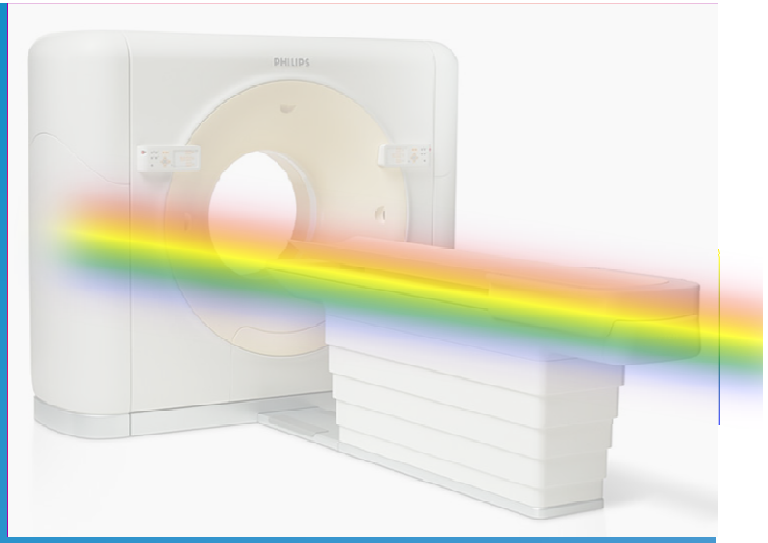


Spektrale CT-Bildgebung

19. APT Seminar – 3. Theo Schmidt –Symposium – Nürnberg

Ewald Rößl
Philips Research Hamburg
13. Juni 2015

innovation + you

PHILIPS

Übersicht

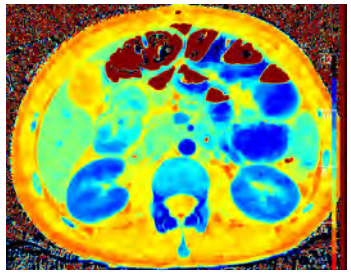
- Spektral Detektor CT
- Röntgentomographie mit Photon-zählenden Detektoren

Übersicht

- Spektral Detektor CT

- Röntgentomographie mit Photon-zählenden Detektoren

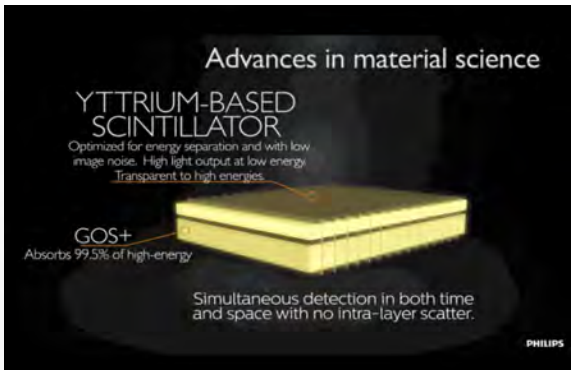
IQon – Spectral CT



Z Eff

Weltweiter erster Spektral Detektor CT

- Gleichzeitigkeit
- Retrospektiv
- Niedrigdosis
- Routine



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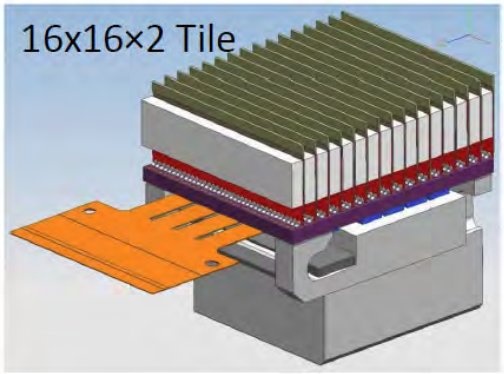
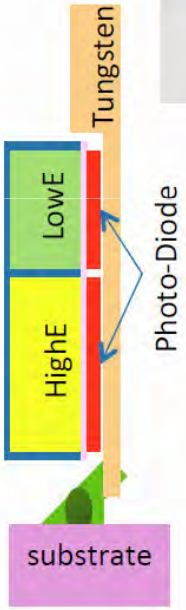
Der IQon – Detektor

- 16 x 16 x 2 Tile; pitch wie bei iCT
- Oberer Szintillator: niederenergetische Photonen
- Unterer Szintillator: hochenergetische Photonen
- Kein Filter zwischen den Schichten
- Seitwärtsgerichtete Photodioden für verbesserte Lichtausbeute
- Wolfram Schirmung gegen direkte Bestrahlung der Photodioden, X-Talk Unterdrückung und mechanische Robustheit
- 2mm dickes GOS im unteren Szintillator (iCT: 1.4mm); Detektoreffizienz: >99%





The Low E scintillator (low density Garnet):

- Spectral properties
- High light output
- Low afterglow
- Good temperature stability

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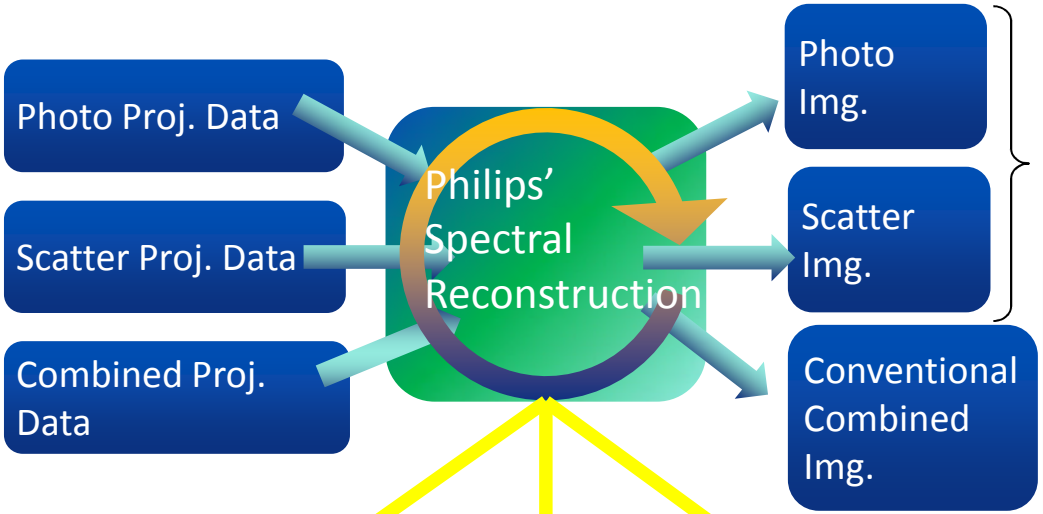
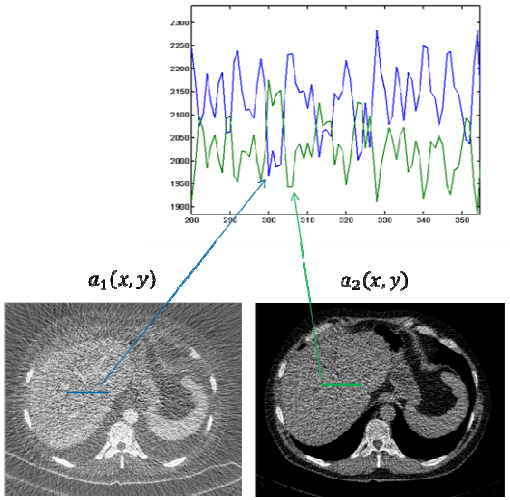
Philips‘ Spektrale Rekonstruktion



Spectral-Base Images for all spectral results and applications

- -Mono Chromatic Images
- -Virtual Non-Contrast Images
- -Material Specific Images
- -Material Removal Images
- -Iodine Maps
- -Effective Atomic Number
- -Electron Density
- -Proton-Stopping Power Maps
- …

Modell für anti-korreliertes Rauschen



Regularisierte Log-Likelihood funktion

Synchronisation mit dem herkömmlichen Bild

Courtesy to A. Altman, GRAD CT, Haifa, Israel

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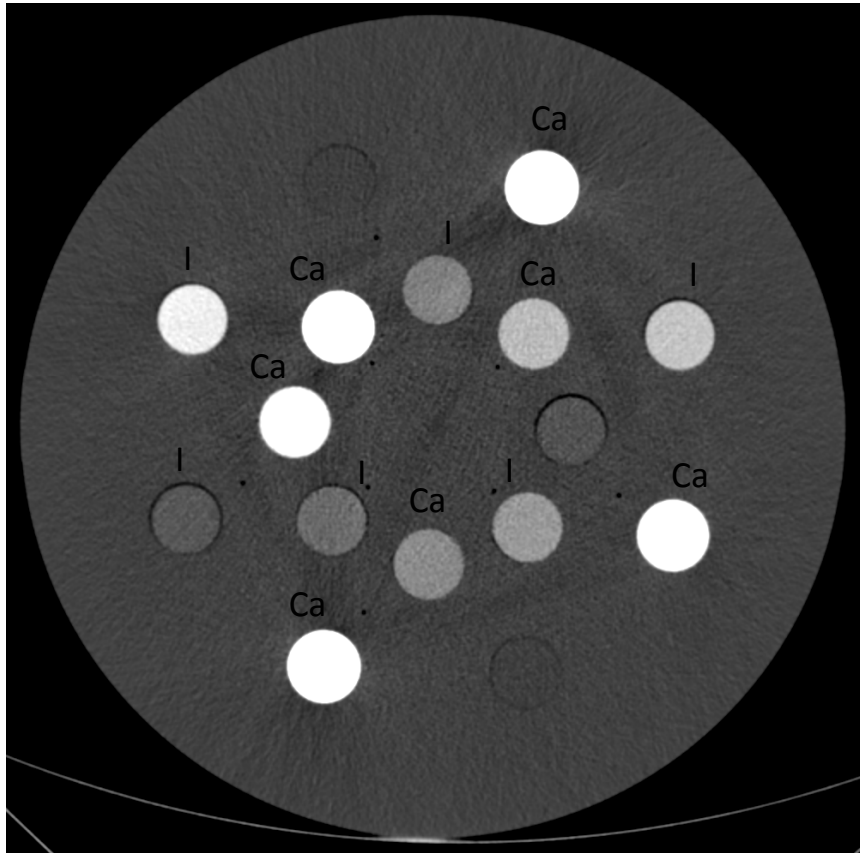
Spektrale Materialtrennung

Gammex Phantom

Conventional CT image



Courtesy to A. Altman, GRAD CT, Haifa, Israel

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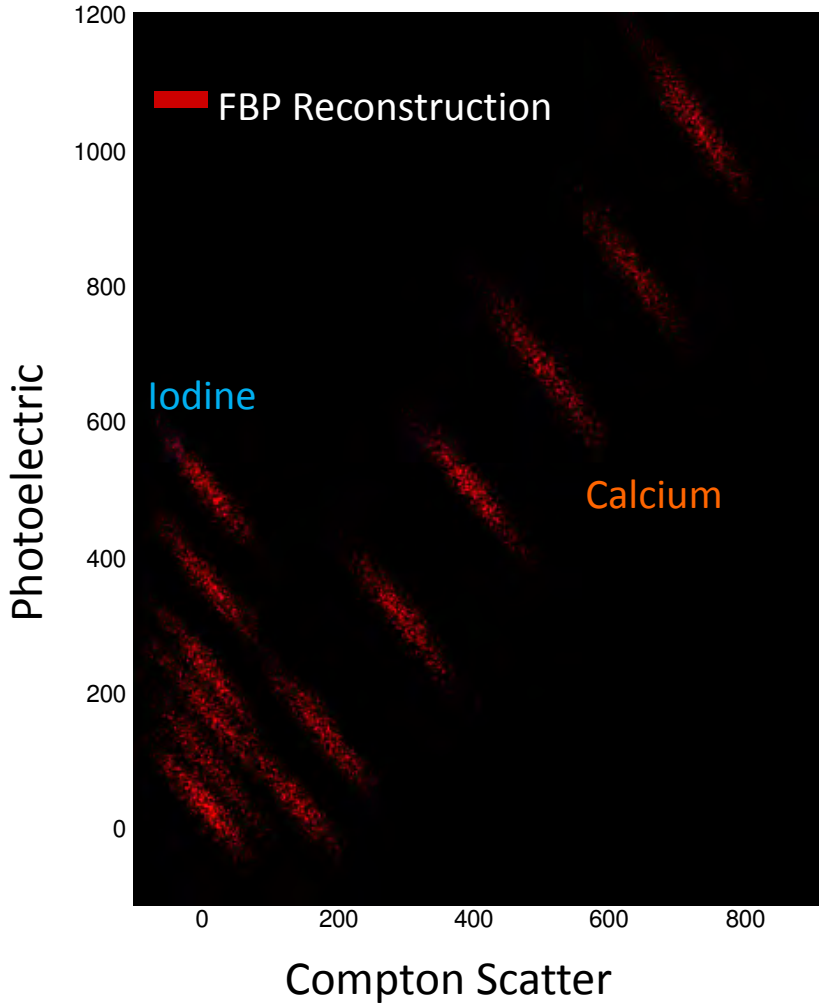
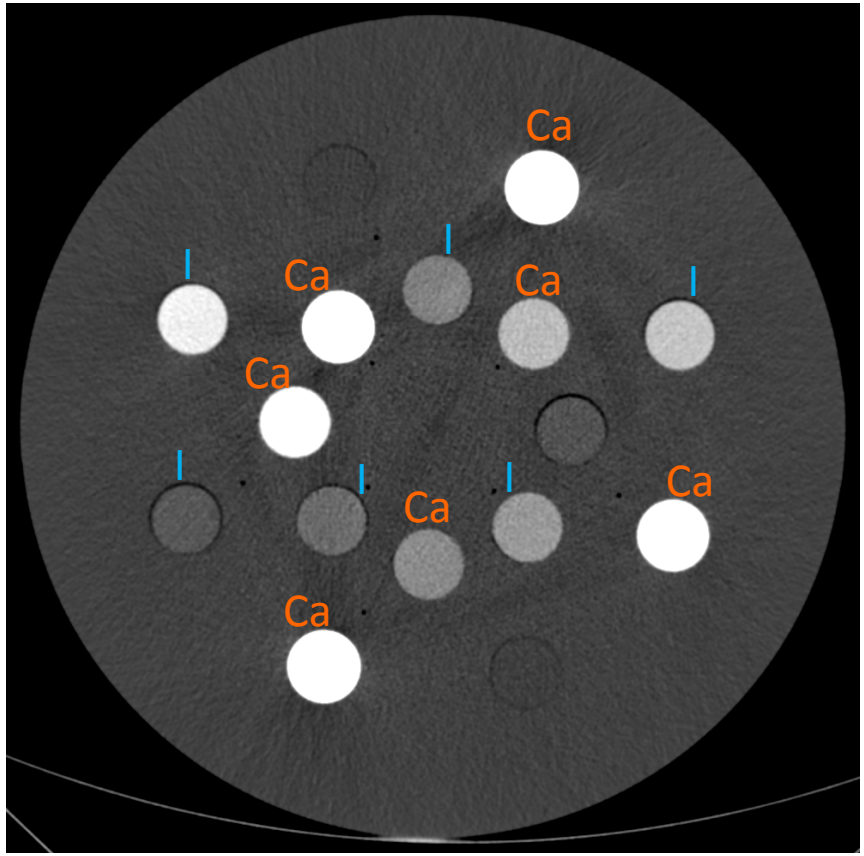
Spektrale Materialtrennung

Scatter-plot diagram



Conventional image - Gammex phantom

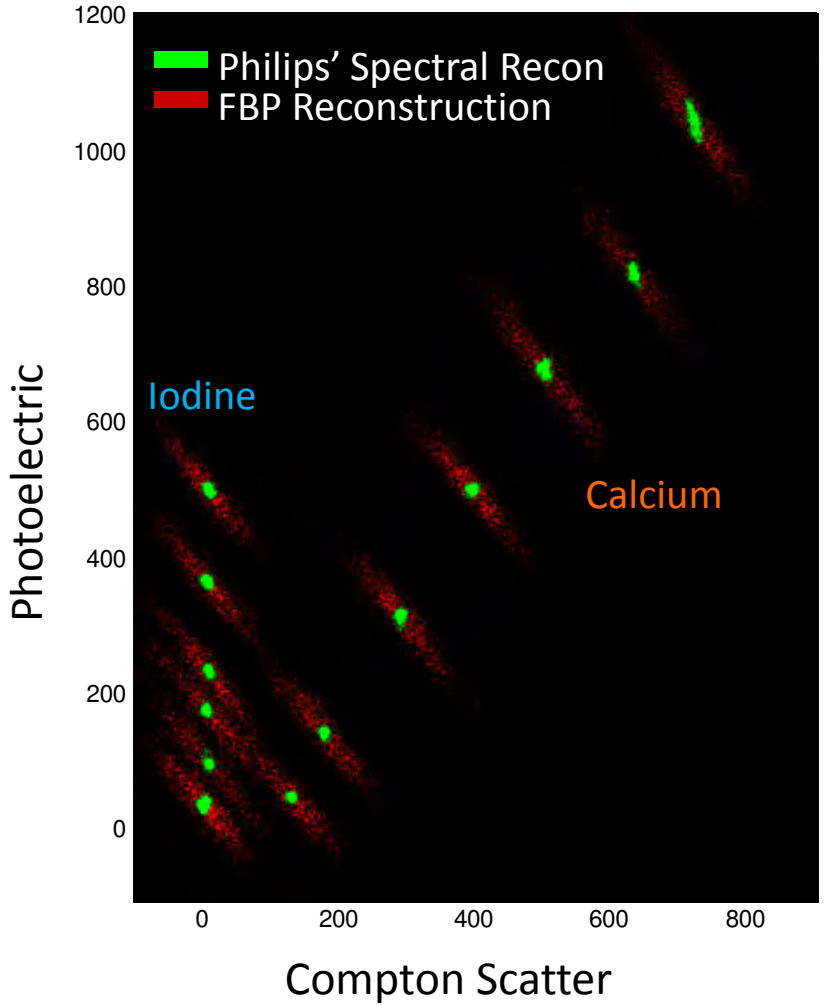


Courtesy to A. Altman, GRAD CT, Haifa, Israel

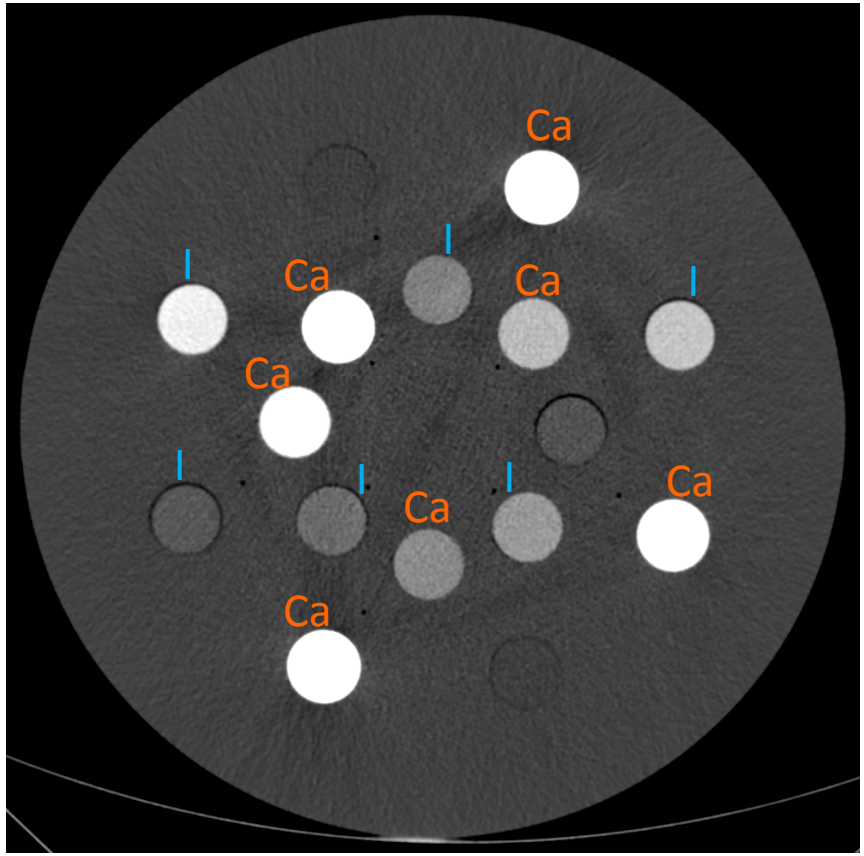
PHILIPS

Spektrale Materialtrennung

Scatter-plot diagram



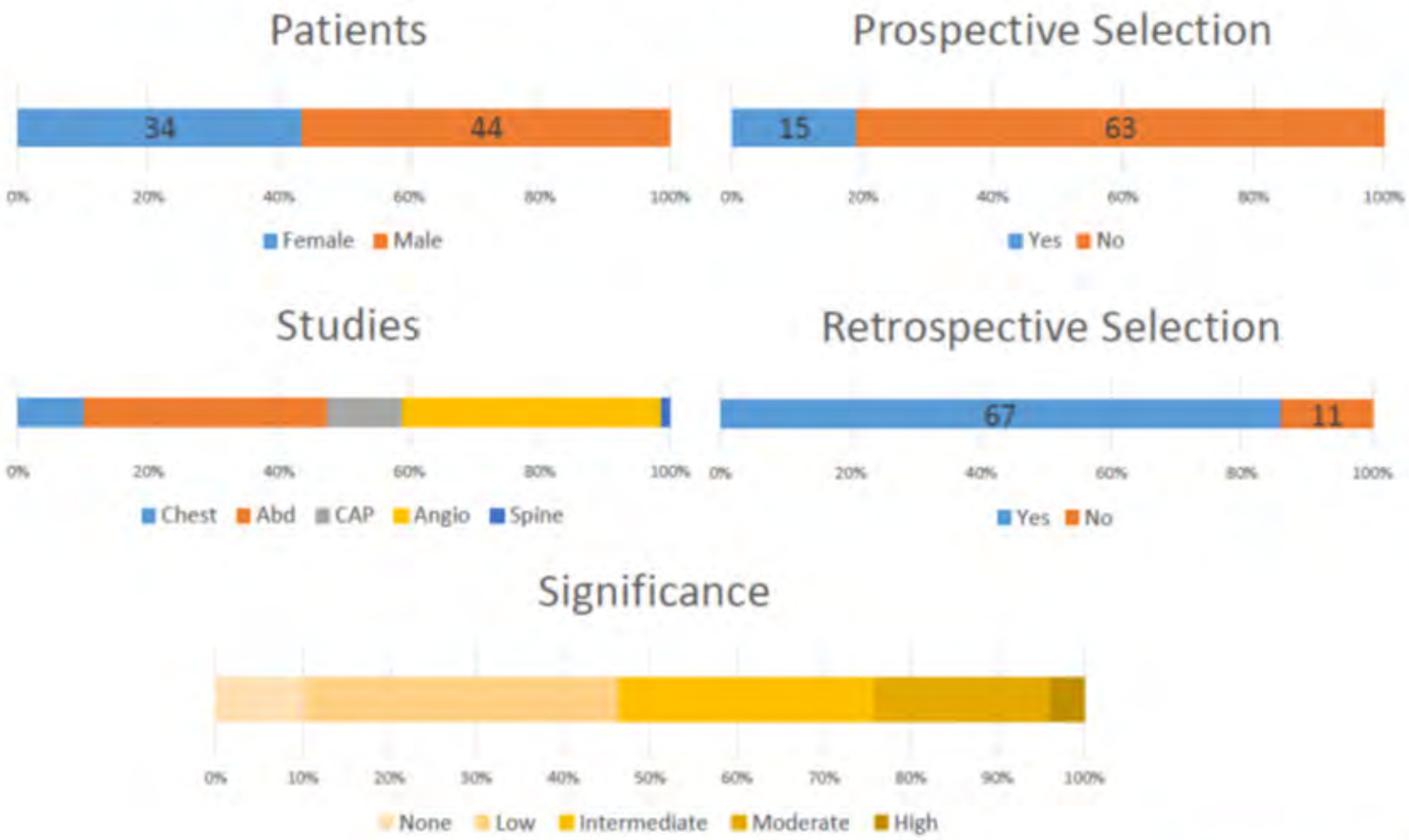
Conventional image - Gammex phantom



Courtesy to A. Altman, GRAD CT, Haifa, Israel

PHILIPS

The Power of Retrospective Analysis



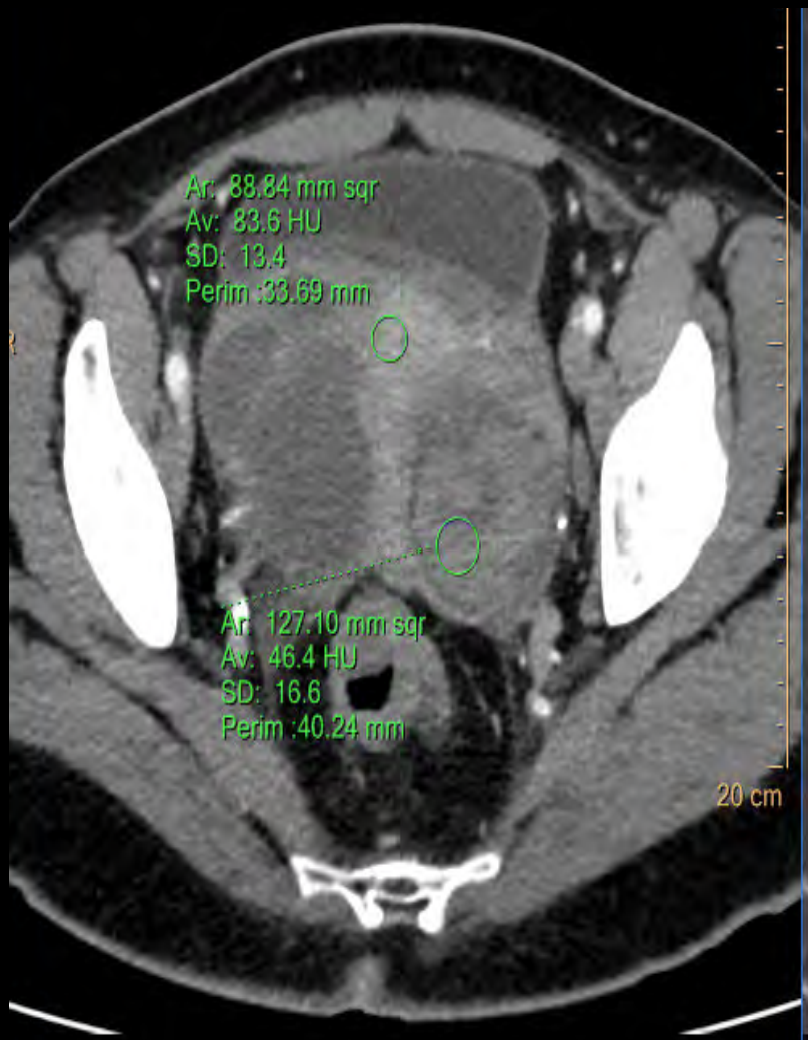
Courtesy to E. Shefer CT, Haifa, Israel

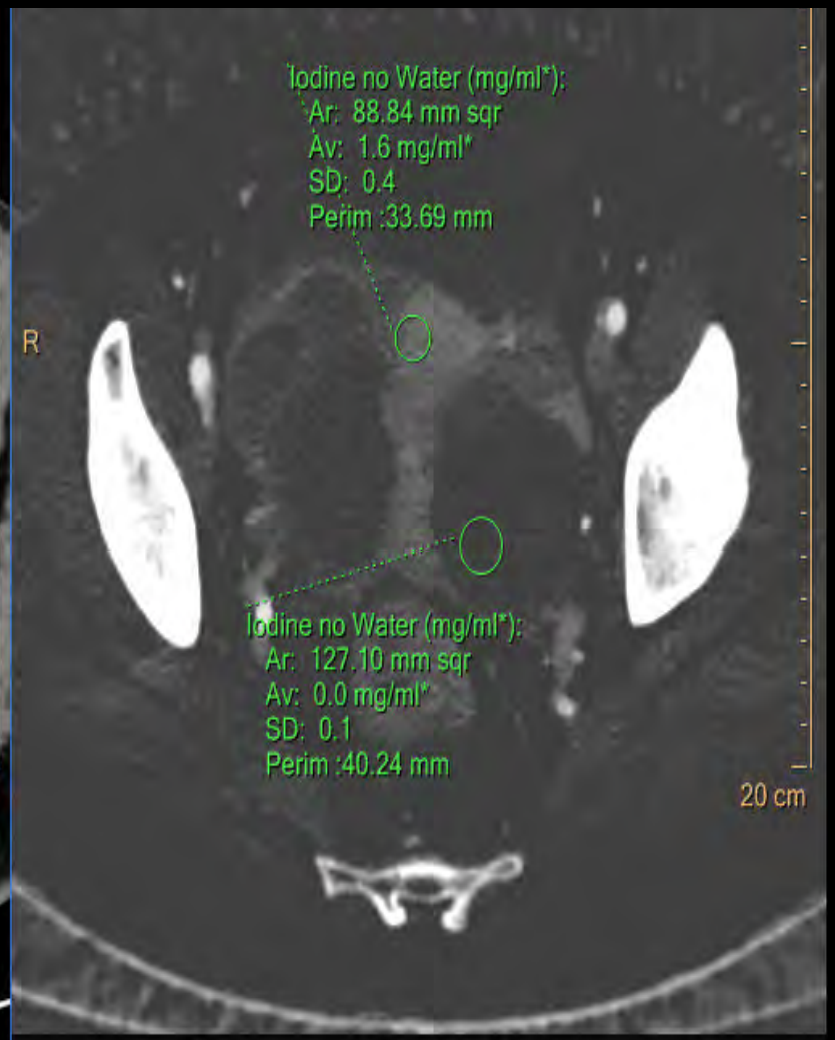
PHILIPS
Courtesy of UHCMC

Lesion Characterization

Lesion vs. Debris

Power of retrospective analysis





Conventional 120kVp

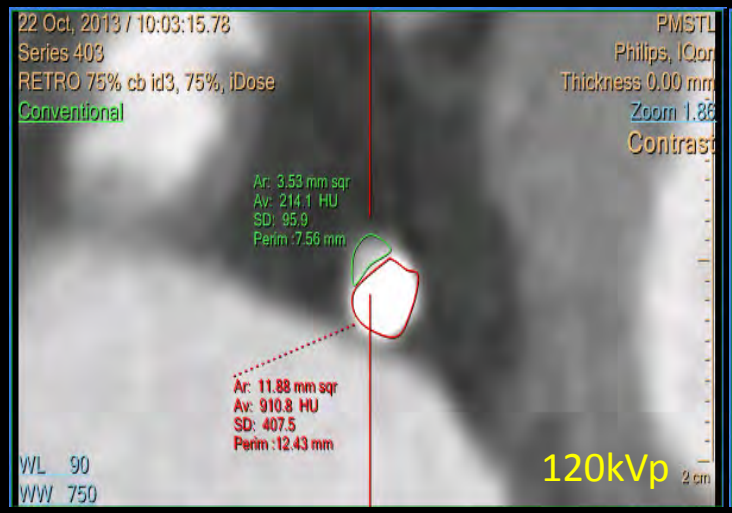
Iodine no H_2O [mg/ml]

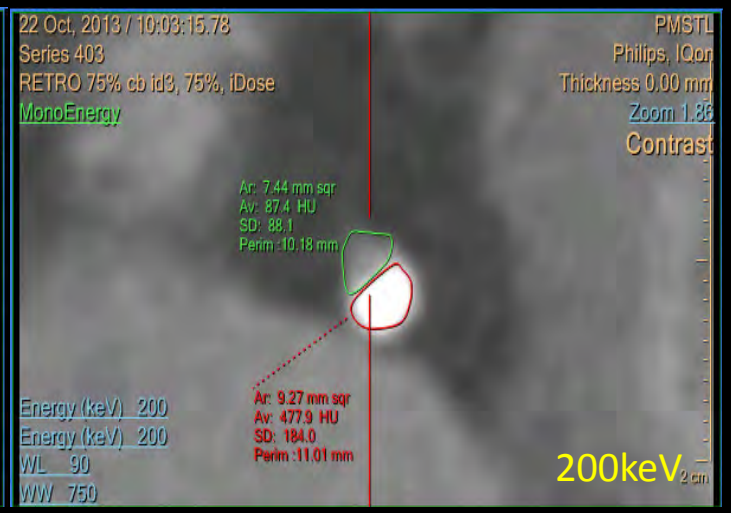
Images courtesy of Hadassah Medical Center, Jerusalem, Israel

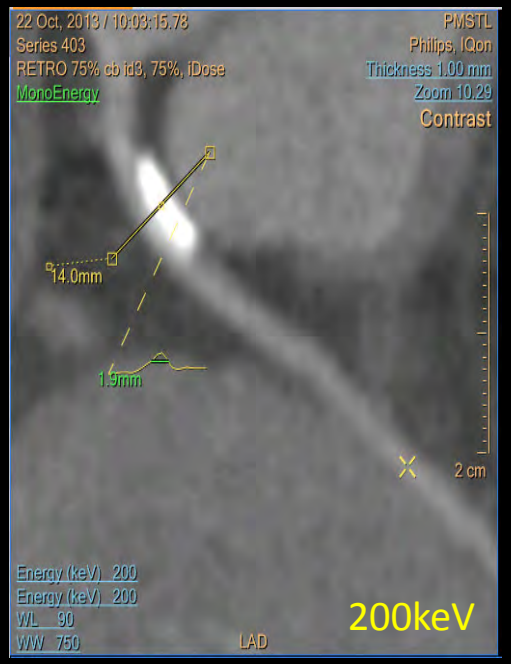
Increased Diagnostic Confidence

Coronary Stenosis Assessment

Reduced Calcium Blooming

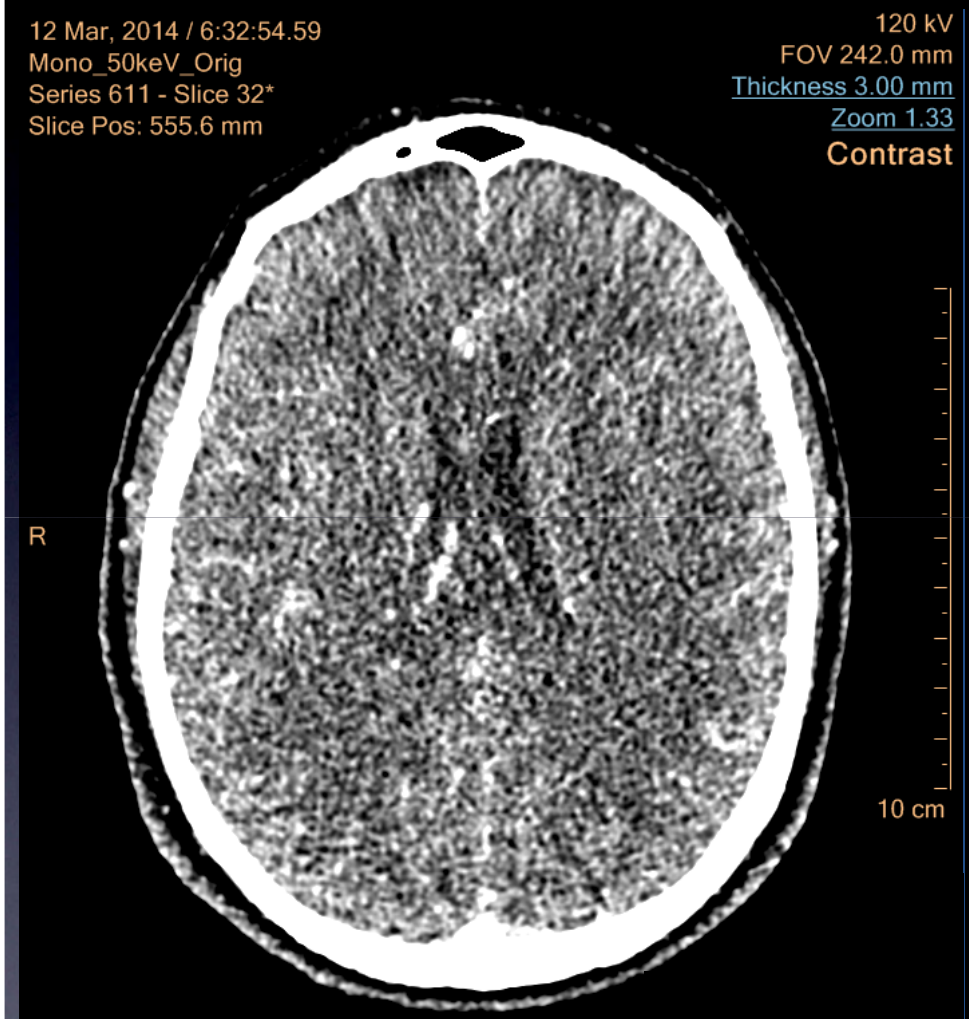




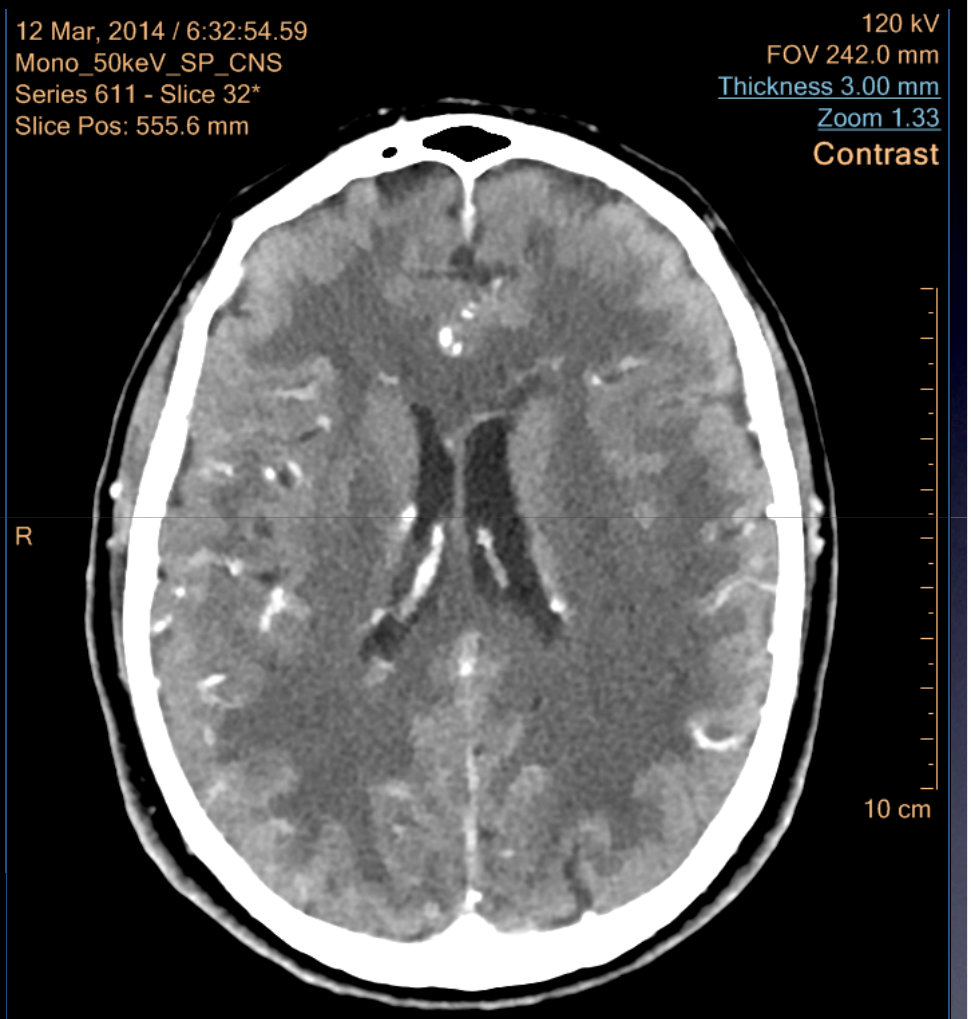


Courtesy of UH Hospitals, Cleveland, OH, USA

Spectral Monochromatic 50keV Brain Example



FBP



Philips' Spectral Reconstruction

Übersicht

- Spektral Detektor CT
- Röntgentomographie mit Photon-zählenden Detektoren

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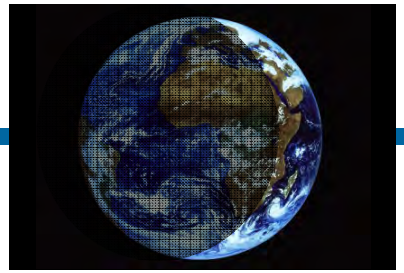
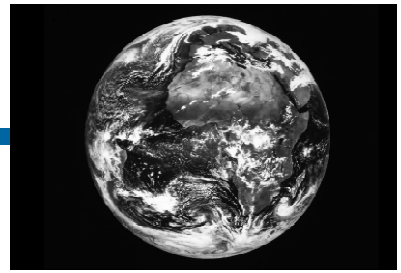
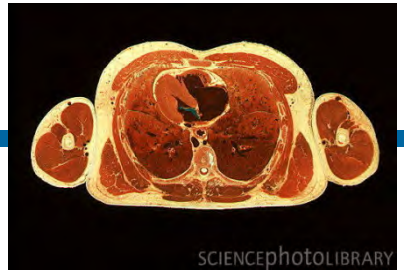
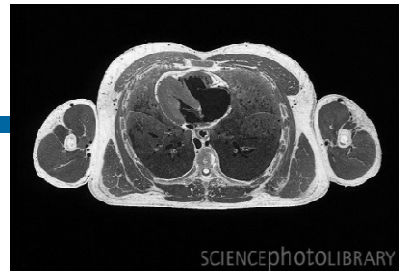
Von Schwarz-Weiss-, zu Farbbildgebung in der Röntgencomputertomographie

Schwarz-Weiss Bildgebung

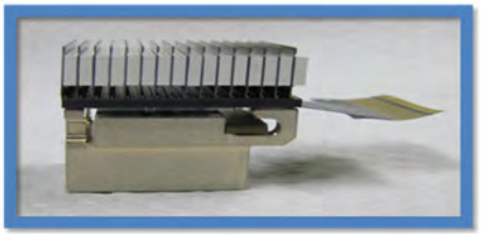


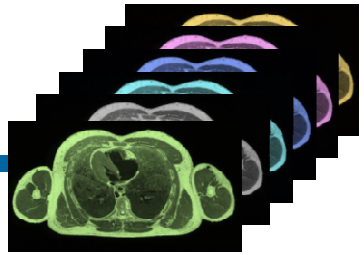






Innovative Detektortechnologie



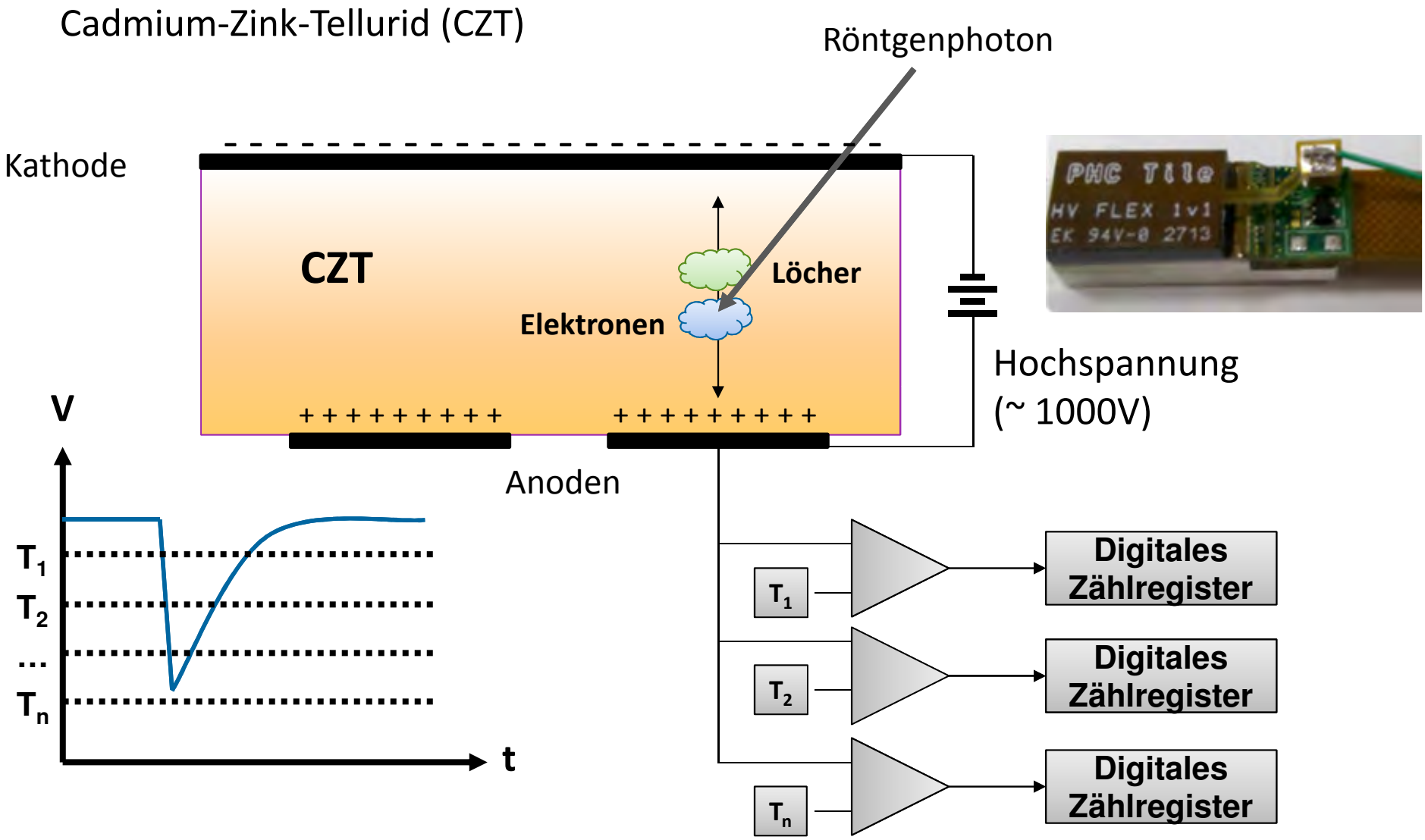


Farbbildgebung

PHILIPS

Prinzip des Halbleiterröntgendetektors

Cadmium-Zink-Tellurid (CZT)

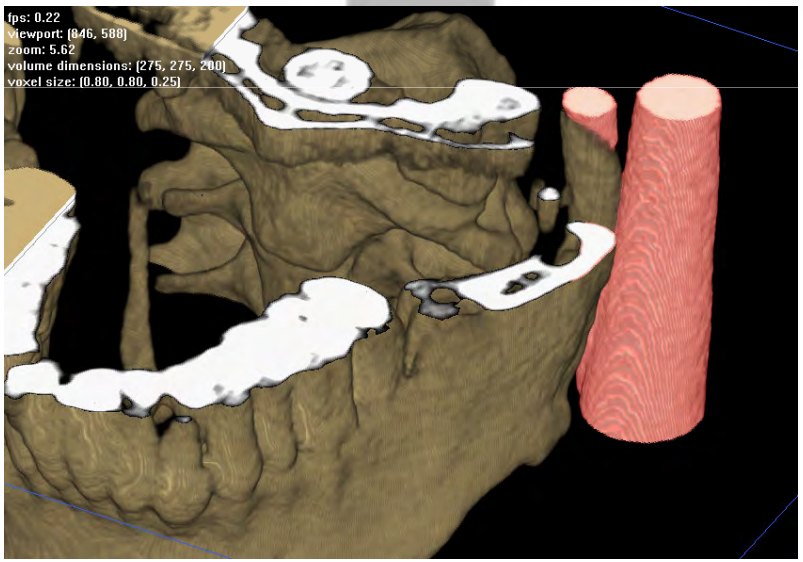


Pulshöhe ist indikativ für die Energie des Primärphotons

PHILIPS

Anwendungsgebiete in der Computertomographie

- Quantitative Bildgebung
- Reduktion der Strahlendosis
- Verbesserte räumliche Auflösung
- Verbesserung der Bildqualität
- Verbesserung der Differenzierung von Weichteilgeweben
- Reduktion von Beam-hardening
- Neuartige bildgebende Methoden:
  - e.g. K-Kantenbildgebung zur selektiven Detektion von spezifisch bindenden Kontrast-mitteln



Verbesserte Darstellung von Läsionen in Karotidenarterien durch K-Kantenbildgebung (Simulation)

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Photon-zählender CT Prototyp

Parameter	Spezifikation
Platform	Philips iCT
Röhrenspannung [kVp]	80, 100, 120
Röhrenstrom [mA]	10-120
Fokusgröße [mmxmm]	0.6 x 0.7
Gantry Rotation [s]	0.75
Ortsauflösung [lp/cm]	> 20
Coverage im Iso-zentrum [mm]	2.5
FOV [mm]	168
Sensor Material	CZT

Philips Research und Philips CT

Installiert an Universität Lyon, Prof. Douek, Prof. Boussel 2015

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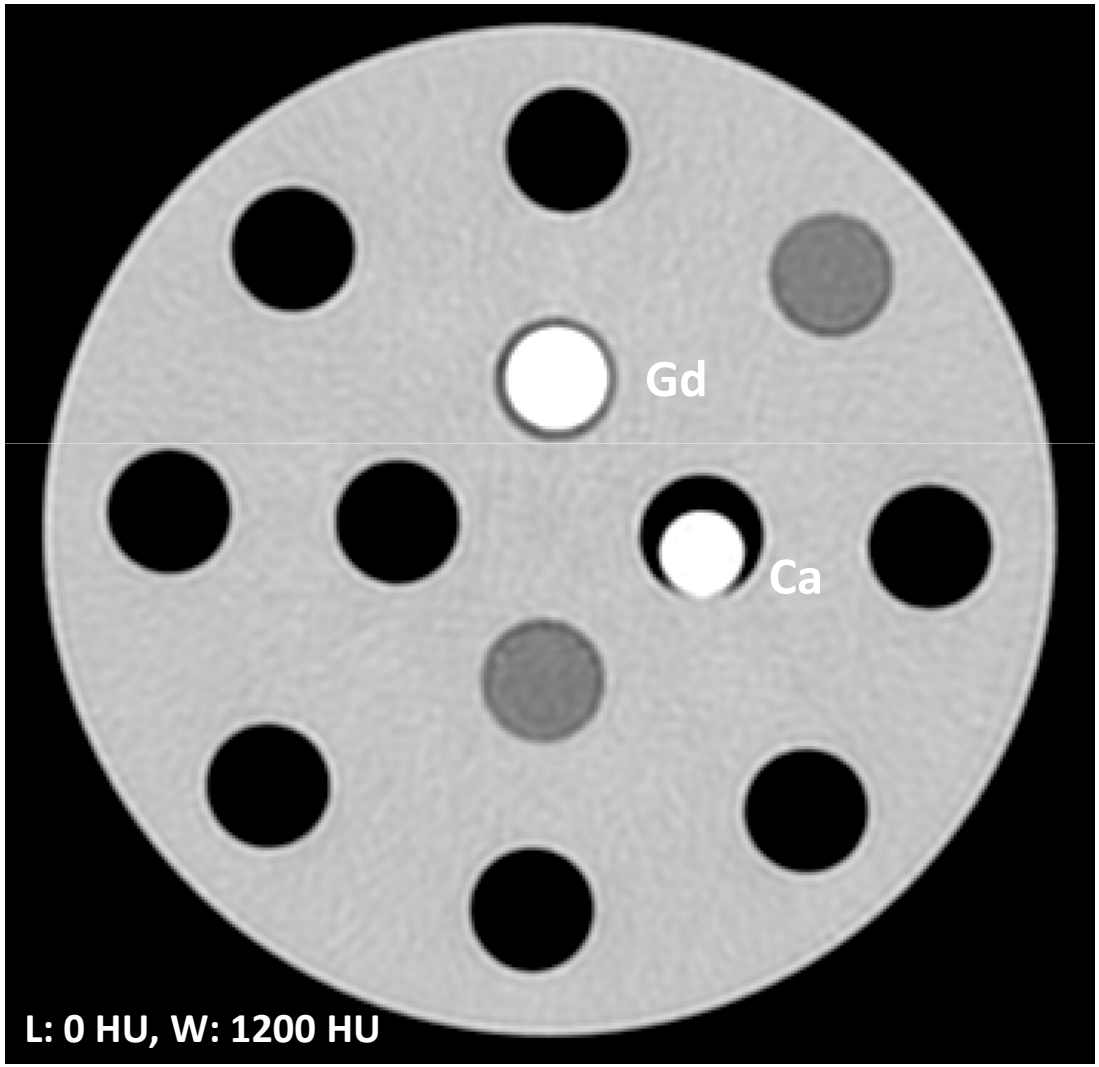
Verbesserte räumliche Auflösung

an eines Beinphantoms
0kVp, 100mA, T=1s, SW=0.27mm

PHILIPS

HU Bildqualität

Delrin Phantom (Polyoxymethylene, POM), Dichte=1.41 g/cm^3



Scan Parameter:

- 120 kVp
- 100 mA
- Niedrigste E-schwelle : 30 keV
- 1s axialer scan , 360 deg.
- 2400 Projektionen

Phantom Größe

- 13 cm Durchmesser

Gd and Ca in hoher Konzentration

HU Bild aus allen Energiebins erzeugt

PHILIPS

HU Bildqualität – Delrin-Iod Phantom

Delrin (Polyoxymethylene, POM), Dichte=1.41 g/cm^3

Scan Parameter:

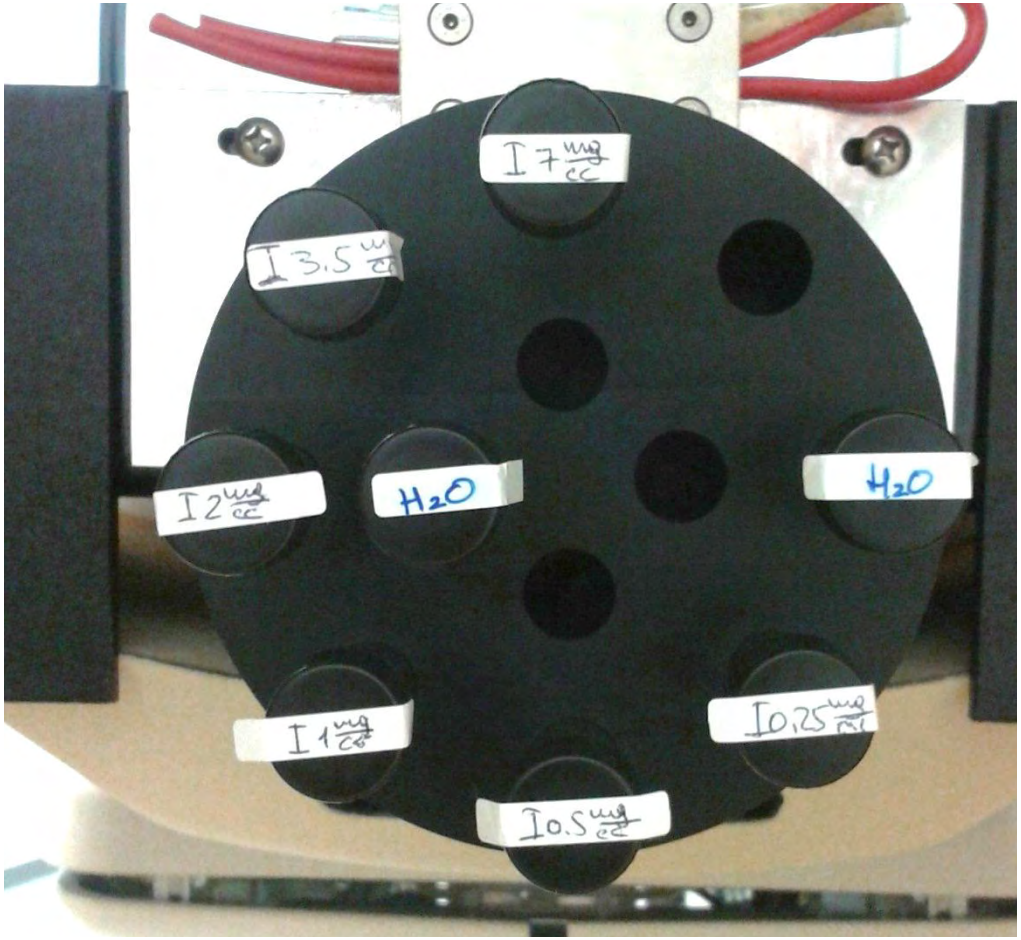
- 120 kVp
- 100 mA
- 1s Scanzeit über 360 deg.
- 2400 Projektionen

Phantom Größe:

- 13 cm Durchmesser

Iod Konzentration:

7.0, 3.5, 2.0, 1.0, 0.5, 0.25 mg/cm^3



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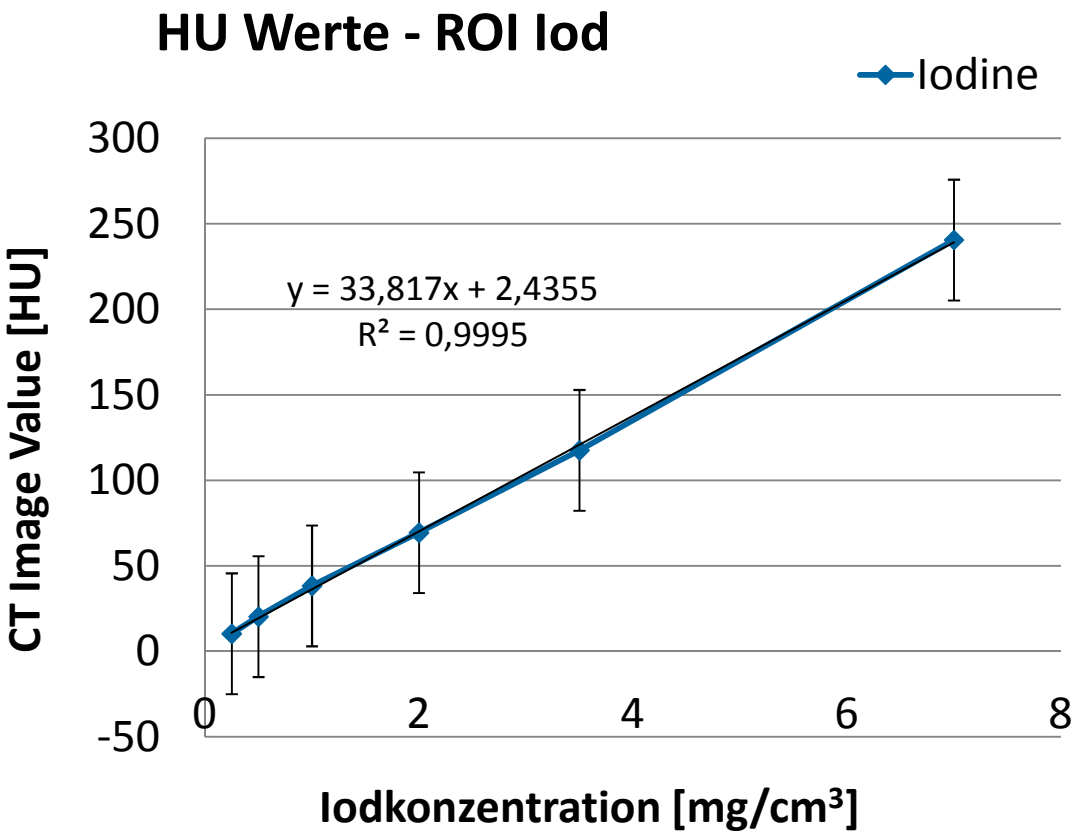
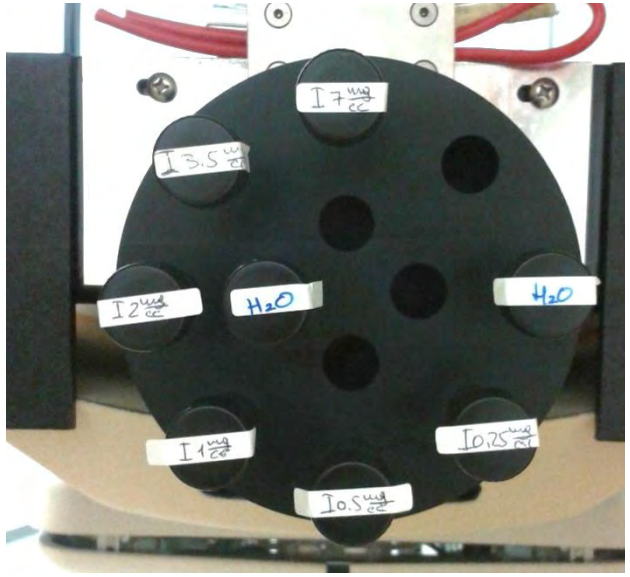
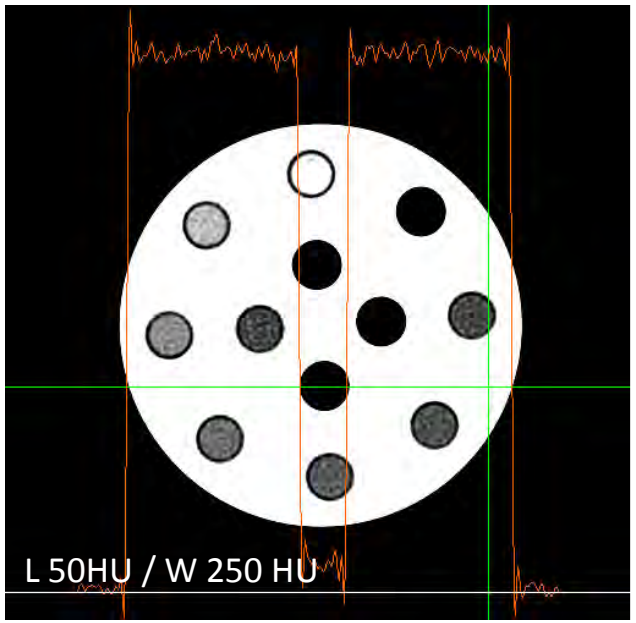
HU Bildqualität – Delrin-Iod

Linearität des Iodkontrast im HU Bild





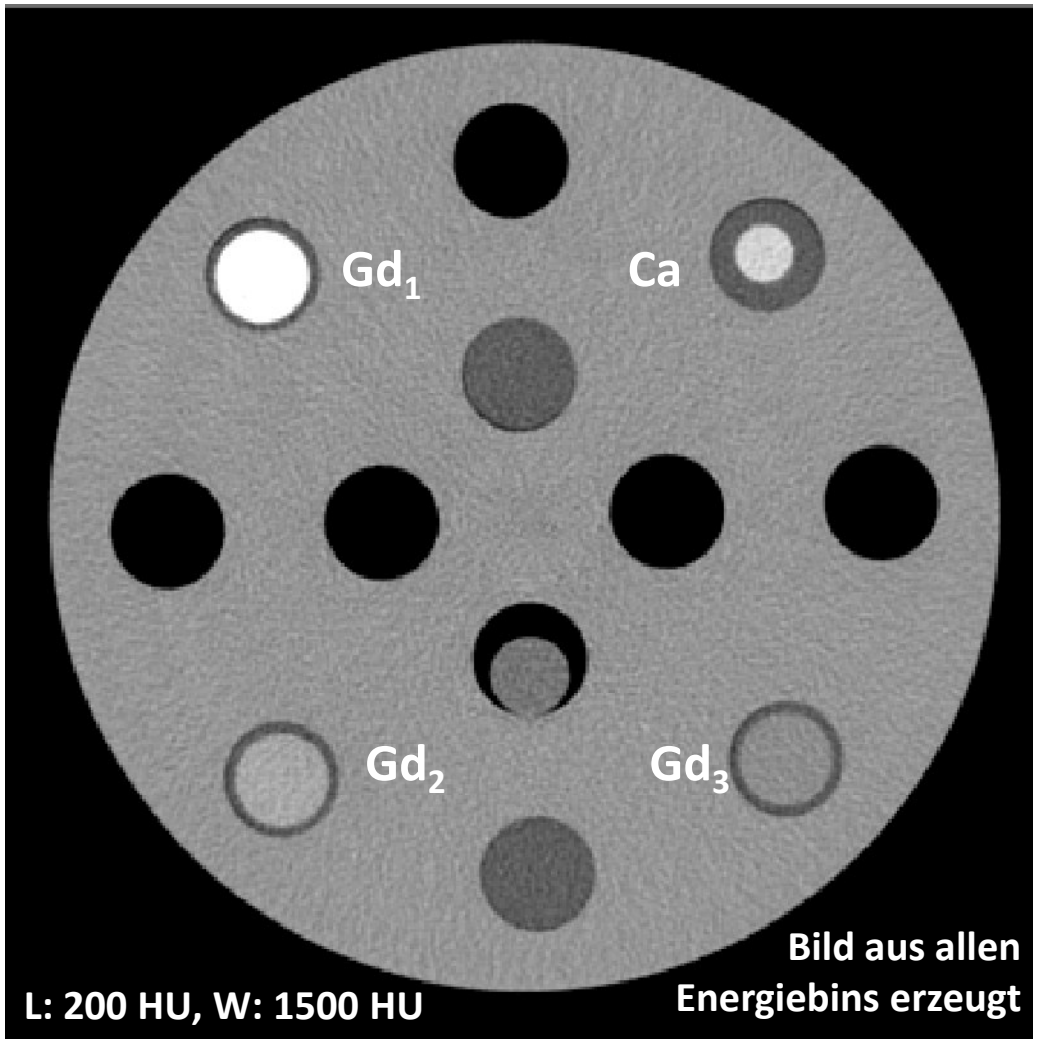


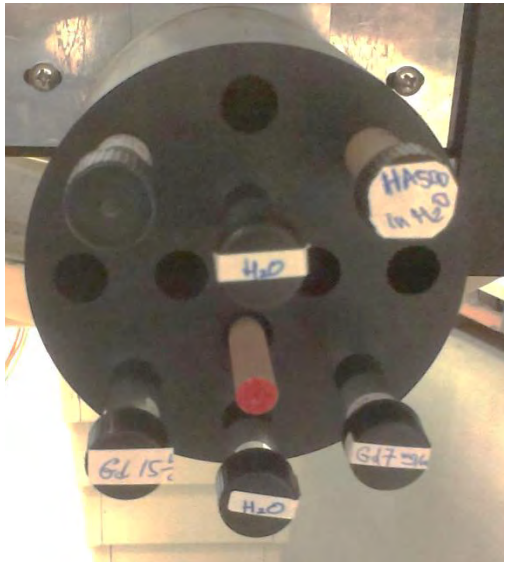
PHILIPS

Spektrale Materialtrennung

Gadolinium-Kalzium Trennung

Gd_1 : 36mg/cm³
Gd_2 : 15mg/cm³
Gd_3 : 7mg/cm³





Scan Parameter:

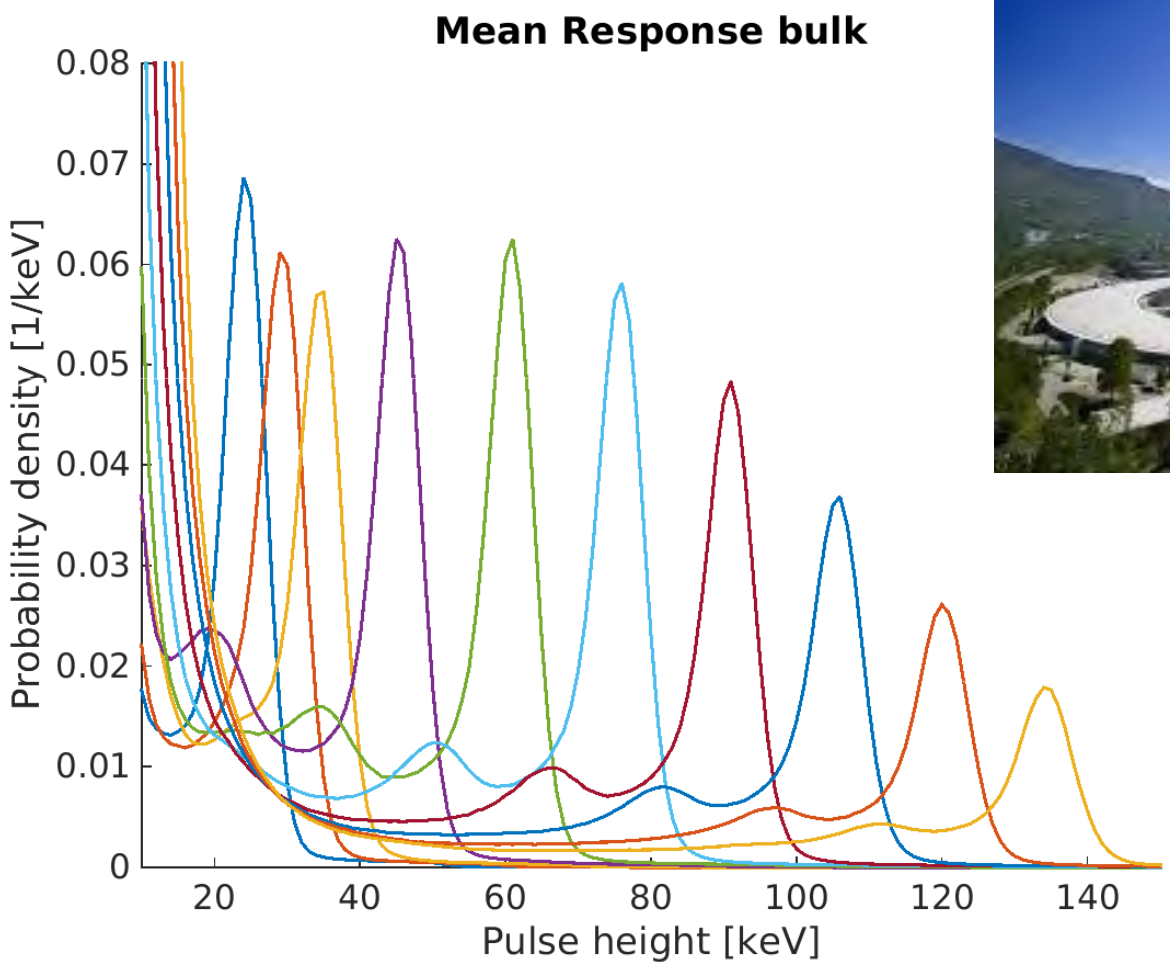
- 120 kVp, 100 mA
- Niedrigste E-schwelle : 30 keV
- 1s axialer Scan , 360 deg.
- 2400 Projektionen

Phantomgröße

- 13 cm Durchmesser

PHILIPS

Messung der Spektralen Detektorantwortfunktion Europäische Synchrotronquelle ID 17



ESRF, Grenoble, France

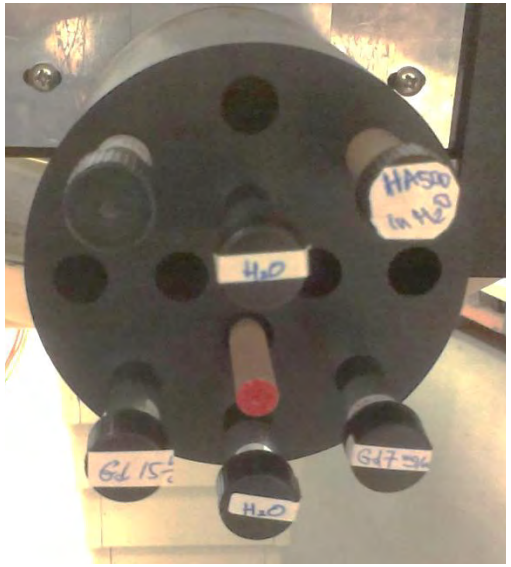
In Zusammenarbeit mit Prof. P. Douek and Prof. L. Boussel, M. Sigovan, F. Peyrin

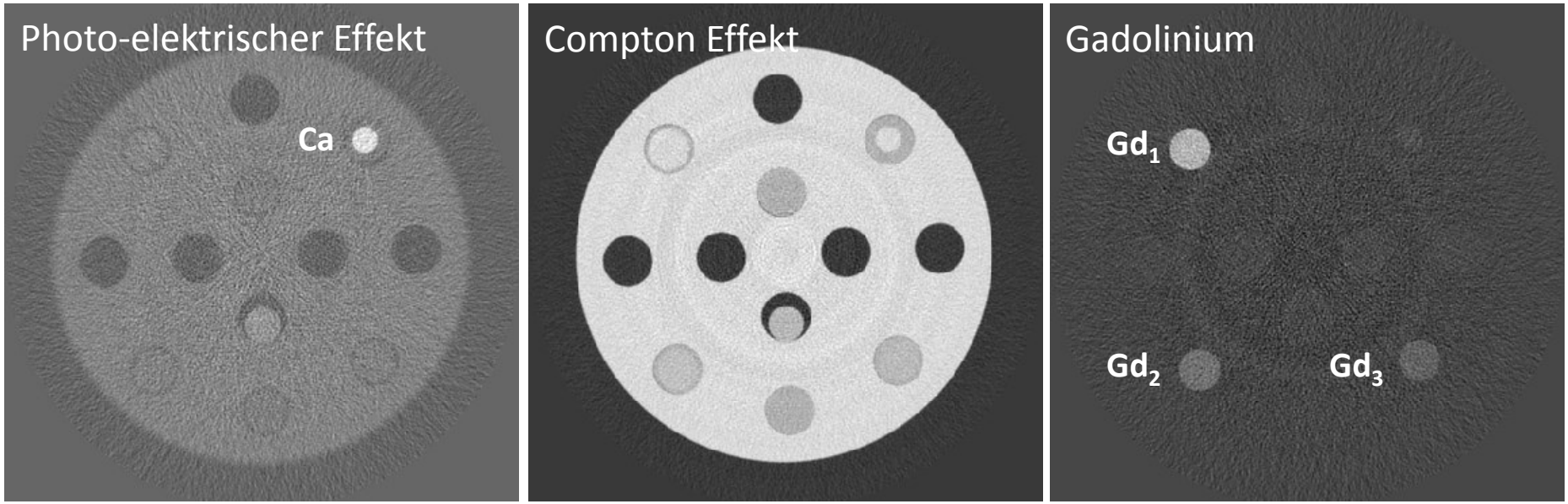
PHILIPS

Spektrale Materialselektion

Maximum-Likelihood Methode zur Materialtrennung in Photo/Compton/Gd

- 120 kVp, 100 mA
- Niedrigste Energieschwelle: 30 keV
- 1s axialer scan , 360 deg.
- 2400 Projektionen





- Sehr gute spektrale Materialtrennung
- Hohe Anforderung an spektrale Kalibration (Bildartefakte)

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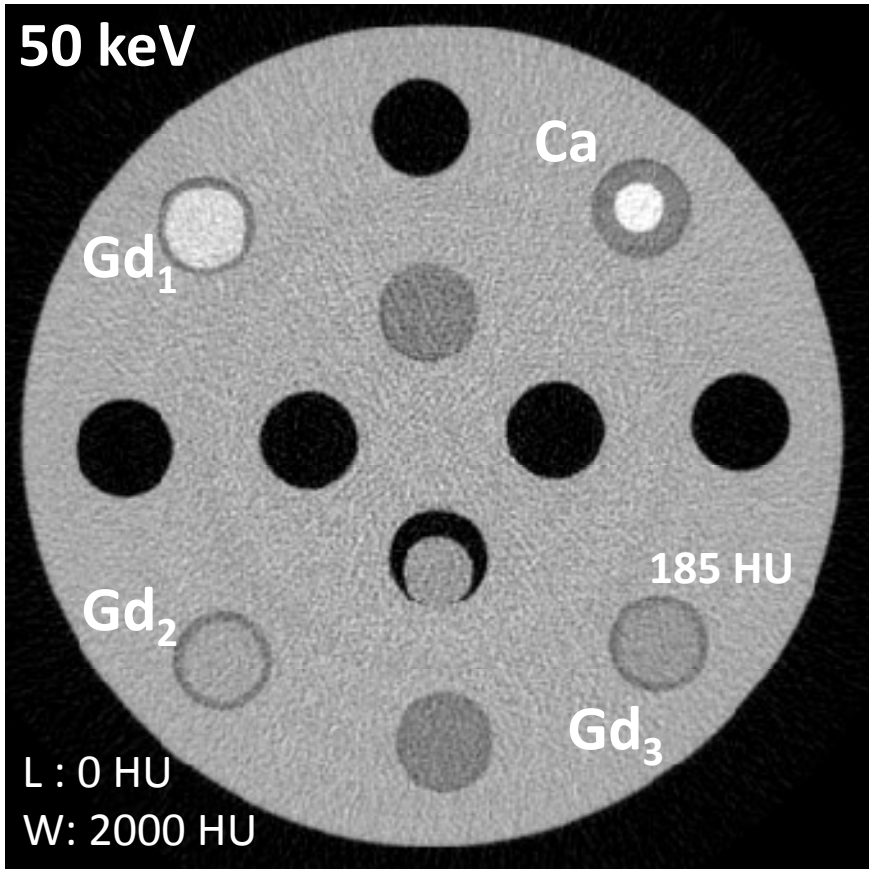
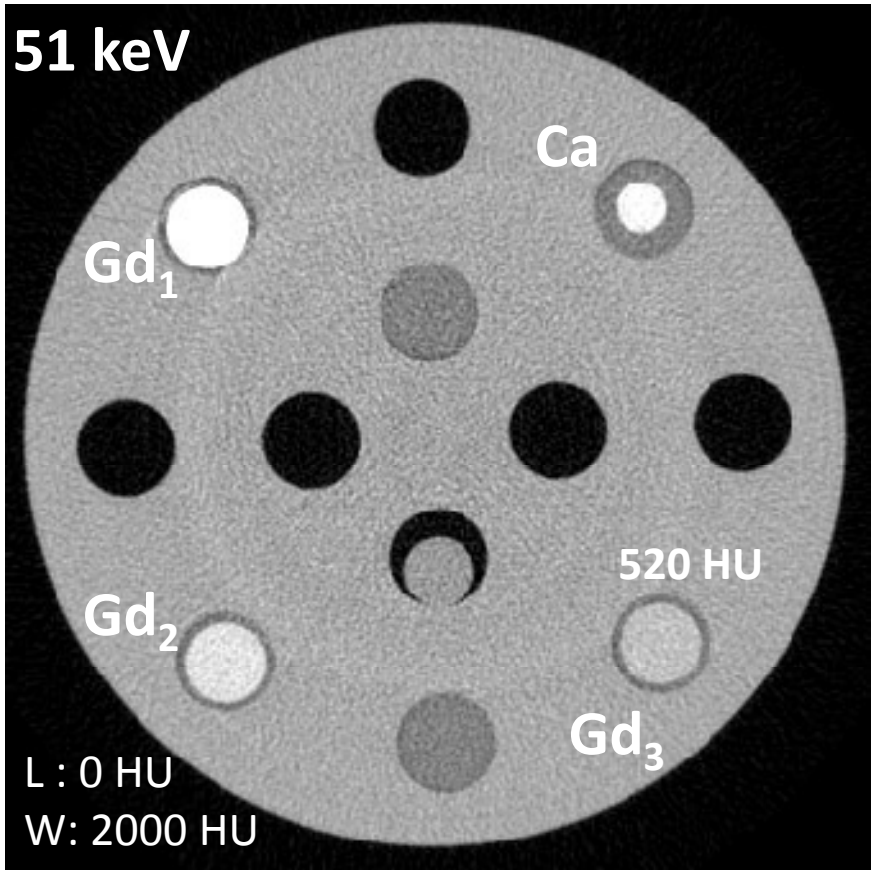
Spektrale Bildgebung

Monochromatische Schwächungsbildgebung

K-Kante von Gd: 50.3 keV

CT#	50keV	51keV
Gd_1	685 ± 135	1940 ± 135
Gd_2	275± 120	775 ± 125
Gd_3	185± 115	520 ± 100
Ca	935 ± 150	1000 ± 110



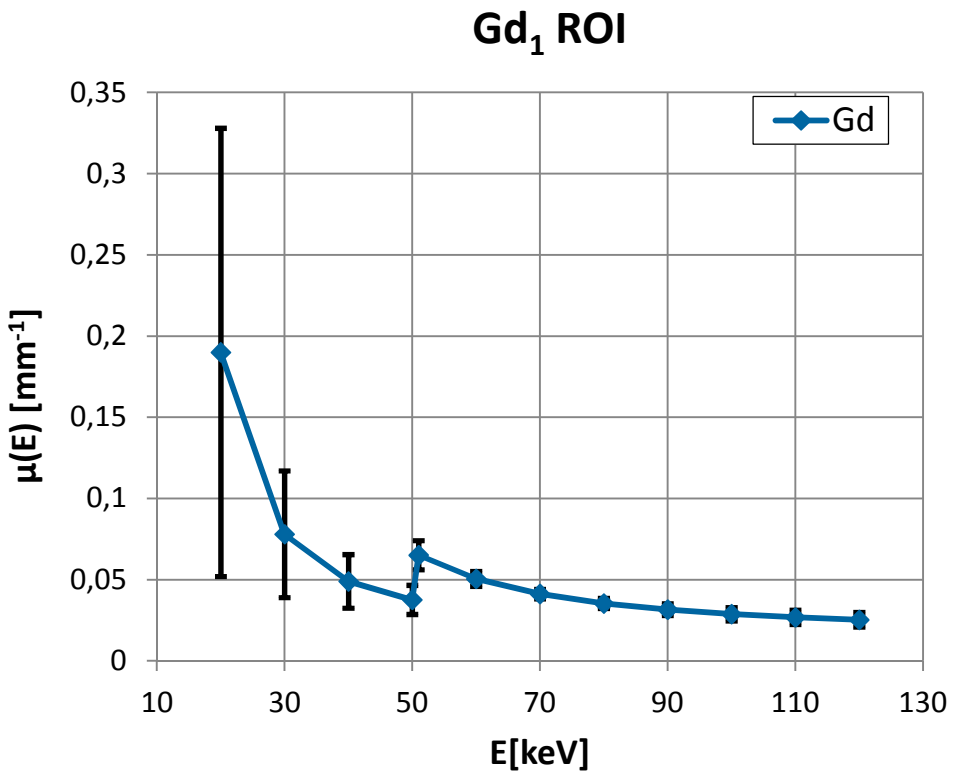


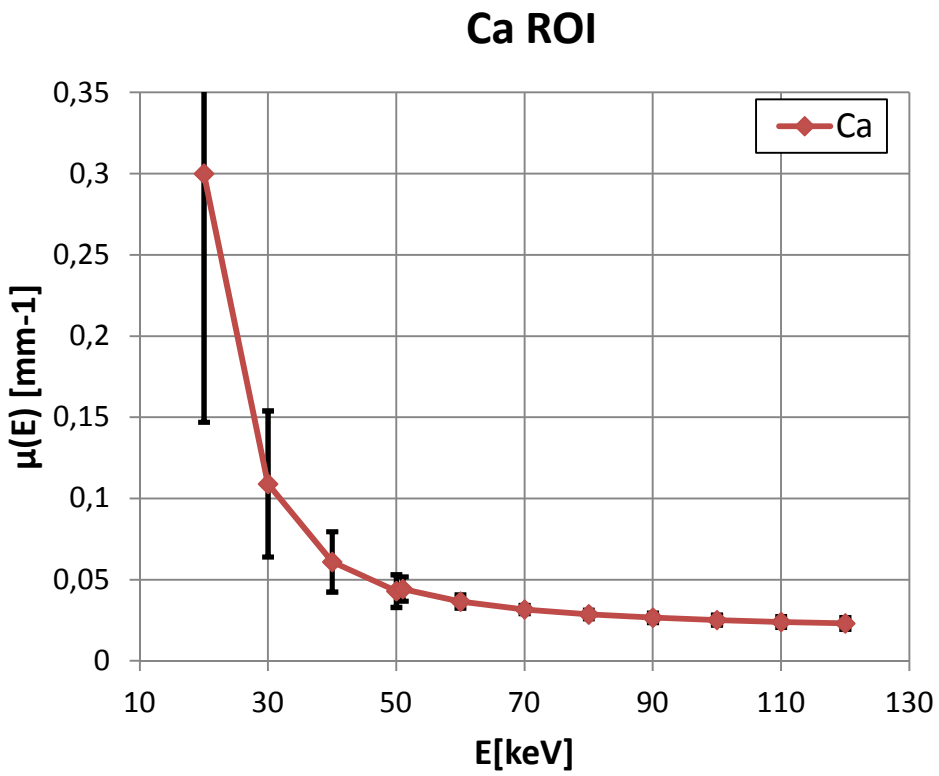
PHILIPS

Spektrale Trennung von Gadolinium und Kalzium

Quantitative mono-chromatische Bildgebung

Gemessene Schwächung in Gd und Ca ROIs



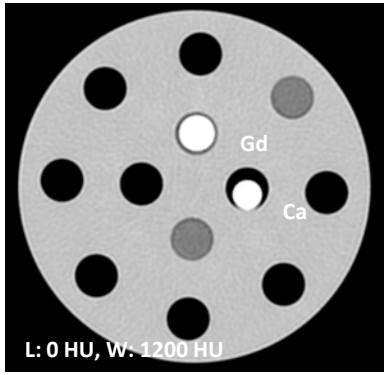


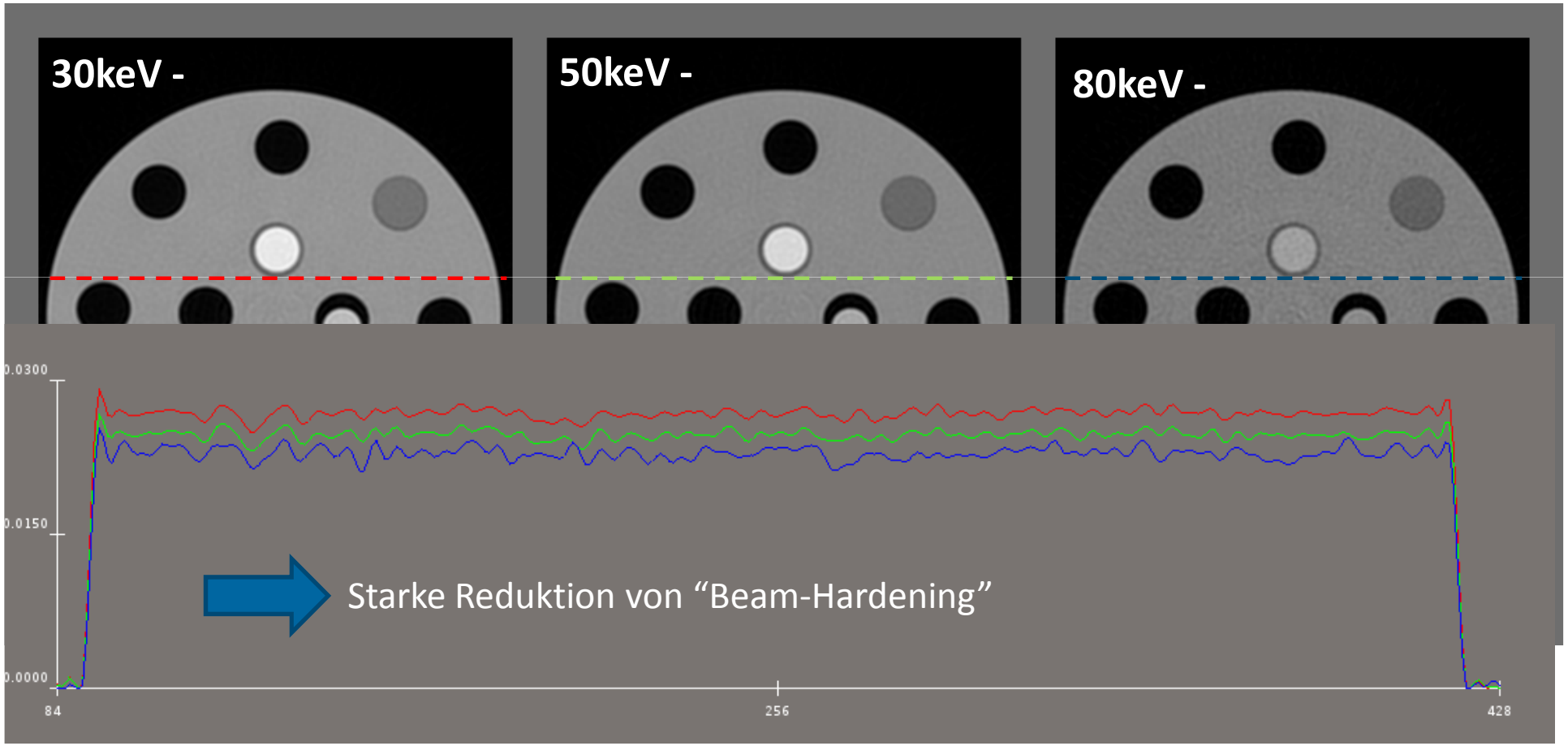
Präzise Quantifizierung der Schwächung aus mono-chromatisch Bilder

PHILIPS

Spektrale Bildgebung

CT Bildgebung aus einzelnen Energiebins
120keV, 100mA 1s axial scan



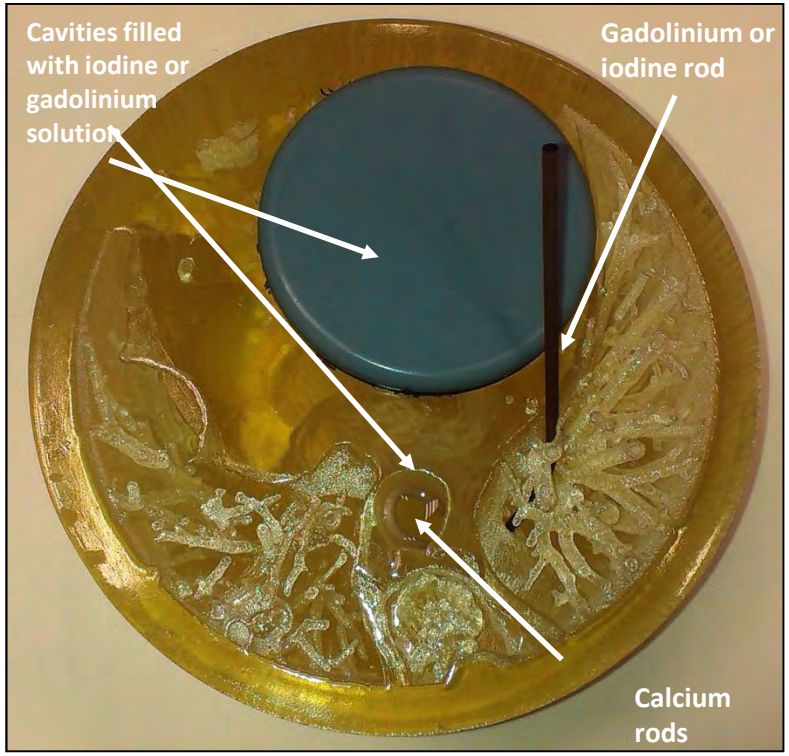


PHILIPS

Demonstration der spekralen Materialtrennung

Virtuelles 3D Modell eines Herz CT Scans

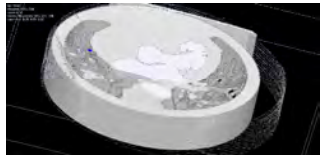
3D Druck desselbigen 3D Modells

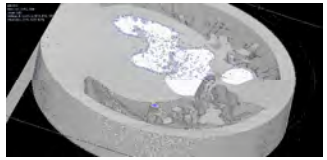


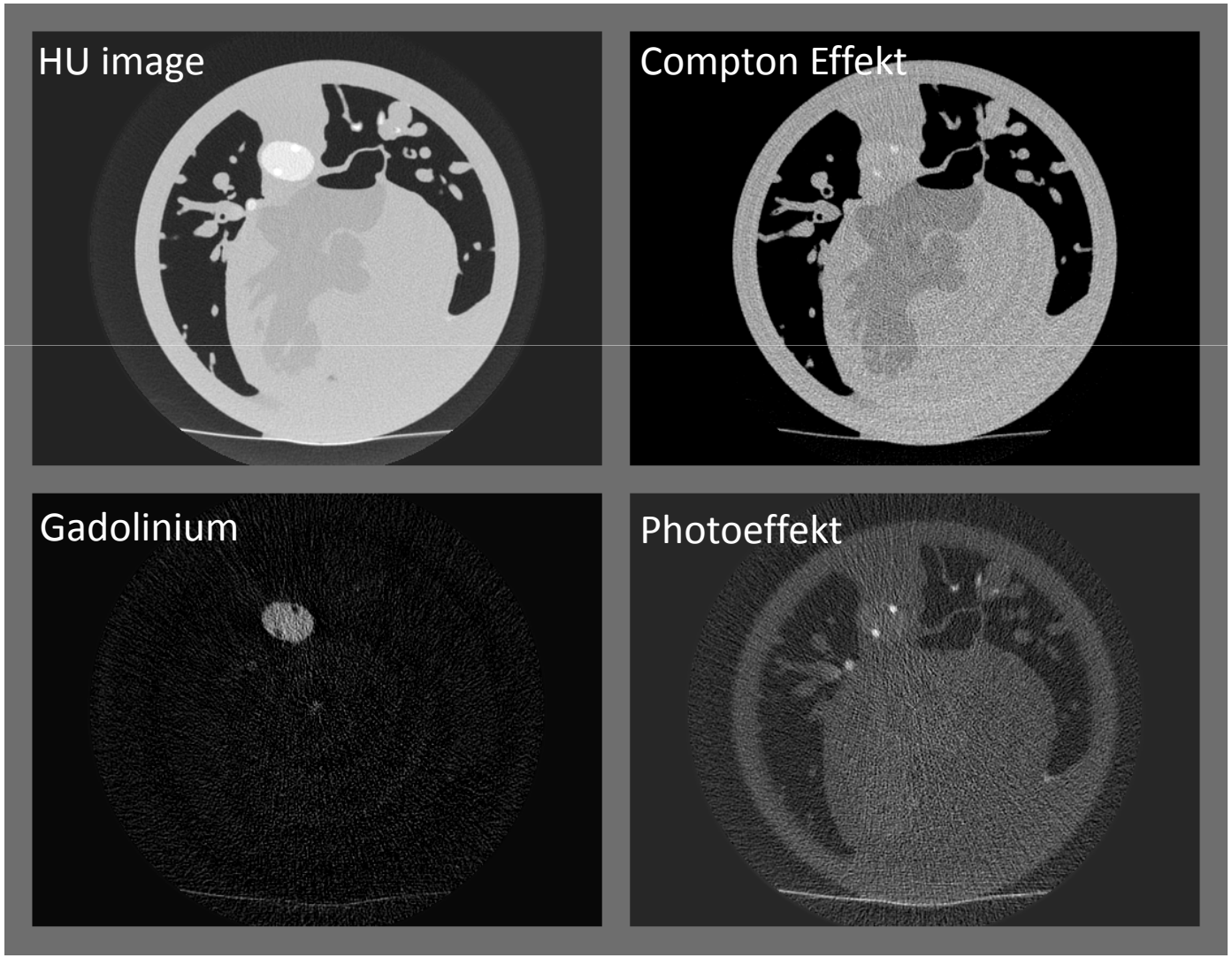
PHILIPS

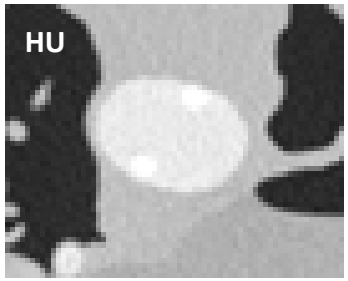
Spektrale Materialtrennung

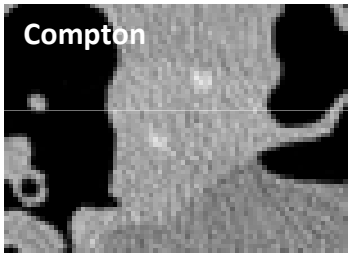
Gadolinium und Kalzium Trennung

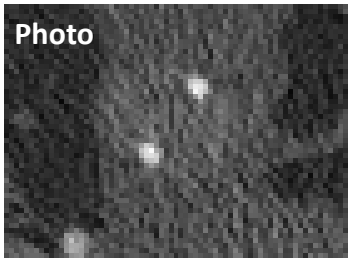


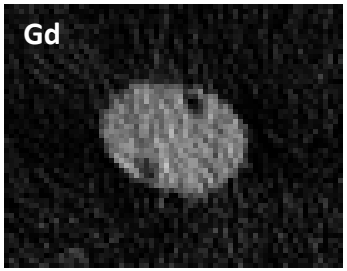






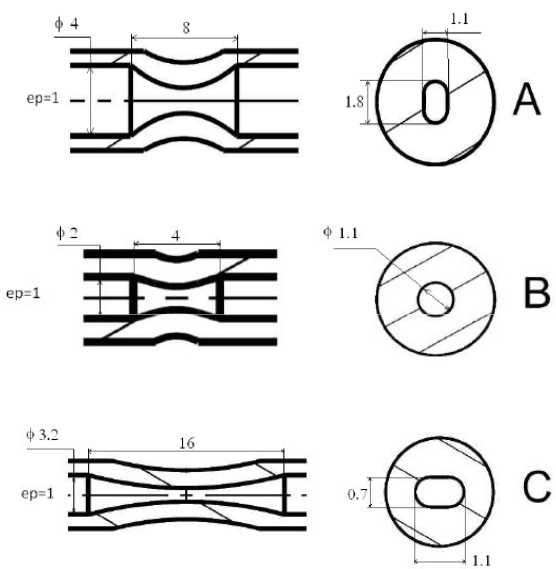




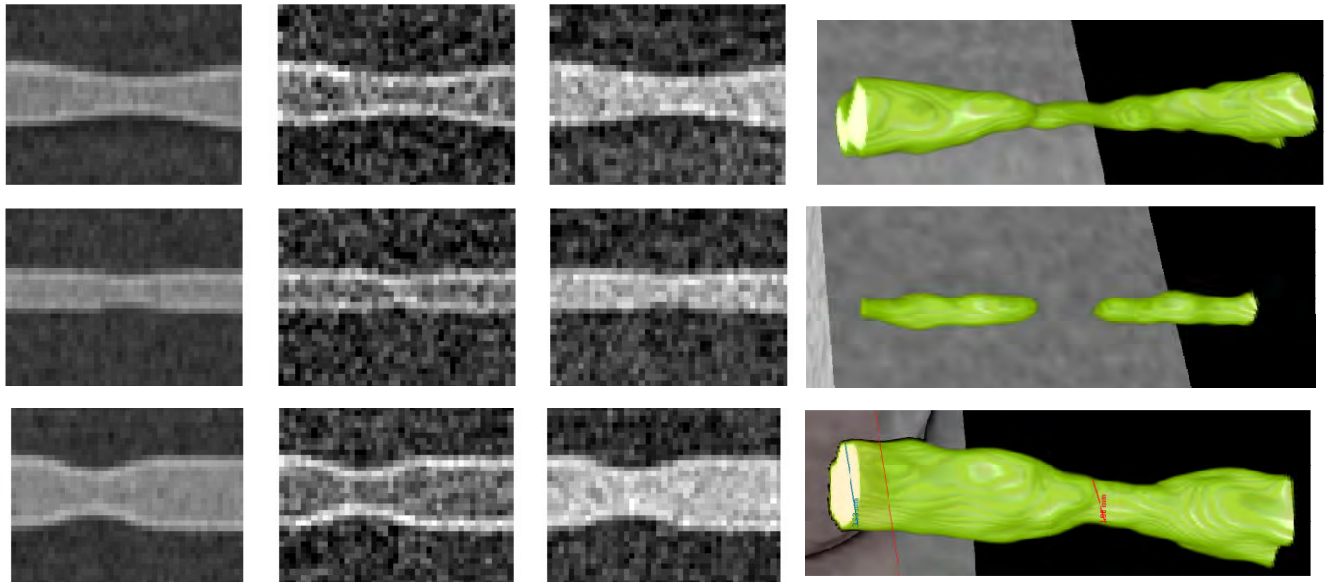


K-Kantenbildgebung von Gadolinium

Phantomstudie: Stenosephantom



HU Bild | **MonoE 48 keV** | **MonoE 52keV** | **Gd Basisbild (Volume rendering)**



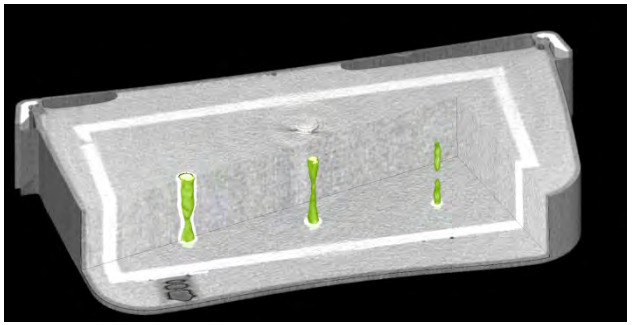
Scan Details

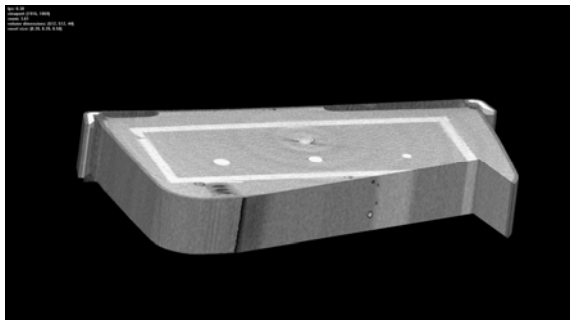
120kVp, 100mA

48000 spiral CT

FOV (z) = 2,2 cm

Gd 7.8 g/cm^3 = 50 mM





In Zusammenarbeit mit Prof. P. Douek and Prof. L. Boussel

PHILIPS

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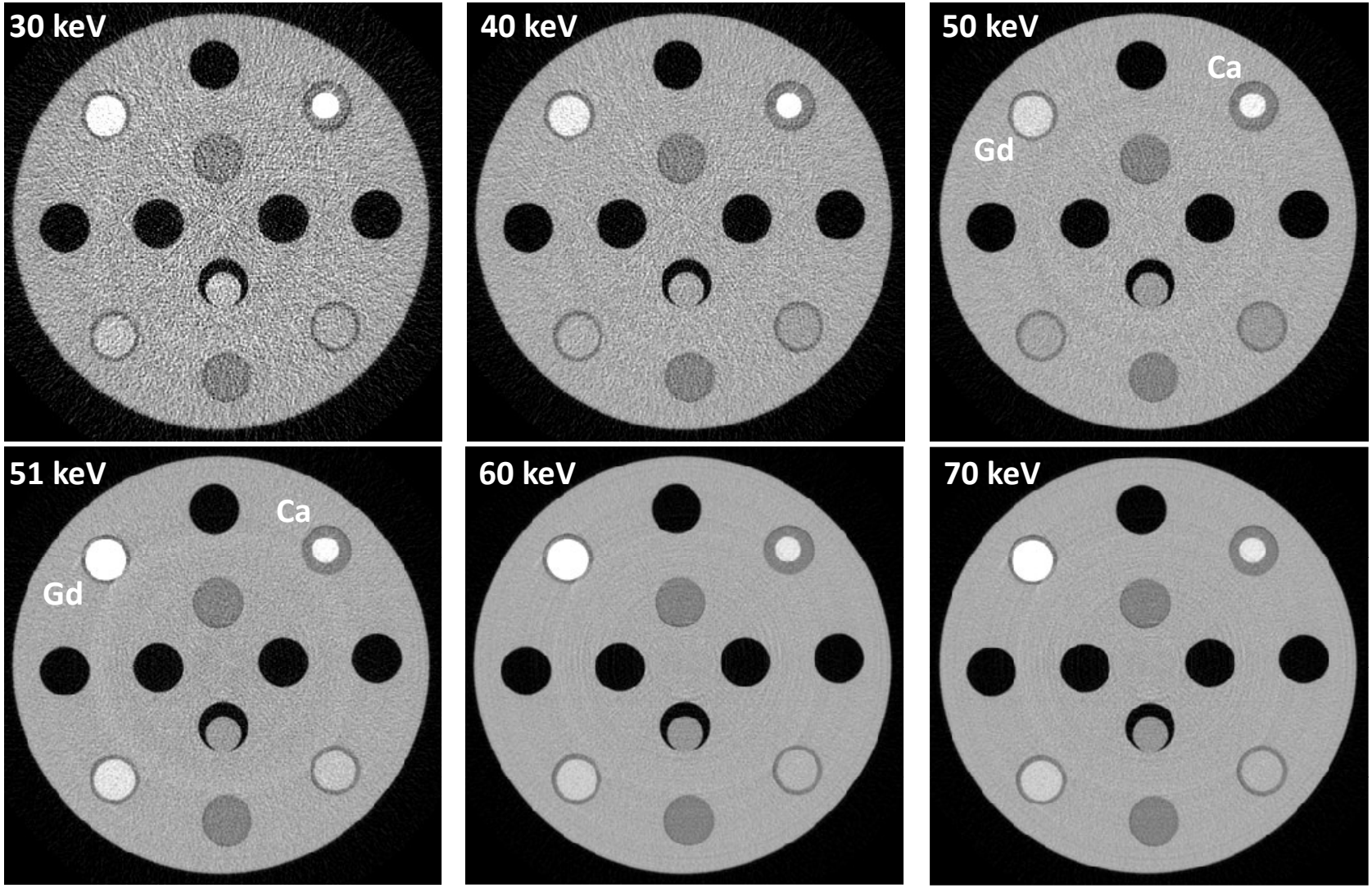
Spektrale Bildinformation – MonoE Bildgebung

Energieabhängigkeit der Schwächung

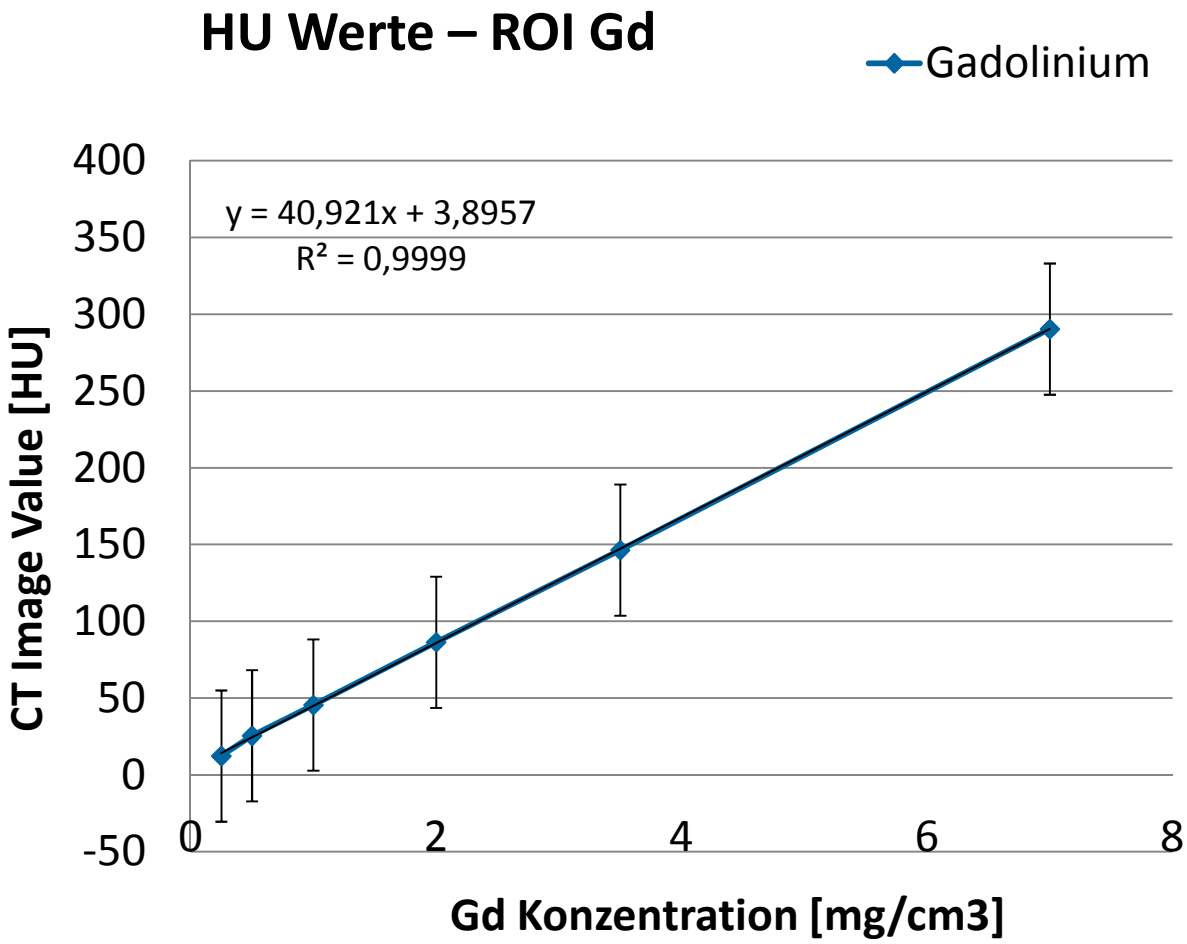


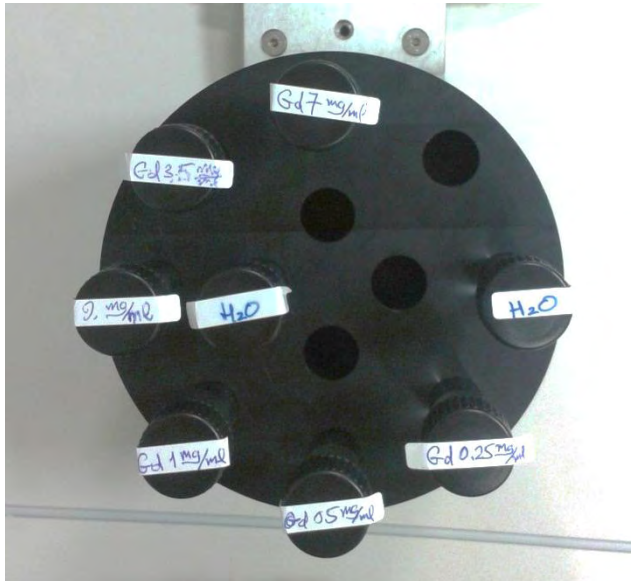
L : 0 HU, W: 2000 HU

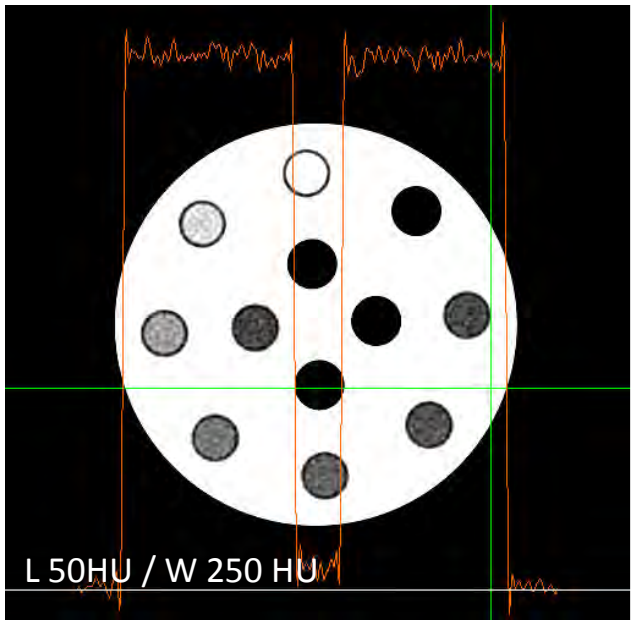
PHILIPS

HU – Bildqualität

Linearität des Gadoliniumkontrast im HU Bild







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