

Status and further perspectives for small animal PET machines

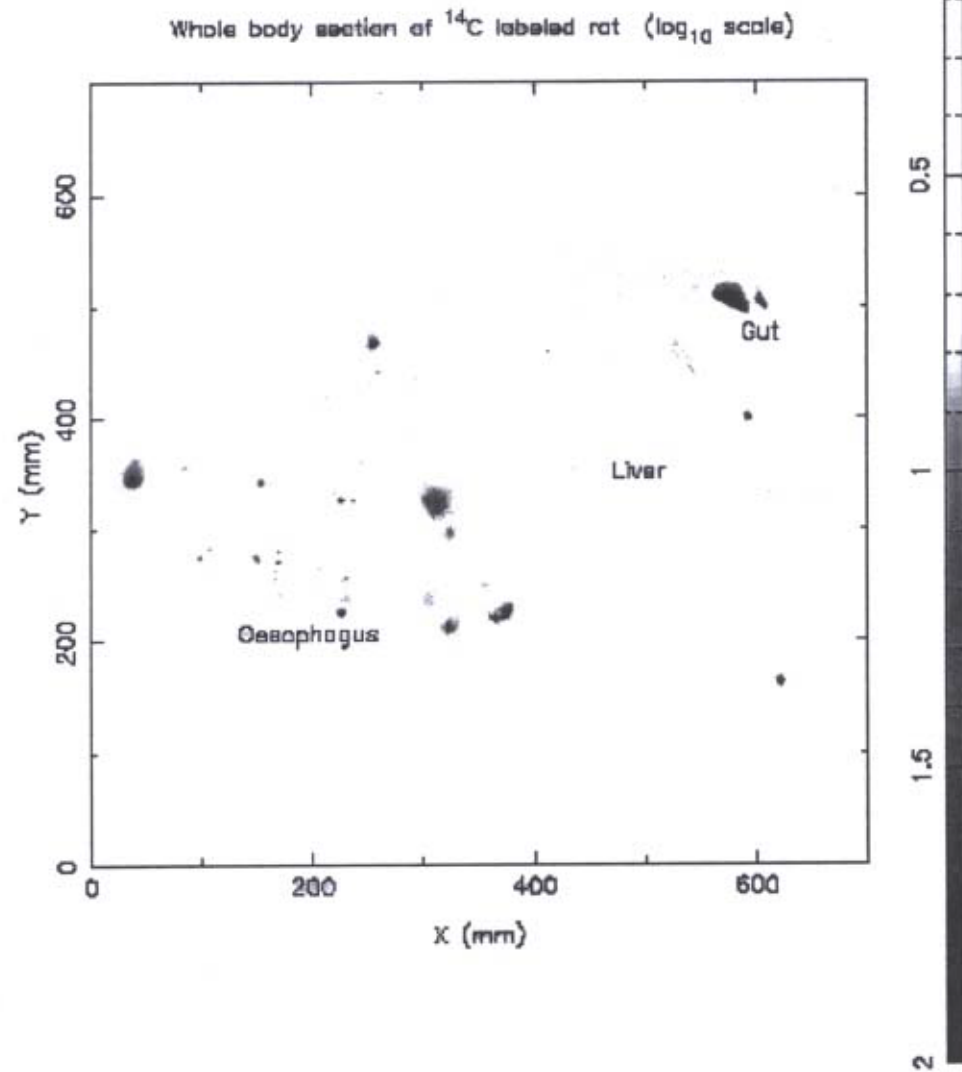
Stefaan Tavernier

VUB

Calor-2000, Annecy, France

- Why small animal PET?
 - ◆ Drug development
 - ◆ Evaluation of protocol

- But autoradiography is inexpensive and gives much better images



Yes, but large series of animals are needed

- State of art in clinical PET machines
 - ◆ Block detectors
 - ◆ 3-4 mm spatial resolution

- Resolution not sufficient for small animal PET scanner

- Count rate!

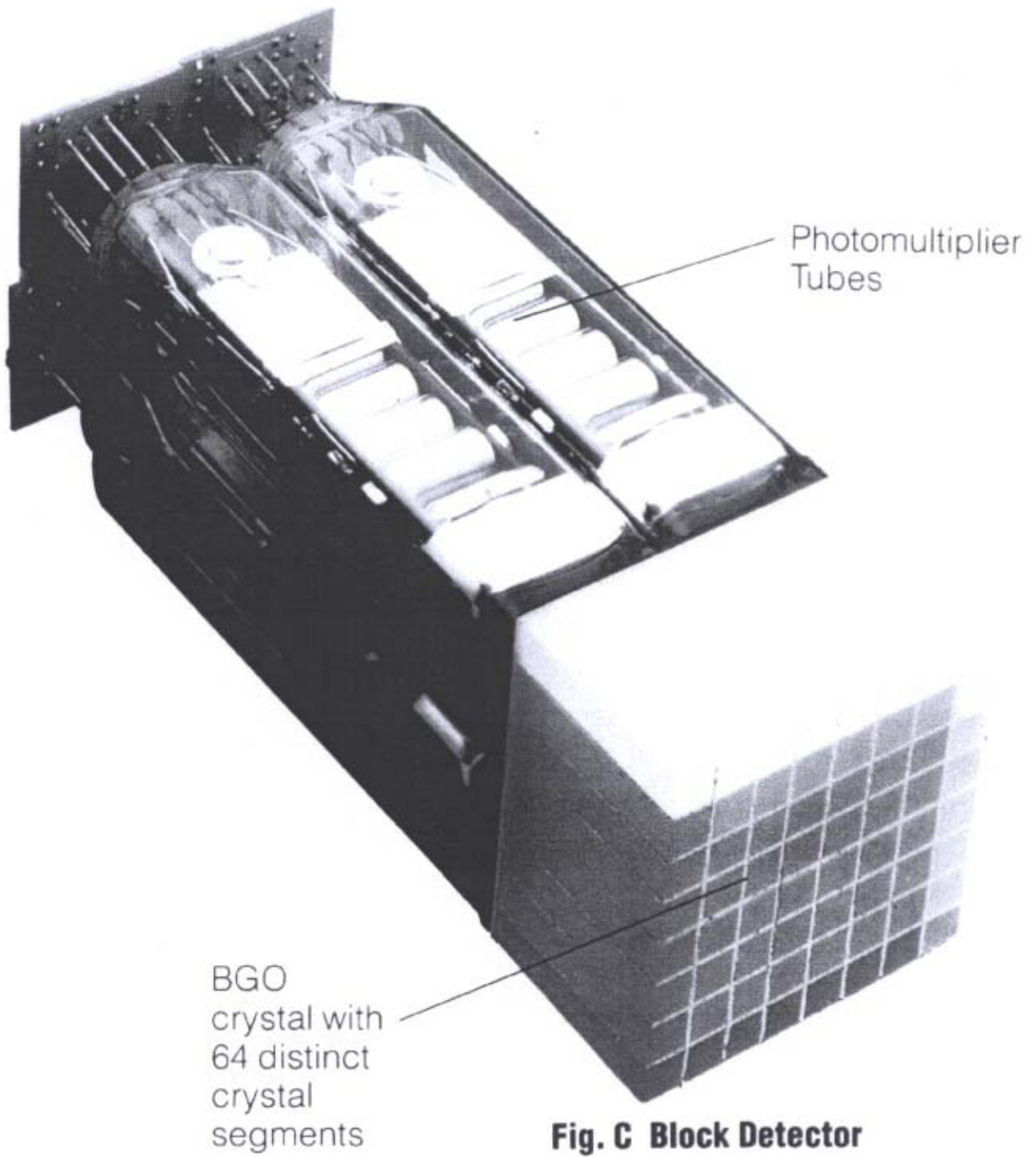


Fig. C Block Detector

How many events do we need to make a PET image

$$N \approx \left(\frac{L}{\sigma}\right)^4 \cdot \left(\frac{A}{\Delta A}\right)^2.$$

- Image of a brain
 - ◆ resolution $\sigma = 5\text{mm}$
 - ◆ $\Delta A/A = 7\%$

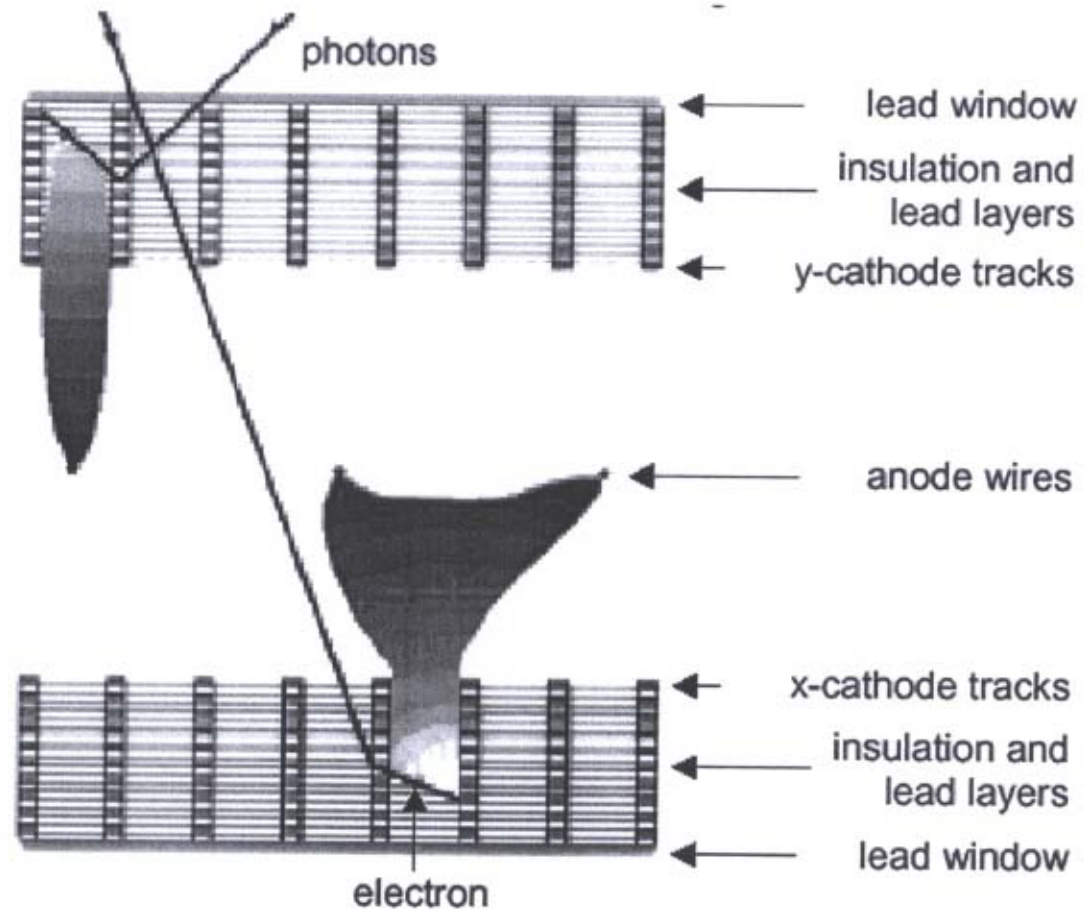
- Need $2.5 \cdot 10^9$ events

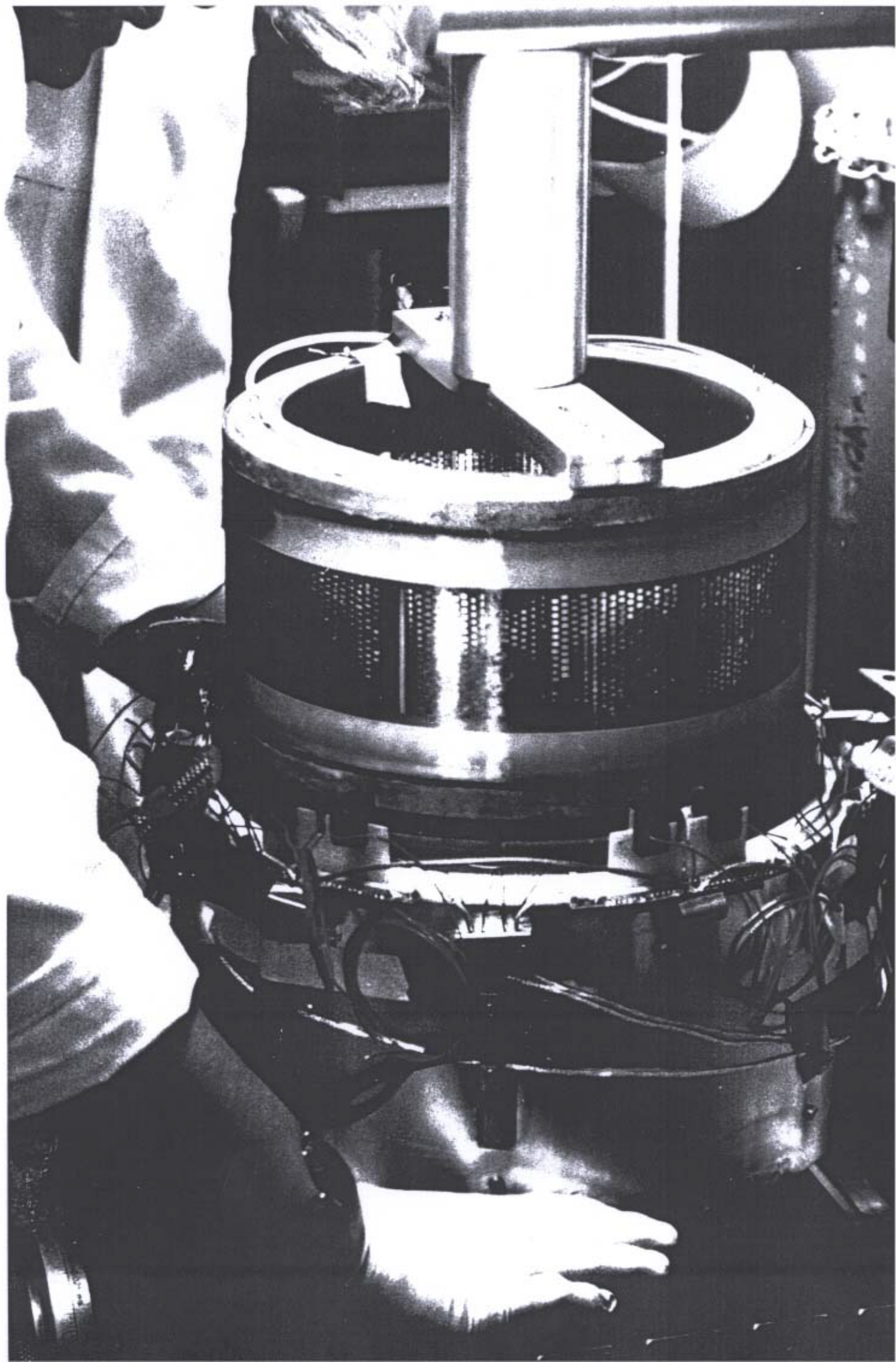
- Requirements for a Small animal PET
 - ◆ 1-2 mm
 - ◆ Sufficient sensitivity
 - ✦ Large solid angle
 - ✦ High detection efficiency

- Difficult to reach the desired resolution with bloc detector, we need something else
 - ◆ Wire chamber like detectors
 - ◆ Position sensitive PMT
 - ◆ Avalanche photodiodes

Early designs : in the 70ties

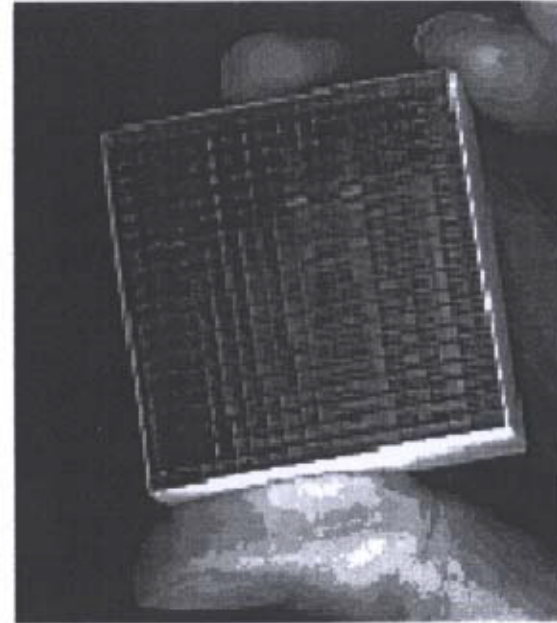
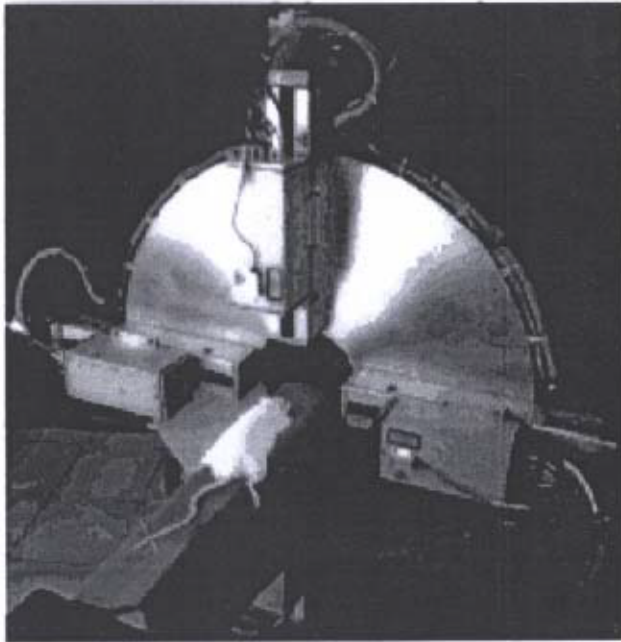
HYDAC-PET : lead converter Wire Chamber combinations





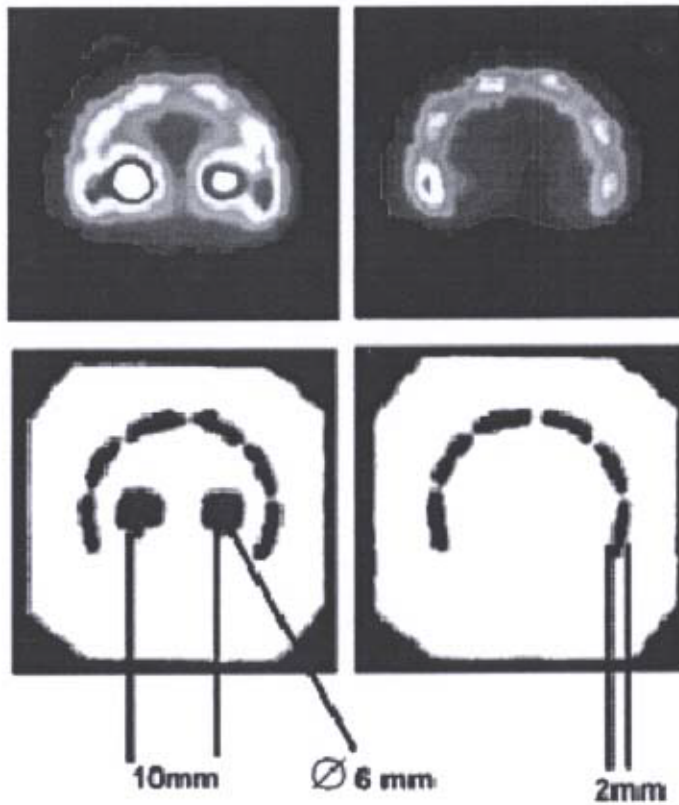
Position sensitive PM and YAP matrix

TierPET Julich

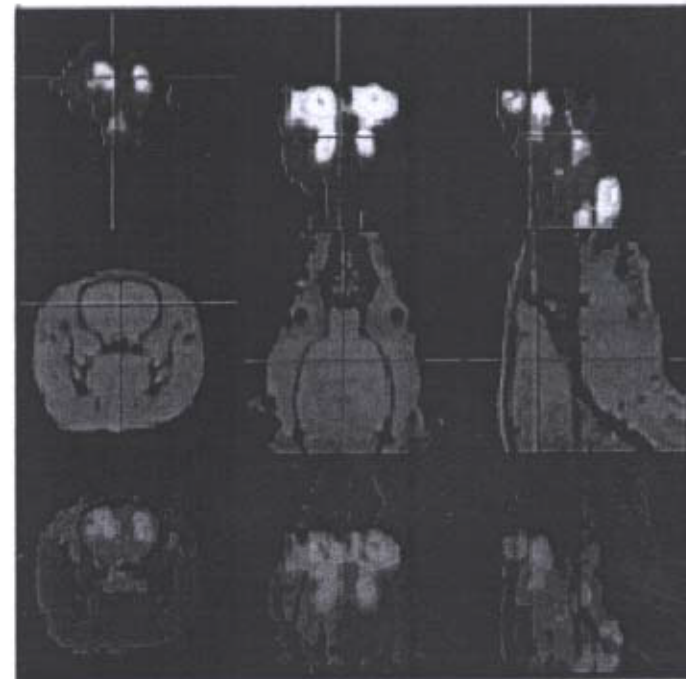


Results with TierPET (Julich)

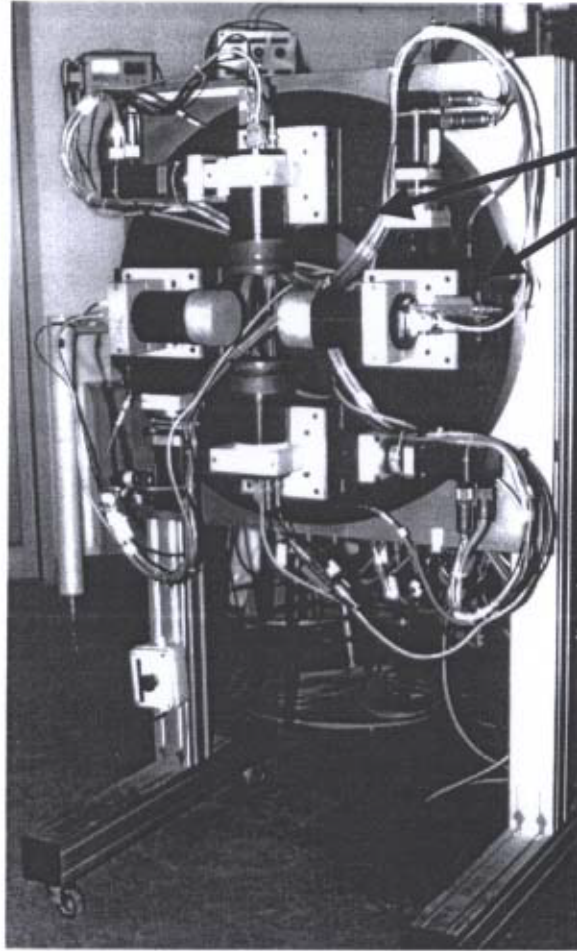
Rat brain phantom



PET image superimposed o MRI image

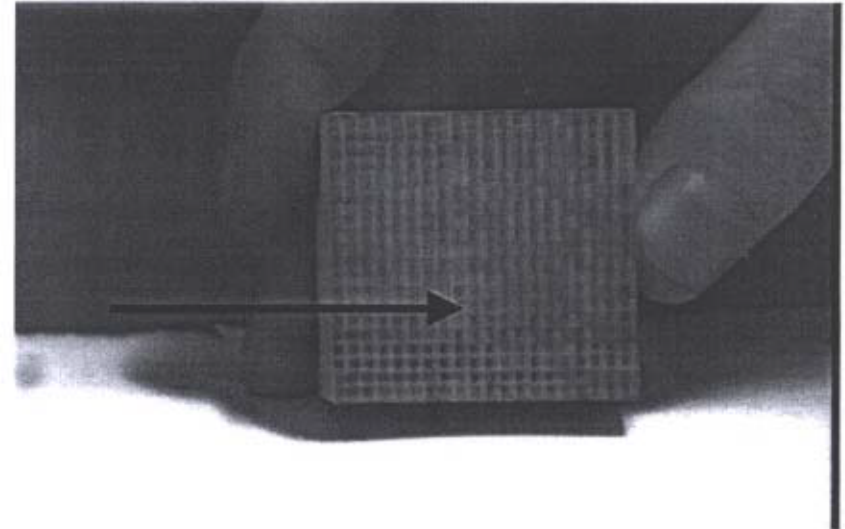


Animal PET / SPECT



PSPMTs

YAP:Ce
Scintillator
(2x2x30 mm)

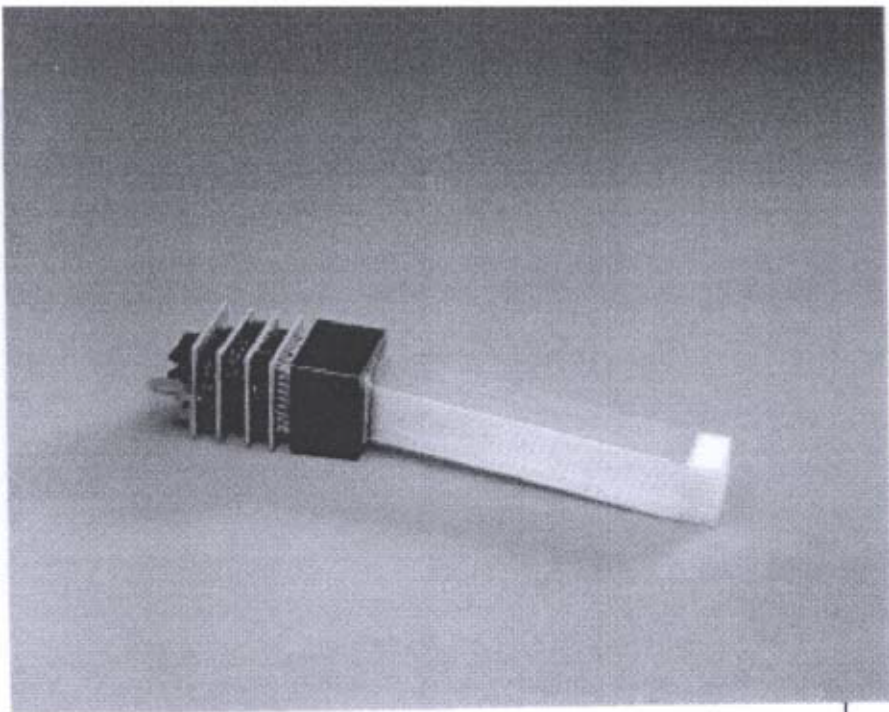


- Dual Modality (PET/SPECT)
- New Scintillator (YAP:Ce)
- Position Sensitive PMT
- Small Animal Imaging

*Image courtesy of Alberto DelGuerra, Dept.of Physics, Univ. of Pisa



1000



CONCORDE MicroPET is the only commercially available system

Spatial resolution is $\approx 2\text{mm}$.



PIN diodes?

- Noise of the amplifier ≈ 1000 electrons ($\tau = 250\text{ns}$, 10 pF)
- PIN diodes

Scintillator	Light Yield in electron-hole pairs (QE=60%)
BGO	620
LSO:Ce	5600
YAP:Ce	1800

Avalanche Photodiodes

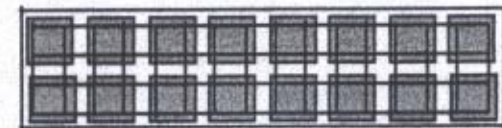
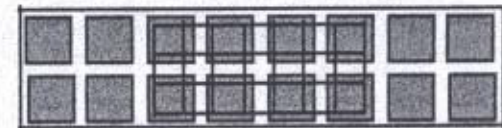
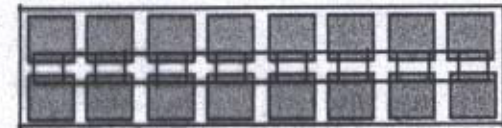
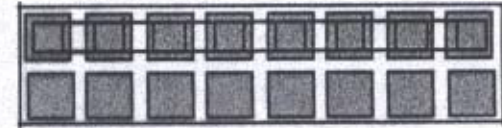
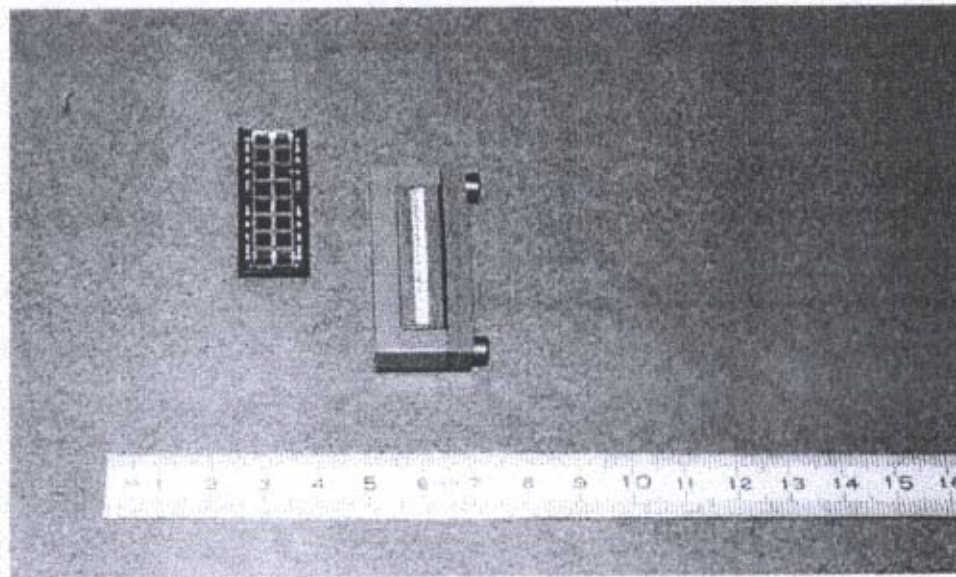
- Internal gain 50-500
- QE \approx 60-80%
- Capacitance \approx 10pF/mm
- Excess noise factor \approx 2.5
- Can be subdivided in pixels at no extra cost
- Cost ? Large quantities \approx 100 \$/cm²
(CMS-ECAL price)

APD-Scintillator configurations

* 2 x 2 x 10 mm³

Discrimination :

- only 1 APD > threshold
- 2 adj APD's > threshold
- (- 4 adj APD's > threshold)



Other APD Suppliers . Radiation Monitoring Devices

PET-ARRAY
Pixel area = 2.1 x 2.1 mm

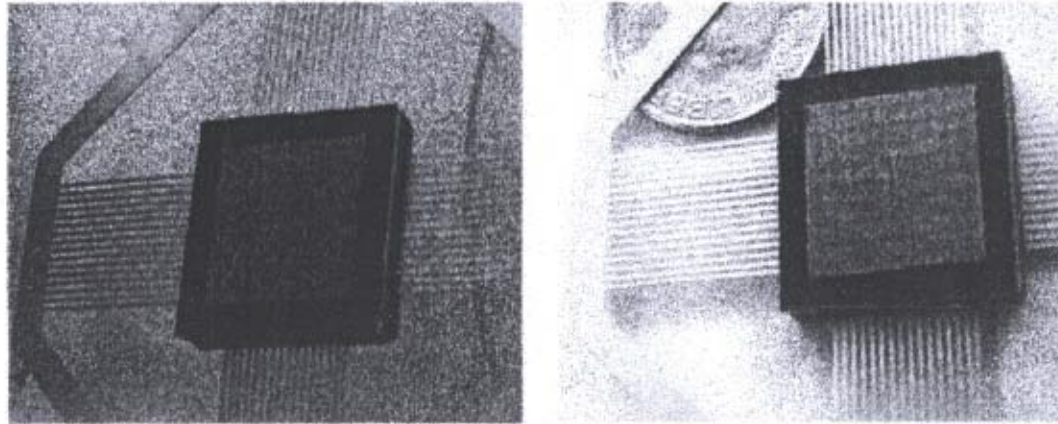
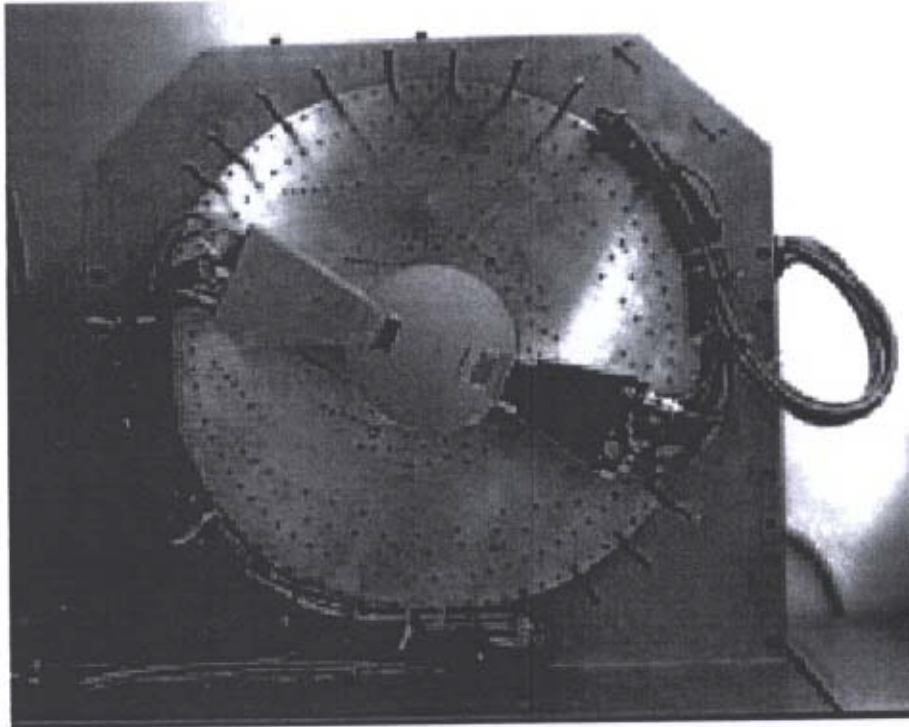


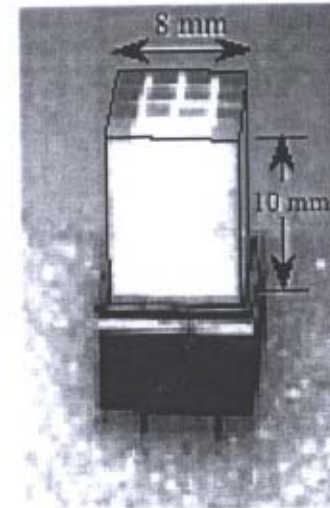
Figure 4. Photographs of packaged APD arrays. (left) 4 X 4 elements for PET
(right) 8 X 8 elements for SciFi.

R. Farrell, RMD, presented at Beaune99

Prototype APD-LSO PET scanner with 2
modules,
(from Pichler et al. Munchen)



Lecomte et al.
APD block detector



conclusions

- There is a real demand for small animal PET scanners
- Position sensitive PMT's and APD's seem presently the most promising techniques
- Evolution of the cost of APD's and position sensitive PMT's will determine which technique will eventually win