Accelerator Magnet Technology R&D at Danfysik



Arnd Baurichter, VP Sales & Marketing, Danfysik A/S

Danfysik today

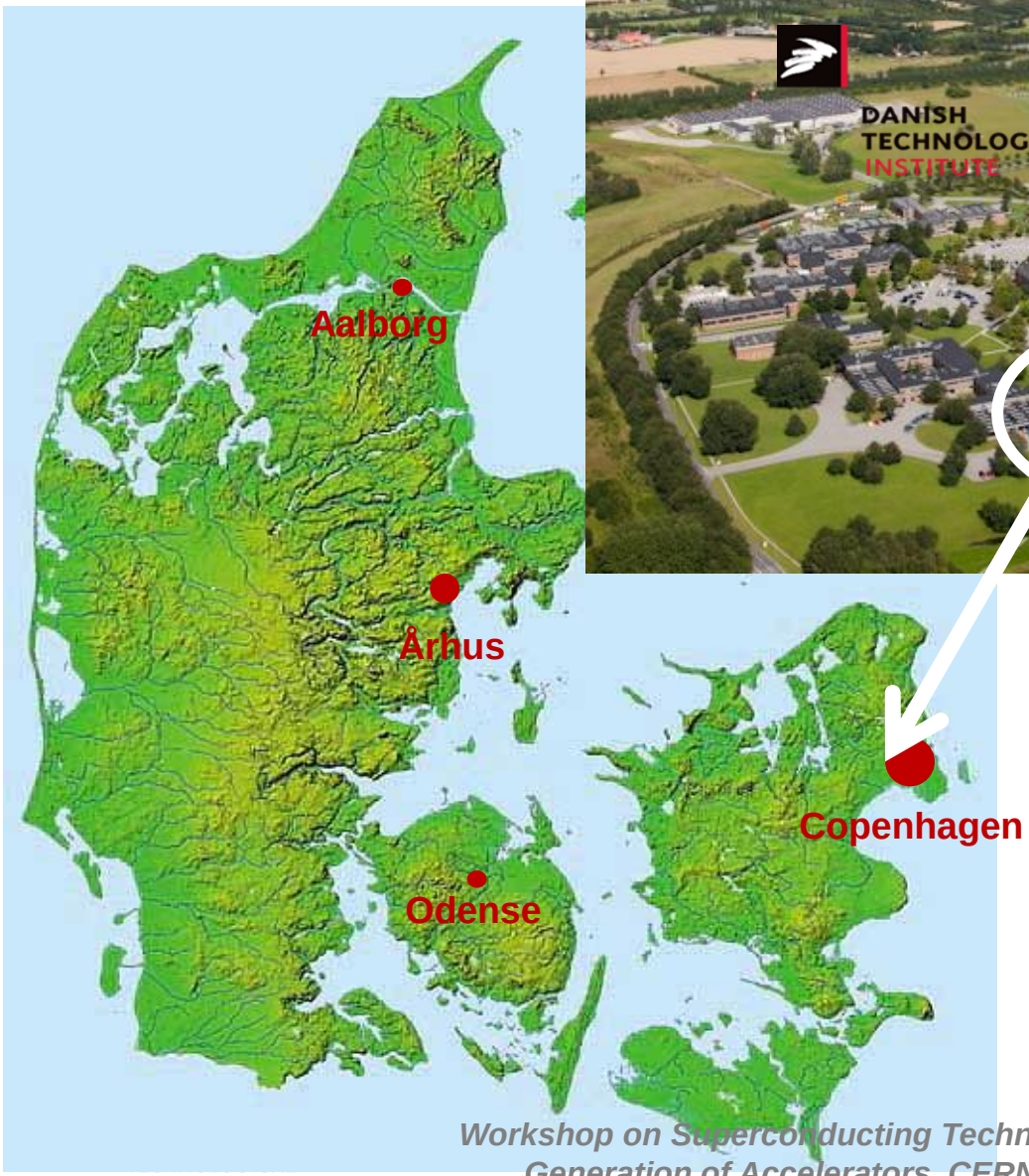
Staff : 104

Design & Projects:	30
Production and Logistics:	40
Admin., Sales & Service:	20
Particle Therapy:	14

Ownership:

100% subsidiary of Danish Technological Institute

Location



- Taastrup,
  ~ 20 km west from downtown CPH
- Approx. 30 min from CPH airport

Mission

We provide high performance particle accelerators and related equipment for research, health care and industry globally

Accelerating Technology Business
-> www.danfysik.com

DANFYSIK

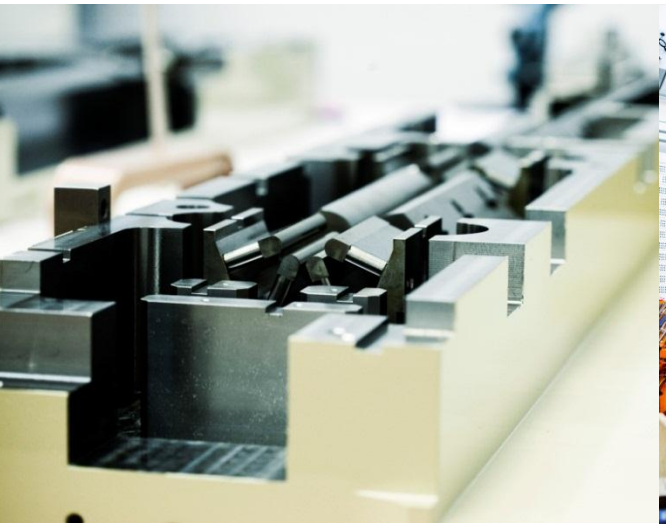
Accelerator products, services & systems

- Magnets (fast & slow), electrostatics + related equipment
- Ultrastable power supplies (fast & slow) + converter technol.
- Insertion devices, undulators and wigglers
- Ion sources and beam diagnostics
- Ion accelerators, ion implanters and isotope separators
- Turn-key systems, electron & ion synchrotrons, microtrons
- Installation, commissioning and after-sales service

DANFYSIK products

Magnet technology

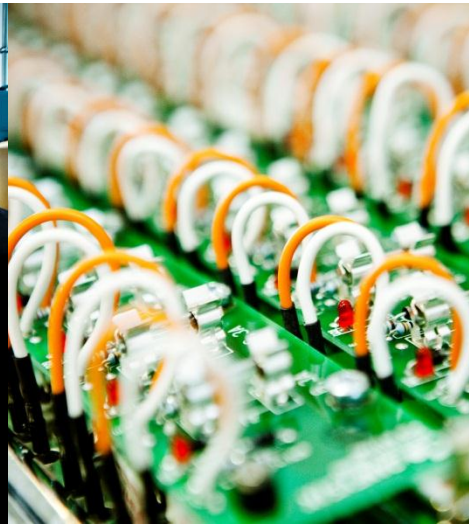
- Normal and superconducting magnets
- State-of-the-art magnetic field calculations 2D, 3D and ”4D”
- Manufacturing design
- Coil winding and yoke lamination
- Assembly (clean room)
- Magnetic testing (2D, 3D and harmonic content)
- Magnet measurement systems



DANFYSIK products

Power converter technology

- Development of current stabilized/regulated precision power supplies
  uni-/bipolar, 10 A ... 32 KA, KW ... MW,
  stability classes 100 ppm, 10 ppm, 1 ppm and 0.1 ppm
- Normal & sc magnet loads; quench protection
- Manufacturing design
- Assembly & testing
- Service & maintenance



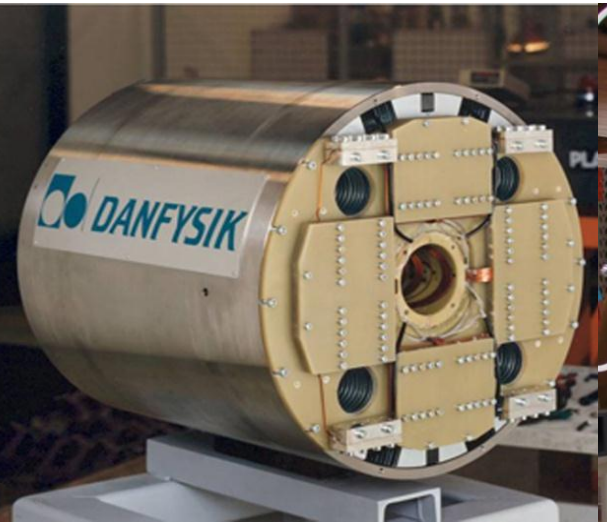
R&D at Danfysik

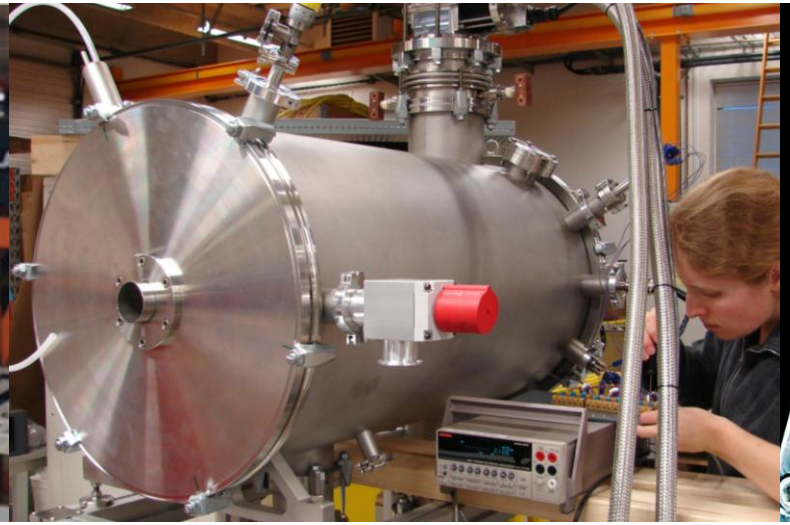
DANISH
TECHNOLOGICAL
INSTITUTE

DANFYSIK

Superconducting magnets (LTS)

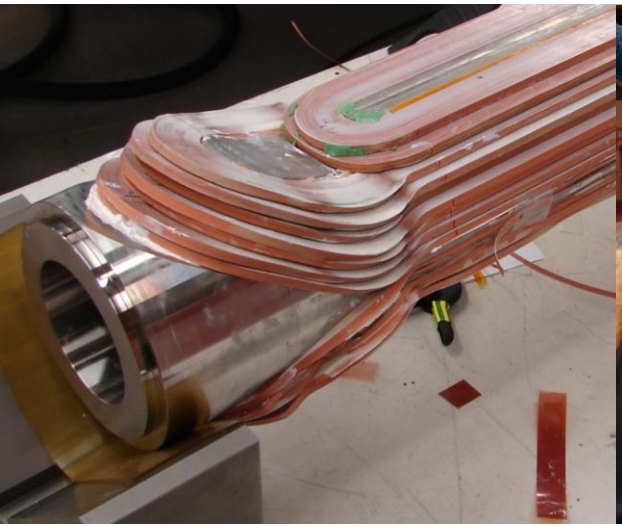
- CERN / LHC (Switzerland)
  - MCBX low-β dipole corrector prototype for the Large Hadron Collider (NbTi)
  - Operating dipole field 3.3 T, Integr. dip. field 1.21 Tm (1.1 Tm)
- IUAC (India)
  - Four superconducting solenoid magnets (NbTi)
  - Field 8.5 T, length 200 mm, 70 A, persistent mode

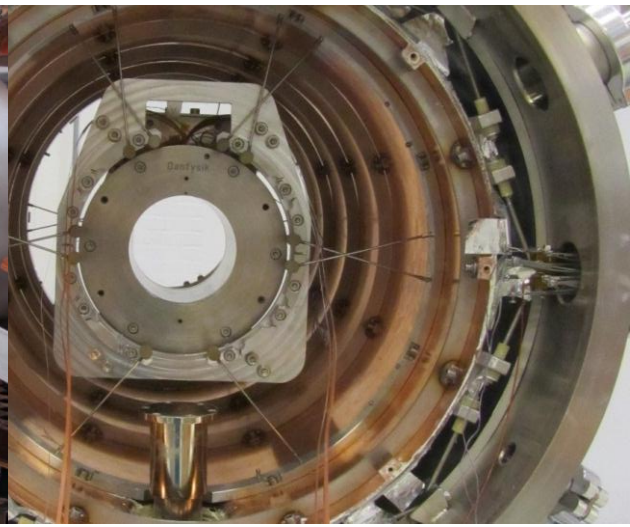




Superconducting magnets (HTS)

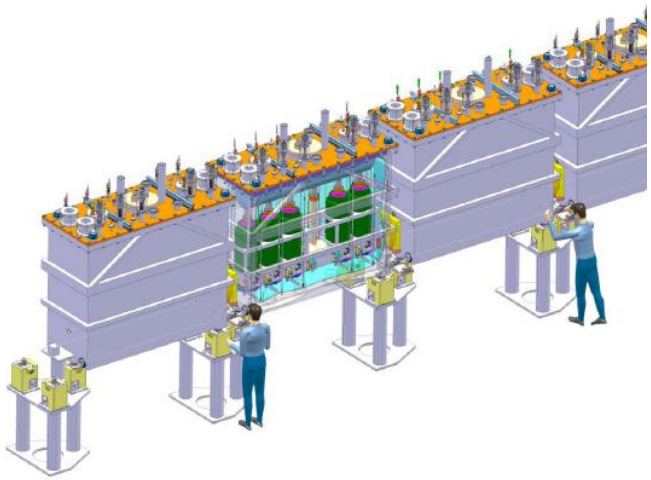
- Demo dipole magnet for carbon therapy gantry
  - 2G HTS tape from SuperPower, in-house epoxy isolation
  - On-axis B-field: 3 T, T_{op}< 20K (solid state cooling – no liquids)
- Small HTS solenoid for superconducting electron gun for WiFEL at the University Wisconsin-Madison
  - Test @ 70K; Operation @ 5K≤T≤70K, B_c = 0.28 T, @ 0A: ≤ 10 mG
  - Inner bore Ø 91 mm, outer diam. <300 mm, l= 150 mm,
  - ”Build-in-and-forget”

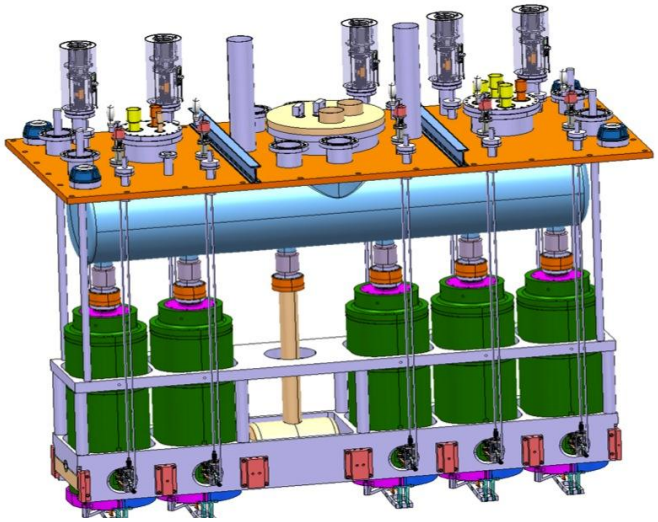


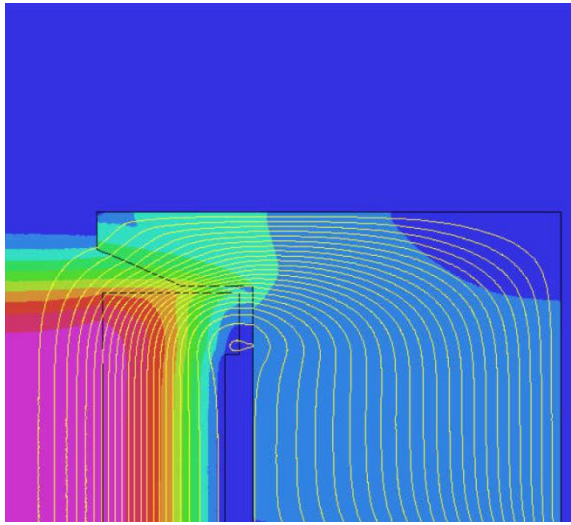


Recent project with CERN (just started)

- Four solenoids for HIE-ISOLDE low-β cryo-modules
  - 9 T center field, 13.5 Tm^2 integrated field (NbTi)
  - Fringe field at RF cavity wall < 0.021 T
  - Dimensions:
    outer solenoid diameter ≤ 230 mm, length ≤ 305 mm
    cold bore diameter ≥ 30 mm







Assembly and measurements

Clean room

- Clean room class
  < 100.000
- Temperature stability
  ± 0.5°C
- Air lock access with overpressure
- Strict dress code

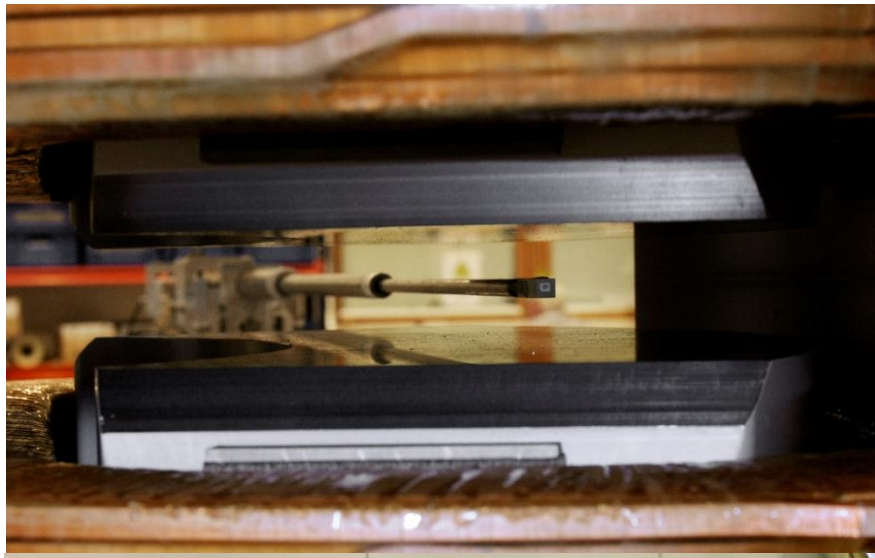
3D (4D) field mapping

Hall probe field mapping

- step-by-step or on-the-fly
- Short term probe drift:
  $2 \cdot 10^{-5}$ for B ≈ 0.1 T
  $1 \cdot 10^{-4}$ for B ≈ 0.01 T
- Short term repeatability:
  ±0.005 mT for B ≤ 0.1 T
  ±0.02 mT for B > 0.1 T
- Positioning accuracy < 0.1 mm

Group3 Hall probes (0..2 T ± 0.1mT):

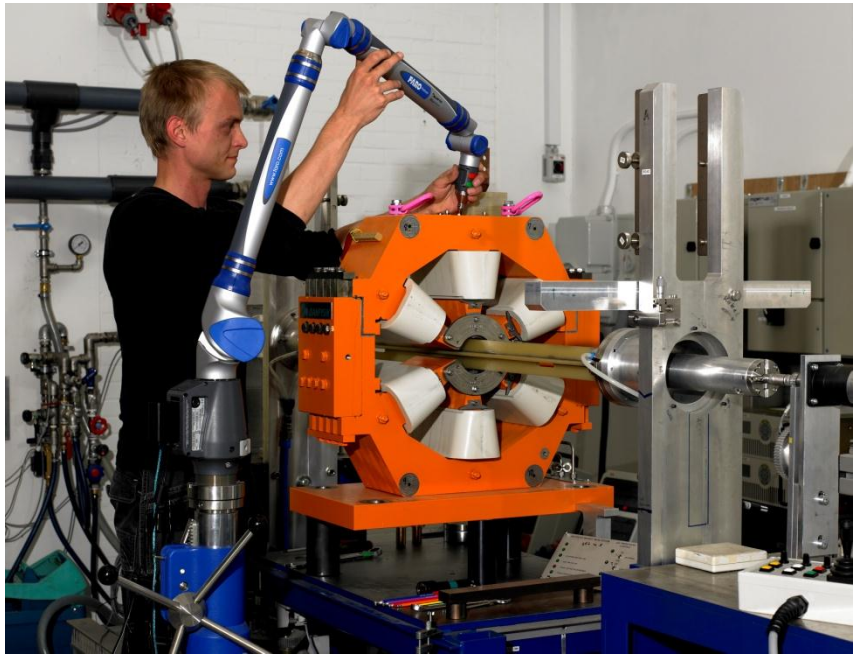
- Digital: ± 0.01% (or reading + 0.006% of full scale) up to 3 Hz
- Analog: ± 0.02% (or reading +0.01% of full scale) up to 10 kHz



Rotating coil measurements

Fast rotating multipole test system 690:

- Coil length range: 500 – 1100 mm
- Existing measuring rod radii:
  7.6 … 44.5 mm
- Measuring in the magnet center
- Amplitude measurement



Slow rotation multipole test system 692:

- Coil length range: Custom-built for specific magnet application
- Existing measuring radius: 30 mm
- Magnet alignment within:
  ±0.03 mm, ±0.2 mrad
- Accuracy of the harmonics: $\pm 3 \cdot 10^{-4}$

Flip coil bench

- Integral field measurements
- Coil diameter from 2 to 10mm
- Used down to 4 mm gap
- Random x, y-position error of only 3 μm
- Twisted for second field integral