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INTERSECTING STORAGE ACCELERATOR NOTES

For the Measurement of Multiplicities - The "Multimeter"

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N O T I C E

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FOR THE MEASUREMENT OF MULTIPLICITIES - THE "MULTIMETER"

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In a standard spark chamber or multiwire proportional chamber (MWPC) experiment which takes the x and y projections of particle tracks, one is faced with n^2 possible x y combinations for an event with n tracks. Usually, the rejection of incorrect associations is accomplished with additional information from oblique and redundant chambers. At ISABELLE energies, however, the event rates and multiplicities can reach a level for which computing time and event reconstruction efficiency may be serious problems. In an experiment dealing with the measurement of multiplicities and correlations it is particularly desirable to minimize the dependence of the event reconstruction efficiency on the complexity of the event.[1]

In low luminosity operation, it is likely that visual detectors can provide useful information about the general characteristics of this energy regime, but it also seems clear that a detector which provides a multiplicity signature at higher luminosities will be essential for the exploration of more detailed (and probably more interesting) features and correlations with specialized apparatus such as particle identifiers, spectrometers, etc. The detector discussed here is intended to demonstrate the feasibility of such a device, even within today's technology. One can reasonably expect with normal progress in electronic integrated circuitry that by the time ISABELLE is nearing operation, the "multimeter" should be a practical and reliable instrument.

The basic idea is to use MWPC's in an x-y configuration and to record not only which wires are hit, but also to measure where along the wire the signal is generated.[2] If this can be done with an accuracy of, for example, 0.01 L where L is the length of the MWPC wire, then the chamber is effectively divided into ~ 10,000 independent detection "elements" in the sense that ambiguities can occur only if more than one track passes through such an element. Thus 50 tracks randomly distributed in such a chamber have only a few percent chance of overlap. A minor problem arises though if more than one track is registered on the same wire. In any case though, two such x-y planes are needed to define a track, and with the additional constraint that the tracks must originate at a common vertex within the interaction volume, ambiguities should be reduced to a manageable if not negligible frequency. It may be possible to reach substantially greater accuracy than 0.01 L, and since the probability of ambiguities depends quadratically on this resolution, effort in this direction would appear to be well spent.

The position along the wire corresponding to the track can be found by utilizing the pulse height registered at each end of the wire, treating the wire as a resistive divider.[2] Typical tungsten wires used in contemporary MWPC's have 200 ohms/meter, a quite convenient value. The brute force approach, envisaging an individual analog-to-digital converter for each end of every wire in addition to the usual thresholding and logic circuitry, seems conceivable, but another scheme offering significant advantages also suggests itself based on the author's experience with flat multiconductor transmission lines.

For the latter option, it is proposed that the MWPC analog signals themselves are transmitted to a remote sample-and-hold analyzer system. In this case,

the quantity of electronics needed for the pulse height analysis (sequential processing) can be drastically reduced, and it is conceivable that the electronic circuitry at the chambers can be reduced to zero! Since access to an experimental area is precluded once beams are stored in the ISABELLE, the advantage of totally remote electronics is very real. An additional benefit of the cables is that sufficient delay may be provided so that a selective trigger can be created to accept only the interesting event candidates into the pulse height analysis system. As for reliability, not one failure or problem of any kind has occurred with the flat transmission cables of the Columbia 5000 wire MWPC system in more than a year of continuous operation at the AGS.

It should be noted that the feasibility of directly transmitting the MWPC pulses over transmission lines has been demonstrated by a Los Alamos group.[3] With the magic gas mixture, the pulses are quite large, $\geqslant$ 50 mV, fast rising, $\sim$ 10 nsec, and uniform in pulse height due to saturation, even when driving the low impedance typical of transmission lines.[4] These characteristics are quite compatible with electronic measurements for pulse height analysis of a few parts/1000 accuracy. The presence of more than one track on a given wire will generally give larger pulses, and can be detected in this way.

What remains to be solved is the problem of cross talk and noise picked up by the cables. In the Columbia MWPC system, cross talk is about 5% between adjacent channels and differentially received noise is about 5 mV, but no difficulties exist in this instance since the transmitted pulses have been shaped. An improved cable design with these goals in mind, combined with cable-to-cable shielding, may give an adequate solution.

With 2 mm signal wire spacing, a simple 4π detection system around an interaction region consisting of a rectangular box geometry perhaps 1 m x 1 m x 2 m in size will contain 8000 wires and require 16,000 PH circuits. Since two concentric boxes are required another 11,000 wires and 22,000 PH circuits are needed for the outer shell of the multimeter. If the total circuitry costs per wire are kept down to ~ $15, then the electronics amounts to only $300,000, a quite tolerable expense on the scale of ISABELLE. For this sum, one has acquired a system with $\sim 3 \times 10^5$ independent track localizaing detectors, in the sense of eliminating ambiguity difficulties.

With regard to rates, a luminosity of 3×10^{33} will produce $\sim 10^8$ interactions/sec, leading to the registration of fragments of about four extra events (average charged multiplicity of 12) in addition to the event of interest, assuming 50 nsec resolution. With the multimeter it should be straightforward to recognize and reject tracks not originating from the vertex of interest, at least at large angles. The average wire rate is only 10 kilocycles, although wires near the beam pipe can be expected to count much more often.

If gammas and other neutrals become of sufficient interest that their distributions should be determined as well, converters can obviously be included in additional concentric shells. The only point to be made here is that the PH analyzing principle will give the mean position of the shower along the wire, which is the most desirable result. Difficulties may arise here due to the larger dynamic range of input pulses to the analysis system.

A realization of these comments is shown in the accompanying figure. The chambers are conceived along the elegant design for the CERN ISR SFM.[5] Dead regions are reduced to a very small fraction of the total solid angle by mitreing the corners. The cables for the inner shell pass by the edges

References

1. See, for example, CRISP 71-23, 71-9, and R. Arnold, et al., "Charged Particle Multiplicity and Angular Correlation Measurements in pp and yp collisions."

2. The precise origin of this notion is unknown to me, but a discussion of similar notions is given in G. Charpak, Ann. Rev. Nucl. Sci. 20, 195, (1970).

3. D.F. Jones and E.R. Martin, Nucl. Instr. & Meth. 98, 535 (1972). No pulse height analysis was attempted in this system other than conventional threshold sensing.

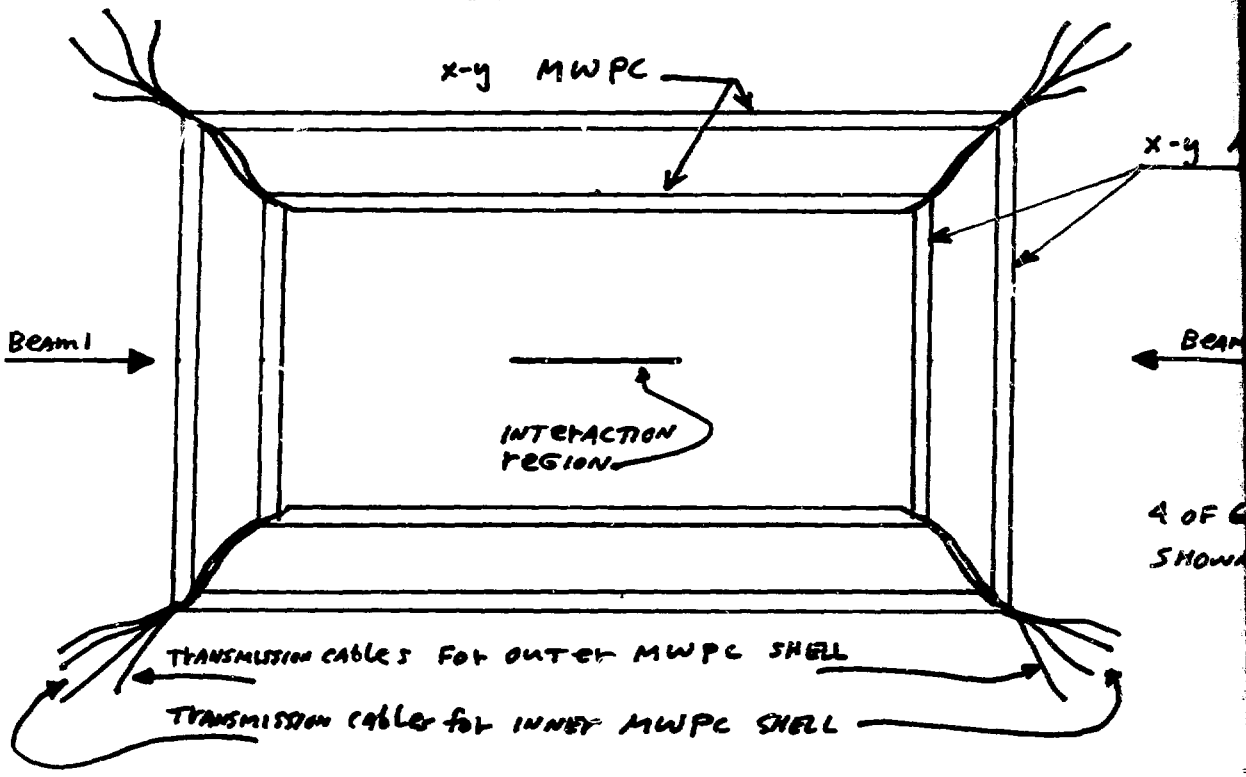
4. Bill Sippach, LAMPF Summer Study Proceedings, 1971, LA4824-MS, p. 151, Los Alamos Scientific Laobratory.

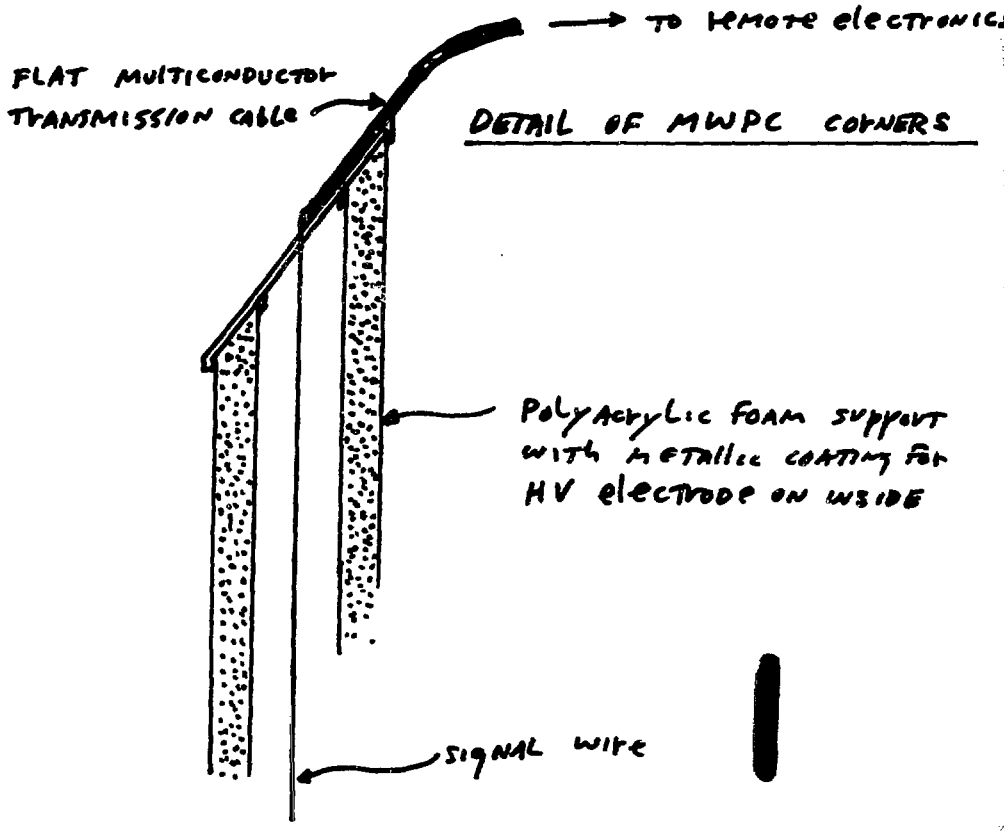
5. CERN Courier, March issue, 1971.

of the outer shell with negligible contribution to the gap. Many layers are possible. How the beams get in and out is a problem left for the future. An advantage of the x-y only approach is that the simple box geometry is very convenient; oblique wires can be included, although it seems awkward with this geometry.

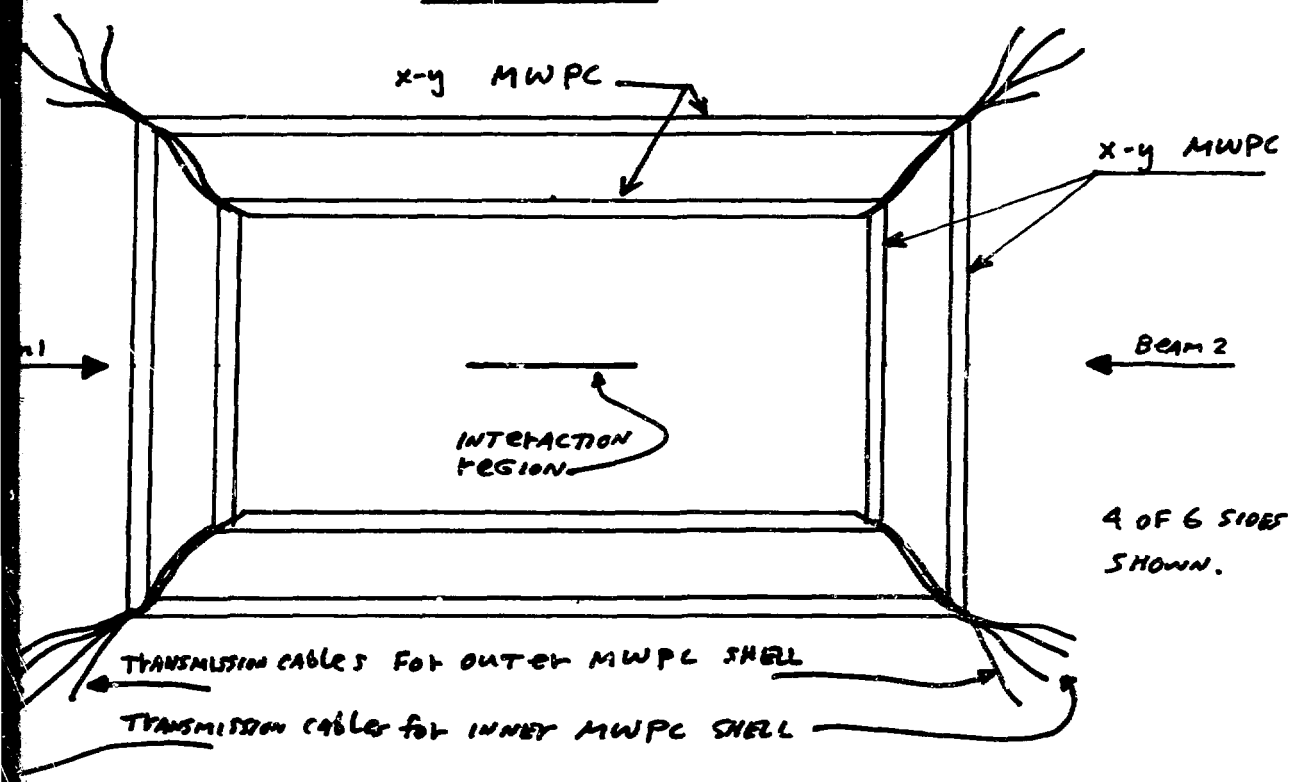
In summary, a very powerful multiparticle 4π detector with inherent reliability and flexibility seems to be within the grasp of today's technology and tomorrow's budget. Possibly the most appropriate attitude might be to ask not what might be achieved with the multimeter, but rather to consider how one may be limited without it.

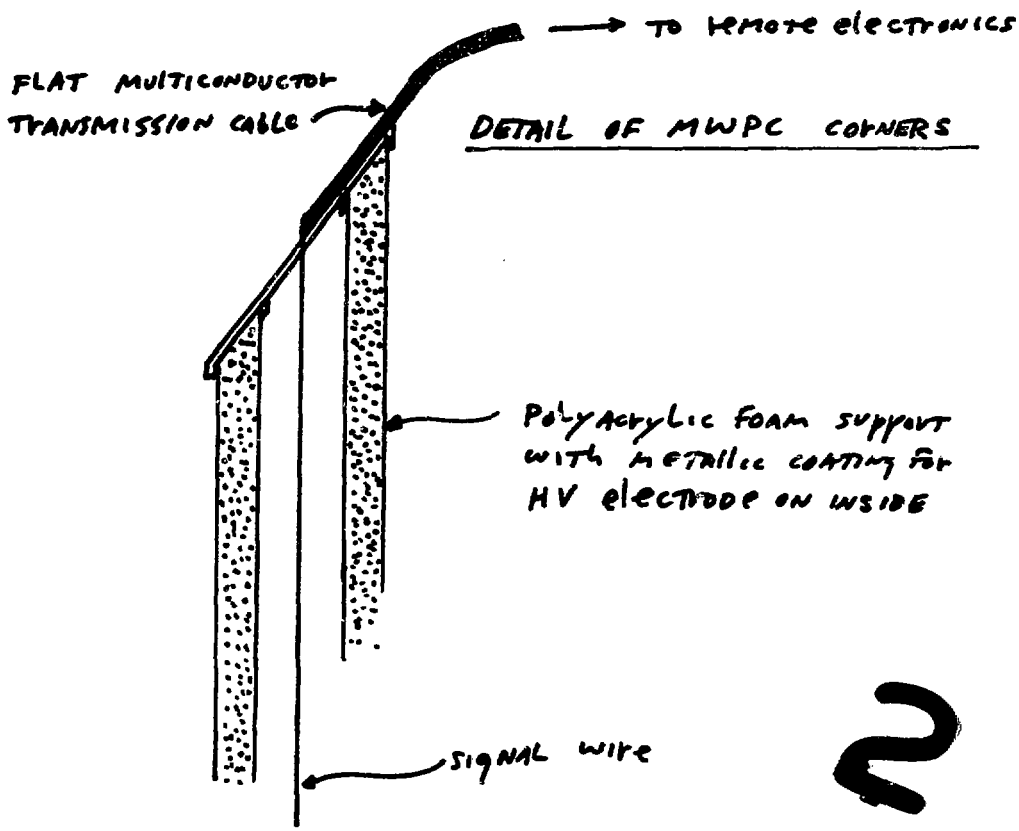
MULTIMETER


x-y MWPC
x-y
Beam I
Beam
INTERACTION REGION
4 OF 6
SHOWN
TRANSMISSION CABLES FOR OUTER MWPC SHELL
TRANSMISSION CABLES FOR INNER MWPC SHELL


TO REMOTE ELECTRONICS
FLAT MULTICONDUCTOR TRANSMISSION CABLE
DETAIL OF MWPC CORNERS
Polyacrylic foam support with metallic coating for HV electrode on inside
SIGNAL WIRE

MULTIMETER





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