

From Divonne to Chavannes and Beyond

**Introduction
to the 3rd CERN/ECFA/NuPECC
Workshop on the Design of the LHeC**

Max Klein

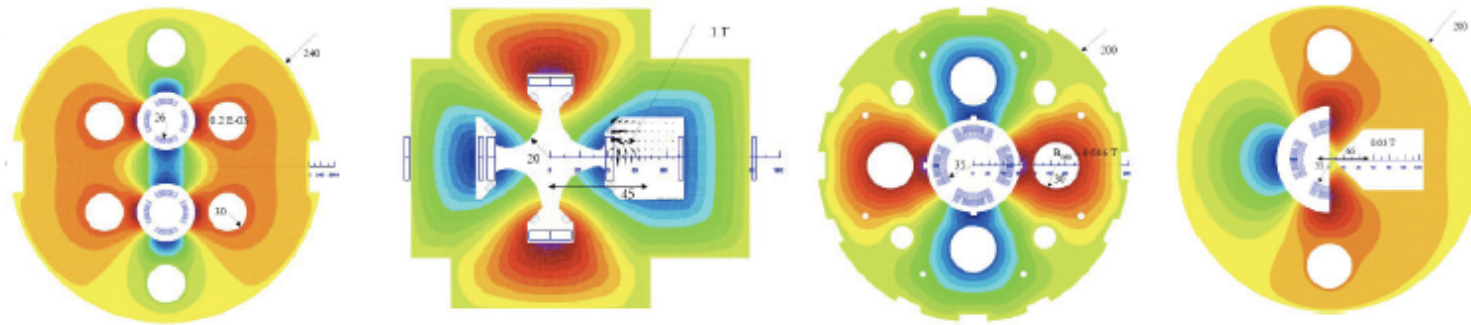


LHeC Workshop Chavannes-de-Bogis, 12.11.10

Divonne 2009



Chavannes 2010



Two Options

$$L = \frac{N_p \gamma}{4\pi \epsilon_p \epsilon_{pn}} \cdot \frac{I_e}{\sqrt{\beta_{px} \beta_{py}}}$$

$$N_p = 1.7 \cdot 10^{11}, \epsilon_p = 3.8 \mu\text{m}, \beta_{px(y)} = 1.8(0.5)m, \gamma = \frac{E_p}{M_p}$$

$$L = 8.2 \cdot 10^{32} \text{ cm}^{-2} \text{ s}^{-1} \cdot \frac{N_p 10^{-11}}{1.7} \cdot \frac{m}{\sqrt{\beta_{px} \beta_{py}}} \cdot \frac{I_e}{50 \text{ mA}}$$

$$I_e = 0.35 \text{ mA} \cdot P[\text{MW}] \cdot (100/E_e[\text{GeV}])^4$$

Ring-Ring

Power Limit of 100 MW wall plug
 “ultimate” LHC proton beam
 60 GeV e^\pm beam

$\rightarrow L = 2 \cdot 10^{33} \text{ cm}^{-2} \text{ s}^{-1} \rightarrow O(100) \text{ fb}^{-1}$
 HERA 0.5 fb^{-1} with 100 times less L

[1 and 10^0 differ by factor 2..]

LINAC Ring

Pulsed, **60 GeV**: $\sim 10^{32}$

High luminosity:

Energy recovery: $P = P_0 / (1 - \eta)$

$\beta^* = 0.1 \text{ m}$

[5 times smaller than LHC by
 reduced I^* , only one p squeezed
 and IR quads as for HL-LHC]

$L = 10^{33} \text{ cm}^{-2} \text{ s}^{-1} \rightarrow O(100) \text{ fb}^{-1}$

140 GeV LINAC few times 10^{32}

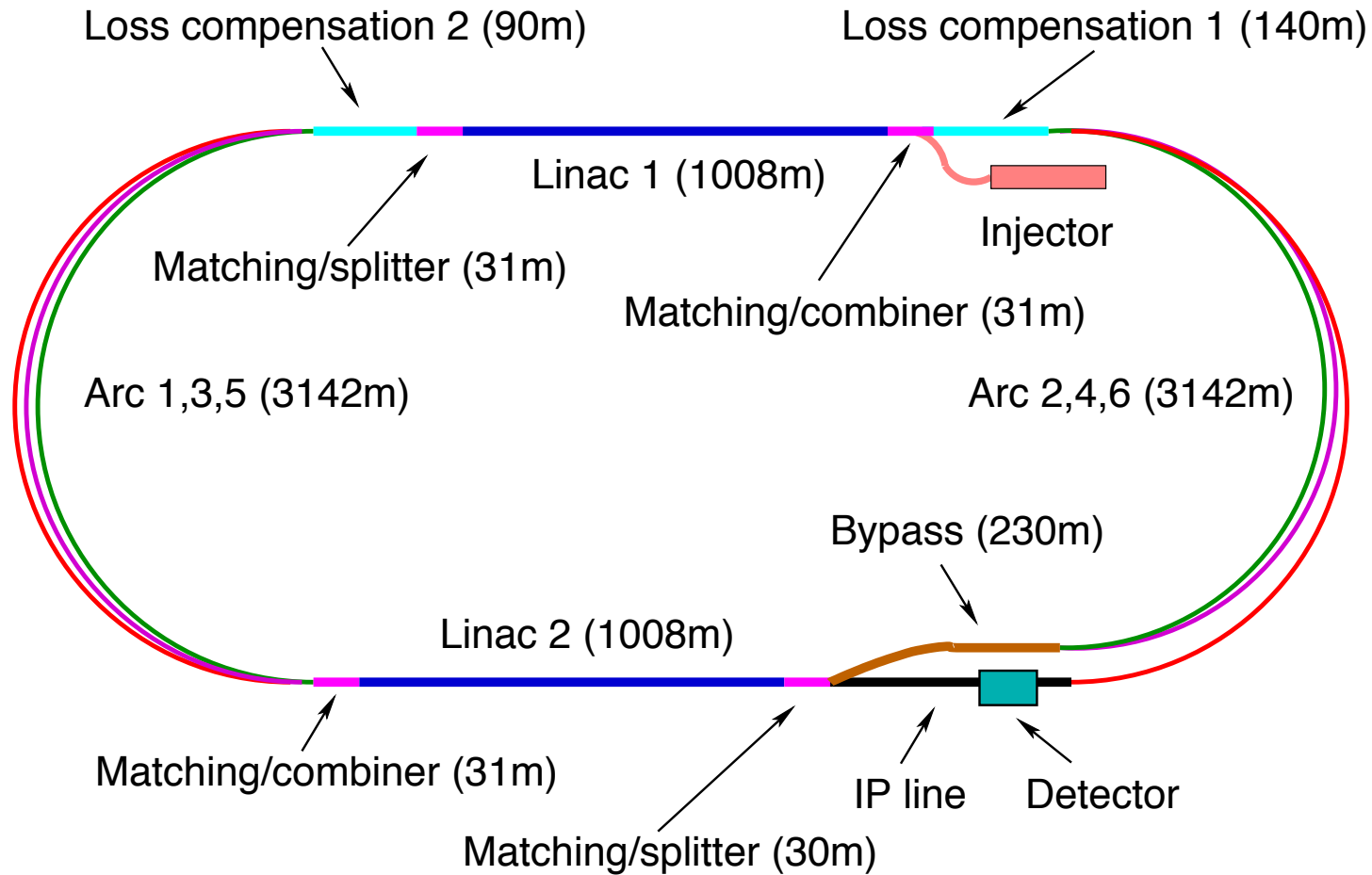
$$L = \frac{1}{4\pi} \cdot \frac{N_p}{\epsilon_p} \cdot \frac{1}{\beta^*} \cdot \gamma \cdot \frac{I_e}{e}$$

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

$$L = 8 \cdot 10^{31} \text{ cm}^{-2} \text{ s}^{-1} \cdot \frac{N_p 10^{-11}}{1.7} \cdot \frac{0.2}{\beta^*/m} \cdot \frac{I_e/\text{mA}}{1}$$

$$I_e = \text{mA} \frac{P/\text{MW}}{E_e/\text{GeV}}$$

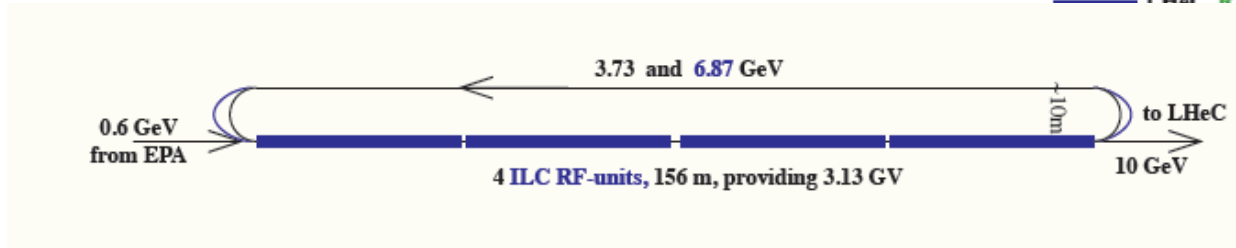
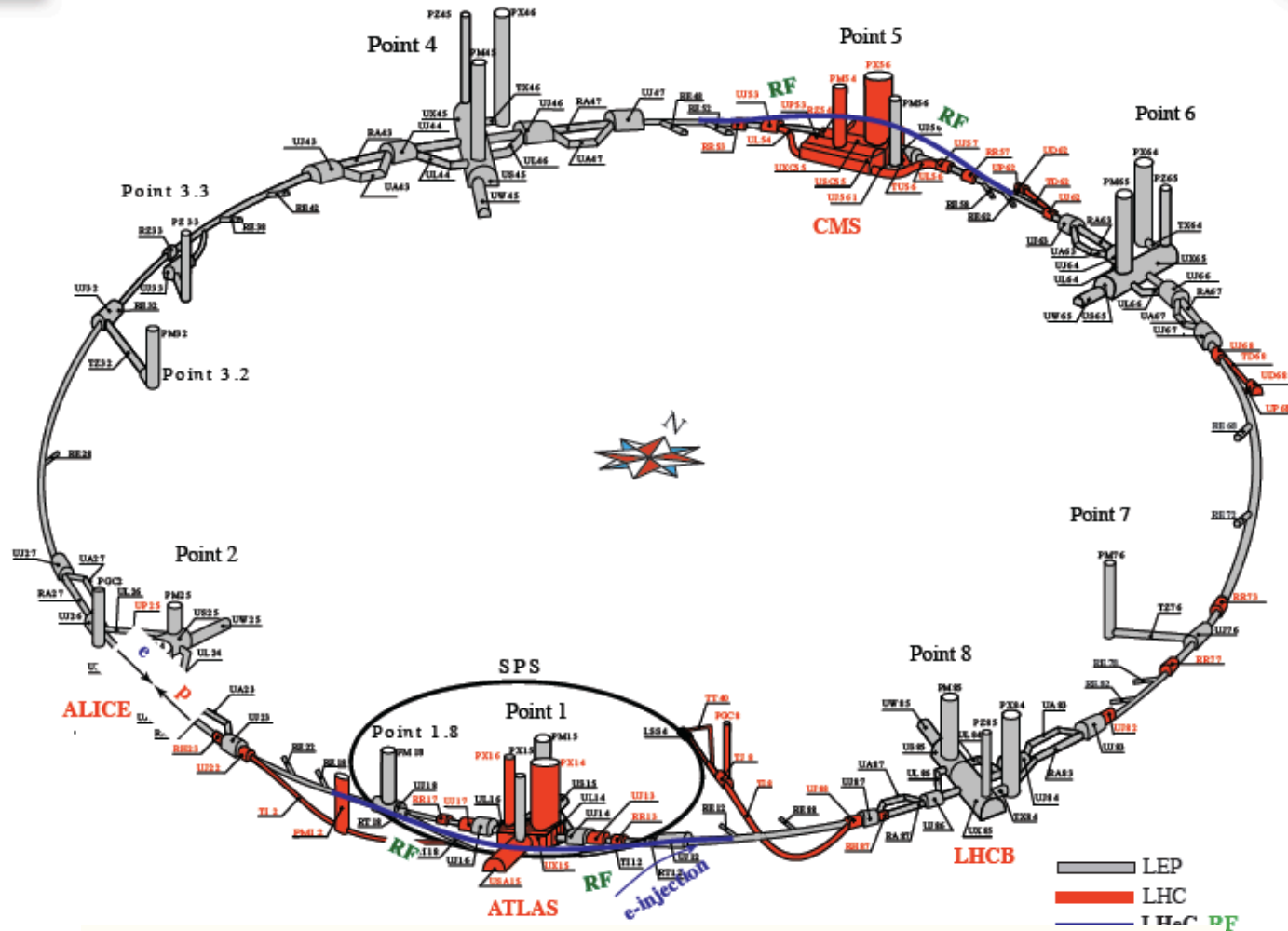
A 60 GeV Energy Recovery "LINAC"



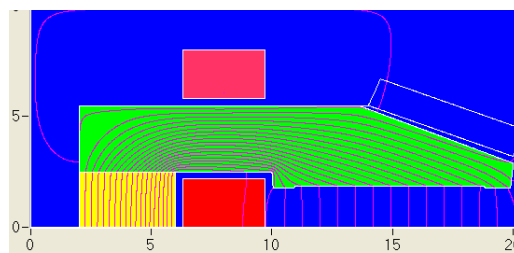
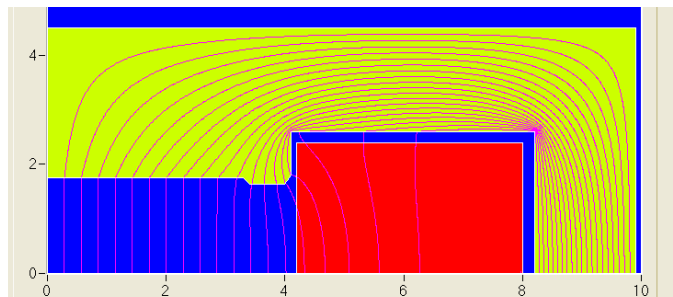
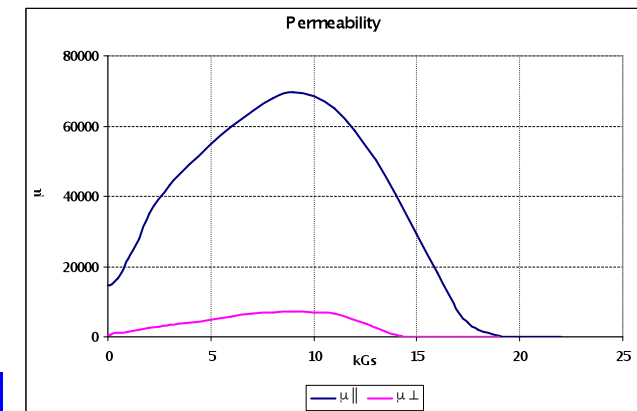
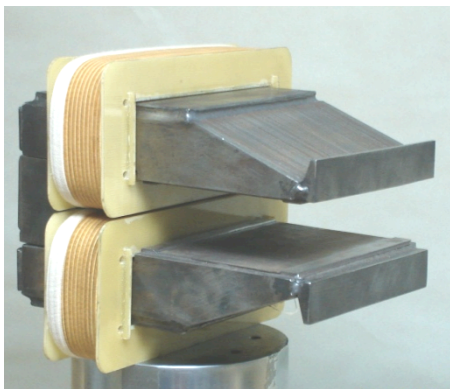
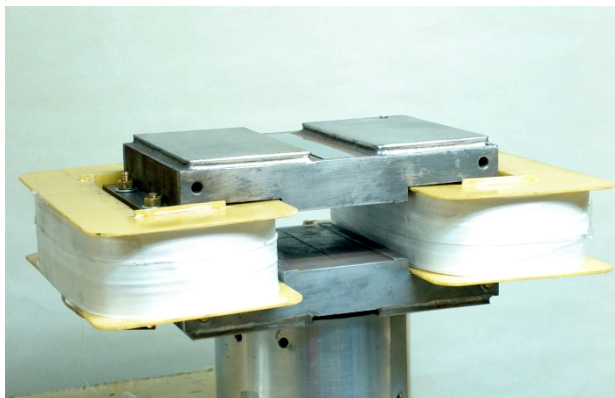
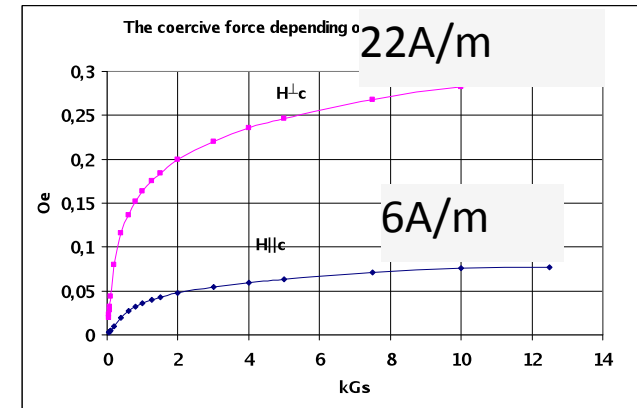
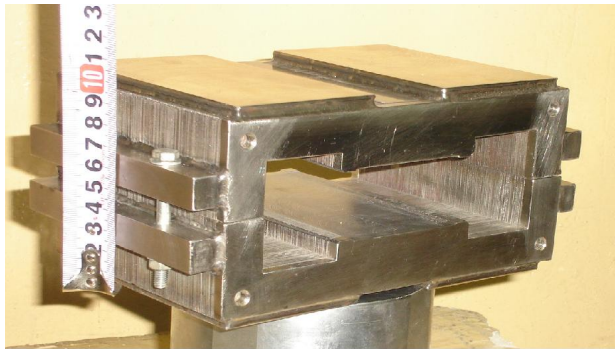
A 140 GeV pulsed LINAC



A 60 GeV Ring with 10 GeV LINAC Injector



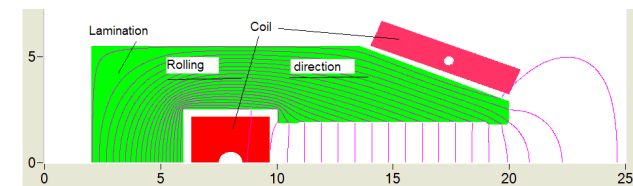
The First Bit of Hardware Built for the LHeC - BINP



same results for the two alternatives

laminations of alternated rolling

3408 grain oriented steel
0.35 mm thick laminations



Reproducibility of injection field is below 0.1 Gauss!

Cf talk of D. Tommassini



#7

#8

#9



Oxford

Georgia – on my mind

or an alternative

SLAC



“A bold extrapolation of existing technology “
(R.Taylor)

~~CalTech-SLAC-MIT~~

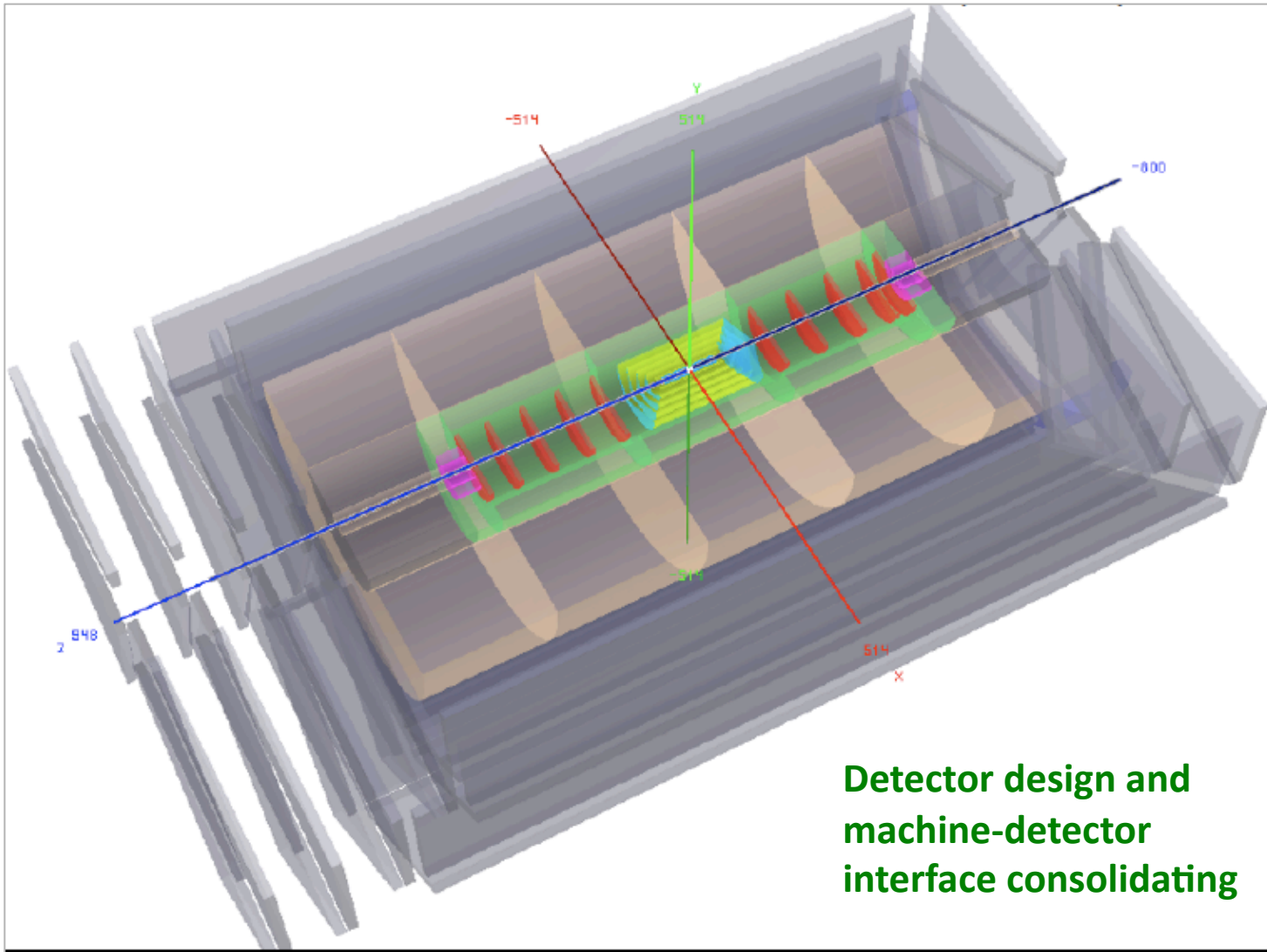
“... to collect data which may be of use for future experiments..”

3km: $Q^2=20 \text{ GeV}^2$

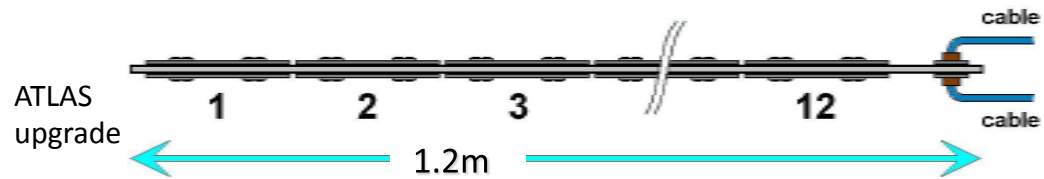
9-26 km: $Q^2=1000000 \text{ GeV}^2$

be better if all the efforts that we expend on the discussions on which form of field theory one should use were devoted to arguing for a higher-energy accelerator so that we can do more experiments over the next generation and really learn more about the basic structure of matter.

Gell-Mann 1966

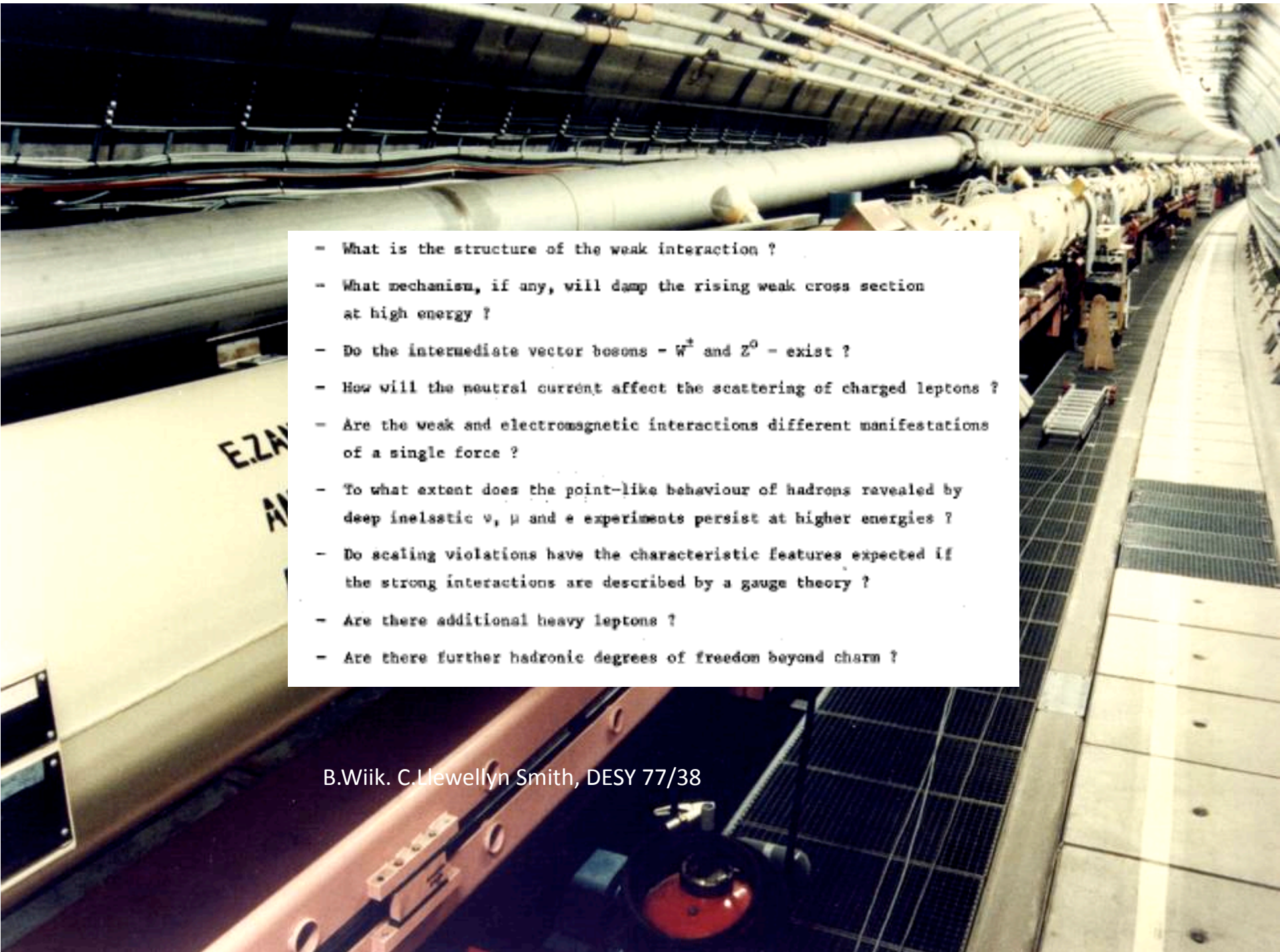


Detector design and machine-detector interface consolidating



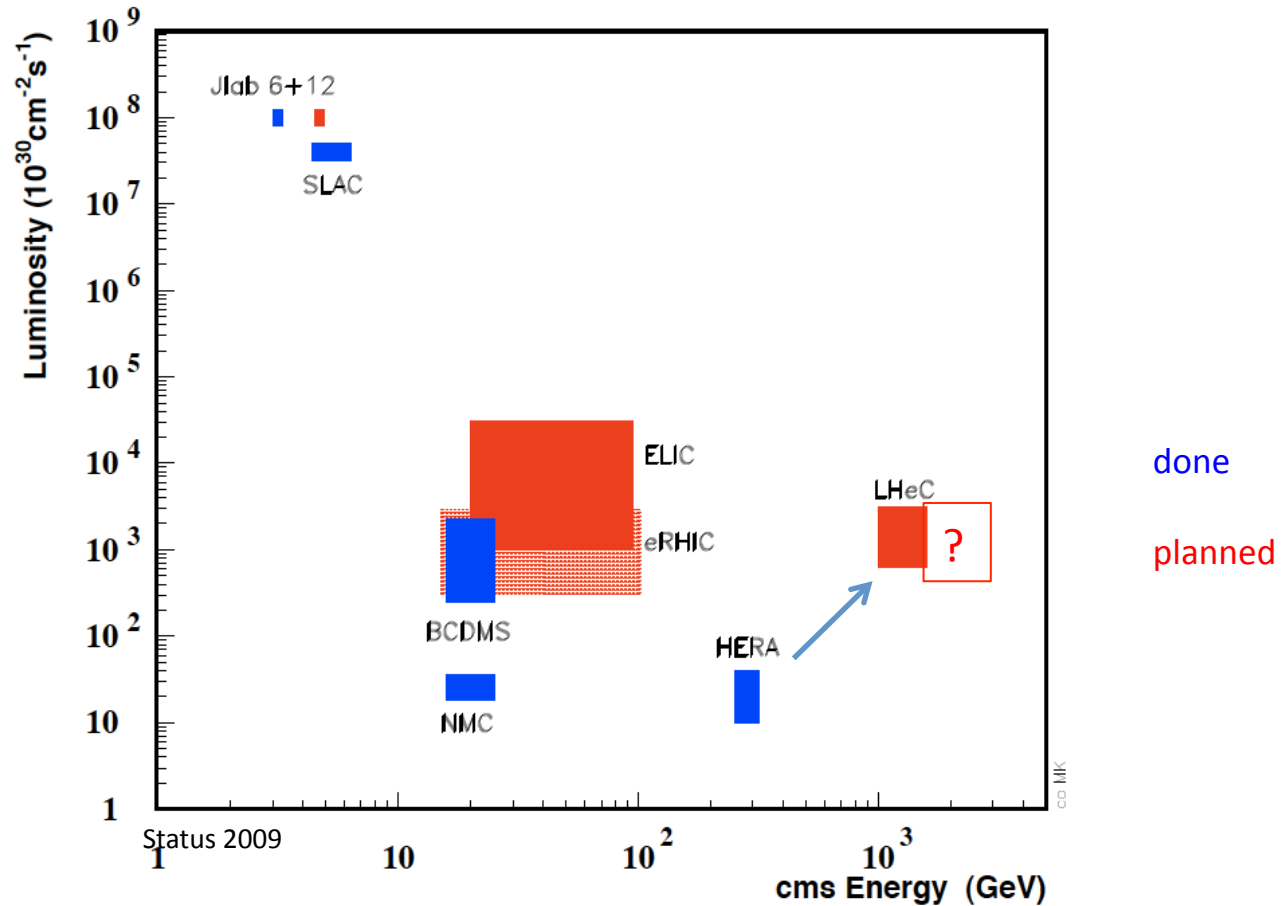
Use existing technology (developments)

Detector for $150 \times 15000 \text{ GeV}^2$?

- 
- What is the structure of the weak interaction ?
 - What mechanism, if any, will damp the rising weak cross section at high energy ?
 - Do the intermediate vector bosons - W^\pm and Z^0 - exist ?
 - How will the neutral current affect the scattering of charged leptons ?
 - Are the weak and electromagnetic interactions different manifestations of a single force ?
 - To what extent does the point-like behaviour of hadrons revealed by deep inelastic ν , μ and e experiments persist at higher energies ?
 - Do scaling violations have the characteristic features expected if the strong interactions are described by a gauge theory ?
 - Are there additional heavy leptons ?
 - Are there further hadronic degrees of freedom beyond charm ?

B.Wiik. C.Llewellyn Smith, DESY 77/38

Lepton-Proton Scattering Experiments



LHeC is a unique DIS machine project at the high energy frontier

**Scale of new physics is TeV, Unitarity violation in ep and eA, Electroweak physics, Single top, Higgs..
This machine also does large x, low Q^2 , photoproduction, amplitudes..., NOT polarised-polarised IN**

QCD/electroweak:

Guido Altarelli, Alan Martin, Vladimir Chekelyan

BSM:

Michelangelo Mangano, Gian Giudice, Cristinel Diaconu

eA/low x

Al Mueller, Raju Venugopalan, Michele Arneodo

Detector

Philipp Bloch, Roland Horisberger

Interaction Region Design

Daniel Pitzl, Mike Sullivan

Ring-Ring Design

Kurt Huebner, Sasha Skrinsky, Ferdinand Willeke

Linac-Ring Design

Reinhard Brinkmann, Andy Wolski, Kaoru Yokoya

Energy Recovery

Georg Hoffstatter, Ilan Ben Zvi

Magnets

Neil Marx, Martin Wilson

Installation and Infrastructure

Sylvain Weisz

Editorial Process

ECFA 26.11.2010

Draft 0.9 [about 500 pages]

Editorial Board:

Oliver Bruening, John Dainton, Stefano Forte,
Max Klein, Paul Laycock, Wesley Smith

31.1. – Draft 1.0 to Referees

31.3. – Feedback from Referees
(consultation with authors+CERN)

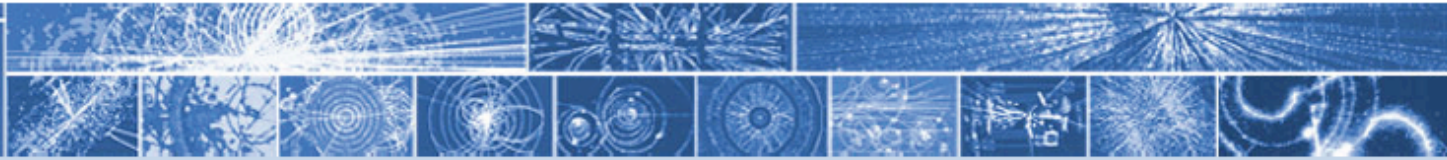
... Update of CDR^{*)} including plan for
R+D, installation, schedule [Oliver today]

... formal response from referees

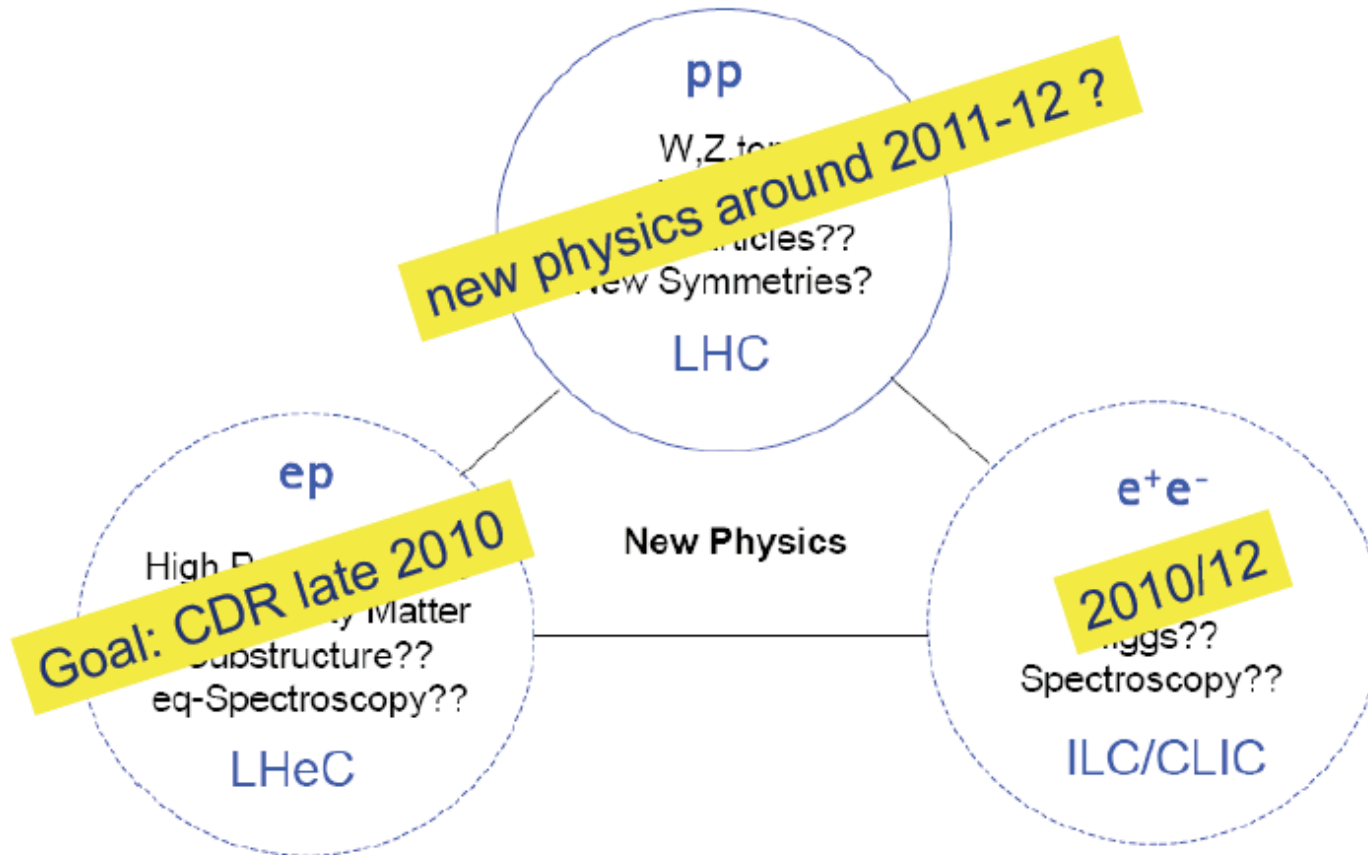
-- Print → Europe's Strategy Debate

LHeC CDR Referees invited by CERN Directors

^{*)} this CDR presents a design concept and its motivation



The TeV Scale [2008-2033..]



Conclusion

[Oliver in the afternoon]

Keeping an LHeC option open for the LHC requires:

- ➔ launch of R&D and design activities for key components (magnets, RF) needs to start very soon
- ➔ planning the installation of the ring-ring option requires careful synchronization with LHC operation schedule (assume minimum of two long shut downs for installation)
- ➔ Civil engineering must start before 2018

Requirements:

- ➔ The above work can not be done with the current arrangement and requires a focused team and sufficient resources

Conclusion:

- ➔ Decision on LHeC option should be taken by 2012



Chateau Ferney Voltaire (bought 1758)



Chateau Coppet – Jaques Neckar (1776 Louis XVI; bought 1784)

Thanks to Johannes Bluemlein

Workshop

Friday: 10.30-13.00 14:00-16:30 17:00-19:30

Physics: QCD/electroweak New Physics at High Scales High Parton Densities

Detector: Overview/Tracking joint IR Comparison/Calo/y,n..

Accelerator: Overview IR Hardware

Lunch 13:00-14:00 Dinner at 20:00

Saturday:

9-10:30 Physics 11:00-12:30 Detector and Accelerators

Thank you all for coming, for your continuous interest and encouraging work

Thanks to CERN (Rolf, Sergio, Steve) /ECFA (Tatsuya) /NuPECC (Guenther, JJ) for support

Rudern zwei

Rudern zwei durch die Nacht

Ist der eine kundig des Meeres

Ist der andere kundig der Sterne

Und in der Erinnerung

Das Meer wird blau sein

Reiner Kunze



Dedicated to Anna-Dorothea Klein
born 12. November 1925