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The First Result on X-Ray Test Station for Cathode Strip Muon Chambers

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Abstract:

The first results on an X-ray diagnostic device test are presented. A special X-ray tube with an anticathode made of praseodymium is briefly described. Short description of a silicon crystal monochromator selecting 36 keV K alpha1 Pr line is presented. A small volume copper strip chamber with Xe gas mixture was used for the space resolution, count rate and peak to background ratio measurement. All measured values are in good agreement with calculations.

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THE FIRST RESULT ON A X-RAY TEST STATION FOR CATHODE STRIP MUON CHAMBER

1. Introduction

In the GEM report TN-92-136 a X-ray diagnostic device was proposed. It was shown that by using a X-ray tube with appropriate anticathode material,a crystal monochromator and a proper gas mixture one could utilize hard enough X-rays to penetrate a wall material of a chamber while maintaining spatial resolution of the order 100 microns. Calculations shown that for the xenon containing gas mixture the $K_{\alpha 1}$ praseodymium X-ray line was the most appropriate. Here we report on the first result of the X-ray tube test.

2. The X-ray tube

We used the low power sharp focus X-ray apparatus manufactured by "Svetlana" in St.Petersburg. The photograph of the apparatus assembled with X-ray monochromator and X-ray tube is shown in Fig.1. In the Fig.2 a sketch of the tube and the monochromator is displayed. Electrons focused by an electrostatic lens into a spot of about 100 microns diameter was incident on the thin

praseodymium layer placed in inner surface of the beryllium exit window. Additional magnetic focusing was not used. The characteristics of the apparatus are listed in the Table 1. The energy spectrum from the tube with praseodymium anticathode is shown in Fig 3.

3. The monochromator

On the first step we used a single crystal monochromator with Bragg reflection on (111) planes of silicon. A mosaic on which an angle width of a reflecting beam depended was measured by a double flat crystal spectrometer using $K_{\alpha 1}$Mo line and the (333) reflex. In Fig.4 the rocking curve for two identical crystal in parallel position is shown. Taken into account that Bragg width for this reflex is about 0.65 arcs one can estimate the mosaic to be about 2.2 arcs (10μrad). A design of the monochromator is shown schematically in the Fig.2. In the Fig.5 the energy spectrum measured after the monochromator is shown. In the Table 2 the X-ray beam parameters for 70 micron exit slit are listed.

4. Description of a chamber used for the test

The measurements were performed in specially designed proportional small volume chamber, which is shown in Fig.6. The cathode strip chamber with delay line readout was used as position sensitive one-coordinate detector. With a xenon gas filled chamber we could investigate the position resolution for 36 keV X-rays. The chamber was installed on an ajustable support to fit the X-ray beam into proper angle relative to the chamber. The parameters of chamber were: sensitive area - 50mm*100mm, anode wire spacing - 2.5mm, anode wire diameter - 0.025mm, anode to cathode spacing - 2.3mm. All anode wires were connected toget-

her. The upper cathode (the entrance window for X-ray beam) was made from 0.035mm copper cladding G-10 type plastic of 0.5mm thick. The lower cathode was consisted of the narrow printed circuit copper strips with pitch 2mm. All strips were connected to delay-line. The delay line parameter was 5 ns/mm. Both cathodes were grounded. Positive high voltage was applied to anodes. Signals were taken from the both ends of the delay line and fed to amplifier, constant fraction discriminator and then to a time converter (TDC). The amplitude signals from anode wires and cathode's strips were measured by amplitude converter (ADC). The amplitude selection of events was possible to do during the data taking. We used the following gas mixtures at atmospheric pressure: 90%Xe+10%CO_2 , 25%Xe+22.5%Ar+15%CF_4+37.5%CO_2 and 30%Ar+20%CF_4+50%CO_2. The gas flow rate was 1.5 l/h that allowed to exchange gas volume of the chamber more than 50 times per hour. It was provided the good reproducibility of the measured results. The distance between the monochromator exit slit and the entrance wall of the chamber was about 3 cm.

5. The results of the measurements

In Fig.7 the position distribution for 70 micron exit slit width is shown for gas mixture 90%Xe+10%CO_2 without amplitude selection of events. Before this measurement the optimal position of the chamber relative to the x-ray beam was found. The solid line in the drowing is the result of the fit.
Calculated peak to background ration 33:1 was in agreement or better with prediction. However the obtained resolution about 266 microns FWHM is not in a good agreement with measured one by G.Smith at the BNL synchrotron light source.

In Fig.8 the cathode amplitude spectrum is shown. It contains ~~to~~ regions of small and big amplitude that might aggra-

vate the space resolution. To check this supposition we selected the cathode signals corresponding to the ~ 6 KeV energy escape peak (the selected region is shown in Fig.8 by arrows). Energy spectrum from anode wires under this selection is demonstrated in Fig.9. The measured position resolutions have improved. The FWHM in this case was 225 microns. The peak to background ratio emproved to 100:1. Assuming that the size of the photo and Auger electron cluster was underestimated we measured the position resolution for the 25%Xe+22.5%Ar+15%CF_4+37.5%CO_2 mixture with the equivalent amplitude selection where the cluster size should be bigger. Opposite to this assumption one can see in Fig.11 that the position resolution became even slightly better 210 microns. So we conclude that the relatively big line width is connected probably with the electronic system resolution. The peak to background ratio became ~ 60:1, count rate was 8.4 per sec when about one thousand 36 KeV quanta per second was incident on the chamber. Accumulated statistic 2900 events in the peak provided position error about 2.2 microns. Finally we measured the position distribution of the gas mixture without xenon. In Fig.13 this distribution is shown. As it was expected the position resolution was quite poor (FWHM = 2.3 mm). It has to be noticed that this distribution is the main component of the background in the case of the gas mixture with xenon.

6. Conclusion

The first test of x-ray apparatus with praseodymium anticathode tube supplied with the single crystal monochromator have shown that there are good perspective to use it for the x-ray test station

Table 1 REIS-100 x-rays tube with praseodymium anticathode

V	100	KV	
I	60	μA	without magnetic focusing
I	25	μA	with magnetic focusing

Table 2 X-ray beam parameters

Reflex width	70 micron
Angle width	< 50 μrad
Reflex counting rate (for V = 95 KV, I = 30 μA)	1000 per sec. for $K_{\alpha 1}$

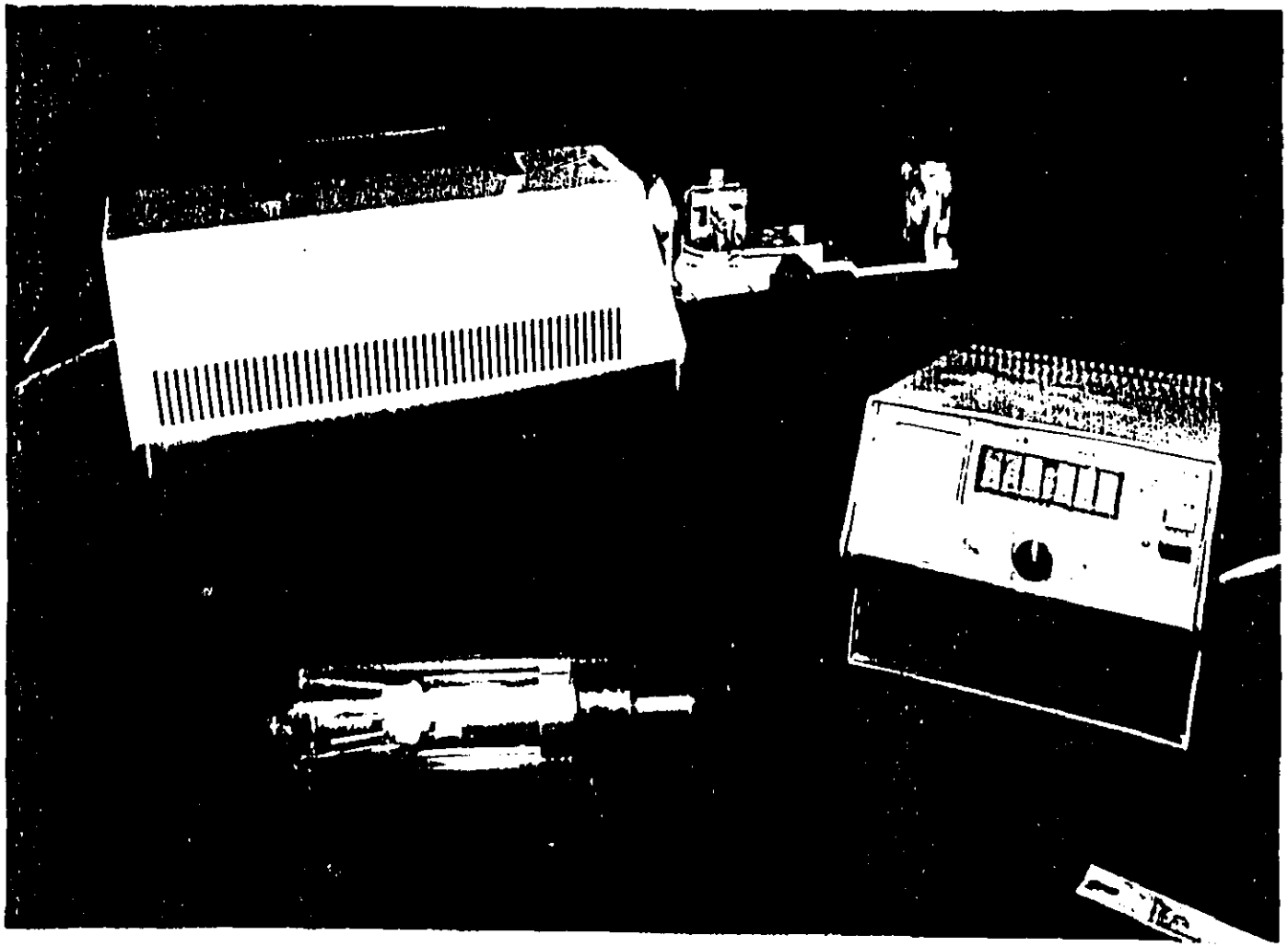


Fig.1 Vew of the REIS x-ray apparatus with the monochromator. Aside the x-ray tube is seen.

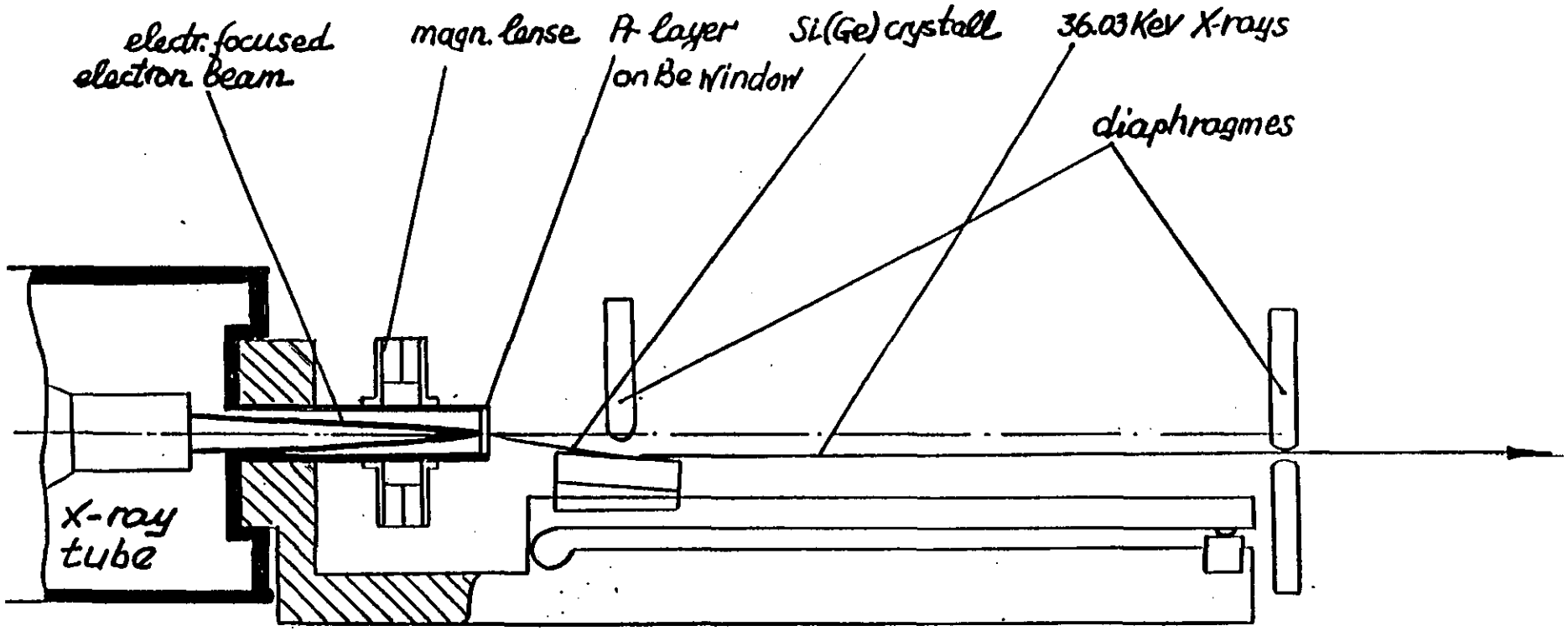


Fig. 2 Schematic diagram of the single crystal monochromator

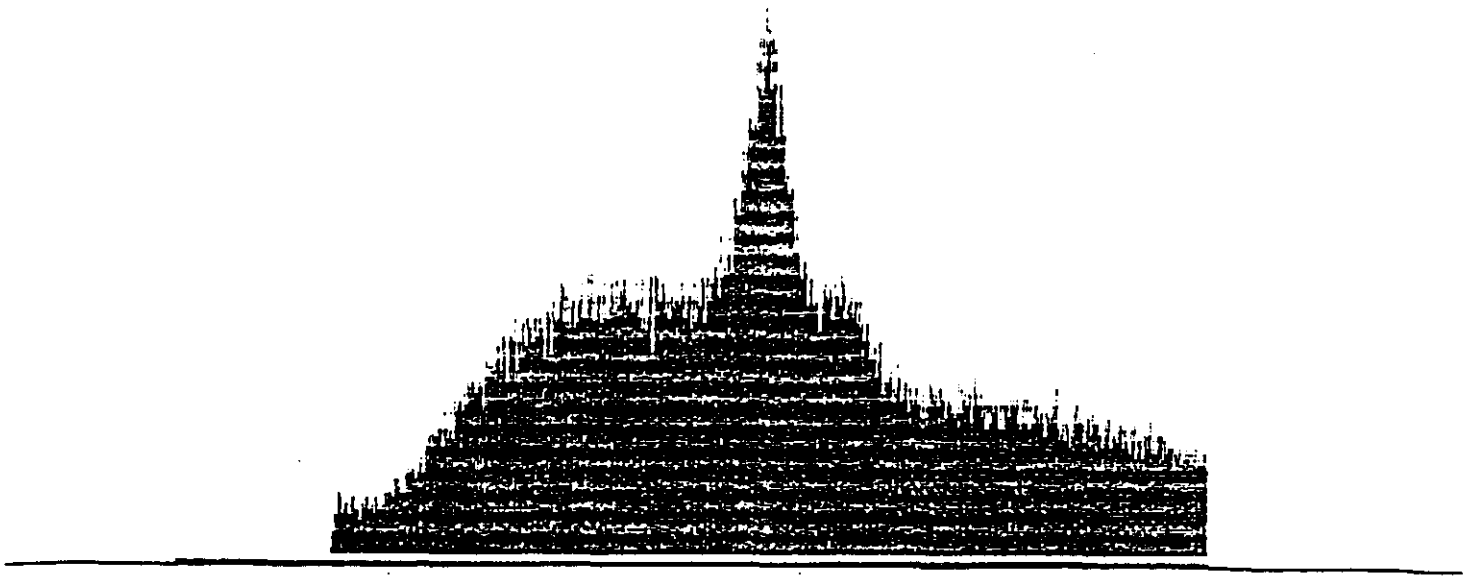
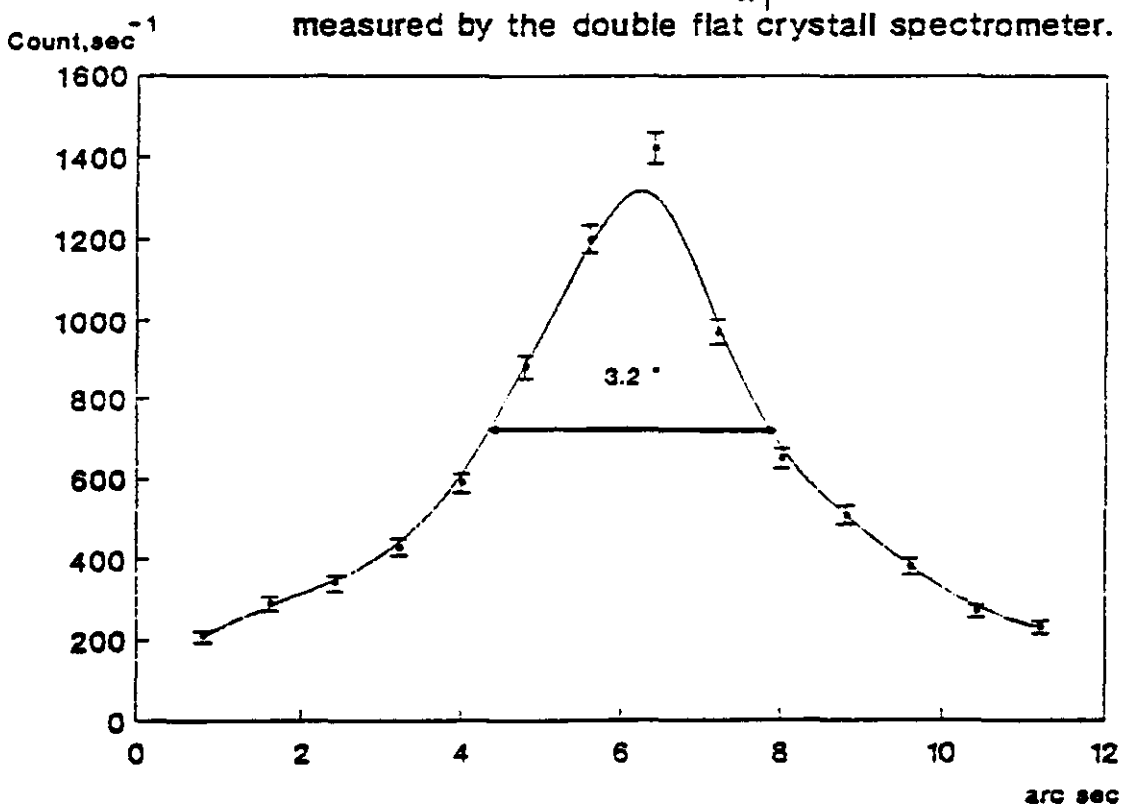


Fig. 3 Energy spectrum of the praseodymium anticathode tube, radiation measured by the GE(Li) detector.

Fig. 4 Si (333) reflex MoK_{α_1} rocking curve measured by the double flat crystall spectrometer.



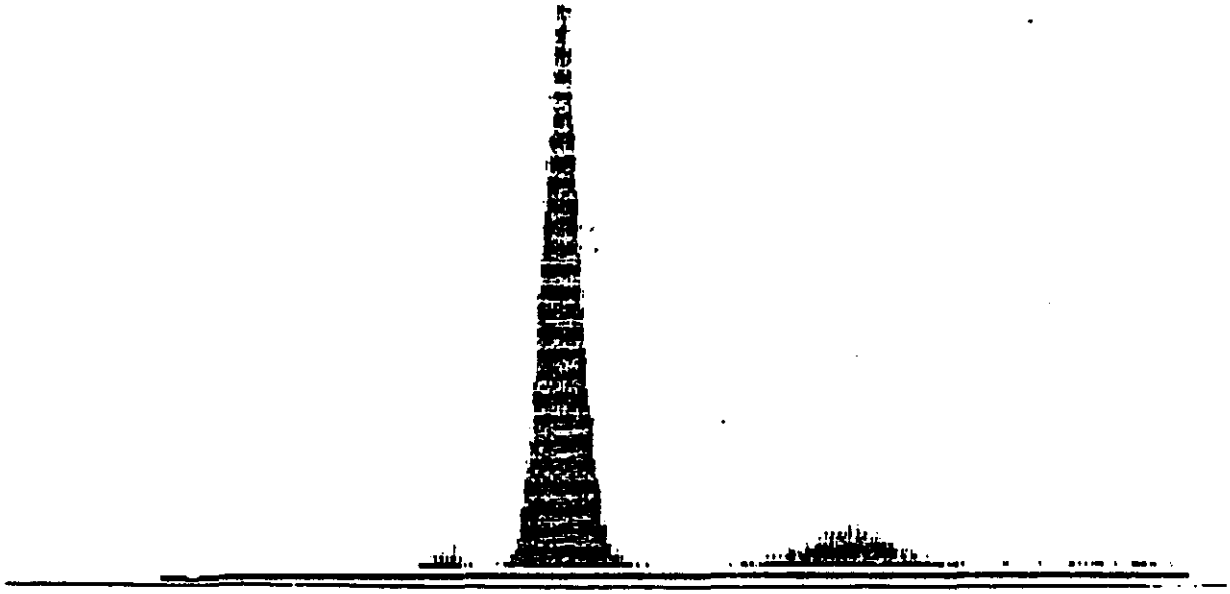


Fig. 5 Energy spectrum after the monocromator.

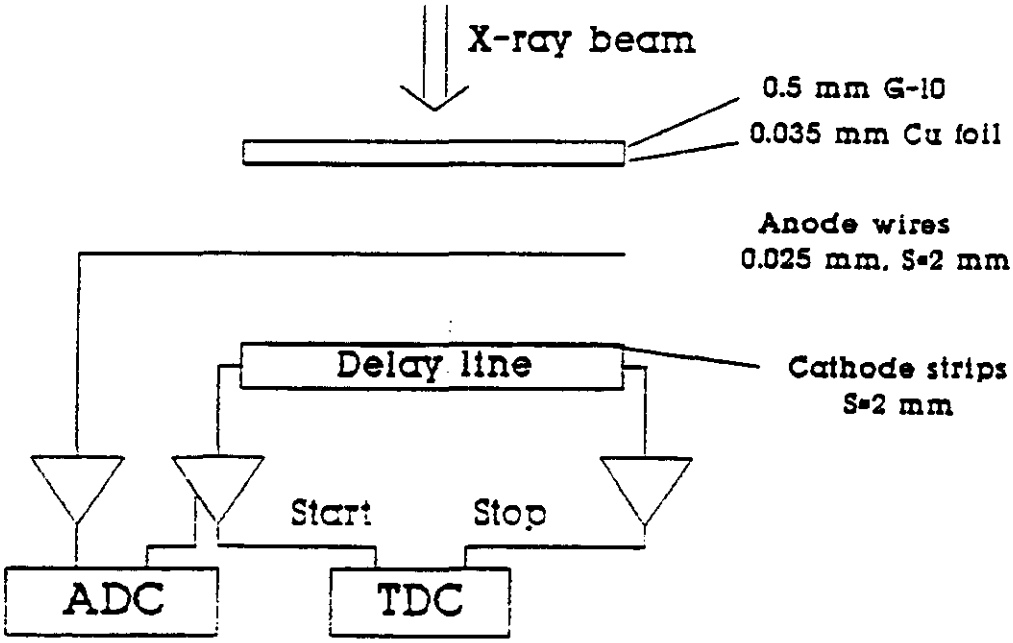
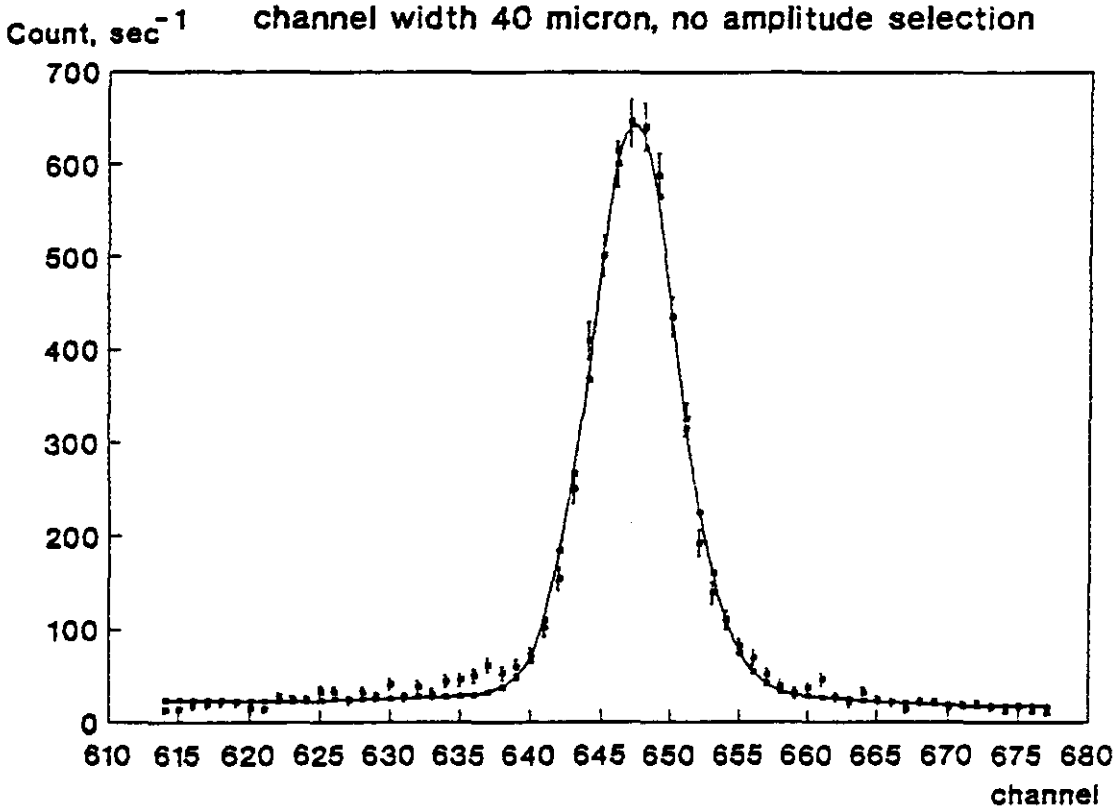


Fig. 6 Shcematic view of the experimental set-up and arrangement of the electronics for X-ray studies.

Fig. 7 Position distribition; 90% Xe + 10% CO_2
channel width 40 micron, no amplitude selection



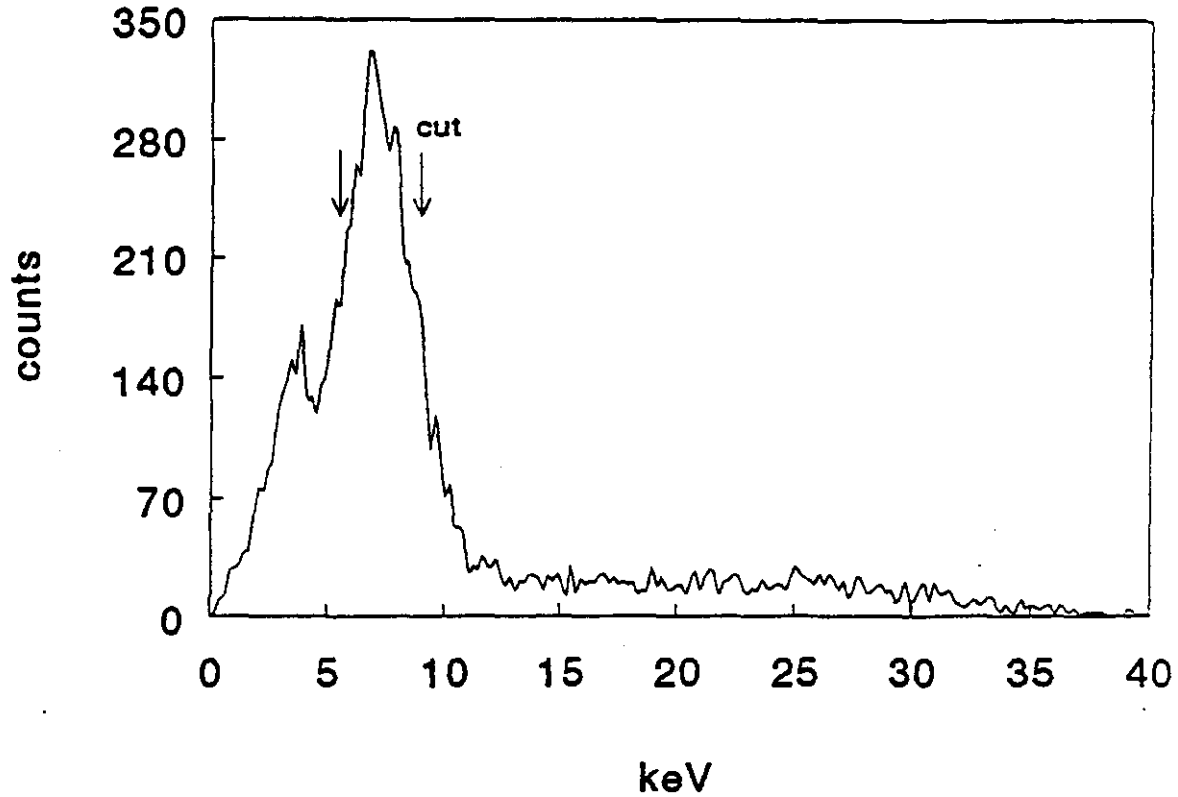


Fig. 8 Cathode amplitude spectrum,arrows show the selected amplitude region.

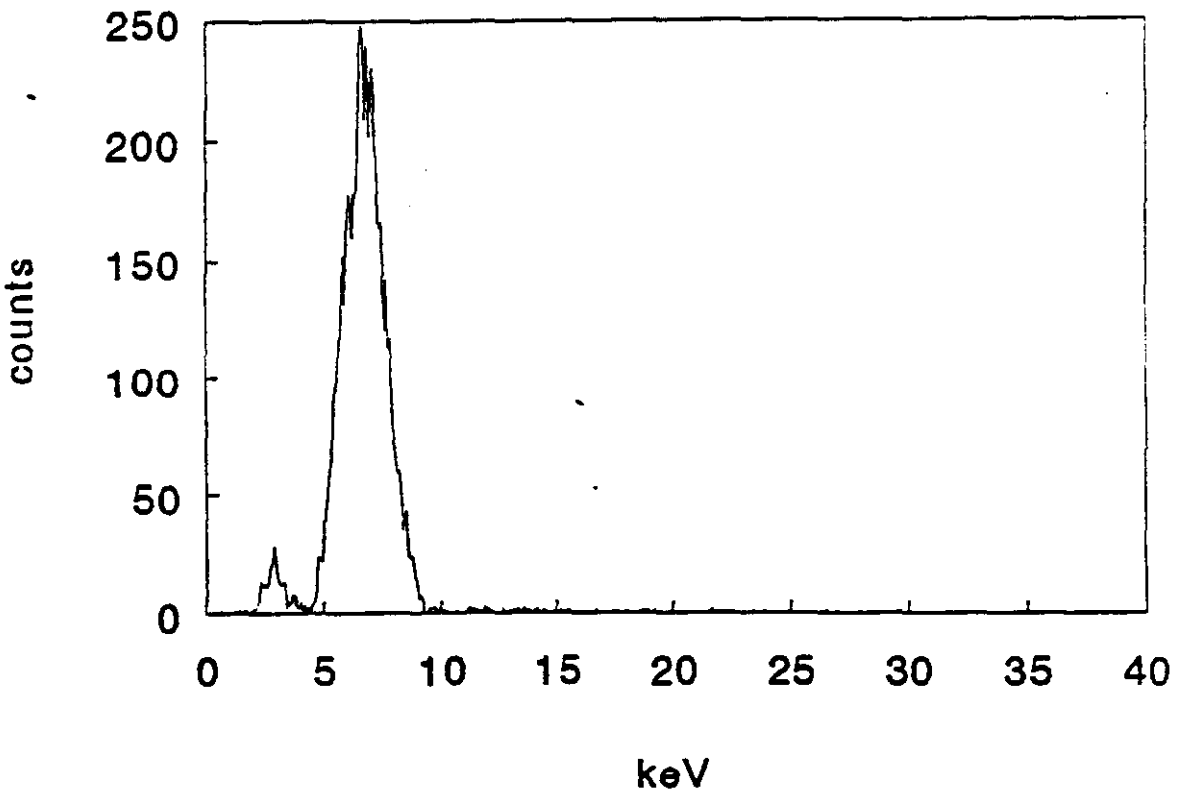


Fig. 9 Anode amplitude spectrum under selection shown

Fig.10 Position distribution; 90%Xe+10%Co_2 gas mixture under selection shown in Fig.8

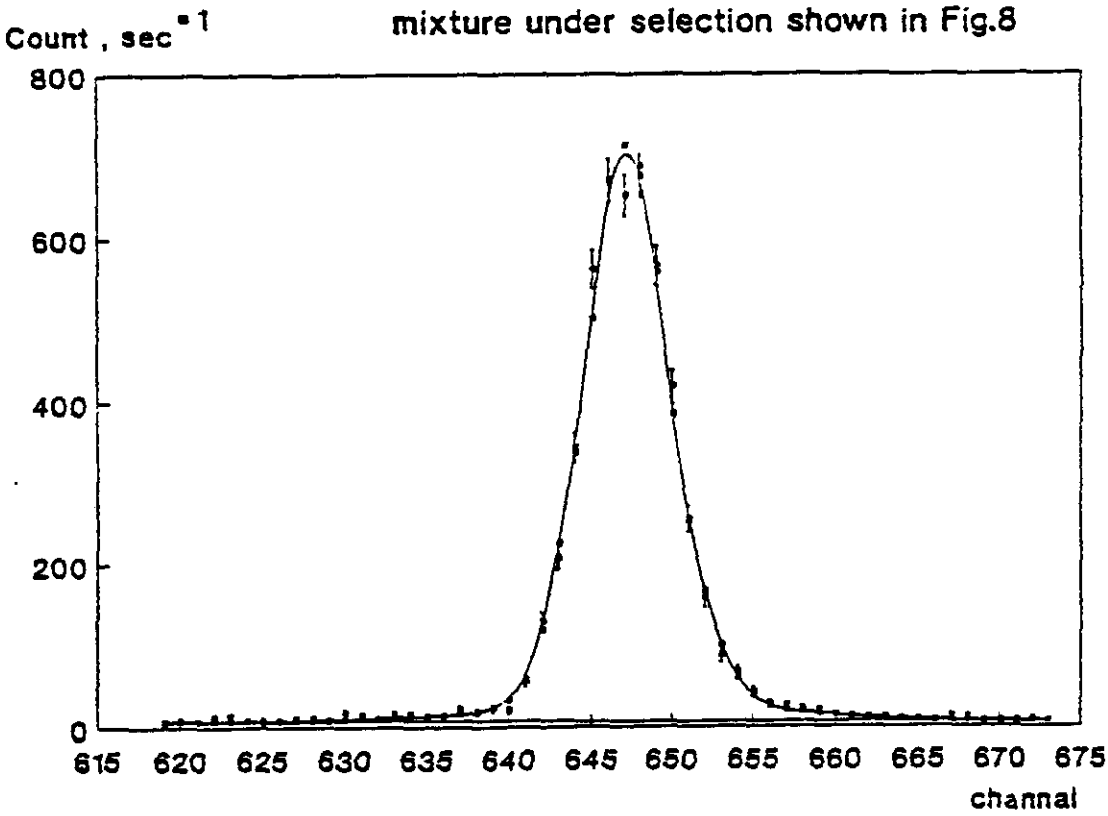
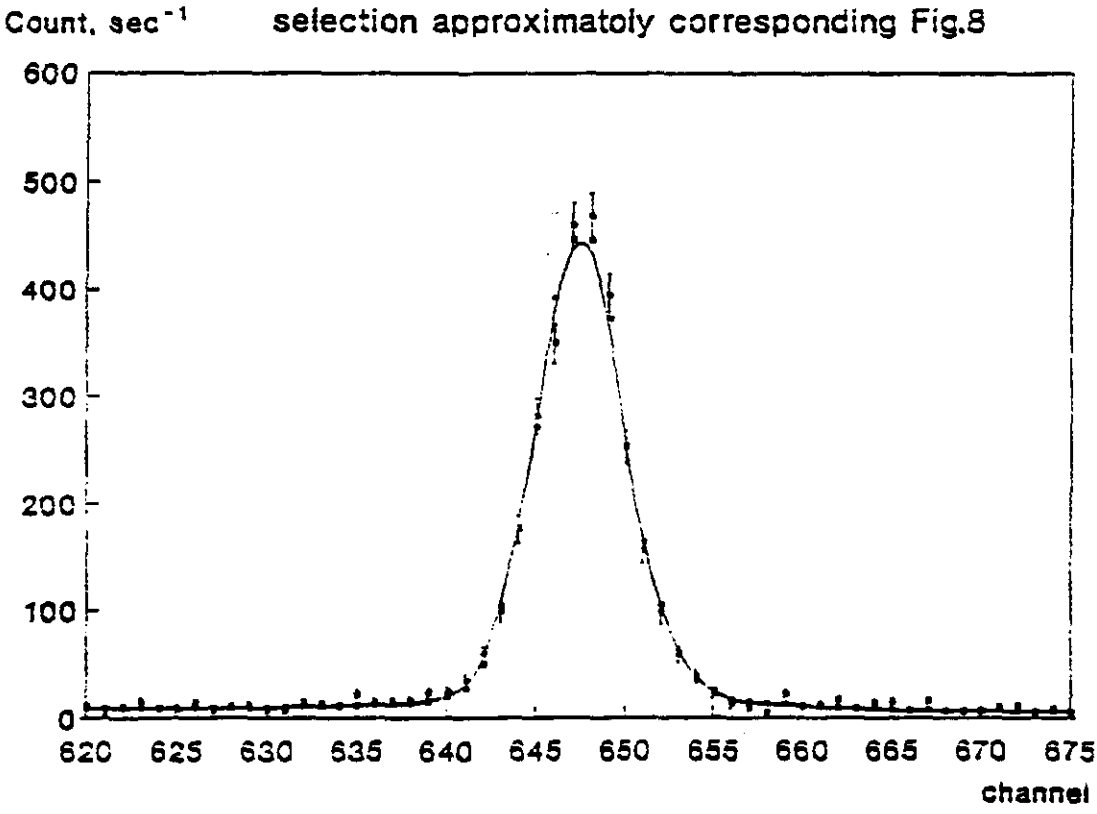


Fig.11 Position distribution; 25%Xe+22.5%Ar+15%CF_4+37.5%CO_2 selection approximatoly corresponding Fig.8



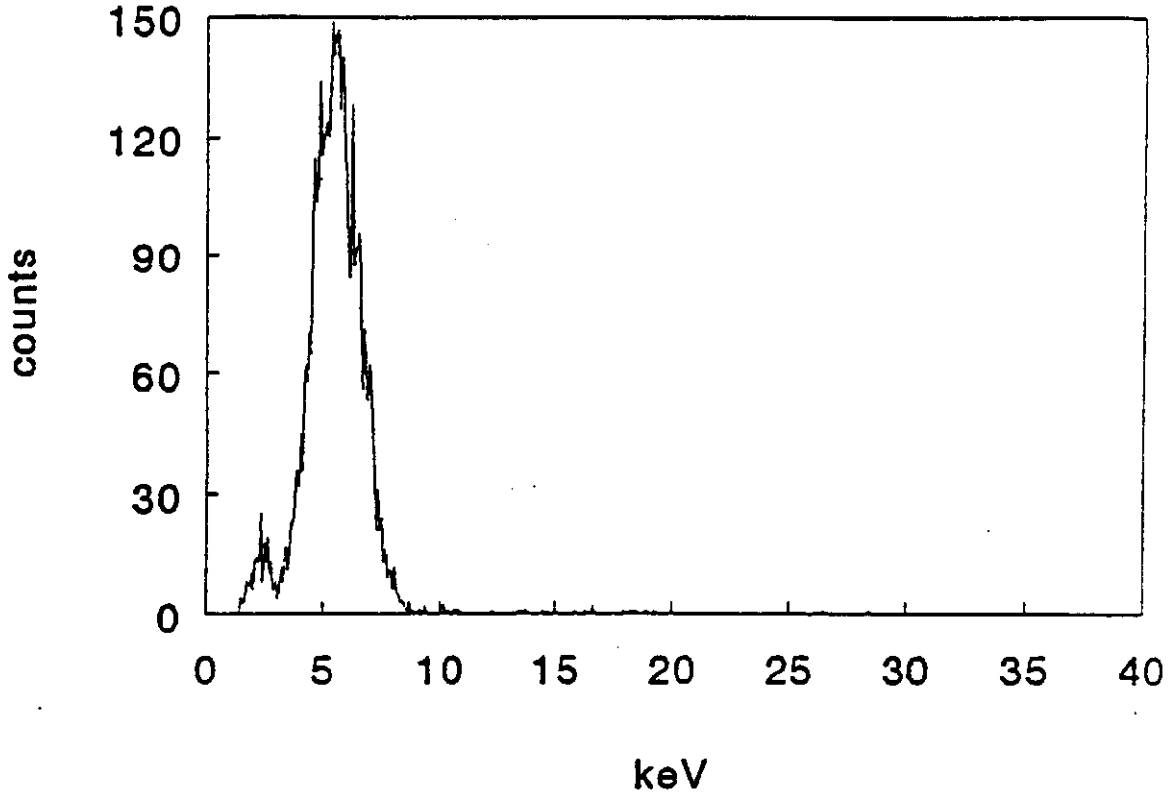


Fig. 12 Anode amplitude spectra under selection approximataly corresponding Fig. 8 25% Xe + 22.5%. Ar +15% CF_4 +37.5% CO_2

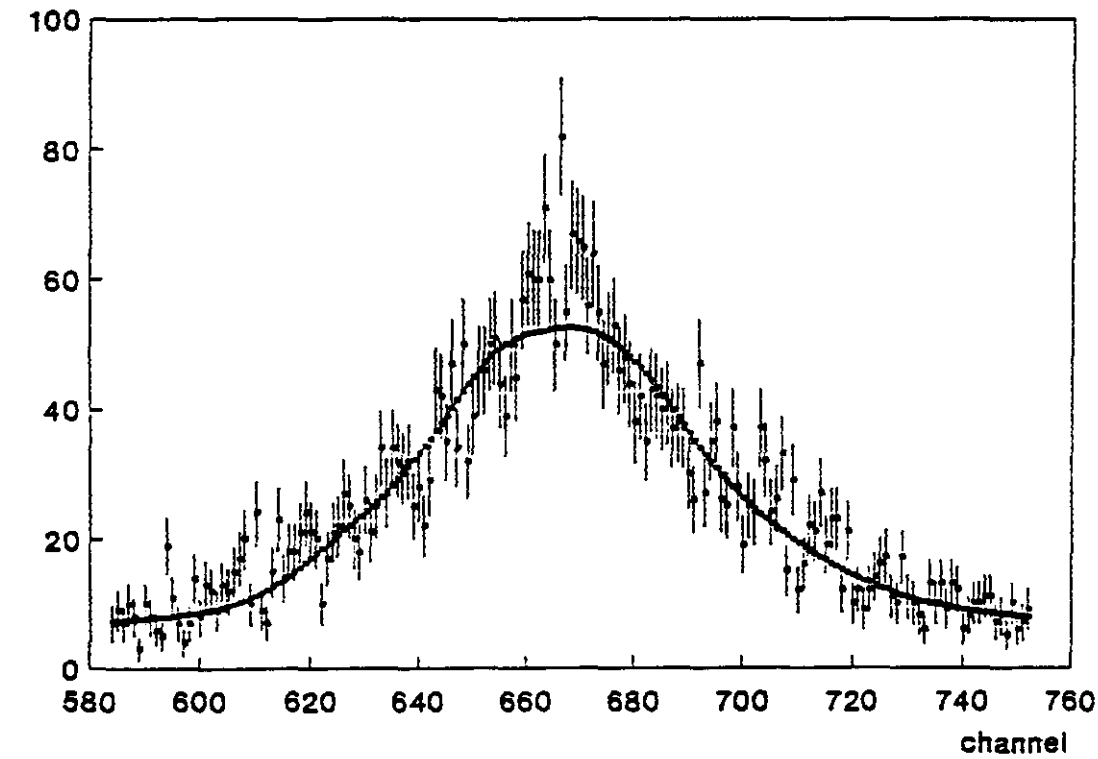



Fig.13 Position distribution; 30%Ar+20%CF_4+50%CO_2 gas mixture (without Xe)