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**SPEED, NOISE AND UNIFORMITY OF A LIQUID ARGON
ELECTROMAGNETIC CALORIMETER PROTOTYPE**

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*Representing the SDC liquid argon calorimeter group and the liquid argon large subsystem collaboration. This work was supported by a fellowship from the Texas National Research Laboratory Commission and by the Director, Office of Energy Research, Office of High Energy and Nuclear Physics, Division of High Energy Physics of the U.S. Department of Energy under Contract Number DE-AC03-76SF00098.

SPEED, NOISE AND UNIFORMITY OF A LIQUID ARGON ELECTROMAGNETIC CALORIMETER PROTOTYPE

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ABSTRACT

A liquid argon EM calorimeter prototype has been tested in the AGS A3 test beam line at the Brookhaven National Laboratory. The design is very similar to that proposed for the SDC experiment at the SSC. Preliminary results indicate that the electrode structure gives speed of response fast enough for SSC operation, that the electronic noise and timing resolution are understood and predictable, and that the uniformity of response is acceptable in the crack between modules and very good elsewhere.

1. Introduction

The EM calorimeter tested at BNL in June 1991 consists of two modules, each containing six towers. It is constructed from 6 mm lead plates separated by a 2 mm liquid argon (LAr) gap, a 1.6 mm G10 readout board, and a second 2 mm LAr gap. The two modules are separated by 3 mm — the azimuthal crack for SDC. The calorimeter is tilted 3° to make the crack non-projective. The towers are 11.4 cm square. In depth, each contains a massless gap channel (used to correct for energy lost in material preceding the calorimeter), EM1 (5 layers), a layer of shower maximum strips to measure the shower position, and EM2 (19 layers), for a total thickness of 28 X_0 . The strips and massless gaps are not included in this preliminary analysis because of calibration uncertainties. The calibration of EM1 and EM2 has been found by minimizing the resolution. The final results, which will be ready by the Fall 1991 Corpus Christi conference, will include all channels with correct electronics calibration.

2. Speed of Response

Figure 1 shows the current in the liquid argon gap. The fast risetime of the signal is slowed and the collected charge reduced by the finite time required to transfer the charge from the gap to the preamp. This time is minimized by placing the preamps in the LAr, connected to the gaps via low impedance striplines. Figure 2 is a plot of the charge collected in EM1 and EM2 for 10 GeV electrons as a function of t_{peak} . No significant loss of signal is observed for the minimum peaking time available, 50 ns. The peaking time planned for SDC is 60 ns.

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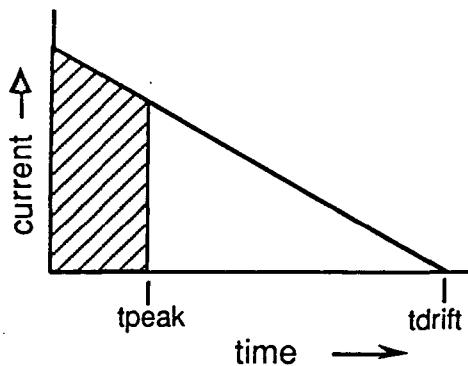


Fig. 1. The current into the electrode for uniform charge deposition across the LAr gap. The shaded area is the charged collected during the effective integration time, the peaking time of the bipolar shaper following the preamp.

3. Electronic Noise and Timing Resolution

The series thermal noise from the equivalent series resistance of the preamp and from the series damping resistor are the only significant noise sources for JFET preamplifiers and short integration times; parallel and $1/f$ noise is negligible.¹ To reduce the noise, the capacitance of the detector is matched to that of the preamp by a ferrite-core transformer. The pedestal width and 10 GeV μ minimum ionizing peak for an EM2 channel is shown in Fig. 3. For 100 ns peaking time, two EM1 channels have measured noise of 16 ± 2 and 17 ± 2 MeV, while the EM2 channels have 50 ± 7 and 67 ± 7 MeV. The predicted values are 23 ± 5 and 50 ± 10 MeV, respectively. The errors reflect uncertainties in calibration and preamp properties. The agreement indicates that the noise is predictable and that there is no significant pickup. The predicted noises for SDC are 27 MeV for EM1 and 75 MeV for EM2. These values assume $t_{peak} = 60$ ns, $\sim 50\%$ higher detector capacitance (4 mm lead vs 6 mm), and a 30% improvement in preamp performance.

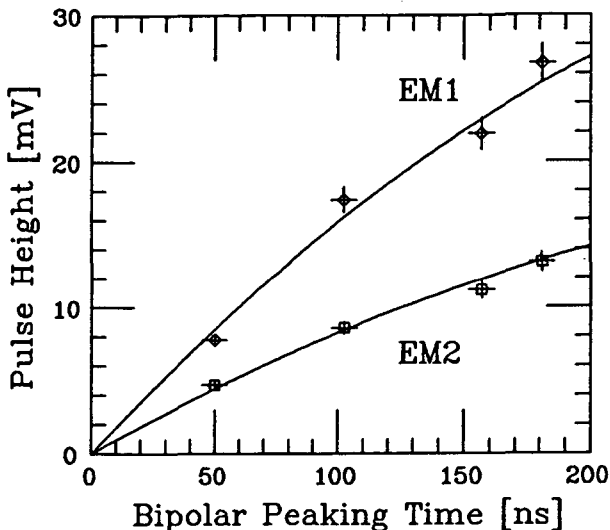


Fig. 2. Measured pulse heights vs t_{peak} for 10 GeV e^- . Curves are expected values for fast ($\ll 50$ ns) risetime.

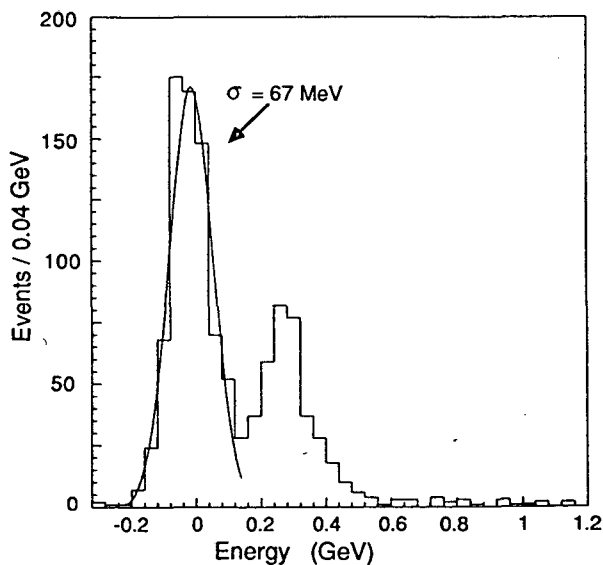


Fig. 3. Pedestal and muon peak for EM2.

The timing resolution for 10 GeV electrons is determined using the zero-cross of the bipolar output of the shaping amplifier. The measured value for $t_{peak} = 100$ ns, EM2 alone, is $\sigma_t = 1.5 \pm 0.2$ ns, in good agreement with the prediction of 1.3 ns. The resolution for SDC would be comparable.

4. Uniformity

Data were taken at several cryostat locations to determine the response across the intermodule gap. The location of each electron was determined from a scintillating fiber hodoscope. The response, excluding the shower max strips, is shown in Fig. 4. The signal in EM2 increases near the crack because the shower starts later, while the signals in EM1 and the shower-max strips decrease. The enhancement at the crack is an artifact of excluding the strips from the sum and is predicted by Geant simulation. The uniformity in the region excluding the crack is calculated to be 0.5%.

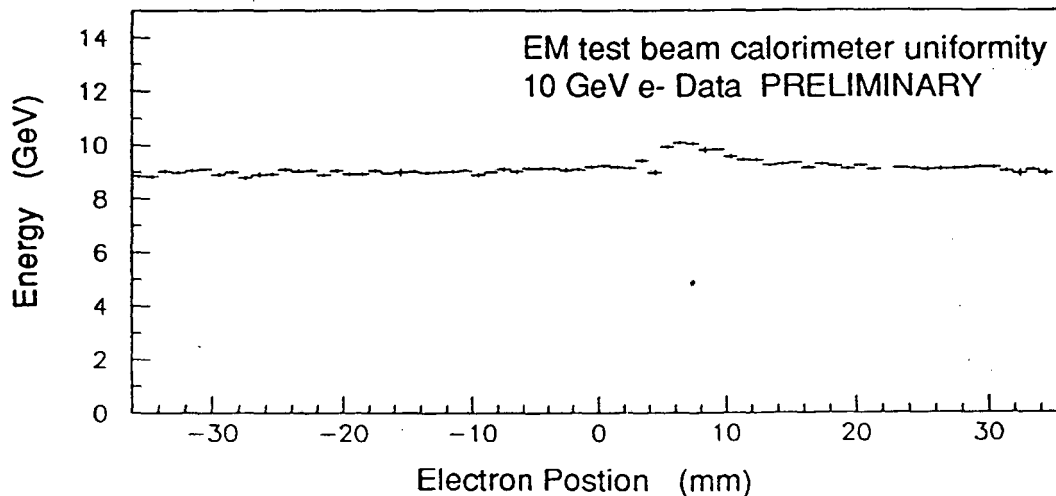


Fig. 4. Measured response across the azimuthal crack for 10 GeV electrons. Shower max strips not included in sum.

5. Summary

An EM calorimeter, similar in design to that proposed for SDC, has been tested at the BNL test beam. Preliminary results indicate that the intrinsically fast rise time of LAr signals is preserved. The measured electronic noise agrees with expected values. The corresponding timing resolution was measured for 10 GeV electrons to be 1.5 ± 0.2 ns. The response across the azimuthal crack ensures that no electrons will be unobserved; the uniformity elsewhere is very good. These results indicate that a high-quality EM calorimeter could be built for SDC with a similar design.

References

1. V. Radeka and S. Rescia, *Nucl. Instrum. Methods* **A265** (1988) 228.

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