To add spatial information to muon spin rotation and relaxation (μSR) measurements, we investigated the reconstruction of three-dimensional source distributions from muon decay positron tracks. With hit information from only a few detector layers, the emission point of an individual positron generally cannot be determined uniquely. We therefore combine observations from many independent decay events and estimate the spatial distribution of emission points by solving an inverse problem.

Using Geant4 simulations, we characterized the response of a scintillating-fiber detector by mapping emission positions to observed hit patterns while accounting for scattering and detection efficiency. With this response held fixed, we used maximum-likelihood expectation–maximization (MLEM) to reconstruct the source distribution from the observed tracks, correcting for position-dependent event acceptance. Using simulated data independent of those used to calibrate the response, we compared the effects of different detector geometries on the reconstruction of three-dimensional source distributions.

In this presentation, we discuss the capabilities and limitations of detector-response-based three-dimensional reconstruction and the challenges that remain before applying it to experimental data.