Diffractive DIS with E_e=70GeV and E_p=7TeV at the LHeC

P.Newman, diffractive sessions, HERA-LHC workshop, Wed 7 June 2006

For general physics aim and sketch of machine design, see plenary talk of E. Perez …

… what could the increased energy and luminosity bring for diffraction?… some first thoughts …

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Deep Inelastic Electron-Nucleon Scattering at the LHC*

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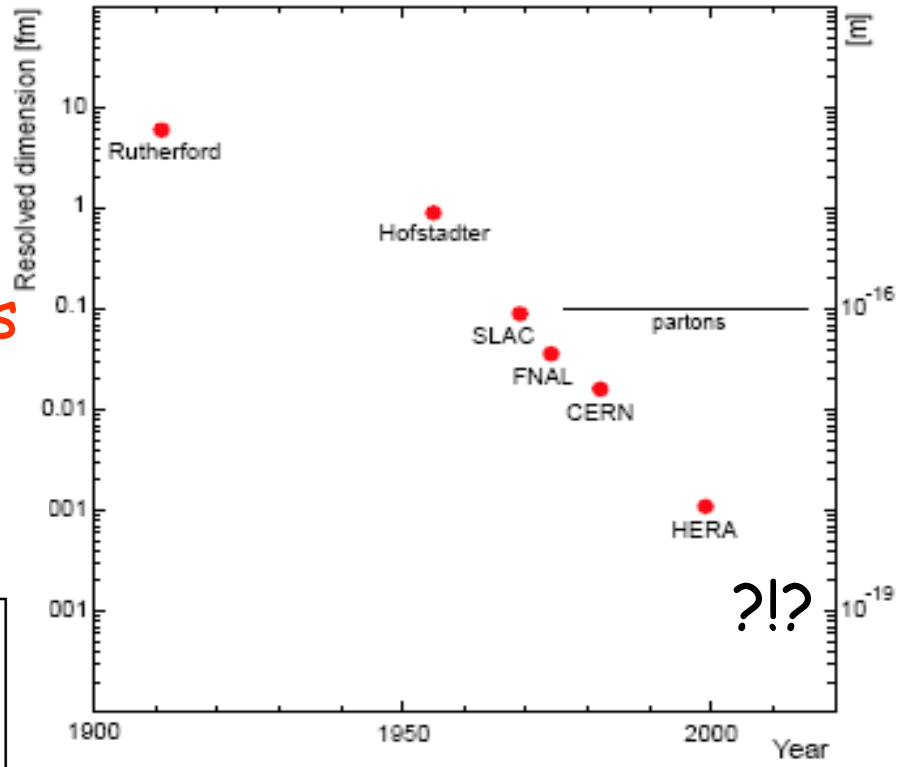
Abstract

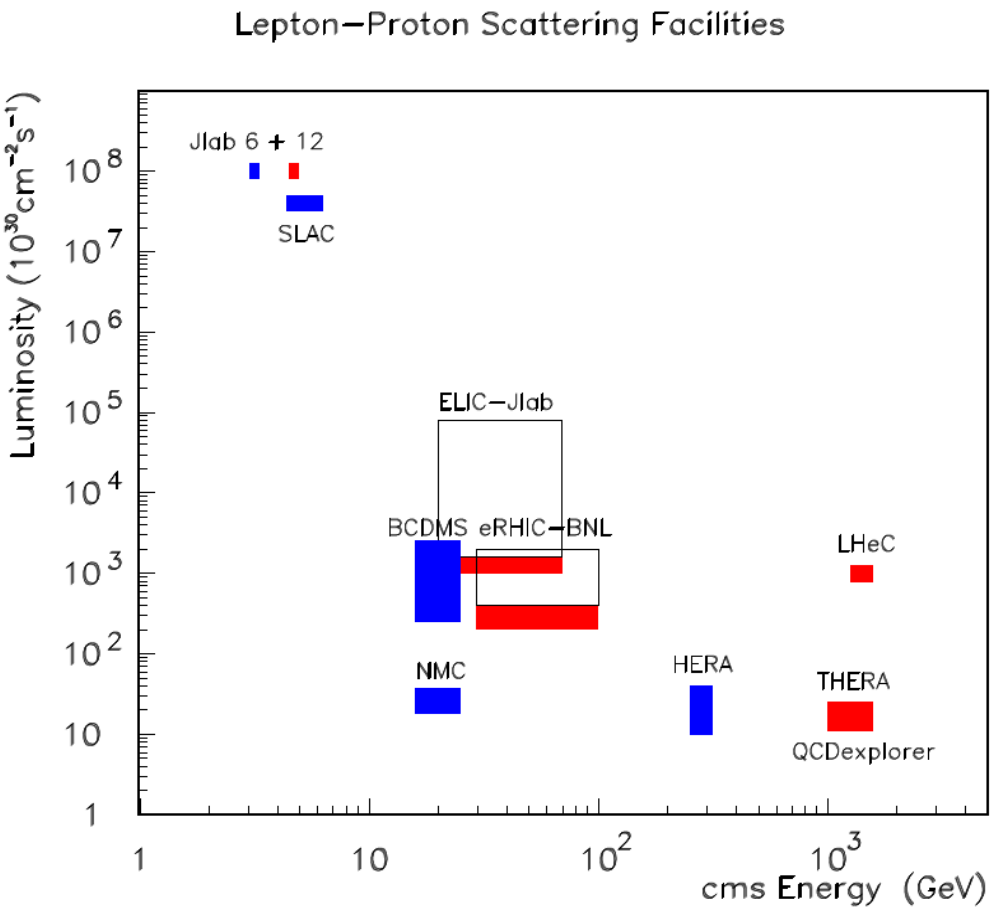
The physics, and a design, of a Large Hadron Electron Collider (LHeC) are sketched. With high luminosity, $10^{33}\mathrm{cm}^{-2}\mathrm{s}^{-1}$, and high energy, $\sqrt{s} = 1.4\,\mathrm{TeV}$, such a collider can be built in which a 70 GeV electron (positron) beam in the LHC tunnel is in collision with one of the LHC hadron beams and which operates simultaneously with the LHC. The LHeC makes possible deep-inelastic lepton-hadron (ep, eD and eA) scattering for momentum transfers Q^2 beyond $10^6\,\mathrm{GeV}^2$ and for Bjorken x down to the 10^{-6}. New sensitivity to the existence of new states of matter, primarily in the lepton-quark sector and in dense partonic systems, is achieved. The precision possible with an electron-hadron experiment brings in addition crucial accuracy in the determination of hadron structure, as described in Quantum Chromodynamics, and of parton dynamics at the TeV energy scale. The LHeC thus complements the proton-proton and ion programmes, adds substantial new discovery potential to them, and is important for a full understanding of physics in the LHC energy range.

*Contributed to the Open Symposium on European Strategy for Particle Physics Research, LAL Orsay, France, January 30th to February 1st, 2006.

Context

Latest of several proposals to increase cms energy in ep physics … but with unprecedented lumi!

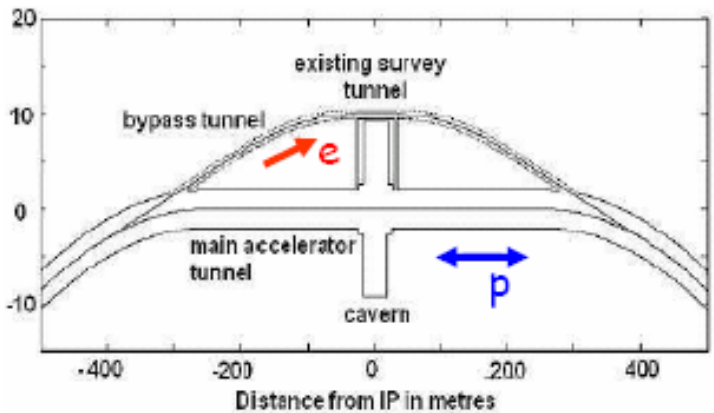




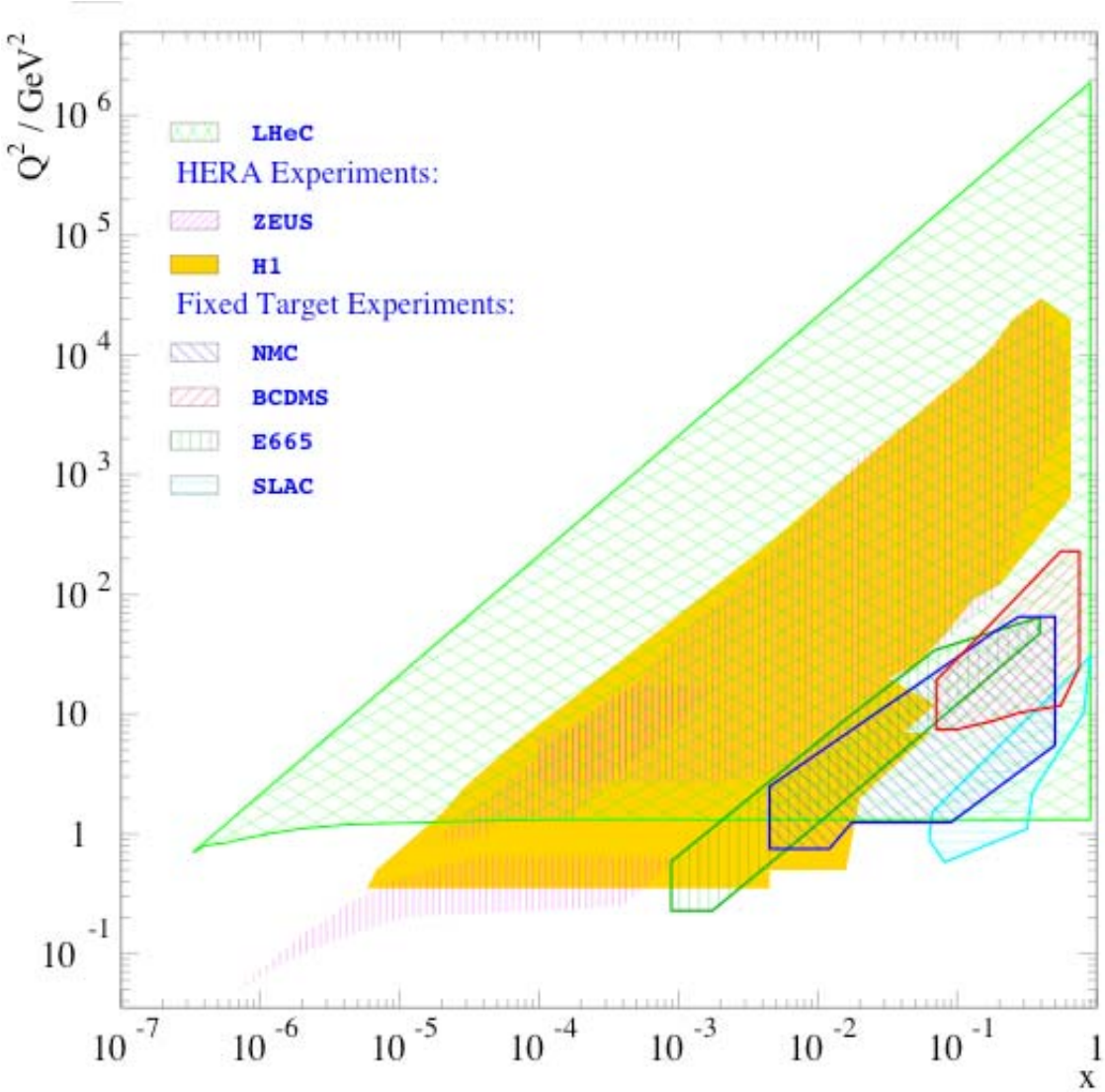
Motivated by discovery / spectroscopy of eq bound states, but also by the low x frontier … naturally building on high density QCD `discoveries' and developments at HERA

Basic Principle

- On timescale of LHC upgrades
- Run ep in parallel with high lumi pp operation by adding e beam with energy 70GeV, current 70mA, bunch spacing 25ns …
- …luminosity $10^{33}cm^{-2}s^{-1}$
- New detector required, possibly replacing LHCb at end of their programme



Inclusive Kinematics



$E_e = 70$ GeV

$E_p = 7$ TeV

$\sqrt{s} = 1.4$ TeV

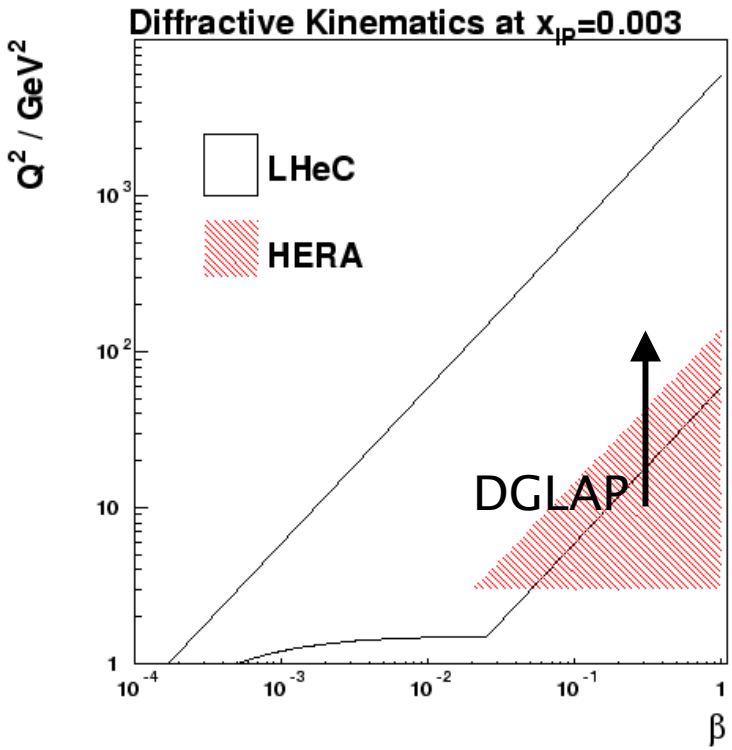
$M_{eq} \leq 1.4$ TeV

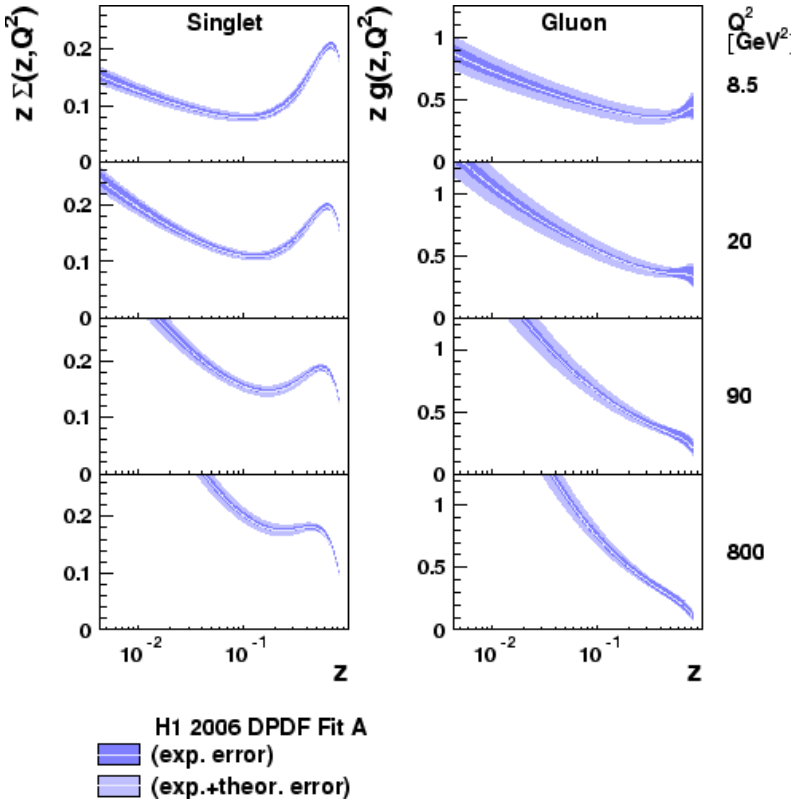
$Q^2 \leq 2.10^6$ GeV^2

$W \leq 1.4$ TeV

$x \geq 5.10^{-7}$ at $Q^2 \leq 1$ GeV^2

Diffractive Kinematics

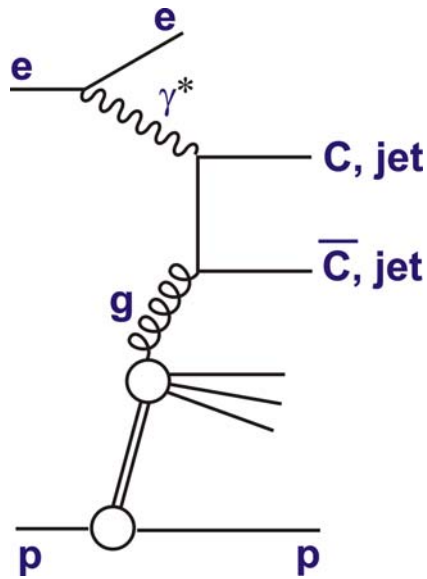


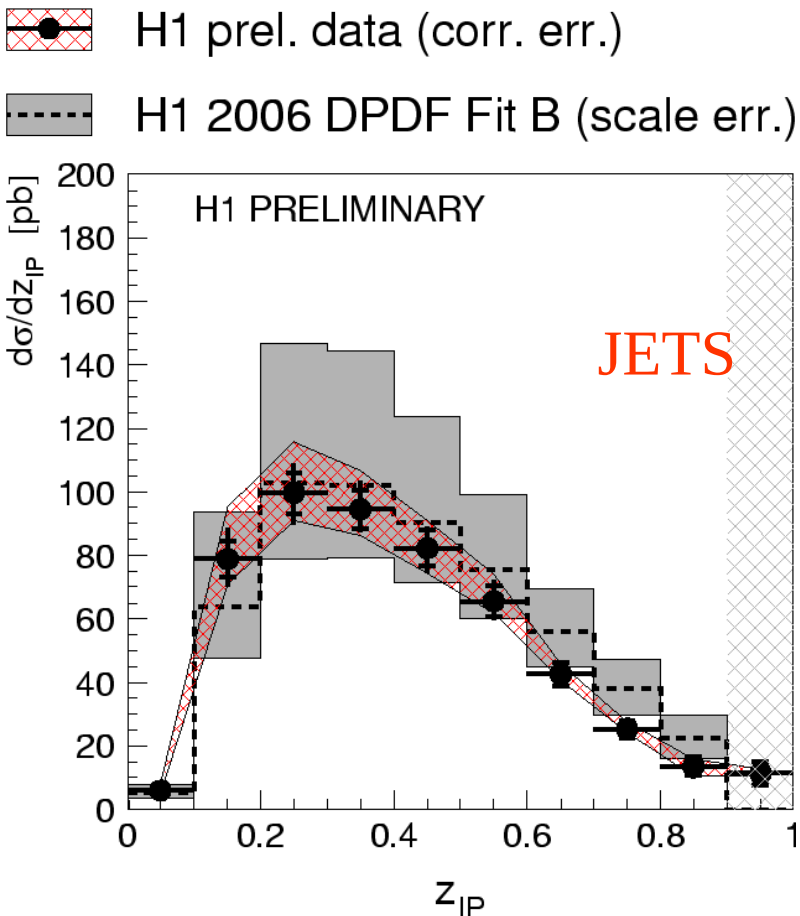


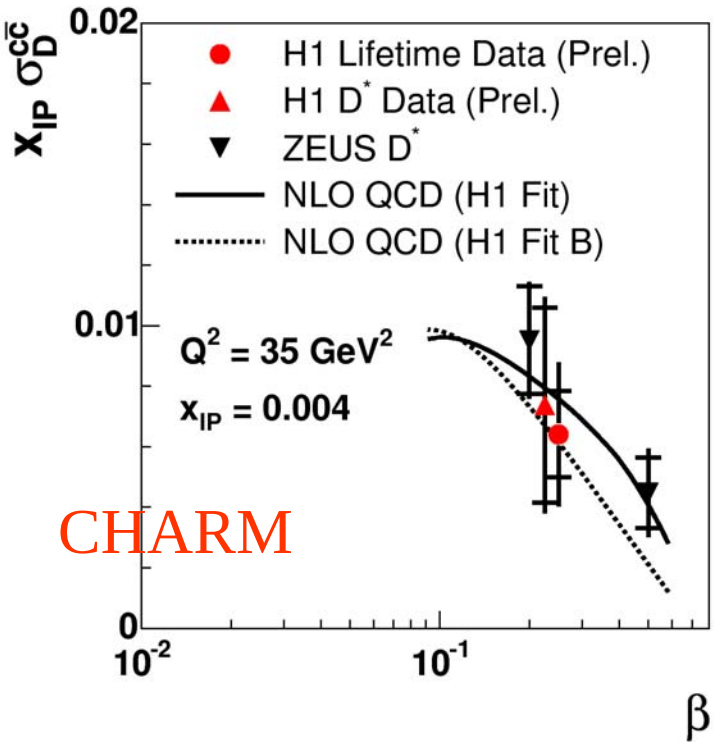
- Factorisation tests / DGLAP applicability / gluon: DPDFs extracted from HERA data predict LHeC cross section at moderate to large β but higher Q2.
- New dynamics: LHeC opens new low β region – parton saturation, BFKL etc showing up first in diffraction?
- eA: Enhanced opportunities to study saturation / shadowing…

Final States in Diffraction

- Factorisation tests done at HERA with gluon initiated jet / charm processes… "success!"…
- BUT kinematically restricted to high β region where F_2^D is least sensitive to the gluon!

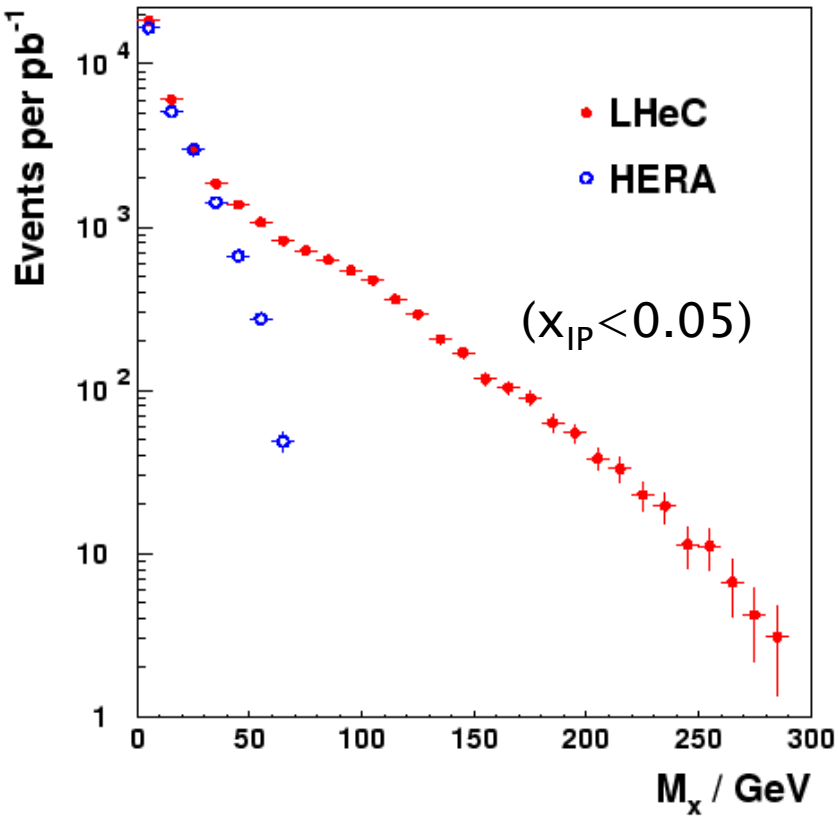






Final States in Diffraction at the LHeC

(RAPGAP simulation)



- At LHeC, diffractive masses M_x up to hundreds of GeV can be produced with low x_{IP}

- Low β, low x_{IP} region for jets and charm accessible… much better DPDF studies

- New diffractive channels … beauty, W / Z bosons

- Unfold quantum numbers / precisely measure exclusively produced new / exotic 1^- states

- Massive extension in x, W range for vector mesons, DVCS …

Detector Considerations

HERA E_e=30GeV → ← E_p=920GeV

LHeC E_e=70GeV → ← E_p=7000GeV

- Considerably more asymmetric than HERA!

- Accessing x_{IP} = 0.05 with rapidity gap method would require η_{max} cuts in the region 6-8…
…forward instrumentation essential!

- Roman pots, FNC should clearly be an integral part

- The work going on in this community (Totem, FP420 …) already tells us a lot about what is (not) achievable and may provide recyclable technology. Dedicated studies needed!

Summary

LHC is a totally new world of energy and luminosity

LHeC is the natural place to go if there is a will to include ep physics and pursue low x physics / diffraction further.

This taster was based on a very quick first study (1/2 day!)

Surely there is much more to be done to fully evaluate the physics potential!

Tentative plan to hold a workshop in October 26-28.

All are invited to think about the possibilities (easy) or contribute (harder!)