Perfect focusing optics for long neutron guides

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The emerging long-pulsed European Spallation Source (ESS) will have many instrument placed more than 150 meters from the source. This fact has spawned many investigations of geometries for long neutron guide systems. However, most guide shapes have limited abilities to focus the beam on to the sample, and a large amount of the beam will miss the sample and in stead create background from secondary scattering events.

The Selene-type guide system is a neutron-adaption of the Montell optics used in X-ray optics. Here, a point-like source is mirrored one-to-one on to the sample position by pairs of perfect elliptical double mirrors. This guide system is planned for the short ESS instrument Estia. However, Montell optics for very ling instruments will be both very expensive and vulnerable to minor misalignments as well as to gravity.

We here present a new design idea, where a 160 m standard ballistic guide system with good transport properties is followed by a 4-8 m Selene guide system. We have investigated the system by detailed Monte-Carlo simulations using McStas. We show that under certain conditions, this set-up works surprisingly well, with a brilliance transfer of about 20% for neutrons of wavelength 4-8 Å. We demonstrated that the guide system is able to focus the beam almost perfectly on to samples sizes in the range 0.1-2 mm.

We furthermore show that our Selene system is insensitive to gravity and to reasonable values of guide waviness. Finally we show that in our set-up, the beam can even be matched to the sample shape by a slit before the Montell optics.

We argue that our guide system can be useful as an optional guide insert when small samples are used in the vicinity of bulky sample environment, e.g. for high-field or high-pressure experiments. We believe a realistic implementation of the Selene add-on-guide is via a change of the last part of a long guide, and we sketch how such a two-guide solution could be realized in practice.