

Si-APD linear-array detector system and High-Z loaded plastic scintillators

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We have developed an X-ray detector system using silicon avalanche photodiode (Si-APD) linear array and fast pulse-counting electronics for multichannel scaling (MCS) [Fig. 1]. The Si-APD linear array consists of 64 or 128 pixels, which have 100×200 or $100 \times 400 \mu\text{m}^2$ in size, pixel pitch of $150 \mu\text{m}$, and depletion depth of 10 or $30 \mu\text{m}$. Ultrafast Amplifier-Shaper-Discriminator (ASD) ASICs and FPGAs can record timing of X-rays arriving at each pixel with 0.5 ns interval at minimum. The detector was used for nuclear resonant forward scattering on ^{57}Fe , which spatial resolution and detection efficiency were improved by inclining the detector up to 12° from the incident beam. We will show the present status on the Si-APD linear array detector system, including some problems.

One more topic is high-Z loaded plastic scintillators. We fabricated fast plastic scintillators (PLSs) by loading HfO_2 nanoparticles. Such a heavy metal loaded PLS will be useful for measurements of high-energy X-rays with up to a high count-rate $> 10^7 \text{ s}^{-1}$. A 40 and 60 wt% HfO_2 nanoparticle-loaded plastic scintillators (Hf-PLS) were successfully polymerized by mixing with polystyrene and (2-(4-tert-butylphenyl)-5-(4-biphenyl))-1,3,4-oxadiazole (b-PBD) as fluorophore [Fig. 2]. We tested the 40 wt% Hf-PLS (8 mm in diameter, 3 mm in thickness) mounted on a photomultiplier tube (PMT) using synchrotron X-ray beam at beamline BL-14A of the Photon Factory (PF). The detection efficiency at 50.0 keV reached $44.3 \pm 0.2\%$. Counting rates of up to $2.8 \times 10^7 \text{ s}^{-1}$ were recorded in the multibunch-mode operation of the PF ring. A superior time resolution (FWHM) of $0.29 \pm 0.06 \text{ ns}$ was obtained but with a time resolution of 0.46 ns at best using a commercially available 5 wt% lead loaded PLS, EJ-256. A $\sim 3 \text{ mm}$ cube 40 wt% Hf-PLS on a Si-APD (Geiger-mode or proportional-mode) was also investigated as a new fast scintillation detector for high-energy X-rays.

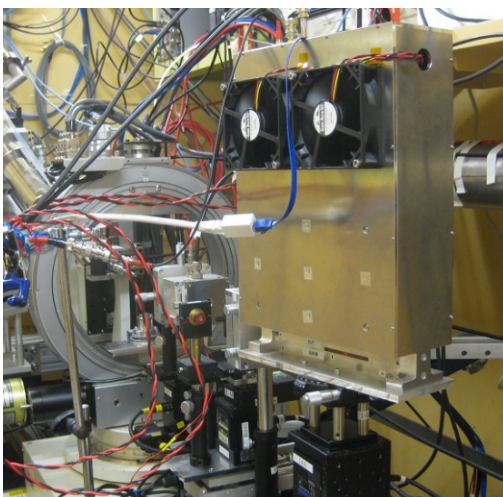


Fig. 1: Photograph of the 128 channel Si-APD linear-array detector (front).



Fig. 2: Photograph of 40 wt% (left) and 60 wt% (right) HfO_2 nanoparticle-loaded plastic scintillators, approximately 8 mm in diameter and 3 mm in thickness.