



FUTURE CIRCULAR COLLIDER

Innovation Study

FCCNoW 2020 – EPJ+ Special Issue

Current Status

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The Future Circular Collider Innovation Study (FCCIS) project has received funding from the European Union's Horizon 2020 research and innovation programme under grant No 951754.

Title: A future Higgs & Electroweak factory (FCC): Challenges towards discovery.

Journal: EPJ+: <https://epjplus.epj.org/>

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Final manuscripts submitted to Springer/Nature: 20th December 2020.

Publication on time for the next FCC Week (2021)

Need to review the timelines?



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- 1 Introductory essay on Physics (TH/EP) – Current Landscape by Matthew Reece (Harvard University)
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Part I: Accelerators & Technology

- **FCC-ee: the synthesis of a long history of e+e- circular colliders, but new aspects Design overview [lessons from previous machines – LEP, B factories, SuperKEKB; design approaches; new challenges].** Authors: Jorg Wenninger (CERN), Katsunobu Oide (KEK).
- **How to increase the physics output per MW.h?** Author: Dmitry Shatilov (BINP).
- **IR challenges and the Machine Detector Interface at FCC-ee.** Author: Manuela Boscolo (INFN) [contacted] [SN OA Italy agreement - Roma Tre]
- **Beam polarization and the super precise energy calibration.** Authors: Alain Blondel (University of Geneva, CERN), Eliana Gianfelice (FNAL).
- **The challenge of monochromatization.** Author: Frank Zimmermann (CERN), Angeles Faus Golfe (LAL)

Open Items

- **RF system challenges [Large power, radiation and the vacuum system and superconductivity, coating technologies, the challenge of energy efficient klystrons].**
- **Challenges towards optimized machine design [energy efficiency, availability and maintainability]. Lessons from LEP/LHC.**
- **How to operate a marvelous clockwork like FCC-ee efficiently and automatically? (Discussing: Operation efficiency: injector, luminosity optimization, polarization and depolarization).**

Part II: Physics Opportunities and challenges (1/2)

- **Overview: new physics opportunities create new challenges.** Authors: Alain Blondel (University of Geneva & CNRS), Patrick Janot (CERN).
- **Higgs and top challenges (b/c/g separation, particle flow, kinematic fits etc).** Author: Patrizia Azzi (INFN Padova), Loukas Gouskos (CERN), Michele Selvaggi (CERN), Frank Simon (MPI Munich).

TeraZ Challenges

- **Z line shape challenges : ppm and keVs.** Authors: Patrick Janot (CERN), Juan Alcaraz (CIEMAT), Alain Blondel (University of Geneva & CNRS, CERN), Mogens Dam (Niels Bohr Institute) -
- **Heavy quark challenges at FCCs.** Author: Stéphane Monteil (CERN), Guy Wilkinson (Uni. Oxford)
- **The tau challenges (Vertex detector and EM calorimeter requirements).** Author: Mogens Dam (Niels Bohr Institute)
- **Hunting for rare processes and long lived particles.** Authors: Rebeca Gonzalez Suarez(Uppsala University), Marcin Chrzęszcz (Polish Academy of Sciences), Stéphane Monteil (Uni. Clermont-Ferrand).
- **The W mass challenge.** Author: Paolo Azzurri (INFN Pisa)
- **A special Higgs challenge (1): Measuring the electron Yukawa coupling via s-channel Higgs production.** Author: David d'Enterria (CERN)
- **A special Higgs challenge (2): the mass and cross section measurements.** Author: Paolo Azzurri (ETH), David d'Enterria (CERN), Patrick Janot (CERN)

Part II: Physics Opportunities and challenges (2/2)

Exploring requirements and exploring detector solutions for FCCs.

- **From physics benchmarks to detector requirements.** Authors: Patrizia Azzi (INFN Padova), Emmanuel Perez (CERN)
- **Calorimetry at FCC-ee.** Authors: Martin Aleksa (CERN) Franco Bedeschi (INFN Pisa & Uni. Pisa), Roberto Ferrari (INFN Pavia), Felix Sefkow (DESY), Chris Tully (Princeton)
- **Tracking and vertex detectors at FCC-ee.** Authors: Paula Collins (CERN), Nicola Bacchetta (INFN Padova)
- **Muon detection at FCC-ee.** Authors: Paolo Giacomelli (INFN Bologna), Sylvie Braibant (Universita di Bologna).
- **Luminosity measurement at FCC-ee .** Author: Mogens Dam (NBI)
- **Particle Identification at FCC-ee.** Author: Guy Wilkinson (Uni. Oxford)

Part III: Theoretical challenges at the precision frontier

- **Overall perspective and introduction.** Author: Christophe Grojean (DESY). *Note: Focusing on FCCs*
- **Theory challenges for electroweak and Higgs calculations [including MC aspects].** Authors: Staszek Jadach (Polish Academy of Sciences), Sven Heinemeyer (UAM-CSIC).
- **Theory challenges for QCD calculations [including MC and top quark aspects].** Authors: Pier Monni (CERN), Giulia Zanderighi (Max Planck Institut für Physik)
- **Indirect discovery of physics beyond the Standard Model.** Authors: Nathaniel Craig (University of California, Santa Barbara) and Jorge de Blas (University of Valencia, IFC)
- **Direct discovery of new light states. [Long-lived particles, rare events].** Authors: Simon Knapen (CERN, IAS, Princeton) and Andrea Thamm (University of Melbourne)
- **Theoretical challenges for flavour physics.** Author: Zoltan Ligeti (LBNL)
- **Theoretical challenges for tau physics.** Author: Tony Pich (IFIC, University of València – CSIC).

Part IV: Software Development & Computational Challenges

- **Key4hep, a framework for future HEP experiments and its use in FCC**
Overall modular structure, role of the common Event Model, available services, integration in FCC software. Authors: V. Volkl (SFT, CERN), G. Ganis (SFT, CERN), C. Helsens (ADE), P. Mato (CERN)
- **Offline Computing resources for FCC-ee and approaches to sustainable computing (i.e. Needs in terms of storage and CPU, Adoption of models developed for HL-LHC, Heterogeneous computing/Data centres/Cloud?).** Authors: G. Ganis (SFT, CERN), C. Helsens (ADE)
- **Integrating spin, beam-beam interaction and imperfections in one accelerator supercode. Common shared data format, removal of duplications, integration in key4hep.** Authors: H. Burkhardt (CERN, BE-ABP-HSS), M. Boscolo (INFN-LNF), G. Ganis (SFT, CERN), C. Helsens (ADE)
- **On-line computing challenges detector & readout requirements.**
Author: M. Dam (Niels Bohr Institute), E. Perez (CERN) C. Leonidopoulos (Uni. Edinburgh) + (include LHCb co-author, e.g. C. Fitzpatrick or A. Pearce).

List of Guest Editors

PART I

Andrei Seryi (Director of Accelerator Division at Jefferson Lab) - seryi@jlab.org

Anke-Susanne Müller (Director of the Institute for Beam Physics and Technology (IBPT))

PART II

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Part III

Pilar Hernandez (University of Valencia, IFC) - Pilar.Hernandez@ific.uv.es

Matthew McCullough (CERN, Theory Division) - matthew.mccullough@cern.ch

PART IV

Gloria CORTI (CERN, in charge of simulation in LHCb and also co-convener of the HSF simulation group) - gloria.corti@cern.ch

Junichi TANAKA (Professor at Univ Tokyo, has been in charge of ATLAS MC production) - junichi.tanaka@cern.ch

Note: This is a proposed division of workload as eventually you will all appear as one group of Guest Editors for this Special Issue of EPJ+



Thank you
for your attention.