Other Medical Imaging Challenges

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Technological opportunities in Medical Imaging I

**From a report presented to the EIT, Dic 2015*

Improvement of the accessibility and the efficiency and cost reduction of the medical imaging services

- Low cost, small size, easy to use imaging systems
- Small Region Networks solutions and support using TIC (communications)
- Image processing and analysis based on *open* solutions (cost, availability)

Multimodality

- Anatomy and function must go together
- Electrophysiology based imaging

Tracers and Contrast agents

- Biomarker identification
- Biocompatibiity
- Sensibility and specificity


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Technological opportunities in Medical Imaging II

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Medical imaging quantification y visualization

- Segmentation
- Quantification
- Multidimensional view

Healthcare Data Analytics

- Massive increase of medical information (neuroimaging, r-x, MRI, NM, NPI, molecular imaging, molecular imaging, imagen molecular, US, elastrography, optoacoustic imaging, tomosynthesis, etc.)
- Integration with genetic information
- Integration with e-health and self-quantification

Magnetic Resonance Imaging

- Hardware
- Large cohorts
- "Functional" MRI (DTI, DWI, MPI, contrast imaging)

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Technological opportunities in Medical Imaging III

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Low-dose CT

- Reduce dose by 60% to 80%
- Real time imaging
- Other contrast besides tissue density (diffraction, phase contrast…)
- Low cost systems
- Photon counting

Image-Guided Interventions

- Intra-operative radiotherapy
- Navigation

Proton Therapy Imaging

- Instrumentation
- In-beam imaging
- Dosimetry

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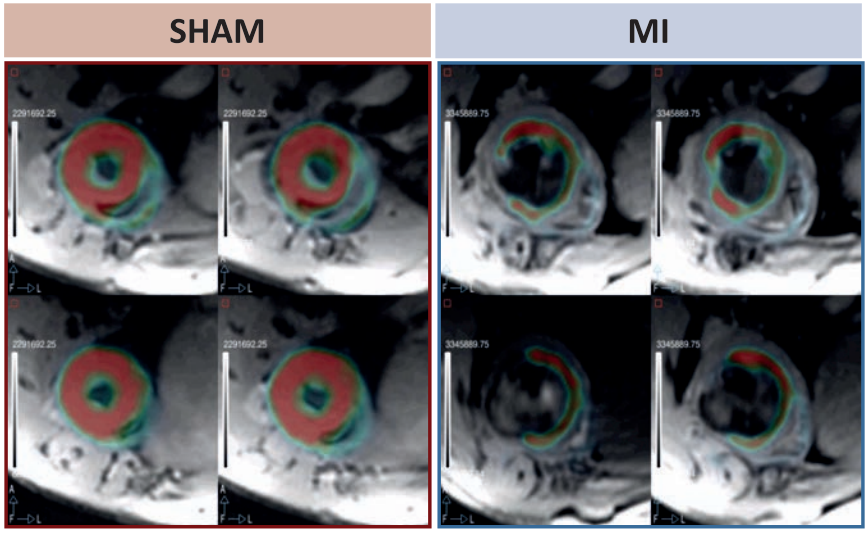
4D Cardiac PET-MR scan at 7T

FDG (metabolism) – LGE (fibrosis), rat model



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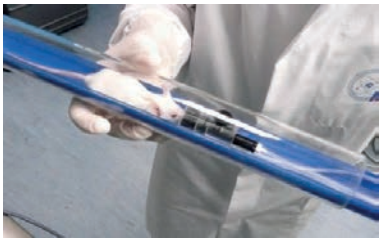
Sequential PET-MR scans at 1.5, 3 and 7T

Dijon, France



Animal holder

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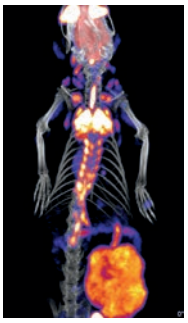
Motivation

Make sequential PET/MRI workflow as “smooth” as current PET/CT

PET/CT



PET/MRI

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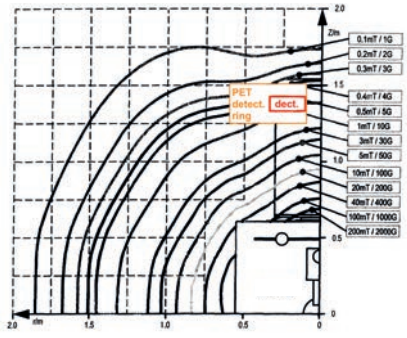
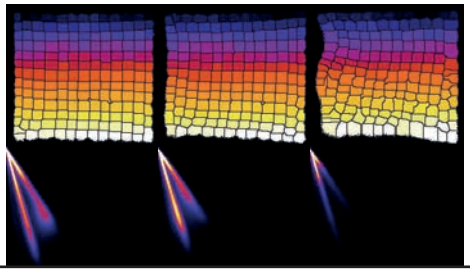
MR B_0 effect on the PMTs

- Superconductive 3 Tesla
- Cryogen free, no magnet quench boil off provision required
- Small foot print and fringe field
- No room RF shield needed, magnet provides the RF shield
- Total weight – 395 kg



Y axis 1mT Y axis 3mT Y axis 5mT



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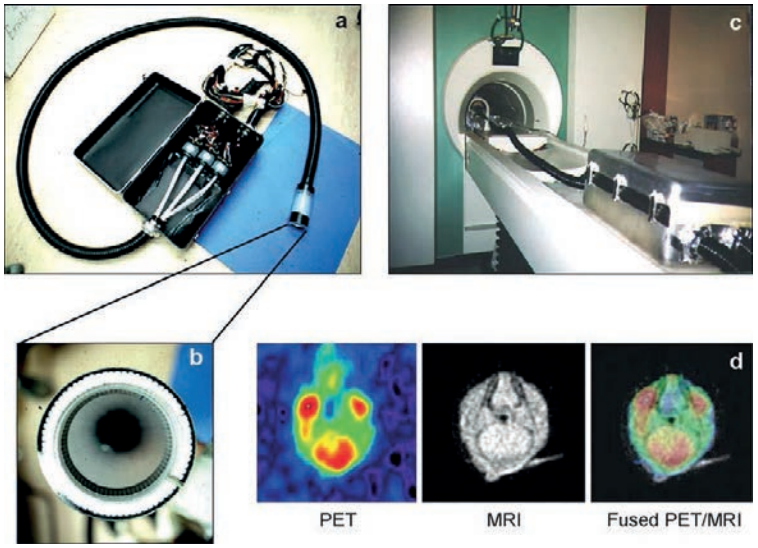

Shao Y, Cherry SR, Farahani K, et al. Phys Med Biol 42: 1965-1970; 1997

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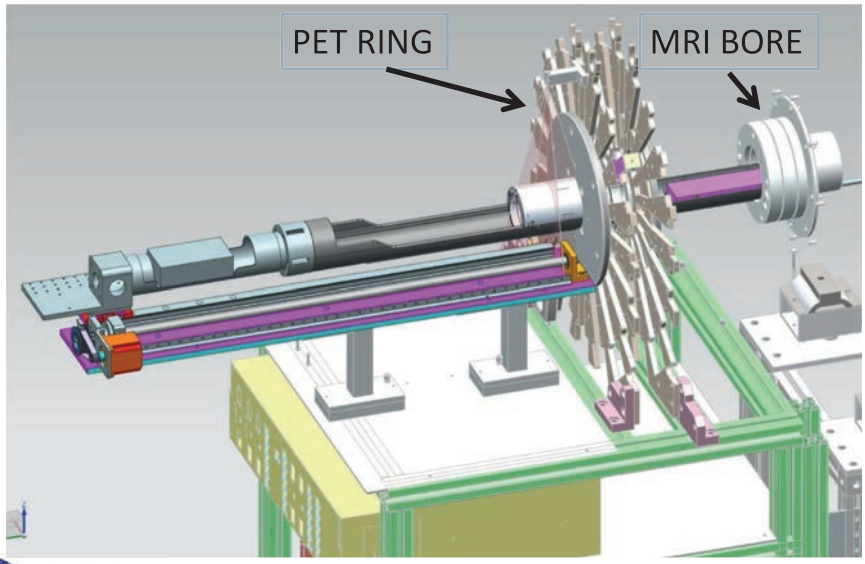
Automatism for bed movement between scanners



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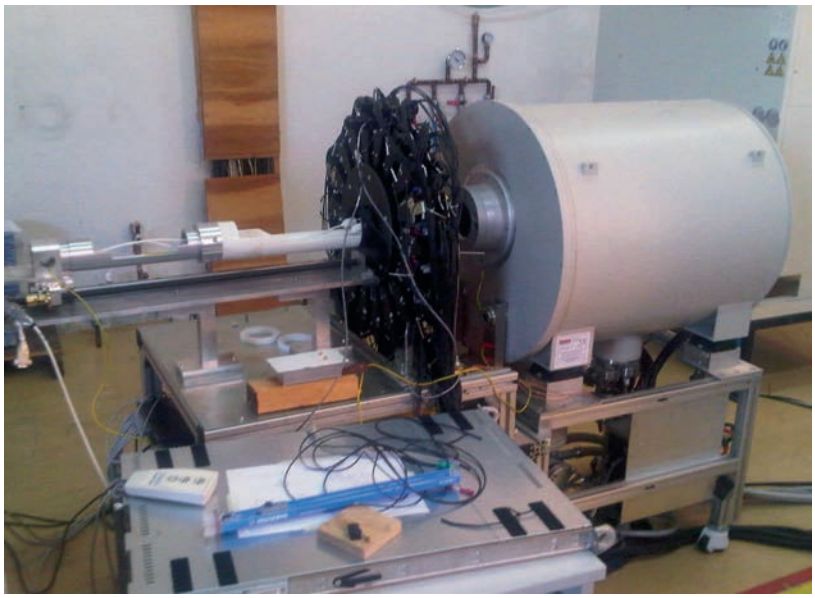

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Philips PET/MRI system

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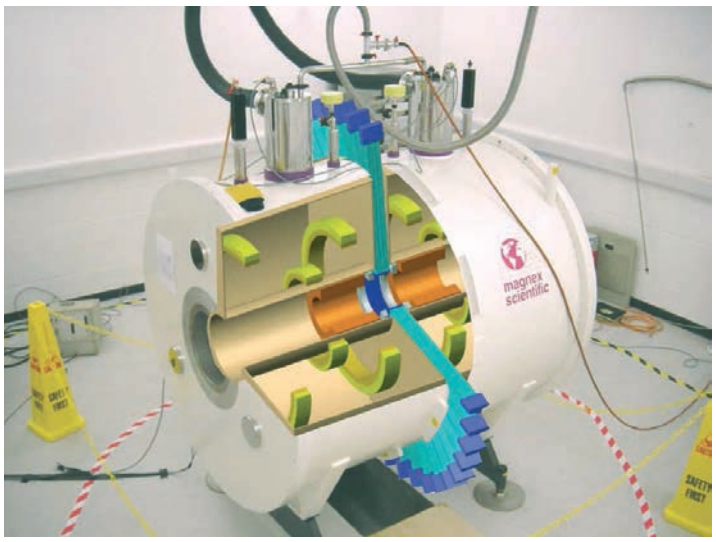

A Lucas, et al. University of Cambridge

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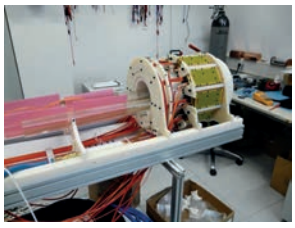
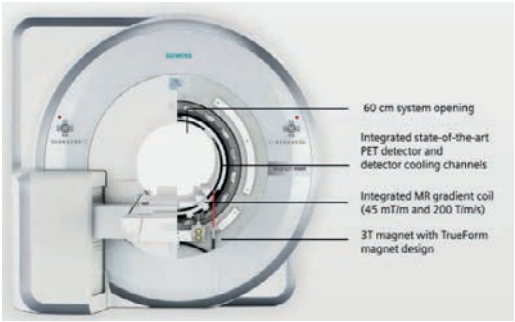
SiPm and the brith fo the PET insert



Hyperion I

Biograph mMR



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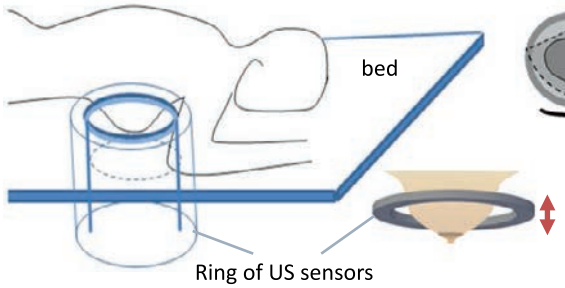
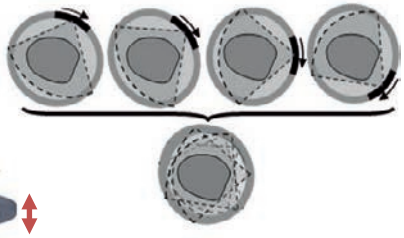
US mamo-tomography





Multiple angle data acqusition

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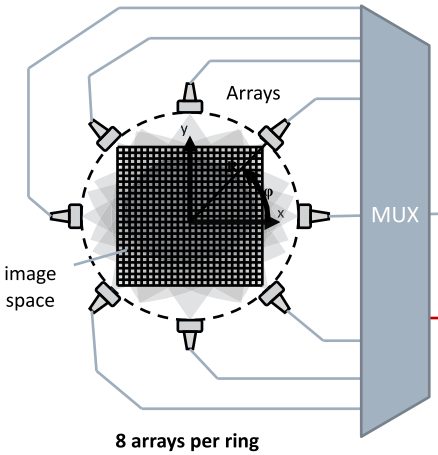
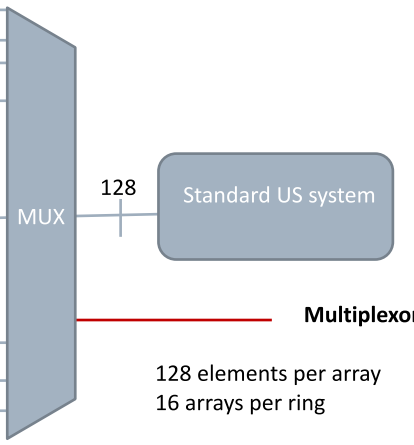
US mamo-tomography





Multiplexor

128 elements per array
16 arrays per ring

Multiplexing de **2048 to 128 channels**

Measuring velocity and attenuation maps

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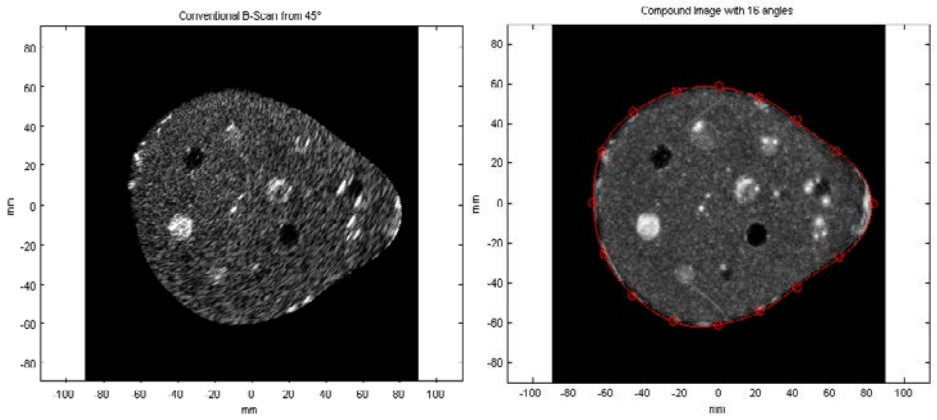
US mamo-tomography



Better contrast
Speckle reduction
Better resolution (micro-calcifications)

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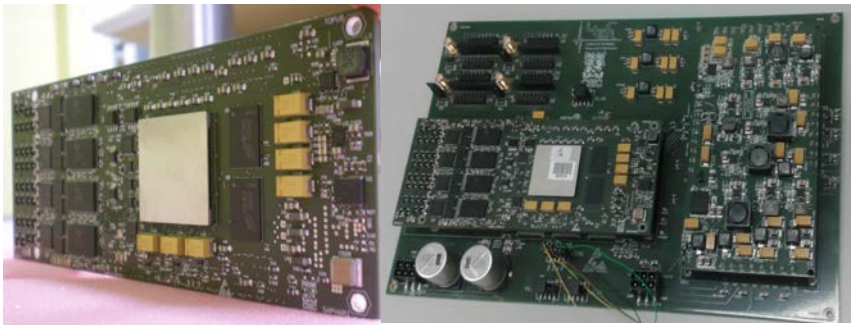
US mamo-tomography

High speed data processing: 16 million meassurements per tomogram



System based on FPGAs Kintex y Zynq
1 GB DDR-3, AFEs and pulsers integration, 1 Gb/s LVDS links and 10Gb/s GTX

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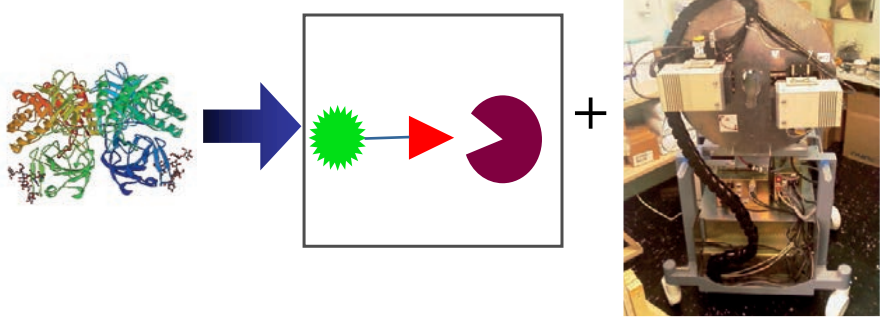
Tracer imaging

Biomarkers
biomarkers identified from studies of the Human Genome & Proteome

Targeted Chemistry
Add targeted chemistry that selectively binds to them and amplifies their imaging signal

Diagnostic Technology
Using high-sensitivity, high-resolution imagers



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Cyclotron and radiopharmacy

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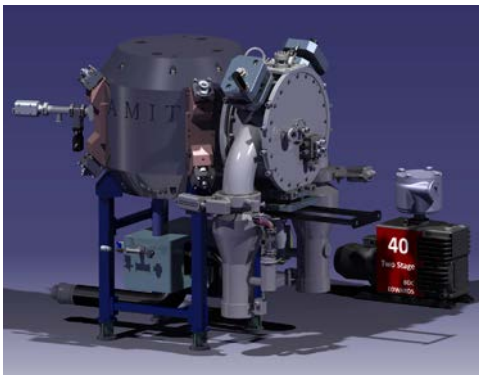
CIEMAT – AMIT consortium cyclotron for ^{11}C and ^{18}F



PARAMETRO	VALOR/TIPO
1) GENERAL	
1.a) Energía	> 8.5 MeV
1.b) Corriente	> 10 μA
1.c) Tipo de Ciclotrón	Lawrence
2) IMAN	
2.a) Tipo	Superconductor
2.b) Configuración	Hierro Caliente
2.c) Material Superconductor	NbTi @ 4.2 K
2.d) Campo Central	4 T
3) SISTEMA DE RF	
3.a) Configuración	Una D de 180º
3.b) Tensión de Aceleración	< 60 kV/gap
4) FUENTE DE IONES	
4.a) Tipo	Interna
4.b) Iones	H-

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Technological opportunities in Medical Imaging III

Low-dose CT

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Image-Guided Interventions

- **Intra-operative radiotherapy**
- **Navigation**

Proton Theraphy Imaging

- **Instrumentation**
- **In-beam imaging**
- Dosimetry

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Image guided surgery

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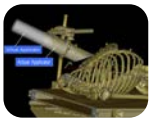
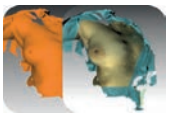
IOERT Treatment Planning



Navigation: initial tests

Clinical Experience

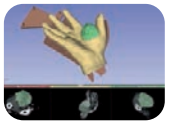


SL 3D Surface Scanning

Conoprobe Tissue Scanning

Sacral Neuro-modulation

AR in the Surgical Room



3D printing + navigation

US breast navigation

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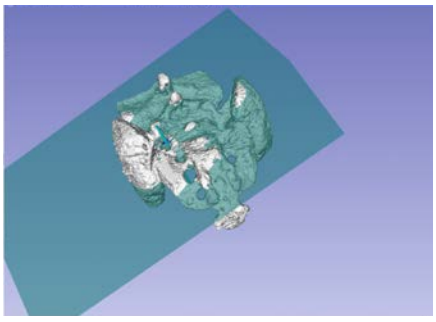
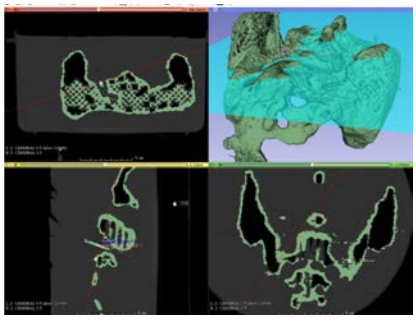
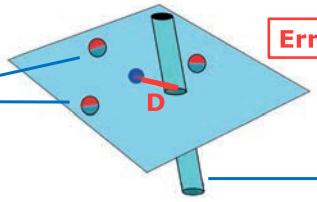
Errors assessment in sacral neuro stimulation







Landmarks in the phantom

Needle

Error = |DCT - DVirtualScene|

5 insertions, 5 CTs

Mean error: 2,33mm

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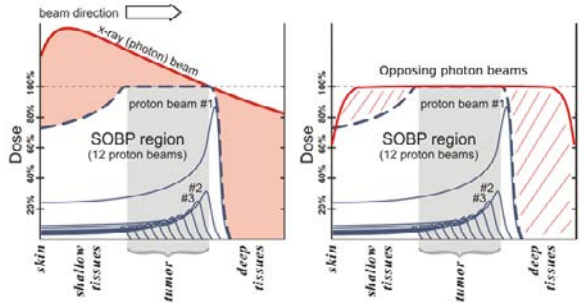
Radiation therapy: Bragg peak



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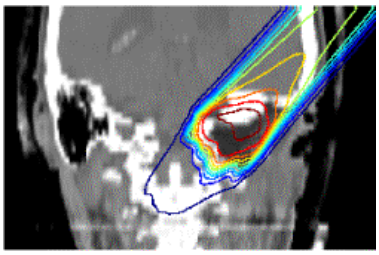
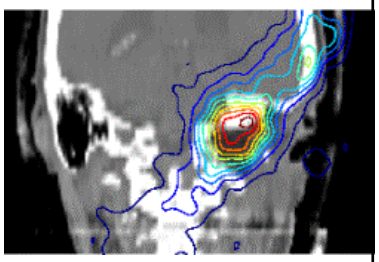
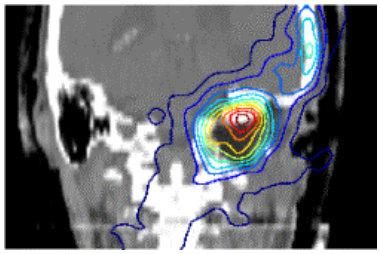
Treatment monitoring



planning



simulation



measured (in beam)

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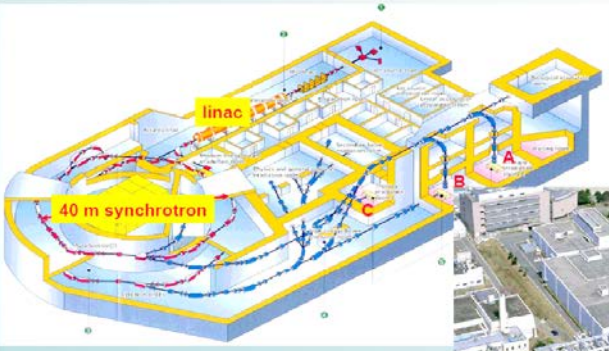
Particle Therapy Facilities – HIMAC/Japan



The Heavy Ion Medical Accelerator of NIRS (since 1994)

Two identical 800 MeV/u synchrotrons for ions up to Argon; mainly Carbon is used

4,500 patients treated

HIT

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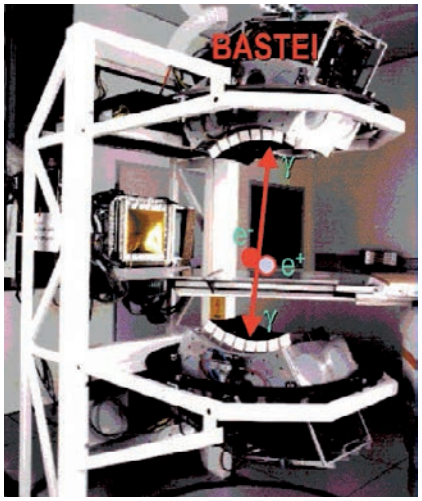
Imagers at GSI



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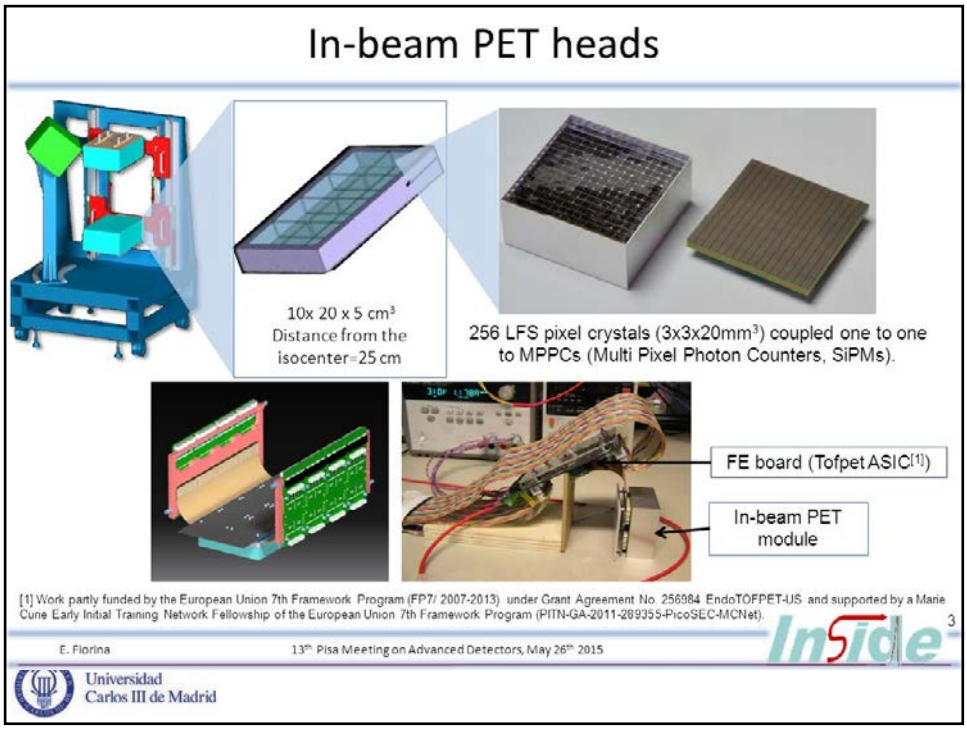

Technological opportunities in Medical Imaging III

Low-dose CT

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- **Real time imaging**
- **Other contrast besides tissue density (diffraction, phase contrast…)**
- **Low cost systems**
- **Photon counting**

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Proton Therapy Imaging

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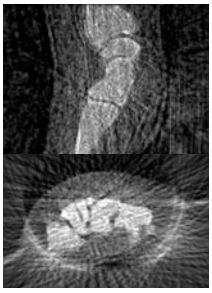
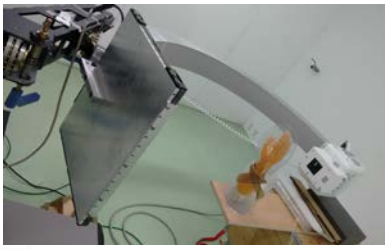
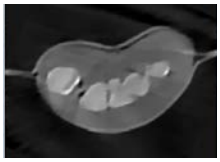
X-ray tomography using a C-arc

- 60 projections, span angle of 360 degrees



- 42 projections, angle span of 120 degrees





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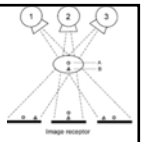
Tomosyntehsis



- Complete tomosynthesis workflow in real system

- Automatization of tomosynthesis acquisition
- Evaluation of different geometries
- Image improvement: Iterative reconstruction

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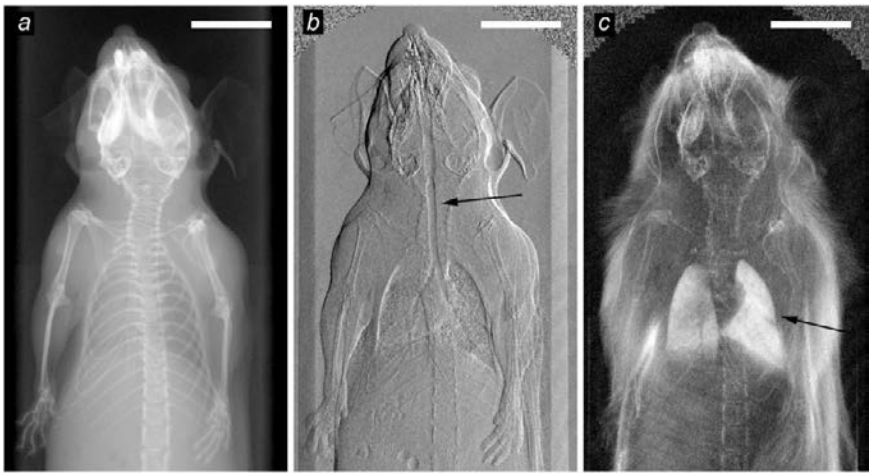
Phase-contrast and dark field imaging



(a) Conventional x-ray image based on attenuation. (b) Differential phase-contrast image based on x-ray refraction. (c) Dark-field image based on x-ray scattering. The white bars correspond to 1 cm.

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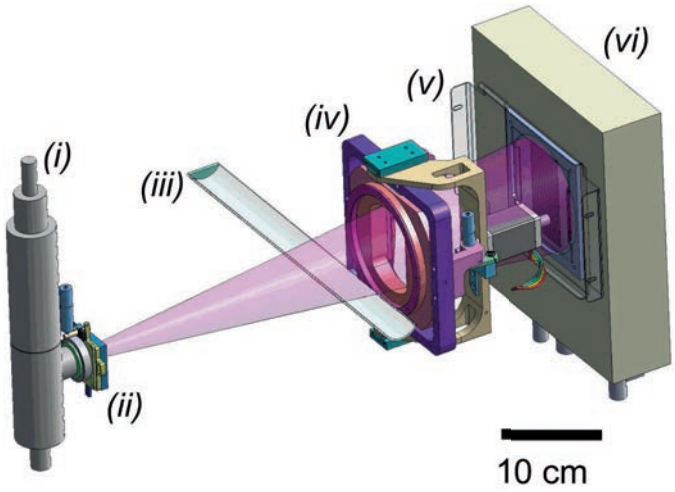
*Bech et al., Scientific Reports **3**, doi:10.1038/srep03209 (2013)*



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*Bech et al., Scientific Reports **3**, doi:10.1038/srep03209 (2013)*

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Improvement of the accessibility and the efficiency and cost reduction of the medical imaging services

- ✓ Multimodality
- ✓ Tracers and Contrast agents
- ✓ Medical imaging quantification y visualization

Healthcare Data Analytics

Magnetic Resonance Imaging

- ✓ Low-dose CT
- ✓ Image-Guided Interventions
- ✓ Proton Therapy Imaging

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