Top quarks and tau leptons
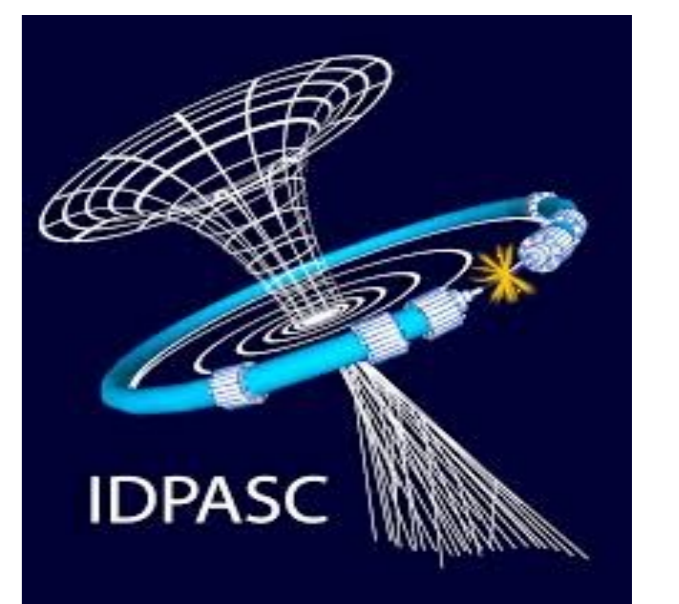
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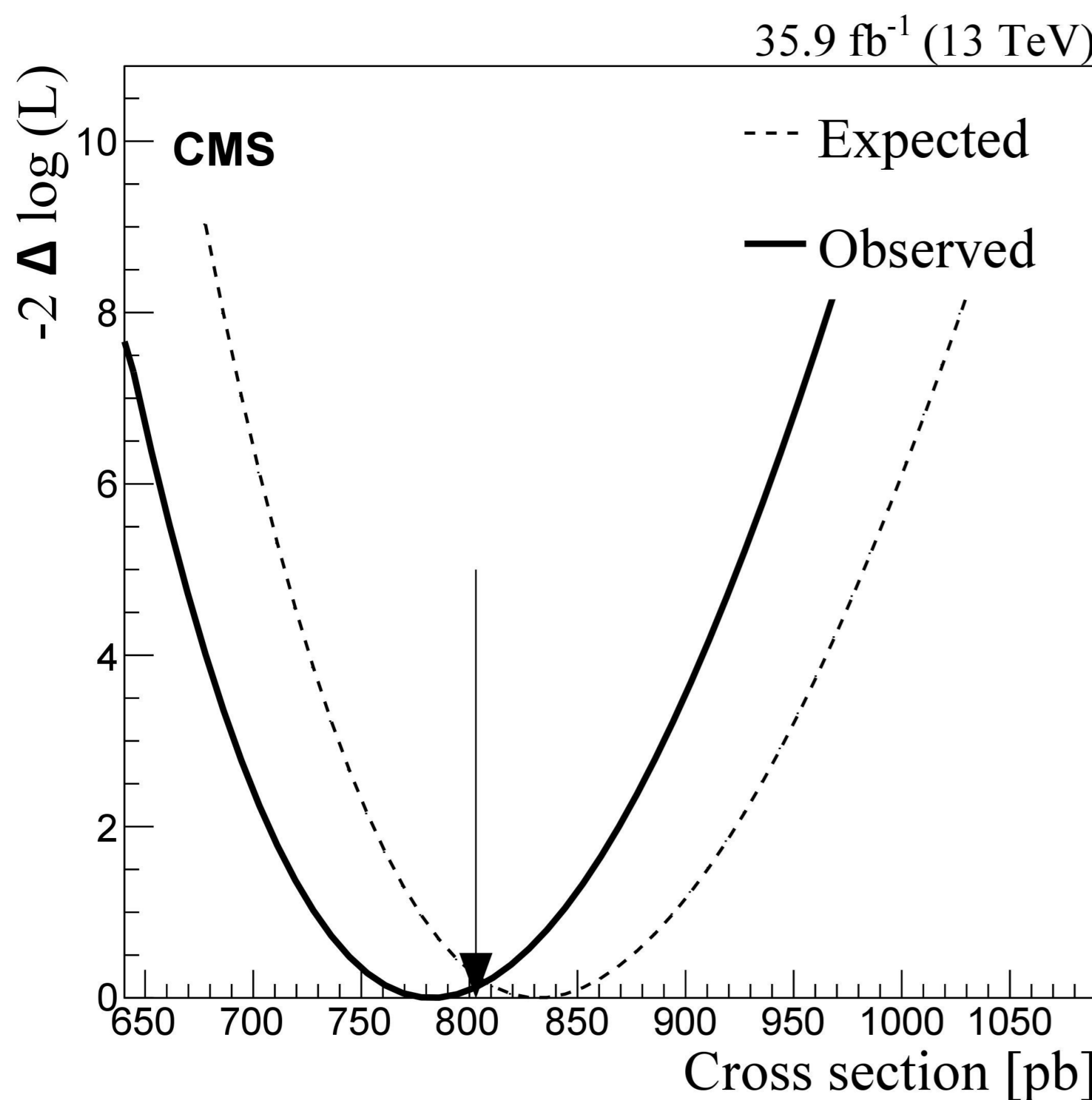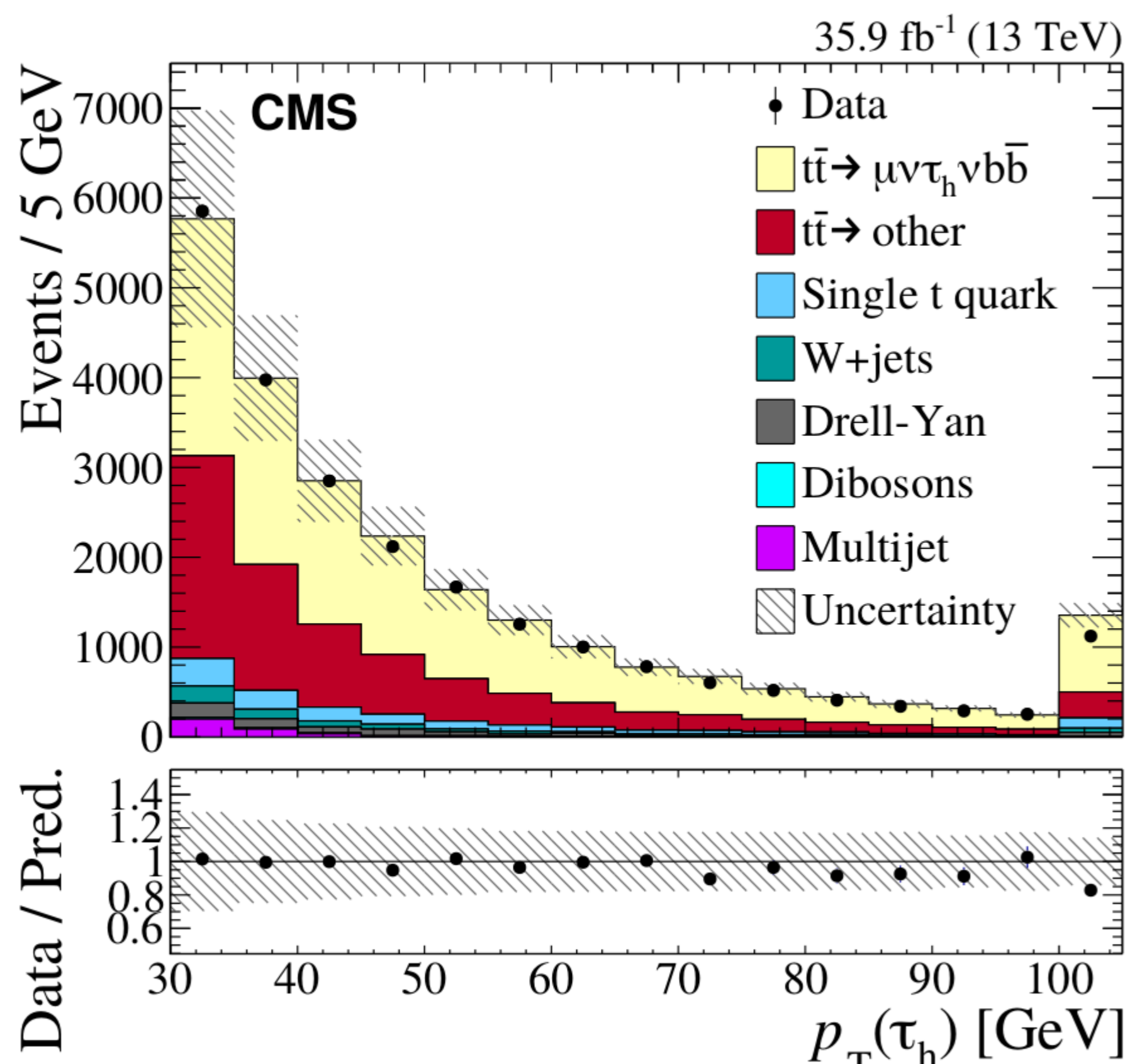
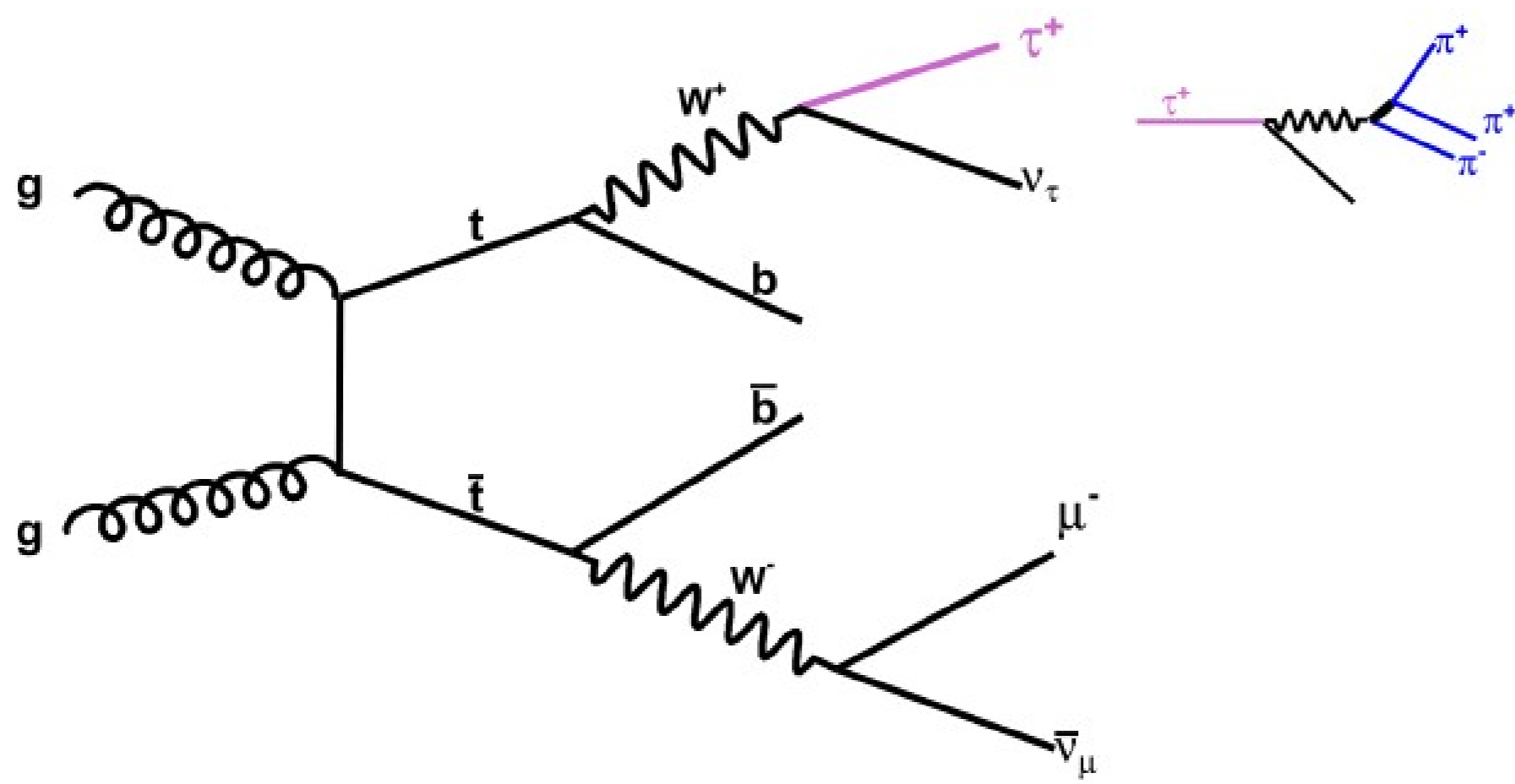## Top quark pair decay into 2 leptons with one tau lepton

35.9 fb⁻¹ (13 TeV) — Events / 5 GeV vs $p_T(\tau_h)$ [GeV]

35.9 fb⁻¹ (13 TeV) — $-2\,\Delta\log(L)$ vs Cross section [pb]

$\Gamma(\tau^+\nu)/\Gamma(e^+\nu)$				Γ_4/Γ_2
VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
1.046±0.023 OUR FIT				
0.961±0.061	980	[42] ABBOTT 00D	D0	$E_{cm}^{p\bar{p}}$ = 1.8 TeV
0.94 ±0.14	179	[43] ABE 92E	CDF	$E_{cm}^{p\bar{p}}$ = 1.8 TeV
1.04 ±0.08 ±0.08	754	[44] ALITTI 92F	UA2	$E_{cm}^{p\bar{p}}$ = 630 GeV
1.02 ±0.20 ±0.12	32	ALBAJAR 89	UA1	$E_{cm}^{p\bar{p}}$ = 546,630 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.995±0.112±0.083	198	ALITTI 91C	UA2	Repl. by ALITTI 92F
1.02 ±0.20 ±0.10	32	ALBAJAR 87	UA1	Repl. by ALBAJAR 89

$$\frac{\sigma(\mu\tau_h)}{\sigma(\mu\mu)} = \frac{\mathcal{B}(W\to\tau\to\tau_h)}{\mathcal{B}(W\to\mu)+\mathcal{B}(W\to\tau\to\mu)} = \frac{\frac{\mathcal{B}(W\to\tau)}{\mathcal{B}(W\to\mu)}\mathcal{B}(\tau\to\tau_h)}{1+\frac{\mathcal{B}(W\to\tau)}{\mathcal{B}(W\to\mu)}\mathcal{B}(\tau\to\mu)}$$

We can extract the ratio between W boson branching fractions in top quark pair decay.

Method

● Double ratio with Drell-Yan to constrain tau ID uncertainty

● A tight tau selection for pure selections of top quark pair and DY

● The rest of the selection requirements are the same

$$\frac{\sigma(t\bar{t}\to\mu\tau_h)}{\sigma(t\bar{t}\to\mu\mu)} \bigg/ \frac{\sigma(DY\to\mu\mu)}{\sigma(DY\to\tau_\mu\tau_h)}$$

Motivation

● First measurement in this final state at 13 TeV

● Improve uncertainty with respect to Run1

● Access to BSM measurements, a test of Lepton Universality in W boson decays

Method

Many particular final products:

● 2 b-jets (displaced vertex of jet)

● 1 light lepton (muon or electron)

● 2 neutrinos

● 1 hadronicaly decaying tau lepton

A typical event selection:

● select events with ID algorithms for all the final state objects

● the main background is from the misidentified taus in lepton+jets final state

Estimation of the background with misidentified taus:

● misidentified candidates per the physical process of origin

● shape fit to tau-independent parameters: the transverse mass between lepton-MET, kinematics of jets

● Profile Likelihood Ratio fit to binned distributions taken from the simulation templates and data-driven QCD

Results

● Measurements of the production cross section and partial width of the decay at 13 TeV

● Improved uncertainty with respect to Run1

● Developmenet of the Lepton Universality test

Lepton Universality in W boson decays

● The best measurement up to date is from LEP2

● 2.5 sigma deviation from the unity

● 2% of relative uncertainty

● Performed in virtual WW final state
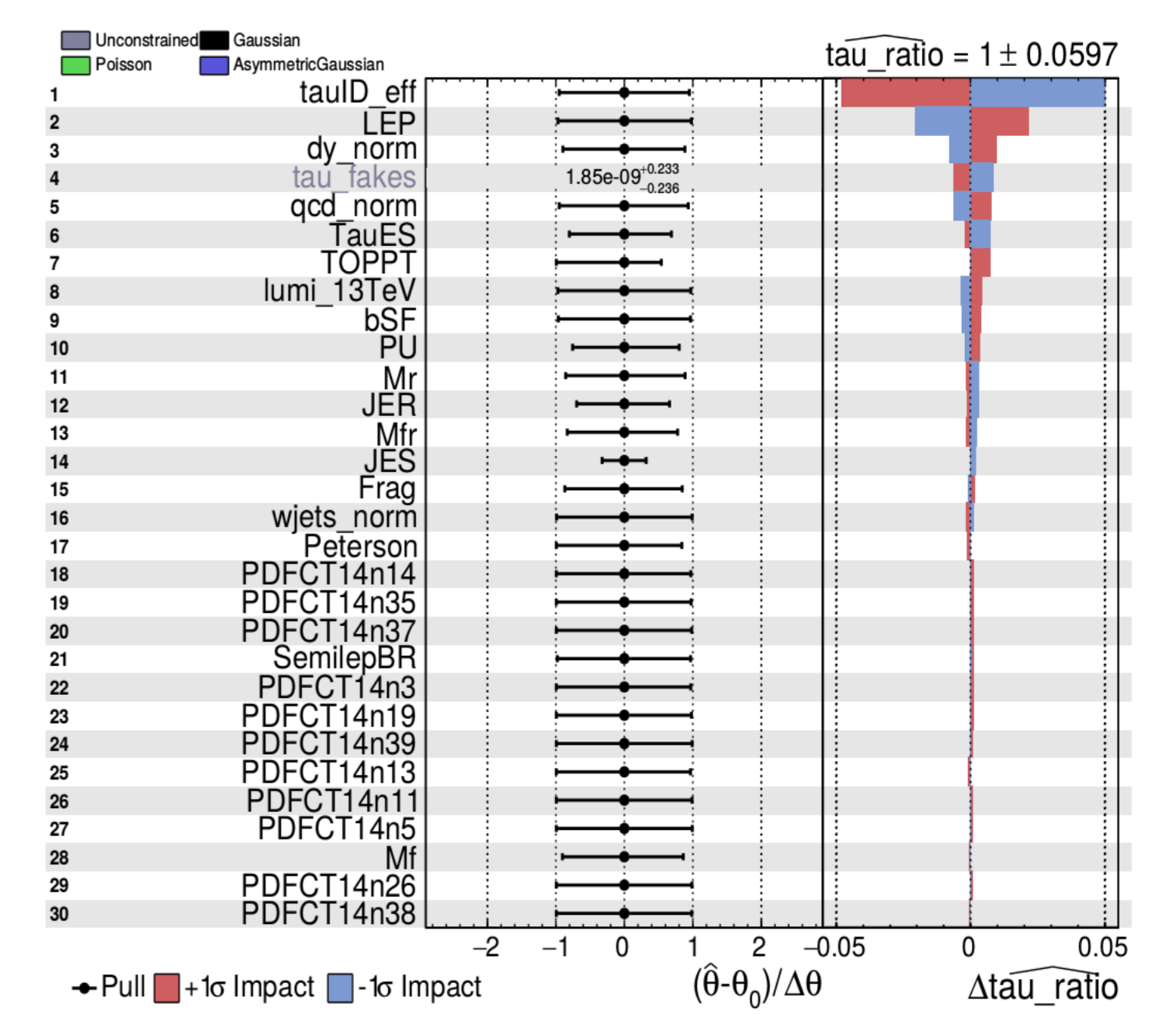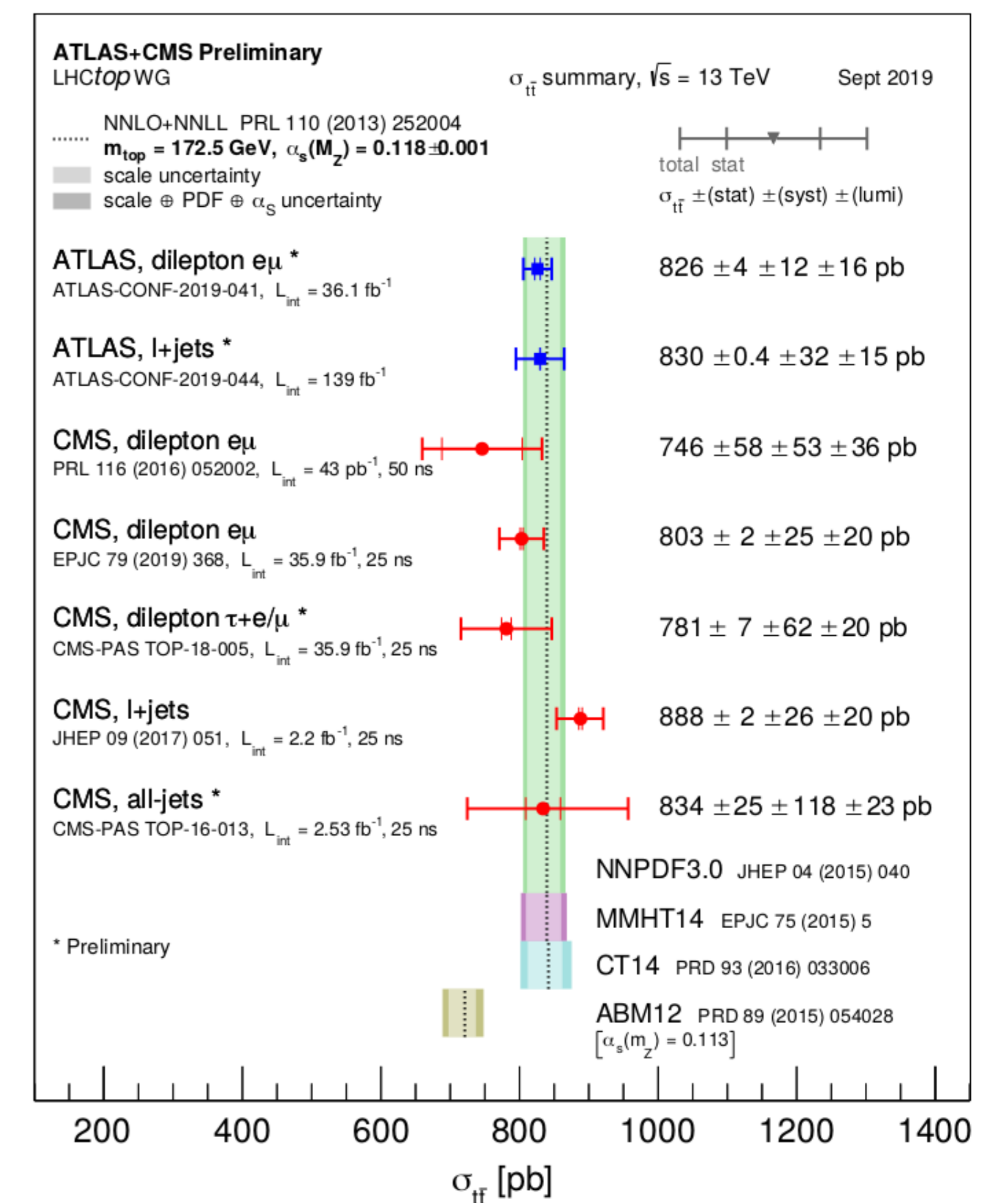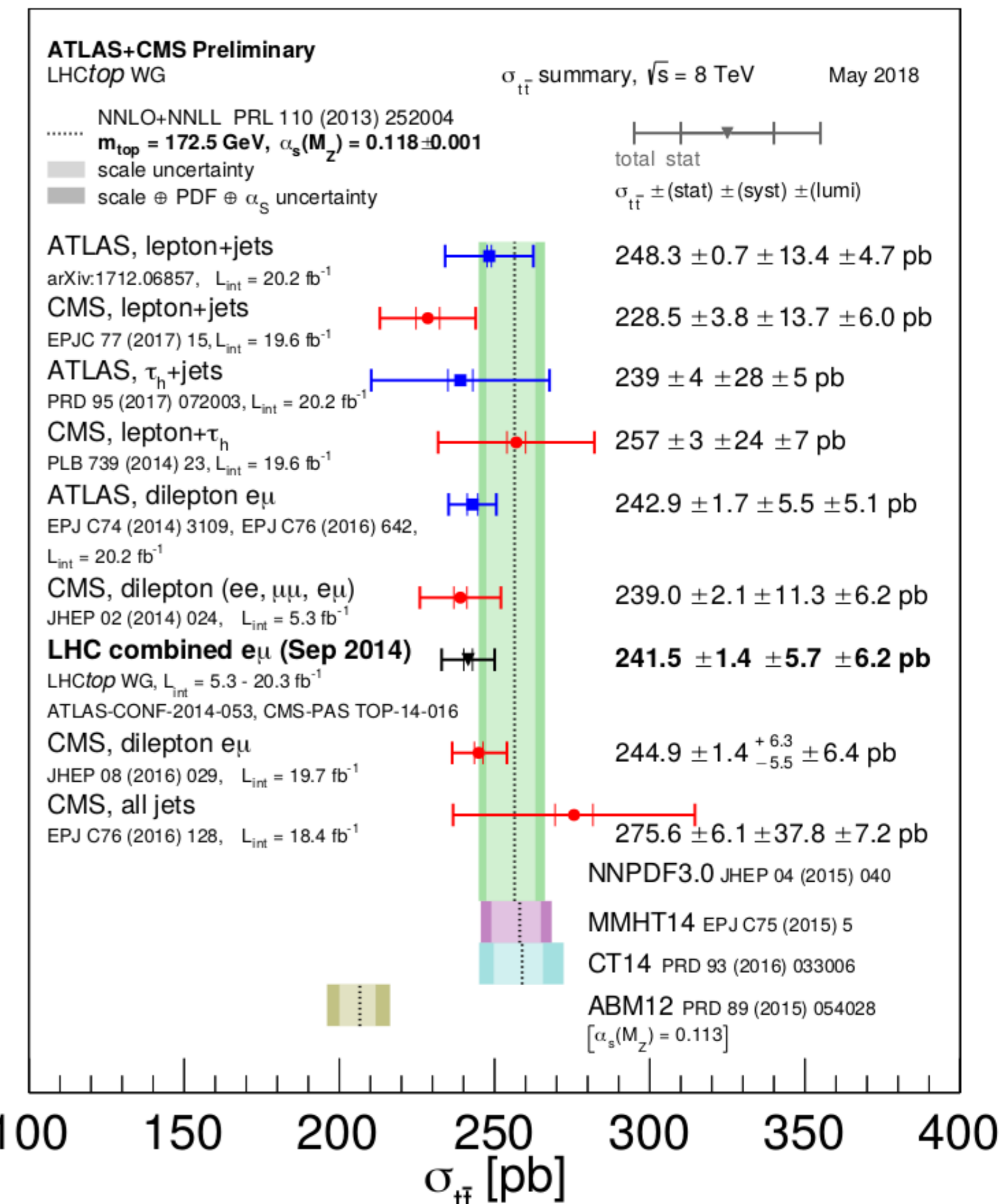
● Similar deviations in B physics

Feasibility study for Run2

● MC study of the event selection

● The uncertainties do cancel out

● But the result is statistically limited

● About 3% of overall uncertainty with full Run2 dataset

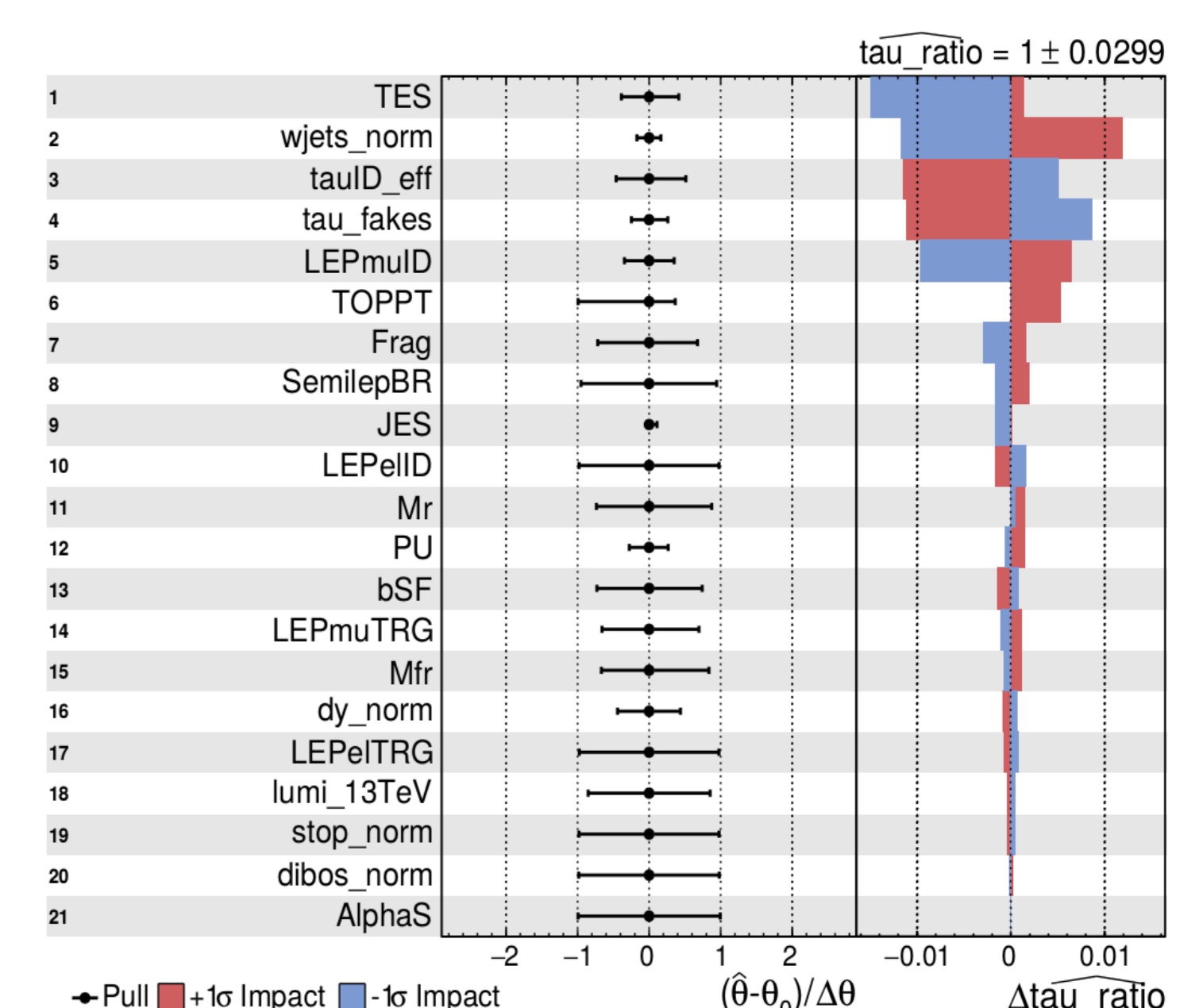● The possibilities to improve the event selection are studied

ATLAS+CMS Preliminary — LHCtop WG — $\sigma_{t\bar{t}}$ summary, $\sqrt{s}$ = 8 TeV — May 2018

ATLAS+CMS Preliminary — LHCtop WG — $\sigma_{t\bar{t}}$ summary, $\sqrt{s}$ = 13 TeV — Sept 2019

The cancellation of systematic uncertainties in the ratio between only the top quark channels.

The systematic uncertainties in MC study of the double ration with 140 fb^-1 luminosity.