ZEBRA: The New Single-Crystal Neutron Diffractometer Optimized for Small Samples and Extreme Conditions

Laboratory for Neutron Scattering and Imaging

O. Zaharko[1], J. Schefer[1], A. Bollhalder[2], U. Sigrist[3] and M. Forster[2]

[1] Laboratory for Neutron Scattering and Imaging, Paul Scherrer Institute, 5232 Villigen PSI, Switzerland
[2]Laboratory for Developments and Methods, 5232 Villigen PSI, Switzerland, [3]AMI, Paul Scherrer Institute 5232 Villigen PSI, Switzerland

ZEBRA - Concept

ZEBRA, a new single crystal neutron diffractometer optimized for parametric studies and an extended q-range for crystallographic investigations, is presently under construction at SINQ and its commissioning is expected for 2017. This new SINQ instrument will be capable of resolving scientific challenges emerging in systems available as small crystals only and requiring extreme sample environments.
The new ZEBRA will replace the present TriCS single crystal diffractometer installed at the thermal beam port R42 in the target hall of the Swiss neutron spallation source SINQ in Villigen.
The tilting option together with the detector concept (1D, 2D and 1D with an analyzer) covers the requests of our user community in an optimal way.

Science at a Glance

The scientific projects in focus include

- unconventional magnetic phases in frustrated magnets
- Mott-insulating states in spin-orbit coupled systems
- unconventional superconductors
- functional metal-organic and perovskite materials

The ZEBRA instrument will achieve high peak-to-background ratio and will host extreme sample environments.

Research Goals of the New Single Crystal Neutron Diffractometer ZEBRA

Neutron single crystal diffraction is a method commonly used by chemists, physicists and crystallographers to investigate crystal structures and magnetic arrangements as well as phase transitions driven by temperature, magnetic fields or pressure. Neutron diffraction is indispensable for allocating hydrogen and light elements atomic positions in crystal structures, in investigating short-range and long-range magnetic correlations, in solving complex magnetic structures and in probing novel states at low temperatures and high magnetic fields.
The present tendency in neutron scattering centers is focused to accelerate data collection locating new instruments at high-flux sources, using large area detectors and employing polychromatic Laue and time-of-flight techniques.
We haven chosen a **complementary strategy** for the neutron single crystal diffractometer Zebra at SINQ. According to our inquiry the Swiss scientific community is interested in **novel materials with unconventional magnetic properties and new functionalities**.

These research activities require a new neutron diffractometer focused on

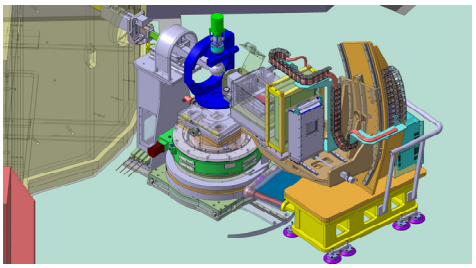
- Magnetic structures with magnetic moments down to 0.1 μ_{Bohr}
- small samples down to 5 mg
- sophisticated sample environment (high field up to 15 Tesla, high pressure, low and high temperature)
- capable to perform also conventional diffraction up to $\sin(\Theta)/\lambda$=0.9Å^{-1}

Key Properties of ZEBRA

- Non-magnetic sample environment allows fields up to 15 Tesla
- High precision sample positioning for minimized incoming beam size
- two detectors units mounted on air-cushions can be exchanged easily

- 2D detector and 1D detector, switchable in minutes
- 1D detector for full data set collections up to high q
- 2D detector exploring reciprocal space in 3D

- 1D detector with analyser (ΔE~0, elastic line) parametric studies with very low background



Detector unit with tiltable 2D and 1D detectors

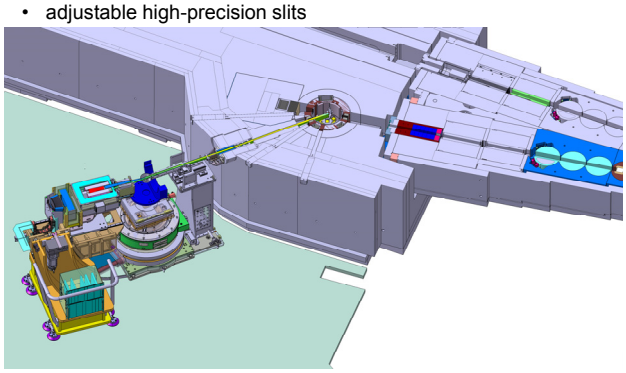
Easy to exchange
Higher q-range compared to TriCS

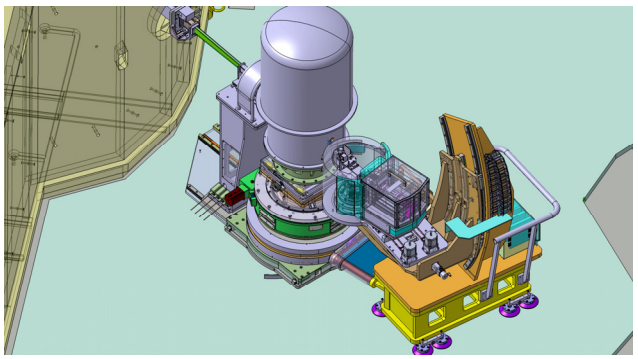
Tiltable analyzer unit in front of a 3-inch single-tube detector

- ideal for parametric studies
- high field magnet s(15 Tesla) due to the un-magnetic instrument
- $C_{002/004}$ - analyser in front of the 1D reduces background for Ge_{311} (1.18Å) or PG_{002} (2.34Å)

New Primary Optics

- uncooled Sapphire filter
- reinforced shielding
- adjustable high-precision slits





Conclusions

- ZEBRA is optimized for parametric studies: f (magnetic field H, pressure p, temperature T)
- ZEBRA extends the q-range for crystallographic data collections
- ZEBRA will increase the peak/background ratio by a factor >10 by optimized beam optics, high-precision sample mounting, monochromators and shielding

Funding: R'Equip(SNF)/PSI