Purpose: The authors are developing a novel high-resolution preclinical PET system based on twelve liquid xenon (LXe) detectors arranged in a ring geometry. Each detector consists of a LXe time projection chamber (TPC) viewed by two arrays of large area avalanche photodiodes (LAAPDs). The LXe detector that uses both ionization and scintillation signals measures the energy and coordinates of each photon.
In this work, we evaluate the simulated imaging performance of the PET system according to a subset of NEMA-NU4 measurements and we report on the measurements of the spatial resolution obtained with cosmic rays.

Methods: The LXePET prototype was simulated with the Geant4 code. Positron range and photon non-colinearity were integrated in the model. Instrumental responses were parametrized. Combined light-charge energy was used to reject scatter events. A Compton reconstruction algorithm was employed to identify the first interaction point in multi-site events. List-mode data were reconstructed with the software for image reconstruction STIR. To evaluate sensitivity, scatter fraction, and spatial resolution of the LXePET system, a point source was simulated. To ascertain the image quality, a micro-Derenzo phantom was used. To measure the detector spatial resolution, muon cosmic ray data were acquired with a LXePET sector.

Results: The simulation studies indicated that the noise equivalent count rate peaks at 899 kcps at 212 MBq and 1312 kcps at 224 MBq for mouse and rat phantoms. The absolute sensitivity at the center of the field of view was 12.6% and the resolution in the trans-axial plane was < 1 mm (FWHM). Experimental measurements with a LXePET sector show a spatial resolution better than 0.5 mm.

Conclusions: High sensitivity, spatial and energy resolutions, and image quality are achievable with PET scanners employing LXeTPC detectors. The use of new image reconstruction algorithms tailored for high-resolution scanners could further improve image quality.