**Purpose:** To investigate the yields and the yield-depth distributions of positron-emitting nuclei (PEN) $^{10}C$, $^{11}C$, and $^{15}O$ induced by protons and carbon ions in PMMA through detection of annihilation gamma rays using Geant4 Monte Carlo Toolkit. **Method and Materials:** An application utilizing various physics packages (low and standard electromagnetic, parameterized and Binary Cascade inelastic and parameterized elastic) was constructed with Geant4 Monte Carlo Toolkit. A phantom (9 cm x 9 cm x 30 cm) consisting of PMMA ($C_5H_8O_2$, density 1.18 g/cm$^3$) was irradiated with 70, 110 MeV protons and 204 A, 212.12 A MeV carbon-ions. Beams (1 cm FWHM; 0.2% Gaussian energy spread FWHM) were used. In each simulation the energy deposited was recorded for every 0.1 mm increment of depth in the phantom. The resulting PEN and their yield were recorded at the production point and the point of decay in increments of 1 mm. **Results:** The overall percentage yields and the yield-depth distributions of PEN per incident particle for both protons and carbon ions were obtained. **Conclusion:** Our yields of PEN are in excellent agreement with other simulations (FLUKA and MCHIT) and existing experimental data. However, we found in our simulation overestimation of the percentage yields of $^{10}C$ with incident carbon ions and underestimation of the percentage yields of $^{11}C$ for 110 MeV incident protons when compared to existing experimental data**.** The application built in this study thus can predict the amount of PEN as well as their yield-depth distributions.