

Muon spectrometer design for the first muon facility in China

Muon spin spectroscopy, known as a collection of muon spin rotation, relaxation and resonance (μ SR) techniques, uses highly polarized muons to study the microscopic magnetic structure and dynamics of condensed matter. The interaction between muon spins and the local field inside materials forms the physical basis of μ SR techniques. Such information is extracted by the detection of positrons decaying from muons inside a sample and asymmetrically emitted at the solid angle of 4π steradians. Currently, there are five international muon facilities providing continuous or pulsed muon beams for material characterization. In addition to the existing facilities, the first Chinese muon source, the Muon station for sciEnce technoLOgy and inDustrY (MELODY), is planned to be constructed at Phase II of the China Spallation Neutron Source (CSNS). It aims to provide intense and pulsed muon beams to conduct μ SR applications in multiple disciplines, including condensed matter physics, material science, chemistry, and energy science. The group from the University of Science and Technology of China (abbreviated as the USTC group) participated in the collaboration with the CSNS accelerator group for the construction of the muon source. The USTC group dominated the R&D of the first-generation photomultiplier tube (PMT)-based μ SR spectrometer and the design of the second-generation silicon photomultiplier (SiPM)-based spectrometer. The PMT-based spectrometer is a 128-channel prototype to demonstrate and develop key detector and electronics technologies for the planned MELODY. After several iterative designs and updates of detectors and electronics, the spectrometer prototype achieved a 7-ns dead time, which is shorter than that of the ISIS spectrometer and can record more positrons in each pulse. Based on the technologies developed from the first-generation spectrometer, the second-generation spectrometer will use SiPMs to accommodate over 2500 detector units to make full use of muons in MELODY. The development of μ SR spectrometers will greatly boost the construction of MELODY and provide high-quality data to users to interpret material properties.

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