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SCINTILLATOR PLATE CALORIMETRY

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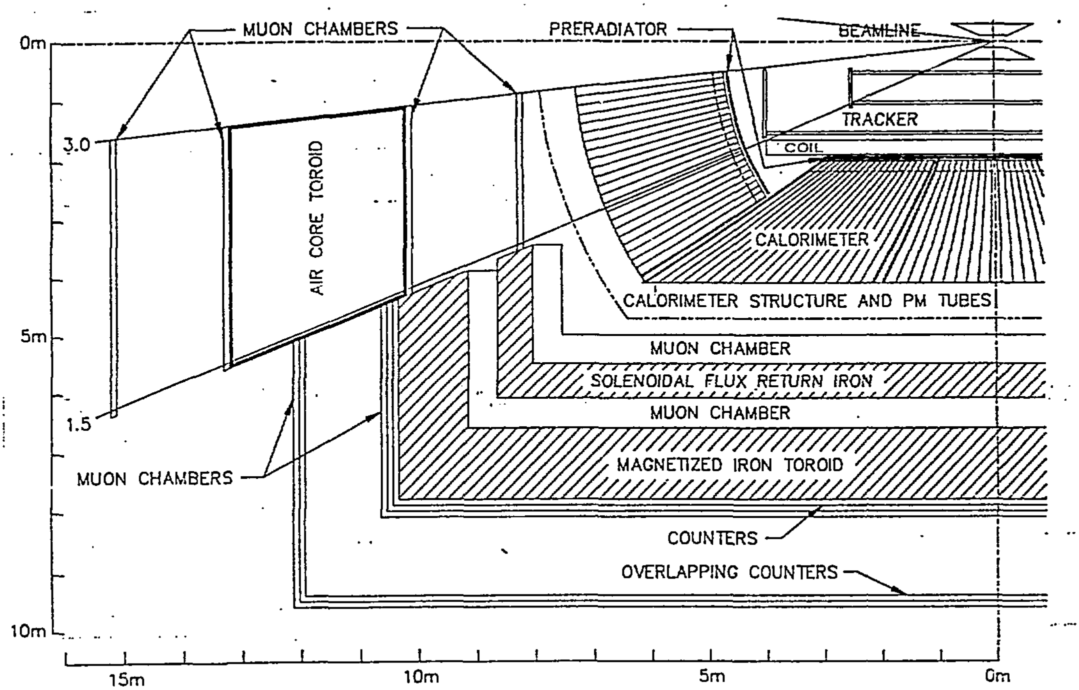
Calorimetry using scintillator plates or tiles alternated with sheets of (usually heavy) passive absorber has been proven over multiple generations of collider detectors. Recent detectors including UA1, CDF, and ZEUS have shown good results from such calorimeters. The advantages offered by scintillator calorimetry for the SSC environment, in particular, are speed (< 10 nsec), excellent energy resolution, low noise, and ease of achieving compensation and hence linearity. On the negative side of the ledger can be placed the historical sensitivity of plastic scintillators to radiation damage, the possibility of nonuniform response because of light attenuation, and the presence of cracks for light collection via wavelength shifting plastic (traditionally in sheet form).

This approach to calorimetry is being investigated for SSC use by a collaboration of Ames Laboratory/Iowa State University, Argonne National Laboratory, Bicron Corporation, Florida State University, Louisiana State University, University of Mississippi, Oak Ridge National Laboratory, Virginia Polytechnic Institute and State University, Westinghouse Electric Corporation, and University of Wisconsin. This group has received funding from SSC Laboratory under the Major Subsystem R&D program. H. Spinka of ANL is the spokesperson of the collaboration. Major tasks have been identified with coordinators as follows: Calorimeter Electronics (E. Rosenberg, W. Smith); Position Measuring System (A. B. Wicklund); Optical Systems and Scintillator Development (R. McNeil, L. Mo); Materials Evaluation (D. Reeder); and Simulation and Mechanical Design (J. Proudfoot, H. Spinka).

The overall layout of a scintillator plate calorimeter is shown in Fig. 1 as presently conceived (the mechanical design is evolving rapidly), set into an overall detector concept. The design will attempt to achieve approximate projectivity in both barrel and endcap regions. The layout of a single module (two towers) is shown in Fig. 2, showing the alternating plate structure, sheets of wavelength shifter alongside the scintillator plates, and photomultiplier tubes in the strong mechanical structure at the outside of the module. An alternative design using wavelength shifting fibers embedded in the scintillator plates is also being developed. This approach was proposed, at least in the SSC context, by an FNAL group and is described in the paper by J. Freeman in these proceedings.

R&D on radiation-hard plastic scintillator is rapidly erasing the concern about darkening of the plastic in the SSC radiation field. Calculations[1] show that the maximum radiation dose, found at electromagnetic shower maximum


MUON CHAMBERS
PRERADIATOR
BEAMLINE
0m
3.0
AIR CORE TOROID
TRACKER
COIL
CALORIMETER
CALORIMETER STRUCTURE AND PM TUBES
5m
MUON CHAMBER
SOLENOIDAL FLUX RETURN IRON
MUON CHAMBER
1.5
MUON CHAMBERS
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COUNTERS
OVERLAPPING COUNTERS
10m
15m
10m
5m
0m

Fig. 1

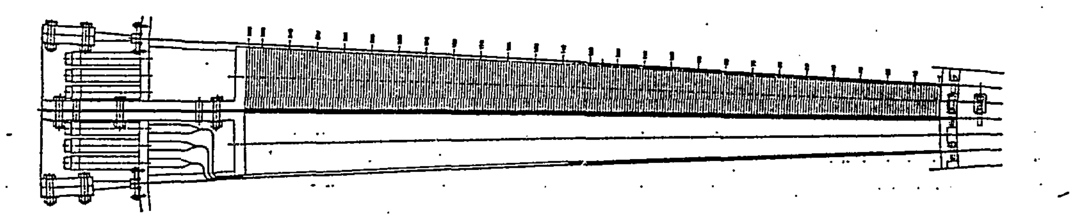

Fig. 2

at the most forward angle ($\eta \leq 3$), amounts to less than 20 Mrad in the 10 year expected lifetime of the detector. Our collaborators in the Bicron Corporation, for instance, have recently produced a blue-emitting scintillator with a modified plastic base called RH-1 whose response to electron irradiation is shown in Fig. 3. After 10 Mrad γ (squares) exposure (and a two-week recovery period) at 20 cm from the source of light (roughly the size of the biggest tiles), only 10% of the light has been lost because of the irradiation. The other curves are 30 Mrad (triangles) and 100 Mrad (open circles). Bicron expects to continue to develop increasingly radiation-tolerant scintillators. Other companies such as Kuraray in Japan and Nanoptics in the US have also made substantial progress in radiation hardness of plastic scintillator.

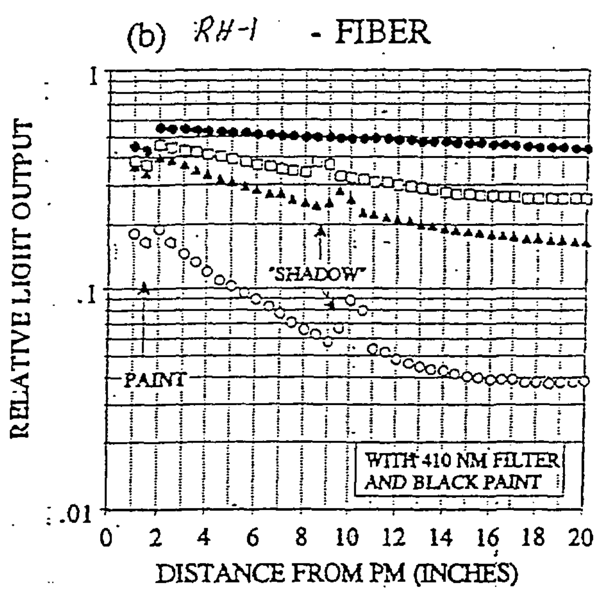

Fig. 3.

Optimization of the unit cell (thicknesses of absorber and scintillator and choice of absorber) is an important early task for the subsystem investigation. The ultimate in resolution is achieved with depleted uranium absorber, where compensation is achieved with relatively thin thicknesses of absorber and sampling fluctuations are minimized. A study of compensation in scintillator calorimeters for varying thicknesses of uranium, lead and iron is shown in Fig. 4 as a function of the ratio of absorber thickness (T_{abs}) to scintillator thickness (T_{sci}). Points are annotated with the thickness in cm. In agreement with a study of Fesefeldt[2] (but not that of Wigmans[3]), the curve for iron shows almost no dependence on absorber thickness, suggesting that there may be no compensating ratio. Iron is of interest to calorimeter designers because of the elegant mechanical solutions that it offers. This

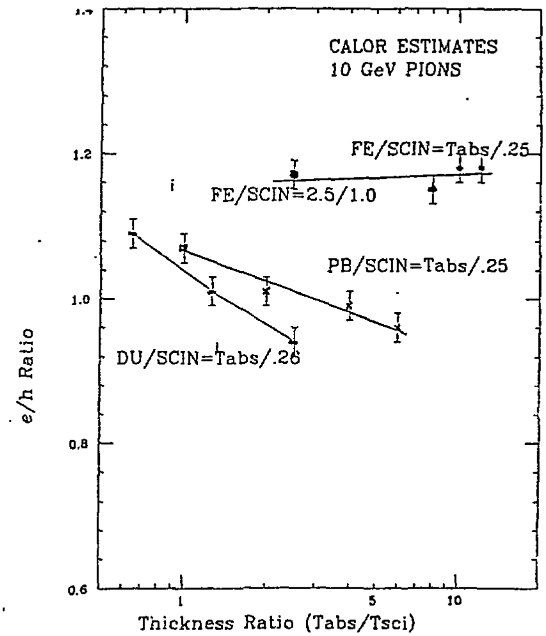

Fig. 4.

subsystem collaboration is focused mostly on lead and uranium absorbers, but we will also investigate iron/lead hybrids.

CDF and ZEUS have shown that optical masking techniques can correct for small amounts of attenuation in scintillator, as long as the attenuation stays approximately constant in time. Cracks for wavelength shifter lightguides, then, remain as a potential problem to be faced in the design. ZEUS has shown that uniformity can be achieved across readout gaps by adding lead between wavelength shifter plates. As shown in Fig. 5 (end view of barrel), we expect to tilt the electromagnetic modules azimuthally by a few degrees to avoid particles that go straight along readout gaps. The problem of readout gaps can be considerably reduced by use of fiber readout, particularly in the electromagnetic section and we will be working with the FNAL group to demonstrate their suitability.

Front end electronics are being developed to take advantage of the fast time response of scintillator and to feed appropriately into a first level trigger system.

Interest in depleted uranium absorber is dampened by the potential cost (ZEUS is paying $12/pound for clad sheets). As a result, one goal of the subsystem R&D is the investigation of alternative methods of production that may be considerably cheaper. Initial investigations suggest that savings of a factor of 2 may be readily achievable. Many of the benefits of uranium absorber may also be realized with mixtures of uranium and lead or other cheaper material.

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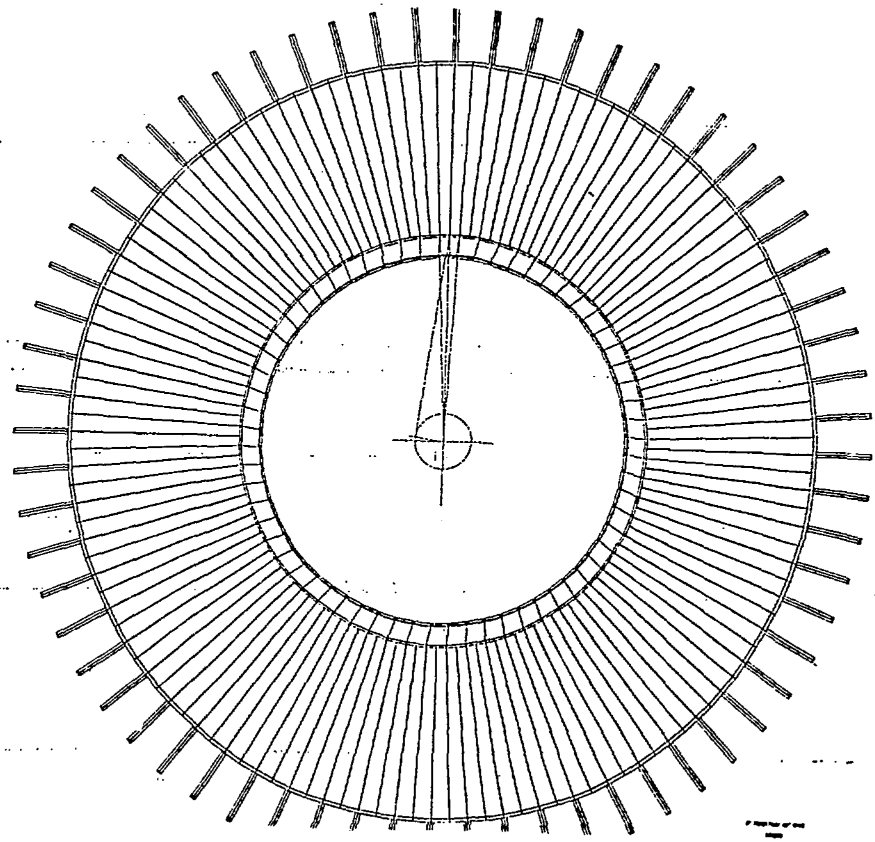

Fig. 5

References

1. D. Groom, SSC-SR-1033.

2. H. Fesefeldt, Nucl. Instr. Meth. in Phys. Res. A263, 114 (1988).

3. R. Wigmans, Nucl. Instr. Meth. in Phys. Res. A259, 389 (1987).