Towards the CDR on the LHeC

Open questions under study and the programme of Divonne 2

Max Klein

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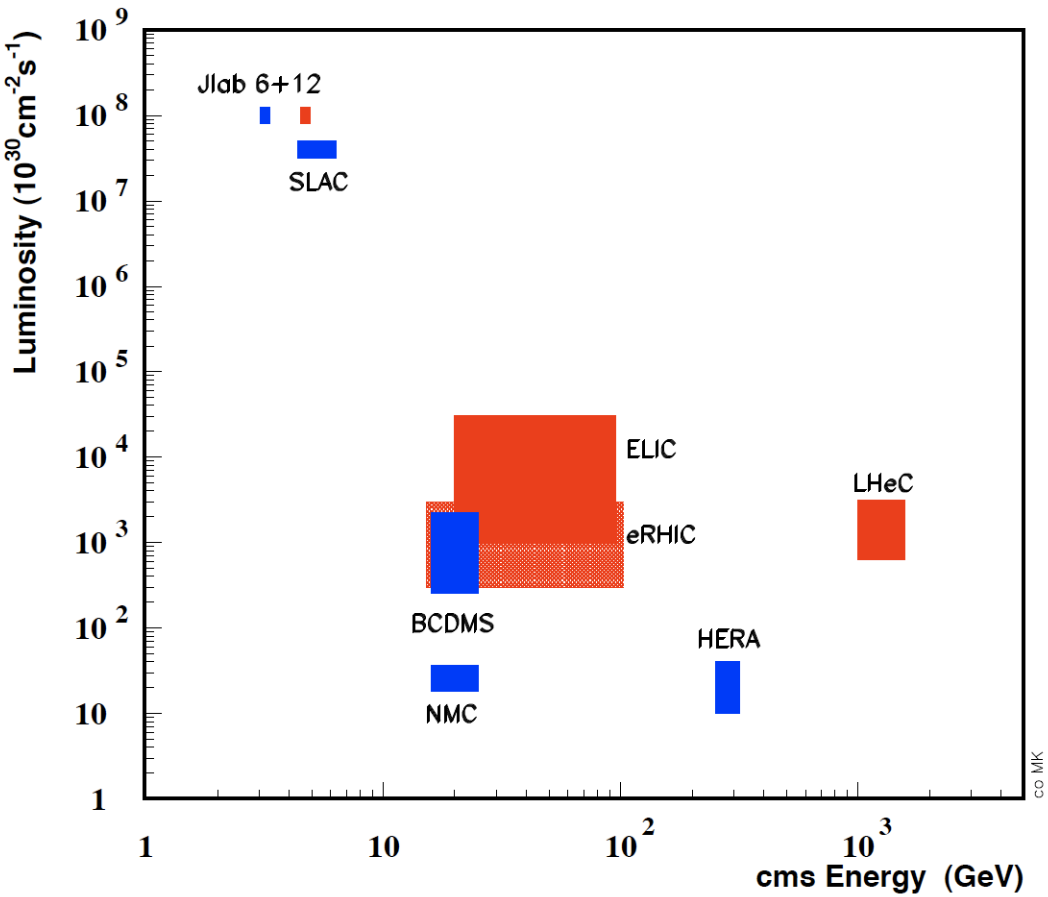
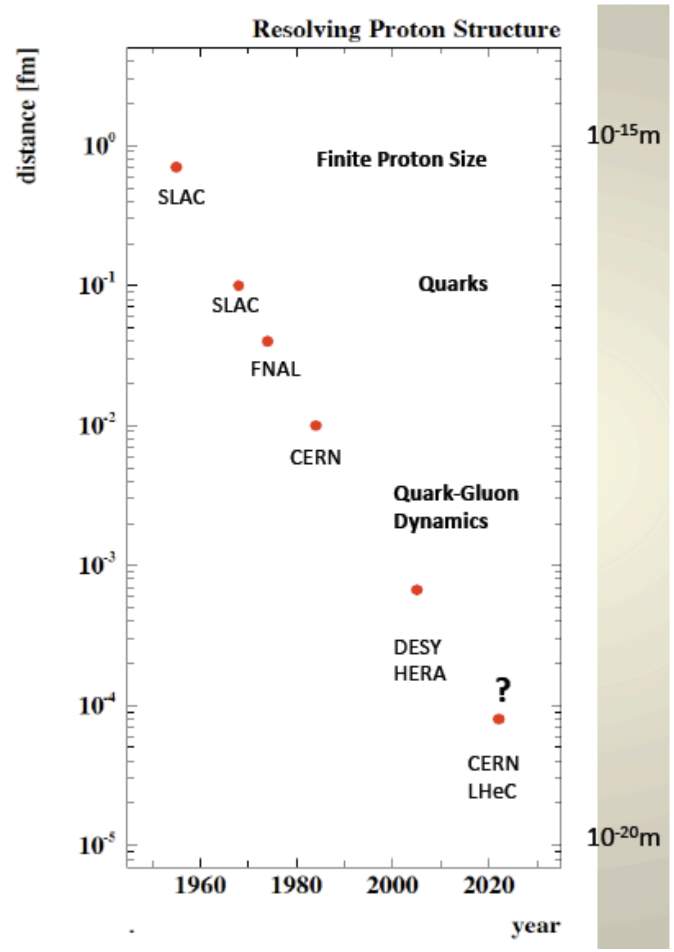
John Dainton	(Cockcroft)
Albert DeRoeck	(CERN)
Stefano Forte	(Milano)
Max Klein - chair	(Liverpool)
Paul Newman	(Birmingham)
Emmanuelle Perez	(CERN)
Wesley Smith	(Wisconsin)
Bernd Surrow	(MIT)
Katsuo Tokushuku	(KEK)
Urs Wiedemann	(CERN))

Report of the Steering Group to the CERN-ECFA-NuPECC Workshop on the LHeC

Divonne, France, 1st of September 2009

Basic LHeC

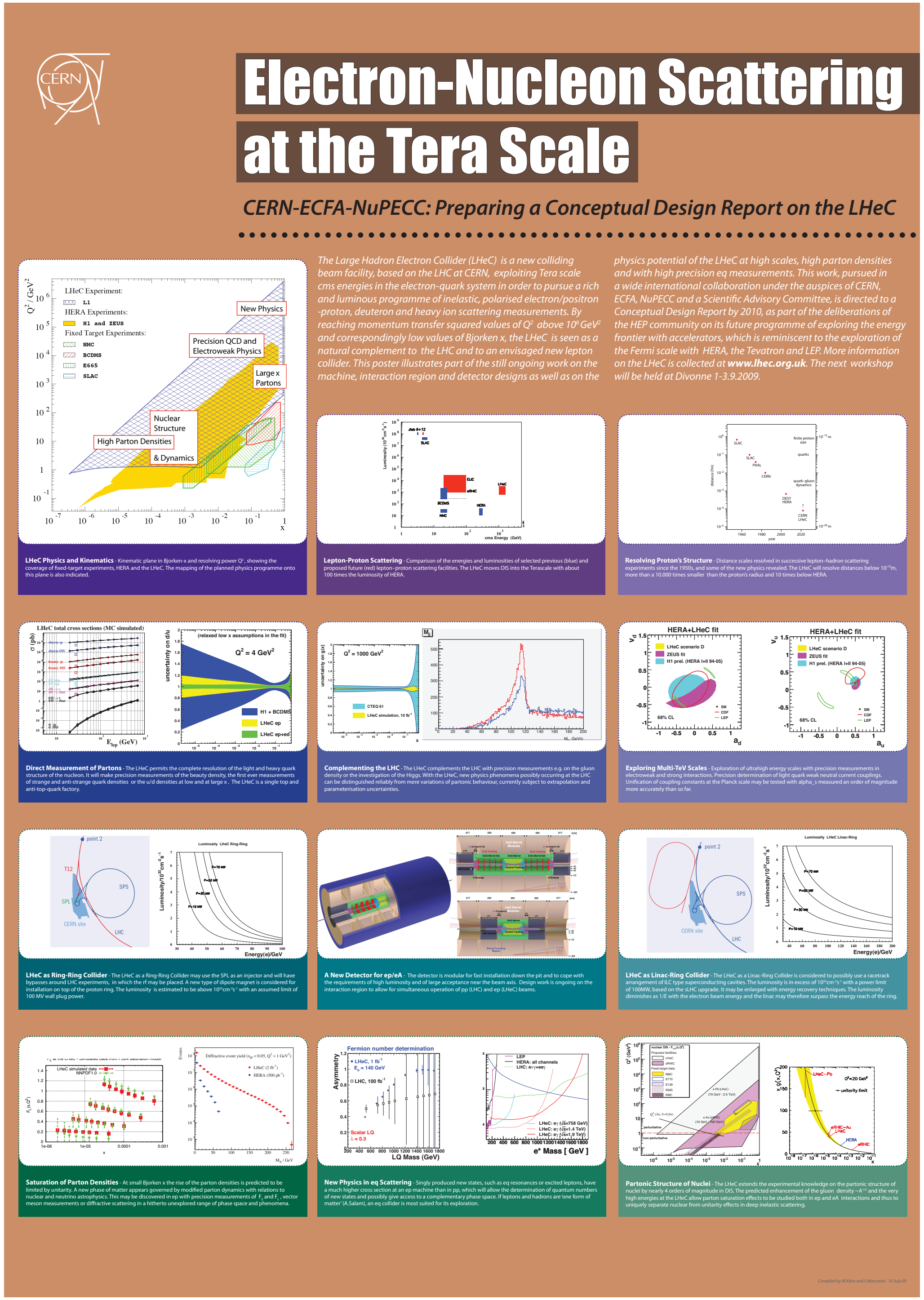




Tera scale:
pp, ee, ep: high E and high L
[like Tevatron, LEP, HERA]

LHeC in parallel to LHC
High precision eq scattering

100 MW , E_{max} 150 GeV, p,D,A



After Divonne 2008

2008

September	NuPECC Meeting at Glasgow
October	ICFA Seminar at SLAC
November	ECFA Plenary at CERN
December	Convenor's Meeting at CERN

2009

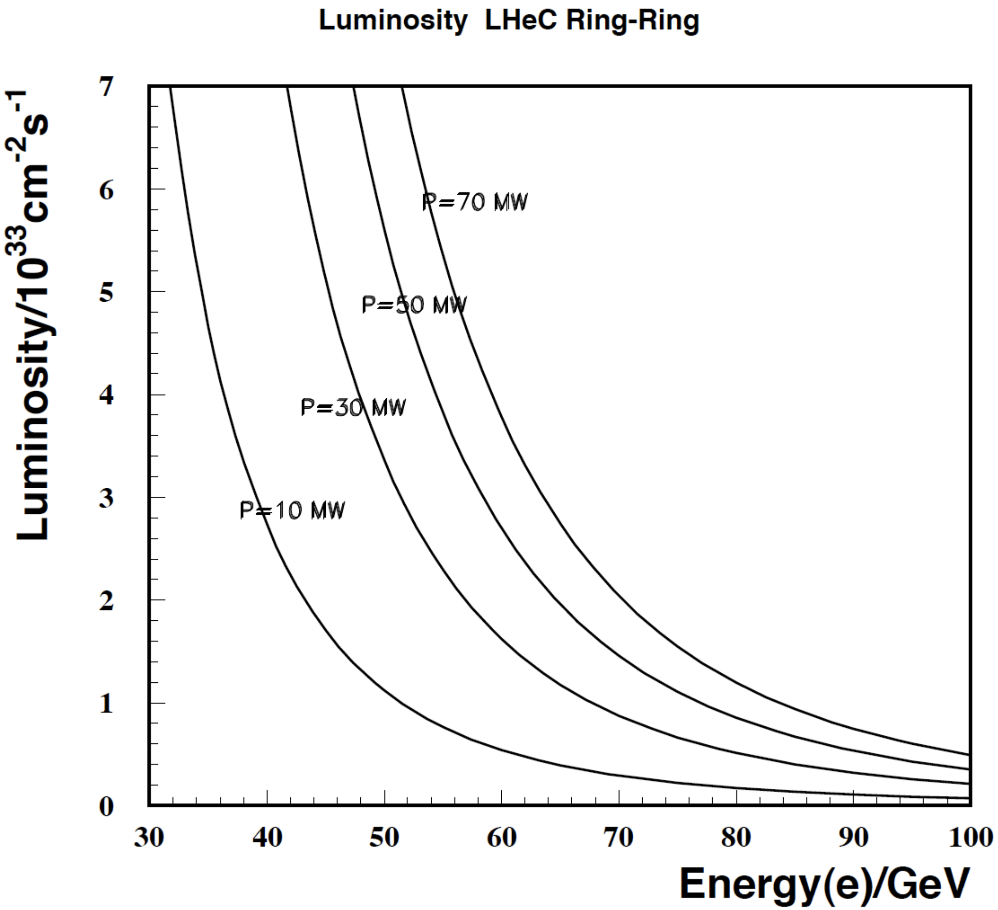
March	Visit at SLAC
April	DIS09 at Madrid LHeC premeeting, parallel, SAC, plenary panel (arXiv:0908.2877 [hep-ex])
April	PAC09 at Vancouver - Papers, Talk, Proceedings
May	Visit at BNP Novosibirsk NuPECC decides to join the LHeC CDR Workshop
June	Low x / HPD meeting at CERN, pre-Blois
July	Talk and Poster at EPS09 at Cracow
August	Poster at Lepton-Photon09 at Hamburg

Continuous development of the web page. www.lhec.org.uk

Conceptual Design Report
Large Hadron Electron Collider (LHeC) at CERN

DRAFT - February 2009

Ring-Ring Luminosity



High L confirmed in detailed studies

[FW: 70 GeV 50MW, BH: 50 GeV 14 MW (s)LHC]

Energy limited to 70-80 GeV (700m rf) - $I_e \sim P/E^4$

With 50 MW, 50 GeV reach 5 10^{33} $cm^{-2}s^{-1}$.

This is 100 times HERA at its best day
and 50 fb^{-1} in a typical year.
It can be reached with the standard LHC p beam.

Polarisation

Injector to Ring

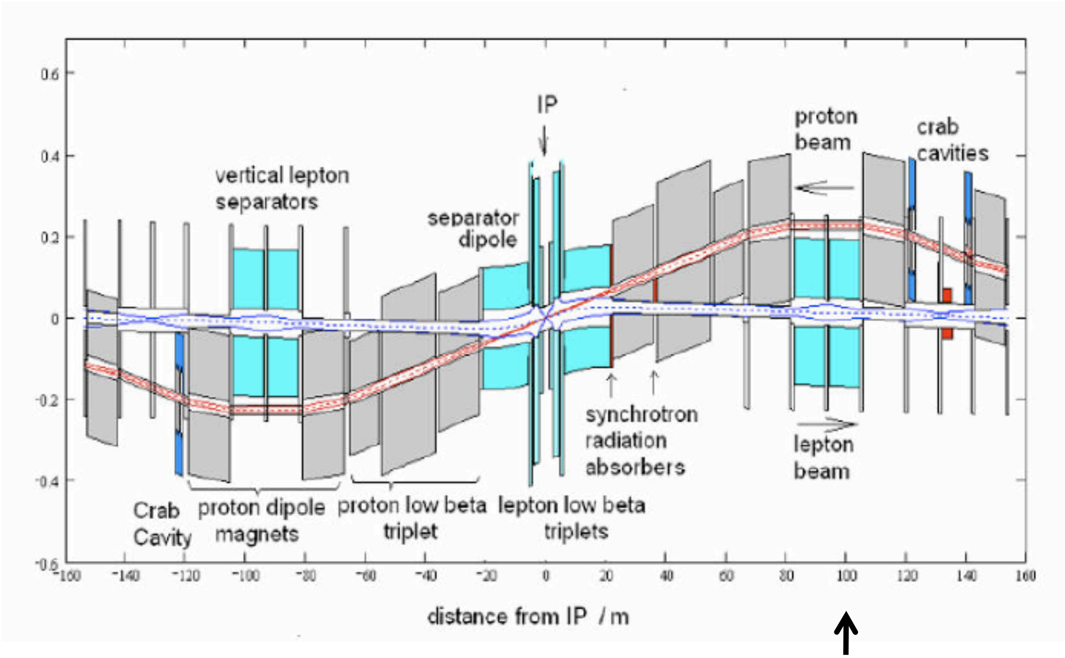
SPL

Possibly include alternative
(e.g. ELFE downscaled HB DIS08)

Bunch intensity modest
$1.4\ 10^{10}$ vs $4\ 10^{11}$ (LEP)

Injection energy of order 10 GeV

Interaction Region



← 50cm

↑ 100m

Interaction region design for **simultaneous pp and ep operation**
(FW. JINST06, BH et al Divonne08)

Separation requires ~ 2mrad xing angle

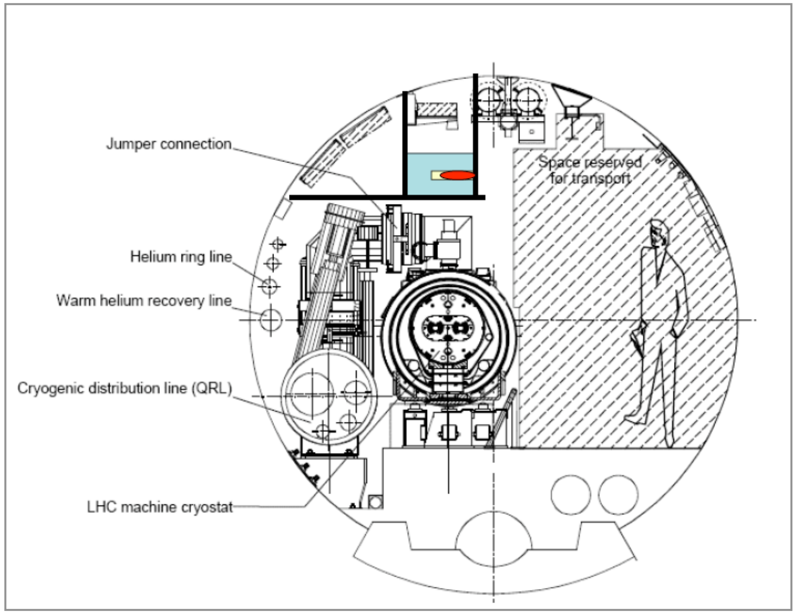
Crab cavities for compensation (~2?)

Measurement of ep → epγ ?

(Backscattering of) syn.rad
beam pipe dimension → detector size!

Large angle IR ("1° or low x IR")

Ring Installation



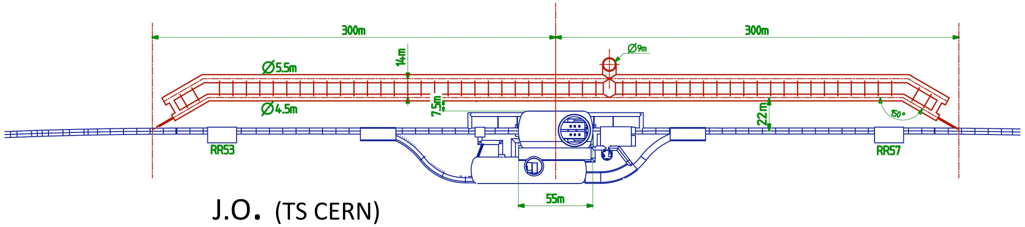
Detailed inspection of LHC installation

New dipole magnet design

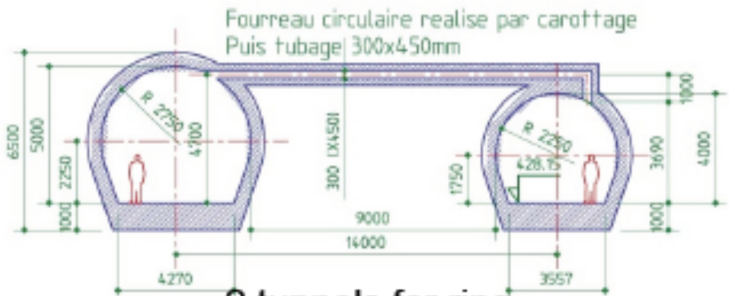
LEP: 5.75m long steel concrete cores, 4.6 tons
LHeC: reduce aperture, new concepts → lighter

Visit to BNP Novosibirsk in May 09

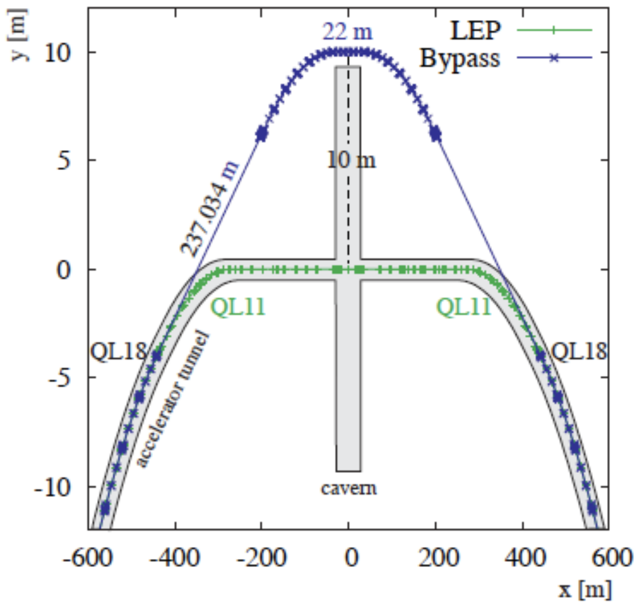
Bypasses



J.O. (TS CERN)



2 tunnels for ring
and shielded rf



Decouple from ATLAS, CMS..

1 shaft, excavation during operation

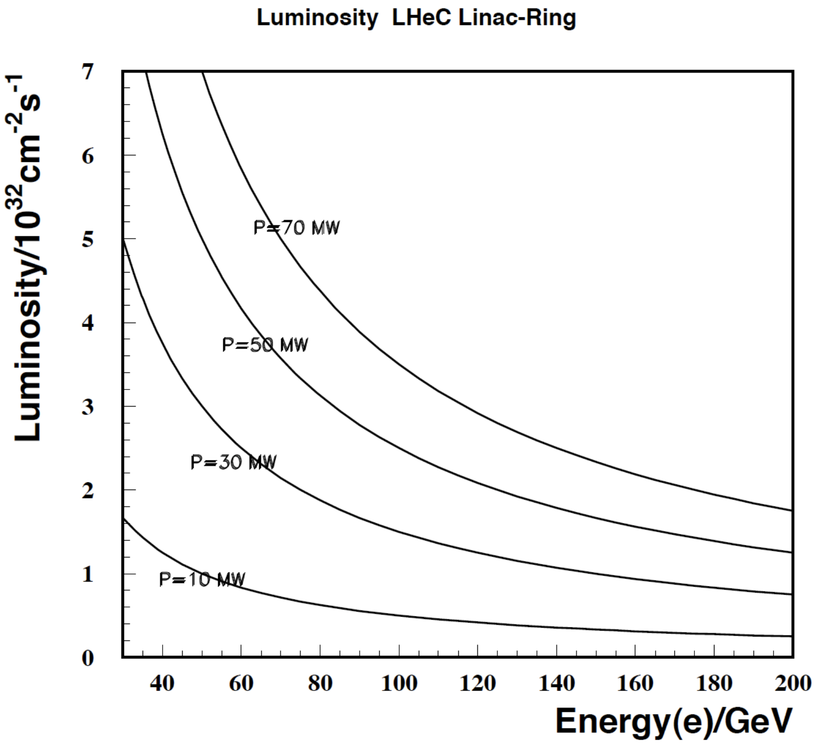
Rf installation (~ 500m for 70 GeV)

Bigger distance to beam:
New lattice

Detailed consideration of tunnel intersection

H.B DIS08

Linac Ring Luminosity



	$N_{b,p}$	$T_{\rm sep}$	$\epsilon_p\gamma_p$	$\beta^*_{p,\rm min}$
LHC	1.7×10^{11}	25 ns	3.75 μm	0.25 m
LHC*	5×10^{11}	50 ns	3.75 μm	0.10 m

LR Lumi estimates use LHC*

With 50 MW, 50 GeV
may reach 5 10^{32} $cm^{-2}s^{-1}$
which is equivalent to 10^{33} for ring-ring.
May have more than 10^{32} at high energies (~ P)

Basic Layout (different Linacs for different E)

visit to SLAC (March 09), contact to Cornell

Positron intensity [10 times ILC, large number of bunches]

Polarisation

Linac Layout

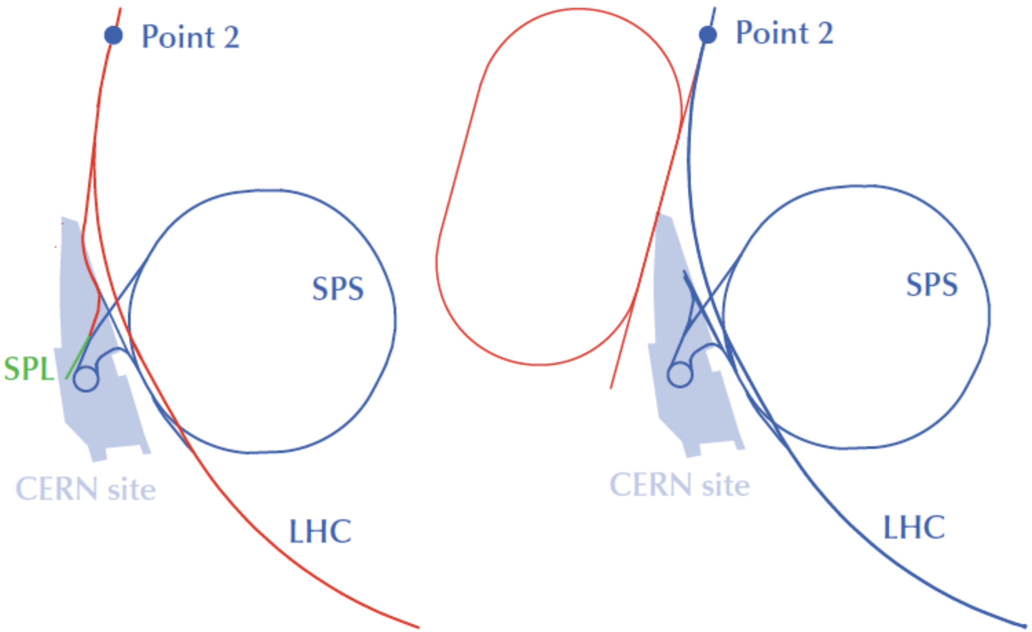


Table 2: Recirculating linac parameters for LHeC-RL.

LHeC-RL scenario	lumi	baseline	energy
final energy [GeV]	60	100	140
cell length [m]	24	24	24
cavity fill factor	0.7	0.7	0.7
tot. linac length [m]	3000	2712	3024
cav. gradient [MV/m]	13	25	32
operation mode	CW (ERL)	pulsed	pulsed

F. Zimmermann et al, PAC2009, Proceedings

Fix main parameters for CDR

Consider also highest “possible” E

Note that tangential to Point 8 is more space

Injection to p ring

IR for Linac-Ring

Photon-Nucleon Collider

Accelerator Work Packages

RING-RING

1. Lattice Design
2. Rf
3. Injector
4. Injection areas and beam dumps
5. Beam-beam effects
6. Impedance
7. Vacuum
8. Integration and machine protections
9. Magnet Design
10. Powering

LINAC RING

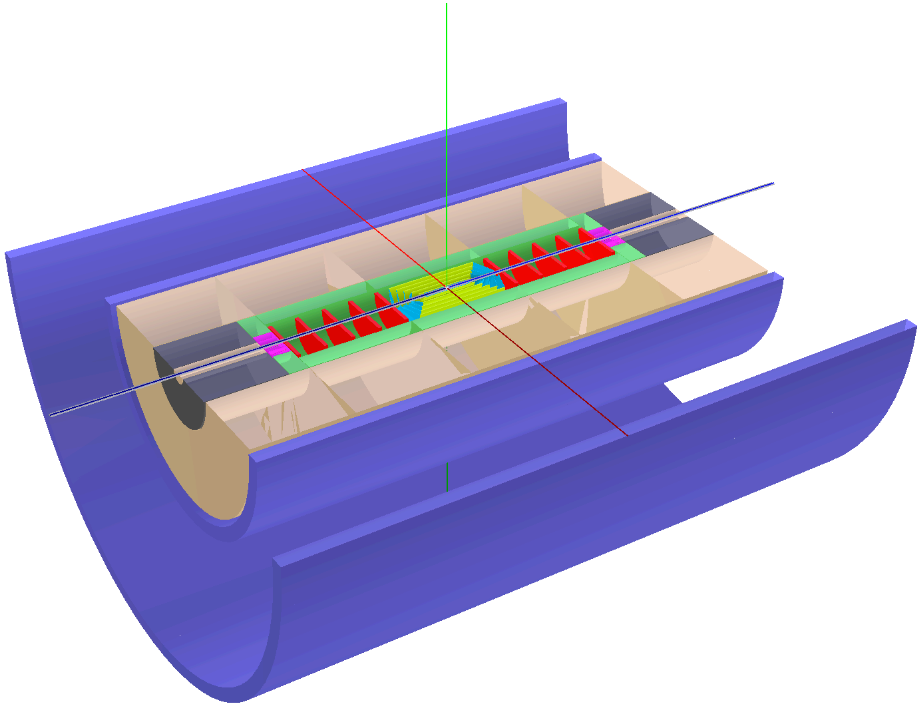
1. Baseline e+p
2. Rf
3. Source
4. Lattice and Impedance
5. Beam-beam effects
6. Vacuum
7. Integration and machine protections
8. IR
9. Magnet Design
10. Powering

Draft 4/09 - OB

Contact persons for work packages [BE-ABP, RF, BT, VAC, PO]

Collaboration: Novosibirsk, EPFL Lausanne, SLAC , CI, DESY, BNL, Cornell

Detector



IR → beam pipe → detector layout

Choices of technologies

Coil(s)

Forward Tracking (high x)

Fwd (p,n,d) / bwd (e,γ) Taggers

GEANT 4 simulation – link to physics

Scenarios

config.	E(e)	E(N)	N	∫L(e⁺)	∫L(e⁻)	|Pol|	$L/10^{32}$	P/MW	years	type
A	20	7	p	1	1	-	1	10	1	SPL
B	50	7	p	50	50	0.4	25	30	2	RR hiQ^2
C	50	7	p	1	1	0.4	1	30	1	RR lo x
D	100	7	p	5	10	0.9	2.5	40	2	LR
E	150	7	p	3	6	0.9	1.8	40	2	LR
F	50	3.5	D	1	1	--	0.5	30	1	eD
G	50	2.7	Pb	0.1	0.1	0.4	0.1	30	1	ePb
H	50	1	p	--	1	--	25	30	1	lowEp

high x!

http://hep.ph.liv.ac.uk/~mklein/simdis09/lhecsim.Dmp.CC, readfirst

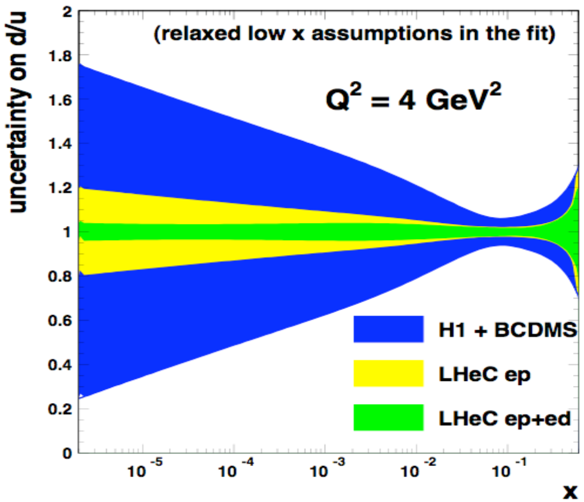
For DIS09:

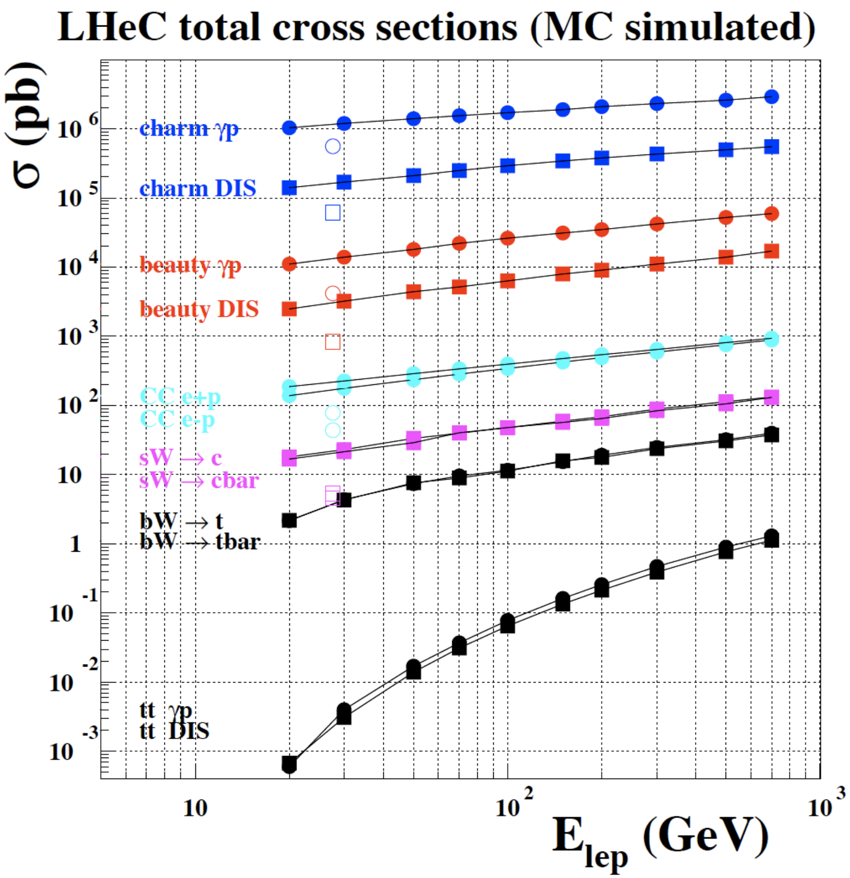
Complete simulation of NC and CC including systematic errors
[Det. two times better than H1 and wider fwd/bwd acc.]

Separately F_L, F_2^{QQ}

Shall fix or modify these settings 'now'

Unfolding the Partonic Structure of the Proton





u_v, ubar, d_v , dbar,
s, sbar c, b, single t

p,d, c,b tag, NC, CC

Plots wrt current knowledge
(data-data, NNPDF)

Importance of deuterons

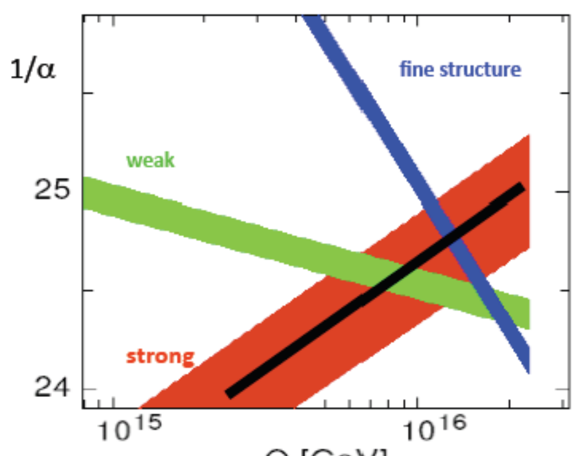
Photon Structure

Zoom into high x

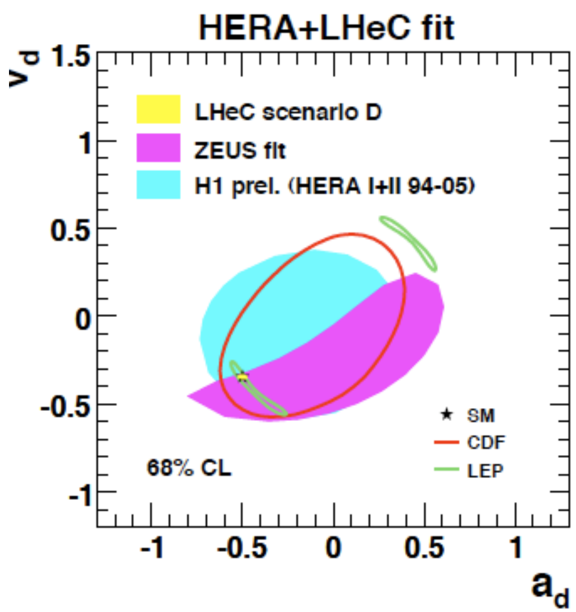
GPD's – DVCS

Exploration of Superhigh Energy Scales

Simulation of α_s measurement at LHeC



MSSM - B.Allnach et al, hep-ex/0403133



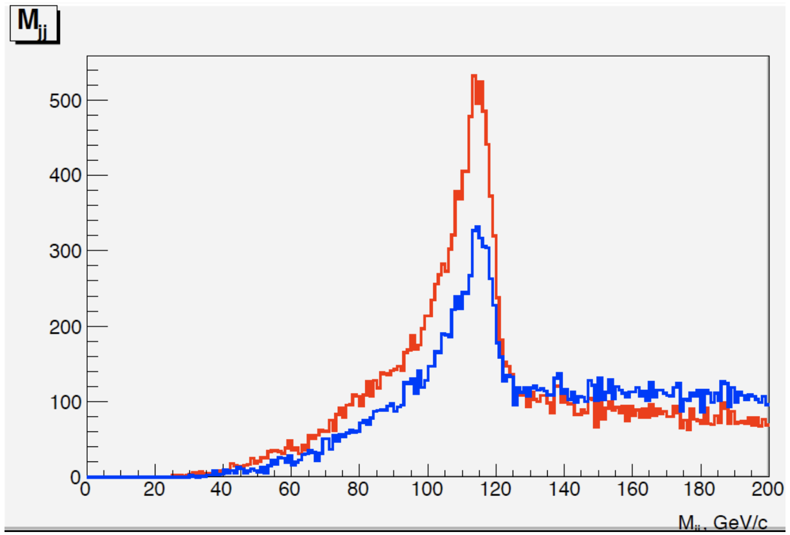
Precision measurement of α_s [incl + jets]
Independent of BCDMS

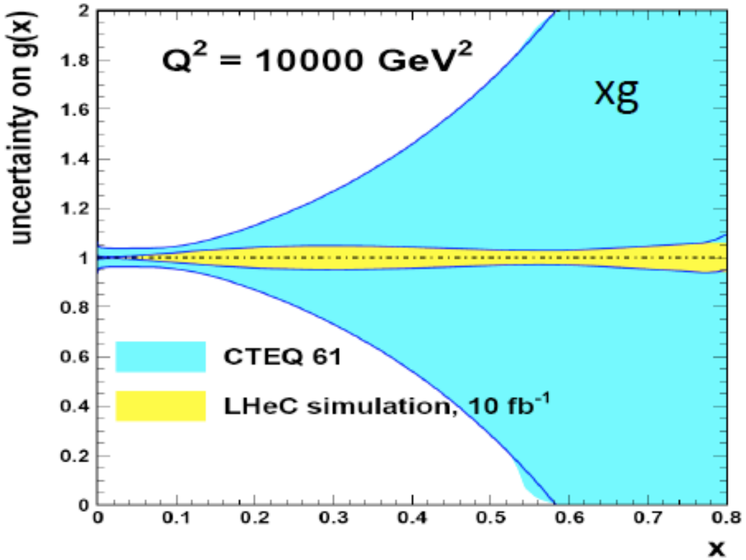
→SUSY predictions for grand unification

Precision electroweak measurements

→effective couplings, flavour dependence..

Contact Interactions and extra dimensions (DIS08 FZ)





Complementing the LHC

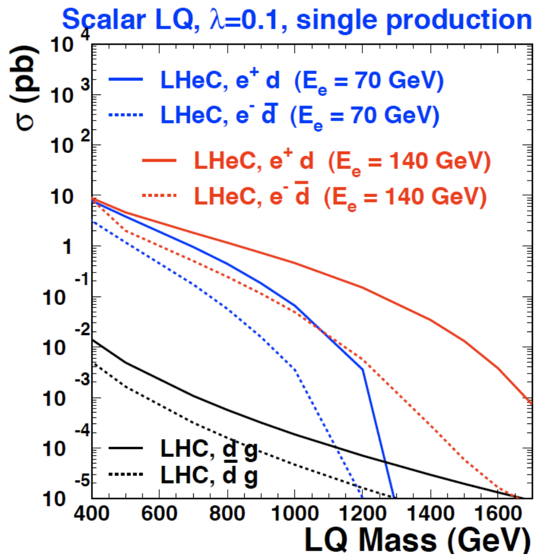
Higgs to bbar in CC   background and ep detector

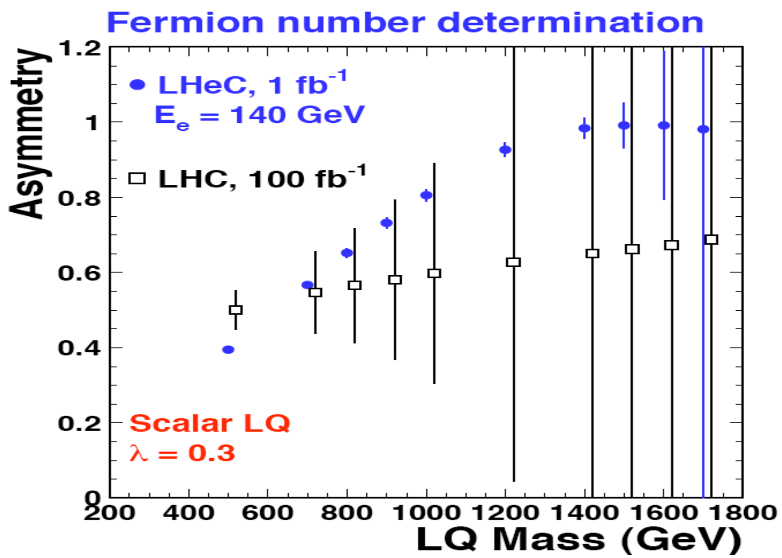
What about no Higgs?

PDFs and new physics (CI-pdf's, ED's)

Understanding QCD (parton dynamics)

New Physics at the LHeC



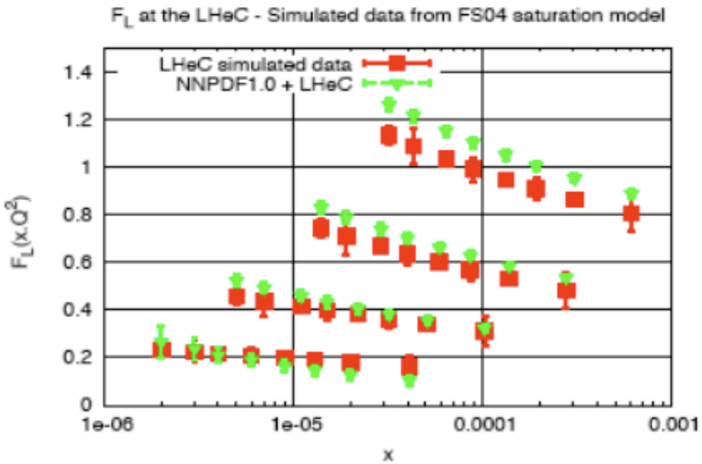


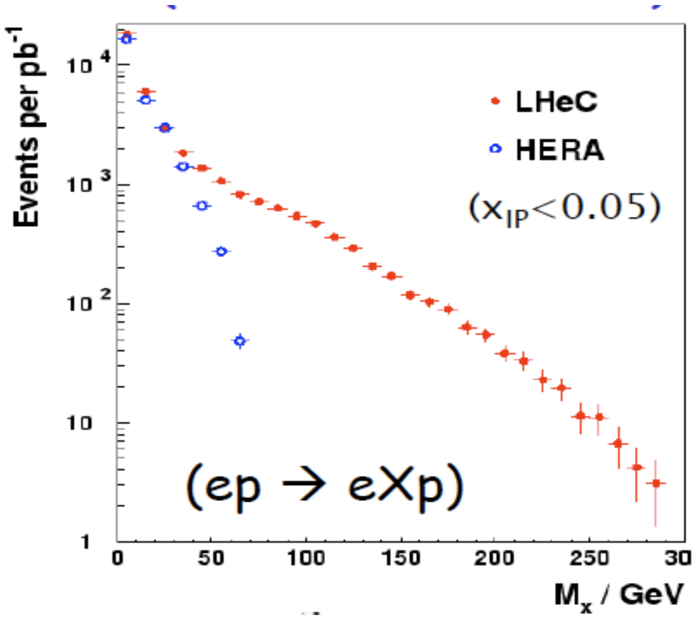
Fermion number: charge asymmetry
Spin: angular distributions
Chiral structure: polarisation

Singly produced states:
Excited fermions [e*, ν*, q*]
RPV SUSY

Review-further study potential of pp vs ep [a decade after ATLAS, CMS]

Parton Saturation at Low x





Two analyses – FKNP, NNPDF – 'unify'

DVCS

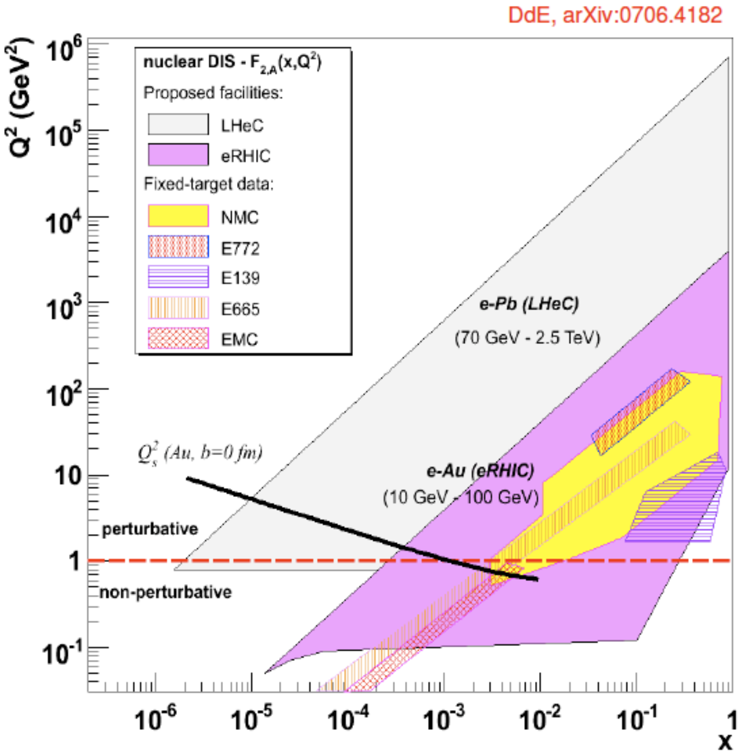
Vector Mesons

Diffractive b,W,Z,H?

Forward jets and hot spots in p?

Illustrate BB limit (F_2, J/Psi, 50% Diffraction)

Nuclei [eA]



Saturation in DIS region!

Nuclear parton distributions

Relation to AA at the LHC

Amplification of xg – x_{eff}~ 10^{-8}

Link to superhighE neutrino physics

DRAFT **Steps to Complete the CDR in 2010** (tbc)

Divonne 09: Fix parameters of the Machine

[50-150 GeV E_e , 100 MW wall plug, p (7 TeV), D, Ca, Pb -- Scenarios. Acc to 1-179^o]

30. January: Fix Machine Lattice and Main Parameters for RR and LR

15. April: Draft of all Chapters for:

Presentation to Physics and ACC Communities at DIS10 and IPAC10

30. May: Draft of CDR Chapters to Referees

1. September: Referee Reports and final review (3rd Workshop)

30. October: Finalization of CDR

November 10: Final Reports to CERN, ECFA, NuPECC

Print of CDR and handover to whom Rolf (CERN), Tatsuya (EFCA) and Guenther (NuPECC) appoint
timing should be in accord with European Strategy update, LHC, NuPECC long term plan..

Convenors+Steering group meet tomorrow. **Input + full support are essential**

Organisational Matters

For documentation:
LHeC Notes: ACC, DET, PHY, GEN, INT: LHeC-ACC-007-05-2009

Offices: CERN provides 4 offices and a meeting room in hut 561

Next **ECFA progress report** expected in November 2009

If it comes to a TDR, the organisation will have to be adapted.
So far it is suggested in agreement with CERN to keep the structure we work with, i.e. the Steering group, Working Groups and the Scientific Advisory Committee

Working Groups and Convenors

ACC - Accelerator Design

Oliver Bruening (CERN)

John Dainton (CI/Liverpool)

IRF - Interaction Region and Fwd/Bwd

Bernhard Holzer (DESY)

Uwe Schneeekloth (DESY)

Pierre van Mechelen (Antwerpen)

DET - Detector Design

Peter Kostka (DESY)

Rainer Wallny (UCLA)

Alessandro Polini (Bologna)

NUP - New Physics at Large Scales

Georges Azuelos (Montreal)

Emmanuelle Perez (CERN)

Georg Weiglein (Durham)

QCE - Precision QCD and Electroweak

Olaf Behnke (DESY)

Paolo Gambino (Torino)

Thomas Gehrmann (Zuerich)

Claire Gwenlan (Oxford)

HPD - Physics at High Parton Densities

Nestor Armesto (CERN)

Brian Cole (Columbia)

Paul Newman (Birmingham)

Anna Stasto (MSU)

Welcome to Claire and Georges

Scientific Advisory Committee

Guido Altarelli (Rome)
Sergio Bertolucci (CERN)
Stan Brodsky (SLAC)
Allen Caldwell **Chair** (MPI Munich)
Swapan Chattopadhyay (Cockcroft)
John Dainton (Liverpool)
John Ellis (CERN)
Joel Feltesse (Saclay)
Lev Lipatov (St.Petersburg)
Roland Garoby (CERN)
Roland Horisberger (PSI)
Young-Kee Kim (Fermilab)
Aharon Levy (Tel Aviv)
Karlheinz Meier (Heidelberg)
Richard Milner (Bates)
Joachim Mnich (DESY)
Steven Myers (CERN)
Tatsuya Nakada (Lausanne, ECFA)
Guenter Rosner (Glasgow, NuPECC)
Alexander Skrinsky (Novosibirsk)
Anthony Thomas (Jlab)
Steven Vigdor (BNL)
Frank Wilczek (MIT)
Ferdinand Willeke (BNL)

Welcome to

Sergio Bertolucci (CERN)
Tatsuya Nakada (ECFA)
Joachim Mnich (DESY)

Thanks to

Jos Engelen (ex CERN)
Karlheinz Meier (ex ECFA)
Rolf Heuer (ex DESY)

The **meeting with SAC at DIS09** was an attempt to establish closer relations and get in time advice from the committee for the CDR and the project. This will be followed closer for the CDR finalization. Various **members of the SAC have made invaluable contributions** to our work, and we count on the committee's advice and insight in the development of particle physics.

In 3 sentences

The physics of the LHeC is unique, fundamental and complementary to pp, e^+e^-.

The LHeC is a very serious candidate for a further TeV collider, as it may be built using known technology at not exceedingly high cost.

For the deliberations on the future of HEP, with the LHC opening a new dimension, the Conceptual Design Report has been requested by (r)ECFA and CERN. It may be delivered if we keep working together and the LHeC receives the support it deserves.

Think of ~1 word instead of 3 sentences –
Is that the worlds' new microscope?

Thank you for coming here.

Thanks to all for the many contributions and thoughts on the ep/eA collider including those who are engaged in lower energy and polarised EIC's.

Thanks to CERN, Rolf, Sergio, Steve, to ECFA and NuPECC

Thanks to Patricia and Antonella

Enjoy Divonne and the dinner, today at 8pm.