

# General vs. Organ Dedicated PET and SPECT Systems

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# Overview

- Rationale for dedicated cameras
- Designing a dedicated organ camera
- An overview of cameras currently commercially available
- Dedicated cameras in clinical practice

# Dedicated Organ vs. General Purpose Cameras

- General Purpose Cameras

- Can be used for a wide variety of imaging procedures/protocols.
- Can accommodate a wide range of radioisotopes.
- Flexible geometry.

- Dedicated Organ Cameras

- Designed to perform one imaging procedure only.
- Optimized for radioisotopes used for the specified procedure.
- Rigid geometry optimized for organ of interest.

# What are the possible advantages of dedicated organ cameras?

# Benefits of Dedicated Organ Cameras

- By designing a camera specifically to image a single organ or region of the body, the camera can offer improved performance in the two areas that matter the most in nuclear medicine imaging:
  - Sensitivity
  - Spatial resolution

# Sensitivity

- Increases in sensitivity result in more detected counts, decreasing image noise.
- Increases in sensitivity can be achieved by:
  - Increasing the geometric efficiency for the coverage of the detectors relative to the organ being imaged.
  - Using collimators optimized for focusing on the organ of interest.
  - Using thicker scintillator crystals.



# Effects of Improved Sensitivity

- A camera with improved sensitivity can be used in one of three ways:
  - Acquire lower noise images with the same acquisition time and injected dose.
  - Acquire equivalent noise images with a shorter acquisition time.
  - Acquire equivalent noise images with less injected dose.

# Spatial Resolution

- The spatial resolution of a general purpose camera may be lower than a dedicated cameras due to:
  - Detector closer to organ of interest with dedicated camera.
  - Better intrinsic resolution of dedicated camera.
- Limited resolution will lead to decreased image contrast.

# Effects of Improved Spatial Resolution

- Improving spatial resolution allows improved image contrast, leading to improved lesion detectability.
- But.... This will require using a smaller image pixel size, necessitating the acquisition of a greater number of counts.

# Benefits of Dedicated Organ Cameras Continued

- In addition to the performance benefits of dedicated cameras, other benefits might include:
- Cost savings
  - Do not need to purchase multiple collimator sets.
  - Detectors often much smaller, requiring fewer components.
- Smaller physical footprint



# When should a dedicated organ camera be considered?

- Like any camera purchase, we need to answer the following questions:
  - Will the new camera acquire images that are superior to what we can acquire on our existing cameras?
  - Will the new camera allow us to increase our patient throughput?
  - Is the dedicated camera meant to replace a general purpose camera or to be an addition to an imaging department?



# Organs/Procedures to Consider for Dedicated Cameras

- Myocardial perfusion SPECT imaging
- Breast imaging (Gamma, SPECT, PET)
- Brain imaging (SPECT, PET)

# Overview of Available Organ Dedicated Cameras

- A few caveats:
- Not an exhaustive list of all available cameras.
- Systems described had to be currently commercially available.
  - Could not be one-off prototypes.
  - Could not be discontinued products.
- List heavily influenced by list of exhibitors at the upcoming Society of Nuclear Medicine Meeting.

# Myocardial Perfusion SPECT

- Very large clinical demand/case load.
  - Many centers already have cameras used primarily for myocardial perfusion scanning.
- Procedure is well established and widely used.
- Cardiac imaging often exists as stand-alone clinic, so general purpose cameras are not required for other studies.

# Dedicated Cardiac Cameras

- There are two approaches to designing a cardiac camera:
- As a scaled down version of a general purpose camera.
  - Approach generally taken by large manufacturers.
  - Quickest route to market and easy acceptance in NM community.
- Using an alternative system geometry.
  - Approach commonly taken by smaller companies promoting new technologies.

# Scaled Down General Purpose Design

- Commonly termed ‘small footprint’ cameras.
- Typical design features:
  - Smaller gamma camera heads, still based on continuous NaI crystals with PMT array readout.
  - Fit through standard doorway when being installed.
  - More open geometry than general purpose cameras.
  - Detector heads fixed at 180°.

# Small Footprint Cameras

- GE Ventri



<http://www.ge.com>

- Philips CardioMD



<http://www.philips.com>

# Another Approach to a Small Footprint Camera

- Siemens c.cam
  - Scaled down camera with chair instead of bed.
  - Detector head design very similar to GE Ventri and Philips CardioMD.
  - Detectors mounted on robotic arm.
  - Patient sits in dental type chair.



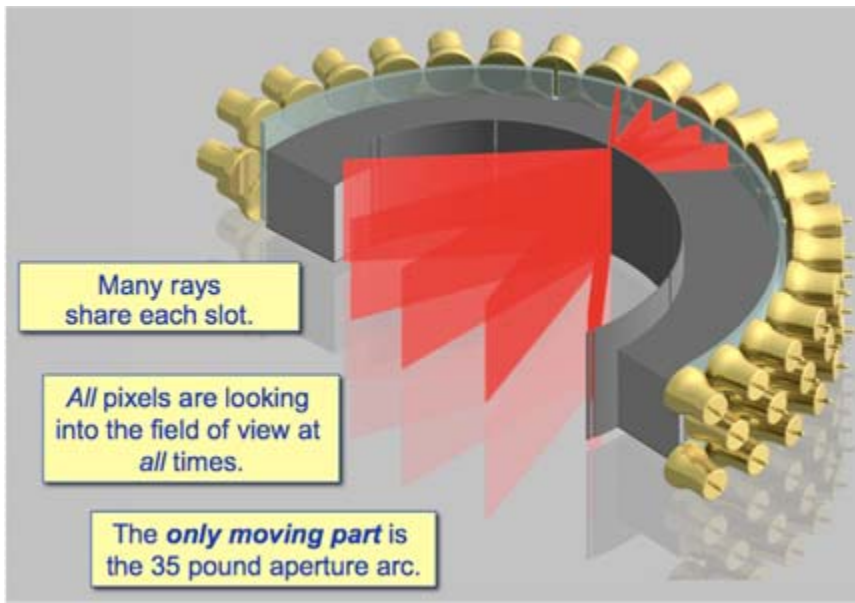
# Digirad Cardius 3 XPO

- Patient sits in chair and puts arms on arm rest.
- Three gamma cameras rotate about patient torso.
- Detectors are pixelated CsI(Tl)
  - Resolution typically improved by using pixelated crystals.
- Minimum room size 8' x 7'
- Also have two headed version



# CardiArc HD-SPECT

- Similar in design appearance to Digirad system, with patient sitting upright in chair.
- Difference is that the detectors are stationary, consisting of continuous, curved NaI crystals.
- Collimator moves in order to acquire tomographic data.



# Spectrum Dynamics D-SPECT

- Uses 9 pixelated CZT detectors that swivel independently about vertical axis.
- Claim imaging times as little as 2 minutes (when standard SPECT required 11 minutes), with sensitivity 10 times higher than conventional camera.



Figure from Gambhir et al. J. Nucl Med., 50(4) 635. (2009)

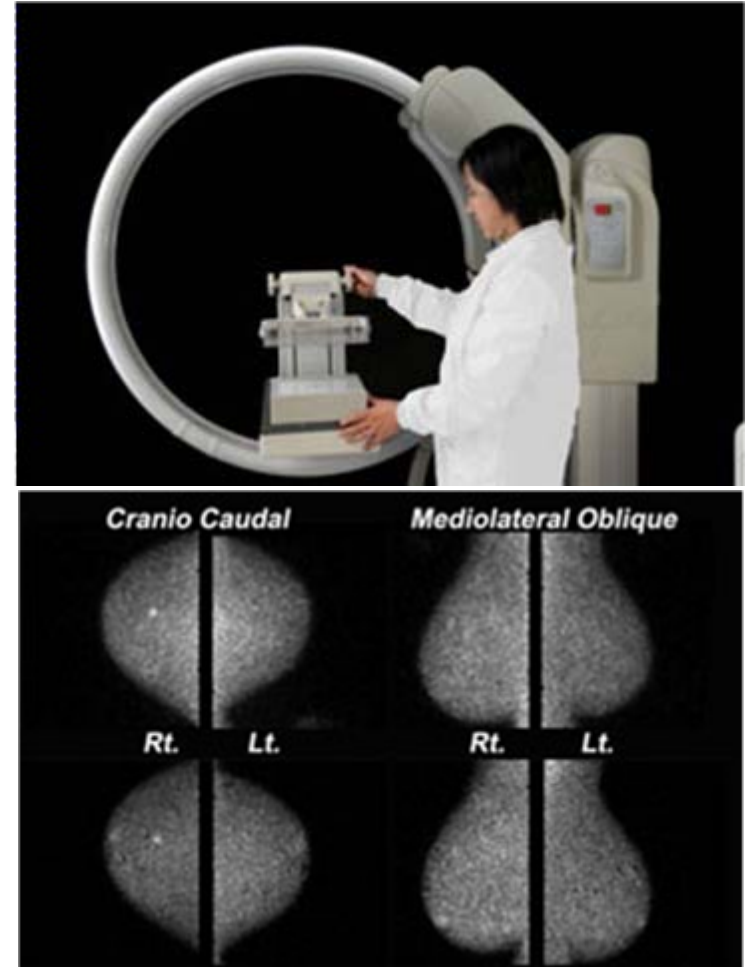
# Breast Imaging

- The breast is an unique imaging target.
  - Contains only soft tissue.
  - Imaging system can be in physical contact with organ being imaged.
  - Geometry of breast can be changed by using compression.
- Well established anatomical imaging techniques (mammography, ultrasound) exist for comparison of imaging results.
- But... NM imaging techniques are not yet widely used for breast imaging.



# Breast Scintimammography

- Gamma-Medica Ideas LumaGEM
  - 16 x 20 cm<sup>2</sup> FOV
  - Pixelated CZT array, 1.6 mm pixels
  - Energy resolution < 5%, intrinsic spatial resolution of 1.6 mm.
  - Uses parallel hole collimator.
  - High resolution achieved by bring camera in contact with breast.



<http://www.gm-ideas.com>

# Dilon 6800 Gamma Camera

- Scintillator/PMT based detector
  - Uses discrete crystal elements.
- Marketed as both breast and spot imaging camera for thyroid/extremities.
- Similar in performance to the Gamma-Medica LumaGEM device.



Dilon 6800 Gamma Camera

<http://www.dilon.com>



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# Dedicated Breast SPECT

- Despite extensive interest in breast scintimammography, there are not yet any dedicated breast SPECT cameras on the market.
  - Unlike case of cardiac imaging, breast imaging with NM is not yet widely used.
  - Smaller number of patients than cardiology.
- Several systems under development at university research centres.



# Positron Emission Mammography (PEM)

## Feasibility study for positron emission mammography

- First description and use of the term PEM was in a paper by Dr. Chris Thompson of the Montreal Neurological Institute in 1994..

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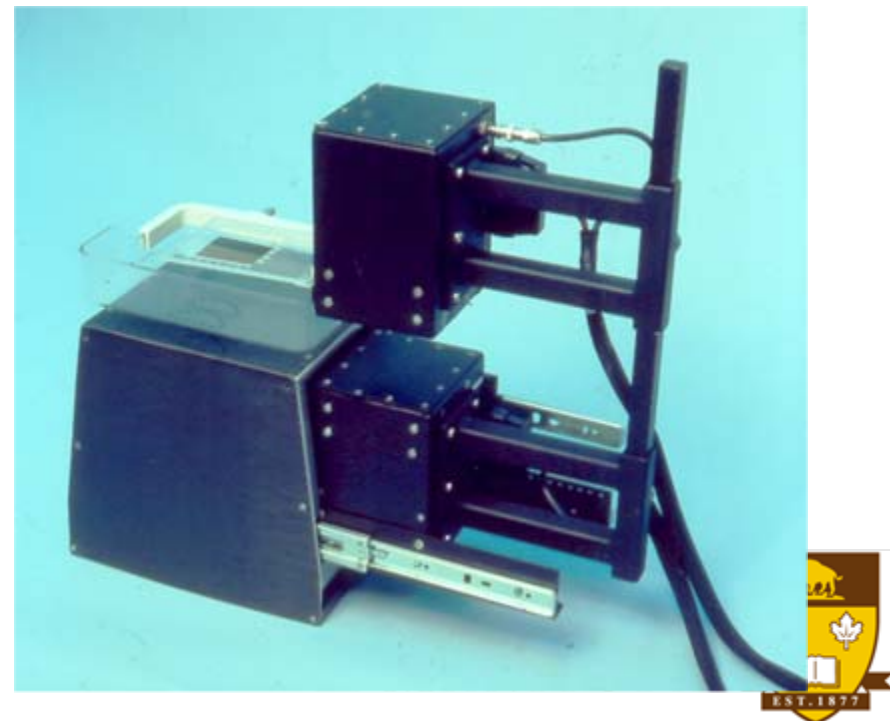
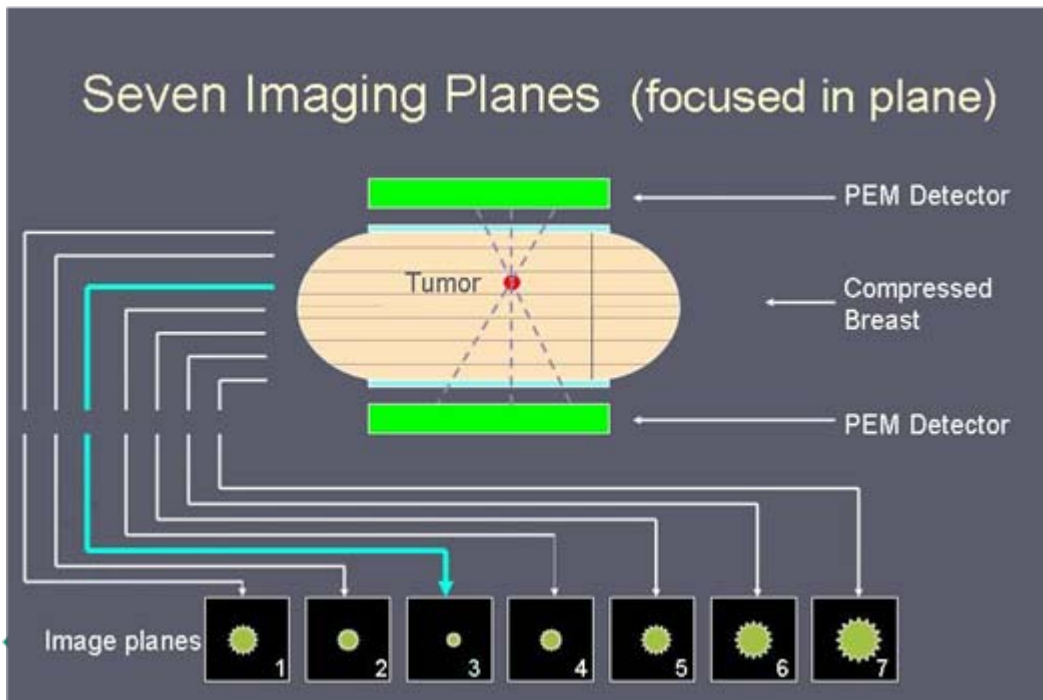
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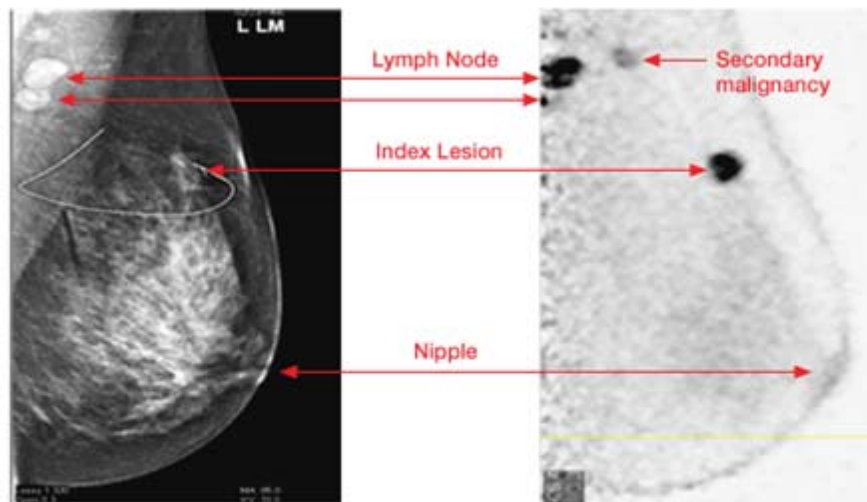
Med. Phys., 21(4):629-538, 1994.



# Naviscan PEM Scanner

- Descendent of original PEM prototype.
  - Spatial resolution of 2 mm
  - FOV: 16 x 24 cm
  - 4-10 minute scan time

## PEM Complementing Mammography



Pathology: Left Breast:  
Mammography found index lesion but missed secondary malignancy found in PEM.  
Metastatic cancer to lymph node also identified on PEM.



# Dedicated Brain Cameras

- A number of dedicated brain cameras have been developed over the years for use in neurological research centres.
- As the performance capabilities of whole body imaging cameras has improved to the point where good quality brain images can be acquired, dedicated brain cameras have become the exception, rather than the rule.
- Generally, neurological imaging makes up a relatively small fraction of a nuclear medicine practise.
- But... with improvements in radiotracers designed for early detection of degenerative conditions (i.e. Alzheimer's Disease), we may see a resurgence of dedicated brain cameras.



# Dedicated PET Brain Camera

- PhotoDetection Systems Inc. NeuroPET.
  - Designed to fit in 10' x 14' room.
  - Detectors based on wavelength shifting fibres.
  - Powered by 115V, 20A electrical.
  - 27 cm transverse FOV, 4.3 mm resolution
- Designed as a research camera for high sensitivity brain imaging.
  - Allows use of minimal injected dose to allow repeat scanning in clinical trials.



<http://www.photodetection.com>

# Is a Dedicated Camera Right for Our Facility?

- Will it improve the diagnostic quality of our imaging studies?
- Is there sufficient clinical demand for the imaging procedure?
- Will we increase the number of patients we can image?
- Will we have to give up a general purpose camera to install it?

# Conclusions

- Dedicated organ cameras can be a valuable addition to a Nuclear Medicine Department provided the camera is chosen to meet the clinical demand.
- At the present time, the largest market for dedicated cameras is in cardiac imaging.
  - Proven clinical utility of myocardial perfusion imaging.
  - Large clinical patient population/imaging demands.
  - Many stand-alone cardiac imaging clinics.
- The growth in demand for dedicated cameras for other organs will depend on the growth of Nuclear Medicine techniques designed for imaging these organs.
  - E.g. Receptor-based radiotracers for breast tumour imaging.

