Summary of Detector & Physics Sessions (Part I)

Zhiqing ZHANG

Focusing on

- Detector (including IR, polarimetry, forward instrumentation)
- Importance of precision PDFs determination
- EW physics

Talks Covered in This Summary

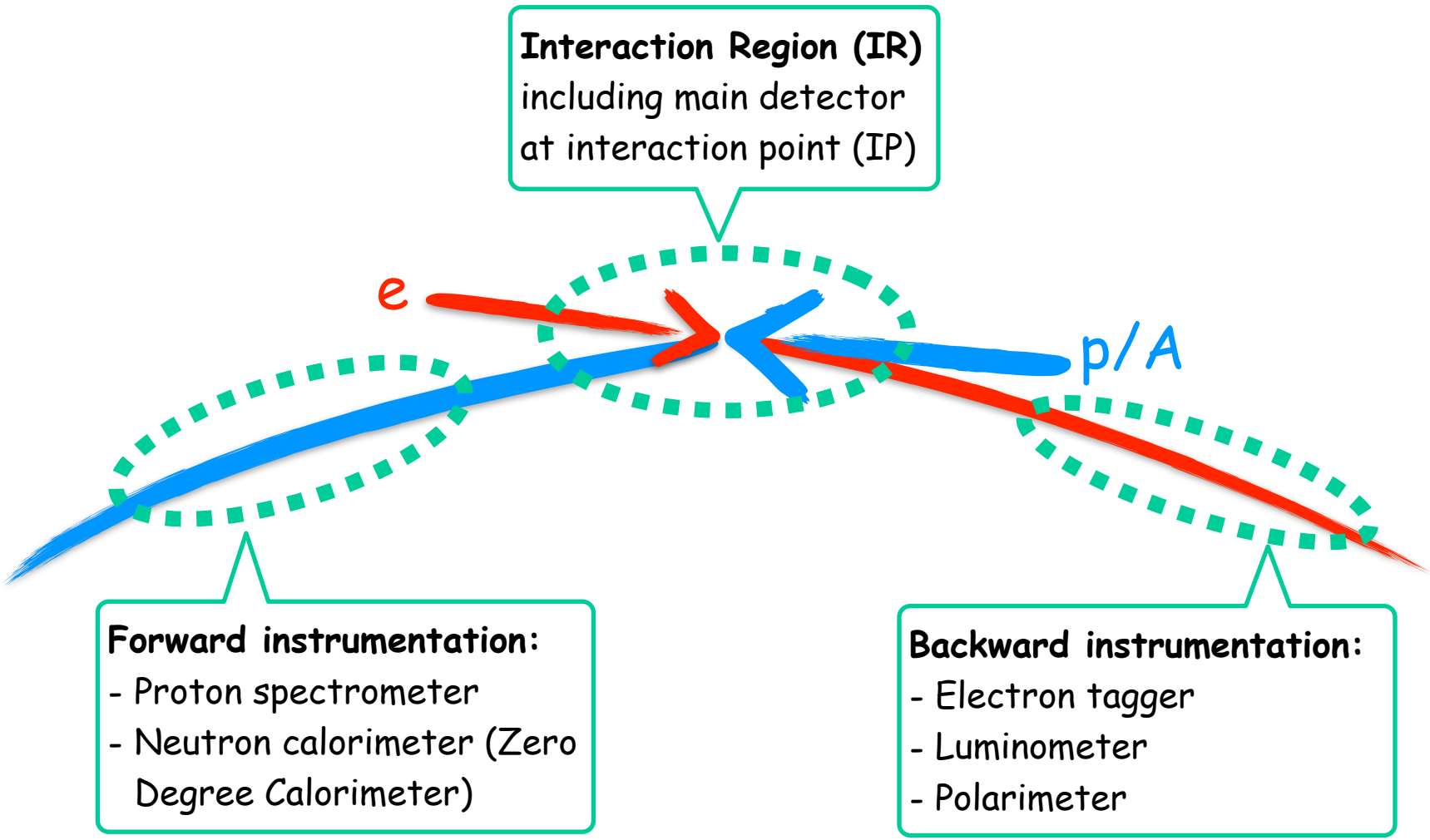
- Detector (4)
  - Max Klein: Detector design for LHeC/HE-LHeC/FCCeH
  - Paul Newman: Forward instrumentation from HERA via the LHC to the LHeC
  - Aurelien Martens: High precision polarimetry at the LHeC
  - Elke Aschenauer: eRHIC: detector and IR design

- PDFs and strong coupling constant (5)
  - Simone Marzani: On the impact of small-x resummation
  - Amanda Cooper-Sarkar: Impact of low-x resummation on QCD analysis of HERA data
  - Gavin Pownall: Proton PDFs at the LHeC and the FCC-eh
  - Sven-Olaf Moch: Towards DIS at NNNLO
  - Anna Staśto: Diffraction studies at LHeC and FCC-eh

- EW physics (2)
  - Nansi Andari: Impact of LHeC PDFs on W mass and weak mixing angle measurements
  - Daniel Britzger: electroweak physics at LHeC/FCCeh

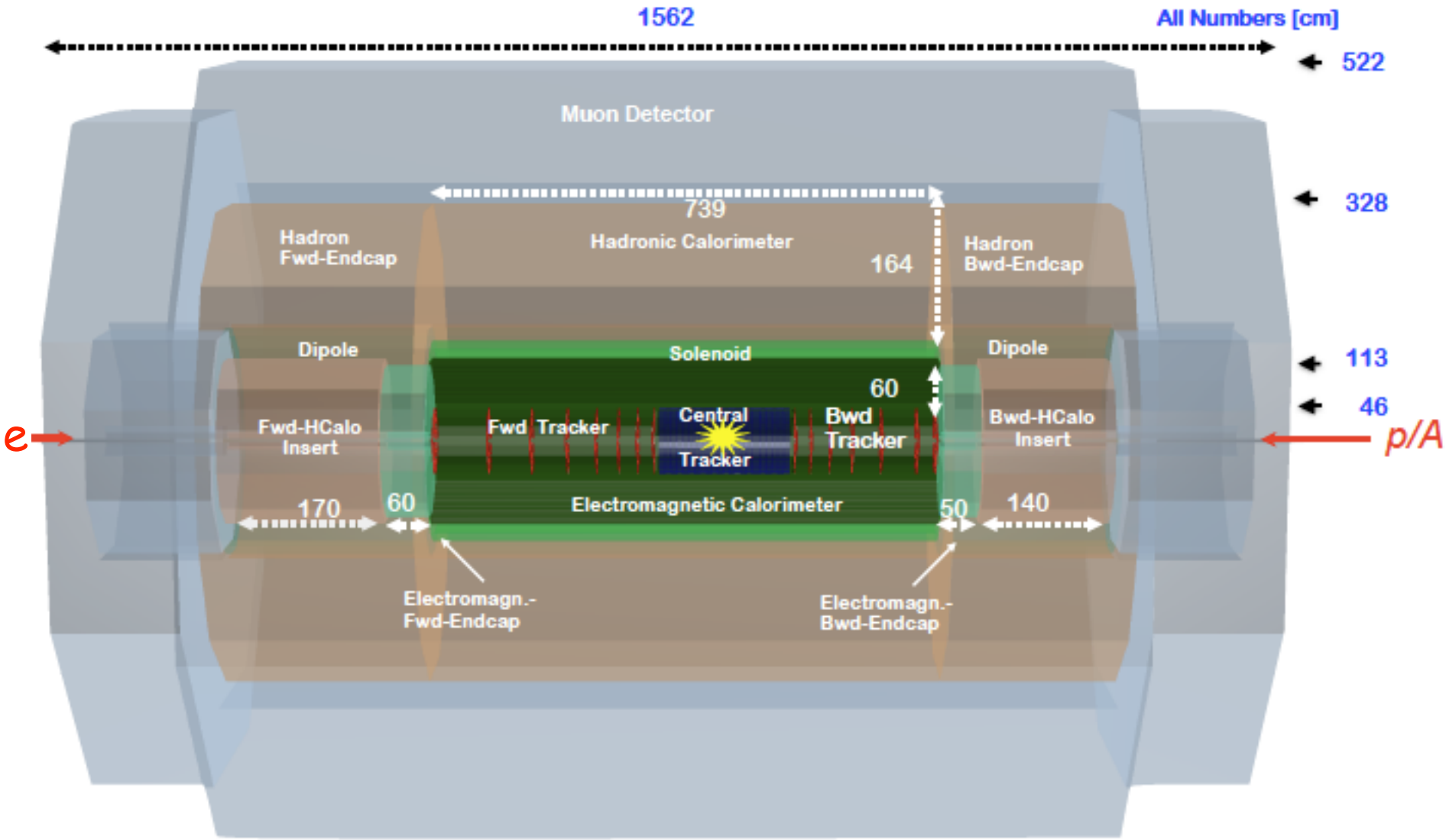
Detectors

Need (excellent) detectors to achieve (precision) measurements or discovery



The Main Detector

Max Klein



Length x Diameter: LHeC (13.3 x 9 m2) HE-LHC (15.6 x 10.4) FCCeh (19 x 12)

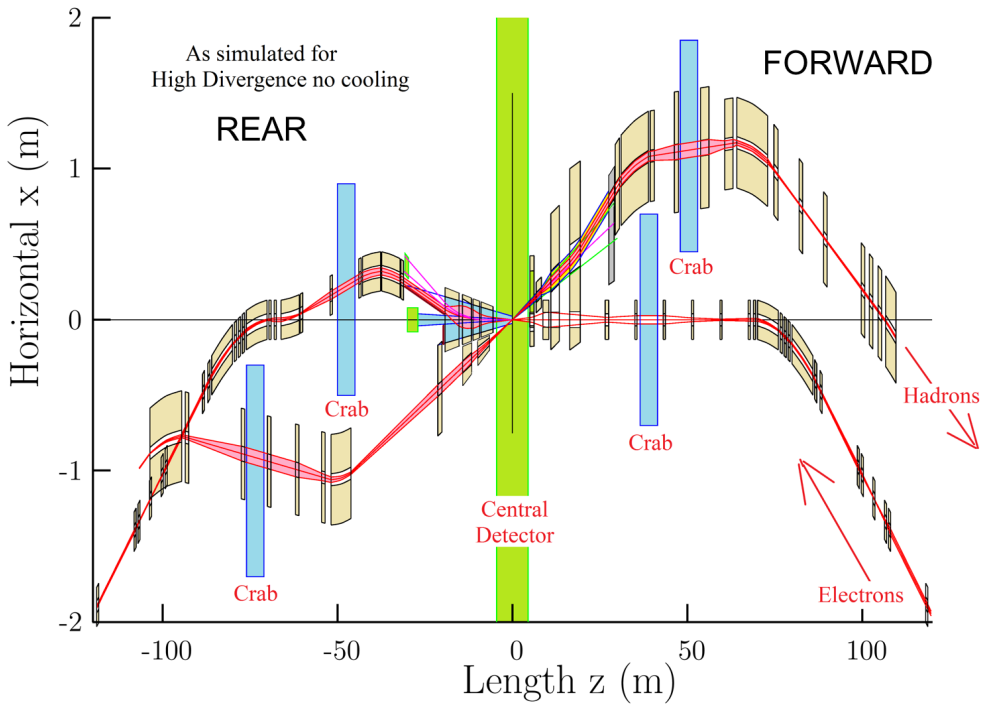
ATLAS (45 x 25) CMS (21 x 15): [LHeC < CMS, FCC-eh ~ CMS size]

Interaction Region (at EIC)

Elke Aschenauer

Conflicting requirements from

- Physics
  - Largest acceptance
  - High ever rate (luminosity)
- Machine point of view
  - High luminosity (strong focusing elements closer to IP)
  - Beam separation (head-on or crossing angle?)
- Beam background at IR
  - IR vacuum design



More involved design/realisation for LHeC/FCCeh given the 3 beams

High Precision Polarimetry at the LHeC

Aurelien Martens

1005.2741

- reviewed previous polarisation measurements at SLC, HERA
  - % level precision achieved with Compton polarimetry
  - One HERA measurement was made with Fabry-Perot cavity designed/constructed at this lab
  - Realised a number of applications since then
- presented on-going development for ILC
  - Need to reach 0.25% or better
- for LHeC
  - Laser design: industrial table-top laser or Fabry-Perot cavity
  - Need detailed simulation studies
  - Systematic uncertainties (detector alignment)
  - Radiation hardness, background level (location)
  - Time response of detectors

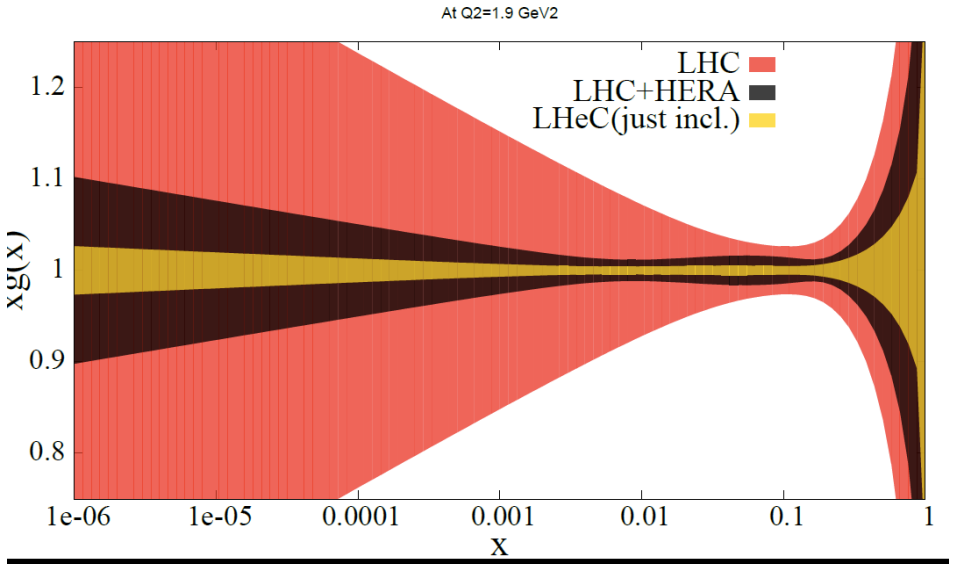
Forward Instrumentation at the LHeC

Paul Newman

- Main detector acceptance of 1°/179° insufficient for forward physics
  - Selection of diffractive events
  - Separation of coherent / incoherent events
- Need forward proton/neutron detectors near/within p beam pipe
  - Forward detectors already used at HERA
  - Improved at LHC with 2nd generation proton spectrometers
- For LHeC
  - Locations of pots restricted by beam elements
  - Scattered proton trajectories blocked by collimators
  - Sensitive detectors can't approach arbitrary close to beam
  - More studies with realistic optics needed

Importance of PDFs Determination

courtesy of Amanda Cooper-Sarkar



- The importance of HERA ep collider for our current PDFs knowledge should never be underestimated
- Can't imagine by how much the results of Tevatron and LHC would have been affected without the constraints on PDF from HERA data
- Yet many LHC precision measurements and searches are already limited by current PDFs uncertainties
- Even with the HERA data, PDFs are not so well known (see below)

- In a same way, can't imagine the impact of "poor" PDFs on future FCC-hh programme without LHeC/FCC-eh

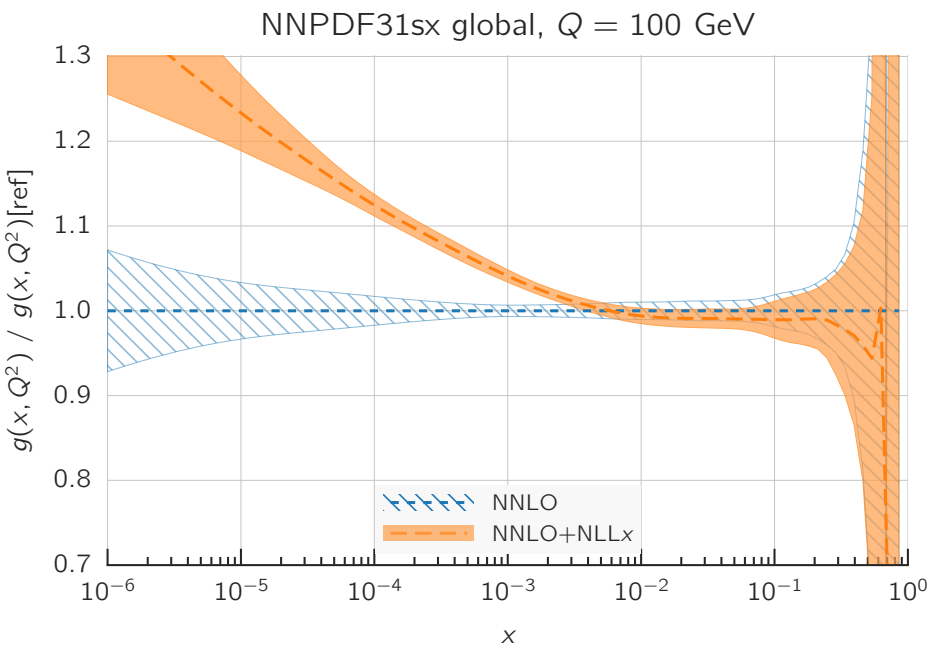
Resummation at Low x

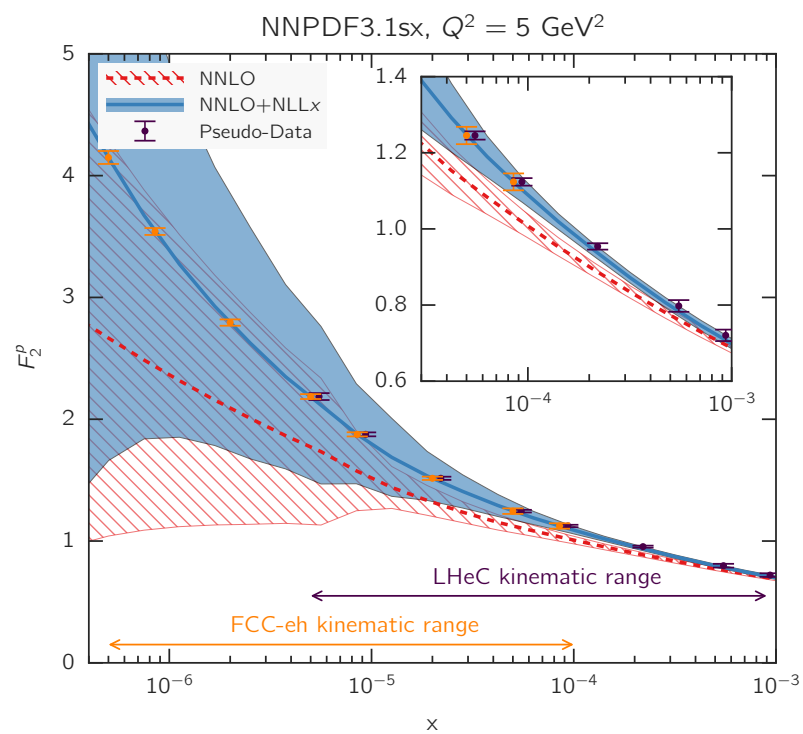
1710.05935

Simone Marzani

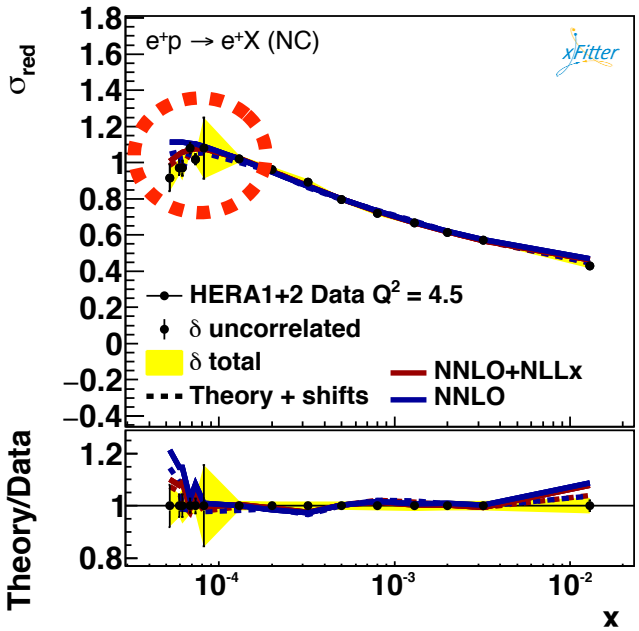
Same HERA input data but different cross section predictions result in completely different gluon PDFs beyond the HERA kinematic limit

Difference on predicted F2 is smaller but only LHeC and FCCeh data can improve the uncertainties of the predictions at low x





Impact of the Resummation on HERA Data



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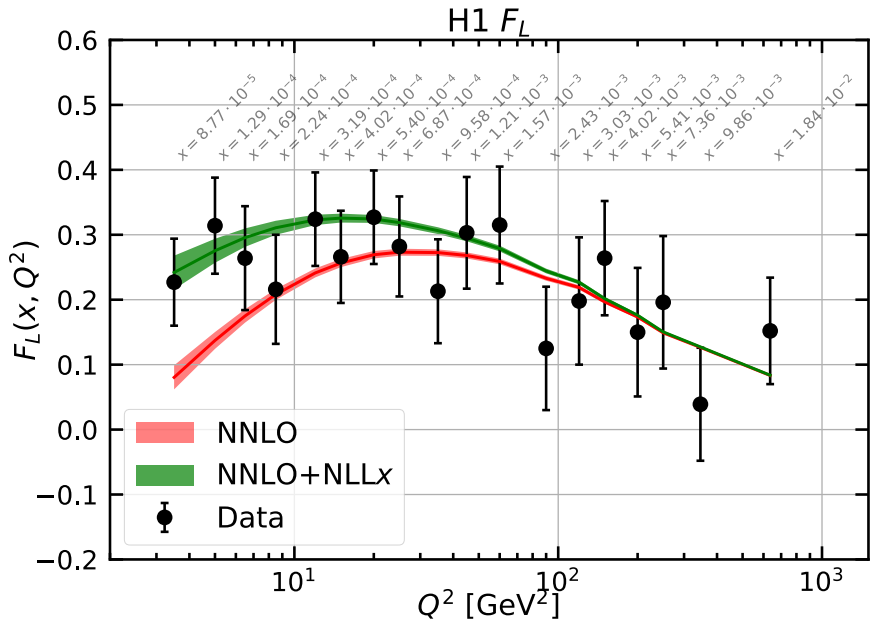
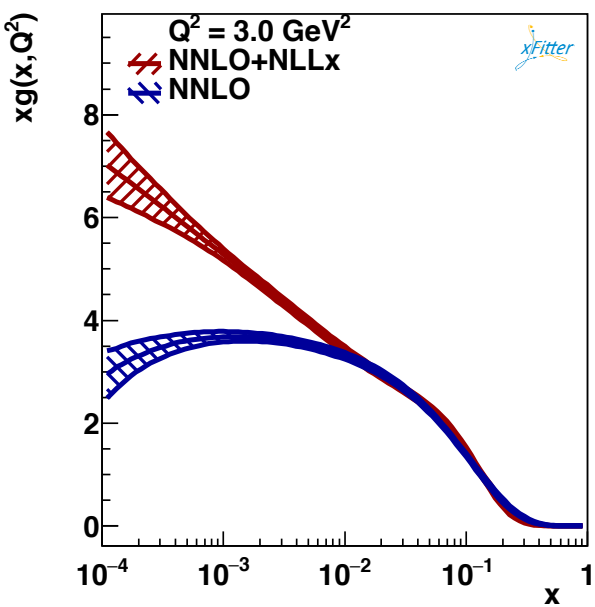
Amanda Cooper-Sarkar



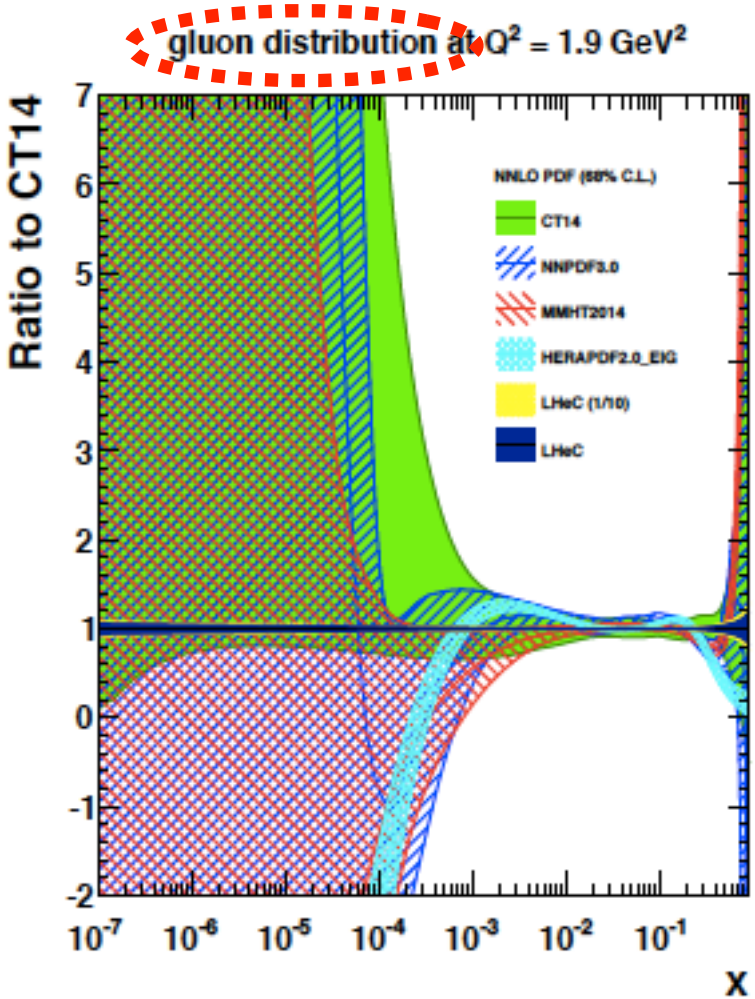


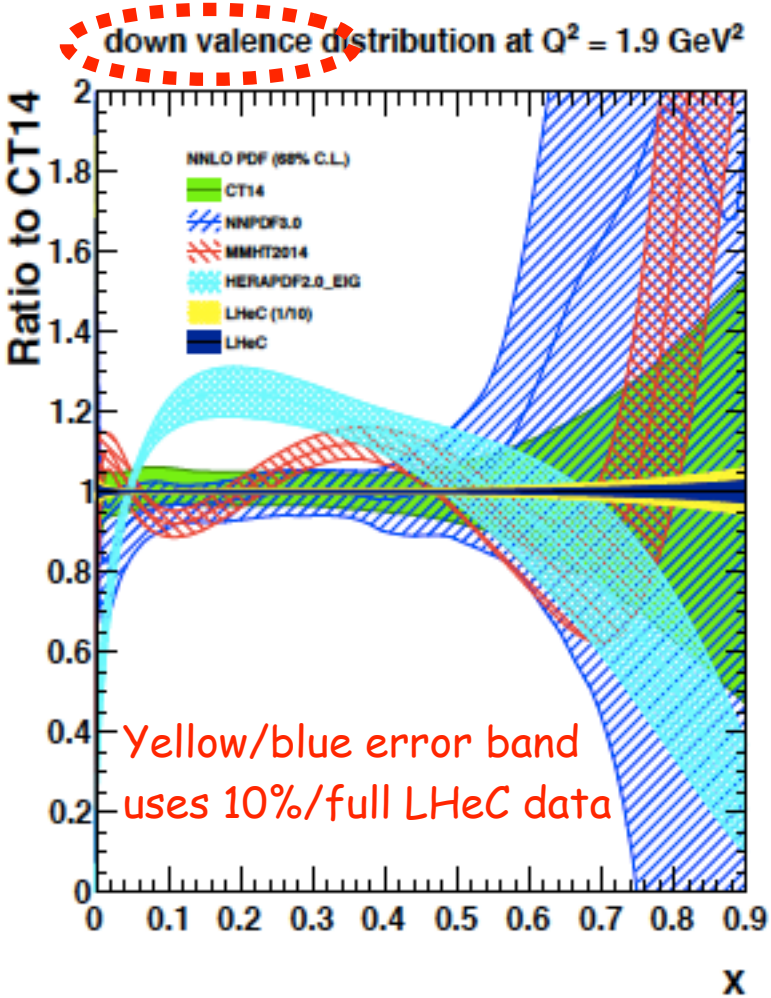
Low-x resummation

- improves the description of HERA data at low-x, low-Q^2 and high-y
- results in a rising low-x gluon, which is now always larger than the total sea

Expected PDFs Precision at LHeC

Gavin Pownall



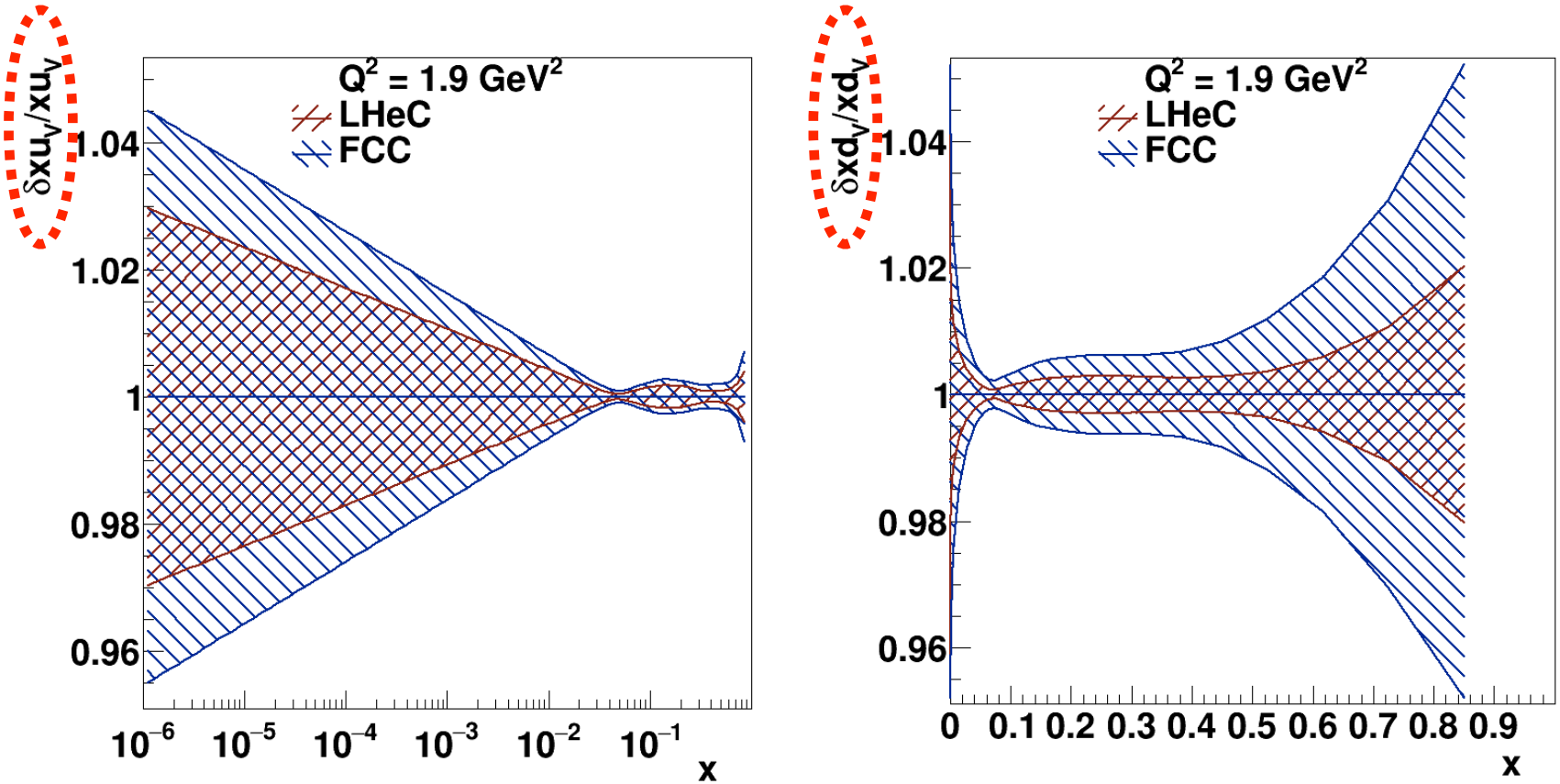


Low-x gluon relevant for all Higgs/ SUSY particle production at FCChh

High-x quark relevant for high mass searches already at the LHC

Expected PDFs Precision: LHeC vs FCCeh

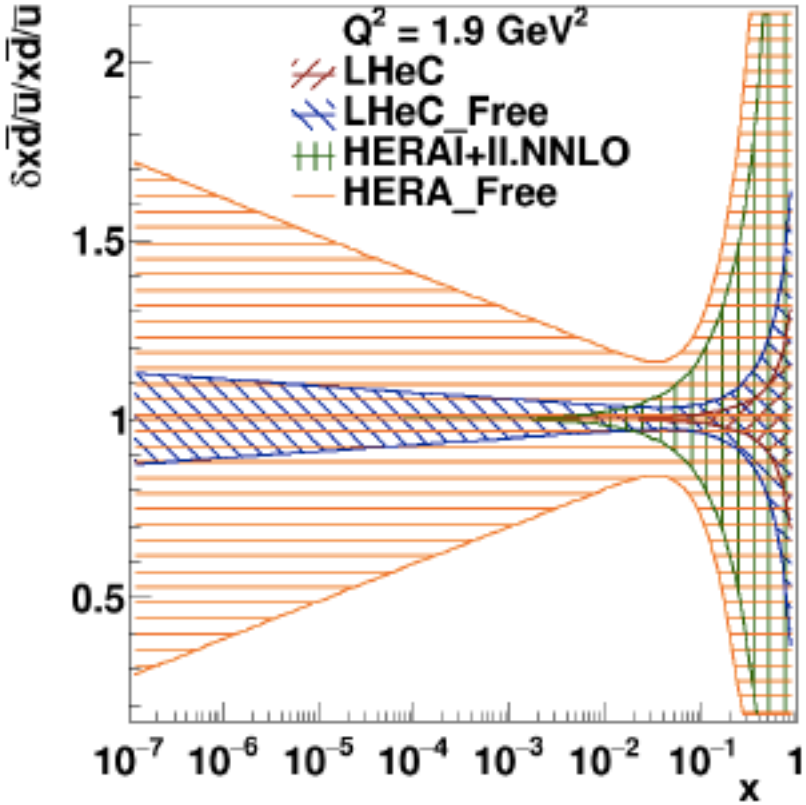
Gavin Pownall

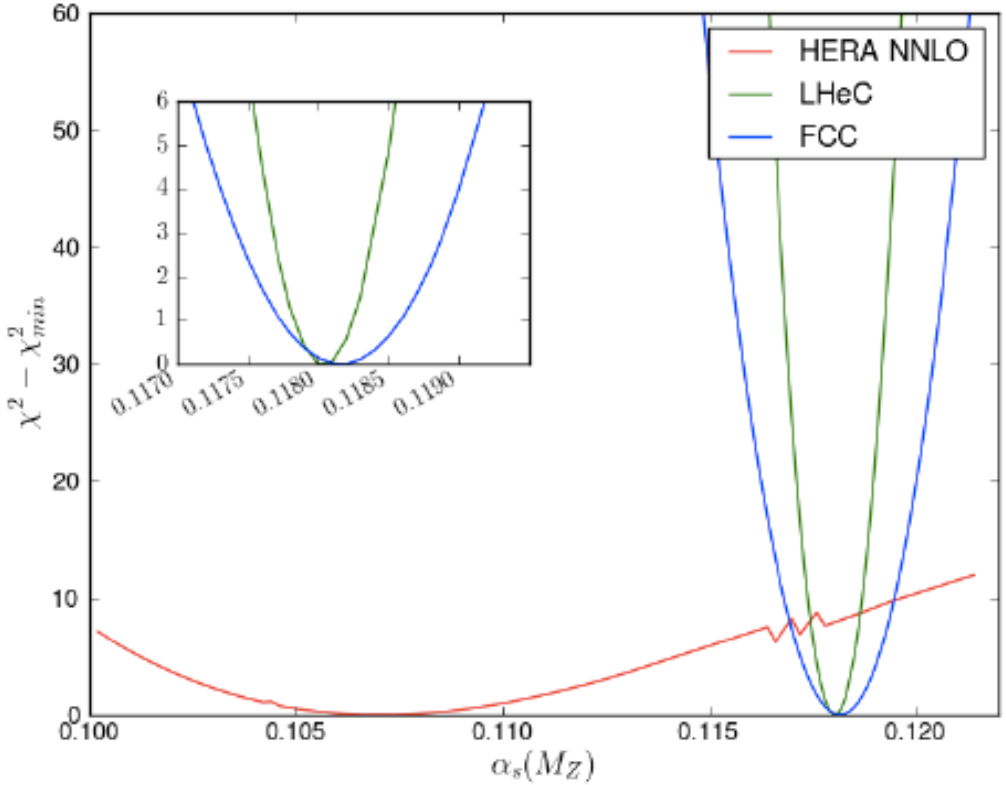


FCCeh improves further the precision of valence quarks at low- and high-x

Others Improvements at LHeC/FCCeh

Gavin Pownall



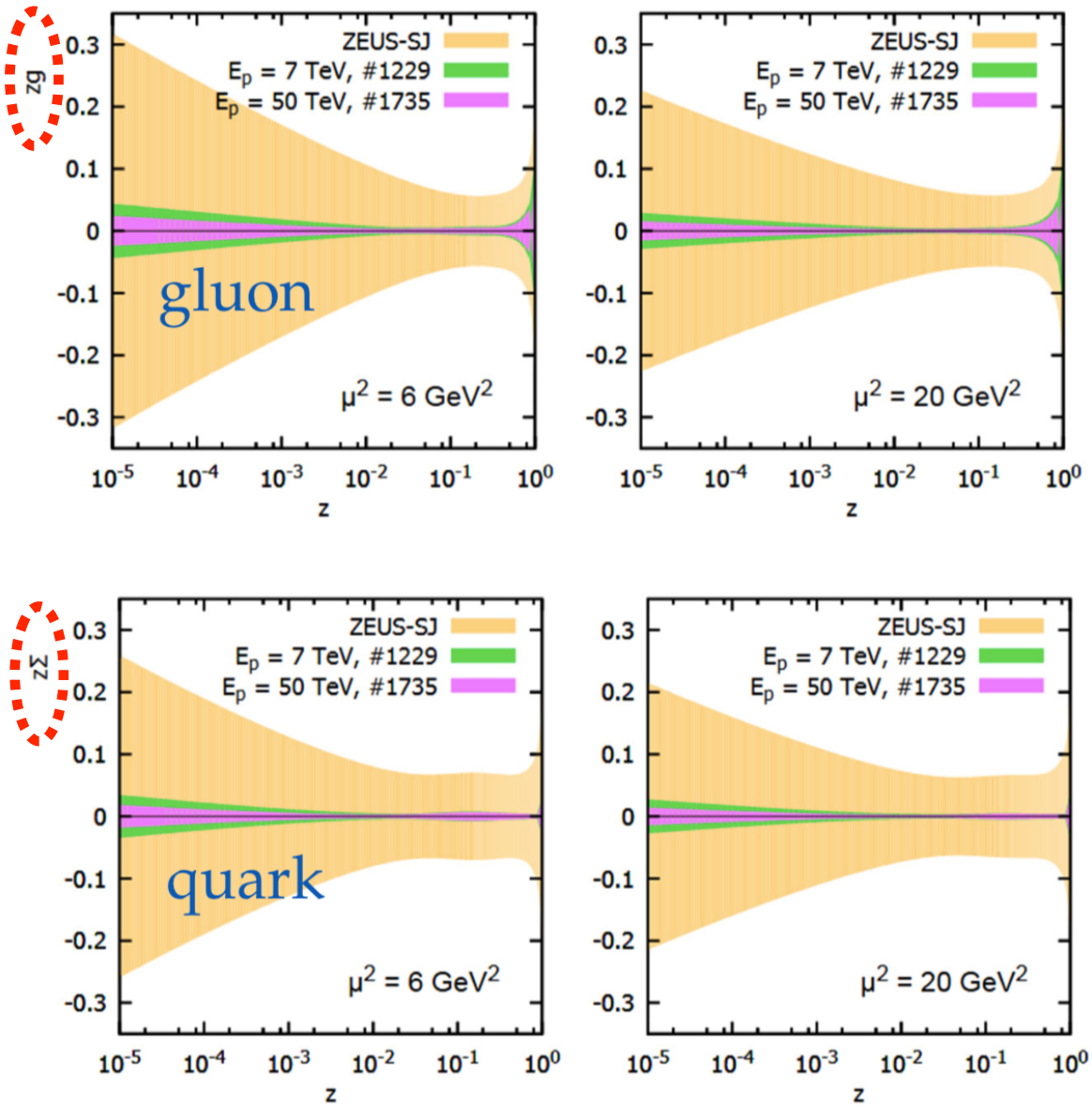


Less constrained parameterisation makes big difference between HERA & LHeC PDFs

Relative precision on strong coupling constant: LHeC: 0.2%, FCCeh: 0.5%

Improvements on Diffractive PDFs

Anna Stasto

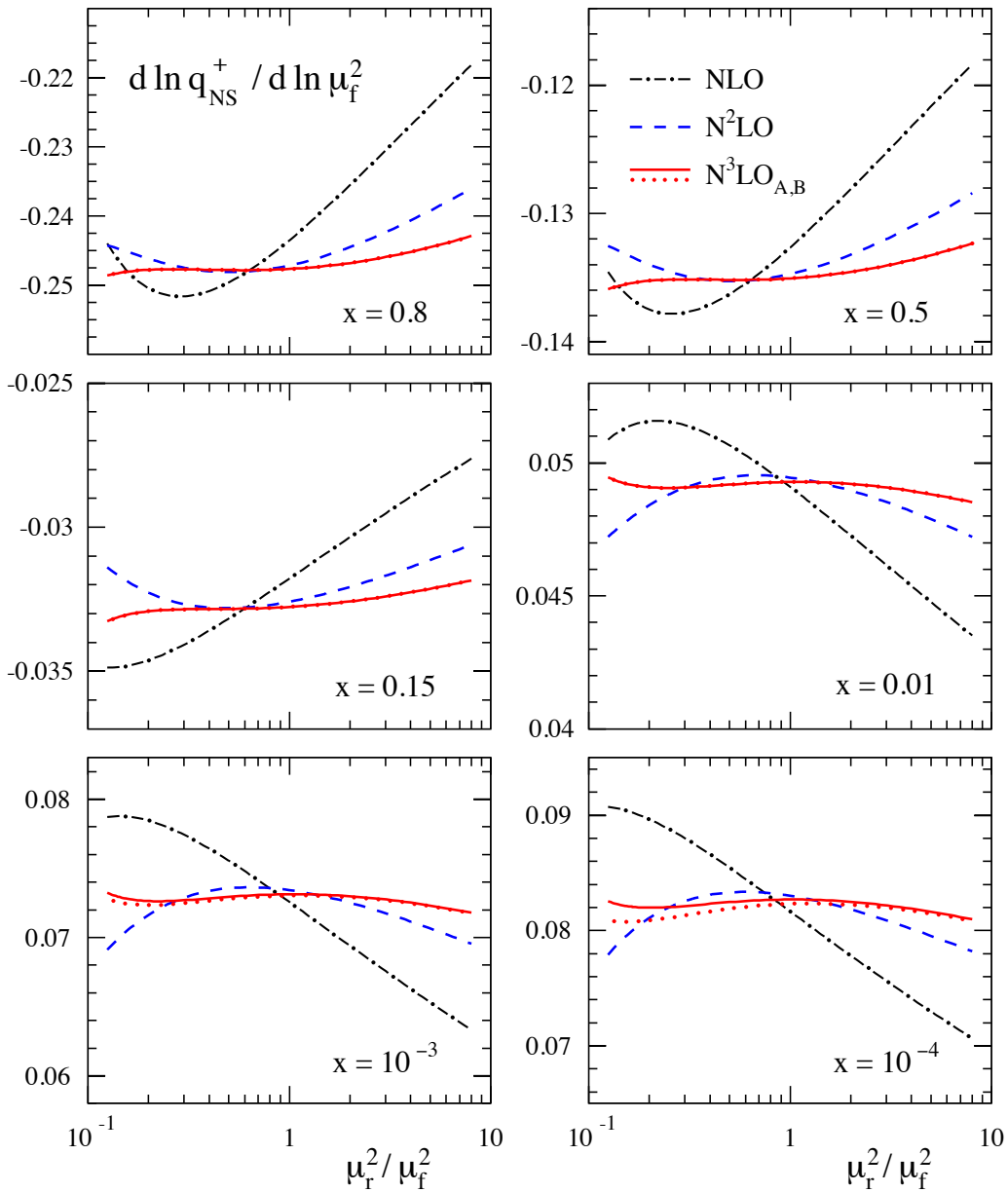


$$Q^2_{\min} \approx 5\ \mathrm{GeV}^2$$

Accuracy increased by

- ✓ factor ~10 for LHeC
- ✓ factor ~20 for FCC-he

Towards DIS at N3LO



Sven-Olaf Moch

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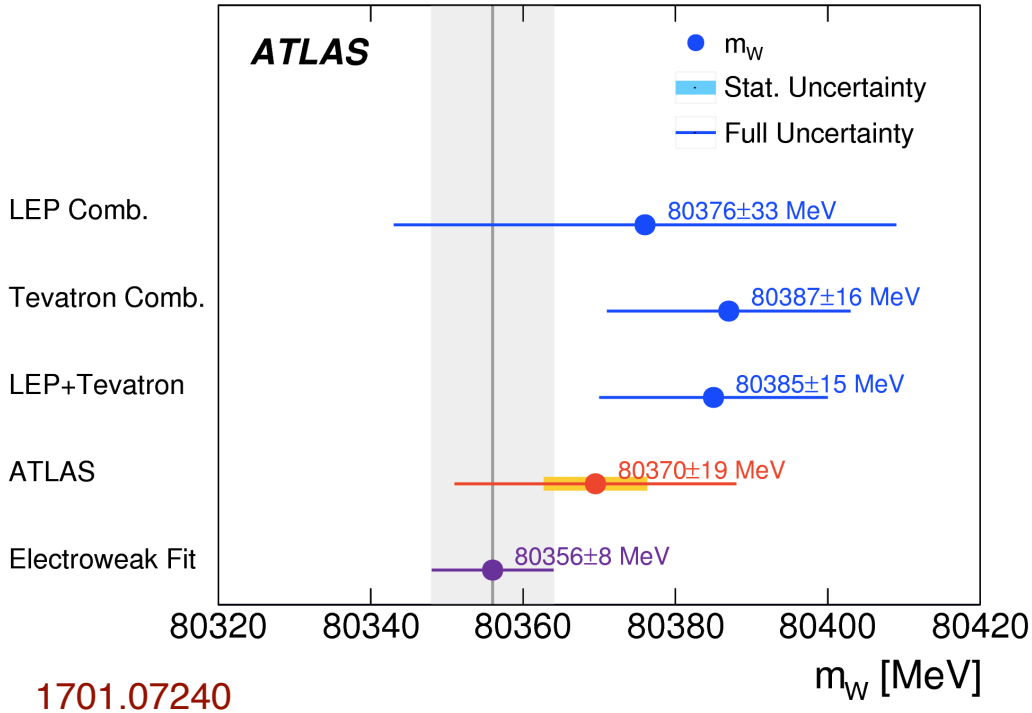
N3LO calculation:

- a formidable achievement
- reduced renormalisation scale dependence of evolution kernel
- a major step forward for PDFs and strong coupling constant determination at N3LO
- N3LO PDFs are needed to match N3LO ggF Higgs cross section predictions

Impact of LHeC PDFs on EW measurements

Nansi Andari



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Both the mW mass (ATLAS) and weak mixing angle (CMS) measurements at the LHC are limited by uncertainties of PDFs

The PDFs from LHeC would reduce the uncertainties by a factor ~3

Combined categories	Value [MeV]	Stat. Unc.	Muon Unc.	Elec. Unc.	Recoil Unc.	Bckg. Unc.	QCD Unc.	EWK Unc.	PDF Unc.	Total Unc.	χ^2/dof of Comb.
m_T-p_T^ℓ, $W^\pm$, e-μ	80369.5	6.8	6.6	6.4	2.9	4.5	8.3	5.5	9.2	18.5	29/27

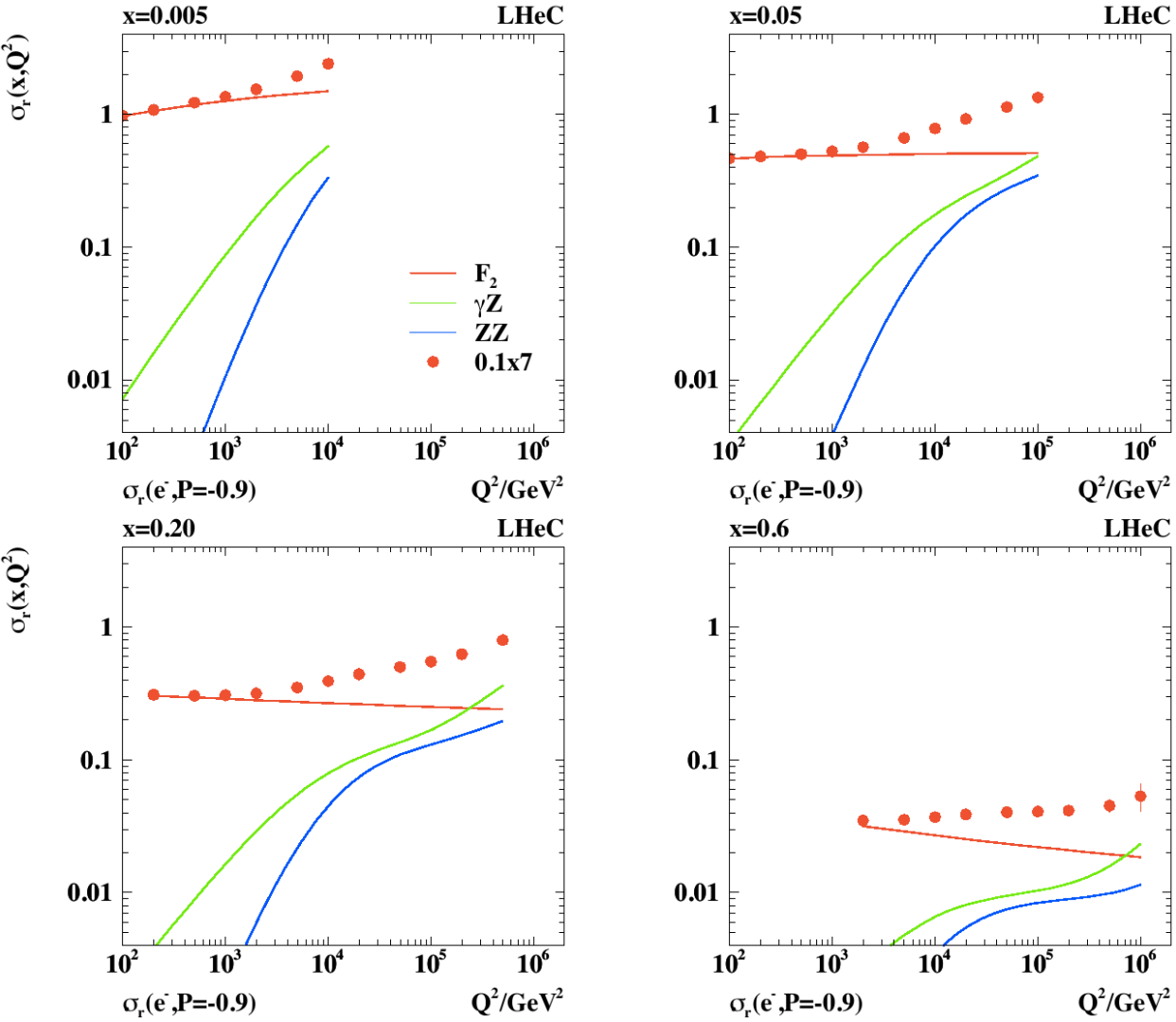
1806.00863

CMS: $\sin^2\theta_{\rm eff}^{\ell} = 0.23101 \pm 0.00036(\text{stat}) \pm 0.00018(\text{syst}) \pm 0.00016(\text{theo}) \pm 0.00031(\text{PDFs})$

Electroweak Physics at LHeC/FCCeh

Daniel Britzger

1206.2913

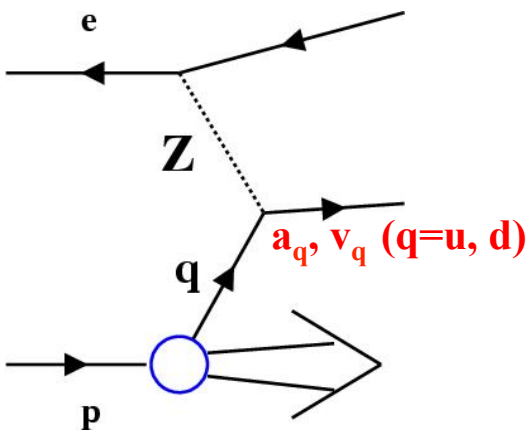


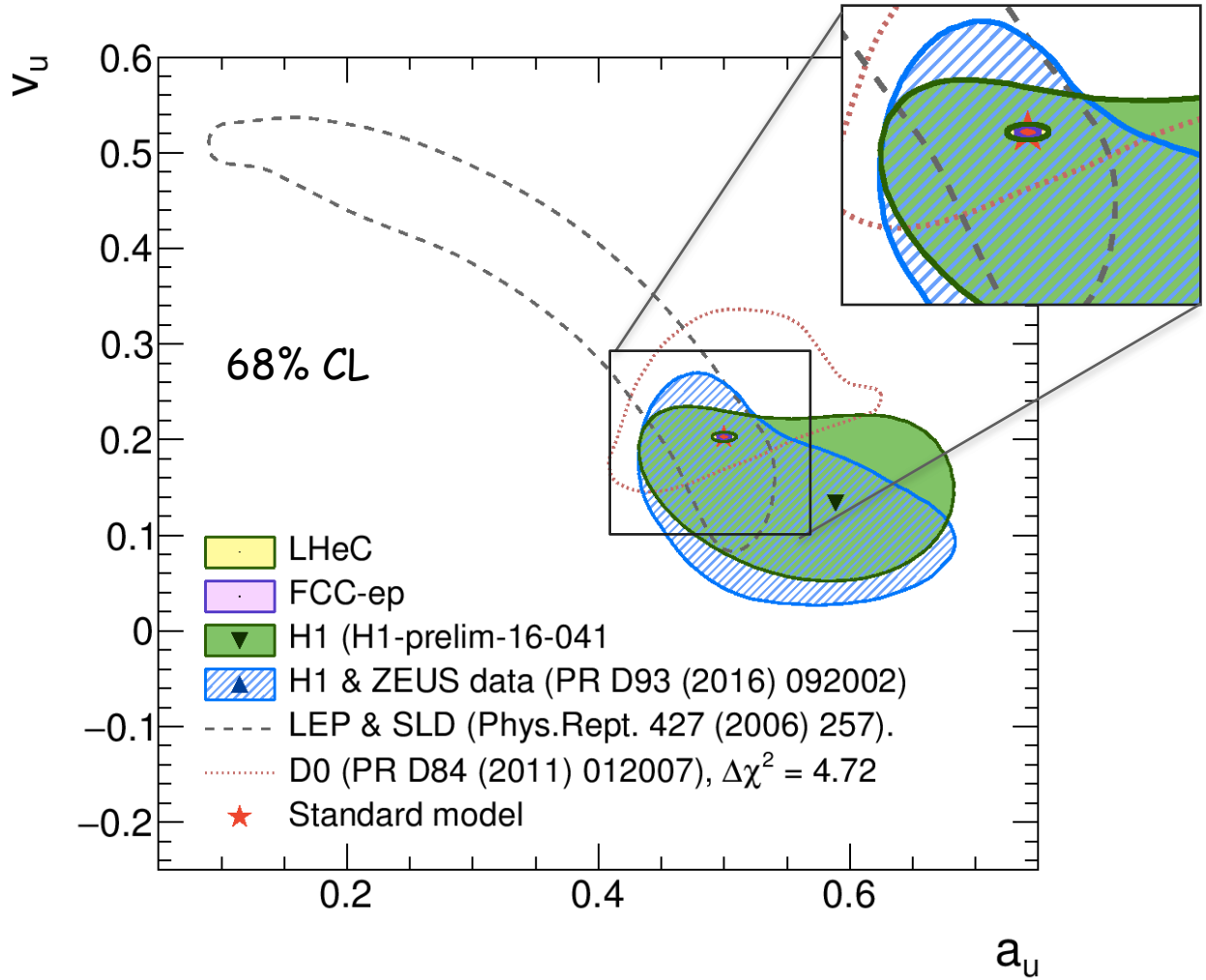
- NC cross section at high Q2 receives increasingly important Z boson exchange & γZ interference contributions
- together with CC cross section, they are sensitive to EW parameters

Electroweak Physics at LHeC/FCCeh

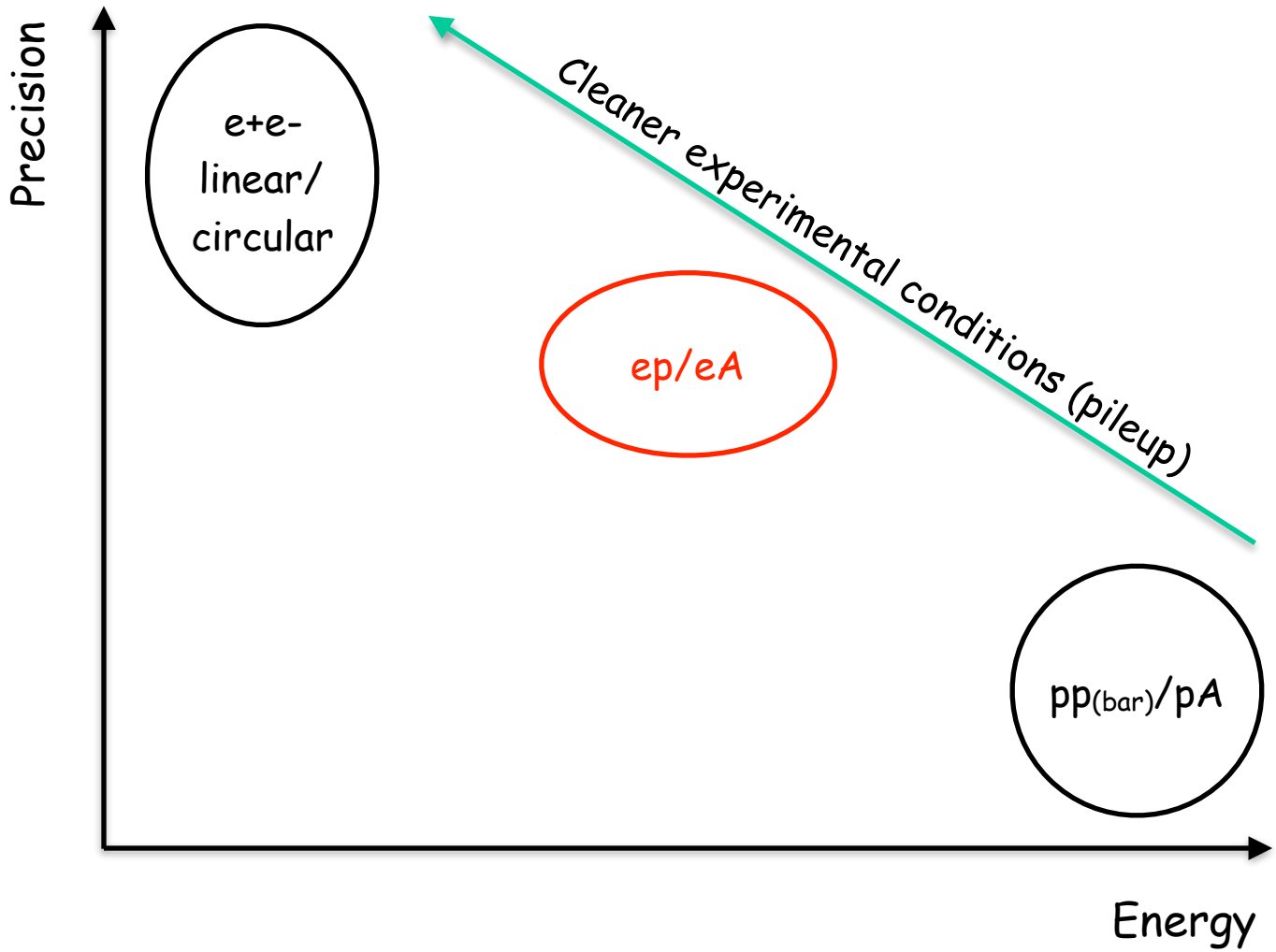
Daniel Britzger

Vector and axial-vector couplings for u-type quarks determined together with PDFs





My Personal Conclusion: eh vs e+e- and hh



LHeC is so cheap in comparison with other colliders and the physics programme is so unique and rich, it would be a mistake not to go for it!