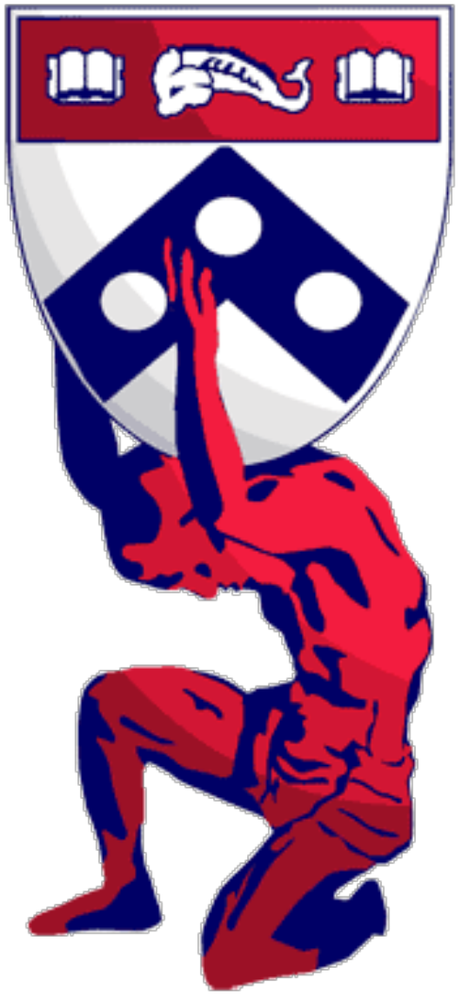
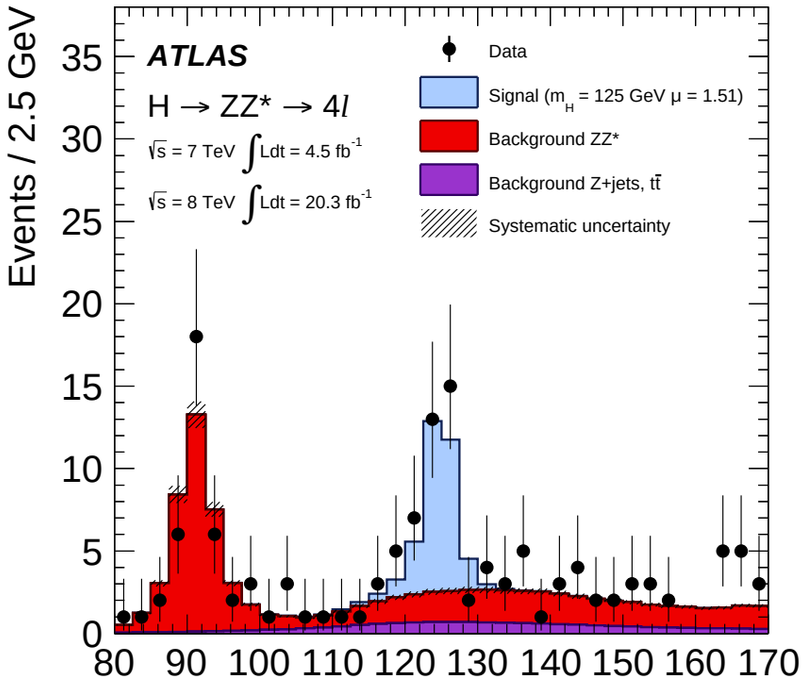
Evidence for H→ττ at ATLAS



Alex Tuna
for the ATLAS Collaboration

50th Rencontres de Moriond EW
17 March 2015

Higgs with ATLAS at LHC



huge Higgs discovery program at ATLAS

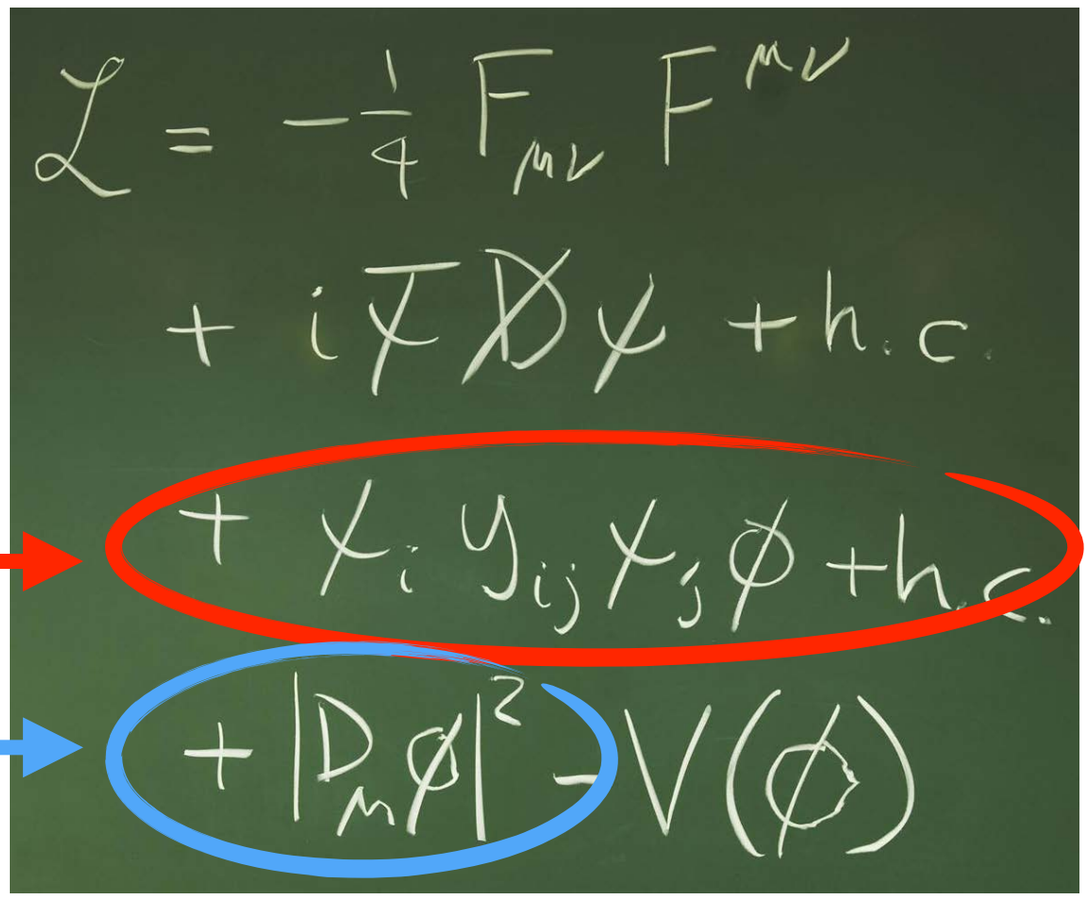
evidence of H→bosons in 2012

bosons: γγ, ZZ*, WW*

what about decay to fermions?

same behavior?

H→fermions:
not a direct consequence of EWSB

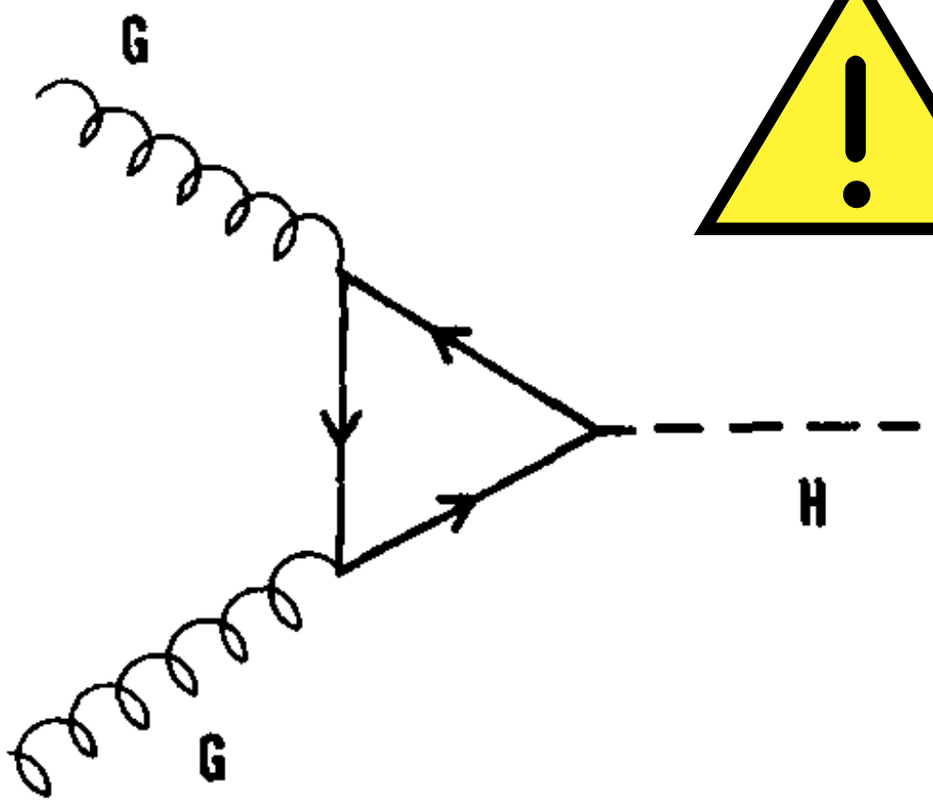


$H \rightarrow \tau\tau \Rightarrow$ VBF H

assuming $m_H \sim 125$ GeV

$BR(H \rightarrow \tau\tau) = 6\%$

big background from $Z \rightarrow \tau\tau$



$$\frac{\sigma(\text{VBF } H \rightarrow \tau\tau)}{\sigma(\text{VBF } Z \rightarrow \tau\tau)} \gg \frac{\sigma(\text{QCD } H \rightarrow \tau\tau)}{\sigma(\text{QCD } Z \rightarrow \tau\tau)}$$

~ 1 vs. $\sim 10^{-3}$

$\Rightarrow$ best search: VBF production

Cahn and Dawson
PLB 136 (1984) 196

H→ττ ⇒ VBF H

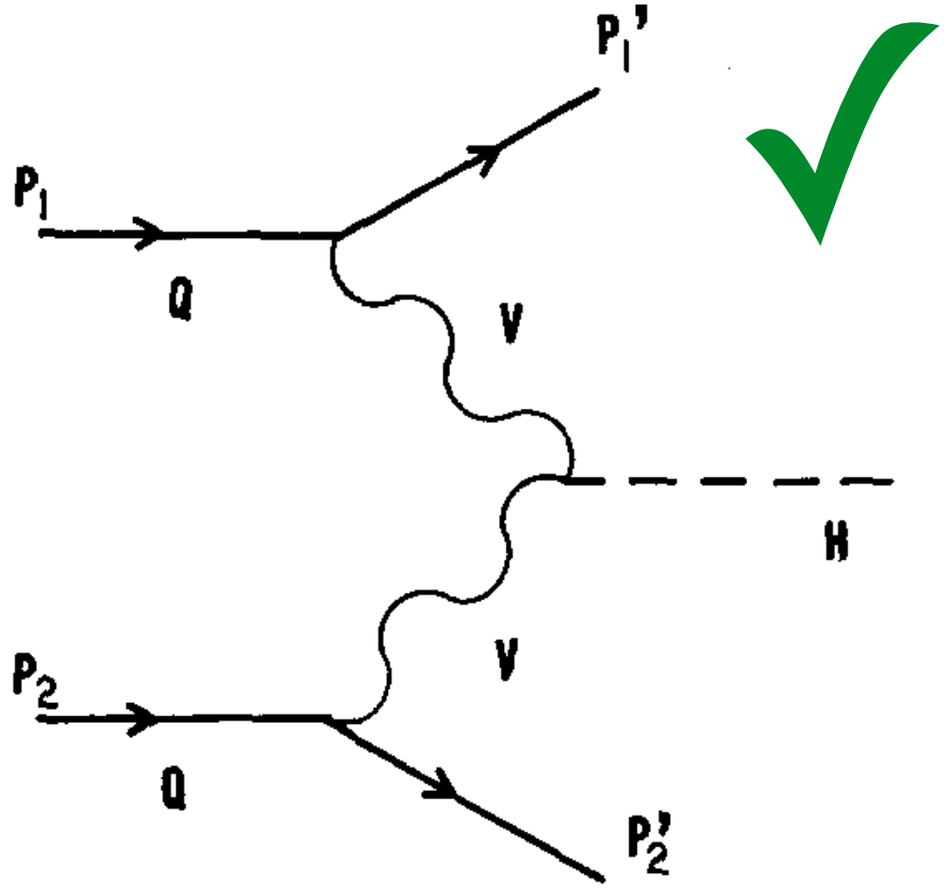
assuming
m_H ~ 125 GeV

BR(H→ττ) = 6%

big background from Z→ττ

$$\frac{\sigma(\text{VBF } H\to\tau\tau)}{\sigma(\text{VBF } Z\to\tau\tau)} \gg \frac{\sigma(\text{QCD } H\to\tau\tau)}{\sigma(\text{QCD } Z\to\tau\tau)}$$

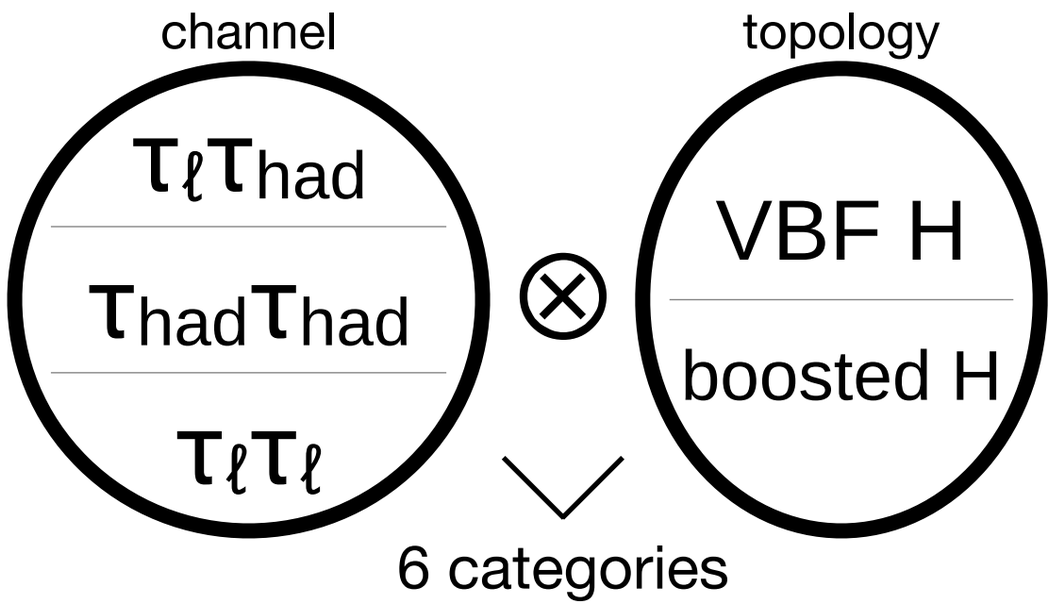
~1 ~10^{-3}



⇒ best search: VBF production

Cahn and Dawson
PLB 136 (1984) 196

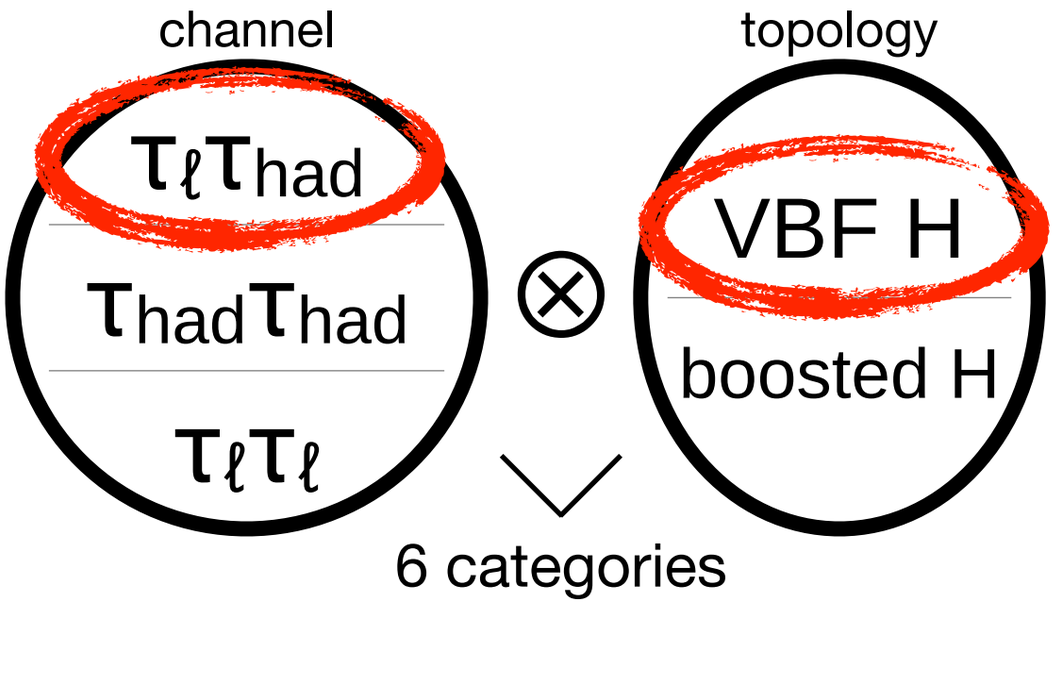
categorization, MVA

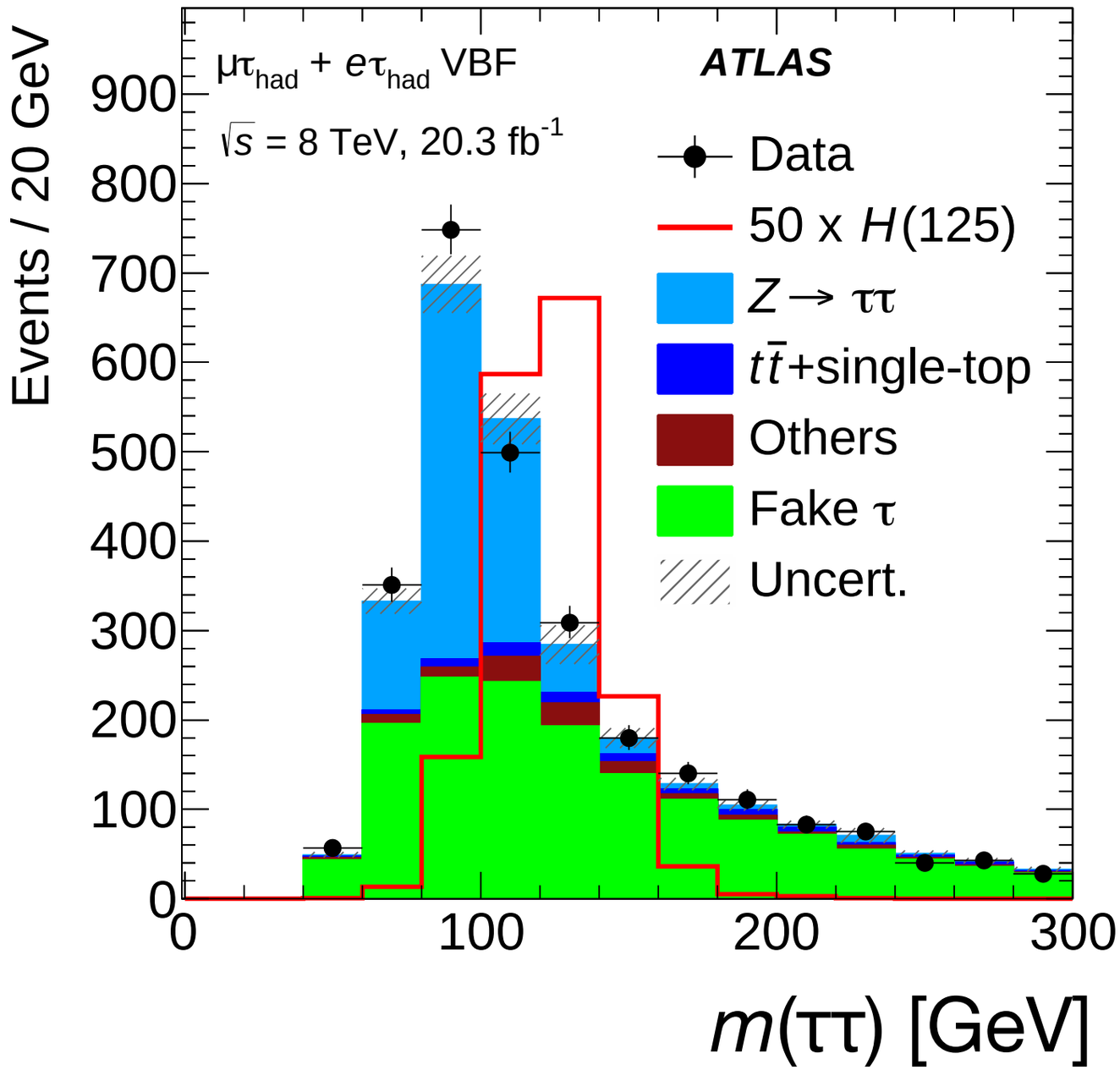


each category:
separate signal vs. background
with BDTs

categorization, MVA

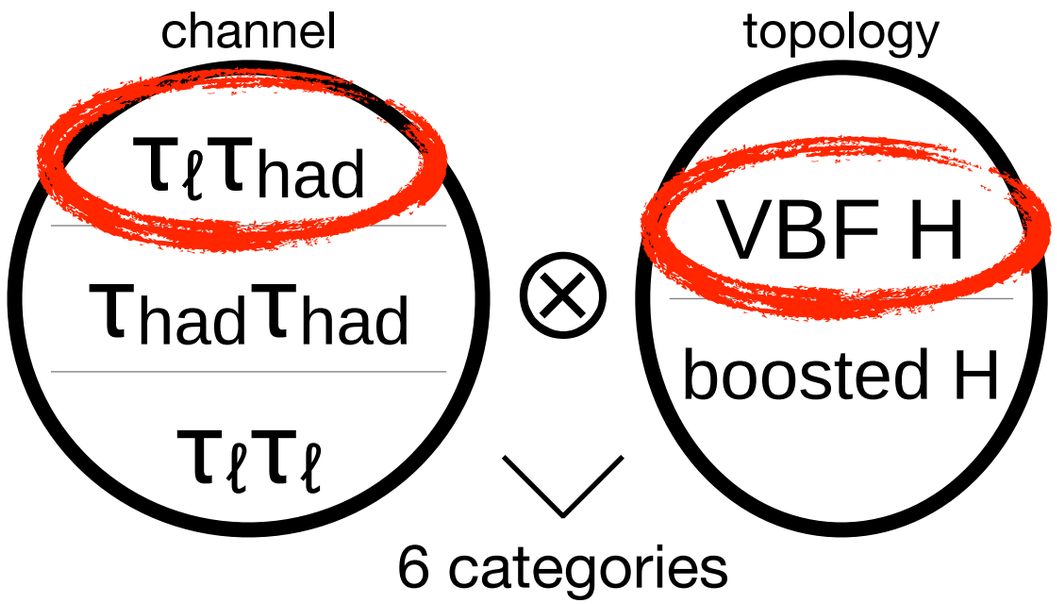
BDT inputs: **H→ττ kinematics**

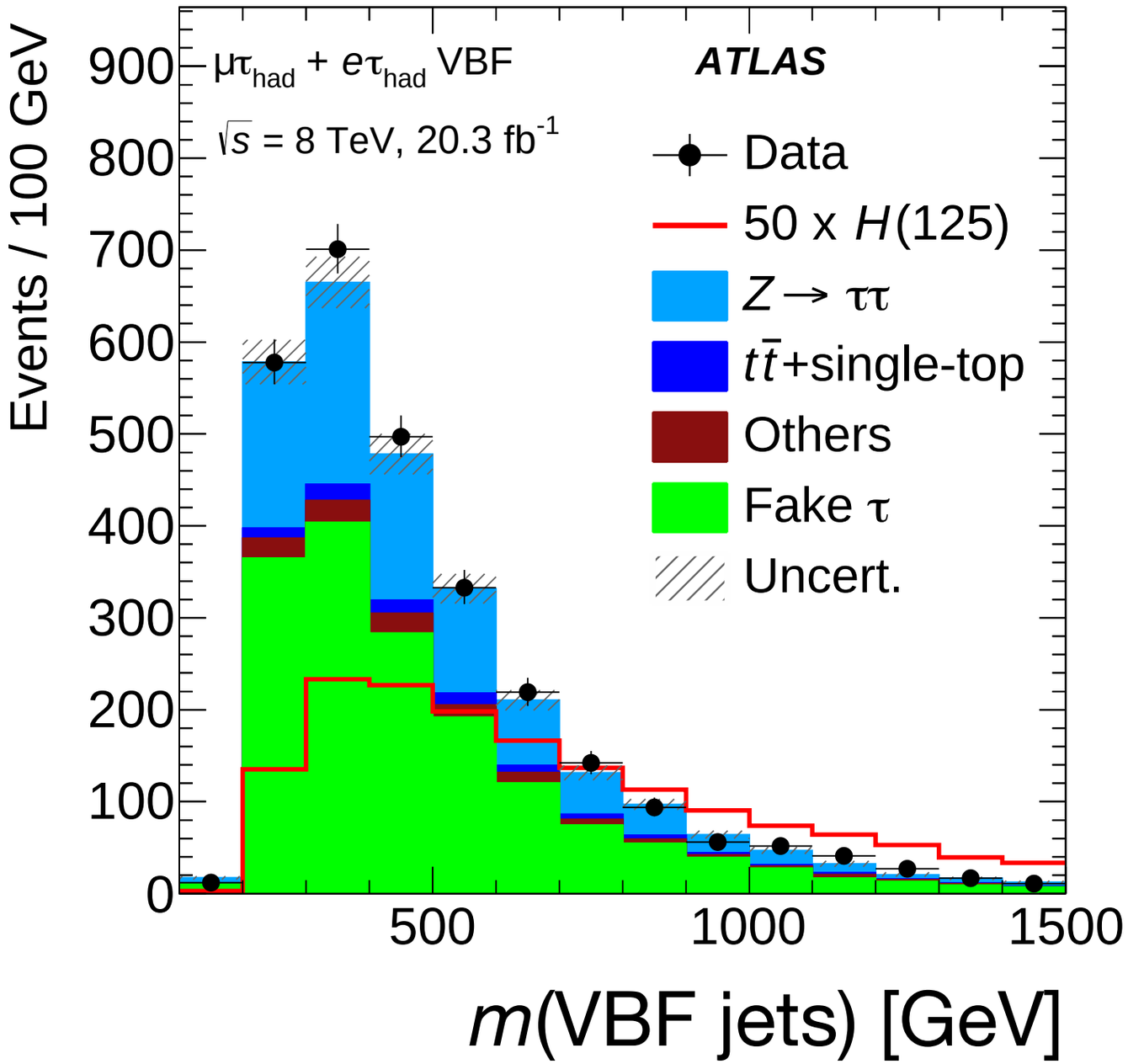




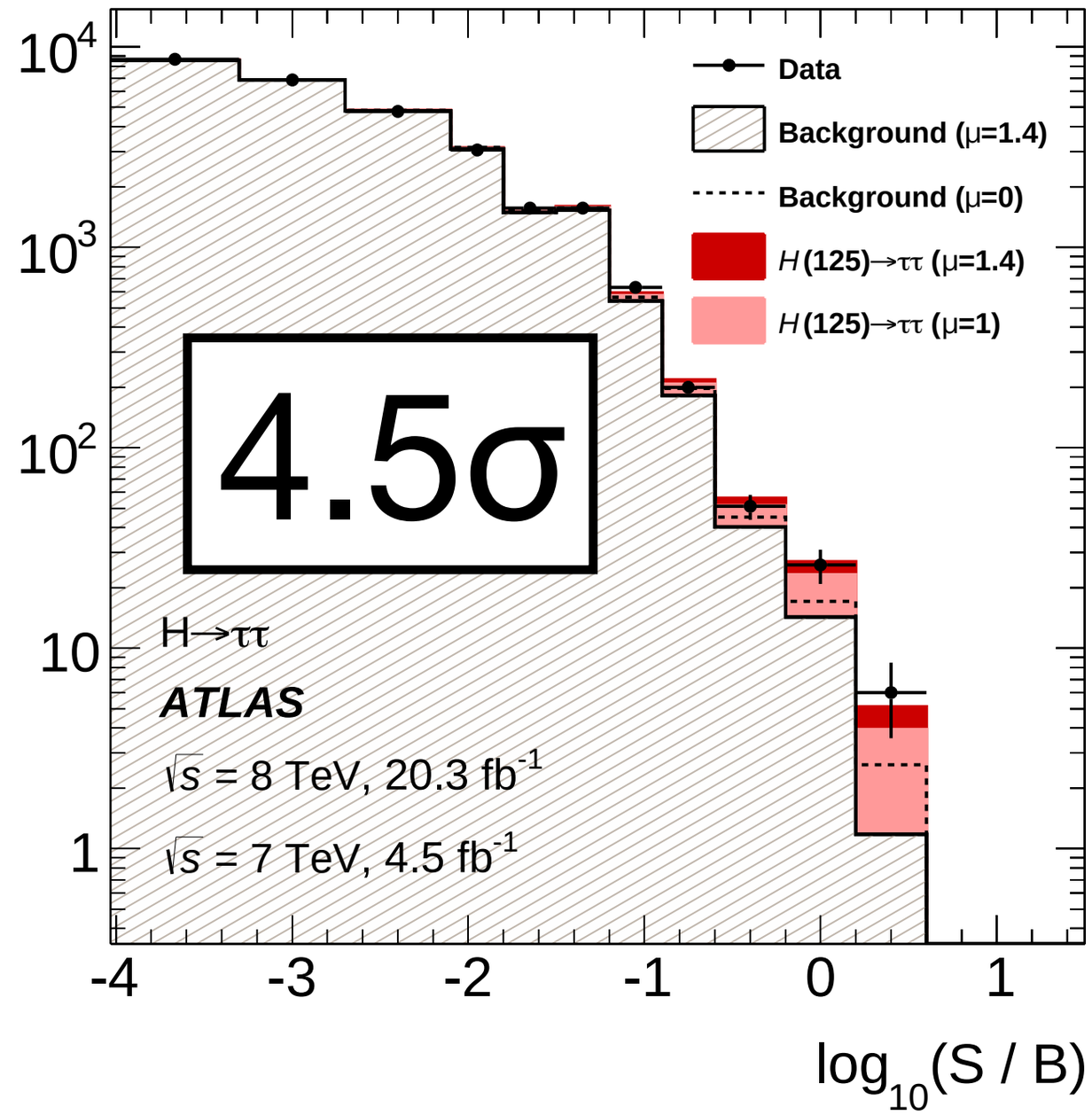
categorization, MVA

BDT inputs: **VBF H kinematics**

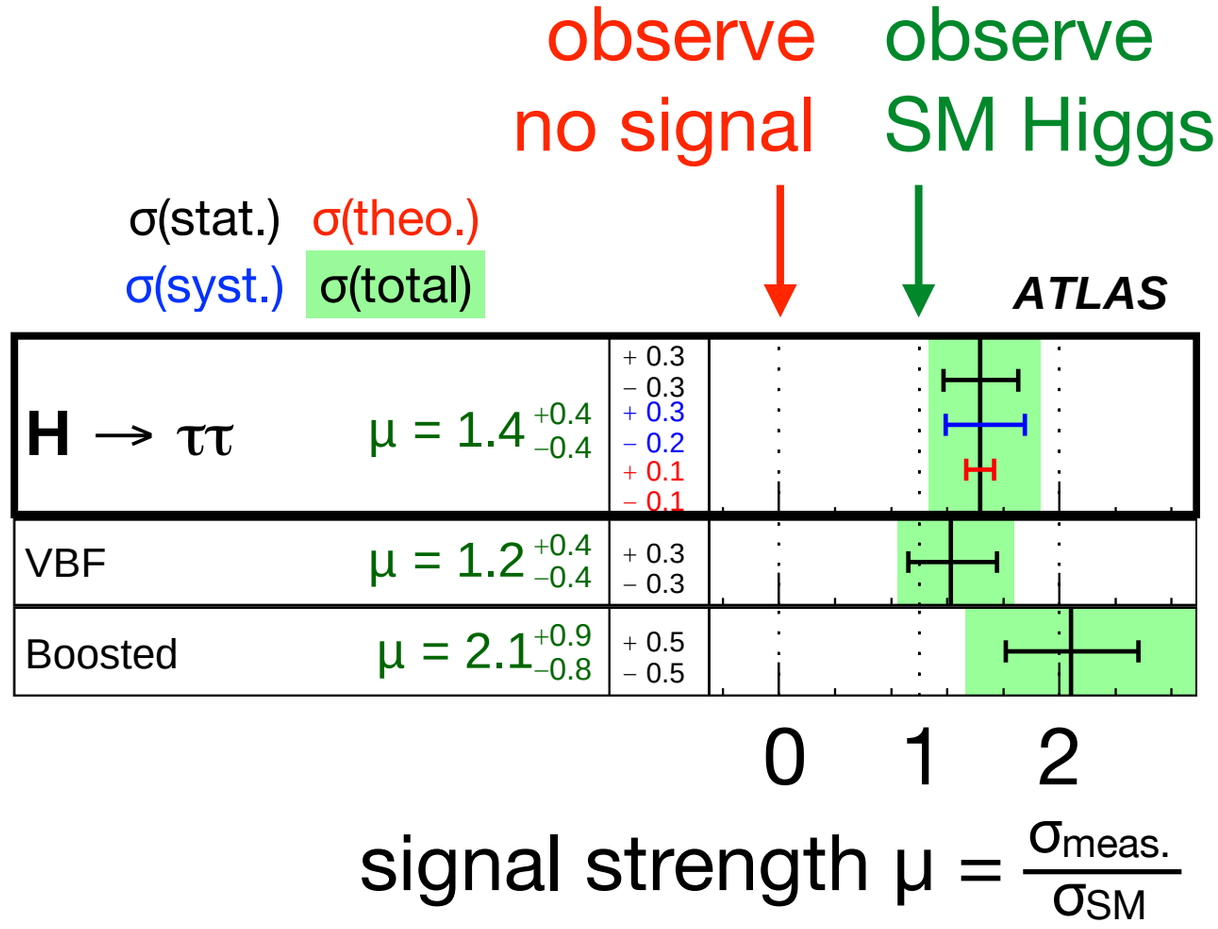




H→ττ results



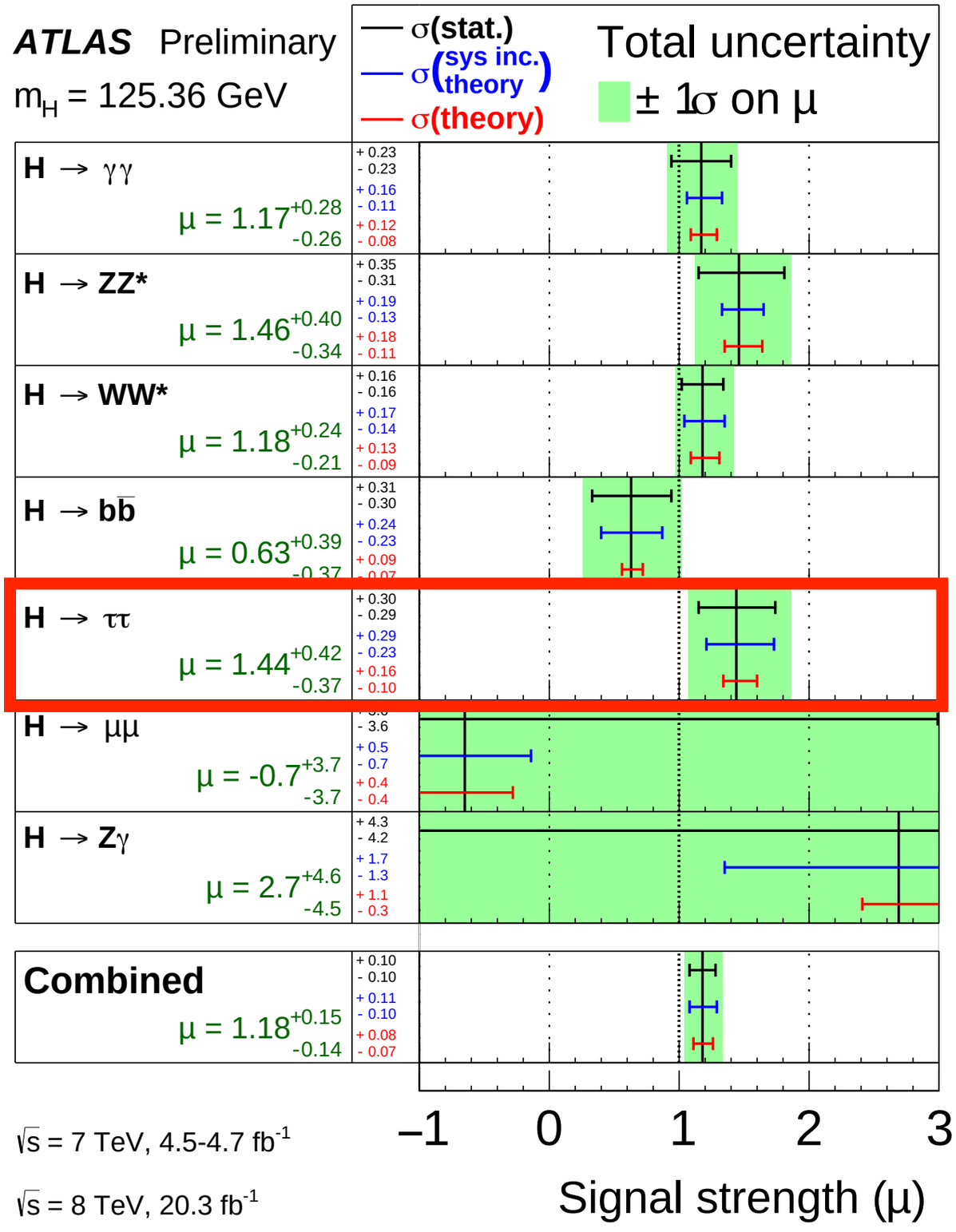
BDT bins from all six categories, ordered by S/B



signal hypothesis favored

μ = 1.4 ± 0.4

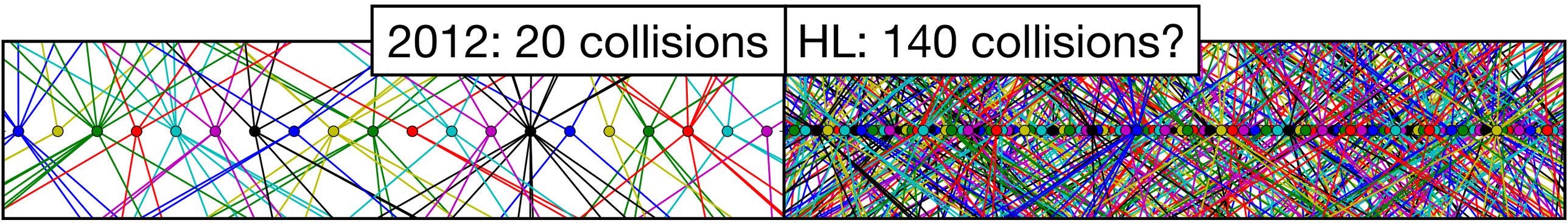
Higgs results



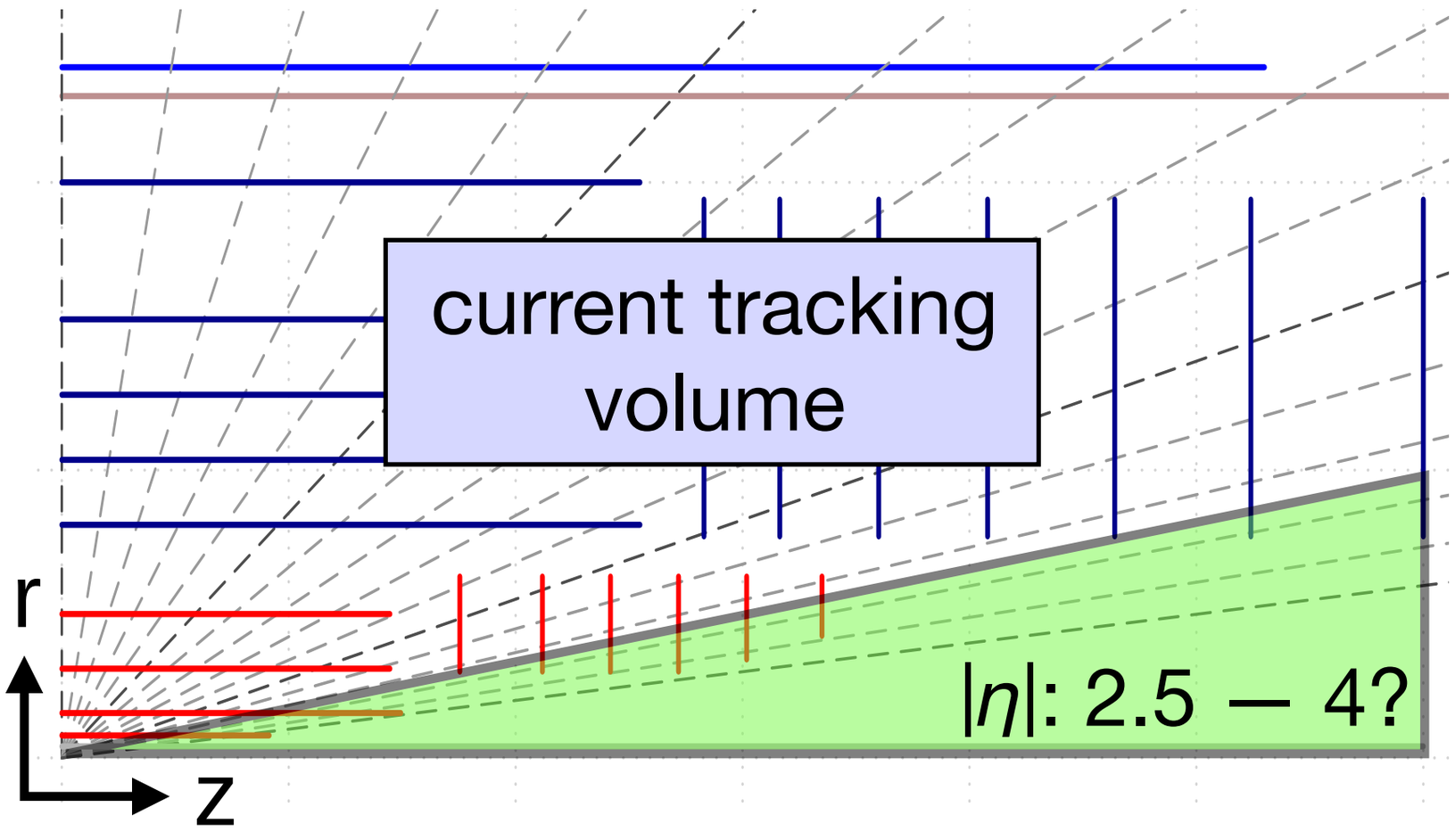
H→ττ with bb, strongest fermion measurement

H→ττ at HL-LHC

VBF H→$\tau_\ell\tau_{had}$ only



proposal: ATLAS forward tracker



forward tracking	Δμ(ττ)
none	24%
$\|\eta\| < 3.0$	14%
$\|\eta\| < 3.5$	11%
$\|\eta\| < 4.0$	8%

⇒ reject VBF jet candidates from other *pp*'s

summary

evidence for H→ττ at ATLAS with Run-I dataset

observe 4.5σ (expect 3.4σ)

$\mu = 1.4 \pm 0.4$

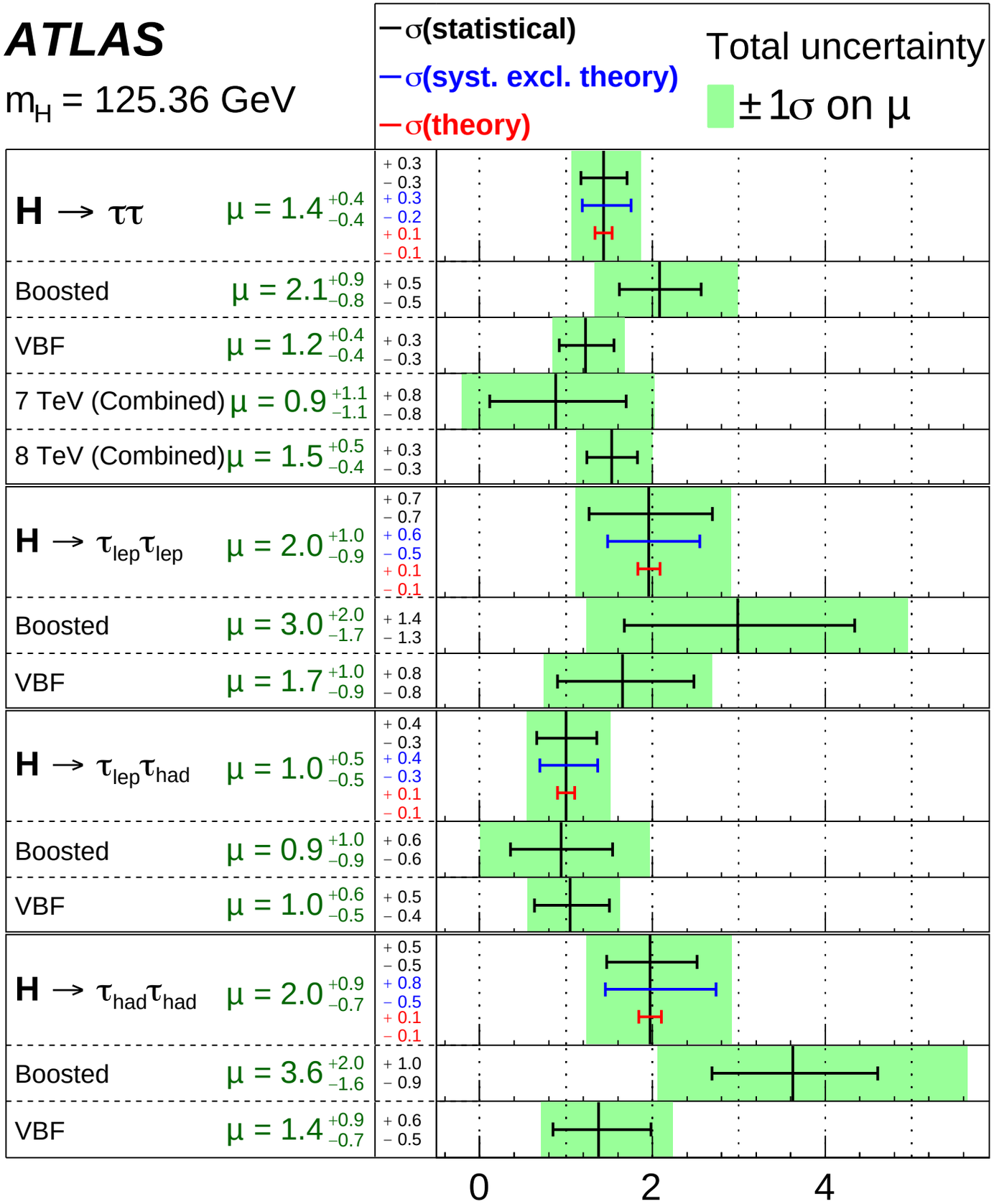
potential for precision measurements at HL-LHC

bonus

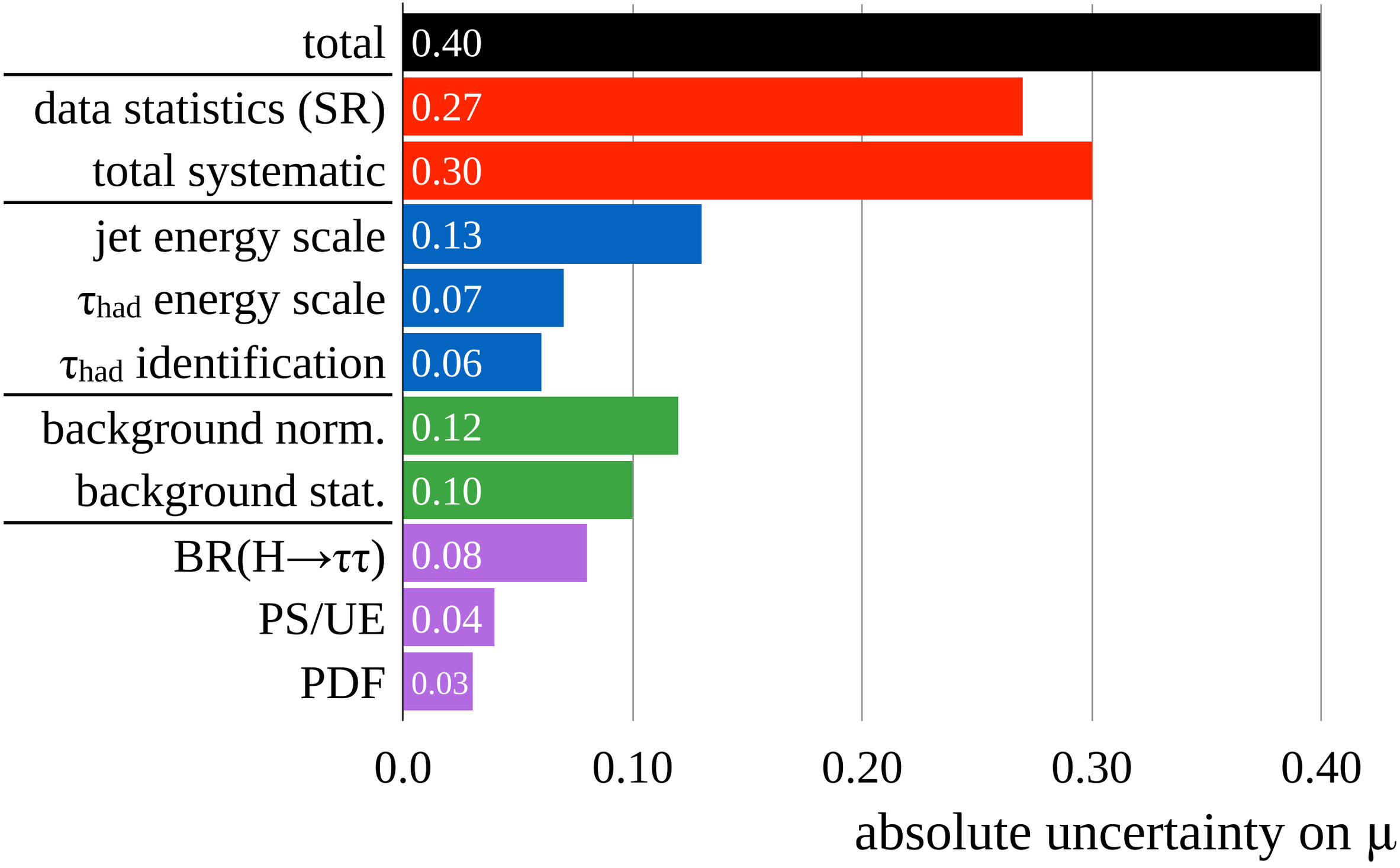
References

Cahn and Dawson	PLB 136 (1984) 196
ATLAS H→ττ	arXiv:1501.04943 [hep-ex]
ATLAS Higgs summary	CombinedSummaryPlots/HIGGS
ATLAS H→ττ, HL-LHC	ATL-PHYS-PUB-2014-018
ATLAS ITK IDR	PLOT-UPGRADE-2014-001

$\mu(H \rightarrow \tau\tau)$



Δμ(H→ττ)


total
0.40
data statistics (SR)
0.27
total systematic
0.30
jet energy scale
0.13
τ_{had} energy scale
0.07
τ_{had} identification
0.06
background norm.
0.12
background stat.
0.10
BR(H→ττ)
0.08
PS/UE
0.04
PDF
0.03
0.0
0.10
0.20
0.30
0.40
absolute uncertainty on μ

Quarks and Leptons

excluded by gauge invariance. An attractive feature of the standard model is that the same Higgs doublet which generates $W^{\pm}$ and Z masses is also sufficient to give masses to the leptons and quarks. For example, to generate the electron

$$+\left|\left(i\partial_\mu - g\frac{1}{2}\tau\cdot\mathbf{W}_\mu - g'\frac{Y}{2}B_\mu\right)\phi\right|^2 - V(\phi)$$

$\Big\{$ $W^{\pm}$, Z, γ, and Higgs masses and couplings

$$-(G_1\bar{L}\phi R + G_2\bar{L}\phi_c R + \text{hermitian conjugate}).$$

$\Big\{$ lepton and quark masses and coupling to Higgs

Z, H cross sections

QCD Z→ττ 1303 pb HIGG-2013-32	QCD H(125)→ττ 1.218 pb CERNYellowReportPageAt8TeV
EW Z→ττ 0.37 pb HIGG-2013-32	VBF H(125)→ττ 0.0997 pb CERNYellowReportPageAt8TeV