Thermal Neutron Single-Crystal Diffractometer Zebra at the Swiss Spallation Neutron Source SINQ

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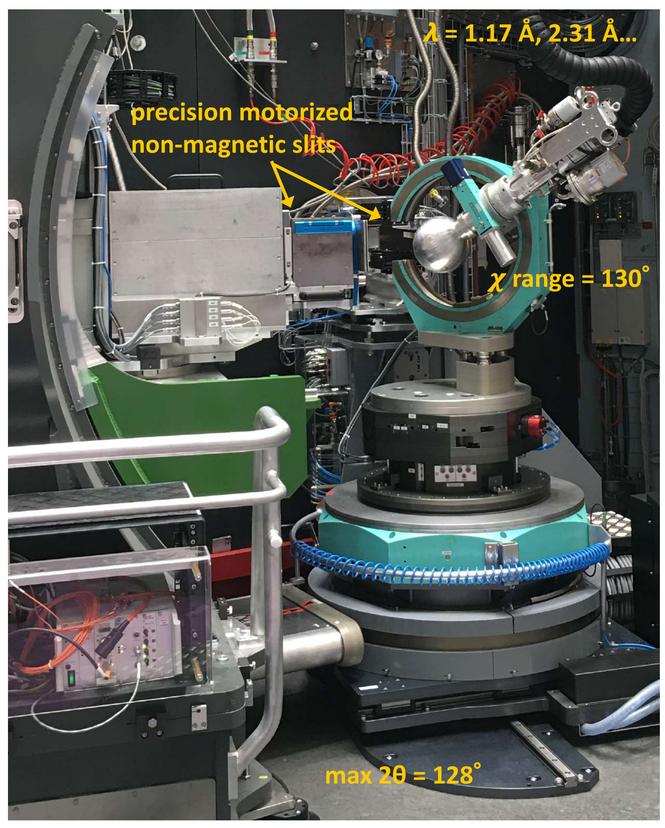
PROPOSAL DEADLINES: 15th May & 15th November

Zebra was commissioned in 2016 and designed to tackle new challenges in condensed matter. The instrument can collect crystallographic data for both magnetic and nuclear structures.

Typical sample volumes vary from 1 mm^3 up to about 1 cm^3 (maximal beam spot 1 cm^2). High-precision slits allow measuring much smaller samples down to a small fraction of mm^3 (see examples below).

Three detectors are available: (1) a conventional point detector with collimation capabilities, (2) an area detector with 14×14 degrees angular coverage equipped with a non-magnetic radial oscillating collimator, and (3) a 2-inches ^{3}He tube point detector equipped with a graphite analyzer. All detectors can be lifted out-of-plane (υ±15˚) when sample environment requires.

A broad range of sample environments allows various kinds of parametric studies:



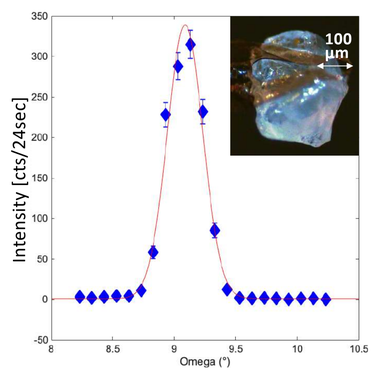
Zebra in 4-circle (left) and tilting (right) geometry, respectively using a CCR and a 10 T vertical magnet with dilution fridge. The three detectors are spotted on the right.

monochromator (swappable within seconds)	Ge 422	Ge 311	Ge 220	PG 002
wavelength λ (Å)	0.788	1.178	1.383	2.305
intensity (10^6 n/cm^2/s) at usual proton current	~0.15	1.38	~2.21	0.85
λ/2 contamination	-	-	~1 %	~0.1 %

- various devices for 4-circle experiments (CCR 4K, Joule-Thomson CCR 1.6K, Small Furnace 800K, optical furnace 1000K);
- vertical (6T, 10T and 15T) and horizontal (7T and 11T) magnets, all usable with dilution refrigerators (0.05K);
- cryostats for zero-field experiments in combination with dilution refrigerators, pressure cells and applied electric fields…

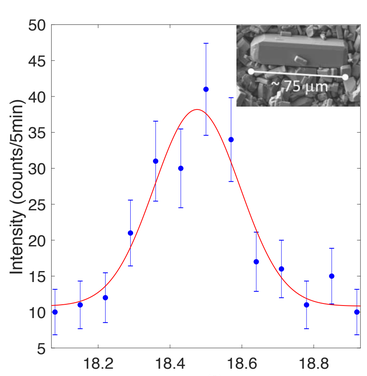
Example data focusing on weak signals (tiny crystals, thin films, small magnetic moments…)

A crystal of volume 0.12 mm^3 of a metal-organic magnet was measured in 4-circle geometry for magnetic structure solution.



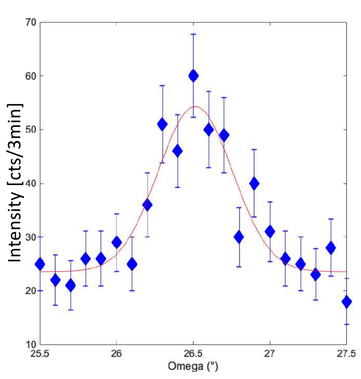
Background ~ 0.02 cts/sec
Dataset with 24 sec/point

A crystal of 50×50×75 µm ($2×10^{-4}$ mm^3) of an oxide was measured in 4-circle geometry. Incident beam width 0.4 mm.



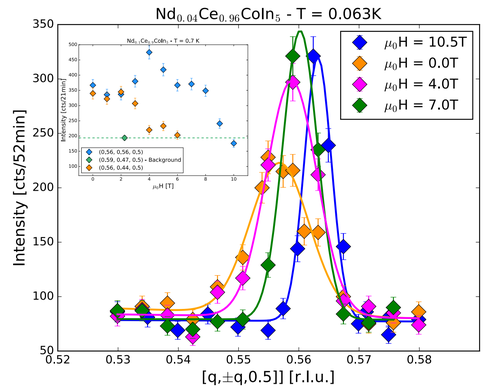
Background ~ 0.02 cts/sec
5 min/point (nuclear peaks)

A thin film of thickness 80 nm of a multiferroic material was measured in 4-circle geometry (4K and 300K). Beam 10×10 mm.



Background ~ 0.13 cts/sec
3 min/point (magnetic peak)

Crystals of about 20 mg of $Nd_xCe_{1-x}CoIn_5$ (x=0.04 and 0.10) were measured in vertical magnets (15T and 10T) using a dilution fridge. Moment sizes down to 0.2 μ_B.



Background ~ 0.03 cts/sec. 52 min/point.
Phys. Rev. Lett. 123, 097201 (2019)

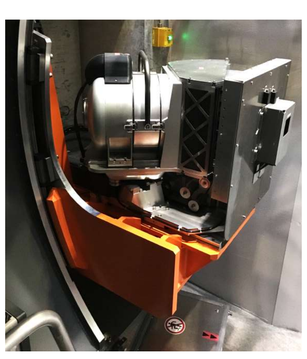
Graphite analyzer

A graphite analyzer mounted on a separate unit filters scattered beams before a 2-inches ^{3}He tube. The assembly is entirely non-magnetic, can be installed within minutes and tilted by ±15 degrees. Collimators and slits can be mounted before and after the crystal analyzer.

performances test on a 0.5 cm^3 crystal:

Point detector —(Intensity / 2 ; Background / 10)→ Analyzer

Consistent crystallographic datasets are obtained using the analyzer.



pyzebra

A modern python-based data analysis package is being developed, for the visualization, integration and analysis of both point- and area-detector data. Features include indexing and UB determination from area-detector data, integration of datasets, parametric studies…