ΕΘΝΙΚΟΝ & ΚΑΠΟΔΙΣΤΡΙΑΚΟΝ
ΠΑΝΕΠΙΣΤΗΜΙΟΝ ΑΘΗΝΩΝ

NATIONAL & KAPODISTRIAN
UNIVERSITY OF ATHENS

Τμήμα Φυσικής

Department of Physics

Construction of a High-Resolution Mobile γ-Camera System for Mammography Study

M. Zioga[a], M. Kontos[b], D. Maintas[c], M. Mikeli[a], A.-N. Rapsomanikis[a] and E. Stiliaris[a,d]

(a) Department of Physics, National and Kapodistrian University of Athens, Athens, GREECE
(b) LAIKON Hospital, Medical School of Athens, UoA, Athens, GREECE
(c) Institute of Isotopic Studies (IIS), IATRIKON Hospital, Athens, GREECE
(d) Institute of Accelerating Systems & Applications (IASA), Athens, GREECE

Outline

- Introduction
- Problems
- Small Field γ-camera
  - Components
  - Motion Correction
  - Clinical Environment Adaptations
- Conclusions

Introduction

In Nuclear Medicine a general purpose γ-Camera device is commonly used.

Since its introduction, it has become a standard choice for clinical in vivo tests. It provides information about the distribution of a radiotracer administered to a patient allowing noninvasive measurement of physiological functions.

Disadvantages

A large detector of a standard commercial γ-Camera :

- Cannot be placed close to the organ of interest, accepting background activity from other neighbor organs
- Allows only certain planar projections to be imaged.

These factors imply that the general purpose γ-Cameras have non optimal spatial resolution and poor image contrast regarding the small organ imaging

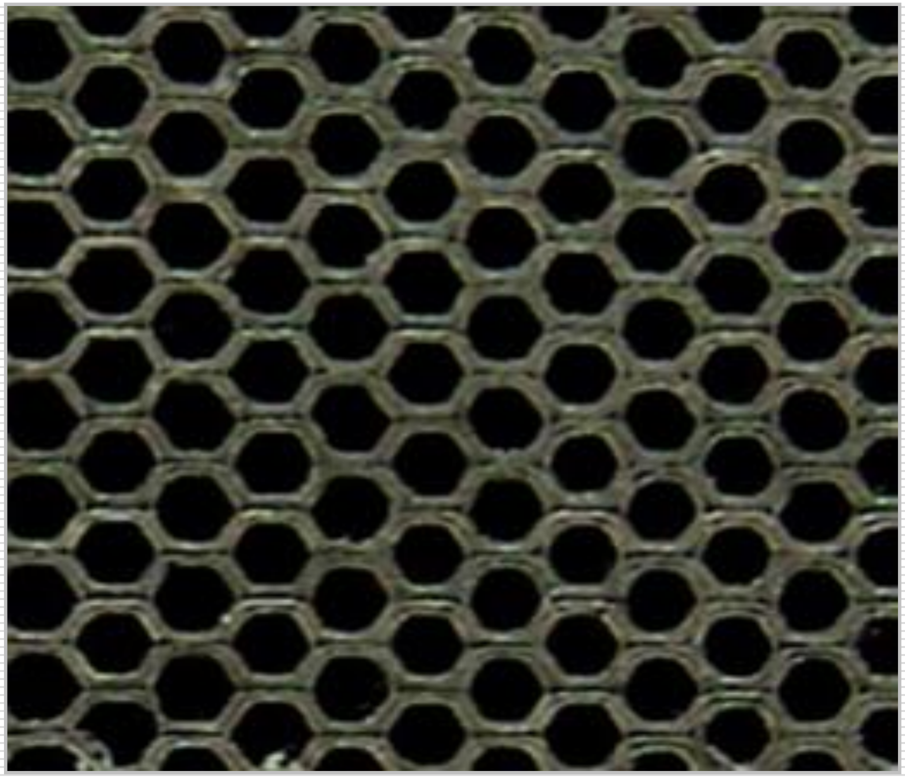
Solution → A dedicated, small field, high resolution portable γ-Camera for clinical use

Small Field 3’’ γ-Camera

Size only 3 inches!!!

Small Field 3'' γ-Camera

1. Collimator

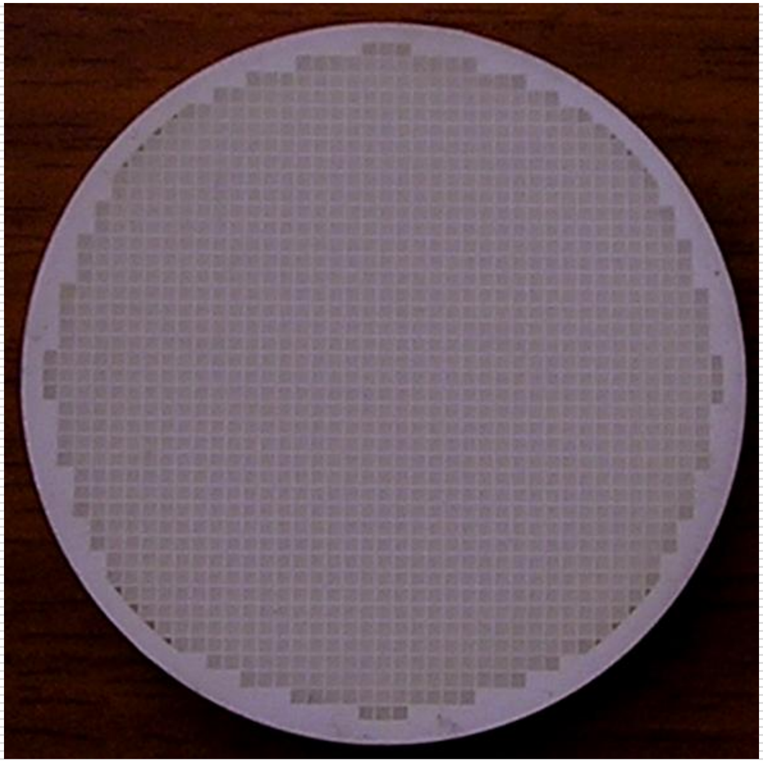


Total Area	59.5×60.4 mm^2
Thickness	26.8 mm
Radius R of circumscribed circle	0.75 mm
Septum (Pb) S	0.25 mm
Total Number of holes along X (Nx)	32
Total Number of holes along Y (Ny)	23

Small Field 3'' γ-Camera

2. Scintillation Crystal

- 4mm CsI(Tl) pixelated scintillation crystal
- Pixel size: 1mm × 1mm separated by 0.1 mm epoxy



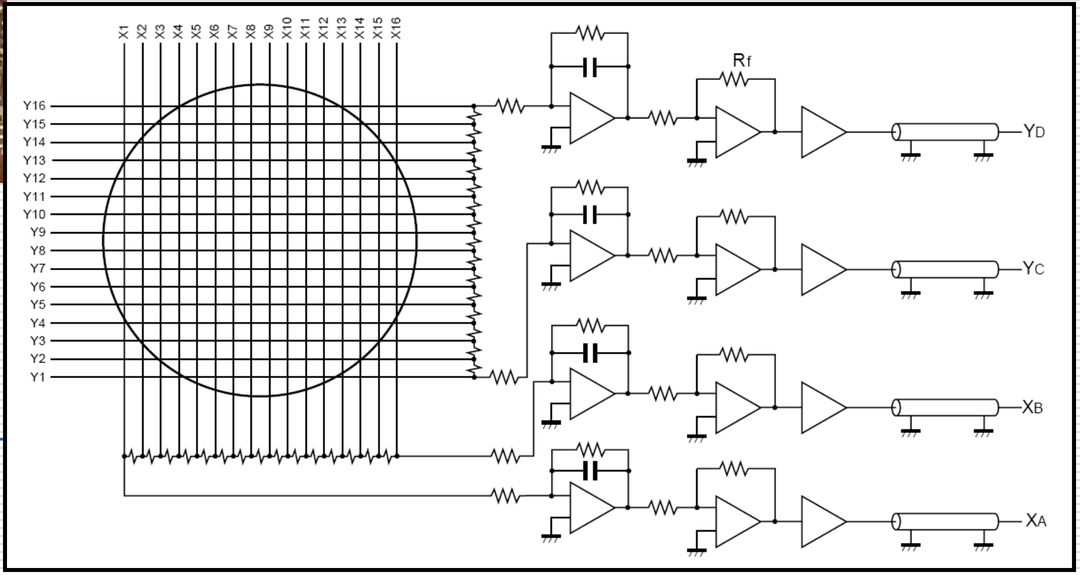
Small Field 3'' γ-Camera

3. The Position Sensitive Photomultiplier Tube (PSPMT)

16 X-wires & 16 Y-wires

Resistive Chain Technique

Only 4 Signals: $\{X_A, X_B, Y_C, Y_D\}$



HAMAMATSU

Model R2486

3'' Diameter

Circular Envelope PSPMT

Evaluation

Our small-field γ-Camera prototype, based on the PSPMT resistive chain readout technique, has been recently characterized on planar and tomographic level and exhibits high efficiency.

The cameras characteristics are:

- **Resolution on a planar level:**

$\langle\sigma x\rangle = (0.95 \pm 0.05)$ mm, $\langle\sigma y\rangle = (1.07 \pm 0.07)$ mm

- **Resolution on a tomographic level: 2 mm in both X- and Y-Axis**

- **Sensitivity on a tomographic level: Minimum volume which can be detected V = 0.080 cm^3 (which corresponds to 20 μCi activity for a tracer solution of special activity 0.25mCi/cm^3)**

D. Thanasas *et al.: A correction method of the spatial distortion in planar images from γ-Camera systems,* Journal of Instrumentation 4 (2009) P06012

Clinical Environment Adaptations

Key elements required by a portable γ-Camera for optimal results in a clinical environment are:

- **Mobility**, in order to be used in Operating or in Intensive Care Rooms.
- **Sensitivity** for acquiring planar images within reasonable time interval in real-time device operation.
- **Automatic Mapping Orientation** with respect to the actual anatomical information of the obtained planar images.
- **Activity and Energy Calibration**, in order to obtain the real tracer activity distribution according to the recorded intensity distribution on the projected image.

Motion Correction

event-by-event

The Nintendo's Wii Remote sensors, a small handheld device which can be easily coupled to the portable camera.

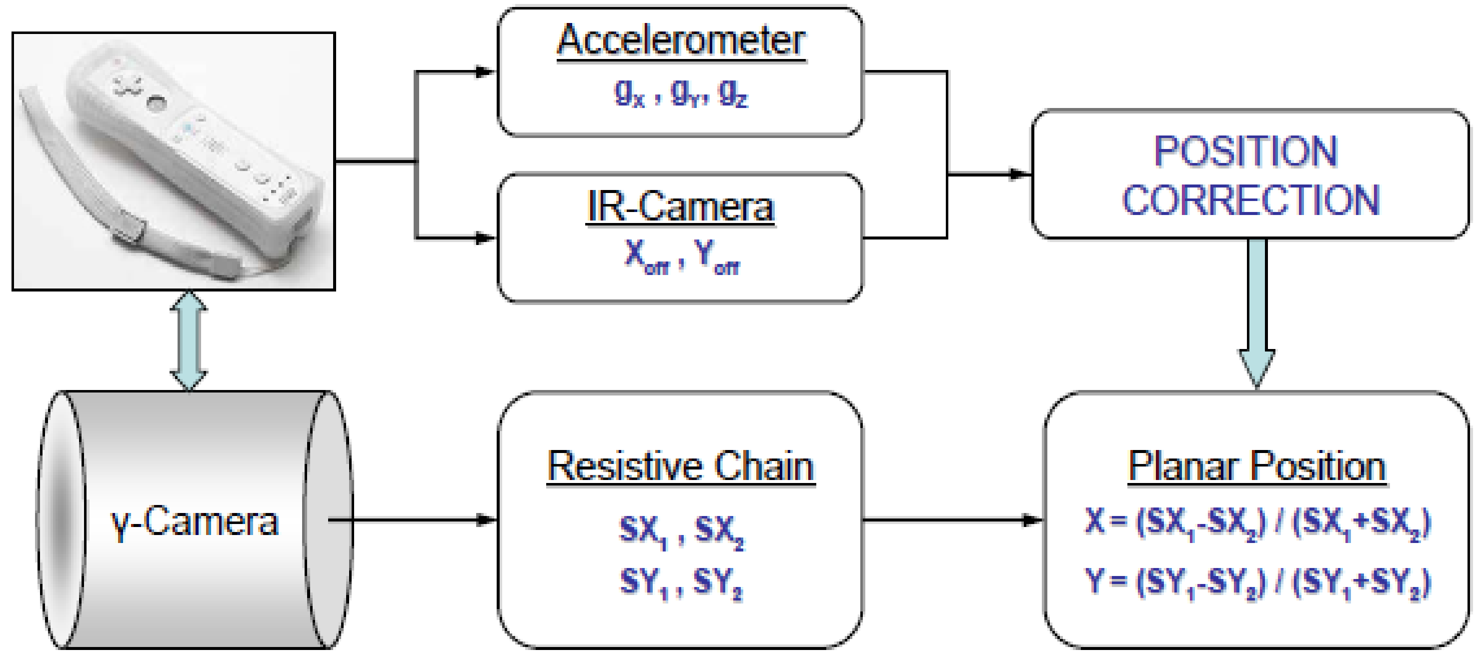


Figure 1: Flow diagram of the DAQ-recorded parameters during the operation of the portable γ-Camera system.

Motion Correction

Based on the definition of the *Euler angles:*

$$\begin{pmatrix} g_x \\ g_y \\ g_z \end{pmatrix} = \begin{pmatrix} \cos\psi\cos\varphi - \cos\theta\sin\varphi\sin\psi & \cos\psi\sin\varphi + \cos\theta\cos\varphi\sin\psi & \sin\theta\sin\psi \\ -\sin\psi\cos\varphi - \cos\theta\sin\varphi\cos\psi & -\sin\psi\sin\varphi + \cos\theta\cos\varphi\cos\psi & \sin\theta\cos\psi \\ \sin\theta\sin\psi & -\sin\theta\cos\varphi & \cos\theta \end{pmatrix} \cdot \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$$

The rotation angles θ and ψ are calculated for any detected event. These angles, together with the planar offsets (Xoff , Yoff) recorded by the infrared-camera can be used to correct the position of the incident γ- photon on the planar image.

Example

Motion correction results using a ^{137}Cs source

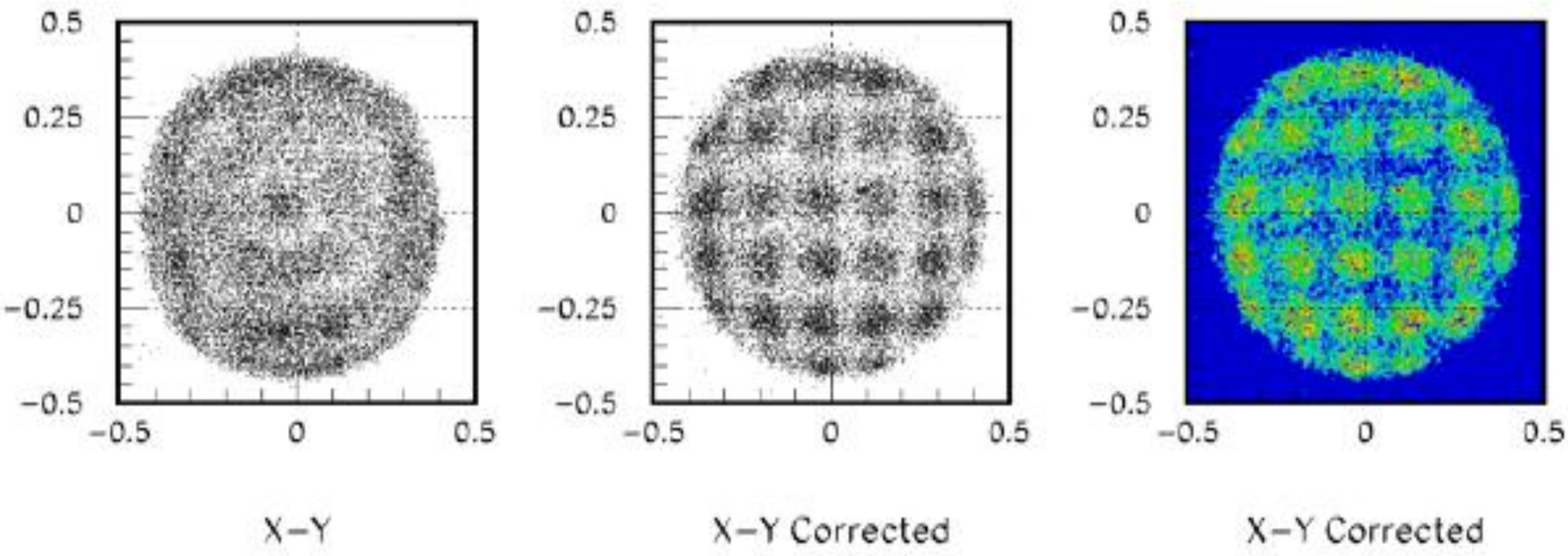


Figure 2: A typical planar image taken with a uniform source and a hole-screen in front of the moving γ-Camera system. *Left:* Uncorrected planar image. *Center:* Motion corrected image with the developed procedure. *Right:* Contour plot of the motion corrected image.

Future Plans

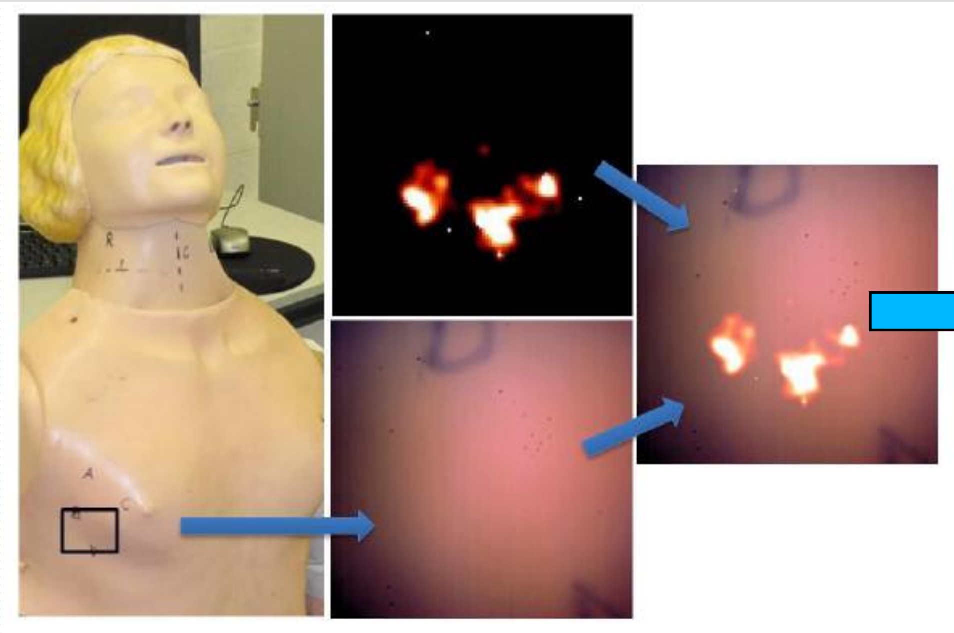
- A proper shielding is necessary to ensure the light isolation of the detector's head-system. A gun-like casing will be ideal for a comfortable operation during the surgical procedures.

- A proper DC-to-DC converter must be used to provide high voltage to the isolated head system, allowing a safe connection with the rest of the low voltage system's wiring.

- The γ-Camera will be connected via a USB portal to a computer with a DAQ system, operating in the previously described digitization mode (4-channel ADC).

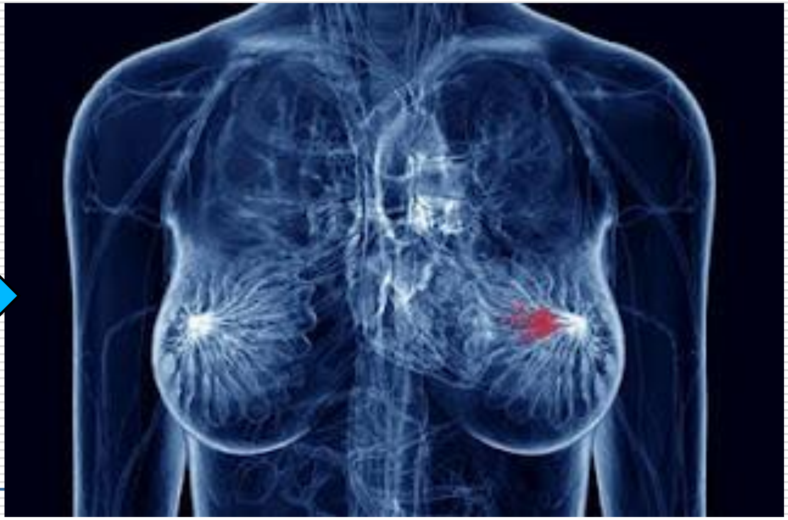
Obtained data (event-by-event recording) will be automatically converted to intensity distribution images. With a proper calibration system, they will reflect the radioactive tracer distribution in real time allowing the data translation to tomographic images with off-line usage of home developed reconstruction algorithms. Energy and movement corrections will also be applied to the raw-data for image quality optimization.

Future Plans



- A Hybrid γ-Camera

This Hybrid Mini γ-Camera is to have an optical and a γ-photon camera in co-aligned configuration that offers high spatial resolution multi-modality imaging with a fused image output.



- The StereoScope

An extension of the hybrid concept to a two camera design that offers the potential for stereoscopic imaging with depth estimation for γ emitting source


Thank you

bAckUp

Motion Correction

The Wii Remote has the ability to sense acceleration along three axes through the use of the ADXL330 accelerometer. ADXL330 reports acceleration in the device's three dimensions (gx, gy, gz) , expressed in units of the earth's gravity g with are solution of 8 bits per axis and a100 Hz update rate. The Wii Remote also features a PixArt optical (infrared) sensor, allowing it to determine where the Wii Remote is pointing. Data communication occursover the Bluetooth protocol.

The Data Acquisition System of this portable camera has been developed on the LabVIEW environment. In addition to the four primary signals from the photomultiplier resistive chain (SX1, SX2, SY1, SY2) the three g-components (gx, gy, gz) and the planar offset Xoff and Yoff from the Wii Remote device are recorded (Fig.1).

A general purpose γ-Camera shows disadvantages when used for imaging of small organs, such as breast, thyroid or sentinel lymph node, due to the large field of view and volume occupied, which affects the spatial resolution of the obtained images. For such small organ studies, the large detector of a standard commercial γ-Camera cannot be placed close to the organ of interest, accepting background activity from other neighbor organs and allowing only certain planar projections to be imaged. These factors imply that the general purpose γ-Cameras have non optimal spatial resolution and poor image contrast regarding the small organ imaging

Even though this camera has many advantages because of it's portability it appears to be affected from the hand's stability during operation. In order to overcome this difficulty, a real time motion correction technique based on commercially available equipment is proposed in the current work. It utilize

A typical example of a planar image taken with the γ-Camera system moving around an eccentric point inside the field-of-view is shown in Fig. 2. In this example, a distant point 137Cs-source is used with a holescreen in front of the system. The motion corrected image and its contour plot are shown in the same figure, where the rotation-free planar information is clearly reproduced.