DOE/ER/40719--T2

Final Technical Report
DOE Grant DE-FG02-92ER40719
Support of Experimental High Energy Physics Research at the University of South Carolina

2/92 - 2/96

M.V. Purohit, C. Rosenfeld, and J.R. Wilson
Department of Physics and Astronomy
University of South Carolina
Columbia, South Carolina

Abstract

This brief report summarizes the activities of the University of South Carolina's high energy physics group during the three-year period of DE-FG02-92ER40719. The activities of the group began in 1980 under a predecessor grant from DOE, and continue today under a successor grant. The retirements of one grant in favor of another were for reasons of administrative convenience or necessity. The characterization of the report as "final" is not reflective of the group's projects, which by-and-large continue with support from the successor grant.

DISCLAIMER

Contents

1 Introduction

Part of the U.S. Department of Energy's mission is the support of high energy physics in the United States. It does this in part by building and supporting the major national laboratories, Brookhaven National Lab, Fermilab, and Stanford Linear Accelerator Center. It also supports the university groups who contribute to the design, construction, and operation of the detectors used at the US laboratories, and at foreign laboratories, to do the intended research. The two go hand-in-hand to provide a pool of individuals competent to do research in this most fundamental of all areas of experimental physics.

DOE support of the University of South Carolina high energy group began in 1980 with contract DE-AS09-80ER10690. The DOE extended this contract annually until 1992 when for administrative reasons it replaced the contract with grant DE-FG02-92ER40719. This grant was in turn replaced in 1995 by grant DE-FG05-95ER40910, again for administrative reasons. This document is the formal final report for DE-FG02-92ER40719. Only some of

the activities summarized here, however, have concluded. The others continue unabated with support from the successor DOE grant.

In 1992 the tenured and tenure track faculty members of the USC high energy group were F.T. Avignone, R.L. Childers, C.W. Darden, C. Rosenfeld, and J.R. Wilson. Avignone, who was department chairman from the inception of the group, was applying the lion's share of his research effort to the study of double beta decay in germanium. This work was independently supported, and Avignone received no compensation from this grant. His role in the group was more one of kindred spirit than of active engagement. Childers and Darden were the charter members of the group; Rosenfeld joined in 1986; and Wilson joined in 1990. Childers withdrew from the group in December 1993 in order to dedicate more time to preparation of a textbook. Darden retired from the University in July 1994. His positions both in the Physics Department and in the high energy group were filled in August 1994 by M.V. Purohit who joined the department as a tenured Associate Professor. This grant provided Purohit's salary during his first nine months at USC during which he directed all of his effort to high energy physics research.

The experiments with which the USC group had some significant relationship during the period of this grant were ARGUS (at DESY's DORIS e^+e^- collider), AMY (at KEK's TRISTAN e^+e^- collider), Fermilab E687, Fermilab E789, Fermilab E791, Fermilab E803, and Fermilab E872. We give below a brief synopsis of USC's participation in each of these projects and a few projects of lesser magnitude as well. A more detailed account that covers all but the last seven months of the project period is available in the group's 1994 Technical Progress Report.

2 ARGUS

Professors Childers and Darden were charter members of the ARGUS Collaboration and invested considerable time in this project during the 1980's. They formally withdrew in 1991 in order to dedicate their research effort to E789. They are coauthors on eight ARGUS publications that appeared in 1992. We list these in section 12.

3 AMY

Professor Rosenfeld joined the USC group in 1986, bringing with him his responsibilities on the AMY experiment. The AMY detector occupied the Oho experimental hall of the TRISTAN e^+e^- collider at the Japanese National Laboratory for High Energy Physics in Tsukuba. On 30 June 1994 the AMY experiment recorded its last event. This day brought to a close 7.5 years of productive operation of the detector. AMY's integrated luminosity reached 340 pb^{-1} surpassing the collaboration's target.

3.1 The AMY trigger system

As its major contribution to the AMY apparatus the USC group designed, constructed, installed, and commissioned the major components of the trigger system. (Rutgers, Ohio

State. and U.C. Davis were minority contributors.) This system performed extraordinarily well. It enabled us to trigger on diverse classes of events while maintaining the rate comfortably within the three-event-per-second capacity of the data logging system. The challenge for the trigger is principally in the domain of low multiplicity events. With efficiency exceeding 99% our system accepted events having as few as two charged tracks and did not require that these tracks be back-to-back. Not allowing success to stand in the way of "progress," we installed a multifaceted upgrade to the trigger system in 1991 and 1992. The most expensive component of the upgrade succeeded only in making incremental improvements to the original system (most of which remained in place). A second component incorporated signals from the endcap detector elements newly installed with the AMY 1.5 upgrade. A third component. the least ambitious of all. provided a major unplanned benefit. In the face of gross deterioration of AMY's inner tracking chamber the new hardware preserved the efficiency of the two-track trigger logic (essential for dimuon events). The trigger upgrade made a significant improvement in our data, though in ways we had not anticipated.

3.2 AMY analyses completed at USC

The USC personnel that participated in AMY during the grant period were, in addition to Rosenfeld. graduate students S. Lusin and L. Zheng. For his thesis Lusin analyzed the $e^+e^- \rightarrow \mu^+\mu^-$ and $e^+e^- \rightarrow \tau^+\tau^-$ channels. In the TRISTAN energy range these final states exhibit asymmetry in the angular distribution as a consequence of γ-Z interference. When the analysis was complete, the data were in agreement with the Standard Model. Lusin defended his dissertation in November 1993 and is now on the research staff of the high energy group at the University of Wisconsin, Madison. Lusin's analysis was further developed and extended to a larger data set in the thesis of C. Velissaris. a University of Rochester student. The collaboration submitted a paper based on Velissaris's thesis to Physics Letters B in April 1994. Rosenfeld served as one of the internal referees for this paper. At the close of this grant Zheng was analyzing the channel $e^+e^- \rightarrow c\bar{c}$ using inclusive techniques. As with the dilepton work, the objective is to observe the asymmetry induced by γ-Z interference. Zheng's results were in accord with the standard model, and she defended her thesis on this topic in December 1995.

4 Fermilab experiment E687

Experiment E687 became a project of the USC group as consequence of the addition of Professor Wilson to the group in 1990. He had been deeply involved in this experiment as a research staff person at the University of Illinois. Wilson is the only USC participant in this project. The collaboration's apparatus is the spectrometer in the wideband photon lab at Fermilab. The project is aimed at studies of the photoproduction and decays of charmed mesons and baryons. Data-taking concluded in 1991, and the resulting harvest was 90,000 reconstructed charm particle events. During the three years of this grant E687 produced numerous analyses and publications. We list the publications in section 12.

5 Fermilab experiment E789

E789 was proposed as a high luminosity experiment optimized for producing and detecting rare two-body decays of beauty mesons. Shortly after the fixed target running period commenced these goals were reexamined in light of the running conditions actually experienced, and the experiment was slightly reconfigured to increase sensitivity for $B \rightarrow J/\psi + X$ decays. Some running time was set aside for the original $B \rightarrow h + \overline{h}$ as well as some charm A-dependence studies. The experiment recorded nearly two billion events on tape. Preliminary analysis has achieved a B signal of about 50 events in the $J/\psi + X$ mode. Results have been published on $D^o \rightarrow \mu^+\mu^-$ limits, A-dependence of the production of the D^o, and on the X_F dependence of J/ψ hadroproduction.

Faculty members Richard Childers, Colgate Darden, and Jeff Wilson were the South Carolina contingent involved with E789. During the E789 running period the South Carolina group was responsible for recommissioning and operating the Ring Imaging Čerenkov Counter (RICH). This task involved making many improvements to the counter's gas system, primarily the addition of three titanium getter pumps which can reduce impurities in a noble gas to below 1 part in 10^8. The readout and data acquisition system for the RICH was also totally redone. Immediately after the run we put much effort into reworking the RICH analysis software. Our success in that project is demonstrated by Fig. 1 which shows the Čerenkov radius measured for tracks from some of the B running. The curve superimposed on the data is a one-parameter fit to the standard Čerenkov threshold curve. The RICH was apparently working during this part of the data-taking, but so little B dihadron data was taken that the sensitivity of the experiment was too low to be interesting. We tried instead to use the RICH to investigate charmonium χ-meson decays into dihadrons. These states have a very short lifetime. Therefore the only tool for reducing background is particle identification information. We intended to search for evidence of the new P-wave resonance recently observed by E760 at the Fermilab accumulator, but our preliminary work has shown that the background levels remaining after applying the most stringent particle ID cuts possible are much too large to allow the observation of any known χ state using our data.

6 Fermilab experiment E791

The physics objectives of Fermilab experiment E791 have substantial overlap with those of E687, discussed above, and E831, discussed below. E791 distinguished itself by operating in a hadron beam and accepting an impressively large number of triggers. With this approach it surpassed E687 by a substantial margin in number of reconstructed charmed particle decays. The sample size advantage is muted by higher backgounds in some channels, and the experiments are for many purposes complementary. The USC group became a party to this project as a consequence of the addition of Professor Purohit to the group about six months prior to the nominal end of the project period. Purohit was cospokesman of this collaboration prior to joining USC and continued in that role. At the end of the project period of this grant (including extension) E791 had concluded taking data and was deeply

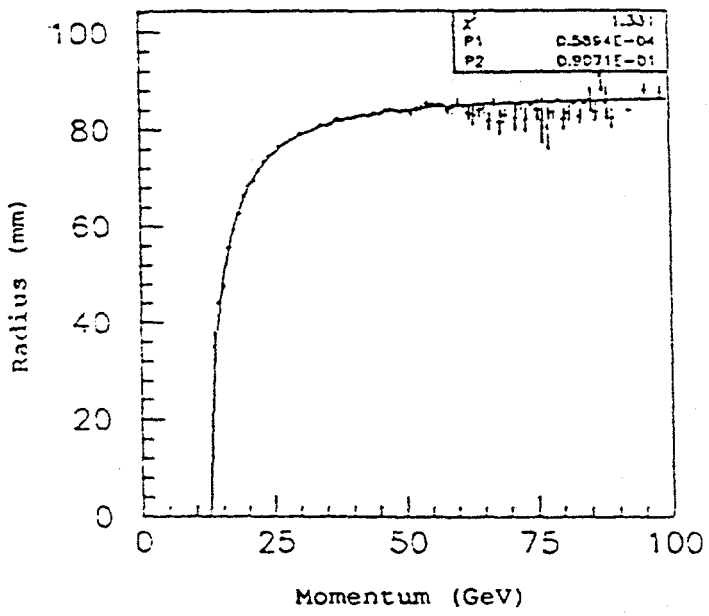

Figure 1: Čerenkov threshold curve showing radius vs. momentum. Superimposed is a one-parameter fit of the theoretical threshold function.

into analysis. Their publications, however, began to appear only after the termination of this grant, and so are not included in the list in section 12. In supporting a full year of research leave for Purohit, this grant made a substantial contribution to the product of E791, which is documented in the technical progress reports of the successor grant.

7 Fermilab experiment E831

Experiment E831 is the successor to E687. It aims to utilize an upgraded version of E687's spectrometer in Fermilab's wideband photon lab to generate a factor of ten more data. Wilson's long term membership in E687 evolved naturally into participation in E831. Soon after coming to USC Purohit also joined E831. The collaboration recruited him in order to benefit both from his E791 experience with silicon readout electronics and from his expertise in analysis of data on charmed particles.

USC has a role in three of the spectrometer upgrades planned for E831. These are: 1) an "optical trigger" that by clever use of Čerenkov radiation in a crystal will suppress e^+e^- production in favor of hadroproduction. 2) A new "outer muon hodoscope" to replace the dysfunctional version of E687, and thereby to improve dramatically the acceptance for single-muon and especially dimuon events. 3) Electronics to service four additional silicon planes furnished for the vertex detector by the Italian contingent of E831. The technical aspects of the optical trigger and the muon hodoscope were covered in our technical progress report for 1994. Design of the optical trigger apparatus continued to evolve during the extension of the project period into 1995. The key components of the new muon hodoscope are resistive plate chambers (RPC's) fabricated by General Technica of Rome. USC ordered the RPC's

during the one-year extension of the grant, and they were ultimately delivered in the summer of 1996, following the order by about one year.

The electronics for the silicon planes became a major undertaking of the USC group. The design changed considerably from the system described in our 1994 technical progress report. The original design salvaged considerable equipment from the silicon plane readout of E791, but could latch only a single bit for each hit in the silicon.. The revised plan calls entirely for new custom ADC modules designed by USC. These modules dynamically adjust for baseline shift and deliver a six-bit pedestal-subtracted pulse height for each channel every 50 ns. The design of this system was nearing completion at the end of the extended project period.

8 Search for the 17-keV neutrino

The first claim for the existence of a 17 keV neutrino was based on a measurement of the β-decay spectrum of tritium published by Simpson in 1985 [1]. Interest in the subject increased dramatically in December 1990 when two papers reporting the spectra of ^{35}S [2] and ^{14}C [3] confirmed the claim. Professor T. Ohshima of KEK formed a collaboration to investigate the 17 keV neutrino in ^{63}Ni using an iron-free magnetic spectrometer at the Institute for Nuclear Science, Tokyo (INS). In 1991 both Rosenfeld and our graduate student S. Wilson were in residence at KEK working on AMY. Together they accepted Professor Ohshima's invitation to join in the search for the heavy neutrino. Data collection was completed in September 1991. An analysis of the data, performed principally by Ohshima, yielded an upper limit for the branching fraction to a 17 keV neutrino well below the 1% level associated with Simpson's effect. This result appears in Physics Letters B287, 45 (1992). Wilson undertook an independent analysis of the data for his Ph.D. thesis. At the conclusion of the project period he was making consistent progress on this task.

9 Fermilab experiment E803

E803 (spokesman, N. Reay from Kansas State) will search for the oscillation of ν_μ to ν_τ with sensitivity better by a factor of 200 than previously achieved. The many searches already conducted for neutrino oscillations attest to the fundamental significance of this phenomenon. Were it to be observed, it would imply that neutrinos have mass and that generational mixing is a feature that leptons share with quarks. Our interest in ν_μ/ν_τ oscillations is stimulated by questions from cosmology as well as particle physics. If the τ neutrino oscillates and therefore has mass, then it is a candidate for the cosmological dark matter.

E803 seeks to observe the appearance of τ leptons in emulsion exposed to an intense ν_μ beam. Professors Avignone and Rosenfeld became charter members of P803 in 1989. The proposal advanced at a snail's pace through the Fermilab review process. Our patience was ultimately rewarded in November 1993 with Stage I approval, four years after we joined the project. Research Fellow A. Kulik joined us in E803 when he came to USC

in 1994. Subsequent to the end of the project period the USC group accepted responsibility for the charged particle detection system that will generate the primary trigger signals. These detector components could be plastic scintillation counters. but our group plans to investigate resistive plate chambers as a possible alternative with attractive features. Although P803/E803 captured much of our interest during this grant. it did not absorb group resources beyond modest travel funds.

10 Fermilab experiment E872

E872 received approval from Fermilab in June 1994. The co-spokesmen are B. Lundberg of Fermilab and V. Paolone of U.C. Davis. This experiment seeks to observe $\nu_\tau \rightarrow \tau + X$ where the ν_τ's are produced by protons from the Tevatron incident on a beam dump. Like E803 this experiment will observe the taus in emulsion. Calculations suggest that with 10^{18} protons on target 100 τ neutrinos may be observed. The experiment will occupy the hall formerly occupied by experiment E771, and much of E771's detection equipment can be salvaged for E872. At the conclusion of this grant the collaboration was just getting itself organized. and the role that USC would play was not yet established. Subsequently USC acquired much of the responsibility for recommissioning the lead glass calorimeter left by E771. We also committed to preparing electronics that would enable the calorimeter to generate signals for a second level trigger. Avignone, Kulik, and Rosenfeld are participating in E872. E872 captured much of our interest during this grant, but it did not absorb group resources beyond modest travel funds.

11 Charged particle detection by photostimulated luminescence

Our interest in E803 sparked an interest in a novel method of charged particle detection. The neutrino interaction frequently produces a tightly collimated jet of many charged particles. We would like to have high precision coordinates for these particles as they exit the target. These precision measurements would point to track stubs on the exit sheet of the emulsion stack to be followed upstream under the microscope. Since the neutrino beam invariably illuminates several square meters of emulsion, the desired detector combines high spatial resolution and good multiparticle capability with low cost per unit area so as to be affordable. Because the event rate in a neutrino experiment is unlikely to rise much above 1 Hz, considerable time is available for acquisition of the high precision track coordinates.

As a possible answer to this challenge Kulik and Rosenfeld propose the application of photostimulated luminescence (PSL), a phenomenon not previously used for the detection of individual ionizing events. Some inorganic scintillators are also "storage phosphors." BaFCl(Eu) is perhaps the best studied example. In response to ionizing radiation these materials, in addition to emitting prompt scintillation light, store some of the deposited energy in long-lived metastable levels called "color centers" (traps). At some long time after an ionizing event the material may be exposed to visible light at an appropriate wavelength,

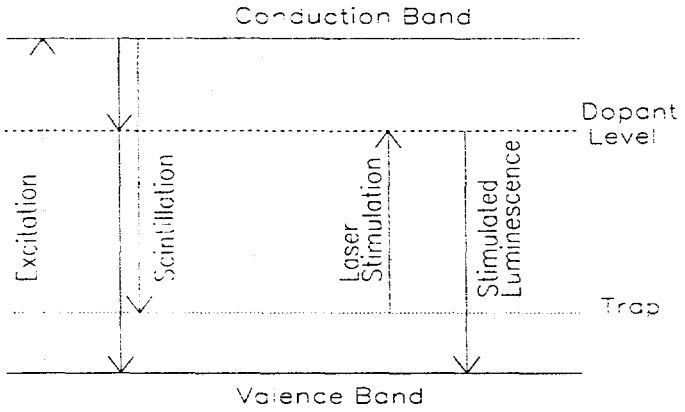

Figure 2: Energy levels in storage phosphor.

which promotes the color centers to higher levels that then decay radiatively to the ground state [4]-[12]. In this system the induced fluorescence is at a shorter wavelength than the stimulating light. Figure 2 depicts the energetics of these processes.

In the detector that we propose the charged particles traverse a thin sheet of single crystal storage phosphor. After exposure to the ionizing radiation a laser beam raster scans the sheet, and some of the induced fluorescence is detected in a nearby photomultiplier tube (PMT). The amplitude of the photomultiplier signal at any instant is a measure of the ionizing radiation exposure at the corresponding position of the laser beam. The crystal sheet is dual purpose. It serves both as the sensitive medium and as a light guide that brings the fluorescent light to the edge of the sheet where it enters the PMT.

At the end of the project period we had just launched an effort to demonstrate the observation of single charged particles by photostimulated luminescence. This effort achieved its goal some months after the conclusion of this grant.

12 Publications coauthored by members of the South Carolina high energy group, 1992–1994, augmented by selected publications from 1995 and 1996.

Entries except those marked with † are included in the collection of reprints furnished with this report.

12.1 ARGUS publications coauthored by R.L. Childers, C.W. Darden, and other group members.

A Measurement of Asymmetry in the Decay $\Lambda_c^+ \rightarrow \Lambda\pi^+$.
ARGUS Collaboration (H. Albrecht *et al.*).
Phys. Lett. B274, 239 (1992).

First Evidence of χ_c Production in B-Meson Decays.
ARGUS Collaboration (H. Albrecht *et al.*).
Phys. Lett. B277, 209, (1992).

A Measurement of the Inclusive Semileptonic Decay Fraction of Charmed Hadrons.
ARGUS Collaboration (H. Albrecht *et al.*).
Phys. Lett. B278, 202 (1992).

The Measurement of D_s^+ and D^+ Meson Decays Into $\bar{K}^{*+}\bar{K}^{*0}$.
ARGUS Collaboration (H. Albrecht *et al.*).
Z. Phys. C53, 361, (1992).

Measurement of Exclusive One-Prong and Inclusive Three-Prong Branching Ratios of the Tau Lepton.
ARGUS Collaboration (H. Albrecht *et al.*).
Z. Phys. C53, 367, (1992).

Production of D_s^+ Mesons in B Decays and Determination of $F(D_s)$.
ARGUS Collaboration (H. Albrecht *et al.*).
Z. Phys. C54,1 (1992).

Measurement of R and Determination of the Charged Particle Multiplicity in e^+e^-Annihilation at $\sqrt{s}$ Around 10 Gev.
ARGUS Collaboration (H. Albrecht *et al.*).
Z. Phys. C54, 13, (1992).

A New Determination of the B^0–$\bar{B}^0$ Oscillation Strength.
H. Albrecht *et al.* (ARGUS Collaboration).
Z. Phys. C55, 357, (1992).

†Physics with ARGUS.
ARGUS Collaboration (H. Albrecht *et al.*).
Physics Reports 276, 223-405 (1996).

12.2 AMY publications coauthored by C. Rosenfeld and other group members.

Evidence for Hard Scattering of Hadronic Constituents of Photons in Photon-Photon Collisions at TRISTAN.
R. Tanaka *et al.* (the AMY Collaboration).
Physics Letters B277, 215 (1992).

The Design of the AMY Central Drift Chamber and Performance in a 3 Tesla Magnetic Field.
K.Ueno, H.W. Zheng, C. Back, D. Blanis, S. Eno, T. Haelen, Y.H. Ho, Y.K. Kim, T. Mori, S.L. Olsen, N.M. Shaw, E.H. Thorndike, J. Edwards, C. Rosenfeld, Y. Higashi, and Y. Kobayashi.
Nuclear Instruments and Methods in Physics Research A323, 601 (1992).

Search for Anamalous $\gamma\gamma$ Production at TRISTAN.
K.L. Sterner *et al.* (the AMY Collaboration).
Physics Letters B303, 385 (1993).

Measurement of α_S from the Moment of Particle Momenta Within Jets from e^+e^- Annihilation.
K.B. Lee *et al.* (the AMY Collaboration).
Physics Letters B313, 469 (1993).

Measurement of the Inclusive Jet Cross Section in Photon-Photon Interactions at TRISTAN.
B.J. Kim *et al.* (the AMY Collaboration).
Physics Letters B325, 248 (1994).

Forward-Backward Charge Asymmetry of Quark Pairs Produced at the KEK TRISTAN e^+e^- Collider.
D. Stuart *et al.* (the AMY Collaboration).
Physical Review D49, 3098 (1994).

Measurements of Cross Section and Asymmetry for $e^+e^- \rightarrow b\ \bar{b}$ and Heavy Quark Fragmentation at KEK TRISTAN.
F. Liu *et al.* (the AMY Collaboration).
Physical Review D49, 4339 (1994).

Measurements of Cross-Section and Charge Asymmetry for $e^+e^- \rightarrow \mu^+\mu^-$ and $e^+e^- \rightarrow \tau^+\tau^-$ at $\sqrt{s} = 57.8$ GeV.
C. Velissaris *et al.* (the AMY Collaboration).
Physics Letters B331, 227 (1994).

12.3 Fermilab E687 publications coauthored by J.R. Wilson.

Description and Performance of the Fermilab E687 Spectrometer.
P.L. Frabetti *et al.* (the E687 Collaboration).
Nuclear Instruments and Methods in Physics Research A320, 519 (1992).

Measurement of the Decays $D^o \rightarrow \pi^+\pi^+\pi^-\pi^-$, $D^o \rightarrow K^-K^+$, and $D_s^+ \rightarrow \phi\pi^+\pi^+\pi^-$.
P.L. Frabetti *et al.* (the E687 Collaboration).
Physics Letters B281, 167 (1992).

Study of $D^o \rightarrow K_s^o\pi^+\pi^-$ and $D^o \rightarrow K_s^oK^+K^-$ in High Energy Photoproduction.
P.L. Frabetti *et al.* (the E687 Collaboration).
Physics Letters B286, 195 (1992).

First Evidence of $\Omega_c^\circ \to \Omega^- \pi^+$
P.L. Frabetti *et al.* (the E687 Collaboration).
Physics Letters B300, 190 (1993) .

Measurement of the Mass and Lifetime of the Ξ_c^+.
P.L. Frabetti *et al.* (the E687 Collaboration).
Physical Review Letters 70, 1381 (1993).

Measurement of the Λ_c^+ Lifetime.
P.L. Frabetti *et al.* (the E687 Collaboration).
Physical Review Letters 70, 1755 (1993).

Measurement of the Lifetime of the Ξ_c°.
P.L. Frabetti *et al.* (the E687 Collaboration).
Physical Review Letters 70, 2058 (1993).

Analysis of the Decay Mode $D^+ \to \bar{K}^{*\circ} \mu^+ \nu$.
P.L. Frabetti *et al.* (the E687 Collaboration).
Physics Letters B307, 262 (1993).

Studies of $D\bar{D}$ Correlations in High Energy Photoproduction
P.L. Frabetti *et al.* (the E687 Collaboration).
Physics Letters B308, 193 (1993).

Precise Measurement of the D_s^+ Meson Lifetime.
P.L. Frabetti *et al.* (the E687 Collaboration).
Physical Review Letters 71, 827 (1993).

A Measurement of $\Gamma(D_s^+ \to \varphi \mu^+ \nu) / \Gamma(D_s^+ \to \varphi \pi^+)$.
P.L. Frabetti *et al.* (the E687 Collaboration).
Physics Letters B313, 253 (1993).

Evidence of the Cabibbo-Suppressed Decay $\Lambda_c^+ \to pK^- K^+$.
P.L. Frabetti *et al.* (the E687 Collaboration).
Physics Letters B314, 477 (1993).

Study of $D^\circ \to K^- \mu^+ \nu$ in High Energy Photoproduction.
P.L. Frabetti *et al.* (the E687 Collaboration).
Physics Letters B315, 203 (1993).

A Measurement of Elastic J/ψ Photoproduction Cross Section at Fermilab E687.
P.L. Frabetti *et al.* (the E687 Collaboration).
Physics Letters B316, 197 (1993).

Measurement of the Masses and Widths of L = 1 Charm Mesons.
P.L. Frabetti *et al.* (the E687 Collaboration).
Physical Review Letters 72, 324 (1994).

Observation of an Excited State of the Λ_c^+ Baryon.
P.L. Frabetti *et al.* (the E687 Collaboration).
Physical Review Letters 72, 961 (1994).

A Measurement of the Cabibbo-Suppressed Decays $D^o \rightarrow K^-K^+$.
P.L. Frabetti *et al.* (the E687 Collaboration).
Physics Letters B321, 295 (1994).

Precise Measurements of the D^o and D^+ Meson Lifetimes.
P.L. Frabetti *et al.* (the E687 Collaboration).
Physics Letters B322, 459 (1994).

Measurement of the Form Factors for the Decay $D_s^+ \rightarrow \varphi\mu^+\nu$.
P.L. Frabetti *et al.* (the E687 Collaboration).
Physics Letters B323, 184 (1994).

First Observation of the $\Sigma^-\pi^+\pi^+$ Decay Mode of the Λ_c Baryon and its Branching Ratio Relative to the $\Sigma^-\pi^+\pi^+$ Mode.
P.L. Frabetti *et al.* (the E687 Collaboration).
Physics Letters B328, 193 (1994).

Analysis of Three $D \rightarrow K\pi\pi$ Dalitz Plots.
P.L. Frabetti *et al.* (the E687 Collaboration).
Physics Letters B331, 217 (1994).

Search of CP Violation in Charm Meson Decay.
P.L. Frabetti *et al.* (the E687 Collaboration).
FERMILAB-Pub-94/071, Physical Review D,.to be published.

Observation and Mass Measurement of $\Omega_c^0 \rightarrow \Sigma^+K^-K^-\pi^+$
P.L. Frabetti *et al.* (the E687 Collaboration).
Physics Letters B338, 106 (1994).

Branching Ratios of the Decays $D^0 \rightarrow \bar{K}^0K^0$ and $D^0 \rightarrow K_s^0K_s^0K_s^0$.
P.L. Frabetti *et al.* (the E687 Collaboration).
Physics Letters B340, 254 (1994).

12.4 Fermilab E789 Publications coauthored by R.L. Childers, C.W. Darden, J.R. Wilson, and other group members.

Preliminary Results from Fermilab E789.
M.S.I. Kowitt *et al.* (the E789 Collaboration).
Moriond, Hadronic, 1992, pp. 491-494.

Preliminary Results from Fermilab E789.
J.C. Peng *et al.* (the E789 Collaboration).
Fermilab-Conf-92-301, presented at the 26th International Conference on High Energy Physics (ICHEP 92), Dallas, Aug. 6-12, 1992, p. 1050.

Nuclear Effects on Heavy Quark Production Results from Fermilab Experiments E772 and E789.
M.J. Leitch *et al.* (the E772 and E789 Collaborations).
Nuclear Physics A544, 197c (1992).

†Beauty and Charm Production from Fermilab Experiment 789.
D.M. Jansen *et al.* (the E789 Collaboration).
Moriond 1993, Hadronic, 345.

†E789 and P865: High Rate Fixed Target Studies of Charm and Beauty.
D.M. Kaplan *et al.* (the E789 and P865 Collaborations).
Frascati 1993, Heavy Quarks at Fixed Target, pp. 111-116.

Production of J/ψ at Large x_F in 800 GeV/c p-Copper and p-Beryllium Collisions.
M.S. Kowitt *et al.* (the E789 Collaboration).
Physical Review Letters 72, 1318 (1994).

Nuclear Dependence of Neutral-D-Meson Production by 800 GeV/c Protons.
M.J. Leitch *et al.* (the E789 Collaboration).
Physical Review Letters 72, 2542 (1994).

Measurement of the Bottom-Quark Production Cross Section in 800 GeV/*c* Proton-Gold Collisions.
D.M. Jansen *et al.* (the E789 Collaboration).
Physical Review Letters 74, 3118-3121 (1995).

Measurement of J/ψ and ψ' production in 800 GeV/*c* Proton-Gold Collisions.
M.H. Schub *et al.* (the E789 Collaboration).
Physical Review D52, 1307-1315 (1995), erratum ibid 53, 570 (1996).

12.5 Publications on miscellaneous additional topics coauthored by various group members.

CAMAC Staggered Memory Look-up Module and ECL Fan-in for Fast Trigger Applications.
C. Rosenfeld, A.T.M. Wang, S.R. Wilson, L.Y. Zheng, and K.W. Broome.
IEEE Transactions on Nuclear Science 39, 848 (1992).

High Sensitivity search for a 17 keV Neutrino. Negative Indication with an Upper Limit of 0.095%.
H. Kawakami, S. Kato, T. Ohshima, C. Rosenfeld, H. Sakamoto, T. Sato, S. Shibata, J. Shirai, Y. Sugaya, T. Suzuki, K. Takahashi, T. Tsukamoto, K. Ueno, K. Ukai, S. Wilson, and Y. Yonezawa.
Physics Letters B287, 45 (1992).

No 17-keV Neutrino: Admixture < 0.073-Percent (95-Percent C.L.)
T. Ohshima, H. Sakamoto, T. Sato, J. Shirai, T. Tsukamoto, Y. Sugaya, K. Takahashi, T. Suzuki, C. Rosenfeld, S. Wilson, K. Ueno, Y. Yonezawa, H. Kawakami, S. Kato, S. Shibata, and K. Ukai.
Physical Review D47, 4840 (1993).

A Fast Ring-Imaging Cerenkov Counter for a Fixed-Target Heavy-Quark Experiment.
D.M. Kaplan, L.D. Isenhower, M. Atac, C.N. Brown, C.W. Darden.
Nuclear Instruments and Methods in Physics Research A343, 316 (1994).

Search for the Decay $D^0 \rightarrow \mu^+\mu^-$.
C.S. Mishra *et al.* (the E789 Collaboration including R.L. Childers and C.W. Darden).
Physical Review D50, R9-R12 (1994).

Nuclear Dependence of J/ψ Production by 800 GeV/c Protons Near $x_F = 0$.
M.J. Leitch *et al.* (the E789 Collaboration including R.L. Childers and C.W. Darden).
Physical Review D52, 4251-4253 (1995).

Nuclear Dependence of Single-Hadron and Dihadron Production in *p-A* Interactions at $\sqrt{s}$ = 38.8 GeV.

C.N. Brown *et al.* (the E789 Collaboration including R.L. Childers and C.W. Darden). Physical Review C54, 3195-3198 (1996).

†SDC Test Beam Results of Massless Gap: Electromagnetic Energy Resolution and Additional Charged Pion Rejection

M. Hulbert, I. Leedom, S. Reucroft, D. Ruuska, T. Yasuda (Northeastern U.), A. Bhatti, K. Goulianos, P. Melese, R. Rusack (Rockefeller U.), P. Bonamy, G. Comby, J. Ernwein, P. LeDu, J.R. Hubbard (Saclay), H. Fenker, K. Morgan, T. Regan (SSCL), A.T.M. Wang, J. Wilson (South Carolina U.), P. Cushman, S.R. Hou (Yale U.).
SDC-92-294.

†Performance of a Prototype SDC Shower-Maximum Detector

M. Hulbert, I. Leedom, S. Reucroft, D. Ruuska, T. Yasuda (Northeastern U.), A. Bhatti, K. Goulianos, P. Melese, R. Rusack (Rockefeller U.), P. Bonamy, G. Comby, J. Ernwein, P. LeDu, J.R. Hubbard (Saclay), H. Fenker, K. Morgan, T. Regan (SSCL), A.T.M. Wang, J. Wilson (South Carolina U.), P. Cushman, S.R. Hou (Yale U.).
SDC-92-343.

†Particle Identification in SDC: Shower Maximum and Preshower Detectors.

P. Cushman, representing the Shower Maximum Subsystem, M. Hulbert, I. Leedom, S. Reucroft, D. Ruuska, T. Yasuda (Northeastern U.), A. Bhatti, A. Maghakian, P. Melese, R. Rusack, A. Titov (Rockefeller U.), P. Bonamy, G. Comby, J. Ernwein, J.R. Hubbard, P. LeDu (Saclay), H. Fenker (SSCL), A.T.M. Wang (South Carolina U.), P. Cushman, S.R. Hou(Yale U.).
The Third International Conference on Calorimetry (Corpus Christi, Sept 29 - Oct 2, 1992)
SDC-92-344

Effect of a Preshower Detector on Calorimetry Performance.

M. Hulbert, I. Leedom, S. Reucroft, D. Ruuska, T. Yasuda (Northeastern U.), A. Bhatti, P. Melese, R. Rusack (Rockefeller U.), P. Bonamy, G. Comby, J. Ernwein, J.R. Hubbard (Saclay), H. Fenker, K. Morgan, T. Regan (SSCL), A.T.M. Wang (South Carolina U.), P. Cushman, S.R. Hou (Yale U.).
Nuclear Instruments and Methods in Physics Research A335, 427-438(1993).

References

[1] J.J. Simpson, Phys. Rev. Lett. 54 (1985) 1891.

[2] A. Hime and N.A. Jelley, Phys. Lett. B257 (1991) 441.

[3] B. Sur et al., Phys. Rev. Lett. 66 (1991) 2444.

[4] Solid State Luminescence, Theory, Materials and Devices, pp. 354-372. Ed. by A.H. Kitai. Chapman & Hall.

[5] H. von Seggern et al., J. Appl. Phys. 66 (1989) 4418.

[6] A. Meijerink et al., Mater. Chem. and Phys. 21 (1989) 261.

[7] A. Meijerink et al., J. Phys. D: Appl. Phys. 24 (1991) 997

[8] A. Meijerink and G. Blase, J. Phys. D: Appl. Phys. 24 (1991) 626.

[9] E.A. Radzhabov and A.V. Egranov, J. Phys.: Condens. Matter 6 (1994) 5639.

[10] E.A. Radzhabov and V. Otroshok, J. Phys. Chem. Solids. 56 (1995) 1.

[11] H.H. Rüter et al., Phys. Rev. Lett. 65 (1990) 2438.

[12] K. Takahashi et al., J. Electrochem. Soc.: Solid State Science and Technology 132 (1985) 1492.