# Simulation and modeling of He ion transmission channeling through thin membranes for superfocusing applications

**Sourav Bhakta and Pratap Kumar Sahoo***

*School of Physical Sciences, National Institute of Science Education and Research, An OCC of Homi Bhabha National Institute, Jatni, Odisha - 752050, India.*

*pratap.sahoo@niser.ac.in , sourav.bhakta@niser.ac.in

## Abstract

Ion beam channeling is one of the powerful and interesting tool to understand the interaction of ions with atomic potential inside matters. Rutherford backscattering channeling (RBS-C) technique provides many fascinating scope to identify the type of impurities, elemental information, layer thickness in the selective area of the sample. Apart from the conventional RBS-C, transmission ion channeling (TIC) through thin membrane is an innovative technique that yields the idea of interaction with atomic potential, temperature, divergence and tilting effect and the focused pattern of spatial and angular distribution [1]. The superfocusing effect (sub-angstrom) through transmission channeling of protons originates due to crystal rainbow effect. It has been observed that the spatial and angular rainbow points consist of lines emerging from the superfocusing and zero degree focusing points along the channeling direction, respectively [2]. In this work, we studied the simulation of transmission channeling of He ions through 100 nm thin Ge film to observe ions' spatial and angular distribution with respect to different parameters, which can be a suitable application for next-generation superfocusing He ion microscope.

The 2 MeV He ions shows a star-like focused pattern, which starts defocusing with lowering the ion energy. The spreading increases to twice compared to the focused pattern for 200 keV at room temperature (Fig. 1). In our simulation, the interaction of host atoms with ions is introduced by the Ziegler-Biersack-Littmark (ZBL) universal potential. The variation of temperature from 10 – 450 K does not affect the pattern distribution. It is observed that the increasing of beam divergence and small tilt angle from the channelled direction enhance the large scale of defocusing of the pattern, which implies that the incident beam should be normal to the thin membrane during the experiment. To avoid scattering, the thinner membrane is more suitable for TIC distribution. We proposed a model where the parallel He ion beam can be brought to focus after magneto-static lens that incident normally on Ge membrane at room temperature in order to get the superfocusing pattern to verify the simulated results (Fig. 2). The superfocusing beams achieved in TIC can be an advantageous method for advanced lithography and imaging microscopes to be used in materials and biological applications.

**References:**

[1] M. Motapothula, Z. Y. Dang, T. Venkatesan, M. B. H. Breese, M. A. Rana, and A. Osman, Influence of the narrow {111} planes on axial and planar ion channeling, *Physical review letters* 108, no. 19, 195502 (2012).

[2] M. Cosic, N.Neskovic and S. Petrovic, Superfocusing and zero-degree focusing in planar channeling of protons in a thin silicon crystal. *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms*, *444*, 10 (2019).

**Figures:**

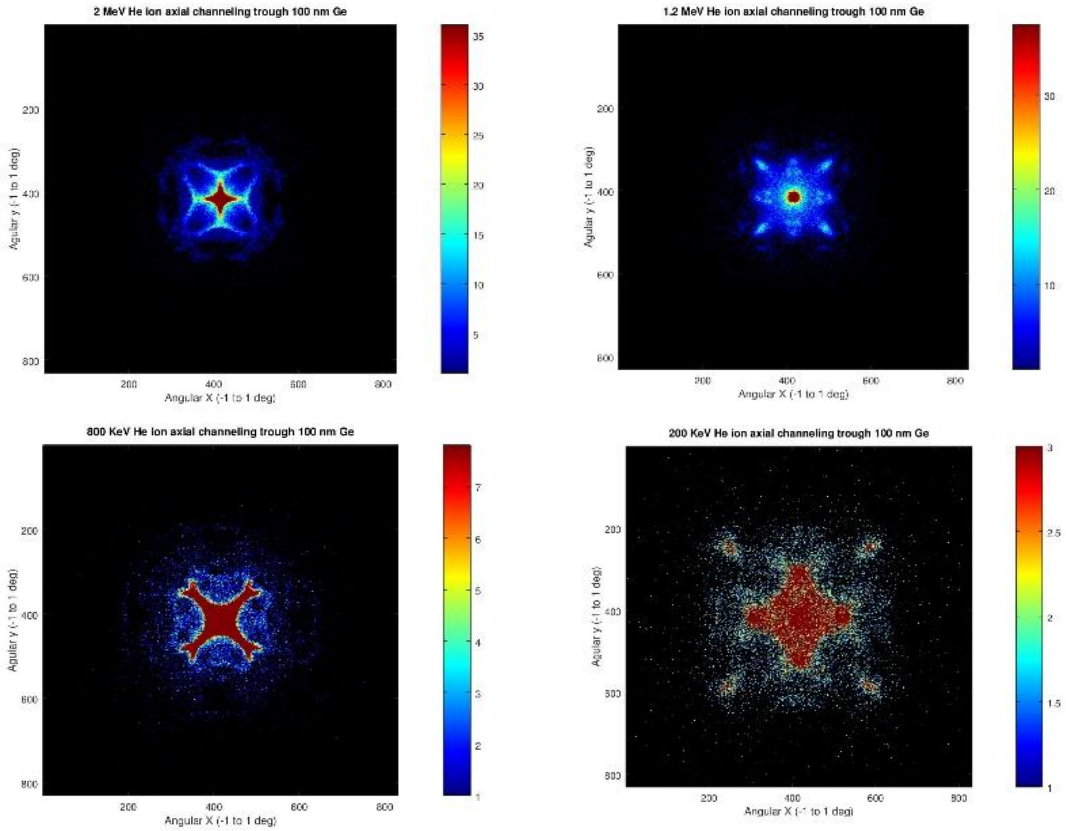


Figure 1: The angular distribution of FLUX simulation of transmission channeling pattern of 1 MeV, 1.2 MeV, 800 KeV and 200 KeV He ions in 100 nm thin Ge membrane respectively (top left to bottom right).

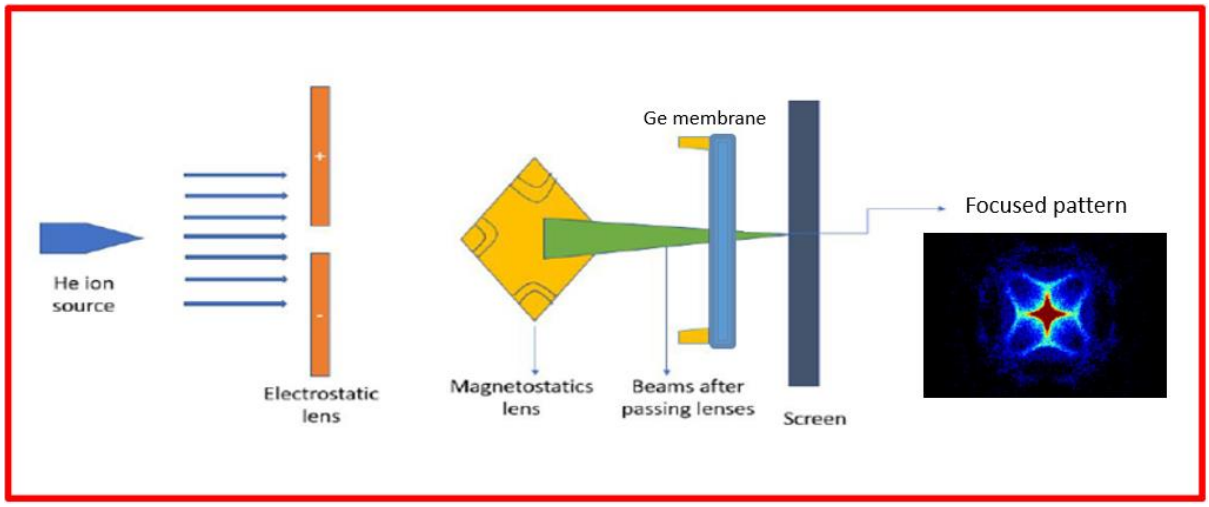


Figure 2: The schematic of the possible experimental transmission channeling and expected simulated focus spot.