



A High Precision Signals Readout System for Micromegas Detector Based on the VMM



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1.Introduction

Compared with other types of detectors, high resolution of time and position is one of prominent characters of the micromegas detector. Micromegas detector is a parallel plate structure gas detector, and it consist of a drift electrode, a micromesh and signal strips. When a cosmic ray or a charged particle goes through the detector, a larger number of electron-ion pairs are generated in the detector's conversion gap. Because of the drift electric field, electrons move to the amplification gap where the avalanche breakdown occurs. Because the drift electrode and the micromesh are connected to different negative voltage, and signal strips are connected to the ground, therefore, the charge polarity of the strips is negative.

There are three important parameters to value the performance of micromegas detector: energy resolution, time resolution, and position resolution. Both of the detector and the readout electronics system have obvious impacts on resolutions. High energy resolution requires the readout system can sample signals with high precision; high time resolution requires the readout system have a short dead time; high position resolution means high density of signal strips, so it requires readout system can process multi-channel signals and a huge mess of signal data. The VMM is an appropriate front-end ASIC to realize the micromegas readout system. It has adjustable signal polarity and 64 linear front-end channels. For sampling signals with high precision, the VMM integrate lots of high precision ADCs. This paper introduces a high precision readout system for micromegas detector, and the whole system has three main parts: front-end electronics based on the VMM, data acquisition system and the control software.

2.System Design

The simplified block diagram of the readout electronics system for micromegas detector based on the VMM is illustrated in Fig.1. When a cosmic ray or a charged particle goes through the detector, the detector output corresponding signals to the front-end board, and then these signals will be measured by VMM3 chips on the front-end board. The FPGA on the front-end board buffer the data from VMM3 chips, and send the data to the data acquisition board (DAQ board). The DAQ board wrap the VMM3 data, and send the data to host computer through Ethernet. This is a whole data readout process of the readout system.

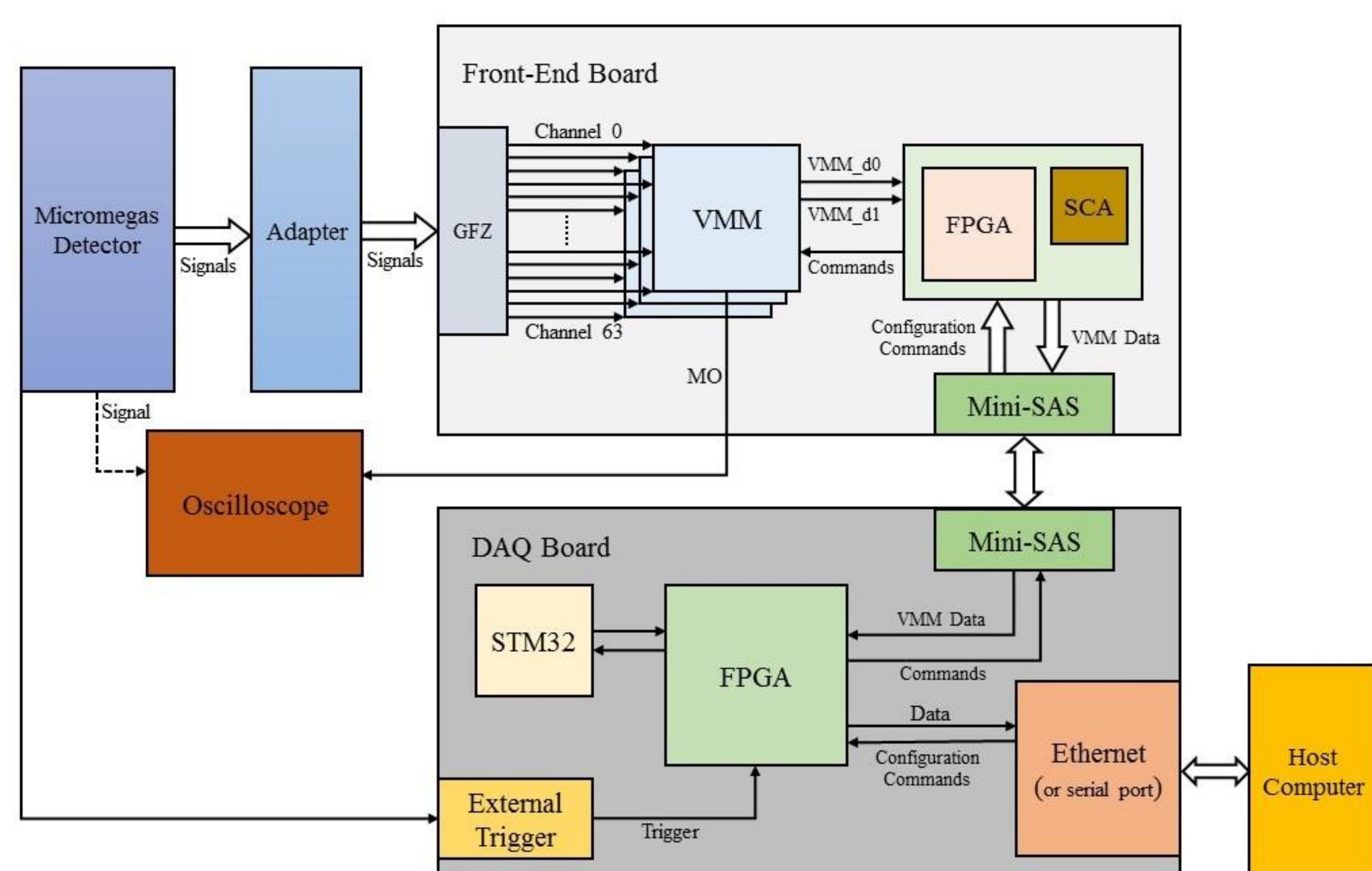


Fig.1. Schematic block diagram of the readout system

Before the readout process, users should configure the VMM3 chips at first. Users set needed configurations at the control software on the host computer, and send configuration commands to control the working mode of VMM3 chips. The DAQ board is in charge of the commands communication between FEB and host computer, because the front-end board can't connect with host computer directly.

The product photograph of the front-end board is shown in Fig. 2. The front-end board mainly consists of a GFZ connector used as detector signals input ports, three VMM3 chips, a FPGA, a slow control adapter (SCA), and two mini-SAS connectors. VMM3 chips send out measure results of the signals through VMM_d0 and VMM_d1 two data lines to the FPGA. The FPGA on the front-end board analysis and pack the data, through the mini-SAS cable, signals data are sent to the DAQ board. The SCA is mainly used for configuring VMM3 chips. Besides the digital signal data, there is also an access to observe each channel's analog signal through the MO port.

There are three VMM3 chips (192 channels) on this type front-end board, for different detector requirements, changing the number of VMM3 chips to control the number of front-end electronics channels.

The product photograph of the data acquisition board (DAQ board) is shown in Fig. 3. The DAQ board mainly consists of mini-SAS connectors, a FPAG, a STM32 chip, an Ethernet module, and an external trigger module. The FPGA on the DAQ board receives VMM data from mini-SAS connectors, and then analysis and wrap the data to meet Ethernet transmission requirements. The wrapped data are sent to the host computer for analyzing or storing.



Fig.2. Photograph of the front-end board



Fig. 3. Photograph of the front-end board

During the configuring process, configuration commands from host computer are decoded on the DAQ board, with the cooperative work of the STM32 chip and the FPGA, and then the FPGA send decoded commands to the front-end board to configure VMM3 chips.

Besides, there is an external trigger module on the DAQ board to control the data acquisition process. The external trigger comes from micromegas detector, and it is a start signal for the DAQ board to read out signal data.

Users can conveniently set VMM3 configurations and acquire data on the control software GUI (Graphical User Interface). During the experiment, user just need to control the GUI, don't have to adjust the physical readout system.

3.Readout System Performance

As shown in Fig.6, a signal from micromegas detector cause analog outputs of on VMM3 channels. The output signals have good SNR (signal to noise ratio) and good shaping result. Fig. 7 shows an energy spectrum of Fe55 X-ray which is the statistics result of the readout data from this readout system. Analyzing this energy spectrum, the energy resolution is 20.6%. The energy resolution can reach a lower degree by adding test time and adjusting VMM3 configurations.

For VMM3 chips, each channel has a minimum 200 ns dead time after a peak is found, which can totally meet the requirement of micromegas detector to realize the high time resolution. For VMM3 chip integrates 64 front-end channels, it's quite convenient to realize high channel density readout system, which can ensure the high position resolution of micromegas detector.

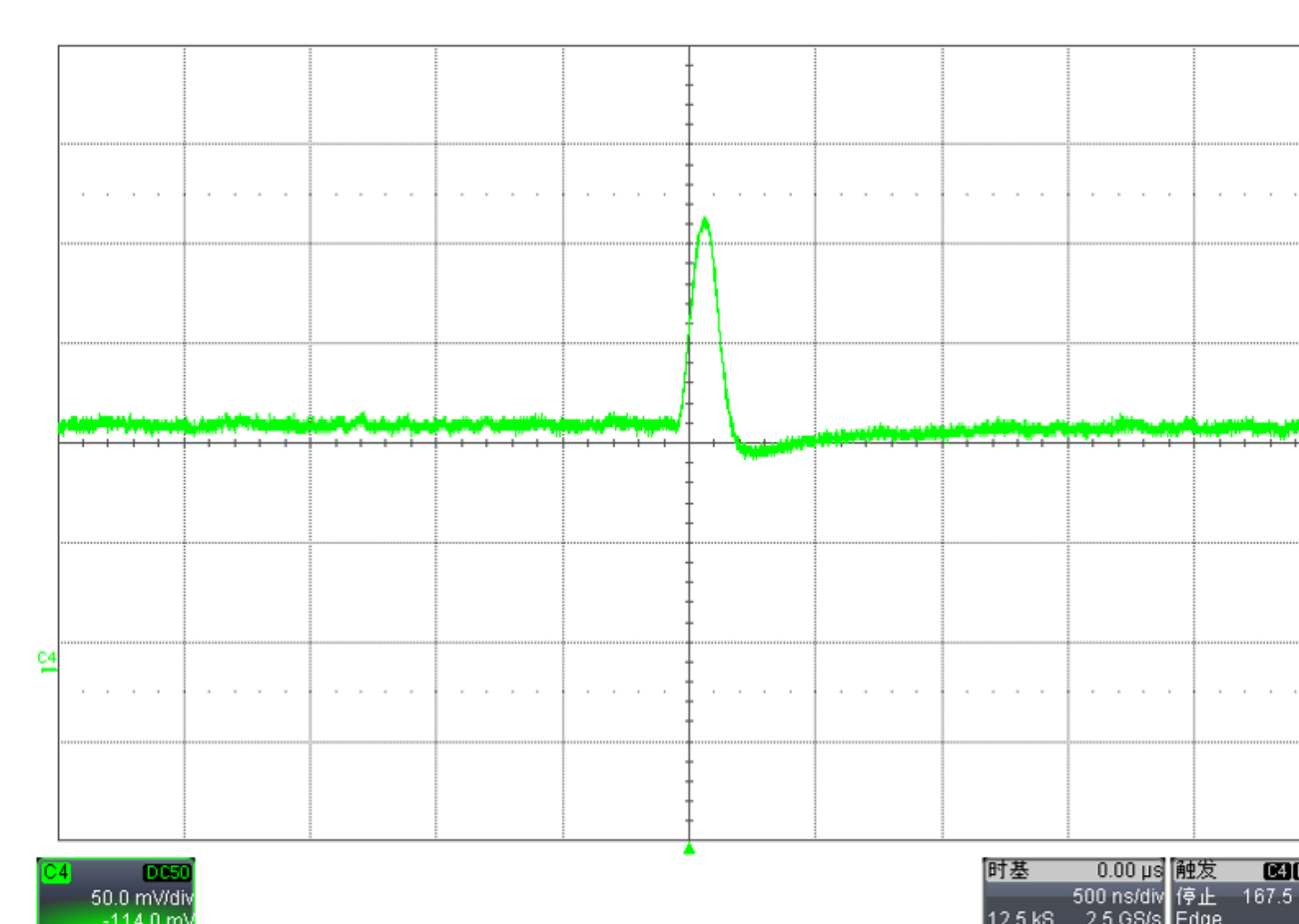


Fig. 4 Analog signal output of a VMM3 channel

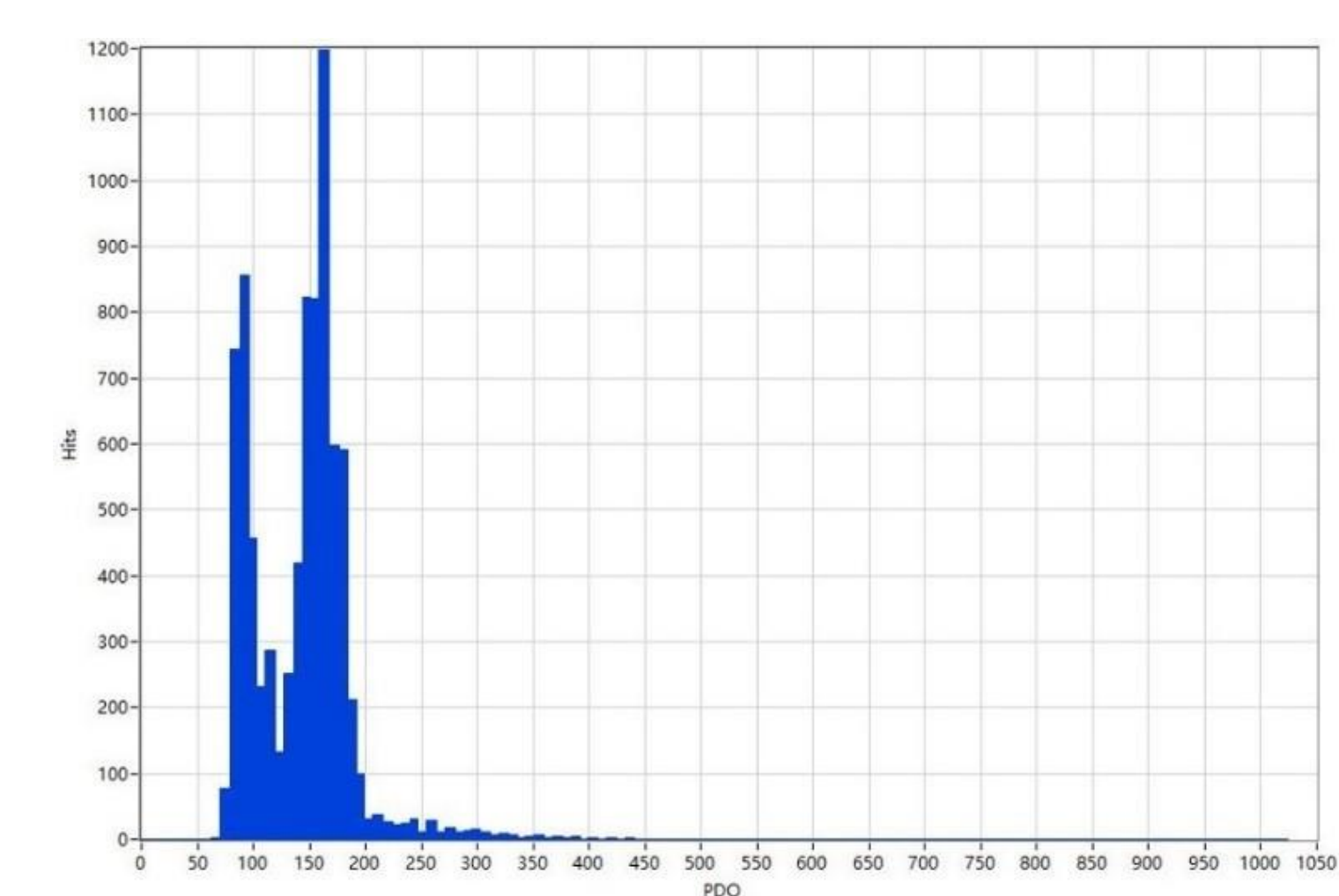


Fig. 5 Energy spectrum of Fe55 X-ray

4.Conclusions

The whole readout system include three important parts: front-end electronics, data acquisition system and the control software. The core of the front-end electronics is the VMM3, and the data transmission between the host computer and the data acquisition system uses Gigabit Ethernet. In view of the applicability of VMM3 chips and this readout system, this high precision readout system can also be used in other kinds of detectors.

References

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