appendix for the May 22, 2012

Reflectometers 2012 Q1 Work Package Report

2.3 Work unit 3: Focusing Reflectometer

2.3.2 Achievements for the period

1. conceptual work

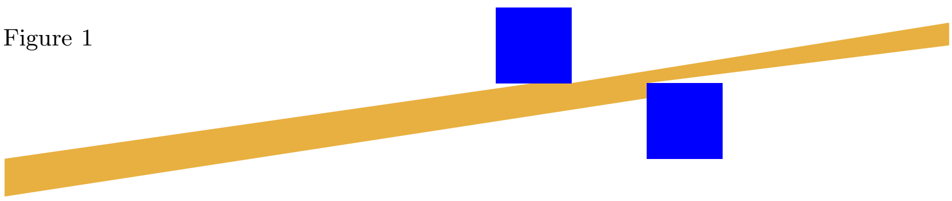
   Most of the Selene-guide concept has been developed over the last 2 years, starting with a single elliptic reflector and a multilayer (ML) monochromator. This idea was based on a concept by F. Ott to obtain a λ-encoding in θ from an elliptic guide coated with a gradient ML.

   The general layout and possible operation modes have been presented in the first progress report, in various talks and publications (see below). Here a new idea is presented.

   (a) definition of the footprint

   Since the Selene-guide creates a 3-dimensional image of the slit at the 1st focal point, one can design a slit system defining the footprint on the sample in both lateral directions. The picture illustrates this for the scattering plane: The beam is reduced spatially by two plane parallel absorbers, where the distance between the relevant edges defines the length of the footprint on the sample.

   Figure 1

   Assuming a homogeneous divergence of the incoming beam, one also gets the full divergence for every point within the footprint. In reality (according to analytical calculations) the not completely eliminated aberration of the guide system leads to a slight distortion of the phase space element at the sample position.

2. simulations & analytical calculations

   (a) simulations for designing the prototype on BOA

   The available space at BOA and the needed angular resolution restricts the total length of the Selene guide system to 4 m (i.e. from 1st slit to sample). The asymmetry of the ellipses was optimized by McStas simulations by T. Panzner, taking into account the divergence available, the wavelength range and a reasonable reflectivity for $m = 5$ supermirrors. The input parameters $I(\theta, \lambda)$ were determined experimentally.

   (b) adaptation of the prototype instrument file to the liquids reflectometer for ESS

   The McStas instrument file for the prototype was adapted the the measures at the ESS by U. Hansen and T. Panzner and a feeder has been added. With this (and the ESS beam characteristics) the suitability of the Selene concept for a reflectometer for liquid interfaces is investigated by U. Hansen. A slit system as described in 1(a) is implemented to restrict the illuminated area e.g. within a Langmuir trough.

(c) simulations on liquids instrument

Results from simulations on the initially chosen area of $50 \times 50\,\mathrm{mm}^2$ reveale undesired illumination inhomogeneities. We therefor defined an acceptable lower limit for the sample size of $20 \times 50\,\mathrm{mm}^2$ and with this we will check the accessibility of the focusing guide.

Figure 2

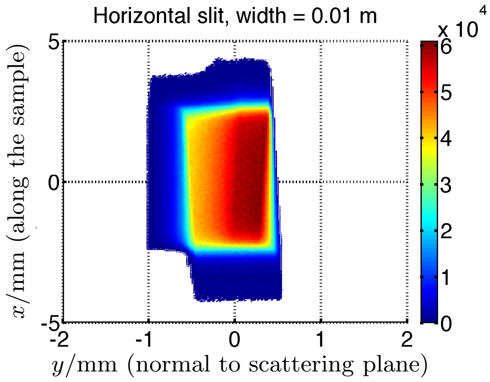


Figure 2 shows the intensity map $I(x, y)$ at the sample position for a diaphragm opening of 10 mm in y direction, i.e. normal to the scattering plane, and 50 mm in x direction, i.e. along the sample surface. One can see that the intensity for $y < 0$ is smeared out, which means a reduced intensity on the sample, and illumination of the environment.

(d) horizontal diaphragm concept tested

Using the (simpler) McStas instrument file for the prototype the performance of the slit setting described in 1(a) was simulated.

Figure 3

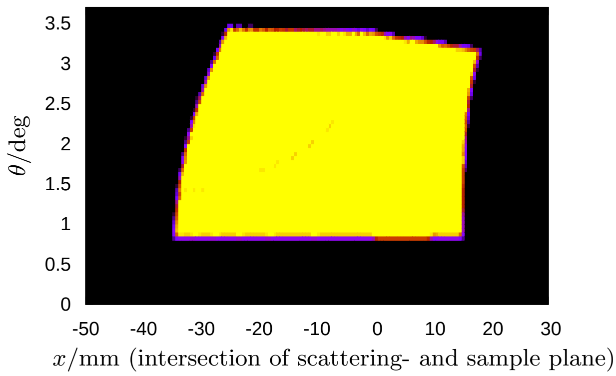


Figure 3 shows the analytically obtained $I(x, \theta)$ map at the sample position. The footprint is only slightly larger than the horizontal distance of the first slits of 50 mm and the divergence is almost homogeneous over that length.

3. prototype

We are building a prototype of a Selene-type guide system with two 2-sided reflectors at PSI. The purposes of this are to validate the analytical calculations and the simulations, and to uncover problems with the actual data collection and analysis.

(a) completion of the design

The guide system is optimized for the set up on the test beam line BOA at SINQ, PSI. The total space available and the angular resolution needed limits the total length of the guide system to 4 m. In front there is space for a chopper, a multilayer bandpass or a feeder as will be needed at the ESS. The latter one is not yet realized.

The minimum wavelength was chosen to correspond to the flux-maximum at BOA, i.e. $\lambda_{\mathrm{min}} = 3.5\,\text{Å}$. This led to the half-axes parameters $a = 1000\,\mathrm{mm}$, $b = 21\,\mathrm{mm}$; the acceptance angle is $\Delta\theta = 1.8°$ and the coating will be a $m = 5$ supermirror.

(b) construction of most of the components

All mechanical parts for the guide support (including alignment), the choppers and sample holder were constructed.

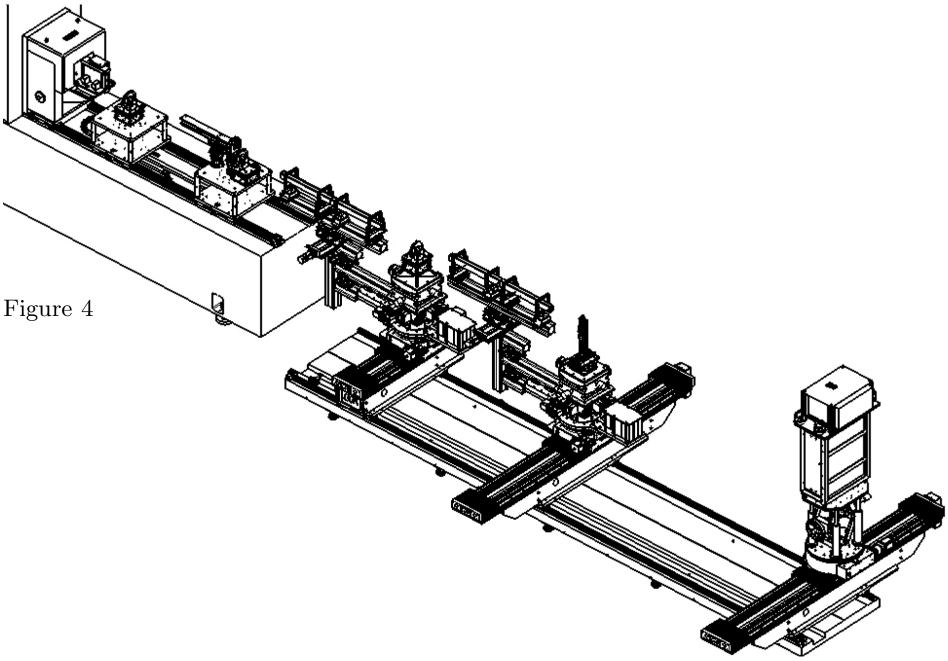


Figure 4

Figure 4 shows the overall view of BOA with the components to be used for the tests. In detail these are:

- 2 choppers ($= 160\,\mathrm{mm}$) to mimic the ESS pulse structure (adopted to the instrument length, i.e. they will run at 60 Hz);
- 1 precision x-y-slit to define the beam spot;
- 1 double bounce multilayer reflector to allow for λ/θ-encoding;
- 1 sample holder with shielding, mounted on a z-y stage;
- 1 support with z translation to hold the area detector (borrowed from Morpheus);
- 2 support systems to hold the two elliptic guides.

Yet missing are the

- 2 guides;
- 4 alignment supports, mounted on the support system and actually holding the 4 guide elements (2 times 2);
- 2 slit-systems to prevent direct line of sight and to adjust the divergence.

(c) start of fabrication of mechanical parts

The fabrication of all mechanical parts besides the guides and slits started. These items will be produced in-house at PSI. The scheduled delivery date is beginning of June.

(d) preliminary tests for the guide manufacturing by SwissNeutronics

SwissNeutronics made a series of tests to optimize the fidelity of the shapes. From previous investigations we found that the glue used to assemble the individual guide segments caused problems. Finally the guide segments for the prototype will not be glued together.

4. presentations

The Selene concept was presented at various workshops and seminars.[1]

(a) oral presentation (J. Stahn) at the *Workshop on off-specular neutron scattering*, 09.-10. 01. 2012, Brussels, Belgium: "Concept for a reflectometer for the ESS with focusing in the sample plane and in the scattering plane"

(b) oral presentation (J. Stahn) at the *IKON 2*, 09.-10. 02. 2012, Malmoe, Sweden: "progress report of the Swiss-Danish instrument initiative for the ESS, WP2: focusing reflectometer"

(c) invited talk (J. Stahn) at the *TUM & FRM II seminar*, 12. 03. 2012, Munich, Germany: "concept for a reflectometer using focusing guides"

A paper on measurements on AMOR using an elliptic reflector has been published:
J. Stahn *et al.*: "Focusing specular neutron reflectometry for small samples"
The European Physical Journal, Applied Physics **58**, 11001 (2012)
DOI: http://dx.doi.org/10.1051/epjap/2012110295

[1]All presentations by J. Stahn can be found on
URL `http://people.web.psi.ch/stahn/publications.html#oral`