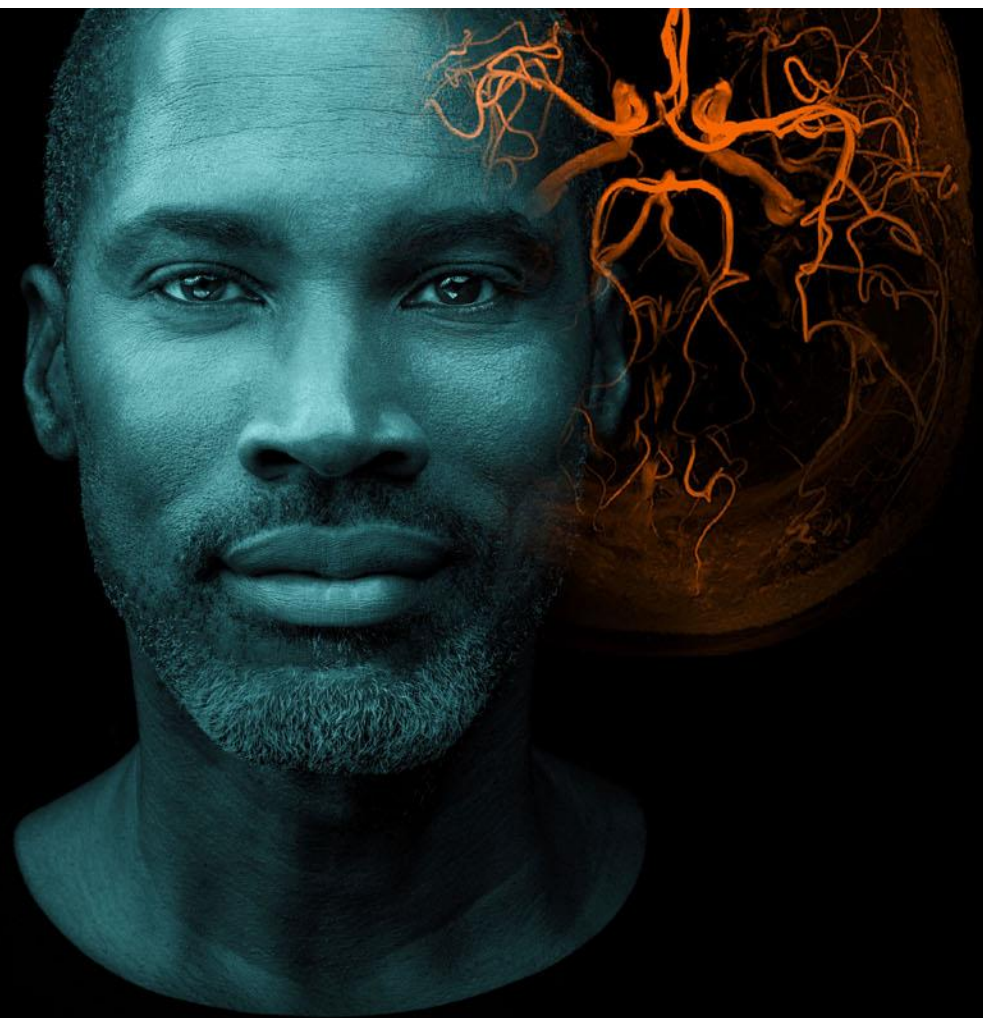
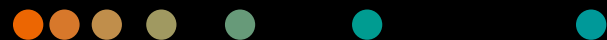


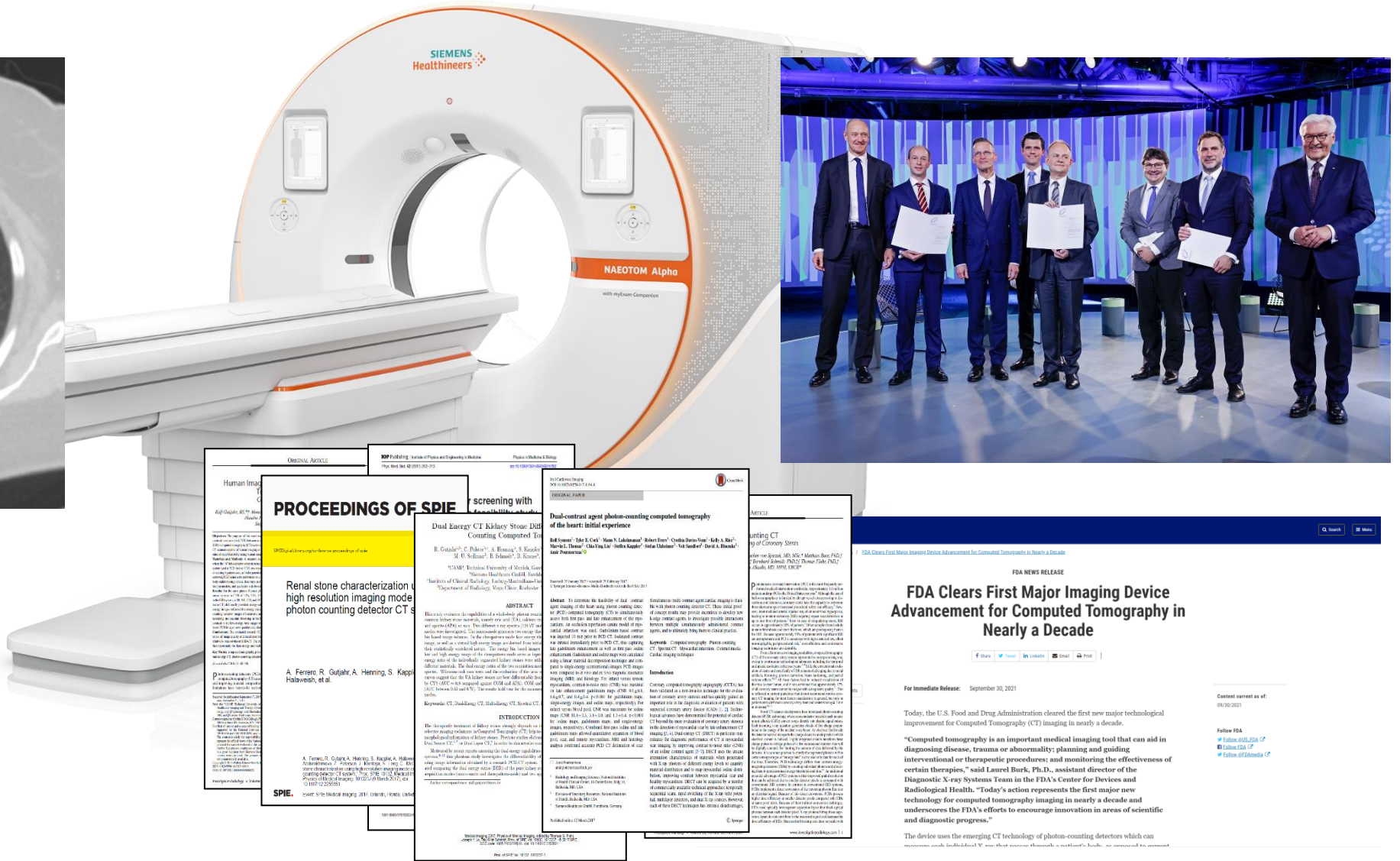
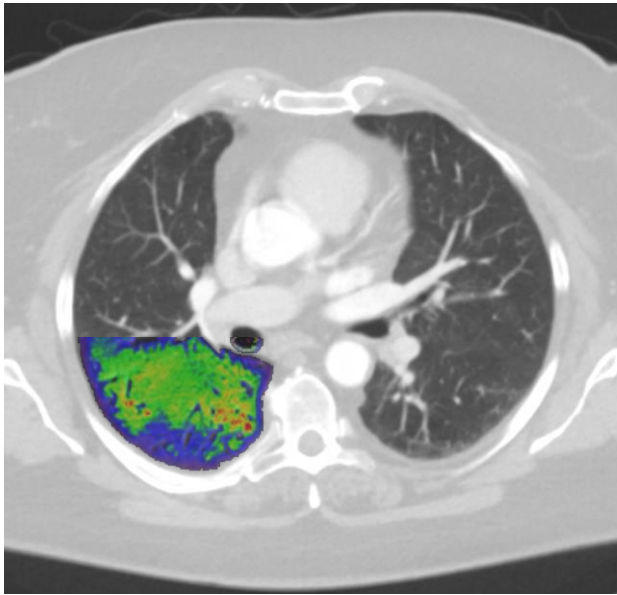
Electronics Integration Challenges in Computed Tomography Scanners

ESTC 2024

Dr. Michael Hosemann
Siemens Healthineers AG



World's 1st Photon-counting Computed Tomography Scanner – NAEOTOM Alpha



- Emergencies
- Heart conditions
- Lung
- Stroke
- Cancer

PROCEEDINGS OF SPIE

Dual Energy CT Kidney Stone DfF Counting Computed To

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ABSTRACT
This study aims to evaluate the effectiveness of dual energy CT in characterizing renal stones. Dual energy CT provides two different energy spectra (80 kVp and 140 kVp) to generate dual energy images. The maximum advantage of dual energy CT is its ability to generate virtual monoenergetic images (VMI) and virtual non-contrast (VNC) images. The VMI images show better contrast between stones and soft tissue compared to conventional CT. VNC images are used to identify stones that are not clearly visible on conventional CT. The purpose of this study is to evaluate the effectiveness of dual energy CT in characterizing renal stones. The study includes 50 patients with renal stones who were scanned on a dual energy CT scanner. The stones were characterized based on their attenuation coefficients (HU) at different energies. The dual energy CT images showed better contrast between stones and soft tissue compared to conventional CT. VNC images were also able to identify stones that were not clearly visible on conventional CT. The results show that dual energy CT is an effective tool for characterizing renal stones.

Renal stone characterization using photon counting detector CT

A. Ferrero¹, R. Gafar², A. Henning³, S. Kapte⁴, Halavesh⁵, et al.

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ABSTRACT
Photon counting detector CT (PCD CT) is a new technology that offers higher spatial resolution and lower radiation dose compared to conventional CT. PCD CT uses a silicon photon counting detector instead of the traditional indirect detector. This allows for better discrimination of different materials based on their atomic number. PCD CT is particularly useful for characterizing renal stones, as it can distinguish between different types of stones (e.g., calcium, strontium, uric acid) based on their attenuation properties. This study aims to evaluate the effectiveness of PCD CT in characterizing renal stones. The study includes 50 patients with renal stones who were scanned on a PCD CT scanner. The stones were characterized based on their atomic numbers. The PCD CT images showed better discrimination between different types of stones compared to conventional CT. The results show that PCD CT is an effective tool for characterizing renal stones.

FDA Clears First Major Imaging Device Advancement for Computed Tomography in Nearly a Decade

FDA NEWS RELEASE

September 30, 2021

For Immediate Release: September 30, 2021

Today, the U.S. Food and Drug Administration cleared the first new major technological improvement for Computed Tomography (CT) imaging in nearly a decade.

"Computed tomography is an important medical imaging tool that can aid in diagnosing disease, trauma or abnormality; planning and guiding interventional or therapeutic procedures; and monitoring the effectiveness of certain therapies," said Laurel Burk, Ph.D., assistant director of the Diagnostic X-ray Systems Team in the FDA's center for Devices and Radiological Health. "Today's action represents the first major new technology for computed tomography imaging in nearly a decade and underscores the FDA's efforts to encourage innovation in areas of scientific and diagnostic progress."

The device uses the emerging CT technology of photon-counting detectors which can measure each individual X-ray that passes through a patient's body, not just the average.

The products/features (mentioned herein) are not commercially available in all countries. Due to regulatory reasons their future availability cannot be guaranteed. Please contact your local Siemens Healthineers organization for further details.

Photon-counting CT – sharper images for a new level of detail

Pushing the boundaries of what is visible in CT



SOMATOM Force
15.6 mGy



NAEOTOM Alpha
8.14 mGy

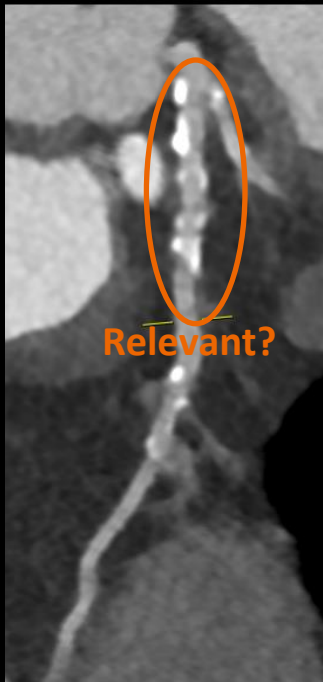
Photon-counting CT – sharper images for a new level of detail

Ultra-high resolution may overcome limitations of coronary CTA

PCD-CT addresses the challenge of Ca blooming

- 80-year-old female patient pre-TAVR planning, dual source PCD-CT, 2 x 120 x 0.2 mm

0.6 mm Bv40



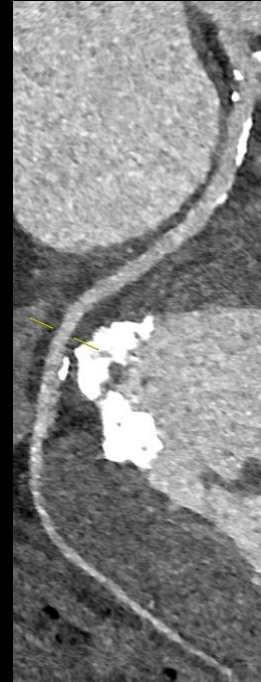
0.2 mm Bv56



0.6 mm Bv40

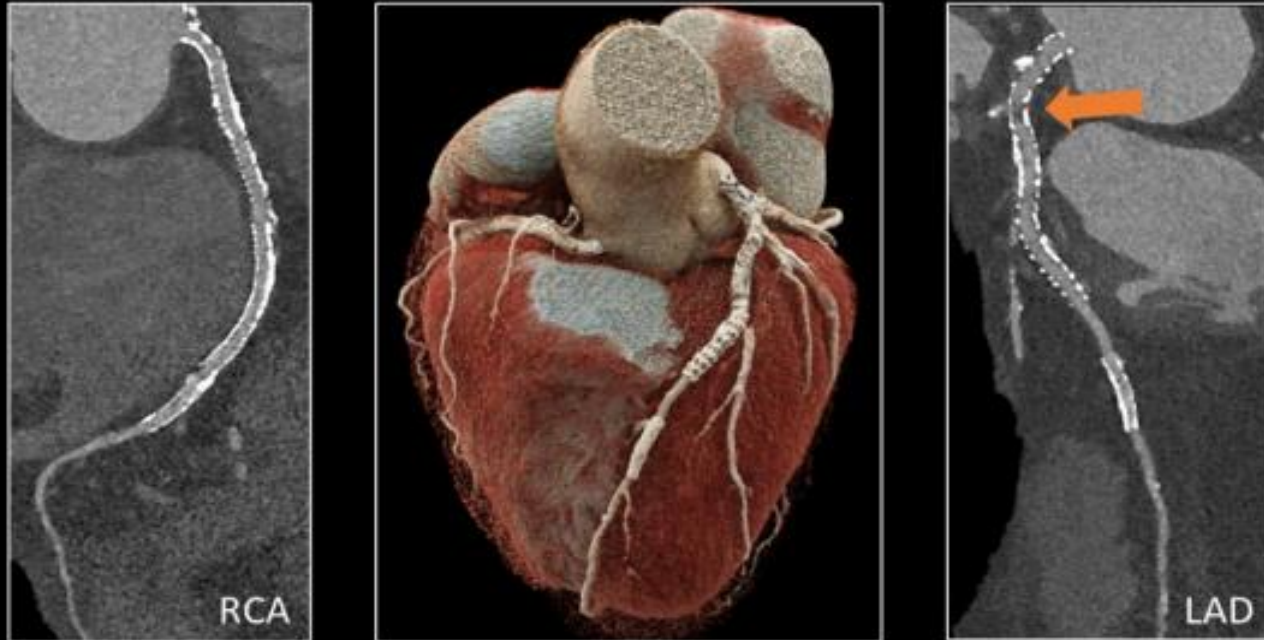


0.2 mm Bv56



Photon-counting CT – sharper images for a new level of detail

Clinical advantages using PCCT for stent evaluation



The figure shows PCCT images (Bv60, 0.2 mm, 512x512, QIR 3) of long, partially overlapping stents in the left anterior descending artery (LAD) and the right coronary artery (RCA). Orange arrow indicate in-stent restenosis of the stent in the proximal LAD

Amnestic Data

81-year old male referred for stent patency evaluation after multiplex PCI (6 stents) due to recurrent angina.

Heart rate was 55/beats during scan

Imaging parameters and contrast protocol

UHR: 0.2 mm, BV 60
IQ 64, QIR 3, 512x512 matrix
72 ml Iomeron 370
120kV, CCTA DLP= 290 mGycm
Sequential scan mode

Significance and novelty

Accurate visualization of in-stent restenosis is challenging using conventional energy-integrating detector CT due to the blooming artifacts by metal struts. High-resolution PCD-CT imaging provides superior spatial resolution and reduced blooming for the evaluation of stent patency.

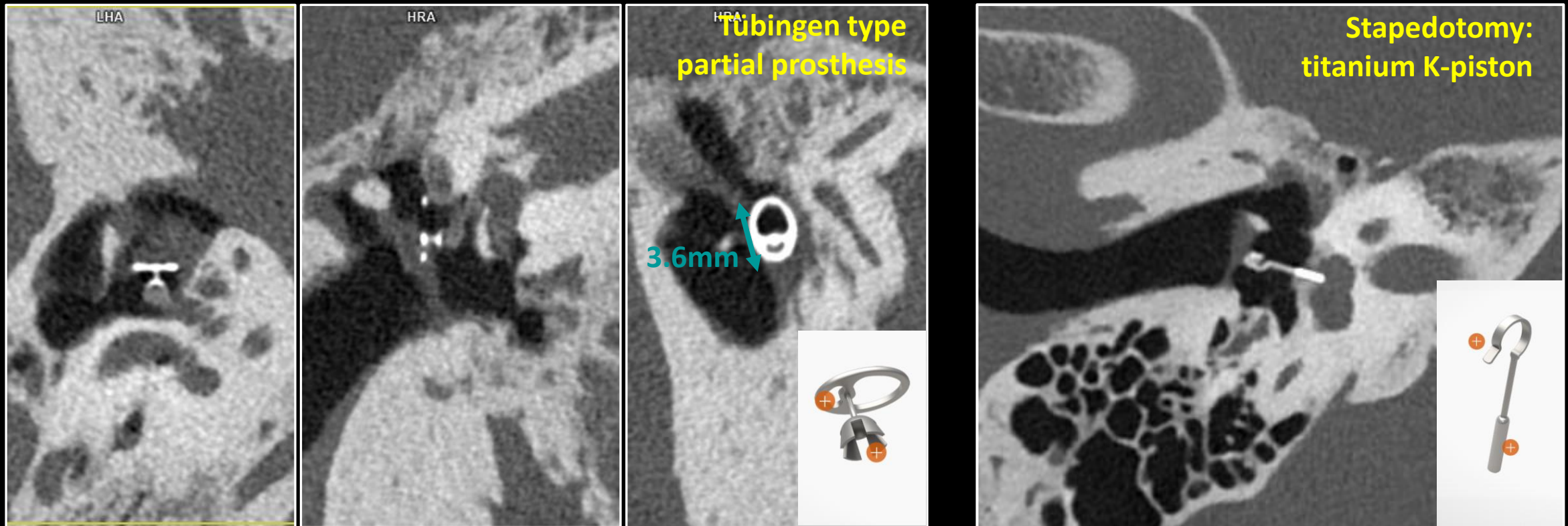
Courtesy of Semmelweis University, Budapest, Hungary.

Source: https://journals.lww.com/investigativeradiology/abstract/2023/07000/characterizing_the_heart_and_the_myocardium_with.9.aspx

The statements by Siemens Healthineers' customers described herein are based on results that were achieved in the customer's unique setting. Because there is no "typical" hospital or laboratory and many variables exist (e.g., hospital size, samples mix, case mix, level of IT and/or automation adoption) there can be no guarantee that other customers will achieve the same results.

Photon-counting CT – sharper images for a new level of detail

Superior visualization of inner ear structures



Courtesy of A. van der Lugt, Erasmus Medical Center, Rotterdam, The Netherlands

Source: https://www.symposiumparkstad.nl/upload/documents/CT_2022/handout/1_PhotonCounting_2022_PCCT_RBooij.pdf

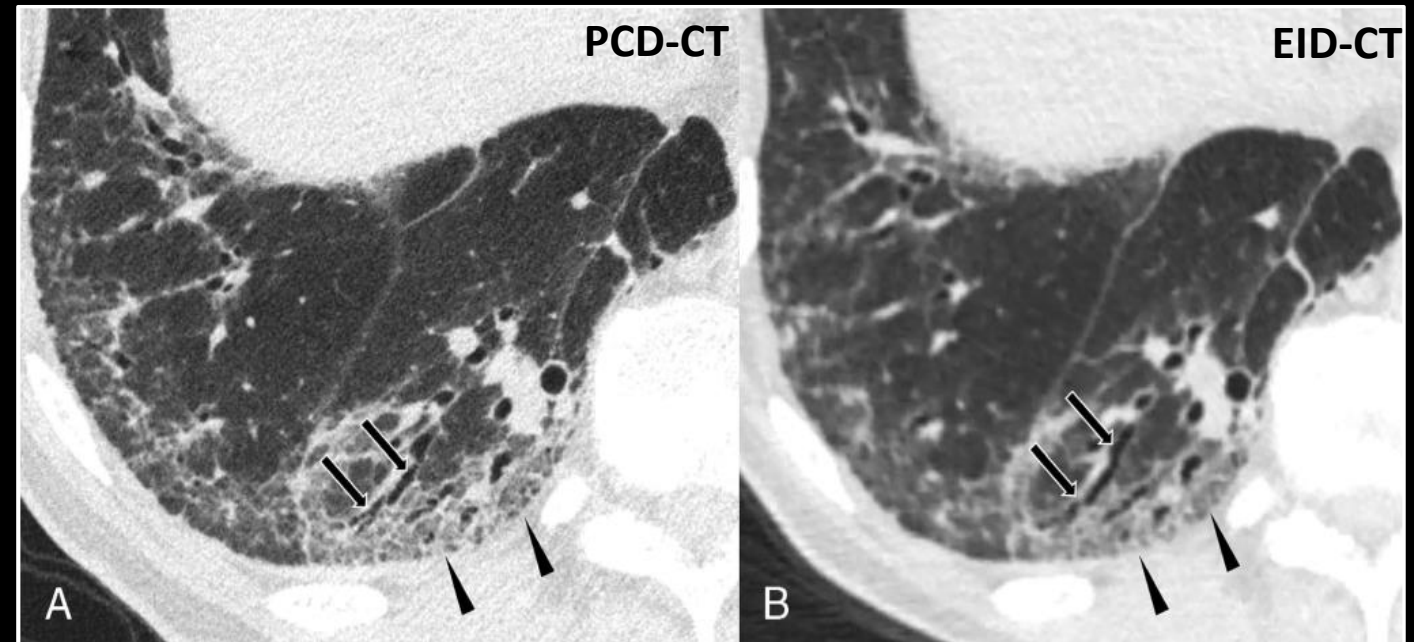
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Photon-counting CT – sharper images for a new level of detail

Increased reader confidence in diagnosis of interstitial lung disease

Chest CT of patients suspected of interstitial lung disease*

- EID-CT 128 x 0.6 mm or 192 x 0.6 mm
mean DLP = 219.8 mGy cm
- PCD-CT UHR 120 x 0.2 mm
mean DLP = 193.8 mGy cm

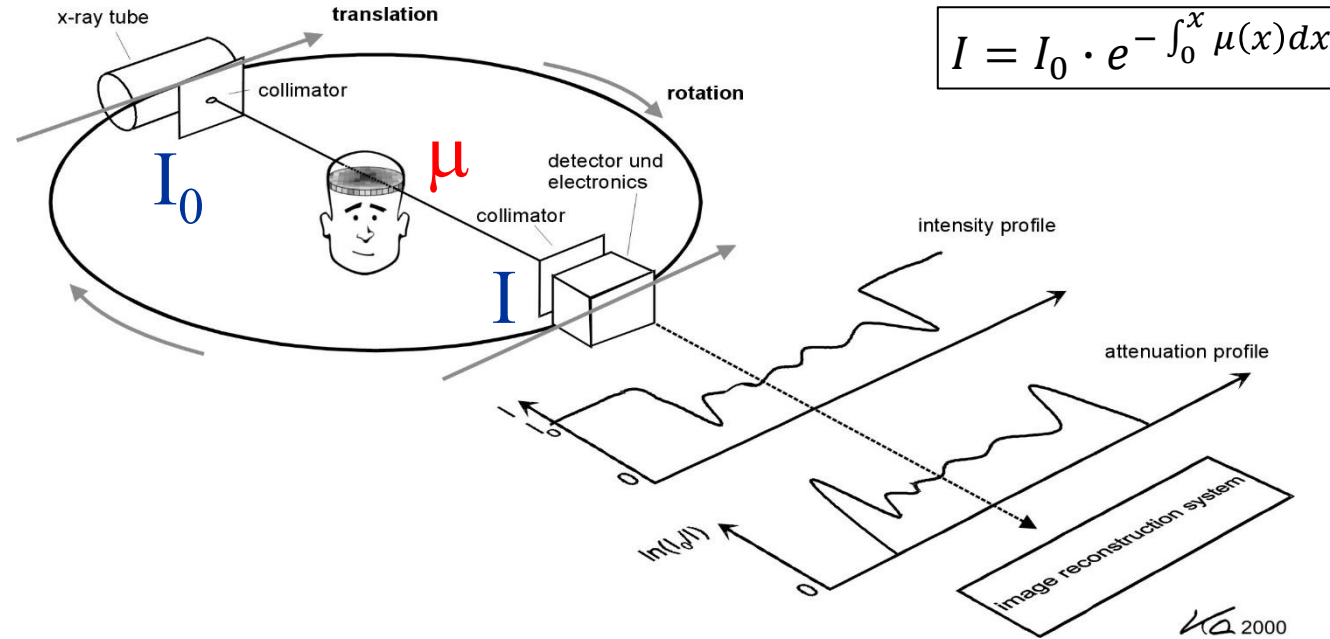


Conclusions: Photon-counting detector CT provided better image quality and improved the reader confidence for presence or absence of imaging findings of reticulation, GGO, and mosaic pattern with idiosyncratic improvement in confidence in UIP presence.

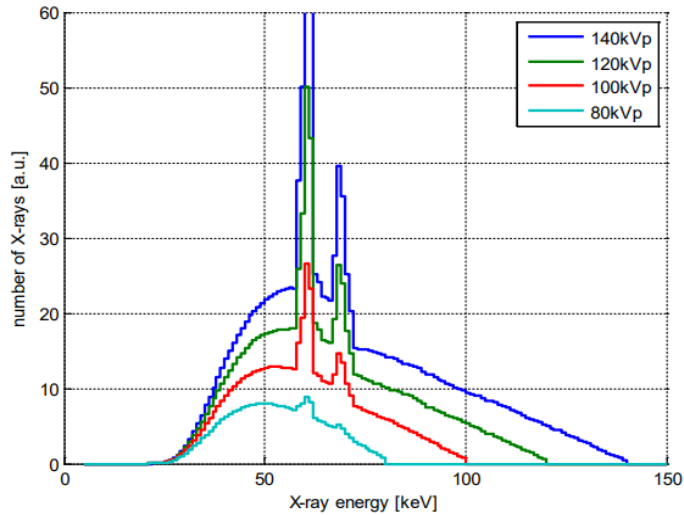
Functional principle of a CT system



Wilhelm Conrad Röntgen, ca. 1900

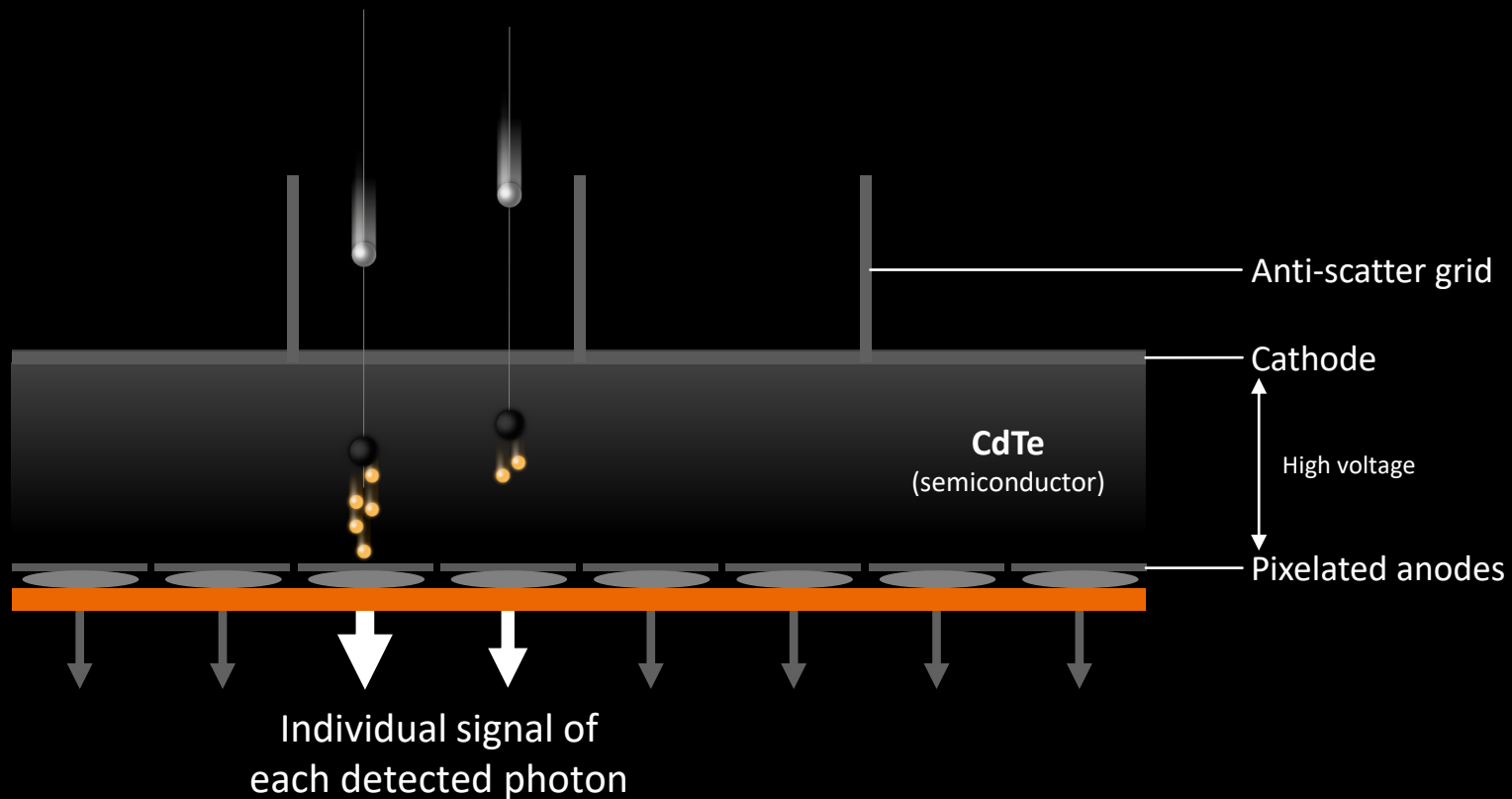


Functional principle of a CT system, adapted from:
 Kalender, Willi A.: Computed tomography: fundamentals, system technology,
 image quality, applications. John Wiley & Sons: 2000.



Typical spectrum used in a CT x-ray tube

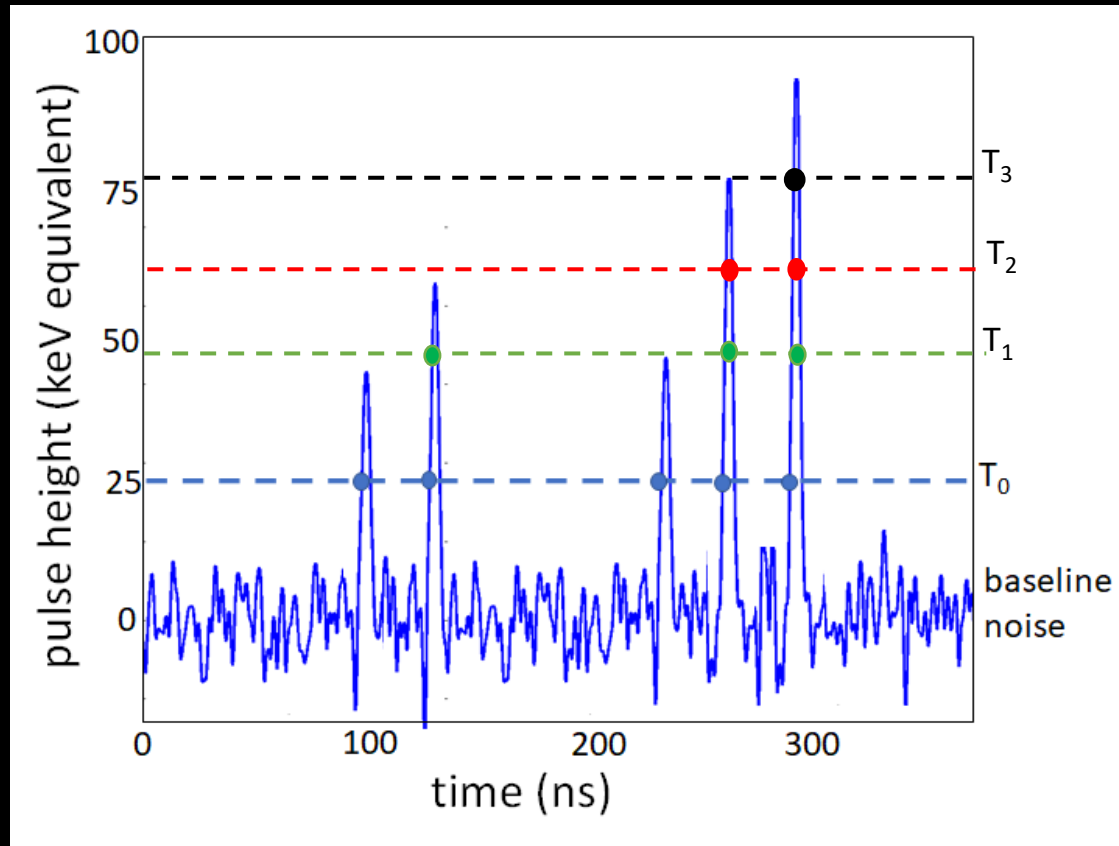
Operation principle – Photon-counting CT detectors



- **Semiconductor**
as direct X-ray converter (cadmium telluride)
- Photoelectron creates **electron hole pairs**
- Number of pairs proportional to X-ray energy (100keV photon \rightarrow 3.64fC)
- Electric field causes fast drift of charges toward anode pixels
- Electrons induce short charge pulses when approaching the pixelated anode pads

\rightarrow Each photon is counted separately and measured by its energy level

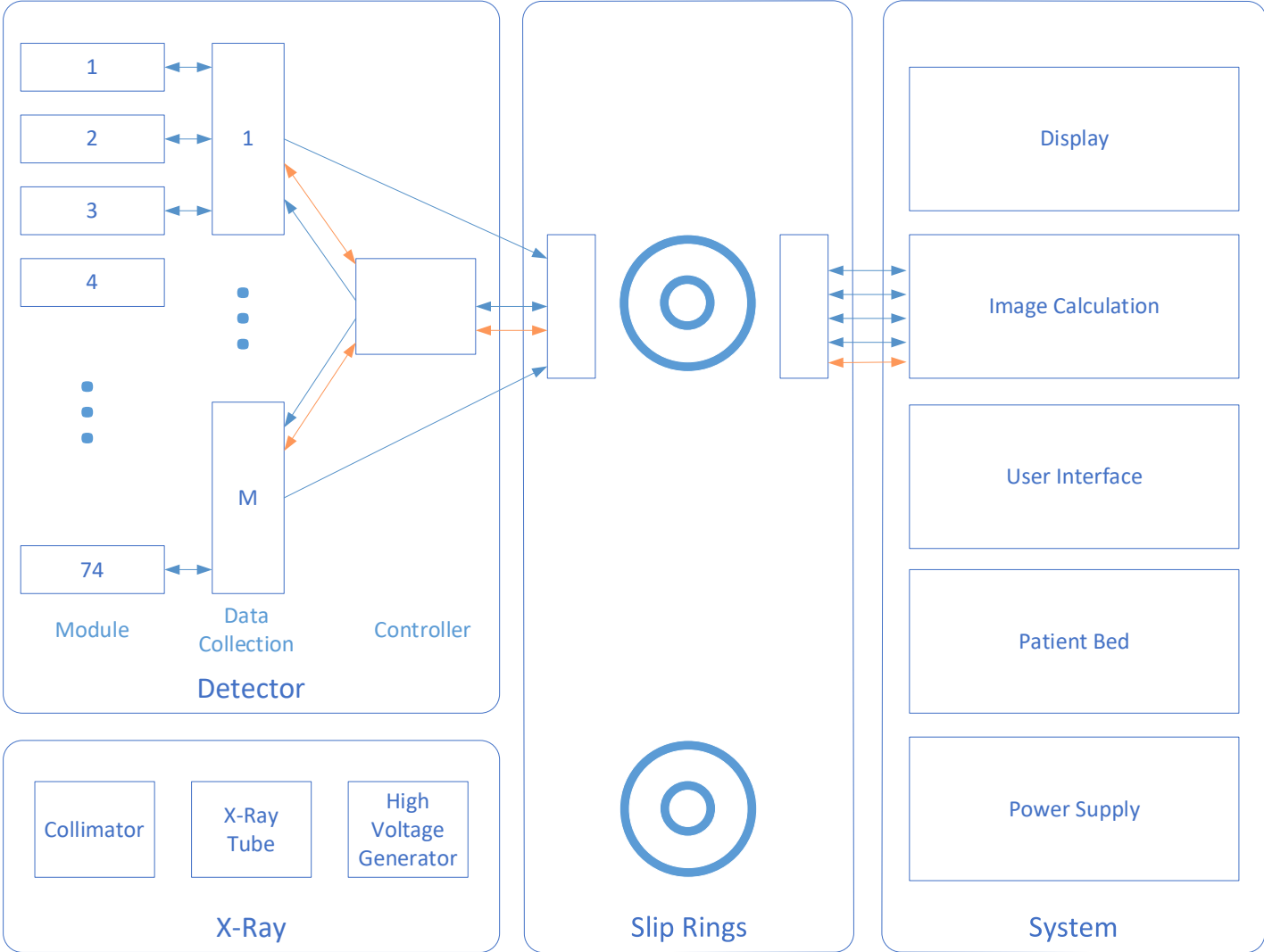
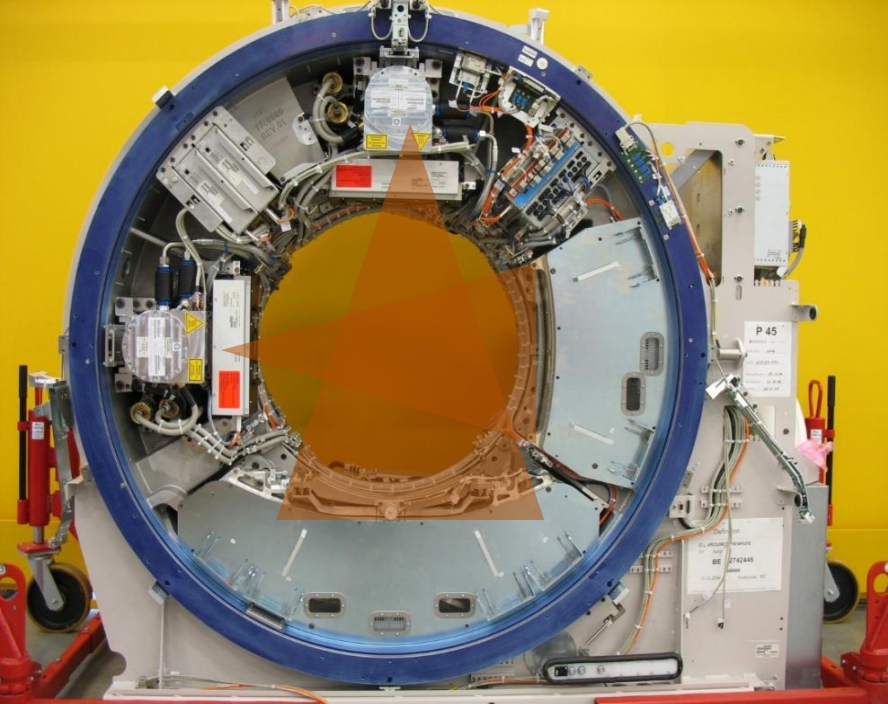
Operation principle – Photon-counting CT detectors



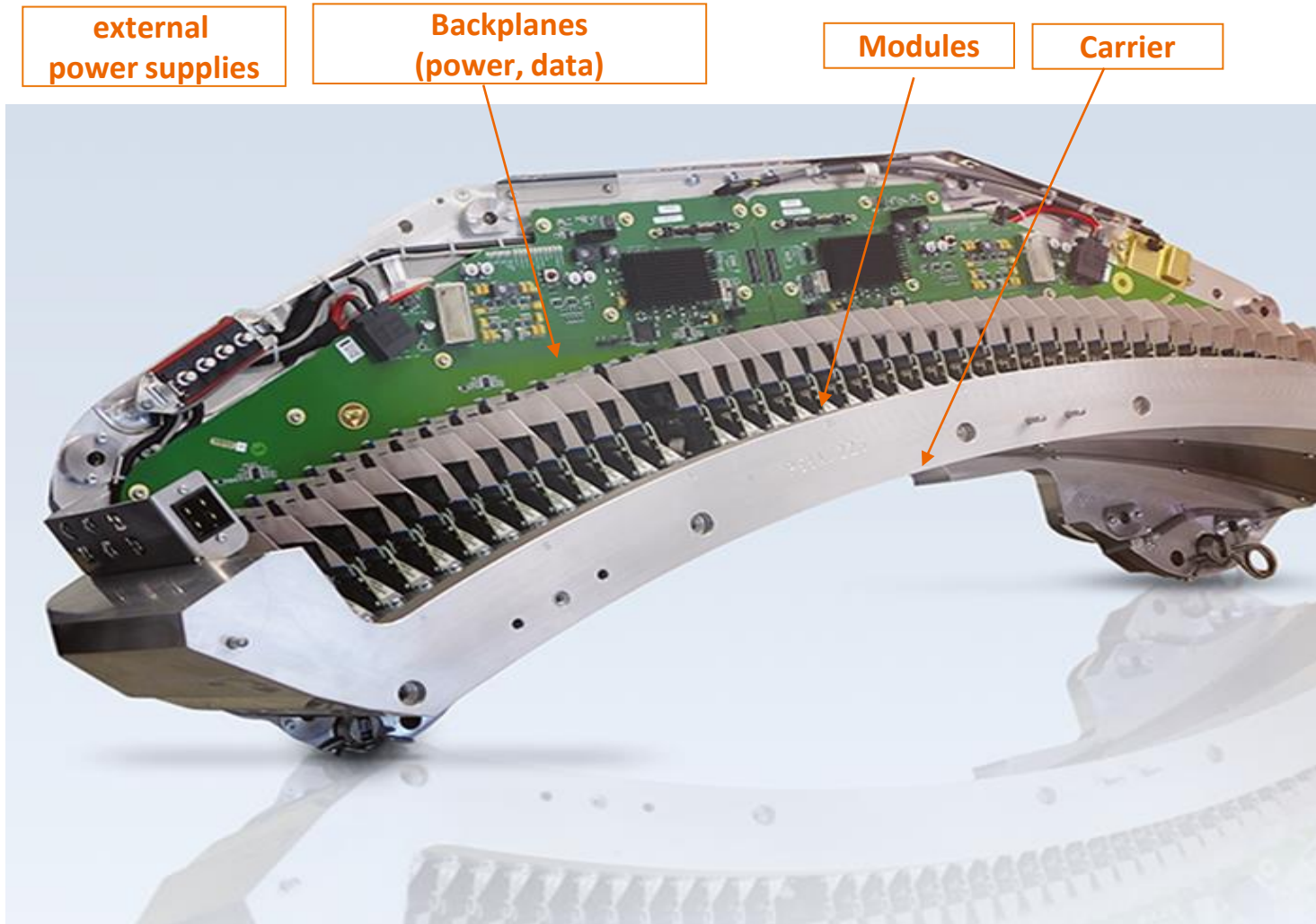
- Charge pulses at ASIC input
- Typ. <10ns duration (~1GHz Bandwidth)
- Input capacitance affects conversion to input voltage
- Electronics noise converts to threshold noise
- Pulses are counted over typ. 100..200 μ s

→ Keeping input capacitance low is key to low noise

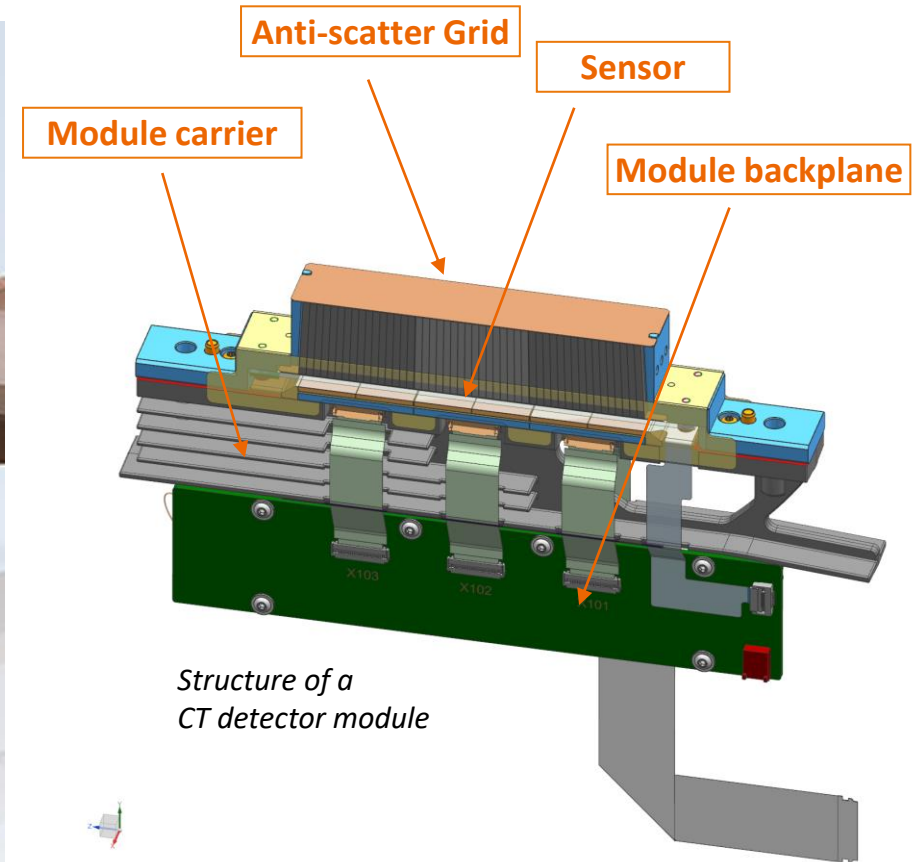
Inside NAEOTOM Alpha



Inside NAEOTOM Alpha The Detector



Structure of a CT detector



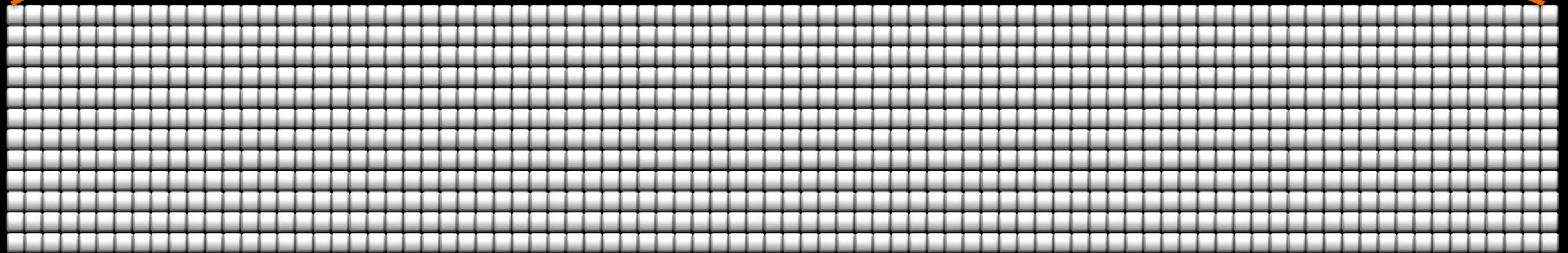
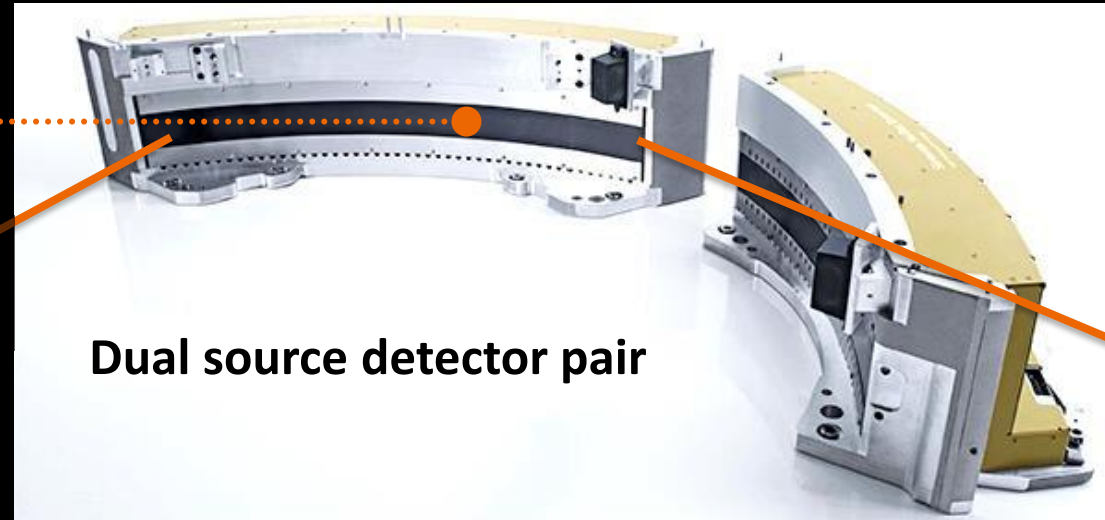
Structure of a
CT detector module

Inside NAEOTOM Alpha

The Detector

X-ray entrance
window

Typical detector area: $90 \times 60 \text{ cm}^2$
Realistic die size: 1 cm^2

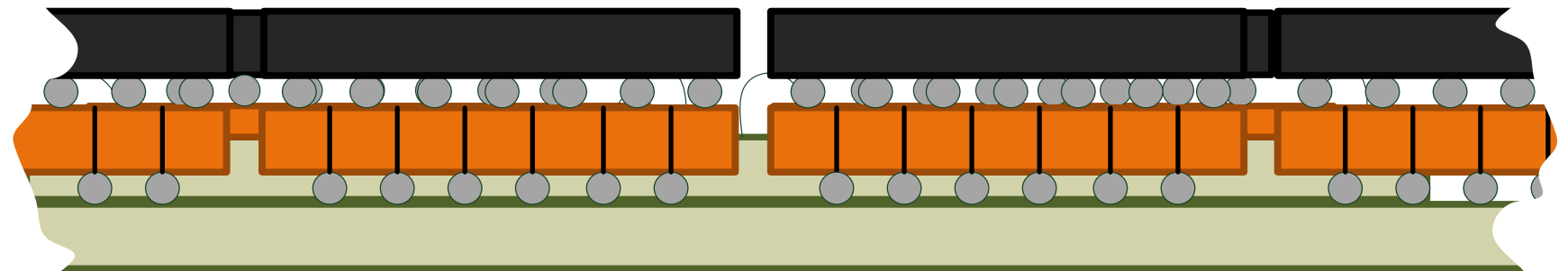
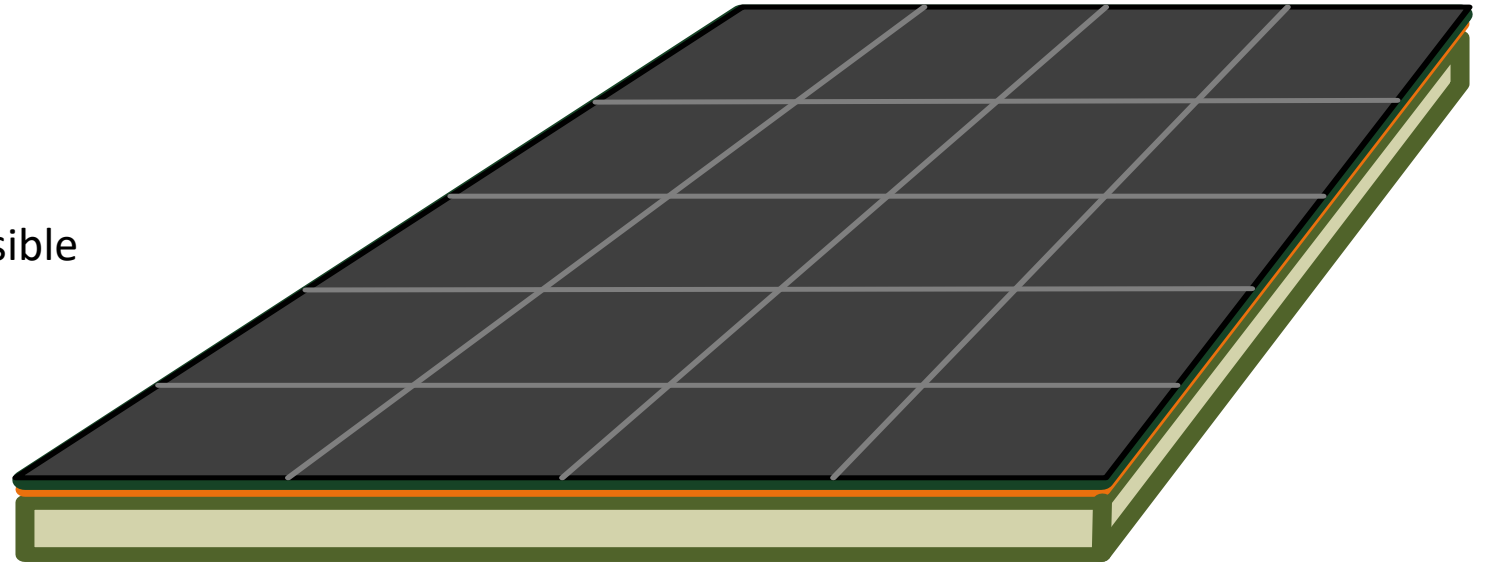


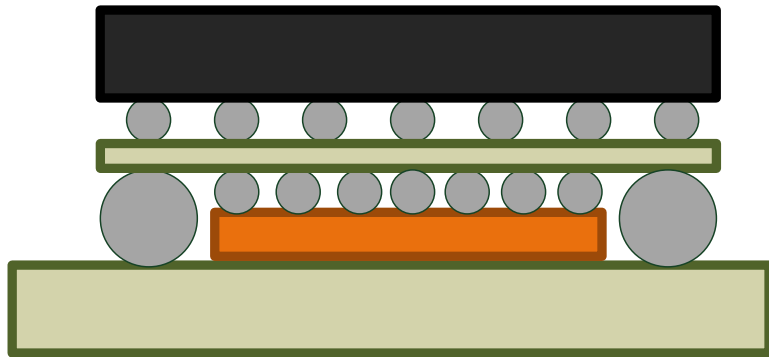
ASIC die tiling requires four-side buttable assembly

Inside NAEOTOM Alpha

The Detector

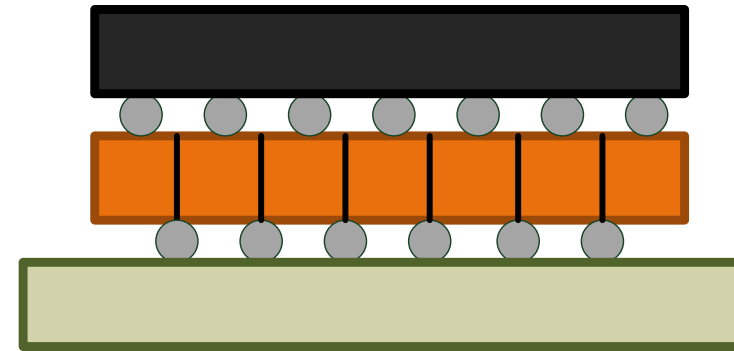
- Detect almost all radiation!
-> As few and narrow dead spaces as possible
- Make components four-side buttable
-> Enable efficient mass production





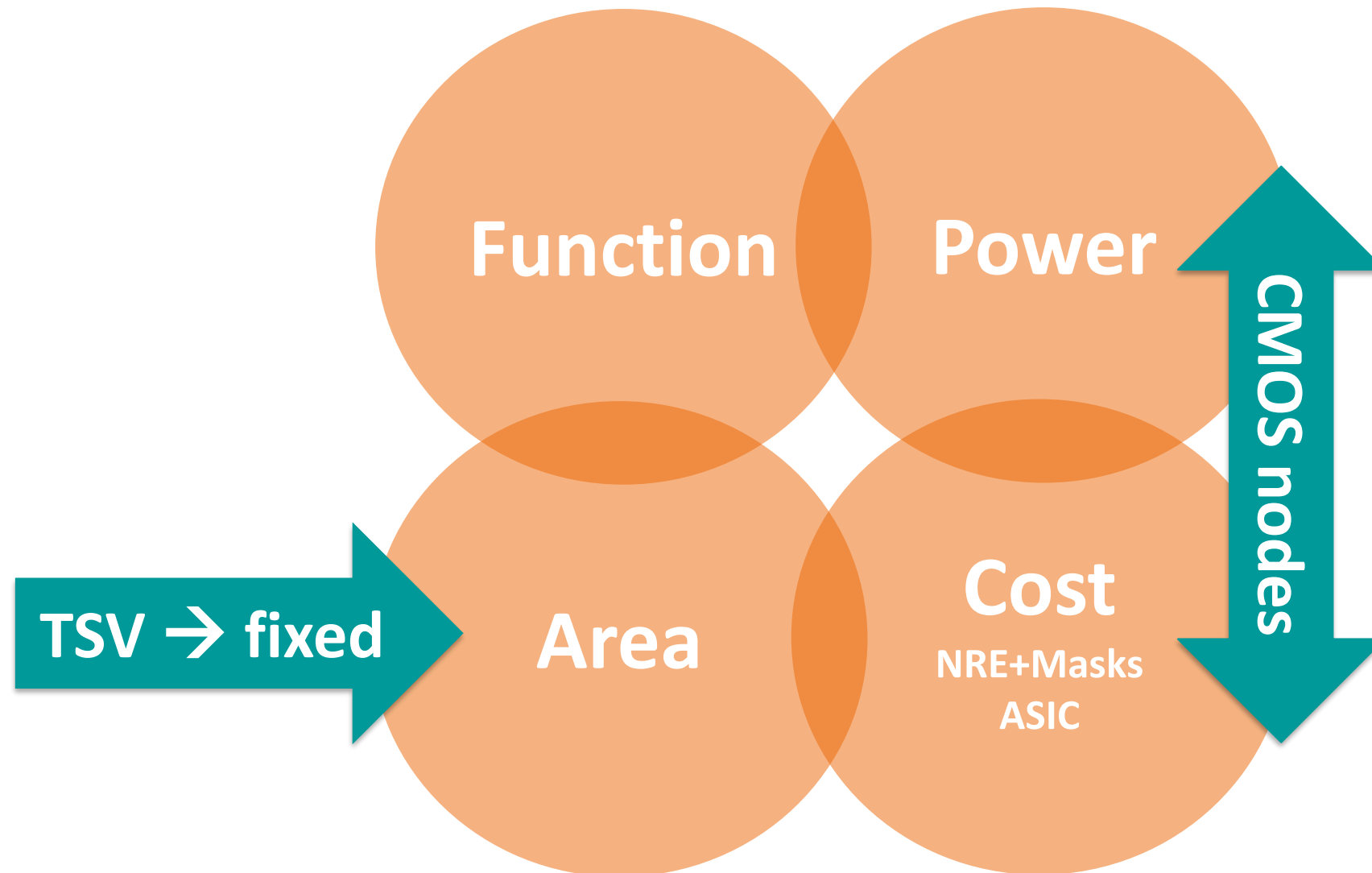
Interposer between Sensor and ASIC

- **Geometry uncoupled**
Smaller ASIC die than sensor
Flexible pixel geometry
- **Parasitic capacitance**
Noise
Cross-coupling
Regular patterns

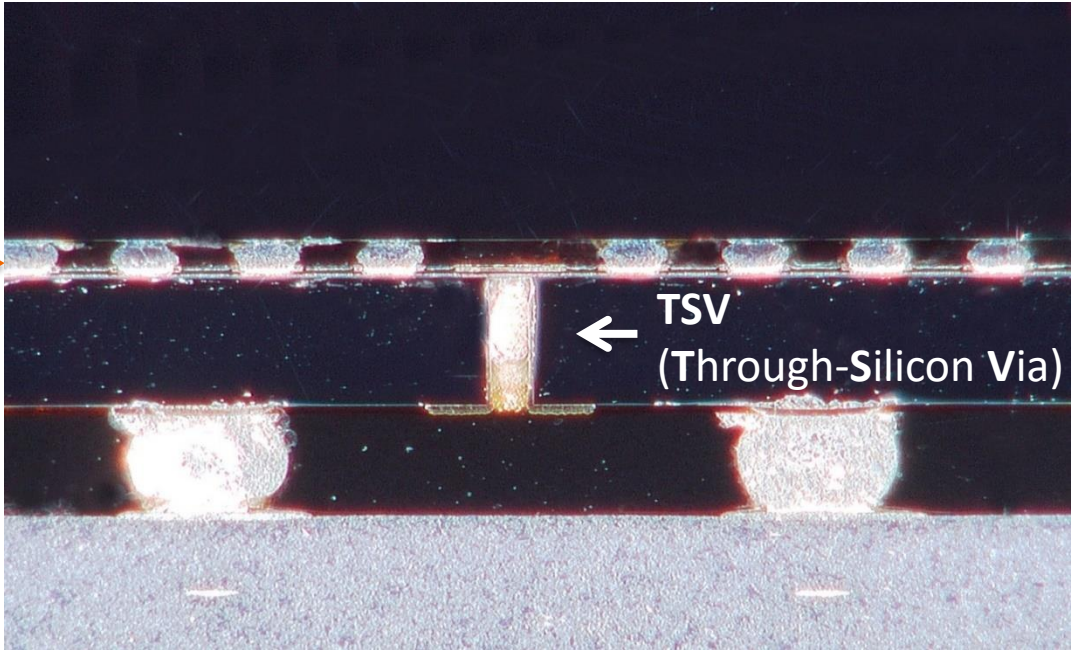
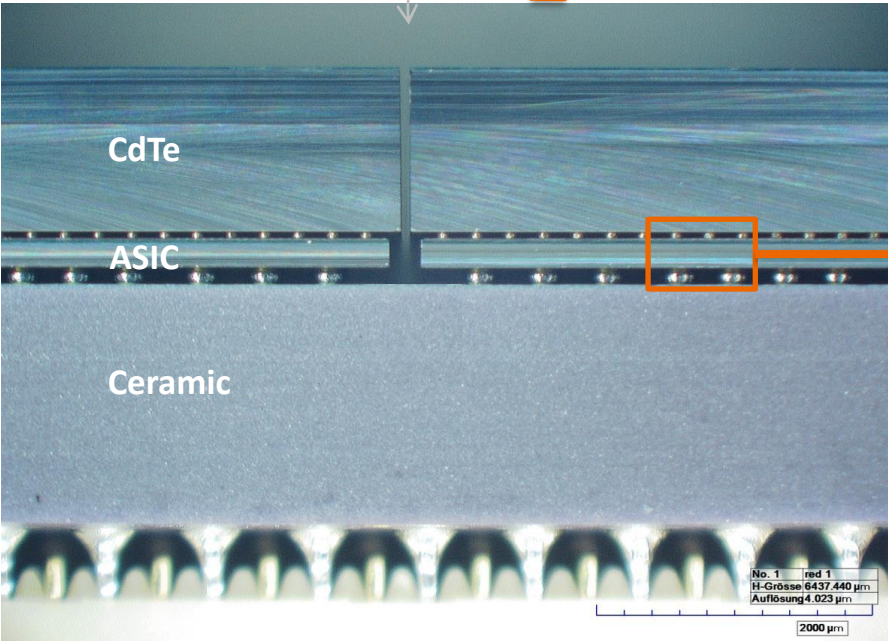
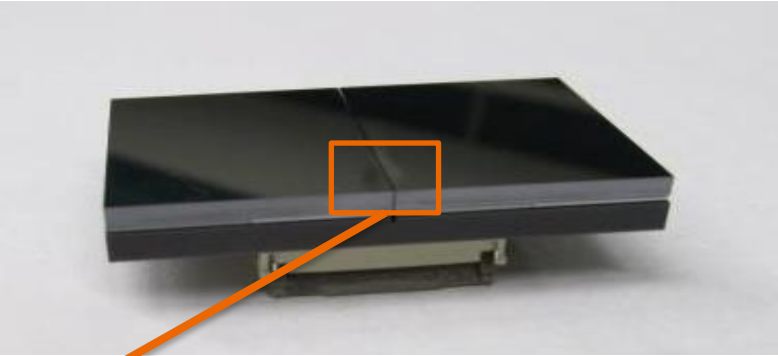


Through-Silicon Vias in ASIC

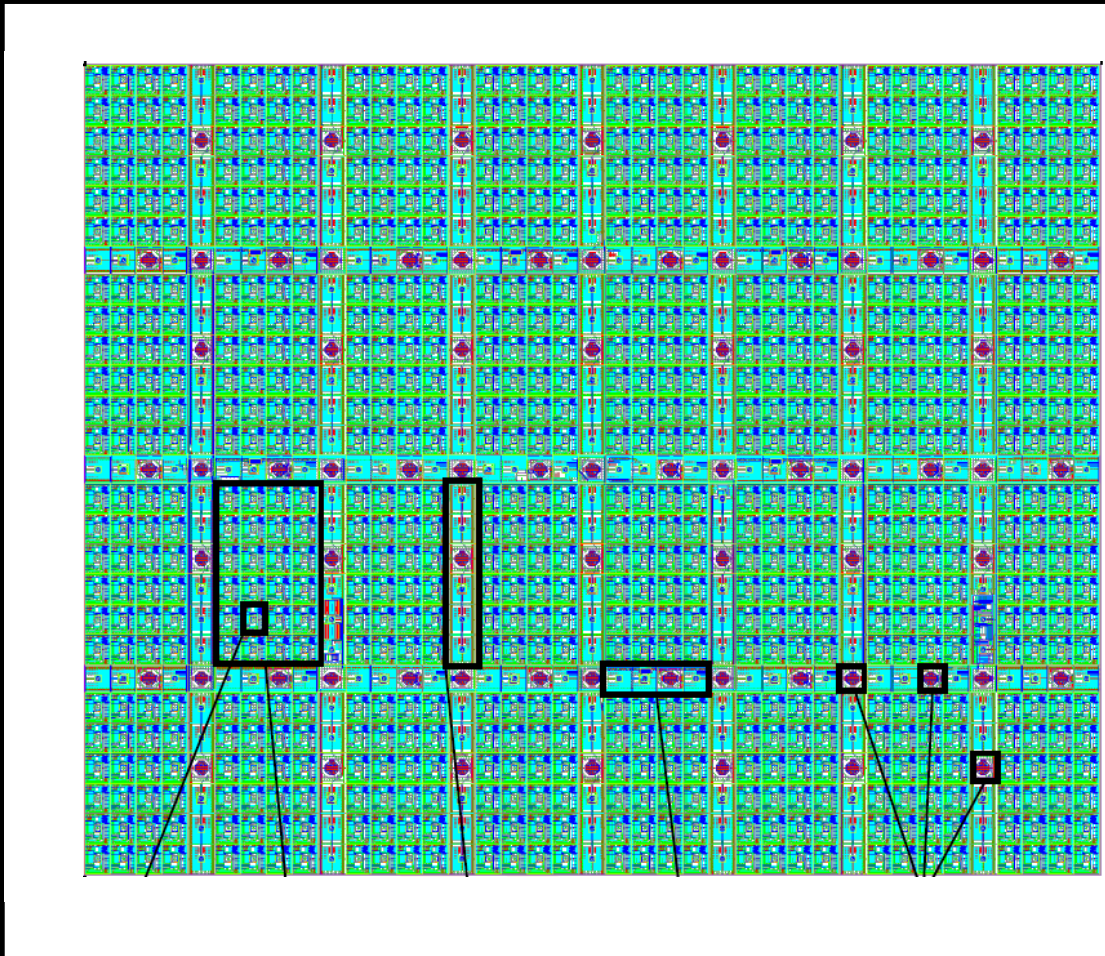
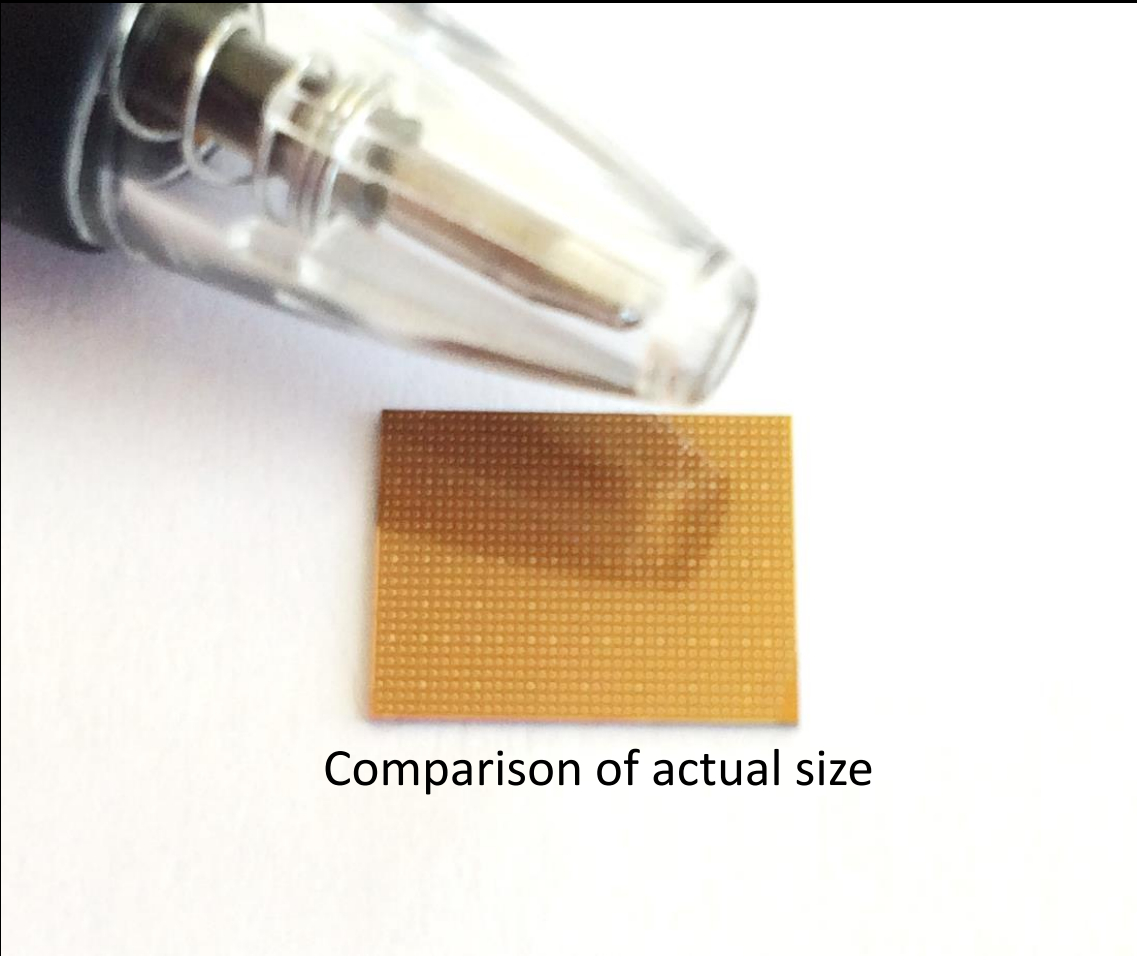
- **ASIC geometry determined by sensor**
Costly re-designs
- **Shortest possible connection between sensor and ASIC**
Lowest noise
No cross-coupling



Inside NAEOTOM Alpha – ASIC & Sensor Integration



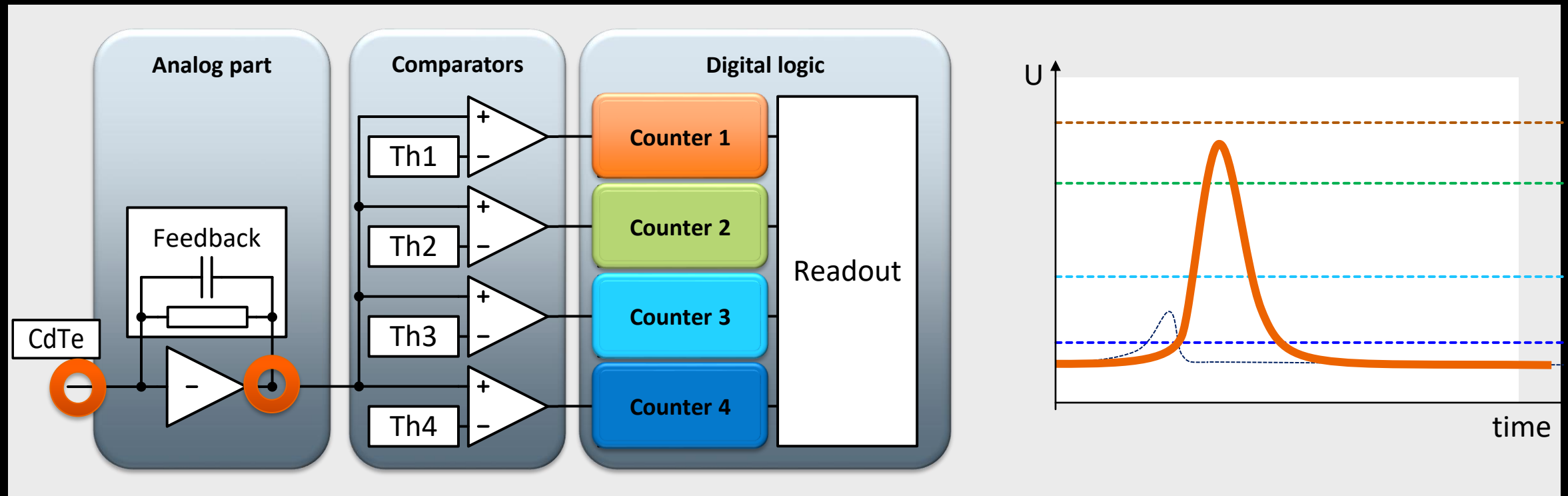
Inside NAEOTOM Alpha MC3 ASIC



Inside NAEOTOM Alpha MC3 ASIC

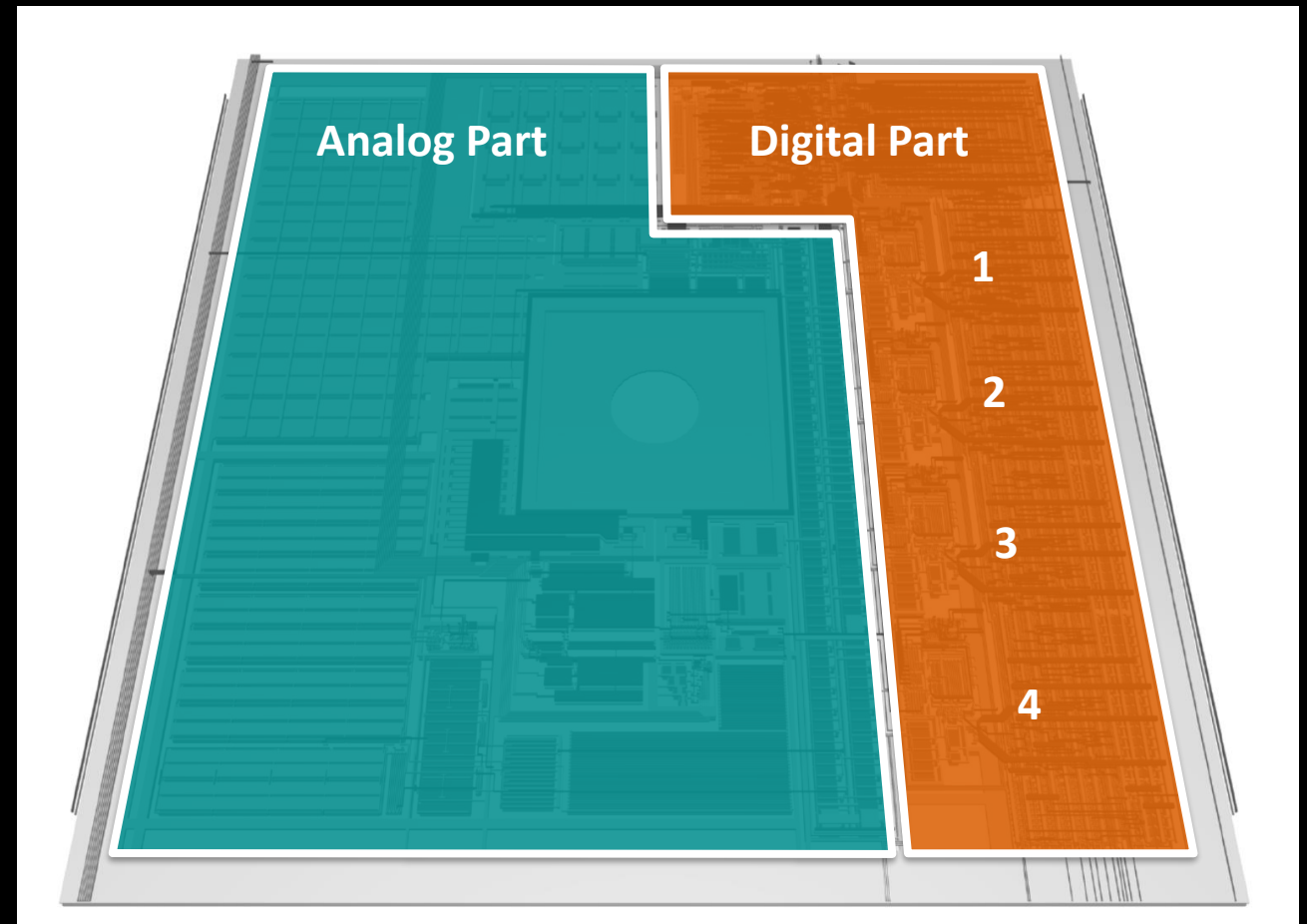
charge signal

(spectral) count rate

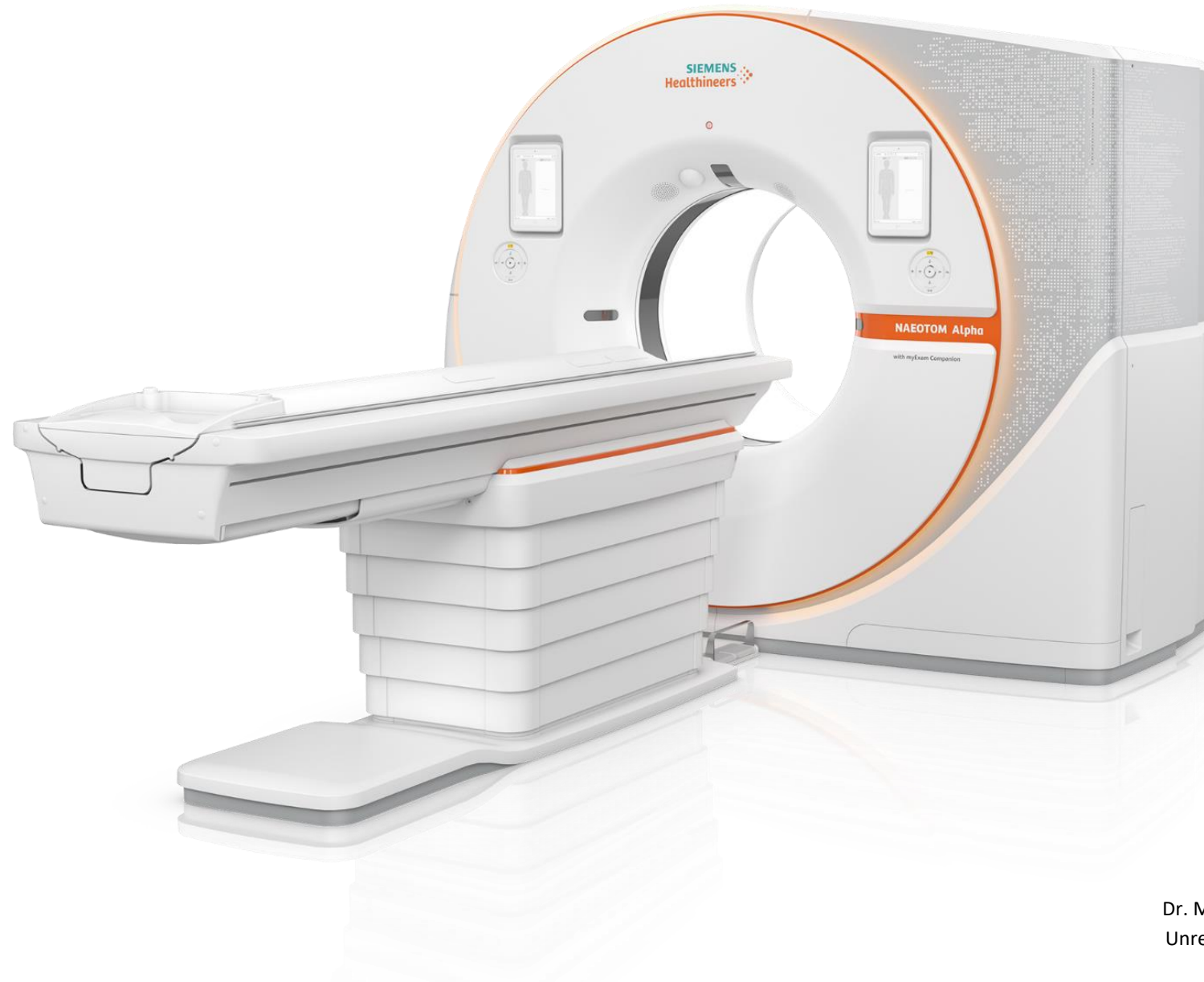


Inside NAEOTOM Alpha MC3 ASIC

Die size:	89 mm ² (~10 * 9 mm)
Pixel matrix:	32 x 24
Thresholds:	4
Counter depth:	16 bit
Readout speed:	300 Mbit/s <200 μs per full frame
Threshold range:	0 - 195 keV
Pulse width:	12.5 ns (FWHM)
Counter type:	non paralyzable



Thank You!



Thank you for your enthusiasm!

Dr. Michael Hosemann

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