

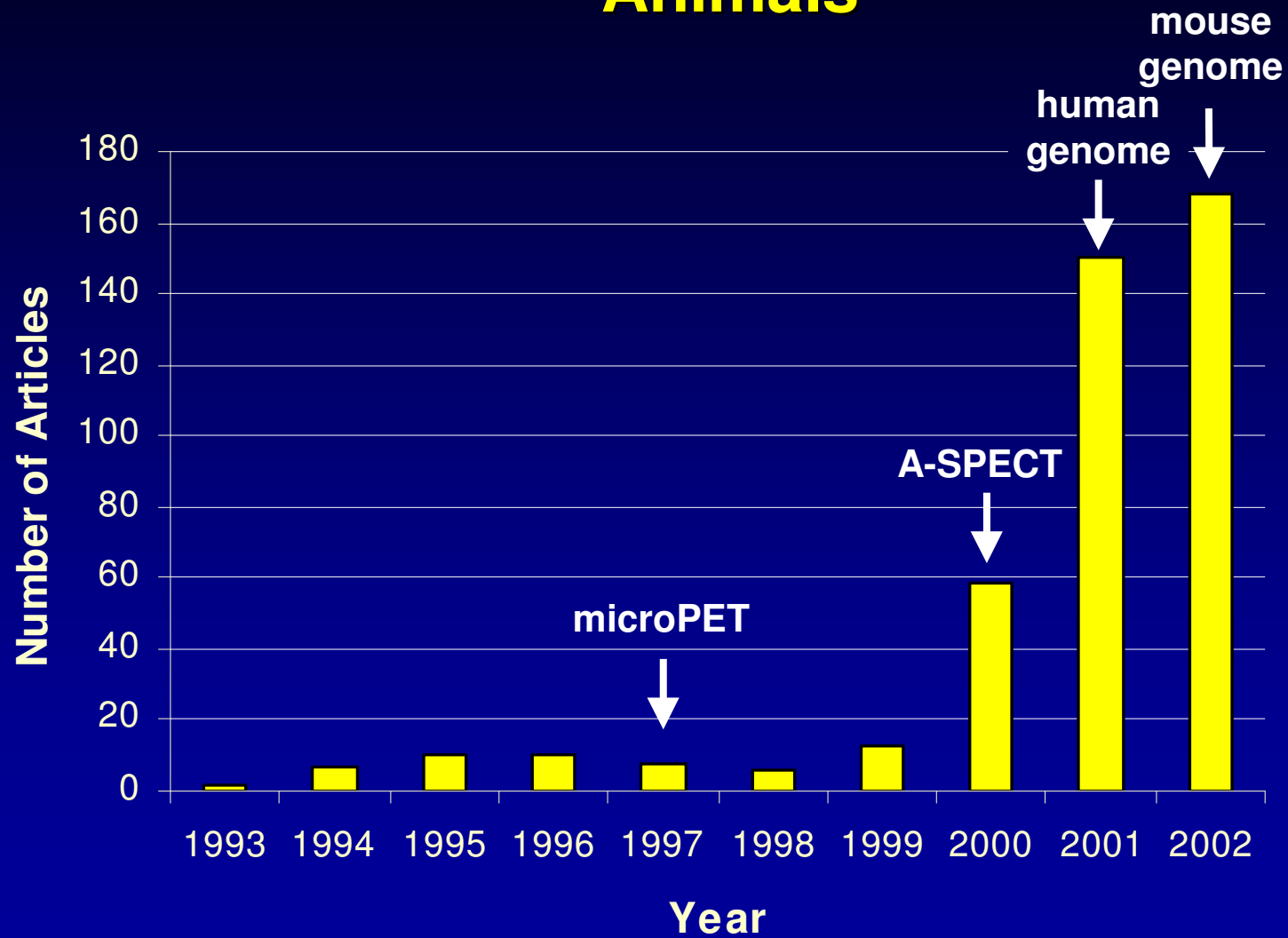
Small Animal SPECT

Pushing the Limits ?

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Dept of PET & Nuclear Medicine
Royal Prince Alfred Hospital, Sydney

Publications on Non-invasive Imaging of Animals



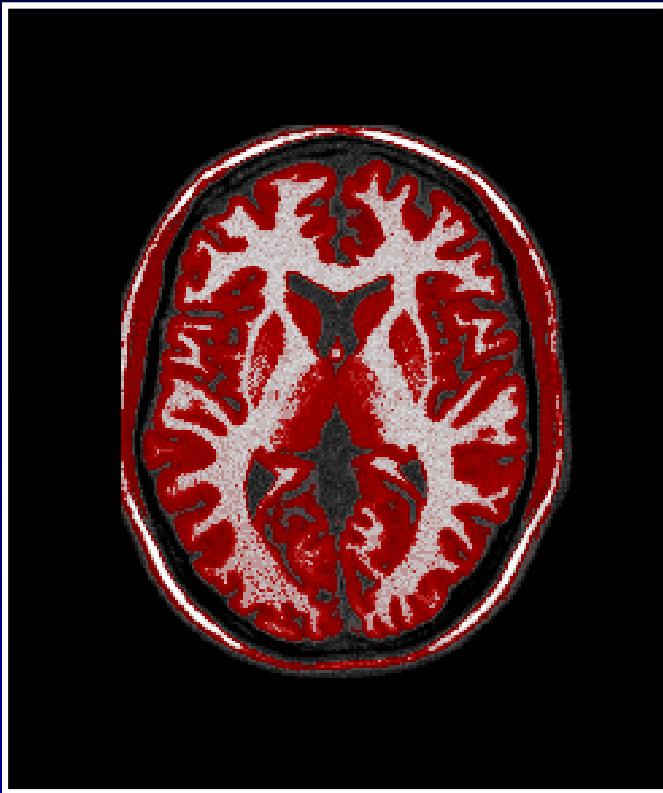
Animal Models of Human Disease



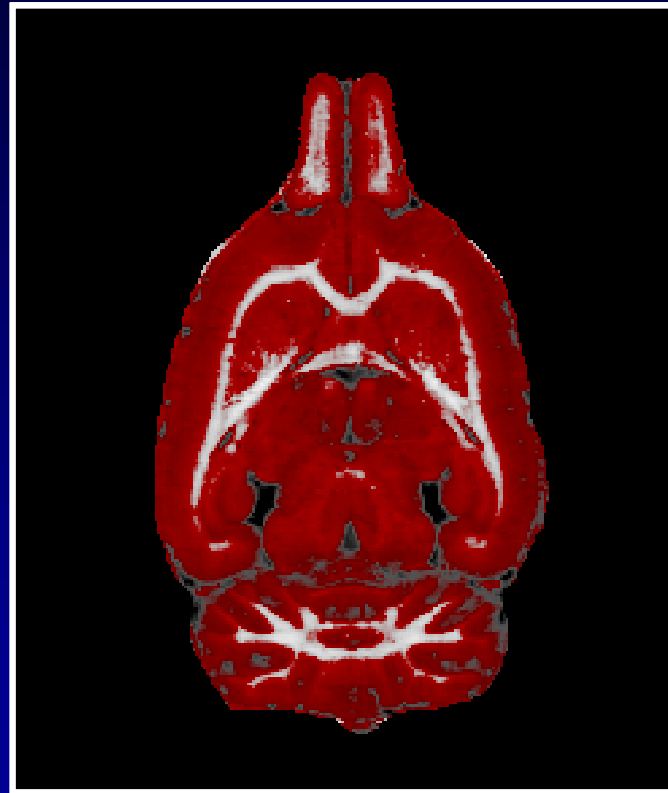
99% genes in common



The Challenge of Imaging Small Animals

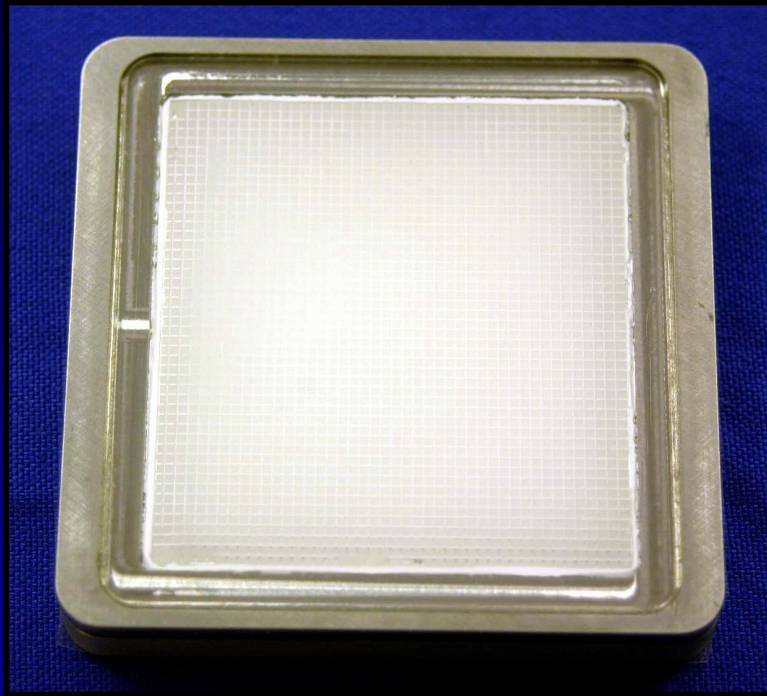


Human



Rat

High Resolution Detectors

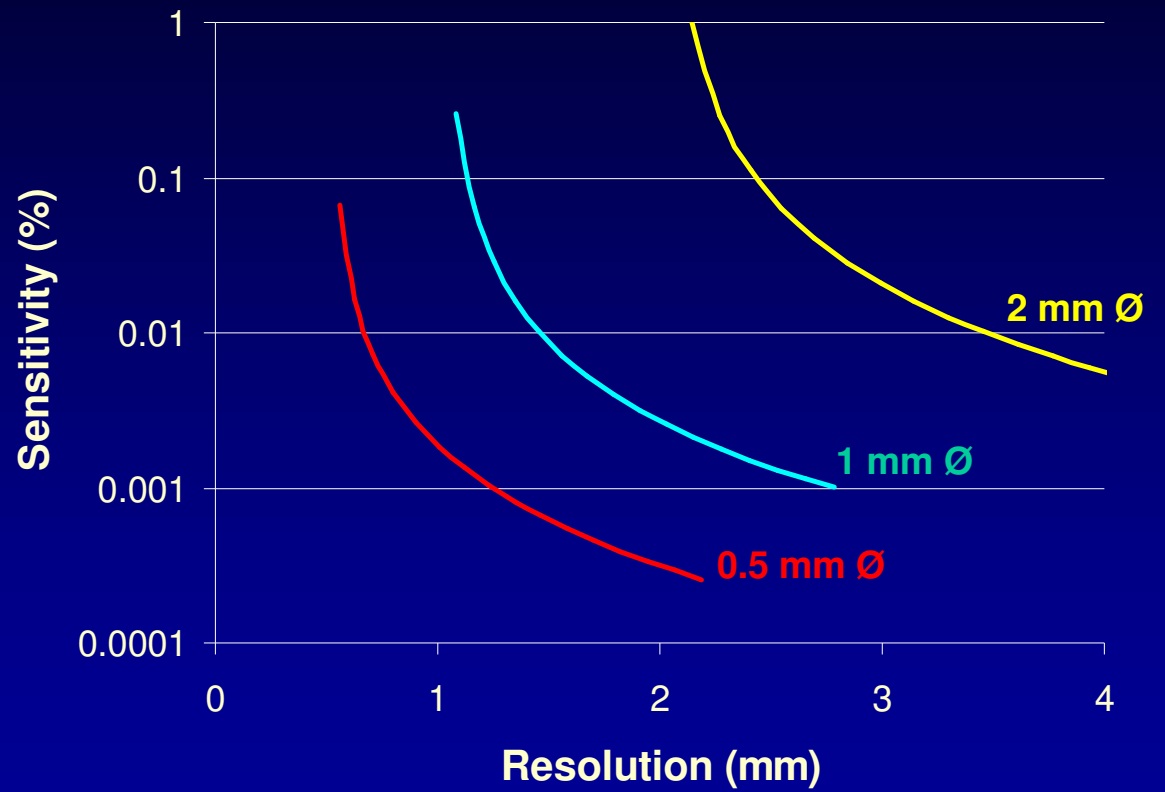
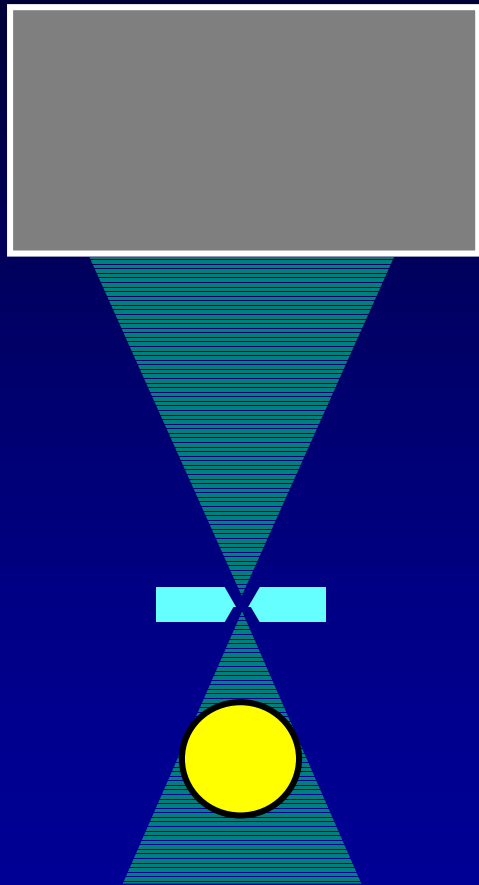


Pixellated scintillators



Position-sensitive PMTs

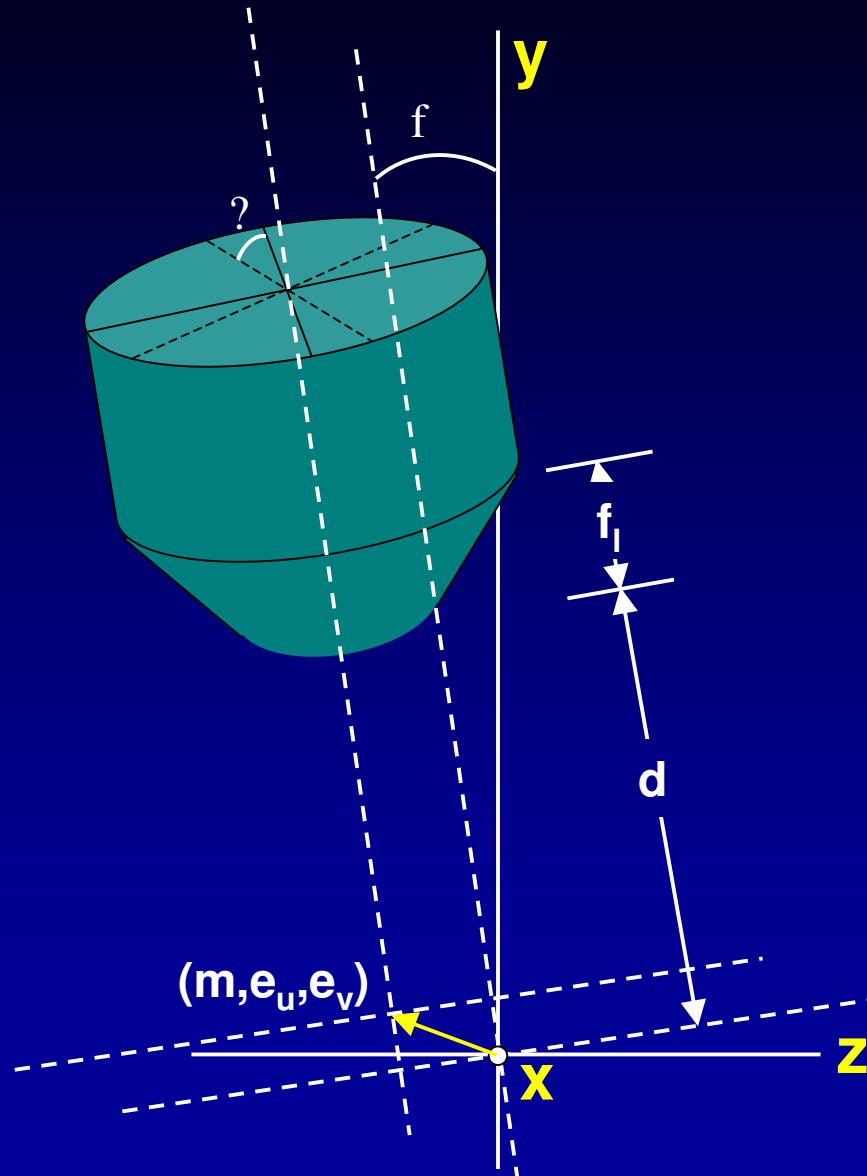
Pinhole SPECT



Pinhole SPECT Reconstruction

- iterative algorithm (usually ML-EM or MAP \pm ordered subsets) with 3D ray-driven fwd/back projector
- include modelling of:
 - geometric sensitivity
 - pinhole aperture function & edge penetration
 - detector response function
 - depth of interaction
 - attenuation (10-20% at 140 keV)

Estimation of Geometric Parameters



Bequé et al, *Trans Med Imag*, 22:599, 2003

- perform SPECT acquisition of 3 point source phantom
- iteratively estimate parameters by minimising distance b/w projected & measured points using downhill simplex



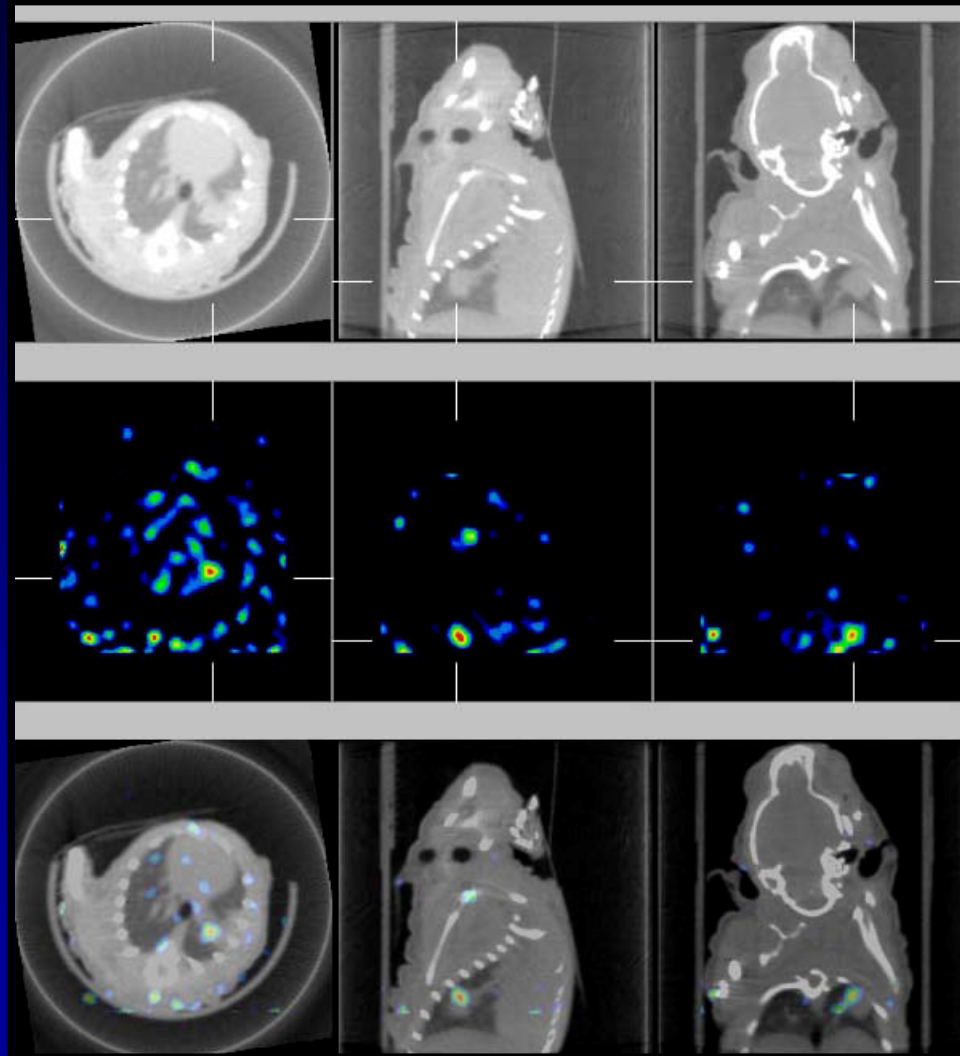
Commercial Systems

Gamma Medica X-SPECT



Commercial Systems

Gamma Medica X-SPECT



CT

SPECT

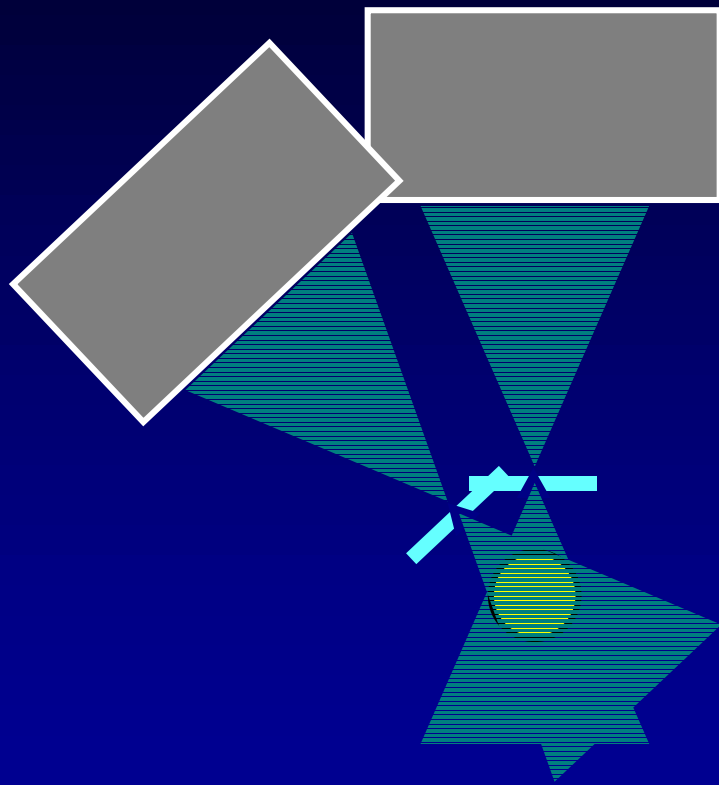
fused

^{99m}Tc -depreotide
lung tumour model

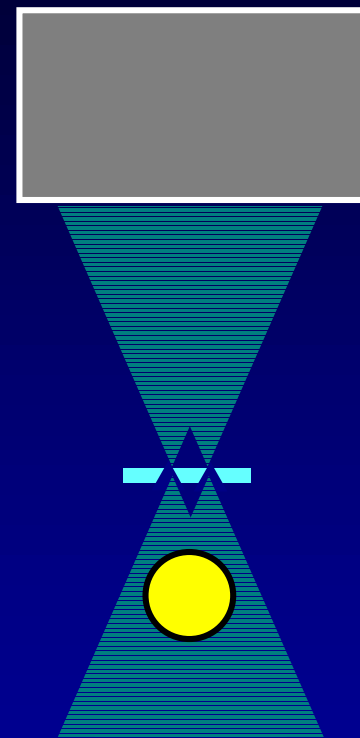
Pushing the Limits ?

- **sensitivity**
- **spatial resolution**
- **dual isotope imaging**
- **motion correction**

Multi-pinhole SPECT

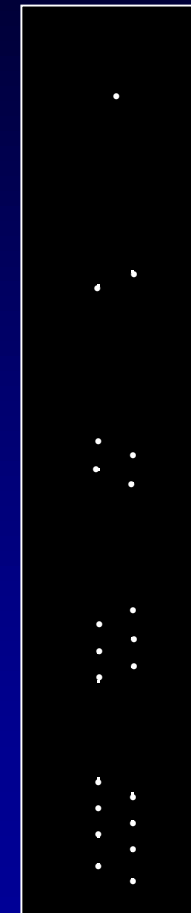
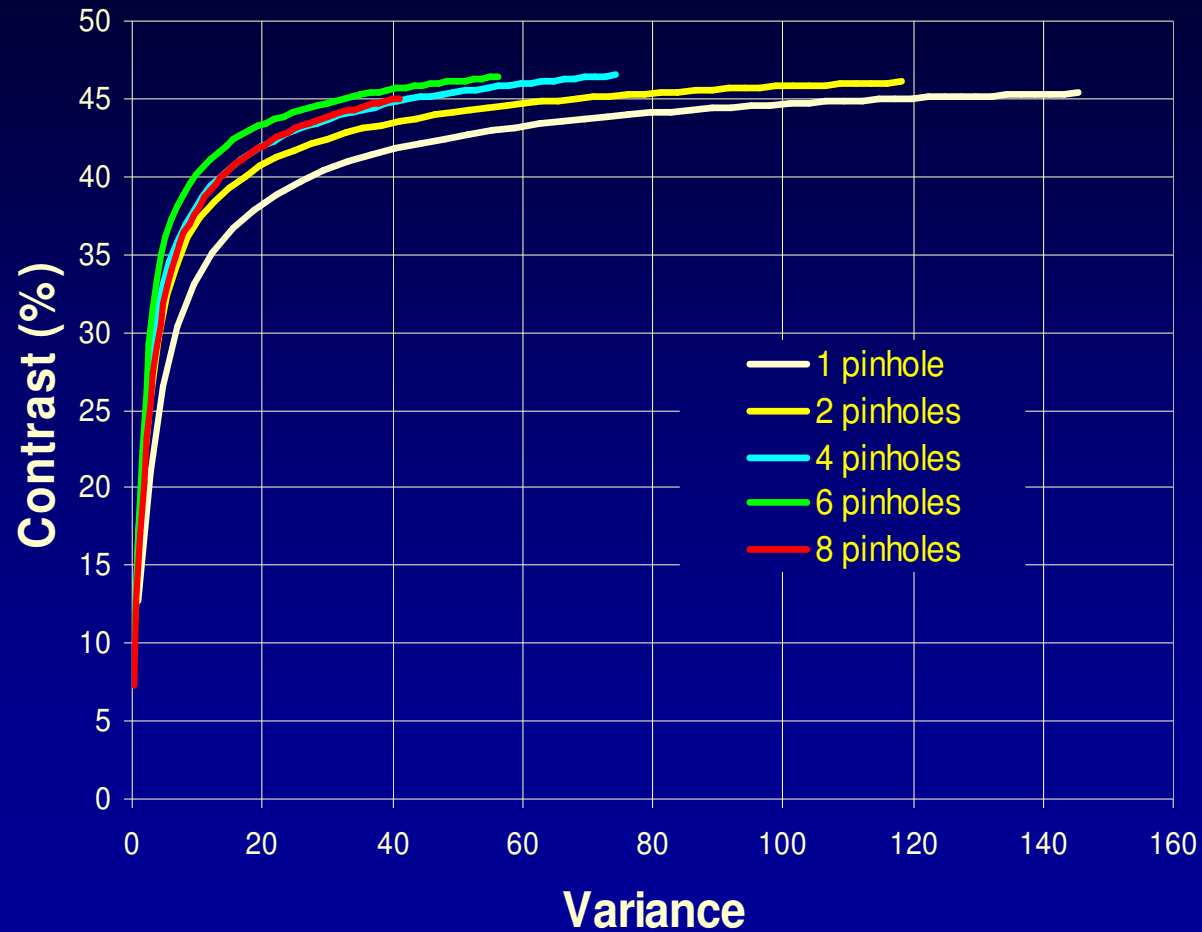


Non multiplexed



Multiplexed
(Coded Aperture)

Simulation Experiments



1 pinhole

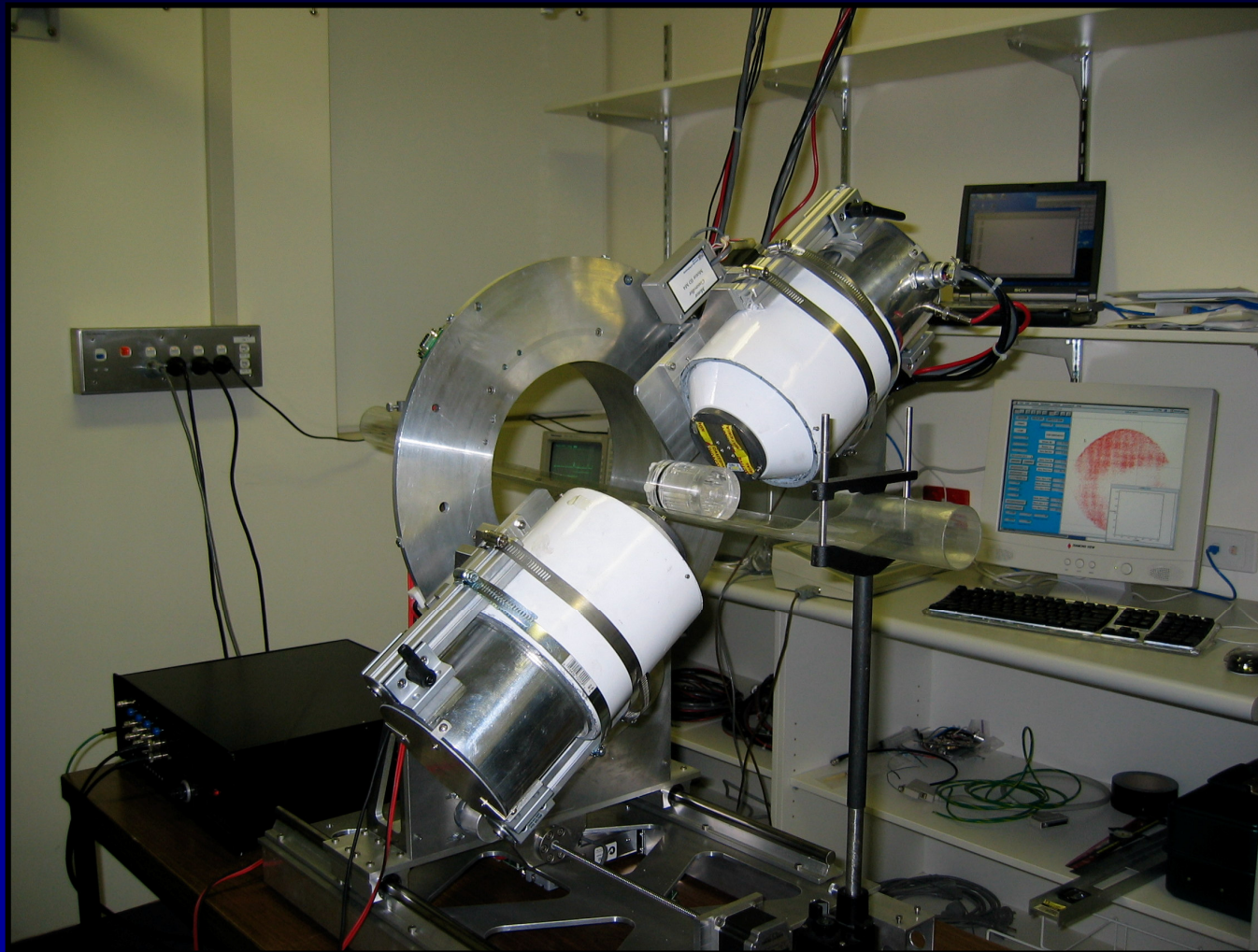
2 pinholes

4 pinholes

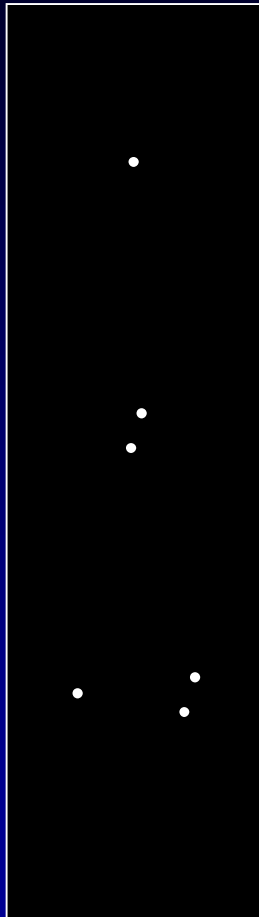
6 pinholes

8 pinholes

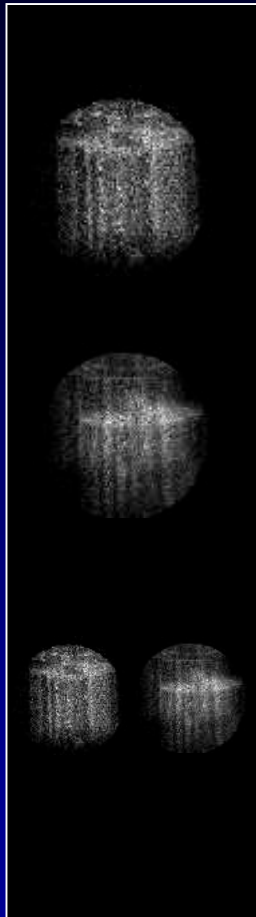
Coded Aperture Laboratory Animal Scanner (CoALA-SPECT)



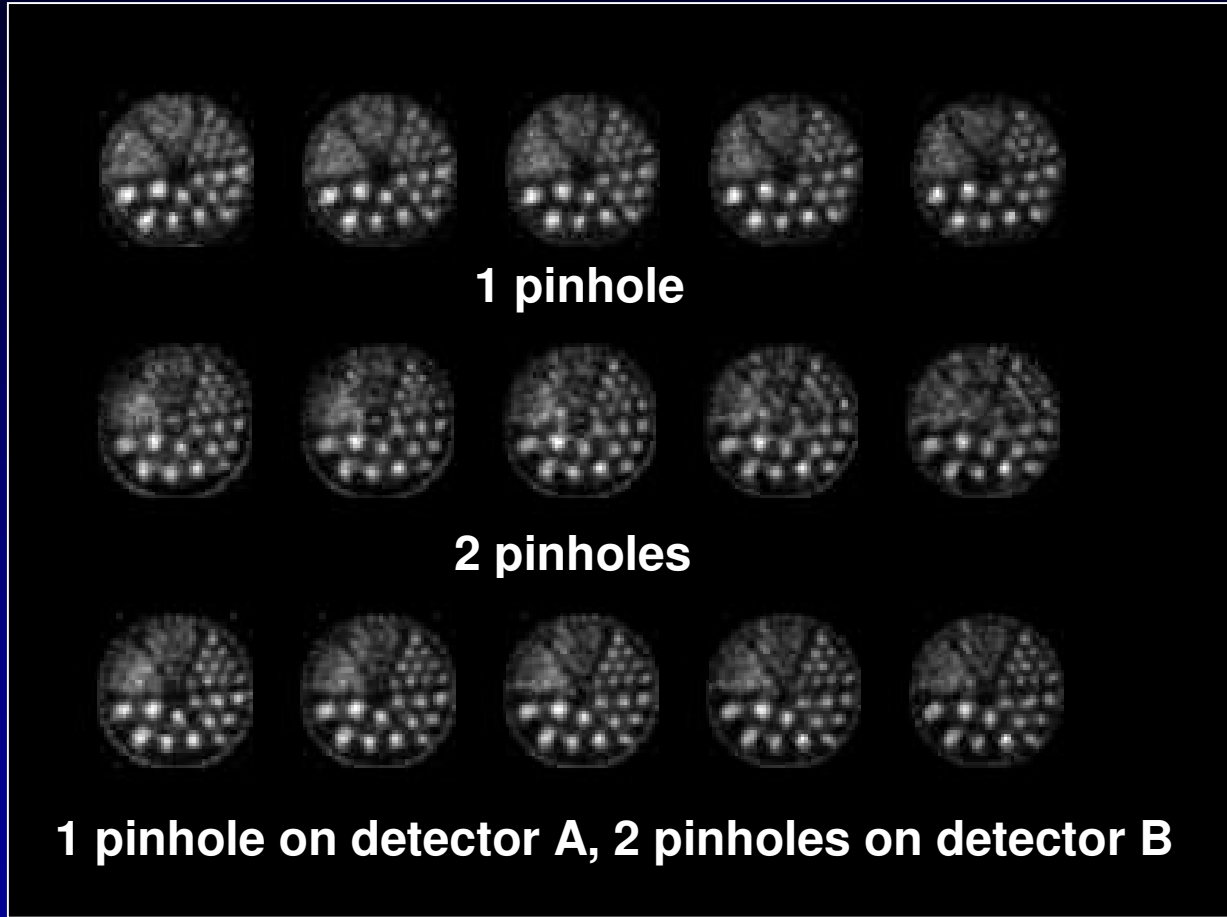
micro Deluxe Resolution Phantom



aperture



projection



1 pinhole

2 pinholes

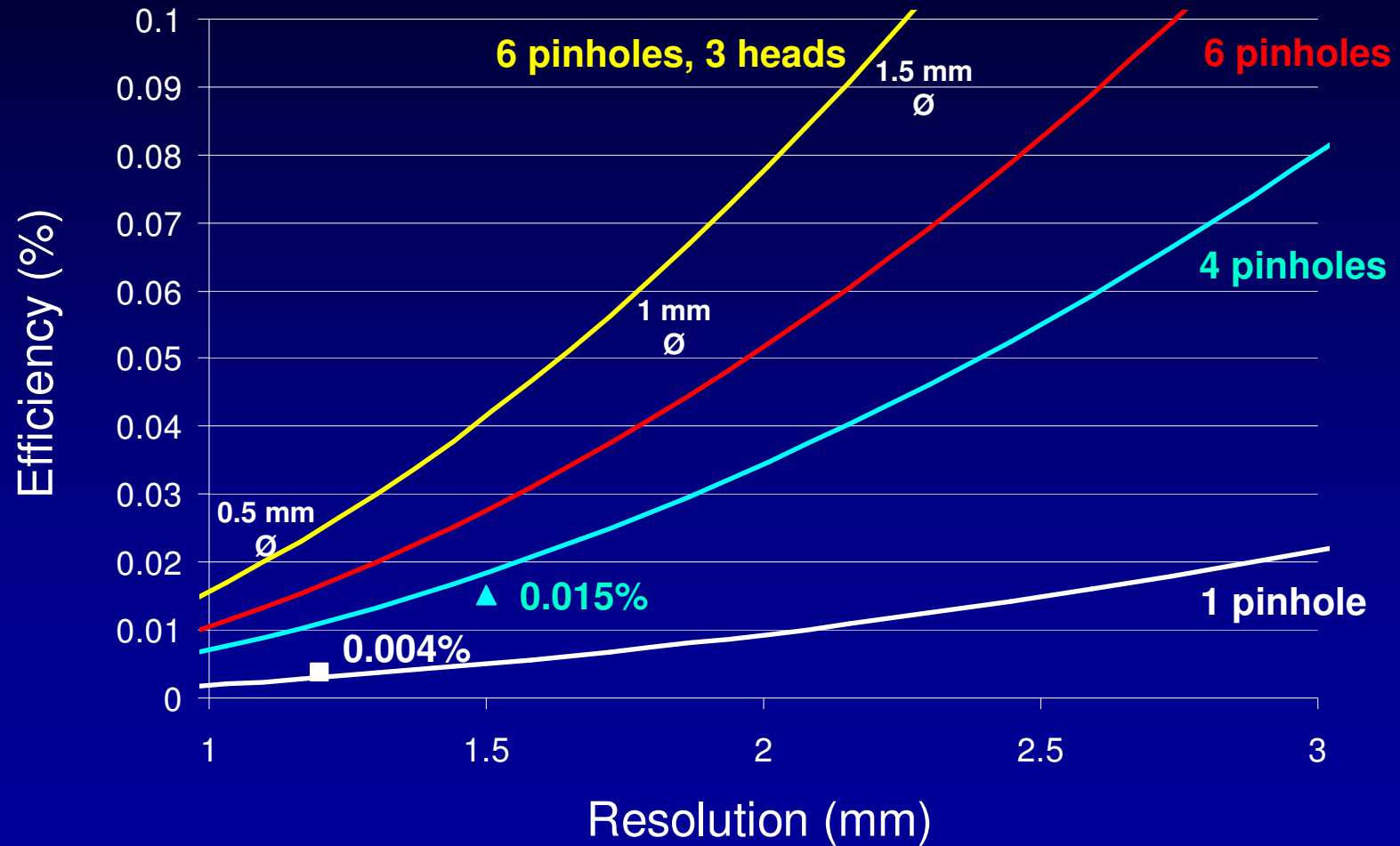
1 pinhole on detector A, 2 pinholes on detector B

image

$f_1 = 8$ cm, $d = 6$ cm, $\text{Mag} = 1.3$, $\text{FoV} = 8.2$ cm
Acq = 40 x 60 sec, Rec = 5 iter, 8 subs

Efficiency vs Resolution

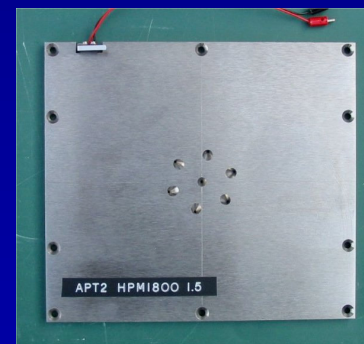
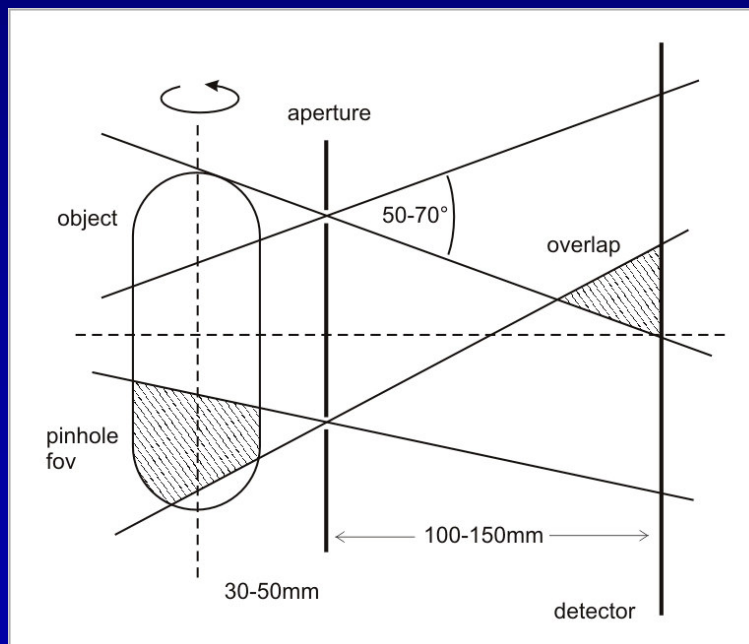
$f_1 = 8$ cm, $d = 4$ cm, $\text{Mag} = 2$, $\text{FoV} = 5.5$ cm



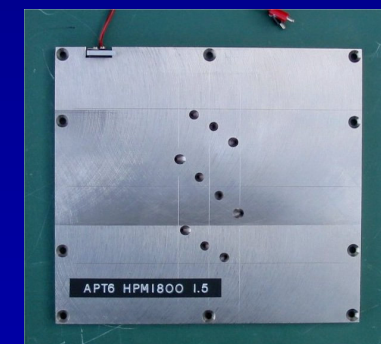


Multi-Pinhole SPECT

- Aim: SPECT on mice and rats
- Commercial gamma camera
- Custom-built multi-pinhole collimator
- Dedicated reconstruction software



7-pinhole
 $\text{Ø}=1.5\text{mm}$

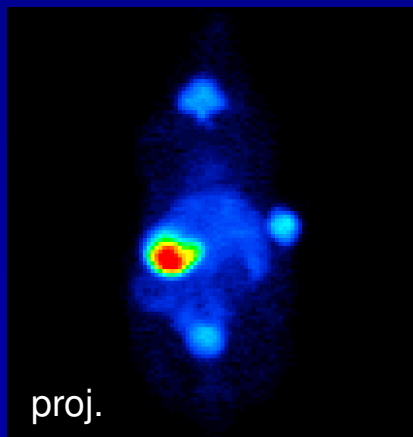


10-pinhole
 $\text{Ø}=1.5\text{mm}$

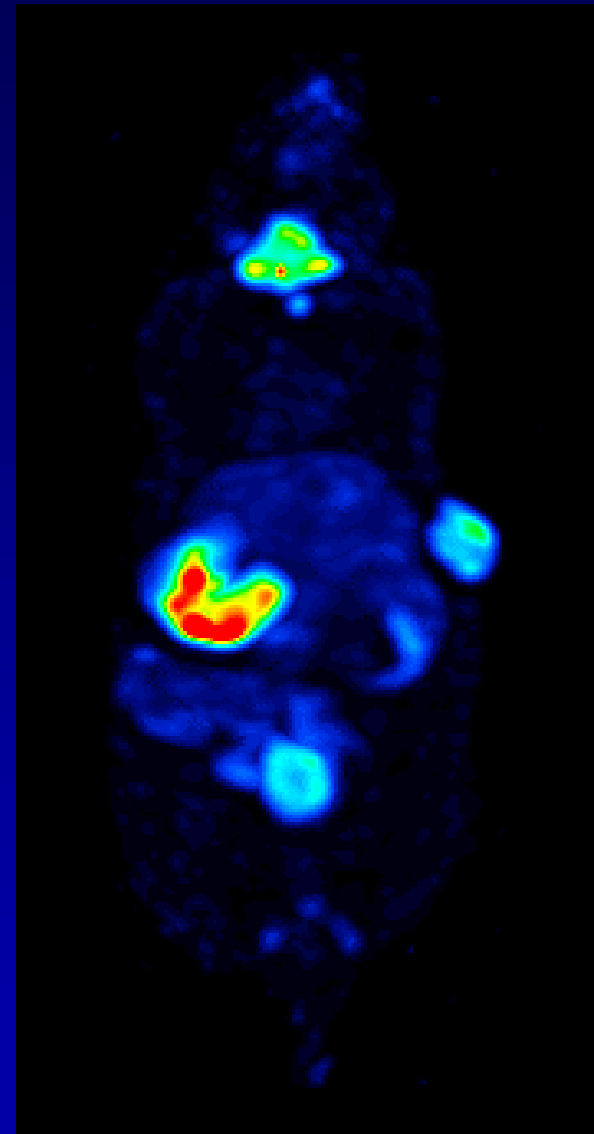


Tumor study in mouse

- NIS transfected tumor + control
- Anesthesia: Ketanest + Xylazine
- 18mCi pertechnetate, 1:20 p.i.
- Single-pinhole measurement
- 60 projections, ROR: 48mm
- Reconstruction: 11 iterations



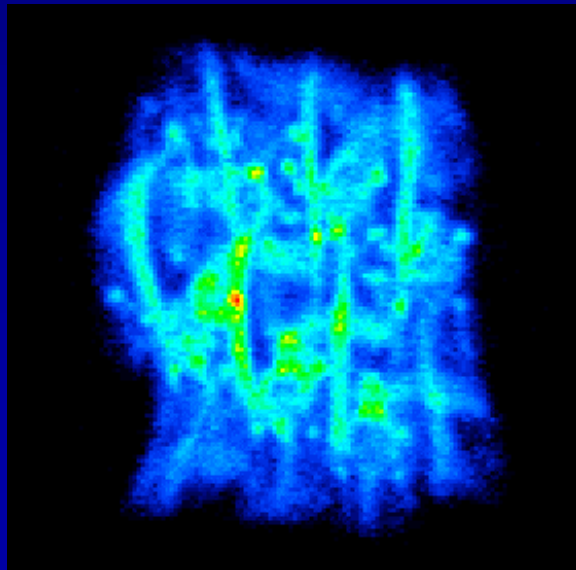
→
reconstruction



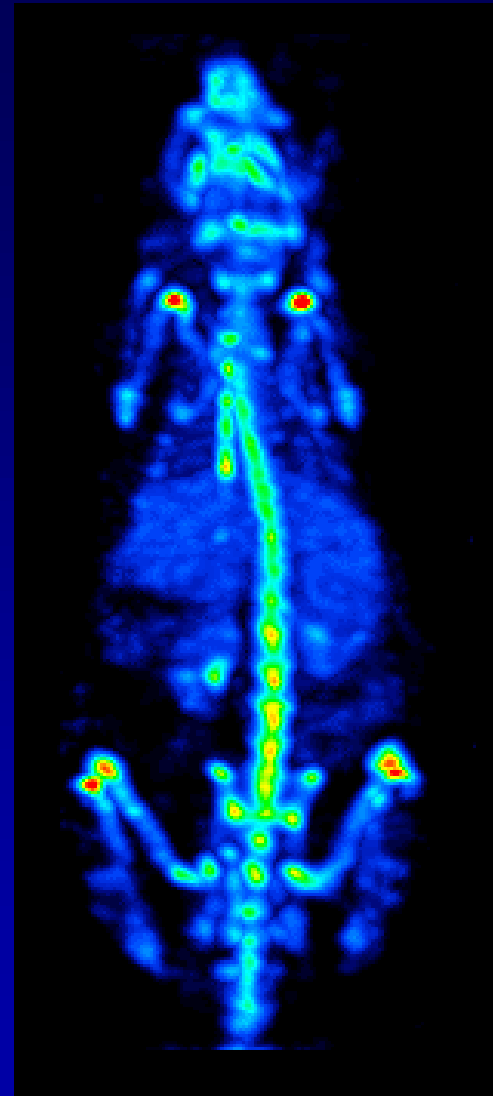


10-pinhole study

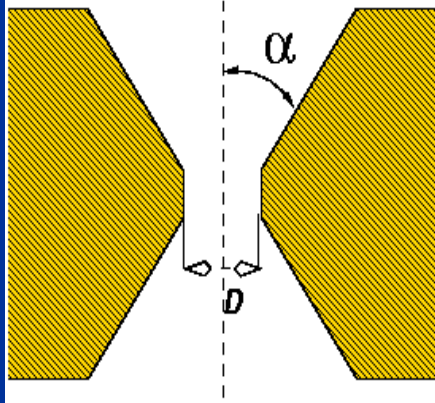
- 60 projections, ROR: 50mm
- Overlap: 71%
- Reconstruction: 11 iterations
- Resolution: 1.7mm
- Sensitivity gain: $\times 5.2$



→
rec.



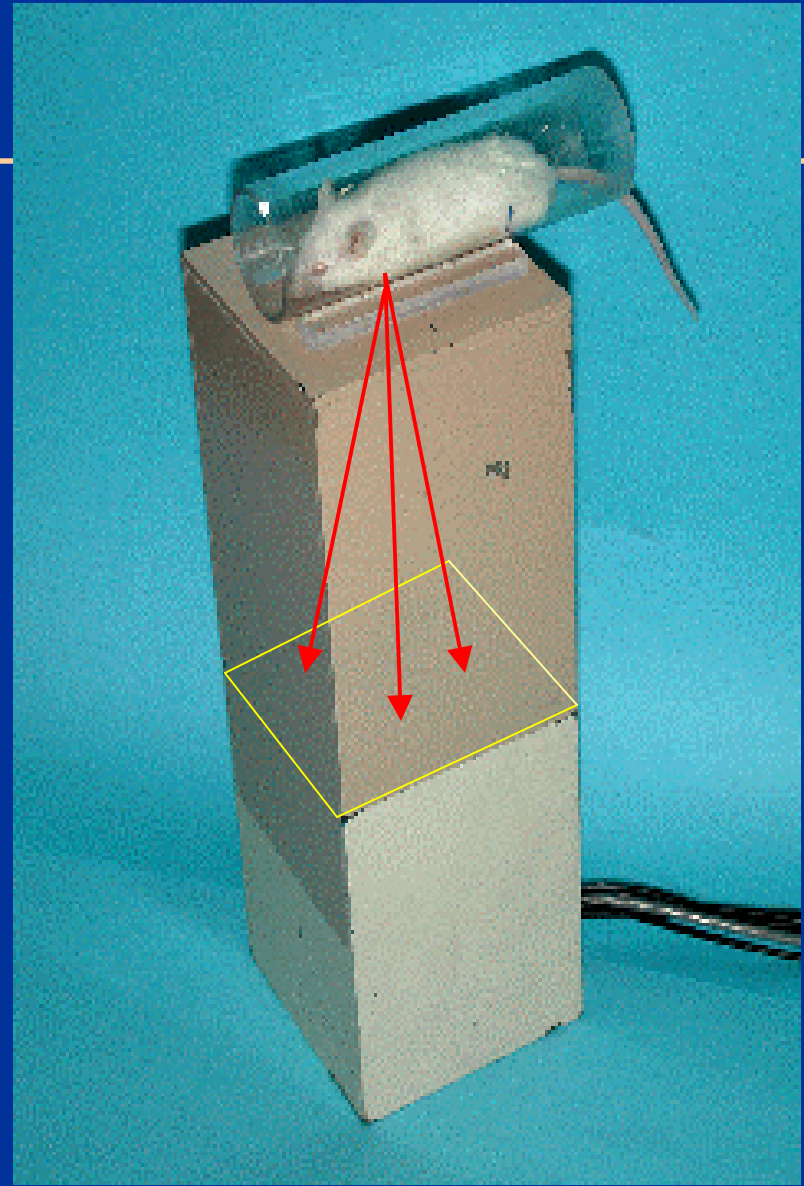
Ultra-high resolution planar desktop pinhole imager



Au/Pt alloy pinhole



Image of 100 microns pinhole

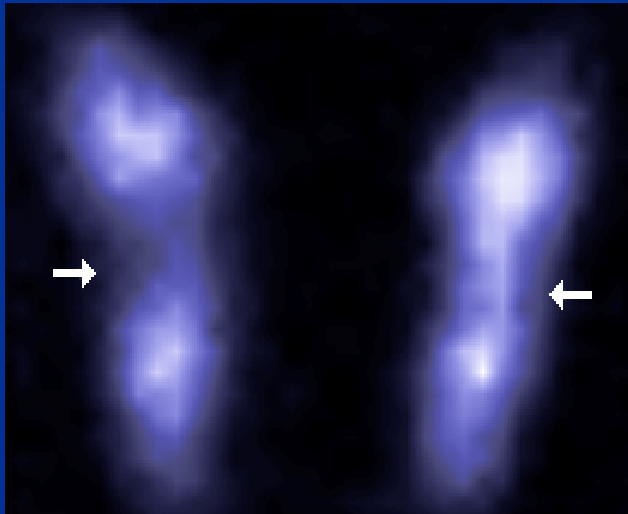


Beekman et al. (Utrecht Univ. & UCLA)
Eur J. Nucl. Med & Mol. Im., 2002

Planar Mouse Thyroid Image

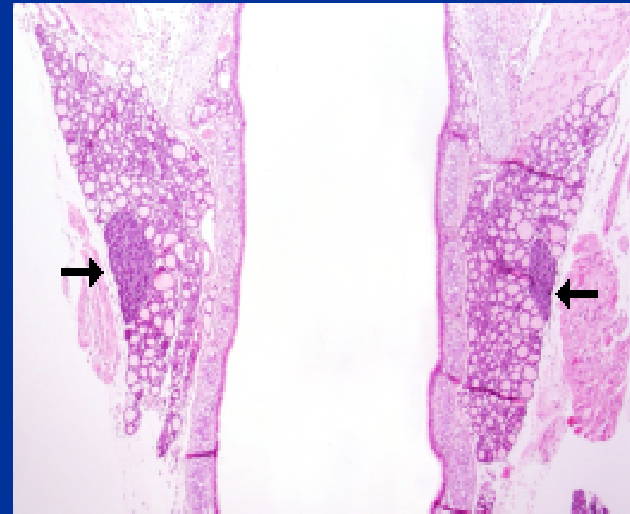
≈ 1 mm

I-125 pinhole image

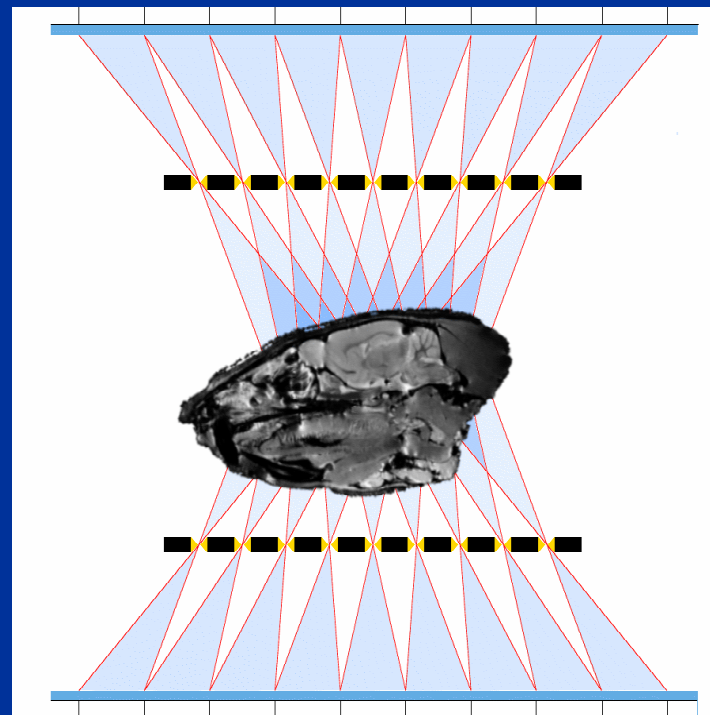
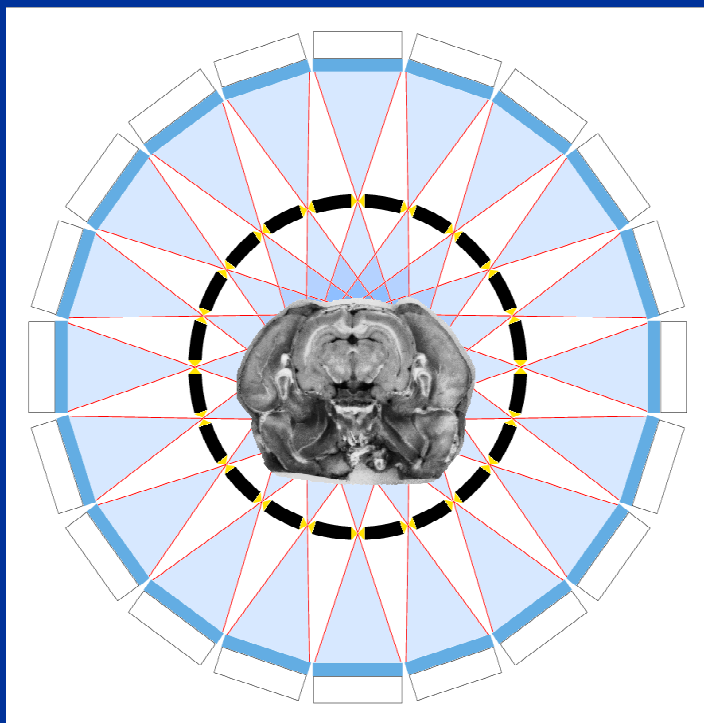


20 min. acquisition

Microscopic slide



U-SPECT: micro-SPECT at University

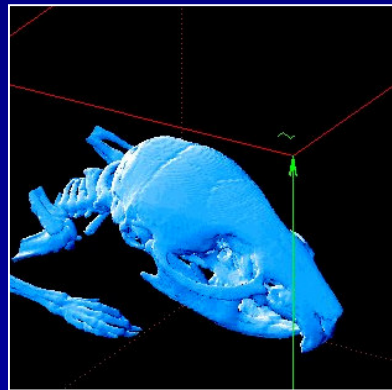


Nine rings with 20 pinholes each:
⇒ 180 micro-pinhole cameras
acquiring non-overlapping projections

Co-Registered Anatomic and Functional Imaging of Unrestrained, Unanesthetized Mice

Jefferson Lab
Oak Ridge National Lab
Johns Hopkins School of Medicine
Royal Prince Alfred Hospital

funded by U.S. Dept of Energy, Office of Biological & Environmental Research

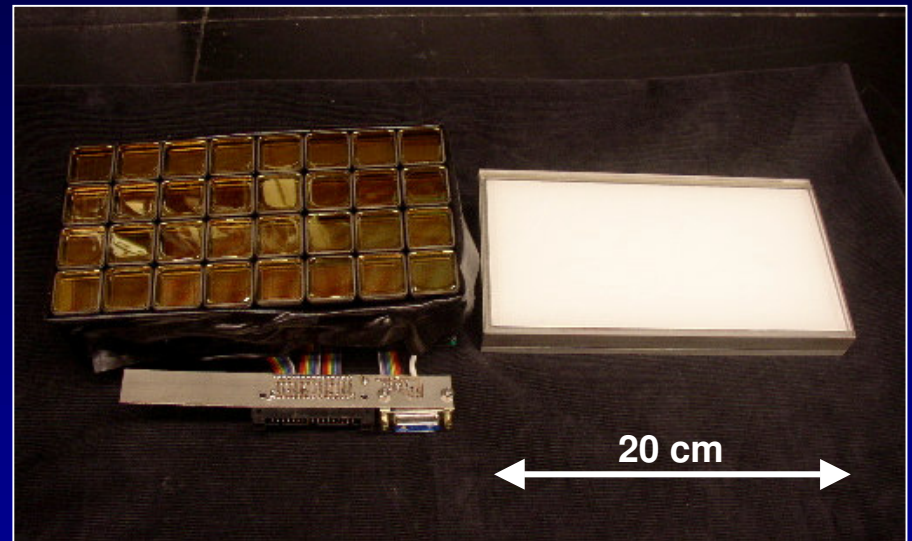
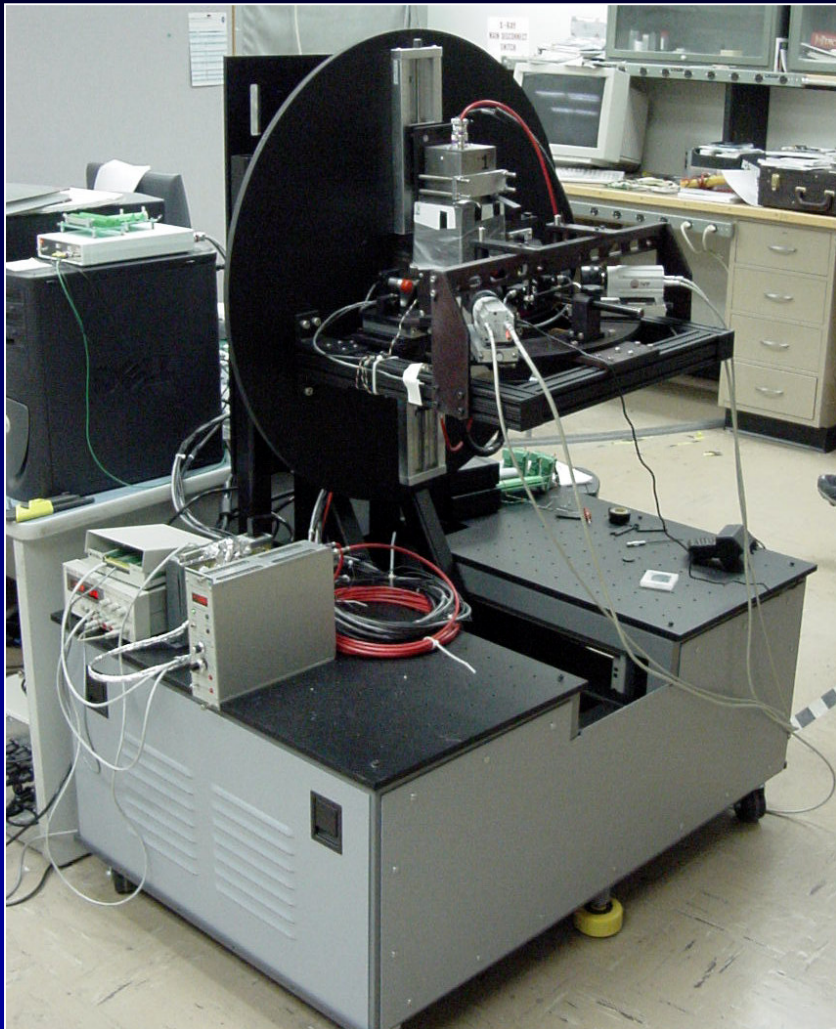


reference frame



moving frame

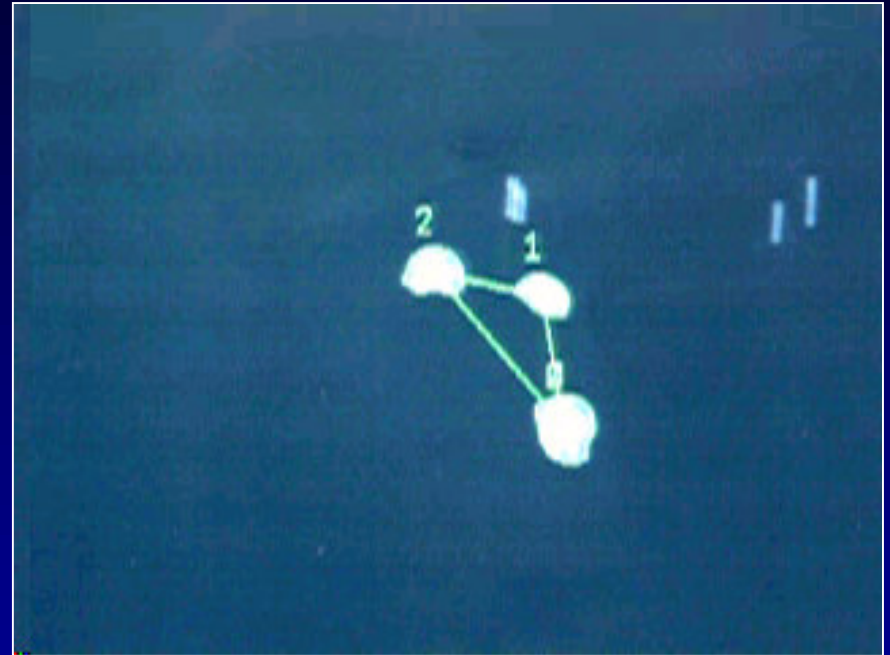
Assembled Gantry



First Live Mouse Experiment

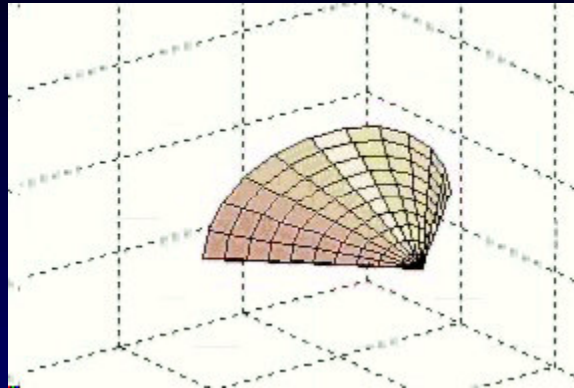


Movie of sleeping animal

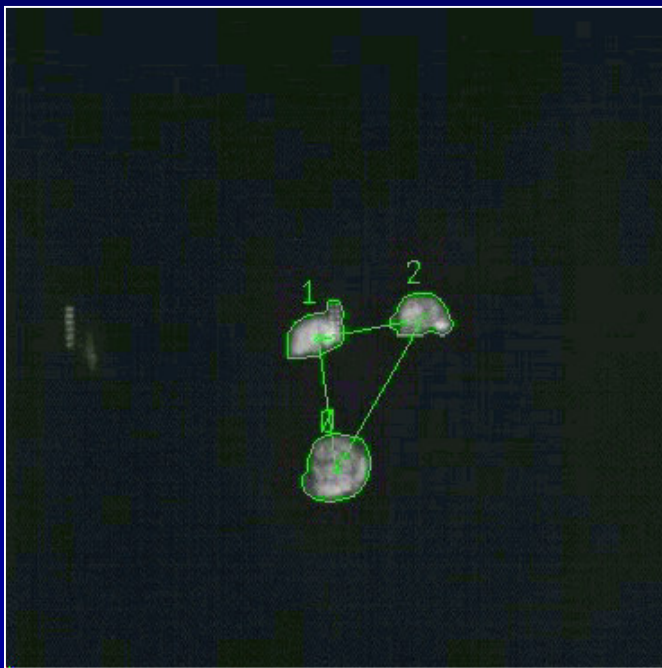


Movie of segmented image from camera #1

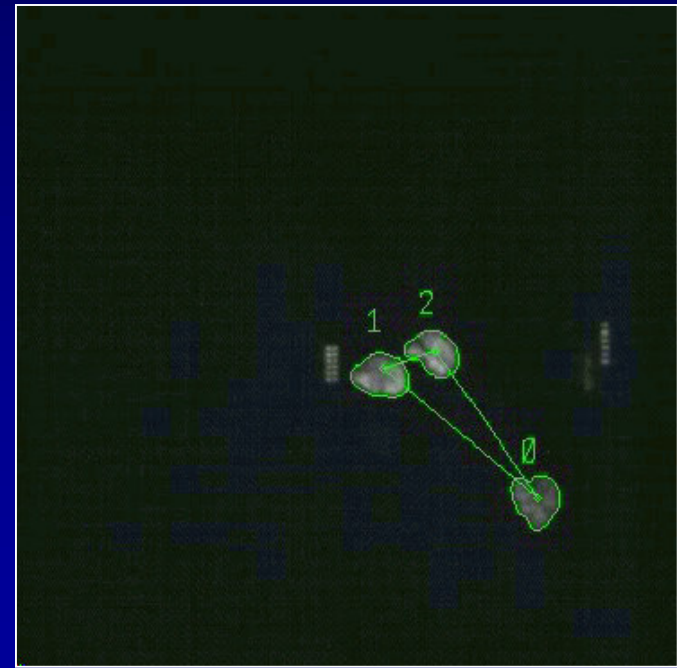
Awake Animal Experiment



Calculated Pose



Camera 1



Camera 2

Topical Review

**“In Vivo Molecular and Genomic Imaging:
New Challenges for Imaging Physics”,
S.R. Cherry, *Phys Med Biol* 49 2003 (in press)**