Activities at TagusLIP

Tahereh Niknejad

PET: Positron Emission Tomography

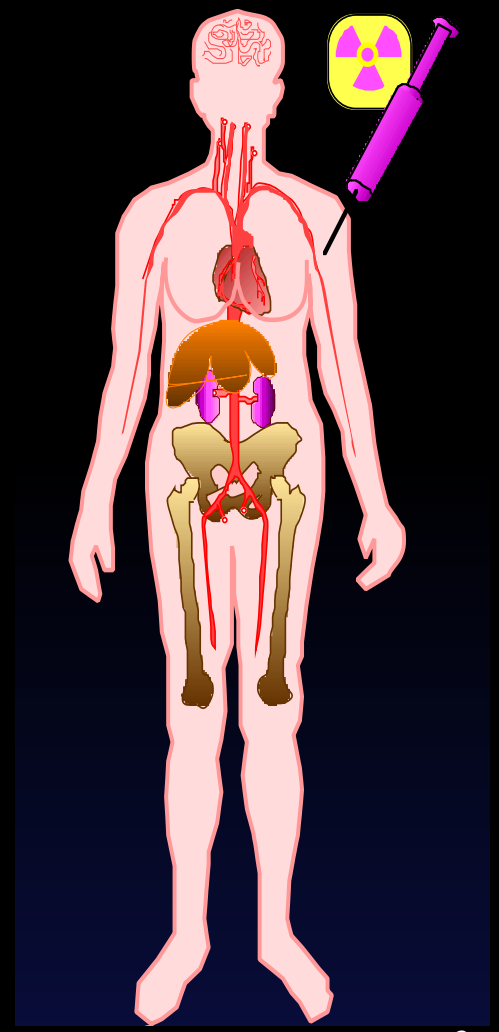
- How it works?

✓Drug (Glucose) is labeled with positron emitting radionuclide.

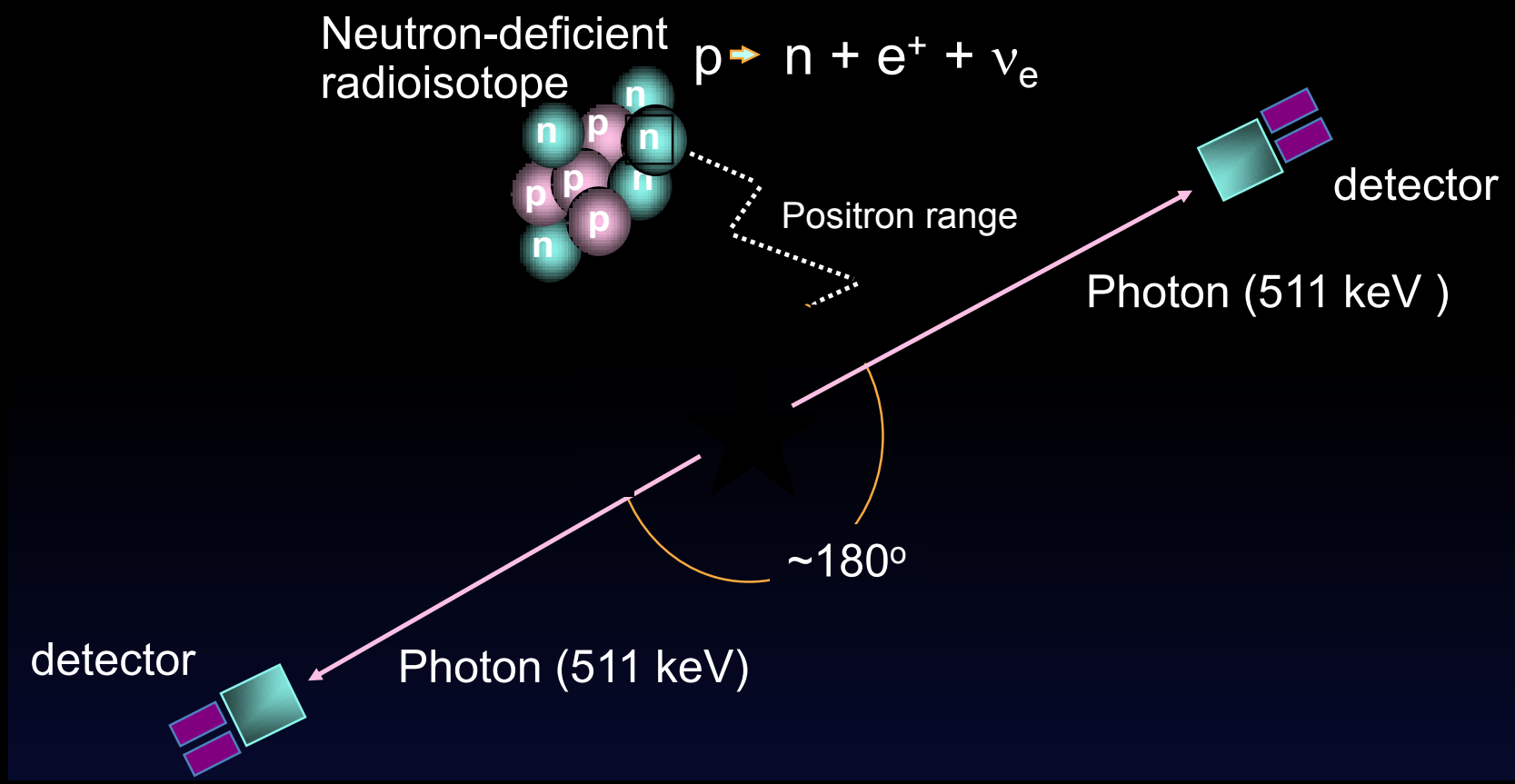
✓Glucose mainly concentrate in cancerous cells

✓Trace distribution of the drug in body

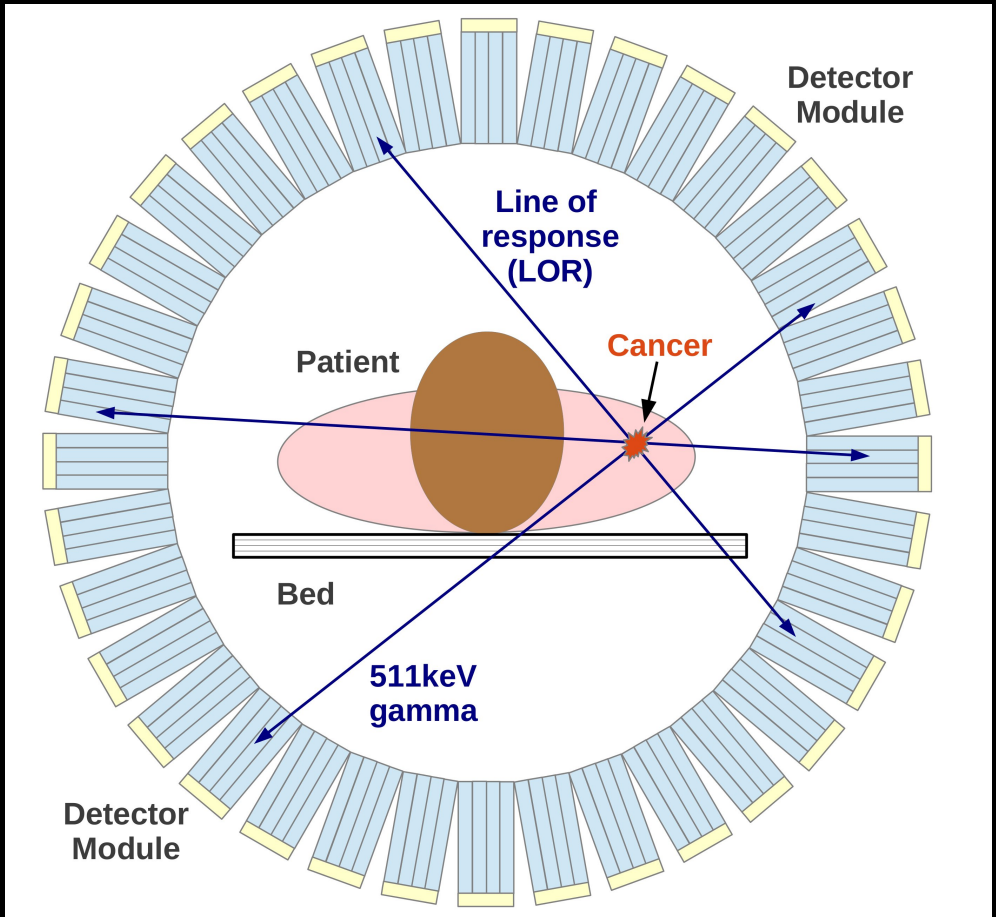
✓Radiation dose fairly small

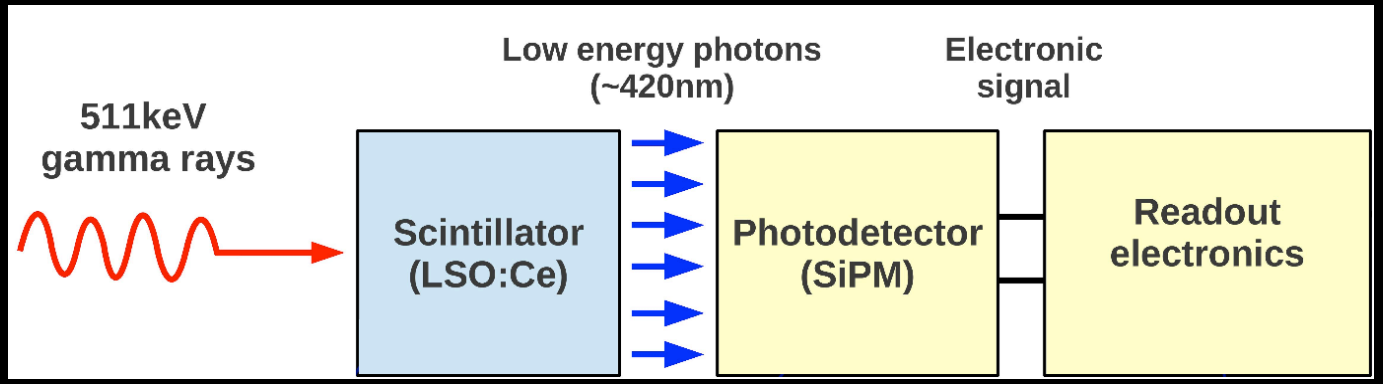


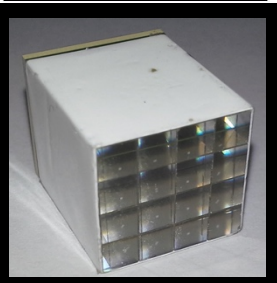
PET: detection

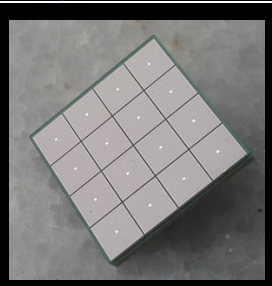


PET: Camera

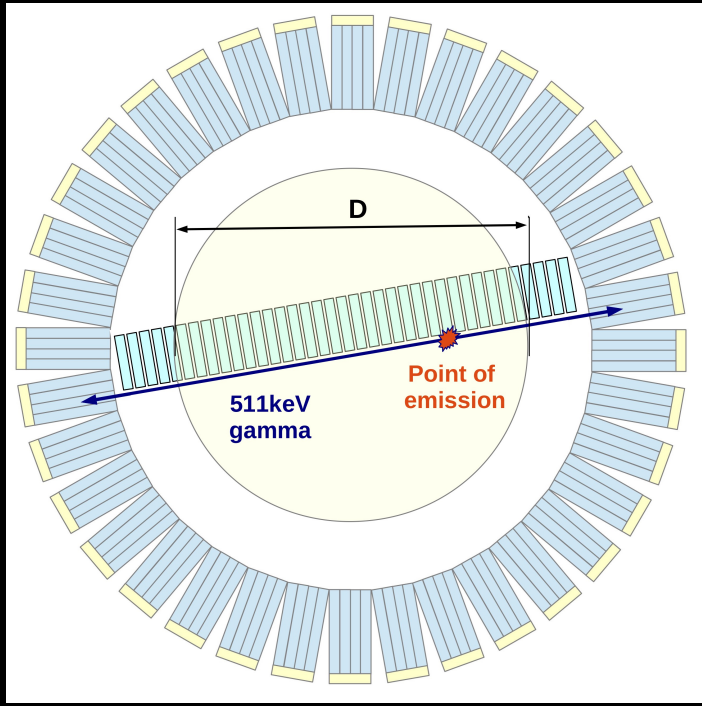

Detector Module
Line of response (LOR)
Patient
Cancer
Bed
511keV gamma
Detector Module


511keV gamma rays
Low energy photons (~420nm)
Electronic signal
Scintillator (LSO:Ce)
Photodetector (SiPM)
Readout electronics

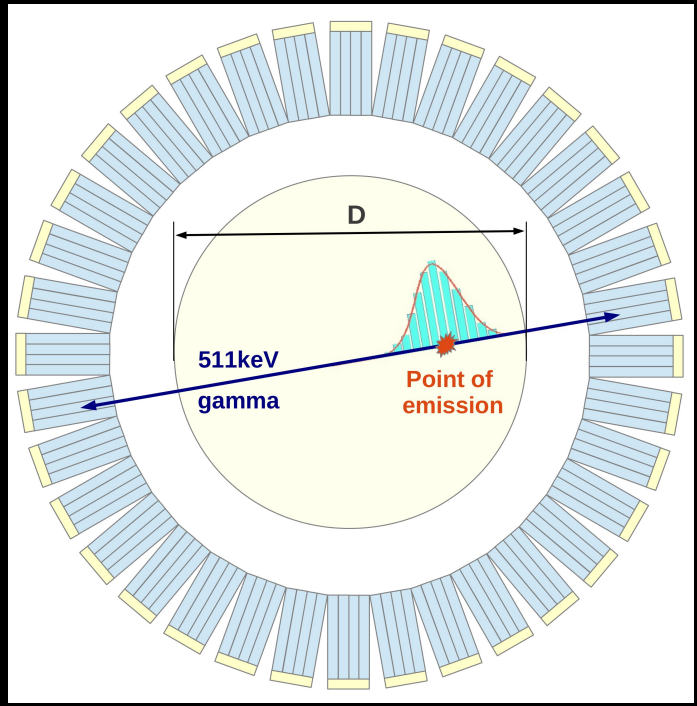




PET: Time of Flight (TOF)

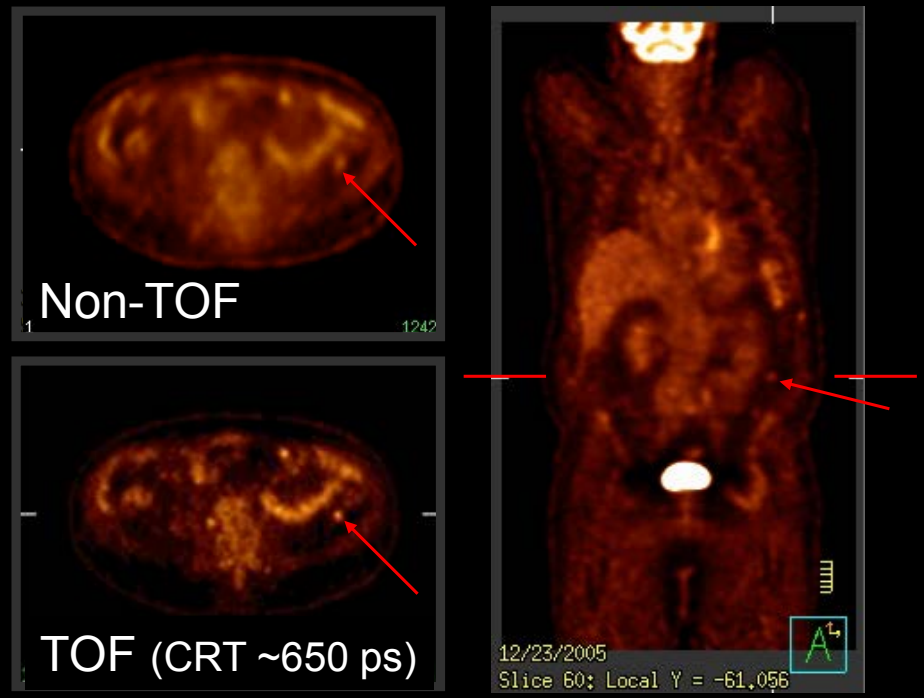


→ Without timing the positron emission could have happened anywhere along the line of response (LOR).



→ Time of flight can effectively confine the positron emission point.

→ Timing is determined by the full width at half maximum (FWHM) of the coincidence time resolution (CTR).

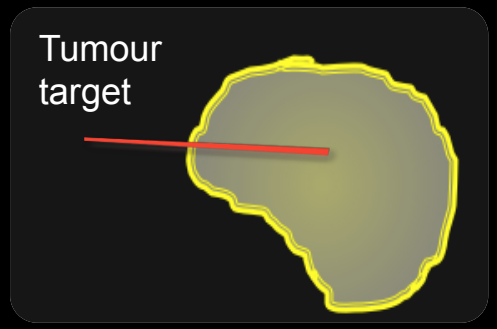


Colon cancer, left upper quadrant peritoneal node
13.4 mCi; 2 hr post-injection

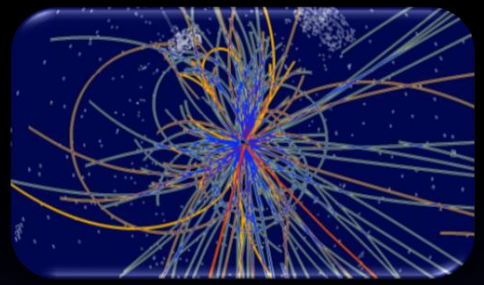
$$G = \frac{SNR_{TOF}}{SNR_{non\,TOF}} = \sqrt{\frac{2*D}{c*CTR}}$$

CERN Technology transfer

Accelerate particle beams



Hadron therapy



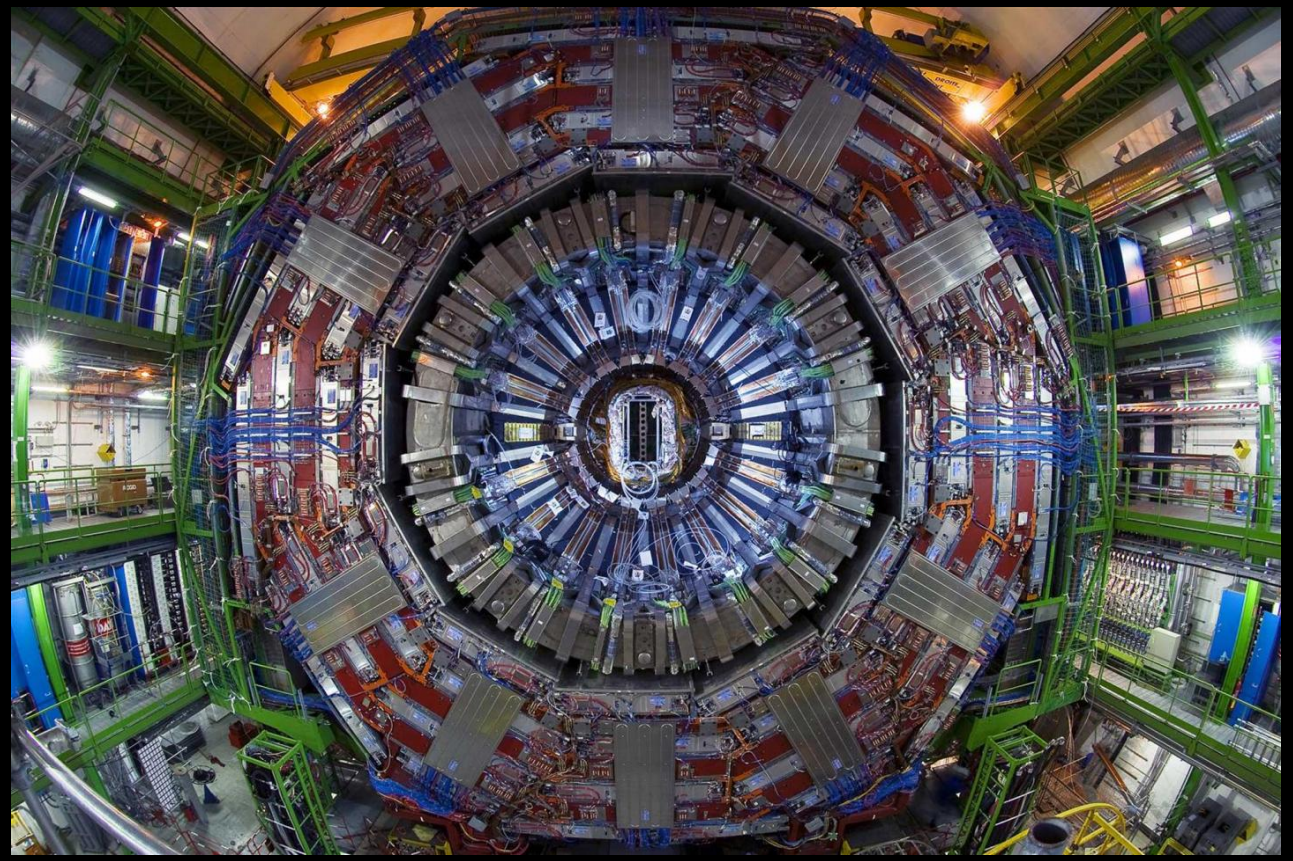
Detect particles

Medical imaging

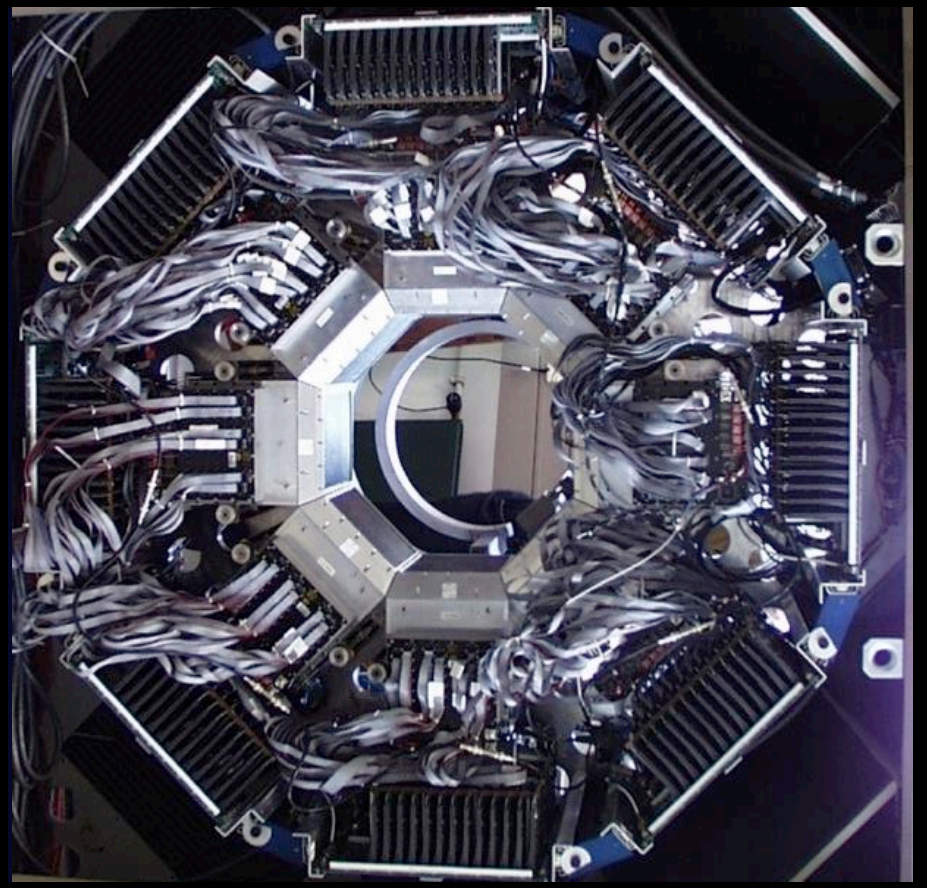
Large scale **Computing** (Grid)

Grid computing for medical data management and analysis

PET vs photon detection in High Energy Physics (HEP): same challenges



CMS



PET camera

From HEP to PET

Requirements for HEP crystal calorimeters

❖ **Crystals**
- High density (>6gr/cm^3)
- Fast emission (<100 ns, visible spectrum)
- Moderate to high light yield
- High radiation resistance

❖ **Photodetectors**
- Compact
- High quantum efficiency
- High stability

❖ **Readout electronics**
- Fast shaping
- Low noise

❖ **Software**
- Handling of high quality data

❖ **General design**
- Compact integration of a large number of channels (>>10’000)

Technology transfer

Requirements for PET scanners

❖ **Crystals**
- High density (>7gr/cm^3)
- Fast emission (<100 ns, visible spectrum)
- Moderate to high light yield
- High radiation resistance

❖ **Photodetectors**
- Compact
- High quantum efficiency
- High stability

❖ **Readout electronics**
- Fast shaping
- Low noise

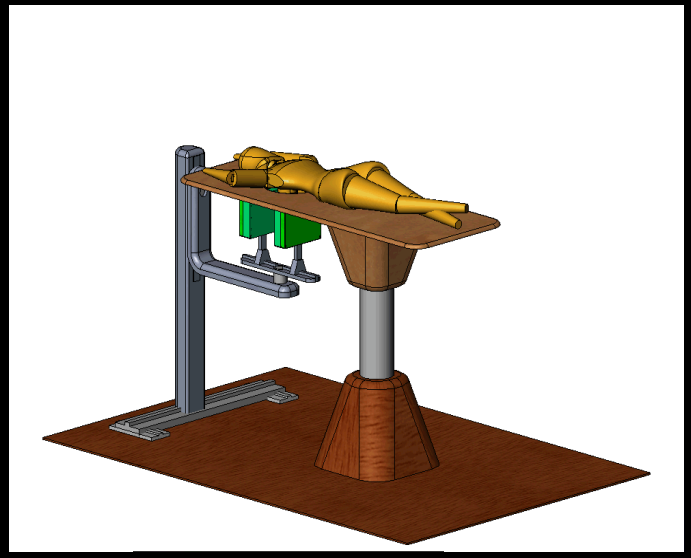
❖ **Software**
- Handling of high quality data

❖ **General design**
- Compact integration of a large number of channels (>>10’000)

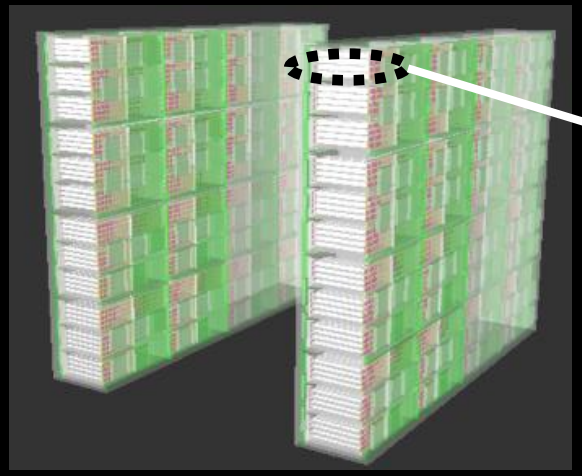
Tagus LIP activities

- Development and validation of medical imaging technologies (readout electronics and detector modules)
- Design, produce and test/validate prototype imaging equipment.
- Design of new ASICs and front-end boards for the CMS upgrade

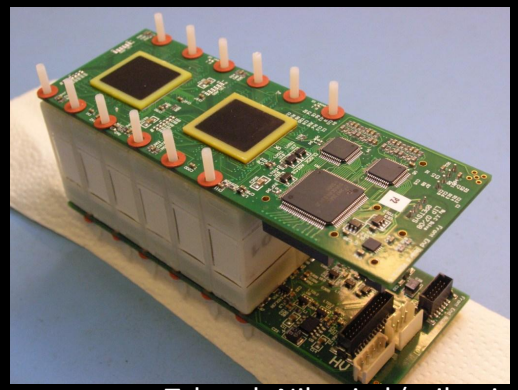
ClearPEM (2010)

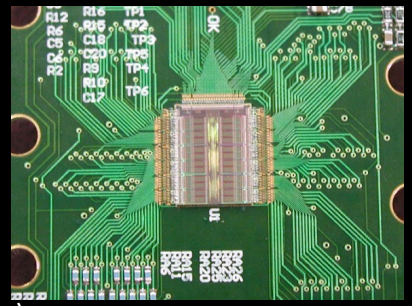


- PET detector dedicated to breast cancer screening
- Extremely sensitive to small tumor masses
- Spatial resolution1-2 mm
- High counting sensitivity

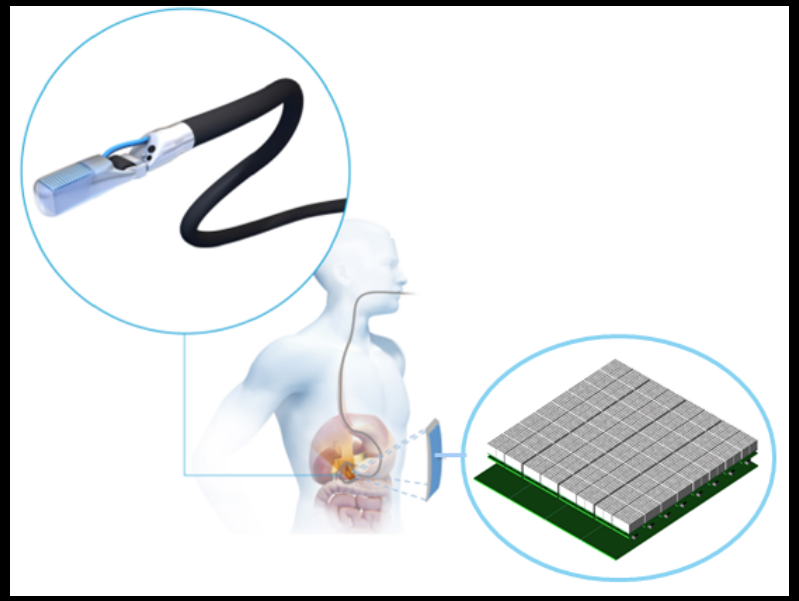


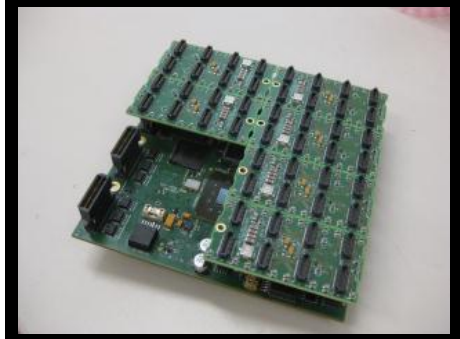
LYSO+APD



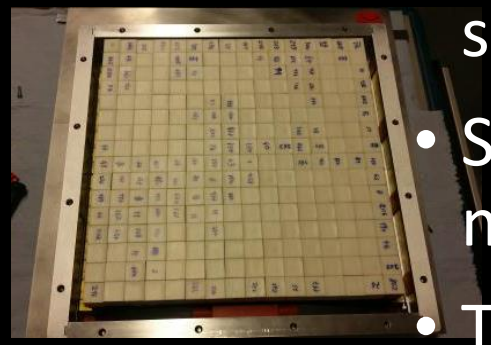


EndoTOFPET (2013)





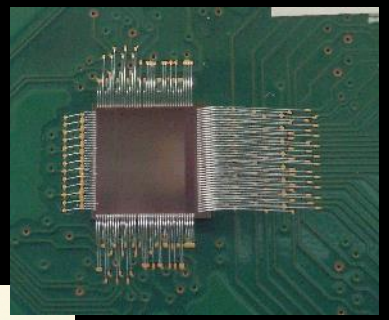
LYSO+SiPM

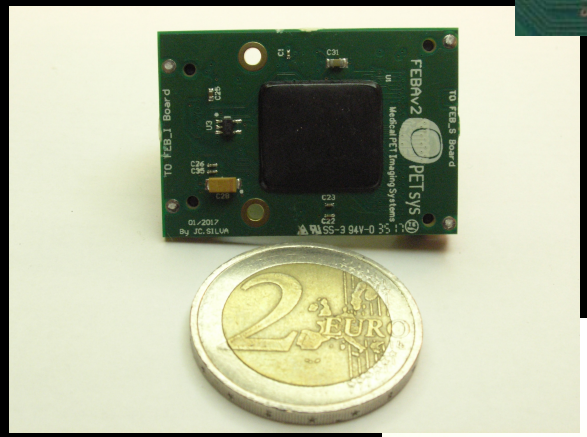


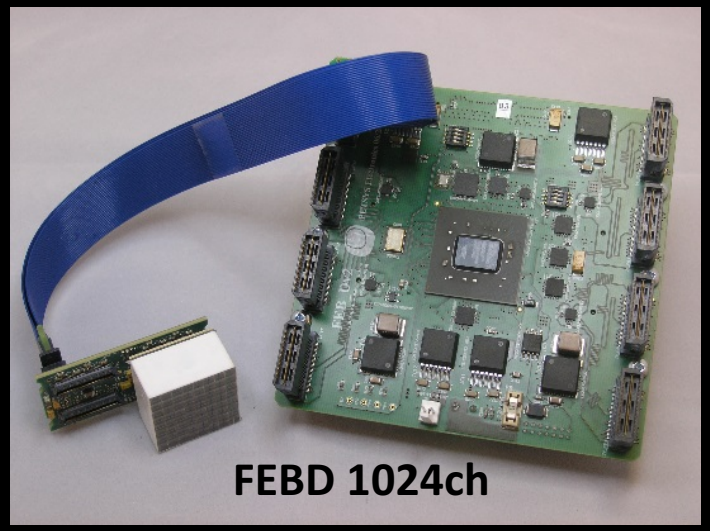
- PET detector dedicated to pancreatic cancer screening
- Spatial resolution ~1 mm
- Timing resolution ~350 ps FWHM
- High counting sensitivity

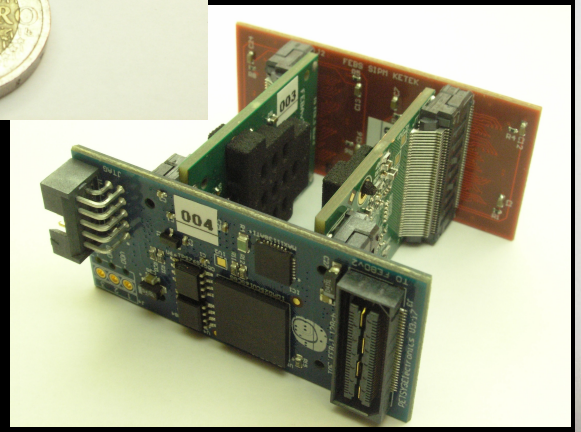
TOF ASIC for PET and HEP

64chASIC
(5x5mm)

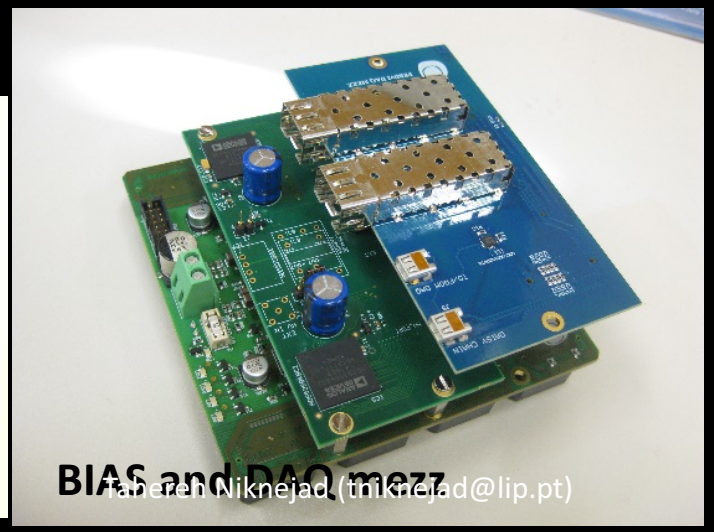




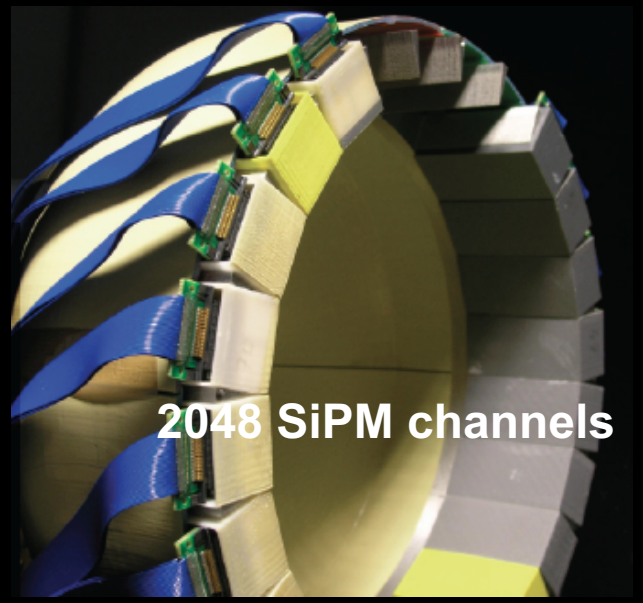




Front end
module
128ch



- Highly integrated readout electronics scalable to several hundreds of channels



ASIC for TOF applications

	PET	HEP
TOFPET1	✓	✓
TOFPET2	✓	✓
TOFEE (CT-PPS)		✓
TIGER (BES III)		✓
TOFHiR (CMS: BTL)		✓

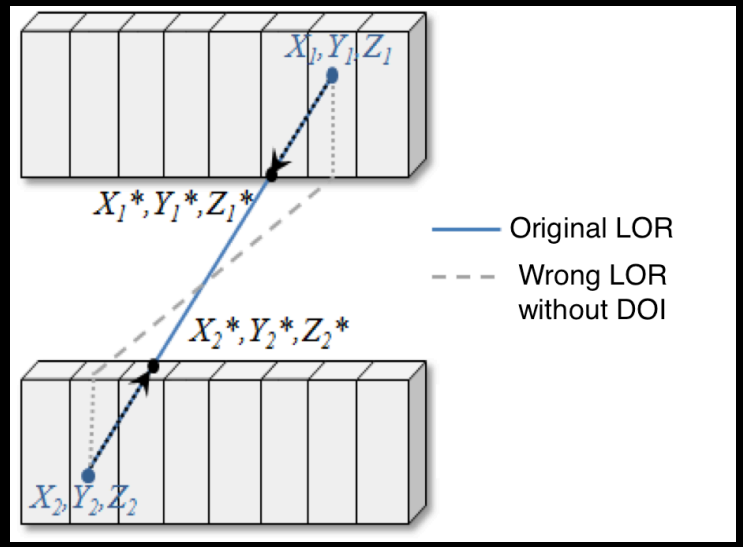
Thank you for you attention

Any question?

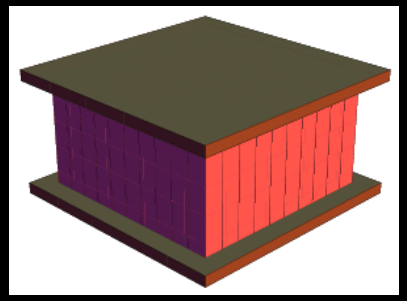
Backup slides

Depth of interaction

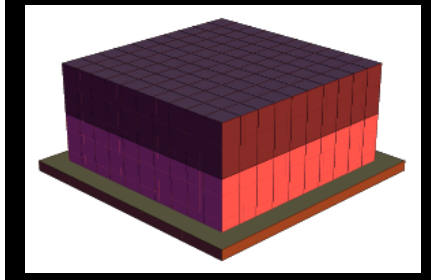
→ **Without DOI wrong LORs are assigned to the events**



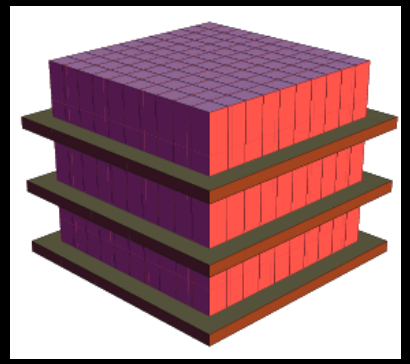
→ **Depth-of-interaction determination**



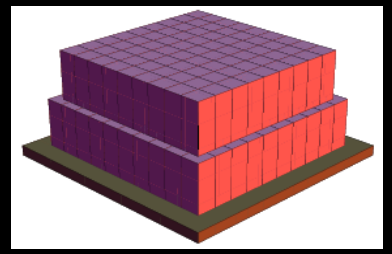
Dual Ended Readout



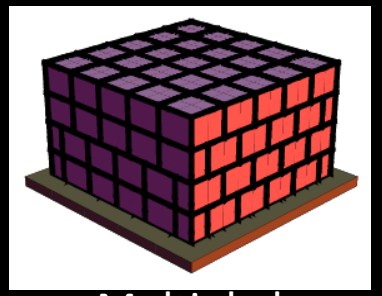
Phoswich



Stacked Detector



dual Layer with Offset



Multiple layer with offset

→ **Drawbacks: Complexity and costs**

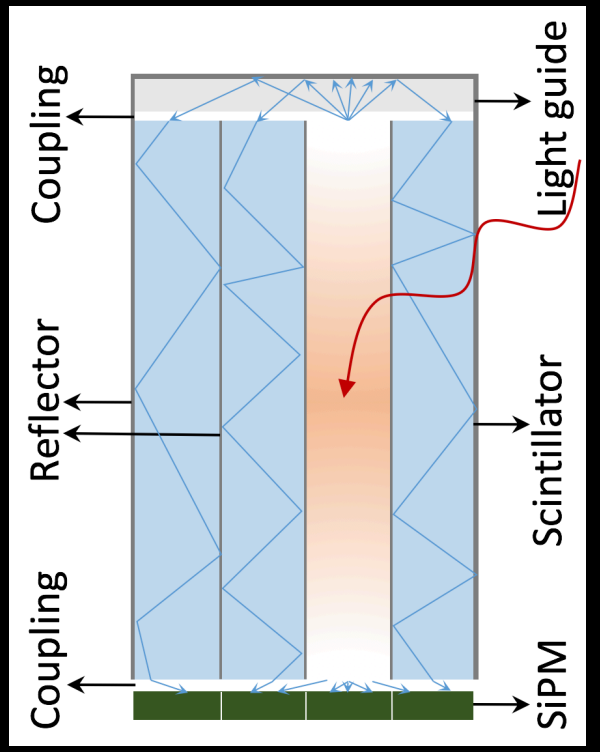
New method for DOI

→Only one side readout

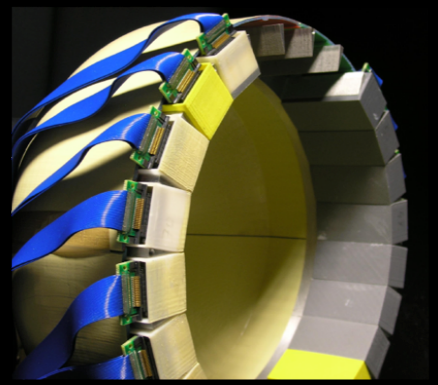
→A light guide is placed on the top of the module (same dimension of the matrix).

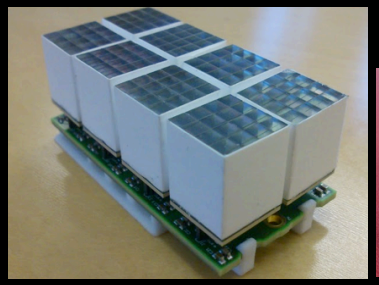
→The reflector recirculates the light and redirects it to the MPPC array.

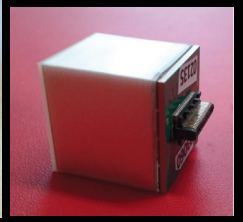
→Optical treatment of the lateral surfaces of the crystals: depolished

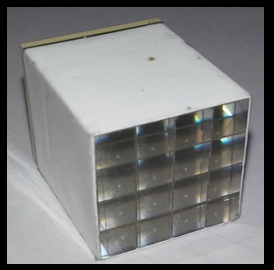


Design and fabrication of TOF-PET demonstrator





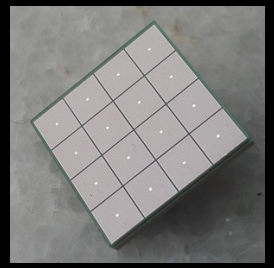


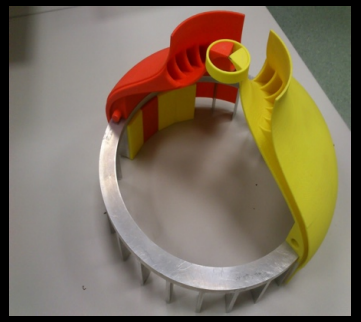


→ **16 Detector Modules (8 on each side)**
- Ring diameter: 235 mm

→ **Each module 2x4 array of crystal**

→ **LYSO crystal block**
- Array of 4x4 LYSO
- Pixel size 3x3x15 mm^3
- Separated by Vikuiti foils
- Pitch 3.2 mm





→ **SiPM from Hamamtsu**
- Active area 3x3 mm^2
- Array of 4x4

→ **Using cooling system: ~19°C**