

Performance characteristics of a small animal PET camera for molecular imaging

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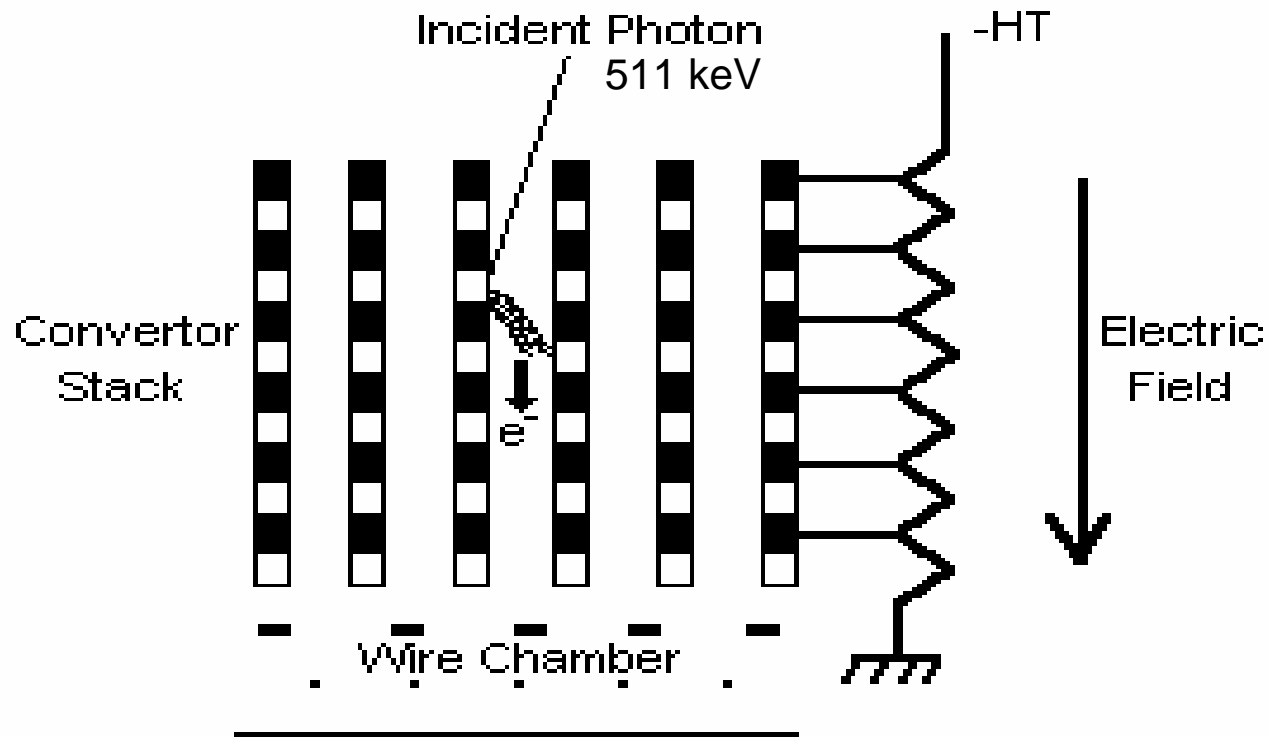
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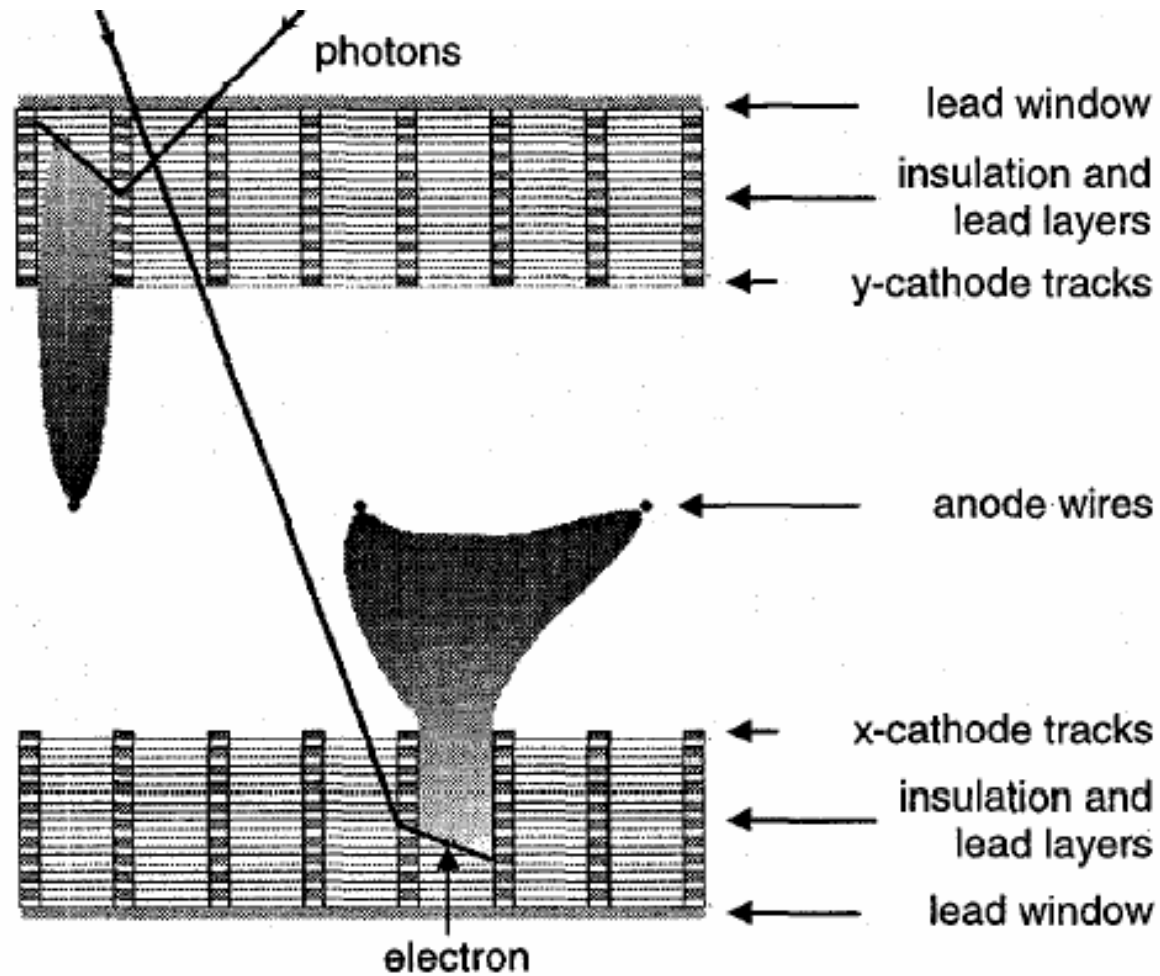
⁵Manchester Molecular Imaging Centre, University of Manchester.

HIDAC Detector Module

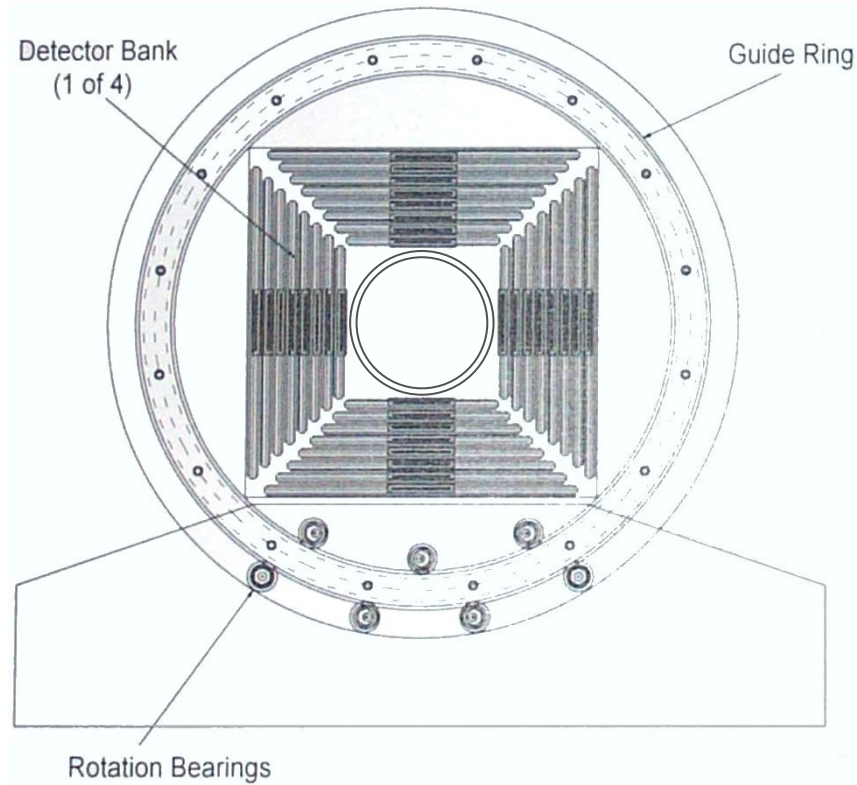


- Lead
- Insulator

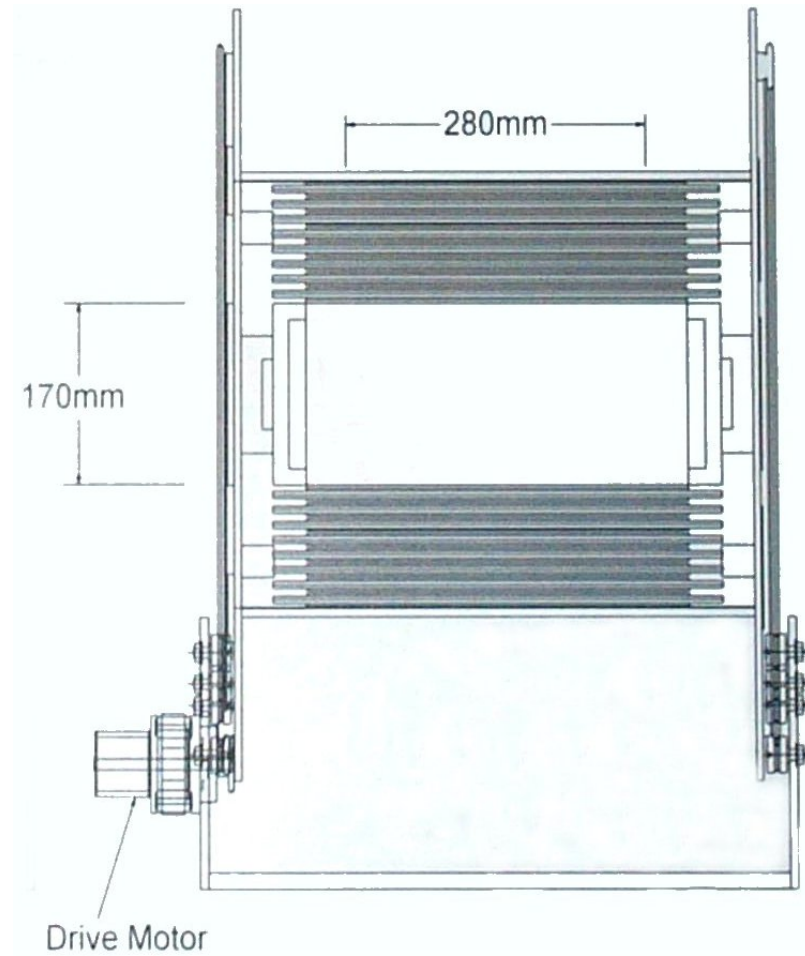
Quad HIDAC Detector



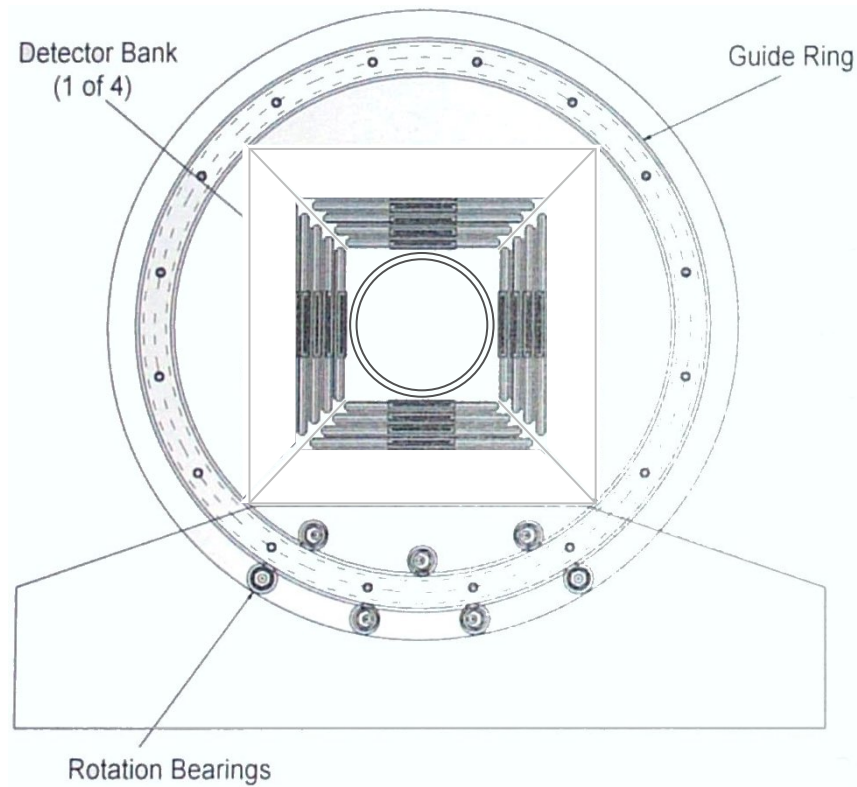
Quad HIDAC Camera



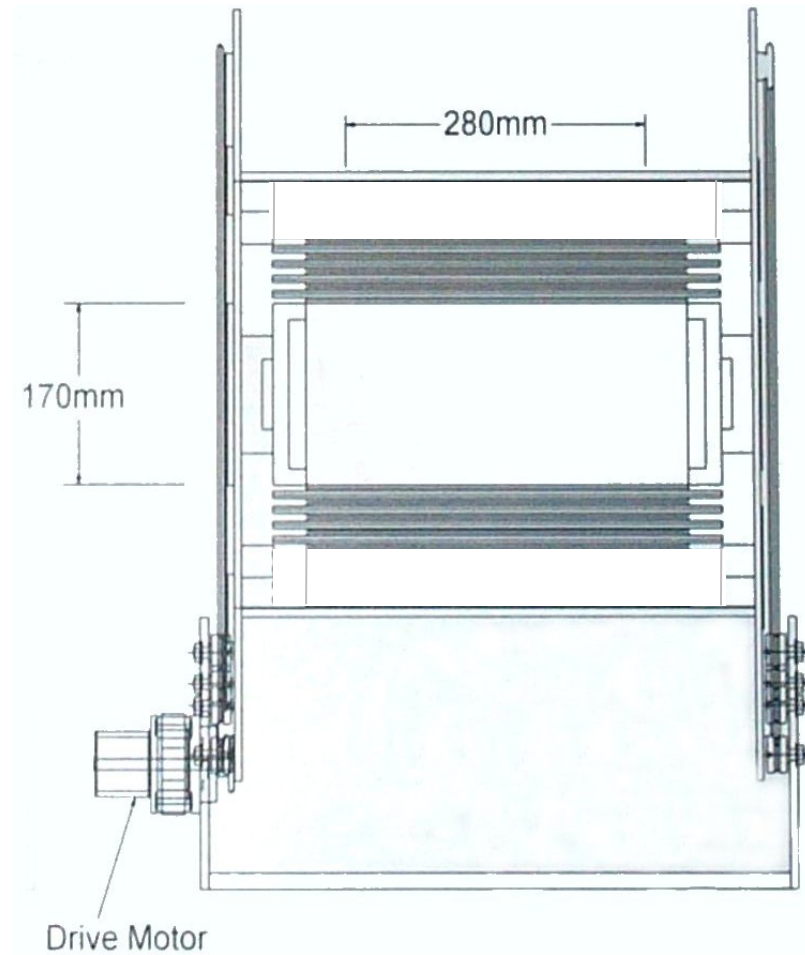
13 million sub-millimetre detectors



Quad HIDAC Camera



4 million sub-millimetre detectors



Spatial Resolution

Line source glass/polyamide tube

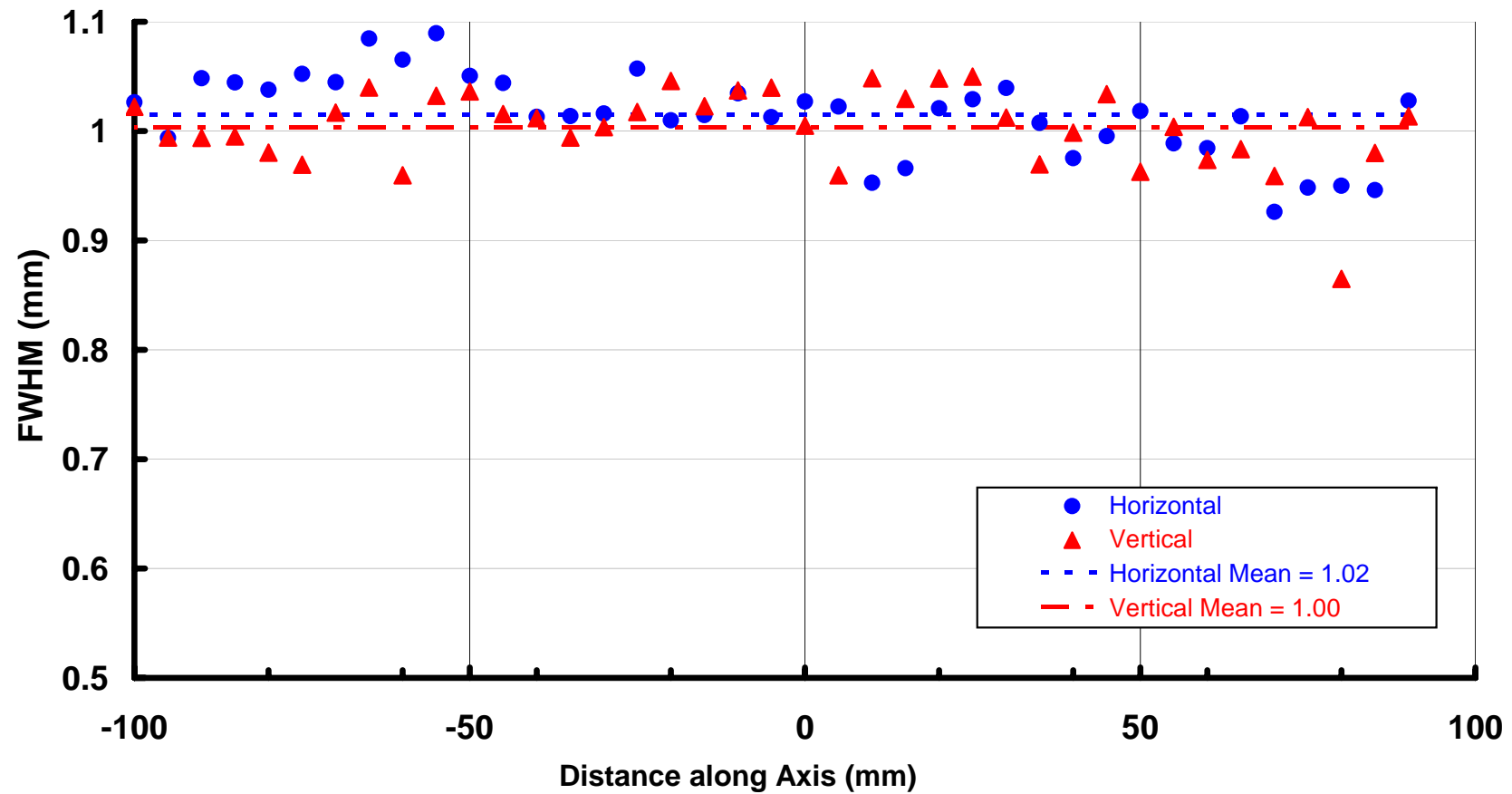
- **50 μ m internal diameter**
- **300 μ m external diameter**
- **^{22}Na concentration of 75 kBq/ml**

Iterative reconstruction

- **0.25mm voxels**
- **16 iterations**
- **1 subset**
- **no resolution modeling**

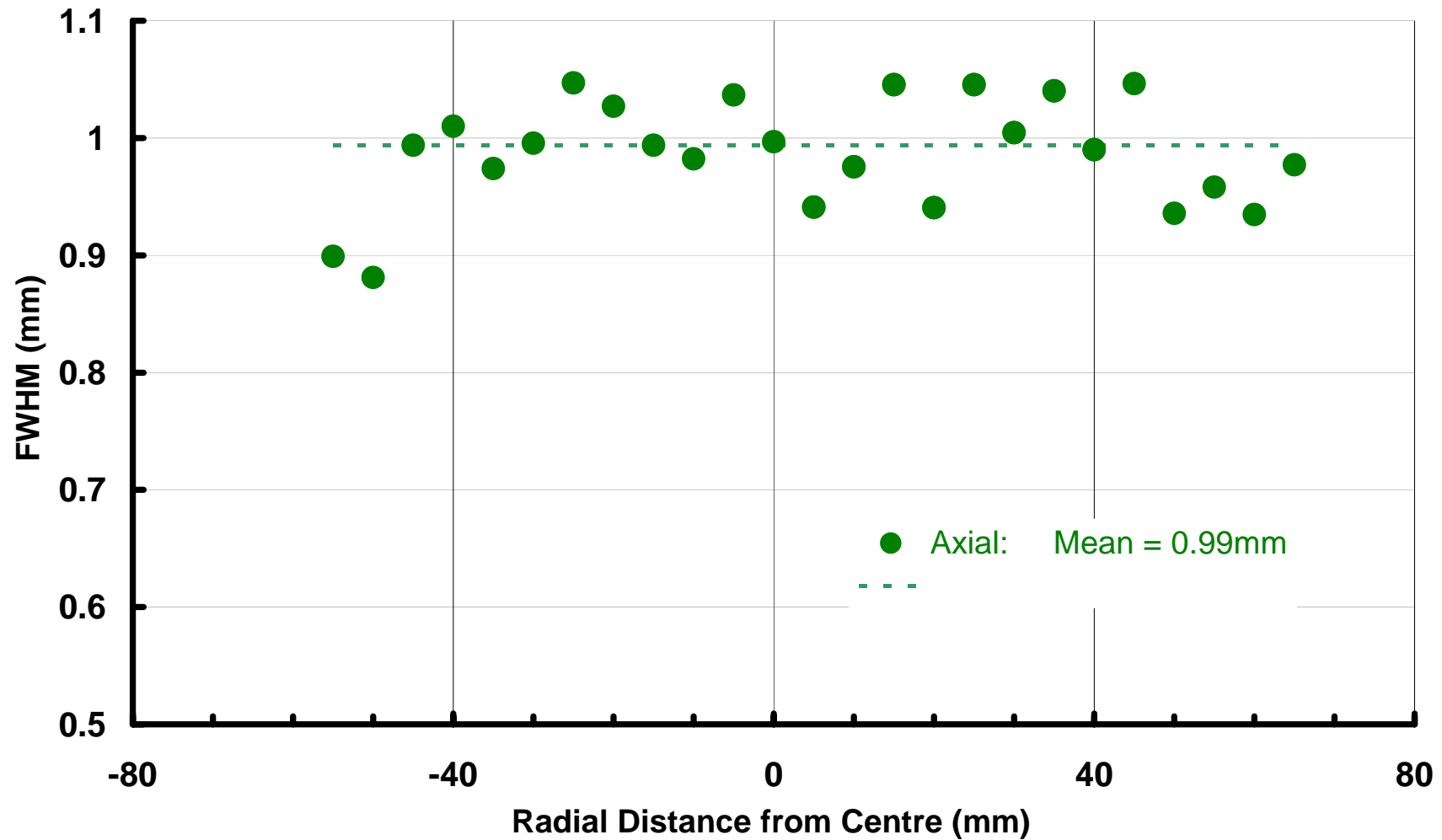
FWHM determined according to NEMA

Spatial Resolution Transaxial



Spatial Resolution

Axial Resolution



Spatial Resolution

FWHM (mm)

	Transaxial Horizontal	Transaxial Vertical	Axial
Mean	1.02	1.00	0.99
Max	1.09	1.05	1.05
Min	0.93	0.86	0.88
Standard Deviation	0.04	0.04	0.05

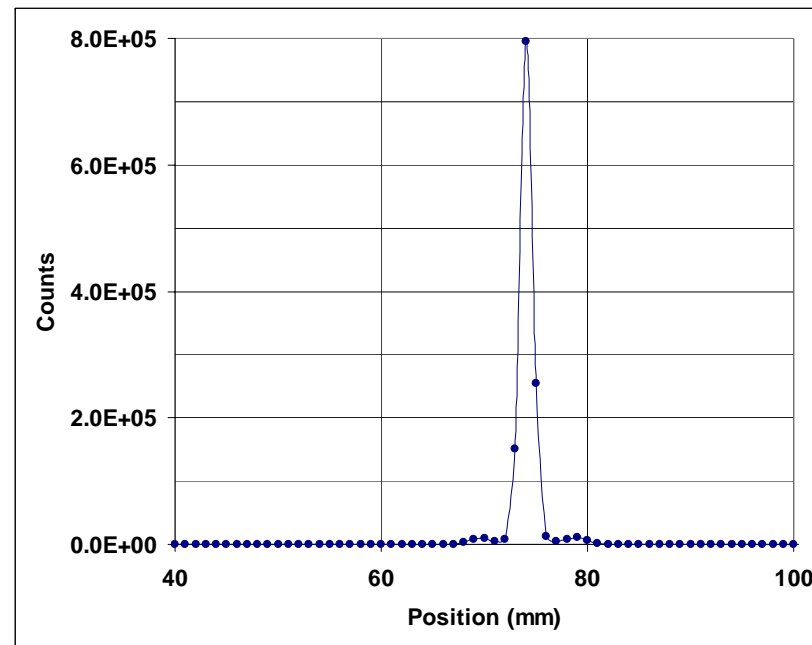
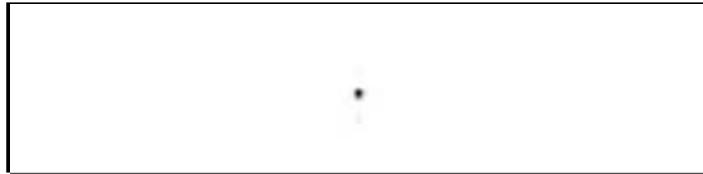
Sensitivity

- Point source of ^{18}F - 175.2 kBq
- Electroplated ^{18}F on tip of an Al wire
- 5mm blu-tack ball on tip as positron annihilator
- Iterative reconstruction
 - 1mm voxels
 - length = 250mm; diameter = 150mm
 - regularization = 0
 - resolution recovery = none
 - Iterations = 1, subsets = 32

Sensitivity

Point Source and Profile

PET image



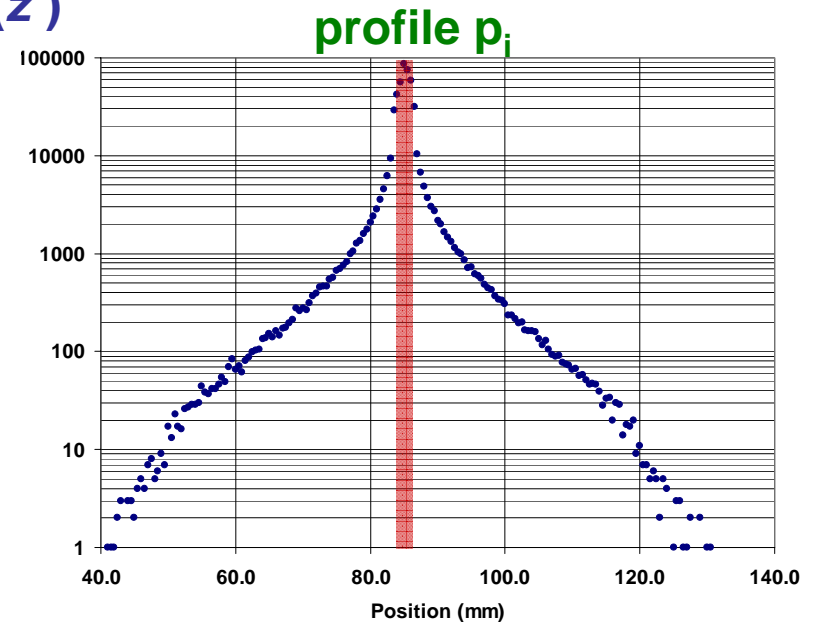
Sensitivity

$$S = \frac{\text{Events acquired}}{\text{Number of positron emissions during scan time}} \times 100\% = 0.95\%$$

$$S_c = \text{sensitivity corrected for scatter background} = 0.75\%$$

- Bin data into 2D parallel projections (bin size 0.5mm)
- Integrate over the 2D plane in the axial (z')
 - single 1D profile p_i (for $i=1\dots I$ bins)
- Trues are in +/- 1.5mm of peak
- Ratio of trues to scatter-background

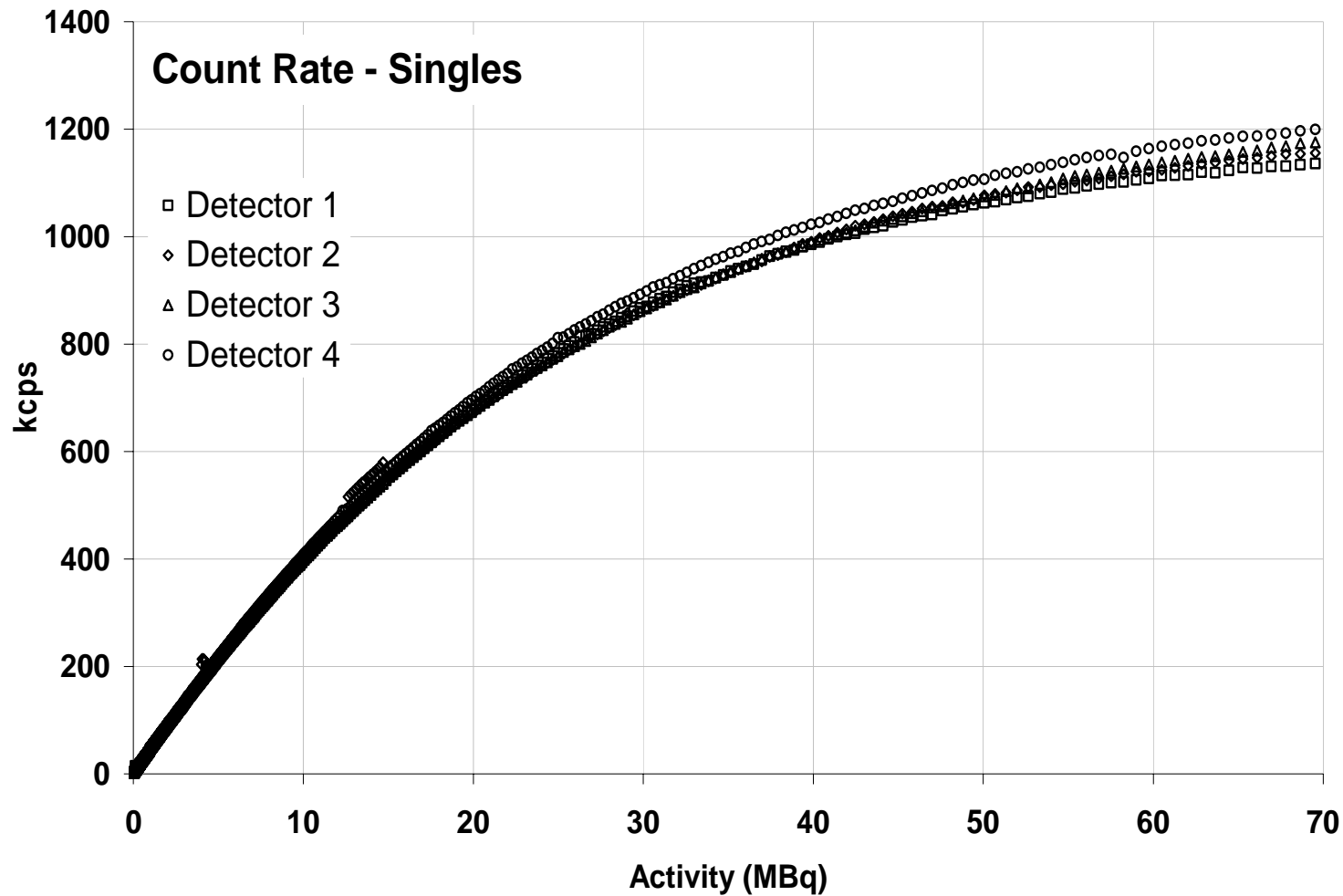
$$\frac{\sum_{i \in T} p_i}{\sum_{i=1}^I p_i} = 0.786$$



Count Rate Capability

- **Cylindrical phantom to simulate a mouse**
 - diameter 30mm, length 50mm
 - start activity = 74 MBq ^{18}F
- **List mode acquisition for 21 hours**
 - final activity = 0.04MBq
 - refresh rate 120 seconds
 - total coincidences, singles, randoms rates recorded

Count Rate Capability Singles



Count Rate Capability

Noise Equivalent Count Rate

$$T = (Totals - R) \times (1 - SF)$$

SF = scatter fraction = 29%
(Missimer 2004 *)

$$NECR = \frac{T}{1 + \frac{2kR}{T} + \frac{S}{T}}$$

T = trues rate
S = scatter rate
R = randoms rate

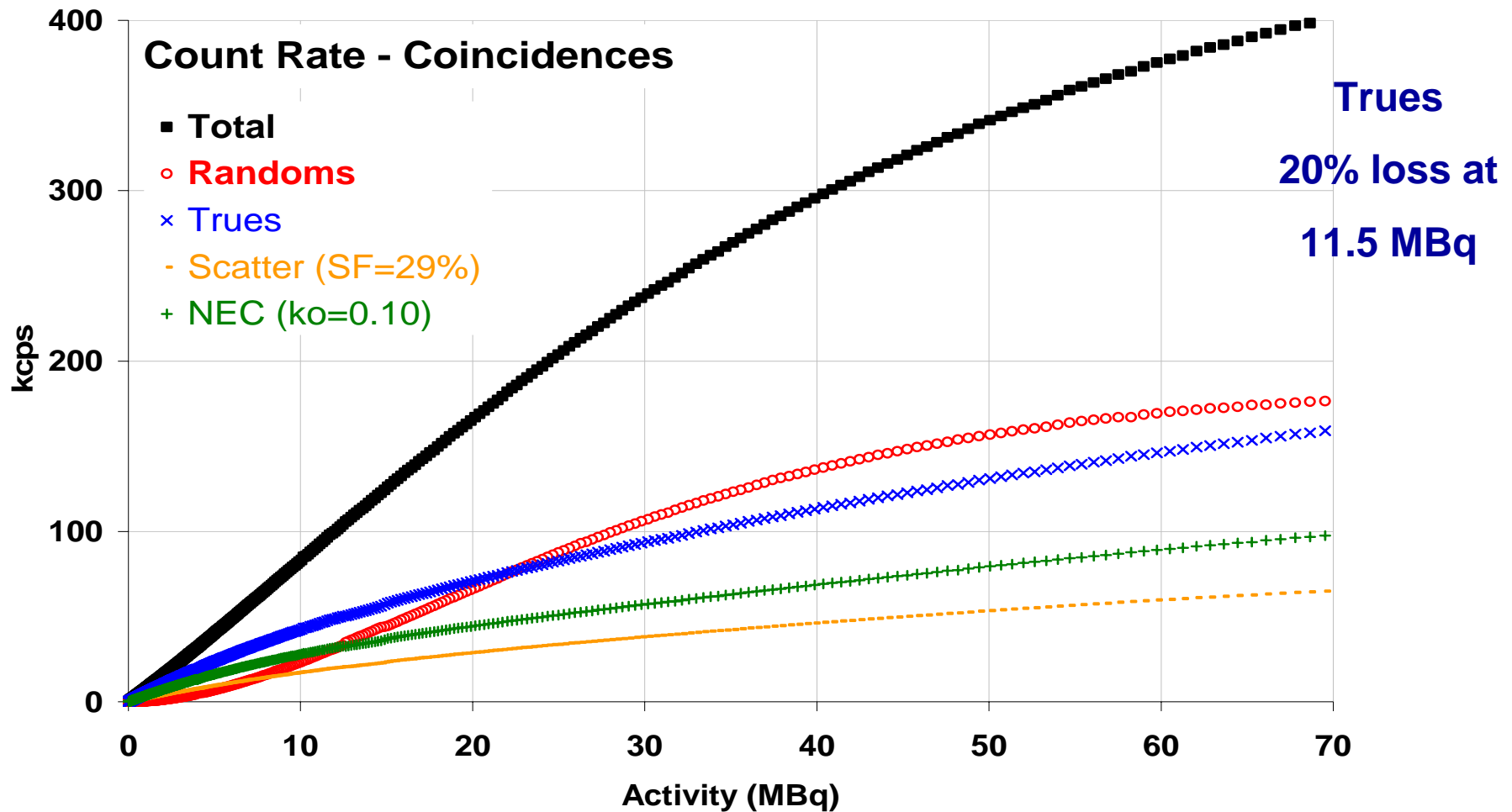
$$S = SF \times (Totals - R)$$

k = proportion of the object subtended
by the imaging device (?? 0.10)

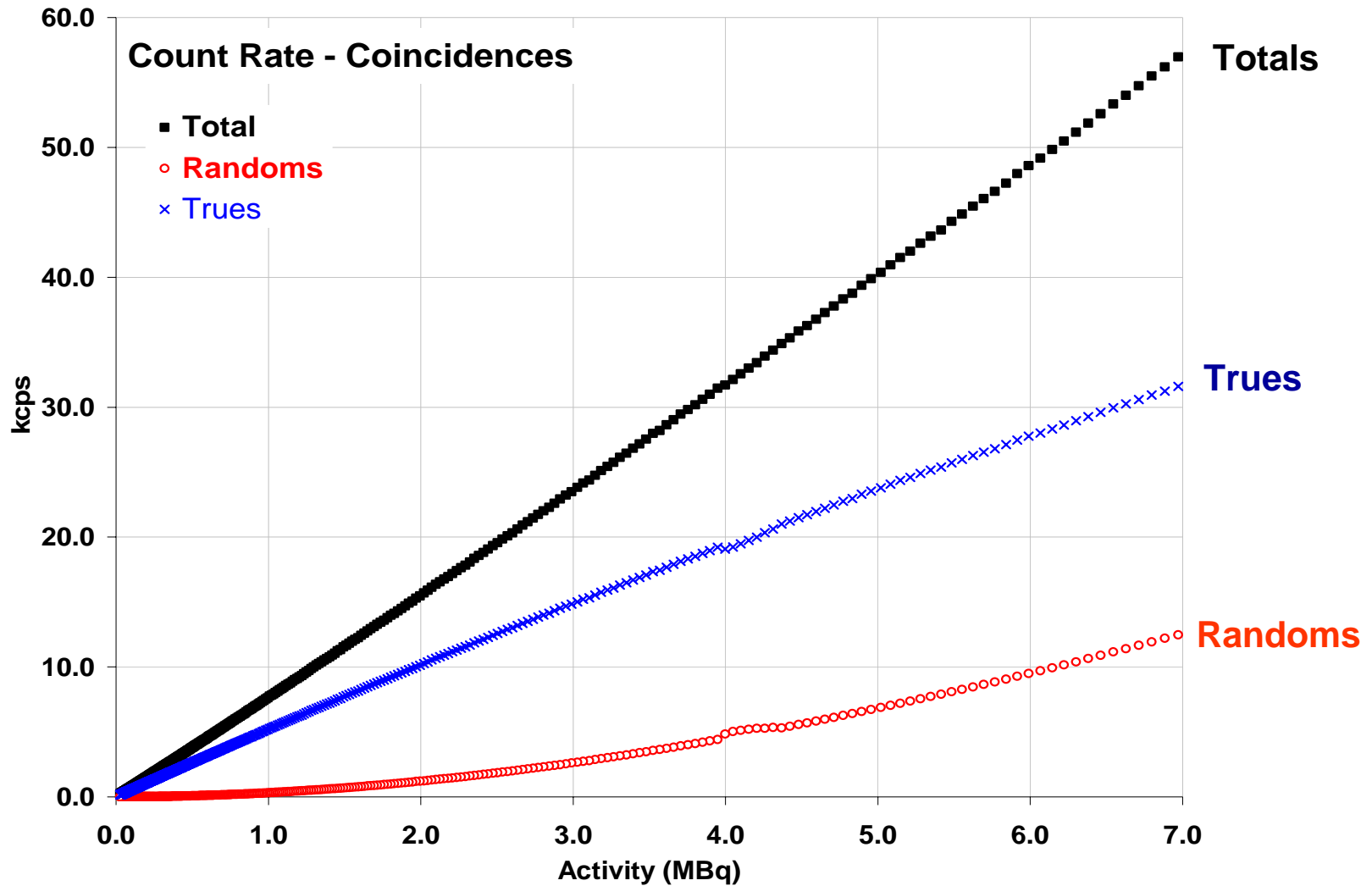
* Missimer et al, Phys Med Biol. 49 (2004) 2069-2081

Count Rate Capability

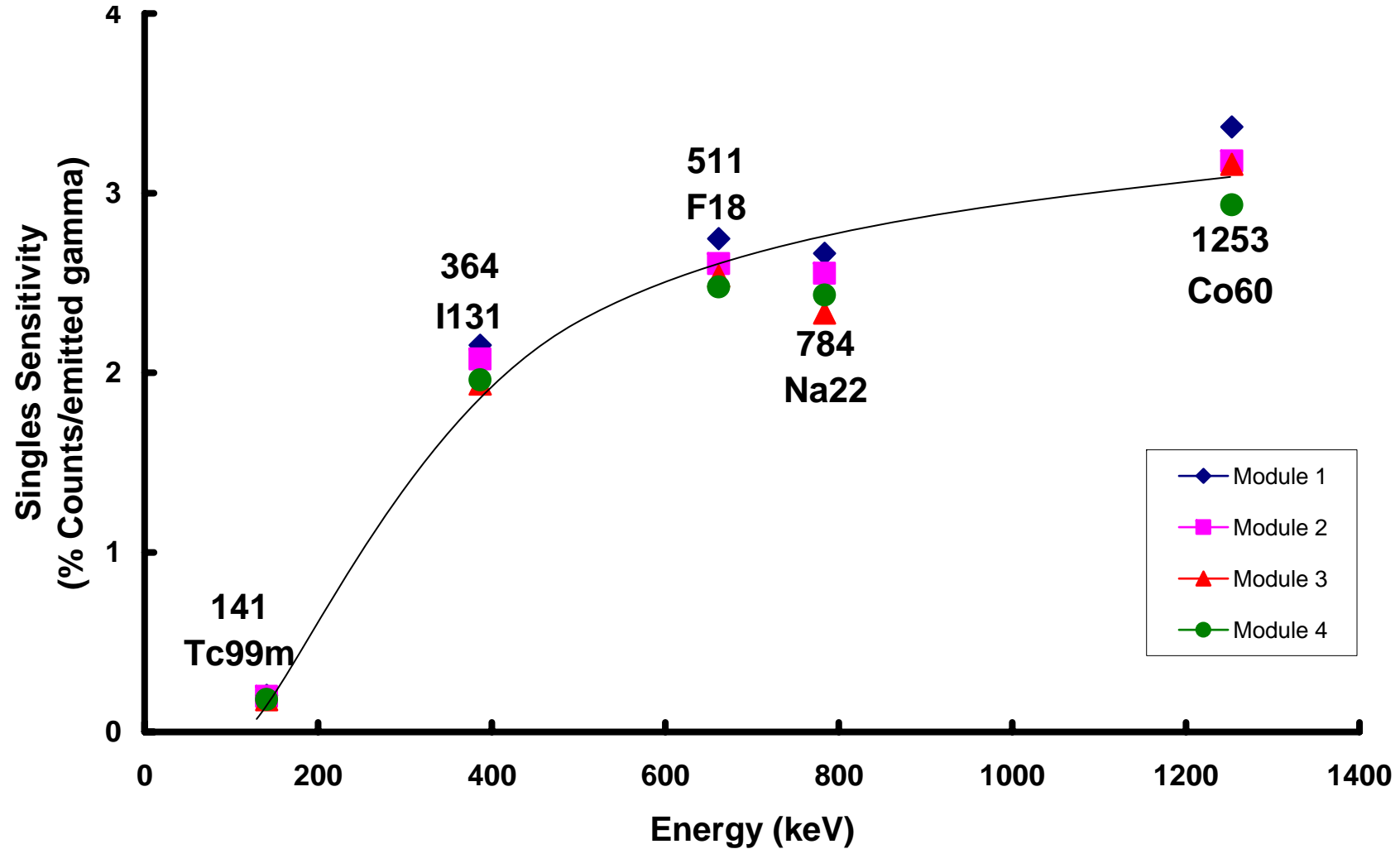
Coincidences



Count Rate Capability



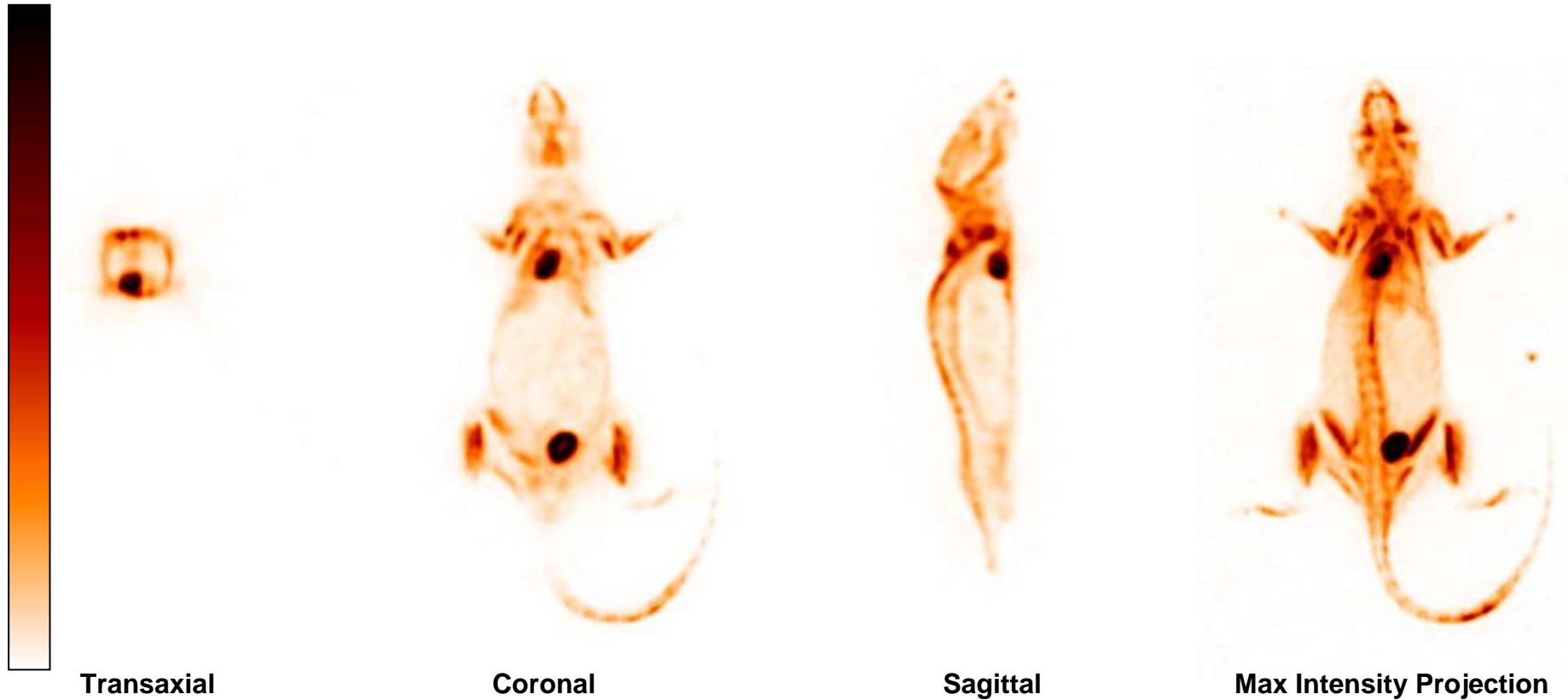
Energy Dependence of Efficiency



Summary of Results

Parameter	Measured
Spatial Resolution	Transaxial horiz 1.02 (0.04) Transaxial vert 1.00 (0.04) Axial 0.99 (0.05)
Sensitivity	Uncorrected = 0.95% Corrected = 0.75%
Count Rate	20% loss rate at 11.5MBq
Spatial Calibration	Deviation = 0.0 mm

PET Images of 18-FDG Mouse - 1



Mouse injected with 18-FDG
Image reconstructed into 0.5mm voxels
Slice thickness 0.5mm
Transaxial, Coronal & Sagittal slices centred on the heart

18F-Fluoride Bone Images in Mouse



Sagittal



Coronal

Courtesy: Munster University Hospital

It's a long road



It's a long road

