

EasyPET Technologies

22nd IEEE Real Time Conference



RI-TE
RADIATION IMAGING TECHNOLOGIES, LDA



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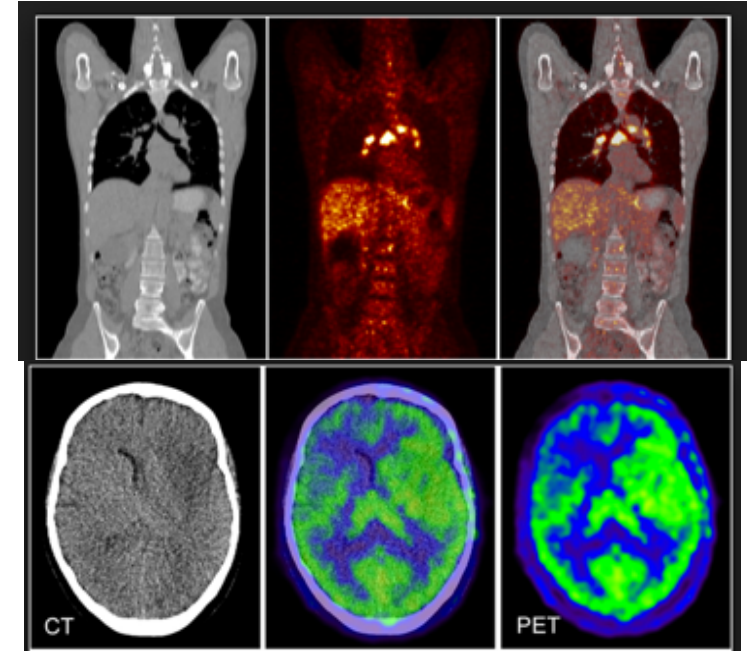
² RI-TE, Lda - Radiation Imaging Technologies, Portugal, www.ri-te.pt

*corresponding author pmcorreia@ua.pt

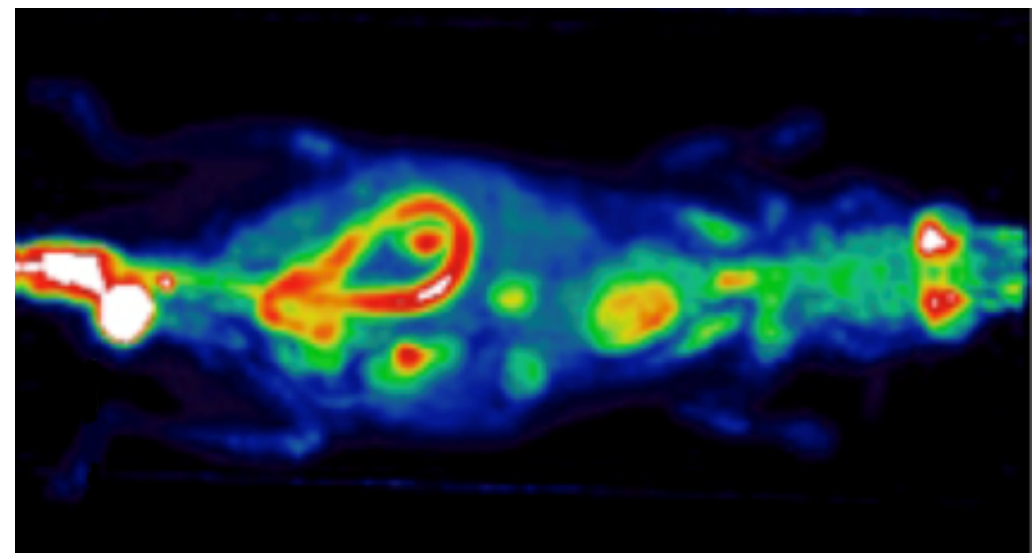
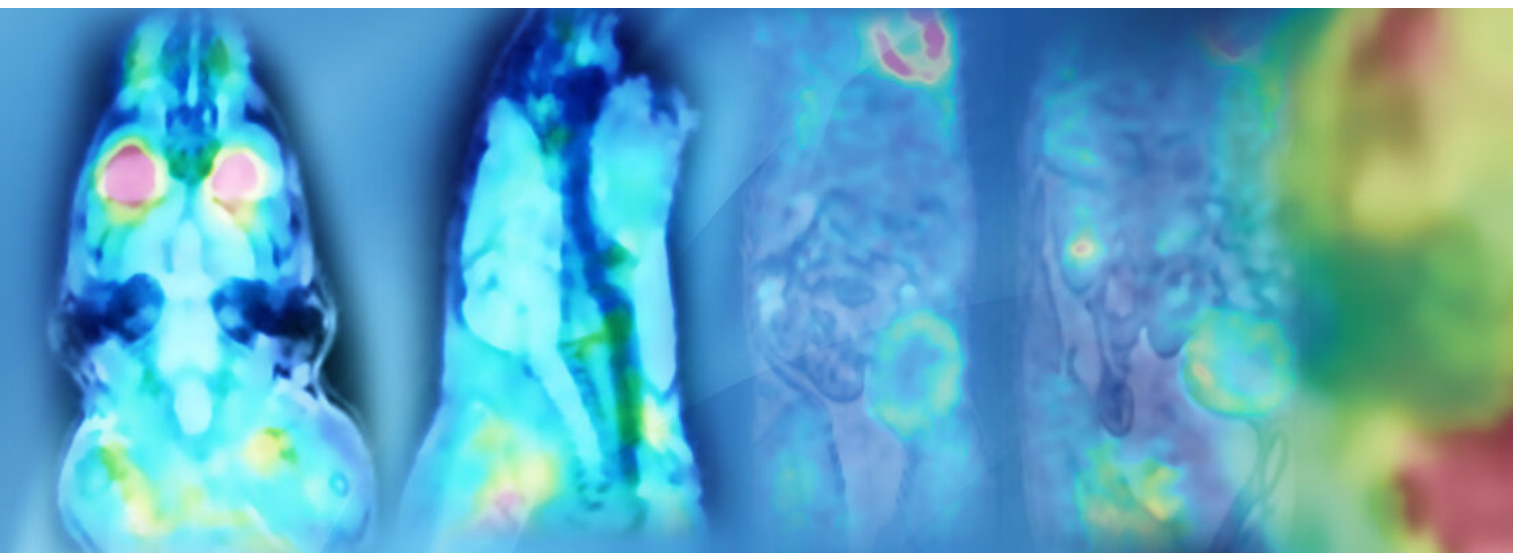
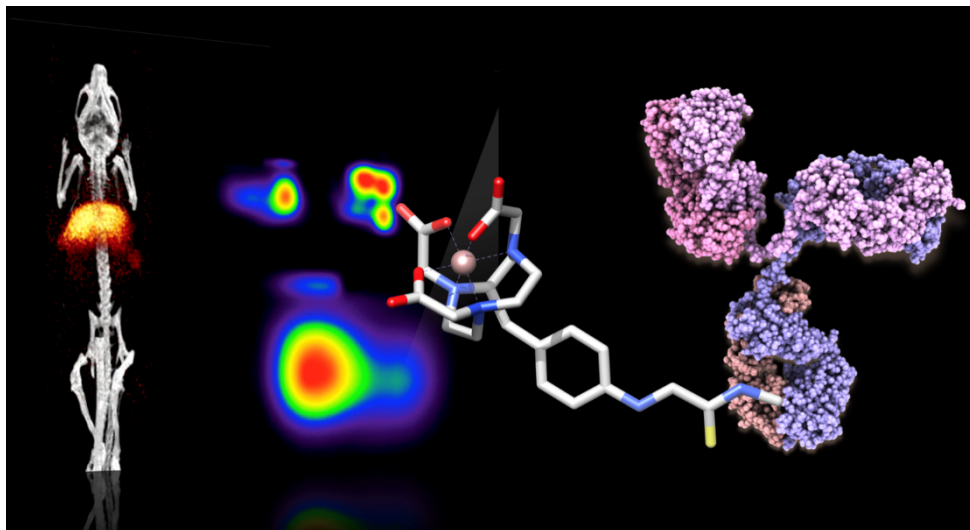
PET imaging

- PET is a major in vivo **nuclear imaging modality** that provides **functional information of the physiological processes** of organs and tissues
- PET has a unique role in **oncology, neurology and cardiology** due to its capability of disease detection, staging and therapy effect monitoring

PET, combined with morphological imaging through CT or MRI, has a **recognized superiority over all other imaging modalities**



Preclinical PET





PET scanners are too costly and bulky



**whole body
>3M€**



**breast
>1M€**



**preclinical
0.5-1M€**

PROBLEM .

PRECLINICAL PET SYSTEMS COSTS

~ 1.000.000 €

Limited access to:

X CROs

X Universities, Health Schools

“ ... this imaging technique has become a critically important tool in animal-based biomedical research. The application of small-animal PET has been expanded into many additional clinical indications.”

Small-Animal PET: What Is It, and Why Do We Need It?

Rutao Yao, et al.; J Nucl Med Technol 2012; 40:1–9

easyPET Concept

- **International patent**



PCT/IB2016/051487



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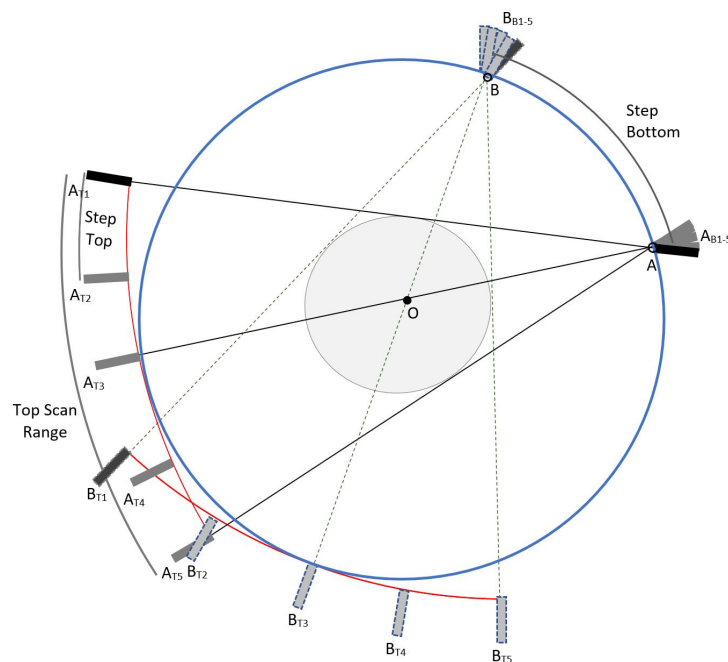
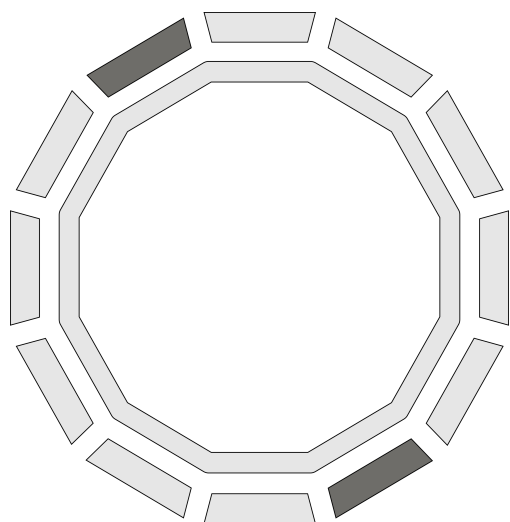


US20180070893A1

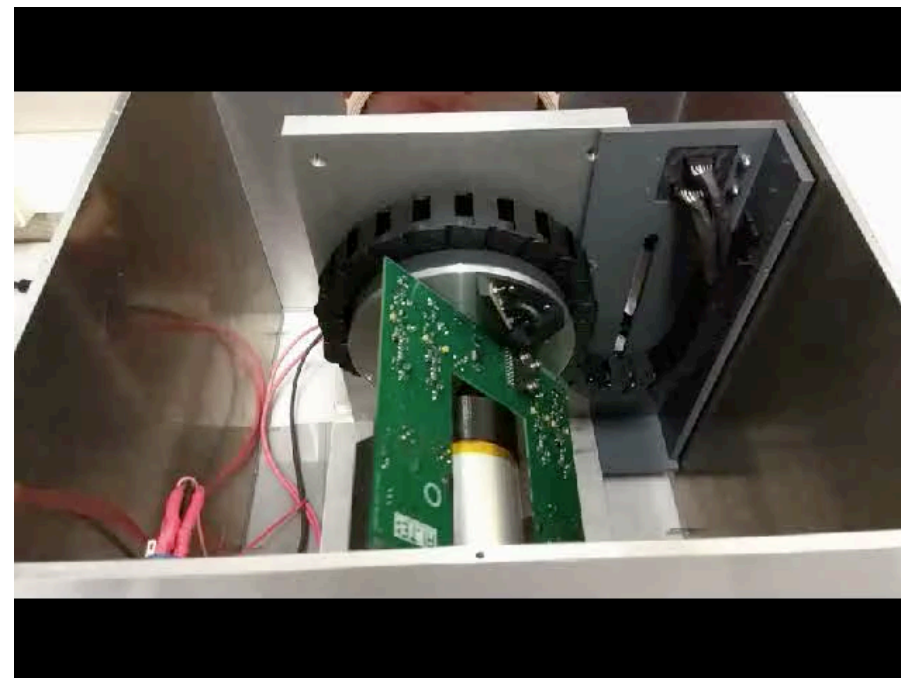


universidade
de aveiro

Single pair of collinear detectors executing two types of movements, a rotation and a scan, to provide the image reconstruction irrespective of the source position.

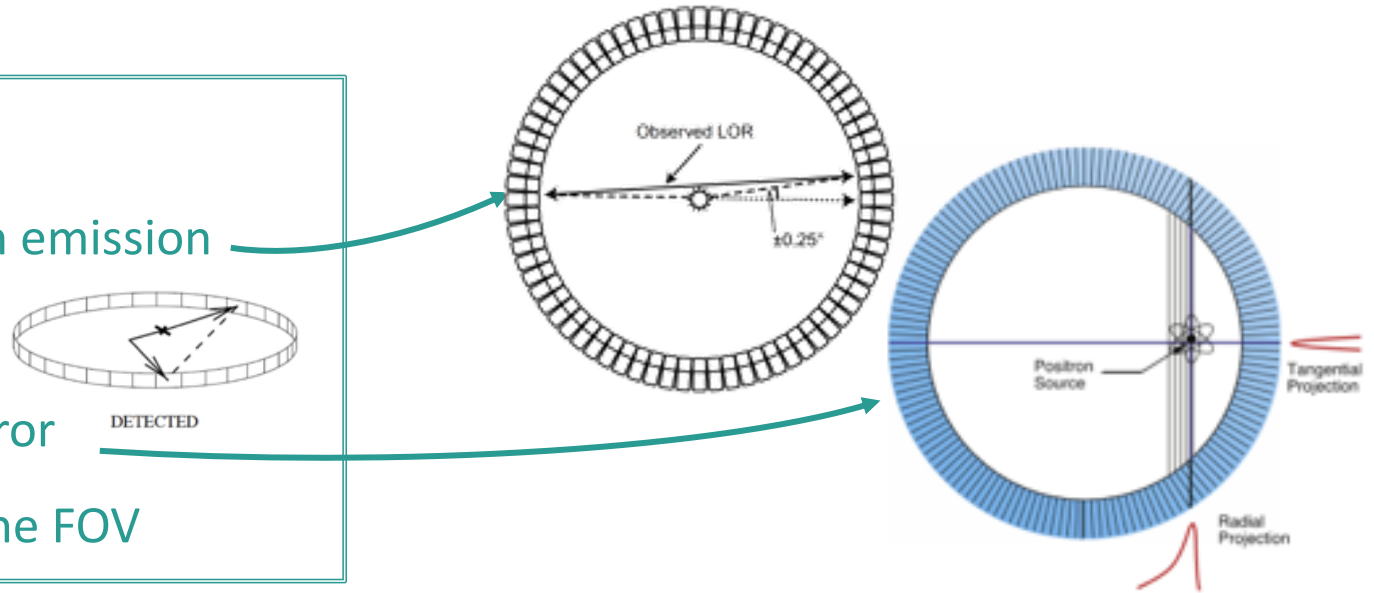


2 rotating detector blocks instead of full ring

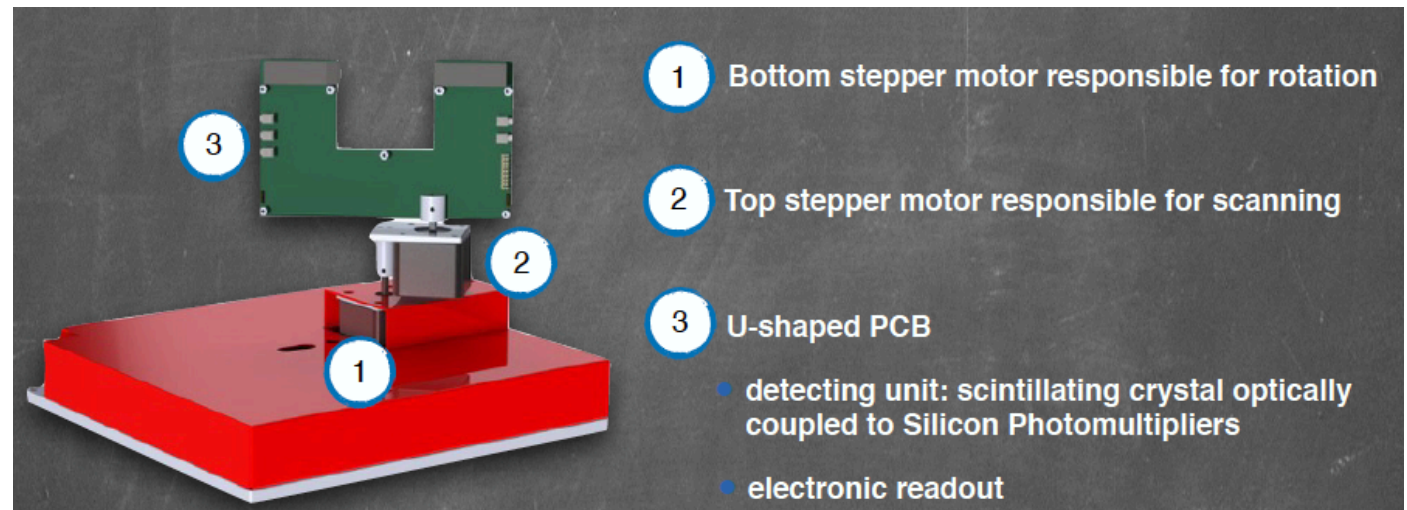


easyPET Concept

- Reduced system complexity and cost
- Intrinsic immunity to acollinear photon emission
- Intrinsic immunity to scatter radiation
- Intrinsic robustness against parallax error
- High spatial resolution, uniform over the FOV

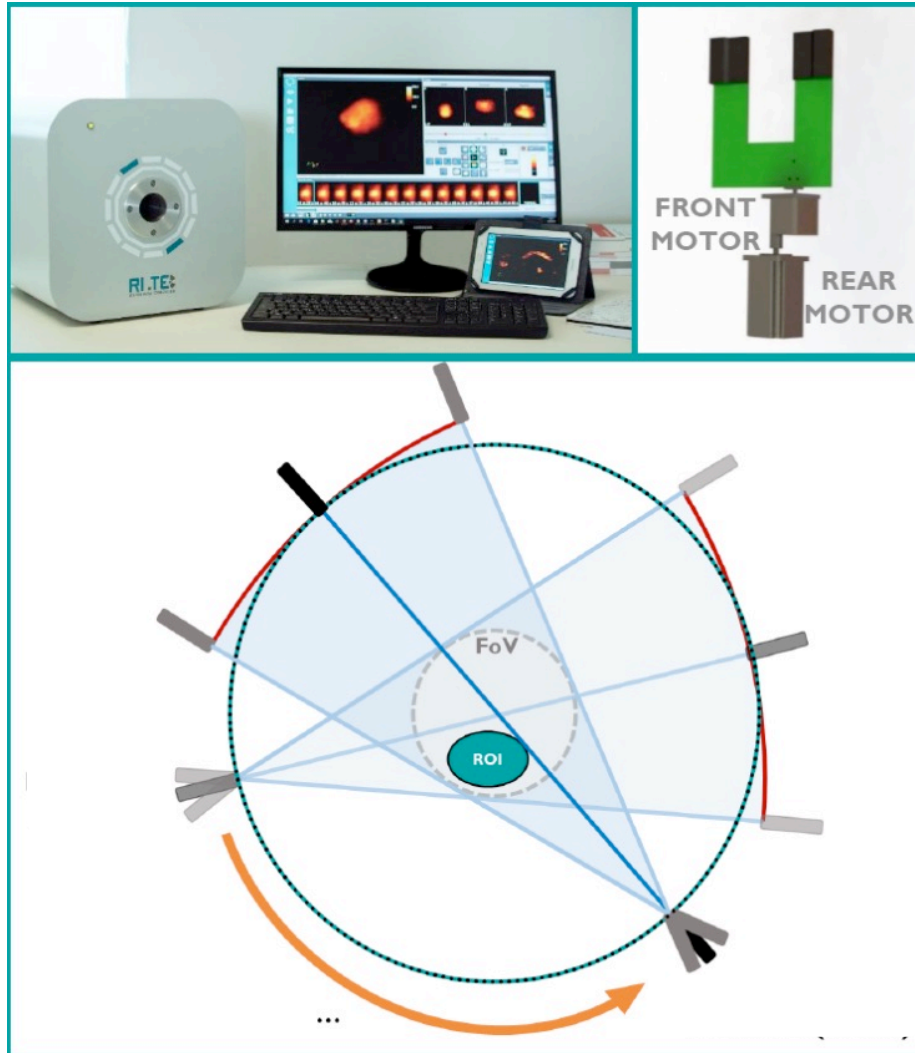


n edu CAEN Educational



easyPET Technology

Smart rotation of 2 detector modules instead of full ring



PATENTED

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PCT/IB2016/051487



cost reduction
5-10x

high quality images
res. < 1mm

from

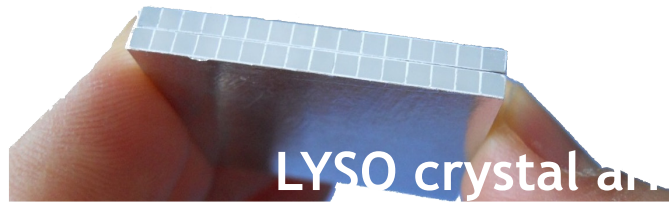
educational ...

EasyPET.3D

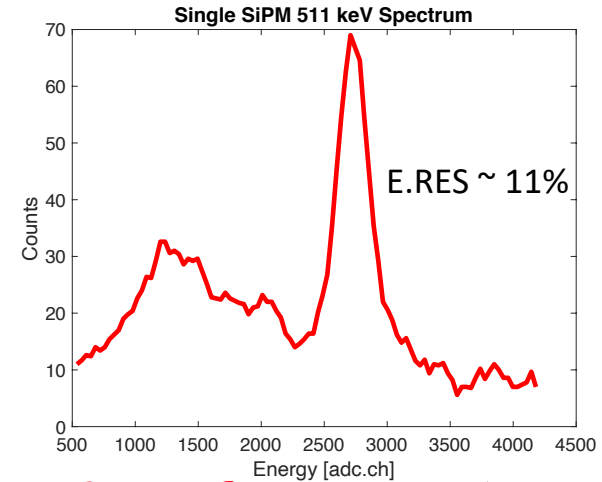
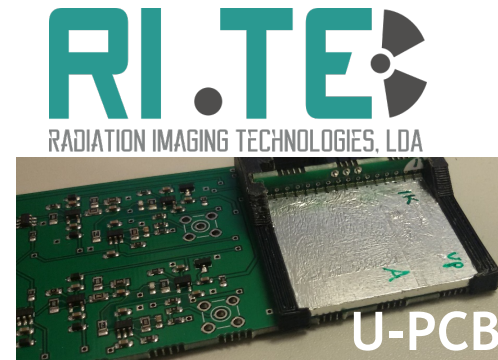
... to preclinical

easyPET.3D

- state-of-the-art detectors

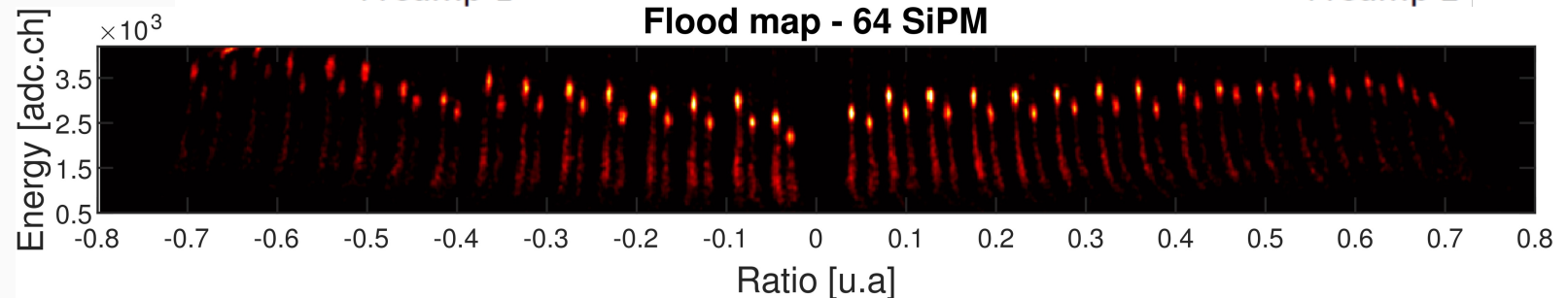
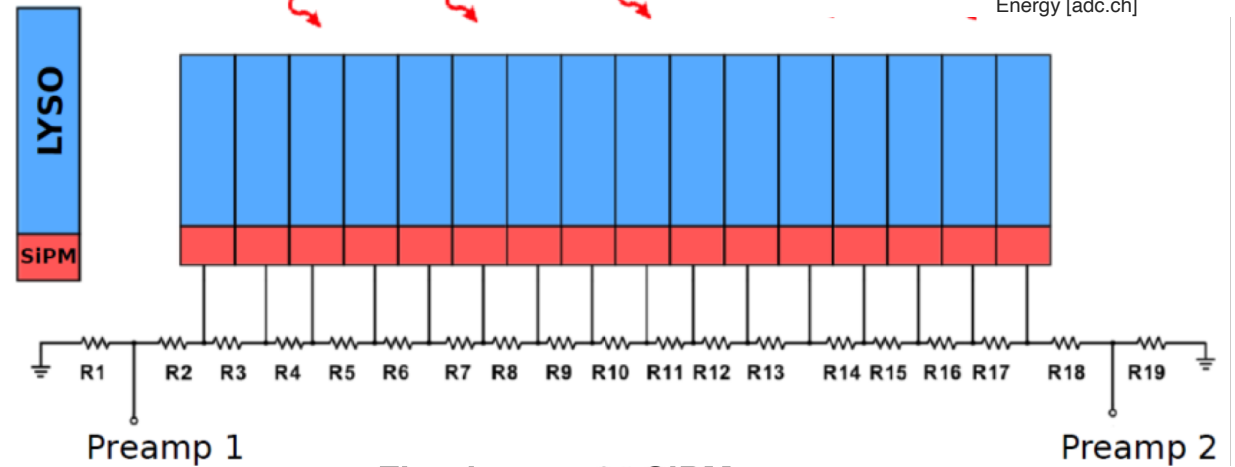
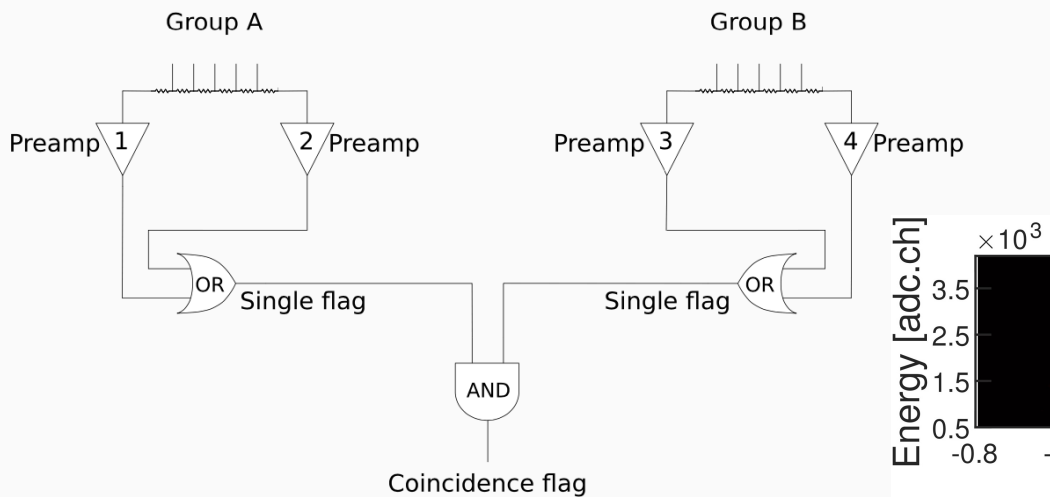


+



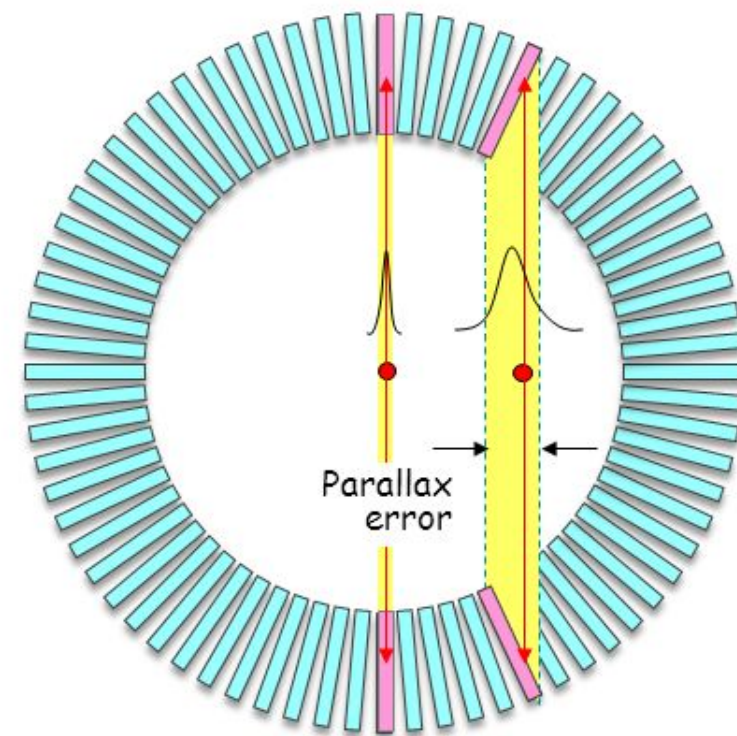
- simplified readout electronics

- model validation with 16+16 cells, in usage 64 + 64
- 2 x 2 x 30 mm. LYSO scintillators
- 1.3 x 1.3 mm. SiPM – MPPCs from Hamamatsu



easyPET.3D advantages

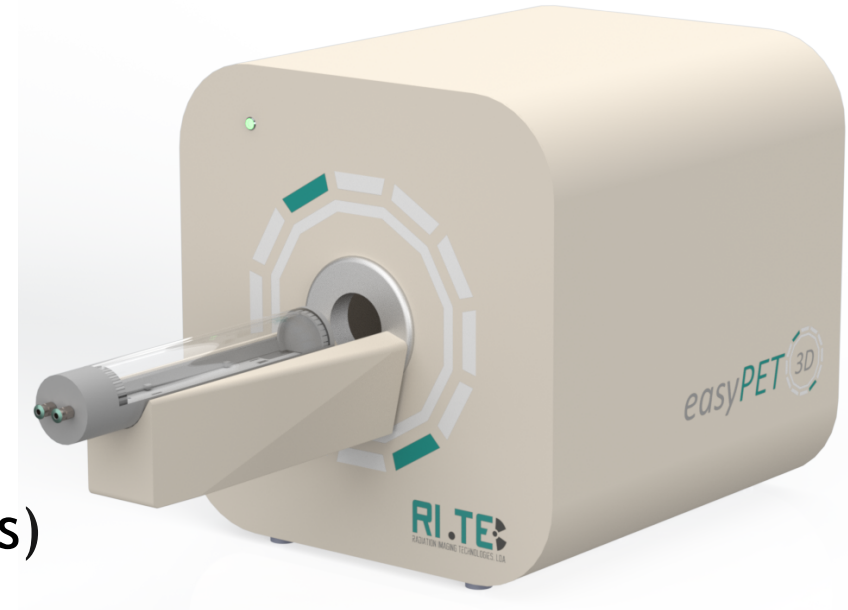
- ✓ uniquely affordable
- ✓ very compact - benchtop
- ✓ high performance - spatial resolution and uniformity (parallax errors can be avoided)
- ✓ real time 3D reconstruction (GPU accelerated)
- ✓ adjustable field-of-view, up to $\sim 7 \times 5$ cm
- ✓ intelligent scan of specific regions of interest
- ✓ all-in-one, streamlined software



Parallax effect
in ring-based PET

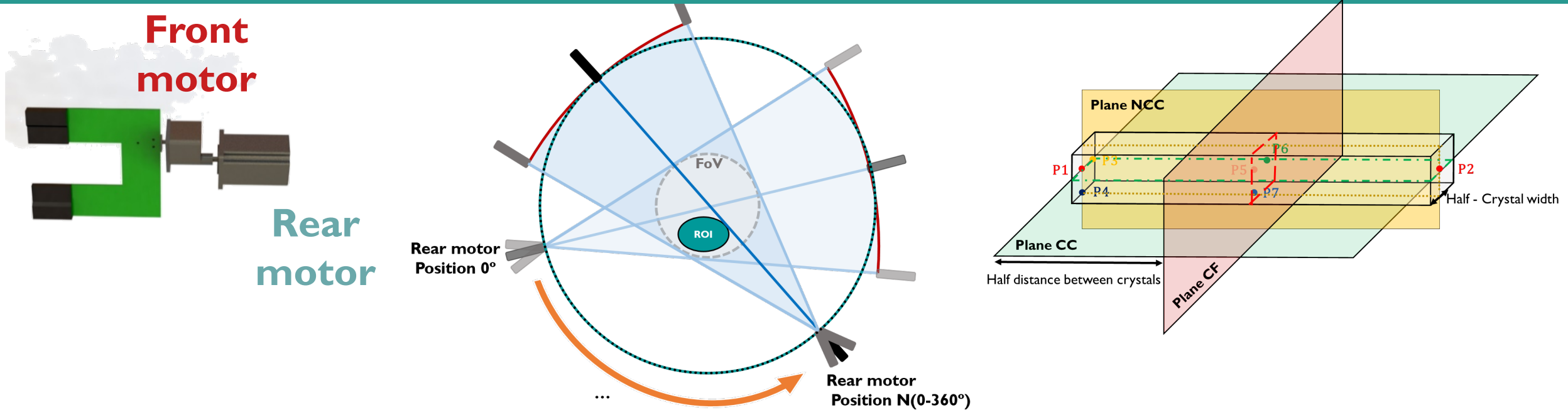
easyPET.3D applications

- 3D PET image reconstruction and analysis
- **in-vivo molecular imaging** of mice, zebrafish, plants, ...
(^{18}F , ^{68}Ga , ^{124}I , ^{89}Zr , ^{64}Co , ^{22}Na)
- fast dynamic scans in the first minutes post-injection
(complementing existing high-end preclinical PET systems)
- **hands-on professional training** of PET procedures:
calibrations, protocols, acquisitions, positioning, phantom imaging



Nuclear Medicine, Medical Imaging, Radiopharmacy, Biomedical Engineering

easyPET.3D Image Reconstruction



Computation problem

Based on the rotation of 2 detector modules achieving very **high spatial resolution** and sampling with only a small number of cells.

The 2 motors can sample each an angle as small as **0.014°** resulting in **billions** of possible ToRs resulting in a image reconstruction **challenge**.

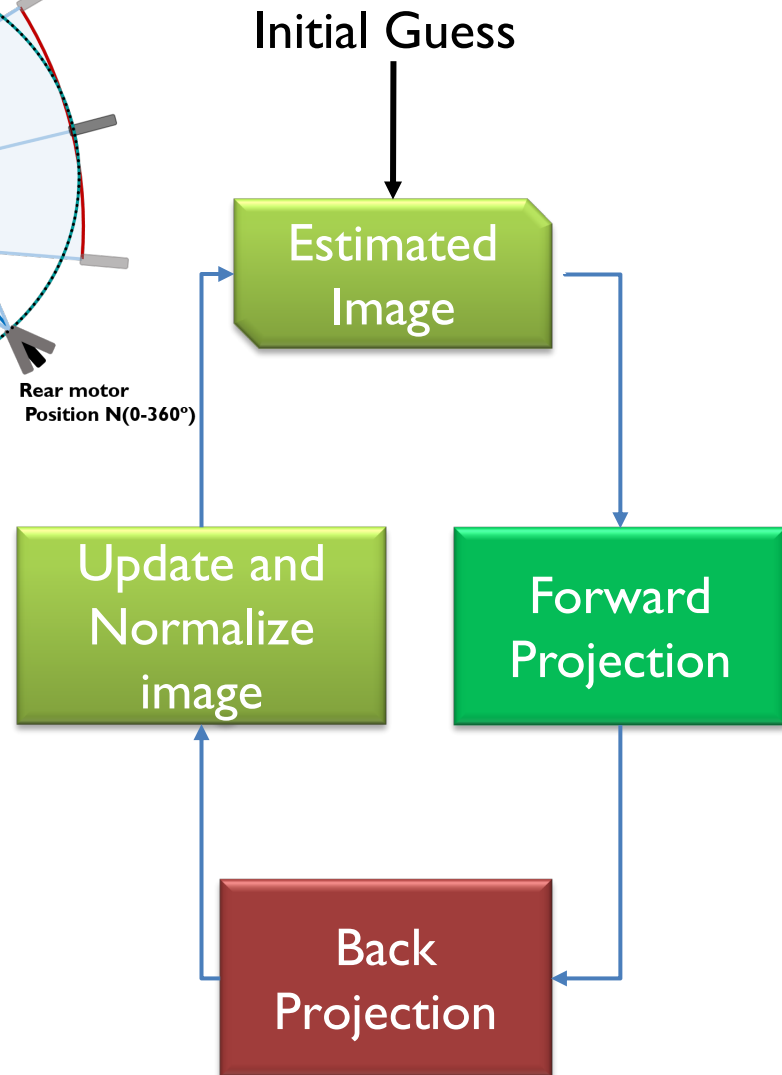
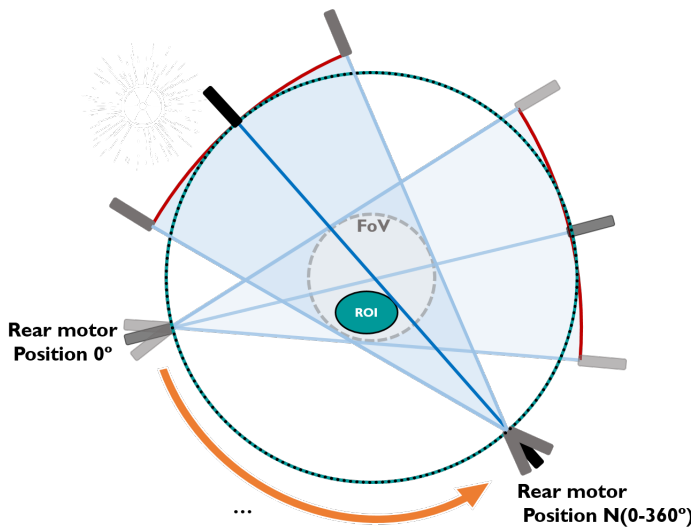
More than 2600 millions of possible ToRs for 64 crystals on each side

Solution:

GPU

Image reconstruction and on-the-fly calculation approach

easyPET.3D Image Reconstruction - GPU



GPU implementation:

- **Forward projection** – ToR-driven approach where each ToR is assigned to an independent GPU thread.
- **Back projection** – a voxel-driven approach was chosen to **avoid race conditions**.

The image update and normalization is performed by the CPU.

The algorithm described was developed with single-kernel approach for each operation.

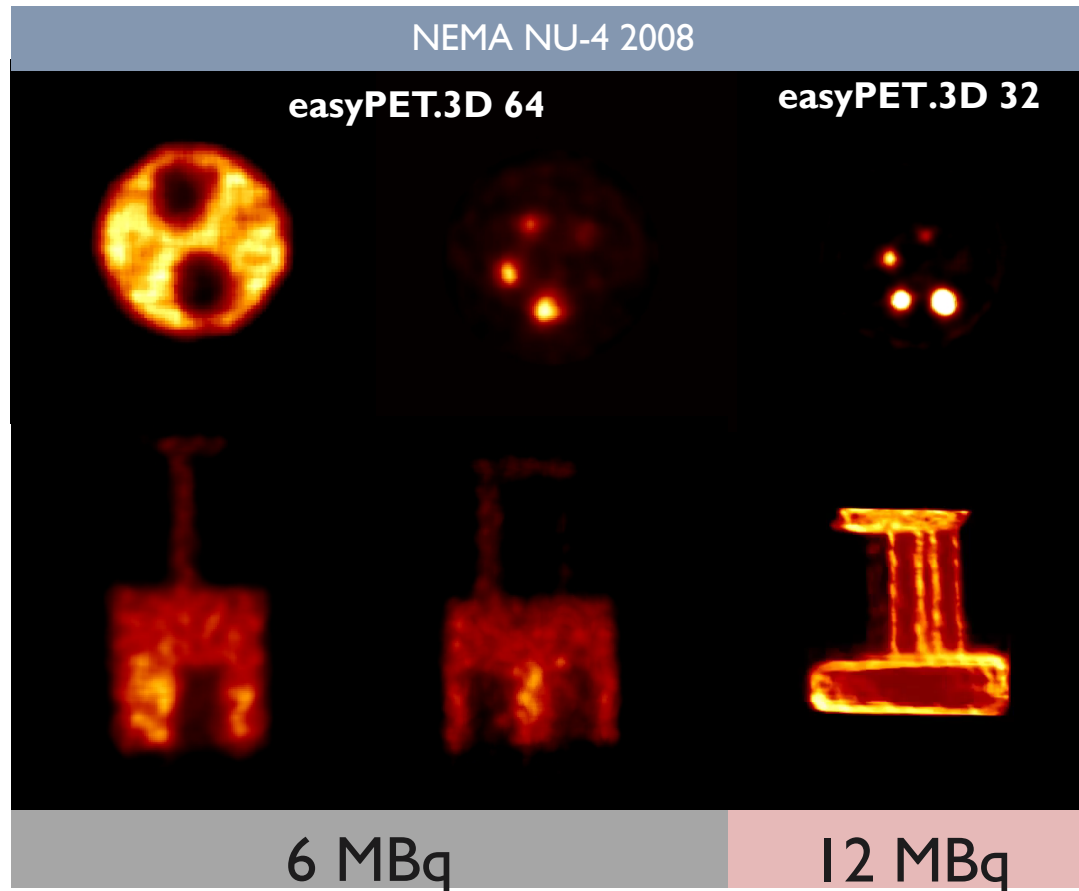
Preliminary results show a possible speed up of **3 to 4 times** by using a multiple kernel approach and optimizing the load transfers to the GPU.

for a Nvidia 2080 Ti

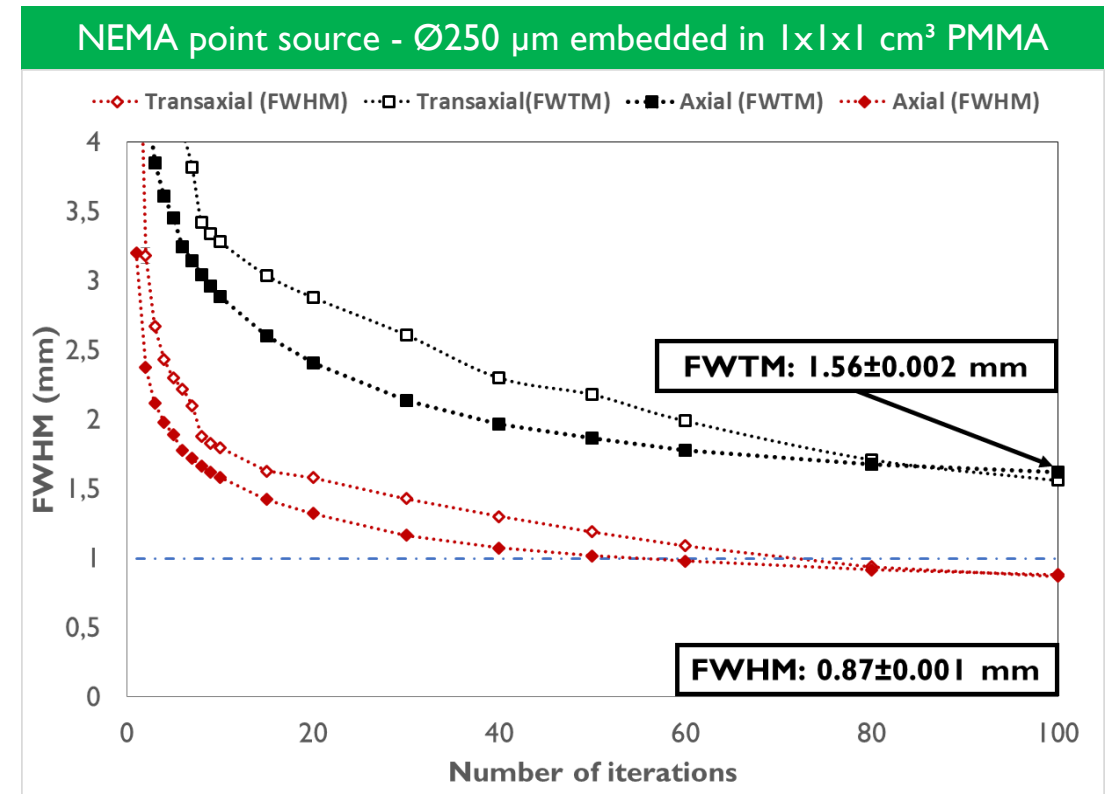
Current Speed ~ 0.2×10^{12} updated voxels per second

First (Coarse) Images available in seconds

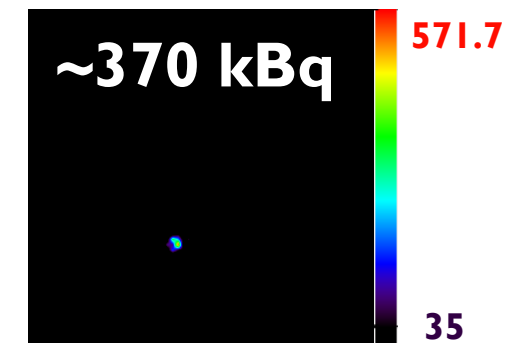
easyPET.3D Phantoms and point source



With a higher scanning granularity



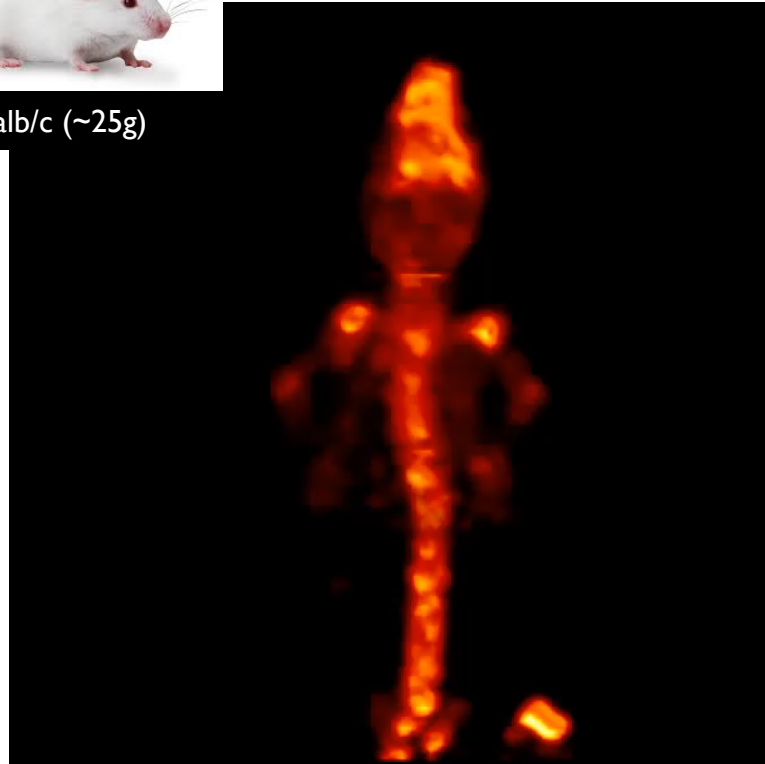
Measured at **10.4 mm** from the center FoV with 20 mm radius



easyPET.3D Preclinical Studies



Balb/c (~25g)



The image shows a healthy mouse injected with 7.8 MBq of ^{18}F -NaF bone tracer acquired by easyPET.3D

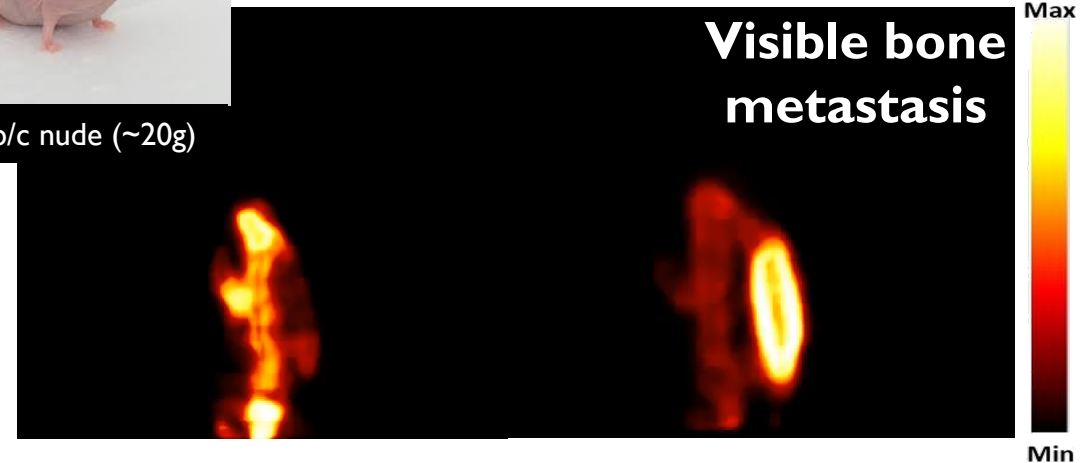
Hypothesis: Bone metastasis could grow from WiDr cell line (human colon cancer)?

Balb/c nude healthy mouse (control)
versus

5th week after WiDr injection



Balb/c nude (~20g)



8.2 MBq of ^{18}F -NaF

5.5 MBq of ^{18}F -NaF

easyPET.3D software

dedicated GUI

The screenshot displays the easyPET.3D software interface, which is divided into several functional areas:

- Volume View:** A large central window showing a 3D volume rendering of a PET scan. A color scale on the right indicates intensity values from 0.0 to 93.0. A yellow box highlights a region of interest, and a red line indicates a slice plane. A small 3D coordinate system (A, R, I) is visible in the bottom left of this view.
- Image View:** A window on the right showing three orthogonal slices: Axial, Coronal, and Sagittal. The Axial view is labeled 'A' and 'L-P'. The Coronal view is labeled 'R' and 'R I-L'. The Sagittal view is labeled 'A' and 'S I-P'. Below these views is a slider for slice position, currently set at (61.56, 20.35, 39.0) mm.
- Image Tools:** A toolbar below the image views containing:
 - Camera:** Controls for camera movement and zoom.
 - 3D:** Controls for 3D rendering, including rotation and zoom.
 - 2D:** Controls for 2D rendering, including interpolation (set to Gaussian) and filter radius (set to 4).
 - Colormap:** A color map control set to 'Hot' with a corresponding color scale.
- Dynamic views:** A row of three small image thumbnails at the bottom. The first two are labeled '03 m 40 s' and '07 m 20 s'. The third is labeled 'TOTAL' and '07 m 19 s'.
- Bottom Panel:** A status bar at the very bottom showing 'Frame Total', 'Counts: --', 'DataBase: Localhost', 'EasyPET link: Connected', and 'Temperature: Not available'.

Acknowledgements



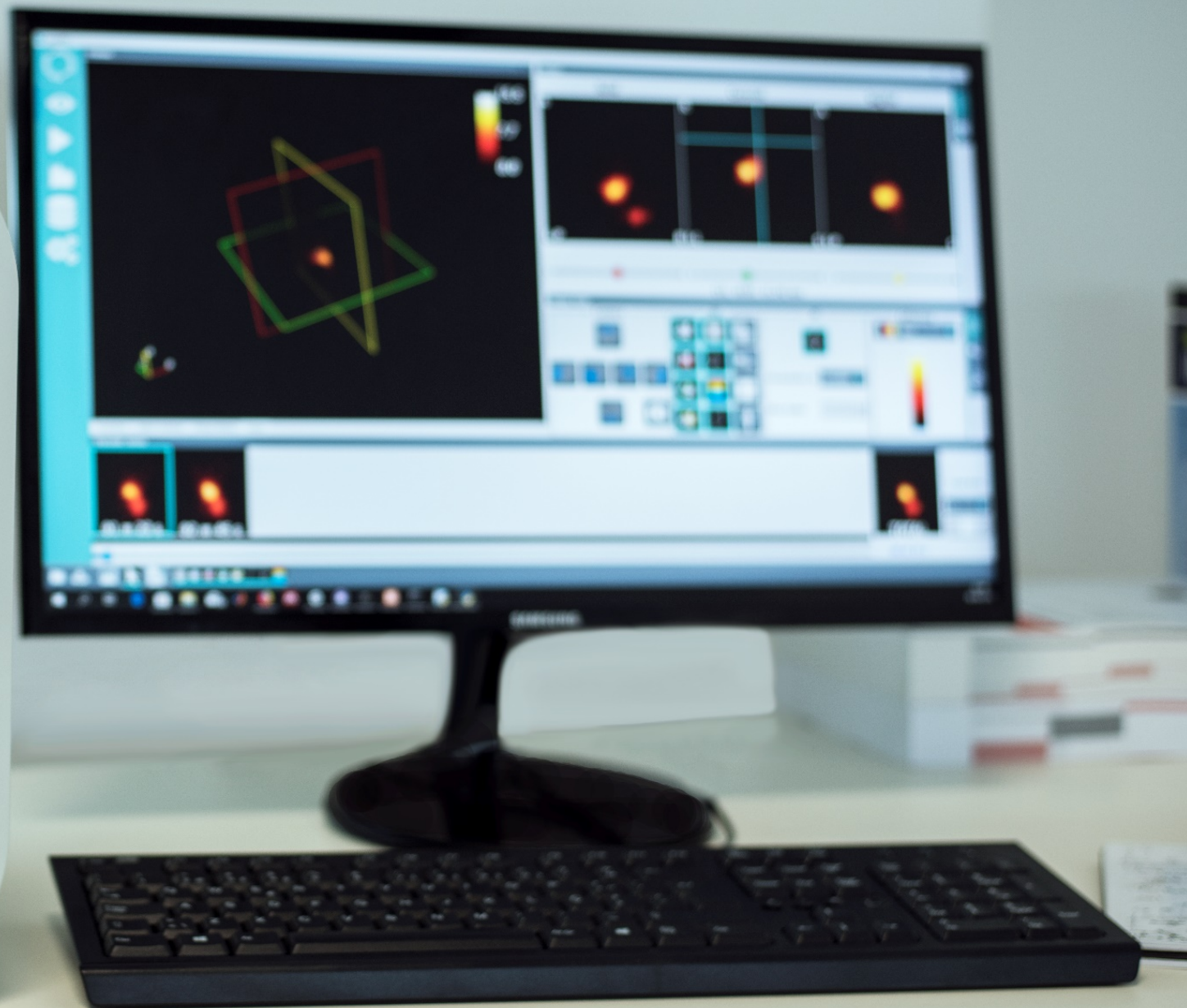
Special thanks to Prof. Dr. Ana Cristina Santos (IBILI-ICBR) for the small mice studies and the Coimbra University Hospital (CHUC) for the supply of ^{18}F radiopharmaceuticals.

P. M. C. C. Encarnação and F. M. Ribeiro are thankful to FCT (Fundação para a Ciência e Tecnologia) for PhD grants SFRH/BD/143964/2019 and SFRH/BD/137800/2018.

This work was supported by project CENTRO-01-0247-FEDER-039880, co-financed by the EU through ERDF (CENTRO2020 program).



Keep PET simple!



Backup Slides



universidade de aveiro



UNIVERSIDADE DE COIMBRA



The University of Manchester



UNIVERSITAT DE VALÈNCIA



Technological and
Intelligent Systems, Lda



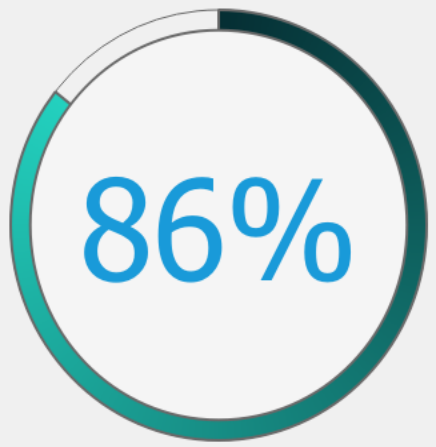
Accelerated by
Health



ESCOLA SUPERIOR DE
TECNOLOGIA DA SAÚDE
DE LISBOA



Subject - ID: Animal - Nude-1-Jun-2018
Healthy: Yes



Observations:
Important information about acquisition. Do not forget to click on Submit button when the acquisition is over...

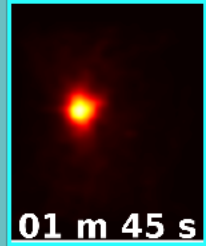
Submit



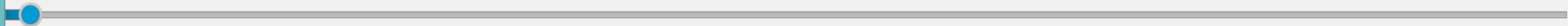
DataBase: Localhost EasyPET link: Connected System Temperature: 27.1° Correct Counts: 1899.0

Parameters Subject Database Energy Window Volume

Dynamic views



01 m 45 s



02 m 59 s

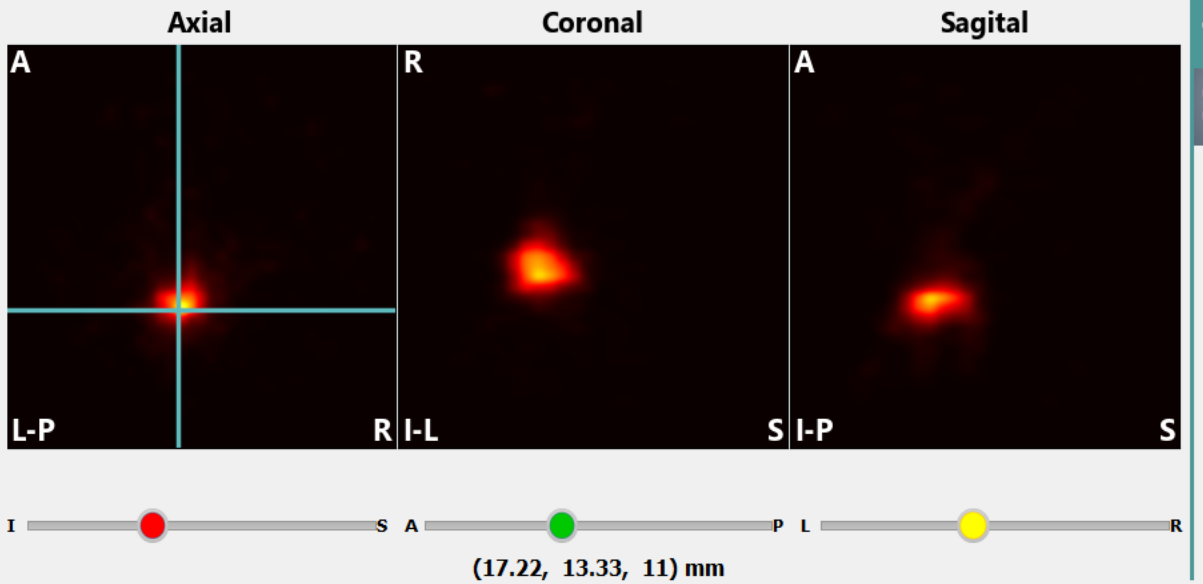


Image Tools

Camera: [Icons for camera views]

3D: [Icons for 3D visualization]

2D: [Crosshair icon]

Interpolation 2D: Gaussian

Filter Radius: 4

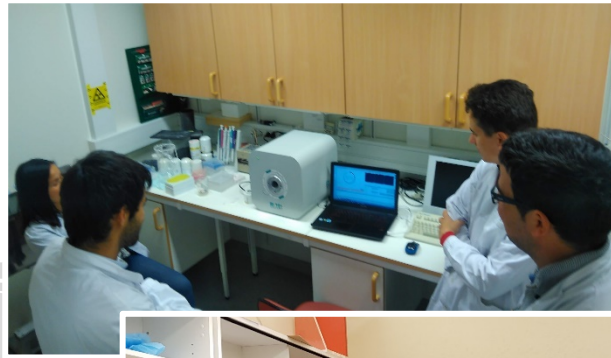
Colormap: Hot

Frame Rate

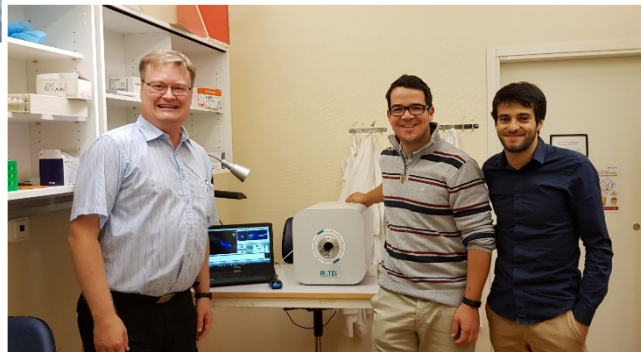
1 s



Europe



Karolinska Institute
(Sep. 2019)



Uppsala Univ.



Sweden

2020 - place easyPET.3D for pilots/benchmarking at Karolinska Institute: world top R&D institute in the field

Germany

IP (patent) rights
Market potential

UK

Partners / Users



France

Market potential

Italy

Partners



Spain

