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PROPORTIONAL CHAMBER AND ELECTRONICS DEVELOPMENT AT SLAC*†

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1. Introduction

This note briefly summarizes recent developments in proportional chambers and electronics at SLAC. A brief resume of the chamber requirements of possible future applications is included. Some remarks are made concerning the possible utilization of medium-to-large scale integrated circuits in future applications. The views presented here are a composite of a number of individual opinions and do not necessarily reflect a concensus of the laboratory.

2. Chamber Development

The principal proportional chamber development so far at SLAC has been on chambers for the 20 BeV spectrometer.[1,2] The system consists of 4 chamber planes of about 100 wires each, with the following characteristics[3]:

a. wire spacing - 2 mm

b. wire-to-HV plane spacing - 4 mm

c. wire diameter - 20 μ

d. wire type - "Thermionic" electrically etched gold-coated tungsten

e. gas mixture - 80% Argon, 20% Isobutane

It is planned to use a coincidence gate width of 30 nsec for the system.

During the development of the above chambers, a 1 mm wire spacing was tried in order enhance the timing resolution. The resulting chamber worked but proved unreliable; consequently the effort has been temporarily abandoned.

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The 20 BeV system will be tested starting in early November, 1970. Assuming it is successful, similar systems are planned for both the 8.0 and 1.6 BeV spectrometers.

Other groups which are studying small chambers at SLAC are Experimental Group E (T. Zipf) and a group from University of Washington (J. Rothberg). In both cases, electronics of the TEDDY[4] design are being used. Group E reports[5] they have built several small chambers with 1 mm wire spacing which work very reliably. They are now attempting a 1 mm chamber about 60 cm long. This group has experimented extensively with Charpak's "magic gas" and essentially duplicated the CERN results. They have experienced poisoning of chambers if breakdown is allowed with this gas mixture. It appears that deposits form on the wires which cannot be removed with ordinary solvents. This is a potential problem which must be considered in any practical system.

The Washington group is setting up a small parasite experiment in early November to check their 2 mm chamber in a π beam. This group has a pion-proton scattering experiment scheduled for March 1971 in which it is planned to use a proportional chamber hodoscope of about 400 wires placed near the target.

Several other groups at SLAC have expressed an interest in proportional chamber development, and a number of small systems have been discussed for possible implementation in mid-1971.

3. Electronics Development

The major electronics development has been for the 20 BeV spectrometer program.[6] In this system, amplifiers are located at the chambers, and long-haul coaxial cables are used for signal transmission as well as for delay. No fast outputs are taken from the logic, since an event trigger is determined from scintillation counters connected to NIM-type logic. The system is expensive, approximately $30 per wire, for a number of reasons:

1. Individual coaxial cables and connectors used for each channel.
2. MECL II logic was used for best possible time resolution.
3. A 4-bit coincidence-latch is used in each channel, rather than the normal 1-bit, in order to resolve multiple tracks within the 1.6 μsec beam pulse.

The other major development is the TEDDY circuit mentioned earlier, which is built on the concept that all fast electronics including the latch will be placed at the chamber; this system therefore contains an active one-shot delay of about

200 nsec. Delays are matched by adding a fixed 5% trim resistor to each channel. In a recent test, 48 channels were matched to ± 2.5 nsec; only 3 of these required more than one 5% trim resistor. Measured temperature coefficients for four different channel delays were better than 0.15%/^{o}C, while variations with supply voltage were 0.1% for a 1% voltage change. Output slewing for an input amplitude range of 1 mV to 10 mV was 12 nsec, where the threshold was somewhat less than 1 mV.

In the original design, no fast outputs were required. However, a fast output OR of the four channels on each board is now being added for possible use in chamber decision-making.

The cost of one channel of this design is estimated to be about $12.

No special readout electronics have yet been developed for the TEDDY system.

4. Future Applications

All future applications discussed so far are for small systems of a few hundred wires. This has been primarily dictated by cost considerations. There appear to be no large systems planned where proportional chambers are essential — that is, applications where either magnetostrictive or capacitive readout chambers would not work as well. Most foreseeable applications seem to envisage small proportional chamber hodoscopes working in conjunction with scintillator, wire chamber or other detector systems. However, it is not clear whether proportional chambers can be made to function reliably in the electrically noisy environments of pulsed magnetostrictive, capacitor readout, or optical chambers, and some of these applications may not be feasible.

There is also concern that since very long proportional chambers have not yet been demonstrated in a large practical system, implementation of such chambers may reveal serious problems with the support of 1-3 meter signal wires. The resulting large chambers may be disproportionately more expensive or less reliable than the < 1 meter systems tested so far.

The immediate future applications thus seem to be limited to small systems of a few hundred wires each. Implementation of large chamber systems will probably not be attempted at SLAC until such time as (a) the cost of a system becomes more competitive with magnetostrictive and capacitor readout systems, and (b) the successful implementation of very large chambers is demonstrated.

5. Applicability of a Special Integrated Circuit Development

It is apparent that implementation of electronics using off-the-shelf devices will not be possible for less than about $10 per wire. A large factor of improvement is needed. Hybrid techniques may improve matters by a factor of 2. Beyond this, special integrated circuits seem to be the only recourse.

Several factors it seems are important. First, it appears that if the time resolution of the electronics is compromised too severely in an integrated circuit design, much of the utility of proportional chambers will be lost. Not only would the chamber be less useful in decision-making, but also spatial resolution would deteriorate in situations where angular tracks are being measured.

One particular aspect of electronics performance which seems to have been largely ignored in existing designs is time-slewing as a function of amplitude (see Ref. 4). It is important to operate in a region where the time delay through the electronics is essentially constant with input amplitude, which in turn means that large amplifier gains and low input thresholds are usually required. For systems with time resolutions of 30-50 nsec, amplifier time slewing is an important consideration.

To develop a special integrated circuit may be difficult in view of the likelihood of special requirements unique to one laboratory. The answer may well be the development of several independent monolithic or hybrid integrated circuits which, for an increased initial development cost, would result in maximum flexibility for the system designer. This could be an argument for the separation of integrated circuits vertically (by function), rather than horizontally (by channel) as in most systems proposed to date.

6. Acknowledgement

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