RECENT DEVELOPMENTS OF HTS MAGNETS FOR POLARIZED NEUTRON SCATTERING

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HTS-110 , New Zealand

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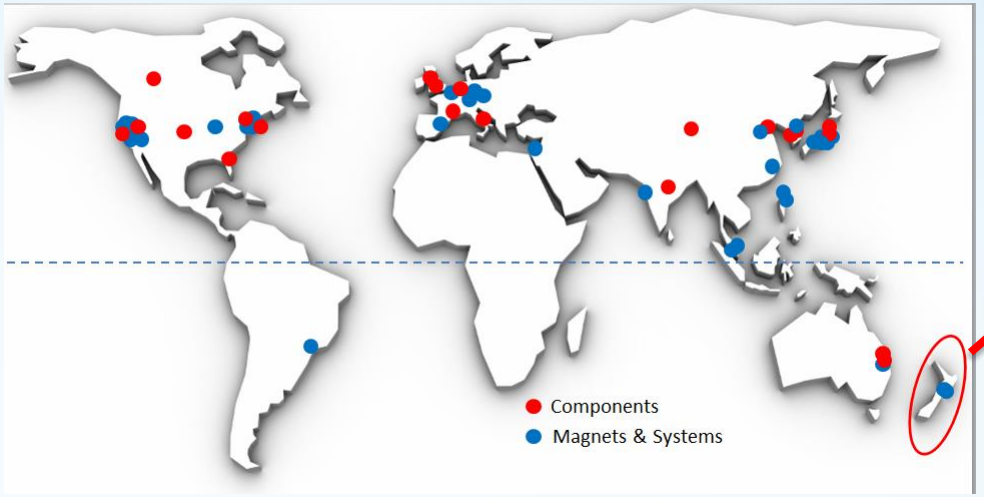
Outline

- Introduction
- Review of symmetric, passive shielding HTS magnets developed polarized neutron scattering
- Recent developments of a new asymmetric, active shielding HTS magnet for polarized neutron scattering
- Summary

What is HTS-110

- HTS-110 is a New Zealand company specialising in the design and manufacture of HTS magnets
- Established in April 2004 building on 20 years of HTS R&D in government research labs.
- Owned by Scott Technology, a listed New Zealand company.



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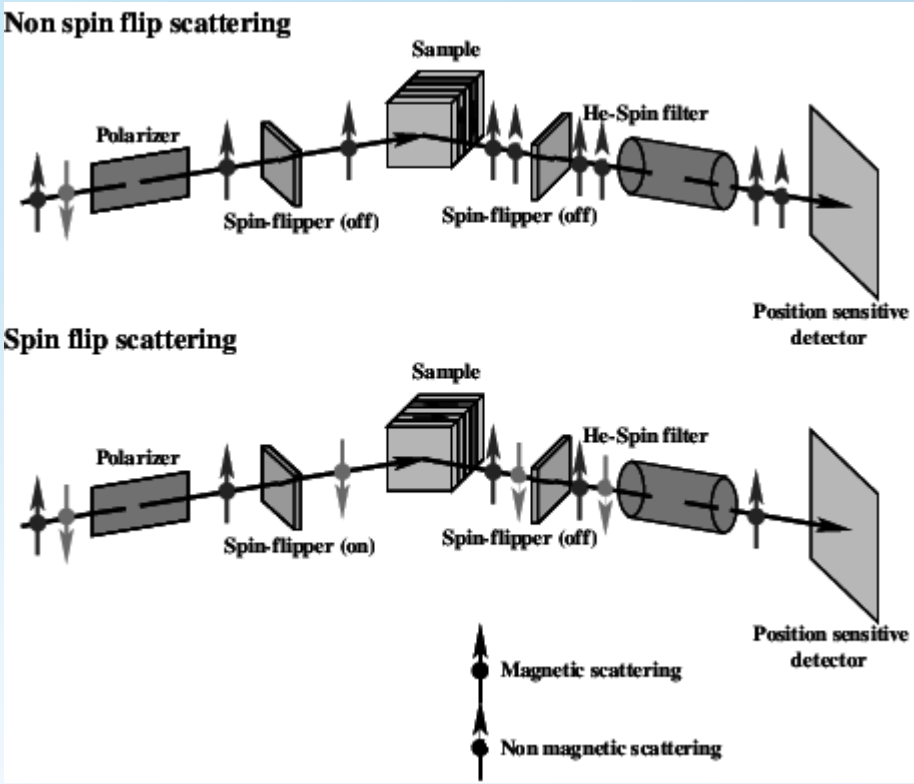
Magnet requirements for polarized neutron scattering

- Polarized neutron scattering is a powerful tool for probing magnetic structures.
- One of the key issues of polarized neutron scattering experiments is to maintain the polarization of a neutron beam on its way through the main field inside and the fringe field outside a high field superconducting magnet. It is required adiabatic passage across the entire beam cross-section.
- In addition, ^{3}He spin-filter cells extensively used for polarization and analysis of the neutron beam are very sensitive to the fringe field. It is required very low fringe fields at the positions of polarizer and analyser.

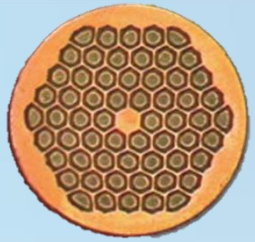


Experimental setup for neutron polarization analysis by Wolff et al.(2006)

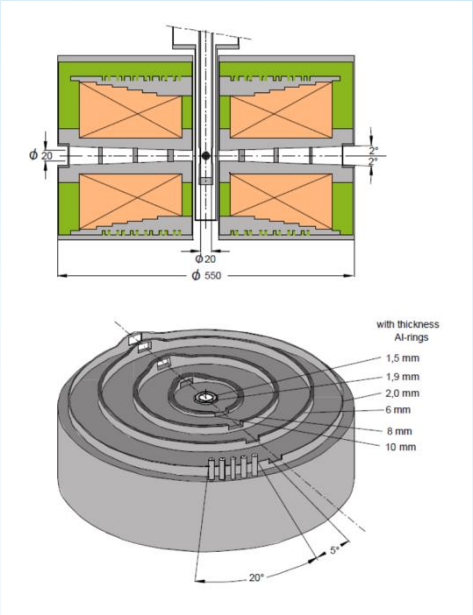
Conventional LTS magnets for polarized neutron scattering

- Wire: NbTi or Nb_3Sn
- Split pair geometry
- Horizontal or vertical field configuration
- Symmetric or asymmetric mode (for polarised neutrons)
- Compatible with VTI
- Active shielding to reduce magnetic fringe fields
- Coil support with Aluminium rings, or “wedge” pillars
- Cooling: mostly LHe wet or recondensing systems

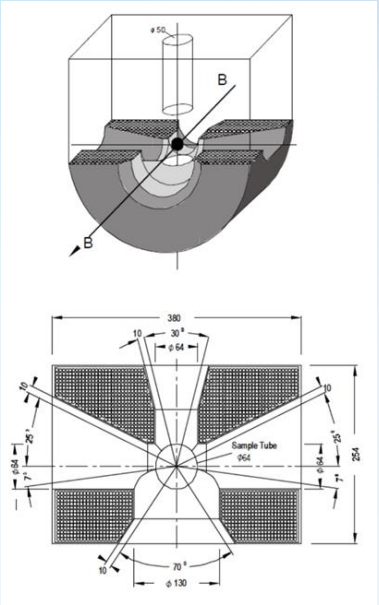
NbTi Wire in channel



Nb_3Sn wire



Vertical configuration



Horizontal configuration

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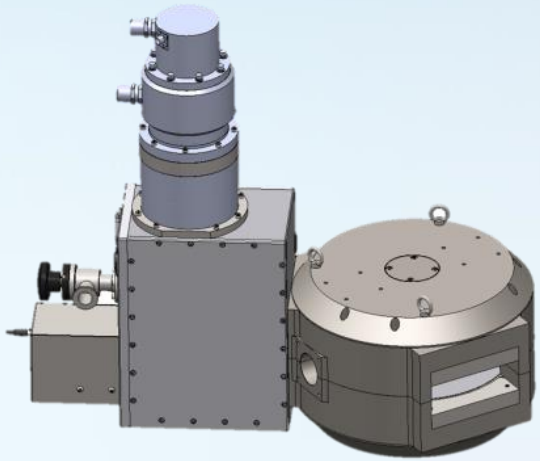
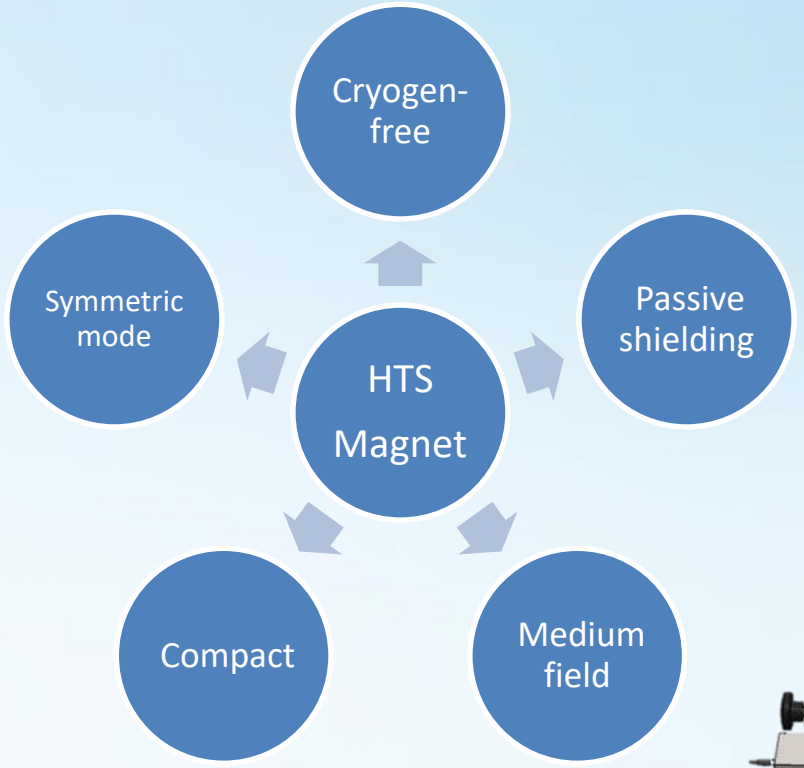
HTS magnets for polarized neutron scattering





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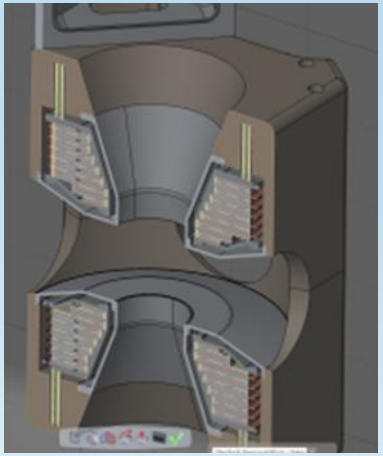
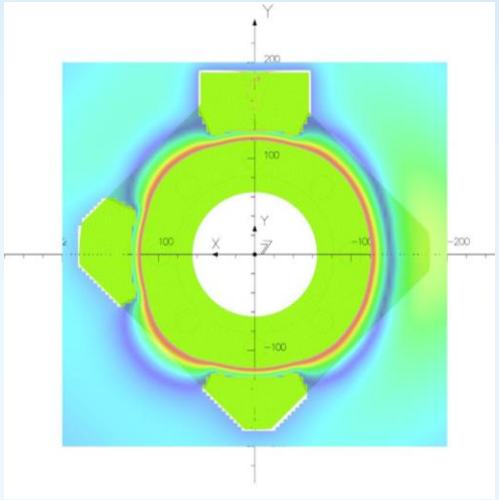
Type I HTS magnet

Description	Value
Peak Central Field	> 2.3 T
Sample volume	Ø25 mm
Vertical room temperature bore	2 X Ø80 mm with an opening angle of 40°
Horizontal room temperature bore	2 X Ø80 mm with an opening angle of 40° 1 X Ø80 mm with a horizontal opening angle of 150° and a vertical opening angle of 40°
Fringe field at distance of 1.8 m from centre of magnetic field	5 Gauss
Field homogeneity in 15 mm DSV	< 2%
Maximum current	220 A
Ramping rate to full field	< 10 min
Cool-down time	< 1 day
Dimensions	363 x 596 x 794 mm
Mass - magnet and cryocooler (Approx.)	185 kg
Mass – compressor (F-70L)	100 kg





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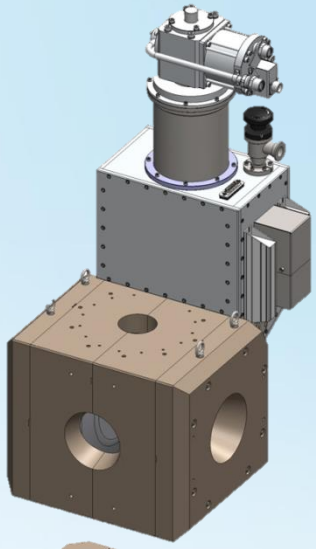
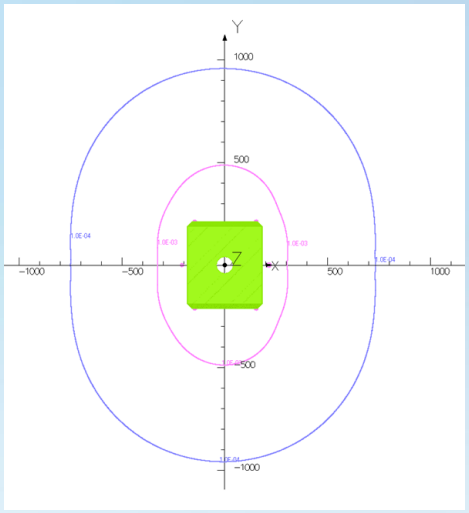
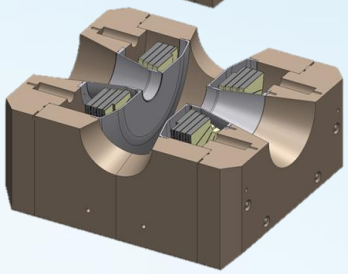
Type II HTS magnet

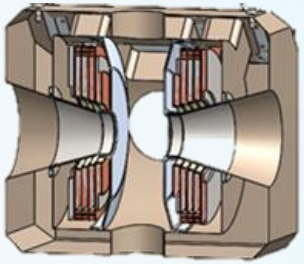
Description	
Peak Central Field	> 3 T
Sample volume (Diameter Spherical Volume)	21 mm
Vertical sample access	Ø81 mm
Horizontal opening angle	±16°
Zero field nodes	Outside of the magnet body
Fringe field at 0.4 m outside of the magnet shielding in the direction perpendicular to the field	< 10 Gauss
Field homogeneity in 21 mm DSV	< 3.5%
Field homogeneity in 15 mm DSV	< 2%
Zero-field nodes	Outside the magnet cryostat
Maximum current	225 A
Ramping rate	0.6 T/min
Cool-down time	1 day
Dimensions	< 550 x 550 x 1000 mm
Mass - magnet and cryocooler (Approx.)	< 360 kg
Mass – compressor (F-70H)	100 kg

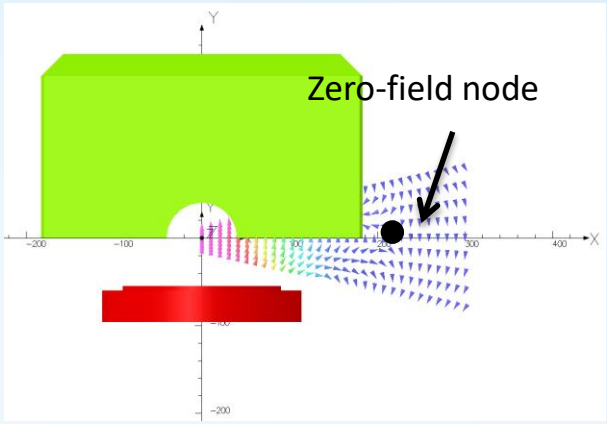




Fringe fields







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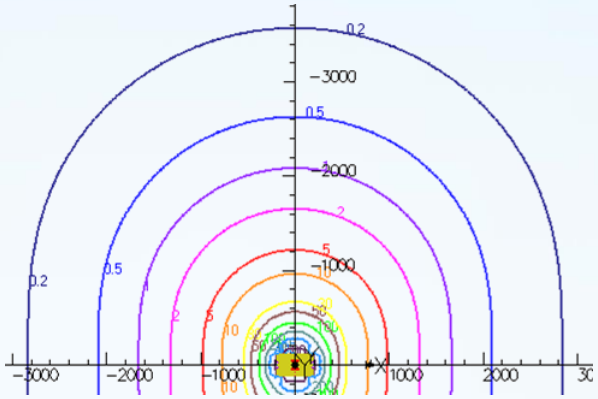
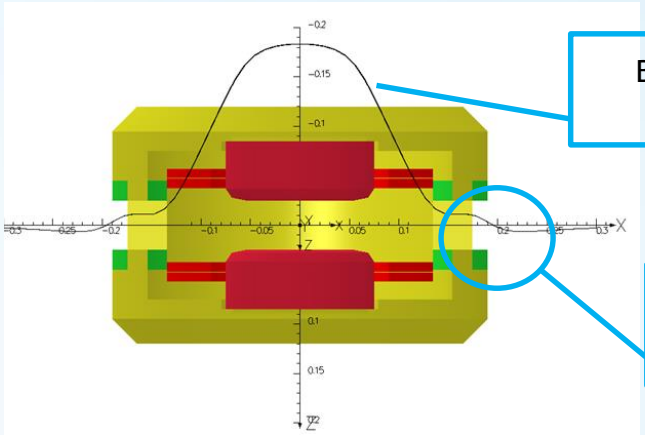
Type III HTS magnet

Vertical field up to 3 T

- 52 mm pole gap
- Sample (beam) access: 52 X 160 mm
- Ø52 mm transverse access
- Cool-down time: 30 hours
- Fringe field: < 5 Gauss (at 1 m)
- Weight: 180 kg
- Dimensions: 711 X 577 X 684 mm
- Optional magnetic field entry/exit correction





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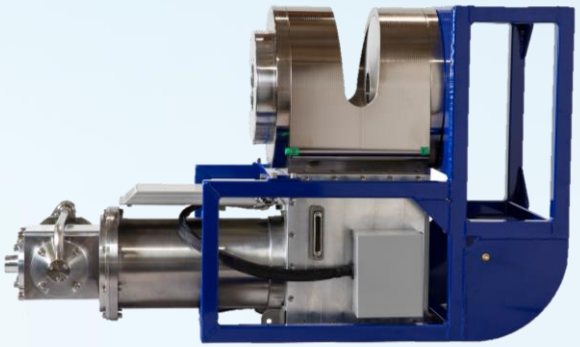
2.5 T HTS magnet for x-ray scattering

Description	Value
Peak Central Field	>2.5 T
Magnetic field	Variable fields form 0 to 2.5 T
Magnet type	Cryogen-free
Field orientation	Vertical and horizontal
Field homogeneity in 10 mm DSV	±0.7%
Axial room temperature bore	Ø50 mm
Axial Bore Length to Magnet Centre	130 mm
Horizontal room temperature bore	Ø50 mm with a horizontal opening angle of 180° and a vertical opening angle of ±5°
Cryostat Radius	130 mm
Magnet Center to BSA Support	< 380 mm
5 Gauss line in the axial direction to magnet centre @2.5 T	< 1.4 m
5 Gauss line in the radial direction to magnet centre @2.5 T	< 1.1 m
Maximum operating current	230
Dimensions	509 X 395 X 703 mm
Maximum ramping time	< 3 minute
Cool-down time	< 24 hours
Peak inductance (approx.)	0.55 H
Mass – magnet, cryocooler and cradle (approx.)	112 kg
Mass - compressor	100 kg



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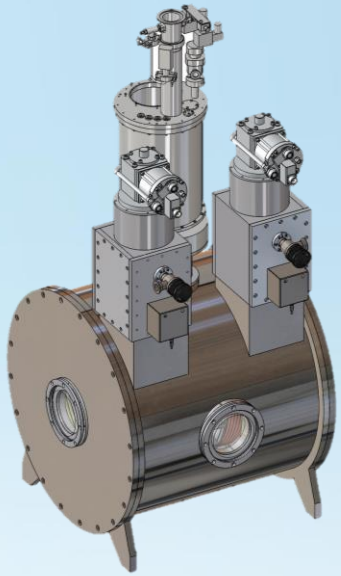
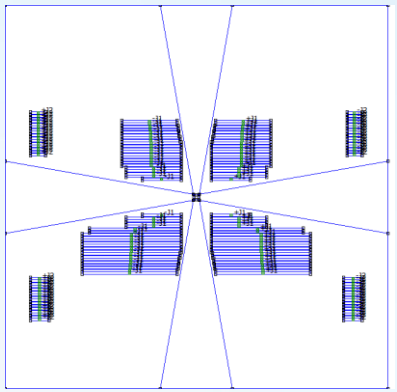
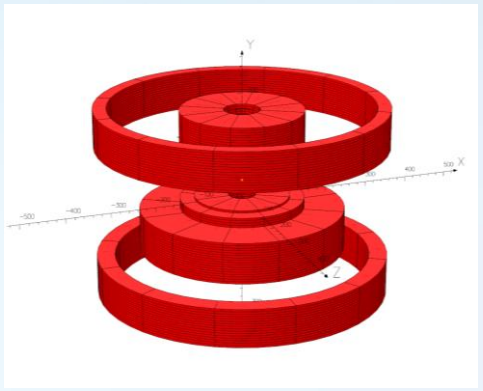
10 T asymmetric, active shielding magnet

Description	Value
Peak Central Field	10 T
Field orientation	Horizontal
Sample volume	10X10X10 mm
Vertical sample access	Ø50 mm
Horizontal neutron access	two beam path in vacuum, perpendicular to each other, , enclosed with sapphire window
Scattering angle	± 10°
Zero field node	outside the neutron beam
Fringe field at 1 m distance in the small coil axial direction	< 10 Gauss
Fringe field at 1 m distance in the radial direction	< 10 Gauss
Fringe field at 4 m distance in the big coil axial direction	< 0.5 Gauss
Field homogeneity in 1 cm^3	< 2.0%
Maximum current	225 A
Operating temperature	15 K
Inductance	27 H
Total energy	0.65 MJ
Ramping rate to full field	40 min
Cool-down time	5 day
Estimated Dimensions	800 x 750 x < 1500 mm
Estimated Mass - magnet and cryocooler	600 kg
Mass – compressor (F-70H)	2 X 100 kg







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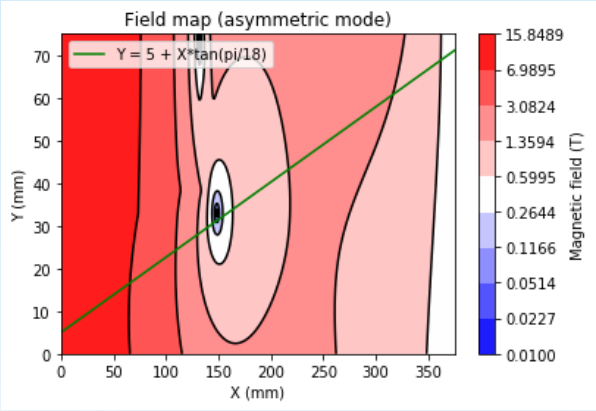

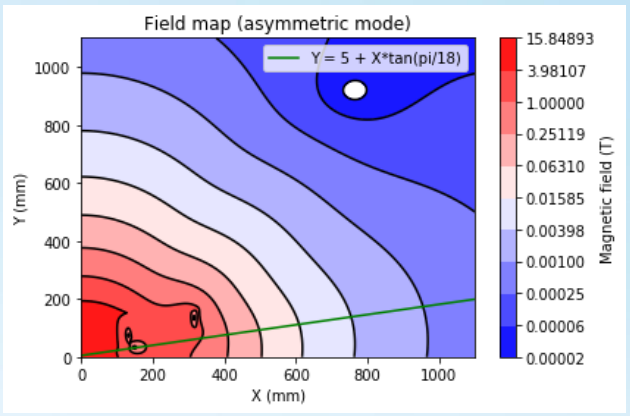

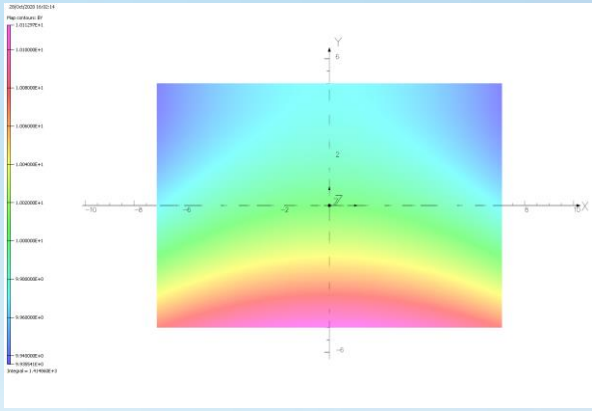

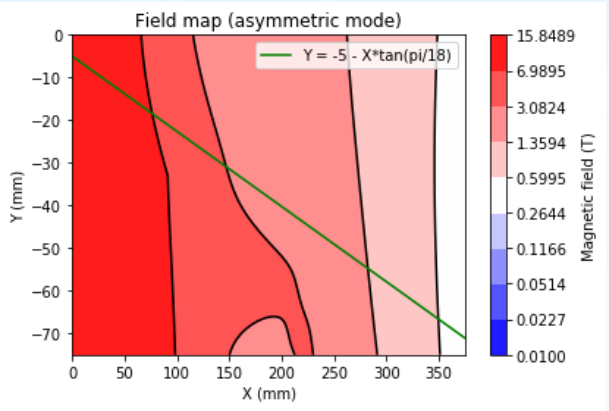

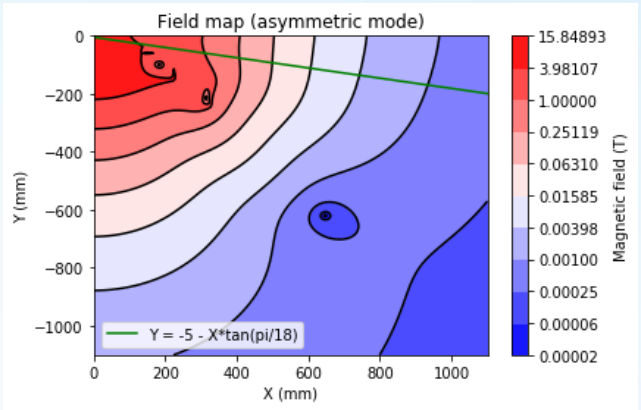

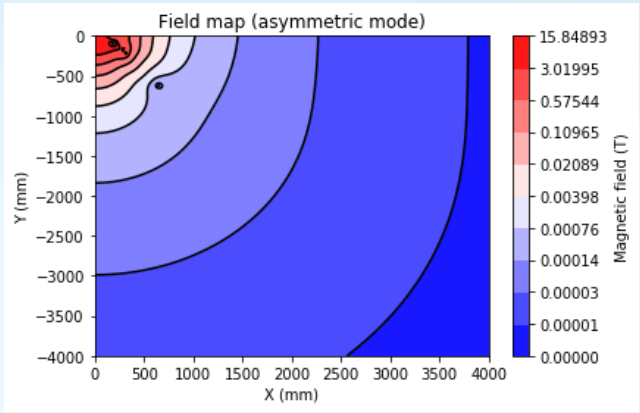

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Summary

- By exploiting the use of iron in the magnetic circuits, three types of passively shielded HTS magnets with symmetrical coils were successfully developed for polarized neutron scattering experiments over the last decade. These magnets are well used in neutron facilities worldwide. However, these magnets are designed to provide medium magnetic fields up to 3 T.
- Recently a horizontal, asymmetric and actively shielded HTS magnet for polarized neutron scattering is being developed by Heinz Maier-Leibnitz Zentrum (MLZ) and HTS-110 to provide a maximum magnetic field of 10 T with fringe fields less than 10 Gauss at 1 m from the magnetic centre. This design demonstrated HTS magnets would be a great candidate for polarized neutron scattering at higher fields.

Thank you for your attention!!!

Any questions?

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