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(E)

STATUS AND FUTURE PLANS FOR THE MARK II DETECTOR AT SLAC*

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SECTION I. INTRODUCTION AND STATUS OF PEP

In this brief talk, I want to report to you on three subjects. First, I want to tell you about the present status of PEP, where there has been a very large increase in the luminosity in the past five months. Next, I want to tell you a little about the present status of the Mark II detector, whose secondary vertex detector constitutes a very important part of the physics which our collaboration is doing at PEP. Finally, I want to review for you the design of the upgraded Mark II Detector which will be used at the Stanford Linear Collider (SLC).

In the summers of 1981 and 1982 the final focus quadrupoles at PEP were moved nearer to the interaction points; the distance of the nearest quadrupole from the interaction point being decreased from 11 meters to about 7 meters. In the fall of 1983 extensive machine physics studies and accelerator physics calculations were carried out for this new arrangement of quadrupoles. In January of 1983 a configuration was attained which has

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resulted in excellent luminosity parameters for PEP. These luminosity parameters are:[1]

$$
\begin{aligned}
L_{max} &= 3.2 \times 10^{31}\ cm^{-2}\ s^{-1} \\
L_{average,typical} &= 1000\ nb^{-1}/day \qquad (1) \\
L_{average,maximum} &= 1500\ nb^{-1}/day
\end{aligned}
$$

These substantial accomplishments are described in detail by a recent paper of R. Helm et al.[1] In that paper the authors also describe three other factors which have contributed enormously to these improvements. These factors are: improvements in instrumentation and software; superb efforts by the PEP operators to empirically adjust many parameters of beam operation and to continually increase the productivity of PEP; and the finding of so-called 'golden orbits'.[2]

This improved luminosity has produced, of course, substantial improvements of the rate at which the detectors at PEP can acquire data. For example, our Mark II detector in the first week of April passed the 100,000 nb^{-1} mark in acquiring data. And so, if you will pardon a bit of poetics, our dream of being able to collect 100,000 nb^{-1} a year has now become a reality.

SECTION II. THE STATUS OF THE MARK II DETECTOR AT PEP

The physicists now operating and using the Mark II detector at PEP are listed in Table I. There are, of course, other physicists who have worked with the Mark II collaboration in the past and who have contributed substantially to the construction and operation of the Mark II detector at SPEAR and at PEP.

The major improvement in the Mark II detector since we moved it to PEP has been the insertion of a high spatial resolution drift chamber inside the main drift chamber. The details of the construction and use of this secondary vertex chamber have been described by J. Jaros.[3,4] Some details of the chamber construction and performance are shown in Figs. 1 and 2, and are listed in Eq. 2.

length = 120 cm

average radius of 4 inner layers = 12 cm

average radius of 3 outer layers = 30 cm (2)

measurement accuracy in actual use in Mark II = about 90 μm/layer

The secondary vertex detector, as its name implies, has been used to look for secondary vertices to measure the lifetimes of short-lived particles. A new measurement of the lifetime of the tau using this detector has already been presented[4] and work is progressing on further measurements of the lifetime of the tau, on a measurement of the lifetime of B mesons, and on further studies of the lifetimes of the D mesons. We are also beginning to explore how to use secondary vertices to tag those events which have short-lived particles in them. Although physicists at present and future colliding beams facilities dream of having a reliable secondary vertex, on-line, trigger; it is clear to us through our present work with this secondary vertex detector that there is a large amount of technical improvements and analytical studies which have to be done to realize that dream.

As some of you know, the Mark II detector is now operating at approximately one-half its designed field, about .24 T rather than .5 T. We have had to operate that way because in the spring of 1982 a short developed between the inner and outer layers of the magnet coil; and we continued operating by just powering the outer layer. We do not know the reason for the short, it occurred after operating the coil for almost eight years without any problems. We do know how to return the coil to full field and we are now considering the appropriate time to do so.

Our present plans are to continue to acquire data at PEP with the Mark II detector until the summer of 1984. At that time we plan to make some substantial changes in the Mark II detector to upgrade it for use at the Stanford Linear Collider. The plans for that upgrading are the subject of the next and final section of this talk.

SECTION III. THE DESIGN OF THE UPGRADE OF THE MARK II DETECTOR

A. Introduction

A collaboration, Table II, is being formed to upgrade the Mark II detector for use at the SLC. Table III lists the components of the Mark II detector which will be retained through the upgrade and those components which will be replaced. As you will note, the two major replacements are a new drift chamber and its associated electronics, and new electromagnetic shower detecting endcaps. Another replacement item is that new time-of-flight, scintillation counters will be installed. Finally, the present secondary vertex detector is not suitable for use at the SLC and will have to be replaced.

B. Schedule for the Upgrading of the Mark II Detector

Our present plans are as follows. In the summer of 1984 we plan to begin to replace the present drift chamber by a new drift chamber and its associated electronics. In the fall or early winter of 1984 we plan to resume operation of the Mark II detector at PEP. This resumption of operation of the detector at PEP has two purposes. First, we want to put the new drift chamber and its associated electronics into operation under running conditions. Second, we would like to acquire additional data at PEP. During this second period of operation of the Mark II detector at PEP we also plan to use the new electromagnetic shower endcap detectors. The moving of the Mark II detector from PEP to the SLC is now proposed to take place in the early part of 1986. The proposal is to assemble the detector off-line at the SLC and to check it out on cosmic rays. Finally, we hope that we can begin operation of the detector at the SLC in early 1987.

C. The New Drift Chamber

Figure 3 presents a schematic horizontal cross section of the upgraded detector. The new drift chamber is designed to meet the following objectives: excellent momentum resolution, good solid angle coverage, high tracking efficiency, simplicity of pattern recognition, and measurement of dE/dx to provide an independent aid to calorimetry for electron-hadron separation. The chamber is a large cell design, Fig. 4, with 6 sense wires in each cell. There are 12 concentric layers of these cells. Alternate layers have their wires parallel to the axis or at a stereo angle of $\pm 3.5^{\circ}$. Figure 5 shows the overall layout. The length of the chamber is 2.3 meters.

The chamber provides good tracking efficiency for the angular region $|\cos\theta| \leq 0.89$. The expected position accuracy per wire is $\lesssim 200$ μm; and the expected impact parameter error for track extrapolation to the beam line is 150 μm for particles which traverse most of the chamber. A precision σ_p/p^2 of 0.12% GeV^{-1} is expected with vertex constraint for $|\cos\theta| \lesssim 0.65$. This increases to 0.45% GeV^{-1} at $|\cos\theta| = 0.85$.

There are seventy-two samples of track ionization, which we calculate will provide a resolution of about 7%. Our objective is to aid the separation of pions from electrons, we calculate that this separation will be better than three standard deviations up to about 9 GeV/c.

Figure 6 is a schematic diagram of the new electronics to be associated with the drift chamber. Further details on the electronics and on mechanical construction can be obtained from the technical proposal[5] entitled "Proposal for the Mark II at SLC" dated April 1983.

D. The New Electromagnetic Shower Detector Endcap

The new endcaps are intended to match in performance the liquid argon, barrel, electromagnetic shower calorimeters which we are retaining. The endcap construction consists of aluminum proportional tubes sandwiched between lead sheets. Each endcap will have 36 layers of lead sheets and proportional tubes each layer corresponding to 0.5 of a radiation length. The proportional tubes are rectangular, 0.9 cm x 1.5 cm in cross section, and are arranged to lie along four different coordinate axes. We expect to obtain an energy resolution for incident photons and electrons of about $18\%/\sqrt{E}$ for energies between 1 and 50 GeV. The ability of the endcaps to separate electrons from pions is expected to be equal to that ability in the present liquid argon, electromagnetic shower detector system.

E. Time-of-flight System

The scintillation counter, time-of-flight system is being modified in order to improve the segmentation by a factor of 2. Ninety-six counters will now be used, and a resolution equal to, or better than 200 ps is expected.

F. Precision Vertex Detection

As I noted before we cannot use the present secondary vertex detector at the SLC. Three different methods for precision vertex detection are being explored. One method is an extension of our present secondary vertex detector; that is, we are exploring the use of a pressurized, very high-precision, drift chamber. The goal is 30 μm resolutions per layer with an ultimate impact parameter precision of 20 μm. The second method being explored is the use of silicon microstrip detectors. These would have a position precision of 5 μm, a double-track resolution of 30 to 50 μm, and an impact parameter resolution of about 15 μm. A preliminary design has about 30,000 strips arranged in three concentric layers at radii between 1.5 and 4 centimeters. The third method which is being studied would use solid state charge-coupled optical imagers called CCD arrays. The resolution would be of the order of 15 μm. A three-layer detector would require about 300 chips, each about 1 cm^2 in area.

G. Small-Angle Detector

It is important to be able to detect electrons at angles smaller than those encompassed by the main drift chamber. For that reason the detector will have a small-angle electron detector and luminosity monitor. Figure 3 shows one possible position for this device. An alternate position would be between the beam pipe and the endcaps.

H. New Magnet Coil

The upgraded detector will have a new room temperature, aluminum coil which will produce a field of 0.5 tesla.

I. Acknowledgment

In this very brief talk I have not been able to do justice to the immense amount of work being done on the Upgrade of the Mark II by the physicists and engineers listed in Table II. Reference 5, our proposal, gives much more detail.

REFERENCES

1. R. Helm et al., SLAC-PUB-3070 (1983).
2. To quote from Ref. 1 on 'golden orbits':
   "Once a good configuration has been established, it is always found that the orbit which works best is not the 'best' orbit as indicated by the position monitors. Evidently the inspired green-thumbing by the operators eventually compensates for effects such as position monitor errors, local phase and β errors, dispersion functions, and x-y coupling. A very useful feature of the orbit correction program is the ability to save the 'golden orbit' and subsequently correct to it rather than to the 'best' orbit."
3. J. Jaros, Proc. Int. Conf. on Instrumentation for Colliding Beam Physics (SLAC Report 250, 1982), p. 29.
4. J. Jaros, SLAC-PUB-3044 (1983).
5. Caltech, LBL, U.C.Santa Cruz, Univ. of Hawaii, Univ. of Michigan Collaboration; "Proposal for the Mark II at SLC"; April 1983; CALT-68-1015.

TABLE I: Members of the Mark II Collaboration at PEP as of April, 1983

SLAC	LBL
A. Boyarski	G. Abrams
M. Breidenbach	D. Amidei
P. Burchat	A. Baden
D. Burke	C. De La Vaissiere
J. Dorfan	G. Gidal
G. Feldman	M. Gold
G. Hanson	G. Goldhaber
C. Matteuzzi	L. Golding
R. Hollebeek	D. Herrup
L. Gladney	I. Jurici
W. Innes	J. Kadyk
J. Jaros	M. Nelson
R. Larsen	P. Rowson
B. LeClaire	H. Schellman
A. Lankford	P. Sheldon
N. Lockyer (Spokesman)	G. Trilling
V. Lüth	
R. Ong	
M. Perl	**HARVARD**
B. Richter	
M. Ross	M. Levi
J. Yelton	R. Schwitters
C. Zaiser	T. Schaad

TABLE II: Physicists and Engineers (E) who are upgrading the Mark II Detector for use at the SLC as of April, 1983

LBL

G. Abrams, G. Gidal, G. Goldhaber, D. Herrup, J. Kadyk, P. Sheldon, G. Trilling (Spokesman), K. LEE (E), M. Nakamura (E)

Caltech

B. Barish, G. Fox, T. Gottschalk, C. Peck, R. Stroynowski, R. Cooper (E)

U.C.Santa Cruz

D. Dorfan, C. Heusch, H. Sadrozinski, T. Schalk, A. Seiden, W. Nilsson (E)

University of Hawaii

R. Cence, F. Harris, S. Parker, D. Yount

University of Michigan

C. Akerlof, J. Chapman, D. Meyer, D. Nitz, R. Thun, A. Seidl

SLAC - Group A

W. Atwood, H. DeStaebler, R. Pitthan, L. Rochester

SLAC - Group C

A. Boyarski, F. Bulos, J. Dorfan (Spokesman), R. Hollebeek, A. Lankford, R. R. Larsen, V. Lüth

SLAC - Group E

D. Burke, G. Feldman (Spokesman), G. Hanson, W. Innes, J. Jaros, M. Perl

SLAC - Group BC

J. Ballam, T. Carroll, T. Glanzman, C. Field, K. Moffeit

SLAC Engineers

B. Denton (E), D. Horelick (E), C. Hoard (E), D. Hutchinson (E), D. Porat (E)

Table III: Changes to be made in the Mark II Detector to upgrade it for use at the Stanford Linear Collider

Component	Changes
Secondary vertex detector	Will be changed; no design concept has been selected.
Main drift chamber	New drift chamber being built. Will use new timing electronics and new dE/dx electronics.
Time-of-flight scintillation counters	Scintillator is being replaced, the electronics is being retained.
Liquid argon, barrel, electromagnetic shower calorimeter	Entire system is being retained, minor changes may be made in the electronics.
Magnet	The iron work is being retained; the coil is being replaced.
Muon detection system	Entire system is being retained.
Endcap electromagnetic shower calorimeters	New endcaps being built. Will use new electronics.
Data acquisition and calibration system	Being retained except for changes required by new drift chamber and new endcap.
On-line and off-line data analysis programs	Being retained except for changes required by new drift chamber, new endcaps and higher energy.

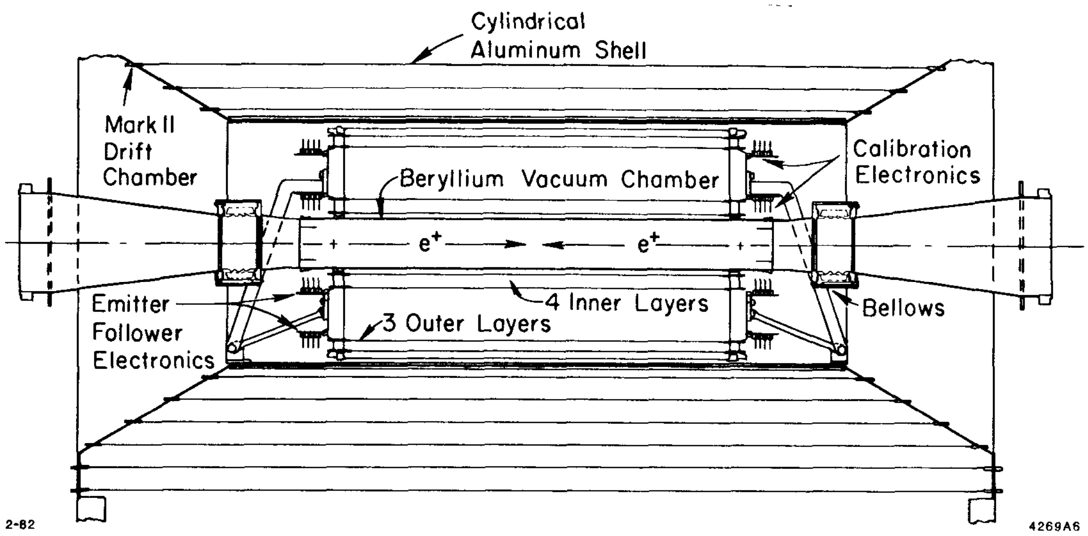

Fig. 1. Cross section of the secondary vertex chamber as installed in the Mark II Detector at PEP.

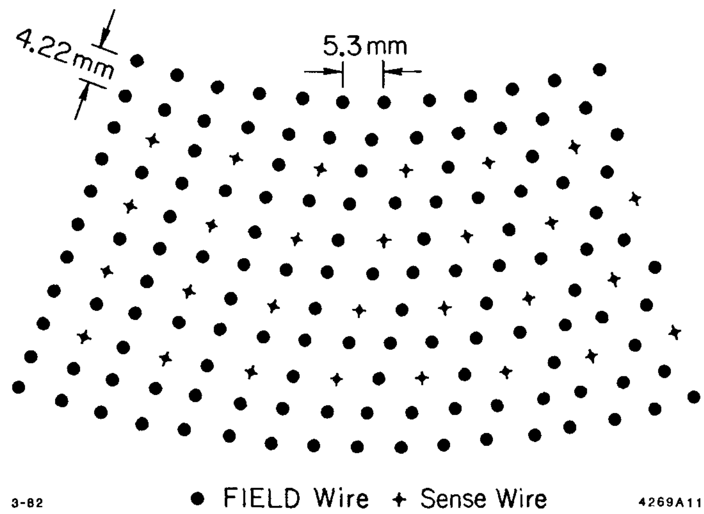

Fig. 2. Arrangement of wires in the 4 inner layers of the secondary vertex detector.

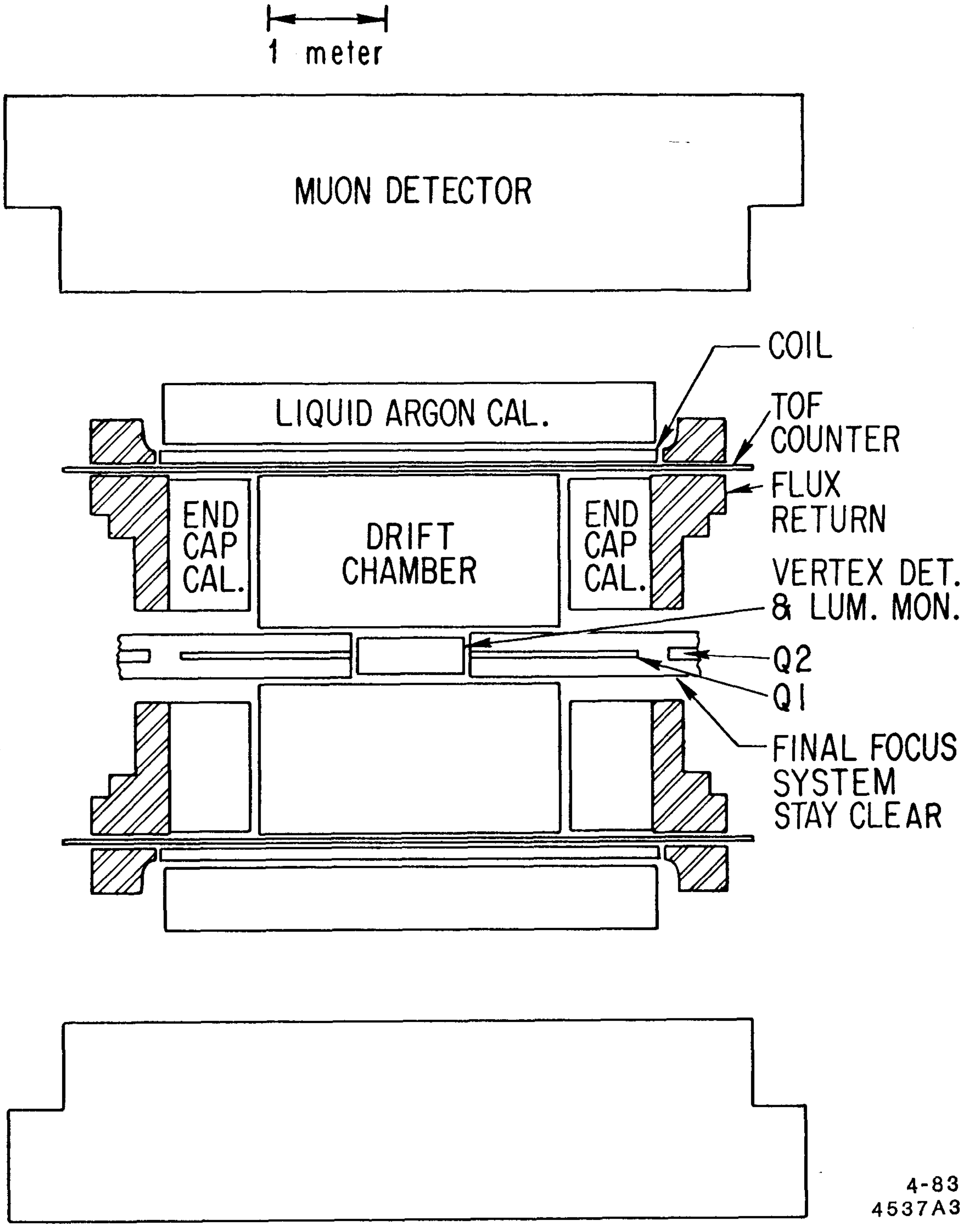

Fig. 3. Schematic, horizontal cross section of the upgraded detector.

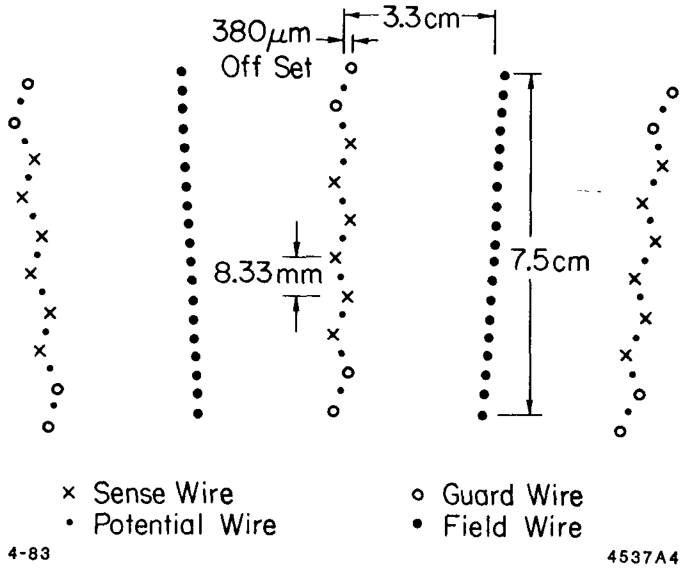

Fig. 4. Cell structure of the new drift chamber.

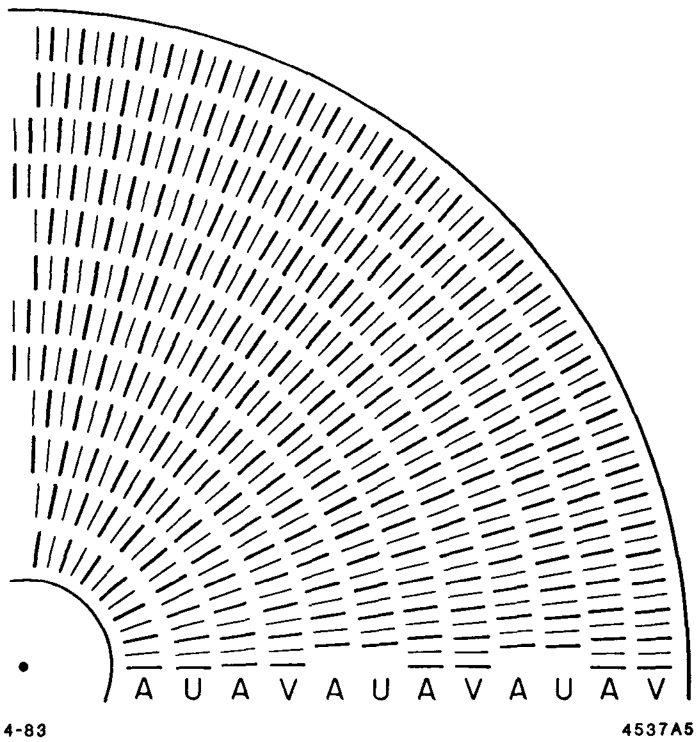

Fig. 5. The layer structure of the new drift chamber. Axial layers are indicated by A; stereo layers by U and V.

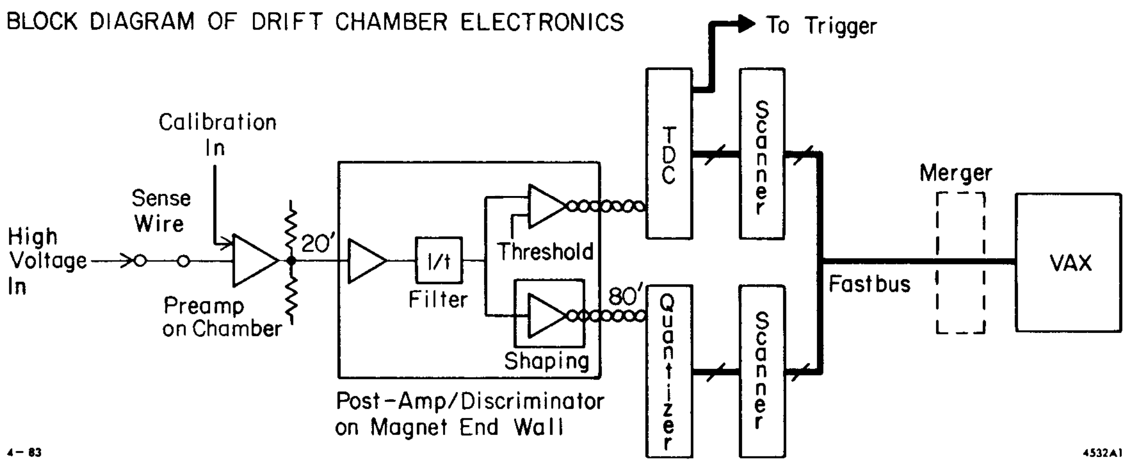

Fig. 6. Schematic of electronics for drift chamber. After the post-amp/discriminator, the upper electronics path is for processing the drift time measurement, the lower electronics path is for processing the dE/dx measurement.