

Modification of a Medical PET scanner for PEPT Studies

Alireza Sadrmomtaz^{1,2}, David J Parker¹

¹School of Physics and Astronomy, University of Birmingham, Edgbaston, B15 2TT, UK

²Department of Physics, Gilan University, Rasht. PO Box 41365-1159, Iran

- **PET and PEPT**
- **Previous PEPT detector systems**
- **Development of modular PEPT system**
- **Results**
- **Future Plans**

PET (Positron Emission Tomography)

- PET → imaging concentration of radioactive tracer
- PET is widely used in medicine
- At Birmingham, PET used to study engineering processes

PET CHARACTERISTICS

1-Slow process

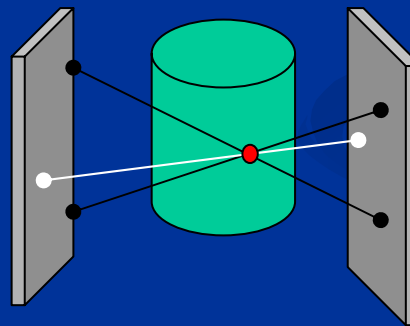
2-Requires at least 10^6 events to produce an image

3- Random and scatter events distort the image and can only partially be corrected after backprojection

PEPT (Positron Emission Particle Tracking)

1-This technique was invented at the University of Birmingham

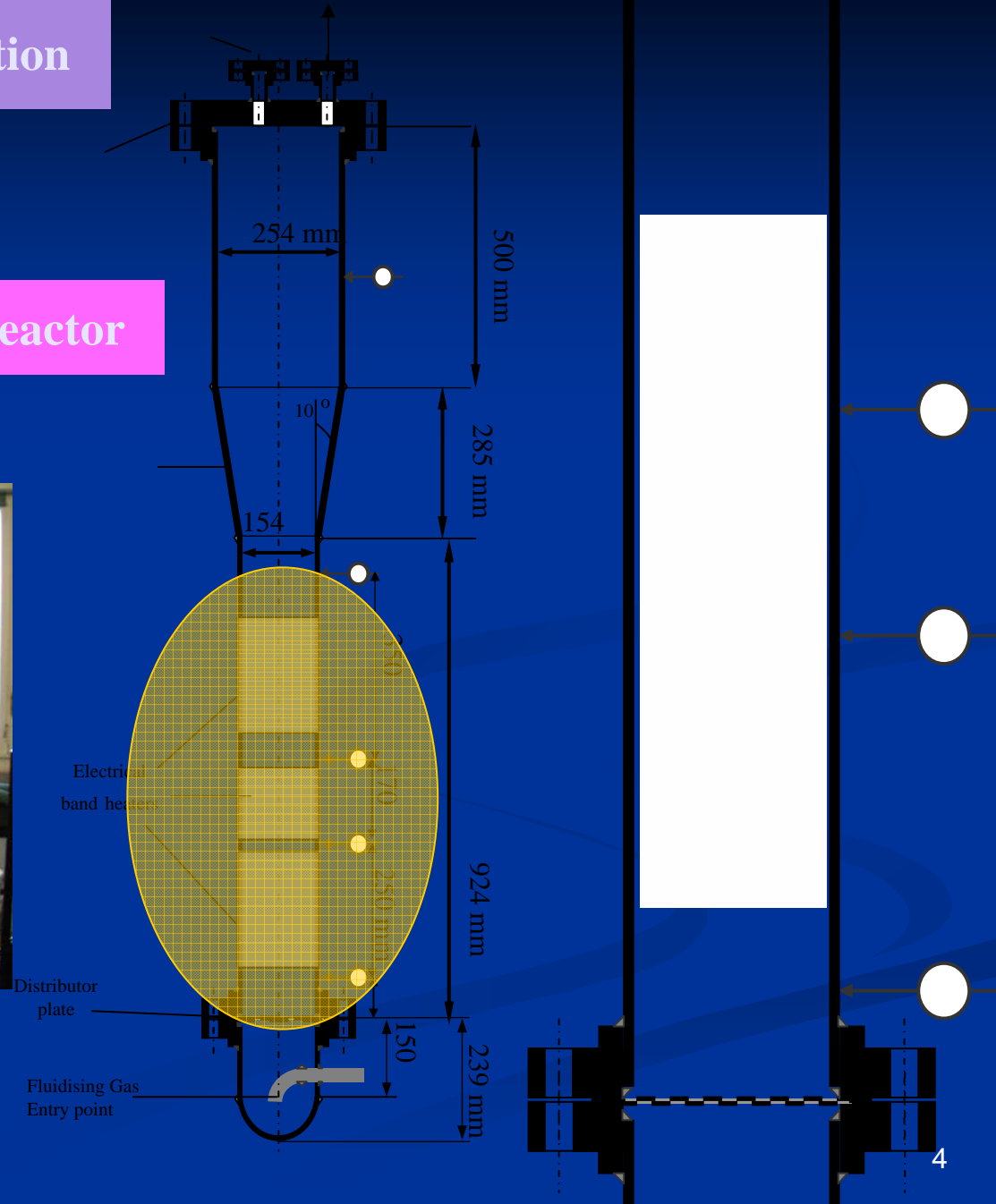
2-In PEPT a single tracer particle is introduced into the system. The location of this particle tracer can be determined from detection of a small number of pairs of back to back gamma rays, so that this can be achieved many times per second and the track of a particle can be reliably followed.



3-Powerful tool for studying the behaviour of granular materials in systems such as mixers and fluidised beds.

Example of PEPT application

High Pressure Fluidised Bed Reactor



PEPT CHARACTERISTICS

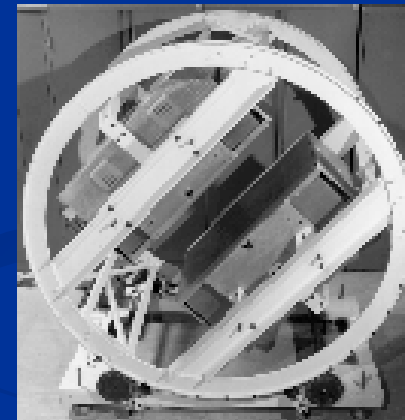
- 1-Single positron emitting particle is used**
- 2-Fast process**
- 3-Needs 10^2 events to calculate the location of tracer with accuracy around 1mm**
- 4-Random and scatter events will be discarded and do not contribute to calculation of location**
- 5-PEPT results show velocity and dynamical behavior of the system under investigation**

PEPT detector systems

1984-1999



Multiwire Proportional Chambers



1999



Replaced by ADAC gamma camera

ADAC Camera

- Consists of two digital gamma camera heads which are used in coincidence. Each head contains a single sodium iodide crystal $590 \times 470 \times 16 \text{mm}^3$ backed by 55 PMTs

Spatial resolution(PET)	6mm
Efficiency each head	23% total/16% photopeak
Max true coincidence rate	100kcps

Limitations of ADAC scanner

- 1- Limited count rate
- 2- Maximum head separation 75cm
- 3- Not transportable



ECAT 931 Scanner

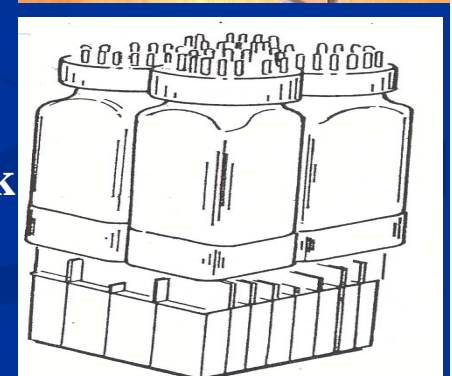
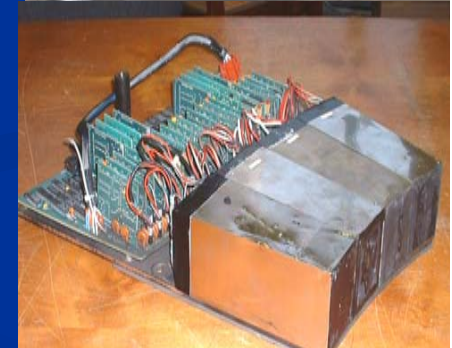
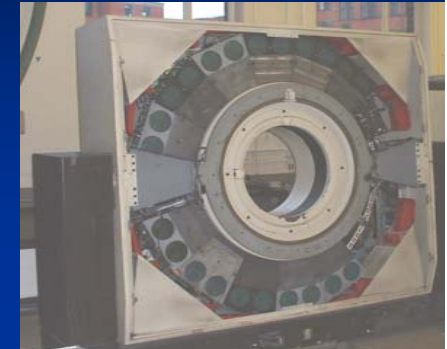
- Installed at Hammersmith Hospital 1987
- Presented to Birmingham University 2002
- Installed in Positron Imaging Centre 2003-4

Ecat scanner → **32 detector buckets**
arranged in two rings
each ring 16 detector buckets

Each bucket → **4 blocks**

Each block → **32 bismuth germanate crystals**
8×4 array
dimension 6x12mm² and 30mm thick
coupled to 4 PMTs

Total number of detectors → **4096**



Idea

Reconfigure ECAT 931 buckets as PEPT system

- 1-Higher count rate
- 2-Modular
- 3-Flexible geometry allowing PEPT tests on larger systems
- 4- Mobility

New geometry

- Two rectangular arrays of buckets
- Buckets spaced to maximise field of view without allowing any gaps

Horizontal centre to centre spacing —→ 380 mm, with a gap of 180mm between buckets

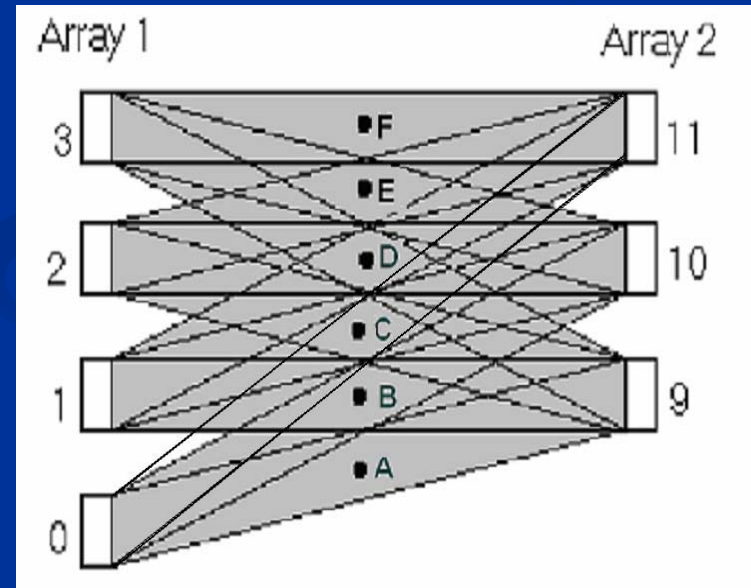
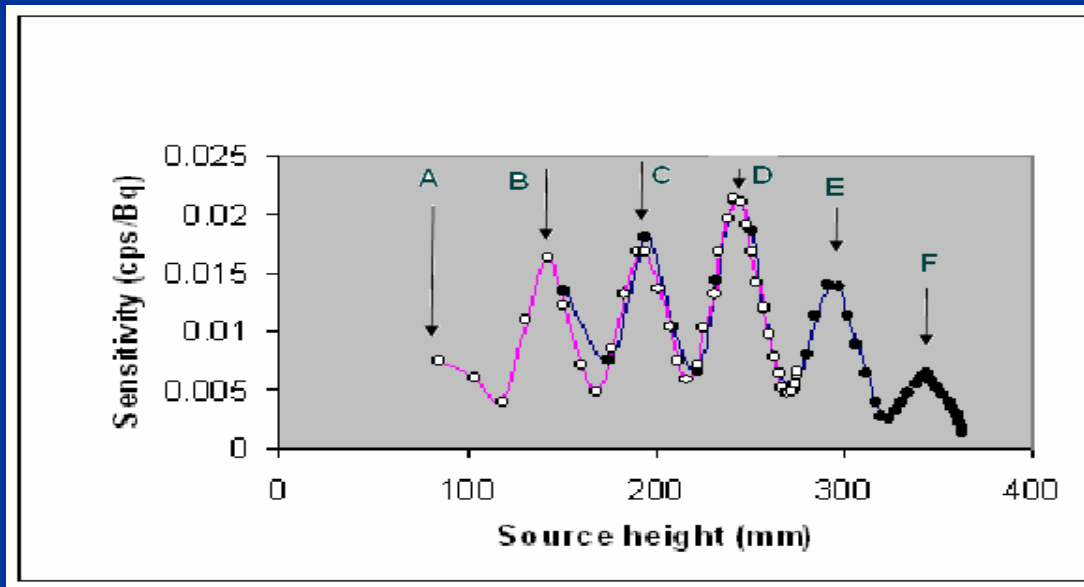
Vertical centre to centre spacing —→ 100mm, with a gap of 44mm between buckets for this work (can be adjusted)

Number of buckets used —→ 14, four pairs mounted on one half frame and three pairs on the other



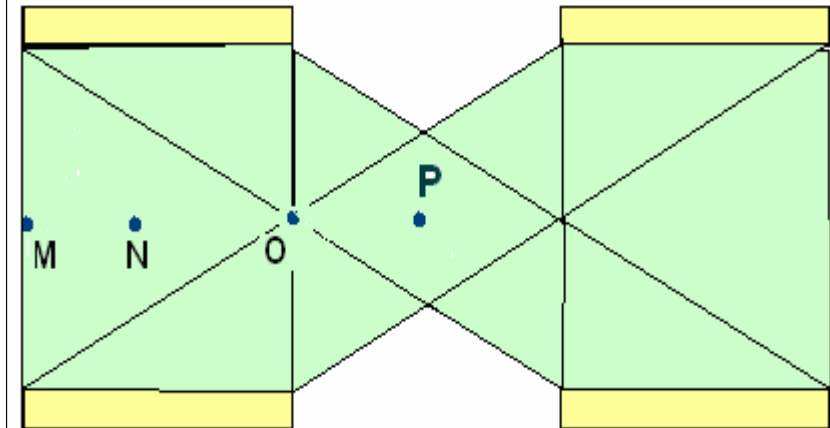
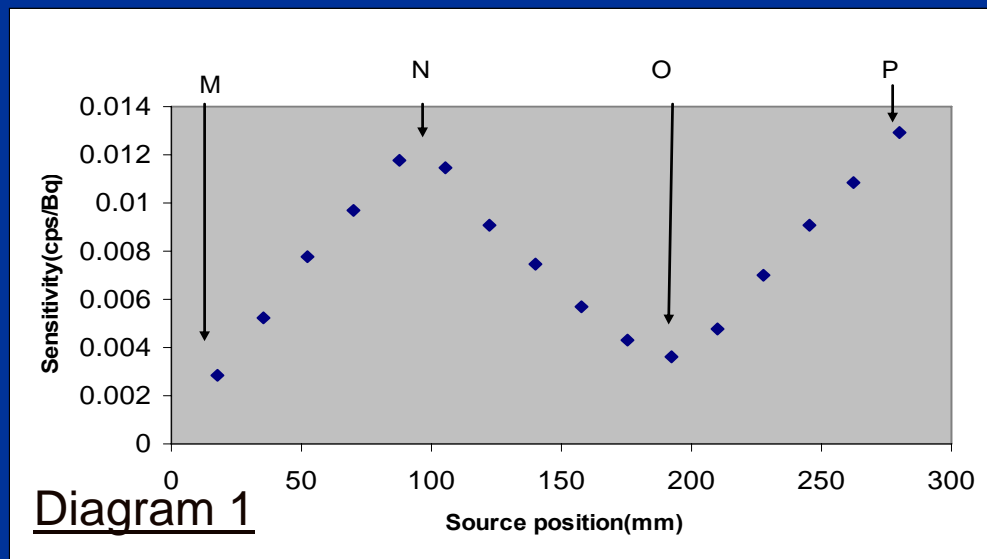
Vertical variation in sensitivity

- Diagram 1 shows the variation of measured sensitivity along the central vertical axis
- Highest sensitivity obtained was around 2×10^{-2} cps/Bq



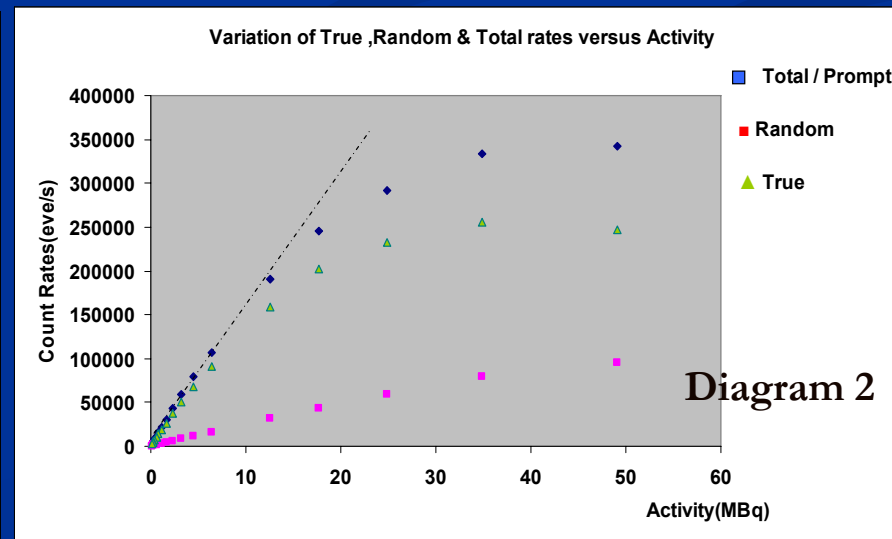
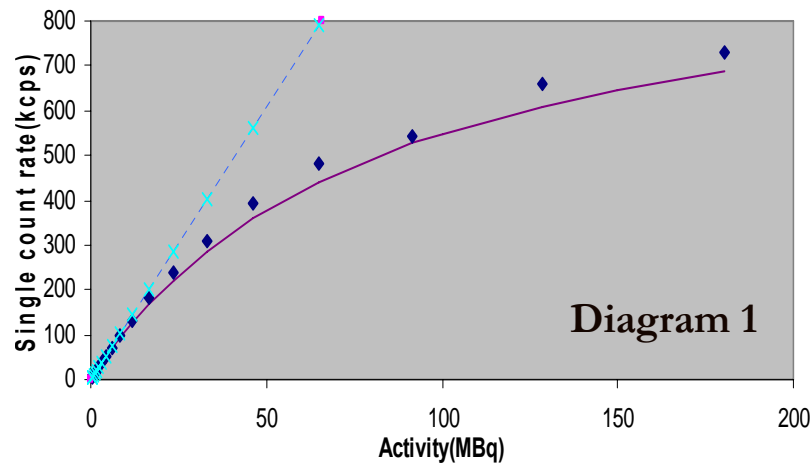
Horizontal variation in sensitivity

- Diagram 1 shows the variation of sensitivity along a horizontal axis
- The efficiency achieved for each block was approximately 50%



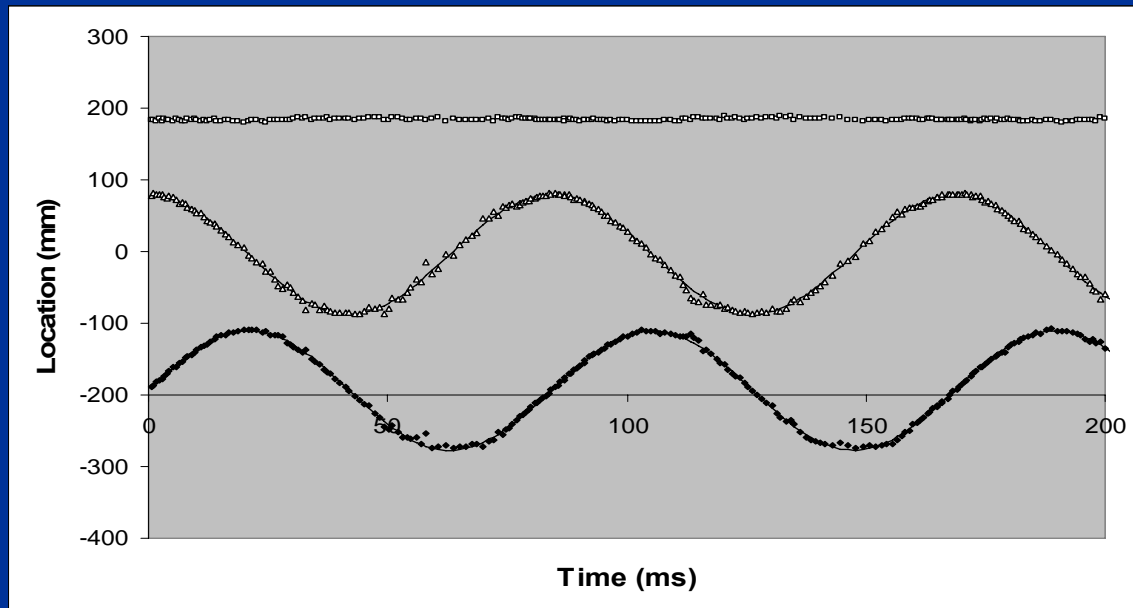
Count rate

- Diagram 1,2 shows the variation of singles and coincidence count rates with activity (measured using a decaying source)
- The highest coincidence count rate was about 250 kcps (2.5 times that of ADAC)



Source on a turntable

- Diagram shows PEPT results from tracking a source on a turntable mounted at level F and rotating at approximately 12rev/s (6 m/s)
- Approximately 110 kevents/s were recorded giving approximately 1100 PEPT locations per second with an accuracy of 1.4 mm in 1D, 4.7mm in 2D and 5mm in 3D



Compared with ADAC

	ADAC camera	New Configuration
Singles efficiency	23%	50%
Max true coincidence rate(kcps)	100	250
Accuracy for PEPT(1D)	1mm	1.4mm
PEPT locations/s	300	1100
Speed of particle (m/s)	2	6

Future plans

- Spread out blocks within each bucket to reduce variations in sensitivity
- Use more buckets (up to 32)
- PEPT measurements on large vessels
- This modular system is transportable, and will be used to perform PEPT studies outside Birmingham