We are in the process of building a high performance positron emission tomography (PET) system for small animal research using a semiconductor detector material known as cadmium zinc telluride (CZT). If successful, this system will enable substantial improvements in the ability to detect, visualize, and quantify molecular-based signatures of disease in vivo using PET. Unlike nearly all other PET system designs, which use scintillation detector technology, CZT directly collects electron-hole pairs created from the absorption of a 511 keV annihilation photon. This approach has advantages both in terms of construction as well as performance of high resolution PET systems that we will describe in this presentation. We will also present other unusual features of the system design, results of detector spatial, energy, and temporal resolution measurements performed in the laboratory, image reconstruction strategies, as well as predicted system photon sensitivity, noise-equivalent count rate, and reconstructed spatial resolution performance results obtained using Monte Carlo simulation studies.