A. Warm Liquid Calorimetry

(Dr. Brandenburg, Prof. Geer, Dr. Oliver, Mr. Sadowski, Mr. Daw, Mr. Ptohos)

To be sensitive to new physics signals SSC detectors must have a wide and general detection capability. This implies a $4\pi$ detector geometry with good electron, muon, and jet detection; good calorimetry will be crucial for any such detector. The main issues will be 1) good energy resolution with uniform response to electromagnetic and hadronic interactions, 2) good segmentation, 3) good hermeticity (few cracks and holes), 4) fast response times, and 5) radiation resistance. We believe that an attractive readout medium for an SSC calorimeter would be warm liquids along the lines of those tested for the UA1 calorimeter upgrade. Such liquids as TMP and TMS have good electron mobility. They have also been shown to be extremely resistant to radiation. The radiator material could be uranium, lead or tungsten, and the radiator thickness should be chosen so as to equalize the electromagnetic and hadronic response.

The first area we have investigated is the electron mobility of different liquids. This was done in collaboration with a group from Brookhaven. Several candidate liquids other than TMS and TMP have emerged from these studies. A graduate student from Harvard worked at Brookhaven carrying out this work under the supervision of Prof. Geer and with the assistance of Dr. Holyrod of Brookhaven.

The major goal of our project has been the construction and testing of a prototype "swimming pool" calorimeter. We hope to provide a "proof of principle" for a warm liquid calorimeter design where the readout and radiator plates are totally immersed in the liquid as in liquid argon devices. Dr. Brandenburg has coordinated this effort and Mr. Sadowski has spent a major fraction of his time on the engineering aspects. In addition to the other Harvard participants, Dr. Theriot of Fermilab has helped with the design of this prototype. We are currently members of the WALIC collaboration, and will be assisted by them in the filling and testing of the prototype.
We decided that a small electromagnetic calorimeter would be the most appropriate device to build as a first prototype. Therefore we designed and built a sealed box which contains 25 layers of radiator plates and ionization gaps. It is subdivided into 16 towers each with two depth segmentations. The radiator is one radiation length of tungsten and the liquid gap width is 1.5mm. The box has been constructed using stainless steel and ceramics so that it can be cleaned by baking. We have investigated the use of depleted uranium which is clad with stainless steel as the radiator. However, because of the difficulties cleaning and baking out the clad uranium, for the first prototype we have used tungsten, which is simpler to clean and can be directly immersed in the liquid. This device has been completed at Harvard, has been filled with TMP at LBL, and has been tested in a beam at Fermilab in collaboration with the WALIC group. A NIM paper will be written summarizing the results.

Finally, our group joined with the SSC Subsystem Group (Moishe Pripstein, spokesman) to study the design of a complete warm-liquid calorimetry system for the SDC detector. We have been assisted in this effort by an engineering team from EG&G Corporation. Our starting point was a conceptual design that emerged from the Tuscaloosa SSC Calorimetry Workshop earlier this year. This study has not only been concerned with the internal details of the calorimetry, but the structural issues of constructing a huge detector has been investigated along with related topics such as placement of electronics, routing of cables, access for maintenance. The design will be optimized for hermeticity, i.e. inter-module cracks will be minimized, and front-end electronics will be located as close to the active elements as is possible. The goal is to build a full-scale warm-liquid calorimeter test beam module (TBM). The Harvard and Penn groups are responsible for the readout system of the TBM. It should be ready for testing in 1992.

This project was initially funded under the generic R&D program, and in 1990 and 1991 has received SSC subsystem funding.

B. Front End Electronics

(Drs. Brandenburg and Oliver, Prof. Feldman)

The second project is a study of the possibilities for fast readout of calorimetry towers. The capacitance of a stack of plates and the inductance of the signal cabling are the limiting factors in obtaining short readout times. Thus proper segmentation of a calorimeter and proximity of front end electronics are the crucial design issues. Dr. Oliver has been studying
the optimization of these factors at Harvard. He also has an informal collaboration with Dr. Radeka and his group at Brookhaven. He and Dr. Brandenburg are currently members of the SSC Front End Electronics Subsystem Group. (Brig Williams, spokesman) investigating the issues.

Our major effort in front end electronics has been in analog signal processing circuits for calorimetry. In particular we have been investigating several methods of implementing externally programmable shapers, in an integrated circuit process. Such circuits are required in order to optimally filter calorimeter signals in the presence of front end electronic noise as well as detector pile-up. Furthermore, the time structure of the filtered signals must be of sufficient accuracy to associate the event with the appropriate 16ns rf bucket of the SSC. This must be done in the face of variations in calorimeter capacitance and front end amplifier risetime as well as process variations in the shaper integrated circuits. Programmable shaping time is required to fulfil these goals.

This work has led to two different design approaches. One approach utilizes "translinear" circuit techniques and could be implemented in a bipolar transistor process. The other approach utilizes biCMOS technology and has the advantages of wider dynamic range, more functionality per chip, and lower power. We plan to implement the latter approach in a custom IC. Prof. C. Blocker of Brandeis has collaborated on this project and we have been in close consultation with V. Radeka, S. Rescia, P. O'Connor, and others at BNL on the formulation of device specifications and implementations.

Finally as a part of our CDF/SDC group's work on muon systems, Dr. Oliver and Prof. Feldman are coordinating the development of the front-end electronics for the SDC muon system. They are working closely with the Penn and Michigan groups on this project and may be requesting further SSC subsystem funding for this work in 1992.

C. Silicon Drift Detectors

(Profs. Wilson and Clark, Drs. Henderson and Oliver)

A third collaboration is with the SSC Subsystem Group headed by Dr. Pavel Rehak of Brookhaven National Laboratory to study the applicability of silicon drift detectors to the SSC program. A silicon drift detector is, in principle, an elegant solution to the problem of vertex detection. Each particle traversing the detector gives an x, y readout independently of all other particles. In addition the low capacitance (0-3pf) of the readout pads allows a good signal to
noise ratio, and permits the design of JFET preamplifiers with high radiation resistance. It is even possible to include the preamp on the high resistivity silicon wafer of the detector itself, avoiding the connection problems.

In collaboration with Brookhaven National Laboratory we plan to study radiation damage in these detectors. Sample wafers and their electronics have already been tested at HEPL with weak sources. For further testing with minimum ionizing particles we will use a Co$^{60}$ source; probably at BNL using their radiation facility. We also have available the Co$^{60}$ radiotherapy facilities at Massachusetts General Hospital. For heavily ionizing particles, we will probably use the Harvard Cyclotron, with 150 MeV protons, but the Lowell University neutron generator is also available.

The silicon devices to be tested will hopefully include the circular drift detector developed by Munich-BNL-Milan for the NA39 experiment at CERN. We will also test the detectors made by SI of Oslo for the CLEO detector. (See Section 40). We will measure the time and position resolution both before and after the irradiation. We expect to use up to $10^6$ rads of gamma rays and $2 \times 10^5$ rads of neutrons and protons.

We also plan, on a slow and measured time scale, to work on the integrated electronic circuits for read out of these devices. The preamplifier is likely to be the preamp made of high resistivity silicon of Rehak; the waveform analyzer, the chip by Kleinfelder; although since this is CMOS and subject to radiation damage, we hope to change this at a later date. The primary development task will be the pulse shaping chip.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.
END

DATE

FILMED

3 / 20 / 92