PAUL SCHERRER INSTITUT

Wir schaffen Wissen – heute für morgen

Paul Scherrer Institut

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Monte Carlo Simulations for Complex Neutrons Optics

Overview about the activities

steps that are done:

- check up for low cost upgrade possibilities of the parabolic lens used at neutron reflectometer AMOR at PSI (using existing McStas components)

- development of a new McStas component for simulations of multichannal focusing devises with thruly curved walls

- McStas simulations and optimasations for the elliptical shaped SELENE-devise for fast multi q-value measurements

steps have to be done:

- implementation of gravity and diffuse scattering in the simulations

- built and test the SELENE devise

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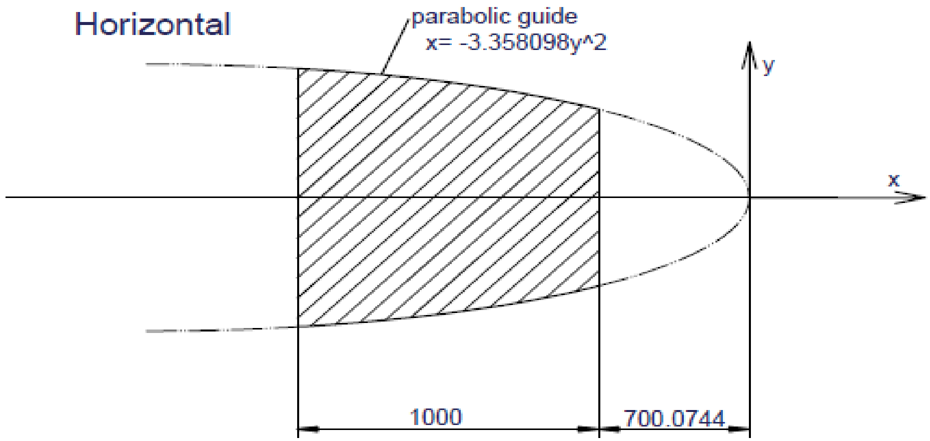
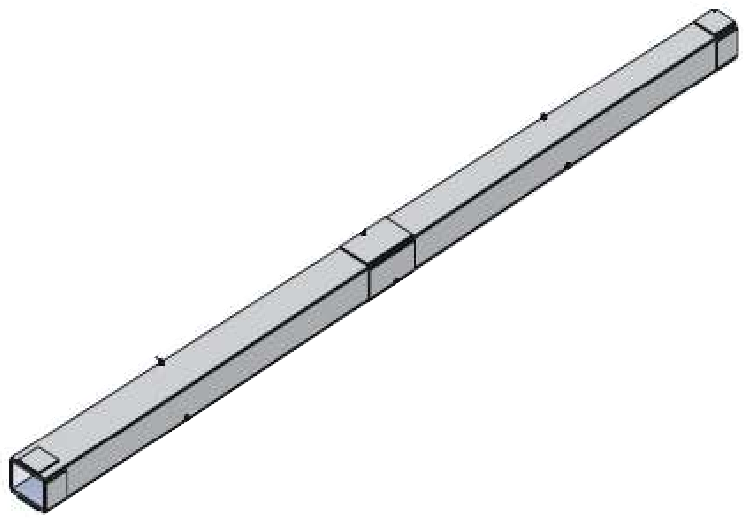
Parabolic lens at AMOR

horizontal focusing devise used in a vertical reflectivity set up





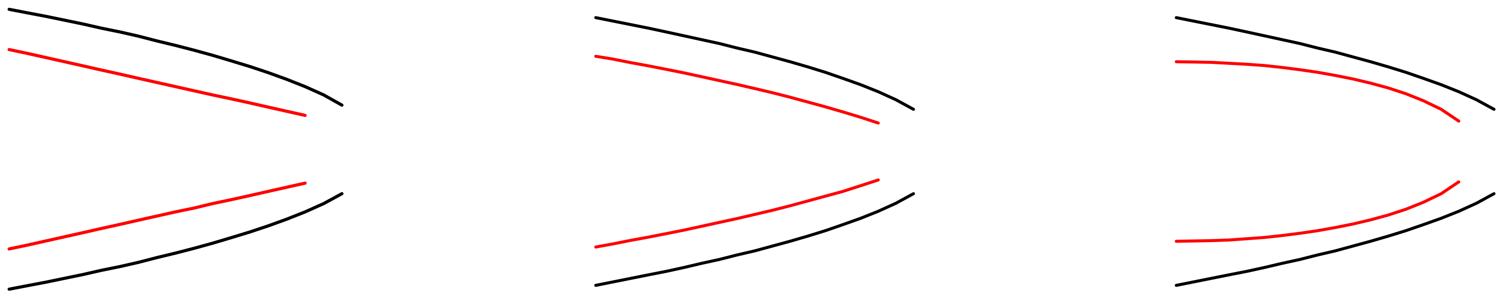
- lens was optimized for sample sizes of around 1cm^2
- the achieved gain factor for the intensity was 2.1 (2 Å) – 2.4 (7 Å)

- question:
  Can the performance be enhanced by a simple low-cost-inset?

simulation results for different inset variants

simulation are done using component ‘tapering guide’ and McStas group feature: coating m=3.6, different geometries

linear inset | parabolic inset | elliptical inset



Gain factors compared to set up w/o lens	λ = 2 Å	λ = 3 Å	λ = 5 Å	λ = 7 Å
w/o inset	2.13 +/- 0.04	2.31 +/- 0.06	2.4 +/- 0.05	2.45 +/- 0.06
linear	2.76 +/- 0.06	3.01 +/- 0.07	3.14 +/- 0.06	3.25 +/- 0.06
parabolic	2.85 +/- 0.05	2.85 +/- 0.07	2.92 +/- 0.05	3.02 +/- 0.06
elliptic	2.58 +/- 0.05	3.02 +/- 0.07	3.28 +/- 0.06	3.33 +/- 0.07

simulation results for different inset variants

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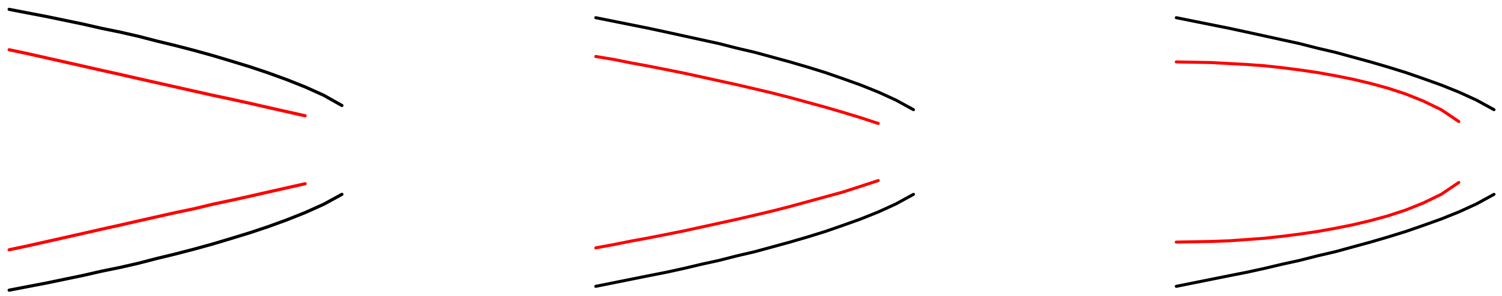
linear inset　　　parabolic inset　　　elliptical inset



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w/o inset	2.13 +/- 0.04	2.31 +/- 0.06	2.4 +/- 0.05	2.45 +/- 0.06
upgrade canceled due to low intensity gain (only 36%)				
parabolic	2.85 +/- 0.05	2.85 +/- 0.07	2.92 +/- 0.05	3.02 +/- 0.06
elliptic	2.58 +/- 0.05	3.02 +/- 0.07	3.28 +/- 0.06	3.33 +/- 0.07

new McSas component: four_side_guide

idea: modification of ‘tapering guide’ component by keeping all existing features

modifications: - real curvatures
- possibility of transparent walls
- multi channel (up to 10 outer channels realized)
- neutrons can pass by

result: - new component with 44 individual programmable walls
- the properties of every wall can be tuned by up to 15 parameters directly and by the clinging walls indirectly

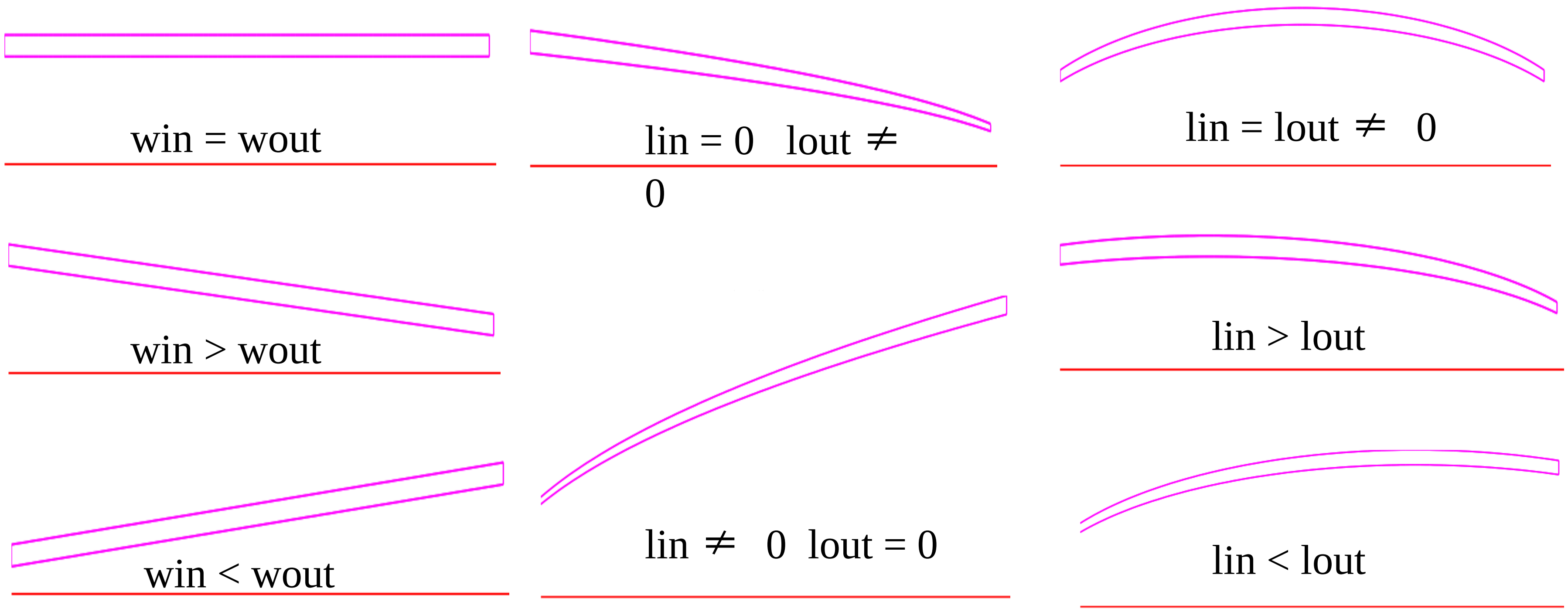
first tests: - recheck to the component ‘tapering guide’
- use in two simulation scenarios (SELENE and adaptive optics)

wall curvature tunning: example for direct tunning

controlled by: - distance from focal points to guide wall (lin , lout)

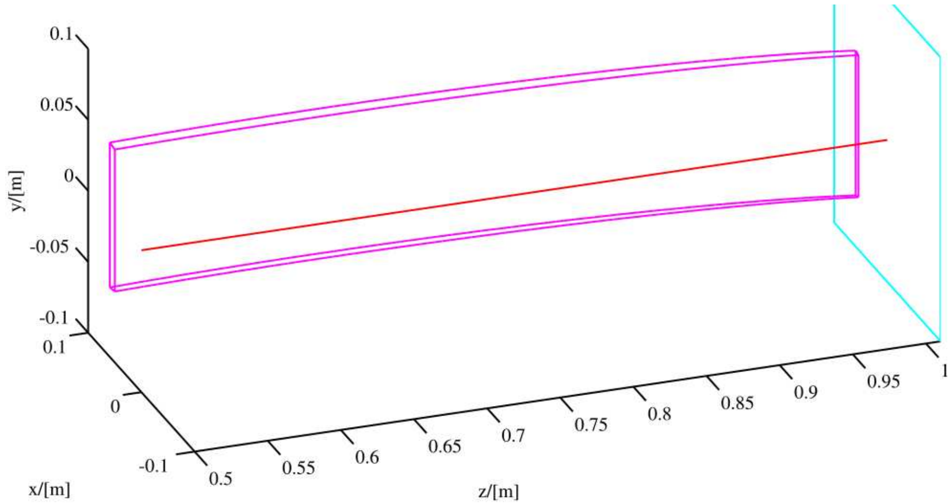
- entrance and exit width (win, wout)

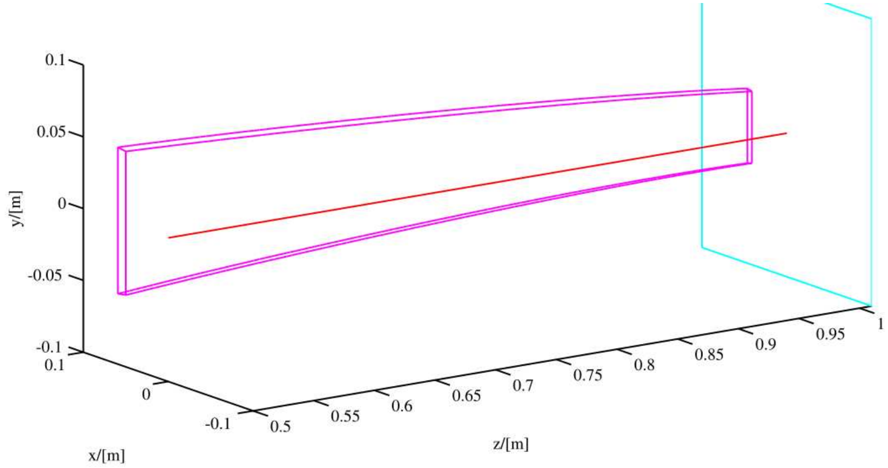
linear : lin=lout=0 | parabolic: | elliptic:

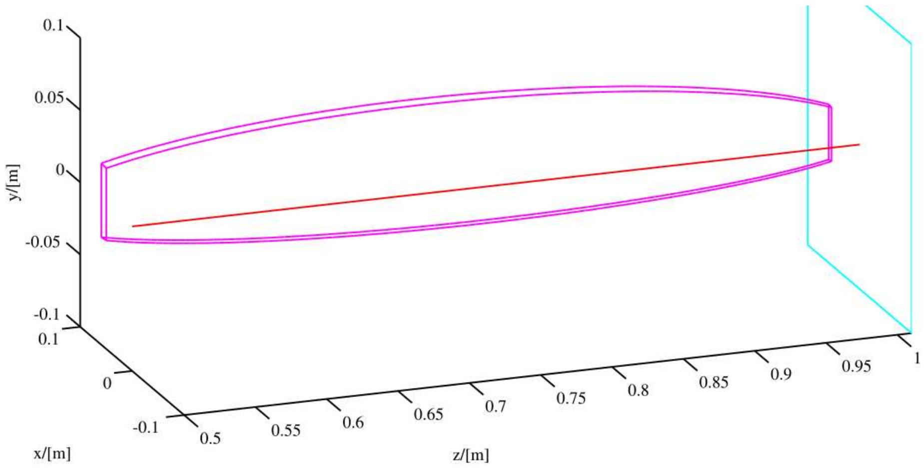


wall shape tunning: example for indirect tunning

shape of a wall can be influenced by the bending of the clinging walls
(even if they are transparent and not seen by the neutrons)





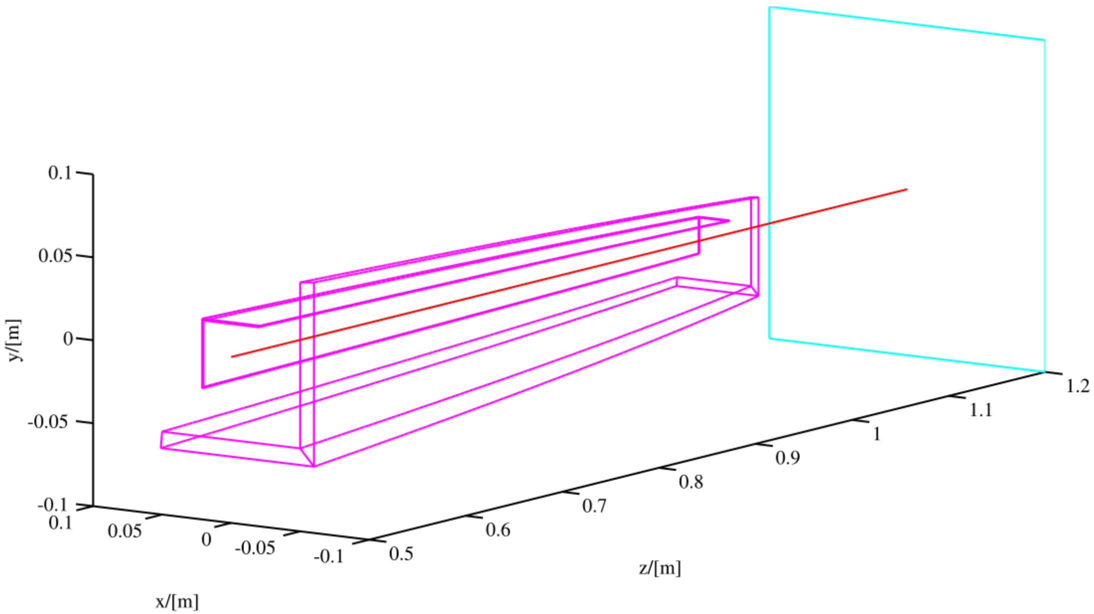


example for a 2 shell parabolic lens devise

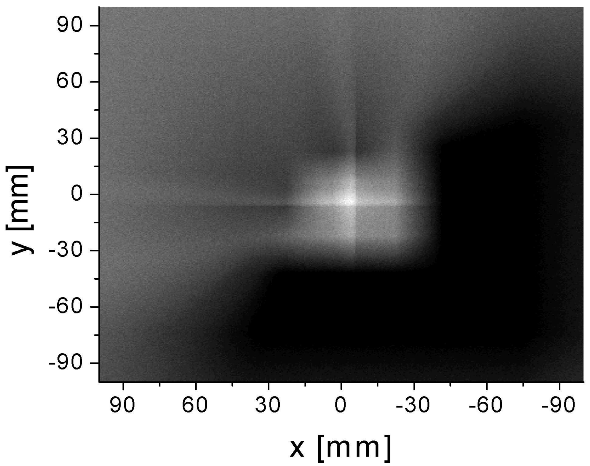
- only 2 sides of every of every shell are used (others are trans-parent)

- sides are reflecting with m=6

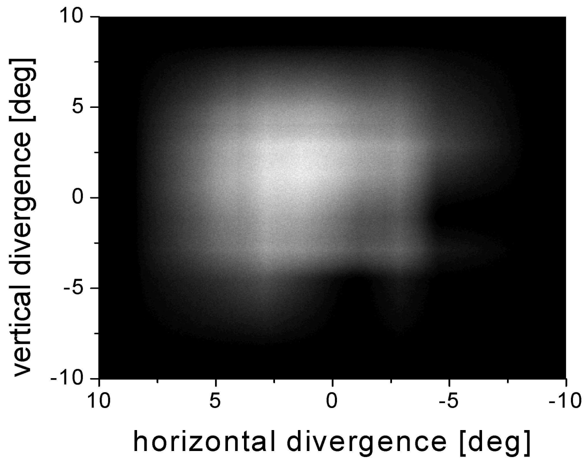
- all sides are parabolic and have the focal point the detector plane (light blue)



PSD detector

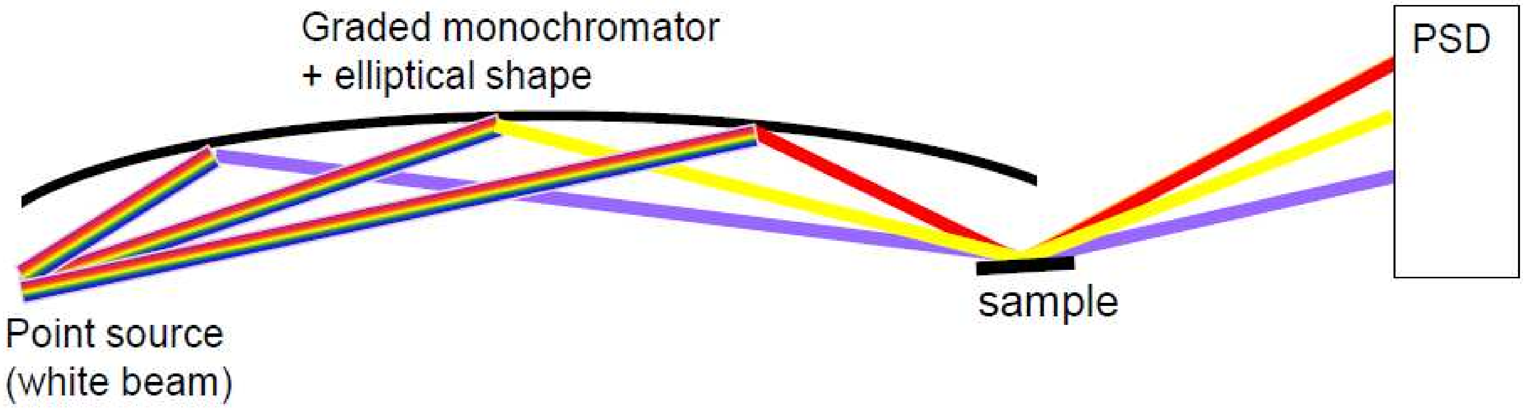


divergence detector

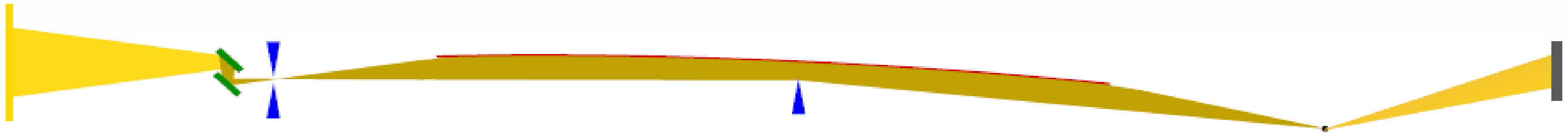


multi-q reflectivity measurements

mean idea from F. Ott and A. Menelle (NIMA A 586 , 2008, 23-30) : REFOCUS
(or as talk under http://optics.neutron-eu.net/FILES/NOP2010_Ott.pdf)



version by J. Stahn: SELENE-concept
(under http://optics.neutron-eu.net/FILES/NOP2010_Stahn.pdf)



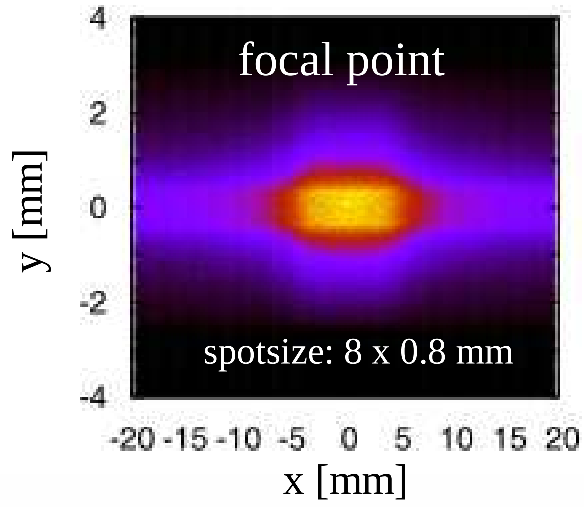
- separation of the monochromator from the focusing devise lets to an easier sputtering process of the elliptical guide.
- beam properties can be changed by the monochromator type

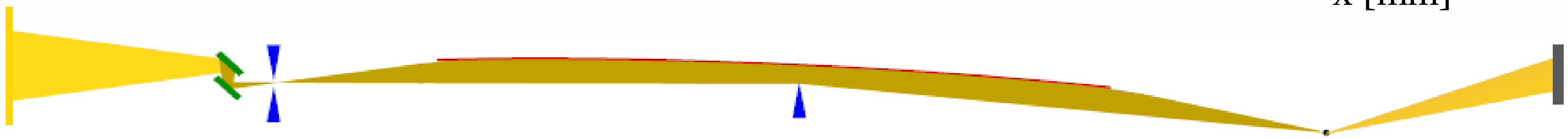
SELENE simulations

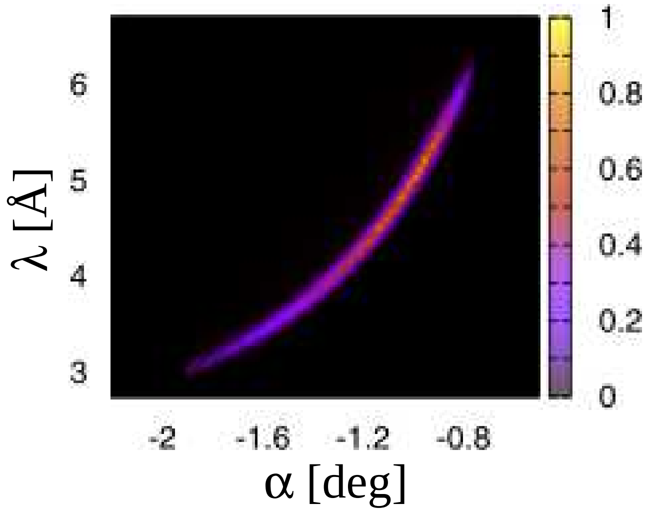
- the pre-optic determine the wavelength-angle distribution at the sample (white beam or ‚single' wavelength)

- properties can be optimized for the experiment

- additional horizontal focusing is possible (small sample investigations)



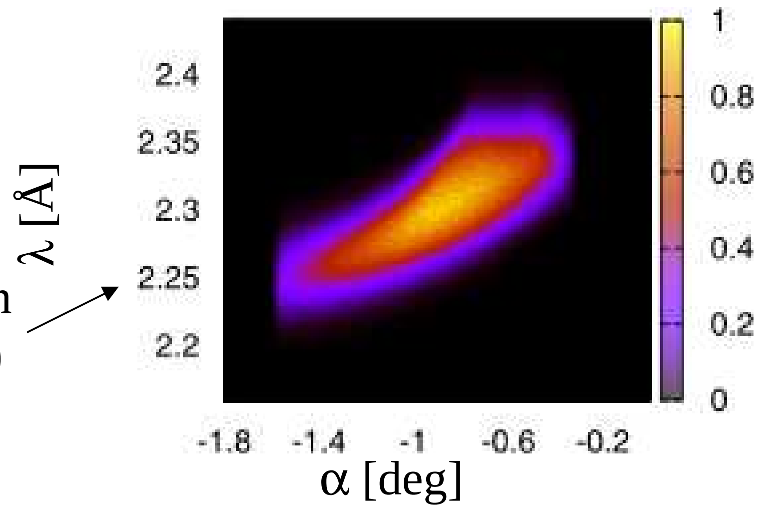




white beam
(by multilayer)

or

monochromatic beam
(by monochromator)



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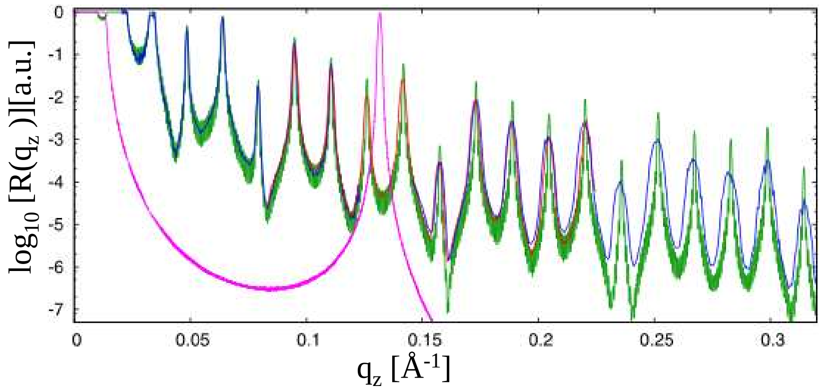
simulation results for different pre-optics

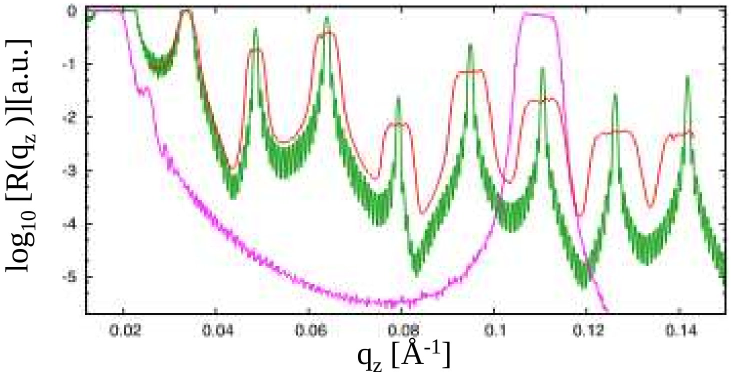
test for a calculated test-multilayer-sample (represented by the green line)

double multilayer m=6:



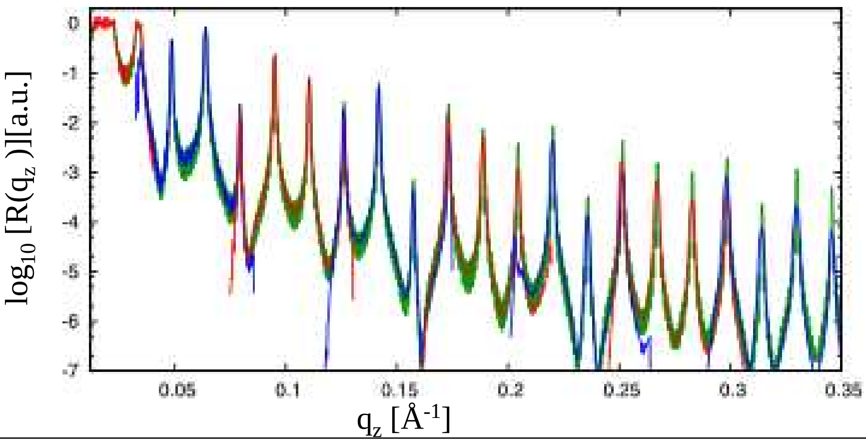
the reflectivity properties of the multilayers are presented by the magenta lines

double multilayer m=5:



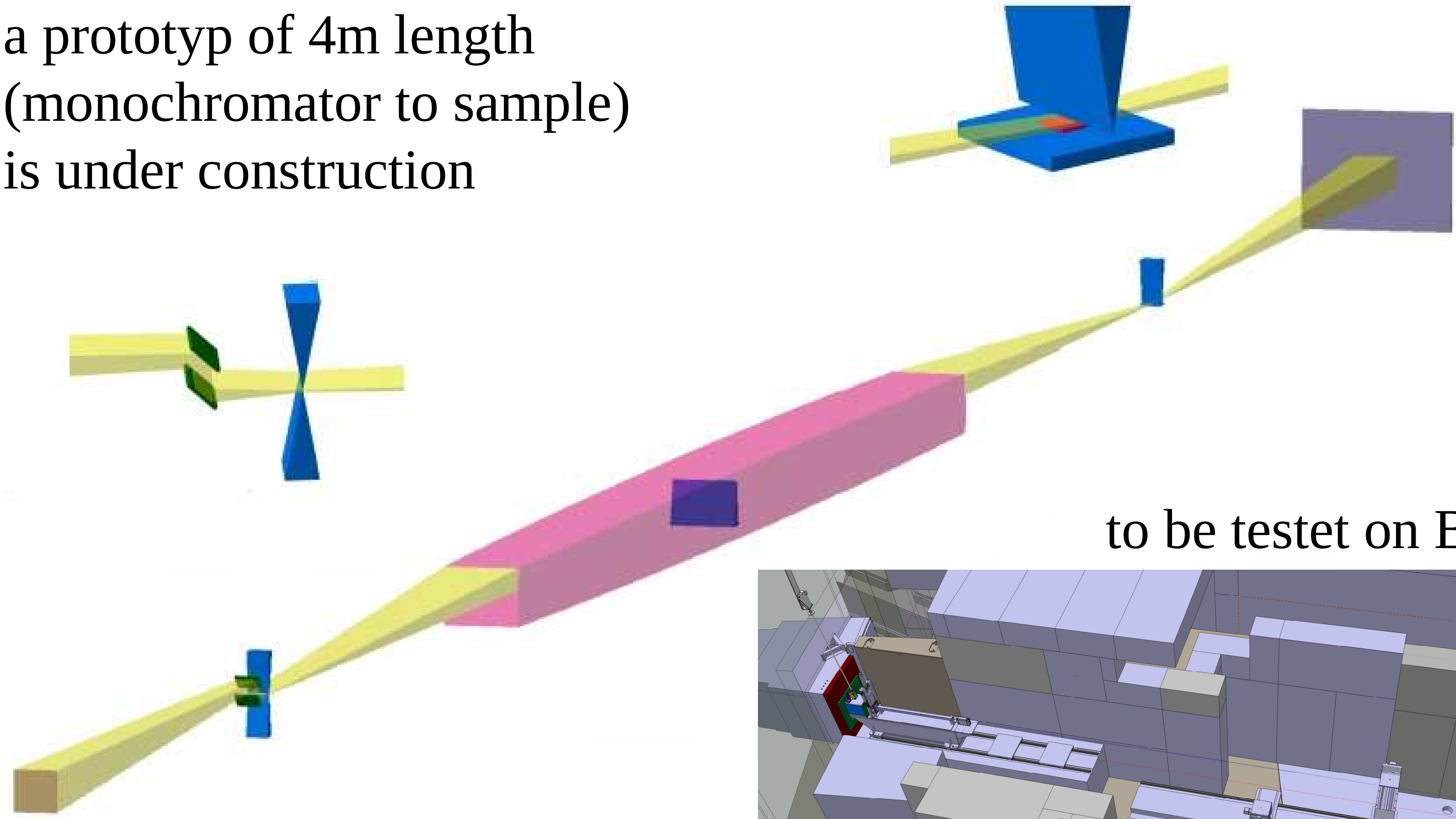
the simulated measurements are represented in blue and red (every blue or red part represent a different sample angle)

double PG monochromator with $\Delta\alpha = 0.16^{\circ}$:

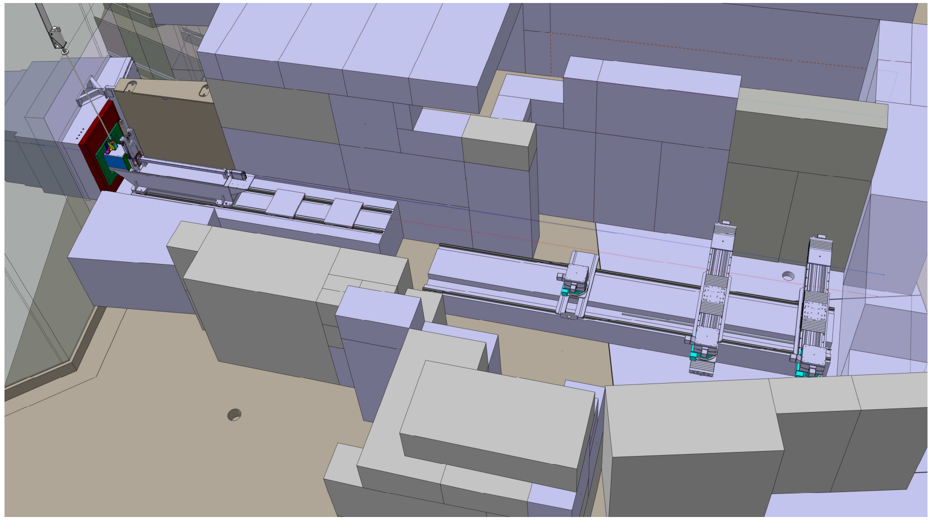


near future : testing at BOA beamline

a prototyp of 4m length
(monochromator to sample)
is under construction



to be testet on BOA



thanks to: **NMI3-FP7 for financial support and YOU for your attention**