Recent developments in Higgs precision calculations

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What's new in Higgs predictions?

... give me more time and it's not just gluon fusion!

- Fixed order results NNNLO
- Resummation at NNNLL, multiple limits
- Top, bottom mass effects at NLO
- Electroweak effects
The low hanging fruits are gone..
High fruits #1: $N^3LO$ Higgs inclusive in EFT

Mistlberger '18; Anastasiou, Duhr, Dulat, Herzog, Mistlberger '15
High fruits #2: Inclusive joint resummation

*threshold and high energy*

\[
\sqrt{s} = 13 \text{ TeV}
\]

\[m_H = 125 \text{ GeV}\]

\[\mu_F = \mu_R = m_H/2\]

\[\sigma \text{ [pb]}\]

Bonvini, Marzani ’18
High fruits #3: pT resummation

$\text{NNLOJET@SCET} \quad p p \rightarrow H + \geq 0 \text{ jet} \quad m_{H}=125 \text{ GeV} \quad \sqrt{s}=13 \text{ TeV}$

PDF4LHC15
Scale Profile
variation of 66 combinations

1805.00736

$\frac{d\sigma}{dp_T} [\text{pb}/\text{GeV}]$

$\frac{\text{Ratio to NNLO@N3LL}}{\text{p}_T [\text{GeV}]}$

Chen, Gehrmann, Glover, Huss, Li, Neill, Schulze, Stewart, Zhu '18
see also Bizon, Chen, Gehrmann-De Ridder, Gehrmann, Glover, Huss, Monni, Re, Rottoli, Torrielli '18
Further fruits..

QCD corrections to $QCD \times EW: \approx 5\%$

*Bonetti, Melnikov, Tancredi ’18*

Towards single differential Higgs at $N^3$ LO:

- analytic differential NNLO
  *Dulat, Lionetti, Mistlberger, Pelloni, Specchia ’17*
- analytic differential $N^3$ LO, threshold expansion
  *Dulat, Mistlberger, Pelloni ’17*
- classification of elliptic integrals
  *Broedel, Duhr, Dulat, Penante, Tancredi ’18*
Progress in Higgs+jet

NNLO EFT result known, scale uncertainty ~5%

Chen, Gehrmann, Glover, Jaquier ’14;
Boughezal, Caola, Melnikov, Petriello, Schulze ’13, ’15; Boughezal, Focke, Giele, Liu, Petriello ’15

recent study discussing low $p_T$: tb-interference, $p_T$ resum.

Caola, Lindert, Melnikov, Monni, Tancredi, Wever ’18
High energy: Uncertainty due to EFT approx.

- Inclusion of exact real emission, jet merging
  *Frederix, Frixione, Vryonidou, Wiesemann ’16*
- Inclusion of exact real emission, 1/mt-expansion
  *Williams, TN ’17*

Region of high $p_T$ is highly relevant now for analyses: CMS $H \to b\bar{b}$ in highly boosted regime $p_T \geq 450$ GeV (1709.05543)
High energy expansion

Approximation of two-loop virt.
- high
- low $1/m_t^4$
- EFT
- EFT rescaled
- low $1/m_t^2$

TN ’18; see also Lindert, Kudashkin, Melnikov, Weaver ’18
**Full top quark mass dependence**

Evaluating $\mathcal{O}(100)$ master integrals using sector decomposition

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*Jones, Kerner, Luisoni '18*
Summary

Amazing progress in gluon fusion Higgs and Higgs+jet!

- For H+2jet, VBF, VH, HH, ttH, etc. see e.g. 1803.07977

  $3000 \, fb^{-1}$ LHC will reduce uncertainties
  ~3% (incl.) and ~10% (excl.)

- Inclusive: $N^3$LO in EFT, EW effects, mass effects, thres. resummation (iHixs, SusHi, ..)

- Higgs+jet: NNLO in EFT (no public code?), NLO t/b effects, NLO full top! (MCFM, ..?)

Highest hanging fruits: Combine as many things as possible and reliably assess uncertainties!