Development of Three-Dimensional gamma-CT Scan System in BL1U-UVSOR-III

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Abstract: We are planning to measure a Three-Dimensional Gamma Computed Tomography image for the preparation of 3D NRF-CT image with the LCS gamma-ray beam at BL1U in UVSOR-III synchrotron radiation facility. To obtain the 3D gamma-CT image within the UVEOR-III machine time in a weak (around 60 hours), we have been developing an automatic CT target movement stage and data acquisition system. The 3D gamma-CT scanning system and the obtained image will be reported in the presentation.

Keywords: Computed Tomography, Laser Compton Gamma-ray Beam, Nuclear resonance fluorescence

Summary: Nuclear Resonance Fluorescence (NRF) absorption method enables us to identify the specific nuclide by measuring the scattered gamma-ray which has the excitation energy of the nuclide or the absorption of the incident gamma-ray. NRF has been studied for non-destructive diagnostics in the industrial application, and the isotope imaging inside the spent nuclear fuel canisters and nuclear wastes [1]. Zen et al. [2] demonstrated a CT imaging of a lead isotope (^{208}Pb) in a natural lead rod concealed inside in an iron cylinder filled with aluminum together with an iron rod. One of the remarkable features for NRF-CT is that it is possible to identify only the isotope of interest from a sample including several isotopes. From the principle, NRF-CT should have isotope selectivity. Our previous study which carried out at the BL1U in UVSOR-III synchrotron radiation facility has proposed a method to perform an isotope selectivity of the Computed Tomography (CT) imaging based on the NRF absorption method using a quasi-monochromatic Laser Compton Scattering (LCS) gamma-ray beam in the MeV region for a sample target including two enriched lead isotope rods made of ^{206}Pb and ^{208}Pb with a diameter of 6 mm implanted in a thick aluminum holder. Two-dimensional NRF-CT image of ^{208}Pb isotope distribution in the sample target was selectively obtained for the first time using an excited state with $J\pi=1^-$ at 5.512 MeV in ^{208}Pb. The CT image was clearly obtained with a 2-mm pixel size resolution which was determined by the horizontal step size of the CT stage. The intensity of the LCS gamma-ray beam was greater than 10^8 photons/second without a collimating. We are looking forward to obtaining a three-dimensional NRF Computed Tomography (3D NRF-CT) image for the isotopes inside the desired targets. For this purpose, we are developing an automatic measurement system which consists of the CT target movement stage and data acquisition system. A three-dimensional Gamma-CT measurement in UVSOR-III is being planned to test the developing system. We will use a CT target including two rods of isotopes in a specific dimension. The two rods will be implanted in an aluminum cylindrical holder with a diameter of 25 mm and a 20-mm height with three holes. Two of these holes will include the two rods and the other one was not filled as a vacancy. The rods types, their arrangements and the density distribution of the vertical direction inside the holder are under preparation. We will use a fiber laser system with a maximum average power of 50 W and 1.896 nm wavelength to generate an LCS gamma-ray beam with maximum gamma-ray energy of 5.528 MeV with a head-on collision with a 746 MeV electron beam. And also, a lead collimator with a hole diameter of 1 mm will be used for limiting the scattering angle of the LCS gamma-ray beam. The development in the measuring system, the obtained 3D gamma-CT image and for the ^{208}Pb and the acquiring time will be discussed.

References:

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