



Tomografia computerizzata a raggi X con scanner dedicati alla mammella

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ABSTRACT

Al fine di eliminare il problema della sovrapposizione delle strutture anatomiche nell'imaging mammografico 2D, a partire dal 2001 sono stati sviluppati, prima in USA e poi in EU, scanner CT (Computed Tomography) dedicati, per la diagnosi del tumore alla mammella.

La geometria di irraggiamento prevede la paziente in posizione prona e la mammella non compressa che pende liberamente da un foro del lettino, sotto cui un gantry ruotante acquisisce centinaia di proiezioni a 360 gradi attorno all'organo.

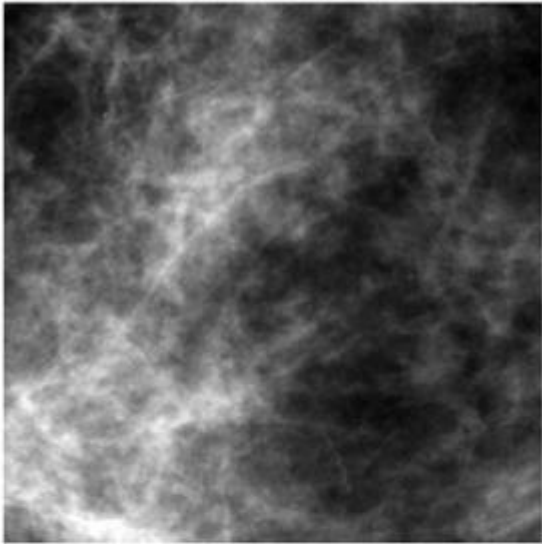
Tali scanner impiegano fasci semi-conici di raggi X da tubo radiogeno a 50--80 kV che irradiano solo la mammella, con dosi ghiandolari che sono paragonabili a quella delle due viste mammografiche. In tale metodica, finora sviluppata a livello sperimentale, vengono prodotte mappe 3D del coefficiente di attenuazione dei tessuti mammari e delle eventuali lesioni, con eccellente risoluzione in contrasto e buona risoluzione spaziale.

Dal 2015 uno scanner di tal tipo è anche disponibile commercialmente in USA per imaging in combinazione con la mammografia.

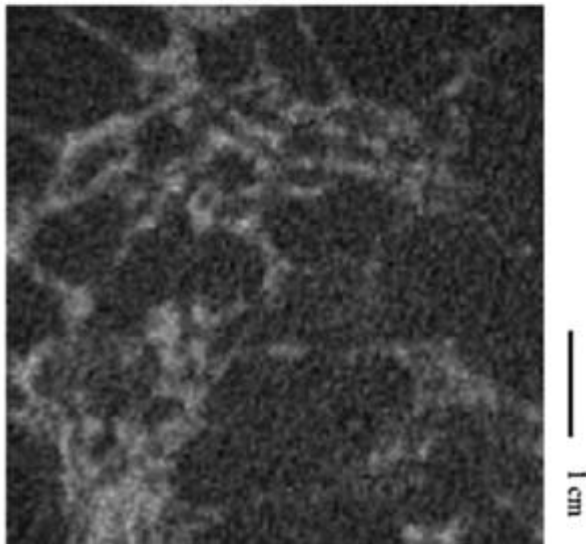
Nella relazione verrà descritta tale metodica con riferimento all'attività dei principali gruppi di ricerca internazionali e di alcuni spinoff in USA ed EU.

Breast anatomical noise

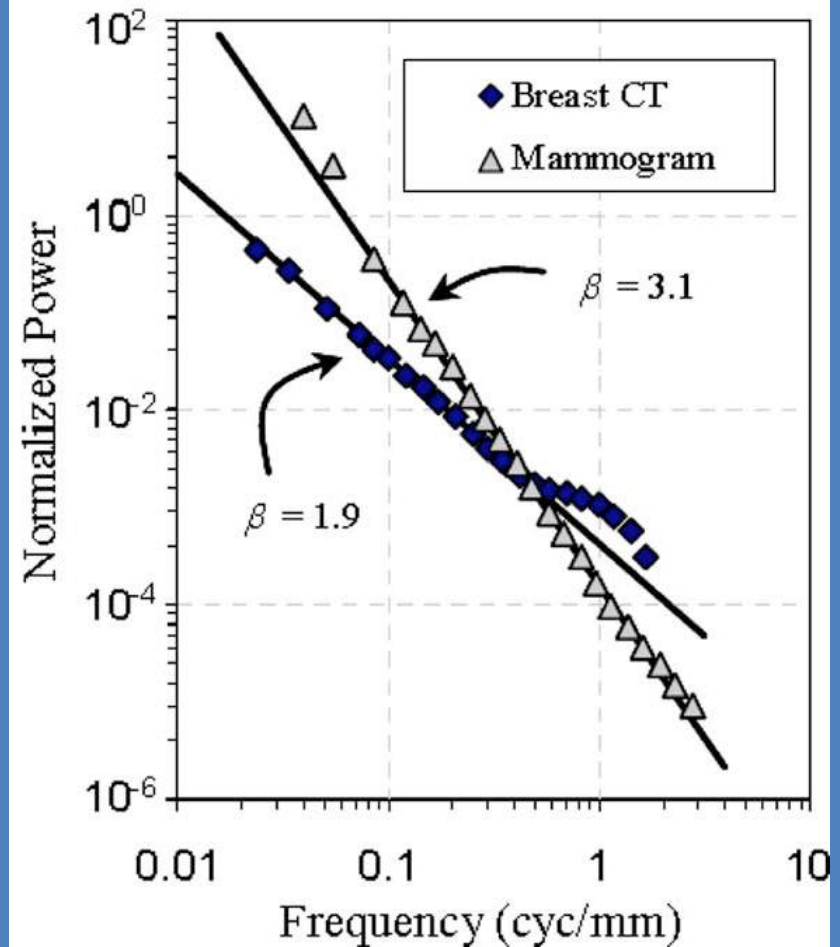
A. Mammogram



B. Breast CT



C. Power Spectra



University of California
at Davis

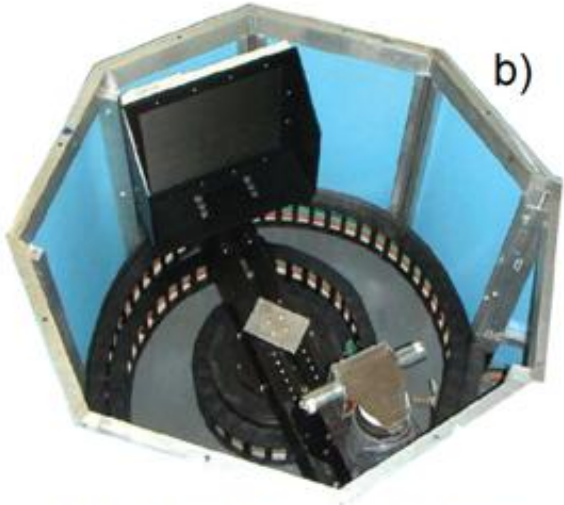
Prof. John Boone
(2001-present)

Dedicated Breast CT scanners

- 80 kV
- Mean Glandular Dose comparable to two-view mammography (< 5 mGy)
- 300-500 views
- 10-17 s scan time (breath hold)



a)



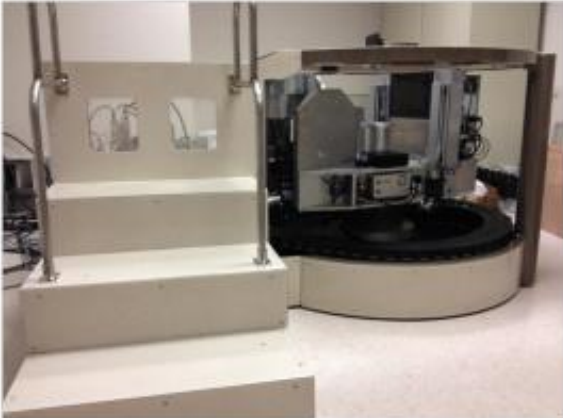
b)



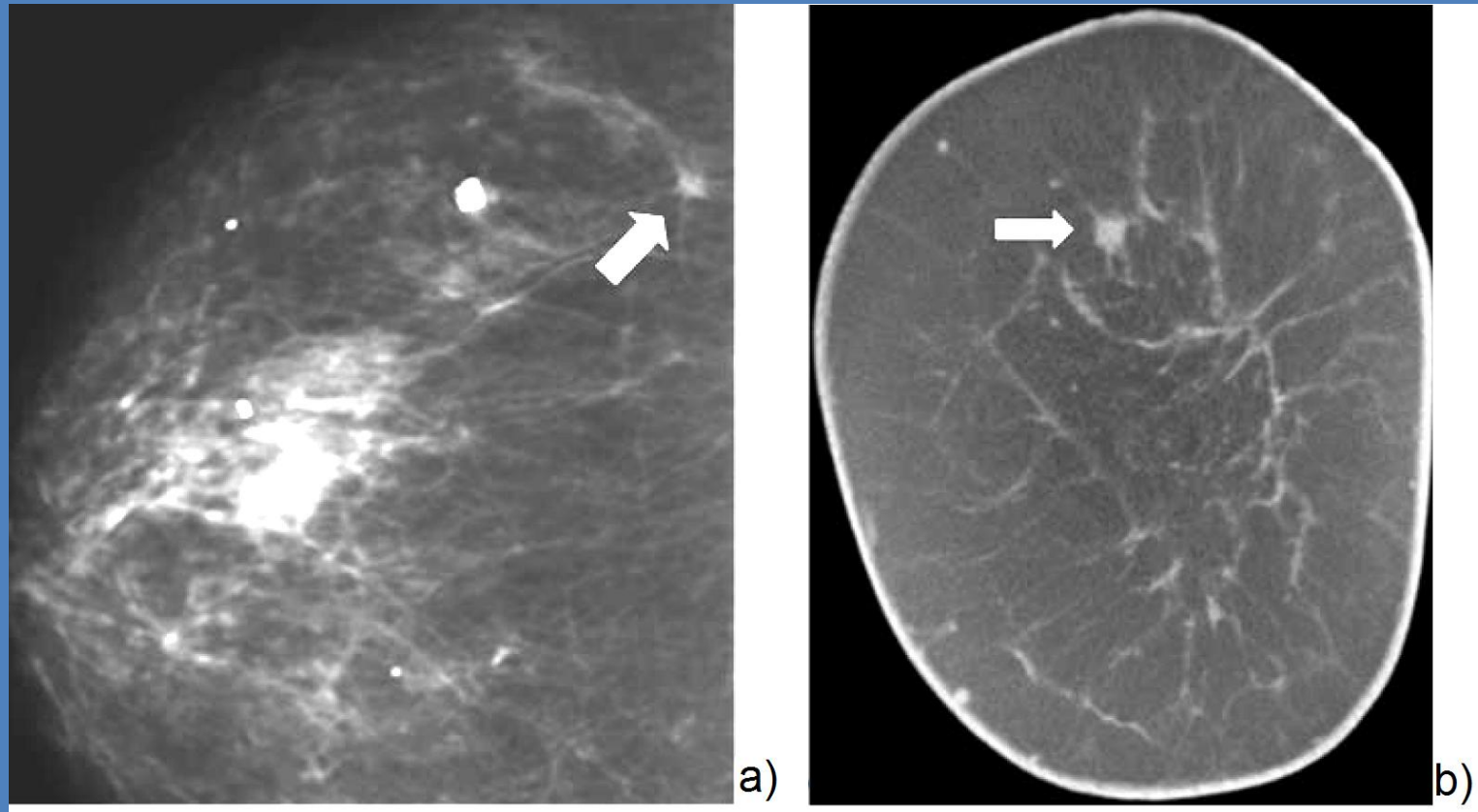
c)



d)

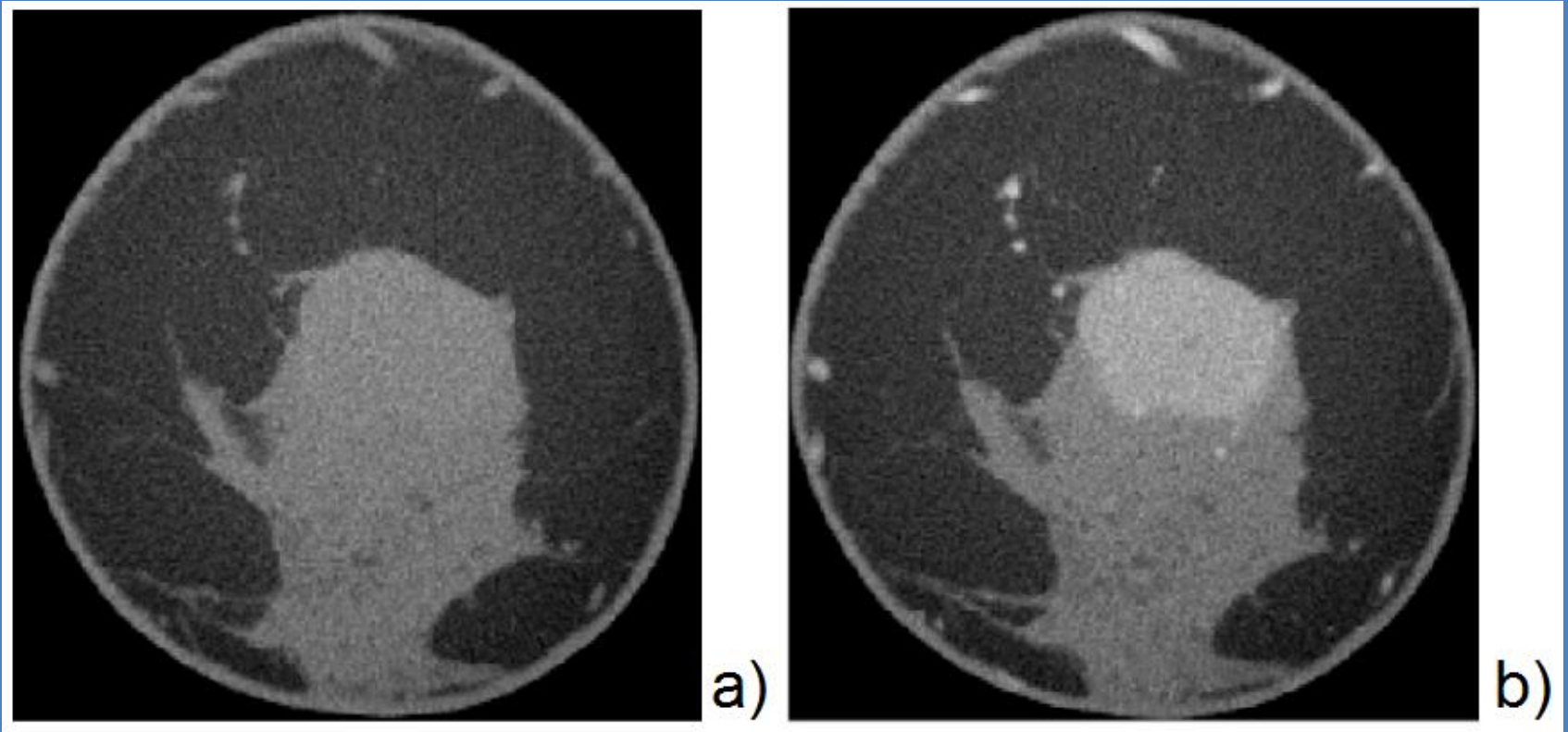


e)



Clinical trials at UC Davis showed that mass conspicuity (4-mm infiltrating ductal carcinoma) was better in a BCT slice (b) than in a mammography screen-film CC view (a) (K. K. Lindfors, J. M. Boone et al. *Radiology*, **246**, 725–733 (2008)).

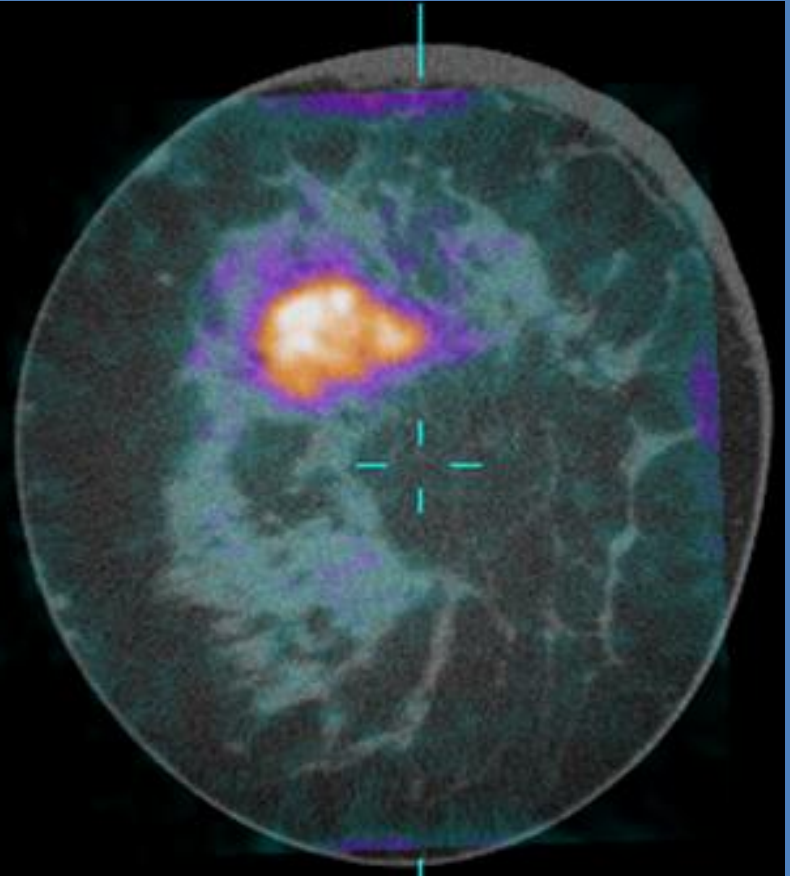
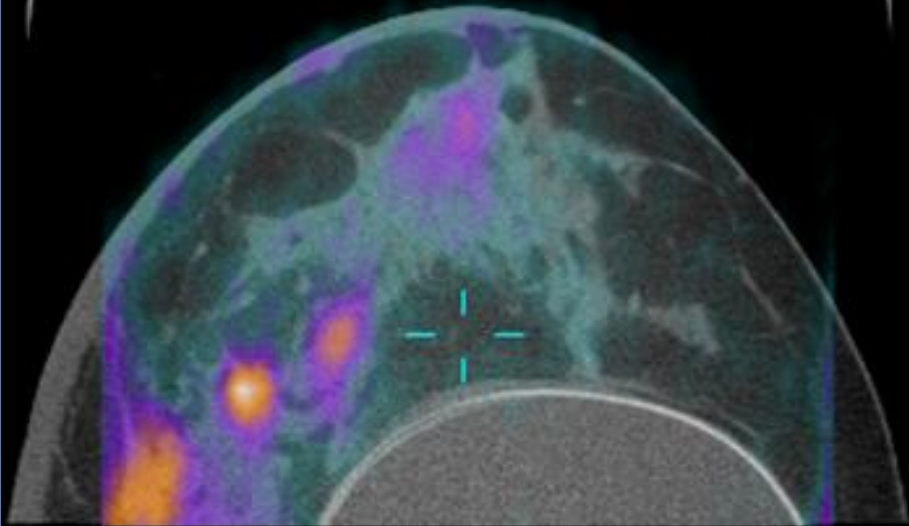
Contrast-enhanced breast CT



University of California at Davis (courtesy of Prof. J. Boone)

N. D. Prionas, Ket al., Radiology **256**, 714–723 (2010)

Dedicated breast PET/CT



University of California at Davis (courtesy of Prof. J. Boone)

Research group	Laboratory/clinical system developed	Surgical/autoptic specimens scanned	Clinical trials ongoing	Spinoff company
UC Davis	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Duke U	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
U Erlangen	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
UMASS	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
U Naples	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
U Rochester	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
U Texas	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
U Trieste	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

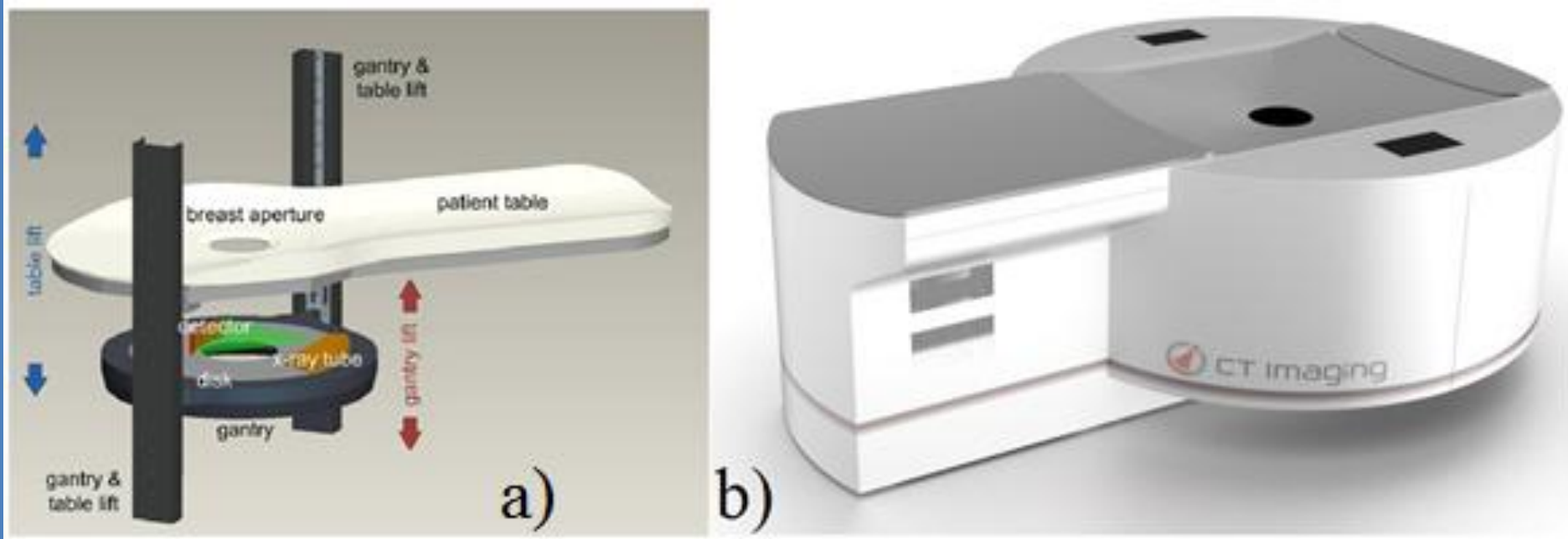


Breast CT scanner of University of Rochester (Prof. R. Ning)



Koning Corp. Commercial scanner
(FDA approved January 2015 for diagnostic
imaging in combination with mammography)

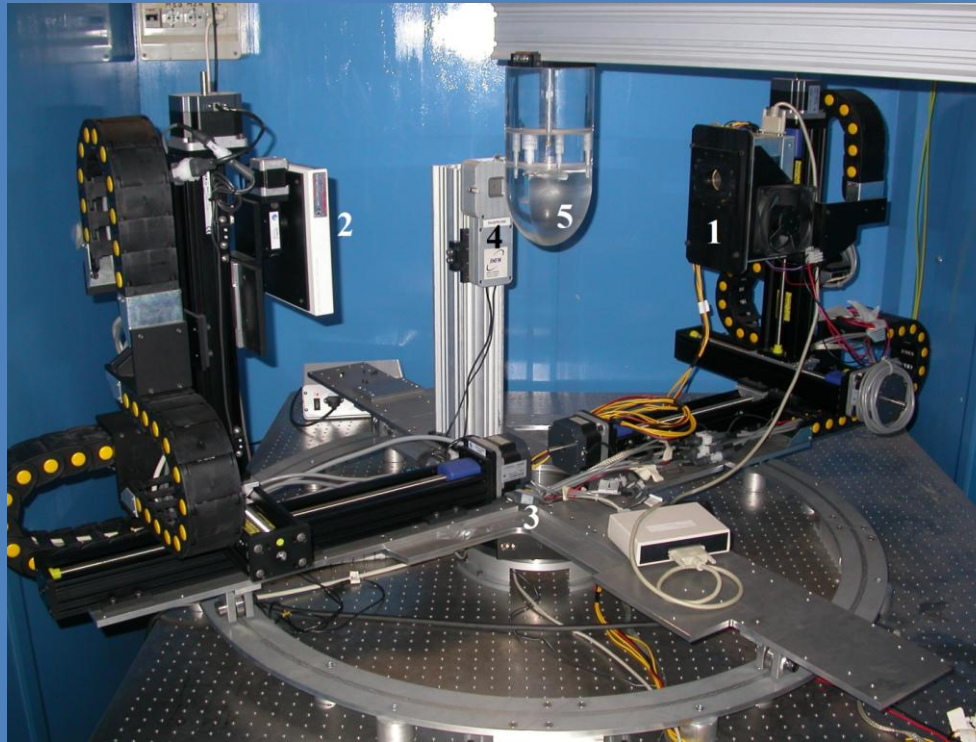
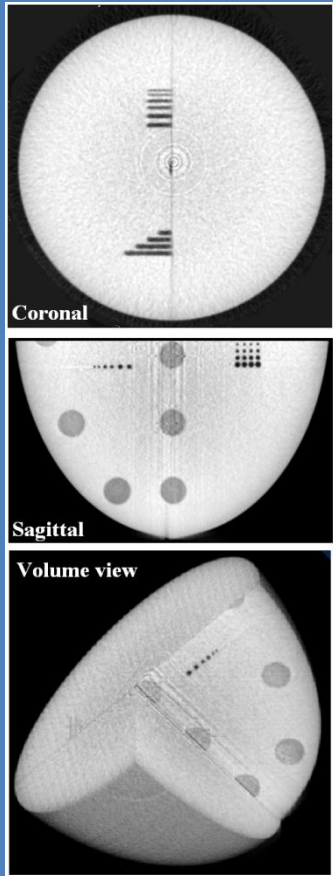
MPI, University of Erlangen & CT Imaging
(Prof. W. A. Kalender)



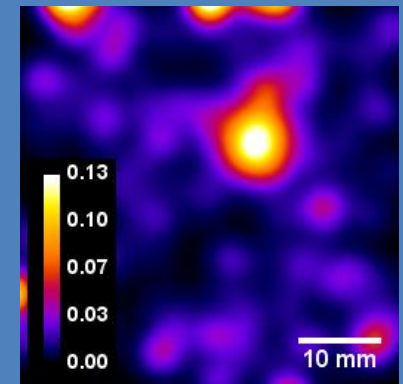
Photon-counting CdTe imaging detector
Helical scanning, 2 s rotation time, 10 s scan time

INFN Esperimenti BREAST-CT e BCT (2007-2012)

Scanner CT (raggi X) e SPECT (raggi gamma) dedicato al seno *X-ray phase-contrast tomography*

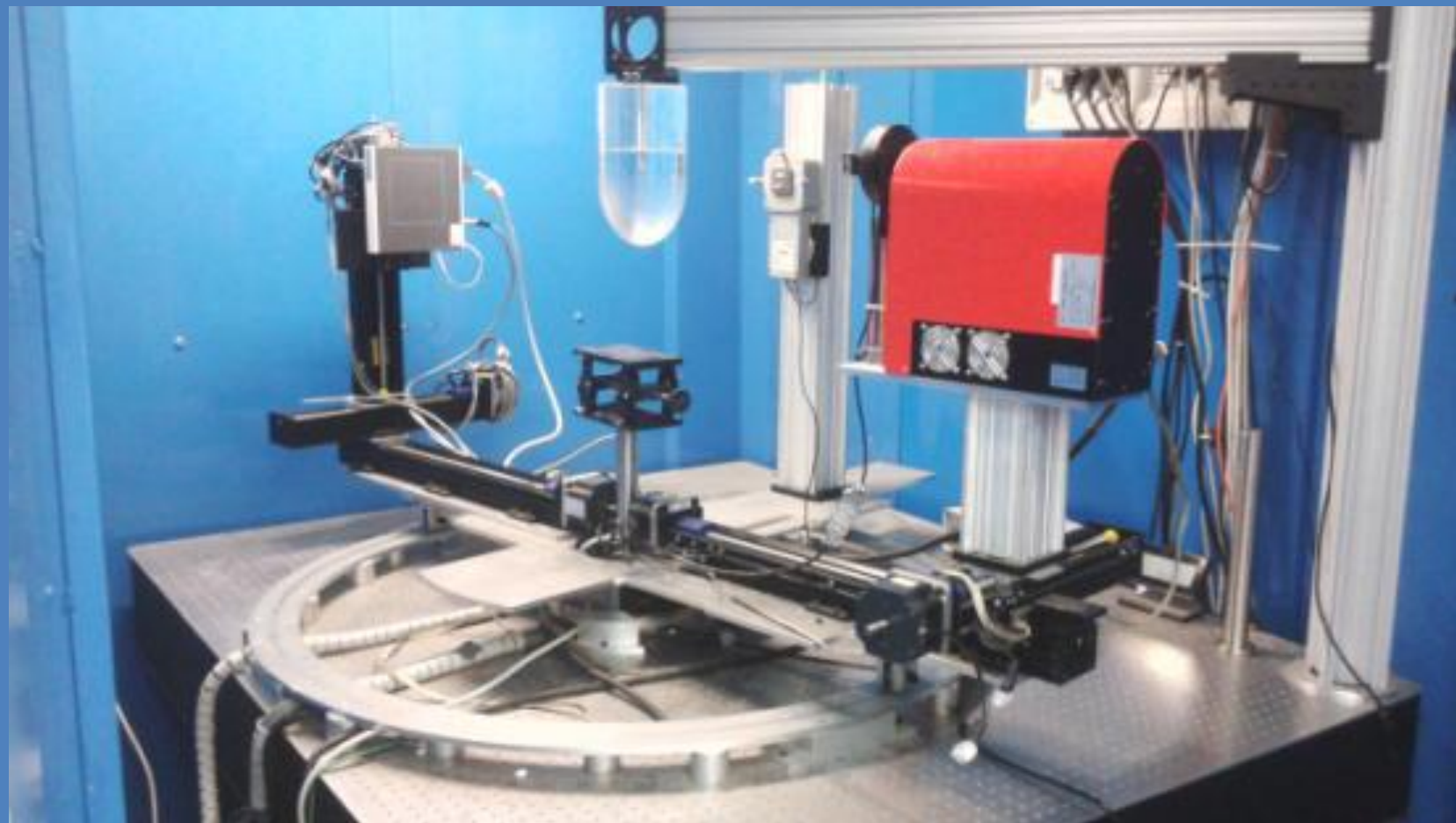


CdTe Medipix2 detector
5 mm hot detail
15:1 activity ratio ^{99m}Tc



First European prototype (5 in USA) for Cone-Beam Breast CT/SPECT for laboratory investigations. X-ray tube (1), flat panel detector (2), rotating gantry (3), pinhole compact gamma camera (4) and PMMA breast phantom (5).

Phase-contrast breast CT w/ SPECT head



University & INFN Napoli

Breast holders (U. Napoli)



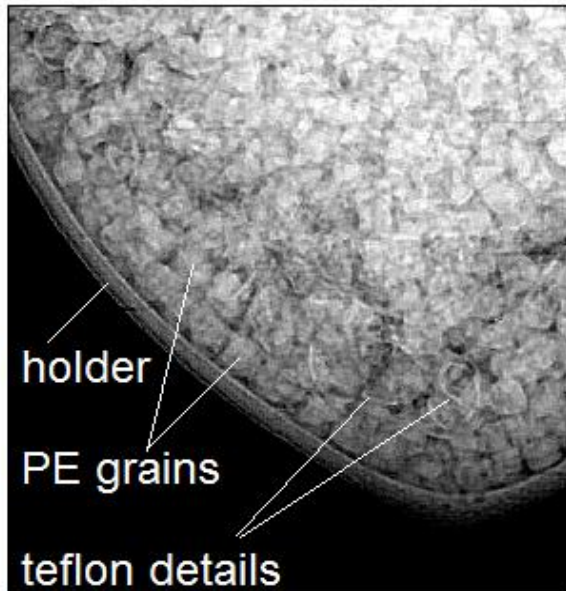
a)



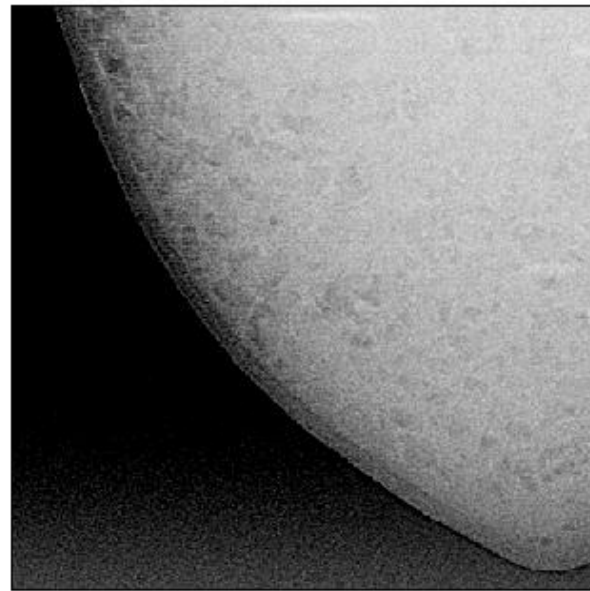
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c)

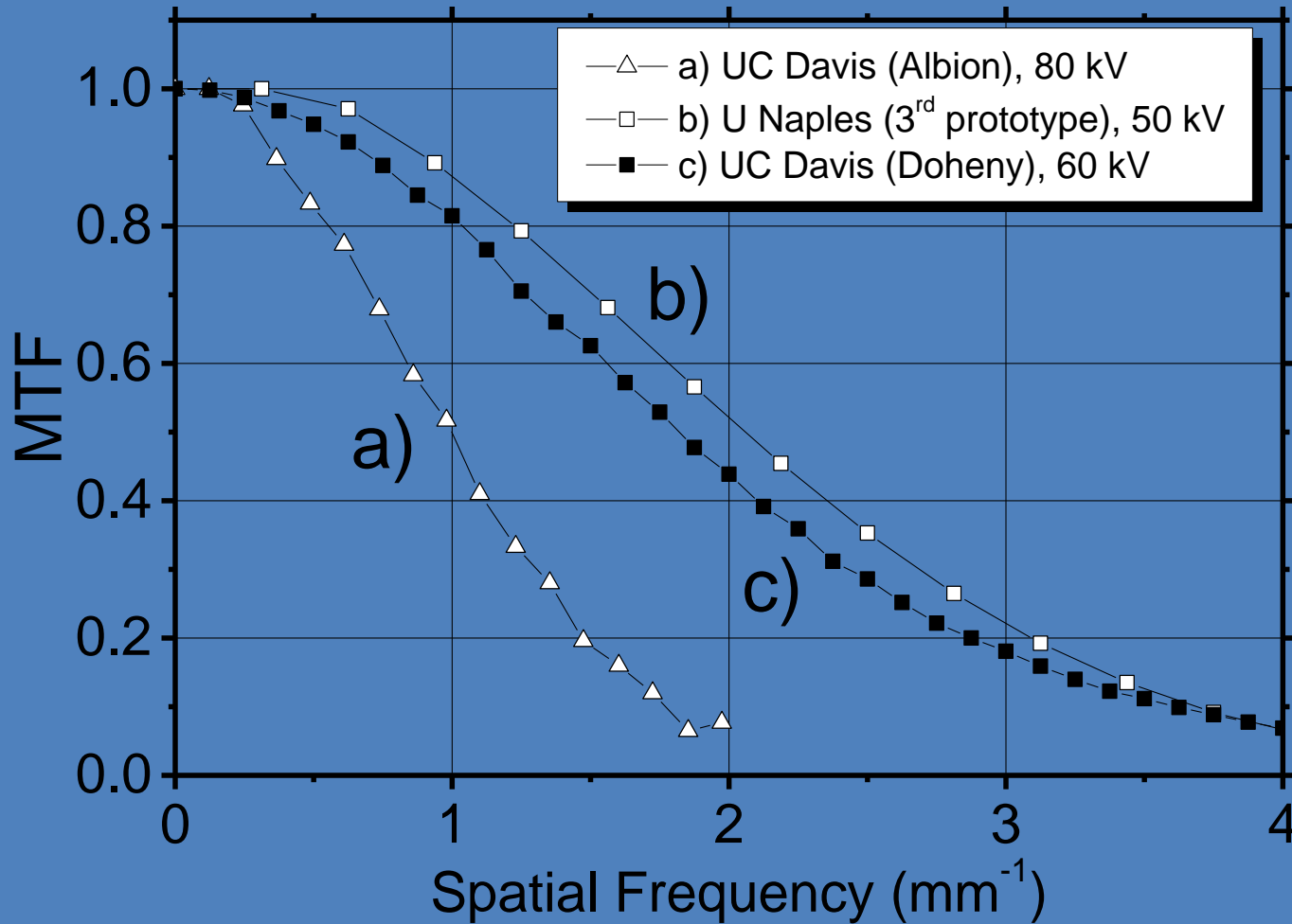


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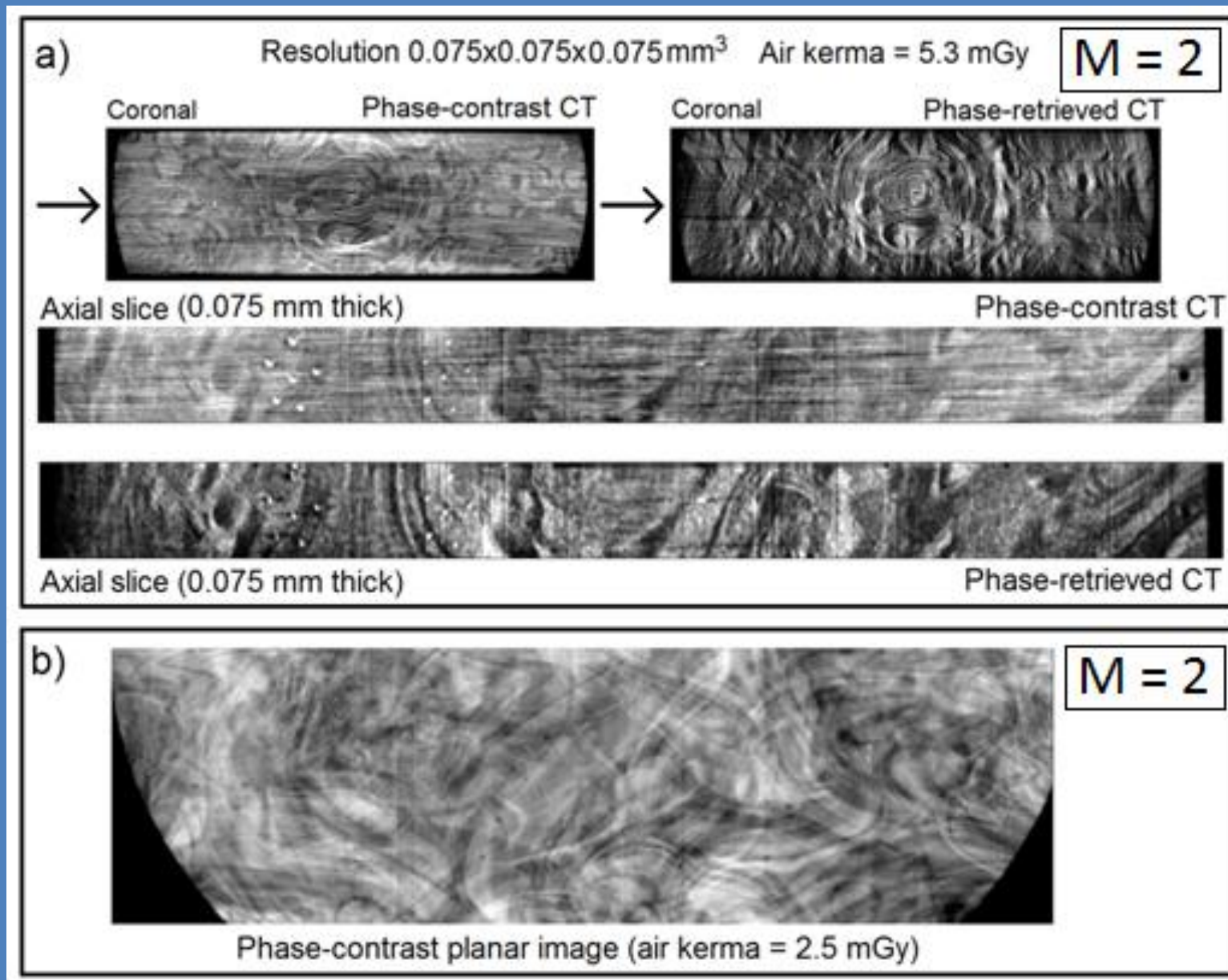


e)

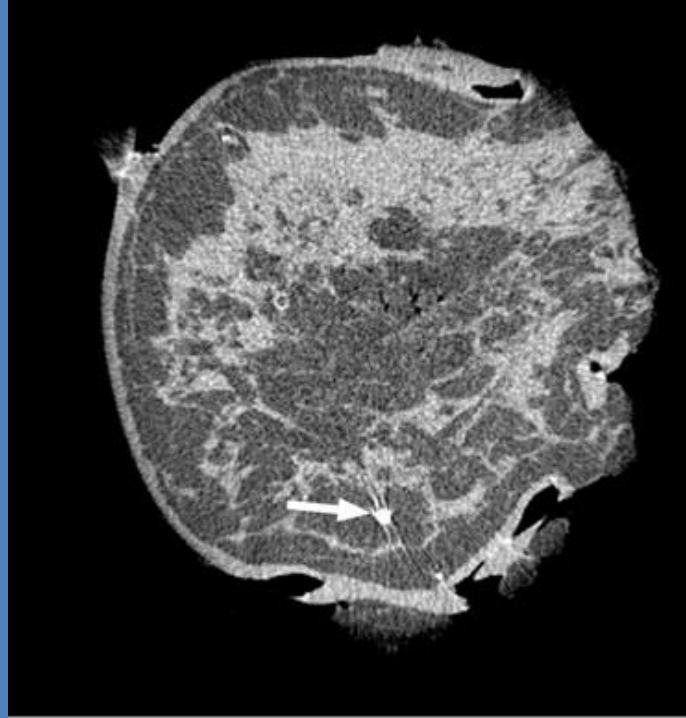
Spatial resolution



Phase-contrast cone-beam breast CT (U. Napoli)



Phase-contrast breast CT with monoenergetic synchrotron radiation



CT slice of a cadaveric frozen breast sample obtained with synchrotron radiation at 28 keV and with 0.8 mGy MGD. The white arrow points out a calcification (S. Pani, et al., Phys. Med. Biol. **49**, 1739–1754 (2004))



SYRMA-CT project (TS, BO, CA, NA, PI, SS)

Breast CT with dedicated scanners

PRO's

- 3D imaging (avoids superposition of anatomical structures)
- Isotropic resolution (about $0.3 \times 0.3 \times 0.3 \text{ mm}^3$)
- No breast compression
- Excellent contrast resolution

CON's

- Microcalcification visibility to be improved
- High MGD values for the commercial scanner