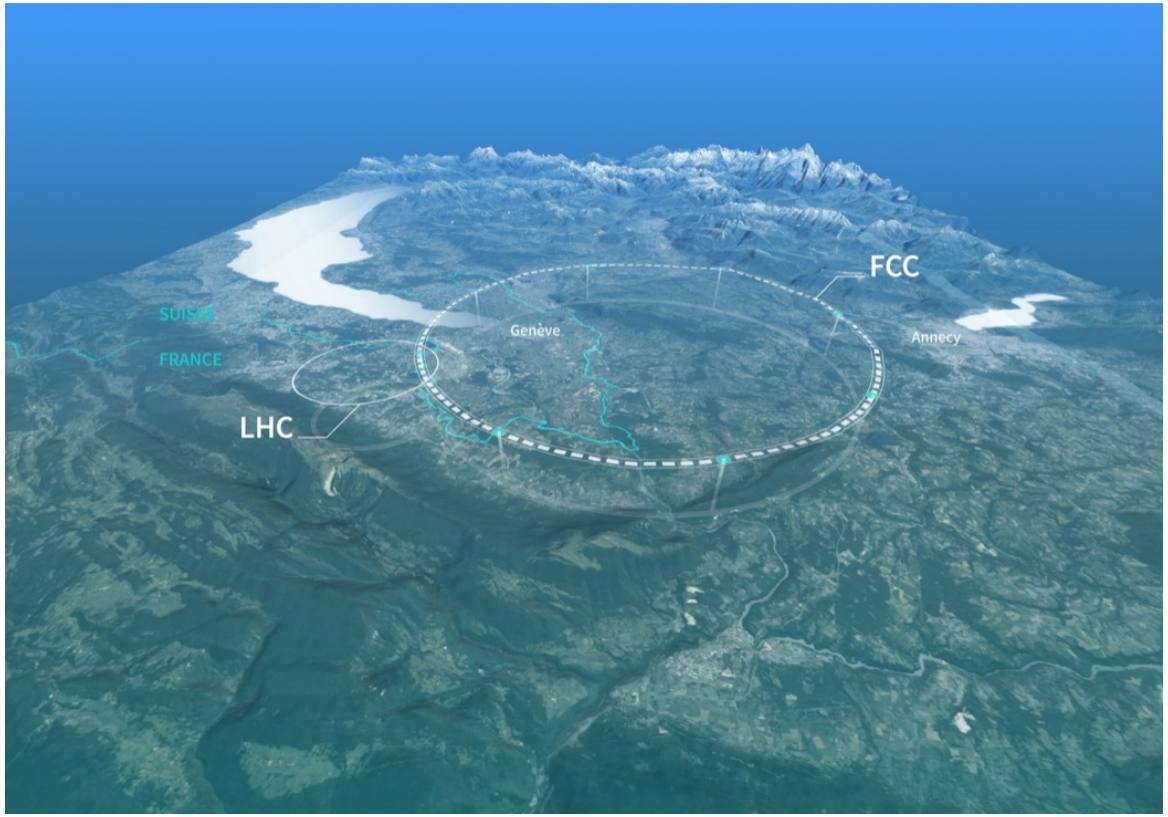
FCCIS – **The Future Circular Collider Innovation Study**. This INFRADEV Research and Innovation Action project receives funding from the European Union's H2020 Framework Programme under grant agreement no. 951754.

FUTURE CIRCULAR COLLIDER Innovation Study

FCCIS 2023 WP2 Workshop

FCC in the INFN Strategy
(and INFN in the 2020 ESPPU)



P. Campana
Frascati & INFN Executive Board

The ESPP

ESPP published on 19/6/2020

The European Strategy for Particle Physics is the cornerstone of Europe's decision-making process for the long-term future of the field. Mandated by the CERN Council, it is formed through a broad consultation of the grass-roots particle physics community, it actively solicits the opinions of physicists from around the world, and it is developed in close coordination with similar processes in the US and Japan in order to ensure coordination between regions and optimal use of resources globally.

INFN management was heavily engaged in this process and fully supported the ESPP outcomes in the final meeting at Bad Honnef (January 2020)

Higgs studies and FCC next priorities (feasibility study)

A. An electron-positron Higgs factory is the highest-priority next collider. For the longer term, the European particle physics community has the ambition to operate a proton-proton collider at the highest achievable energy. Accomplishing these compelling goals will require innovation and cutting-edge technology:

· the particle physics community should ramp up its R&D effort focused on advanced accelerator technologies, in particular that for high-field superconducting magnets, including high-temperature superconductors;

· Europe, together with its international partners, should investigate the technical and financial feasibility of a future hadron collider at CERN with a centre-of-mass energy of at least 100 TeV and with an electron-positron Higgs and electroweak factory as a possible first stage. Such a feasibility study of the colliders and related infrastructure should be established as a global endeavour and be completed on the timescale of the next Strategy update.

Accelerator and detector R&D among the priorities of CERN and Member States through the collaboration with national infrastructures

B. Innovative accelerator technology underpins the physics reach of high-energy and high-intensity colliders. It is also a powerful driver for many accelerator-based fields of science and industry. The technologies under consideration include high-field magnets, high-temperature superconductors, plasma wakefield acceleration and other high-gradient accelerating structures, bright muon beams, energy recovery linacs. ***The European particle physics community must intensify accelerator R&D and sustain it with adequate resources. A roadmap should prioritise the technology, taking into account synergies with international partners and other communities such as photon and neutron sources, fusion energy and industry. Deliverables for this decade should be defined in a timely fashion and coordinated among CERN and national laboratories and institutes.***

C. The success of particle physics experiments relies on innovative instrumentation and state-of-the-art infrastructures. To prepare and realise future experimental research programmes, the community must maintain a strong focus on instrumentation. ***Detector R&D programmes and associated infrastructures should be supported at CERN, national institutes, laboratories and universities. Synergies between the needs of different scientific fields and industry should be identified and exploited to boost efficiency in the development process and increase opportunities for more technology transfer benefiting society at large. Collaborative platforms and consortia must be adequately supported to provide coherence in these R&D activities. The community should define a global detector R&D roadmap that should be used to support proposals at the European and national levels.***

The role of INFN through its infrastructures and its scientific and technical personnel

- INFN is willing to play a major role in this scenario
- If FCC approved → sizeable contribution from Italy, both on experiments and accelerator
- INFN must be ready to put in place a program for technology development, know-how consolidation and for the involvement of the high tech industrial national system
- INFN has to identify specific activities on accelerator and detectors where to focalize its main contributions and to build-up the necessary critical mass

INFN: steps taken so far

- Participation to the implementation of Roadmap by LDG & Council, through the Accelerator and Detector R&D groups

- Kick-off coordination of National efforts

→ 1st FCC Italy Workshop – Rome, March 21-22, 2022

→ FCC France-Italy Workshop – Lyon, November 21-23, 2022

- Activation of bilateral consultations with major European partners to promote a common view on 2020 ESPPU: BMBF, CEA, CNRS, PSI, STFC, etc …
- Implementation of specific agreements with CERN on FCC and on ESPPU-related item

More recently, **implementation of a series of specific funding initiatives** devoted to promote INFN capabilities to participate to FCC (detectors and accelerators) and to implement ESPPU Roadmap

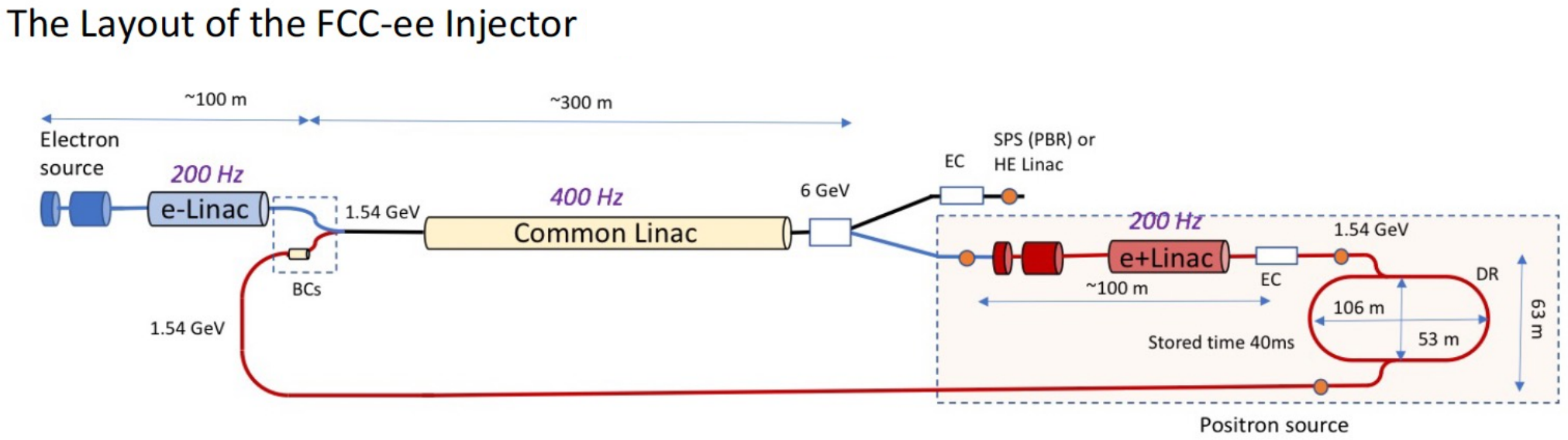
R&D on 2020 Strategy (specifically-funded INFN initiatives)

1. **FCC-ee**, Machine Detector Interface & Main Injector (Frascati)
2. **SRF cavities**, [FCC-ee, μ-coll, ILC, synergies] (LASA-Milano, Legnaro)
3. **μ-collider**, [colling cell, HFM solenoids, MDI] (various INFN labs)
4. **HFM**, High Field Magnets program [various targets]

+ foreseen R&D on detector activities for FCC

Globally, ~ **5 ME** (hardware & personnel) invested on items 1-3 in years 2023-2026 through "call for proposals" mechanism
Budget on HFM to be assessed (2024-2028). Expected same amount (~ **5 ME**)

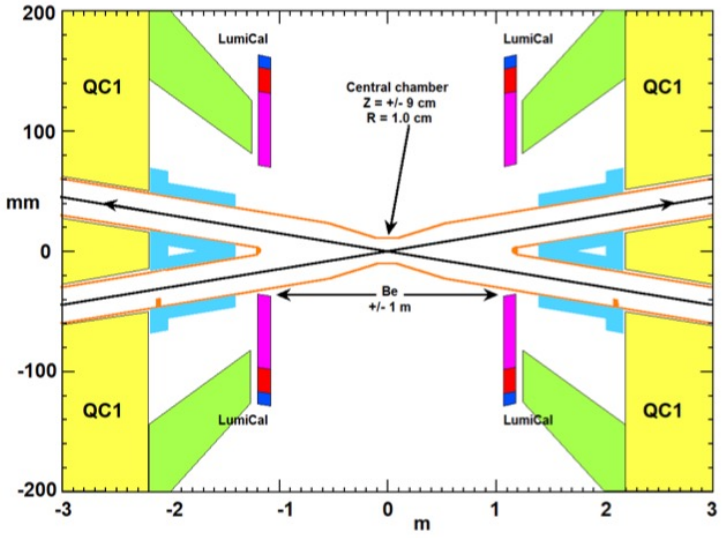
FCC-ee: Damping Rings and Transfer Lines (Frascati)



Based on expertise acquired in construction and operation of DAFNE facility
Milardi (resp.), De Santis, Spampinato, Osgur, in collaboration with CERN and PSI

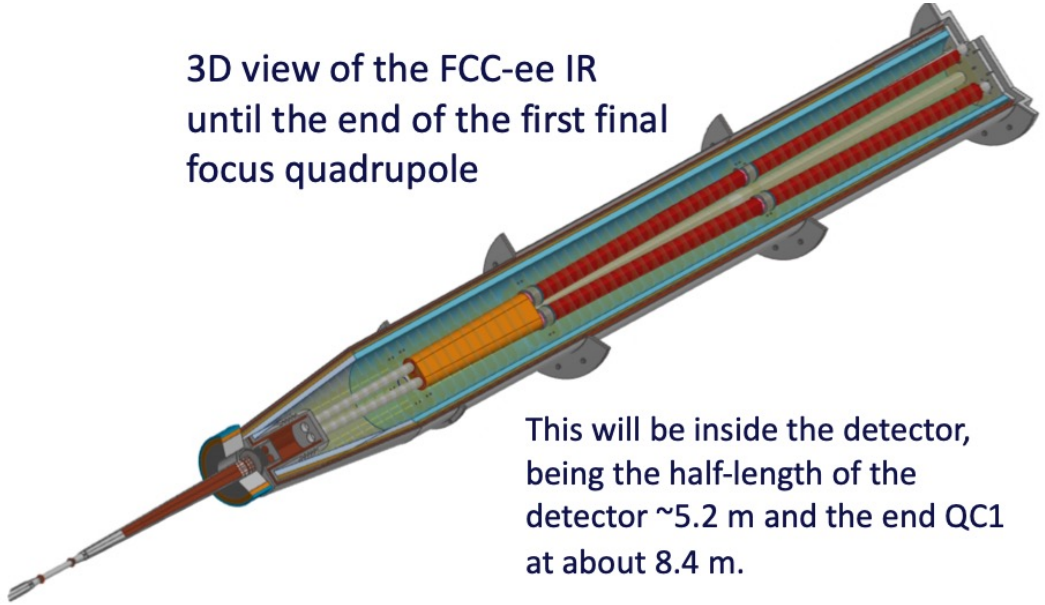
FCC-ee: Machine Detector Interface (Frascati)

FCC-ee Interaction Region

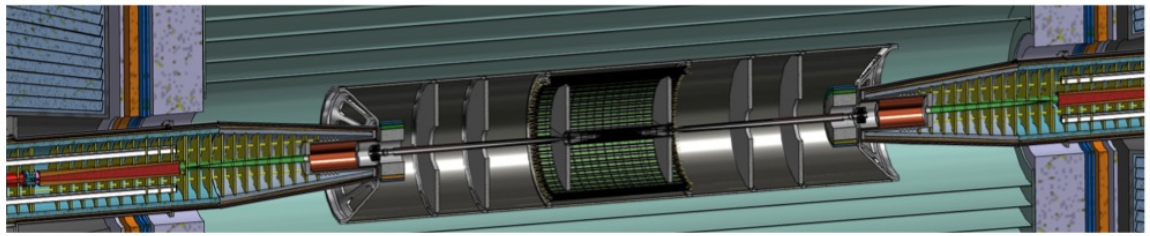


Boscolo (resp.), Pellegrino, Fransesini and technical support from LNF-Acc. Div. and Pisa

3D view of the FCC-ee IR until the end of the first final focus quadrupole

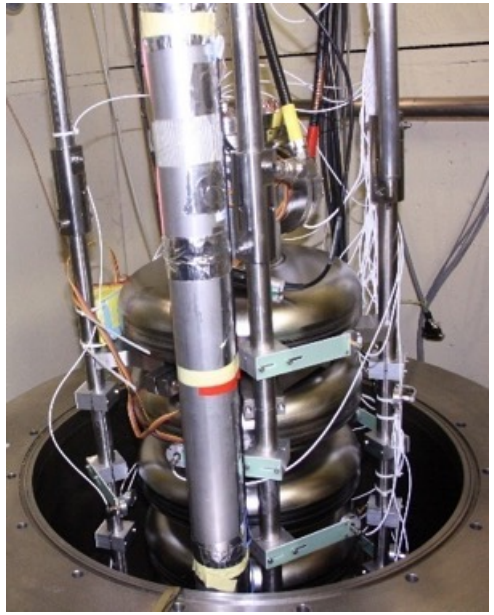


This will be inside the detector, being the half-length of the detector ~5.2 m and the end QC1 at about 8.4 m.



3D view of FCC-ee IR including the rigid support tube, vertex detector and outer trackers.

SRF-cavity activities



- **Milano-LASA** (expertise from X-FEL, ESS, PIP-II constructions)

R&D for **high Q - high gradient** SRF cavities with new recipes in treatments

Technology transfer to industry to allow future high quality yields in mass productions

Support for prototypes, refurbishment of LASA Laboratory + manpower support

Monaco (resp.), Sertore, Bertucci, Bosotti, Paparella, + postdocs and technicians)

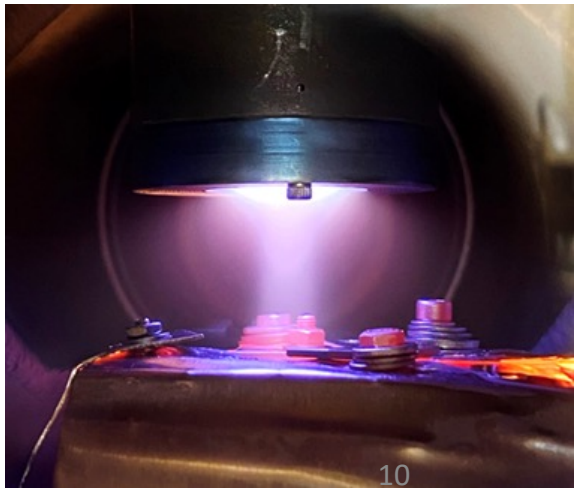
- **Legnaro** (expertise in surface treatments)

- Nb3Sn sputtering on Cu (1.3 GHz in collaboration with CERN)

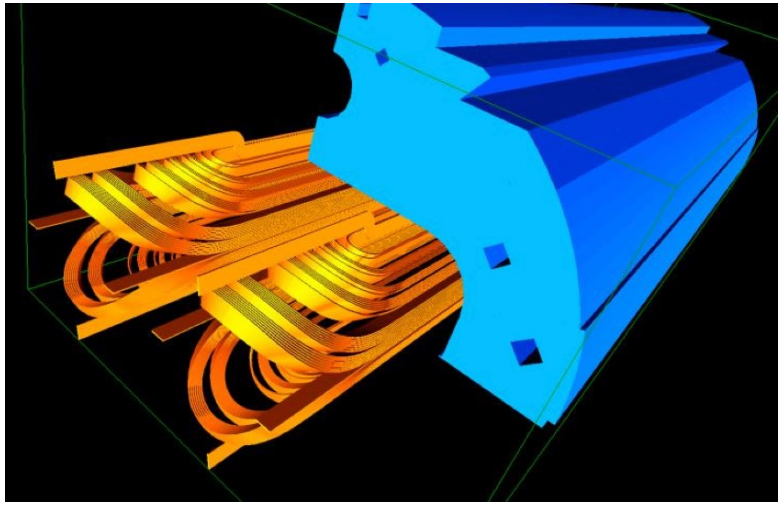
- Plasma electropolishing in Cu and Nb (INFN patent)

Support for prototypes, refurbishment of LASA Laboratory + manpower support

Pira (resp.), Keppel, + postdocs and technicians



INFN Superconductivity programs



- In collaboration with CERN: Nb3Sn FCC dipoles (**Falcon-D**)

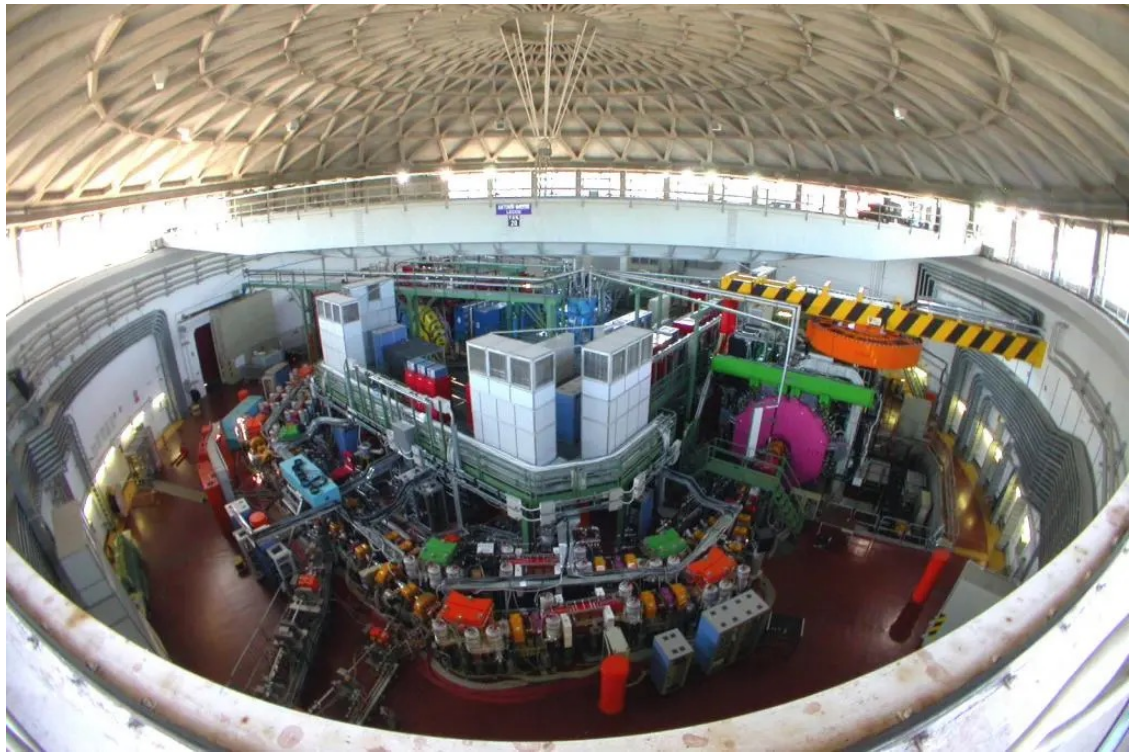
- Large EU Recovery Funds INFN program (60 ME) on SC

IRIS (Innovative Research Infrastructure on applied Superconductivity)

- HTS (MgB_2) high power (40kA)/high voltage (25kV) ZERO CONSUMPTION transmission line L=140m, at T=20 K
- R&D on low consumption HTS (ReBCO) dipoles for future HEP magnet applications, dipoles construction,

Involved labs (refurbishing infrastructures) at:
LASA, Genova, Salerno (site for the test, HTS power line), Frascati

FCC-ee potential test site

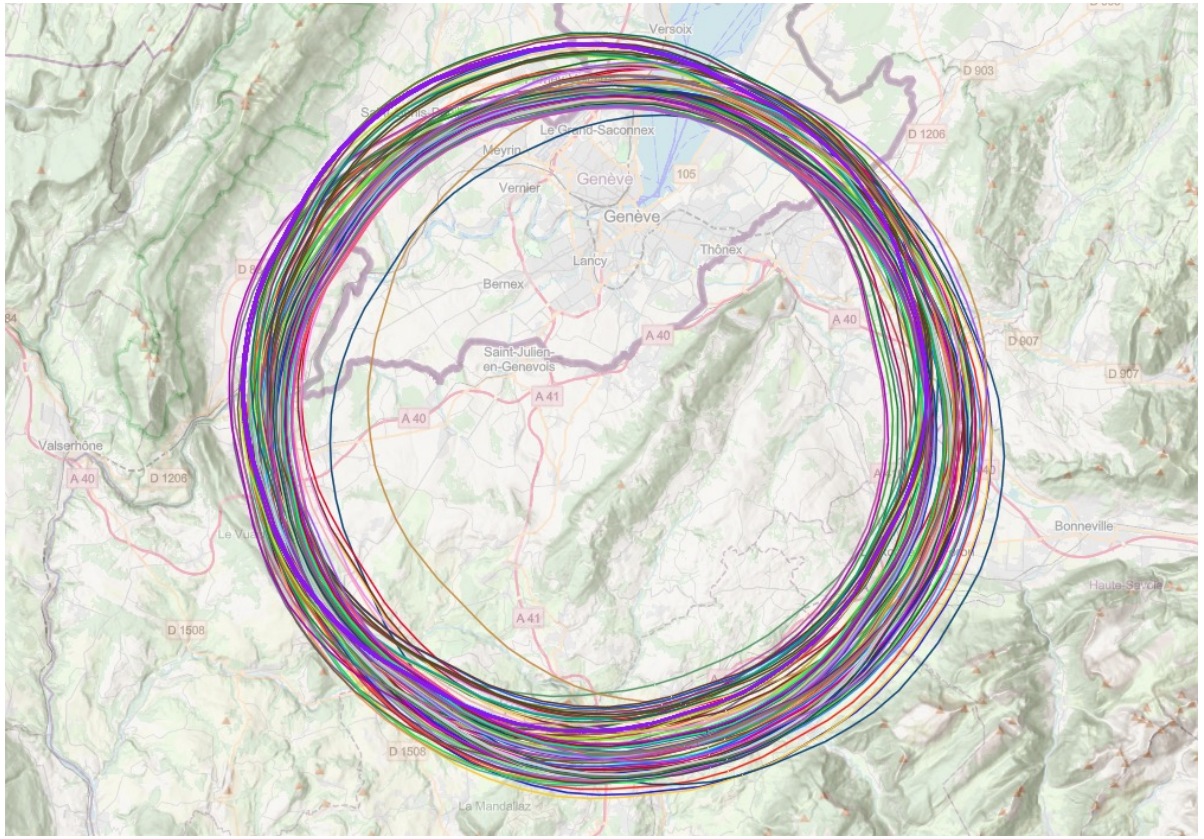


In 2024-25 DAFNE will end its collider mode operation (end of Siddharta data taking)

Unique high current, two-beam infrastructure for ee studies:
- beam dynamics, emittance studies, etc…
- test bed for new technologies: vacuum pipes SEY, controls, diagnostics, feddback, solid state RF, crystal for beam focusing, etc…
- young scientists training

Ideas and proposals from FCC-ee world are welcomed NOW !

Conclusions



INFN is fully engaged in 2020 ESPPU, having as main target the feasibility study for a Higgs machine in a ~100 km tunnel

In 2023, a comprehensive support program for various R&Ds related to the Strategy has been financed by INFN, several specifically targeting FCC, and the support will continue up to 2026, to be completed for the next ESPPU

The rationale is to have INFN Laboratories, research groups and national industry ready to fully contribute, if decided, to the FCC challenging endeavor