



PET-MRI Project in FP7

LIP Motivations and Proposals

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**Joao Varela
LIP, Lisbon**

The institutions

LIP-Laboratory for Particle Physics, Lisbon

Detector and electronics development for CERN experiments since 20 years
Medical applications



PET-Consortium

Eight technology and medical institutions, since 2003
New PET imaging technologies in breast cancer detection



PETsys, SA

Start-up company, 2008



The background

PET mammography scanner in operation (ClearPEM)

Large APD-based system (12'000 channels)

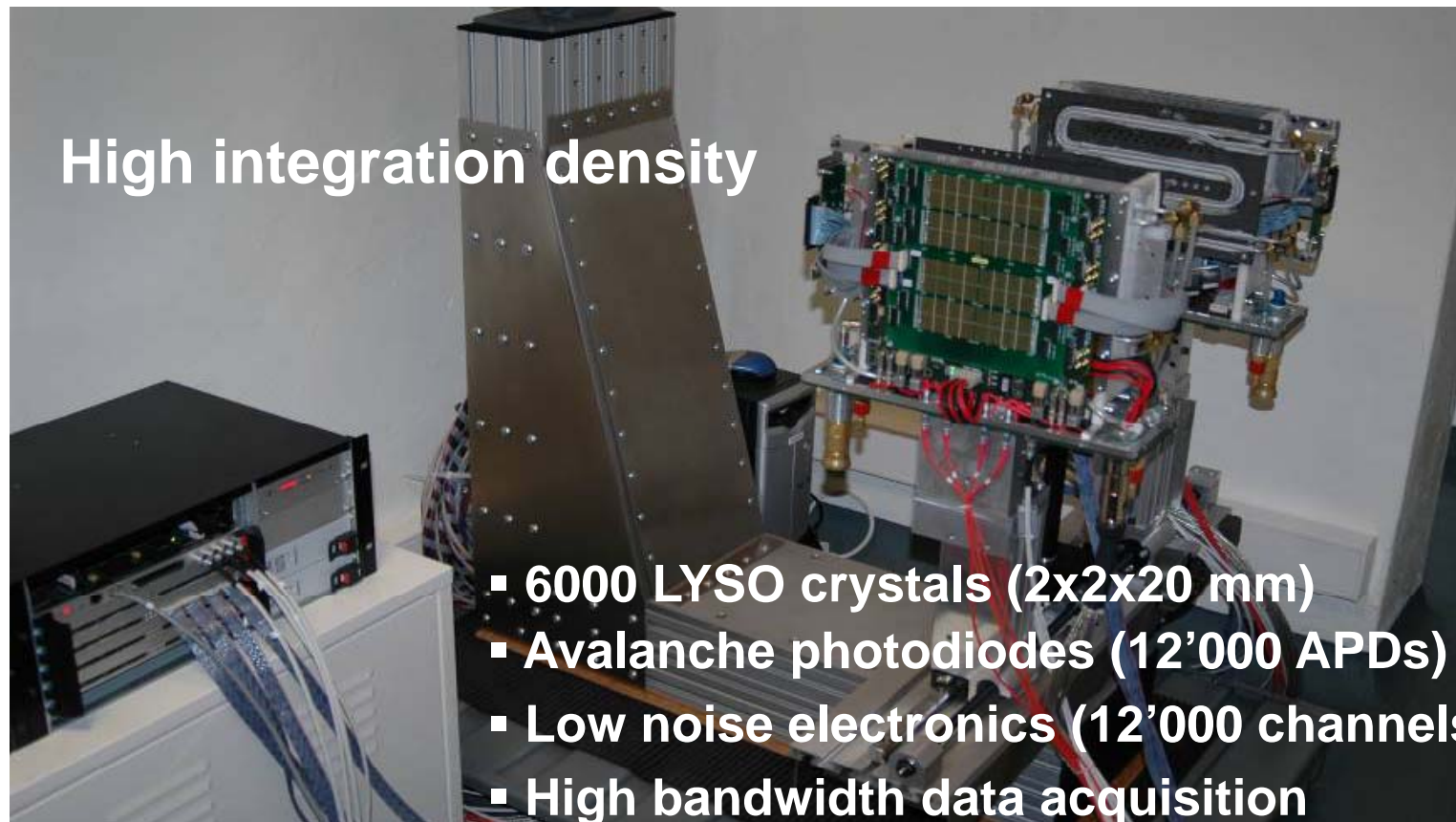
Highly integrated readout system

Compact technology immune to magnetic fields

5 years development; 4.5 M€ investment

ClearPEM Detector

- Two detection plates
- 192 crystal matrices (8x4 crystals each)
- Front-back APD readout for DoI measurement



Detector Technology

20 mm long LYSO:Ce crystals

Crystal matrices

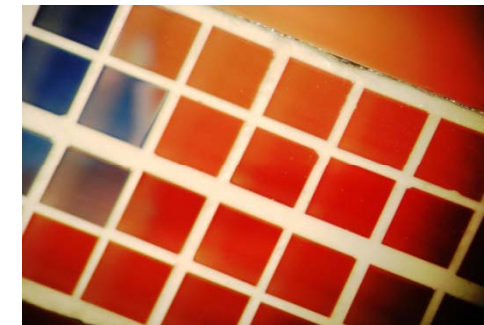
Avalanche Photo Diodes (APD)

Double readout mode

Depth-of-interaction (DOI) measurement



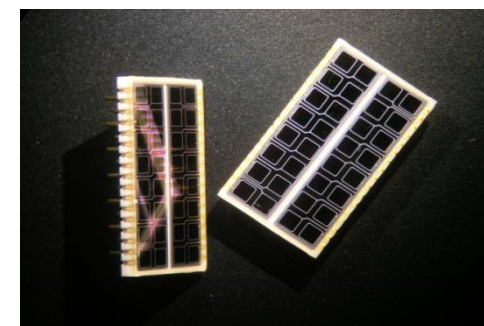
6144 crystals



Crystal matrices



192 detector modules



384 APD arrays

Frontend ASIC

State of the art detector frontend electronics

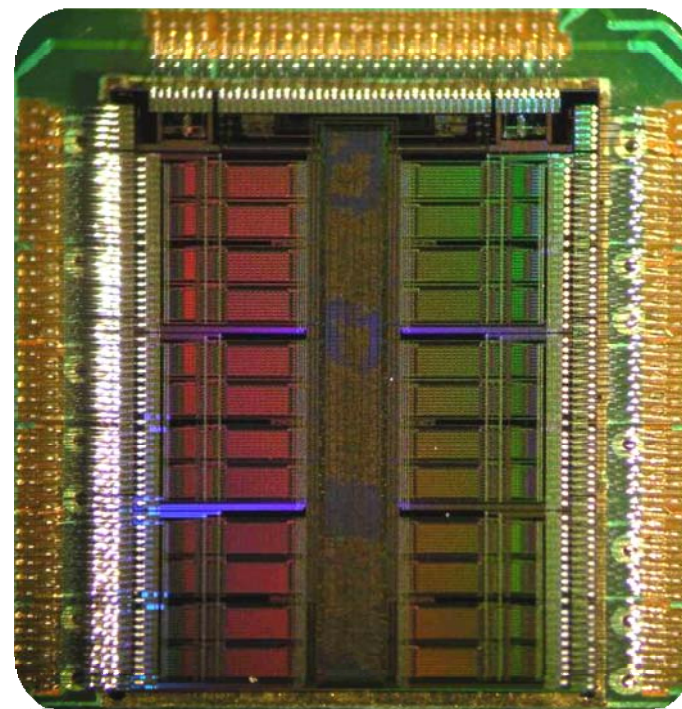
Very low noise amplifiers, analog memories and multiplexers

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

Largest number of input channels in a chip for APDs readout

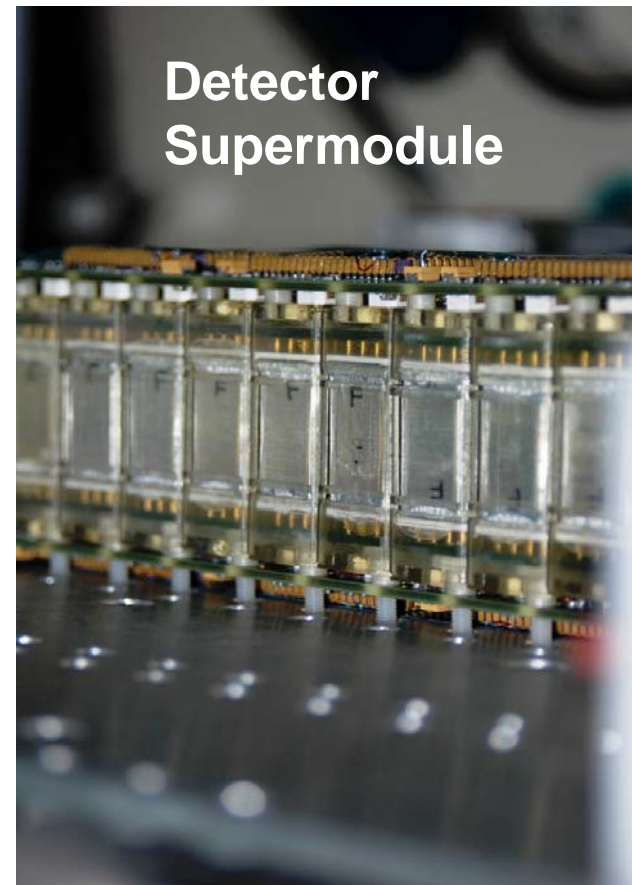
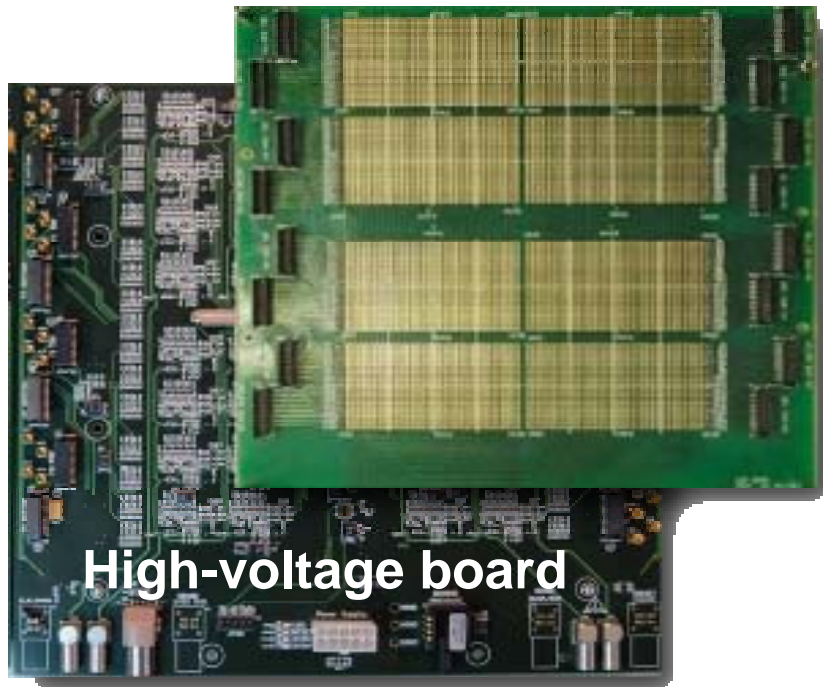


- Technology: CMOS 0.35 μm
- Chip area: 70 mm²

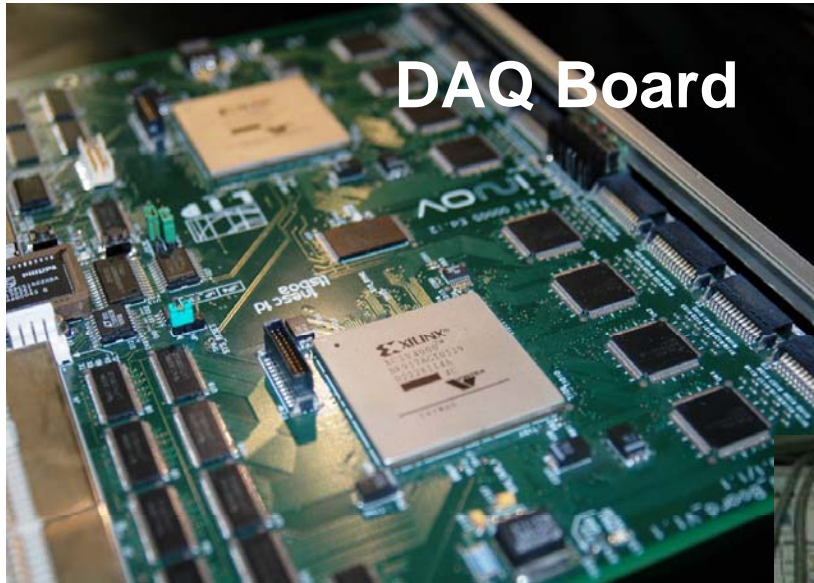
Frontend Electronics Integration

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

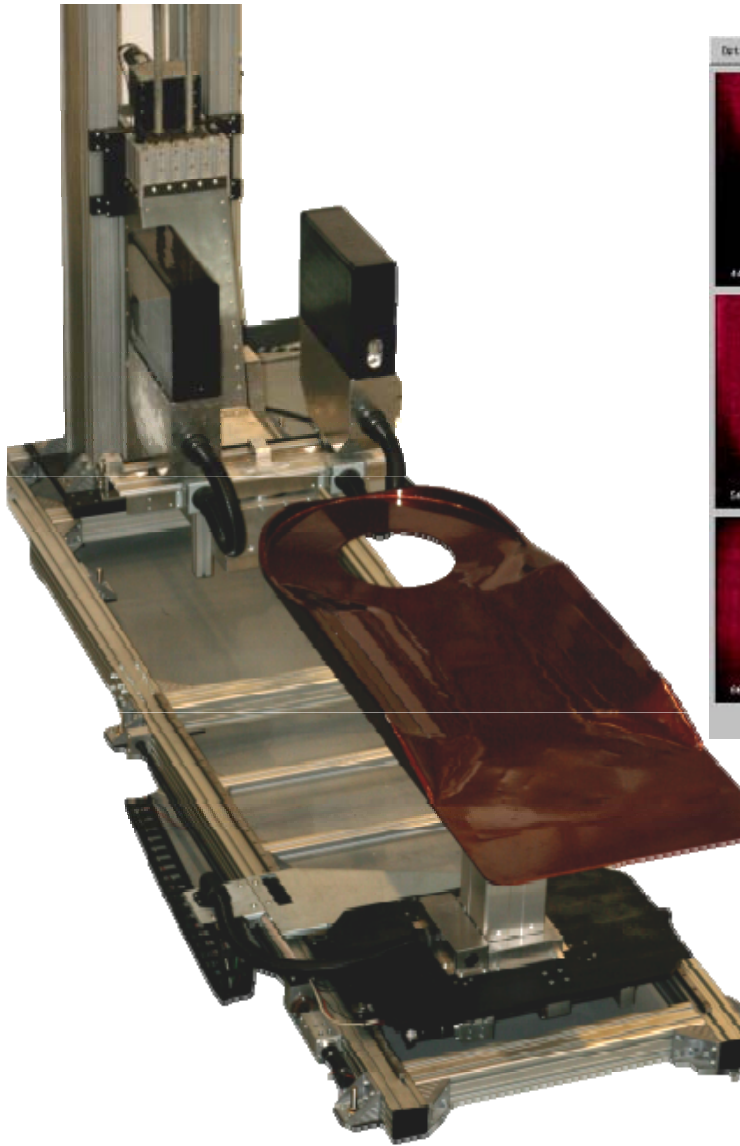


- CMS-like trigger and data acquisition system
- System is housed in a single crate with two dedicated buses



ClearPEM scanner

Operation, Monitoring, Reconstruction and Visualization Software



Options Save Image One Image

File: 12.cimg

46 47 91

Current Color Table:

Options Save Image One Image

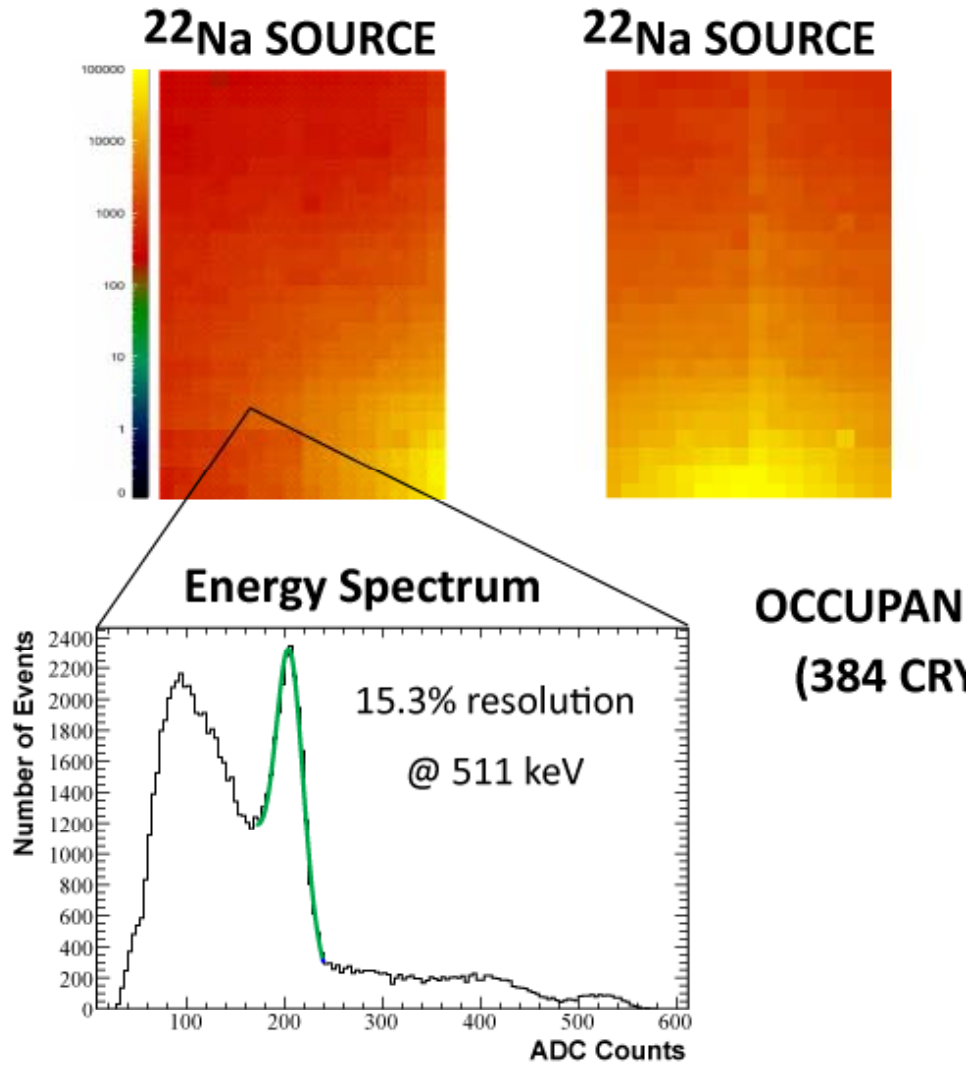
File: 2.cimg

50 50 64

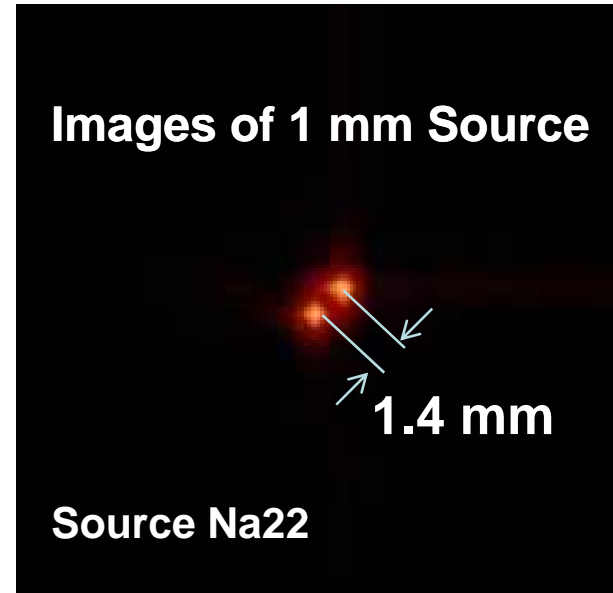
Current Color Table:

Scanner Performance

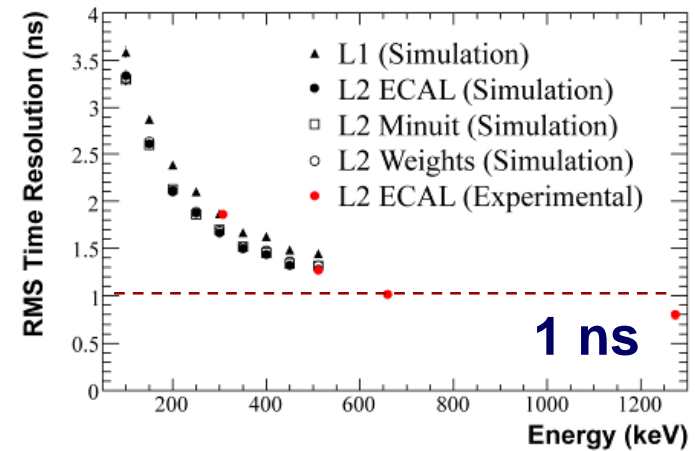
Detector occupancy maps



Images of 1 mm Source



Time resolution



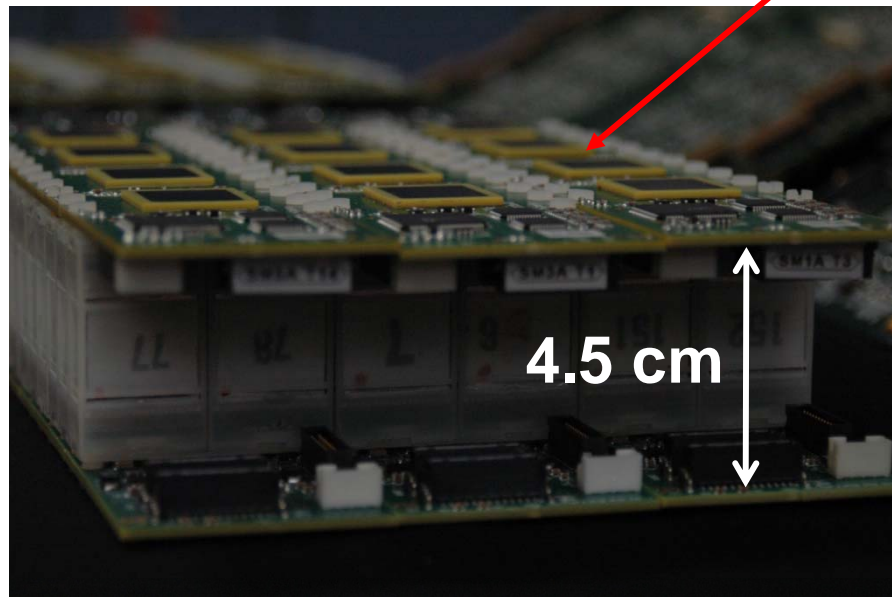
Our interests in FP7 PET-MRI project

Two sub-projects:

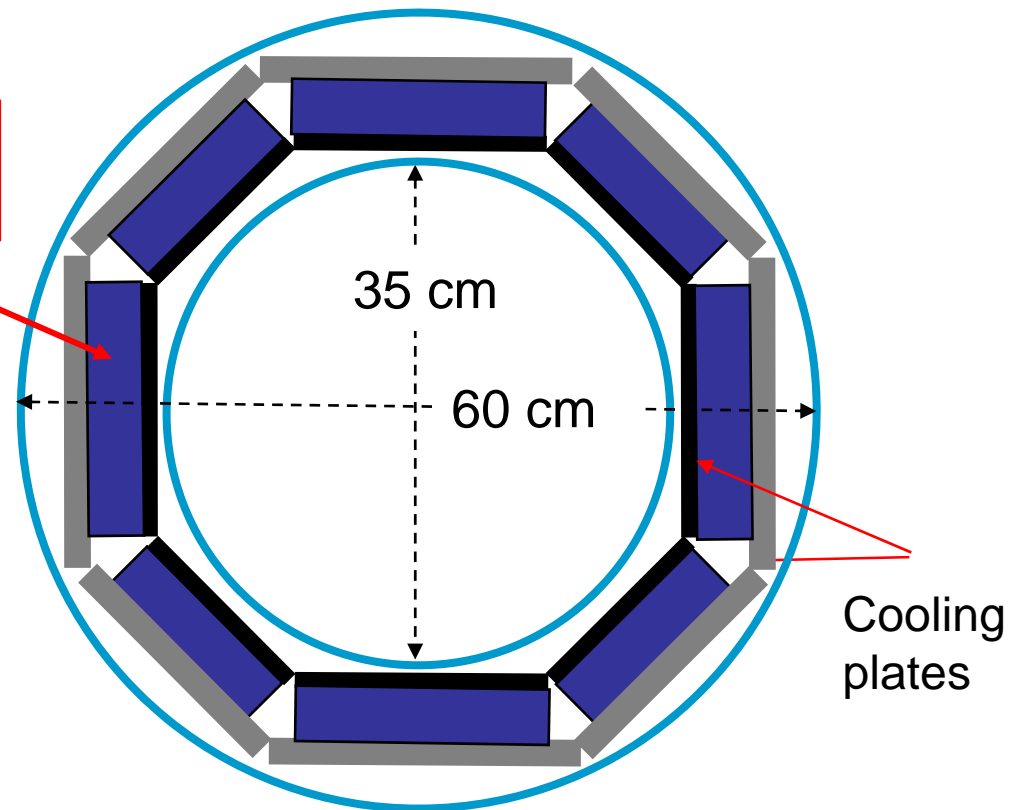
- ❑ Construction and evaluation of PET insert for brain MRI, based on APDs
- ❑ R&D on readout and data acquisition for SiPM-based PET TOF

PET insert for brain MRI

Collaboration with EPFL – CIBM, Lausanne, Suisse
Professor Rolf Gruetter.



Detector modules



PET insert for brain MRI

Sub-project :

- Based on ClearPEM technology (IP protected)
- Technology upgrade for MRI-PET e.m. compatibility
- Development of full prototype:
 - Time scale ~1-2 year; bare cost ~1M€; development costs ~2M€
- Integration with MRI system in collaboration with CIBM/EPFL, Lausanne
- Other collaborators:
 - MRI-PET e.m. compatibility and magnetic transparent PET gantry
 - PET-MRI image fusion software
 - Evaluation of PET-MRI imaging

Justification:

- APD-based technology for PET-MRI not mature (no commercial machines available).
- One single prototype brain PET/MRI developed so far (Siemens)
- ClearPEM technology has better resolution:
 - individual crystal-channel coupling, DoI capability 2mm
- Full prototype in time for PET-MRI imaging evaluation within the project

SiPM-based PET technology MRI compatible

SiPM technologies and detector configuration for PET-MRI with TOF capabilities

Sub-project

- Readout ASIC and data acquisition system for SiPM with time measurement (time scale ~3 years)
- Technologies scalable to full whole-body scanner
- Development of a small scale lab demonstrator within the project
- Collaboration with CERN in ASIC development

Justification:

- TOF with 100 ps resolution for brain and whole-body imaging: large gains in sensitivity
- Compatibility with MRI

PET-MRI imaging evaluation in a follow-up project.