Calibration of a pixel sensor using both fluorescence and transmitted X-ray photons

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Abstract: Pixel sensors have been calibrated using both fluorescence X-ray photons and a X-ray beam obtained by transmission technique. The X-rays were generated by a Amptek EDIX 40 X-ray tube (Maximum voltage 40 kV). During the fluorescence calibration the pixel sensor was placed in front of the target in a off-beam position, the resulting photons hitting the detector were emitted by fluorescence in all directions with an energy which is typical of the fluorescence lines of the target material. During the calibration in transmission mode the detector was placed behind the target, acting now as a filter, and the energy of the photons is tuned by adjusting the voltage of the tube and the thickness of the target. In this poster presentation the comparison between the two methods will be shown. From the results of this test, it is possible to infer that transmission is more efficient (higher photon yield) and flexible (more energy points are possible) but produces broader spectral lines while fluorescence has a better energy definition. A reasonable strategy to benefit from both methods is using fluorescence to calibrate a spectrometer that will be used to evaluate the energy of the X-rays emitted in transmission mode. The results of this calibration will be shown in the poster.

The measurement has been performed with two measurement setups. Both setup uses Amptek EDIX 40 X-ray tube having the following characteristics:

- Maximum Voltage: 40 kV
- Maximum current: 200 µA

The detector is a Amptek X-ray spectrometer for the spectrometer detector setup (Fig.1) and a pixel sensor bump bonded to a ROC chip is the pixel detector setup (Fig. 2). This bump bonded pixel detector is used in the pixel detector of the CMS experiment. Both setups have been used for making the measurements described in this poster.

Fig. 1 Amptek spectrometer setup

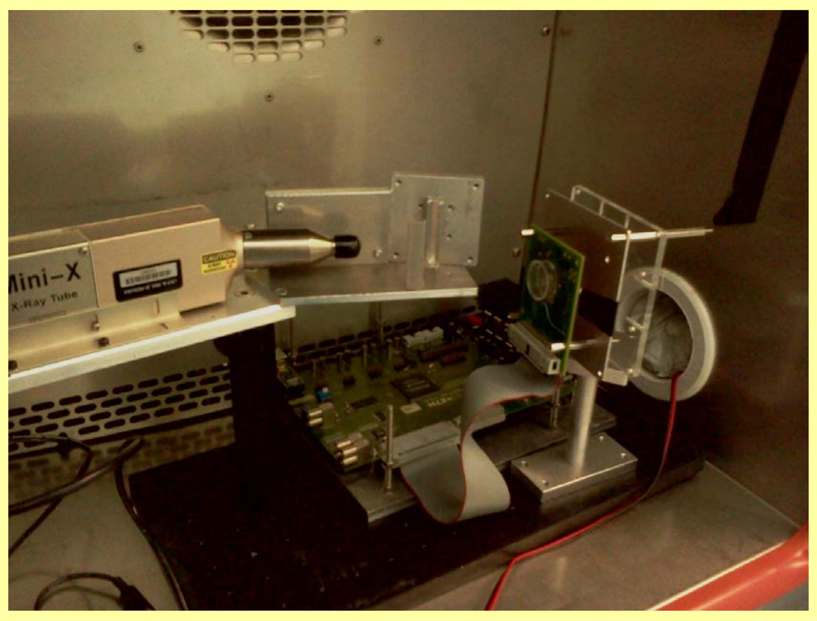

Fig.2 Pixel detector setup

The Amptek spectrometer setup

Using the spectrometer setup it is possible to compare fluorescence spectra with trasmission spectra (Fig.3). Florescence spectra have narrower energy lines but since they come from the isotropic fluorescence emission with limited efficiency the produced photon rete is relatively low. Furthermore their energy depends on the target material, therefore for each energy a different target is needed.

On the other hand transmission is more efficient in terms of photon rate and more flexible because playing with the tube energy and target tickness is possible to obtain many different energy values, however the energy of the resulting beam is less defined. Figure 4 shows different energies obtained in trasmission mode with different target thickness and tube energies. The error in the graph is the Half Width at Half Maximum of the energy distribution. Its relative values goes from 3.6% to 17%.

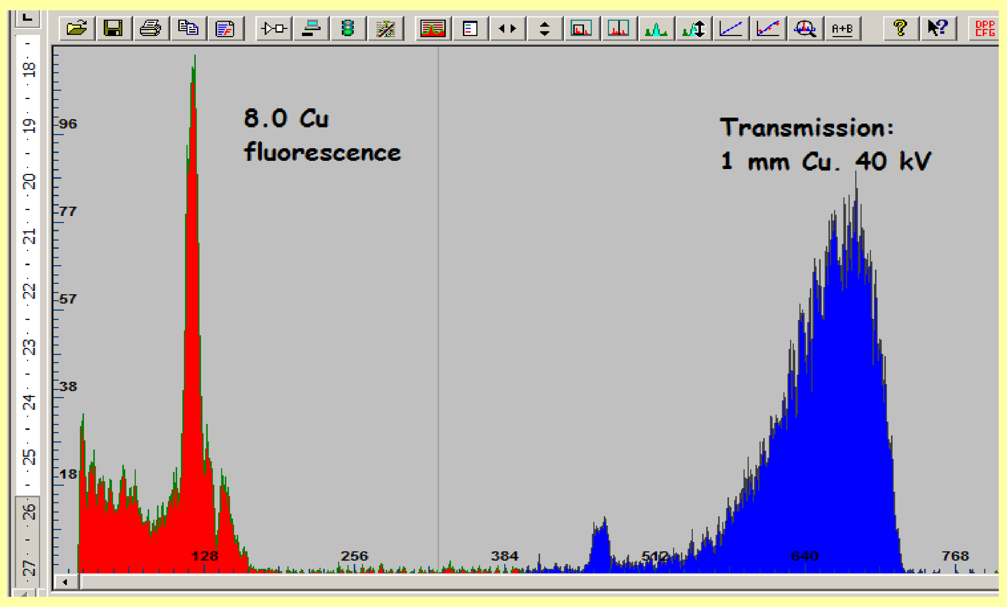

Fig.3 Transmission and Fluorescence spectra

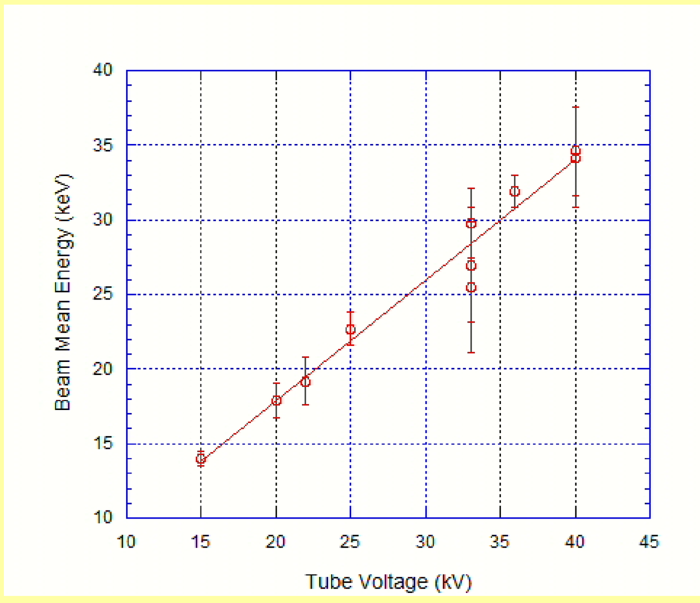

Fig. 4 Tube voltage versus beam energy.
The error is the HWHM of the energy distribution

The pixel detector setup

Once the various fluorescence and trasmission X-ray beams have been characterized using the Amptek spectrometer, the pixel detector have been irradiated with these beams.This pixel detector can be readout in two modes: direct charge digitization from the variuos pixel (charge spectrum mode) and threshold scan mode (S-curve mode) where the spectrum (integrated) is determined by counting the events above a certain moving threshold. Typical spectra both in fluorescence and in trasmission mode are shown in figures 5 and 6. By changing the beam energy we obtained the linearity plots observed in fig.7 and 8. We notice that a good linearity is obtained in both readout modes.

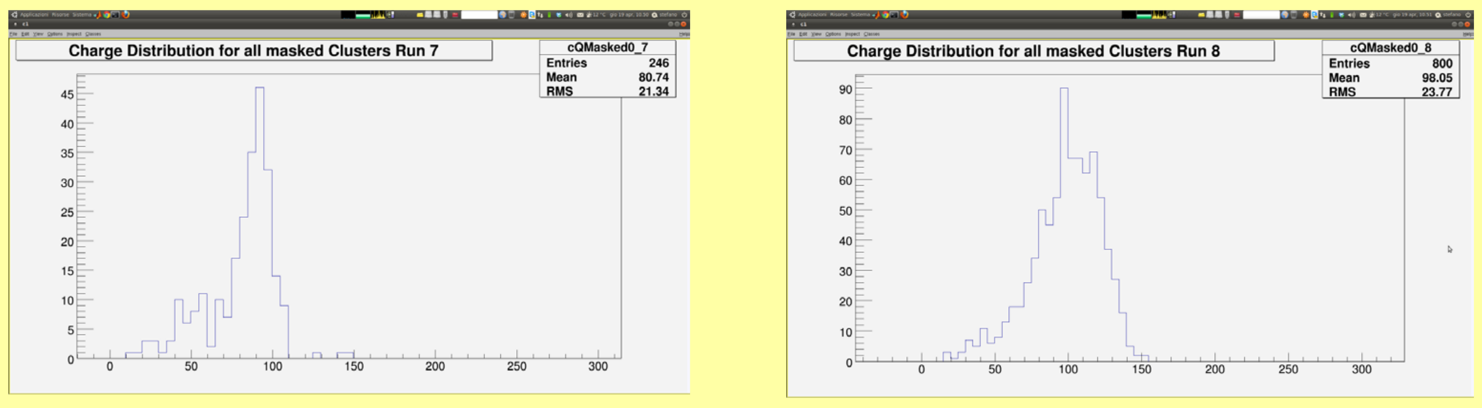

Fig.5 Charge spectrum in fluorescence (left) and in transmission mode (right)

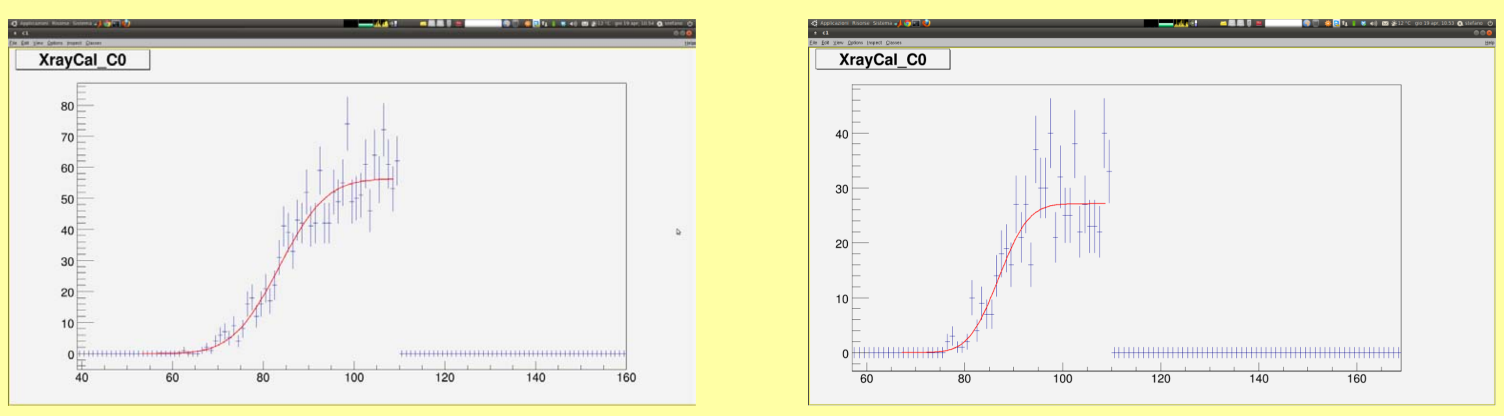

Fig.6 Typical S-curve in transparency mode (left) and in fluorescence mode (right)

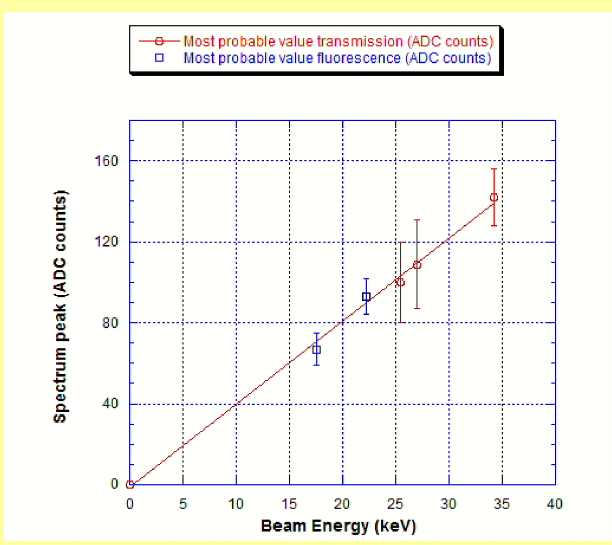

Fig. 7 Tube energy versus most probable amplitude in transparency and fluorescence mode

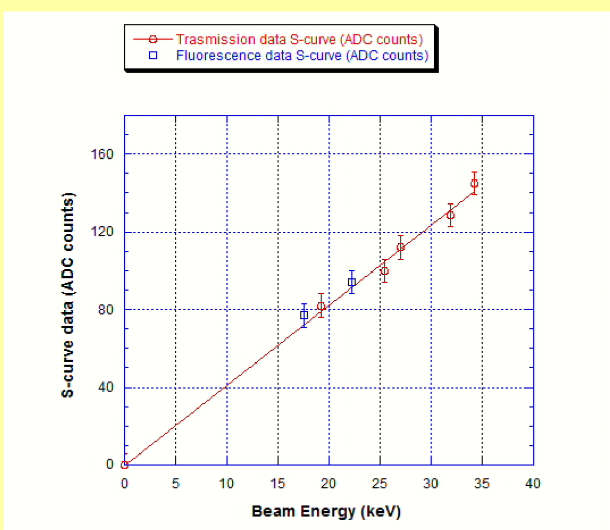

Fig.8 Tube energy versus S-curve mean point in transparency and fluorescence mode