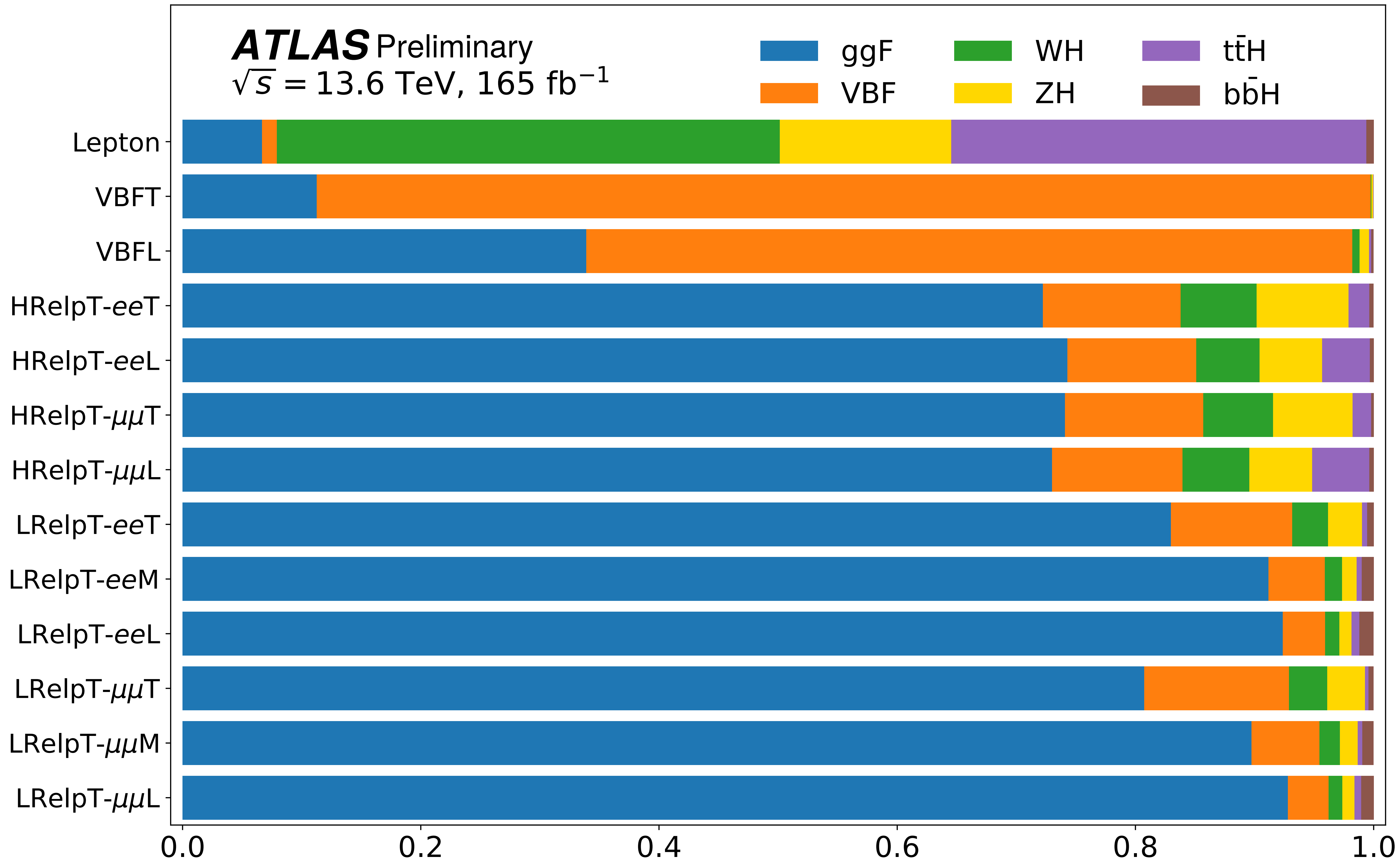


- Events after preselection are classified into 13 categories
  - BDT classifications for VBF, HRelpT and LRelpT categories.
- **Lepton category**
  - Additional lepton (***N_lepton*≥3**)
- **VBF category:**
  - Train the events with ***N_jet*≥2** and categorize to two region: Tight and Loose
- **High Relative pT category**
  - Train the events with ***pT_γ/m_llγ* ≥0.4**, split them by channel, and categorize to Tight and Loose for each channel
- **Low Relative pT category**
  - Train the events with ***pT_γ/m_llγ* <0.4**, split by channel, categorize to Tight, Medium and Loose for each channel

Slides link

Signal decomposition in each category

$H \rightarrow Z\gamma$



- **Lepton category: VH and ttH dominant**
  - VH 56% and ttH 35%
- **VBF category:**
  - 89% VBF and 11% ggH in VBF tight
  - 64% VBF and 34% ggH in VBF Loose
- **HRelpT category:**
  - ~73% ggH and ~11% VBF
- **LRelpT category**
  - ~92% ggH and ~6% VBF

Slides link

Signal modeling

$H \rightarrow Z\gamma$

- The three-body invariant mass distribution is fitted independently in each category using the Double-Sided Crystal Ball (DSCB) function.

$$N \cdot \begin{cases} e^{-t^2/2} & \text{if } -\alpha_{\text{Lo}} \leq t \leq \alpha_{\text{Hi}} \\ \dfrac{e^{-0.5\alpha_{\text{Lo}}^2}}{\left[\frac{\alpha_{\text{Lo}}}{n_{\text{Lo}}}\left(\frac{n_{\text{Lo}}}{\alpha_{\text{Lo}}} - \alpha_{\text{Lo}} - t\right)\right]^{n_{\text{Lo}}}} & \text{if } t < -\alpha_{\text{Lo}} \\ \dfrac{e^{-0.5\alpha_{\text{Hi}}^2}}{\left[\frac{\alpha_{\text{Hi}}}{n_{\text{Hi}}}\left(\frac{n_{\text{Hi}}}{\alpha_{\text{Hi}}} - \alpha_{\text{Hi}} + t\right)\right]^{n_{\text{Hi}}}} & \text{if } t > \alpha_{\text{Hi}}, \end{cases}$$

$t = \Delta m_H / \sigma_{CB}$

$\Delta m_H = m_{ll\gamma} - \mu_{CB}$

N: normalization parameter

μ_{CB}: the peak of the Gaussian distribution

Mean and resolution in each category

Category	Mean [GeV]	Resolution [GeV]
Lepton	125.009	1.617
VBFT	125.021	1.422
VBFL	125.020	1.566
HRelpT-eeT	125.138	1.136
HRelpT-eeL	125.243	1.452
HRelpT-$\mu\mu$T	124.907	1.456
HRelpT-$\mu\mu$L	125.055	1.584
LRelpT-eeT	125.137	1.566
LRelpT-eeM	125.163	1.637
LRelpT-eeL	124.941	1.889
LRelpT-$\mu\mu$T	124.883	1.628
LRelpT-$\mu\mu$M	124.940	1.713
LRelpT-$\mu\mu$L	124.827	1.828

Slides link

Run2 & Run3 combination correlation scheme

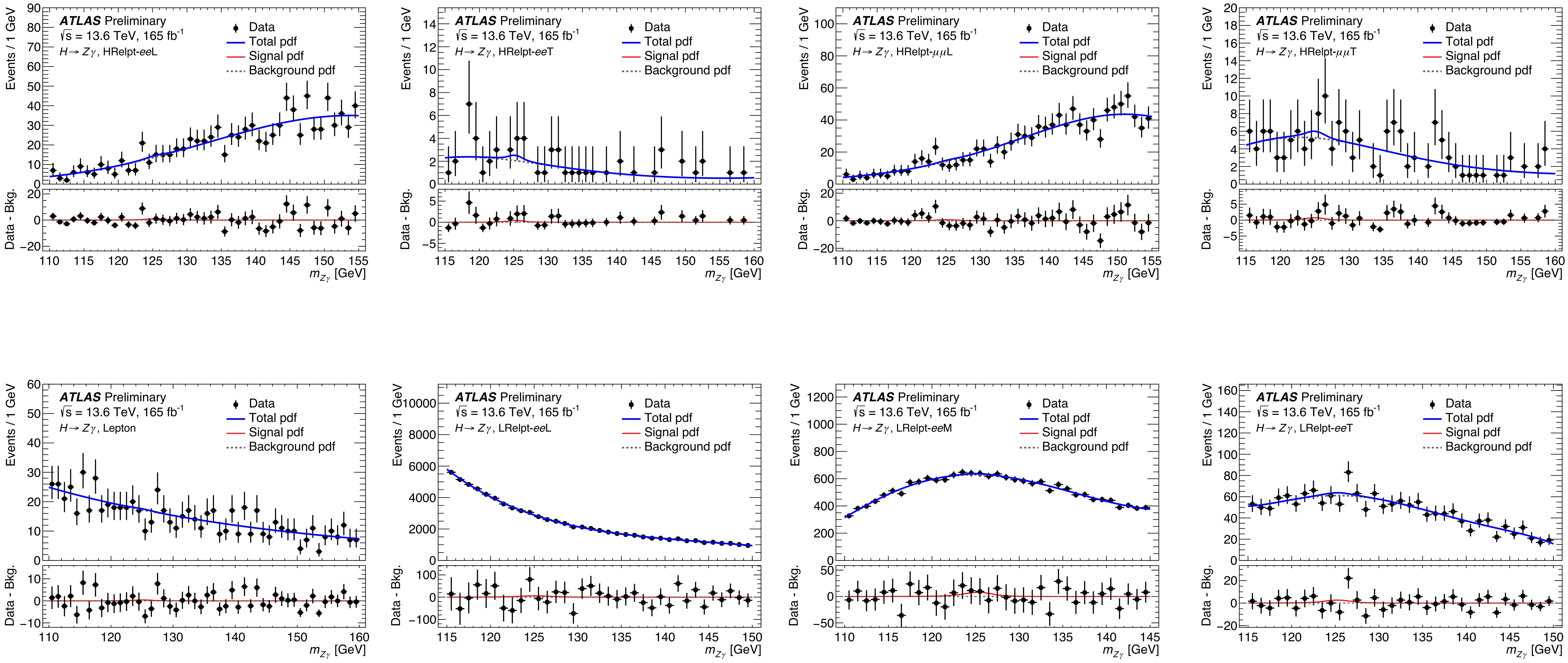
$H \to Z\gamma$

- Experimental uncertainty correlation
  - **Trigger uncertainties: decorrelation** between Run2 and Run3. In addition, in Run3 decorrelation between 2022 and 2023/2024 due to the new L1 trigger change.
  - **Luminosity: decorrelated** between Run2 and Run3
  - **EGamma: decorrelated** between Run2 and Run3
  - **JET: correlate** everything between Run2 and Run3 except for **InSitu NonClosure PreRec** components.
  - **Muon uncertainties: correlate** everything between Run2 and Run3.
  - **Spurious signal uncertainties: de-correlated** between Run2 and Run3 since categorization change
- Theoretical uncertainties
  - **Branch ratio** uncertainty are correlated
  - **QCD, PDF and alphas** are correlated
- **Negligible impact from correlation!**

Slides link

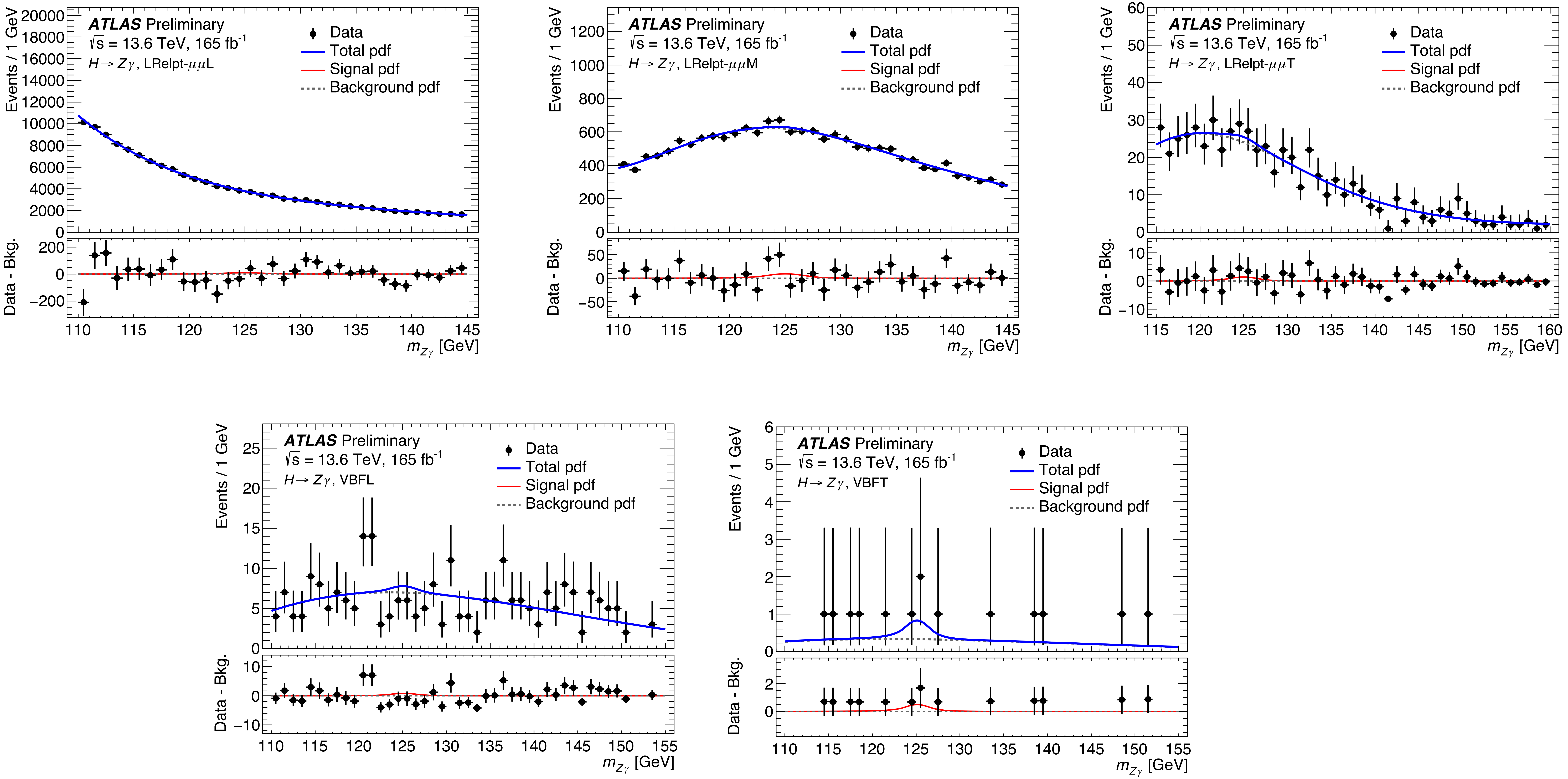
Individual categories in the H->Zγ analyses

H → Zγ

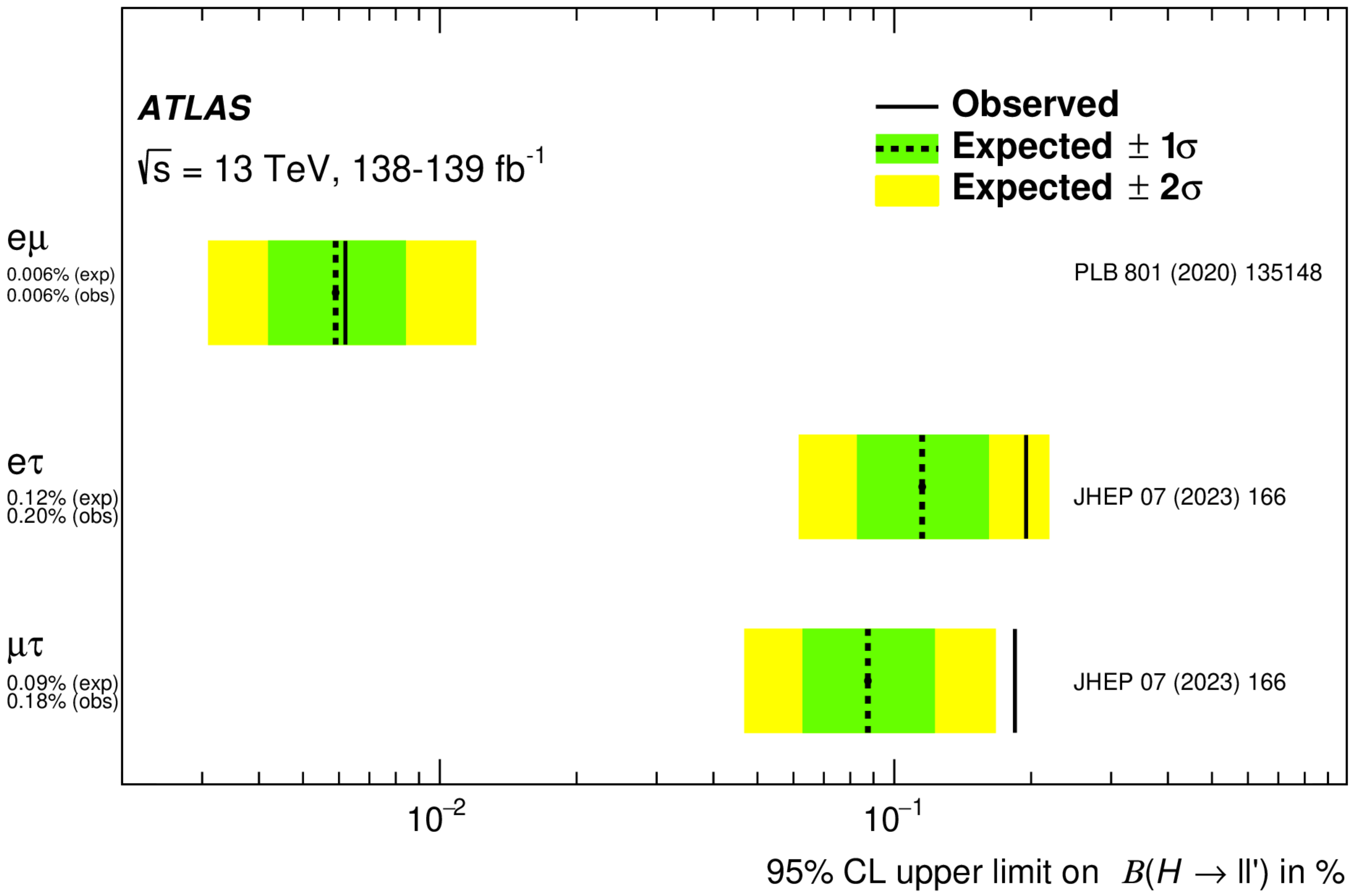


Individual categories in the H->Zγ analyses

$H \rightarrow Z\gamma$

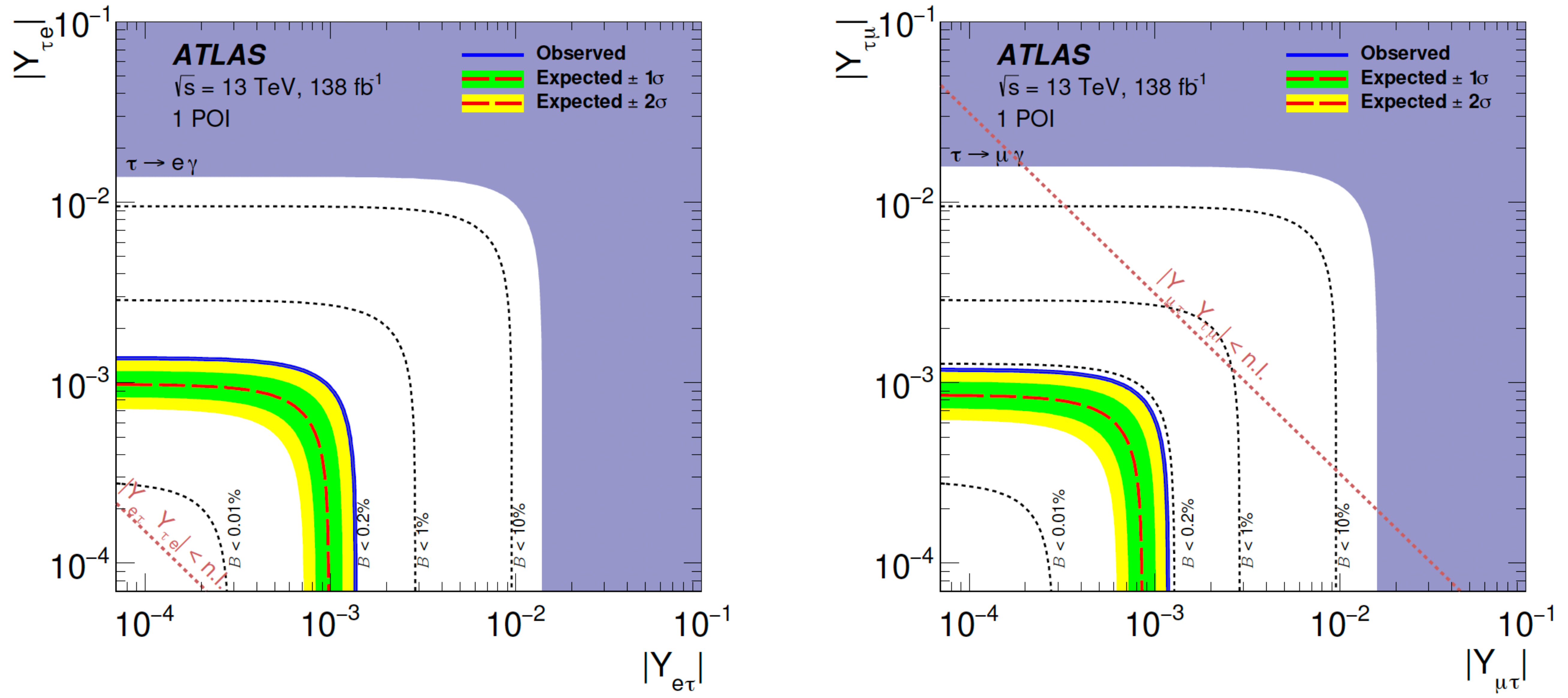


LFV Higgs searches



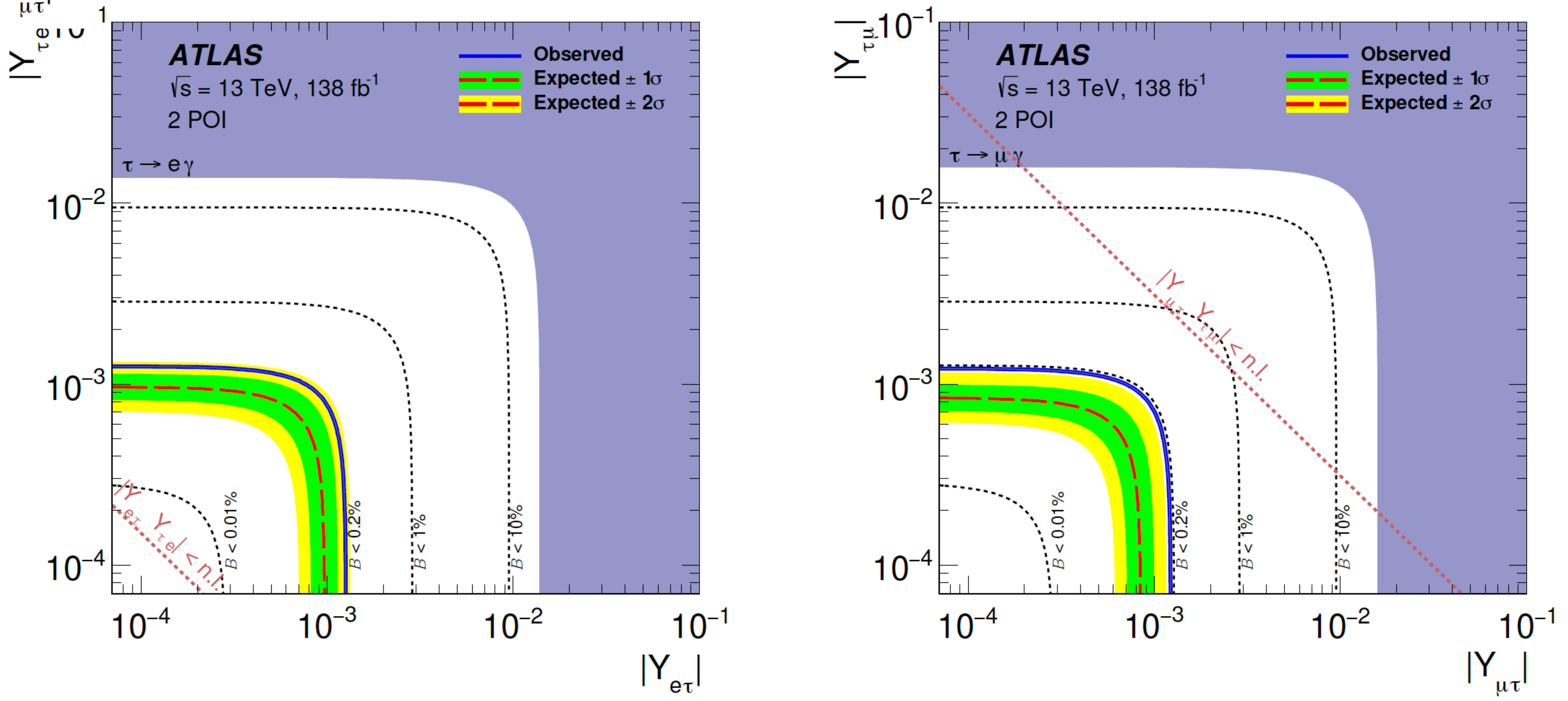
LFV decay	Direct searches	
	Upper limit	**Reference**
$H \to e\mu$	0.061%	ATLAS 139 fb^{-1} [1909.10235]
$H \to e\tau$	0.22% 0.20%	CMS 137 fb^{-1} [2105.03007] ATLAS 138 fb^{-1} [2302.05225]
$H \to \mu\tau$	0.15% 0.18%	CMS 137 fb^{-1} [2105.03007] ATLAS 138 fb^{-1} [2302.05225]

LFV Higgs: Yukawa couplings

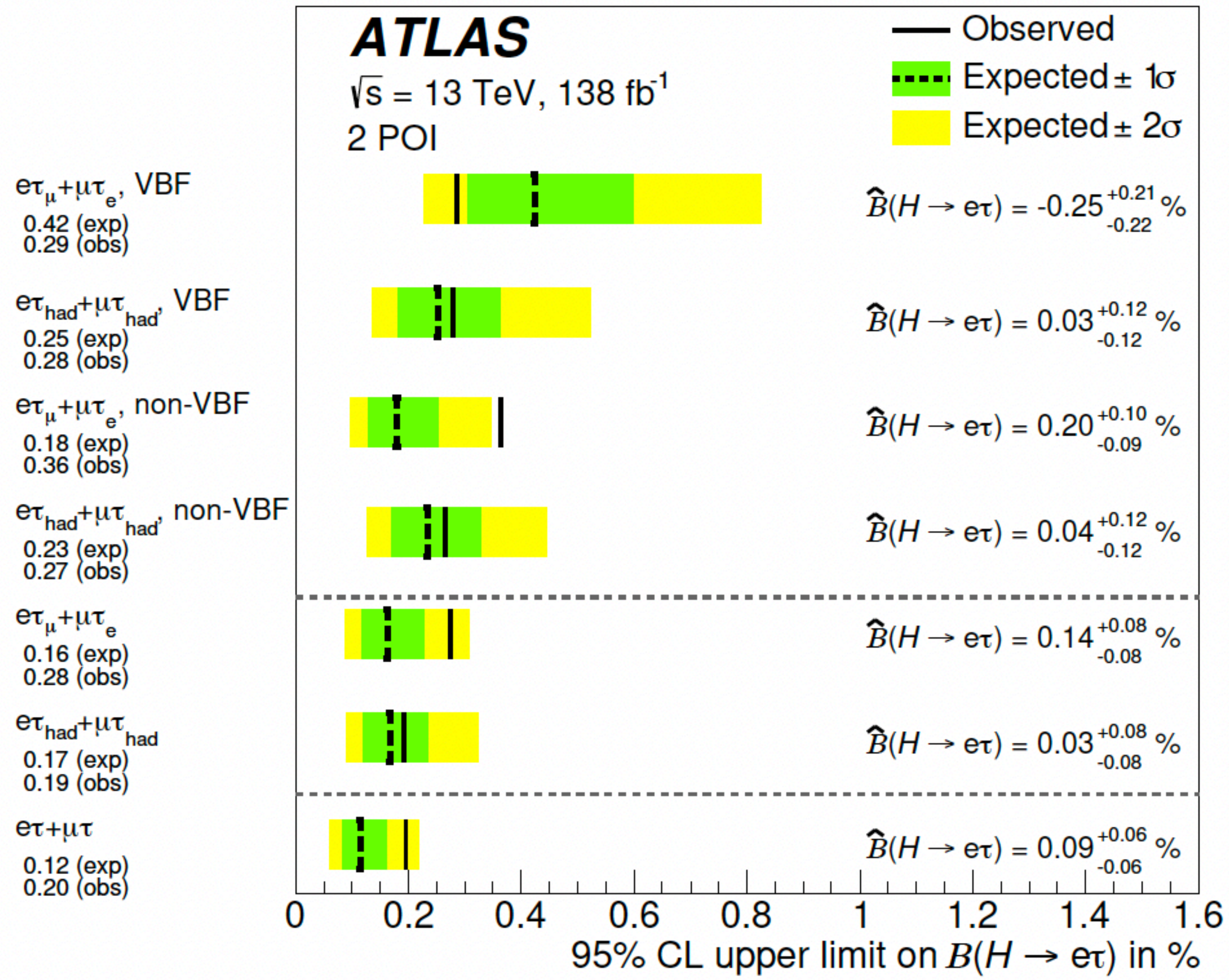


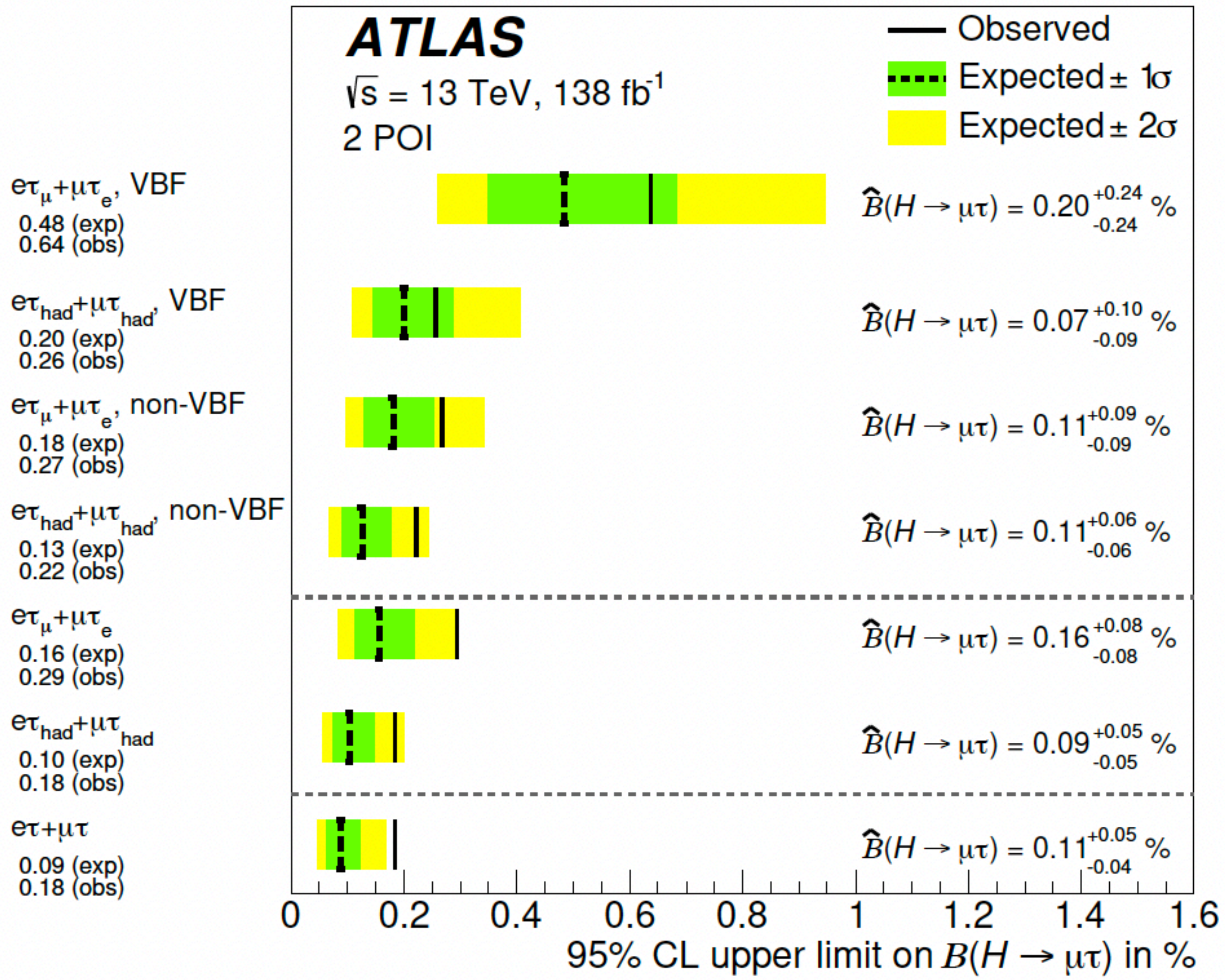
The short-dashed lines represent limits corresponding to different branching ratios (0.01%, 0.2%, 1% and 10%), while the dotted line indicates the naturalness limit (denoted by n.l.).

Expected (red long-dashed line) and observed (solid blue line) 95% CL upper limits from the simultaneous fit (1/2 POI) of the two searches on the absolute value of the couplings Y_{taul} and Y_{ltau} together with the most stringent indirect limits from tau to gamma searches (dark purple region) for (a) l = e or (b) l = μ.



LFV Higgs: 2 POI





For the H → τμ (H → τe) signal, a 2.4 (1.6) excess is observed. In the case of the H → τe signal, this is driven mainly by the non-VBF category of the leplep final state based on the MC-template method.
In the case of the H → τμ signal, it is driven by the non-VBF category of the lephad final state.