

FCC Cryogenics Feasibility Studies Status

TE FCC workshop, 16th of May 2024

TE-CRG Summary

FCC-ee Cryogenics

- Detailed feasibility study ready to be delivered for all configurations (Z/W, H, ttbar) including:
 - Layout & implementation with respect to latest FCC-ee version
 - Cryogenic design (plants & process)
 - Energy optimization & required services (energy, HVAC)
 - Complete cost estimate for all configurations
 - Complete resources FTEs estimate for all configurations
 - Strong R&D in the Cryogenic Laboratory in collaboration mainly with TE-VSC, SY-RF, EP-DT
- **What cannot be delivered due to missing input:**
 - MDI (Machine Detector Interface) cryogenics (design, layout, implementation)
 - Detectors' cryogenics (hints of layout & implementation proposed, based on CMS-like magnetic systems and ATLAS-like noble gas calorimetry)
 - Possible coupling of the MDI and Detectors cryogenics

Out of feasibility scope & baseline: HTS4 developments on superconducting magnets for FCC-ee: On request from PSI team, preliminary study & cost estimate on centralized cryogenics (plants & distribution) delivered, not retained due to the very high cost, without synergy with the above core FCC-ee cryogenics for SRF.

FCC-hh Cryogenics; update vs CDR

- Solid CDR cryogenics baseline Nb₃Sn @ 1.9 K, validated by industry
- CDR cryogenics adapted to new layout and reduced access points
- Cryogenics layout for Nb₃Sn @ 1.9 K, surface requirements & services updated
- Cryogenic system Nb₃Sn @ 4.5 K, distribution system (vs FCC-ee tunnel) compatible

- Cryogenic system HTS @ 20 K, many unknown parameters; Work in progress:
 - W/m @ 20 K, 40-60 K ?, transients ?, ramping losses ?, very preliminary, **distribution system (vs FCC-ee tunnel) seems compatible.**
 - Heat load scaling, Cooling schemes (gaseous helium high pressure, liquid hydrogen)

- R&D in the Cryogenic Laboratory in collaboration mainly with HFM, TE-VSC
 - Thermal design of coils with reduced He content (i.e. conduction cooling)
 - Reduced He cooling demonstrator, Thermal conductivity and diffusivity, Thermal contraction, Heat extraction of coil packs
 - HTS tape beam screen coating (stripped tape thermal conductivity)

Cryogenics resources allocated to comply with Project's requirements (feasibility study)

Accelerator

Part time TE-CRG academic staff (accounting for 2 FTE on FCC in total):

- Krzysztof Brodzinski
- Laurent Delprat
- Torsten Koettig
- Boyan Naydenov
- Patricia Tavares
- Rob van Weelderen

• Graduates (2 FTE, full time on FCC):

- **New post** for replacement of B. Naydenov by 01.07.2024 demanded; **approved in FCC**
- **New post** demanded to start 01.07.2024: **refused in FCC (CDR revision)**
- **New post** requested to start 01.07.2024; **approved in HFM project (cooling schemes FCChh)**

Detectors

- Fellow (**Fernando Zarate**); noble gas calorimeters R&D (funded by EP dept.)
- No input on the future super conducting magnets of the experiments (no allocated resources)

MDI (Machine Detector Interface) region: input to cryogenics from the accelerator and detectors magnets very low; at the present state, impossible to provide any consolidated picture of cryogenics (common or not)

External member for cryogenics: N/A

- Studies from major world-wide cryogenics industrial suppliers (Air Liquide/Linde) completed & delivered

Thanks to all my colleagues for their strong commitment to provide a solid FCC (ee/hh) cryogenics feasibility study to the Project