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INFLUENCE OF DETECTOR SPATIAL RESOLUTION IN THE SCALING OF NAL EXPERIMENTS

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The purpose of this note is to point out the enormous savings in cost, complexity and increased flexibility that would flow from having detectors capable of improved spatial resolution. A typical component of many proposed experiments is the wire-plane magnet spectrometer, and devices with apertures of 10 ft × 2 ft are under construction for the use at the AGS. It is clear that an improvement by a factor of, say, 4 in spatial resolution will reduce this aperture to $2\frac{1}{2}$ ft × $\frac{1}{2}$ ft with no loss in solid angle. The savings in magnet cost go much faster than linearly. The gains in field uniformity (and computer time), surveying, mobility, etc. are very large. One can argue that the entire experiment shrinks toward the target until it reaches the finite beam and target size and then it depends upon specific details. One should note that NAL beams have intrinsically fine optics; high intensity also permits short targets. Finally, at civilized apertures, cryo and superconducting magnets become thinkable and give improvements in momentum resolution over AGS experiments.

As a specific example, standard wire chamber readouts give resolutions of 0.3 mm fairly routinely. Lindenbaum is covering a 10 ft × 2 ft × 3 ft magnet with wire planes. This magnet provides a deflection of ~ 40 mrad at 10 GeV/c and requires an angular resolution of 0.3 mrad on ingoing and outgoing tracks for a 1% measurement. With 0.3 mm resolution, the distance between planes is 150 cm. If the spatial resolution were to be improved by a factor of 10, the aperture of the magnet could be reduced by this factor, the volume of field being reduced by $10^{3/2} = 30$ which measures the cost savings for a given value of magnetic field. The advantages of flexibility, surveying simplicity (optical bench as opposed to coast and geodetic survey) and mobility are also considerable.

The possibility of now going to 3 or 4 times the field via cryomagnets now permits measurements at 30 or 40 GeV to 1% with "reasonable" sized magnet. Forward peaking at higher energies also means that smaller apertures are required and this may be used to raise futher the momentum for which 1% measurements may be made. Multiple scattering in typical wire chamber configurations at 30 GeV/c is ~ 0.02 mrad and, therefore, negligible.

Thus, the payoff on spatial resolution is tremendous and I discuss here some possibilities all of which follow some ideas of Charpak.[1]

The key idea is to operate wires at dc potential in the proportional region. There is then a diffusion of the ionization electrons to the wire in times which can be controlled from ~ 100 nsec to 1000 nsec. If this time can be measured relative to some t = 0 established by a scintillator, then the spatial interval between wires can be split by the time measurement to a degree limited only by statistics of electron collection and the frequency of micro-delta rays. In practice, such things as surveying, mechanical stability and compromises with area coverage and time resolution may also limit the spatial resolution. However, a limit of ± 0.01 mm does not seem to be unreasonable as an ultimate objective.

Consider, for example, an array of wires as shown in Fig. 1.

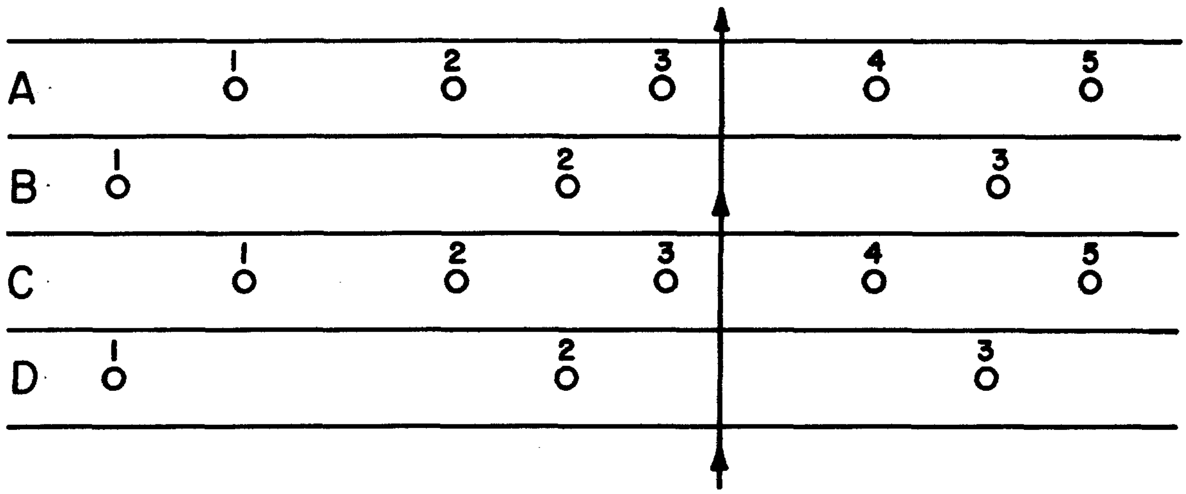

Fig. 1

The digital information that wires 3, 2 fired in planes A, B, C and D are recorded conventionally. All wires of the same number are in parallel. The purpose of the parallel planes is simply to improve the statistics. The time from $t = 0$ to the leading edge of the pulses is also recorded. Planes B and D remove the left-right ambiguity of A and C. Also, B and D ensure that a long transit time is always recorded. This arrangement should be good to ± 0.03 mm for normally incident tracks. A group of say, 30 wires can be covered by a scintillator of 12 cm width and the wire electronics would then require only 45 registers, the relevant scintillator providing the identification signal. A 1-meter aperture might require 10 scintillators and 450 wires per plane but provide a spatial resolution ~ 0.03 mm. Some additional virtues stressed by Charpak are the high rate capacity (→ 1/Mc/s per wire!) and the insensitivity to magnetic field.

The Charpak proportional wire chamber shows very great promise of increasing both the space and time resolution and is a development critically needed in the NAL domain in order to reduce costs and complexity. It deserves vigorous development.

FOOTNOTE* AND REFERENCE

*Editor's Note--See also prior work by R. G. Roddich and L. J. Koester, Jr., A Wire Proportional Counter Study, Eng. Note # 112, Electronics Division, Argonne National Laboratory, April 14, 1965 (unpublished).

[1] G. Charpak, R. Bouclier, T. Bressani, J. Favier, and C. Zupancic, The Use of Multiwire Proportional Counters To Select and Localize Charged Particles, Nucl. Instr. and Methods 62, 262 (1968).