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X-Ray Detector Technology Optimization In CT Imaging

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Abstract : Most of multi-slices CT scanners are built with detectors composed of scintillator - photodiodes arrays. The photodiodes arrays are mainly based on front-illuminated technology for detectors under 64 slices and on back-illuminated photodiode for systems of 64 slices or more. The designs based on back-illuminated photodiodes were being investigated for CT machines to overcome the challenge of the higher number of runs and connection required in front-illuminated diodes. In backlit diodes, the electronic noise has already been improved because of the reduction of the load capacitance due to the routing reduction. This translated by a better image quality in low signal application, improving low dose imaging in large patient population. With the fast development of multi-detector-rows CT (MDCT) scanners and the increasing number of examinations, the clinical community has raised significant concerns on radiation dose received by the patient in both medical and regulatory community. In order to reduce individual exposure and in response to the recommendations of the International Commission on Radiological Protection (ICRP) which suggests that all exposures should be kept as low as reasonably achievable (ALARA), every manufacturer is trying to implement strategies and solutions to optimize dose efficiency and image quality based on x-ray emission and scanning parameters. The added demands on the CT detector performance also comes from the increased utilization of spectral CT or dual-energy CT in which projection data of two different tube potentials are collected. One of the approaches utilizes a technology called fast-kVp switching in which the tube voltage is switched between 80kVp and 140kVp in fraction of a millisecond. To reduce the cross-contamination of signals, the scintillator based detector temporal response has to be extremely fast to minimize the residual signal from previous samples. In addition, this paper will present an overview of detector technologies and image chain improvement which have been investigated in the last few years to improve the signal-noise ratio and the dose efficiency CT scanners in regular examinations and in energy discrimination techniques. Several parameters of the image chain in general and in the detector technology contribute in the optimization of the final image quality. We will go through the properties of the post-patient collimation to improve the scatter-to-primary ratio, the scintillator material properties such as light output, afterglow, primary speed, crosstalk to improve the spectral imaging, the photodiode design characteristics and the data acquisition system (DAS) to optimize for crosstalk, noise and temporal/spatial resolution.

Keywords : computed tomography, X-ray detector, medical imaging, image quality, artifacts
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