ScintoTube: An Edgeless preclinical PET insert

Marta Freire[1], Andrea Gonzalez-Montoro[1], Gabriel Cañizares, Celia Valladares, Stuart S. Berr[2], Mark B. Williams[2] Carlos Correcher[3] and Antonio J. Gonzalez[1]

[1]Institute for Instrumentation in Molecular Imaging, i3M CSIC-UPV, 46022-Valencia, SPAIN.
[2]Department of Radiology and Medical Imaging, The University of Virginia, UNITED STATES
[3]Bruker NMI, Valencia, SPAIN

contact: mfreire@i3m.upv.es

Abstract

Improving spatial resolution and sensitivity drive the instrumentation research in small animal Positron Emission Tomography (PET) imaging. Moreover, including accurate photon Depth of Interaction (DOI) information plays an important role. In order to achieve these goals, we already constructed an edgeless PET system for small animals based on a single scintillator annulus. However, this design results in some undesired internal reflections. To mitigate these drawbacks, we present an upgraded version based on a single LYSO piece with both inner and outer faces. In this work we report the First prototype design and preliminary results including both nuclear and optical simulations.

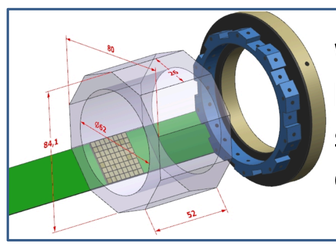
Introduction

Positron Emission Tomography (PET) scanners are usually based on several detector modules forming one or more rings and presenting gaps between modules in both transaxial and axial axis, which produces degradation of the spatial resolution and loss of sensitivity (1).

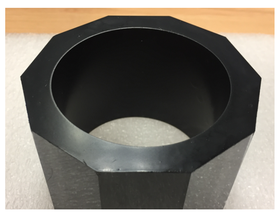
Our goal

Improving spatial resolution and sensitivity of PET inserts.
Including Depth Of Interaction (DOI) for correcting parallax errors.

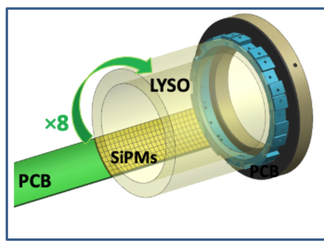
ScintoTube I



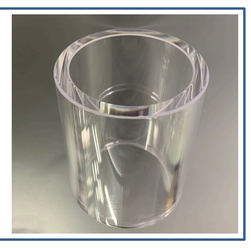
We already built this PET insert based on a single monolithic scintillator LYSO tube with inner circular face but ten outer facets (2).



ScintoTube II



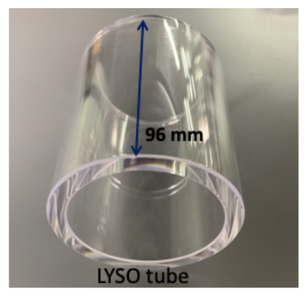
We have modified the design and now both inner and outer faces are cylindrical. The system has been assembled. We report the first prototype desing and preliminary results.

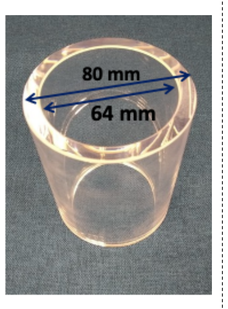


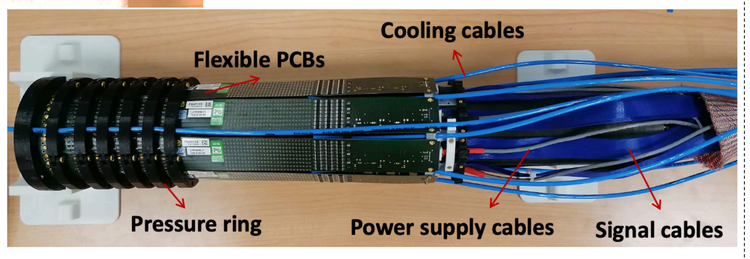
Materials and Methods

Sytem Design:

LYSO monolithic crystal tube OD / ID = 80 / 64 mm,
with inner and outer edges black painted
8 custom flexible PCBs with 27x9 (3x3 mm^2) SiPMs
6 Pressure rings to flex the PCBs







Experimental acquisition:

Calibration data was acquired moving a ^{22}Na point source attached to the inner face of the tube.

Simulations:

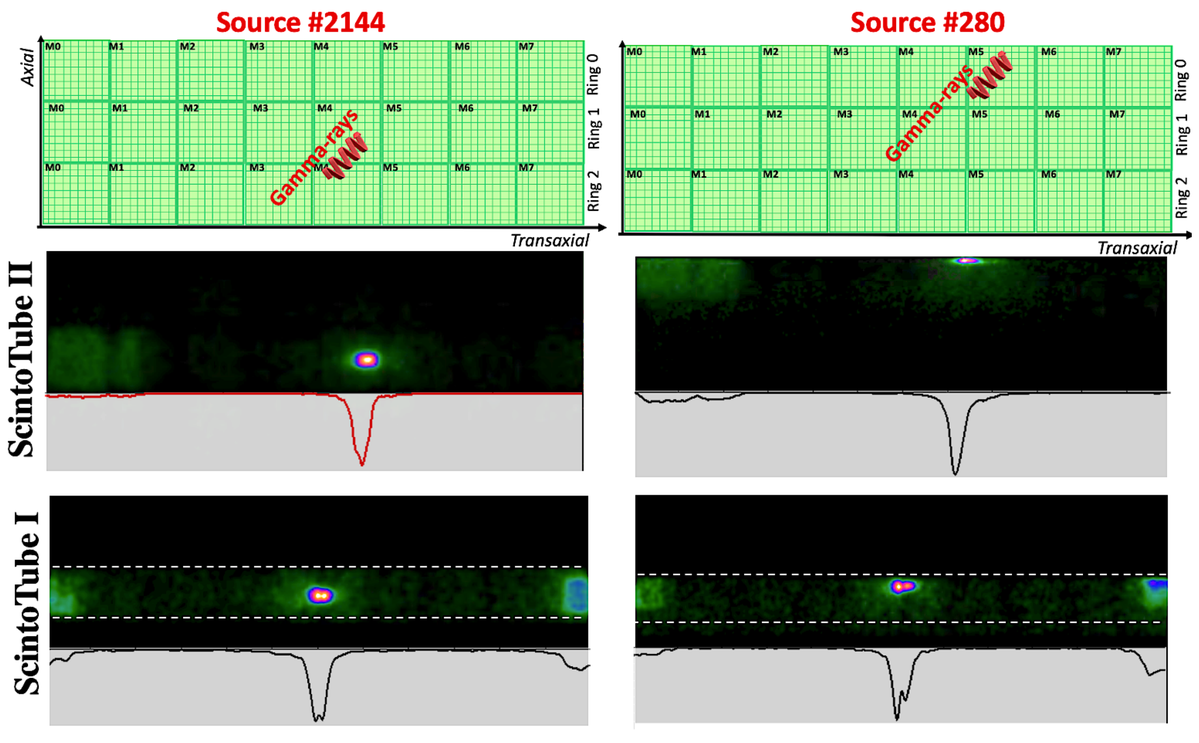
Using Gate v7.2 platform and including both nuclear and optical tracking
^{18}F source (0.25 mm in diameter) at different radial positons
Image Quality (IQ) phantom containing five rods with dimeters of 1, 2, 3, 4 and 5 mm

Data Processing and Image Reconstruction:

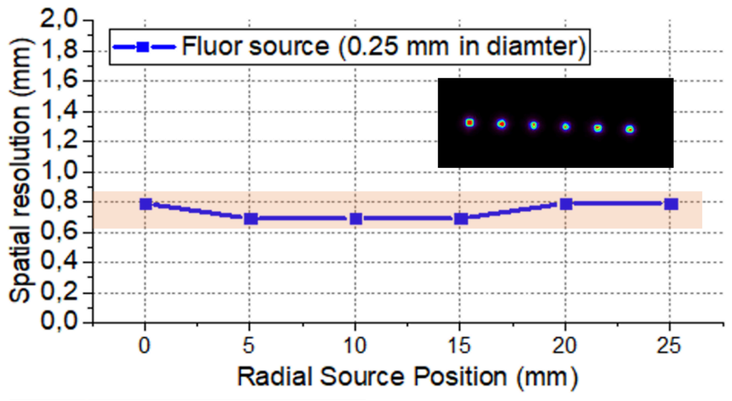
RTP method for X and Y estimation, E/I_{max} estimator for DOI estimation.
"List-Mode" algorithm , using Tube of Responses (TOR) projector [3]. No normalization and no attenuation corrections were applied.
^{18}F point sources. 10 iterations, 0.5 mm voxel size
Image Quality phantom. 10 iterations, 0.5 mm voxel size

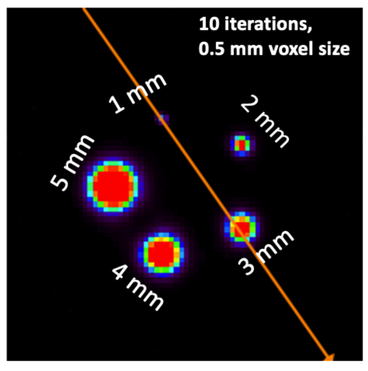
Results

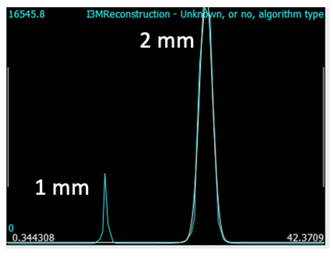
Experimental

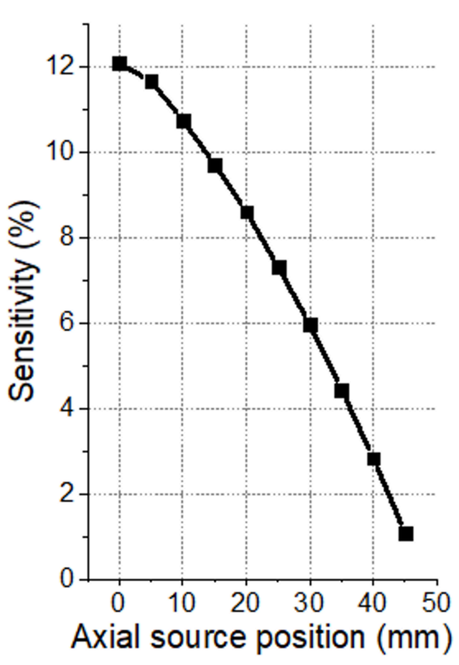


Simulations









Summary

- We have presented a novel edgeless PET insert approach based on a cylindrical annulus.
- With this novel design accurate Light Distributions are collected on the photodetector plane.
- Simulations of this prototype shows good system performance in terms of spatial resolution.
- The systems has been already assembled and A system calibration will be performed as well as the NEMA characterization with the extended MRI requirements.

References:

1] A. J. Gonzalez et al., Front. In Med. 5, 328, 2018.
[2] M. Freire, et al., in 2020 IEEE NSS/MIC , 1-5, 2020.
[3] L. Moliner, Nucl. Instrum. Methods. Phys. Res. A, 702, 129-132, 2013