

# Position sensitivity in a 3" x 3" LaBr<sub>3</sub>:Ce scintillator

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## Introduction – Experimental Set Up

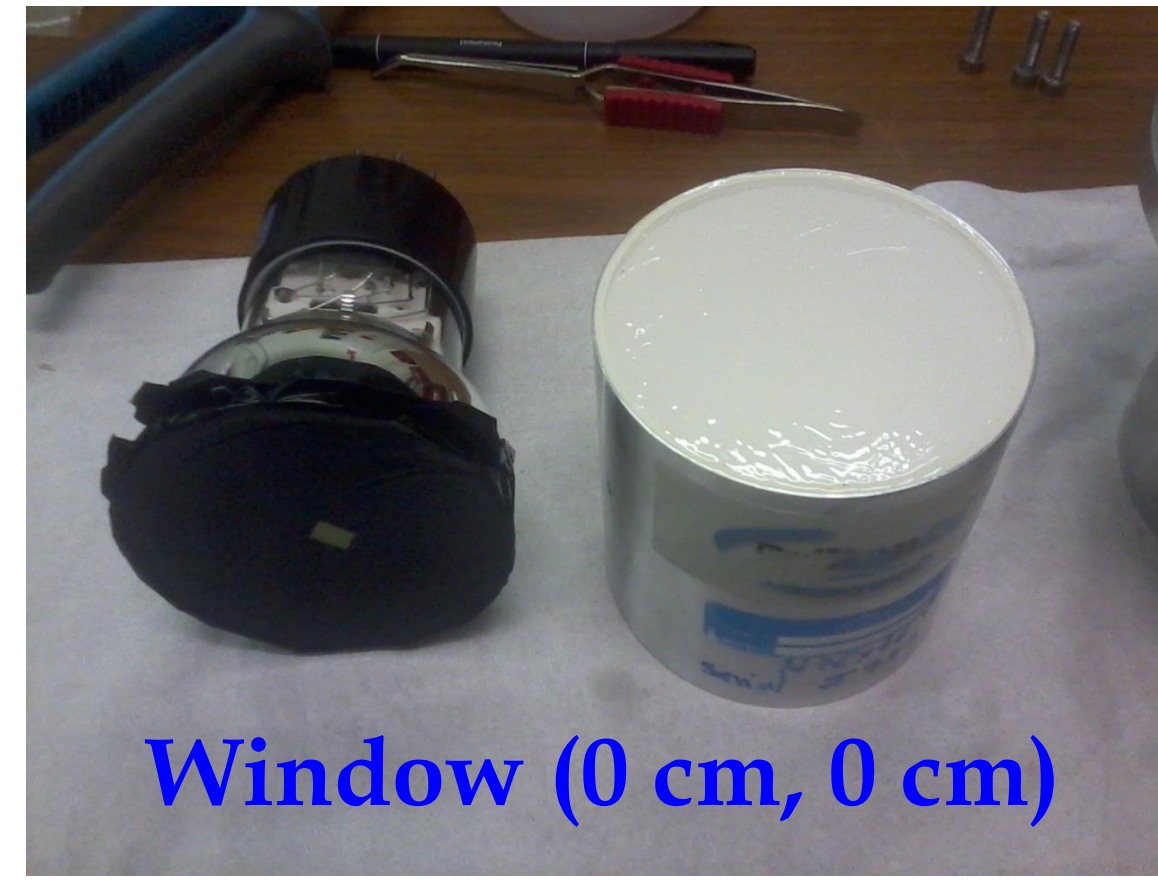
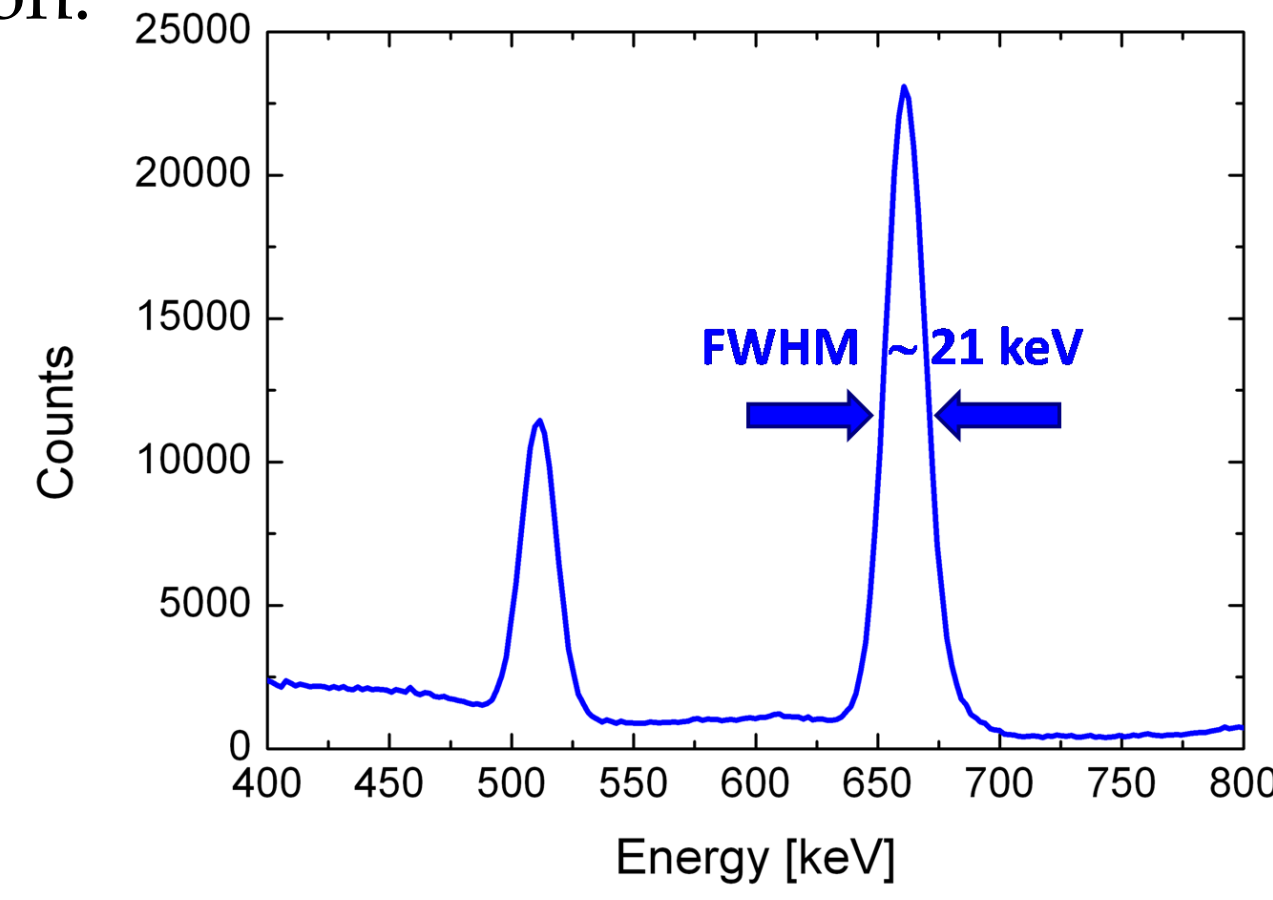
The **position sensitivity** of a 3" x 3" LaBr<sub>3</sub>:Ce scintillator was studied using a shielded HAMAMATSU R6233-100SEL PMT + E1198-26 voltage divider (VD) and a collimated gamma ray source (<sup>400</sup>MBq <sup>137</sup>Cs). The presence of a position sensitivity will be useful for applications and to reduce Doppler Broadening.

The 3"x3" LaBr<sub>3</sub>:Ce crystal has **diffusive/reflective surfaces** to optimize the energy resolution.

The experimental setup consist of a TENNELEC TC 244 spectroscopy amplifier an ORTEC 926 MCA.

The detector was supplied with a CAEN N1470 4 channel HV supply.

The measured energy resolution (without shield) was **3.1% (FWHM ~ 21 keV) at 662 keV**.



The PMT was shielded with black tape, a **square of 1 x 1 cm was unshielded** in order to mimic a position sensitive PMT.



Three positions were studied:

- PMT **center** ;
- **1.5 cm** from PMT center
- **3 cm** from PMT center



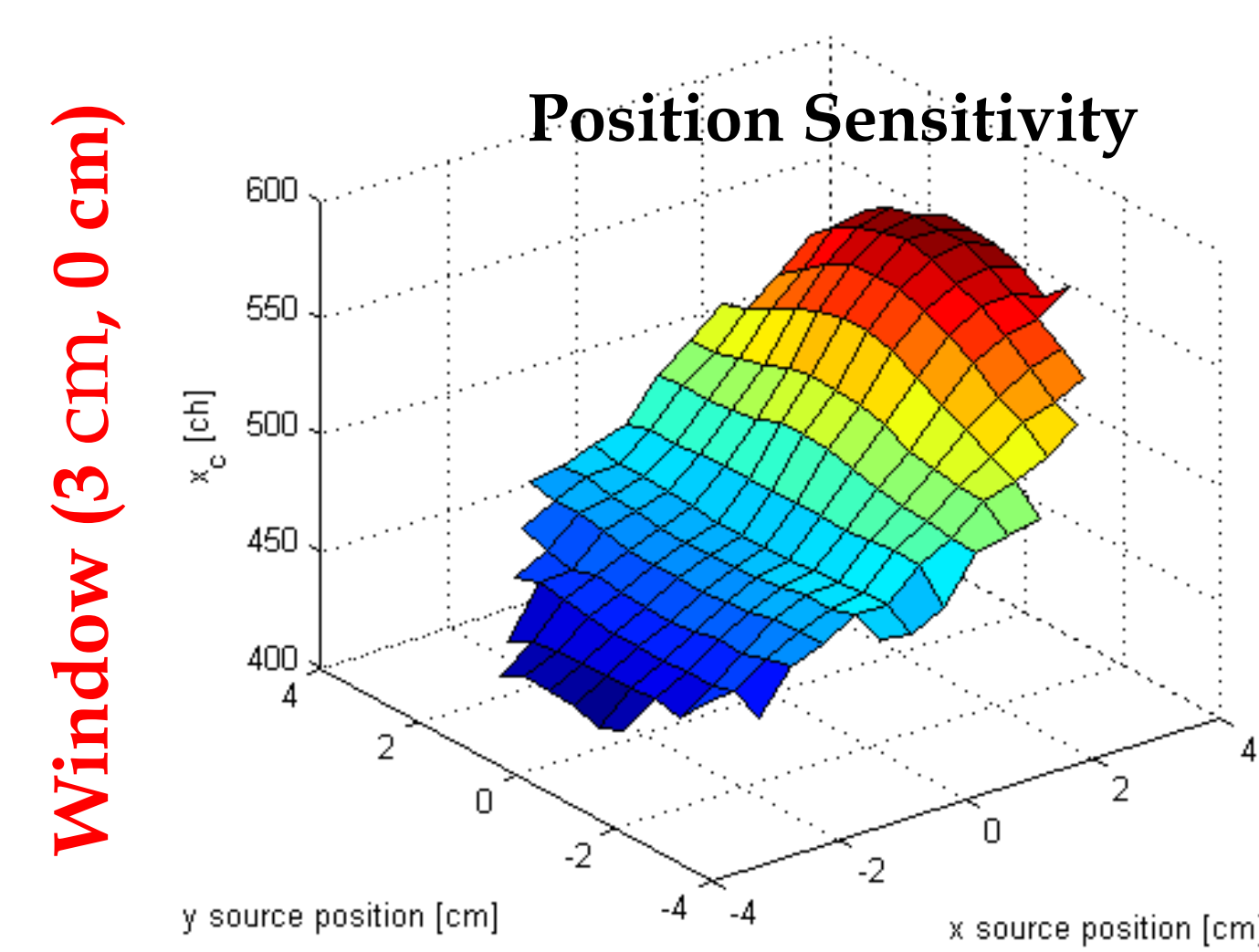
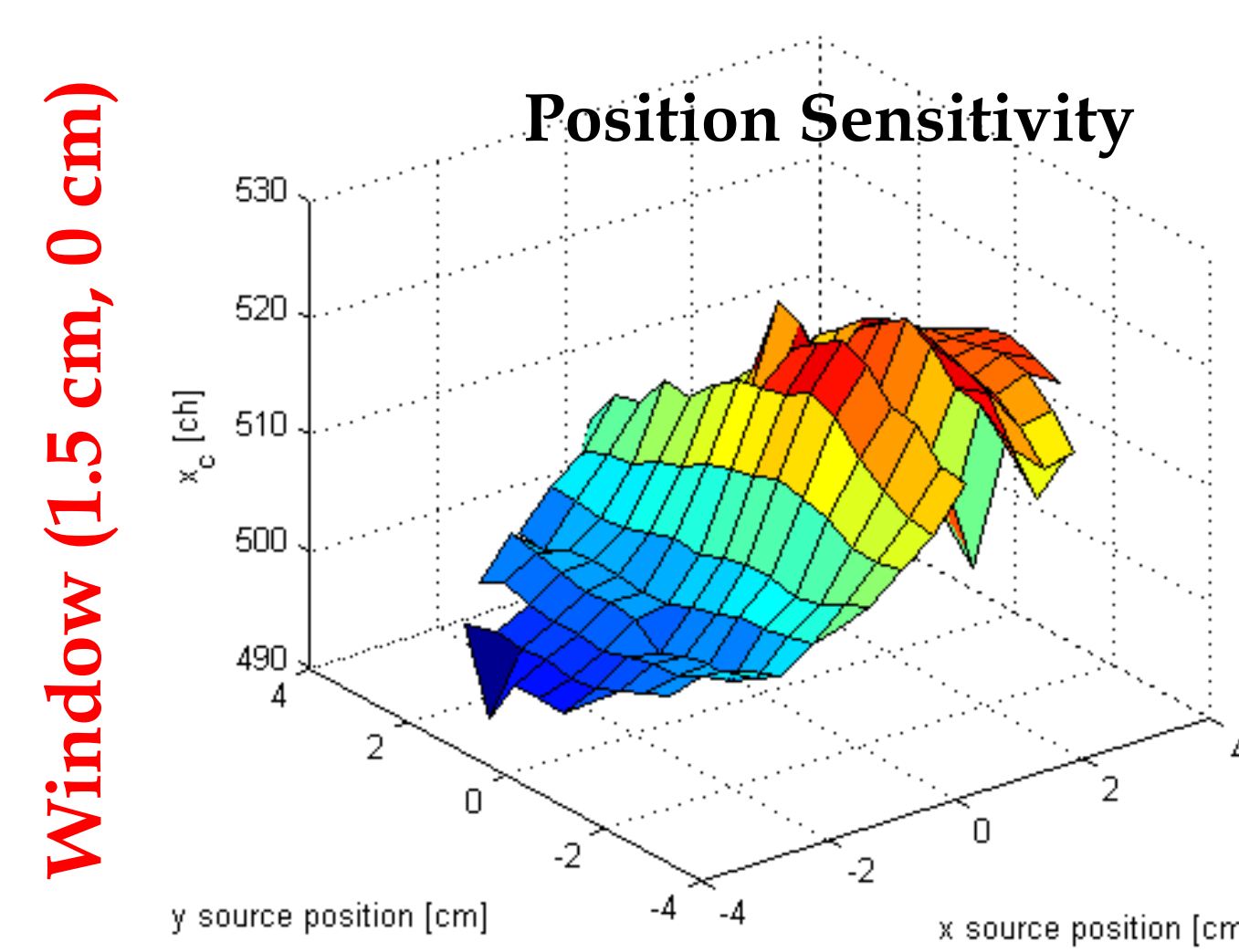
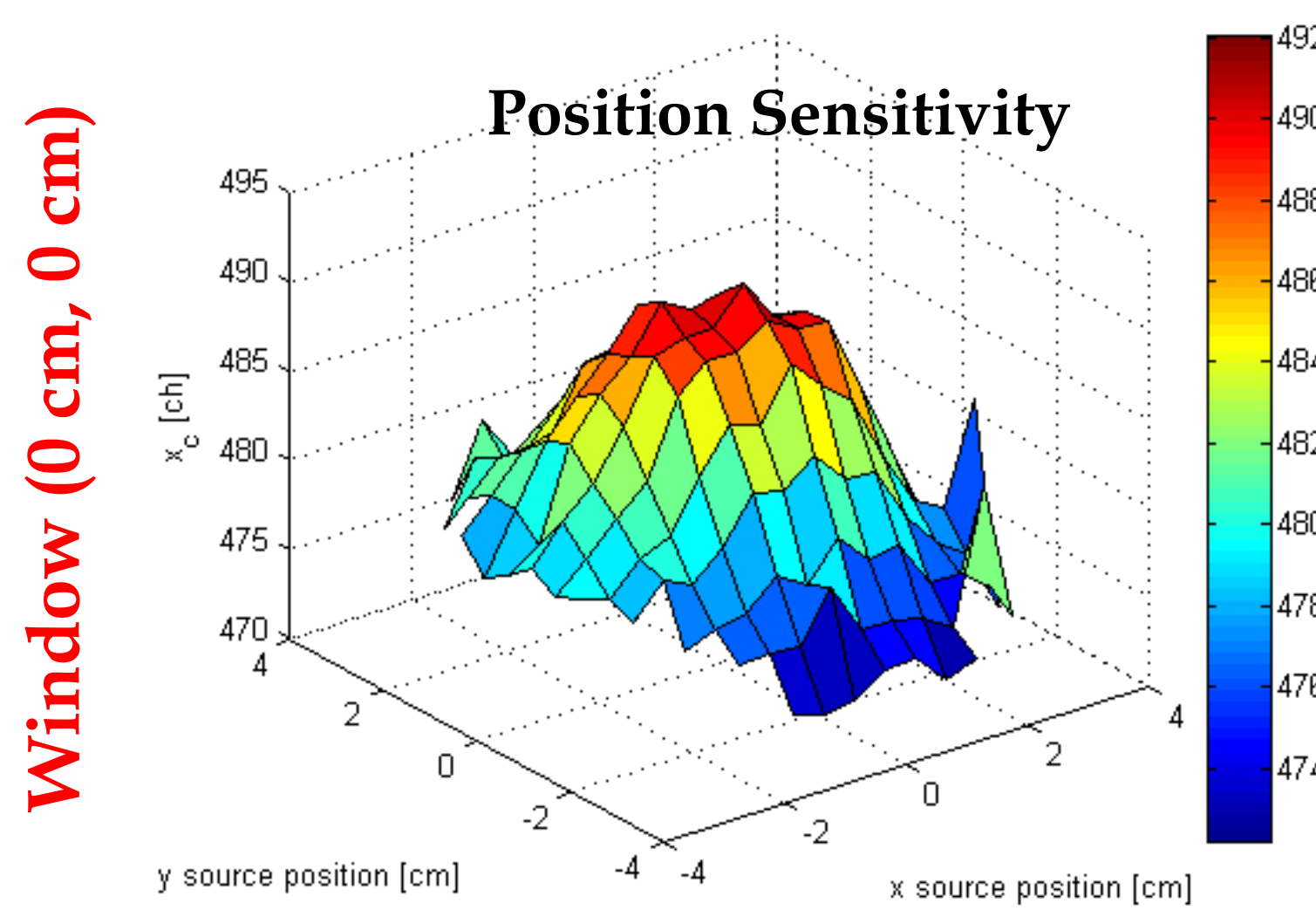
A detailed scan with a **grid of 0.5 cm** was performed using the 662 keV gamma rays of a <sup>137</sup>Cs collimated source.

## Crystal Scan Results

From the spectra we extracted the following observables, performing a bigaussian curve fit for all the source positions in the grid and for all three PMT windows:

- The position of the 662 keV peak **centroid**;
- the **energy resolution** at 662 keV;
- the **ratio between  $\sigma_{\text{left}}$  and  $\sigma_{\text{right}}$** ;
- the **area** of the 662 keV peak;

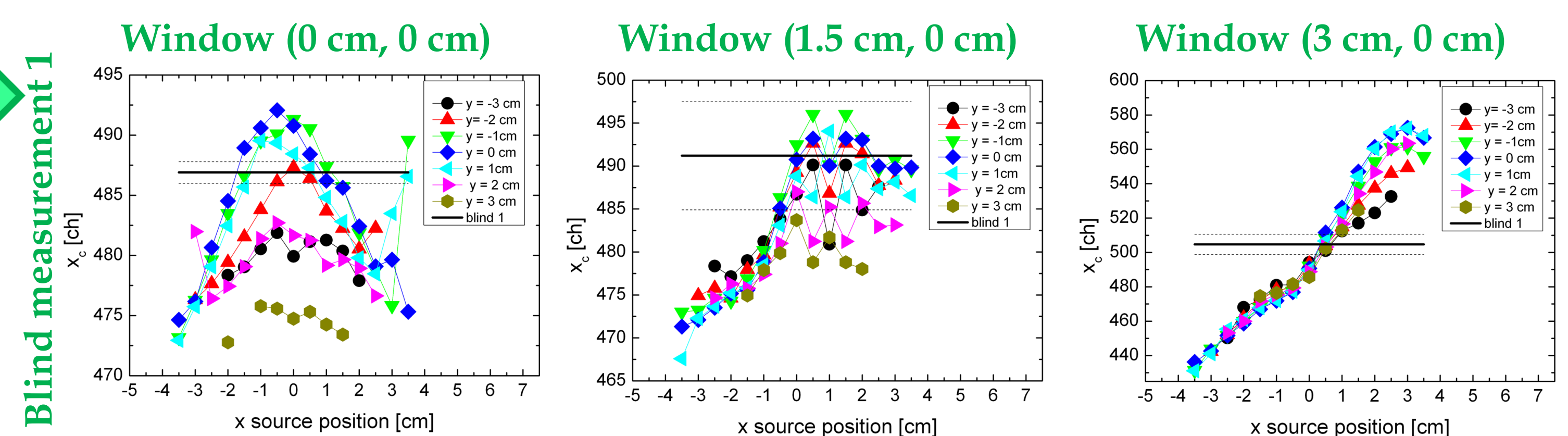
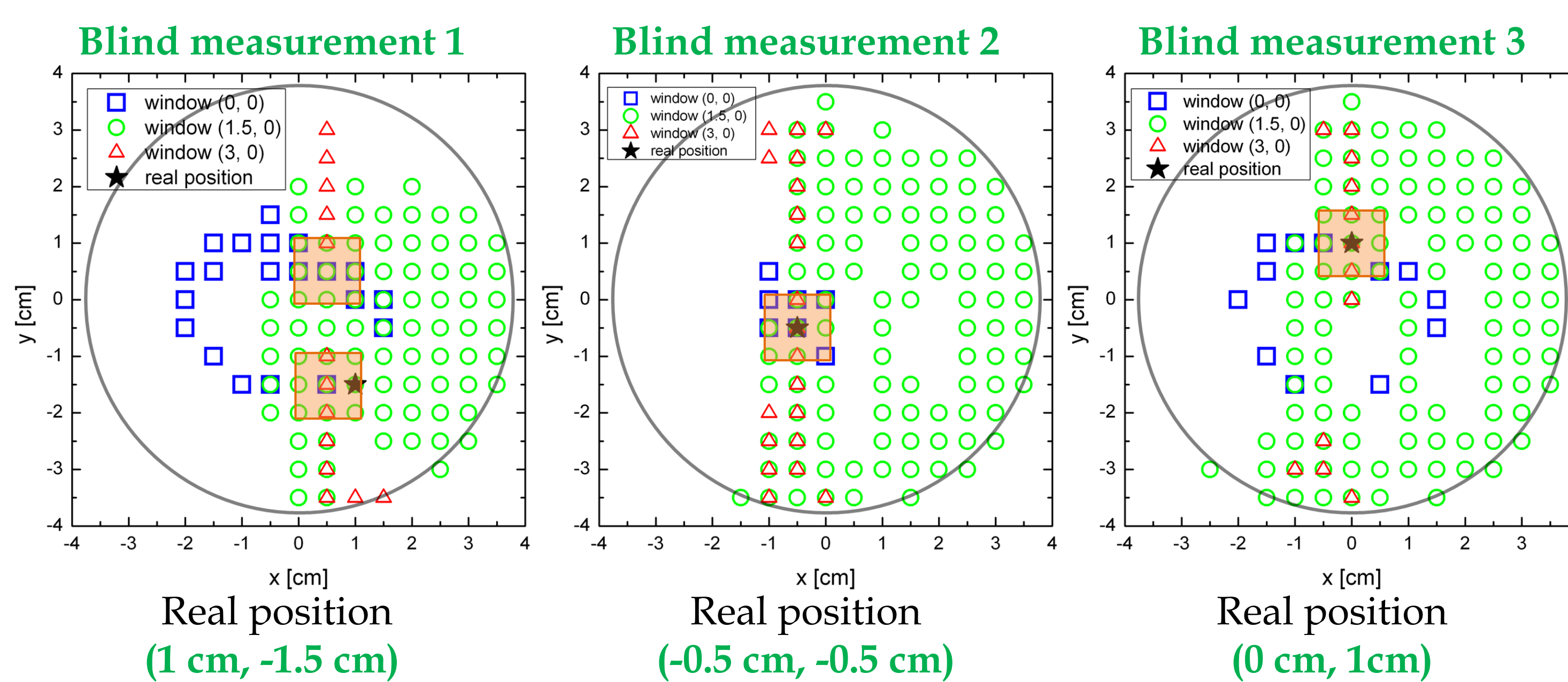
The **centroid of the 662 keV peak**, proportional to the average number of photo-electrons, shows a clear **position sensitivity**.



Gamma rays which enter in different positions produce **different intensity patterns** on the photocathode. It is possible to use such patterns to identify the gamma-ray incident position.

## Blind Measurements

We performed three blind measurements, where the same (unknown) source position was measured with all PMT windows. The centroid of the 662 keV peak was compared to the results of the grid scan.

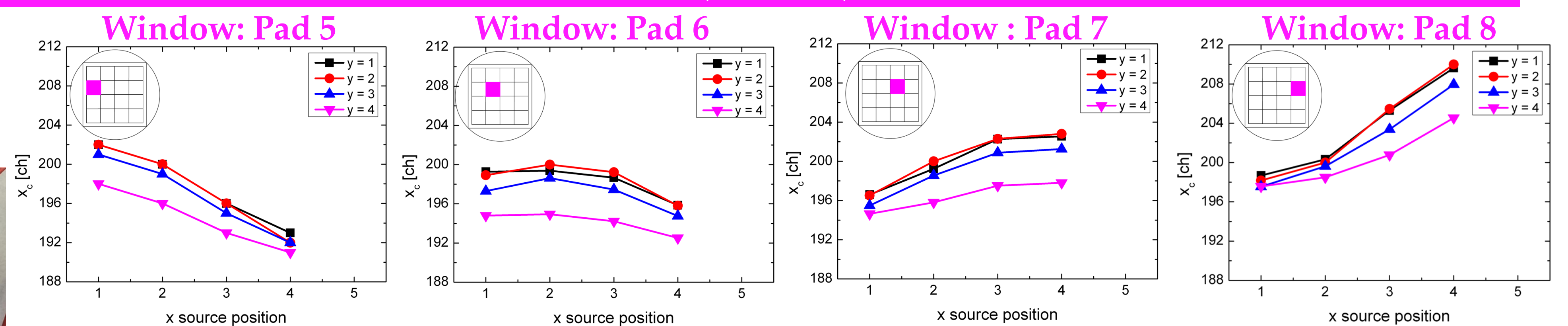
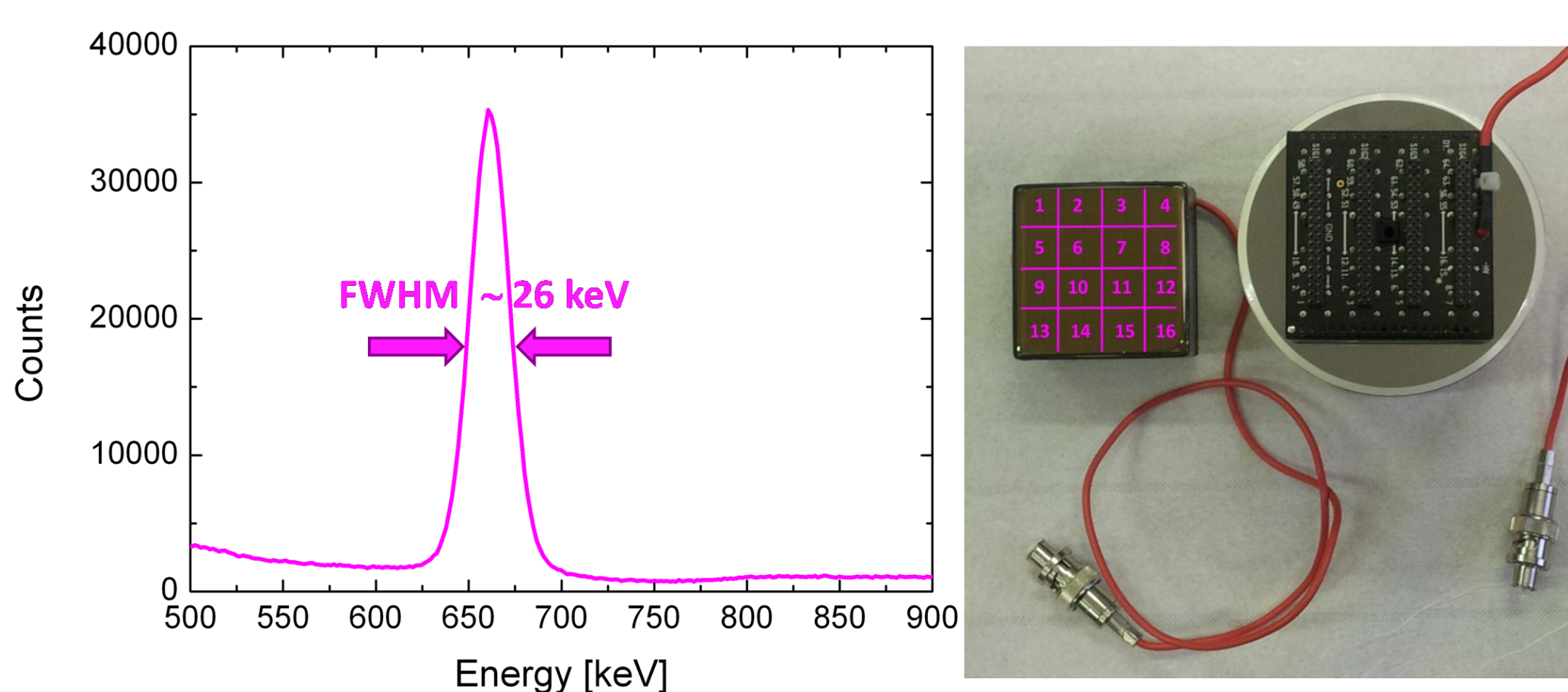


- Each window gives different information about the source position:
- Window (0 cm, 0 cm) gives the **radial position** of the source (blue squares);
  - Window (1.5 cm, 0 cm) provides the **left or right half** (green circles);
  - Window (3 cm, 0 cm) provides the **x source position** (red triangles).

The combination the three windows allows the **identification of the position**. With a segmented PMT it is possible to combine the information of a large number of small photocatodes, obtaining a more complete information.

## Perspectives: Position Sensitive PMT (H8500)

The next step will be the study of position sensitivity in 3"x3" LaBr<sub>3</sub>:Ce by using an HAMAMATSU H8500 **segmented PMT**.



The **HAMAMATSU H8500** has **64 segments** and its surface is 5 cm x 5 cm (therefore 43% of the crystal surface is not covered). We measured an **energy resolution of ~ 26 keV** using all the anodes short-circuited. In this test the signals of 4 segments was summed together to have a segmentation of 16 pads of 1.2 x 1.2 cm. As expected, we measured the same **position sensitivity** in the centroid of the full-energy peak.

In this work the **position sensitivity was studied in average**. The next step will be the reconstruction of the position of the interacting  $\gamma$  ray on an **event by event basis** as only in this way it will be possible to reduce the **Doppler Broadening**.