

# LHeC white paper section III (4 pages)

Claire, Maarten

- Reminder of PDF improvements (in numbers, refer to plots in section II)
  - Assume PDFs discussed in Section II
- Impact on HL-LHC measurements (mostly from CDR update)
  - Higgs couplings and cross sections
  - Electroweak :  $\sin^2\theta_{\text{eff}}$ ,  $m_W$ , oblique parameters
    - New context
  - Searches
- Impact on future programmes?
  - There exists literature on FCC-eh physics per se, but no on its feedback on future hadron programs

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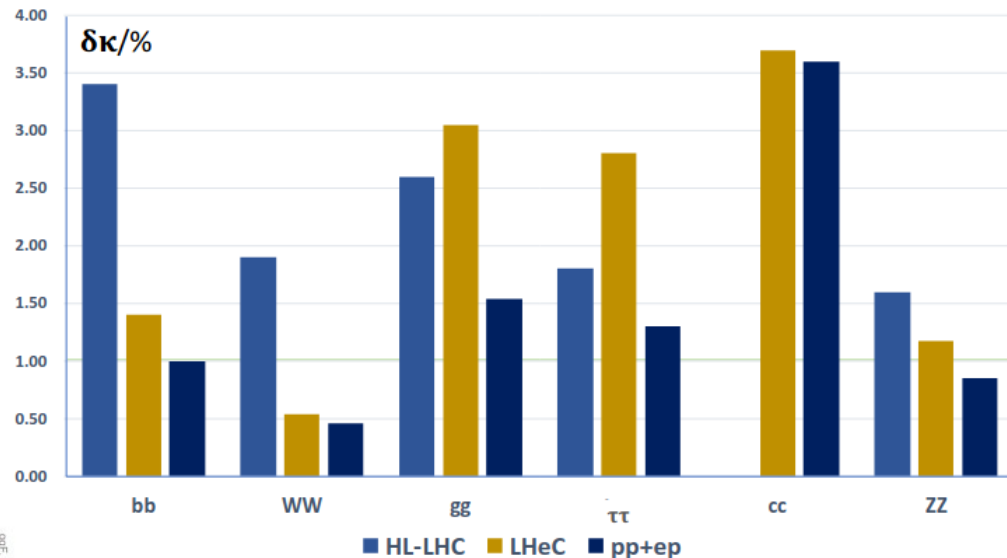
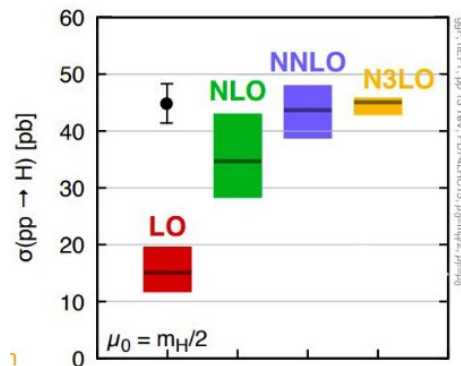
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- Higgs physics

Process	$\sigma_H$ [pb]	$\Delta\sigma_{\text{scales}}$	$\Delta\sigma_{\text{PDF}+\alpha_s}$	
			HL-LHC PDF	LHeC PDF
Gluon-fusion	54.7	5.4%	3.1%	0.4%
Vector-boson-fusion	4.3	2.1%	0.4%	0.3%
$pp \rightarrow WH$	1.5	0.5%	1.4%	0.2%
$pp \rightarrow ZH$	1.0	3.5%	1.9%	0.3%
$pp \rightarrow t\bar{t}H$	0.6	7.5%	3.5%	0.4%



To be updated :



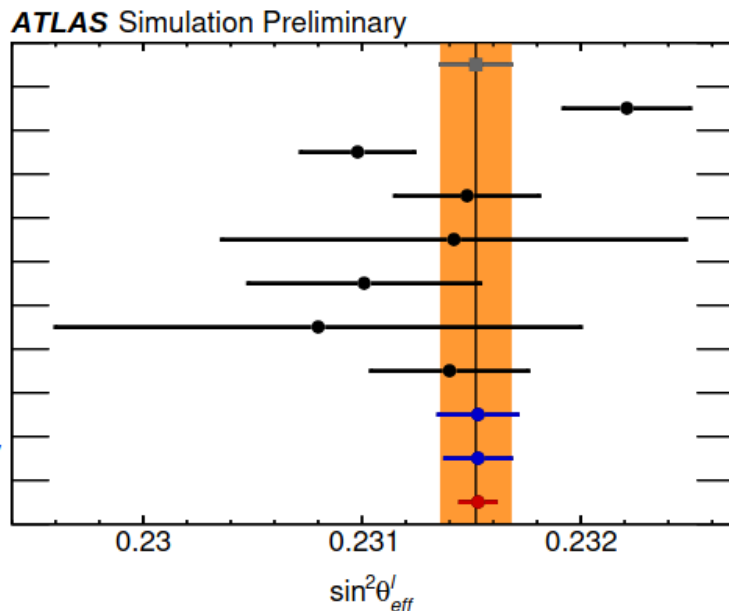
+ comments on impact on rare Higgs decay modes unique to pp programs

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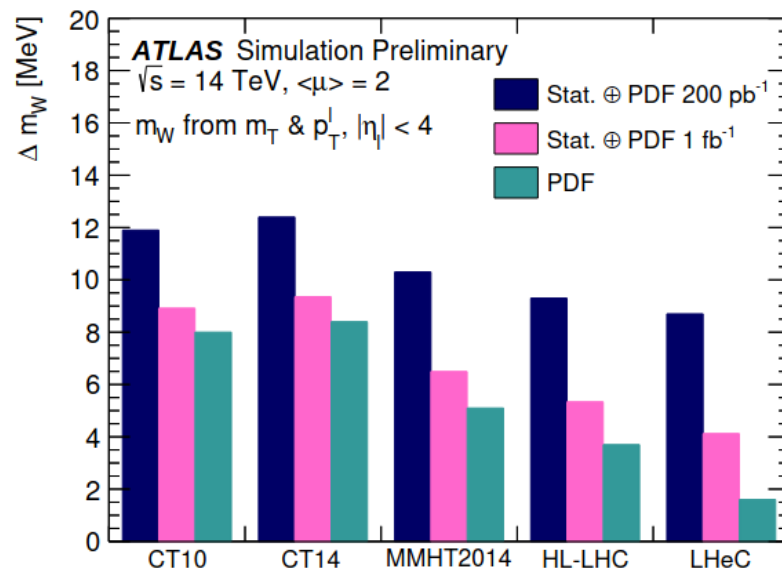
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- EW physics

- LEP-1 and SLD: Z-pole average
- LEP-1 and SLD:  $A_{FB}^{0,b}$
- SLD:  $A_1$
- Tevatron
- LHCb: 7+8 TeV
- CMS: 8 TeV
- ATLAS: 7 TeV
- ATLAS Preliminary: 8 TeV
- HL-LHC ATLAS CT14: 14 TeV
- HL-LHC ATLAS PDF4LHC15<sub>HL-LHC</sub>: 14 TeV
- HL-LHC ATLAS PDFLHeC: 14 TeV

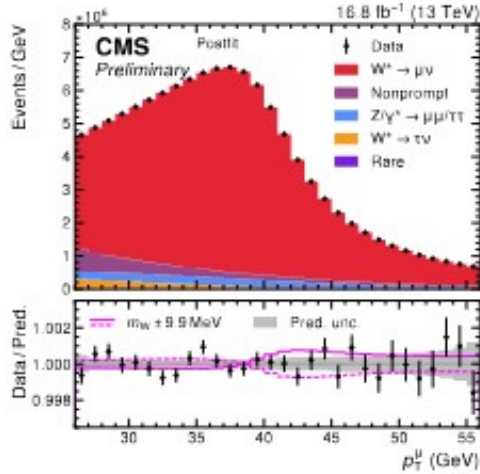


$\delta\sin^2\theta_{eff} \ 0.00015 \rightarrow 0.00008$



from dedicated low-pile-up data

- EW physics – new context



Source of uncertainty	Impact (MeV)	
	Nominal	Global
Muon momentum scale	4.8	4.4
Muon reco. efficiency	3.0	2.3
W and Z angular coeffs.	3.3	3.0
Higher-order EW	2.0	1.9
$p_T^V$ modeling	2.0	0.8
PDF	4.4	2.8
Nonprompt background	3.2	1.7
Integrated luminosity	0.1	0.1
MC sample size	1.5	3.8
Data sample size	2.4	6.0
Total uncertainty	9.9	9.9

## ATLAS

PDF set	$m_W$	$p_T^\ell$ fit		$\chi^2/n.d.f.$
		$\sigma_{tot}$	$\sigma_{PDF}$	
CT14	80358.3	+16.1 -16.2	4.6	543.3/558
CT18	80362.0	+16.2 -16.2	4.9	529.7/558
CT18A	80353.2	+15.9 -15.8	4.8	525.3/558
MMHT2014	80361.6	+16.0 -16.0	4.5	539.8/558
MSHT20	80359.0	+13.8 -15.4	4.3	550.2/558
ATLASpdf21	80362.1	+16.9 -16.9	4.2	526.9/558
NNPDF3.1	80347.5	+15.2 -15.7	4.8	523.1/558
NNPDF4.0	80343.7	+15.0 -15.0	4.2	539.2/558

Modern  $m_W$  analyses designed to reduce PDF sensitivity

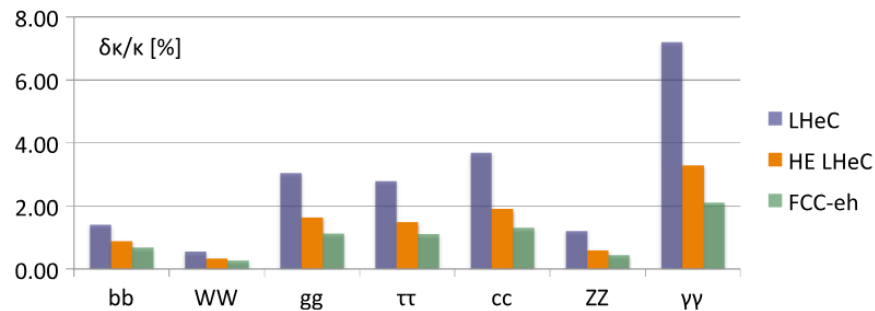
Studies ongoing (~1-2 weeks) to evaluate impact of improved PDFs in this context

- Searches at high mass

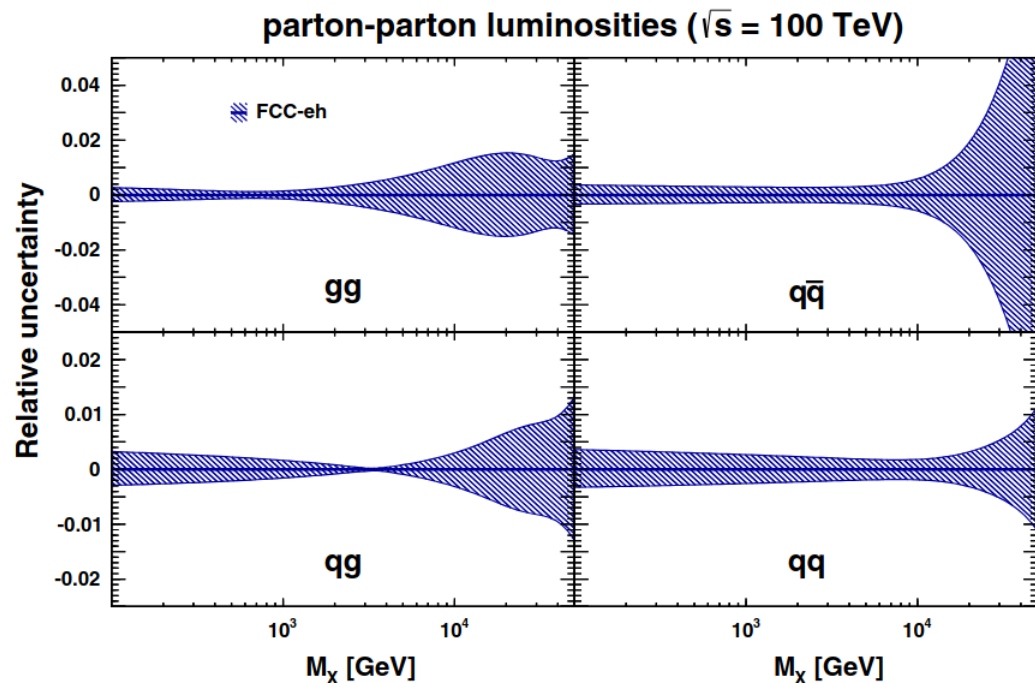
$$\mathcal{L}_{\text{CI}} = \frac{g^2}{\Lambda^2} \eta_{ij} (\bar{q}_i \gamma_\mu q_i) (\bar{\ell}_i \gamma^\mu \ell_i),$$

Model	ATLAS (Ref. [709])	HL-LHC	
	$\mathcal{L} = 36 \text{ fb}^{-1}$ (CT14nnlo)	$\mathcal{L} = 3 \text{ ab}^{-1}$ (CT14nnlo)	$\mathcal{L} = 3 \text{ ab}^{-1}$ (LHeC)
LL (constr.)	28 TeV	58 TeV	96 TeV
LL (destr.)	21 TeV	49 TeV	77 TeV
RR (constr.)	26 TeV	58 TeV	84 TeV
RR (destr.)	22 TeV	61 TeV	75 TeV
LR (constr.)	26 TeV	49 TeV	81 TeV
LR (destr.)	22 TeV	45 TeV	62 TeV

- FCC-hh/eh : brief comments



**Fig. 1.5.** Determination of SM Higgs couplings in the seven most abundant decay channels, from a fit to simulated WW and ZZ fusion production channels, including acceptance, background and efficiency effects. The statistics is assumed to be collected in simultaneous ep operation with pp at the LHC (HL, HE) and FCC.



+ comments re. Katarzyna/Paul's studies

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- Incorporate material from this morning :
  - Katarzyna / Paul
  - Elie
  
- Proposal : brief chat this afternoon to jointly outline sections II and III?