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Beam transport calculation and beamline design for μSR facility in RAON

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Introduction

- ❖ Rare Isotope Science Project (RISP) has been constructing a heavy ion accelerator RAON in Daejeon since 2011, which have Muon Spin Rotation/Relaxation/Resonance (μSR) facility.
- ❖ The μSR facility is used for studying material science by irradiation muons generated from the interaction of high energy proton with maximum energy of 600 MeV and beam current of 660 μA and graphite target to an experimental sample.
- ❖ The muon beams generated from the target should be delivered to the sample with sufficient intensity (>10^5 μ^+/s) through a beamline consists of various electromagnets.
- ❖ The configuration of the muon beamline and the specification of components were determined through the beam transport calculations by using G4beamline code.
- ❖ The trajectories and transmission rate to the 1.5 × 1.5 cm^2 sample of the muon beam were estimated taking into account the fringe field effect of all components.

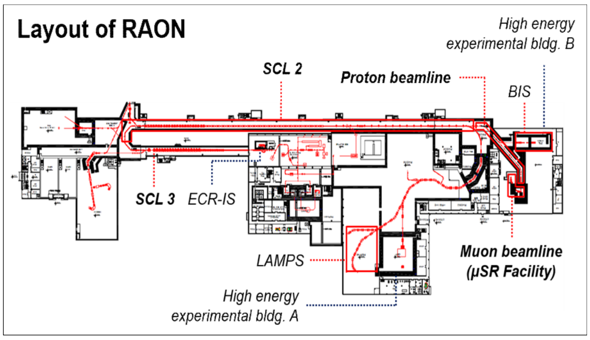

Figure. 1. Layout of the RAON accelerator complex.

Method and Results

- ❖ The designed beamline consisted of 2 solenoids for collecting muons, 2 dipoles for bending the trajectories with a deflection angle of 70°, 9 quadrupoles for beam focusing and a Wien filter for rotating muon spin angle and removing contamination.

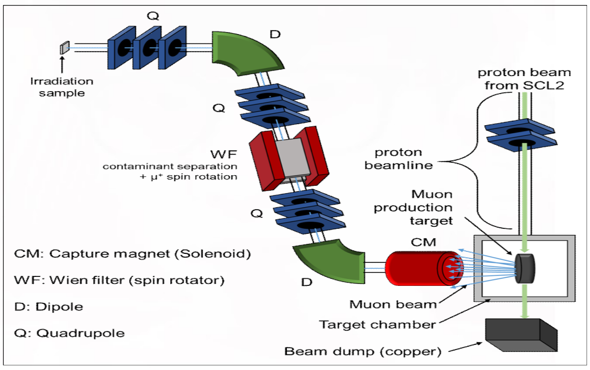

Figure. 2. Layout of the μSR facility and the muon beamline

- ❖ The solenoids were designed to collect the muons with large solid angle acceptance (~107 msr) and rotate the phase space of beam as 83° in order to reduce momentum dispersion.
- ❖ Dipole specifications were determined considering the magnetic rigidity of muon ($B\rho$ = 0.074 T × 1.3 m) to bend the trajectories as 70° taking into account the shielding of the facility.
- ❖ Wien filter is used to remove particles which have different momentum and mass and rotate muon spin as 45° by using orthogonal magnetic and electric field.
- ❖ The arrangement and specification of components were decided taking into account the shielding structure of the facility and the transmission rate.
- ❖ Beam transport calculation was carried out using G4beamline to estimate the transmission rate and the trajectories of the muon beam. The fringe field effect is included for every component which is derived by using OPERA-3D code.
- ❖ The muon intensity at the experimental sample was estimated to be 5.7 × 10^6 μ^+/s at a proton current of 660 μA.

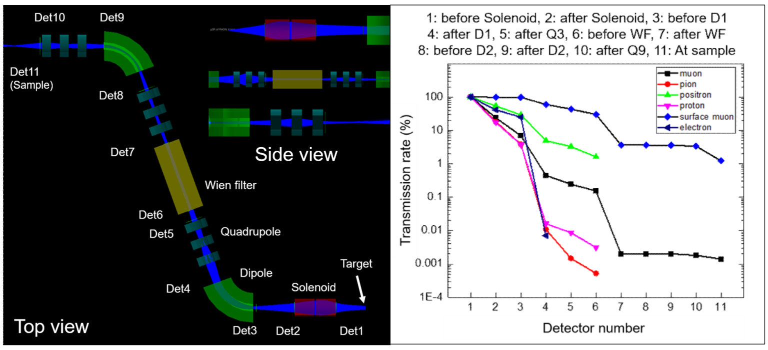

Figure. 3. (Left) G4beamline calculation of muon beam trajectories through the beamline (Right) Transmission rate of particles by components

Conclusion

- ❖ The muon beamline of μSR facility of RAON, composed of 2 solenoids, 2 dipoles, 9 quadrupoles and a Wien filter, was designed by determining the positions and the specifications of components.
- ❖ Beam transport calculation was performed to estimate transmission efficiency and trajectories of the beam.
- ❖ Other particles except for muon were removed by the Wien filter.
- ❖ Muon flux injected to the 1.5 × 1.5 cm^2 sample was estimated to be 5.7 × 10^6 μ^+/s at a proton current of 660 μA.
- ❖ μSR facility of RAON is being manufactured with some components with the goal of completion in 2021.

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