Equipment development for muon mobility measurement in rare gases

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Synopsis We developed a drift tube with scintillation fibers for measuring a muon mobility in rare gas.

Researches utilizing muon beam span across many fields such as a muon-catalyzed fusion, a muon-spin relaxation, and an X ray spectroscopy. In these types of experiment, the quantum state of the muon charged atoms and molecules has always been a problem, and until now, it was indirectly determined by comparing the result of the first principle calculation and the experimental result. The first principle calculation involving muon needs to consider the effect of quantum fluctuation as well and it is still in a state of development. In order to verify the first principle calculation, the basic data for the collision cross section at low energy region corresponding to the binding energy of muon and the target molecule is necessary. Especially the elastic scattering cross section and the potential energy surface in the thermal energy region are extremely important in studying the muon behavior in the environment. However, since the collision experiment in this energy region is technically difficult, the report of experimental results for the interaction between two bodies in an isolated system, especially for the elastic scattering, is sparse. By applying the drift tube technique to the muon collision experiment, we consider that muon-gas molecule interaction information can be obtained for less than 1 eV region.

Figure 1 shows the schematic for the drift tube for muon mobility measurement under development. The positive or negative muons (~4 MeV) generated from J-PARC MLF muon beam line are passed through an aluminum plate about 0.6 mm in thickness to decelerate it to about 10 keV. The decelerated muons enter the drift tube and travel a few cm by repeatedly colliding with buffer gas (~10kPa) and then thermalizes. Monte Carlo calculation code PHITS were used to evaluate the trajectory of muons. The thermalized muon travels with certain mobility toward the back due to the uniform electric field (~100 V/cm) applied to the inside of the drift tube. After the muons travel a few cm from the point where it thermalized, they decay with a life of 2.2 μsecond to positrons (electrons in case of negative muon) with an average energy of 35 MeV. The decayed positrons/electrons pass through the double scintillation fiber installed on the outside of the drift tube. The light emitted from the fiber is observed with pixel type avalanche photodiode (MPPC) and signal processed using the new detection system KALLIOPE (KEK Advanced Linear and Logic board Integrated Optical detector for Positron and Electron) [1]. By installing the fiber in double the flight direction of the positron can be determined and the projection diagram to the central axis of the drift tube at the decay point can be obtained. The muon velocity distribution in the drift tube can be approximated with a Gaussian distribution and the decay point can be analyzed from the axial projection. By expressing the decay point with a time function, the muon mobile speed inside the drift tube can be calculated and the mobility can be derived. In the poster, the classic trajectory calculation of the muon mobility and the status of the equipment development will be announced.

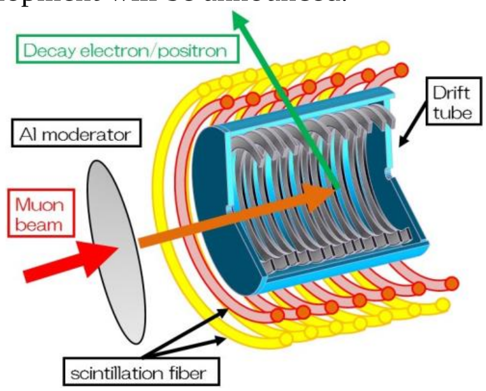

Figure 1. Drift tube with scintillation fiber.

References

[1] K. Kojima *et al.*, Journal of Physics: Conference Series 551 (2014) 012063
http://openit.kek.jp/project/lists/mppc-tdc-sitcp/public/mppc-tdc-sitcp

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