Intelligent scanning preclinical PET: project status and first animal imaging

P.M.M. Correia[1,2*], A.L.M. Silva[1,2], J. Menoita[1], F. M. Ribeiro[1], N.O. Romanyshyn[1], F. C. Rolo[1] I.F. Castro[1,2], P.M.C.C Encarnação[2], F. Rodrigues[2], A.C. Santos[3], C. Ramos[3], F. Caramelo[3], N.C. Ferreira[3,4], D.A. Sá[3,4], N. Matela[5], P. Almeida[5], P.M. Sá[5], V. Arosio[6], M. Caccia[6], R. Santoro[6], J.F.C.A. Veloso[1,2]

1 i3N – Departamento de Física da Universidade de Aveiro, 3810-193 Aveiro, Portugal
2 RI-TE - Radiation Imaging Technologies, Lda, IEUA Edifício 1, 3810-193 Aveiro, Portugal
3 Institute for Clinical and Biomedical Research (iCBR), Biophysics Institute, Faculty of Medicine, Univ. of Coimbra 3000-548 Coimbra, Portugal
4 ICNAS, Universidade de Coimbra 3000-545, Coimbra, Portugal
5 Instituto Biofísica e Engenharia Biomédica, Faculdade de Ciências, Universidade de Lisboa, 1749-016 Lisboa, Portugal.
6 Dipartimento di Scienza e Alta Tecnologia, Università degli Studi dell'Insubria, Via Valleggio 11, 22100 Como, Italy

*correspondent author
pmcorreia@ua.pt

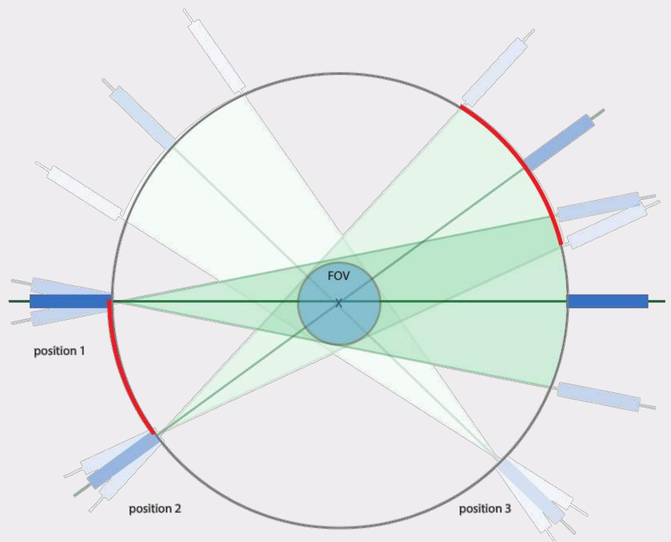
Abstract

EasyPET is a new concept of an affordable PET scanner using an innovative acquisition method based on two rotation axes for the movement of detector pairs. The concept allows achieving high and uniform position resolution over the whole field of view (FoV), by eliminating parallax errors due to the depth of interaction (DoI), which are typical of ring-based PET systems. Full axial imaging is possible with EasyPET using only a small number of detector elements, reducing production costs.

An intelligent scanning mode allows the selective scanning of the regions of interest, thus increasing the sensitivity and the image S/N ratio and reducing the acquisition time. A small concept demonstrator for 3D imaging with 16 + 16 detector cells was built, based on LYSO scintillators coupled to SiPMs, covering a 50 mm diameter × 34 mm long field of view. The performance of the system is evaluated using the NEMA NU 4-2008 standards.

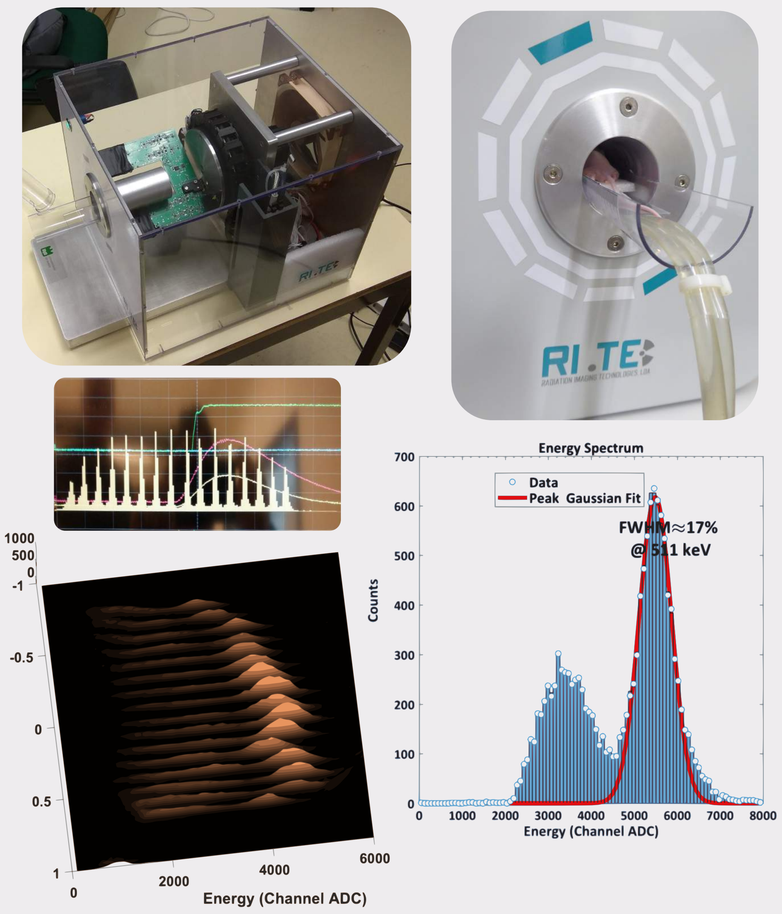
An overview of the project status is given, including a comparison between simulation obtained with GATE and experimental results in terms of system performance, as well as some preclinical acquisitions examples, will be presented.

Operation Principle



Acquisition method - based on **2 rotation axes** for the movement of detector modules.
Allows full axial imaging (full animal body) with a small number of crystals.
High spatial resolution and uniformity over the **whole FOV.**
Eliminate the parallax error due to depth of interaction (DOI):
-does not impose limitations on the proximity of the detector elements to the FOV;
-favours system sensitivity.

The easyPET demonstrator

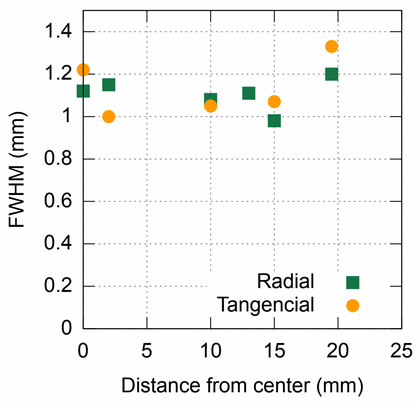


Energy Spec. and Multiplexed Pulse Ratio (for crystal separation) for the 16 crystals (1 side) used in the prototype.

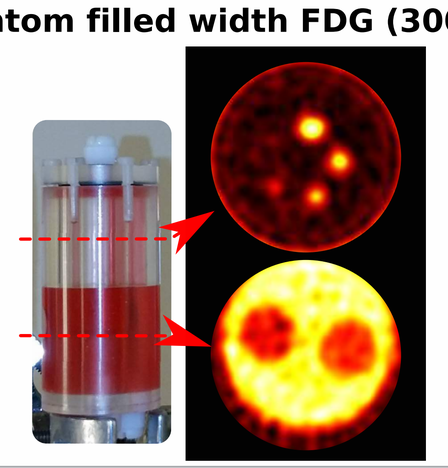
easyPET demonstrator (16 + 16 : 2 x 2 x 30 mm LYSO crystals) : Experimental results

NEMA NU 4-2008 Spatial Resolution

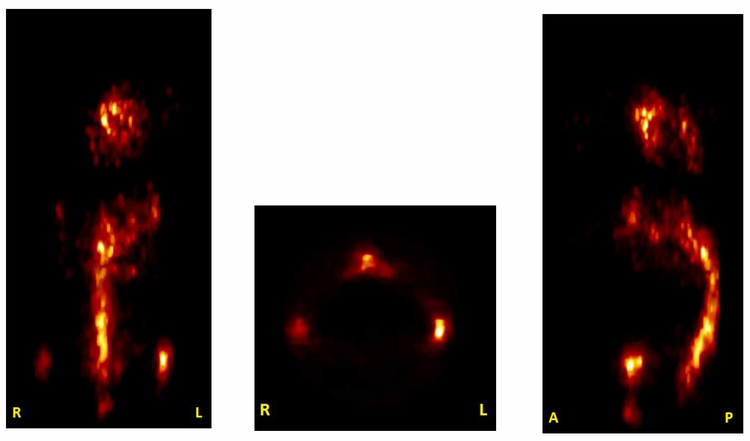
Position Resolution (PSF)



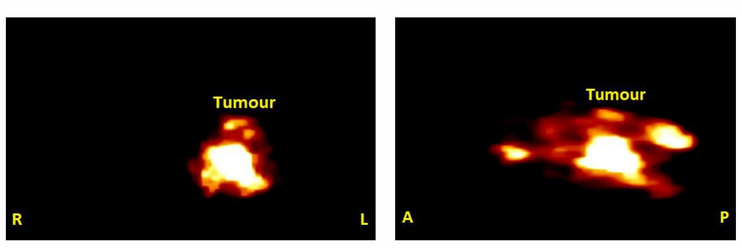
NEMA NU 4-2008 Micro-PET IQ phantom filled width FDG (300 uCi)



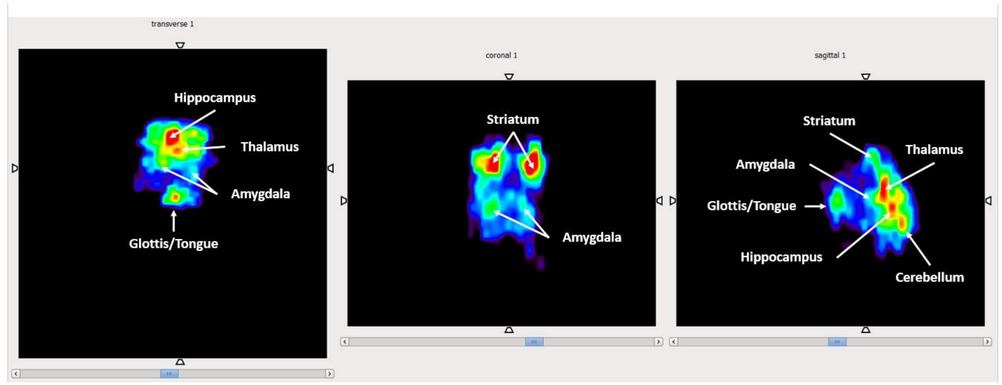
Mouse (20 g) – NaF bone scan (290 uCi injected), 90 min PET acquisition. Transverse, coronal and sagittal views: edema in the left knee joint diagnosed



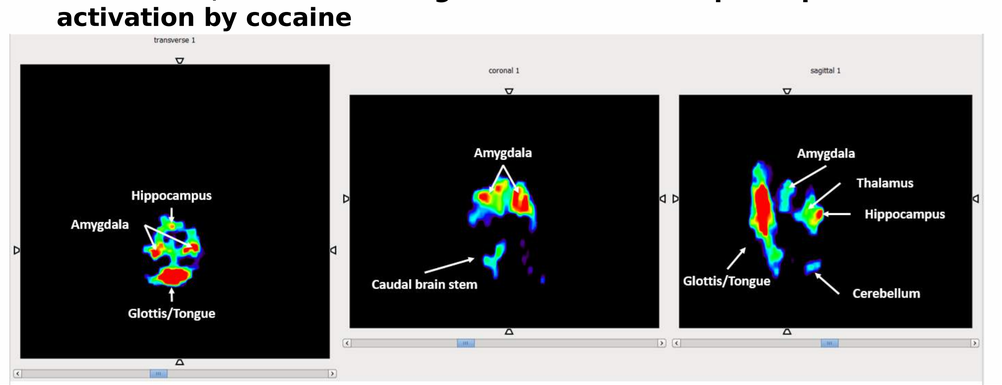
Mouse (22 g) - FDG brain scan (395 uCi injected), 50 minute PET acquisition. Tranverse and sagittal views. breast cancer cells injected in the skull for bone metastasis induction. Tumour identified (~ 6 x 4 mm).



Mouse (23 g) - FDG scan (4 uCi injected), 50 min PET acquisition. Control subject (no stimulus). Transverse, coronal and sagittal views: identification of the main brain structures - striatum, hippocampus, thalamus, amygdala and cerebellum



Mouse (23 g) - FDG scan (4 uCi injected), 50 min PET acquisition. Transverse, coronal and sagittal views: brain uptake post-activation by cocaine



Conclusions

Simple and unique image acquisition method

Demonstrator/Training version

- Excellent spatial resolution of around 1.1 mm FBP and uniform over the whole FOV
- Cell identification trought resistive chain – only 4 readout channels
- Good biodistribution studies capability
- Commercial version for training purposes was developed

Scaled up version (50x5 + 50x5 : 1.5x1.5x20 mm LYSO crystals)

- For high performance preclinical studies
- Low cost
- High spatial resolution below 1 mm (FWHM) over the whole FOV
- Fair sensitivity of about 2% (estimated with intelligent scanning)

There is room for improvement:

- Intelligent scanning - only subject volume will be scanned
- Sensitivity - Background reduction and contrast increase
- Scanning step smaller than crystal size - super-resolution

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Acknowledgements

P. M. M. Correia is grateful to the I3N laboratory, funded by UID/CTM/50025/2013
P. M. M. Correia is supported by the FCT (Lisbon) scholarship BD/52330/2013.This work was partially supported by project POCI-01-0145-FEDER-016855 and PTDC/BBB-IMG/4909/2014, projetct easyPET nº 17823, UID/CTM/50025/2013 and Pest-OE/SAU/IU0645/2013, through COMPETE, FEDER, POCI and FCT (Lisbon) programs.