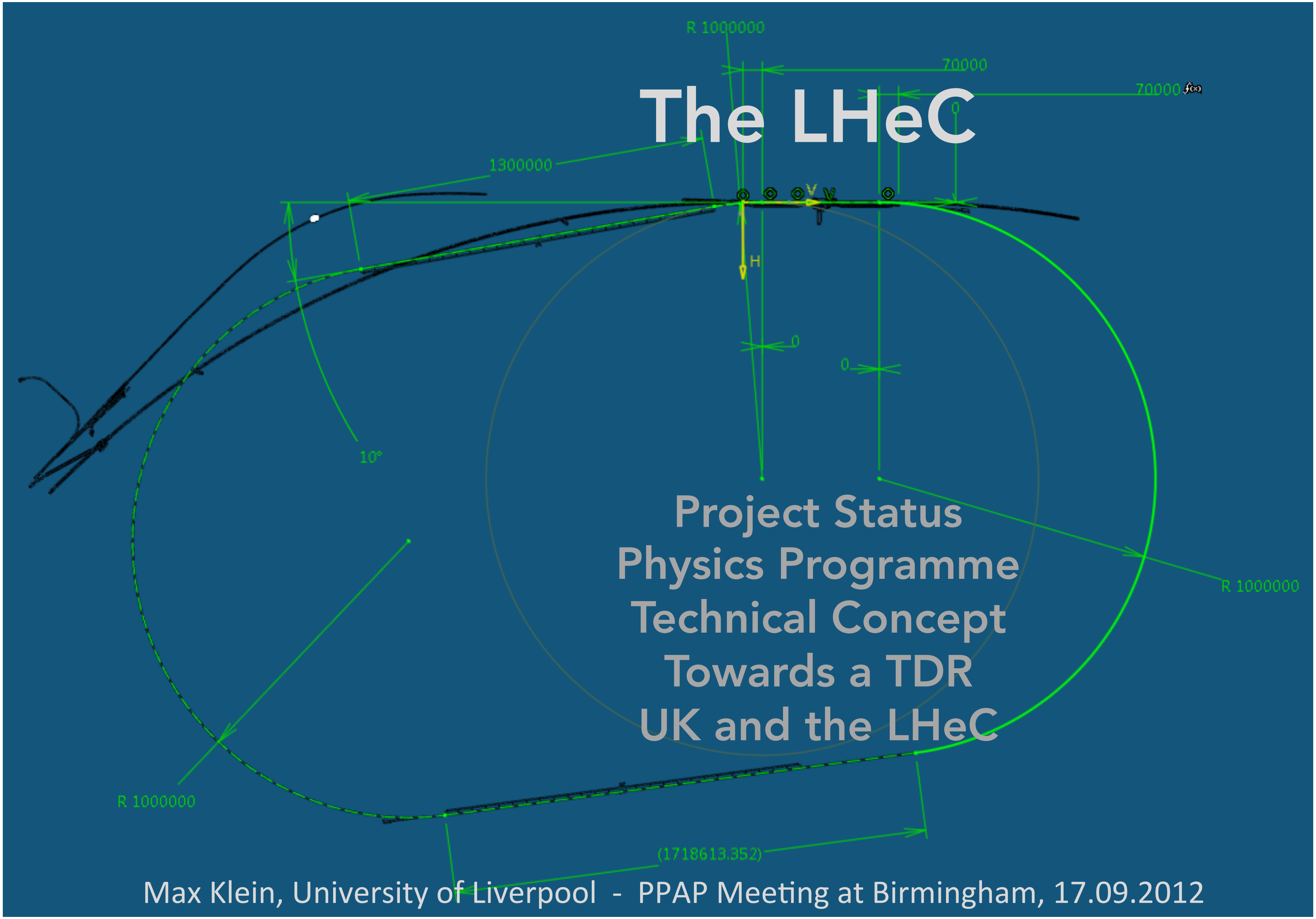
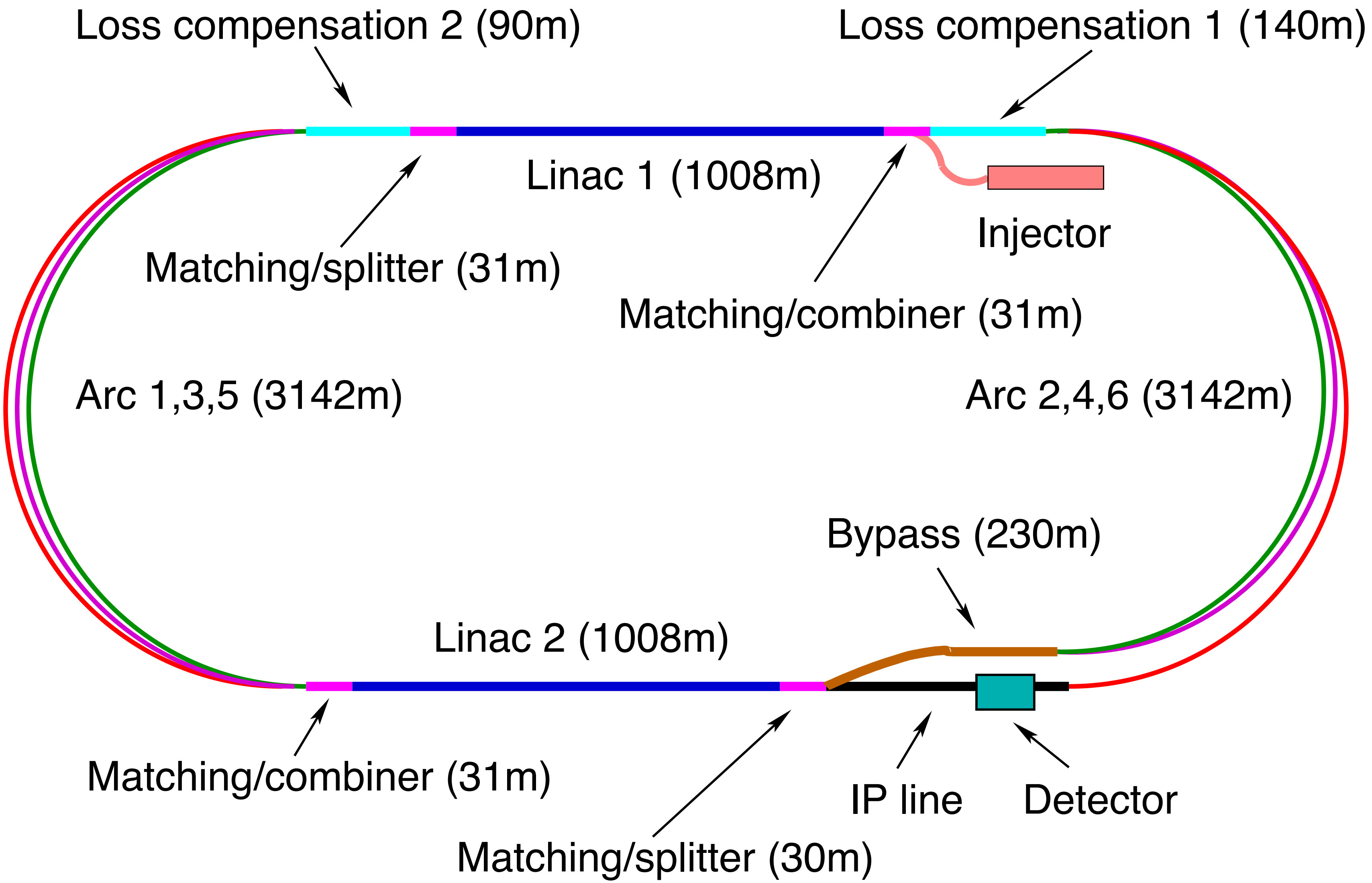
The LHeC



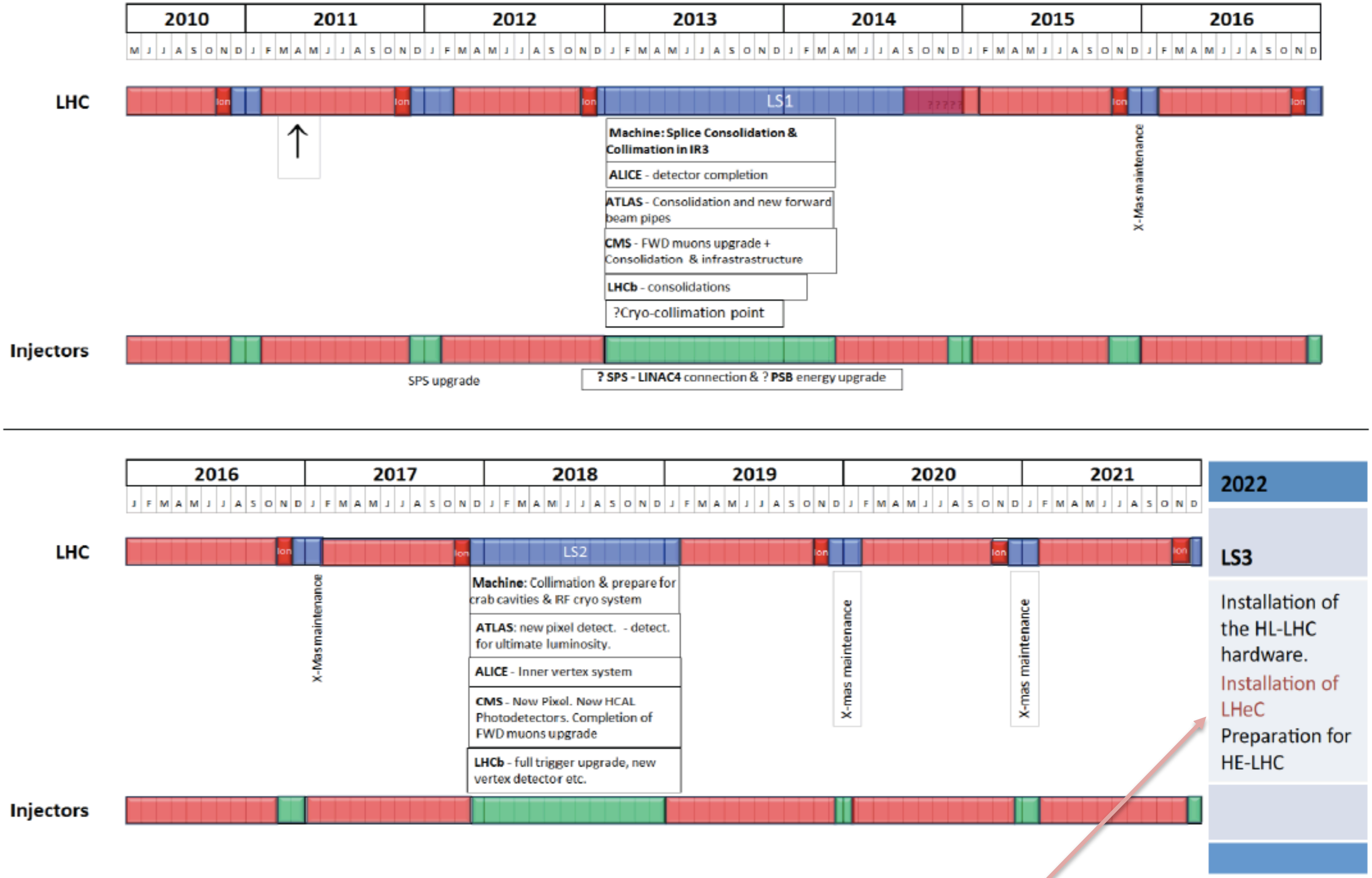
Project Status
Physics Programme
Technical Concept
Towards a TDR
UK and the LHeC

Max Klein, University of Liverpool - PPAP Meeting at Birmingham, 17.09.2012



60 GeV electron beam energy, L= 10^{33} $cm^{-2}s^{-1}$, √s=1.3 TeV: Q^2_{max} 10^6 GeV^2, $10^{-6} < x < 1$
Recirculating linac (2 * 1km, 2*60 cavity cryo modules, 3 passes, P < 100 MW, ERL)

LHC Schedule for the coming decade



Machine: Splice Consolidation & Collimation in IR3

ALICE - detector completion

ATLAS - Consolidation and new forward beam pipes

CMS - FWD muons upgrade + Consolidation & infrastrastructure

LHCb - consolidations

?Cryo-collimation point

? SPS - LINAC4 connection & ? **PSB** energy upgrade

Machine: Collimation & prepare for crab cavities & RF cryo system

ATLAS: new pixel detect. - detect. for ultimate luminosity.

ALICE - Inner vertex system

CMS - New Pixel, New HCAL Photodetectors. Completion of FWD muons upgrade

LHCb - full trigger upgrade, new vertex detector etc.

LS3

Installation of the HL-LHC hardware.

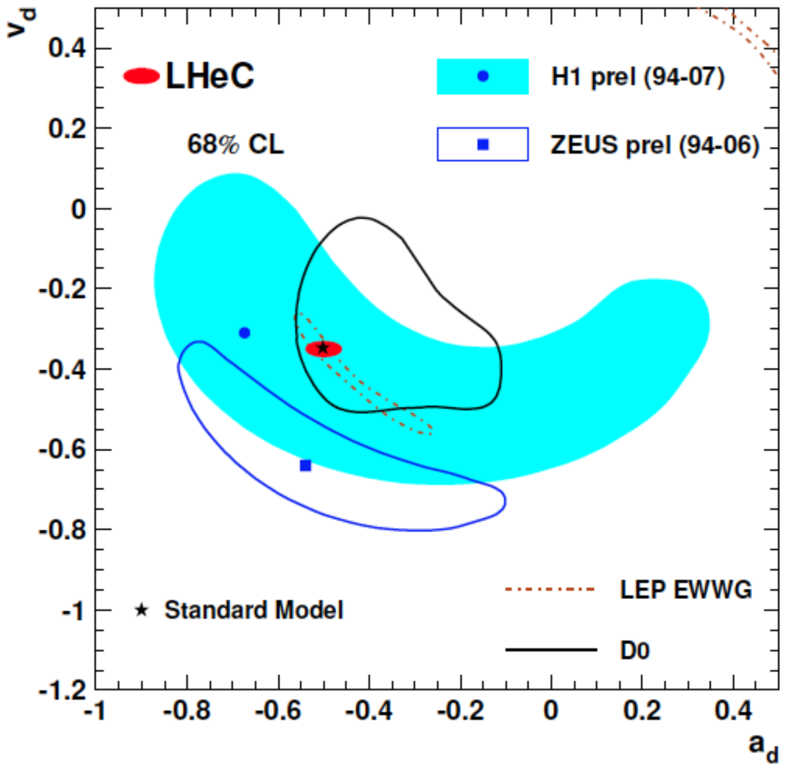
Installation of LHeC

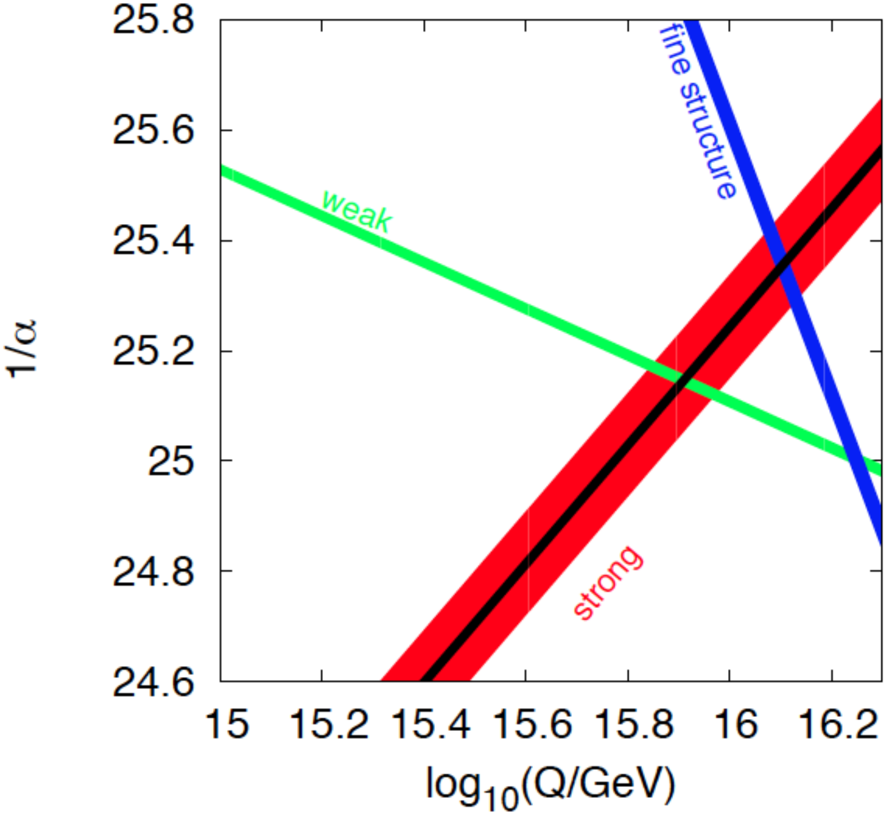
Preparation for HE-LHC

Figure 11.1: CERN medium term plan (MTP), draft as of July 2011

as shown by S. Myers at EPS 2011 Grenoble - Principal guidance of CDR

High Precision DIS



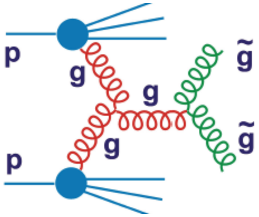


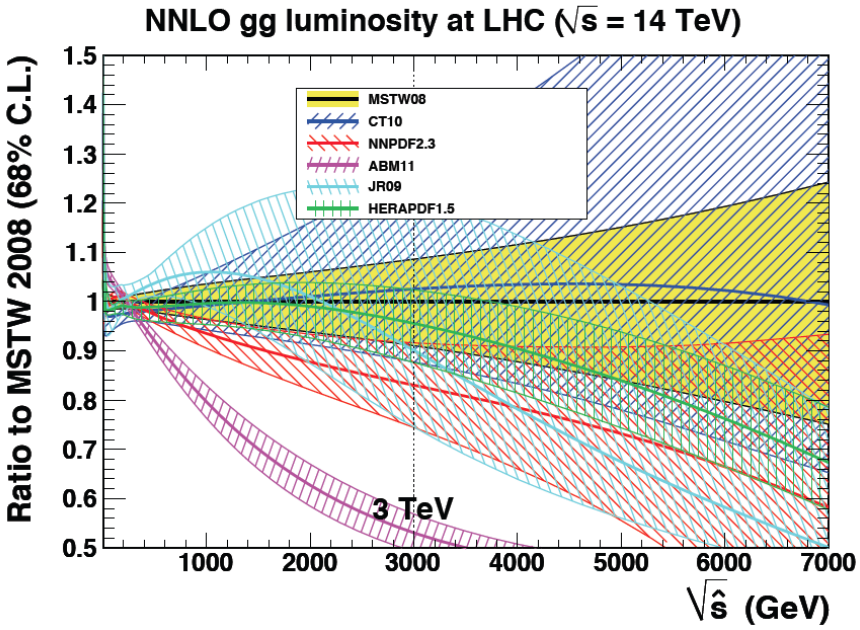
$Q^2 >> M_{Z,W}^2$, hi luminosity, large acceptance
Unprecedented precision in NC and CC
Contact interactions probed to 50 TeV
Scale dependence of $\sin^2\theta$ left and right to LEP

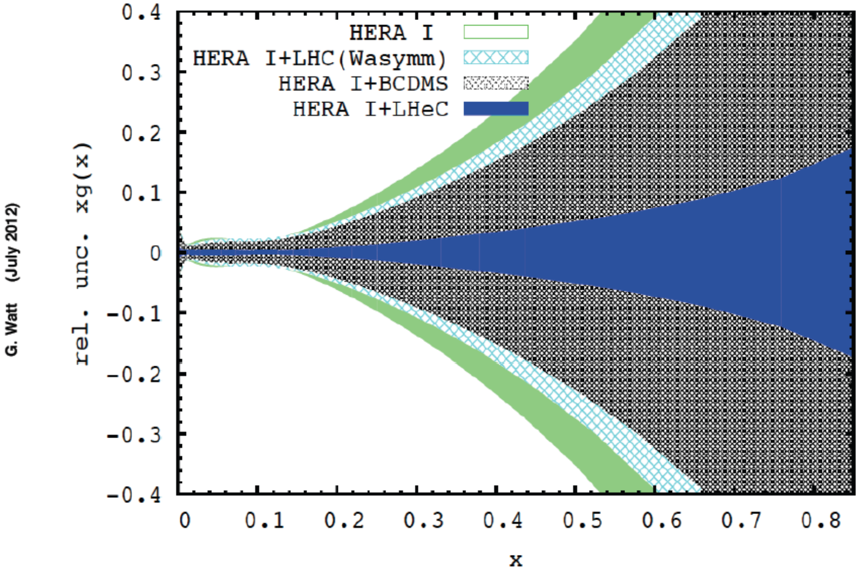
→ **A renaissance of deep inelastic scattering** ←

Solving a 40 year puzzle:
α_s small in DIS or high with jets?
Per mille measurement accuracy
Testing QCD lattice calculations
Constraining GUT (CMSSM40.2.5)
Charm mass to 3MeV, N^3LO

LHeC and the HL-LHC (SUSY searches)







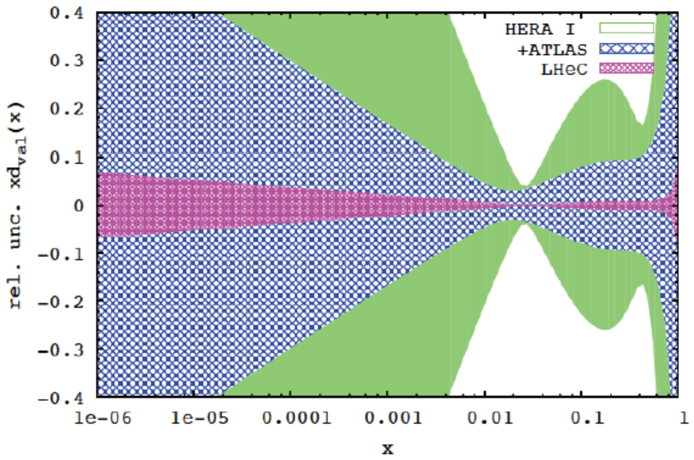
With high energy and luminosity, the LHC search range will be extended to high masses, up to 5 TeV in pair production. At correspondingly high x (> 0.5) the PDFs are unknown to a considerable extent [cf gg luminosity → ğğ and gluon density from LHeC (10% at x=0.6)]

The HL-LHC (search) programme requires a much more precise understanding of QCD, which the LHeC provides (strong coupling, gluon, valence, factorisation, saturation, diffraction..)

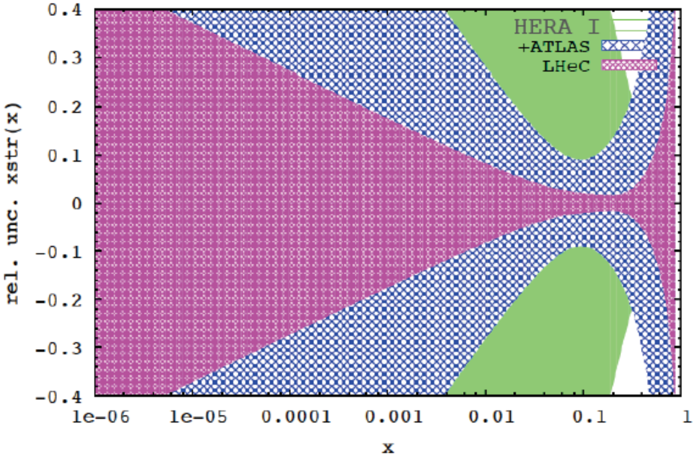
PDFs from HERA+LHC and LHeC

QCD fit with free u,d,s, HERA plus ultimate ATLAS and full systematic error simulation on LHeC

d valence



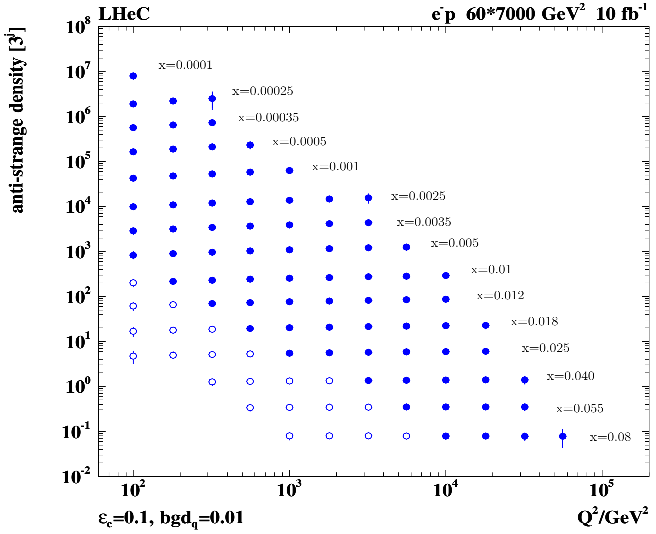
strange



DIS is the appropriate process to determine PDFs (just compare HERA – Tevatron PDF constraints)

LHeC: first time ever to fully determine PDFs, free of symmetry and ad hoc assumptions in huge and unexplored kinematic range

LHC: precision Drell-Yan data provide constraints *(cf for example the ATLAS determination of s/d)* Yet, high precision (<1%) only achievable at W,Z scale (miss the evolution) and large eweak-QCD theory uncertainties complicate interpretation



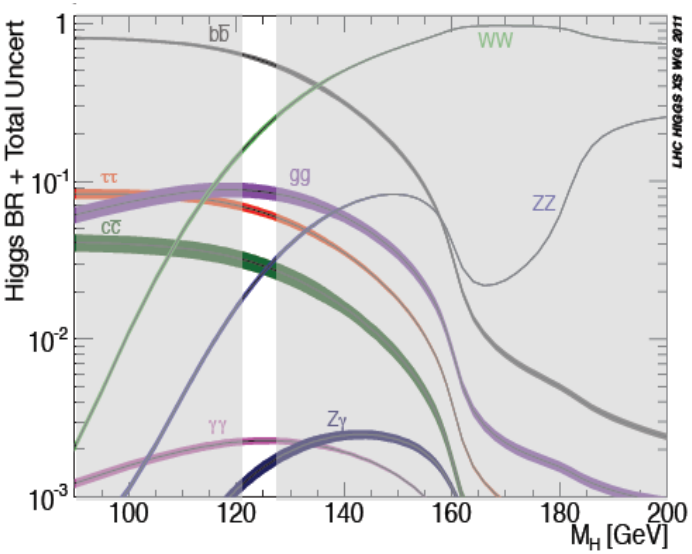
Direct strange measurement from charged current Ws→c in ep → νcX [high lumi, large range, small spot ~7μm^2]

Higgs and LHeC

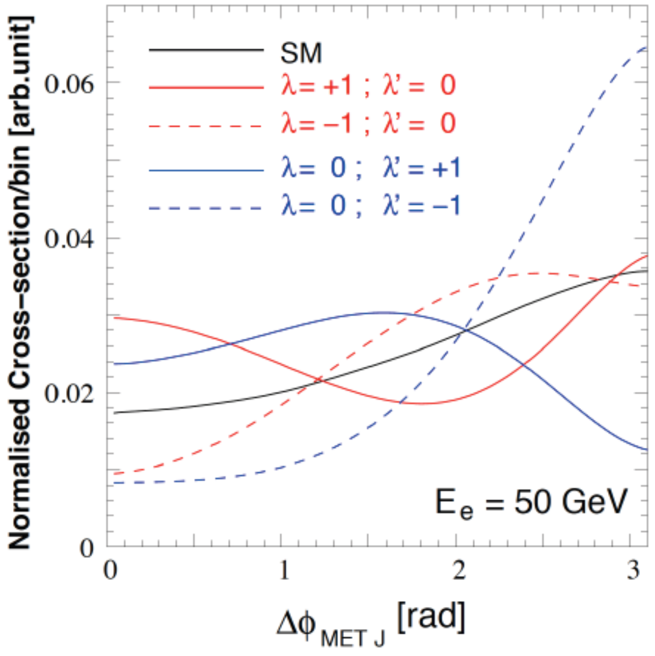
Precision measurements of couplings in WW and ZZ production (so far: bb in CC to 4%)
Measurement of CP properties ($J^{PC}=0^{++}$ in SM; MSSM has 2 CP-even and 1 CP-odd states)
Reduction of theoretical uncertainties for pp measurements

Initial study of WW → H → bb

PGS for detector, cut based analysis,
S/N =1, 500 H-bb events for $100 fb^{-1}$



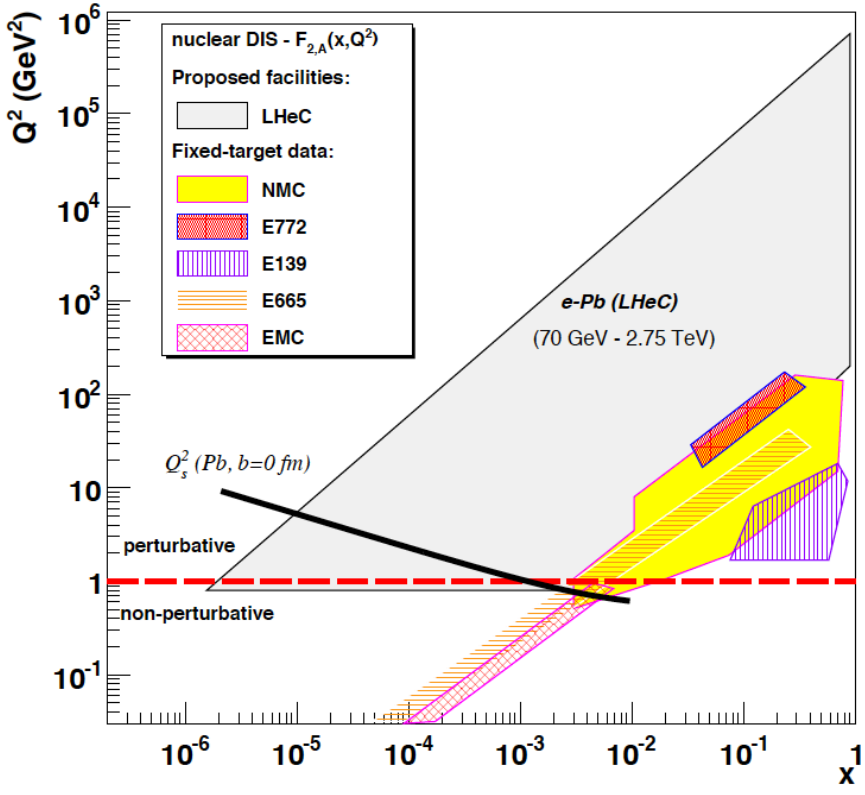
$$\Gamma^{(\mathrm{BSM})}_{\mu\nu}(p,q) = \frac{-g}{M_W}\left[\lambda\,(p.q\, g_{\mu\nu} - p_\nu q_\mu) + i\,\lambda'\,\epsilon_{\mu\nu\rho\sigma} p^\rho q^\sigma\right]$$

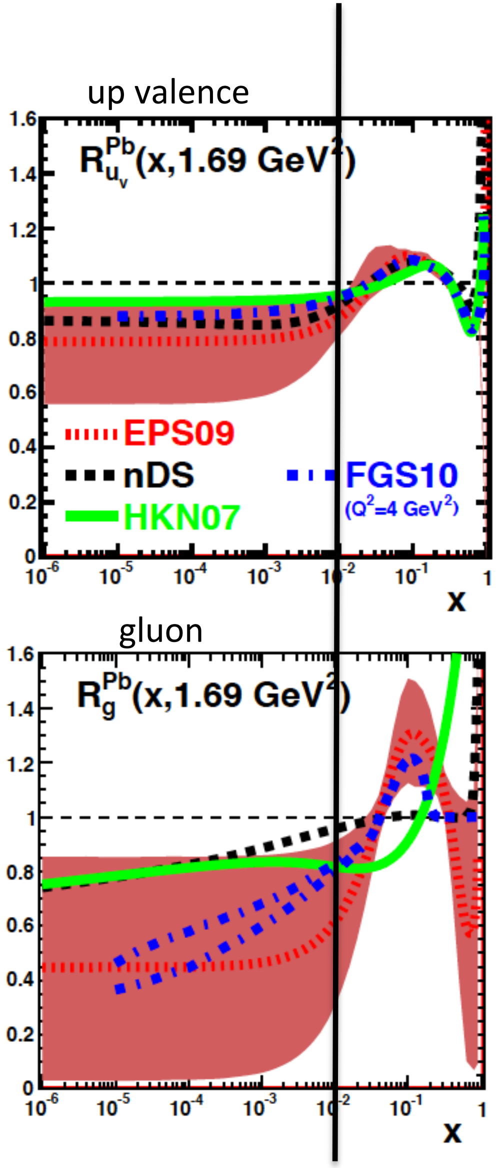


ICHEP12: J Campbell: ultimate limitation of Higgs measurements from LHC by PDFs/QCD

With high luminosity the LHeC has a huge potential for precision Higgs physics, which is being further evaluated.

Heavy Ion Physics



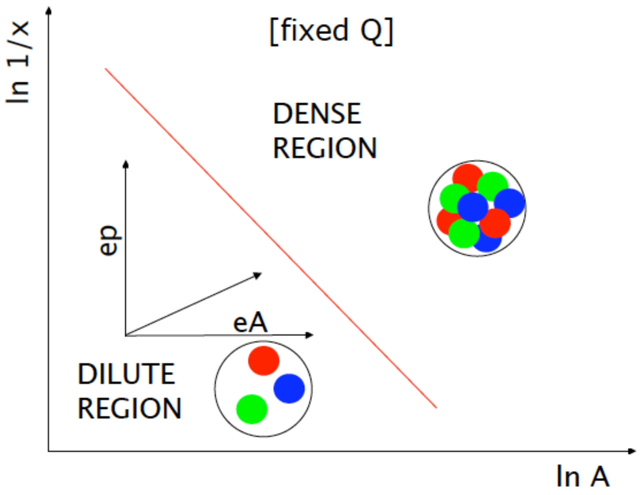


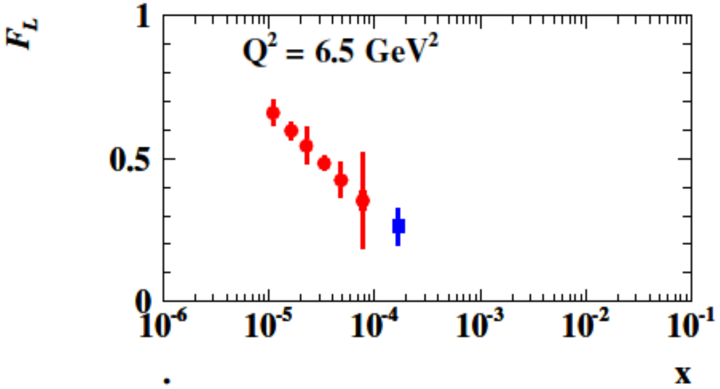
unmeasured | known?

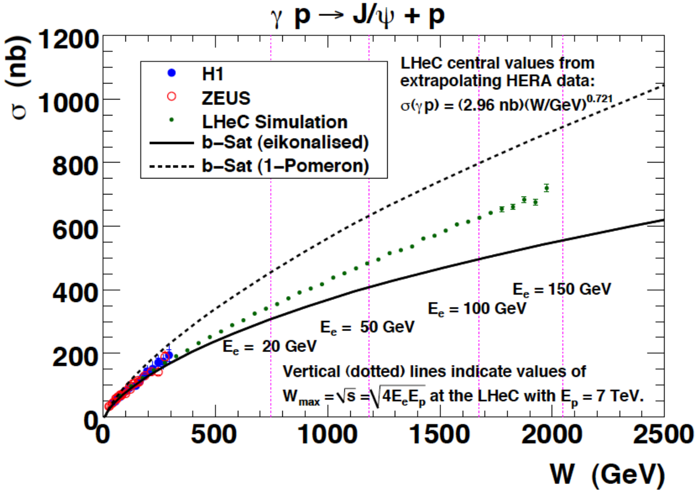
eA physics is essentially not done yet (no eA at HERA)
LHeC has huge discovery potential for new HI physics
(bb limit, saturation, deconfinement, hadronisation..)
It will put nPDFs on completely new ground and constrain the initial conditions of the Quark-Gluon Plasma

Saturation – Low x Physics

Precision Measurements of crucial observables (F_2, F_L, J/ψ..



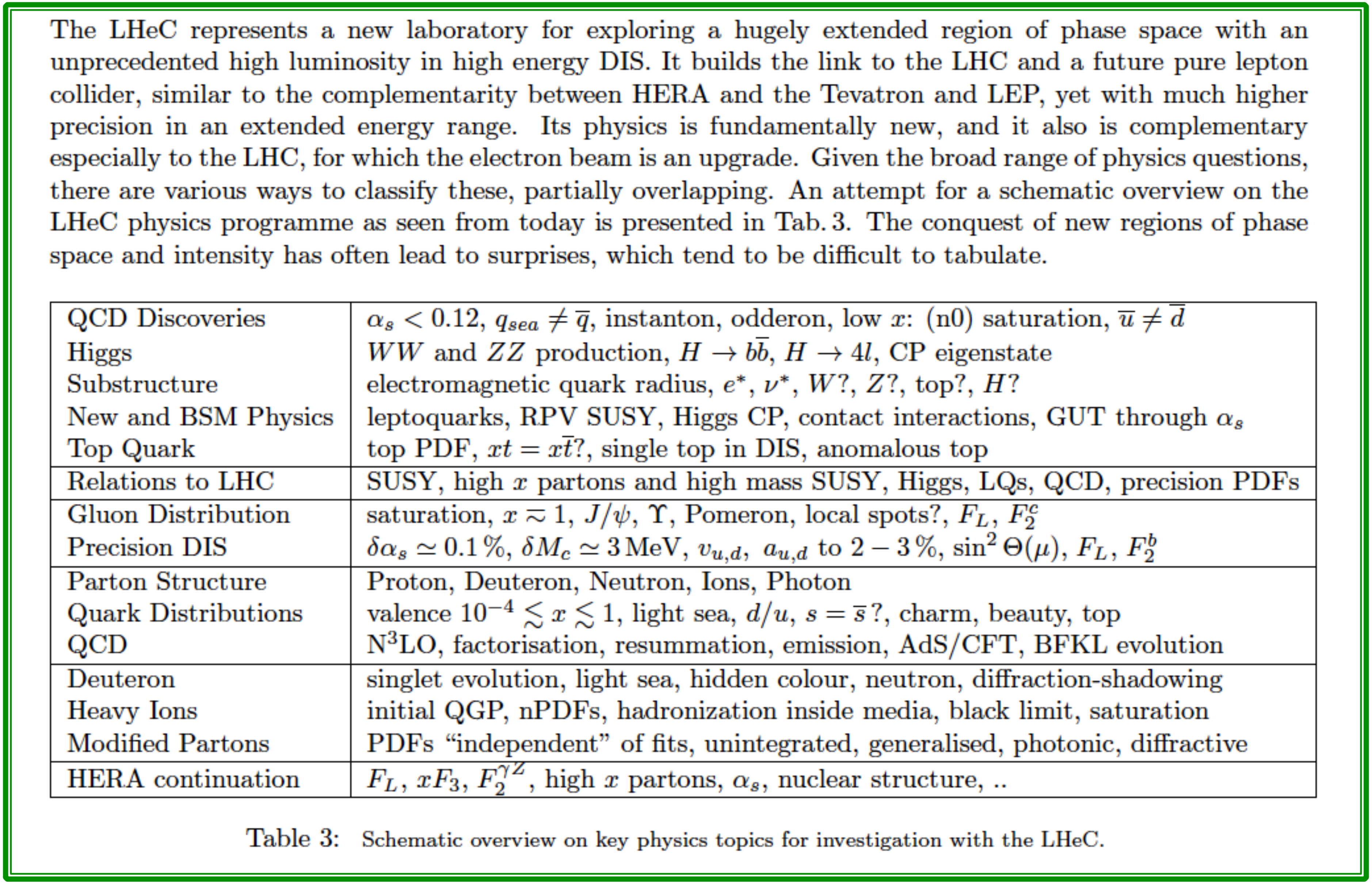




New phase of matter: small coupling but non-linear parton-parton interactions:

- End of DGLAP ? BFKL?
- Access to 10 TeV scale SUSY via BFKL ("DP") arXiv:1205.6713 Kowalski, Lipatov, Ross
- Restauration of unitarity?
- Relevant for UHE neutrino scattering

Summary of LHeC Physics [Cracow paper 147]



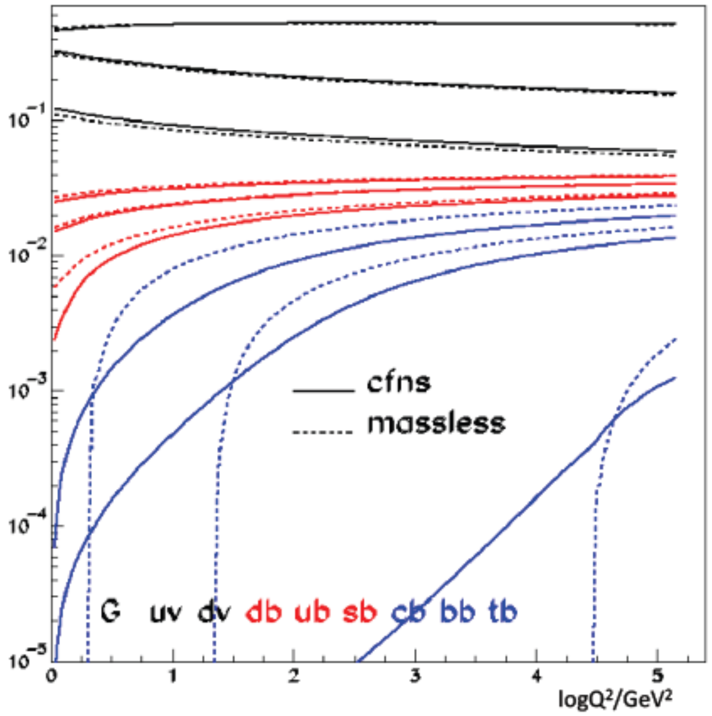
The LHeC represents a new laboratory for exploring a hugely extended region of phase space with an unprecedented high luminosity in high energy DIS. It builds the link to the LHC and a future pure lepton collider, similar to the complementarity between HERA and the Tevatron and LEP, yet with much higher precision in an extended energy range. Its physics is fundamentally new, and it also is complementary especially to the LHC, for which the electron beam is an upgrade. Given the broad range of physics questions, there are various ways to classify these, partially overlapping. An attempt for a schematic overview on the LHeC physics programme as seen from today is presented in Tab. 3. The conquest of new regions of phase space and intensity has often lead to surprises, which tend to be difficult to tabulate.

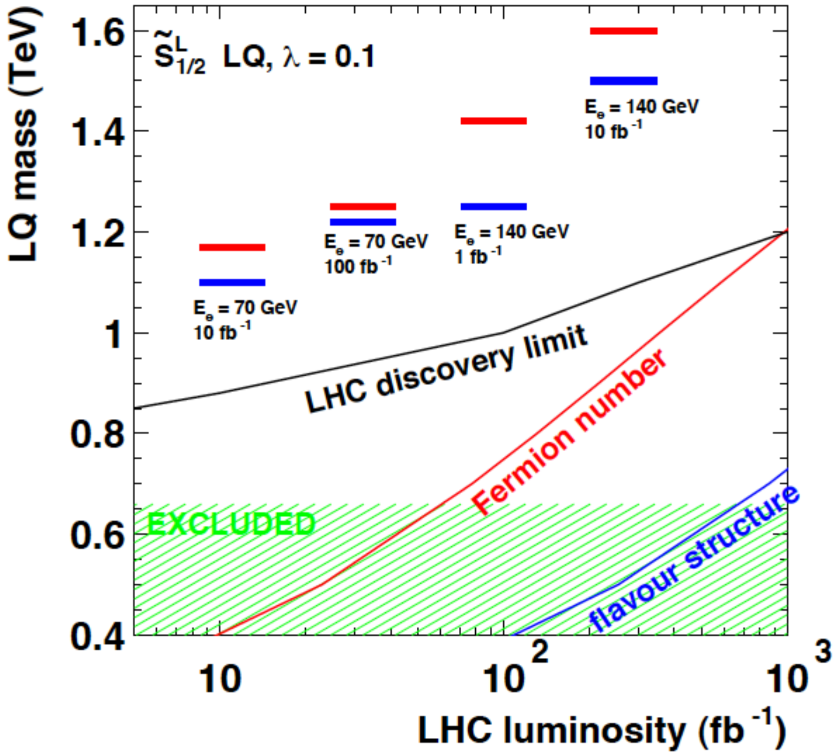
QCD Discoveries	$\alpha_s < 0.12$, $q_{sea} \neq \overline{q}$, instanton, odderon, low x: (n0) saturation, $\overline{u} \neq \overline{d}$
Higgs	WW and ZZ production, $H \to b\overline{b}$, $H \to 4l$, CP eigenstate
Substructure	electromagnetic quark radius, e^*, ν^*, W?, Z?, top?, H?
New and BSM Physics	leptoquarks, RPV SUSY, Higgs CP, contact interactions, GUT through α_s
Top Quark	top PDF, $xt = x\overline{t}$?, single top in DIS, anomalous top
Relations to LHC	SUSY, high x partons and high mass SUSY, Higgs, LQs, QCD, precision PDFs
Gluon Distribution	saturation, $x \approx 1$, J/ψ, Υ, Pomeron, local spots?, F_L, F_2^c
Precision DIS	$\delta\alpha_s \simeq 0.1\,\%$, $\delta M_c \simeq 3\,\mathrm{MeV}$, $v_{u,d}$, $a_{u,d}$ to $2-3\,\%$, $\sin^2\Theta(\mu)$, F_L, F_2^b
Parton Structure	Proton, Deuteron, Neutron, Ions, Photon
Quark Distributions	valence $10^{-4} \lesssim x \lesssim 1$, light sea, d/u, $s = \overline{s}$?, charm, beauty, top
QCD	N^{3}LO, factorisation, resummation, emission, AdS/CFT, BFKL evolution
Deuteron	singlet evolution, light sea, hidden colour, neutron, diffraction-shadowing
Heavy Ions	initial QGP, nPDFs, hadronization inside media, black limit, saturation
Modified Partons	PDFs "independent" of fits, unintegrated, generalised, photonic, diffractive
HERA continuation	F_L, xF_3, $F_2^{\gamma Z}$, high x partons, α_s, nuclear structure, ..

Table 3: Schematic overview on key physics topics for investigation with the LHeC.

Top Quark and Leptoquarks

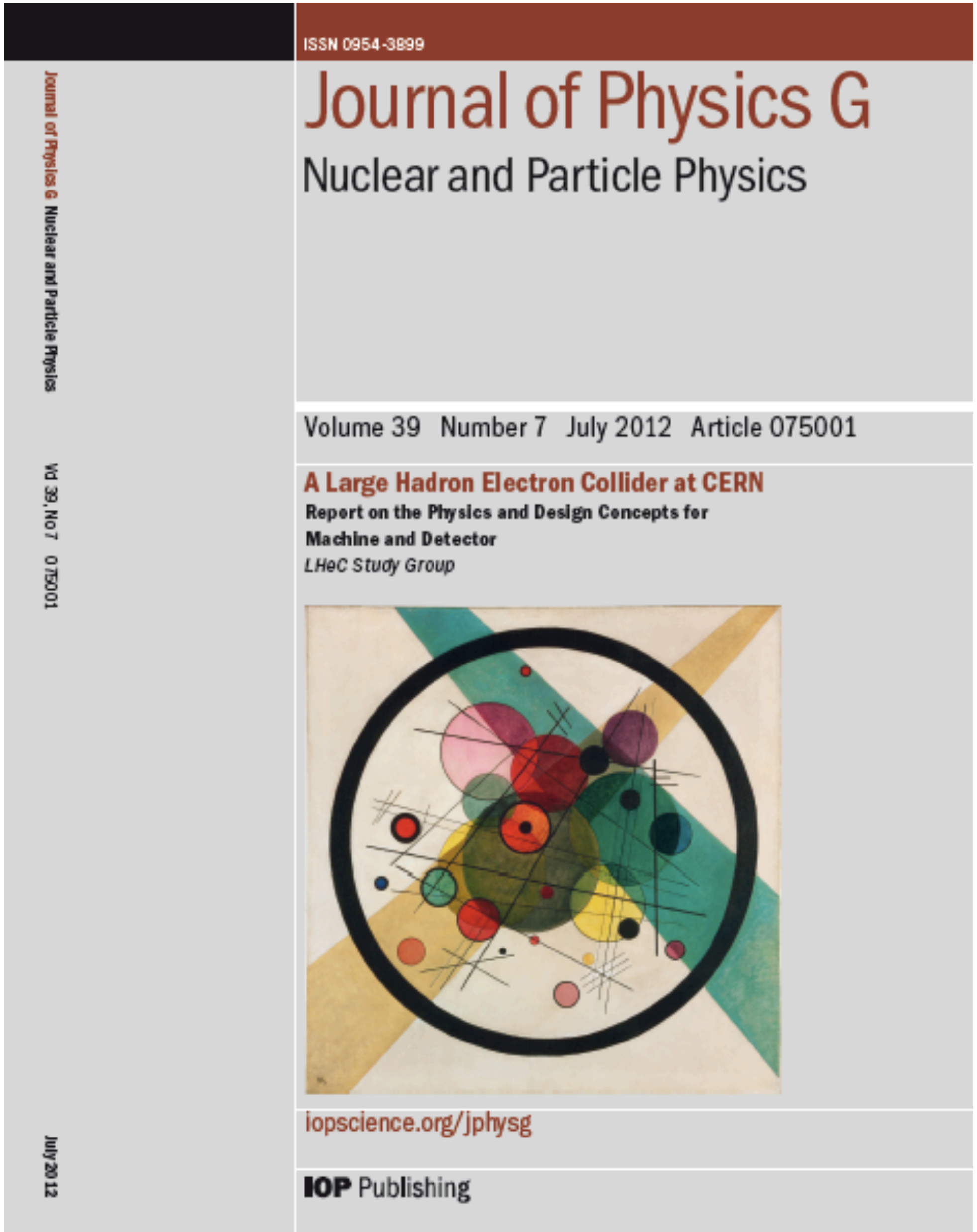
The LHeC is a (single) top quark production factory, via Wb → t. Top was never observed in DIS. With ep: top-PDF → 6 flavour VFNS, precision M_t direct and from cross section, anomalous couplings





Leptoquarks (-gluons) are predicted in RPV SUSY, E6, extended technicolour theories or Pati-Salam.

The LHeC is the appropriate configuration to do their spectroscopy, should they be discovered at the LHC.



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Nuclear and Particle Physics

Volume 39 Number 7 July 2012 Article 075001

A Large Hadron Electron Collider at CERN

Report on the Physics and Design Concepts for Machine and Detector

LHeC Study Group

iopscience.org/jphysg

IOP Publishing

CERN Referees

Ring Ring Design
Kurt Huebner (CERN)
Alexander N. Skrinsky (INP Novosibirsk)
Ferdinand Willeke (BNL)
Linac Ring Design
Reinhard Brinkmann (DESY)
Andy Wolski (Cockcroft)
Kaoru Yokoya (KEK)
Energy Recovery
Georg Hoffstaetter (Cornell)
Ilan Ben Zvi (BNL)
Magnets
Neil Marks (Cockcroft)
Martin Wilson (CERN)
Interaction Region
Daniel Pitzl (DESY)
Mike Sullivan (SLAC)
Detector Design
Philippe Bloch (CERN)
Roland Horisberger (PSI)
Installation and Infrastructure
Sylvain Weisz (CERN)
New Physics at Large Scales
Cristinel Diaconu (IN2P3 Marseille)
Gian Giudice (CERN)
Michelangelo Mangano (CERN)
Precision QCD and Electroweak
Guido Altarelli (Roma)
Vladimir Chekelian (MPI Munich)
Alan Martin (Durham)
Physics at High Parton Densities
Alfred Mueller (Columbia)
Raju Venugopalan (BNL)
Michele Arneodo (INFN Torino)

Published 600 pages conceptual design report (CDR) written by 200 authors from 60 Institutes and refereed by 24 world experts on physics, accelerator and detector, which CERN had invited.

CDR Model

2008-2012

Scientific
Advisory
Committee

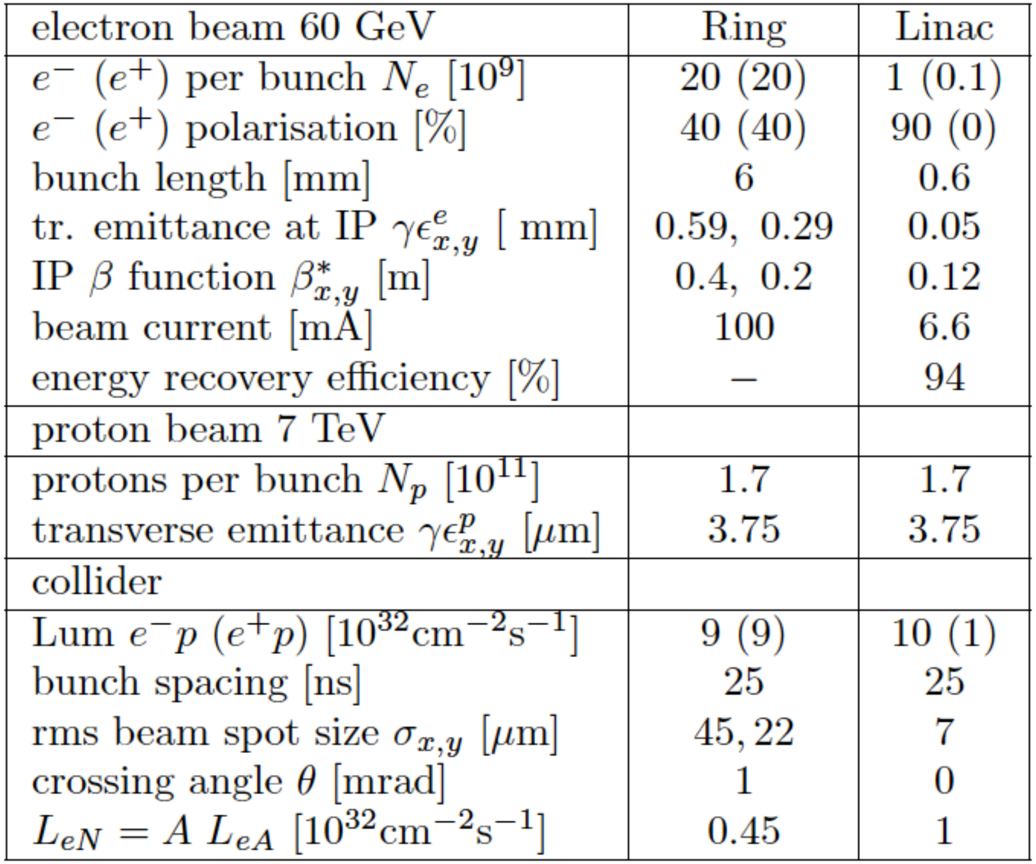
CERN
ECFA
NuPECC

Steering Group

- Accelerator
- Interaction Region
- Detector
- New Physics
- QCD and Electroweak
- High Parton Densities

Organisation of the LHeC Conceptual Design Report

LHeC Parameters

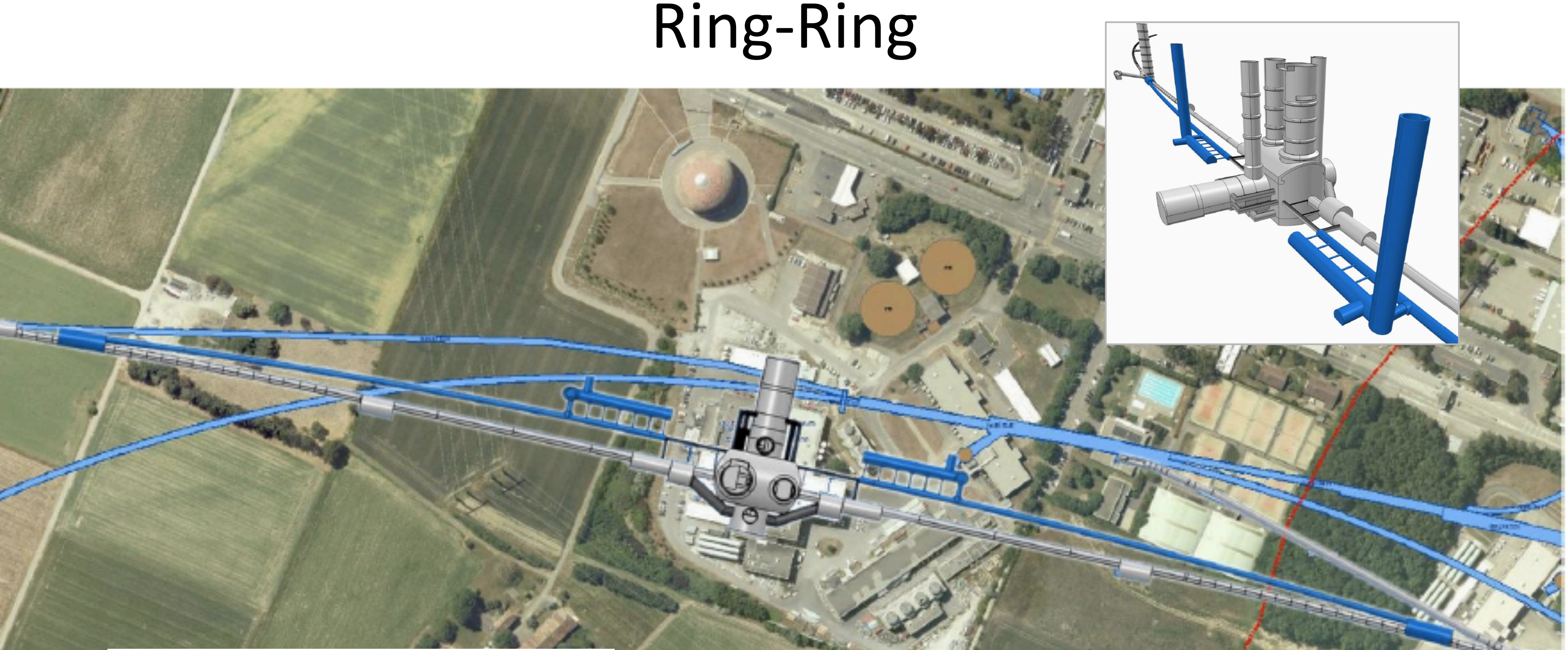


electron beam 60 GeV	Ring	Linac
e^- (e^+) per bunch N_e [10^9]	20 (20)	1 (0.1)
e^- (e^+) polarisation [%]	40 (40)	90 (0)
bunch length [mm]	6	0.6
tr. emittance at IP $\gamma\epsilon^e_{x,y}$ [mm]	0.59, 0.29	0.05
IP β function $\beta^*_{x,y}$ [m]	0.4, 0.2	0.12
beam current [mA]	100	6.6
energy recovery efficiency [%]	–	94
proton beam 7 TeV		
protons per bunch N_p [10^{11}]	1.7	1.7
transverse emittance $\gamma\epsilon^p_{x,y}$ [μm]	3.75	3.75
collider		
Lum e^-p (e^+p) [10^{32}cm^{-2}s^{-1}]	9 (9)	10 (1)
bunch spacing [ns]	25	25
rms beam spot size $\sigma_{x,y}$ [μm]	45, 22	7
crossing angle θ [mrad]	1	0
$L_{eN} = A\ L_{eA}$ [10^{32}cm^{-2}s^{-1}]	0.45	1

Source	Power [MW]
Cryogenics (linac)	21
Linac grid power	24
SR compensation	23
Extra RF cryopower	2
Injector	6
Arc magnets	3
Total	**78**

CDR: Two options for electron beam: Ring or (Racetrack) Linac with E-recovery for L > 10^{33}cm^{-2}s^{-1}
Synchronous operation of pp and ep in HL-LHC phase. e Ring required bypassing pp experiments

Ring-Ring



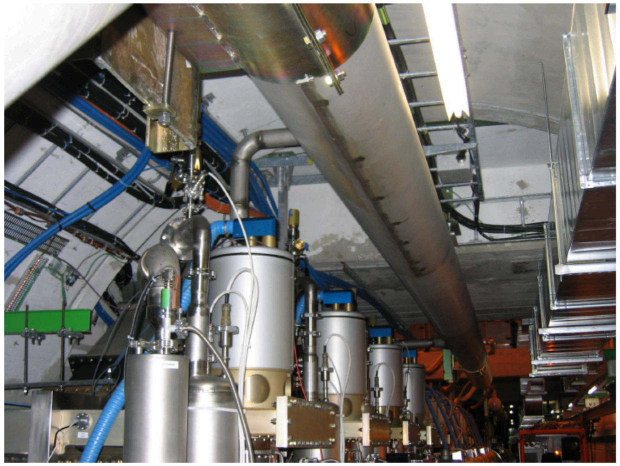


Figure 7.60: Tight space restriction in Point 4 due to the LHC proton RF installation.

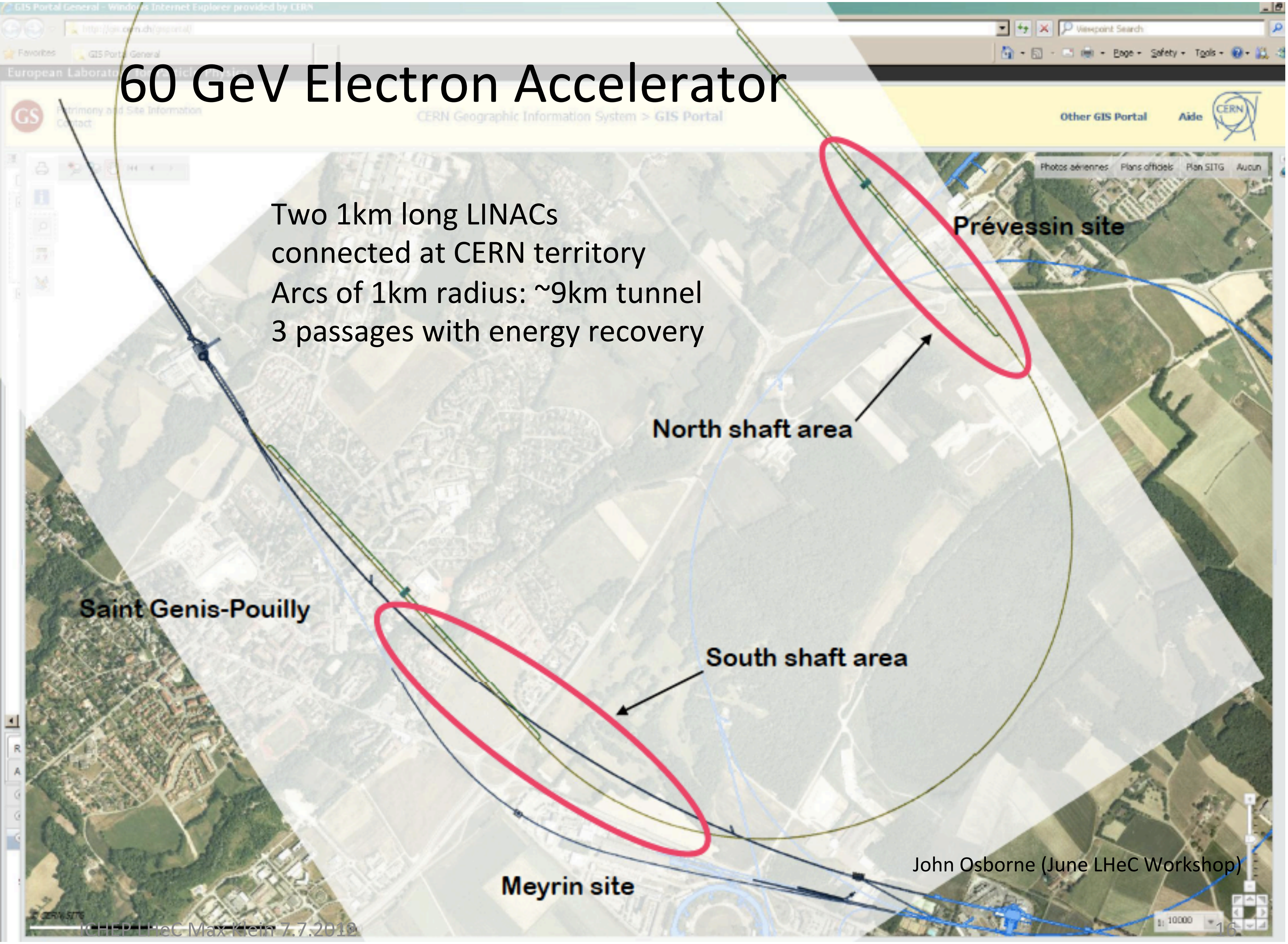
Civil engineering studied and reviewed by CH company Amber, both for ring and for linac options. Bypass in ring option used to house rf. ~4years of installation

Quite some interference with LHC: cryo jumpers (asymmetric FODO), connection of bypasses, access to LHC, proton dump area (point 3), RF (point 4), .. Cf CDR

June workshop, after CDR: RR not preferred, design LR

Situation for LEP3 would be much tougher: few km long RF, two rings, much higher synchrotron radiation, hi-jack or bypass CMS/ATLAS…

60 GeV Electron Accelerator

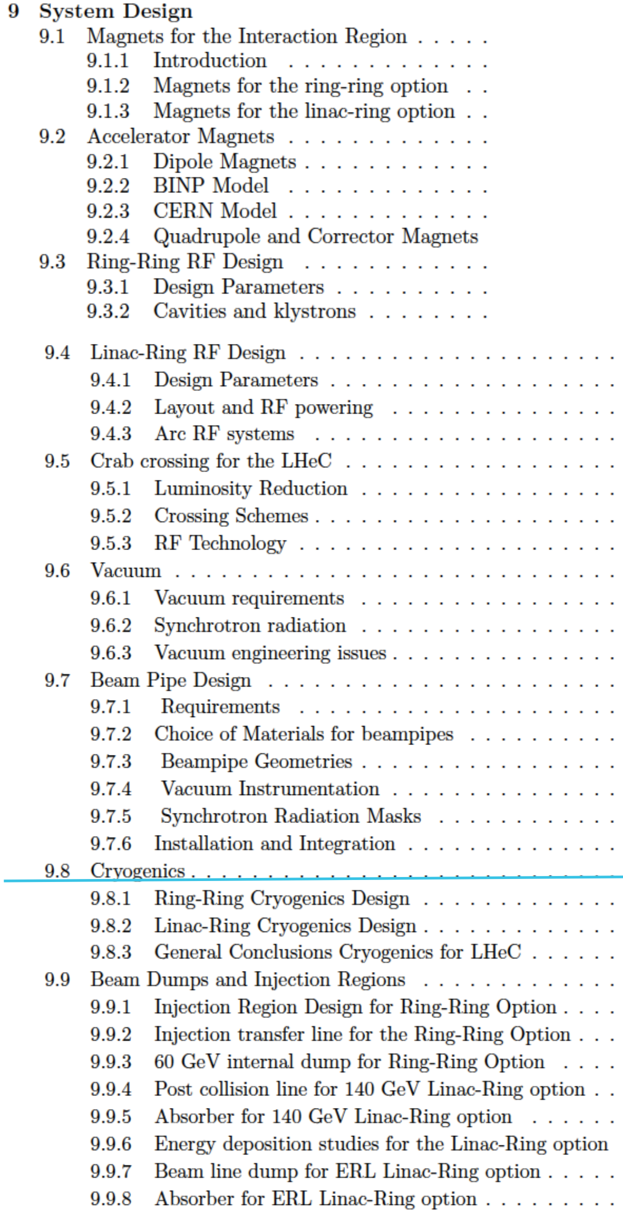


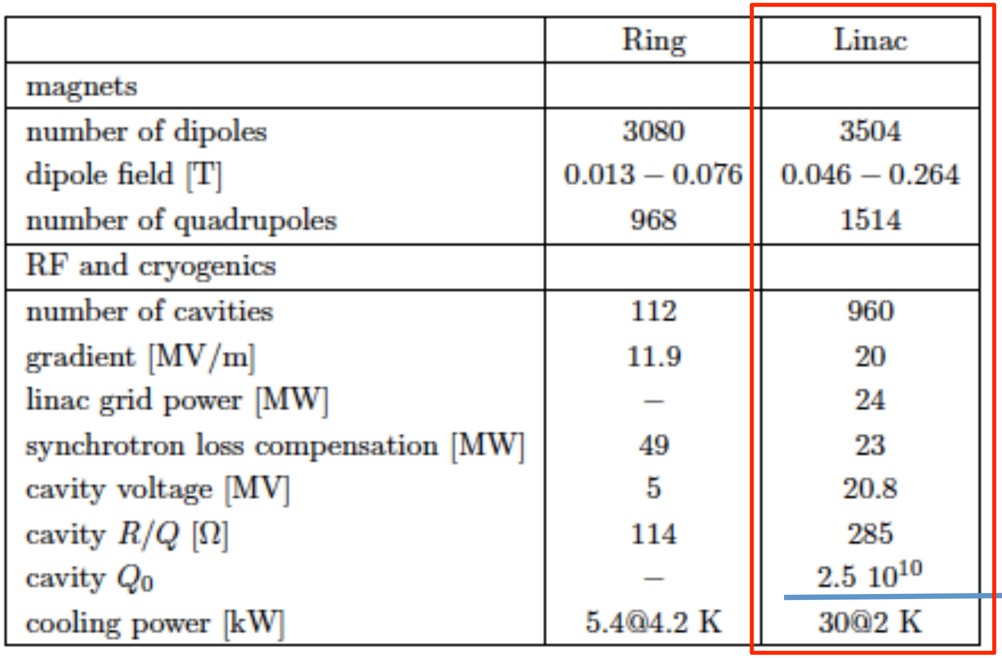
Two 1km long LINACs
connected at CERN territory
Arcs of 1km radius: ~9km tunnel
3 passages with energy recovery

John Osborne (June LHeC Workshop)

Components and Cryogenics

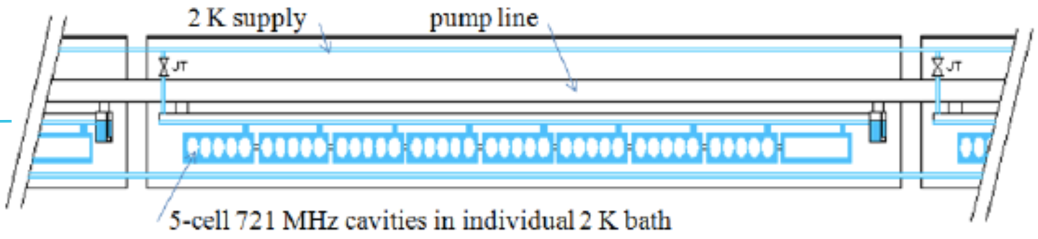
Chapter 9 of CDR



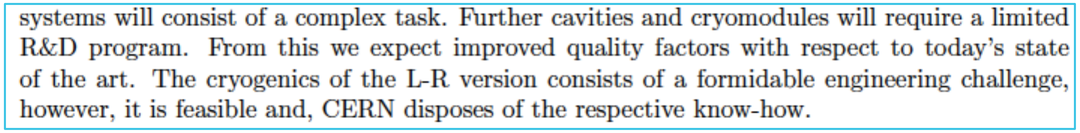


	Ring	Linac
magnets		
number of dipoles	3080	3504
dipole field [T]	0.013 – 0.076	0.046 – 0.264
number of quadrupoles	968	1514
RF and cryogenics		
number of cavities	112	960
gradient [MV/m]	11.9	20
linac grid power [MW]	–	24
synchrotron loss compensation [MW]	49	23
cavity voltage [MV]	5	20.8
cavity R/Q [Ω]	114	285
cavity Q_0	–	2.5 10^{10}
cooling power [kW]	5.4@4.2 K	30@2 K

Jlab:
4 10^{11}



Need to develop LHeC cavity (cryo-module)



systems will consist of a complex task. Further cavities and cryomodules will require a limited R&D program. From this we expect improved quality factors with respect to today's state of the art. The cryogenics of the L-R version consists of a formidable engineering challenge, however, it is feasible and, CERN disposes of the respective know-how.

from CDR LHeC

R+D Tasks for LHeC

LHCC
MAC/LMC

2012-2015

ECFA
NuPECC

Coordination
Enable decision by 2015 ("TDR")
Oversight of Physics, Detector, Accelerator Issues. Finances
CERN + International Collaborations on Detector + Accelerator
Response to CERN Directorate and Committees, Conferences etc.

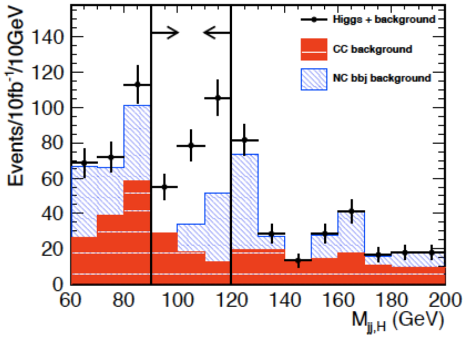
Physics	Detector	Computing	IR	CE	RF+Cryo	ERL	Magnets
Stimulate new DIS physics	Performance (precision, acc.)	Physics processes	Pipe for 1°	Site specific linac design	Cavity-cryo module (Q)	Beam dynamics	Q design and prototypes
t,Higgs,RPV..	Technical design	Computing model, support	Syn.radiation, beam backgrd	Junction of e,p beam lines	Cryogenics system design	Protection, dumps	Return arc magnets
Adjust to LHC	Prototypes	Simulations	Masks, collimators..	Technical integration	Power, coupler	Electron source	Rotator
Tool development	Installation model	DAQ and Trigger	Fwd and bwd detectors	Power, GS..	Test facility	Positron R+D	Integration

Draft

S.Bertolucci June 2012

Physics until 2015

Higgs:



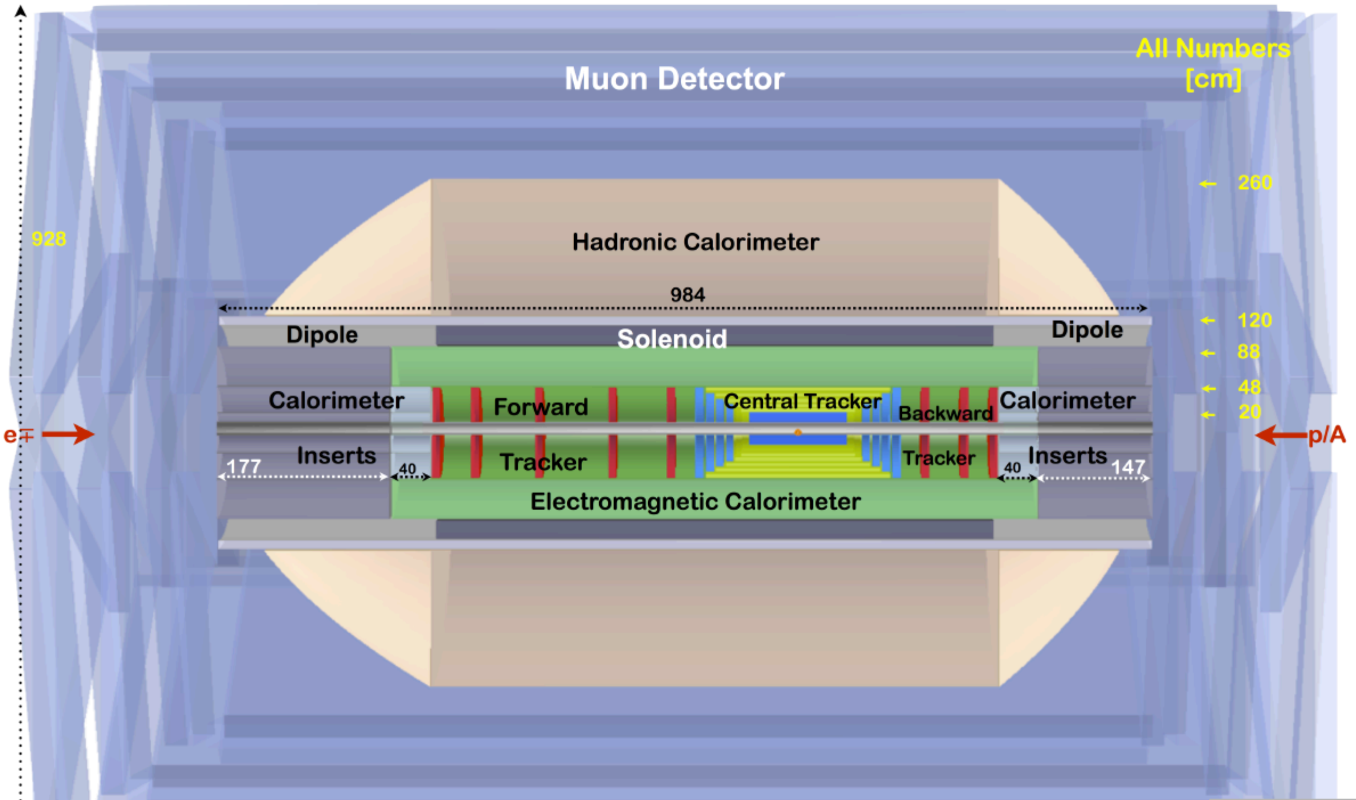
Redo analysis with LHeC detector simulation
Consider all accessible decay channels
Simulate CP SM and non-SM measurements
Optimise b, fwd jet tagging
Consider 10^{34}cm^{-2}s^{-1} (F.Zimmermann Chamonix 12)

Top: Simulation in LHeC detector and ultimate M_t and cross section accuracy

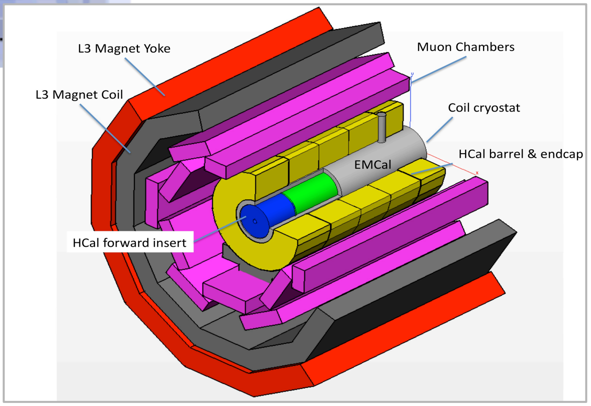
Generalised Parton Distributions, Photon structure, …

The physics case of the LHeC is “persuasive” (Alan Martin in his CDR referee report).
Still desirable to further work out a few “top” physics issues and optimise the design of the detector and accelerator correspondingly. Develop link to LHC.

Detector until 2015



The LHeC detector fits into the L3 magnet support in IP2. CDR installation study by Ghaddi/Herve: 30 months



Detector concept for high precision, large acceptance DIS. Technical (P.Bloch, R.Horisberger), cost and effort reviewed (M.Nordberg). Next: Full simulation with forward oriented software. Detailed installation study. Further development of various features (fwd tracking, muons,..). Choices of technology based on input and experience from proto-LHeC-Collaboration, which will be formed in 2013 -- **preparation of LoI**

Computing until 2015

Steps towards an LHeC software framework

Status now:

Interaction region simulation → synchrotron radiation ← GEANT4, IRSYN(MadX)
Detector volumes, flux calculation: ROOT → GDML → GEANT4, → FLUKA

Computer development & experiences of others → move to:

ROOT (TGeo and VMC(GEANT3,4,(5),FLUKA), Cling (interpreter for LLVM, Clang),
Fast code C/C++-like languages, basket definitions - **parallelizing**
make use of: Ali-, Fair-, CBM-, Panda-, …. -Root experiences
LHcb - e.g. "swimming" in trigger simulations → optimise detector granularity
Incorporate HL-LHC optics → interaction region design

DAQ/Trigger: physics, hardware / software driven decisions

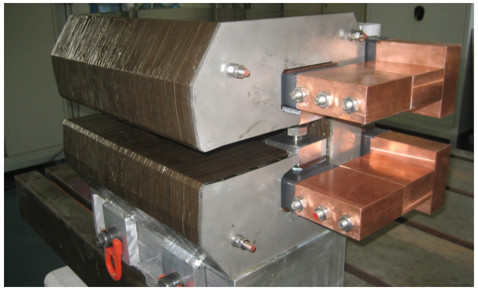
depend on granularity needed, pre-processing, trigger & bandwidth requirements

- → benchmark channels dictate the required solutions
- → b tagging & maximal acceptance

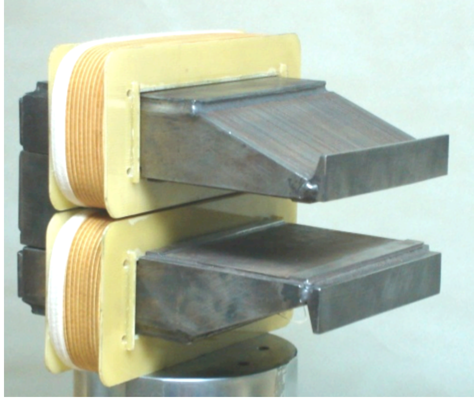
ep physics description requires generator updates: Pythia8, Herwig++

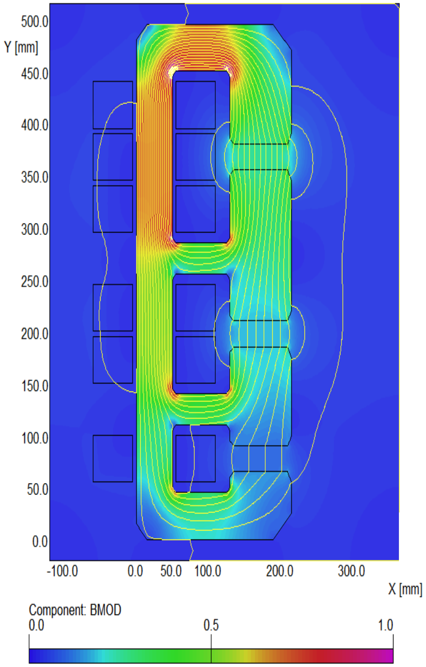
P.Kostka

Magnets until 2015



Prototypes for Ring dipoles
Fabricated and tested by
CERN (top) and Novosibirsk





flux density in the gaps	0.264 T 0.176 T 0.088 T
magnetic length	4.0 m
vertical aperture	25 mm
pole width	85 mm
number of magnets	584
current	1750 A
number of turns per aperture	1 / 2 / 3
current density	0.7 A/mm^2
conductor material	copper
resistance	0.36 mΩ
power	1.1 kW
total power 20 / 40 / 60 GeV	642 kW
cooling	air

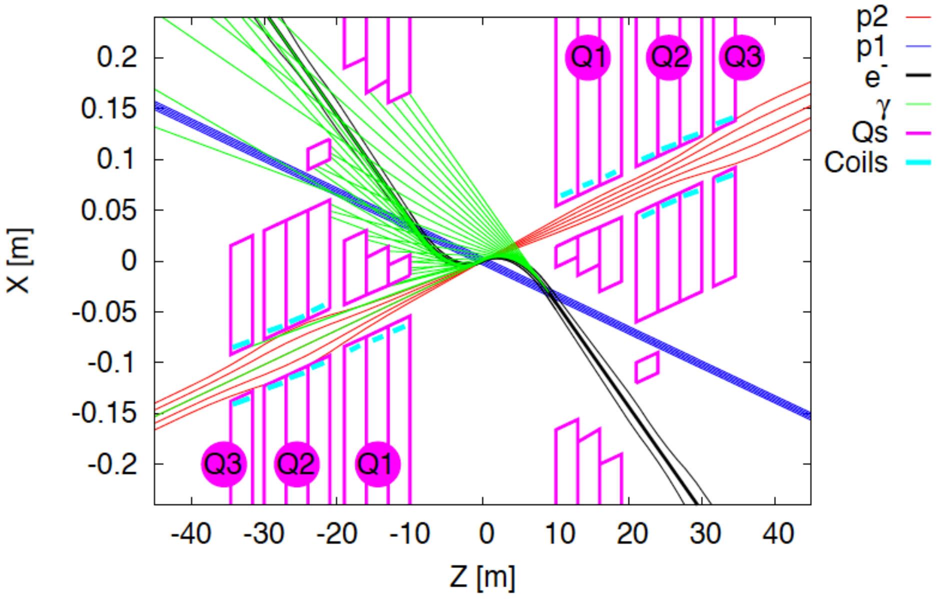
LR recirculator dipoles and quadrupoles
New requirements (aperture, field)?
Combined apertures?
Combined functions (for example, dipole + quad)?
LR linac quadrupoles and correctors
New requirements (aperture, field)?
More compact magnets, maybe with at least two families for quadrupoles?
Permanent magnets / superconducting for quads?
A.Milanese, Chavannes workshop

1/2m dipole model
Full scale prototype
Quadrupole for Linac

Magnets for ERL test stand

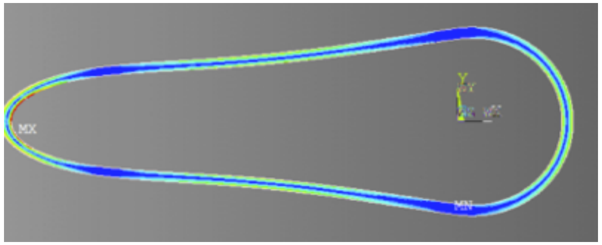
Collaboration of CERN, Daresbury and Budker

IR until 2015



Beam pipe: in CDR 6m, Be, ANSYS calculations

Composite material R+D, prototype, support..
→ Essential for tracking, acceptance and Higgs



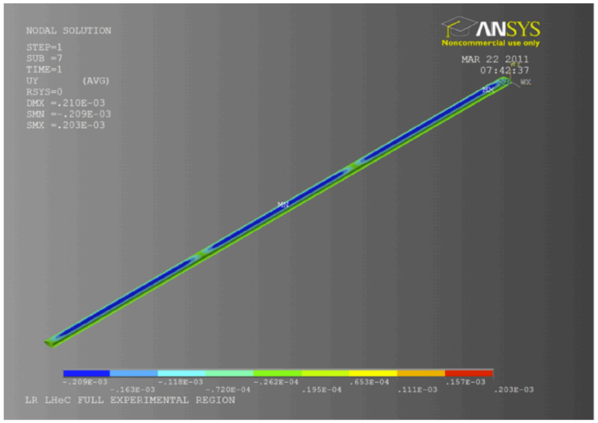


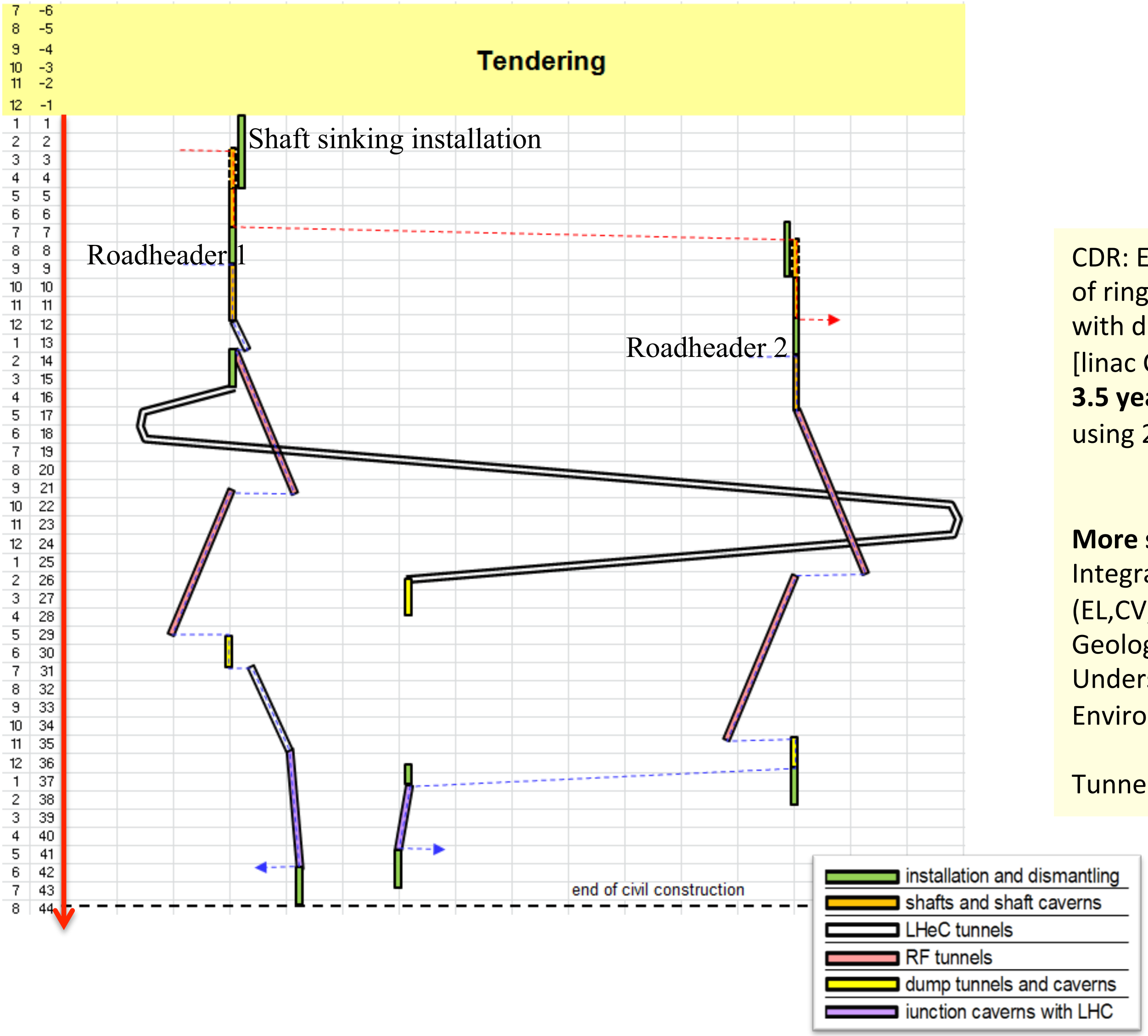
Figure 9.32: 3-D view of the LR geometry showing contours of bending displacement [m].

Have optics compatible with LHC and β*=0.1m
Head-on collisions mandatory →
High synchrotron radiation load, dipole in detector

Specification of Q1 – NbTi prototype (with KEK?)
Revisit SR (direct and backscattered),
Masks+collimators
Beam-beam dynamics and 3 beam operation studies

Optimisation: HL-LHC uses IR2 quads to squeeze IR1
(“ATS” achromatic telescopic squeeze) Start in IR3.? R.Tomas et al.

Civil Engineering until 2015



CDR: Evaluation of CE, analysis of ring and linac by Amber Zurich with detailed cost estimate [linac CE: 249,928 kSF..] and time: **3.5 years for underground works** using 2 roadheaders and 1 TBM

More studies needed for
Integration with all services (EL,CV, transport, survey etc).
Geology
Understanding vibration risks
Environmental impact assessment

Tunnel connection in IP2

J.Osborne, Chavannes

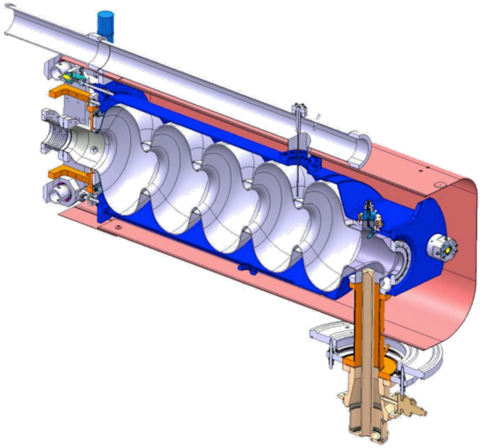
RF until 2015

Frequency choice: *n* * 120.237 MHz
N=6: 721 MHz, n=11: 1.3GHz (XFEL)

Detailed comparison (threshold current, cryo power, Rf power, size, cost, collaboration, synergy..)

ALICE 1.3 GHz, not CW – only EU ERL facility operational
Daresbury develops cryomodule for ESS (700 MHz)
CERN: in house collaboration with SPL, and eRHIC/BNL

SPL cryomodule 704 MHz

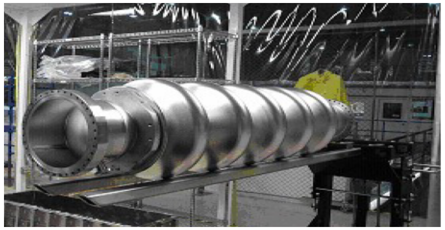


Accelerator physics motivation:
- ERL demonstration, FEL, γ-ray source, e-cooling demo!
- Ultra-short electron bunches

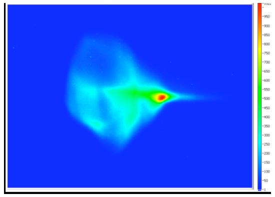
One of the 1st low-frequency, multi-pass SC-ERL
- synergy with SPL/ESS and BNL activities

High energies (200 … 400 MeV) & CW
Multi-cavity cryomodule layout – validation and gymnastics
Two-Linac layout (similar to LHeC)
MW class power coupler tests in non-ER mode
Complete HOM characterization and instability studies!
Cryogenics & instrumentation test bed … E.Jensen

BNL 704 MHz cavity (20 MV/m with high Q0 demonstrated)



Steps: Design of LHeC ERL TF, cavity-cryo module (hi Q), lattice, optics, magnets, source, ….
Watch out for surprises as humming bird:
Building international collaboration
(CERN,Daresbury, Jlab, others?)

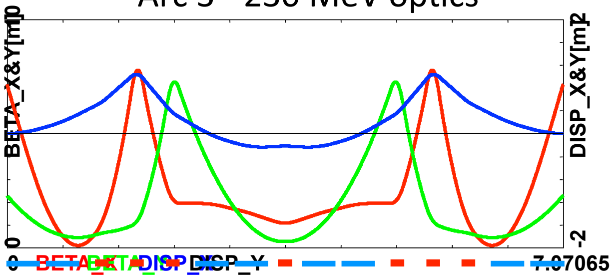


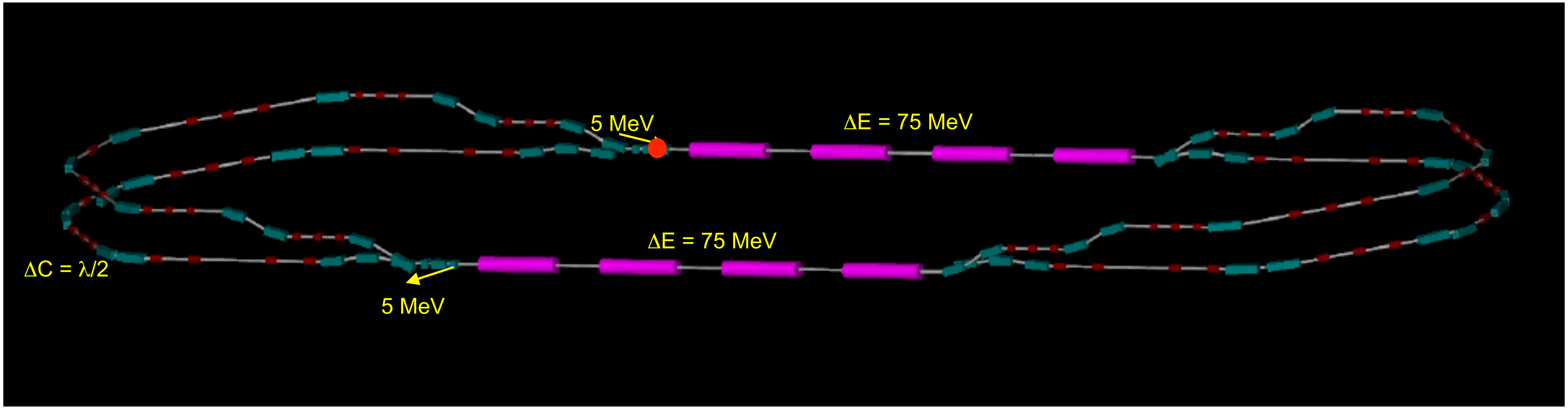
beam structure at ALICE with 230-kV DC gun voltage

LHeC - ERL-TF

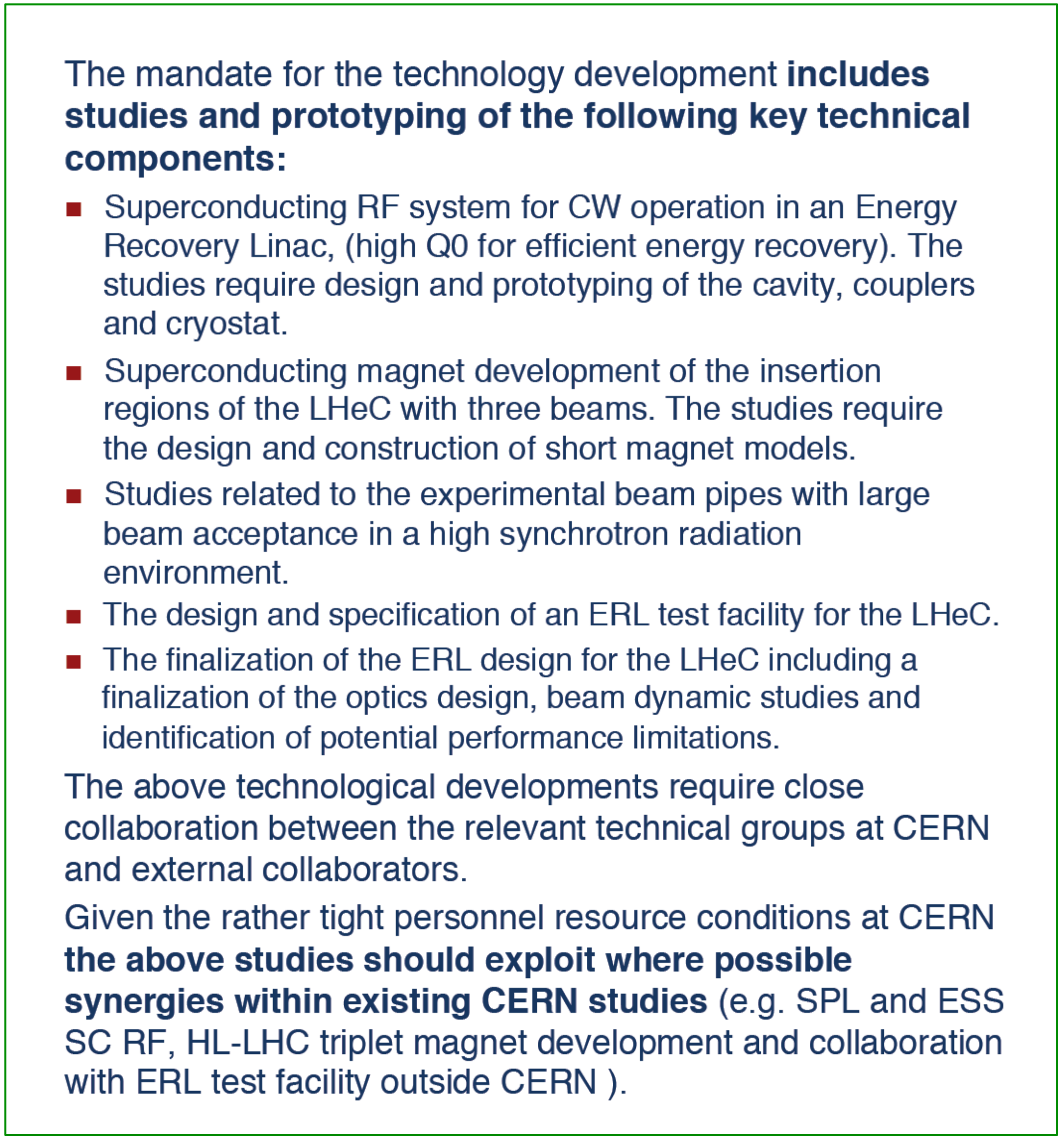
Tentative study of multipass optics and lattice

Arc 3 - 230 MeV optics





LHeC Preparations



The mandate for the technology development **includes studies and prototyping of the following key technical components:**

- Superconducting RF system for CW operation in an Energy Recovery Linac, (high Q0 for efficient energy recovery). The studies require design and prototyping of the cavity, couplers and cryostat.
- Superconducting magnet development of the insertion regions of the LHeC with three beams. The studies require the design and construction of short magnet models.
- Studies related to the experimental beam pipes with large beam acceptance in a high synchrotron radiation environment.
- The design and specification of an ERL test facility for the LHeC.
- The finalization of the ERL design for the LHeC including a finalization of the optics design, beam dynamic studies and identification of potential performance limitations.

The above technological developments require close collaboration between the relevant technical groups at CERN and external collaborators.

Given the rather tight personnel resource conditions at CERN **the above studies should exploit where possible synergies within existing CERN studies** (e.g. SPL and ESS SC RF, HL-LHC triplet magnet development and collaboration with ERL test facility outside CERN).

S.Bertolucci at Chavannes workshop 6/12 based on
CERN directorate's decision to include LHeC in the MTP

→ Corresponding first steps being taken

Preparation of MoUs by/with CERN

Much increased attention from international community:
LINAC12 BNL, Jlab, SLAC, ESS, BESSY, GSI, DESY, ..

At Cracow new expressions of interest in detector collaboration from several institutes in Italy, Sweden, Slovakia

Principal agreement with ALICE about LHeC following ALICE in IP2 (NuPECC meeting at Sevilla 10/12)

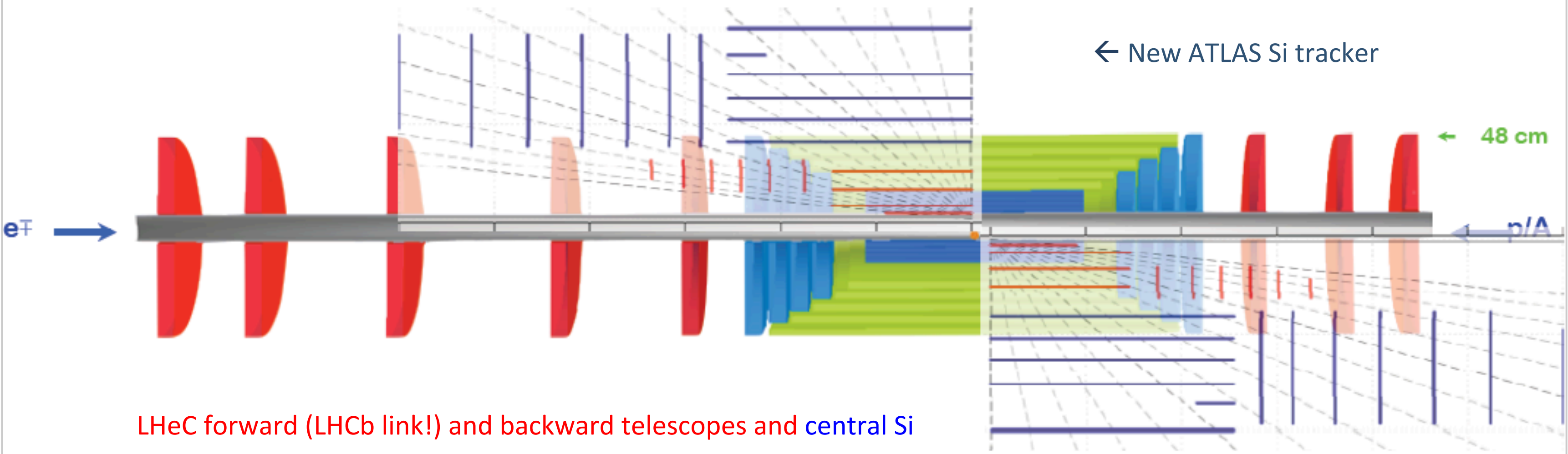
Visible support by the ESG process will allow moving the LHeC development to the required next level of support.

The UK ..

UK and the LHeC

… the UK has played a leading role in the initialisation and design of the LHeC concepts, convenors, ideas, advisory board, 4 members and chair of the LHeC steering committee since 2007. For example, out of 5 talks at ICHEP on the LHeC, partially very visible (cf DG ICHEP slides on LHeC and Higgs), 3 had been given by UK physicists. The presentation at Cracow was awarded to P Newman…

By now, 5 UK Universities have worked on or expressed a serious interest in the detector development (Birmingham, Lancaster, Liverpool, Manchester, QMW), also nuclear physics groups from various (UK) institutes as the LHeC links PP with NP in a unique way. It also relates to ATLAS activities (interest in tracking and trigger developments, cf ongoing upgrade preparations).



← New ATLAS Si tracker

LHeC forward (LHCb link!) and backward telescopes and central Si

LHeC: no pile-up, less radiation, smaller momenta apart from forward region

SoI to come in due time, consultations with STFC, and UK community

UK Accelerator Engagement

Topics of joint interest and priority
Meeting ASTEC/CI 5.9.12 at CERN

Electron source for TF

Design of IR, Optics for p beams, synrad tracking

Test facility design (OPAC fellow)

Sc cavity design, coupler, HOM damper, tuner..

Instrumentation for TF…

With only somewhat reduced priority: beam dynamics, positron source, magnets ..

Preparation of MoU, with view also to other partners

Deepa Angal-Kalinin[1], Robert Appleby[5], Ian Bailey[3], Steve Buckley[1], Graeme Burt[3], Neil Bliss[2], Swapan Chattopadhyay[3,4,5], Jim Clarke[1], Peter Corlett[1], Philippe Goudket[1], Andy Goulden[1], Joe Herbert[1], Kai Hock[4], Frank Jackson[1], Steve Jamison[1], James Jones[1], Lee Jones[1], Alexander Kalinin[1], Oleg Malyshev[1], Neil Marks[1], Peter McIntosh[1], Julian McKenzie[1], Keith Middleman[1], Boris Militsyn[1], Andy Moss[1], Bruno Muratori[1], David Newton[4], Tim Noakes[1], Shrikant Pattalwar[1], Yuri Saveliev[1], Ben Shepherd[1], Susan Smith[1], Rob Smith[1], Trina Thakker[1], Luke Thompson[5], Reza Valizadeh[1], Carsten Welsch[4], Alan Wheelhouse[1], Peter Williams[1], Andy Wolski[4]

[1]ASTeC/STFC, [2]TD/STFC, [3]University of Lancaster, [4]University of Liverpool, [5]University of Manchester

The LHeC represents a unique opportunity for the Daresbury Campus (ASTEC and CI), but also for the wider UK accelerator community (A.Seryi co-author of CDR) to be at the forefront of accelerator developments, building on their unique expertise, a very welcome strong expression of interest, and its strong links to Universities, CERN and industry.

Summary

The LHeC has a unique physics programme (QCD, Higgs, BSM, HI).
It has a rich synergy with the LHC, SPL,ESS.. and links NP and PP.
The now published design report moved the dream of a TeV scale electron-hadron collider to the "real axis" (SB). We can realise it.

Many thanks to CERN, NuPECC, ECFA and to the expanding LHeC Group

"Energy frontier,
Precision,
QCD,
QGP"
Tatsuya Nakada

J.L.Abelleira Fernandez[16,23], C.Adolphsen[57], A.N.Akay[03], H.Aksakal[39], J.L.Albacete[52], S.Alekhin[17,54], P.Allport[24], V.Andreev[34], R.B.Appleby[14,30], E.Arikan[39], N.Armesto[53,a], G.Azuelos[33,64], M.Bai[37], D.Barber[14,17,24], J.Bartels[18], O.Behnke[17], J.Behr[17], A.S.Belyaev[15,56], I.Ben-Zvi[37], N.Bernard[25], S.Bertolucci[16], S.Bettoni[16], S.Biswal[41], J.Blümlein[17], H.Böttcher[17], A.Bogacz[36], C.Bracco[16], G.Brandt[44], H.Braun[65], S.Brodsky[57,b], O.Brüning[16], E.Bulyak[12], A.Buniatyan[17], H.Burkhardt[16], I.T.Cakir[02], O.Cakir[01], R.Calaga[16], A.Caldwell[70], V.Cetinkaya[01], V.Chekelian[70], E.Ciapala[16], R.Ciftci[01], A.K.Ciftci[01], B.A.Cole[38], J.C.Collins[48], O.Dadoun[42], J.Dainton[24], A.De.Roeck[16], D.d'Enterria[16], P.DiNezza[72], A.Dudarev[16], A.Eide[60], R.Enberg[63], E.Eroglu[62], K.J.Eskola[21], L.Favart[08], M.Fitterer[16], S.Forte[32], A.Gaddi[16], P.Gambino[59], H.García Morales[16], T.Gehrmann[69], P.Gladkikh[12], C.Glasman[28], A.Glazov[17], R.Godbole[35], B.Goddard[16], T.Greenshaw[24], A.Guffanti[13], V.Guzey[19,36], C.Gwenlan[44], T.Han[50], Y.Hao[37], F.Haug[16], W.Herr[16], A.Hervé[27], B.J.Holzer[16], M.Ishitsuka[58], M.Jacquet[42], B.Jeanneret[16], E.Jensen[16], J.M.Jimenez[16], J.M.Jowett[16], H.Jung[17], H.Karadeniz[02], D.Kayran[37], A.Kilic[62], K.Kimura[58], M.Klein[24], U.Klein[24], T.Kluge[24], F.Kocak[62], M.Korostelev[24], A.Kosmicki[16], P.Kostka[17], H.Kowalski[17], G.Kramer[18], D.Kuchler[16], M.Kuze[58], T.Lappi[21,c], P.Laycock[24], E.Levichev[40], S.Levonian[17], V.N.Litvinenko[37], A.Lombardi[16], J.Maeda[58], C.Marquet[16], B.Mellado[27], K.H.Mess[16], A.Milanese[16], S.Moch[17], I.I.Morozov[40], Y.Muttoni[16], S.Myers[16], S.Nandi[55], Z.Nergiz[39], P.R.Newman[06], T.Omori[61], J.Osborne[16], E.Paoloni[49], Y.Papaphilippou[16], C.Pascaud[42], H.Paukkunen[53], E.Perez[16], T.Pieloni[23], E.Pilicer[62], B.Pire[45], R.Placakyte[17], A.Polini[07], V.Ptitsyn[37], Y.Pupkov[40], V.Radescu[17], S.Raychaudhuri[35], L.Rinolfi[16], E.Rizvi[71], R.Rohini[35], J.Rojo[16,31], S.Russenschuck[16], M.Sahin[03], C.A.Salgado[53,a], K.Sampei[58], R.Sassot[09], E.Sauvan[04], U.Schneekloth[17], T.Schörner-Sadenius[17], D.Schulte[16], A.Senol[22], A.Seryi[44], P.Sievers[16], A.N.Skrinsky[40], W.Smith[27], H.Spiesberger[29], A.M.Stasto[48,d], M.Strikman[48], M.Sullivan[57], S.Sultansoy[03,e], Y.P.Sun[57], B.Surrow[11], L.Szymanowski[66,f], P.Taels[05], I.Tapan[62], T.Tasci[22], E.Tassi[10], H.Ten.Kate[16], J.Terron[28], H.Thiesen[16], L.Thompson[14,30], P.Thompson[06], K.Tokushuku[61], R.Tomás García[16], D.Tommasini[16], D.Trbojevic[37], N.Tsoupas[37], J.Tuckmantel[16], S.Turkoz[01], T.N.Trinh[47], K.Tywoniuk[26], G.Unel[20], J.Urakawa[61], P.VanMechelen[05], A.Variola[52], R.Veness[16], A.Vivoli[16], P.Vobly[40], J.Wagner[66], R.Wallny[68], S.Wallon[43,46,f], G.Watt[16], C.Weiss[36], U.A.Wiedemann[16], U.Wienands[57], F.Willeke[37], B.-W.Xiao[48], V.Yakimenko[37], A.F.Zarnecki[67], Z.Zhang[42], F.Zimmermann[16], R.Zlebcik[51], F.Zomer[42]

Title

ERL Test Facilities

IHEP ERL-TF	HZB BERLinPro	BINP	Peking FEL	BNL ERL-TF	KEK cERL	Daresbury ALICE	JAERI	CERN ERL-TF
35 MeV	100 MeV	11-40 MeV	30 MeV	20 MeV	245 MeV	10 MeV	17 MeV	300 MeV
1.3 GHz 9 cell	1.3 GHz	180 MHz	1.3 GHz 9-cell	704 MHz 5-cell	1.3 GHz 9-cell	1.3 GHz 9-cell	500 MHz	721 MHz 2x4x5 cell
10 mA	100 mA	30 mA	50 mA	50-500 mA	10-100 mA	13 µA	5-40 mA	2-6 mA
60 pC	10-77 pC	0.9-2.2 nC	60 pC	0.5-5 nC	77 pC	80 pC	400 pC	500 pC
1 pass	1-2 pass	4 passes	1 pass	1 pass	2 passes	1 pass	1 pass	2 passes
under construction	planned / construction	operating		under construction	under construction	operating	operating	first ideas

E.Jensen

Project Milestones

2007: Invitation by SPC to ECFA and by (r)ECFA to work out a design concept

2008: First CERN-ECFA Workshop in Divonne (1.-3.9.08)

2009: 2nd CERN-ECFA-NuPECC Workshop at Divonne (1.-3.9.09)

2010: Report to CERN SPC (June)
3rd CERN-ECFA-NuPECC Workshop at Chavannes-de-Bogis (12.-13.11.10)
NuPECC puts LHeC to its Longe Range Plan for Nuclear Physics (12/10)

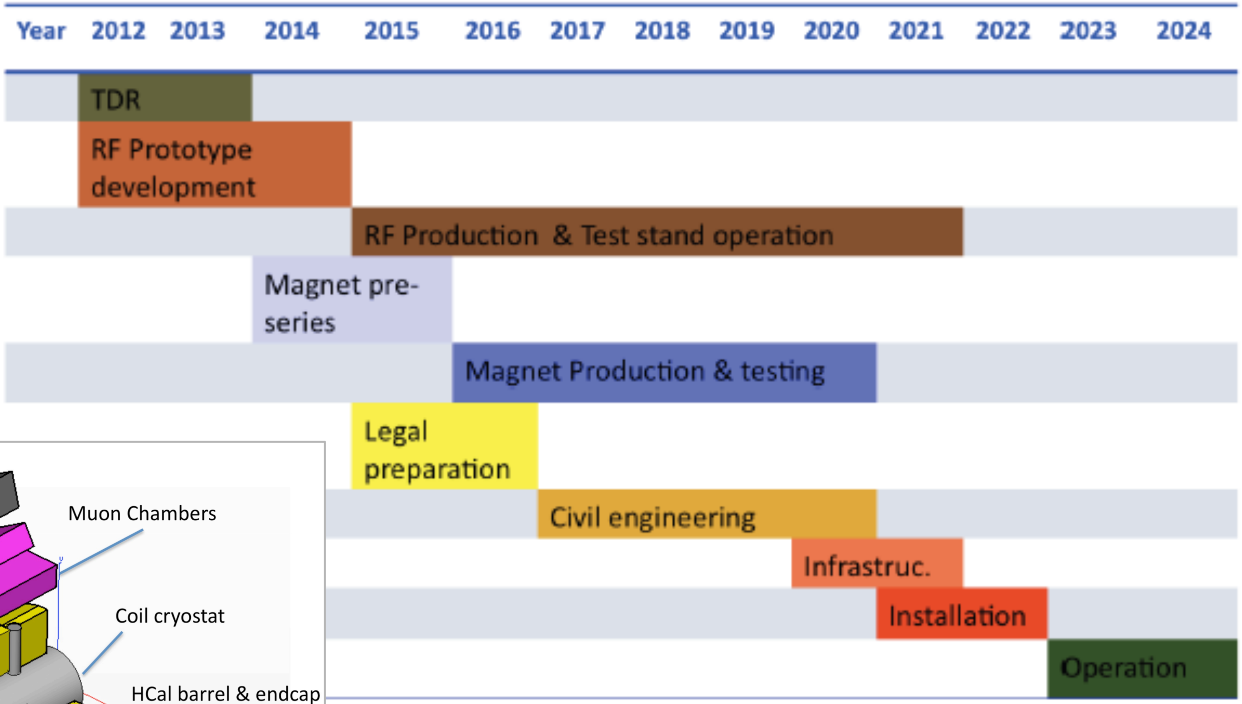
2011: Draft CDR (530 pages on Physics, Detector and Accelerator) (5.8.11)
being refereed and updated

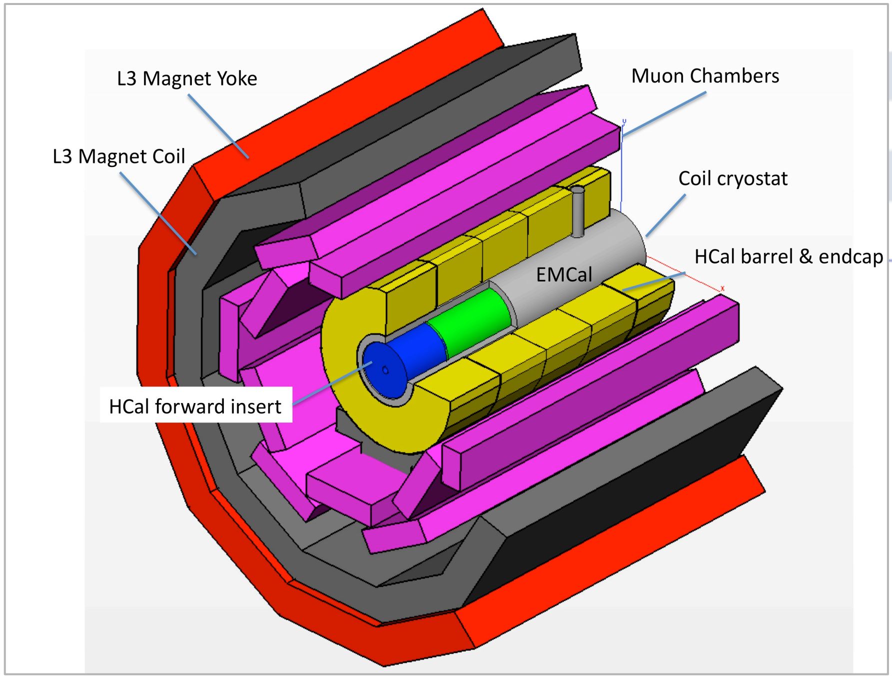
2012: Publication of CDR – European Strategy
New workshop (Chavannes, June 14-15, 2012)

Goal: TDR by 2015
Perspective: Operation by 2023 (synchronous with pp)

CDR - Time Schedule*)

Detector installation study for IP2, reuse of L3 magnet as support for LHeC. Estimated 30 months





LHeC is to operate synchronous with HL-LHC

LS3 requires 2-3 years for ATLAS+. It is the one extended time period, which will allow installation and connection of LHeC

*) LS3 → schedule most likely shifted by +2 years