Purpose: A high-resolution micro-PET system based on liquid xenon (LXe) is under development. The system employs LXe time projection ionization detectors (TPC) and large-area avalanche photodiodes (LAAPDs) light sensors. The energy and positions of interactions with the liquid xenon are measured by combining signals received from ionization charge in the TPC with scintillation light from the LAAPD arrays. The energy from scintillation light is used to select events in the 1st-stage of a 2-stage event selection. In this work we investigated methods of determining interaction locations from the LAAPD data by employing neural network (NN) computation algorithms. The position resolutions achievable by these methods under various degrees of reflectivity of the surfaces within the detector are presented.

Methods: Simulations were performed using GEANT4 code. A simulated isotropic point source of 10220 optical photons (representing scintillation light from 511 keV gamma photons) was located at various points within the sector. The scintillation signal on the LAAPDs was calculated for all points within the sector on a 2x2x2 mm three dimensional grid for various levels of reflectivity. A random distribution of interactions within the sector was then evaluated with the NN algorithm.

Results: The simulation studies indicate that under conditions of no optical reflectivity within the sector, interaction locations can be successfully reconstructed in 3 dimensions with approximately 8 mm FWHM 3-D spatial resolution. When reflective surfaces are added to the inner walls of the sector, the position resolution is improved to 3.5 mm FWHM 3-D spatial resolution, depending on the amounts and locations of the reflective surfaces.

Conclusions: Scintillation position measurements of up to 3.5 mm FWHM 3-D spatial resolution are achievable with various levels of surface reflectivity for the PET scanner employing LXeTPC detectors. Further analysis and techniques for improving signal to noise ratio in LAAPDs could improve the resolution.