IMAGING JRA

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Objectives

Working within the research activity new techniques and modelling tools will be made available for a large number of users from the large communities of the nanomagnetism, engineering and generally from materials science.

Task	Status
18.1. Nano- and micro structures resolved dark-field imaging with grating interferometers.	Ongoing
18.2. Direct high-resolution neutron imaging.	Ongoing
18.3. Energy-selective neutron imaging.	Ongoing
18.4. SANS 3D: vectorial magnetic imaging of nano-particles with a resolution of 1nm to 100 nm.	Ongoing
18.5. Precession techniques for imaging magnetic structures in thin film systems.	Ongoing
18.6. Tomographic imaging of magnetic structures at the µm scale.	Ongoing

DELIVERABLES

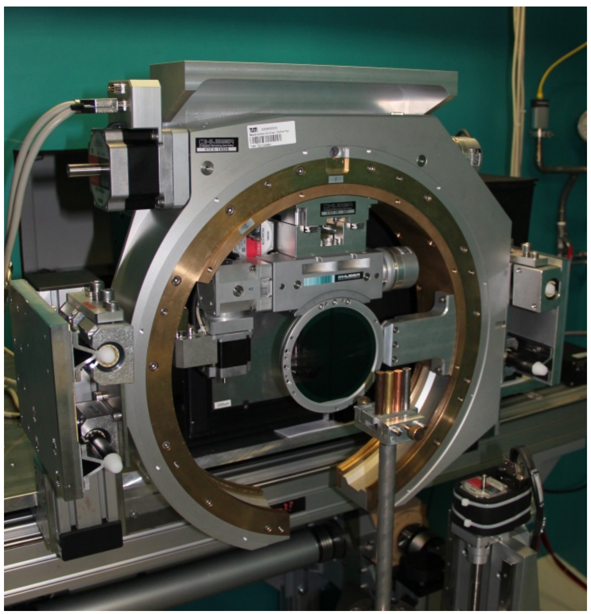
Del. no.	Deliverable name	Lead beneficiary	Nature	Delivery date from Annex I (proj month)	Actual / Forecast delivery date	Delivered Yes/ No/ Ongoing
18.1	**Implementation of grating interferometry for visualization of residual stresses**	**PSI**	**O**	**36**	**36**	**Yes**
18.2	**Publication and interim report**	**HZB**	**R**	**36**	**36**	**Yes**
18.3	Grating interferometry experiments performed with university partners	TUM	O	48	48	Ongoing
18.4	**Optimization of high-resolution detector system**	**HZB**	**O**	**18**	**18**	**Yes**
18.5	**Adapting of high-resolution detector system**	**PSI**	**O**	**36**	**36**	**Yes**
18.6	**High-resolution experiments performed with university partners**	**TUM**	**O**	**48**	**48**	**Yes**
18.7	**Optimization of monochromator parameters for high wavelength resolution**	**HZB**	**O**	**18**	**18**	**Yes**
18.8	**Bragg-edge mapping and energy-selective experiments**	**PSI**	**R**	**36**	**36**	**Yes**
18.9	Extending the technique towards ToF-imaging	PSI	O	48	48	Ongoing
18.10	**Evaluation of the PASANS**	**CEA**	**R**	**18**	**18**	**Yes**
18.11	**User friendly sample environment**	**Jülich**	**R**	**36**	**36**	**Yes**
18.12	User friendly platform for PASANS	STFC	O	48	48	Ongoing
18.13	**Evaluation of the Precessional spectroscopy techniques possibilities**	**CEA**	**R**	**18**	**18**	**Yes**
18.14	**Precession spectroscopy measurements**	**CEA**	**R**	**36**	**36**	**Yes**
18.15	User friendly platform for the exploitation of precession data	STFC	O	48	48	Ongoing
18.16	**Imaging of magnetic structures in bulk samples with high resolution**	**HZB**	**R**	**18**	**18**	**Yes**
18.17	**Direct magnetic imaging experiments**	**PSI**	**R**	**36**	**36**	**Yes**
18.18	Data processing platform	TUM	R	48	48	Ongoing
18.19	Wiki pages on NMI3 portal	CEA	R	48	48	Ongoing

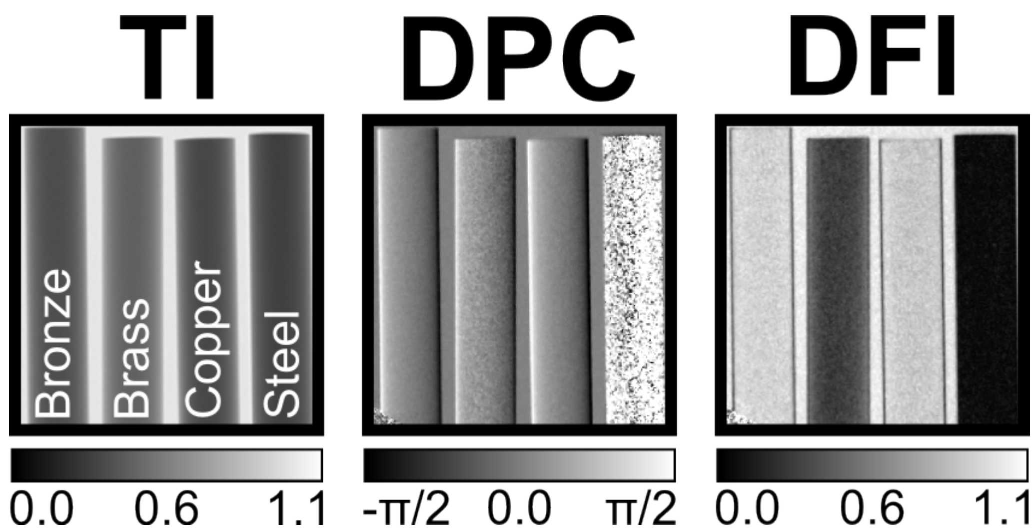
Summary (Aug 2013 – Jan 2015)

Task	Work performed	Main results
18.1	New technique for manufacturing of analyser gratings is developed in collaboration between PSI and TUM.	Gratings with better performance are available for the next generation of nGI setups.
	New grating interferometry setup is installed at FRM-2. Test experiments are performed	nGI is ready to be used by the user community at FRM-2.
18.2	The high resolution neutron imaging detector at HZB (pixel size of 6.5 µm) was used for user experiments.	Users achieve new insights in materials research and publish the results in high-impact journals.
	New high-resolution prototype detector was tested at PSI.	Dedicated lens system in combination with innovative scintillator screen provide detector system with pixel size of 1.5 µm.
18.3	Bragg-edge mapping experiments were performed at HZB with external partners.	Users achieve new insights in materials research and publish the results in high-impact journals.
18.4	Polarized SANS measurements on nano-magnetic systems were performed	Magnetic nanowires for permanent magnet fabrications and defects have been studied
	New polarimeter at MLZ for SANS measurements was constructed and tested	The new polarimeter shows excellent performance.
18.5	Magnetic scanning technique for high spatial resolution is developed	Microbeams were generated by using of reflection techniques and waveguides.
18.6	Direct magnetic imaging of magnetic flux penetration in Nb superconductor was performed at FRM-2	New method is developed for investigation of superconductive phenomena.

Task 18.1 Dark-field neutron imaging with grating interferometery.

New nGI setup at the ANTARES neutron imaging beamline at FRM-2

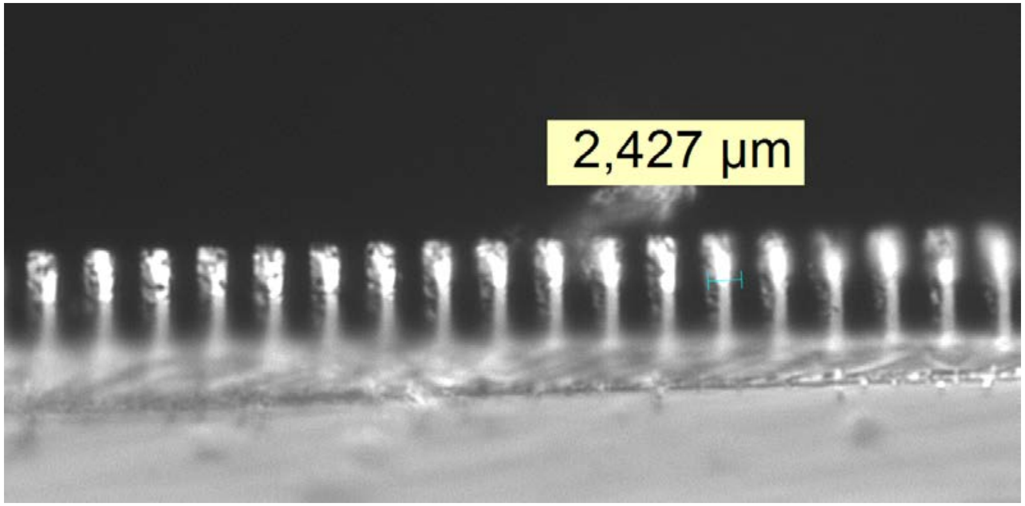




The new nGI setup at FRM-2 – a photo on the left. First test results of using the new nGI setup – Transmission Image, Differential Phase Contrast and Dark Field Contrast images of different materials on the right.

Task 18.1 Dark-field neutron imaging with grating interferometery.

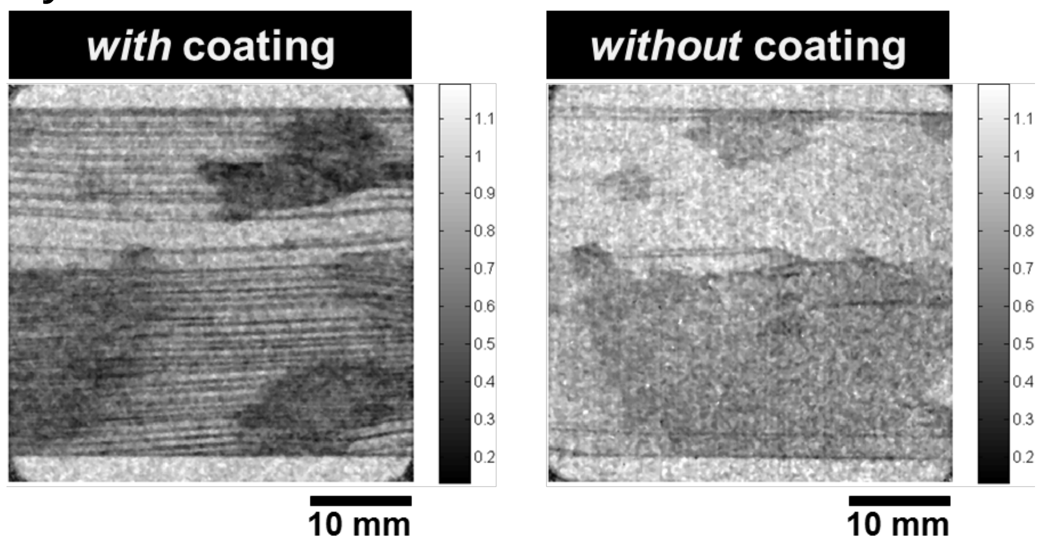
N***ew technique for manufacturing of analyser grating*** was developed in collaboration between the groups at PSI and TUM - collimated skew sputtering onto an Si substrate grating.



TEM image of transversal section of Gd absorption grating.

Task 18.1 Dark-field neutron imaging with grating interferometery.

Mesurements of residual stresses by nGI (Deliverable 18.1) - compressive stress of isolation layer in GO electrical steel was measured at PSI.

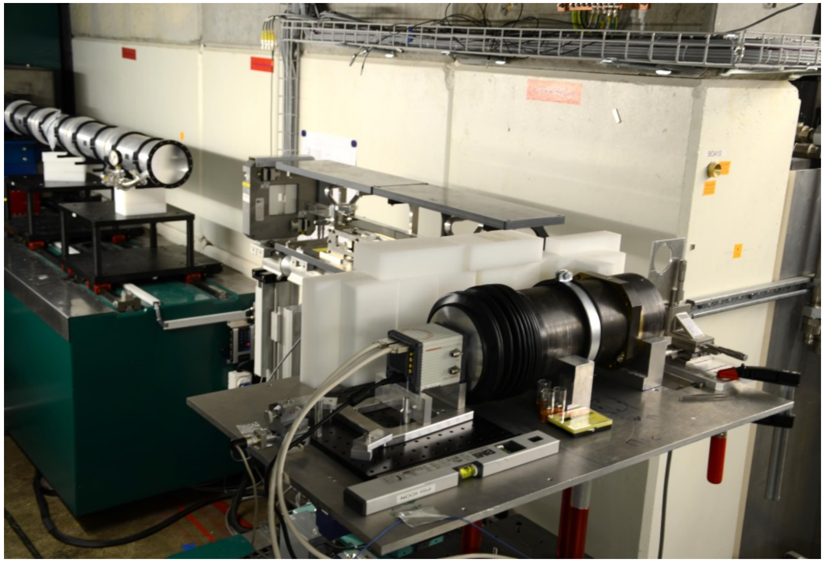


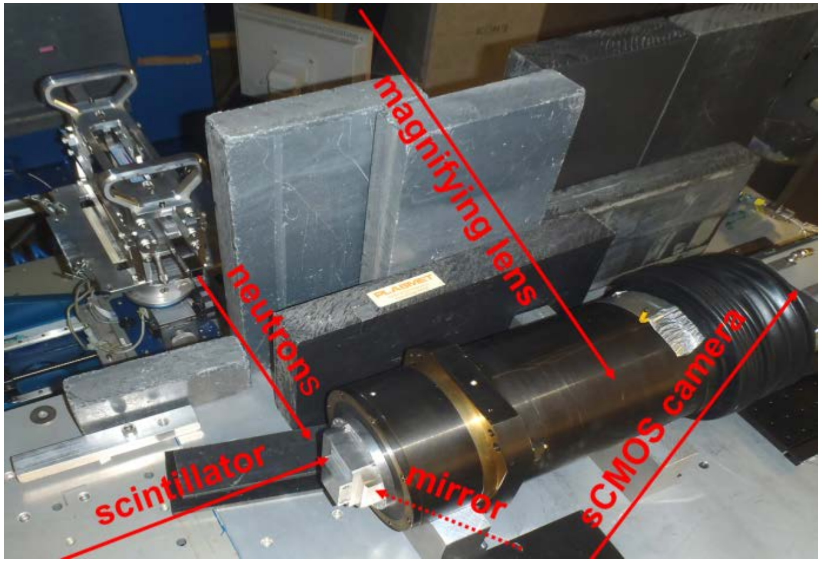
Neutron dark-field image (DFI) of a 270 µm thick GO lamination with coating. Black color corresponds to domain walls or domain wall rich areas. (left) lamination with coating which is transparent for neutrons and the DFI shows individual domain walls. (right) same lamination polished, without coating and the domain structure has changed dramatically.

C. Grünzweig et al., Physics Procedia 69 (2015)

Task 18.2 High resolution neutron imaging.

A prototype of a ***high-resolution neutron detector system*** called “Neutron Microscope” ***has been built at PSI***





Photograph of the experimental set-up of the first prototype of the Neutron Microscope installed at (left) BOA beamline and (right) ICON beamline.

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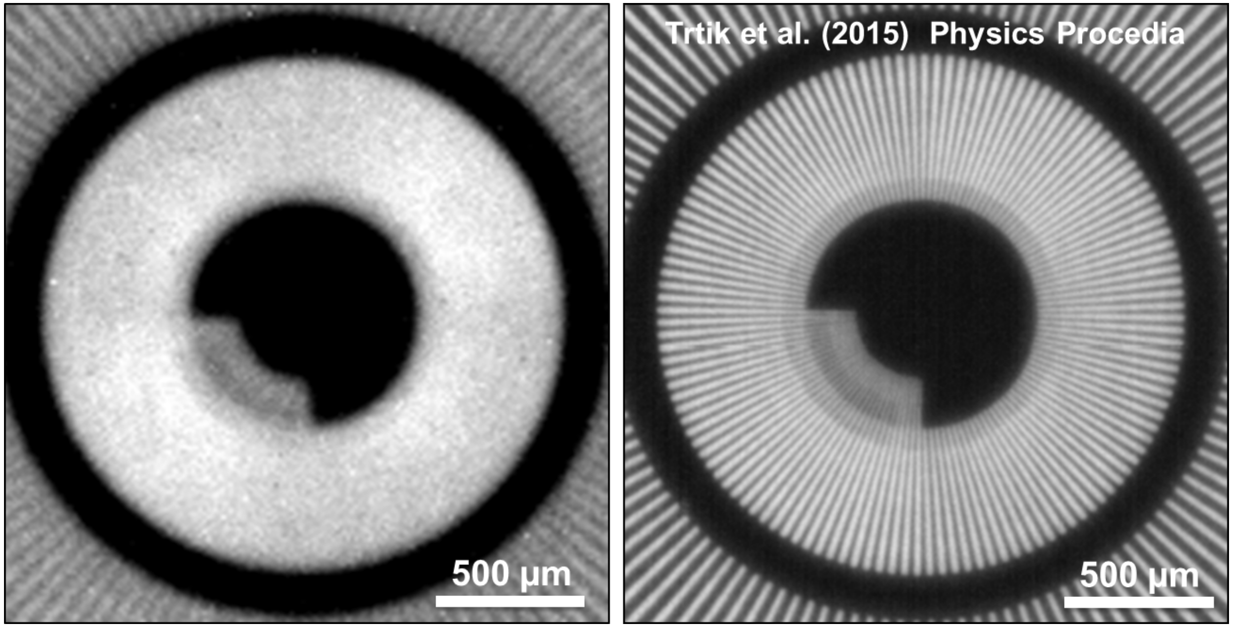
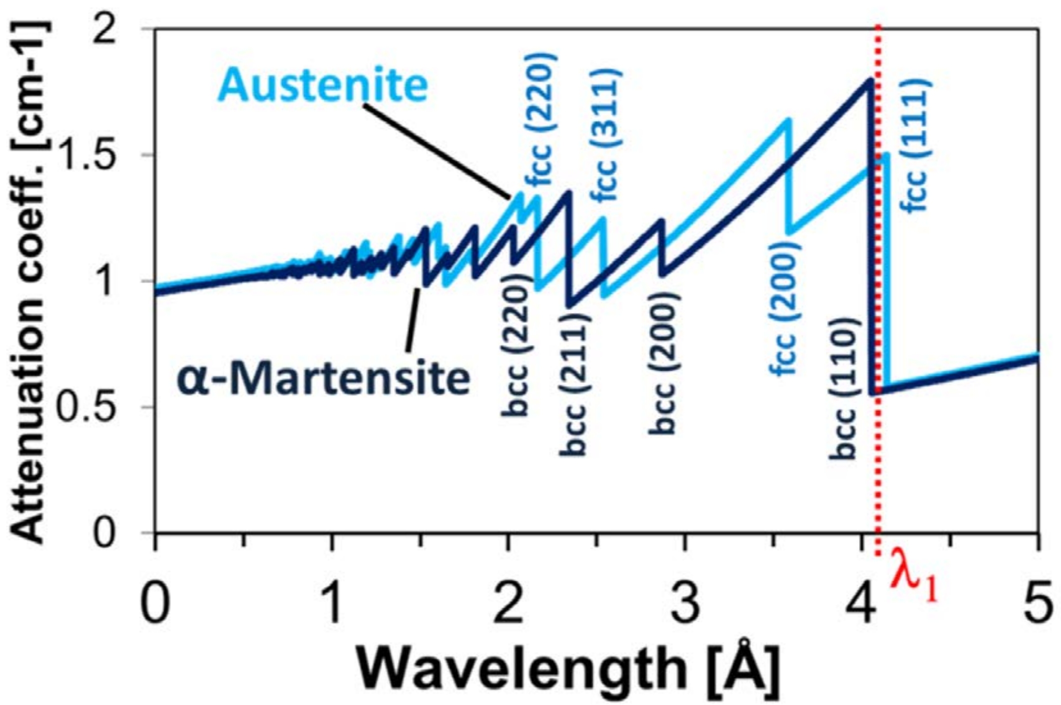


Neutron radiograph of Gd-Siemens star (left) using the standard high-resolution setup with 13.5 µm pixel size and 20 µm thick Gadox scintillator and (right) using the Neutron Microscope prototype with 1.5 µm pixel size and 4 µm thick Gadox scintillator. The spatial resolution of the images is equal to 32.9 µm and 7.6 µm respectively.

P. Trtik et al., Physics Procedia 69 (2015)

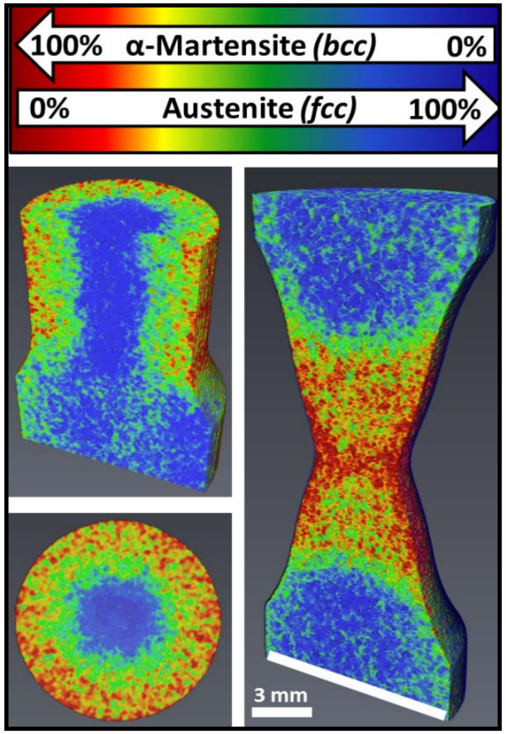
Task 18.3 Energy selective neutron imaging

The ***energy-selective setup*** at the neutron imaging instrument CONRAD2 at HZB is ***provided to external users***. Texture orientations and phase transitions in metal samples were investigated.

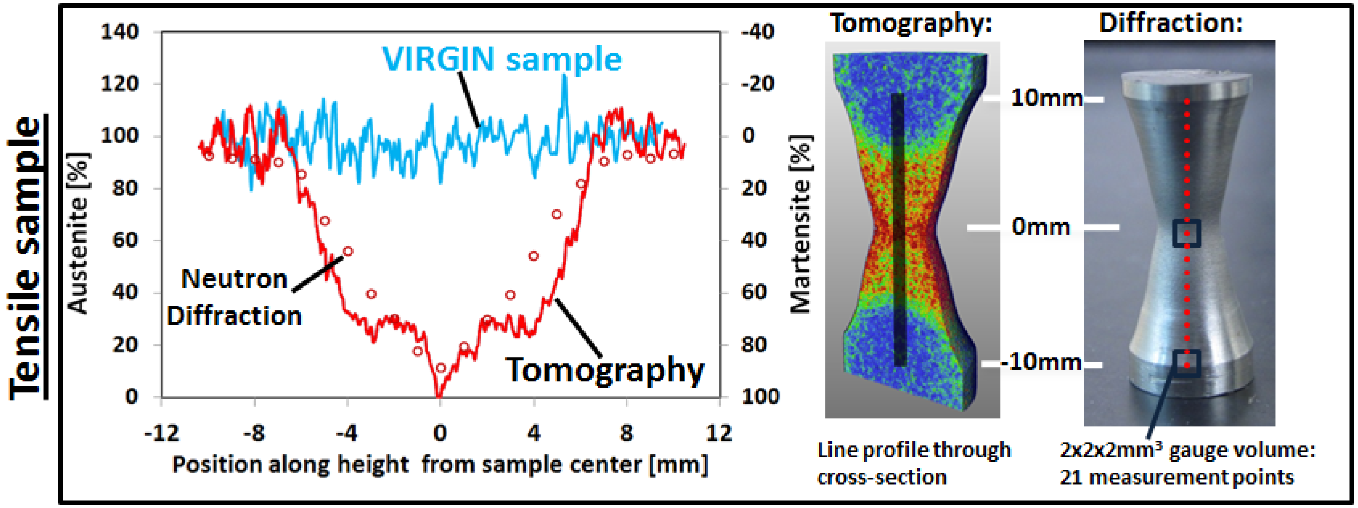


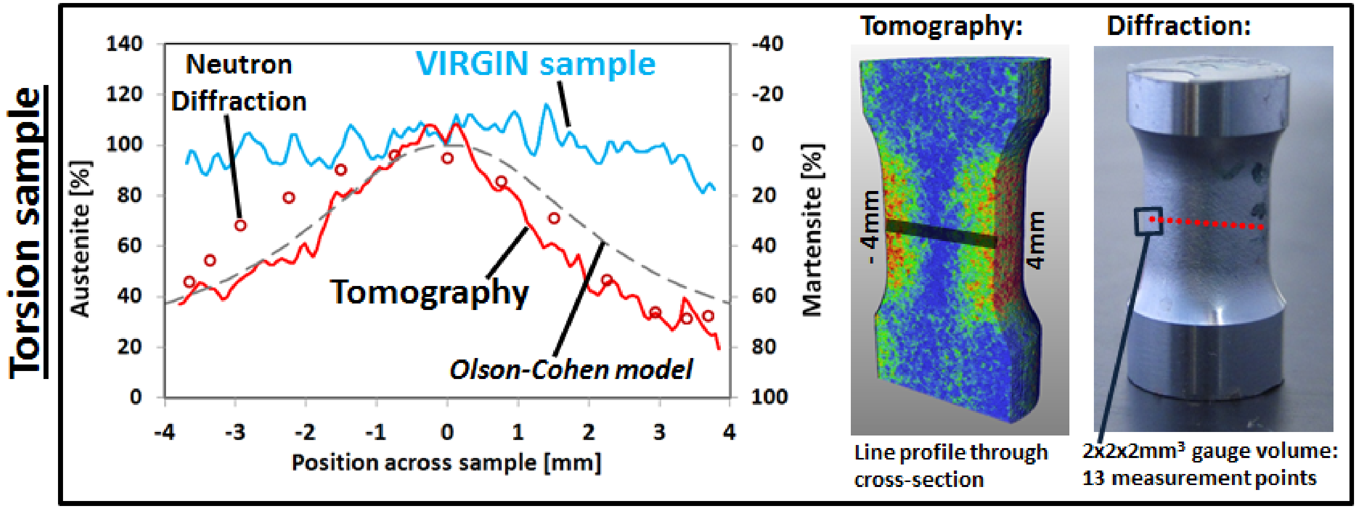
R. Woracek et al., Advanced Materials 26 (2014)

Energy-selective neutron tomography of TRIP-steel



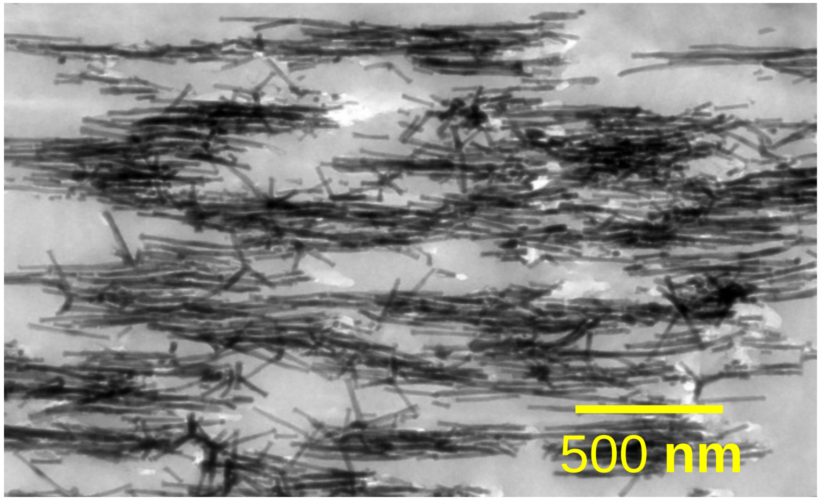
Task 18.3 Energy selective neutron imaging

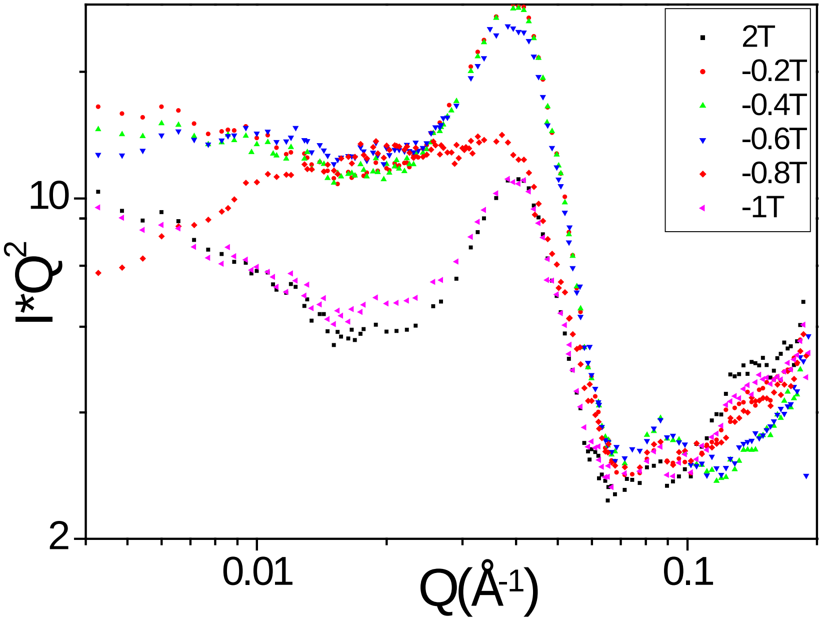




Task 18.4 SANS 3D: vectorial magnetic imaging of nano-objects

Magnetic SANS scattering on nano-magnetic systems have been performed at partner's facilities (JNCS, FRM2 and LLB)



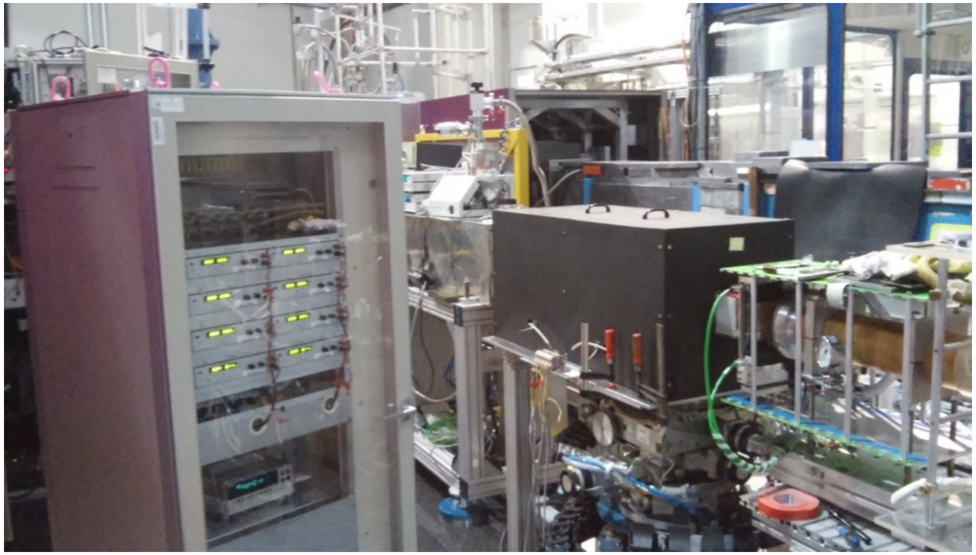


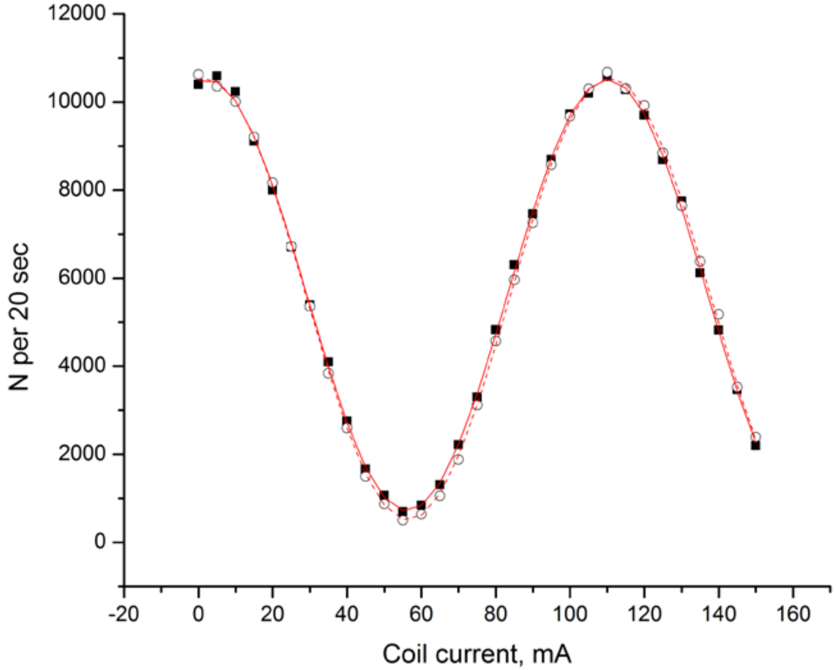
Arrays of aligned magnetic nanowires (left). Evolution of the magnetic scattering as a function of the applied field measured at SANS-I at FRM2 (right).

W. Fang, PhD Thesis University Paris-Sud , 2014

Task 18.4 SANS 3D: vectorial magnetic imaging of nano-objects

New polarimeter was constructed and tested at MLZ.

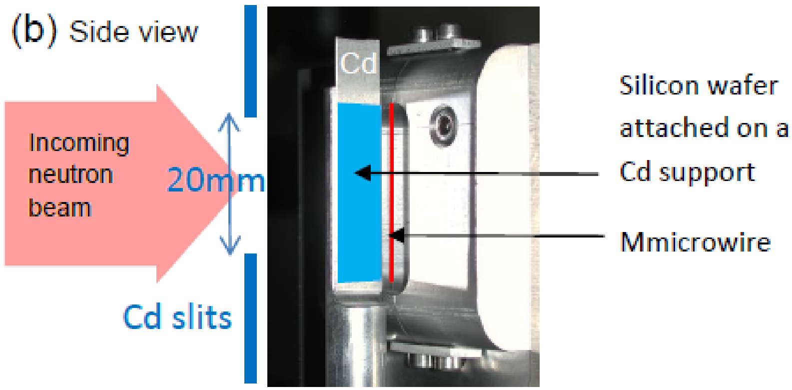




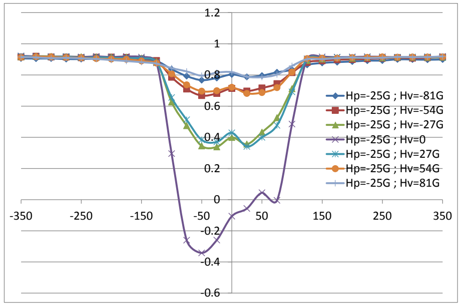
Polarimeter installed and tested on the TREFF instrument at MLZ (left). Neutron spin rotation around y-axis in spin turner IN (closed squares) and OUT (open circles). Solid and dashed lines represent the fitting curves for IN and OUT spin turners (right).

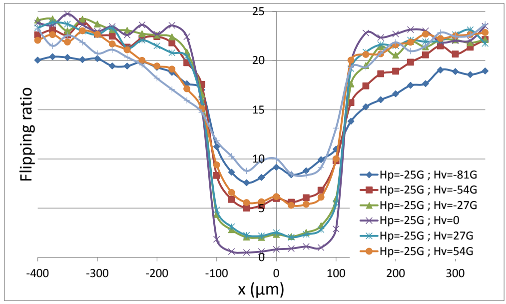
Task 18.5 Precession techniques for imaging magnetic structures in thin film systems.

Development of a **magnetic scanning technique to achieve high spatial resolution**



Micro-beam produced by using a reflection system used to study a magnetic micro-wire. The spatial resolution which can be achieved is on the order of 20µm

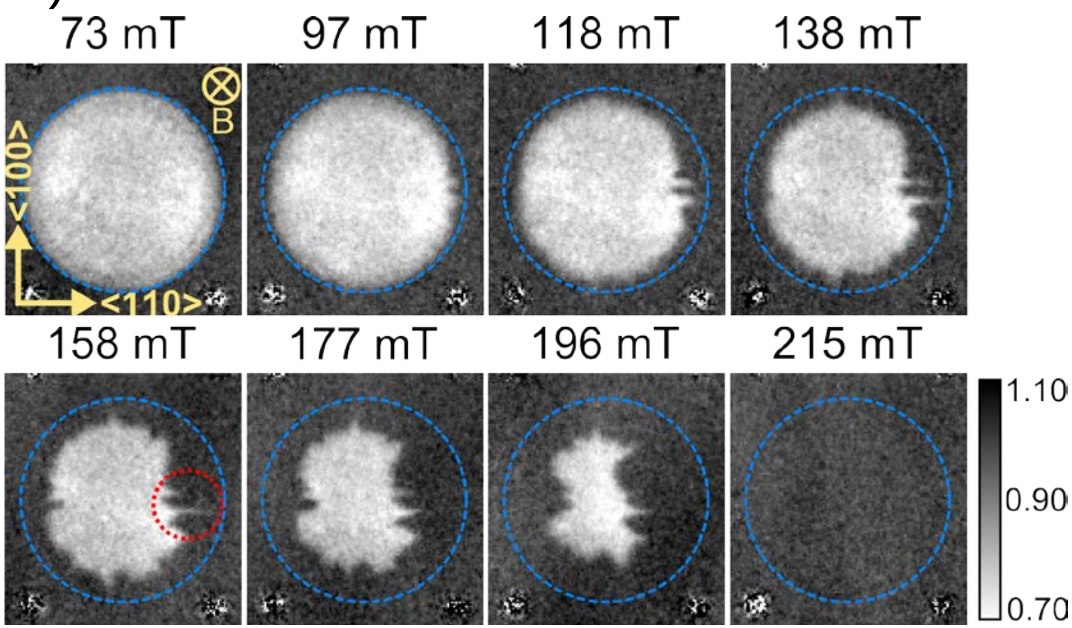




Neutron precession measurement through a magnetic micro-wire with a 30µm spatial resolution measured for different applied fields. In the center of the wire, one can see the signature of the vortex state. It is also possible to quantify the stray fields outside the microwire.

Task 18.5 Tomographic imaging of magnetic structures at the µm scale.

Magnetic structures at the µm scale were visualized by neutron Grating Interferometry (nGI)



Dark Field Imaging (DFI) of superconducting Nb (blue circle) in different magnetic fields. The white contrast marks regions where a domain structure exists. The white region shrinks due to further field penetration into the superconductor.

NPI

The JRA Imaging combines neutron experimental techniques in the direct and the reciprocal space in order to resolve structural and magnetic features on different length scales.