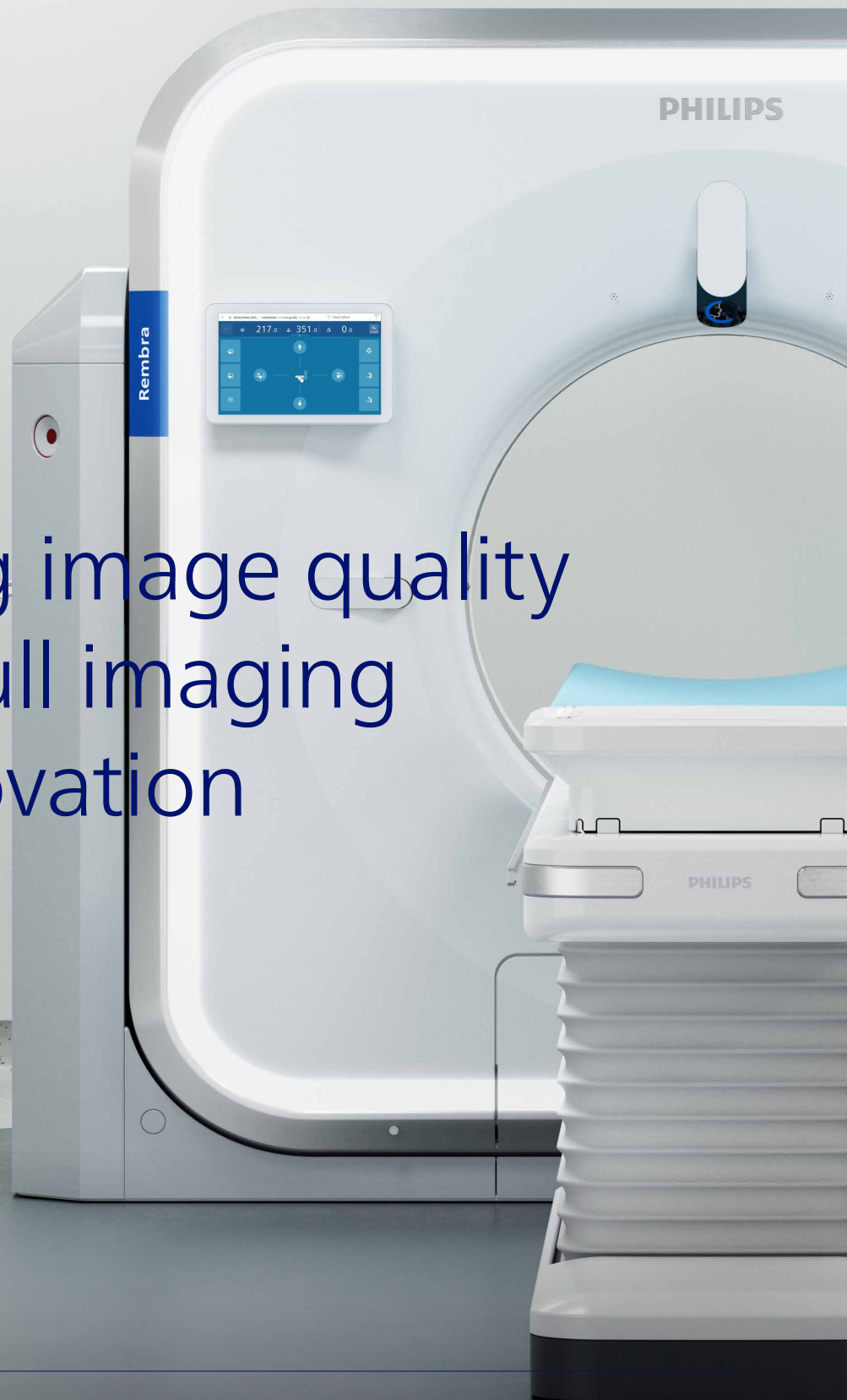


Advancing image quality through full imaging chain innovation

Rembra

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Executive summary

CT imaging has traditionally required trade-offs between spatial resolution and radiation dose. Achieving finer anatomical detail often relies on sharper reconstruction kernels or comb filter activation, approaches that can increase image noise and/or require higher radiation dose exposure.

Rembra addresses this challenge through a coordinated redesign of the CT imaging chain. Rather than relying on detector aperture restriction (e.g., comb filter activation, which partially masks the detector elements), the system integrates advances in scatter rejection, smaller detector elements and reconstruction filtering to improve signal capture and recovery.

The Rembra platform introduces:

- **High-resolution (XD) detector pixels** with a 32% reduction in pixel area compared to the previous generation, increasing native sampling frequency and intrinsic spatial resolution
- **2D anti-scatter grid (ASG)**, established in the Philips premium CT platforms, improving signal purity and contrast stability by reducing in-plane and out-of-plane scatter
- **Matched high-resolution reconstruction filters** optimized for the XD detector architecture to recover high-frequency detail while maintaining controlled noise behavior

Compared to previous-generation CT systems, all new elements combined resulted in an improvement in spatial resolution (task-transfer-function or TTF50%) of up to 127% at equal radiation dose.

By aligning detector physics with reconstruction design, Rembra advances high-resolution CT while maintaining dose-conscious performance, including demonstrated dose neutrality between 85 cm and 72 cm bore configurations under matched clinical protocol conditions.

In standard clinical modes, Rembra is complemented by AI-based reconstruction (Precise Image*), enabling improved contrast-to-noise (CNR) performance while preserving familiar image appearance.

High spatial resolution is clinically relevant in tasks requiring precise anatomical delineation, while contrast stability and controlled noise are essential for routine diagnostic confidence and therapy planning workflows. The Rembra platform addresses both high-frequency detail and CNR performance within a unified detector architecture, while maintaining dose neutrality across bore configurations. This architecture is implemented across the Rembra and Areta CT platforms, including radiology and radiation therapy (RT) system configurations, supporting consistent imaging performance across clinical applications.



Rembra imaging chain: enabling high-resolution imaging through system integration

The imaging-chain innovations described here form the technical foundation of the Rembra and Areta platforms, including configurations designed for both radiology and RT workflows.

Conventional approaches to improving spatial resolution often rely on reducing effective detector element size by means of a comb filter or applying increasingly sharp reconstruction kernels. While these strategies increase spatial resolution, they do so by

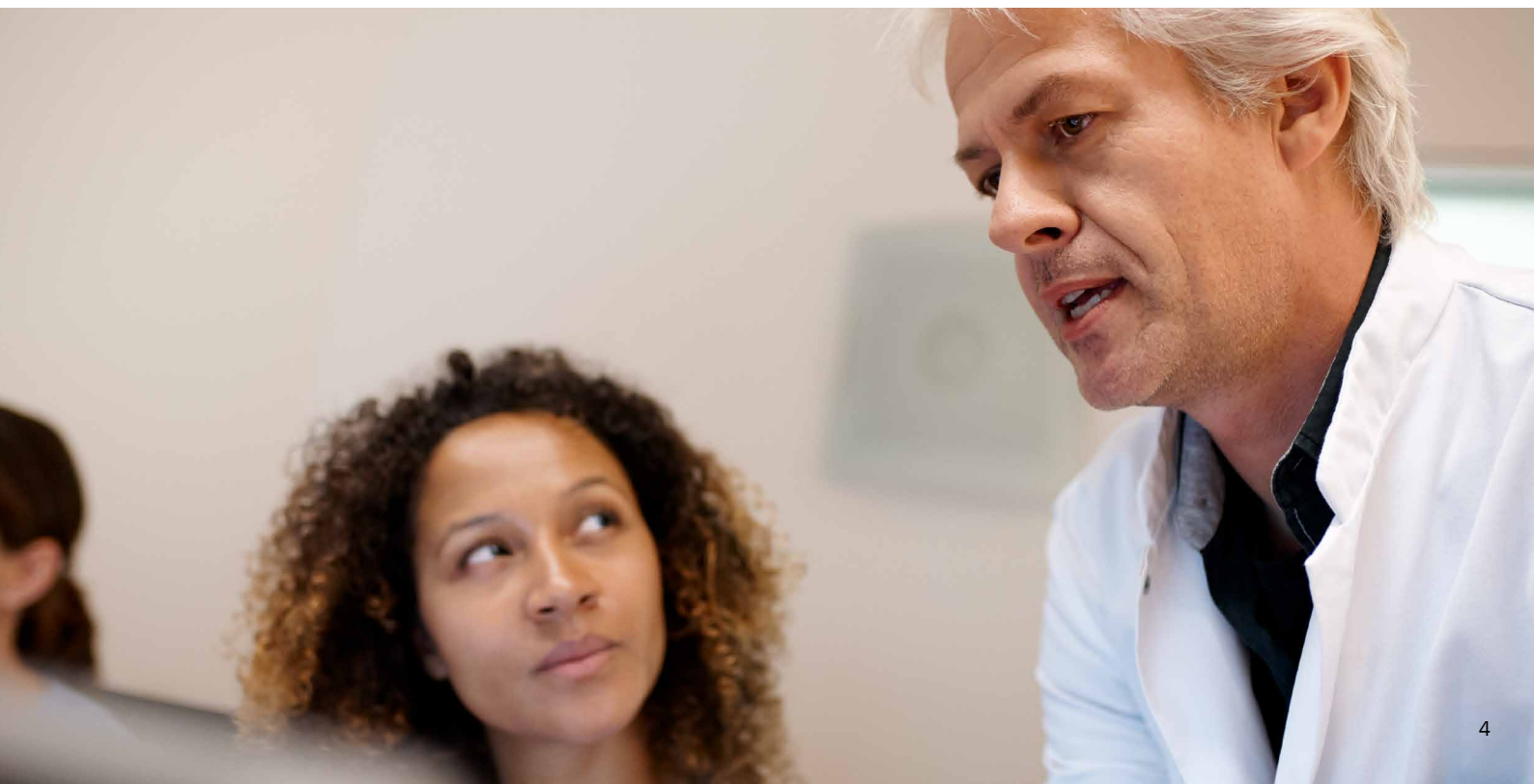
reducing photon efficiency or amplifying high-frequency noise, thereby increasing radiation dose.

Rembra approaches high-resolution imaging differently. Rather than masking detector elements to reduce their size, the system improves how signal is captured, preserved and recovered across the imaging chain. Three coordinated design elements support this strategy.

1. Higher native sampling: high-resolution detector pixels

Spatial resolution in CT is strongly influenced by detector element size. One approach to increase spatial sampling during high-resolution acquisitions is the use of a comb filter. In this mode, part of the detector is physically blocked to increase spatial sampling. While this improves nominal resolution, it also reduces the number of photons reaching the detector. Smaller detector elements, by contrast, increase sampling without blocking photons, preserving efficiency.

The XD detector architecture implemented in Rembra features a 32% reduction in detector pixel area compared to the previous generation, increasing native sampling density while preserving photon efficiency. In this way, resolution is derived from true sampling improvements rather than geometric aperture reduction, meaning high-resolution imaging can be achieved without the photon-efficiency penalty associated with comb filters.



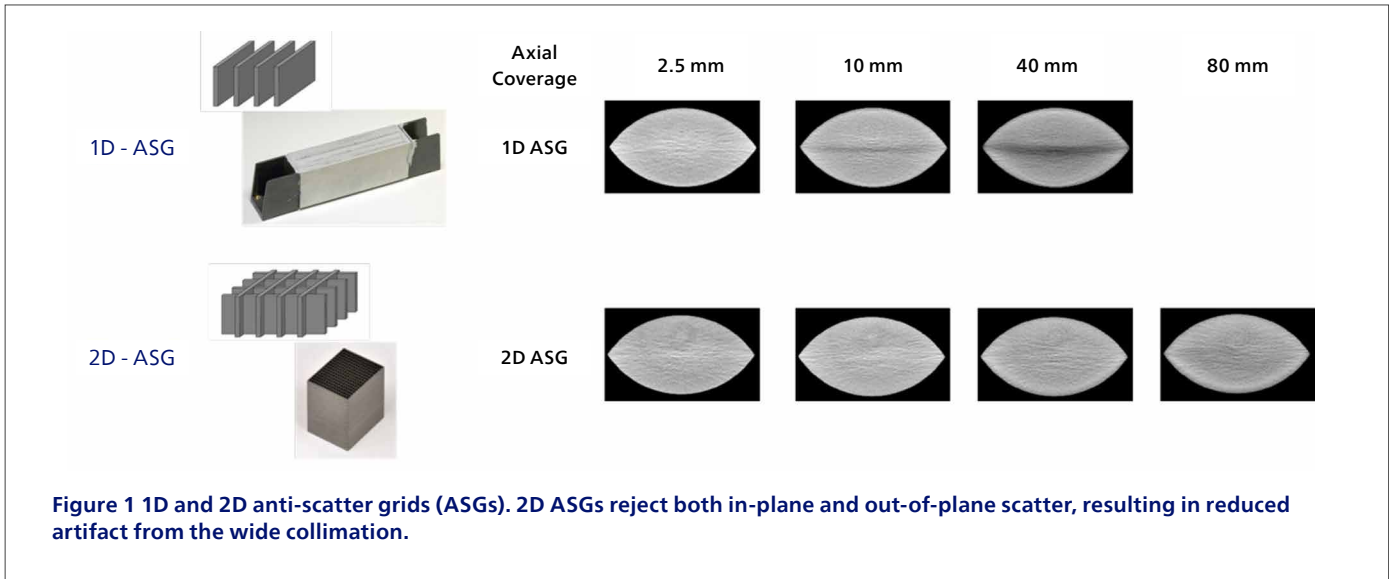
2. Cleaner signal: 2D anti-scatter grid (ASG)

In CT, scatter radiation degrades CT images by introducing low-frequency signal contamination that reduces contrast stability and contributes to shading artifacts. In wide-collimation systems and larger patients, scatter becomes increasingly significant, limiting the effective visibility of fine structures.

Rembra incorporates the two-dimensional anti-scatter grid (2D ASG) technology established in the Philips premium CT platforms, now implemented within the Rembra system architecture (**Figure 1**).

The 2D ASG rejects both in-plane and out-of-plane scatter components before they reach the detector, improving primary-to-scatter ratio and enhancing signal purity.

By reducing scatter at the acquisition stage, the system stabilizes contrast representation and supports consistent image quality across patient sizes. Cleaner projection data provide a stronger foundation for subsequent high-frequency recovery during reconstruction.



3. Matched high-frequency recovery: reconstruction filters tuned to detector physics

High-resolution detectors require reconstruction filters that are specifically tuned to their sampling properties. Applying legacy kernels to smaller detector element data might not make use of the high-resolution data to the fullest extent.

Rembra introduces a family of high-resolution reconstruction filters designed specifically for the XD detector architecture. These filters are optimized to recover high-frequency information captured by the novel detector while maintaining controlled noise behavior.

By aligning reconstruction design with detector physics, the system avoids the common pattern of increasing sharpness at the expense of noise amplification (**Figure 2**).

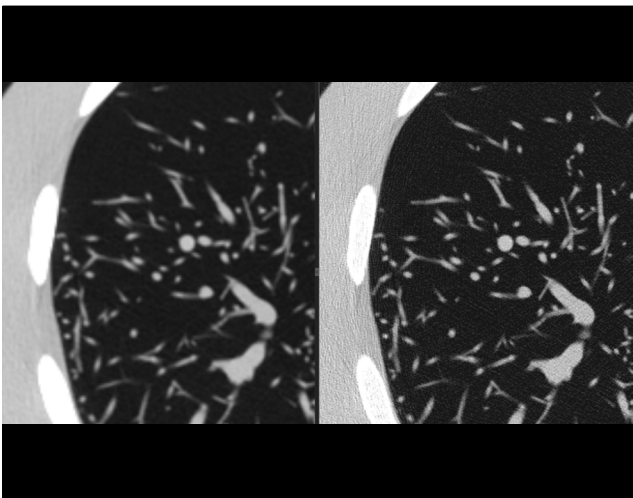


Figure 2 Example of the improved spatial resolution between the standard filter and 512 matrix (left) and a new high-resolution filter and 1024 matrix (right).

Integrated effect: resolution without aperture penalty

Taken together, these three elements (reduced detector element size, 2D scatter reduction and matched high-resolution reconstruction filters) provide an improved pathway to high spatial resolution. The resulting end-to-end system performance is reflected in the spatial frequency specifications shown in **Table 1**.

The following sections present quantitative phantom data alongside clinical image examples, demonstrating how this imaging-chain approach translates into measurable gains in spatial resolution and resolution efficiency.

Line pair/cm	MTF50%	MTF10%	MTF0%
SD Detector	5.5	10.2	16.2
XD Detector	10.6	17.8	23.1

Table 1 System spatial frequency specifications for standard detector (SD) and high-resolution detector (XD) configurations. MTF50%, MTF10%, and MTF0% values (line pairs/cm) reflect end-to-end detector and reconstruction performance.

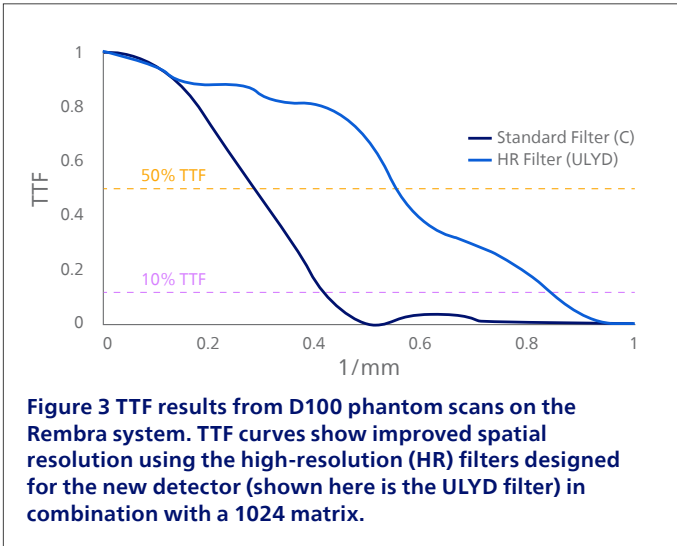
Quantitative validation: resolution efficiency in practice

Traditionally, CT resolution is described using the modulation-transfer-function (MTF). For Rembra, a clear improvement in terms of the MTF is indicated, with an improvement from 16 line-pairs per centimeter (lp/cm) for the previous-generation CT system, to a theoretical sampling limit of 23 lp/cm (0% MTF) and measured spatial resolution of 21.1 lp/cm at 2% MTF for Rembra.

However, the MTF does not describe the clinical resolution seen under clinical conditions, such as routine radiation dose, standard clinical field-of-view, clinical contrasts, etc. For this, the task-transfer-function (TTF) has been introduced.¹ The TTF provides a clinically meaningful measure of spatial resolution performance beyond simple line-pair specifications. Importantly, TTF can be evaluated alongside image noise to assess resolution efficiency rather than peak resolution alone.

To assess the TTF of Rembra, an anthropomorphic chest phantom (QRM Chest, QRM) was scanned using a routine clinical HR chest protocol. At the center of the chest phantom, an insert with a calcium hydroxyapatite calibration disk (diameter 3.0 cm, density 540 mg/mL) in a solid water background was positioned. The edge of the calibration disk was subsequently used to assess the system resolution by means of the TTF, as previously described.²

Measured results show 50% TTF (TTF50%) improvements of up to 127% and 10% TTF (TTF10%) improvements of up to 107% relative to when comparing high definition mode (1024 matrix with high-resolution reconstruction filter) to standard reconstruction (512 matrix with standard filter) on the same platform (**Figure 3**). These gains reflect increased native detector sampling combined with reconstruction filters specifically tuned to the XD detector architecture.



The measured improvements in spatial frequency transfer translate directly into improved depiction of fine anatomical structures. **Figure 4** provides a clinical illustration of this relationship, comparing a standard detector system with the XD detector architecture.

The enhanced visualization of small osseous structures in the inner ear reflects the increased native sampling density and matched reconstruction filtering demonstrated quantitatively in the TTF analysis.

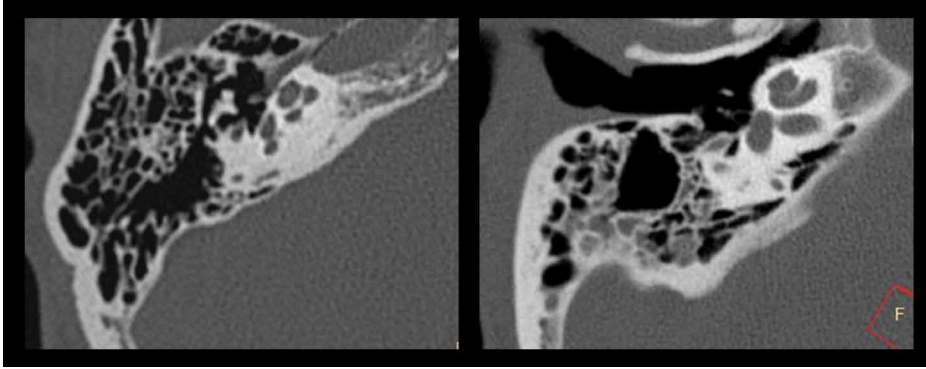


Figure 4 Example of the improved spatial resolution between the CT 5300 system (left) and the Rembra system (right). The enhanced depiction of fine osseous structures reflects increased native detector sampling and matched high-resolution reconstruction filtering.

Resolution efficiency at matched dose

To evaluate resolution efficiency, phantom acquisitions were performed on Rembra and a conventional detector architecture

(Philips iCT) operating in comb filter mode under matched tube potential and CTDIvol settings.

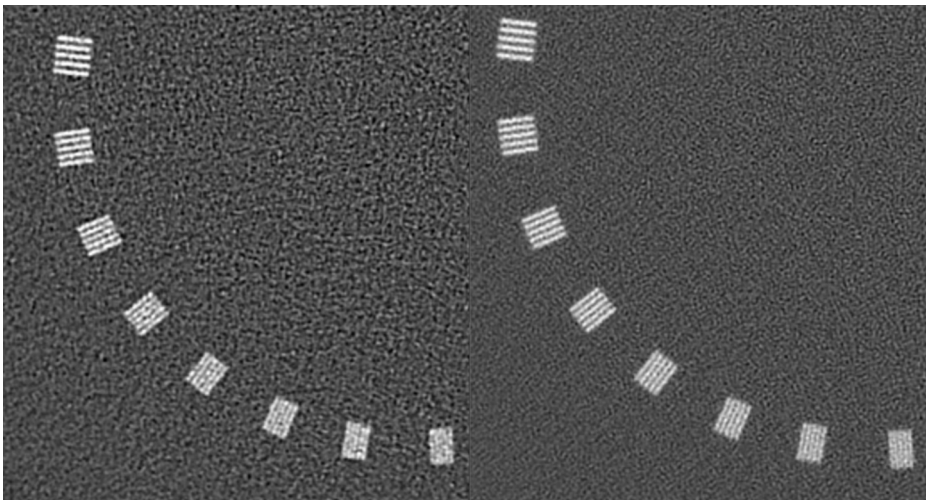


Figure 5 Images of the Catphan high resolution module from a system with a comb filter (left) and the Rembra system (right) at matched dose levels. By using smaller detector pixels rather than comb filter activation, Rembra is able to achieve higher detail and reduced noise at equivalent dose.

Spatial resolution (as assessed by MTF metrics) and noise magnitude were evaluated using dose-matched protocols.

At matched CTDIvol, Rembra demonstrated improvements in spatial resolution and lower noise (**Figure 5**). Increases of up to 26% and 56% in MTF50 and MTF10, respectively, relative to the comb filter system were achieved, confirming that high-frequency detail is achieved without detector aperture reduction. Furthermore, noise magnitude at matched dose was reduced

by up to 31% on the Rembra system compared to the comb filter system, supporting improved resolution efficiency without requiring photon-restrictive geometry.

Spatial resolution performance was interpreted in conjunction with noise behavior rather than peak I_p/cm values alone. By evaluating TTF and noise together, resolution efficiency is assessed as the spatial frequency response achievable at clinically usable noise levels and radiation dose.

Clinical comparison with comb filter architecture

The quantitative findings are supported by visual comparison under matched acquisition conditions. **Figure 6** illustrates high-resolution

imaging obtained using comb filter activation compared with Rembra high definition mode under matched acquisition conditions.

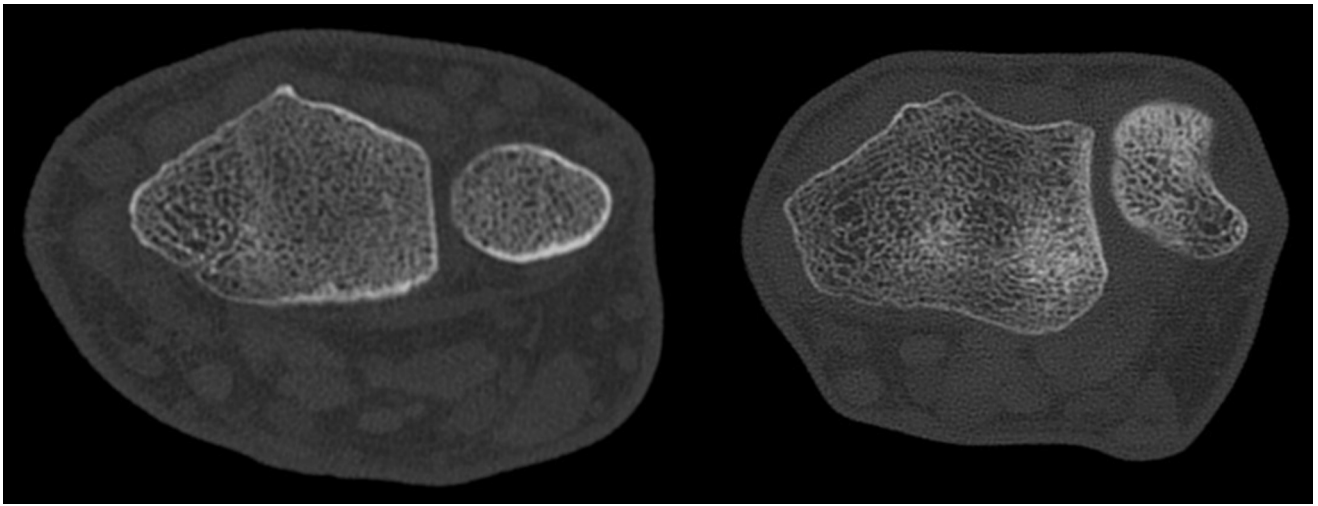


Figure 6 Images from a system with a comb filter (left) and the Rembra system (right). Images illustrate high-resolution visualization achieved without comb filter activation.

Despite the absence of aperture reduction, Rembra demonstrates comparable depiction of fine anatomical structures. This supports the quantitative findings that high-resolution performance is achieved through enhanced detector sampling rather than geometric photon restriction.

These results confirm that spatial resolution improvements are driven by increased native sampling density and matched reconstruction filtering, supporting resolution efficiency without requiring comb filter activation.

Contrast performance with AI-based reconstruction

Complementary to high-frequency spatial resolution performance, clinically meaningful image quality depends equally on contrast-to-noise behavior in routine imaging conditions. Beyond its XD detector architecture, Rembra integrates AI-based reconstruction (Precise Image*) to enhance contrast, supporting dose-conscious workflows in standard acquisition modes without altering detector sampling characteristics.

Catphan phantom analysis demonstrated up to a 269% increase in CNR, calculated between the acrylic insert and water-equivalent background, up to a 239% increase in low-contrast detectability

(LCD), assessed using the low-contrast insert CNR relative to background, and up to a 69% reduction in noise magnitude measured as the standard deviation of HU values in the uniformity module, relative to filtered back projection (FBP) under matched acquisition conditions (**Figure 7**).

These results demonstrate that AI-based reconstruction enhances contrast performance through reconstruction-stage noise reduction rather than changes in detector sampling or acquisition parameters.

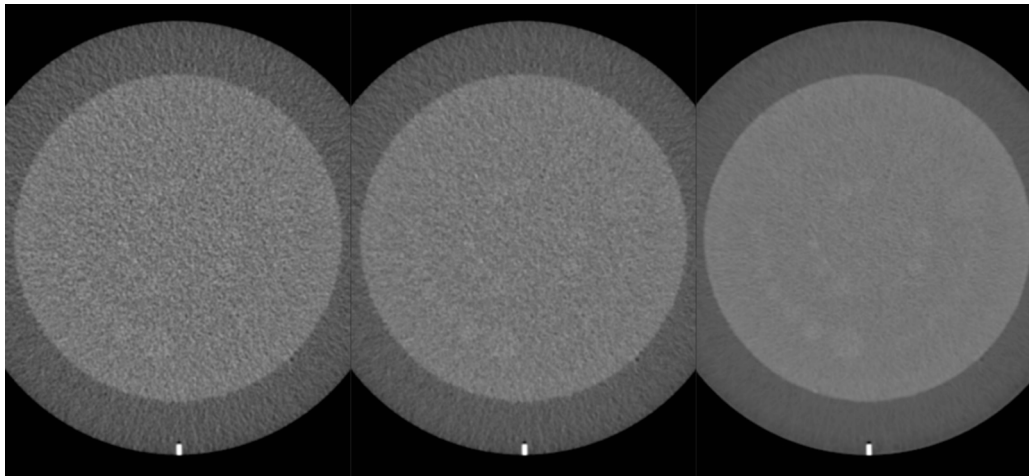


Figure 7 Images of the low-contrast module of the Catphan Phantom reconstructed with filtered back-projection (left), iDose (middle) and Precise Image* (right). Rembra achieves improved low contrast detectability by implementing Precise Image* to reduce noise, thereby improving the contrast-to-noise ratio.

The clinical relevance of these quantitative findings is illustrated in **Figure 8**, which compares brain images reconstructed using iDose and Precise Image* under matched acquisition settings.

Importantly, this contrast optimization is complementary to the high-resolution capabilities of the XD detector architecture. While high definition mode prioritizes spatial resolution through increased sampling density, AI-based reconstruction enhances low-contrast visibility and dose optimization in routine acquisition modes.

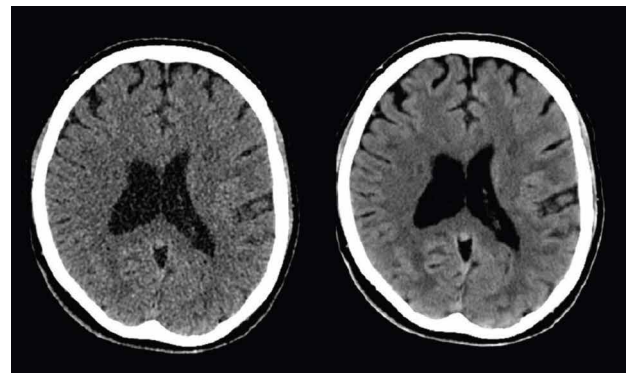


Figure 8 Example of the image quality with iDose (left) and Precise Image* (right) reconstructions. The improved contrast with lower noise is evident in the AI-based (Precise Image*) reconstruction.

Dose neutrality across system geometry

Beyond image quality performance, system geometry must also be considered in dose evaluation. Larger bore platforms are often assumed to require increased radiation output. The following assessment examines dose neutrality between the 85 cm bore Rembra system and a 72 cm Incisive system under matched clinical protocols.

An anthropomorphic Multi-Energy CT phantom (Sun Nuclear), representing a large patient habitus, was scanned on both systems using an identical clinical abdominal protocol. Acquisitions were performed at 120 kVp with automatic tube current modulation set to a Dose Right Index (DRI) of 15, corresponding to a clinically relevant abdominal imaging setting. For each acquisition, mAs and CTDI_{vol} were extracted from DICOM metadata.

CT system	Dose right index (DRI)	Tube current time product (mAs)	CTDI _{vol} (mGy)
Incisive (CT 5100)	15	184	15.0
Rembra CT	15	217	15.0

Table 2 Radiation dose metrics for the two CT systems used--Incisive and Rembra--at identical clinical abdominal protocols

Although the tube current–time product was higher on Rembra (217 mAs) compared to Incisive (184 mAs), the volumetric CT dose index (CTDI_{vol}) was identical at 15.0 mGy on both systems.

The higher mAs on the 85 cm bore system reflects compensation for geometric differences; however, the resulting patient-equivalent radiation dose, as represented by CTDI_{vol}, remained unchanged. These findings demonstrate dose neutrality between the 85 cm

bore Rembra system and 72 cm bore platforms under matched protocol conditions. High-resolution and wide-bore imaging capabilities are therefore achieved without inherent dose escalation.

Maintaining dose neutrality in wide-bore configurations is particularly relevant in workflows requiring patient positioning flexibility, including RT simulation environments.

Key clinical takeaways

The Rembra platform integrates detector sampling, scatter rejection and reconstruction optimization to deliver balanced imaging performance.

- **Resolution efficiency:** Enhanced spatial frequency response achieved without detector-masking or aperture restriction
- **Contrast optimization:** AI-based reconstruction improves contrast-to-noise performance in routine imaging modes
- **Dose neutrality:** Equivalent CTDIvol demonstrated between 85 cm and 72 cm bore configurations under matched protocols
- **Platform consistency:** The high-resolution detector architecture underpins both radiology and RT system configurations

Together, these capabilities support flexible imaging workflows across clinical applications while maintaining dose-conscious operation.

Conclusion

The novel full imaging chain innovation of Rembra addresses traditional challenges of high-resolution CT imaging. Conventionally, high-resolution CT approaches based on comb filters or aggressive kernel sharpening often compromise radiation dose or noise behavior. With Rembra, these challenges have been overcome through coordinated innovation across the imaging chain. Reduced detector element size, enhanced scatter rejection and matched reconstruction filtering now allow for high-resolution imaging.

Evaluated through the framework of resolution efficiency, spatial frequency response achievable at clinically usable noise levels and dose, Rembra delivers balanced, dose-conscious performance.

In combination with AI-based reconstruction for contrast optimization and demonstrated dose neutrality across bore sizes, the system provides a flexible platform for modern CT imaging.

References

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