Design and Simulation of a Spin Rotator for Longitudinal Field Measurements in the Low Energy Muons Spectrometer

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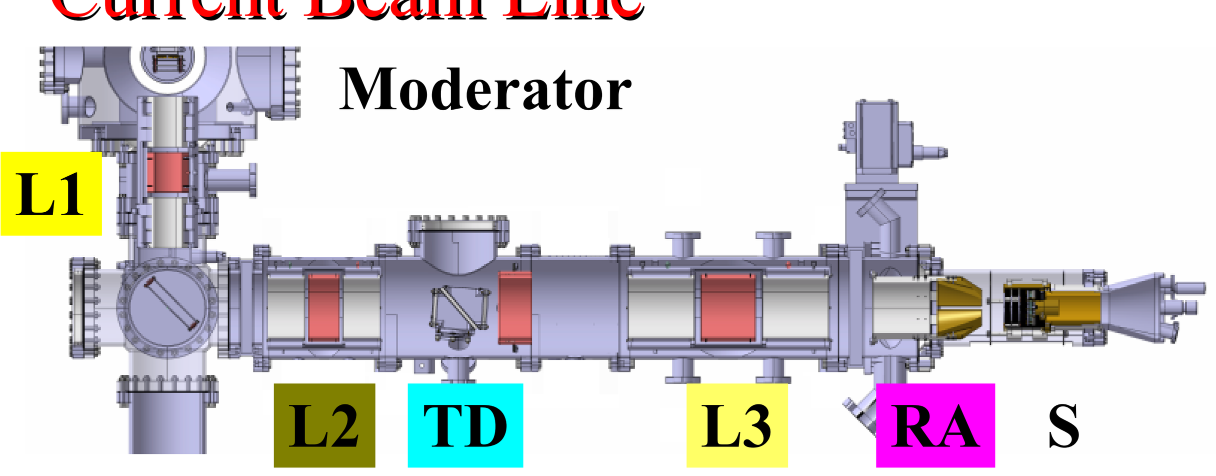
Abstract:
We used Geant4 to accurately model the low energy muons (LEM) beam line, including scattering due to the 10-nm thin carbon foil in the trigger detector. Simulations of the beam line transmission give excellent agreement with experimental results for beam energies higher than 12 keV. We use these simulations to design and model the operation of a spin rotator for the LEM spectrometer, which will enable longitudinal field measurements in the near future.

Introduction

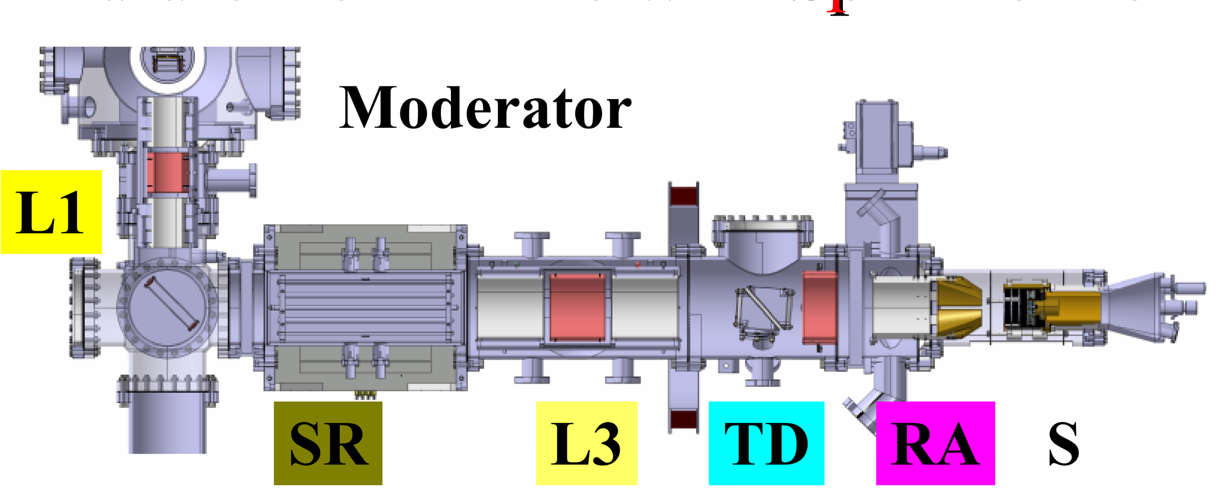
The low energy muons (LEM) spectrometer is a unique instrument that enables muon spin precession measurements in thin films and multilayers. This is possible due to the tunable implantation energy (1-30 keV) of the muons, allowing depth resolved SR measurements between 1-300 nm. The geometry of the LEM beam line results in a muon spin polarization that is parallel to the surface of the studied samples. Together with the available magnets in the spectrometer, SR measurements on LEM are restricted to either zero field (ZF) or transverse field (TF) applied either in or out of the sample plane. However, for many systems, in particular magnetic ones, the availability of longitudinal field (LF) capability is of great importance, e.g. to distinguish between static or dynamic internal fields, or to decouple them.

Currently, a project is underway at PSI to develop a spin rotator (SR) for the LEM spectrometer to enable LF measurements. We accurately model the current LEM beam line using Geant4. We then use these simulations to design and model the operation of a SR for LEM and optimize the transmission of the beam line. Using these simulation we expect to eventually achieve a spin rotation in the range -90 to +90. Moreover, we make small modifications to the trigger detector that will increase the number of muons on the sample, e.g. by 15 - 30% at 15 keV beam energy.

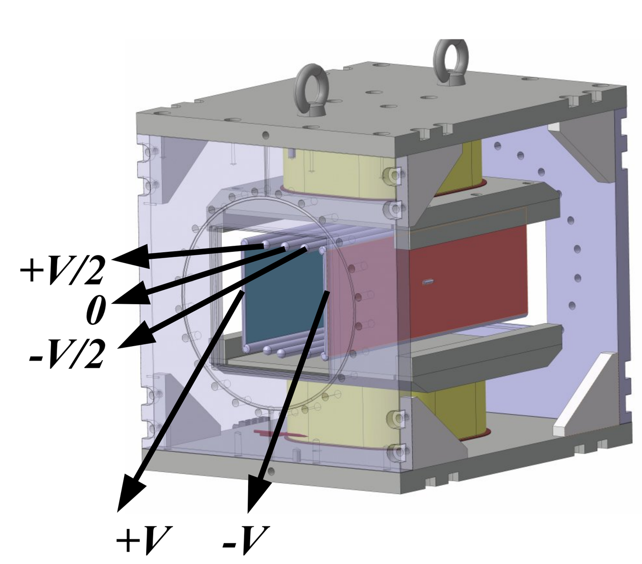
Current Beam Line



Future Beam Line with Spin Rotator

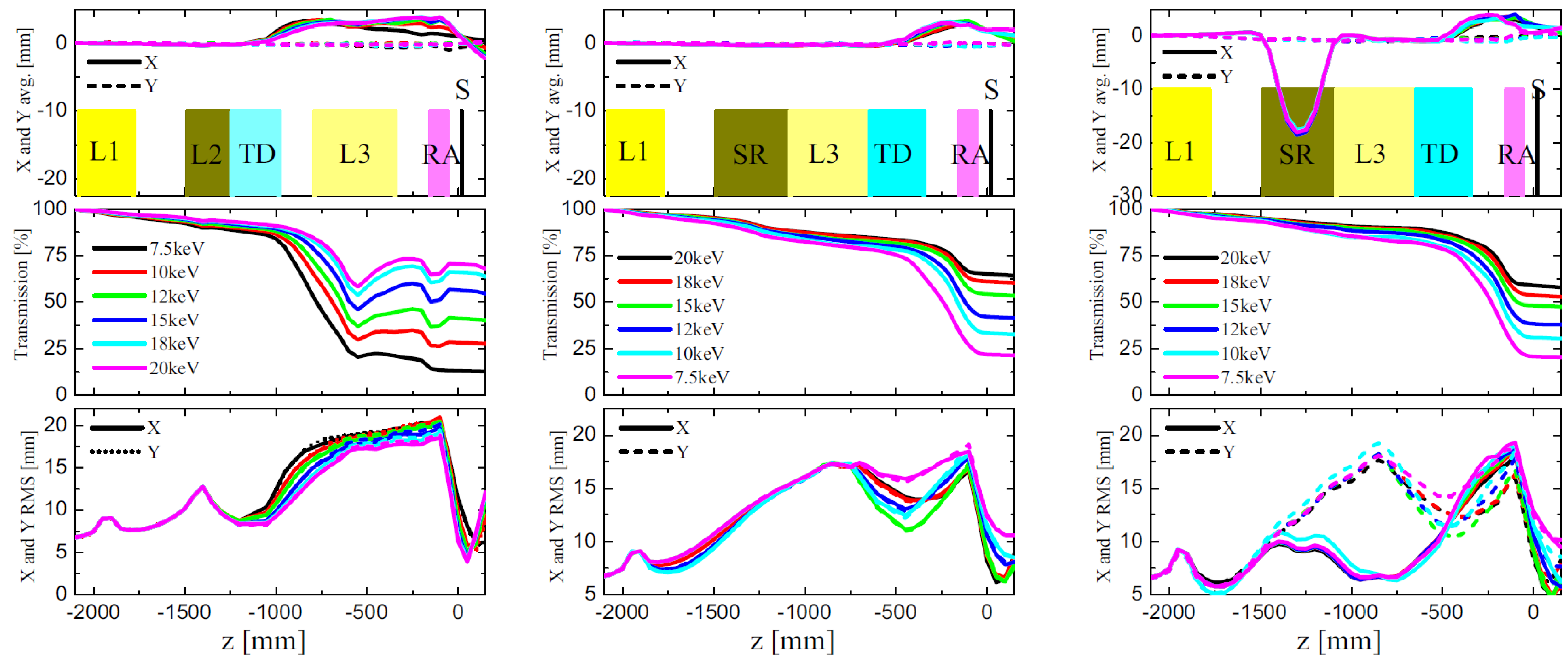


The Spin Rotator



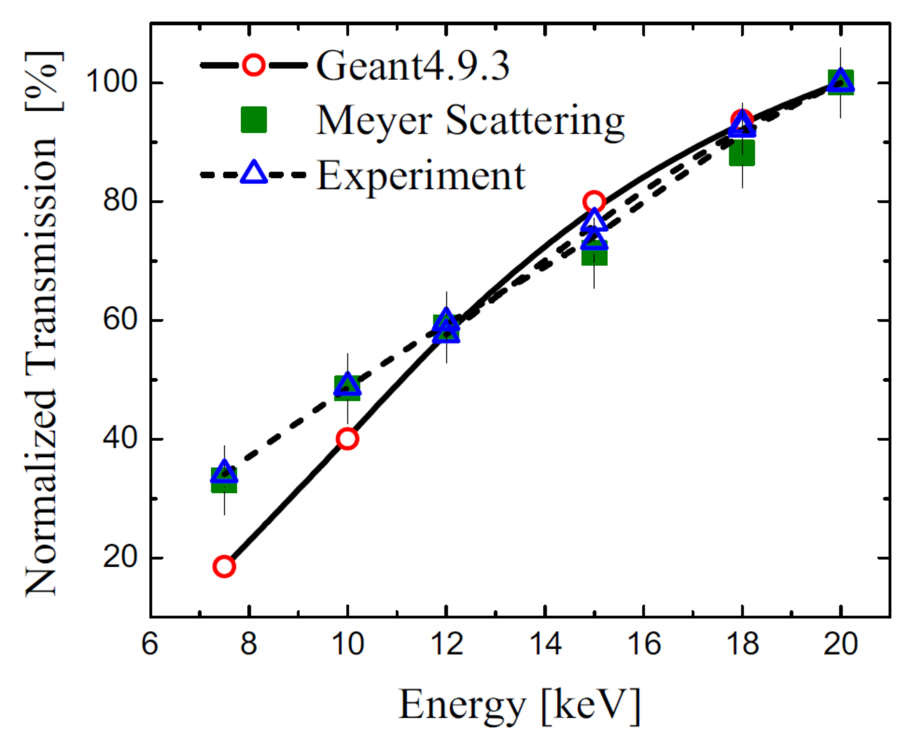
Simulations : Beam Properties

The current beam line | **The future beam line with spin rotator off** | **with spin rotator on (+90°)**



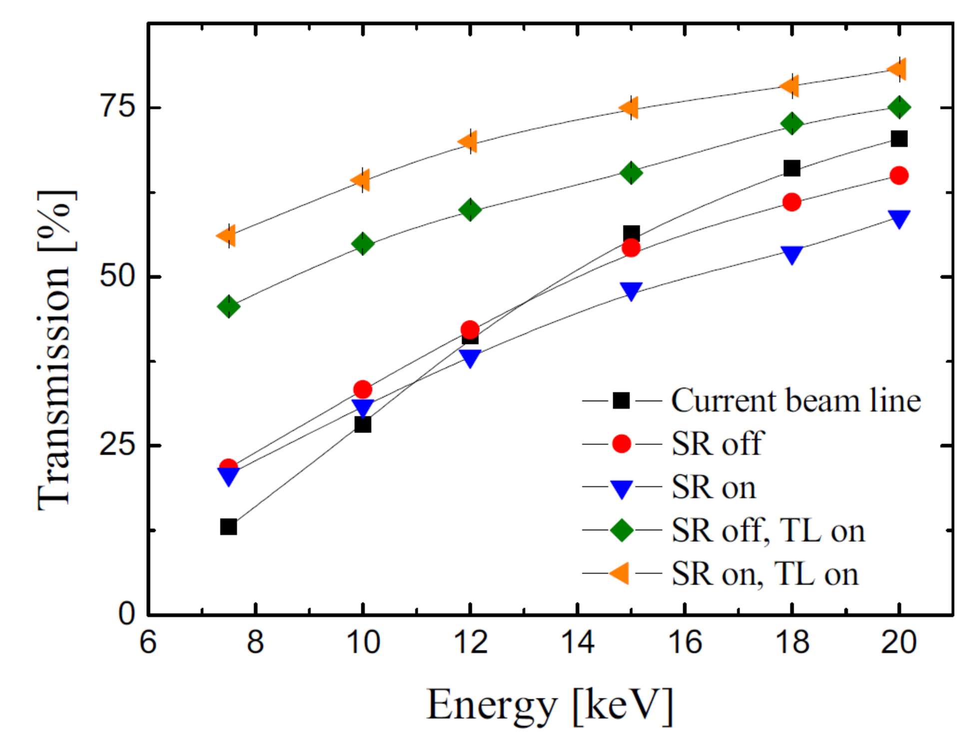
Simulations : Beam Transmission

The current beam line



•Excellent agreement with experimental transmission for E>12 keV.

The future beam line



•Full +90° to -90° rotation of the spin.
•Enhancement of the transmission by 15-30 % at high energy and 100-200% at low enegy.