Study of Inorganic Scintillators for Medical Applications

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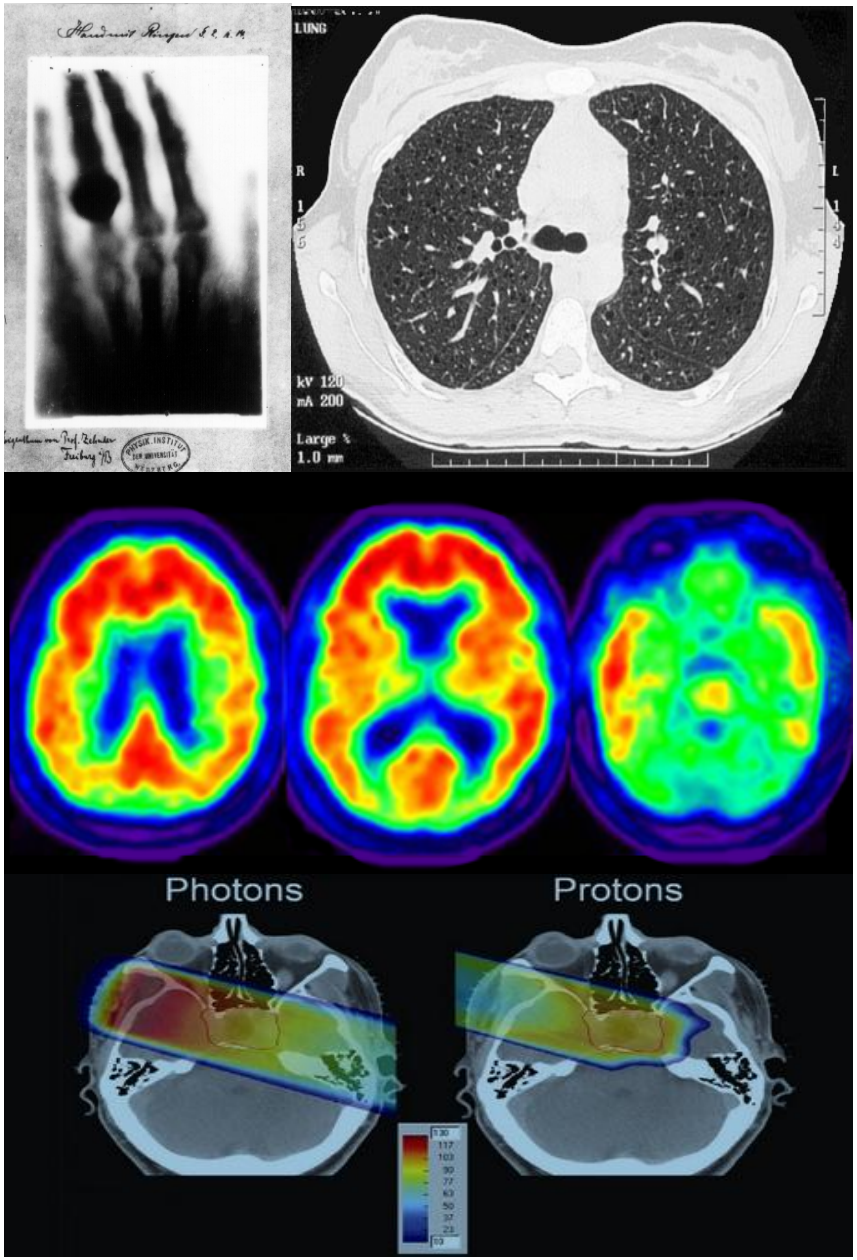
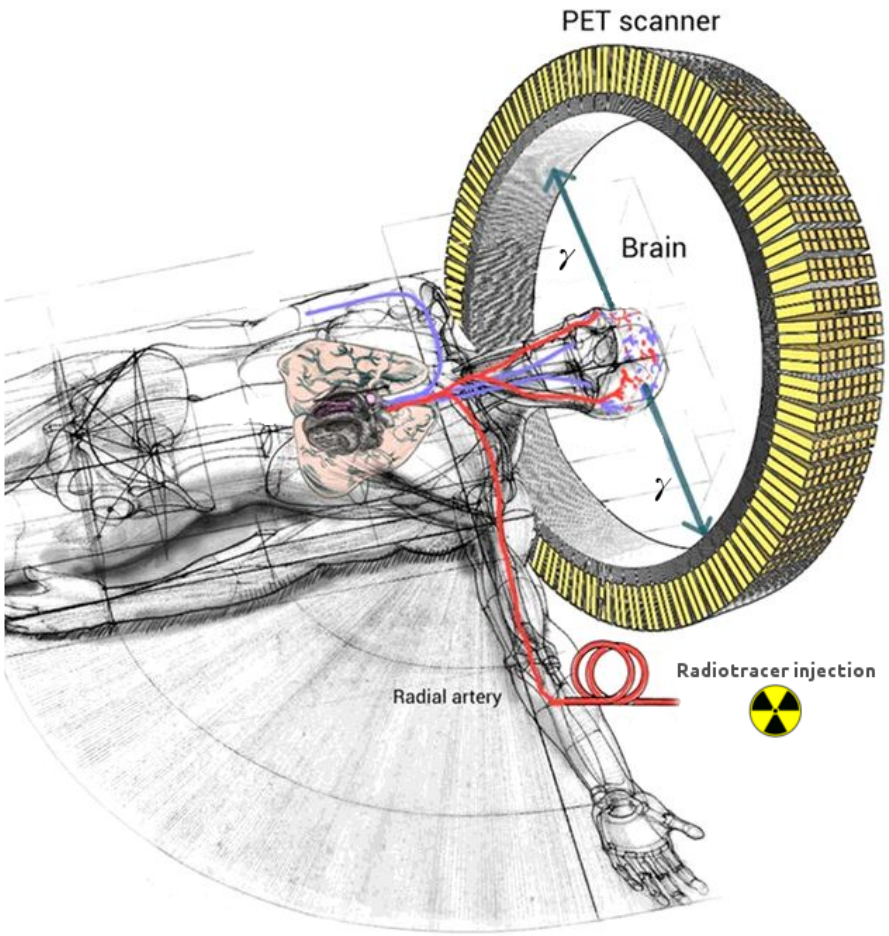
Medical Physics



Medical Physics ➔Medicine and Healthcare

- Diagnosis (TAC,PET,SPECT,MRI)
- Treatments (Radiotherapy, Hadrontherapy)

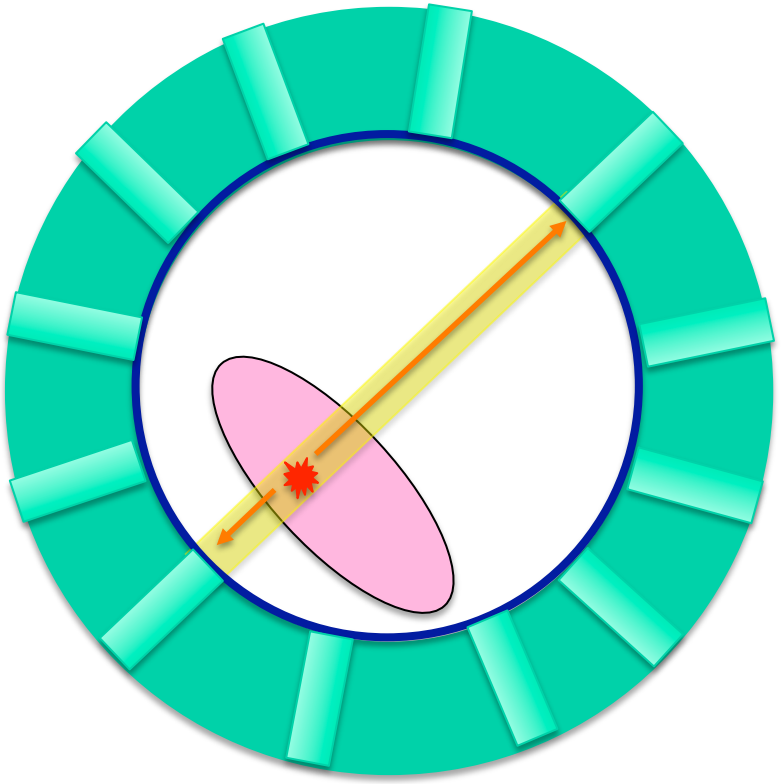
Positron Emission Tomography



- Radiotracer labeled with a positron emitter (^{18}F-FDG).
- Production of two back-to-back gammas (511 keV) due to the annihilation of the emitted positron
- Detection of the two gamma in coincidence using a scintillator detector

Tomography Reconstruction

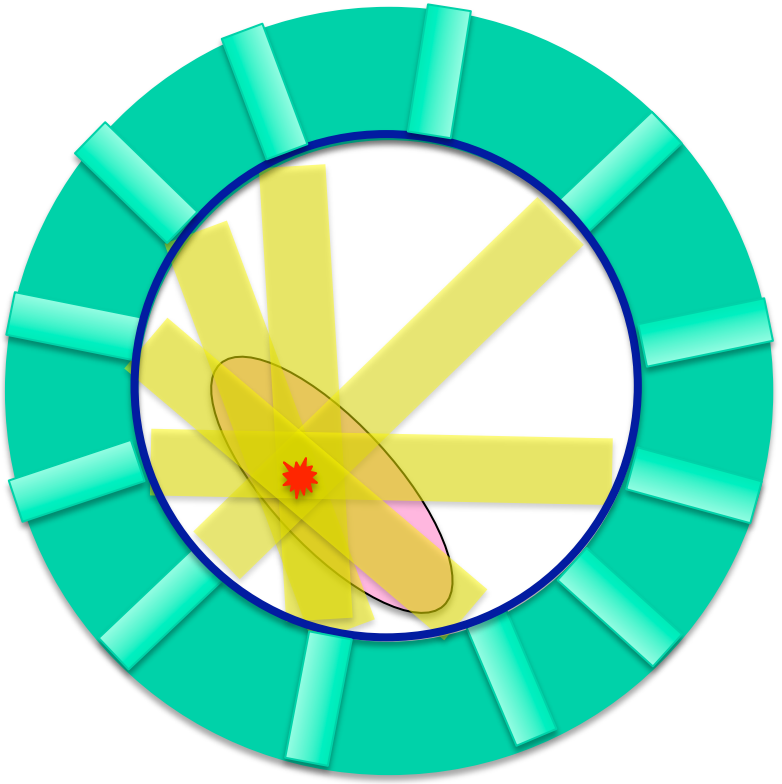
- The detection of the two back-to-back gammas identifies a Line of Response (LOR)



Ricostruzione Tomografica

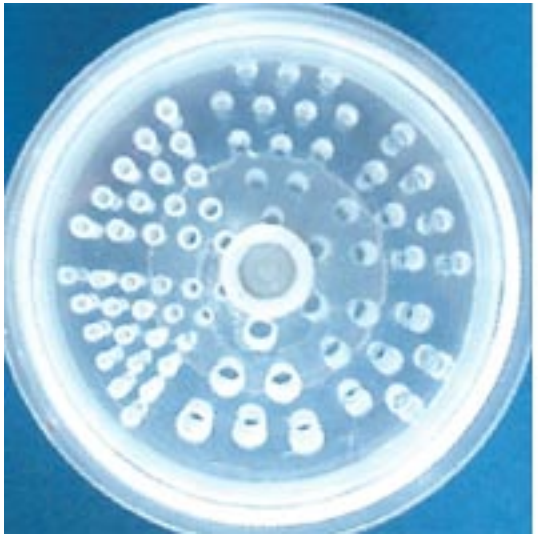
- The detection of the two back-to-back gammas identifies a Line of Response (LOR)

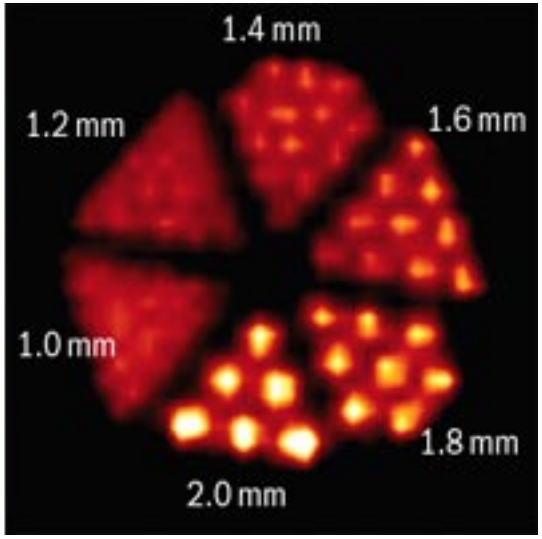
- Thanks to Tomography Algorithm, it is possible to use lots of LORs to obtain the radiotracer density in the patient body.



Spatial Resolution

The Spatial Resolution is the measure of the PET system ability to reproduce the metabolic image. It is defined as the minimum distance between two points in an image that can be detected.



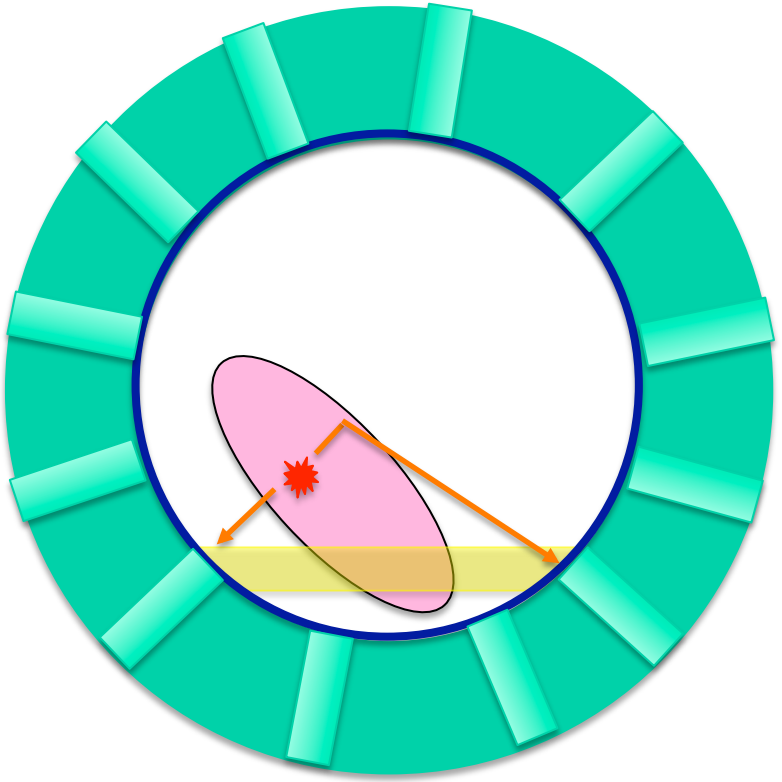


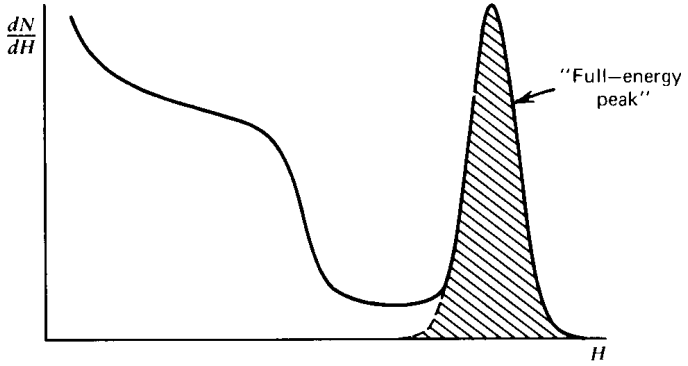
Energy Resolution

Compton Scattering Events

➔ Reconstruction of a wrong LOR

High Energy Resolution to discriminate this kind of events



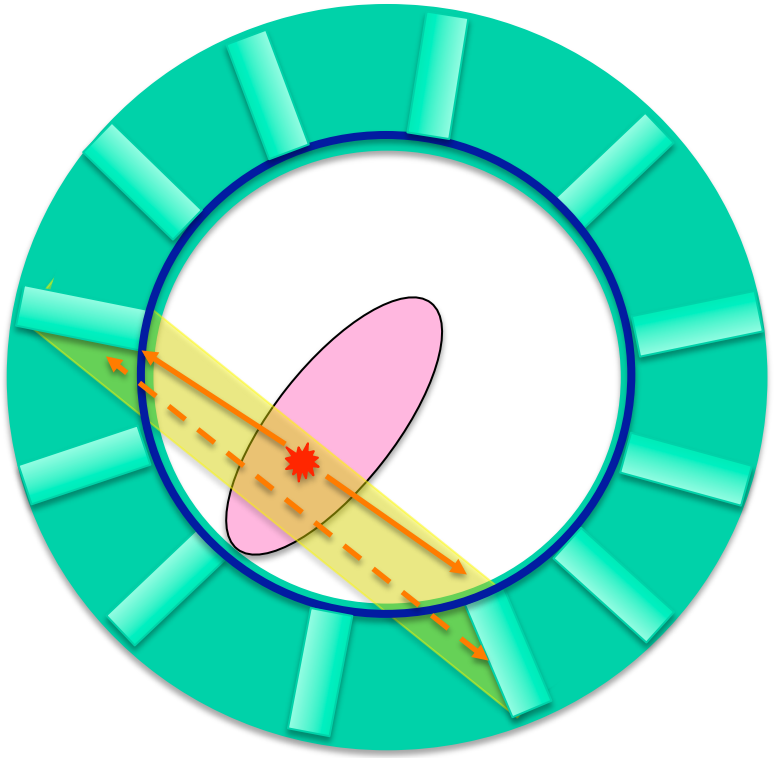


Depth Of Interaction

The Gamma interaction can take place along all the crystal lenght

➔ Parallax error and decreasing of the spatial resolution

The Depth of Interaction (DOI) information is needed



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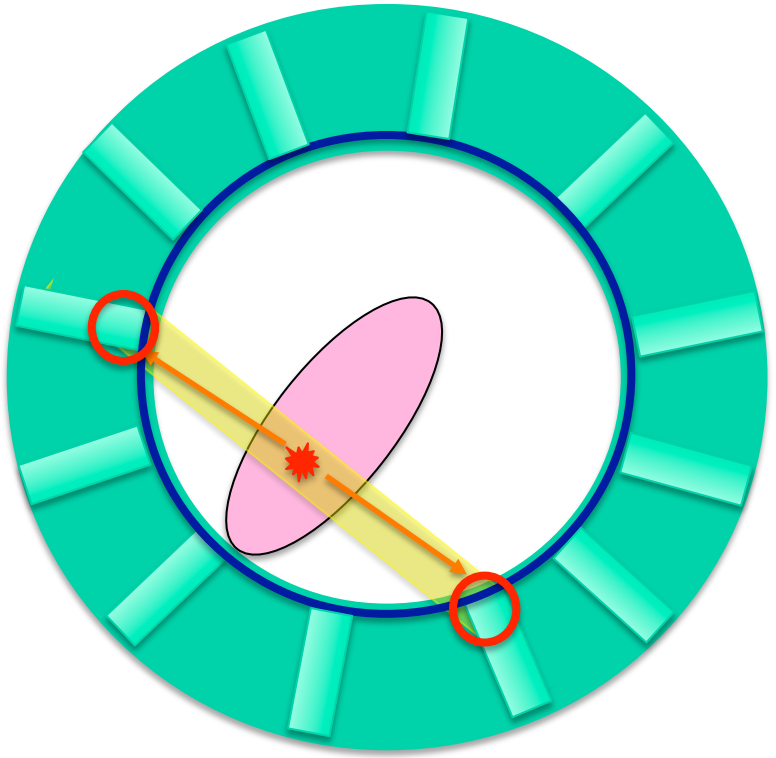
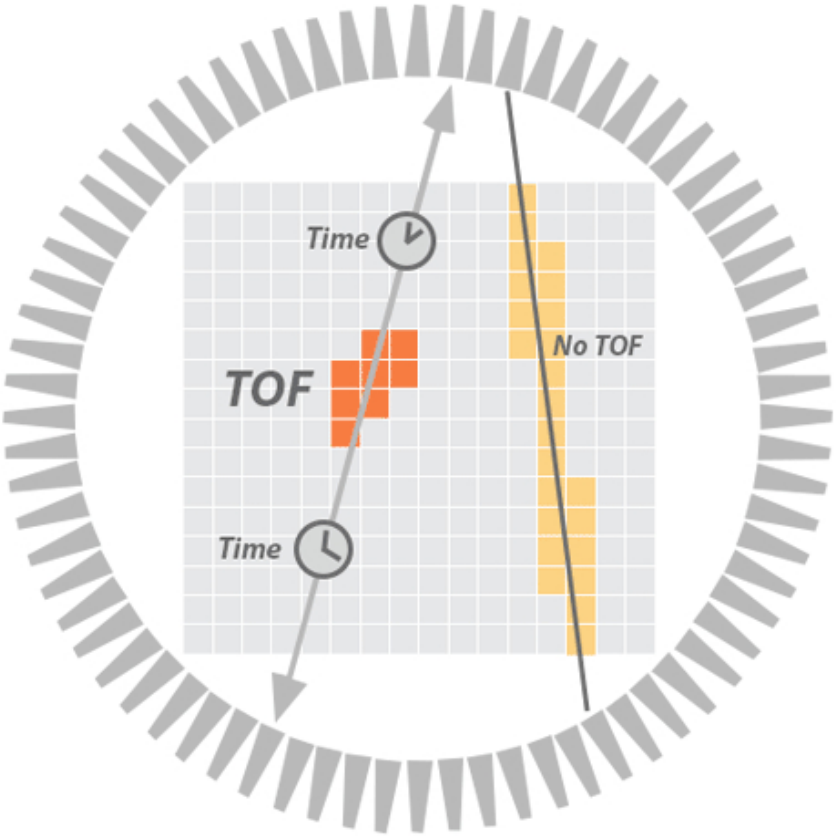


Coincidence Time Resulution

Time-Of-Flight PET

Knowing the arrival time of the two gammas, it is possible to increase the signal to noise ratio and decrease the region where the annihilation took place



➔Fast detector

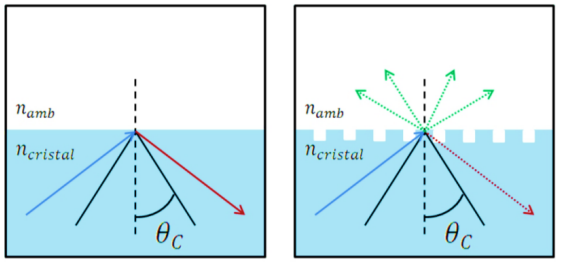
$$CTR = 2.36 \times t_{1st}\sqrt{2}$$

$$t_{1st} \propto \sqrt{\frac{\tau_{fall} \cdot \tau_{rise}}{N_{firing}}}$$

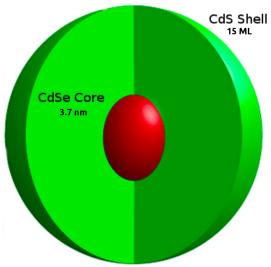
La Fisica Medica @ UNIMIB

The research work of the Unimib Medical Physics group is divided in three main fields:

- Photonic Crystals



- Nanocrystals



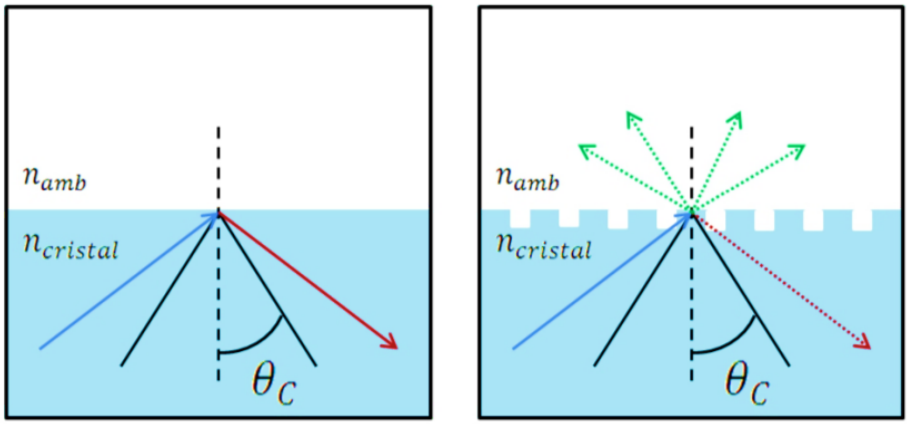
- Development of a high resolution module for the ClearPEM scanner

Photonic Crystals

Increase the number of photons extracted from the crystal

➔ Higher energy resolution

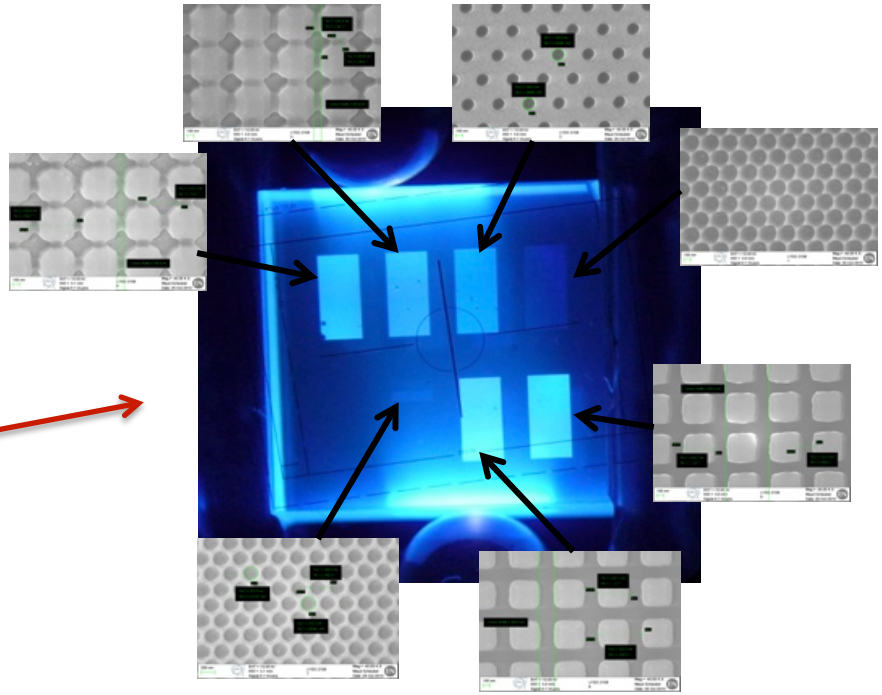
➔ Better CTR



Snell's law

$$n_1 \bullet \sin \vartheta_1 = n_2 \bullet \mathrm{sen}\vartheta_2$$

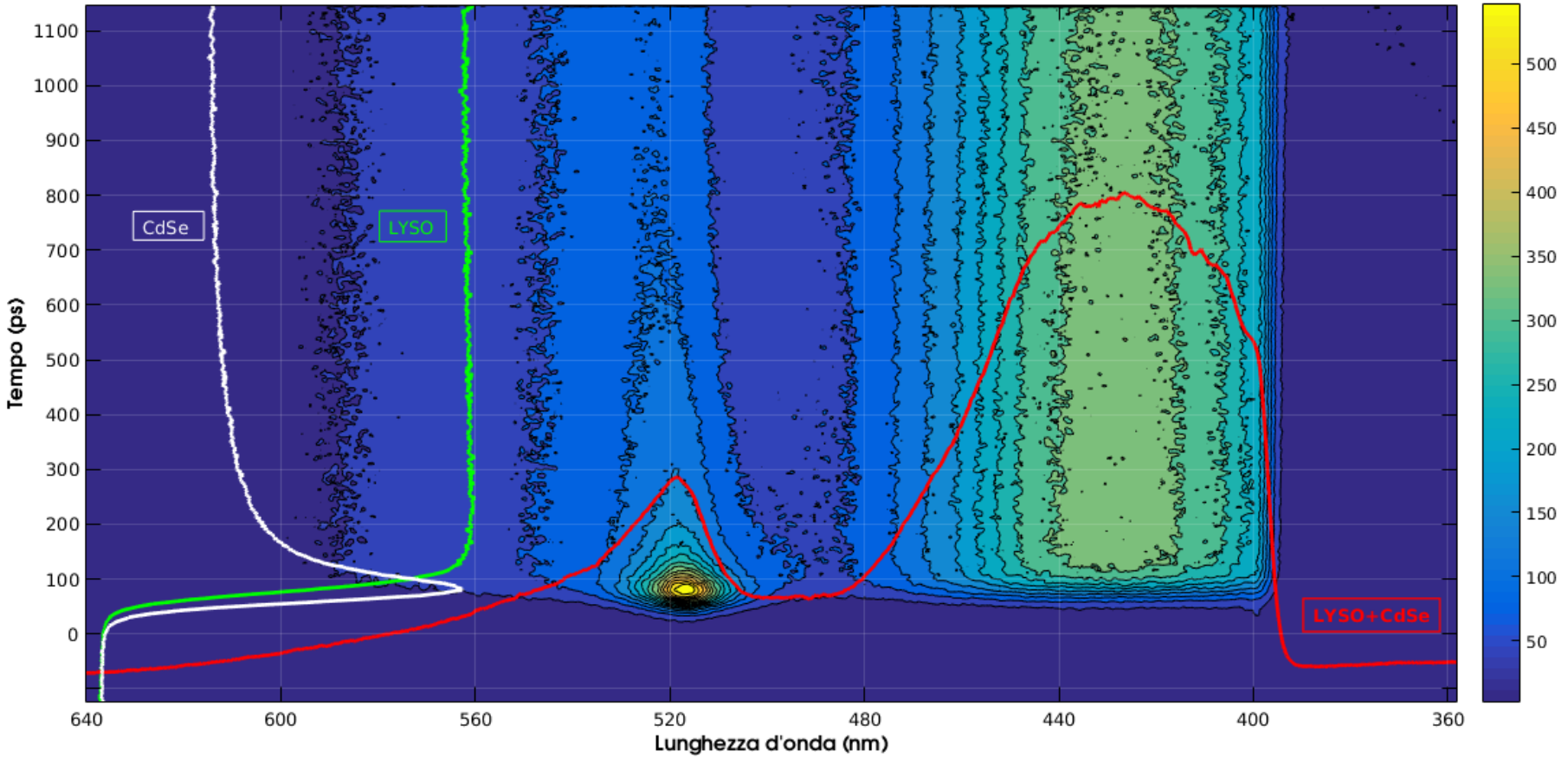
Different pattern available



Nanocrystals

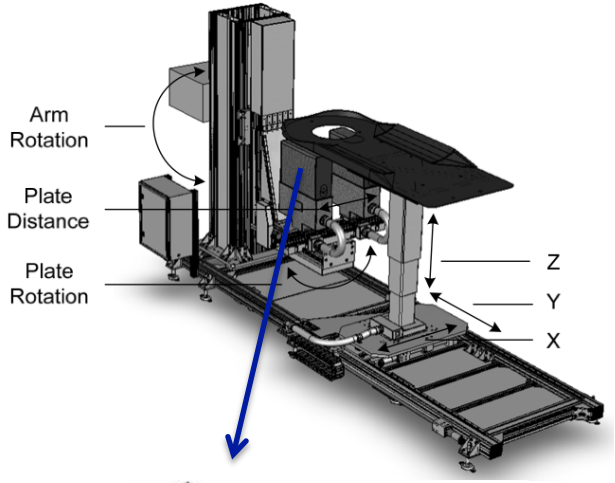
Smaller rise time and decay time of the scintillating pulse.

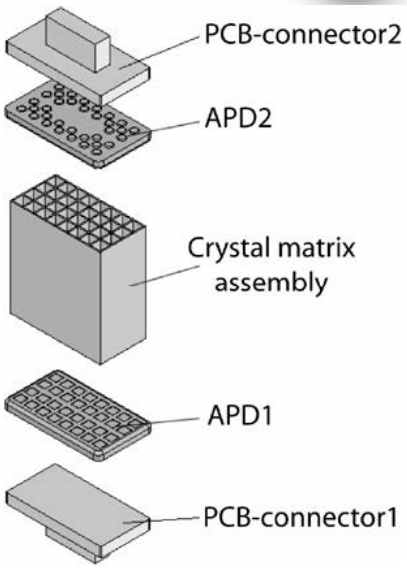
➔Better CTR



ClearPEM

Scanner PET for the diagnosis of the breast tumor. Two prototypes are actually installed at San Gerardo Hospital (Monza, IT) and at ICNAS (Coimbra,PT).

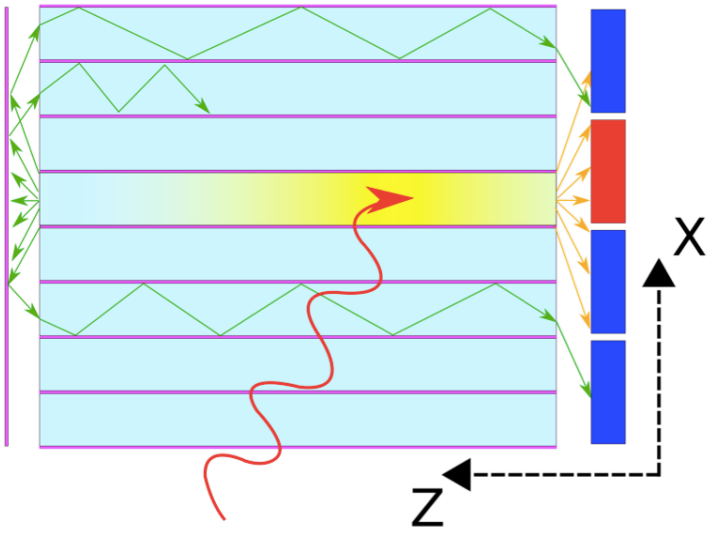




4x8 LYSO Crystals matrix read at the both sides by Avalanche Photodiodes (APD).

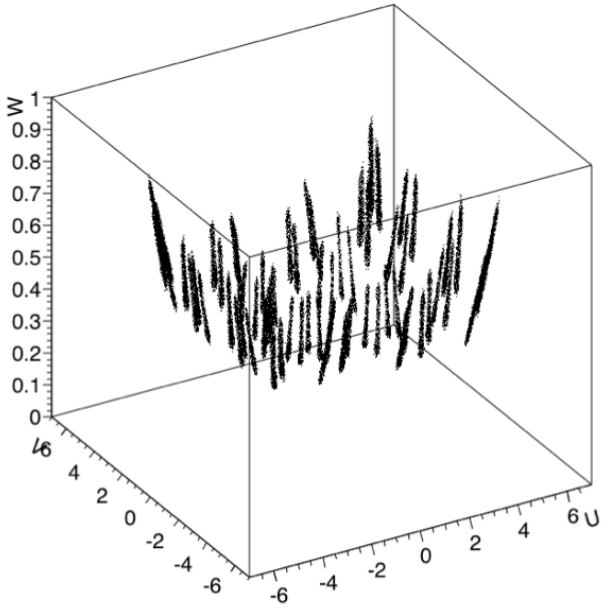
Development of a ClearPEM Module

8x8 LYSO crystals matrix read by a 4x4 MPPC array (only single side readout).



Development of a method to obtain the (x,y,z) impact point position:

- High Spatial Resolution
- Energy Resolution 12%
- DOI Resolution 3.5 mm (FWHM)



Conclusion

All these studies are performed in the frame of the Crystal Clear Collaboration at CERN Laboratories.

Final aim of the research work:

- Build a PET demonstrator
- Apply these technology to commercial PET scanners

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