MULTIWIRE PROPORTIONALCHAMBERS IN M1 AND M3 SPECTROMETERS OF CHARMED BARYON EXPERIMENT (E781) AT FERMILAB

by

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MASTER’S THESIS

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ABSTRACT

The status of the multiwire proportional chambers in the FERMILAB E781 experiment and a general description of the readout system are given.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER I

INTRODUCTION

This essay will describe the system of multiwire proportional chambers (MWPC) that are part of the Fermilab experiment E781 setup. Multiwire proportional chambers are often used in particle physics experiments because they can determine the position of charged particles very accurately (less than a millimeter).

The E781 experiment which is also called SELEX (SEgmented LargE- X) is a spectrometer designed to study the production and decay of charmed baryons. MWPCs are part of the 3-stage charged particle spectrometer (Figure 1). Each spectrometer stage includes a bending magnet and chambers. More information about E781 experiment is given in the Appendix.

In the following, some basic concepts of MWPCs will be given briefly. After that the multiwire proportional chambers (M1PWC and M3PWC) that are used in the E781 fixed target experiment will be described. Then a general description of the readout system for both M1PWC and M3PWC setups will follow. Finally the tests done on both sets of chambers will be explained in detail.

CHAPTER II

MULTIWIRE PROPORTIONAL CHAMBERS

Ionization detectors have long been used for radiation detection. The Radiation is detected by collecting the electron-ion pairs produced by charged particles as they pass through the detector. It has been shown that gas is a suitable medium for the collection of ionization electrons and ions produced by the passage of charged particles. In liquid and solid mediums charge collection efficiency will be much lower since the electron-ion pairs will be stopped before reaching the anode and cathode much more quickly because of higher density.

Gaseous detectors are usually operated in three different modes depending on the magnitude of the high voltage applied to the detector. These can be classified as ionization, proportional, and Geiger-Mueller mode. When a charged particle passes through matter it leaves a trail of electron-ion pairs. As the high voltage applied to the gas is increased, more of these electron-ion pairs are collected before they can recombine. At some high voltage value, all the electron-ion pairs created will be collected. Further increase in the high voltage for a specific range above this value will not have much effect. A detector working in this region is called an ionization chamber sin ce it collects the ionization produced by the charged particles passing through the gas.

If HV increased beyond the ionization chamber value there will be a noticeable increase in current. This occurs because of secondary ionization. The electric field is then strong enough to increase the energy of the primary electrons sufficiently to ionize more gas molecules in the detector. These secondary ionizations will further multiply until an avalanche occurs near an anode wire since electric field is stronger in this region. The number of electron-ion pairs in the avalanche is proportional to the number of primary electrons with a multiplication factor depending on the applied voltage. This factor can be as high as 10^6. A detector working in this region is called a proportional counter. Since the number of electron-ion pairs created by a charge particle passing through matter is proportional to its energy, current will be proportional to the energy of the charge particle.

If high voltage is increased beyond proportional range, the energy gained by the electrons will become large enough that the avalanche will occur throughout the gas giving rise to a breakdown. Current is no longer proportional to the energy of the incident particle. Detectors working in this voltage region are called Geiger-Mueller (GM) counters or breakdown counters. A further increase in voltage can lead to spontaneous breakdowns in which case they become useless as particle detectors. In particle physics experiments

proportional counters are preferred because they have a higher gas gain than the ionization chamber and faster recovery time compared to GM counters.

In proportional counters several factors affect the selection of the specific gas mixture. These factors are low working voltage, high gain, good proportionality, and high rate capability. To operate at low voltages (2-3 kV) noble gases are preferred since they require low electric field intensities for avalanche formation. Argon is the most suitable gas for this purpose because of its higher ionization and low cost. However it is not possible to optimize all the above factors using a monatomic gas. The disadvantage of using argon gas is the fact that it leads to a discharge at about 10^3 - 10^4 gain. This problem can be reduced by adding a polyatomic gas, such as CO_2, BF_3. These polyatomic molecules act as quenchers by absorbing the radiated photons that cause secondary avalanches. P10 (90% argon, 10% methane) mixture is commonly used in proportional counters. This allows one to go to higher voltage and thus higher gains before the onset of discharge. Isobutane is also

used as a quenching agent. A further improvement can be achieved by adding an electronegative gas to the mixture resulting in an increase in the gains before Geiger-Mueller discharge. Best known electronegative gases are Freons (CF_3Br in particular) or ethyl bromide. Apart from their additional photon-quenching capability, the electronegative gases capture free electrons forming negative ions that cannot induce avalanches in field values normally met in a proportional counter and gains around 10^7 can be safely obtained before discharge or breakdown[2]. A very high gain can be obtained using a gas mixture consisting of isobutane (24.5 %), argon(75 %) and Freon-13B1 (0.5 %). This mixture is also called "magic gas". A gain factor as high as 10^7 can be obtained with this mixture

Proportional multiwire chambers contain anode and cathode planes (Figure 3). Anode planes are constructed by equally spaced (typically 20 - 40 micrometer in diameter) gold plated tungsten wires mounted on frames. Cathode planes are made of thin metal foils or wire mesh or thin strips of

conducting material stretched on similar frames. The detector windows are usually made of mylar and the frames are bolted together with O-rings in between to ensure a good sealing. Another important factor in the chamber construction is the electromechanical stability of the wires which is achieved by winding the wire plane with proper tension in the wires. When high voltage is applied to the wires there will be an electrostatic repulsion between them, which must be balanced by the mechanical tension in the wires. The relation between tension in the wire and applied voltage is given by [2]

$$V \leq \frac{s}{lc}\sqrt{4\pi\varepsilon_0 T} \text{ ,}$$

where s is the wire spacing, l is the length of the wire, c is the capacitance per unit length, T is the wire tension, V is the applied voltage. $1/4\pi\varepsilon_0 = 9.0\times10^9$ N m^2/C^2. The implication of the above equation is that there is a maximum voltage that can be applied to the chamber for a given tension in the wires.

CHAPTER III

MULTIWIRE PROPORTIONAL CHAMBERS IN E781

There are three sets of MWPCs in E781 setup. The first and the third set will be described here. The second set of chambers was operated by the Russian group (see Figure 1).

3.1 M1 MULTIWIRE PROPORTIONAL CHAMBERS(M1WPC)

Outside dimension of each chamber is 2390x2390 mm^2 and inside dimension is 2000x2000 mm^2. Each chamber consists of 11 stesalit (Predominantly, epoxy and phenolic resins reinforced with carbon, aramid or glass fibers) frames each 6 ± 0.05 mm thick (Figure 2). The cathode planes are built by stretching plastic foils over these stesalit frames. These foils are coated on both sides with graphite to ensure the conductivity and to remove the charges accumulated on the surface. The graphite coating of the planes was applied by twice spraying the planes with Acheson 502 paint diluted with 50% methy-butyl ketone. The tension of the foil was set to about 490.5 N/m (50 kg/m) by using a dynanometric key. The conductive external sides of the first and the last cathode foils remove electrostatic charges accumulated on the surface.

The M1 Multiwire Proportional Chamber consists of a set of thin, parallel, and equally spaced anode wires located between two cathode planes. For chambers with a sensitive area of 2x2 m^2, each plane is made of 640 gold plated tungsten wires, spaced 3 mm apart. The wires are 25 μm thick and are soldered on printed boards with a precision of 0.1 mm and a tension of 0.6867$\pm$0.04905 N (70$\pm$5 g). There are three guard wires with diameters of 50, 75, and 100 μm, located at the edges to make sure that the electric field is uniform throughout the plane.

There are four different anode plane orientations (X, Y, V and U) in each MWPC (Figure 3), vertical, horizontal and slanted planes with an angle of $\pm 28.07^0$ with respect to the vertical direction. These angles are chosen because their sine and cosine values are rational numbers (8/17 and 15/17). Computer programs written for specific calculations involving such numbers can be optimized to run faster. It is necessary to use two sets of coordinate planes, X-Y and U-V, to resolve the left-right ambiguity in the hit position obtained from the wire number. The separation between two anode wire planes is 12±0.05 mm. Each chamber has two zig-zag shaped Mylar strips (garlands), 5 mm wide, located between the cathode foils and the anode wires (Figure 4). They reduce the effective free wire length to a third of the total that is measured to be about 0.7 m for this kind of chamber. In case of unbalanced electrostatic force the garlands suppress the bending of the cathode foils. The garlands are 0.3 mm thick and they are attached to a supporting nylon wire at three points. The nylon wires are connected at both ends to the stesalit frames with a tension of 9.81 N (1 kg). There are also insulated field wires, 0.9 mm diameter, stretched along the garlands in the 1 mm space between the garlands and the anode wires. These field wires are used to restore the local chamber efficiency reduced by the garlands. In E781, these wires are set to 1500 V.

Iron frames hold the 11 staselit frames and cathode-anode planes together. The frames are made of iron because the thermal expansion coefficients of iron and stesalit are nearly the same. The MWPCs are assembled with pins and screws through the frames. The gas tightness is secured by O-rings placed in grooves in the chamber frames. There are four gas inlets and outlets distributed along two opposite sides of the frame to provide a uniform gas flow.

3.2 M3 MULTIWIRE PROPORTIONAL CHAMBERS (M3PWC)

There are three types of Multiwire Proportional chambers located in the downstream after the M3 magnet in E781 experiment. These so-called Lambda Chambers are smaller than the M1PWCs mentioned above. The first chamber consists of four planes (V, Y, X and U). The second one has only two planes (Y and X) and the third one has three planes (Y, X, and V). One significant difference between these chambers and the large chambers discussed above is that these chambers have wire cathode planes with transparent windows as opposed to having a graphite surface plane with opaque covers (Figure 3).

3.2.1 FIRST LAMBDA CHAMBER (M3PWC1)

The size of the first Lambda chamber is 64x64 cm^2 (internally) and each plane has 320 wires with a 2 mm wire spacing. There are two wire cathode planes for each anode plane and there is a gap, 8 mm, between the two cathode planes. The slanted planes are installed at an angle of $\pm28.07^0$ with respect to the vertical similar to the M1PWCs. The distance between the V and the Y plane is 52±0.05 mm, so is the distance between the X and the U planes. On the other hand, the distance between the X and the Y plane is 14±0.05 mm (Figure 3)

3.2.2 SECOND LAMBDA CHAMBER (M3PWC2)

The second chamber is the same as the first one except it has two planes: X and Y, with a 24±0.05 mm separation. The wire spacing is the same as for the first Lambda chamber.

3.2.3 THIRD LAMBDA CHAMBER (M3PWC3)

The third Lambda chamber is quite different in comparison to the first and second Lambda chambers. The internal dimensions of this chamber are 115x89 cm^2. It has three planes: Y, X and V with a 2 mm wire spacing. The first plane consists of 448 wires, the second one has 576 wires and third one has 672 wires. The plane separation is 12±0.05mm.

3.3 MWPC ELECTRONICS

Several methods have been used in different experiments in order to get information from a MWPC. The standard method is to take account of each wire in the chamber as a separate detector connected to its own electronics. In Figure 5 a general pulse processing circuit is shown for one wire. The signal is amplified, discriminated and shaped to a standard logic level[1]. A similar set up is also used in E781 experiment. The readout system for the Lambda chambers is the same as that for the M1PWC's. In E781 the M1PWC readout system is called RMH12 and the Lambda or M3PWC readout system is called RMH3.

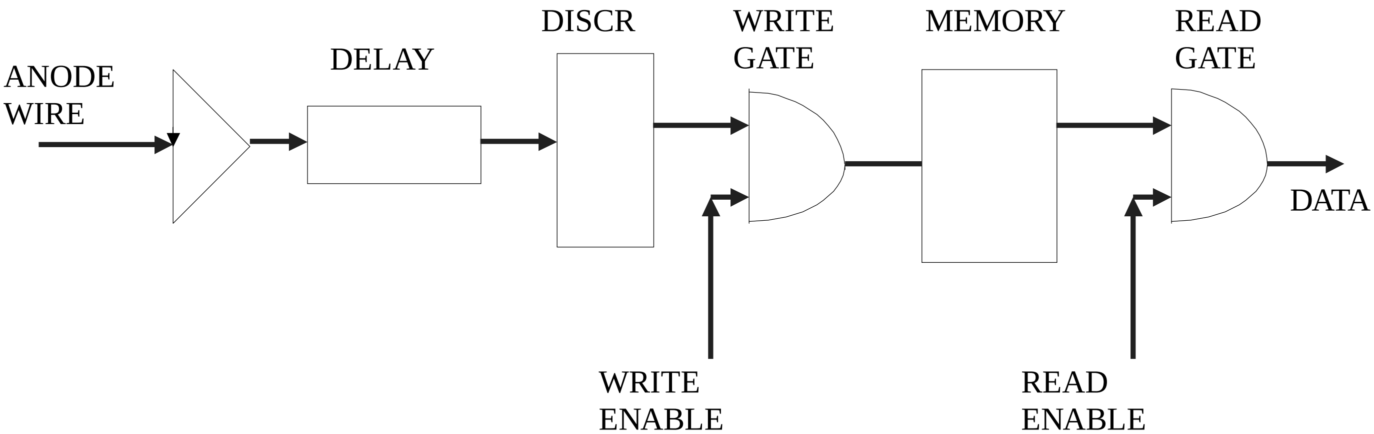

Figure 5. Block diagram of the readout electronics for a wire in a MWPC.

The electronics setup for the chambers will be discussed in three parts: preamplifier cards, the readout system, and the readout control logic.

3.3.1 PREAMPLIFIER CARDS

The signals from each wire are usually too weak to be transferred to the readout system directly. Preamplifiers are used to amplify the weak signals from the detector and to drive them through the twisted cables that connect the preamplifiers with the readout system. Because of the low signal levels the noise might be significant and also additional noise may be picked up. In order to reduce or keep the noise level to a minimum the preamplifiers need to be mounted as close to the detector as possible. Each preamplifier card contains 32 individual amplifiers with a differential gain of 7±1 for each channel. Preamplifier cards are supplied with -5.2 V.

3.3.2 READOUT SYSTEM

The RMH[2] (Receiver-Memory Hybrid) readout system, developed at CERN, is used for the purpose of processing the PWC signals, encoding the resulting hit pattern, and transferring the encoded data to the main data acquisition system. Each RMH crate contains 22 RMH modules, 1 Crate Controller (CC), 1 Crate Encoder (CE). The overall RMH system is read out with 1 system Encoder (SE), Branch Receiver (BR), and Interface (IF).

RMH Modules

The RMH modules discriminate the received detector signals and strobe them into memory. The signals from the individual wires amplified by the preamplifier cards installed on the chambers come to the RMH modules via a special 32 pair twisted cable. The length of this cable is chosen so as to

delay the chamber signals to allow enough time for the trigger to be formed. In the E781 experiment this cable length is 80 m long and it gives us 400 ns (1m=5ns) delay in the chamber signals. Each RMH module has inputs and outputs on the front panel and on the back. The front panel inputs consist of 32 wire signal inputs (push-pull via edge connector), a flag switch to indicate the beginning of a different detector in a specific unit, one fast strobe (NIM lemo connector) and a threshold control which can be screwdriver adjusted through a front panel trimpot in the Crate Controller (CC) unit. The threshold level measured at the monitor posts can be from -1.4 V to -5.2 V corresponding to -5mV to -25 mV in the signal (Figure 6). The threshold has to be set to such a voltage that all valid signals will be accepted and noise will be rejected. The outputs include a monitor giving real time signals for each channel that has a nonzero input.

The rear connector inputs consist of a fast strobe (crate), a read, a reset, and a threshold control. Outputs consist of data (16x2 pins), a flag (1x2 pins), memory OR upper 16 channels (2

pins), memory OR lower 16 channels (2 pins), memory OR of 32 channels (2 pins) and a monitor (2 pins)[4]

The RMH modules are located in a special RMH crate that contains at most 22 RMH modules. Each crate should have a crate encoder (CE). Up to 16 CEs can be connected to the branch highway. All the CEs communicate with a system encoder (SE) which is mounted in a regular CAMAC crate. In E781, there are four crates in RMH1, eight crates in RMH2 and eight crates in RMH3 readout system.

Crate Controller

The crate controller[4] (CC) is similar to a CAMAC crate controller and designed for the specifics of the RMH system. It contains the threshold adjustment, an overall monitor output and a fast reset input to reset all RMH modules in the crate. All modules can be strobed in parallel via the CC strobe input. Slot 25 is occupied by the CC in each crate.

Crate Encoder

The main purpose of the crate encoder[6] (CE) is to receive the data pattern from the RMH modules and to encode this data pattern into a 16-bit data word, including the relevant information about the station number of the specific RMH module and the crate address. The crate address is set with a screw driver by selecting the appropriate number in the switch in the front panel of the CE. The data from the RMH modules are logically divided into lower and upper halves (channels 0 - 15 and channels 16-31). Only the halves of modules containing data are addressed. The CE occupies station 23 and 24 in the RMH crate.

System Encoder

The system encoder[7] (SE) is housed in a CAMAC crate. It is used to control the data pattern from the crate encoder modules. It starts the readout via the start read signal (ST/R) that comes from an external device such as the CAMAC interface (In E781 case a DYC interface is used). The SE receives branch data in strobed mode and forms for each piece of data a 16 -bit binary coded word. The output data flow is controlled via double handshake mode and end of read (EOR) signal indicates the completion of an event.

Branch Receiver

The branch receiver[8] (BR) is used to extend the addressing capability of the RMH system. More than one (up to 18) BRs could be connected. Any branch cable should be connected to one of the BRs to transfer the data in that particular branch to the Data Acquisition System (DAQ). In E781 experiment no branch receiver is used. Each set of chambers sends data to their system encoder directly.

Interface

The regular CAMAC interface[9] is designed to communicate with the System Encoder via the internal output bus and to perform block transfer operations via repeat, pause, or stop mode. There is an interface that is specially designed to communicate with a damn yankee controller (DYC) unit (see below) in the E781 DAQ system, called a DYC interface. It is located inside the same CAMAC crate as that for SE and BR units.

DYC3b[10]

This module has been designed and built by the Fermilab Physics Department. It buffers the data from the RMH and reformats the 16 bit-word data into 32 bit-word data. It is a double-wide CAMAC module. It accepts data and control signals from the RMH modules; latches four front panel input bits (event ID), attaches a leading word count to the RMH data and transmits a header longword (word count and front panel bits). The front panel of the DYC3b consists of some lemo connectors and LEDs. The lemo connectors are:

- FERA(Fastbus Encoding Readout and Anolog to Digital Converter) CLEAR and GATE Input: Both are NIM(Logic 1 output: -14 to -32 mA, input: -12 to -32 mA. Logic 0 output: <+2 mA, input: -4 to 20 mA) signals which are retransmitted on the FERA bus. (DYC unit is designed to be compatible with FERA format). Where FERA consists of module designed for fast conversion of anolog information, either charge or time intervals, into a digital format; it also provide fast readout to a storage memory module or to a computer for further processing.

- **RESET Input: NIM signal which resets the DYC3b, 40 ns is the minimum pulse width.**
- **PERMIT IN(input) PERMIT OUT(output): Both are TTL level signals (Transistor-Transistor Logic. Signal levels defined as follows:**
  Logical 0=0 to 0.8 V and Logical 1= 2.0 to 5.0 V), used for multiple DYC3b configuration.
- **HF/AF (Half Full/Almost Full) output: Jumper selectable for either Almost full or Half full. In the case of E781 experiment HF is being used. It is a NIM level signal. Half Full is synchronous with End of Event (EOE) signal.**
- **BUSY OUT: NIM level output of request (REQ) signal which indicates that FERA read out is in progress.**
- **EOE: a NIM input signal which tells us that it is the end of an event cycle. It must be at least 35 ns wide. Since it encodes the header word and the event ID, it must satisfy 10 ns setup and 10 ns hold requirements with respect to the leading edge of EOE.**

The front panel LEDs are:

- **EMPTY: indicates that FIFOs(First In First Out) are empty.**
- **ALMOST FULL: the FIFOs are almost full and the FERA read out is paused.**
- **FERA STROBE: the DYC3b is currently receiving data from FERA.**

3.3.3 READOUT CONTROL LOGIC

There are two trigger level signals that are used for the data processing, T1 and T2. T1 produces a strobe signal that is sent to all the crate controllers to start latching the data into the memory (Figure 7). The trigger logic system also sends a signal (T2) which is redefined as REQ. This is sent to the DYC3b for starting the data processing. The T2 signal may not come at every event since the existence of a T2 signal by definition indicates a valid event type. If the event is an unwanted event there will be no T2 but a $\overline{T2}$ signal. Upon receiving the REQ signal, the DYC3b sends a read-enable (REN) signal to the DYC Interface. Then the DYC Interface sets the BUSY on

so that there will be no additional T1 and T2 signals coming. This BUSY signal is sent to the trigger logic system to be included in the general trigger. When the SE receives the start-read (ST/R) signal through the DYC interface, it starts transferring the data encoded by individual CEs in each crate. SE and DYC interface are connected internally. In addition to turning on the BUSY signal, the SE also sends a write strobe (WST) signal to the DYC3b after receiving the REN signal. Then DYC3b reads one data word. This process continues until all data words in the RMH system are transferred to the DYC3b buffer memory. When the data transfer is completed DYC interface sends an end-of-read (EOR) signal to turn off the REQ signal latched by a gate-and-delay generator. At the same time it also sends an end-of-event (EOE) signal to the DYC3b. When the DYC3b receives the EOE signal, it turns off the REN signal to the DYC interface which causes the BUSY signal to go off. This signals the completion of the readout cycle of the RMH system to the main trigger.

CHAPTER IV

EFFICIENCY OF THE MWPC

Basically, chamber efficiency depends on the number of electron-ion pairs produced and collected in the chamber[1]. There are several aspects that affect the efficiency of the chambers. As mentioned before these are the gas mixture, high voltage, the threshold setting, and the gate width on the readout electronics that selects the correct signals.

4.1 GAS MIXTURE

The most commonly used gas mixture is isobutene (24.5 %), argon (75 %) and Freon-13B1 (CF_3Br)(0.5 %), which is the so-called "magic gas". As mentioned before, using this gas mixture provides gains of 10^7. The concentrations for different gas types in a gas mixture can slightly vary according to the chamber specifications. For instance, chambers with 2 mm wire spacing can plateau at over 90% efficiency with 0.3% Freon, 22% isobutane and 77.7 % argon mixture. R.Bouclier et al. (1970)[11]

determined that one cannot reach full efficiency if Freon concentration is larger than 0.3 %. Various tests have been done with different isobutane and Freon concentrations in order to find an appropriate mixture for the chambers mentioned in this essay. The test results can be seen on the following figures: Figure 8 and 9 show efficiency vs. HV with different gas mixtures for M3PWC X plane of the first, the second and the third chamber. The relation between isobutane and HV can be seen on Figure 10 for M1 and M3PWCs. For chambers with 2 mm wire spacing it turns out that the best mixture is that containing 0.3% Freon and 22% isobutane. For chambers with 3 mm wire spacing this ratio is different. In the case of E781 experiment M1PWCs operate best with a 24.0 % isobutane and 0.15 % Freon concentration. Desired gas mixture for each chamber system is supplied by a dedicated gas handling system.

4.2 HIGH VOLTAGE

In E781 experiment M1 multiwire proportional chambers are operated at a HV value of 3.0 kV with a 24.0% Isobutane and 0.15% Freon concentration. On the other hand, the M3 multiwire proportional (Lambda) chambers are currently operated at 4.3 kV (2mm wire spacing) with a 22% Isobutane and 0.3% Freon concentration. Since there are unacceptable dark currents (currents observed with no beam) in some of the Lambda chambers, the optimum gas mixture is yet to be decided.

4.3 THRESHOLD SETTINGS

The threshold setting is very important in optimizing the operation of the chambers. In M1 multiwire proportional chambers, the thresholds are set to - 1.4 V. On M3PWCs the threshold setting is -1.6 V. The threshold settings are selected to reduce the noise without lowering the efficiencies.

4.4 GATE WIDTH ON THE READOUT ELECTRONICS

The main idea for the RMH system is to put all the hit information into the memory simultaneously, since all the signals come in at the same time, and to read out the information stored in the memory sequentially. The signals from the hit wires amplified by the preamplifiers are transferred to the RMH modules by twisted pair cables. The data input of the RMH modules are activated by a strobe signal. That is, every pulse present at the data input of a module during a strobe signal is transferred to the latch circuit where it is stored for later readout.

In E781, the strobe gate signal has been adjusted to be 210 ns wide for M1PWCs and 400 ns for M3PWCs. This is a time window sufficient for collecting the data from the chambers. This gate has to be wide enough to accept all the signals from the chambers and short enough to reject the signals considered to be noise.

CHAPTER V

EFFICIENCY CALCULATION

The efficiency studies were done by two different methods: source and beam method.

In the source method, the chamber efficiency is usually calculated by locating the chamber between two beam-defining scintillation counters. Using the coincidence between the counters as a trigger, the number of signals coincident with this trigger divided by the number of triggers yields the efficiency[1]. Several tests have been done for the MWPCs. A Sr^{90} source, that emits electrons with sufficient energy was used. A small scintillation counter was placed behind the chamber. Electron source was in front of the chamber. Signals coming from the small counter behind the chamber were assumed to be produced by the electrons that passed through the chamber. The efficiency in this case is obtained by dividing the number of chamber signals in coincidence with the scintillation counter signals divided by the number of scintillation counter signals. Several plateaus were obtained under different conditions (Figure 11). The first plateau curve is from a previous experiment (8/14/83). The other plateau measurements were done with a source with different gas mixtures (Figure 11) in the E781 experiment. Data shown in Figure 12 were taken with beam with M1, M2, and M3 magnets off and the target out of the beam.

In the beam method, the negative pions from the hyperon beam are used. The efficiency is calculated by using the pions whose tracks are determined by different detectors. For instance, for M1PWCs, beam, vertex and M2 detectors are used to select a well defined pion-track that passes through the chambers. In this method, all the track segments for such a pion from other detectors are combined to give a single full track. Then this track is either interpolated or extrapolated to a specific chamber plane position depending on the type of the track segments selected. The efficiency is then simply the ratio of the number of tracks that are accompanied with a nearby hit to the total number of tracks used. This way of measuring the efficiency is more realistic since it is done under actual running conditions. The efficiency of the M1PWCs is usually very high, with values of 97-99 %. The track segments used to measure the efficiency of M1PWCs are taken from beam, vertex and M2 detectors.

The efficiency calculation for M3PWCs were done using the beam as explained above. Using the beam pions in this case is more critical since the M3PWCs are located downstream far from the upstream part of the setup (see the location of the M3PWC in Figure 1). Using the tracks for particles with short lifetime may result in a lower efficiency than the actual value since some of these particles may decay or scatter before reaching the M3PWCs. The efficiency of the M3PWCs were measured by using the track segments obtained from beam transition radiation detectors (BTRD) and M2 detectors.

CHAPTER VI

CONCLUSION

After testing the readout system for the M1PWCs, it has been decided to have two, almost independent, systems for transferring the data from the RMH memory to the main DAQ. Otherwise the data coming from all 11 planes would be readout by a single system. Having a single system was observed to cause frequent hang-ups in the main DAQ. The DYC3bs for each system were daisy chained together so that the data could be transferred through the same fiber optic system. However, the data coming from the M3PWCs can be read out by a single system since there are only nine planes that are smaller than the M1PWC planes.

The M1PWC readout system is currently operational with occasional glitches in the system

(somewhat random and maybe due to instantaneous high rates in the system). M3PWC system will be finalized after determining the optimum operating conditions for each individual chamber.

Various gas mixtures were tested for M1PWC chambers. The highest efficiency (95 % per plane) with the beam is obtained with a gas mixture having 24.0 % isobutane, 0.15 % Freon, and 75.85 % argon plus a small amount of isopropyl alcohol. The operating voltages were determined to be 3.0 kV. On the other hand, the optimum gas mixture and the HV for the M3PWCs have not been determined yet. Since there was no dedicated gas handling system for these chambers, testing different gas combinations to find the best possible mixture was impossible. With the recent modifications to the gas handling system, independent adjustments to the M3PWC gas mixture can be made. Tests to determine the optimum gas mixture for M3PWCs are under way. The M3PWC system, both chambers and readout parts, will be finalized soon.

CHAPTER VII

APPENDIX

E781 SEGMENTED LARGE-X (SELEX) EXPERIMENT

The aim of this experiment is to make a systematic survey of charm baryon production and decay physics[12]. The apparatus for the experiment is located in the Proton Center beam line (PC4) at Fermilab. The experiment is using a 600 GeV "Hyperon" beam that is a mixture of negative sigmas (Σ^-) and negative pions (π^-) produced by a 800 GeV primary proton beam provided by the Fermilab Tevatron. Intensity of the primary beam is about 7×10^{11} protons and 7×10^{6} particles per spill (hyperon beam). Each spill is 20 sec long.

The SELEX experiment is designed as a multi-stage spectrometer to study the production and decay of charmed baryons. The beam spectrometer is designed to measure the incident beam trajectory to a precision of 3 mm in x and y, using 20 mm pitch silicon strip detectors (SSDs). The transition radiation detector (TRD) system is used to separate sigmas and pions.

The Ring-imaging Cherenkov (RICH) counter is one of the major systems in SELEX. RICH is useful for pion/Kaon (π/K) separation up to 250 GeV/c.

The drift chambers or so-called Vee chambers have been designed to track lambda decays. The Vee chambers consist of nine drift chambers set in three stations.

Forward lead (Pb) glass array and neutron calorimeter are designed to detect neutral particles, photons, neutrons, neutral pions, and so on. There are three magnets located in PC4:

- M1, a large acceptance low-momentum (2.5 GeV/c) magnet, is designed to detect soft pions,
- M2, a 15 GeV/c high-momentum acceptance magnet, is designed for decay products of charmed baryons.
- M3 is placed downstream of the decay spectrometer and is designed to measure the momentum of the particles produced in a lambda decay.

Each magnet along with some MWPCs and other detectors form a spectrometer. Each spectrometer is used for different tracking purposes. For more details see reference 12.

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Spokesperson: J. Russ, Carnegie-Mellon University.

16/May/2000

Figures of My Master Thesis

Multiwire Proportional Chambers In M1 and M3 Spectrometers Of Charmed Baryon Experiment(E781) Fermilab

University of IOWA

Mithat Kaya

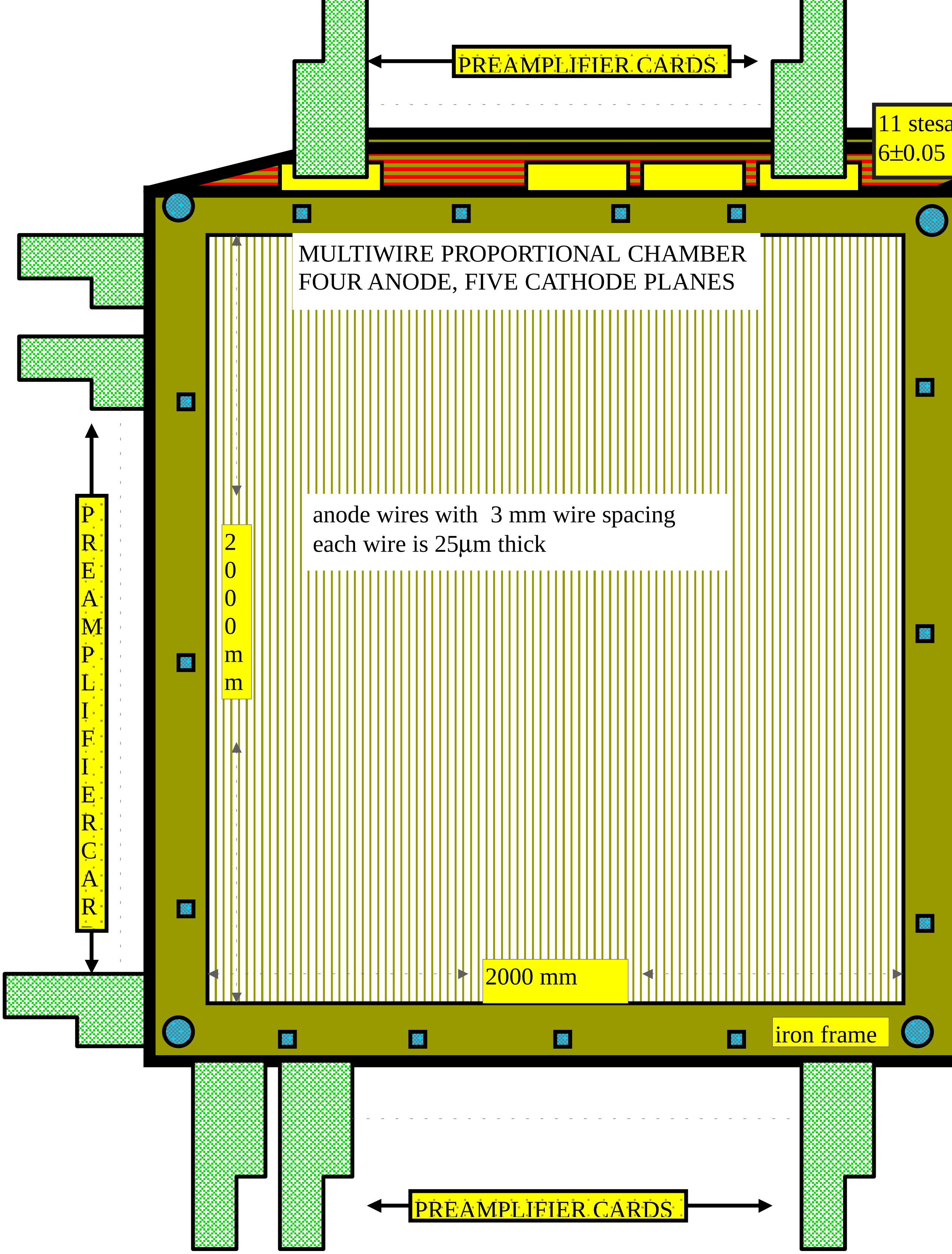


Figure 2. Shematics of one of the M1PWC

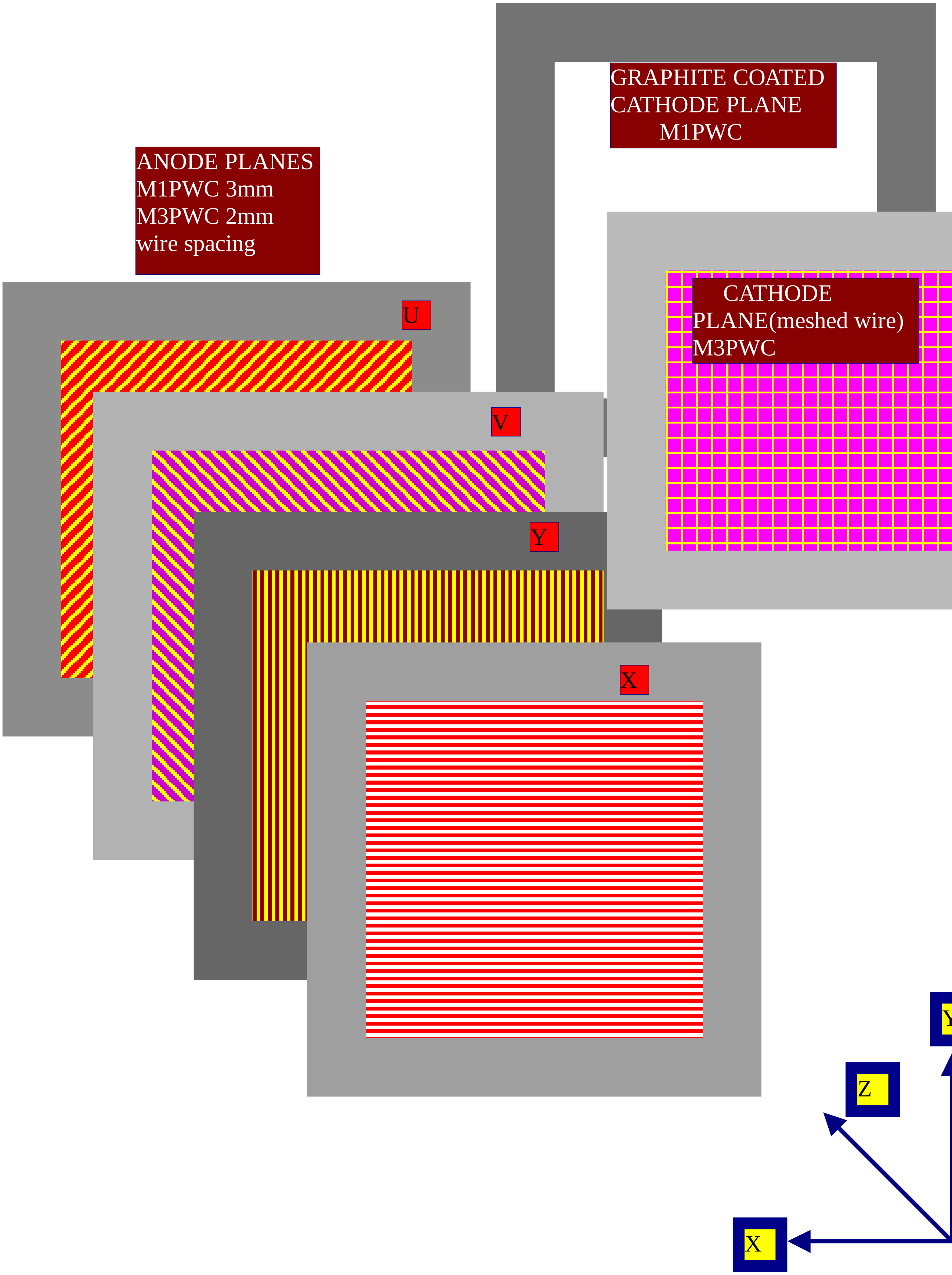


Figure 3. Plane organization of M1 and M3PWCs

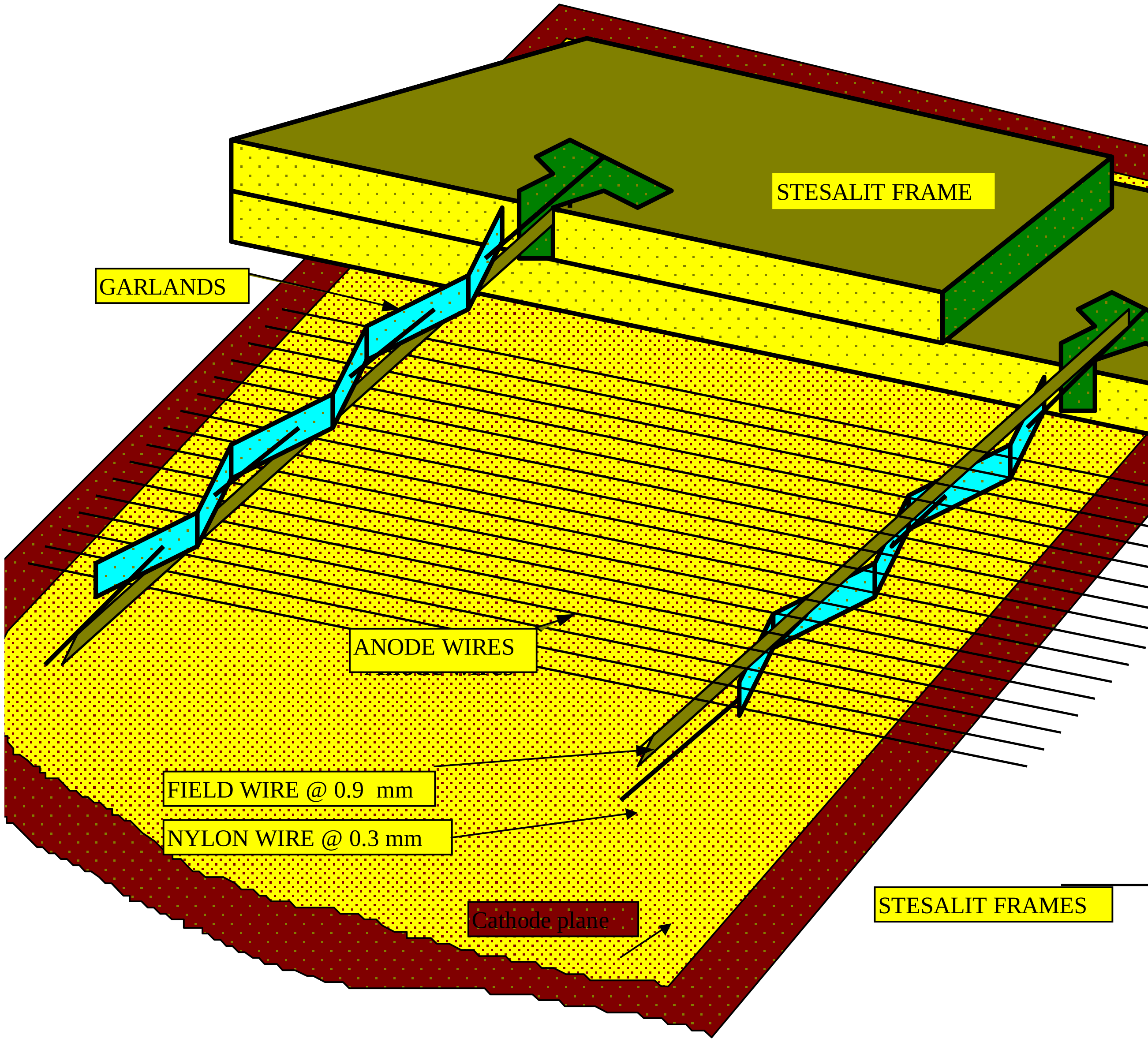


Figure 4. Mylar strips (garlands) in the Multiwire Proportional Chamber

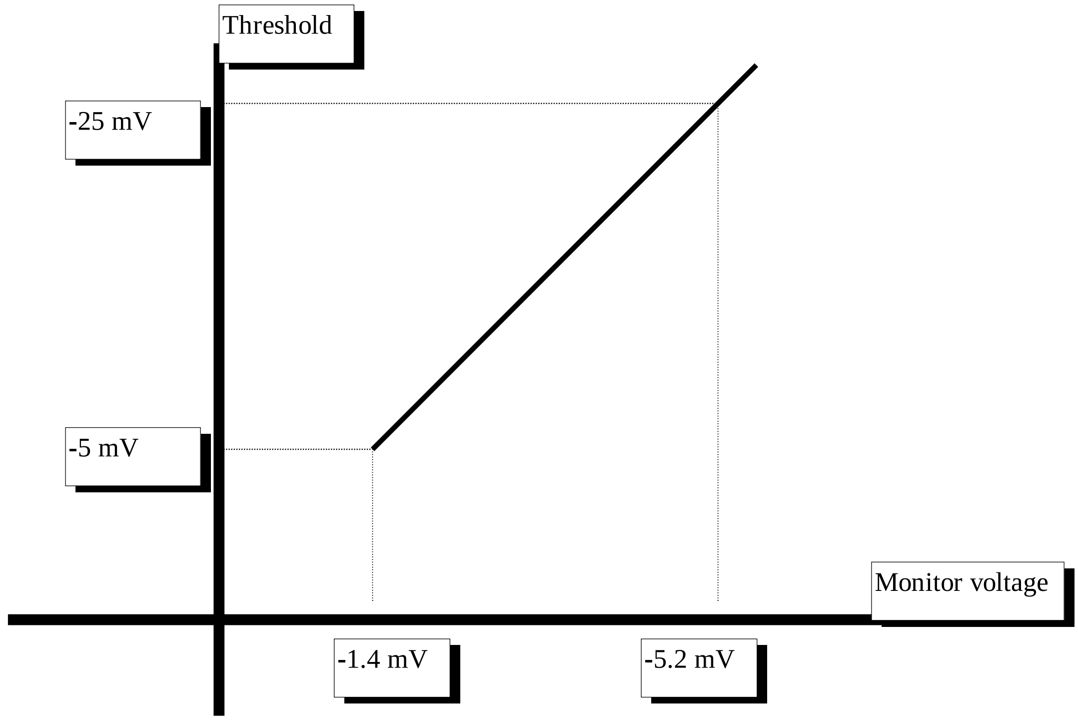


Figure 6. The relation between the actual threshold and the monitor voltage.

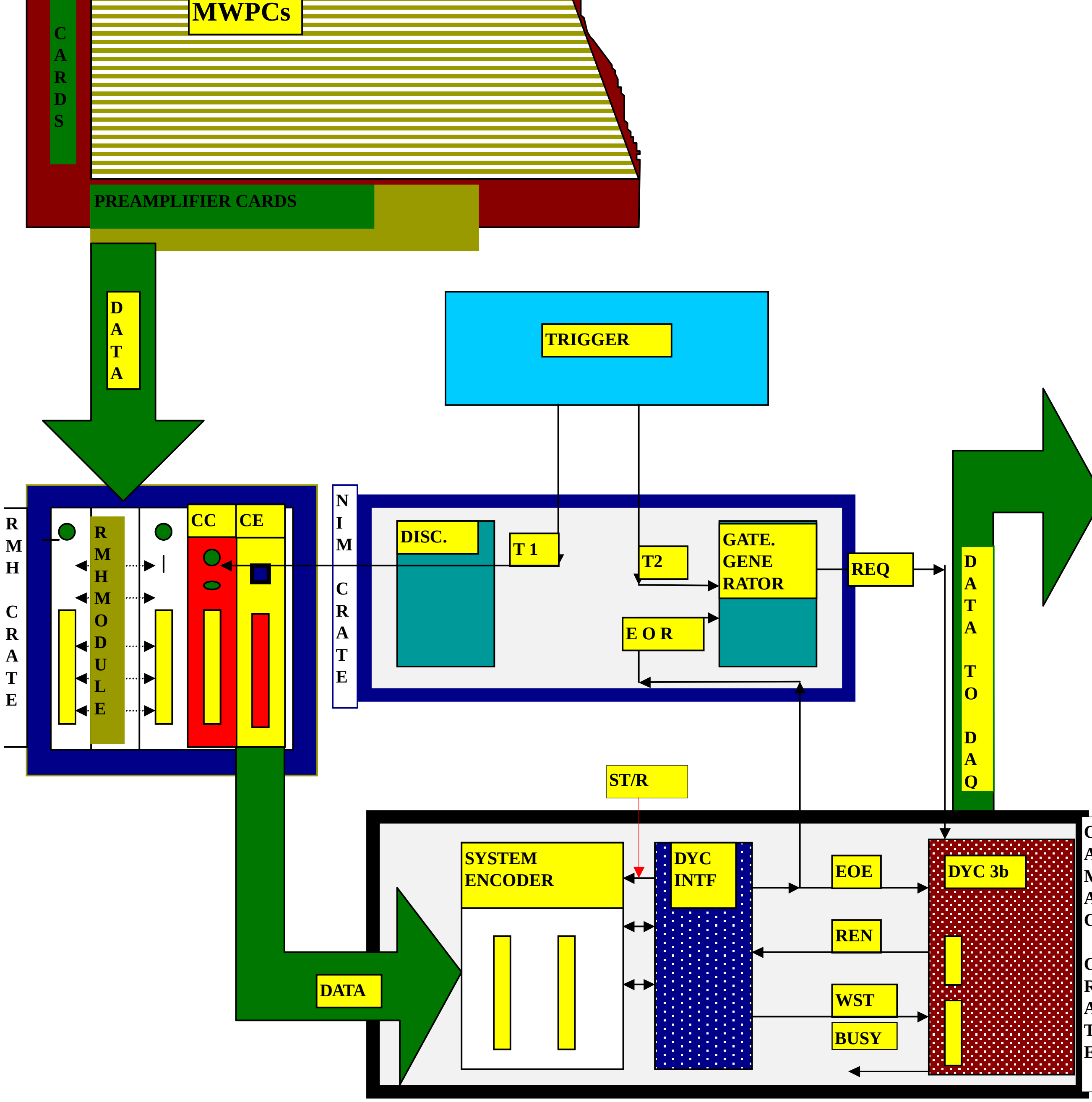
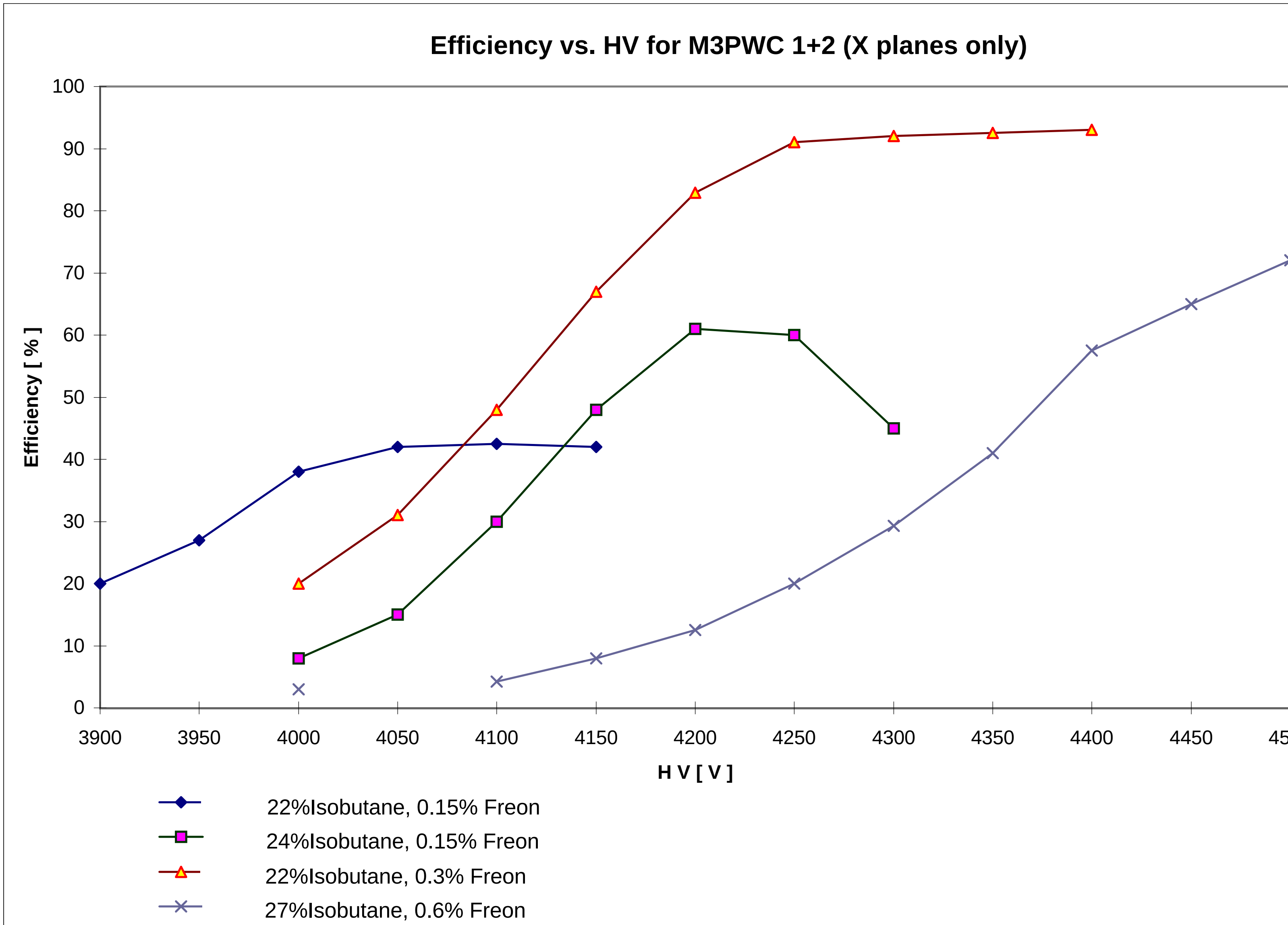
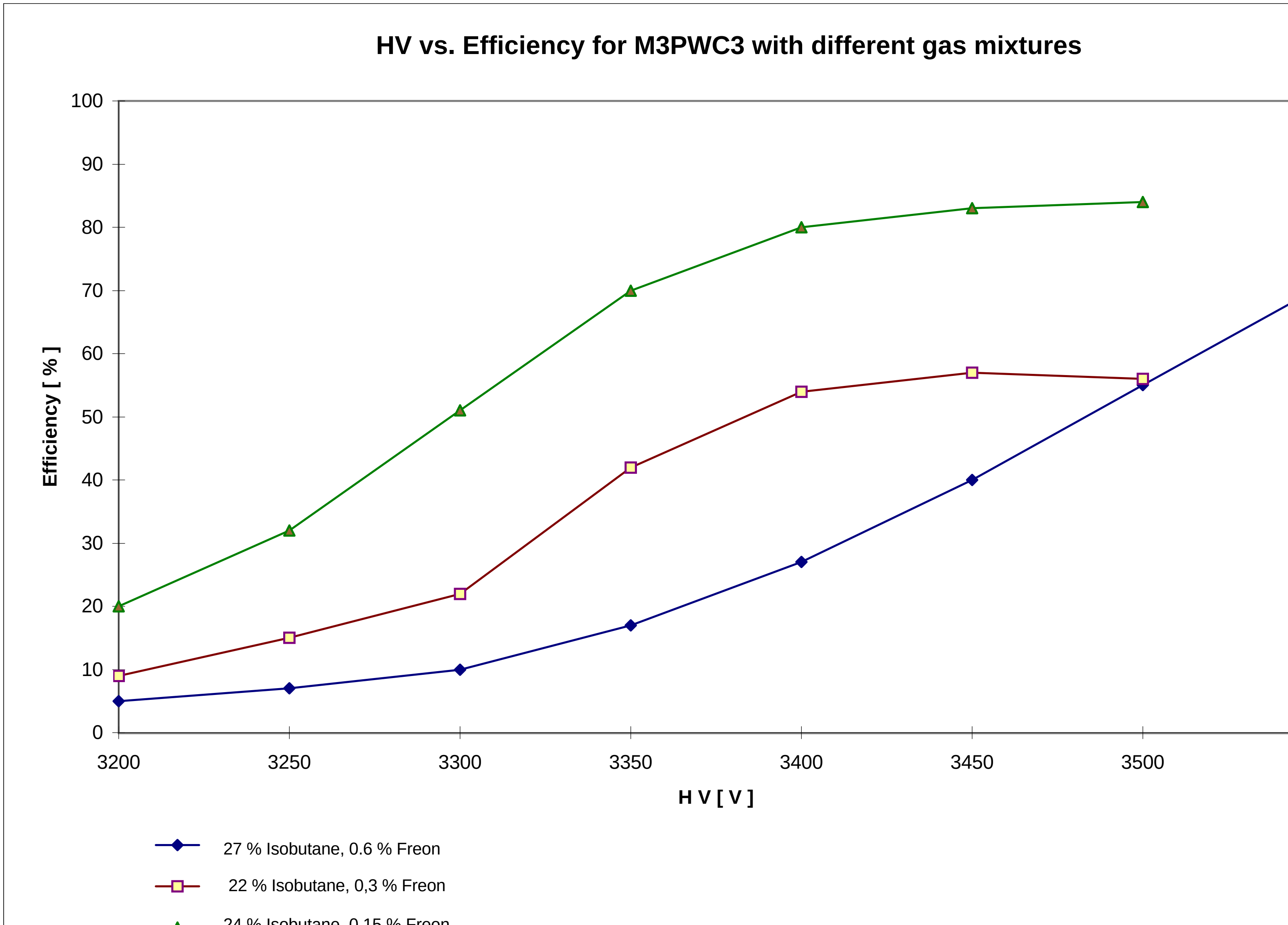
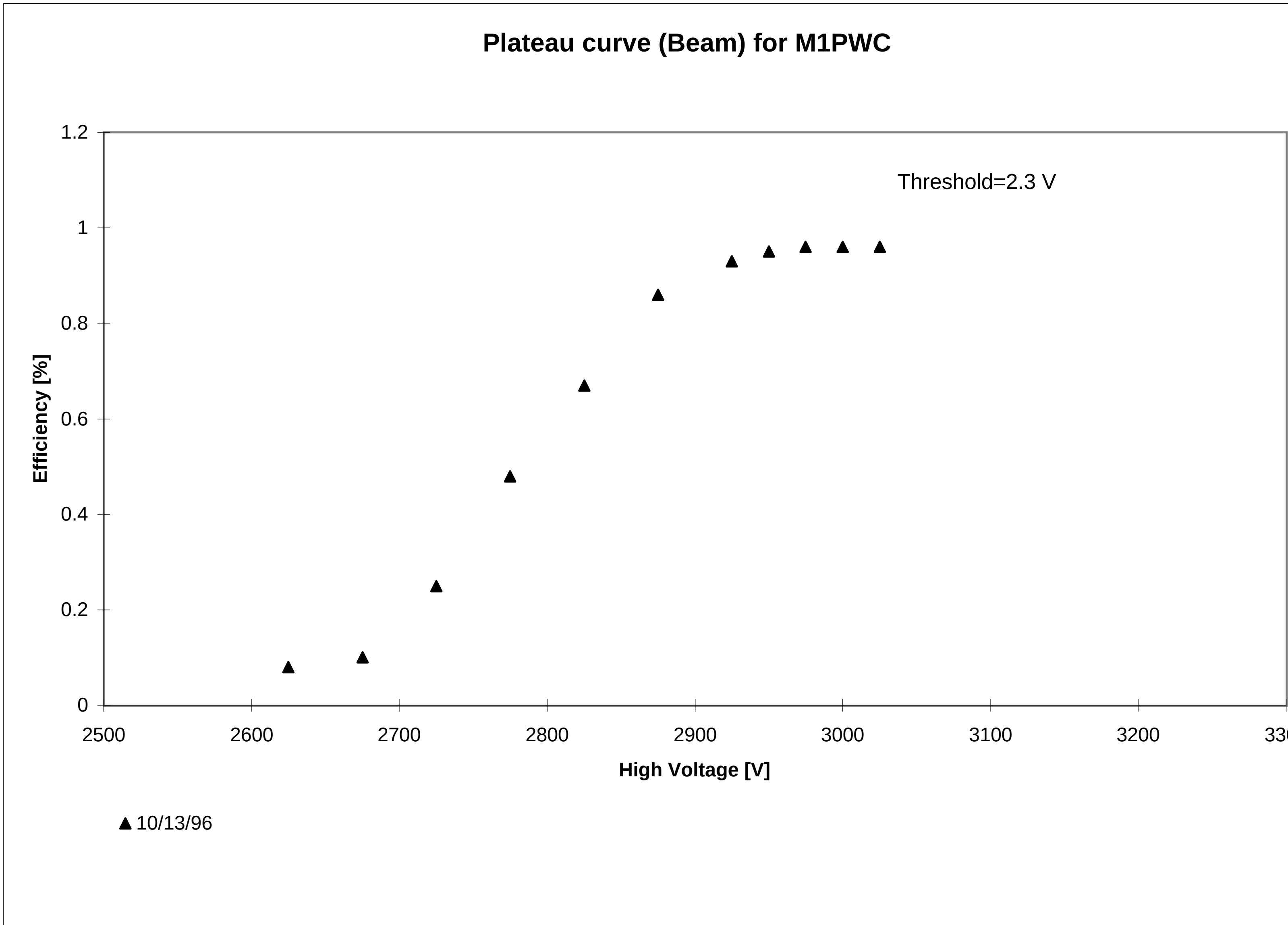


Figure 7. The block diagram of the readout control logic.


Efficiency vs. HV for M3PWC 1+2 (X planes only)
Efficiency [%]
100
90
80
70
60
50
40
30
20
10
0
3900
3950
4000
4050
4100
4150
4200
4250
4300
4350
4400
4450
H V [V]
22%Isobutane, 0.15% Freon
24%Isobutane, 0.15% Freon
22%Isobutane, 0.3% Freon
27%Isobutane, 0.6% Freon


HV vs. Efficiency for M3PWC3 with different gas mixtures
Efficiency [%]
100
90
80
70
60
50
40
30
20
10
0
3200
3250
3300
3350
3400
3450
3500
H V [V]
27 % Isobutane, 0.6 % Freon
22 % Isobutane, 0,3 % Freon


Plateau curve (Beam) for M1PWC
Threshold=2.3 V
1.2
1
0.8
0.6
0.4
0.2
0
Efficiency [%]
2500
2600
2700
2800
2900
3000
3100
3200
High Voltage [V]
10/13/96