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The thermal triple-axis-spectrometer EIGER at the continuous spallation source SINQ

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ABSTRACT

EIGER is the new thermal triple-axis-spectrometer at the continuous spallation SINQ at PSI. The shielding of the monochromator consists only of non- or low magnetizable materials, which allows the use of strong magnetic fields with the instrument. This shielding reduces the high energy neutron contamination to a comparable level of thermal spectrometers at reactor sources. The instrument design, the performance and first results of the spectrometer are presented.

1. Introduction

Since the early days of neutron scattering triple-axis-spectrometers (TAS) are the most commonly used instruments for inelastic neutron spectroscopy of single crystals at continuous neutron sources. Spallation neutron sources are typically pulsed where direct time-of-flight instruments are favorable. The only continuous spallation neutron source is SINQ at PSI [1] and the instrumentation at SINQ is similar to reactor based sources and very different to other spallation sources. Up to 2012 at SINQ there were two cold TAS but no thermal one. One reason for this is that at a spallation source there are more high energy neutrons with even higher energy, than at a reactor [2,3]. For cold neutron instruments this is not relevant since the instruments are built at neutron guides far away from the neutron source. Since the neutron guides are much less effective for thermal neutrons than for cold neutrons, a large distance between neutron source and monochromator would reduce the neutron intensity of a thermal TAS at SINQ to an inacceptable level. As a consequence the high energy neutrons make the design of a thermal TAS, where low background is very important, more challenging at a continuous spallation source than it is at a reactor based source.

In this paper we report on the design, performance and first results of the thermal TAS EIGER at the continuous spallation source SINQ.

2. The EIGER instrument

2.1. General design

Fig. 1 shows the layout of the instrument. The primary instrument consists of a beam tube with a sapphire filter, a virtual source, a double-focusing pyrolytic graphite (PG) monochromator and the shielding. The secondary instrument of the former cold TAS DrüchaL was upgraded and is now in operation at EIGER. It is similar to that of the cold TAS TASP [4]. It is equipped with a horizontal focusing PG analyzer and a single tube ^{3}He detector.

2.2. Beam tube

A water scatterer, placed within the heavy water moderator tank, provides EIGER with neutrons. The entrance window has size of 80×150 mm^2. Behind the entrance window there is a 100 mm sapphire filter which reduces the flux of neutrons with energies above about 100 meV. The beam tube up to the virtual source is converging with an exit window of 40 mm width and is equipped with a neutron supermirror and includes three rotatable steel cylinders used as high energy neutron shutters. Unfortunately, an unknown amount of the supermirror coating peeled off which causes some loss of intensity especially at lower neutron energies. After the virtual neutron source with an adjustable width between 0 and 40 mm, there is space in the shielding which can be used for a neutron velocity-selector which is intended to

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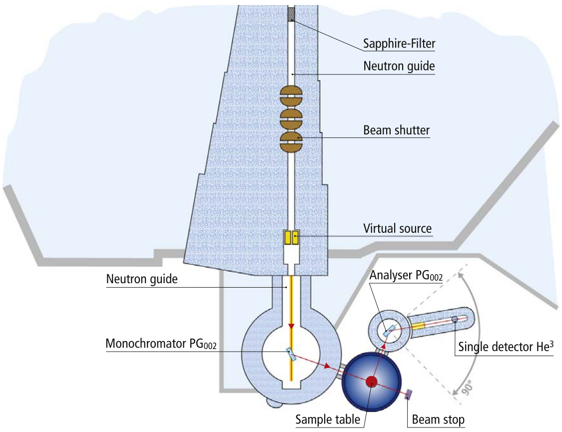

Fig. 1. Sketch of the instrument EIGER.

be installed at the next upgrade of EIGER.

2.3. Monochromator shielding

The main task of the shielding is an efficient reduction of the γ- and fast neutron radiation. It is important that the shielding does not become too thick otherwise the monochromator-sample distance would become too large which would reduce the intensity at the sample position. An additional requirement for the EIGER-shielding is that it should contain only low-magnetizable materials, since the instrument is intended to be used also in combination with high magnetic fields. Therefore, a composite design with layers of mainly the four materials: tungsten-paraffin wax mixture, lead, low-magnetizable heavy concrete and borated polyethylene was selected. A more detailed description of the shielding can be found in [5]. The tungsten-paraffin composition is used in the region where the highest fast neutron fluxes occur and where space limitations are most disturbing the operation of the instrument. The Tungsten-paraffin block is shielded by a Cadmium layer which ensures that only a low amount of thermal neutrons will activate the compound. Most of other parts are made of low-magnetizable heavy concrete with a density of about 5.2 g/cm^3. The concrete is loaded with 5% boron carbide to improve the absorption of slowed down neutrons. A further goal of the monochromator shielding design was to reduce the neutronic background which can hit the sample or even worse the detector system. The goal was reached by a triangular surface, filled with boron Carbide, of the inner part of the monochromator which acts as a neutron trap.

Within the monochromator shielding there is sufficient space for additional monochromators, which might complete the instrument in later upgrades.

2.4. Monochromator

Fig. 2 shows a picture of the present PG monochromator. The design of the monochromator is similar to that of MACS [6]. The 135 PG pieces have a mosaicity of about 0.5 degree and a size of 20×20 mm^2. Nine pieces of the PG are screwed on each of the 15 Al lamella, therefore the total surface of the PG on the monochromator is 300×180 mm^2. Vertical focusing of the monochromator is achieved by bending, horizontal focusing by rotating the lamella. The advantage of this design of a double focusing monochromator is that there is only very small amount of material in the beam. Therefore, the contribution of neutrons scattered at supporting material of the monochromator is reduced to a minimum. However, the bending of the lamella for vertical focusing causes a shift of the PG crystals which has to be compensated by a translation of the whole monochromator in order to avoid any misalignment.

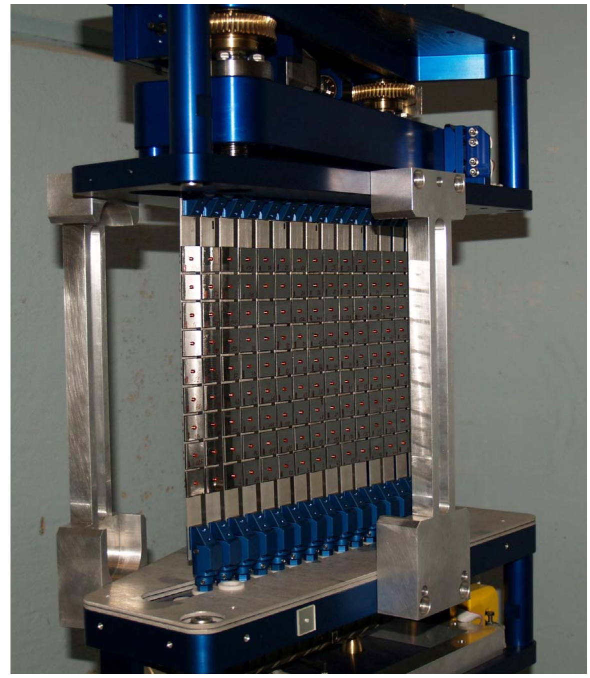

Fig. 2. Picture of the EIGER monochromator.

Fig. 3. Picture of the monochromator shielding, sample table and the secondary spectrometer with the analyzer housing and the detector shielding of EIGER.

2.5. Secondary instrument

A picture of the secondary instrument and the monochromator shielding is given in Fig. 3. The distances between monochromator - sample and sample - analyzer are variable with minimum distances of 2530 mm and 1090 mm, respectively. The sample table can be rotated and is equipped with two goniometers for tilting the sample. The PG-analyzer, 175×150 mm^2 in size, has a horizontal focusing option, but no vertical curvature. The detector is a vertical ^{3}He-tube with a diameter of 50 mm and a height of 170 mm. The effective width of the detector can be reduced by a slit in front of the detector. Typically a slit of 20 mm is used in combination with the horizontal focusing of the analyzer. Soller collimators with a collimation of 20′, 40′ or 80′ can be inserted after the monochromator, after the sample and after the