progress report of the
Swiss-Danish instrument initiative
for the ESS
WP2
focusing reflectometer

IKON 2
09.–10.02.2012, Malmö, Sweden
**aims**

**development and proof of concepts** for two reflectometers for the ESS, optimized for:

- **small samples** (<1 mm²)
  - horizontal scattering geometry
  - polarization & analysis
  - voluminous sample environment
  - moderate to low resolution
  - ...

- **liquid surfaces**
  - vertical scattering geometry
  - time-resolved studies ($\Delta t < 1$ s)
  - wide $q_z$-range with one (few) angular setting(s)
  - high to low resolution
  - ...
generic instrument layout

cut in the scattering plane
stretched by 10 normal to incident beam

initial slit $\hat{=} \text{projected sample size}$

1\textsuperscript{st} elliptic reflector

no direct line of sight

sample
detector

knife blade

2\textsuperscript{nd} elliptic reflector
generic instrument

why focusing?

beam profile
penumbra
umbra

slits
reflective / refractive optics
generic instrument

why an elliptic reflector?

an **elliptic** reflector allows for
  point-to-point focusing
    - small source point
    - convenient beam manipulation (chopper, filtering)
    - early beam definition
      - low background
      - low radiation
    - disentangling of spot size and divergence
  - λ/θ encoding

a **parabolic** reflector turns beam size into divergence and *vice versa*
why only one branch of an ellipse?

- no structured $I(\theta, z)$

- in most cases one branch can cover $\Delta \theta$
generic layout

why two subsequent elliptic guides?

- convenient beam manipulation
- guide dimensions not too large
- correction for coma aberration!
**operation modes:**

**for TOF**

(non-TOF operation is also possible!)
operation modes:

almost conventional

- beam is still convergent
- off-specular measurements are feasible
operation modes:

wide $q$-range

- vary $\theta$ with fixed sample position
- shift diaphragm (chopper) between pulses

- suited for liquid surfaces
operation modes:

small spot size

- uses focusing due to coma aberration
- scanning mode possible

$I(y,z)$ and $I(z,\theta_z)$ at the sample for a $1 \times 1 \text{mm}^2$ entrance slit

use coma aberration to reduce beam size
operation modes:

angle/energy encoding

- uses a ml-monochromator at the intermediate image
- spectral analysis of the beam: $\lambda / \theta$ encoding

- large $\lambda$ on small $\theta$  
  $\Rightarrow$ wide $q_z$-range
operation modes:

high-intensity specular reflectivity

- energy- and angle-dispersive ⇒ gain > 10
- for fast scanning (\( T, H, E \ldots \))
- or if off-specular scattering is no problem

\[
\log_{10}[R(q_z)]
\]
operation modes:

high-intensity specular reflectivity vs. almost conventional
operation modes:

high-intensity specular reflectivity vs. almost conventional

\([\text{La}_{2/3}\text{Sr}_{1/3}\text{MnO}_3/\text{SrTiO}_3]_4/\text{NGO}\) \(4 \times 5 \text{ mm}^2\)

- no focusing in sample plane
- TOF mode, \(\lambda \in [2 \ldots 18 \text{ Å}]\)
- measurement time:
  - conventional \(6.5 \text{ h}\)
  - Selene \(45 \text{ min}\)

$\log_{10}[R(q_z)]$

gain-factor 8.3

by courtesy of C. Aruta and F. Miletto
Boa is a test beam line at SINQ, PSI

- **guide-end** ($40 \times 150 \text{mm}^2$, $\Delta \theta_y = 1.4^\circ$, $\Delta \theta_z = 2.0^\circ$)
- **chopper** ($\varnothing = 150 \text{mm}$)
- **slit**
- **elliptic guides**
- **sample position**
- **area detector**

**Diagram Details:**
- **Total length** $\approx 8.6 \text{m}$
- **Wavelength** $\lambda \in [1.5, 12] \text{Å}$
- **Polarized beam**
- **Setup operational** 8. 2012

**Textual Diagram:**

- $x/y$ translation, $2\theta/\omega$ rotation stages
concept for the ESS

schematic lay-out of the reflectometer for tiny samples
concept for the ESS

source
coarse slit
initial slit

intermediate image

detector
sample

$\Delta \lambda \Rightarrow \text{total length}$

repetition rate multiplication chopper $\Rightarrow \Delta \lambda / \lambda \approx 1\%$

ml-monochromator $\Rightarrow \Delta q_z / q_z \approx 5\% \ldots 20\%$
**Schedule**

January  
February  
March  
April  
May  
June  
July  
August  
September  

**Concept Studies**

- **Generic Instrument** (T. Panzner)
- Adaption to BOA
  - incl. off-specular scattering (K. Lefmann)
  - incl. gravity (E. Rantsiou)
- ESS Instrument for small samples (N.N.)
- ESS Instrument for liquid surfaces (U. B. Hansen)

**McStas Simulations**

**Construction** (D. Graf, M. Schild)
- Offer for guides (SwissNeutronics)
- Set up on BOA
- Experiments

**Manufacturing** (PSI)
Selene is a guide concept

which . . .

• prevents direct line of sight
  • reduces radiation in the guide
  • allows for convenient beam manipulation
  • reduces illumination of the sample environment
  • allows for a convergent beam set-up
⇒ flux gain > 10