Normal conducting magnet activities at CERN (incl. FCC-ee magnet development)

J. Bauche, D. Schoerling

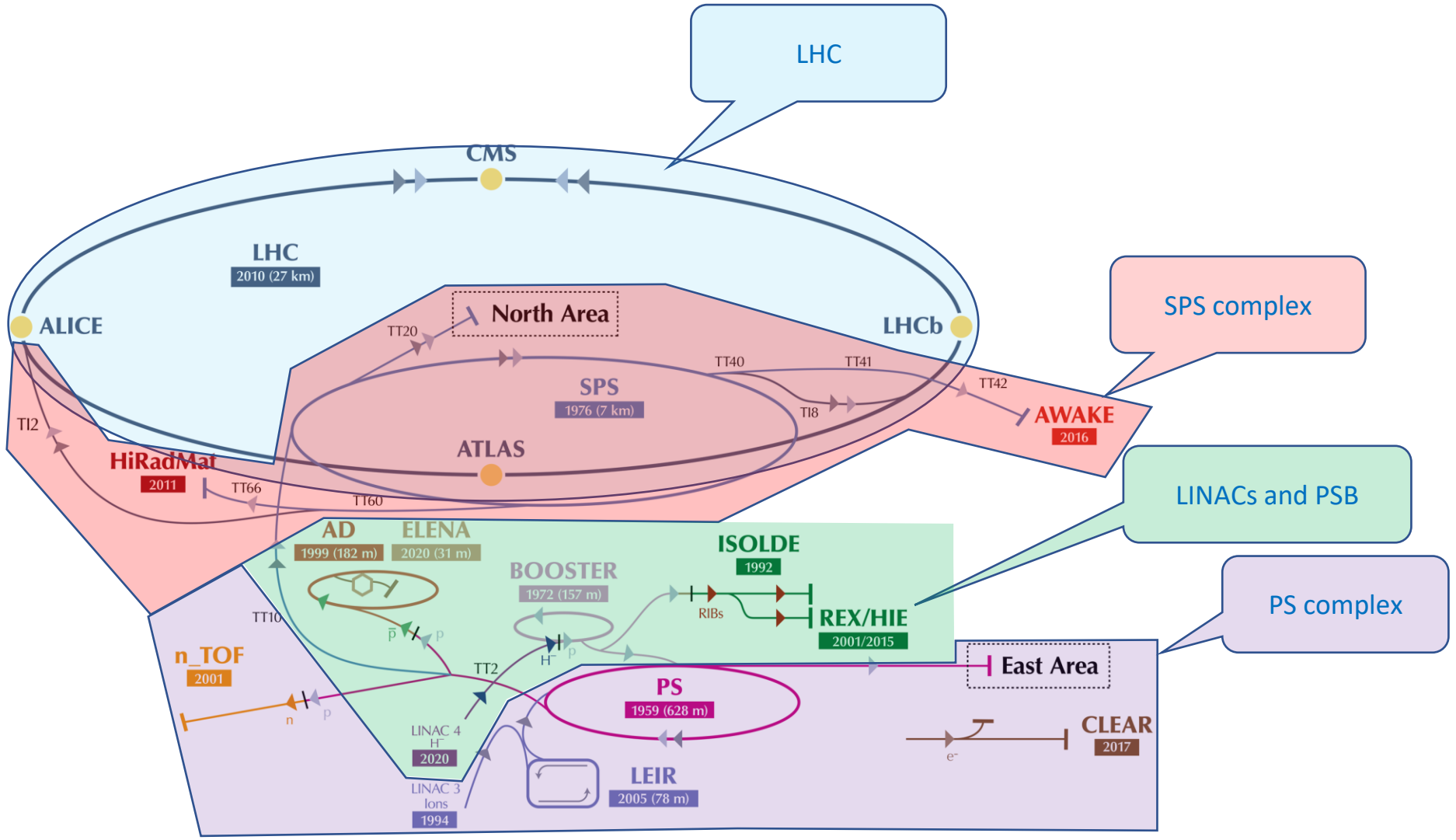
Outline

- Normal Conducting (NC) magnets in the CERN accelerator complex
- The NCM section
  - Our facilities
  - Maintenance and consolidation
  - Production and procurement
  - Quality assurance
- Project examples
  - Medical application: DEFT
  - FCC-ee

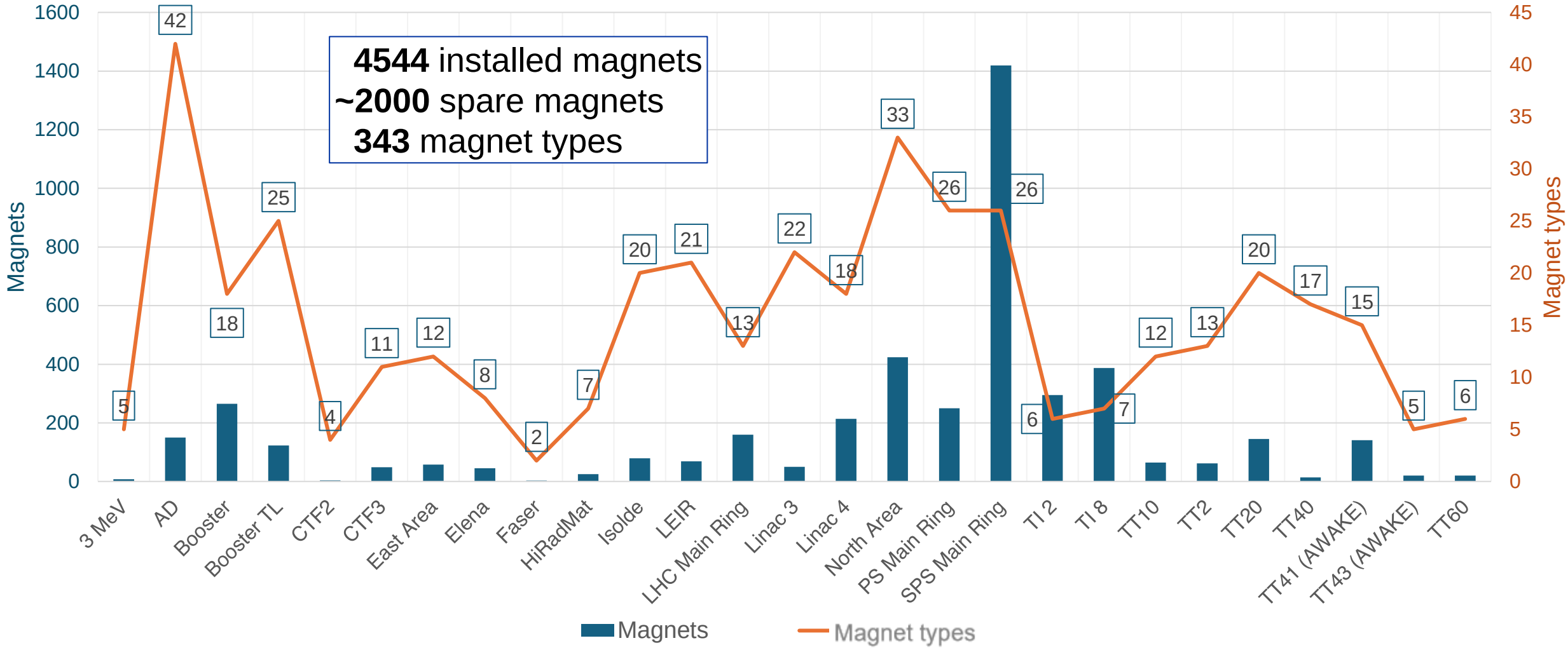
NC magnets in the CERN accelerator complex

The CERN accelerator complex

Almost exclusively NC magnets (except LHC)



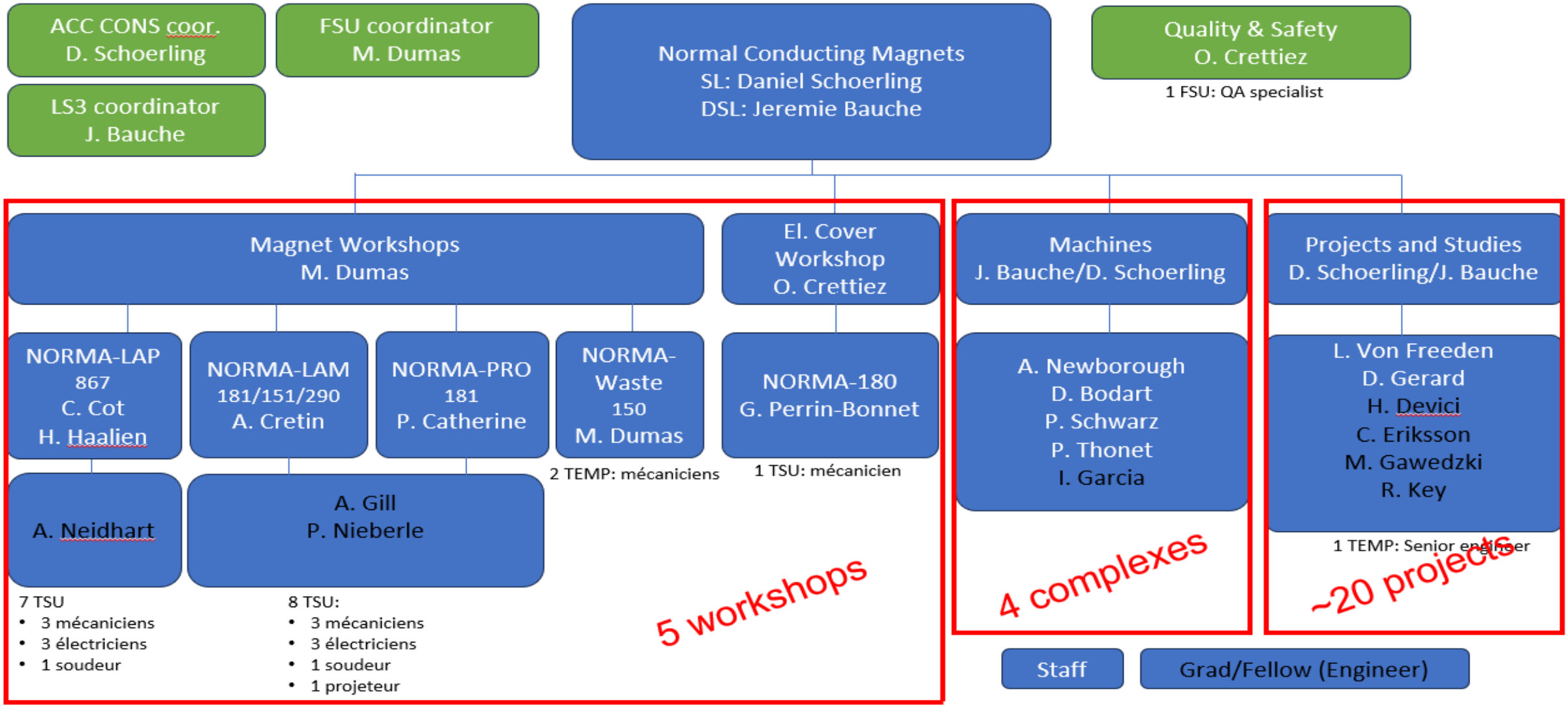
A large magnet zoo



The Normal Conducting Magnet section (TE-MSC-NCM)

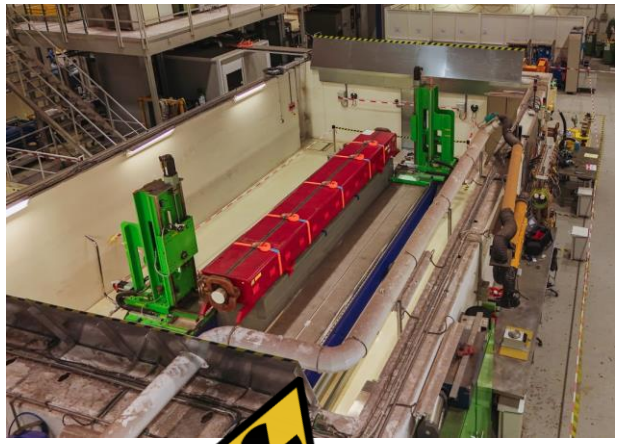
The NCM Team

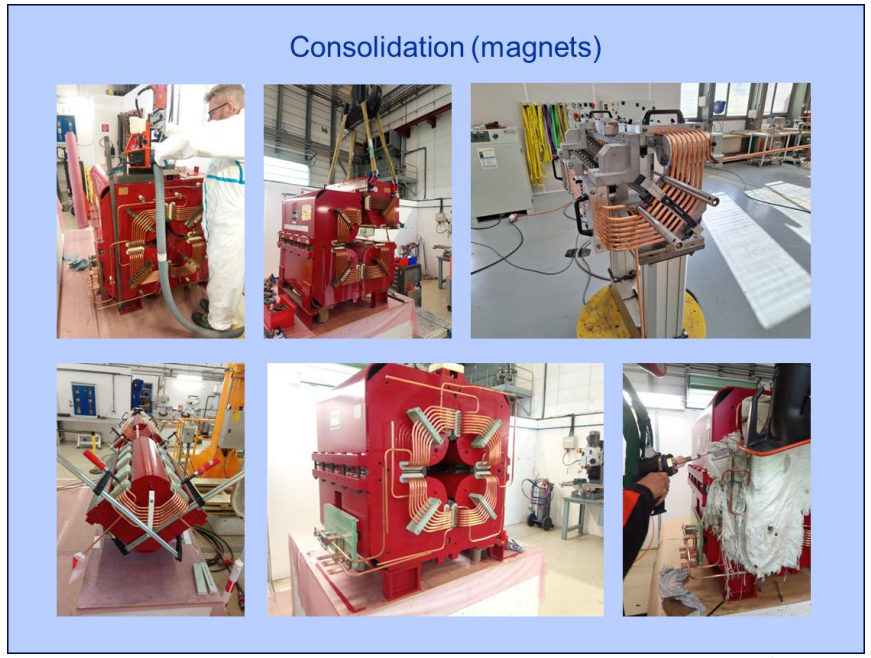
~40 persons
(MPE + MPA)



Our radioactive magnet workshops

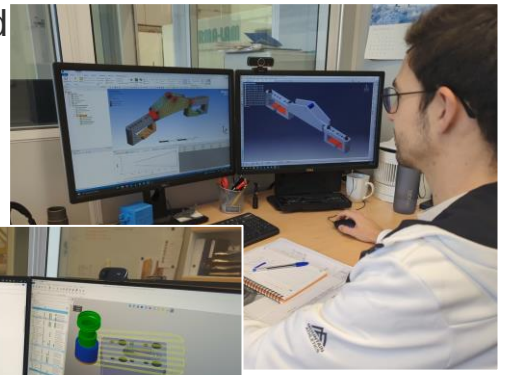
We certify for use ~70 magnets/year for spare use or installation. The majority is used for preventive maintenance and new installations.

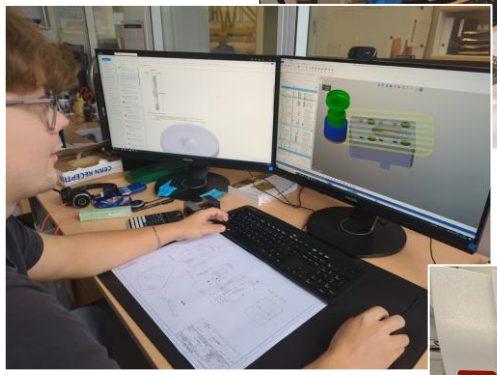




We maintain and improve our magnets

Catia 3D Design and Ansys engineering simulations

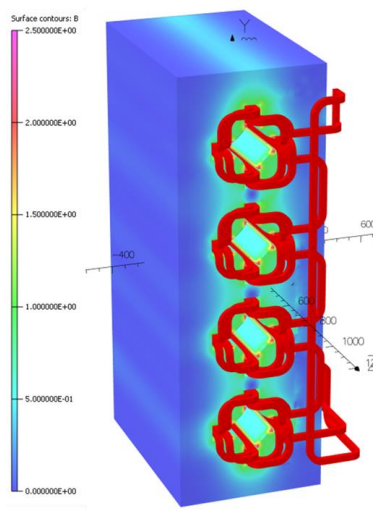


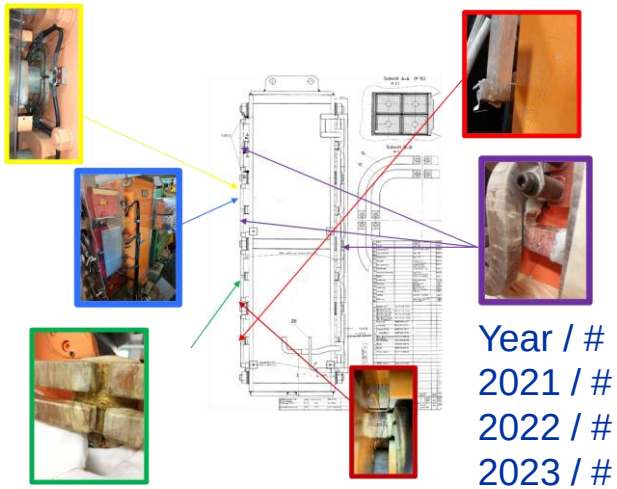


CAM programming

NCM Workshop 290 3 and 3+1 axis CNC Machine

Example of consolidation: PSB quadrupoles

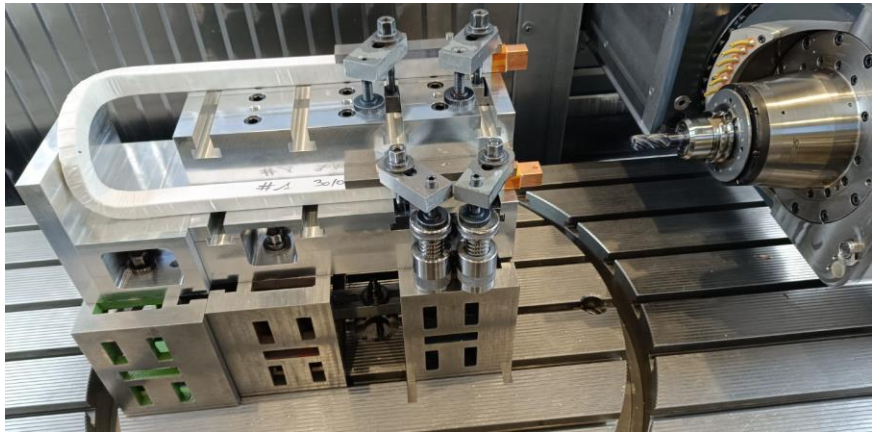




Year / # Leaks
2021 / # 2
2022 / # 3
2023 / # 1
2024 / # 3

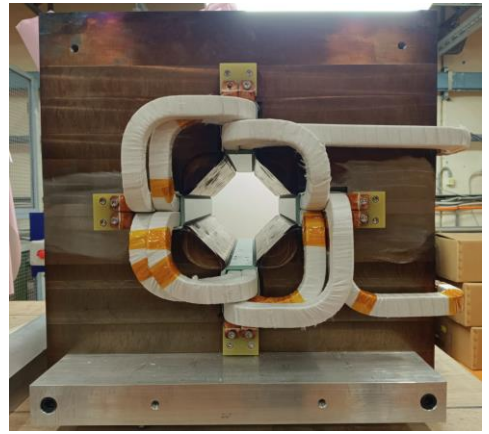
Electro-magnetic analysis

- Reverse engineering to build 12 new identical spare magnets, including:
  - Lamination procurement
  - Yoke manufacturing
  - Magnet assembly and qualification
- Refurbishment of the original (radioactive) magnets, including:
  - Dismantling of bonded assemblies
  - Coil forming and machining
  - Assembly, impregnation and qualification



CNC machining of bent and wrapped coil parts

Mechanical and electrical test samples



Single aperture mock-up

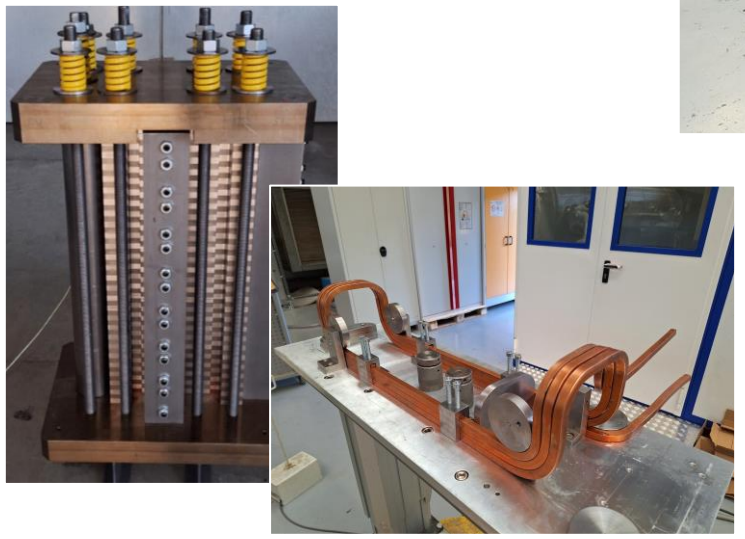
Magnet production in our proto lab

Isolde triplet/doublet Spare coils

Helmholtz Coils (ASACUSA)

SPS MBB Coil winding line

ESC Coil (Quench induction coil for SMC Magnet)

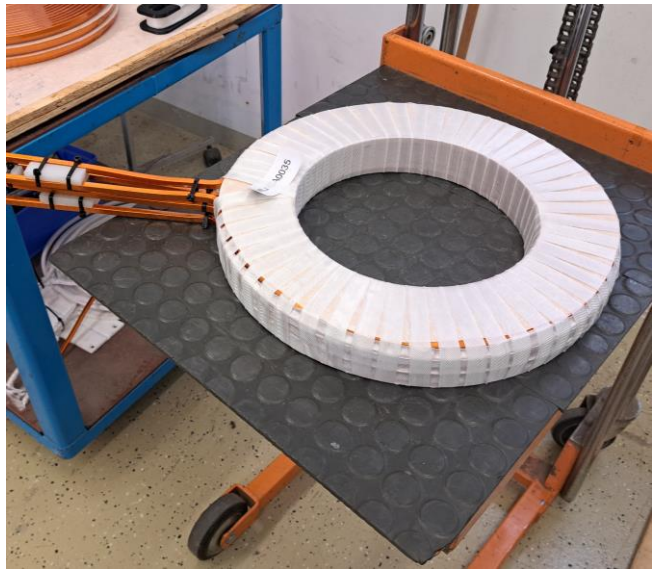


FCC-ee Booster Dipole Prototype Construction

We build magnets

Magnet procurement

- We have to procure 50 different magnet/coils for the consolidation of the accelerator complex
- This year, we have launched 10+ Invitation to Tenders and Price Enquiries
- Almost 30 travel.persons during the year for follow-up of contracts



We work with industry

NCM Quality Assurance

NORMA Database

We have developed our own database and maintenance support tool

- To secure all the magnet data
- To coordinate our maintenance plan

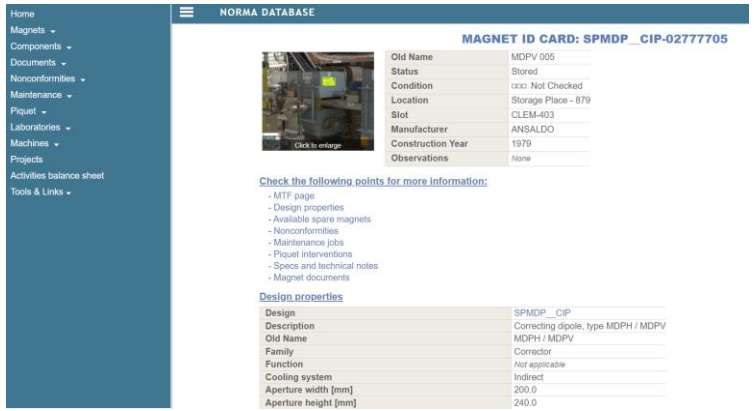
New version under development with EAM

Risk assessment

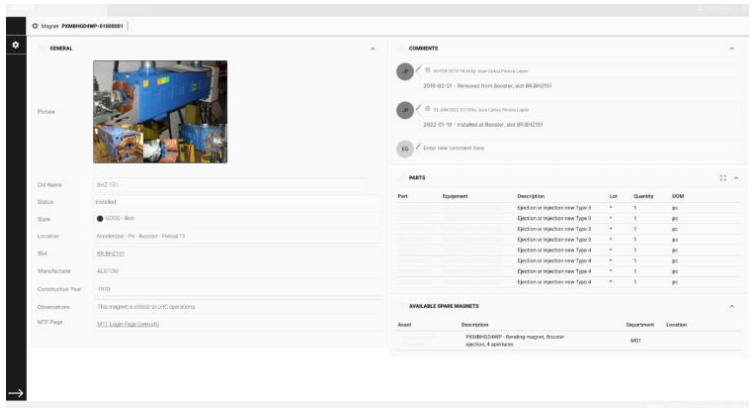
Risk analysis of installed magnets mutually reviewed in the section establishing mitigation measures

We keep track of the magnet life to establish targeted maintenance and consolidation plans

NORMA DB



NORMA DB mock-up



NCM projects

List of present projects

Studies for Magnet Systems for future CERN accelerators

- FCC-ee collider magnets (J. Bauche, C. Eriksson)
- FCC-ee booster magnets (L. von Freeden, H. Deveci)
- FCC-ee transfer line magnets (P. Thonet)
- CLIC (J. Bauche)

New magnets for CERN accelerators & approved experiments

- AWAKE2c magnet system (P. Schwarz)
- AWAKE, CLEAR and DEFT solenoids (R. Key)
- LHC BGI magnet system (D. Bodart)
- McKeehan coils for ASACUSA (M. Dumas)
- ALPHA solenoid (L. von Freeden, R. Key)
- SHiP/BDF hadron shielding (P. Schwarz)

Consolidation activities

- SPS MBB spare coils (P. Schwarz)
- PSB quadrupoles (A. Newborough, I. Garcia)
- ISOLDE triplets (C. Eriksson, M. Dumas)
- AD quad and dipole target magnets (P. Thonet)
- AD electron cooler (L. von Freeden, D. Gerard)
- TCC2 magnets (MSN, MTN, QSL) (P. Schwarz)
- Refurbishing of existing magnets (production plan)
- Spare coils for existing magnets (production plan)
- Electrical cover project (O. Crettiez)

Collaborations

- EuroSIG scanning magnet (P. Schwarz)
- DEFT (FLASH) magnet system (J. Bauche, R. Key)
- ESC coil for SMC quench induction (I. Garcia)
- LHCb magnet consolidation (P. Thonet)
- EP experimental magnets (P. Schwarz)

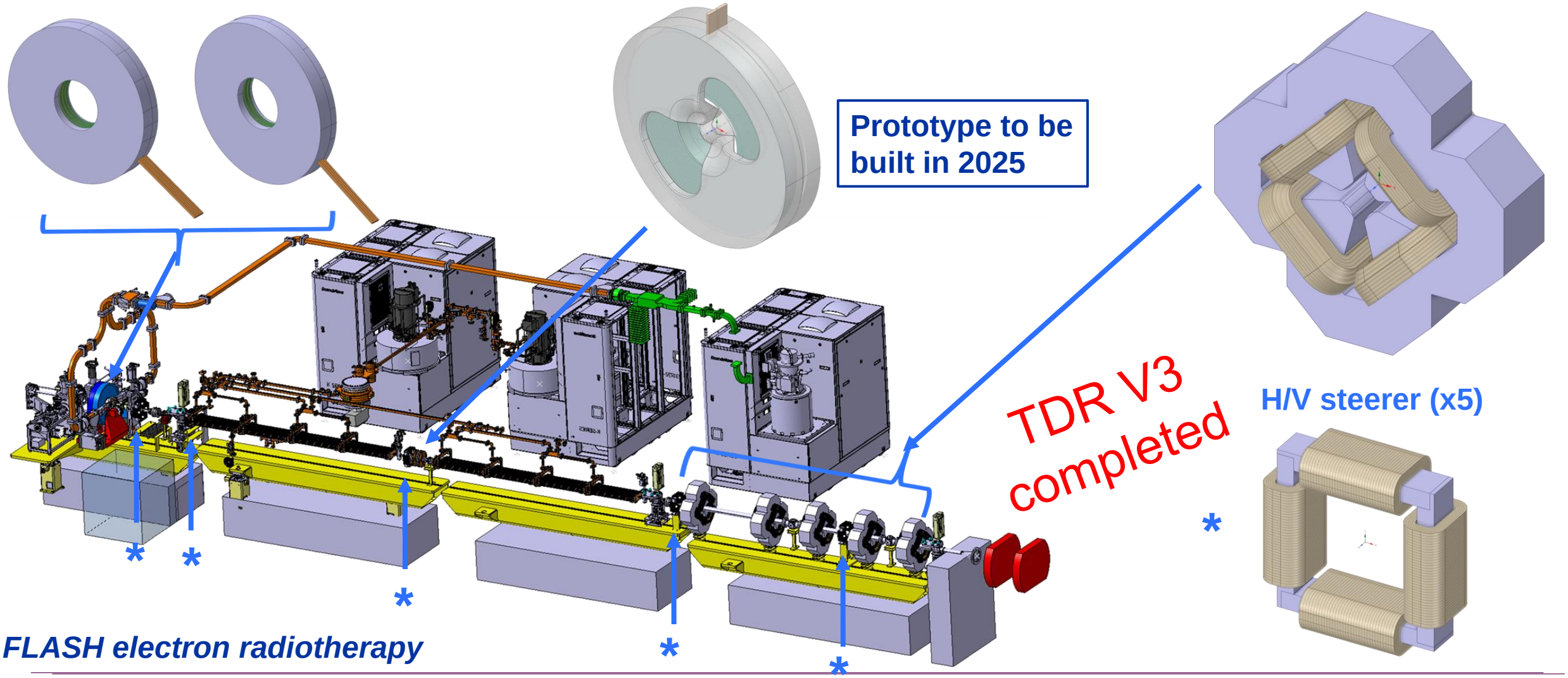
20++ projects

Diversity program: DEFT, a radiation therapy accelerator

Source solenoids

Claw-pole quadrupole (x2)

BDS quadrupole (x5)



Prototype to be built in 2025

TDR V3 completed

H/V steerer (x5)

*

*

*

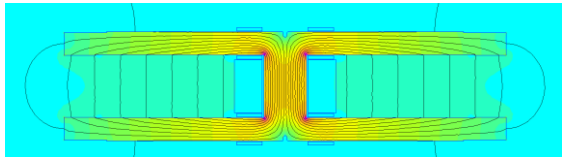
*

*

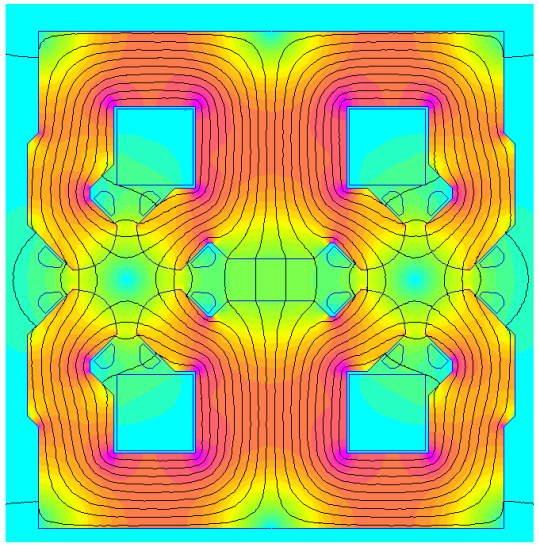
*

FLASH electron radiotherapy

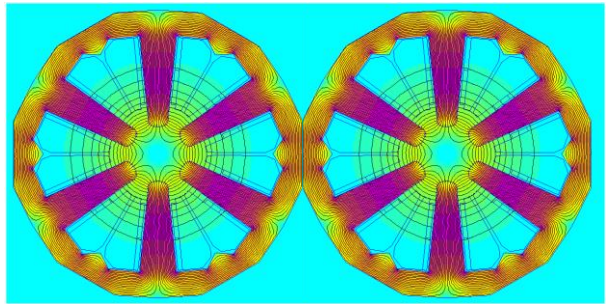
Magnets for FCC-ee: Collider



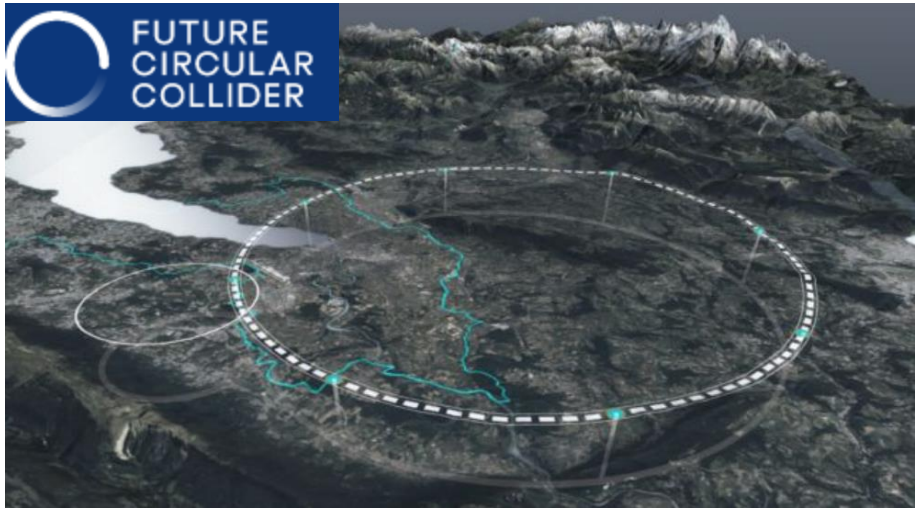
5680 units x 10.5 m ≈ 60 km



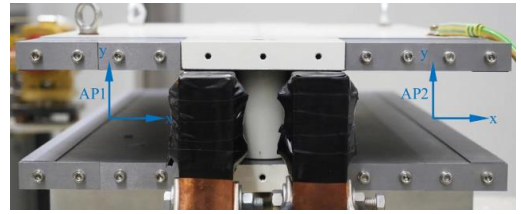
2840 units x 2.9 m ≈ 8 km

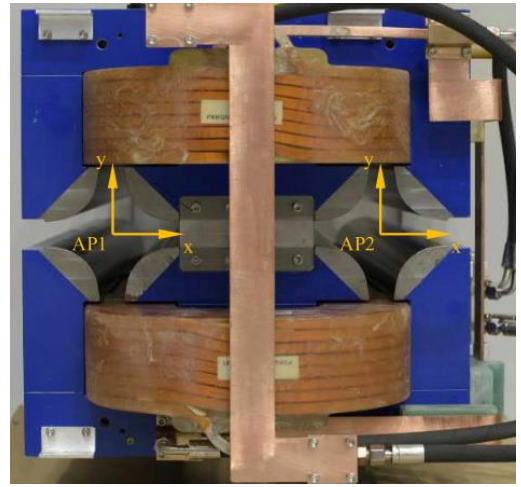


4672 units x 1.3 m ≈ 6 km

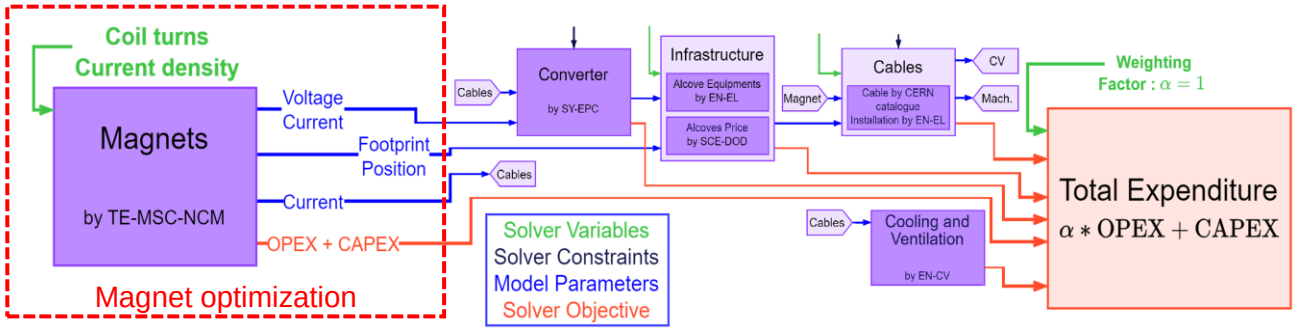


FCC-ee: 90 km ring, 75 km of magnets!





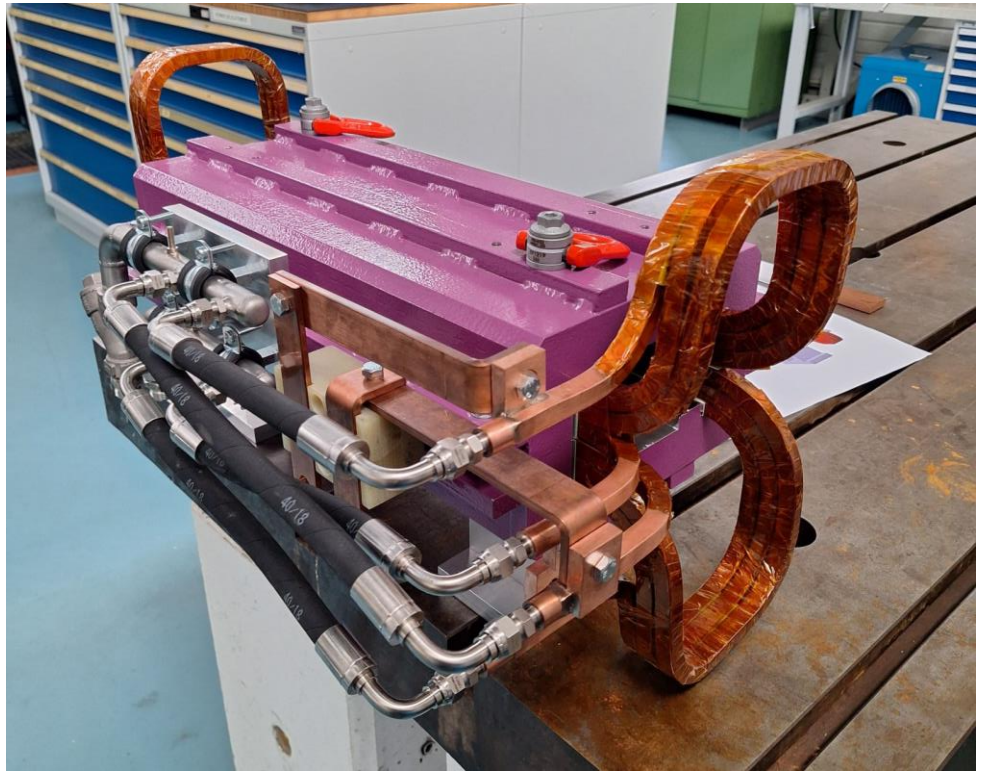
Magnet prototypes



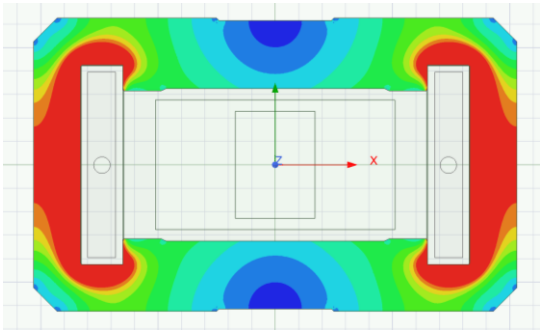
Lifetime cost optimization of magnet circuits

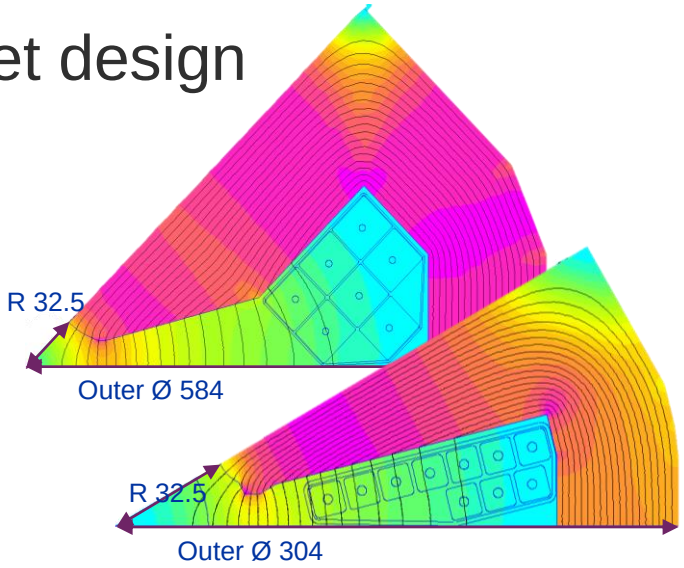
Feasibility report in preparation

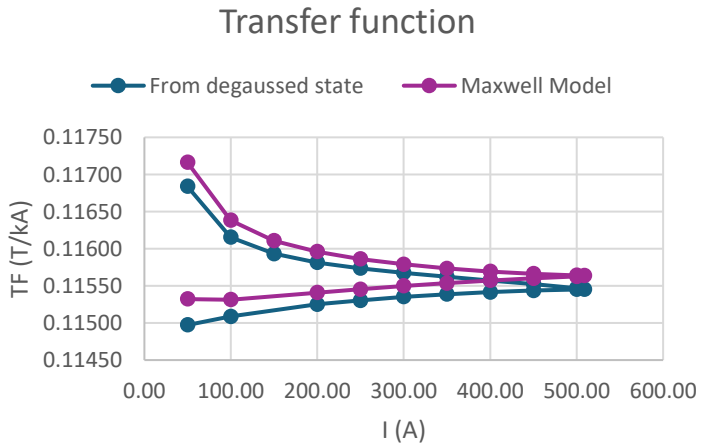
Magnets for FCC-ee: Booster



Completed main magnet design fulfilling the v. 24 optics requirements



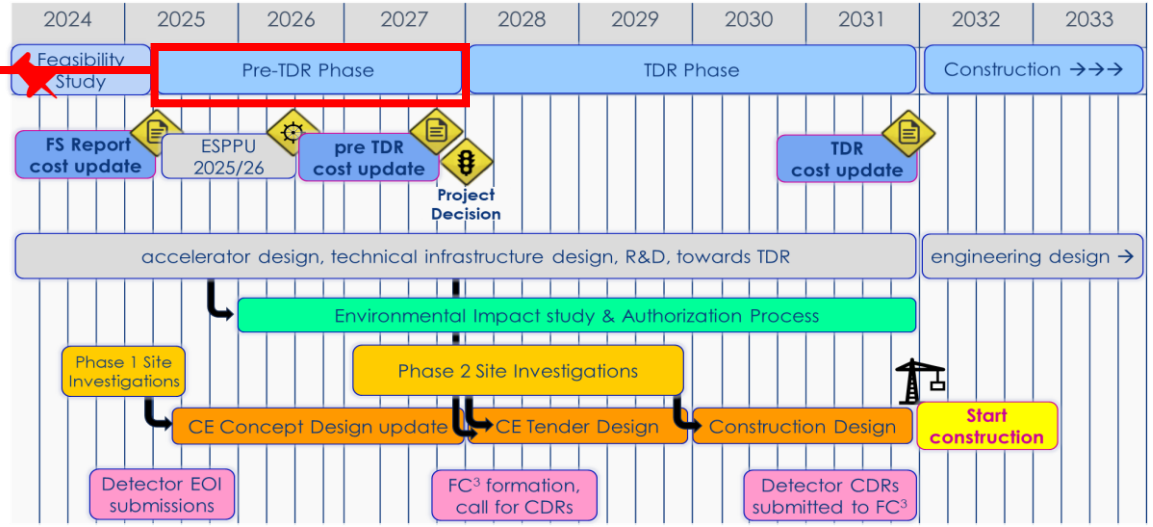




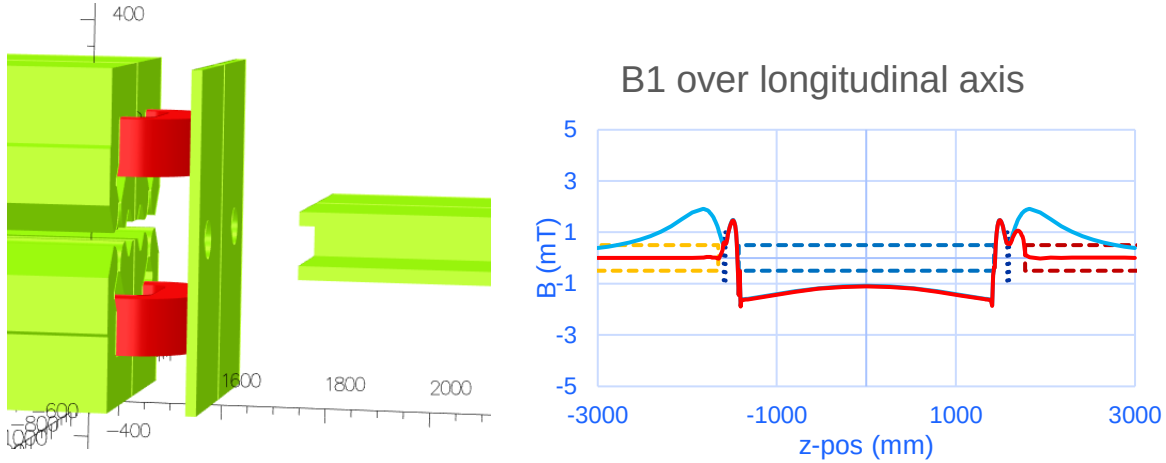
Validated >99% predictive accuracy of hysteresis modeling

We showed that 20 GeV injection field seems feasible!

Magnet development for FCC-ee: next steps



FCC timeline (M. Benedikt, FCC Week 2024)

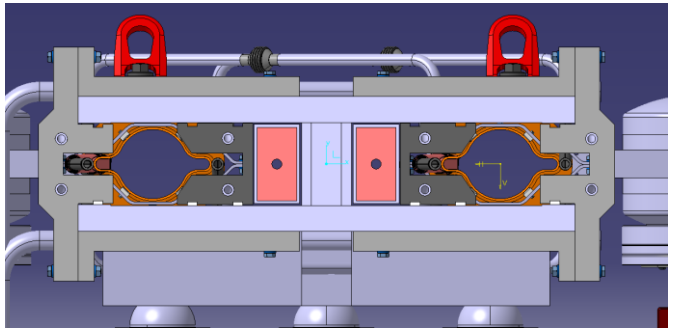


EMC mitigation studies

Magnet development during pre-TDR phase

- **Magnet design and optimization** for collider, booster and injector
  - Study for alternative collider optics (LCC vs. GHC, or else)
  - EM vs. PM magnets for injector – booster transfer line
  - Orbit correctors
- **Prototype** construction and measurements
  - 1 of each main magnets
- Study of **industrialization strategy** and manufacturing methods
  - Manufacture
  - Measurements and qualification

Opportunities for collaborations!



SR shielding integration

Thank you for your attention.