Characterization of charge sharing and fluorescence effects by multiple counts analysis in a Pixie-II based detection system.

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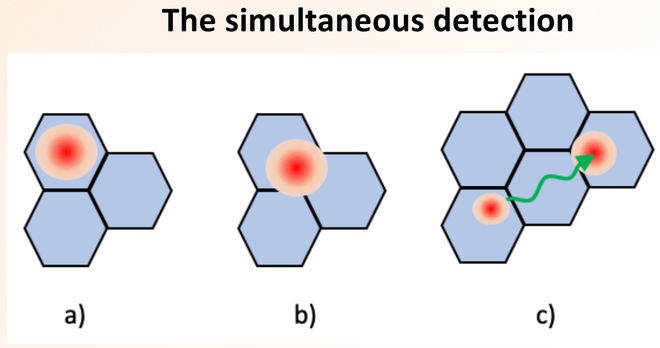
- The imaging performance of X-ray Photon Counting Detectors (XPCD) based on high Z crystal sensors is mainly affected by the simultaneous detection of a single interacting photon by different pixels. Such multiple counts worsen the spatial resolution and cause loss of spectral resolution.
- In this work we presents an experimental study for the systematic characterization of multiple counts detection in a Pixirad-I/Pixie-II system.

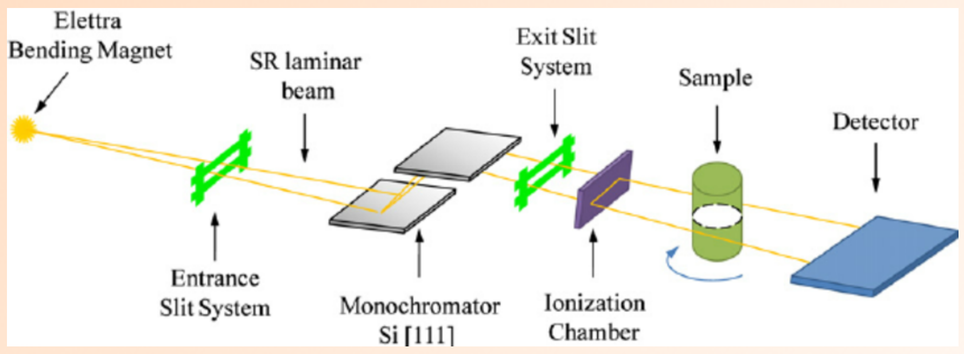
The detection system: Pixirad/Pixie II

- Hybrid architecture, 650 µm thick *CdTe* sensor and Pixie-II readout system
- Honeycomb matrix of *512x476* hexagonal pixels
- *60 µm* horizontal pitch and *51.96 µm* vertical pitch

The simultaneous detection

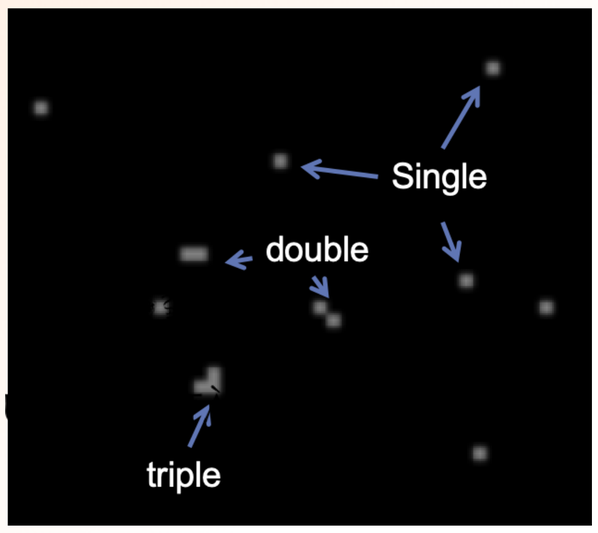


An interacting photon releasing all its energy can be registered by a single pixel a) or by a "cluster" of different adjacent pixels due to charge sharing b). Fluorescence can lead to multiple counts, even from disjointed clusters c).



The monochromatic X-ray source

- SYRMEP (SYnchrotron Radiation for Medical Physics) beamline of Elettra synchrotron, Trieste
- Energies in this study: *[18, 22, 26, 27, 30, 34, 36, 38] keV*

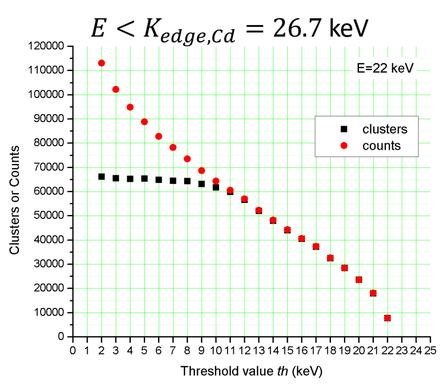


The method

- We acquired large stacks of images, for each of which only few photons interact in the whole sensor
- We observed, in single images, the presence of clusters of different size
- By counting the clusters of different size, we studied the dependence of the multiple counts on the energy of the impinging photons and on the discrimination threshold

Results

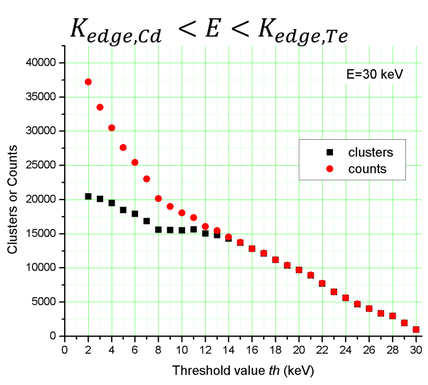
$E < K_{edge,Cd} = 26.7$ keV



For 2 keV $< th < E/2$, the number of clusters is almost constant while the number of counts grows more and more as th decreases.

Clusters and counts in function of the threshold *th* for for $E = 22$ keV.

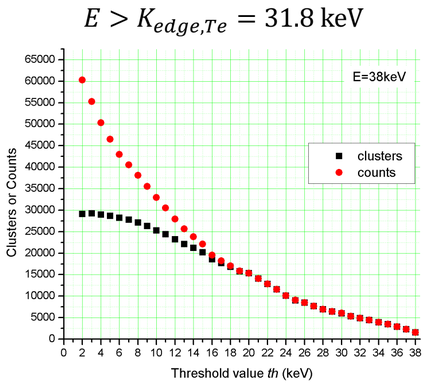
$K_{edge,Cd} < E < K_{edge,Te}$



Fluorescence in *Cd* occurs. When $th <$ $8\ keV$, the number of clusters grows as th decreases because disjointed clusters, generated by the same primary photon, are detected.

Clusters and counts in function of the threshold *th* for for $E = 30$ keV.

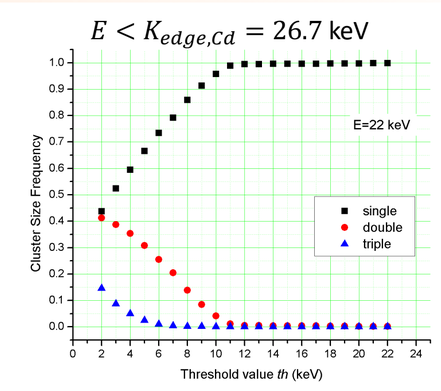
$E > K_{edge,Te} = 31.8$ keV



Fluorescence photons emitted by the *Te* are present. When $E - E_{Fl,Cd} > \frac{E_{Fl,Cd}}{2}$, there is not a range of possible th where $N_{clusters} = N_{photons}$.

Clusters and counts in function of the threshold *th* for for $E = 38$ keV.

$E < K_{edge,Cd} = 26.7$ keV

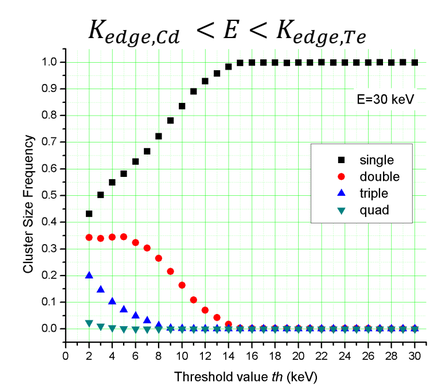


Only single clusters for $th \geq E/2$ are present.

Triple clusters start to appear at low thresholds, when $th \leq E/3$.

Relative distribution of the clusters, by size, in function of th in the case $E = 22$ keV.

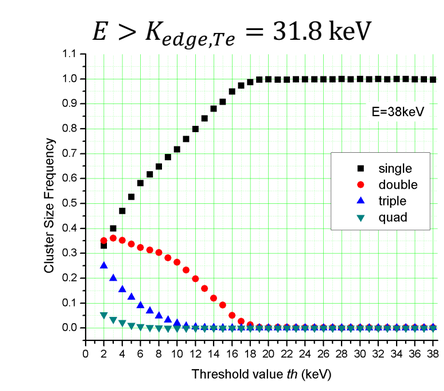
$K_{edge,Cd} < E < K_{edge,Te}$



An excess of single clusters is observed at low threshold, corresponding to sites where fluorescence events generate.

Relative distribution of the clusters, by size, in function of th in the case $E = 30$ keV.

$E > K_{edge,Te} = 31.8$ keV



The number and the maximum size of the clusters increase with the energy of the impinging photons.

Relative distribution of the clusters, by size, in function of th in the case $E = 38$ keV.

Conclusions

When photons with energies below the Cd K-edge are employed, the plots of number and size of the detected clusters against the relative thresholds (i.e. Threshold/Energy) are independent from the energy of the impinging photons. In particular, when the relative threshold is set to 0.1, the relative frequencies of clusters corresponding to single, double and triple counts are respectively of 0.4, 0.4 and 0.2. Setting the relative threshold close to 0.5, multiple counts can be avoided with no loss in detection efficiency.

When imaging with photons having energy above Cd K-edge, clusters of more than 4 pixels are observed. In this case, the number and the maximum size of the clusters increase with the energy of the impinging photons. Furthermore the threshold can be set to record only "primary" events, at the cost of a reduction in the detection efficiency.

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