Lepton Flavor Violation at the LHC

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COFI Workshop
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This talk is not about the fascinating observations in B decays.

My assignment is to focus is on heavier particles:

gauge bosons, the Higgs boson, and the top quark

Of course, lepton flavor violation has already been observed through neutrino oscillations.

This implies, through loops, charged lepton violation.

The predicted rate is far too small to be observed, however.

If charged lepton violation is observed at the LHC,
then new physics beyond the standard model must be present.

This makes it worthwhile.

Three opportunities for Lepton Flavor Violation:

1) At a vertex (not necessarily at tree level)

   Example: Z decays to e mu

2) Non-universality of gauge couplings

   Example: BF(Z to ee) and BF(Z to tautau) are different

3) Participation of a non-SM boson with non-universal couplings

   Example: top decays to tau are enhanced due to charged Higgs

Z decays that violate lepton flavor conservation

- In principle, already strongly constrained indirectly.
  - Indirect constraints always have loopholes.

- LEP experiments tested this with a few million recorded Z decays.
  - Pristine event properties make this relatively easy(?)

- What can the LHC experiments do?
  - They have *many* more Z decays.
  - Events are messy, but lepton reconstruction and ID are excellent.
  - A good opportunity.

Synopsis of a search for Z decays to eμ

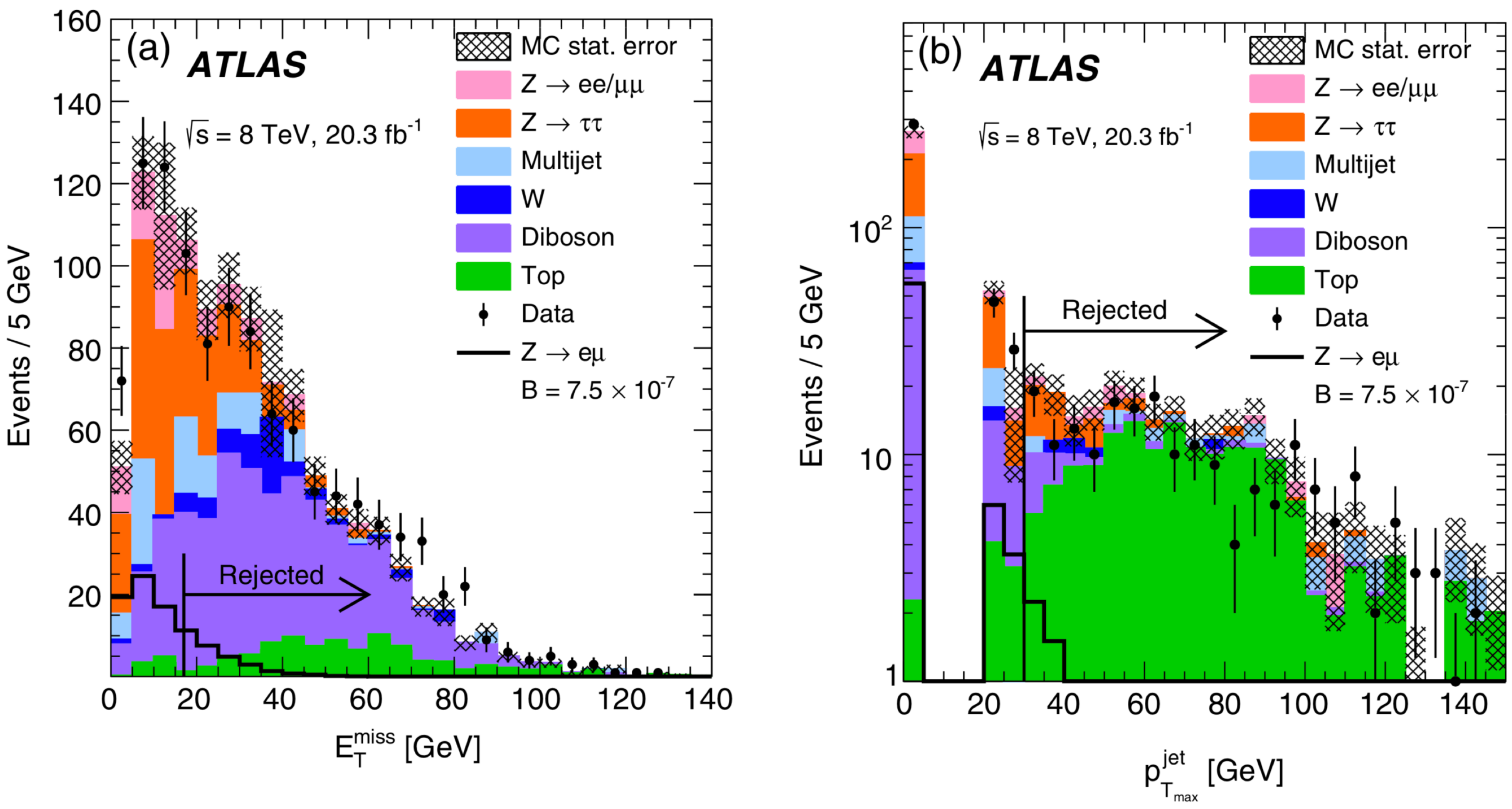
- Signal marked by a Z resonant peak in the eμ invariant mass spectrum.
  - Mass resolution is very good.

- Major backgrounds from τ pairs, W pairs, top pairs
  - Lead naturally to the eμ final state

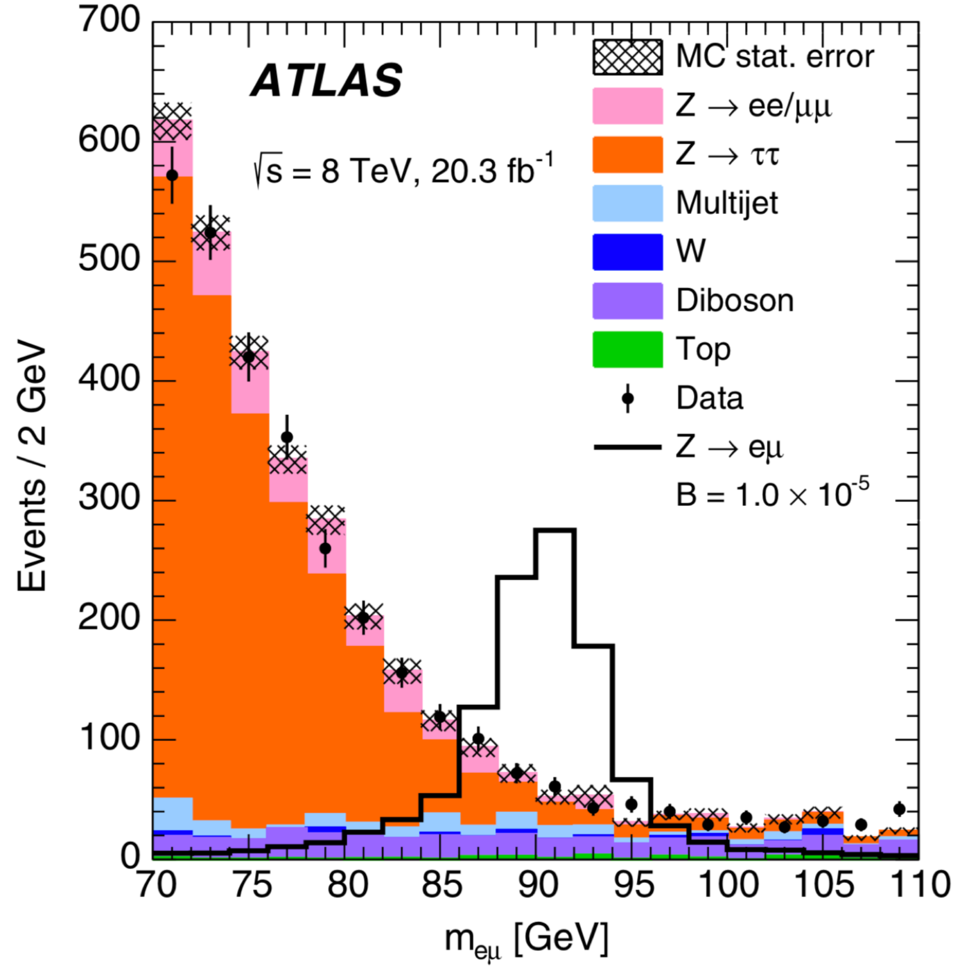
  - Suppress Z → ττ using missing energy p_T^{miss}
  - WW also suppressed by p_T^{miss} cut
  - Suppress tt by vetoing events with (*b*-)jets

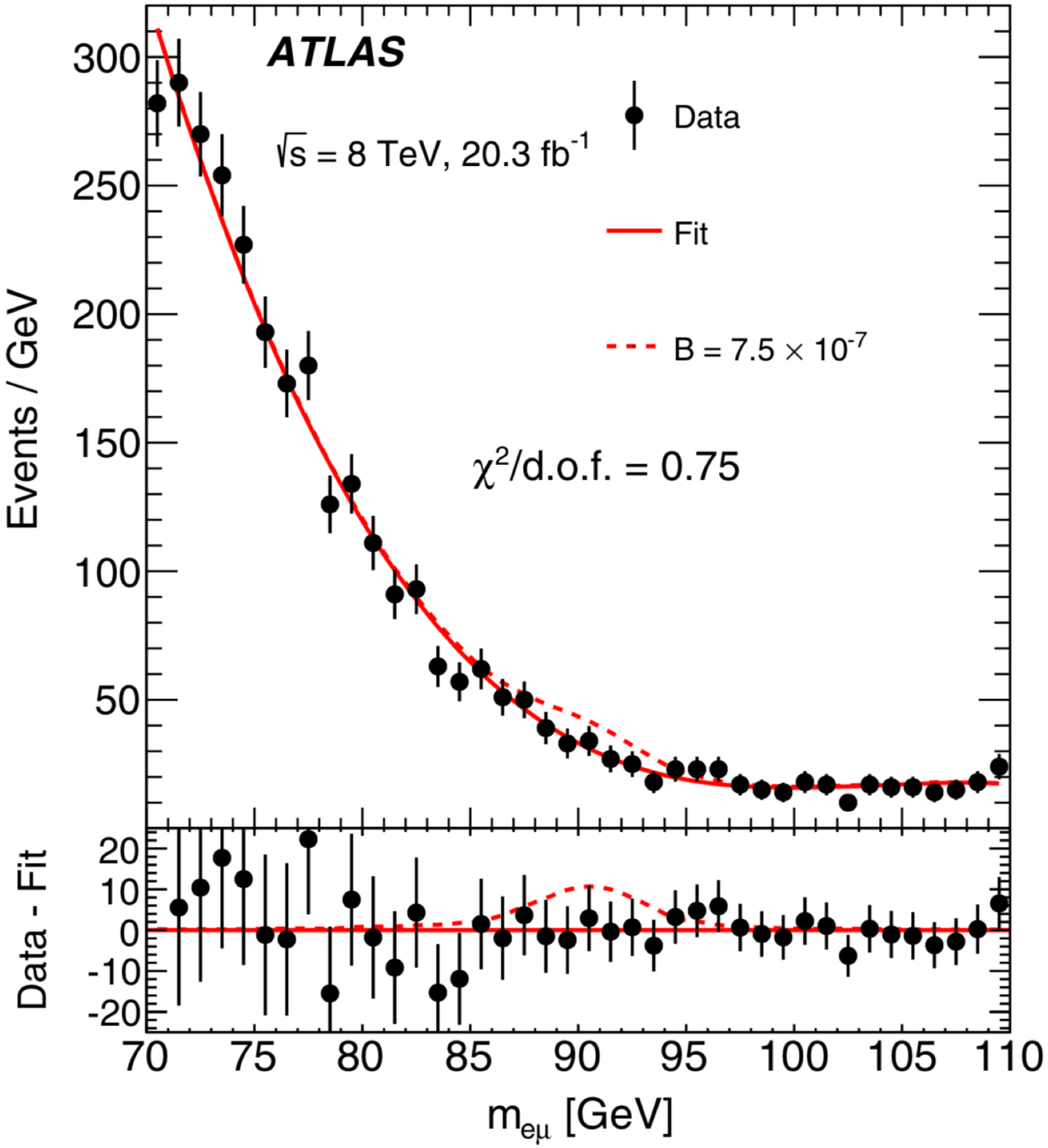
  - Difficult background from Z → μμ

PRD **90** 072010 (2014)



After all cuts applied, perform fit for a signal peak on a smooth background:





ATLAS result (8 TeV 20 fb^{-1})

- **$B(Z \rightarrow e\mu) < 7.5 \times 10^{-7}$ (95% CL)**
- Better than the LEP result: 17×10^{-7}
- Similar but unpublished [public] result from CMS.

ATLAS also searched for $Z \rightarrow e\tau$ and $Z \rightarrow \mu\tau$

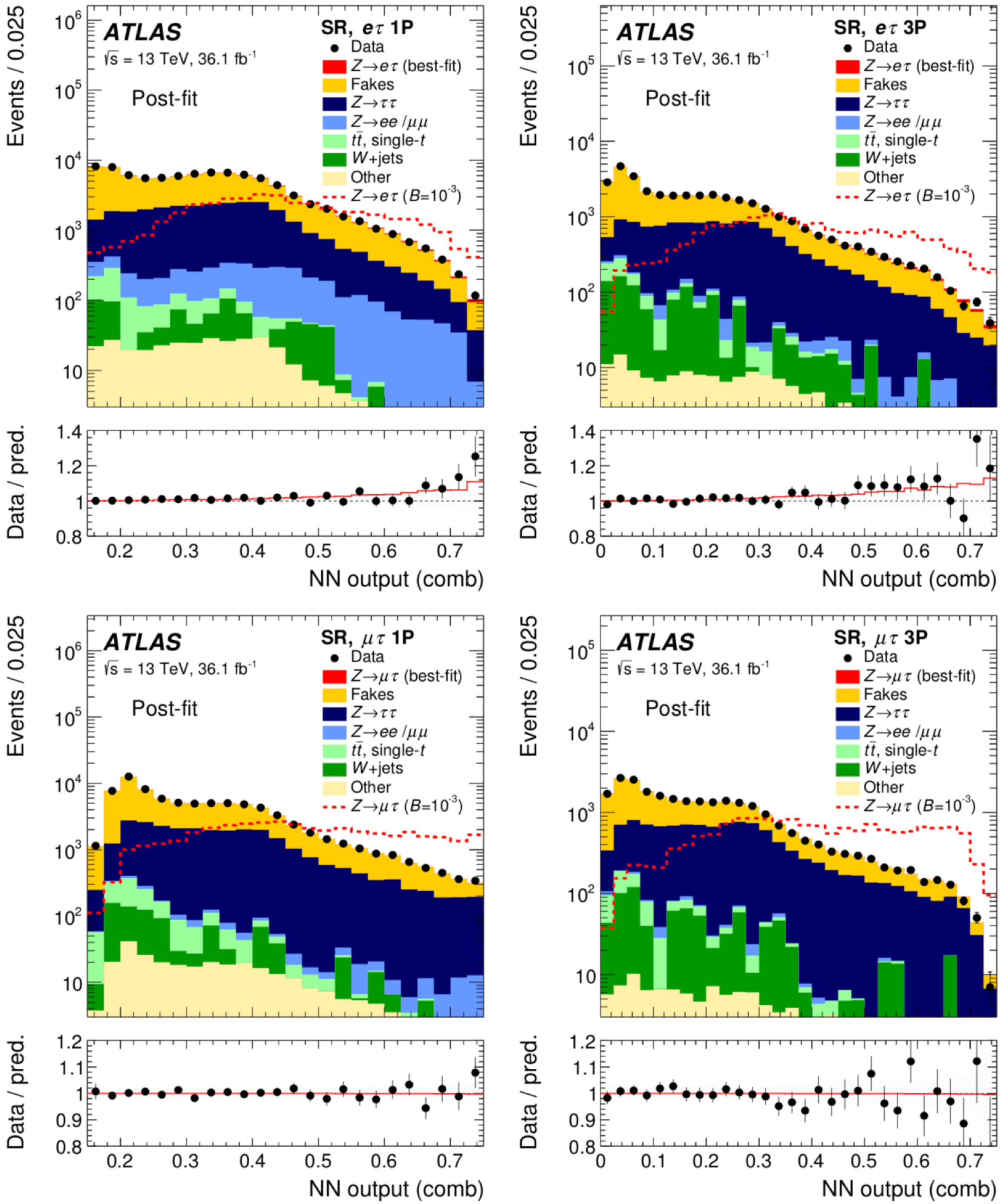
- 13 TeV 36 fb^{-1}
- Reconstruct τ leptons in hadronic decay modes
- Use neural network classifiers to identify signal events
- Fit the output of the classifier
- **$B(Z \rightarrow e\tau) < 5.8 \times 10^{-5}$** but **mild excess observed**
- **$B(Z \rightarrow \mu\tau) < 2.4 \times 10^{-7}$**

Output of NN classifier

electrons

1-prong τ on left.   3-prong τ on right

muons



Higgs decays that violate lepton flavor conservation

- Higgs boson is the one real fundamental discovery from the LHC.
- It opens a new window on the SM and possibly onto new physics.
- SM predictions are very concrete – are they correct?

- This probes something completely different: Yukawa couplings.

- Indirect bounds are relatively weak, especially for $e\tau$ and $\mu\tau$ decay channels.

- A great opportunity.

Synopsis of a search for H decays to eμ, eτ, μτ

- Similar to LFV decays of Z bosons.
  - Signal appears as a resonant peak
  - Background sources are the same.

- Several event categories / signal regions
  - Utilize all possible Higgs production mechanisms.
  - Mass resolution differs across the detector.
  - Backgrounds have different characteristics.

- For eτ, μτ use the collinear mass M_{coll}
  - neutrino parallel to visible τ decay products
  - systematic uncertainties associated with Higgs production modes

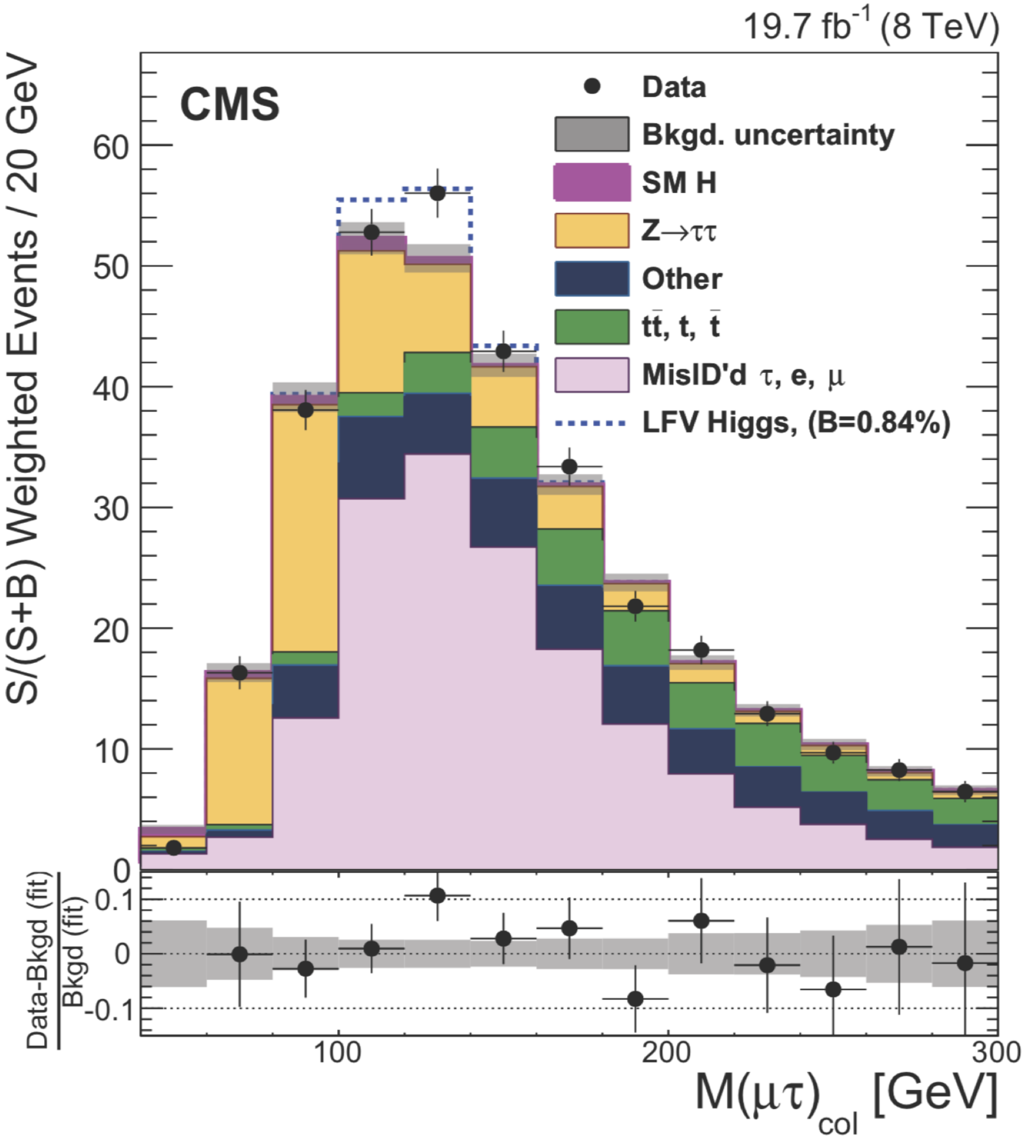
PLB 763 (2016) 472

CMS result (8 TeV 20 fb^{-1})

- B(H→eμ) < 0.035%
- B(H→eτ) < 0.69%
- B(H→μτ) = 0.84 +/- 0.38 %

  excess observed! (2.4σ)

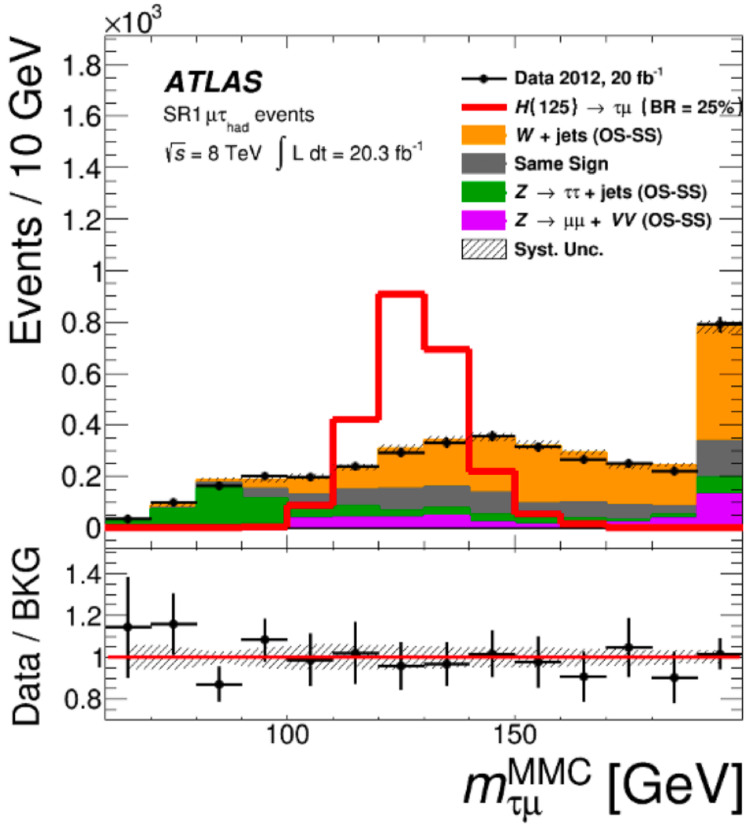
- UL: B(H→μτ) < 1.51%

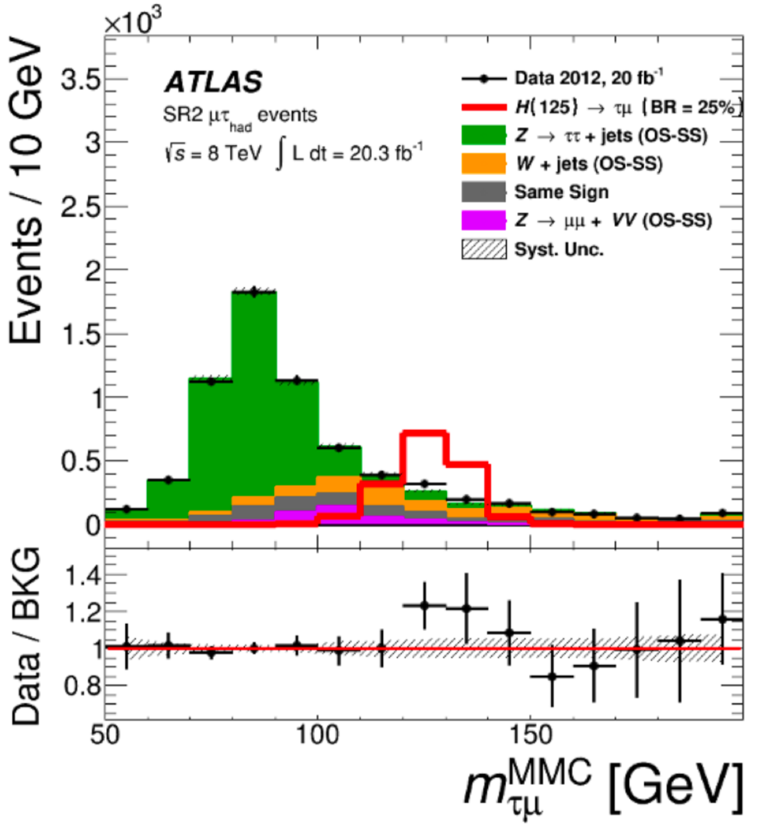


ATLAS responded with a search for H → μτ (8TeV 20 fb^{-1})

JHEP11(2015)211

- Use the same tools as Z → μτ
- Define two signal regions
  - SR1 dominated by W + jets
  - SR2 dominated by Z → ττ
- Use hadronic τ decays.

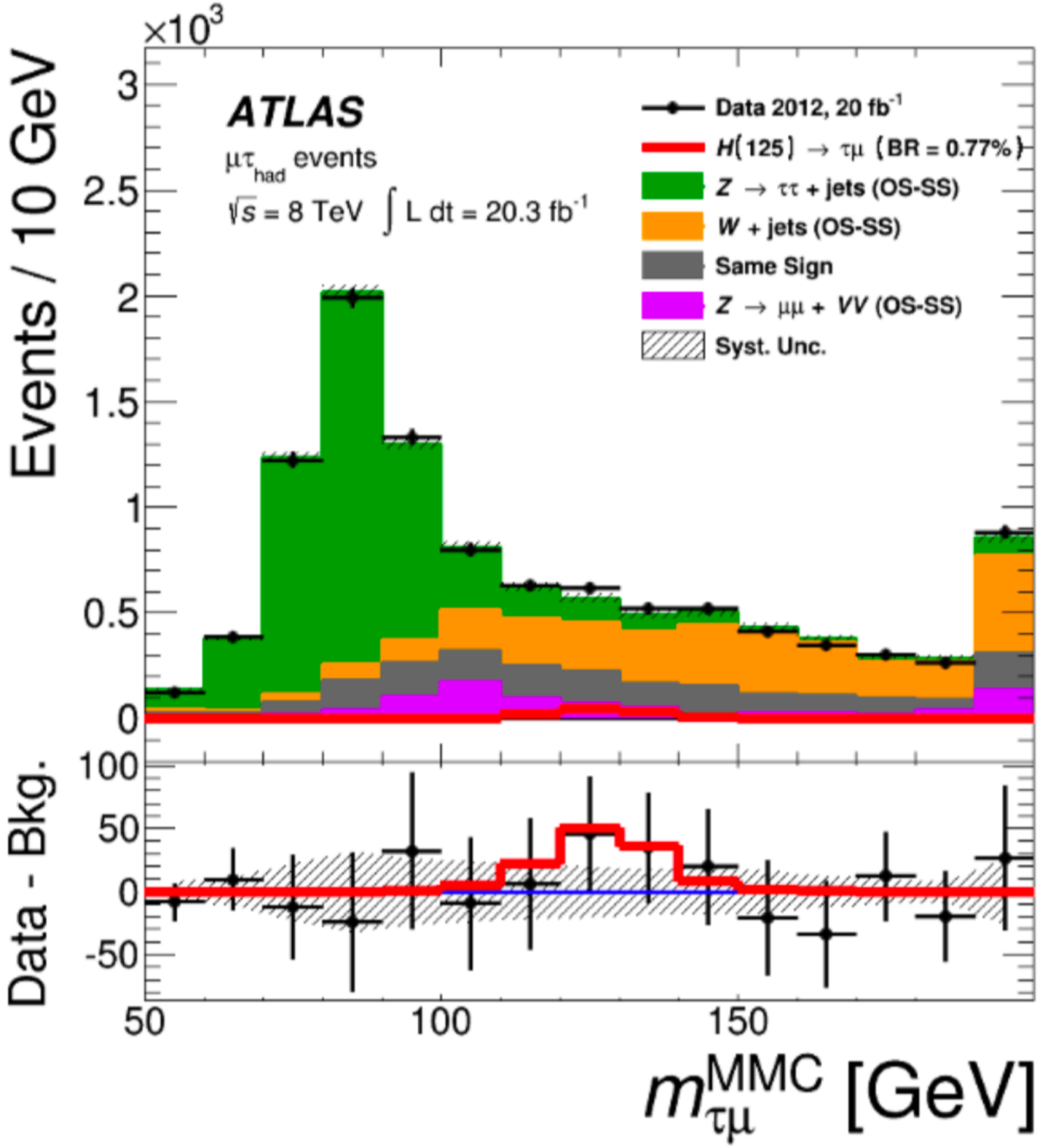




ATLAS result:

- B(H→μτ) = 0.77 +/- 0.62 %

  excess observed! (2.2σ)
- UL: B(H→μτ) < 1.85 %

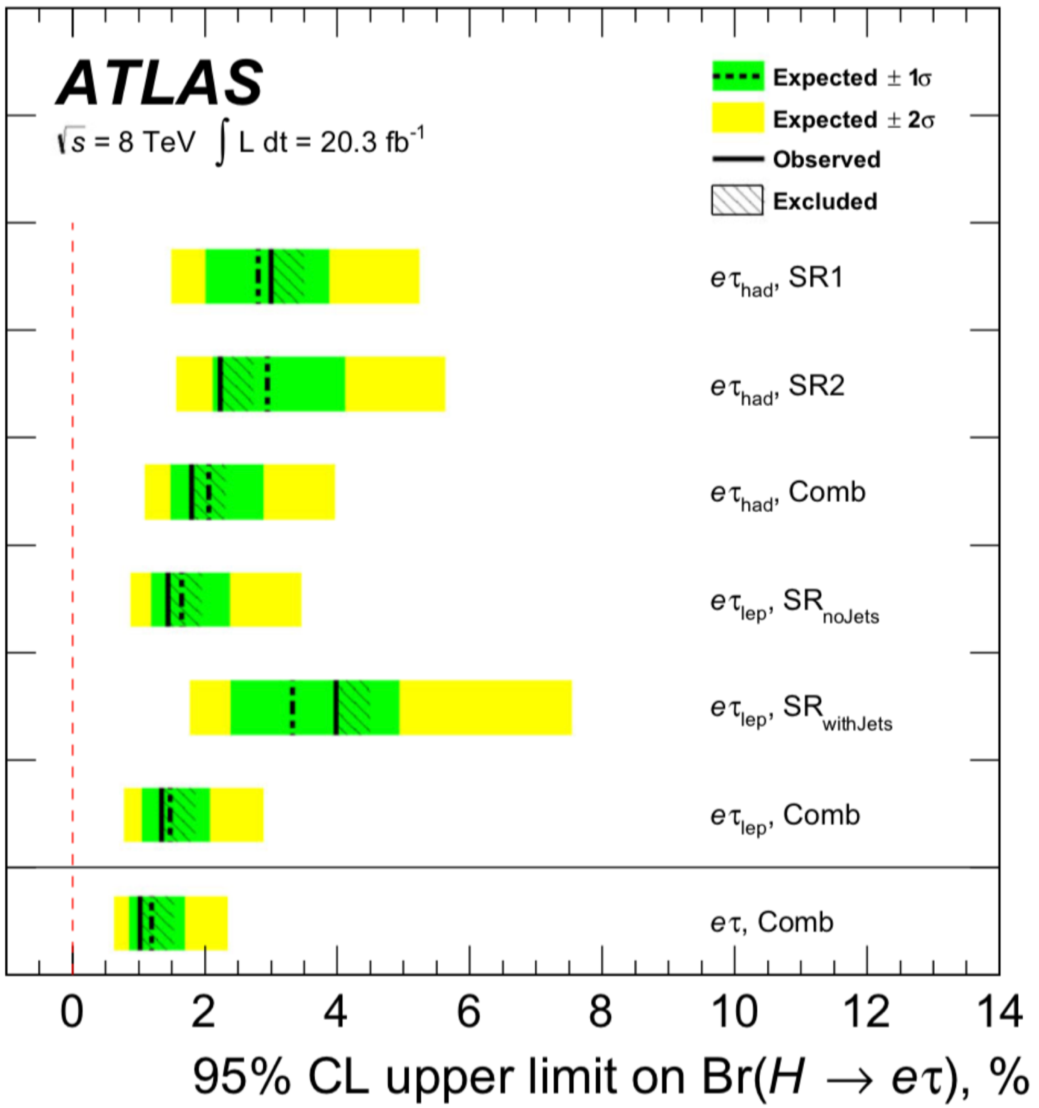


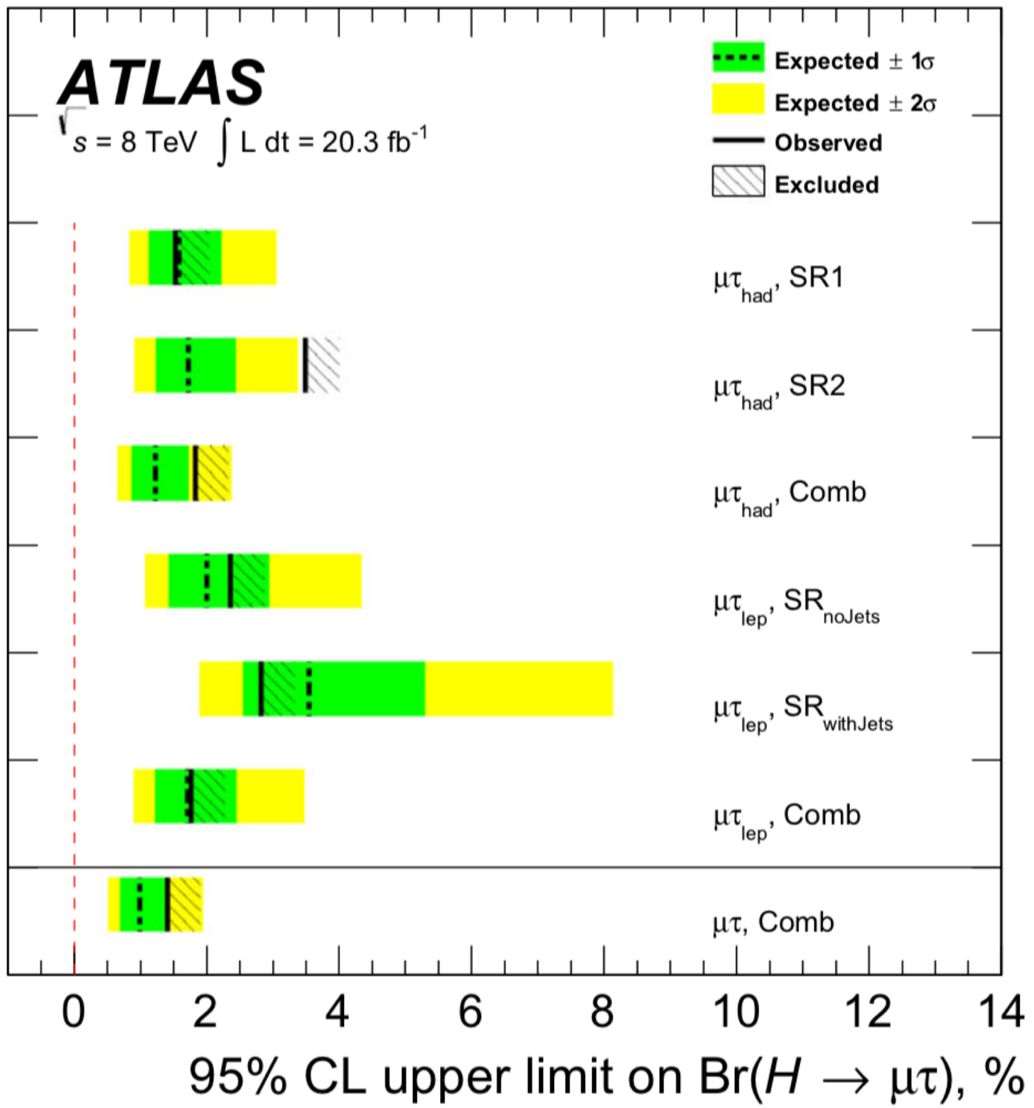
Reminder, CMS result:

- B(H→μτ) = 0.84 +/- 0.32 %

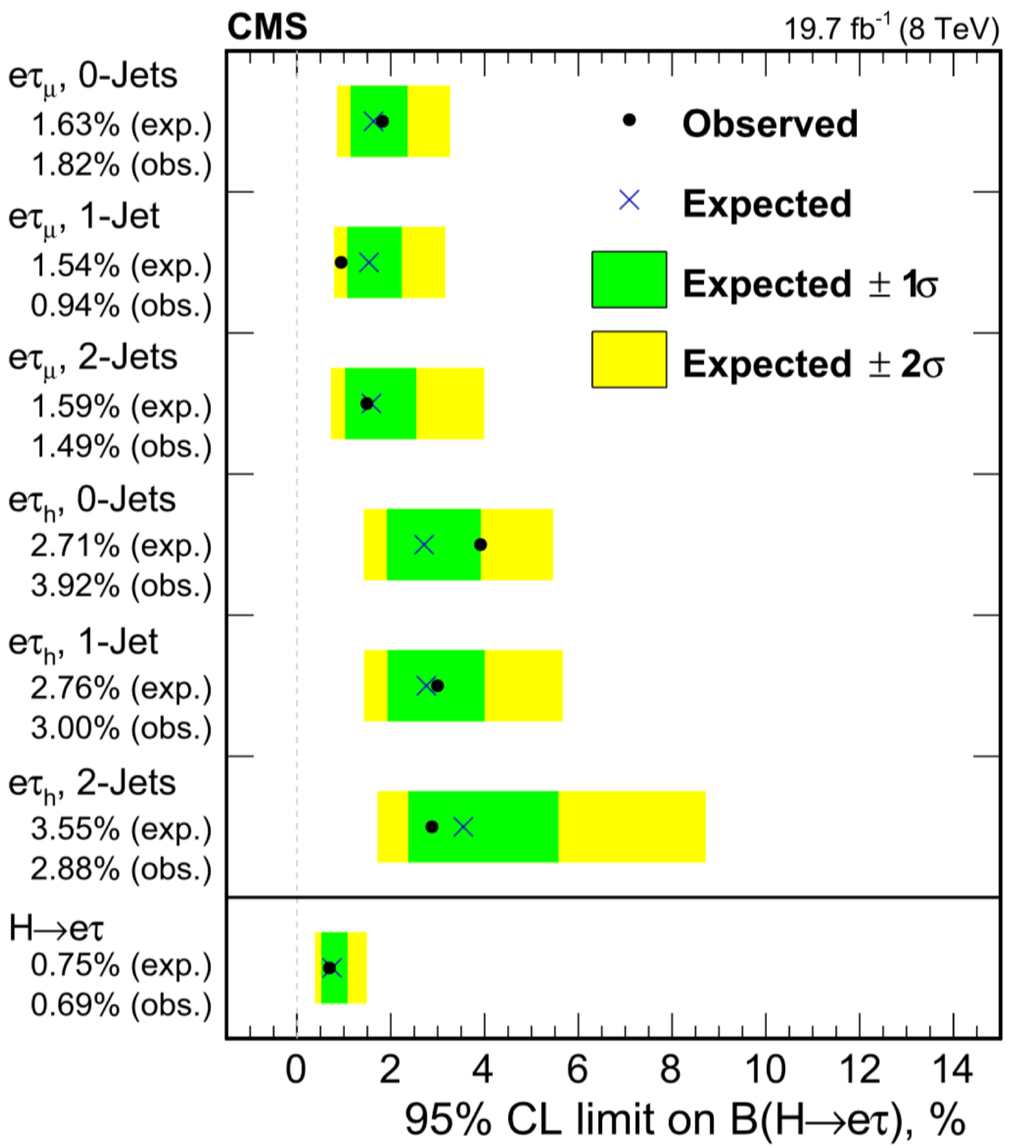
  excess observed (2.4σ)
- UL: B(H→μτ) < 1.51 %

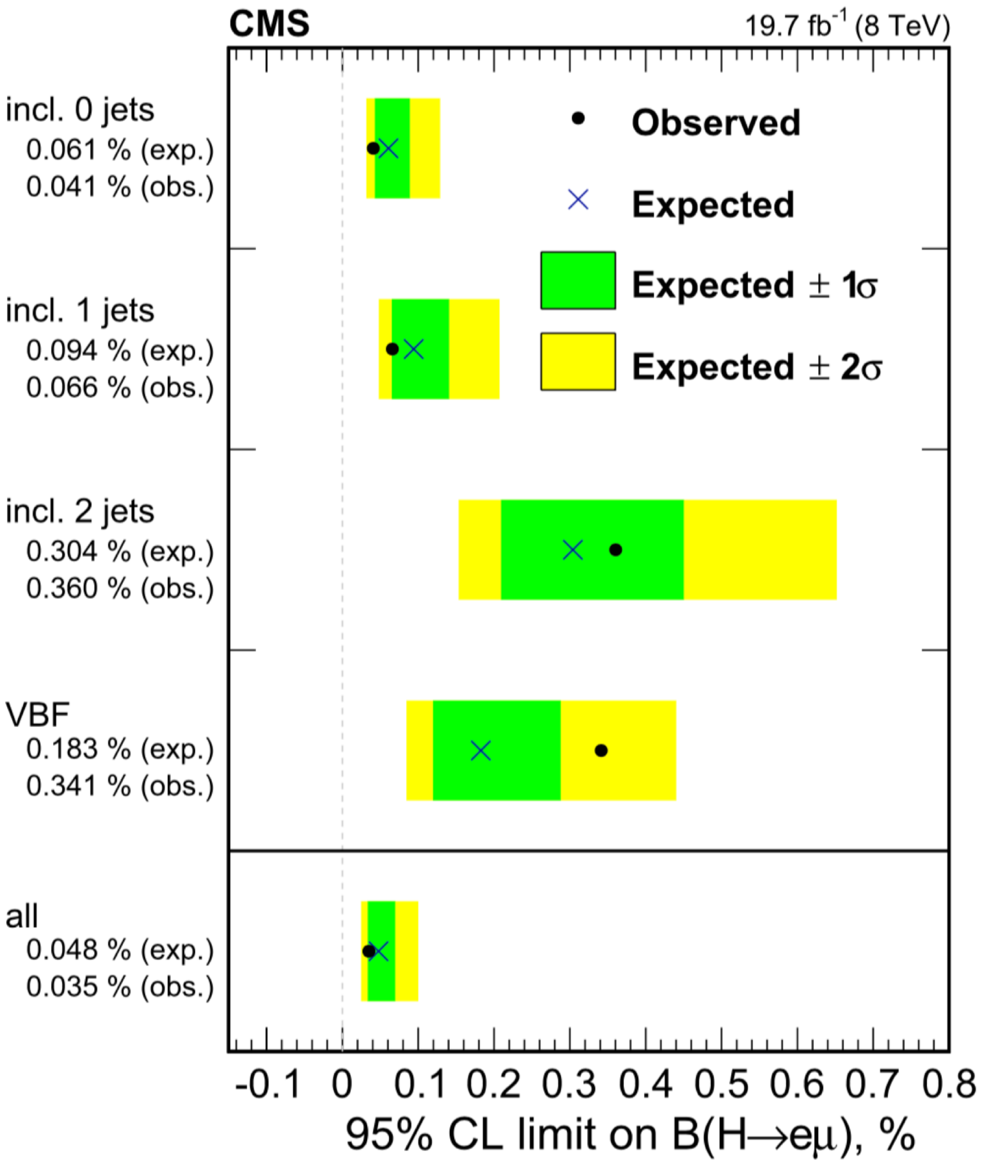
A more complete ATLAS analysis (8 TeV 20 fb^{-1})





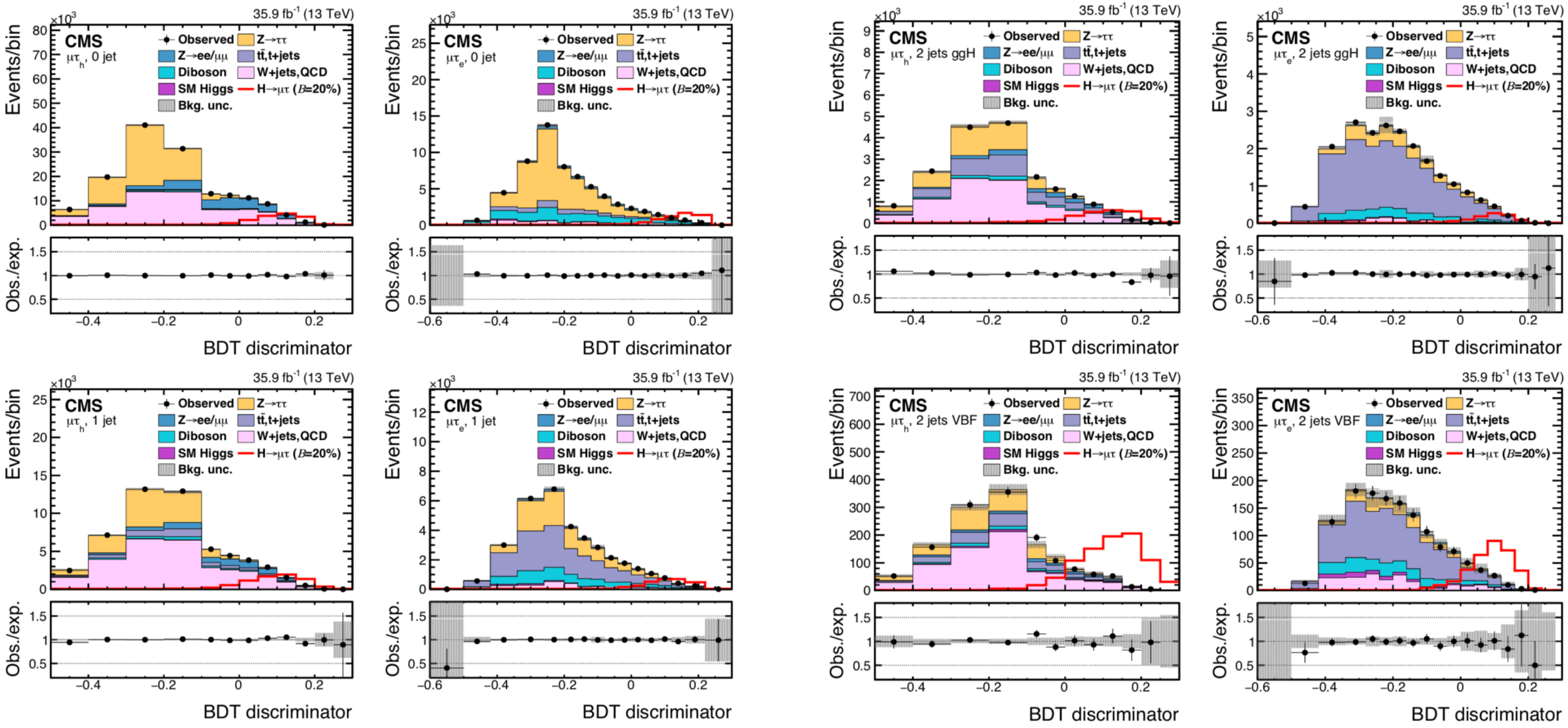
Additional CMS analyses (8 TeV 20 fb^{-1})





Sophisticated CMS analysis based on 13 TeV data: Many categories and a Boosted Decision Tree classifier

arXiv:1712.07173



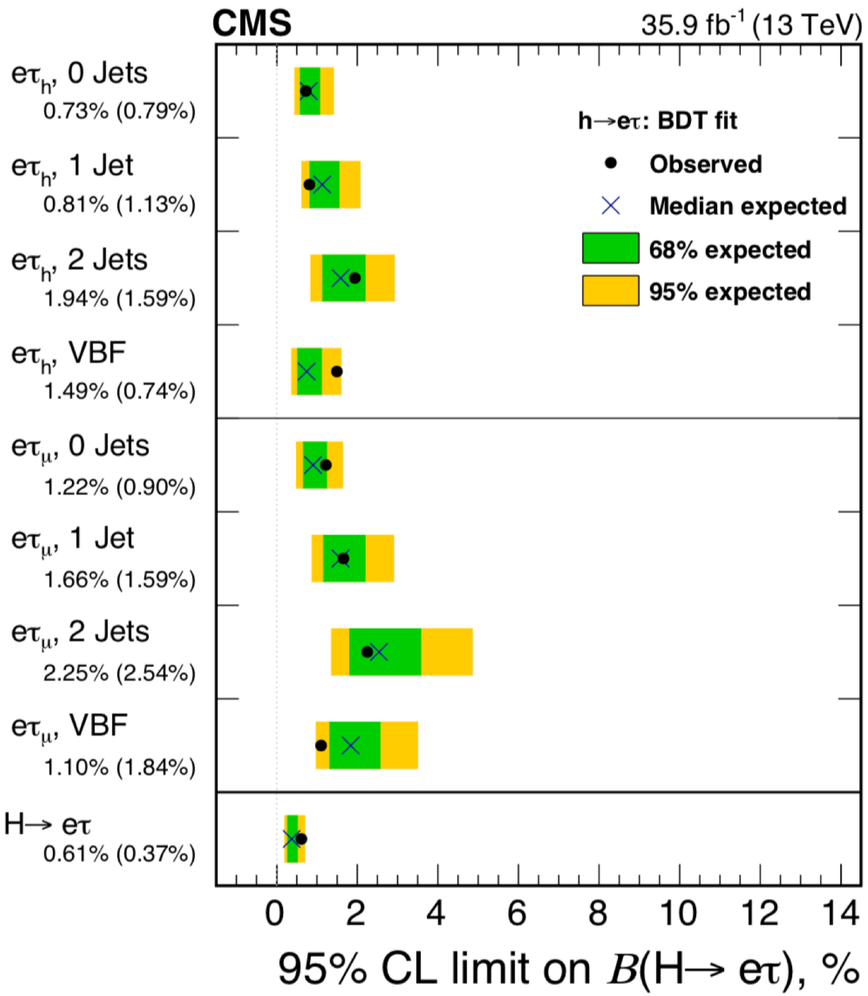
CMS results (13 TeV 36 fb^{-1})

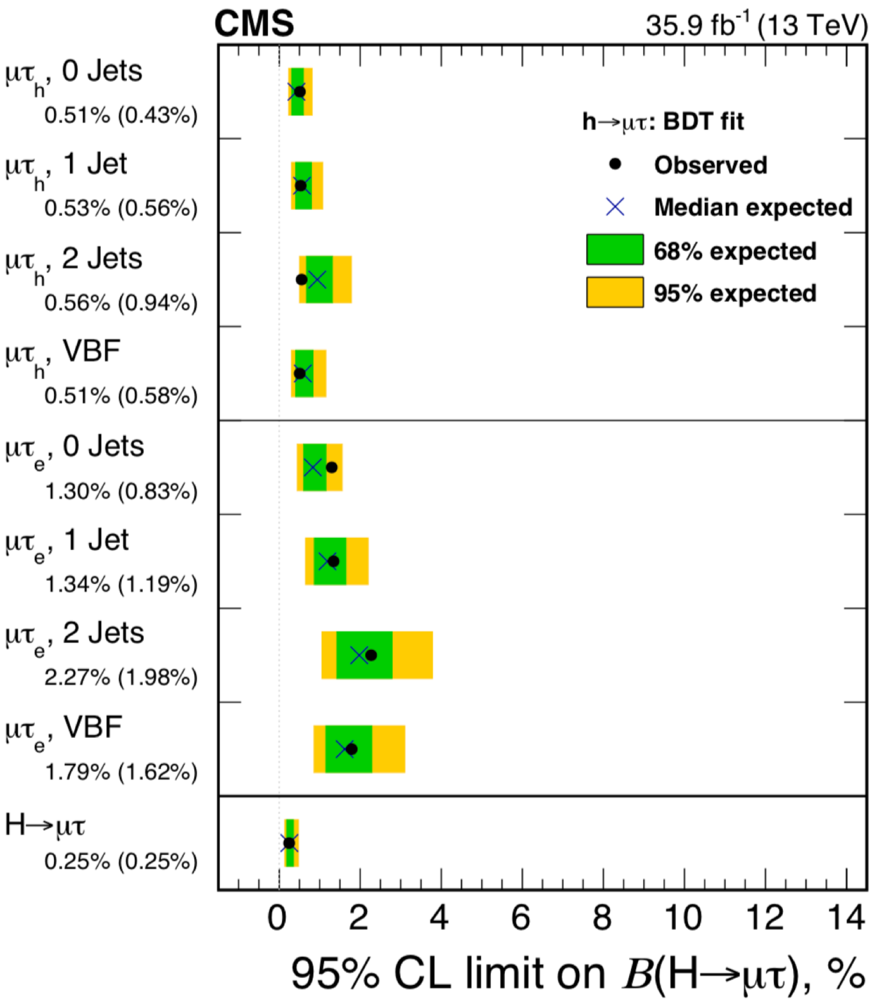
B(H→eτ) < 0.61%

arXiv:1712.07173

excess not confirmed

B(H→μτ) < 0.25%

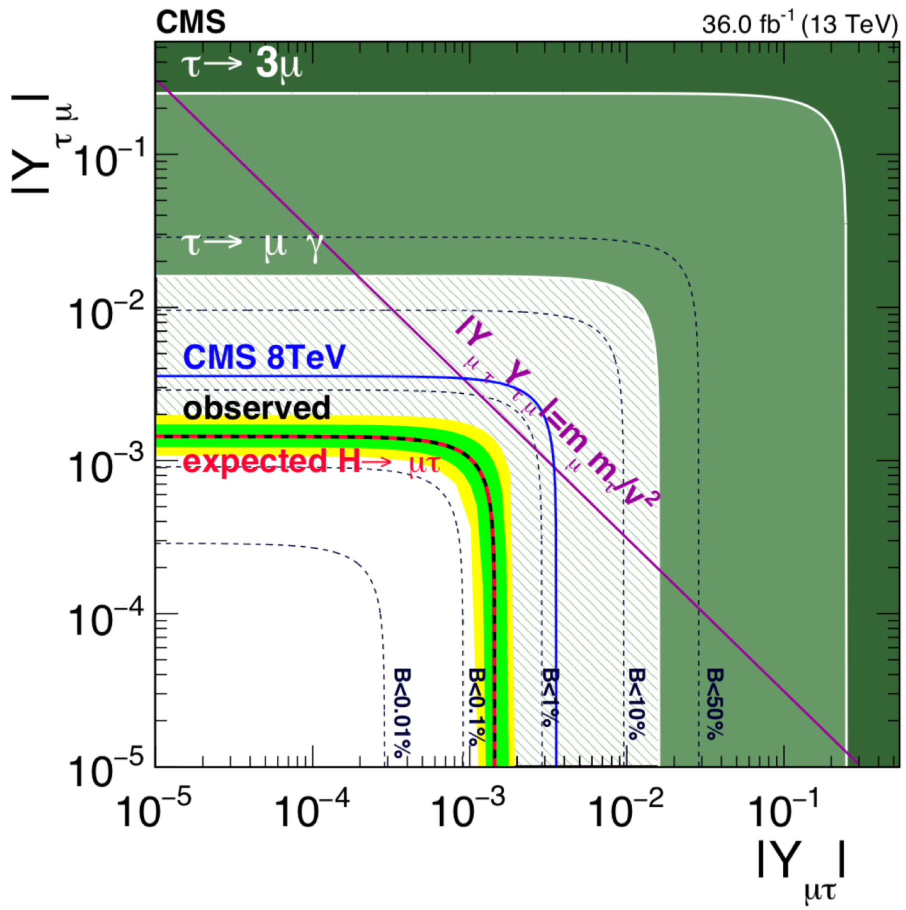


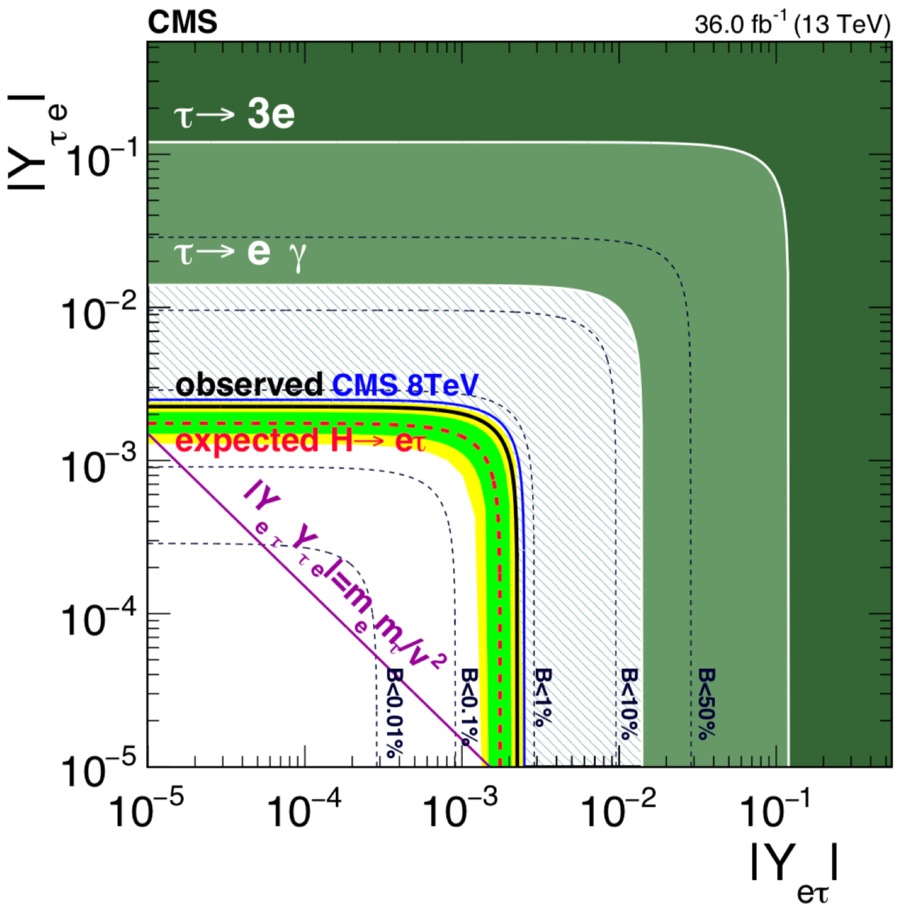


Limits on non-diagonal Yukawa couplings:

$$\sqrt{|Y_{\mu\tau}|^2 + |Y_{\tau\mu}|^2} < 1.43 \times 10^{-3}$$

$$\sqrt{|Y_{e\tau}|^2 + |Y_{\tau e}|^2} < 2.26 \times 10^{-3}$$





W decays: universal?

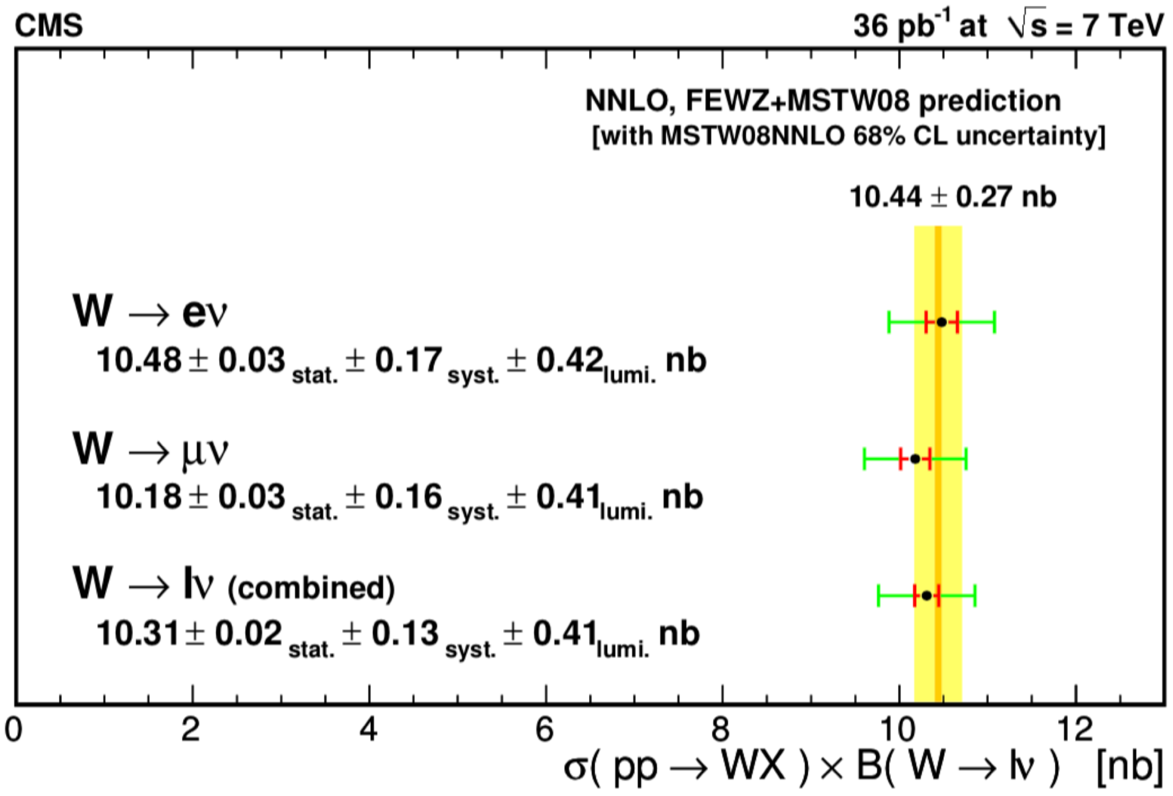
- SM assumes that gauge couplings are universal.
- This is not a necessary assumption.

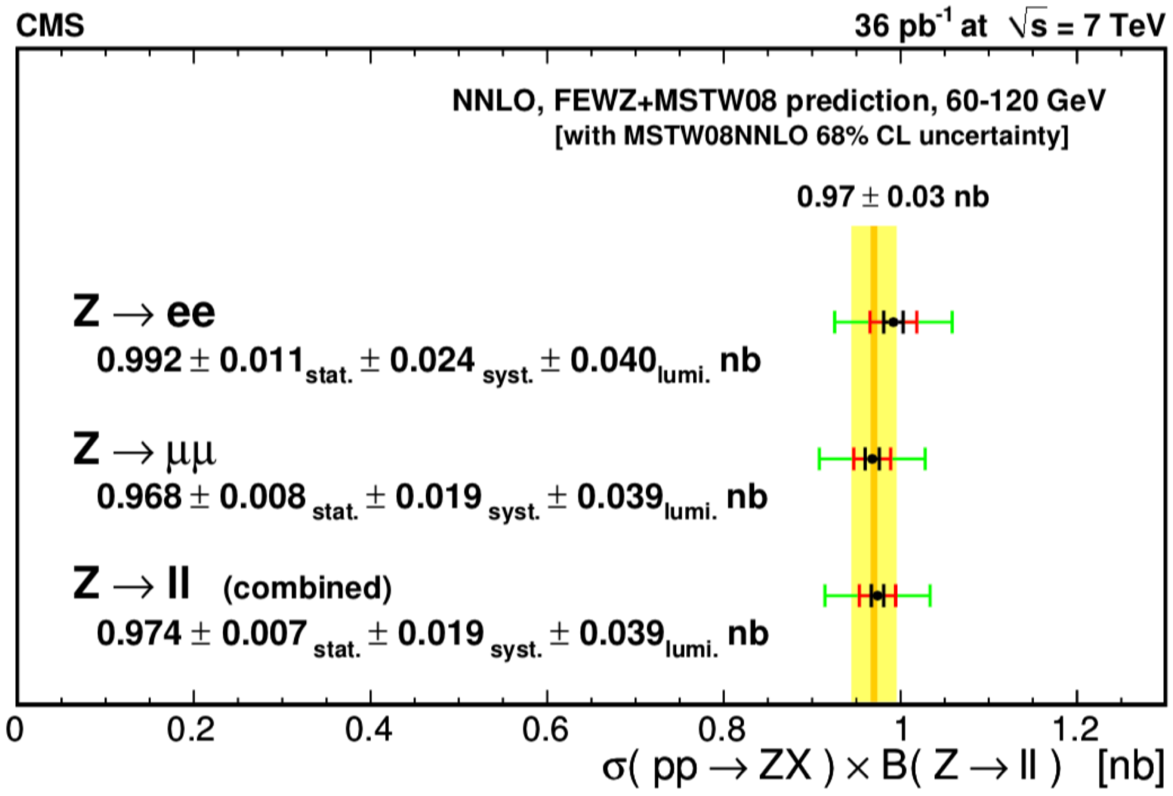
- LEP experiments put strong constraints on Z decays.
- No real opportunity to improve.

- W boson constraints are not as strong.
- Are they the same? **$B(W \rightarrow e\nu)$** **$B(W \rightarrow \mu\nu)$** **$B(W \rightarrow \tau\nu)$**

Very early indication from CMS (7 TeV 36 pb^{-1})

Inclusive cross section measurements depend on branching fractions.

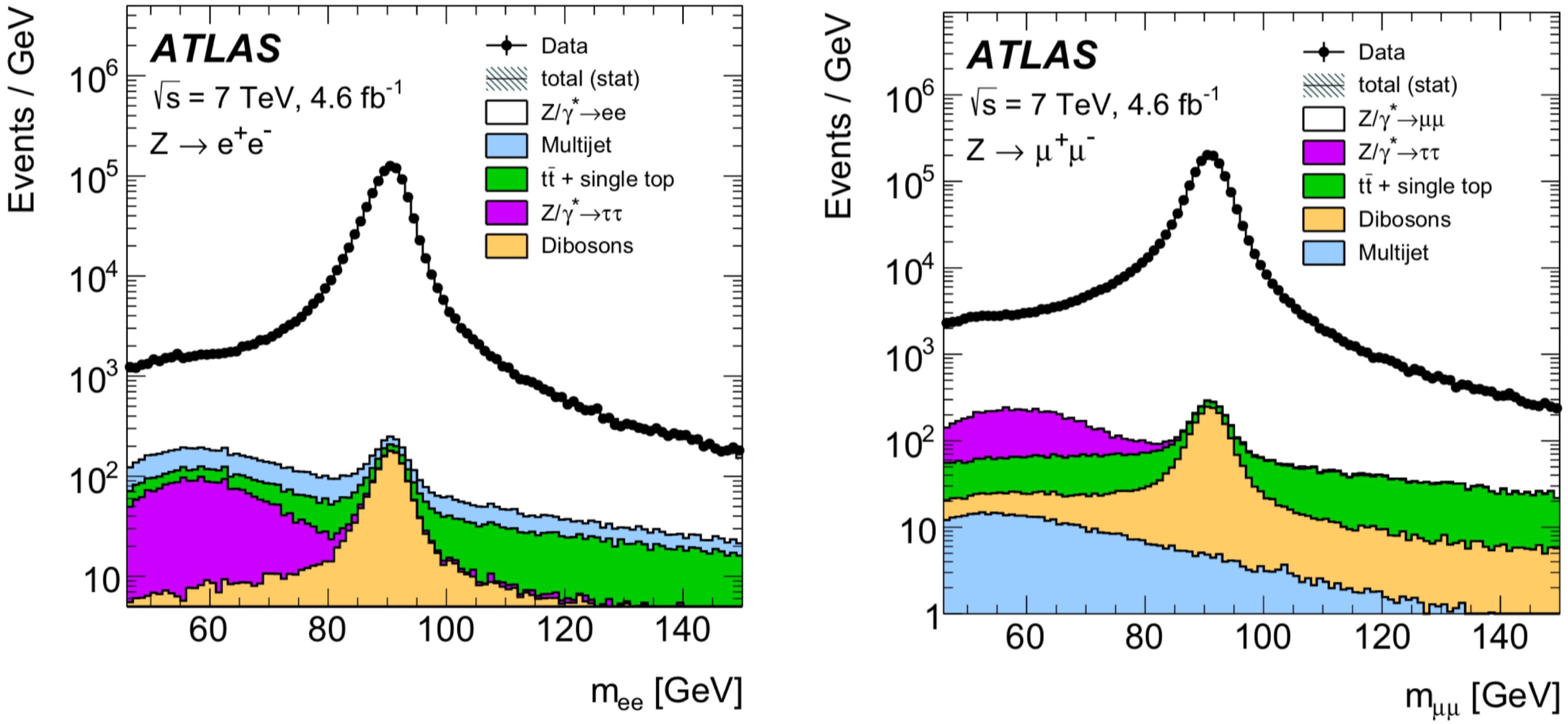




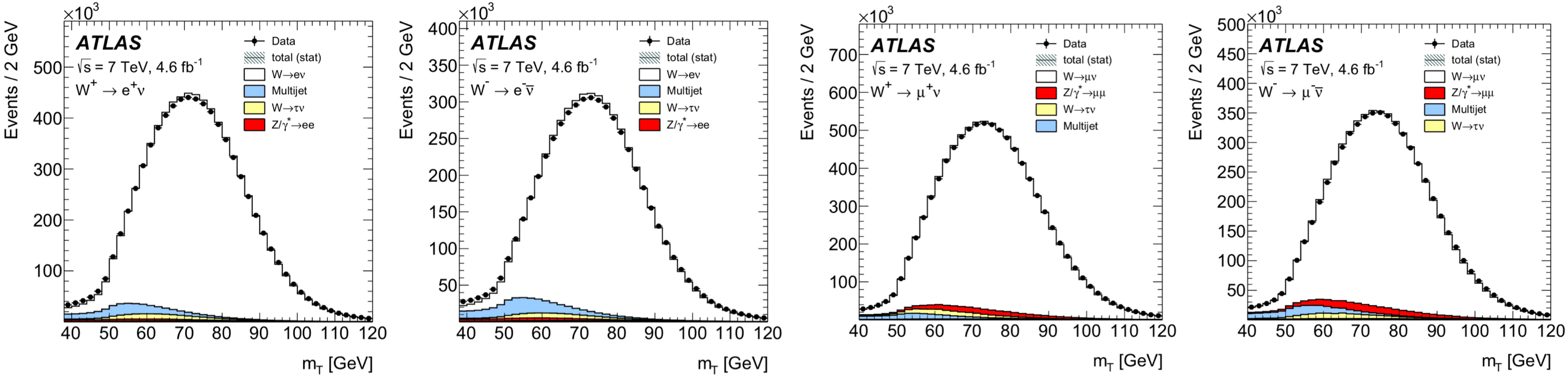
Reanalysis of early ATLAS data (7 TeV 4.6 fb^{-1})

Eur. Phys. J. C77 (2017) 367

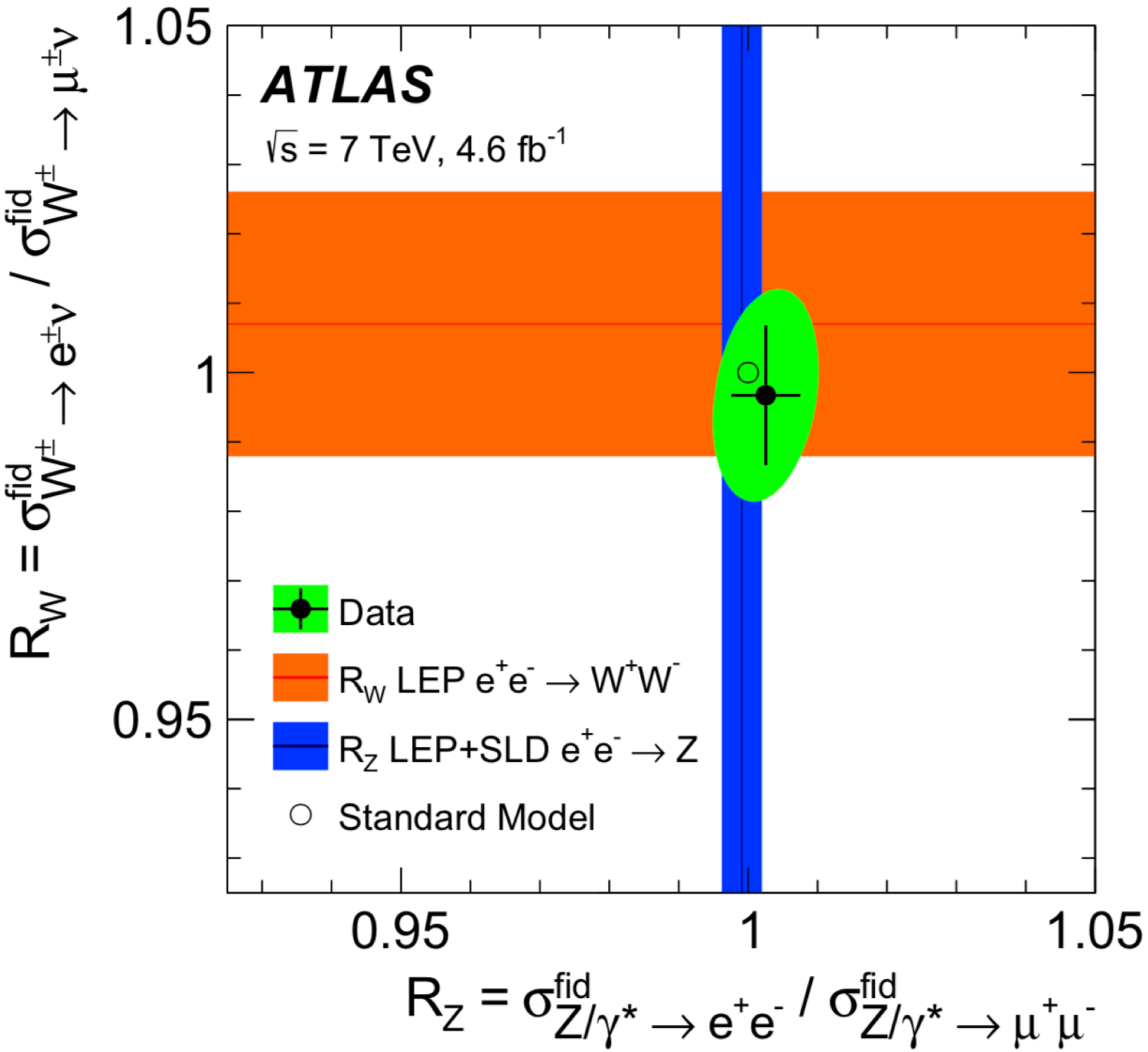
- High yields
- Excellent control over signals and backgrounds



- High purity



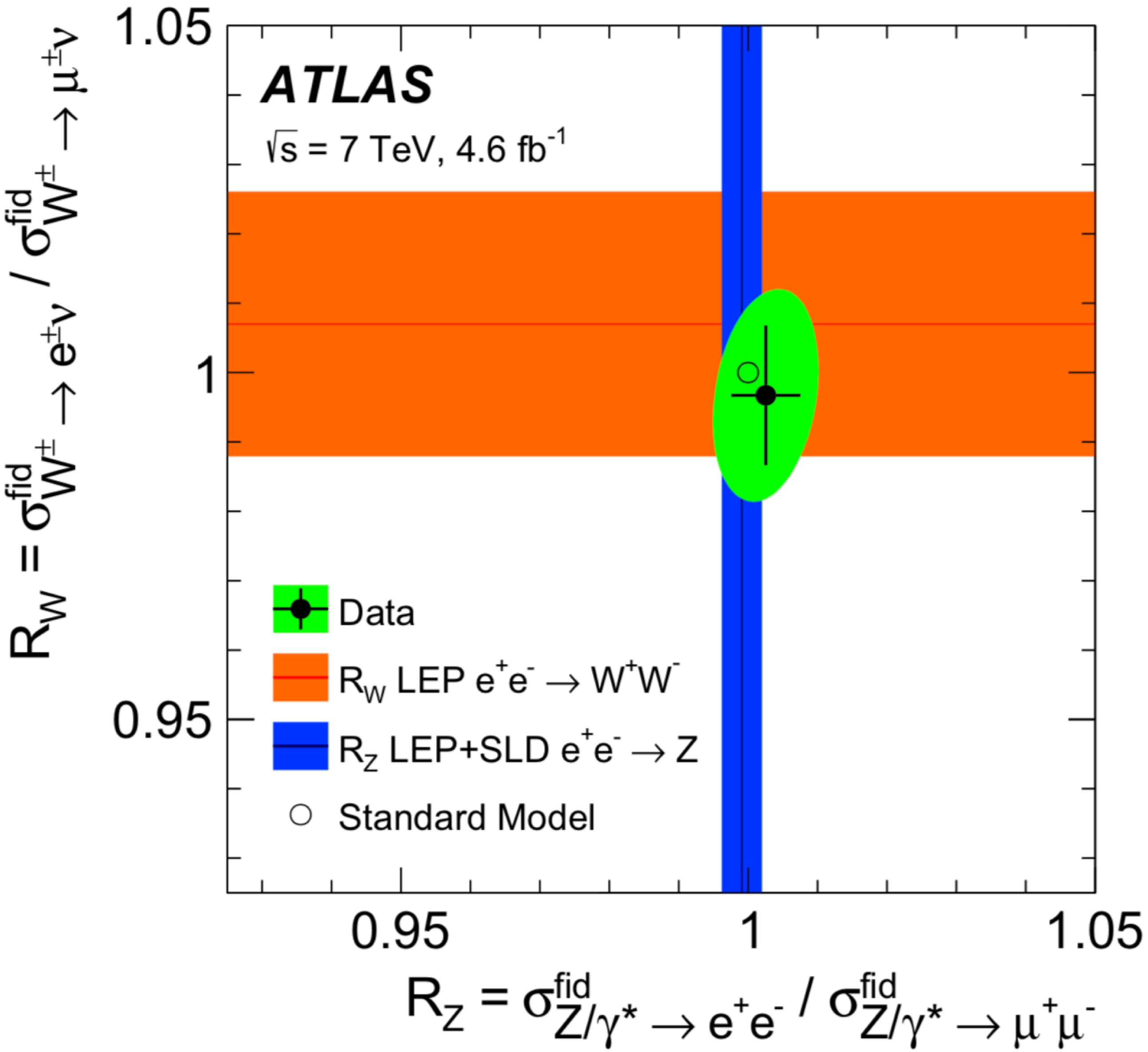
$W^+ \rightarrow e\nu$ $W^- \rightarrow e\nu$ $W^+ \rightarrow \mu\nu$ $W^- \rightarrow \mu\nu$

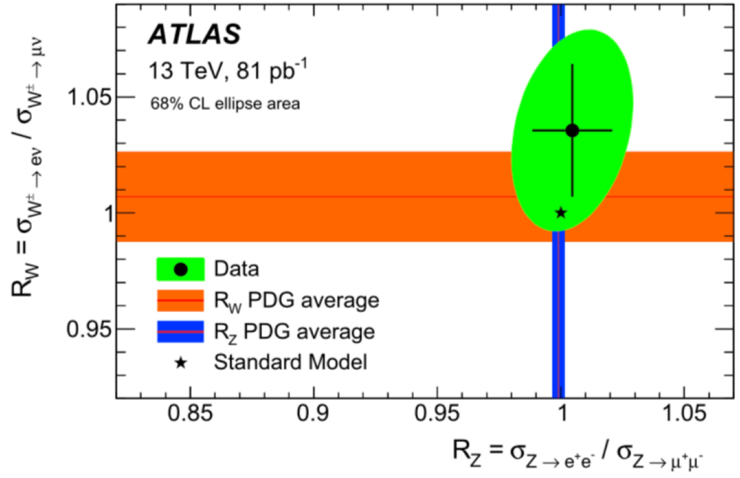


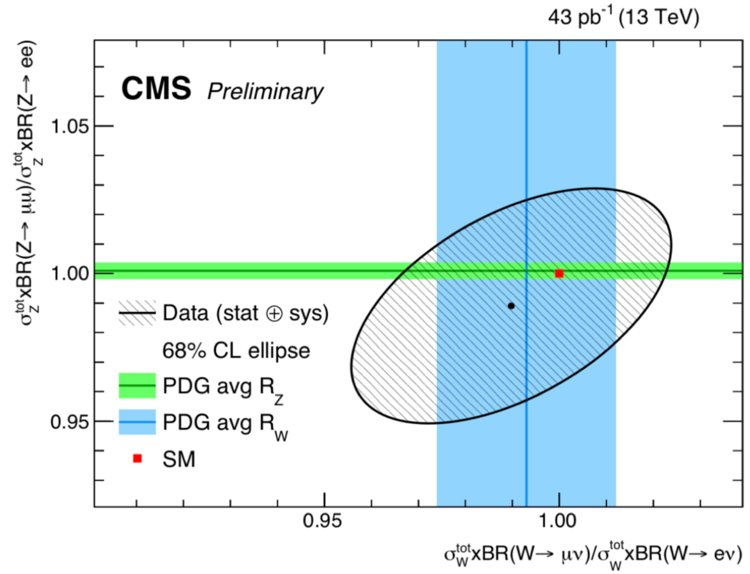
$R_W = B(W \rightarrow e\nu) / B(W \rightarrow \mu\nu)$

- **R_W = 0.997 +/- 0.010**
- **LEP: 1.007 +/- 0.019**
- **CDF: 1.018 +/- 0.025**
- **LHCb: 1.020 +/- 0.019**

- **R_Z = 1.0026 +/- 0.0050**
- **LEP: 0.9991 +/- 0.0028**


ATLAS
$\sqrt{s}$ = 7 TeV, 4.6 fb^{-1}
Data
R_W LEP $e^+e^- \to W^+W^-$
R_Z LEP+SLD $e^+e^- \to Z$
Standard Model
$R_W = \sigma^{fid}_{W^\pm \to e^\pm\nu} / \sigma^{fid}_{W^\pm \to \mu^\pm\nu}$
$R_Z = \sigma^{fid}_{Z/\gamma^* \to e^+e^-} / \sigma^{fid}_{Z/\gamma^* \to \mu^+\mu^-}$


ATLAS
13 TeV, 81 pb^{-1}
68% CL ellipse area
Data
R_W PDG average
R_Z PDG average
Standard Model
$R_W = \sigma_{W^\pm \to e\nu} / \sigma_{W^\pm \to \mu\nu}$
$R_Z = \sigma_{Z \to e^+e^-} / \sigma_{Z \to \mu^+\mu^-}$


43 pb^{-1} (13 TeV)
CMS Preliminary
Data (stat ⊕ sys)
68% CL ellipse
PDG avg R_Z
PDG avg R_W
SM
σ^{tot}_ZxBR(Z→ μμ)/σ^{tot}_ZxBR(Z→ ee)
σ^{tot}_WxBR(W→ μν)/σ^{tot}_WxBR(W→ eν)

What about top decays?

- Top quarks do not couple directly to leptons.
- They decay by emitting a W boson, and we just tested W bosons.
- The point is that there may be other, non-SM decays that themselves are not universal, leading to an apparent lepton flavor violation.

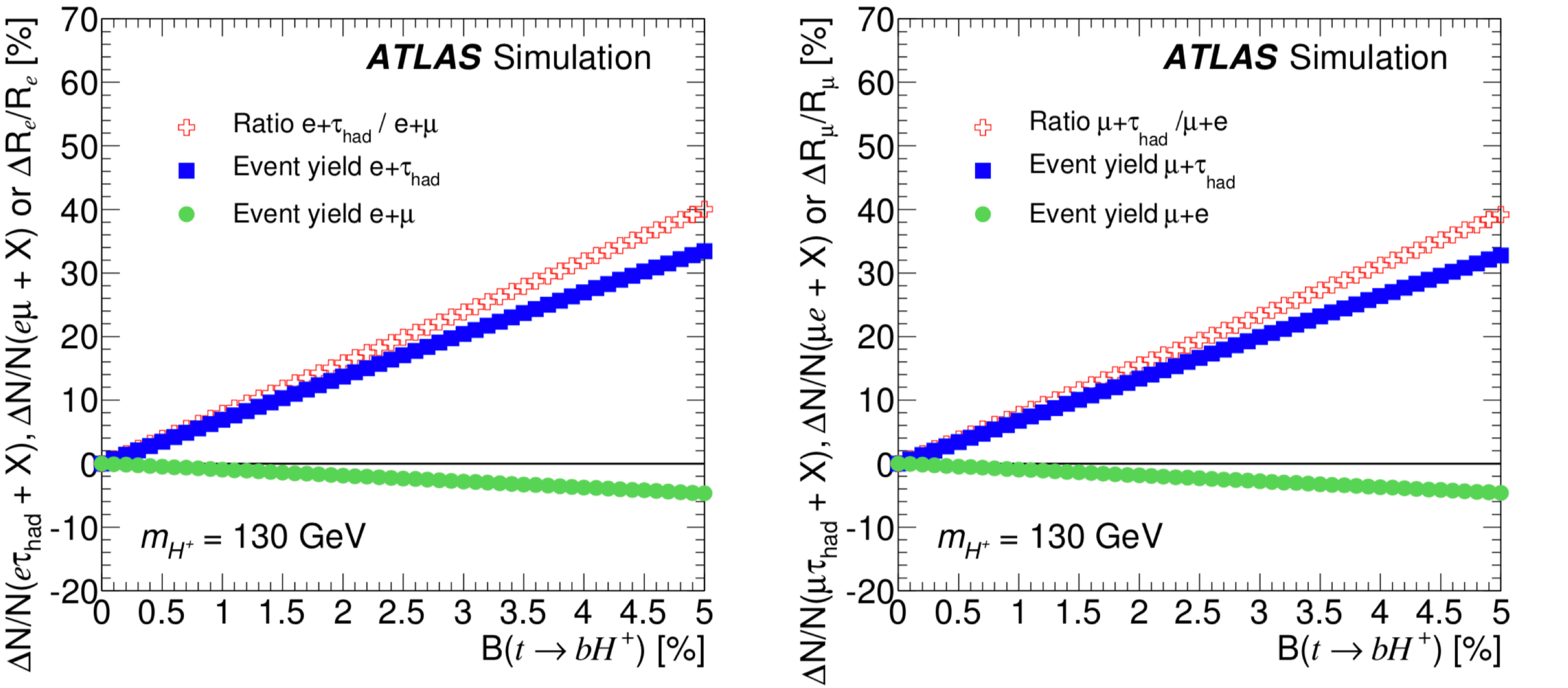
$$t \rightarrow H^+ b \qquad\qquad H^+ \rightarrow \tau^+ \nu$$

- If this decay exists then top would produce more τ leptons than expected.

ATLAS search for charged Higgs (7 TeV 4.6 fb^{-1})

JHEP03(2013)076

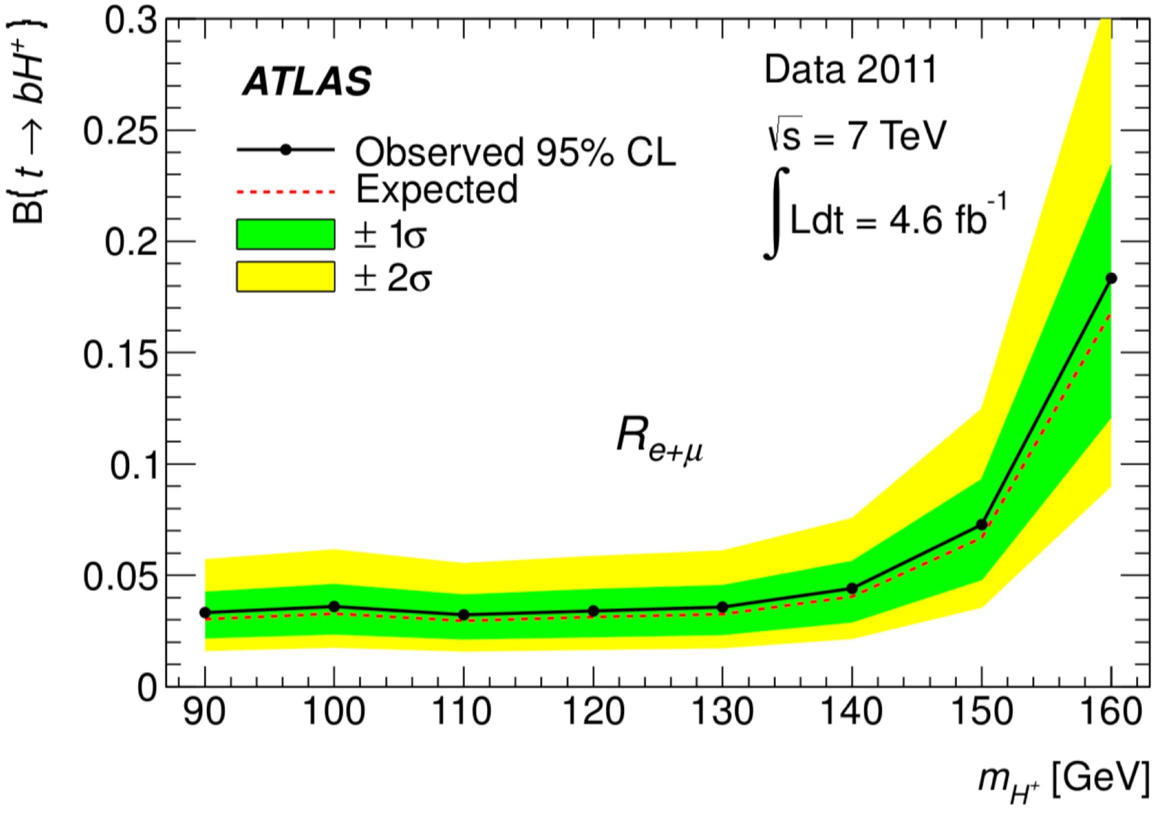
- Look at double-semi-leptonic ttbar events.
- Check the relative rates of (e&τ) and (e&μ) also (μ&τ) and (μ&e)



No signs of excess τs.

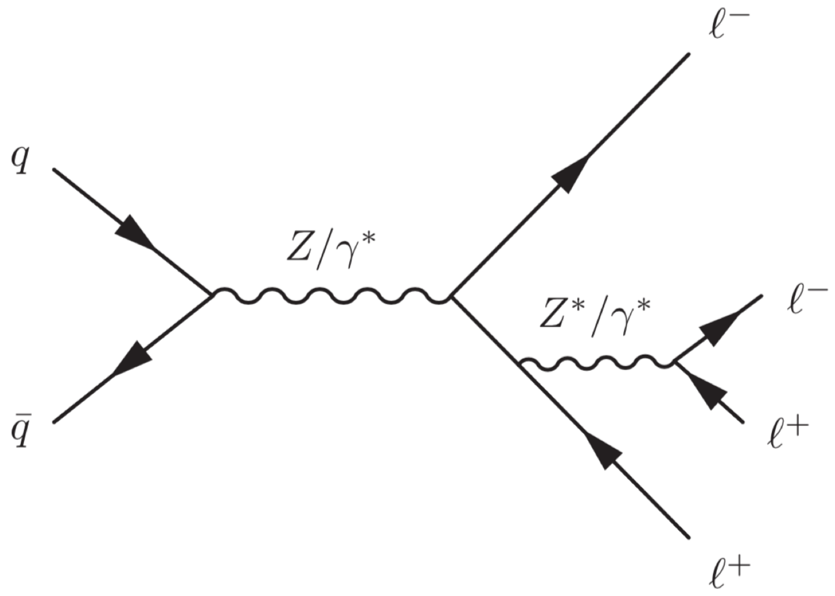
JHEP03(2013)076

Ratio	R_e	R_μ
SM value	0.105 ± 0.012	0.166 ± 0.017
Measured value	0.115 ± 0.010 (stat)	0.165 ± 0.015 (stat)

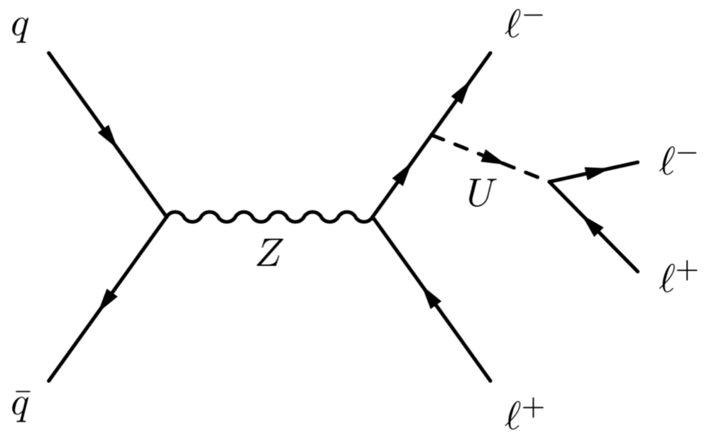


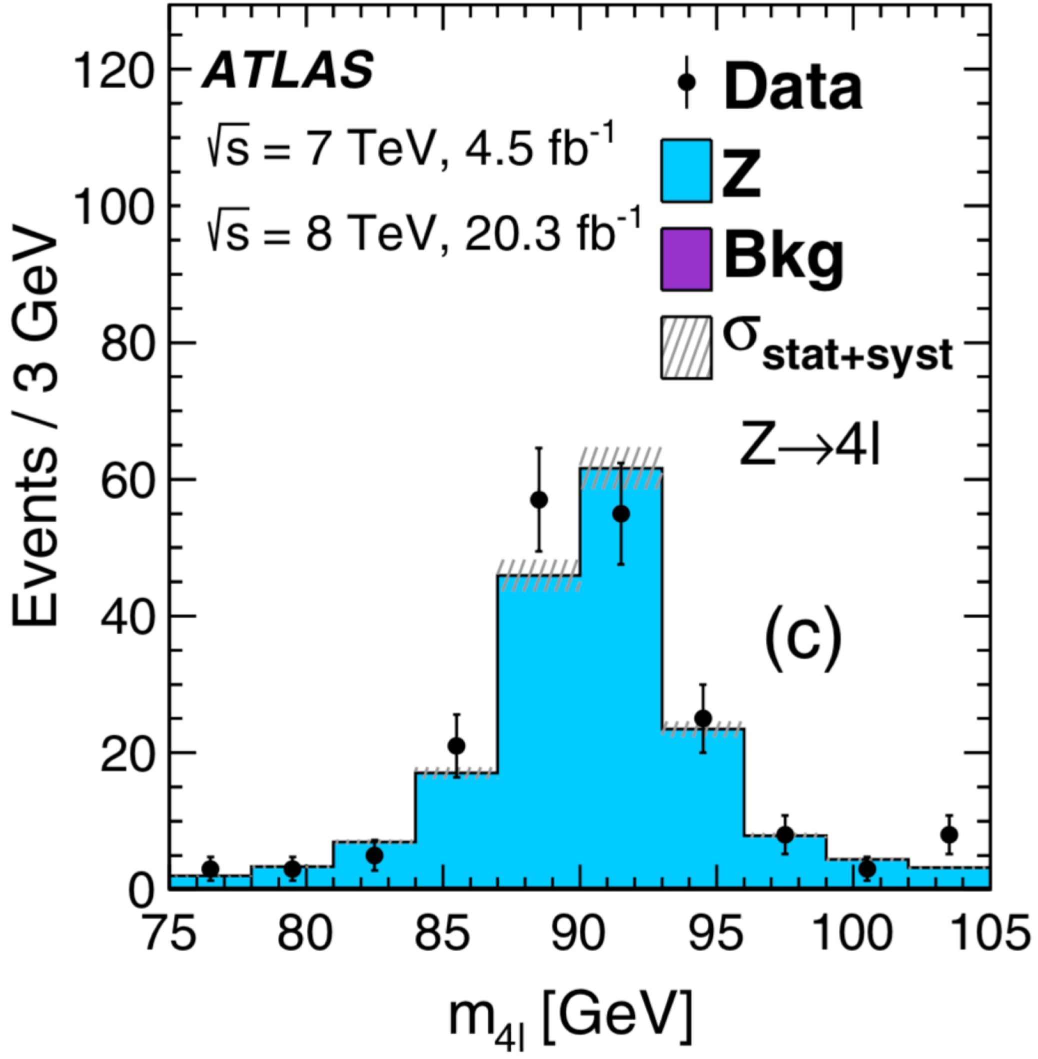
A last look at Z decays.

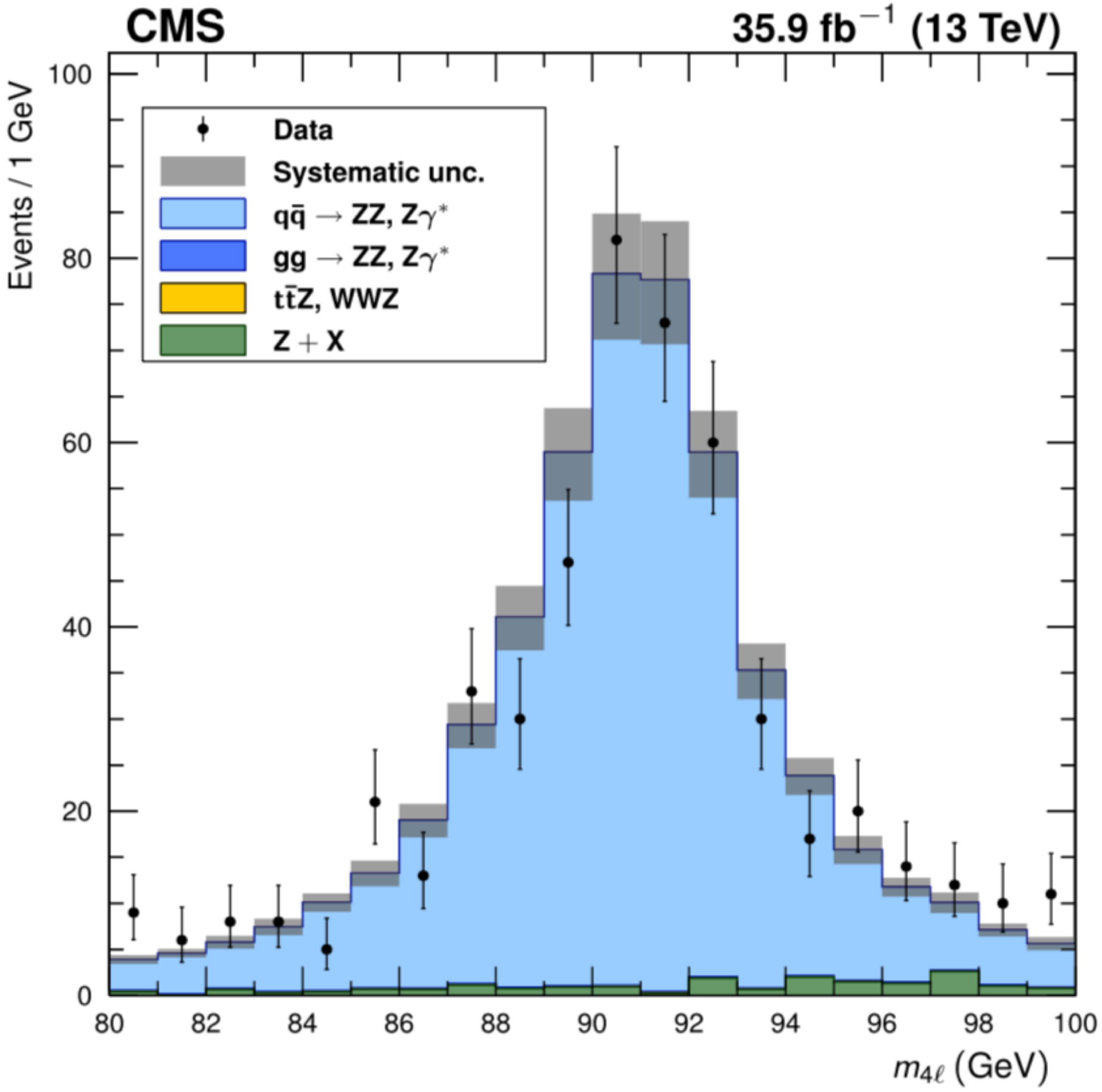
- Z decays to 4 leptons are rare, but observable.
- They were observed as part of the Higgs search in the mode H → Z Z* → 4 leptons (e or μ)



- These decays provide a window onto light bosons that might have non-universal couplings.
- A difference in eeee and μμμμ rates would signal new physics.




ATLAS
$\sqrt{s}$ = 7 TeV, 4.5 fb^{-1}
$\sqrt{s}$ = 8 TeV, 20.3 fb^{-1}
Data
Z
Bkg
$\sigma_{stat+syst}$
Z→4l
(c)
Events / 3 GeV
m_{4l} [GeV]


CMS
35.9 fb^{-1} (13 TeV)
Data
Systematic unc.
$q\bar{q} \rightarrow$ ZZ, Zγ^*
gg $\rightarrow$ ZZ, Zγ^*
$t\bar{t}$Z, WWZ
Z + X
Events / 1 GeV
$m_{4\ell}$ (GeV)

ATLAS measurement (7 TeV 4.6 fb^{-1} and 8 TeV 20 fb^{-1})

$\sqrt{s}$	4ℓ state	$N_{4\ell}^{\mathrm{obs}}$	$N_{4\ell}^{\mathrm{exp}}$	$N_{4\ell}^{\mathrm{bkg}}$	$C_{4\ell}$	$\sigma_{Z4\ell}^{\mathrm{fid}}$ [fb]	$A_{4\ell}$		$\sigma_{Z4\ell}$ [fb]
7 TeV	$ee+ee$	1	1.8 ± 0.3	0.12 ± 0.04	21.5%	$0.9^{+1.4}_{-0.7} \pm 0.14 \pm 0.02$	7.5%	$4e, 4\mu$	$32 \pm 11 \pm 1.0 \pm 0.6$
	$\mu\mu+\mu\mu$	8	11.3 ± 0.5	0.08 ± 0.04	59.2%	$3.0^{+1.2}_{-0.9} \pm 0.07 \pm 0.05$	18.3%		
	$ee+\mu\mu$	7	7.9 ± 0.4	0.18 ± 0.09	49.0%	$3.1^{+1.4}_{-1.1} \pm 0.16 \pm 0.05$	15.8%	$2e2\mu$	$44 \pm 14 \pm 3.3 \pm 0.9$
	$\mu\mu+ee$	5	3.3 ± 0.3	0.07 ± 0.04	36.3%	$3.0^{+1.6}_{-1.2} \pm 0.30 \pm 0.06$	8.8%		
	combined	21	24.2 ± 1.2	0.44 ± 0.14					$76 \pm 18 \pm 4 \pm 1.4$
8 TeV	$ee+ee$	16	14.4 ± 1.4	0.14 ± 0.03	36.1%	$2.2^{+0.6}_{-0.5} \pm 0.20 \pm 0.06$	7.3%	$4e, 4\mu$	$56 \pm 6 \pm 1.8 \pm 1.6$
	$\mu\mu+\mu\mu$	71	68.8 ± 2.7	0.34 ± 0.05	71.1%	$4.9^{+0.7}_{-0.6} \pm 0.13 \pm 0.14$	17.8%		
	$ee+\mu\mu$	48	43.2 ± 2.1	0.32 ± 0.05	55.5%	$4.2^{+0.7}_{-0.6} \pm 0.16 \pm 0.12$	14.8%	$2e2\mu$	$52 \pm 7 \pm 2.4 \pm 1.5$
	$\mu\mu+ee$	16	19.3 ± 1.3	0.18 ± 0.04	46.2%	$1.7^{+0.5}_{-0.4} \pm 0.10 \pm 0.04$	7.9%		
	combined	151	146 ± 7	1.0 ± 0.11					$107 \pm 9 \pm 4 \pm 3.0$

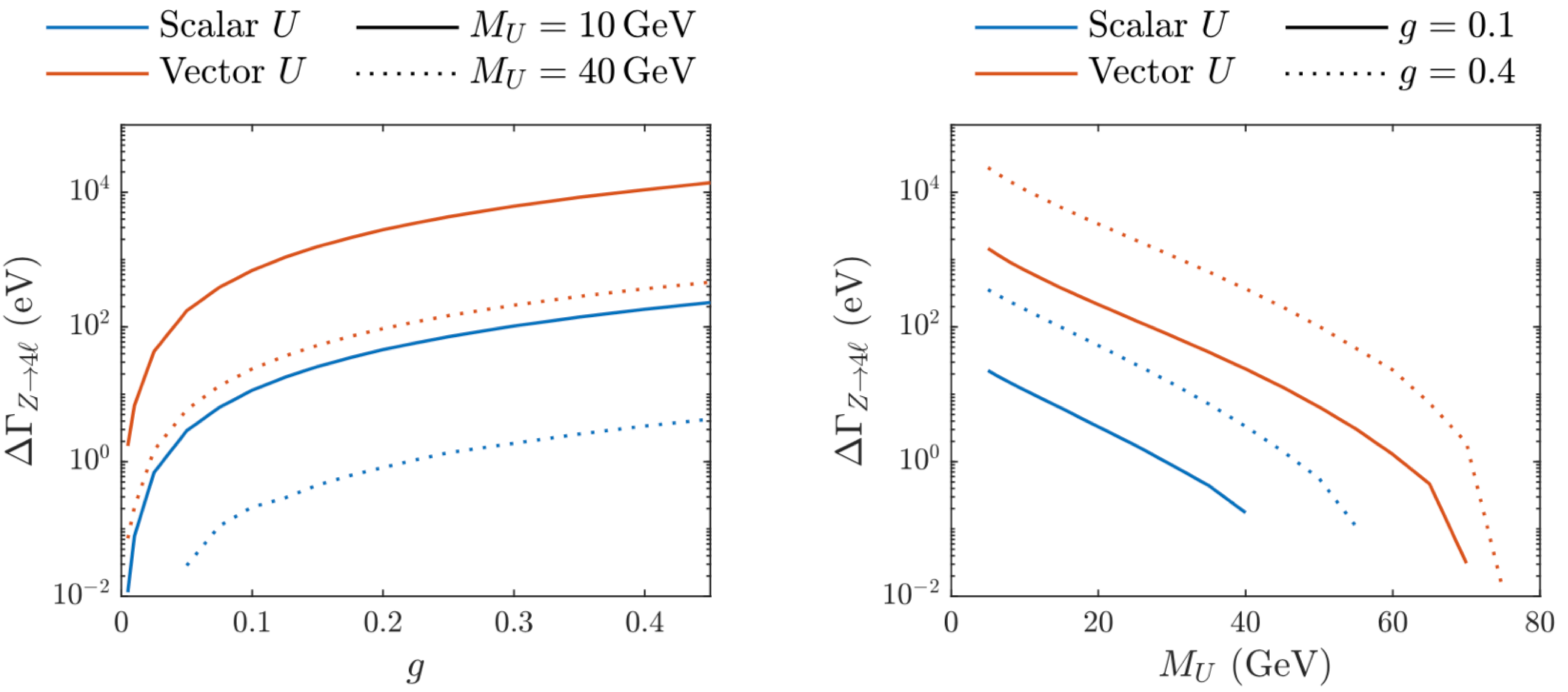
CMS data (13 TeV 36 fb^{-1})

Table 2 The observed and expected yields of four-lepton events in the mass region $80 < m_{4\ell} < 100$ GeV and estimated yields of background events, shown for each final state and summed in the total expected yield. The first uncertainty is statistical, the second one is systematic. The systematic uncertainties do not include the uncertainty in the integrated luminosity

Final state	Expected $N_{4\ell}$	Background	Total expected	Observed
4μ	$224 \pm 1 \pm 16$	$7 \pm 1 \pm 2$	$231 \pm 2 \pm 17$	225
$2e2\mu$	$207 \pm 1 \pm 14$	$9 \pm 1 \pm 2$	$216 \pm 2 \pm 14$	206
4e	$68 \pm 1 \pm 8$	$4 \pm 1 \pm 2$	$72 \pm 1 \pm 8$	78
Total	$499 \pm 2 \pm 32$	$19 \pm 2 \pm 5$	$518 \pm 3 \pm 33$	509

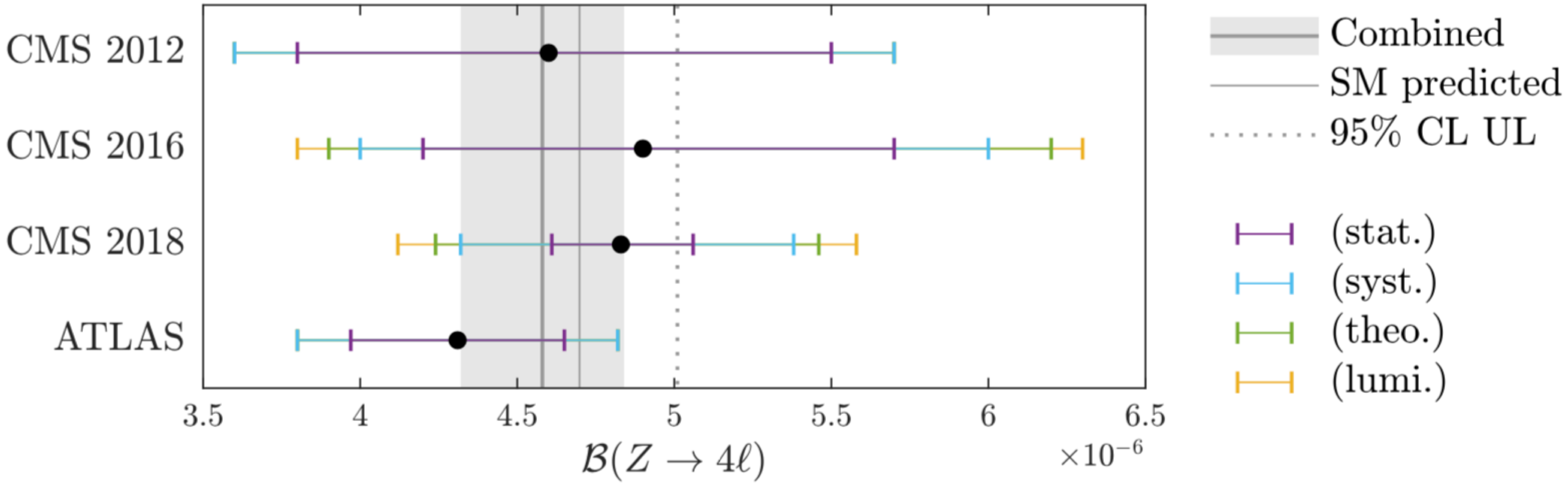
arXiv:1805.05791

Construct simple ad hoc model with an extra boson "U"



arXiv:1805.05791

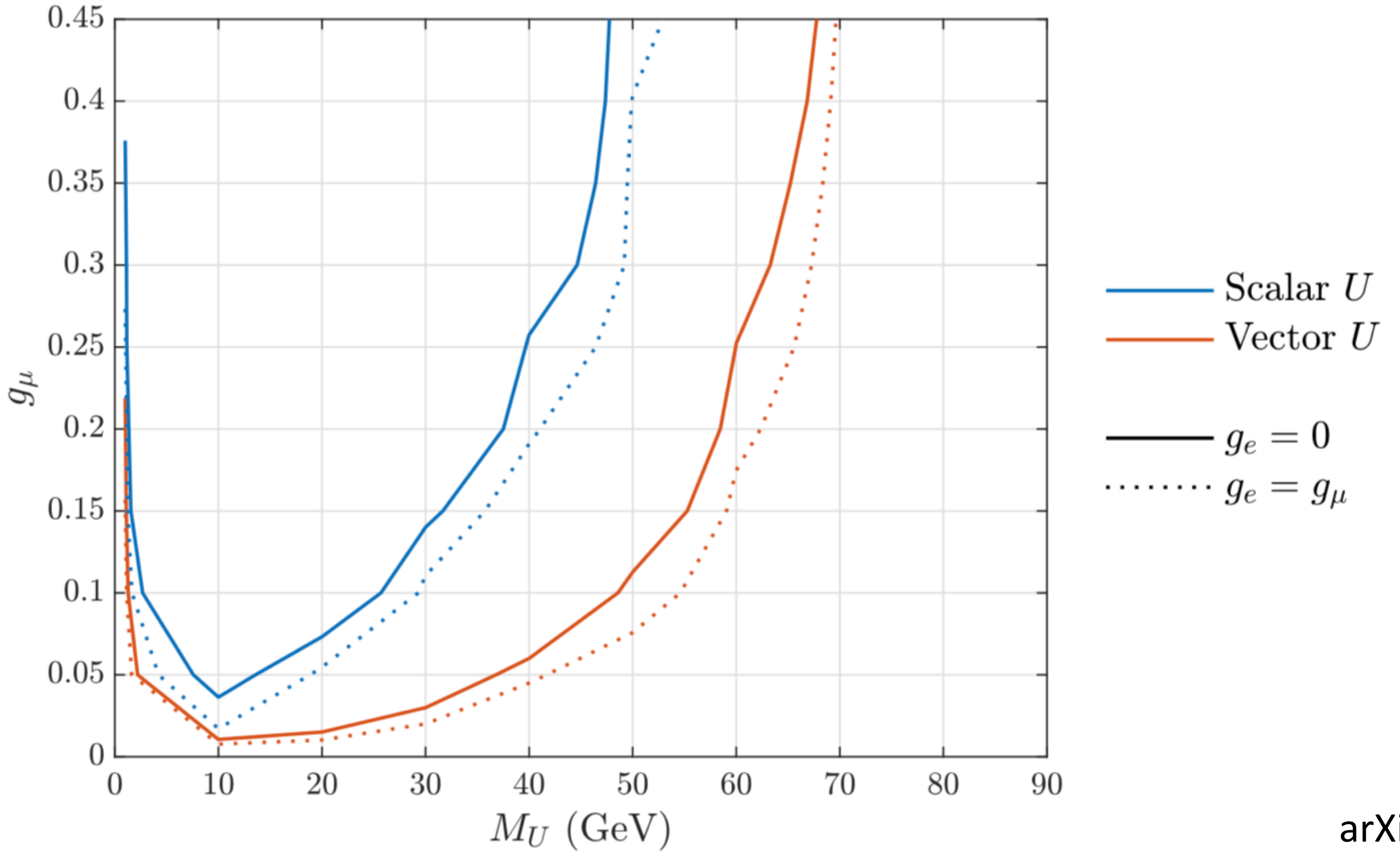
Combine LHC measurements for better discriminating power.



combined value: $\mathcal{B}(Z \to 4\ell) = (4.58 \pm 0.26) \times 10^{-6}$

(By the way, the PDG got it wrong…)

Excluded region for *U* bosons couplings to muons only.



arXiv:1805.05791

Closing Remarks:

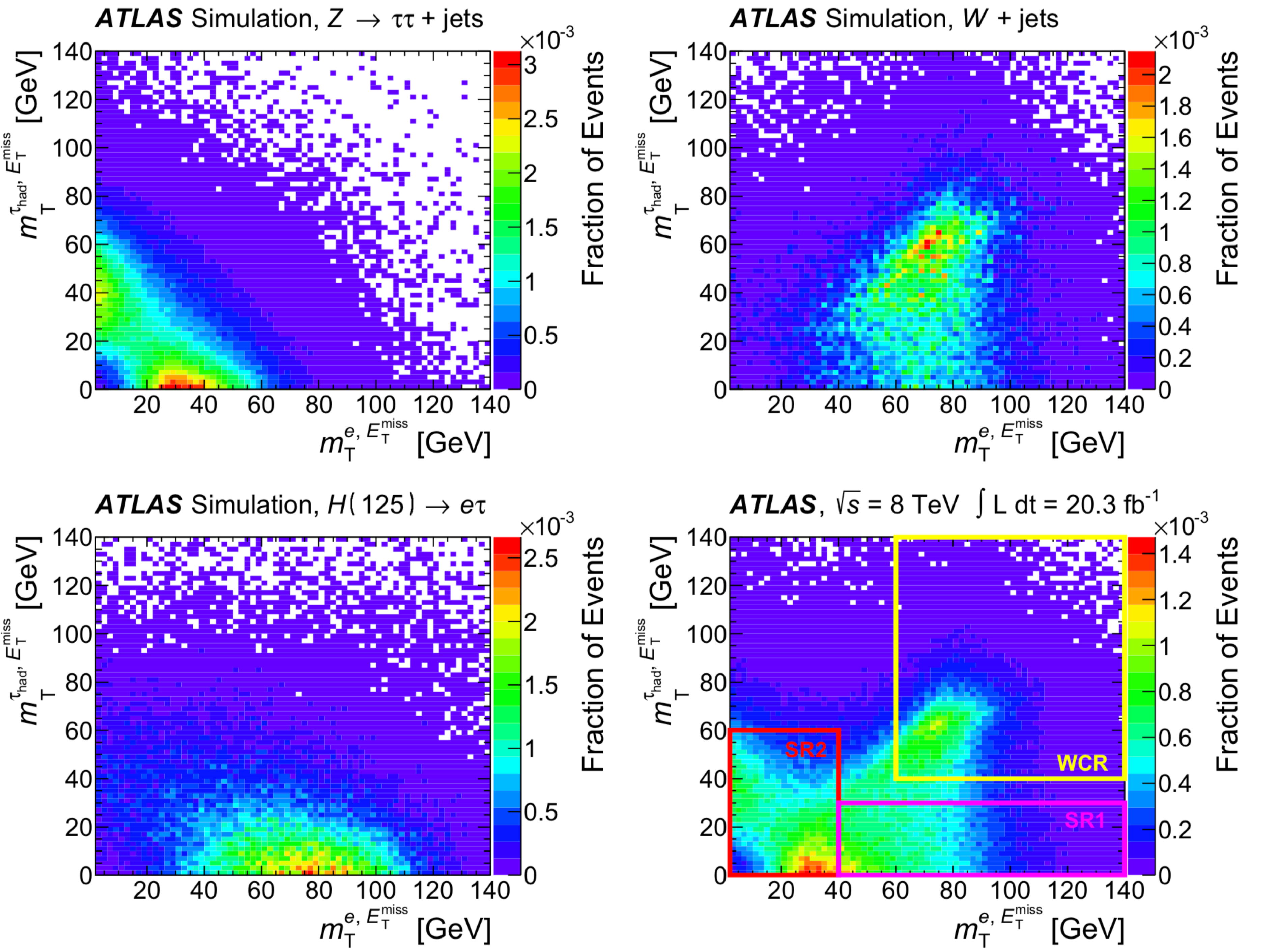
- LHC experiments can probe new territory for violations of lepton universality.

- The nature of the probe tests different features of the SM:
  vertices, universal gauge couplings, off-diagonal Yukawa couplings

- The exploration has been rather limited and most tests have used only a small fraction of existing LHC data.

- Opportunities for bright ideas and careful work.
  The flavor sector is mysterious and a discovery would be momentous!

BACKUP SLIDES



ATLAS Simulation, $Z \rightarrow \tau\tau$ + jets
ATLAS Simulation, W + jets
ATLAS Simulation, $H(125) \rightarrow e\tau$
ATLAS, $\sqrt{s}$ = 8 TeV $\int$ L dt = 20.3 fb^{-1}
$m_T^{\tau_{had}, E_T^{miss}}$ [GeV]
$m_T^{e, E_T^{miss}}$ [GeV]
Fraction of Events
$\times 10^{-3}$
SR2
WCR
SR1

Channel	Category	Expected limit (%)	Observed limit (%)	Best fit Br (%)
	SR1	$2.81^{+1.06}_{-0.79}$	3.0	$0.33^{+1.48}_{-1.59}$
$H \to e\tau_{\text{had}}$	SR2	$2.95^{+1.16}_{-0.82}$	2.24	$-1.33^{+1.56}_{-1.80}$
	Combined	$2.07^{+0.82}_{-0.58}$	1.81	$-0.47^{+1.08}_{-1.18}$
	$\text{SR}_{\text{noJets}}$	$1.66^{+0.72}_{-0.46}$	1.45	$-0.45^{+0.89}_{-0.97}$
$H \to e\tau_{\text{lep}}$	$\text{SR}_{\text{withJets}}$	$3.33^{+1.60}_{-0.93}$	3.99	$0.74^{+1.59}_{-1.62}$
	Combined	$1.48^{+0.60}_{-0.42}$	1.36	$-0.26^{+0.79}_{-0.82}$
$H \to e\tau$	Combined	$1.21^{+0.49}_{-0.34}$	1.04	$-0.34^{+0.64}_{-0.66}$
	SR1	$1.60^{+0.64}_{-0.45}$	1.55	$-0.07^{+0.81}_{-0.86}$
$H \to \mu\tau_{\text{had}}$	SR2	$1.75^{+0.71}_{-0.49}$	3.51	$1.94^{+0.92}_{-0.89}$
	Combined	$1.24^{+0.50}_{-0.35}$	1.85	$0.77^{+0.62}_{-0.62}$
	$\text{SR}_{\text{noJets}}$	$2.03^{+0.93}_{-0.57}$	2.38	$0.31^{+1.06}_{-0.99}$
$H \to \mu\tau_{\text{lep}}$	$\text{SR}_{\text{withJets}}$	$3.57^{+1.74}_{-1.00}$	2.85	$-1.03^{+1.66}_{-1.82}$
	Combined	$1.73^{+0.74}_{-0.49}$	1.79	$0.03^{+0.88}_{-0.86}$
$H \to \mu\tau$	Combined	$1.01^{+0.40}_{-0.29}$	1.43	$0.53^{+0.51}_{-0.51}$

Table 8

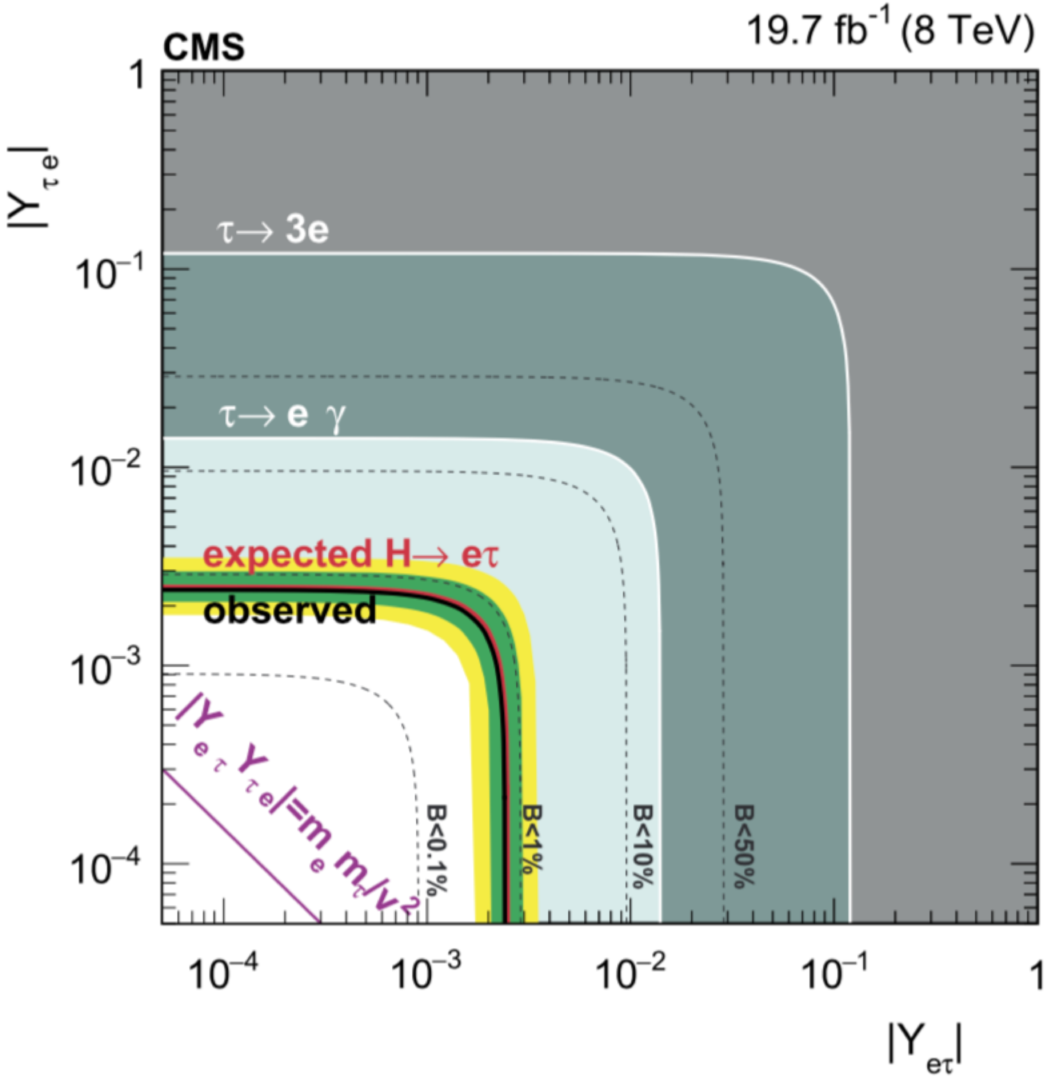
Event yields in the signal region, 100 GeV < M_{col} < 150 GeV, after fitting for signal and background for the $H \to e\tau$ channel, normalized to an integrated luminosity of 19.7 fb^{-1}. The LFV Higgs boson signal is the expected yield for $\mathcal{B}(H \to e\tau) = 0.69\%$ assuming the SM Higgs boson production cross section.

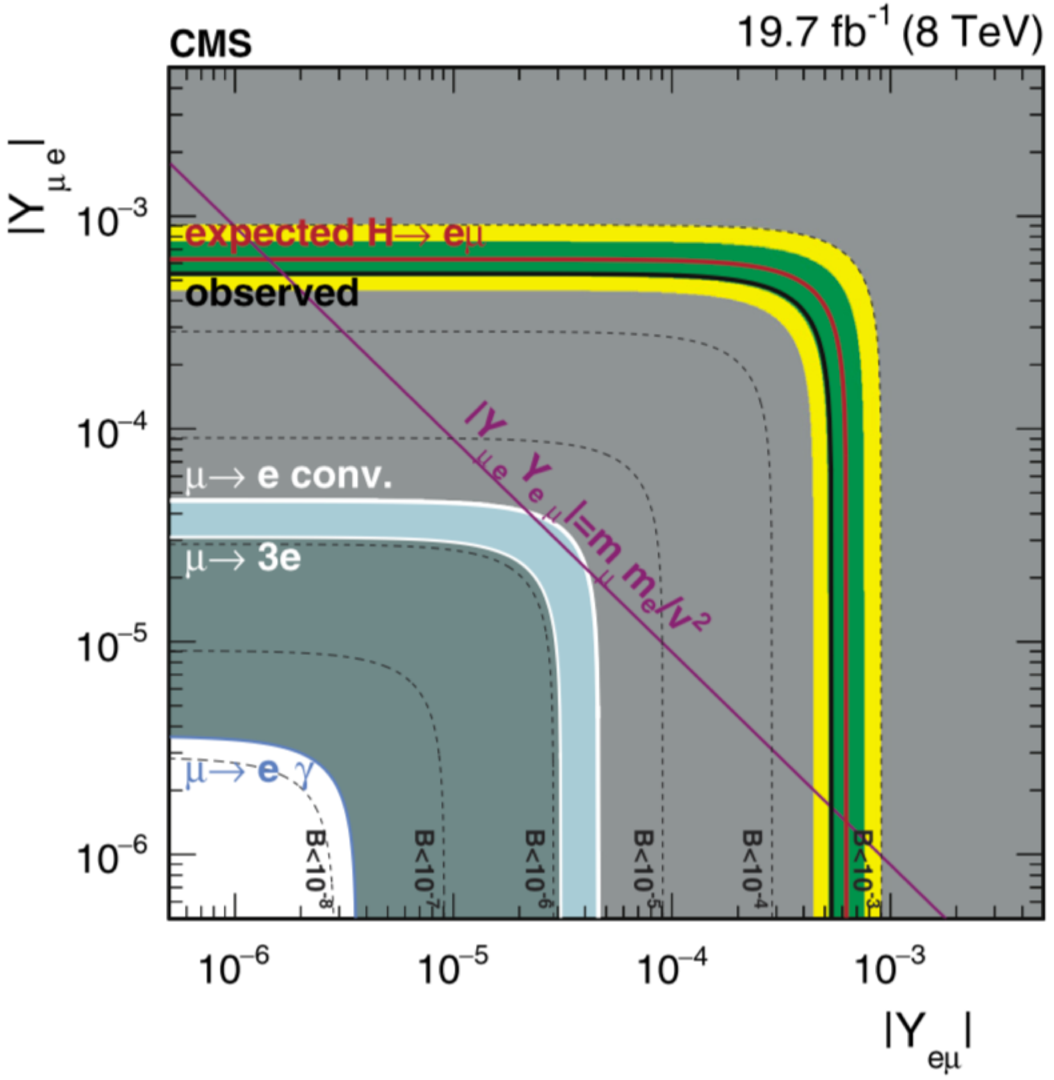
Jet category	$H \to e\tau_\mu$			$H \to e\tau_h$		
	0-jet	1-jet	2-jet	0-jet	1-jet	2-jet
Misidentified leptons	85.2 ± 5.9	38.1 ± 3.9	2.1 ± 0.7	3366 ± 25	223 ± 11	8.7 ± 2.2
$Z \to ee, \mu\mu$	2.3 ± 0.6	5.4 ± 0.5	–	714 ± 30	85 ± 4	3.2 ± 0.2
$Z \to \tau\tau$	84.7 ± 2.1	113.3 ± 4.2	8.5 ± 0.6	270 ± 10	32 ± 3	1.6 ± 0.3
$t\bar{t}$, t, $\bar{t}$	13.8 ± 0.3	69.4 ± 2.3	12.7 ±0.8	10 ± 2	13 ± 2	0.5 ± 0.2
ZZ, WZ, WW	83.0 ± 2.7	51.7 ± 2.0	3.6 ± 0.4	53 ± 2	6 ± 1	0.3 ± 0.1
$W\gamma(^*)$	2.2 ± 1.0	1.2 ± 0.6	–	–	–	–
SM H background	2.3 ± 0.3	3.6 ± 0.4	1.1 ± 0.2	12±1	3 ± 1	1.0 ± 0.1
Sum of background	273.5 ± 6.1	282.0 ± 6.0	28.1 ± 1.3	4425 ± 28	363 ± 11	15.3 ± 2.3
Observed	286	268	33	4438	375	13
LFV H signal	23.1 ± 1.6	16.0 ± 1.2	5.9 ± 1.0	61 ± 4	15 ± 1	2.8 ± 0.5

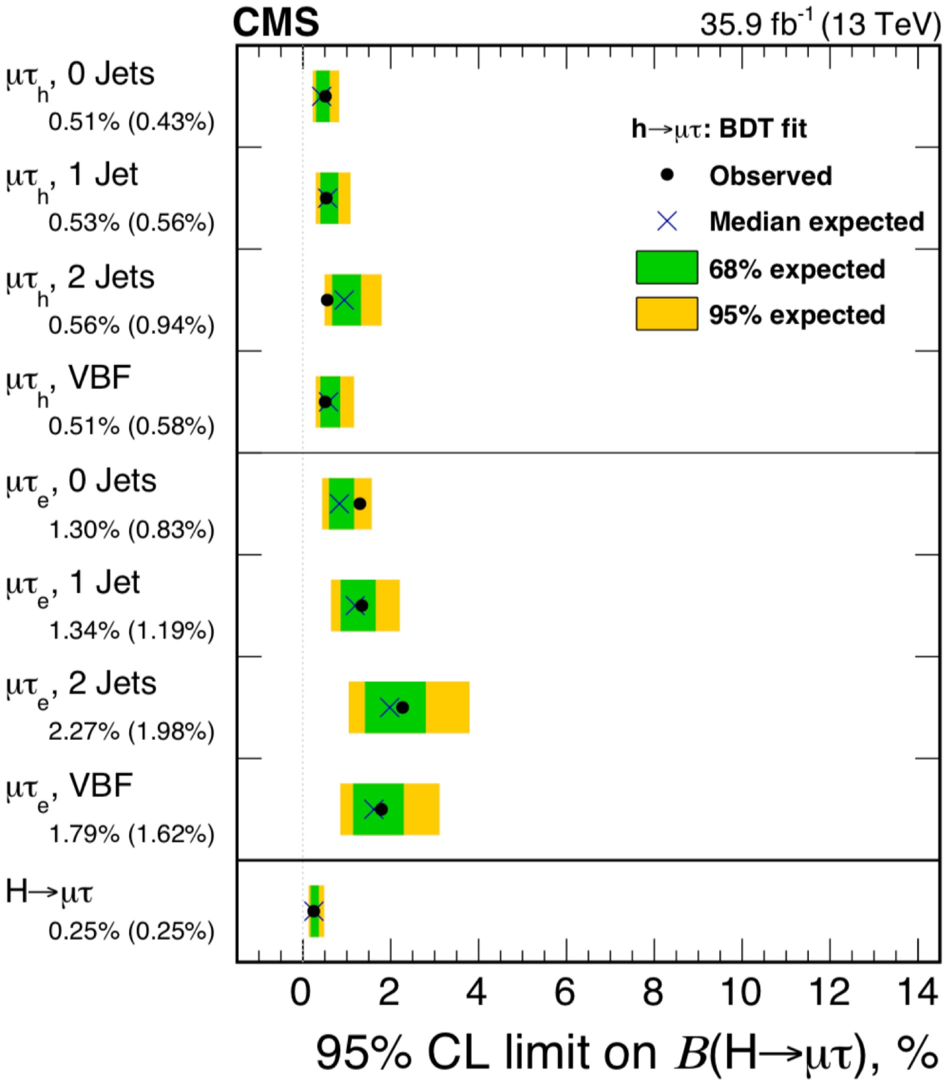
$$L_V \equiv -Y_{e\mu}\bar{e_L}\mu_R \mathrm{H} - Y_{\mu e}\bar{\mu_L} e_R \mathrm{H} - Y_{e\tau}\bar{e_L}\tau_R \mathrm{H}$$
$$- Y_{\tau e}\bar{\tau}_L e_R \mathrm{H} - Y_{\mu\tau}\bar{\mu_L}\tau_R \mathrm{H} - Y_{\tau\mu}\bar{\tau}_L \mu_R \mathrm{H}$$

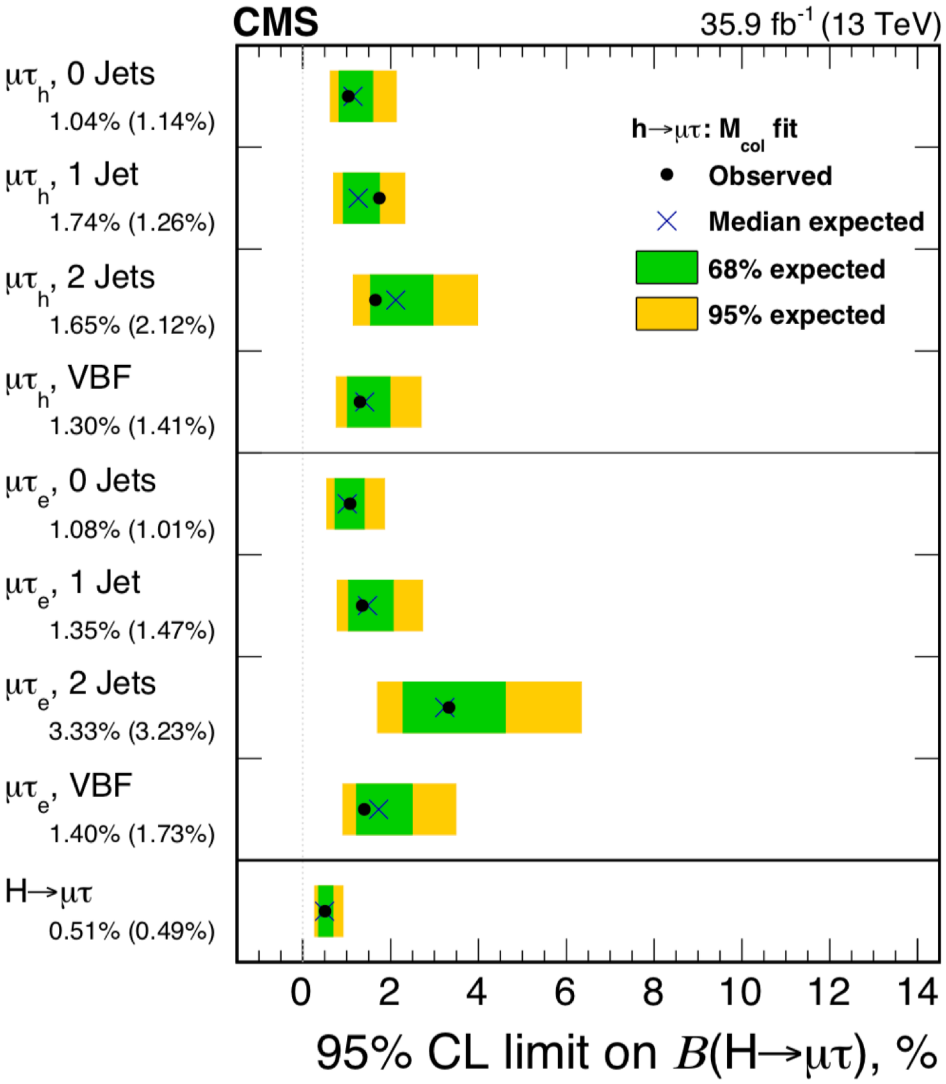
$$\Gamma(\mathrm{H} \to \ell^\alpha \ell^\beta) = \frac{M_\mathrm{H}}{8\pi}\left(|Y_{\ell^\beta \ell^\alpha}|^2 + |Y_{\ell^\alpha \ell^\beta}|^2\right)$$

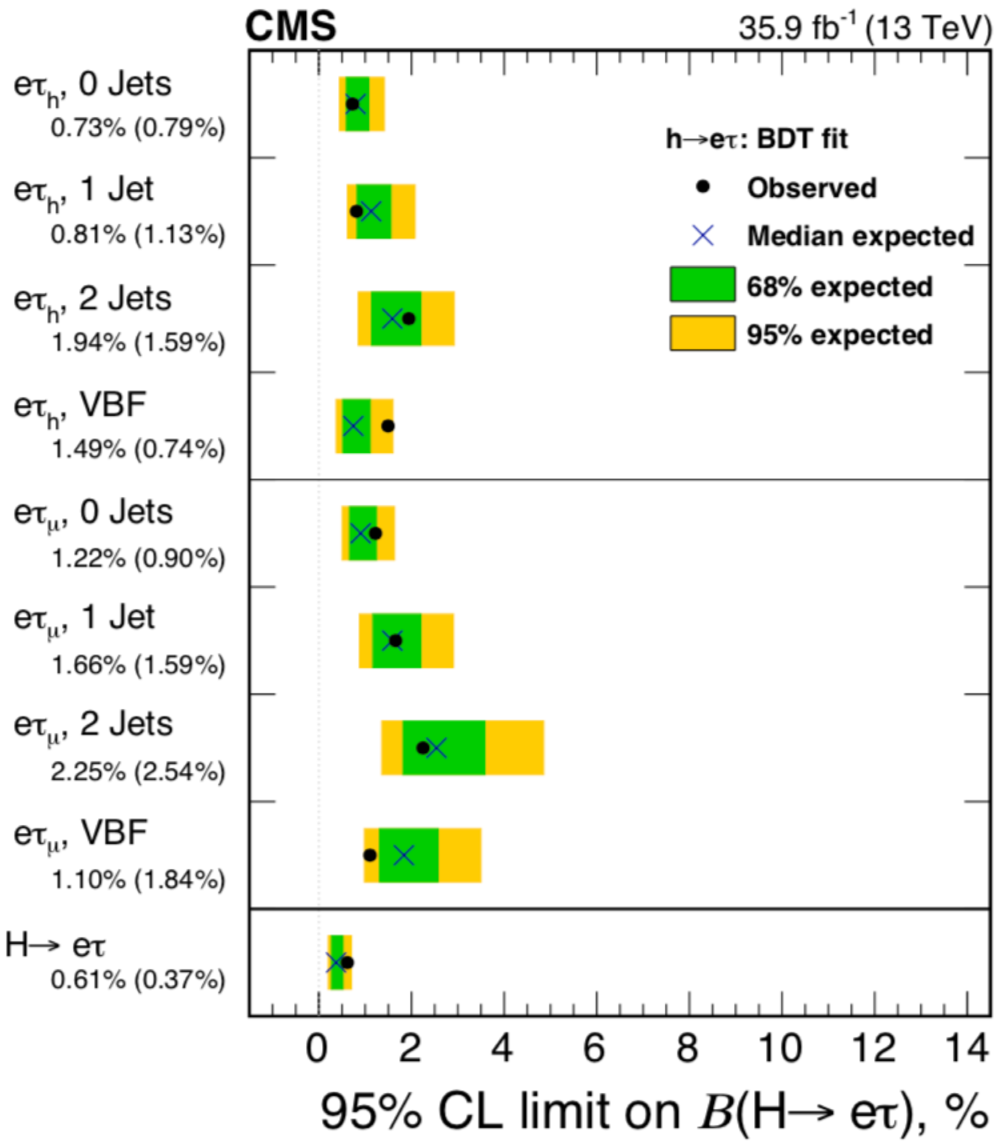
$$\sqrt{|Y_{\mathrm{e}\tau}|^2 + |Y_{\tau\mathrm{e}}|^2} < 2.4 \times 10^{-3},$$
$$\sqrt{|Y_{\mathrm{e}\mu}|^2 + |Y_{\mu\mathrm{e}}|^2} < 5.4 \times 10^{-4}$$

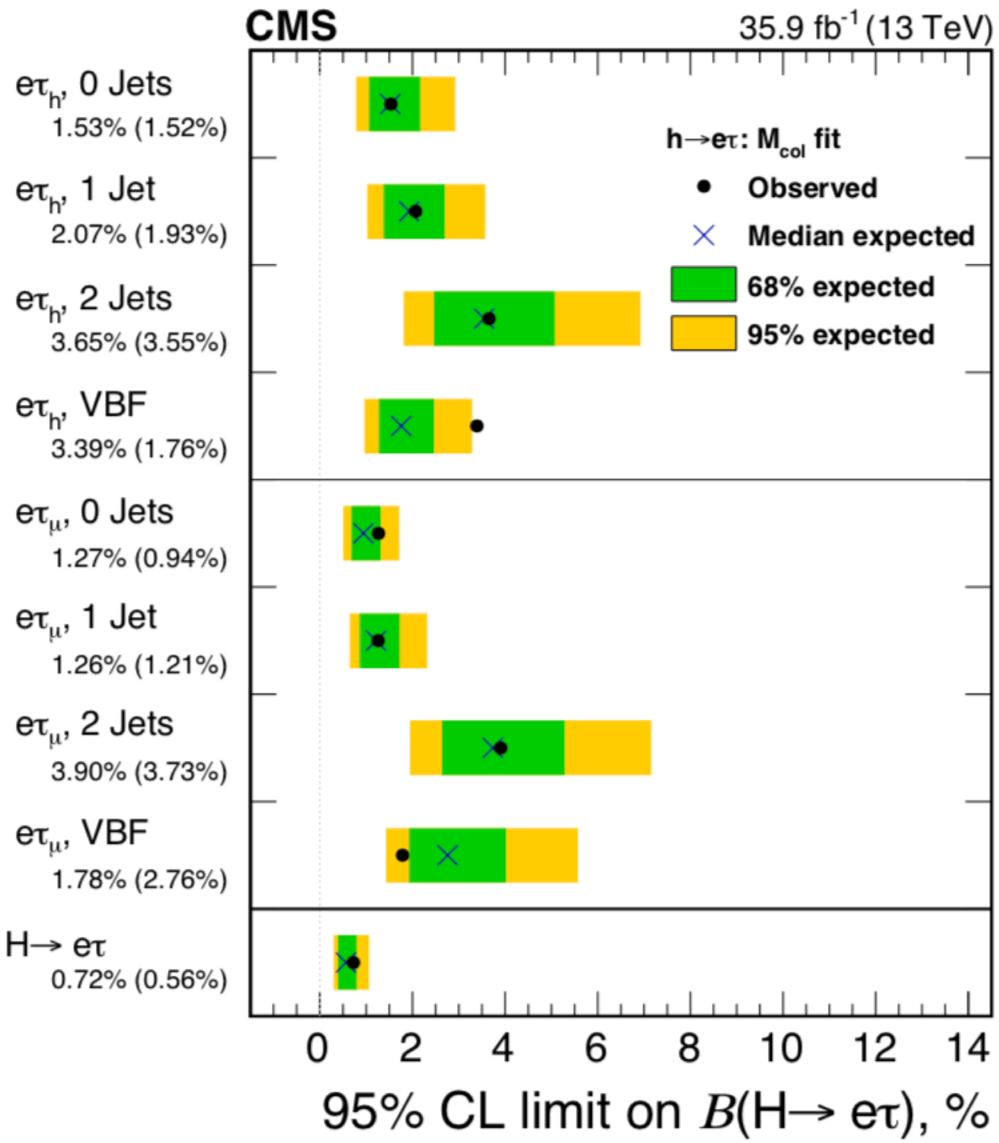

CMS
19.7 fb^{-1} (8 TeV)
$|Y_{\tau e}|$
$|Y_{e\tau}|$
$\tau \rightarrow 3e$
$\tau \rightarrow e\ \gamma$
expected $H \rightarrow e\tau$
observed
$|Y_{e\tau} Y_{\tau e}| = m_e m_\tau / v^2$
B<0.1%
B<1%
B<10%
B<50%

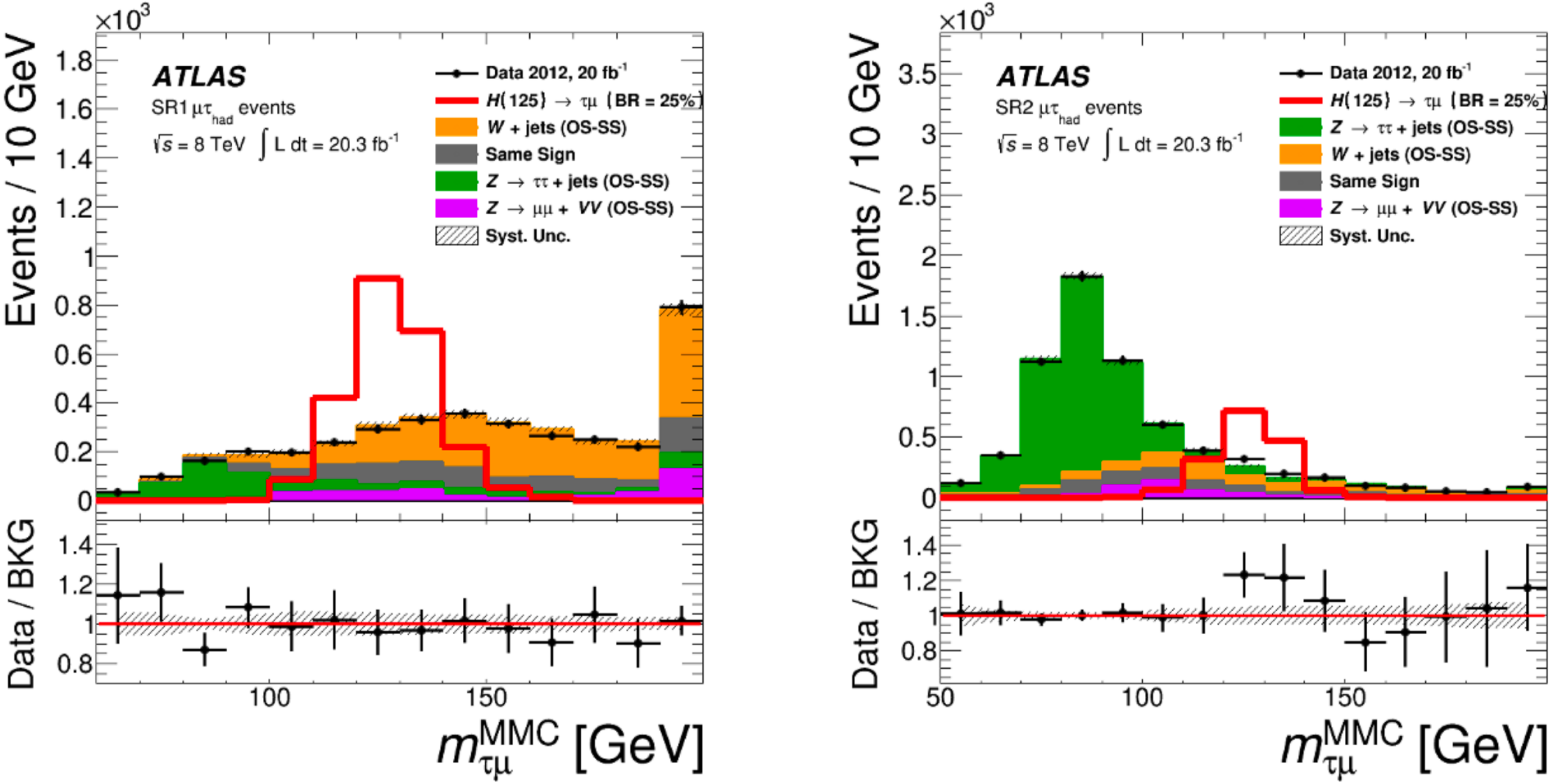

CMS
19.7 fb^{-1} (8 TeV)
$|Y_{\mu e}|$
$|Y_{e\mu}|$
expected $H \rightarrow e\mu$
observed
$\mu \rightarrow e$ conv.
$\mu \rightarrow 3e$
$\mu \rightarrow e\ \gamma$
$|Y_{\mu e} Y_{e\mu}| = m_\mu m_e / v^2$
B<10^{-8}
B<10^{-7}
B<10^{-6}
B<10^{-5}
B<10^{-4}
B<10^{-3}


CMS
35.9 fb-1 (13 TeV)
μτh, 0 Jets
0.51% (0.43%)
μτh, 1 Jet
0.53% (0.56%)
μτh, 2 Jets
0.56% (0.94%)
μτh, VBF
0.51% (0.58%)
μτe, 0 Jets
1.30% (0.83%)
μτe, 1 Jet
1.34% (1.19%)
μτe, 2 Jets
2.27% (1.98%)
μτe, VBF
1.79% (1.62%)
H→μτ
0.25% (0.25%)
h→μτ: BDT fit
Observed
Median expected
68% expected
95% expected
0 2 4 6 8 10 12 14
95% CL limit on B(H→μτ), %


CMS
35.9 fb-1 (13 TeV)
μτh, 0 Jets
1.04% (1.14%)
μτh, 1 Jet
1.74% (1.26%)
μτh, 2 Jets
1.65% (2.12%)
μτh, VBF
1.30% (1.41%)
μτe, 0 Jets
1.08% (1.01%)
μτe, 1 Jet
1.35% (1.47%)
μτe, 2 Jets
3.33% (3.23%)
μτe, VBF
1.40% (1.73%)
H→μτ
0.51% (0.49%)
h→μτ: Mcol fit
Observed
Median expected
68% expected
95% expected
0 2 4 6 8 10 12 14
95% CL limit on B(H→μτ), %


CMS
35.9 fb^{-1} (13 TeV)
$h \rightarrow e\tau$: BDT fit
Observed
Median expected
68% expected
95% expected
$e\tau_h$, 0 Jets
0.73% (0.79%)
$e\tau_h$, 1 Jet
0.81% (1.13%)
$e\tau_h$, 2 Jets
1.94% (1.59%)
$e\tau_h$, VBF
1.49% (0.74%)
$e\tau_\mu$, 0 Jets
1.22% (0.90%)
$e\tau_\mu$, 1 Jet
1.66% (1.59%)
$e\tau_\mu$, 2 Jets
2.25% (2.54%)
$e\tau_\mu$, VBF
1.10% (1.84%)
$H \rightarrow e\tau$
0.61% (0.37%)
0 2 4 6 8 10 12 14
95% CL limit on $\mathcal{B}(H \rightarrow e\tau)$, %


CMS
35.9 fb^{-1} (13 TeV)
$h \rightarrow e\tau$: M_{col} fit
Observed
Median expected
68% expected
95% expected
$e\tau_h$, 0 Jets
1.53% (1.52%)
$e\tau_h$, 1 Jet
2.07% (1.93%)
$e\tau_h$, 2 Jets
3.65% (3.55%)
$e\tau_h$, VBF
3.39% (1.76%)
$e\tau_\mu$, 0 Jets
1.27% (0.94%)
$e\tau_\mu$, 1 Jet
1.26% (1.21%)
$e\tau_\mu$, 2 Jets
3.90% (3.73%)
$e\tau_\mu$, VBF
1.78% (2.76%)
$H \rightarrow e\tau$
0.72% (0.56%)
0 2 4 6 8 10 12 14
95% CL limit on $\mathcal{B}(H \rightarrow e\tau)$, %



ATLAS
SR1 μτhad events
√s = 8 TeV ∫L dt = 20.3 fb-1
Data 2012, 20 fb-1
H(125) → τμ (BR = 25%)
W + jets (OS-SS)
Same Sign
Z → ττ + jets (OS-SS)
Z → μμ + VV (OS-SS)
Syst. Unc.
Events / 10 GeV
Data / BKG
m τμ MMC [GeV]
ATLAS
SR2 μτhad events
√s = 8 TeV ∫L dt = 20.3 fb-1
Data 2012, 20 fb-1
H(125) → τμ (BR = 25%)
Z → ττ + jets (OS-SS)
W + jets (OS-SS)
Same Sign
Z → μμ + VV (OS-SS)
Syst. Unc.
Events / 10 GeV
Data / BKG
m τμ MMC [GeV]