Discussion: Uncertainties for Signal cross sections

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IPA Workshop, December 2, 2019

Goal of the workshop

- Collect/address open questions raised in the process of the preparation of the EPPSU and related to precision physics at the LHC

- Reevaluate precision reach of HL-LHC

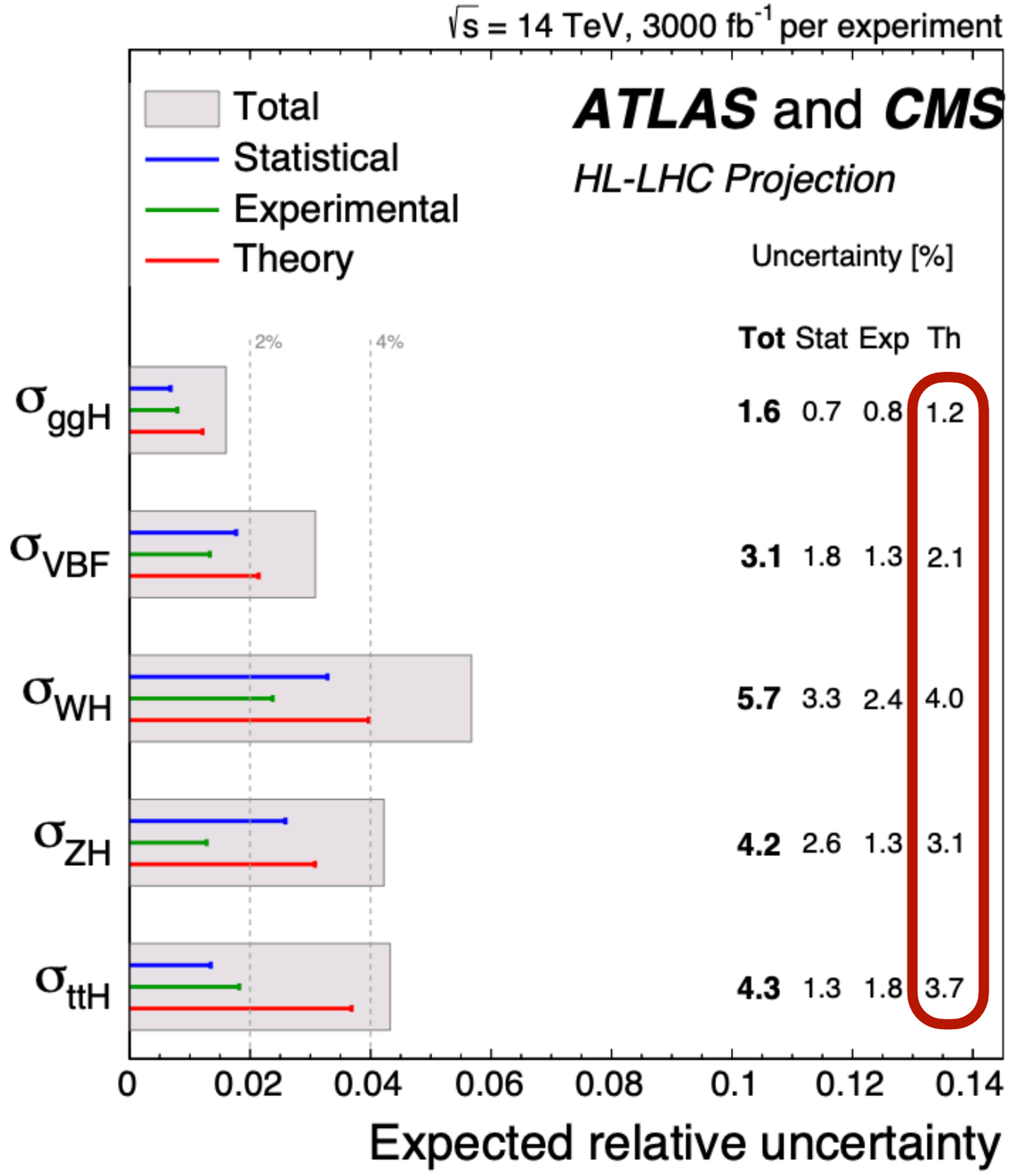
Expected uncertainties

"Optimistic scenario" S2:

- TH Uncertainties halved
- Linear combination replaced by combination in quadrature (ggF)

HL-HE YR (2019)

Very ambitious: is it realistic ?

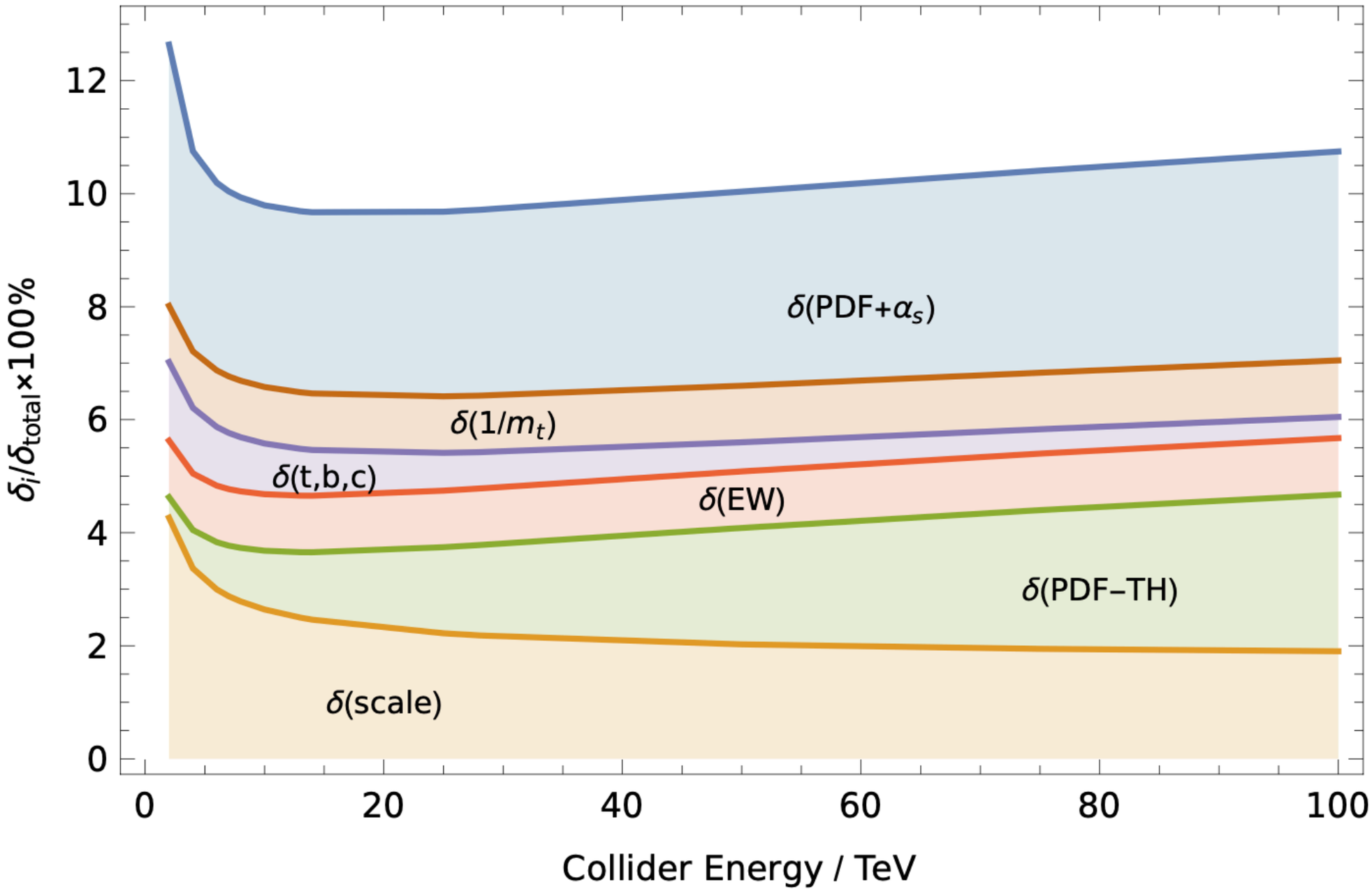


Current status: ggF

$\sqrt{s}$	σ	δ(theory)		δ(PDF)	$\delta(\alpha_s)$	
13 TeV	48.61 pb	$^{+2.08\text{pb}}_{-3.15\text{pb}}$	$\left(^{+4.27\%}_{-6.49\%}\right)$	± 0.89 pb ($\pm 1.85\%$)	$^{+1.24\text{pb}}_{-1.26\text{pb}}$	$\left(^{+2.59\%}_{-2.62\%}\right)$
14 TeV	54.72 pb	$^{+2.35\text{pb}}_{-3.54\text{pb}}$	$\left(^{+4.28\%}_{-6.46\%}\right)$	± 1.00 pb ($\pm 1.85\%$)	$^{+1.40\text{pb}}_{-1.41\text{pb}}$	$\left(^{+2.60\%}_{-2.62\%}\right)$
27 TeV	146.65 pb	$^{+6.65\text{pb}}_{-9.44\text{pb}}$	$\left(^{+4.53\%}_{-6.43\%}\right)$	± 2.81 pb ($\pm 1.95\%$)	$^{+3.88\text{pb}}_{-3.82\text{pb}}$	$\left(^{+2.69\%}_{-2.64\%}\right)$

Linear combination of several sources of uncertainties

Current status: ggF



Current status: ggF

Anastasiou et al. (2016)
HXSWG YR4
HL-HE YR

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$\alpha_S(m_Z) = 0.118 \pm 0.0015$ (PDF4LHC15 and YR4)

$\alpha_S(m_Z) = 0.1181 \pm 0.0011$ (PDG2018)

Roughly speaking: relative impact of α_S uncertainty doubled in the Higgs cross section

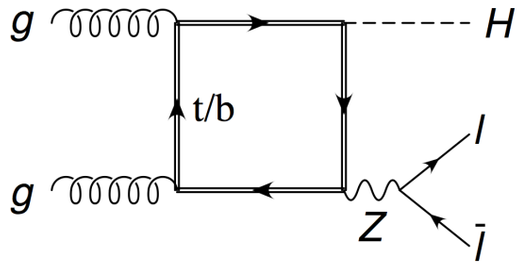
To achieve O(0.6%) precision in σ we need O(0.3%) precision on α_S !

Other channels: possible improvements

- VBF: Current theory uncertainties at the per mille level but using structure function approach

  → computation of non factorised terms at NNLO

- VH: $gg \to ZH$ with full mass dependence



- ttH: signal cross section known with O(10%) uncertainties

  → NNLO needed at some point

Comments

- To reach the control of theory systematics anticipated in Scenario S2 just computing one more perturbative order will not be enough !
- A major step forward is required in

- PDFs

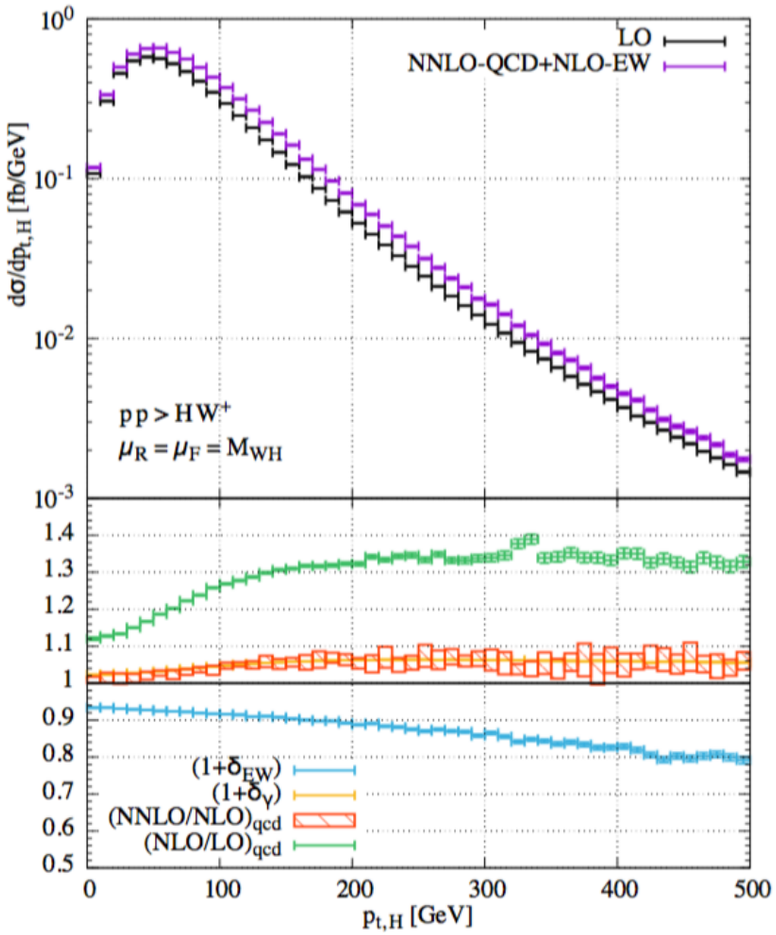
- QCD coupling α_S

- Th/Exp cross talk

- Correlations

- Monte Carlo generators (Logarithmic accuracy, Merging matching…)

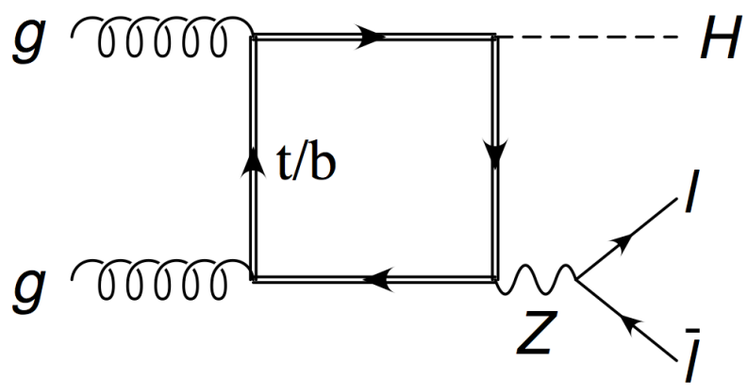
NLO: gg→ZH



S.Dittmaier et al. HXSWG YR4 (2016)

Despite highly accurate NNLO QCD+NLO-EW predictions still ZH not fully under control

gg induced loop contribution (first appears at NNLO and leads to large uncertainties !)



Impact of gg → ZH

σ (fb)	NLO	NNLO (DY-like)	NNLO
LHC8	$0.2820^{+2\%}_{-2\%}$	$0.2574^{+3\%}_{-4\%}$	$0.3112^{+3\%}_{-2\%}$
LHC14	$0.2130^{+10\%}_{-12\%}$	$0.1770^{+7\%}_{-6\%}$	$0.2496^{+5\%}_{-2\%}$

+21%

+41%

Very important in the boosted region

NLO corrections known only in large m_t limit (~100%)

Altenkamp et al. (2012)