The Large Hadron Electron Collider Project

Max Klein, University of Liverpool

Future of DIS. Panel. Madrid 30.4.2009 -DIS09

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2005: LHeC: * DIS, Madison
2006: $10^{33}cm^{-2}s^{-1}$: 2006 JINST **1** 10001
2007 CERN Council and [r]ECFA
2008 Divonne I, NuPECC, ICFA,ECFA
2009 Divonne II (1.-3.9.), ECFA 11/09

→ **2010: Conceptual Design Report**

http://www.lhec.org.uk

LEP*LHC (1990), Thera (2001), QCD explorer (2003)

Tentative, preliminary, often incomplete results based on many people's work.
cf DIS07,08, EPAC08 and for DIS09 see premeeting and summary talks of
B.Holzer, A.Stasto, U.Klein, O.Behnke, A.Polini, and J.Rojo

Working Group Convenors

Accelerator Design [RR and LR]
Oliver Bruening (CERN),
John Dainton (CI/Liverpool)

Interaction Region and Fwd/Bwd
Bernhard Holzer (DESY),
Uwe Schneeekloth (DESY),
Pierre van Mechelen (Antwerpen)

Detector Design
Peter Kostka (DESY),
Rainer Wallny (UCLA),
Alessandro Polini (Bologna)

New Physics at Large Scales
Emmanuelle Perez (CERN),
Georg Weiglein (Durham)

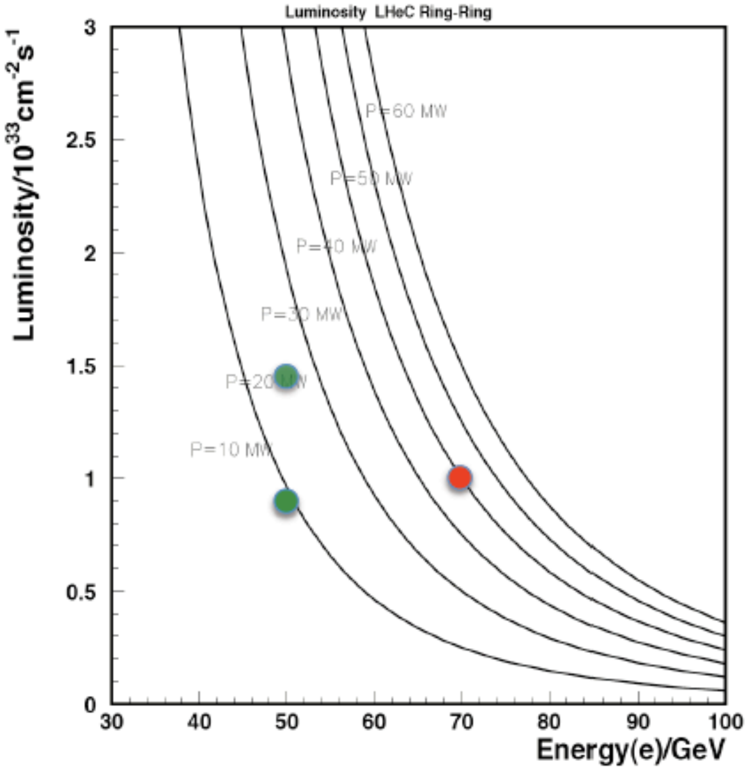
Precision QCD and Electroweak
Olaf Behnke (DESY),
Paolo Gambino (Torino),
Thomas Gehrmann (Zuerich)
Claire Gwenlan (Oxford)

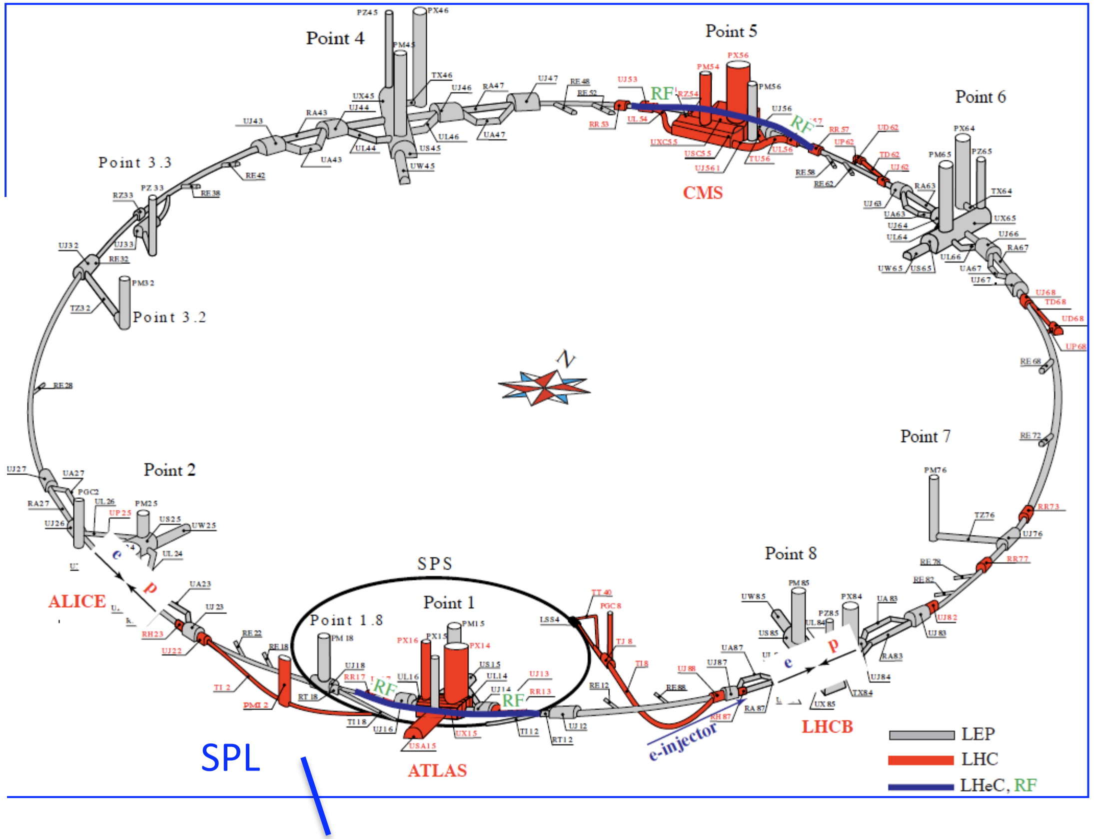
Physics at High Parton Densities
Nestor Armesto (CERN),
Brian Cole (Columbia),
Paul Newman (Birmingham),
Anna Stasto (MSU)

Ring – Ring Design tentative

$$L = \frac{N_p \gamma}{4\pi e \varepsilon_{pn}} \cdot \frac{I_e}{\sqrt{\beta_{px}\beta_{py}}} = 8.3 10^{32} \cdot \frac{I_e}{50mA} \frac{m}{\sqrt{\beta_{px}\beta_{pn}}} cm^{-2}s^{-1}$$

$$I_e = 0.35mA \cdot \frac{P}{MW} \cdot \left(\frac{100GeV}{E_e}\right)^4$$





$$2 \cdot 10^{33} cm^{-2}s^{-1}, 5y : 100 fb^{-1} ... 50 ... 80 GeV$$

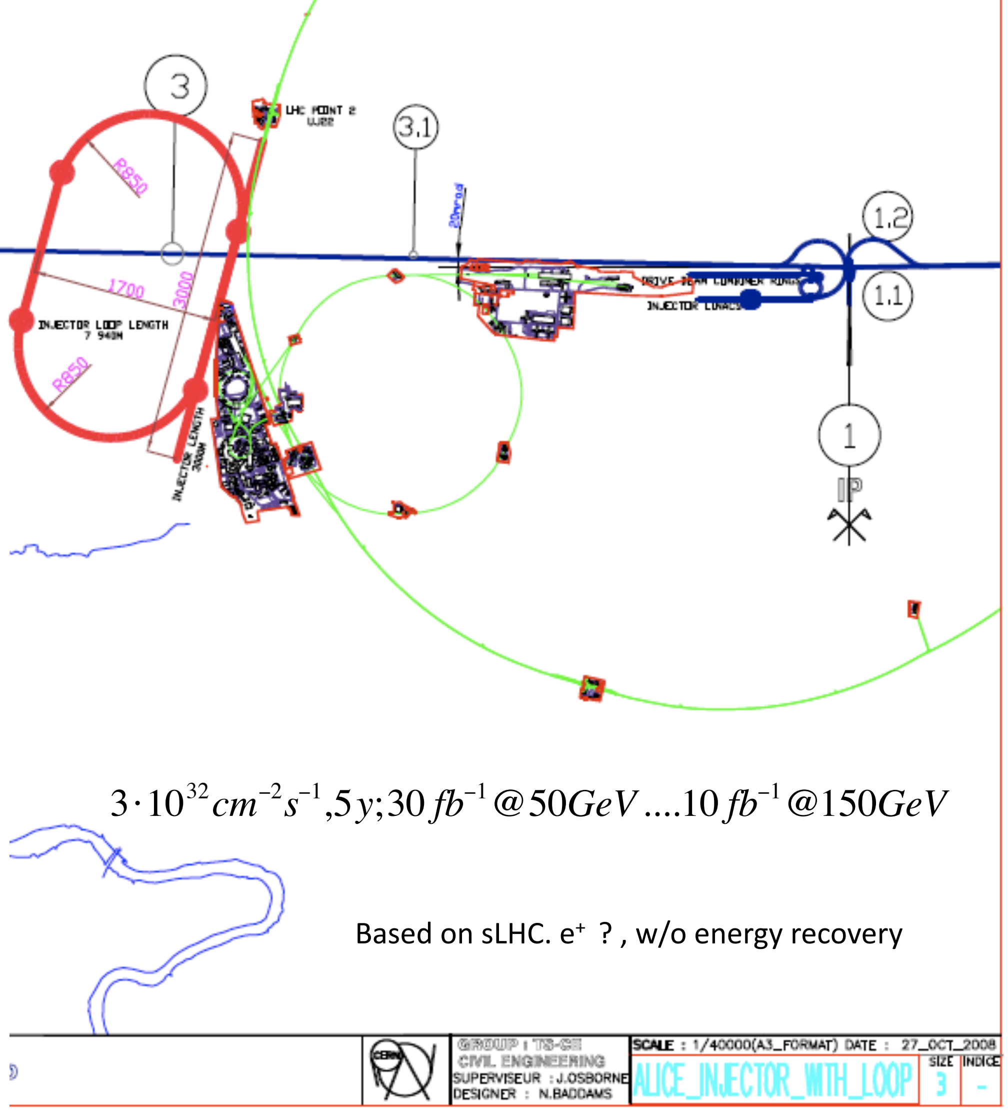
F.Willeke, 70GeV * 7TeV, 50MW [JINST 2006]

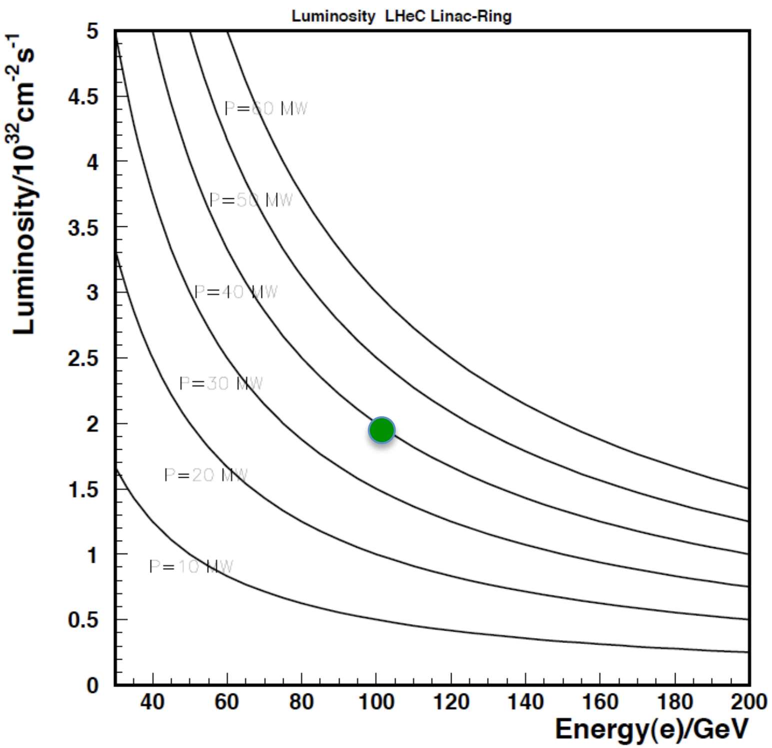
B.Holzer, A.Kling et al, Divonne08,ECFA08

Subject to LHC, power, tuneshifts etc. – 100 times HERA luminosity

LINAC-Ring Design - tentative

$$L = \frac{N_p \gamma}{4\pi e \varepsilon_{pn} \beta^*} \cdot \frac{P}{E_e} = 5 \cdot 10^{32} \cdot \frac{P/MW}{E_e/GeV} cm^{-2} s^{-1}$$



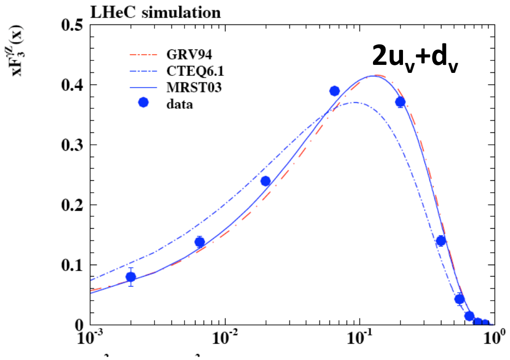


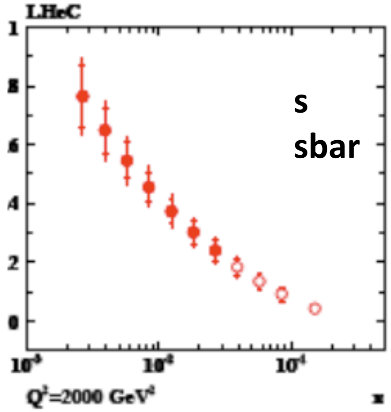
$$3 \cdot 10^{32} cm^{-2} s^{-1}, 5y; 30\, fb^{-1} @ 50 GeV \ldots 10\, fb^{-1} @ 150 GeV$$

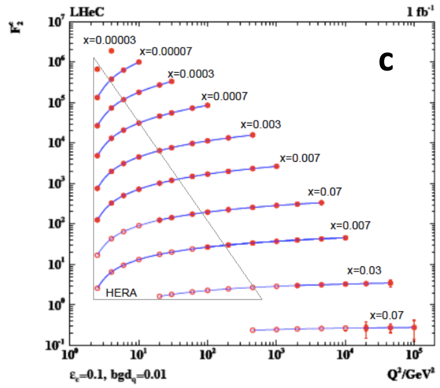
Based on sLHC. e^+ ? , w/o energy recovery

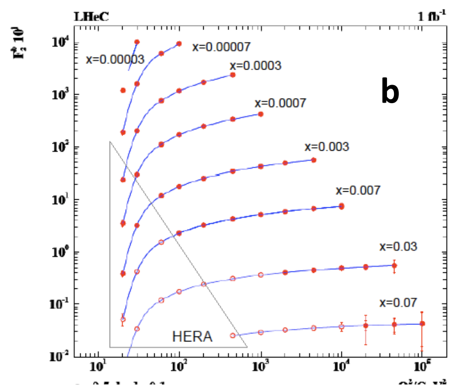
F. Zimmermann ECFA11/08

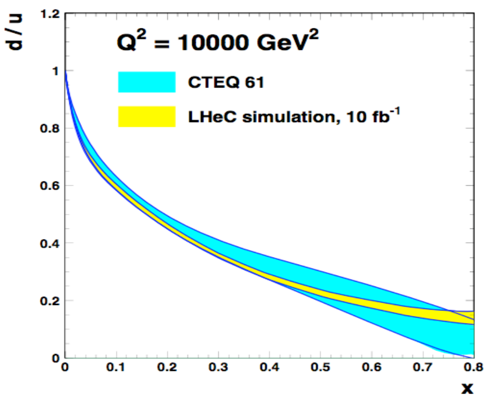
1. Unfolding Proton Structure – DIS, complete for the first time

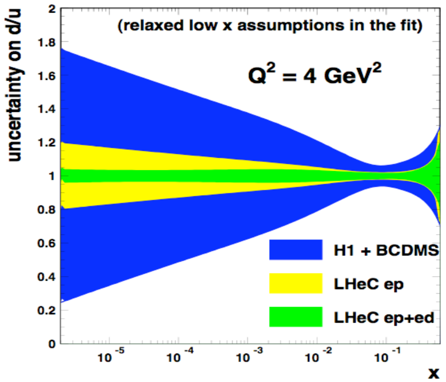




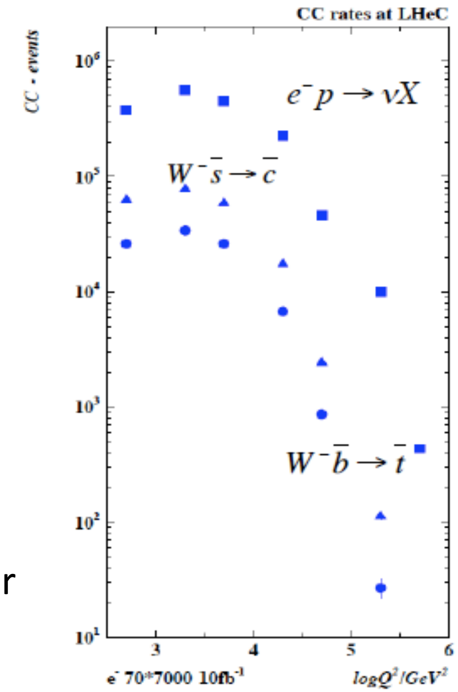


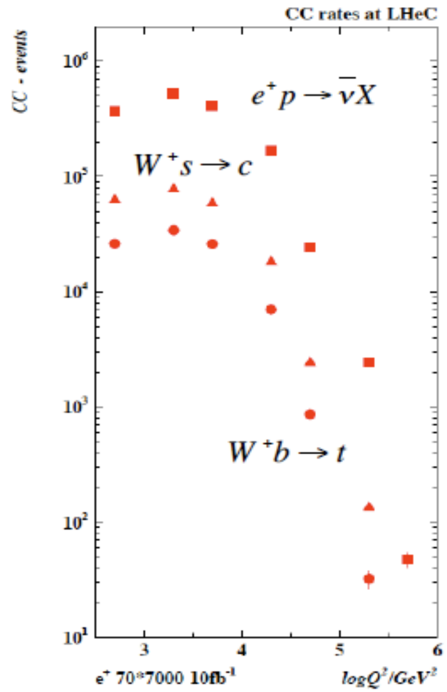






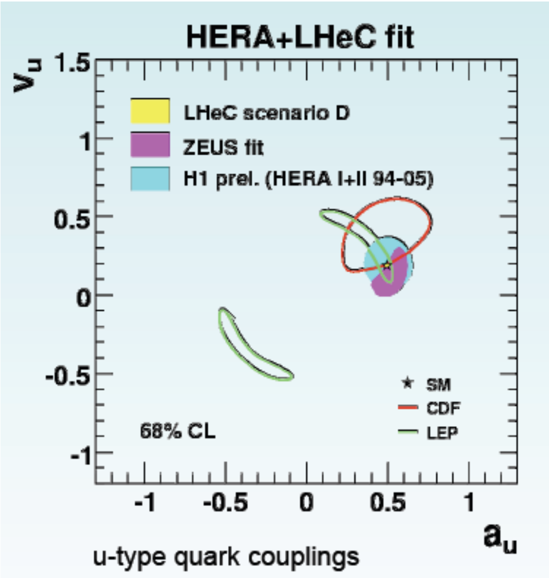
+
parton dynamics
photon structure
neutron structure
..
Instantons
Odderons
Multiquark exotica
Intrinsic heavy flavour

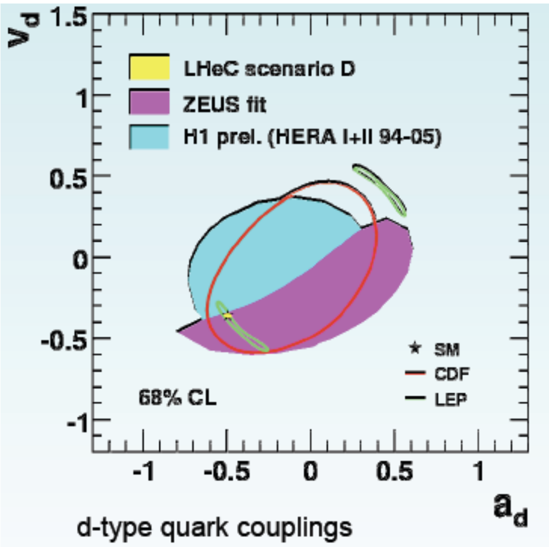




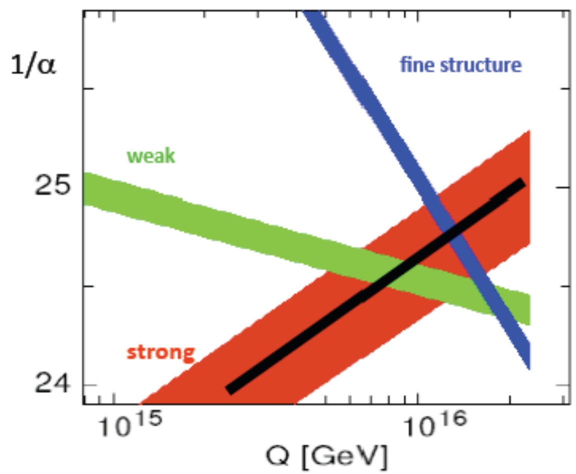
Single t, tbar factory O(10)pb

2. Exploration of High ("swerch") Scales – High Precision in ep





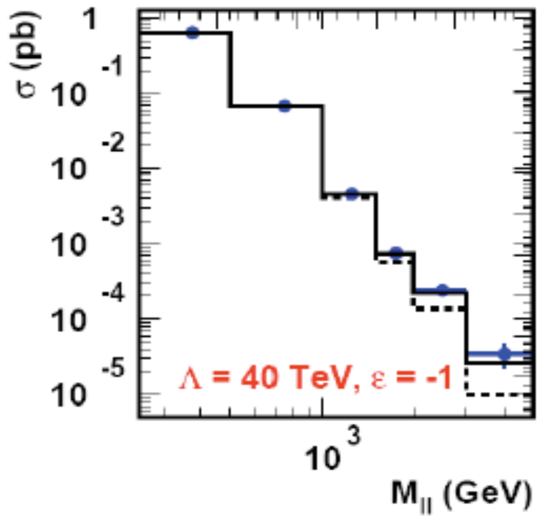
Simulation of α_s measurement at LHeC

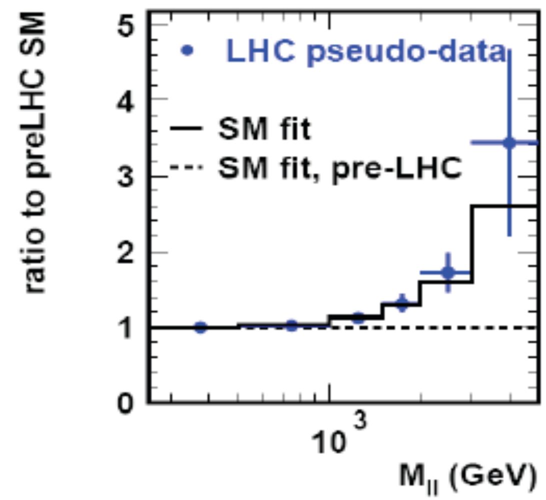


MSSM - B.Allnach et al, hep-ex/0403133

GUT/SUSY unification?
effective couplings?
resolving CI type
observations at the LHC

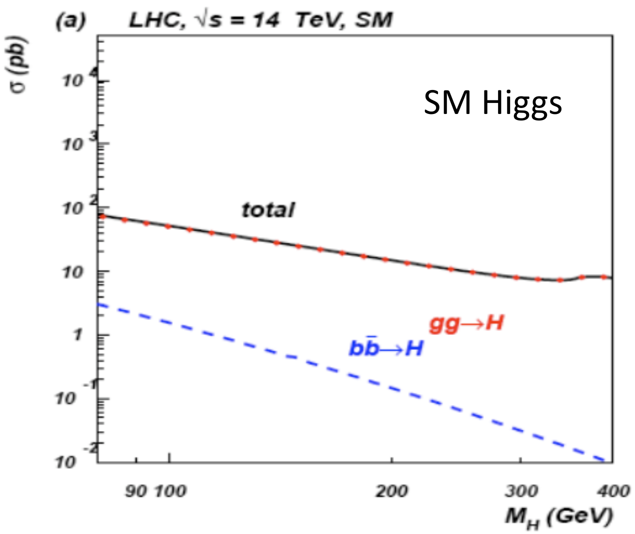
… access to much higher
scales with precision DIS
challenge to N^{k}LO QCD

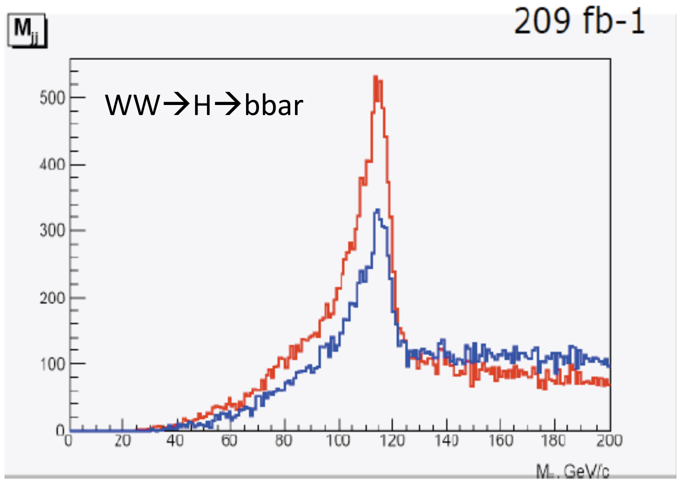


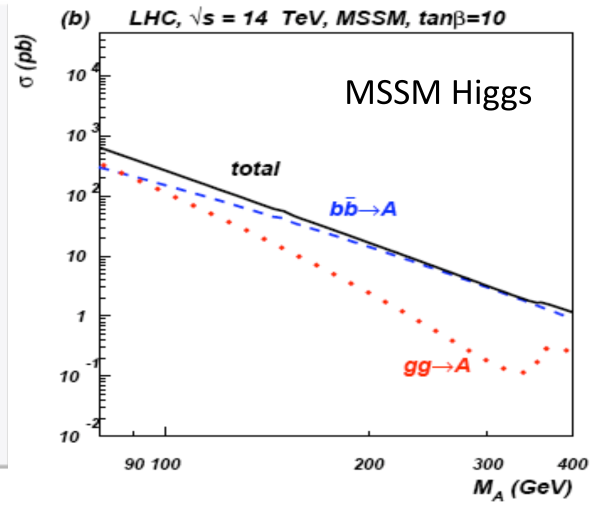


LHeC freezes the pdfs to allow new physics to be revealed. HERA+BCDMS reshuffle the sea… ED similar study

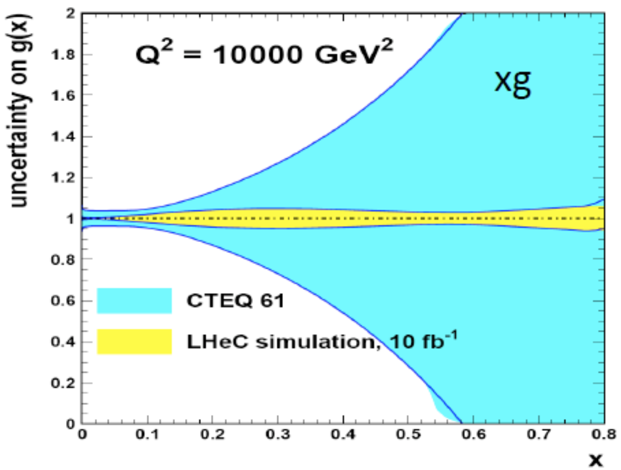
3. Complementing the LHC – Higgs and gluon (for example)

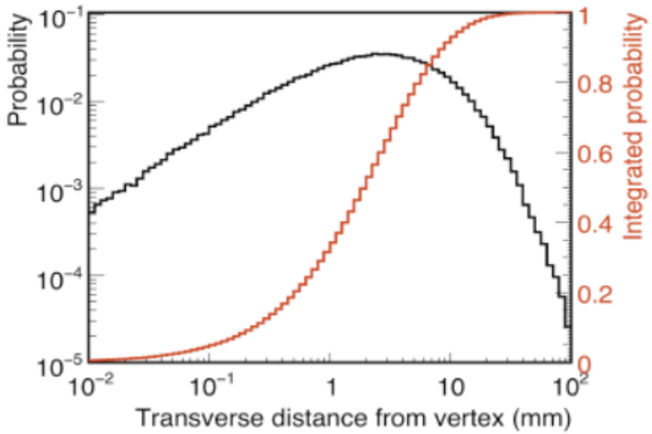






Bgd study ongoing, B tagging promising





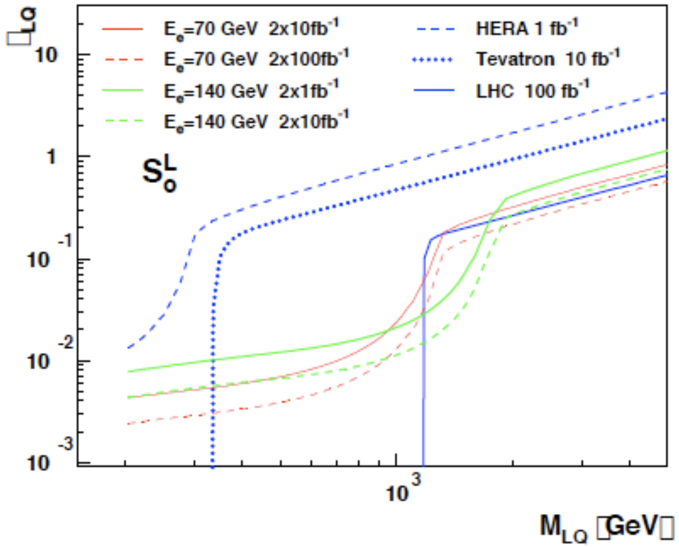
clean(er) environment

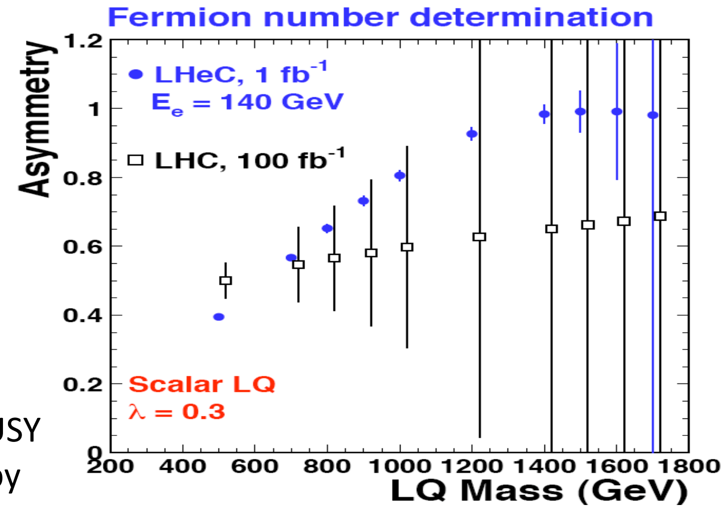
huge range in Q^2
access to large x,
high mass region

B tagging mandatory.

confirmed at DIS09 within
factor 2 for error treatment

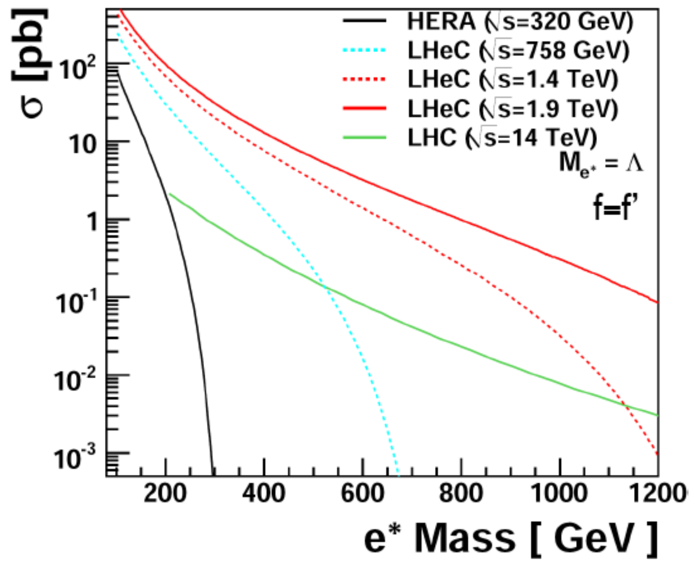
4. New Physics in the eq Sector – unique eq as compared to qq

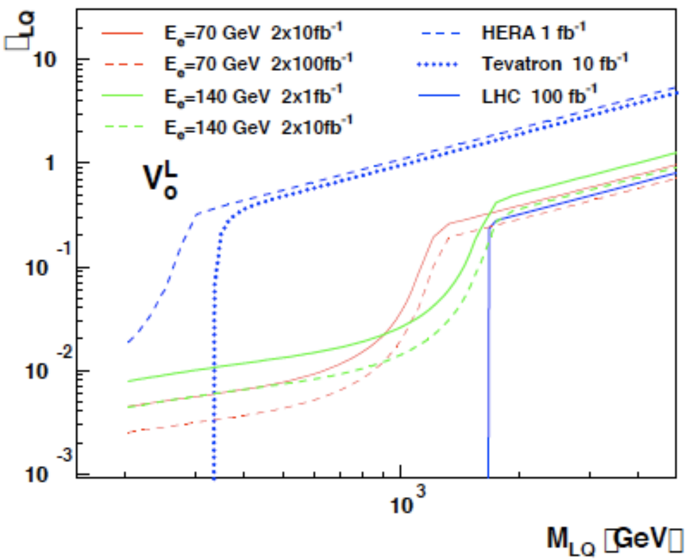




?LQ, RPV SUSY Spectroscopy

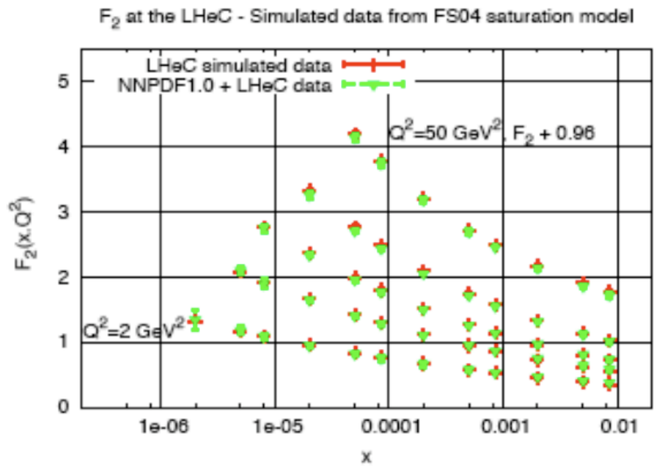
?Excited fermions

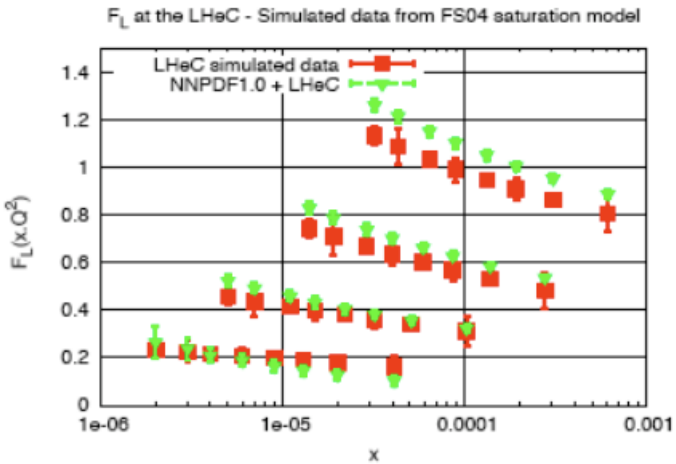




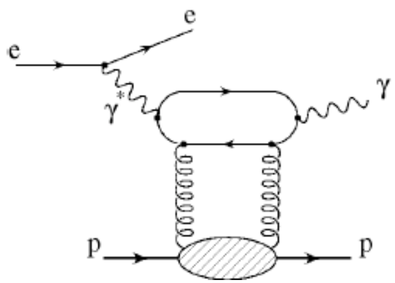
SUSY studies to come

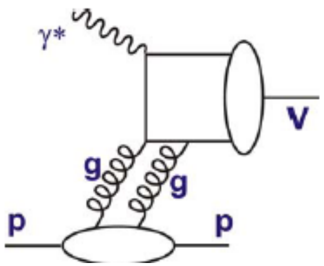
5. Parton Saturation – low x beyond the unitarity limit in DIS ep





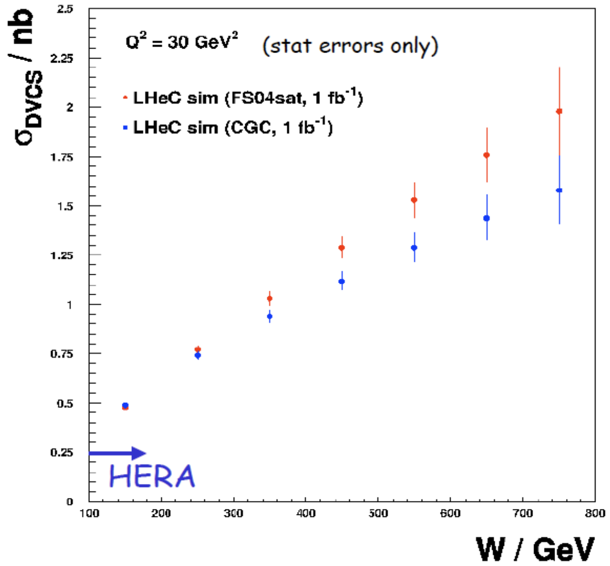
Saturation from precision F_2 and F_L

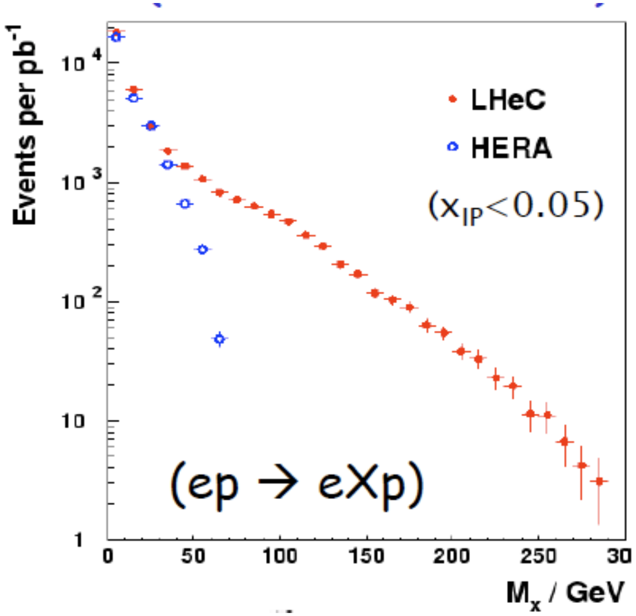




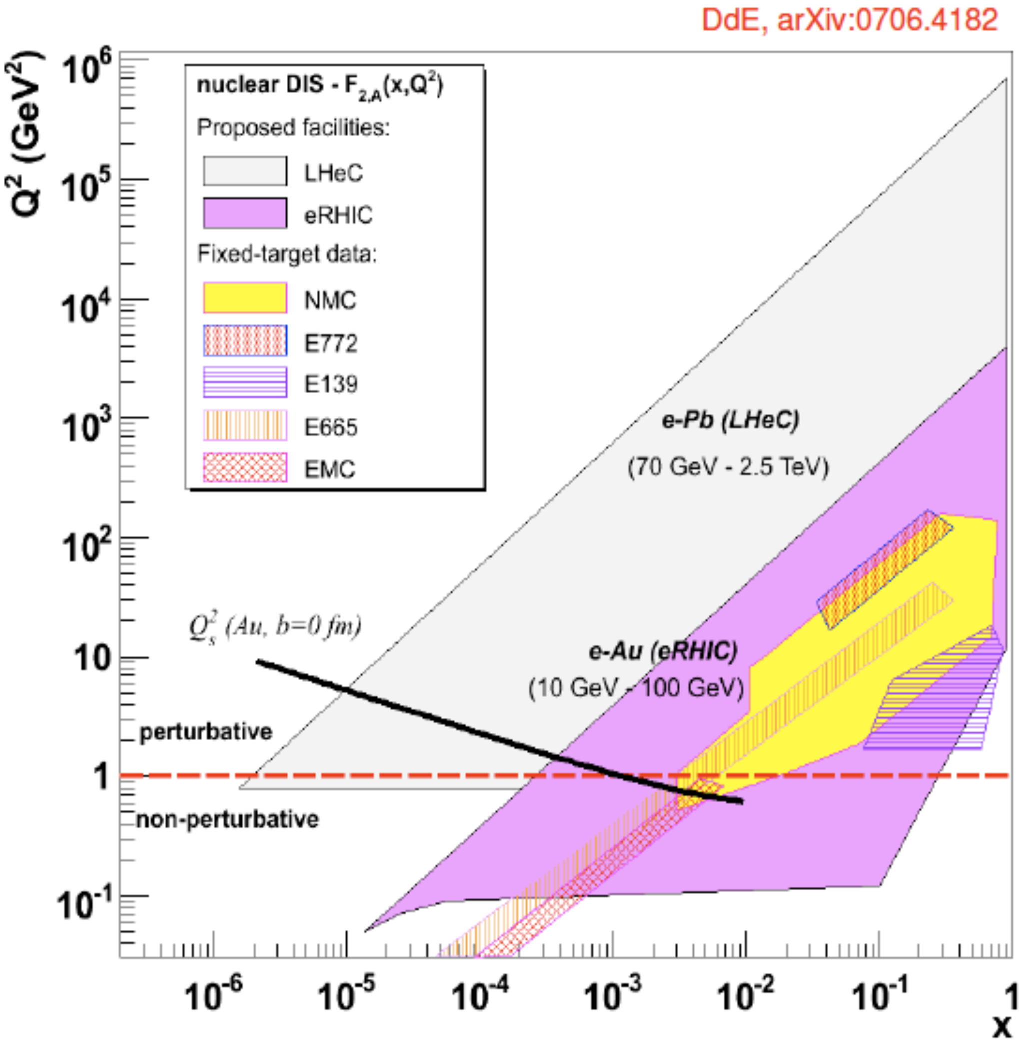
Diffractive
B,W,Z,H?

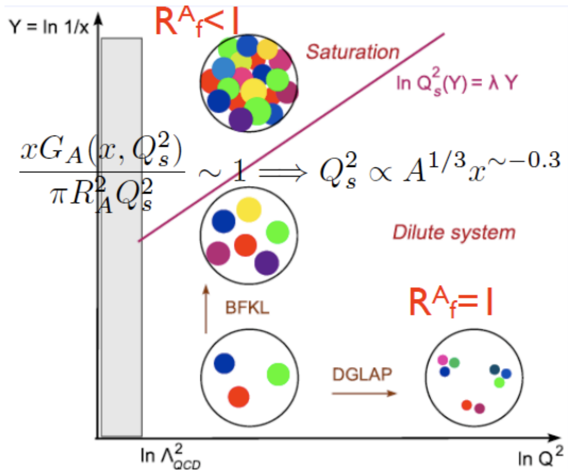
Forward jets, VMs..





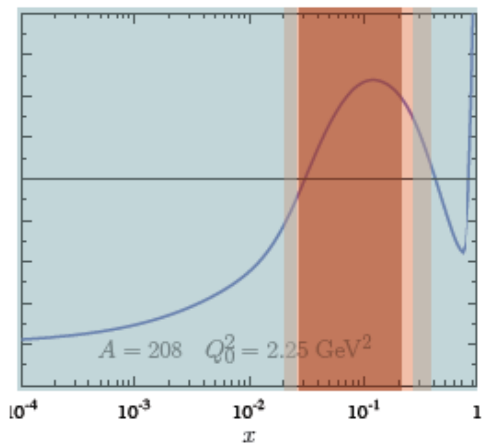
6. Partonic Structure of Nuclei – a new phase of matter





Nuclear parton distributions
xg ~ $A^{1/3}$
black disc limit (F_2~ln(1/x))
50% diffraction..
A must to understand AA

Gluon "a desaster" (NA)



THE UNCONFINED QUARKS AND GLUONS

Abdus Salam

International Centre for Theoretical Physics,
Trieste, Italy and Imperical College, London,
England

1. Introduction

Leptons and hadrons share equally three of the basic forces of nature: electromagnetic, weak and gravitational. The only force which is supposed to distinguish between them is strong. Could it be that leptons share with hadrons this force also, and that there is just one form of matter, not two?

Tbilissi 76

Surprises and Theory

Things may evolve differently than we think, but one can rely on the ingenuity of our theory colleagues to deal with the unexpected.

Design a maximum energy, high luminosity, affordable **collider**

$E^+ \rightarrow e^+g$

S.Adler, arXiv:hep-th/9610104

In summary, we suggest that the production and decay of the excess HERA events, interpreted as leptogluons, could be accounted for in our model when augmented by either the assumption that the Z_6 condensate that breaks $SU(4)$ to color $SU(3)$ contains a small component that further breaks color $SU(3)$ to glow $SO(3)$, or by the assumption that color symmetry remains exact but that color neutralization is incomplete in hard processes.

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

DRAFT - February 2009

Accelerator Design

Organisation

RING-RING

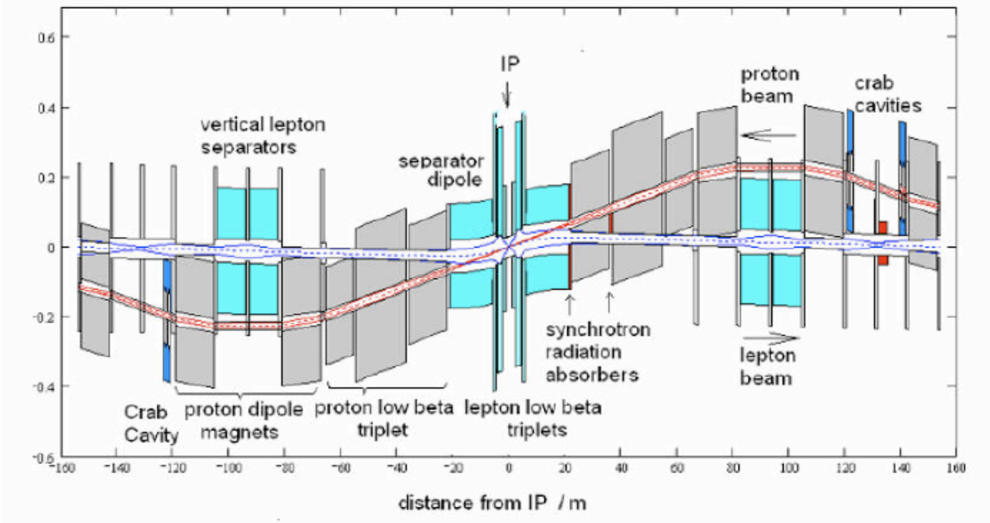
1. Lattice Design
2. Rf
3. Injector
4. Injection areas and beam dumps
5. Beam-beam effects
6. Impedance
7. Vacuum
8. Integration and machine protections
9. Magnet Design
10. Powering

LINAC RING

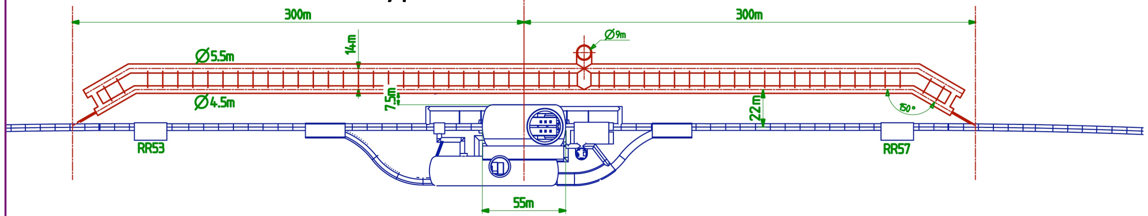
1. Baseline e+p
2. Rf
3. Source
4. Lattice and Impedance
5. Beam-beam effects
6. Vacuum
7. Integration and machine protections
8. IR
9. Magnet Design
10. Powering

Concepts

IR for simultaneous pp and ep operation



Bypass around ATLAS+CMS

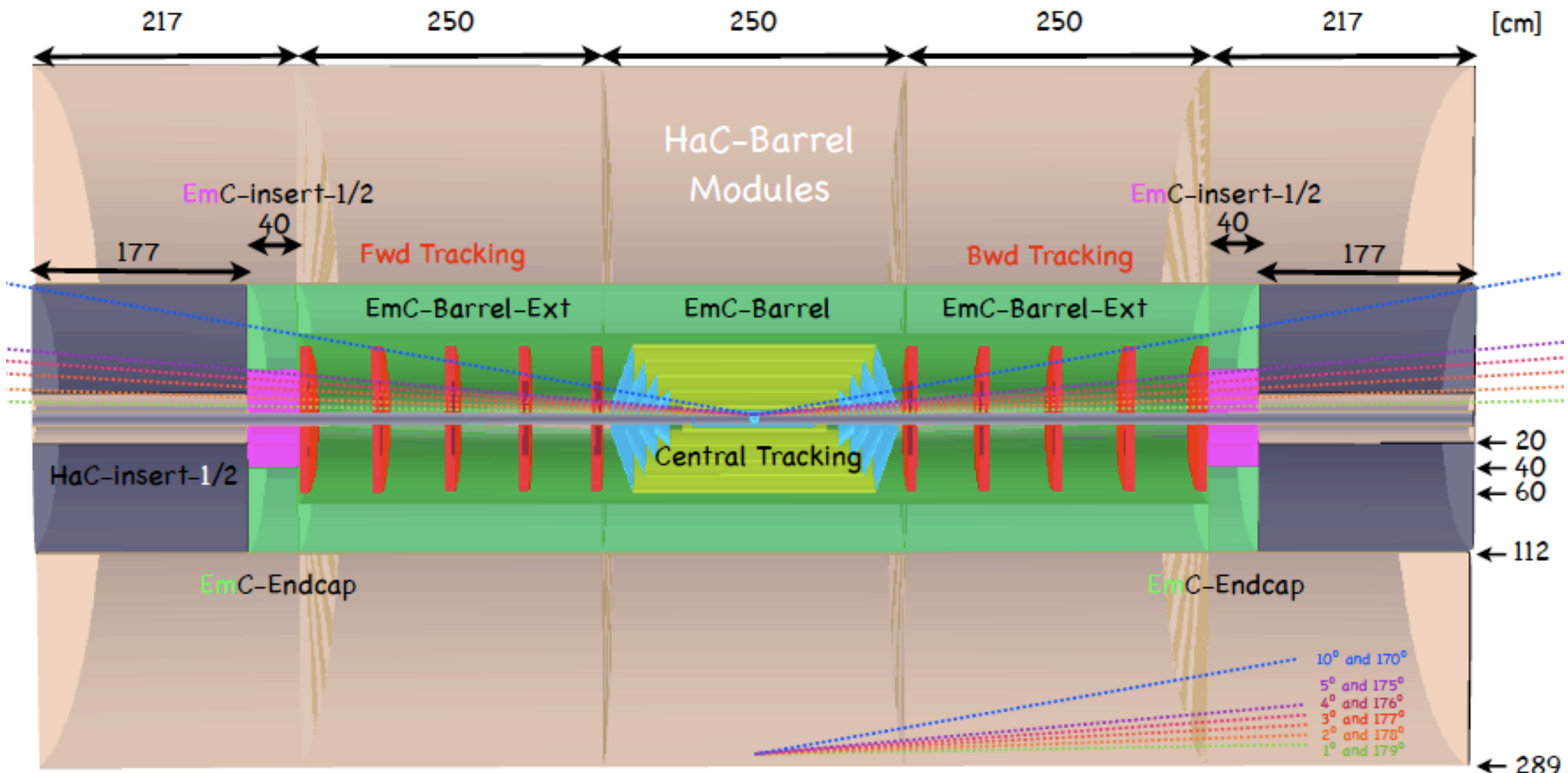


Contact persons for workpackages [BE-ABP, RF, BT, VAC, PO]
O.Bruening, B.Holzer, E.Chiapola, H.Burkhardt,B.Goddard, W.Herr, F.Zimmermann
M.Jimmenez, KH.Mess, D.Tommasini, F.Bordry,G.Hofstatter, L.Rinolfi, D.Schulte.

Collaboration: Novosibirsk, EPFL Lausanne + [tbd]: SLAC , CI, DESY, BNL, Cornell

L1 Low Q^2 SetUp

(to be optimised)



P.Kostka, A.Polini, R.Wallny

Tentative design: full coverage, high precision, no material…
- modular for installation (CMS), dimensions determined by beam pipe-IR-synchr. rad. : to be simulated
- focusing magnets nearer to IR for high Q^2, high luminosity (instrumented?)
-variation of beam energies to access low Q^2 and large x at "medium" Q^2 ~ 20000 GeV^2
- contacts to ILC (4th concept: coil? ALIROOT) and ATLAS/CMS detector developments

Deep Inelastic Scattering

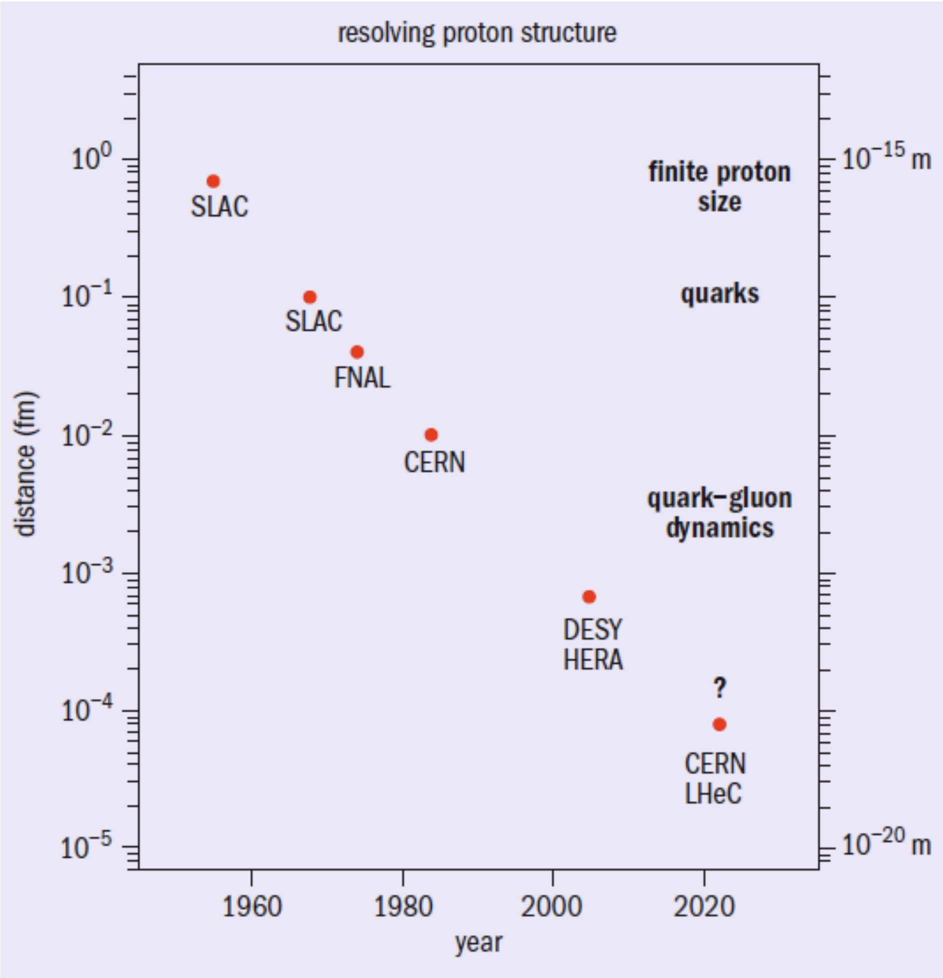


Fig. 1. Distance scales resolved in successive lepton–hadron scattering experiments since the 1950s, and some of the new physics revealed.

www.lhec.org.uk, EPAC08, .. also for proper referencing of work presented above.

SLAC 69: 2m LINAC: a "bold extrapolation of existing technology" to "collect data which may be of future use..."

Many thanks to very many gifted and enthusiastic colleagues in thy, exp and acc, to ECFA, CERN and NuPECC.

50 000 times Q^2 possibly with 5 times the accelerator length..

In one year we hope to know how to build the ep/eA collider complement of the LHC, and we will start to look into the TeV scale physics with pp. The CDR should help shaping our future.