

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

J. Bauche, D. Schoerling

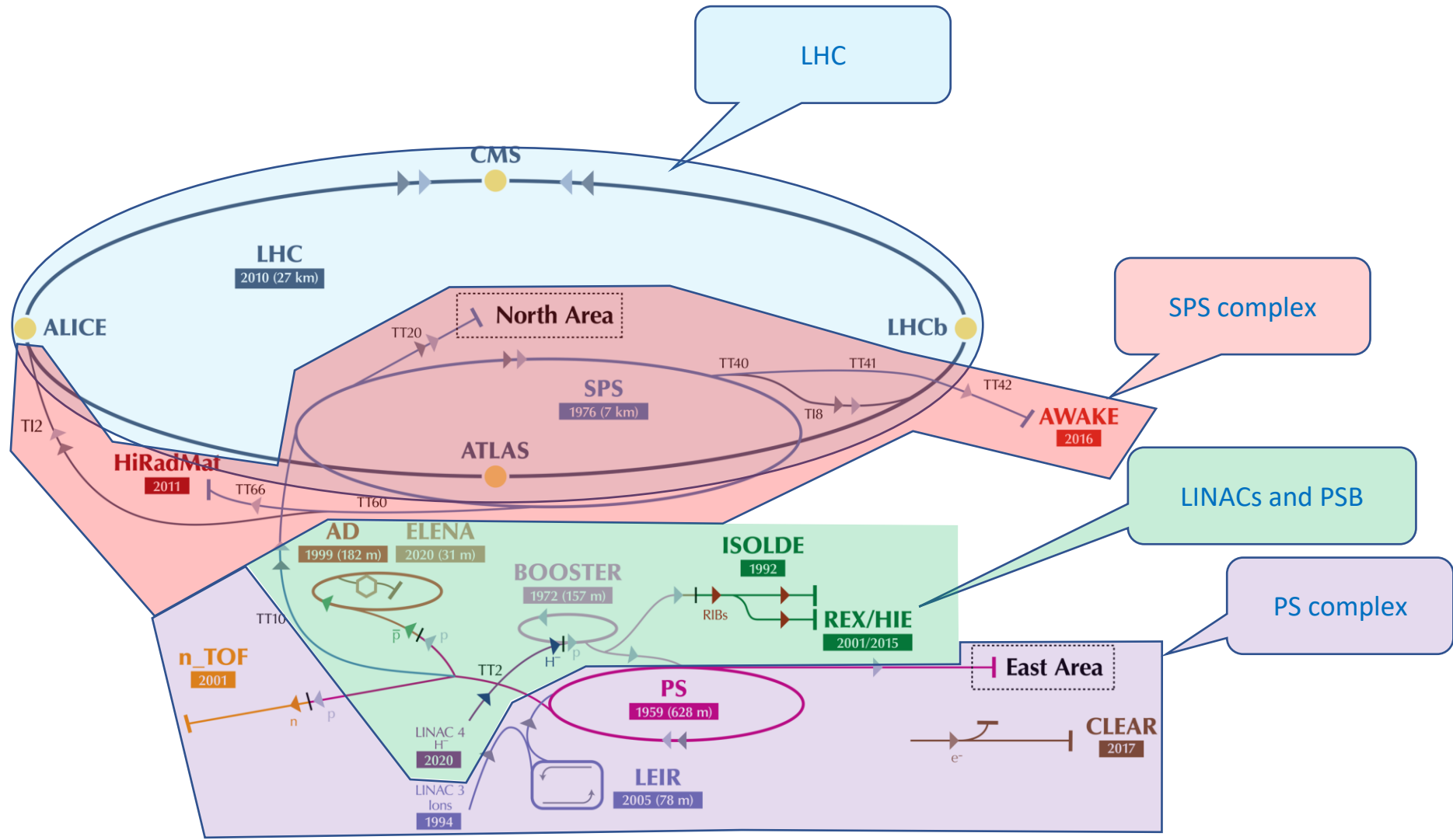
Outline

- 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

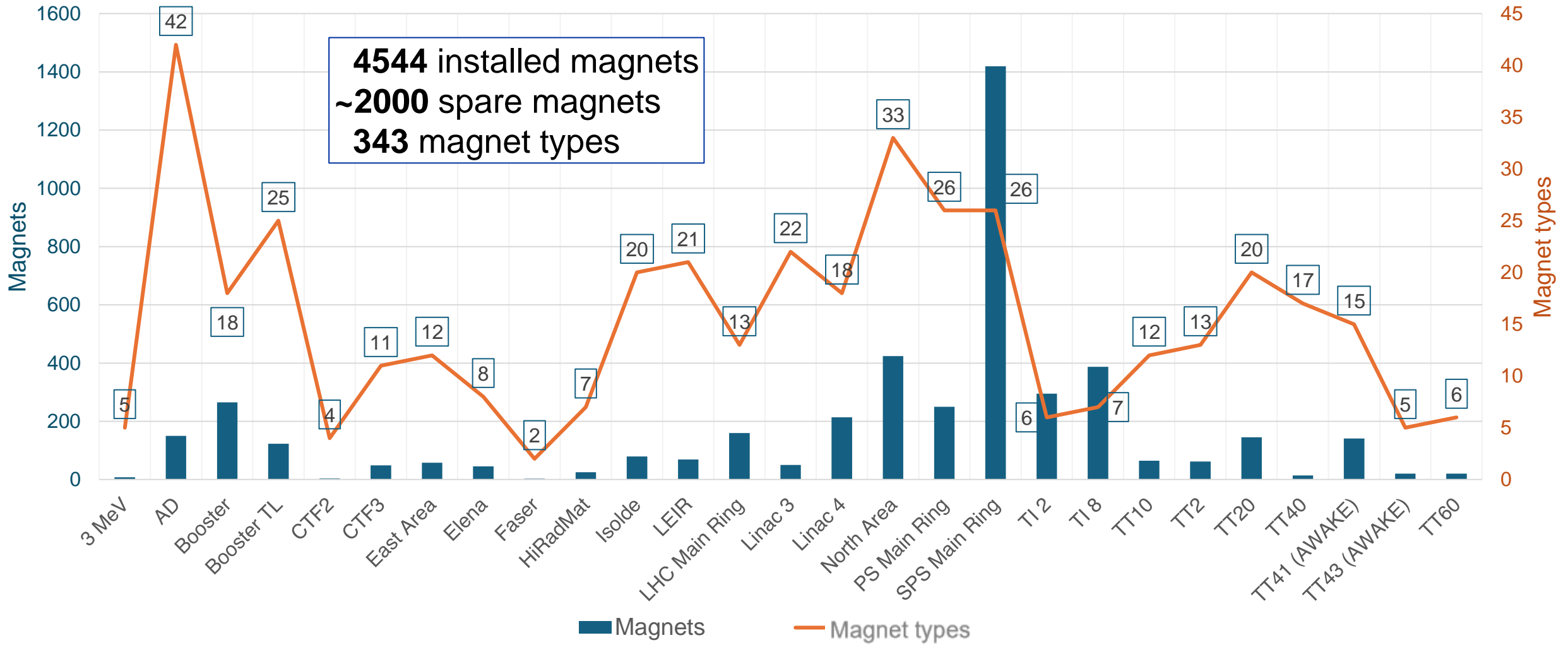
NC magnets in the CERN accelerator complex

The CERN accelerator complex

Almost exclusively
NC magnets
(except LHC)



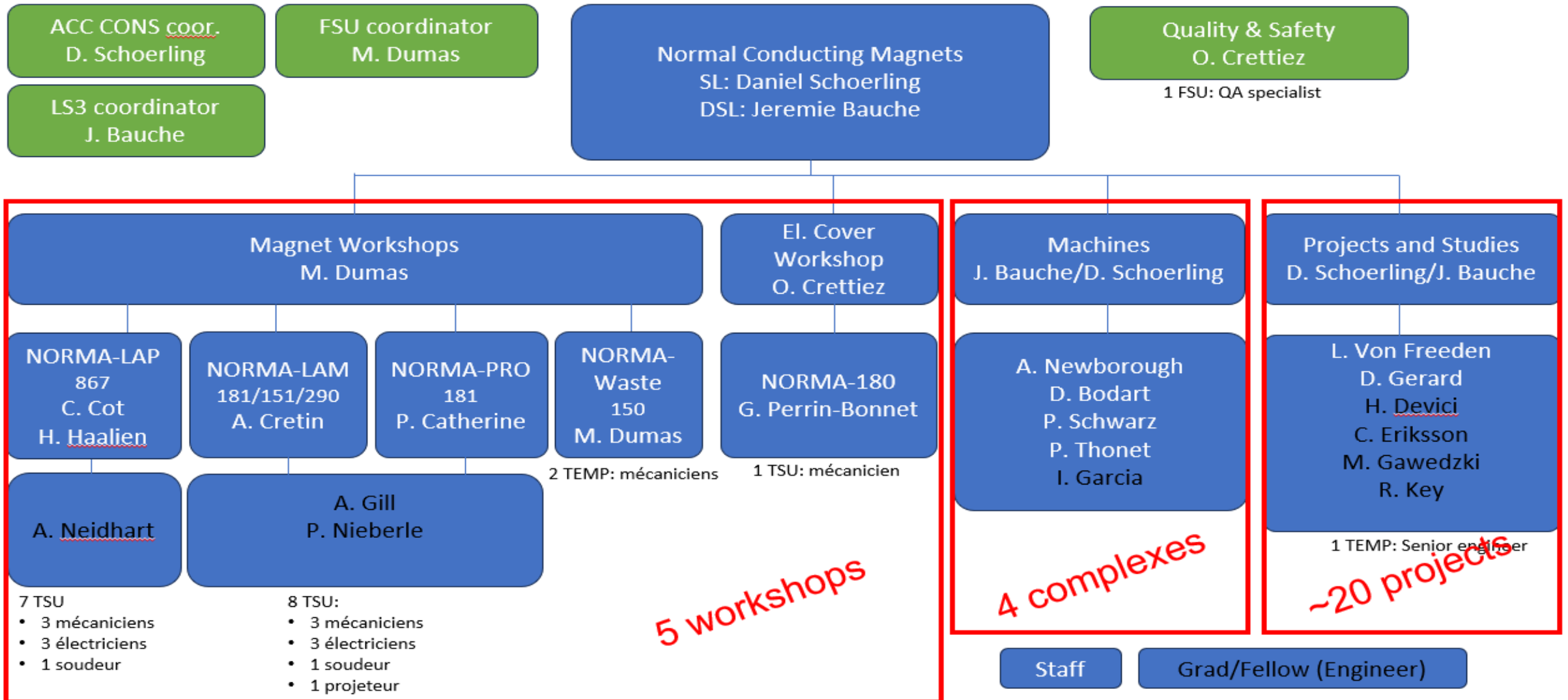
A large magnet zoo



The Normal Conducting Magnet section (TE-MS-C-NCM)

The NCM Team

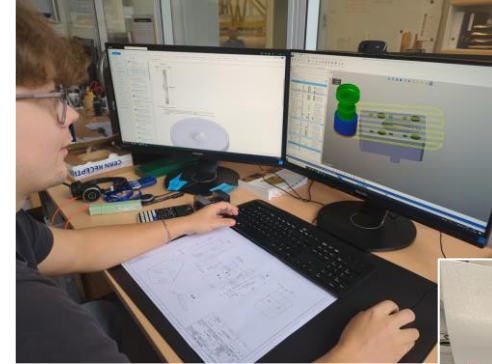
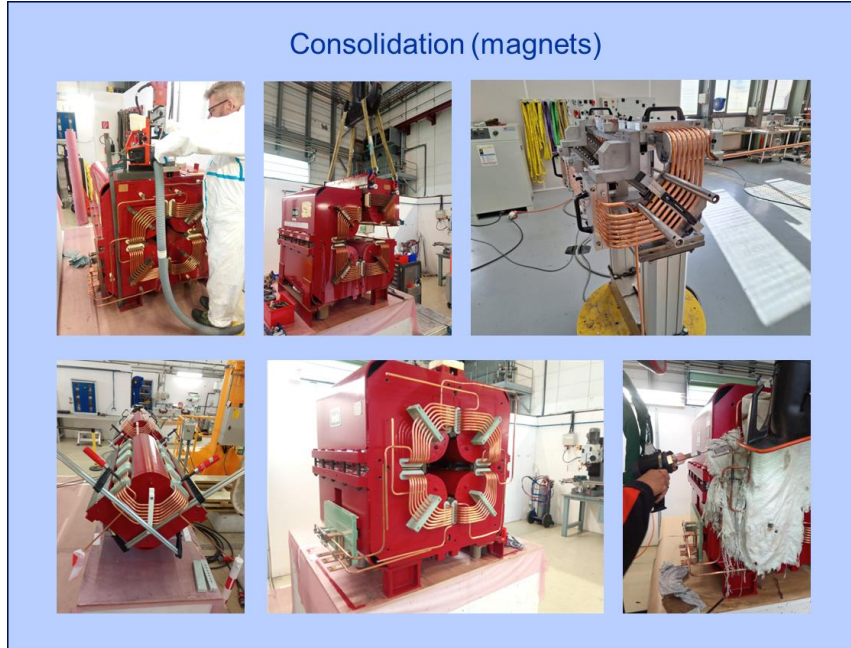
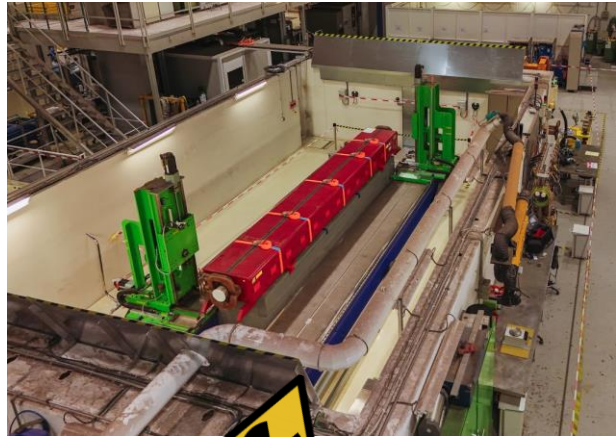
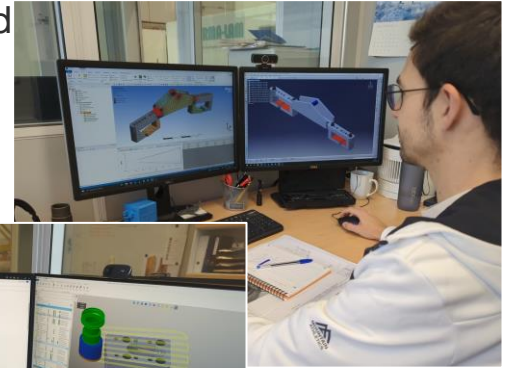
~40 persons
(MPE + MPA)



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.

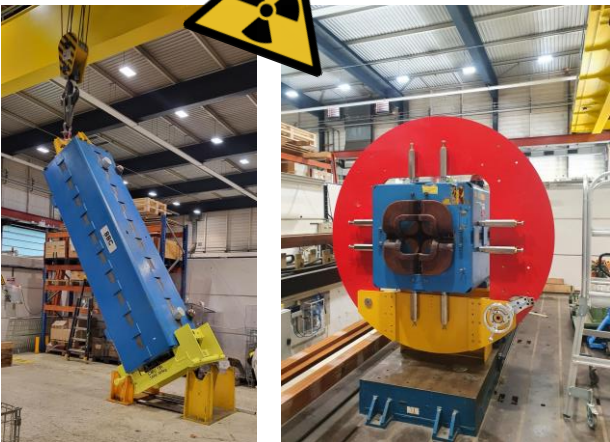
Catia 3D Design and Ansys engineering simulations



CAM programming

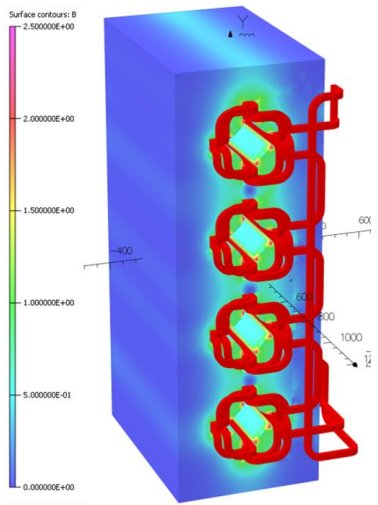


NCM Workshop 290
3 and 3+1 axis CNC
Machine

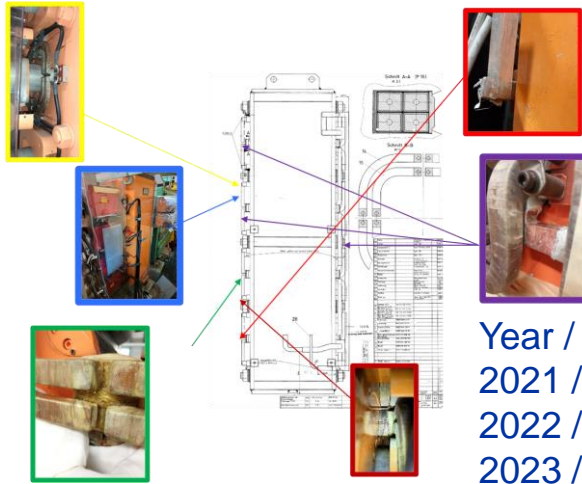


We maintain and improve our magnets

Example of consolidation: PSB quadrupoles

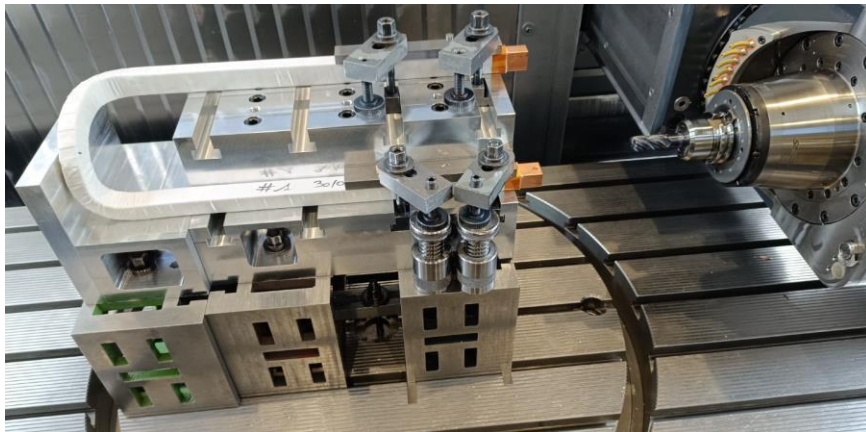


Electro-magnetic analysis



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

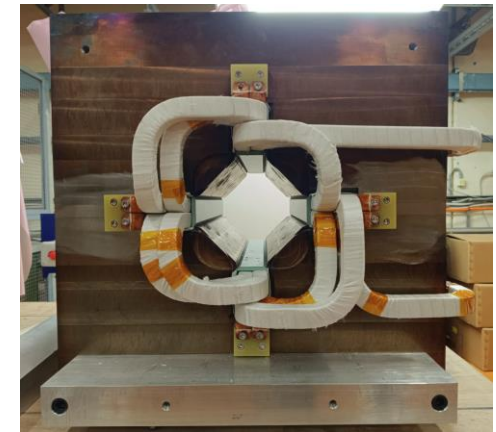
- Reverse engineering to build 12 new identical spare magnets, including:
 - Lamination procurement
 - Yoke manufacturing
 - Magnet assembly and qualification
- Refurbishment of the original (radioactive) magnets, including:
 - Dismantling of bonded assemblies
 - Coil forming and machining
 - Assembly,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



CNC machining of bent and wrapped coil parts



Mechanical and electrical test samples



Single aperture mock-up

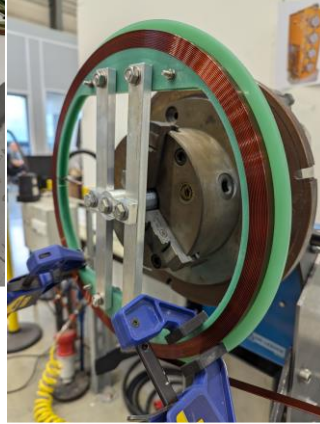
Magnet production in our proto lab



Isolde triplet/doublet Spare coils



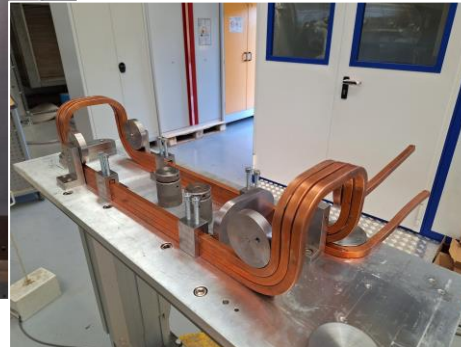
Helmholtz Coils
(ASACUSA)



SPS MBB Coil winding line



ESC Coil
(Quench
induction coil for
SMC Magnet)

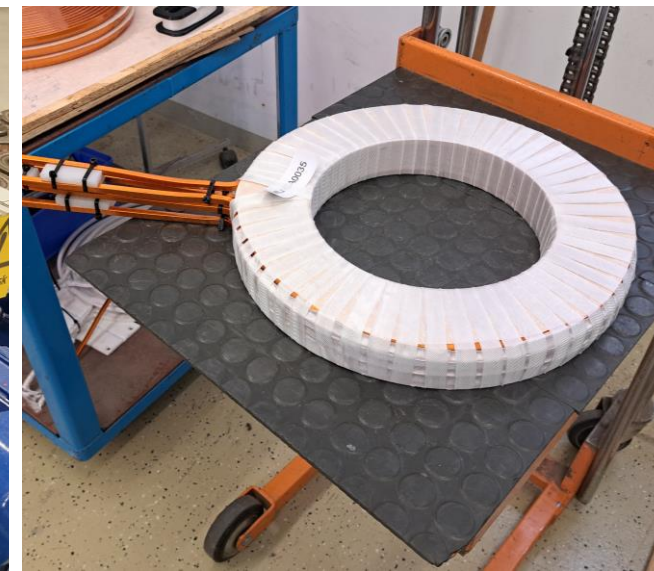


FCC-ee Booster
Dipole Prototype
Construction

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

The screenshot shows the NORMA DATABASE interface. On the left is a navigation menu with items like Home, Magnets, Components, Documents, Nonconformities, Maintenance, Piquet, Laboratories, Machines, Projects, Activities balance sheet, and Tools & Links. The main content area displays a 'MAGNET ID CARD: SPMDP_CIP-02777705'. It includes a photo of the magnet, a table of key data (Old Name: MDPV 005, Status: Stored, Condition: OK, Location: Storage Place - 879, Slot: CLEM-403, Manufacturer: ANSALDO, Construction Year: 1979, Observations: None), a list of links for more information (MTF page, Design properties, Available spare magnets, Nonconformities, Maintenance jobs, Piquet interventions, Specs and technical notes, Magnet documents), and a 'Design properties' table.

Design	SPMDP_CIP
Description	Correcting dipole, type MDPH / MDPV
Old Name	MDPH / MDPV
Family	Corrector
Function	Not applicable
Cooling system	Indirect
Aperture width [mm]	200.0
Aperture height [mm]	240.0

NORMA DB mock-up

The screenshot shows a mock-up of a magnet record in the NORMA DB. It includes a photo of the magnet, a table of key data (Old Name: BSC 101, Status: Installed, Location: Accelerator - PH - Booster - Period 13, Slot: BSC233, Manufacturer: ALSTOM, Construction Year: 1978, Observations: This magnet is used by LHC operators, MTF Page: MTF Login/Repair controls), and a 'PARTS' table.

Part	Equipment	Description	Lot	Quantity	UOM
		Exception on injection error Type 3		1	pc
		Exception on injection error Type 1		1	pc
		Exception on injection error Type 2		1	pc
		Exception on injection error Type 3		1	pc
		Exception on injection error Type 4		1	pc
		Exception on injection error Type 5		1	pc
		Exception on injection error Type 4		1	pc
		Exception on injection error Type 4		1	pc
		Exception on injection error Type 4		1	pc

Below the parts table is an 'AVAILABLE SPARE MAGNETS' section with a table showing spare magnets available for use.

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. Devenci)
- 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)

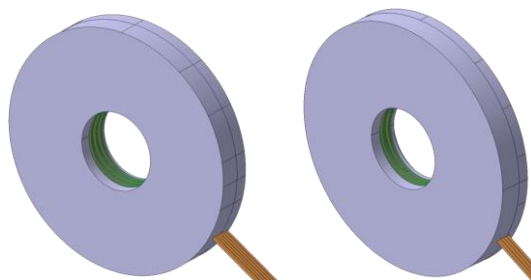
Collaborations

- 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)

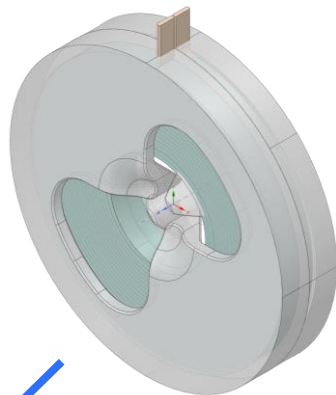
20++ projects

Diversity program: DEFT, a radiation therapy accelerator

Source solenoids

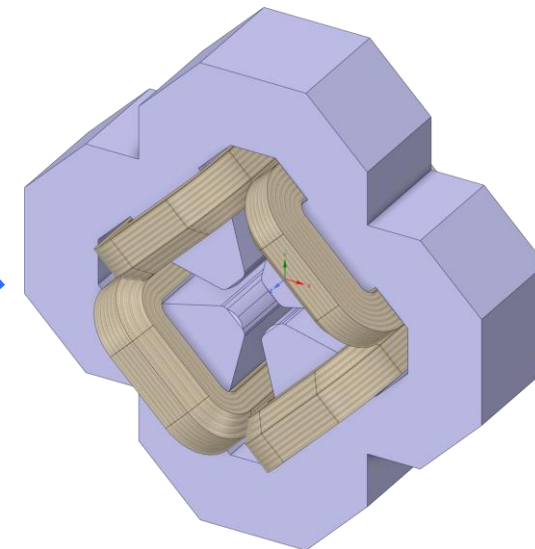


Claw-pole quadrupole (x2)

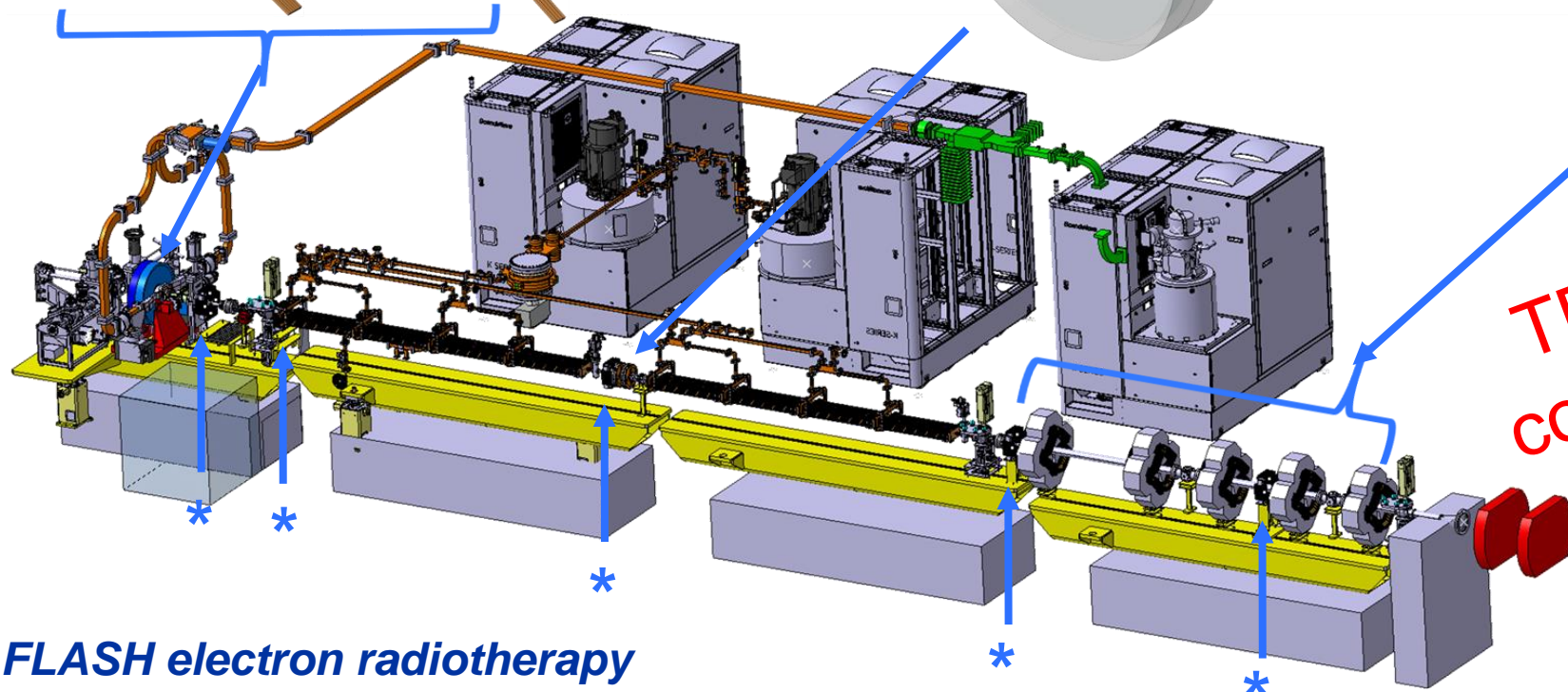
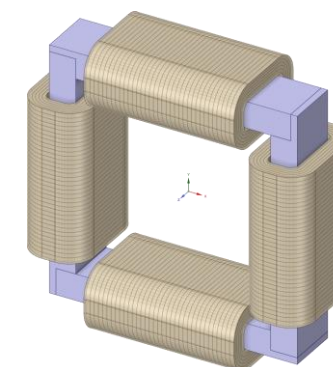


Prototype to be built in 2025

BDS quadrupole (x5)



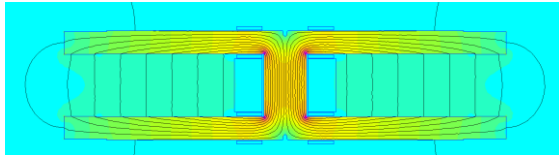
H/V steerer (x5)



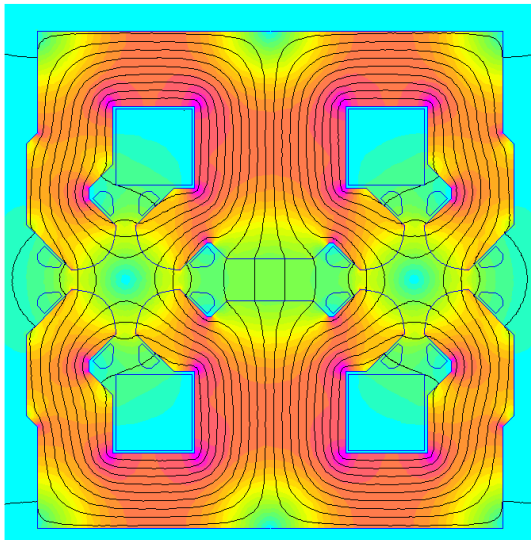
TDR V3 completed

FLASH electron radiotherapy

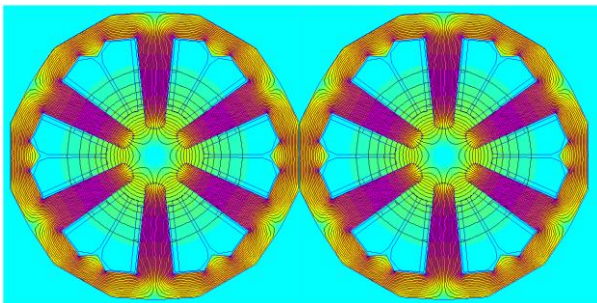
Magnets for FCC-ee: Collider



5680 units x 10.5 m \approx 60 km



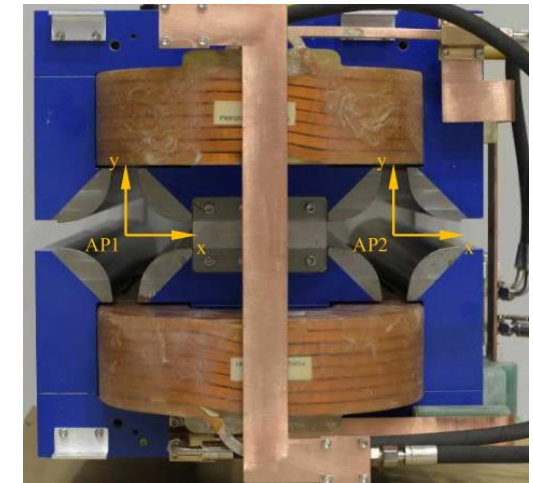
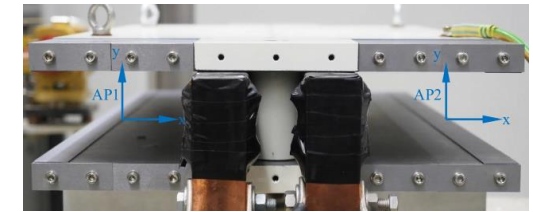
2840 units x 2.9 m \approx 8 km



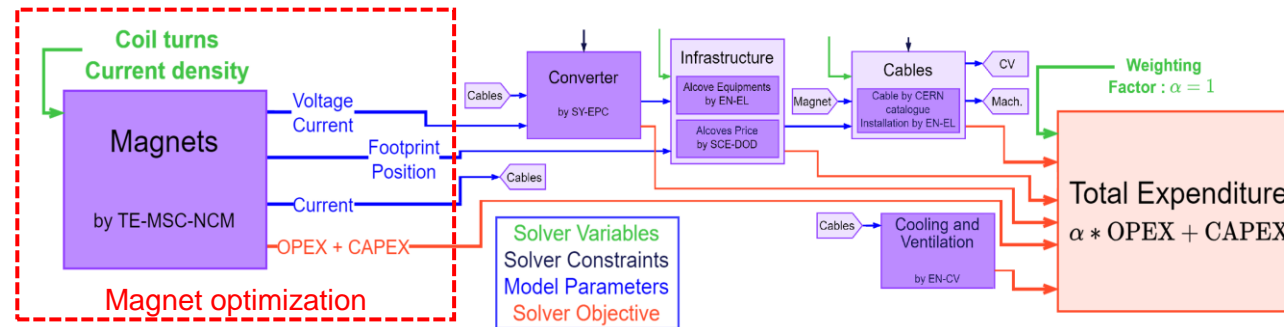
4672 units x 1.3 m \approx 6 km



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



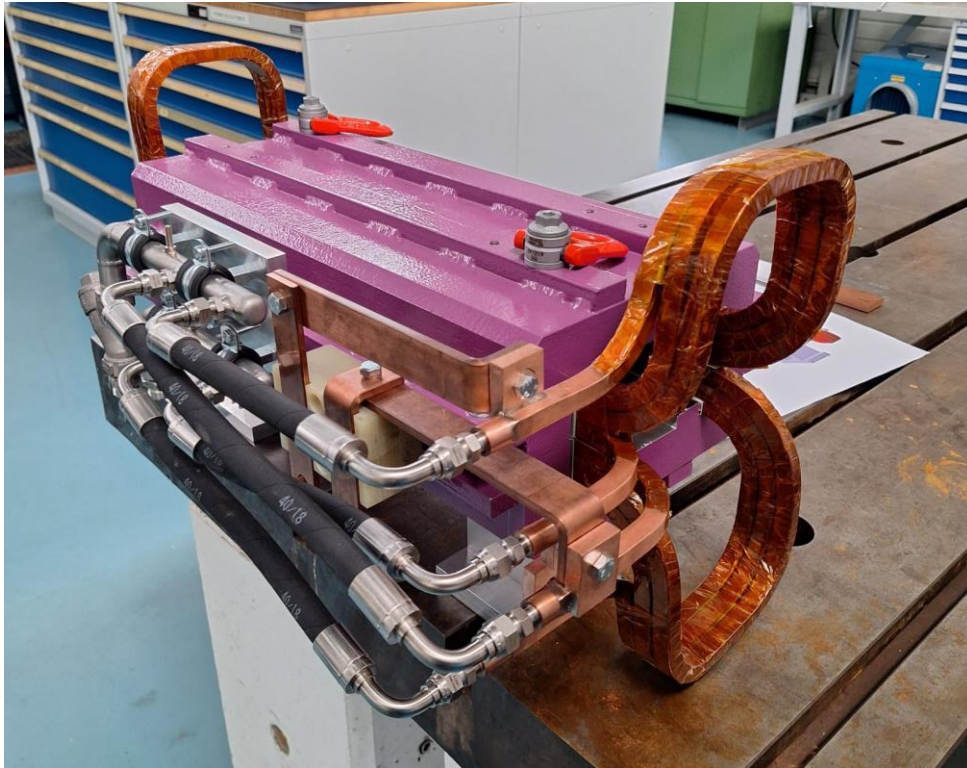
Magnet prototypes



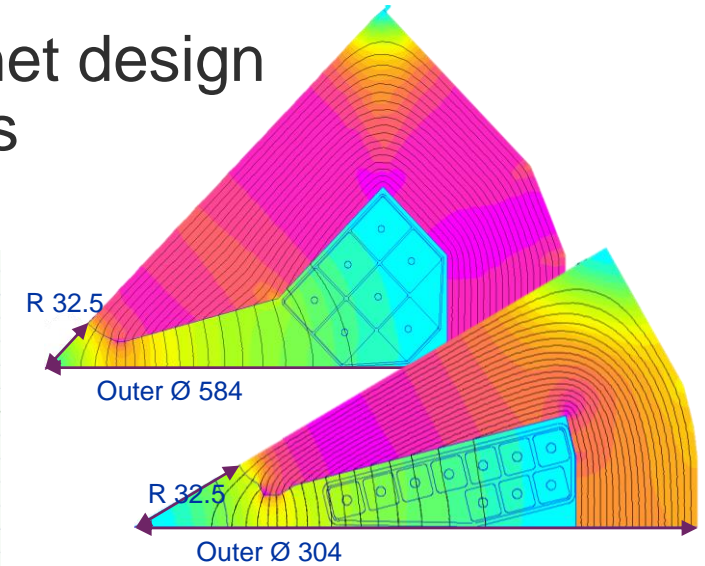
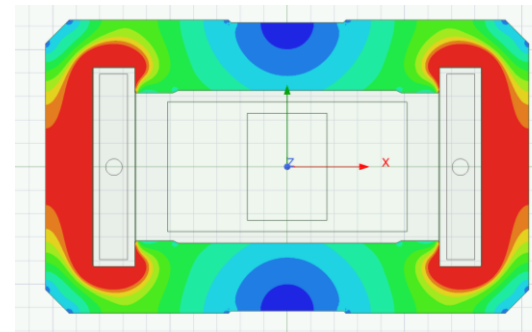
Lifetime cost optimization of magnet circuits

Feasibility report in preparation

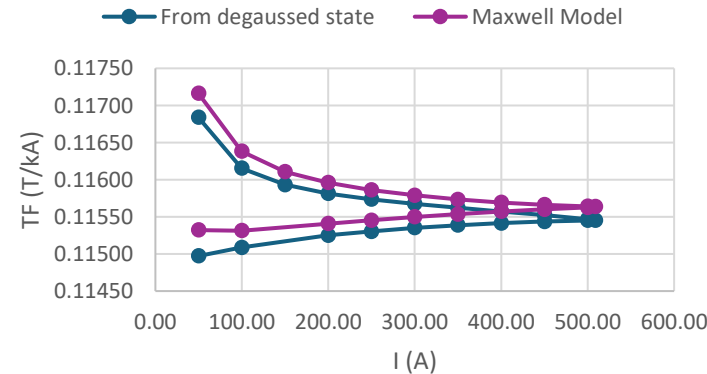
Magnets for FCC-ee: Booster



Completed main magnet design fulfilling the v. 24 optics requirements



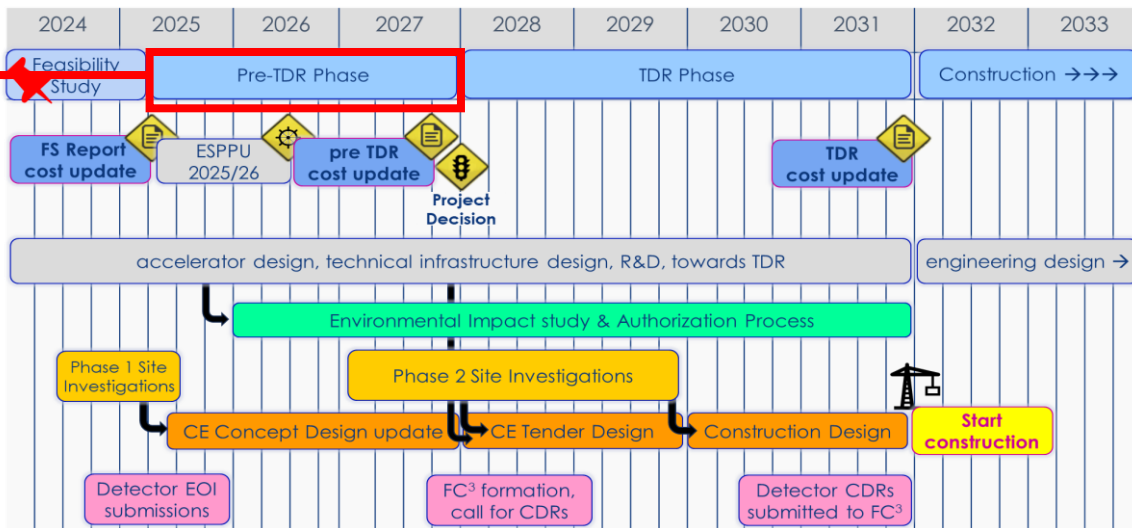
Transfer function



Validated >99% predictive accuracy of hysteresis modeling

We showed that 20 GeV injection field seems feasible!

Magnet development for FCC-ee: next steps

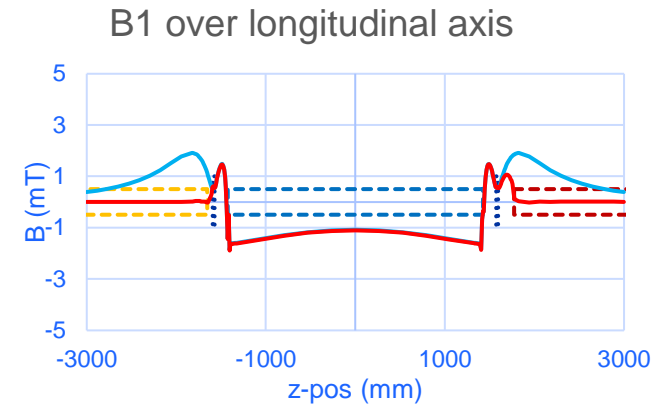
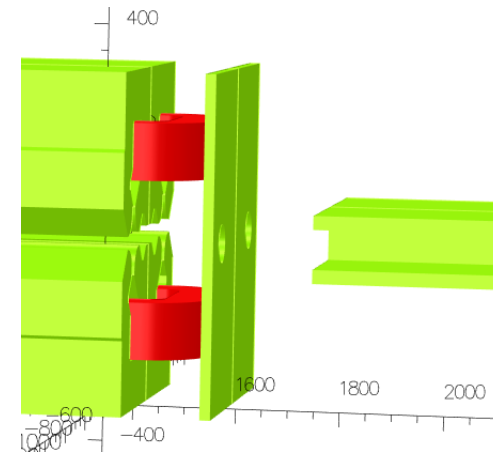


FCC timeline (M. Benedikt, FCC Week 2024)

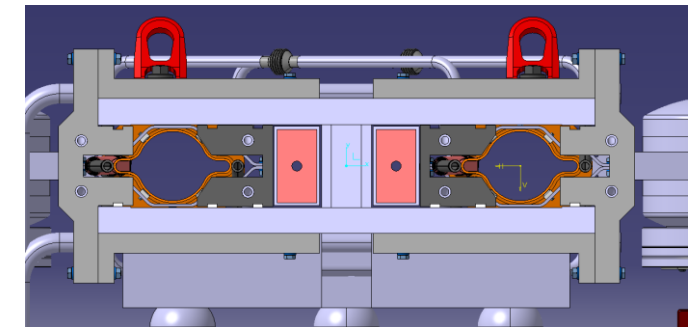
Magnet development during pre-TDR phase

- **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!**



EMC mitigation studies



SR shielding integration

Thank you for your attention.