SINQ guide concept

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Introduction

In this paper we describe the present concept for the layout of the neutron guides at SINQ. The characteristics of the source will make it particularly competitive in the cold neutron region [1] through the inclusion of a liquid D_2 source, which is described in [2]. However, concommittant with the cold neutron production, there will be high energy neutrons (E > 15 MeV) emitted from the source, which significantly influence many of the design parameters and, in particular, the required shielding. The guide system, although based on the demands for the foreseen instrumentation, has been designed to be as flexible as possible to allow reasonable future development, while taking into account the particular background problems arising from the high-energy neutrons.

General requirements and aims

A clear aim for any general layout is to provide the maximum useful neutron flux over the wavelength range required by the instruments, while at the same time ensuring a minimum background. Thus, our concept for the SINQ guides, although not dependent on, does allow for the possibility of supermirror coatings for the guides outside the main shielding, with a critical angle of reflection m times that of natural nickel, giving a factor m^2 increase in effective flux. Because these supermirrors constitute an essential part of the system, there is an active program within the institute to develop them. A survey of planned and possible future instruments to be accommodated in the guide hall has indicated a demand for wavelengths in the range 2 - 12 Angstroms and a variation of beam sizes. The guide system has thus been designed according to the following principles:

- The transmission is to be optimized for wavelengths in the range 2 - 12 Angstroms.
- In order to allow the implementation of focusing methods, the nominal guide size has been set at 120 mm high and 50 mm wide.
- The first sections of the guides will be curved to avoid direct line of sight for the fast and (more importantly) high-energy neutrons. For this curvature to be effective, good shielding must be mounted close to the guides to provide tight collimation, and all instruments should be placed at least 5 m after the line of sight.
- The guides outside the main shielding may have supermirror coatings with m = 1.5, giving a flux increase of 125% with respect to natural nickel. If high-reflectivity supermirror coatings cannot be made routinely at the time of

guide fabrication, ^{58}Ni (m = 1.2) will be used with a corresponding flux gain of 40% over natural nickel.

Figure 1 shows a general layout of the SINQ target and guide halls on which schematic drawings of some proposed spectrometers have been included to illustrate the probable beam positions. Referring then to Fig. 1, the guide system can be subdivided into four distinct parts: the in-shield sections, the shutter section, the blockhouse section and the guides in the guide hall proper.

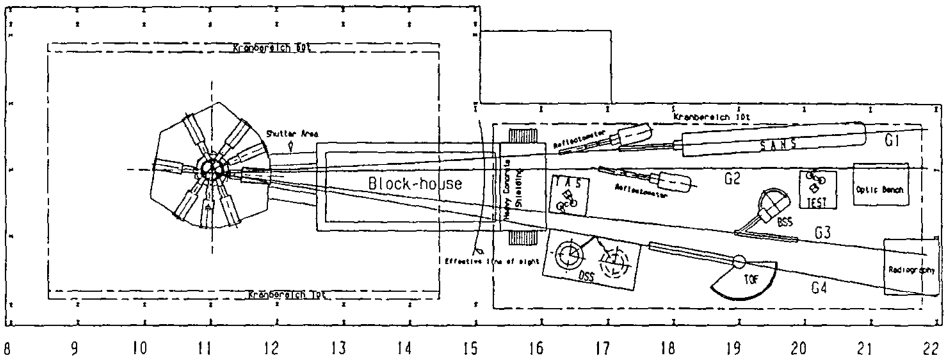

Fig. 1 Neutron guide layout.

In-shield section

Four straight guides, with angles of ± 4 and ± 6 degrees with respect to the plug axis, will view the cold source from a distance of 1.5 m and continue 4.5 m to the outside of the main shielding where they will be directly coupled to the shutter sections. These guides will be fabricated from either non-boron glass or polished nickel plates with a surface coating of ^{58}Ni and will be slightly converging away from the source to fully illuminate the following sections of guide having supermirror surfaces. The design of the insert will allow installation of a further central guide if required in the future.

Shutter section

The shutter will be situated on the outside of the main shielding and will provide a means of replacing a 1 m evacuated guide section by a beam blocker. The details of this shutter have not yet been defined.

Blockhouse section

After the shutter the guides are mounted in a shielding blockhouse, where they will be curved and tightly shielded to remove direct transmission of high-energy neutrons. In addition (referring to Fig. 1) guides G1 and G2, and similarly guides G3 and G4, will be curved in opposite directions such that the main shielding against direct flight neutrons will be situated between each pair of guides.

The combination of the requirements of a short characteristic wavelength, λ*, together with a large guide width, w = 5 cm, leads to an excessively long line-of-sight length, Ls, for all realistic values of m. This problem may be overcome by using curved guides that are divided vertically into subguides by means of thin glass plates similarly coated with supermirror, allowing the radius of curvature to be decreased.

Table 2 shows the line-of-sight lengths obtained and the radii of curvature (R) required for different characteristic wavelengths as a function of the parameter m and the subguide width a. However, assuming that the center glass plates are transparent to high-energy neutrons, the effective line of sight, Le, will be determined by the total guide width, w, and the effectiveness of the adjacent shielding. The estimated values of Le (for w = 5 cm) are also given in Table 2.

Table 2

λ* = 2 Å

a (cm)		m = 1	1.2	1.5	2	2.5
5	Ls (m)	59	49	39	29	23
	R (km)	8.7	6.0	3.8	2.2	1.4
	Le (m)	59	49	39	29	23
2.5	Ls (m)	29	24.5	19.6	14.7	11.8
	R (km)	4.3	3	1.9	1.1	0.7
	Le (m)	42	35	27.5	20.5	16.3
1.67	Ls (m)	19.6	16	13.1	9.8	7.8
	R (km)	2.9	2	1.3	0.7	0.5
	Le (m)	34	28	22.5	16.7	13.3

λ* = 1.5 Å

a (cm)		m = 1	1.2	1.5	2	2.5
5	Ls (m)	78.5	65	52.3	39.2	31.4
	R (km)	15.4	10.7	6.8	3.8	2.5
	Le (m)	78.5	65	52.3	39.2	31.4
2.5	Ls (m)	39	32.7	26.1	19.6	15.7
	R (km)	7.7	5.3	3.4	1.9	1.2
	Le (m)	55.4	46	37	27.7	22.2
1.67	Ls (m)	26.1	21.8	17.4	13.1	10.5
	R (km)	5.1	4.3	2.3	1.3	0.82
	Le (m)	45.3	37.5	30.2	22.6	18.1

Thus, in keeping with the design goals, each of the guides in the blockhouse will be constructed as two subguides (i.e., with one central glass plate) having a a radius of curvature of 1.9 km. The effective line of sight for the present system (including the initial straight sections) is shown in Fig. 1 and falls within the blockhouse.

The use of supermirror coatings (m = 1.5) in the curved sections is essential to ensure the characteristic wavelength of 2 Å, even though some instruments may not make use of the increased beam divergence. The effect of replacing the supermirror by ^{58}Ni (m = 1.2), or eventually natural nickel (m = 1) for the SANS and the reflectometer, would be to increase the characteristic wavelength to 2.5 or 3 Å respectively, in addition to reducing the total flux.

The theoretical fluxes, based on the calculations of [2] with a 10^{14} incident flux on a D_2 source with a 10 cm re-entrant hole and taking into account the transmission of the curved guides (reflectivity = 100%), are shown in Fig. 2 for m = 1.5.

It is clear that the center channel will leave a hole in the illuminated phase space of the following open guide and that this hole will be transmitted, albeit transformed in shape, down the guide. We are at present performing calculations to investigate both the effect of this gap in illumination on the instruments, in particular those with crystal monochromators, and the possible optimum sitings along the guides to reduce adverse effects.

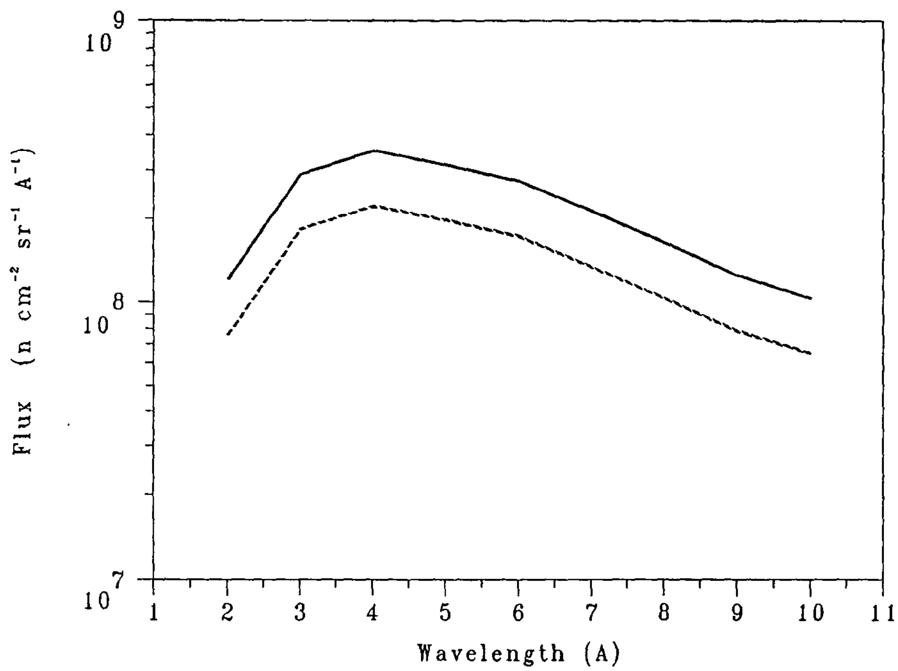

Fig. 2 The solid line shows the theoretical flux in the guides as described in the text. The dashed line represents the expected flux allowing for 10% absorption in the cold source structure and a realistic guide transmission of 70%.

Guide-hall sections

After passing through the end wall of the blockhouse, the guides will be continued straight as single open guides, i.e., without a central reflector, through another 5 m of heavy concrete shielding before exiting into the guide hall. At present it is intended to continue guides G3 and G4 with the full size (120 x 50 mm^2) for instruments that can make use of focusing techniques. It is possible that the final residual beams from one of these guides could be used for neutron radiography. Guides G1 and G2, however, may be split for an optimum disposition of instruments.

Guide G1. This guide will be split horizontally to provide two individual beams of cross-section 50 x 50 mm^2; the top beam for a SANS instrument and the lower for another instrument, ideally, a reflectometer. Since both these instruments, in principle, cannot use large beam divergences, all or part of this guide could be made with a natural nickel coating. However, a reflectometer, which is intended to be used for surface diffraction, would require short wavelengths so that an alternative position has been foreseen on guide G2.

Guide G2. This guide will be similarly divided into two beams, the lower of which may be reserved for a reflectometer. The top half will continue in a guide of cross section 50 x 50 mm^2 to a neutron optic bench[3] situated in a special vibration free area at the end of the guide hall. The present design of this optic bench requires a beam 20 mm wide so that a third beam of cross section 50 x 30 mm^2 may be extracted from the guide either for another instrument or for test purposes.

Instruments. Of the instruments shown in Fig. 1, it is planned to have three operational in the guide hall as soon as neutrons are available. These are the SANS, Optic bench, and Time-of-flight spectrometers. Further instruments will be built depending on demand and the availability of funding. Hence, it will only be necessary to install three of the four guides for the initial source operation.

Acknowledgements

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References

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