PSI Center for Photon Science

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Fermilab

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ESRF The European Synchrotron

Towards the magnetic characterization of a meter-long bulk high-temperature superconducting undulator

Alexandre Arsenault :: Center for Photon Science :: Paul Scherrer Institute

Magnetic measurement workshop #23

October 11, 2024, Bad Zurzach

LEAPS INNOVATION

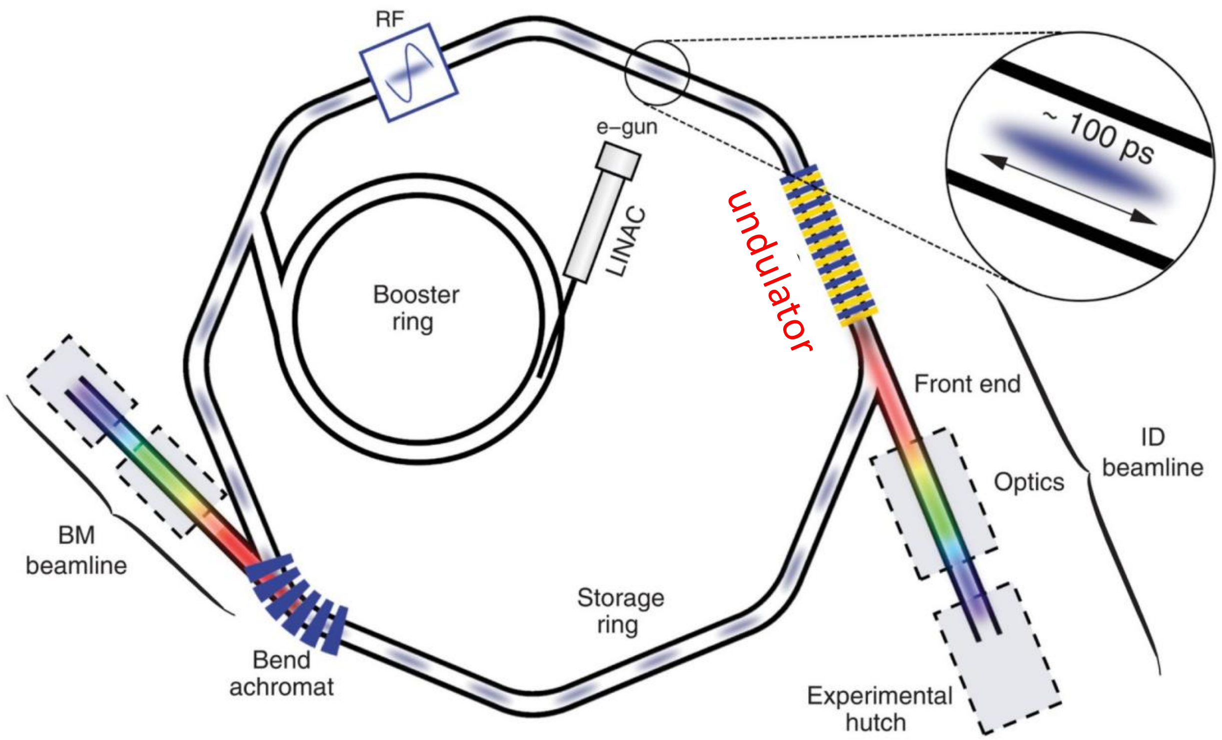
SLS2.0

CHART Swiss Accelerator Research and Technology

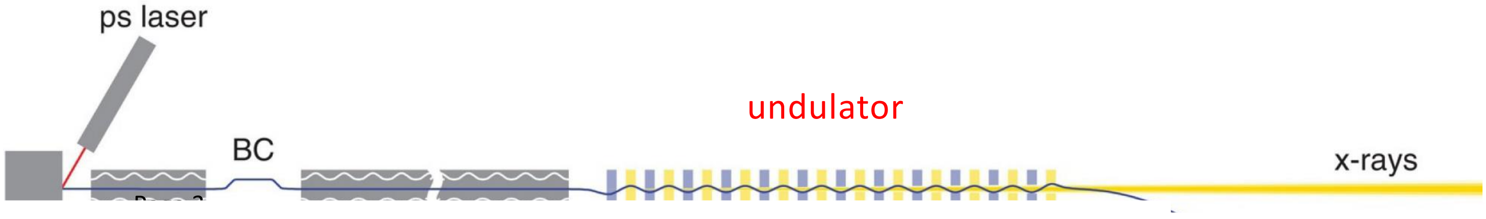
Overview

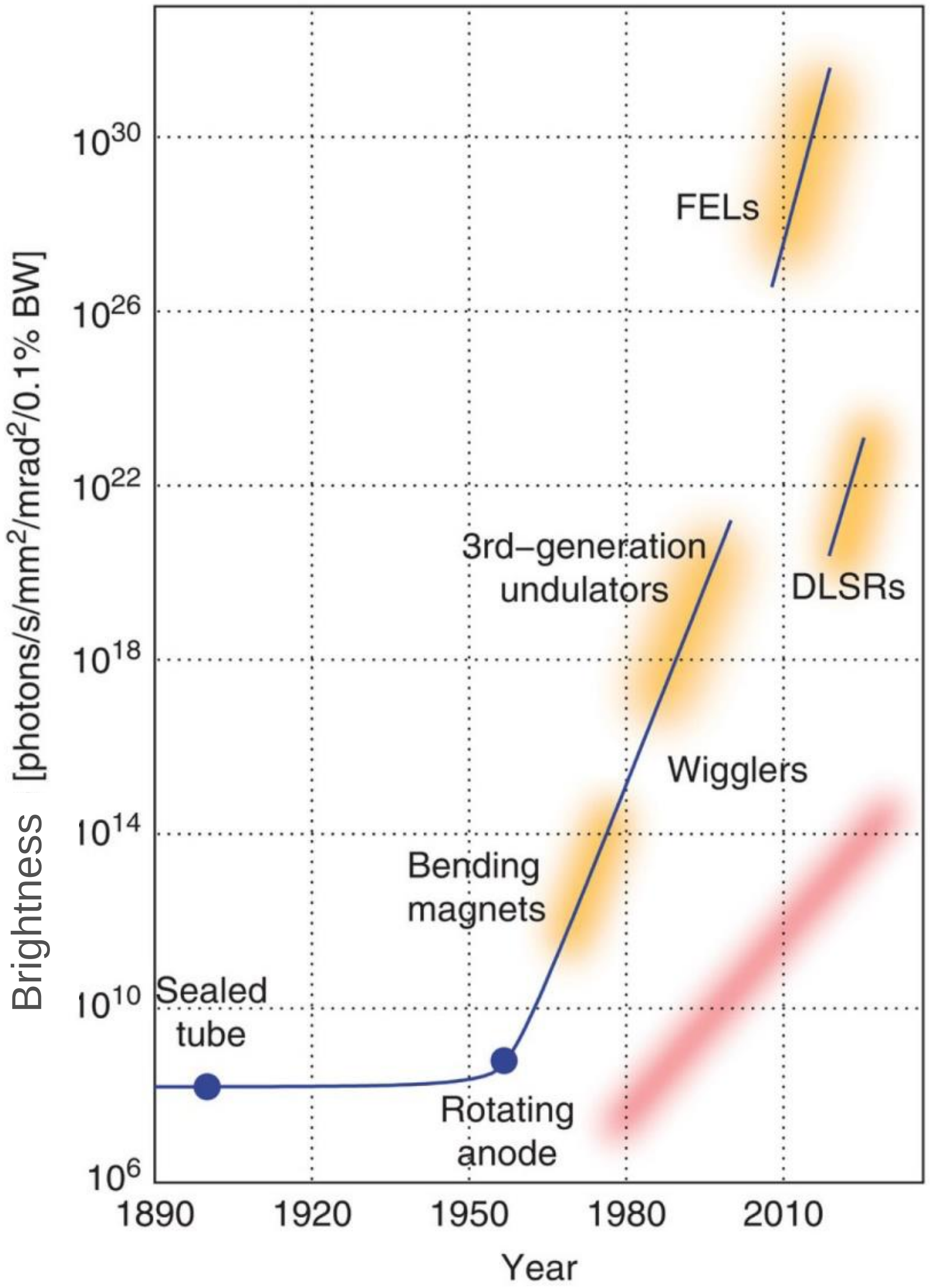
- The HTS (REBCO) bulk Staggered Array undulator
- Results on short samples
- Status of the meter long HTS Undulator prototype
- Conclusions

Introduction



$$\lambda = \frac{\lambda_u}{2n\gamma^2}\left(1 + \frac{1}{2}K^2\right) \qquad K = \frac{B_0 e}{mc}\frac{\lambda_u}{2\pi}$$





The new µ-Tomography beamline of SLS2.0

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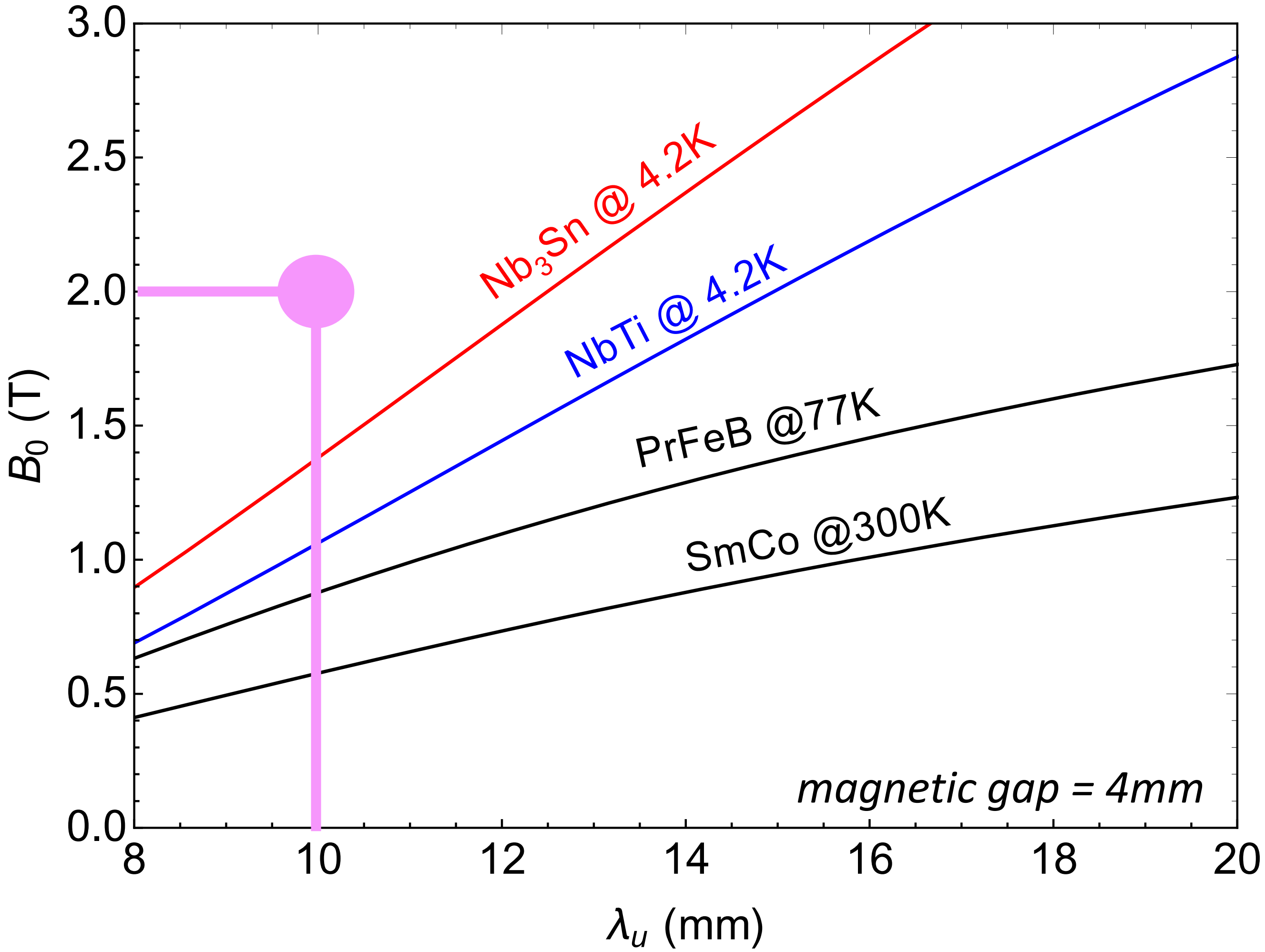
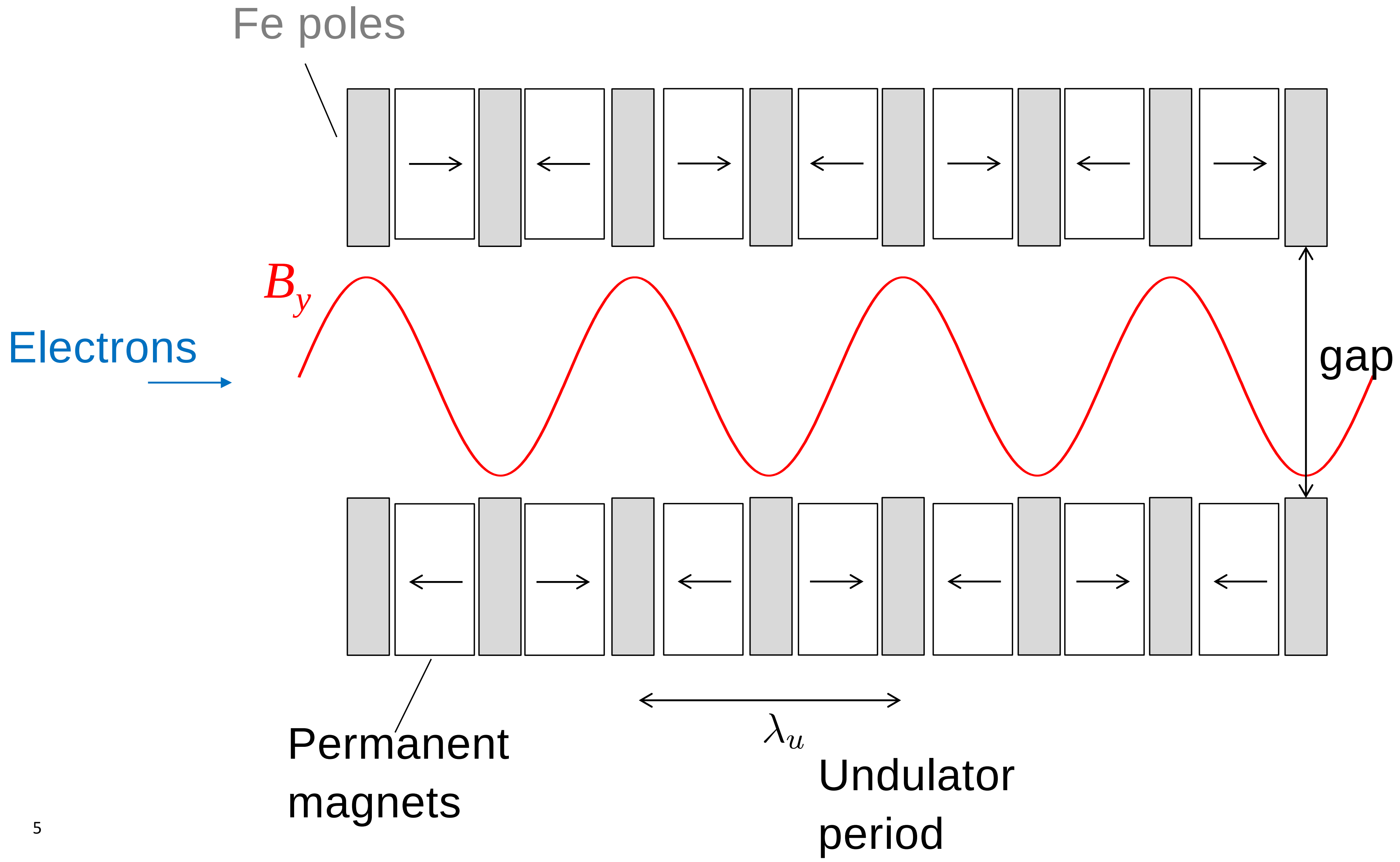
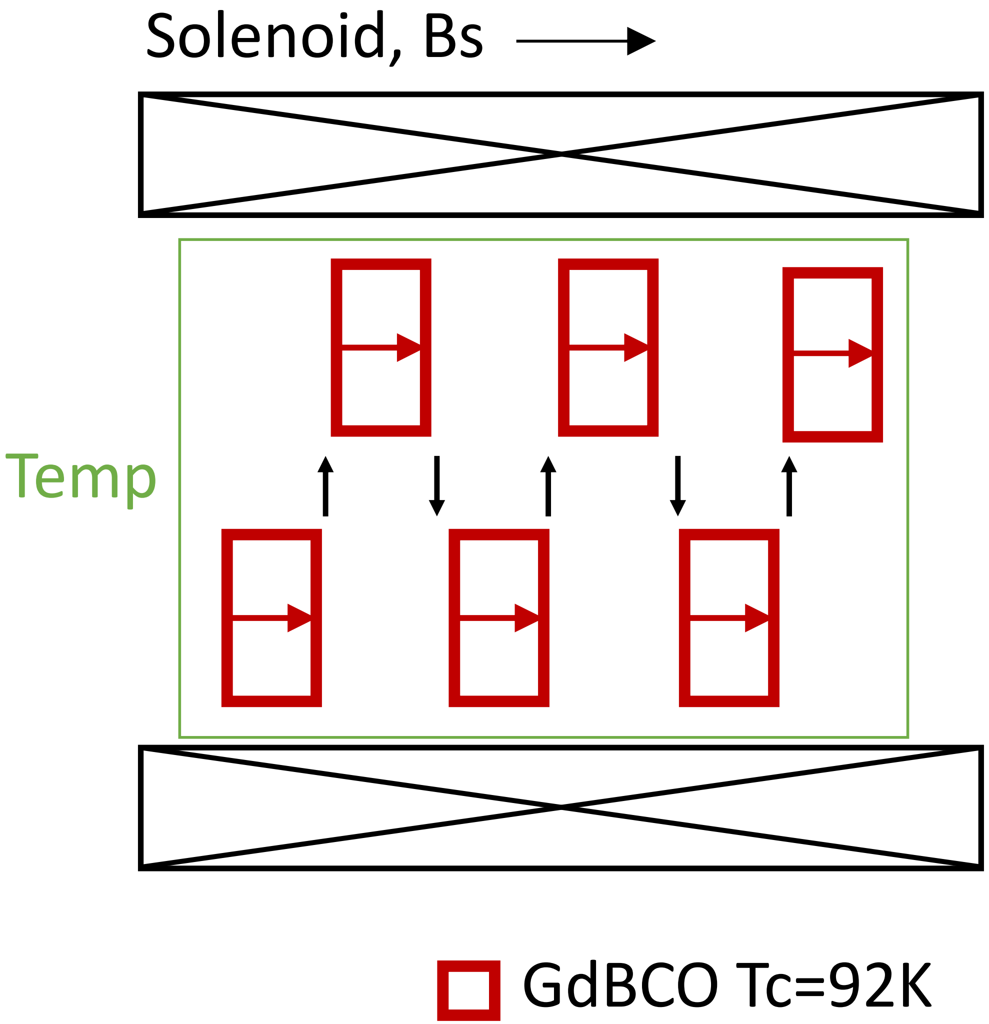


[Scaling laws: E.R. Moog, R.J. Dejus, and S. Sasaki , Light Source Note: ANL/APS/LS-348
James Clarke, FLS 2012, March 2012, Ryota Kinjo Physical Review Special Topics, Accelerator and Beams 17, 022401 (2014)]

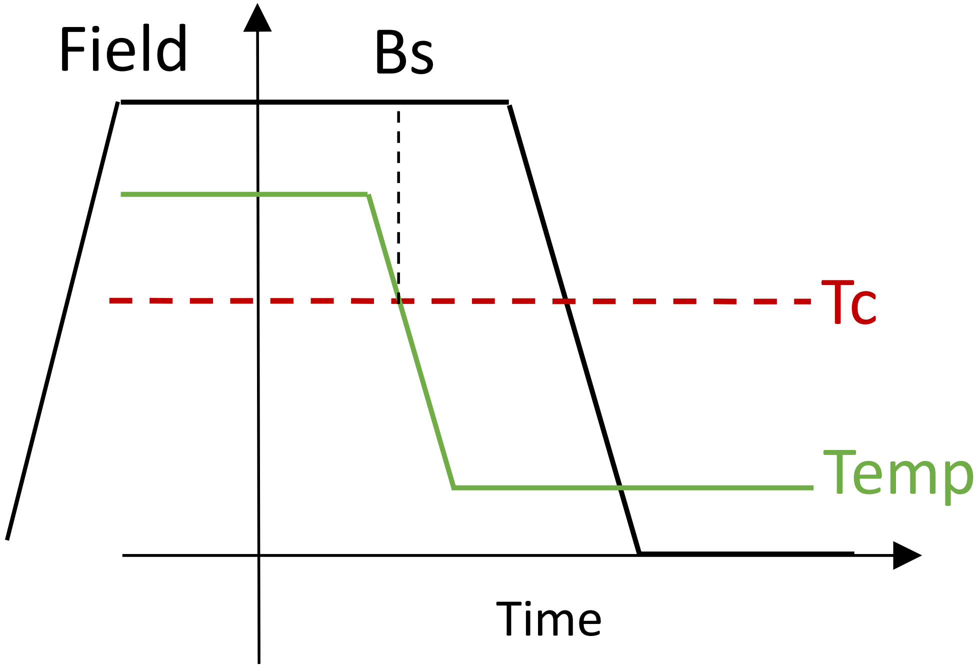
Permanent Magnet Undulator with Fe poles



Superconducting Staggered Array Undulator

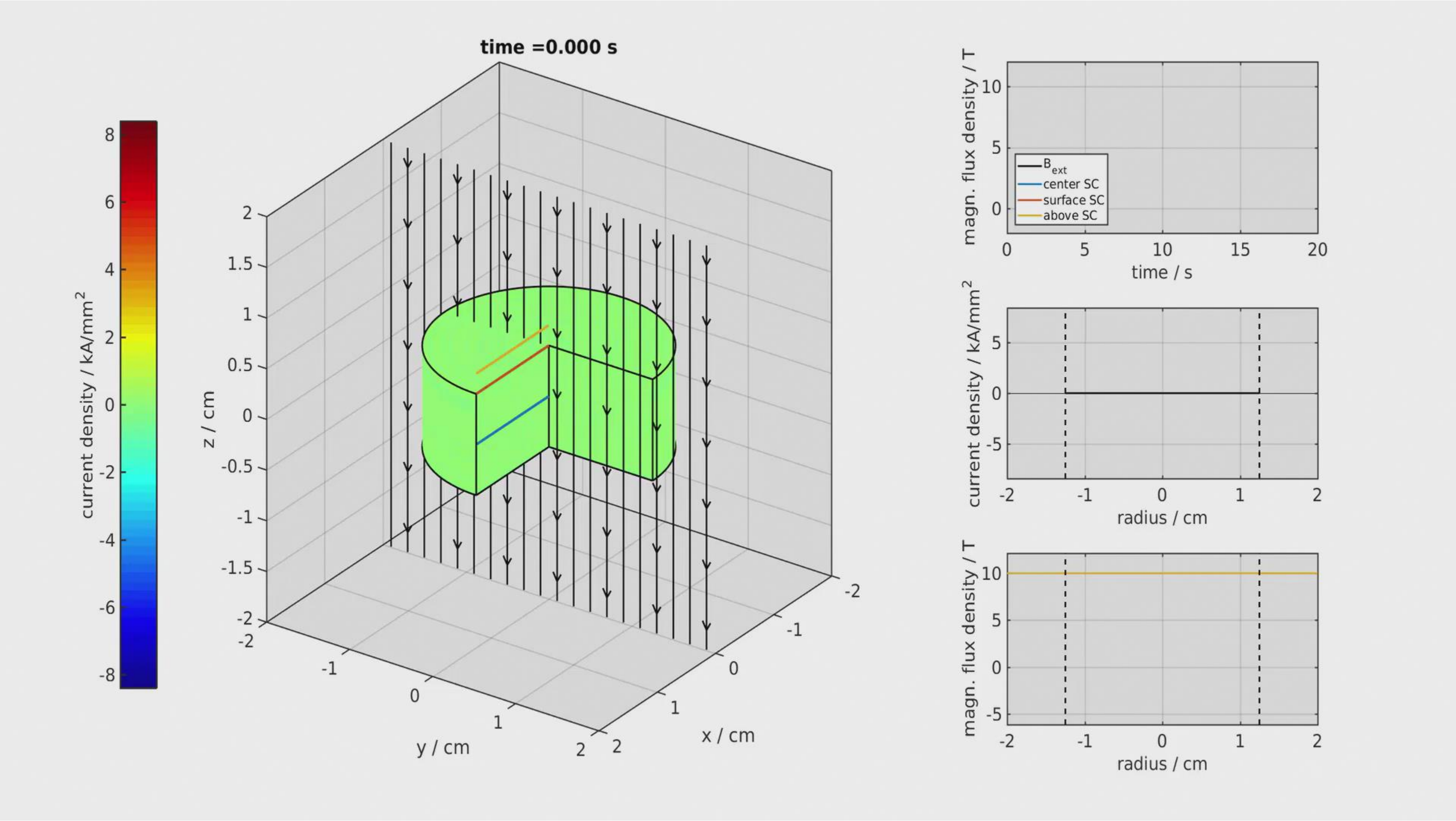


Example of *field cooling* magnetisation

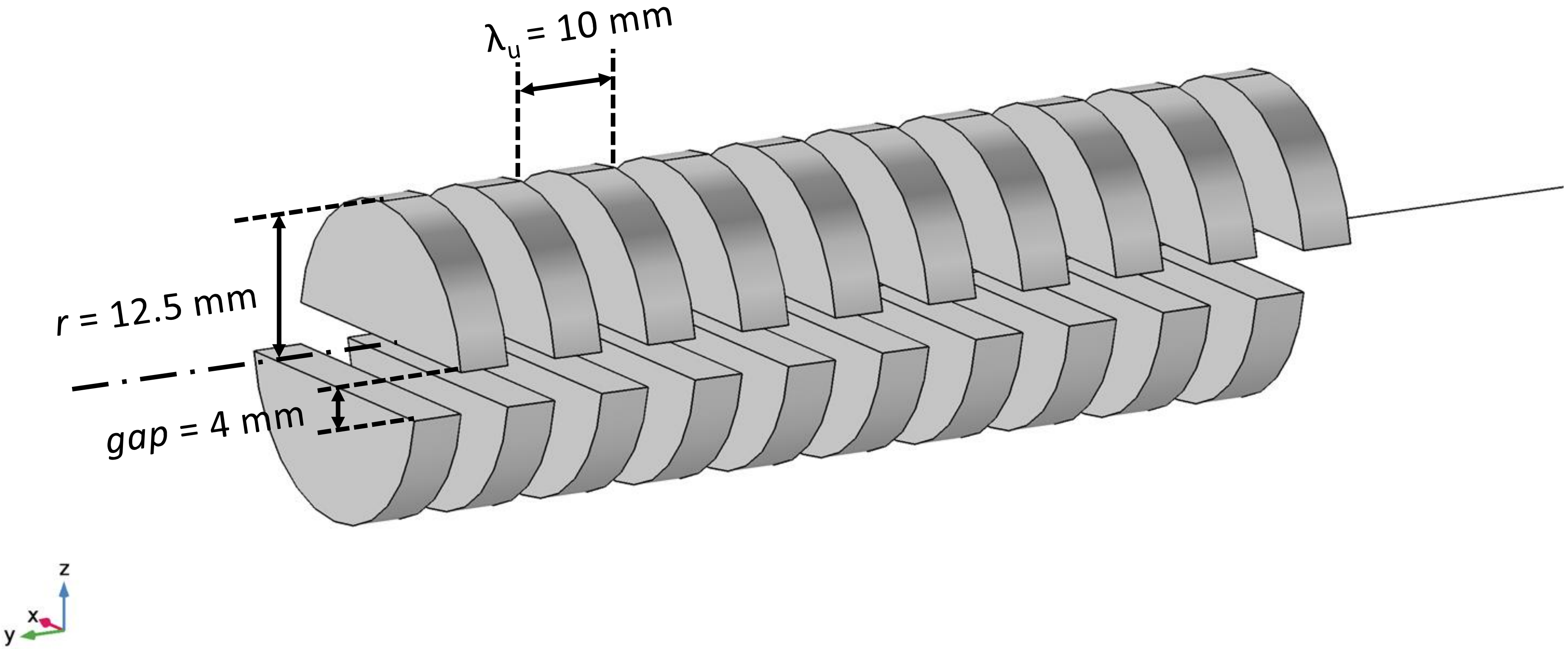


T. Kii, et al.: Proc. FEL2006 (2006) p. 653.

Example of Field Cooling (FC)

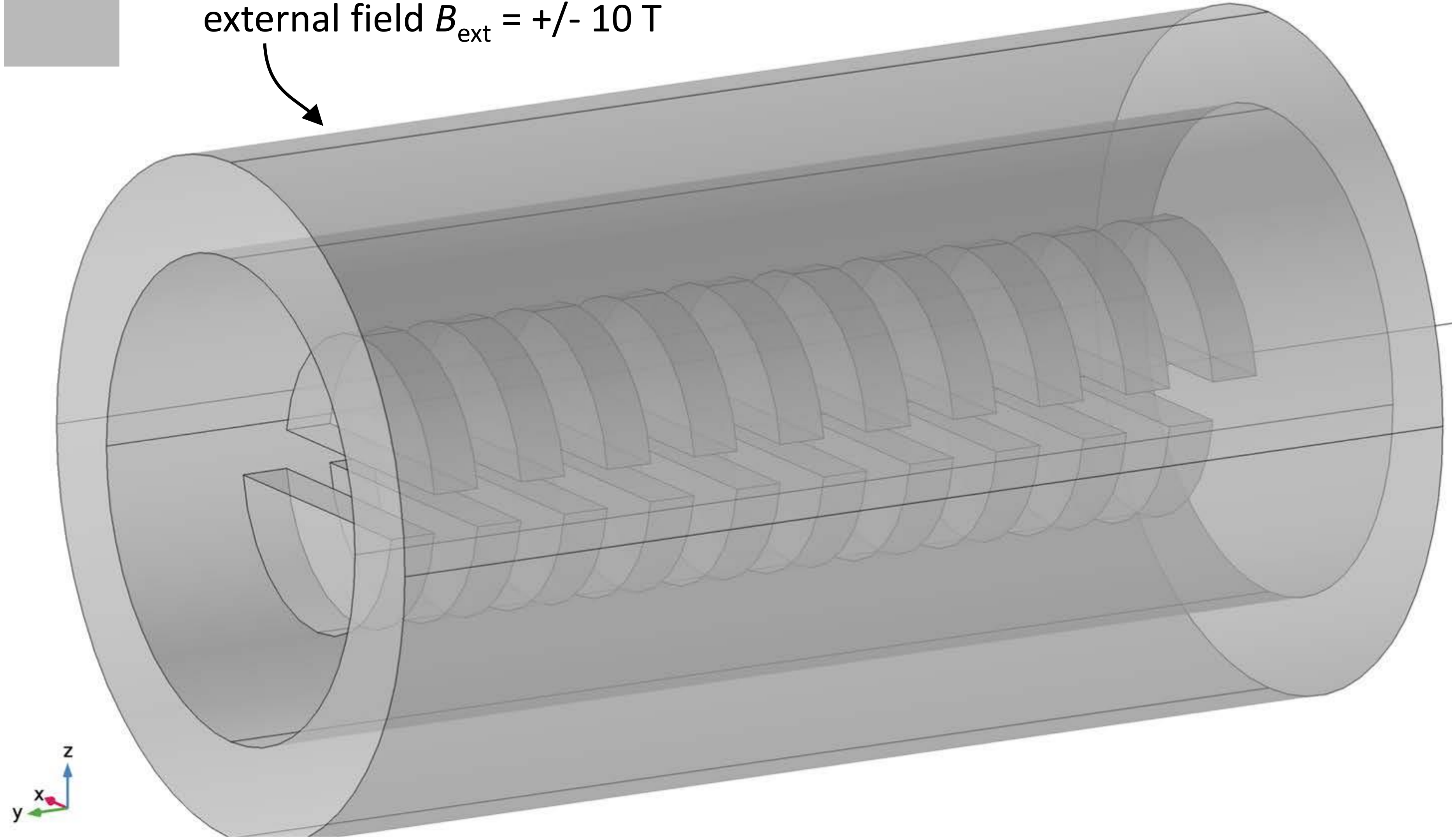


Superconducting Staggered Array

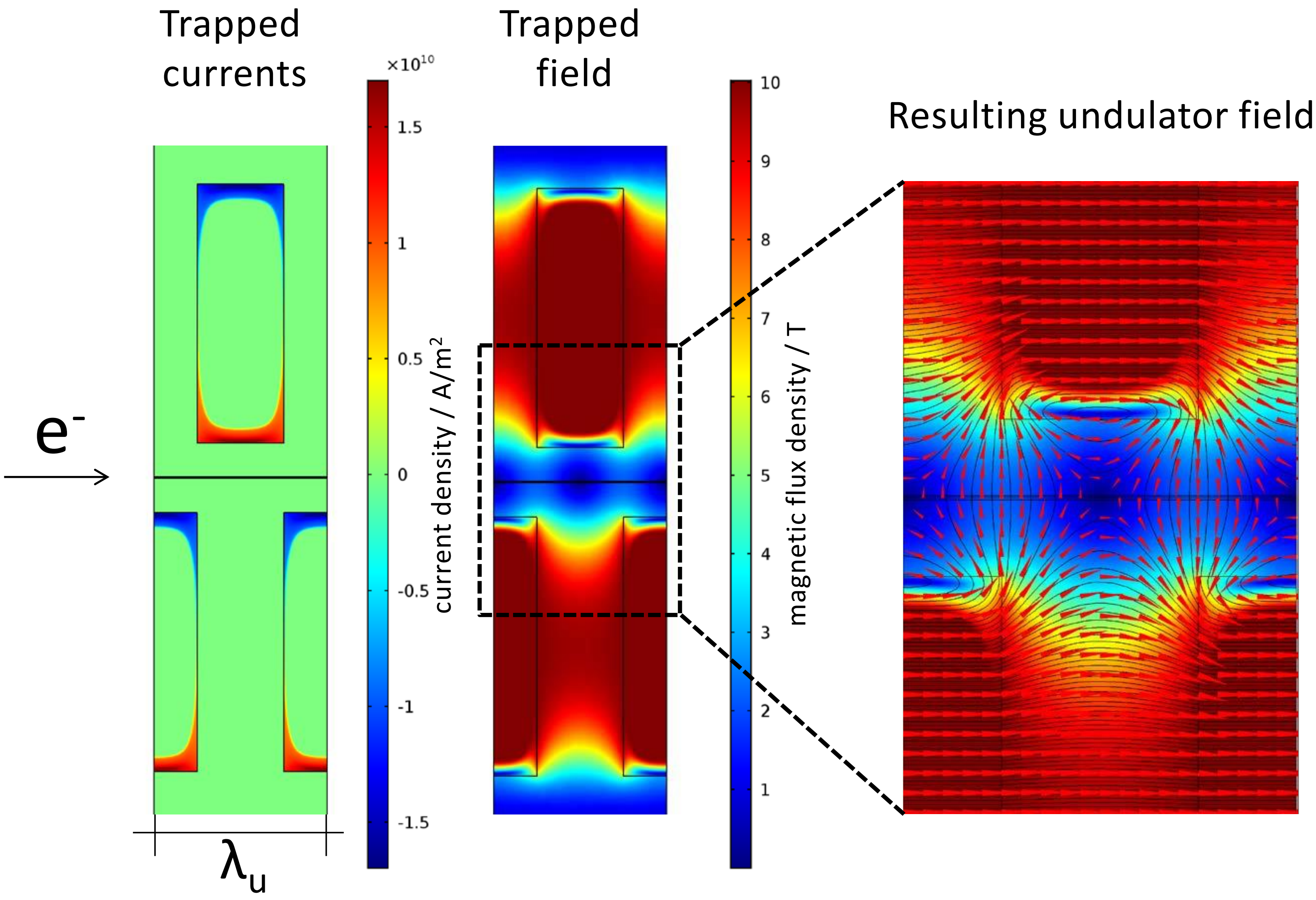


Superconducting Staggered Array

- Superconducting solenoid providing external field B_{ext} = +/- 10 T



Superconducting Staggered Array



Overview

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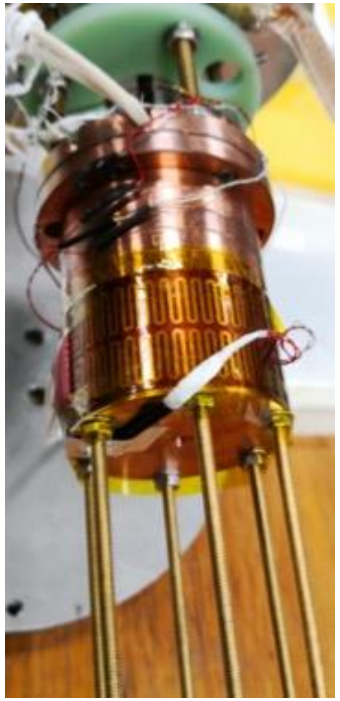
Samples Overview

1st Bulk Sample



6mm gap

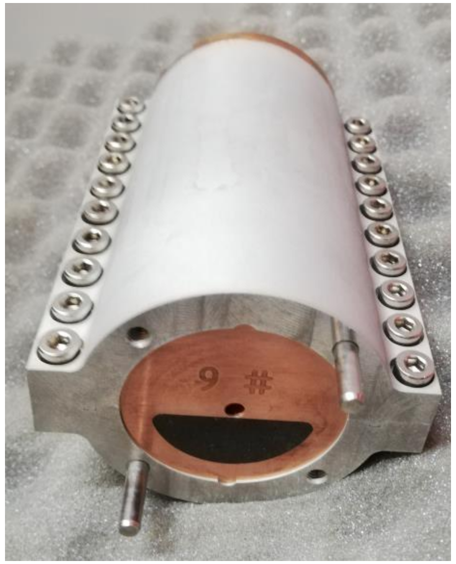
2nd Bulk Sample

4mm gap

Bulk Industrial Sample

4mm gap

Bulk Simplified Sample



4mm gap

The "Good" Sample

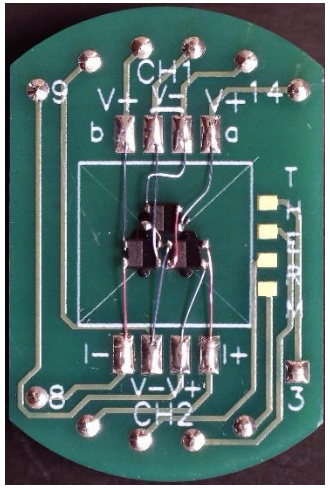
4mm gap

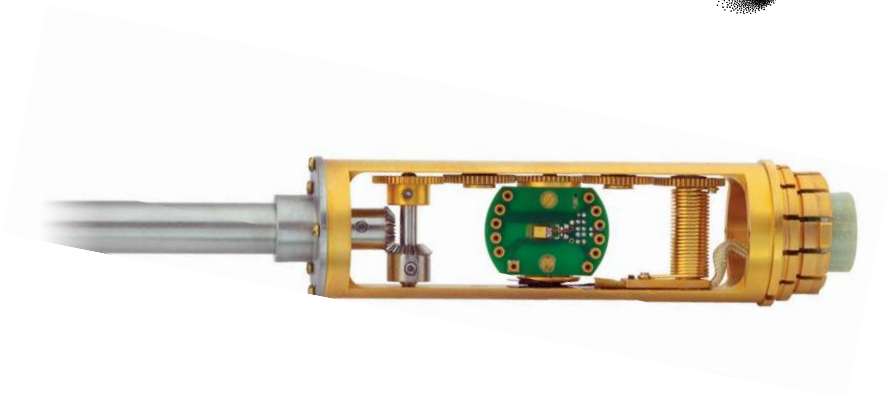
2019

2021

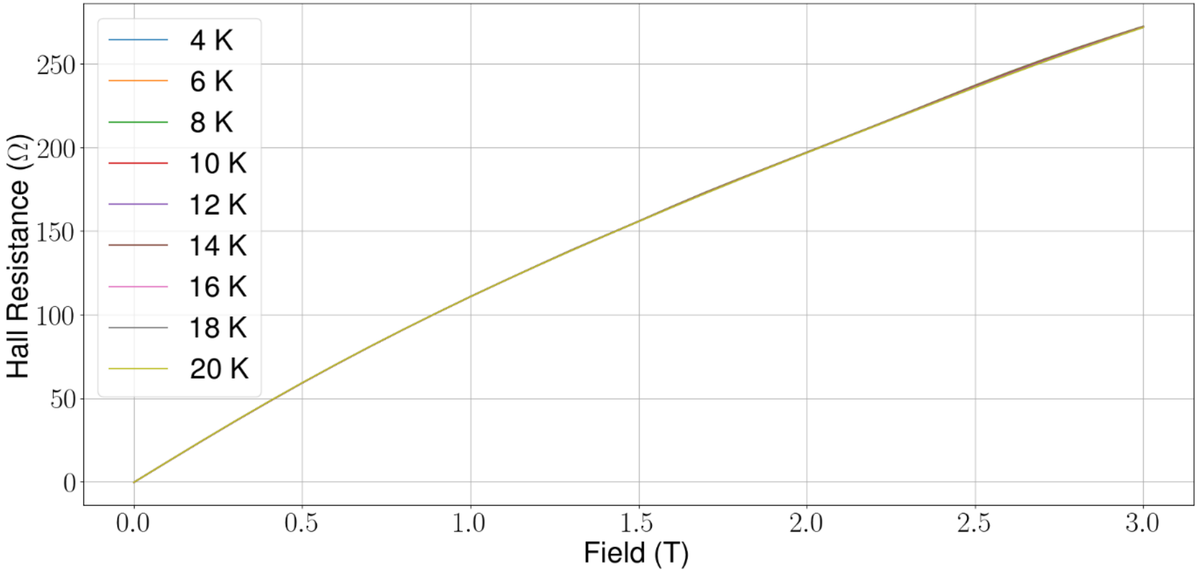
2023

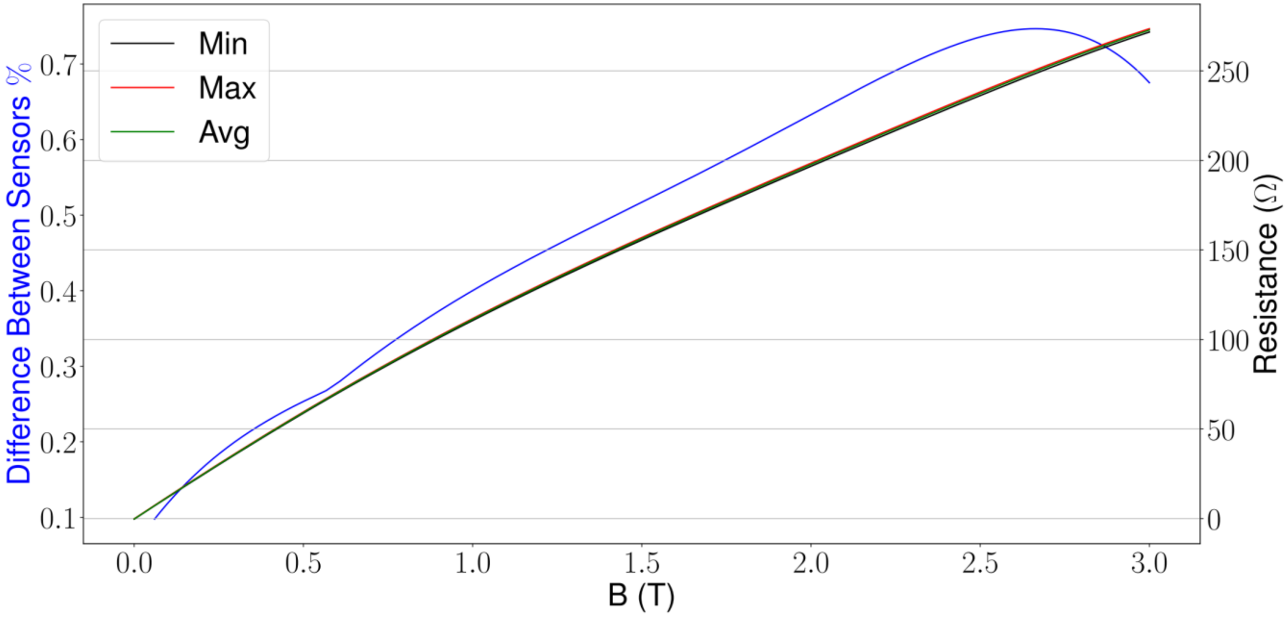
Hall sensor array





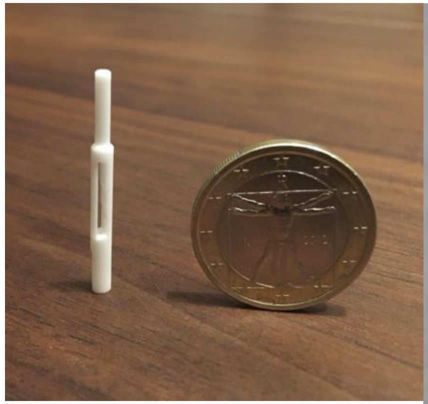
- Calibrated 12 Hall sensors in a PPMS from 4-20 K and from 0-3 T
- Difference of <0.8 % between sensors

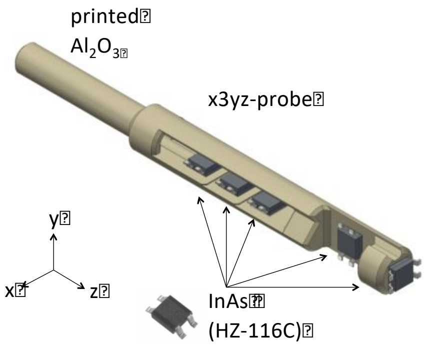




Hall sensor array

- 5 Hall sensors embedded in 3D printed holder
- 3 offset sensors to measure the undulator field
- 2 others to measure the perpendicular fields





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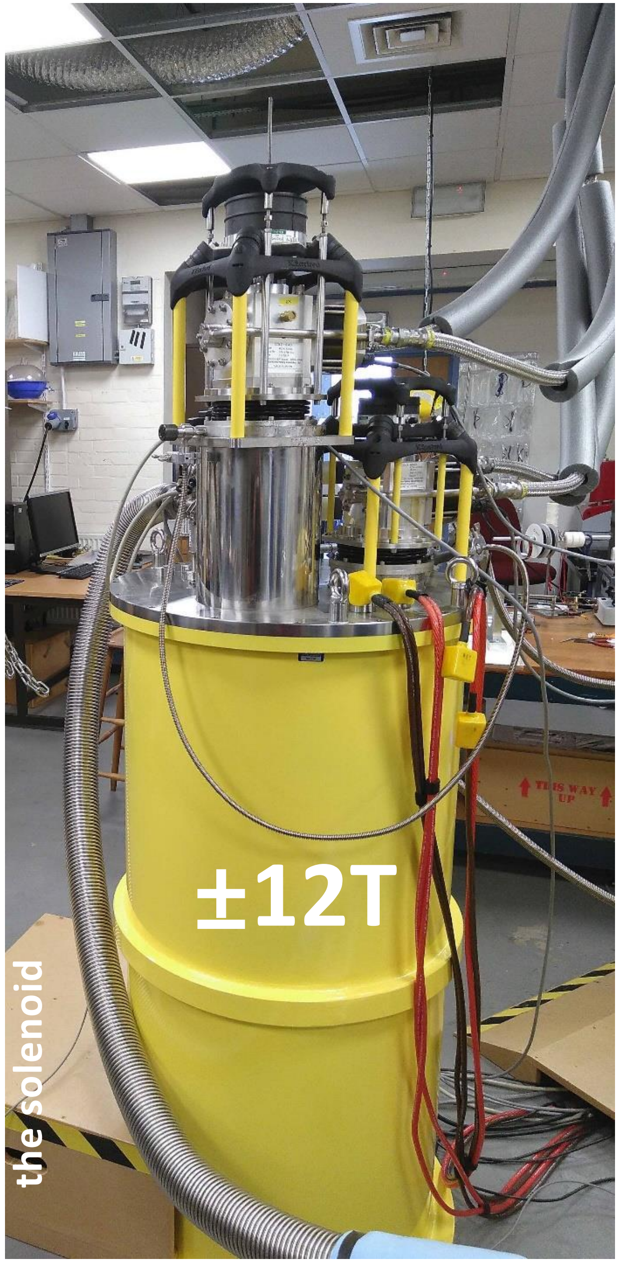

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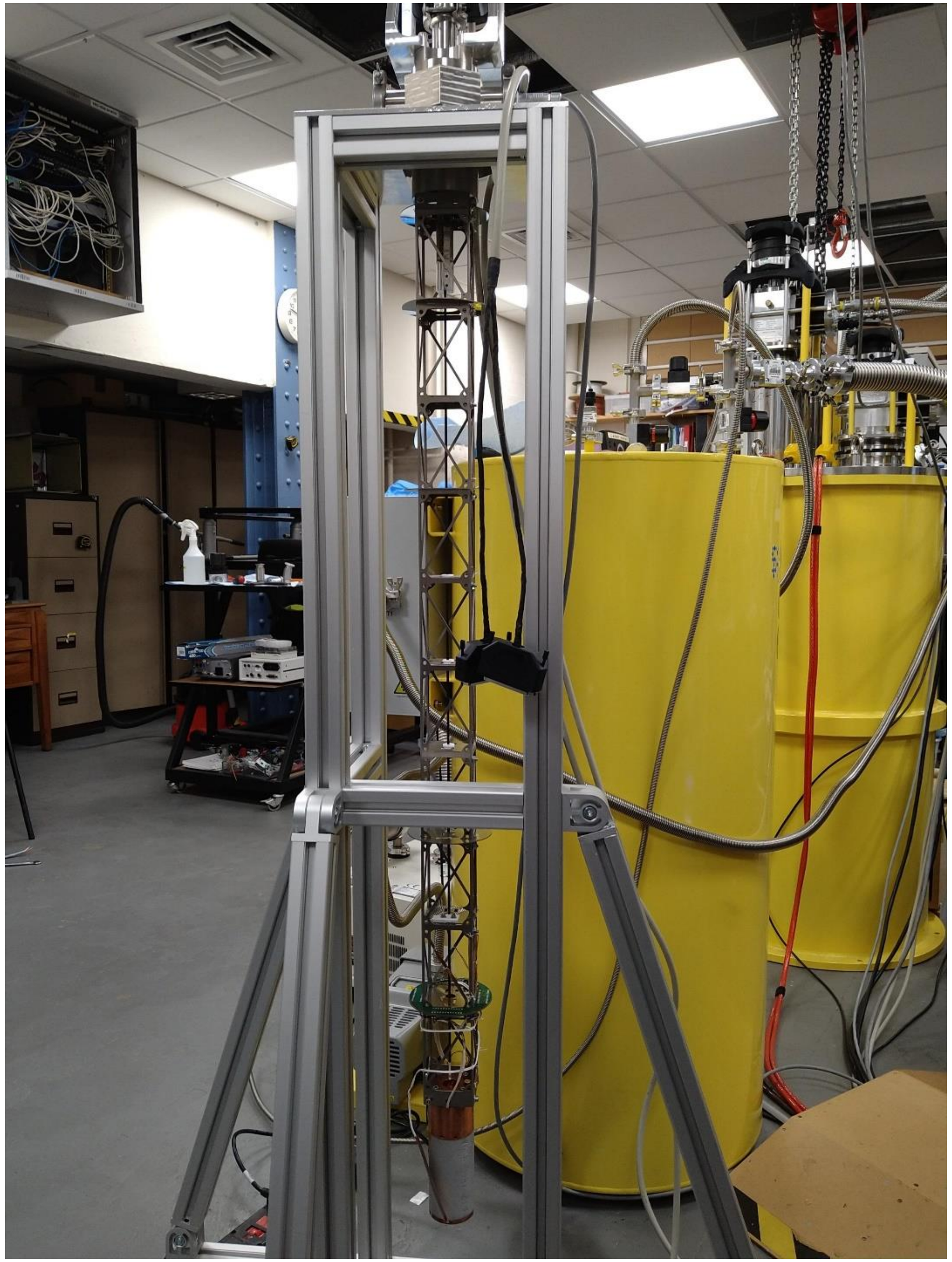
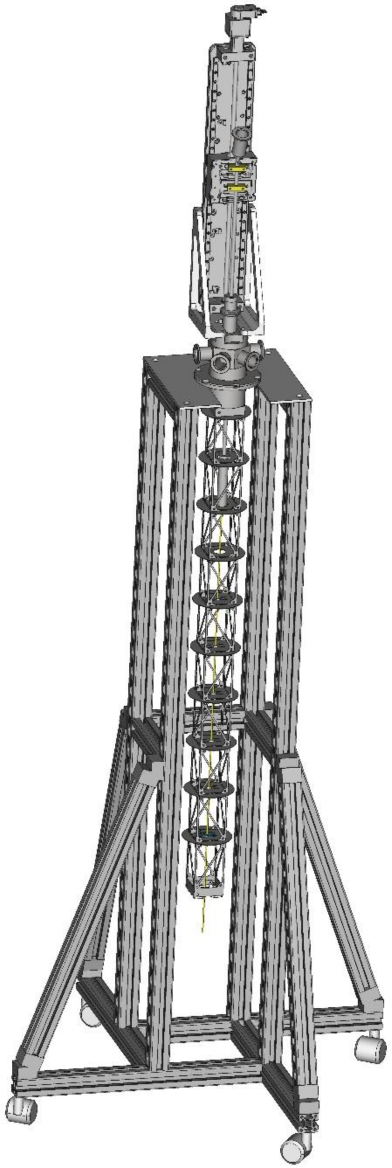
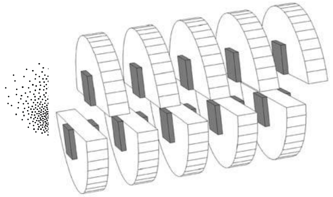
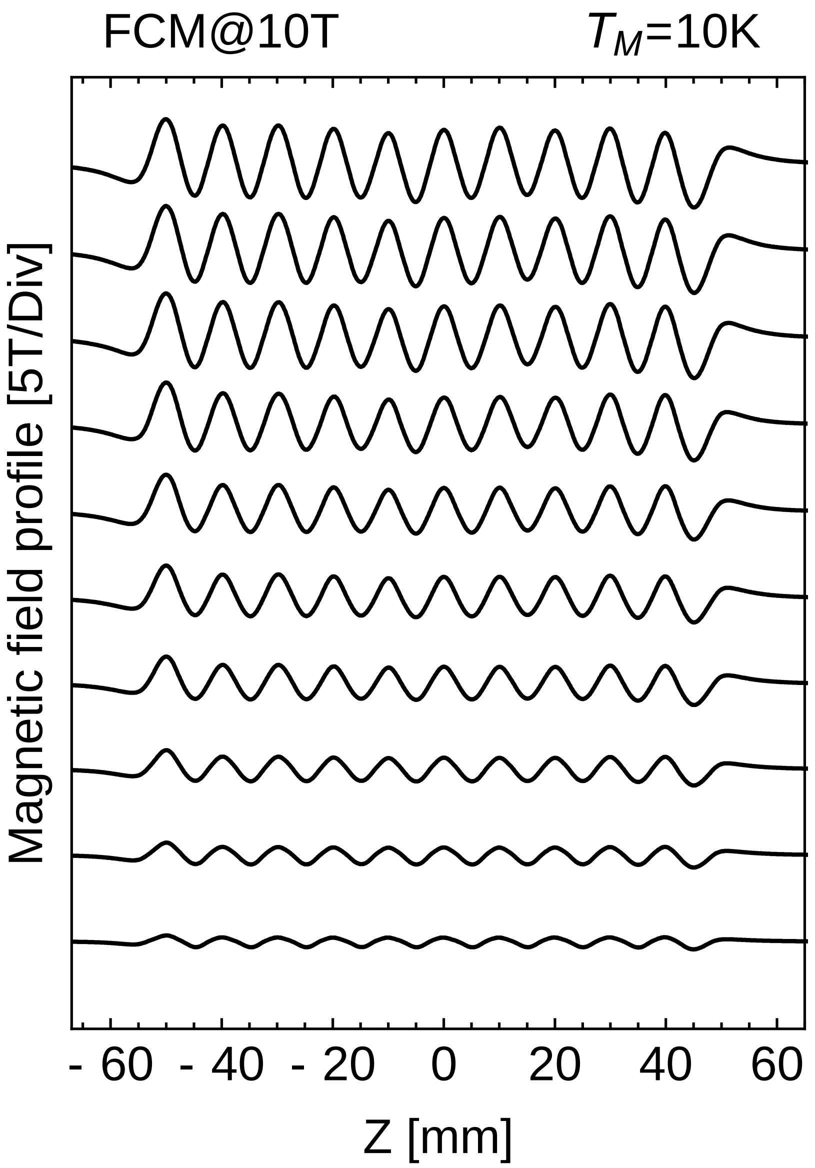


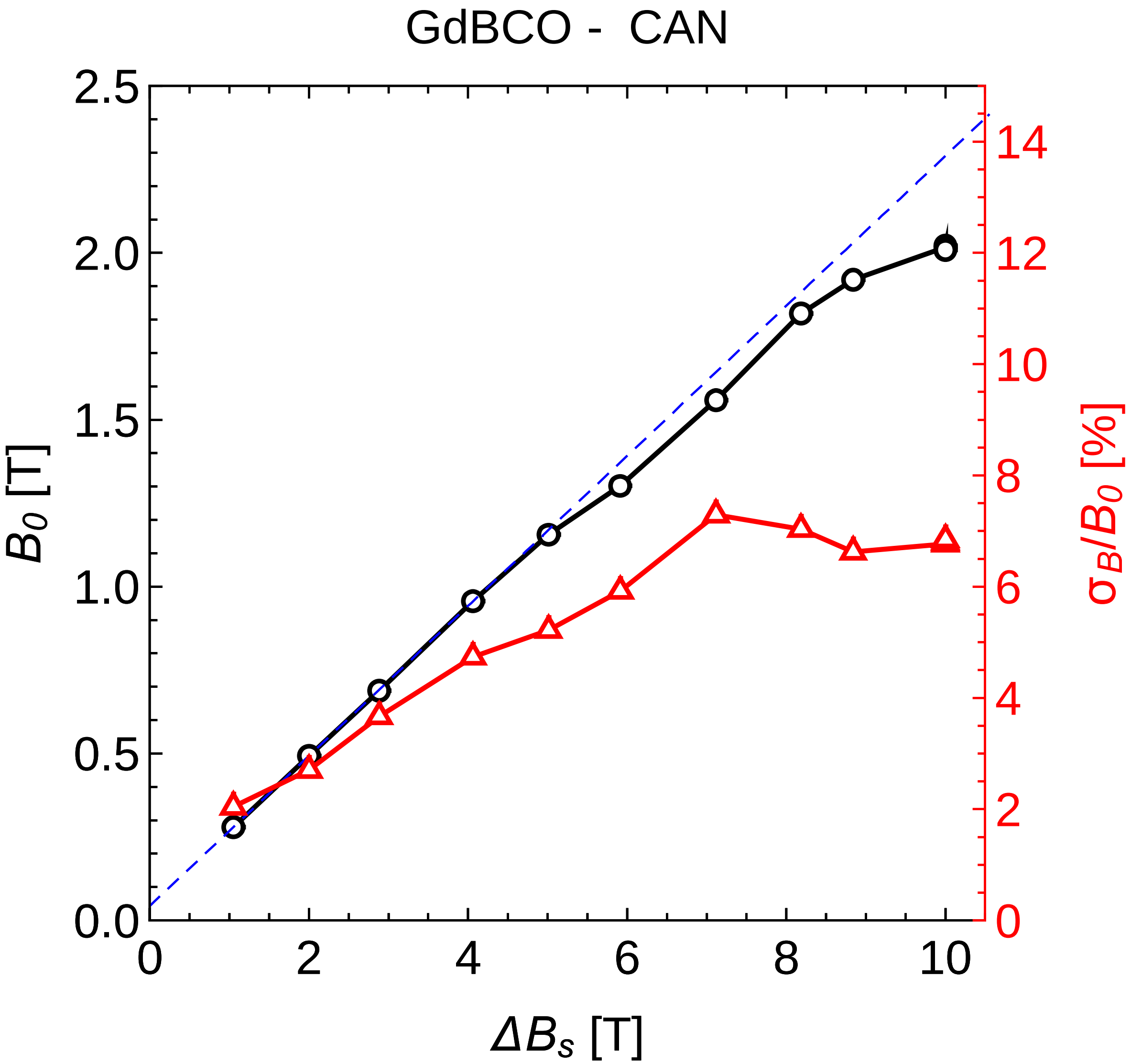


Planar Hybrid: CAN-SUPERCONDUCTOR





Planar Hybrid: CAN-SUPERCONDUCTOR



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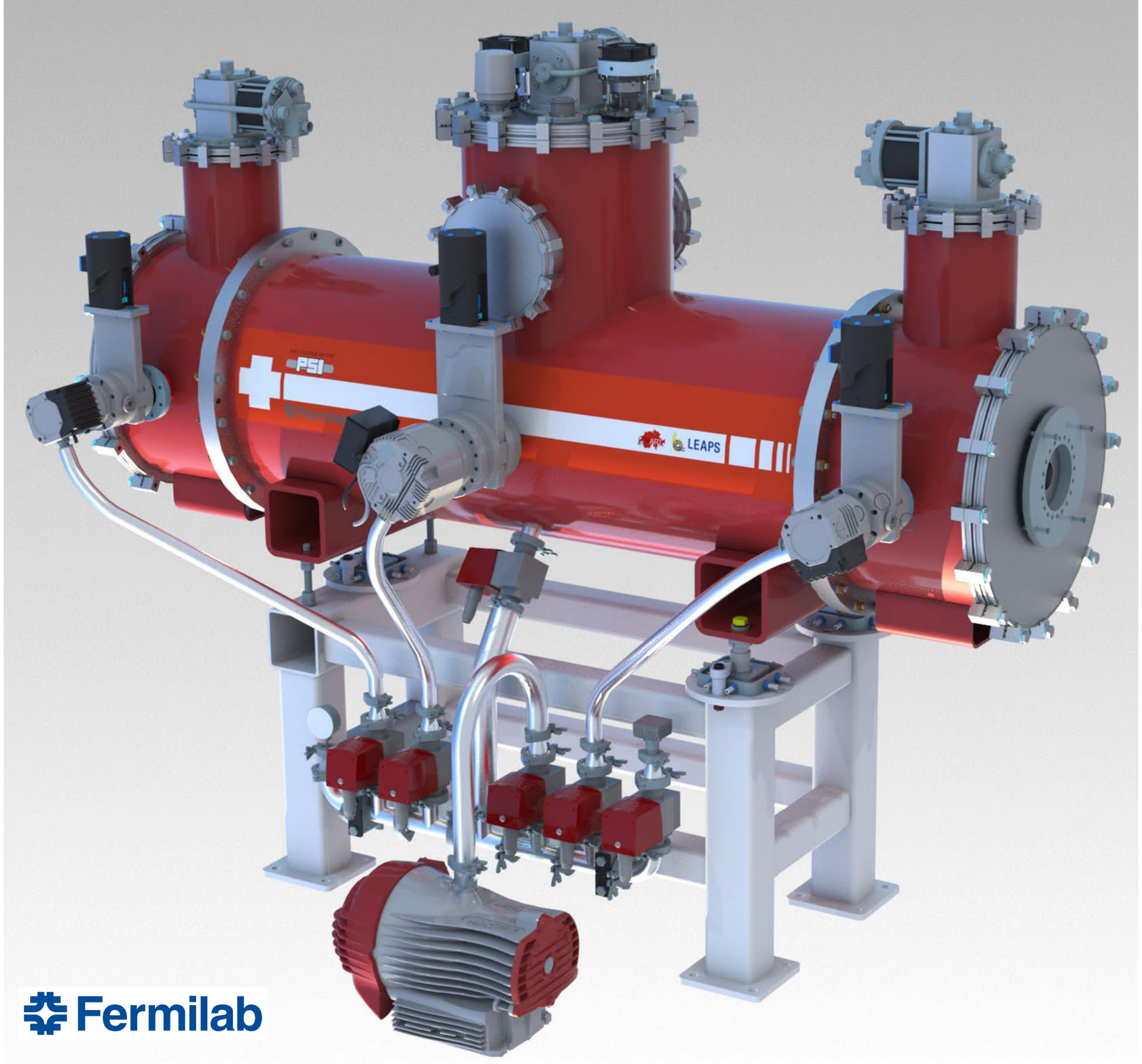
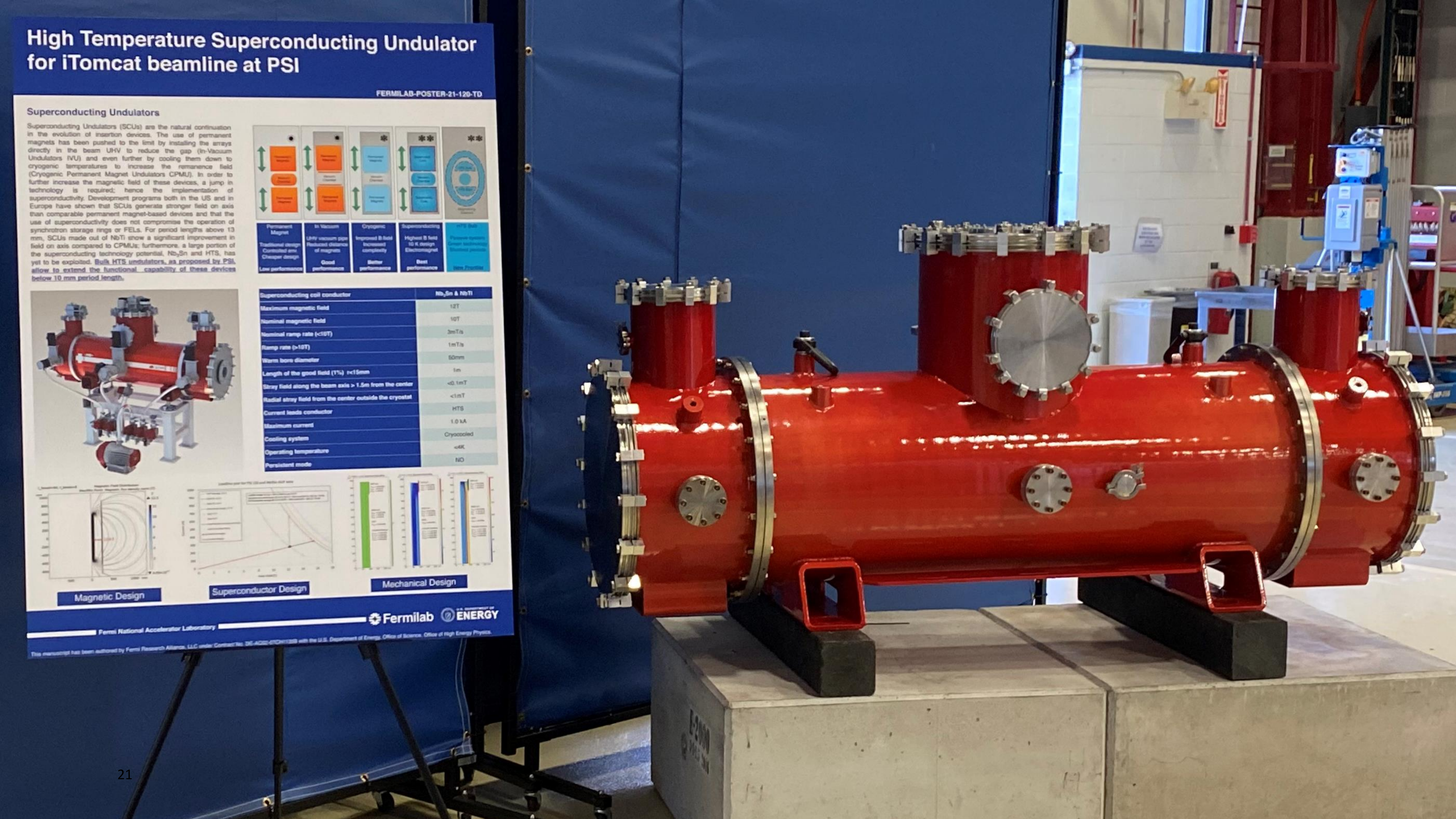
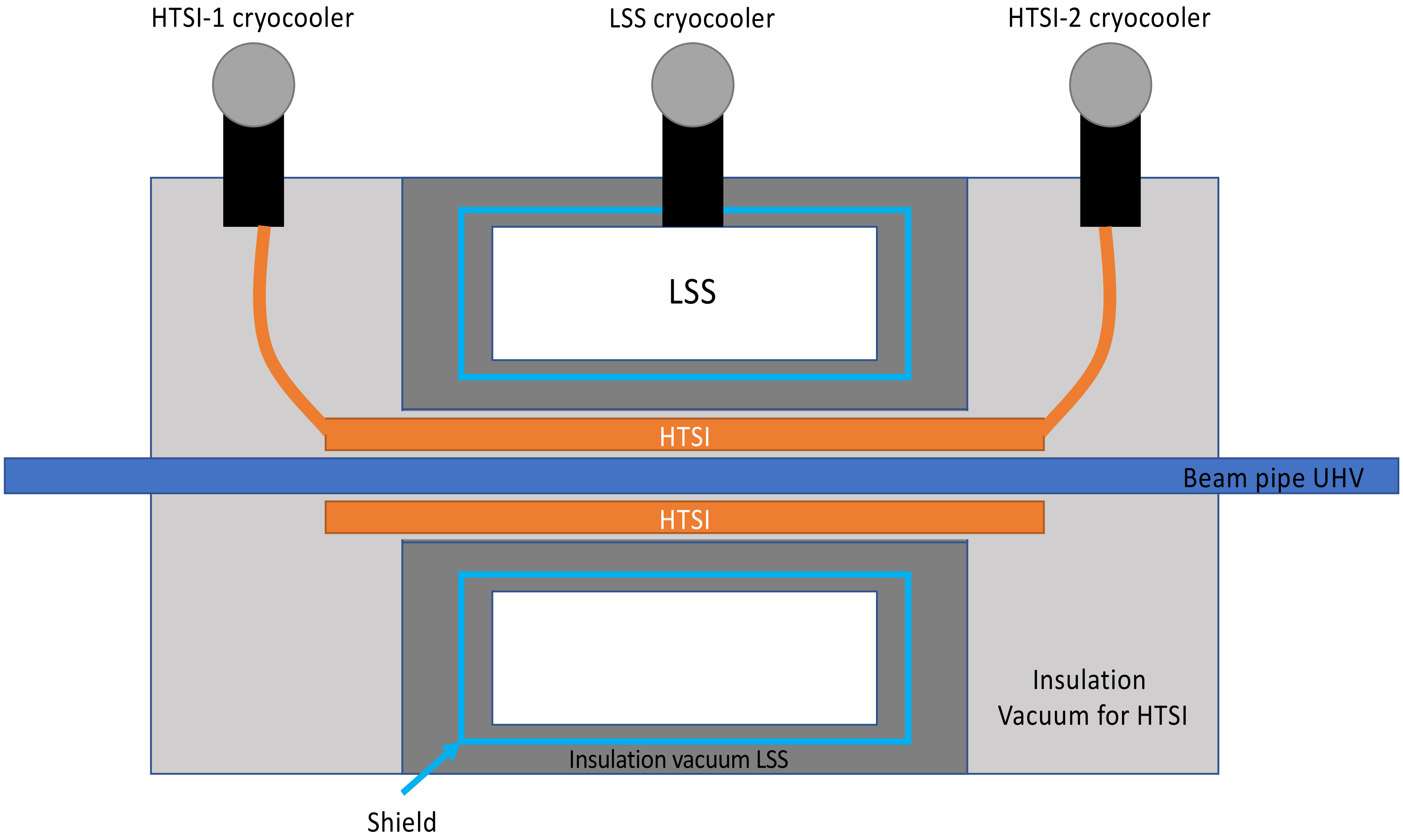


THE METER LONG PROTOTYPE

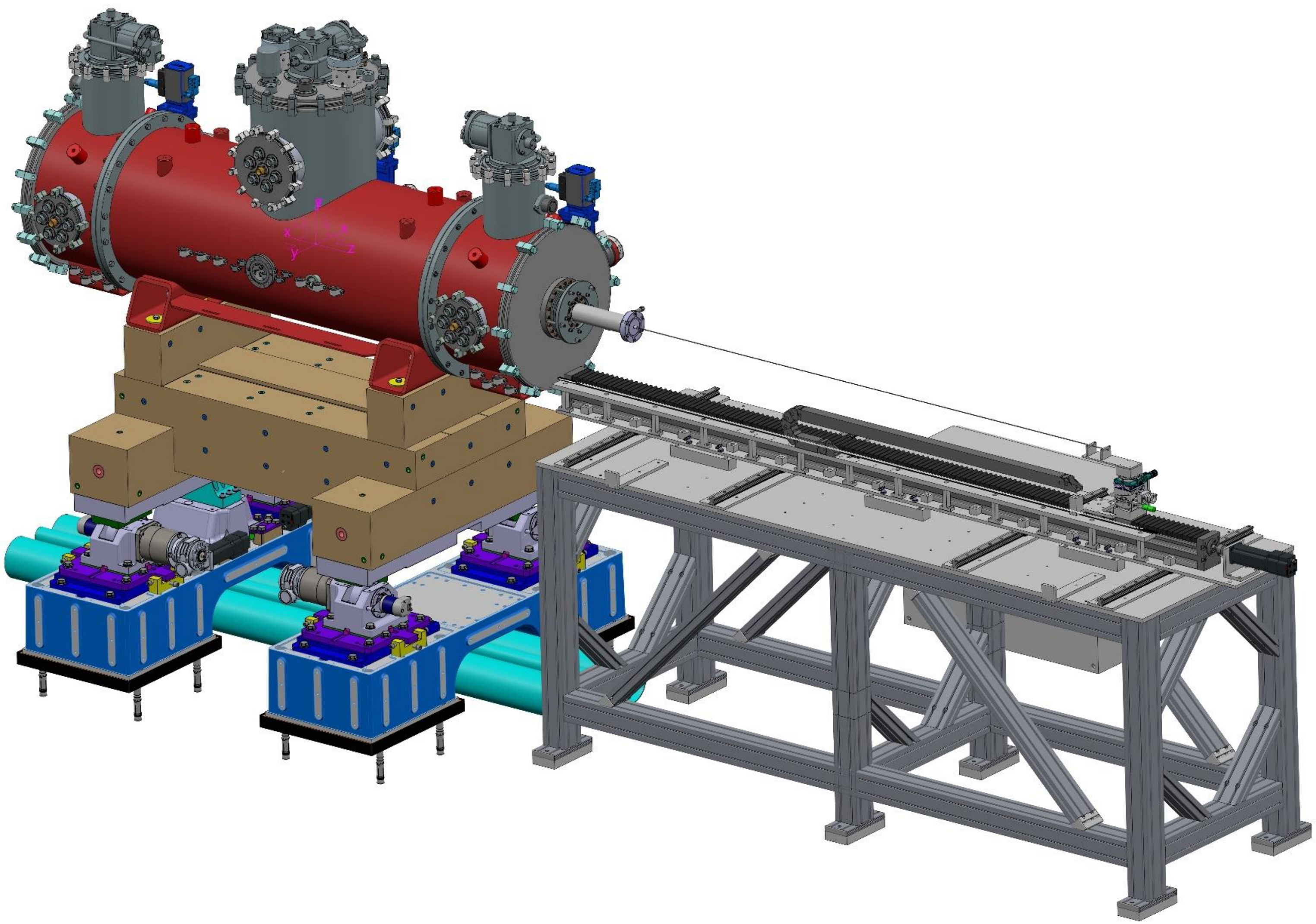
Active length : 1.0 m
Total length : < 2m
period length : 10.5 mm
magnetic gap : 4.5 mm
$B_0 \sim 1.8$ T
Cryocoolers
HTS Mag-temp 10K
LTS temp 4.0K


High Temperature Superconducting Undulator
for iTomcat beamline at PSI
FERMILAB-POSTER-21-120-TD
Superconducting Undulators
Magnetic Design
Superconductor Design
Mechanical Design
Fermilab
ENERGY
Fermi National Accelerator Laboratory

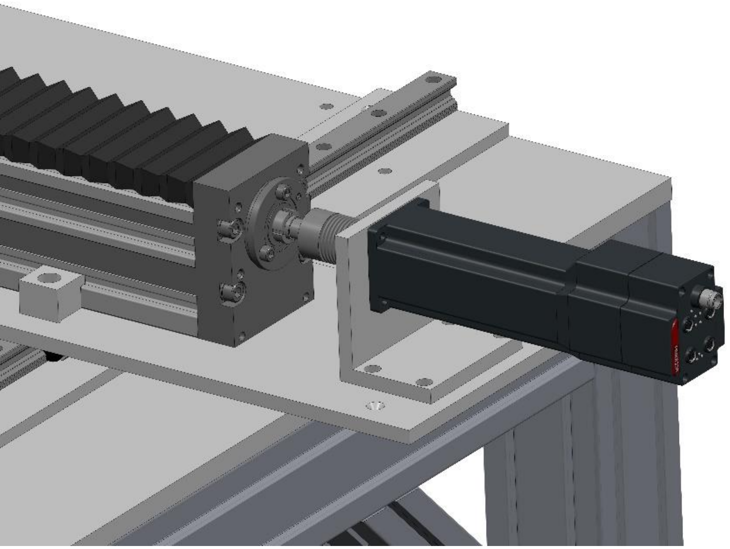
Cooling scheme

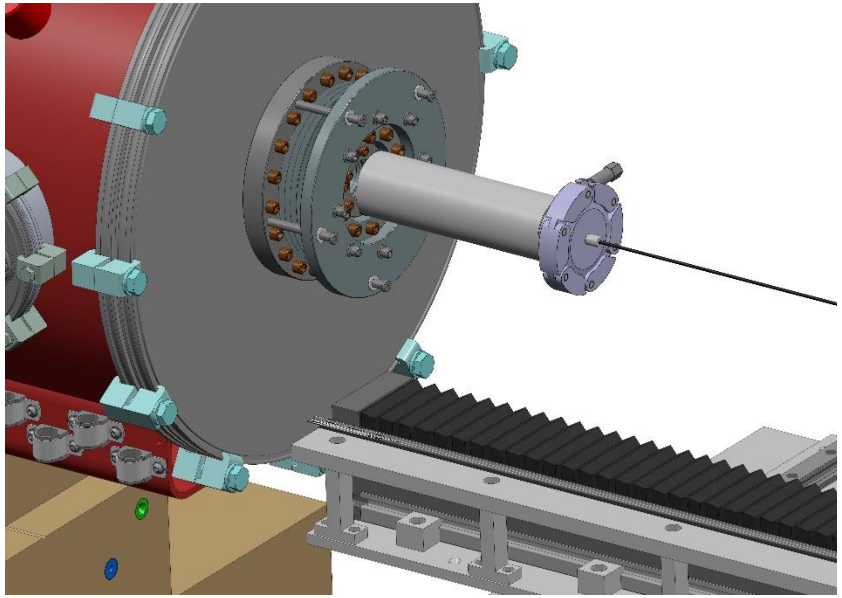


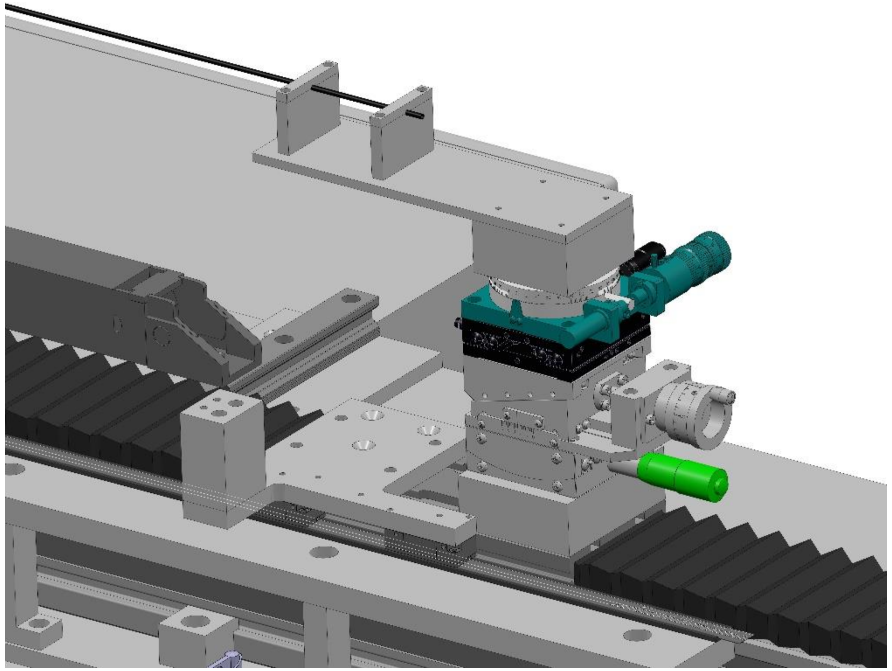
Horizontal measurement bench



Horizontal measurement bench

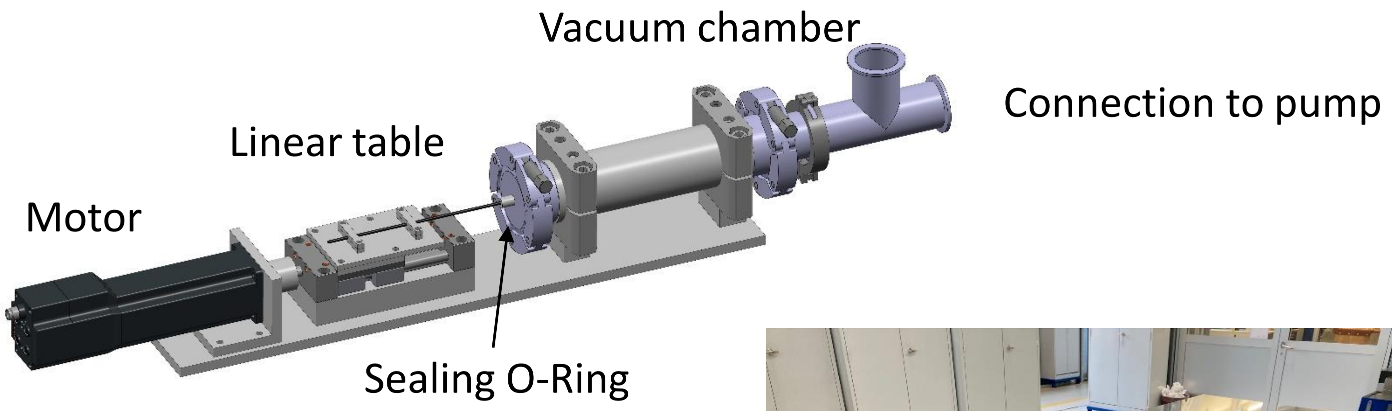


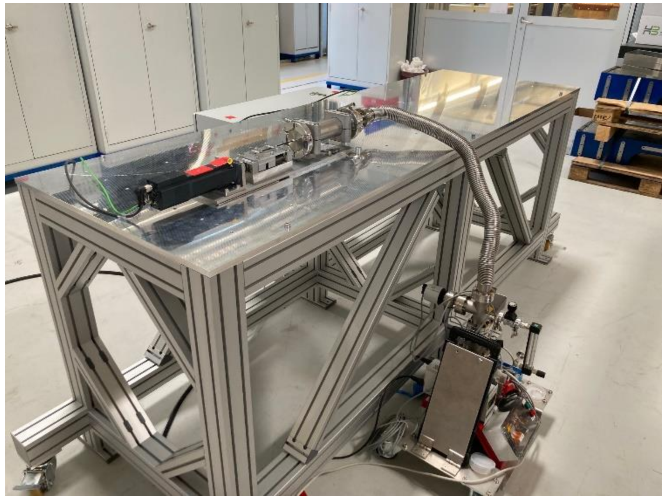




Horizontal measurement bench

- Tested the sealing of the vacuum insert with an O-ring
- Vacuum remains stable, but the cryogenics are also a concern





Conclusions & outlooks

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- We demonstrated high magnetic field in a short sample staggered array undulator made of GdBCO bulks high temperature superconductors.
- With 5 Hall probes, we were able to measure the undulator field vertically in the short sample
- We are now working on the measurement bench for the meter-long undulator, expected to arrive in early 2025

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