Empowering High-Quality Minimal Radiation Exposure CT Lung Scans with SilverBeam and DLR

Canon Medical's SilverBeam introduces a novel X-ray filtration system specifically developed for CT imaging. This innovative solution capitalizes on the physical properties of silver, leveraging its outstanding ability to optimally filter low energy X-rays. Combined with Advanced intelligent Clear-IQ Engine (AiCE), a pioneering Deep Learning Reconstruction (DLR) algorithm for CT, SilverBeam elevates the potential for high-quality imaging with significant utility in scenarios that necessitate dose minimization. In particular benefits are observed for larger patients and challenging anatomical regions in the context of lung cancer screening.

CT in Lung Cancer Screening

Lung cancer remains the leading cause of cancer-related deaths worldwide, responsible for over 270,000 deaths annually in Europe alone. Despite long-standing interest in the European medical community for lung cancer screening with low-dose computed tomography (LDCT) to reduce lung cancer mortality, supportive European data has only recently become available from a European Randomised Controlled Trial (NELSON). The use of LDCT in NELSON was associated with a significant reduction in lung cancer mortality, ranging from 26% in men to 39-61% in women[1,2] leading to advocacy for LDCT screening implementation in Europe.

Because of the high mortality rate associated with lung cancer, earlier detection through screening programs could significantly improve patient outcomes, such as survival rates, treatment options, and overall prognosis. LDCT lung cancer screening is an increasingly important screening tool, and its potential benefits in Europe are being seriously considered[1].

Although CT is widely used for its high spatial resolution and detailed anatomical information, CT scans always pose risks from ionizing radiation. Therefore there is a growing interest in developing techniques that reduce radiation exposure, such as low and ultra-low-dose CT (ULDCT) protocols.

"This novel CT technology demonstrates the ability to produce images of exceptional quality while minimizing patient radiation exposure, within the realm of plain chest X-rays."

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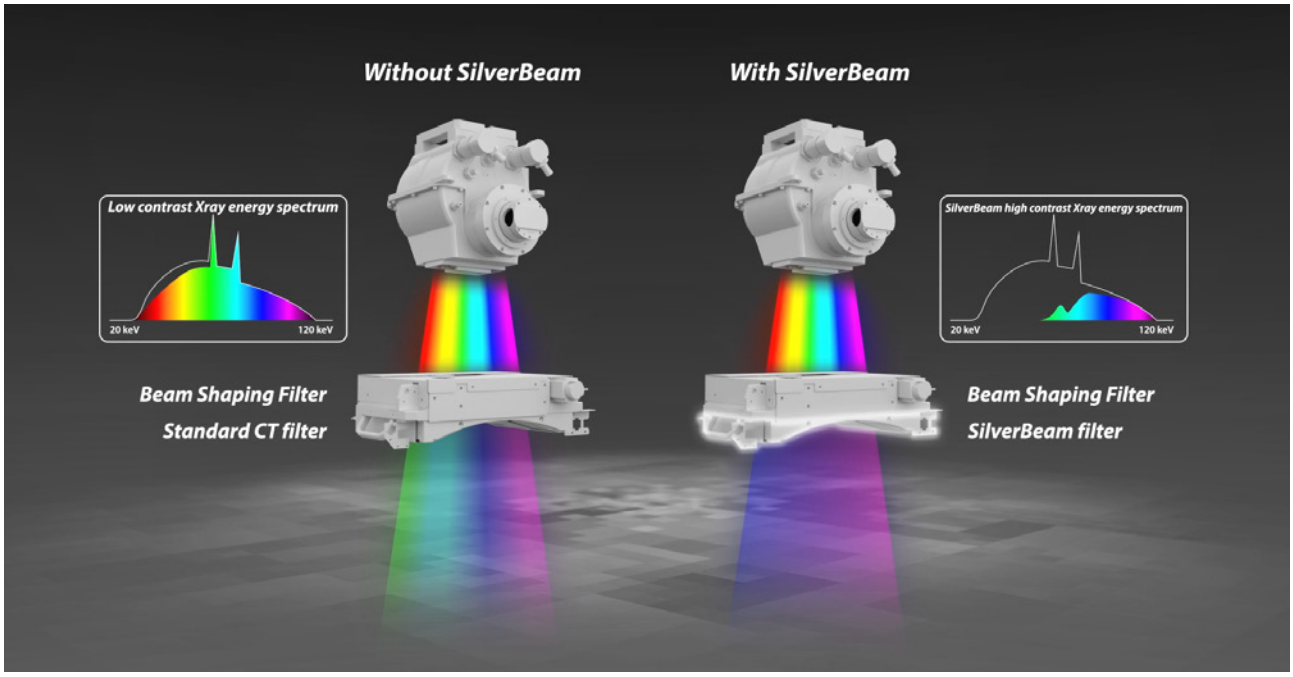


Figure 1: SilverBeam is an energy filter that utilizes the photo-attenuation characteristics of silver to selectively eliminate low-energy photons from a polychromatic X-ray beam. This process results in the formation of an energy spectrum shifted toward higher energies.

These protocols have shown promise in clinical applications such as pulmonary nodule evaluation and lung cancer screening, but their use requires balancing radiation dose and image quality. While the term "ultra-low dose" typically refers to protocols that aim to match the radiation dose of a chest X-ray, the definition of "low dose" may not be consistent over time, leading some clinicians to prefer the term "reduced-dose" protocols.

Despite the benefits of reduced-dose CT, in general, lowering the radiation dose can lead to increased image noise, decreased image quality, and reduced sensitivity to pulmonary pathologies. Therefore it is critical to optimize the imaging chain to ensure both patient safety and diagnostic accuracy.

It has been shown that reduced-dose CT with conventional filtering and hybrid iterative reconstruction (HIR) is more effective than chest radiography in detecting chest pathologies[3]. However, there is potential for further improvement of image quality and accuracy using advanced filtering techniques and deep learning reconstruction algorithms. By applying beam filters made of materials with high atomic numbers, such as silver, and utilizing deep learning reconstruction (DLR), it is possible to enhance the images acquired at reduced- dose and achieve even higher sensitivity and specificity in detecting subtle abnormalities.

SilverBeam

Canon SilverBeam is a new silver-based filtration that selectively eliminates low-energy photons from a polychromatic X-ray beam. The outcome of this process is the generation of an energy spectrum that exhibits a shift towards higher energies, as depicted in Figure 1. As a result, the X-ray energy spectrum becomes narrower, featuring a reduced number of quanta at lower energies, thereby leading to an overall increase in the mean energy. SilverBeam can help to achieve the desired image quality while minimizing the amount of radiation dose received by the patient. Because it enhances the signal-to-noise ratio, SilverBeam is especially useful for lung cancer screening. Due to its inherent high contrast and low absorption properties, SilverBeam proves advantageous for non-contrast chest CT scans. By effectively diminishing photon starvation, it proves particularly beneficial in challenging, high-attenuation scenarios such as the shoulder region of all patients. Moreover, SilverBeam can improve detectability of anatomical areas, that are difficult to detect, such as lung apices, with lower tube voltages due to the high attenuation of photons by the shoulder bone for reduced-dose CT screening.

SilverBeam and Deep Learning Reconstruction

The novel reduced-dose SilverBeam plus AiCE scanning method, results in an improvement in image quality, and further reduction in noise, ultimately resulting in superior SNR values compared to the conventional filtration and HIR approach.

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Figure 2: Clinical images of low dose Lung Cancer Screening CT scan acquired with SilverBeam Filter and reconstructed with AiCE Lung. CTDIvol=0.9 mGy, DLP = 38.7 mGy E= 0.54 mSv (k=0.014 mSv·mGy^{-1}·cm^{-1}). The yellow circle indicates a lung nodule.

Clinical Example

A clinical example of the SNR properties is provided in Figure 2, which shows a small lung nodule well-demonstrated in the upper right lung using reduced dose, at a CTDIvol of 0.9 mGy, chest CT combining SilverBeam with DLR. The dose-length product (DLP) was 38.7 mGy • cm. With a conversion factor (k) of 0.014 mSv • mGy-1 • cm-1, the effective dose (E) equals 0.54 mSv.

The dose used in this CT scan is 11-16 times lower than the typical European effective doses for chest CT (~5.5 mSv)[4].

SilverBeam, the novel silver-based filtration, selectively eliminates low-energy photons from a polychromatic X-ray beam, thus offering numerous advantages that position it as the preferred approach over other filtration materials for specific applications, like reduced dose lung screening. When combined with AiCE technology, SilverBeam demonstrates the ability to produce images of high quality while minimizing patient radiation exposure. By leveraging this innovative solution, patients can now experience the benefits of a safe and effective diagnostic tool. This significant advancement in CT technology represents an important milestone and may contribute to the ongoing battle against this horrible disease. //

References

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