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Life is precious – Take CARE

Redução da Dose em Tomografia Computorizada

Ana Chaves
CT Application Specialist
ana.ichaves.ext@siemens.com

Líder na Inovação
e Soluções Técnicas e Clínicas

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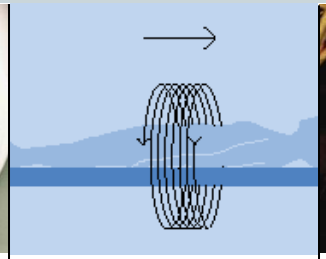
Primeiro CT no mercado

Produzir imagens seccionais

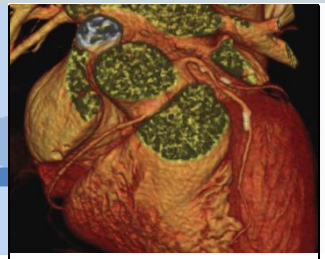
1974



Primeiro CT espiral

Deixar mundo sequencial

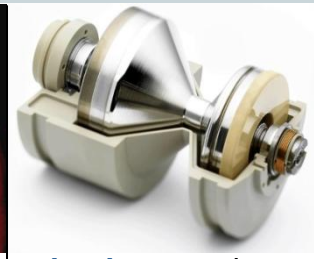
1987



Primeiro CT cardiaco

Explorar o coração

1999



Primeira ampola de raios-X 0 MHU

Fazer exames sem compromisso

2003

Primeiro CT 64-cortes

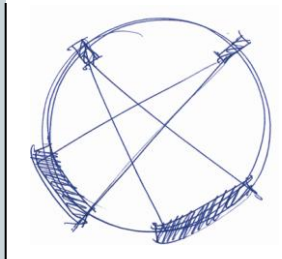
Exames cardíacos de emergência

2003

Primeiras CT Clinical Engines

Utilizar cor e 3D em rotina

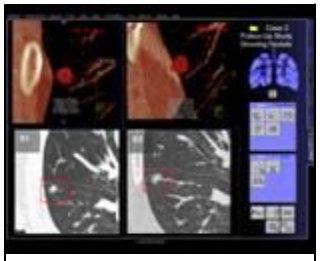
2005



Primeiro Dual Source CT

Aliviar compromisso

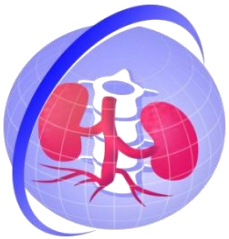
2005



Primeiro Computer Assisted Detection

Oferecer segunda opinião

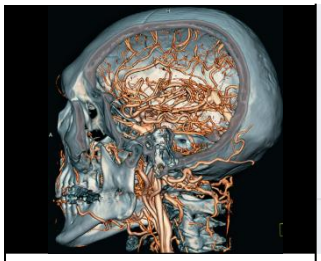
2005



Primeiro web-enabled CT

Permite total flexibilidade

2006



Primeiro CT com Dual Energy de rotina

Mudar a face da CT

2006

Primeiro CT Adaptivo

Adapta-se a qual-quer necessidade

2007

Primeiro Flash speed, redução de dose

CT healthier

2008

Tomografia Computorizada
A corrida mudou …

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Meta:

Menor dose de radiação possível, sem compromisso da qualidade diagnóstica das imagens usando tecnologia inovadora

Porque está CT sob este escrutínio?

Porque usa raios-X e a Radiação Ionizante causa danos…

Raios-X têm energia suficiente para ionizar a matéria.
A célula tem mecanismos de reparação suficientes.

No entanto, radiação em excesso causa danos.

1. Efeitos determinísticos >> 500 mSv.
Não relevantes em CT!

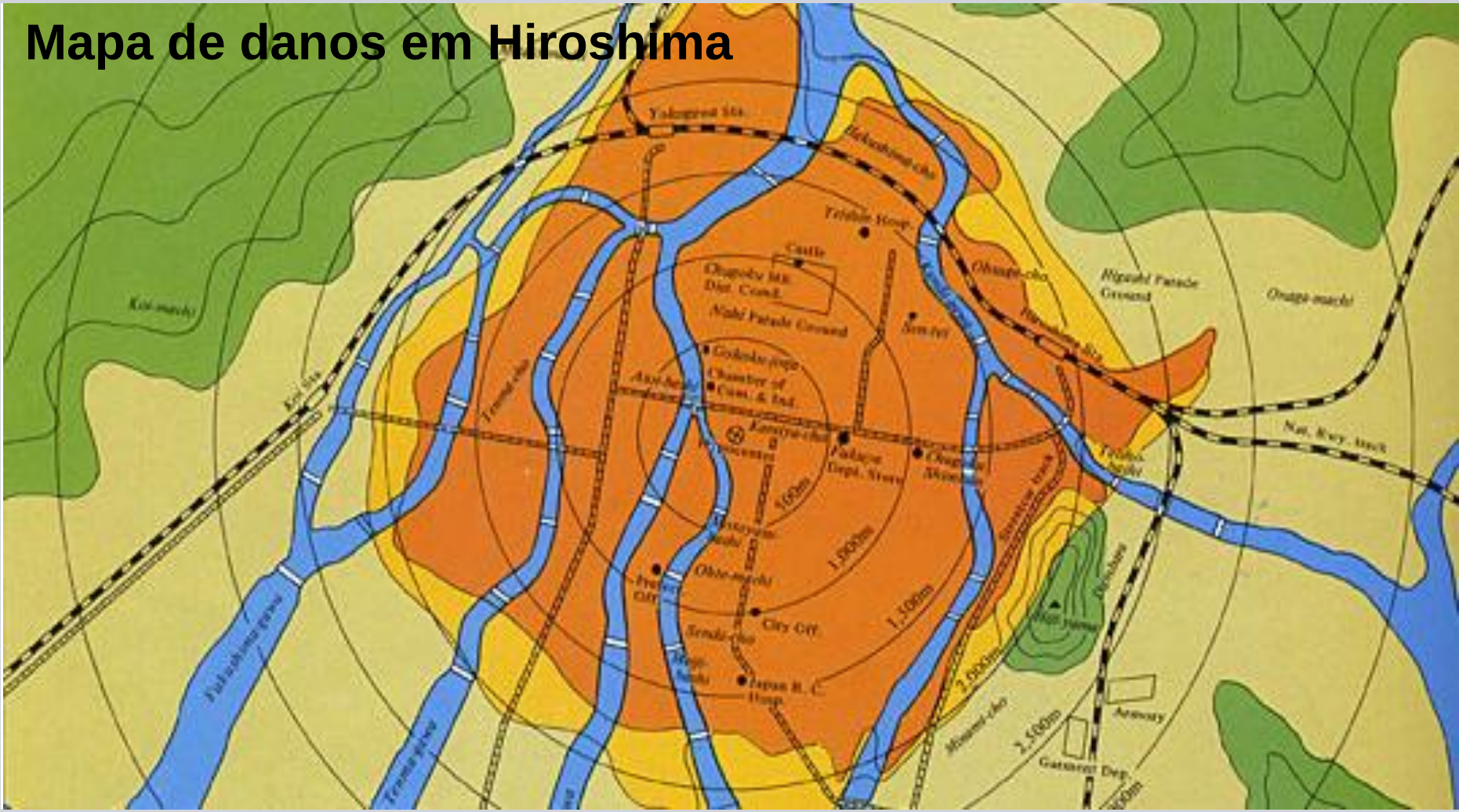
2. Efeitos estocásticos sem threshold
a) Dano é reparado → célula viável
b) Dano não pode ser reparado → célula morre
c) Dano é reparado → célula mutante

Mutação celular pode originar cancro.

Quebras de cadeia

O risco da exposição a doses mais baixas é elevado?

Não há resposta definitiva!



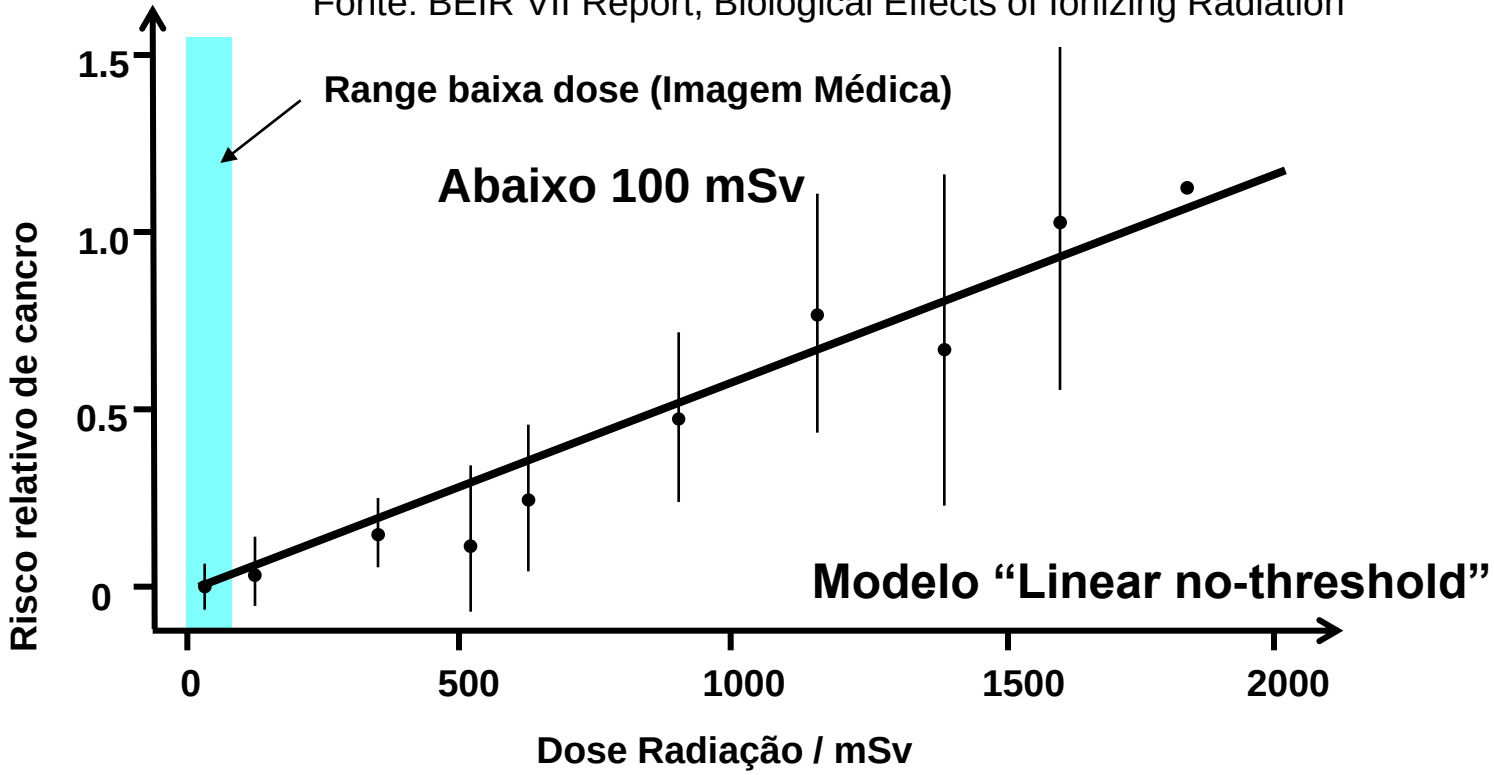
O risco da exposição a doses mais baixas é elevado?

Não há resposta definitiva!

Modelo de risco derivado dos acidentes de Hiroshima e Nagasaki.

O modelo mais aceite é o modelo “linear no-threshold” (LNT).

Fonte: BEIR VII Report, Biological Effects of Ionizing Radiation



Porque está CT sob este escrutínio?

Pequenos riscos potenciais em combinação com um grande número de exames

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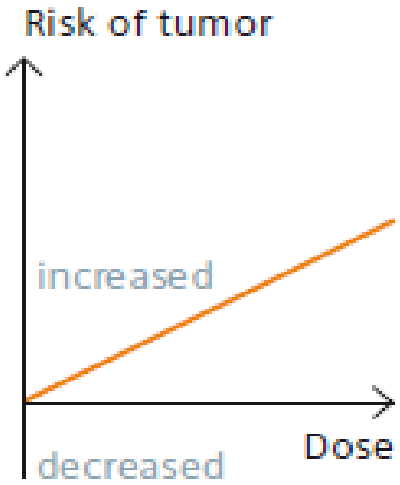
“Linear no-threshold“



→ Por cada + 10 mSv

o risco de mortalidade

por cancro aumenta

0.05%

Mortalidade por cancro no mundo ocidental:

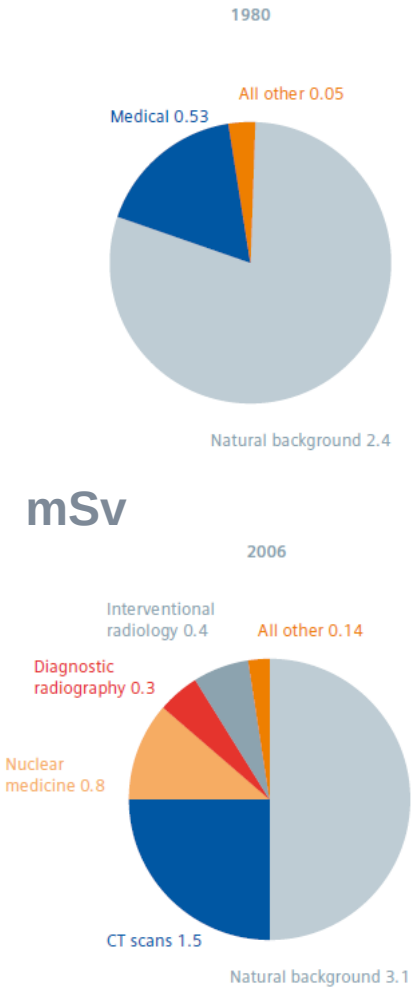
25%

Exame CT 10 mSv aumenta risco para:

25.05%

Número exames de CT nos EUA:

70 milhões



O risco da exposição a doses mais baixas é elevado?
Não há resposta definitiva!

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- Agência Internacional de Energia Atômica (AIEA) confirmou que a explosão provocada por um incêndio no reator 2 da usina nuclear de Fukushima (…) **libertou radiação diretamente na atmosfera**.

- No local, foi registrado nível de radioatividade de até **400 microsievert** por hora, diz a AIEA.

- Porta-voz do primeiro-ministro japonês admite que o **nível de radiação** na área estava **"perigoso" para a saúde da população**.

CT está sob escrutínio mas…
Benefícios da Tomografia Computorizada

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- Indolor, não invasivo e preciso.
- Imagem osso, tecidos moles e vasos sanguíneos.
- Rápida e simples, em emergências pode salvar vidas.
- Possível em pacientes com todo o tipo de implantes/dispositivos médicos.
- Imagens em tempo real para intervenções guiadas por CT.
- Em alguns casos, elimina necessidade de cirurgia exploratória.

Maior Portfolio na Redução de Dose em Tomografia Computorizada

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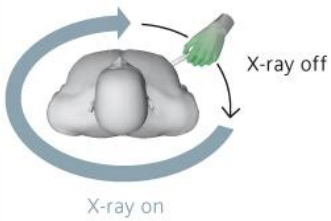
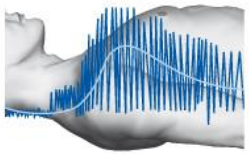
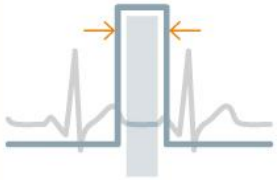
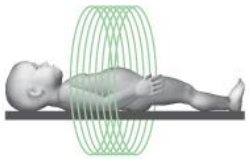
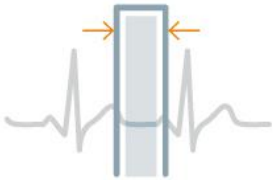


	1994	1997	1999	1999	2002	2005	2007	2007
	CARE Dose4D	UFC	Adaptive ECG-Pulsing	HandCARE	Pediatric 80 kV Protocols	DSCT	Adaptive Cardio Sequence	Ada Dos Shi
Dose Saving	Up to 68%	Up to 30%	Up to 50%	Up to 70%	Up to 50%	Up to 50%	1–3 mSv Cardio	Up to





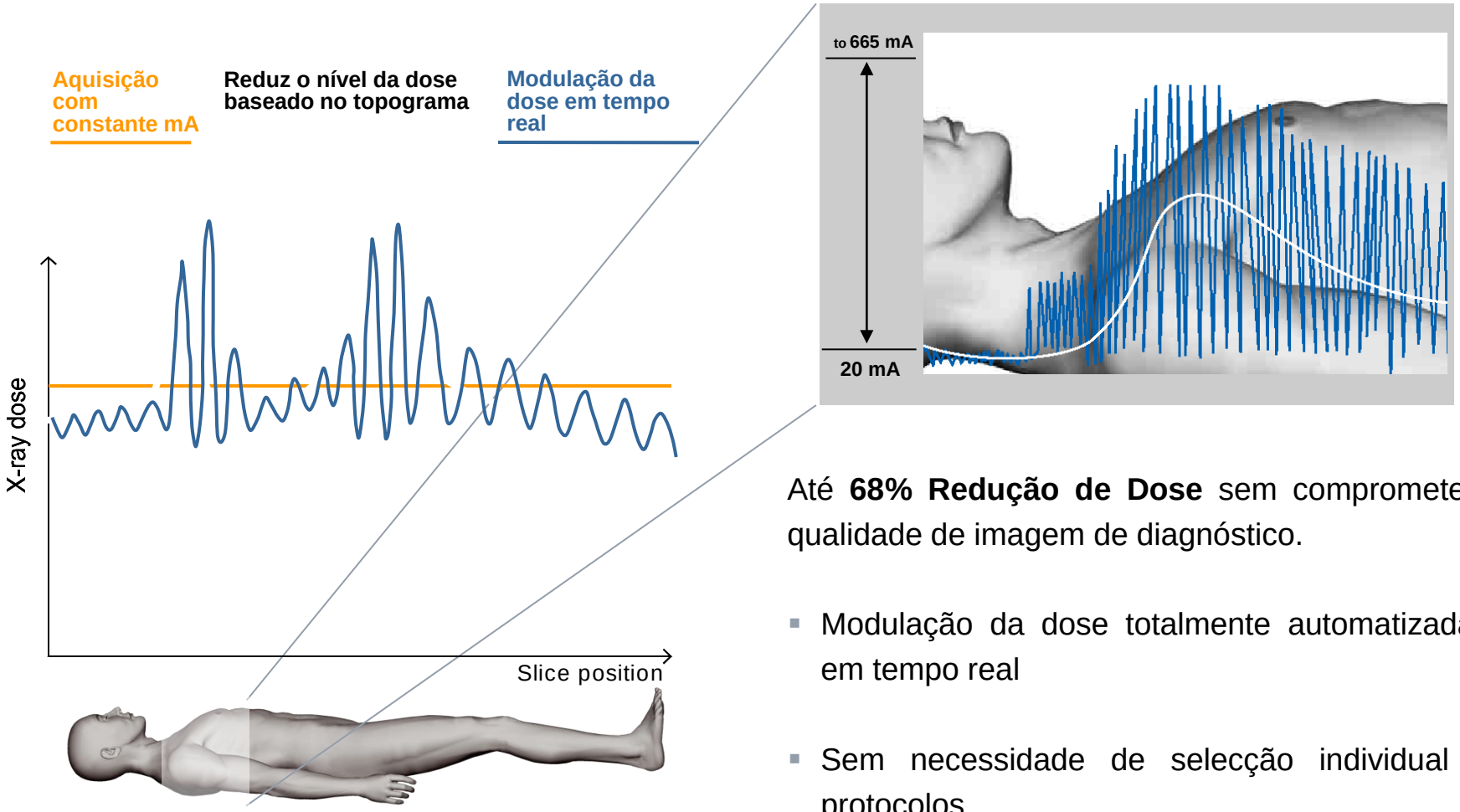




For internal use only

CARE Dose4D

Dose mínima, Máxima Qualidade, completamente automático

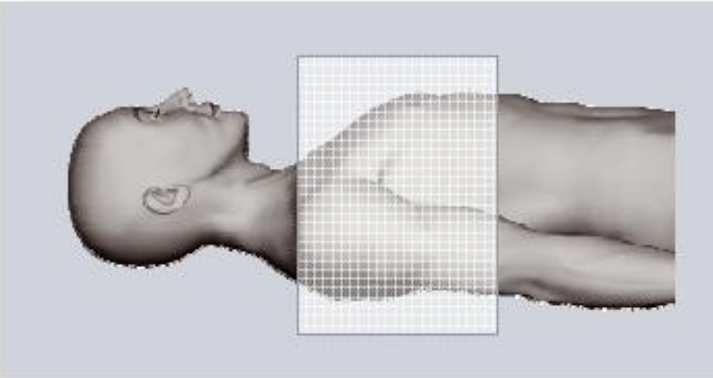


Até **68% Redução de Dose** sem comprometer a qualidade de imagem de diagnóstico.

- Modulação da dose totalmente automatizada e em tempo real
- Sem necessidade de selecção individual de protocolos

CARE kV

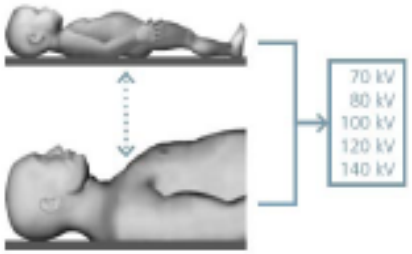
Dose mínima, Máxima Qualidade, completamente automático



Parâmetros de dose relevantes

- Pitch e tempo de exame independentes da dose
- mAs efectivos
- Tamanho do paciente
- **kV**

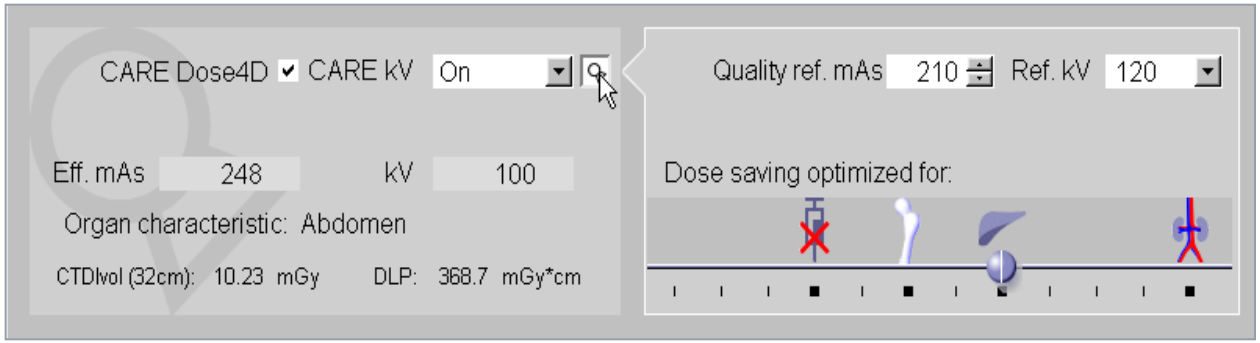
CARE kV



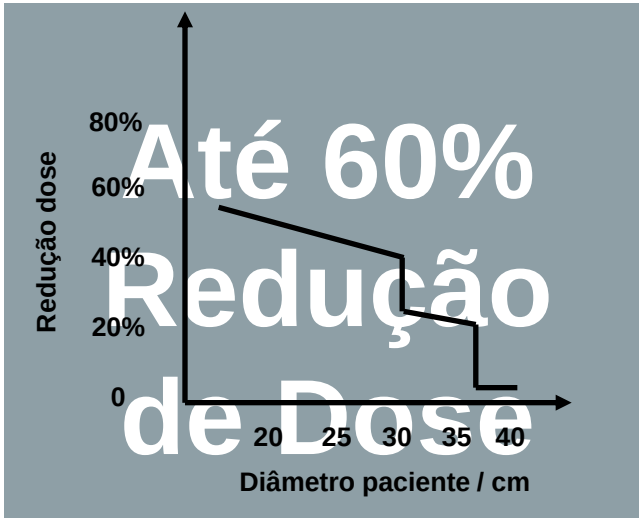
- **Selecção automática de kV com base no paciente e exame**
- **Cálculo automático dos outros parâmetros**

CARE kV

Dose mínima, Excelente Qualidade, completamente automático

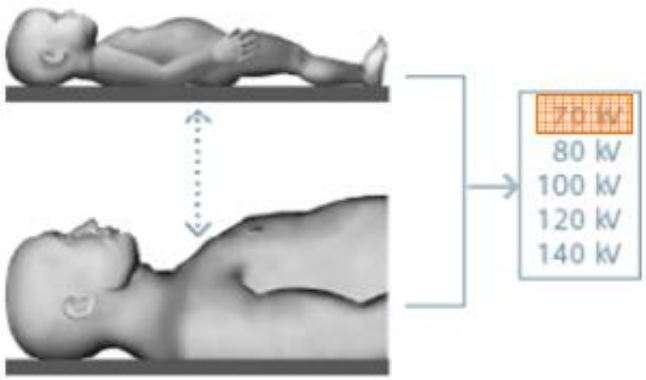


- **Optimização de kV automática**
- **Redução de dose até 60%**
- **70 kV para maior redução de dose**



CARE Child

Porque a minimização da dose é imperativa…



- **Modo de exame com 70 kV com a "renovada" STRATON**

- **Curvas de modulação específicas para crianças**
- **Protocolos pediátricos dedicados**

X-CARE
Redução da dose em orgãos sensíveis

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Tecnologia Convencional

- **Radiação total na mama**
- Mamas incluídas em qualquer exame diagnóstico de tórax mas não são orgão de interesse

X-CARE
Até 40% redução de dose

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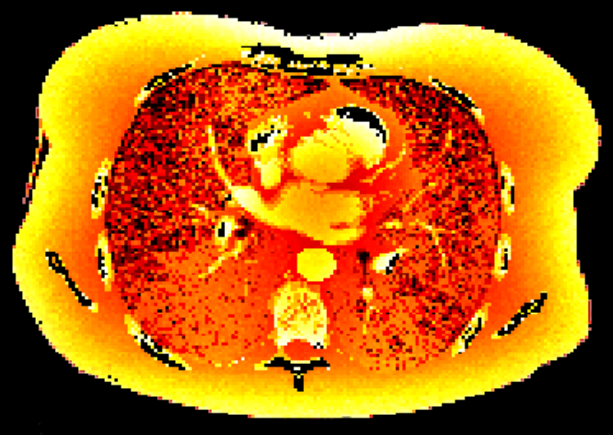
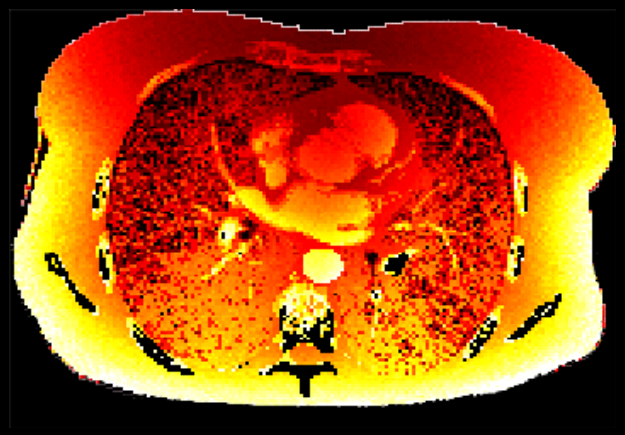


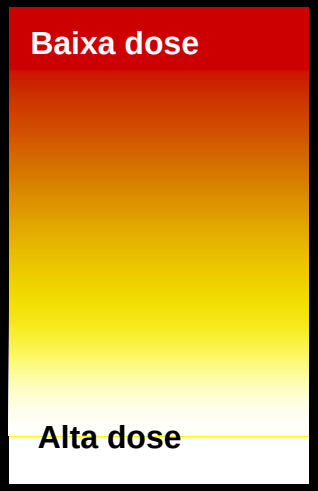
sem X-CARE



com X-CARE

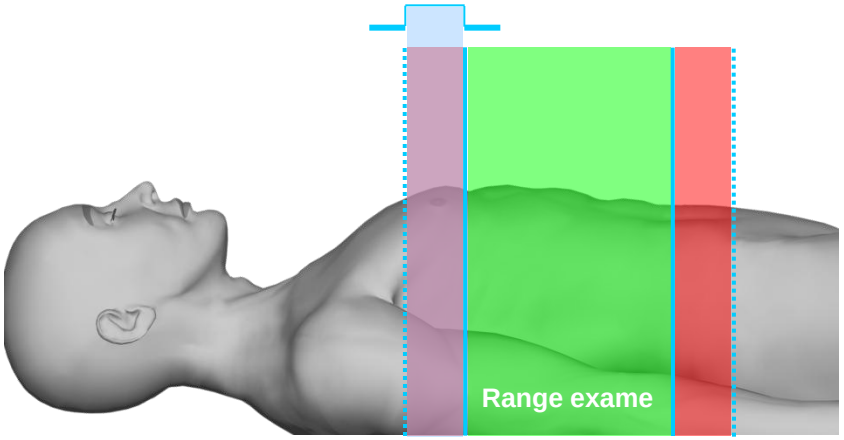
Até 40%
redução da dose

X-CARE

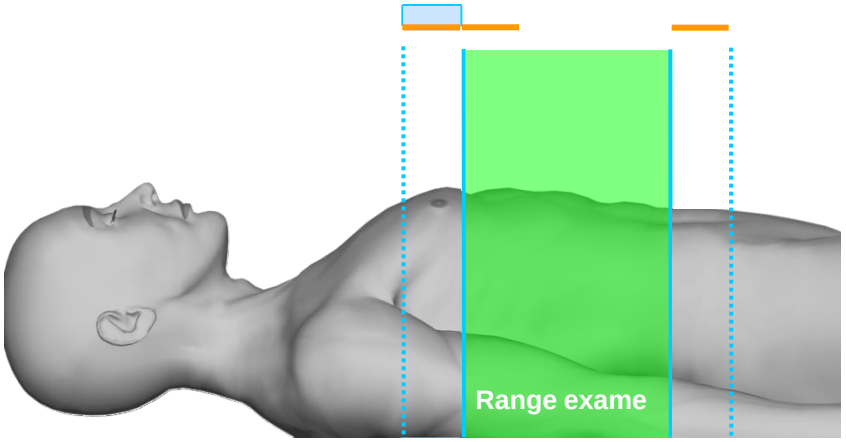


Fonte: Vollmar, Kalender - Reduction of dose to the female breast: a comparison of standard-protocol, bismuth-shielded partial and tube-current-modulated CT examinations, Eur Radiol 2008

Adaptive Dose Shield
Redução da dose até 25%



Tecnologia Convencional sem Dose Shield



Tecnologia com **Adaptive Dose Shield**

Adaptive Dose Shield
Redução da dose até 25%

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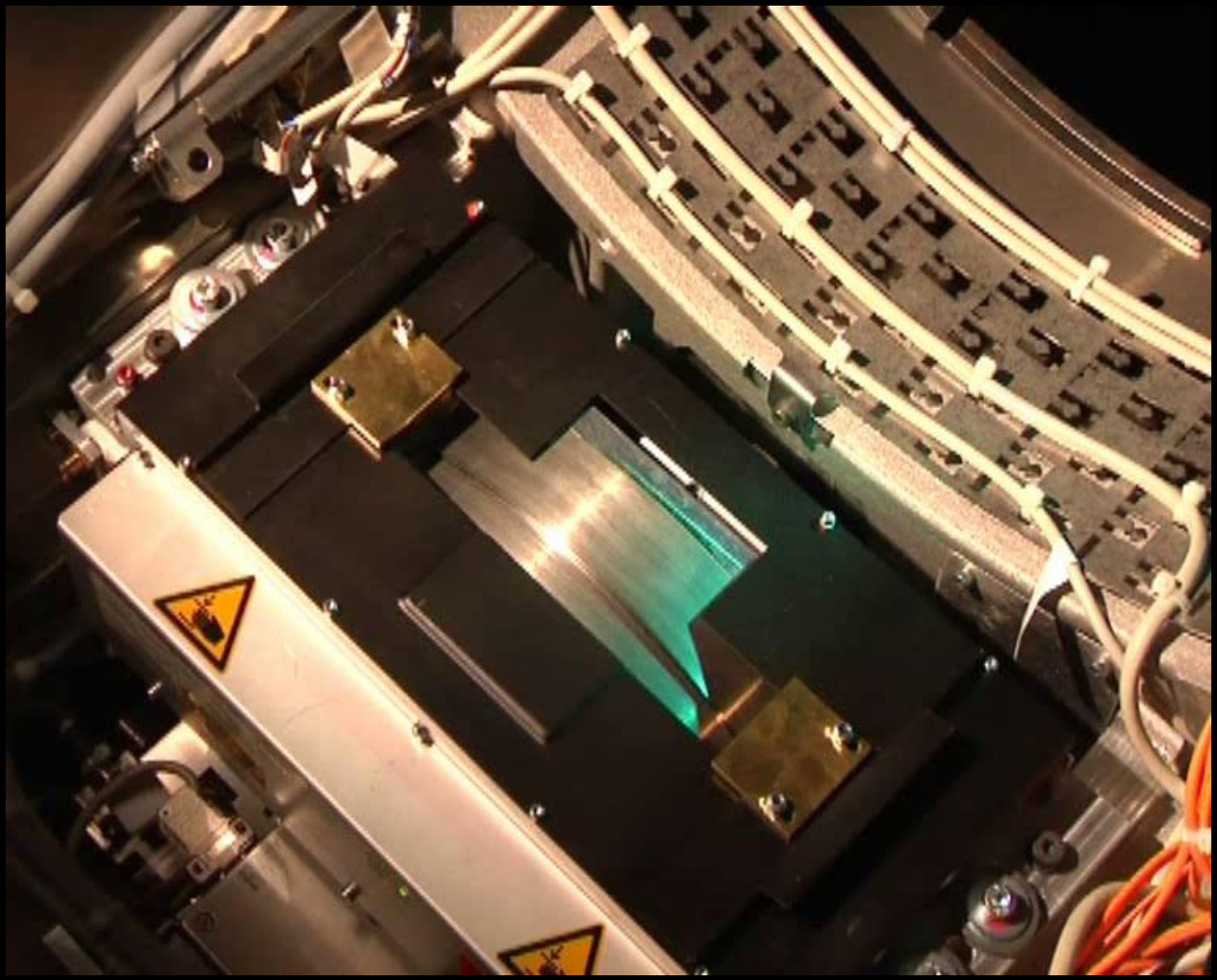
- Movimento paralelo preciso dos colimadores

- Protecção completa da dose a qualquer valor de pitch



Flash speed. Lowest dose.
Redução da Radiação em CT

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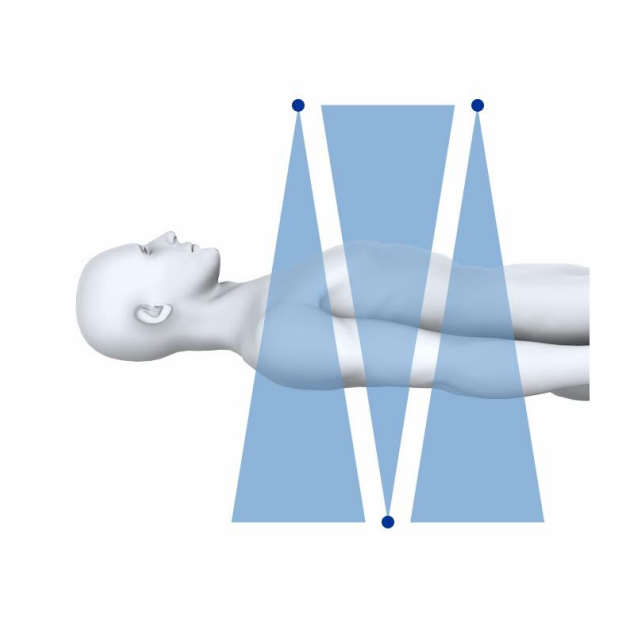
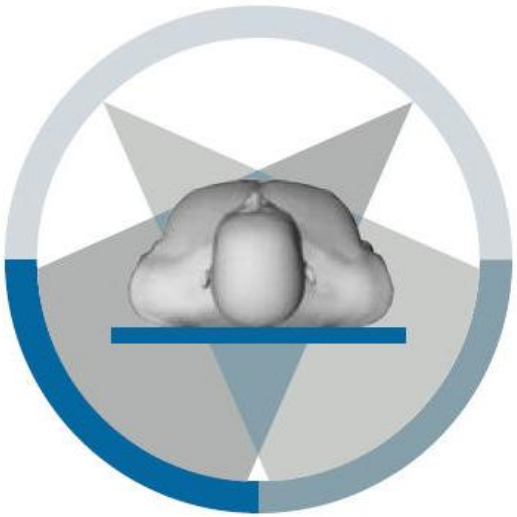
CT uma âmpola



CT uma âmpola limitado baixo pitch e reduzida velocidade de exame

DSCT Flash Spiral



Flash Spiral permite pitch 3.2 para maior rapidez de 43 cm/sec sem gaps

Flash speed. Lowest dose.
Redução da Radiação em CT

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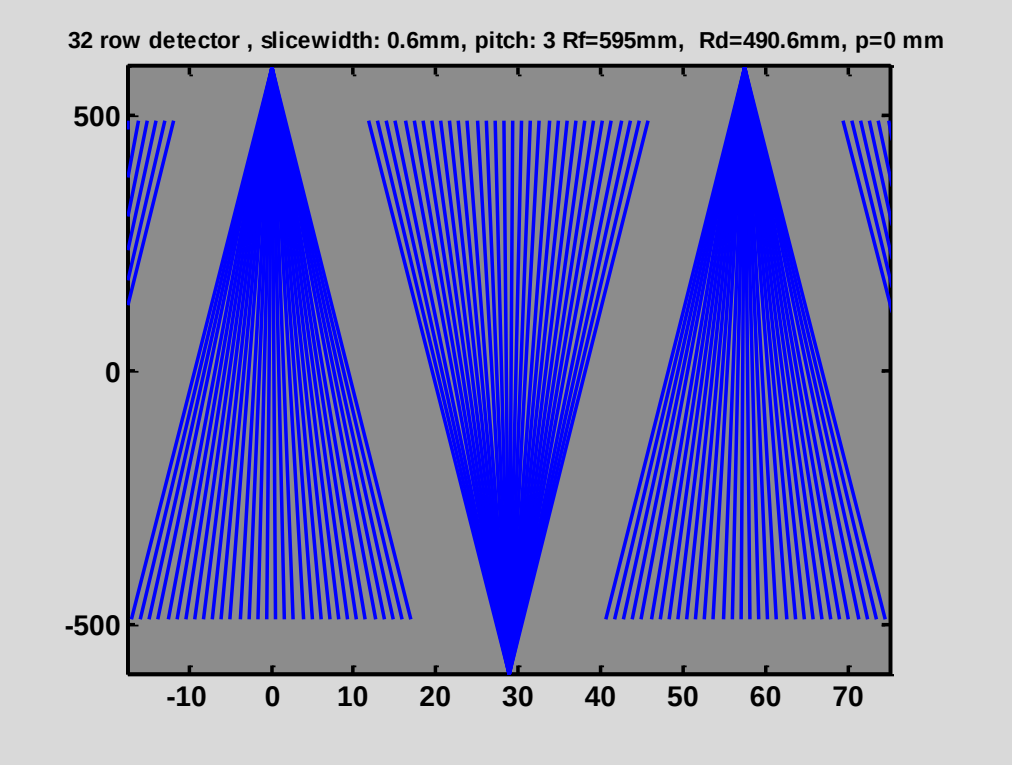
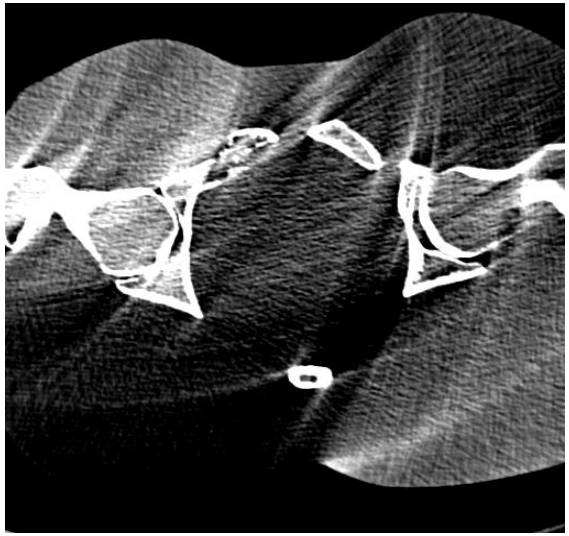
- Com os equipamentos de uma única âmpola, o pitch máximo é de 1.5 para garantir a informação necessária no eixo z.
- Uma aquisição mais rápida levaria a "gaps" no eixo z, degradando a qualidade da imagem.





Eixo z

Flash speed. Lowest dose.
Redução da Radiação em CT

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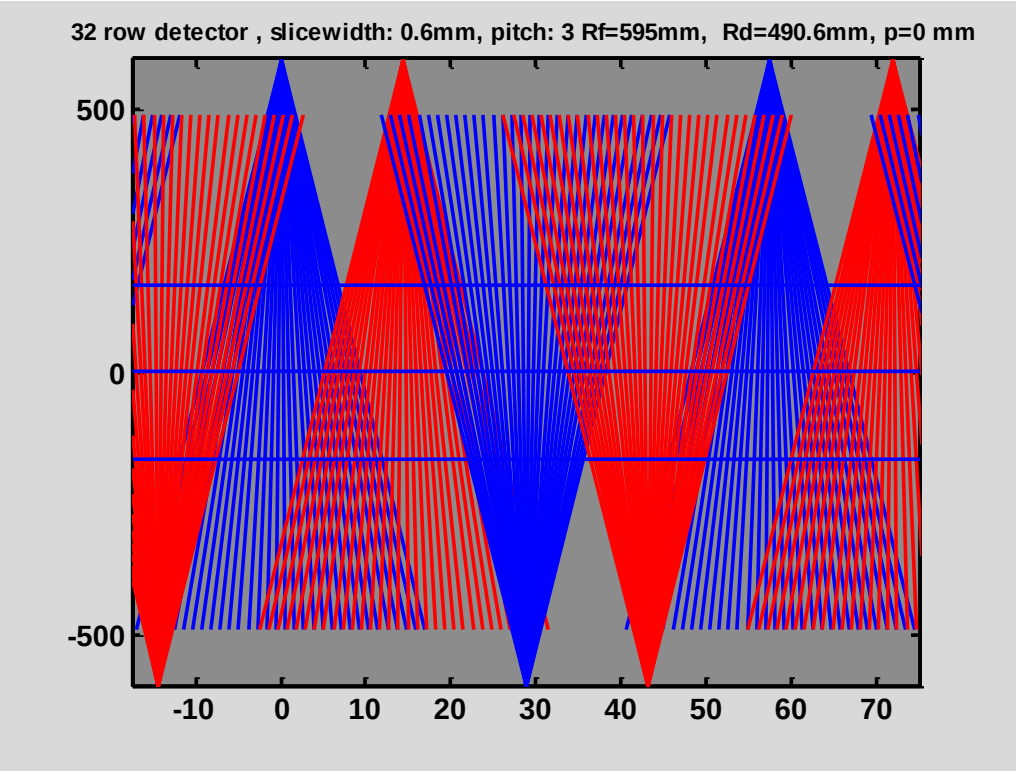
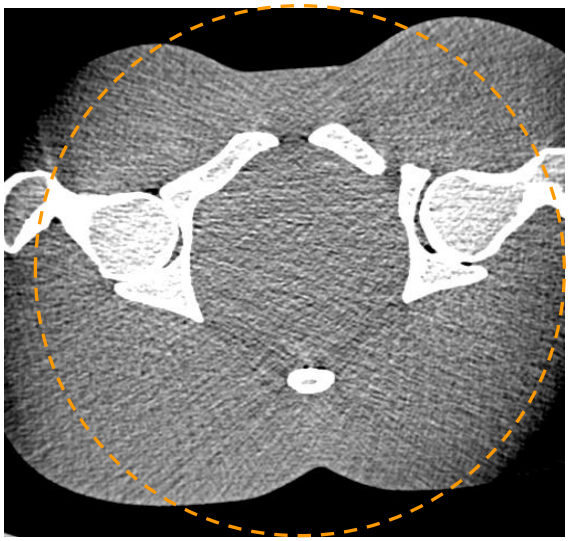
- Com a tecnologia Dual Source do Definition Flash podemos adquirir exames com um pitch de até 3.4





Eixo z

Aquisição "Flash Spiral"

Tórax Pediátrico – Flash Spiral em 0.37 s

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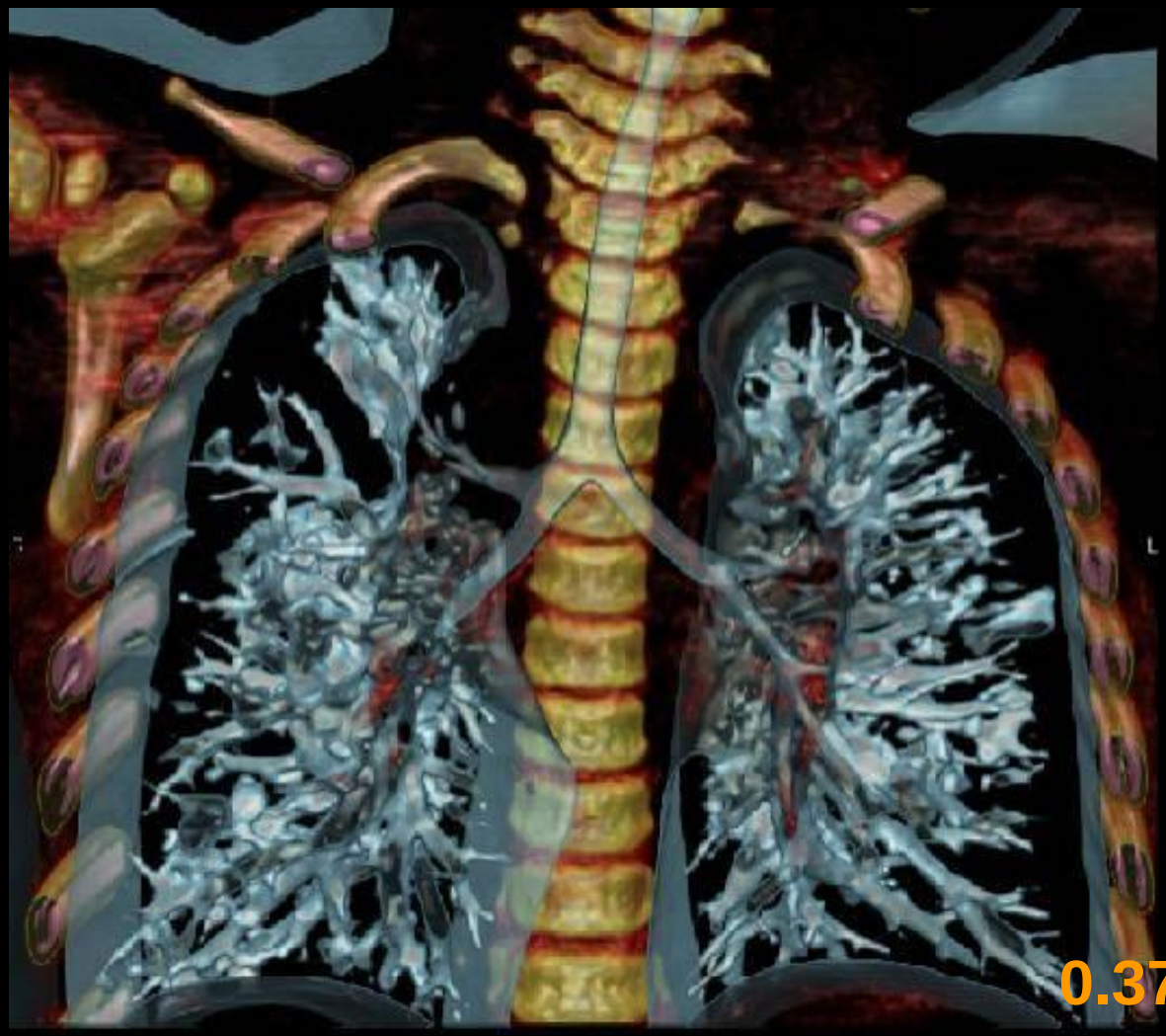

SOMATOM Definition Flash

Flash speed.
Lowest dose.

Res. temp. 75 ms
Col. 128 x 0.6 mm
Res. esp. 0.33 mm
0.37 s para 146 mm
Rotação 0.28 s
100 kV, 70 mAs / rotação

Tórax Flash Spiral

Courtesy of Friedrich-Alexander University Erlangen-Nuremberg - Institute of Medical Physics/ Erlangen, Germany

Aquisição "Flash Spiral"

Tórax Pediátrico – Sequestro extrapulmonar

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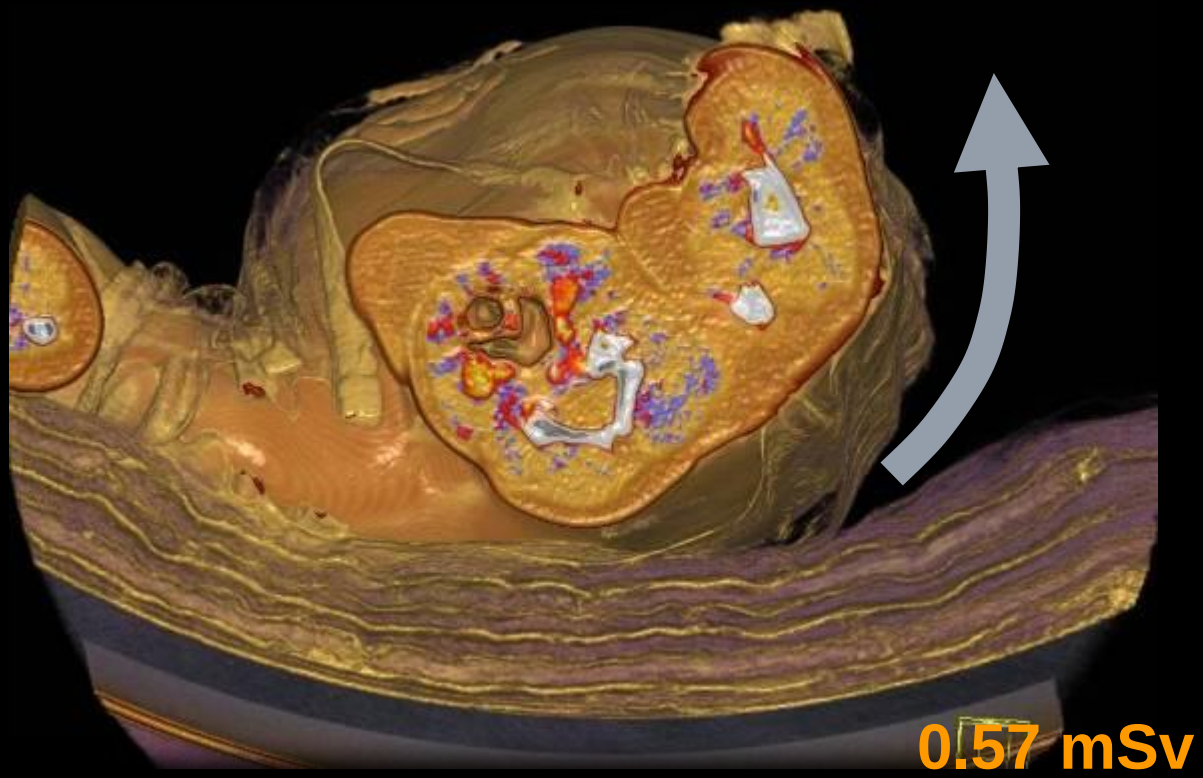
- Sem apneia
- Não colaborante
- Dose efectiva 0.57 mSv



Courtesy of Friedrich-Alexander University Erlangen-Nuremberg

SOMATOM Definition Flash: 0.33 mm spatial resolution, 0.28 second rotation, 0.57 mSv eff dose

Aquisição "Flash Spiral"

Tórax Flash Spiral

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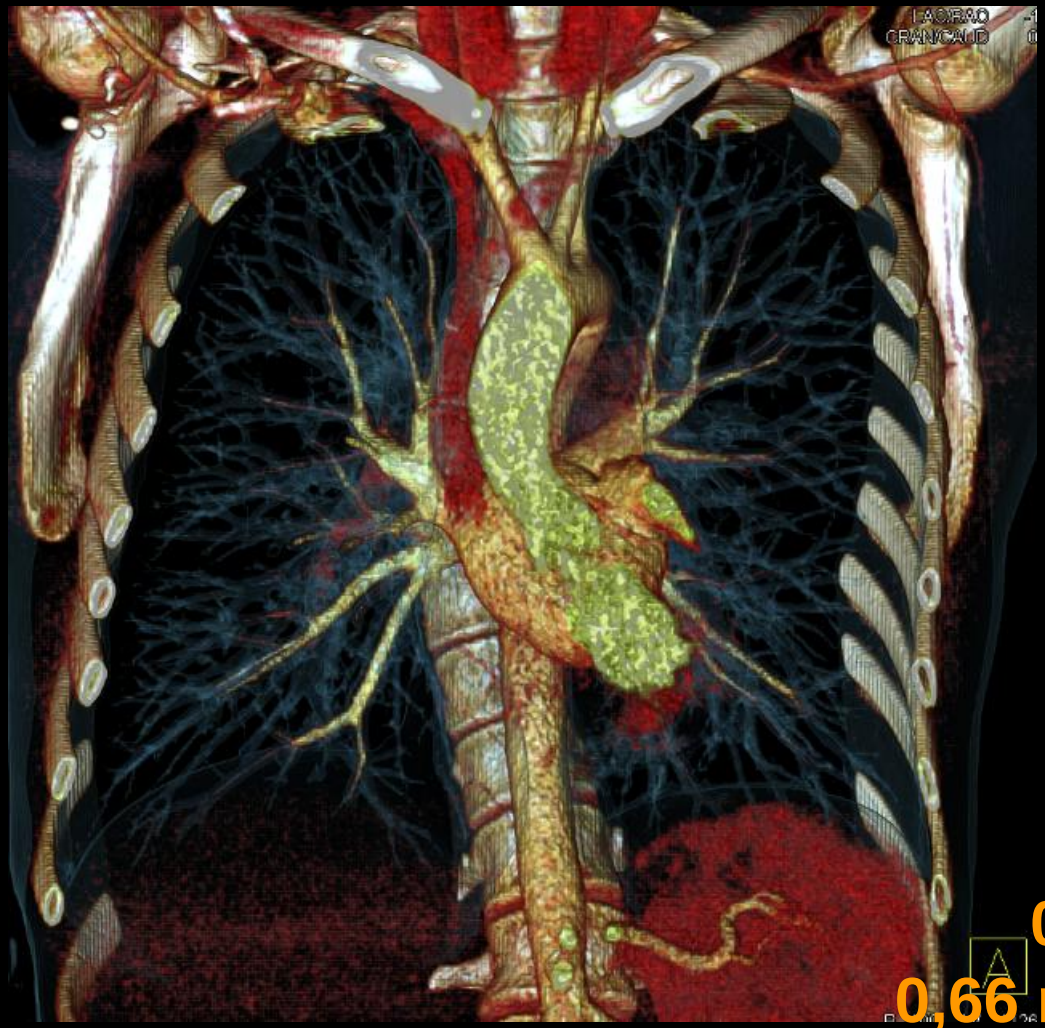

SOMATOM Definition Flash

Flash speed.
Lowest dose.

Res. temp. 75 ms
Col. 128 x 0.6 mm
Res. esp. 0.33 mm
Rotação 0.28 s
120 kV, 30 mAs / rotação

Tórax Flash Spiral

Courtesy of Dr.João Carlos Costa – Diagnóstico por Imagem; Hospital Particular de Viana do Castelo, Portugal

Aquisição Flash
Cardíacos Sub-mSv

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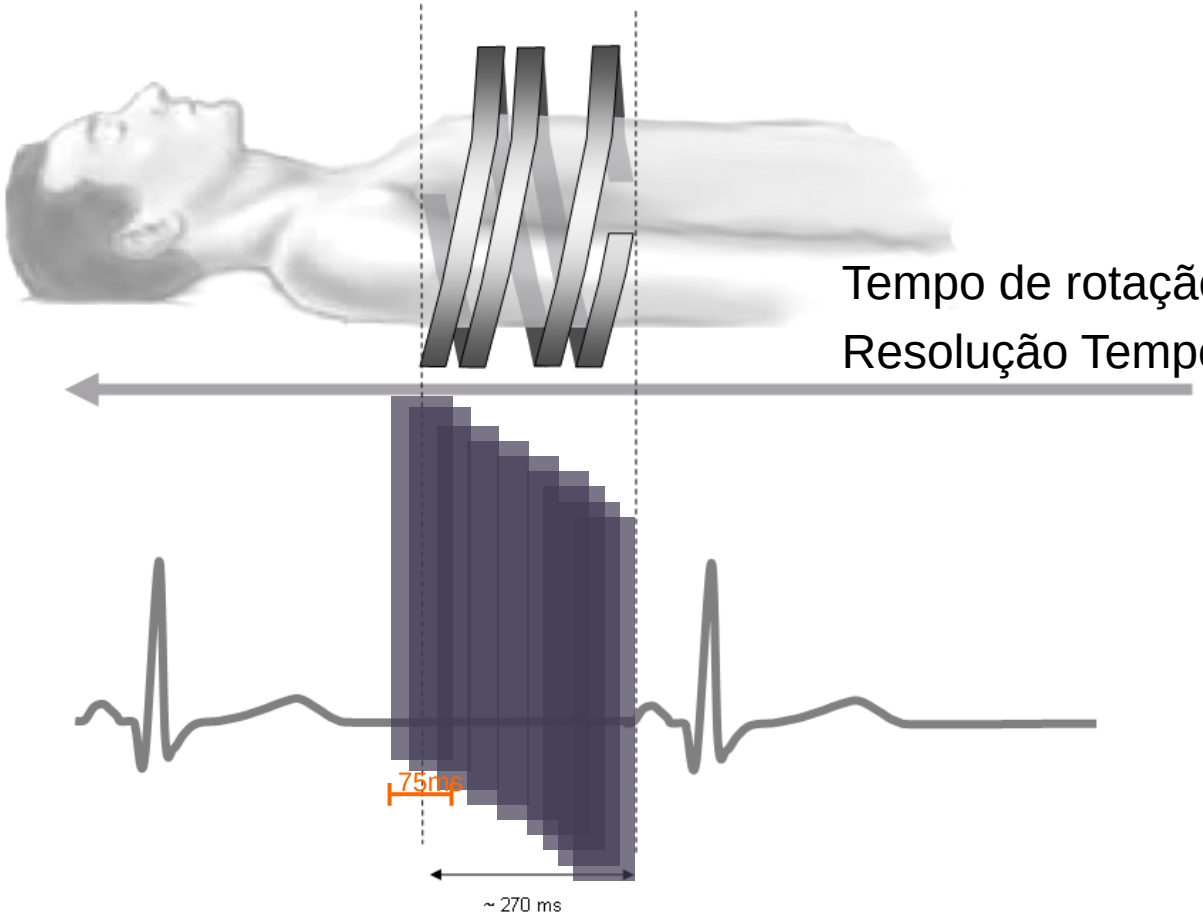
Aquisição “Flash Spiral” sincronizada com ECG (Pitch~3)



Tempo de rotação 0,28 seg.

Resolução Temporal 70 ms

Todas as imagens são adquiridas na fase diastólica de um só batimento

Aquisição "Flash Cardio Spiral"

Primeiras publicações

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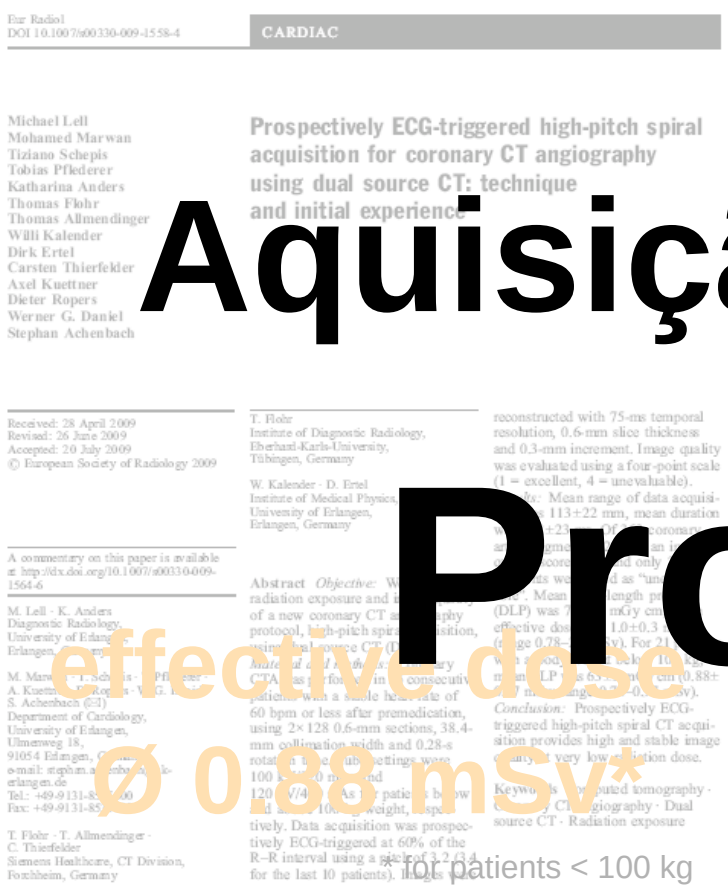
Eur Radiol
DOI 10.1007/s00330-009-1558-4

CARDIAC

Michael Lell
Mohamed Marwan
Tiziano Schepis
Tobias Pflederer
Katharina Anders
Thomas Flohr
Thomas Allmendinger
Willi Kalender
Dirk Ertel
Carsten Thierfelder
Axel Kuettner
Dieter Ropers
Werner G. Daniel
Stephan Achenbach

Prospectively ECG-triggered high-pitch spiral acquisition for coronary CT angiography using dual source CT: technique and initial experience

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M. Lell · K. Anders
Diagnostic Radiology,
University of Erlangen,
Erlangen, Germany

M. Marwan · T. Schepis · T. Pflederer · A. Kuettner · D. Ropers · W. G. Daniel · S. Achenbach (✉)
Department of Cardiology,
University of Erlangen,
Ulmenweg 18,
91054 Erlangen, Germany
e-mail: stephan.achenbach@uk-erlangen.de
Tel.: +49-9131-85-[illegible]00
Fax: +49-9131-85-[illegible]

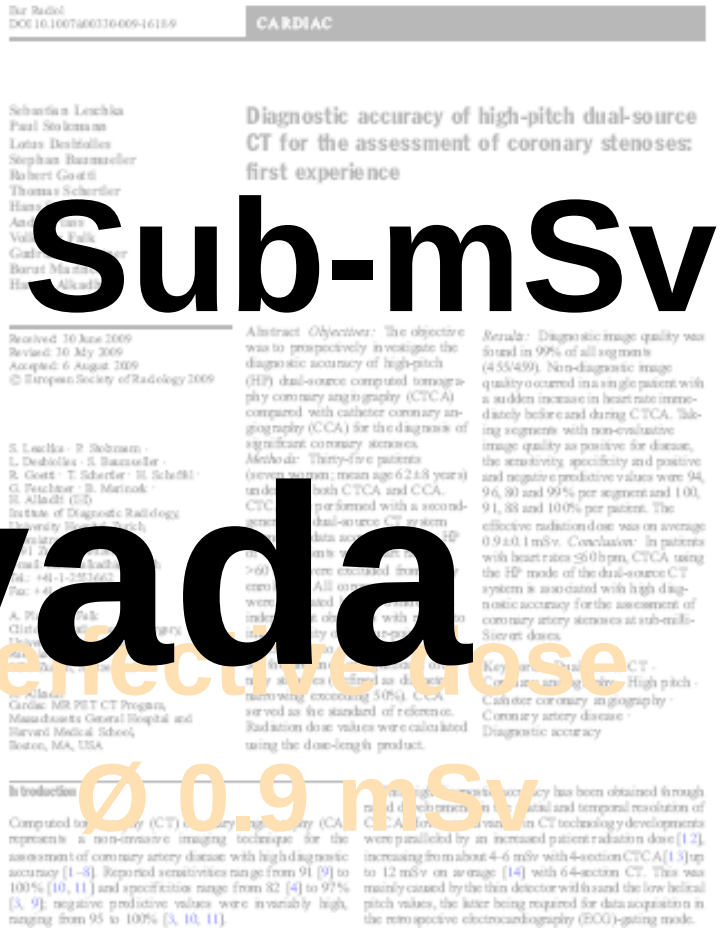
T. Flohr · T. Allmendinger · C. Thierfelder
Siemens Healthcare, CT Division,
Forchheim, Germany

T. Flohr
Institute of Diagnostic Radiology,
Eberhard-Karls-University,
Tübingen, Germany

W. Kalender · D. Ertel
Institute of Medical Physics,
University of Erlangen,
Erlangen, Germany

Abstract *Objective:* W[illegible] radiation exposure and i[illegible] of a new coronary CT a[illegible]phy protocol, high-pitch spir[illegible]isition, using dual source CT (D[illegible] *Materials and Methods:* [illegible]y CTA was performed in [illegible] consecutiv[illegible] patients with a stable heart rate of 60 bpm or less after premedication, using 2×128 0.6-mm sections, 38.4-mm collimation width and 0.28-s rotation time. Sub settings were 100 kV, 200 mAs and 120 kV/400 mAs for patie[illegible] below and above 100 kg weight, respectively. Data acquisition was prospectively ECG-triggered at 60% of the R–R interval using a pitch of 3.2/3.4 for the last 10 patients). Images were reconstructed with 75-ms temporal resolution, 0.6-mm slice thickness and 0.3-mm increment. Image quality was evaluated using a four-point scale (1 = excellent, 4 = unevaluable). *Results:* Mean range of data acquisi[illegible] 113±22 mm, mean duration [illegible] 23[illegible] of coronar[illegible] [illegible] generally [illegible] scores were [illegible] as "un[illegible]". Mean [illegible]ength p[illegible] (DLP) was 7[illegible] mGy cm[illegible] effective dose [illegible] 1.0±0.3 [illegible] (range 0.78–[illegible]). For 21 [illegible] patients [illegible] 100 kV [illegible] mean LP[illegible] 63[illegible] cm (0.88±[illegible] mSv; range [illegible]–0.[illegible] mSv). *Conclusion:* Prospectively ECG-triggered high-pitch spiral CT acquisition provides high and stable image quality at very low radiation dose.

Keywords Computed tomography · Coronary CT angiography · Dual source CT · Radiation exposure


Eur Radiol
DOI 10.1007/s00330-009-1618-9

CARDIAC

Sebastian Leschka
Paul Stolzmann
Lotus Desbiolles
Stephan Baumueller
Robert Goetti
Thomas Schertler
Hans[illegible]
An[illegible]
Vo[illegible]
Gab[illegible]
Barut Ma[illegible]
Ha[illegible] Alkadhi

Diagnostic accuracy of high-pitch dual-source CT for the assessment of coronary stenoses: first experience

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S. Leschka · P. Stolzmann · L. Desbiolles · S. Baumueller · R. Goetti · T. Schertler · H. Scheffel · G. Feuchter · B. Marincek · H. Alkadhi (✉)
Institute of Diagnostic Radiology,
University Hospital Zurich,
[illegible]
Tel.: +41-1-255[illegible]
Fax: +[illegible]

A. [illegible]
Cardiac MR PET CT Program,
Massachusetts General Hospital and
Harvard Medical School,
Boston, MA, USA

Abstract *Objectives:* The objective was to prospectively investigate the diagnostic accuracy of high-pitch (HP) dual-source computed tomography coronary angiography (CTCA) compared with catheter coronary angiography (CCA) for the diagnosis of significant coronary stenoses. *Methods:* Thirty-five patients (seven women; mean age 62±8 years) underwent both CTCA and CCA. CTCA was performed with a second-generation dual-source CT system in HP mode. [illegible] data acquisition [illegible] were excluded from [illegible]. All other patients were included [illegible] with a heart rate [illegible] 60 bpm. CTCA [illegible] with CCA served as the standard of reference. Radiation dose values were calculated using the dose-length product. *Results:* Diagnostic image quality was found in 99% of all segments (455/459). Non-diagnostic image quality occurred in a single patient with a sudden increase in heart rate immediately before and during CTCA. Taking segments with non-evaluative image quality as positive for disease, the sensitivity, specificity and positive and negative predictive values were 94, 96, 80 and 99% per segment and 100, 91, 88 and 100% per patient. The effective radiation dose was on average 0.9±0.1 mSv. *Conclusion:* In patients with heart rates ≤60 bpm, CTCA using the HP mode of the dual-source CT system is associated with high diagnostic accuracy for the assessment of coronary artery stenoses at sub-mSv Sievert doses.

Keywords [illegible] CT · Coronary artery [illegible] · High pitch · Catheter coronary angiography · Coronary artery disease · Diagnostic accuracy

Introduction

Computed to[illegible]y (CT) c[illegible]y angiography (CA[illegible]) represents a non-invasive imaging technique for the assessment of coronary artery disease with high diagnostic accuracy [1–8]. Reported sensitivities range from 91 [9] to 100% [10, 11] and specificities range from 82 [4] to 97% [3, 9]; negative predictive values were invariably high, ranging from 95 to 100% [3, 10, 11]. [illegible] accuracy has been obtained through [illegible] improvements in spatial and temporal resolution of CT. A [illegible] CT technology developments were paralleled by an increased patient radiation dose [12], increasing from about 4–6 mSv with 4-section CTCA [13] up to 12 mSv on average [14] with 64-section CT. This was mainly caused by the thin detector width and the low helical pitch values, the latter being required for data acquisition in the retrospective electrocardiography (ECG)-gating mode.

Aquisição Sub-mSv

Provada

effective dose
Ø 0.88 mSv*

effective dose
Ø 0.9 mSv

* for patients < 100 kg

Aquisição Flash
Cardíacos Sub-mSv

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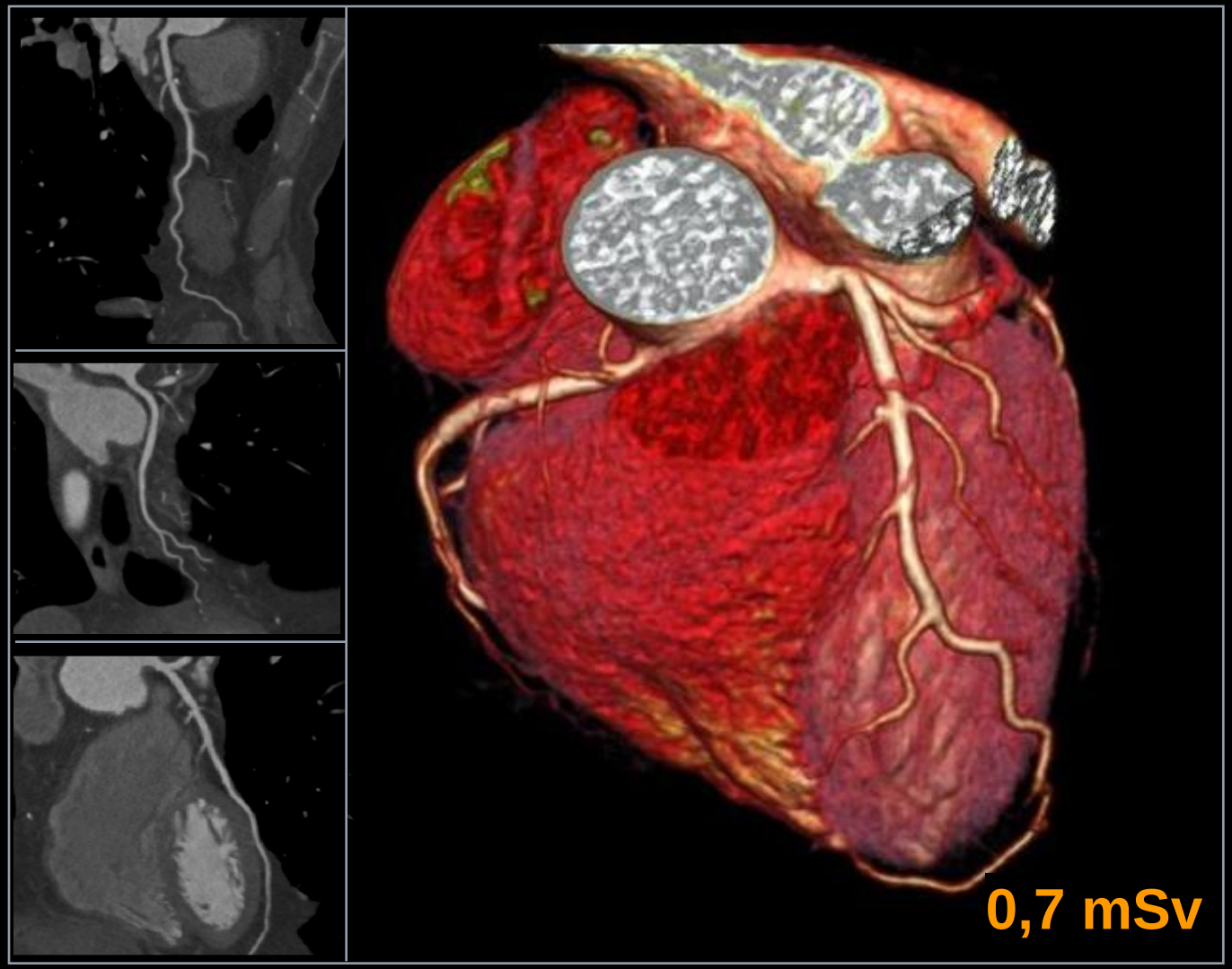


SOMATOM Definition Flash

Flash speed.
Lowest dose.

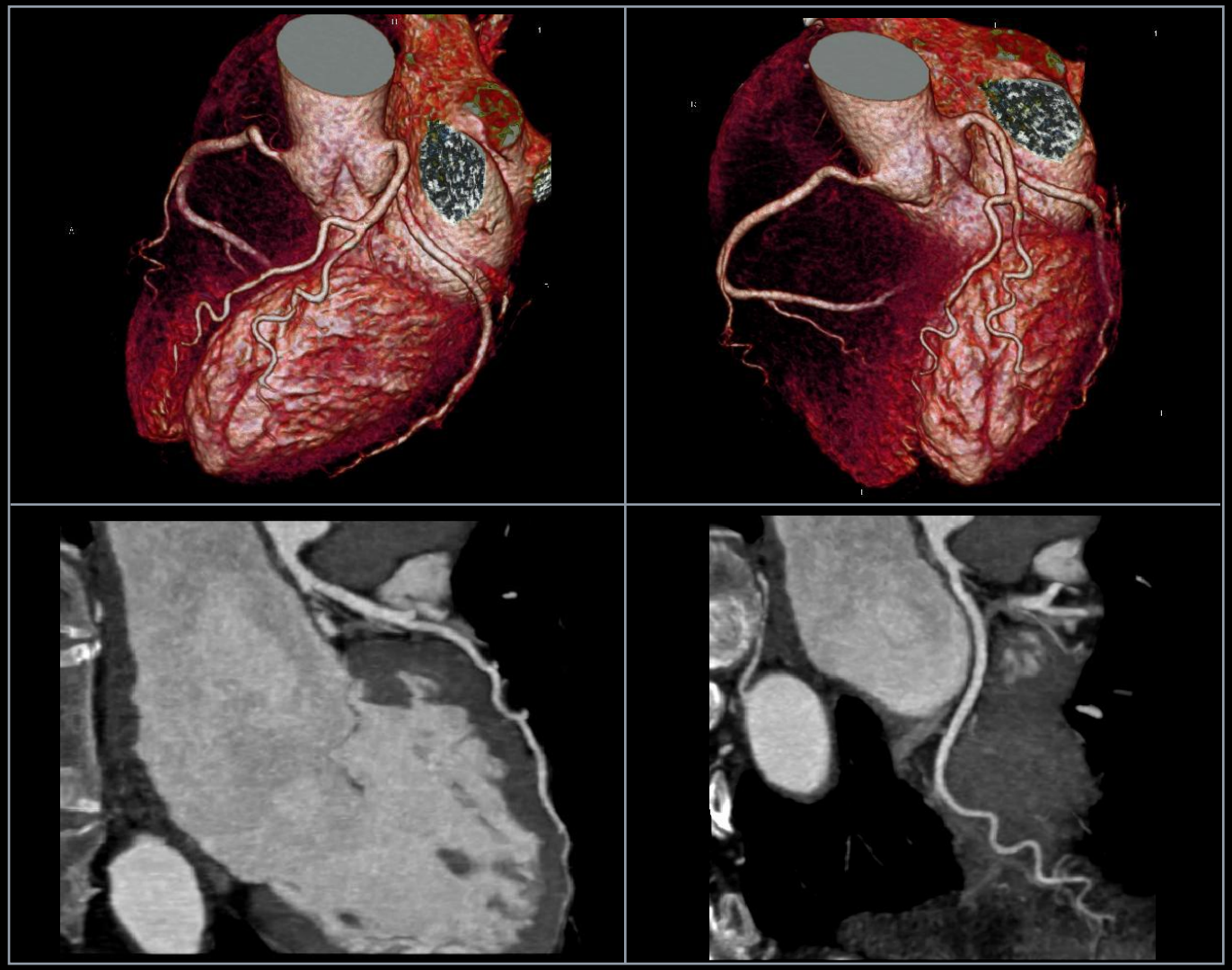
Resol. Temp. 75 ms
Col. 128 x 0.6 mm
Resol. Esp. 0.33 mm
230 ms para 100 mm
Rotação 0.28 s
100 kV, 320 mAs / rotação

Flash Spiral Cardio
0.7 mSv

Courtesy of Friedrich-Alexander University Erlangen-Nuremberg - Institute of Medical Physics/ Erlangen, Germany

SOMATOM Definition Flash
Flash Spiral

SIEMENS



SOMATOM Definition Flash

Flash speed.
Lowest dose.

Resol. Temp. 75 ms
Col. 128 x 0.6 mm
Resol. Esp. 0.33 mm
270 ms para 120 mm
Rotação 0.28 s
100 kV, 320 mAs / rotação

0.95 mSv

0,95 mSv

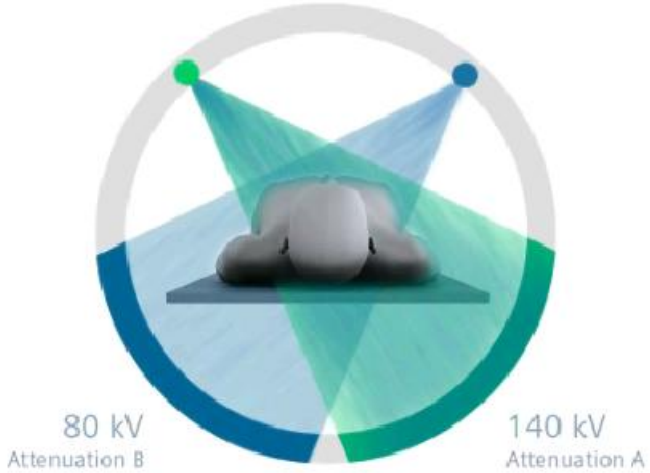
Courtesy of Friedrich-Alexander University Erlangen-Nuremberg - Institute of Medical Physics / Erlangen, Germany

Redução da Radiação em CT

Dupla Energia sem compromisso de dose

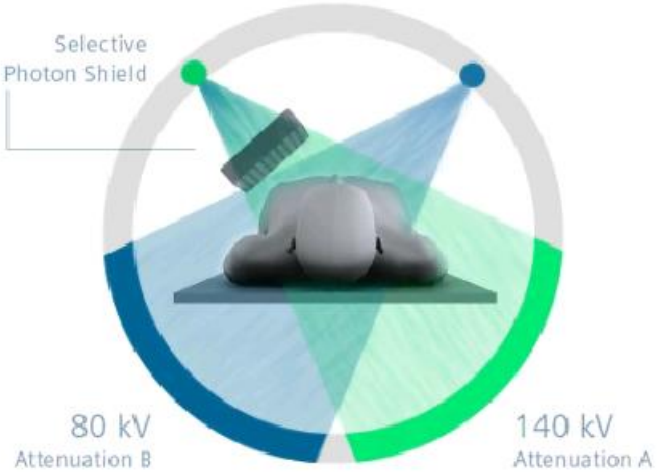
SIEMENS

Dual Energy



- **Caracterização tecidular**
- **Sempre segundo contraste**

DE com Selective Photon Shield



- **Caracterização tecidular**
- **Sempre segundo contraste**
- **Dose-neutra** comparado com exame convencional 120 kV

Redução da Radiação em CT

Dupla Energia sem compromisso de dose

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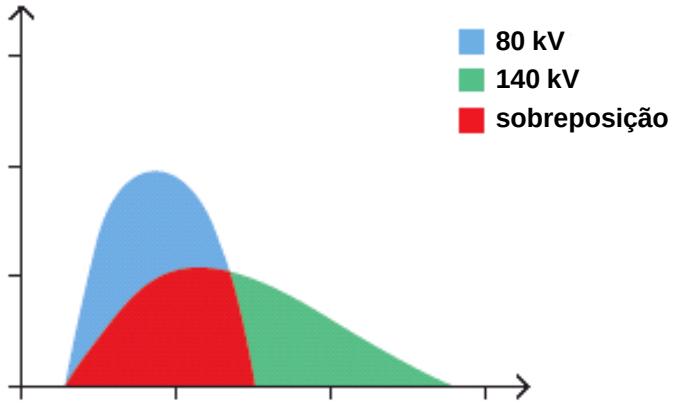
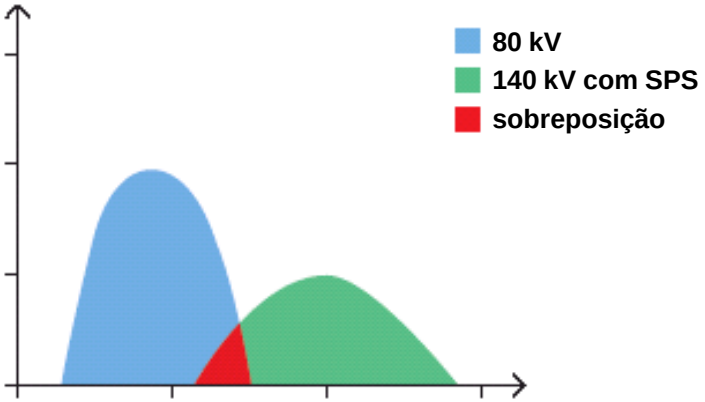
DE Convencional



- Sobreposição significante do espectro
- Limita separação da energia
- **Limita eficiência da dose**

DE com Selective Photon Shield



- Minimiza sobreposição do espectro
- Melhoria de 80% na separação de energia
- **Neutralidade completa da dose**
- **Apenas “Dual Source”**

Redução da Radiação em CT

Resultados Iniciais – grupo Grosshadern (submitido a publicação)

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Estudo

- Fantoma Antropomórfico "Alderson" com detectores termoluminescentes (TLD)
- 100/140Sn kV, 120 kV

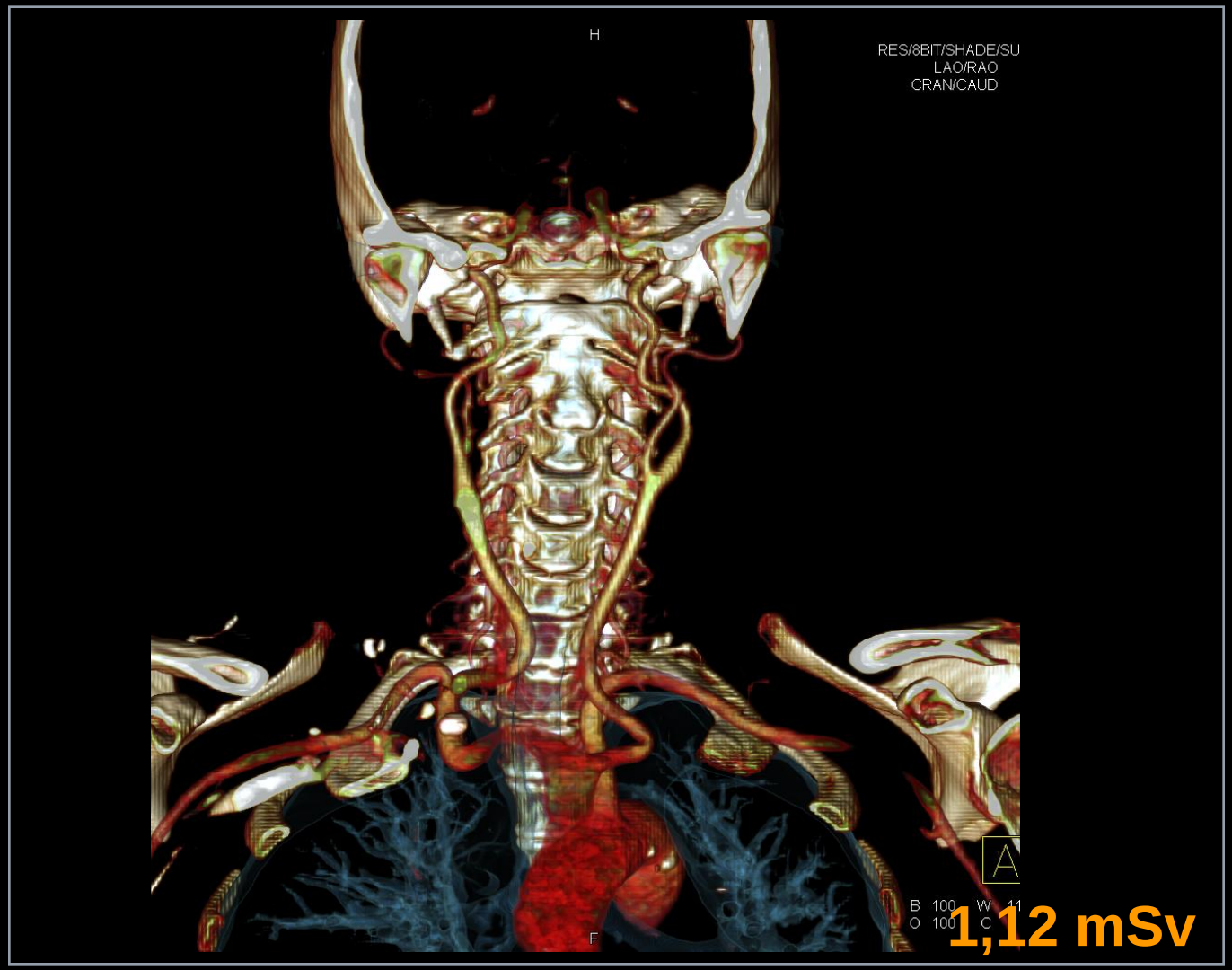
"A Dupla Energia pode ser usada em CT por rotina sem qualquer compromisso de dose ou qualidade de imagem"

Neutralidade da dose

Provada

Dupla Energia sem compromisso de dose

DE Head Bone Removal – Angiografia Carótidas e Polígono de Willis



SOMATOM Definition Flash

Flash speed.
Lowest dose.

Res. temp. 75 ms
Col. 128 x 0.6 mm
Res. esp. 0.33 mm
Rotação 0.28 s
100/Sn140 kV
100/130 mAs ref.

DE Head Bone Removal

Courtesy of Dr.João Carlos Costa – Diagnóstico por Imagem; Hospital Particular de Viana do Castelo, Portugal

Dupla Energia sem compromisso de dose

DE Head Bone Removal – Angiografia Carótidas e Polígono de Willis

SOMATOM Definition Flash

Flash speed.
Lowest dose.

Res. temp. 75 ms
Col. 128 x 0.6 mm
Res. esp. 0.33 mm
Rotação 0.28 s

DE Head Bone Removal

1,12 mSv

Courtesy of Dr.João Carlos Costa – Diagnóstico por Imagem; Hospital Particular de Viana do Castelo, Portugal

Perfusão de Volume
Adaptive 4D Spiral

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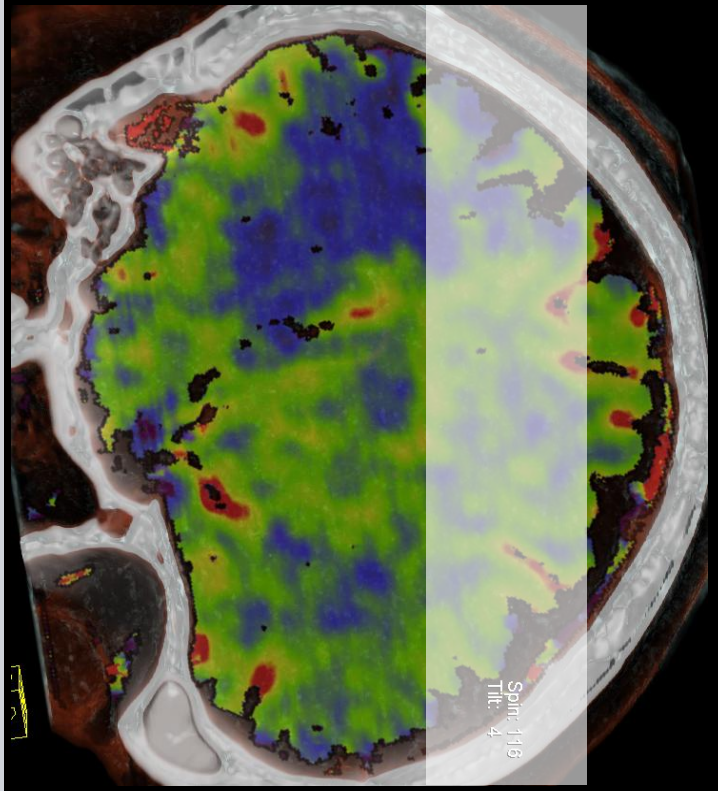
Within weeks of Alabama teacher Becky Coudert's CT perfusion brain scan, a bald strip circled her head. She reportedly had received several times the correct dose of radiation. (December 7, 2009)

Adaptive 4D Spiral: Perfusão de Volume

Cobertura de até 14.6 cm com 50% de redução de dose



Future 510(k). The information about this product is being provided for planning purposes.
The product requires 510(k) review and is not commercially available in the U.S.

Adaptive 4D Spiral

Redução 4D do Ruído – Princípio similar MPEG

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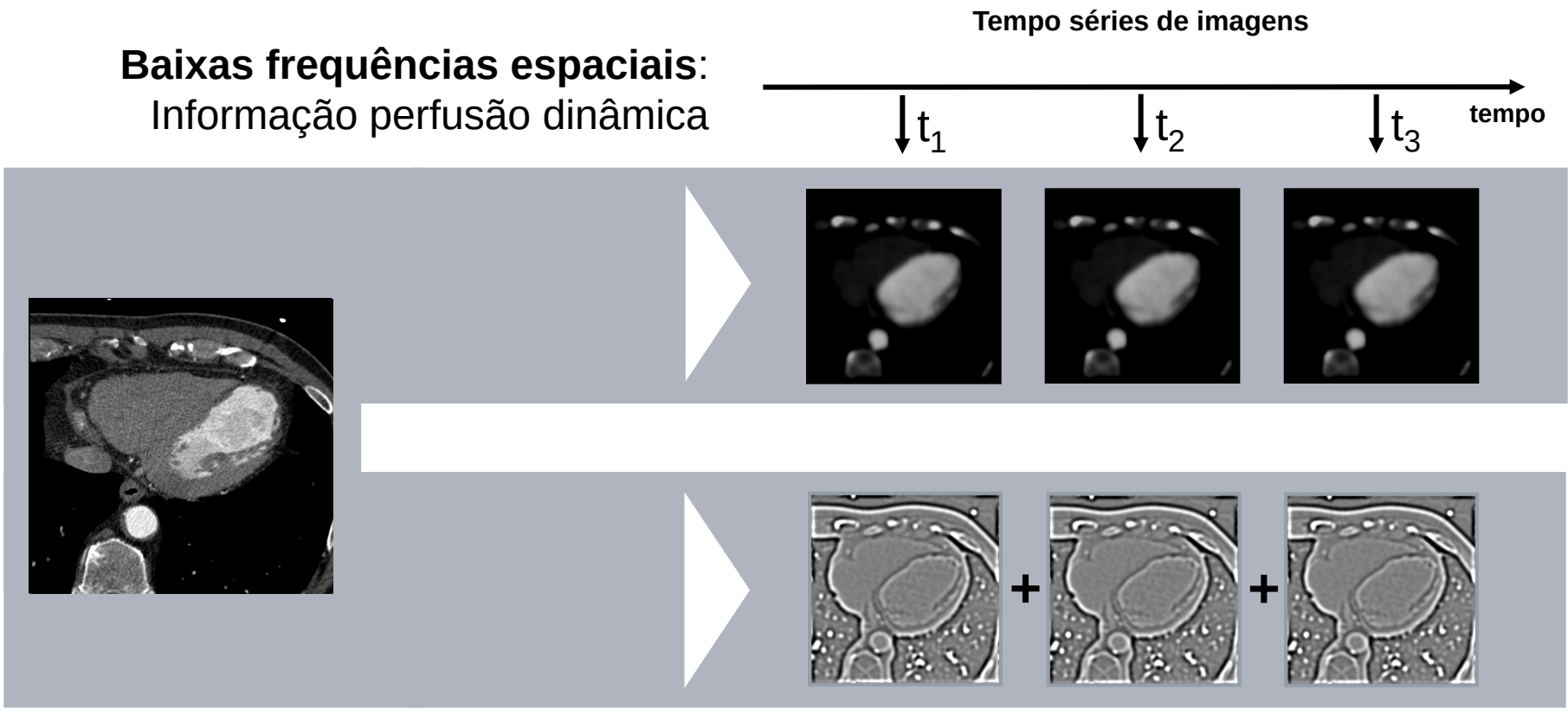
Baixas frequências espaciais:
Informação perfusão dinâmica



Altas frequências espaciais :
Info anatómica estática, detalhes + ruído

Redução ruído da imagem pela acumulação de dose

Adaptive 4D Spiral
Redução 4D do Ruído

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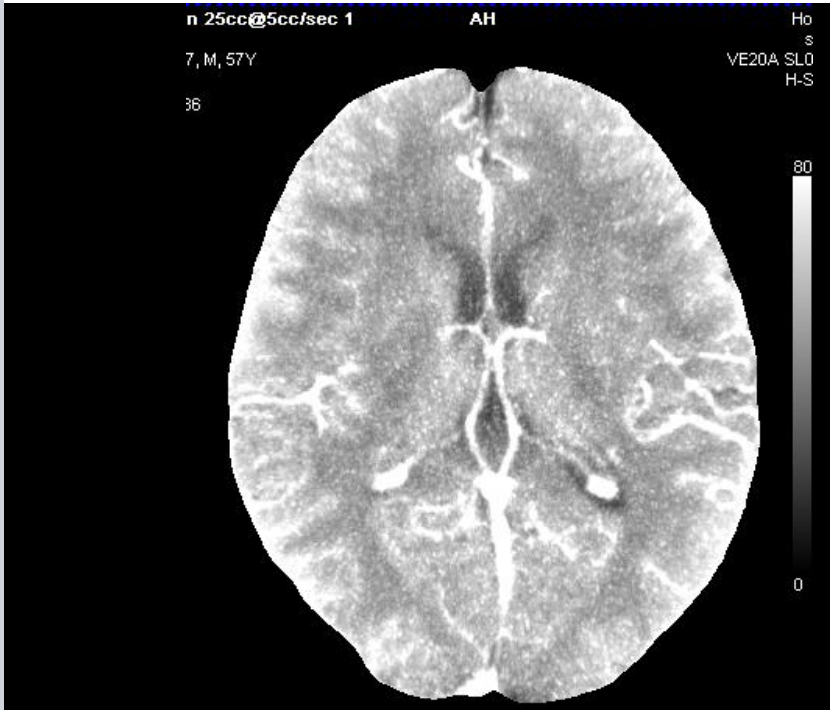
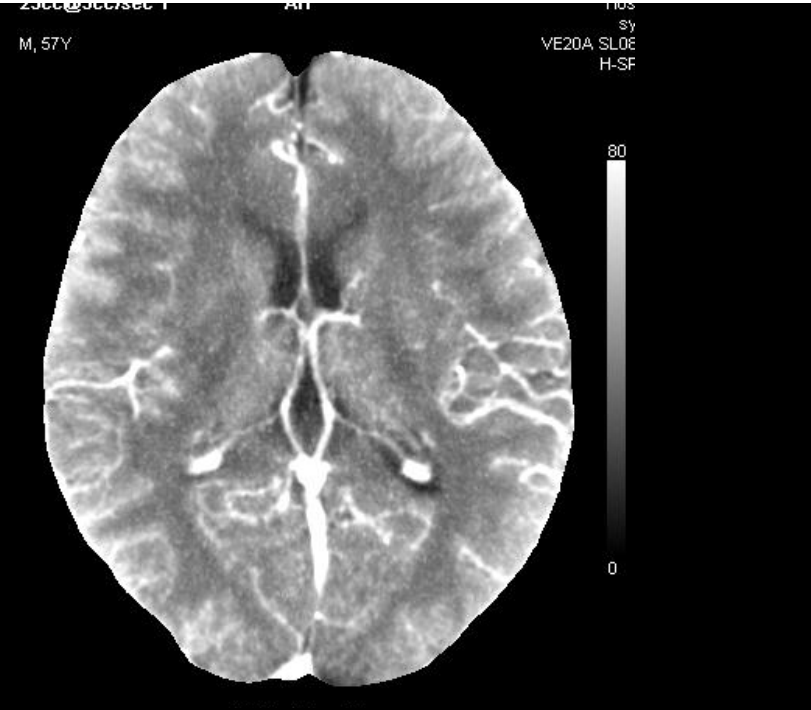


Sem redução 4D do ruído



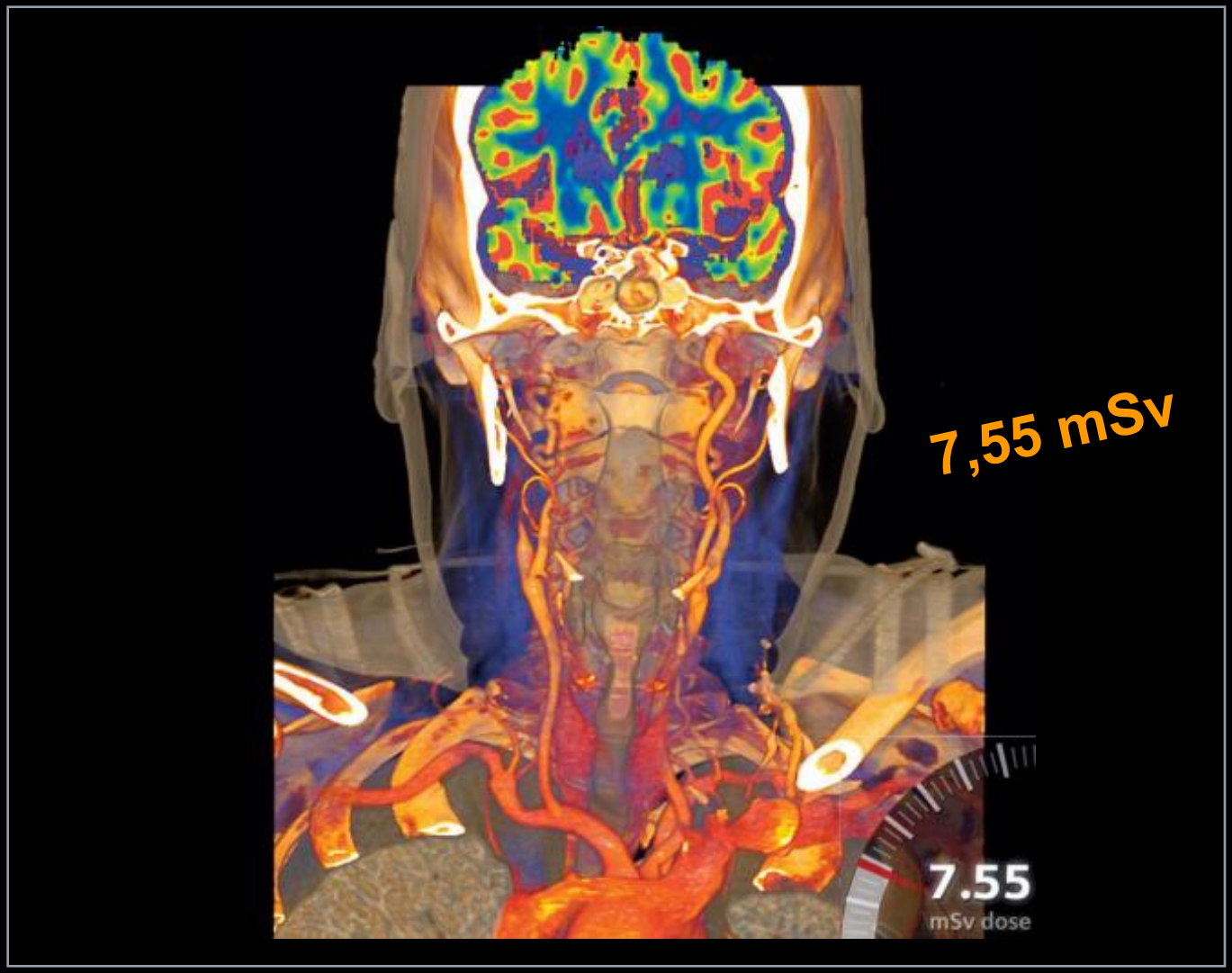
Com redução 4D do ruído

- Reduz dose até 50% sem compromisso da qualidade de imagem

Adaptive 4D Spiral: Perfusão de Volume

Perfusão após oclusão de stent

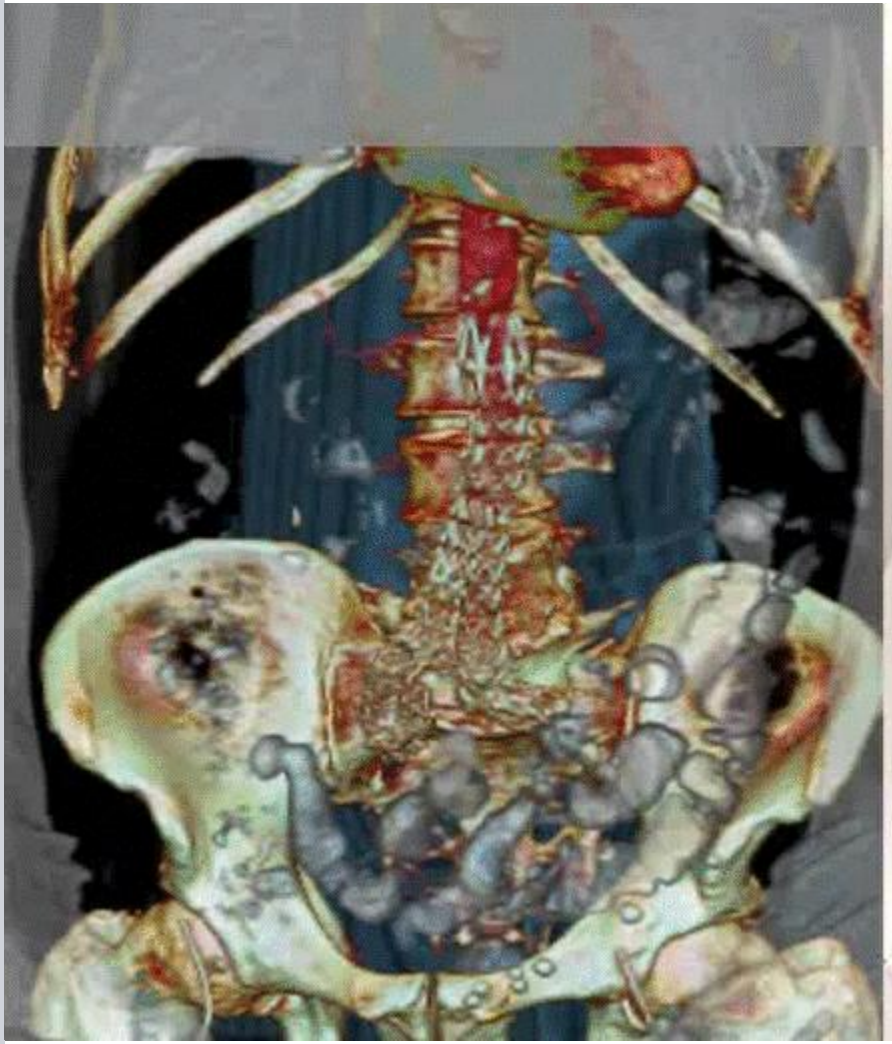
SIEMENS



Courtesy of Robert McGregor, MD; Boundary Trails Health Centre; Canada

Adaptive 4D Spiral

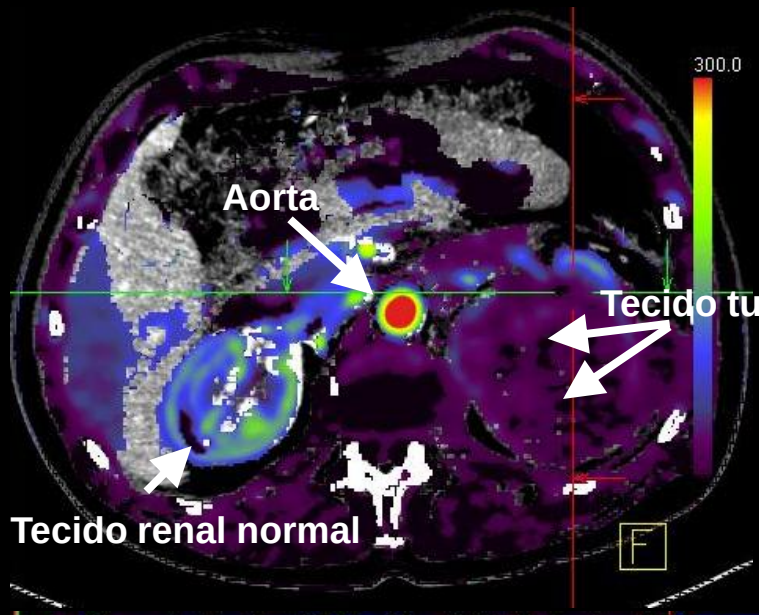
Estudos dinâmicos de 48 cm para cobertura total da região

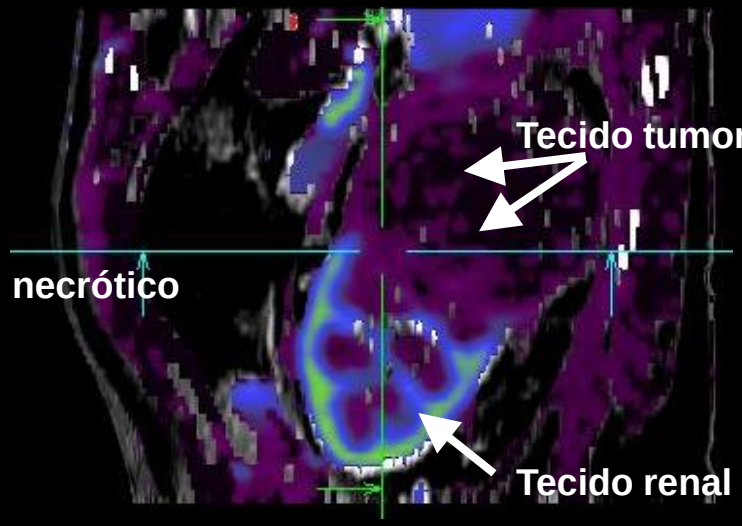


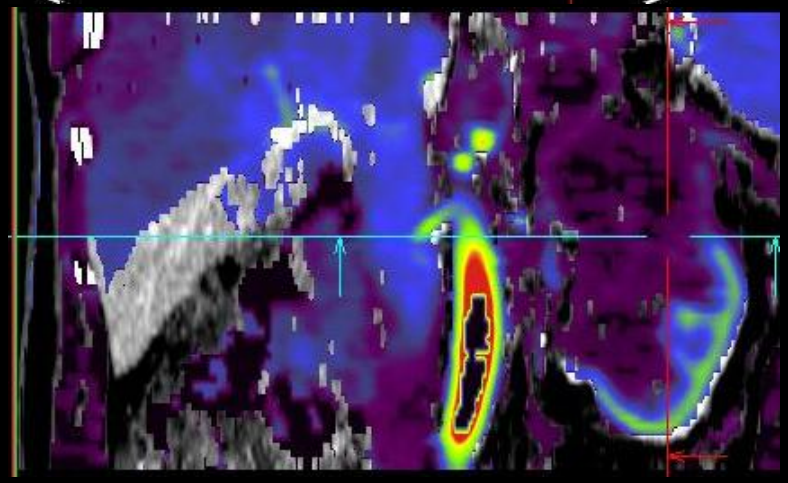
Perfusão Volumétrica de Corpo

Baixa perfusão de tumor renal após terapia

SIEMENS







Exemplo: Baixa perfusão de tecido tumoral renal indica terapia anti angiogénica bem sucedida

- **Baixa perfusão**
- **Perfusão normal**
- **Alta perfusão**

Courtesy of Dept of Radiology University of Munich / Grosshadern, Germany

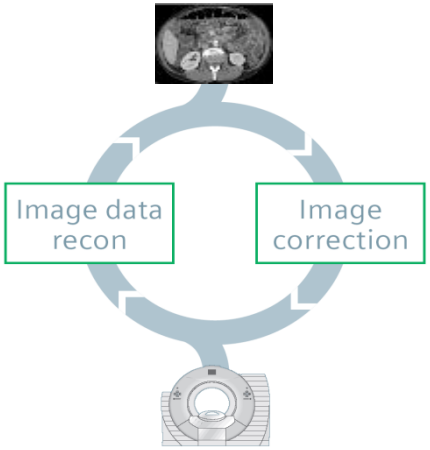
IRIS – “Iterative Reconstruction in Image Space”

Até 60% redução da dose ou melhor qualidade de imagem

Standard Filtered Back Projection

- Redução de dose limitada
- Boa qualidade de imagem

Iterative Recon. in Image Space



- Até 60% redução de dose
  ou
- Melhor qualidade de imagem

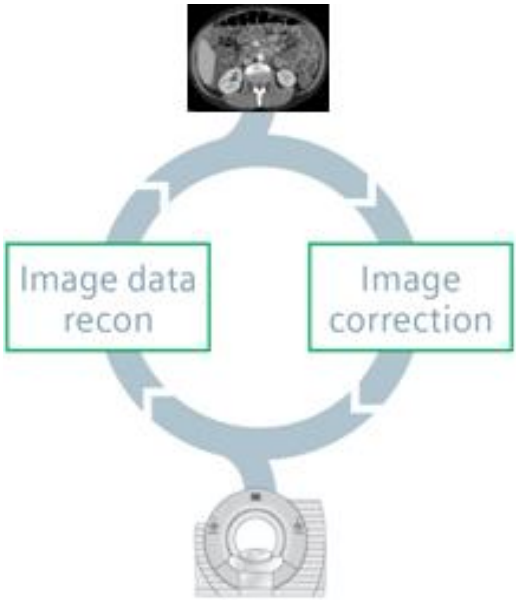
IRIS – “Iterative Reconstruction in Image Space”

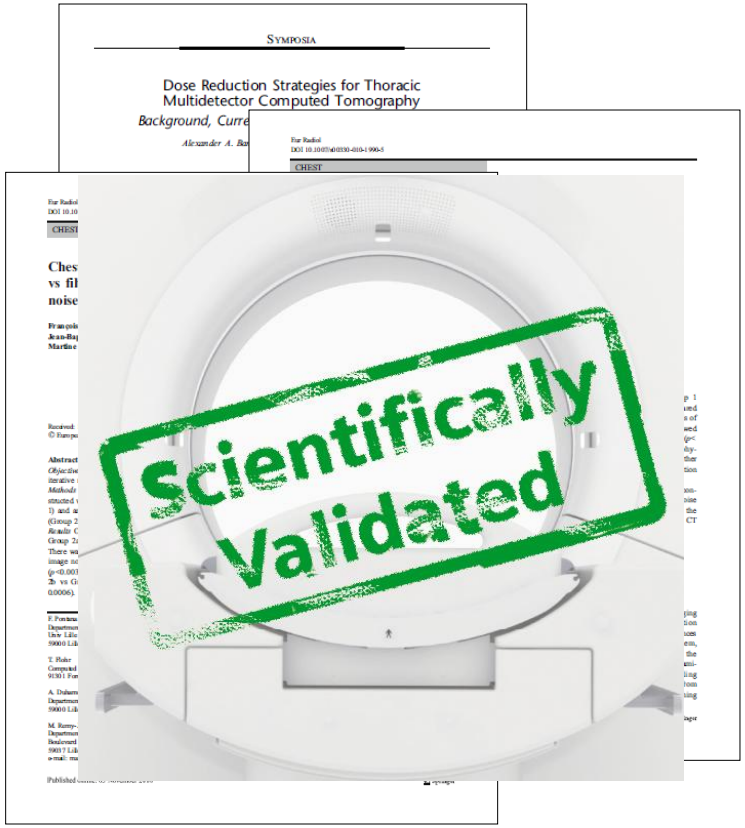
Até 60% redução da dose ou melhor qualidade de imagem

SIEMENS

Redução da dose até

60%

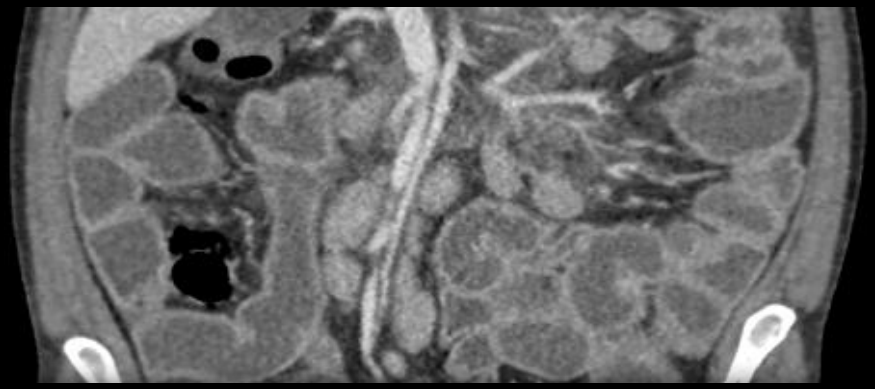




IRIS

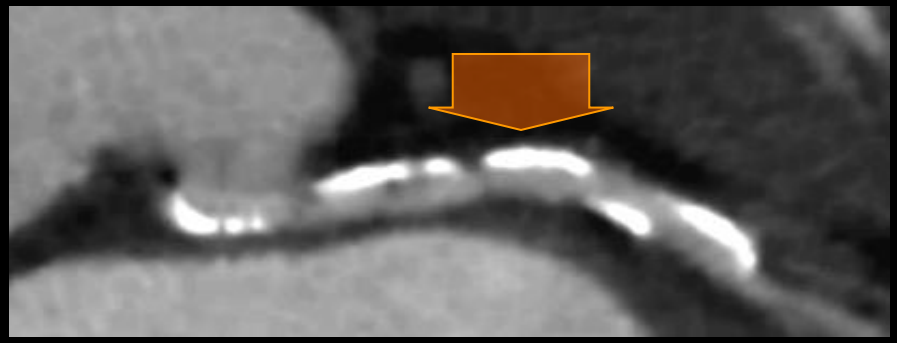
Até 60% redução da dose ou melhor qualidade de imagem

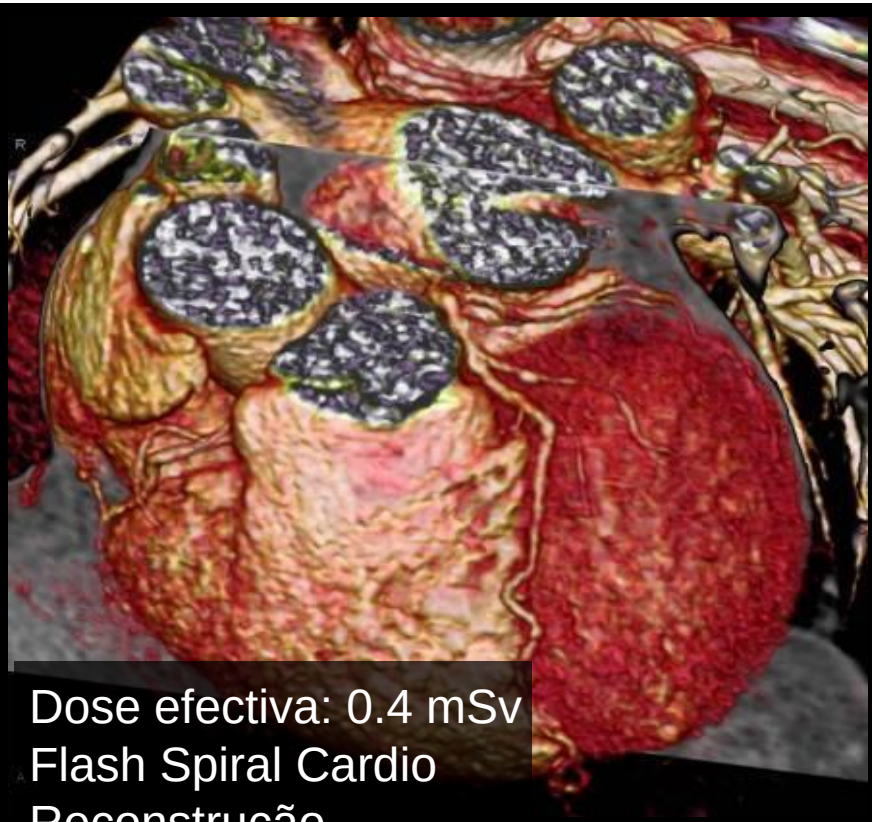
Iterative Recon. in Image Space



Abdomen rotina com menos 60% de dose

IRIS reduz artefactos





Dose efectiva: 0.4 mSv
Flash Spiral Cardio
Reconstrução
“Iterative”

Courtesy of German Heart Center/ Munich, Germany

SAFIRE

Sinogram Affirmed Iterative Reconstruction

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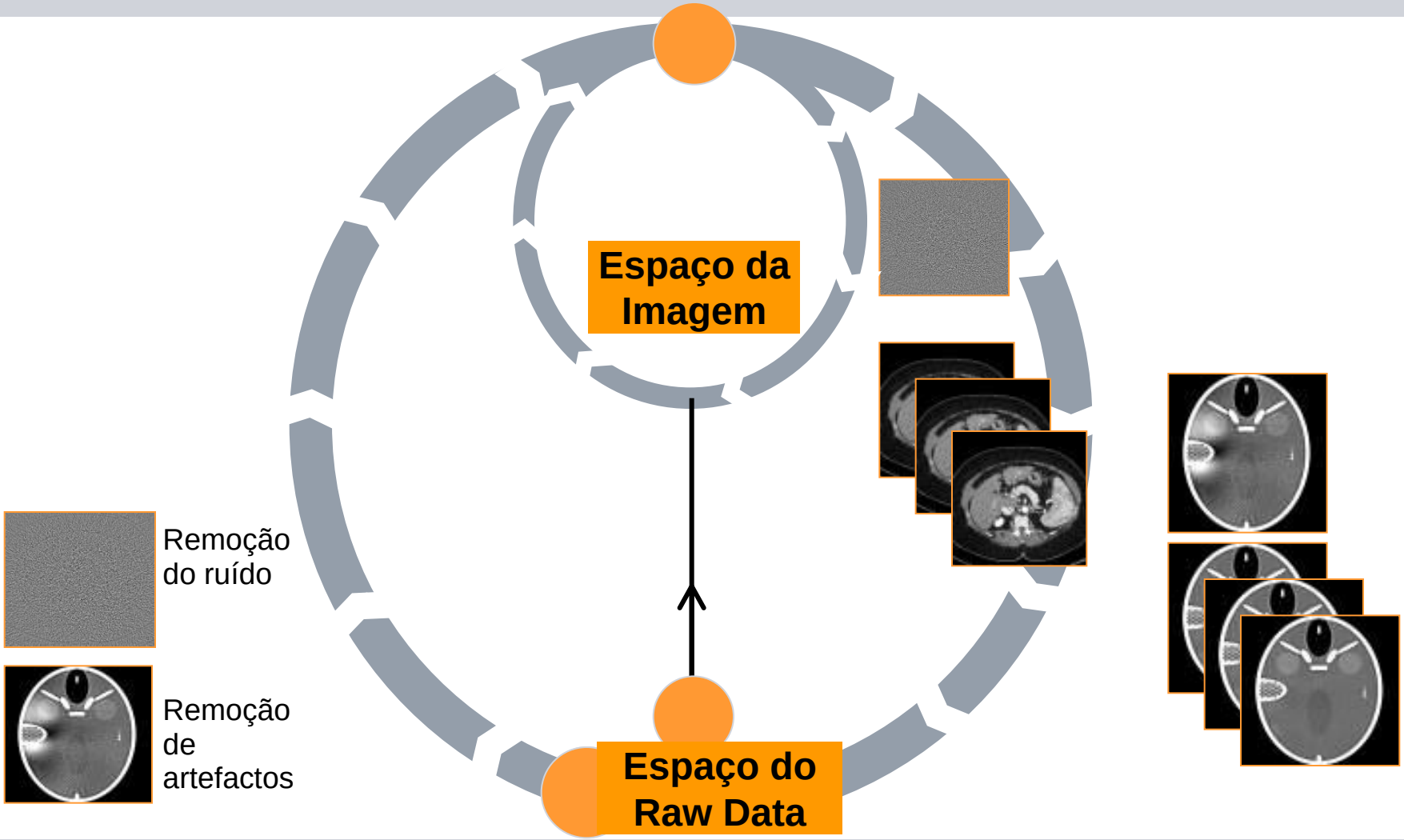
SAFIRE

A primeira reconstrução iterativa no espaço do Raw Data



SAFIRE

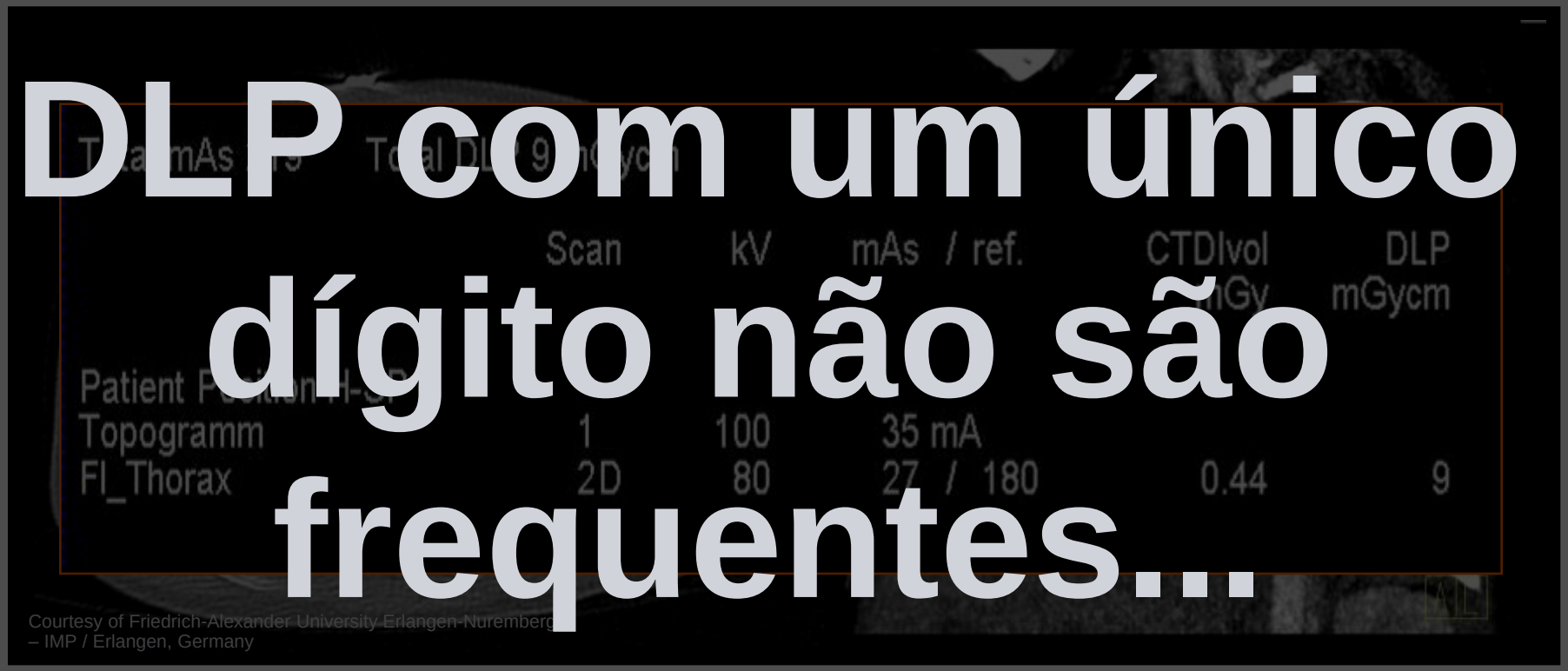
Até 60% redução da dose com superior qualidade de imagem

- Maior redução de dose e de artefactos que os métodos baseados na imagem
- Até 60% de redução da dose
- Qualidade de imagem superior
- Workflow melhorado e qualidade de imagem customizada

Avanços Tecnológicos
na **Redução da Radiação em CT**

SIEMENS

- Criança 17 meses
- Estadiamento oncológico pumonar

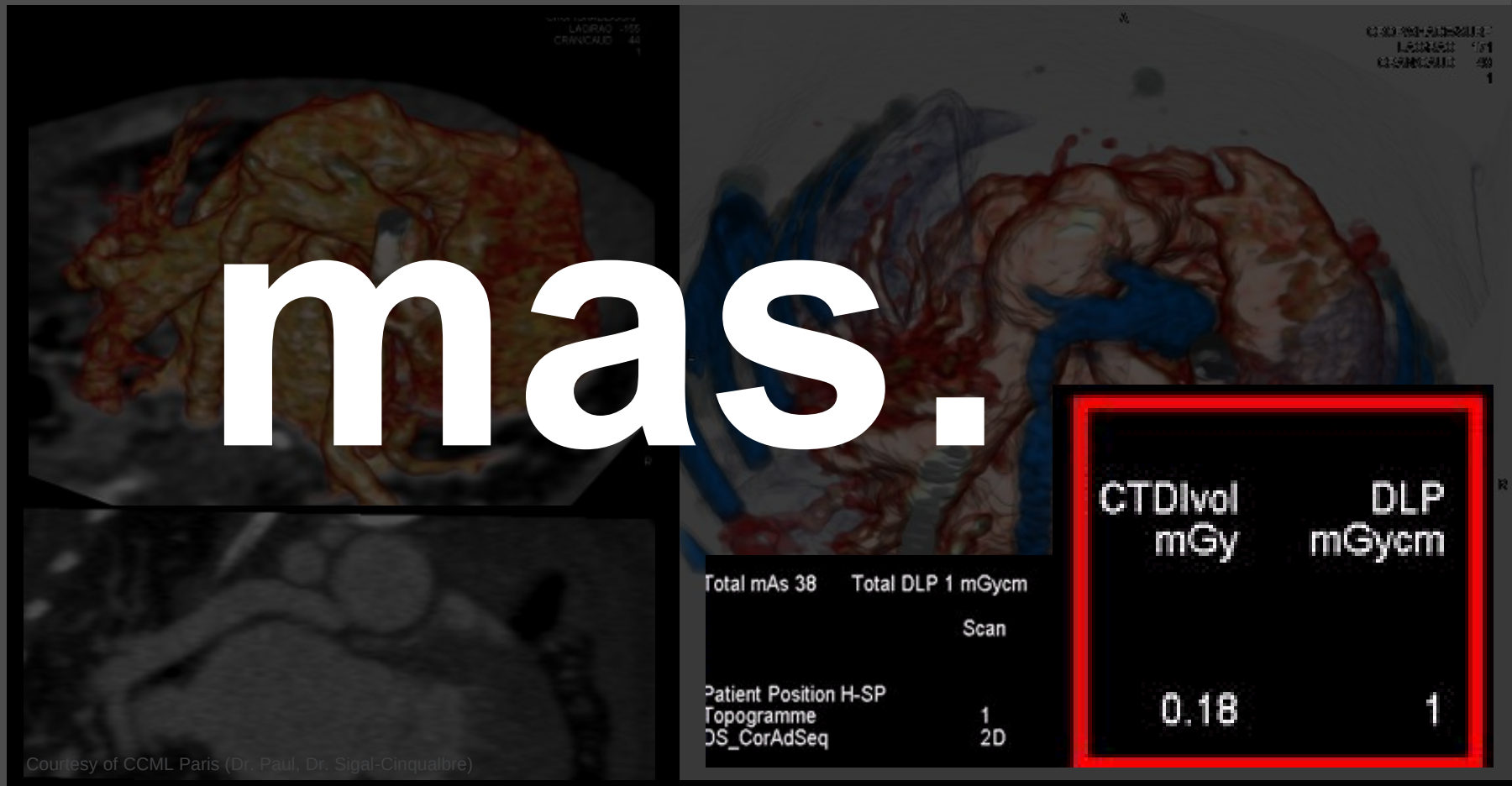


DLP com um único dígito não são frequentes...

Redução da Radiação em CT

Exame pediátrico Aorta Descendente com **0.05 mSv**

SIEMENS



Courtesy of CCML Paris (Dr. Paul, Dr. Sigal-Cinqualbre)

SOMATOM Definition Flash: 0.33 mm spatial resolution, Neonate (premature), 1.5-2kg (HR 165 bpm, 0.28 second rotation, 80 kV, 22 mAs / rotation).

"O nosso objectivo como líderes na inovação é reduzir a dose de radiação de **todos** os exames de CT de rotina

abaixo de 2.4mSv"

Sami Atiya - CEO Siemens CT

SIEMENS

Siemens Computed Tomography.
We make the Difference.