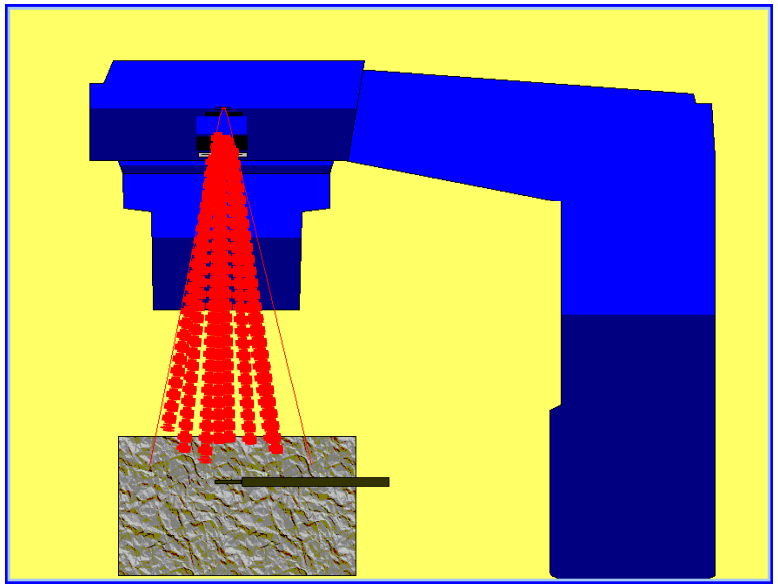
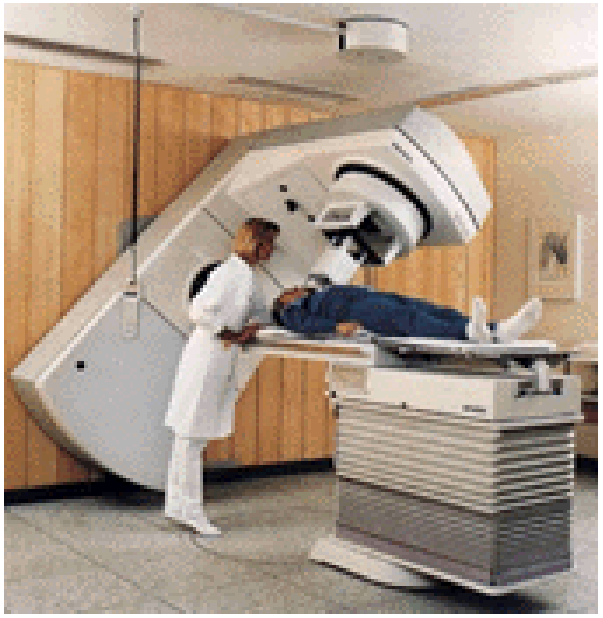
Aplicações à Medicina

Luis Peralta

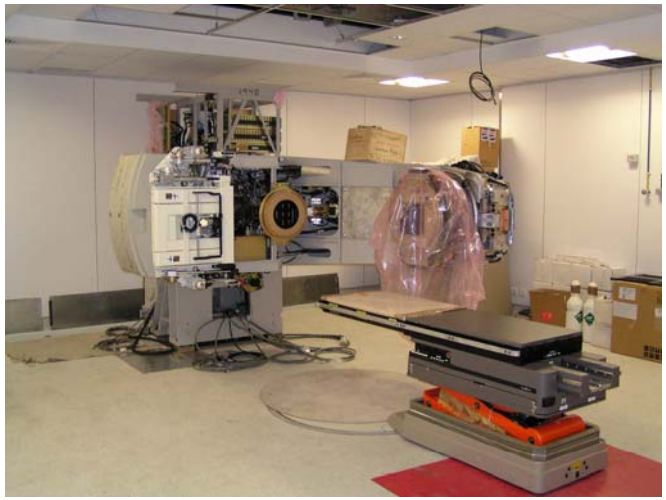
(FCUL e LIP)

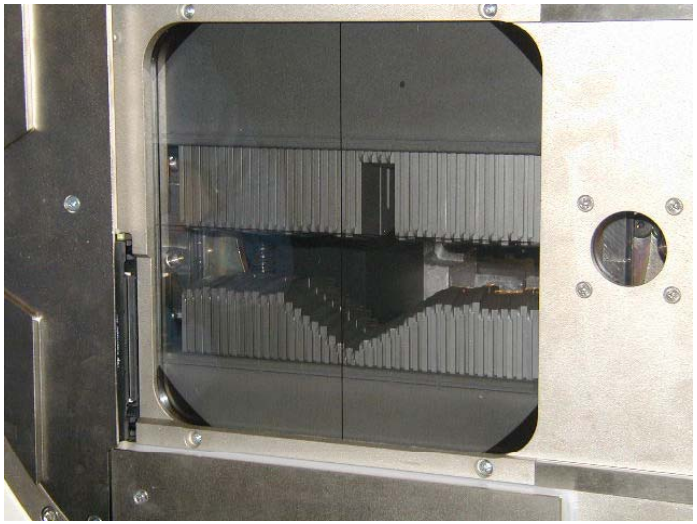
Radioterapia Externa

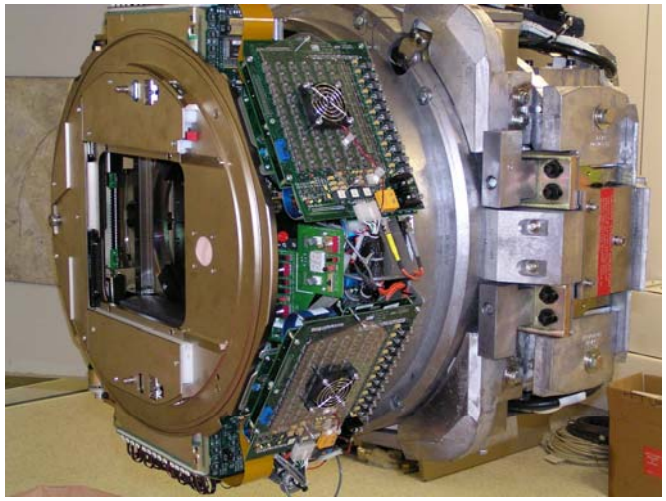




Um acelerador linear em fase de instalação

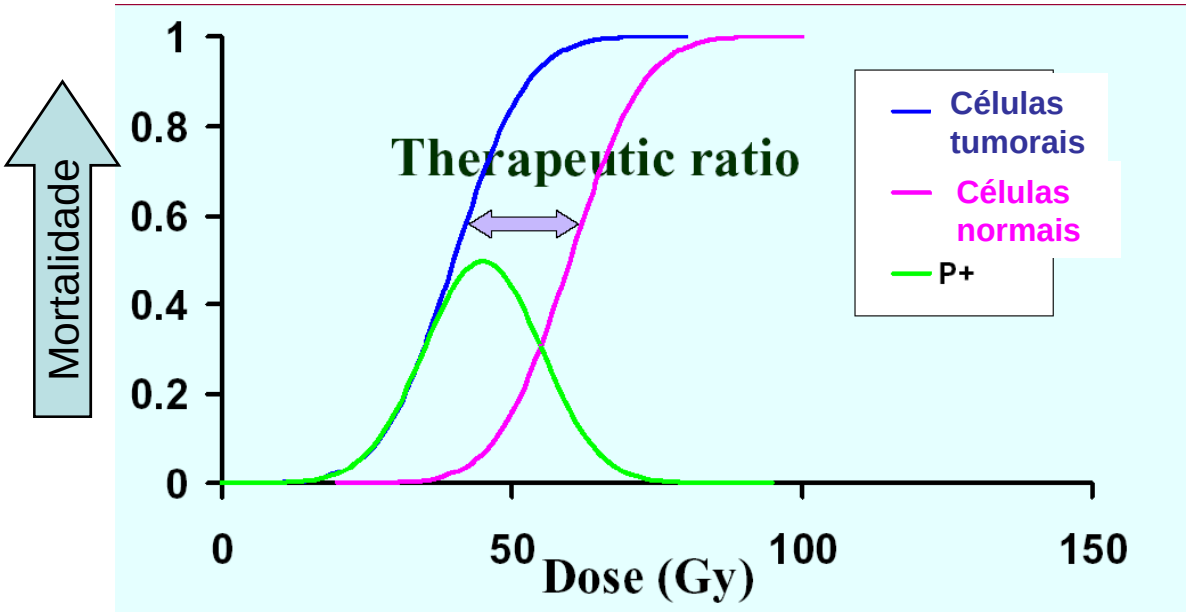


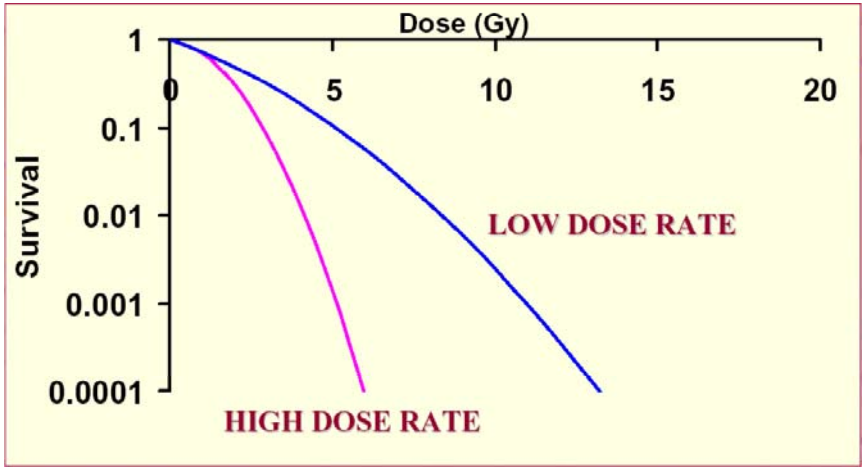




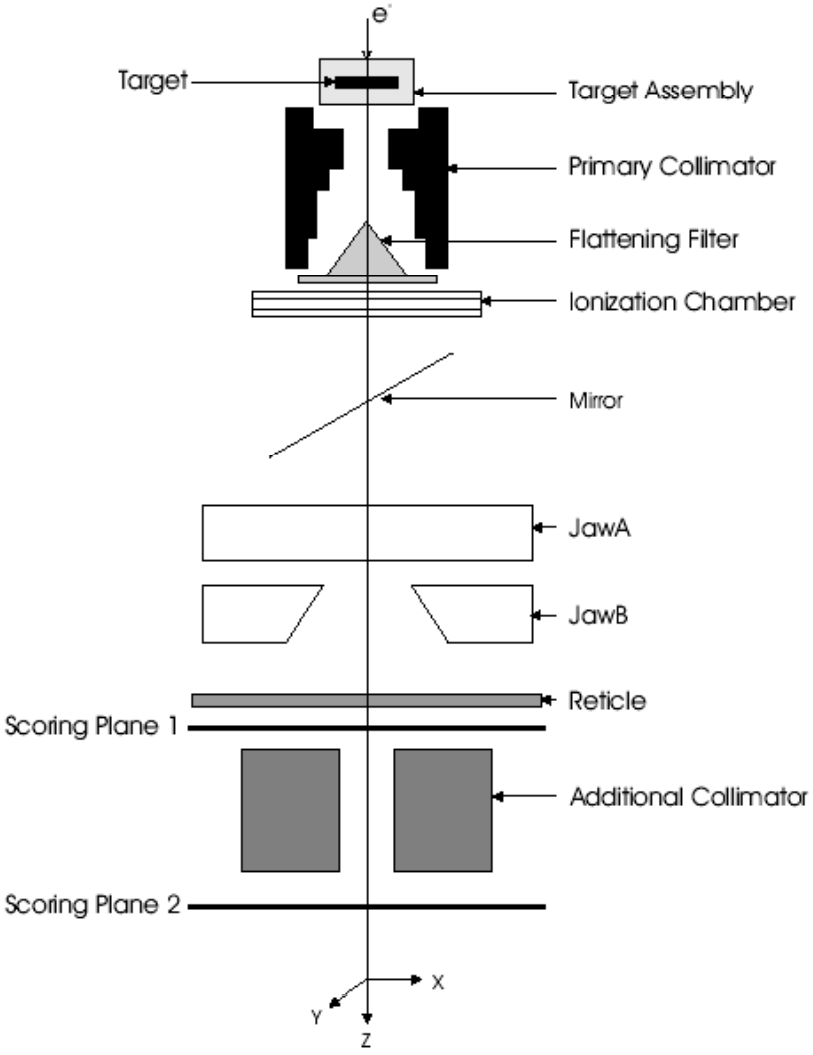
Radioterapia no IPO de Coimbra

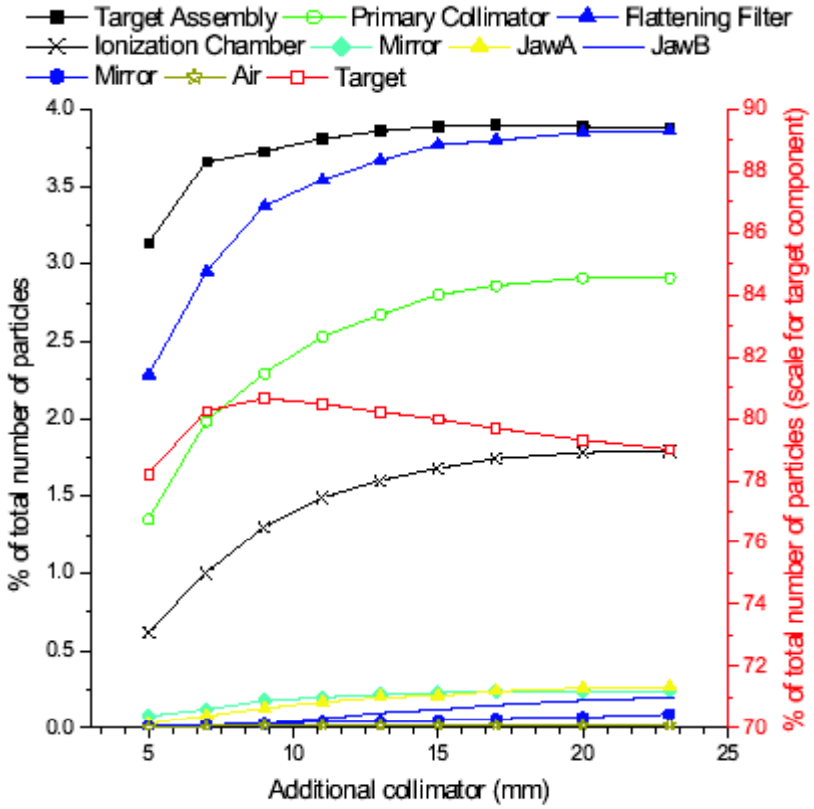
Sobrevivência de células tumorais / normais



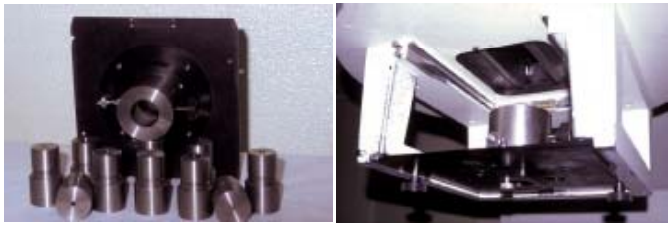


Simulação do acelerador



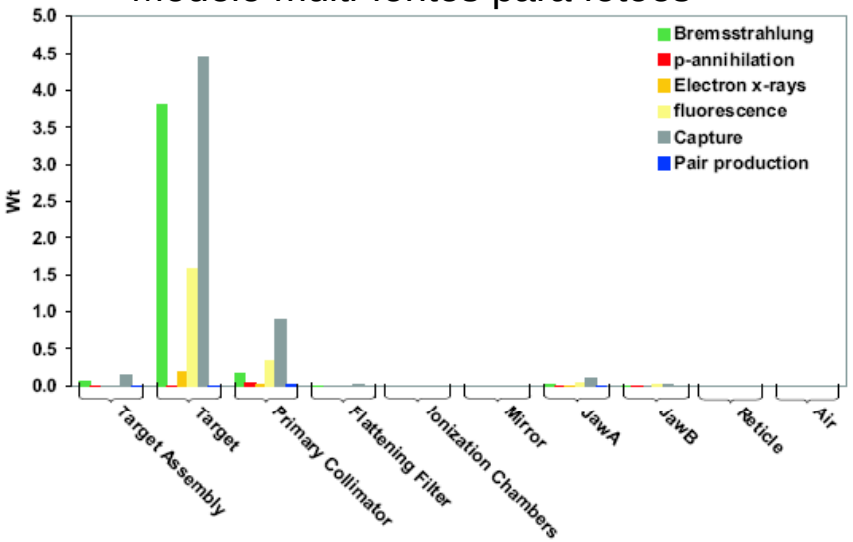


Feixes finos com fotões de alta energia

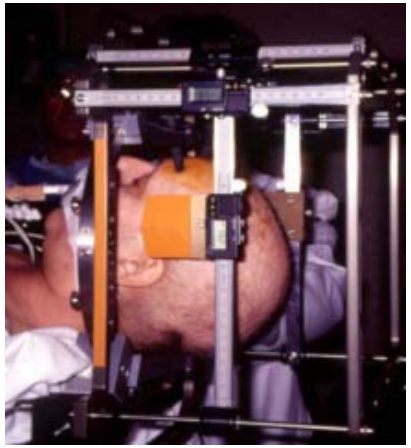


colimadores adicionais

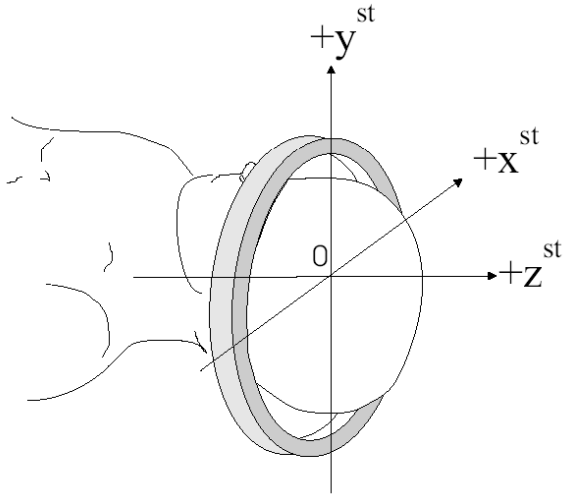
Modelo multi-fontes para fotões

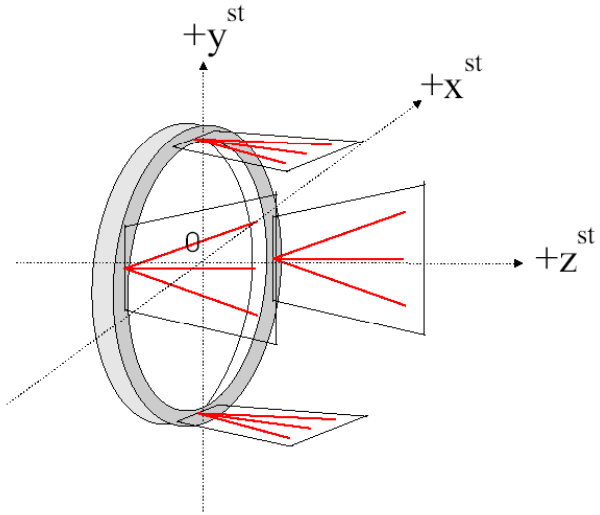


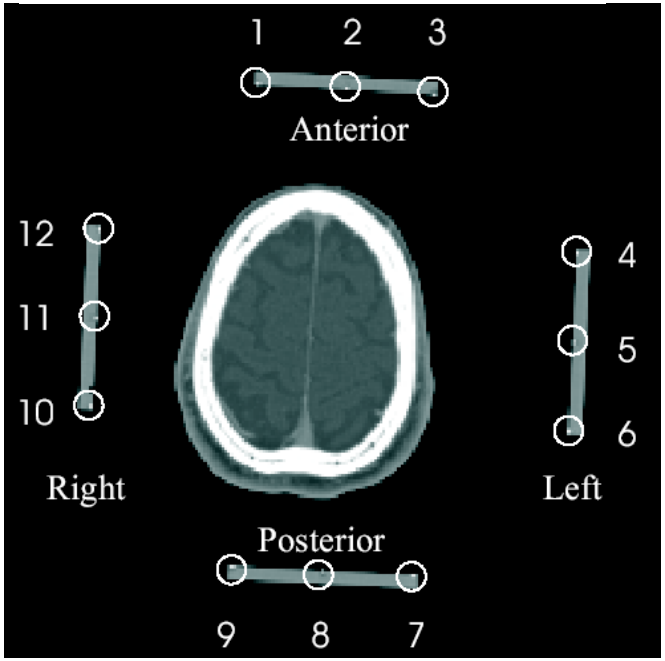
Radiocirúrgia

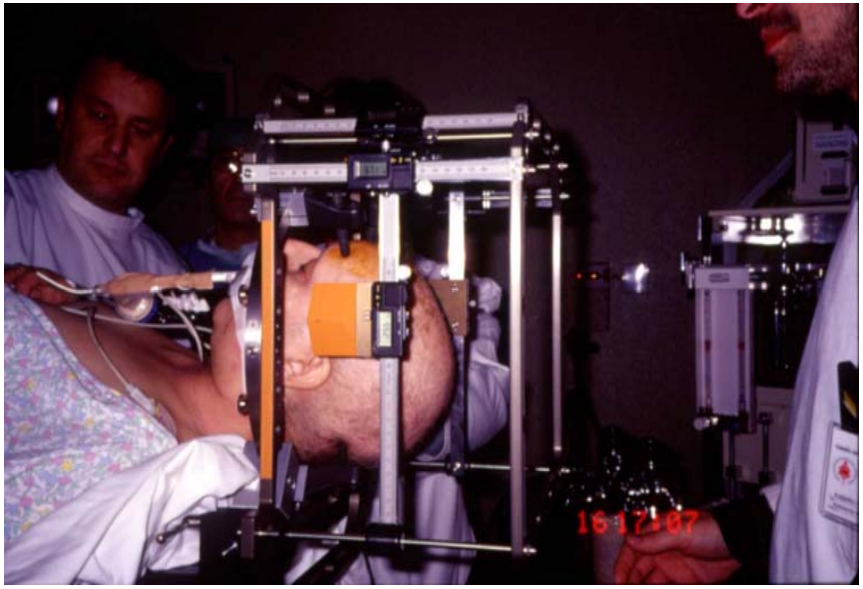


O exemplo da radiocirurgia



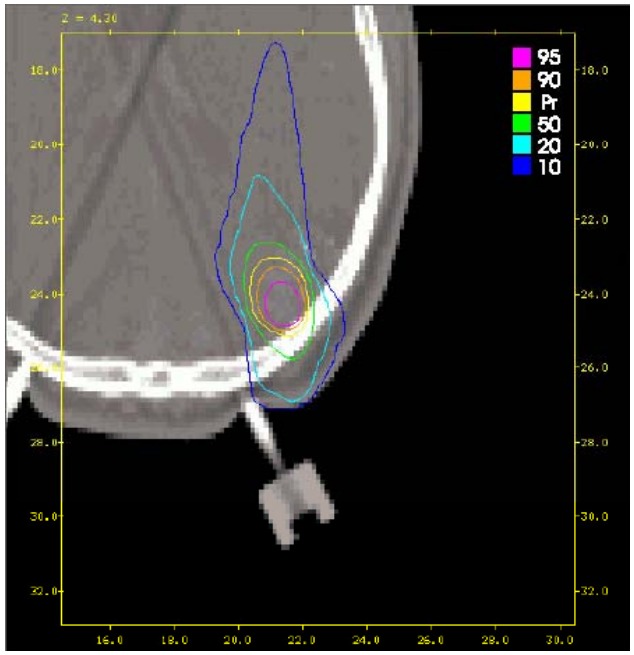




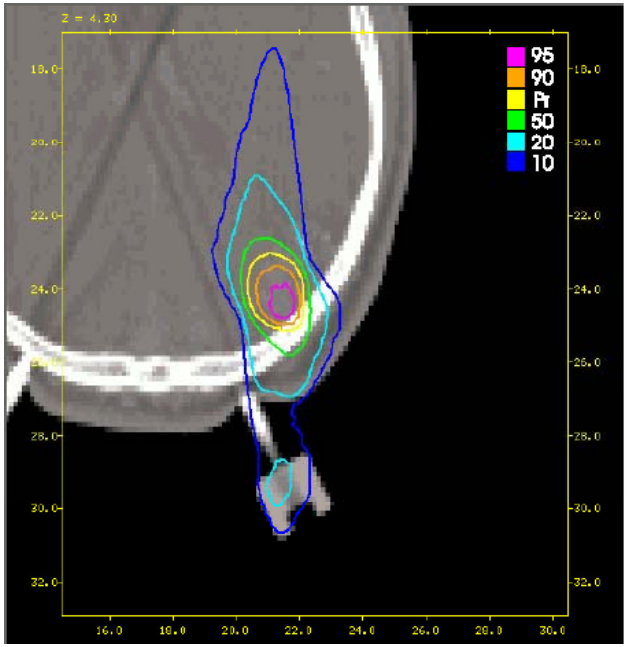


Cálculo de dose

Sistema planeamento comercial



MC s/ heterogeneidades

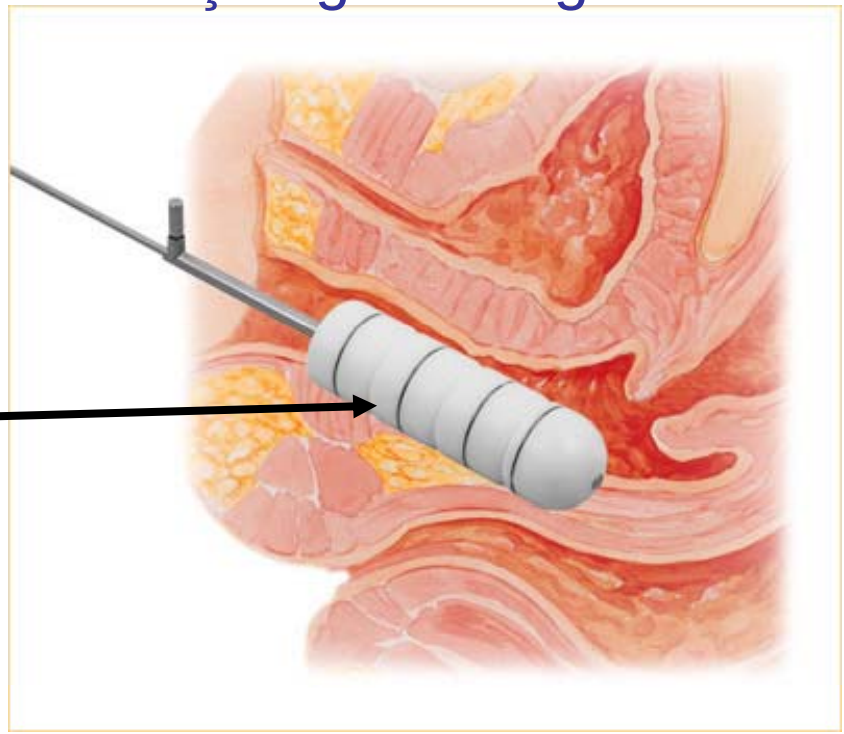


MC c/ heterogeneidades

Radioterapia intracavitária

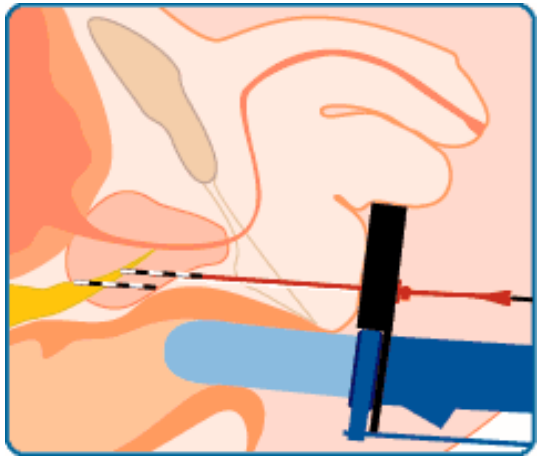
Irradiação ginecológica

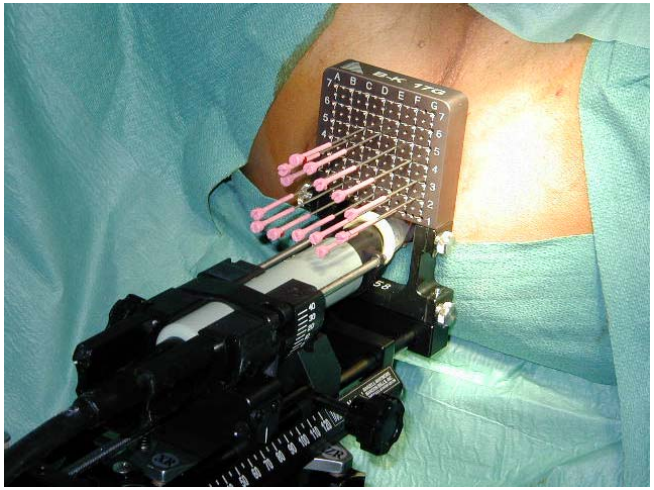
Fonte Ir-192

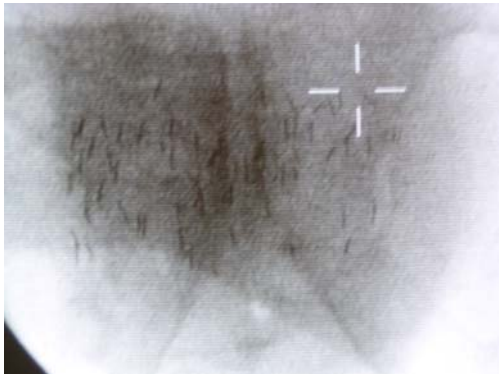


Braquiterapia Mamária

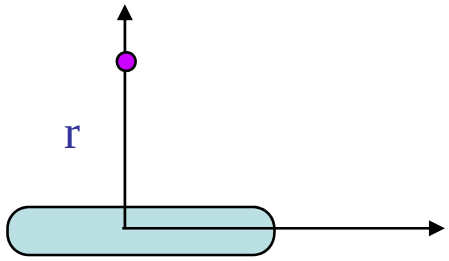
Braquiterapia da Próstata

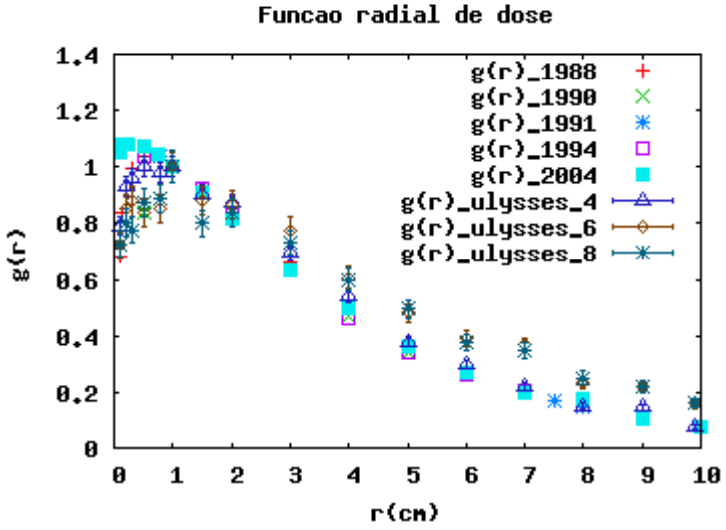




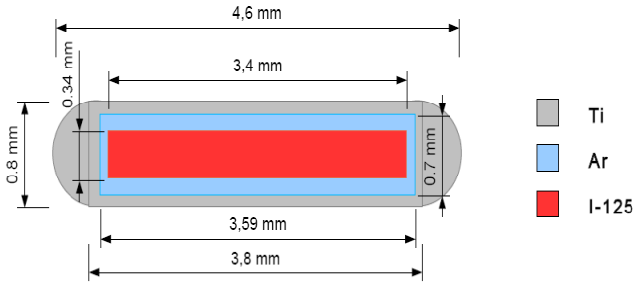


Simulação de fontes de iodo-125

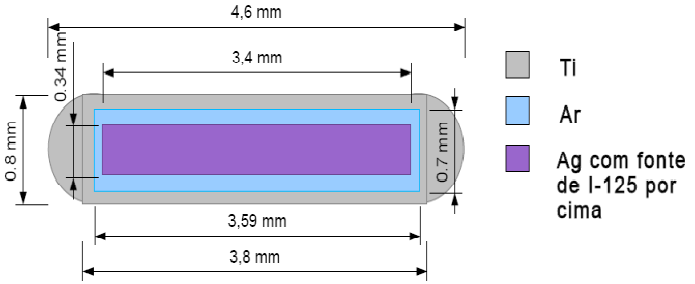




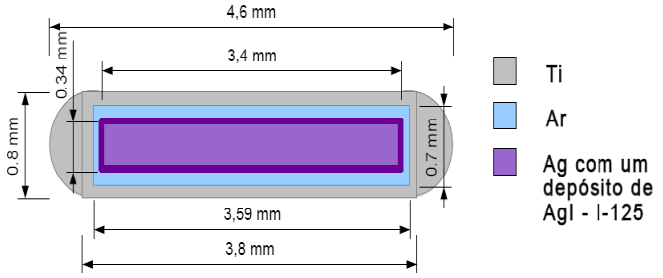
SEMENTE 4



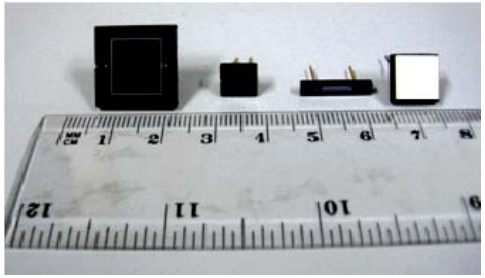
SEMENTE 6

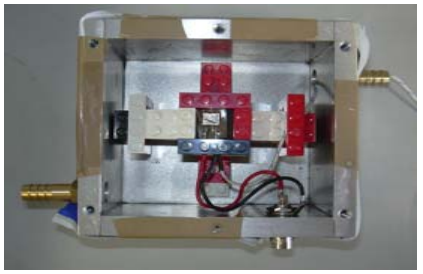


SEMENTE 8



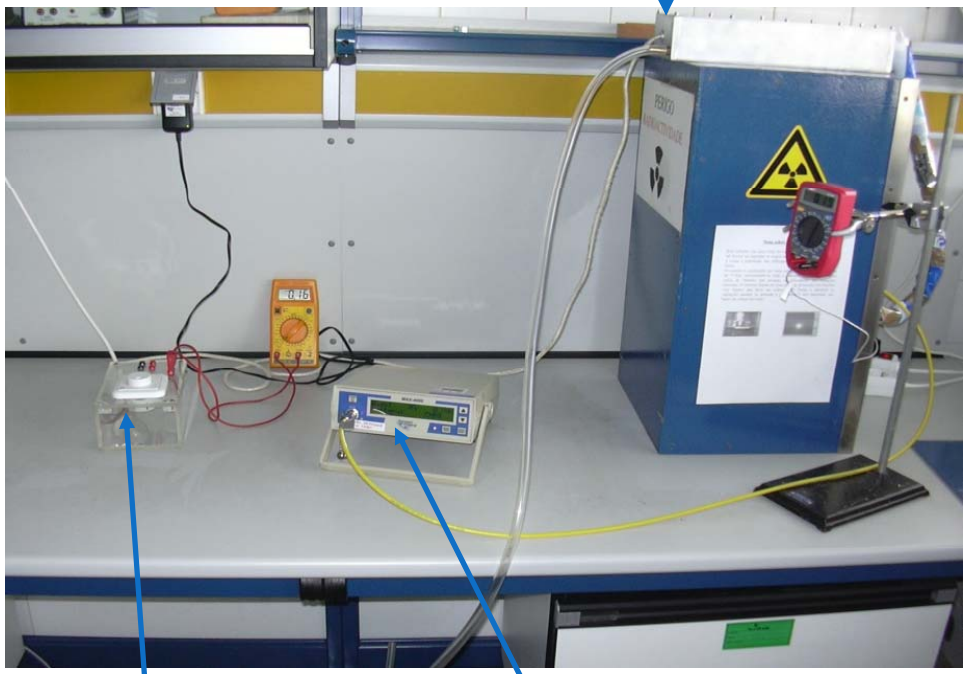
Dosímetros para aplicações médicas/escolares





Caracterização em função da temperatura

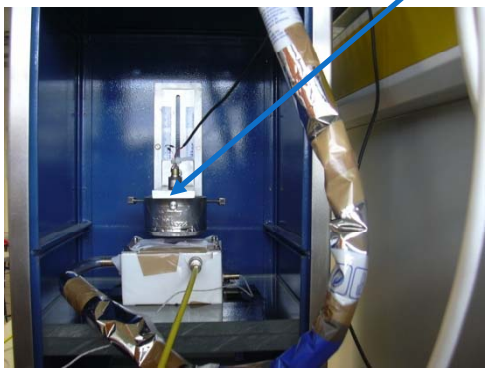
Sistema de aquecimento

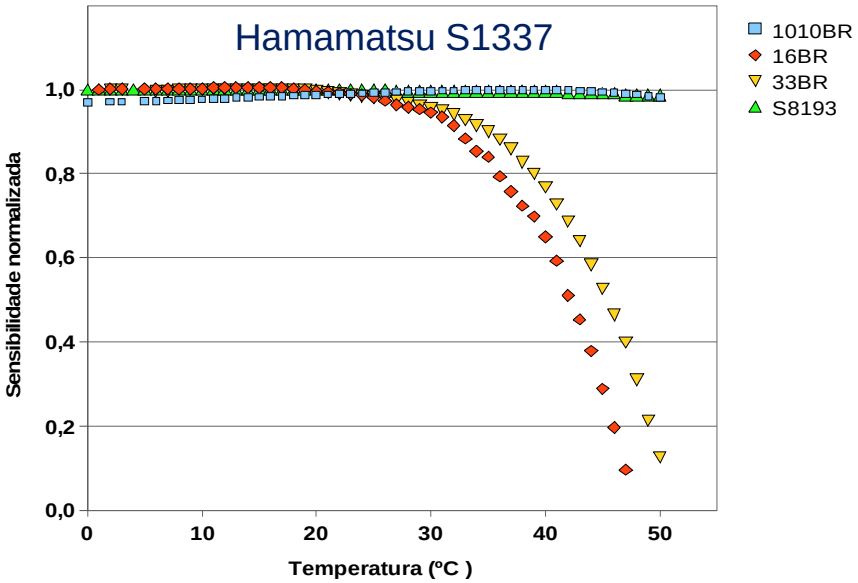


Regulador de potência

Electrómetro

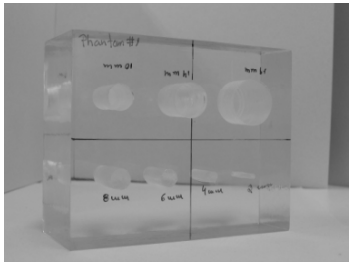
Fonte radioactiva

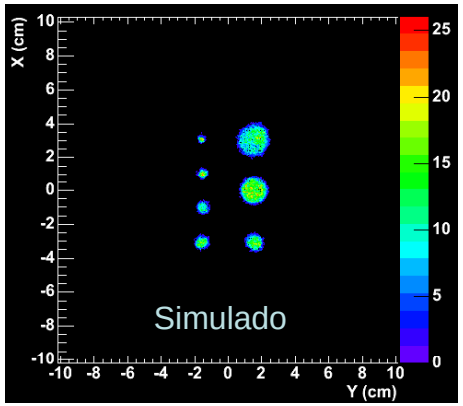


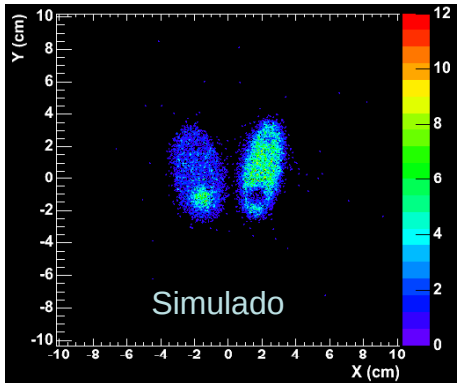


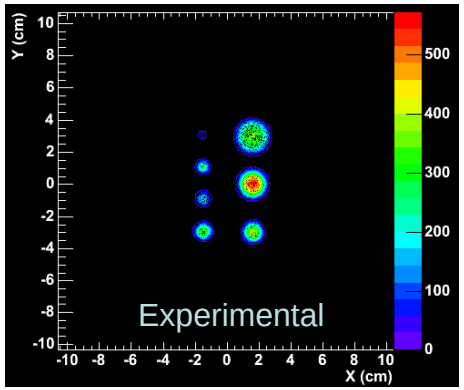
Simulação da Siemens E.Cam Dual Head

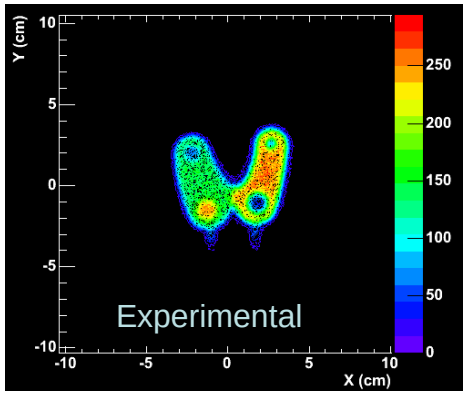
Câmara gama
Hospital do Alvor



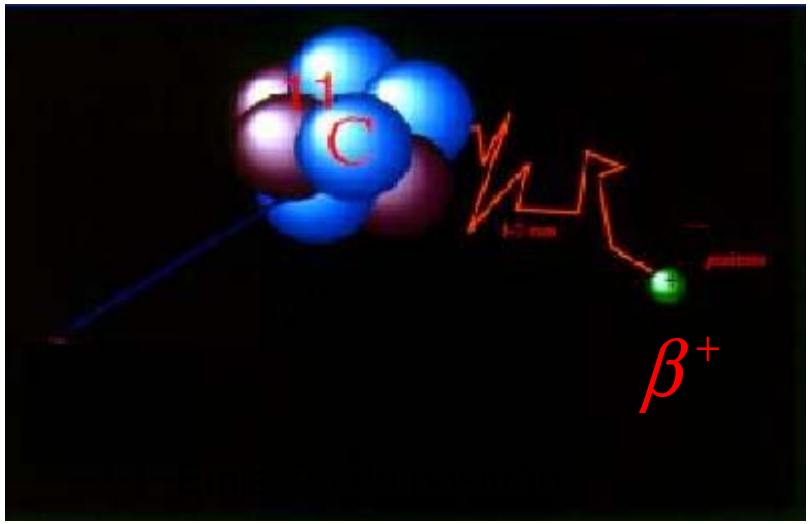




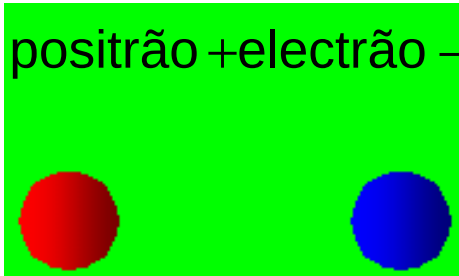




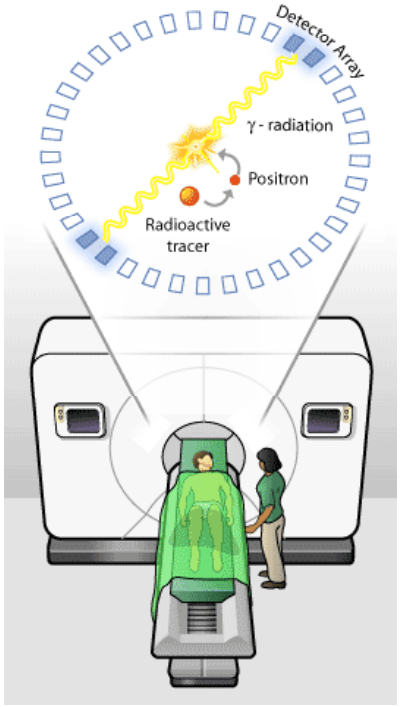
Princípio Físico do PET



positrão + electrão → 2 fotões

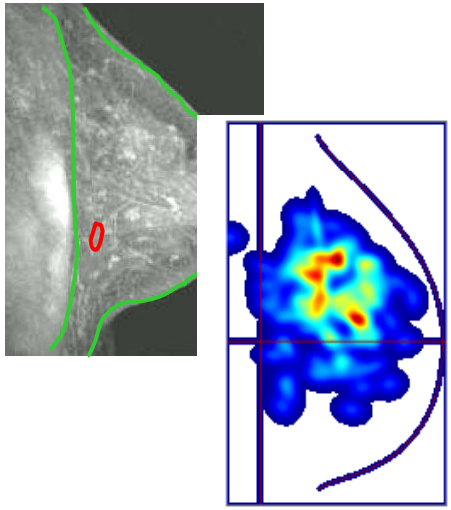


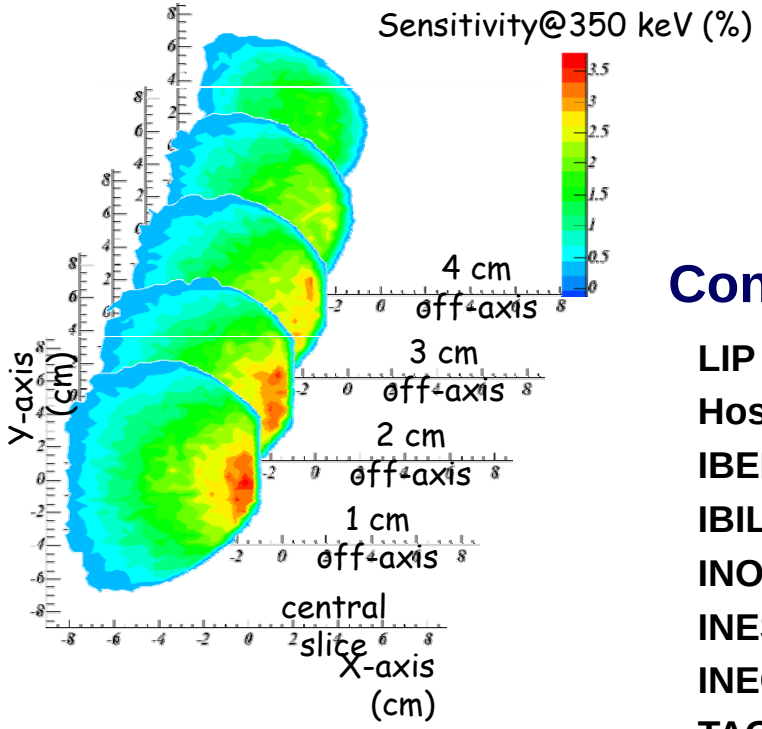
Aniquilação



ClearPEM Project

The ClearPEM scanner is developed in the framework of the Crystal Clear Collaboration at CERN by the consortium PET-Mammography





Consortium PET-Mammography.

LIP - Laboratório de Instrumentação e Partículas
Hospital Garcia Orta - Serviço Medicina Nuclear
IBEB - Instituto Biofisica e Engenharia Biomédica
IBILI - Instituto Biomédico de Investigação da Luz e Imagem
INOV- INESC Inovação
INESC-ID - Instituto de Engenharia de Sistemas e Computadores
INEGI - Instituto de Engenharia Mecânica e Gestão Industrial
TAGUSPARK – Parque de Ciência e Tecnologia

Positron Emission Mammography

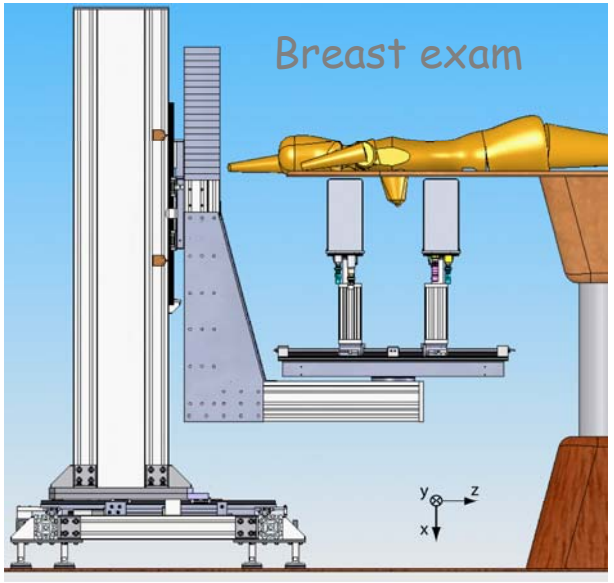
→ **Dedicated PET scanner for breast imaging**

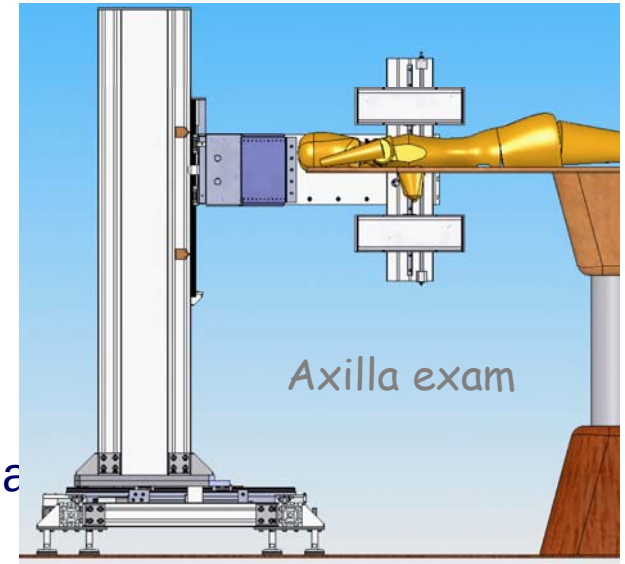
→ **ClearPEM requirements:**

- → High detection sensitivity
- → Spatial resolution (1-2 mm FWHM)
- → Time resolution for backgr. rejection (1-2 ns)
- → Shorter exams and/or less dose (370 MBq)

→ **Detector concept:**

- → Two planar heads
- → Mammary gland and axilla region exams
- → Exam with the patient in prone position
- → Adjustable distance between heads and rotation a





Detector Technology

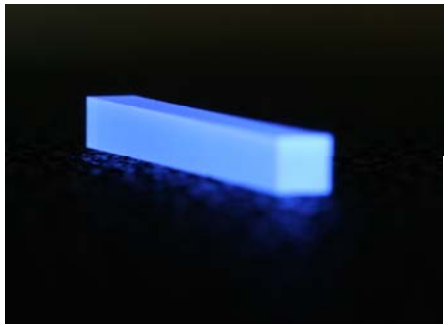
→ 20 mm long LYSO:Ce crystals

→ Crystal matrices with $BaSO_4$ reflector

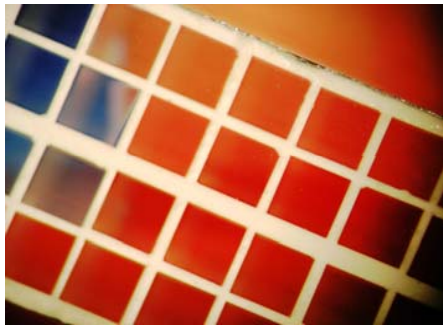
→ Avalanche Photo Diodes (APD)

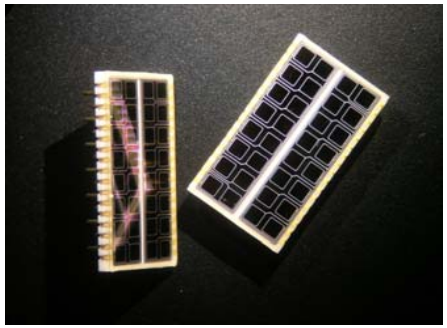
→ Double readout mode

→ Depth-of-interaction (DOI) measurement



6144 crystals





384 APD arrays

192 detector modules

Frontend ASIC

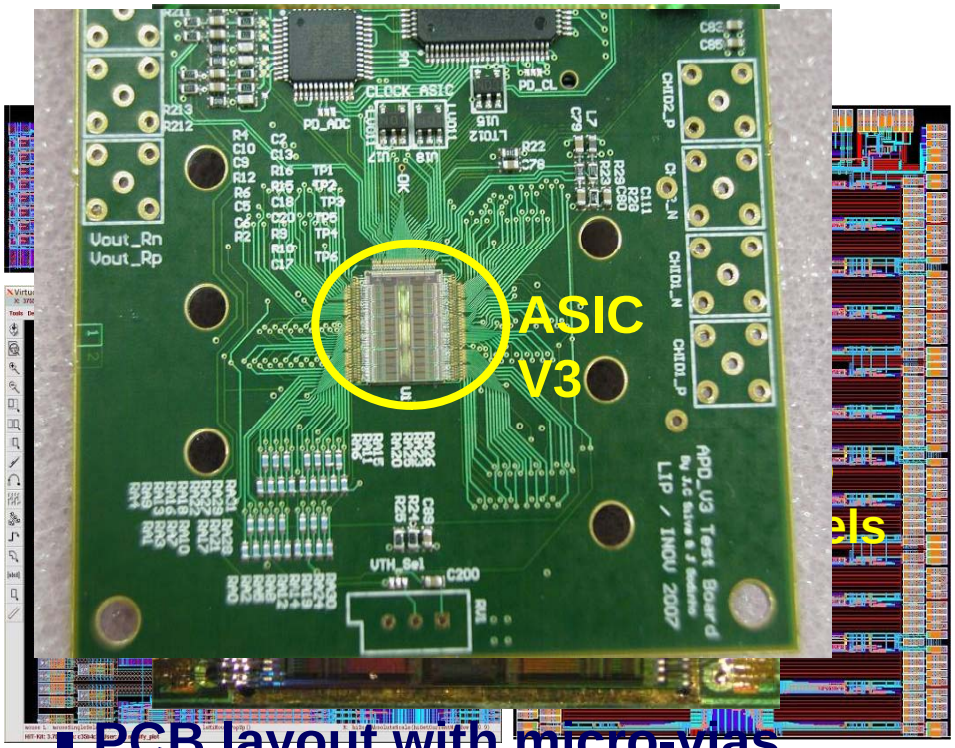
State of the art detector frontend electronics

Very low noise amplifiers, analog memories and multiplexers

Typical input charge ~30 femto Coulomb

Data driven synchronous architecture

Input:	**192 channels**
Max input charge:	**90 fC**
Shaping:	**40 ns**
Noise:	**ENC ~ 1300 e-**
Clock frequency :	**100 MHz**
Analog memories:	**10 samples**
Output multiplexing: 2 highest channels	
Power:	**3 mW/channel**



- PCB layout with micro-vias
- Technology: CMOS 0.35
- Wire-bonding of chip on-board
- Chip area: 70 mm2

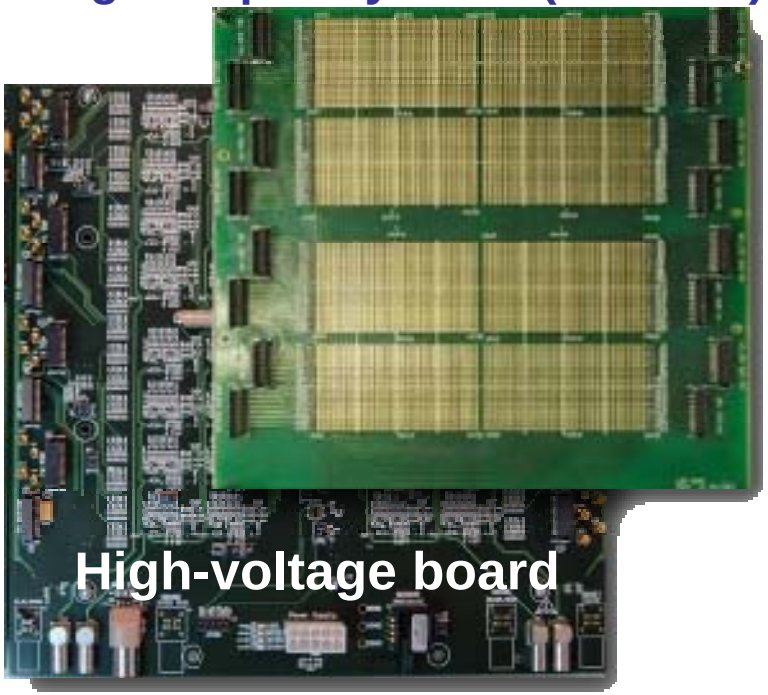
Largest number of input channels in a chip for APDs readout

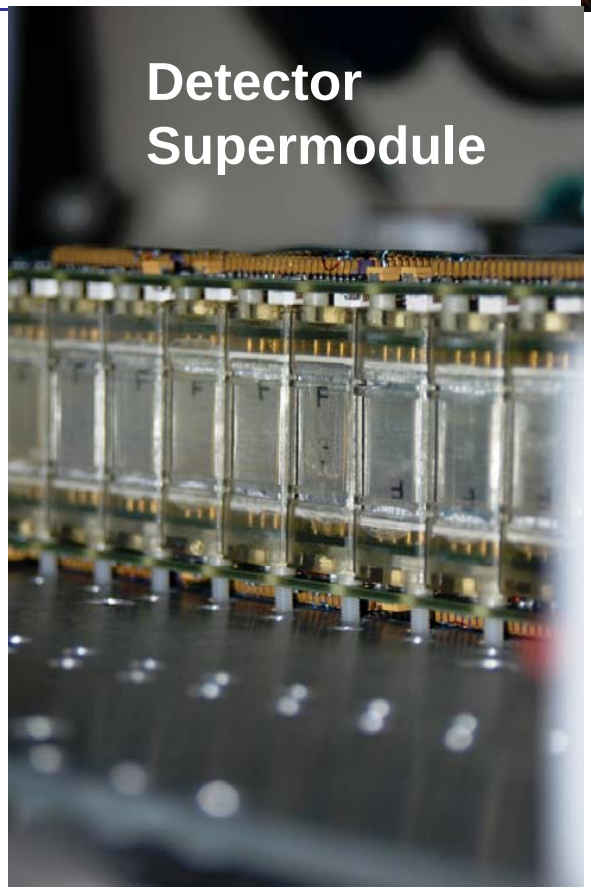
Frontend Electronics Integration

Compact system inside the Detector

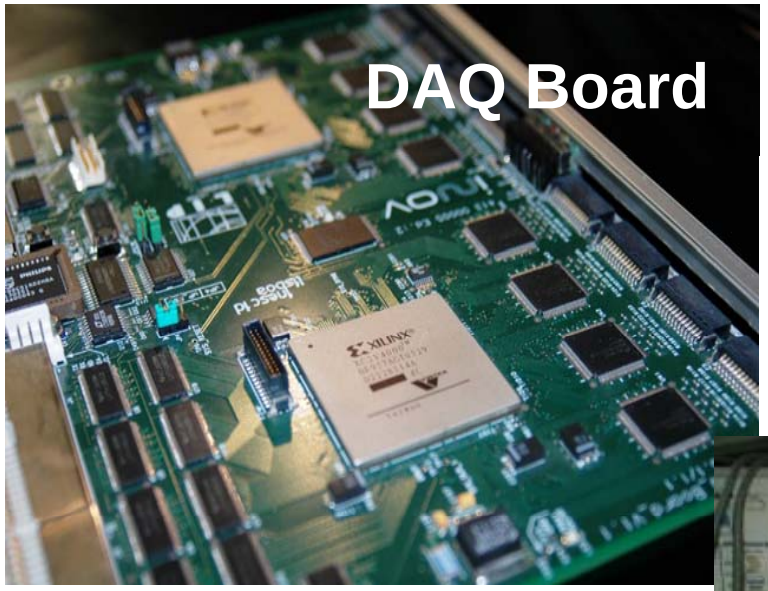
Head:

- 6000 APD channels
- 400 HV lines
- 160 high speed (600 MHz) output lines
- High frequency clock (100 MHz)





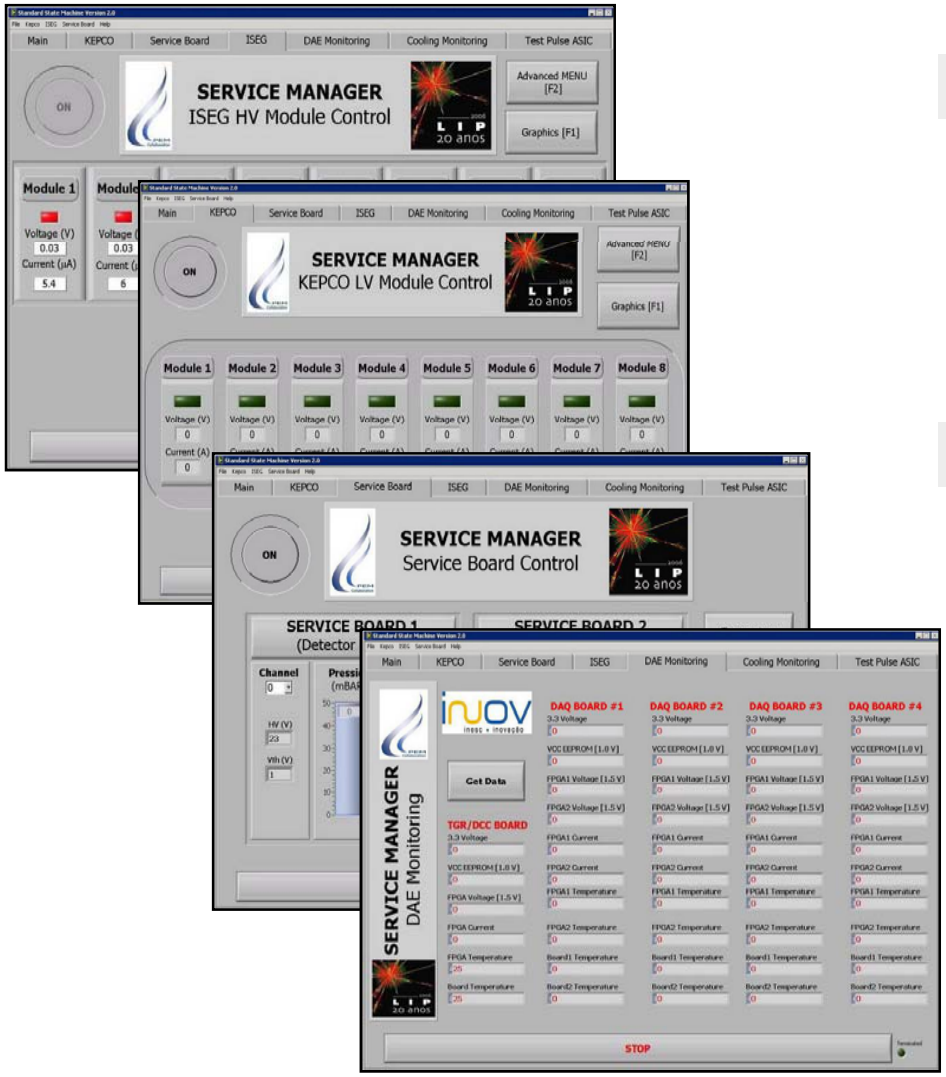
Data Acquisition System



- CMS-like trigger and data acquisition system
- System is housed in a single crate with two dedicated buses

Detector Services

Control panels



DAQ Test System

DAQ Server

8 cores, 2 TB disk array

Service Manager

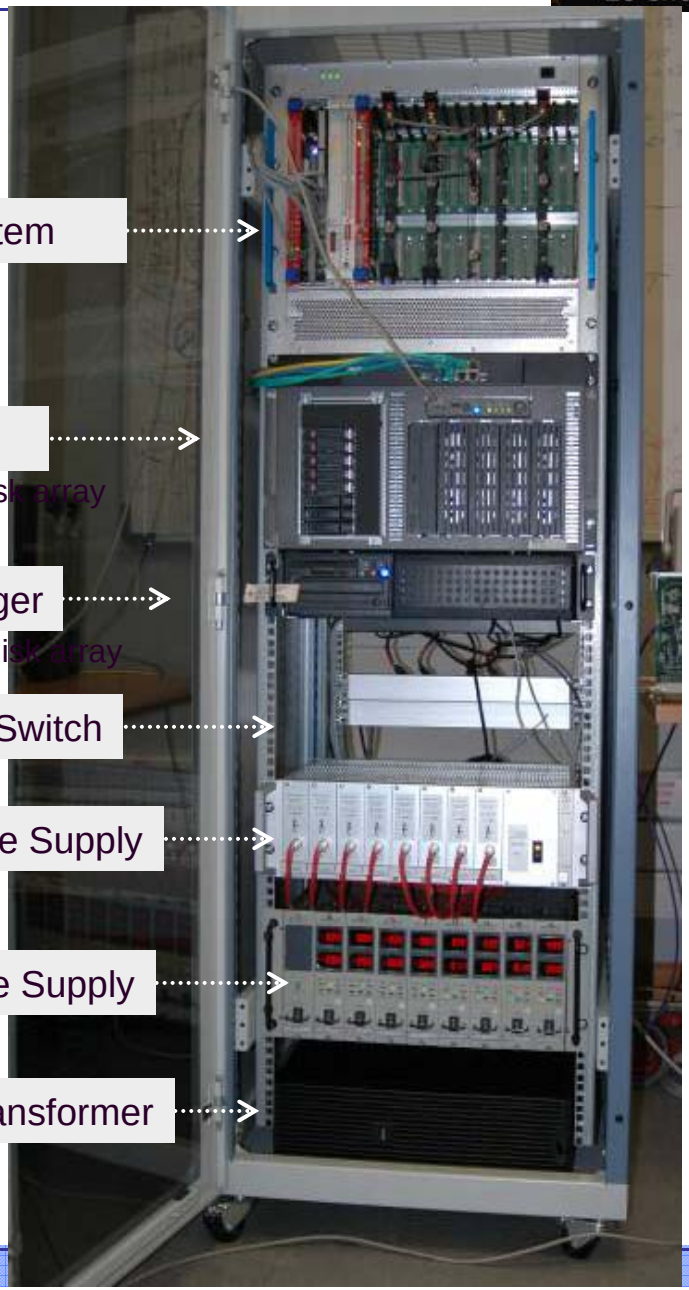
2 cores, 0.5 TB disk array

Gigabit Switch

High Voltage Supply

Low Voltage Supply

Isolator Transformer



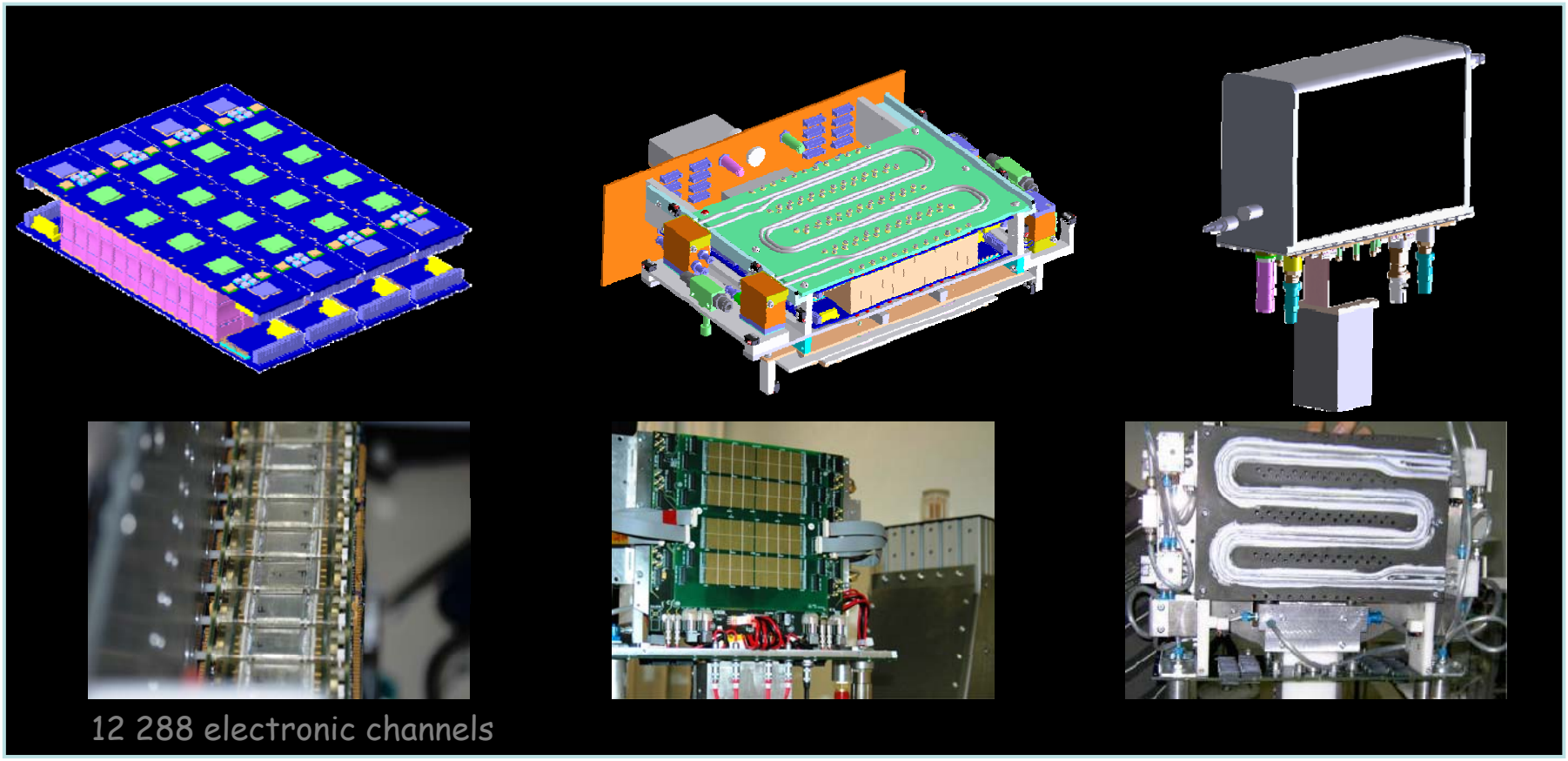
Detector Head

Supermodule:

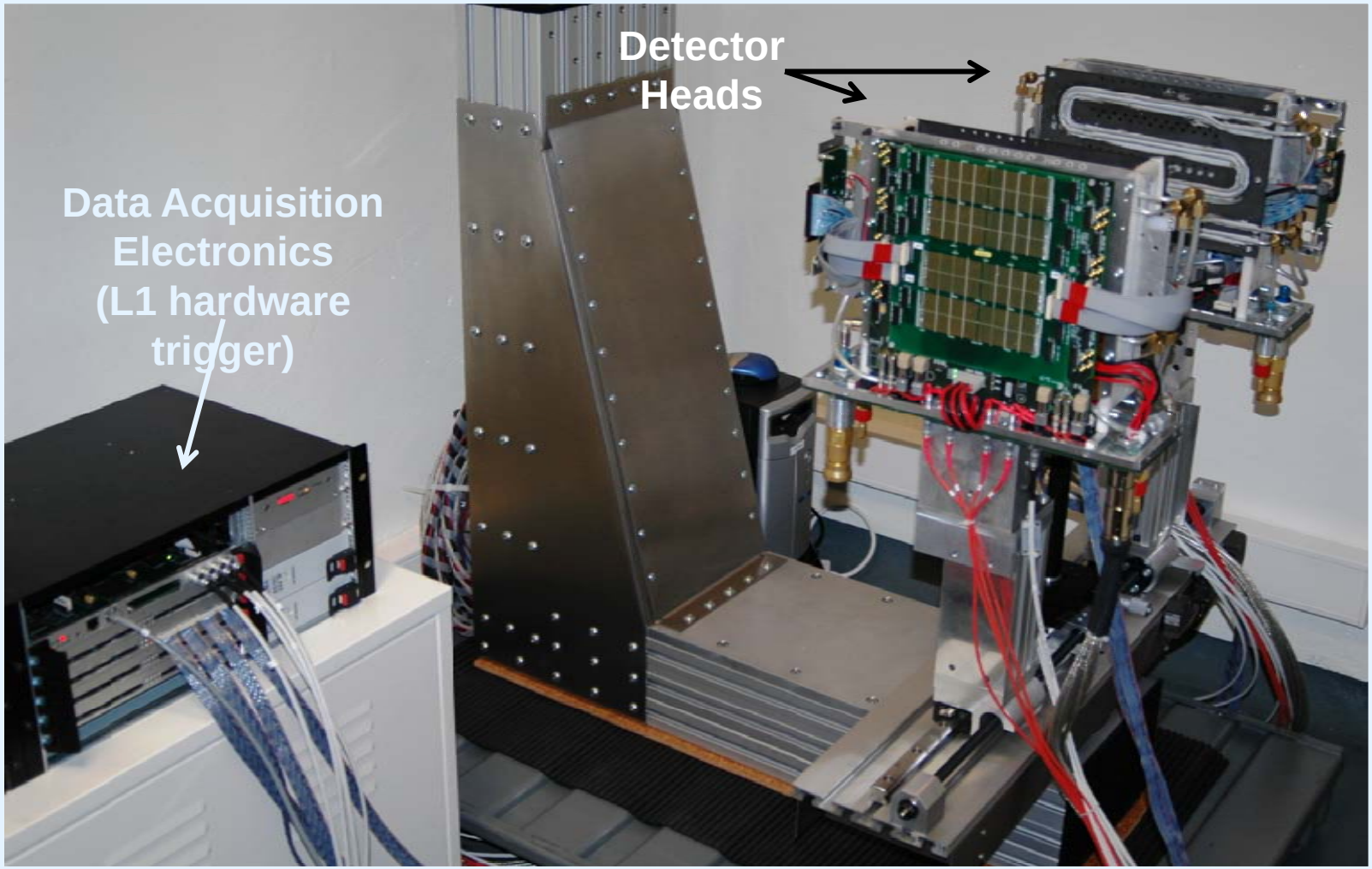
- groups 24 detector modules
- 2 Front-End Boards
- 4 ASICs with 192 channels

Detector head :

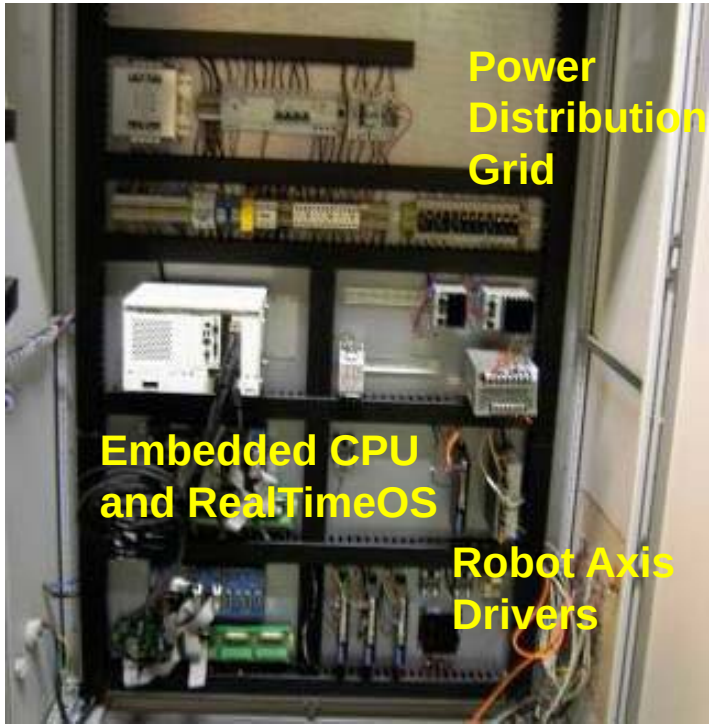
- 4 supermodules
- 1 Service Board
- 2 cooling plates

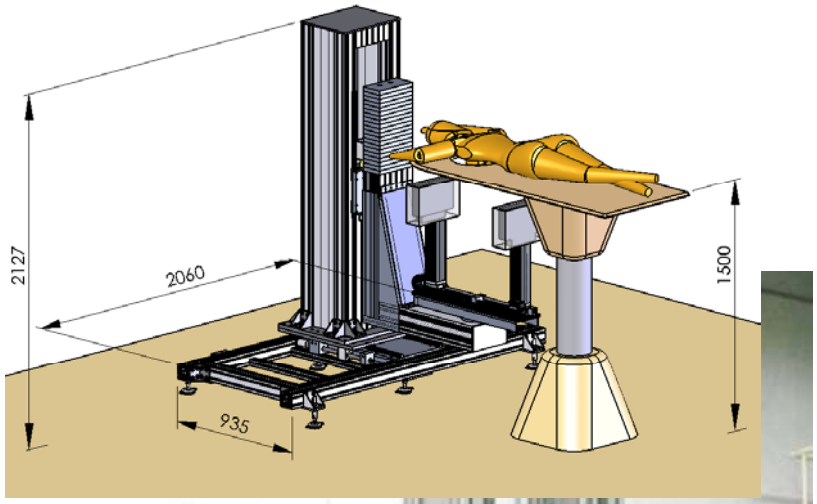


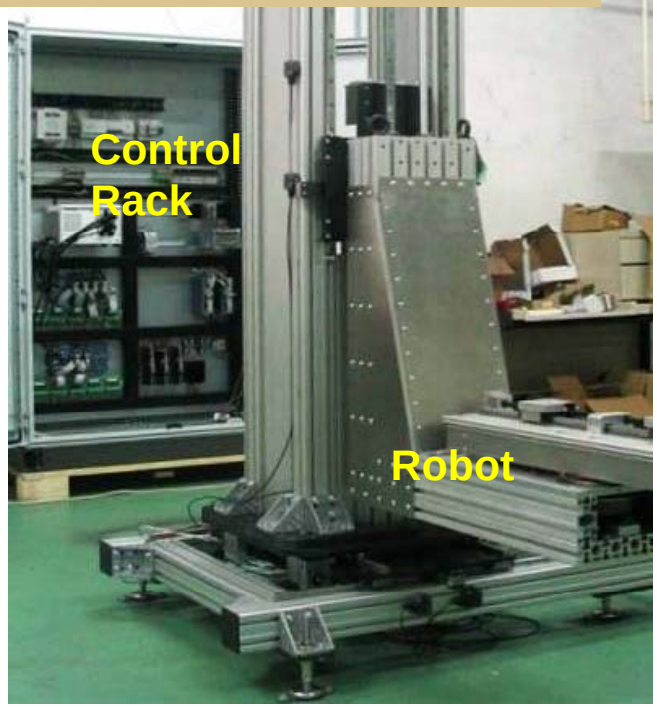
Assembled Detector Heads



ClearPEM Robotic Manipulator



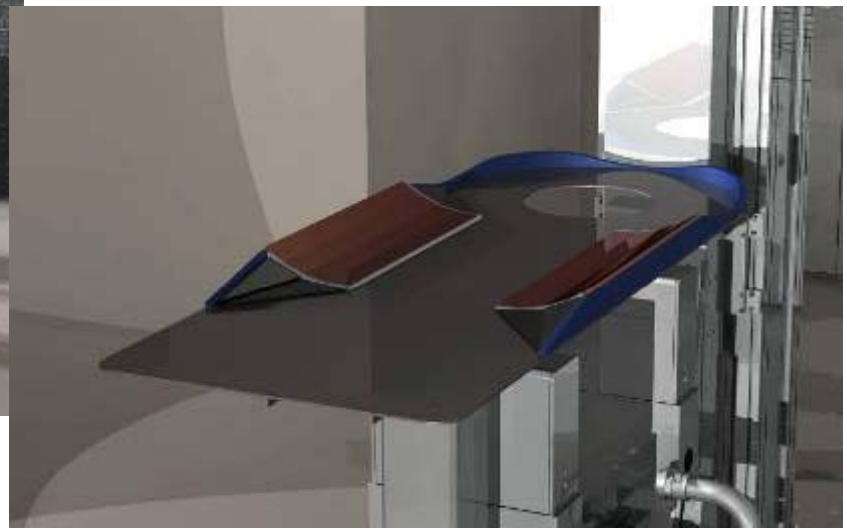




To be installed at HGO as soon the civil work is concluded in the examination room

ClearPEM Examination Bed

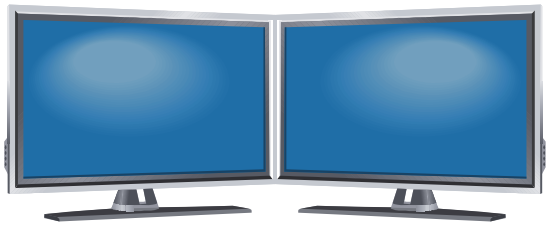
PET room at HGO



- **Three motion axis of the ClearPEM robot will be moved the examination bed**
- **Preparing installation at hospital**

Control Workstation

Operation, Monitoring, Reconstruction and Visualization Software



4 cores, 4 GB RAM, 1 TB disk array

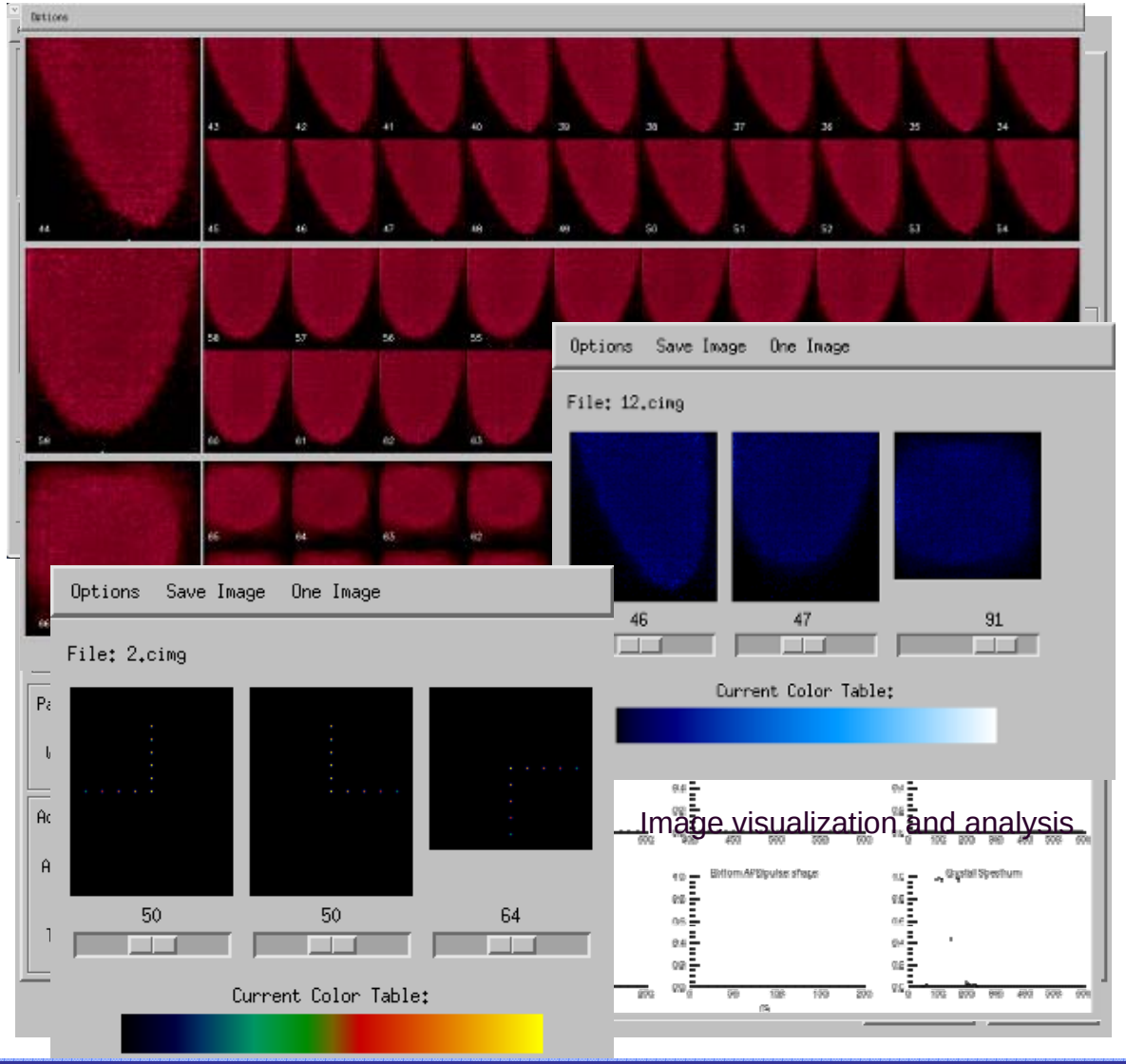
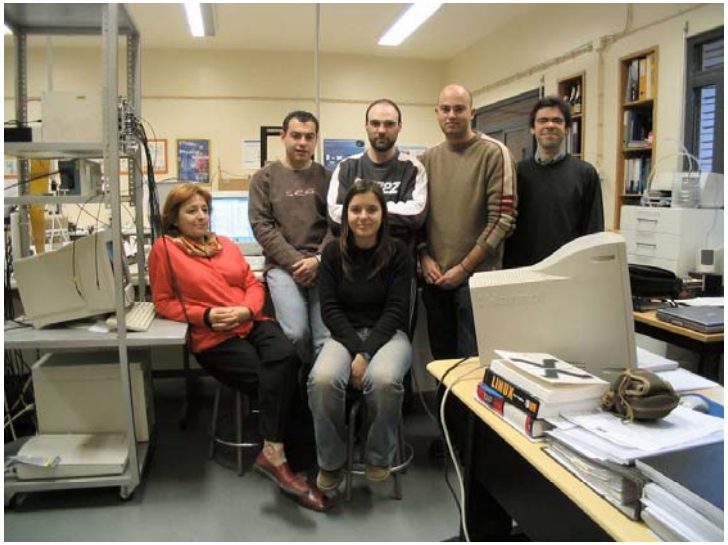


Image visualization and analysis

O Detector ISPA



Background motivation

ISPA group at CERN
(**I**maging **S**ilicon **P**ixel **A**rray)

High-energy semiconductor particle tracking detectors

Technology transfer

Low-energy imaging applications

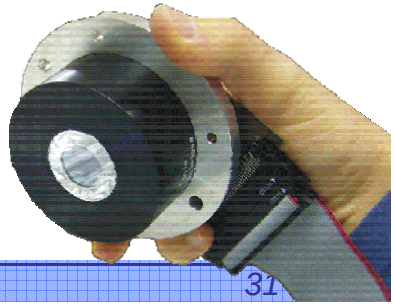
Nuclear Medicine

Planar Imaging
SPECT
~~PET~~

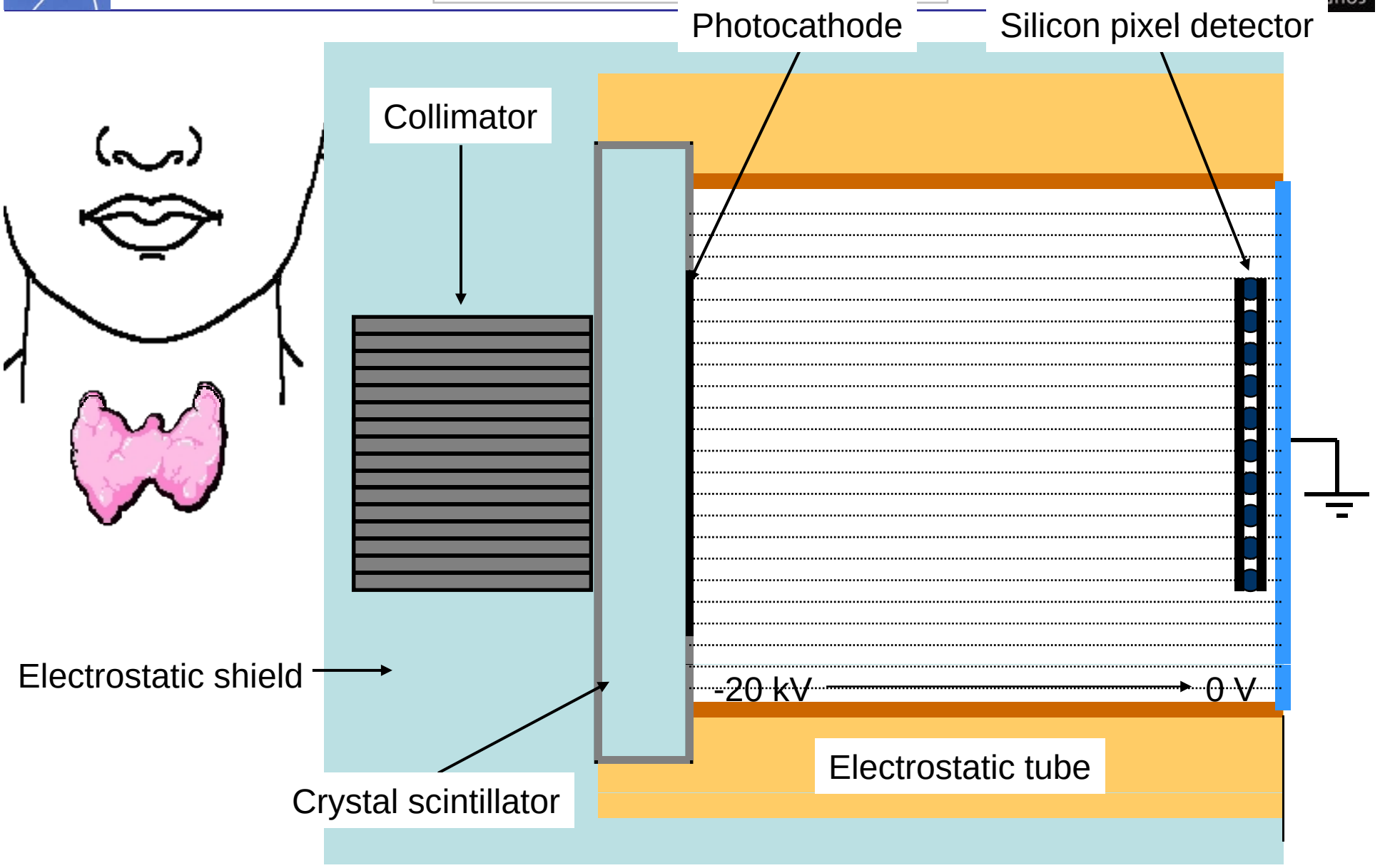
Low spatial resolution (typically 3 to 8 mm)

Anger gamma camera

Compact, **handheld** and **high resolution** gamma camera system

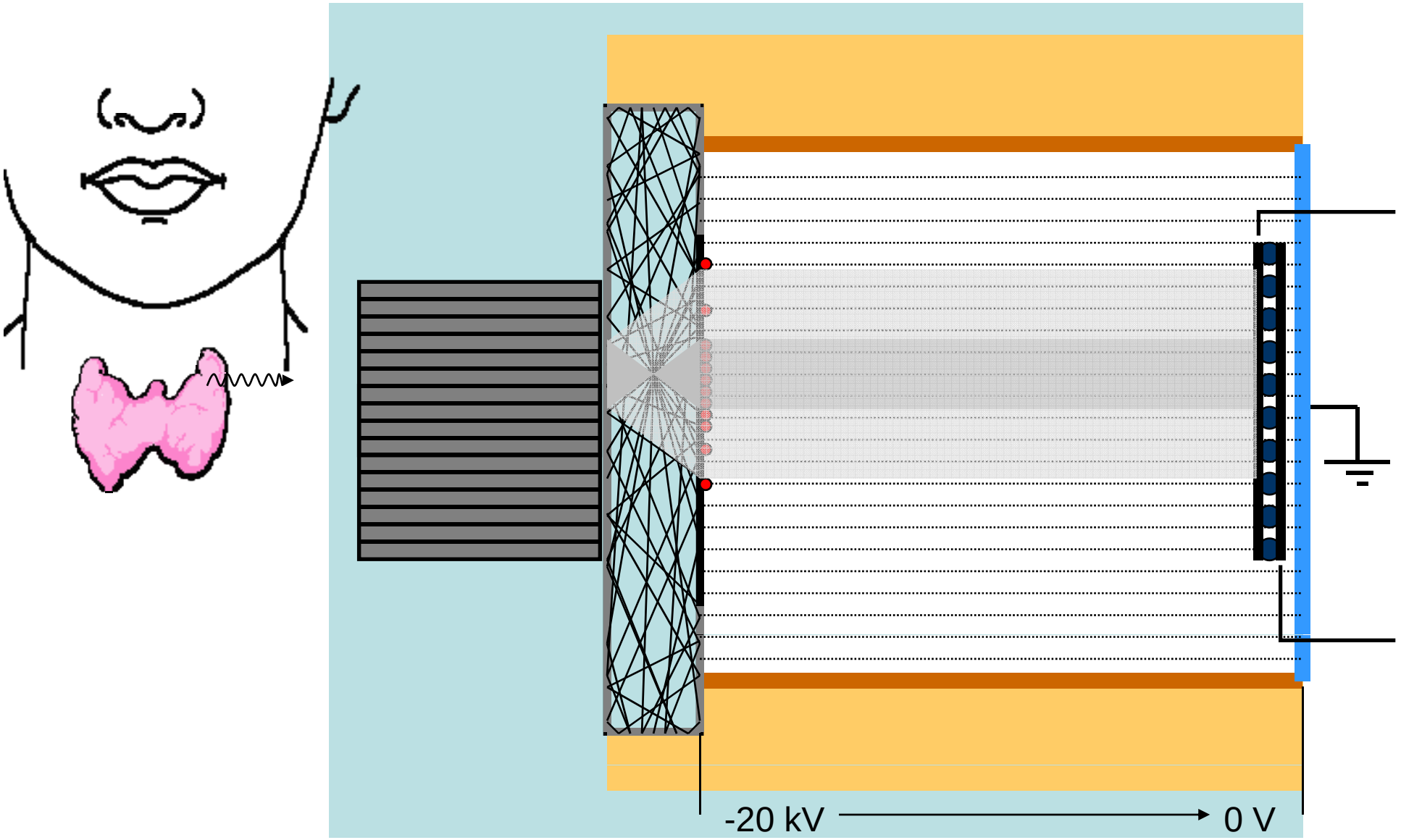


Operation principle



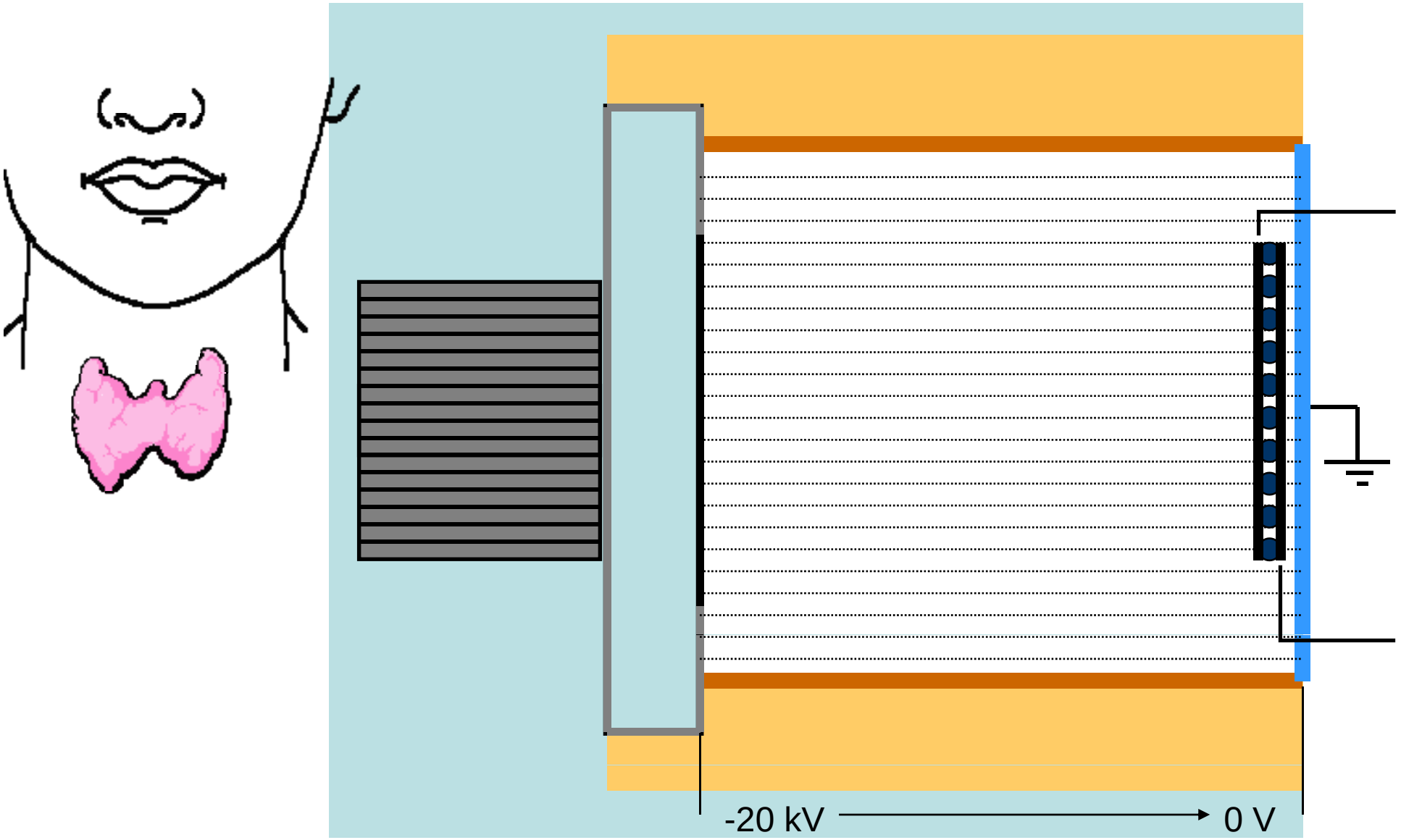
Not to Scale

Operation principle



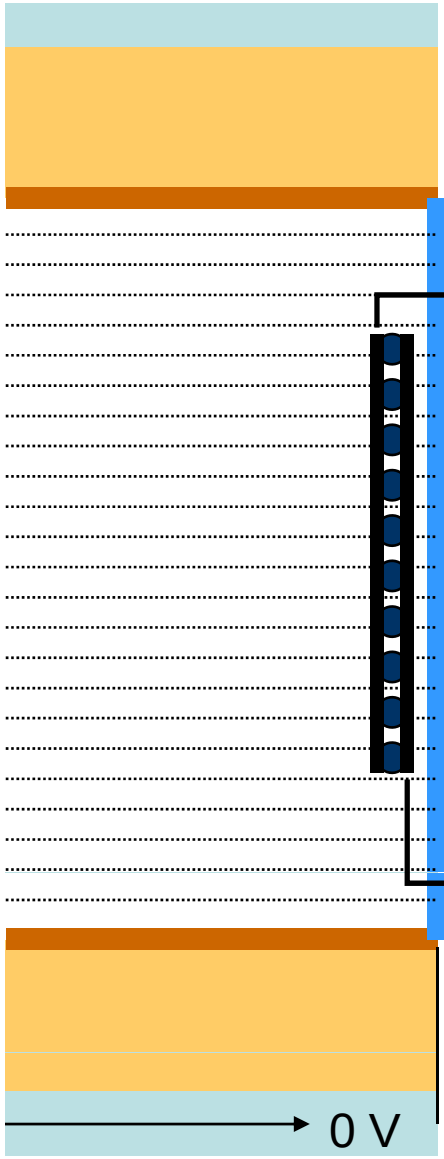
Not to Scale

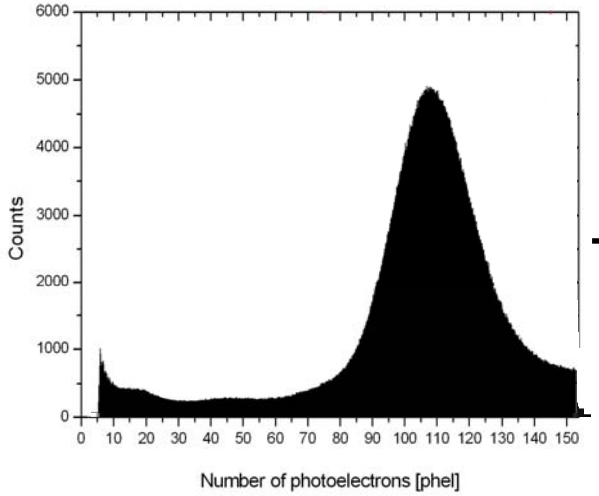
Operation principle

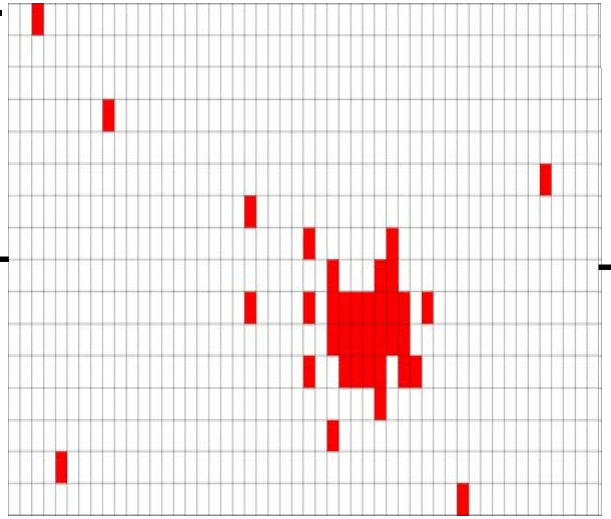


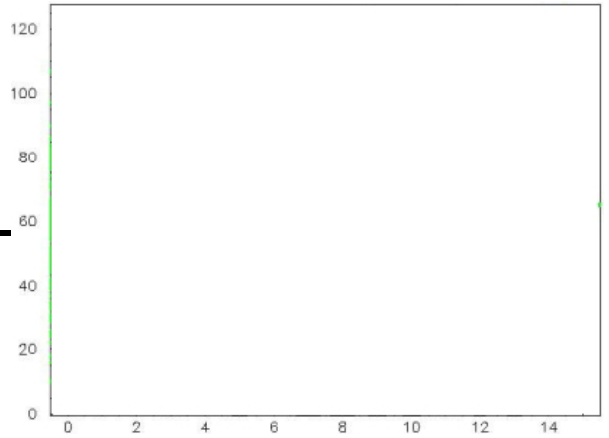
Operation principle

Analog information







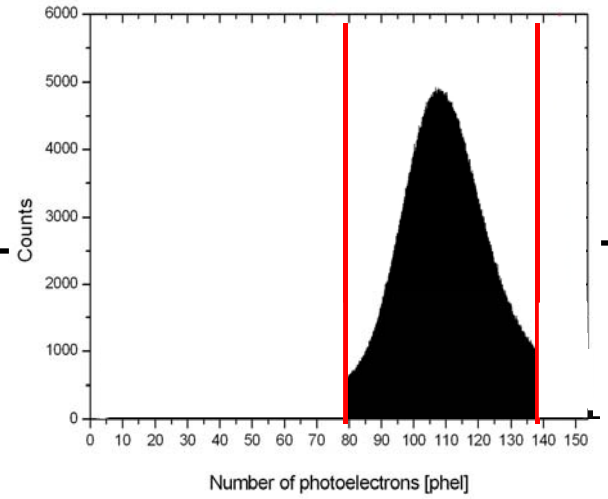


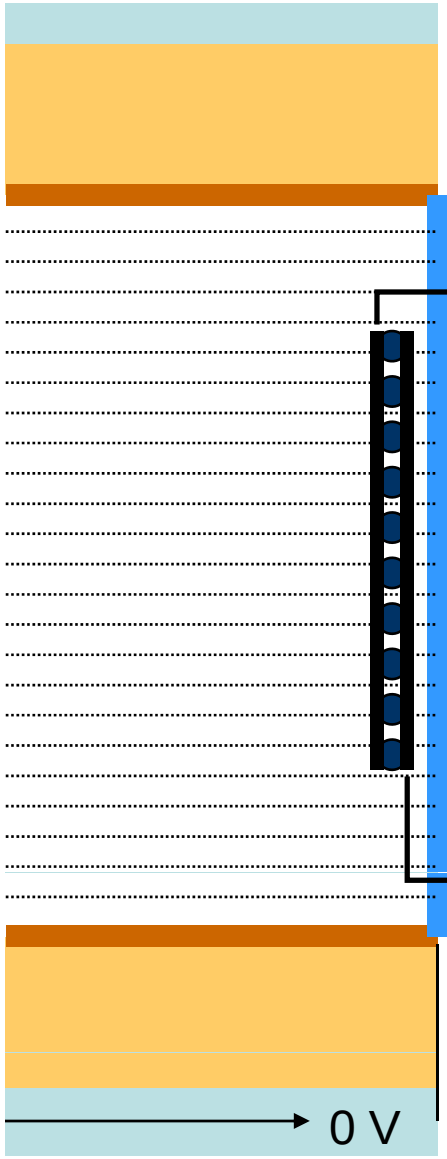
Valid 2D hit maps

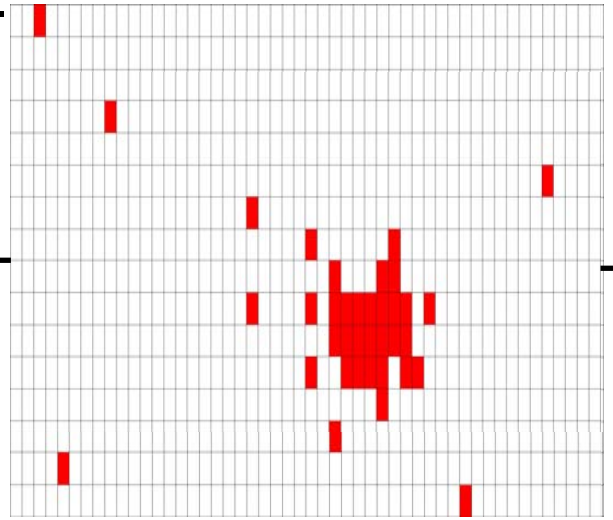
Digital information

Operation principle

Analog information

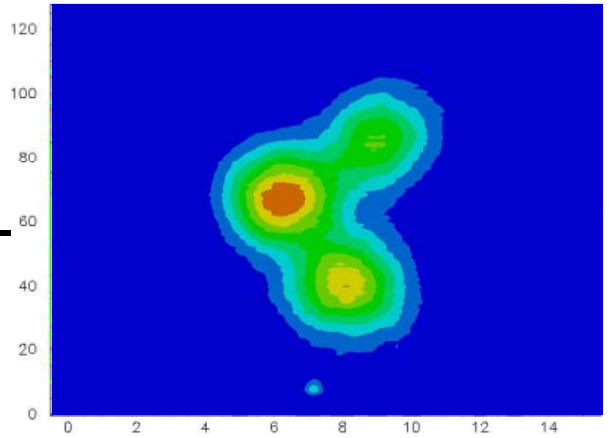


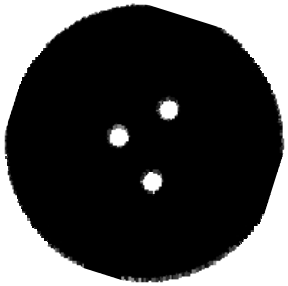




Digital information

8 mm x 6.4 mm



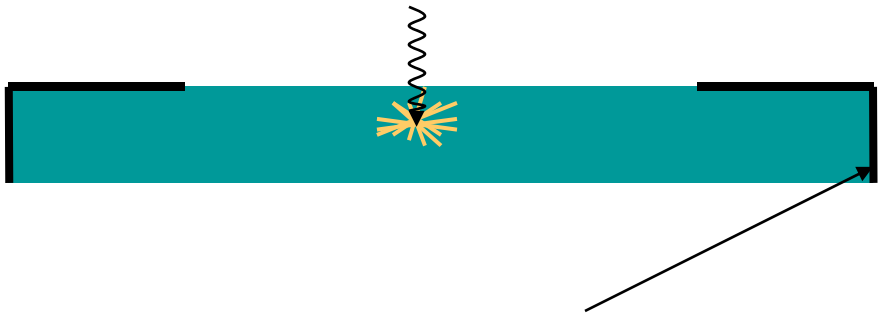


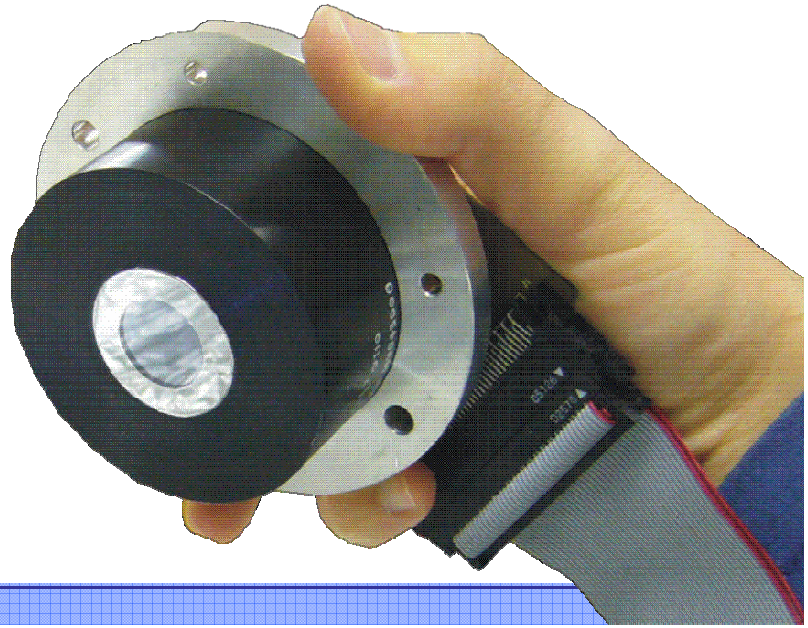
3 holes of 1 mm separated by 2 mm

Technical implementations and results

ISPA-tube **CRYSTAL SCINTILLATOR**

Material	YAP:Ce (Yttrium-Aluminiun Perovskite doped with Cerium)
Size	31 mm diameter
Thickness	2 mm
Light yield	10 ph/keV
Decay time	27 ns
Wavelength of maximum emission	370 nm
Absorption efficiency	89% @ 60 keV

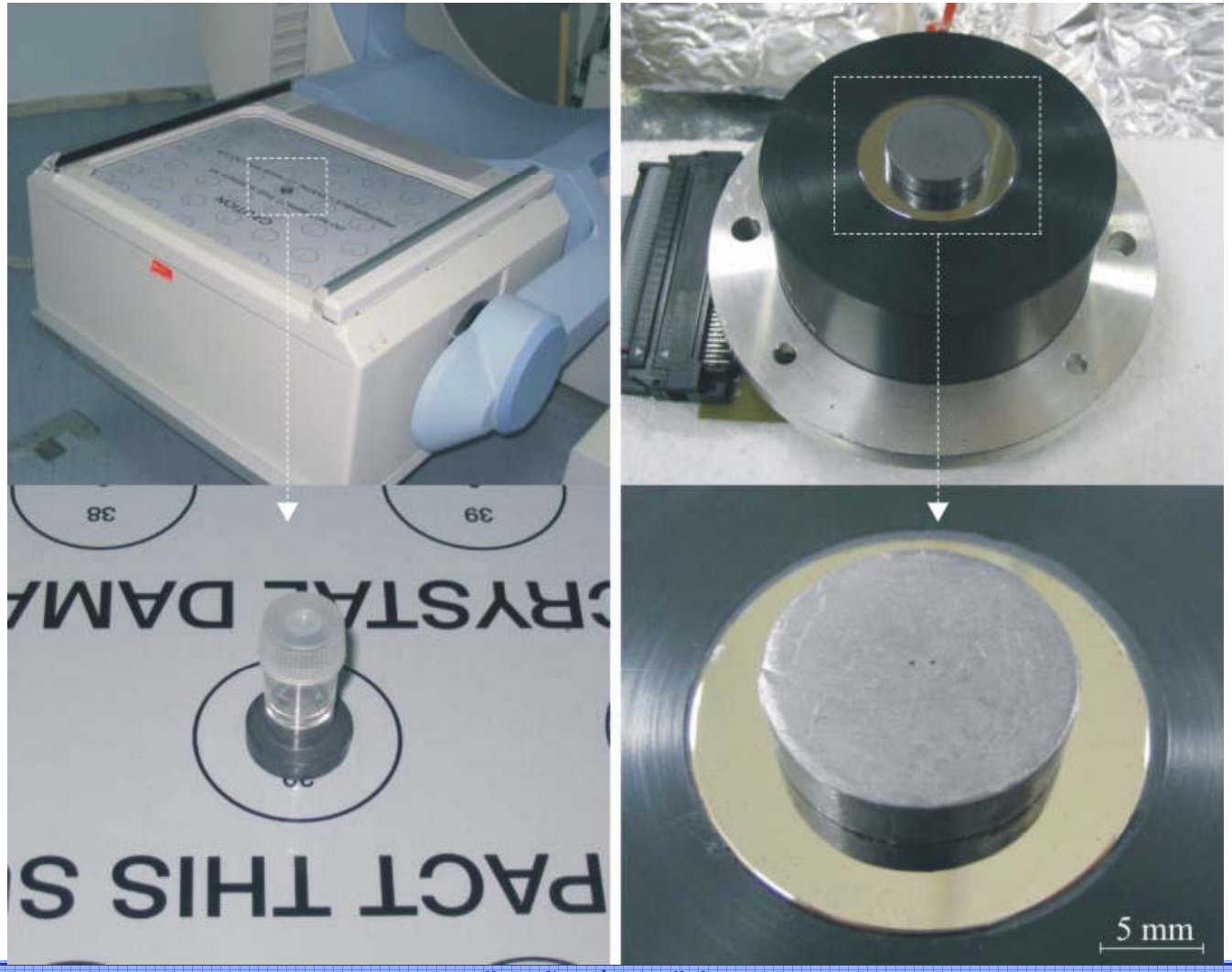




Final evaluation

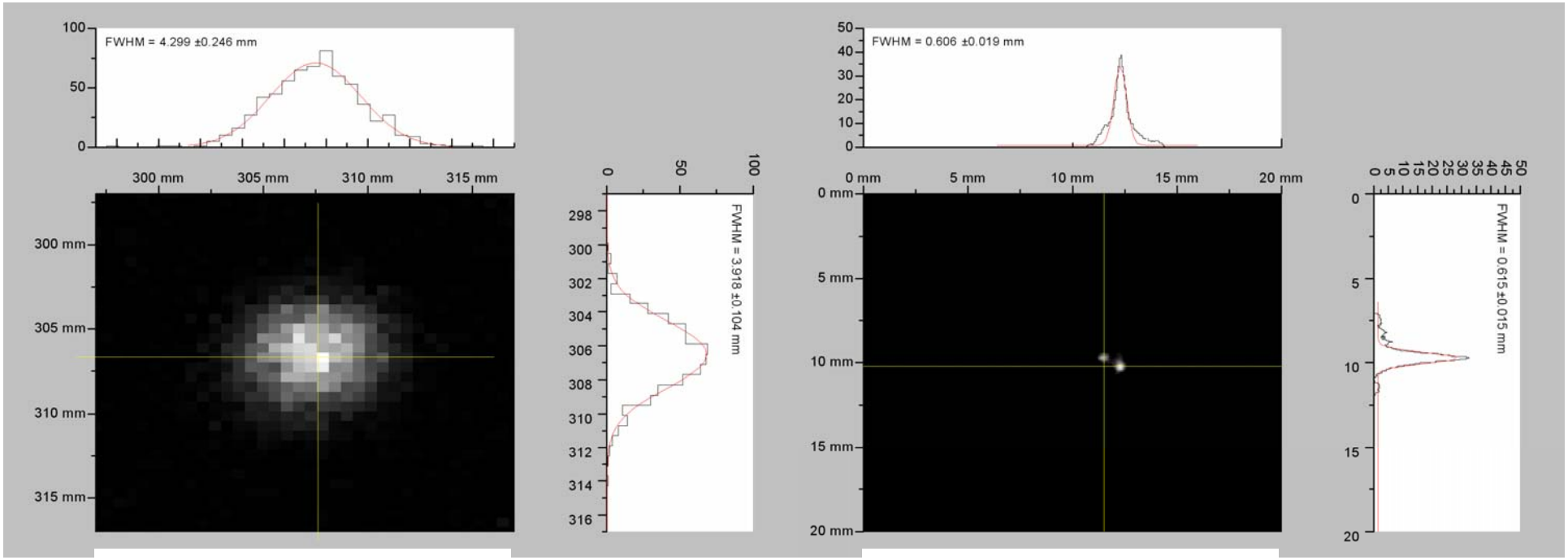
SPECT camera
140 keV point source

ISPA-tube
122 keV point source



Final evaluation

After a normalization of both test condition setups
(time-activity concentration and energy sensitivity)



SPECT camera

ISPA-tube

14000 counts
FWHM ~4.3 mm

5 minutes
equivalent

2800 counts
FWHM ~0.6 mm

Agradecimentos

João Varela (ClearPEM)

Patrick Sousa e Conceição Abreu (ISPA)

Adérito Chaves (Radiocirurgia)