PARTICLE LOCALIZATION USING FIBRE OPTIC Hodoscopes

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At Saclay a group of engineers have achieved the large scale production of plastic clad scintillating and optical fibers with attenuation lengths of the order of the meter (Ref 1), and such fibers are actually being commercialized by OPTECTRON (Ref 2).

The fibers appear promising in a number of different applications for particle detectors. The purpose of this talk is to give a brief tour of different detectors whose design is at present being actively pursued at Saclay, (this does not preclude other laboratories working on the same subjects either in collaboration or separately, but to my knowledge all are using plastic fibers made by Saclay or OPTECTRON) with an emphasis being placed on the problems encountered from the point of view of fiber technology.

1 - The UA1 calorimeter improvement program.

The calorimeter will consist of a very large number of scintillating plates interleaved with sheets of Uranium. (Ref.3). The light from the scintillating plates will be collected by fluorescent fibers embedded in the plate, and this light will be carried by a clear fiber, through various twists and turns to a PM 5 meters away. A schematic is shown in Fig.1.

The studies at Saclay concentrate for the moment on the different ways to embed to fiber in the scintillator plate so as to obtain an efficient and uniform light collection. One would like to obtain at least one photoelectron (at the PM 5 meters away) for a minimum ionizing particle traversing one thickness of scintillator plate (30 x 30 x 2.5 mm). Green fibers doped with K 27 appear favorable.
One also requires a practical and efficient coupling between the fluorescent fiber and the optical fiber, with losses not exceeding 15% at the junction. Optical glues, with the fibers held in narrow sleeves, appear to meet this requirement. One also requires a number of bends with radii of the order of a few cm, again with losses not exceeding 10% per bend.

These problems are being actively tackled at Saclay by a team led by J.P. de Brion.

2 - The UA2 improvement program includes a tracking hodoscope surrounding the interaction vertex, made of layers of fibers. The scintillating fiber detector (SFD) (Ref.4). It consists of seven triple layers of scintillating fibers with a stereo angle forming a 60 mm thick cylinder at an average radius of 410 mm.

At Saclay, with the help of a metal weaving company, GANTOIS, (Ref.5) we have developed an industrial technique of producing layers of neatly ranged fibers, forming a flexible tape or sheet.

In addition we are studying the problems connected with the read out of a large number of fibers, a question which is important not only for the UA2 program but for any track localization using fibers. In particular we are looking into the possibility of using multi anode photomultipliers and the use of integrated solid state readout of multi anodes with techniques developed by G. Comby at Saclay.

3 - Micro vertex detectors. One of the more exciting developments is the production of micro vertex detectors. This work is being done in collaboration with C. Fisher et al (Ref.6). This work has been initiated by others with glass fibers (Ref.7), the interest in using plastic fibers is the possibility of obtaining a greater luminosity and a better resistance to radiation.

Starting from 1 mm polystyrene extruded fibers with a cladding of 100 μm (compared to a 10 μm cladding with normal fibers) we form a bundle 40 mm in diameter which is then pulled to a 2 mm diameter yielding a multifiber with each individual fiber 40 μm in diameter and a cladding of 5 μm. We have succeeded in the production of such multi fibers. At the end of this operation the fibers have taken a hexagonal shape. For the moment we are probably suffering from considerable cross talk between the fibers. We will require a clean measuring system (high resolution image intensifier) to determine this more precisely. One possibility to tackle the cross talk is to use an absorber or better a reflector surrounding every fiber. Eventually however we shall have to incorporate suitable fluorescent products in appropriate concentrations so that the light conversion takes place in a distance of the order of 10 μm or less (as seems to be the case for scintillating glass) while the present conversion distance appears to be of the order of 500 μm. We still have much to learn about the construction of uniform bundles with accurate alignment of the fibers (coherence length).

4 - We have built some small modules with compacted fibers of 1 mm diameter.

The general interest is to have a scintillating plate which allows the precise localization of a particle. In this particular case the purpose was to test the possibility of having a clean separation between two adjacent scintillators without any dead region in between (less than 1 missed count per 10^4 particles traversing). This was a device suggested
by F. Lehar and L. Van Rossum from Saclay (who also tested our modules) to build a counter for total cross section measurements.

For this application we made two test blocks with dimensions approximately as shown in Fig.2 in one case with drawn fibers of 0.5 mm, and the other block with 1 mm extruded fibers.

In this second block we blackened the outside of the fibers before compacting to cut down on the cross talk but this affected the light output. We had 4 to 5 photo electrons per crossing electron from a $^{90}$Sr source and our efficiency was limited by Poisson statistics. The separation width had a $\sigma = 1$ mm. In the second block we extended the fibers directly to the PM, having compacted only the first cm. In this case also the compacted fibers take a hexagonal shape.

I presented here some of the scintillating fiber detectors on which we are working at Saclay.

References:

1 - L. Allemand et al
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3 - CERN/SPSC/84-72
4 - CERN/SPSC/84-95
5 - GANTOIS Saint Dié, France

248