A Multiplicity Jump Trigger Using Silicon Planes

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Since silicon tracking planes are already present in a B decay experiment, it is an attractive idea to use these as part of a multiplicity jump detector. Two average B decays would produce a multiplicity jump of around 10 in the final state. Such a trigger has been tried for a fixed target Charm experiment with disappointing success.[1] The failure was attributed to the difficulty in adequately controlling the gains of a large number of microstrip amplifiers.

One could limit the number of amplifiers needing adjustment by collecting all the charge from a silicon wafer with a single amplifier on the backside of each microstrip detector as shown schematically in Fig. 1. An efficient system for monitoring and calibrating with single beam tracks should be employed frequently during the run.

Input noise does not appear to be a problem for planes as thin as 300 μm. Using a $2.8 \times 2.8\ cm^2$ Hamamatsu plane into a single Fermilab QPA02 amplifier, we obtain 16 mV signals from minimum ionizing particles in the presence of about 5 mV rms noise. Thinner detectors would imply more capacitance and thus more noise and smaller signals.

The Landau tail on the high energy side of the energy loss distribution suggests some difficulty. Fig. 2 shows energy loss distributions for 5 GeV/c pions in a 300 μm plane and several multiplicity jumps of 6. For about 30 secondary particles there is an obvious inefficiency for distinguishing larger statistical fluctuations from a real jump of 6. This problem can be mitigated by working only with plane-pairs and accepting the smaller multiplicity of the pair. See the diminished tail in inset of Fig. 2. For large numbers of planes (such as 90 in the SFT proposal), one can employ more complex algorithms.

The most difficult problem for the silicon detectors comes from the proton spallation products of the heavy nuclear target. The behavior of the spallation protons is essentially independent of beam energy and particle type and well described by a simple computer model.[2]

If silicon wafers are the only target material, then about 45% of the collisions will not have a significant spallation proton (i.e. one which ranges through more than one 300 μm thick wafer). See Fig. 3. If one arranges for most of the target material to be Be, then about 57% of the collisions will not contain a significant spallation proton. For about half of the events a simple multiplicity jump can be used correctly to pass judgement on B production candidates selected by other components of the trigger (e.g. dimuon identification).

The greatest difficulty arises when the target is constructed entirely of active 300 μm wafers. A stopping, normally incident proton can produce a 30X to 40X minimum pulse in the stopping wafer. (See Fig. 4.) If the amplifier does not saturate, it produces a multiplicity jump of 6 to 14 when compared with the preceding wafer. All earlier multiplicity jumps are 5 or less. The simplest procedure would be to reject all events in which any wafer has more than 30X minimum energy deposited in it. This unfortunately would reject about half of the legitimate B events.

The algorithm that used plane-pairs to reduce the Landau tail would also eliminate observation of the large multiplicity jump at the stopping wafer, since that jump involves only one pair of planes. (See Fig. 4.) If one chooses to use passive Be as target material between Si wafers, then the large multiplicity jump of a stopping proton can be vetoed by the large multiplicity decrease in the following plane.

If the pulse heights from the active wafers are immediately digitized by flash ADC's, the simple digital logic for jump detection can be programmed into Xilinx logic arrays. Decisions can probably be made fast enough to participate in a level one trigger.

REFERENCES

1. P. Weilhammer, Proc. of the workshop on *New Solid State Devices for High Energy Physics*, LBL-22778 and CERN EP/86-54 (1985).
2. K. Braune, et al., *Z. Phys.* C13 (1982) 191.

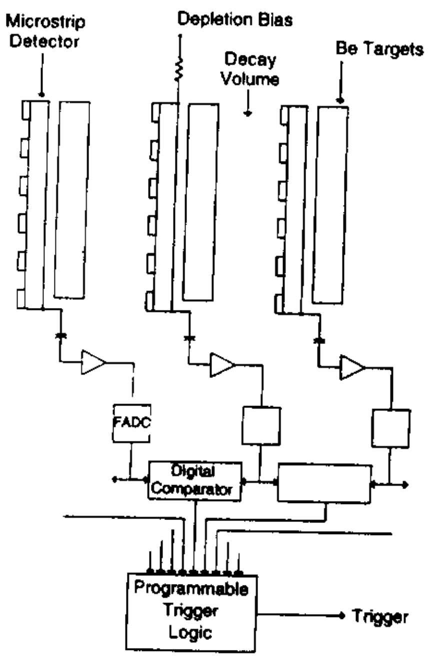

Fig. 1 Portion of a possible multiplicity jump trigger.

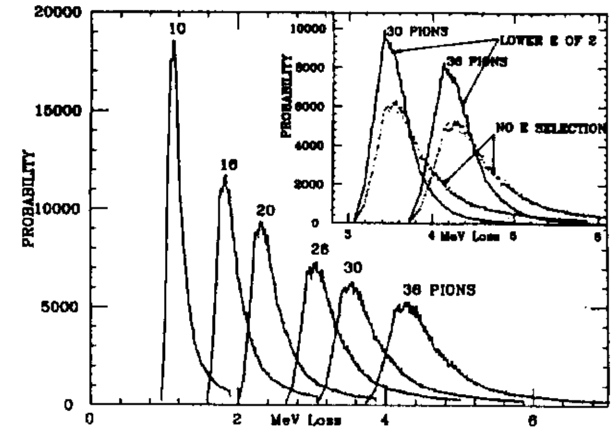

Fig. 2 Some energy loss distributions in 300 μm Si wafers.

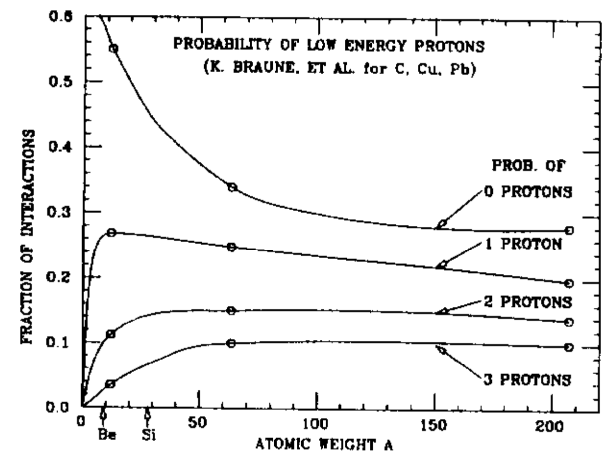

Fig. 3 Fraction of collisions with slow protons vs. atomic weight.

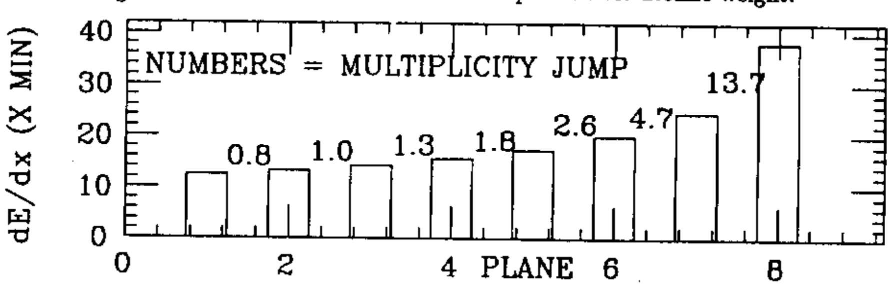

Fig. 4 dE/dx of a stopping proton in 300 μm Si planes expressed as multiples of minimum ionization. Numbers give multiplicity jump between planes.