Report on the Design Concepts for the LHeC

Physics
Ring
Linac
Detector
Conclusion

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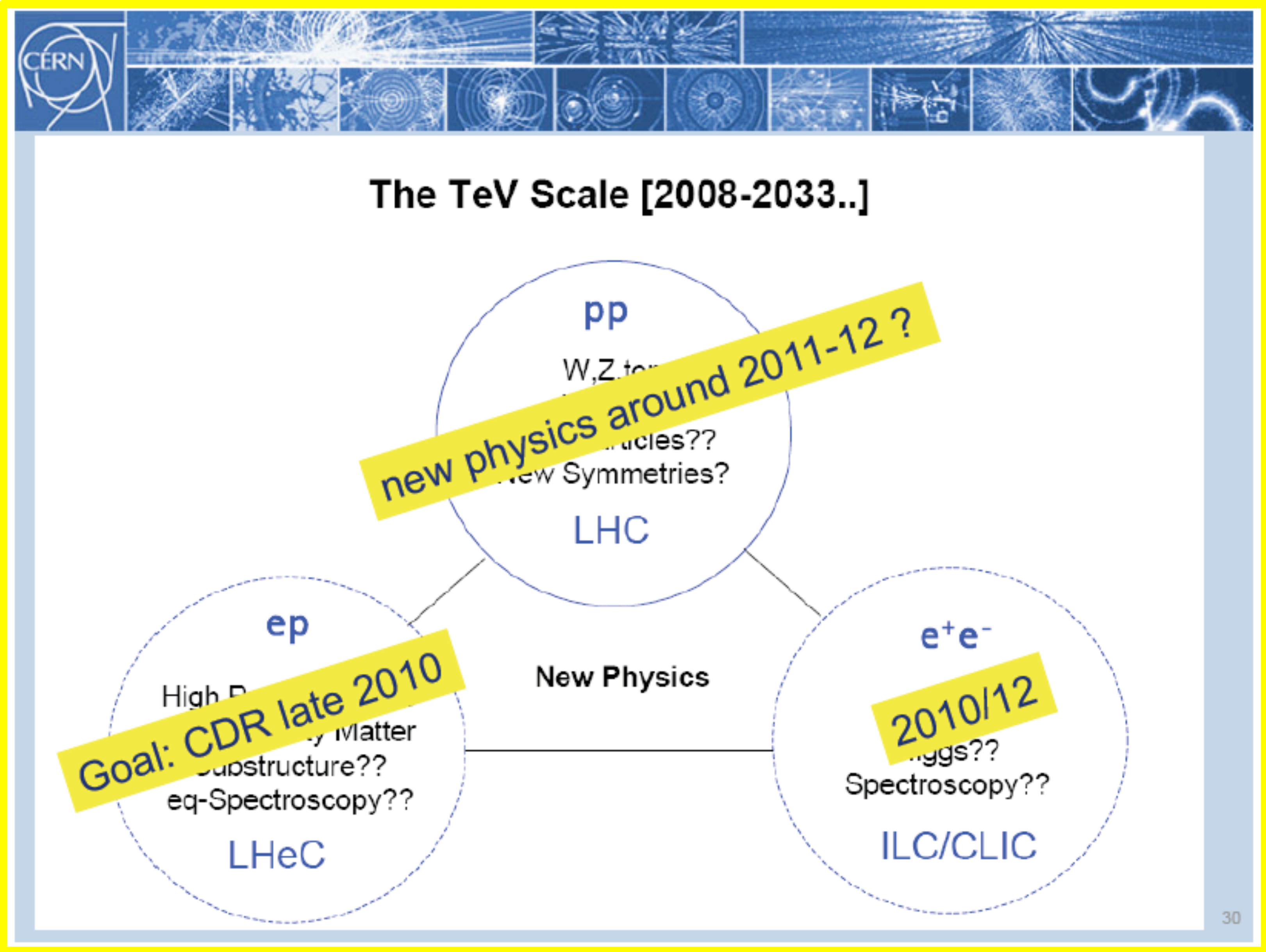
on behalf of the LHeC Study Group

DRAFT 25.11.

ECFA, CERN, 26.11.10



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

LHeC Physics Cornerstones

1. Grand unification? α_s to per mille accuracy: jets vs inclusive BCDMS →
   ultraprecision programme: N^kLO, c, ep/eD,..
2. A new phase of hadronic matter: high densities, small α_s
   saturation of the gluon density? BFKL-Planck scale
   superhigh-energy neutrino physics, proton - isoscalar
3. Partons in nuclei (4 orders of magnitude extension)
   saturation in eA ($A^{1/3}$?), nuclear parton distributions
   black body limit of F_2, colour transparency, …
4. Novel QCD phenomena
   instantons, odderons, hidden colour, sea=antiquarks (strange)
5. Complementarity to new physics at the LHC
   LQ spectroscopy, RPV SUSY, Higgs, CI, e^*, 4^{th} generation quarks
   partons to extend discovery limits

LHeC Fundamental Measurements

1. Complete unfolding of partonic content of the proton
2. Neutron structure free of Fermi motion
3. Diffraction – Shadowing (Glauber)
4. Higgs to bbar
5. Single top and anti-top in CC
6. Gluon field to unprecedented accuracy [baryonic mass]
7. GPDs via DVCS
8. Unintegrated parton distributions
9. Partonic structure of the photon
10. Electroweak Couplings to per cent accuracy
11. Diffractive scattering "in extreme domains" (Brodsky)

….

Every major step in energy can lead to new unexpected results, ep: SLAC, HERA

Requires: High energy, $e^{\pm}$, p, d, A, high luminosity, 4π acceptance, high precision (e/h)

↳ Tev scale physics, electroweak, top, Higgs, low x unitarity

Two Options

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

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

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

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

Ring-Ring

Power Limit of 100 MW wall plug
"ultimate" LHC proton beam
60 GeV $e^{\pm}$ beam

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

[1 and 10° differ by factor 2..]

LINAC Ring

Pulsed, **60 GeV**: ~10^{32}
High luminosity:
Energy recovery: $P=P_0/(1-\eta)$
$\beta^*=0.1m$
[5 times smaller than LHC by reduced l*, only one p squeezed and IR quads as for HL-LHC]
$L = 10^{33}\ cm^{-2}s^{-1}$ → O(100) fb^{-1}
140 GeV LINAC few times 10^{32}

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

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

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

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