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Magnetic Bulk Properties of Silicon Steel Sheets Polarized Neutron Imaging



EUROPEAN
SPALLATION
SOURCE

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PAUL SCHERRER INSTITUT

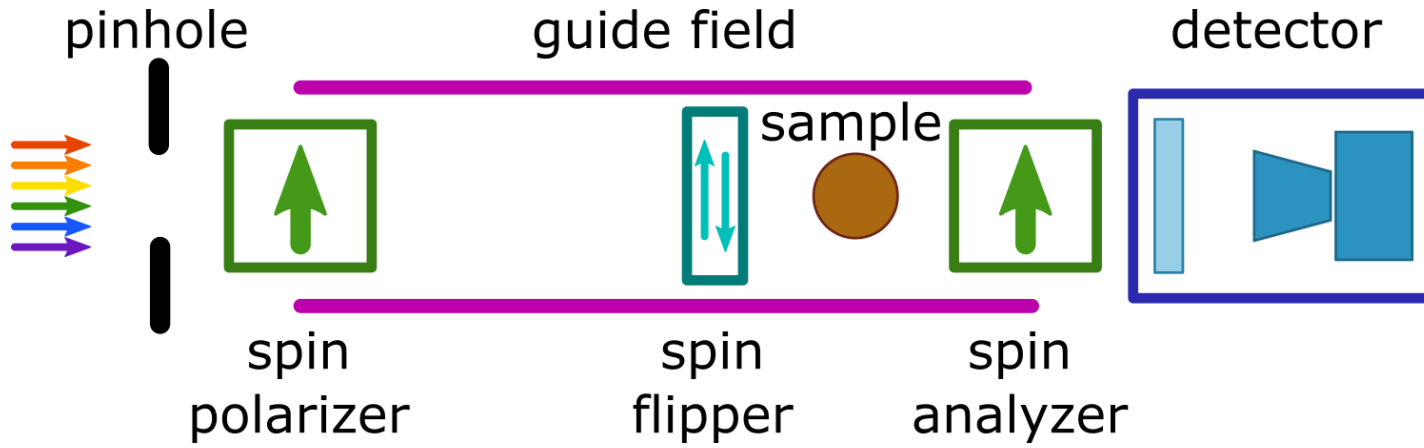


ESS / ILL User Meeting

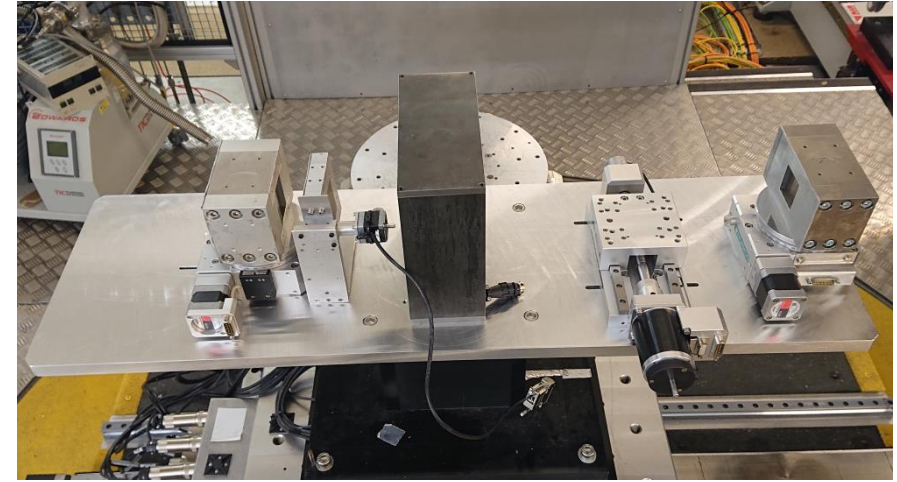
05.10.2022

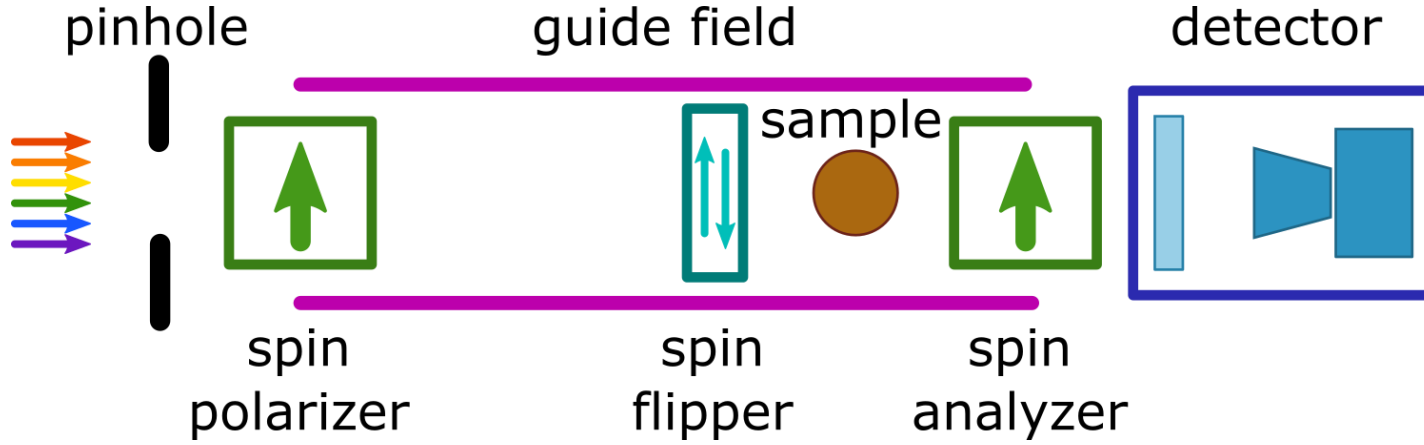


Polarized Neutron Imaging (PNI)

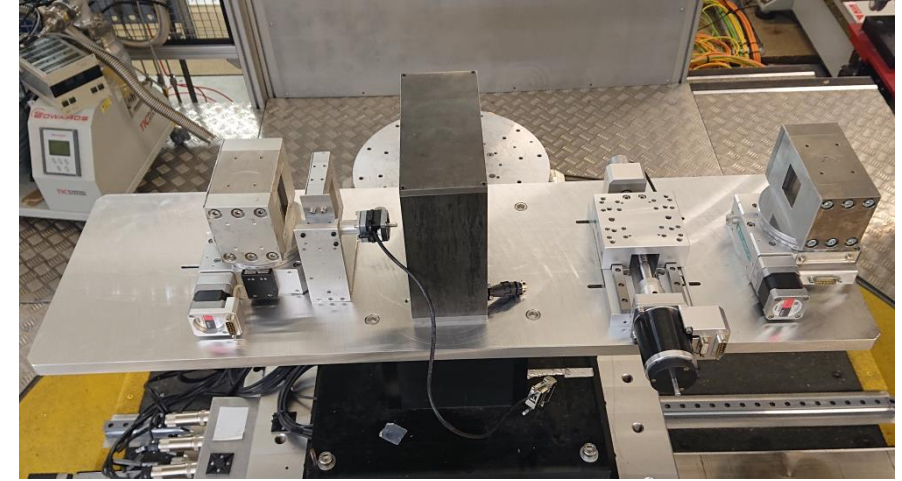


First PNI setup @ IMAT (ISIS)





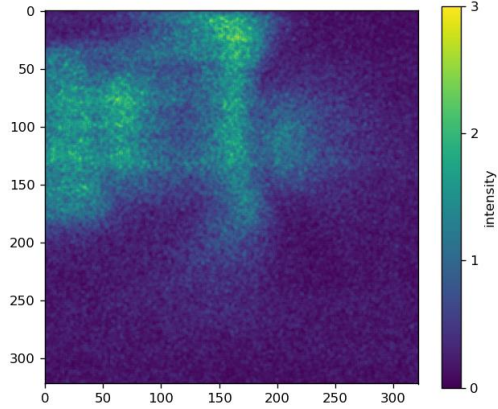
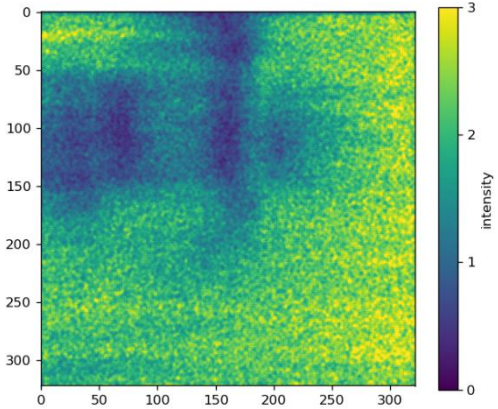
First PNI setup @ IMAT (ISIS)



raw data

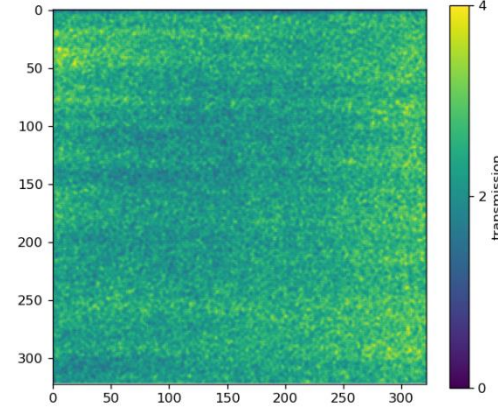
spin up

spin down



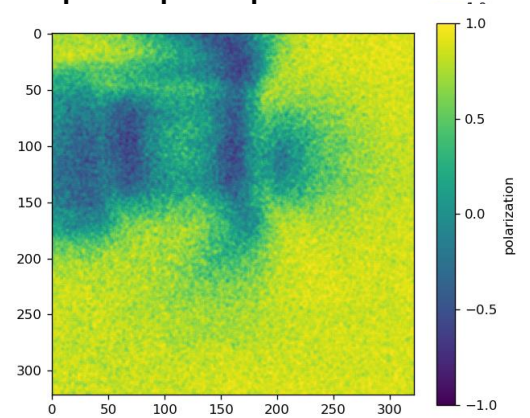
transmission

Spin up + spin down

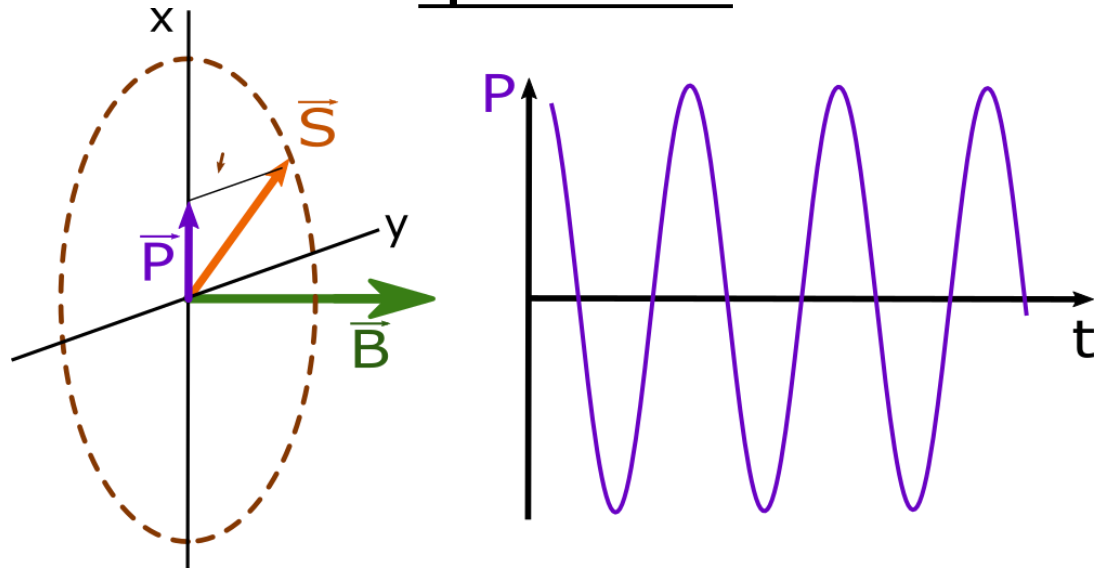


polarisation

Spin up - spin down
Spin up + spin down



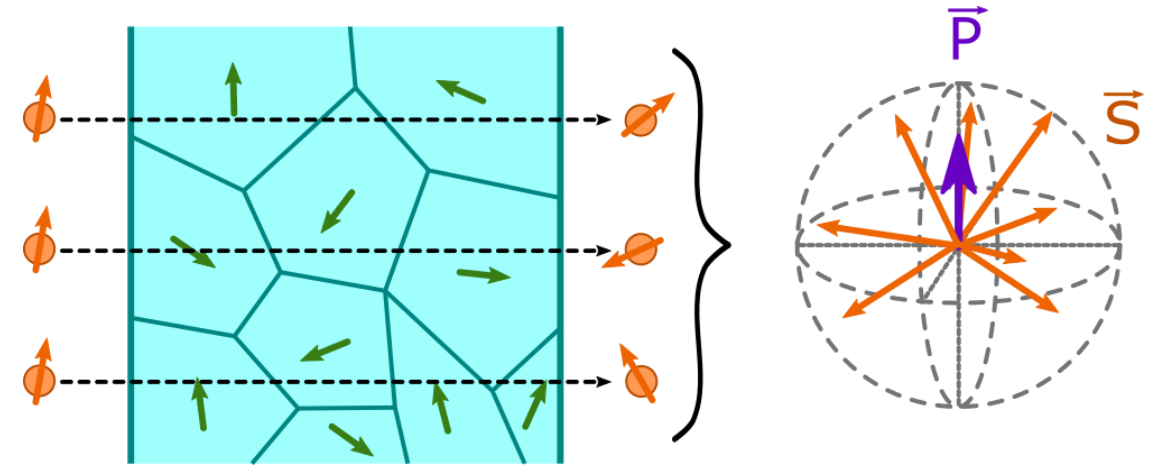
Spin rotation



Neutron wavelength: 3 Å
Path length: 10 mm

Earth magnetic field	0.04 mT	3°
Guide field	2 mT	160°
Electromagnet	100 mT	>20 turns

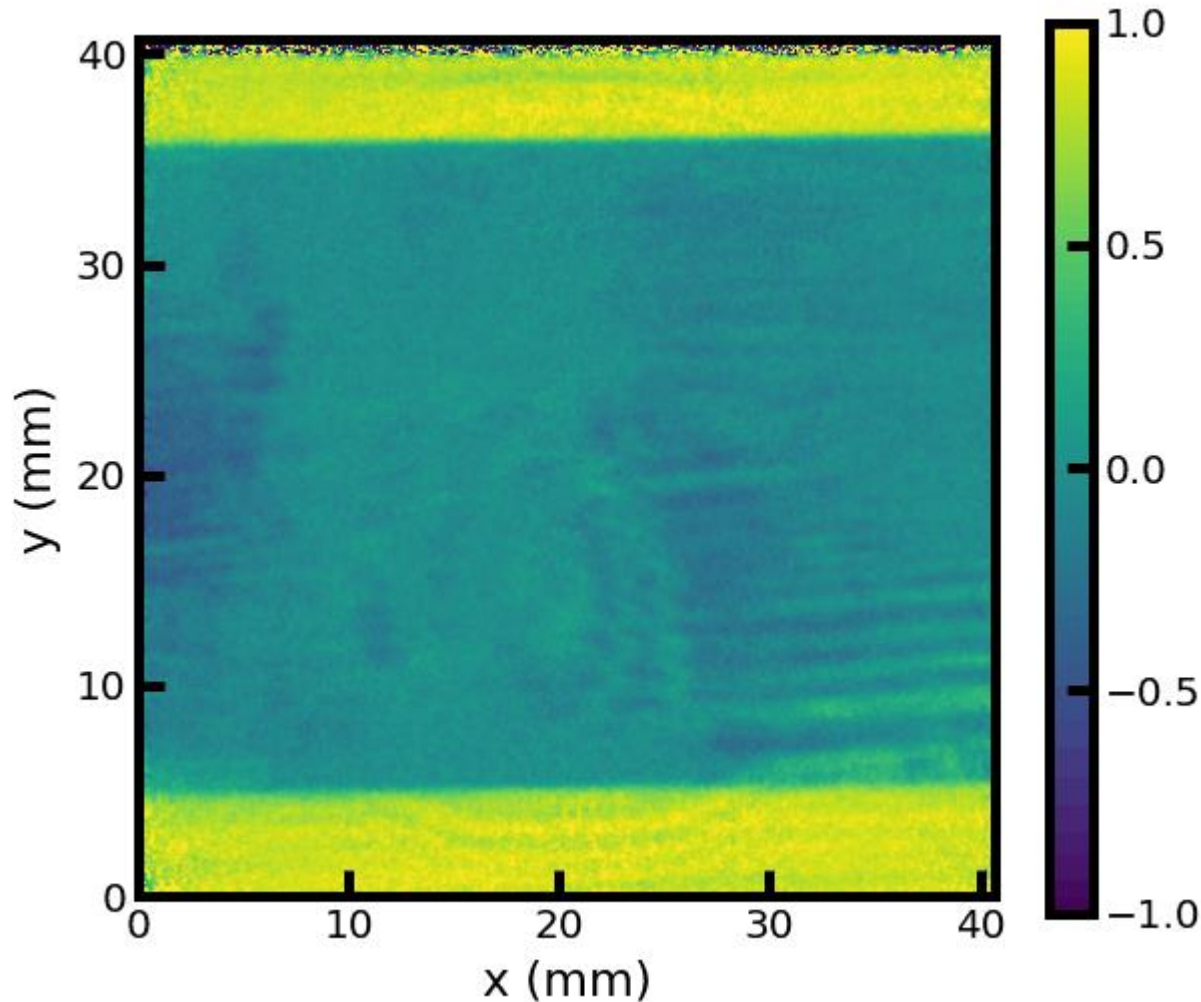
Spin depolarization



Neutron wavelength: 3 Å
Path length: 100 μm

Domains :	1 μm	2 μm	5 μm	10 μm
Iron	20 %	4 %	0 %	0 %
Nickel	80 %	45 %	30 %	10 %

'Zero field' wavelength scan



Double crystal monochromator
3.0 Å – 3.36 Å in 0.03 Å steps

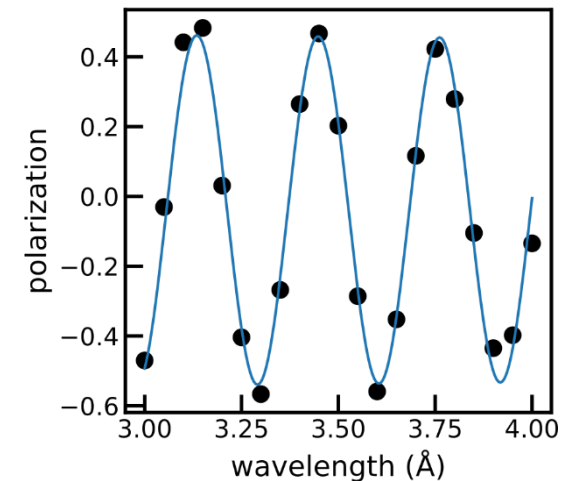
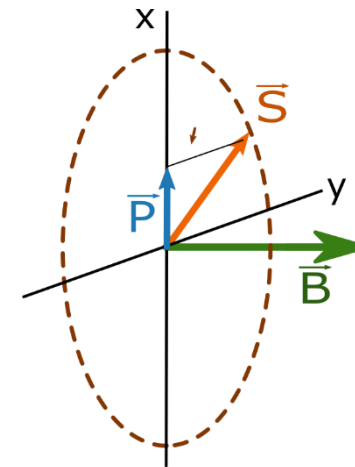
FeSi(3%) sheet

70 mm x 30 mm x 250 μm

Ca 1.7 T saturation magnetization

Large magnetic stripe domains

Extend over sample thickness



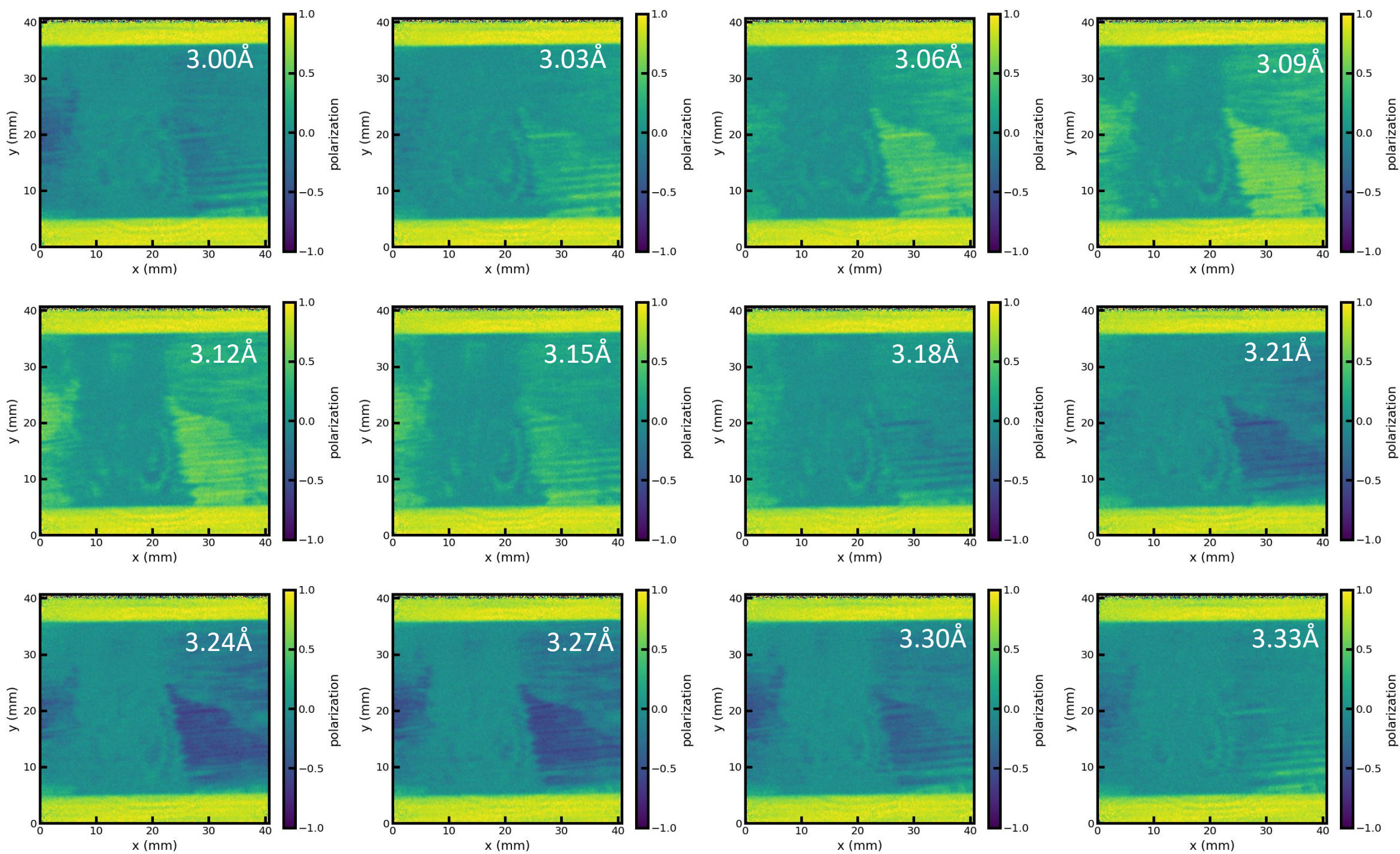
$$P = A \cdot \cos(\omega \cdot \lambda) + O$$

P : polarization

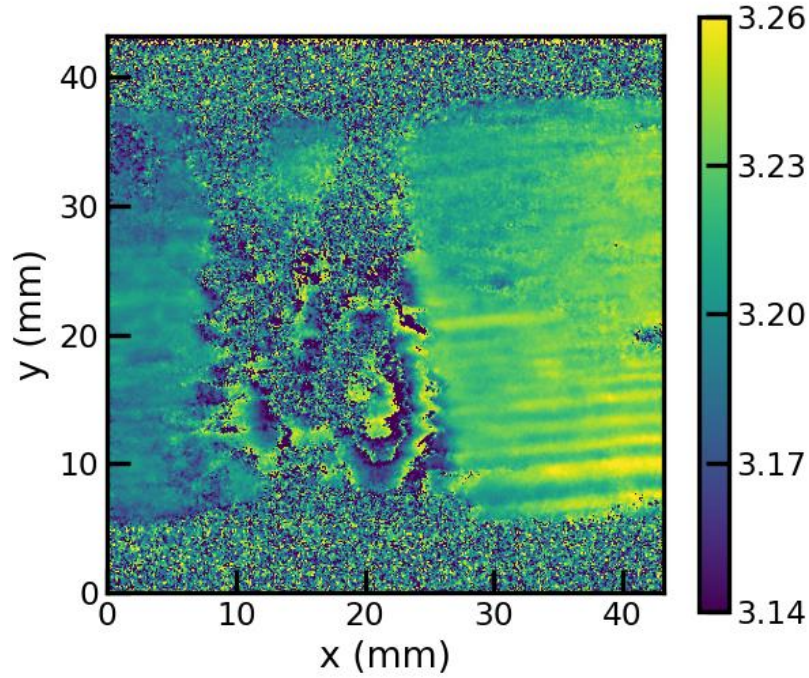
A : amplitude

ω : angular frequency

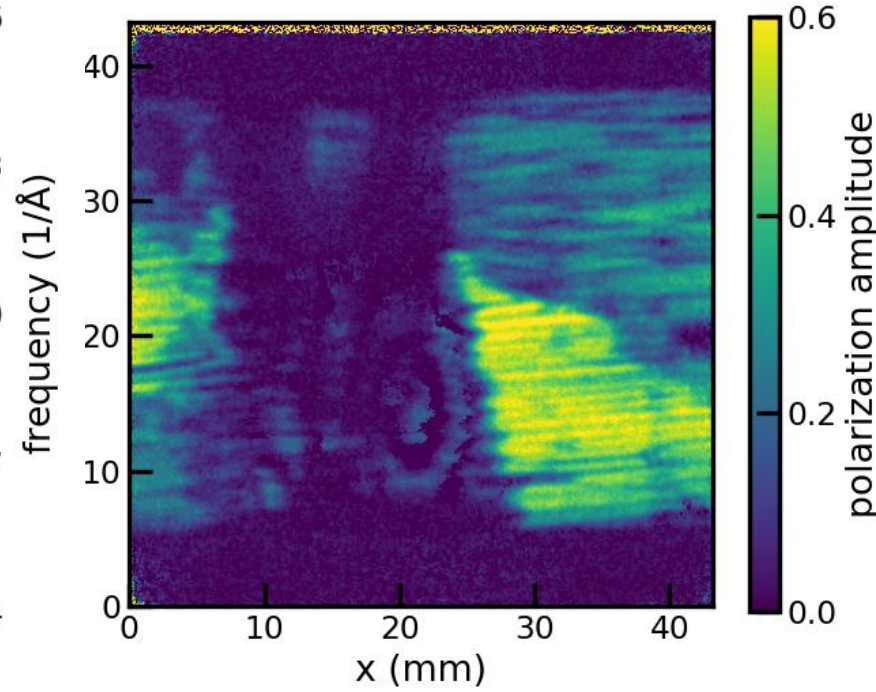
O : offset



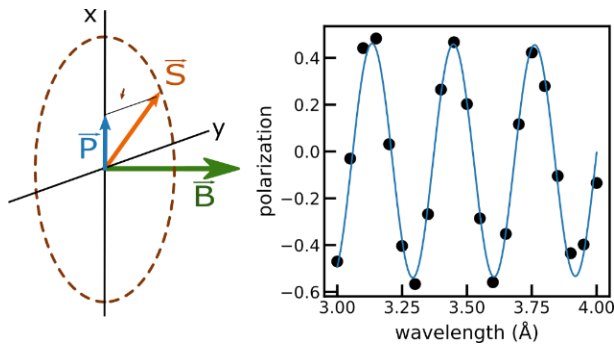
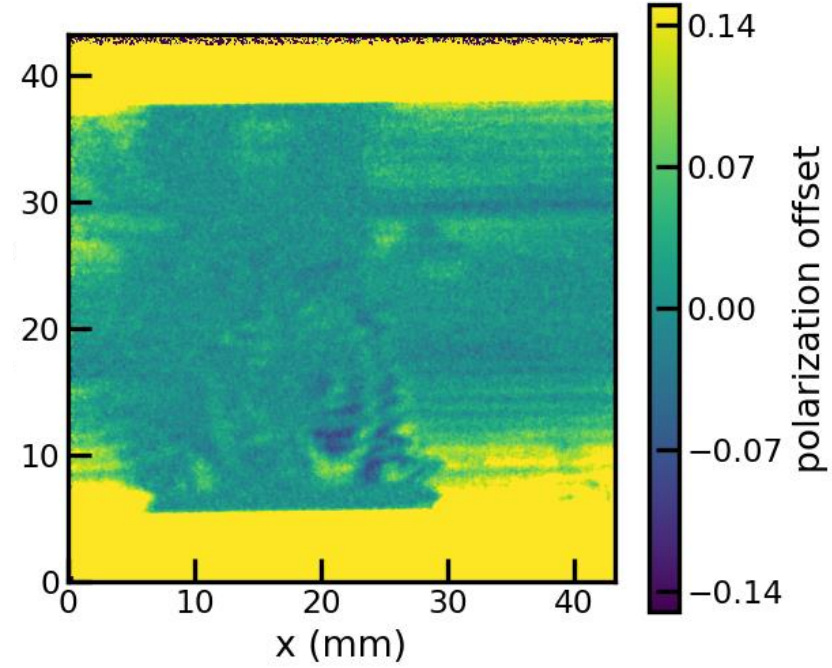
Domains



Domain walls



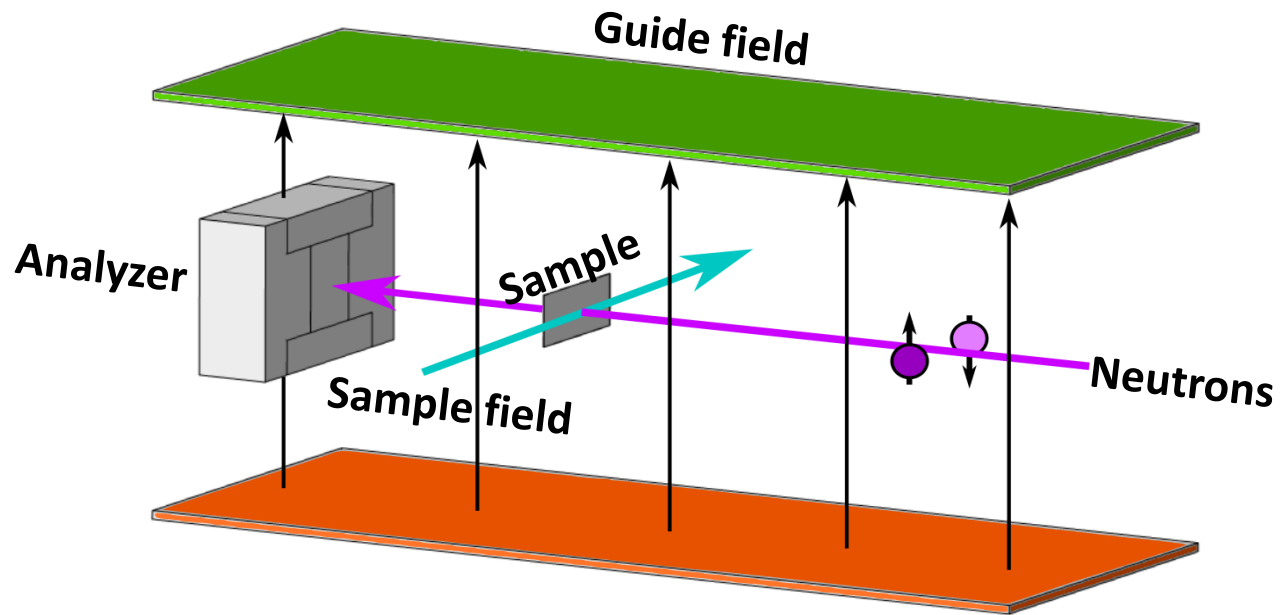
Orientation



$$P = A \cdot \cos(\omega \cdot \lambda) + O$$

- P : polarization
- A : amplitude
- ω : frequency
- O : offset

Perpendicular guide field & sample field

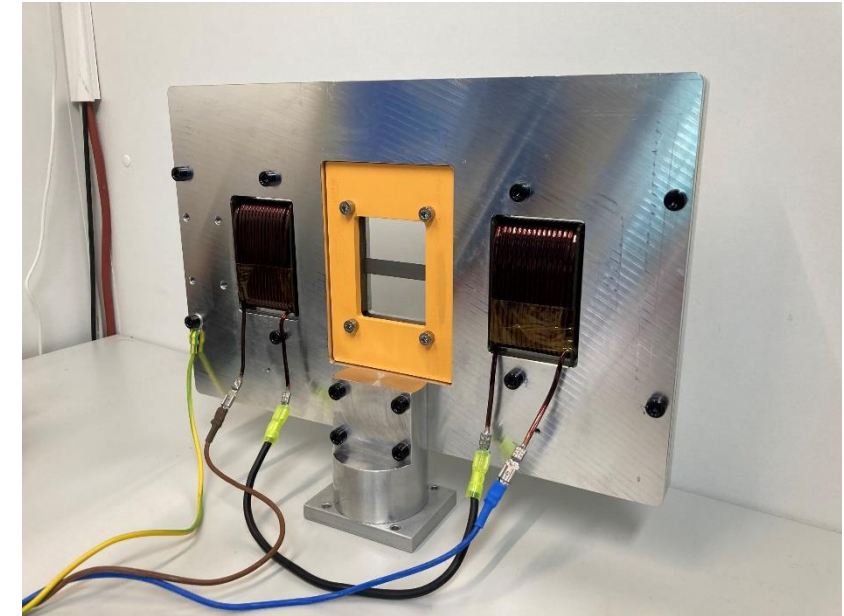


Feature: spin rotation in the sample

Bug: spin rotation in the sample field

Problem: Analyzer stray field

Magnetic yoke



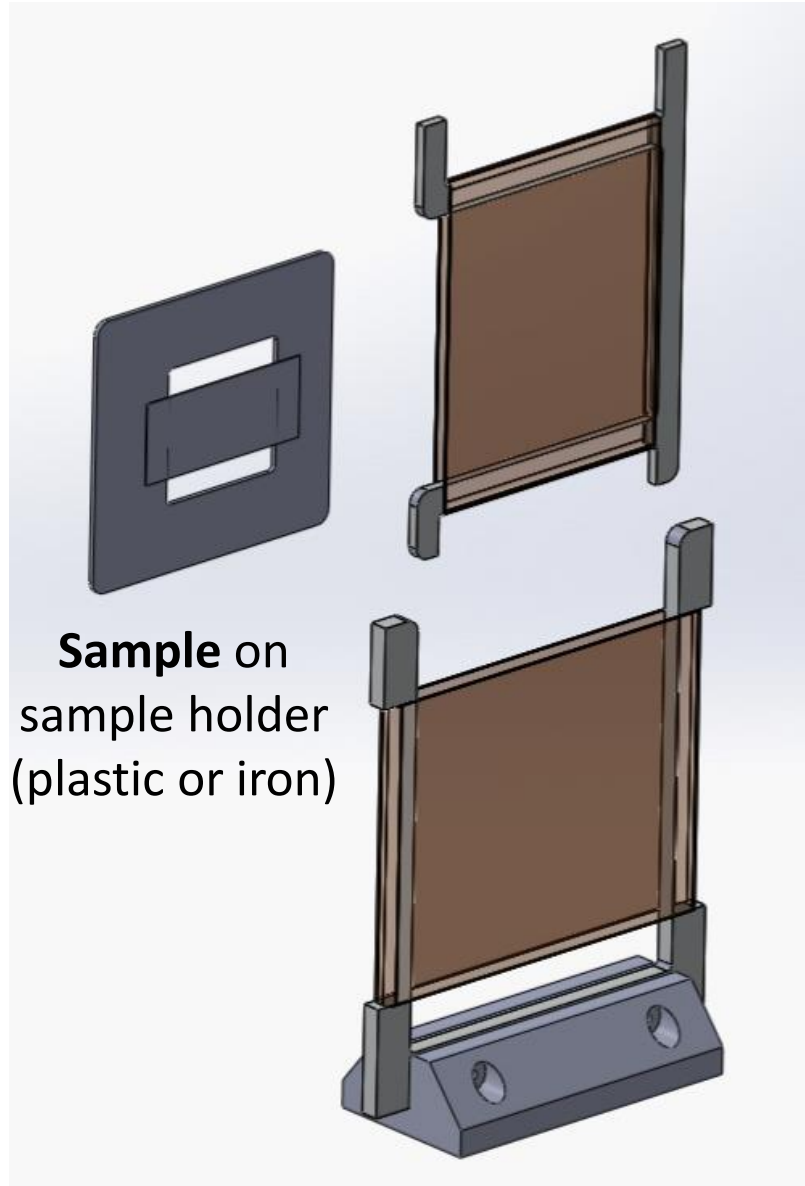
✓ High flux in the sample

✓ Relatively compact

❖ Massive piece of iron in a sensitive magnetic setup

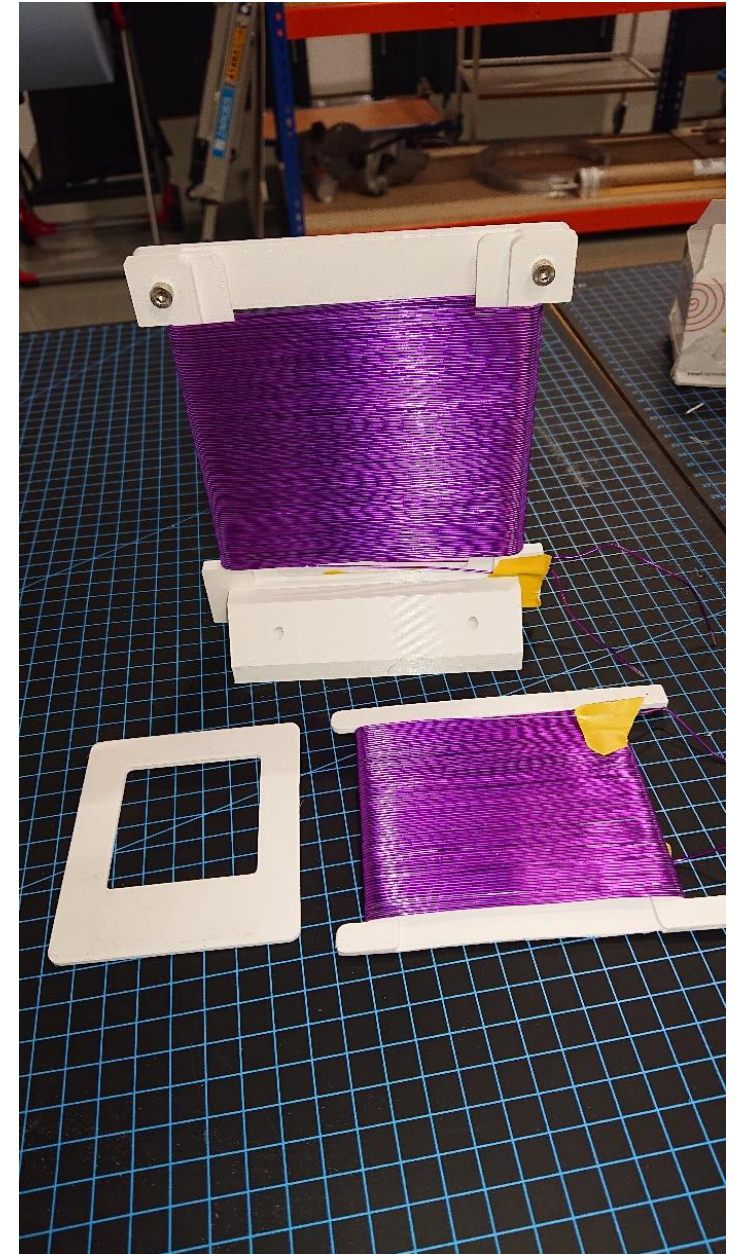
❖ Too strong stray fields

Mezei Spin flipper geometry

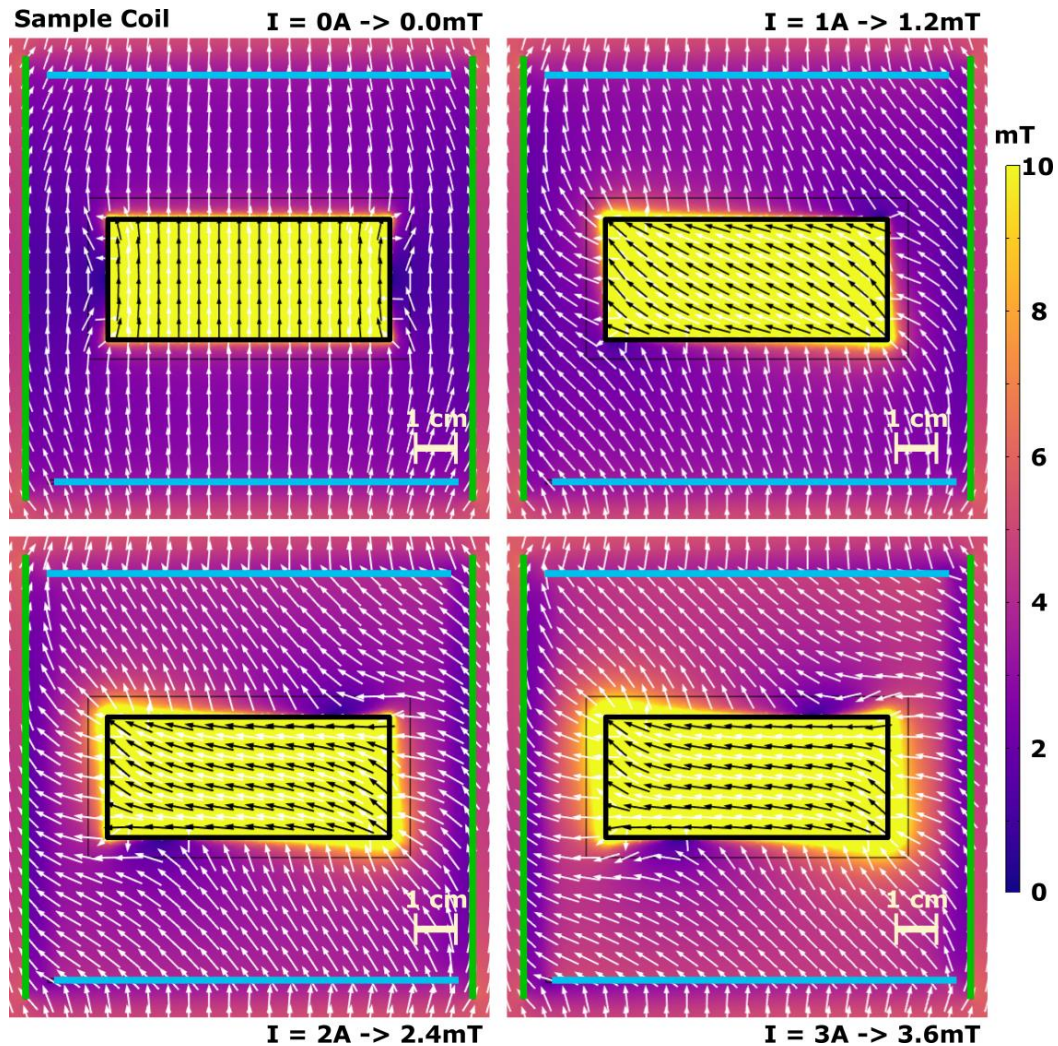


Sample coil
application of a
transverse field

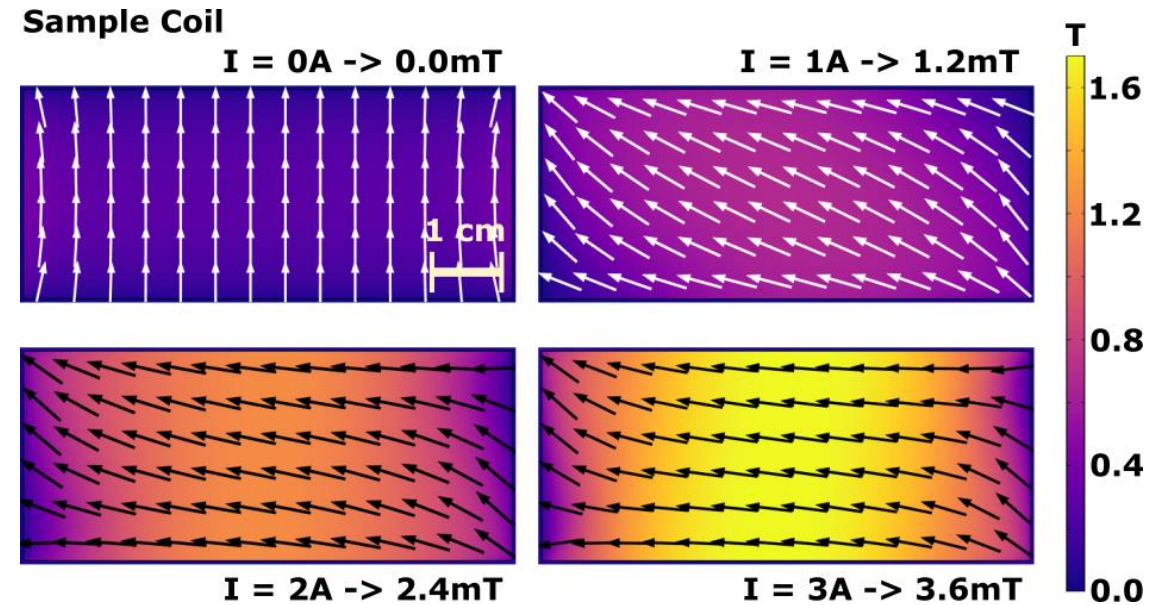
Compensation coil
counteracting the
guide field (5.2 mT)



Field homogeneity around the sample

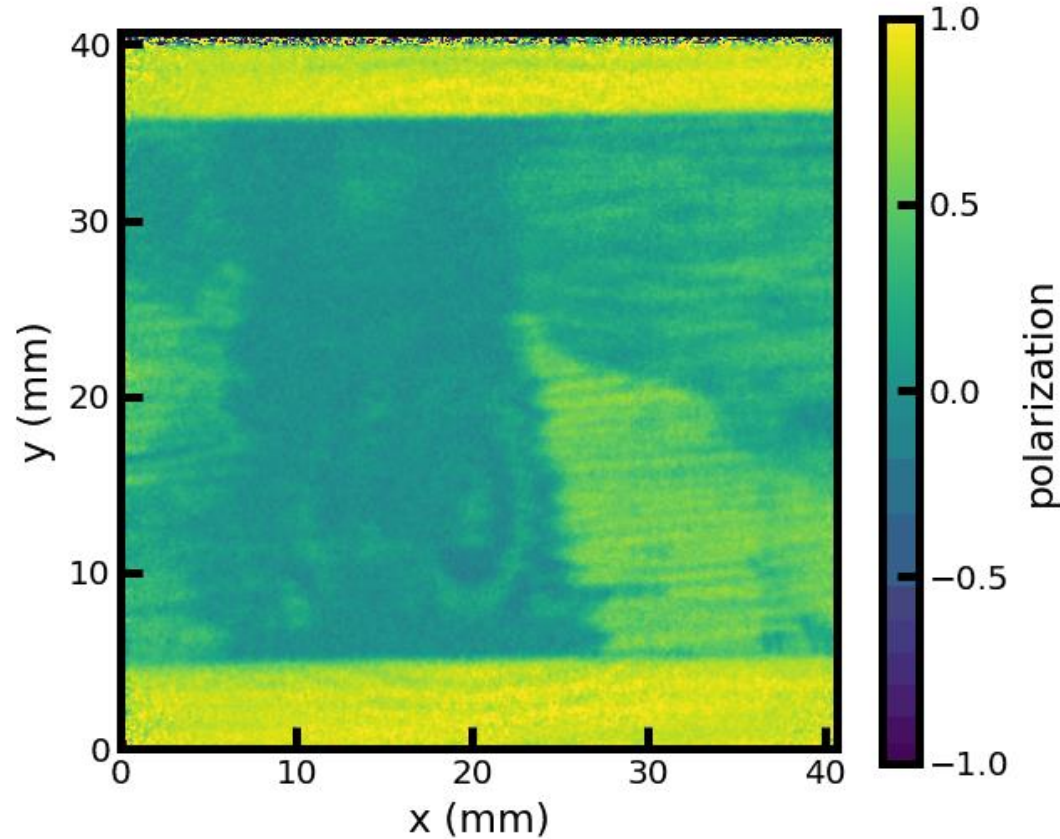


Field direction in the sample

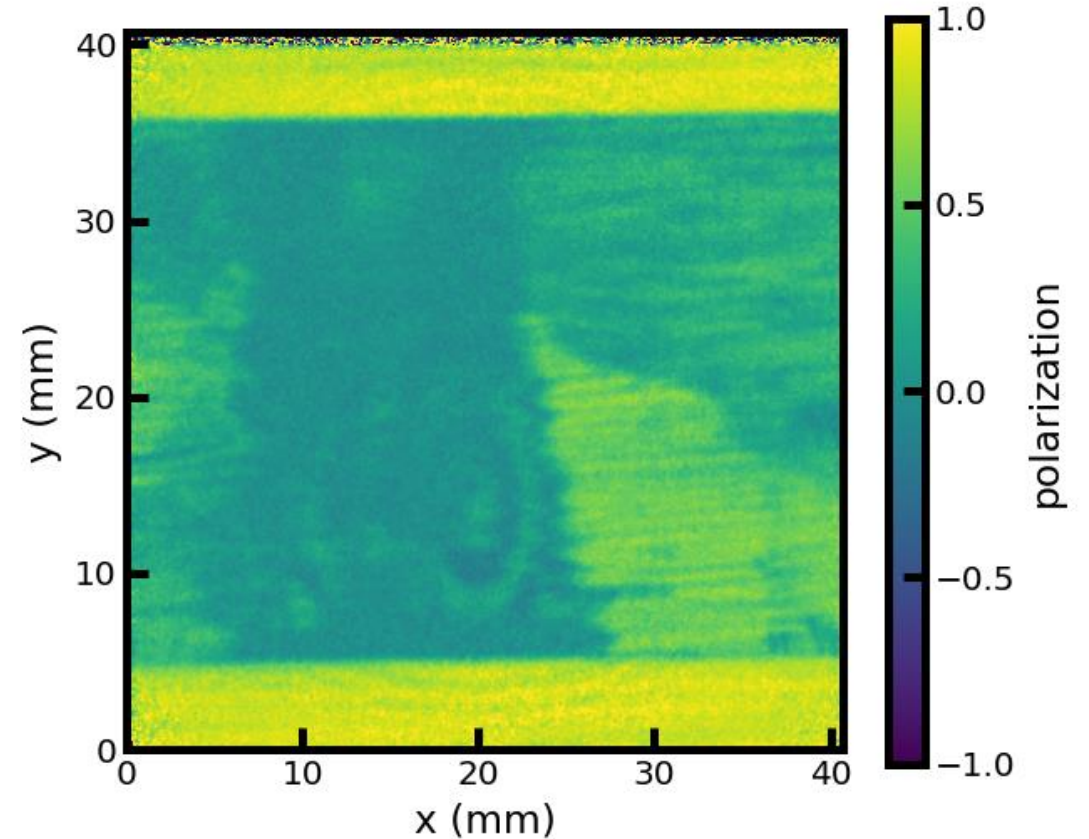


Simulation results for a partially compensated guide field (~ 1.5 mT)

Sample field scan



Sample coil : 0 A \approx 0 mT



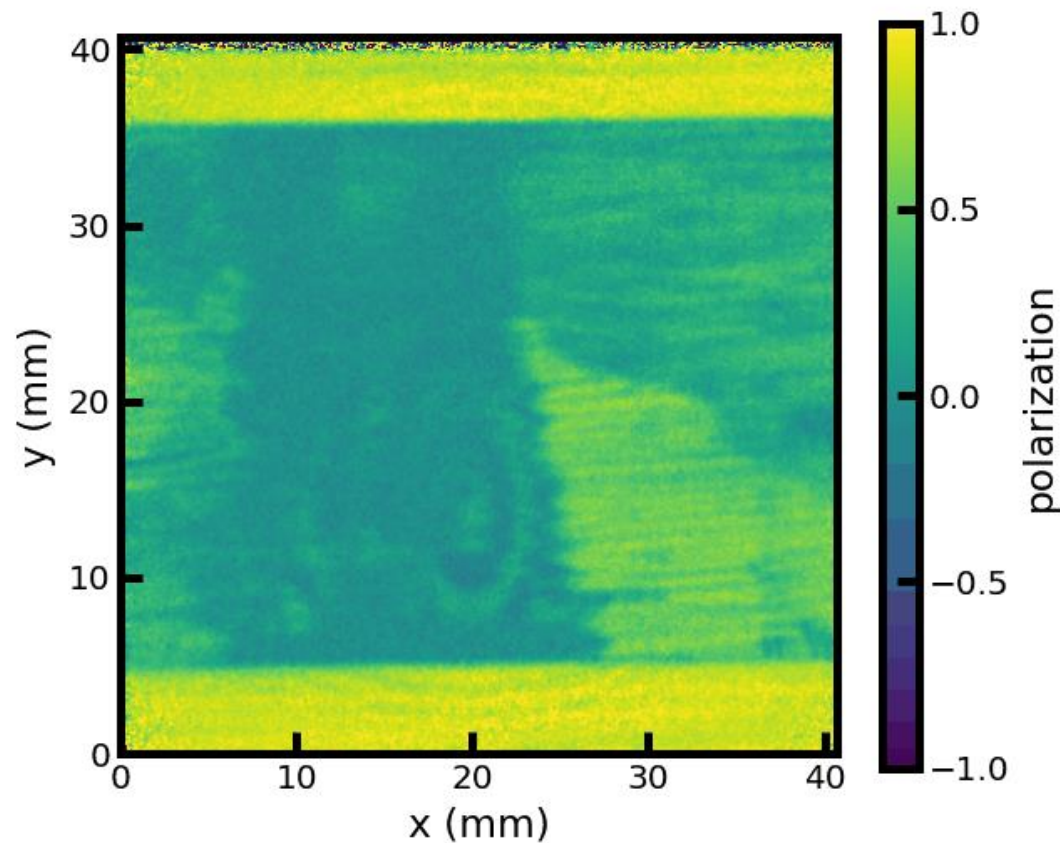
Wavelength: 3.1 Å

Guide field: \sim 7 mT

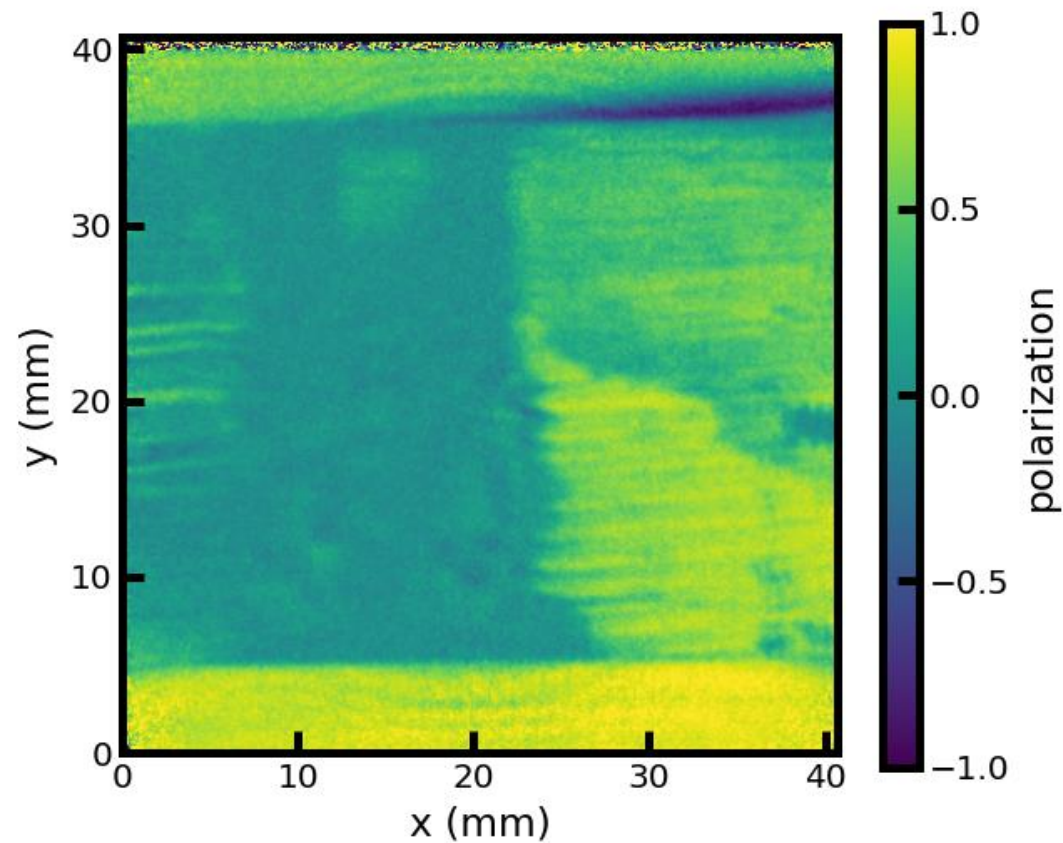
Compensation coil : 2.75 A \approx 6.5 mT

Sample coil 0 – 3.8 A \approx 0 – 4.2 mT

Sample field scan



Sample coil : 1.2 A \approx 1.3 mT



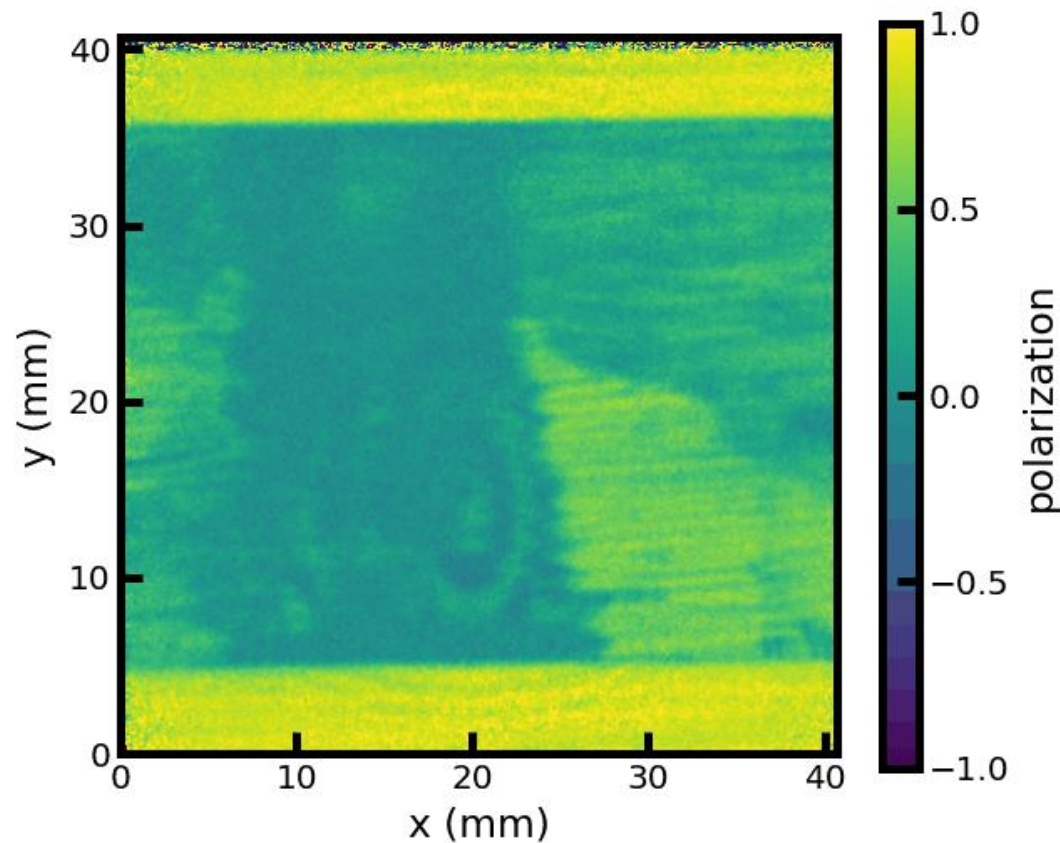
Wavelength: 3.1 Å

Guide field: \sim 7 mT

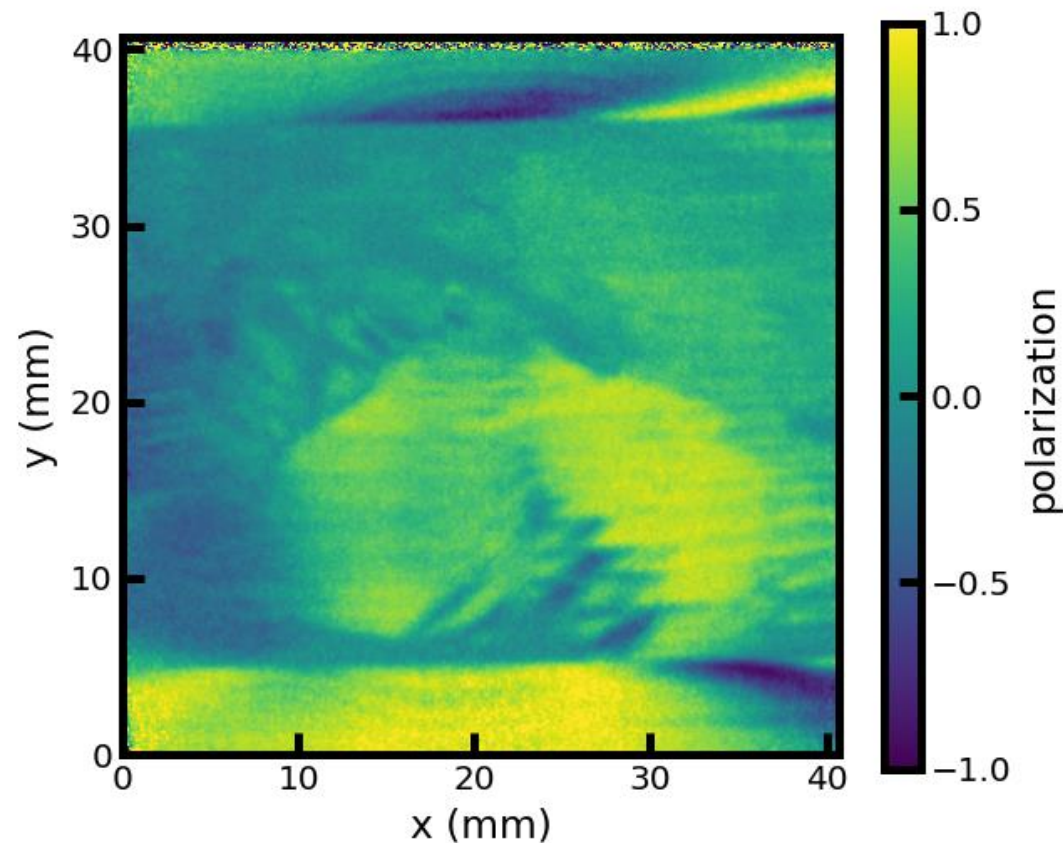
Compensation coil : 2.75 A \approx 6.5 mT

Sample coil 0 – 3.8 A \approx 0 – 4.5 mT

Sample field scan



Sample coil : 2.6 A \approx 2.9 mT



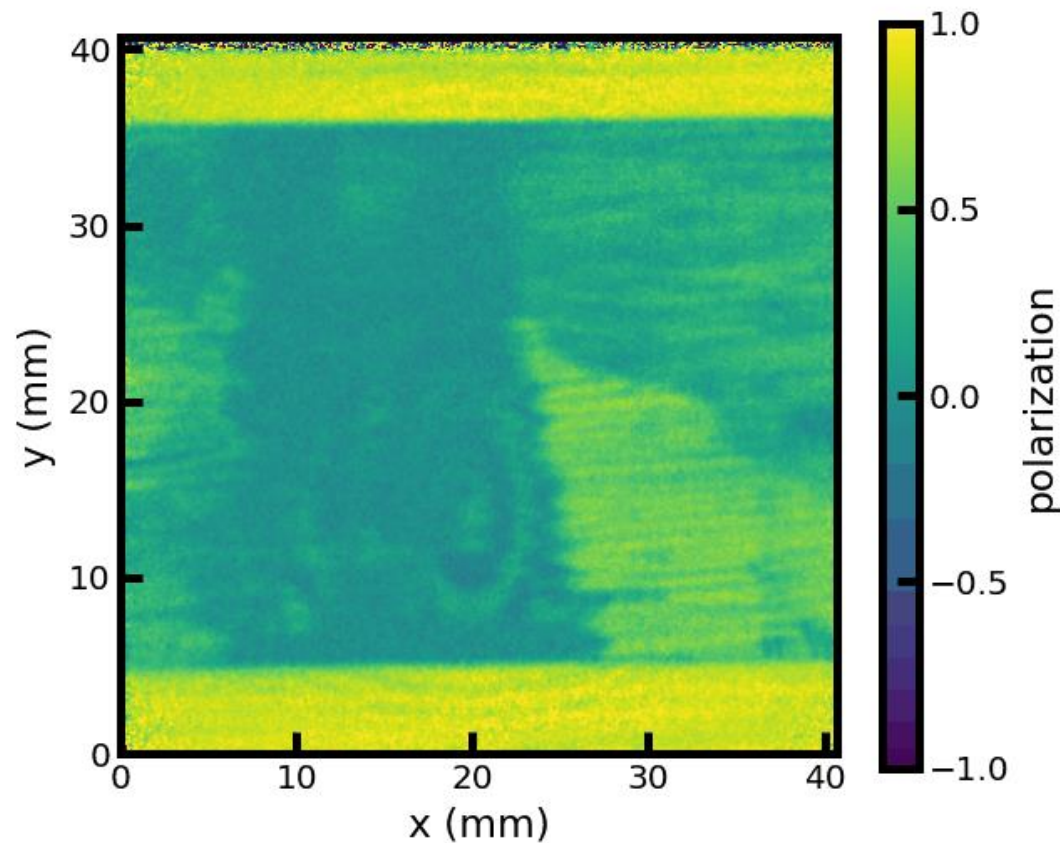
Wavelength: 3.1 Å

Guide field: \sim 7 mT

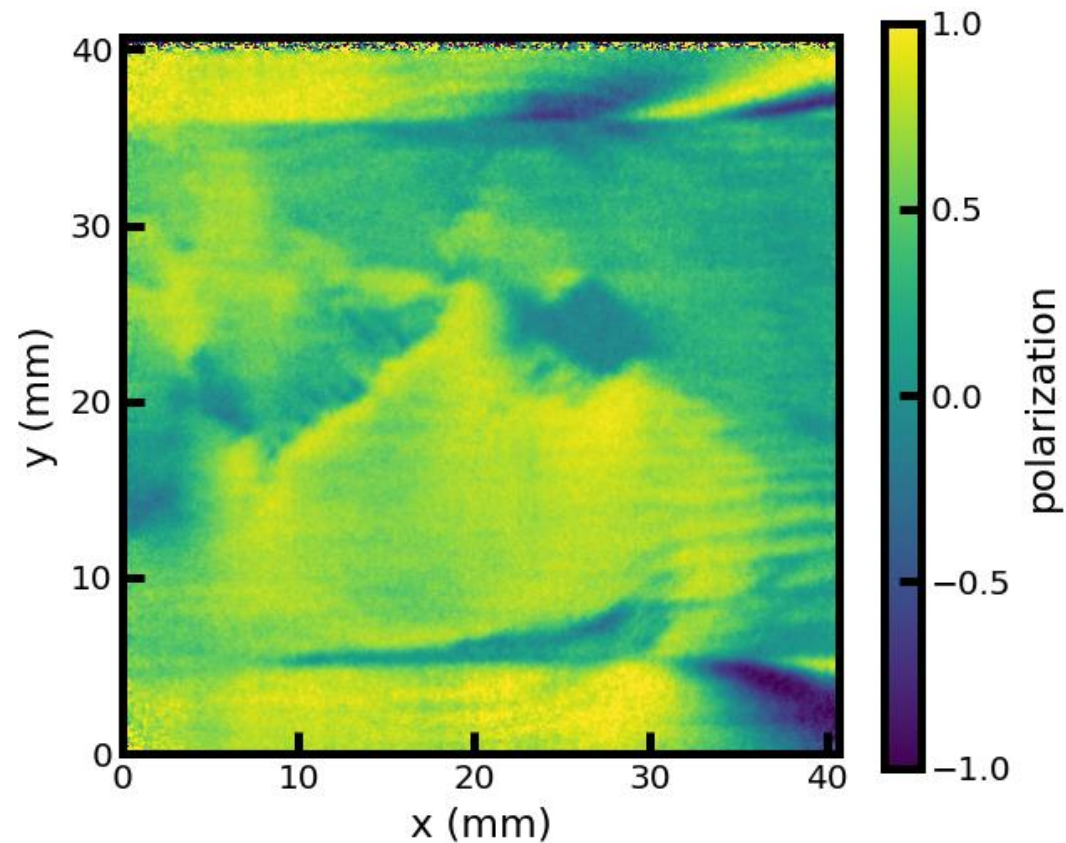
Compensation coil : 2.75 A \approx 6.5 mT

Sample coil 0 – 3.8 A \approx 0 – 4.5 mT

Sample field scan



Sample coil : 3.8 A \approx 4.2 mT

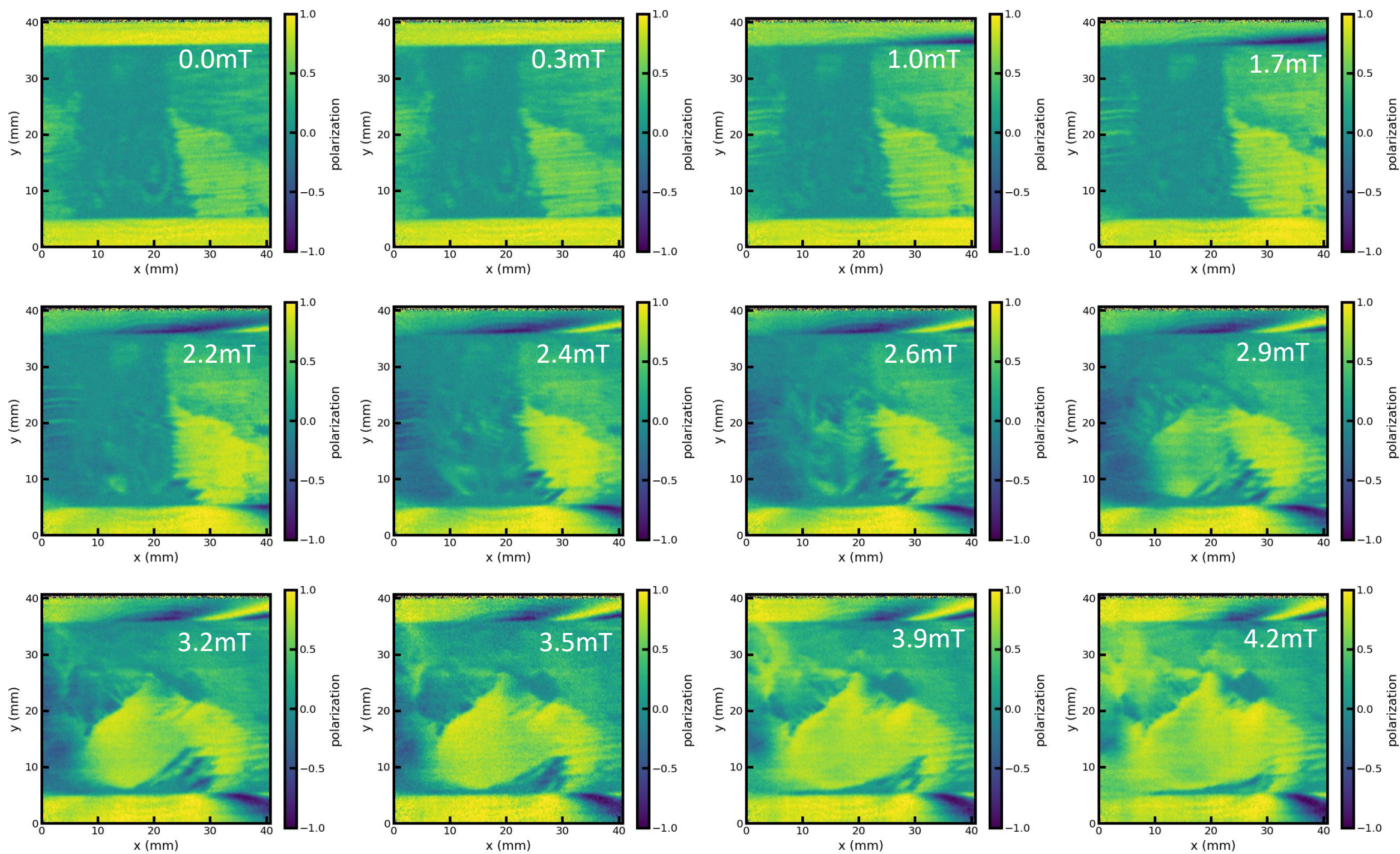


Wavelength: 3.1 Å

Guide field: \sim 7 mT

Compensation coil : 2.75 A \approx 6.5 mT

Sample coil 0 – 3.8 A \approx 0 – 4.5 mT





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**Thank You
For Your
Attention**