

Superconducting YBCO Wollaston prism for Spin Echo Scattering Angle Measurement (SESAME)

F. Li¹, T. Wang¹, P. Stonaha¹, S.R. Parnell¹, H. Kaiser¹, D.V. Baxter¹ and R. Pynn^{1, 2}

¹Indiana University Center for the Exploration of Energy and Matter, Indiana University, Bloomington, IN, USA

²Neutron Science Directorate, Oak Ridge National Lab, Oak Ridge, TN, USA

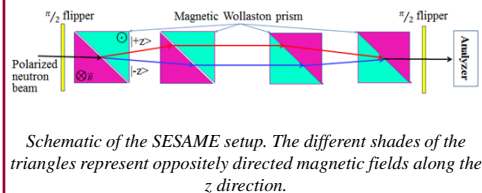


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What is a Wollaston prism?

In optics, a Wollaston prism consists of two birefringent wedges with perpendicular optic axes, which separates two orthogonally polarized components of light into diverging rays at the interface.

For neutrons, the prism is made of two adjacent triangular solenoids with opposite magnetic fields, which introduces spatial separation between two neutron states. It is the basic component of SESAME [1].



The disadvantages of a resistive prism

In SESAME each coil is currently made of resistive wire, but this has some disadvantages:

- Ohmic heating of the wire limits the intensity of the magnetic fields.
- The resistive wire used in current coils has a round cross section, hence the field in the gap between wires is not homogeneous, which means it cannot provide well-defined non-adiabatic field transition across the neutron beam.

The advantages of a superconducting prism

- A prism made with superconducting tape can carry a very high current density with a vanishingly small resistance and thus it can be used to generate intense magnetic fields with little power input.
- In our design, the Mu-metal box surrounding the Wollaston prism homogenizes the generated field while absorbing external stray fields.
- The superconducting film mounted between the two Wollaston prisms provides a well-defined non-adiabatic field transition over a flat surface.

References

[1] Pynn, R, et. al., (2008), *J. Appl. Cryst.*, **41**, 897.

[2] Chubar, O, et. al., (1998), *J. Synchrotron Rad.*, **5**, 481.

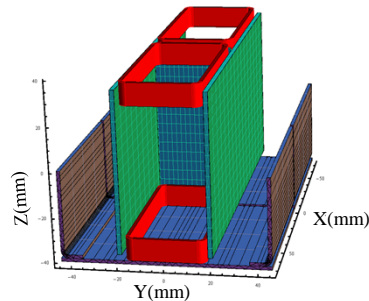
We would like to acknowledge Adam Washington (Indiana) for useful discussions regarding the design of the coils.

Simulations

Modeling of the superconductor:

We use *RADIA* [2] to simulate the magnetic elements of the triangular coils with a simplified **rectangular** coils:

- The YBCO screens are modeled as a linear anisotropic material with a susceptibility $\chi = -1$ in the directions both parallel and perpendicular to the surface and with a very small ($10^{-8}T$) finite remnant magnetization.
- The effects of the mu-metal are simulated using the $M(H)$ curve from the distributor.

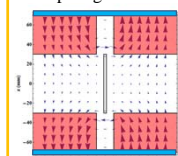


The modeling of the superconducting films: red parts are YBCO tape, green parts are YBCO films and blue part is mu-metal box (only half shown)

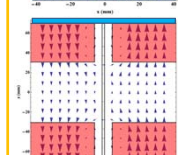
The magnetic field in the beam region is independent of the width of the mu-metal box, so long as the edge of the box is kept at least 2cm from the edge of the YBCO sheet.

Vector plot of the fields in the midplane of the coil pair.

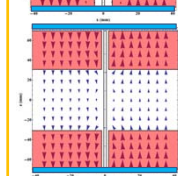
- The red regions indicate the superconducting tapes.
- The white box in the center is the superconducting screen.
- The blue regions indicate the Mu-metal above and below the tape regions.



(a). The distance from the top edge of the YBCO screen to the Mu-metal is 4cm. The distance between the adjacent coils is 1cm



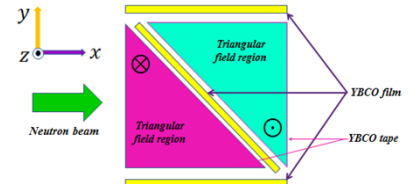
(b). The distance from the top edge of the YBCO screen to the Mu-metal is 0 cm. The distance between the adjacent coils is 1cm



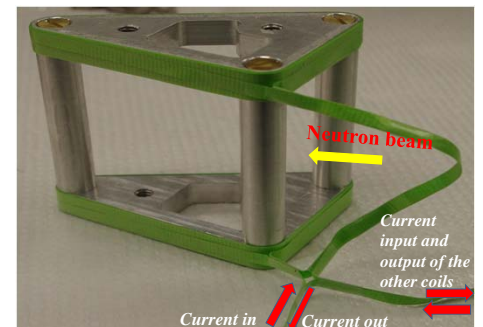
(c). The distance from the top edge of the YBCO screen to the Mu-metal is 0cm. The distance between the adjacent coils is 0.5 cm

The magnetic field strength in the beam region is **maximized** if the YBCO screen spans the entire coil height in 'z', as shown in (b) and (c). Otherwise, flux lines will take the "short circuit" path around the YBCO as in (a).

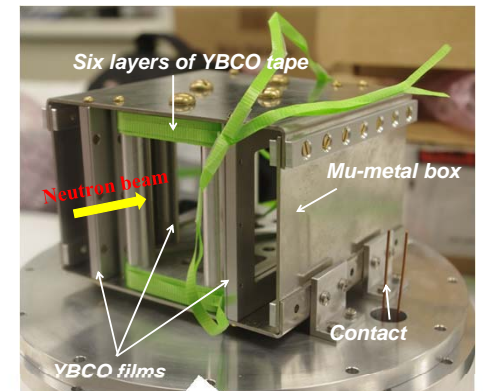
Design



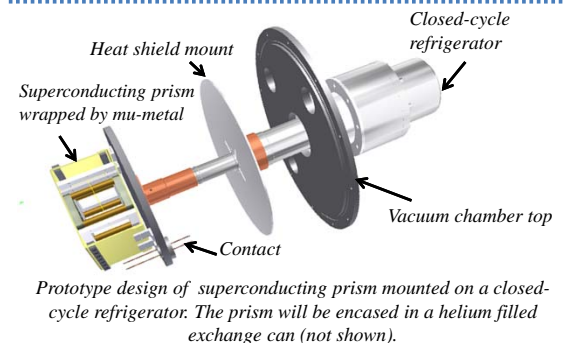
The top view of the prism showing the tape and film arrangement



A triangular coil former wound with ribbon. When not on the former, input and output tape are paired to cancel the stray fields.



Mu-metal box with green ribbon to simulate YBCO superconducting tape, mounted on heat exchanger can top flange



Prototype design of superconducting prism mounted on a closed-cycle refrigerator. The prism will be encased in a helium filled exchange can (not shown).

Future Work

- All the parts will be assembled and tested on the SESAME beam-line at LENS of Indiana University.