First True Gamma-ray Spectroscopic Imaging of Contamination near Fukushima Plant and Extension to the Whole Area in Fukushima

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We have developed Electron-Tracking Compton Camera (ETCC), which provides a well-defined Point Spread Function (PSF) by reconstructing a direction of each gamma as a point, and hence can measure both brightness and energy of incoming gammas within PSF simultaneously. Then obtained images give the emissivity and energy-spectrum of any point, independently of its distance, which no other instruments can give.
Here we present the results of our on-site pilot gamma-imaging-spectroscopy with ETCC, carried out at several contaminated and decontaminated areas around the Fukushima Daiichi Nuclear Power Plant in Japan in 2014, after the major accident of the plant. Obtained brightness (or radioactivity) distributions were directly transferred to the dose on the ground with no ambiguity. The dose distribution was quantitatively consistent with that taken by mapping measurements with a dosimeter, which verifies the complete reproducibility of radioactivity in observed area by ETCC. In addition, imaging spectroscopy reveals quantitatively the complex radioactive features around each target point under intense background of scattered gammas. Notably, the ETCC imaging spectra free of Compton edges enabled us to spot both a “micro hot spot” of remaining caesium, even in a decontaminated area and dominant scattered low-energy gammas from sky in all areas. Thus, ETCC provides the performances expected from geometrical optics completely, which guarantees the universality and general versatility of ETCC. This success enables us to measure directly a distribution of the essential parameter of the radioactivity, which can be coarsely inferred from the dose distribution so far.
Here using this excellent feature of the ETCC, we have simulated the possibility of the detailed spectroscopic imaging for whole contaminated area in Fukushima Prefecture using the improved ETCC which is being developed for the balloon experiment for astronomy in 2018, and will show the possible survey using the airship at the altitude of 100 with a 10 m x 10 m resolution. Then the whole contamination area in Fukushima prefecture (about 20 km x 50 km) may be be mapped with this area resolution during a few months, assuming the working time of 8 hours per day. Some of the spectra obtained in this survey might be found out to be generated by the gammas scattered by something, such as trees in woods, within the grid. Our survey will efficiently detect a hint for those areas, which can be then studied in more detail with on-site measurements, such as ones by backpacks. No successful large-scale survey has been yet performed to monitor the radioactivity in Fukushima. Our upgraded ETCC will be capable of revolutionizing the situation.

Keywords: gamma-ray imaging spectroscopy, Fukushima, Nuclear Power Plant

