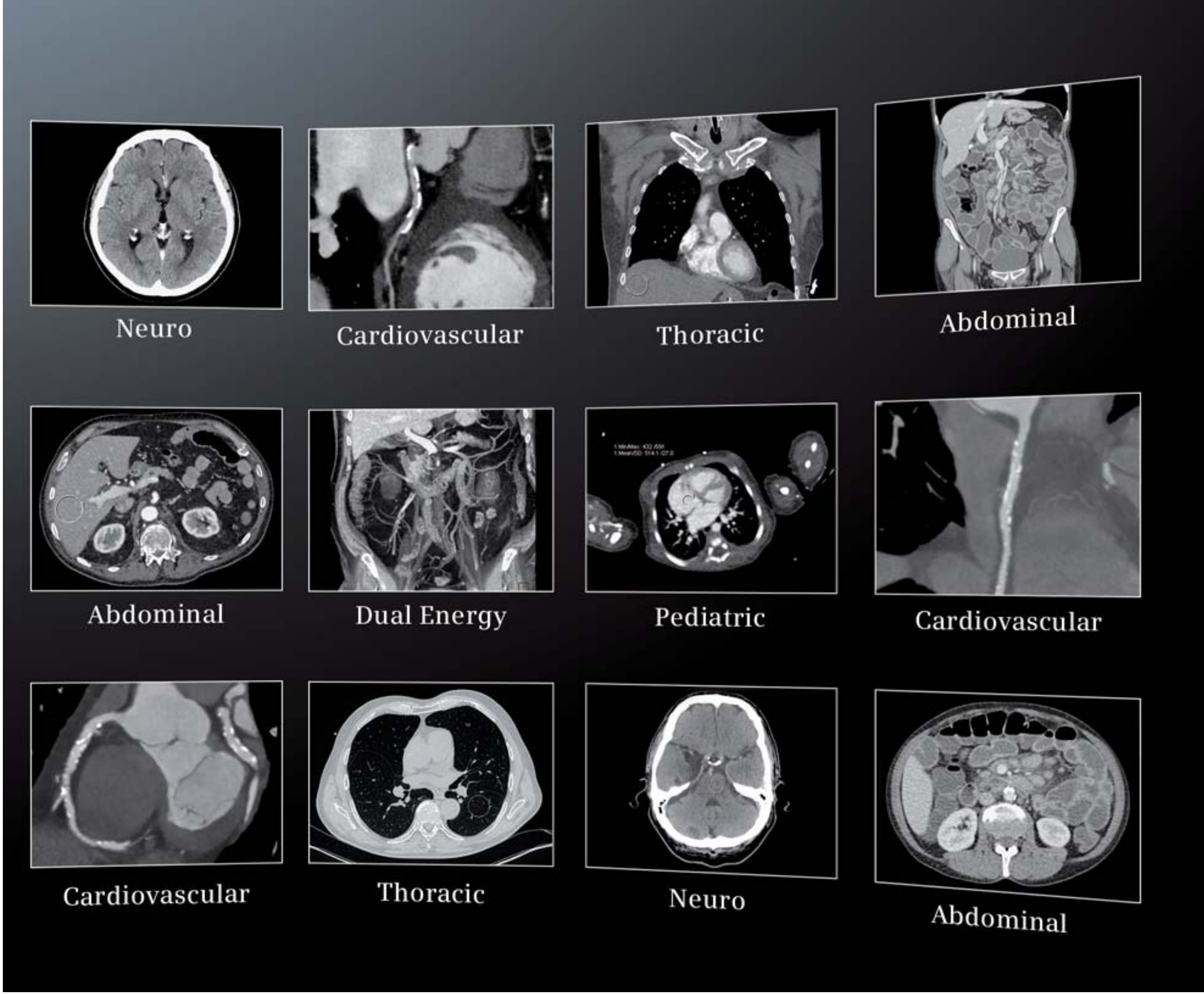


Iterative Reconstruction in Image Space (IRIS) in Clinical Practice

Answers for life.

SIEMENS

Iterative Reconstruction in Image Space* (IRIS)

* Please note: IRIS is used as an abbreviation for Iterative Reconstruction in Image Space throughout this brochure.

Innovation Leader in CT

Innovation leader in CT

Siemens has always believed that even the farthest technical horizons were temporary and could be surpassed with consistent dedication to improved healthcare. This visionary approach has made Siemens the undisputed innovation leader in CT over the past 35 years. Our innovative philosophy is based solidly upon the assumption that achieving the highest technical performance is only important when it meets the needs of the patient and our customers. From the very beginning, one of the most frequent demands of our end users has been patient safety. And in Computed Tomography, patient safety translates primarily into dose reduction.

CARE

For this reason, we have, from the earliest days, developed many significant products and protocols that follow the "As Low as Reasonably Achievable" (ALARA) principle to reduce radiation dose to the lowest possible level. This desire for as little radiation exposure as possible lies at the heart of our CARE (Combined Applications to Reduce Exposure) research and development philosophy. Over the years, Siemens has been highly successful in integrating many innovations into the Siemens scanners that significantly reduce radiation dose in comparison to other systems available on the CT market, for example the Adaptive Dose Shield, introduced on the SOMATOM Definition AS in 2007, or Flash Spiral imaging, the core innovation of the SOMATOM Definition Flash, launched in 2008.

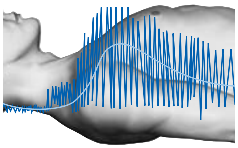
Dedication to Low Dose

The number of exams worldwide is growing, not only because CT offers high diagnostic certainty but also because the acquisition method is simple and results are reproducible. And because of CT's versatility, it has become a standard examination in medical facilities around the globe – and accordingly contributes to a significant amount of overall radiation exposure in the entire population. Because of this factor, all CT facilities and vendors assume a heavy and unavoidable responsibility to minimize radiation and maximize safety for their patients. At Siemens, we see it as one of our core responsibilities to provide medical institutions with solutions that enable them to further lower the radiation dose without compromising on image quality. For this reason, we have, from the beginning, developed many significant products and protocols that follow the ALARA principle.

Dose Saving

1994	1997	1999	1999	2002	2005
CARE Dose4D	UFC	Adaptive ECG-Pulsing	HandCARE	Pediatric 80 kV Protocols	DSCT
Up to 68%	Up to 30%	Up to 50%	Up to 70%	Up to 50%	Up to 50%

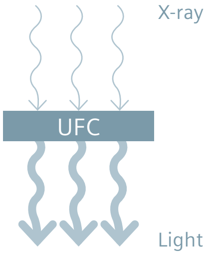
1994 – CARE Dose4D



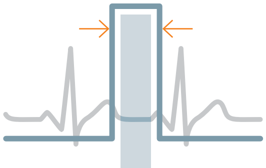
Fully automated dose modulation adapts dose to each individual patient in real time, reducing dose up to 68%.

1997 – UFC

With SOMATOM scanners, saving dose starts right at the point where image data is acquired – the Ultra Fast Ceramic (UFC) detectors enable up to 30% dose reduction.



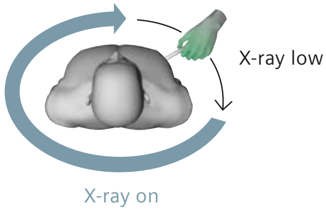
1999 – Adaptive ECG-Pulsing



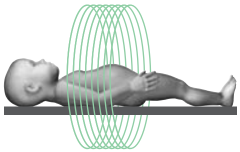
The heartbeat-controlled dose modulation applies the exact dose necessary to collect all data during the diastolic phase, saving up to 50% dose.

1999 – HandCARE

The tube current is switched off within a certain range of projections, minimizing direct exposure to the hands during CT-guided interventions, and saving up to 70% of dose.



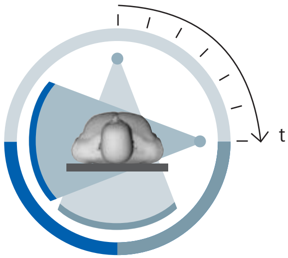
2002 – Pediatric 80 kV Protocols



Enables up to 50% dose savings in pediatric imaging by utilizing dedicated low kV child protocols that allow an individual adaptation of the patient dose to small sizes of pediatric patients.

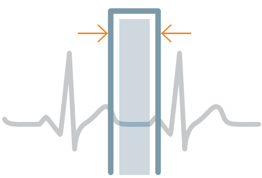
2005 – DSCT

As Dual Source CT images the heart twice as fast, the dose necessary for excellent cardiac imaging can be applied in less than half the time, enabling up to 50% lower dose at typical heart rates.



2007 — Adaptive Cardio Sequence

1–3 mSv Cardio

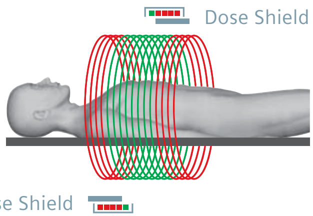


An intelligently triggered sequence that shuts off radiation in the systolic phase, thus enabling low dose cardiac imaging below 3 mSv routinely.

2007 — Adaptive Dose Shield

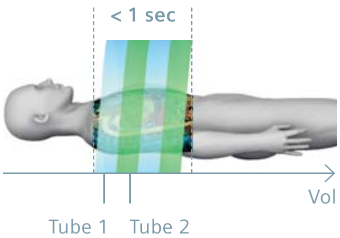
Up to 25%

Its ability to dynamically block clinically irrelevant pre- and post-spiral dose significantly reduces the possibility of over-radiation, saving up to 25% of dose.



2008 — Flash Spiral

< 1 mSv Cardio

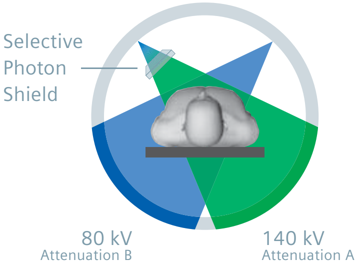


Enables dose values down to under 1 mSv in everyday routine using maximum speed and minimum overall exposure time.

2008 — Selective Photon Shield

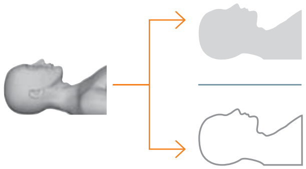
No dose penalty

Enables dose-neutral Dual Energy imaging by blocking unnecessary photons of the X-ray energy spectrum.



2008 — 4D Noise Reduction

Up to 50%

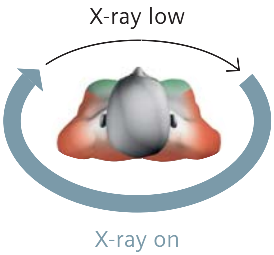


Enables long-range dynamic scanning with up to 50% lower dose utilizing an intelligent image noise suppression algorithm.

2008 — X-CARE

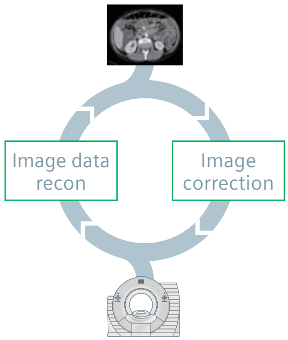
Up to 40%

Reduced dose-sensitive body-region exposure up to 40% by virtually switching the X-ray tube off for a certain range of projections.



2009 — IRIS

Up to 60%



Multiple iteration steps in the reconstruction process eliminating noise, therefore enabling up to 60% dose reduction.

Methods of Iterative Reconstruction

Filtered back projection

Dose reduction with CT has been limited by the currently used filtered back projection (FBP) reconstruction algorithm. When using this conventional reconstruction of acquired raw data into image data a trade-off between spatial resolution and image noise has to be considered. Higher spatial resolution increases the ability to see the smallest detail; however, it is directly correlated with increased image noise in standard filtered back projection reconstructions as they are used in CT scanners today.

Theoretical iterative reconstruction

Iterative reconstruction approaches allow decoupling of spatial resolution and image noise. In an iterative reconstruction, a correction loop is introduced into the image generation process. Synthesized projection data are compared to real measurement data in an iterative manner: the update image is refreshed by a correction image and prior knowledge is imposed onto image data. The application of prior knowledge smoothes the image within homogeneous regions, whereas contrast edges are preserved. The corrected image has the potential to enhance spatial resolution at higher object contrast and to reduce image noise in low contrast areas.

In the last 20 years, a variety of iterative reconstruction approaches have been developed. Although new to CT, iterative reconstruction is widely used in PET. But the introduction into clinical CT practice has been handicapped due to slow convergence of reconstruction and, consequently, the demand for extensive computer power and significant hardware efforts to avoid long image reconstruction times. In a theoretical iterative reconstruction, the physical properties of the scanner's acquisition system are taken into account during the calculation of synthetic projection data. Thereby the quality of the reconstructed images is improved. Modeling the scanner's measurement system is computationally very expensive, hence image reconstruction is cumbersome and time consuming.

Statistical iterative reconstruction

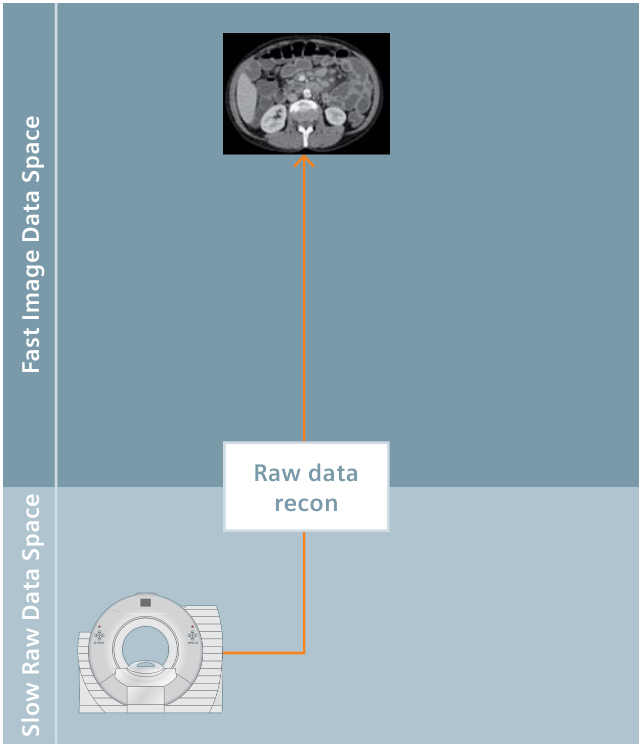
To avoid long image reconstruction times, a first modified and computationally faster iterative reconstruction technique based on only one statistical corrective model, the noise properties of the measurement data, was introduced to simply address image noise. Although this simple model is significantly reducing the need for iterations compared to theoretical iterative reconstruction, the aggressive noise reduction causes a noise-free appearance with unusually homogeneous attenuation. The noise texture of the images is strongly different from standard filtered back projection reconstruction, that limits the clinical use as the users have to get used to working with unfamiliar image impressions.

Iterative Reconstruction in Image Space

Instead of reducing the amount and complexity of corrective models to gain reconstruction speedi Siemens has developed a new method for iterative reconstruction which maintains the image correction quality of theoretical iterative reconstruction. To accelerate the convergence of the reconstruction and to avoid long reconstruction times, the new IRIS applies the raw data reconstruction only once. During this newly developed initial raw data reconstruction a so-called master volume is generated that contains the full amount of raw data information yet at the expense of significant image noise. The following iterative corrections known from theoretical iterative reconstruction are consecutively performed in the image space. They "clean up" the image and remove the image noise without degrading image sharpness. Therefore, a time-consuming repeated projection and corresponding back projection can be avoided. In addition, the noise texture of the images is comparable to standard well-established convolution kernels. The new technique results in artifact and noise reduction, increased image sharpness, and dose savings of up to 60% for a wide range of clinical applications.

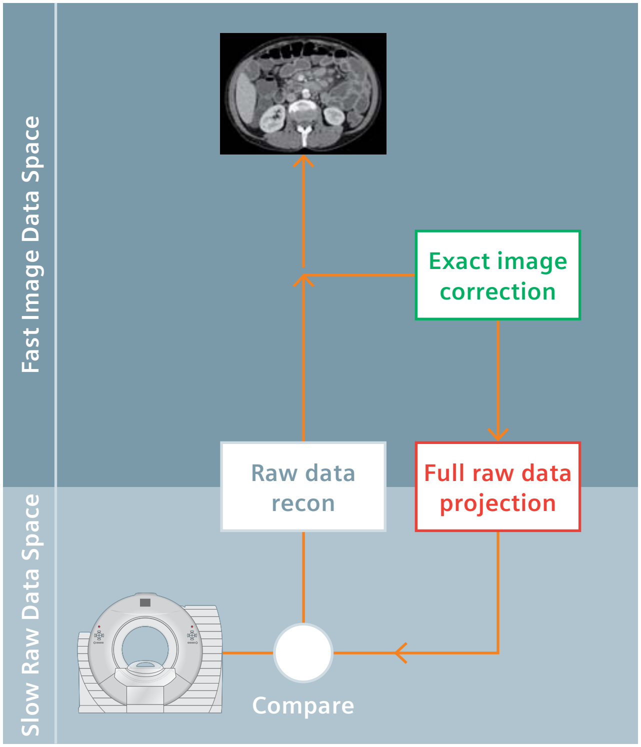
Methods of Iterative Reconstruction

Standard FBP



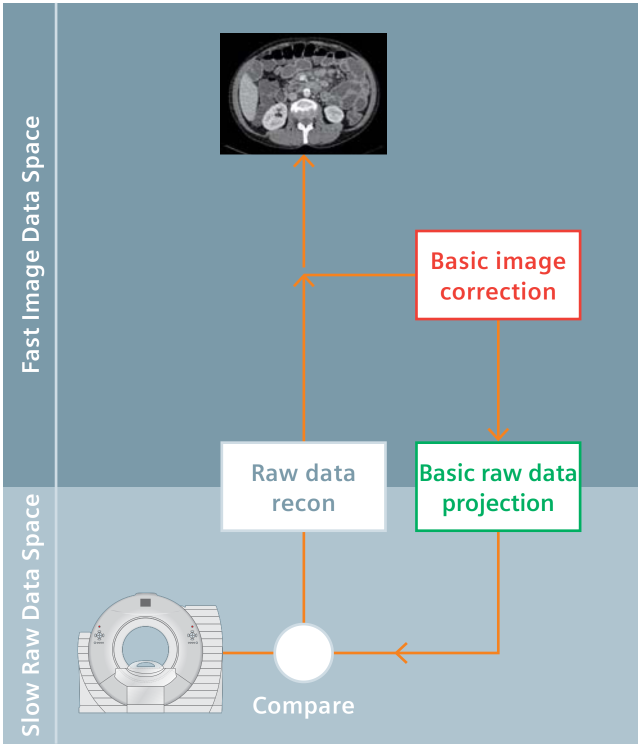
- ✚ Ultra-fast reconstruction without iterations
- ✚ Well-established image impression
- ▬ Limited dose reduction

Theoretical IR



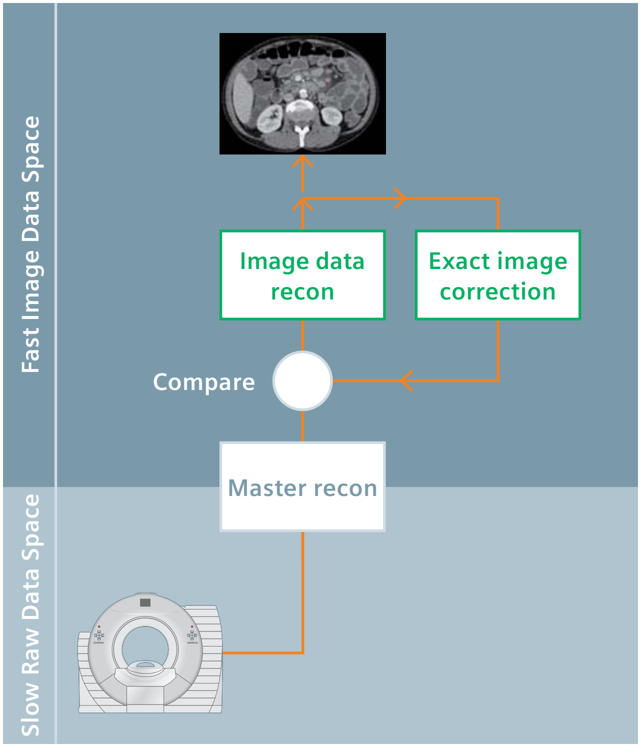
- ✚ Dose reduction or image quality improvement
- ✚ Well-established image impression
- ▬ Very time-consuming reconstruction

Statistical IR



- Dose reduction
- Fast reconstruction with few parameters
- Unfamiliar and plastic-like image impression

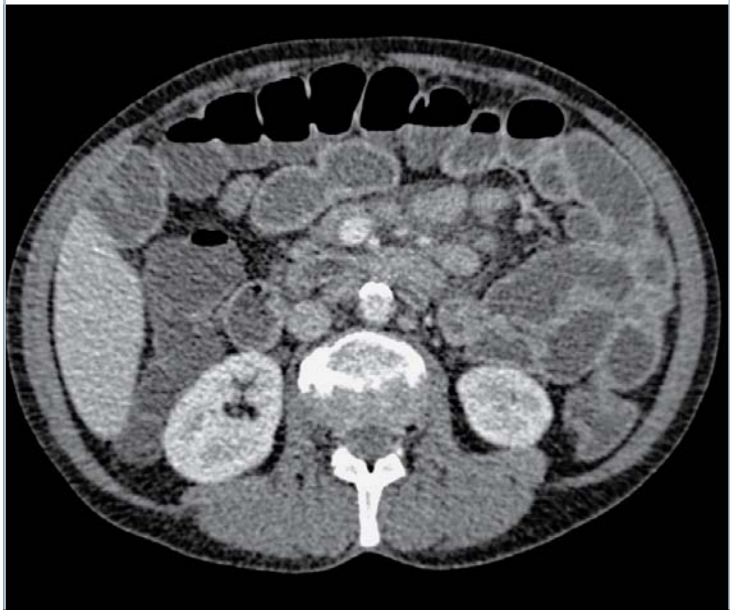
IRIS



- Dose reduction or image quality improvement
- Well-established image impression
- Fast reconstruction in image space

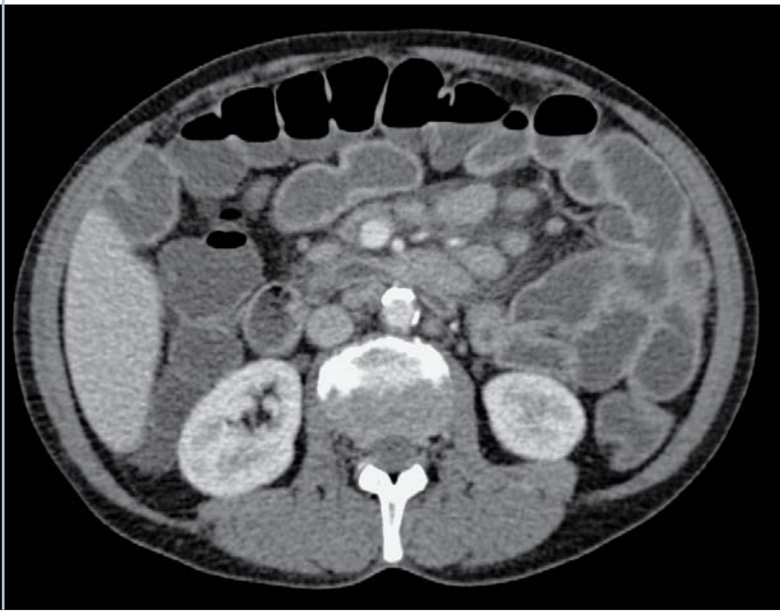
Standard FBP

Routine abdomen scanned at 50% of normal dose resulting in limited image quality with high noise.



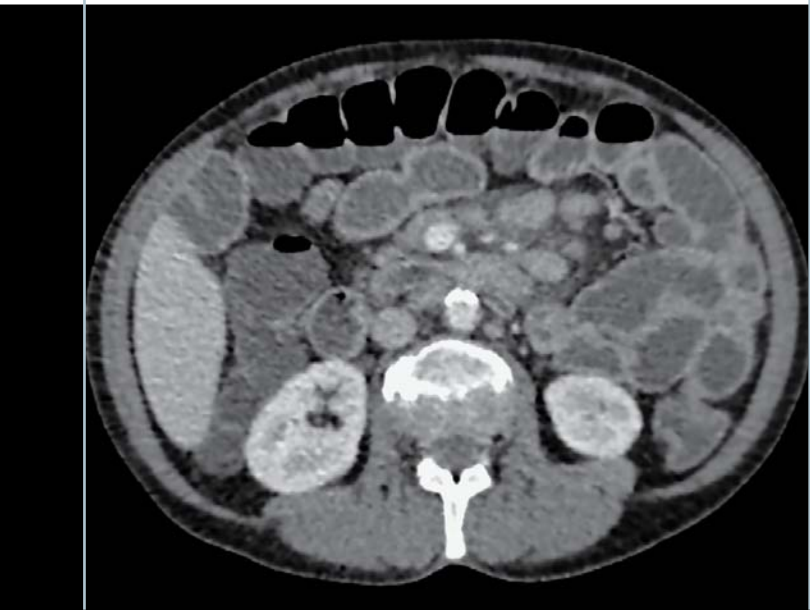
Theoretical IR

Theoretical iterative reconstruction significantly reduces the noise, therefore improving the image quality.



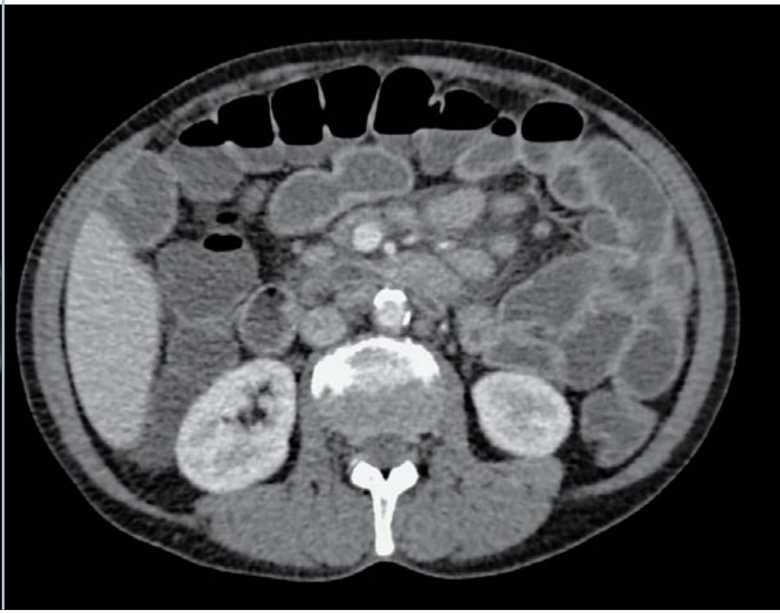
Statistical IR

Statistical iterative reconstruction reduces the noise as well, however the plastic image impression might be unfamiliar to the user.



IRIS

IRIS maintains a well-established image impression and in addition significantly reduces the noise, therefore improving the image quality.



Neuro Imaging

Decreased image noise

CT is considered the initial modality for routine and advanced head imaging. Since the introduction of Siemens' first commercial head scanner in 1974, we have continuously focused on delivering excellent head imaging quality of the entire CT scanner family. With IRIS, we now offer another step in image quality improvement, or dose reduction for neuro imaging.

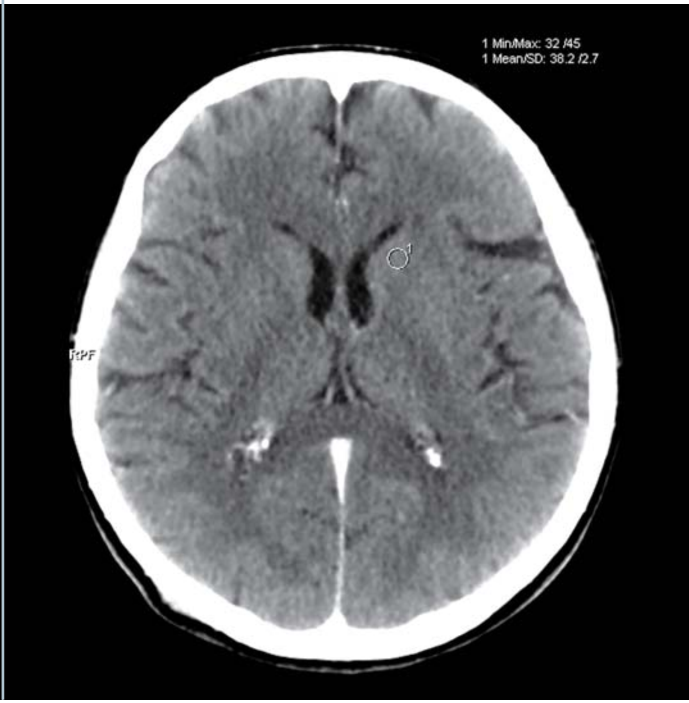
The two images on the right compare two reconstructions of a contrast-enhanced CT scan of the cerebrum on a SOMATOM Definition AS. On the left a conventional reconstruction is shown, on the right Siemens' unique IRIS. The white circles represent the region of interest (ROI) in which the mentioned values (HU = min., max. and mean Houndsfield Units, SD = Standard Deviation) were measured.

Standard FBP

Standard filtered back projection reconstruction, using a H31 kernel.

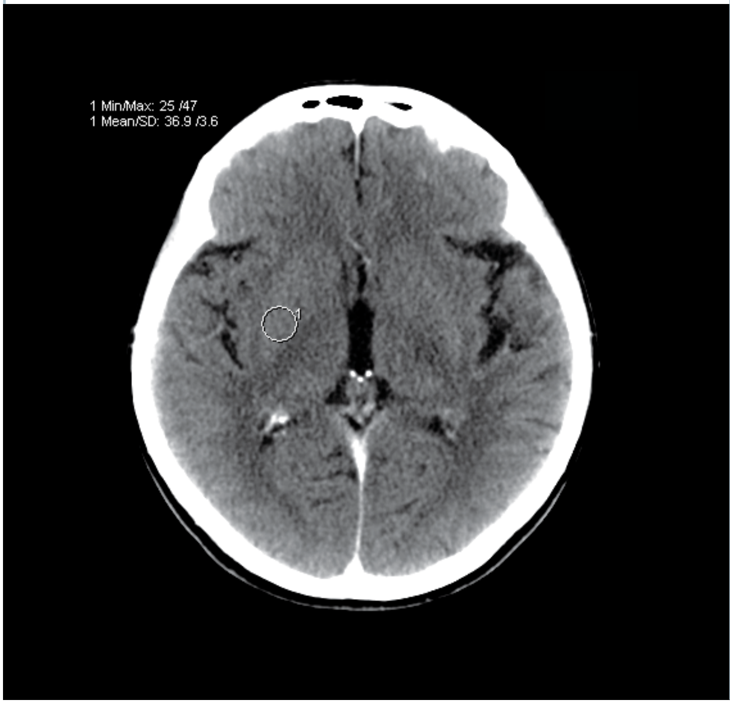
IRIS

This image nicely visualizes the IRIS improvements, the significantly decreased image noise without loss of resolution or gray-white matter differentiation.



Standard FBP

Standard filtered back projection reconstruction, using H31 kernel.

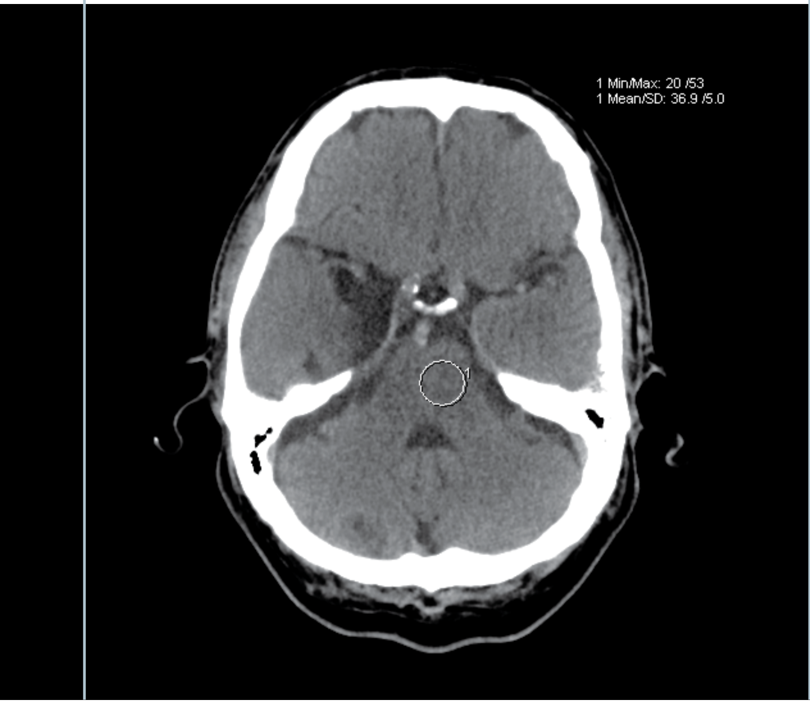


IRIS

The significant reduction in image noise with IRIS can be quantified by comparing the standard deviation (SD) of the region of interest (ROI).

Standard FBP

Standard filtered back projection reconstruction, using a H31 kernel.



IRIS

Improved head image quality in difficult anatomical regions, such as the area between the temporal bones, where significant HU differences are present.

Cardiovascular Imaging

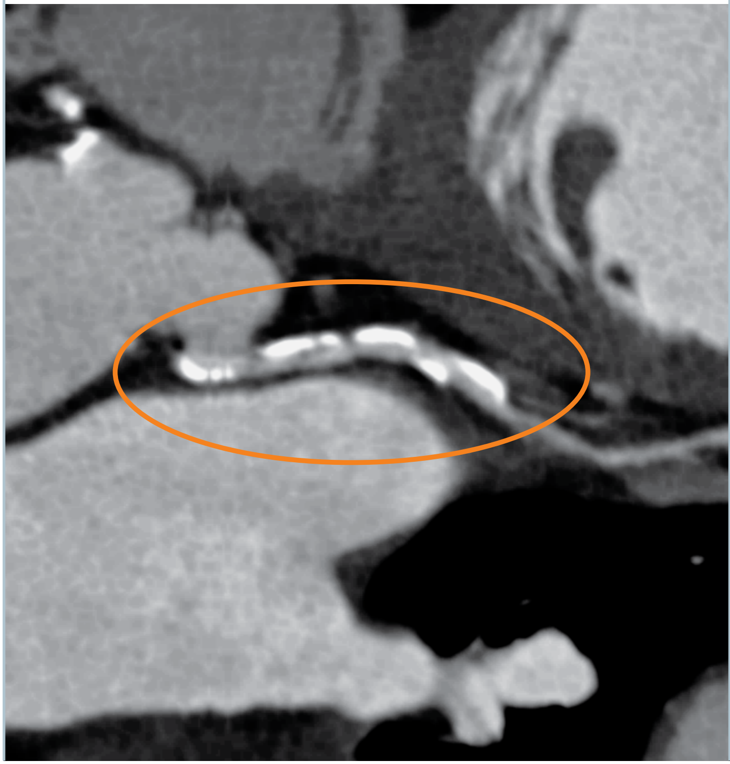
Improved image quality

Cardiovascular diseases (CVD) are the leading cause of death worldwide. CT plays an increasing role in the field of CVD imaging. Robust cardiac CT imaging requires high diagnostic quality and lowest possible dose. With the introduction of IRIS Siemens offers the user a choice to either further reduce the image noise and consequently the dose, or to further improve image quality.

The images on the right show a comparison of SOMATOM Definition Flash cardiac scans reconstructed with the standard filtered back projection (FBP) on the left and IRIS on the right. All other scan parameters have been identical.

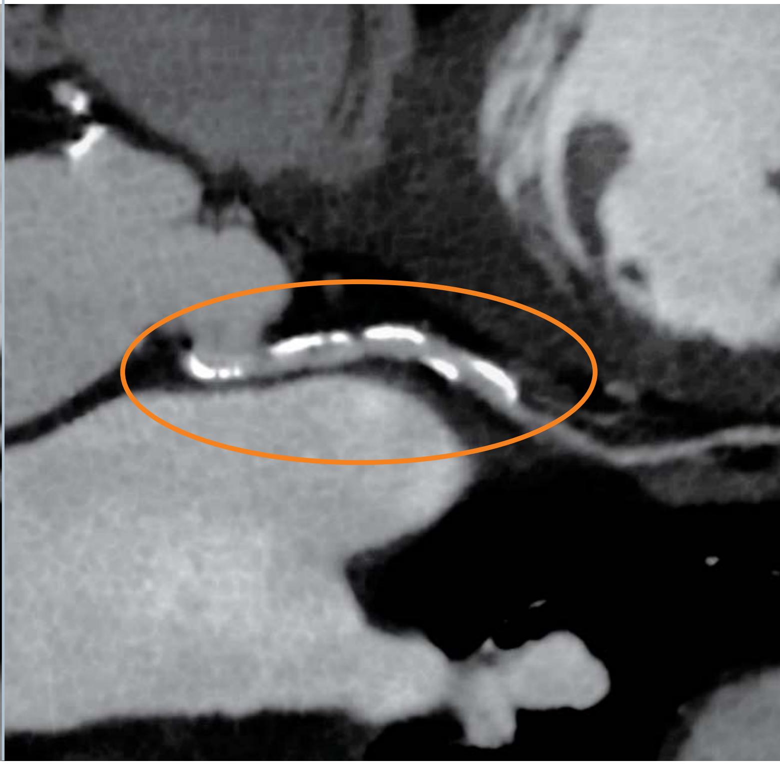
Standard FBP

Conorary artery scanned at 0.98 mSv with the use of standard filtered back projection reconstruction.



IRIS with better image quality

Here, the initial 0.98 mSv scan was reconstructed with IRIS. The resulting improved image quality shows a better visualization of the vessel lumen and the significantly reduced blooming of the calcification.

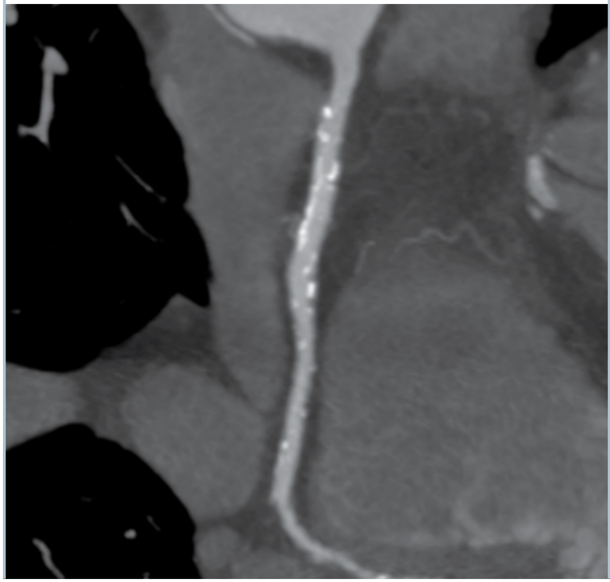


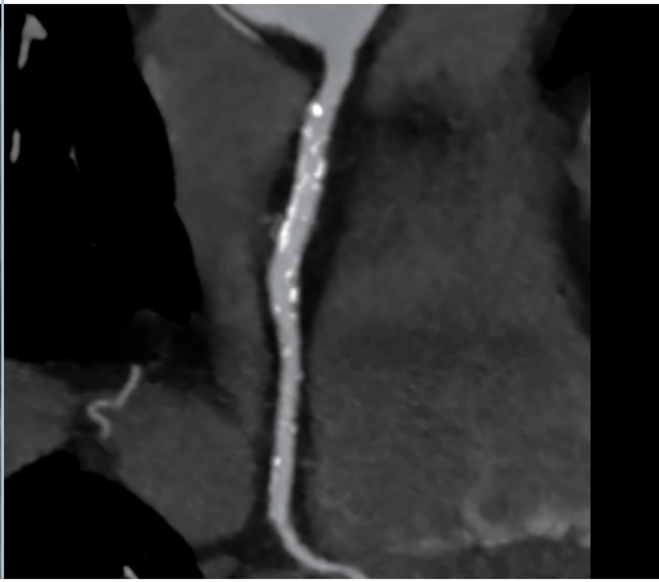
Standard FBP

Standard reconstruction using conventional body kernel scanned at 1.4 mSv.

IRIS with better image quality

Here, the initial 1.4 mSv scan was reconstructed with IRIS. Curved planar reformation of the right coronary artery (RCA) showing significantly sharper visualization of calcifications with IRIS.





Standard FBP

Standard reformated planar right coronary artery.

IRIS with better image quality

This curved planar reformation of the right coronary artery (RCA) shows significantly improved image quality with IRIS, especially in the boundary area between calcification and contrast media.

Thoracic Imaging

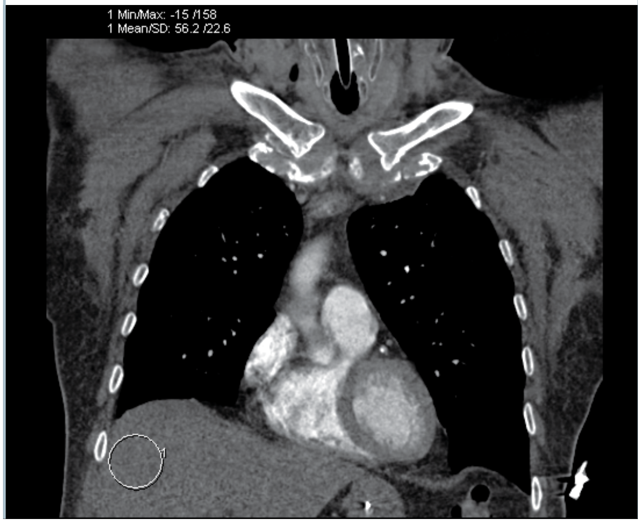
Benefits in clinical practice

One of the most frequently performed examinations in routine include the imaging of the thorax. Overall dose reductions in all body regions can be achieved with IRIS. However, the greatest potential can be seen in those areas scanned most often, which not only include the abdomen or the head, but also the thorax.

IRIS can thus reduce radiation dose or improve image quality especially in those areas that are being scanned most often – offering benefits in daily practice for the patient, as well as the physician.

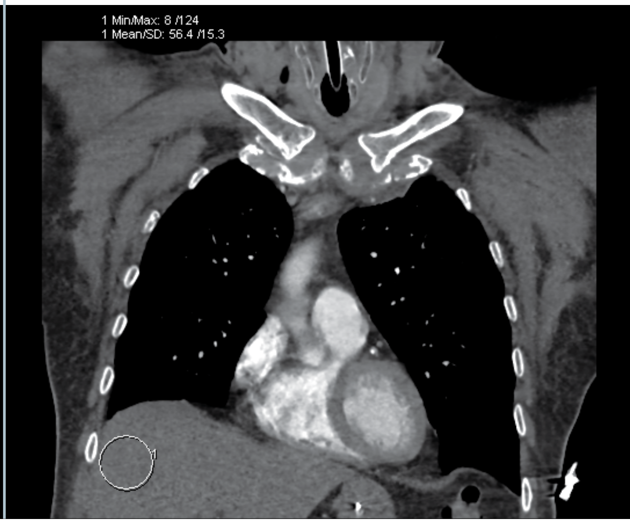
Standard FBP

Coronal image of the entire thorax using standard filtered back projection reconstruction.



IRIS with better image quality

IRIS with sharp image quality in the peripheral thoracic area as well as in the dome of the liver.



Standard FBP

This axial image shows the use of standard filtered back projection.

IRIS

Improved resolution of the thorax with IRIS showing all details of the lung parenchyma. Using this technique, radiation dose could be reduced by up to 60%.

Standard FBP

Coronal reformation using standard filtered back projection.

IRIS at 30% lower dose*

Despite lower radiation dose, significant reduction in image noise with IRIS can be quantified by comparing the standard deviation (SD) of the region of interest (ROI) in the liver, for example.

* Compared to standard protocol

Abdominal Imaging

Up to 60% lower dose

In the broad spectrum of diagnostic methods and equipment available today, CT has assumed more and more importance. As CT has become a standard examination for routine work and the number of exams worldwide is increasing, we at Siemens wanted to further minimize radiation and maximize patient safety. With the introduction of IRIS, routine CT examinations can now be performed with a reduction of image noise, improvement in low contrast detectability and image quality. By reducing the image noise IRIS allows for dose reduction across the entire body by up to 60%.

The images on the right show a comparison of SOMATOM Definition routine abdomen scans from the same patient. The left image is the original scan utilizing two sources. The middle image is based on the same data set, however only the information of one source was used for the reconstruction. Hereby, an initial dose reduction of 60% could be simulated. The right image shows the original scan and the additional utilization of IRIS. All other scan parameters have been identical.

Standard FBP

Coronal reformation using standard filtered back projection.

IRIS at 60% lower dose

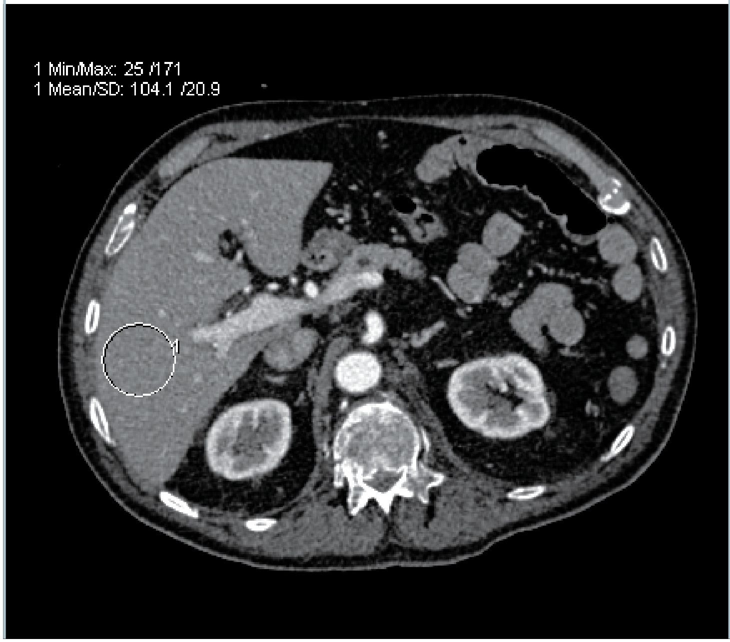
Despite the fact that the middle image was acquired at 60% lower dose it shows the same low noise compared to the original acquisition and similar noise texture of the images maintaining a well-established image impression.

IRIS with better low contrast detectability

IRIS reconstruction performed on the initially acquired data. Improved image quality with better low contrast detection can be nicely visualized.

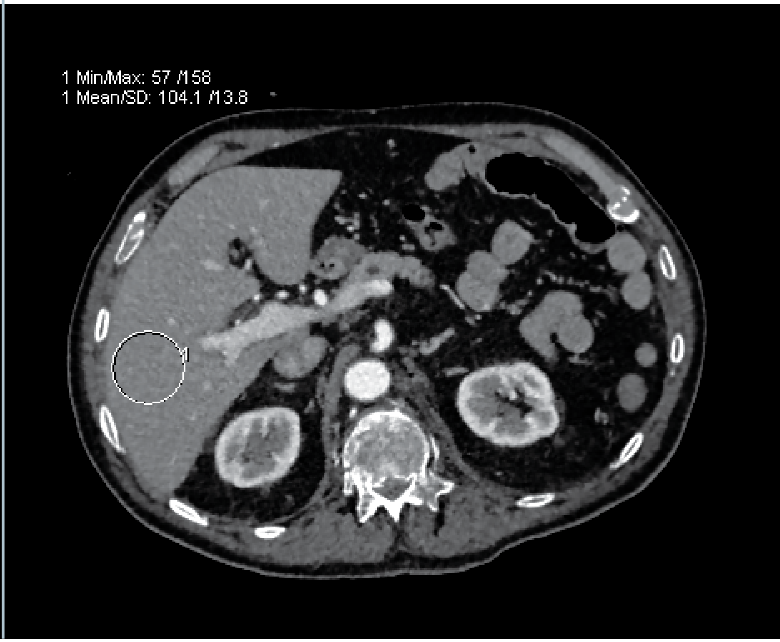
Standard FBP

Standard filtered back projection ensures good image quality in this arterial phase.



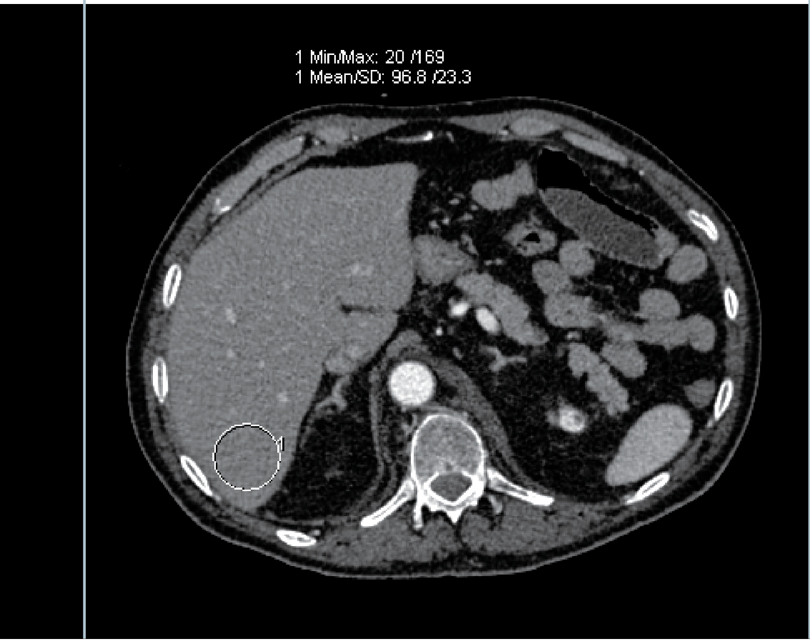
IRIS with improved image quality and better low contrast detectability

In this arterial phase, the kidney parenchyma can be nicely visualized with IRIS providing better image quality than with standard filtered back projection.



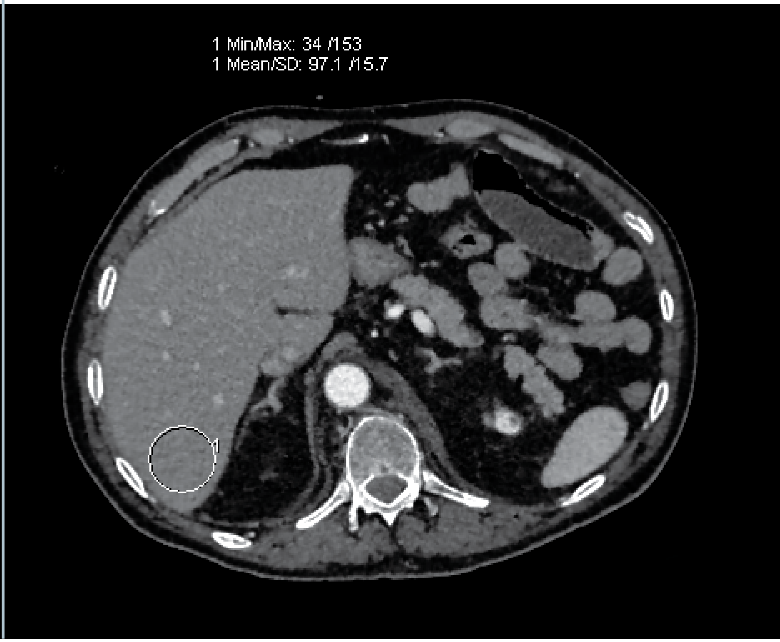
Standard FBP

Standard filtered back projection ensures good image quality in the early arterial phase.



IRIS with improved image quality and better low contrast detectability

In this early arterial phase, the abdominal organs are sharply outlined with IRIS.



Pediatric Imaging

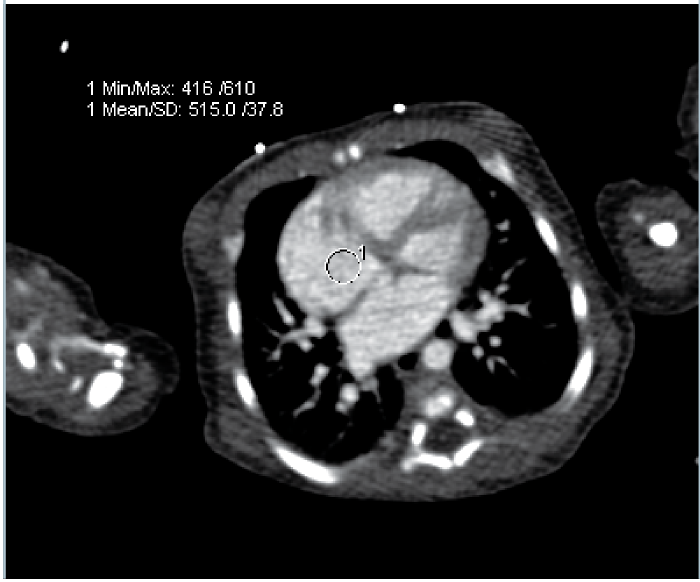
Lowest possible dose

All patients benefit from reduction in radiation dose. However, there are specific patient groups, in which the reduction in radiation dose is of utmost importance – one of these patient groups is pediatrics. Children demand the lowest dose because of long-term, higher potential radiation risks. At the same time, they have smaller body structures, which are more difficult to visualize in CT scanning procedures than the adult sized body structures. IRIS can lower the dose and/or improve image quality.

For example, for children and juvenile patients with mucoviscidosis, IRIS can be a tremendous advantage, because this unstable condition can require frequent CT scans, exposing children to radiation on different occasions.

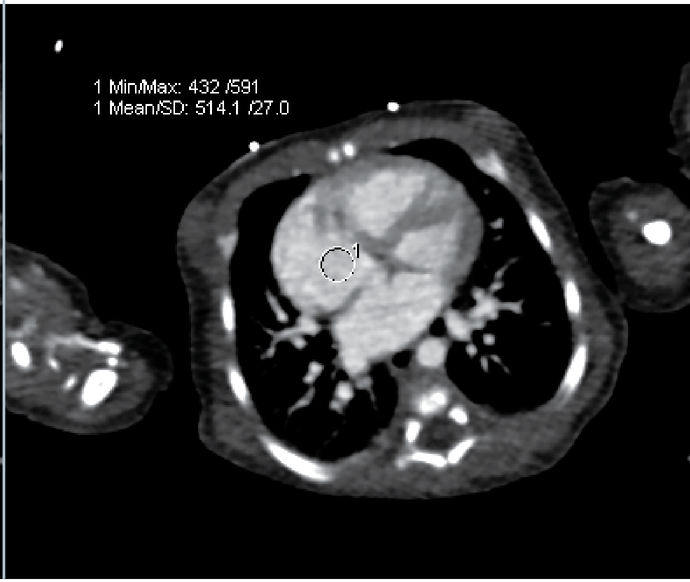
Standard FBP

Axial pediatric image using standard filtered back projection reconstruction.



IRIS

Despite the challenge of scanning pediatric patients, such as due to motion, IRIS delivers excellent image quality even in this patient population.



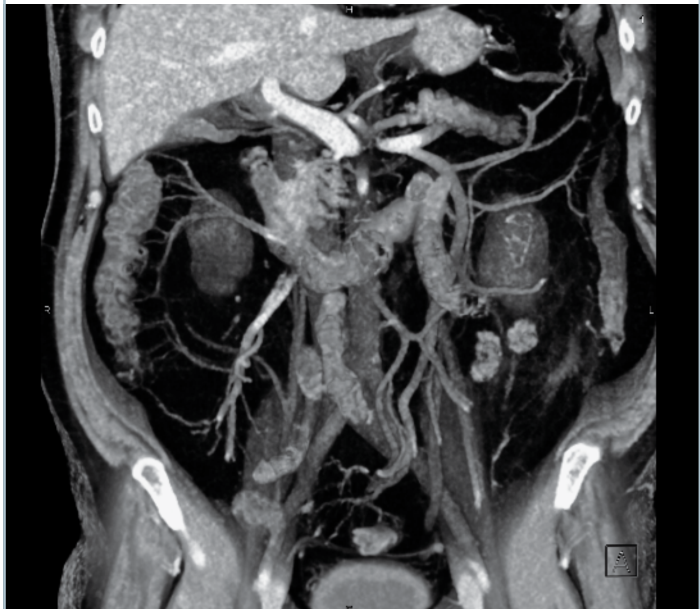
Dual Energy Imaging

IRIS with dose-neutral Dual Energy

It has always been an aim to collect as much information as possible in order to differentiate tissues. Dual Energy opens the door to a new world of characterization, visualizing the chemical composition of material. Two X-ray sources at two different kV levels deliver two spiral data sets acquired simultaneously in a single scan providing diverse information. 12 FDA cleared applications are already available for daily clinical use. Together with the unique Selective Photon Shield, which assures dose neutrality by eliminating spectral overlap, IRIS delivers fascinating Dual Energy examinations at the lowest possible dose.

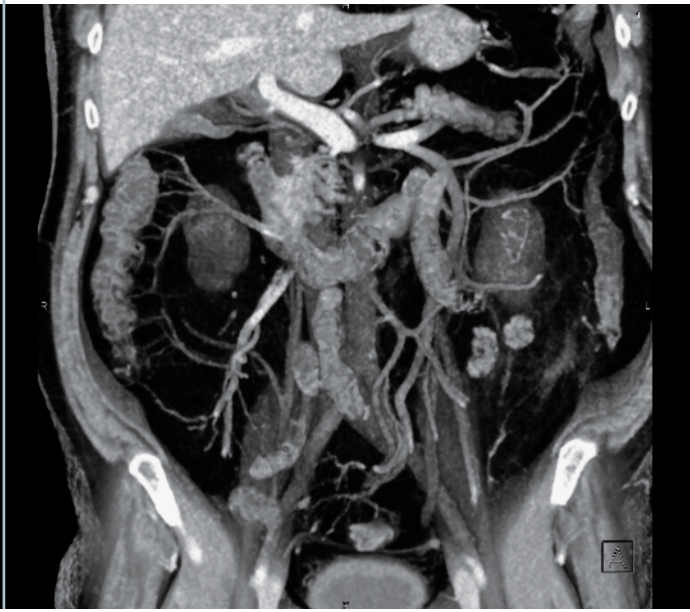
Standard FBP

Standard filtered back projection in combination with Dual Energy imaging.



IRIS with Dual Energy

IRIS delivers significant image quality improvements in combination with dose neutral Dual Energy imaging.



IRIS for Your Scanner

Available in daily clinical practice

Siemens unique Iterative Reconstruction in Image Space is available on the following premium CT scanners:

- SOMATOM Definition Flash
- SOMATOM Definition
- SOMATOM Definition AS

SOMATOM Definition Flash

The SOMATOM Definition Flash combines unprecedented scan speed with lowest dose in CT. Its Flash Spiral reaches scan speeds up to 45 cm/s, for the first time allowing an entire thorax to be scanned in less than one second, if necessary even without breath hold. It enables ultra-fast cardiac scanning with doses down to below 1 mSv and features dose-neutral Dual Energy imaging. At the same time, it helps to protect individual organs and the most radiation-sensitive body regions – for example, female breasts – by accurately and efficiently minimizing exposure.

SOMATOM Definition

The SOMATOM Definition allows you to scan any heart rate without the need of beta-blockers at half the radiation dose compared to a single-source CT. Moreover, it provides one-stop diagnoses regardless of size and condition of the patient, saving precious time and money in acute care. And imagine all the new clinical opportunities Dual Energy offers by characterizing, highlighting, and quantifying different materials.

SOMATOM Definition AS

The SOMATOM Definition AS, the world's first adaptive scanner, is the only CT to adapt to your patients and clinical questions – breaking the barriers of conventional CT, pediatric, obese, stroke, cardiac, trauma, 3D minimal invasive, routine, complex scanning. By modifying every component of multislice CT, we created experts in any clinical field, adapting to virtually any patient and clinical need.

"With Siemens' IRIS I can save up to 60% dose for a wide range of routine applications while maintaining excellent image quality."

U. J. Schoepf, MD
Professor of Radiology and Cardiology,
Director of CT Research and Development,
Medical University of South Carolina, USA

On account of certain regional limitations of sales rights and service availability, we cannot guarantee that all products included in this brochure are available through the Siemens sales organization worldwide. Availability and packaging may vary by country and is subject to change without prior notice. Some/All of the features and products described herein may not be available in the United States.

The information in this document contains general technical descriptions of specifications and options as well as standard and optional features which do not always have to be present in individual cases.

Siemens reserves the right to modify the design, packaging, specifications, and options described herein without prior notice. Please contact your local Siemens sales representative for the most current information.

Note: Any technical data contained in this document may vary within defined tolerances. Original images always lose a certain amount of detail when reproduced.

Global Business Unit

Siemens AG
Medical Solutions
Computed Tomography
Siemensstr. 1
DE-91301 Forchheim
Germany
Phone: +49 9191 18 0
Fax: +49 9191 18 9998

Global Siemens Headquarters

Siemens AG
Wittelsbacherplatz 2
80333 Muenchen
Germany

Global Siemens Healthcare Headquarters

Siemens AG
Healthcare Sector
Henkestr. 127
91052 Erlangen
Germany
Phone: +49 9131 84-0
www.siemens.com/healthcare

Legal Manufacturer

Siemens AG
Wittelsbacherplatz 2
DE-80333 Muenchen
Germany

www.siemens.com/healthcare

Order No. A91CT-30012-26C1-7600 | Printed in Germany | **CC** CT WS 08101. | © 08.2010, Siemens AG