ggF Status Report

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Dec. 4, 2024

ggF WG1: Who We Are

Stephen Jones (Theory)

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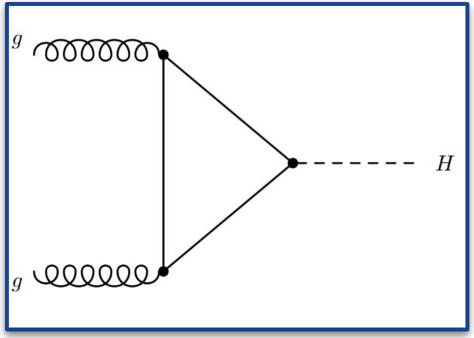
In This Talk

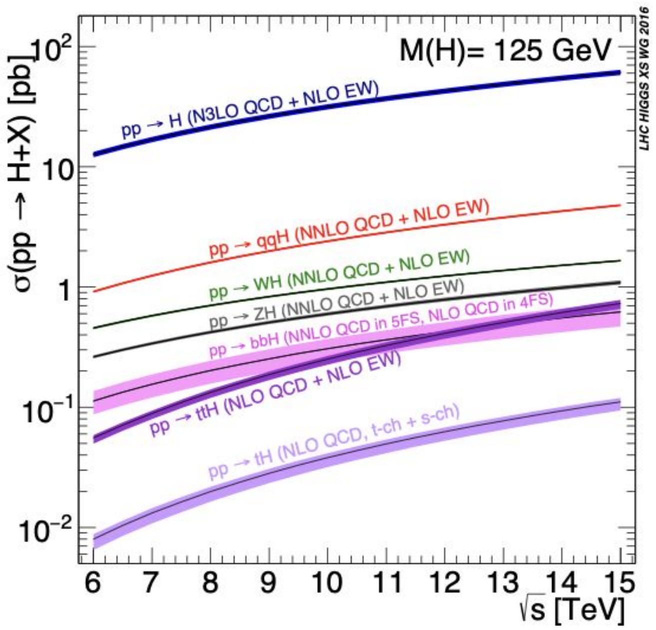
- ggF at the LHC
  - Experimental context
- Theory updates this past year:
  - Quark mass effects in ggF loop: top, bottom mass dependence
  - aN3LO PDFs
  - N4LO soft-virtual approximation
  - 3-loop heavy flavour corrections
- Status of ggF cross-section update for 13.6 TeV
- Possible future areas of focus

ggF at the LHC

Yellow Report 4

- Largest production mode at the LHC.





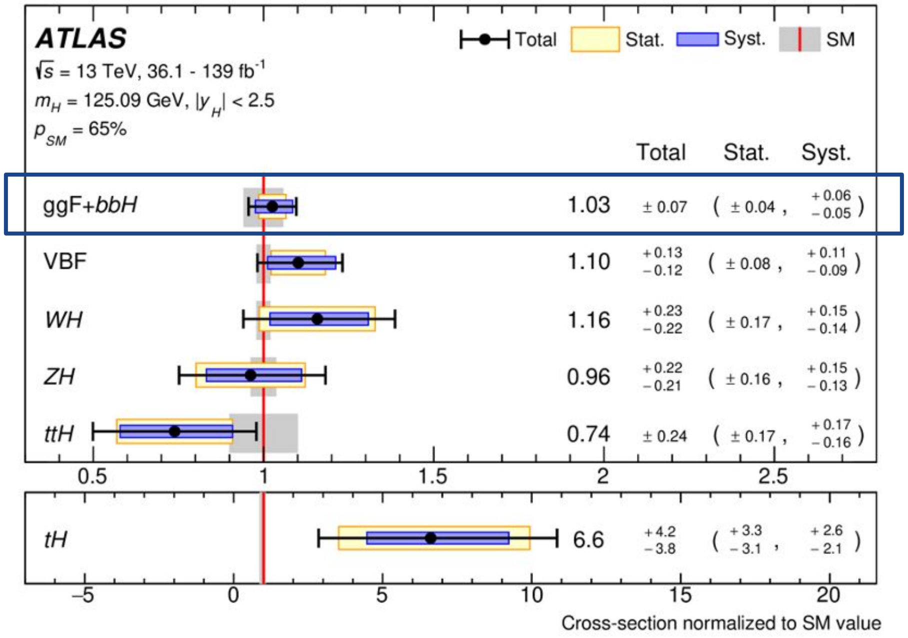
- Experimentally: Large statistics = crucial role in discovery, no distinctive features = best observed in clean decay modes.

- Theoretically: Calculations complicated by the quark loop: introduces dependence on top mass and other heavy quark (b, c).

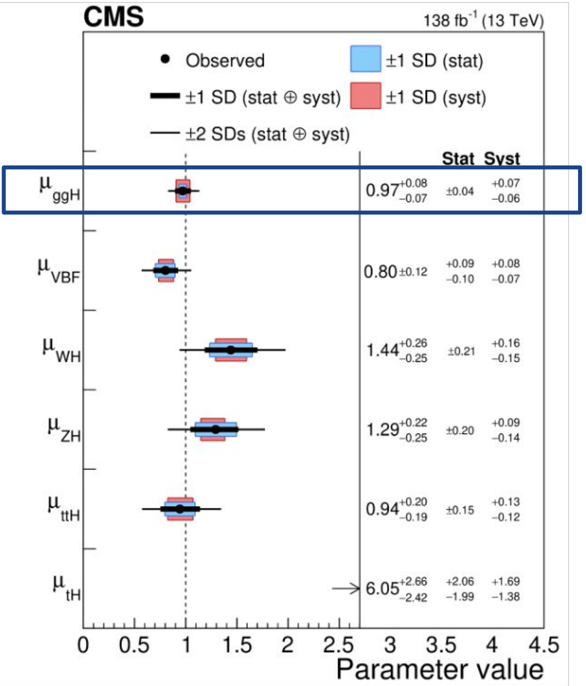
ggF at the LHC

- Run 2: measurements systematics-dominated, ~same precision as theory.

ATLAS HIGG-2021-23

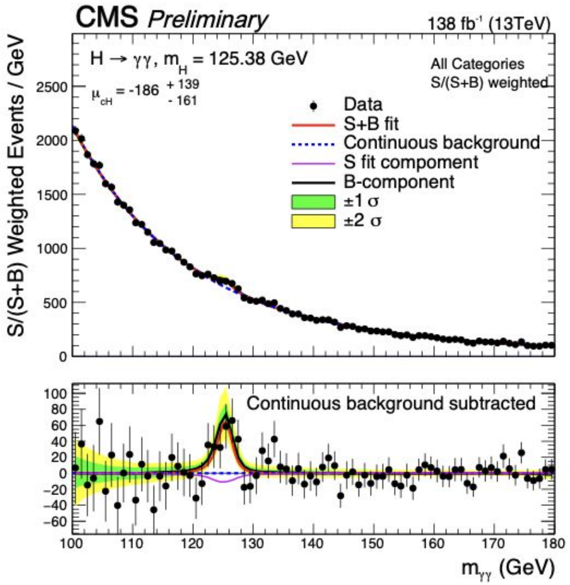


CMS HIG-22-001

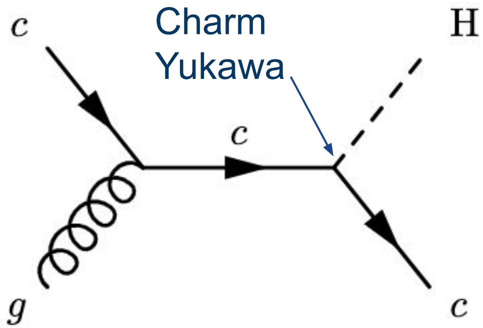


ggF at the LHC

Experiments also studying interesting new modes in Run 2 data, eg. inclusive H+c production with sensitivity to charm Yukawa coupling:



ATLAS and CMS probed inclusive H+c production in the diphoton channel.

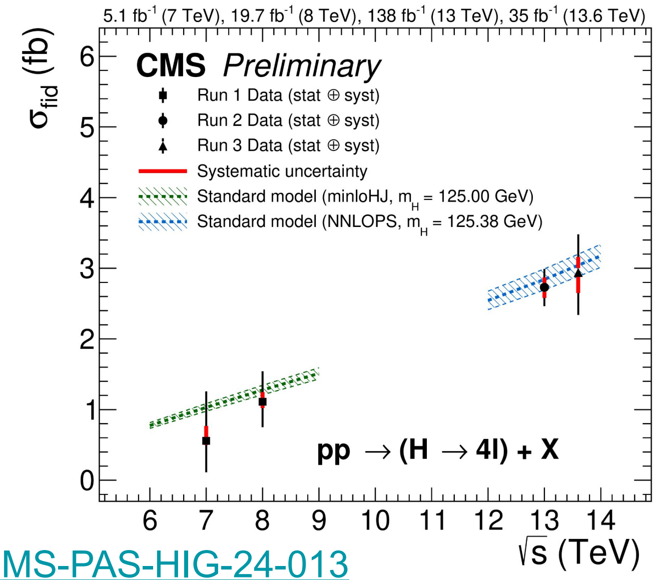


CMS: limits on kappa_c < 38.1 obs (72.5 exp)
ATLAS: H+c cross-section < 10.4 pb at 95% CL

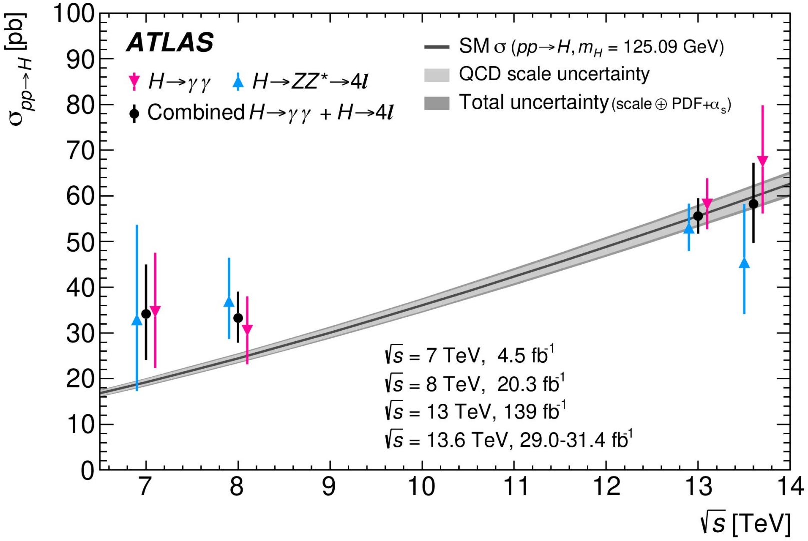
More on this topic in the first talks of the WG1 parallel session!

ggF Cross-Sections at 13.6 TeV

- First results with data at 13.6 TeV already available both from ATLAS and CMS
  - For now using ad interim prescriptions from LHCHWG: arXiv:2402.09955
  - Future analyses will need more precise predictions



CMS-PAS-HIG-24-013



Eur. Phys. J. C 84 (2024) 78

ggF Cross-Sections at 13.6 TeV

- Goal: update cross-section prediction for new COM energy, with theory developments of the last several years.
- Numbers will be included in YR 5
  - Feature updates on next slides
  - Will summarize status and approach after.

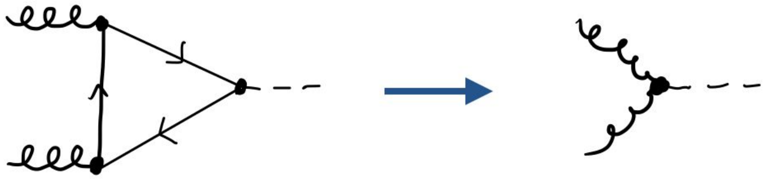
Stephen's summary

Progress

$\delta(1/m_t)$: Now known to NNLO	Czakon, Eschment, Niggetiedt, Poncelet, Schellenberger 24 Czakon, Niggetiedt 20; Czakon, Harlander, Klappert, Niggetiedt 21
$\delta(t, b, c)$: Now known to NNLO	Niggetiedt, Usovitsch 23 Czakon, Eschment, Niggetiedt, Poncelet, Schellenberger 23
$\delta(\mathrm{EW})$: gg known, unc. 1%	Becchetti, Bonciani, Del Duca, Hirschi, Moriello, Schweitzer 20; + Bonetti, Panzer, Smirnov, Tancredi, Melnikov, …
$\delta(\mathrm{PDF-TH})$: Progress but uncertainty persists	McGowan, Cridge, Harland-Lang, Thorne 22; NNPDF 24
$\delta(\mathrm{scale})$: Some ingredients known	Lee, von Manteuffel, Schabinger, Smirnov, Smirnov, Steinhauser 22

Quark Mass Effects

- ggF calculation made extra challenging by presence of massive quarks in the loop.
  - Calculations usually performed in heavy top limit → integrate out the top quark, decrease number of loops.



ggF xsec known to N3LO in heavy top limit!

- Recent theory improvements:
  - Top mass dependence up to NNLO
  - Top x bottom mass dependence in interference up to NNLO

NNLO with Top Mass Dependence

- Top mass dependence at NNLO included since last year.

channel	$\sigma^{\text{NNLO}}_{\text{HEFT}}$ [pb] $\mathcal{O}(\alpha_s^2)$	$+\mathcal{O}(\alpha_s^3)$	$+\mathcal{O}(\alpha_s^4)$	$\left(\sigma^{\text{NNLO}}_{\text{exact}} - \sigma^{\text{NNLO}}_{\text{HEFT}}\right)$ [pb] $\mathcal{O}(\alpha_s^3)$	$\mathcal{O}(\alpha_s^4)$
$\sqrt{s} = 13$ TeV					
gg	+15.966	+19.295(3)	+8.574(13)	+0.0280	+0.2409(7)
qg		+1.483(2)	+0.831(6)	−0.3705	−0.0416(5)
qq		+0.024(1)	+0.101(1)	+0.0317	−0.0505(1)
total	+15.966	+20.802(4)	+9.506(14)	−0.3108	+0.1488(9)
$\sqrt{s} = 13.6$ TeV					
gg	+17.110	+20.754(3)	+9.216(13)	+0.0238	+0.2644(6)
qg		+1.613(2)	+0.916(6)	−0.4034	−0.0459(5)
qq		+0.026	+0.109(1)	+0.0335(1)	−0.0551(1)
total	+17.110	+22.394(4)	+10.241(15)	−0.346	+0.1634(8)

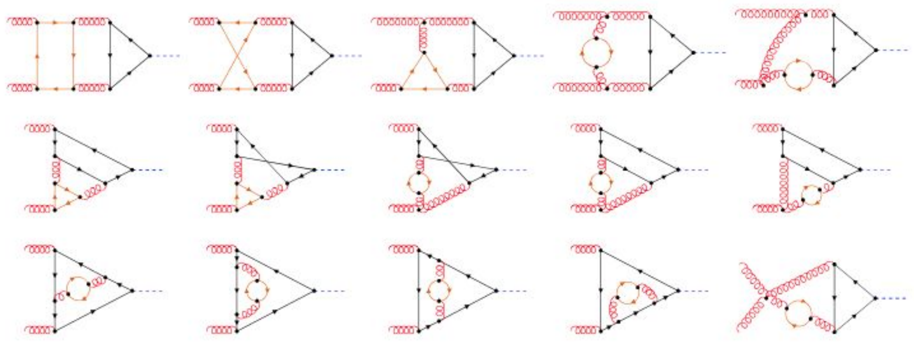
Czakon, Niggetiedt 20;
Czakon, Harlander, Klappert, Niggetiedt 21

- Dependence on renormalization scale for Yukawa: results previously only available in pole mass scheme, but as **of this year** also in MSbar scheme → can be incorporated in ggF xsec update!

NNLO with b,c Mass Dependence

- Top-bottom interference included up to NNLO (remaining effects of bottom and charm mass still at NLO).

Niggetiedt, Usovitsch 23



Quarks in loop 1 and loop 2 can have different masses.

Czakon, Eschment, Niggetiedt, Poncelet, Schellenberger 23

- Results in MSbar scheme → can be incorporated in ggF xsec update!
  - Sensitive to choice of renormalization scheme.

NNLO with b,c Mass Dependence

- Accounting for top-bottom interference decreases cross-section by ~4% at NNLO compared to heavy top limit.
  - Effect very stable on moving from NLO (also 4%) to NNLO.

Interference contribution:

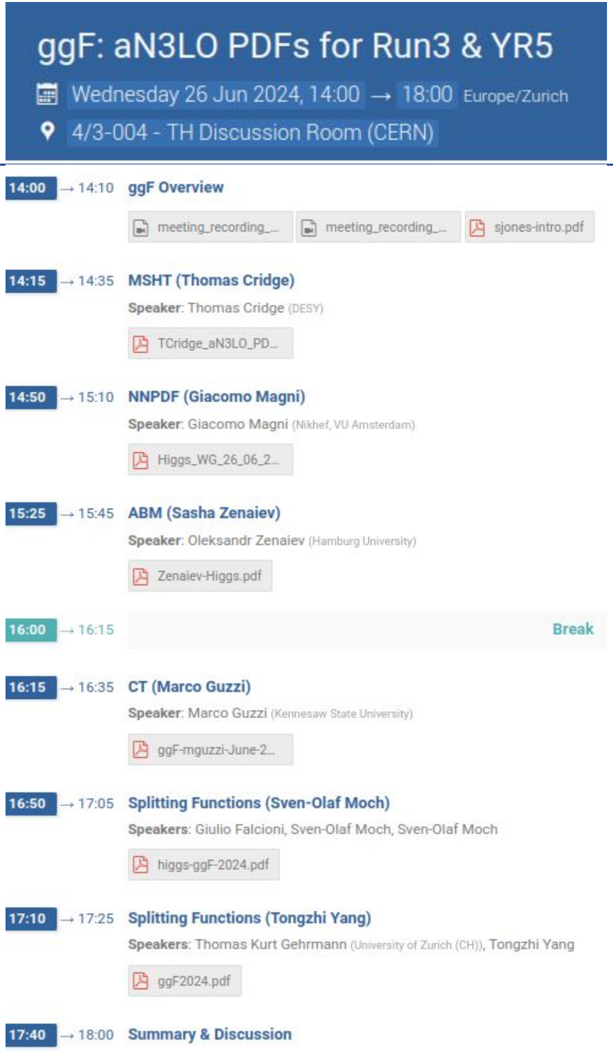
	7 TeV	8 TeV	13 TeV	13.6 TeV	14 TeV
LO	$-0.39^{+0.10}_{-0.15}$ pb	$-0.50^{+0.12}_{-0.19}$ pb	$-1.09^{+0.27}_{-0.42}$ pb	$-1.17^{+0.29}_{-0.45}$ pb	$-1.22^{+0.31}_{-0.47}$ pb
NLO	$-0.66^{+0.11}_{-0.12}$ pb	$-0.82^{+0.13}_{-0.14}$ pb	$-1.72^{+0.26}_{-0.27}$ pb	$-1.84^{+0.28}_{-0.29}$ pb	$-1.91^{+0.29}_{-0.30}$ pb
NNLO	$-0.68^{+0.06}_{-0.02}$ pb	$-0.84^{+0.07}_{-0.01}$ pb	$-1.70^{+0.13}_{-0.01}$ pb	$-1.80^{+0.13}_{-0.01}$ pb	$-1.88^{+0.13}_{-0.01}$ pb

Czakon, Eschment, Niggetiedt, Poncelet, Schellenberger 23

- From experiments: Predictions for finite quark mass effects, differential in pTH, useful for (kt/kb/kc diff xsec interpretations).

aN3LO PDFs

- [Dedicated ggF WG1 meeting] in June
  → Status: NNPDF and MSHT have produced aN3LO PDFs, CT supports full PDF4LHC combo only later. (See PDF talk this week!)


ggF: aN3LO PDFs for Run3 & YR5

Wednesday 26 Jun 2024, 14:00 → 18:00 Europe/Zurich
4/3-004 - TH Discussion Room (CERN)

14:00 → 14:10 **ggF Overview**
meeting_recording_... meeting_recording_... sjones-intro.pdf

14:15 → 14:35 **MSHT (Thomas Cridge)**
Speaker: Thomas Cridge (DESY)
TCridge_aN3LO_PD...

14:50 → 15:10 **NNPDF (Giacomo Magni)**
Speaker: Giacomo Magni (Nikhef, VU Amsterdam)
Higgs_WG_26_06_2...

15:25 → 15:45 **ABM (Sasha Zenaiev)**
Speaker: Oleksandr Zenaiev (Hamburg University)
Zenaiev-Higgs.pdf

16:00 → 16:15 Break

16:15 → 16:35 **CT (Marco Guzzi)**
Speaker: Marco Guzzi (Kennesaw State University)
ggF-mguzzi-June-2...

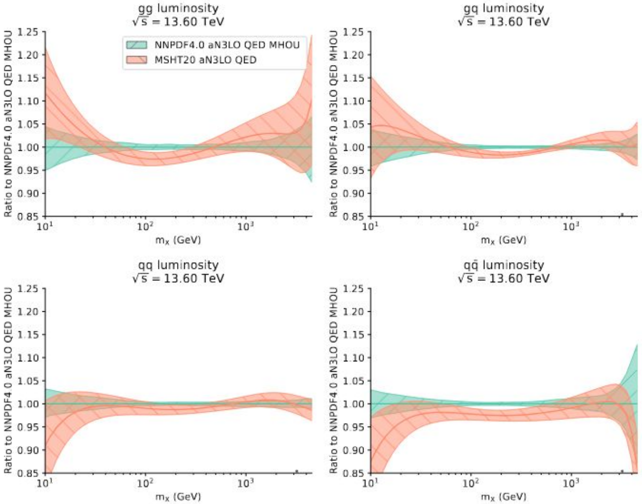
16:50 → 17:05 **Splitting Functions (Sven-Olaf Moch)**
Speakers: Giulio Falcioni, Sven-Olaf Moch, Sven-Olaf Moch
higgs-ggF-2024.pdf

17:10 → 17:25 **Splitting Functions (Tongzhi Yang)**
Speakers: Thomas Kurt Gehrmann (University of Zurich (CH)), Tongzhi Yang
ggF2024.pdf

17:40 → 18:00 **Summary & Discussion**

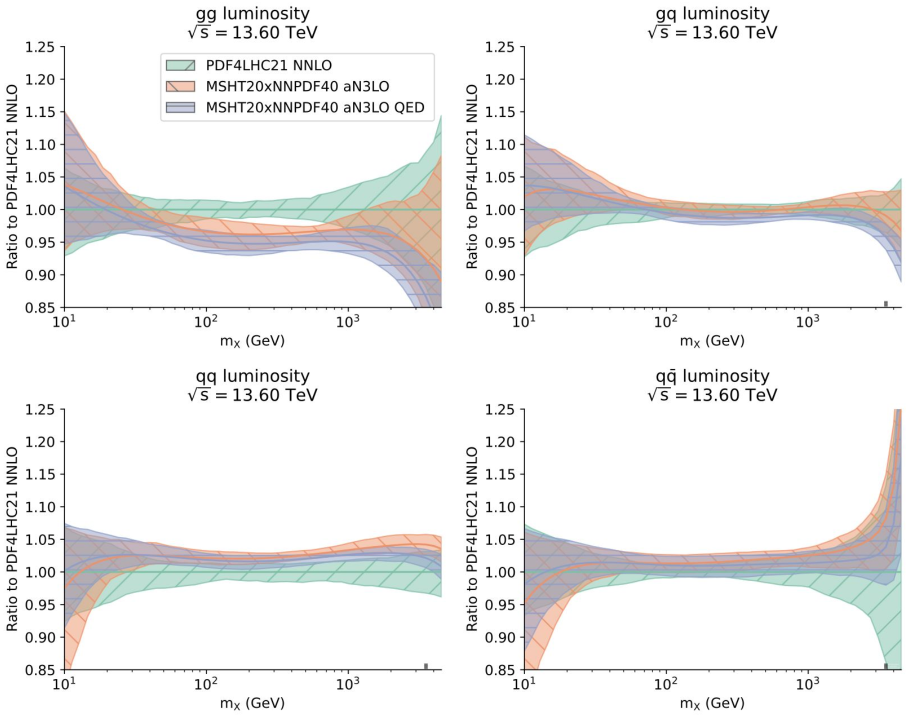
NNPDF: 2402.18635 MSHT: 2207.04739

aN3LO PDFs (incl. QED effects) normalized to NNPDF set.



aN3LO PDFs

After the dedicated meeting, NNPDF and MSHT performed **combination** of their aN3LO PDFs according to PDF4LHC methods:



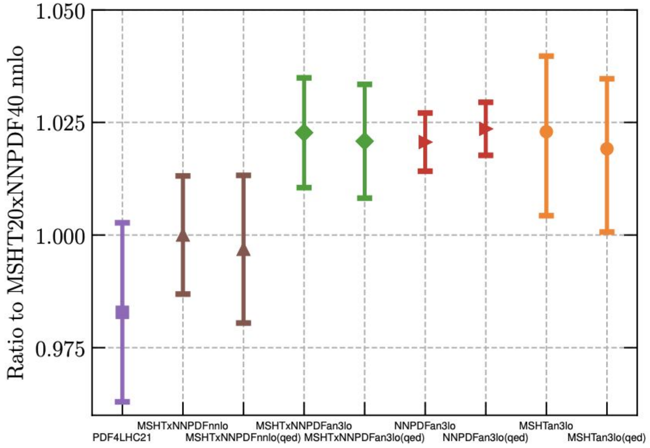
Combined aN3LO pure QCD and QCD+QED sets, shown as a ratio to NNLO.

Combination published in 2411.05373, planned as YR5 submission.

aN3LO PDFs

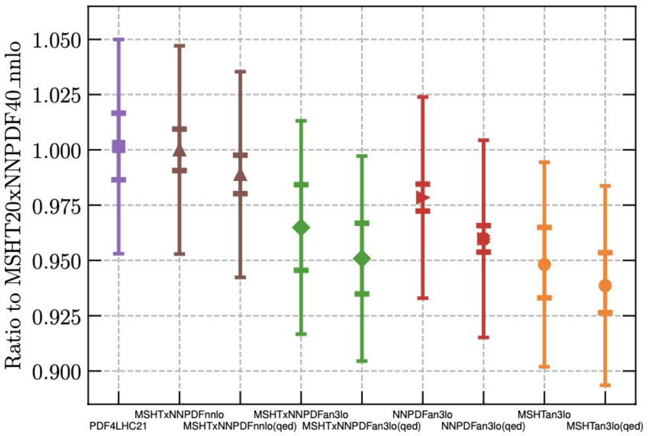
aN3LO PDFs have a sizeable effect on the Higgs production cross-section, especially in VBF and ggF:

VBF



NNLO N3LO

ggF



NNLO N3LO

- Lower ggF xsec by ~3% → previously underestimated PDF-TH uncertainty on ggF xsec? (Was 1.18%, from comparison with PDF4LHC15)

N4LO Cross-Sections with Soft-Virtual Approx

- Work done toward N4LO Higgs production.
  - Matrix elements computed in soft-virtual approximation (assuming additional radiation is soft).

Moch and Das, based on 2004.00563

1.1 Case-I: $\alpha_S^c(m_Z)$ = From LHAPDF (default value)

	N3LO (δ in %)				N4LOsv (δ in %)			
PDF Name	Central	δ(N3LO)	δ(Scale)	δ(PDF)	Central	δ(N4LO)	δ(Scale)	δ(PDF)
ABMP16_5_nnlo [2]	48.8	3.3	$^{+0.2}_{-3.6}$	$^{+1.7}_{-1.7}$	48.7	-0.1	$^{+0.5}_{-2.1}$	$^{+1.7}_{-1.7}$
ABMPtt_5_nnlo [3]	48.4	3.3	$^{+0.2}_{-3.6}$	$^{+1.5}_{-1.5}$	48.4	-0.1	$^{+0.5}_{-2.1}$	$^{+1.5}_{-1.5}$
CT18NNLO [4]	51.3	3.5	$^{+0.3}_{-3.9}$	$^{+2.8}_{-3.6}$	51.3	-0.1	$^{+0.5}_{-2.3}$	$^{+2.8}_{-3.6}$
MSHT20nnlo_as118 [5]	51.4	3.5	$^{+0.3}_{-3.9}$	$^{+1.2}_{-1.2}$	51.3	-0.1	$^{+0.5}_{-2.3}$	$^{+1.2}_{-1.2}$
NNPDF40_nnlo_as_01180 [6]	51.7	3.5	$^{+0.3}_{-3.9}$	$^{+0.6}_{-0.6}$	51.7	-0.1	$^{+0.5}_{-2.3}$	$^{+0.6}_{-0.6}$
PDF4LHC21_40 [7]	51.6	3.5	$^{+0.3}_{-3.9}$	$^{+0.6}_{-0.6}$	51.5	-0.1	$^{+0.5}_{-2.3}$	$^{+0.6}_{-0.6}$
MSHT20an3lo_as118 [8]	48.7	3.5	$^{+0.3}_{-3.9}$	$^{+1.9}_{-1.7}$	48.7	-0.1	$^{+0.5}_{-2.3}$	$^{+1.9}_{-1.7}$
NNPDF40_an3lo_as_01180 [9]	50.6	3.5	$^{+0.3}_{-3.9}$	$^{+0.6}_{-0.6}$	50.6	-0.1	$^{+0.5}_{-2.3}$	$^{+0.6}_{-0.6}$

Table 1: Higgs cross-section along with the absolute error obtained from seven-point scale variation around $(\mu_R^c, \mu_F^c) = (1/2, 1/2)m_H$ as well as intrinsic PDF uncertainty using LHAPDF. $\sqrt{S} = 13.6$ TeV, α_S from LHAPDF (NNLO value).

N4LO affects size of xsec prediction (-0.1% with muR=mH/2) and scale uncertainty (~3% compared to ~4% at NNLO).

3-Loop Heavy Flavour Corrections

- Heavy flavour quark contributions to PDFs have to be accounted for in PDF fits
  - Input to aN3LO PDFs
- New work from Johannes Bluemlein et al. accounts for massive 3-loop corrections in PDF fits

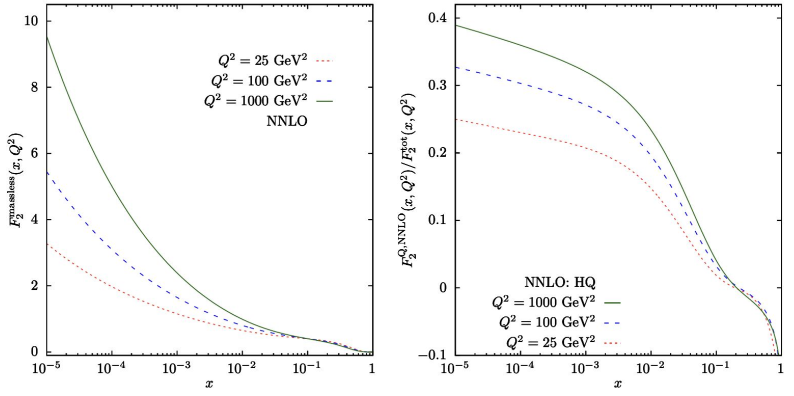


Figure 1: Left panel: the massless contributions to the structure function $F_2(x, Q^2)$ at NNLO using the PDFs of Ref. [42]. Right panel: The ratio of the NNLO single-mass charm and bottom contributions to $F_2(x, Q^2)$ to its total value. Dotted lines: $Q^2 = 25$ GeV^2; dashed lines: $Q^2 = 100$ GeV^2; full lines: $Q^2 = 10000$ GeV^2; from Ref. [41].

Putting it all together: Status of 13.6 TeV xsec update

- Partonic cross-section decomposed:

$$\sigma_{ij} = \mathrm{R_{LO}} C^2 \left(\sigma_{ij}^{\mathrm{LO,HTL}} + \sigma_{ij}^{\mathrm{NLO,HTL}} + \sigma_{ij}^{\mathrm{NNLO,HTL}} + \sigma_{ij}^{\mathrm{N^3LO,HTL}} \right) + \delta\sigma_{ij}^{\mathrm{LO},(t,b,c)} + \delta\sigma_{ij}^{\mathrm{NLO},(t,b,c)} + \delta\sigma_{ij}^{\mathrm{NNLO},(t,b,c)}$$

accounts for top mass effects at LO

xsec in heavy top limit

corrections for massive quarks

- Dependence on t, b, c quark masses:

$$\delta\sigma_{ij}^{\mathrm{LO},(t,b,c)} = \sigma_{ij}^{\mathrm{LO},(t,b,c)} - \left[C_{\mathrm{QCD}}^2 R_{\mathrm{LO}} \sigma_{ij}^{\mathrm{HTL}} \right]_{\alpha_s^2},$$

$$\delta\sigma_{ij}^{\mathrm{NLO},(t,b,c)} = \sigma_{ij}^{\mathrm{NLO},(t,b,c)} - \left[C_{\mathrm{QCD}}^2 R_{\mathrm{LO}} \sigma_{ij}^{\mathrm{HTL}} \right]_{\alpha_s^3},$$

$$\delta\sigma_{ij}^{\mathrm{NNLO},(t,b,c)} = \sigma_{ij}^{\mathrm{NNLO},(t,b,c)} - \left[C_{\mathrm{QCD}}^2 R_{\mathrm{LO}} \sigma_{ij}^{\mathrm{HTL}} \right]_{\alpha_s^4},$$

- With each term decomposed as:

$$\sigma_{ij}^{\mathrm{N^nNLO},(t,b,c)} = \sigma_{ij}^{\mathrm{N^nNLO},(t)} + \sigma_{ij}^{\mathrm{N^nNLO},(b)} + \sigma_{ij}^{\mathrm{N^nNLO},(c)} + \sigma_{ij}^{\mathrm{N^nNLO},(t\times b)} + \sigma_{ij}^{\mathrm{N^nNLO},(t\times c)} + \sigma_{ij}^{\mathrm{N^nNLO},(b\times c)}.$$

known to NNLO

known to NLO

Putting it all together: Status of 13.6 TeV xsec update

- Exact dependence on massive t, and b/t interference, only available for mH=125.09 GeV → extrapolate to other masses:

$$R_n^H(m_H) = \frac{\left[C_{\mathrm{QCD}}^2 R_{\mathrm{LO}} \sigma_{ij}^{\mathrm{HTL}}\right]_{\alpha_s^n}(m_H)}{\left[C_{\mathrm{QCD}}^2 R_{\mathrm{LO}} \sigma_{ij}^{\mathrm{HTL}}\right]_{\alpha_s^n}(m_H^{\mathrm{ref}})},$$

$$\delta\sigma_{ij}^{\mathrm{NNLO},(t),\mathrm{ext}}(m_H) = R_4^H(m_H)\ \delta\sigma_{ij}^{\mathrm{NNLO},(t)}(m_H^{\mathrm{ref}}),$$

$$\delta\sigma_{ij}^{\mathrm{NNLO},(t\times b),\mathrm{ext}}(m_H) = R_4^H(m_H)\ \delta\sigma_{ij}^{\mathrm{NNLO},(t\times b)}(m_H^{\mathrm{ref}}),$$

Conservative uncertainties assigned on the extrapolation, and on the scheme (MSbar vs OS)

- Lots of room for discussion: handling of PDF.
  - Use PDF4LHC21 right now → all inputs produced using this.
  - aN3LO PDFs induce large correction (or large uncertainty): ~-4%.
  - QED evolution effects have also been included in aN3LO PDFs: ~-1%

Putting it all together: Status of 13.6 TeV xsec update

- Current numbers produced at all Higgs mass points and COM energies:

$\sqrt{s}$ [TeV]	M_H [GeV]	σ [pb]	δ(scale)	δ(EWK)	$\delta^{\text{sch.}}(m_t)$	$\delta^{\text{ext.}}$(t)	$\delta^{\text{ext.}}$(t × b)	δ(theory)	δ(PDF + α_s)	δ(PDF)	$\delta(\alpha_s)$	δ^{old}(PDF-TH)
13.6	120.00	53.89	$^{+0.56}_{-3.32}\%$	±1.00%	±0.12%	±0.03%	±0.03%	$^{+1.74}_{-4.50}\%$	$^{+2.68}_{-2.27}\%$	$^{+1.65}_{+1.65}\%$	$^{+2.12}_{-1.57}\%$	±1.21%
13.6	122.00	52.37	$^{+0.56}_{-3.31}\%$	±1.00%	±0.17%	±0.02%	±0.02%	$^{+1.77}_{-4.52}\%$	$^{+2.68}_{-2.27}\%$	$^{+1.65}_{+1.65}\%$	$^{+2.11}_{-1.56}\%$	±1.20%
13.6	124.00	50.91	$^{+0.56}_{-3.31}\%$	±1.00%	±0.16%	±0.01%	±0.00%	$^{+1.72}_{-4.47}\%$	$^{+2.68}_{-2.26}\%$	$^{+1.64}_{+1.64}\%$	$^{+2.11}_{-1.56}\%$	±1.18%
13.6	124.60	50.49	$^{+0.56}_{-3.31}\%$	±1.00%	±0.15%	±0.00%	±0.00%	$^{+1.71}_{-4.46}\%$	$^{+2.67}_{-2.26}\%$	$^{+1.64}_{+1.64}\%$	$^{+2.11}_{-1.56}\%$	±1.18%
13.6	124.80	50.35	$^{+0.56}_{-3.31}\%$	±1.00%	±0.15%	±0.00%	±0.00%	$^{+1.71}_{-4.46}\%$	$^{+2.67}_{-2.26}\%$	$^{+1.64}_{+1.64}\%$	$^{+2.11}_{-1.55}\%$	±1.18%
13.6	125.00	50.21	$^{+0.56}_{-3.31}\%$	±1.00%	±0.15%	±0.00%	±0.00%	$^{+1.70}_{-4.45}\%$	$^{+2.67}_{-2.26}\%$	$^{+1.64}_{+1.64}\%$	$^{+2.11}_{-1.55}\%$	±1.18%
13.6	125.09	50.14	$^{+0.56}_{-3.31}\%$	±1.00%	±0.15%	±0.00%	±0.00%	$^{+1.70}_{-4.45}\%$	$^{+2.67}_{-2.26}\%$	$^{+1.64}_{+1.64}\%$	$^{+2.11}_{-1.55}\%$	±1.18%
13.6	125.20	50.07	$^{+0.56}_{-3.31}\%$	±1.00%	±0.14%	±0.00%	±0.00%	$^{+1.70}_{-4.45}\%$	$^{+2.67}_{-2.26}\%$	$^{+1.64}_{+1.64}\%$	$^{+2.11}_{-1.55}\%$	±1.18%
13.6	125.30	50.00	$^{+0.56}_{-3.30}\%$	±1.00%	±0.14%	±0.00%	±0.00%	$^{+1.70}_{-4.44}\%$	$^{+2.67}_{-2.26}\%$	$^{+1.64}_{+1.64}\%$	$^{+2.11}_{-1.55}\%$	±1.18%
13.6	125.38	49.94	$^{+0.56}_{-3.30}\%$	±1.00%	±0.14%	±0.00%	±0.00%	$^{+1.70}_{-4.45}\%$	$^{+2.67}_{-2.26}\%$	$^{+1.64}_{+1.64}\%$	$^{+2.11}_{-1.55}\%$	±1.18%
13.6	125.60	49.79	$^{+0.55}_{-3.30}\%$	±1.00%	±0.14%	±0.00%	±0.00%	$^{+1.70}_{-4.45}\%$	$^{+2.67}_{-2.26}\%$	$^{+1.64}_{+1.64}\%$	$^{+2.11}_{-1.55}\%$	±1.17%
13.6	126.00	49.52	$^{+0.55}_{-3.30}\%$	±1.00%	±0.14%	±0.00%	±0.01%	$^{+1.70}_{-4.45}\%$	$^{+2.67}_{-2.26}\%$	$^{+1.64}_{+1.64}\%$	$^{+2.11}_{-1.55}\%$	±1.17%
13.6	128.00	48.18	$^{+0.55}_{-3.29}\%$	±1.00%	±0.13%	±0.02%	±0.02%	$^{+1.72}_{-4.46}\%$	$^{+2.67}_{-2.26}\%$	$^{+1.64}_{+1.64}\%$	$^{+2.10}_{-1.55}\%$	±1.16%
13.6	130.00	46.89	$^{+0.55}_{-3.28}\%$	±1.00%	±0.13%	±0.03%	±0.04%	$^{+1.74}_{-4.48}\%$	$^{+2.67}_{-2.25}\%$	$^{+1.64}_{+1.64}\%$	$^{+2.10}_{-1.54}\%$	±1.15%

Central value

Sources of uncertainty

Sum of previous 5 columns

PDF+aS unc.

Old unc. from ½ (NNLO-NLO) PDF → next slide

Putting it all together: Status of 13.6 TeV xsec update

- Can compare size of PDF uncertainty/correction from multiple approaches:

$$\Delta(\text{aN3LO}) = \sigma(\text{MSHTxNNPDF\_aN3LO}) - \sigma(\text{PDF4LHC21})$$

$$\Delta(\text{QED}^{\text{NNLO}}) = \frac{\sigma(\text{MSHTxNNPDF\_NNLO\_qed}) - \sigma(\text{MSHTxNNPDF\_NNLO})}{\sigma(\text{MSHTxNNPDF\_NNLO})}$$

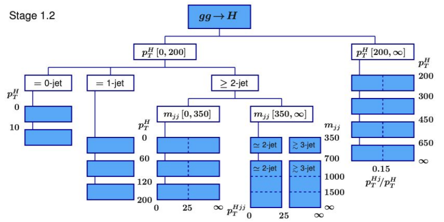
$$\Delta(\text{QED}^{\text{aN3LO}}) = \frac{\sigma(\text{MSHTxNNPDF\_aN3LO\_qed}) - \sigma(\text{MSHTxNNPDF\_aN3LO})}{\sigma(\text{MSHTxNNPDF\_aN3LO})}$$

$\Delta(\text{aN3LO})$ [pb]	$\Delta(\text{QED}^{\text{NNLO}})$	$\Delta(\text{QED}^{\text{aN3LO}})$
$-2.16 = -3.80\%$	-1.10%	-1.45%
$-2.11 = -3.82\%$	-1.10%	-1.45%
$-2.05 = -3.83\%$	-1.11%	-1.46%
$-2.04 = -3.83\%$	-1.11%	-1.46%
$-2.03 = -3.83\%$	-1.11%	-1.46%
$-2.03 = -3.83\%$	-1.12%	-1.46%
$-2.03 = -3.84\%$	-1.12%	-1.46%

Large effects compared to other uncertainties (previous slide)

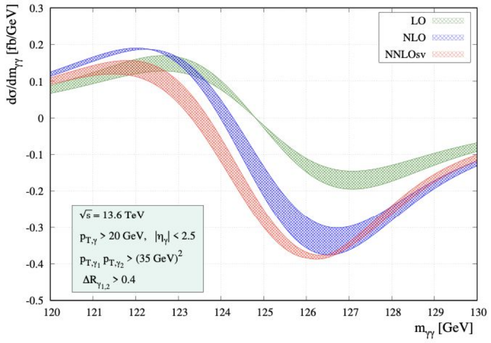
Other Ongoing or Possible Topics

- Boosted Higgs predictions (dedicated WG1 meeting):
  - Update precise predictions in YR5
  - Lots of open topics: PS uncertainty, EW correction, mass scheme uncertainties….
- STXS Stage 1.3 scheme (in coordination with WG2)
  - Plan cross-experiment responsibility for uncertainty scheme



- Signal-background interference effects in ggH diphoton
  - Computation of interference at NNLO
- At this workshop: ggH+cc and ggH+bb (as bkg to HH and H+c searches).
- Your suggestion?

Bargiela, Caola, von Manteuffel, Tancredi 21; Buccioni, Devoto 22; and Buccioni, Devoto, Djouadi, Ellis, Quevillon, Tancredi 23



Conclusion

- Lots of ongoing activities ahead of the YR5 update.
- Please get in touch if you'd like to see what you're working on featured there!

To reach convenors: lhc-higgs-ggf-convener@cern.ch
To follow subgroup activities, subscribe to: lhc-higgs-ggf@cern.ch

Thanks for your attention.