The ClearPETÔ Small Animal PET System

Introduction

The ClearPET™ project is proposed by working groups of the Crystal Clear Collaboration (CCC), namely the Vrije Universiteit Brussel (VUB), the CERMEP & Université Claude Bernard - Lyon1 (UCBL), the European Organisation of Nuclear Research (CERN), the Institute for Nuclear Problems in Minsk, the Université de Lausanne, and the Research Center Jülich (FZJ). CCC granted an exclusive license to the company raytest, Germany.

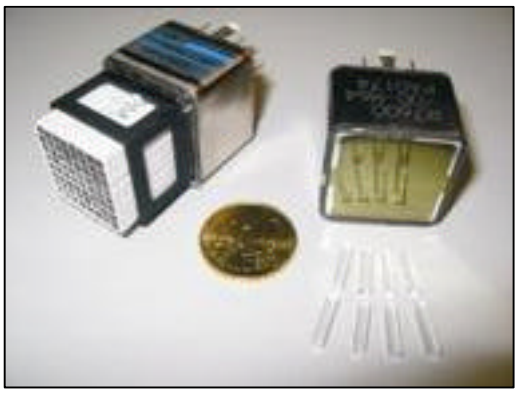
The aim of this project is to apply the non-invasive PET technique to *in vivo* imaging of the small animals like mice and rats or *in vivo* investigations of signal transduction in non-human primates under physiological conditions. While in recently developed dedicated small animal PET systems a high spatial resolution of about 2mm was the main research interest, it has become clear that it is equally important not to sacrifice the sensitivity of the scanners since the specific activity of the radiotracers used may be limited.

The ClearPET™ system is a 2nd generation high performance PET scanner first combining high resolution and high sensitivity by using new technologies in crystals and electronics. It was especially developed and designed for dynamic studies of mice and rats with a high spatial resolution. Additional the ClearPET™ system also offers the possibility to measure larger animals due to its variable detector diameter. The cassettes can be arrested in two positions which result in two detector diameters of 140 and 260mm and two animal ports of 125 and 245mm respectively.

System Description

Detector Module

Phoswich arrangements of 8×8 LYSO and LuYAP:Ce crystals, 2×2×10mm^3 each, are coupled to multi-channel photomultiplier tubes (Hamamatsu R7600). Using these depth-of-interaction (DOI) matrices enables the combination of high sensitivity (20mm total crystal thickness) and high resolution.



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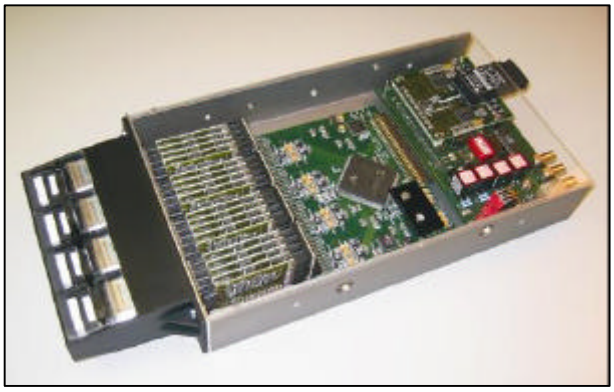
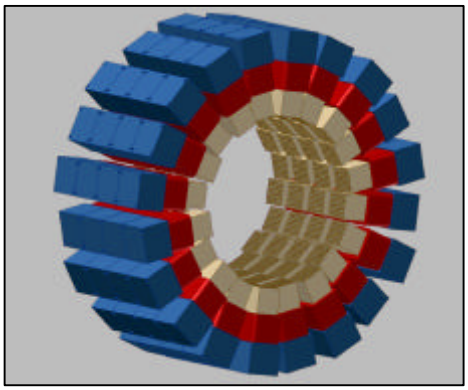
Detector Cassette



A unit of four detector modules arranged in-line represents one of 20 detector cassettes including the corresponding front-end electronics: analogue and decoder boards in the front, one FPGA board, one slow control and finally an opto link transmitter board to send the data from the gantry to the first pre-processing PCs. The detector modules are light and water shielded by a specially designed plastic cap.

ClearPETÔ Scanner



The system consists of 80 detector modules split up in 20 detector cassettes which are arranged in a ring configuration. Every other cassette is shifted by 7mm, ¼ of a PMT length, to linearize the axial sensitivity profile of the scanner. The gantry allows rotation over 360 degrees for a more homogeneous sampling of the field of view. Furthermore two different detector diameters are feasible, which allow to perform whole body studies of mice and rats using the small diameter as well as brain studies of large primates using the large diameter. This means that the ClearPET™ System allows to measure all small animals with only one scanner

Technical Data

Crystals:	2x2x10mm³ LYSO and 2x2x10mm³ LuYAP crystals
# crystals:	10240 (5120 LYSO and 5120 LuYAP crystals)
# pixel:	5120
Crystal matrix:	8x8 LYSO and 8x8 LuYAP crystals in phoswich arrangement
PMTs:	Hamamatsu R7600-M64 (multi channel PMT, # 80)
Detector modules:	80 detector modules in 4 rings
Ring diameter:	two diameters are possible: 140 or 260mm
Animal port:	125 or 245mm
Axial depth:	110mm
FOV:	adjustable per software (axial and transaxial)
Gantry:	rotating >360 degrees

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Data processing

- Acquisition of single events, stored in a list mode file format (LMF)
- Offline coincidence sorting per software
- Coincidence timing window and energy thresholds are adjusted offline per software

System Performance

Average intrinsic spatial resolution (FWHM):	1.48mm
Reconstructed image resolution (FWHM, CFOV):	~1.5mm
Coincidence timing resolution (FWHM):	2.0ns
System peak sensitivity (>250keV):	3.6% (guaranteed)
	4.0% (expected)
Coincidence window and energy thresholds:	adjustable per software within the scope of the offline data processing

ClearPETÔ Demonstrator System

The ClearPET™ Demonstrator System is installed in the Institute of Medicine in the Research Centre Juelich in Germany. The picture shows the open Gantry which is mounted on top of a system base cabinet that also houses the pre-processing electronics and power supplies. For the commercial ClearPET™ these parts will be put in an external rack which allows a full access to the animal bed from all sides.