Clinical applications: Digital detectors for mammography

Kwan-Hoong Ng, PhD, DABMP
Department of Biomedical Imaging &
Medical Physics Unit
University of Malaya
Kuala Lumpur

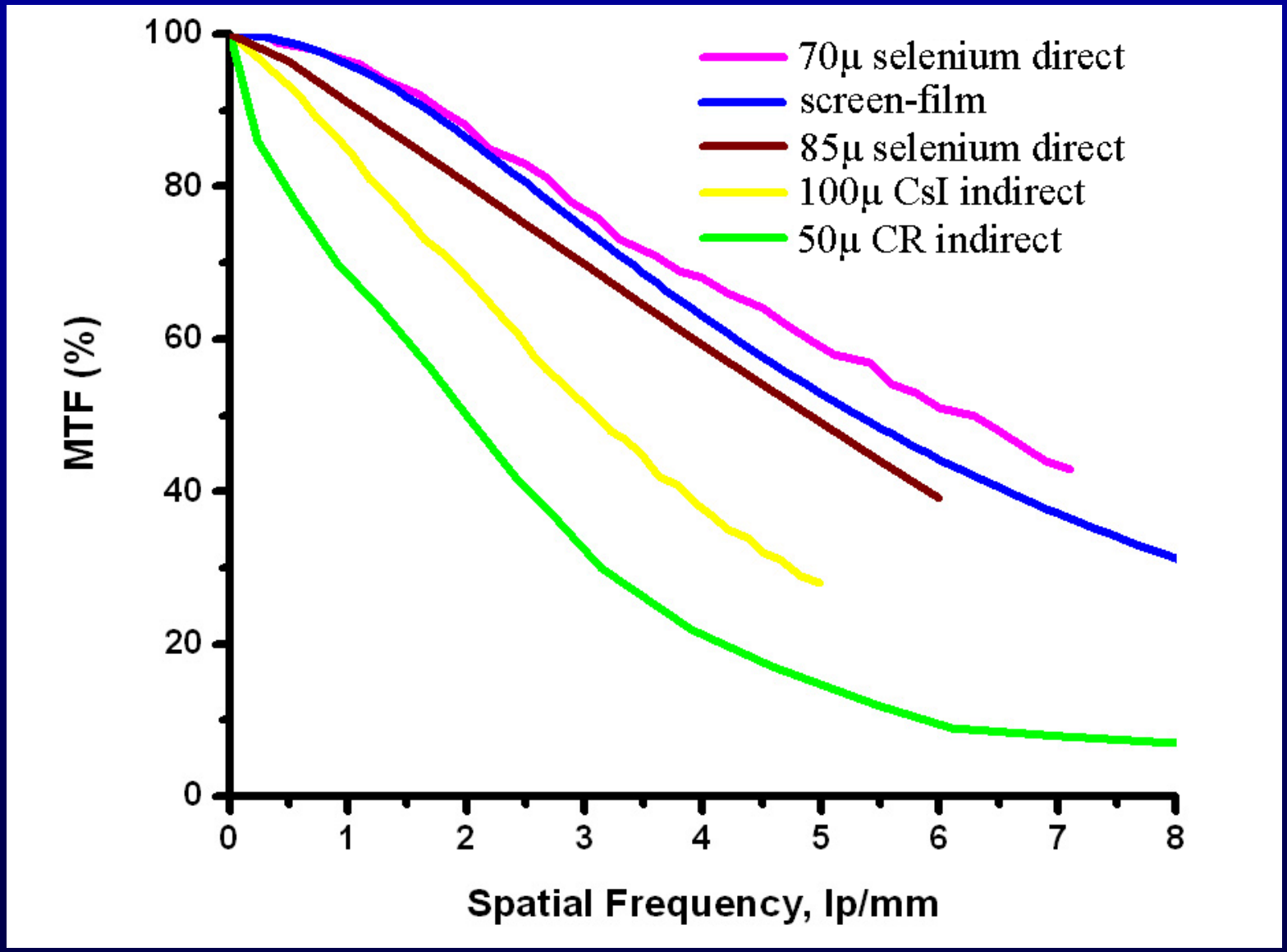
Mammography is unique in radiography as it demands both high resolution (microcalcifications), and high dose efficiency (low dose for screening).

Characterizing Detector Performance

Image Sharpness, Resolution

Dose Efficiency

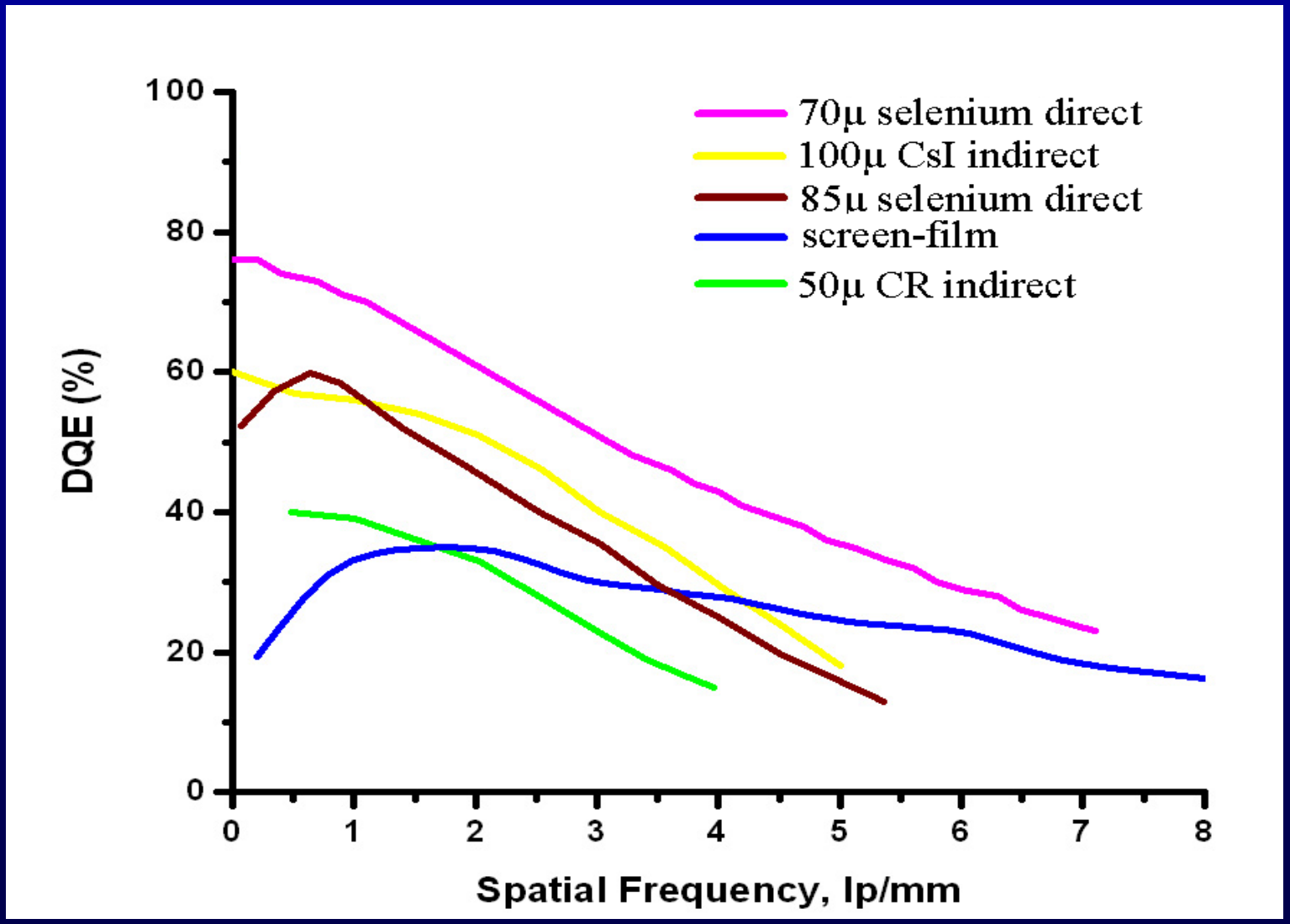
Modulation Transfer Function (MTF)



Wu Tao

KH Ng

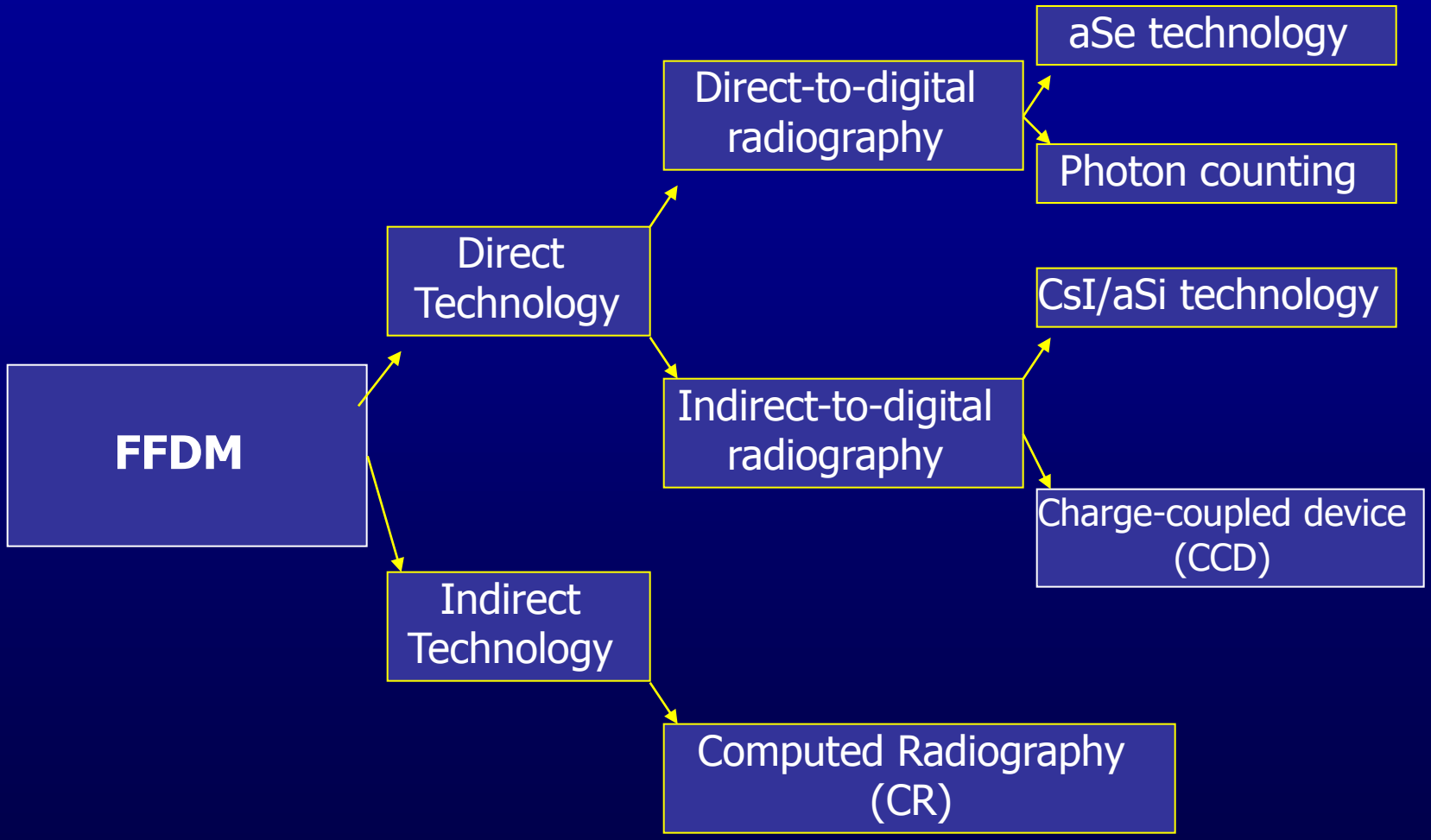
Detective Quantum Efficiency (DQE)



Wu Tao

KH Ng

Detector Technologies used in FFDM Systems



Current CR Mammography Systems

Manufacturer	Model
Agfa	CR 30-Xm / DX-M
Carestream	DIRECTVIEW
Fuji	FCR PROFECT CS
Konica	Xpress CR
Philips	MammoDiagnost with PCR Eleva

UK NHS Digital mammography Buyers' Guide 2008

Current Direct Technology Mammography Systems

Manufacturer/ Model	Technology
GE Senographe DS, Essential	CsI/ TFT array
Hologic Selenia	a-Se/ TFT array
Philips Mammo-Diagnost DR	a-Se/ TFT array
Siemens Inspiration, Novation	a-Se/ TFT array
Sectra microDose	Si wafers/ photon counting
Fujifilm Amulet Innovality	a-Se/ TFT array (Hexagonal Pixel)

UK NHS Digital mammography Buyers' Guide 2008

CR Mammography

Agfa,DX-M

Konica Minolta, Xpress CR

Philips, MammoDiagnost with PCR Eleva

Carestream, Directview

Fujifilm, FCR PROFECT CS

Direct Technology

GE, Senographe Essestial

Philips, Micro Dose SI

Hologic, Selenia Dimension

Siemens, MAMMOMAT Inspiration

Fuji Amulet Innovality

KH Ng

Direct Technology

Italray, Mammograph FFDM

Planmed, NUANCE EXCEL

General Medical Merate, VIOLA D

AMICO JSC, MAMMO-RPD

Metaltronica, Helianthus BYM

KH Ng

Direct Technology

Villa Sistemi Medicali, Melody III

ADANI, MAMMOSCAN

Allengers Medical Systems Limited, Mammography

Angell technology, Angell Digital Mammography

General Medical Italia, LAMBDA DFF

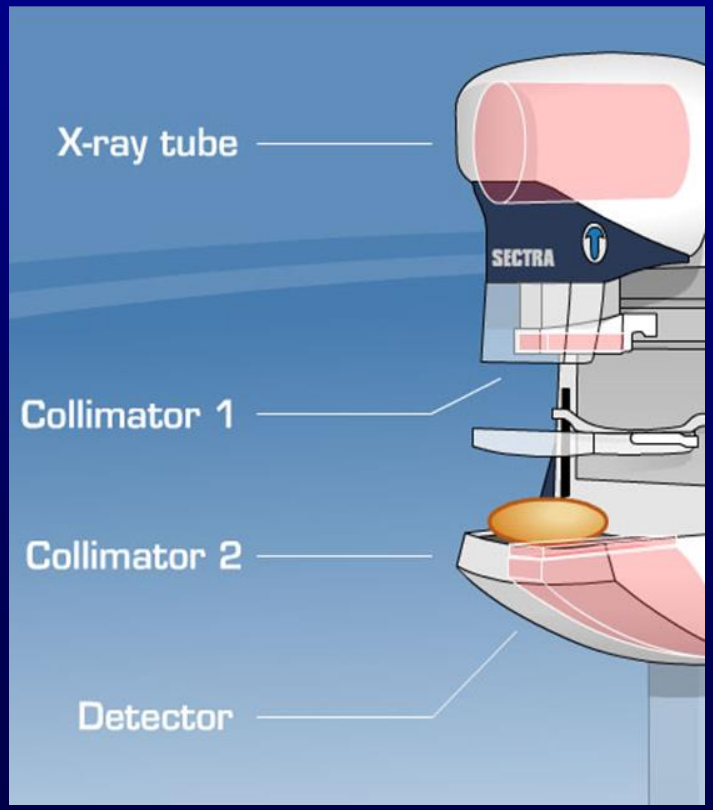
KH Ng

Selected recent innovations

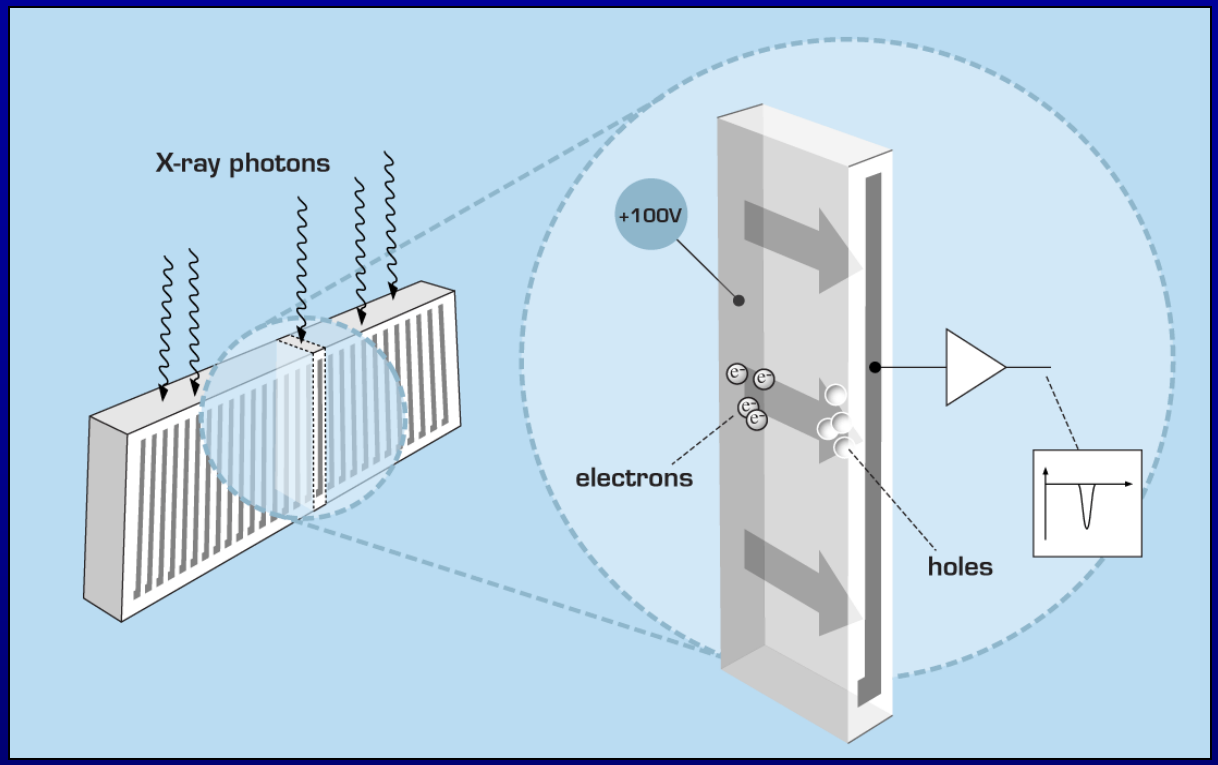
Photon Counting

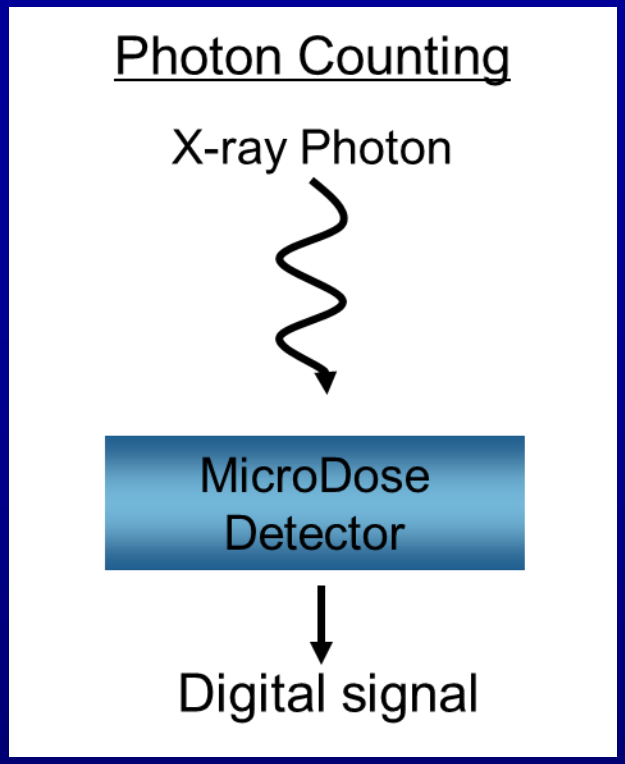
Sectra MicroDose

- Consist of large number of crystalline silicon strip detectors
- 50 μm pixel size, resolution 25 Megapixels
- Dynamic range 15 bits
- FoV 24 x 26 cm
- Scatter rejection with scanned-slit geometry exceeds 94%
- Scan time 3-15 s



KH Ng





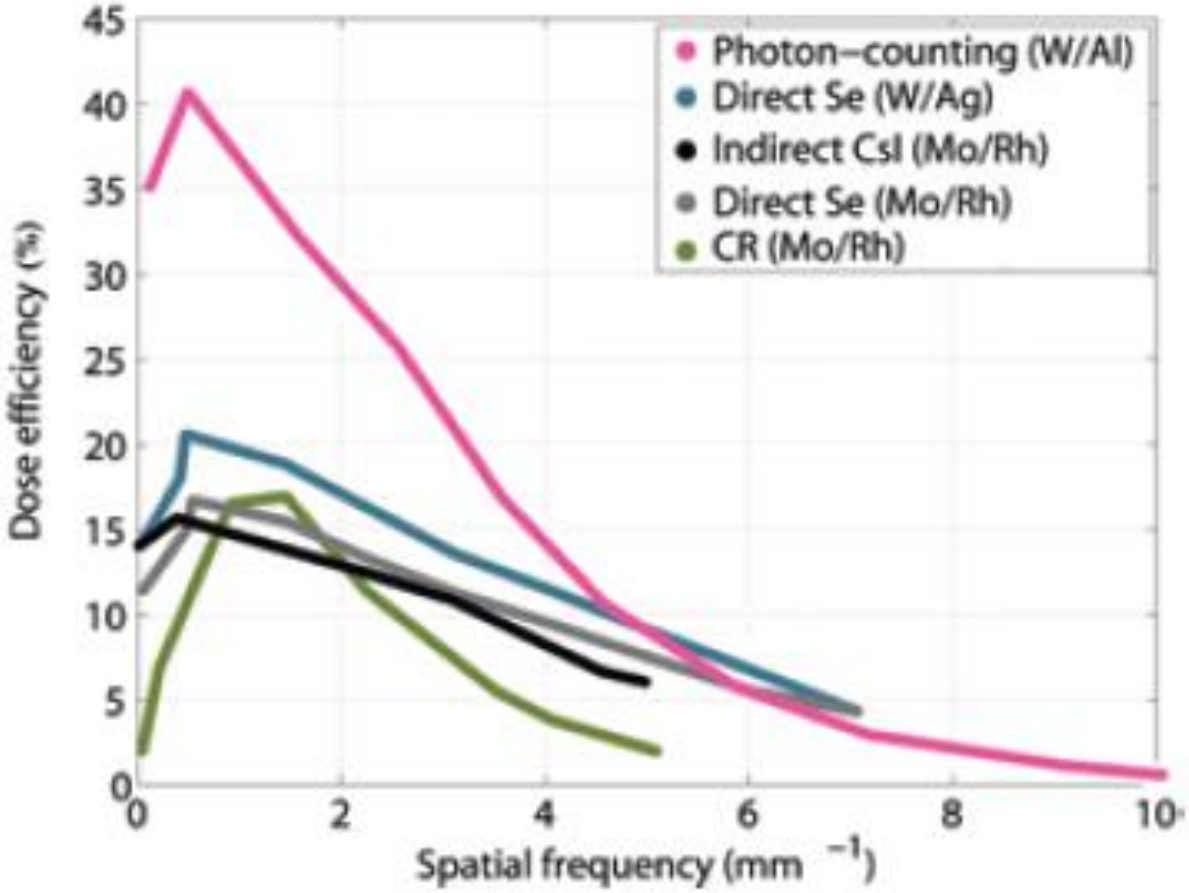
Literally counts each X-ray photon that hits the surface of the detector

X-ray photons directly converted into pixel values

Eliminate Information loss, no added noise, no lost signal

KH Ng

Dose efficiency



Detectors for the future of X-ray imaging. M. Aslund; E. Fredenberg; M. Telman; M. Danielsson, Radiation Protection Dosimetry 2010; doi: 10.1093/rpd/ncq074

HCP (Hexagonal Close Pattern) technology

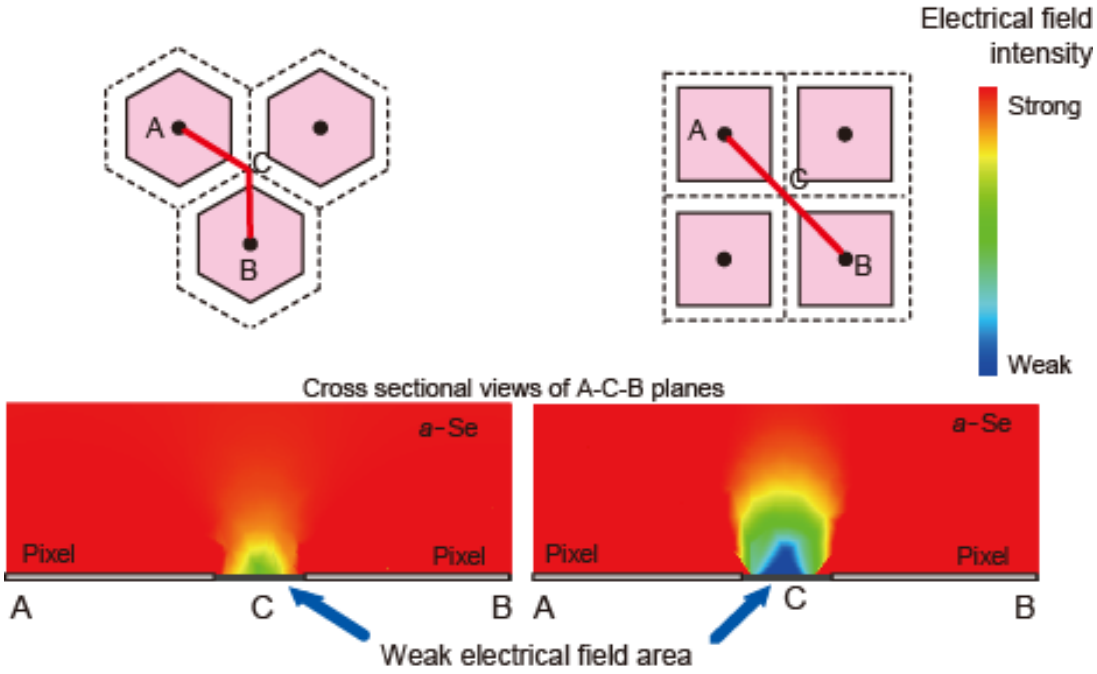
Patented by Fuji AMULET Innovality

Designed to:

- Improve Sensitivity (DQE)
- Improve Sharpness (MTF)
- Reduce Dose
- Fast readout

Comparison between new and conventional detector

【NEW】 Hexagonal pixels 【Conventional】 Square pixels



Inhomogeneities in the electrical field of the detector create an interruption of signal from that area

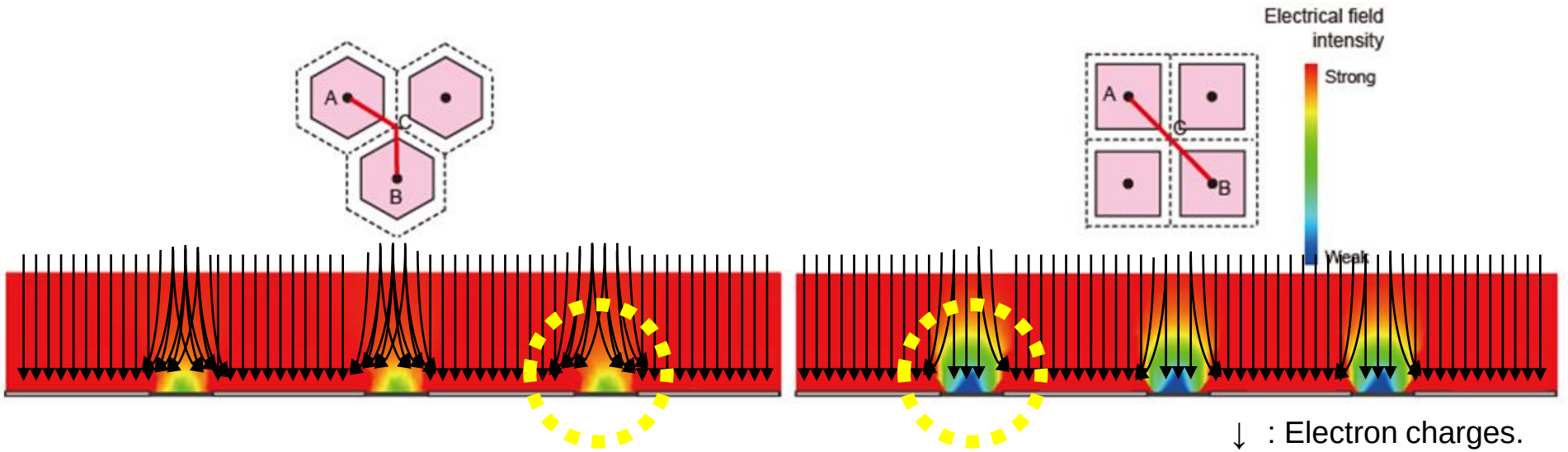
With Hexagonal pixels the electrical field is more uniform and detector efficiency is maximized

Courtesy of Fuji

Comparison between new and conventional detector

HEXAGONAL PIXEL

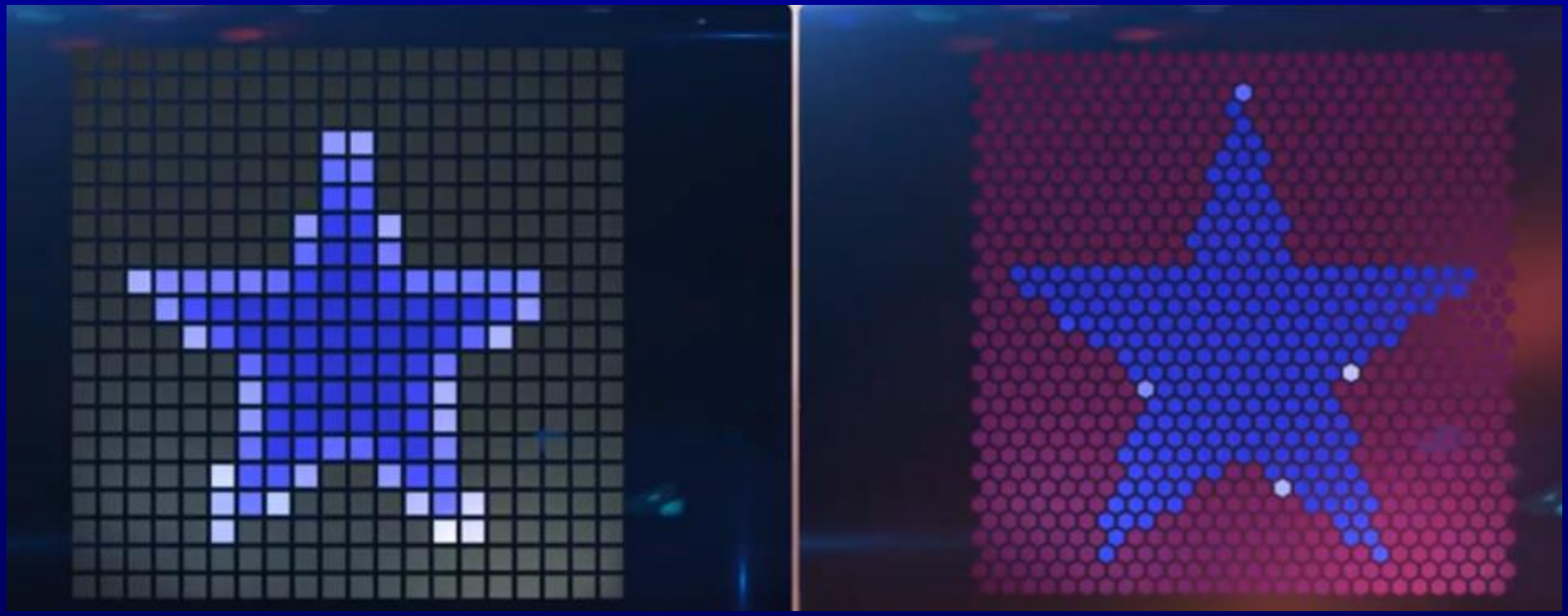
SQUARE PIXEL



Hexagonal pixels collect image information from the interpixel space more effectively

Courtesy of Fuji

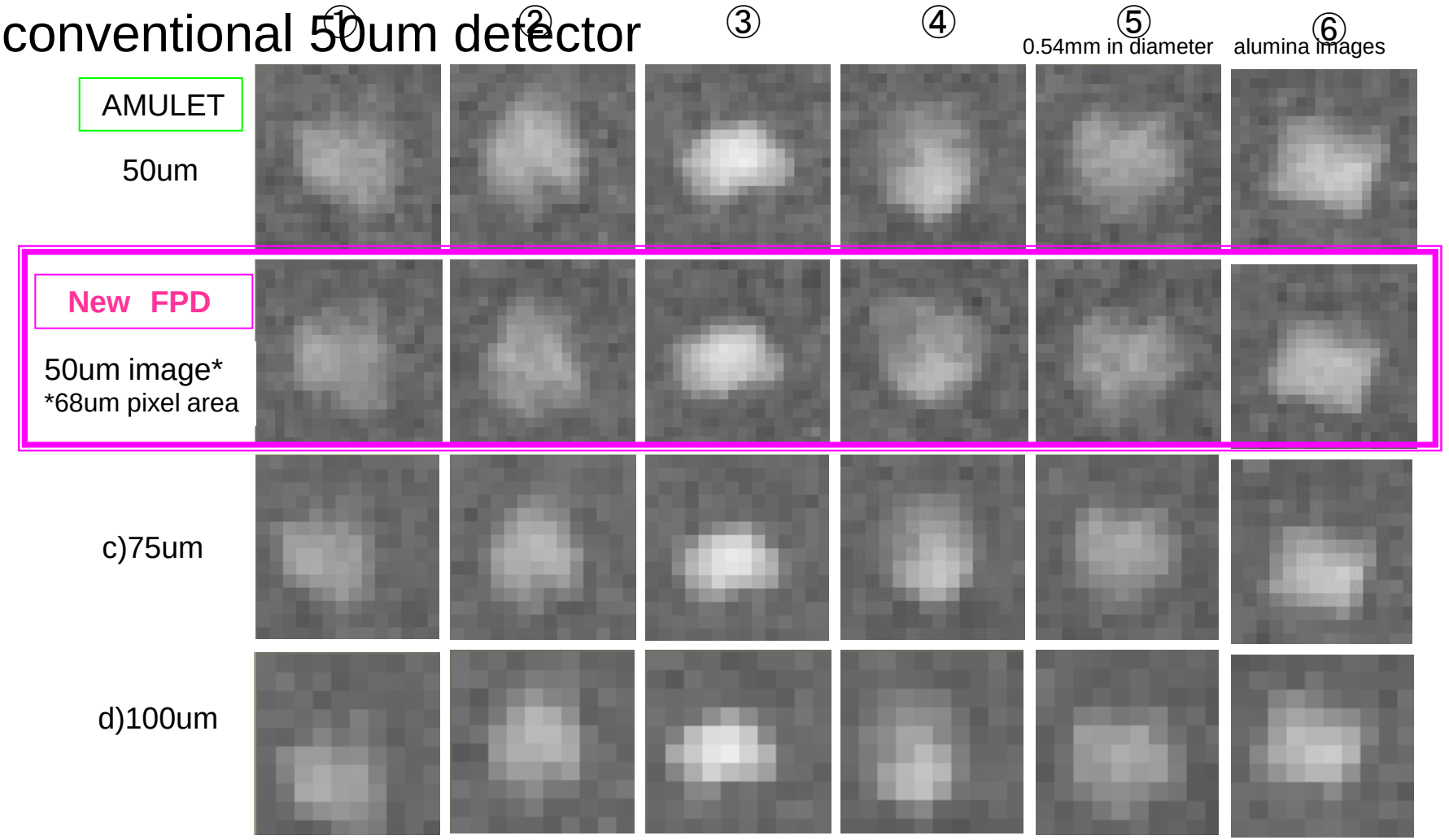
Comparison between square and hexagonal detector



Courtesy of Fuji

Prelim Data

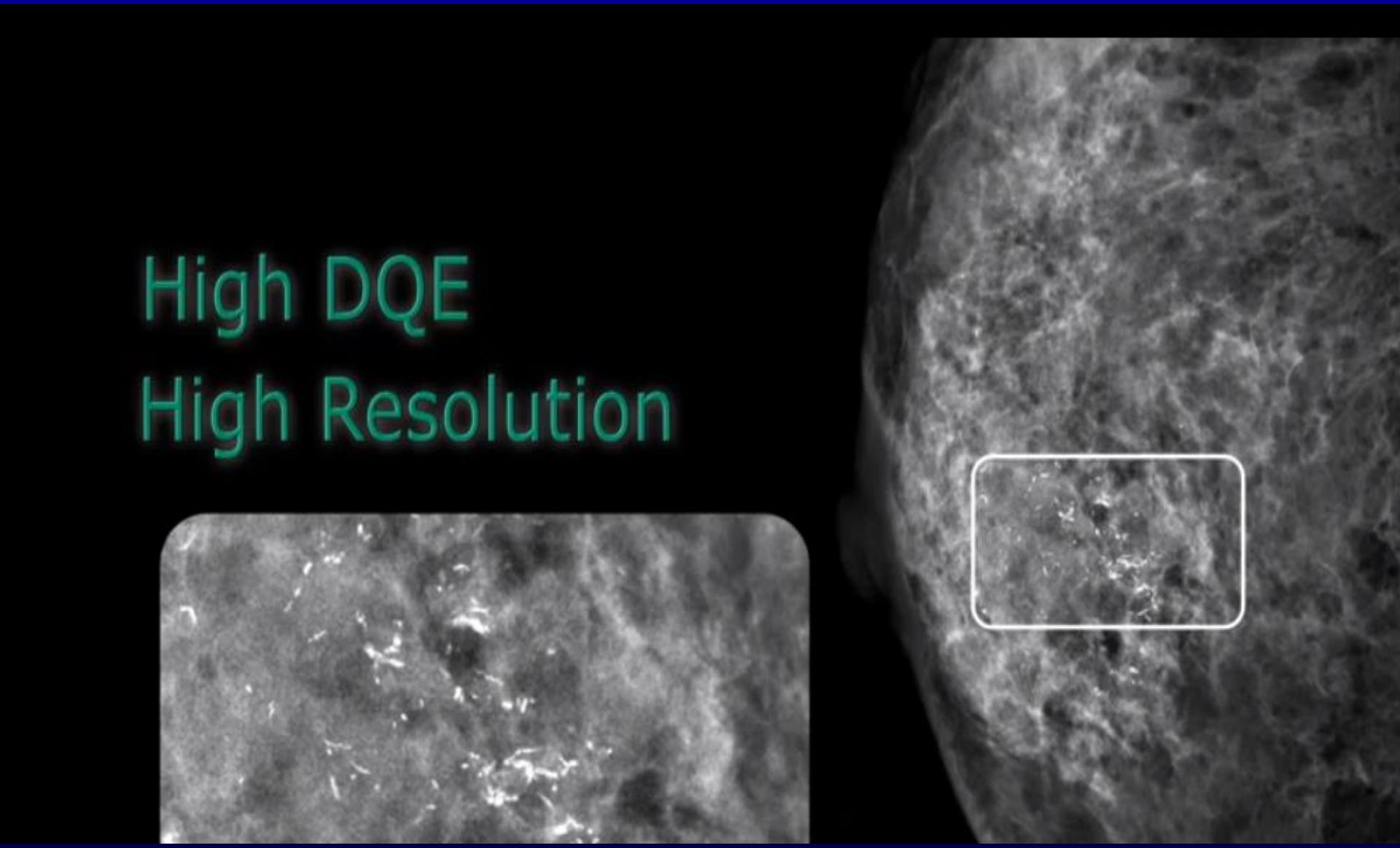
HCP Detector achieves same level of image resolution as conventional 50um detector



Detection of Calcification

* There is no influence on diagnostic performance.

Courtesy of Fuji

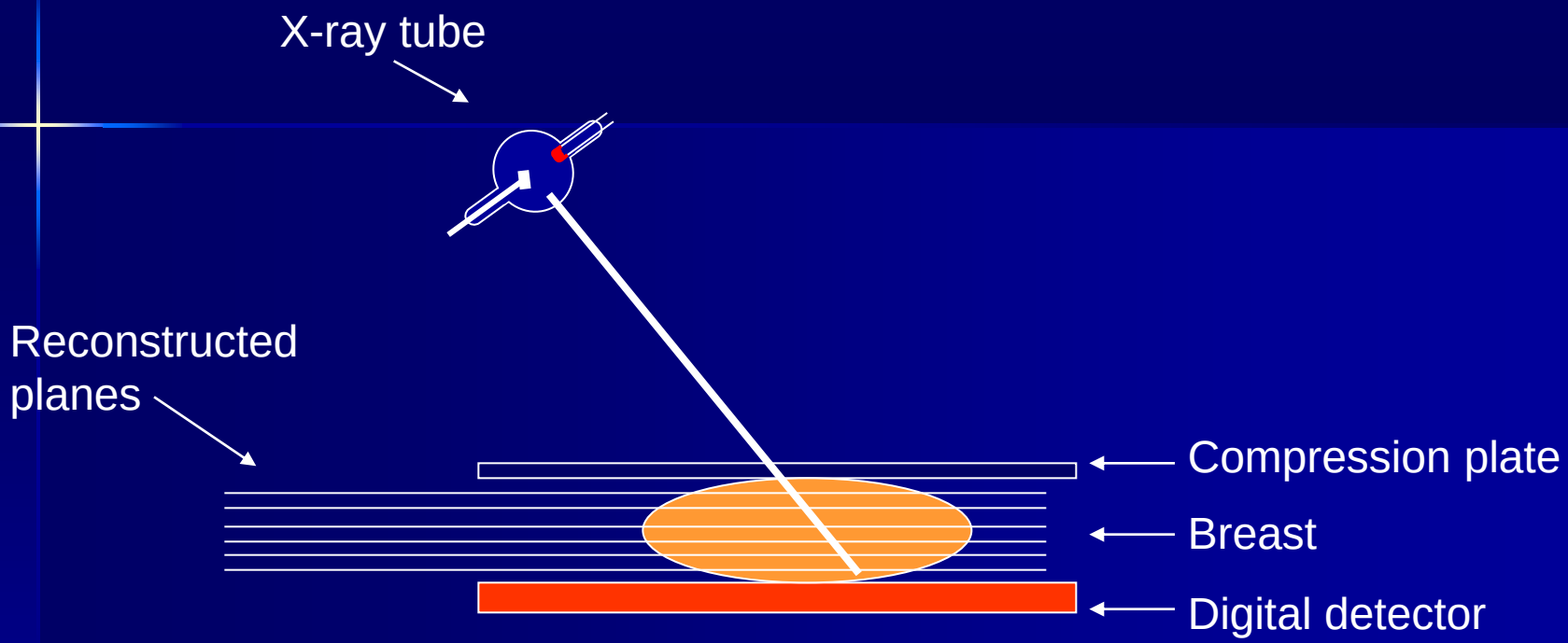


Courtesy of Fuji

FFDM has made possible interesting clinicial applications

- Tomosynthesis
- Contrast enhanced digital mammography
- Dual energy contrast enhanced digital subtraction mammography
- Single shot spectral imaging

Tomosynthesis Acquisition

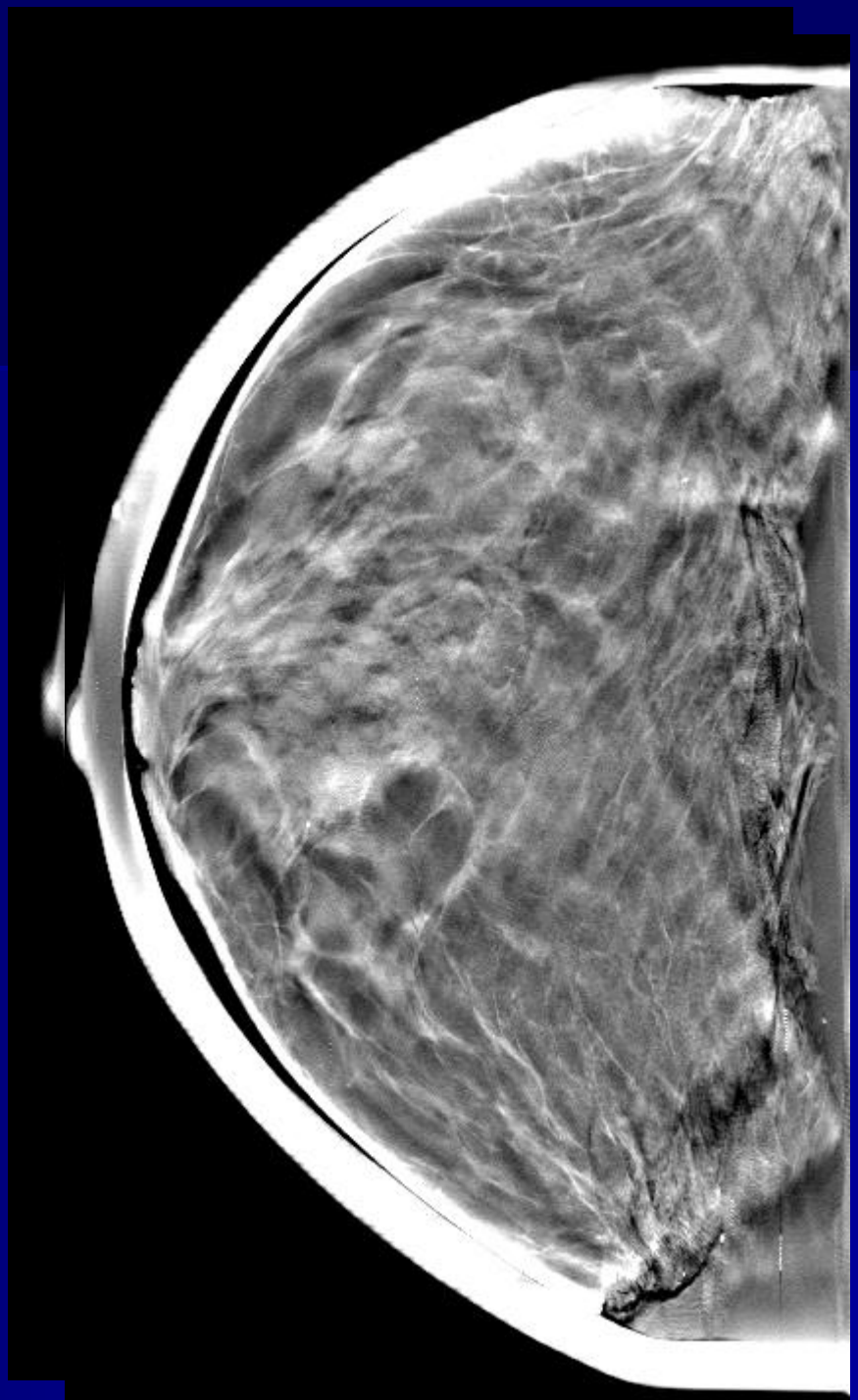


- X-ray tube moves in an arc around the breast
- Series of low dose images are acquired at different angles
- Total dose similar to standard breast exam

KH Ng

Tomosynthesis: 3-D Visualization of Breast Tissue

The next frontier for digital mammography

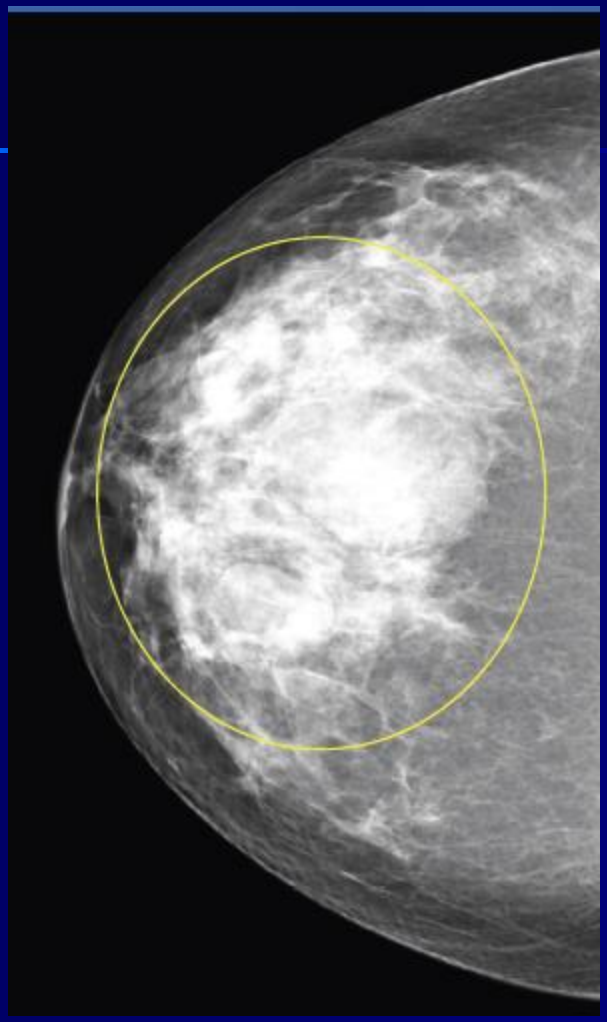


Courtesy Hologic

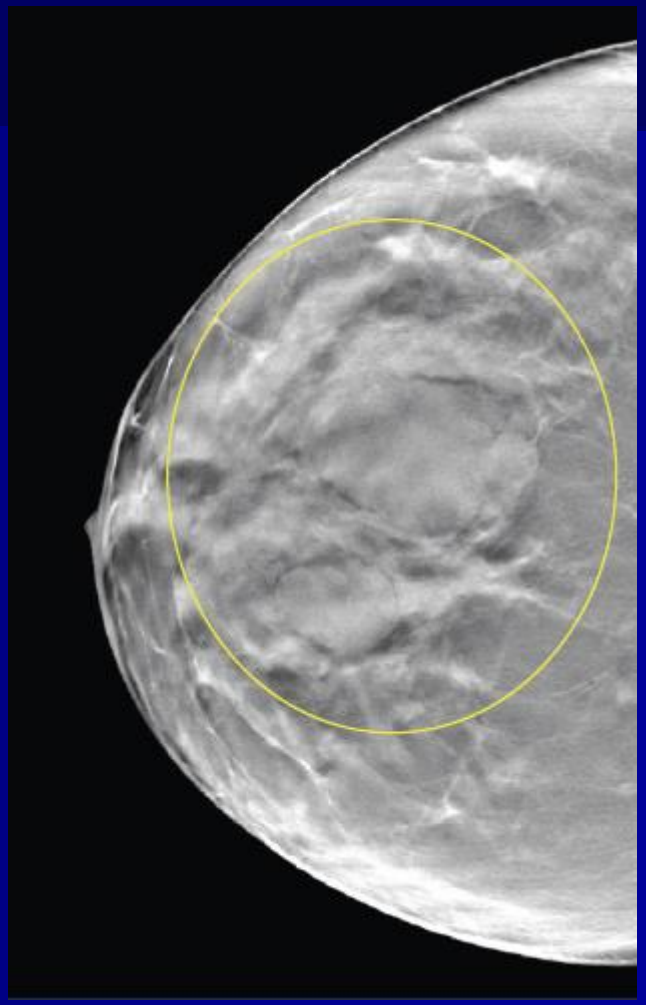
Digital Breast Tomosynthesis

- Address the challenges posed by overlapping breast tissue, which could curb recall rates and false negatives.
- However, it increases radiation dose to 1.5-4 mGy per acquisition. It also may be less sensitive for microcalcifications.
- As an adjunct to standard mammography

Improved visualization of margins



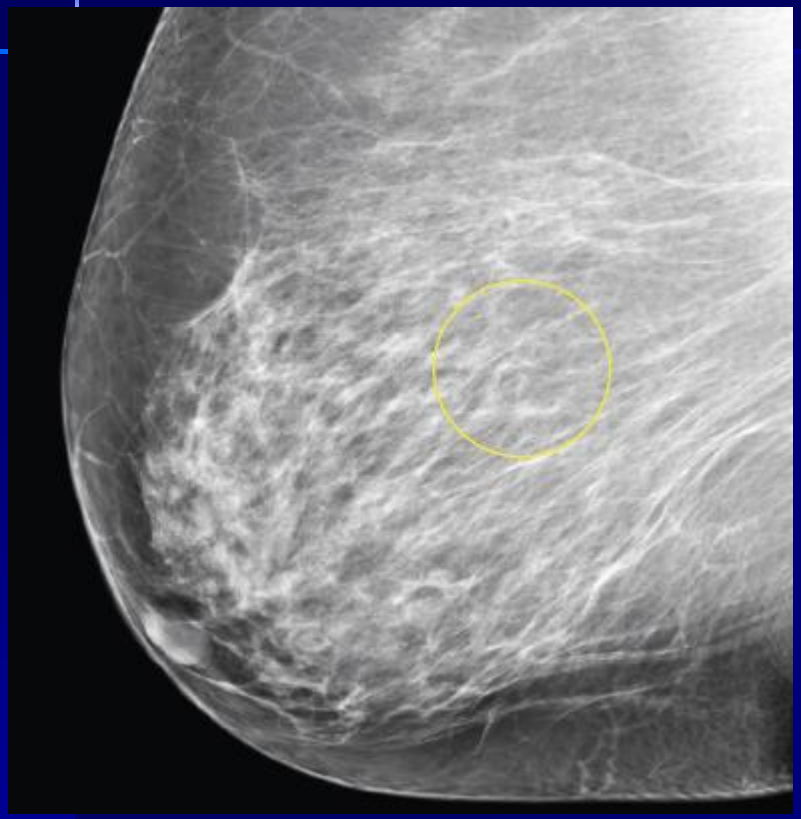
2D digital mammogram



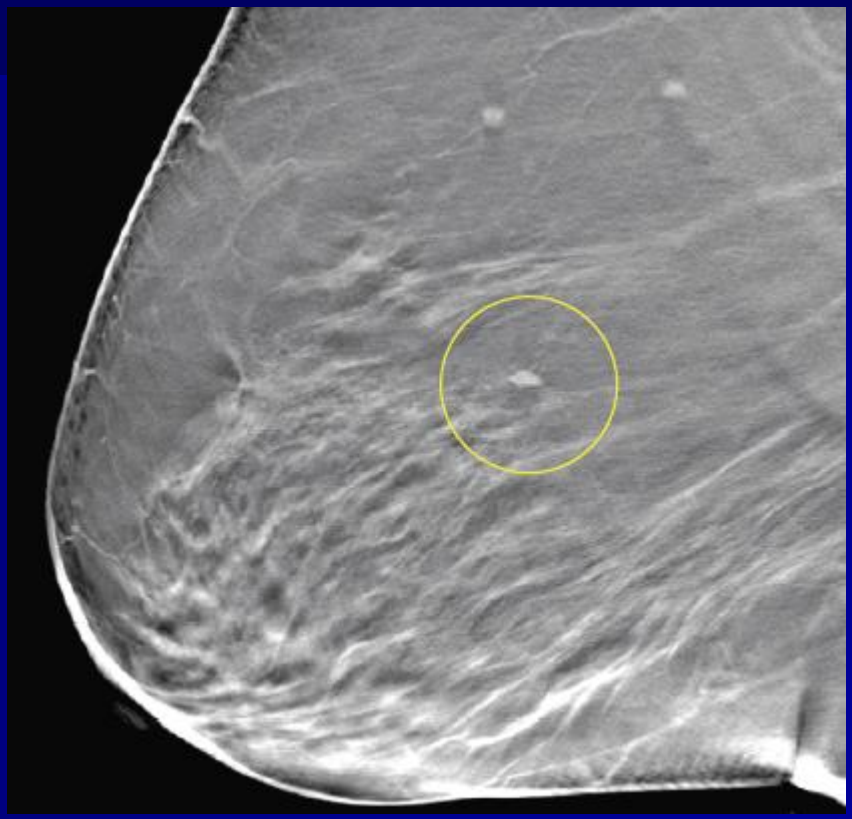
Tomosynthesis slice

KH Ng

Seeing through dense tissue



2D digital mammogram



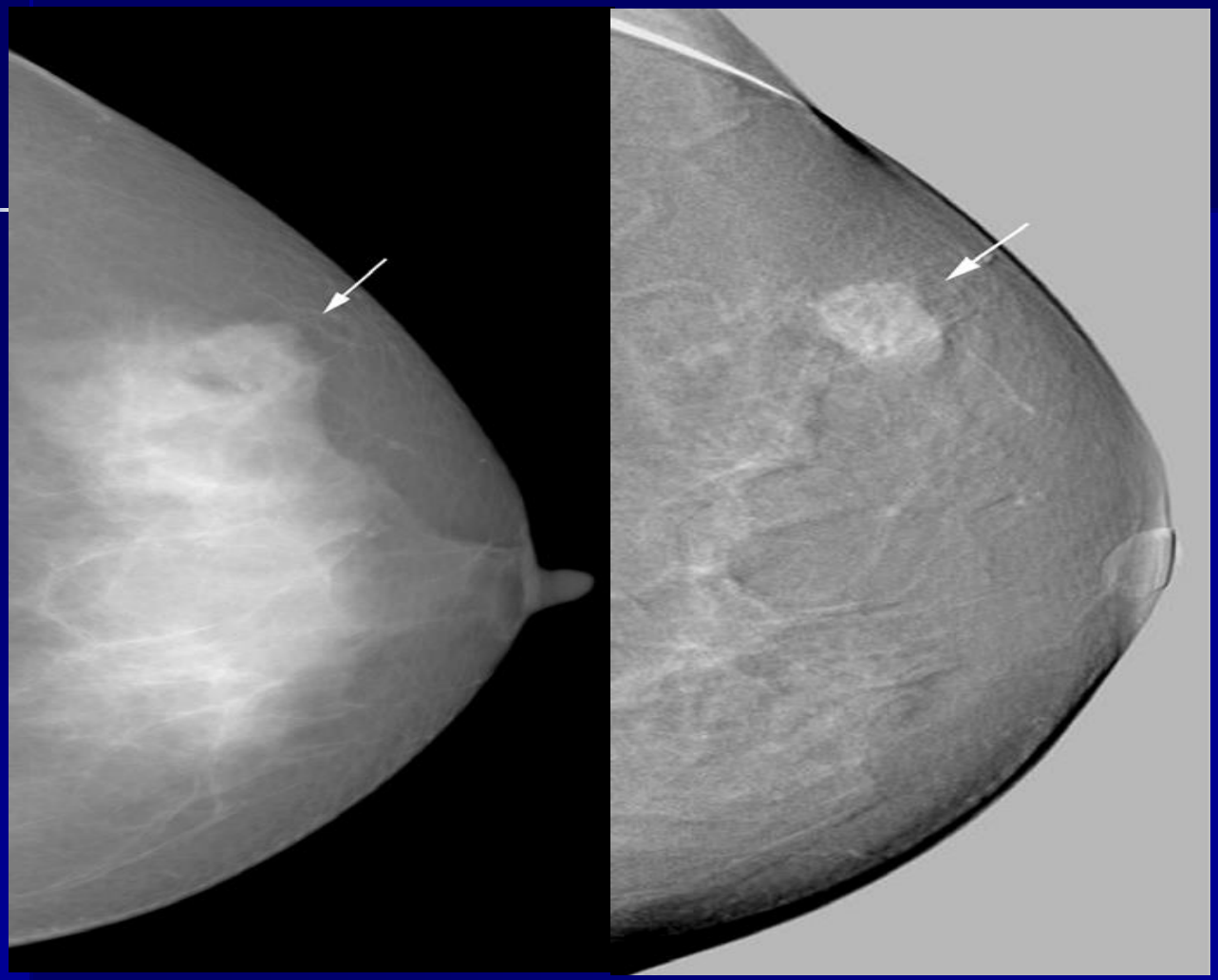
Tomosynthesis slice

KH Ng

Contrast enhanced digital mammography

- Temporal subtraction of images acquired before and after contrast agent administration
- Image blood flow and delivers sensitivity for tumour detection from 78 to 92%
- As an adjunct to standard mammography

Contrast enhanced digital mammography



Craniocaudal mammogram shows well-circumscribed opacity (arrow)

Subtraction image derived from 130-sec contrast-enhanced digital image shows homogeneous enhancement of lesion (arrow)

Dromain et al AJR 2006

KH Ng

Dual energy contrast enhanced digital subtraction mammography

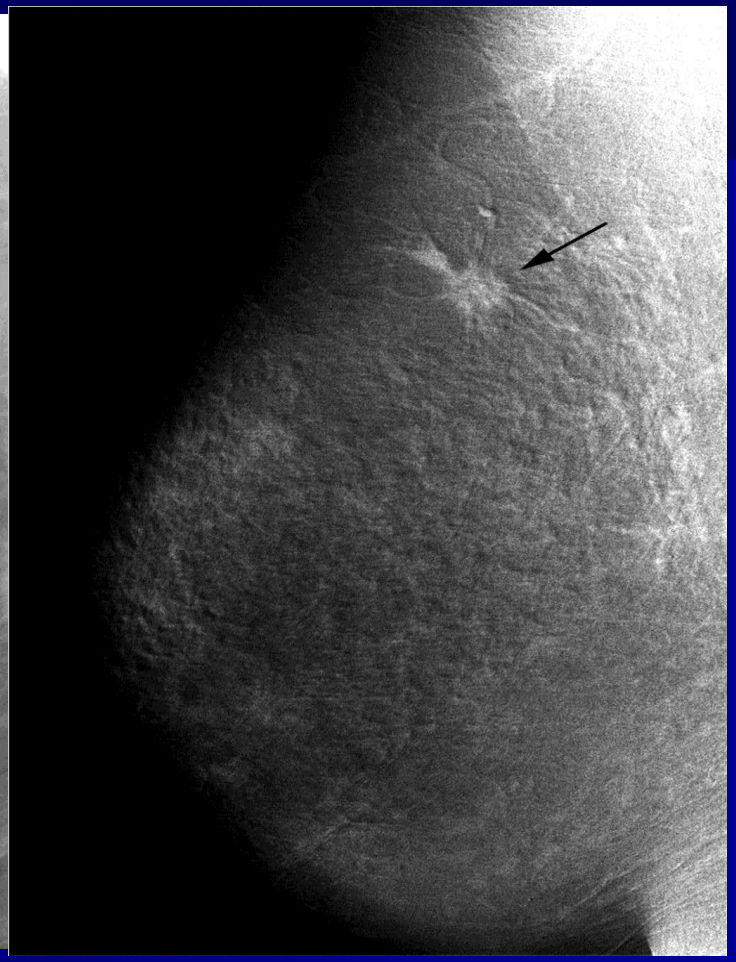
Pairs of low/ high energy images acquired after contrast administration are subtracted

Lewin et al Radiology 2003

KH Ng

Dual energy contrast enhanced digital subtraction mammography

Mediolateral oblique mammogram shows possible spiculated mass (arrow)



Dual-energy enhanced DSM image shows the cancer as an enhancing mass with definite spiculations (arrow)

Lewin et al Radiology 2003

KH Ng

Contrast agent issue

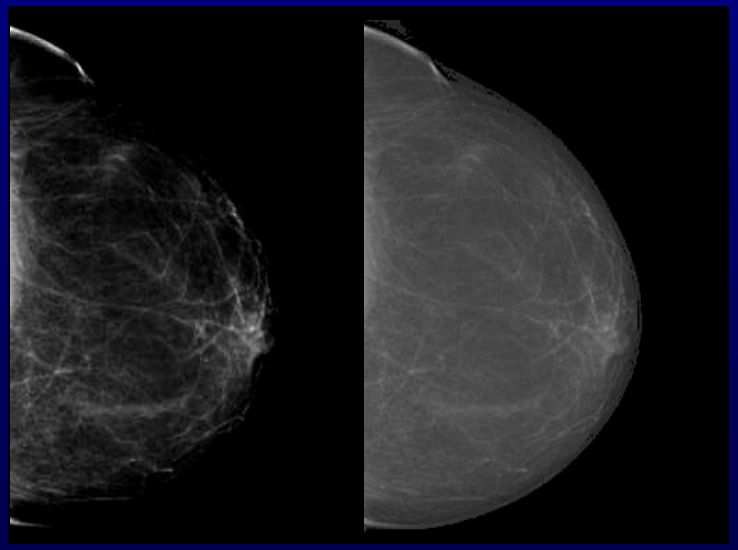
Low energy x-rays are not optimal for visualisation of iodine-based contrast agent (I $Z=53$)

- Need higher energy
- Modify spectrum (Cu filter)
- Develop new contrast agent (Bi $z=83$, Zr $z=40$)

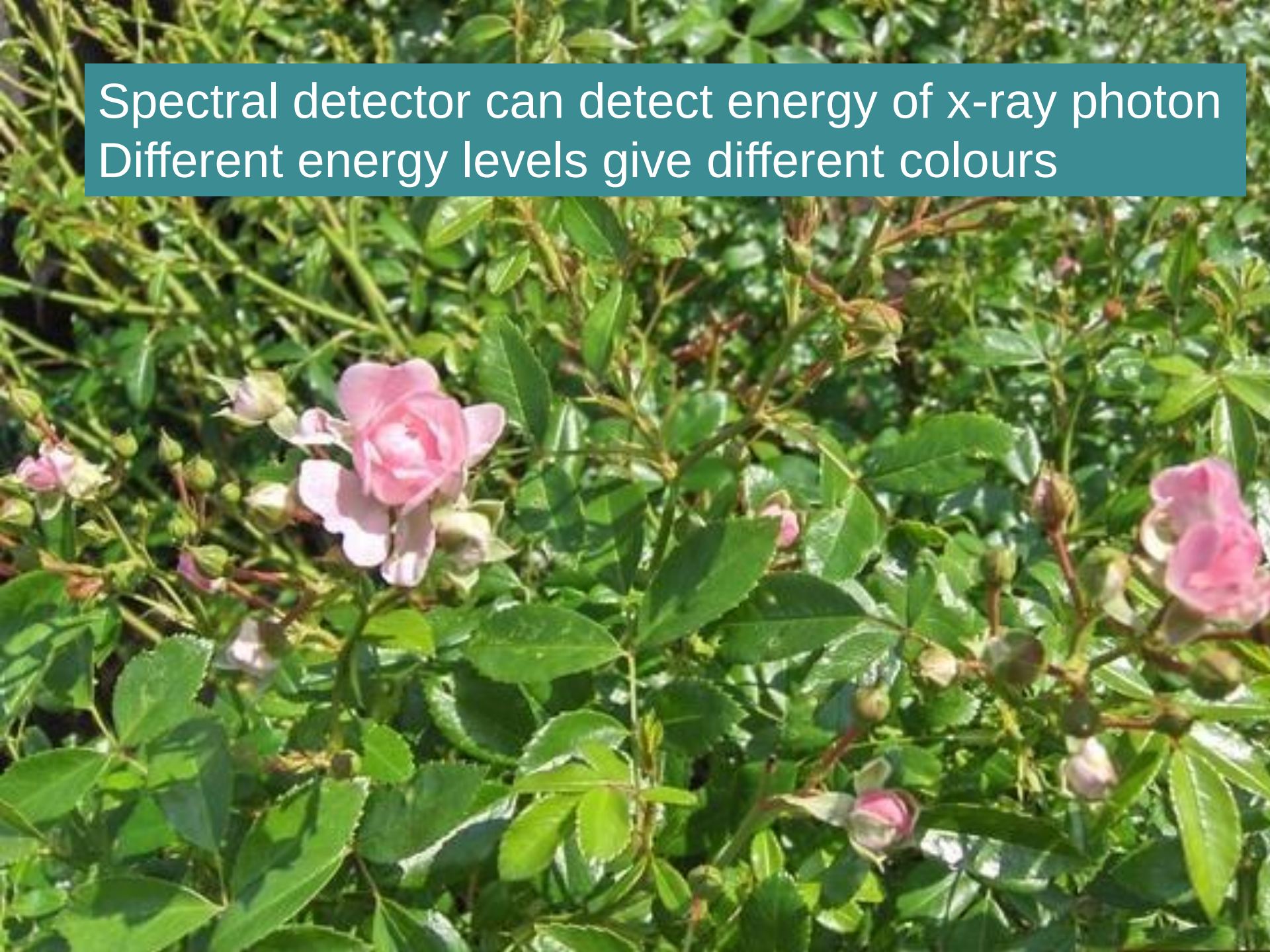
Single Shot Spectral Mammography

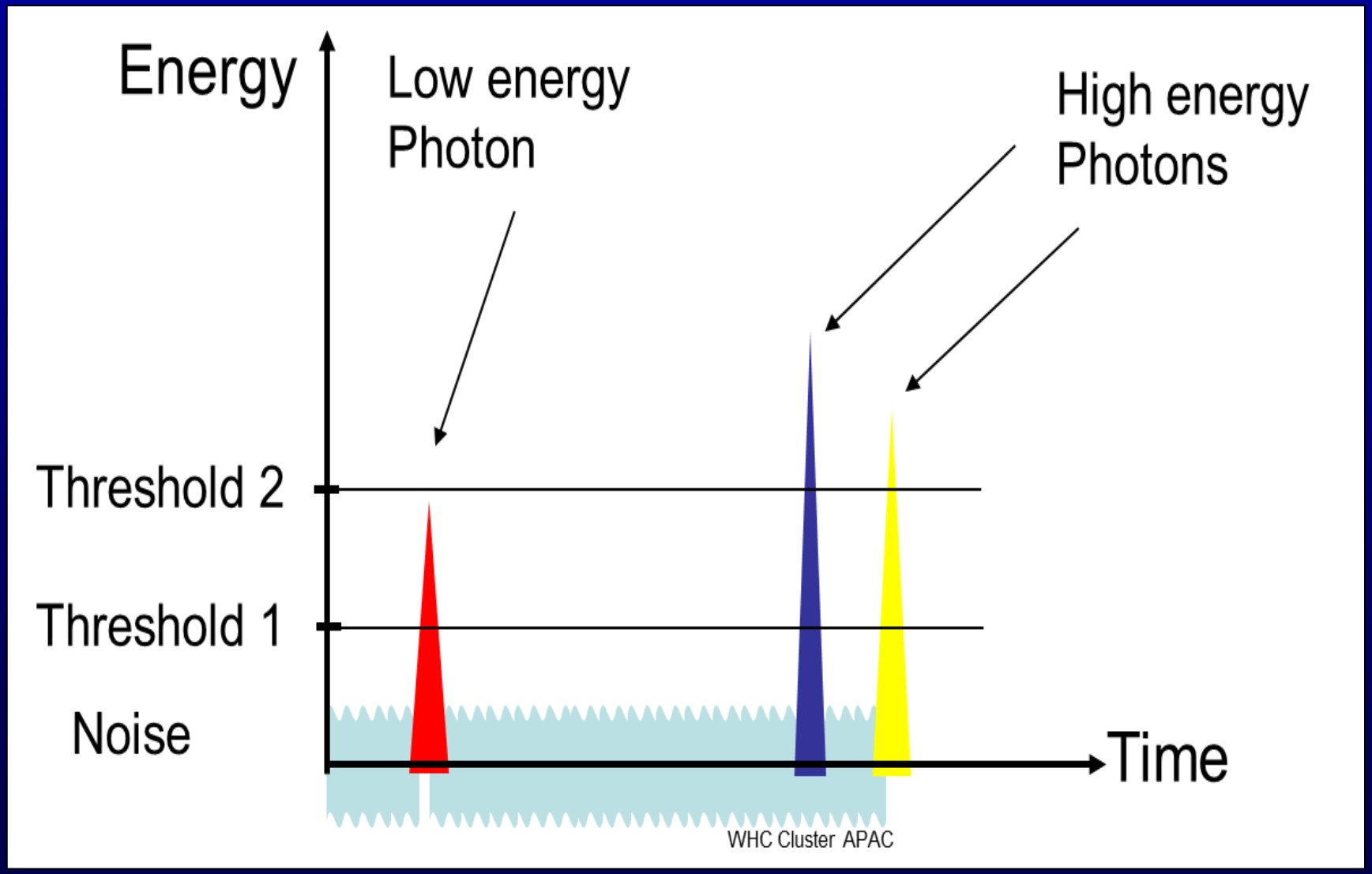
One single exposure – same dose as a normal MicroDose mammogram

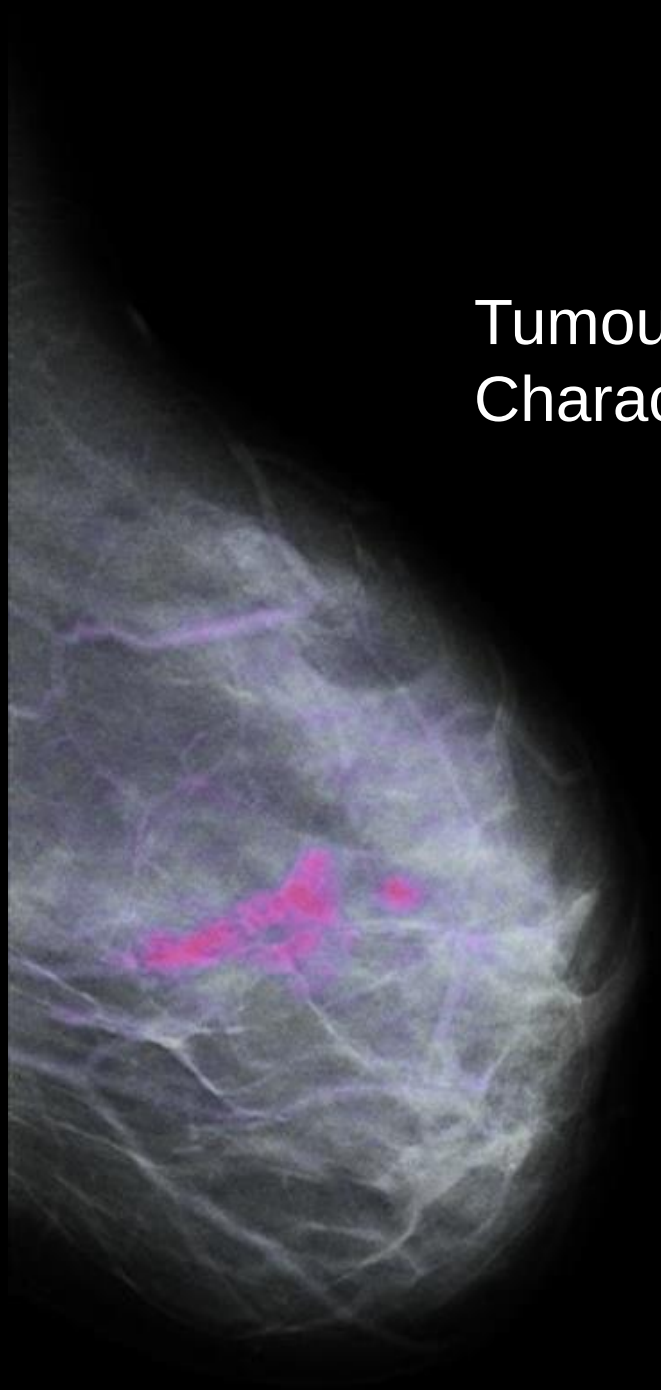
The mammogram is split into one *high energy image* and one *low energy* image



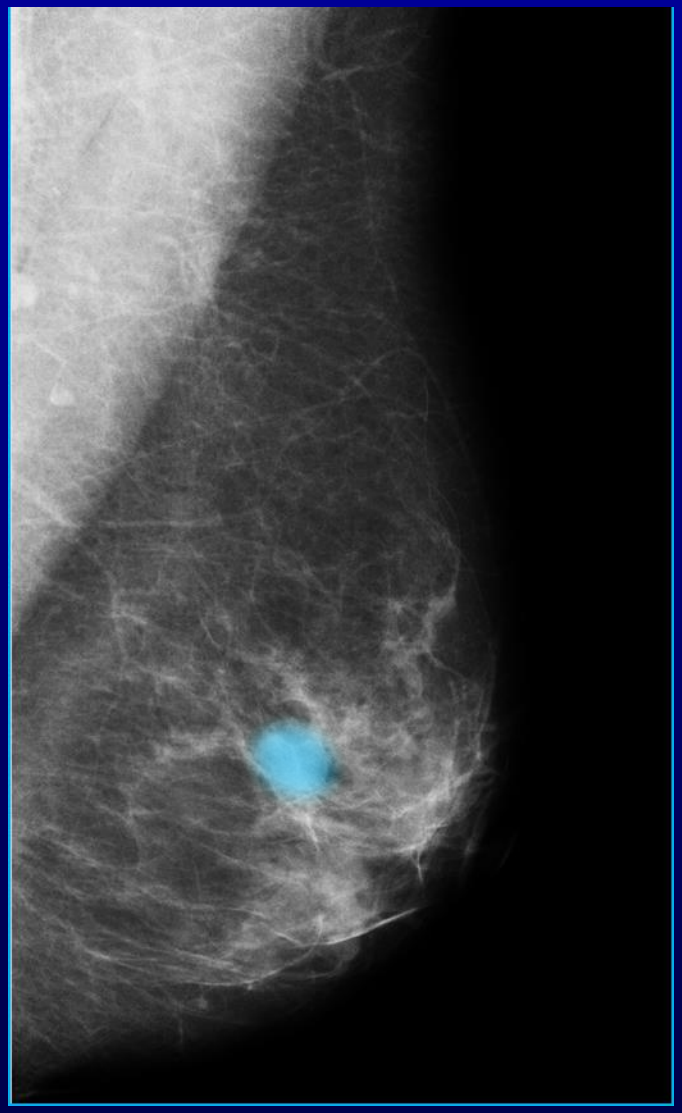
KH Ng


Spectral detector can detect energy of x-ray photon
Different energy levels give different colours


Energy
Low energy
Photon
High energy
Photons
Threshold 2
Threshold 1
Noise
Time
WHC Cluster APAC



Tumour Visualisation & Characterisation



Lesion Characterisation

Water and tissue absorb x-rays at different energy levels

Analysis of the X-ray spectral information could give insights into water content of lesions

With advances in detector technology and image processing, many novel, interesting clinical applications are feasible.