Report to the DoE

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Carnegie Mellon Group

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TASK: BaF$_2$ Calorimeter R&D Project for GEM

1. FNAL Beam Test of BaF$_2$ Matrix

We were involved in the test of a BaF$_2$ calorimeter consisting of a 7 x 7 crystal matrix at Fermilab. The matrix was installed in the N-T beam line (Experiment T849) and data taken between October 1991 and early January 1992. The momentum range of the pion-electron beam was 10 - 180 GeV/c, with an intensity of 100 - 1000 tagged particles per second. A beam spectrometer (magnet + drift chambers) allowed momentum resolution of about 0.6%. Cerenkov counters and a transition radiation detector provided particle discrimination to a level of electron and pion misidentification of less than 0.1% and 1%, respectively. Most of the data were taken with electrons at 68 GeV/c. The crystals were read out initially with "solar blind" photomultipliers (Hamamatsu R4480), and later with phototriodes coupled to preamplifiers. The principal CMU contributions were toward the

(a) design of the support structure for the crystal matrix holder,

(b) data taking (i.e., travel to FNAL and running shifts),

(c) analysis of the beam spectrometer data, and

(d) overall analysis of the data taken with photomultipliers.

(e) In addition, we supplied 8 of the 49 photomultipliers used in the experiment.

In that run we were able to achieve a measured energy resolution $\sigma(E)/E$, of 1.1%. The two main "external" contributions to this number are, (i) about 0.6% due to the momentum resolution of the beam, and (ii) about 0.6% due to the measured degree of non-uniformity of the crystals. (The latter number was estimated from extensive EGS shower simulations.) Subtracting in quadrature those two contributions from our measured value, we determine the intrinsic resolution of the BaF$_2$ calorimeter to be better than 0.7%.
2. UV Gain Monitoring

We had begun to develop a system to monitor the transmission of the crystals and the photodetector response. The system is based on a KrF waveguide laser to feed UV pulses via optical fibers simultaneously to an entire bank of $\text{BaF}_2$ crystals equipped with UV sensitive photoreadout devices. During the report period we established contact with laser manufacturers to narrow down the specifications based on commercial availability. (The negotiations and exchange of test results extended into the spring of 1992. The laser was then purchased via Caltech and delivered in the summer of 1992.) In addition, we purchased a 60Hz cycled UV Hg light source and various types of commercial silica optical fibers which we investigated for optimum UV transmission. (This has subsequently led to the purchase of a bundle of 60 fibers of 5m length into which we feed the UV light pulses from the KrF laser, and on which we are able to observe good channel-to-channel stability.)

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The Carnegie Mellon responsibility in this effort is to design and carry out a study of the response of an integrated detector + preamplifier system appropriate for silicon calorimetry to a combined dose of ionizing radiation and non-ionizing radiation. The preamplifiers are produced by Oak Ridge National Laboratory and the detectors were acquired by the University of Oregon from Hamamatsu as part of the SECC activity.

In the fall-winter period of 1991, the goal was to design and execute a beam study of these detectors at Fermilab during the final days of the fixed target run. The model for the exposure was the series of beam dump experiments carried out at CERN by CMU and other groups to study the radiation dose in hadronic cascades. On the basis of the CERN experiments, the radiation delivered to detectors at the front face of an absorber or at the maximum of the cascade could be quantified and related to the incident beam flux.

The aim of the test is to monitor any changes in the signal size and rise time from radioactive sources mounted on the silicon detectors during the exposure. In SSC applications the dose will be delivered while detector power is on, and the relevant response parameter is the performance of an integrated detector system including electronics. This proposed test was to be the first of its type to be carried out for silicon systems of any sort - strip or calorimetric.

The CMU group went through the procedure of setting up arrangements to fabricate test boards and organize the beam exposure, based on the expected delivery of preamplifiers from Harris Semiconductor to Oak Ridge National Laboratory. Unfortunately, the devices were not delivered on time, and it was not possible to fabricate the test assembly before the Fermilab beam was turned off on January 8, 1992.

However, the tests remain interesting, and we have explored alternatives. The new work will be described in the report for 1992.
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