In this experiment, the dark field image was observed by adjusting the aperture in the Fourier plane to choose the electron divergence angle in the assigned range. This might be useful for defect detection. The bright field image and dark field image of the TEM grid were shown in Fig.5.



Fig. 5 (color online) Bright field image and dark field image of the TEM grid.

## References

- [1] Yanru Wang, Zimin Zhang, IMP & HIRFL Annual Report, (2013)248.
- [2] Y. T. Zhao, Z. M. Zhang, H. S. Xu, et al., A high resolution spatial-temporal imaging diagnostic for high energy density physics experiments, Proceedings of IPAC2014, 2819(2014).
- [3] Q. T. Zhao, S. C. Cao, M. Liu, et al., Nucl. Instrum. and Meth A, 832(2016)144.
- [4] W. Gai, Nucl. Instrum. and Meth. A, 608(2009)S70.

## 5 - 10 Position Response of a LC Delay-line MWPC Detector

Hu Rongjiang, Zheng Yong, Duan Limin, Lu Chengui, Yang Herun, Zhang Junwei and Guan Yuanfan

A position-sensitive MWPC detector based on LC delay-line readout has been developed for precise position measurement for experimental studies of nuclear physics. The detector consists of six electrode wire planes, which is placed in a gas chamber with a sensitive area of  $100 \text{ mm} \times 80 \text{ mm}$ .



Fig. 1 (color online) Layout of the MWPC wire planes.

Fig. 1 shows a schematic drawing with the disposition of the six wire planes. This structure has two anode planes, each is sandwiched between two cathode planes, and the anode-cathode spacing is 4 mm. The anode plane, consist of 15  $\mu$ m gold-plated tungsten wires with a pitch of 3 mm. The two cathode pairs are positioned in such a way that the wires are perpendicular to each other in order to give positions at X and Y directions. The cathode planes in each pair are parallel each other in the orientation of the wires, which are made of 30  $\mu$ m stainless steel wires with a pitch of 0.5 mm. All

wires of each anode are connected together. For the X and Y cathode planes every adjacent four wires and their counterparts in the other plane in the same pair are soldered together to form one strip in order to enhance the induced signals.



Fig. 2 ( color online) The photograph of the LC delay-line board used in our MWPC detector.

In order to improve the read-out uniformity, a LC delay-line readout method is used to extract the X and Y coordinate information from the cathodes. Fig. 2 shows the photograph of the LC delay-line board developed by our group. The delay-line board is attached to the cathode wire plane such that its printed strips are electrically connected with the cathode strips, with a fixed delay of 2 ns per strip.

The position response performance of the assembled MWPC has been tested with a 5.9 keV X-ray  $^{55}$ Fe source. Fig. 3 shows the X and Y spectra of X-rays emitted from the collimated  $^{55}$ Fe source.

The peaks in the histograms were fitted by Gaussian functions and we extracted the position resolutions as  $\sigma_x = 225.9 \ \mu\text{m}$ , and  $\sigma_y = 201.2 \ \mu\text{m}$  at the X and Y directions, respectively. After eliminating the contribution of the

collimator diameter for the observed position resolution using Monte Carlo simulation, we then obtain the intrinsic position resolution as 199.9  $\mu$ m and 154.0  $\mu$ m for X and Y, respectively.



Fig. 3 (color online) Position spectra of X and Y tested with  $^{55}$ Fe source.

In order to provide information on the overall linearity for the X and Y coordinates, in Fig. 4 we present plots of the real coordinate as a function of the peaks centroids along the entire extension of the active area in X and Y. From the plots, one sees that the detector presents good linearity even at the extremes.



Fig. 4 (color online) Plots of the real coordinate as a function of the peaks centroids along the entire extension of the active area in X and Y.

## 5 - 11 Progress Report on Nuclear Electronics in 2016

## Su Hong

The progress and achievements, achieved in 2016 on research of nuclear electronics, developments of the instruments for the activities of nuclear and particle physics, and the relevant interdisciplinary are reported briefly in this paper. Some major creative works and activities implemented are introduced as below:

1. A front-end electronics (FEE) for an energy particle analyzer (EPA) has been developing by us, which will be mounted on the first satellite of our country circling Mars for exploring particles (electron, proton, alpha, heavy ions) in space environment of Mars. The principle prototype of FEE for EPA, and also the preliminary FEE (electric performance model) for EPA have been developed successfully in 2016. Meanwhile, a data acquisition system (DAQ) employed for test performance of the FEE in laboratory has been developed also.

2. A readout electronics with 256 channels was been set up based on  $\mu$ TCA(Micro Telecommunication Computing Architecture) crate, AsAd Zap **and** rCoBo boards from Saclay, France for a TPC detector that is been developing in our institute. Preliminary test combining with the TPC detector has been performed AsAd is a front-end readout board developed based on AGET chips, an ASIC chip for generic electronics of TPC designed by micro-electronics Laboratory of CEA/Irfu (Institut de Recherche sur les lois Fondamentales de l'Univers) in Saclay, France.

3. A new current to frequency converter has been developed for monitoring and measuring the irradiation dose in real time in heavyion treatment facility for cancer therapy Two kinds of circuits with different conversion