Superconducting magnets at CERN

Onno Pfohl und Justus Schacht

Outline

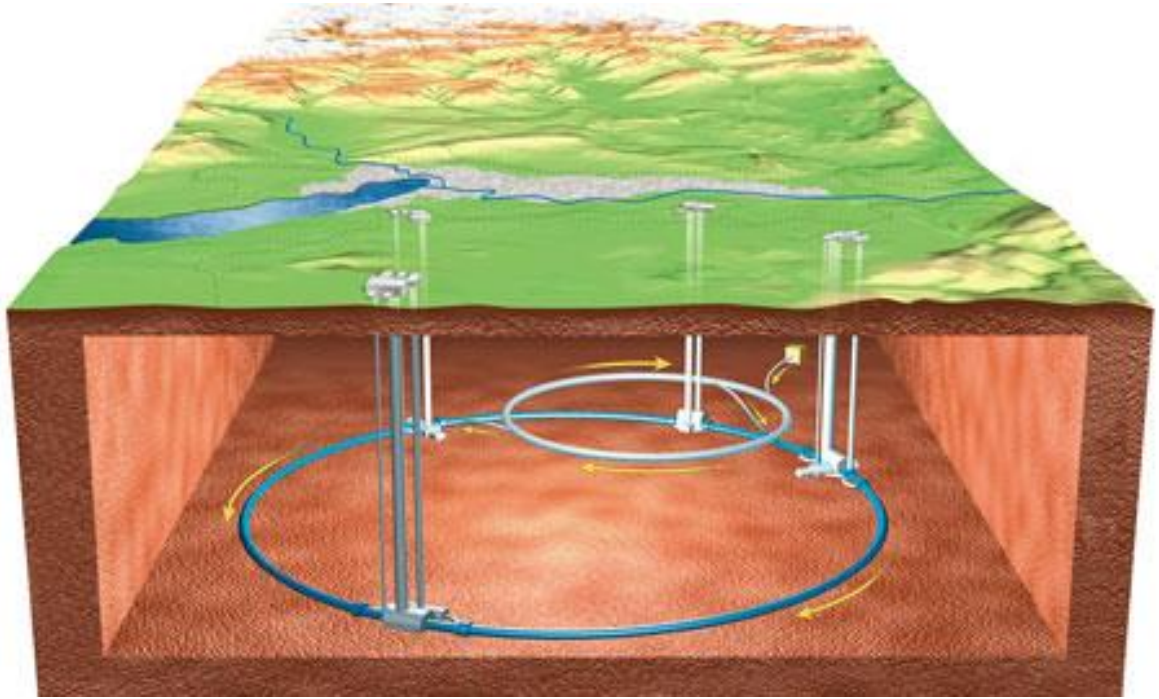
Types and function of magnets

Production of accelerator magnets at the Large Magnet Facility

Our experience: research & development

Conclusion

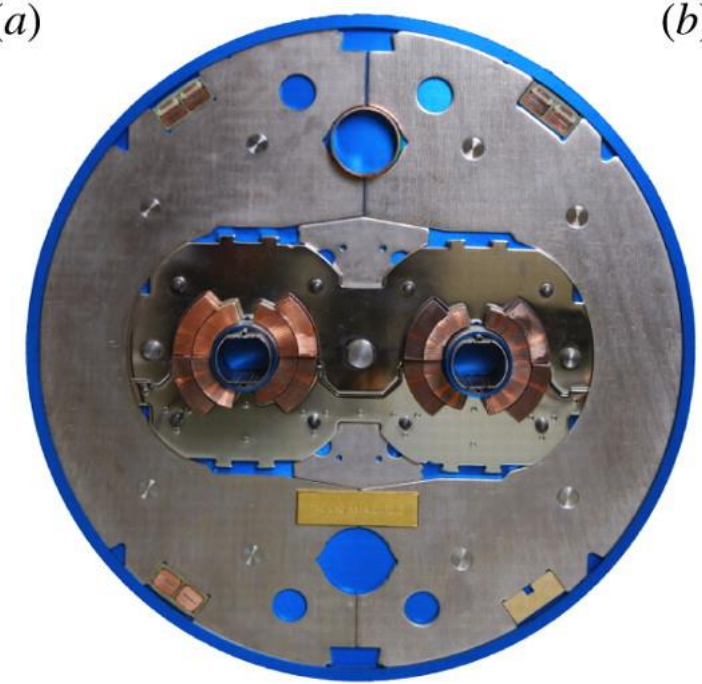
Types and function of magnets



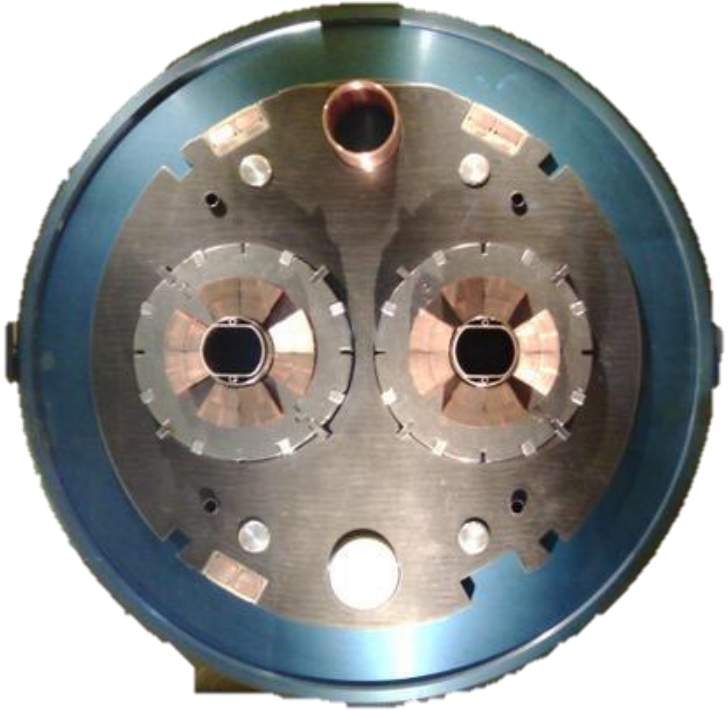
https://www.weltmaschine.de/cern_und_lhc/lhc/

Types and construction

(a)



(b)

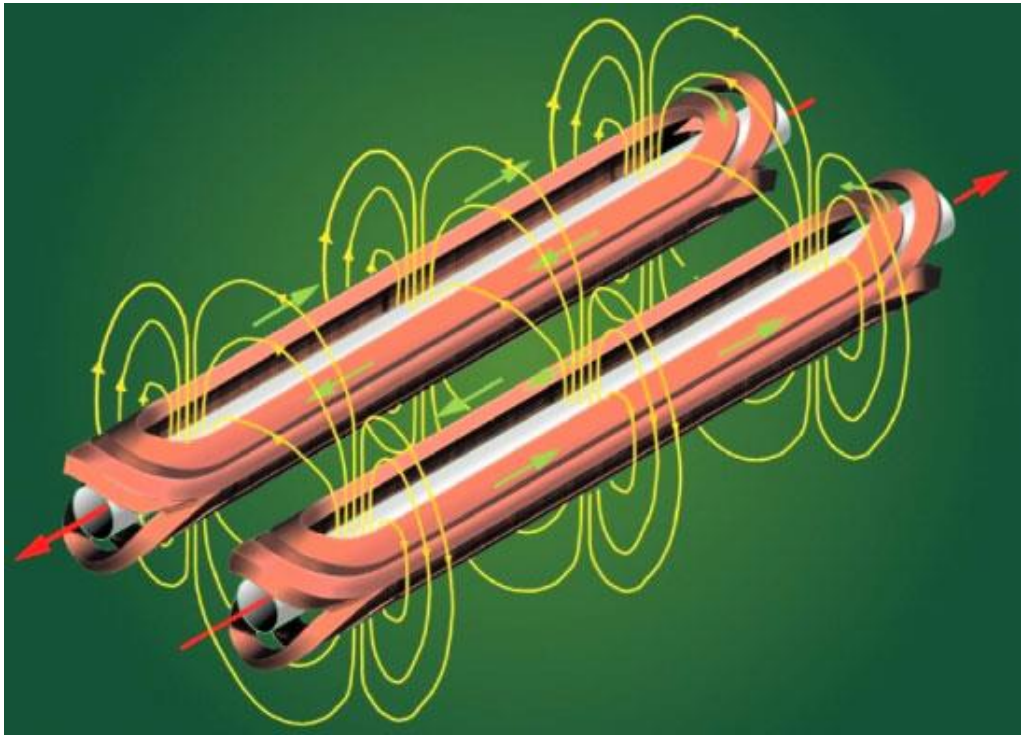


Dipole magnets for bending

1232 main dipoles:
- 15m long
- 28t weight
- Current: 11850A

→ guide particels on a circular path

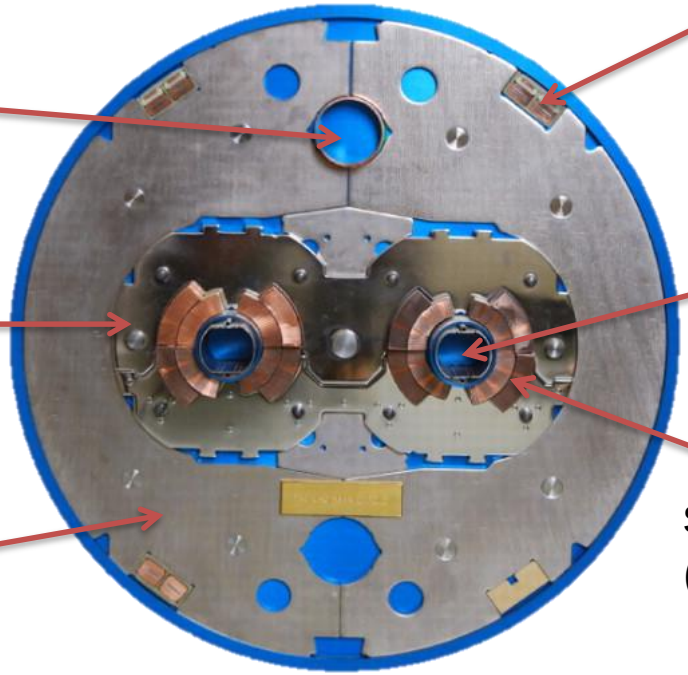
Dipole magnets for bending



http://www.lhc-facts.ch/index.php?page=dipol

LHC: max. 8,36 T
HL-LHC: max. 13 T

Dipole magnets for bending



Quadrupole magnets for focusing

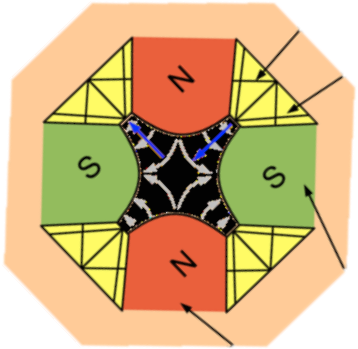
992 main quadrupoles:
- 6,6m long
- 6,5t weight

→ Keep the beam compact and dense

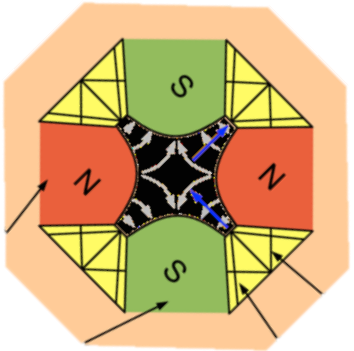
Quadrupole magnets for focusing

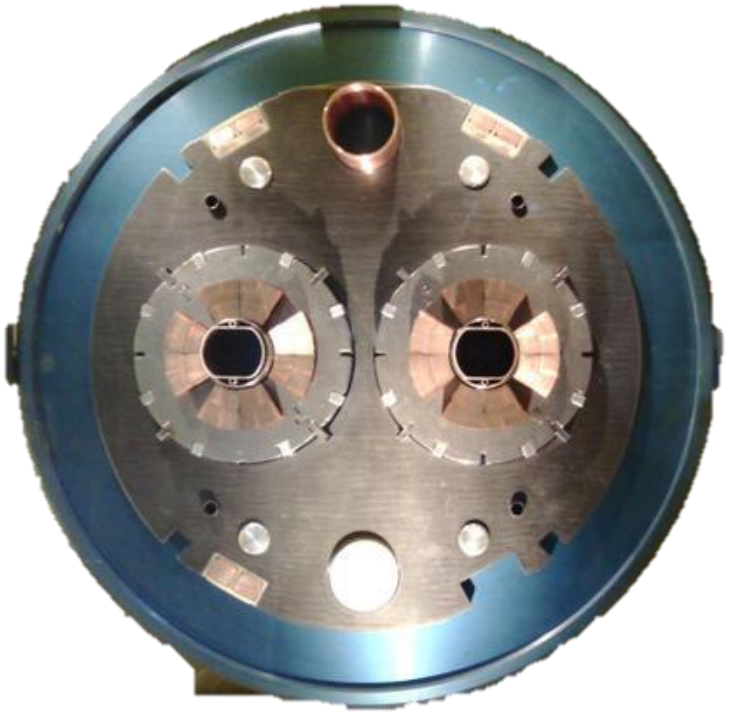
2 possible alternating orientations of the magnetic fields:

Focusing in one direction is linked to defocusing in the other direction

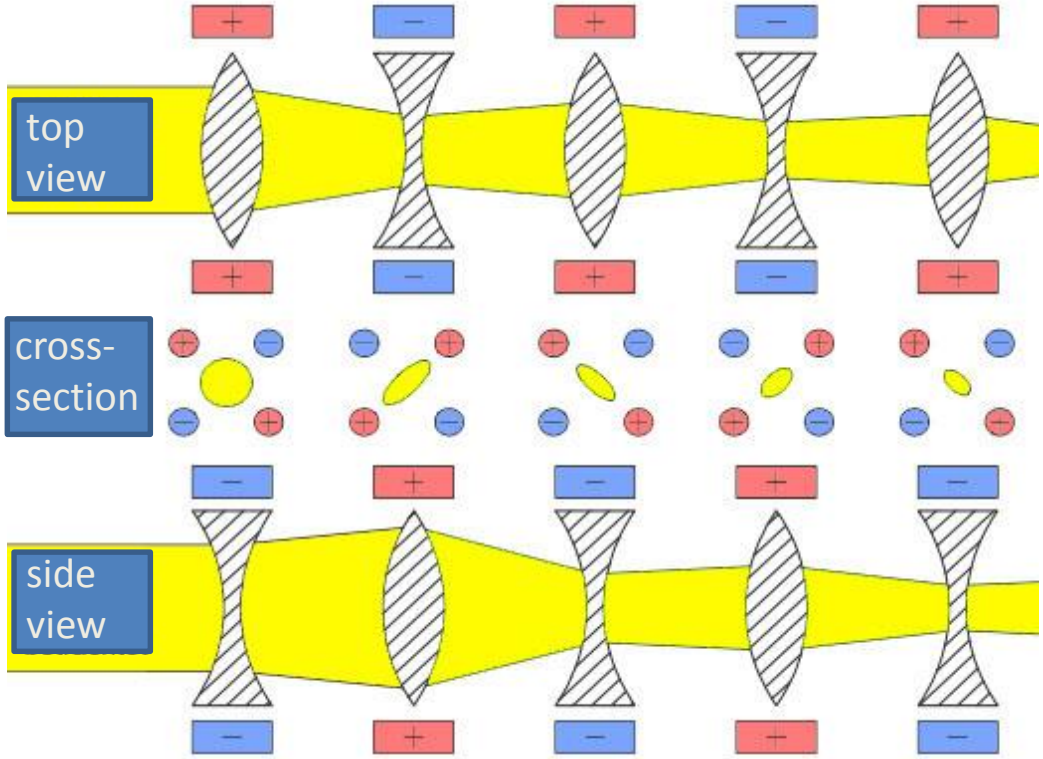


or





Quadrupole magnets for focusing

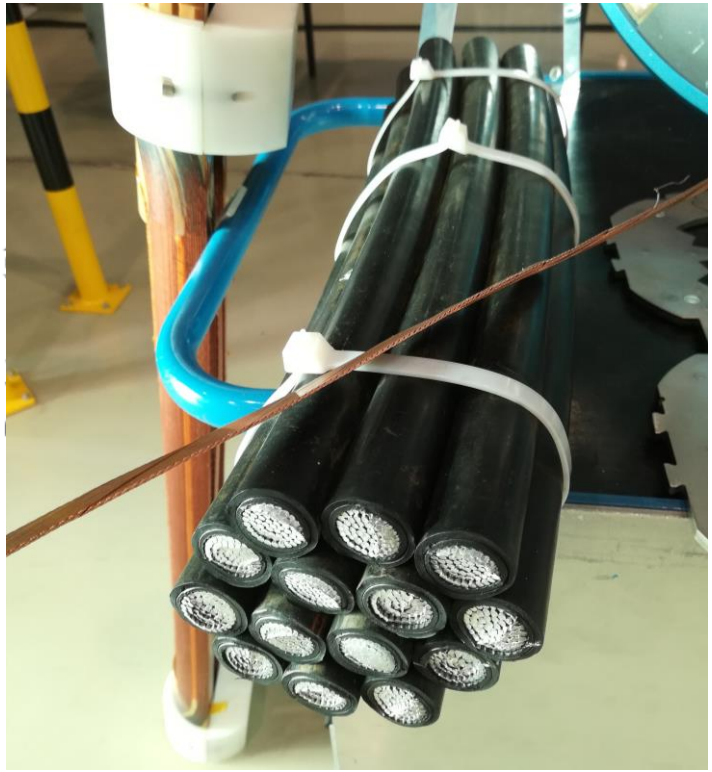


http://www.lhc-facts.ch/index.php?page=quadrupol

The path of the beam is comparable to the path of light trough optical lenses

Sextupole and octupole magnets have the same purpose and work analogous

Superconductivity

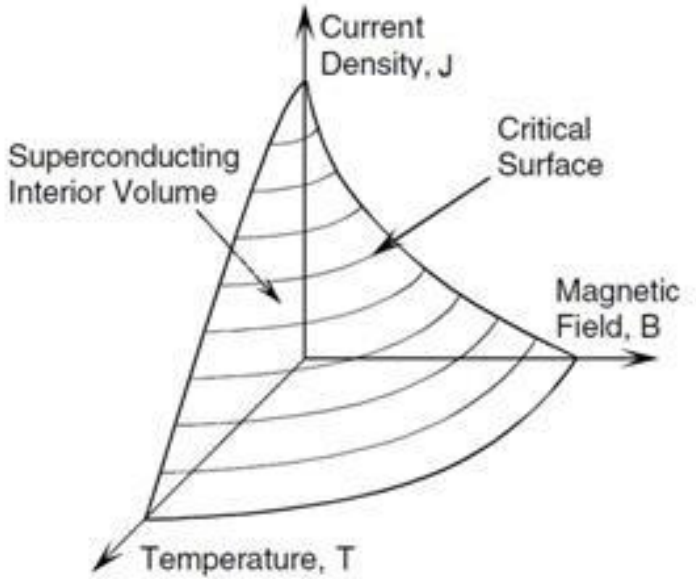


Influencing parameters:
- temperature
- current density
- Magnetic field

Nb-Ti cable
- flexibel
- well-known
- LHC: 8,6T

Nb_3Sn cable
- brittle
- little experience
- HL-LHC: 11T
- FCC: 16T

Superconductivity



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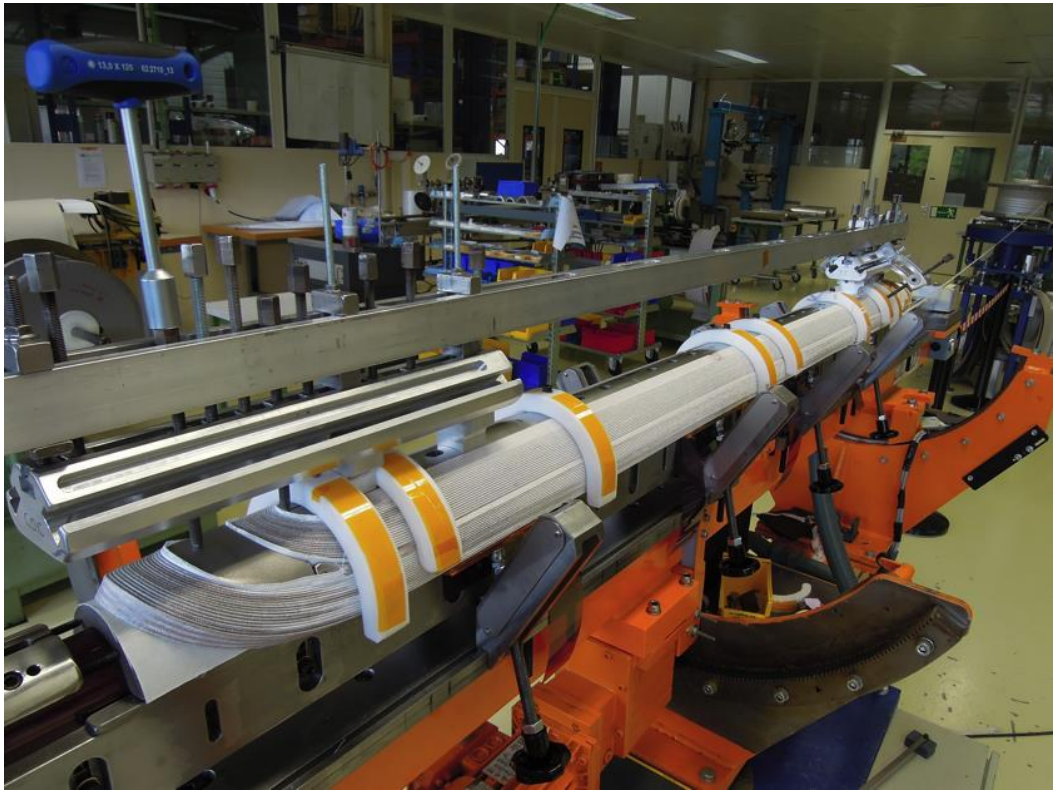
https://www.lhc-closer.es/taking_a_closer_look_at_lhc/0.superconductivity_in_short

Production of accelerator magnets at the Large Magnet Facility

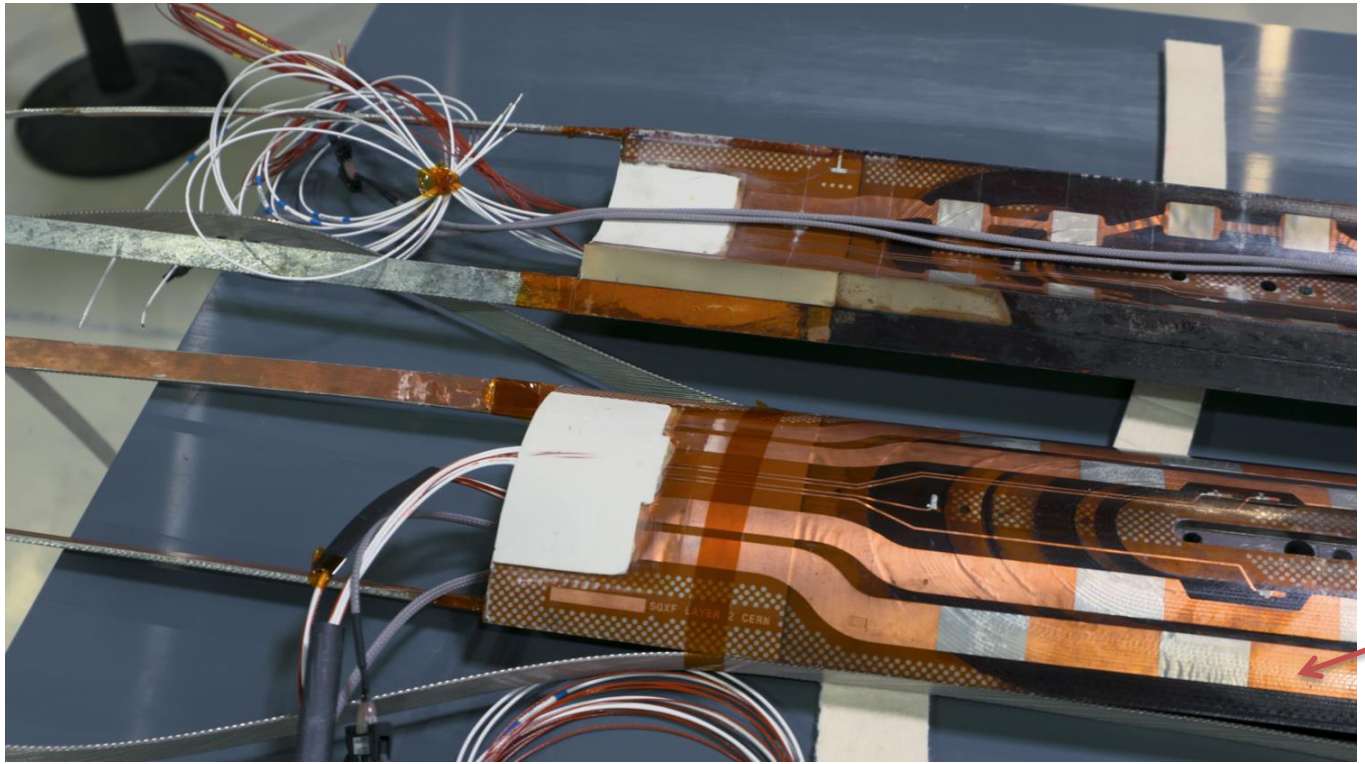
1. „Winding and curing“



2. „Reaction“ (Nb_3Sn only)

heat up to 650°C: Niobium & Tin → Nb_3Sn (unflexible superconductor)

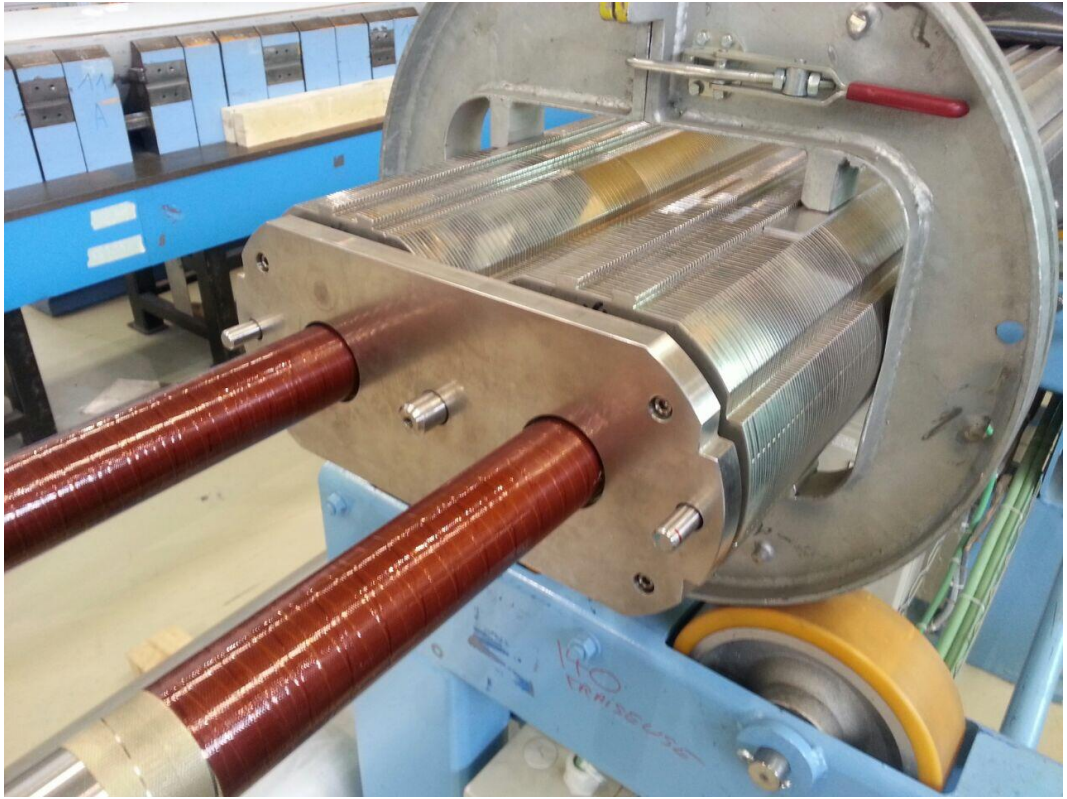
3. „Impregnation“



Quench = transition of a superconductive magnet to normal conductivity → heat generation

Quench-Heater

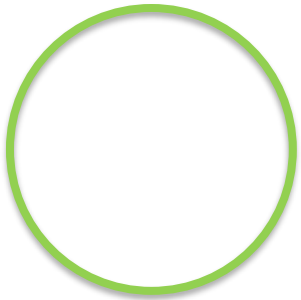
4. „Collaring“

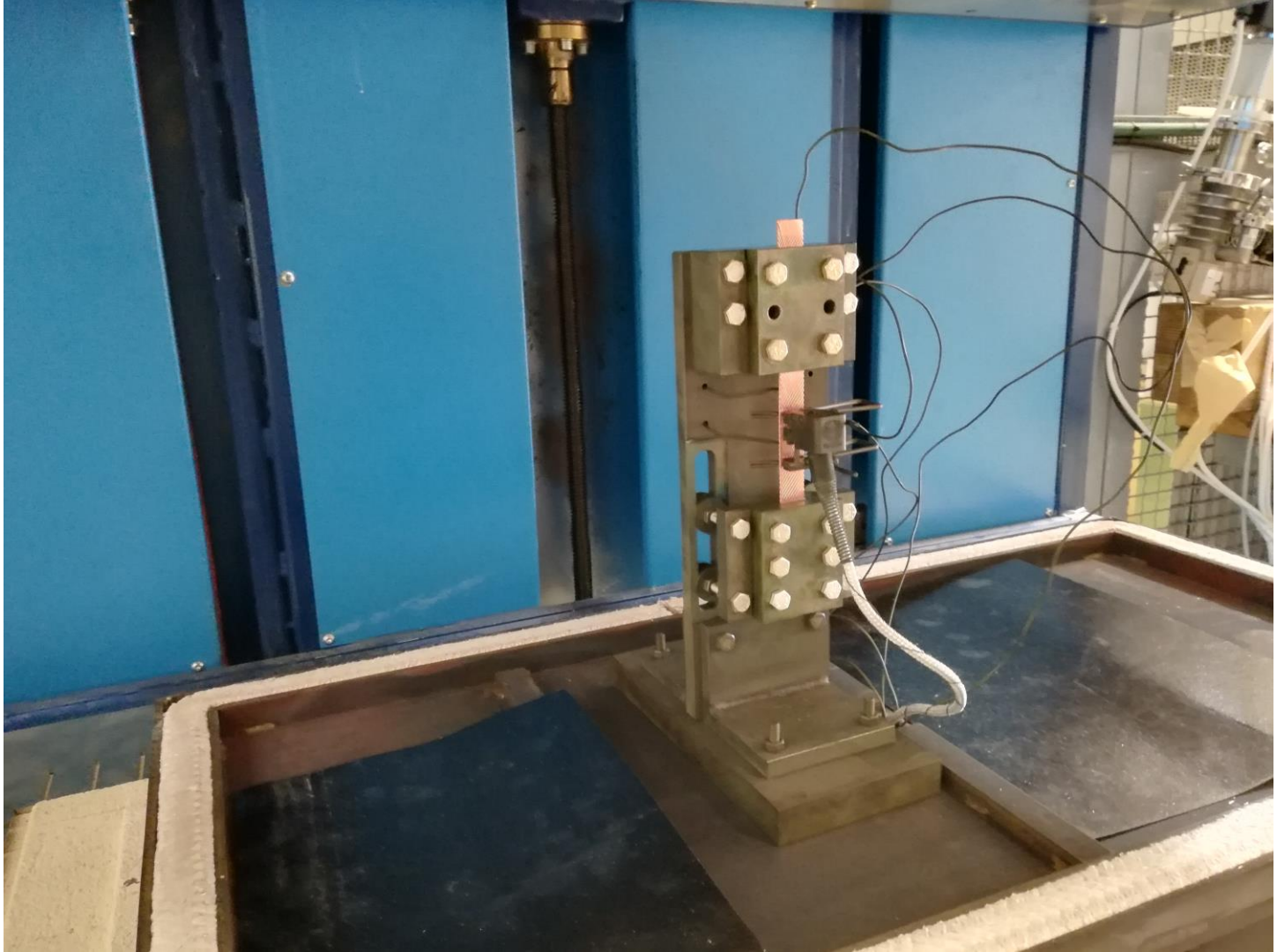


Mechanic pressure is applied to avoid fraying of the strands (→magnetic forces)

Our experience:
research & development

Thermal expansion during the reaction

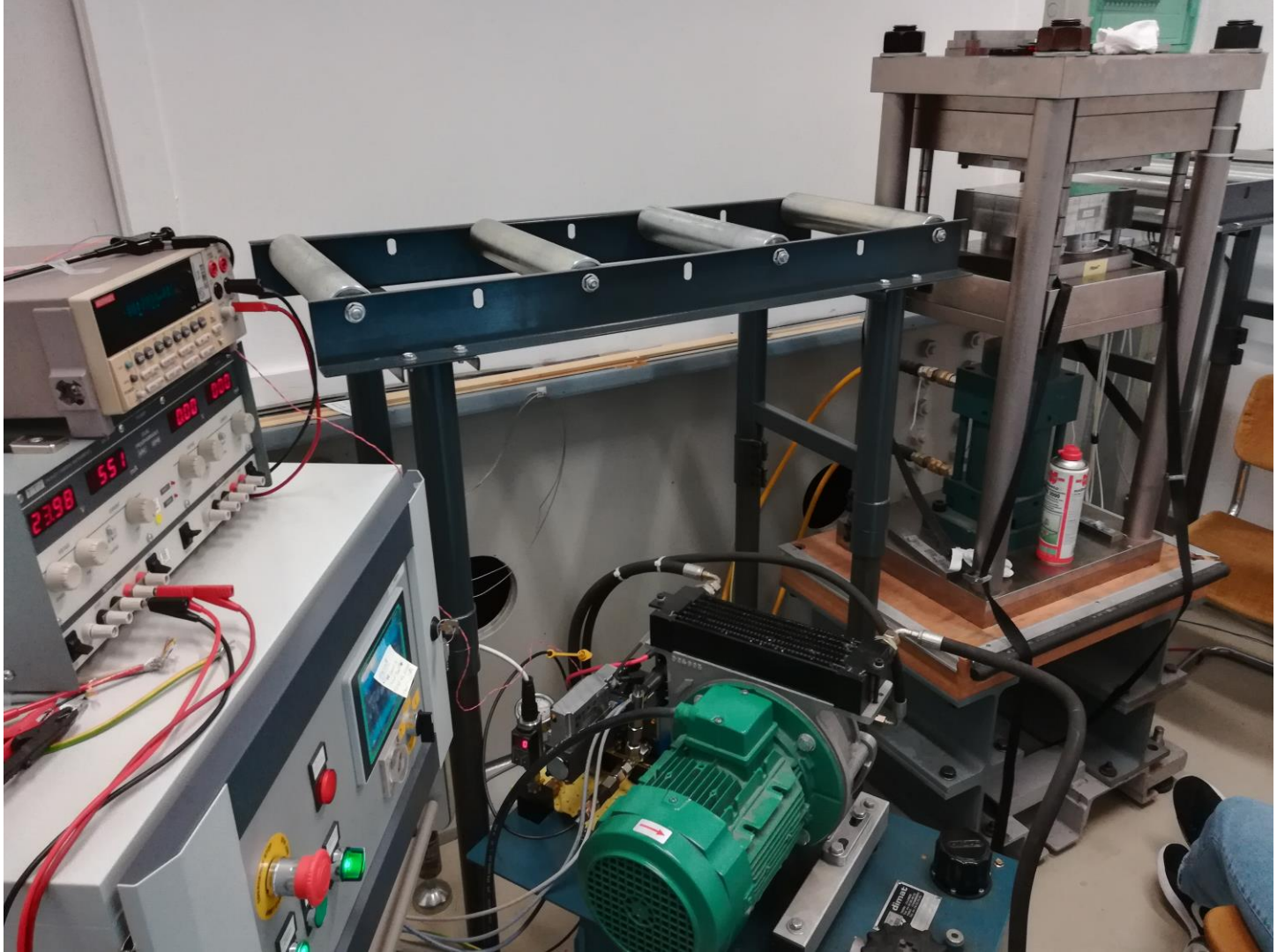





GERO

Pressure stress during the collaring

cabling machine (building 163)



Conclusion

Our experience

- Insight into high precision engineering
- Many interesting conversations (with people from different countries all over europe)
- Exciting experiments with liquid nitrogen ;)
- **Thank you!**