AAPM
SPRING CLINICAL MEETING
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MARCH 5-8 | Grand America Hotel | Salt Lake City, UT

Changing Perceptions and Updated Methods for Mammography Dosimetry

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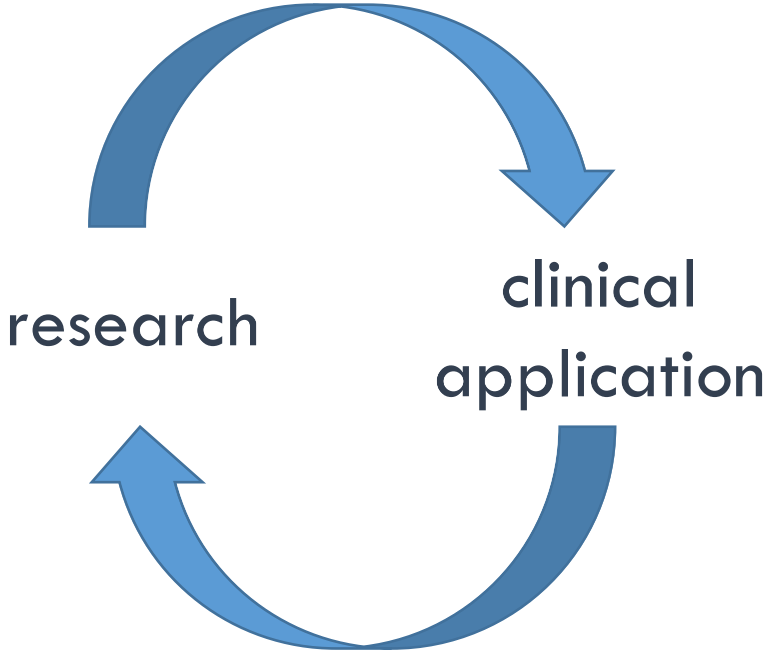
Sacramento, California

Changing Perceptions and Updated Methods for Mammography Dosimetry

Why are things changing?

- Different anode materials (W)
- Higher Tube Potentials (digital)
- Different filter materials (e.g. Al, Ag, Pd, etc.)
- New knowledge about breast geometry & composition
    - Skin Thickness
    - Breast Density (magnitude)
    - Glandular distribution in the breast
- Breast Tomosynthesis (not addressed in this symposium)

Changing Perceptions and Updated Methods for Mammography Dosimetry



<u>This morning's theme:</u>

A series of research vignettes

Examples of clinical utility

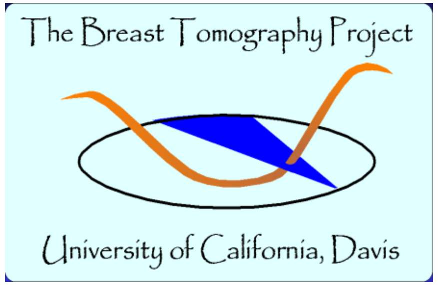
Changing Perceptions and Updated Methods for Mammography Dosimetry

- Breast CT as the Backstory
- Skin Thickness
- Breast Density / the Myth
- New Mammography Spectra
- Density Heterogeneity
- Summary

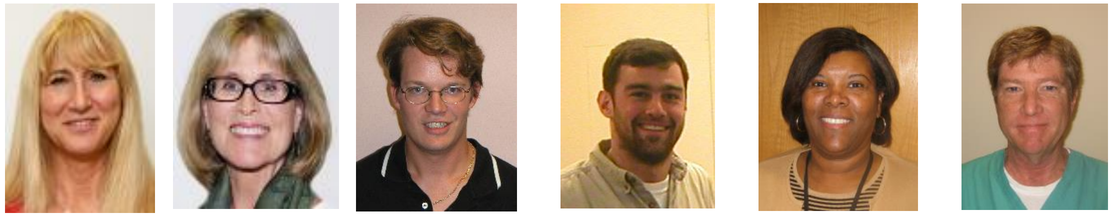
John Boone, Shadi Shakeri, Karen Lindfors, Tony Seibert, Ramsey Badawi, Simon Cherry, John McGahan, Tom Nelson, Craig Abbey, Norbert Pelc, Elizabeth Krupinski, Bruce Hasegawa

Peymon Gazi, Alex Kwan, Hong Zhou, Kai Yang, Orlando Velazquez, Clare Huang, Nathan Packard, Katie Metheany, Dandan Zheng, Shonket Ray, Anita Nosratieh

Martin Yaffe, Jeff Siewerdsen, Loren Niklason, Carey Floyd



Andrew Hernandez, Lin Chen, Sarah McKenny, Nicolas Prionas, Jessie Xia

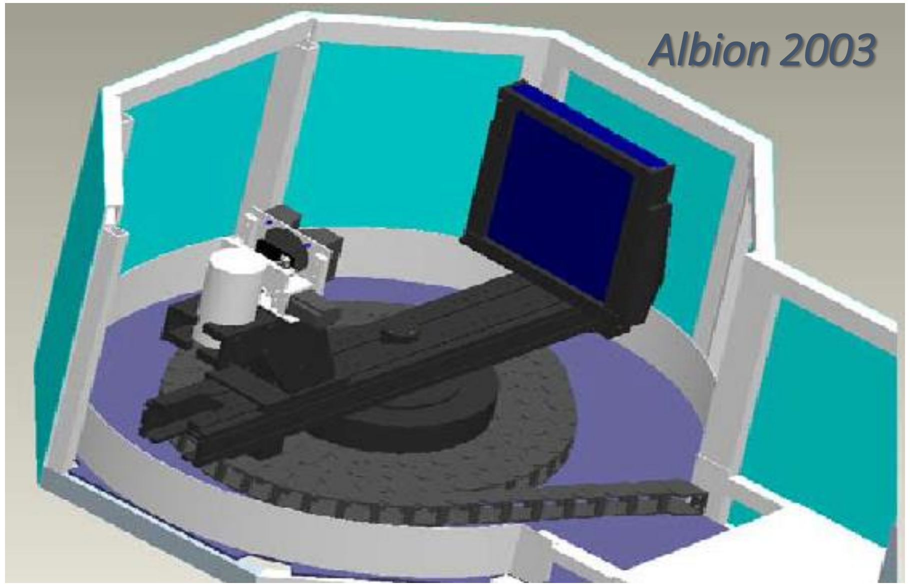


Linda Phelps, Laurie Boling, George Burkett, Whit Miller, Fareedah Simon, John Brock

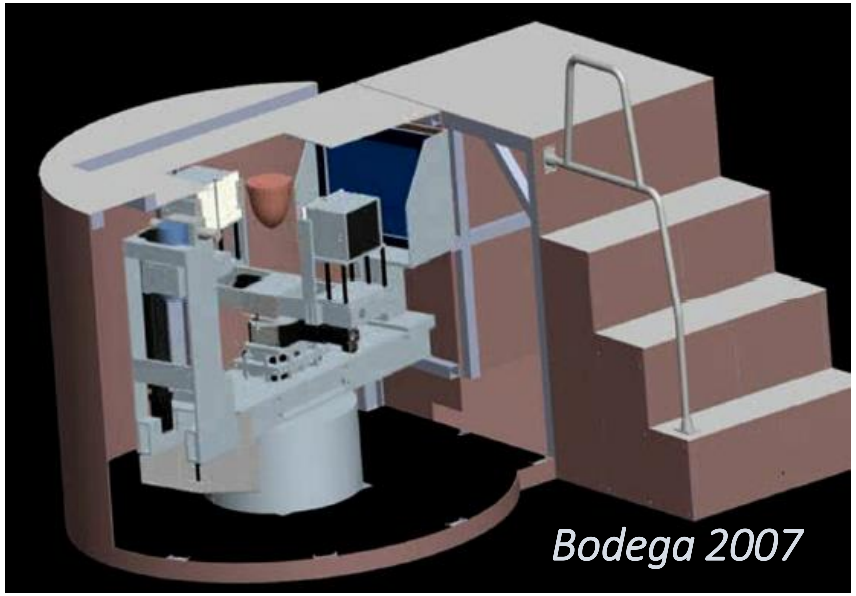
Varian Imaging Systems

Larry Partain
Gary Vishup
John Pavkovich
Hussan Mostafavi
Gerhard Roos
Ed Seppi
Cesar Proano

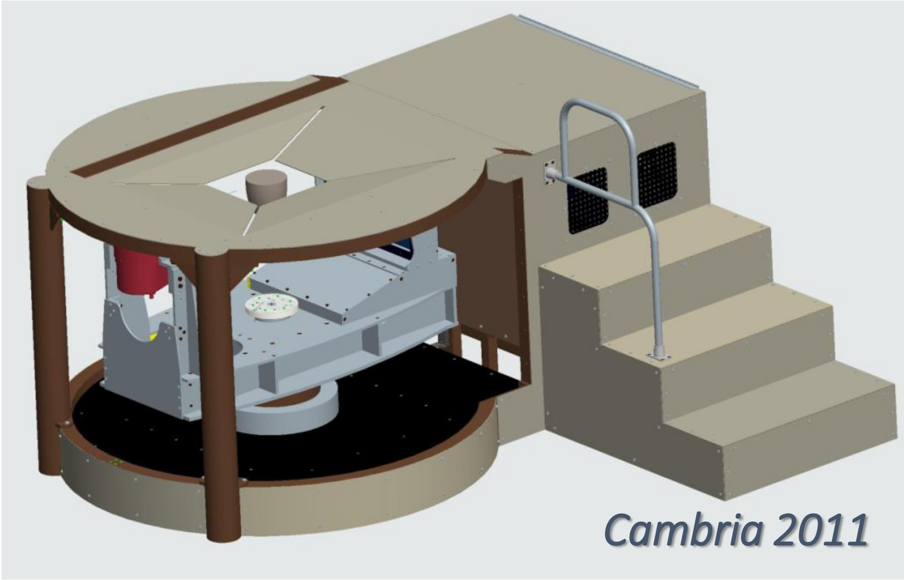
Computer aided design / computer aided manufacture (CAD/CAM)



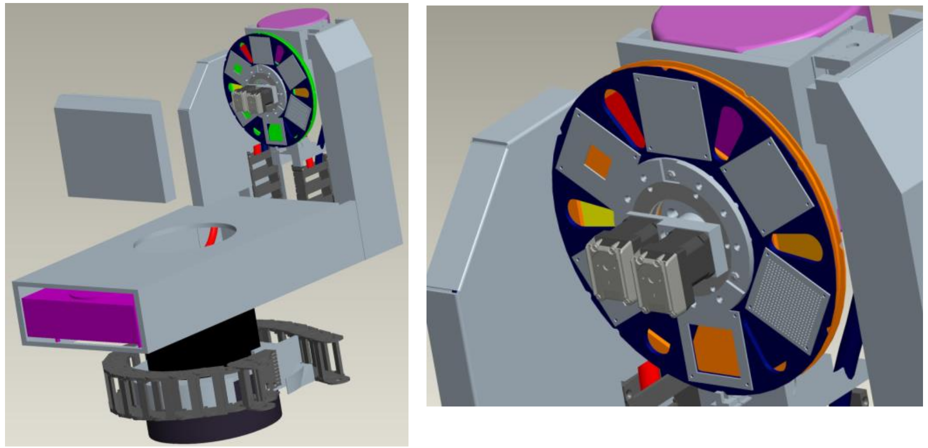
Albion 2003



Bodega 2007



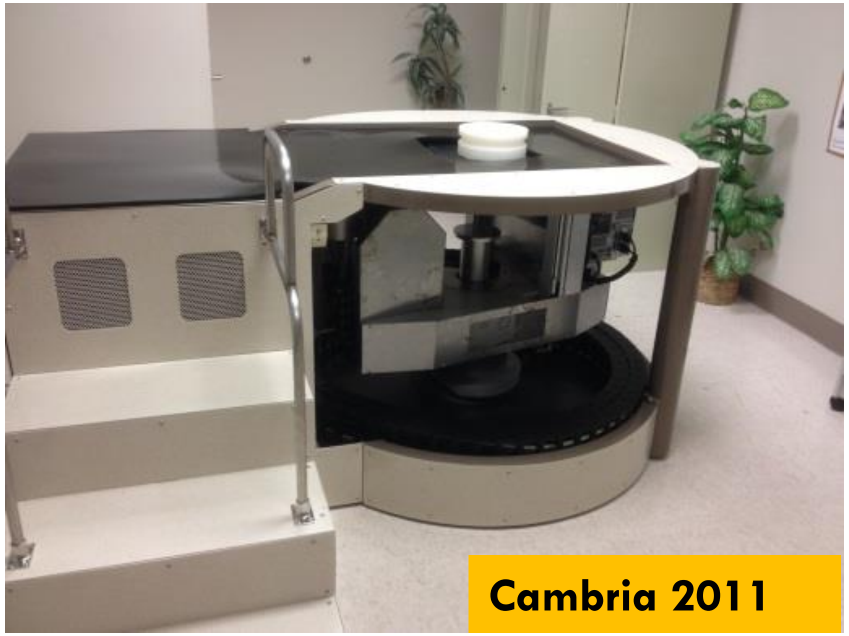
Cambria 2011



Doheny 2014

Albion 2004

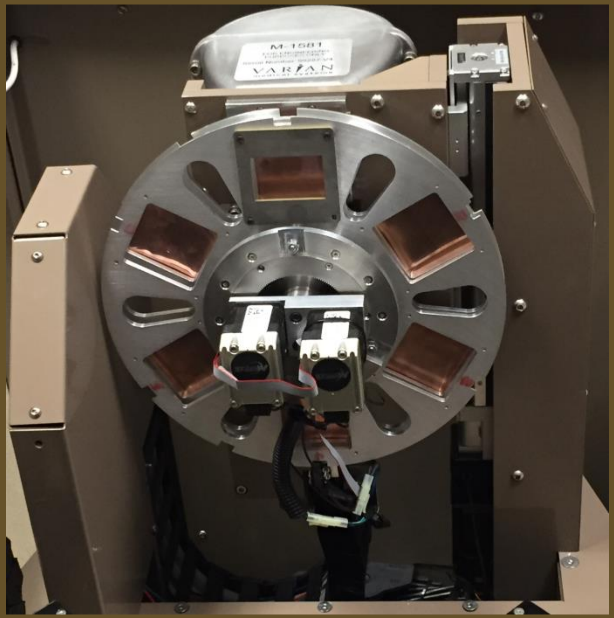
Bodega 2007

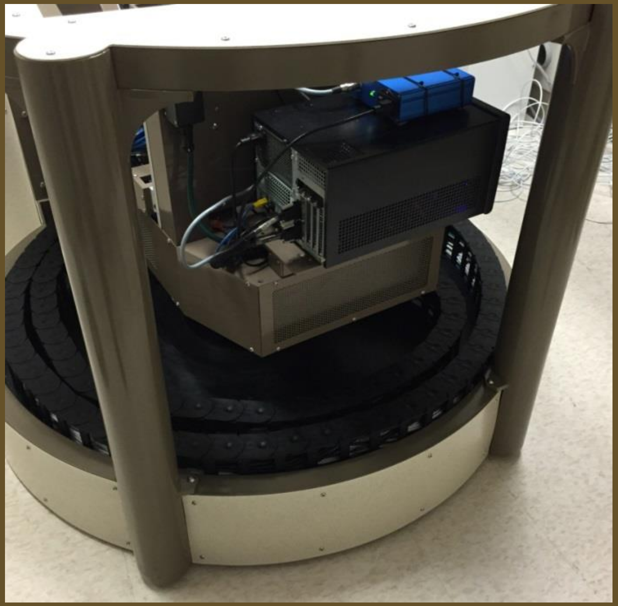


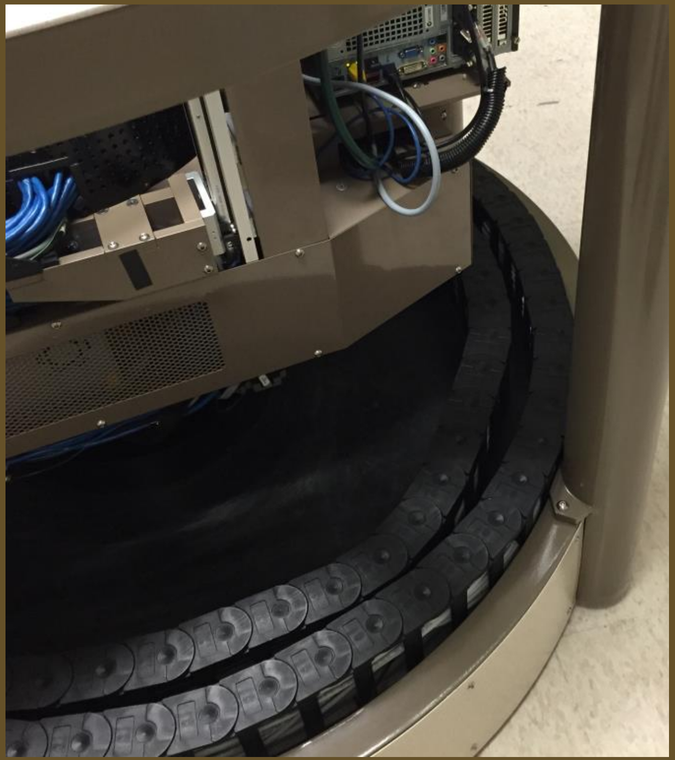
Cambria 2011

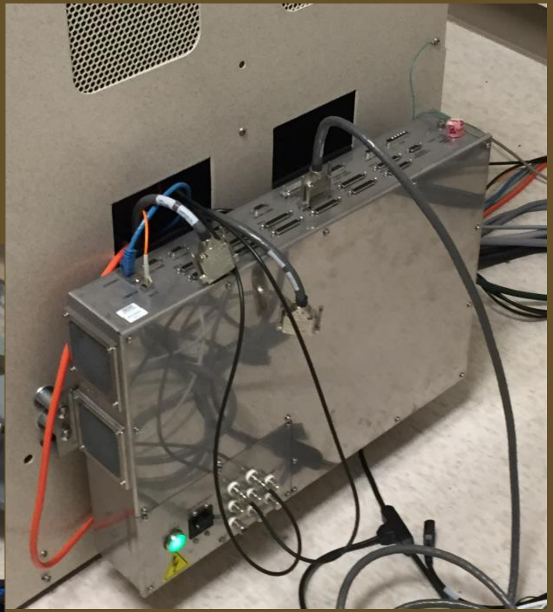
Doheny 2015

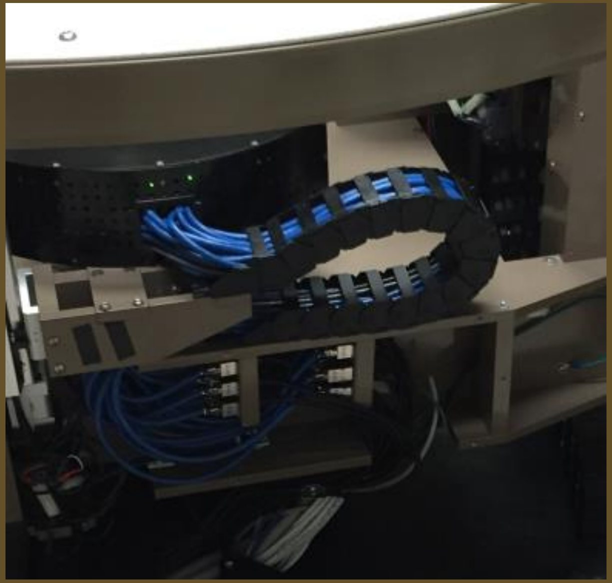
Doheny: Mechanical Assembly

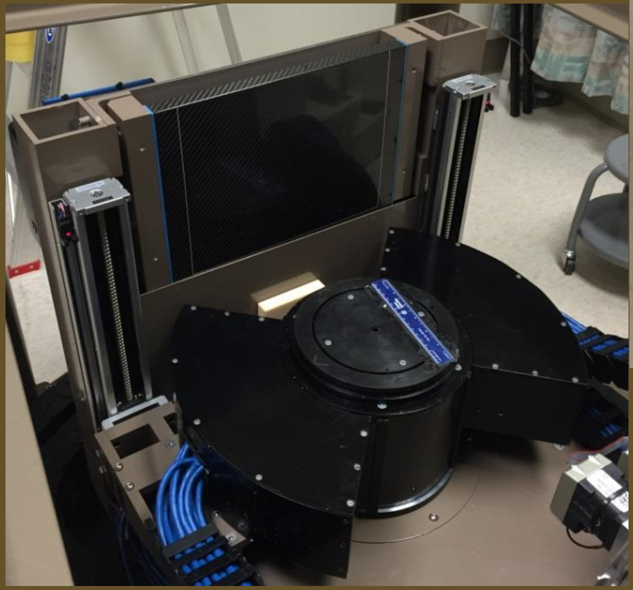


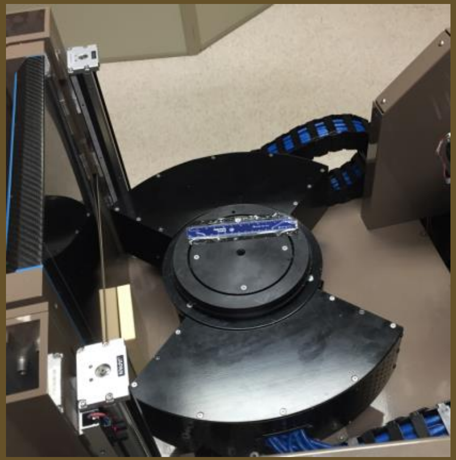












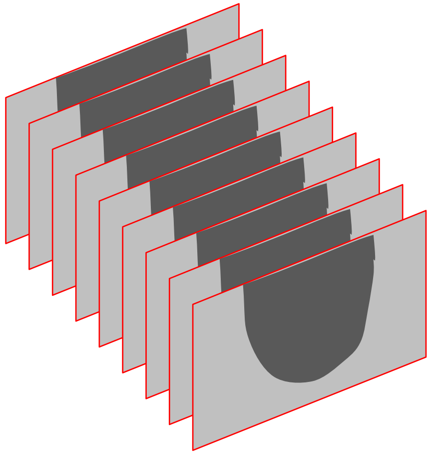
System Integration

motors

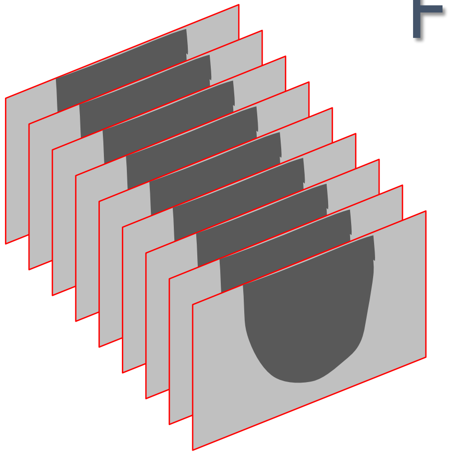
- main motor
- filter wheel
- collimator wheel
- X-ray tube elevation
- PET 1
- PET 2

devices

- generator control
- detector acquisition
- angle encoder
- thermal sensor
- inter-locks

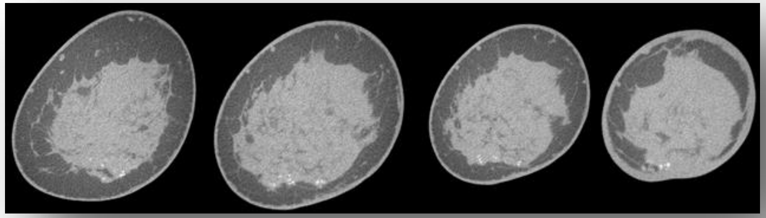


Raw Cone-Beam
Projection Images



Preprocessed
Projection Images

FDK Reconstruction Code



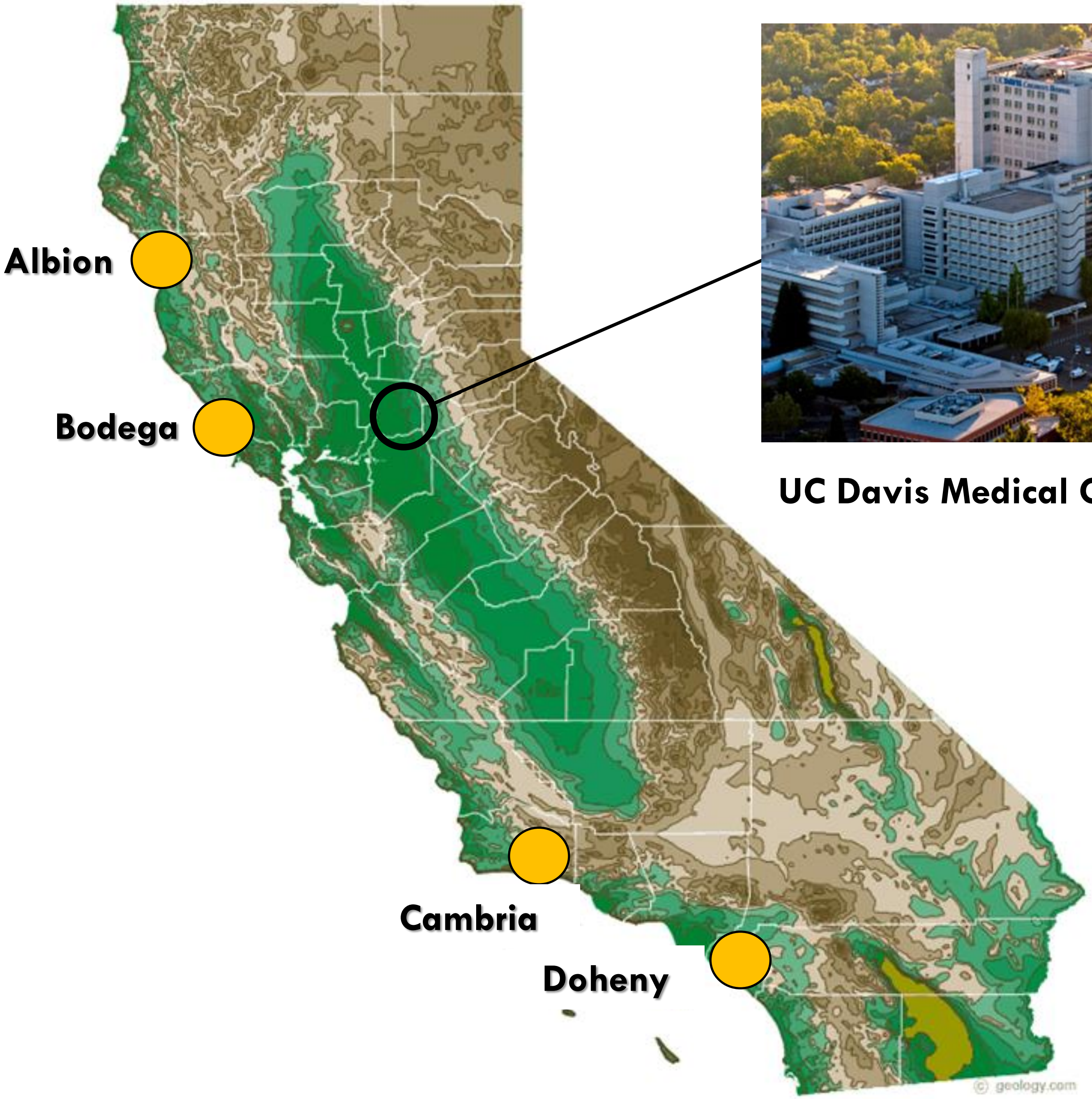
Reconstructed
breast CT images

2003	~42 minutes
2008	~35 minutes
2010	~20 seconds

>100x

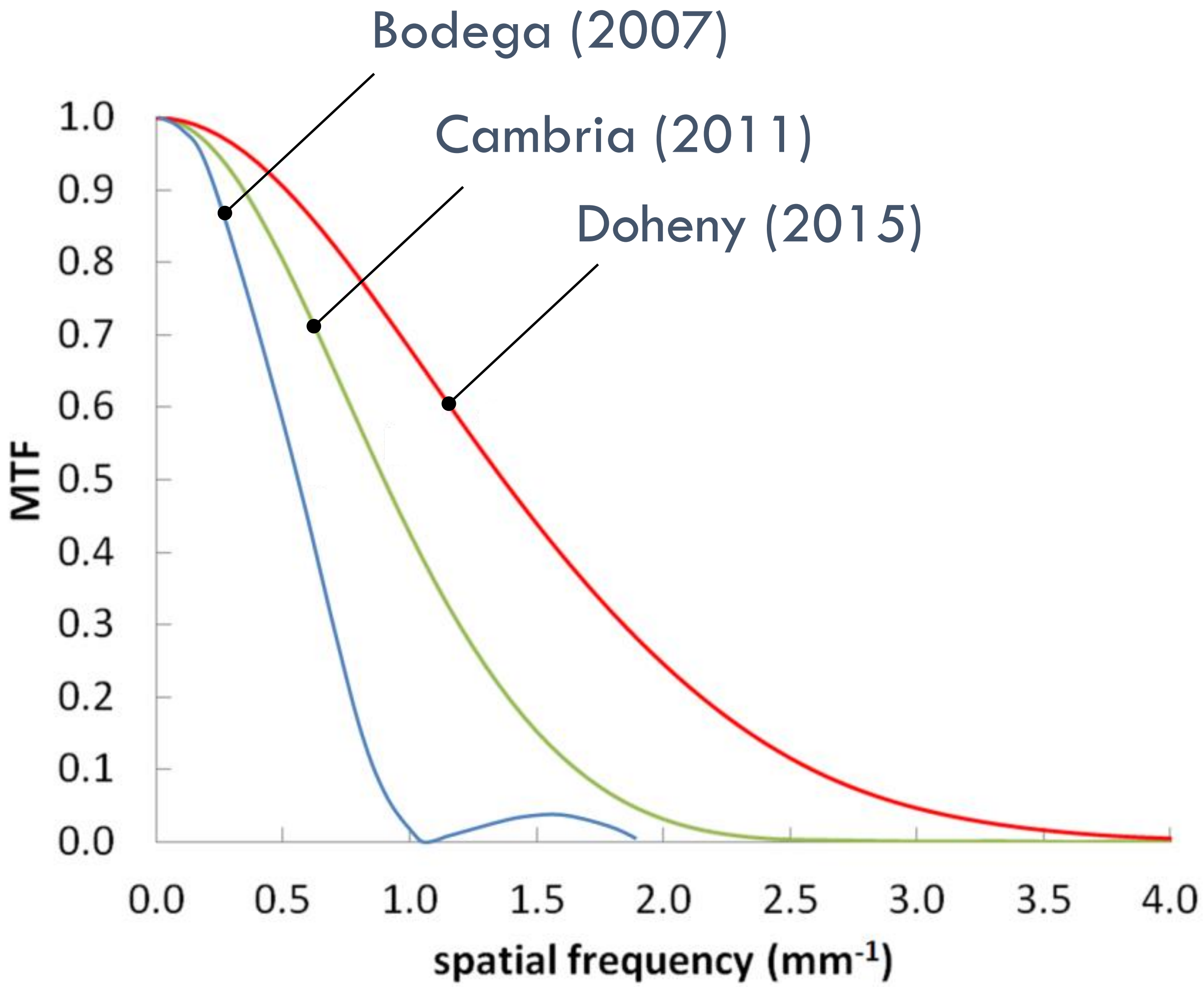
graphics processor unit
(GPU)

Pendant Geometry Imaging
(no compression)



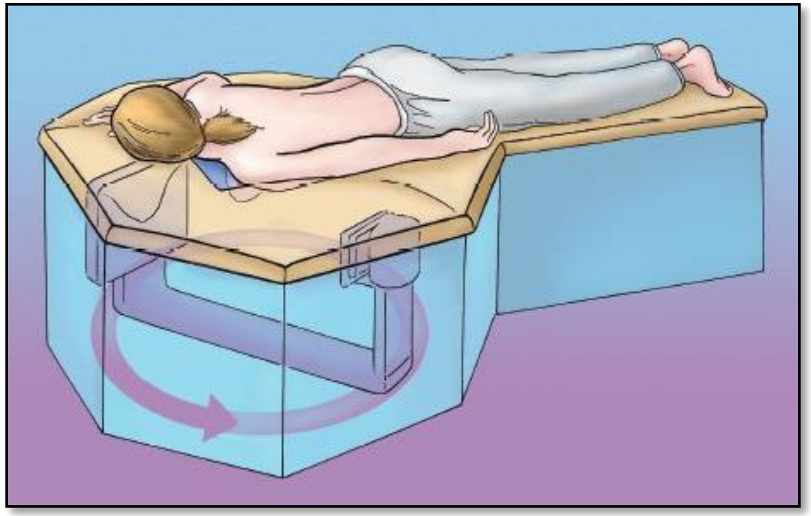
UC Davis Medical Center, Sacramento

Spatial Resolution Improvements

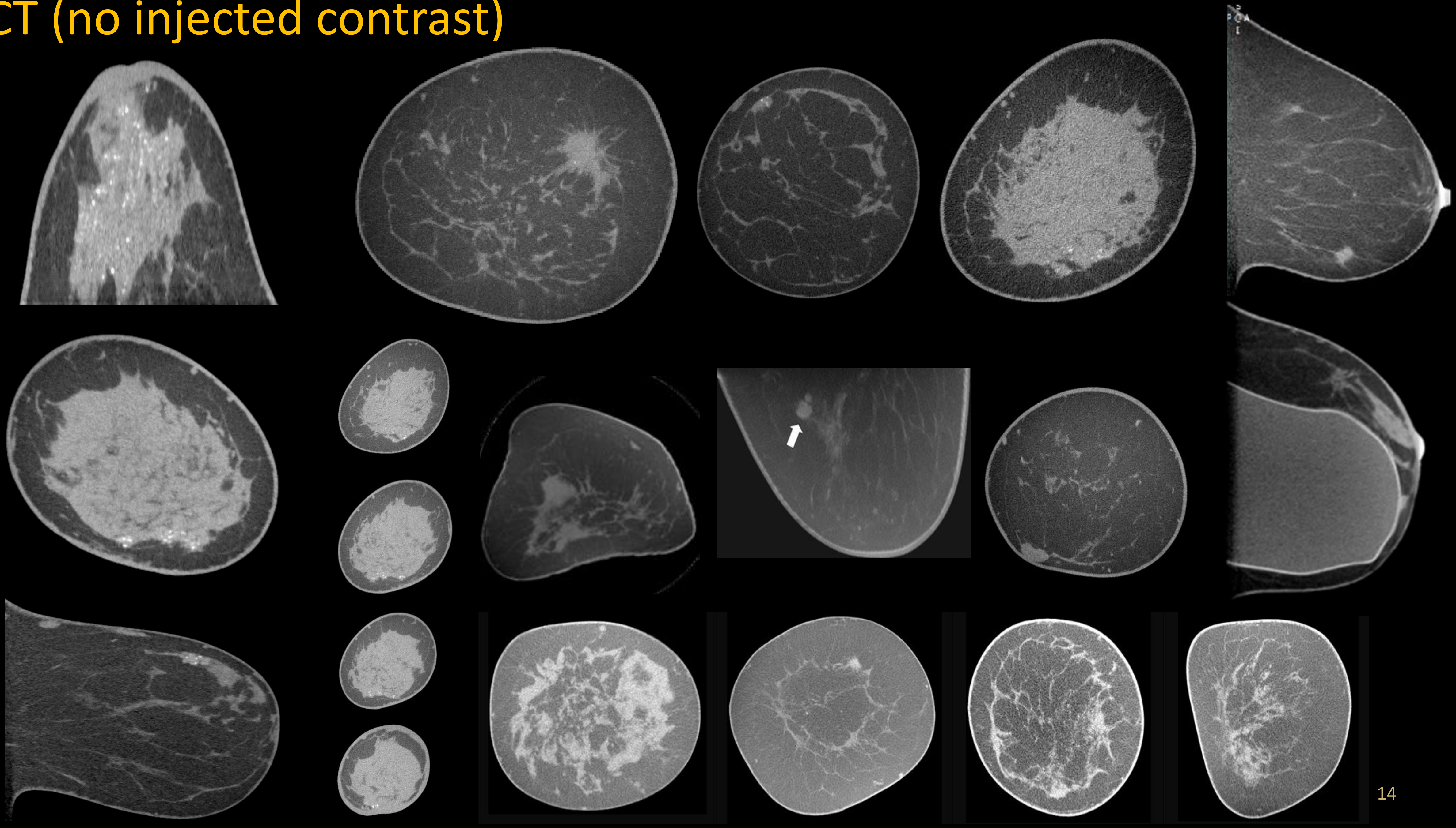


Clinical Imaging

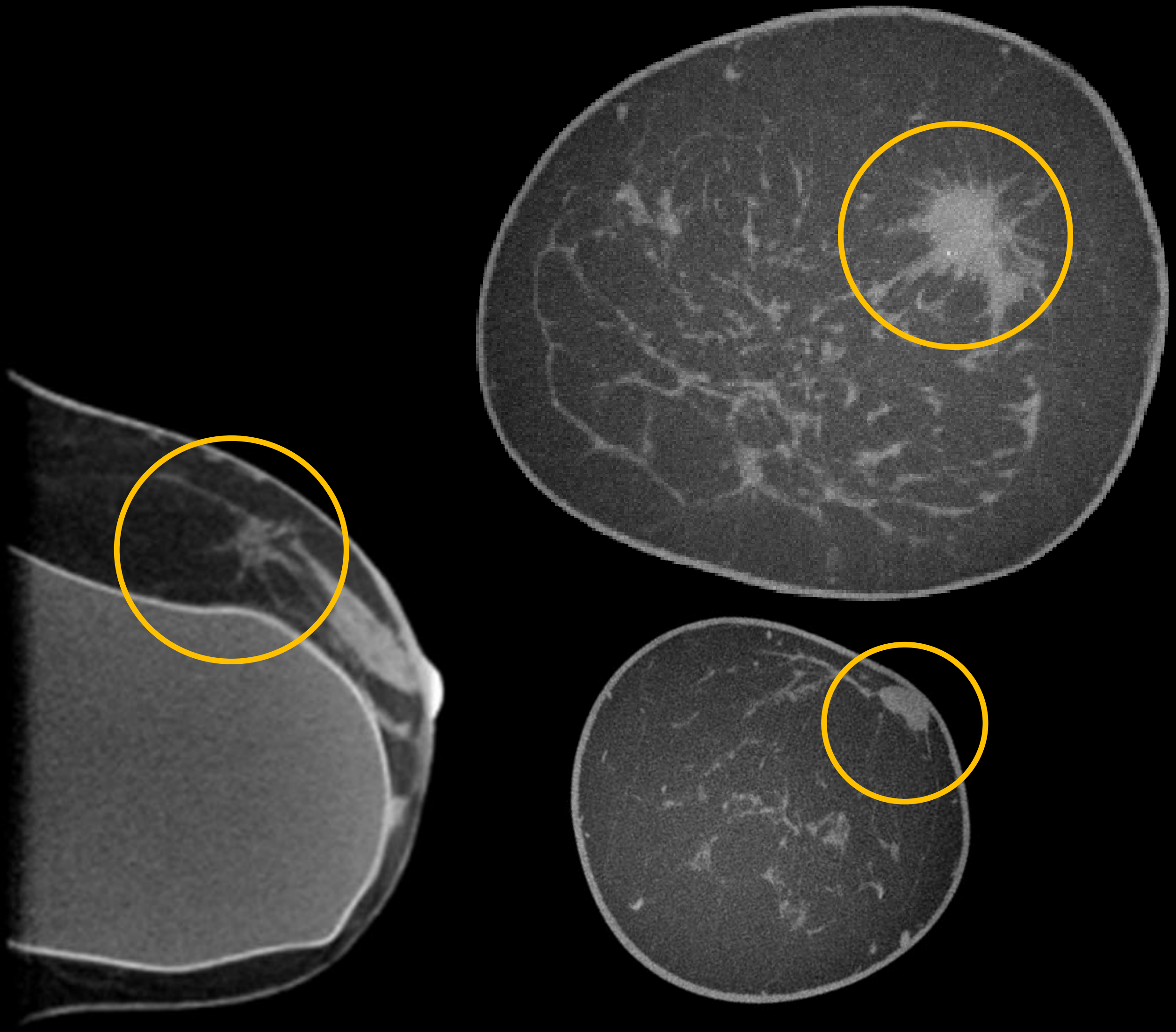
- Patients: women with suspicion of breast cancer (BIRADS 4 & 5's)
- First bCT scan: Nov 22, 2004
- >600 women on UC Davis scanners
- ~2000 bCT volume data sets
- ~260 have had contrast injection
- Radiation dose same as 2V mammography
- Image reconstruction 512^3 or 1024^3



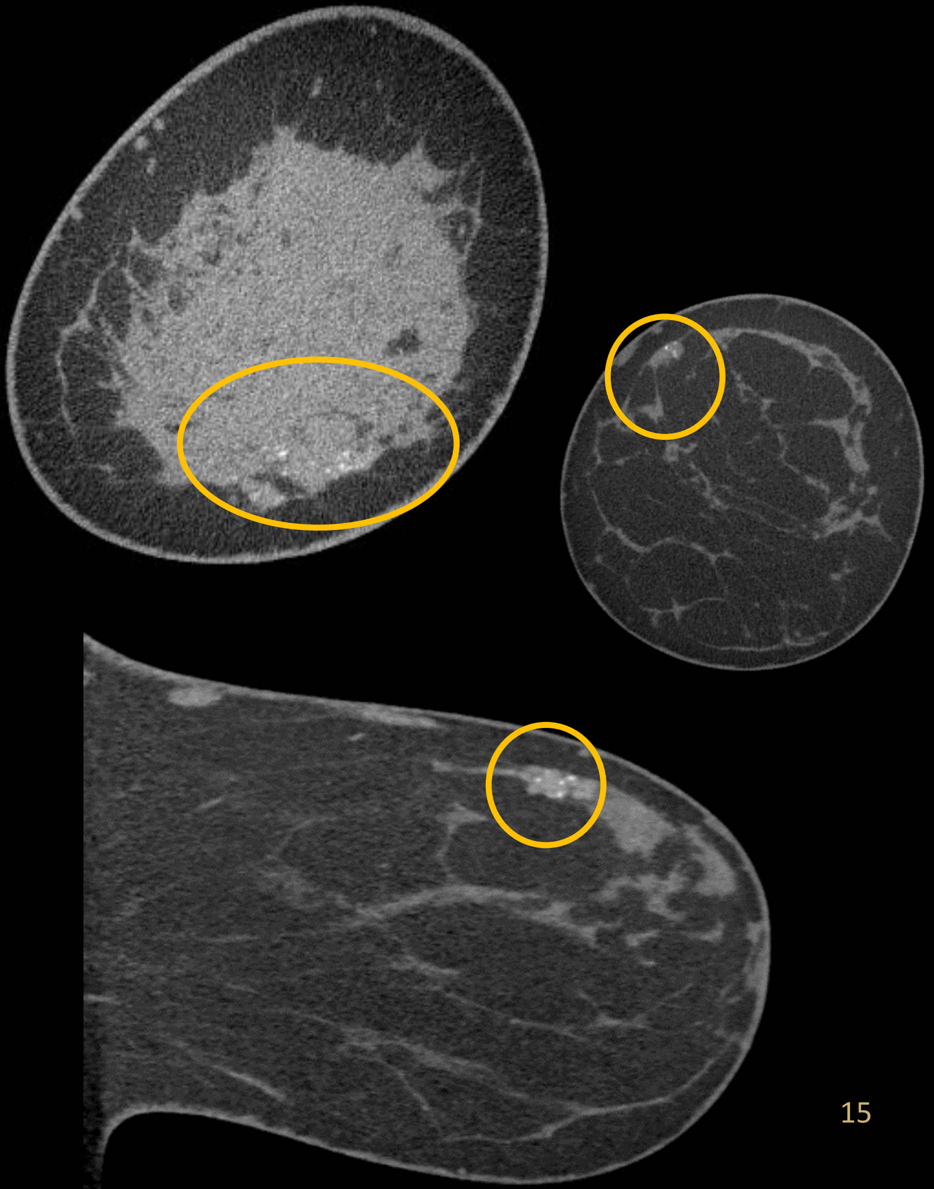
bCT (no injected contrast)



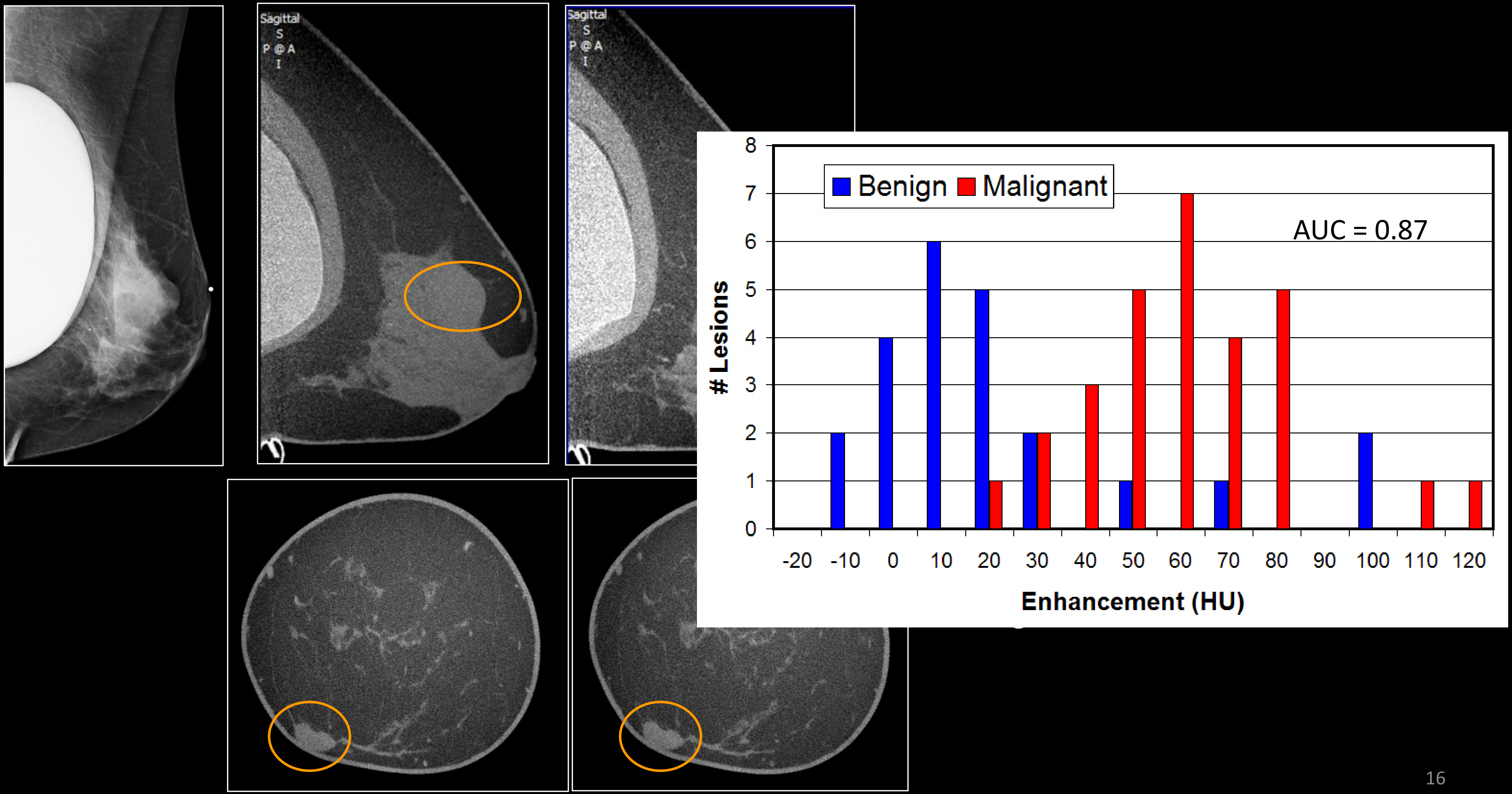
Mass Lesions



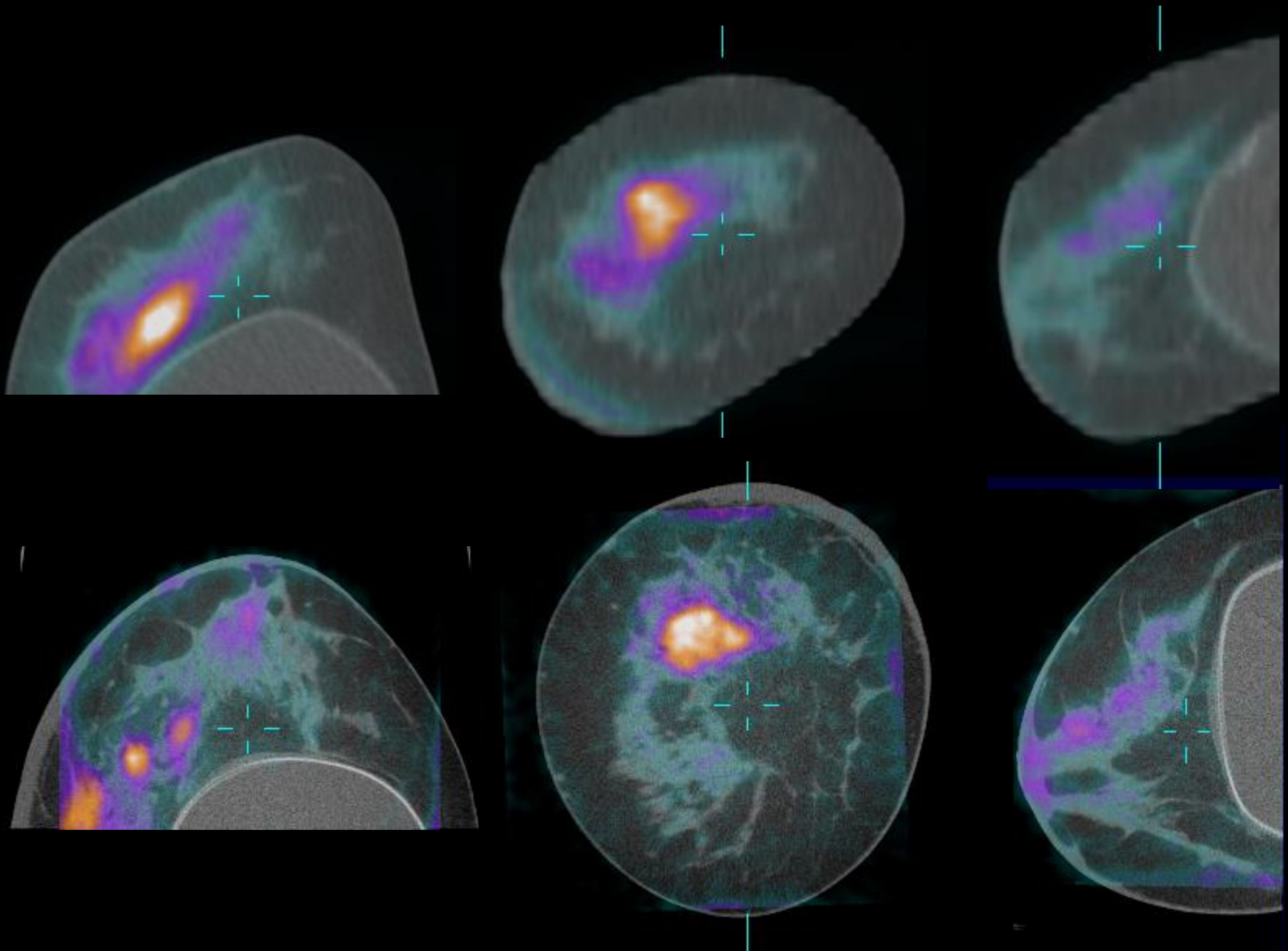
Microcalcifications



Contrasted Enhanced breast CT

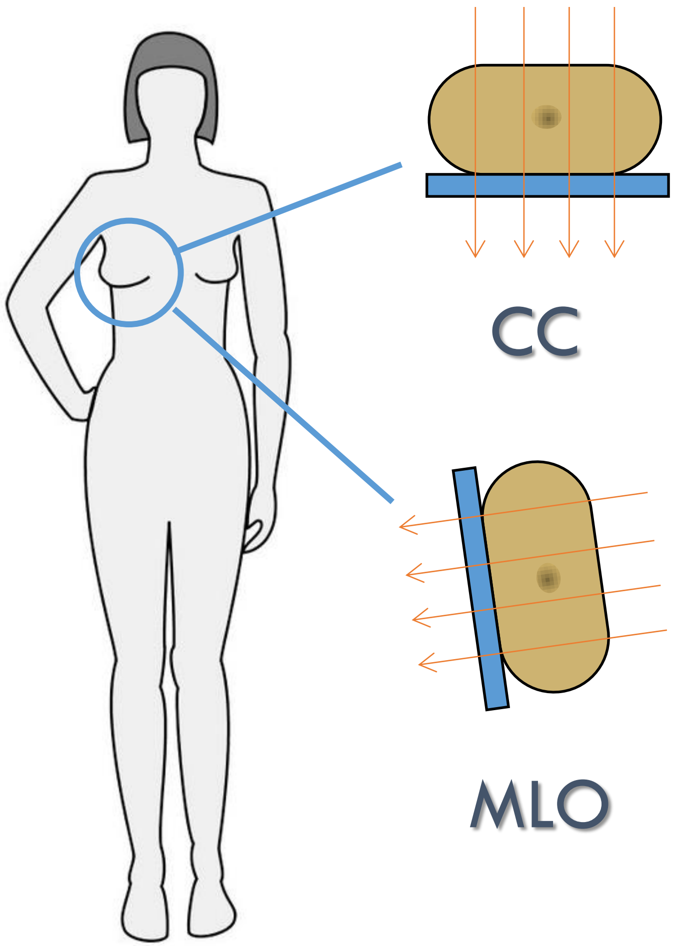


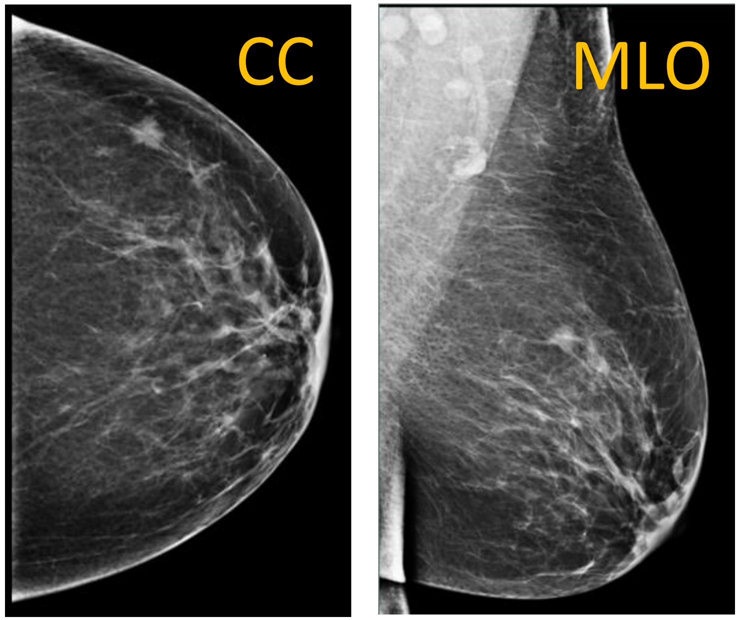
Invasive Mammary Carcinoma

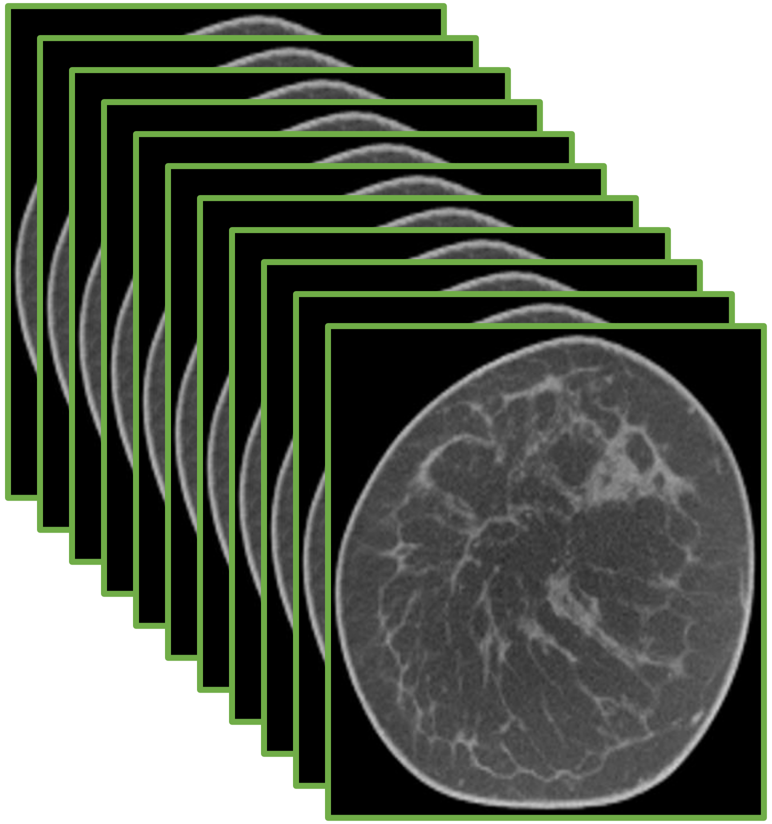


Changing Perceptions and Updated Methods for Mammography Dosimetry

Clinical Implications







Two 2D mammograms

Volumetric breast CT data
~500 contiguous images

The effect of skin thickness determined u
dosimetry

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California 95616 and Department of Radiology, X-Ray Imaging La
4701 X Street, Sacramento, California 95817

Alexander L. C. Kwan
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(Received 24 October 2007; revised 15 January 2008; accep
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The characterization of breast anatomical metri
breast CT

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4860 Y Street, Ambulatory Care Center Suite 3100, Sacramento, California 9

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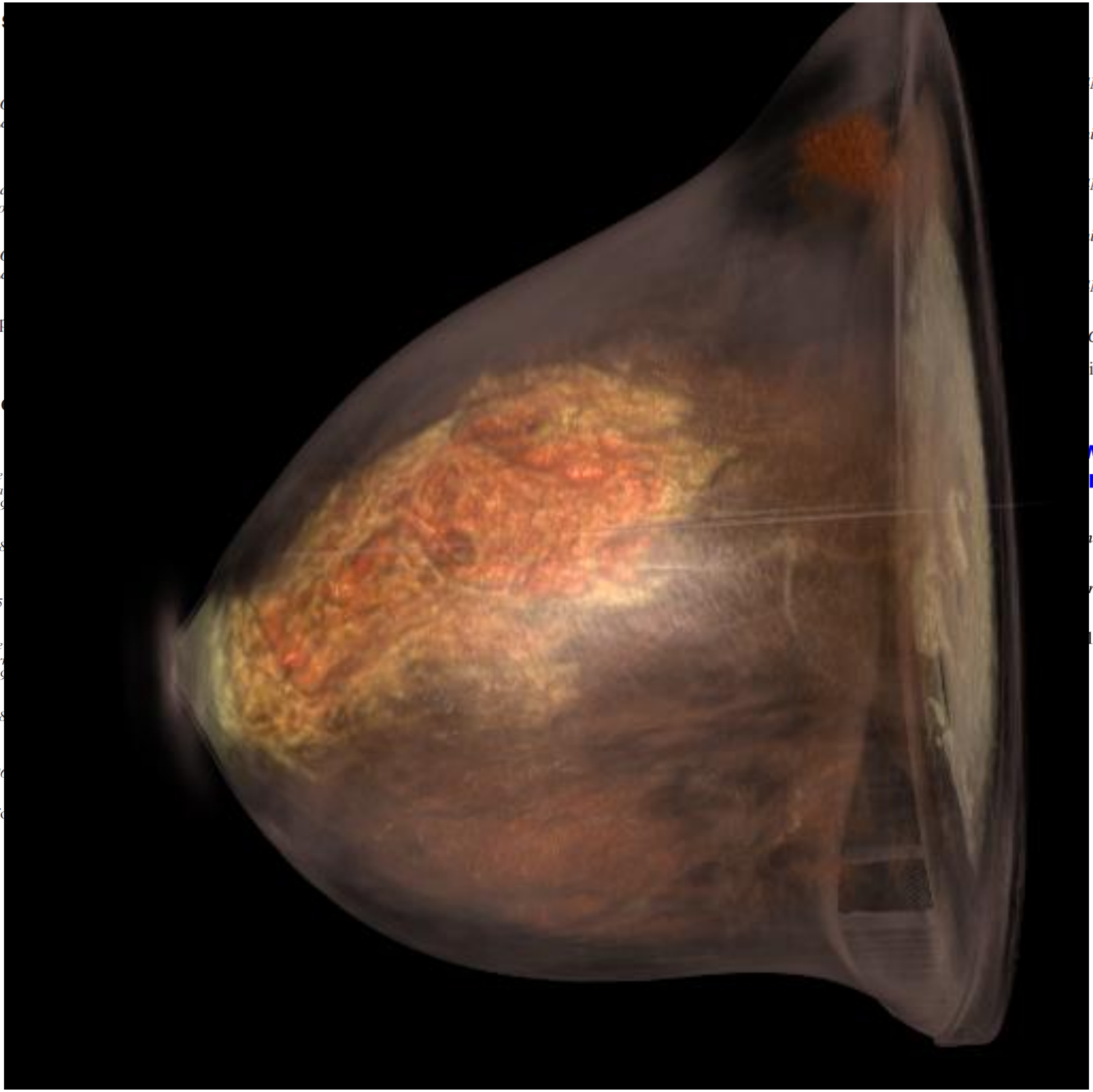

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raduate Group,

15 September 2015;

Changing Perceptions and Updated Methods for Mammography Dosimetry

- Breast CT as the Backstory
- Skin Thickness
- Breast Density / the Myth
- New Mammography Spectra
- Density Heterogeneity
- Summary

Past Monte Carlo Studies typically assumed a 4 mm (or 5 mm) skin thickness for breast dosimetry

- X Wu, GT Barnes, DM Tucker, Spectral dependence of glandular tissue dose in screen-film mammography, Radiology 179: 143-148: 1991
- DR Dance, Monte Carlo calculation of conversion factors for the estimation of mean glandular dose, PMB 35: 1211-1219: 1990
- X Wu, EL Gingold, GT Barnes, DM Tucker, Normalized average glandular dose in molybdenum target-Rhodium filter and rhodium-target-rhodium filter mammography, Radiology 193: 83-89: 1994
- DR Dance, CL Skinner, KC young, et al., Additional factors for the estimation of mean glandular dose using the UK mammography dosimetry protocol, PMB 45: 3225-3240: 2000

Radiology

Medical Physics

John M. Boone, PhD

Index terms:
Breast radiography, radiation dose, 00.47, 0.99
Breast radiography, technology, 00.12
Breast radiography, utilization, 00.99
Physics

Radiology 1999; 213:23–37

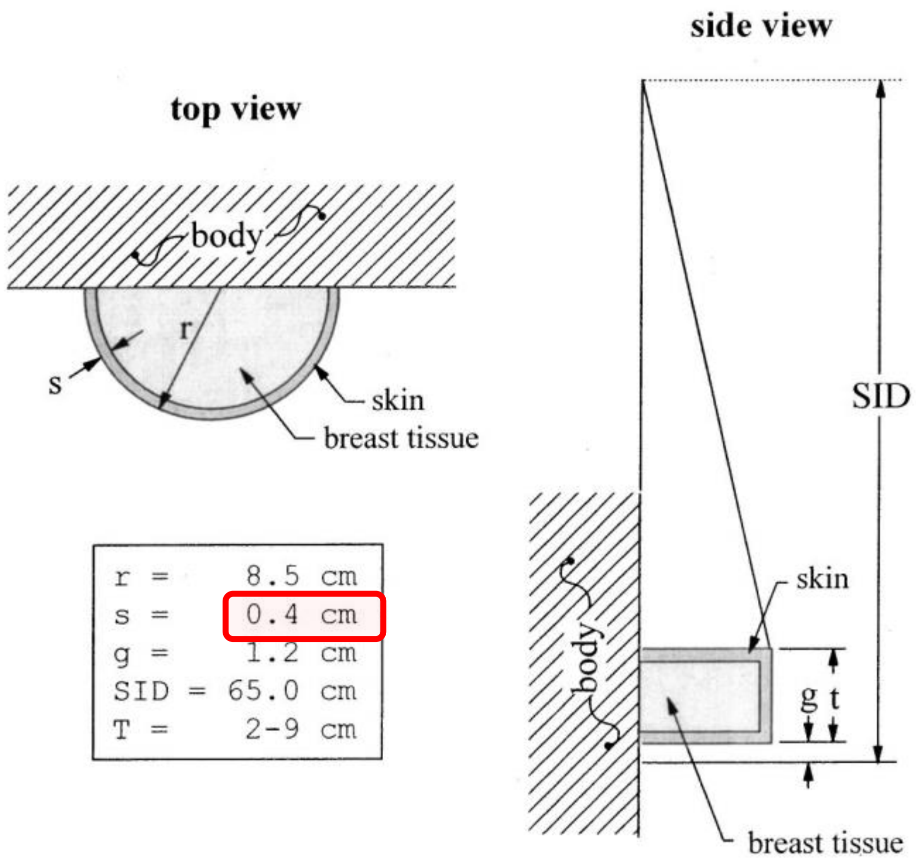
Glandular Breast Dose for Monoenergetic and High-Energy X-ray Beams: Monte Carlo Assessment[1]

Medical Physics

Normalized glandular dose (DgN) coefficients for arbitrary x-ray spectra in mammography: Computer-fit values of Monte Carlo derived data

John M. Boone[a)]
Department of Radiology, University of California, Davis, Sacramento, California 95817

(Received 1 November 2001; accepted for publication 28 February 2002; published 19 April 2002)



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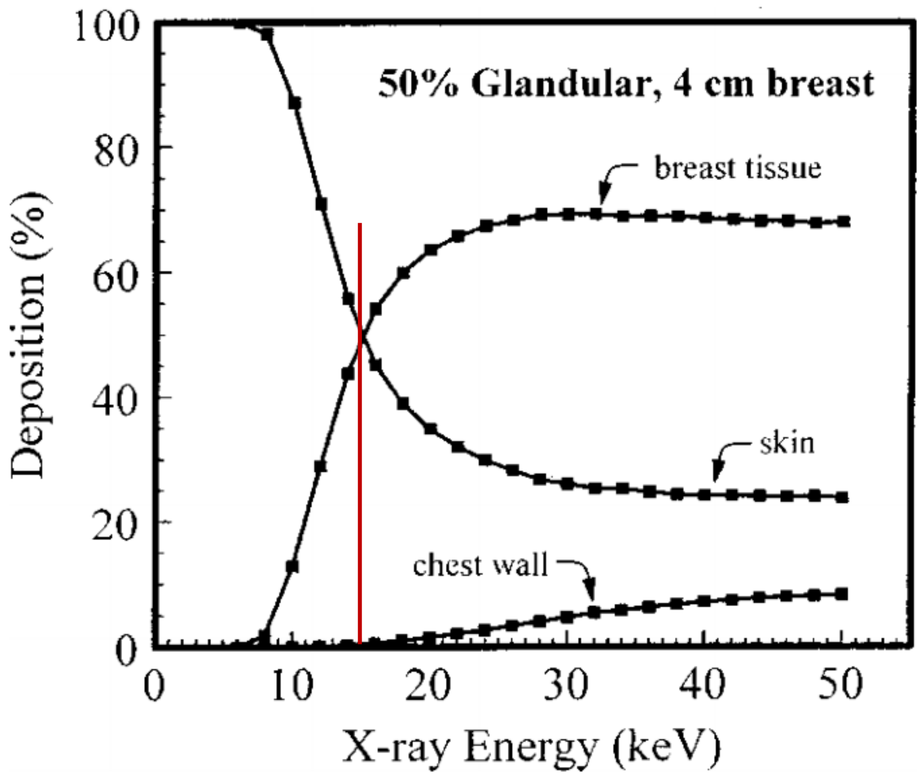
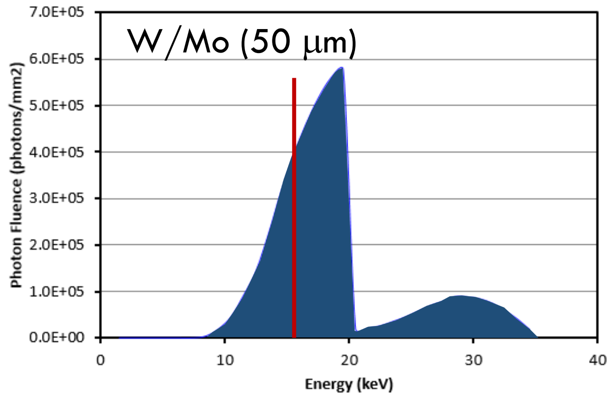
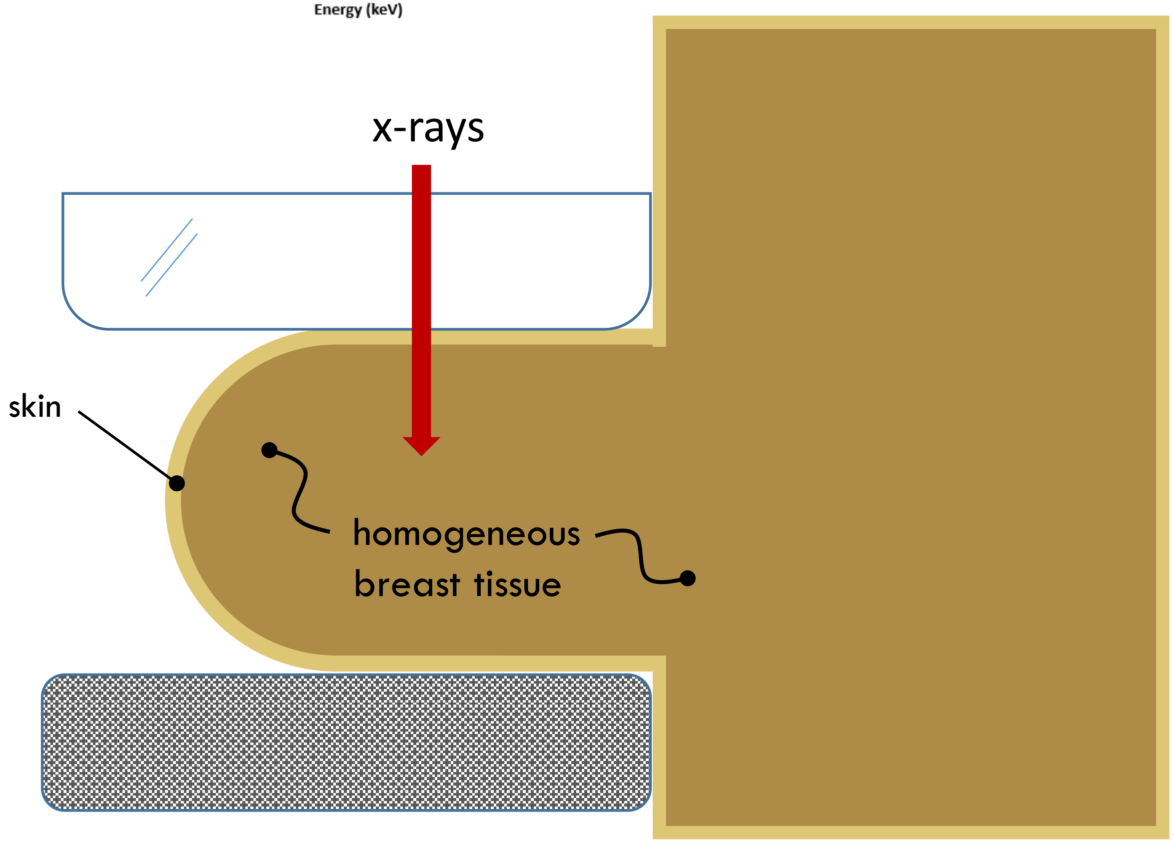
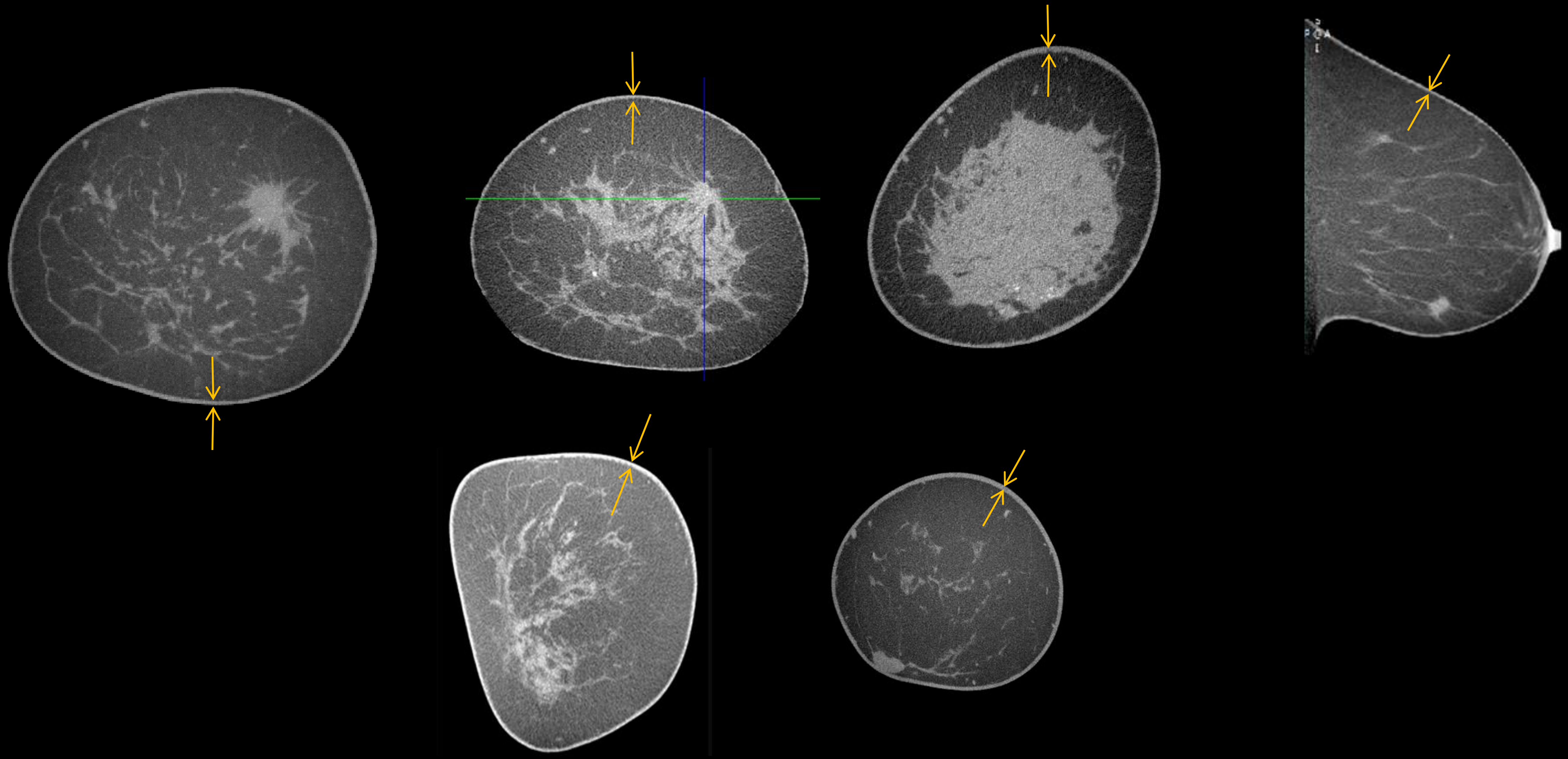






Observation from breast CT images: Skin is not 4 mm thick on the breast



Medical Physics

The effect of skin thickness determined using breast CT on mammographic dosimetry

Shih-Ying Huang, John M. Boone,[a] and Kai Yang
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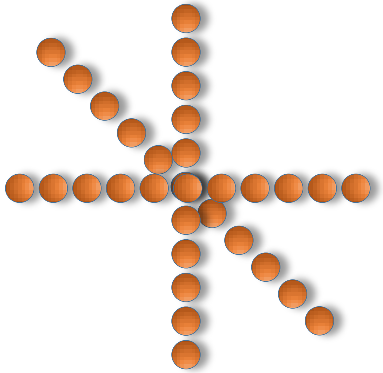
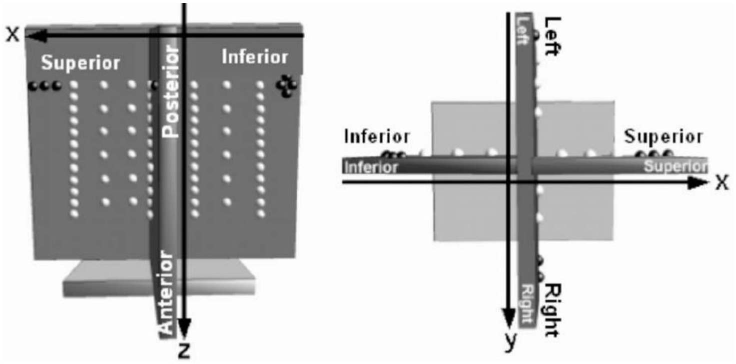
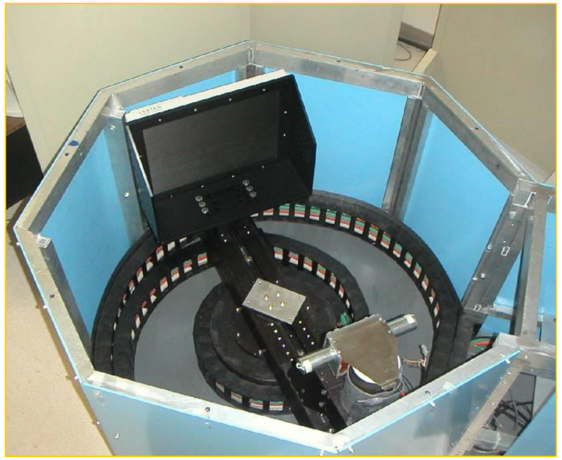
Verified the spatial accuracy in three dimensions

using a phantom…





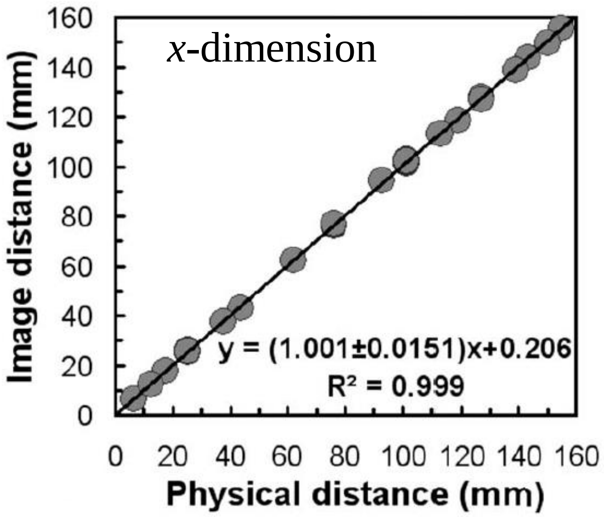


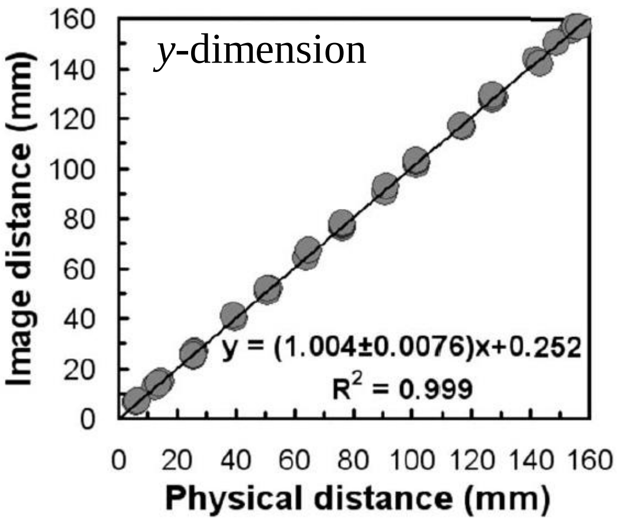
concept

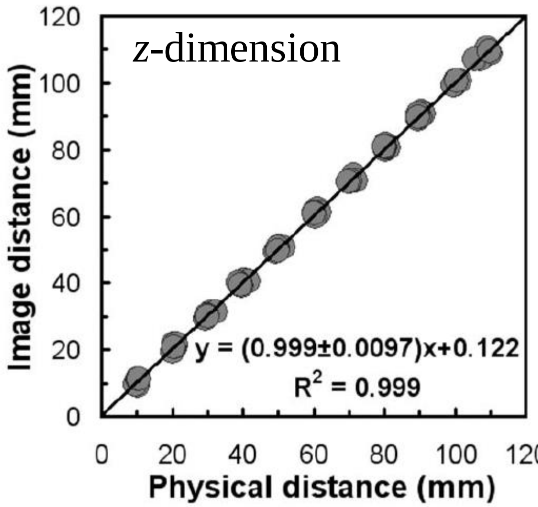
phantom

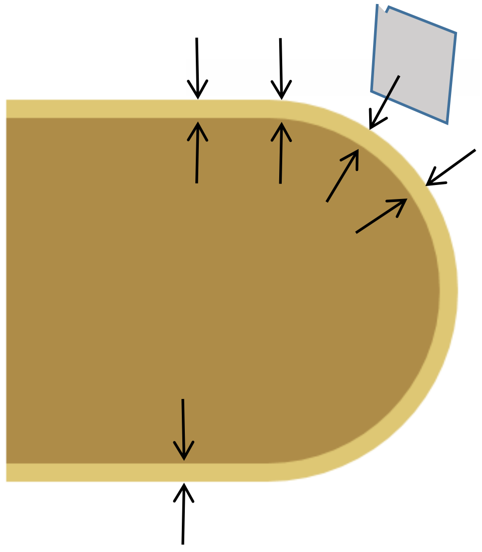
bCT scanner

results

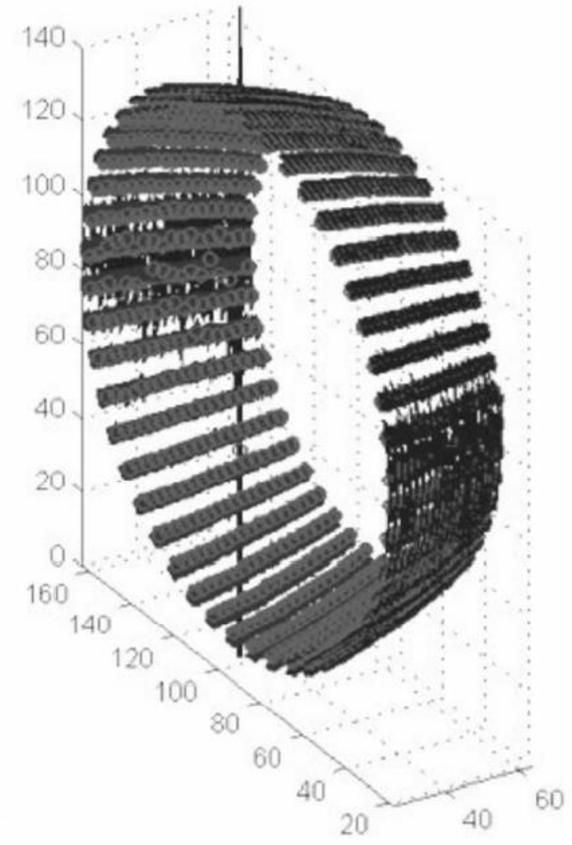






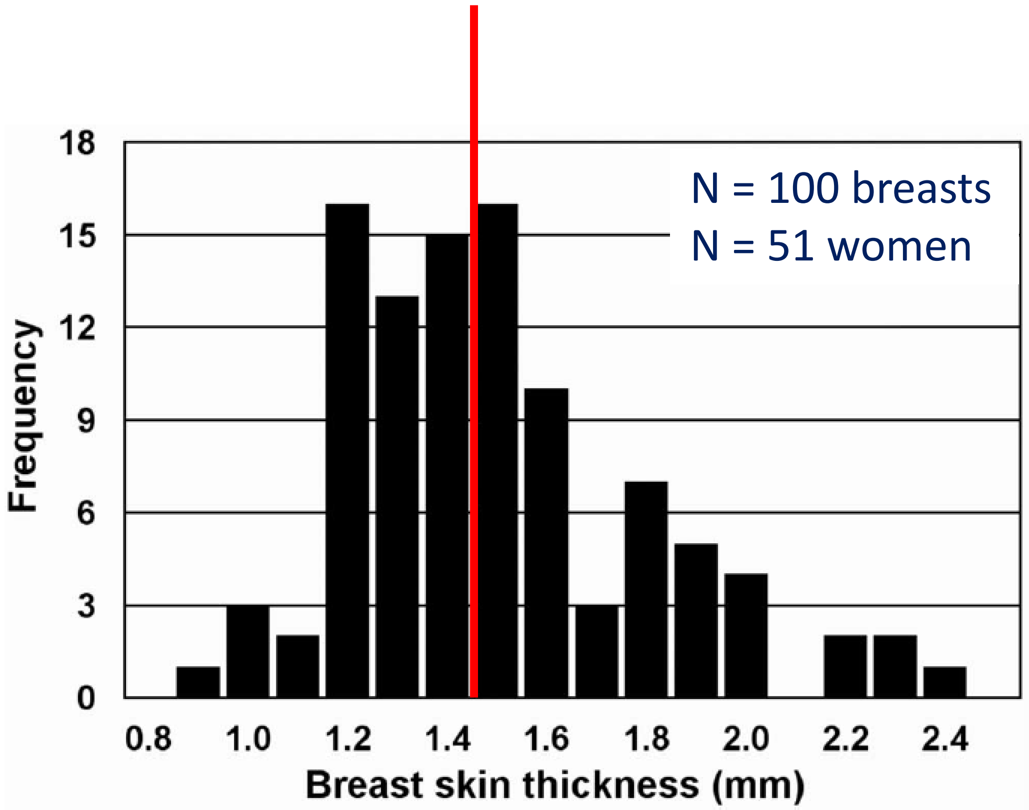


Segmentation Algorithm



Measurements

average = 1.45 mm (σ = 0.30 mm)

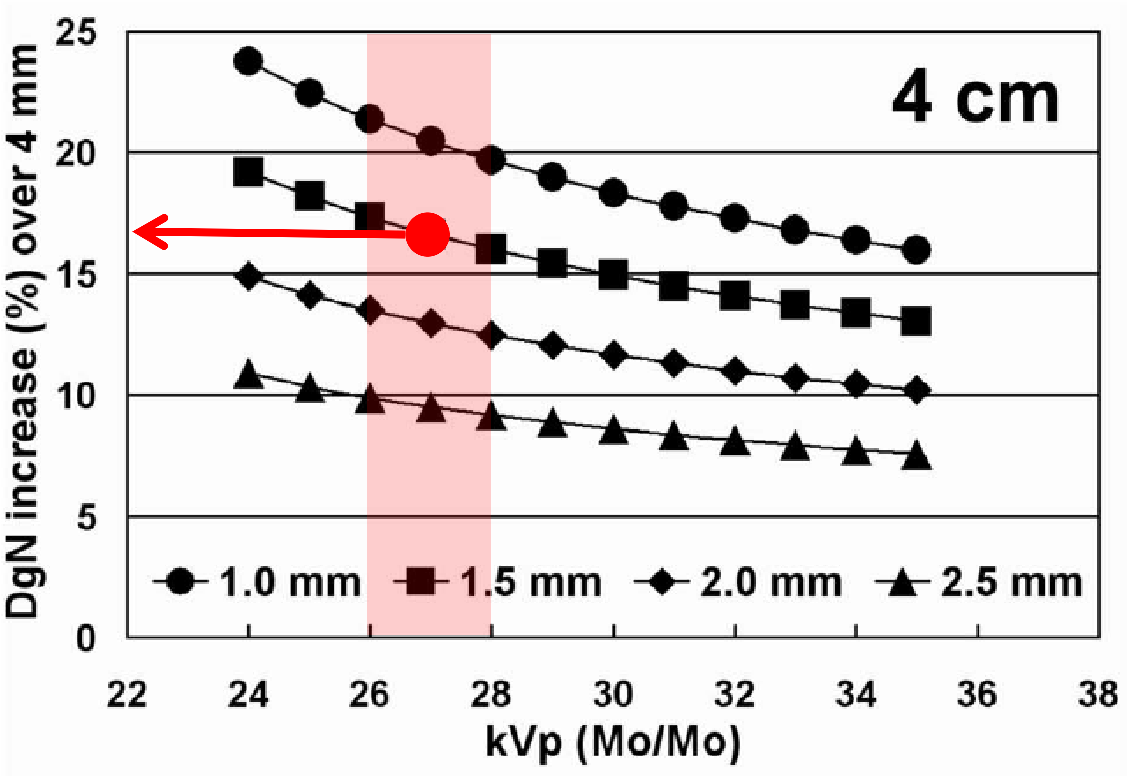


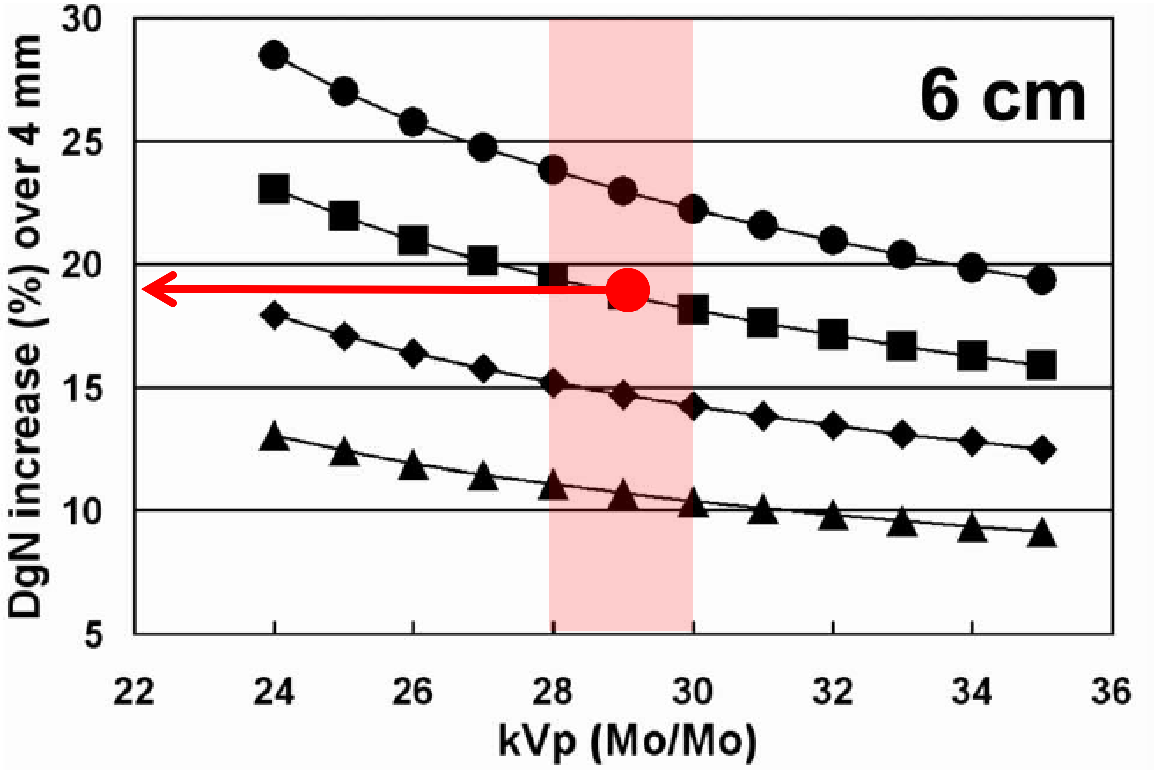
Skin Thickness Results

Changing Perceptions and Updated Methods for Mammography Dosimetry

Clinical Implications

Changing the skin thickness from 4.0 mm to 1.5 mm increased the DgN values by about 17-18%





But this assumes a homogeneous breast composition

Changing Perceptions and Updated Methods for Mammography Dosimetry

Breast CT as the Backstory

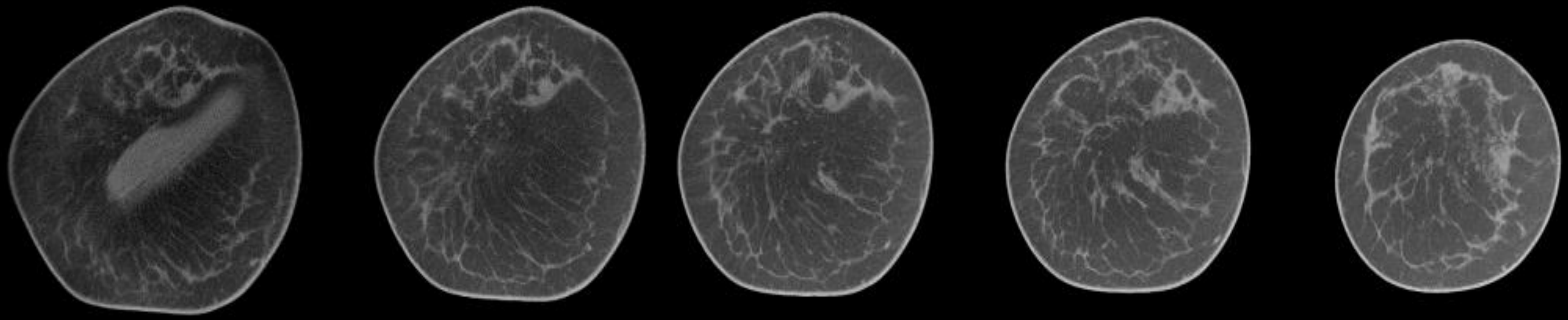
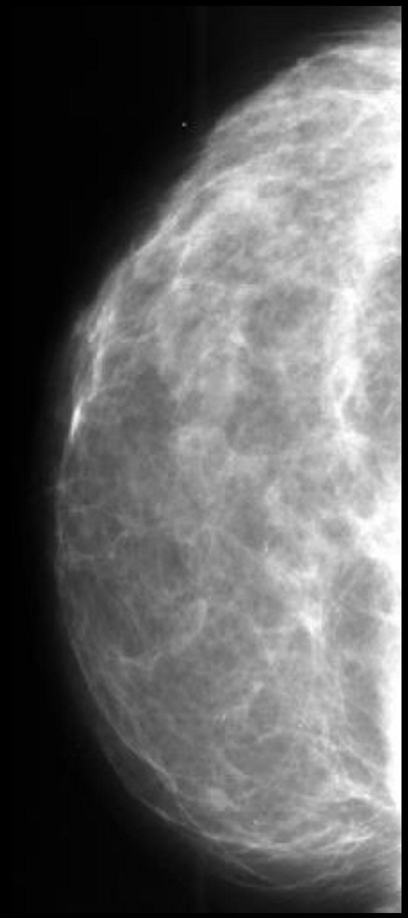
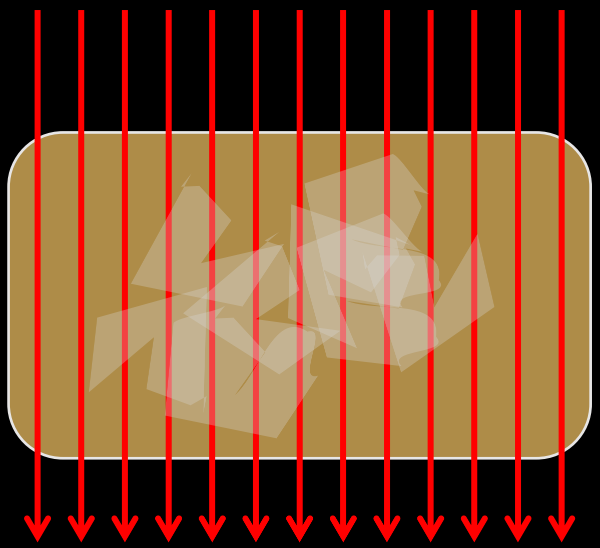
Skin Thickness

Breast Density / the Myth

New Mammography Spectra

Density Heterogeneity

Summary


The characterization of breast anatomical metrics using dedicated breast CT

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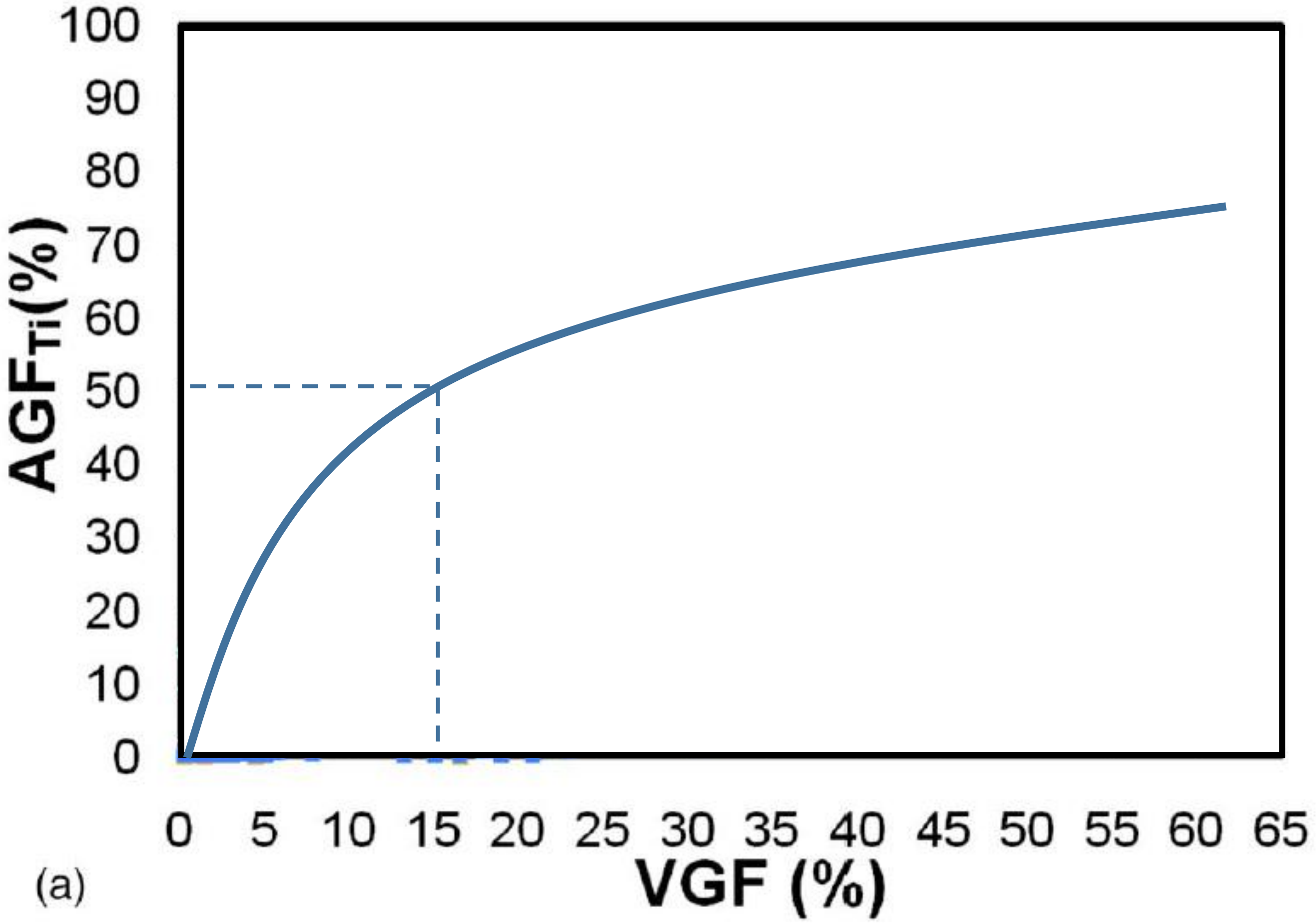
(Received 17 September 2010; revised 23 February 2011; accepted for publication 24 February 2011; published 28 March 2011)

Areal glandular fraction (2D)



(a)

Volume glandular fraction (3D)

X Wu, GT Barnes, DM Tucker, Spectral dependence of glandular tissue dose in screen-film mammography, Radiology 179: 143-148: 1991

DR Dance, Monte Carlo calculation of conversion factors for the estimation of mean glandular dose, PMB 35: 1211-1219: 1990

X Wu, EL Gingold, GT Barnes, DM Tucker, Normalized average glandular dose in molybdenum target-Rhodium filter and rhodium-target-rhodium filter mammography, Radiology 193: 83-89: 1994

DR Dance, CL Skinner, KC young, et al., Additional factors for the estimation of mean glandular dose using the UK mammography dosimetry protocol, PMB 45: 3225-3240: 2000

JM Boone, Glandular breast dose for monoenergetic and high-energy x-ray beams: Monte Carlo assessment, Radiology 213: 23-27: 1999

JM Boone, Normalized glandular dose (DgN) coeffiecients for arbitrary x-ray spectra in mammography: computer-fit values of Monte Carlo derived data. Med Phys 29: 869-875: 2001

All of these papers assumed that "aerial glandular density" was equal to "volume glandular density"

To be clear, there is no such thing as a 100% glandular breast

Only ~4% of women have a volume glandular fraction >50%

SPIE

< Previous Article   Next Article >

Proceedings Article

Glandular segmentation of cone beam breast CT volume images

Nathan Packard ; John M. Boone

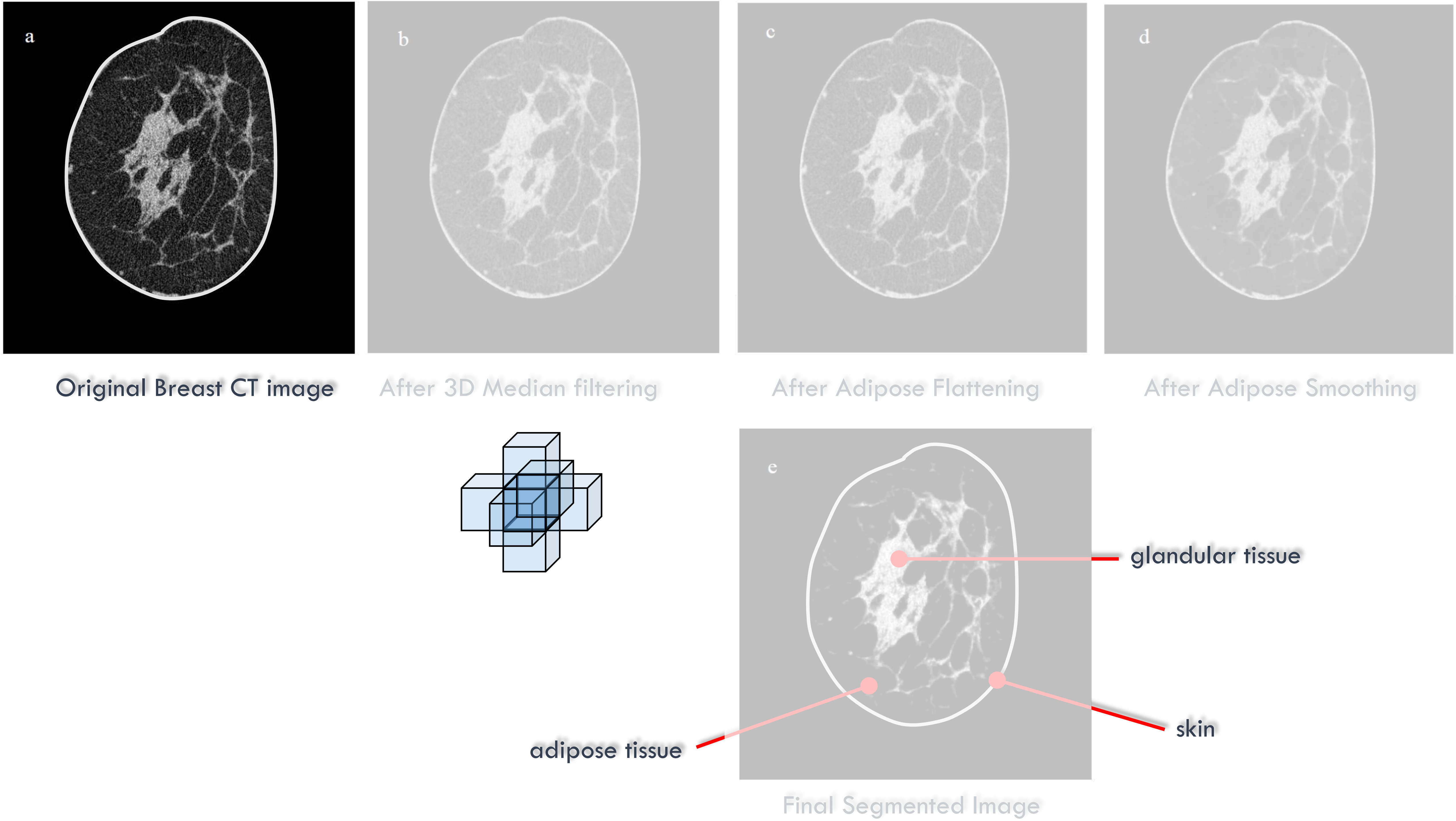
[+] Author Affiliations

Proc. SPIE 6510, Medical Imaging 2007: Physics of Medical Imaging, 651038 (March 17, 2007); doi:10.1117/12.713911

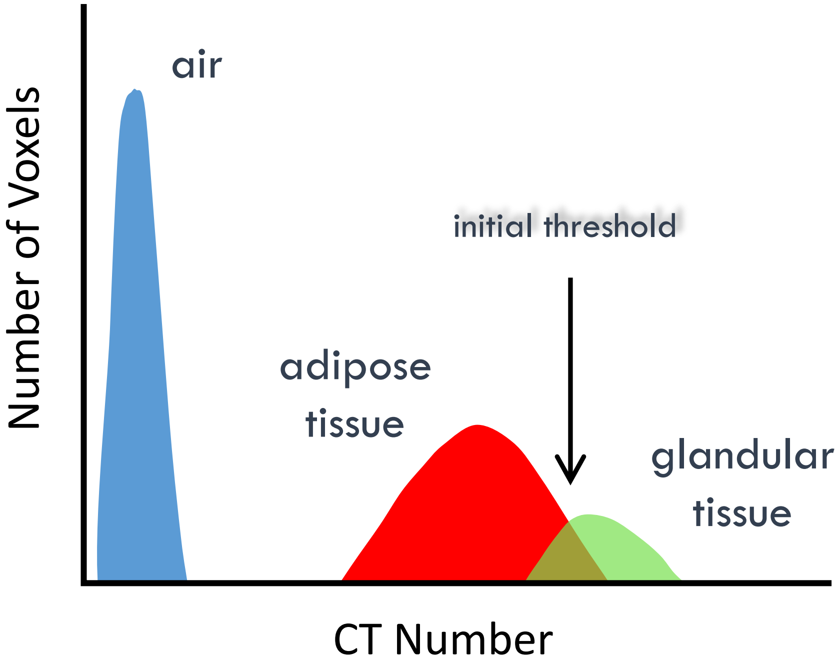
Text Size: A A

From Conference Volume 6510

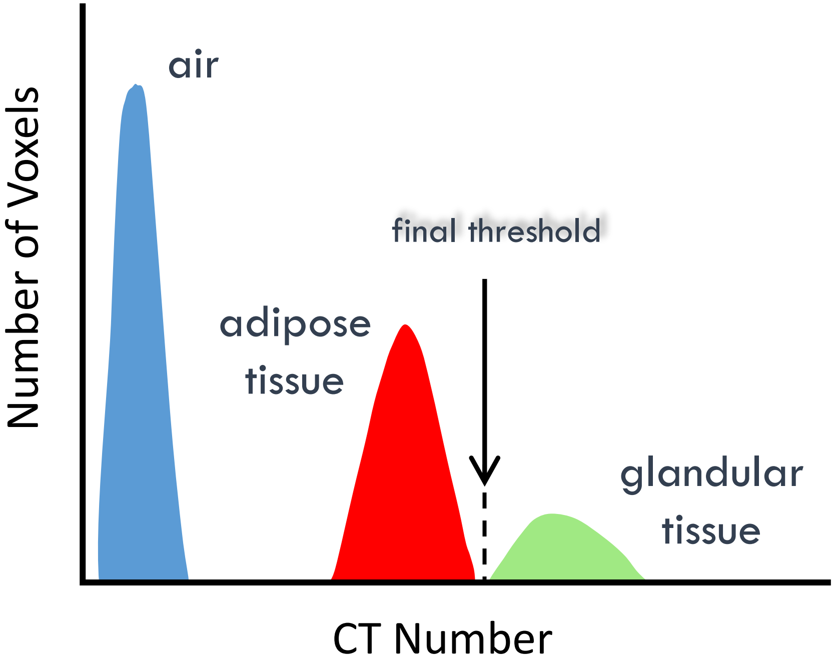
Medical Imaging 2007: Physics of Medical Imaging
Jiang Hsieh; Michael J. Flynn
San Diego, CA | February 17, 2007

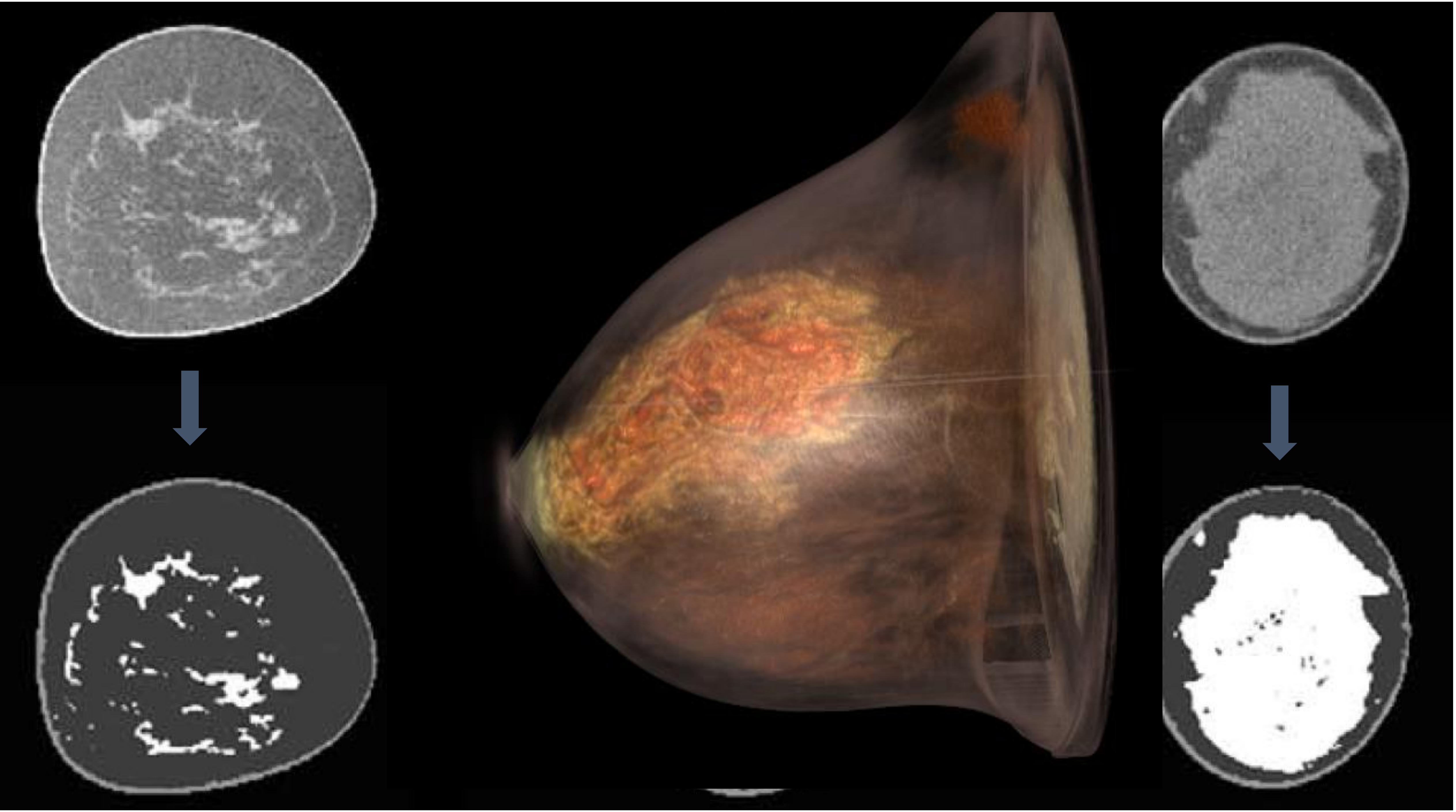

a
b
c
d
Original Breast CT image
After 3D Median filtering
After Adipose Flattening
After Adipose Smoothing
e
glandular tissue
skin
adipose tissue
Final Segmented Image

Original Breast CT image



After Segmentation Algorithm





Medical Physics

The myth of the 50-50 breast

M. J. Yaffe[a)]
Sunnybrook Health Sciences Centre, University of Toronto, Toronto, Ontario M4N 3M5, Canada

J. M. Boone and N. Packard
UC Davis Medical Center, University of California-Davis, Sacramento, California 95817

O. Alonzo-Proulx
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S.-Y. Huang
UC Davis Medical Center, University of California-Davis, Sacramento, California 95817

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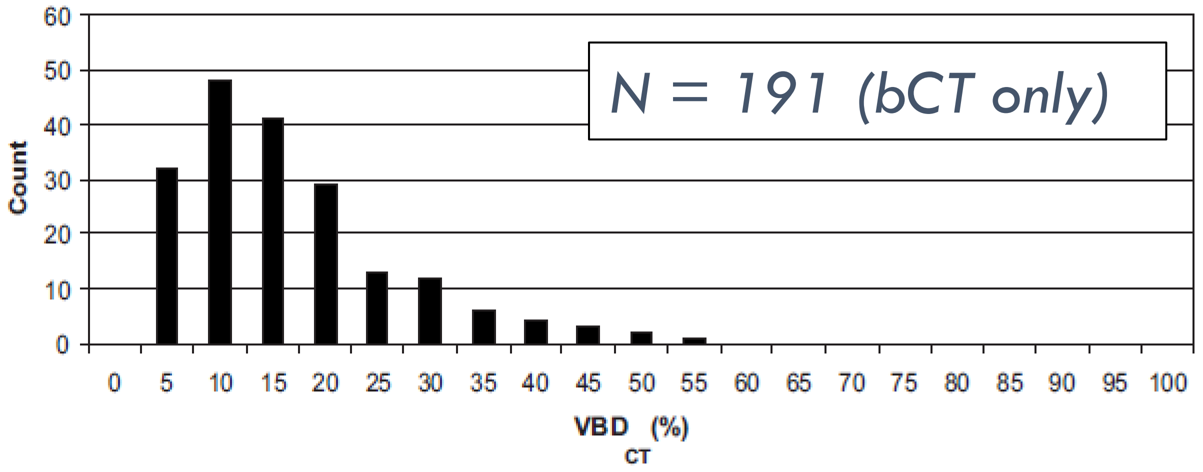
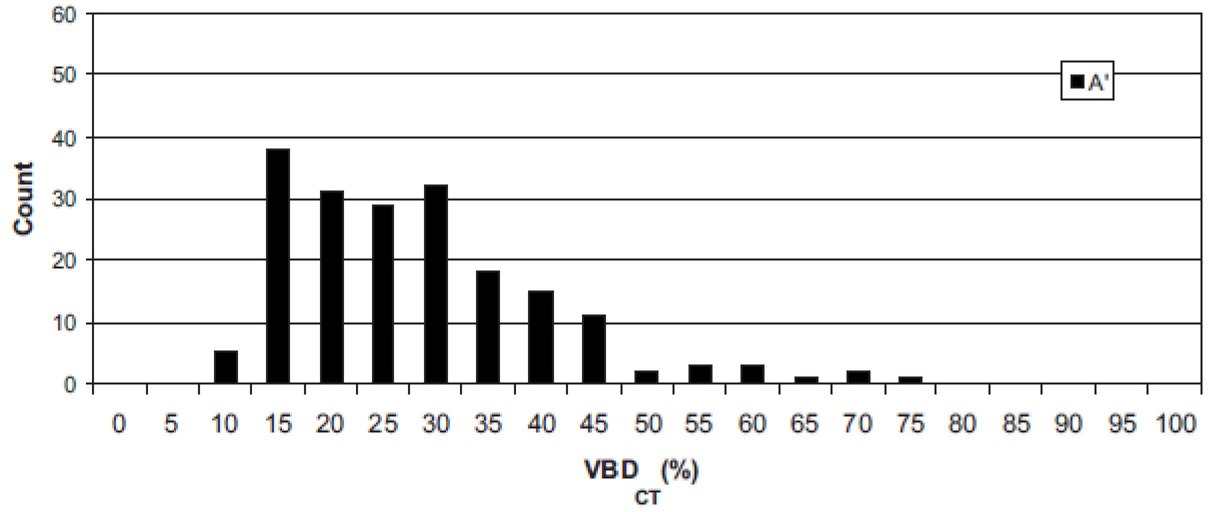
University Health Network, University of Toronto, Toronto, Ontario M5G 2M9, Canada

(Received 30 April 2009; revised 23 September 2009; accepted for publication 29 September 2009; published 5 November 2009)

The Volume Glandular Fraction (VGF)



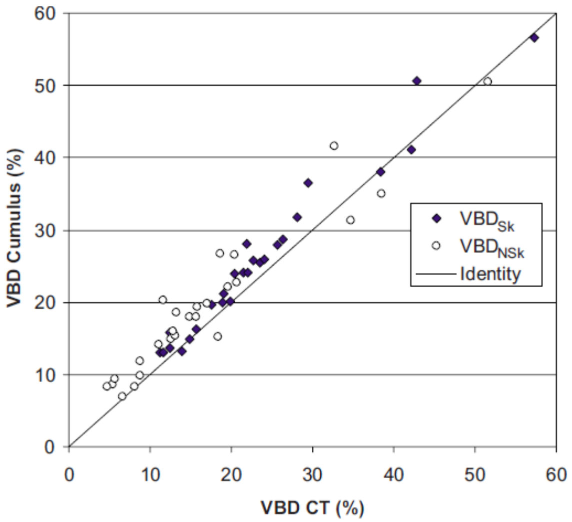


including skin:

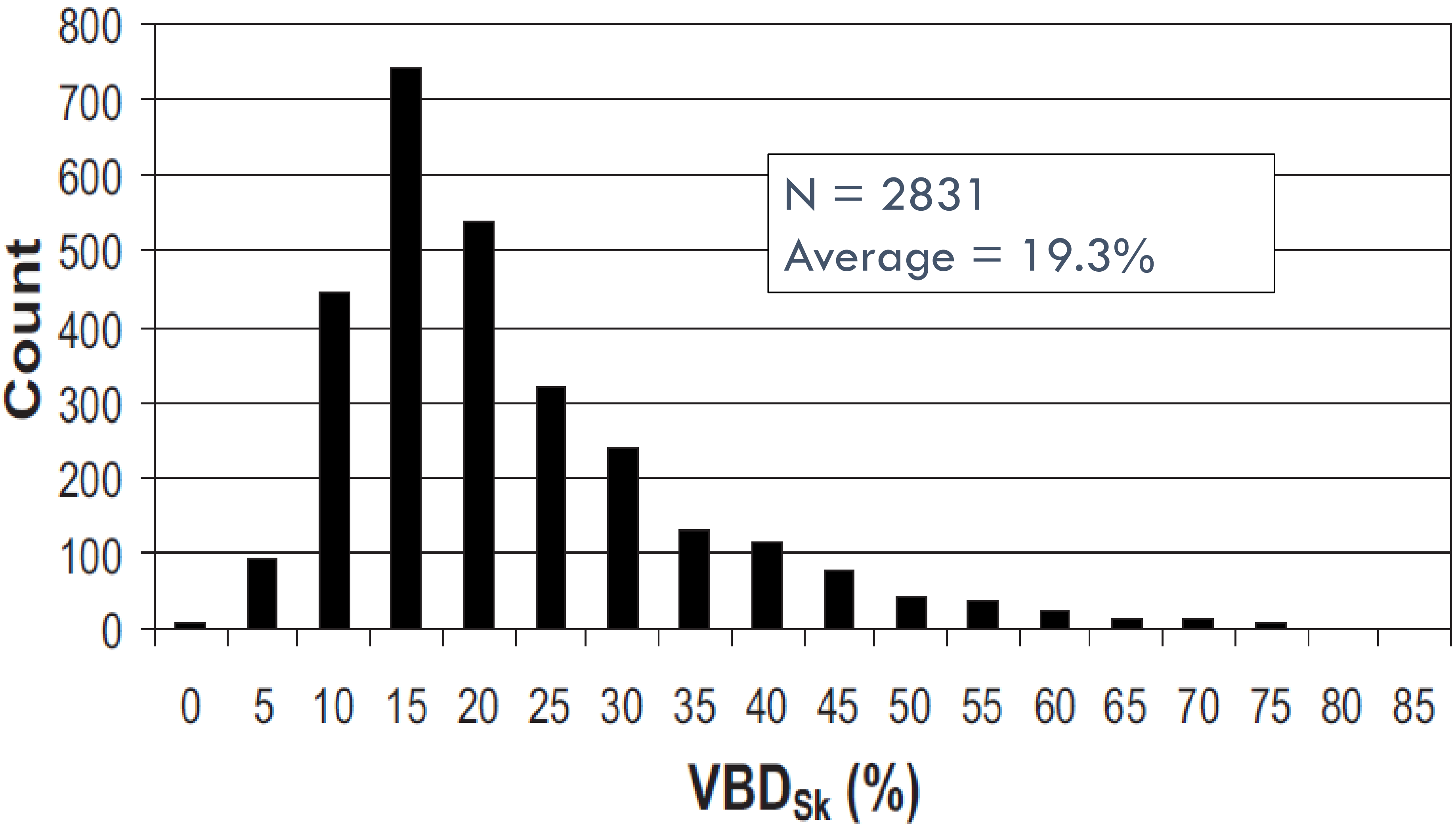
$$VGF = \frac{\text{glandular}}{\text{skin} + \text{glandular} + \text{adipose}}$$

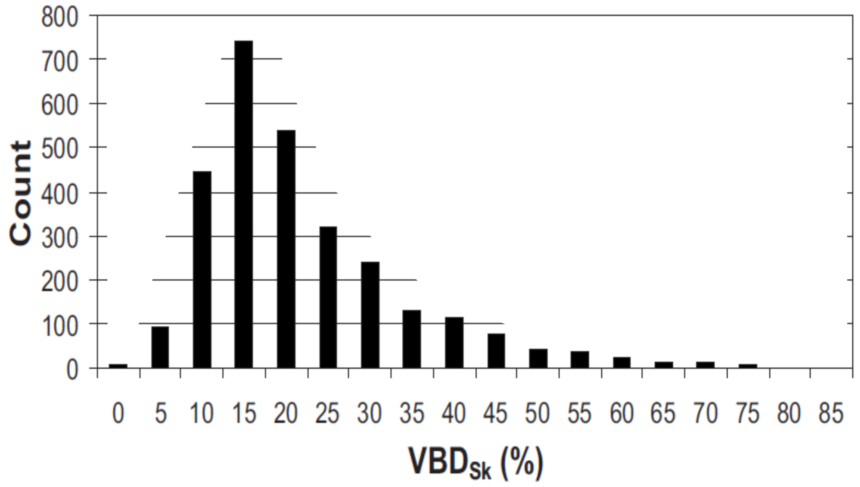
excluding skin:

$$VGF = \frac{\text{glandular}}{\text{glandular} + \text{adipose}}$$



Validation of Toronto versus UC Davis density assessment techniques




Count
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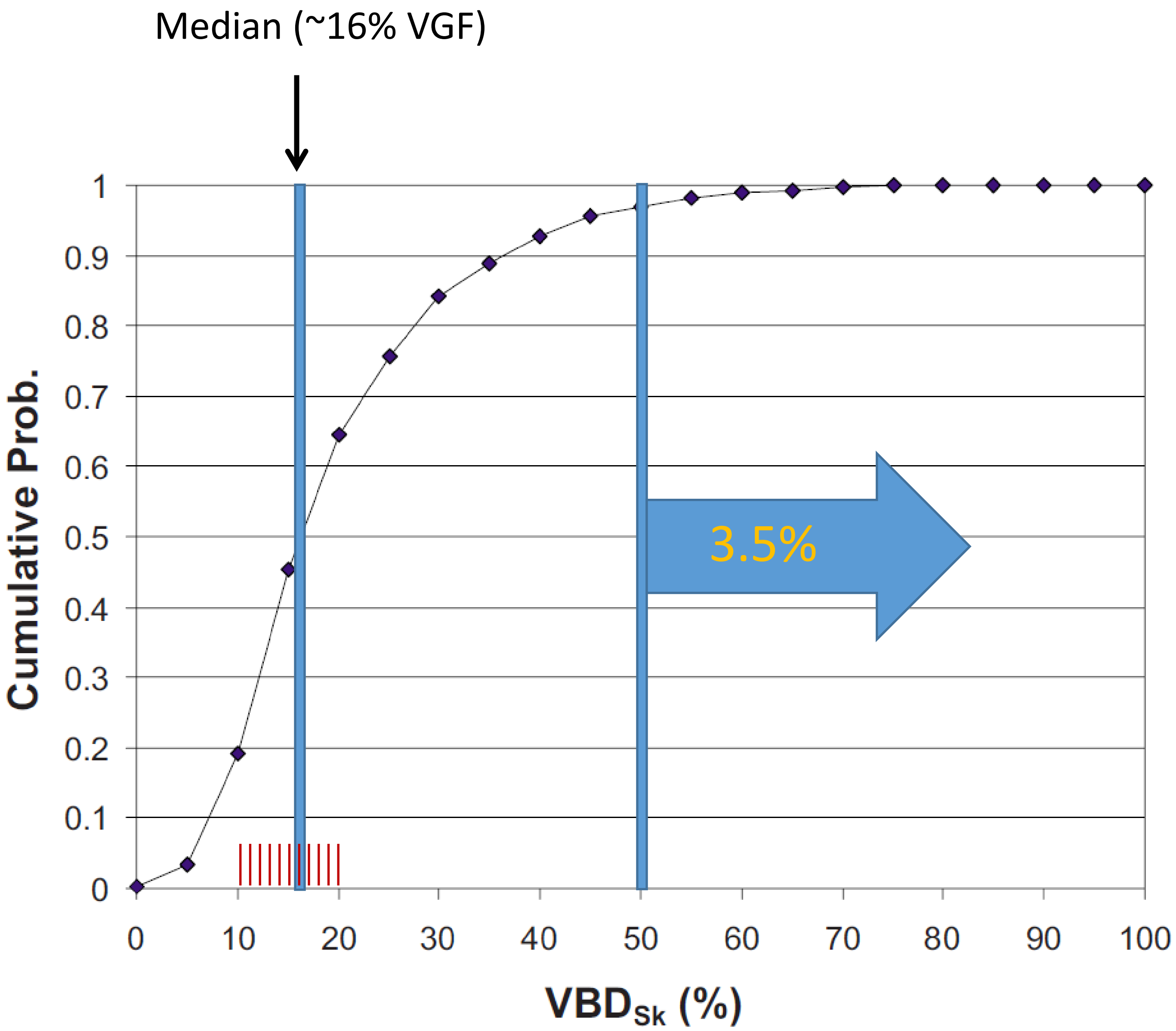
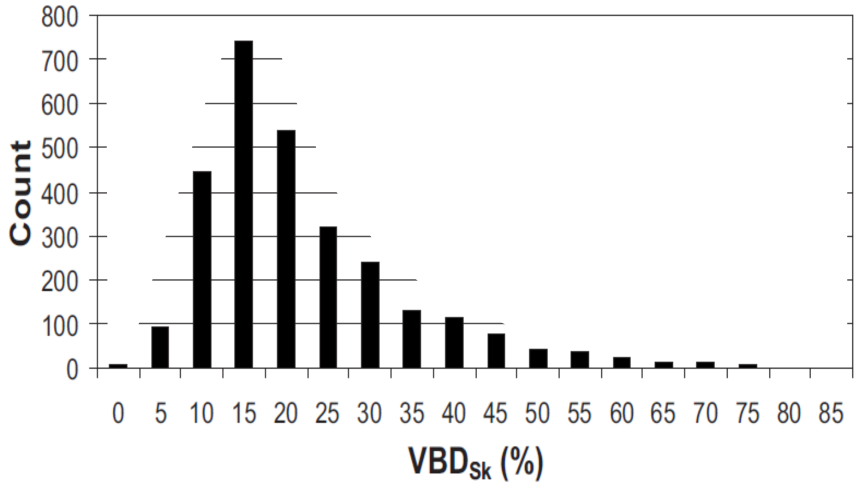
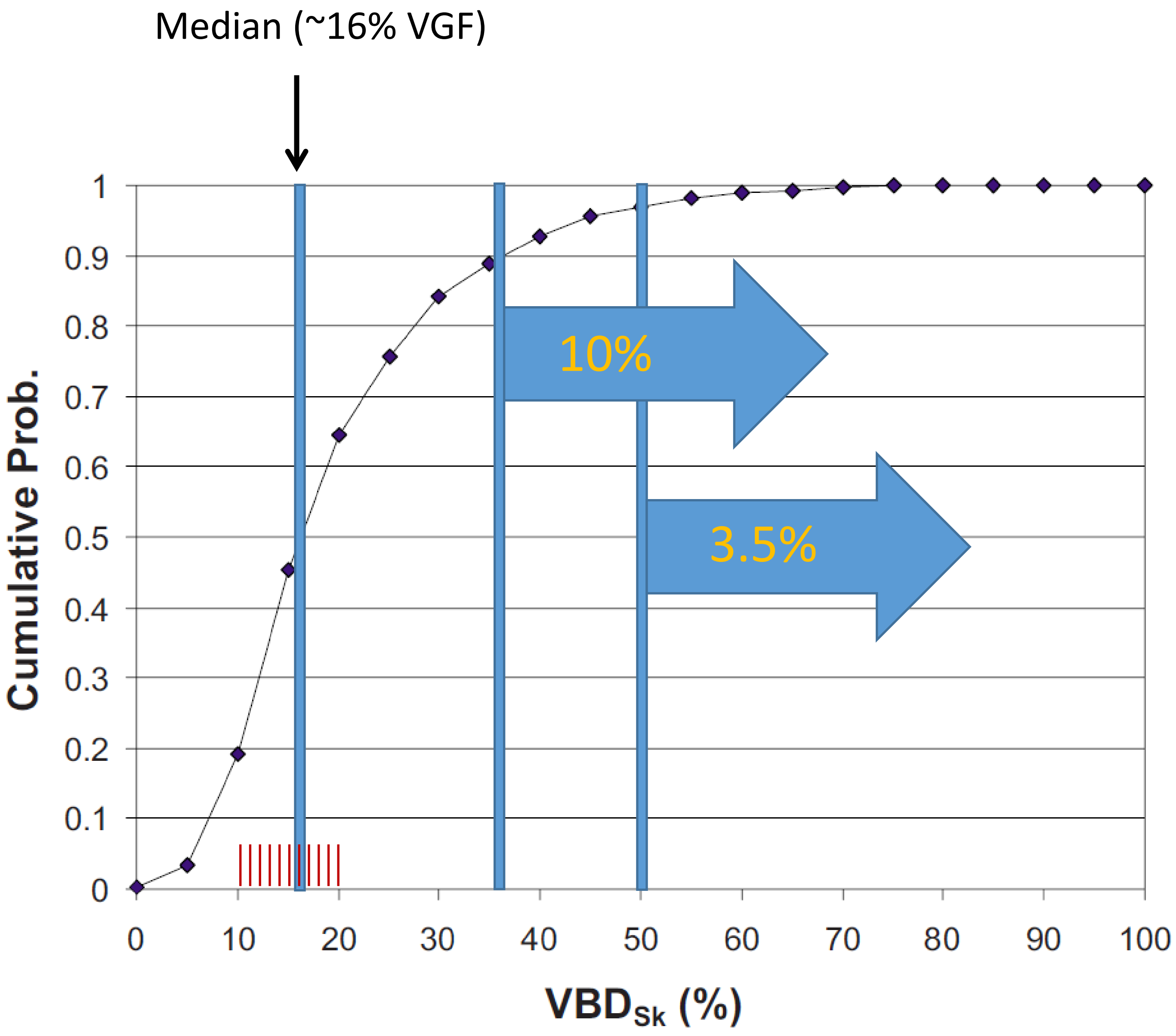
700
600
500
400
300
200
100
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85
VBDSk (%)

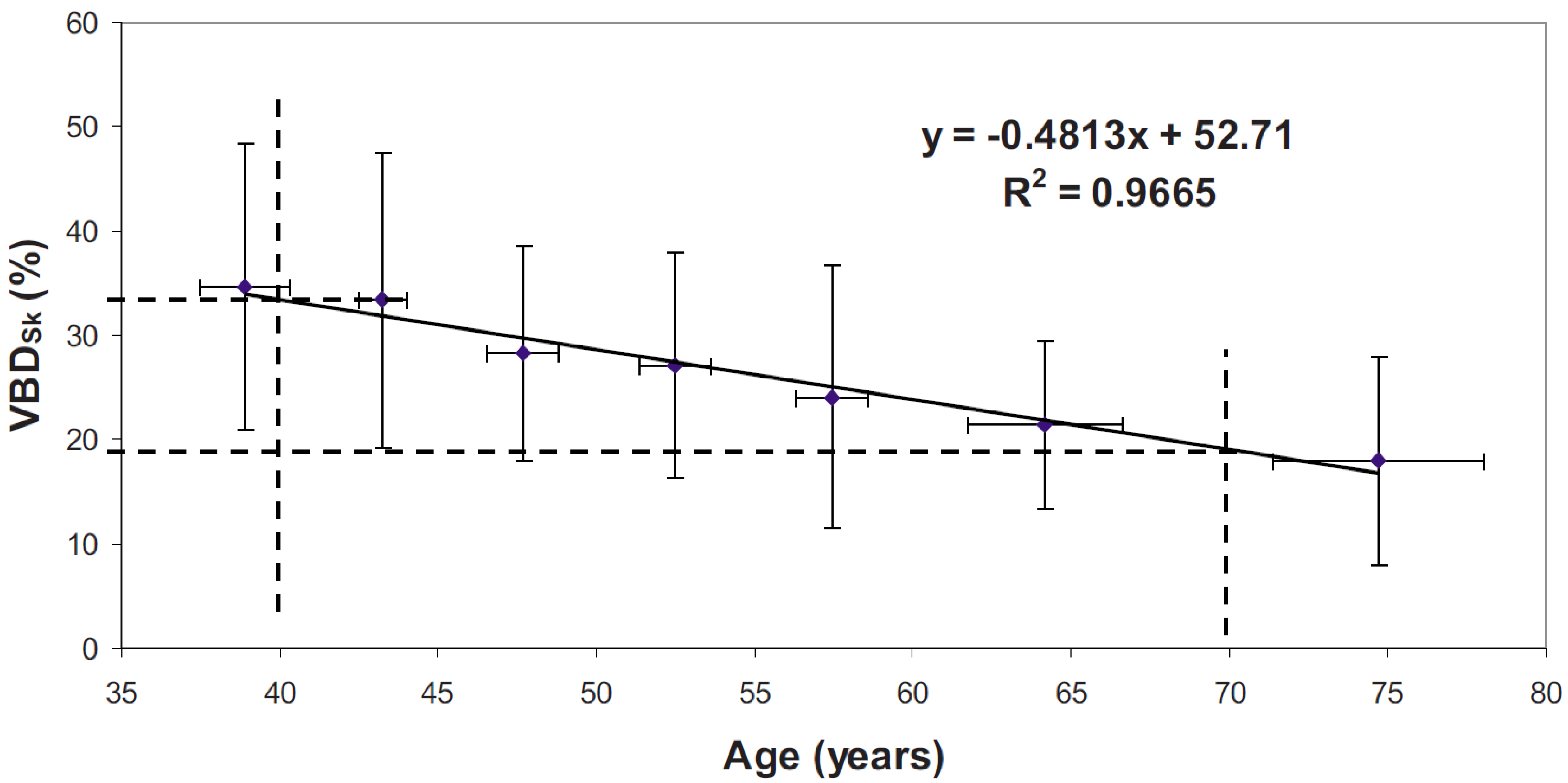

Median (~16% VGF)
Cumulative Prob.
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
3.5%
0 10 20 30 40 50 60 70 80 90 100
VBDSk (%)



Count
800
700
600
500
400
300
200
100
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85
VBD_Sk (%)



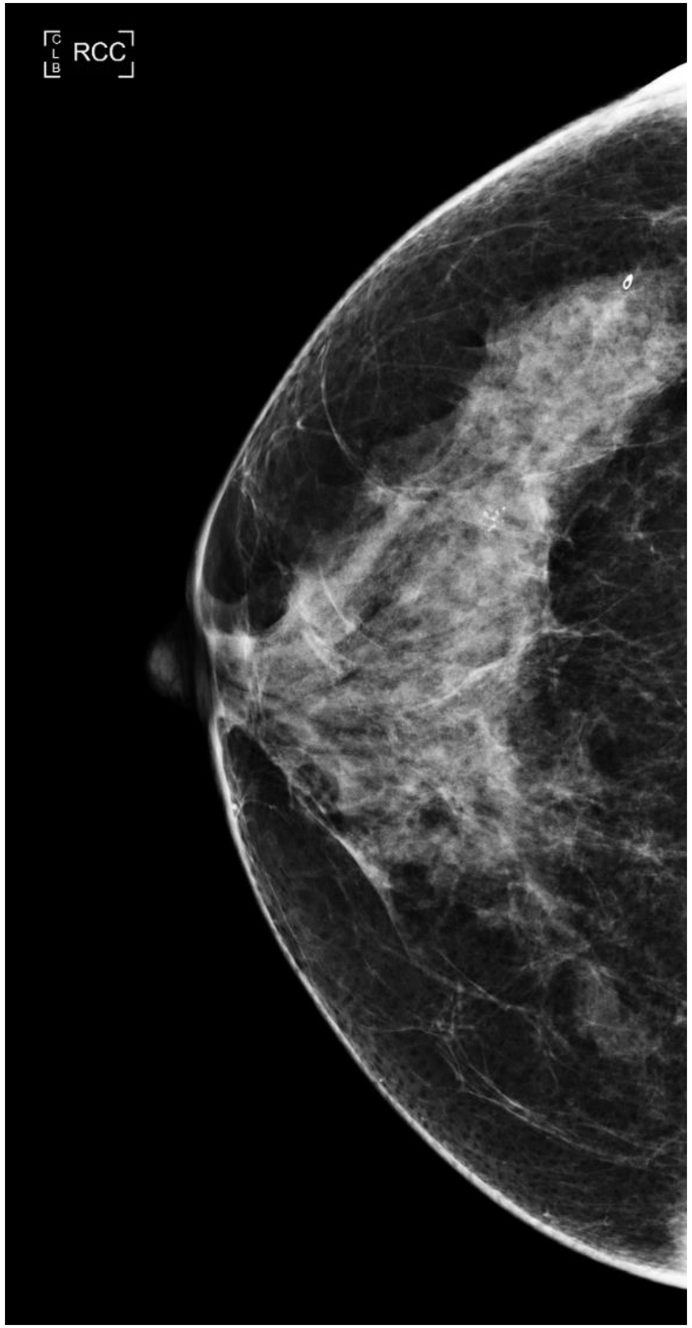
Median (~16% VGF)
Cumulative Prob.
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
10%
3.5%
0 10 20 30 40 50 60 70 80 90 100
VBD_Sk (%)



y = -0.4813x + 52.71
R^2 = 0.9665
VBDSK (%)
Age (years)
0
10
20
30
40
50
60
35
40
45
50
55
60
65
70
75
80

Changing Perceptions and Updated Methods for Mammography Dosimetry

Clinical Implications



kVp: 28
mAs: 157
Thk: 49 mm
Target: TUNGSTEN
Filter: RHODIUM
R cranio-caudal
Mag: 1.073
Size: 2560 x 3328
Angle: 0.0

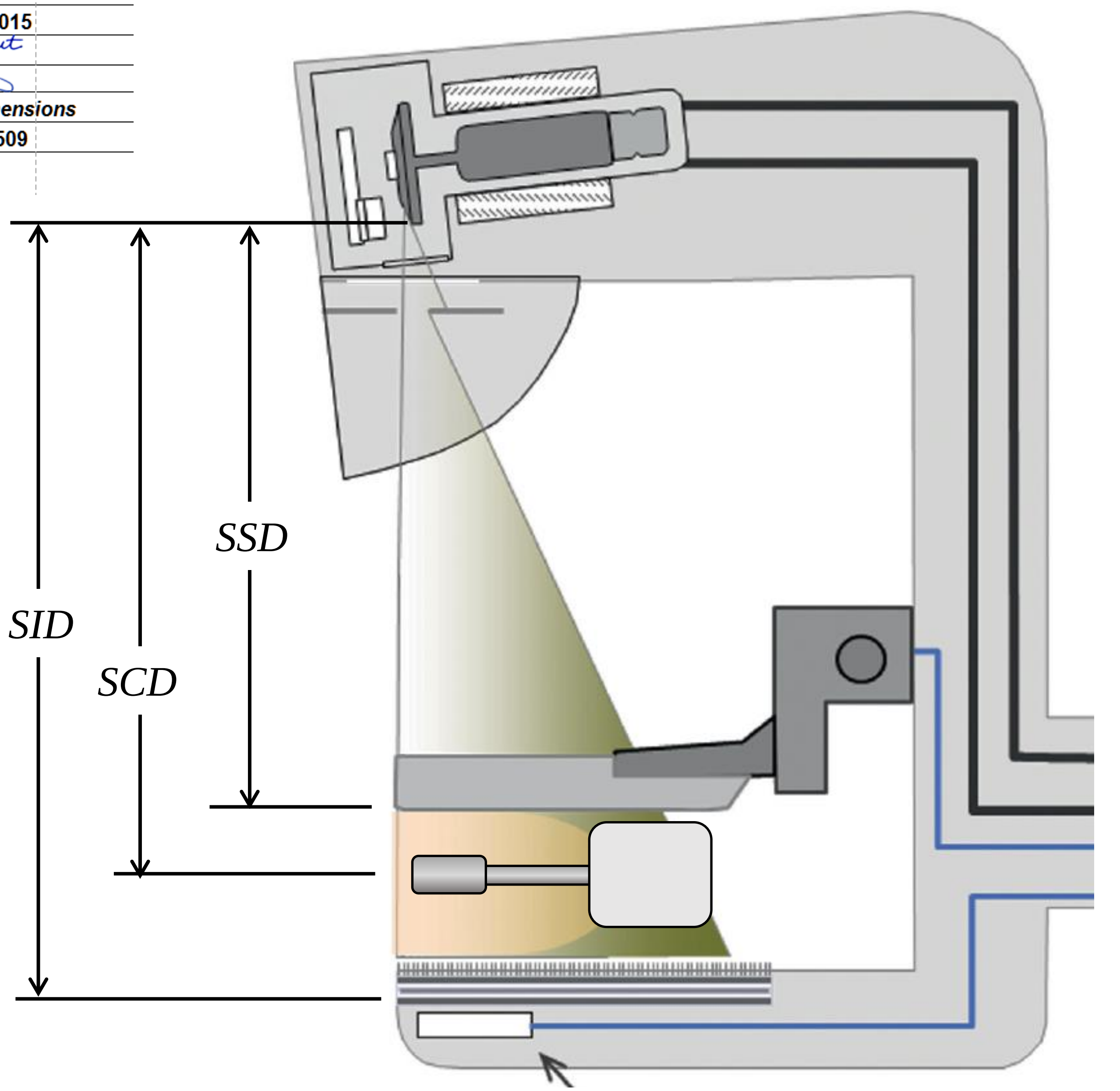
28 kV
W / Rh
Thickness = 49 mm
157 mAs

MEDICAL PHYSICIST'S MAMMOGRAPHY QC TEST SUMMARY

Full-Field Digital - Lorad

Site Name	University of California Davis Medical Center	Report Date	12/23/2015
Address	4860 Y St. ACC #0500 Sacramento, CA 95817	Survey Date	12/21/2015
Medical Physicist	J. Anthony Seibert, PhD	Signature	J Anthony Seibert
	John M. Boone, PhD	Signature	
X-Ray Unit Manufacturer	*Lorad/Hologic*	Model	*Selenia Dimensions*
Date of Installation	21-Dec-15	Room ID	ACC 0509
QC Manual Version #	MAN-0376, Rev 004, April 2015		

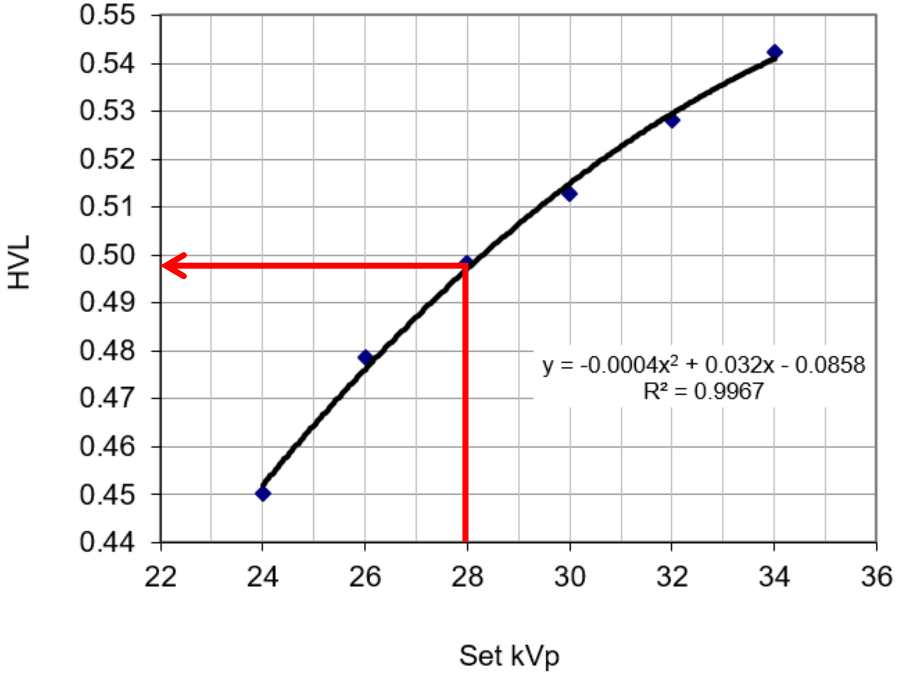
$$K_{ISL} = 0.99$$



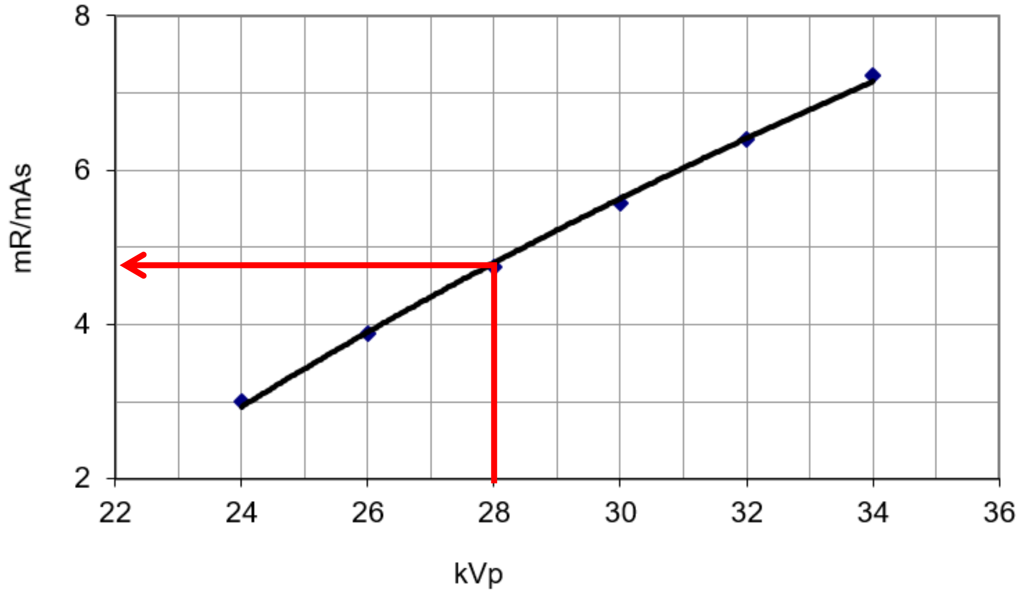
Tungsten / Rhodium Combination

Rh	**Rh**	**Rh**	**Rh**	**Rh**	**Rh**
Yes	Yes	Yes	Yes	Yes	Yes
24	**26**	**28**	**30**	**32**	**34**
50	**50**	**50**	**50**	**50**	**50**
W	W	W	W	W	W
Rh	**Rh**	**Rh**	**Rh**	**Rh**	**Rh**
Yes	Yes	Yes	Yes	Yes	Yes
Exposure measurements (mR)					
150.0	194.3	236.9	278.6	320.1	361.1
80.2	107.5	133.7	159.6	185.5	211.8
70.2	94.5	118.2	141.4	165.3	189.4
			125.9	147.4	169.1
150.0	194.3	236.9	278.6	320.1	361.1
192.2	245.9	297.9	348.6	399.0	448.6
0.78	0.79	0.8	0.8	0.8	0.8
Calculations					
150.0	194.3	236.9	278.6	320.1	361.1
75.0	97.2	118.5	139.3	160.1	180.6
80.2	107.5	133.7	141.4	165.3	189.4
70.2	94.5	118.2	125.9	147.4	169.1
0.4	0.4	0.4	0.5	0.5	0.5
0.5	0.5	0.5	0.6	0.6	0.6
0.450	**0.479**	**0.498**	**0.513**	**0.528**	**0.542**
0.27	0.29	0.31	0.33	0.35	0.37
Pass	**Pass**	**Pass**	**Pass**	**Pass**	**Pass**

Half Value Layer



Radiation Output



W/Rh @ 28 kV
HVL = 0.498 mm Al
Output (at 65.5 cm) = 4.8 mR/mAs

Mean glandular dose coefficients (D_{gN}) for x-ray spectra used in contemporary breast imaging systems

Anita Nosratieh[1], Andrew Hernandez[1], Sam Z Shen[2], Martin J Yaffe[2], J Anthony Seibert[3] and John M Boone[4]

[1] Department of Radiology, Biomedical Engineering Graduate Group, University of California Davis, CA 95616, USA
[2] Sunnybrook Research Institute, University of Toronto, Toronto, ON M5S, Canada
[3] Department of Radiology, University of California Davis, CA 95616, USA
[4] Department of Radiology, Department of Biomedical Engineering, University of California Davis, Davis, CA 95616, USA

jmboone@ucdavis.edu

Table 1. Summary of modeled spectra.

Voltage (kV)	Target + Filter	HVL range (mm Al)	DgN table #	Manufacturer
35–49	Mo + 400 μ Cu	2.24–3.80	2	General system
35–49	Rh + 400 μ Cu	2.21–3.79	3	General system
24–49	Mo + 30 μ Mo	0.28–0.52	4	GE essential
24–49	Mo + 25 μ Rh	0.33–0.56	5	GE senobright low energy
24–49	Rh + 25 μ Rh	0.28–0.65	6	GE essential GE senobright low energy
26–34	W + 50 μ Ag	0.48–0.69	7	Hologic dimensions IMS giotto TOMO
26–38	W + 500 μ Al	0.34–0.61	8	Philips microdose
28–49	W + 700 μ Al	0.46–0.92	9	Hologic dimensions
35–49	W + 200 μ Cu	1.68–2.89	10	Hologic contrast
35–49	W + 300 μ Cu	2.04–3.45	11	Hologic contrast
23–35	W + 50 μ Rh	0.41–0.64	12	Siemens mammomat hologic dimensions IMS giotto TOMO

28 kV HVL = 0.498 mm Al

12.5% Breast Density

Dgn Values W-Rh Anode-Filter 12.5% Glandular Breast (mGy/mGy)							
Energy (kV)		Breast Thickness (cm)					
	HVL	3	4	5	6	7	8
28	0.482	0.426	0.347	0.290	0.246	0.213	0.187
	0.507	0.427	0.349	0.291	0.247	0.214	0.188
	0.532	0.429	0.351	0.292	0.249	0.215	0.189
	0.557	0.431	0.353	0.294	0.250	0.216	0.190
	0.582	0.434	0.355	0.296	0.252	0.218	0.191

$DgN_{12\%} = 0.290$ mGy/mGy

50% Breast Density

Dgn Values W-Rh Anode-Filter 50% Glandular Breast (mGy/mGy)							
Energy (kV)		Breast Thickness (cm)					
	HVL	3	4	5	6	7	8
28	0.482	0.385	0.308	0.253	0.214	0.184	0.160
	0.507	0.386	0.309	0.255	0.215	0.184	0.161
	0.532	0.388	0.311	0.256	0.216	0.185	0.162
	0.557	0.390	0.313	0.257	0.217	0.186	0.163
	0.582	0.392	0.315	0.259	0.218	0.188	0.164

$DgN_{50\%} = 0.254$ mGy/mGy

Incident Air Kerma to Breast:

4.8 mR/mAs × 157 mAs × K_{ISL} = 746 mR = 6.51 mGy [EAK]

Dose (50%) = 6.51 mGy × 0.254 mGy/mGy = 1.65 mGy

Dose (12%) = 6.51 mGy × 0.290 mGy/mGy = 1.89 mGy

14.4% increase due to more accurate glandular fraction assessment

$\underline{1.17} \times \underline{1.144} = 1.34$ or 34 % greater dose

skin thickness

glandular fraction

Changing Perceptions and Updated Methods for Mammography Dosimetry

- Breast CT as the Backstory
- Skin Thickness
- Breast Density / the Myth
- New Mammography Spectra
- Density Heterogeneity
- Summary

Why do we need *another* spectral model

Medical Physics
The International Journal of Medical Physics Research and Practice

Molybdenum, rhodium, and tungsten anode spectral models using interpolating polynomials with application to mammography

John M. Boone, Thomas R. Fewell, and Robert J. Jennings

Citation: Medical Physics **24**, 1863 (1997); doi: 10.1118/1.598100

- Limited kV range: 18 to 42 kV
- Derived from measurements on x-ray tubes of the past

GE
SENOGRAPHE CARE

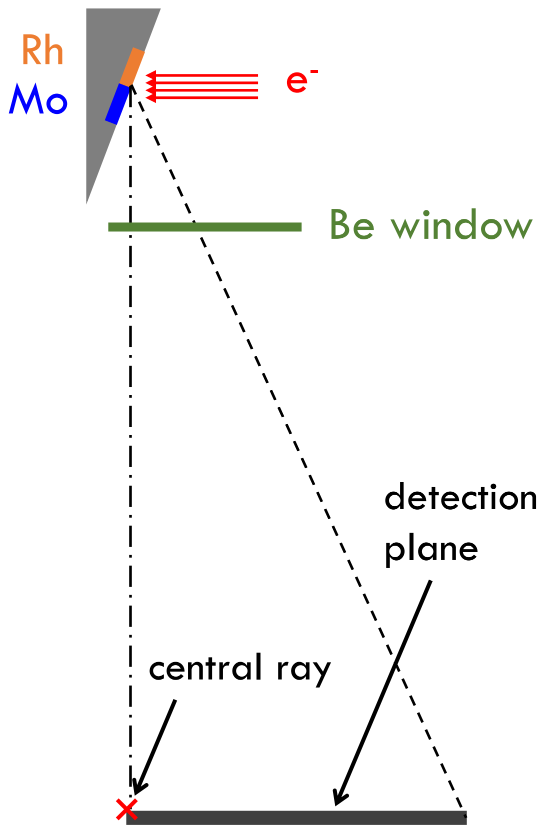
HOLOGIC
SELENIA DIMENSIONS

SIEMENS
MAMMOMAT INSPIRATION

PHILIPS
MICRODOSE

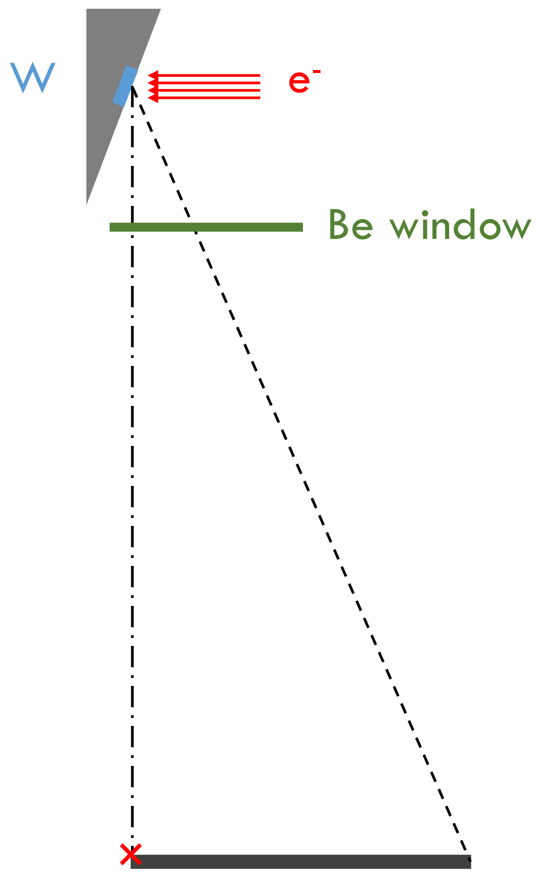
Monte Carlo Simulation Geometry

GE SENOGRAPHE



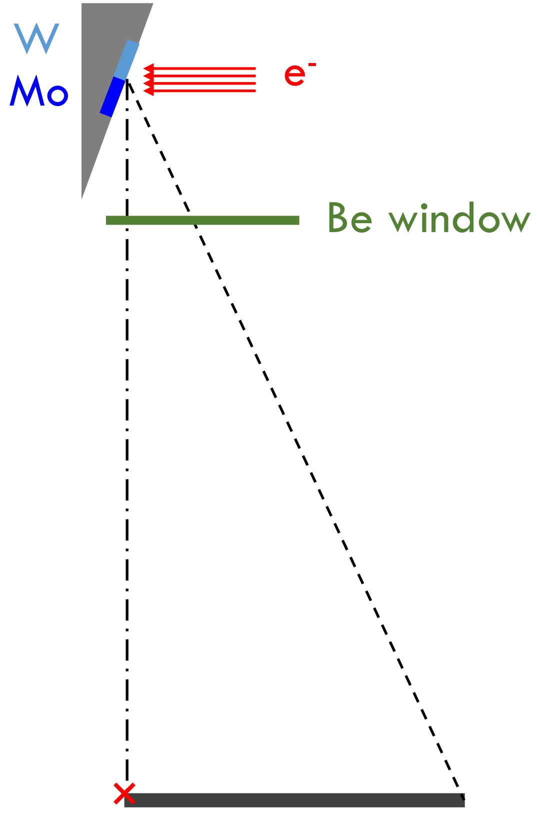
- large & small focal spot on each target

HOLOGIC DIMENSIONS



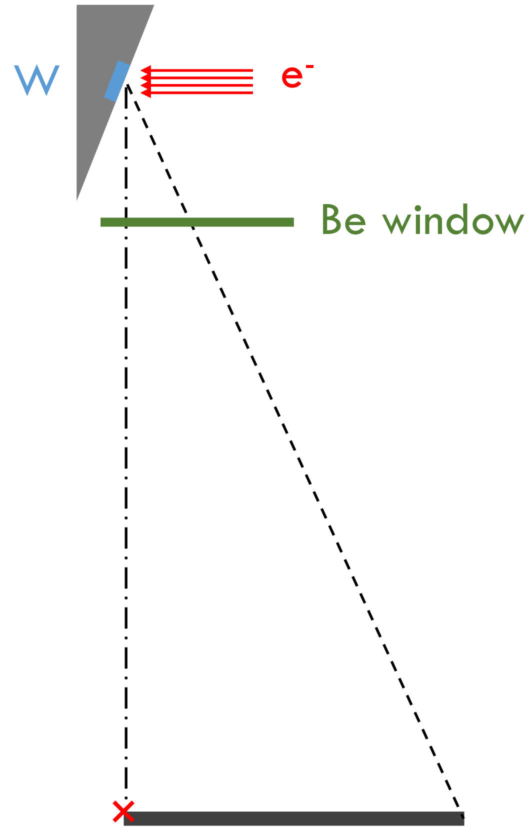
- large & small focal spot

SIEMENS MAMMOMAT



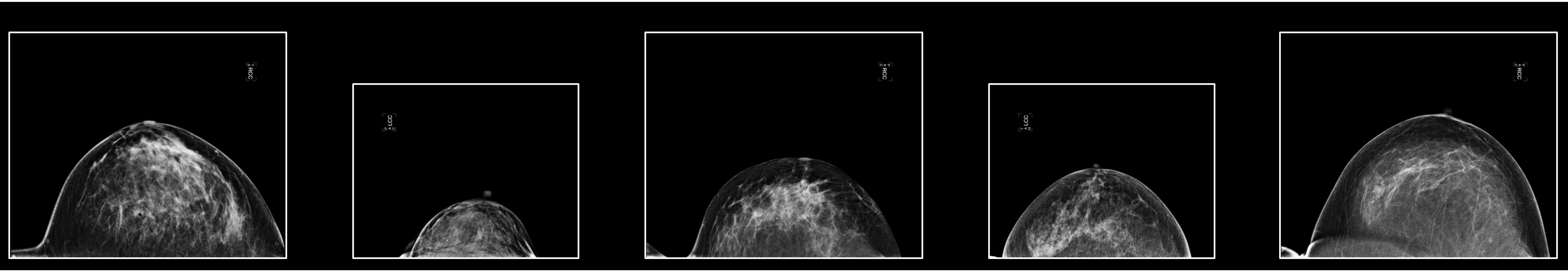
- large & small focal spot on each target

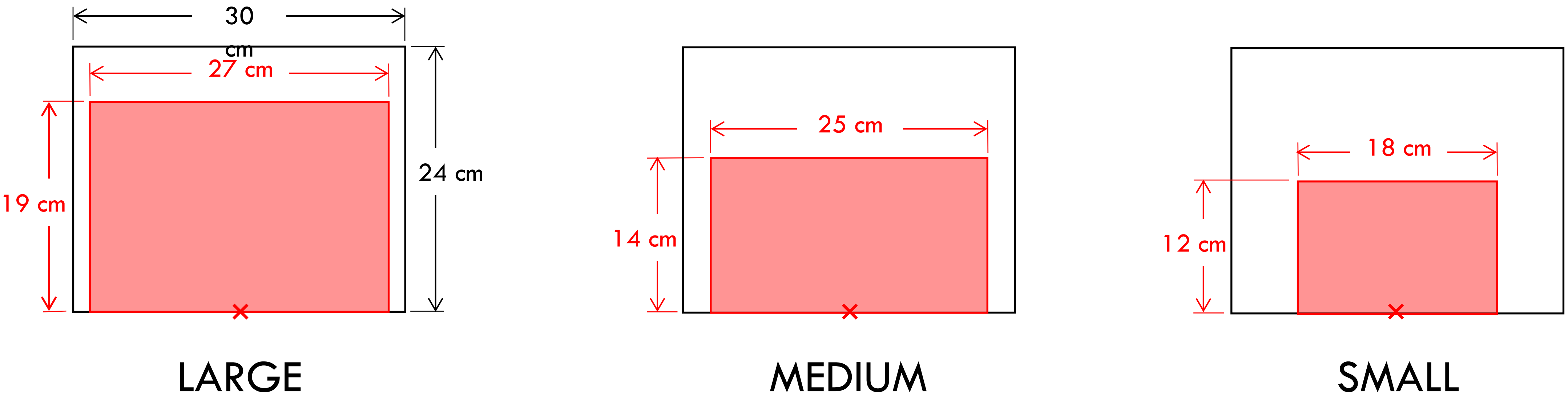
PHILIPS MICRODOSE



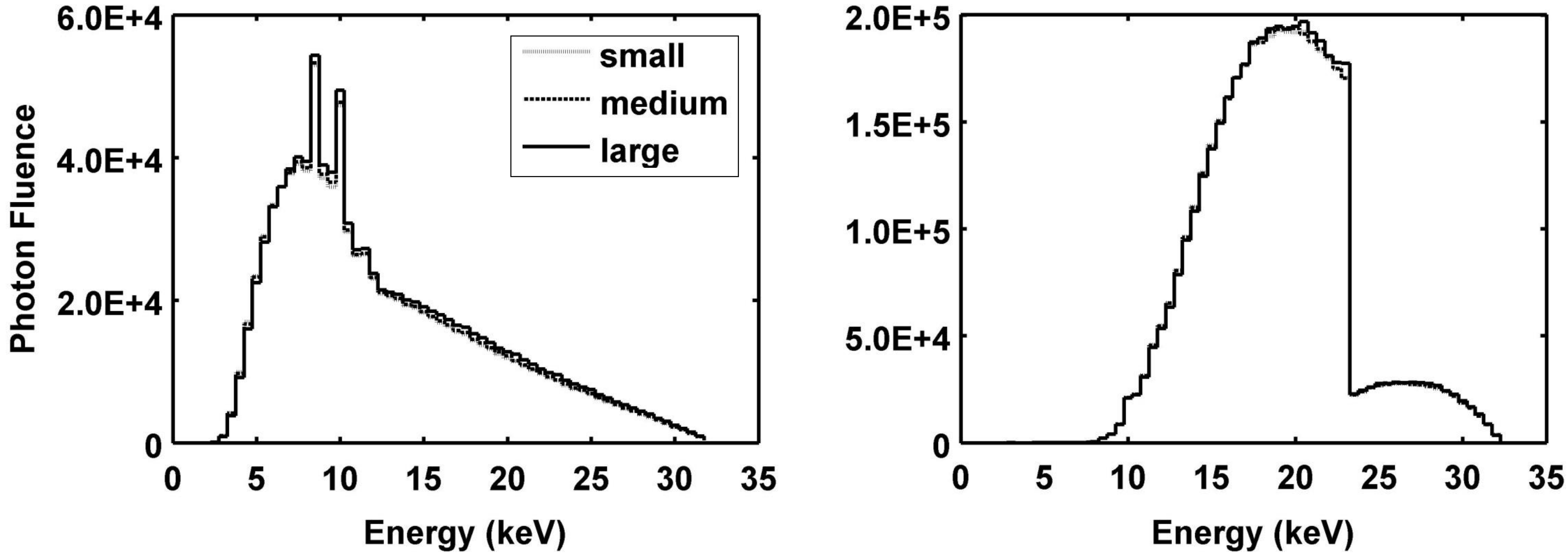
- large focal spot

Detection Plane Size





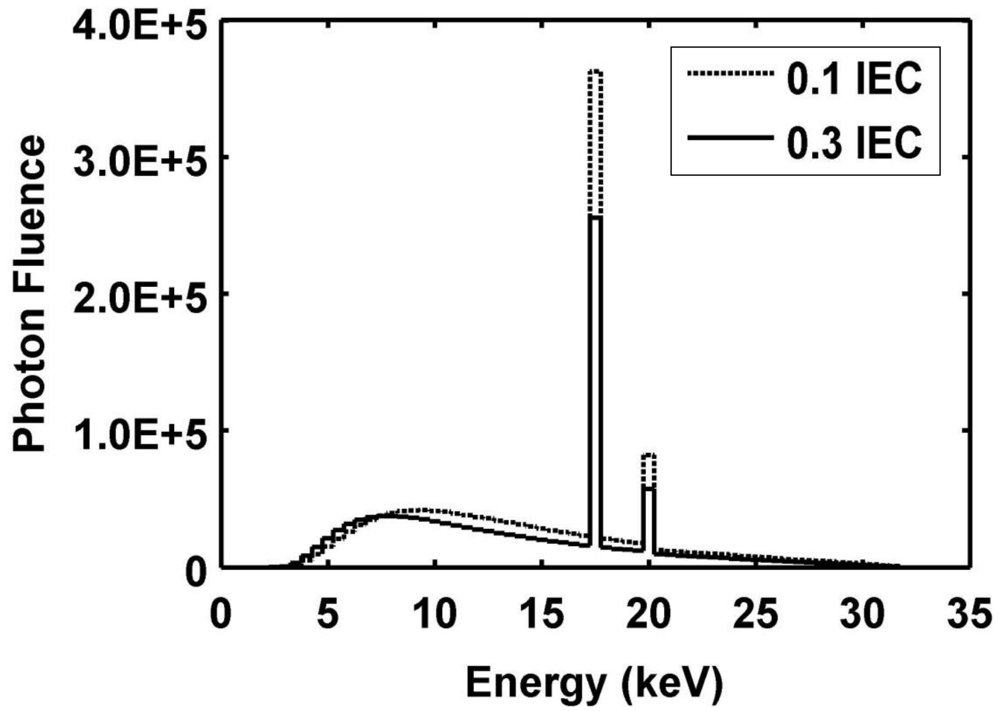
HOLOGIC: W–Be (630 μm)   **HOLOGIC:** W–Rh (50 μm)



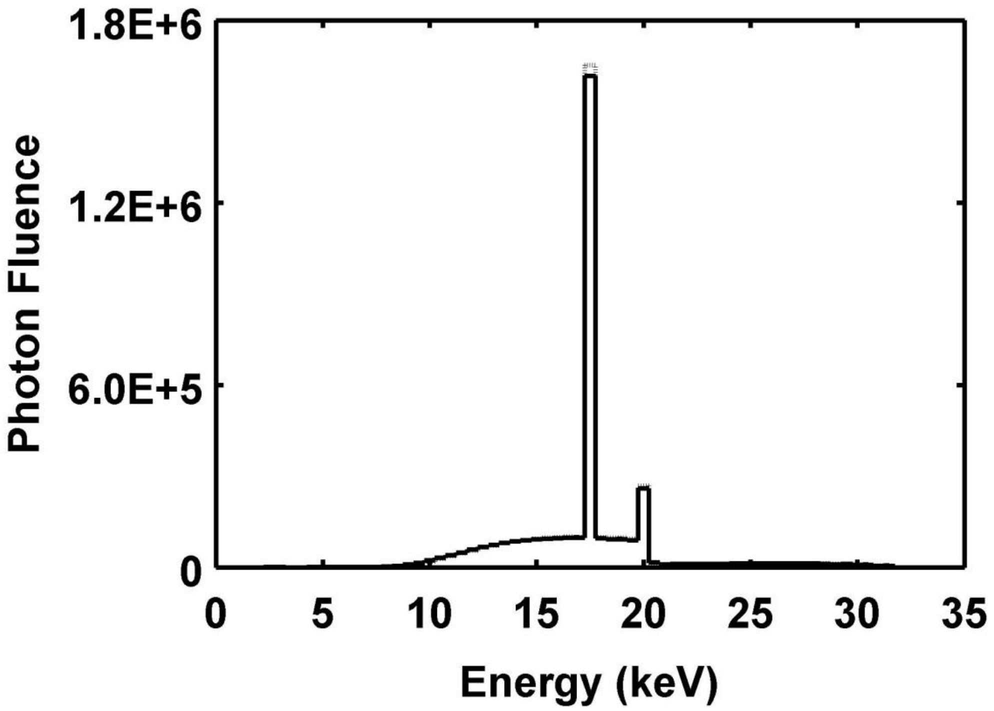
- 0.4 % difference in HVL, averaged across all vendors, after conventional filtration is applied.

=> Detection plane size does not affect spectral shape

GE: Mo – Be (690 μm)

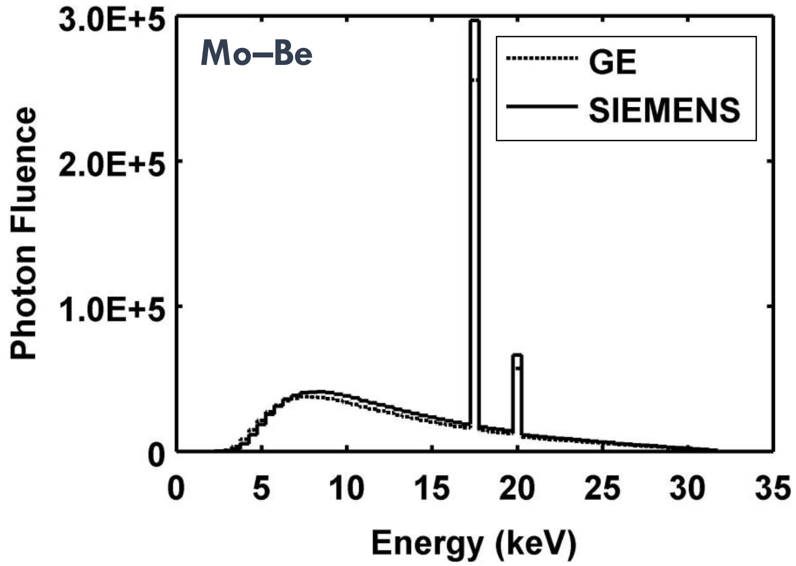


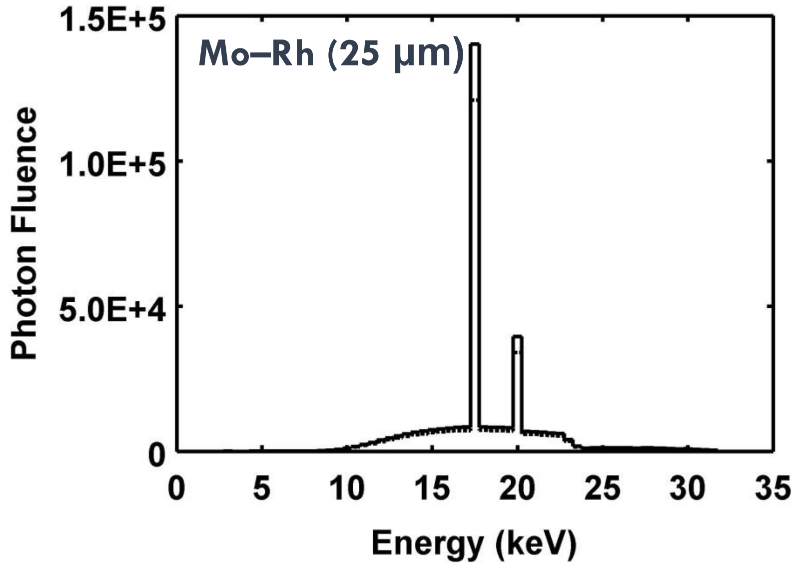
GE: Mo – Mo (30 μm)



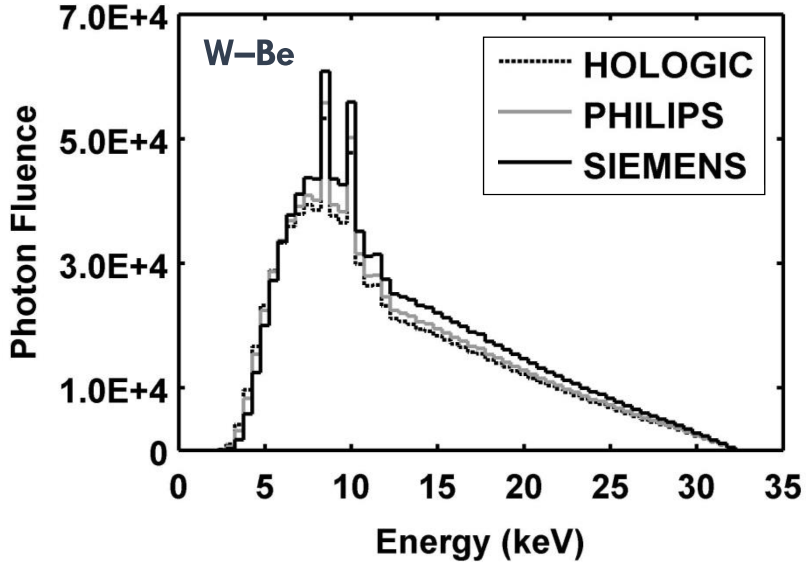
- 1.8 % difference in HVL, averaged across all vendors, after conventional filtration is applied.

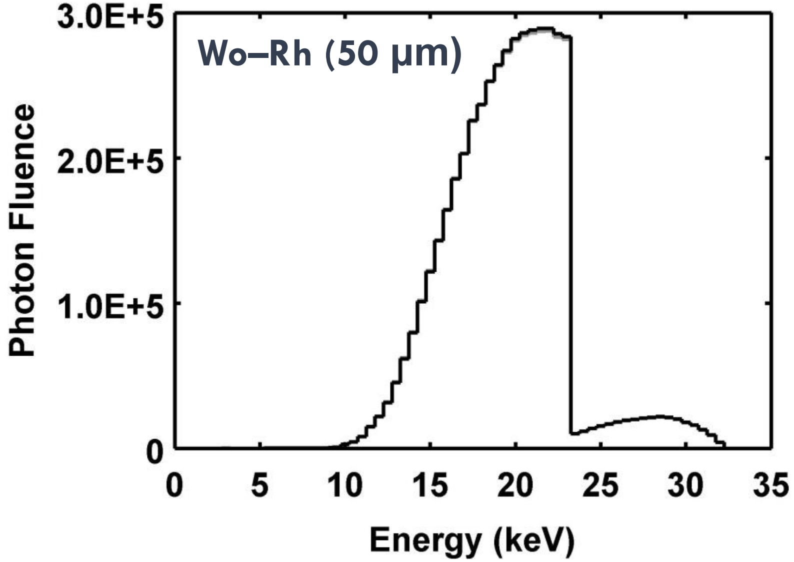
=> Focal spot size does not affect spectral shape



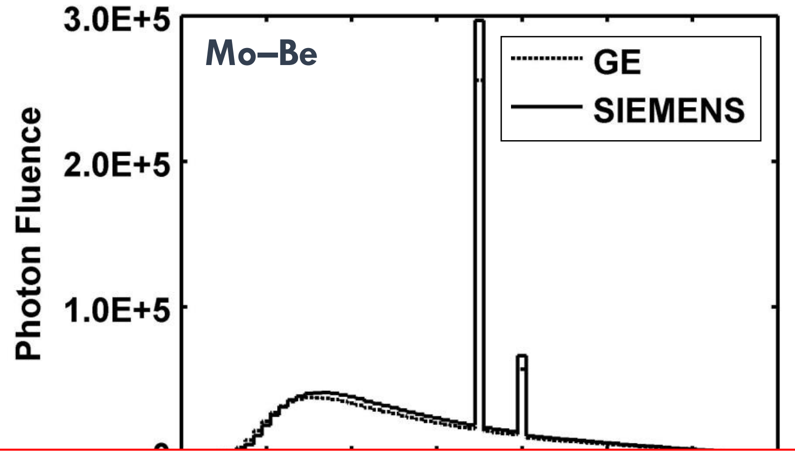


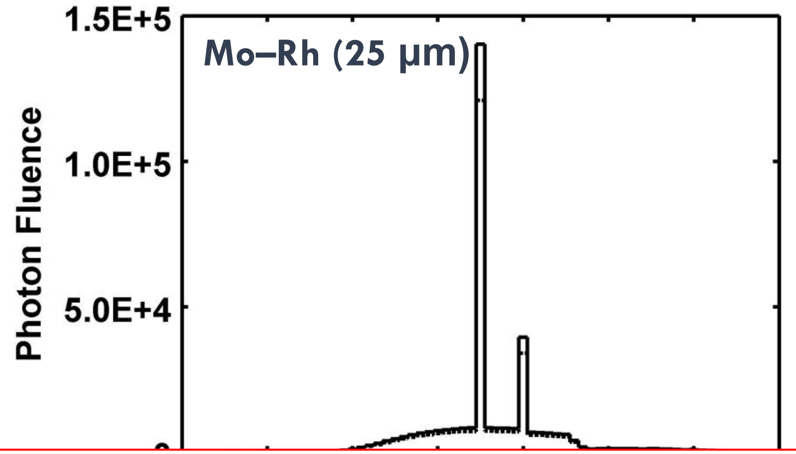
- 0.4 % difference in HVL, for Mo anode systems , after conventional filtration is applied.



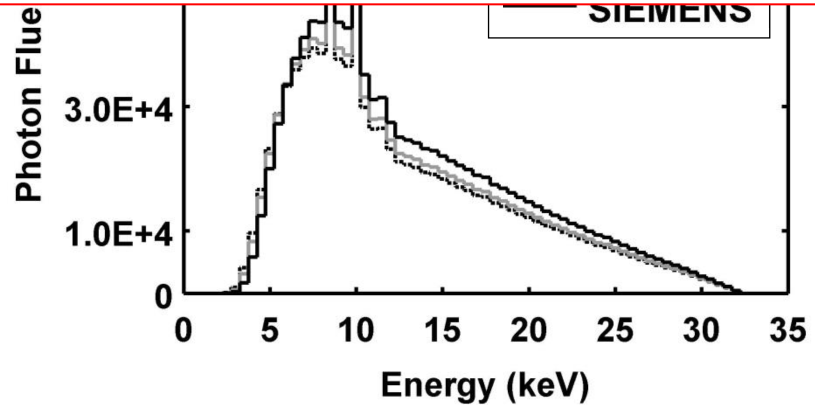


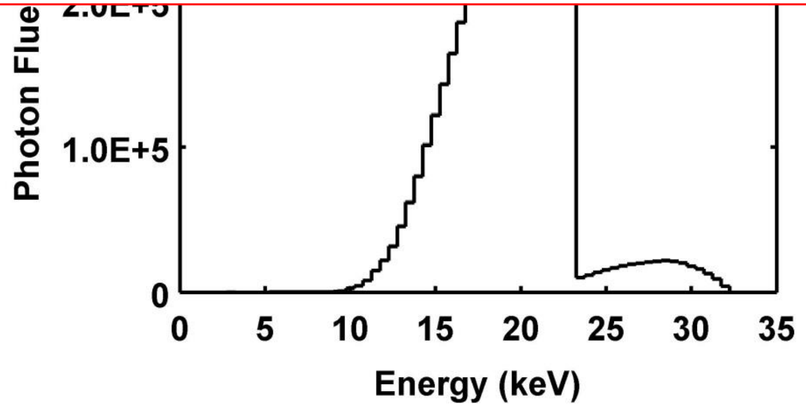
- 0.3 % difference in HVL, for W anode systems , after conventional filtration is applied.





For a given anode composition, vendor-specific geometrical differences do not affect spectral shape





- 0.3 % difference in HVL, for W anode systems , after conventional filtration is applied.

A single mammography system geometry can be used for all commercial systems

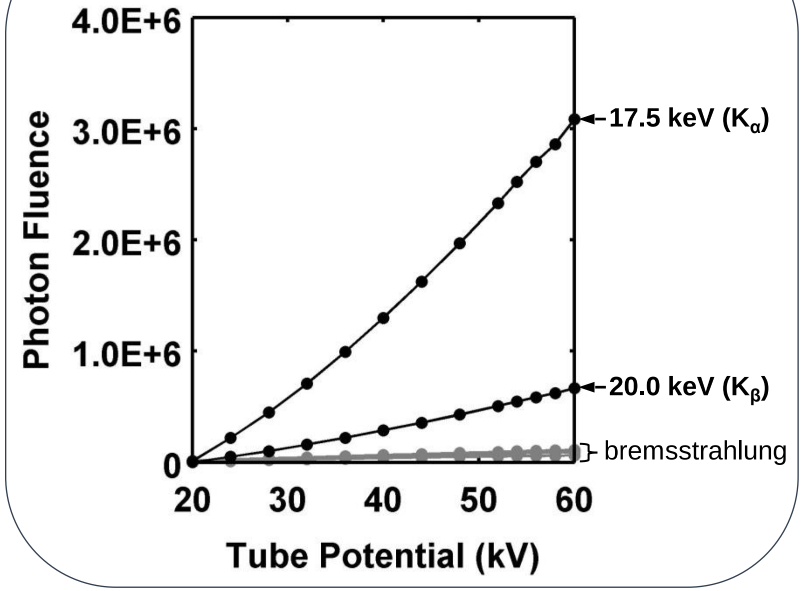
methodology for *new* spectral model adopted from:

Medical Physics
The International Journal of Medical Physics Research and Practice

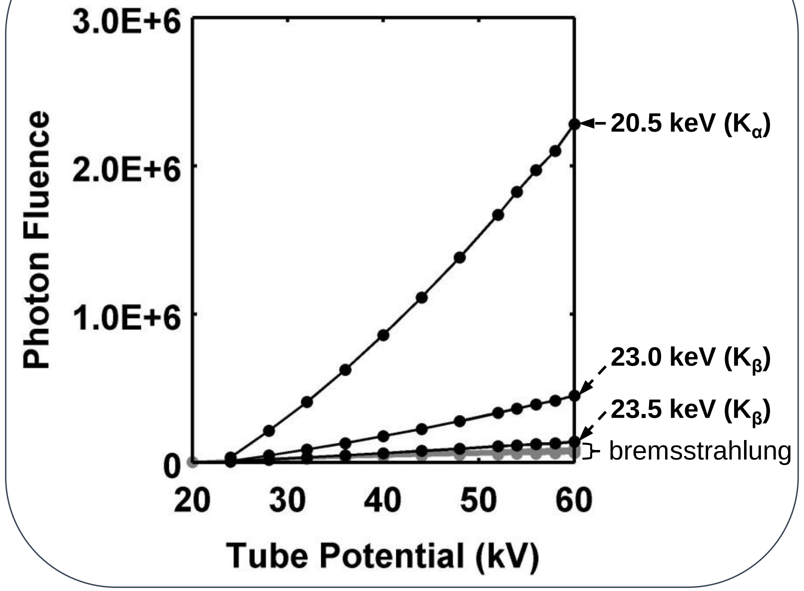
Tungsten anode spectral model using interpolating cubic splines: Unfiltered x-ray spectra from 20 kV to 640 kV

Andrew M. Hernandez and John M. Boone

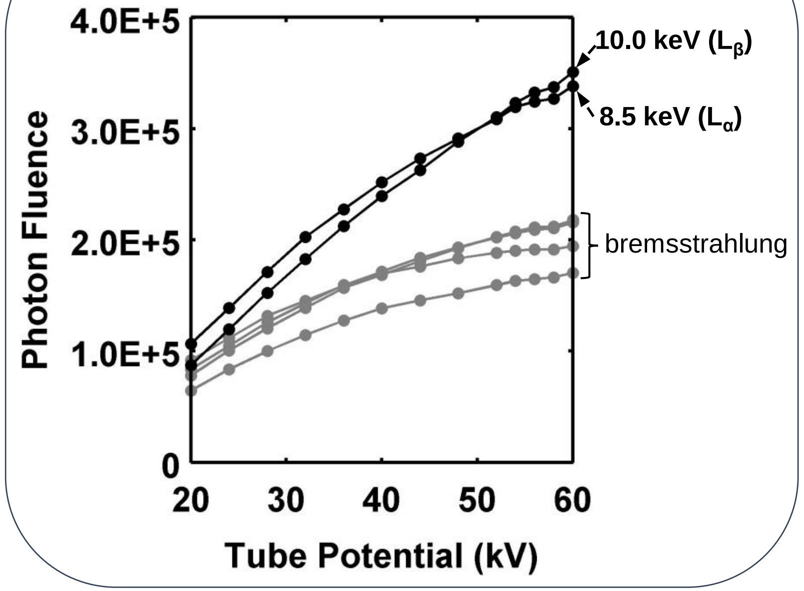
Mo anode



Rh anode



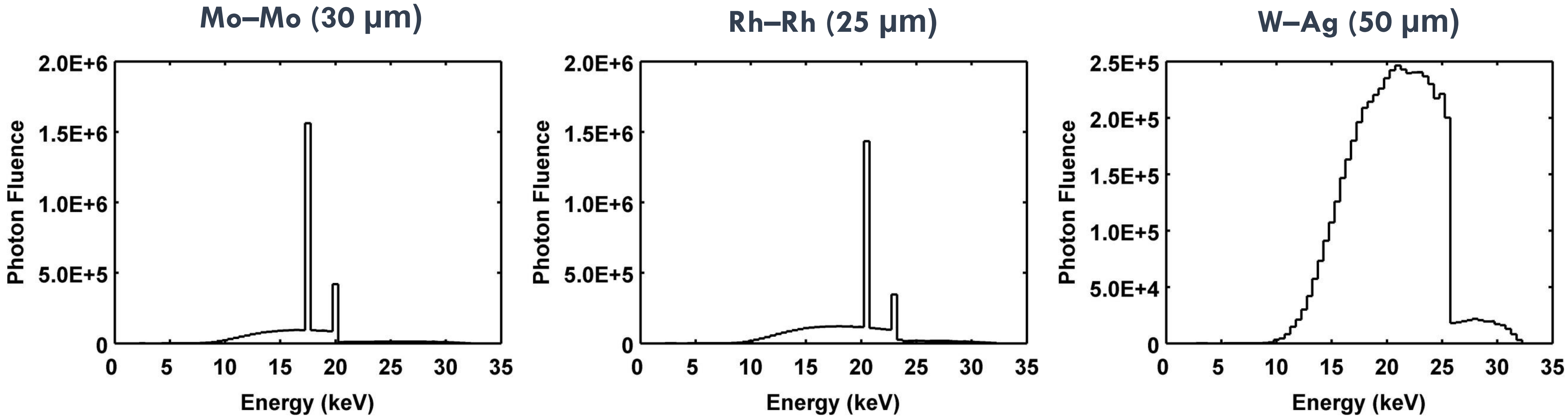
W anode



Molybdenum, Rhodium, and Tungsten Anode Spectral Model using Interpolating Cubic Splines

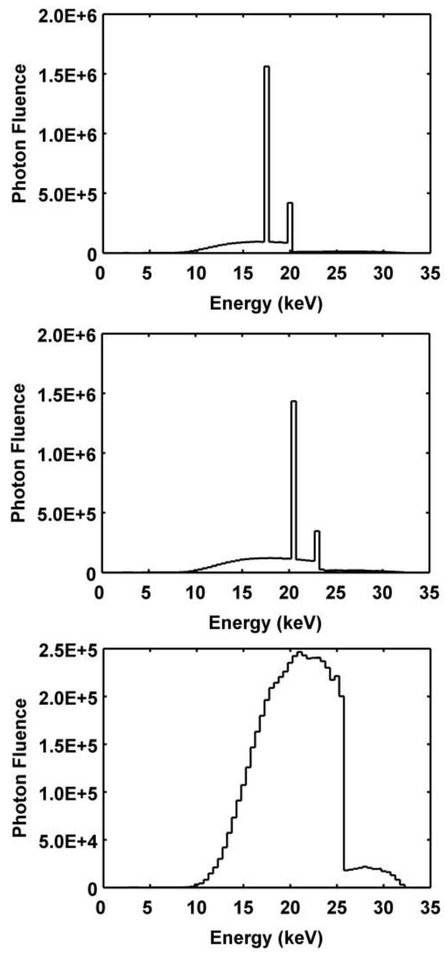
MASMICS, RASMICS, TASMICS

- 20 to 60 kV (1 kV intervals)
- 0.5 keV energy resolution
- Minimal filtration (0.77 mm Be)



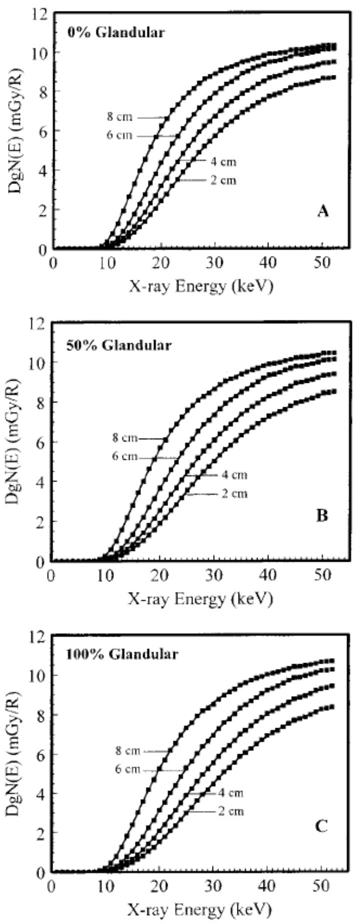
Mean glandular dose coefficients (DgN) for contemporary mammography systems

x-ray spectra



&

DgN(E)



=>

DgN

IOP Publishing | Institute of Physics and Engineering in Medicine Physics in Medicine & Biology
Phys. Med. Biol. **60** (2015) 7179–7190 doi:10.1088/0031-9155/60/18/7179

Mean glandular dose coefficients (D_gN) for x-ray spectra used in contemporary breast imaging systems

Anita Nosratieh[1], Andrew Hernandez[1], Sam Z Shen[2], Martin J Yaffe[2], J Anthony Seibert[3] and John M Boone[4]

Table 12. Sample of D_gN values for W-50 μm Rh anode-filter combination.

D_gN values W–Rh anode-filter 0% glandular breast (mGy/mGy)							
Energy		Breast thickness (cm)					
(kV)	HVL	3	4	5	6	7	8
35	0.535	0.478	0.398	0.337	0.290	0.253	0.223
	0.560	0.494	0.412	0.349	0.301	0.263	0.232
D_gN values W–Rh anode-filter 0% glandular breast (mGy/mGy)							
Energy		Breast thickness (cm)					
(kV)	HVL	3	4	5	6	7	8
35	0.535	0.421	0.342	0.285	0.242	0.209	0.184
	0.560	0.436	0.355	0.296	0.252	0.218	0.192

Changing Perceptions and Updated Methods for Mammography Dosimetry

- Breast CT as the Backstory
- Skin Thickness
- Breast Density / the Myth
- New Mammography Spectra
- Density Heterogeneity
- Summary

Glandular dose is the metric of interest !

Absorbed Radiation Dose in Mammography[1]

G. Richard Hammerstein, M.S., Daniel W. Miller, Ph.D., David R. White, Ph.D.,[2] Mary Ellen Masterson, M.S., Helen Q. Woodard, Ph.D.,[3] and John S. Laughlin, Ph.D.

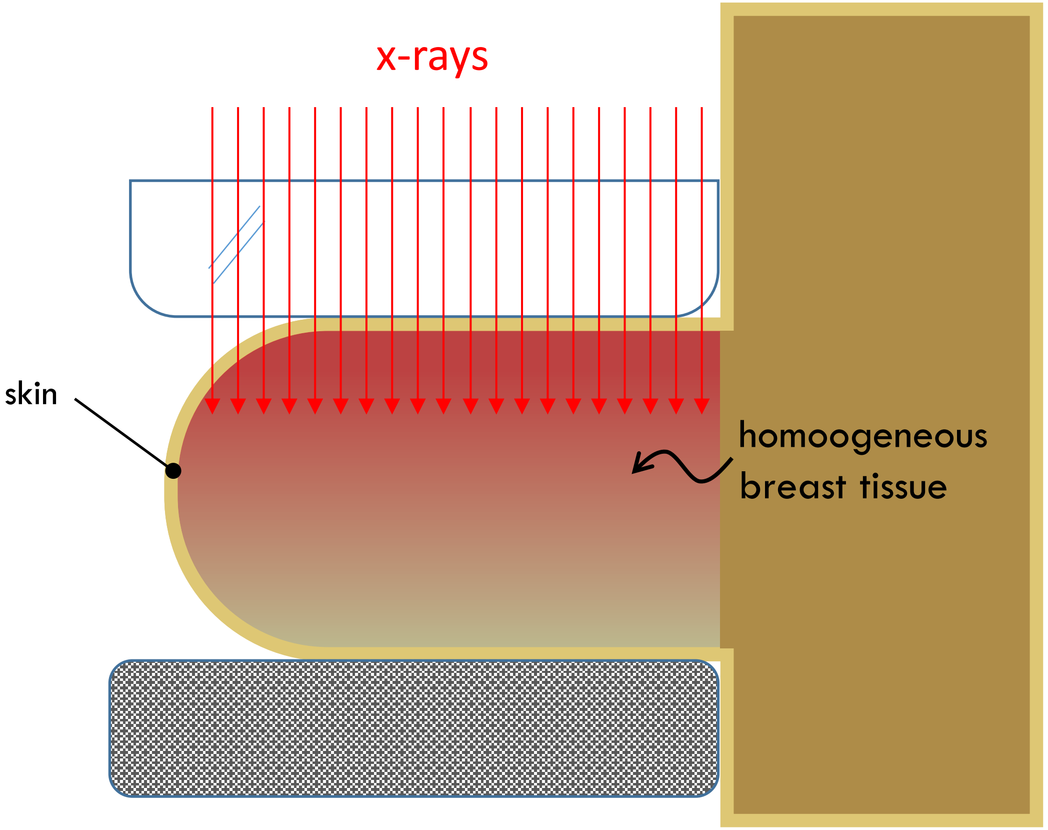
Radiation dose from mammographic techniques was determined as a function of surface exposure, beam quality, and depth. Relative exposure *vs.* depth was measured in tissue-substitute materials by thermoluminescent dosimetry. The *f*-factors were calculated from elemental compositions of mastectomy specimens. Dose at depth depends on beam quality as well as exposure and tissue composition. Analysis of data from the ACS/NCI Screening Centers shows current average midbreast doses to be 25 times lower (film/screen) and 3 times lower (Xerox) than the 2 rads previously estimated. Quantitative risk indicators other than midbreast dose are also discussed.

INDEX TERMS: Breast, neoplasms • Mammography, dosimetry • Mammography, radiation dose • Mammography, radiation hazards

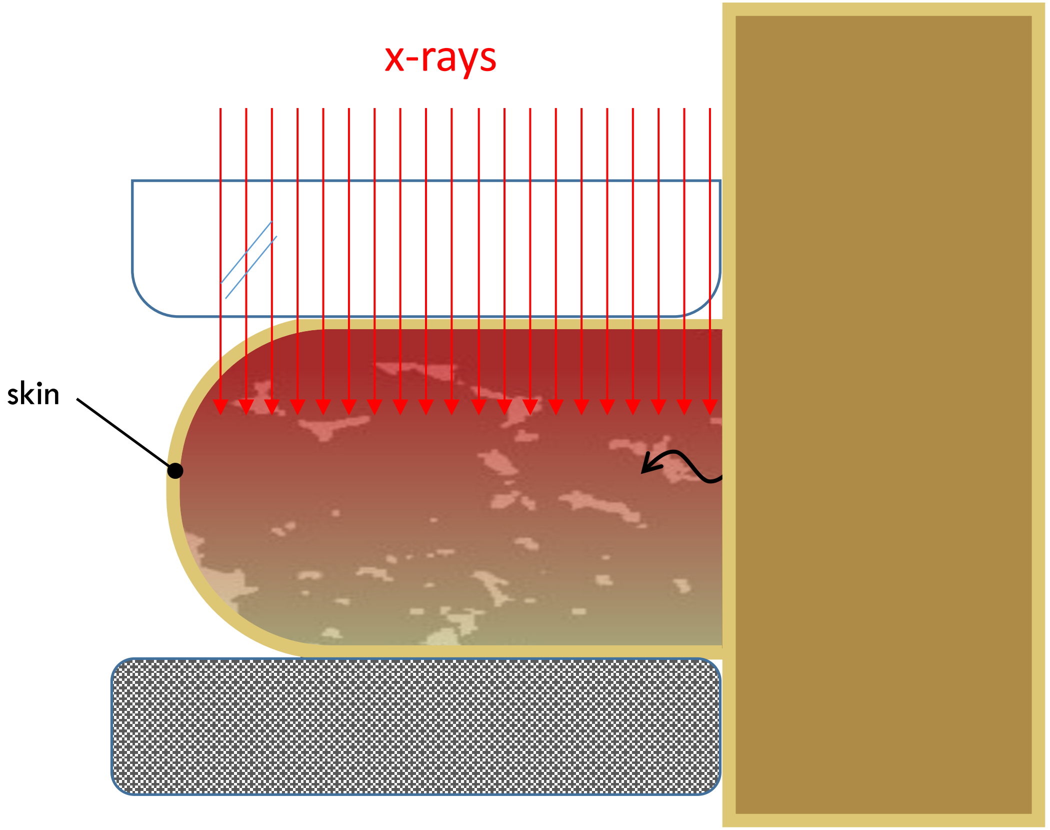
Radiology 130:485–491, February 1979

“Detailed information will have to be obtained on the amount and distribution of gland tissue in many individual cases before individual risk estimates can be made”

Homogeneous
(VGF = 20%)



Heterogeneous
(VGF = 20%)

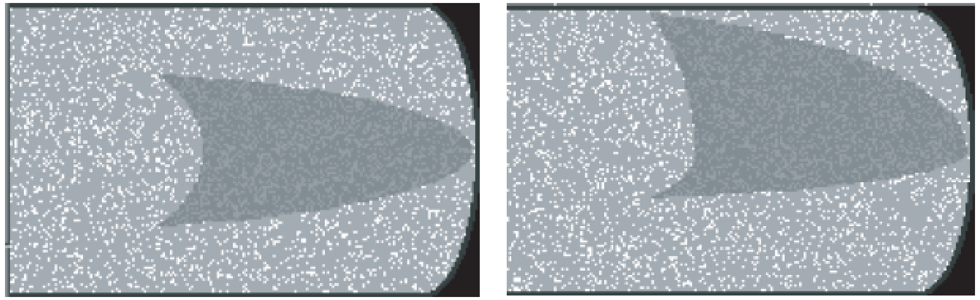


Radiation Protection Dosimetry (2005), Vol. 114, Nos 1-3, pp. 359–363
doi:10.1093/rpd/nch510

BREAST DOSIMETRY USING HIGH-RESOLUTION VOXEL PHANTOMS

D. R. Dance[1,*], R. A. Hunt[1], P. R. Bakic[2], A. D. A. Maidment[2], M. Sandborg[3], G. Ullman[3] and G. Alm Carlsson[3]

10 – 43% overestimation using structure phantoms

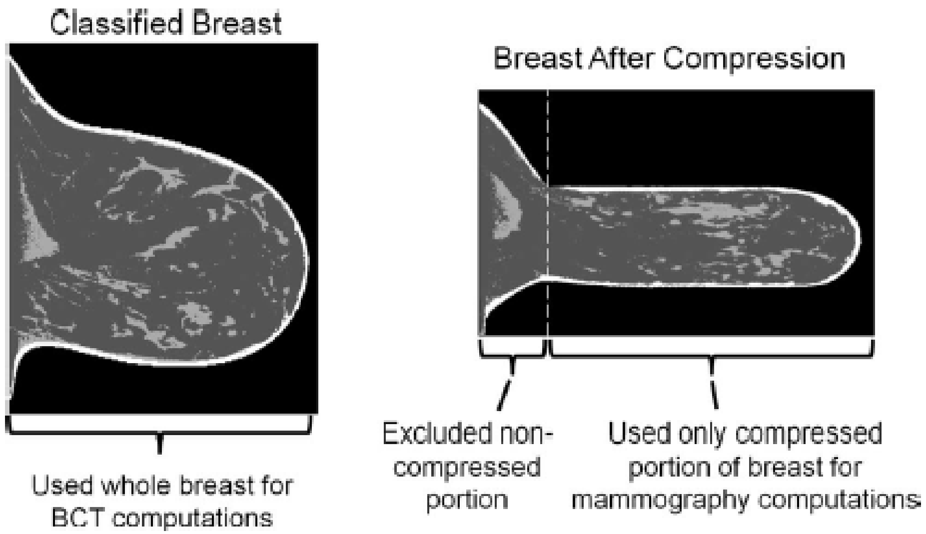


9 – 59% overestimation using unstructured phantoms

Medical Physics
The International Journal of Medical Physics Research and Practice

Characterization of the homogeneous tissue mixture approximation in breast imaging dosimetry

Ioannis Sechopoulos, Kristina Bliznakova, Xulei Qin, Baowei Fei, and Steve Si Jia Feng

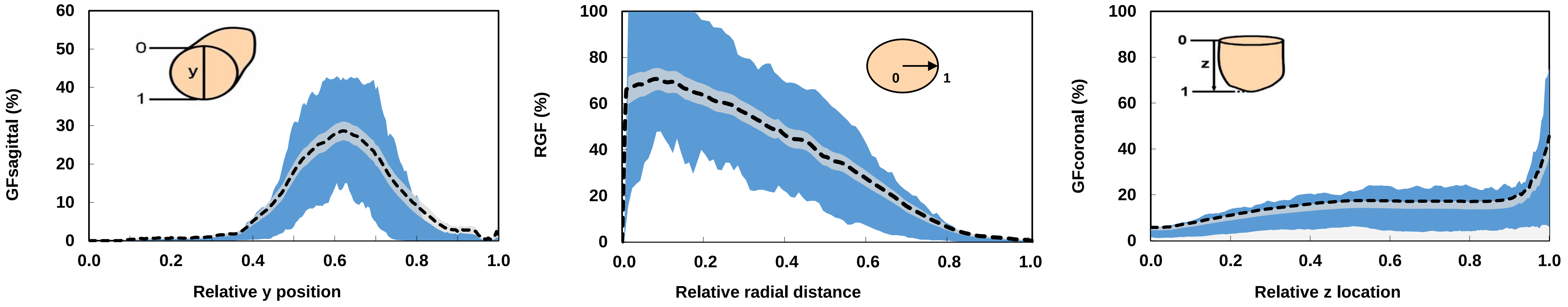


27% overestimation using simulated mechanical compression of bCT images in 20 patients.

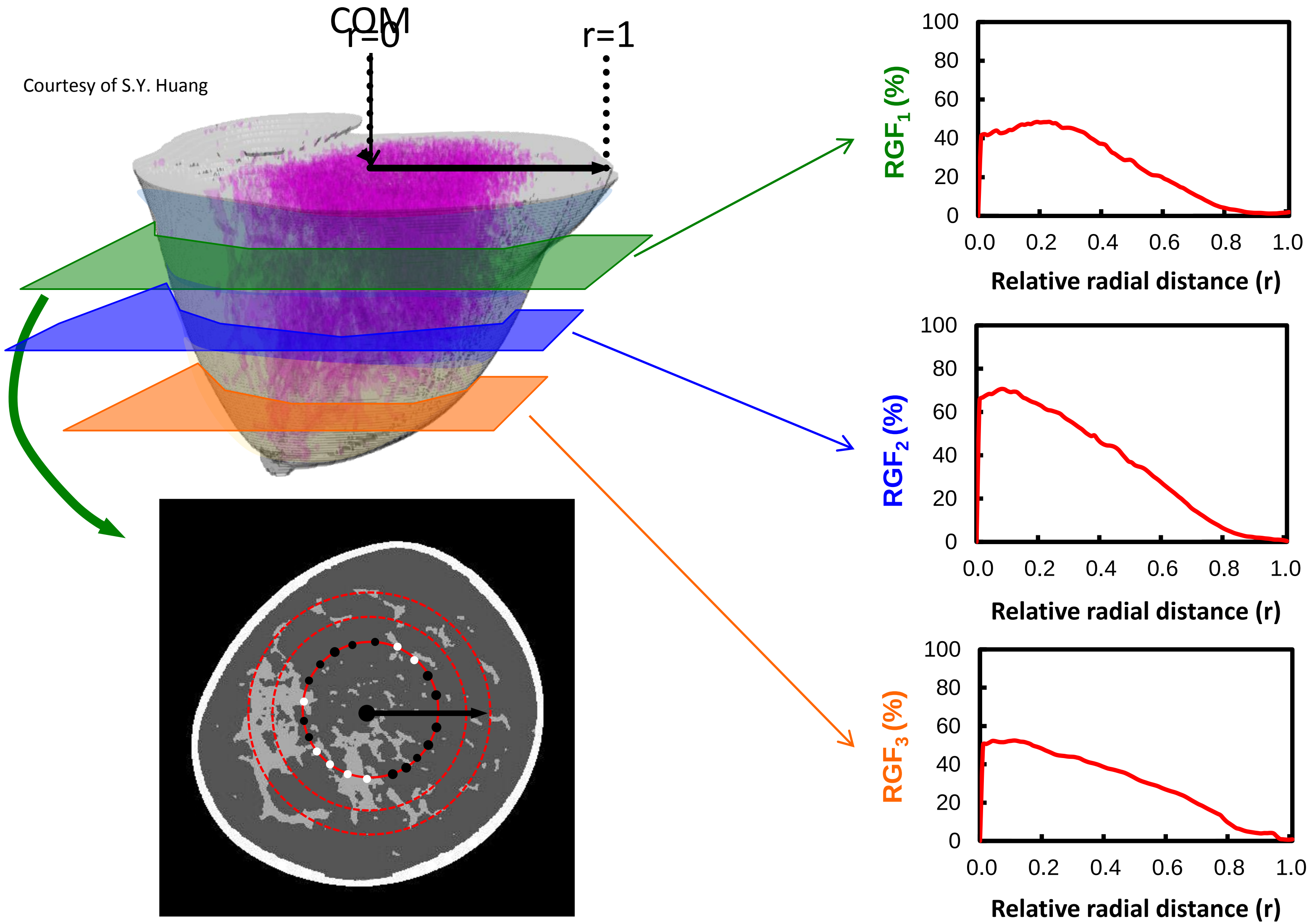
MEDICAL PHYSICS

The characterization of breast anatomical metrics using dedicated breast CT

Shih-Ying Huang[a] and John M. Boone[b]
Department of Biomedical Engineering, University of California–Davis, One Shields Avenue, Davis, California 95616 and Department of Radiology, University of California–Davis Medical Center, 4860 Y Street, Ambulatory Care Center Suite 3100, Sacramento, California 95817



Radial Glandular Fraction (RGF)



Huang S.-Y., Boone J.M. *et al.* "The characterization of breast anatomical metrics using dedicated breast CT" *Med Phys.* 38 (4), April 2011

MEDICAL PHYSICS

The characterization of breast anatomical metrics using dedicated breast CT

Shih-Ying Huang[a] and John M. Boone[b]
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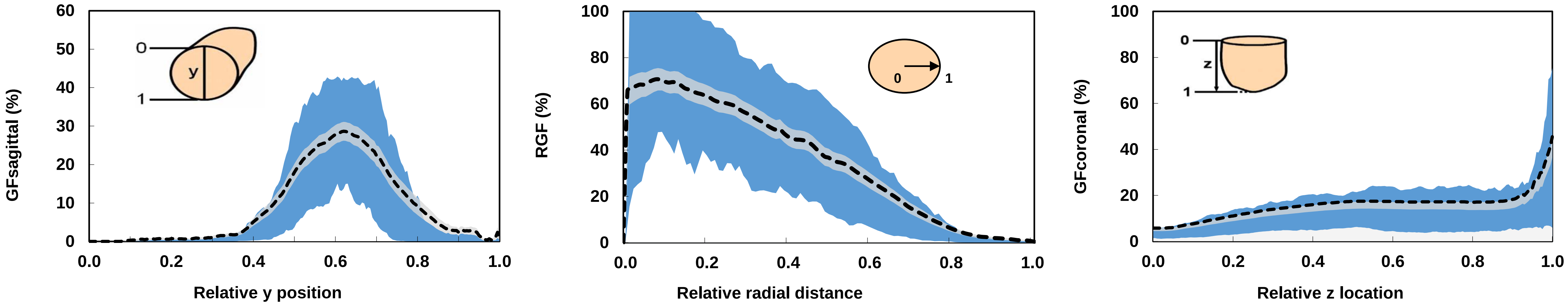
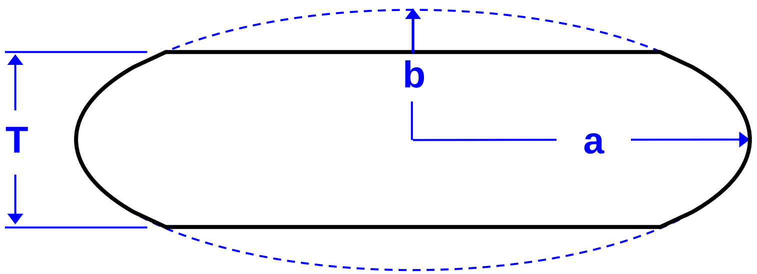
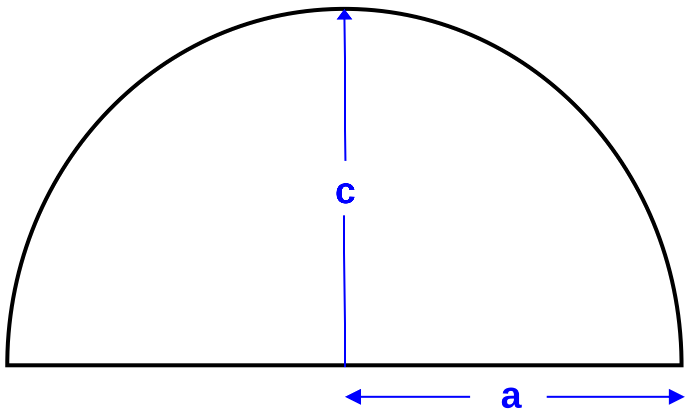


Phantom Design

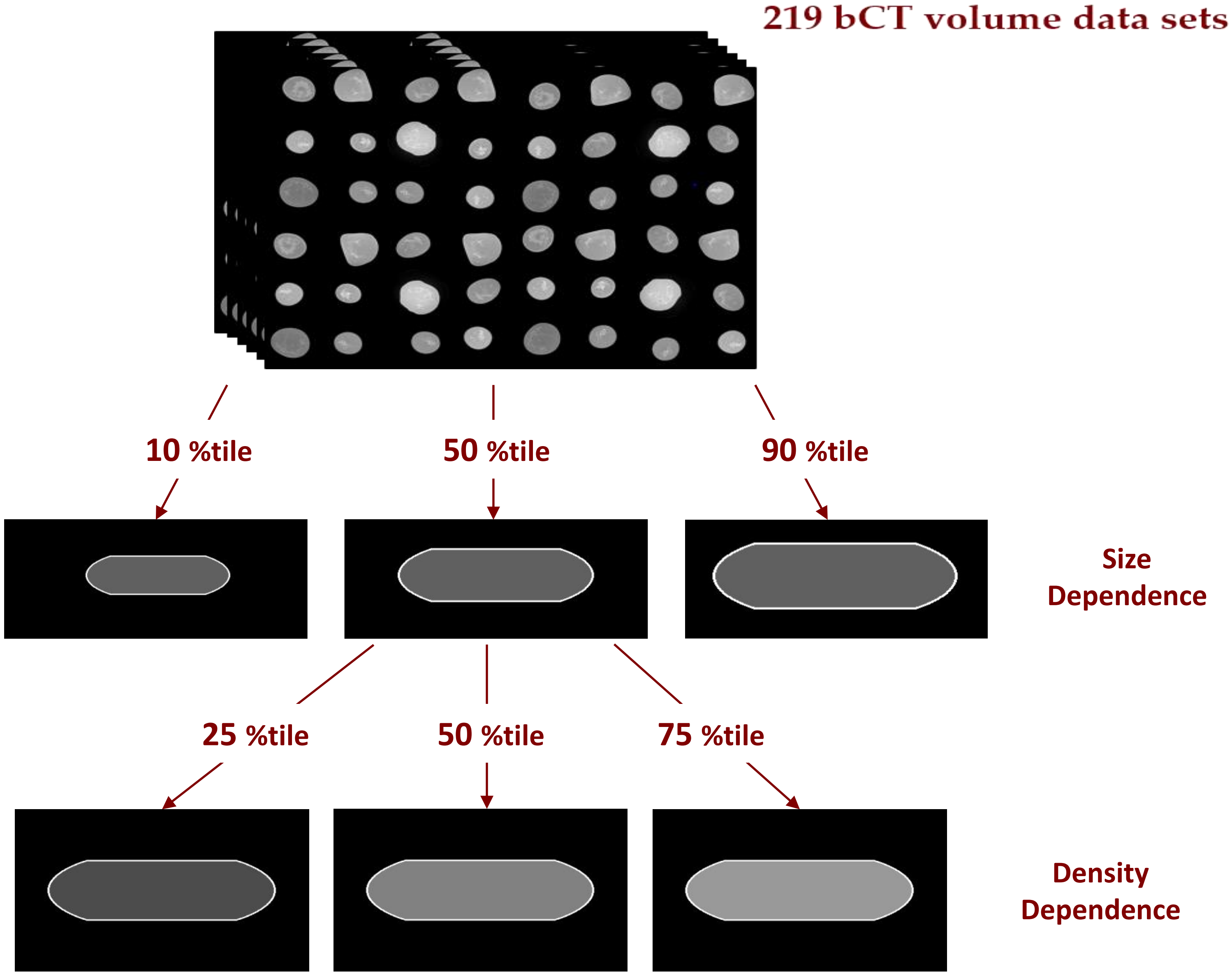
coronal view



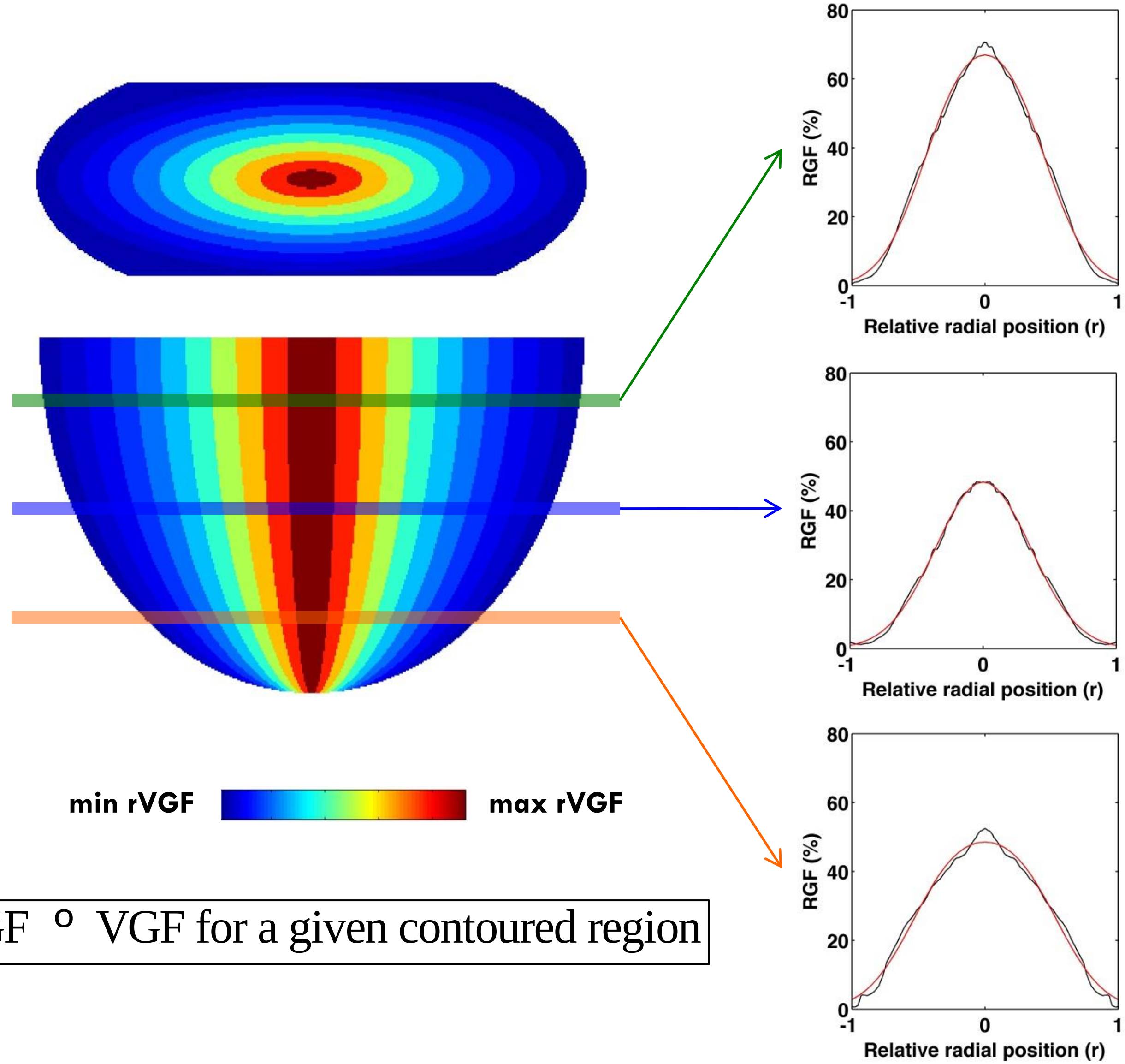
cranial-caudal view

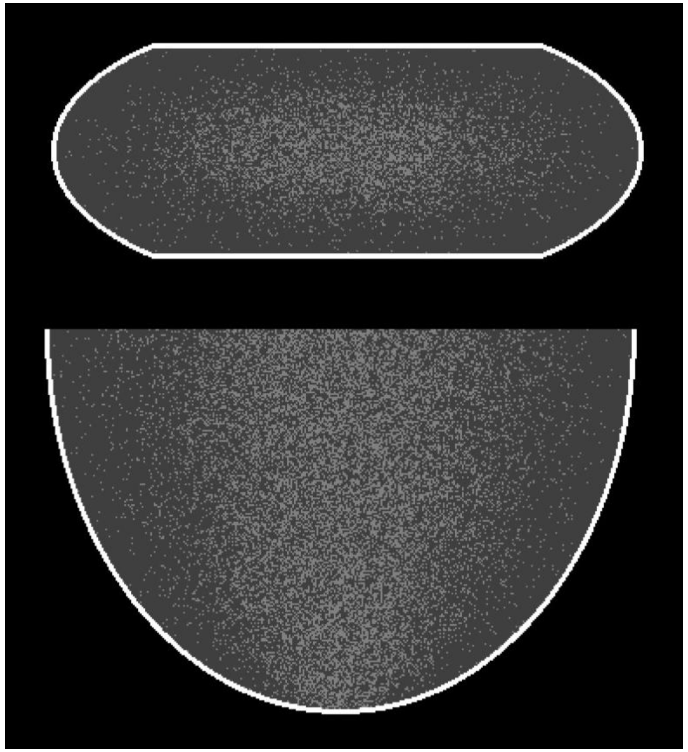


1.5 mm skin thickness



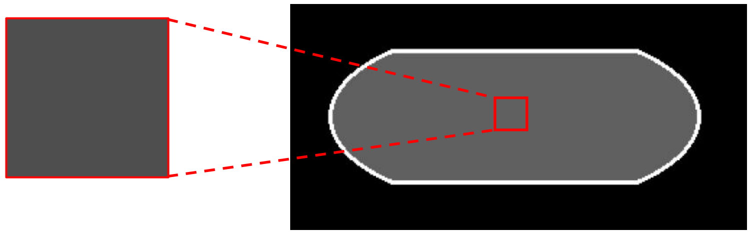
Modeled RGFs in compressed breast phantoms



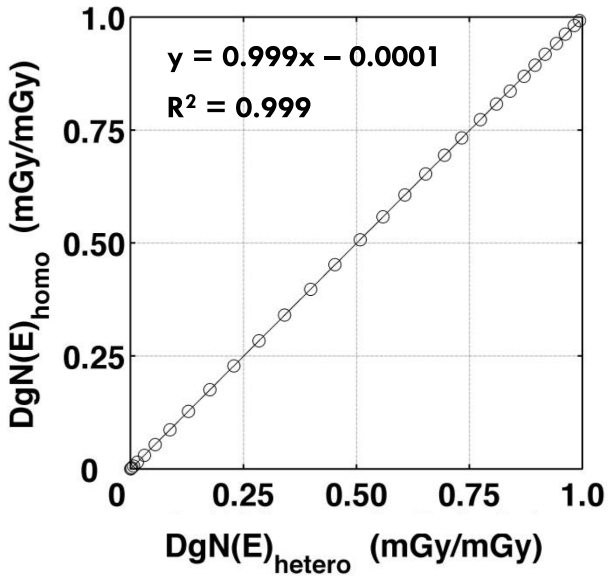


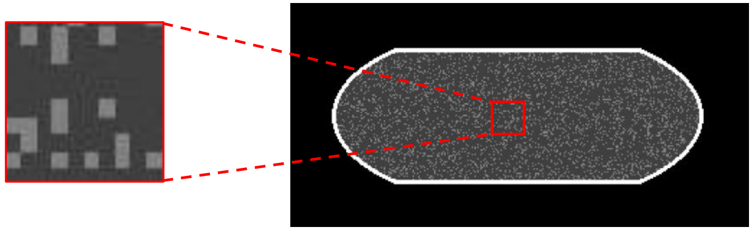
rVGF ° VGF for a given contoured region

Validating Methodology



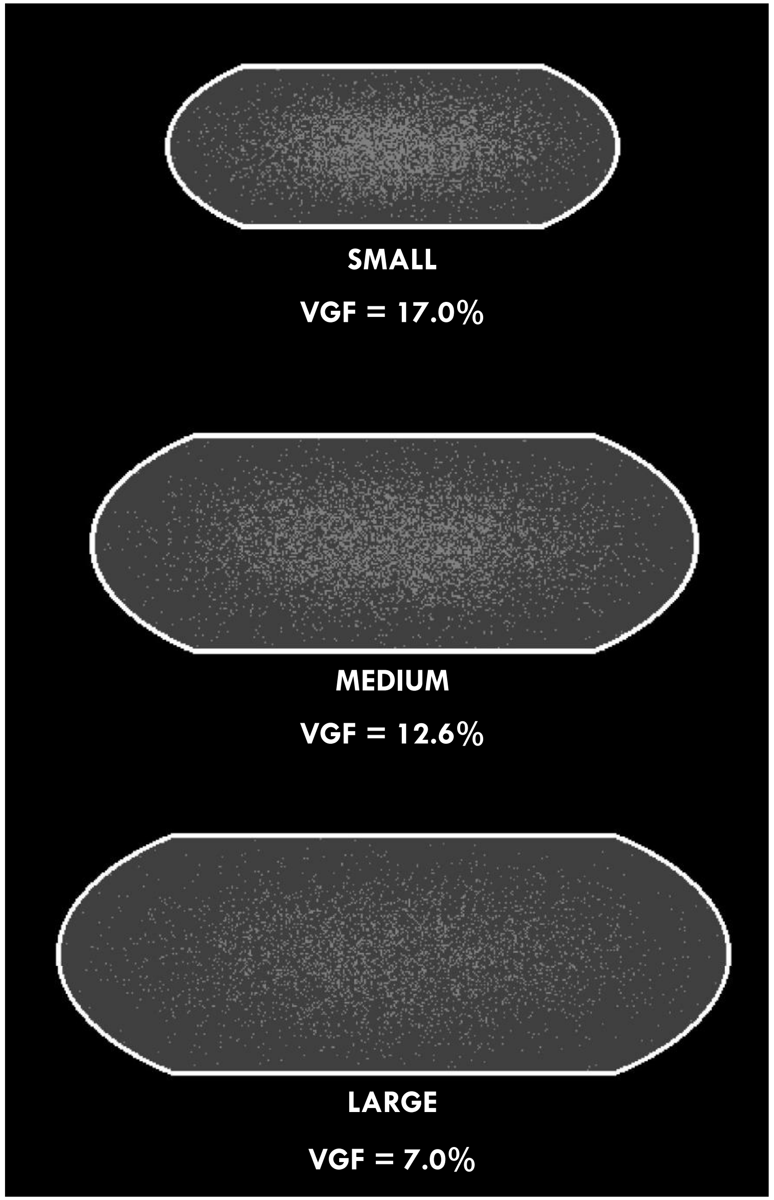
HOMOGENEOUS
(VGF = 20%)

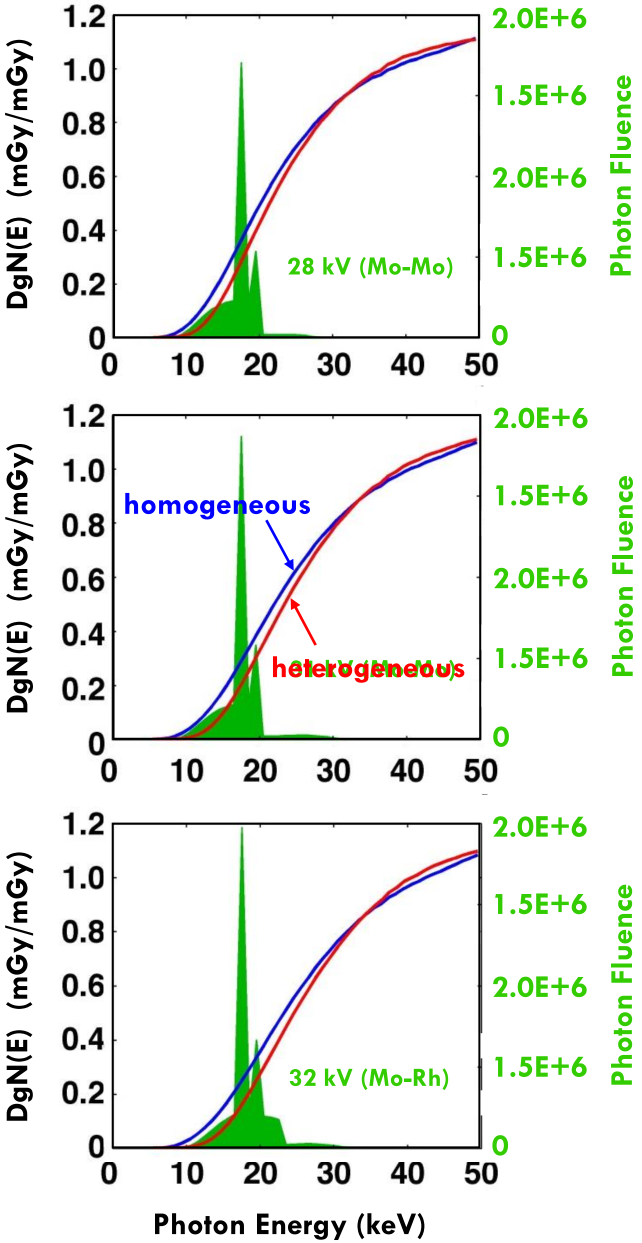




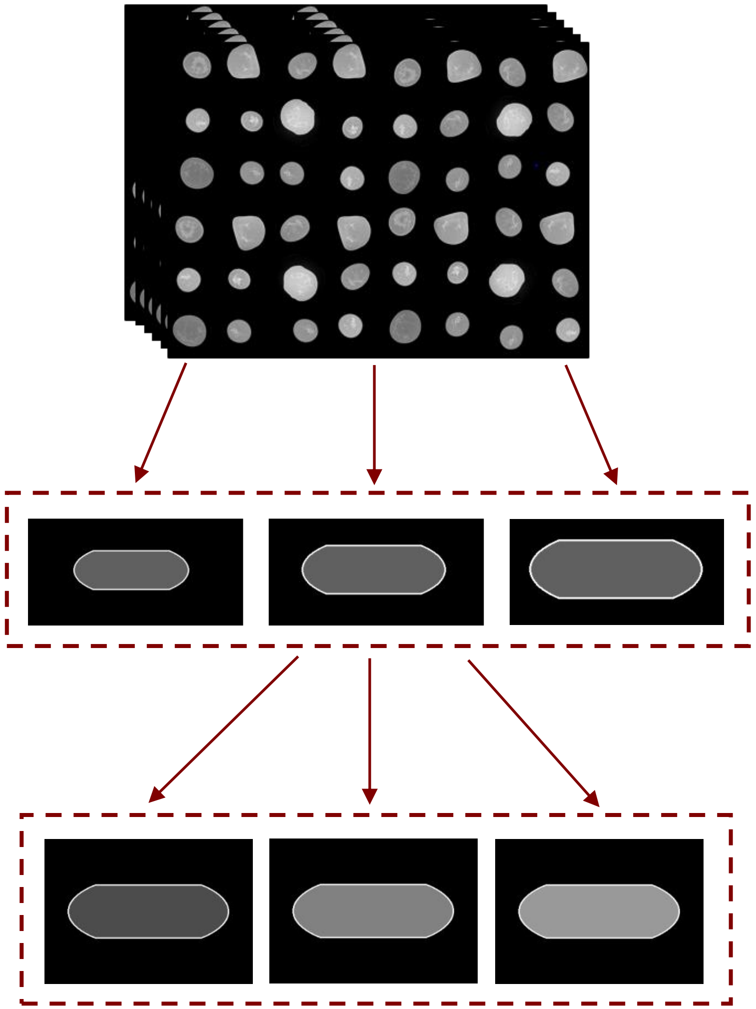
SPATIALLY-INDEPENDENT HETEROGENEOUS
(VGF = 20%)

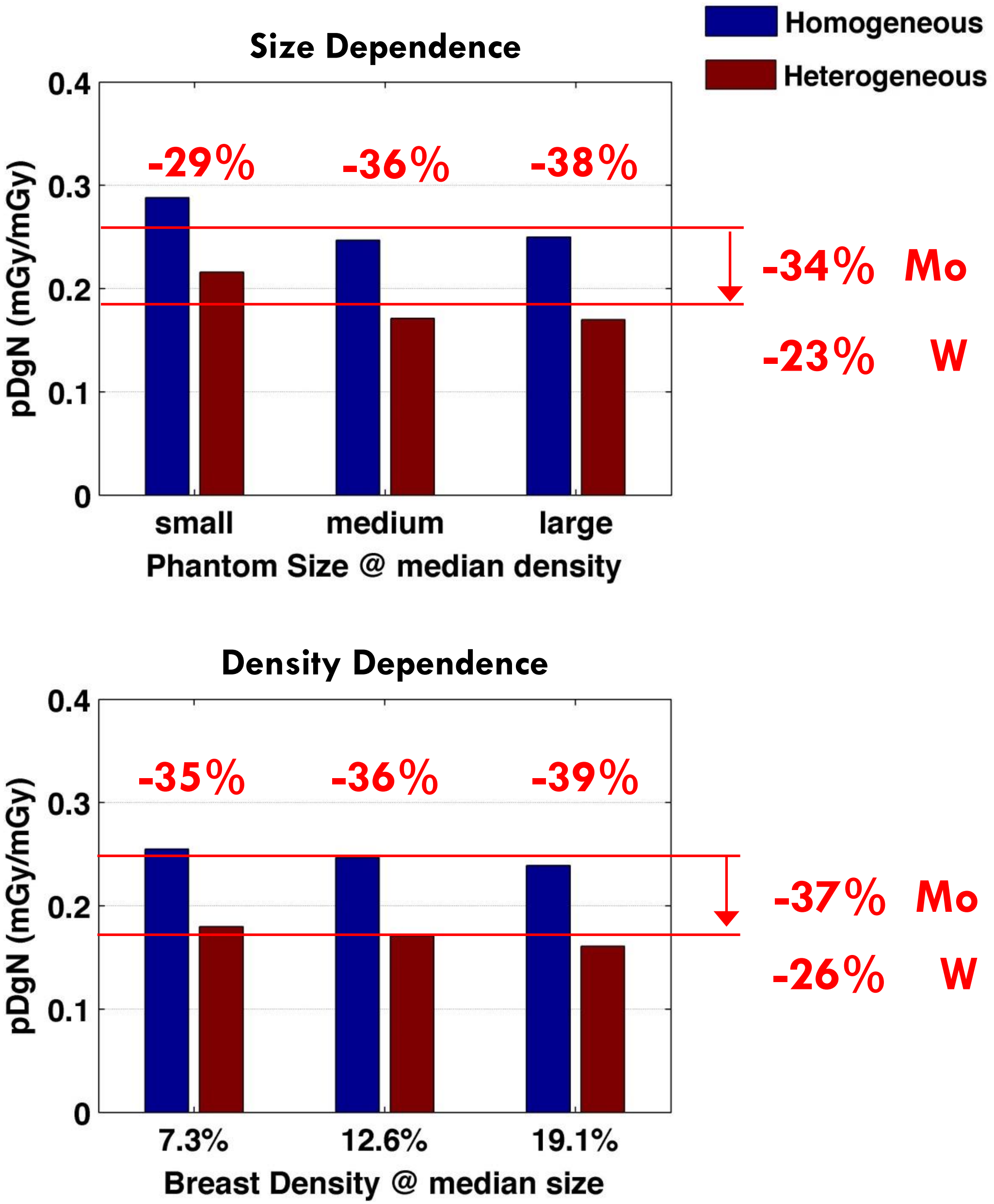
DgN(E): heterogeneous vs. homogeneous



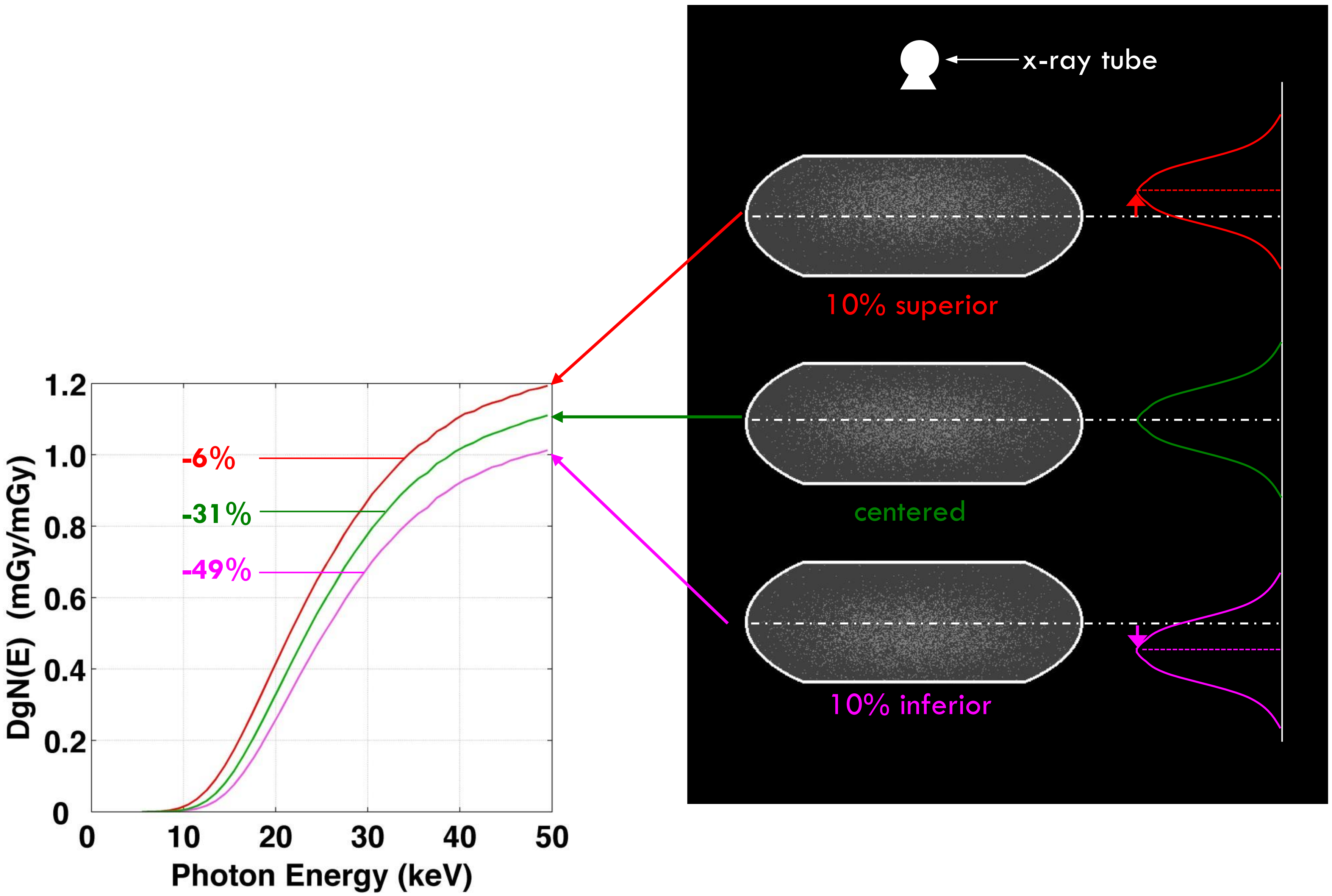


pDgN: heterogeneous vs. homogeneous





Asymmetric shifts in glandular distributions



Changing Perceptions and Updated Methods for Mammography Dosimetry

Breast CT as the Backstory

Skin Thickness

Breast Density / the Myth

New Mammography Spectra

Density Heterogeneity

Summary

Changing Perceptions and Updated Methods for Mammography Dosimetry

- The only breast density metric that matters in breast dosimetry is volume glandular fraction
- A new understanding of breast geometry along with updating anode/filter/kV parameters will make clinical breast dosimetry more accurate
- Skin thickness would be important with homogeneous breast tissue, but less so with heterogeneous models

Changing Perceptions and Updated Methods for Mammography Dosimetry

- The mammography spectra presented here will be made available in spreadsheet format (after it's published) by request
- The DgN values described in a PMB publication (200 pages) will be provided by request
- Heterogeneous breast models represent the next generation in breast dosimetry

Future Directions

- Generate more realistic breast shapes under compression for Monte Carlo studies
- Model MLO projection different from CC
- With some tomosynthesis systems going to much wider angles, a full angled-beam MC analysis will be necessary
- The cycle of CAP → Research → CAP → Research → CAP continues

Future Directions

New AAPM Task Group on Breast Dosimetry

- Ioannis Sechopoulis
- David Dance
- Ken Young
- R. Vanegen
- John Boone

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AAPM SPRING CLINICAL MEETING 2016

MARCH 5-8 | Grand America Hotel | Salt Lake City, UT

Changing Perceptions and Updated Methods for Mammography Dosimetry

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Andrew M. Hernandez, B.S., the brains behind all this
Post-Graduate Researcher
Biomedical Engineering Grad Group
University of California Davis
Sacramento, California