

CHEF (Swiss experimental research for the FCC):

Experimental & theoretical foundations for FCC

Future Collider Session
CHIPP/CHART meeting 2024
June 15th, 2023

Ben Kilminster
University of Zürich
CHIPP Chair

CHIPP roadmap stresses Swiss engagement in FCC



- CHIPP reviews future accelerator proposals 2018-2020
- CHIPP roadmap published 2020
- First recommendation highlights FCC

Recommendation 1a: CHIPP recommends that Switzerland strongly support CERN as the world-leading laboratory in particle physics. CHIPP's research portfolio is well aligned with CERN's such that CHIPP will continue to benefit greatly from and lend strong support to CERN for the foreseeable future.

Recommendation 1b: CHIPP recommends the development of a national strategy towards the participation in CERN's programme for an FCC, starting with FCC-ee, which encompasses detector development, theoretical research, and data analysis and simulation. CHIPP supports CERN's goal to incorporate sustainability considerations into the design of future colliders.

Recommendation 1c: CHIPP recommends that Switzerland maintain involvement in accelerator physics development, especially towards the FCC projects. In particular, CHIPP recommends the continuation of the successful Swiss Accelerator Research and Technology (CHART) programme, it being an excellent example of close collaboration between CERN, a national laboratory, national institutes, and universities.

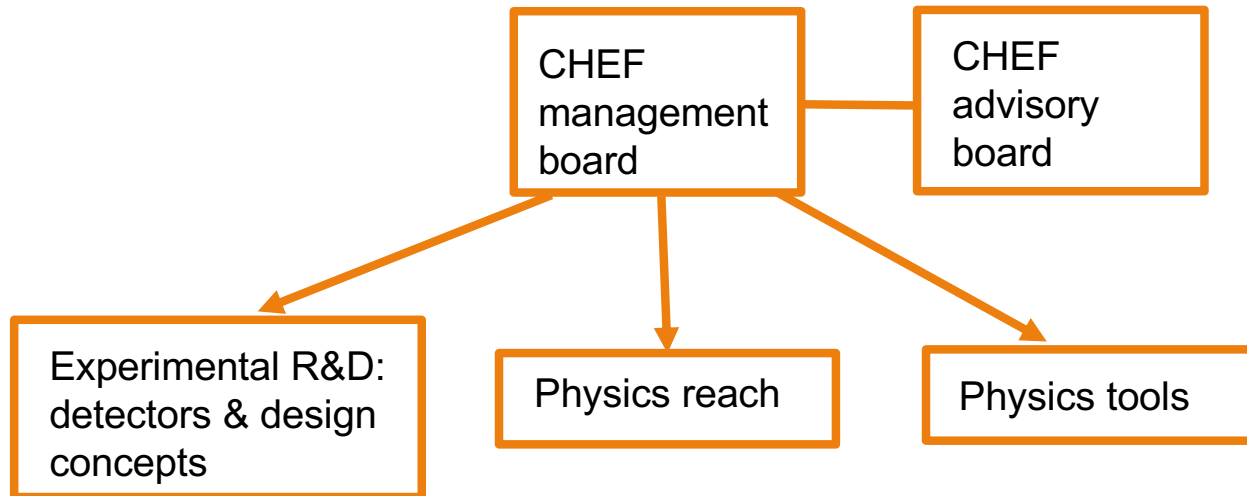
Recommendation 1d: CHIPP recommends that Switzerland maintain strong involvement in detector research and development, which is essential for the future of particle physics and which fosters synergies with other scientific fields.

CHEF inspired by:

- ❑ [2018 Swiss input to strategy update](#) : “Full exploitation of the LHC should remain as the first priority for the European particle physics programme, in parallel with an intensified R&D and design effort to realise the next large project at CERN in the future, namely FCC.”
- ❑ [CHIPP Roadmap : 2025-2028 and beyond](#)
- ❑ [European strategy for particle physics update 2020](#) calls for post-LHC e+e- Higgs factory at CERN with upgrade to 100 TeV hadron collider
 - FCC is the leading contender
- ❑ Two Swiss FCC workshops
 - [September 2021 workshop](#) - kick-off
 - [August 2022 workshop](#) - 100 attendees
- ❑ [CHART \(Swiss Accelerator Research and Technology\)](#):
 - main goal is to “support the future oriented accelerator project FCC at CERN”
 - CHART enables funding of accelerator-based research projects
- ❑ Can we set up something like CHART for FCC detector, experimental, & theoretical physics ?

CHEF formulation

- Summer 2022: formulated basic structure of CHEF
 - ❑ Organization to collect Swiss research topics for FCC
 - ❑ Oversee collection and distribution of research funds



- April 2023 : published [CHEF document](#)
 - ❑ Bottom-up collection of FCC research projects representing expertise and interests of Swiss community

CHEF document

Each item lists a
shovel-ready PhD
thesis proposed by a
Swiss particle-physics
group

2	Experimental research and development	3
2.1	Silicon detector R&D: sensors	4
2.1.1	DMAPS for FCC-ee vertex detectors	4
2.1.2	DMAPS for extreme radiation environment at FCC-hh	5
2.2	Silicon detector R&D: timing capability	5
2.2.1	Timing layer at large radius	5
2.2.2	Ultra-fast MAPS in SiGe BiCMOS	6
2.3	Silicon detector R&D: mechanics and other construction aspects	6
2.3.1	Construction of a gas cooled DMAPS vertex detector demonstrator	6
2.4	Diamond detector R&D	7
2.4.1	Radiation hard 3D diamond detectors for FCC-hh	7
2.5	Fast data processing (online and offline)	8
2.5.1	Real time event selection	8
2.5.2	Development of photonic integrated circuits for vertex detector control and data aggregation and transmission	8
3	Physics reach	9
3.1	Precision studies of the Higgs boson	9
3.1.1	Hadronic event shapes in Higgs production	9
3.1.2	Higgs boson decays	10
3.2	Quark flavour physics	11
3.2.1	Bottom and charm physics	11
3.2.2	Quark FCNC in processes with Z bosons, Higgs bosons, or top quarks	12
3.3	Lepton flavour physics	12
3.4	Standard model precision physics	13
3.4.1	Precision Monte Carlo calculations	13
3.4.2	QCD precision measurements using jets and jet substructure	14
3.5	Searches for new phenomena	15
3.5.1	Heavy neutral leptons and the origin of neutrino masses	15
4	Physics tools	16
4.1	Reconstruction and performance	16
4.1.1	Flavour tagging	16
4.1.2	Application of Machine Learning Methods to the reconstruction and simulation of FCC-ee events	16
4.1.3	Jet reconstruction / pflow	17

Next steps

- 2021 plan :

Timeline :

- 2023: Develop CHEF structure, develop contacts with Swiss institutions.
- 2024: Finalize agreements between SERI, Swiss institutions, and CHEF.
- 2024: Establish CHEF management board and advisory board.
- 2025-2028: Funding for CHEF from SERI and other Swiss institutions.

- Next up :

- ❑ In 2024, CHART will apply for continuation for the period of 2025-2028
- ❑ CHIPP will also apply in 2024 that CHEF be established with a similar agreement for 2025-2028
- ❑ To become effective by/before 2025
 - Encourage CH universities to become vested in FCC / future of CERN
 - Can we already establish some level of locally funded efforts ?

Summary

- CHIPP has strongly prioritized FCC-ee followed by FCC-hh at CERN
- CHEF: CHIPP has developed a set of FCC-related “shovel-ready” research topics
 - ~20 experimental and theoretical PhD projects
- Next steps (2023-2024)
 - Connect with local institutions / funding agencies / SERI to establish how to best realize CHEF
 - Formulate CHEF advisory & management boards by 2024
 - Apply for creation of CHEF towards end of 2024
 - Similar timeline as our roadmap planning exercise