

# Introduction to FCC-he

Max Klein and Oliver Brüning  
University of Liverpool, CERN

FCC Meeting. 14.2.2014  
Breakout Session on Hadron-Electron Collider  
University of Geneva



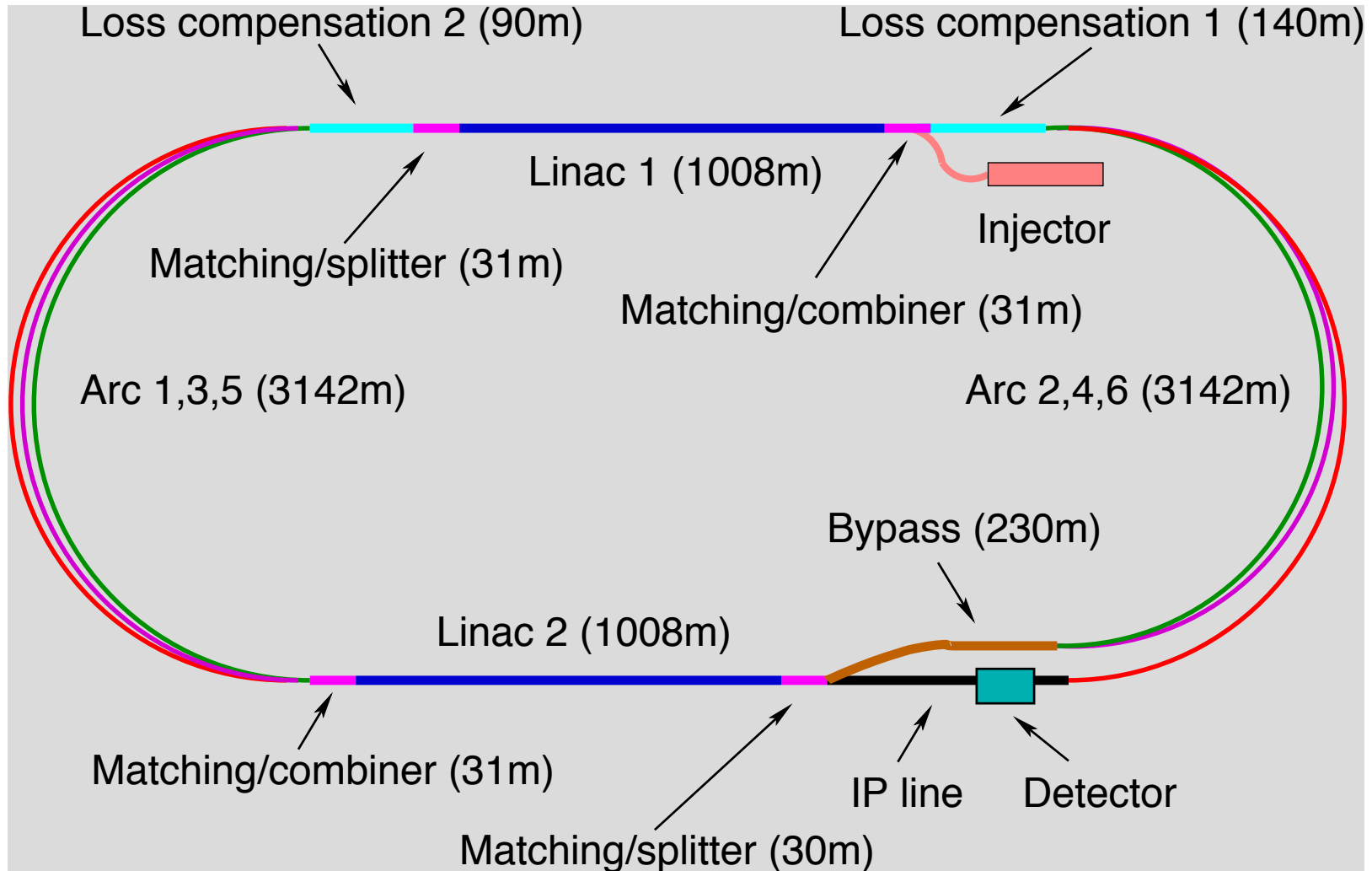
<http://cern.ch/lhec>



60 GeV x 7 TeV (LHC)

60 ... 175 GeV x 50 TeV (FCC-h)

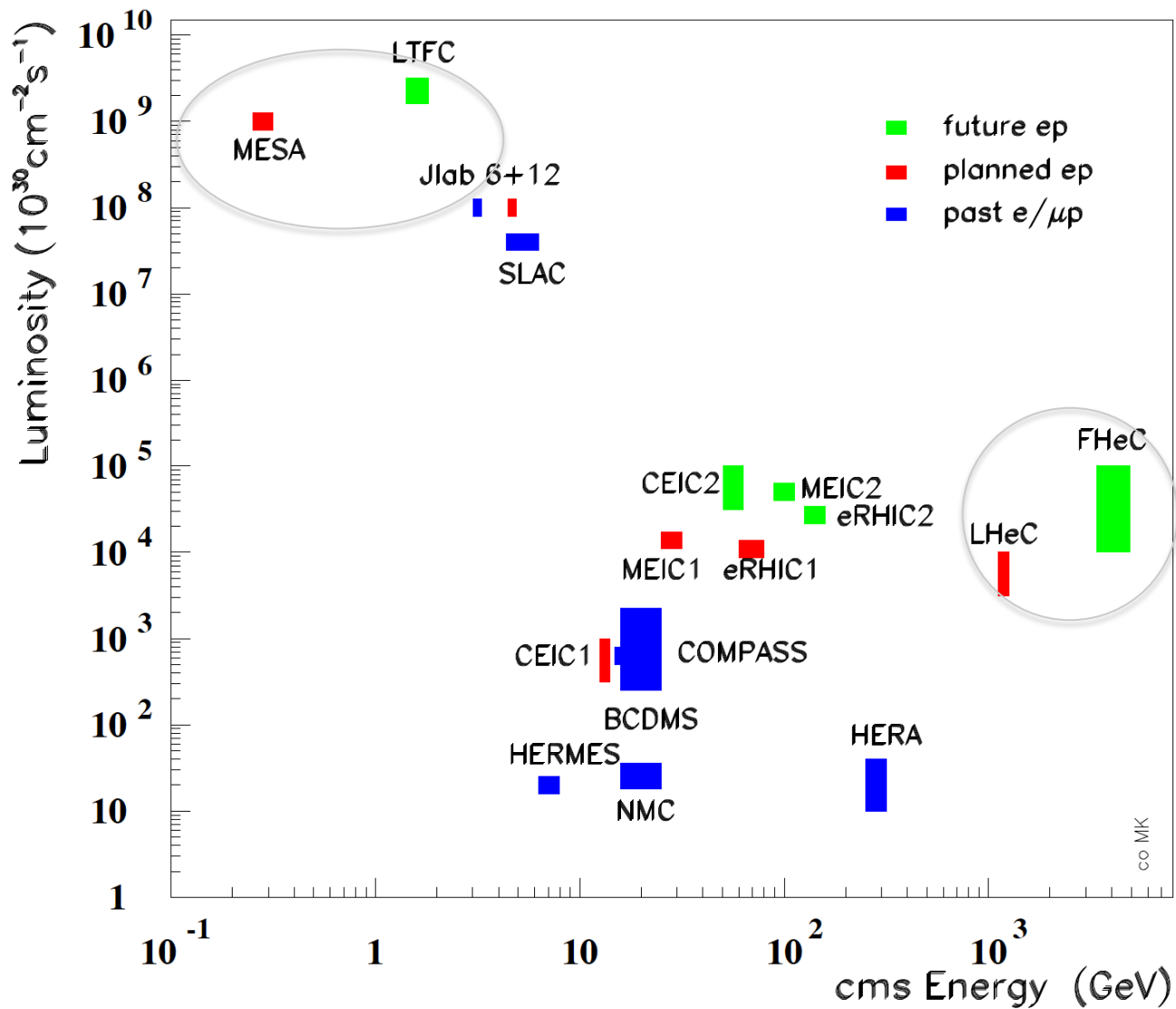
# CDR: Physics, Accelerator, Detector



JPhysG:39(2012)075001, arXiv:1206.2913 <http://cern.ch/lhec>

CDR: default design. 60 GeV.  $L=10^{33}\text{cm}^{-2}\text{s}^{-1}$ ,  $P < 100\text{ MW} \rightarrow \text{ERL, synchronous ep/pp}$

# Lepton-Proton Scattering Facilities



CERN: LHC+FCC: the only realistic opportunity for energy frontier deep inelastic scattering  
 Huge step in energy ( $Q^2, 1/x$ ) and 3 orders of magnitude higher luminosity than HERA

# Further Path Determined with IAC Mandate

The IAC was invited in 12/13 by the DG with the following

Guido Altarelli (Rome) \*)  
Sergio Bertolucci (CERN)  
Frederick Bordry (CERN)  
Stan Brodsky (SLAC)  
Hesheng Chen (IHEP Beijing)  
Andrew Hutton (Jefferson Lab)  
Young-Kee Kim (Chicago)  
Victor A Matveev (JINR Dubna)  
Shin-Ichi Kurokawa (Tsukuba)  
Leandro Nisati (Rome)  
Leonid Rivkin (Lausanne)  
Herwig Schopper (CERN) – **Chair**  
Jurgen Schukraft (CERN)  
Achille Stocchi (LAL Orsay)

## **Mandate 2014-2017**

Advice to the LHeC Coordination Group and the CERN directorate by following the development of options of an ep/eA collider at the LHC and at FCC, especially with:

Provision of scientific and technical direction for the physics potential of the ep/eA collider, both at LHC and at FCC, as a function of the machine parameters and of a realistic detector design, as well as for the design and possible approval of an ERL test facility at CERN.

Assistance in building the international case for the accelerator and detector developments as well as guidance to the resource, infrastructure and science policy aspects of the ep/eA collider.

\*) IAC Composition End of January 2014 +  
Oliver Brüning Max Klein ex officio

# Coordination Group for Future DIS at CERN

LCG (2014-2017)

\*)

Nestor Armesto

Oliver Brüning

Stefano Forte

Andrea Gaddi

Bruce Mellado

Max Klein

Peter Kostka

Daniel Schulte

Frank Zimmermann

Directors (ex-officio)

Sergio Bertolucci, Frederick Bordry

The coordination group was invited end of December 2013 by the CERN directorate with the following mandate (2014-2017)

The group has the task to coordinate the study of the scientific potential and possible technical realisation of an ep/eA collider and the associated detectors at CERN, with the LHC and the FCC, over the next four years. It also should coordinate the design of an ERL test facility at CERN as part of the preparations for a larger energy electron accelerator employing ERL techniques.

The group will cooperate with CERN and an International Advisory Committee, chaired by the emeritus DG of CERN, Professor Herwig Schopper, who also advises the CERN directorate. The Coordination Group is asked to represent the ep/eA collider development towards CERN, its committees and the international community. The currently tentative composition is listed *left*. CERN has asked Max Klein to chair and Oliver Brüning to co-chair this activity

\*) LCG Composition early January 14

## DRAFT - Structure of further work

Physics	Detector	Testfacility	Accelerator	Infrastructure
Higgs Top LHC-LHeC eA Low x Theory	Simulation Design Taggers Collaboration	Cavcryo module Magnets Source Optics Operation Coordination	Optimisation Optics IR Q1,2 Pipe+Vacuum Positrons Deuterons	Installation CE Resources Conferences Outreach Relations

# Important Milestones for the first FCC Phase

- 2014: Higgs, ... Physics → Validate Configuration of LHeC for  $10^{34}$ , Footprint  
Front-end simulation of the ERL  
Detailed p beam dynamics studies with complete integration into HL LHC  
Detector-IR integration for  $10^{34}$   
Detector Simulation for more realistic physics simulation studies  
Collaboration agreements, for RF: 802 MHz Cavity-Cryo Module, warm magnets..
- 2015: March: FCC Workshop  
‘he’ Physics in the ‘hh’ (LHC/FCC) and ‘ee’ (FCC, LC) context  
ERL integration with HL-LHC and FCC-hh  
ERL Testfacility as FCC-ee injector  
Detector design and IR (LR and RR)  
Design of the Testfacility, including its applications  
Further development of International Detector Collaboration

Your input and collaboration is vital

# Tentative Work Plan for FCC-he Accelerator Development

## **Lepton-hadron collider**

### **Overall design parameters**

Baseline layout for lepton-hadron ring-ring collider

Baseline parameters for lepton-hadron ring-ring collider

Baseline layout for lepton-hadron Linac-ring collider

Baseline parameters for lepton-hadron Linac-ring collider

### **Functional machine design**

Beam dynamics related to parallel ep/pp operation for lepton-hadron LR

Beam dynamics related to parallel ep/pp operation for lepton-hadron RR

Interaction region and final focus design for lepton-hadron LR

Interaction region and final focus design for lepton-hadron RR

Machine and tunnel integration concepts

Machine detector interface

Machine protection concepts

### **Technical systems**

Beam transfer elements requirements and concepts

Machine detector integration for lepton-hadron RR

Machine detector integration for lepton-hadron LR

Machine protection needs and concepts

Insertion magnet conceptual design

Vacuum system requirements and conceptual design



# Context of Today

<http://cern.ch/lhec>  
[event-lhec-workshop@cern.ch](mailto:event-lhec-workshop@cern.ch)

## Workshop on the LHeC

Electron-proton and electron-ion collisions at the LHC

**20-21 January 2014**  
Chavannes-de-Bogis, Switzerland

LHeC – Oliver B

Testfacility – Alessandra V

IR – Rogelio T

Detector – Alessandro P

Coffee (15.30-16.00)

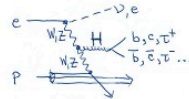
FCC-he - Frank Z

DIS - Max K

Heavy Ions – Brian C

Transition to pheno-session

Higgs – Uta K



### International Advisory Committee

Guido Altarelli (Rome)  
Sergio Bertolucci (CERN)  
Frederick Bordry (CERN)  
Angela Bracco (Milano)  
Hesheng Chen (IHEP Beijing)  
Andrew Hutton (Jefferson Lab)  
Young-Kee Kim (Chicago and Fermilab)  
Victor A. Matveev (JINR Dubna)  
Shin-ichi Kurokawa (Tsukuba)  
Leandro Nisati (Rome)  
Leonid Rivkin (EPF Lausanne)  
Herwig Schopper (CERN) - Chair  
Jürgen Schukraft (CERN)  
Achille Stocchi (LAL Orsay)

### Working Group Convenors

Physics and Detector  
Nestor Armesto (Santiago di Compostella)  
Olaf Behne (DESY)  
Bruce Mellado (Wits University)  
Alessandro Polini (Bologna)  
Accelerator and ERL-Testfacility  
Alex Bogacz (Jefferson Lab)  
Erk Jensen (CERN)  
Daniel Schulte (CERN)

### Organizing Committee

Sergio Bertolucci (CERN)  
Frederick Bordry (CERN)  
Oliver Brüning (CERN)  
Laurie Hemery (CERN)  
Max Klein (Liverpool)



## My clarifying remark:

Any ep/eA project **cannot be  
a major CERN flagship project**

Essentially only one experiment,  
cannot satisfy > 8000 users

**not in competition** with main projects  
(HL-LHC, HE-LHC, CLIC, FCC)  
**complementary (in time, resources)**

Herwig Schopper at Chavannes in the Panel Discussion with the CERN Directorate

**Truth is stranger than fiction, but it is because fiction is obliged to stick to possibilities**  
Mark Twain, cited by Stan Brodsky at Chavannes