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ANTARES: Cold neutron radiography and tomography facility

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Abstract: The neutron imaging facility ANTARES, operated by the Technische Universität München, is located at the cold neutron beam port SR-4a. Based on a pinhole camera principle with a variable collimator located close to the beam port, the facility provides the possibility for flexible use in high resolution and high flux imaging.

1 Introduction

ANTARES offers two different detector positions in chamber 2 and 3, which may be chosen according to the requirements for sample size, beam size, neutron flux and spatial resolution. Both chambers offer abundant space for user-provided experimental systems or sample environment, chamber 2 has a roof elevation for cryostats.

Chamber 1 is separately accessible for the optional installation of beam and spectrum shaping devices provided by the user. At this position, ANTARES also offers built-in options such as a velocity selector, double crystal monochromator, interference gratings, and a Be-filter which are readily available for standard user operation.

Additionally we can provide access to a 300 kV microfocus X-ray CT setup for complementary investigations with a spatial resolution as good as 1 μm.

2 Typical Applications

The ANTARES neutron imaging facility is designed to deliver radiographs and computed tomography of samples, similar to an X-ray machine. The resulting information is often complementary to

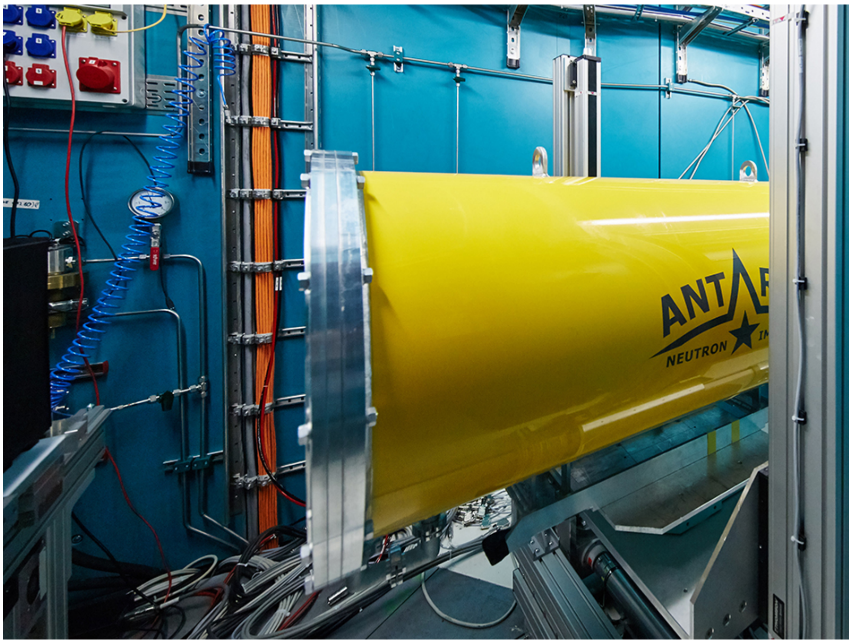

Figure 1: Instrument ANTARES (Copyright by B. Ludewig).

X-ray measurements, with its most important feature the high penetration depth of neutrons in most metals (Fe $\sim$ 4 – 5 cm, Al $\sim$ 20 – 30 cm, Pb $\sim$ 10 – 20 cm) and the high sensitivity for hydrogen. These allow to visualise metal machine parts as well as liquids, sealants and plastics inside of metal parts. Liquid contrast agents can be employed for crack and void detection. Examples of different techniques and their typical applications are:

- **Standard neutron radiography**: Moisture in sandstone, O-rings in machine parts, aerospace pyrotechnical components, fuel cells
- **Computed tomography**: Geological samples, mineral phases, voids in carbon fiber structures (using contrast agents), machine parts, biological samples like e.g. lung tissue
- **Continuous radioscopy**: Video speed radiography of dynamic processes like boiling in refrigerators or water boilers
- **Stroboscopic imaging**: Visualisation of repetitive processes with high time resolution: Oil distribution in running combustion engines
- **Phase contrast**: Edge enhancement, aluminium foams, interfaces of similar alloys
- **Energy / wavelength scan**: Scanning for Bragg edges, phase or material identification, examination of welds
- **Polarised neutron imaging**: Metallurgical homogeneity of ferromagnetic materials, fundamental research on ferromagnetic phase transitions, visualisation of magnetic field profiles
- **Neutron Grating Interferometry**: Measurement of the spatially resolved SANS or USANS signal of the sample. Detection of microstructures on length scales of 500 nm – 10 µm, porous materials, magnetic and superconducting vortex lattice domains

3 Sample Environment

Standard sample environment can be used at ANTARES:

- Closed-cycle cryostats CC, CCR: T = 50 mK – 300 K
- Electro magnet: 0 – 300 mT
- Cooling water and pressurised air

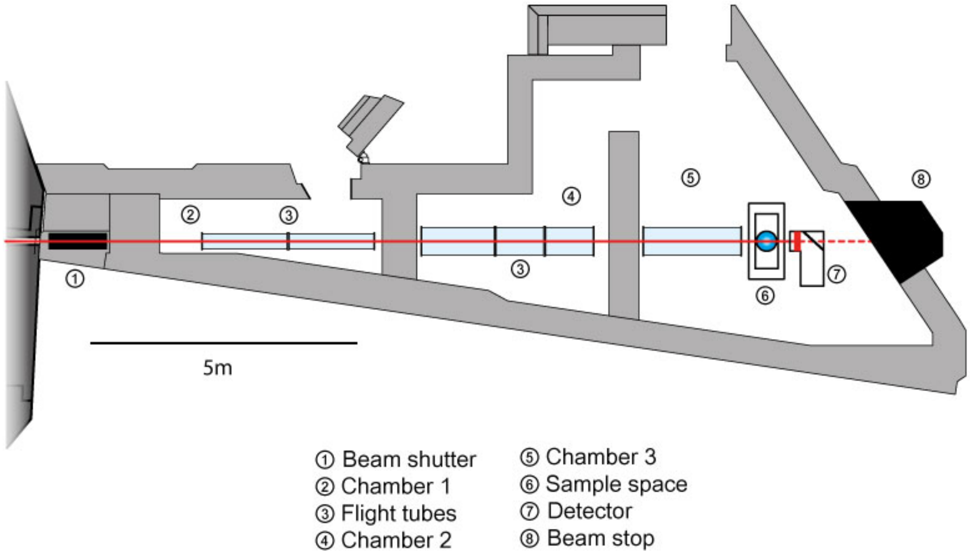

Figure 2: Schematic drawing of ANTARES.

4 Technical Data

4.1 Collimation and flux at the sample position 6

- L/D = 200, $4 \cdot 10^8$ n cm^{-2} s^{-1}
- L/D = 400, $1 \cdot 10^8$ n cm^{-2} s^{-1}
- L/D = 800, $2.6 \cdot 10^7$ n cm^{-2} s^{-1}
- L/D = 8000, $2.6 \cdot 10^5$ n cm^{-2} s^{-1}
- Beam size up to 35 x 35 cm^2

4.2 Neutron beam optics (optional)

- Double crystal monochromator:
  1.4 Å $\leq \lambda \leq$ 6.0 Å ($1\,\% < \Delta\lambda/\lambda < 3\,\%$)
- Neutron velocity selector:
  3.0 Å $\leq \lambda \leq$ 8 Å ($\Delta\lambda/\lambda = 10\,\%$)
- Neutron grating interferometer:
  Sensitive to length scales 500 nm – 10 µm
- Beam Filters:
  Cd filter for epithermal imaging
  Be filter to suppress wavelengths $\lambda < 4$ Å
  Sapphire filter to suppress fast neutrons
- ^{3}He neutron spin filter polariser
- polarising supermirror V-cavity

4.3 Sample table

XY-Phi-table:
- Capacity: 500 kg
- Travel: x = 800 mm, y = 600 mm
- Rotation table: 360° rotation
- additional high precision 5-axes HUBER table for small samples (< 10 kg)

4.4 Detection systems

- various detection systems with spatial resolutions as good as 30 µm
- Camera box with mirror and scintillation screens of different sizes from 6 x 6 cm^2 to 40 x 40 cm^2, screen thickness from 10 µm to 200 µm, plus X-ray screens
- Standard detector: ANDOR cooled CCD camera, 2048 x 2048 pixels, 16 bit
- Fast cooled scientific CMOS camera: ANDOR Neo 2560 x 2160 pixels, 16 bit, up to 50 fps full frame
- Intensified triggerable iStar ANDOR cooled CCD camera, 1024 x 1024 pixels, 16 bit
- Intensified NTSC video camera (30 fps) with analog frame grabber, MPEG-2 and DivX recording
- DürrDental Image Plate scanner for arbitrary imaging plates, focus size 12.5 – 100 µm
- Fuji BAS 2500 Image Plate scanner, focus size 25 – 100 µm
- X-ray and neutron imaging plates
- MAR345 image plate detector, 345 mm diameter, N-sensitive image plate