Questions around the CDR

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1. The mandate
2. Why do we care?
3. What happened in 2009?
4. How do we structure the CDR?
5. Which are the major questions now?
6. Who we believe should sign the Design Report?
7. How do we organise the CDR studies and its writing?

Today

Introduction to the meeting of the LHeC Steering Group and Working Group Convenors at CERN, 15 of December 2009

1. Proposal to ECFA – endorsed by plenary ECFA 11/2007

rECFA and ECFA and CERN DG: CDR on the LHeC within 2 years

As an add-on to the LHC, the LHeC delivers in excess of 1 TeV to the electron-quark cms system. It accesses high parton densities 'beyond' what is expected to be the unitarity limit. Its physics is thus fundamental and deserves to be further worked out, also with respect to the findings at the LHC and the final results of the Tevatron and of HERA.

First considerations of a ring-ring and a linac-ring accelerator layout lead to an unprecedented combination of energy and luminosity in lepton-hadron physics, exploiting the latest developments in accelerator and detector technology.

It is thus proposed to hold two workshops (2008 and 2009), under the auspices of ECFA and CERN, with the goal of having a Conceptual Design Report on the accelerator, the experiment and the physics. A Technical Design report will then follow if appropriate.

2. Physics Programme of the LHeC

+ Unfolding completely the **parton structure of the proton** (and of the neutron and photon) and search for sub-substructure down to 6 10^{-20}m

+ Exploration of **new symmetries and the grand unification** of particle interactions with electroweak and strong interaction measurements of unprecedented precision.

+ Search for and exploration of **new, Terascale physics**, in particular for new states with lepton qu.numbers (RPV SUSY, LQ, excited fermions), complementary to the LHC

+ Exploration of **high density matter** [low x physics beyond the expected unitarity limit for the growth of the nucleon gluon density]

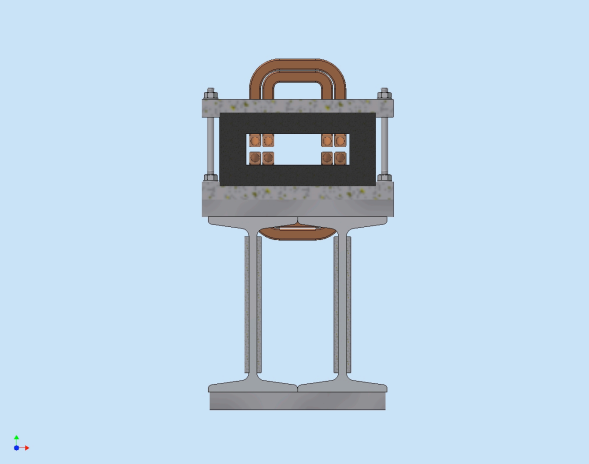
+ Unfolding the substructure and **parton dynamics inside nuclei** by an extension of the kinematic range by four orders of magnitude [initial state of the QGP]

Slide shown at ECFA 2009 (www.lhec.cern.ch) : Mandate reconfirmed end of November

3. What happened in 2009?

-CERN Courier (Divonne 08 report)
-DIS: Preconference, working group, panel: Proceedings. arXiv0908.2877
-PAC in Vancouver: Proceedings – 3 papers
-Visit to SLAC (OB, MK): Linac design study
-Pre Blois low x topical meeting to shape HPD physics and attract colleagues
-Visit to Novosibirsk (KhM, DT, MK): Dipole magnet design →
-Poster on LHeC to EPS Cracow (Acc talk) and ly Hamburg (DIS talk) →
-Divonne workshop 2009. Summary [to DG, ECFA, NuPECC] →
-Monthly meetings with S.Bertolucci and S.Myers
-Offices in Barack 561 →
-NuPECC Scoping Workshop (BC, UW, MK – NA,PN,AS) – long range plan 2010
-ECFA report →
-CDR table of contents [today]
-Cockcroft group joins
-Talks at topical conferences (PN, JBD) and seminars
-…

Dipole Magnets

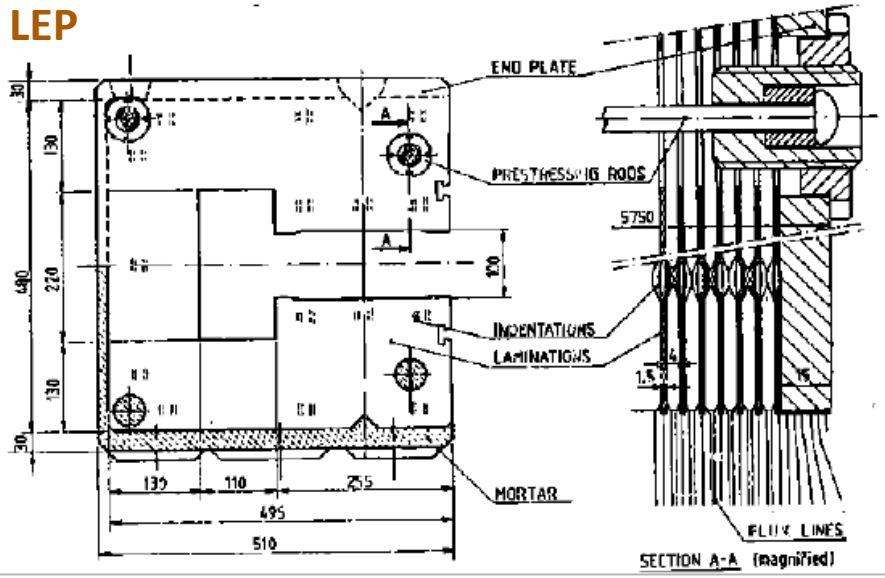


O-shaped magnet with ferrite core [BINP-CERN]

Accelerator	LEP	LHeC
Cross Section/ cm^2	50 x 50	20 x 10
Magnetic field/ T	0.02-0.11	0.02-0.135
Energy Range/GeV	20-100	10-70
Good Field Area/cm^2	5.9 x 5.9	6 x 3.8
FODO length/m	76	53
Magnet length/m	2 x 34.5	2 x 14.76
segmentation	6 cores	14
Number of magnets	736	488
Weight / kg/m	800	240

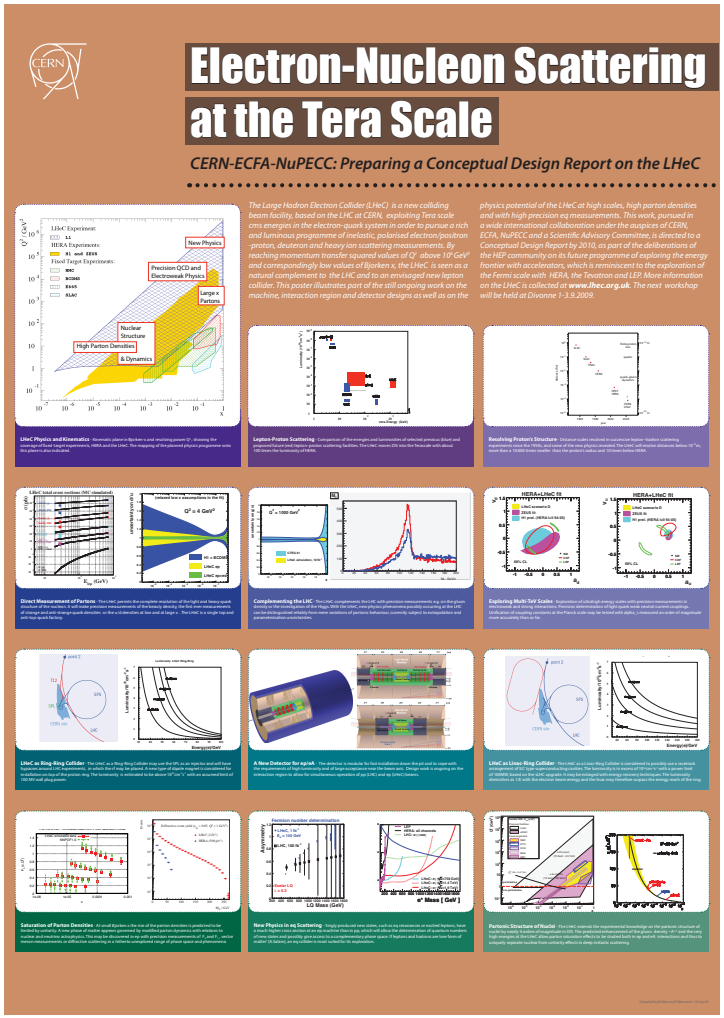
Prototype design under way at Novosibirsk, May 2010

LEP



Large Hadron Electron Collider

Progress Report to ECFA



Poster at EPS09 and Lepton-Photon09

www.lhec.cern.ch

Max Klein

for the LHeC Group

UNIVERSITY OF LIVERPOOL

ECFA at CERN Geneva 27. November 2009

Summary of the 2nd CERN-EFCA-NuPECC Workshop on the LHeC

September 1-3, 2009, Divonne, France

For information of the CERN Directorate, ECFA and NuPECC Chairs.

1. There were **about 100 participants from 40 institutes**, which delivered 64 talks in the plenary and parallel sessions. On the accelerator and interaction region (IR), 23 talks were given by colleagues from BNL, CERN, DESY, EPFL Lausanne, BKP Novosibirsk and SLAC.

2. The LHeC covers 6 orders of magnitude in x and Q^2 with ~100 times the luminosity of HERA. Its **physics programme** is unique and may be summarised in 5 points:

i) Unfolding completely the partonic structure of the proton (neutron and photon) and search for sub-substructure down to scales ten times below HERA's limit; **ii)** Sensitive exploration of new symmetries and the grand unification of particle interactions with electroweak and strong interaction measurements of unprecedented precision; **iii)** Search for and exploration of new Tera scale physics, in particular for singly produced new states (LQ, RPV SUSY, excited fermions), complementary to the LHC pp programme; **iv)** Exploration of high density matter (low x physics beyond the expected unitarity limit for the growth of the gluon density); **v)** Unfolding the substructure and parton dynamics inside nuclei and study of quark-gluon plasma matter, by an extension of the kinematic range of lepton-nucleus scattering by 4 orders of magnitude.

3. The $e^{+/-}$ **accelerator has two options**: i) a storage ring mounted on top of the LHC with new bypass tunnels around then existing LHC experiments and ii) a recirculating LINAC in a new tunnel with injection tangential to the LHC. First schematic layouts and optics calculations exist for both options. At Divonne, a first design of new slim dipole magnets was presented by Novosibirsk. SLAC presented an ERL version of a 60 GeV machine. Stages were discussed of building a LINAC. Both options require a detailed evaluation of the impact for the LHC installation and operation, and both solutions are for consideration in the CDR.

4. A **new detector**, fitting to an IR under design, is being developed, in contact with LHC detectors and also ILC developments, to achieve high precision measurements in DIS, the goal, roughly, being to be twice as accurate as H1 was and extending the polar angle acceptance to 1-179°.

5. Based on the progress presented and also relying on the interest and support expressed at the workshop for the **Conceptual Design Report** on the LHeC by CERN, ECFA and NuPECC, the Steering Group and the Convenors of the 6 working groups [Accelerator, IR, Detector, High Scale New Physics, Precision QCD and Electroweak Physics, High Parton Densities (ep/eA)] decided to produce a draft of the CDR by June 2010 with the aim to **deliver it by the end of 2010**. A detailed table of contents will be worked out by October 2009 and the second annual status report be delivered to ECFA this fall.

Max Klein, Chair of the Steering Group. Liverpool 9.9.2009

Endorsed by DG in September. ECFA, NuPECC, Chair of SAC took note.

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)
Jos Engelen (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)

Steering Committee

Oliver Bruening (CERN)
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)

Completion of the CDR

Steps to go in 2010

1. Finalise physics and technical studies
2. DIS10 Firenze [April] and IPACC Japan [May]
3. Draft CDR June 2010
4. Divonne III – Updates and Discussion with referees
5. November 10: Final report to ECFA
6. Submit CDR to CERN, ECFA, NuPECC

LHeC relies on expertise and enthusiasm of many colleagues and support by ECFA, NuPECC and CERN

LHeC barack 561

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
George Azuelos (Montreal)
Emmanuelle Perez (CERN),
Georg Weiglein (Hamburg)
Precision QCD and Electroweak
Olaf Behnke (DESY),
Paolo Gambino (Torino),
Thomas Gehrmann (Zuerich)
Claire Gwenlan (Oxford)
Physics at High Parton Densities
Nestor Armesto (Santiago),
Brian Cole (Columbia),
Paul Newman (Birmingham),
Anna Stasto (PennState)

4. Structure of the CDR

A Large Hadron Electron Collider
at CERN - the LHeC

Conceptual Design Report

LHeC Collaboration

December 14, 2009

Draft 0.1

Abstract

The physics programme and the design are described of a new $e^{\pm}p/A$ collider based on the LHC. The Large Hadron Electron Collider extends the kinematic range of HERA by two orders of magnitude in four-momentum square Q^2 and Bjorken x, and its design achieves a factor of hundred higher luminosity, of $O(10^{33})\,cm^{-2}s^{-1}$. The LHeC thus becomes the world's cleanest high resolution microscope and a crucial instrument to resolve the expected new physics at the TeV scale of mass and to also continue the path of deep inelastic lepton-hadron scattering into unknown areas of physics and kinematics. The LHeC may be realised as a ring-ring or linac-ring collider, and thorough design considerations are presented for both options in terms of their physics reach and technical realisation. Corresponding designs of interaction regions are presented as is a complete study of a suitable detector including tagging devices in forward and backward directions. The LHeC may be built, installed and operated while the LHC is still in operation. It thus represents a major opportunity for particle physics to progress and for the LHC to be further exploited.

5. Major Questions/Tasks

-The most striking physics arguments, the unique gain for HEP (topical meetings?)

-Can the ring be installed? (Kh.Mess with Y.Muttoni)

-The luminosity of the linac-ring combination (sLHC,ERL,e^+) →

-The detector/beam interface – IR for RR and LR

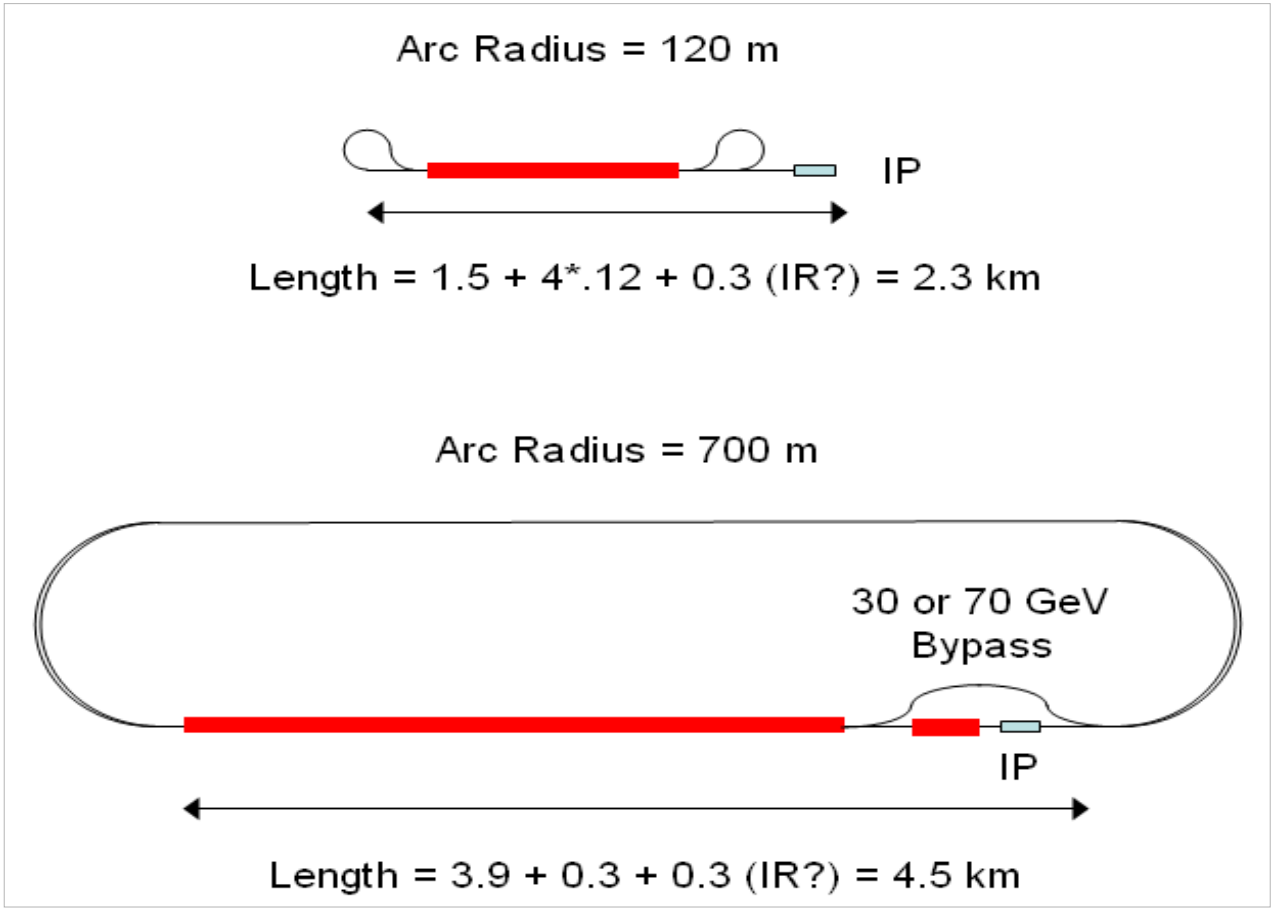
-Installation schedule (needed for NuPECC long range plan)

-Cost assessment (Steve Myers' person of trust)

-Define line between CDR and TDR

…

Two LINAC Configurations [CERN-SLAC]



60 GeV
31 MV/m, pulsed
two passes

60 GeV
13 MV/m CW ERL
4 passes

140 GeV
31 MV/m, pulsed
2 passes

LINAC-Ring Parameters

Configuration	60 GeV, pulsed	60 GeV CW ERL	140 GeV pulsed
N_e/bunch/ 10^9/50ns	4	1.9	2
gradient MV/m	32	13	32
normalised ε/ μm	50	50	100
cryo power/MW	3	20	6
effective beam power/MW	50	$40/(1-\eta_{ERL})$	50

Luminosity for ultimate beam

$$N_p = 1.7 \cdot 10^{11}, \varepsilon_p = 3.8 \mu m, \beta^* = 0.2 m, \gamma = 7000/0.94$$

$$L = 8 \cdot 10^{31} cm^{-2} s^{-1} \cdot \frac{N_p 10^{-11}}{1.7} \cdot \frac{0.2}{\beta^*/m} \cdot \frac{P/MW}{E_e/GeV}$$

An Electron-Proton Collider in the TeV Range

M. Tigner, Cornell Univ., Ithaca, NY
B. Wiik, F. Willeke, DESY, Hamburg, FRG

As the era of e-p colliders begins we need to begin a search for practical schemes for increasing the available center of mass energies. The use of an SC linac on SC proton ring approach may offer a practical possibility while maintaining a favorable electron to proton beam energy ratio.

The LR combination yet requires a still better p beam or/and E_e recovery to come to luminosity beyond $10^{32} cm^{-2} s^{-1}$

6. Supporting the CDR

-DIS10 (AS)
-IPAC Kyoto (papers submitted for RR and LR)
-Seminars (RWTH experience)
-Approaching people (Glasgow, Edinborough)
-Road maps → UK
-US-EIC
-SAC
-Topical meetings as pre Blois: BSM, QCE, DET, IR, FWD
-Discussion of approaching community with CERN
-ECFA
-NuPECC Long range plan
-CERN Courier agreements: Dipole article, Longer report on CDR
-…

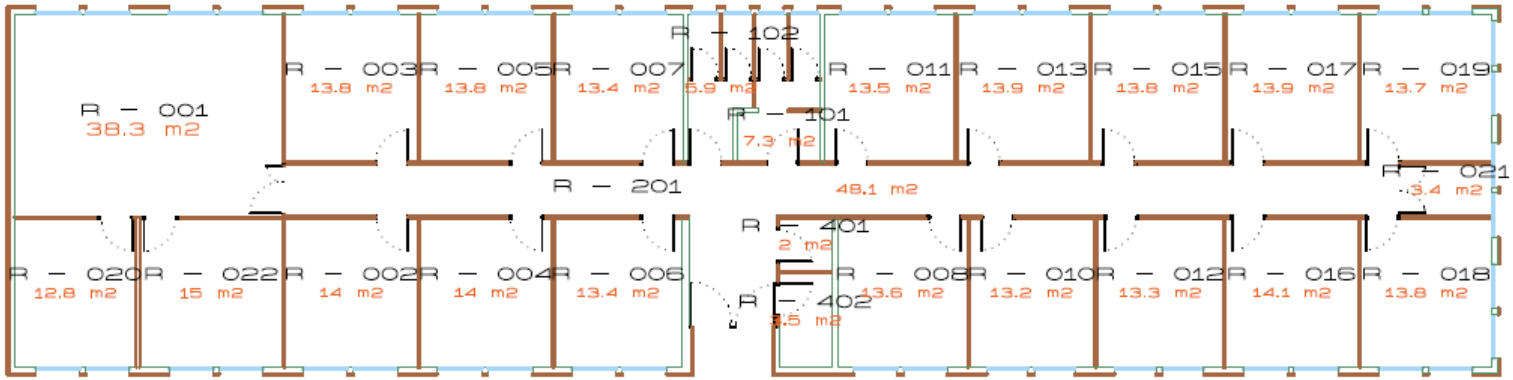
Experimental Facility	Key science question									
	1	2	3	4	5	6	7	8	9	10
Energy frontier physics:										
ATLAS/CMS and their upgrades	✓✓✓	✓✓✓	✓✓✓	✓	✓	✓				✓✓✓
Tevatron experiments	✓✓✓	✓	✓✓✓	✓	✓	✓				✓
High-energy electron-positron collider	✓✓✓	✓✓✓	✓	✓	✓	✓				✓✓✓
High-energy muon collider	✓✓✓	✓✓✓	✓							✓✓✓
High-energy lepton-hadron collider	✓	✓✓✓	✓✓✓			✓				✓✓✓
Flavour physics:										
LHCb and its upgrade	✓	✓	✓	✓✓✓	✓✓✓	✓✓✓				
High-luminosity flavour factory		✓	✓	✓✓✓	✓✓✓	✓✓✓				
High-precision dedicated charm experiments		✓	✓	✓	✓	✓				
High-precision dedicated kaon experiments		✓	✓	✓	✓✓✓	✓				
High-precision dedicated muon experiments		✓		✓		✓✓✓				
Neutrino physics:										
Long-baseline neutrino experiments and/or a neutrino factory		✓		✓✓✓			✓✓✓		✓✓✓	
Reactor neutrino experiments		✓		✓✓✓			✓✓✓		✓	
Direct neutrino mass experiments		✓					✓✓✓	✓		
Neutrinoless double-beta decay experiments		✓✓✓					✓✓✓	✓✓✓	✓✓✓	
Non-accelerator-based physics:										
Direct dark matter search experiments		✓✓✓								✓✓✓
Electric dipole moment search experiments		✓		✓	✓✓✓	✓✓✓				
Nucleon decay experiments		✓✓✓								

Table 1: The relationships between international experimental facilities and the major science questions discussed in Section 2. Three ticks implies that the facility is expected to have a major impact in answering this question. A single tick implies that the facility is capable of making a significant contribution to addressing the question. No tick implies that the facility is likely to have little or no impact on that question.

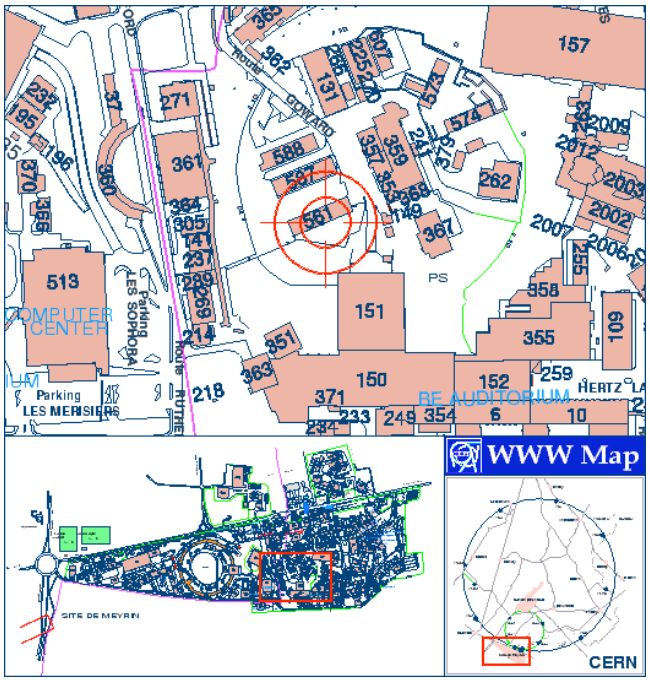
7. Organisation

-Communication: joint steering group+conv. meetings twice a month
-Regular meetings with accelerator physicists in barack 561
-LHeC Notes
-Computing base in 561
-Technical editor/secretary:
  call meetings, edit CDR, check LHeC notes, web?
-Secretary: Patricia (“hypernews”, meetings, email list..)
-Conference contacts – ``speakers buro”
-Appointment of referees with CERN for CDR parts – where, who?
-Need sth. like a project office at CERN for 2010
-…

Barack 561

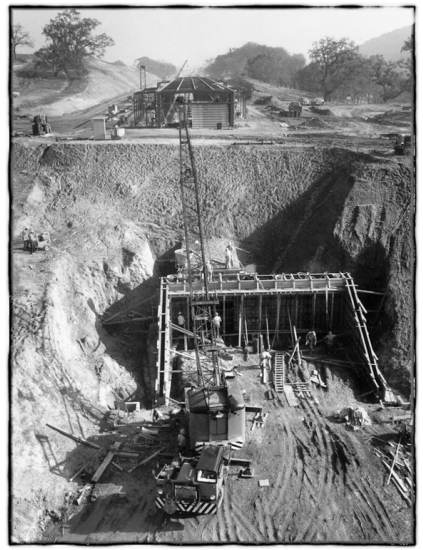


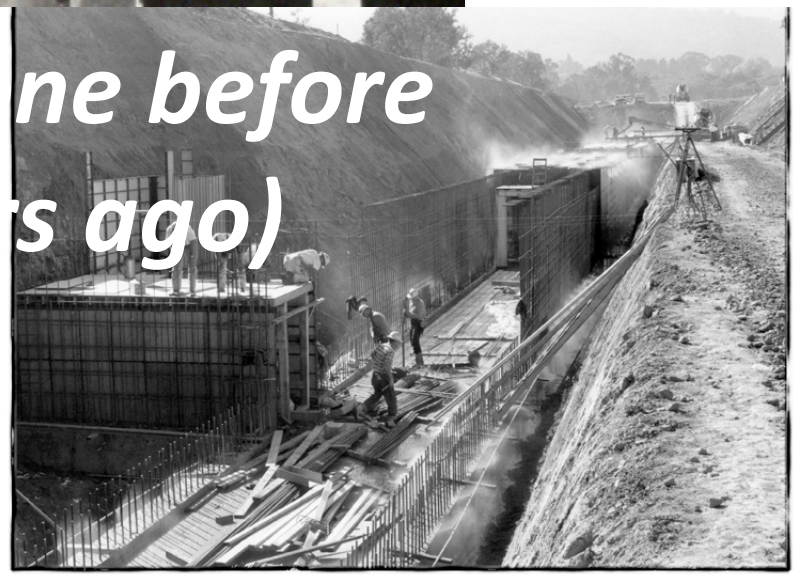
Few offices and meeting room for LHeC



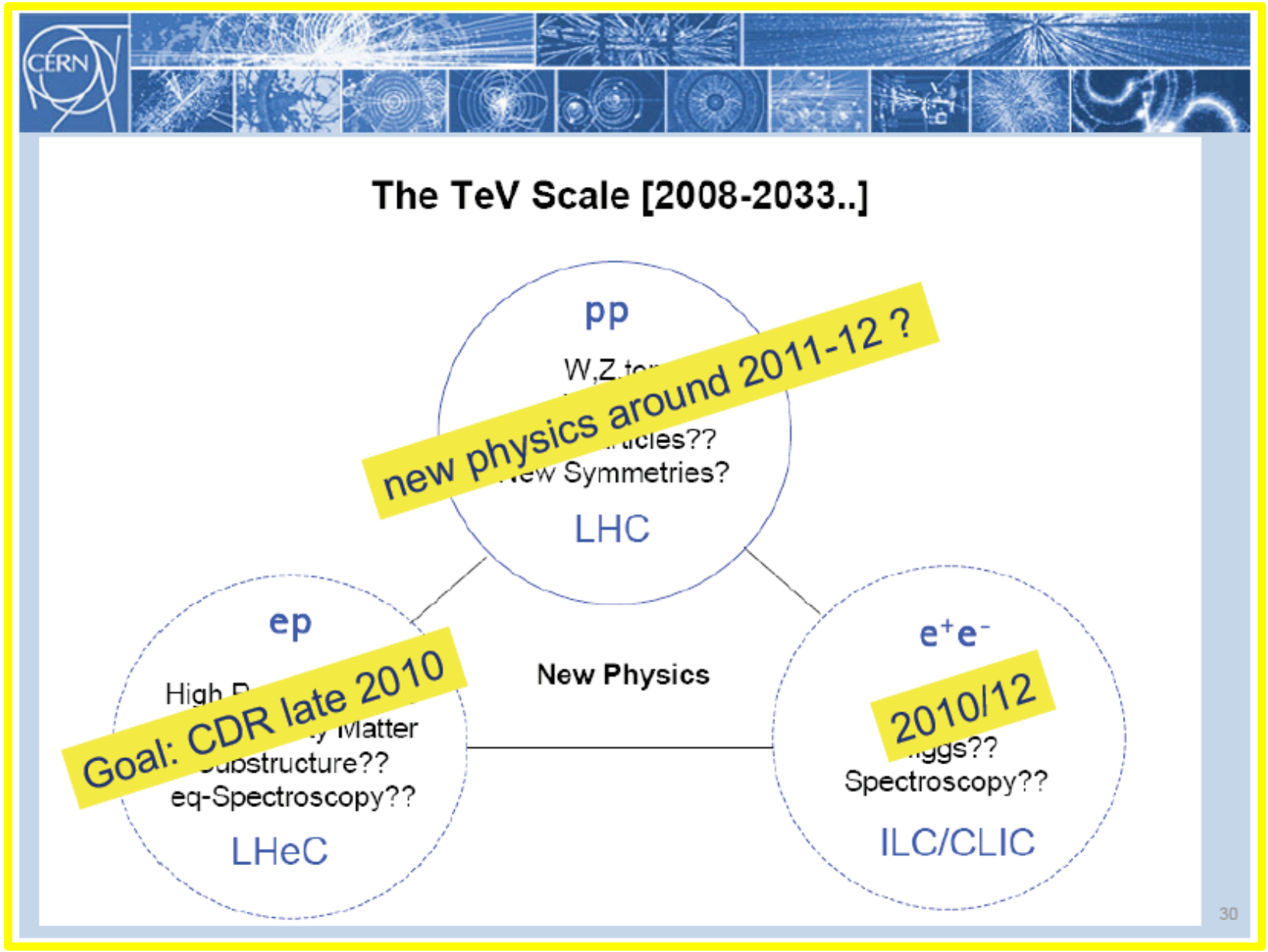
Thanks to Sergio, Steve, Oliver, Delphine, Paula

can one build a 3-km long linac?





it has been done before
(some 50 years ago)



Rolf Heuer: 3/4. 12. 09 at CERN: **From the Proton Synchroton to the Large Hadron Collider**
50 Years of Nobel Memories in High-Energy Physics

Today

9.00-9.30 : Introduction
9.30-10.30: Machine
10.30-11.15: Low x
11.15-12.00: QCD,electroweak

lunch: 12-13.00

13:00-13.45: BSM
13.45-14.30: IR + Fwd
14.30-15:15: Detector

coffee break: 15.15-16.00

16.00-18.00: Discussion of CDR Preparation

Dinner 8pm

Thanks for all the work so far,
for coming/connecting today.

Goal: get the CDR contents and
organisation right

We need a coherent approach
with improved communication.

CERN, ECFA and NuPECC await
the CDR next year and so far
it seems we can deliver it.