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FOCUS: a hybrid TOF-spectrometer at SINQ

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Abstract

The concept of the SINQ-time-of-flight (TOF) spectrometer FOCUS foresees a hybrid-TOF solution that combines a doubly focusing crystal monochromator with a Fermi-chopper. The spectrometer can be operated in time focusing (TF) and monochromatic focusing (MF) mode such that it can be optimised for quasielastic and inelastic scattering applications, respectively. By the use of two interchangeable monochromators (PG and MICA) access is provided to incident energies in the range 0.25 meV < E_i < 20 meV.

Keywords: Neutron instruments; Time of flight; Focusing

At the end of '96 the new Swiss spallation neutron source SINQ is expected to produce its first neutrons. For the first years FOCUS will be the only time-of-flight (TOF) spectrometer at SINQ. It is therefore important that the concept foresees a versatile solution that can be well adapted for various scattering applications.

FOCUS will be a direct geometry hybrid-TOF that combines a crystal monochromator with a Fermi-chopper. A direct copy of the prototype of this kind of spectrometer that is the IN6 at the ILL/Grenoble [1, 2] is not the most appropriate solution to consider at SINQ due to the large divergence emerging from the supermirror-coated guide system [3]. The solution we have chosen [4, 5] is presented in Fig. 1 as a horizontal cut through the main spectrometer components. Directly at the end of the guide a disc-chopper is located that serves both as anti-overlap chopper and together with an optional Be-Filter as higher-order filter. The Fermi-chopper is located at a distance of 0.5 m in front of the sample and will be equipped with interchangeable rotors with different collimation packages. For the day-1 operation the spectrometer will dispose of 200 ^{3}He counter tubes of rectangular shape. Unlike the IN6 solution we have increased the distance between guide and monochromator (GM) to 3 m. Thus, a natural collimation of the beam per single crystal piece of the monochromator is produced. The monochromator consists of several crystal pieces forming a polygon surface. Due to a horizontally and vertically focusing setup of the monochromator combined with variable curvatures in both directions [6] the increase in distance causes only a slight reduction of the intensity but improves the resolution strongly.

The standard monochromator of FOCUS will be a pyrolithic graphite one (mosaicity 0.8°). Due to

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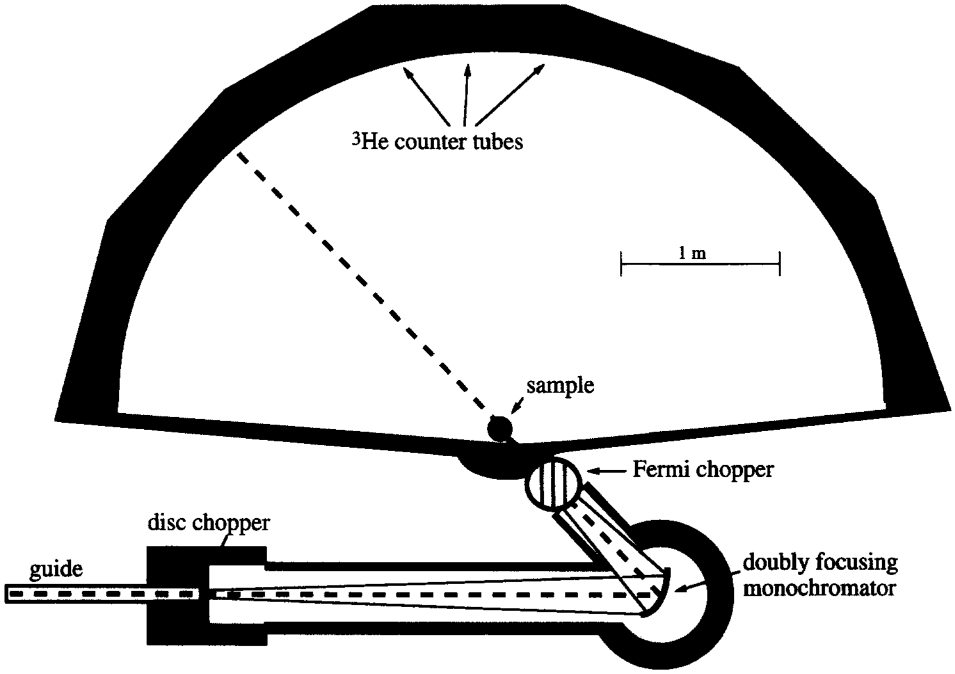

Fig. 1. Horizontal cut through the main spectrometer components. The crystal monochromator focuses the beam both horizontally and vertically through the Fermi-chopper in the direction of the sample. In its first stage FOCUS will be equipped with 200 ^{3}He counter tubes.

a large range of take-off angles ($35° < 2\theta < 130°$) access is provided to a band of initial wavelengths from approx. 2–6 Å. Furthermore, it is foreseen to have a second monochromator interchangeably with the first one made of MICA with a d-spacing of ~ 10 Å. Then it becomes possible to use incident wavelengths up to 18 Å such that the whole spectrum of the cold guide is usable for TOF-experiments.

In its standard configuration FOCUS will be operated in its time-focusing mode [1] that is well suited for scattering applications that address a single excitation or quasi-elastic scattering. This is due to the fact that the time focusing provides a sharp energy resolution just at the focal condition. For problems that address a broad range of energy transfers the monochromatic focusing geometry is the appropriate choice. To operate in this configuration equal distances GM and monochromator–sample (MS) have to be chosen. If the horizontal radius of curvature is adapted, there is no wavelength spread contribution $\Delta\lambda$ from the monochromator, except the one arising from the local divergence. Technically those variable distances are achieved in two ways. First, by moving the spectrometer housing to a further distance from the monochromator and by inserting an additional flight path in between monochromator and sample. Second, the distance GM can be varied by installing a further neutron guide behind the disc-chopper such that the end of the guide is shifted with respect to the monochromator. In such a way FOCUS can be operated besides its time focusing mode in a high resolution or a high intensity monochromatic configuration (see Table 1).

The expected performance of the spectrometer with respect to energy resolution and intensity has been calculated both analytically [7] and by a modified version of a Monte-Carlo algorithm developed by H. Mutka/ILL. Both results agreed well. Table 1 presents the results for various settings of FOCUS at an initial wavelength of

Table 1
Energy resolution and intensity of FOCUS as a result of a Monte-Carlo simulation algorithm. The performance of the original IN6 is also included. The intensities are normalised to the respective neutron sources. For further explanations see text

$\lambda = 6$ Å Instr. Configur.	Intensity $I/(\mathrm{d}\sigma/\mathrm{d}\lambda)$	Resol. (μeV) $\Delta E = -2$ meV	Resol. (μeV) $\Delta E = 0$ meV	Resol. (μeV) $\Delta E = 10$ meV
			PG002	
IN6-ILL				
145 Hz	1.00	66	45	850
FOCUS				
GM/MS/β/ν				
3.0/ 1.5/ 1/ 260 (TF)	0.26	47	35	690
3.0/ 1.5/ 1/ 160	0.67	46	54	1140
1.5/ 1.5/ 3/ 160 (MF)	1.82	26	85	1060
3.0/ 3.0/ 3/ 330 (MF)	0.42	13	46	580

6 Å. The relevant parameters that have been varied are the distances GM, MS, the Fermi-chopper collimation, β, and frequency, ν. For comparison, the performance of the IN6 at the ILL is also included. The intensities are normalised to the respective neutron sources and negative energy transfers denote neutron energy loss scattering. As one can see from the table the time focusing mode of FOCUS provides the best achievable energy resolution at the elastic line. On the other hand, the monochromatic configuration at the 3 m position is very attractive since it provides an intensity gain of almost a factor of 2 combined with a resolution that is very narrow especially for neutron energy loss. Furthermore, the short monochromatic focusing distance (1.5 m) is really a high intensity configuration that provides an intensity gain by a factor of 7 compared to the time focusing mode. Thus, it is possible to choose the most appropriate combination of resolution and intensity and adapt the setting of the spectrometer flexibly to the problem under consideration.

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