Condensed matter research for LARMOR: Quantum phase transitions

Fei Li

PhD work announcement

- Development of hardware and software tools, as well as experiments on micro- and nano-structured condensed matter materials in collaboration with the University of Groningen.

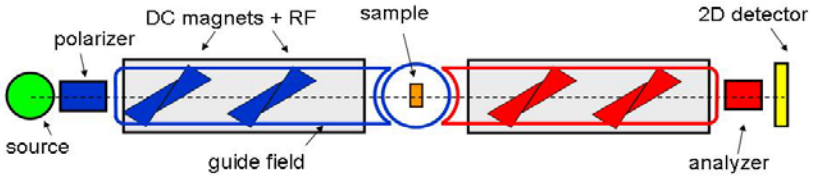
- Evaluation of instrument performance by comparing experimental results with computer simulations and modelling.

- The unique capabilities of the instrument will be utilised to study quantum phase transitions in condensed matter.

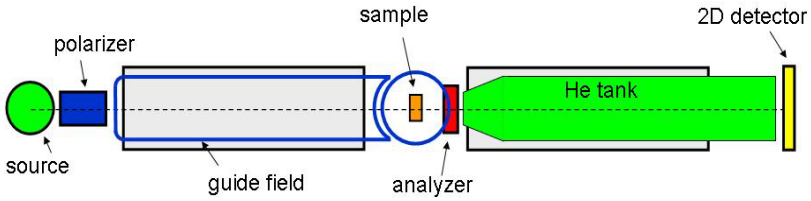
- A particular focus of the project is the interplay between structure and magnetism in materials with emergent properties that are manifestly quantum in origin. These systems challenge our fundamental understanding of the solid state and are also of technological relevance, as quantum criticality offers the possibility to functionalise and tune response and performance, such as in high T_c superconductors or multiferroics.

LARMOR options

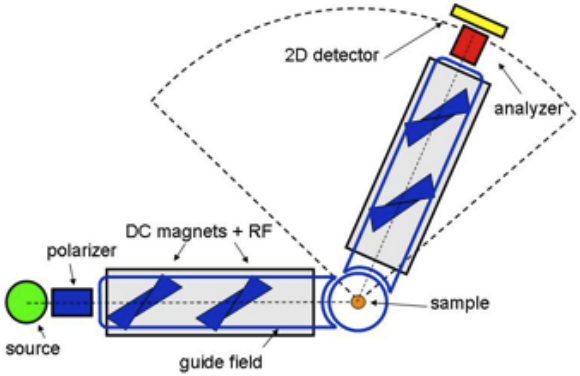
structure



Spin Echo Small Angle Neutron Scattering (SESANS)

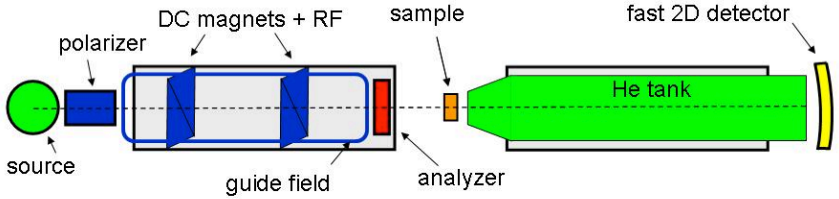


Small Angle Neutron Scattering (SANS)

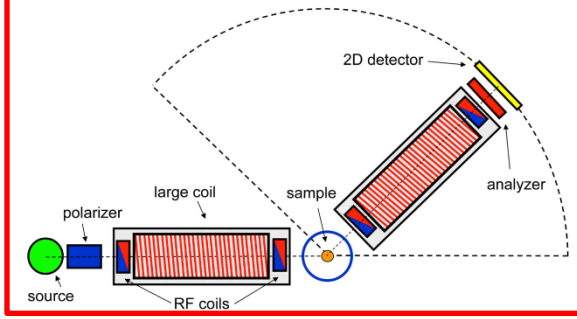


Larmor diffraction

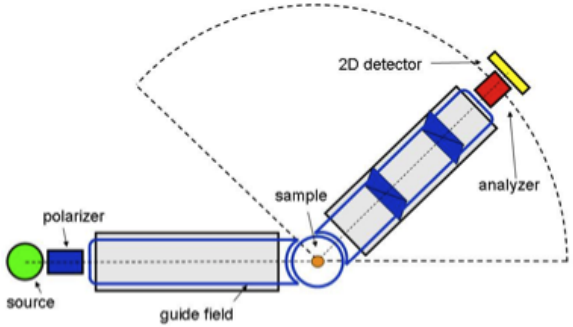
dynamics



Modulated Intensity Small Angle Neutron Scattering (MISANS)



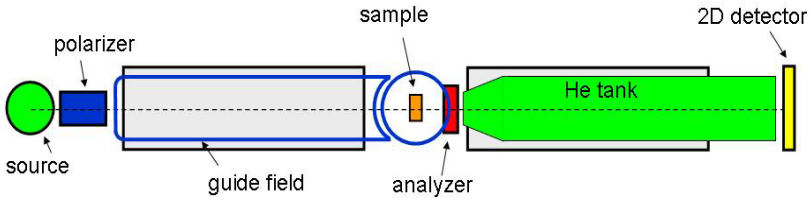
Neutron Resonance Spin Echo (NRSE)



Time-of-Flight Larmor labeling (TOFLAR)

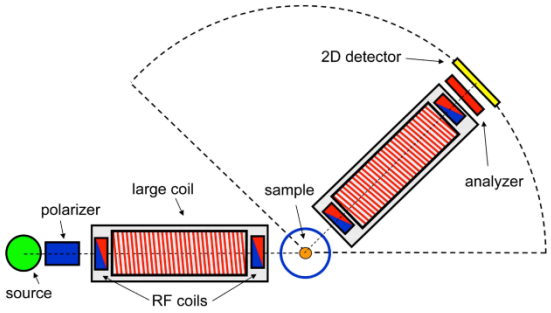
LARMOR options

structure



Small Angle Neutron Scattering (SANS)

dynamics



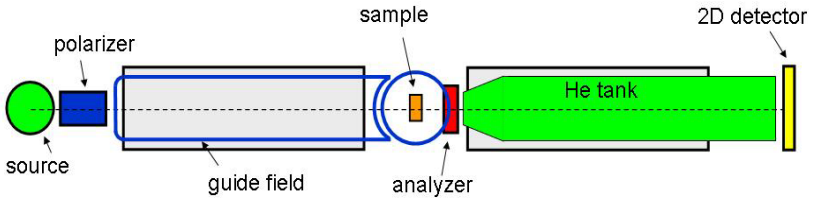
Neutron Resonance Spin Echo (NRSE)

⇒ **Role of (quantum) fluctuations in magnetic phase transitions in the SANS configutration**

⇒ **Ferromagnetic correlations**

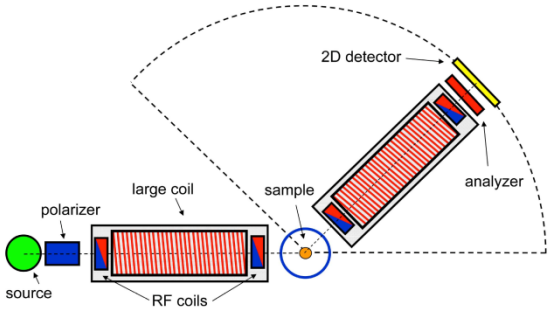
LARMOR options

structure



Small Angle Neutron Scattering (SANS)

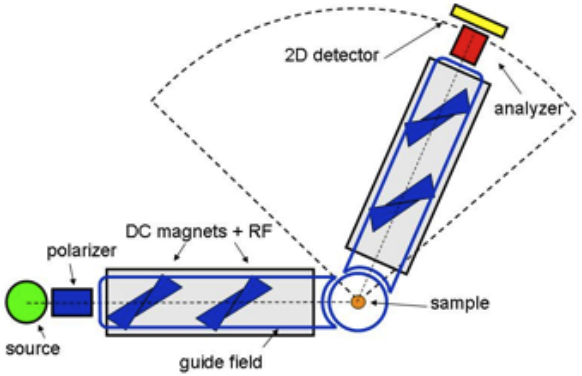
dynamics



Neutron Resonance Spin Echo (NRSE)

⇒ **Role of (quantum) fluctuations in magnetic phase transitions in the SANS configutration**

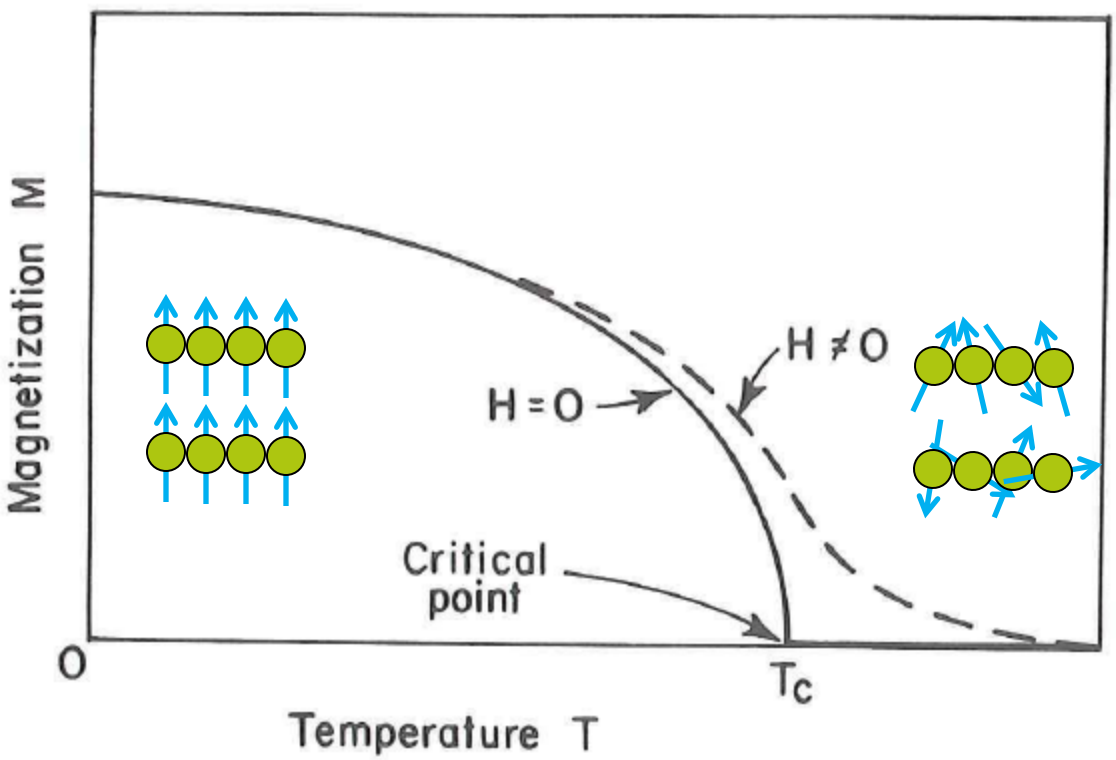
⇒ **Ferromagnetic correlations**



Larmor diffraction

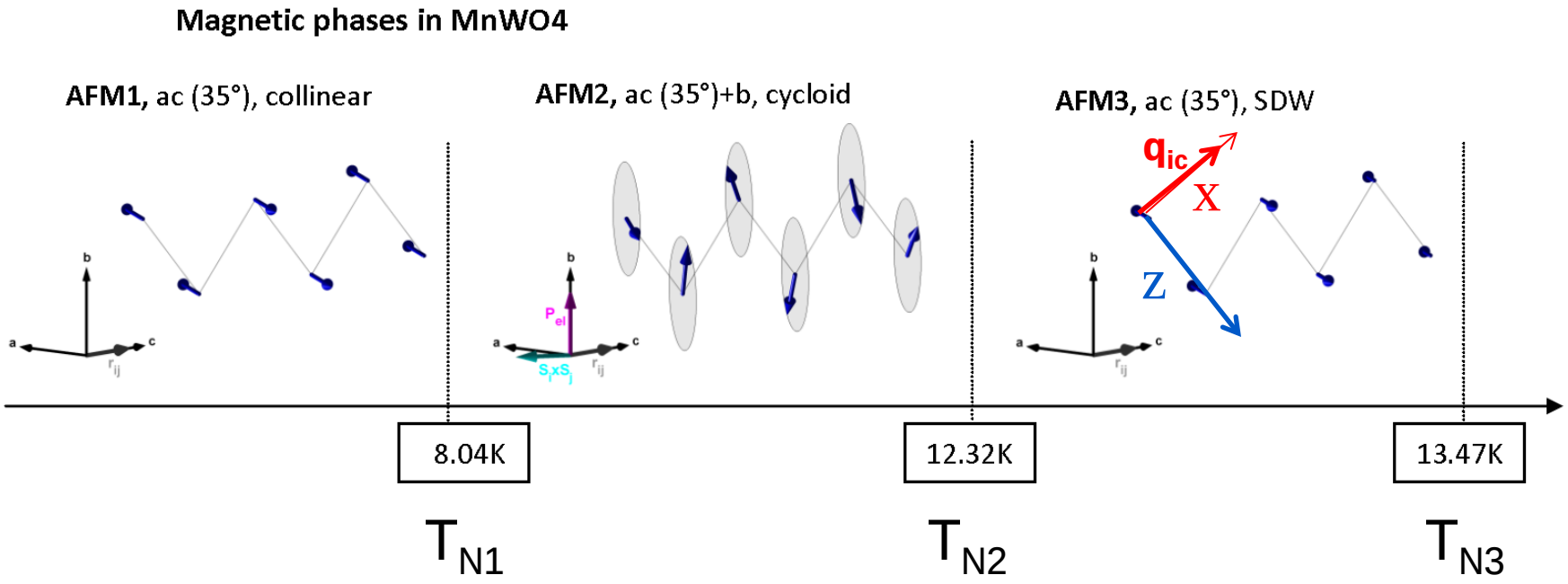
⇒ **Interplay between magnetism and structure**

What is a phase transition?



A typical ferromagnetic-paramagnetic transition.

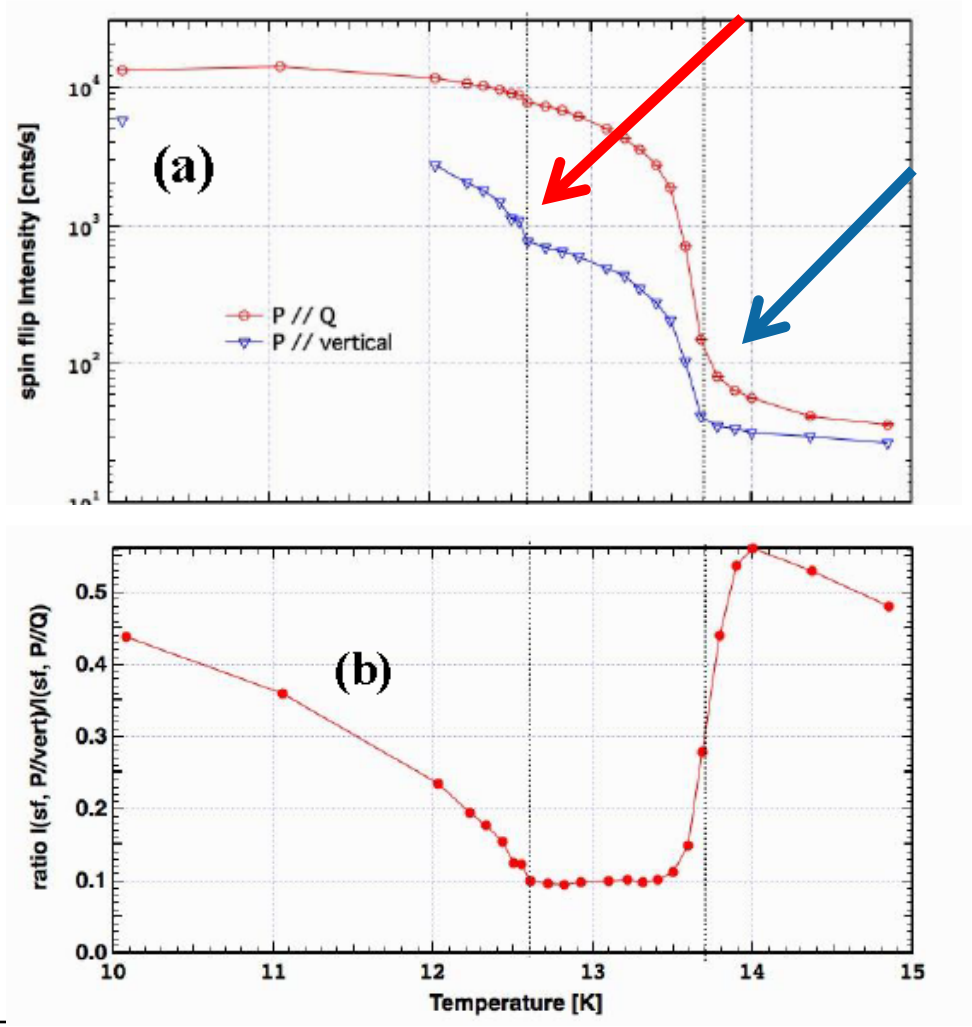
Phase transitions in multiferroic $MnWO_4$



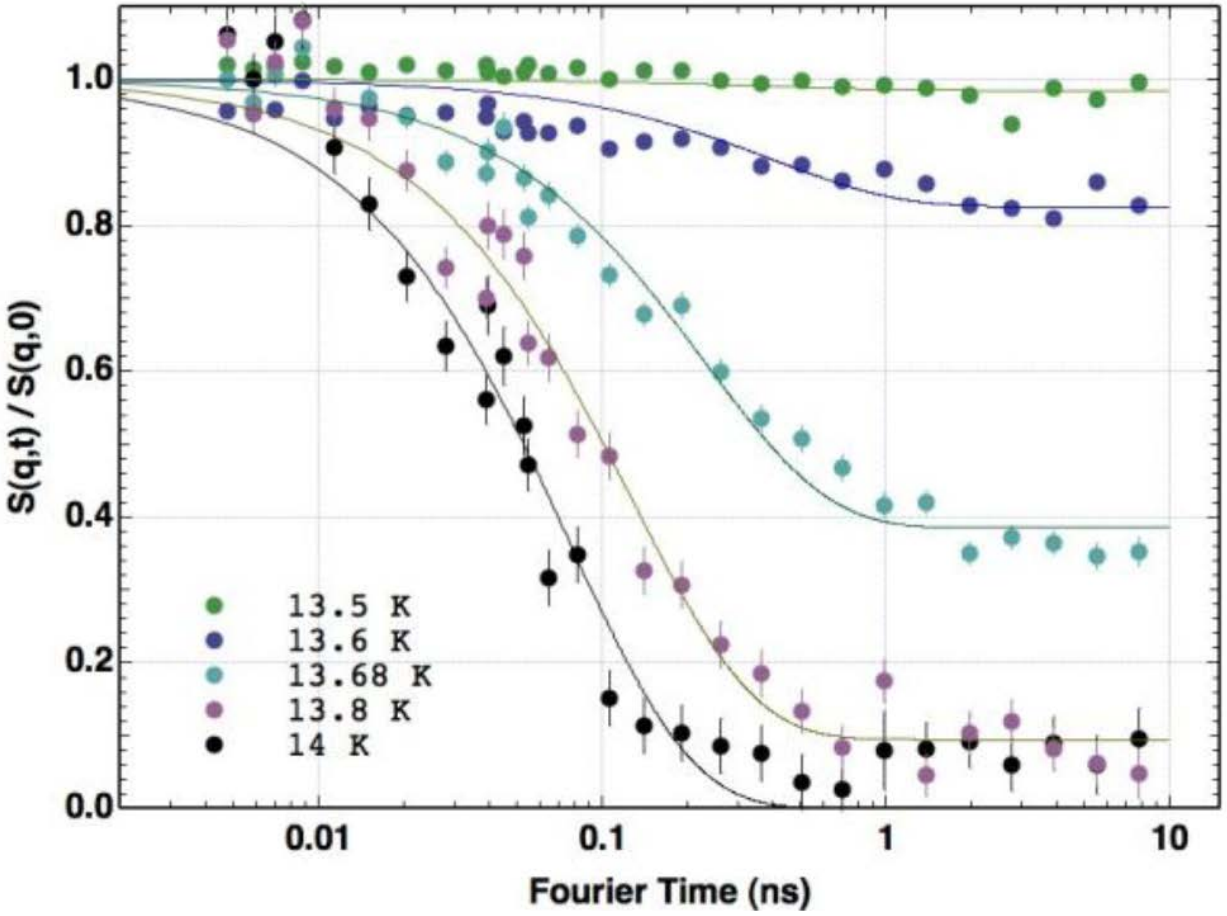
Experiments done at IN11-ILL, November 2014
Simon Holbein, Fei Li, Peter Fouquet,
Katia Pappas, Markus Braden

Phase transitions in multiferroic $MnWO_4$

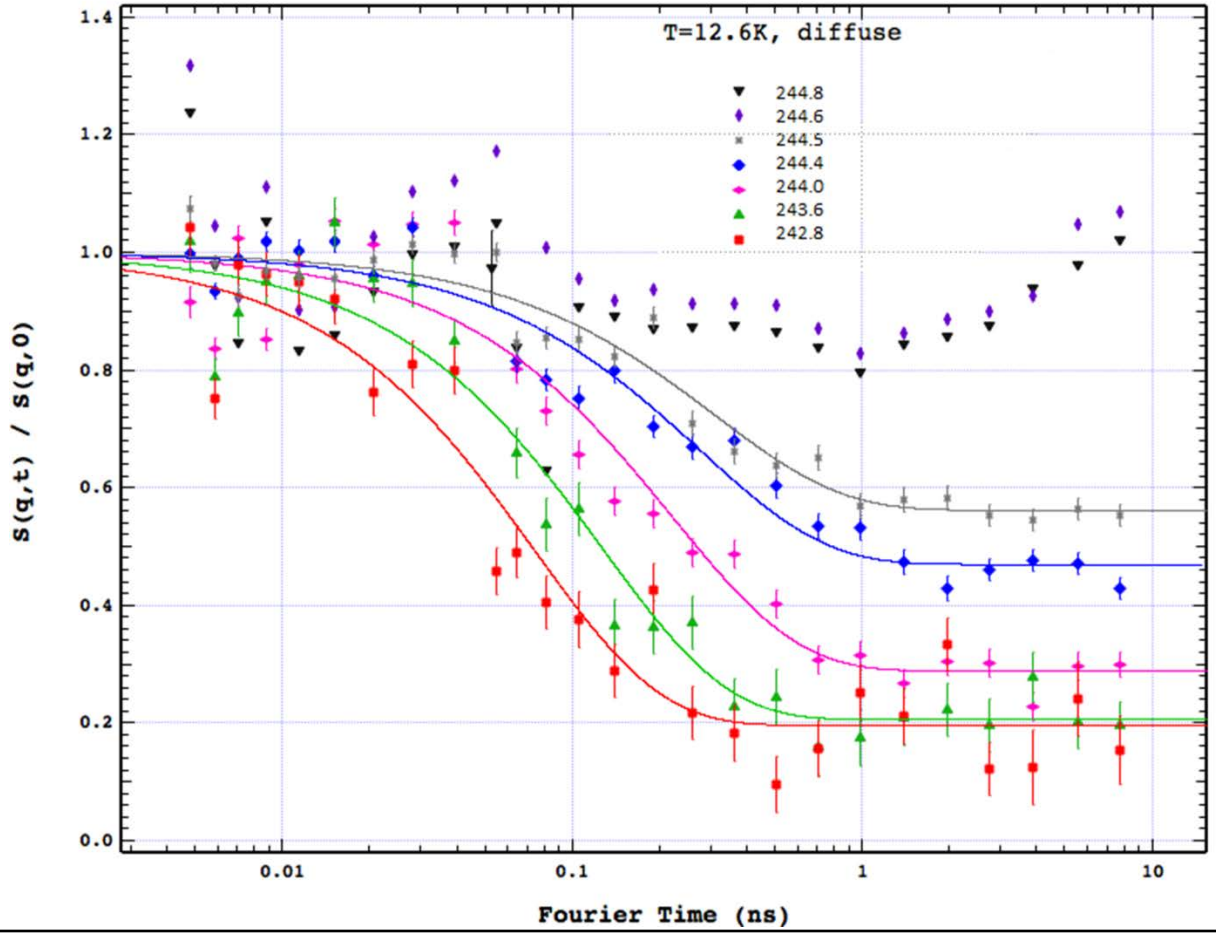
$\mathbf{q}_{ic}$= (-0.214, 0.5, 0.457)



NSE spectra close to T_{N3}



NSE spectra close to T_{N2}



Role of fluctuations in complex phase transitions unexplored

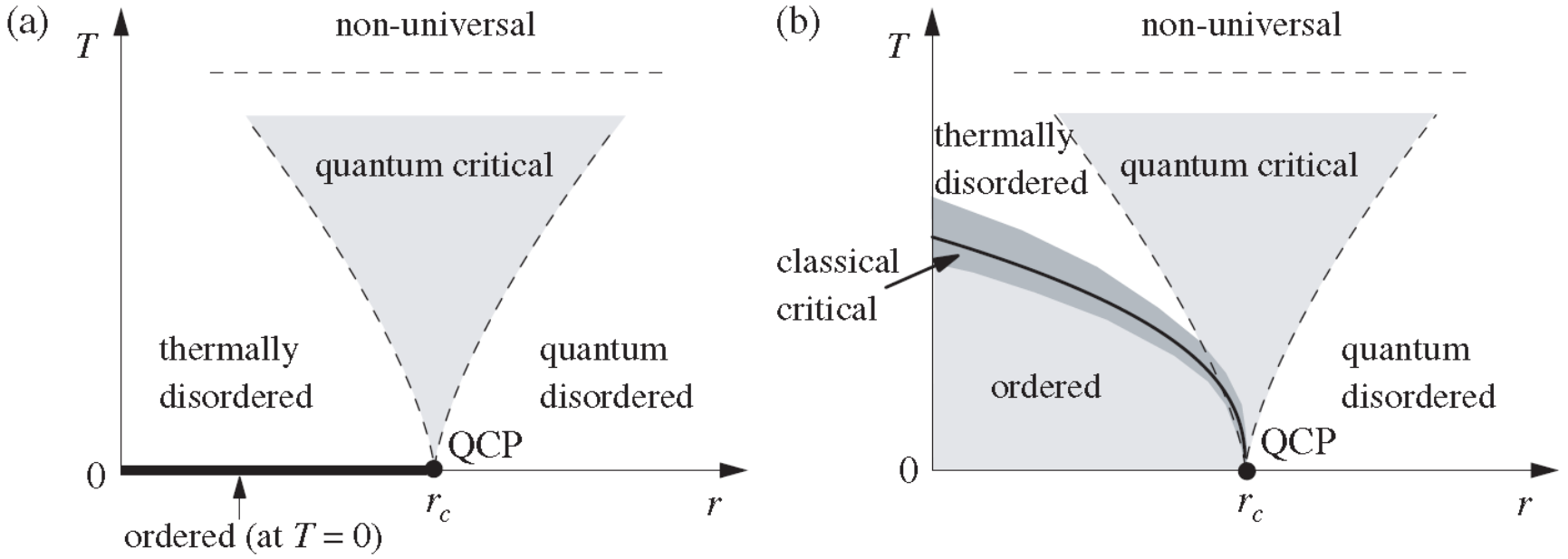
the case of quantum phase transitions

Quantum fluctuations exist which obey Heisenberg uncertainty principle.

- **Driven by non-thermal external control parameters**

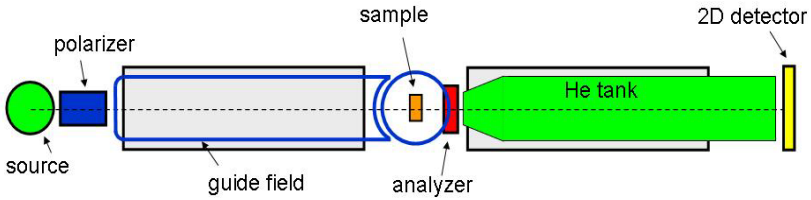
Pressure, magnetic field and chemical composition, etc.

Quantum phase transitions
Typical phase diagrams

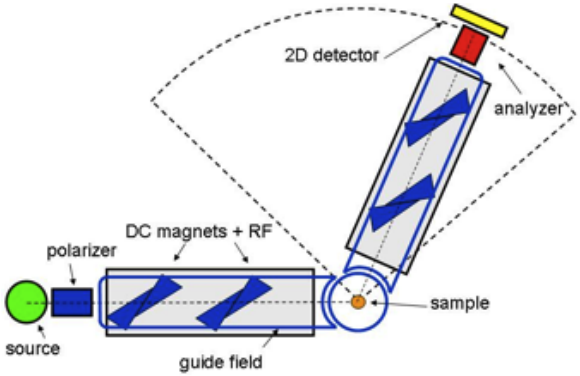


Potential of Neutron Spin Echo spectroscopy and Larmor diffraction unexplored

structure

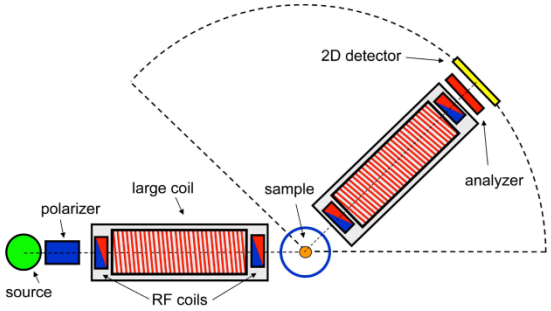


Small Angle Neutron Scattering (SANS)



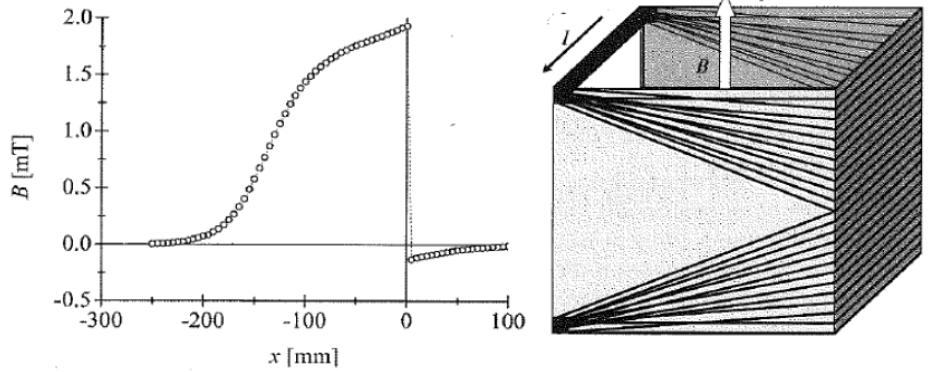
Larmor diffraction

dynamics

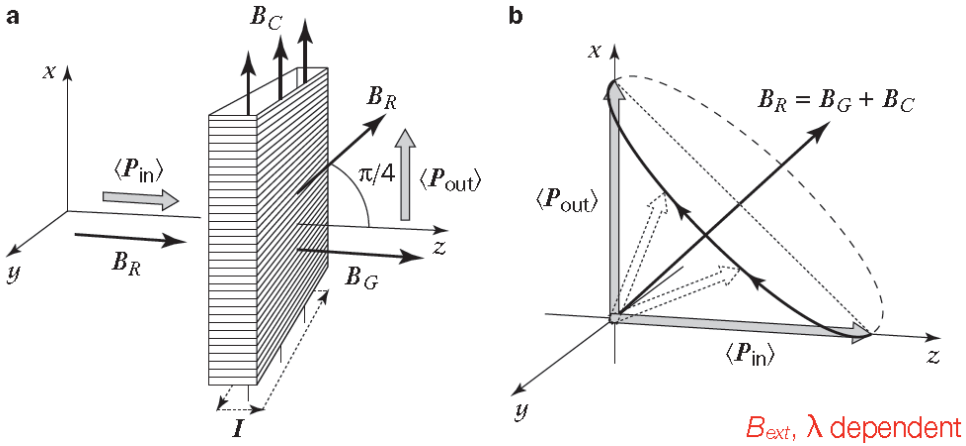


Neutron Resonance Spin Echo (NRSE)

Mezei flipper test for LARMOR

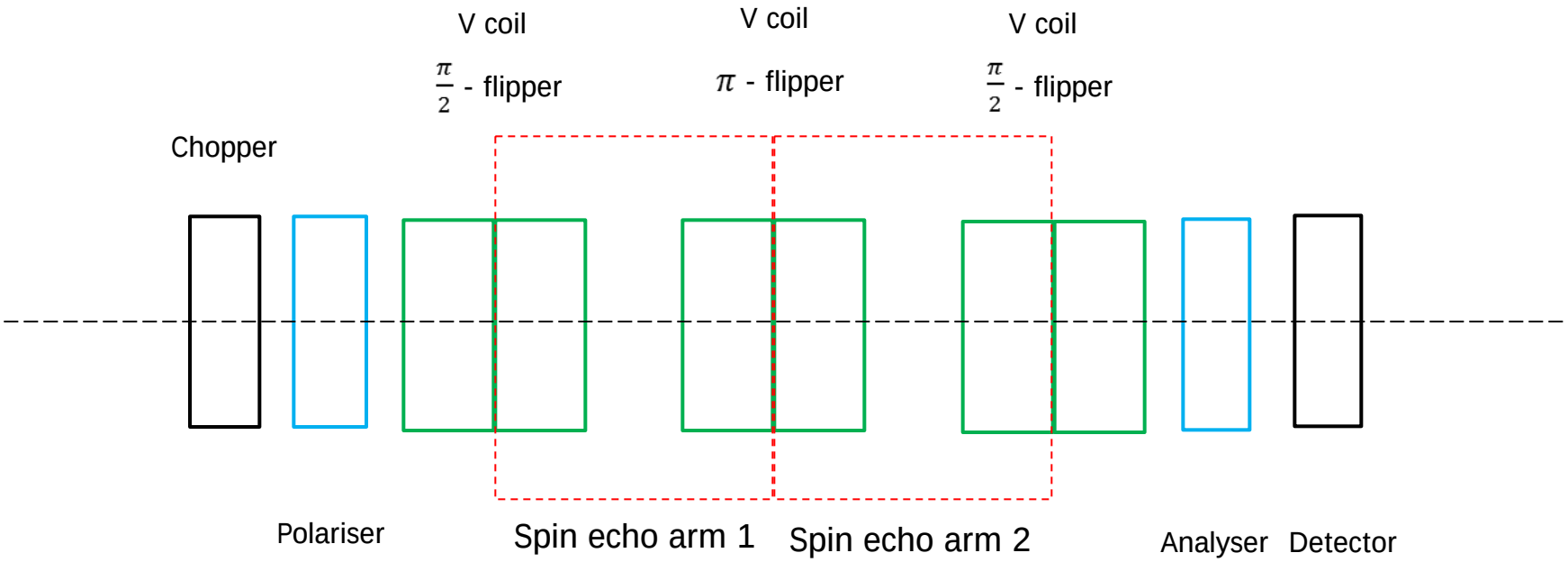


V coil

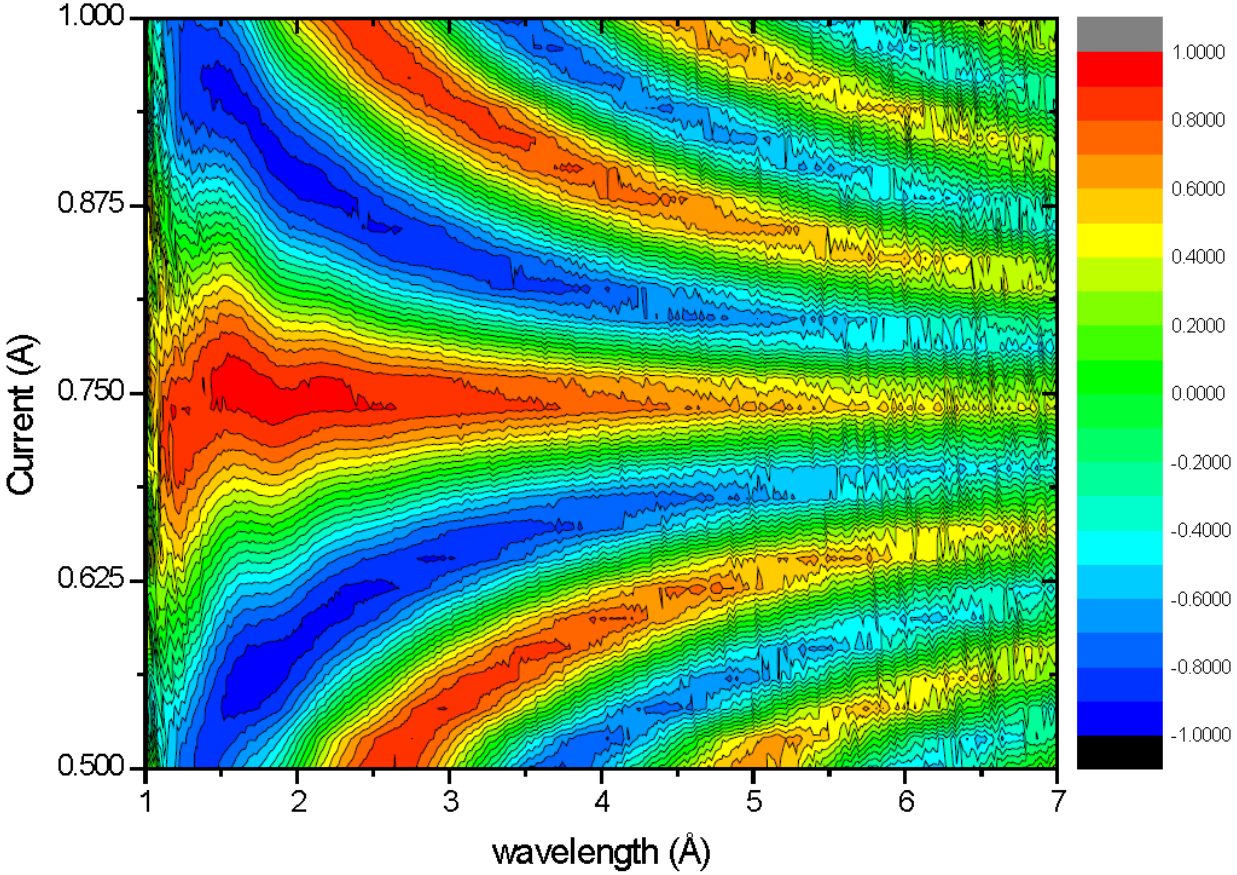


π/2 Mezei flipper

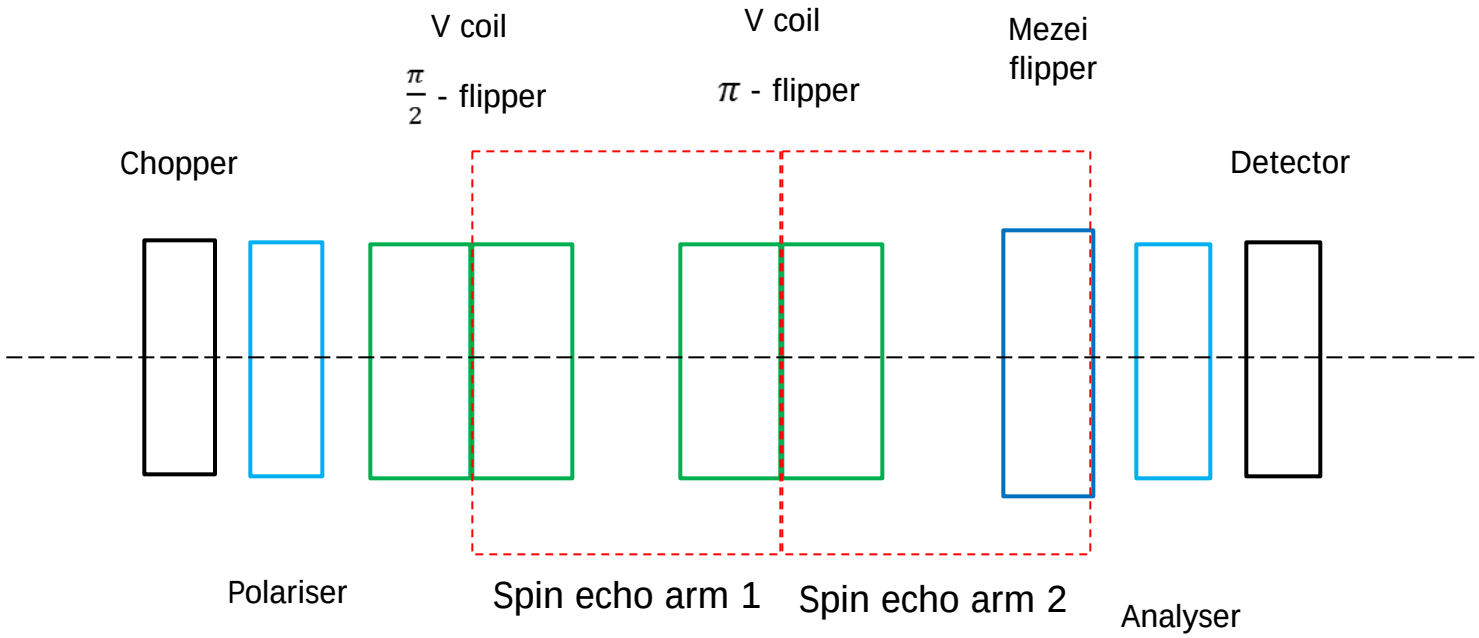
Mezei flipper test for LARMOR set-up without Mezei flipper



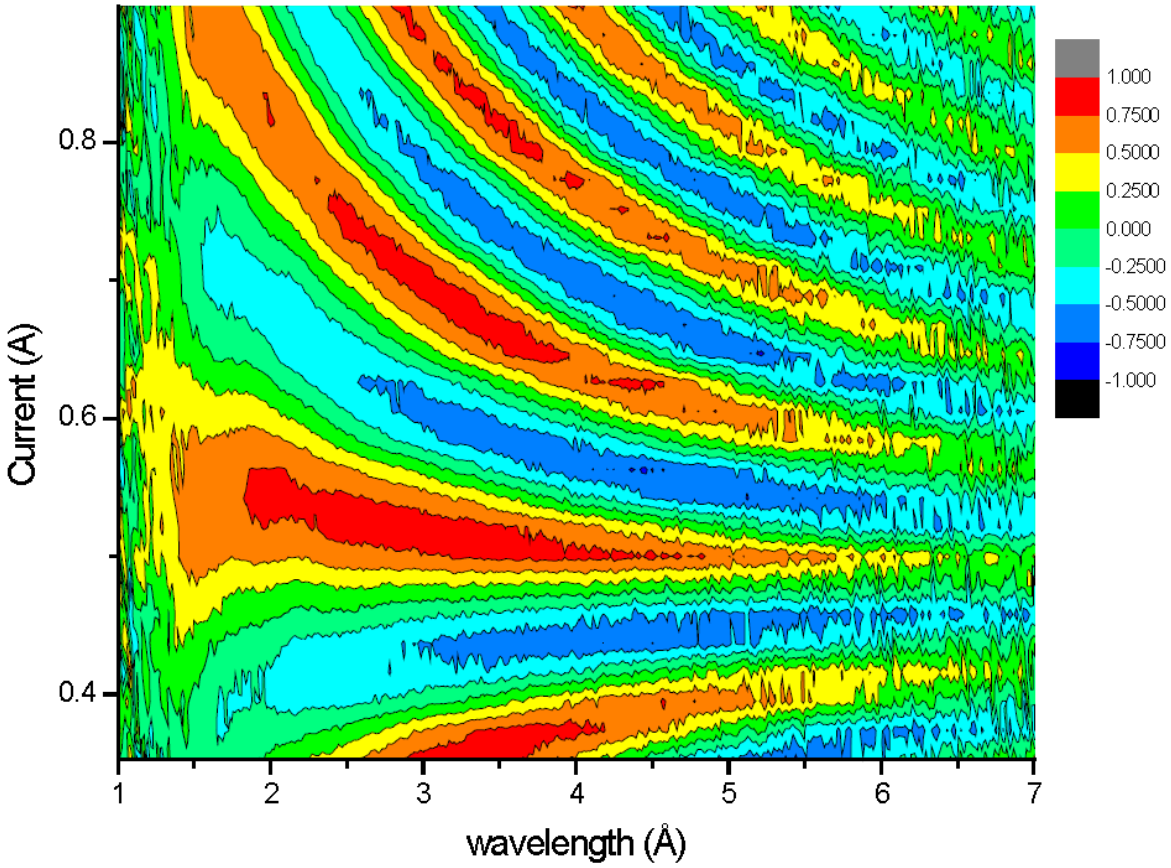
Mezei flipper test for LARMOR
results without Mezei flipper



Mezei flipper test for LARMOR set-up with Mezei flipper



Mezei flipper test for LARMOR results with Mezei flipper



Plan

- Continue literature review on quantum phase transitions and find material systems of interest to work on
- Application for a Lorentz Workshop on Ferromagnetic Quantum Phase transitions
- Apply for beam time on N(R)SE and Larmor diffraction (ILL, FRM2)
- Contribute to the development of the N(R)SE options and Larmor diffraction options of LAMROR
  - Maybe it is necessary to reconstruct a Mezei flipper to decrease the gap between inner coils.

Thank you!