Study of UT glasses for pixel identification performance in multi-anode PMT-based detectors for PET

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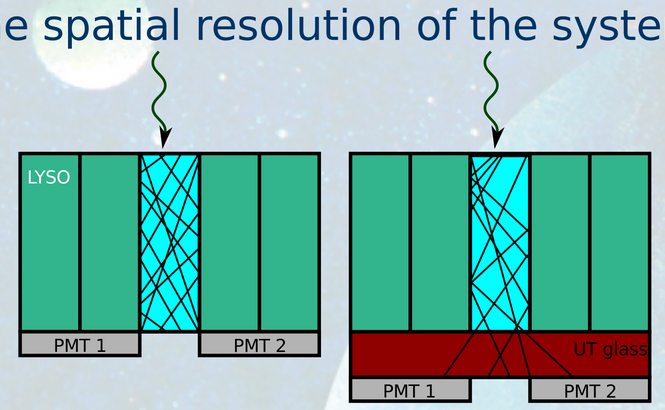
MOTIVATION

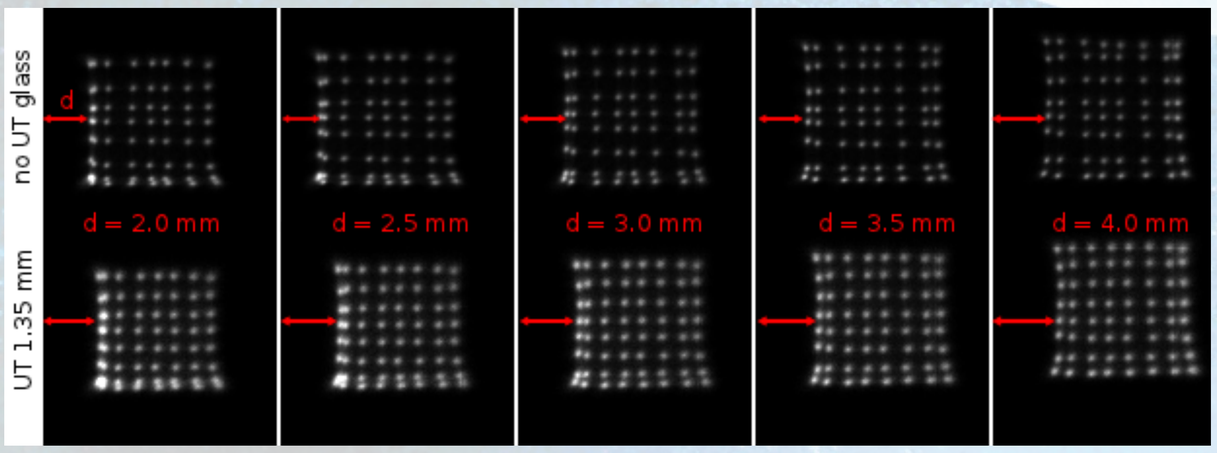
The pixel identification capability is a common problem of gamma-ray detectors using matrices of scintillating materials coupled to position sensitive photodetectors. In Positron Emission Tomography (PET) systems, an improvement of pixel identification leads to a amelioration of the coding error, thus improving the spatial resolution of the system.



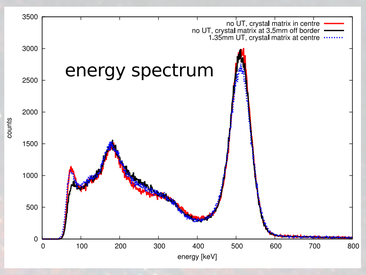
In order to promote light spread and avoid overlap of responses, ultra-transmitting (UT) glasses can be inserted between the crystal matrix and the PMT in order to gain pixel identification efficiency especially at the peripheral active area by exploiting the enhanced light spread.

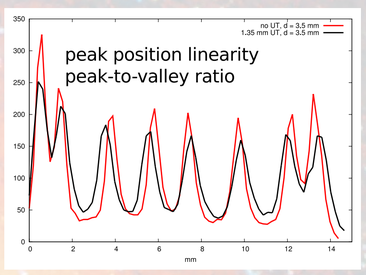
PIXEL IDENTIFICATION #1

To define the pixel identification capability at the PMT's border region, the crystal matrix was placed at five different distances *d* from the border without and with UT glass. Two series of measurements with the thickest (1.35 mm) UT glass and without are shown below.



For an unambiguous pixel identification, the minimum distance to border is 3.5 mm for both setups, i.e. with and without UT glass.



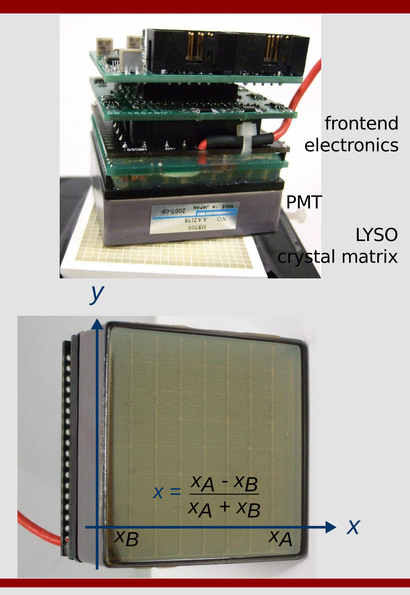


However, each pixel becomes slightly more diffuse with increasing glass thickness leading to a reduced peak-to-valley ratio and marginal worsening of the energy resolution. The following table summarizes the pixel identification properties.

	no UT	0.7 mm UT	1.0 mm UT	1.35 mm UT
energy resolution	11.7%	12.5%	11.9%	11.9%
peak/valley	5.4	3.7	3.5	2.7
linearity ($\pm\sigma$)	1.720 ± 0.315	1.720 ± 0.303	1.720 ± 0.232	1.720 ± 0.171

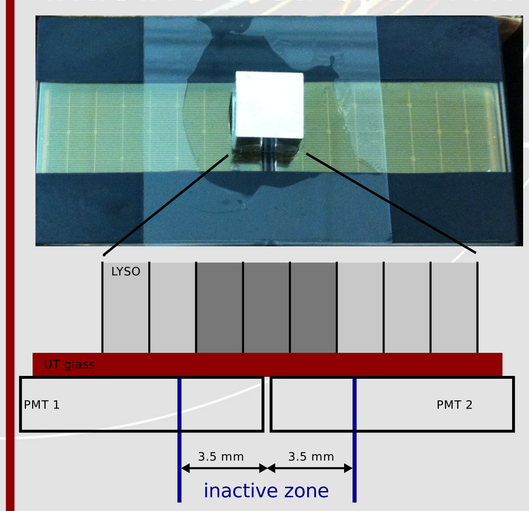
EXPERIMENTAL TEST SETUP

Our detector module for PET measurements consists of a scintillating 8x8 LYSO crystal matrix (pitch 1.7 mm, 13.6 x 13.6 mm^2) coupled to a multi-anode PMT (Hamamatsu H8500C, active area 49 x 49 mm^2) and is read out by modular frontend electronics processing timing and Anger-like position signals.



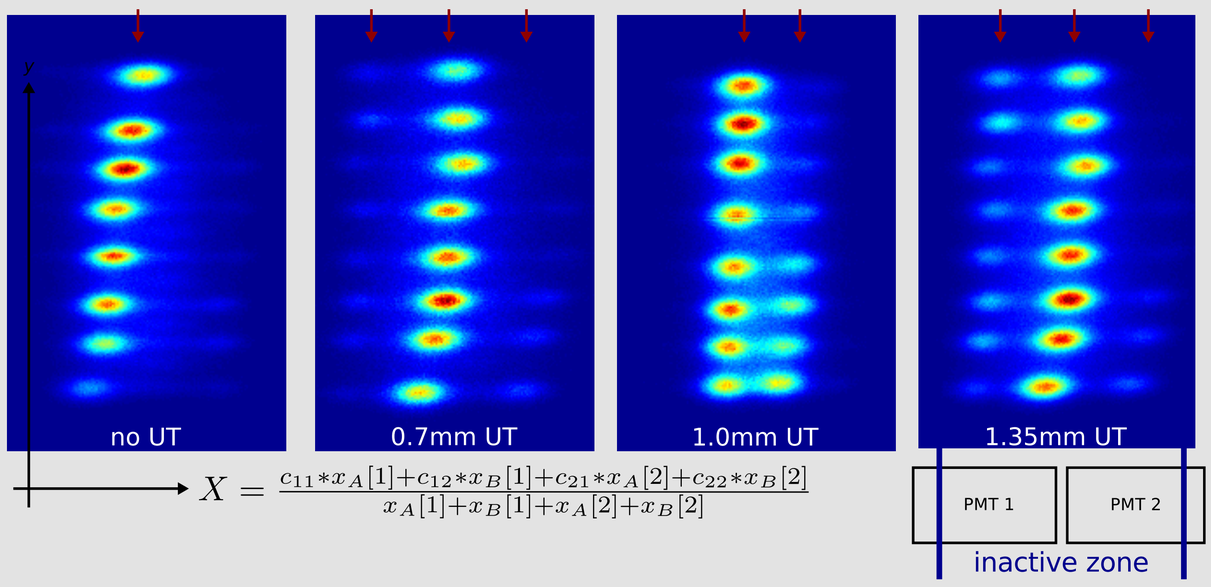
PIXEL IDENTIFICATION #2

A major problem is the pixel identification of the border or, moreover, the inactive area between two directly attached phototubes. Here, part of the light escapes the detector and therefore the pixel position calculation fails. With the help of UT glasses, the light spread is enhanced leading directly to an improved identification capability of pixels in the geometrically inactive area of a PMT.



For our detector setup, the inactive area between two phototubes adds up to 7mm. With a crystal pixel pitch of 1.7 mm, four pixels are geometrically assigned to this region.

As the four figures show clearly, the 'lost' pixels can be recovered by inserting UT glasses. The thicker the glass, the more pixel rows can be identified in the inactive area.



CONCLUSION

With respect to direct coupling, we observed an improvement of the peak position linearity, whereas the peak-to-valley ratio decreases. Especially at the inactive zone between two PMTs, pixel identification could be recovered with no degradation of energy resolution over the full PMT area by using UT glasses.