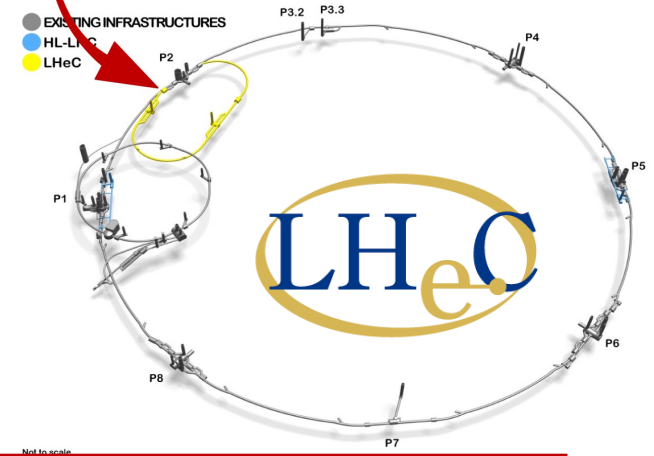


Project Input to UK ESPPU drafting day

Claire Gwenlan (Oxford)
Monica D'Onofrio, Uta Klein (Liverpool)
Paul Newman (Birmingham)

LHeC (>50 GeV electron beams)
 $E_{cms} = 0.2 - 1.3$ TeV, (Q^2, x) range far beyond HERA
run ep/pp together with the HL-LHC (\geq Run5)



Recirculating
Energy-Recovery Linac,
colliding with LHC hadrons

Final upgrade to LHC

Continuity of collisions in
2040s

Bridging towards next major
collider at CERN

- Potentially 'affordable'
- Technically realisable
- Exploring sustainable acceleration with ERL and SRF-cavities
- Developing new detector technologies

- Enabling HL-LHC precision
- Complementing HL-LHC H programme
- Extending energy frontier sensitivity

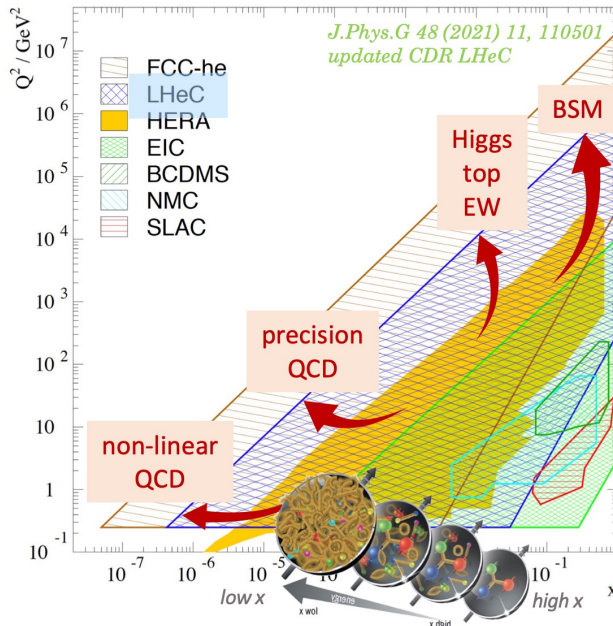
Running Scenarios in CDR-Update (July 2020)

- $e^\pm p$ 50 GeV x 7 TeV ($\sqrt{s}=1.2$ TeV) with lepton polarization up to 80%
- Concurrent with final phase of LHC or standalone

[Pile-up ~0.1]

Parameter	Unit	Run 5 Period	Run 6 Period	Dedicated
Brightness $N_p/(\gamma\epsilon_p)$	10^{17}m^{-1}	2.2/2.5	2.2/2.5	2.2/2.5
Electron beam current	mA	15	25	50?
Proton β^*	m	0.1	0.7	0.7
Peak luminosity	$10^{34}\text{cm}^{-2}\text{s}^{-1}$	0.5	1.2	2.4
Proton beam lifetime	h	16.7	16.7	100
Fill duration	h	11.7	11.7	21
Turnaround time	h	4	4	3
Overall efficiency	%	54	54	60
Physics time / year	days	160	180	185
Annual integrated lumi.	fb^{-1}	20	50	180

Ultimately 1ab-1
in a few years



- Combines properties of General Purpose energy frontier explorer and comprehensive scattering experiment, probing nucleon at unprecedented precision and parton densities

- For further details:

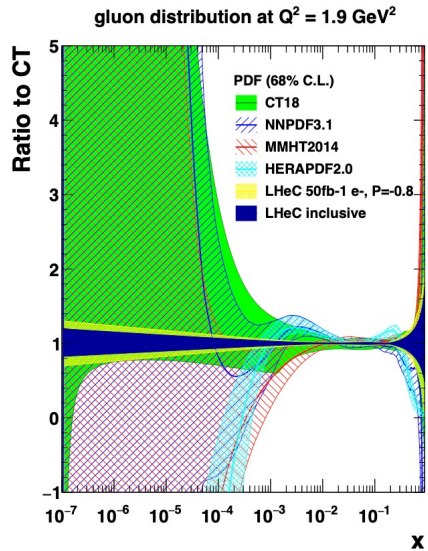
CDR Update: arXiv:2007.14491

Durham talks (Gwenlan, d'Onofrio, Newman)

e.g. Proton PDF Precision: Enabling HL-LHC

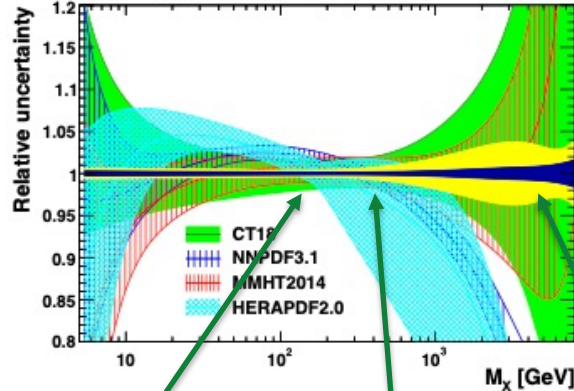
- Extends upper mass reach of many LHC BSM searches
- Facilitates LHC precision measurements (e.g. M_W PDF systs \rightarrow 2 MeV)

e.g. Gluon Density precision transformed in 1-2 years running with HL-LHC

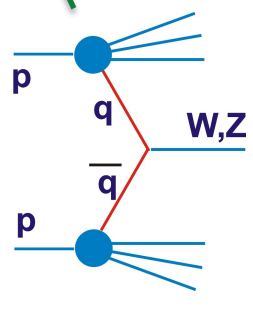
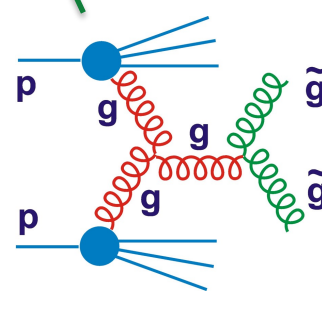
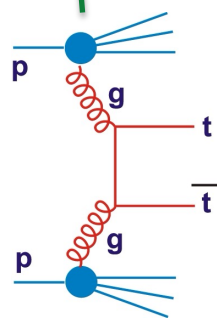
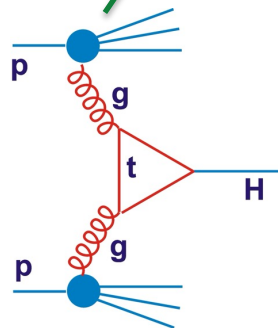
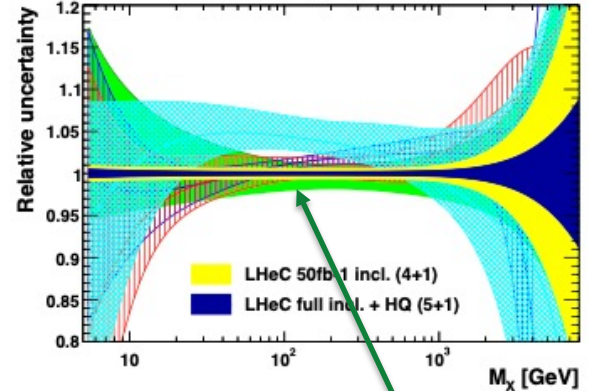


Parton luminosities for pp at 14 TeV

gg luminosity, $\sqrt{s}=14 \text{ TeV}$

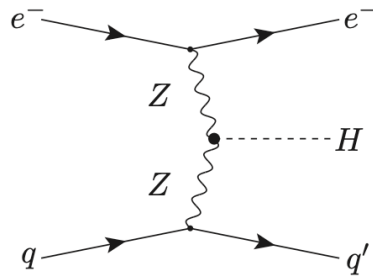
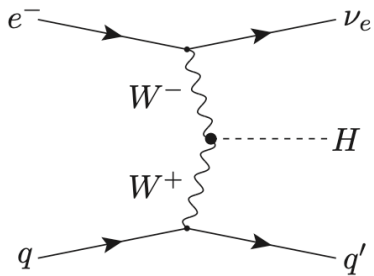


qq luminosity, $\sqrt{s}=14 \text{ TeV}$



- Discovers novel very low x dynamics
- α_s to 0.2%
- $\sin^2\theta_W$ to 0.00015
- ...

e.g. (SM) Higgs Programme



Dominant production mechanism charged current (WW), distinguished event-by-event from sub-dominant neutral current (ZZ)

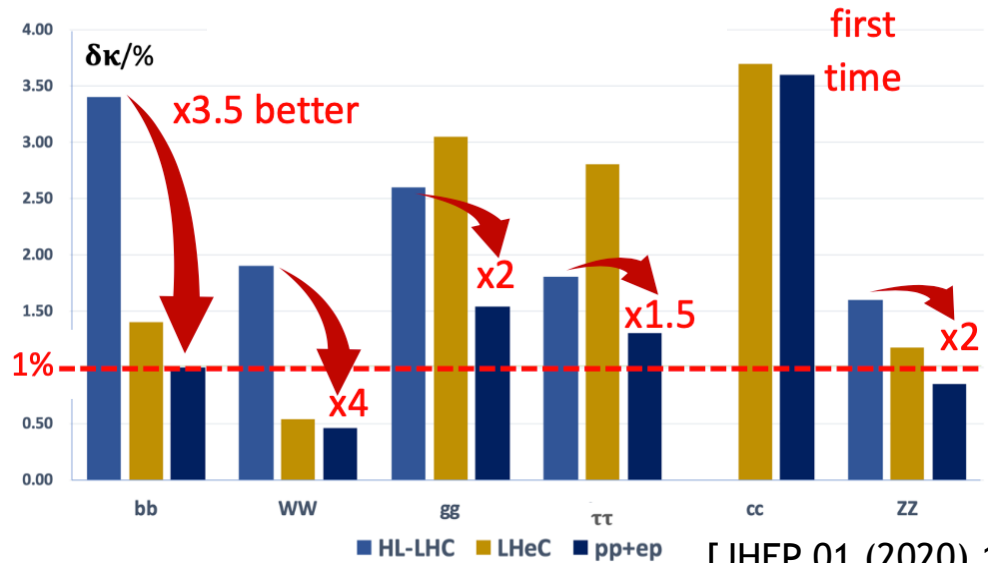
Charged Current cross section $\sim 0.2\text{pb}$ for $P=-0.8 \rightarrow \sim 200,000$ events for 1ab^{-1}

LHeC standalone precision on κ parameters

$\mathcal{L}[1/\text{ab}]$	$b\bar{b}$	WW	gg	$\tau\tau$	$c\bar{c}$	ZZ	$\gamma\gamma$
1	1.9	0.70	3.5	3.1	3.8	1.2	6.8

Higgs Coupling Improvement with respect to HL-LHC

ep:pp complementarity leads to full exploitation of LHC capability for scalar sector



Requested Parameters

Environmental cost of construction: Awaiting lab directors' report.
Annual environmental cost of operation: Small tunnel length & ERL / SRF technologies
→ relatively modest impact

Financial cost: Baseline costed estimated in 2018 at CHF1.4B for 50 GeV electrons (1/5 of LHC circumference)
[O. Bruning, CERN-ACC-2018-0061]

Dedicated submission planned to ESPPU: Yes

Centre-of-Mass Energy: 1.2 TeV for baseline 50 GeV electron option

Integrated Luminosity: A few $\times 100 \text{ fb}^{-1}$ in concurrent operation with HL-LHC
Of order 1 ab^{-1} for a few years standalone operation

Number of Interaction Points: 1 (by design)

Time running: A few years

Wall power: 100 MW (by design) ~ LHC now.

Accelerator length: 5.4km for baseline 50 GeV electron option

Estimated year of 1st collisions: Late 2030s or beyond

Future upgrade paths: Very similar design for FCC-eh