Tomosynthese – Neue Wege in der Mammographie

Ingrid Schulze-Wenck
Philips Healthtech
April 23, 2015

PHILIPS

Beschränkungen der normalen 2D Mammographie

- Es gibt kein einheitliches normales Mammographie-Bild
- Das Drüsengewebe verändert sich mit den hormonalen Änderungen
- Überlappende Strukturen erschweren die Diagnostik im 2D-Bild und können zu falsch negativen Befunden führen

PHILIPS

Warum digitale Brust-Tomosysnthese (DBT)?

- In der Standard 2D Mammographie kann überlappendes, dichtes Drüsengewebe dazu führen, dass
  - die Sichtbarkeit von malignen Befunden reduziert wird
  - oder das Aussehen eines bösartigen Befundes simuliert wird.

  Dies führt zu:
    - unnötigen Wiedereinbestellungen,
    - Biopsien und
    - psychologischem Stress für die Frauen

- Die Gewebeüberlappung und das elektronische Rauschen senken die Bildqualität in der Standard-Mammographie.

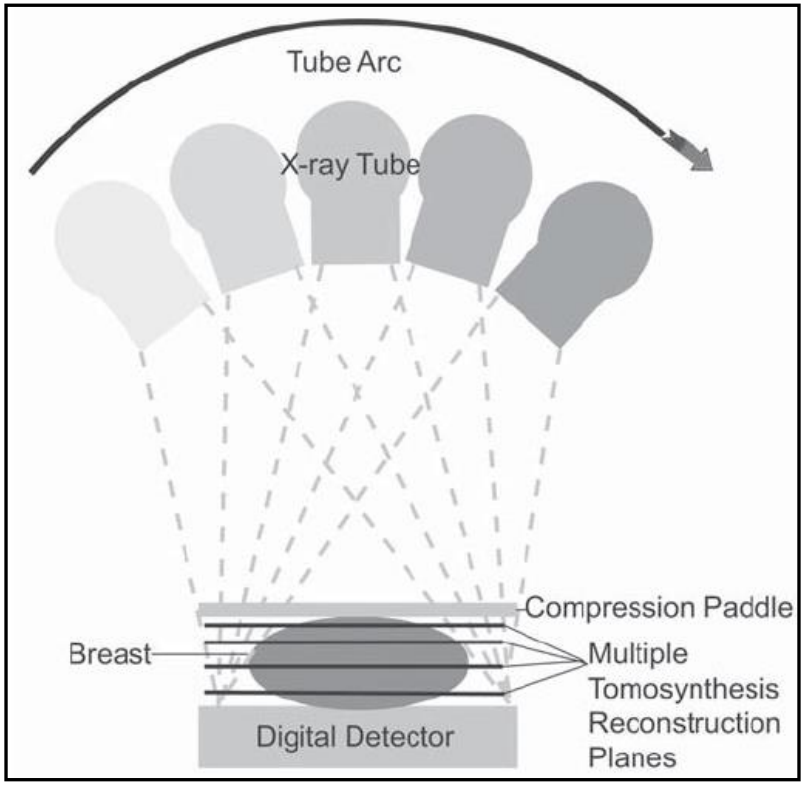
- Dies führt zu der Anforderung nach höhere Sensitivität und Spezifität und damit zu Add-on-Technologien wie die Digital Brust-Tomosynthese.

PHILIPS

Wie funktioniert Tomosynthese?

Digital breast tomosynthesis (DBT) is a newly developed form of three dimensional (**3D**) **imaging**. Compared to Computed Tomography (CT) the projections are acquired over a limited range of angles instead of 360° rotations of tube and detector.

DBT is called: "**limited angle tomography**"

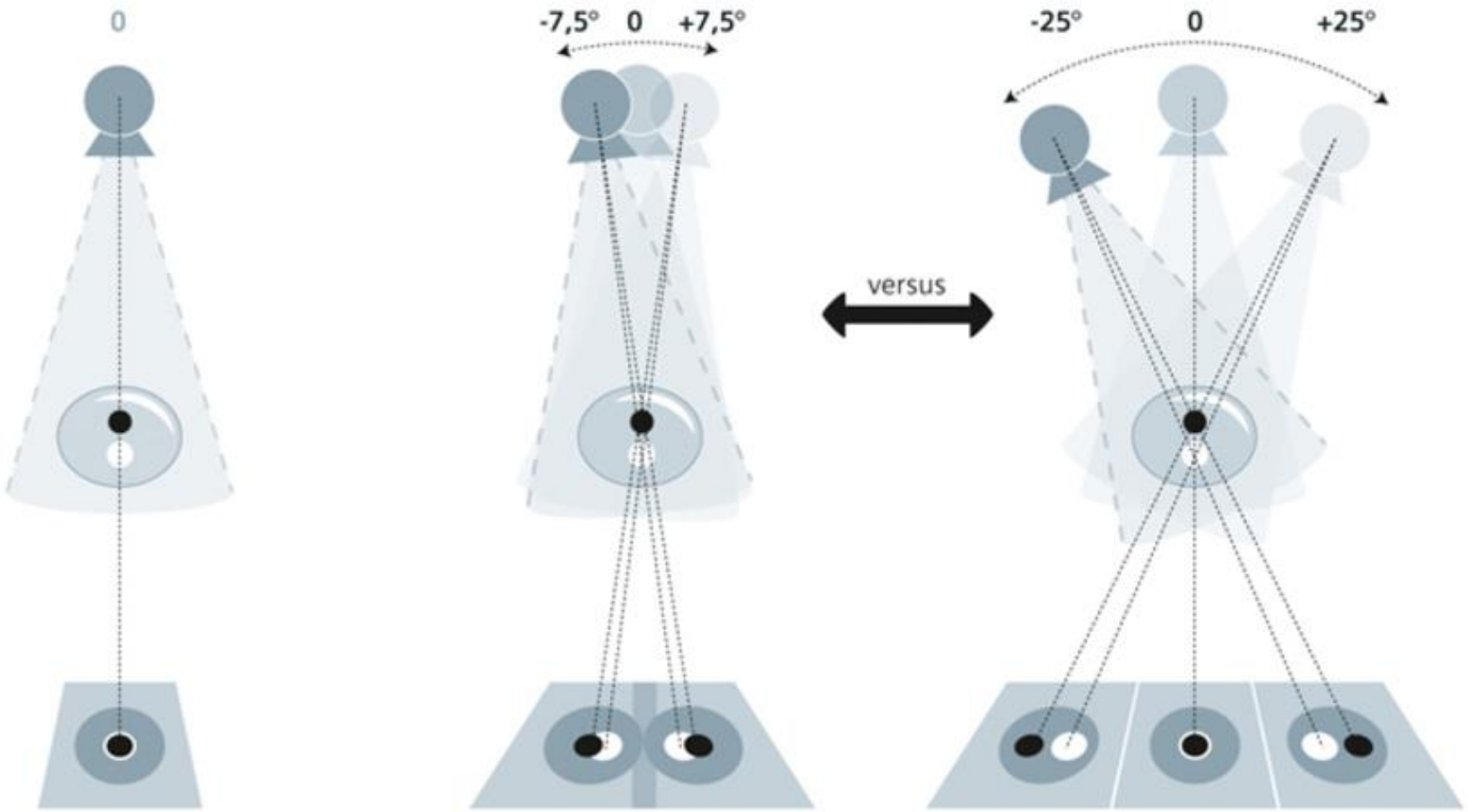


General principle:

- A series of low dose projection images is obtained while the x-ray tube moves in a circular motion, e.g. in an arc of 50° a number of projections (11-25) is taken while the breast remains compressed.

PHILIPS

Wie funktioniert Tomosynthese?



Methodische Unterschiede

- Bewegung der Röhre
- Detektor
- Winkel zwischen 11 und 50 Grad
- Anzahl der Projektionen
- Art und Weise der Rekonstruktion
- Dosis, welche Projektionen (MLO, CC)

PHILIPS

Bewegung der Röhre

Kontinuierlich
- Kann zu Brennfleck-Verwischungen führen
- Schneller und dadurch weniger Bewegunsunschärfen

Step and shoot
- Theoretisch optimale Methode
- Probleme durch Stop und Start Bewegungen der Röhre

Technischer Vergleich

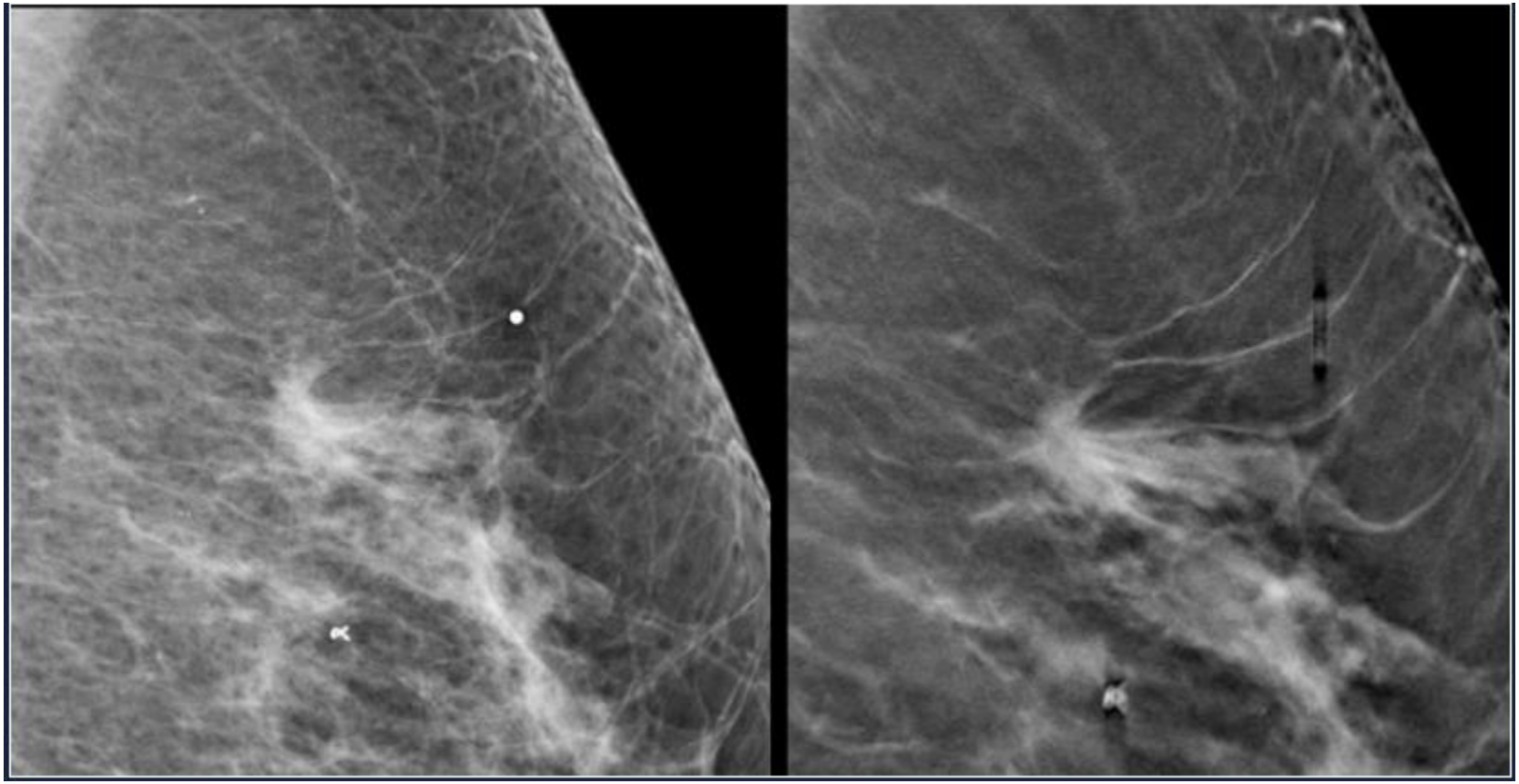
Table 1 **Specifications and geometry of breast tomosynthesis systems currently available or in development (based on Sechopoulos 2013 and subsequent information from manufacturers).**

DBT System	*General Electric Essential*	*Hologic Selenia Dimensions*	*IMS Giotto TOMO*	*Philips Microdose*	*Planmed Clarity3D*	*Siemens Mammomat Inspiration*	*Fujifilm Amulet Innovality*
Type of geometry	Full-field	Full-field	Full-field	Scanning multislit	Full field	Full-field	Full-field
Detector type	Energy integrating	Energy integrating	Energy integrating	Photon counting	Energy integrating	Energy integrating	Energy integrating
Detector material	CsI-Si	a-Se	a-Se	Si	CsI-a-Si	a-Se	a-Se
Detector element size (µm)	100	70	85	50	83	85	68[5]
Focal plane pixel size	100	95-117[1]	85	50	83/166	85	100/150
X-ray tube motion	Step-and shoot	Continuous	Step-and shoot	Continuous	Continuous, Sync-and-Shoot	Continuous	Continuous
Target	Mo/Rh	W	W	W	W	W	W
Filter	Mo: 30µm Rh: 25 µm	Al: 700 µm	Rh: 50 µm Ag: 50 µm	Al: 500 µm	Ag: 75 µm Rh: 60 µm	Rh: 50 µm	Al: 700 µm
Angular range	25	15	40[2]	N/A[6]	30	50	15/40
Number of projection images	9	15	13	21[3]	15	25	15
Source to detector distance (mm)	660	700	680	660	650	655	650
Distance between detector and centre of rotation (mm)	40	0	20	400[4]	4.4	47	46

[1] The pixel size in the focal plane changes with height above the breast support table.
[2] The projection images may not be equally spaced and may not have the same exposure factor.
[3] This system does not have projection images, but 21 datasets from the detector lines.
[4] Below the detector.
[5] Hexagonal shaped detector elements.
[6] Tube movement: 34°.

PHILIPS

MLO view: 2D versus 3D



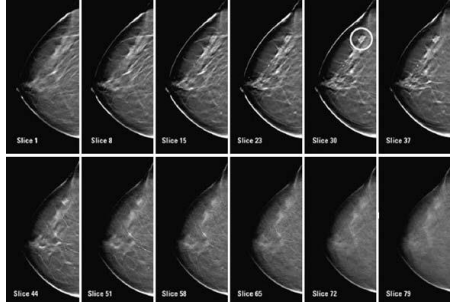
PHILIPS

Artefakte

PHILIPS

PHILIPS

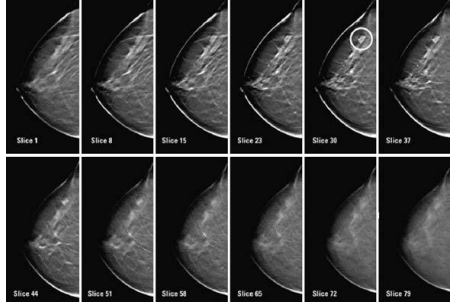
Tomosynthese in der Diagnostik



- Many studies ongoing, showing slight improvement in **specificity** and **sensitivity** and above all **accuracy**
- New clinical studies indicate the effectiveness of tomo, **higher detection rates**, especially of **small invasive cancers**
- Potential replacement for diagnostic views
- GIVES READERS MORE CONFIDENCE IN THEIR RESULT

PHILIPS

Tomosynthese im Screening



- Tomo is being used in screening in USA **TODAY**!
- Recent publications from Europe and USA are showing promising results for screening :
  - Increase in detection rate, up to 53%
  - The majority of published studies looking at screening to date find that the largest improvement in detection is in the combination of 2D/3D
  - First publications show that synthetic mammogram is effective
  - Recall rate up in some studies (e.g. Malmö), down in others
  - No change in DCIS detection
  - **Finding smaller invasive cancers**
  - Improvement in all breast density types
  - Reading times up 50-300%, depending on reader and system.
- Effect on **interval cancer rate** will be investigated

PHILIPS

Where is Tomosynthesis going?

- Clinical breakthrough expected next 2-3 years
- Major recent milestone: Tomosynthesis received Medicare reimbursement in the USA
- Pilot programmes expected in several European countries
- Cost/benefit analysis still needed prior to wide adoption
- Role vs. other modalities (MRI, US) needs to be investigated

- Numerous clinical trials planned and ongoing:
  - Use of tomosynthesis in screening
  - Use of tomosynthesis for diagnostic workup vs. 2D mammo
  - Comparison Tomosynthesis to MRI
  - Performance Combination of Tomosynthesis with Mol.Imaging/US

Malmö Trial:
Enrollment: 15000
Start Date: March 2010
Completion : December 2014

Oslo Trial:
Estimated Enrollment: 25000
Start Date: October 2010
Completion : 2014

Italian (Storm) Trial, part 2:
Estimated Enrollment: 10.000
Start Date: beginning 2014
Completion: 2016

Tomosynthese – Systeme

Hologic
Screening, Diagnostik und Biopsie
C-view = synthetisches 2D, hat auch bereits FDA-Zulassung

GE
FDA-Zulassung
(CESM = duale Energie mit 2 Aufnahmen, Kontrastmittel)

Siemens
FDA-Zulassung in Arbeit (PMA)
Größten Winkel (50 Grad) = Beeinflussung der Auflösung

Fuji
2 Winkel (15 und 40 Grad)

Giotto, Planmed

PHILIPS

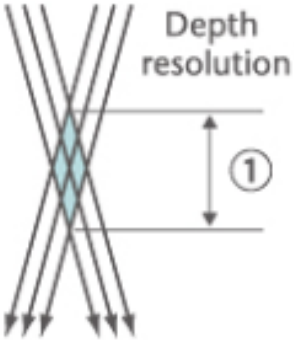
Tomosynthese – Systeme

Two modes suitable for a range of clinical purposes

ST (Standard) mode

Acquisition angle: ±7.5°
Pixel size: 150/100 µm

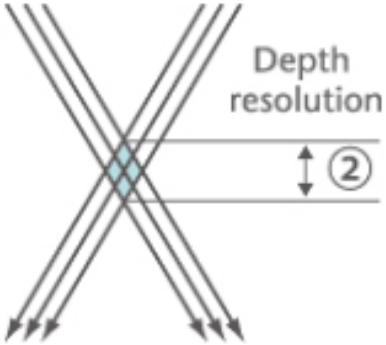
The smaller angular range and fast image acquisition allow Tomosynthesis scans to be quickly performed with a relatively low x-ray dose.

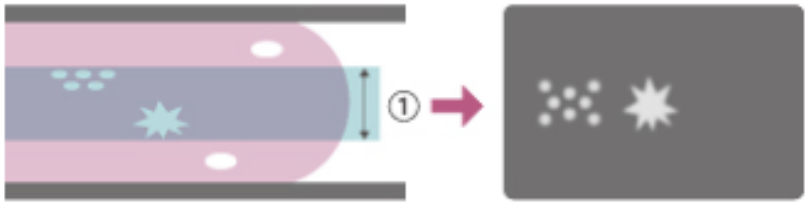


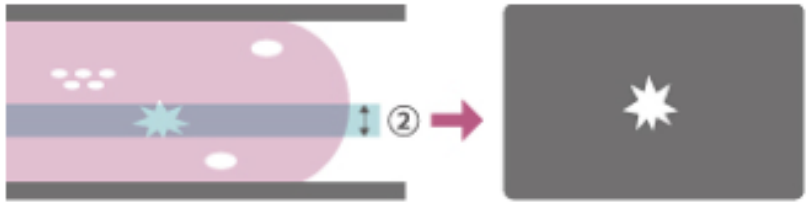
HR (High Resolution) mode

Acquisition angle: ±20°
Pixel size: 100/50 µm

With a larger acquisition angle the depth resolution is improved. This allows the region of interest to be defined more clearly and brought into clearer focus.

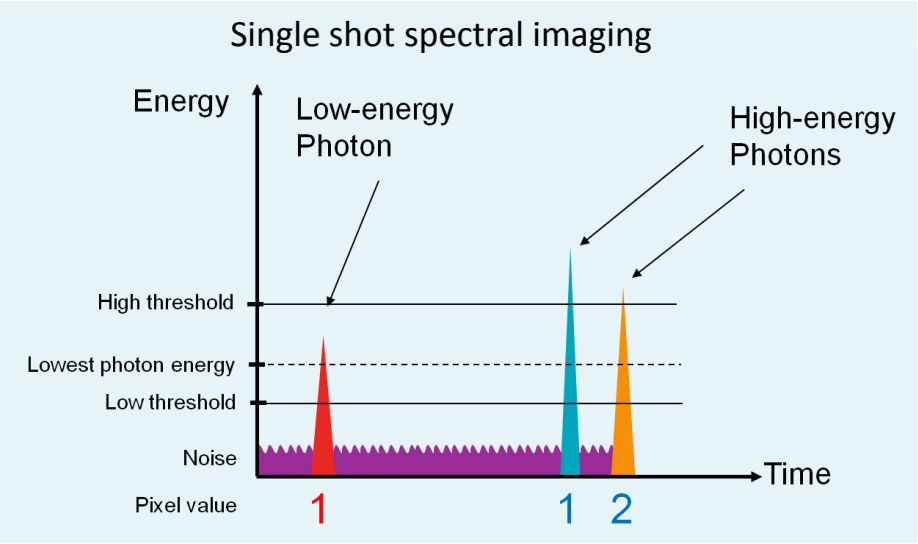


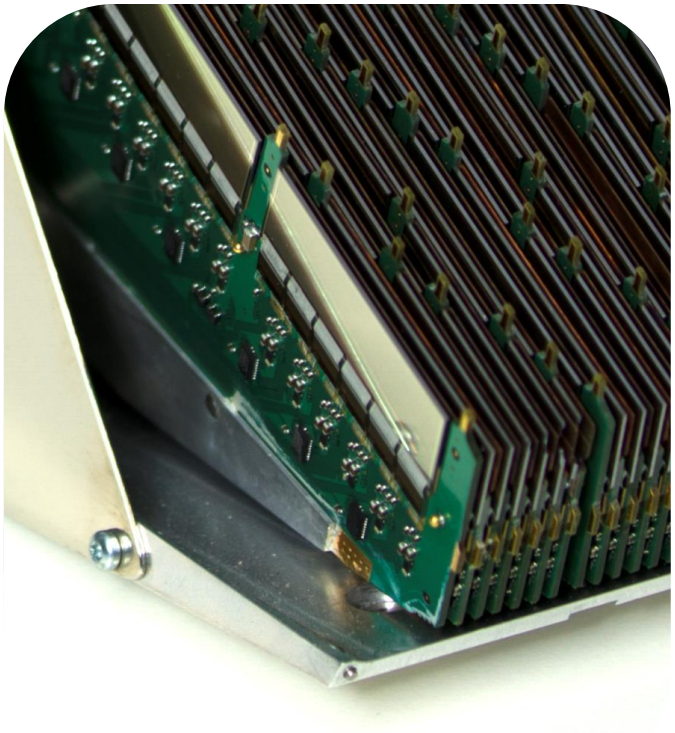




PHILIPS

Spektraler Photon-counting Detektor

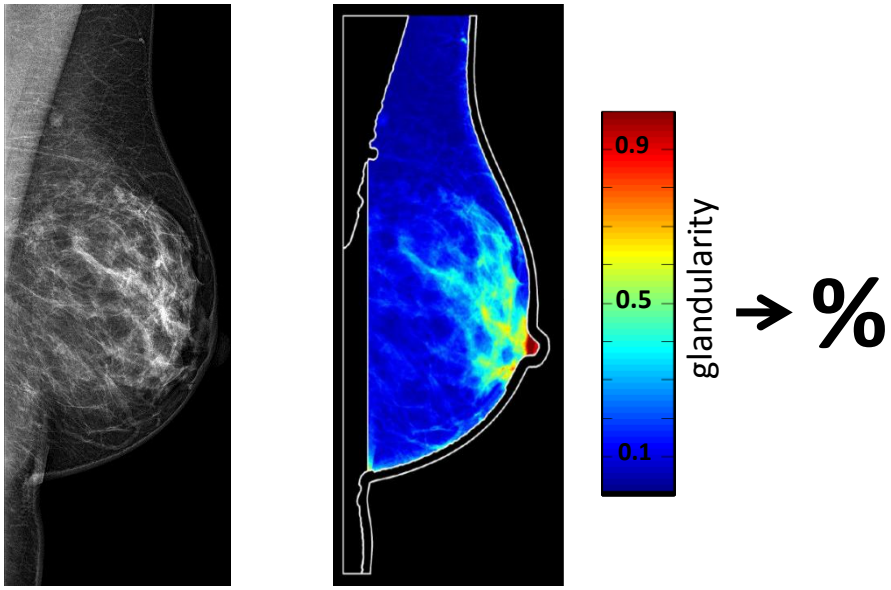




PHILIPS

Application: Breast Density Measurement

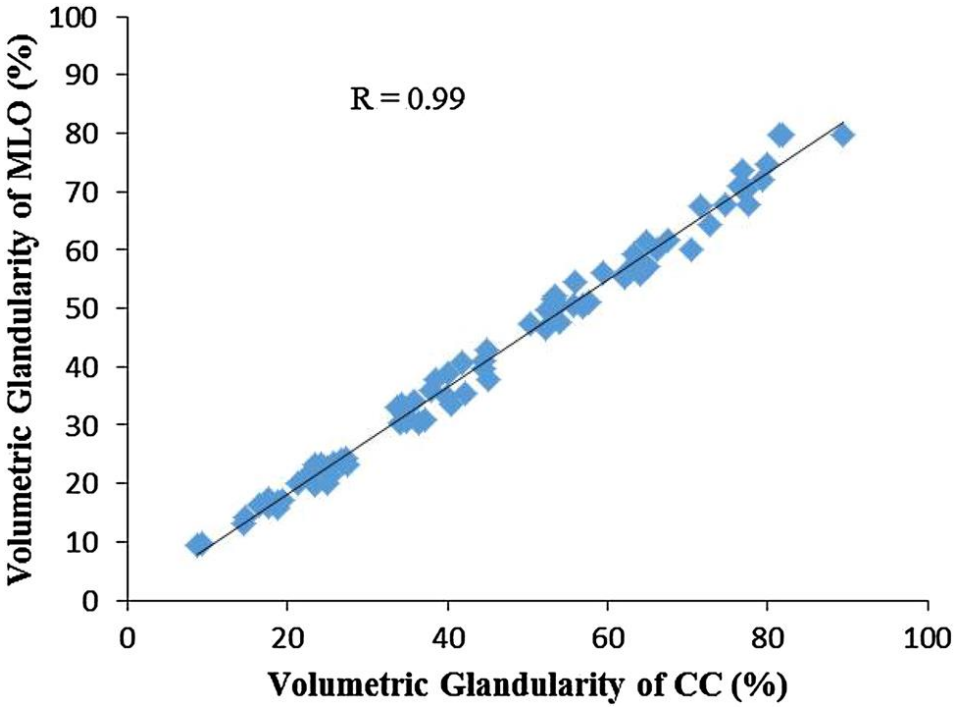
- Spectral imaging allows us to measure the amount of fibro-glandular and adipose (fatty) tissue and calculate the breast density
- Breast density is correlated with risk of breast cancer and risk of missing lesions in screening



PHILIPS

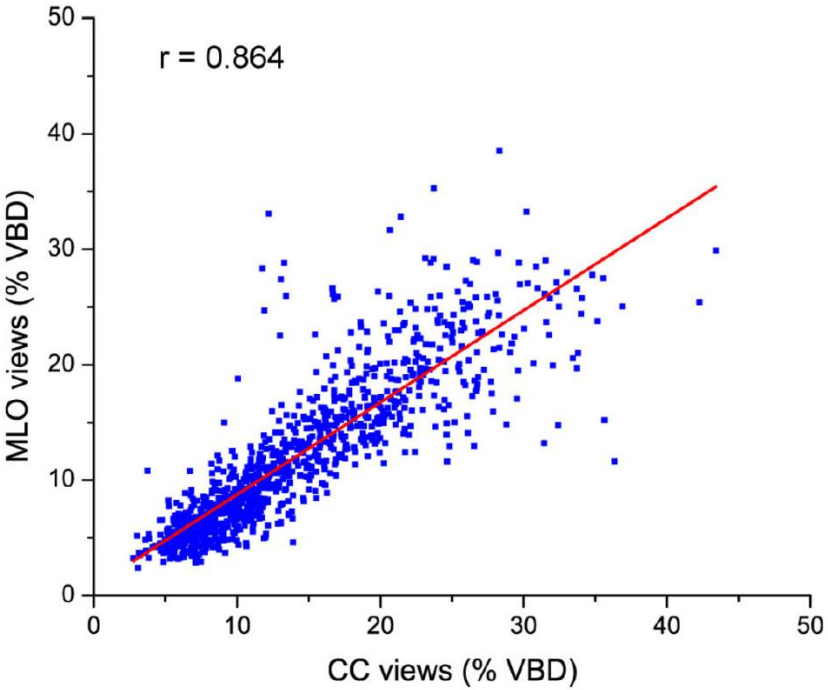
Klinische Resultate

Spectral breast density measurement



Machida, Y, et al., 2014. Feasibility study of a breast density measurement within a direct photon counting mammography scanner system. Jpn J Radiol DOI 10.1007/s11604-014-0333-x.

Conventional breast density assessment

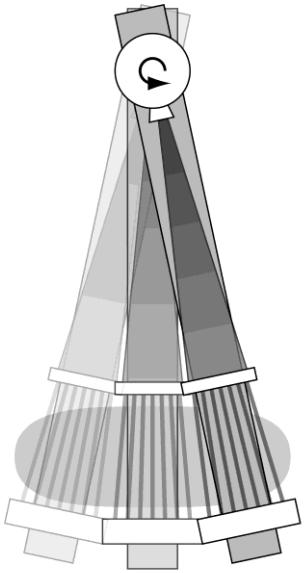


G. Gennaro, R. Highnam, “This is what volumetric breast density is”, Educational Exhibit, ECR 2013, 10.1594/ecr2013/C-1033

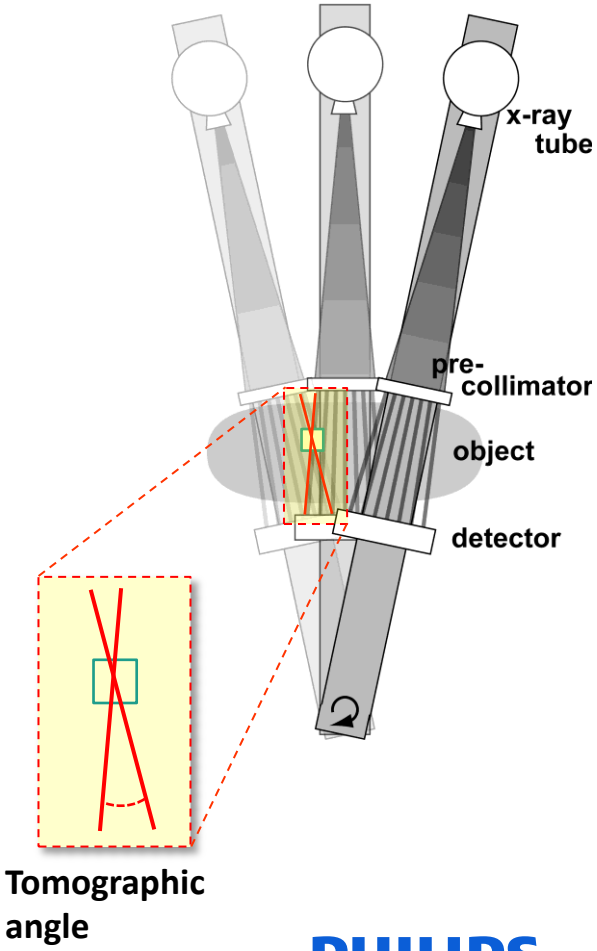
PHILIPS

Spectral photon-counting tomosynthesis*

2D



Tomosynthesis

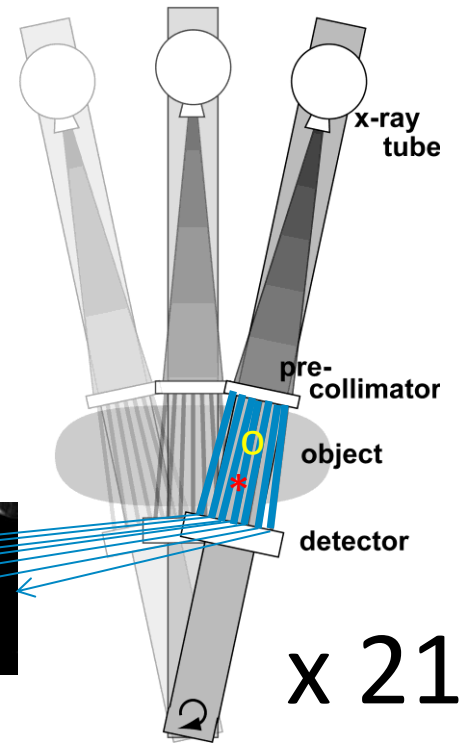


* Work in progress

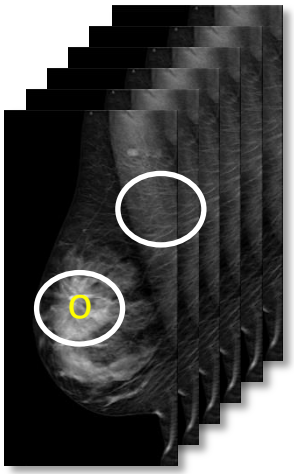
PHILIPS

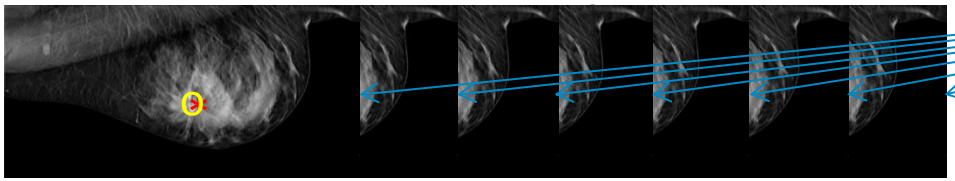
Spectral photon-counting tomosynthesis*

Tomosynthesis



Tomosynthesis slices





Reconstruction

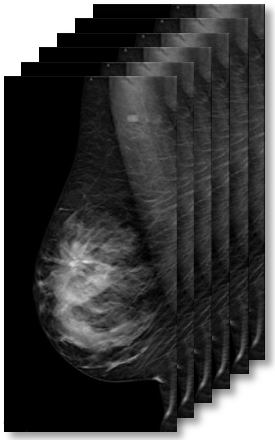
* Work in progress

PHILIPS

Synthetic 2D

- Besserer und schnellerer Vergleich mit Vorbefunden
- Gibt einen Überblick (Workflow)
- Strukturen der Tomosynthese-Schichten werden in einem einzigen Bild dargestellt

Tomosynthesis slices

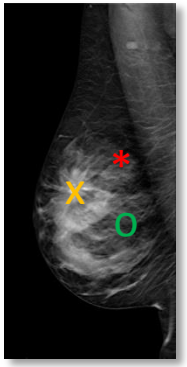


*

o

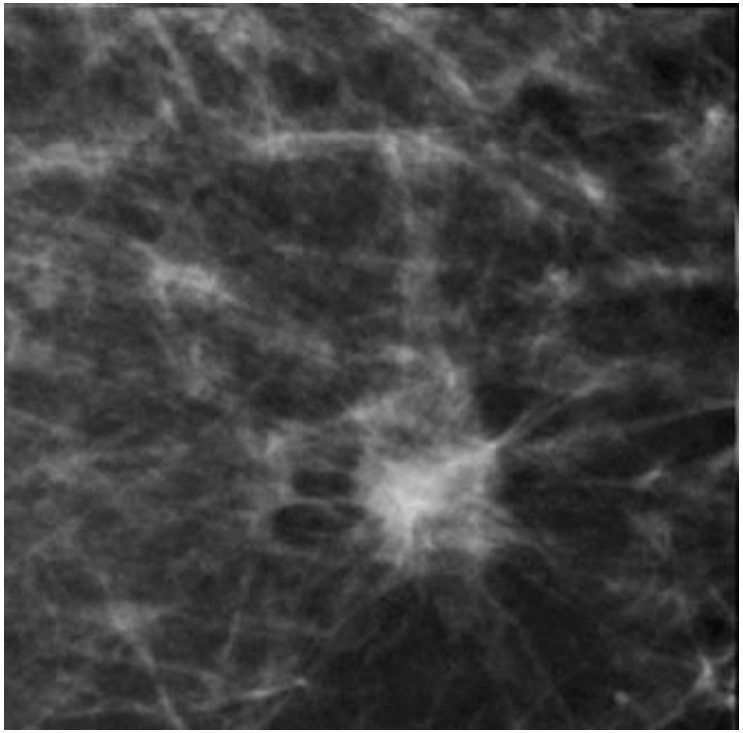
x

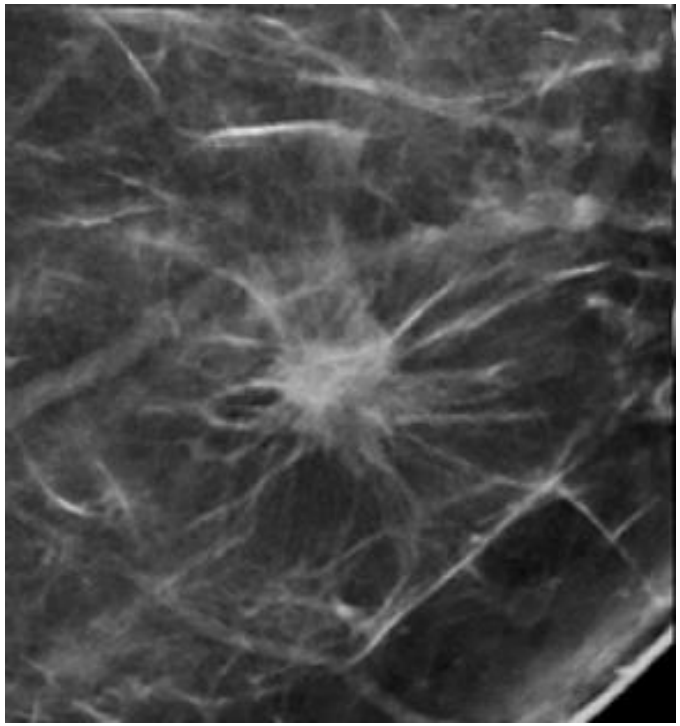
Synthetic 2D



PHILIPS

Vergleich 2D und synth. 2D





PHILIPS

Qualitäts - Kontrolle

Bilddaten

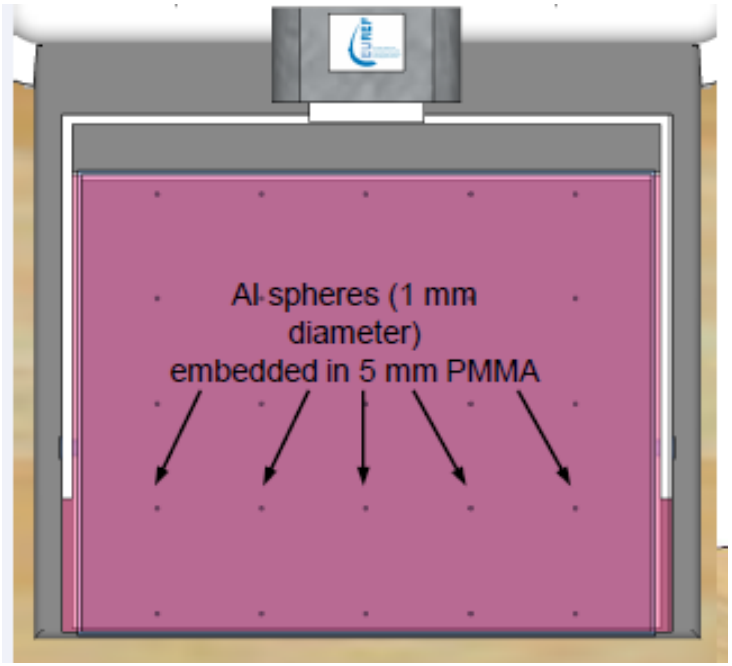
- Projektionsbilder, unprozessiert
- Tomosynthese slices
- Stationärer Modus in 0 Grad
- Synthetisches 2D

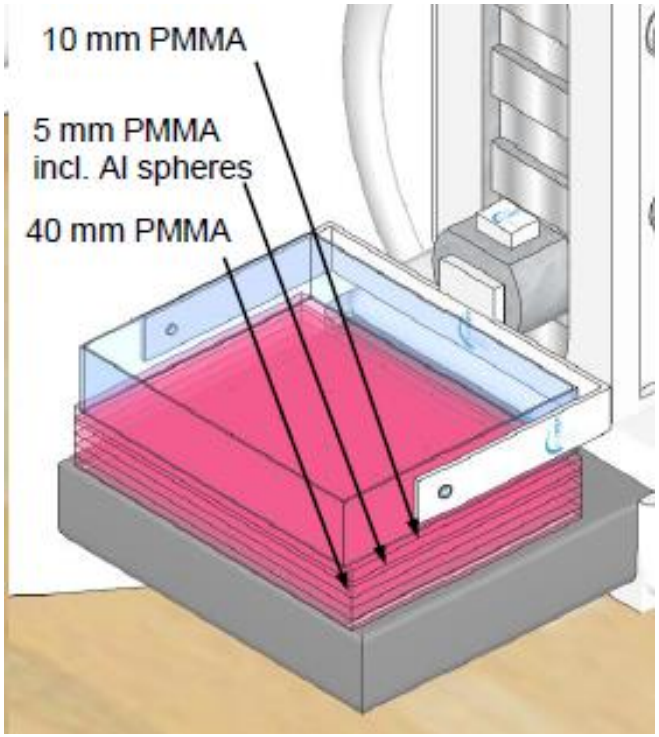
Bildverarbeitung

- Rekonstruktion (Filtered Back Projection, Iterative)
- Shift and Add

Qualitäts - Kontrolle

Auflösung in der Z-Achse, halbjährlich





5 x 10 mm PMMA-Platten plus 5 mm PMMA mit Aluminium-Kügelchen (1 mm)

PHILIPS

Qualitäts - Kontrolle

Auflösung in der Z-Achse, halbjährlich

Quantitative Messung:

Gemessen wird die Ausbreitung der Artefakte, die aus den Aluminium-Kügelchen entstehen.

Messungen werden gemacht in vertikaler Richtung zum Detektor.

FWHM (Full width at half maximum)
FW QM (Full width at quarter maximum)

Half maximum = Mittelwert zwischen dem höchsten Pixelwert innerhalb des Kügelchen und dem Hintergrund in der Ebene des Kügelchens.

Eine Software soll unterstützen!

Qualitäts - Kontrolle

Fehlende Darstellung oben und unten, halbjährlich

1. Kleine Objekte mit hohem Kontrast (z.B. Büroklammern) werden in der Mitte, nahe der Brustwand und in jede Ecke der Bildfläche gelegt. Darauf Standard-PMMA-Block.

2. Die kleinen Objekte werden unter die Kompressionsplatte fixiert. Leichte Kompression des Standard-PMMA-Blocks.

PHILIPS

Qualitäts - Kontrolle

Homogenitätstest der rekonstruierten Ebenen

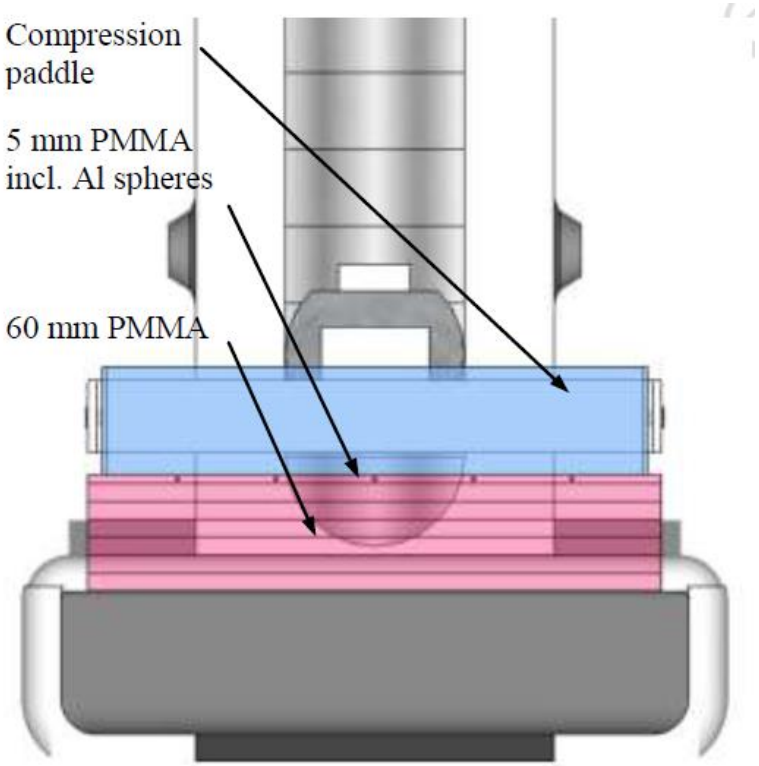
1. Aufnahme des Standard-PMMA-Blocks mit AEC-Technik
2. ROIs von 5 mm x 5 mm: MPV, Standard deviation,
3. Kalkulation von Signal-to-noise-ration SNR

Artefakte können leichter sichtbar sein, wenn eine Aufnahme im stationären Modus in 0 Grad gemacht wird oder auf den Projektionsbildern.

PHILIPS

Qualitäts - Kontrolle

Geometrische Verzerrung, Abnahmeprüfung



Das Phantom wird unten, in der Mitte und oben platziert.

Software-Unterstützung wird zur Verfügung stehen.

Alle Verzerrungen sollen innerhalb der Spezifikation der Hersteller sein.

PHILIPS

Zusammenfassung

- Studien belegen eine bessere Effektivität hinsichtlich einer Reduktion der recall rates, höhere Detektionsrate von kleinen invasiven Tumoren und eine bessere Genauigkeit
- Gibt es eine Reduktion der Interval Tumoren?
- Tomosynthese wird in vielen Ländern heute im diagnostischen Kontext angewandt
- Anwendung von Tomosynthese im Screening-Bereich wird erwartet (schon heute wird Tomo in USA im Sreening eingesetzt)
- Diskussionen über Qualitäts-Standards laufen (IEC, EUREF)