Optimization studies of a polarizer bender for SESAME at LENS

Low Energy Neutron Source

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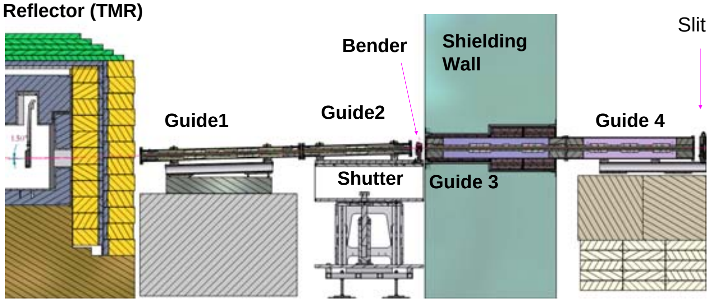
A bender to deliver polarized neutrons in the wavelength band of 3 – 20 Å at the pulsed low energy neutron source (LENS) of the Indiana University Cyclotron Facility has been designed. The bender is optimized for the supermirror index (m), bending angle and low activation by performing ray-tracing simulations of polarization and transmission using VITESS.

SESAME instrument at LENS

A conceptual diagram of the beam guide sections for the Spin Echo Scattering Angle Measurement (SESAME) instrument to be commissioned at the Indiana University's Low Energy Neutron Source is shown below. SESAME is based on encoding scattering angles of polarized cold neutrons in a spin-echo set up and does not require highly collimated neutron beam. SESAME investigates correlations in the length scale of the range of nm - µm in bulk and layered structures and would not only complement the conventional SANS and Reflectometry techniques but also provide additional information in some cases.

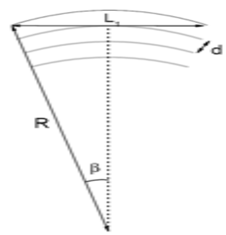
Side View of the Sesame beam port



Need of a solid state polarizer bender for SESAME

The SESAME beam line has a direct view of the target through a cold (20 K) CH_4 moderator, therefore a bender is ideal for deflecting away the useful range of cold neutrons from the fast neutrons. A solid state polarizer bender based on Si channels with supermirror coating of appropriate ferromagnetic materials will polarize and transmit a selected range of the low energy neutron beam and thus avoids the high energy neutron background.

Design criteria



$$L_1 = \sqrt{8 \cdot d \cdot R}$$

$$\beta = \frac{L_1}{2R} = \left(\frac{2d}{R}\right)^{\frac{1}{2}}$$

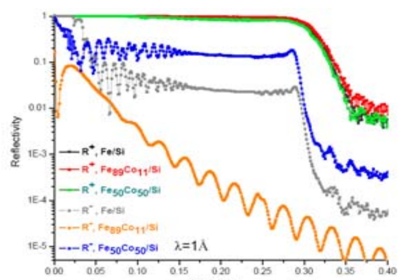
$$\lambda_c = \gamma_c^{-1} \cdot \left(\frac{2d}{R}\right)^{\frac{1}{2}}$$

- The length of the bender > L_1(line of sight)
- Critical wavelength λ_C= 3 Å
- Si wafers of thickness d=150 micron as the channels

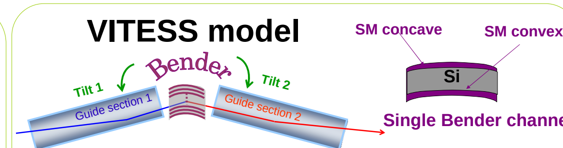
$\Rightarrow$ L_1=3.92 cm, β = 0.88º, R=128.15 cm

- Spin dependent reflectivities of the supermirror coatings with Fe/Si, $Fe_{89}Co_{11}$/Si and $Fe_{50}Co_{50}$/Si are computed for *m*=2 & 3 cases

Computed reflectivities of some polarizer supermirror coatings with different *m=3*

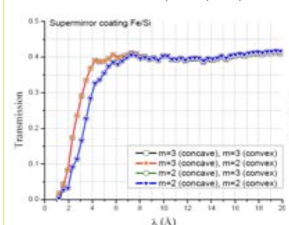


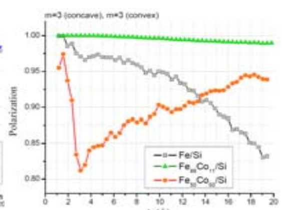
VITESS model

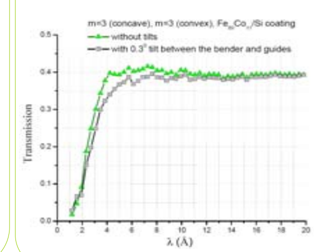


Simulation results

- No change in transmission even when the convex reflecting surface is changed from *m*=3 to *m*=2
- The transmission spectrum shifts to higher lambda when the *m*=2 coating is on the concave reflecting surface
- Best polarization is obtained for $Fe_{89}Co_{11}$(SLD of down-spin neutrons matched to Si)
- Polarization drops rapidly with wavelength for Fe/Si







- Only very small loss of transmission when additional guide tilts of 0.30º are introduced (Tilt 1 & Tilt 2 in the fig. above)
- An *m*=2 Fe/Si coating on the convex and an *m*=3 $Fe_{89}Co_{11}$/Si on the concave surfaces retain the transmission and excellent polarization

Conclusion

Our bender design by simulations optimize the choices of *m* and polarizer material combination, i.e., Fe/Si *m*=2 on convex surface & $Fe_{89}Co_{11}$/Si *m*=3 on concave surface). An option to increase the bend angle is also suggested. This design reduces the Co content without sacrificing polarization and transmission. This design is proposed for the SESAME beamline at LENS, IUCF.

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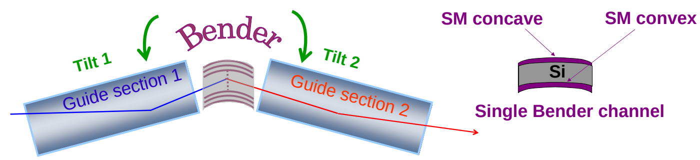
Bender
Tilt 1
Tilt 2
Guide section 1
Guide section 2
SM concave
SM convex
Si
Single Bender channel