RESEARCH PAPER

# Optimizing Photon Counting Detectors for enhanced image quality and noise reduction in low dose setting: A review study

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**Abstract:**
Photon counting detector CT, which has shown significant advancements in recent years. PCDs detect x-rays via a direct conversion mechanism that does not require a scintillator layer Unlike energy-integrating detectors. The semiconductor detector material directly transforms X-ray photons into electronic signals. However, electrical noise, particularly at low doses, can impair detectors and degrade image quality. The various approaches for improving PCDs to improve image quality in low-dose imaging applications are examined in this review paper. The basic ideas of PCDs are first discussed, along with the benefits and drawbacks of this technique compared to traditional energy-integrating detectors. Additionally, we discuss the role of advanced calibration techniques in enhancing PCD performance even more. The review additionally highlights the present limitations and future directions in the development of photon-counting technology.

**Keywords:** Photon Counting Detectors, Image quality, electronic noise

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## Introduction

Since its introduction in 1972, CT has been extensively utilized in both diagnostic and therapeutic medicine due to its rapid scanning capabilities, excellent spatial resolution, and wide accessibility [1]. Currently, the majority of existing CT systems utilize solid-state energy-integrating detectors (EIDs) that feature third-generation rotate–rotate designs to transform X-rays into electrical signals. The indirect conversion method used by EIDs relies on a scintillator layer that changes X-ray photons into visible light, which is later detected by a photodiode layer and transformed into an electric output signal [2]

However, a significant drawback of these EIDs systems arises from the indirect measurement of X-ray photon energy through a scintillator, which converts incoming X-ray photons into visible light before the signal is transformed into an electrical current. Additionally, the detected signal represents a collective assessment of the energy of all incoming X-ray photons and lacks details regarding their total count and individual energy levels. The photon-counting detectors (PCDs) developed has the ability to address these challenges [3]. PCDs use a direct conversion method for x-ray detection that eliminates the need for a scintillator layer, unlike EIDs. The semiconductor material in the detector directly transforms x-ray photons into electron-hole pairs when a bias voltage is applied across the semiconductor, electrons move towards the anode and are collected to produce electronic signals [4,5,6]. The primary semiconductor materials utilized in PCDs are cadmium

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