

WG5 - developing a sustainable LHeC and FCC-eh collider programme

Oliver Brüning and Yannis Papaphilippou, CERN

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The ep/eA study at the LHC and FCC – new impactful goals for the community

WG5

2023

WS

2024

WS

2025

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input to ESPP

proton and nuclear structure from EIC and HERA to LHeC and ECC-eh

novel QCD with high-energy DIS physics: what do we discover when breaking protons and nuclear matter in smaller piece

general-purpose high-energy physics programme: precision physics and searches

ep-physics empowering pp/pA/AA-physics (LHC and FCC)

mproving the ATLAS, CMS, LHCb and ALICE discovery potential with results from a high-energy DIS physics programme

developing a general-purpose ep/eA detector for LHeC and FCC-eh

critical detector R&D (DRD collaborations), integrate in the FCC framework, one detector for joint ep/pp/eA/pA/AA physic

developing a sustainable LHeC and FCC-eh collider programme

design the interaction region, power and cost, coherent collider parameters & run plan, beam optimization, ...

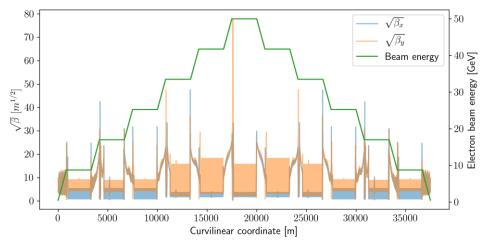
- typically 2-3 conveners per theme
- annual ep/eA workshops (WS)
- final thematic workshop with closing reports to inform the upcoming Strategy process with impactful information (TWS)
- inform the community with regular ep/eA
 Newsletters
- everybody is welcome to join

Coordination Panel: N. Armesto, M. Boonekamp, O. Brüning, D. Britzger, J. D'Hondt (spokesperson), M. D'Onofrio, C. Gwenlan, U. Klein, P. Newman, Y. Papaphilippou, C. Schwanenberger, Y. Yamazaki

Energy Recovery Linac



■ ERL lattice design and dynamics, PhD thesis of Kevin Andre (2022), supervised by Bernard Holzer



- Design options and optimization
 - ☐ Separate **FFAG** arc design and impact on emittance preservation
 - □ Lattice and robustness studies (imperfections) with **improved simulation framework** (X-suite)
 - ☐ Impact of Coherent Synchrotron Radiation and micro-bunching instability handling
- Building **ERL** expertise
 - □ Collaboration with Orsay PERLE and bERLinPRO
 - ☐ Operational experience

Energy Recovery Linac



- Synergy with **FCCee injector design** option with recirculating LINAC (RLI) based on LHeC/FCCeh ERL
 - □ Coherent set of parameters for RLI to replace **LINAC** pre-injectors + Booster, including **positron** production
 - □ Synergy with **SRF pre-series production** while building CERN **SRF expertise** and industrial validation
 - ☐ Impact on **cryogenic system** towards reduced power and cost
 - □ Revive **TLEP option** based on **ERL** (Z, W, H-factory in the LHC tunnel)

Tentative injector parameters with RLI @ 50 GeV (YP, FCC week 2021)

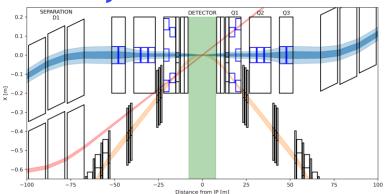
Accelerator	FCCee-Z		FCCee-W		FCCee-H		FCCee-tt		
Energy [GeV]	45.6		80		120		182.5		
Type of filling	Full	Top-up	Full	Top-up	Full	Top-up	Full	Top-up	
RLI # bunches (800 GHz RF)	8	832		1000		328		48	
RLI bunch population [10 ⁹]	3.0	0.15	1.3	0.04	1.9	0.06	2.8	0.08	
RLI injections	1400		140		100		100		
#of BR cycles	-		1		1		1		
# of injections/collider bucket	70		1		1		1		
Total number of bunches	16	16640		2000		328		48	
Filling time (both species) [sec]	0.3	0.3	5.8	5.8	4.9	4.9	8.0	8.0	

Interaction region design

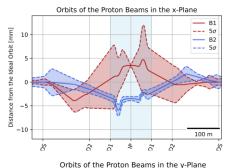


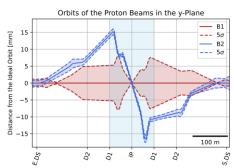
- Optimisation of interaction region (optics and magnets) for LHeC and FCCeh, PhD work of Tiziana Von Witzleben (to be finalised in 2025), supervised by Bernard Holzer
 - ☐ See IPAC 2023 paper on Concurrent Operation of the LHeC and the HL-LHC
 - ☐ See FCC week 2023 <u>talk</u>
 - □ Input for the design asymmetric magnets of the IR (magnets groups) using HL short model coils
- Machine-detector interface, Laurent Forthomme (Un of Krakow post-doc, hosted in BE-ABP @ CERN), supervised by Bernard Holzer Krzysztof Piotrzkowski
 - □ SR radiation handling/shielding in IR for machine and detector protection
 - Optics variants for forward and backward detectors

only e-h collisions



e-h and h-h collisions

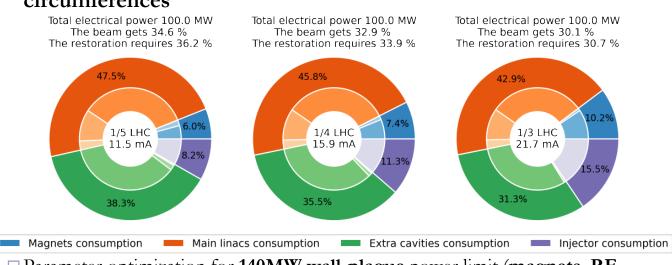




Collider parameters



- Coherent collider parameters and operational scenario, Oliver Brüning, Bernhard Holzer and Yannis Papaphilippou, together with Massimo Giovannozzi (FCChh study coordinator)
 - □ Power and cost ERL power estimates in Kevin Andre's PhD thesis appendix for 50 GeV energy and 100 MW power and various circumferences

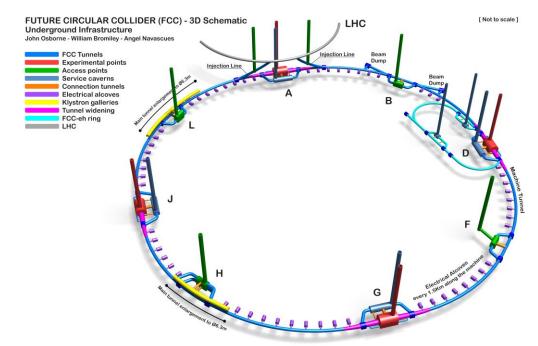


- □ Parameter optimization for 140MW wall-plague power limit (magnets, RF design), injection/dump energy choice
- □ **Dedicated** vs **parasitic running** (increased **e-current**, **BBU limit** in ERL)

Sustainability and life-cycle analysis



- CE optimization based on CO2 emission (J. Osborne)
- **High-Temperature SRF** @ 4.5 K (R. Calaga et al.)
- Fast re-active tuners



LHeC and FCC-eh collider programme – Organisation and Practical aspects

WG convenors: Oliver Brüning, Yannis Papaphilippou

WG indico page: https://indico.cern.ch/category/17311/

Self-subscribe to the WG mailing list: ep-eA-WG5-collider@cern.ch

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