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RMH System and the Accompanying Chambers in E781

Erhan Gülmez
Physics Dept., Boğaziçi University, Bebek 80815 İstanbul, Turkey

Aldo Penzo
INFN, Trieste, Italy

Yaşar Önel
Physics and Astronomy Dept. The University of Iowa, Iowa City, IA 52242, USA

Abstract

This is a simplified description of the RMH system in E781. The status of the system as of September 1995 is also included.

1 Introduction

The two sets of proportional wire chambers, one in the M1 spectrometer the other in the lambda decay region, are read out by a system developed at CERN for proportional wire chambers [1]. These chamber systems can be viewed in three parts: the readout system, the preamplifier cards, and the chambers themselves. For more details on individual units one should refer to the relevant manuals.

2 RMH System

Receiver-Memory Hybrid (RMH) readout system is developed at CERN for the purpose of processing the PWC signals, encoding the resulting hit pattern, and transferring the encoded data to the main data acquisition system.

2.1 A Brief Description of the RMH System

The system consists of the RMH modules, Crate Encoder (CE), Crate Controller (CC), Branch Receiver (BR), System Encoder (SE), and Interface (IF) (Fig. 1). These units require specially modified CAMAC crates.

The live time of a data acquisition system directly affects the efficiency of the data taking during a beam spill. All the signals, including those coming from the chambers, have to be processed as fast as possible to optimize the live time of the data acquisition. For this reason, the RMH system is designed in ECL components requiring CAMAC crates that use ECL instead of TTL circuits. ECL is faster than TTL, but the ECL circuits consume more power than the regular TTL circuits. Special effort has to be spent for the dissipation of the heat that these modules generate. Either special cooling systems designed for a rack of these modified crates or additional fans have to be used to keep the RMH modules from overheating and eventual burning. The RMH system for the upstream employs racks equipped with this special cooling system. The RMH system for the downstream chambers, the so-called lambda chambers, are cooled simply by fans blowing air through

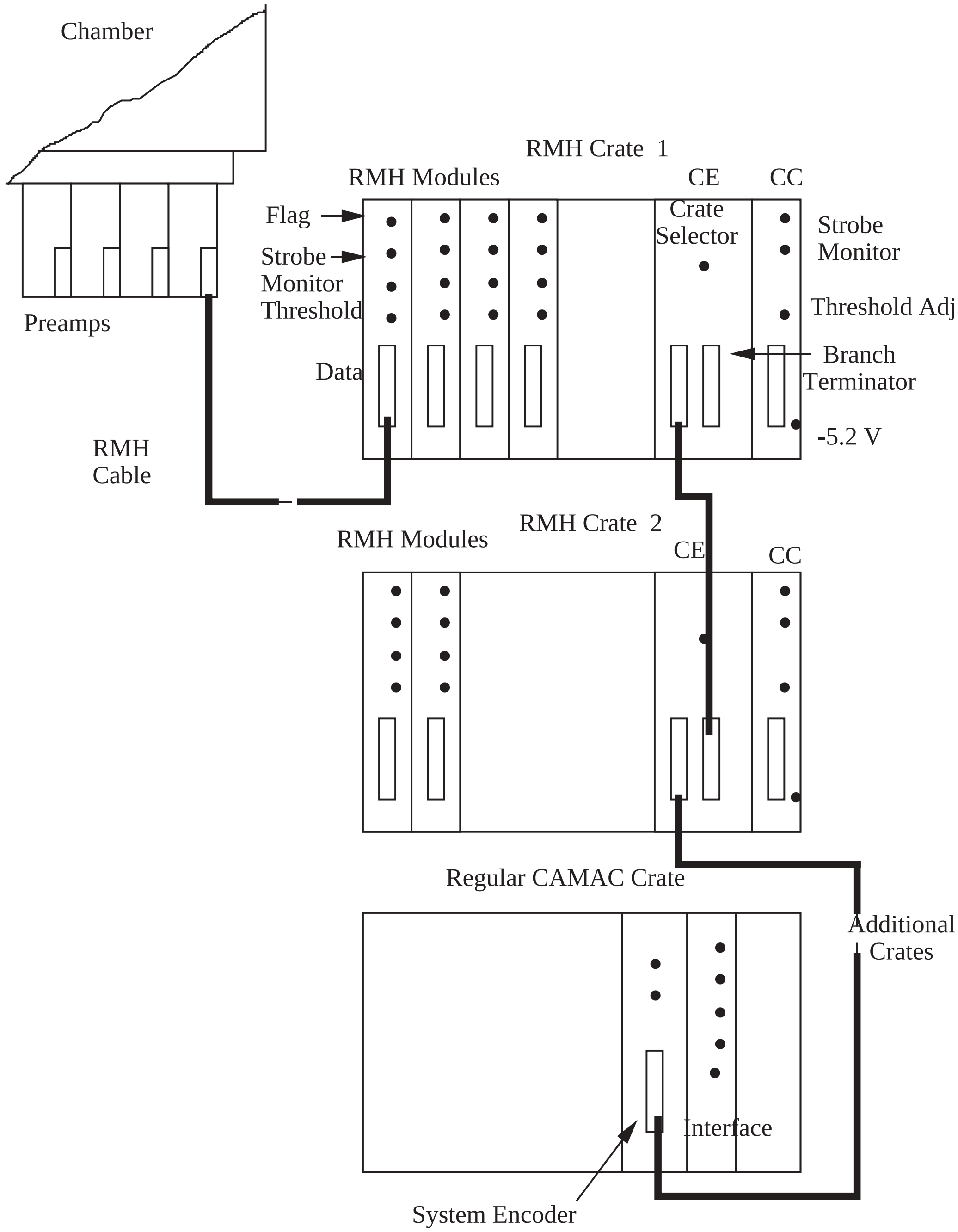

Figure 1: The RMH System.

the crates. However, the density of the crates and the number of fans used in blowing air through the units has to be optimized to keep the crates cool.

RMH Modules RMH modules consist of 32 channels of discriminators whose lower threshold level is controlled through a front panel trimpot in the Crate Controller unit accessible with a screwdriver. Threshold level adjusted by the trimpot is determined by measuring the voltage across the posts next to the pot. The threshold can be adjusted over a range of -1.4 V to -5.2 V which corresponds to -5 mV to -25 mV in the signal levels measured at the input of the preamplifiers. The threshold adjustment over this range is linear (Fig. 1).

The signals from the chambers, i.e., the signals from the individual wires amplified by the preamplifier cards installed on the chambers, come to the RMH modules through a special 32-pair cable which is also used for the purpose of delaying the chamber signals to allow enough time for the trigger to be formed. In the E781 case these cables are about 81 m long and give us about 400 ns delay in the chamber signals.

Each module produces a pattern of hit wires corresponding to the wires they are connected to, i.e., a pattern involving the channel numbers in which there is a signal whose magnitude is above the threshold level set by the front panel threshold pot in the control unit. A further constraint is that the signal should exceed the threshold level within the time period determined by the width of the signal fed into the strobe input of either the individual unit or the crate controller. (A signal going into the crate controller strobe input determines this time interval for the whole crate.) A monitor signal is produced at the monitor output of each unit if there is at least one channel where the signal reaches above the threshold level during the strobe signal is on. The monitor signal output of the crate controller is the OR of all the monitor outputs of the individual units.

Common problems in these modules are the special RMH chips having a broken pin, either from the chip itself or from the solder point, monitor signal being on always, flagged status not being included, a dead channel or a

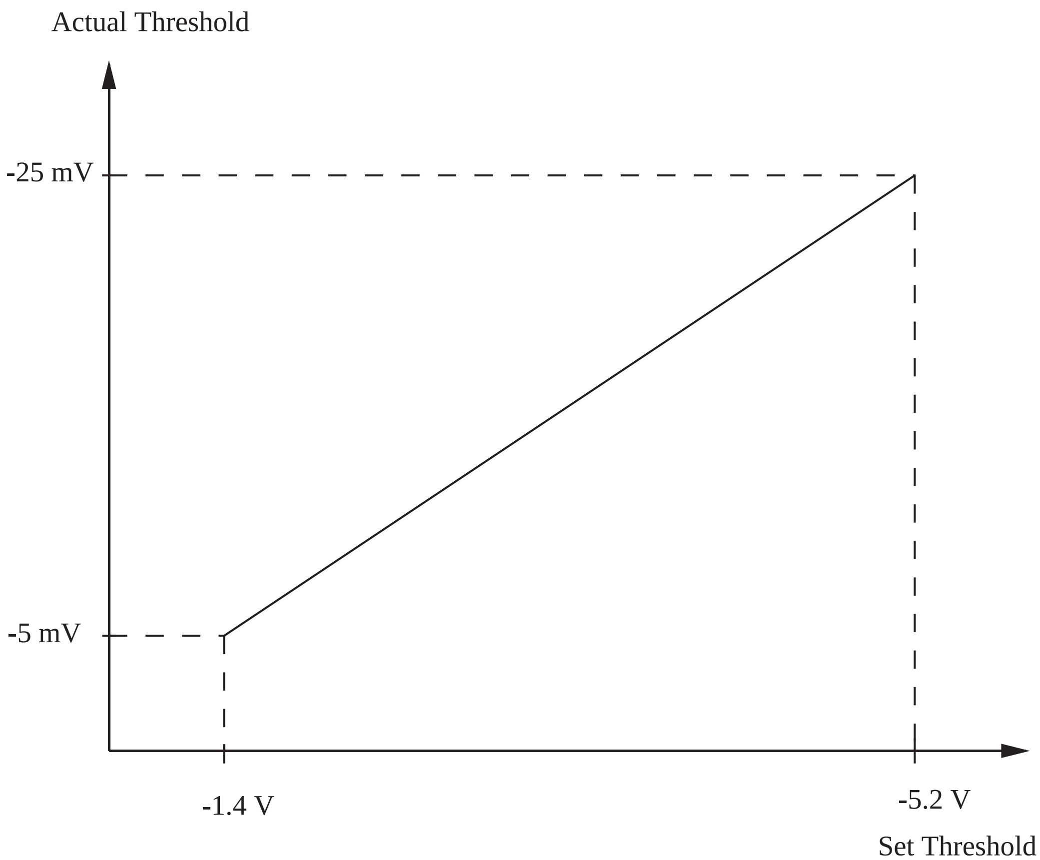

Figure 2: The relationship between the actual threshold level and the set value.

channel being on all the time. The pin that is usually broken is the single pin on the side opposite to the other pins. This pin is connected to the grounding of the chip packaging. It does not seem to be affecting the operation of the corresponding channel in a unit in our simple tests. However, it might create problems in the long run. The ground of the circuit inside the RMH chip is connected to one of the other regular pins (refer to the relevant circuit diagram).

There is also a switch (FLAG) in each unit to flag the beginning of a different detector in a specific unit.

Crate Encoder and Crate Controller Each specially modified CAMAC crate should have a Crate Encoder and a special Crate Controller occupying the slots 23-24 and 25, respectively.

Crate Encoder receives the hit and the flag pattern from the individual RMH modules and encodes these patterns into a 16-bit data word including the relevant information about the station number of the specific RMH module and the crate address. Crate address is set by selecting the appropriate number in the selector switch in the front panel of the CE with a screw driver. Encoded data words are sent to the Branch Receiver through a 32-pair cable same as the cable that transfers the chamber signals from the preamplifier cards to the RMH modules. There are two PCB edge connectors in the CE as opposed to one in the RMH modules. The CEs are connected in a chain by paying attention to the input-output and the cable polarities. The last CE in the chain should be terminated properly with a branch terminator. The first CE in the chain should be connected to a Branch Receiver input.

The format for the data word encoded is the following; 5 rightmost bits are used for the channel number and the next 9 bits are used for the station and crate address. More specifically the formula: (Crate Address-1)*704 + (Station Address-1)*32 + (Channel Number-1) is used to encode a hit wire. Bit 15 is not used and the bit 16 is reserved for the status of the flag switch. In the test DAQ the flag switch being on, i.e., bit 16 being on, is interpreted as -2^{16} + the number calculated for the hit wire by using the above formula.[1] If there is no wire hit in that particular set that is connected to the module, then the first wire number is used to encode the flag status.

Crate Controller has a master input for the strobe signals and a master monitor output which produces the OR of all the individual monitor signals. The strobe signal can be fanned out to all the modules through the backplane of the CAMAC crate. However, one should take into account the propagation delay in the CC and the CAMAC backplane when adjusting the timing for the strobe signal with respect to the chamber signals at the input of the RMH modules. Because of the propagation delays, the position of a module may effect the efficiency of that specific module.

The timing is usually adjusted by looking at the monitor and the signal that is going to be applied to the strobe input simultaneously, while putting the strobe input to "on" level, for example connecting the -5.2 V output supplied by the CC to the strobe input. (The strobe input should be "on," otherwise there will be no monitor signal.) Then the timing of the signal that will be applied to the strobe input is adjusted so that it comes about 40-50 ns earlier than the monitor signal (Fig. 3) (at least 20 ns but to allow for any occasional walk in the timing it is better to leave some slack in the timing). If the strobe signal is to be applied directly to an individual unit, then the strobe signal could come a little bit later, about 10 ns later.

There are also some diagnostic lights in the front panel of the CC. If some dataway levels are continuously on in a specific unit, the corresponding LED will be lit. Units in groups of two or three are ORed together to keep the number of LEDs needed to a minimum.

Branch Receiver, System Encoder, and Interface These three units are usually packaged together since they are interconnected. More than one (up to 18) Branch Receiver could be connected. Any branch cable should

[1] Convention for the wire or channel number for this report is to start from 1. Any references to the channel or the wire numbers should be considered with this convention in mind. Others may have the starting number as 0.

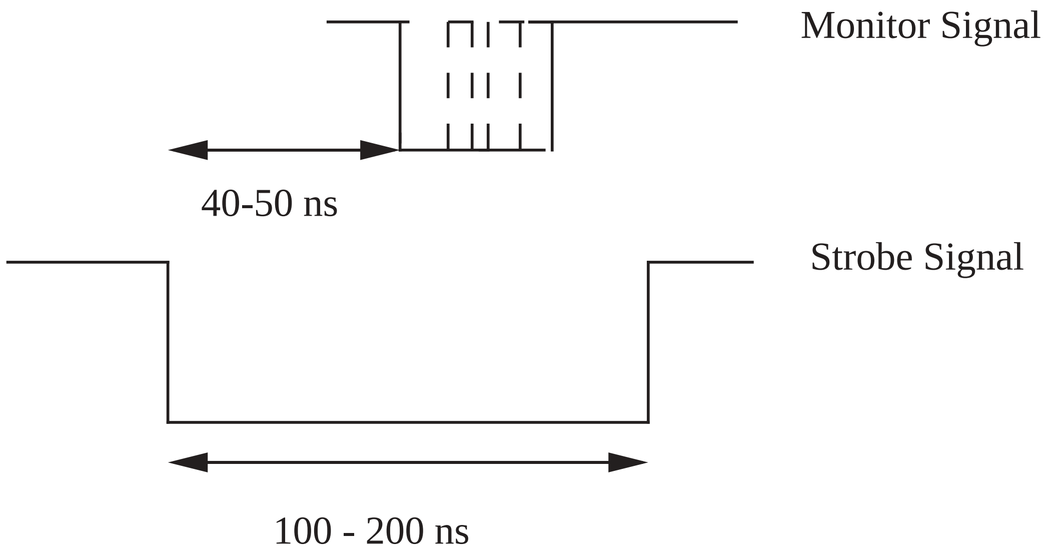

Figure 3: The strobe timing.

be connected to one of the Branch Receivers to transfer the data in that particular branch to the DAQ. The regular interface is designed for standard CAMAC operations. There is an interface specially designed to communicate with a DYC unit in the E781 DAQ system.

2.2 Testing the RMH system

The RMH system can be tested by using a test card designed for the purpose of inserting signals to any channel of a RMH module (Fig. 4). The VAX test DAQ could be used to study the data recorded for each event. An event dump will include the first 100 nonzero data words in an event. With only one test card and assuming that any unit having a channel that is always on is removed from the crate, one would expect to get at most 32 nonzero data words depending on how many of the channels in the test card is turned on (assuming that no flag switch is turned on).

The following procedure is employed for testing the RMH modules.

- Check all the units visually for any broken connection on the circuit

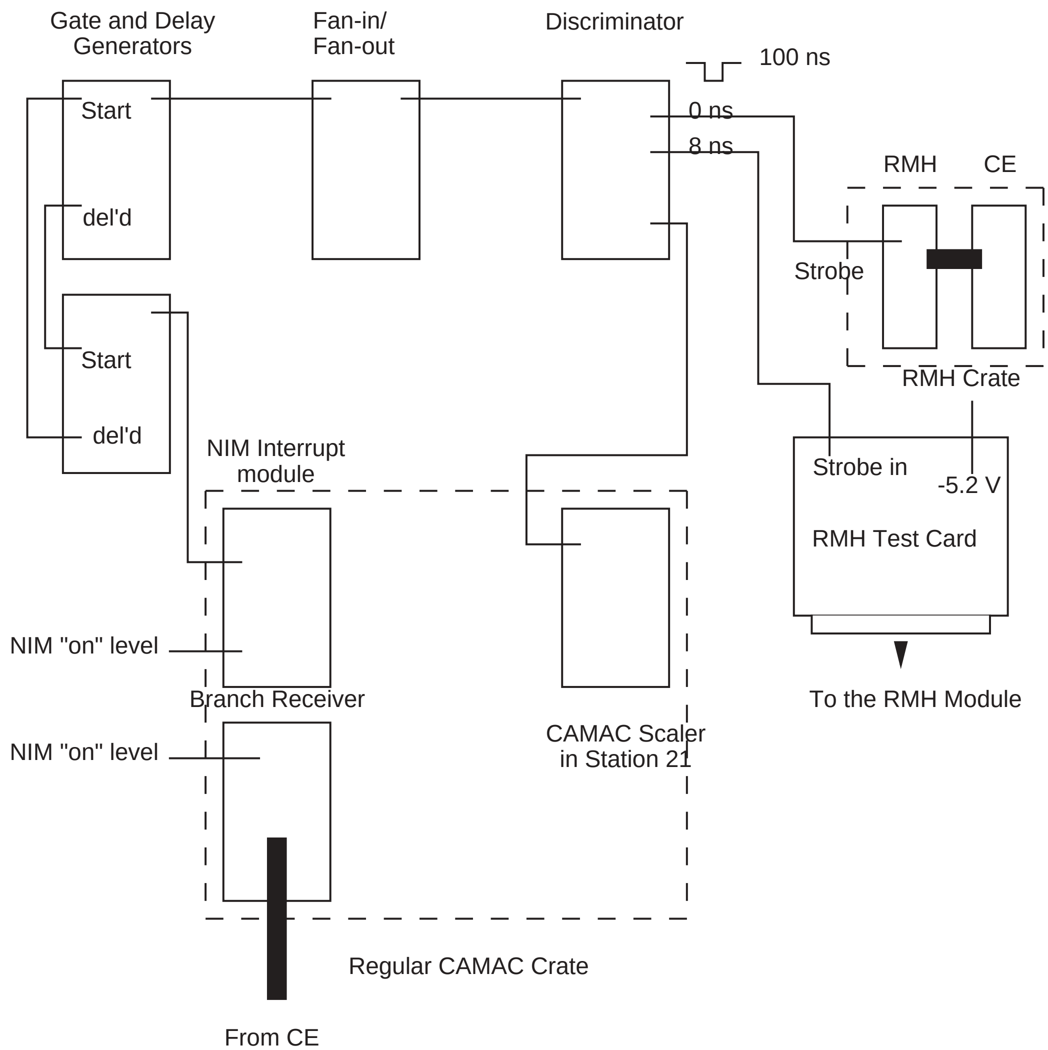

Figure 4: The setup for the data acquisition system for testing the RMH modules with the test card

board.

- Set all the flags off. Look at the event dump.

- Remove any unit that has a channel that is always on without an input.

- Set all the flags on.

- Note the units that do not produce a flag data word to be removed later.

- Plug the test card on the first unit and check if all the channels work by dumping an event. Sometimes the first or the last channel may be missing because the card is not properly plugged onto the edge connector. Check the event dump with the flag switch on and off. Sometimes this shows the noisy or "hot" channels better. Keep the flag switch of the units that are already tested off.

- Continue with the next module until you test all the modules.

In some cases, the flag for the unit in the CAMAC station 17 may disappear even though it is seen at the beginning of the test and when the test card is plugged on the unit in station 17 itself. This is probably allright since the number of flag switches actually set "on" is very small in a given setup.

3 Preamplifier Cards

The signals from each wire is usually too weak to be transferred to the RMH module directly. They are fed into the preamplifier cards installed on the chambers as close to one end of a wire as possible. Each preamplifier card contains 32 individual amplifiers with a nominal gain of 7. The preamplifier cards are supplied with -5.2 V.

3.1 Testing the Cards

Cards are tested in the same way that the RMH modules are tested, namely inserting a test signal at the input and see if there is an output (Fig. 5).

The simplest way of applying a signal to the input of the preamplifiers could be achieved by sending a pulse to the pulser strip on each chamber. The pulse sent to the pulser strip induces a signal in the conducting paths (or the pads) on the board which is part of the frame on which the wires are strung. In case of the big chambers, the pulser strip is a simple copper tape laid perpendicular to the printed circuit paths (or the pads). Because of the transmission losses, the induced signal gets broader as one goes away from the point the pulse is applied. This effect causes a wire position dependent delay after the discrimination. A relative delay of about a maximum (5 ns per module or card) of 100 ns is observed with respect to the pulse applied. To be able to cover all 20 modules in a crate which comes from a single plane, the strobe signal should be about 200 ns.

The copper tape used as the pulser strip for the big chambers is on the preamplifier card side of the frame so it does not tell anything about the wires. On the other hand, the pulser strip is designed better in the first two lambda chambers and it is on the opposite side of the preamplifier cards, hence the signals should go through the wires to get to the preamplifiers. The smaller size of the chambers also helps; not much delay is observed in this case.

In testing the cards, again a visual check is suggested. However, not much can be seen, other than obvious problems like broken board, smashed capacitors, or cracked connectors. One should be aware of the fact that there are two types of connectors, one is longer than the other by an extra pin. The extra pin is there for -5.2 V connection through the printed circuit board of the chamber frame. In our case, this scheme of connecting to the power is not used. So the cards are pushed to one side so that these last (or first, depending on which way one looks at it) pins are not connected to anything. In some cards something is stuffed in one side to guide the connector into the right position.

One disadvantage of using the pulser is the fact that it turns on all the

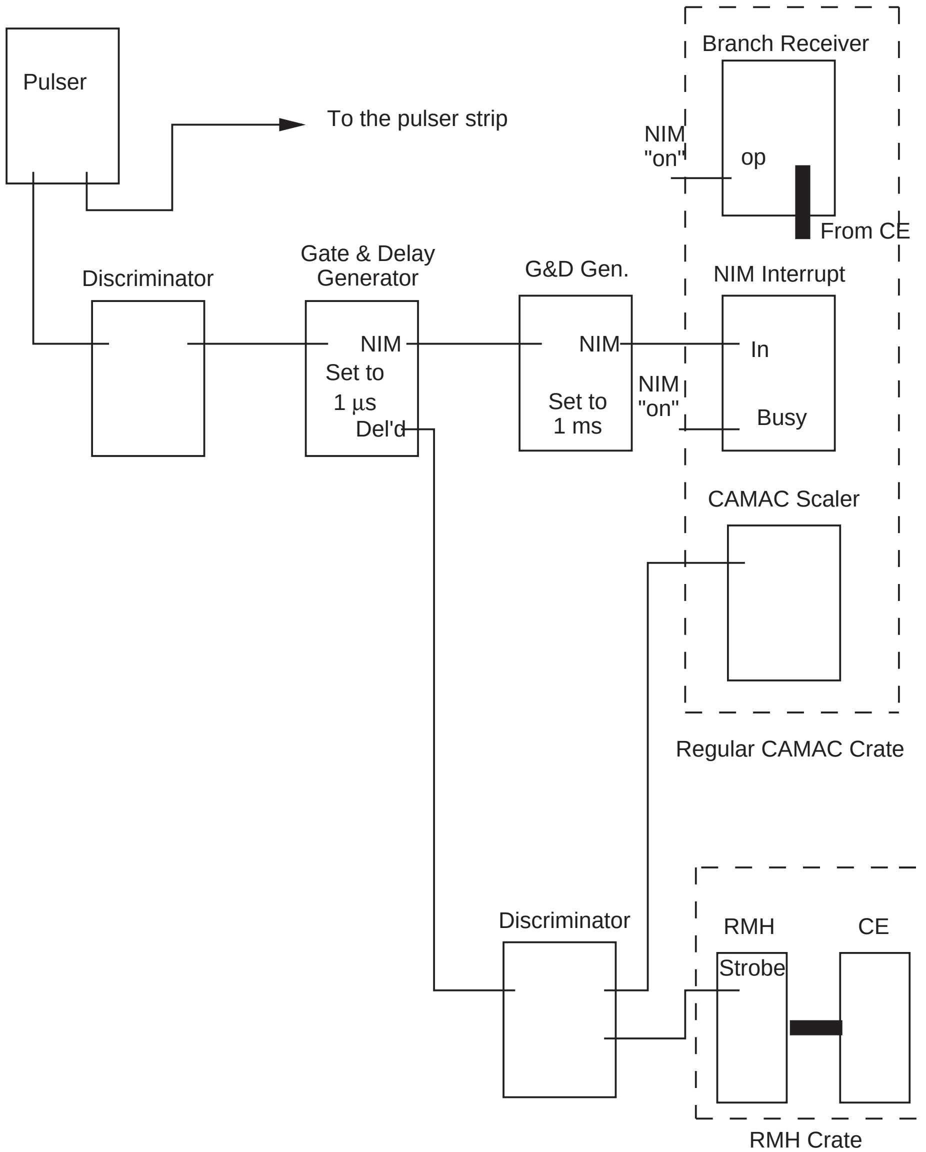

Figure 5: The setup for the data acquisition system for testing the preamp cards. First Gate and Delay Generator is used to adjust the delay for the strobe signal (about ≃400 ns + whatever the cable length that is used for the pulser signal to the pulser strip). The second one is used to provide the wide signals needed for the NIM interrupt unit.

channels. Subtle problems like lower gain or a noisy card could be missed easily. One should watch for these kind of problems when the beam is on.

4 The Chambers

Two types of proportional wire chambers are to be used in E781 setup that are read out by the RMH system. One set is consisted of three big 4-plane chambers and the other set is a combination of various types of small chambers.

The Big Chambers The big chambers (2 m $\times$ 2 m) have four planes of wires; x, y, u, and v planes. Each plane is independent of each other, i.e., their volumes are separated by graphite coated mylar sheets which also serve as cathode planes. HV can be applied to each plane separately or all four planes ganged together. There are provisions to apply voltage on the support wires (garlands). The wire spacing is 3 mm. Magic gas used in these chambers has less freon, 0.15%, compared to the smaller chambers (0.3%). For details refer to reference 2. Beam killer region mentioned in this reference has been disabled by painting it over with the same graphite paint used in the cathode planes and the electrical connections has been made simpler.

The Lambda Chambers The so-called Lambda chambers are smaller (about 1 m by 1 m) and they are a collection of different types of chambers. The current set consists of a chamber with x,y, u, and v planes as the first chamber, a chamber with only x and y planes as the second chamber, and another one with x, y, and a slanted plane as the third chamber. In fact, the chamber that will be used for the third chamber has not been completely decided yet. One significant difference between these chambers and the big chambers is that these chambers have wire cathode planes with transparent windows as opposed to having a graphite surface plane with opaque covers.

5 Status of the System as of September 1995

The RMH System All the available RMH units are tested and the units with problems are identified and labeled accordingly. A complete set of RMH units have been installed and ready to go. There are about 50 RMH modules, 1 CE, 2 CC, and 1 CAMAC power supply spare. More spare units are needed, especially CE, CC and CAMAC power supplies. Some of the units with problems will be repaired in the near future at Trieste.

The Preamplifier Cards All the available cards are tested and classified according to their conditions. All the chambers have good working cards installed on them. There are about 20-30 spare cards. The low voltage power supply connections, distribution, and the safety isuues have not been finalized yet.

The Chambers Testing the chambers under the operating conditions have not been possible because of the delays in the premixed magic gas delivery. However, some test were made with the available few bottles of magic gas with 0.3% freon content.

The first lambda chamber had been shipped from Trieste and installed in its position with the right number of preamplifier cards. This and the second lambda chamber were tested with the magic gas. They were found to be drawing current more than acceptable. Applying HV with negative and positive polarities in alternating intervals seems to have helped in some planes. There are a few planes drawing more than several microamps at about 2000 V. There does not seem to be a broken wire. These chambers have transparent windows.

The available gas was just enough to observe the signals coming from the x and y planes of the second big chamber only. At the operating voltage of 2900 V, the dark current was slightly less than a microamp (0.9 microamp) and some signals were observed. These wire signals were coincident with a scintillating counter placed between the source and the chamber.

The remaining chambers were only tested with an ohmmeter. The first chamber appears to have no broken wires. The u,v planes of the second chamber and the y, v planes of the third chamber seem to have shorts involving number of wires ranging from 6-15 from plane to plane which is a strong indication of the existence of a few broken wires in these planes. These chambers will be further studied in November 1995 and early 1996. The special interface unit will also be finalized at the same time.

6 Acknowledgements

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7 References

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2. De Palma et al., Nucl. Inst. and Meth. **216** (1983)393.