INDUSTRY TRENDS IN MEDICAL IMAGING

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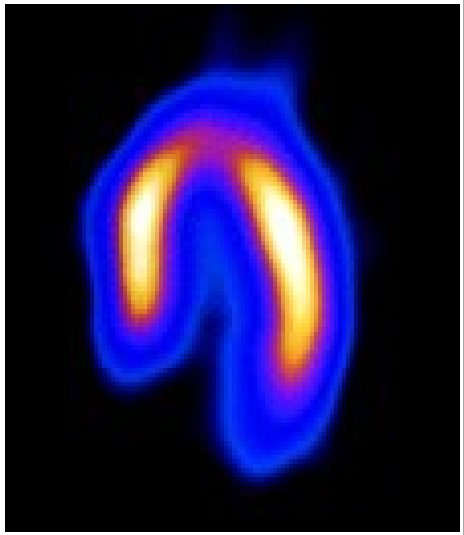
Presentation to the Industry-Academia Matching Event on SiPM and Associated Technologies
CERN 16th Feb 2011

CONTENTS

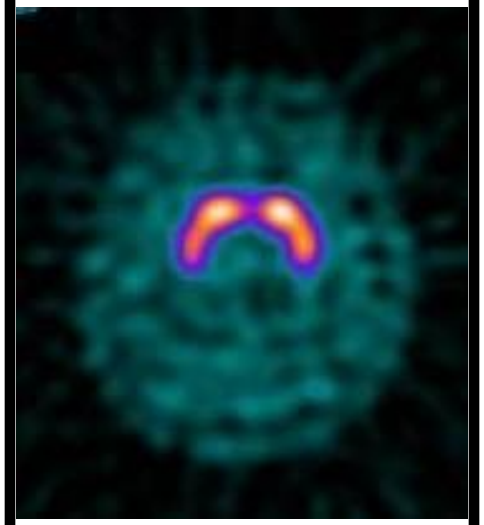
- Nuclear Medicine and Molecular Imaging
- Background to the industry
- 10 major events in the last decade
- The drivers, the achievements, the impact
- Concluding remarks

Radionuclides for labelling

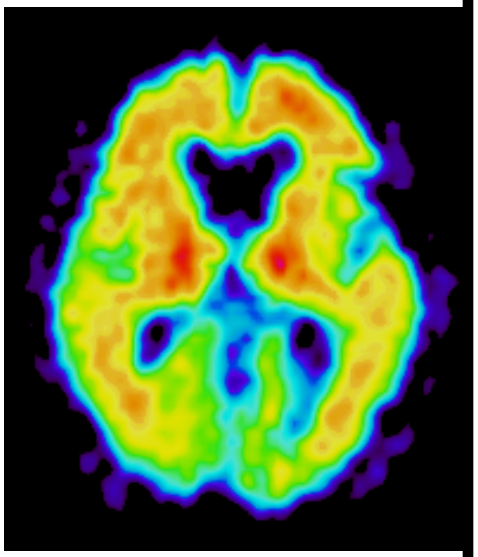
^{99m}Tc

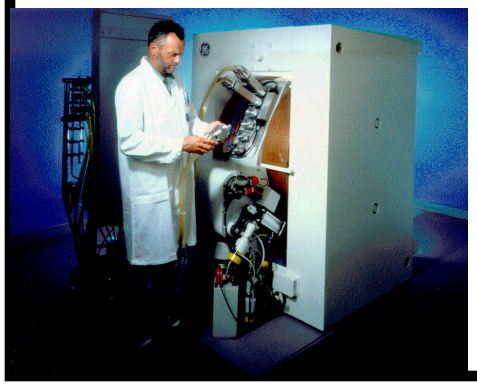


^{123}I



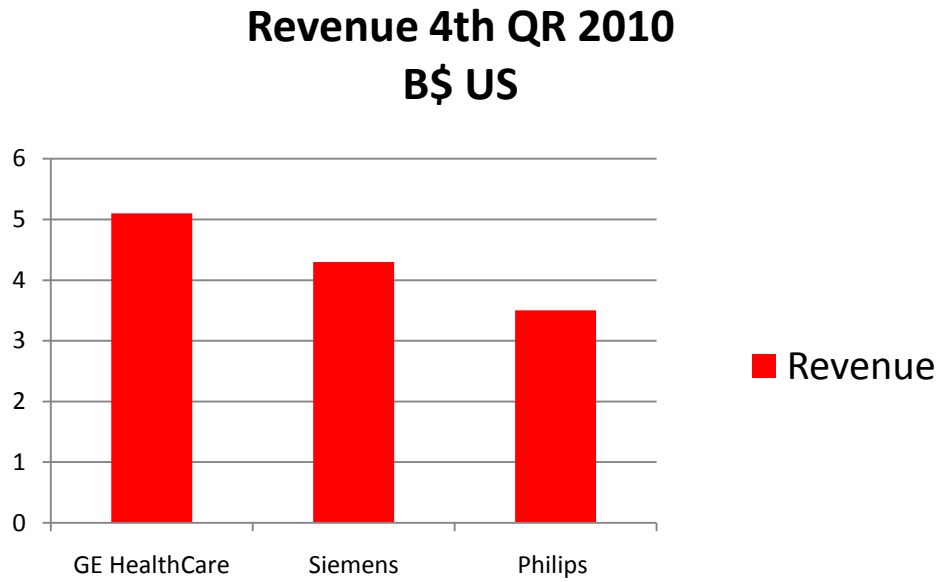
^{18}F

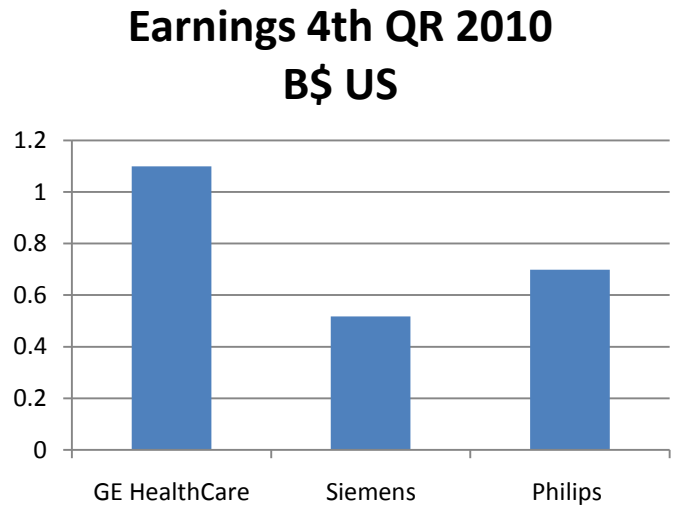


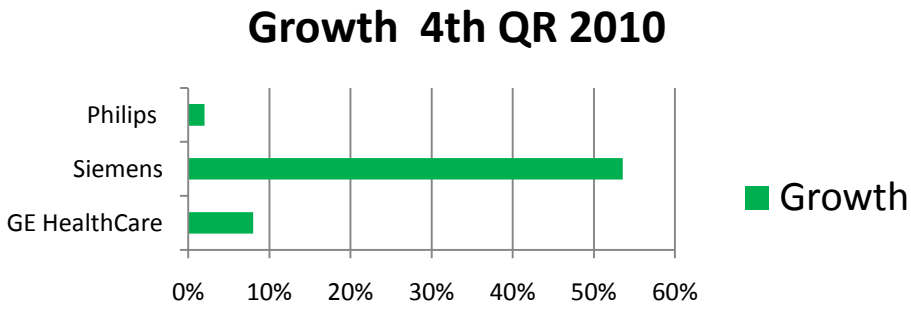


Nuclear Medicine Imaging Industry

Financial Performance

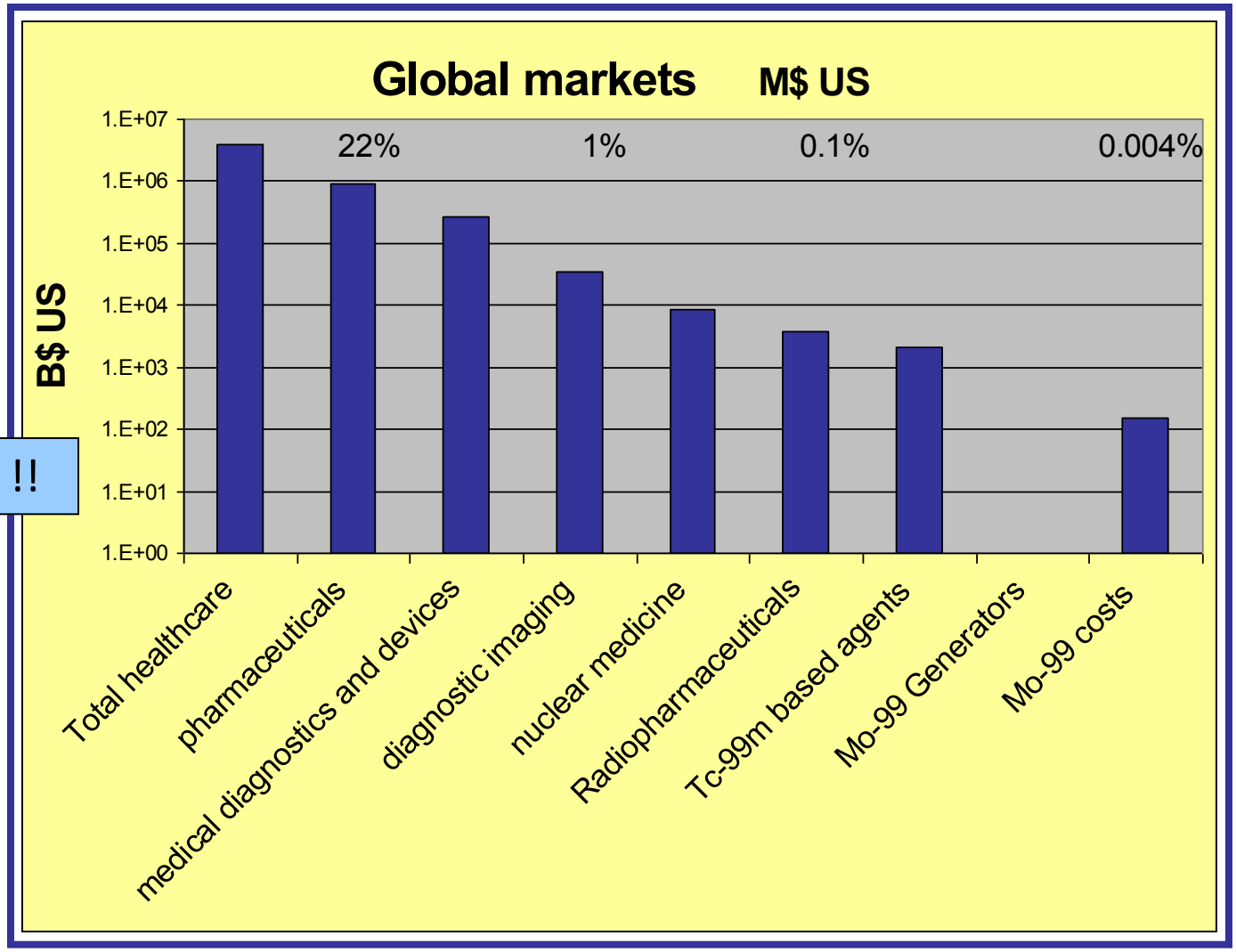






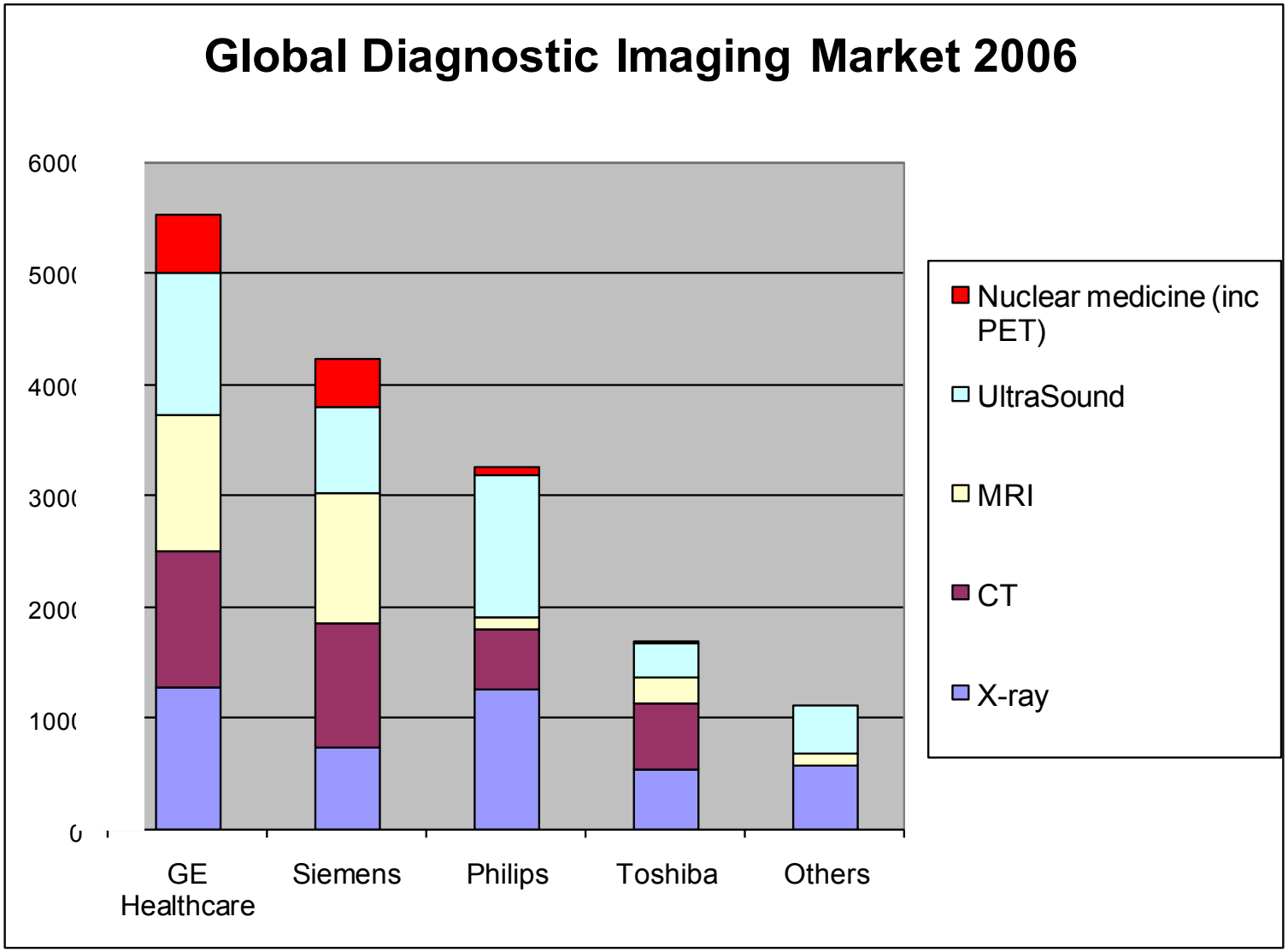
Market Considerations

Global Expenditures



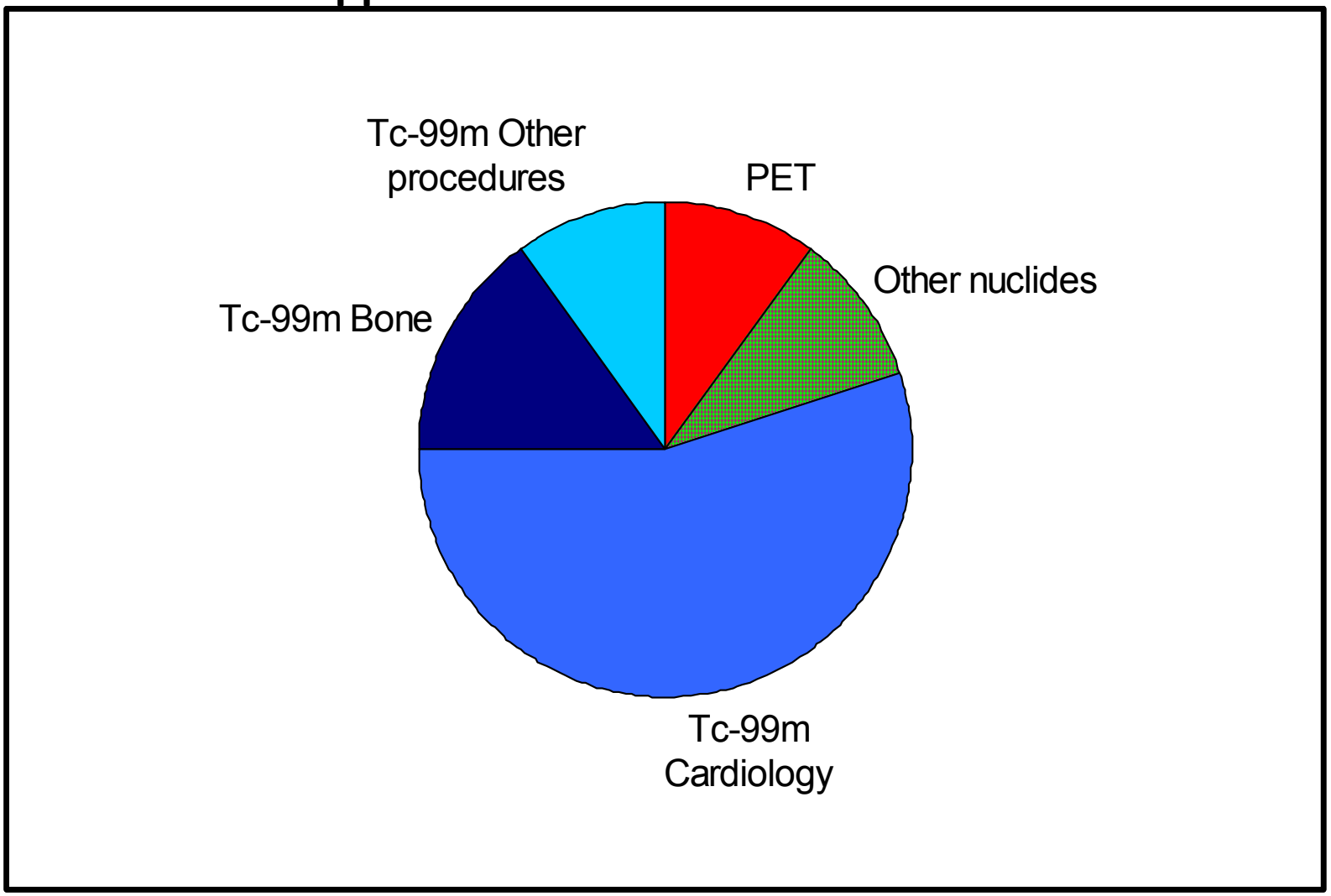
Log scale !!

Market - Medical Scanners



Radionuclide Imaging Clinical Procedures

approx market model for USA 2008



Progress in Nuclear Medicine Imaging

1. PET Radiopharmaceutical Approval
2. Scintillator Development
3. Dual Modality Imaging – PET/CT
4. Pre-Clinical Scanner Improvements
5. Availability of ^{18}FDG
6. Introduction of TOF
7. PET/MRI development
8. Multiwire Proportional Detectors
9. SPECT/CT
10. CZT SPECT Detectors

1. PET Radiopharmaceutical Approvals

FDA – Food and Drug Administration (USA)
CMS – Centre for Medicare and Medicaid Services

- 1970's $Na^{18}F$ approved
- *1984 $^{82}RbCl$ approved*
- *1997 FDA Modernization and Accountability* Act (FDAMA)
- 2000 Preliminary approval for ^{18}FDG for staging lung cancer, coronary artery disease and $^{15}NH_3$ for blood flow

Current indications include:

Diagnosis, Staging and Re-staging of NSLC Lung, Esophageal, colorectal, lymphoma, melanoma, head & neck, breast, thyroid cancers

CAD

Refractory seizures etc

2. Scintillator Developments

Scintillation Materials Used in Nuclear Medicine Instrumentation

Property	NaI(Tl)	BGO	LSO	YSO	Gso	BaF	$LaBr_3$	LYSO
Density (g/cm^3)	3.67	7.13	7.4	4.53	6.71	4.89	5.3	5.31
Effective Z	50.6	74.2	65.5	34.2	58.6	52.2	—	54
Attenuation length	2.88	1.05	1.16	2.58	1.43	2.2	2.1	2
Decay constant (ns)	230	300	40	70	60	0.6	15	53
Relative light output (%)	100	15	75	118	25	5	160	76
Wavelength ([nm])	410	480	420	420	440	220	360	420
Index of refraction	1.85	2.15	1.82	1.8	1.91	1.56	1.9	1.81
Hygroscopic?	Yes	No	No	No	No	No	Yes	No

BGO = bismuth germanate; GSO = gadolinium oxyorthosilicate; LYSO = lutetium yttrium oxyorthosilicate; YSO = yttrium oxyorthosilicate.

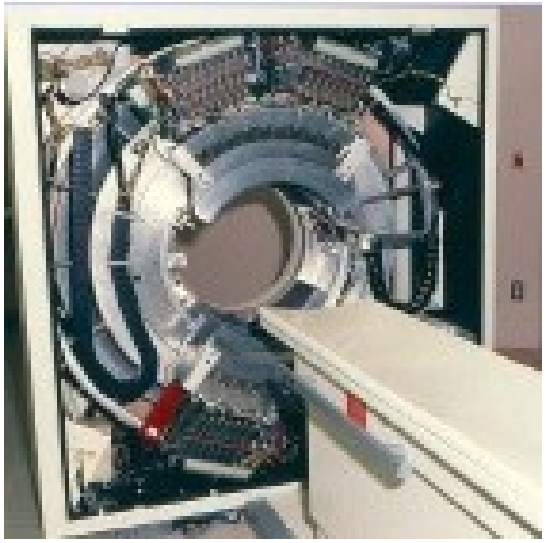
Courtesy of Pichler et.al. JNM Vol 49 No6 (Suppl) June 2008

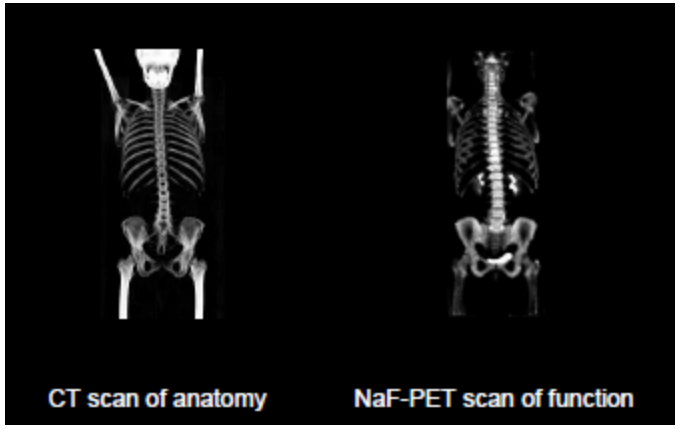
Scintillators for high sensitivity commercial scanners

- Prior to 2000 - NaI(Tl) and BGO scintillators
- Emergence of LSO and use in preclinical systems
- Patent protection, method of mass production and inclusion into clinical systems
- Features - high light output, fast pulse decay, high density, high Z number and stable material
- Subsequent arrival of GSO and LYSO commercial scanners

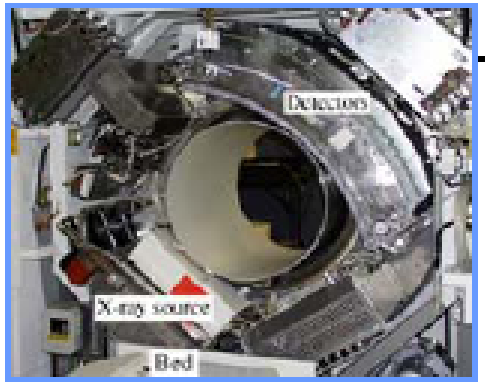
3. The Dual Modality Imaging PET/CT scanners

- 1977 first PET scanner development starts at CERN
- 1991 PET/CT concept
- 1995 PET/CT scanner project receives NIH funding
- 1998 first PET images generated
- 2001 first PET/CT system installed



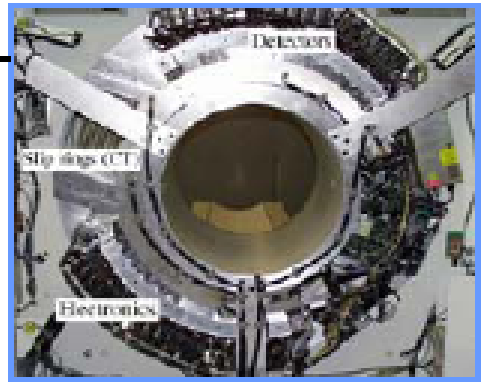


PET/CT prototype design

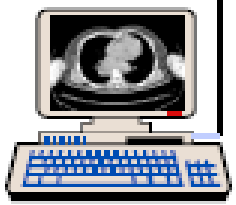


Somatom AR.SP

PET/CT scanner

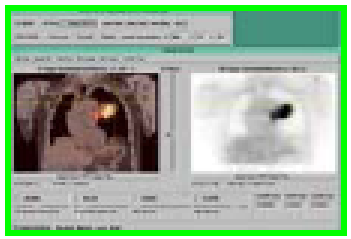


ECAT ART



CT console

CT



Fused image viewer

PET

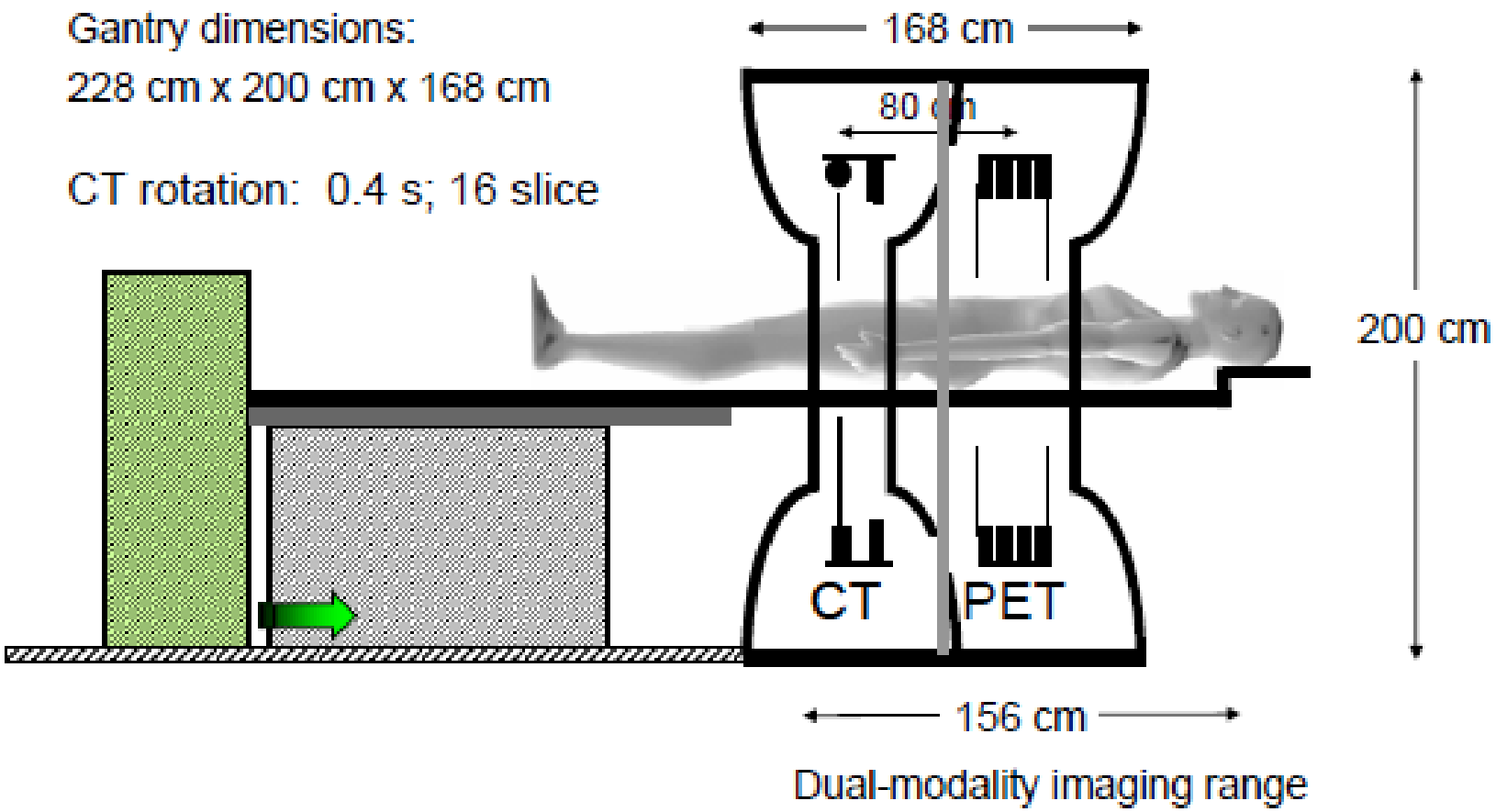
PET console

Slides Courtesy of David Townsend National University of Singapore

A commercial PET/CT scanner design

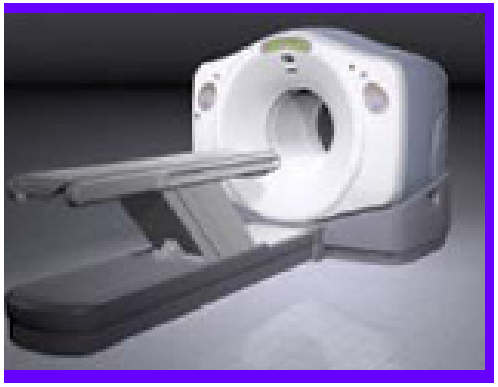
Gantry dimensions:
228 cm x 200 cm x 168 cm

CT rotation: 0.4 s; 16 slice



Dual-modality imaging range

Early PET/CT Scanners from industry



Discovery ST, VCT

BGO
6 mm x 6 mm x 30 mm
2D/3D (septa)
8, 16, 64 slice CT
70 cm port

LYSO
4 mm x 6 mm x 30 mm
2D/3D (septa)
6 ns coincidence
16-slice CT

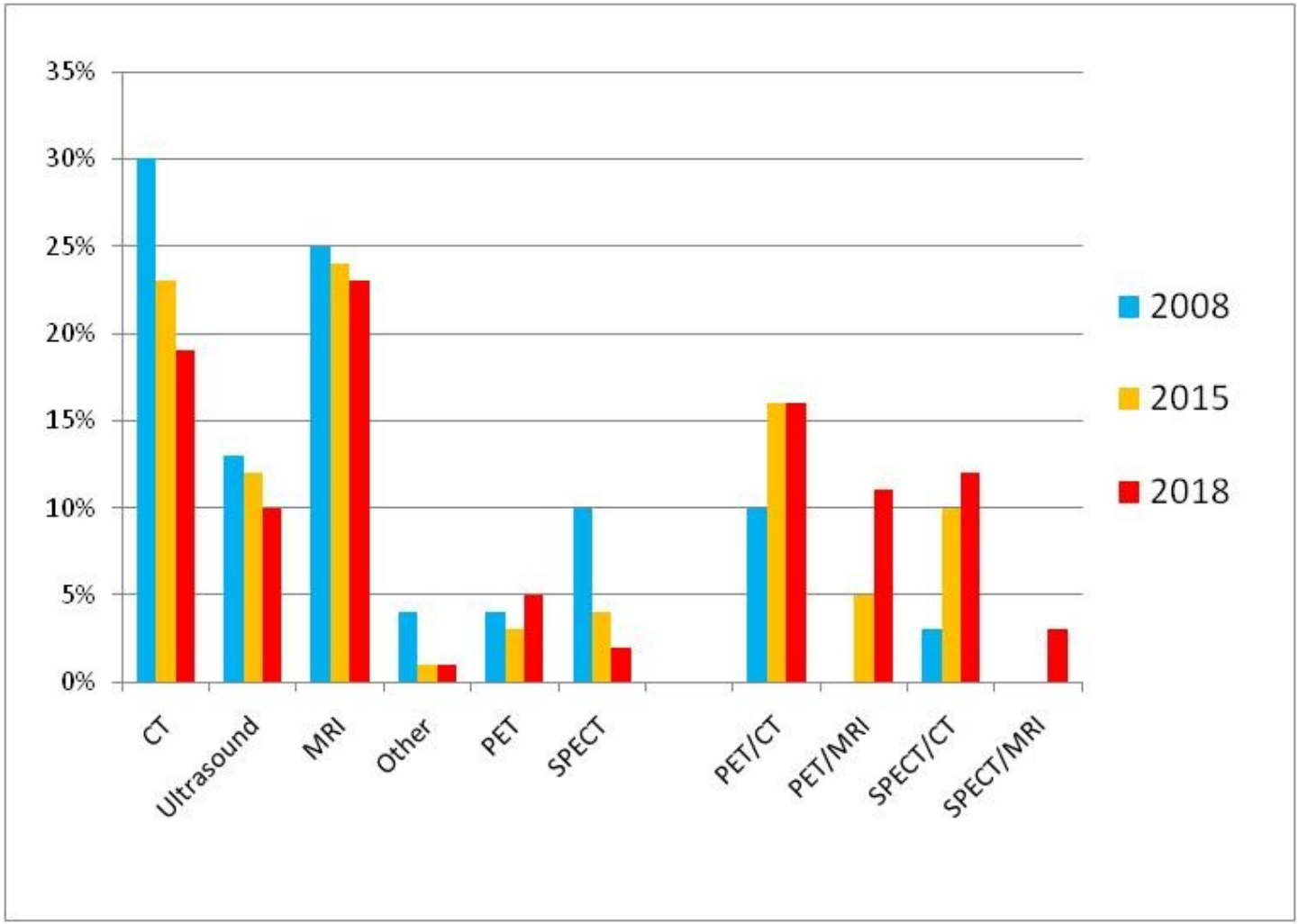
Gemini GXL

GSO (Zr)
4 mm x 6 mm x 30 mm
3D only (no septa)
6, 10, 16 slice CT
70 cm port
6 ns coincidence

biograph 6, 16, 64

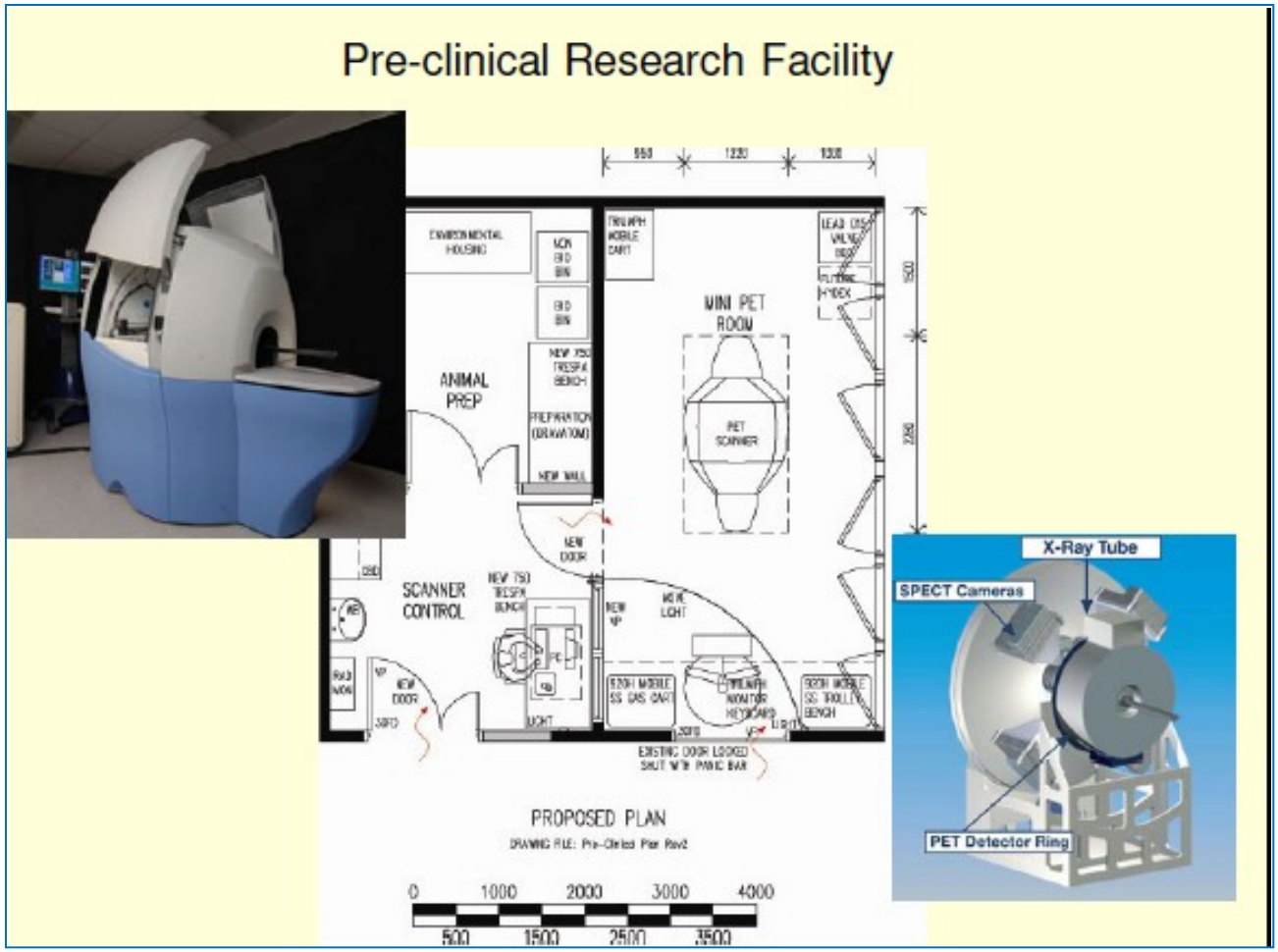
LSO
4 mm x 4 mm x 20 mm
3D only (no septa)
8, 16, 64 slice CT
70 cm port
4.5 ns coincidence

Scanner Placements in Europe



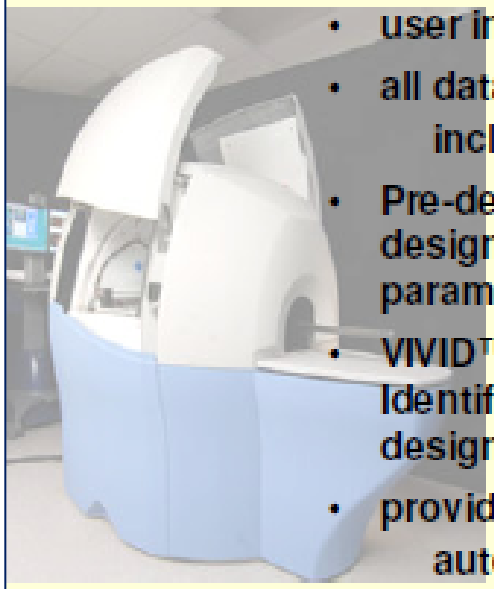
Courtesy of the Petten future Project Group, Holland

4. Preclinical scanner improvements



Courtesy of Peter Edwards Cardiff University UK

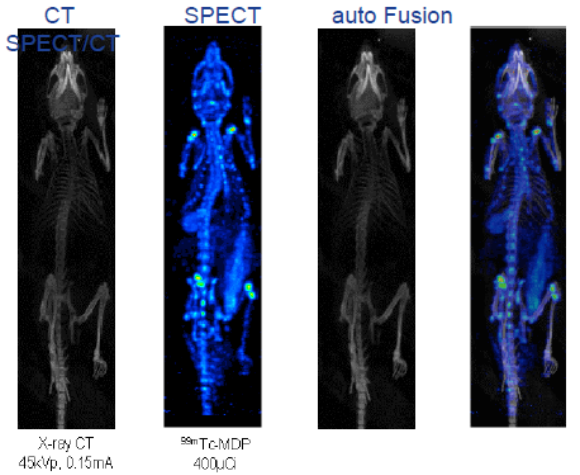
Pre-clinical Research Facility



- user interface controls all modalities
- all data is saved in DICOM format
  including vital signs and specific scan data
- Pre-defined imaging protocols can be designed to ensure the same imaging parameters are used for each subject studied.
- VIVID™ (Volumetric Image Visualization, Identification and Display) software package designed specifically for FLEX *Triumph*™
- provides One-Step Fusion™
  automates fusion and co-display of up to four co-acquired images (SPECT/SPECT/PET/CT).
- automated loading of SPECT, PET and CT image data, automated 2D and 3D visualization modules
- high pixel definition, fast camera manoeuvres for projection data and streamlined image segmentation
- quantification for time-activity curves of dynamic data for bio-distribution studies.

High Resolution Preclinical images

SPECT/CT Animal images using a CZT detector



Triple isotope imaging with ^{201}Tl, ^{99m}Tc , ^{123}I

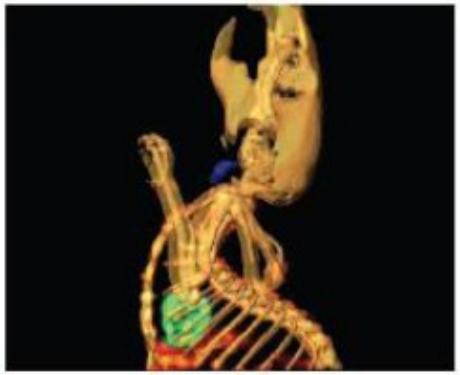
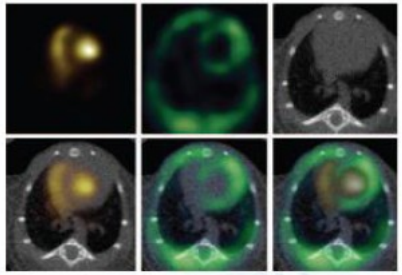
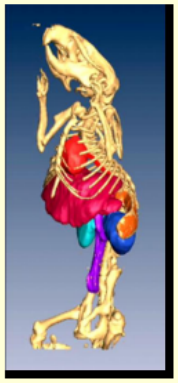


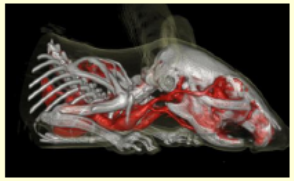
Image courtesy of Dr. T. Doyle, Stanford Small Animal Imaging Facility, California, USA

Dual isotope myocardial perfusion imaging with ^{201}Tl, ^{99m}Tc ,



Images courtesy of Dr R.Choquet and Pr. A. Constantinesco, Hôpital de Hautepierre, Strasbourg, France





X-O™, GMi µ-CT system

- fast whole body image acquisitions
  (< minute: I-based CA's wash out of mice in approximately one min)
- very-high-resolution (43µm) whole body scans
- GOS/CMOS based digital x-ray detector technology
- field of view 9.3 cm diameter by 9.7 cm axial
- x-ray dose < 2cGy in a sixty-second scan.
- can be operated in any laboratory environment - requires no special shielding.
- Visualization software with transaxial, sagittal and coronal views, views from arbitrary angles, contrast adjustment, surface and volumetric rendering, region of interest (ROI) definition capability, and automatic segmentation.

5. Availability of ^{18}FDG

CHOICES OF PET CYCLOTRONS

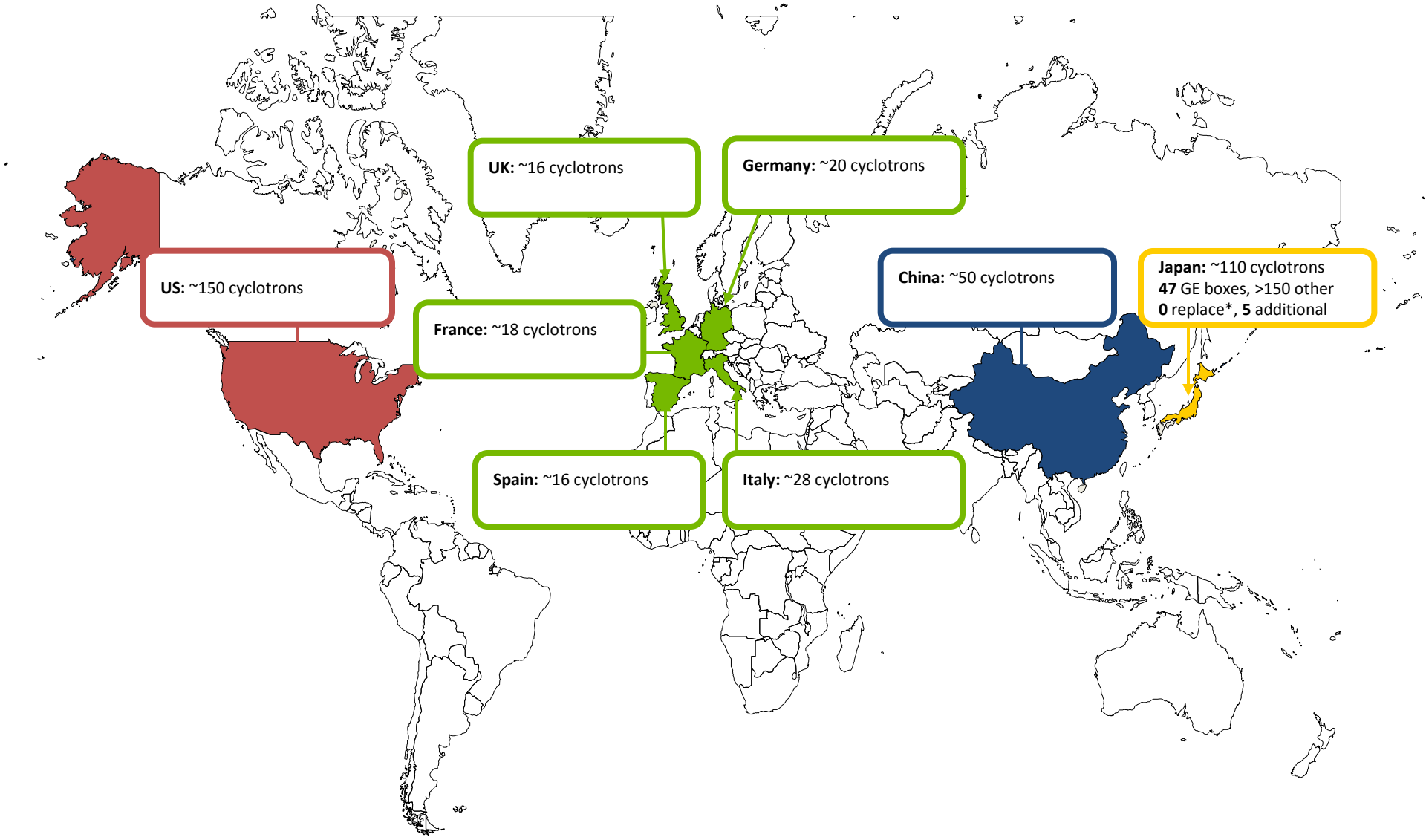
GEHC MiniTrace	11 MeV
GEHC PETrace	17 MeV

Siemens and CTI

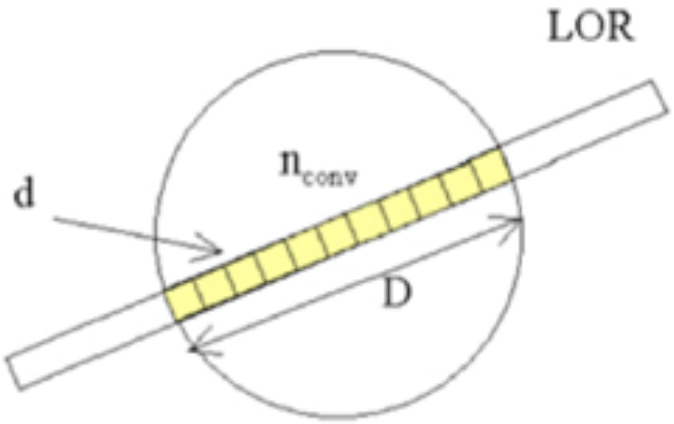
Knoxville, Tennessee

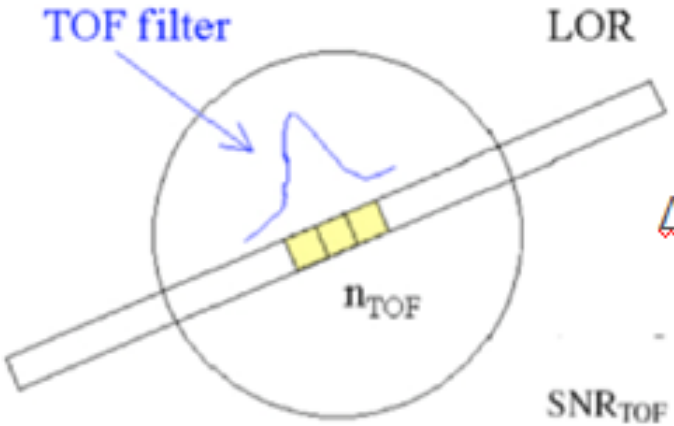
RDS111	11MeV
Eclipse	11 MeV

PET cyclotrons worldwide



6. The use of Time of Flight (TOF) counting





$\Delta x = c^* \Delta t/2$

$$SNR_{TOF} \cong \sqrt{\frac{D}{\Delta x}}\, SNR_{conv}.$$

Image elements contributing to a LOR, for conventional PET (left) and TOF PET (right).

1. Phillips GEMINI
2. Siemens Biograph
3. GE discovery

4. Time resolution 600 to 450 psec

7. PET/MRI Development

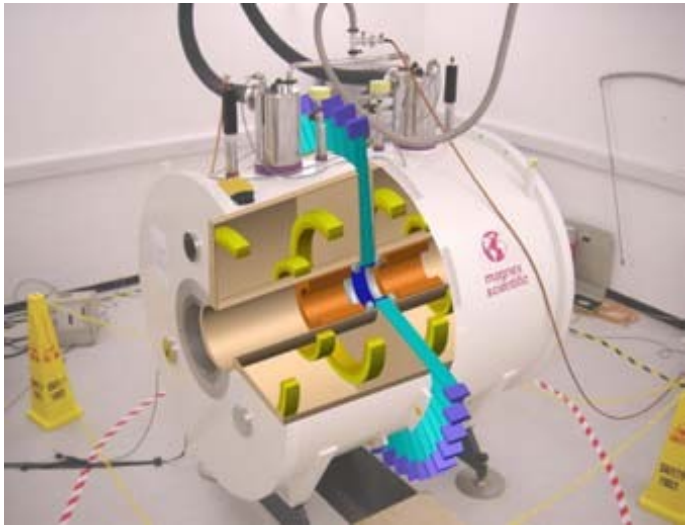
Issues to be addressed:

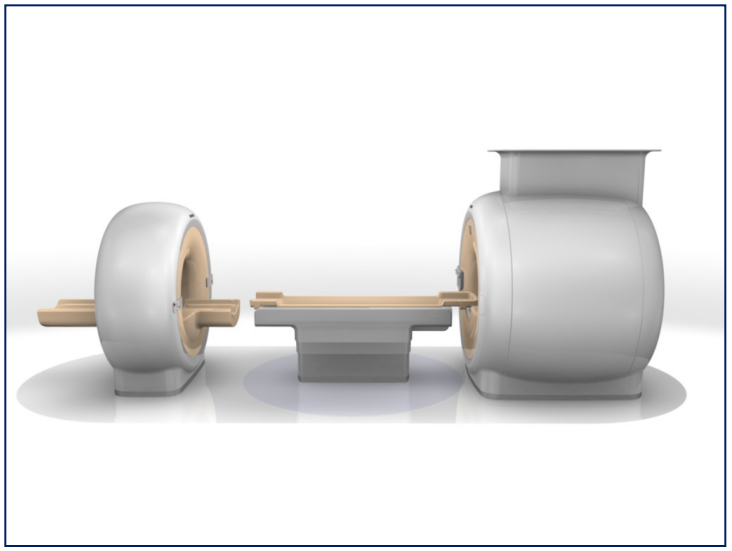
- Clinical Utility
- PET detector design
- Influence of MR magnet on PET detector
- Influence of PET detector on magnetic fields
- Attenuation correction

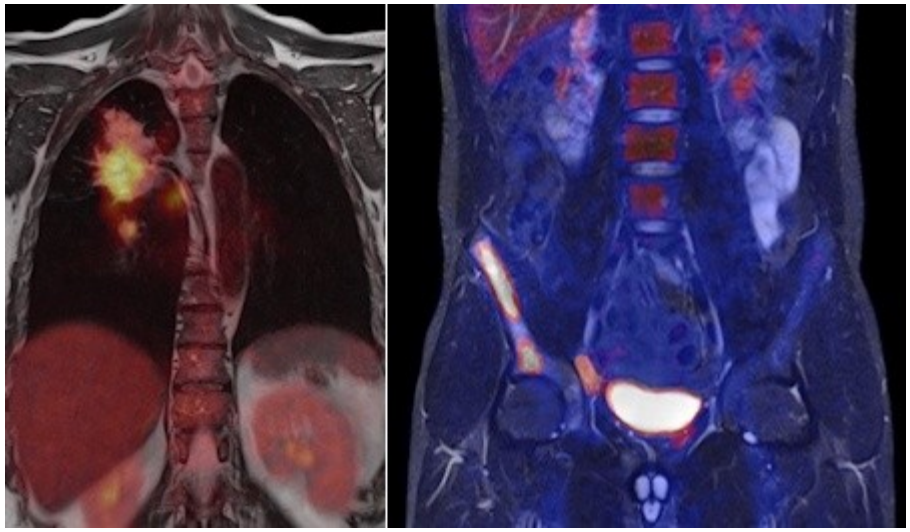
Benefits of PET/MRI:

- No alignment errors
- Fast acquisition – no respiratory motion errors
- Improved soft tissue contrast
- No radiation dose
- Reduced data acquisition time
- Better MR spatial resolution

PET/MRI - Works in Progress

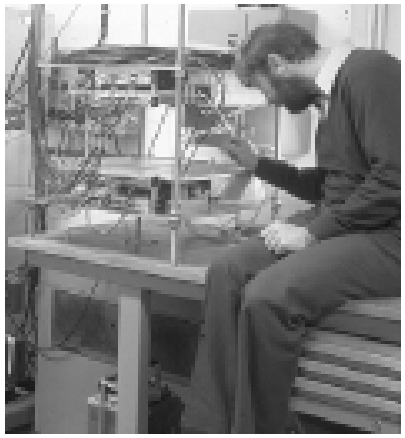






8. The impact of multiwire proportional counters

The HIDAC Camera: 25 years later…..



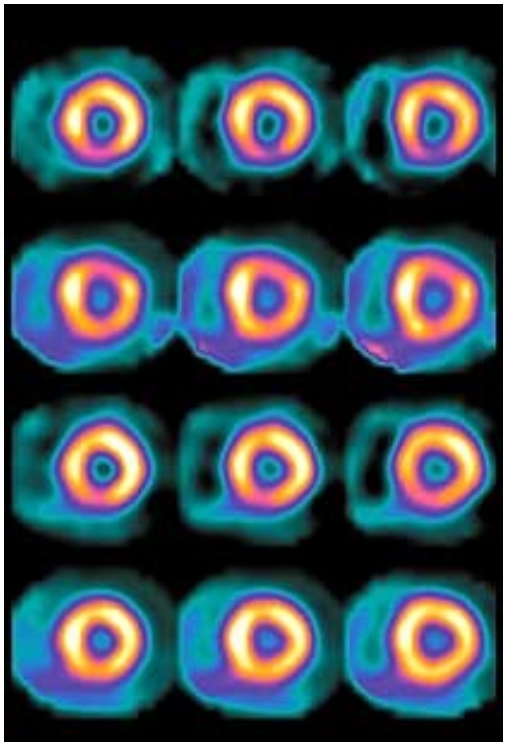
Quad HIDAC small animal scanner

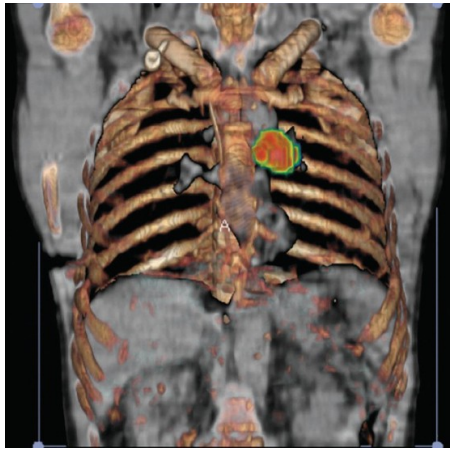
1978

2003

PETRRA whole body imaging

9. Emergence of SPECT/CT scanners





Industry Offerings SPECT/CT scanners

Siemens

Philips

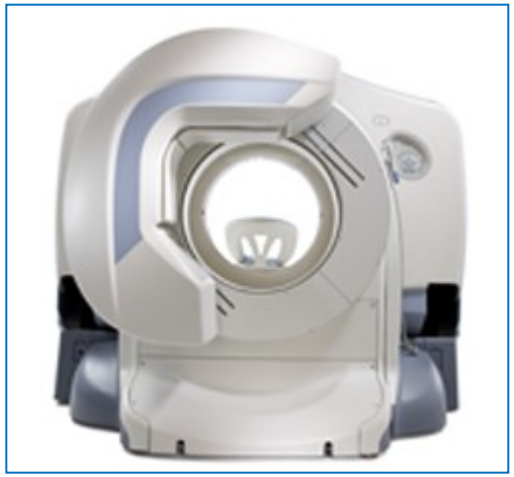
General Electric

10. CZT Detectors for SPECT

Organ specific scanners – Cardiac Scanners

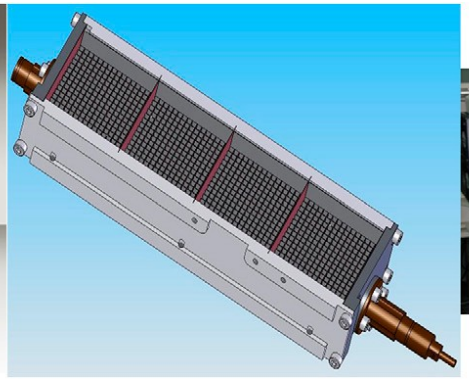
Spectrum Dynamics Inc – the D SPECT

General Electric NM530c and NM/CT 570c



The promise for CZT SPECT scanners

No large collimator
Optimised pin hole collimation
Large solid angle
Camera sensitivity x5
Spatial resolution <7 mm
Dedicated reconstruction software
Possible reduction in scan time’
Possible reduction in radiation dose]
Barin and breast scanners
Whole body scanners


Conclusions

- Demonstration required of clinical utility
- Construction of ‘demonstrator’ device
- Awareness of Regulatory requirements
- Providing software compatibility avenues
- Scintillators and PM tubes being superseded
- APD detectors becoming more available

- No SiPM detectors in regular clinical or industrial products used in molecular imaging

THANK YOU

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