First Applications of the YAPPET Small Animal Scanner

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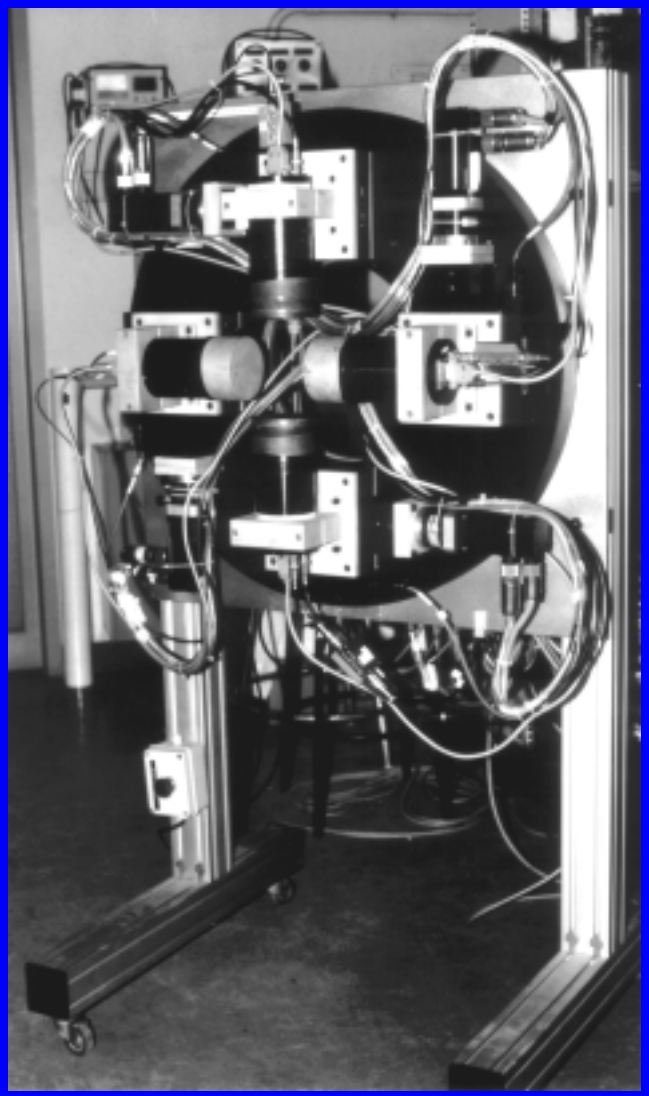
YAP-PET scanner



- **Scintillator: YAP:Ce**
- **Size: matrix of 20x20 match like crystals 2x2x30 mm^3 each**
- **Photomultiplier: Hamamatsu 3 inch position sensitive mod. R2486**
- **Configuration: 4 detector heads mounted on a rotating gantry**
- **FOV: 4 cm axially, ø = 4 cm**
- **Application: small animal**

YAP:Ce crystal

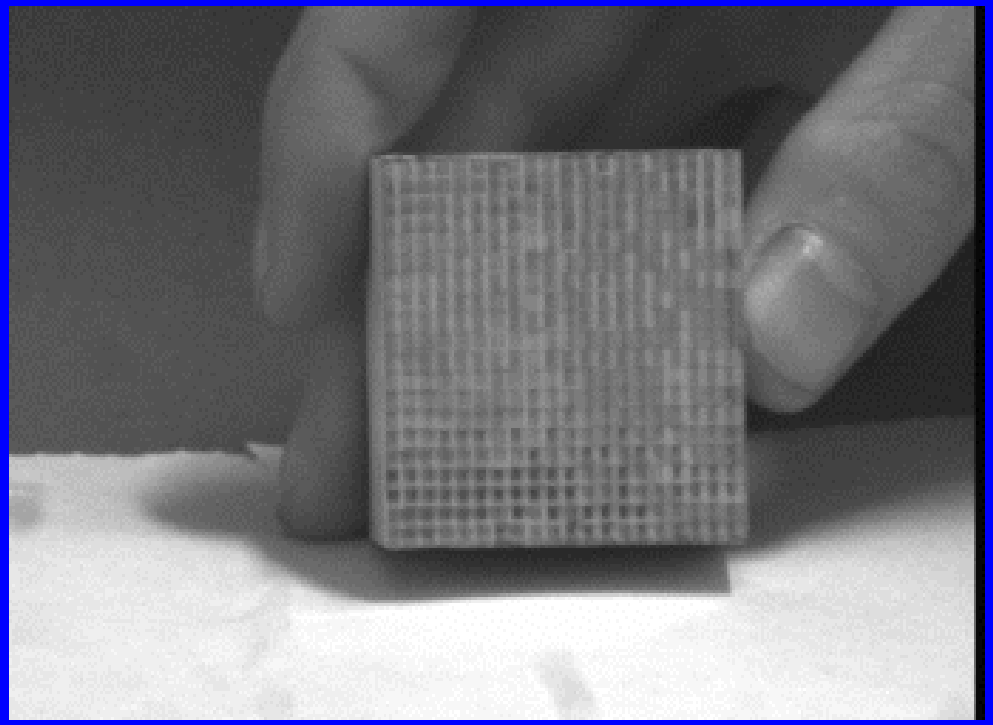


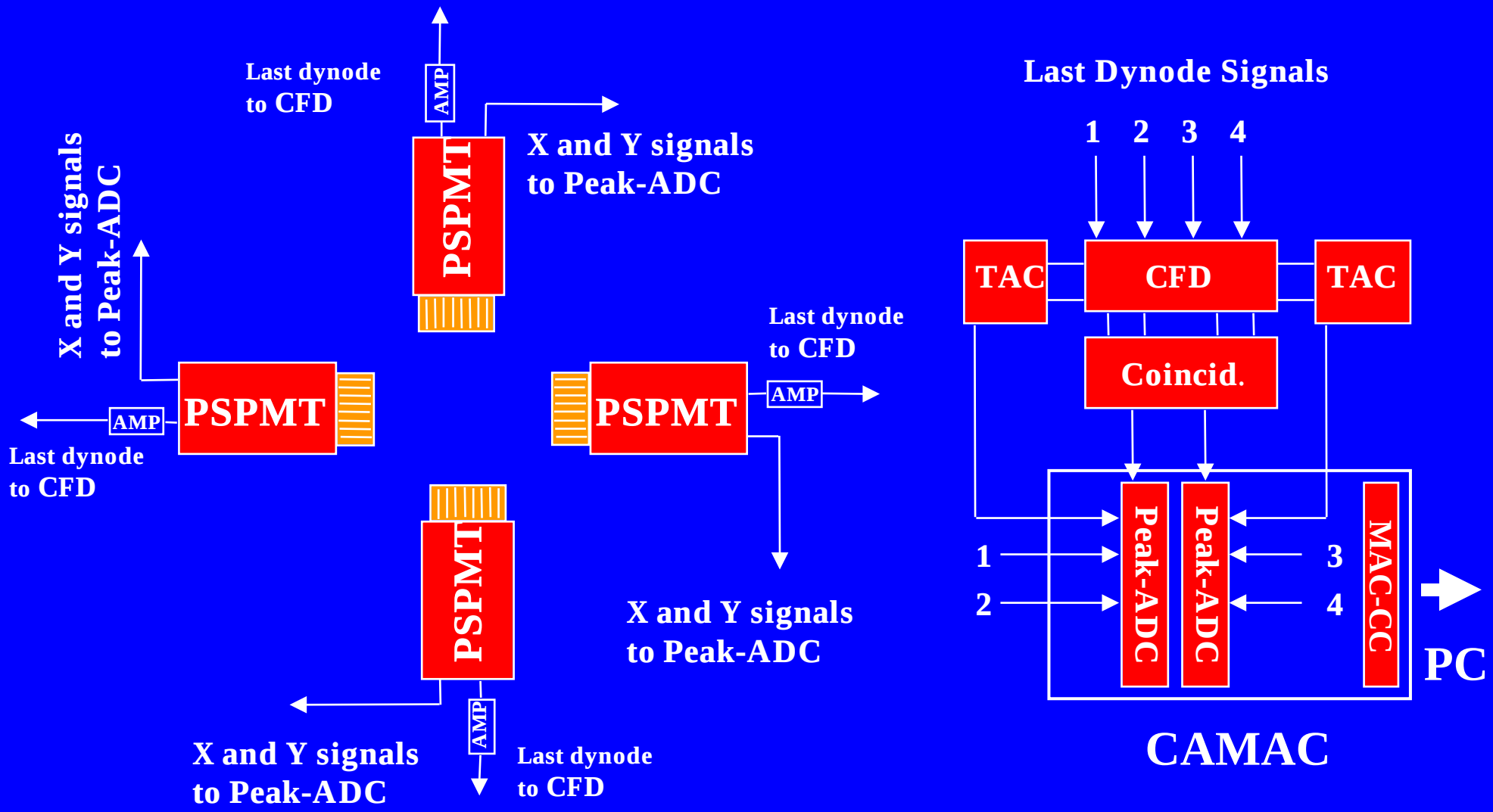
Photo of YAP:Ce (Yttrium Aluminium Perovskite doped with Cerium: $YAlO_3$:Ce) matrix (4 cm x 4 cm). Each match-like crystal is 2 mm x 2 mm x 30 mm.

- Density 5.37 g/cm^3
- Atomic number 39,13,8
- Light yield > 50% of NaI
- Scintillation decay time 27 ns
- Peak wavelength em. 370 nm
- Refractive index 1.95
- Photofraction

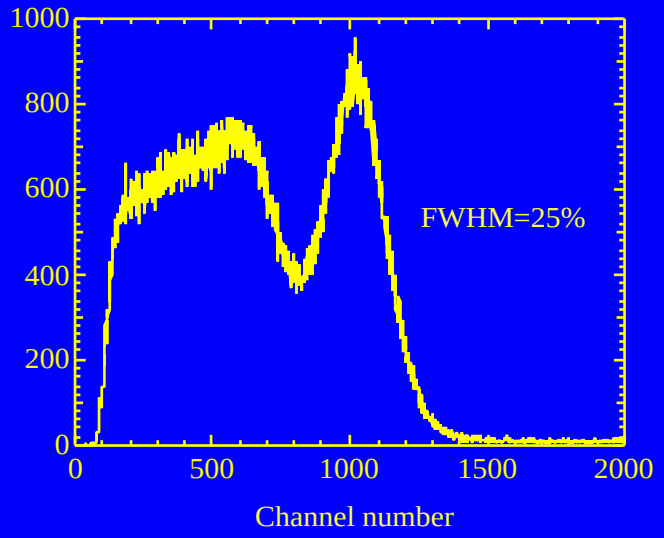
  50% @ 140keV

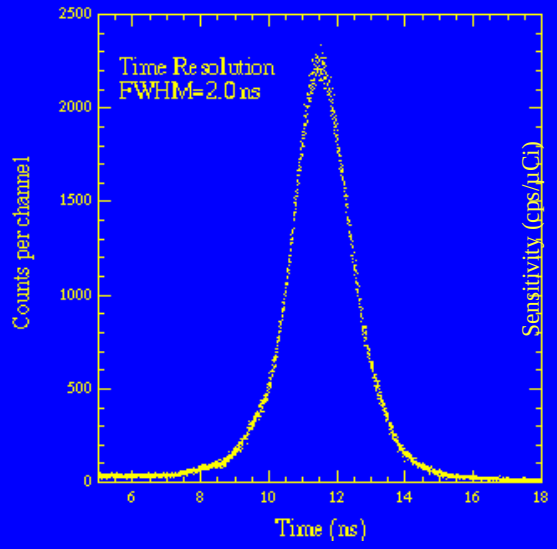
  4% @ 511 keV

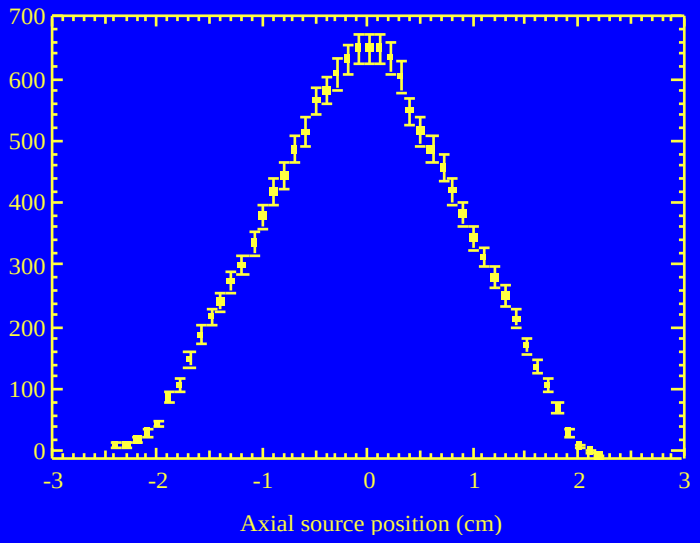
Scheme of experimental setup



PET Performances







Pulse-height spectrum

FWHM = 25%

Time resolution

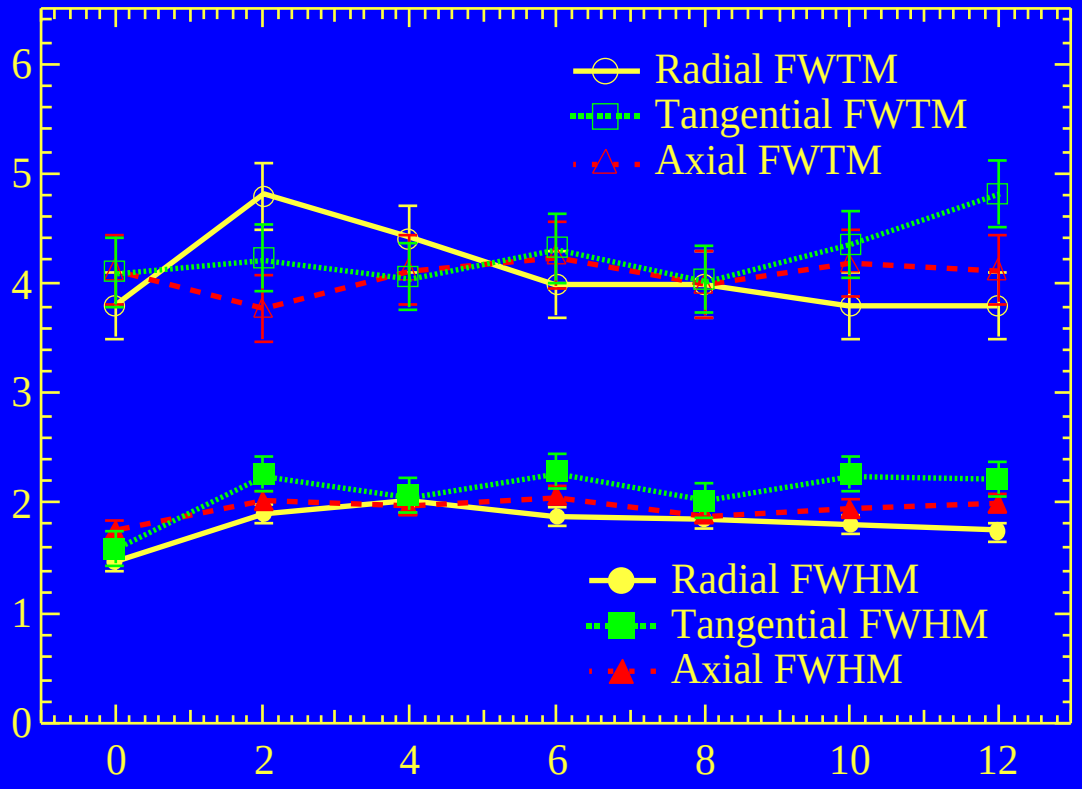
FWHM = 2 ns

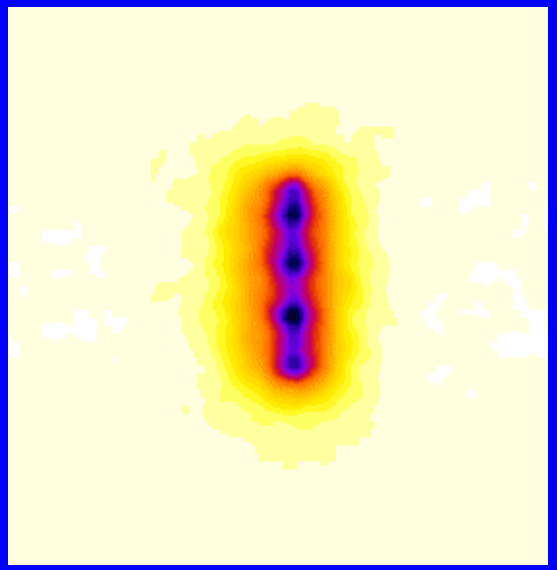
Sensitivity

640 cps/µCi at center

PET performances: spatial resolution

0.8 mm diameter ^{22}Na source

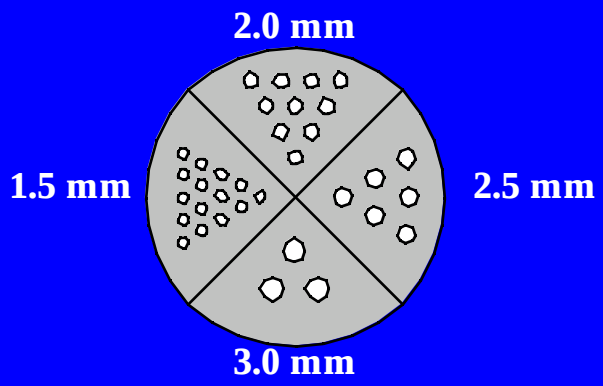




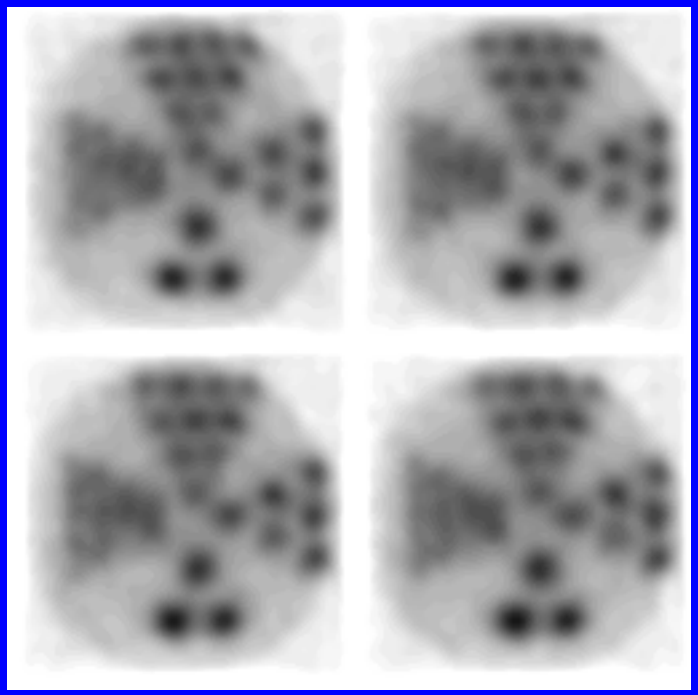
Four sources 2 mm apart
along the axis of rotation

Average FWHM **1.8 mm**
Volume resolution **5.8 mm^3**

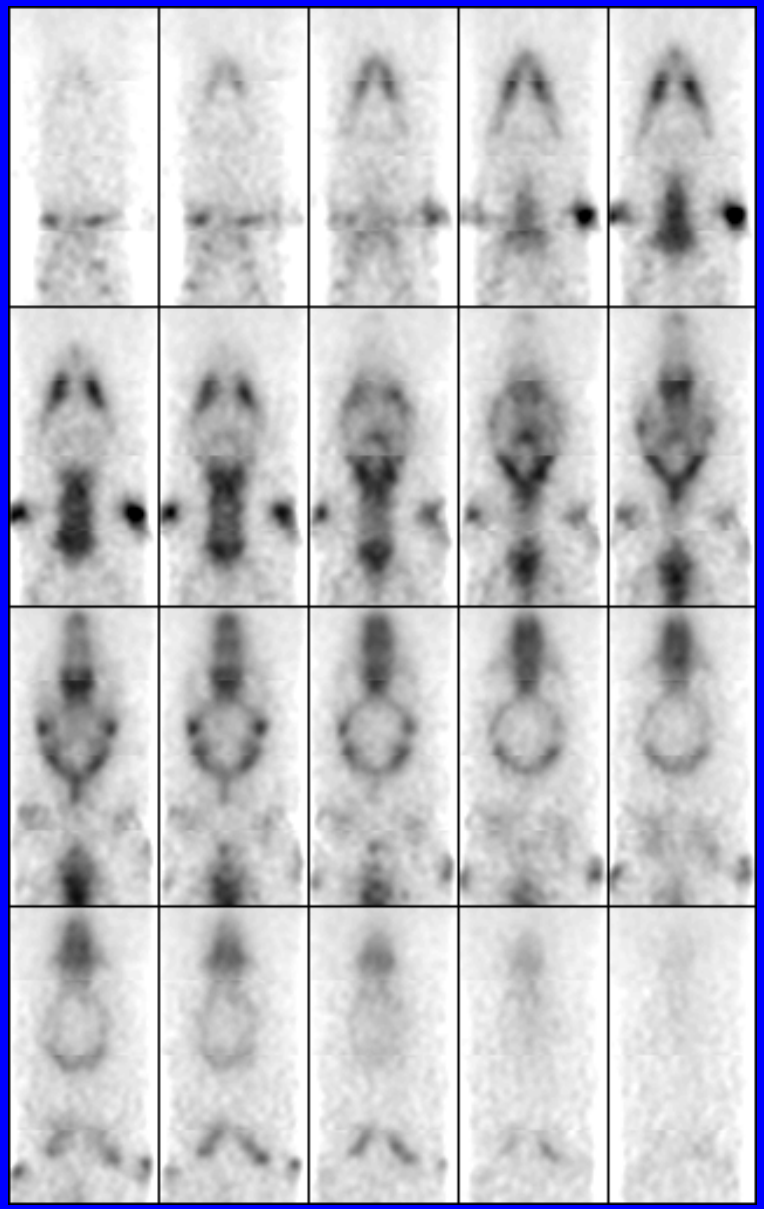
Derenzo-like hot phantom



PET ^{18}F-FDG



PET Fluorine Ion $^{18}F^-$ Study



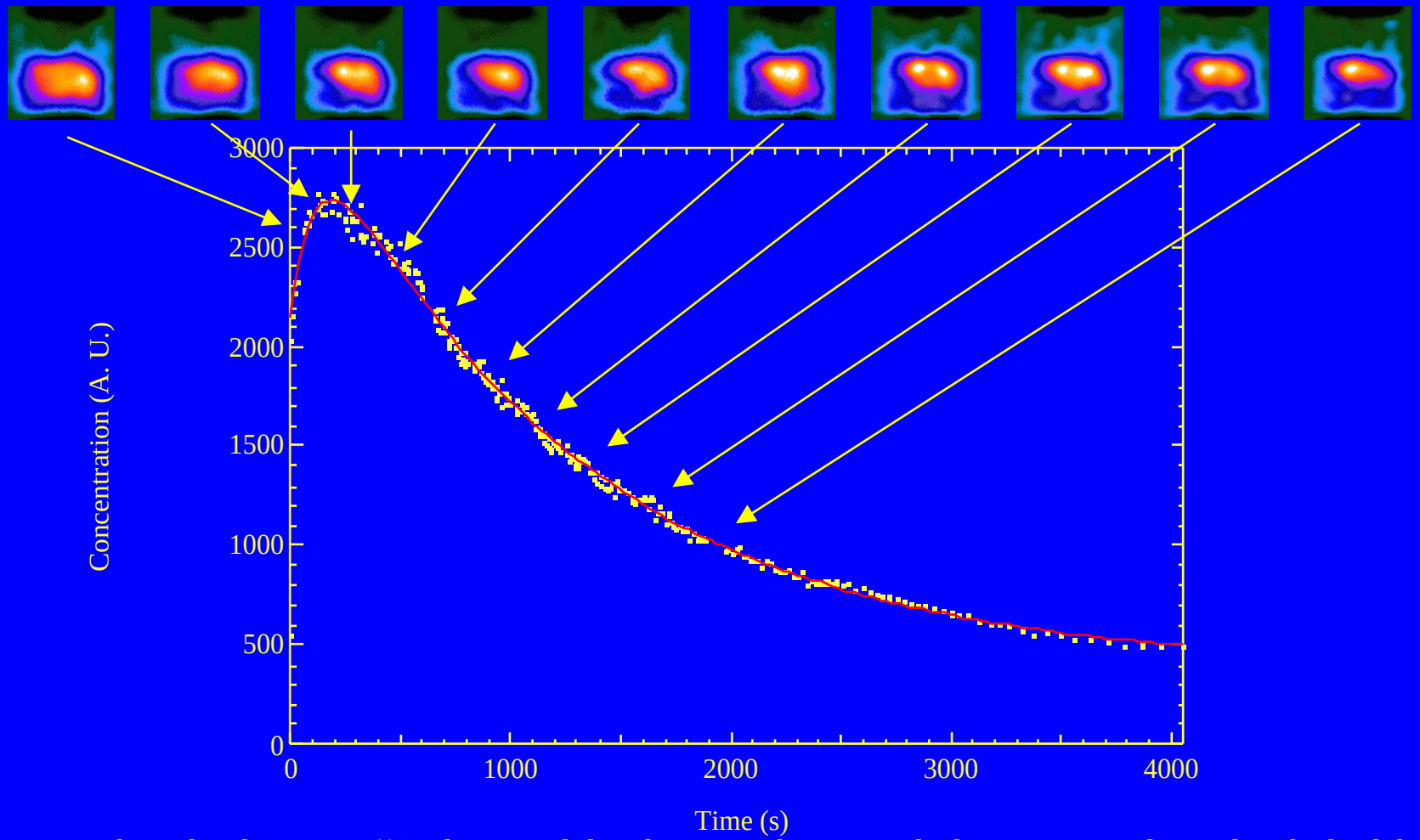
Images of a rat skeleton obtained after having injected the rat with 500 µCi of ^{18}F-. The data were acquired moving the bed along the scanner axis at 4 positions, each 2 cm apart and lasted ten minutes. The images were reconstructed by using a filtered backprojection algorithm.

PET DYNAMIC STUDY

In vivo dynamic imaging of rat brain with ^{11}C-Flumazenil

The rat was injected with 500 µCi of ^{11}C-Flumazenil.

Sagittal section through the center of the brain. (Nose towards the left. Upper skull towards top)



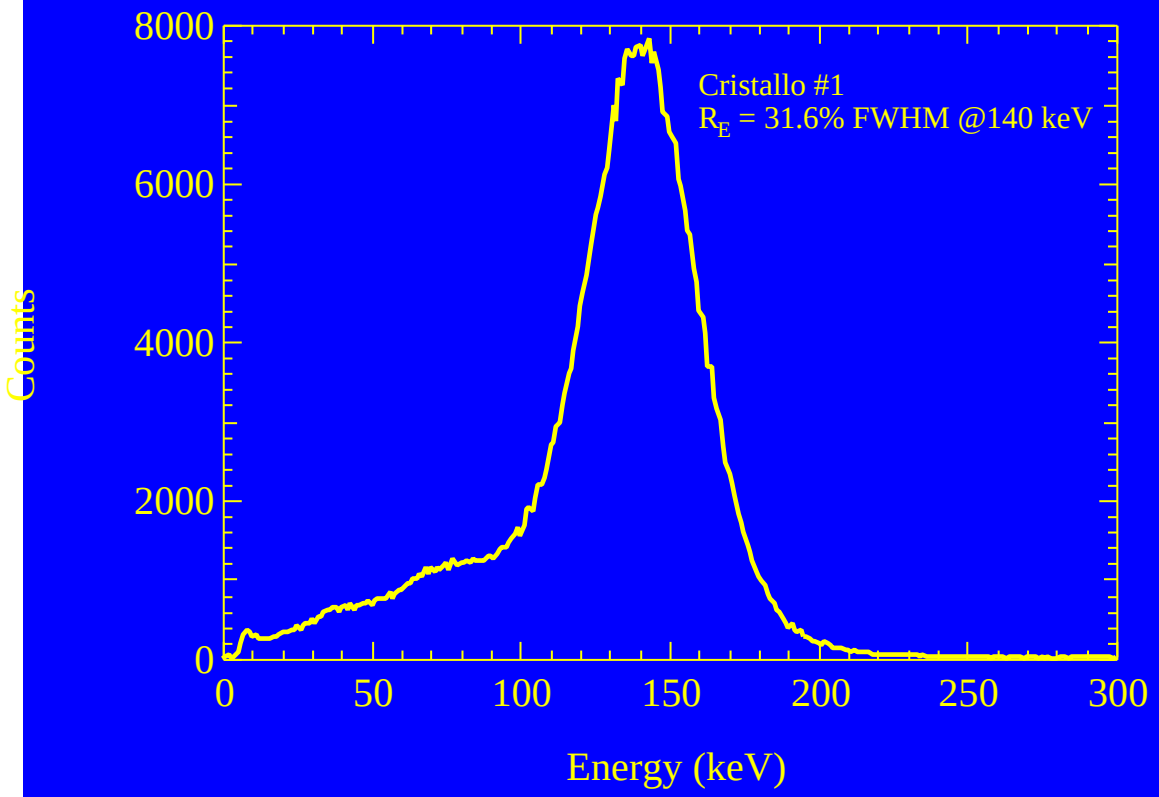
The images show the changes in ^{11}C-Flumazenil distribution with time: at the beginning it is located in the back brain (first image), then it goes into the central part of the brain and finally into the front part of the brain (last image)

Comparison of YAP:Ce characteristics with other commonly used crystals for PET and SPECT

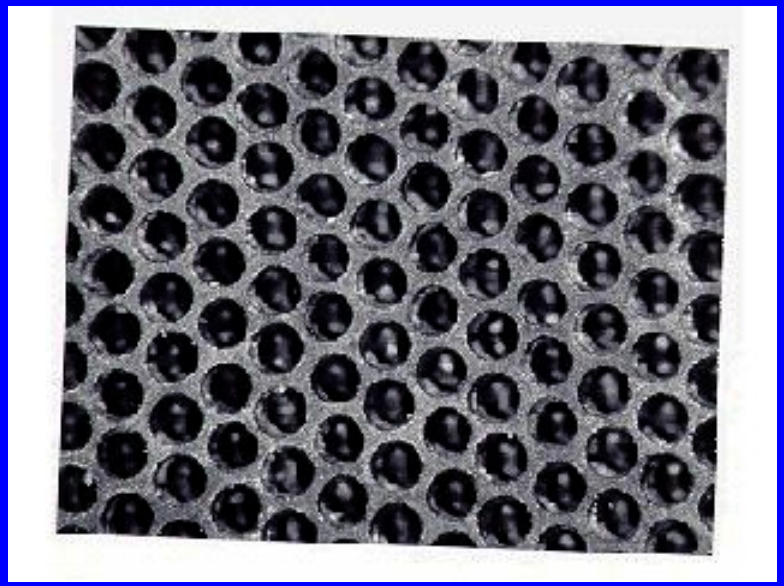
Material	Density [g/cm^3]	Atomic numbers	Light yield [%NaI(Tl)]	Decay time [ns]	Peak wavelength [nm]	Index of refraction	Comments
NaI(Tl)	3.76	11,53	100	230	410	1.85	hygroscopic
BGO	7.13	83,32,8	15	300	480	2.15	low light for SPECT
LSO	7.4	71,32,8	75	40	480	1.82	intrinsic background 400 cps/cm^3
CsI(Tl)	4.51	55,53	45	1000	565	1.80	slow for PET
YAP:Ce	5.37	39,13,8	55*	27	370	1.95	seems like good compromise

* A. Del Guerra, F. de Notaristefani, G. Di Domenico, R. Pani and G Zavattini “Measurement of absolute light yield and determination of a lower limit for the light attenuation length for YAP:Ce crystal” IEEE Trans. Nucl.Sci., vol. 44, no. 6, 1997 pp. 2415-2418.

SPECT performances - I



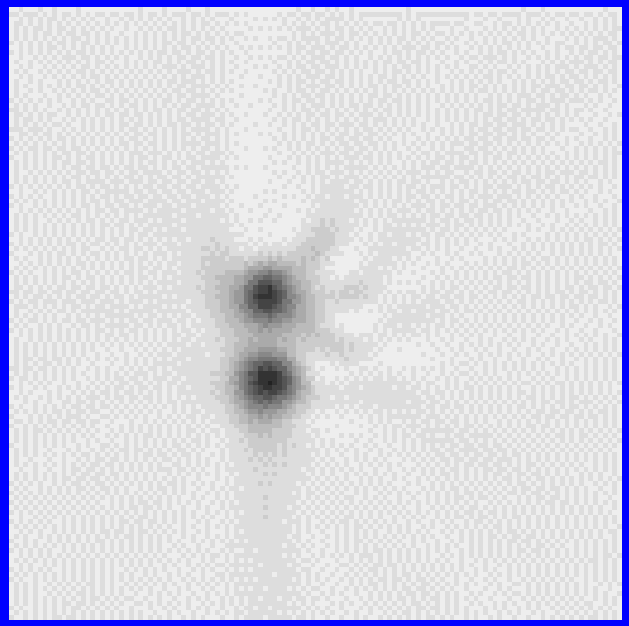
Energy spectra of one of the YAP:Ce matrices (with collimator) after having applied energy corrections to each single crystal spectrum.



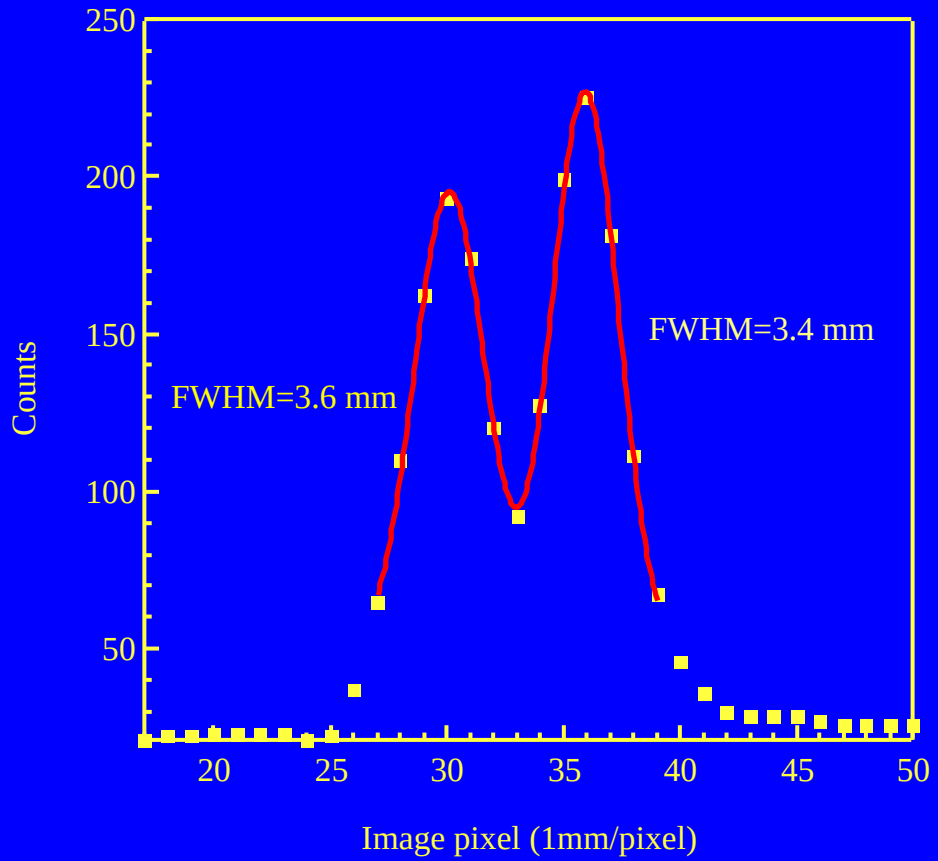
Lead collimator photo: hole diameter 0.6 mm, septa 0.15 mm, height 20 mm.
Geometric efficiency 4.0 10^{-5}

Sensitivity of one detector head 2.1 cps/μCi

SPECT performances - II

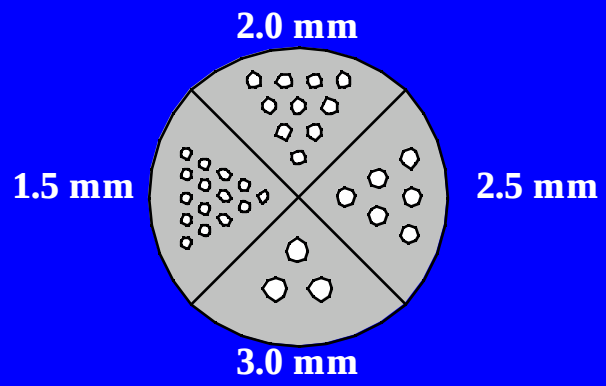


Tomographic image of two 0.8 mm ø capillaries filled with ^{99m}Tc placed 5 mm apart.

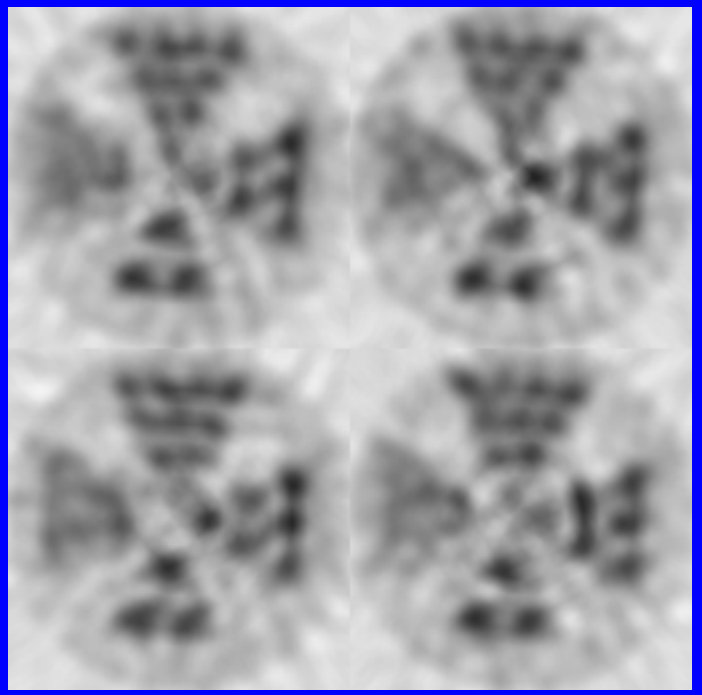


Profile of a tomographic image of two capillaries filled up with ^{99m}Tc placed 5 mm apart.

Derenzo-like hot phantom

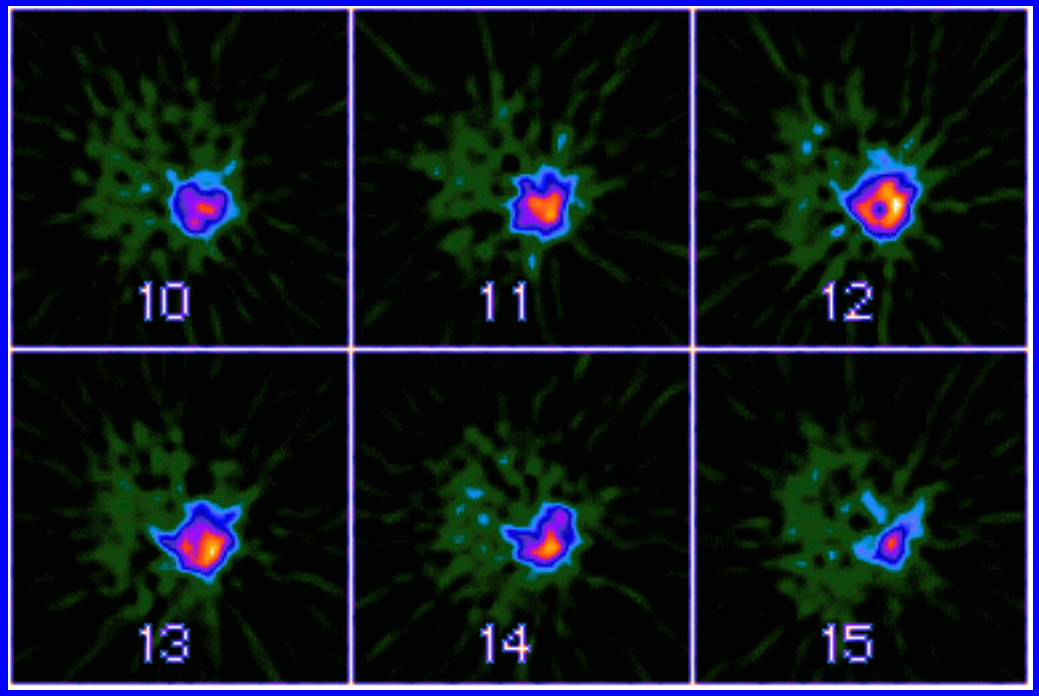


SPECT ^{99m}Tc



SPECT ^{99m}Tc-Sestamibi study

The rat was injected with 1.8 mCi of ^{99m}Tc-Sestamibi.
Some heart structures are visible in these transaxial images.



Conclusions - 1

Summary Performances

Mode	Number of detector heads	Energy resolution FWHM	Spatial resolution FWHM	Sensitivity cps/µCi	FOV
SPECT	2	32% @ 140 keV with collimator	3.5 mm	4.2 costant over FOV	4 cm diameter 4 cm axial
PET	4	14.5% @ 511 keV (Fixed depth)	1.8 mm	640 at center	4 cm diameter 4 cm axial

Conclusions - 2

- We have applied two collimators on two opposite detectors of our YAPPET small animal scanner.
- We have successfully shown that it can be used both in PET and SPECT mode.
- This is made possible due to the choice of YAP:Ce as the scintillator and to the planar geometry of the detector heads.