FLOORS FOR PROJECTIONS

Reminder of our methodology

- Extrapolations from Run 2 analyses aiming for more realistic projections, supported by TDR-based analyses with realistic detector performance
  - Extrapolation to 3000 fb^{-1} based on a double approach: “conservative” (current experimental uncertainties) vs “realistic” (expected floor values for uncertainties)

- Handful of few Delphes-based analyses - tuned to the latest TDR studies - will extend this coverage

- In both cases results should be presented with a explicit uncertainty split: stat +- exp_syst +- theory_syst +- luminosity to simplify comparison and integration into the YR

Basis: ECFA16

RUN 2 UNCERTAINTIES

ECFA16 S1 All systematic uncertainties are kept constant with integrated luminosity. The performance of the CMS detector is assumed to be the unchanged with respect to the reference analysis.

ECFA16 S1+ All systematic uncertainties are kept constant with integrated luminosity. The effects of higher pileup conditions and detector upgrades on the future performance of CMS are taken into account.

ECFA16 S2 Theoretical uncertainties scaled down by a factor 1/2, while experimental systematic uncertainties are scaled down by the square root of the integrated luminosity until they reach the ultimate level expected to be achievable by CMS with a sufficiently large accumulated dataset. The performance of the CMS detector is assumed to be the unchanged with respect to the reference analysis.

UNCERTAINTIES SCALE DOWN WITH LUMI

ECFA16 S2+ Theoretical uncertainties scaled down by a factor 1/2, while experimental systematic uncertainties are scaled down by the square root of the integrated luminosity until they reach the ultimate level expected to be achievable by CMS with a sufficiently large accumulated dataset. The effects of higher pileup conditions and detector upgrades on the future performance of CMS are taken into account.

We keep the same structure

BASIC OBJECT UNCERTAINTIES: RUN2 AND FLOORS

	Run2 examples	YR2018 Floor
Luminosity	2.5 % in recent HIG papers	1 %
Muon efficiency (ID,trigger,iso)	WP dependent, 2 % in [1]	0.5 %
Electron Efficiency (ID,trigger,iso)	WP dependent, 2 % in [1]	1 %
Tau efficiency (ID, trigger, iso)	5%(ID,iso)+5%(trigger) [1]	5%(ID,iso)+5%(trigger)
Photon efficiency	2% (loose WP) [2]	better than 2 % (TBD)
Jet Energy Scale	20X uncertainties (2-15% overall in ttH) [3] At best 0.5-1.0% (pt>30 GeV, central eta range) - 5% (at lowest pt, for eta < 2.7)	0.5-1.0% (pt>30 GeV, central eta range) - 5% (at lowest pt, for eta < 2.7)
B tagging	1.5% (b), 5% (c) and 10% (light) [4]	1% (b), 2% (c) and 5-10-15% (WP dependent,light)

[1] http://cms-results.web.cern.ch/cms-results/public-results/publications/HIG-16-043/CMS-HIG-16-043_Table_003.pdf (TauTau). Lower uncertainty for looser working points (eg in HZZ)

[2] https://cds.cern.ch/record/2255497/files/DP2017_004.pdf (slides 43 and 44)

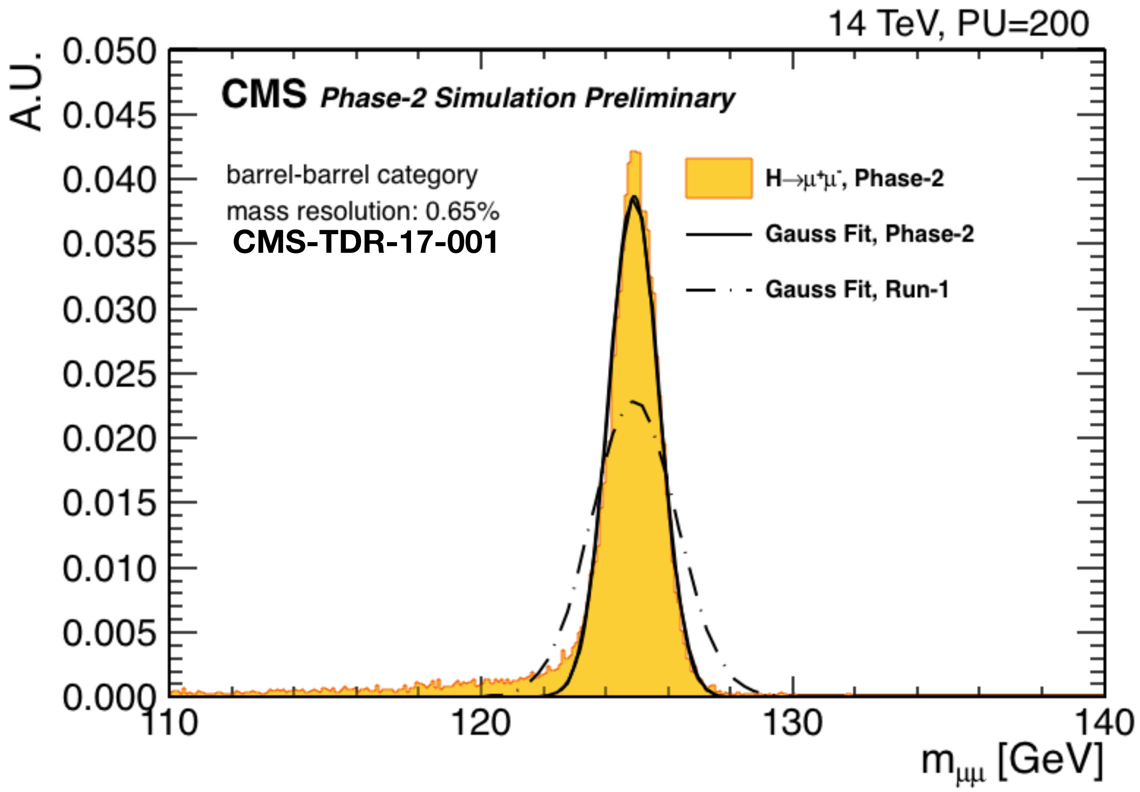
[3] http://cms-results.web.cern.ch/cms-results/public-results/publications/HIG-17-018/CMS-HIG-17-018_Table_004.pdf

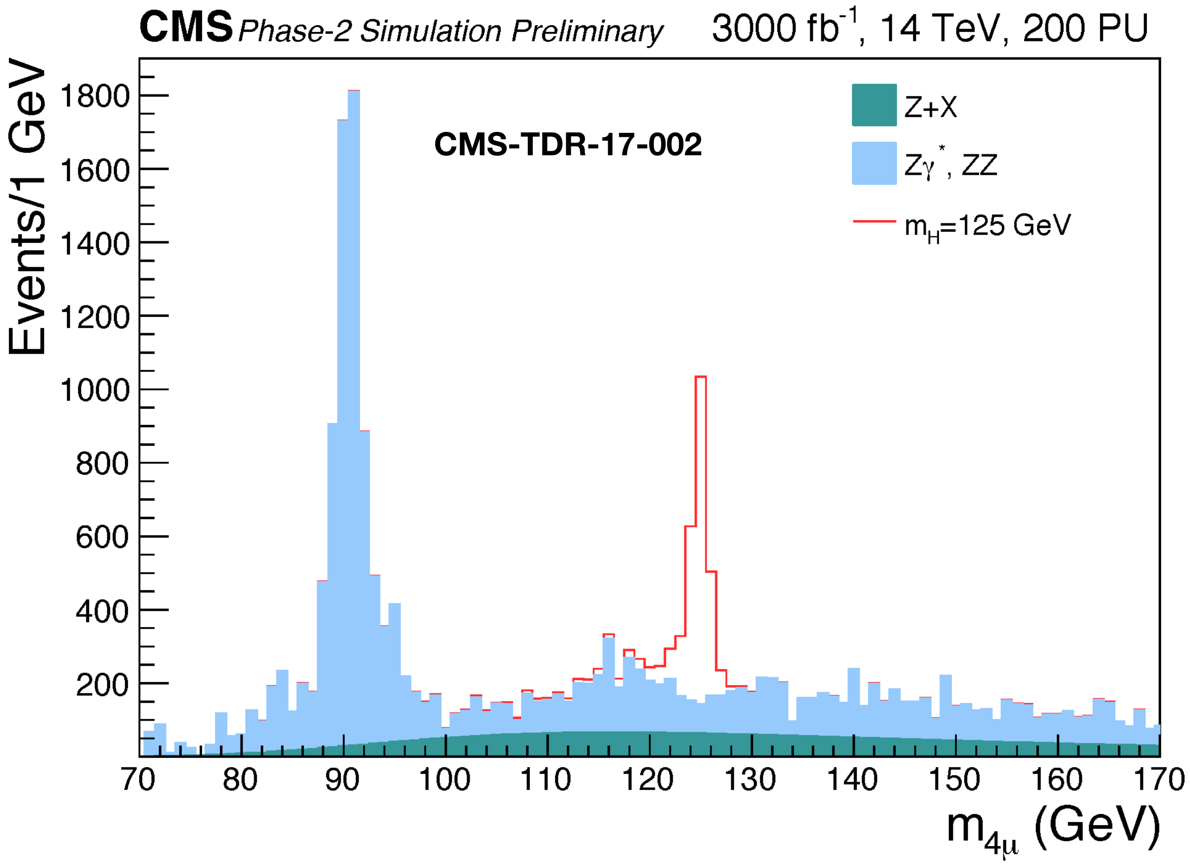
[4] http://cms-results.web.cern.ch/cms-results/public-results/publications/HIG-16-044/index.html

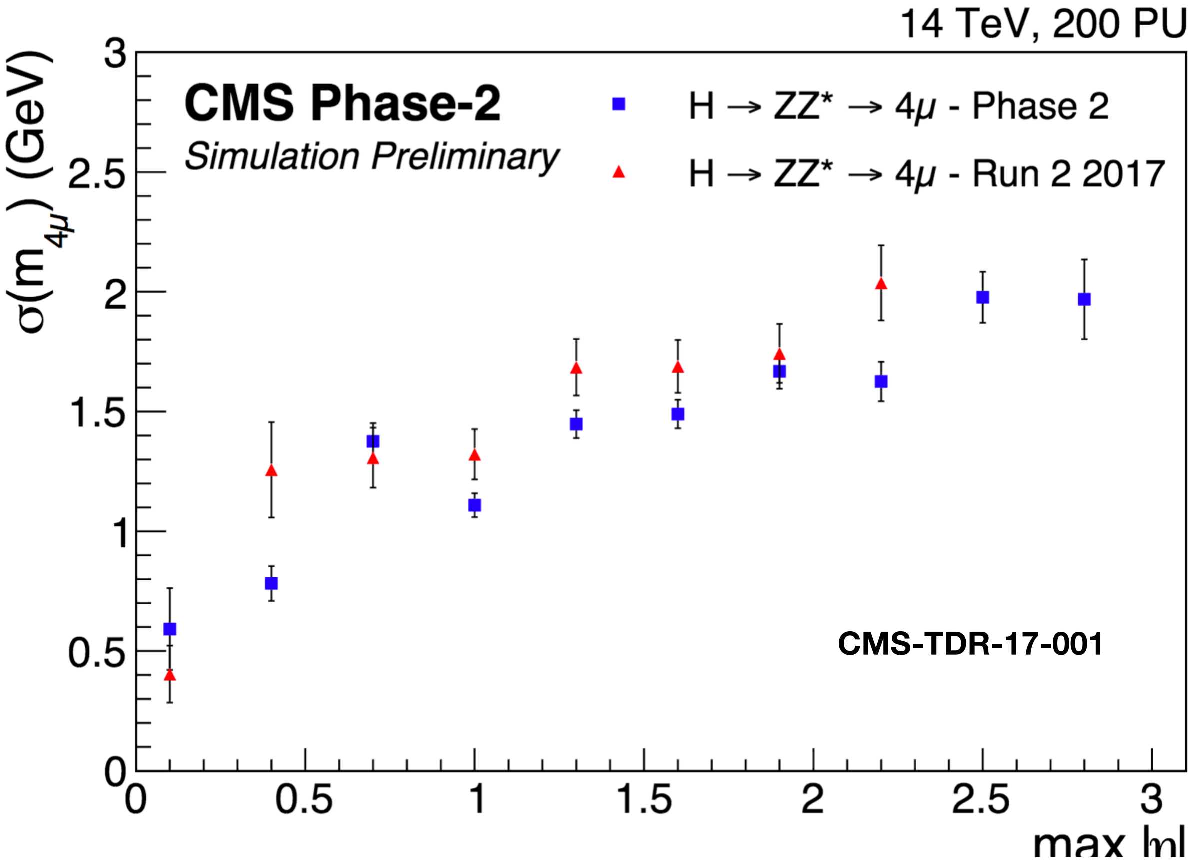
Other uncertainties (JER, MET) as in Run2

Mass Resolution

Tracker upgrade improvement in the dimuon mass resolution needs to be folded in in the projections

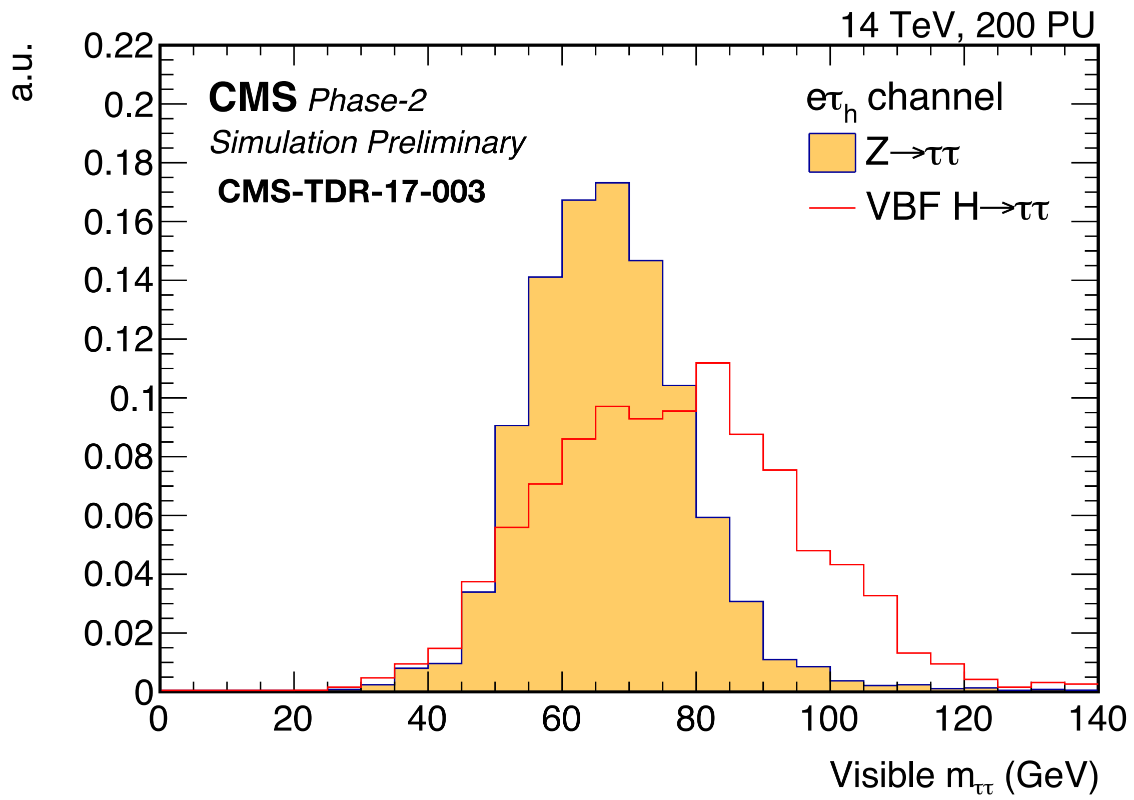


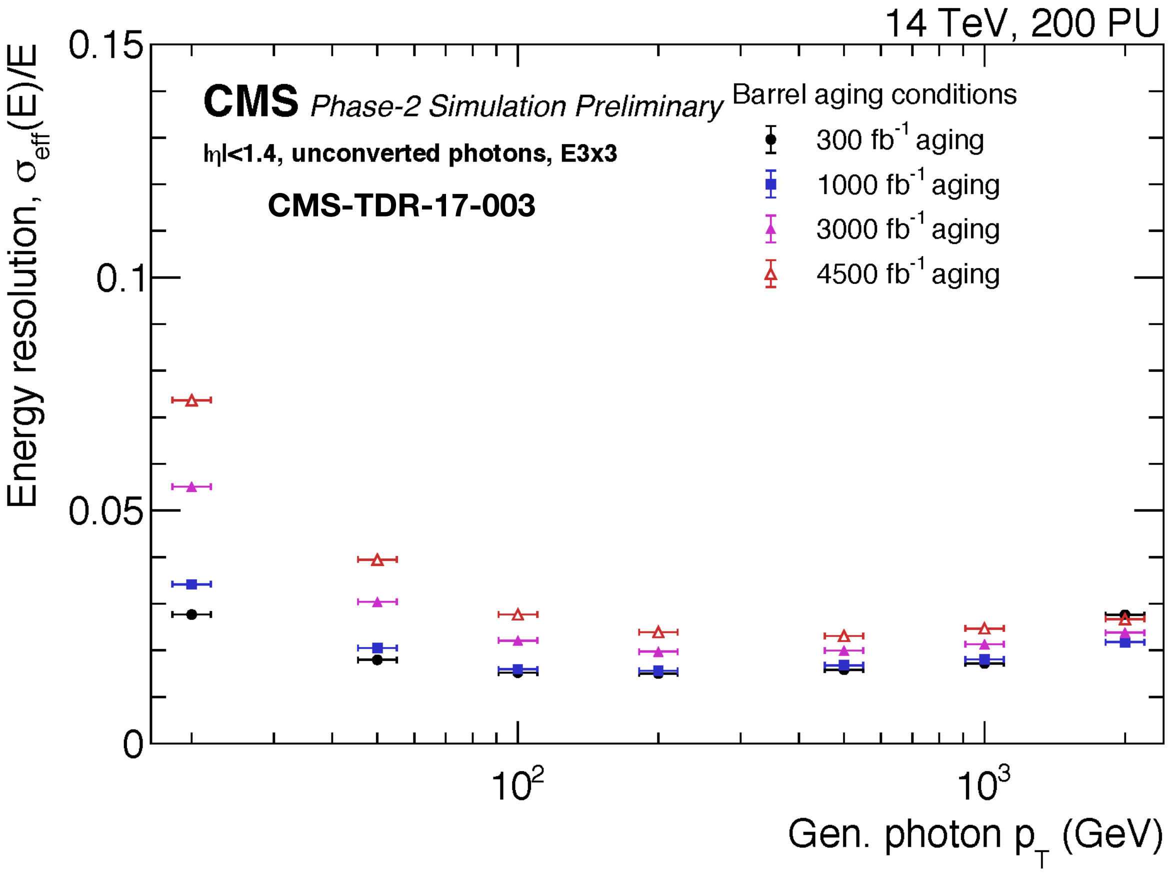


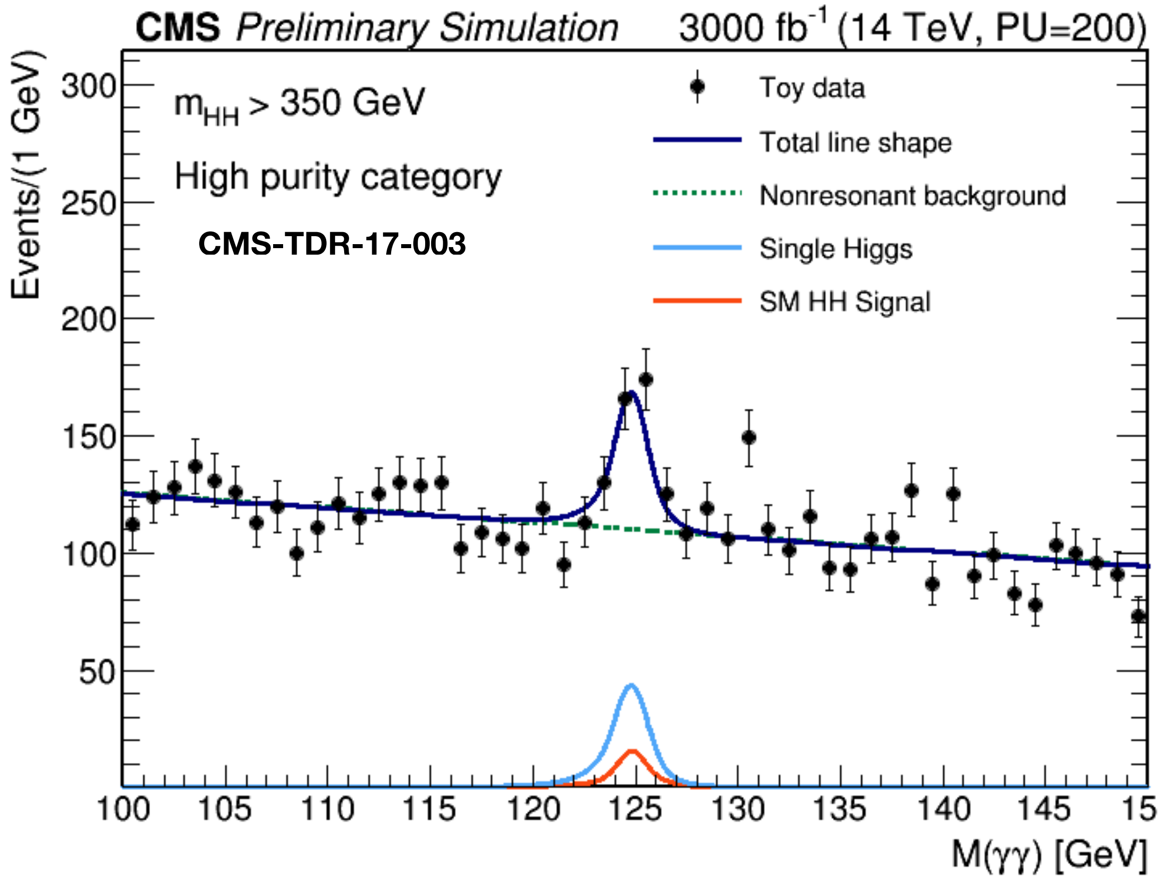


Mass Resolution

Expected to be comparable to Run2 for photons and taus (details in the 2017 TDRs)



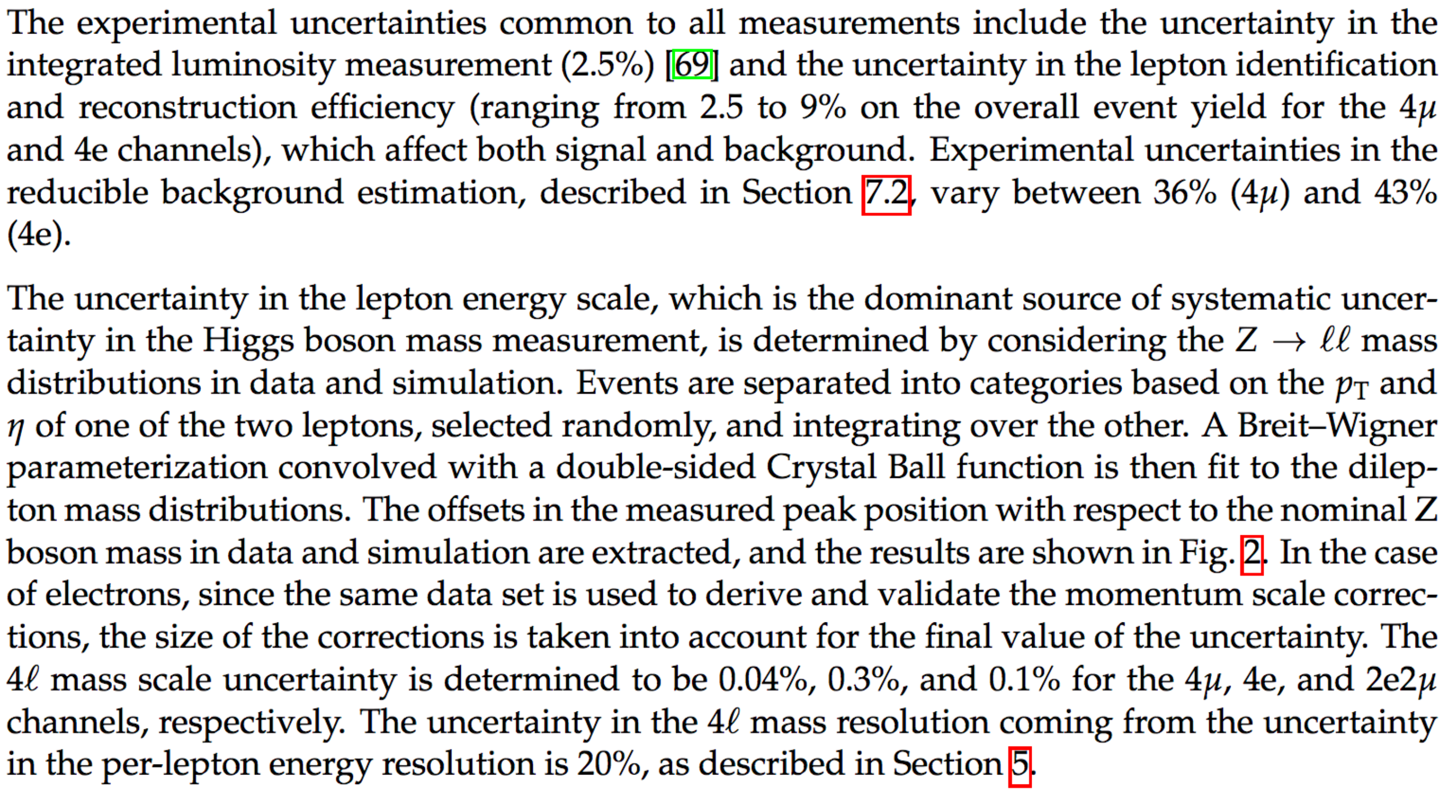




BACKUP

Run2 references

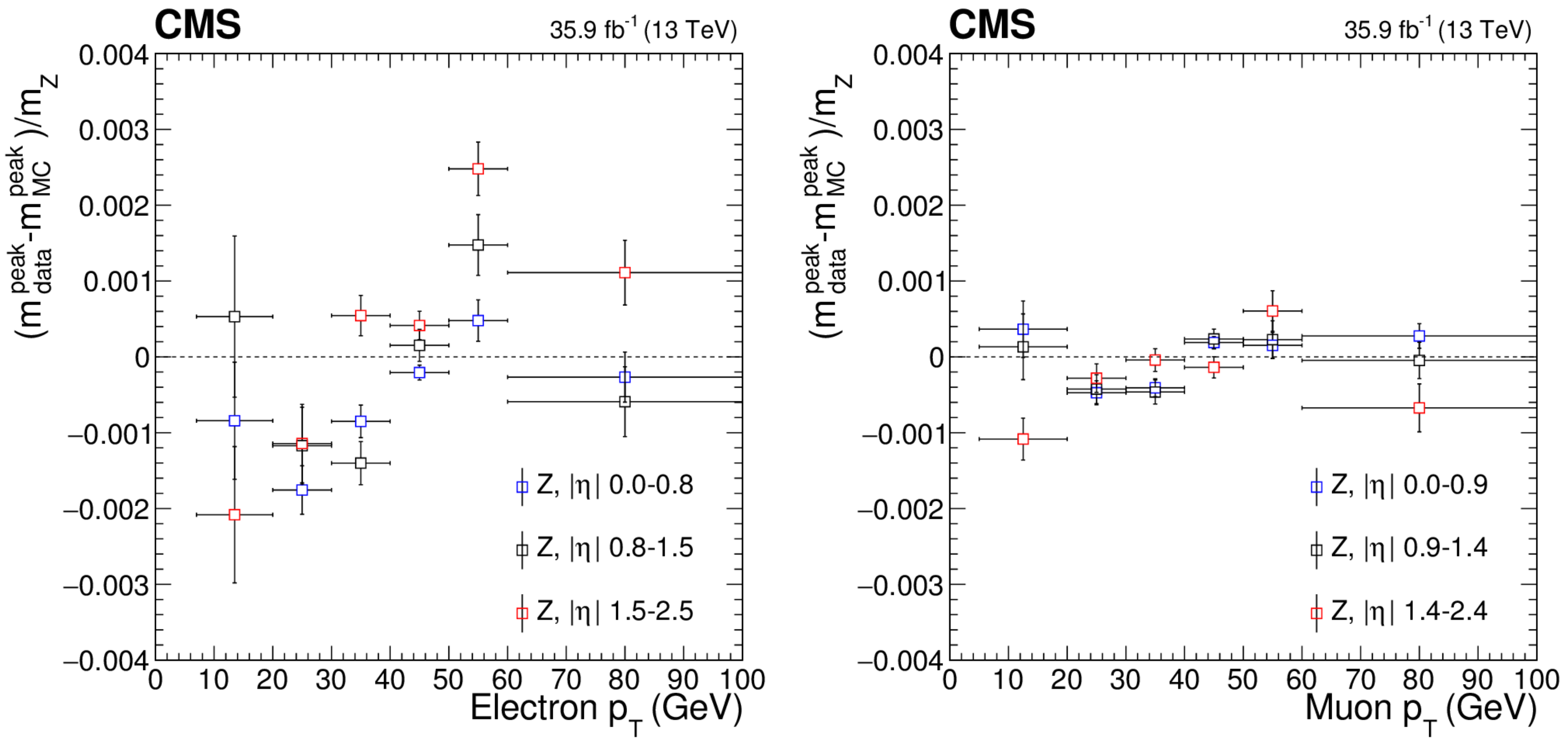
RUN2 VALUES: LEPTONS (I)



The experimental uncertainties common to all measurements include the uncertainty in the integrated luminosity measurement (2.5%) [69] and the uncertainty in the lepton identification and reconstruction efficiency (ranging from 2.5 to 9% on the overall event yield for the 4μ and 4e channels), which affect both signal and background. Experimental uncertainties in the reducible background estimation, described in Section 7.2, vary between 36% (4μ) and 43% (4e).

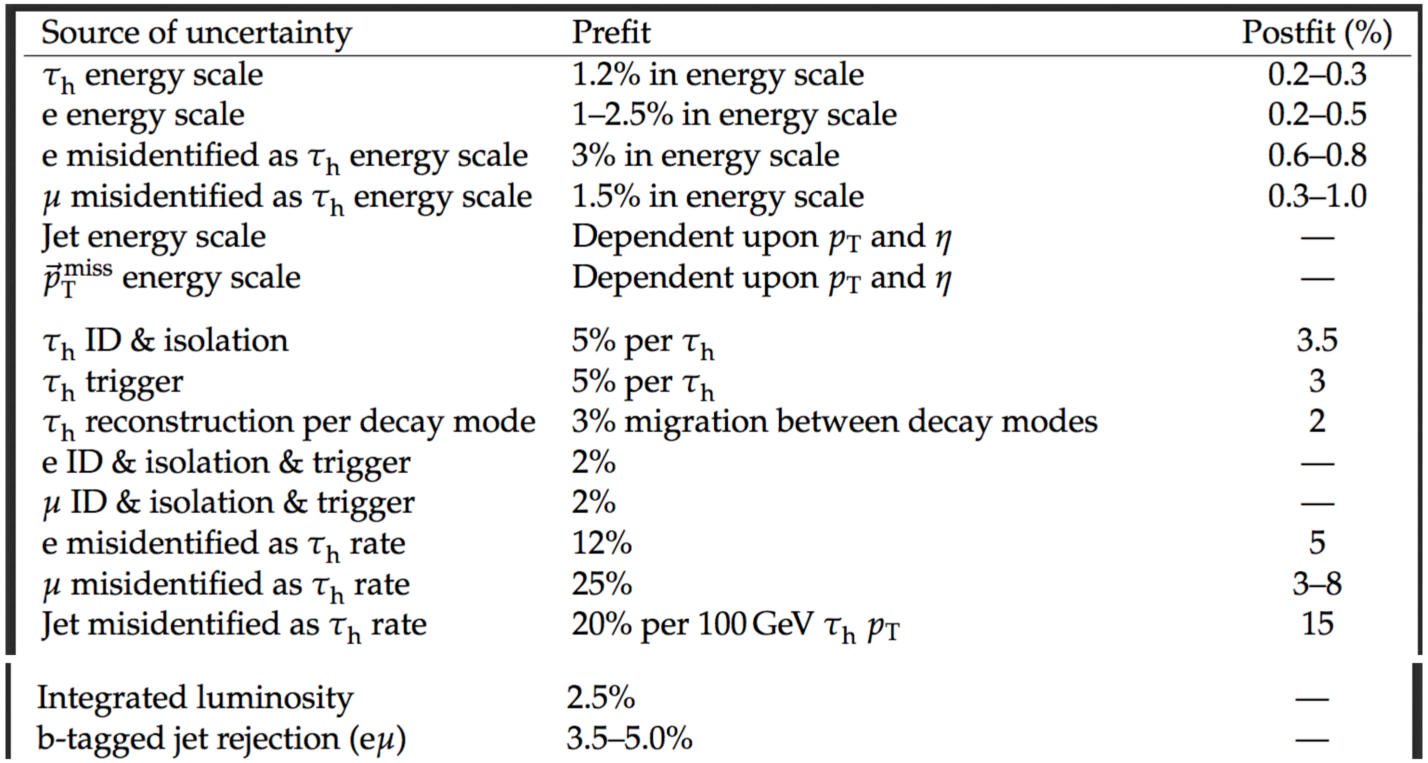
The uncertainty in the lepton energy scale, which is the dominant source of systematic uncertainty in the Higgs boson mass measurement, is determined by considering the $Z \to \ell\ell$ mass distributions in data and simulation. Events are separated into categories based on the p_T and η of one of the two leptons, selected randomly, and integrating over the other. A Breit–Wigner parameterization convolved with a double-sided Crystal Ball function is then fit to the dilepton mass distributions. The offsets in the measured peak position with respect to the nominal Z boson mass in data and simulation are extracted, and the results are shown in Fig. 2. In the case of electrons, since the same data set is used to derive and validate the momentum scale corrections, the size of the corrections is taken into account for the final value of the uncertainty. The 4ℓ mass scale uncertainty is determined to be 0.04%, 0.3%, and 0.1% for the 4μ, 4e, and $2e2\mu$ channels, respectively. The uncertainty in the 4ℓ mass resolution coming from the uncertainty in the per-lepton energy resolution is 20%, as described in Section 5.

http://cms-results.web.cern.ch/cms-results/public-results/publications/HIG-16-041/index.html



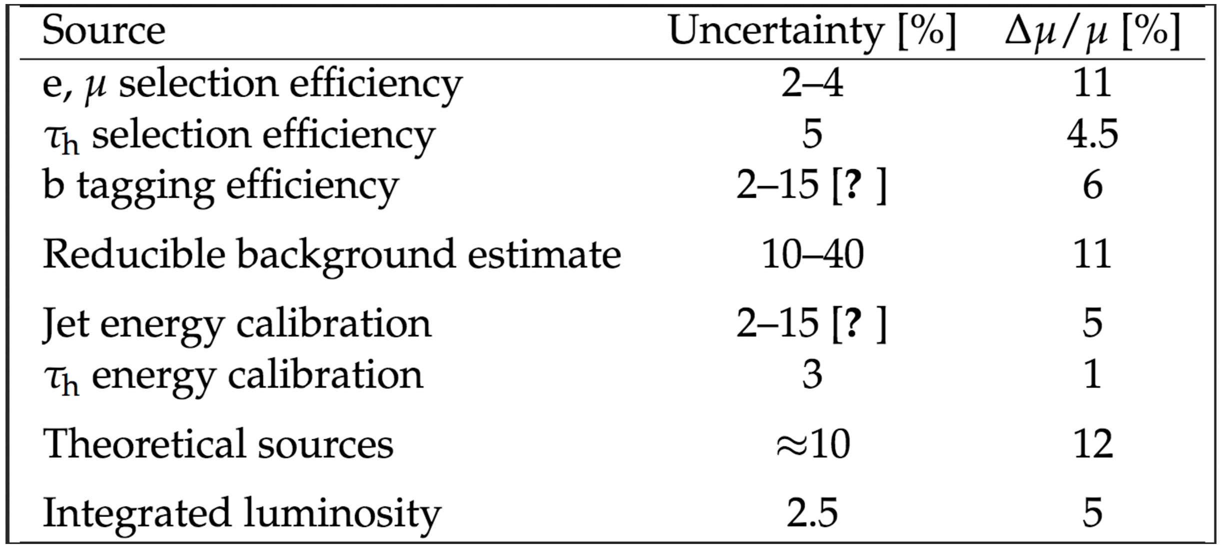
RUN2 VALUES: LEPTONS (II)

- Reference for Higgs: HTauTau or ttH could be good as a basis (almost all objects employed)



Source of uncertainty	Prefit	Postfit (%)
τ_h energy scale	1.2% in energy scale	0.2–0.3
e energy scale	1–2.5% in energy scale	0.2–0.5
e misidentified as τ_h energy scale	3% in energy scale	0.6–0.8
μ misidentified as τ_h energy scale	1.5% in energy scale	0.3–1.0
Jet energy scale	Dependent upon p_T and η	—
$\vec{p}_T^{\,miss}$ energy scale	Dependent upon p_T and η	—
τ_h ID & isolation	5% per τ_h	3.5
τ_h trigger	5% per τ_h	3
τ_h reconstruction per decay mode	3% migration between decay modes	2
e ID & isolation & trigger	2%	—
μ ID & isolation & trigger	2%	—
e misidentified as τ_h rate	12%	5
μ misidentified as τ_h rate	25%	3–8
Jet misidentified as τ_h rate	20% per 100 GeV τ_h p_T	15
Integrated luminosity	2.5%	—
b-tagged jet rejection (eμ)	3.5–5.0%	—

http://cms-results.web.cern.ch/cms-results/public-results/publications/HIG-16-043/CMS-HIG-16-043_Table_003.pdf



Source	Uncertainty [%]	$\Delta\mu/\mu$ [%]
e, μ selection efficiency	2–4	11
τ_h selection efficiency	5	4.5
b tagging efficiency	2–15 [?]	6
Reducible background estimate	10–40	11
Jet energy calibration	2–15 [?]	5
τ_h energy calibration	3	1
Theoretical sources	≈10	12
Integrated luminosity	2.5	5

http://cms-results.web.cern.ch/cms-results/public-results/publications/HIG-17-018/CMS-HIG-17-018_Table_004.pdf

Also worth having a look at slides from Thursdays xtalk: https://indico.cern.ch/event/723480/attachments/1643716/2626252/x-talk-results.pdf

RUN2 VALUES: PHOTONS

Vertex finding: 2%

Photon energy scale & smearing: 0.15-0.5% +0.1-0.2% (nonlinearity) + <0.24% (budget) + <0.15% (shower shape corr.) + 0.07% (nonuniformity) +0.05% (shower modelling)

Per photon energy resolution: 5%

Photon ID

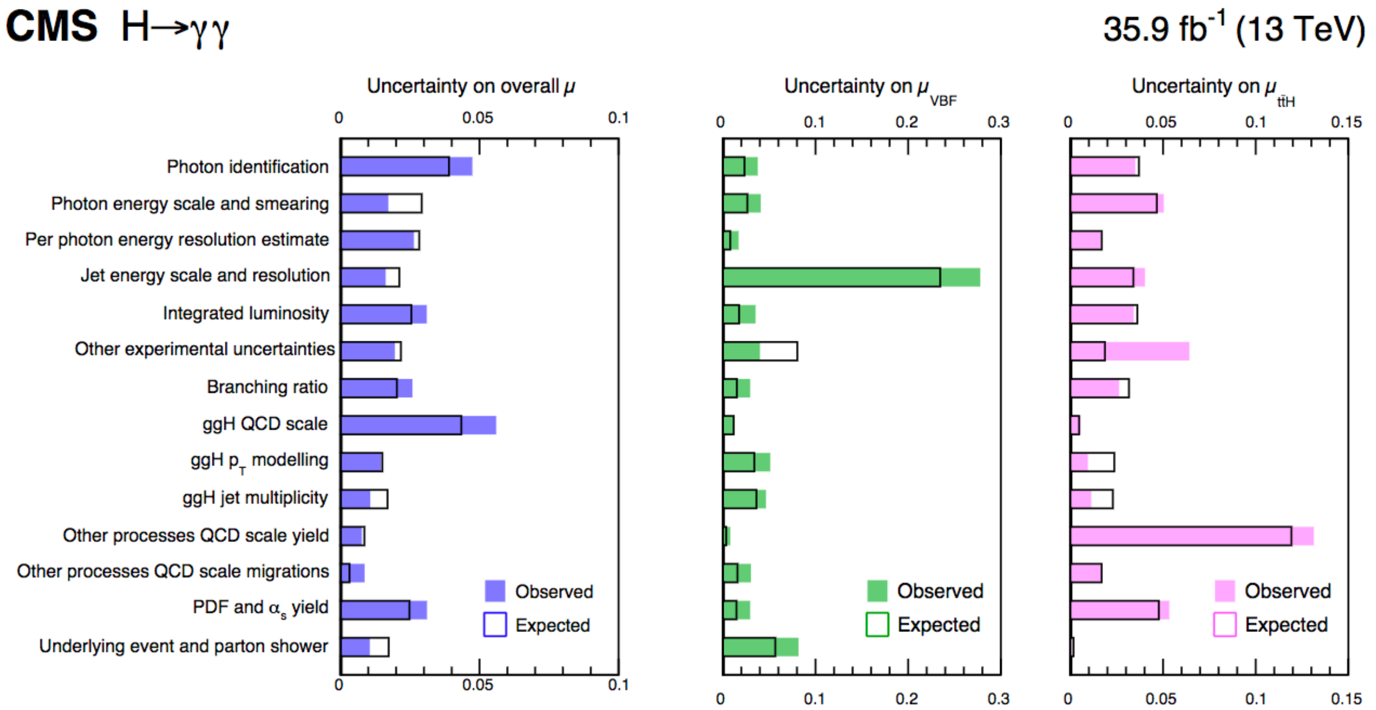
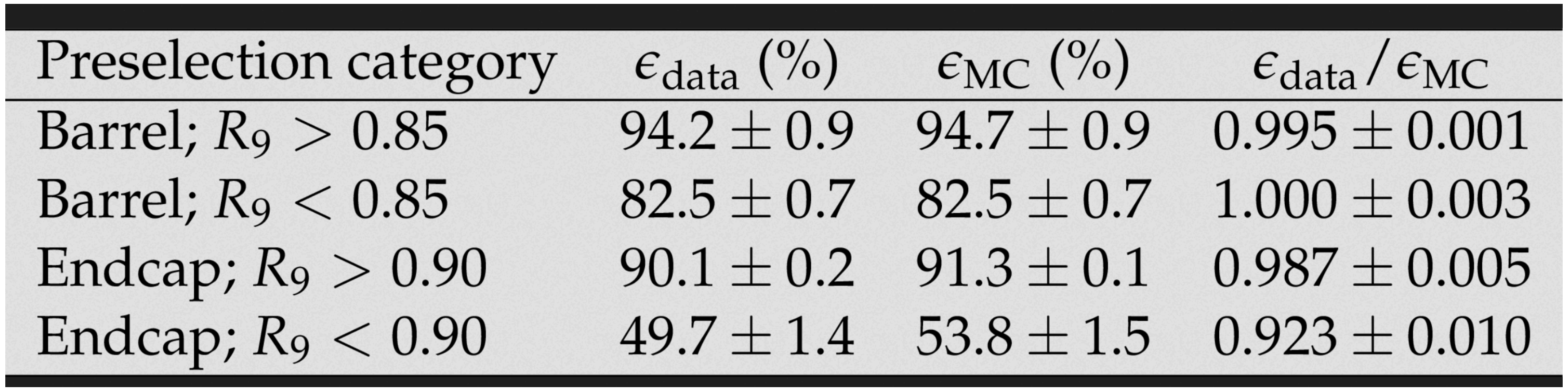
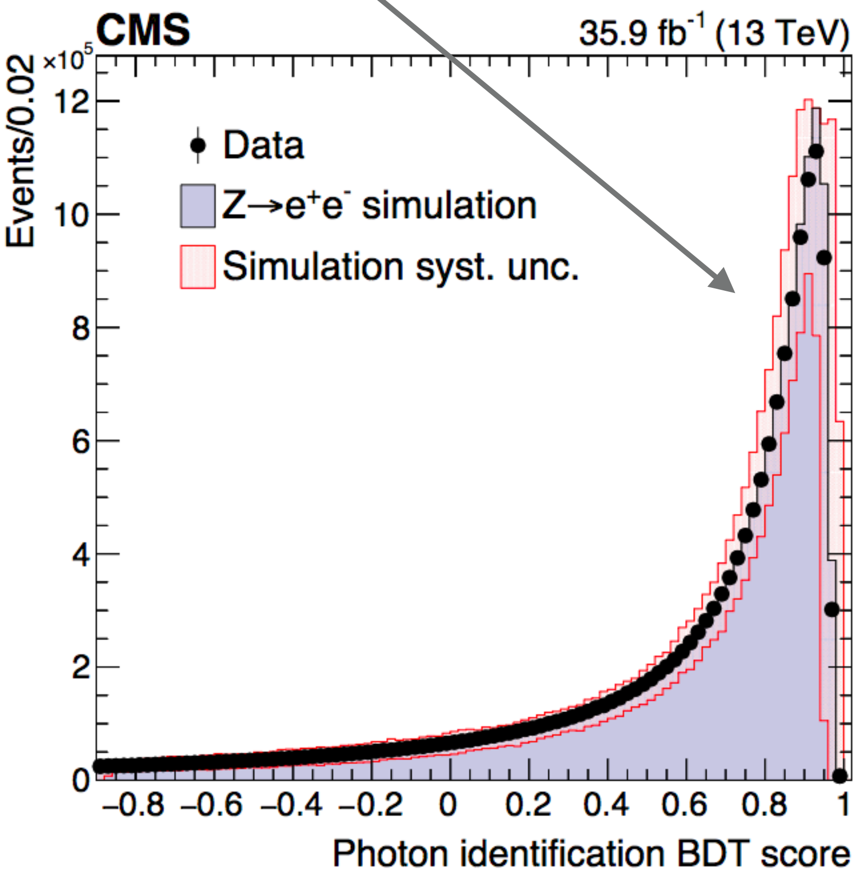


Figure 10: Summary of the impact of the different systematic uncertainties on the overall signal strength modifier and on the signal strength modifiers for the VBF and tt̄H production processes. The observed (expected) results are shown by the solid (empty) bars.



Preselection category	ϵ_{data} (%)	ϵ_{MC} (%)	$\epsilon_{data}/\epsilon_{MC}$
Barrel; $R_9 > 0.85$	94.2 ± 0.9	94.7 ± 0.9	0.995 ± 0.001
Barrel; $R_9 < 0.85$	82.5 ± 0.7	82.5 ± 0.7	1.000 ± 0.003
Endcap; $R_9 > 0.90$	90.1 ± 0.2	91.3 ± 0.1	0.987 ± 0.005
Endcap; $R_9 < 0.90$	49.7 ± 1.4	53.8 ± 1.5	0.923 ± 0.010

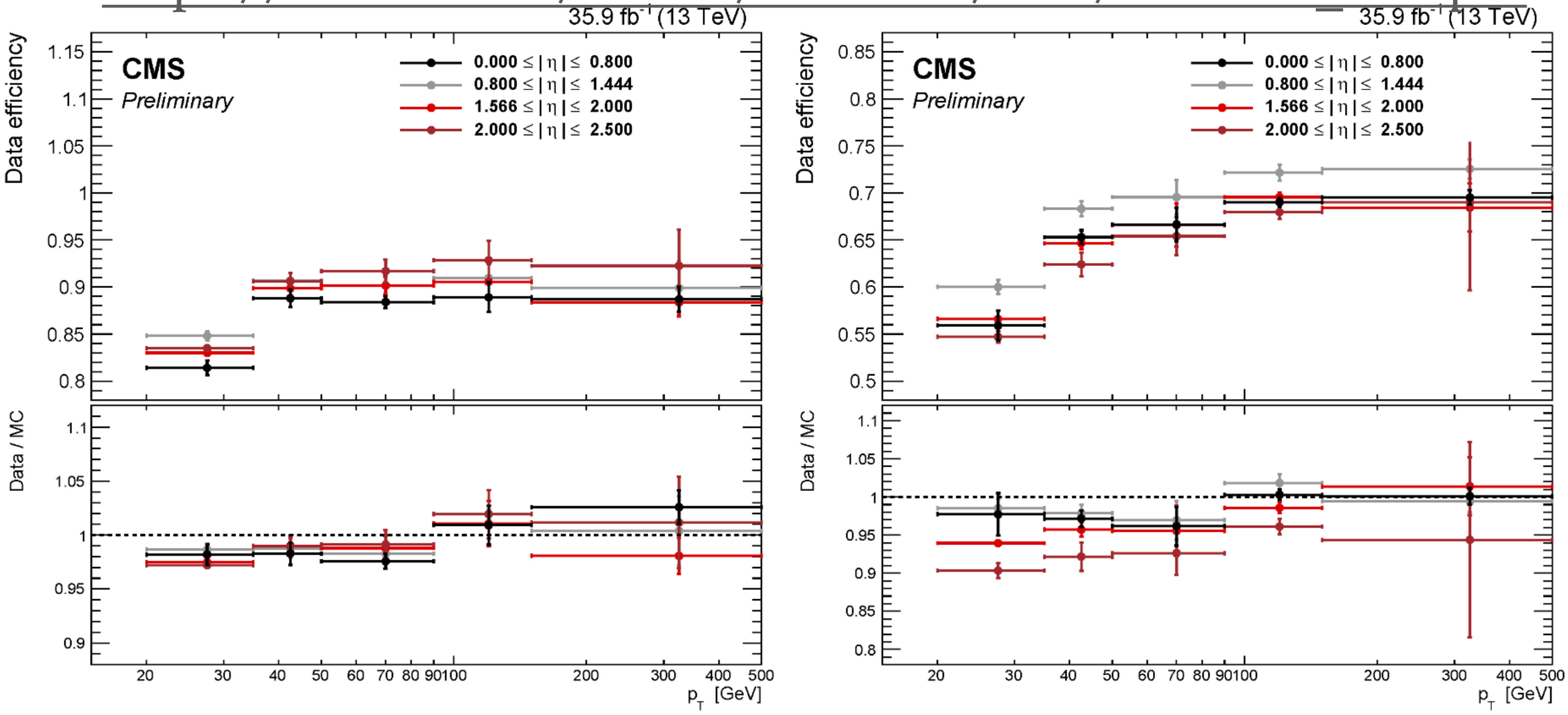


http://cms-results.web.cern.ch/cms-results/public-results/publications/HIG-16-040/index.html

RUN2 VALUES: PHOTONS

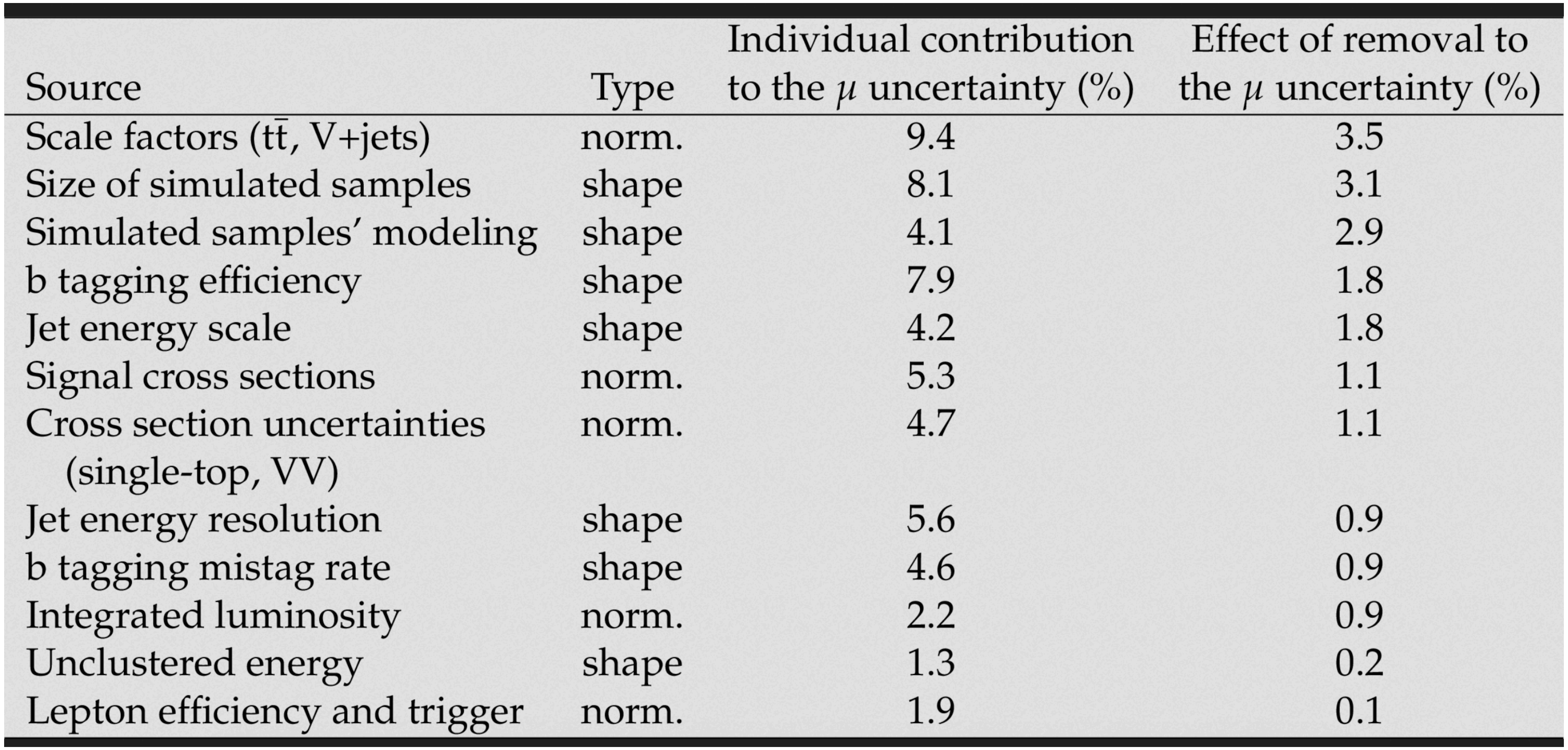
CUT BASED ! Not the same ID as the previous slide

https://cds.cern.ch/record/2255497/files/DP2017_004.pdf

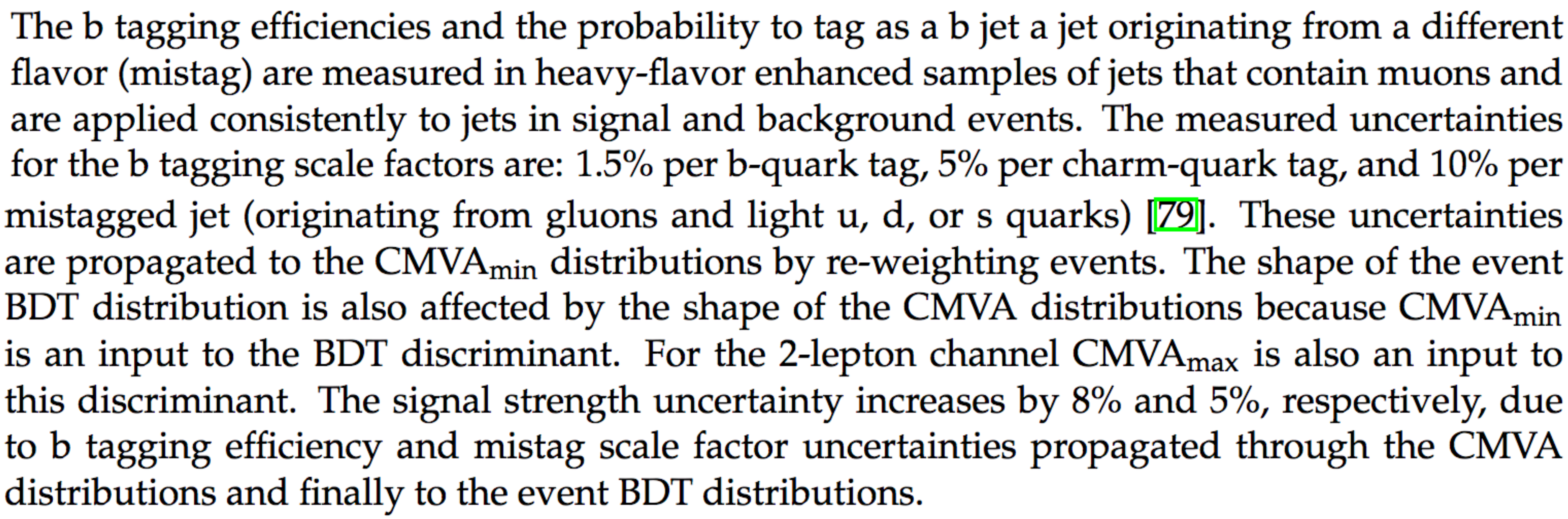


Photon identification efficiency in data and data to MC efficiency ratios measured for the loose (left) and tight (right) cut-based work point. The efficiency is measured with the tag and probe method and shown in four pseudorapidity ranges as a function of the photon transverse energy.

RUN2: HBB



Source	Type	Individual contribution to the μ uncertainty (%)	Effect of removal to the μ uncertainty (%)
Scale factors ($t\bar{t}$, V+jets)	norm.	9.4	3.5
Size of simulated samples	shape	8.1	3.1
Simulated samples' modeling	shape	4.1	2.9
b tagging efficiency	shape	7.9	1.8
Jet energy scale	shape	4.2	1.8
Signal cross sections	norm.	5.3	1.1
Cross section uncertainties (single-top, VV)	norm.	4.7	1.1
Jet energy resolution	shape	5.6	0.9
b tagging mistag rate	shape	4.6	0.9
Integrated luminosity	norm.	2.2	0.9
Unclustered energy	shape	1.3	0.2
Lepton efficiency and trigger	norm.	1.9	0.1



The b tagging efficiencies and the probability to tag as a b jet a jet originating from a different flavor (mistag) are measured in heavy-flavor enhanced samples of jets that contain muons and are applied consistently to jets in signal and background events. The measured uncertainties for the b tagging scale factors are: 1.5% per b-quark tag, 5% per charm-quark tag, and 10% per mistagged jet (originating from gluons and light u, d, or s quarks) [79]. These uncertainties are propagated to the $\mathrm{CMVA}_{\mathrm{min}}$ distributions by re-weighting events. The shape of the event BDT distribution is also affected by the shape of the CMVA distributions because $\mathrm{CMVA}_{\mathrm{min}}$ is an input to the BDT discriminant. For the 2-lepton channel $\mathrm{CMVA}_{\mathrm{max}}$ is also an input to this discriminant. The signal strength uncertainty increases by 8% and 5%, respectively, due to b tagging efficiency and mistag scale factor uncertainties propagated through the CMVA distributions and finally to the event BDT distributions.

http://cms-results.web.cern.ch/cms-results/public-results/publications/HIG-16-044/index.html