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The Use of Hodoscopes at ISABELLE +

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A major problem for experimenters designing detectors for use at ISABELLE is the high interaction rate – one event every 25 nanoseconds at a luminosity of 10^{33}

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cm^{-2} sec^{-1}. Typical multiplicities range from a few at large angles ($\gtrsim 45°$) to ~ 10 nearer the forward direction. This implies average rates as high as a particle every few nanoseconds. For experiments which require high luminosities, detectors must be designed which have very short (~ 1 nsec) response time and/or intercept a small solid angle per element.

These requirements are met by fine-grained scintillation counter hodoscopes. However, it is, at present, impractical to maintain a 10,000 element hodoscope array because of the difficulty of light piping, the complexity and expense of maintaining that many phototubes, and the problems of packaging and readout. Several developments promise to make such large arrays feasible.

Intricate light piping can be simplified through the use of fiber optics light guides as has been done for small hodoscopes.[1] To make large arrays practical, one would like to develop an integral scintillator plus light guide as pictured in Figure 1. Previous attempts at making filaments of plastic scintillators[2] suffered from crazing so that it is important to sheath the scintillator, much like a fiber optic strand is sheathed, in a low index of refraction tube. The smallest practical dimension for such a hodoscope element is about 1 mm since this gives ~ 100 photons[2] or perhaps 10 photoelectrons. For long fibers or light guides, good transmission is important, again implying a fiber optic arrangement. Glass scintillator would probably have the best optical properties but may darken in a high radiation environment. Plastic scintillator is more radiation resistant and is also flexible in 1 mm thicknesses. At present, the attenuation length of plastic fiber optics in only a few feet,[3] however. Another interesting idea is to use glass capillary tubes filled with liquid scintillator. Unfortunately, liquid scintillator has a low index of refraction (~ 1.3) so that light would reflect at the glass-air boundary. Cross talk may be a problem. Once such a fiber optic scintillator is developed, one can imagine readout via flat cables of optical fibers much as PWC cable is presently used. What is then needed is a compact device capable of readout of these low level light pulses.

Multi-anode microchannel plate photomultiplier tubes seem to be well suited and have the additional advantage that they work in a magnetic field.[4] One could imagine mapping the flat cable onto the face of one of these tubes. A 5 in. tube would have a surface area of 10^4 mm^2 or enough to map 10,000 of these hodoscope elements. Such a tube might cost \$300K,[5] but this amounts to only \$30 per channel. Development of the anode would be problematic. It may be possible to segment the anode in 10,000 pieces and then one could use individual reaout like a PWC. One

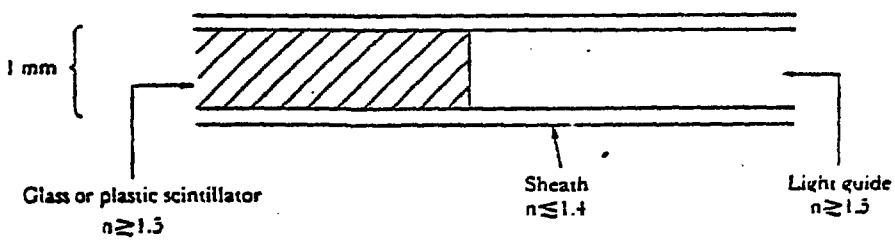

Figure 1. An integral fiber optic scintillator plus light guide.

company[6] has developed a tube with resistive anode which can be read out through charge division techniques. If a 1% accuracy in division can be attained, the number of anode segments reduces to 100. Lifetime of these tubes is, at present, about 1000 hours.[4] This must be increased to make them practical.

An example of an ISABELLE experiment which will almost certainly require a fine-grained hodoscope is the measurement of *pp* elastic scattering in the Coulomb interference region.[7] A 100×100 element array with 1 mm granularity is shown in Figure 2. Several such arrays placed close to the beam pipe, and perhaps staggered,

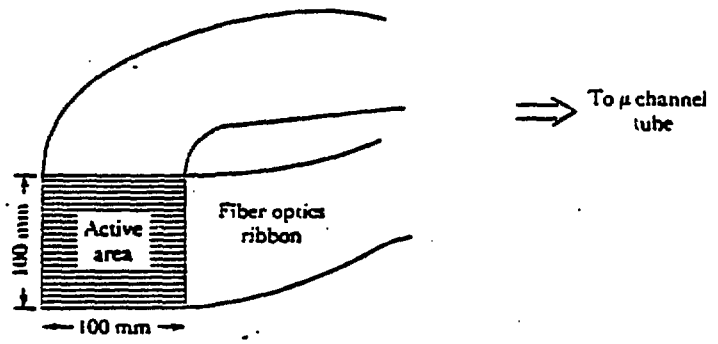

Figure 2. A 100×100 element hodoscope array to be used for small angle *pp* scattering.

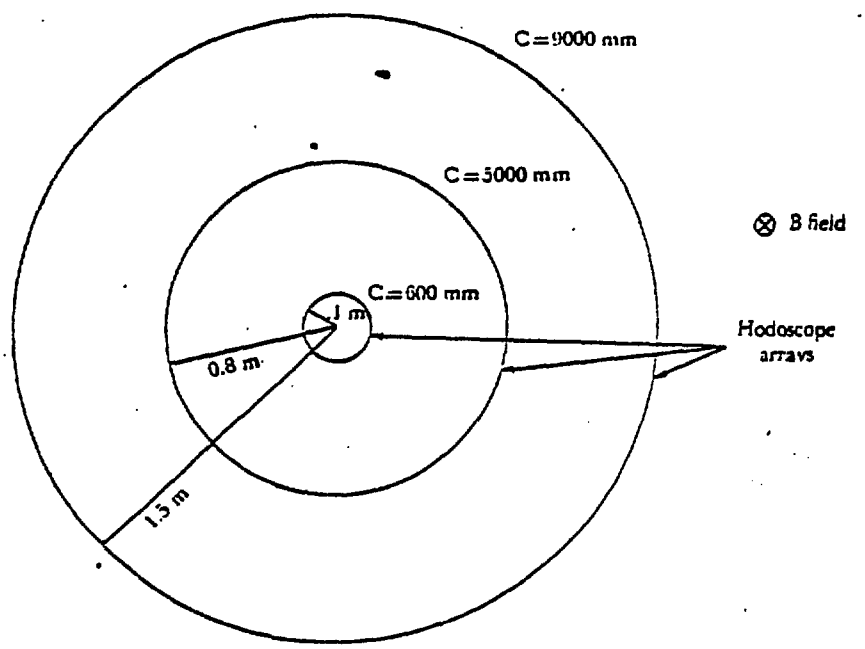

Figure 3. A 15,000 element hodoscope array for use as a fast trigger in a solenoidal magnetic field. The elements are barrel staves in cylinders around the beam pipe with circumferences as shown.

would be sufficient to make the measurement. There would be less than 1000 elements, so that conventional phototubes would be a possibility, but a single 2 microchannel tube seems simpler.

Another example, Figure 3, shows a set of three hodoscope arrays, with 1 mm elements placed along the beam axes inside a solenoidal magnet of 1.5 radius. There are 15,000 elements which could be mapped onto two 5 in. tubes which could remain inside the field. The sagitta of a particle track would be determined with sufficient accuracy to achieve a momentum resolution of 10% for 25 GeV tracks with a field of 30 kilogauss. One could trigger on two-body decays of heavy particles such as the Z^0 even in the presence of hadronic background. Many other topological triggers could be imagined with such an array.

The usefulness of such arrays will depend on further development in the following areas:

1. Design and testing of segmented anode tubes and associated fast electronics.
2. Improvements in the life of channel plates, tests of their uniformity and durability in magnetic fields and high radiation environments.
3. Development of optical connections from scintillator to optical fibers to channel plate tubes.

The advantages for ISABELLE are such that a serious effort should be made now to solve these problems.

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