University of Virginia High Energy Physics Group

Final Performance Report

(for the period June 1, 1989 - Jan., 31, 1994)

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, recom-
mandation, 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.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED.
DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.
Introduction

The US Department of Energy Contracts for 1989 covered the initial year of the University of Virginia High Energy Group. In 1988, B. Cox arrived at the University of Virginia, after several discussions with the US Department of Energy, to set up a High Energy Physics Group in the UVa Physics Department. The first proposal was submitted in the fall of 1988 and the first allocation of funding was received in June of 1989. This first contract which covered the time period June 1, 1989 - Jan. 31, 1990 was in the amount of $186,000 and covered UVa HEP group operations and equipment during that period. At that point, a regular contract year was established and two subsequent contracts were issued for Feb. 1, 1990 - January 31, 1991 and Feb. 1, 1991 - Jan. 31, 1992 with awards of $280,000 and $580,000, respectively. The funding between June, 1989 and Jan, 1992 covered the activities of both the UVa Theory Group (Task A) and the UVa HEP Experimental Group (Task B). Expenditures of all above funds was completed by January 31, 1994.

In this time period, certain initial things were accomplished using the operating funds provided by DOE and the seed funds ($2.2 million over the period). There were three main areas of activities, the building of the University of Virginia HEP infrastructure (construction of lab space, computer facilities, electronic shop, machine shop and office space), the hiring of personnel (faculty, post docs, and students) and the physics activities of the group.

Personnel

A first priority of Cox after arriving at UVa was the building of the HEP Group by hiring the personnel. The first objective was a faculty search to fill one HEP theory faculty position and three HEP experimental faculty positions. The theory faculty position was filled in September of 1989 when H. Thacker formally of Fermi National Accelerator Lab joined the University of Virginia faculty. Thacker joined three other High Energy theorists, Paul Fishbane, P.Q. Hung and Pasha Kabir who were already on the faculty. The support of these individuals was bundled together into Task A from this point on through the three year period. Some of the previous support of the UVa HEP theorists had been from NSF but with issuance of the 1989 DOE contract, all support was transferred to DOE.
The assembly of the UVa Experimental Group took more time since there was no HEP experimental activity at UVa prior to Cox's arrival. The HEP faculty was assembled with the arrival of S. Conetti (formally of McGill University) as a full professor in the spring of 1990 and the hires of K. Nelson (Univ. of Wisconsin) and E.C. Dukes (Univ. of Michigan/CERN) in the fall of 1990 as assistant professors.

During this early time period, M. Arenton joined UVa as a senior scientist in the HEP Group in the fall of 1988 even before the first contract. He was initially supported by Institute for Nuclear and Particle Physics at the University.

Another early arrival, was D. Bunyard who has filled the role of administrative assistant for the HEP group until the present day.

In order to carry out the physics program of the UVa HEP Experimental Group (discussed below), it was necessary to obtain technical and physics personnel as soon as possible since we were very early on in 1989, 90 and 91 constructing a large experiment, E771, at Fermilab and planning for a very large experiment, the Super Fixed Target B Experiment (the SFT) at the Superconducting Super Collider. We hired during the initial period of the contract, M. Recagni (formerly of Northwestern and Pavia Universities) as a physicist/engineer, J. Segal (University of Wisconsin) as a senior technician and A.P. McManus (Notre Dame) as a research associate. We also supported several graduate students during this period (Hanlet, Ramachandran, Timmons, Wall, White, Sun, Pogosyan, Ledovskoy, Klepitch).

With this complement of people, the UVa HEP Experimental Group undertook to build the group facilities at the same time as we were involved with Fermilab Experiment E771 and planning for the SSC.

**Physical Infrastructure**

The UVa experimental group were given as their laboratory space a building which had originally been built with NSF funds to house a Tandem Van der Graaff. It had been some years since the building had been occupied and, in any case, many of its areas required considerable modification to be usable by the HEP group. A good deal of construction
was required and this the immediately usable space had to be set up as office and temporary lab space to support our efforts at Fermilab.

In the fall of 1989 and spring of 1990, seed funds were provided by the State of Virginia through the University and the INPP to refurbish the building and Cox, working with the local architects and building and grounds managers at UVa developed plans and let contracts for the necessary construction. At the end of the 1989-92 contract period, the bulk of the work was finished, resulting in over 10,000 ft$^2$ of laboratory, office and assembly/construction space available for the growing HEP group. This included a climate controlled computer room with regulated power, a 2000 ft$^2$ high bay assembly area with 1.5 ton crane coverage, and a machine shop area (not quite finished) together with an electronics lab and three suites of offices capable of housing the HEP experimental group.

In the same period, we began what has been an evolving task, the setting up of computing facilities. Once again, the funding for these facilities came from the State of Virginia. M. Arenton was mainly responsible for setting up a farm of DEC workstations which represented, at the time, a significant amount of computing power. These workstations were coupled to an assortment of disks, tape units and terminals (Mac's and dumb terminals in that era). This computing power was used for analysis of the E771 data as well as supplying all the usual computer age facilities (word processing, E-mail, etc.).

Finally, J. Segal, K. Nelson and A.P. McManus accumulated and installed a wide variety of electronic gear which allowed us to develop apparatus for the Fermilab experiment.

1989.90 and 91 Physics Program

UVa Experimental HEP Group Program

E705/E705

Much of the physics program of the experimental group revolved around the study of production and decay of heavy flavor (c and b quarks). Some of us (Cox and Conetti) were in the process of analyzing a previous Fermilab experiment, E705, and the entire group was involved in a new Fermilab experiment under construction in 1989,90 and 91 called E771. Both experiment focused on detection of states of heavy flavor by detection of high pt muons and high mass muon pairs from their decays. E705 used
pions at 300 GeV/c to produce these states. E771 was to use 800 GeV/c protons.

During the 1989-91 time period covered by the three contracts, additional equipment funds were received from DOE to help build equipment for the experiment. Cox was the spokesman for both experiments and the UVa group, even though it was very young, was the central group (out of 15 or so groups on E771) in getting E771 built. We had particular roles in the muon trigger (Conetti), the silicon vertex detector (Cox, A.P. McManus, M. Recagni), and the wire chambers (Nelson, Segal) and the electromagnetic detector (E.C. Dukes, Hanlet). Several tens of thousands of channels of electronics were prepared and installed in this time period. We began to test this equipment in the fall of 1991 and had a very brief amount of beam in December, 1991 and January, 1992.

The analysis of this data has gone on since that time and while not strictly a part of this report, we include the list of physics and technical papers that this experiment has generated below.

**E771 Papers**

**E771 Physics Journal Papers**


**E771 Technical Journal Papers**


E771 Publications/Conference Reports/Preprints


[34] "E771 and Beyond", Workshop on "CP Violation and Fixed Target B Physics at Ultra-High Energies at UNK", B. Cox, Dubna, USSR, (1989).


E771 Theses


[8] Elena Evangelista, "Produzione e Decadimento della Ψ(2s) in Interazioni Adroniche a E(cm)=38.7 GeV", Università degli studi di Lecce, Lecce, Italy, Tesi di laurea, (Feb., 1995).


At the same time, we were analyzing the data from E705. We include below the references to the physics papers generated by that collaboration in approximately the time period of this proposal.

**E705 Papers**


SFT at the SSC

In the 1989-91 time period, we were busy developing a new proposal (B. Cox, spokesperson) for a large facility at the Superconducting Super Collider (SSC) under construction then near Dallas, Texas. This work resulted in an "Expression of Interest", EOI-14, which we submitted to the SSC Laboratory in May of 1990. More than 35 institutions worldwide were signers of this EOI and UVa again was the leader of the effort.

After a defense of the EOI in the summer of 1991, we received considerable encouragement from the management of the SSC Lab and the SSC Program committee. We continued our development of our ideas into the next contract period (beyond 1991) until the demise of the SSC in October of 1993.

Once again, since most of the papers, were generated after the contract period in question, this is not strictly a part of this report. However, it is useful to examine the product of this effort.

SFT Papers
[3] "Fixed Target Beauty Physics at the SSC and the LHC", B. Cox, Proceedings of
the 1993 International Workshop on Heavy Quark Physics at Fixed Target, Frascati
[4] "The SFT, A Super Fixed Target Beauty Experiment At The SSC", B. Cox et al.,
Proceedings of the Workshop on B Physics at Hadron Accelerators,
Snowmass, CO, 713(June, 1993).
[5] "Hadron Identification in a Fixed Target Experiment at the SSC", B. Cox and
K. Nelson, Proceedings of the Workshop on B Physics at Hadron Accelerators,
Snowmass, CO, 575(June, 1993).
[6] "Tracking Considerations for Fixed Target Experiments at the SSC and the LHC,
A. P. McManus et al., Proceedings of the Workshop on B Physics at Hadron
Accelerators, Snowmass, CO, 485(June, 1993).
the SFT, B. Cox et al., Proceedings of the Workshop on B Physics at Hadron
Accelerators, Snowmass, CO, 319(June, 1993).
[8] "Observability of Mixing in Partially Reconstructed B_d and B_s at the SFT",
T. Lawry et al., Proceedings of the Workshop on B Physics at Hadron
Accelerators, Snowmass, CO, 371(June, 1993).
Physics at Hadron Accelerators, Snowmass, CO, 595(June, 1993).
[10] "Fixed Target B Experiments and the Angle \alpha Using B \rightarrow \pi^+\pi^- and B \rightarrow a_1\pi^-",
A. McManus et al., Proceedings of the Workshop on B Physics at Hadron
Accelerators, Snowmass, CO, 209(June, 1993).
Workshop on B Physics at Hadron Accelerators, Snowmass, CO,
551(June,1993).
[12] "Measuring the Angle \beta in B_d \rightarrow D^*\bar{D}^* Decays at the SFT",
T. Lawry et al., Proceedings of the Workshop on B Physics at Hadron Accelerators,
Snowmass, CO, 259(June, 1993).
[13] "Comparison of Trigger and Data Acquisition Parameters for Future B Physics
Experiments", S. Conetti and S. Geer, Proceedings of the Workshop on B Physics
at Hadron Accelerators, Snowmass, CO, 589(June, 1993).
[14] "Background to B_d \rightarrow \pi^+\pi^- From Secondary Interactions in a Silicon Microvertex
Detector at the SFT", T.J. Lawry et al., Proceedings of the Workshop on B
Physics at Hadron Accelerators, Snowmass, CO, 231(June,1993).
[15] "On the Configuration of an Active Target for a Fixed Target Experiment at SSC
Energies, E.C. Dukes, Proceedings of the Workshop on B Physics at Hadron
Accelerators, Snowmass, CO, 489(June, 1993).
on B Physics at Hadron Accelerators, Snowmass, CO, 505(June,1993).


UVa HEP Theory Group Program

The UVa theoretical group in the time period, 1989-91 concentrated its research in the areas of electroweak interactions, CP violation, symmetry breaking mechanisms leading to the Standard Model family structure, models for quantum chromodynamics at long distances, lattice gauge calculations of QCD and exactly solvable models in statistical physics. This work had both phenomenological and purely theoretical aspects.

As stated above, in 1988, the UVa theory group was composed of two professors, P. Fishbane and P. Kabir and an assistant professor, P.Q. Hung. With the arrival of the experimental group their support was
combined under the present DOE grant and the group was strengthened in 1989 by the arrival of a fourth professor, H. Thacker who founded a lattice gauge effort at UVa.

The varied work of the UVa group is best summarized by their publications since the 1989-91 startup period.

P.M. Fishbane


P. Kabir

H. Thacker


