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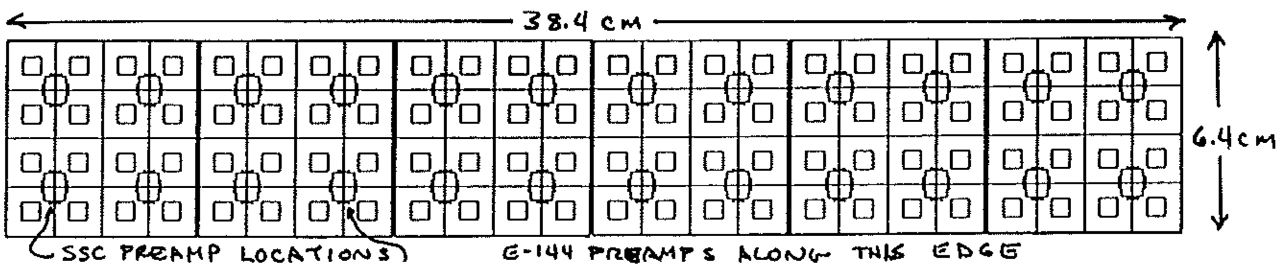
Notes on My Visit to U. Tennessee, 10/23/92

I met last Friday with Bill Bugg and Steve Berridge (electrical engineer) to discuss how U.T. might reconfigure elements of their silicon-tungsten calorimeter prototype into a positron detector for E-144.

U.T. is prepared to commit 120 (existing) silicon wafers to E-144. Each wafer is 6.4×6.4 cm^2 with 16 pads of 1.6×1.6 cm^2 and $\approx$ 100-pf capacitance each. The wafers are 300 μm thick, and were manufactured by Hamamatsu for about \$5/cm^2. The proposed configuration is 20 layers of 6 wafers, with 1 X_0 of tungsten (to be newly purchased for $\approx$ \$1k) between each layer. The expected energy resolution is about $25\%/\sqrt{E}$. A sketch of one layer of silicon appears below:



If all pads are instrumented there would be 96 towers. It is proposed that each tower have two longitudinal segments, perhaps of 10 layers each. As the E-144 positrons form a line source over the face of the detector and the Moliere radius of tungsten is about 12 mm, only the inner two columns of pads would contain significant information about the positrons. Hence it seems reasonable to only instrument 48 towers, or 96 channels counting 2 (longitudinal) channels per tower. (If each pad has its own preamp then 960 of these would be required.) In principle we could gang the adjacent pads in the inner two columns, reducing the channel count to only 48 channels.

The present prototype has fast, moderate noise ($\approx 10^4$ electrons) VLSI preamps mounted very close to the pads inside the Si-W sandwich. The preamps are mounted on a flex printed circuit board, to which the silicon wafers are also glued. The flex circuits are somewhat expensive, and it is proposed that G-10 boards be used for E-144.

The largest unresolved issue is the choice of preamp for E-144. In early running we desire to be sensitive to single positrons in an event. But with a laser operating at $\Upsilon \approx$ 2-4, and some focusing of the electron beam to smaller than 1 mm^2, we could well have 1000 positrons per pulse. This leads to a dynamic range specification that is beyond the capability of any single preamp, we believe.

Some numbers: an electron or positron loses about 10 MeV per radiation length in tungsten (at the critical energy of ≈ 80 MeV), so the track length in the detector is about 100 radiation lengths per GeV. After each radiation length an electron or positron passes through a silicon wafer, forming 24,000 electron-hole pairs in a 300-μm wafer. Hence the signal charge is about 3×10^6 electrons per GeV. We desire sensitivity to as little as 100 Mev (for position interpolation via charge sharing) and as much as perhaps 1000×25 GeV; this is charges from $\approx 10^5$ to $\approx 10^{11}$ electrons, for a dynamic range of 10^6.

The dynamic range for each pad can be similarly estimated. A single track yields 24,000 electrons, but it is desirable to be sensitive to only a few percent of these for good position interpolation. An ambitious spec is 1000 electrons minimum sensitivity. A 25-GeV shower has about 2500 wafer crossings, with a maximum of about 500 of these in a single pad, or about 1.2×10^7 electrons. Thus the dynamic range needed for a single shower is about 12,000. If we eventually need to analyze as many as 100 showers hitting a single tower, the dynamic range required is about 10^6.

A typical dynamic range of a preamp is a few thousand. Thus we may need at least two sets of preamps, or the option to insert attenuators at the inputs of a single set of preamps.

Either way it seems wise to locate the preamps outside the Si-W sandwich, and perhaps on plug-in cards. The latter choice would apparently exclude the use of the fast preamps developed at U.T. for SSC applications. We have no speed requirement in E-144, so very slow preamps could be used in principle. In the latter case we have the option to gang pads together before the preamps (resulting in larger capacitance presented to the preamps).

Once the preamps are chosen, summing/shaping circuits must also be built. Existing designs are almost certainly applicable, but a specific choice must be made and implemented.

The ADC system can be based on existing hardware. U.T. has 3 96-channel LeCroy 1882 FastBus ADC, 4096 counts/channel. One such module would suffice. This requires a FastBus crate (from SLAC?) and a controller, such a LeCroy 1691A, connected to a computer, such as a PC in the case of the LeCroy controller. U.T. has a test setup using the 1882 adc; it remains to be determined whether this would be contributed to running of E-144. Other readout options are readily contemplated...

My understanding of how U.T. would implement a detector for E-144 is that Bill Bugg will set the specifications, Steve Berridge will design the preamp boards, summing/shaping boards and interconnects, and Penny Berridge (electronic technician) will assist in circuit fabrication. A post-doc at U.T., xxx Du (?) would participate in bench tests there. At SLAC, U.T. post-docs Rob Kroeger and Achim Weidemann might take some role in hardware and software operation of the detector in E-144.

Bill and Steve agreed that the resources at U.T. are sufficient to construct the detector by June 1993. A request for modest funding in association with the E-144 effort will be made shortly for their grant cycle beginning April 1993.