A new detector for deep inelastic physics

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on behalf of the LHEC Collaboration

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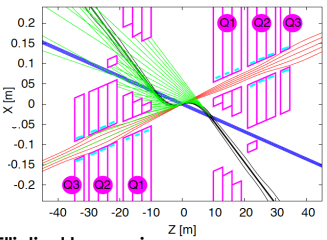
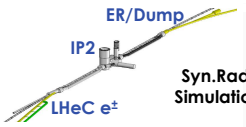
Abstract

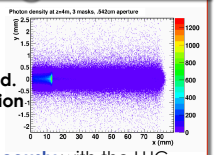
The Large Hadron electron Collider, with a multi-purpose detector, has a unique physics programme of deep inelastic scattering, which can be pursued with unprecedented precision over a hugely extended kinematic range. This contribution summarises the design concepts for a new detector, which combine the demands of very high precision with those of large acceptance into a novel device for electron-proton and electron-ion physics at TeV energies. The physics and technical requirements, choices of detector techniques and the integration of the detector with the 3 beam interaction region including its magnet designs are presented. With increasing luminosity the LHeC becomes a precision Higgs research facility.

LHeC Location and Interaction Region

Civil engineering, access, and constraints of the LHC experiments leave **IP2** as the only viable option to host a detector



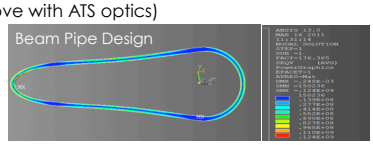




- The LHeC will run **simultaneously** with the LHC, means a **3 beam IP** with compatible optics
- Head-on collisions: large synchrotron radiation fan from outgoing e± beam, **dipoles along the whole beam-pipe (±9m)** required to minimise crossing angle and to get high luminosity (might improve with ATS optics)

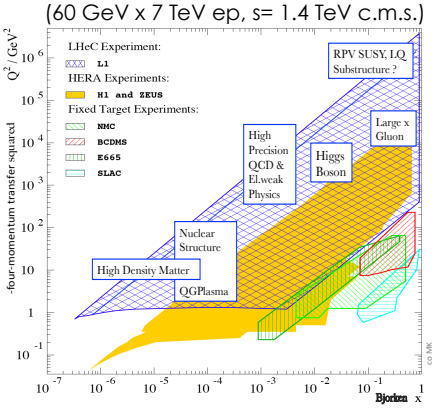
Elliptical beam-pipe necessary:

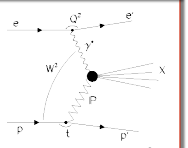
- Inner dimensions employed: circular(x)=2.2cm, elliptical(-x)=10cm & (y)=2.2cm
- CDR: 6m length, Beryllium 2.5-3mm thickness(!), composites also investigated



Physics Program

(60 GeV x 7 TeV ep, s= 1.4 TeV c.m.s.)





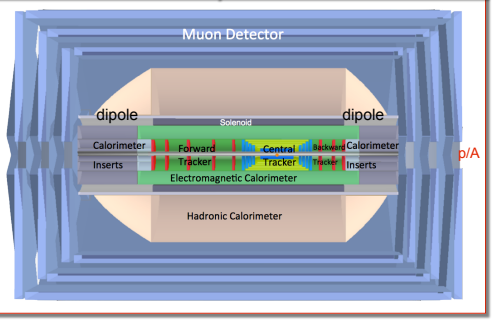
High mass (M_{eq},Q^2) frontier

EW & Higgs Q^2 lever-arm at moderate & high x → PDFs

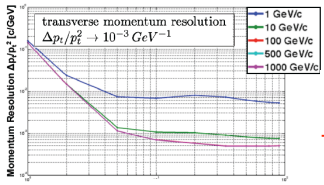
Low x frontier [x below 10^{-6} at Q^2 ~ 1 GeV^2]

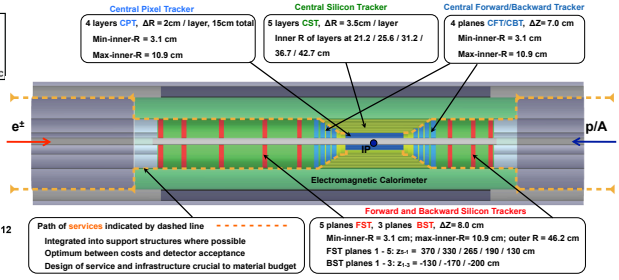
eA →down to x~10^{-6} → novel QCD ...

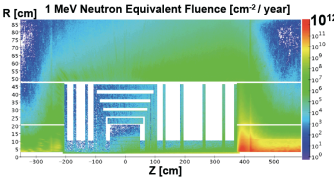
Detector Layout



Tracking System

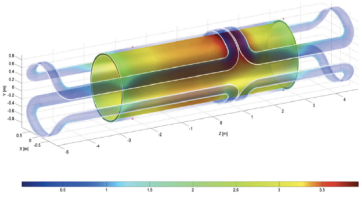


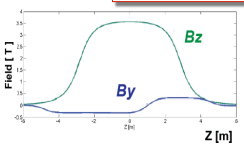




Very compact design, contained within the EMC
More coverage in the proton direction: dense forward jet production (down to 1° in θ)
Services and Infrastructure need very careful design being the main contributor to Material Budget

Magnet System





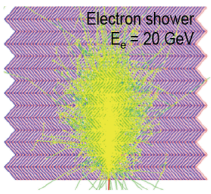
3.5 T coil options considered, placed around the EMC part within the solenoid. Super conducting solenoid and **dipoles (~0.3T)** are placed within the same cold vacuum vessel, but no muon measurement. Impact of dead material between EMC and HAC under study →

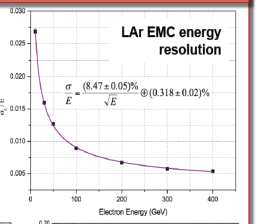
The Calorimetry

EMC LAr Calorimeter
10%/√E EMC 25-30 X_0

HAC Barrel Iron+Tile Scintillator
40%/√E, full containment 7-9 λ_I

Geant4+Fluka Simulation
(including Magnets complex)

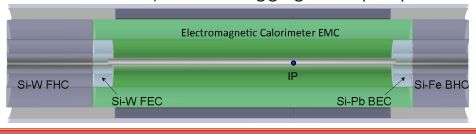




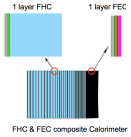
Forward and Backward Electromagnetic and Hadronic Calorimeter inserts:

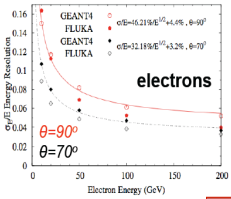
- FEC+FHC: High granularity radiation hard Si-W, high jet energy resolution
- BEC+BHC: Needed for precise e-tagging, Si-Pb (BEC) and Si-Fe/Cu (BHC)

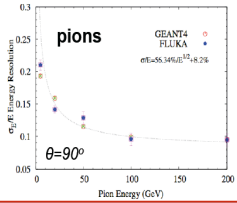
FEC: ~30 X_0
FHC: ~ 8-10 λ_I

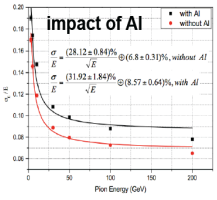


BEC: ~25 X_0
BHC: ~ 6-8 λ_I



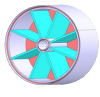


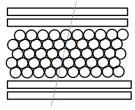


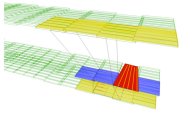


Muons

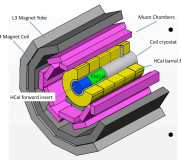
Muon system with 2-3 super-layers surrounding the central detector. Baseline: muon tagging, no independent momentum measurement and use technologies as at LHC (and elsewhere).
Extensions possible: Independent momentum measurement: → larger solenoid or dual coil system with all of calorimeter within inner coil; in forward region: toroid (air core design)







On–site Installation



- Detector assembled on surface as much as possible: ~16 months
  Three months commissioning of coil system on site; preparation for lowering: 1 month; parallel installation of muons, tracker, EMC: 6 months
- Estimated total time: **30 month**

Conclusions

A LHeC baseline detector concept has been worked out, see CDR for full details:
J. Phys. G39 (2012) 075001, arXiv:1206.2913
The design depends heavily on the constraints from the machine and the interaction region and the LHC program. A feasible and affordable concept, fulfilling the physics requirements has been presented. Many improvements may become available; a more precise design will follow from more detailed simulations, engineering and knowledge of machine constraints, aiming at building a collaboration during the Technical Design Phase