LHeC Design Meetings

Introductory Remarks to the First One

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Conceptual Design Report + Project
Status and Goals of Developments
Introductory remarks on Ring-Ring
(Linac when we come to it)

http://cern.ch/lhec
arXiv0908.2877

Opening of Design Meeting Series. CERN. 2. February 2010

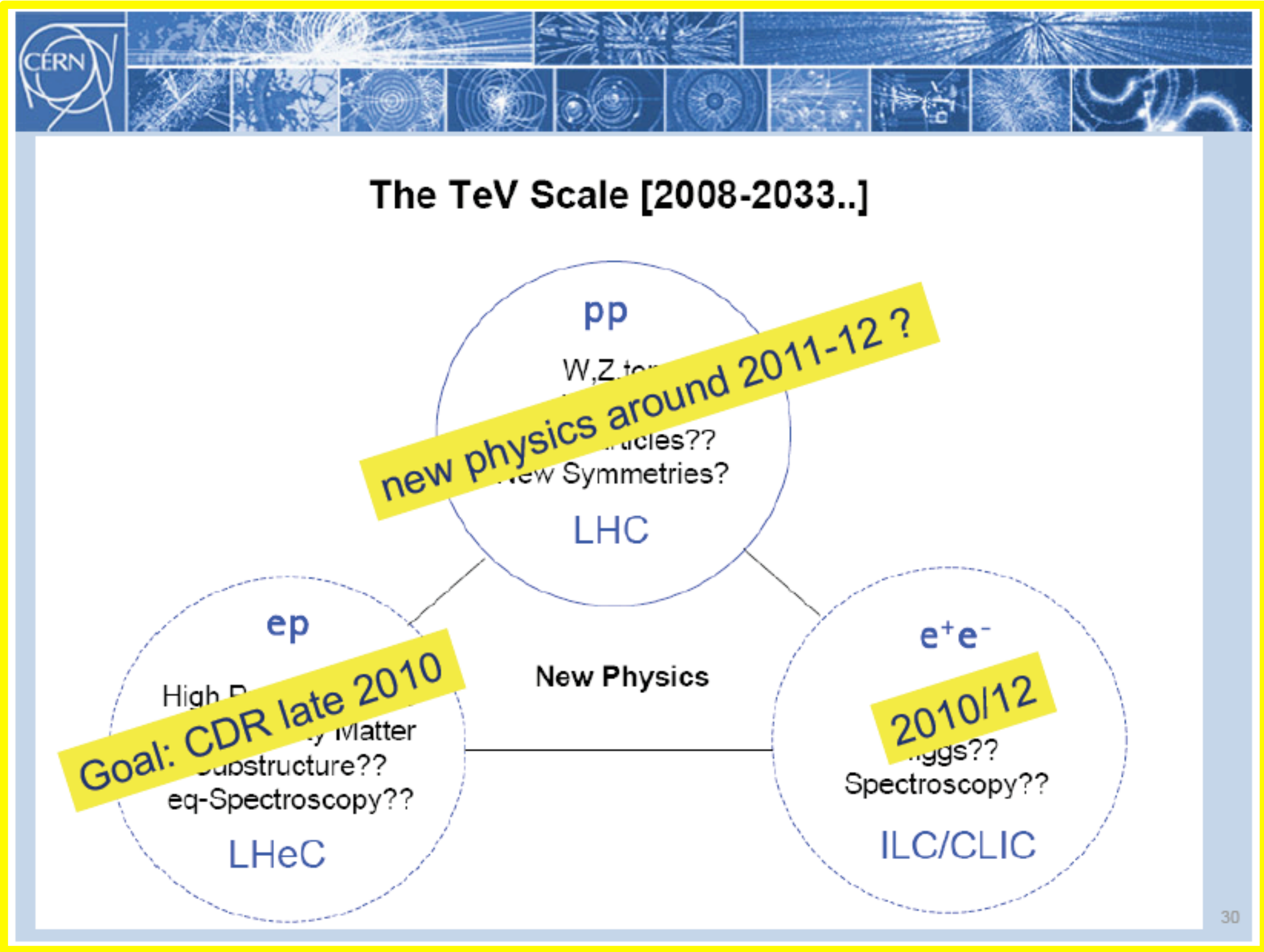
The Next Decades

Initial Phase of LHC will tell the way to go

Possible ways beyond LHC

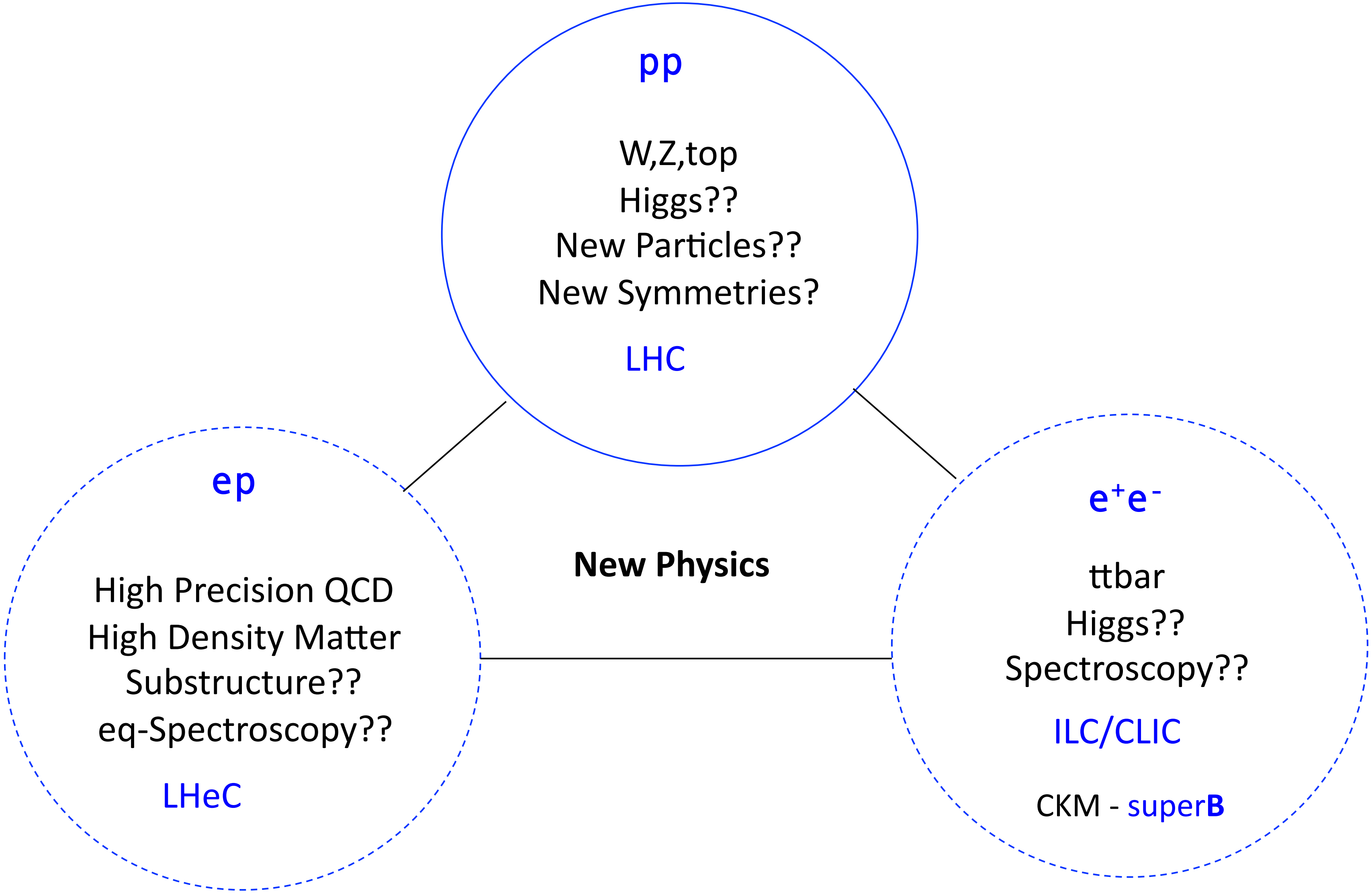
hadron - hadron collider (sLHC / DLHC)
lepton - lepton collider (ILC / CLIC)
lepton - hadron collider (LHeC)

"Best moment to convince funding agencies is when everybody is excited" [DG]



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

The TeV Scale [2010-2035..]



Dates and Plans

9/07: SPC → (r)ECFA 07
Divonne 9/08
Divonne 9/09

DIS10 (Florence, 4/10)
IPAC (Kyoto, 5/10)
1st Draft 30.6.2010
Referees-Updates
Divonne 10/10
2nd Draft
November: Final Report to ECFA/CERN/NuPECC

→ Finalising CDR including:
Physics, Acc (Linac and Ring), IR, Detector … few 100 pages
Design Concept, not a TDR

Biweekly design meetings to get to coherent CDR

A Large Hadron Electron Collider at CERN - the LHeC

Conceptual Design Report

LHeC Collaboration

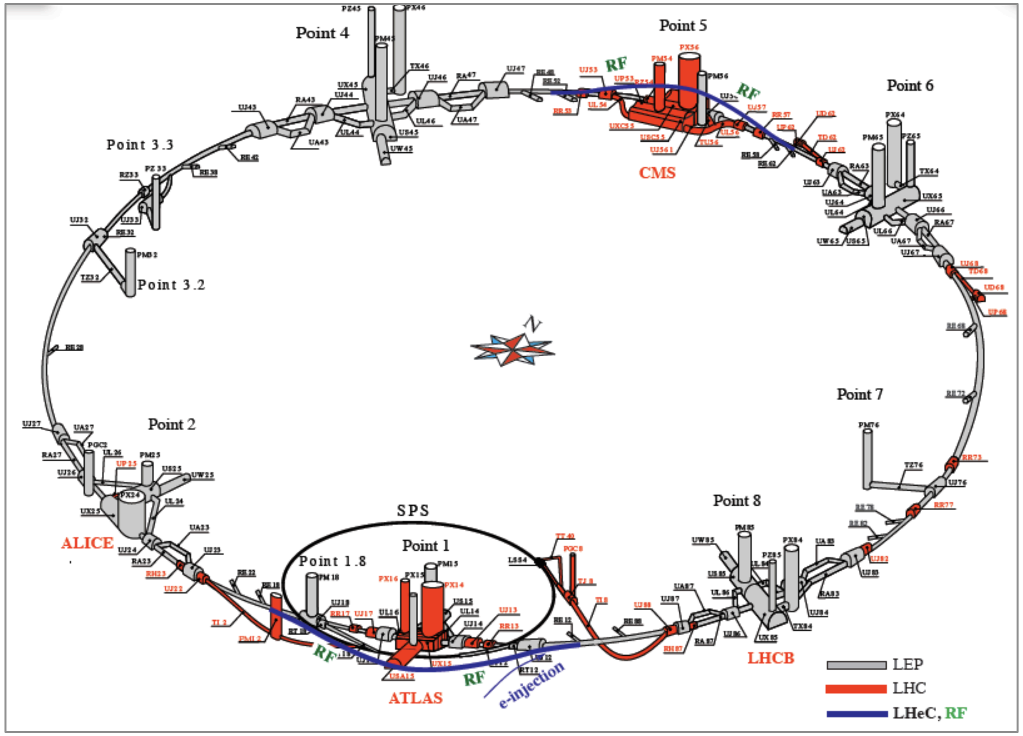
December 14, 2009

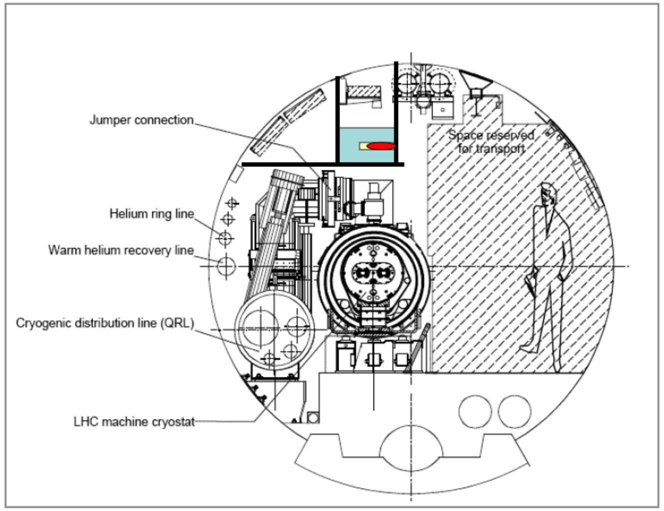
Draft 0.1

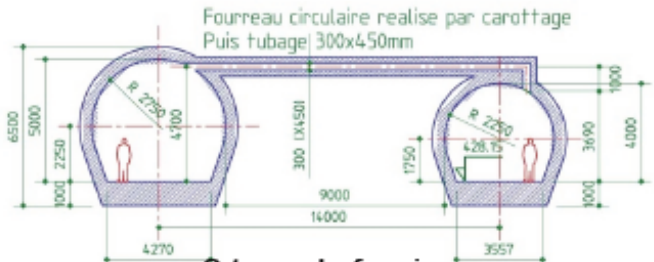
Abstract

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 $\mathrm{O}(10^{33})\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$. 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.

Ring-Ring ep/eA







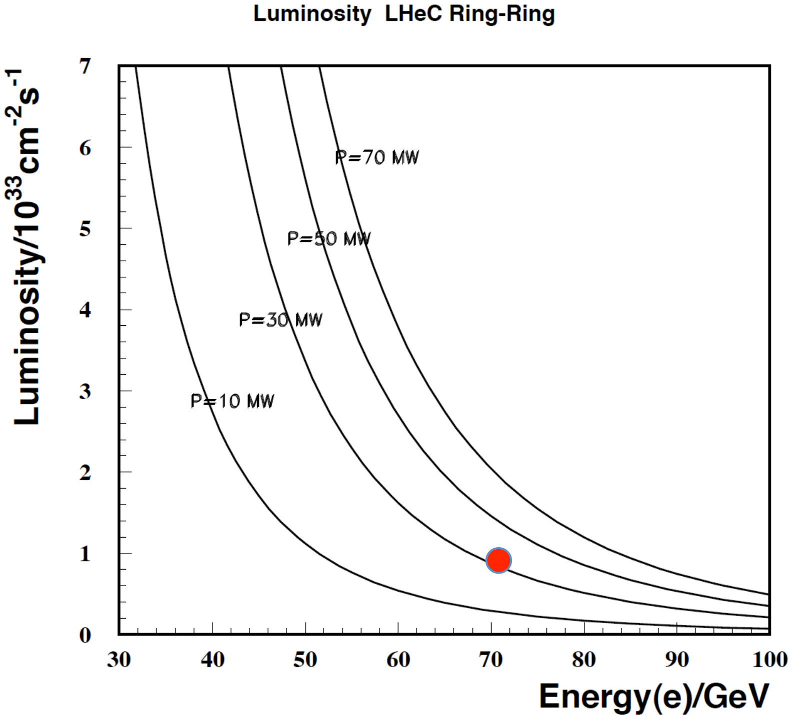
2 tunnels for ring
and shielded rf

E_e=10 … 70 GeV. L_{ep}~$10^{33}cm^{-2}s^{-1}$ (100 times HERA)

Injector: dedicated or SPL based.

Detailed first design study in JINST 1 P1001 (2006)

RR Luminosity and Parameters



Luminosity for e$^{\pm}$p above 10^{33}cm^{-2}s^{-1}

Used "ultimate" LHC beam parameters

Energy limited by injection and syn.rad losses

Power limit set to 100 MW

Small p tuneshift: simultaneous pp and ep

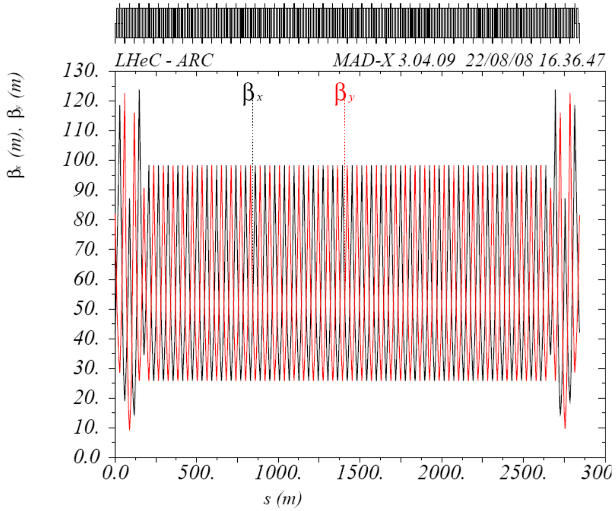
Ultimate Parameter	*Protons*	*Electrons*	
	*Np=1.7*10^{11}*	*Ne=1.4*10^{10}*	*nb=2808*
	Ip=860mA	*Ie=71mA*	
Optics	*βxp=230 cm*	*βxe=12.7 cm*	
	βyp= 60 cm	*βye= 7.1 cm*	
	εxp=0.5 nm rad	*εxe=9 nm rad*	
	εyp=0.5 nm rad	*εye=4 nm rad*	
Beamsize	*σx=34 μm*		
	σy=17 μm		
Tuneshift	*Δνx=0.00061*	*Δνx=0.056*	
	Δνy=0.00032	*Δνy=0.062*	
Luminosity	*L=1.03*10^{33}*		

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

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

e Ring – Optics

Optics in the arcs



β functions for LHeC - 2008

Dispersion was 50-90cm

and horiz. emittance 22 nm

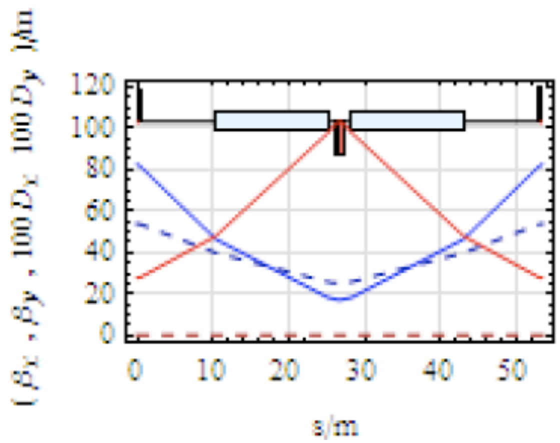
384 60m long cells

2009: optimisation of FODO cell

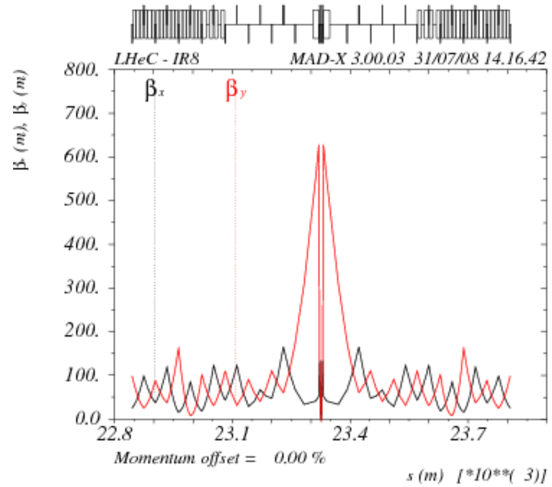
Dispersion reduced to 20-50cm

emittance ε_x=7.5nm ε_y=3.7 nm

MEDIUM or WEAK BEND SOLUTION



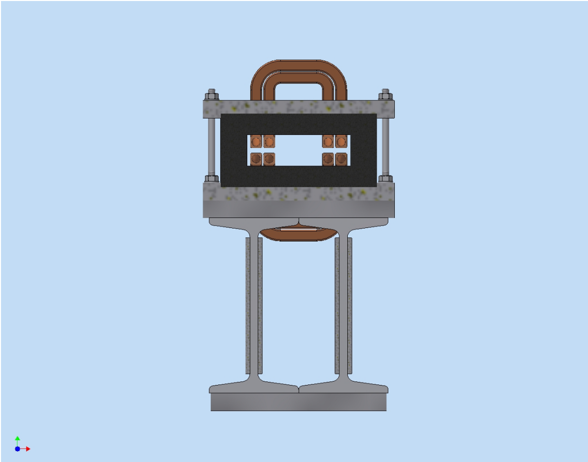
Optimisation ongoing



“inner” triplet focus
β_x=7.1cm β_y=12.7cm

Mini beta design

Dipole Magnets

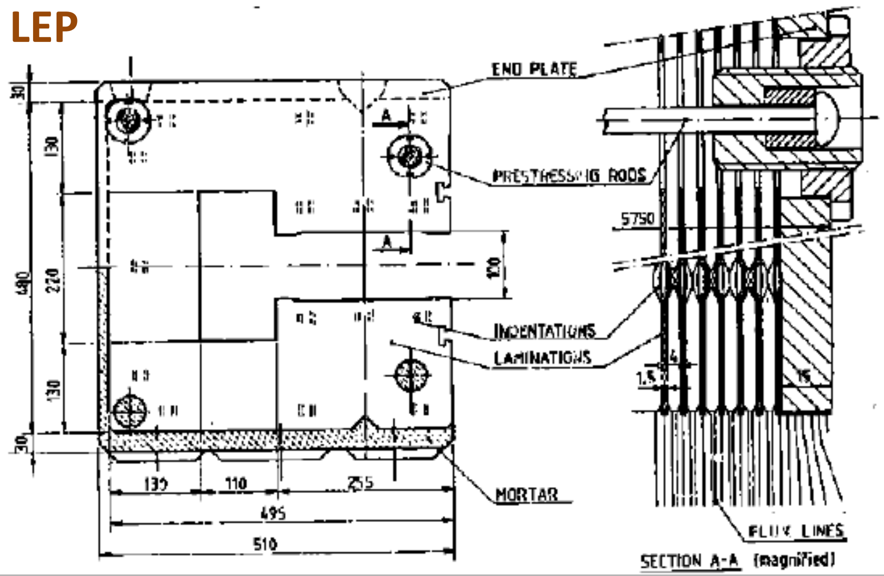


O-shaped magnet with ferrite core [BINP-CERN]

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

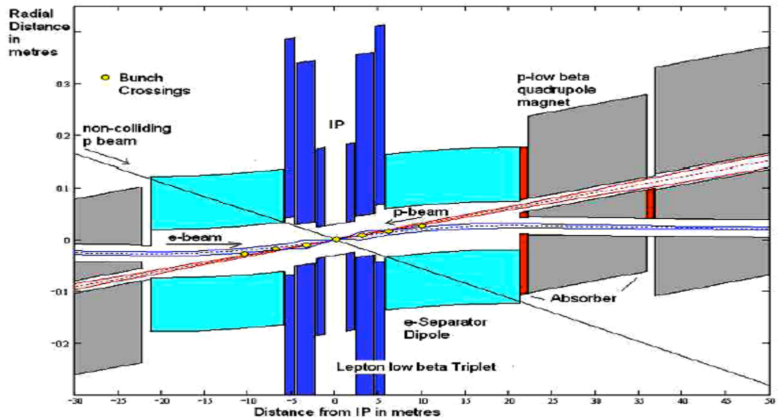
Prototype design under way at Novosibirsk, 2009/10

LEP

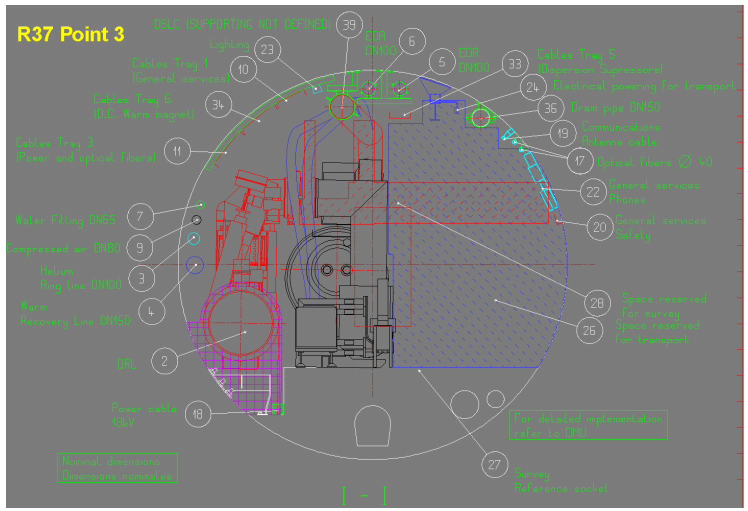


Today

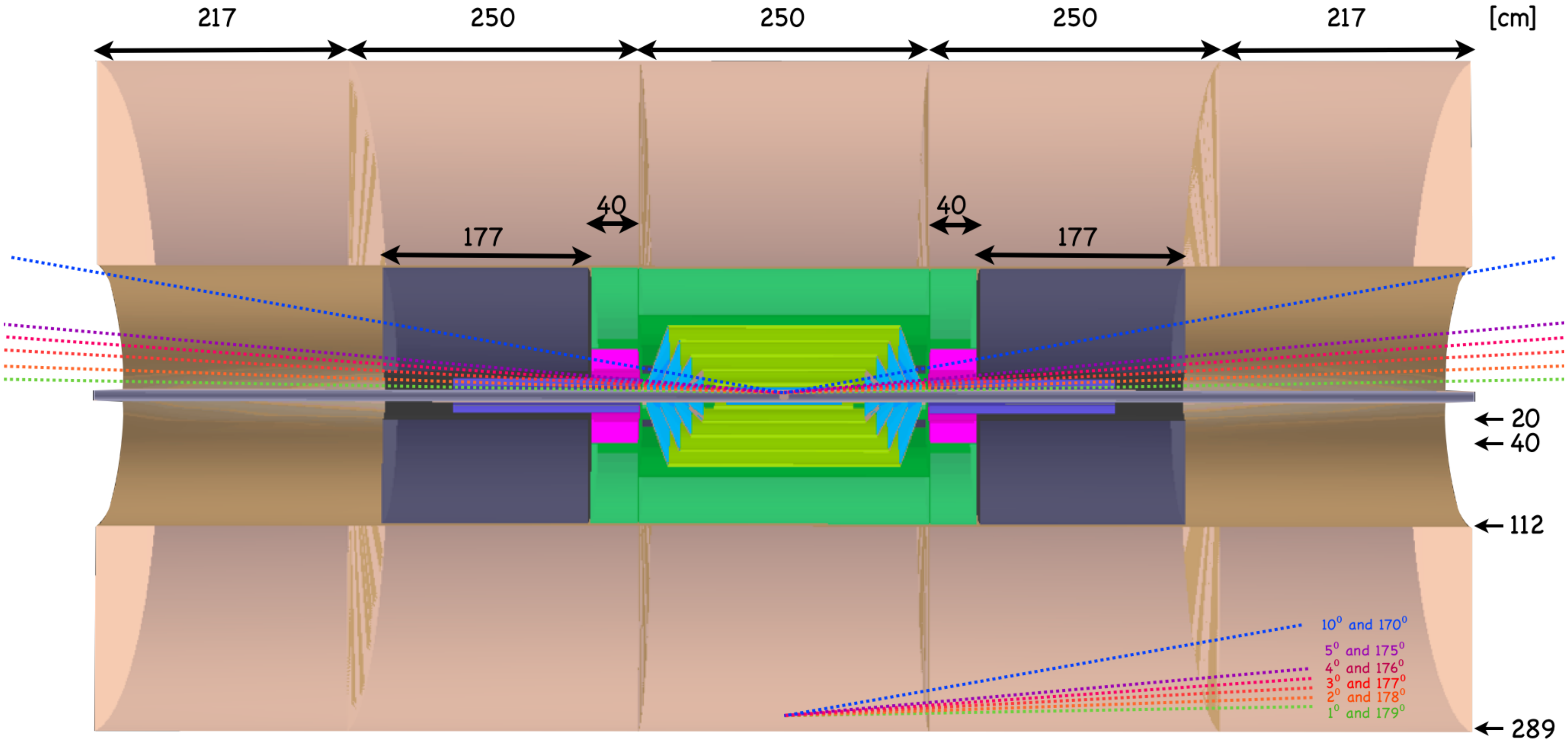
Interaction region design (Uwe)



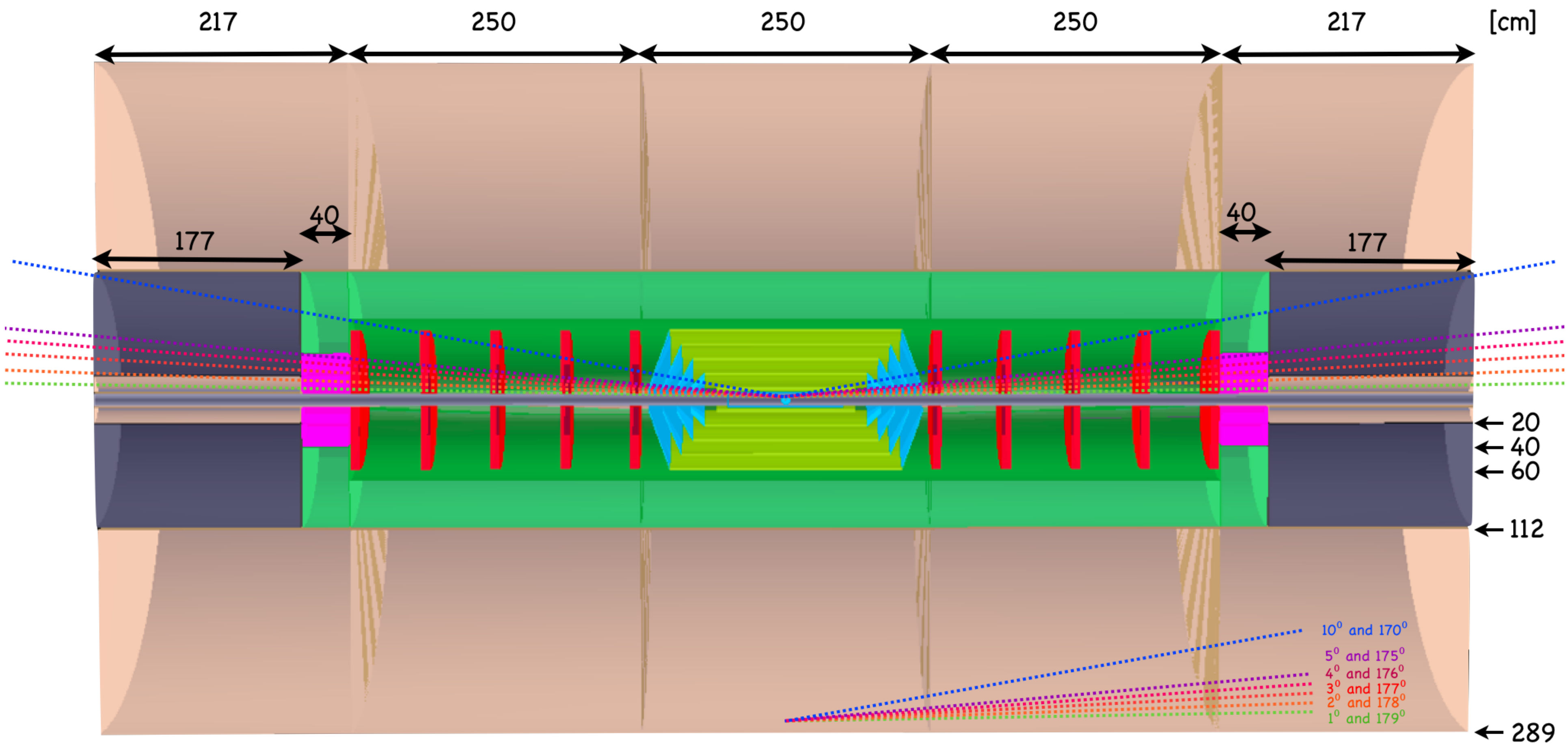
Installation study (Karlhubert)



High Q^2 Detector – rz view



Low x Detector – rz view



Ring-Ring: topics for meetings

-Installation of e ring on top of the LHC: clashes → optics, installation, safety..
-Synchrotron radiation (direct and backscattering) → dimension of detector
-Layout of IR for small angles → Combination of High Q^2 and Low/High x physics
-Concept of magnets → dipole prototype
-Bypassing LHC experiments → shafts (related to LHC plans), rf
-Polarisation of electrons/positrons

-Design of injector
-Design of rf (crab cavity) $L = L_0 / f$

$$f = \sqrt{1 + \left(\frac{\sigma_z}{\sigma_s} \cdot \frac{\theta_c}{2} \right)^2}$$

-...

A similar list exists for the LINAC-Ring. We believe both shall be described in the CDR

Thanks for joining and attention. Please send your input/wishes for presentations to us

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One backup

LHeC Detector version for low x and eA

Muon chambers
(fwd,bwd,central)

Coil (r=3m l=11.8m, 3.5T)
[Return Fe not drawn,
2 coils w/o return Fe studied]

<u>Central Detector</u>
Pixels
Elliptic beam pipe (~3cm - or smaller)

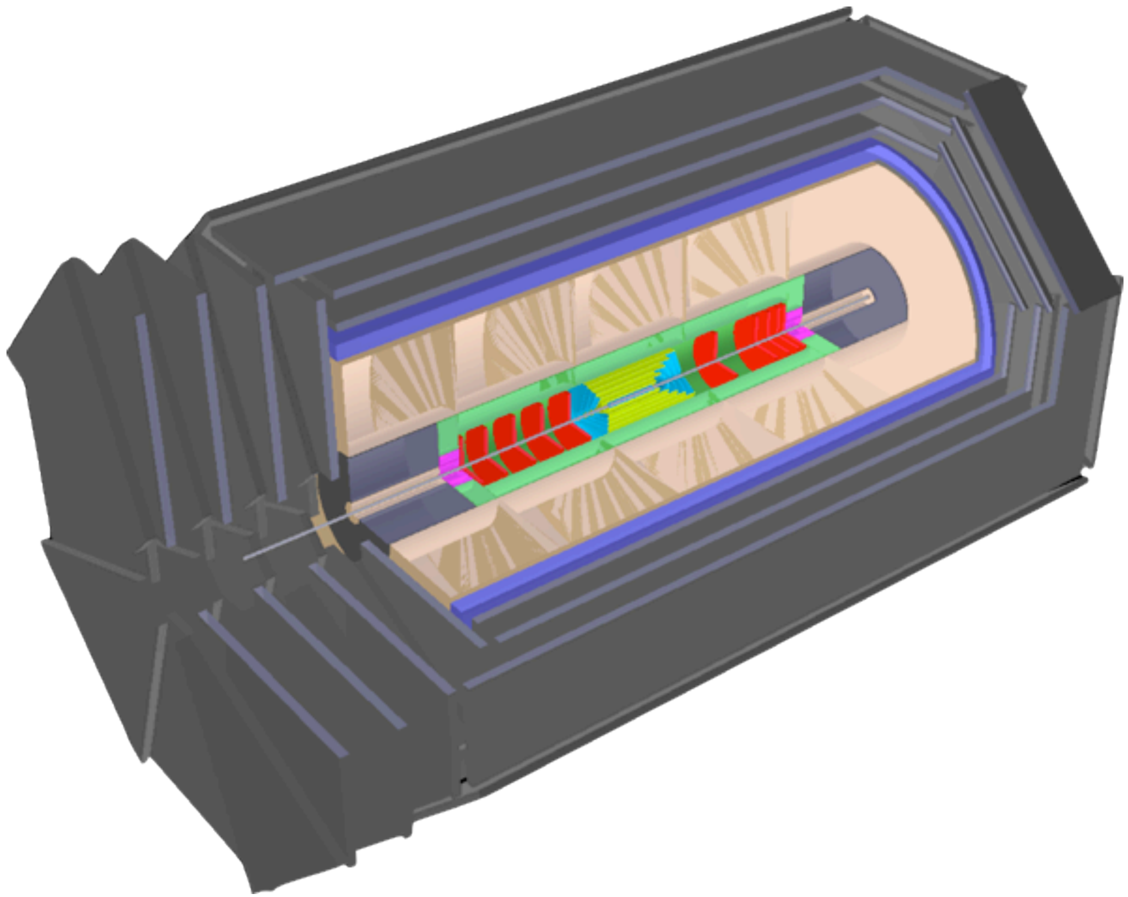
Silicon (fwd/bwd+central)
[Strip or/and Gas on Slimmed Si Pixels]
[0.6m radius for 0.03% * pt in 3.5T field]

El.magn. Calo (Pb,Scint. 9-12X_0)
Hadronic Calo (Fe/LAr; Cu/Brass-Scint. ~30λ)

<u>Fwd Detectors</u>
(down to 1°)
Silicon Tracker
[Pix/Strip/Strixel/Pad Silicon or/and Gas on Slimmed Si Pixels]

Calice (W/Si); dual ReadOut - Elm Calo
FwdHadrCalo:
Cu/Brass-Scintillator

<u>Bwd Detectors</u>
(down to 179°)
Silicon Tracker
[Pix/Strip/Strixel/Pad Silicon or/and Gas on Slimmed Si Pixels]
Cu/Brass-Scintillator,
Pb-Scintillator (SpaCal - hadr, elm)



Extensions in fwd direction (tag p,n,d) and backwards (e,γ) under study.