

INFN Accelerator Activities for the FCC Feasibility Study

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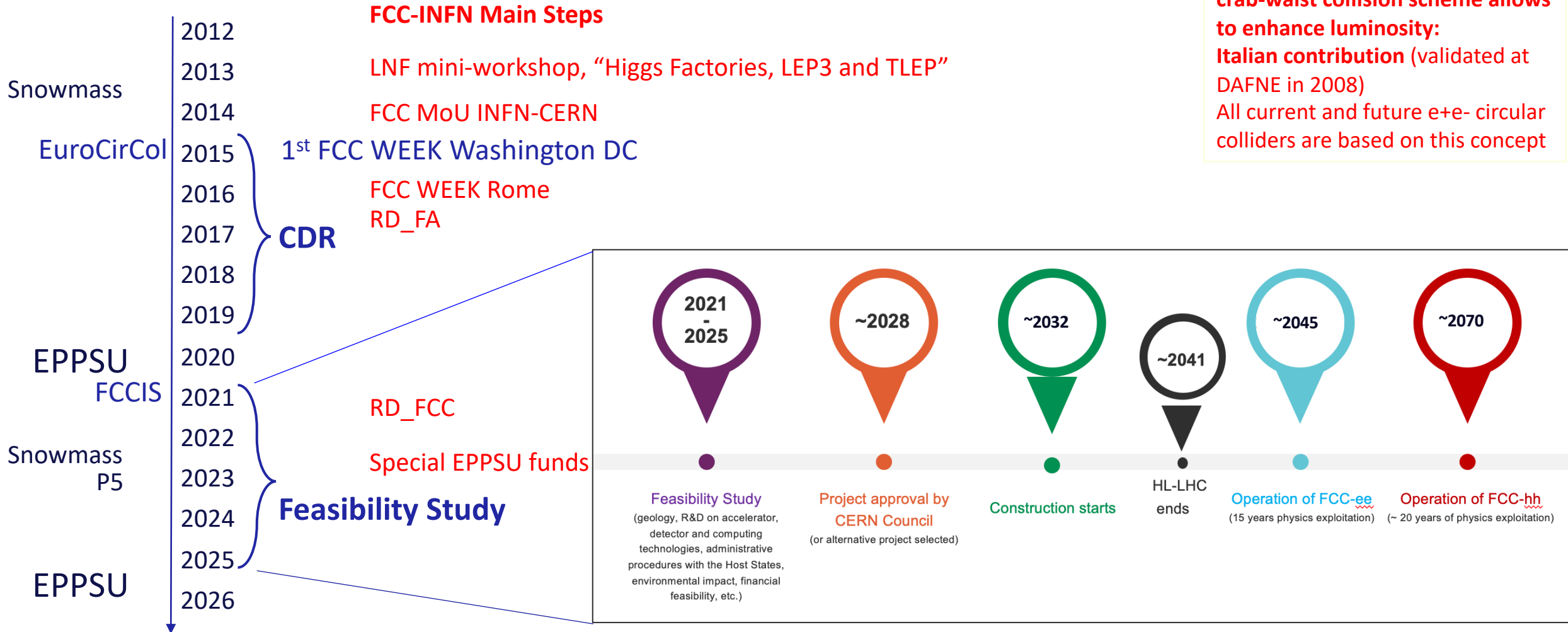
<http://cern.ch/fcc>

photo: J. Wenninger

INFN has been involved since the birth of FCC

Roadmaps and EU projects

FCC Steps of design study



crab-waist collision scheme allows to enhance luminosity: Italian contribution (validated at DAFNE in 2008)
All current and future e+e- circular colliders are based on this concept

European projects for FCC Design Study



European
Commission

Horizon 2020
European Union funding
for Research & Innovation

FCC-hh: EuroCirCol 2015-2019

Strategic activity for the FCC-hh **CDR** and input for the 2019 EPPSU

INFN Involvement in:

- **Experimental insertion region design, WP3 (LNF)**
- **Cryogenic beam vacuum system, WP4 (LNF)**
- **High Field Magnet design, WP5 (Genova, Milano)**
Exploration of different design options for the 16T Nb₃Sn dipoles

- ✓ 3M€ Total Funding
- ✓ INFN grant: 422 KEuro (post-doc contracts)
- ✓ INFN Scientific coordinator: M.B.

FCC-ee: FCC-IS 2020-2024

Strategic activity for the FCC-ee mid-term and **Feasibility Study** reports and input for the 2025 EPPSU

INFN Involvement in:

- **Collider design, WP2**
IR and MDI design, task (LNF)
Collective effects, sub-task (Sapienza, LNF)

- ✓ 3M€ Total Funding
- ✓ INFN grant: 286 KEuro (post-doc contracts)
- ✓ INFN Scientific coordinator: M.B.

INFN special funds to FCC-related R&D

Special funds (>2 M€) have been allocated by INFN executive board to projects on future colliders, in preparation of the Next European Strategy for Particle Physics Update (ESPPU).

Three (out of four) funded projects are FCC-related and belong to CSN1

- FCC-ee IR and MDI full-scale mockup, LNF (co-financed by CERN) see talk by F. Franesini & A. Ciarma
- SRF cavities, LNL see talk by C. Pira
- High Q / High gradient SRF, LASA see talk by R. Paparella
- Muon Collider R&D see talk by D. Giove
- FCC-ee damping ring and transfer lines, LNF (only CHART/CERN funding) see talk by S. Spampinati

Projects are refereed jointly by MAC and Commissione Scientifica Nazionale 1 (CSN1).

Projects timeline: Intermediate outputs will be in support to the next EPPSU

Further funding to the ESPPU R&D studies are allocated as well by the INFN CSN1 (see next slide)

CSN1 supports FCC accelerator activity through RD_FCC

WP2 Accelerator

Coordinator M. B.

Lab and Units involved:

- Frascati
- Roma1
- Legnaro
- Ferrara
- Milano
- Genova
- Pisa
- Perugia

35 Researchers and Technologists

10 FTE (40% of the total FTE involved on RD_FCC)

Coordinated efforts via:

- Doctoral school on Accelerator Physics at University of Rome Sapienza
- CERN technical and doctoral students
- Simil-fellows on accelerator studies?
(proposal for discussion)
- Contributions to topical and major conferences/
workshops (IPAC, FCC WEEK, eeFACT, EPS-HEP, ...)
- Participation to international accelerator and technical
review committees (EIC, CEPC, SuperKEKB)

Important coordination (MDI) and contribution to (mid-term) feasibility study report.

FCC-ee Interaction Region and Machine-Detector Interface

see talk F. Franesini and A. Ciarma (LNF)

- **IR mechanical model**

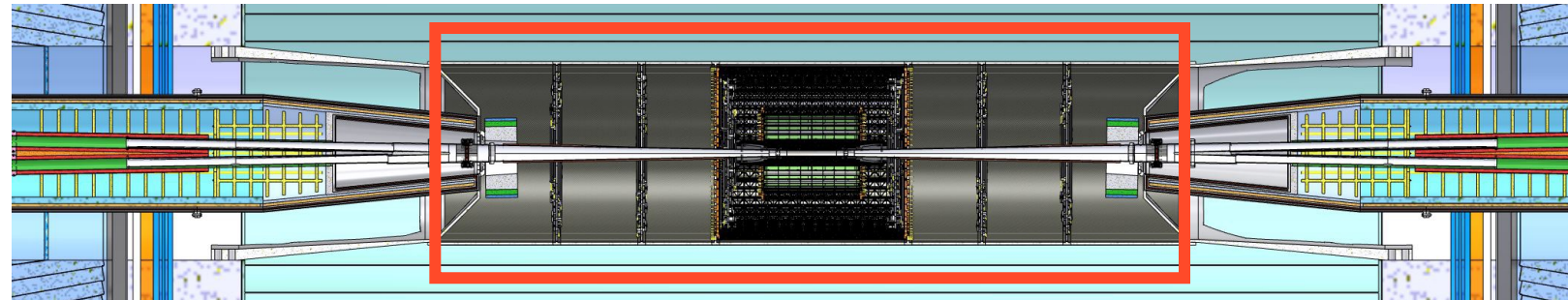
- Vacuum chambers design
- Bellows design
- Vertex detector integration
- Luminosity detector integration
- Supports and assembly
- Services
- Cooling
- Alignments

- **IR superconducting magnet system**

- Minimize emittance growth
- Detector accessibility

- **Beam induced backgrounds evaluation**

- Optimization of shieldings, synchrotron radiation masks and collimators



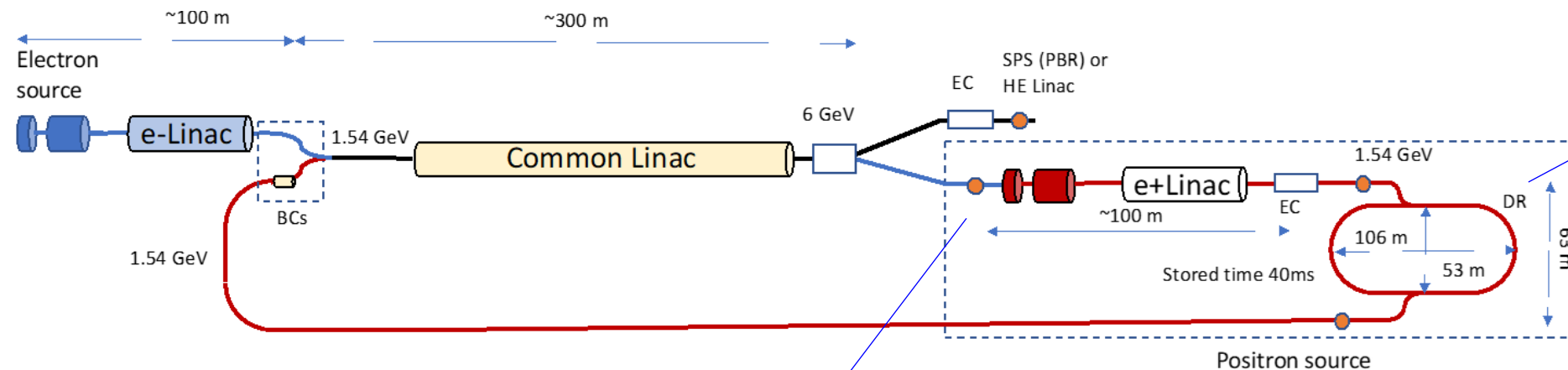
central region ± 1.2 m

IR based on the crab-waist scheme, compact and crowded with tight constraints and many technical challenges → **mockup being built for R&D in Frascati to prove state-of-the-art technological solutions and test its feasibility**

LNF, CERN and INFN-Pisa collaboration (LNF-CERN MoU)

FCC-ee injector

CHART project at PSI, Swiss funding program



e+ Damping Ring and Transfer Lines

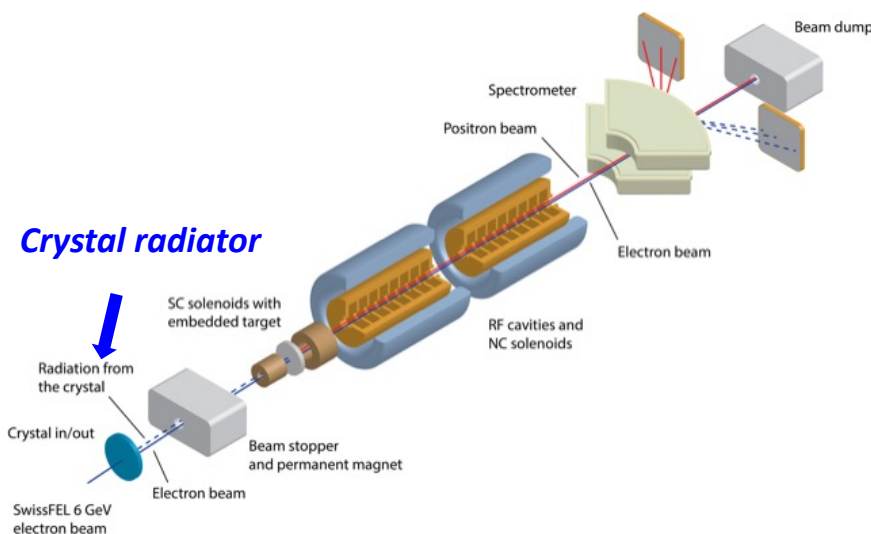
design by LNF
study funded by CHART

see talk S. Spampinati (LNF)

“Positron production experiment” at PSI’s SwissFEL,
beam tests from 2025/26

Hybrid crystal-based e+ source for FCC-ee

Crystal radiator



INFN-Ferrara Collaboration with PSI, CNRS-IJCLab

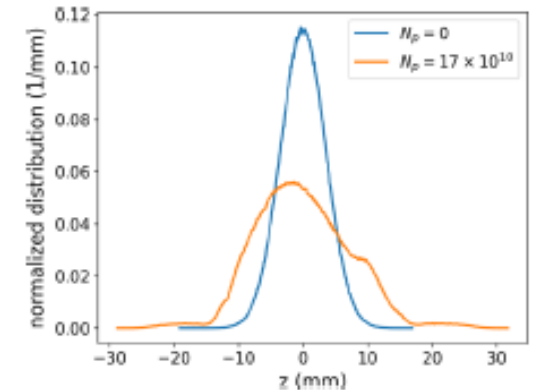
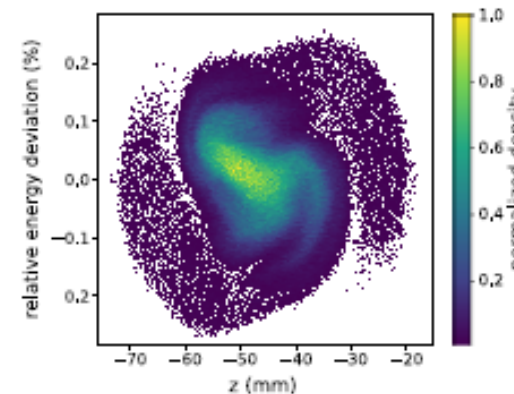
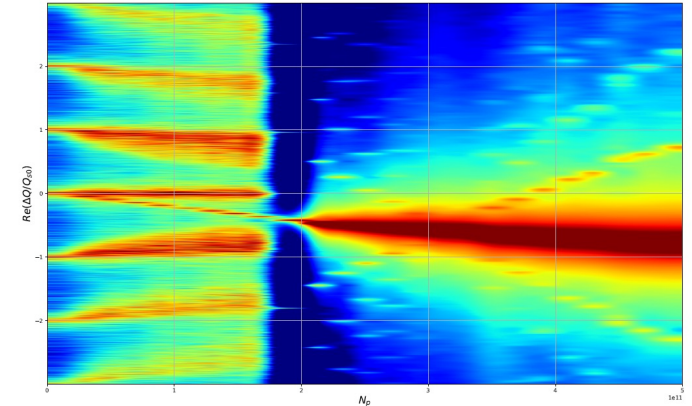
PRIN 2022 funding with INFN-Fe, Uni Naples, Uni Insubria

INFN-Milan: Beam dynamics studies on the e+ beamline optimization

Collective effects for FCC-ee

M. Migliorati, M. Zobov, et al. (Sapienza, LNF)

1. Evaluation of FCC-ee beam coupling impedance budget
2. Study of single bunch instabilities and elaboration of their mitigation techniques
 - Transverse mode coupling instability (TMCI)
 - Longitudinal microwave instability
3. Study of multibunch instabilities and estimates of HOM power
4. Simulation of beam-beam collisions including
 - Nonlinear beam-beam interaction
 - Beam coupling impedances
 - Beamstrahlung
 - Chromaticity
 - Feedback systems



Radio-Frequency System R&D

RF system R&D is key for increasing energy efficiency of FCC-ee

- Nb on Cu 400 MHz cavities, seamless cavity production, coating techniques
- Bulk Nb 800 MHz cavities, surface treatment techniques, cryomodule design
- RF power source R&D in synergy with HL-LHC.

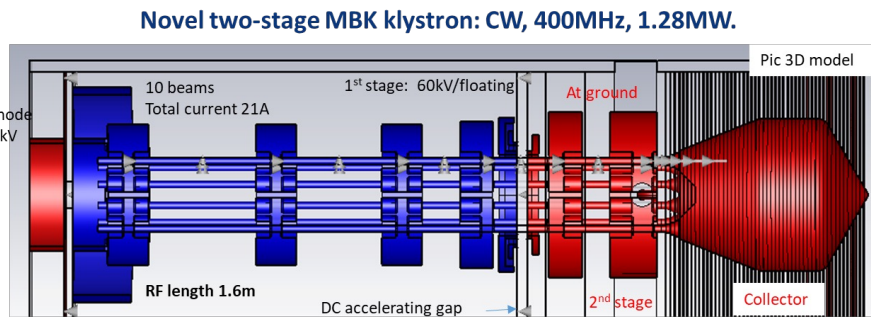
see talk R. Paparella (INFN-Mi)

800 MHz cavity and CM design collaborations with JLAB and FNAL

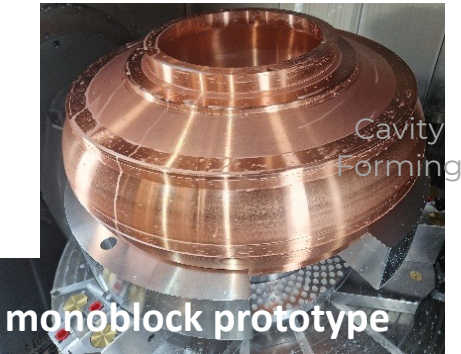


800 MHz segmented design, based on PIP-II

high-efficiency klystron R&D in collaborations with THALES & CANON



400 MHz cavity production in collaboration with KEK

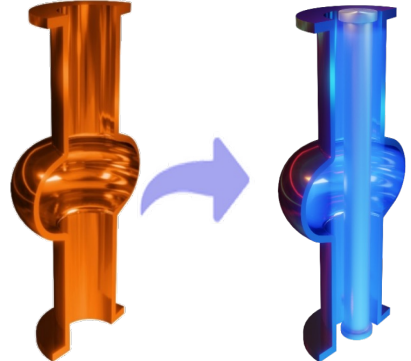


see talk C. Pira (LNL)

High-Q Thin film SRF cavities R&D @LNL

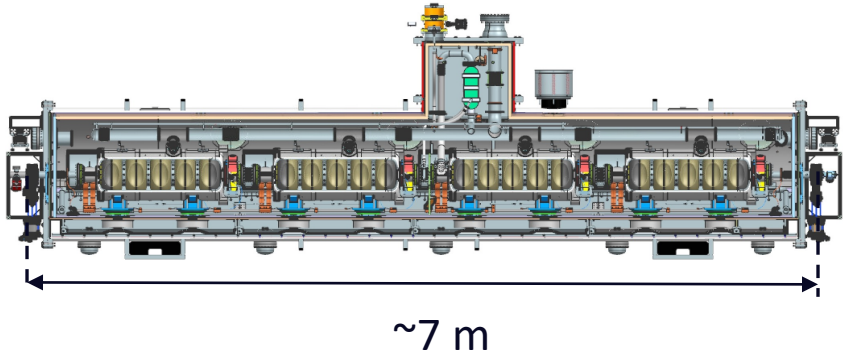
INFN-CERN MOU is in preparation

Surface Polishing SC film coating



WP2
Plasma Electrolytic Polishing

WP1
Nb₃Sn on Cu Coatings



High-field magnets for FCC-hh: Nb₃Sn & HTS R&D

INFN is involved with CERN via FalconD in a global strategy towards 16T Nb₃Sn Magnets

- INFN Milano and Genova: robust concepts using a partnership with industry
- Intermediate 12 T demonstrators towards 16 T → implementation of technology

see talk by S. Farinon

INFN strategy for HTS Magnets

- PNNR_IRIS: development of a HTS (REBCO) dipole in the range 8-10 T
- MU_COL: development of a 20 T Solenoid Coil Demonstrator and study for S.C. large bore dipole for the collider ring

see talk by S. Mariotto

see talk by M. Statera

At FCC-ee:

- The final focus quadrupoles and crab-waist sextupoles are the only superconducting magnets
- Ongoing R&D on HTS at PSI

Summary

- INFN dedicated funds timely leverage expertise on key accelerator R&D.
- Coordinated efforts between INFN and CERN via dedicated MoUs.
- INFN is involved on FCC Accelerator design since the beginning with important contribution to (mid-term) feasibility study report.

- **The first two talks this morning will cover topics included in the FCC-ee feasibility study report**
 - **FCC-ee Machine Detector Interface**
 - **Damping Ring & Transfer Lines**
- **The talks in the first part of the afternoon will present INFN accelerator technologies useful for FCC**
 - **Nb₃Sn, HTS magnets**
 - **SRF cavities, thin film and bulk Nb**