DOE/ER/40576--71

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.

Readout Electronics for a Hybrid Central Tracking Chamber

FINAL REPORT

to the

Department of Energy
Superconducting Super Collider Laboratory

For DOE Award No. DE-AS05-90ER40576

Prepared by

John J. Paulos

Principal Investigator

Department of Electrical and Computer Engineering
North Carolina State University
Raleigh, North Carolina

July 13, 1992

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED
JTB

I. Overview

This is the Final Report for DOE Award No. DE-AS05-90ER40576, Readout Electronics for a Hybrid Central Tracking Chamber. This award is covered by the Memorandum of Understanding for FY 1990 between the Superconducting Super Collider Laboratory (SSCL) and the Hybrid Central Tracking Chamber (HCTC) Collaboration led by Dr. Alfred Goshaw at Duke University. Funding for FY 1990 was primarily intended to support research leading to a proposal by the HCTC Collaboration to the DOE/SSCL SSC Detector Sub-System program in September of 1990. Recognizing that awards for FY 1991 funding might not be available until early 1991, the SSC Laboratory established a contract period of June 25, 1990 through June 9, 1991 for this award. The contract period was later extended through June 9, 1992 to allow completion of a subcontract to Oak Ridge National Laboratory (ORNL). The bulk of the work performed by North Carolina State University under this contract was completed by June 25, 1991.

The primary thrust of the NCSU effort during this period was to evaluate the feasibility of using long (8 meter) straw tubes in an SSC central tracking chamber. The feasibility of long straw tubes was established through a combination of transmission line simulations and experimentation on a 2.6 meter stack constructed at Duke University. NCSU was also responsible for the electrical design of an end plate board assembly to facilitate the use of the 2.6 meter stack in tracking studies. The PC boards were fabricated by ORNL under a subcontract to this award.

II. Summary of Accomplishments

This work has addressed the conceptual design and initial prototyping of readout electronics for a Hybrid Central Tracking Chamber (HCTC). The HCTC design calls for a mix of straw tube and scintillating fiber subsystems. The plastic straw tubes will be 4 mm in diameter and 8 m long, with wire supports located at one meter intervals. An electrical isolator will be placed in the middle of the 8 meter span, and readout electronics will be placed at each end to create two isolated drift chambers. The goals of this project for fiscal year 1990 included: the study of signal propagation on long straw tubes using lumped element transmission line models, the construction of readout circuitry to instrument the prototype straw tube stack, and the evaluation of readout circuits developed by the University of Pennsylvania and the (Japan) National Laboratory for High Energy Physics (KEK).

A. Transmission Line Simulations

The HCTC design calls for the use of 4 mm plastic straw tubes of unprecedented length. A lumped element transmission line model was developed and used to explore the performance of extremely long straw tubes in the SSC environment. Based on these simulations, we predict an attenuation length of approximately 5 meters. (This result has been confirmed experimentally by Seog Oh at Duke on the 2.6 meter stack.) We examined the effect of electrical reflections at the ends of the tube due to improper termination. Generally, these reflections have only a minor impact on pulse timing, but seriously degrade double-hit resolution by interfering with the second hit. The transmission line simulations were also used to study optimal preamplifier, pulse shaping, and pulse detection strategies. Given the extreme importance of double-hit resolution in the (high luminosity) SSC environment, we recommend the use of a large comparator threshold (on the order of 5 electrons) in combination with a relatively wide bandwidth preamplifier (at least 60 MHz). This strategy dramatically reduces the timing error for a second hit given residual reflections from an earlier hit.

Based on these results, we conclude that a 8 meter straw tube, with an electrical isolation at 4 meters and readout electronics at both ends, can meet the requirements of the SSC in terms of detection efficiency, spurious detection, and double-hit resolution. Our primary concerns for such a system are electromagnetic interference (EMI) and cross talk. The straw tubes essentially look like long, weakly shielded antennas, which may be susceptible to noise pick-up from other detector subsystems. Cross talk is likely to be a problem given the high packing density of the readout electronics at the end plates. The impact of these effects will, in all likelihood, not be known until a mockup of a large straw tube assembly (on the order of 1,000 readout channels) is constructed.

B. End Plate Design and Experimental Studies

An end plate for the 2.7 meter straw tube stack was designed in collaboration with Seog Oh at Duke University and Gary Alley at ORNL. The end plate includes a stack of custom printed circuit boards which contain the biasing and termination elements, and which interface through a cable to a pair of 16 channel, LeCroy preamplifier cards. The end plate assembly was constructed by ORNL under a subcontract to this award. This assembly was used by Seog Oh in tracking studies on the 2.7 meter stack using 24 channels of LeCroy TDC's (Time to Digital Converters). These studies were included in the FY 1991 HCTC Progress Report.

A smaller number of channels were instrumented using the University of Pennsylvania preamplifier/shaper chips and preamplifier/discriminator chips from KEK. The Univ. of Penn. and KEK designs are more sensitive than the LeCroy preamps, and hence can be used at lower gas gain. However, in our estimation, the preamplifier bandwidth of the Univ. of Penn. chips is too low to provide good double-hit resolution.

III. Equipment Purchased

Roughly \$30,000 of the \$50,000 award was utilized for the purchase of equipment used in the work described above. The major items purchased are listed below.

1. (2) LeCroy Model 2229, Octal Time Digitizer	\$4,536
2. (2) LeCroy Model 2735DC, 16-Channel Chamber Card	\$1,147
3. (1) Tektronix Model DCS01 Digitizing Camera System	\$5,936
4. (2) Digital Equipment Corp. DECstation 3100 Computers	\$10,750
5. (1) 80386 IBM-Compatible PC	\$3,250
6. (1) End Plate Assembly (Sub to ORNL)	\$4,300
Total	\$29,919

The DECstation 3100 Computers were utilized in the transmission line simulations described above, while Items 1, 2, 3, 5, and 6 were used in the experimental work. A request will be forthcoming to transfer title of this equipment from DOE to NCSU (Items 3, 4, and 5) and Duke University (Items 1, 2 and 6).

IV. Attachments

The end plate design and the experimental studies described above were reported in the HCTC Collaboration Progress Report for FY90. The simulation studies were reported in part in the FY90 report. A more complete discussion of the simulation studies is included here as Attachment A.. This report was included with the HCTC Collaboration Progress Report for FY1991. The simulation studies were also presented at the 1991 Symposium on Detector Research and Development for the SSC. The Proceedings paper from this symposium is included as Attachment B.

Preprints enclosed separately.

END

DATE

FILMED

2/2/94