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Final Report of the  
High Energy Physics Group  
at the  
University of South Alabama  
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Final Report

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The experimental high energy physics group at the University of South Alabama worked on three experiments conducted at the Fermi National Accelerator Laboratory partially funded by the Department of Energy (grant DE-FG05-90ER40564) which spanned the years of 1990 to 1997. These experiments were E-705, E-771 and E-871. Our group helped in taking data, analysis of data, and for one experiment in the construction of a new spectrometer from scratch. Results from this work include 33 papers published in conference proceedings, pre-prints and refereed journals (See Appendix A). Twelve talks were given at conferences by members of our group (see Appendix B). We also sent two undergraduate students to work at Fermilab during the data collection phase of E-771 and had several other undergraduate students working on projects related to this research locally at the University of South Alabama.

Experiment E-705 had completed data collection before our group was formed and funded. This experiment used 300 GeV/c  $p$ ,  $\pi^-$ ,  $\bar{p}$  and  $\pi^+$  on Li to study hadronic production of charmonium and direct photon production. Since a member of our group had helped in the construction of the E-705 spectrometer and data collection as a Post Doc, we participated in the E-705 data analysis. We brought up the tracking program on the Alabama

Cray supercomputer (Cray XMP/24 that was available to researchers in the State of Alabama). Over 70 raw data tapes were processed using this computer. Some of these tapes were used in the calibration of the electromagnetic calorimeter for electron identification.

Our group helped in the assembly of the E-771 spectrometer (essentially the E-705 spectrometer with a silicon micro-vertex detector and improved muon detection). E-771 used 800 GeV/c p-Si interactions to study hadronic beauty production and charmonium production. Our task was to bring up the electromagnetic calorimeter and interface it into the new data acquisition system using a new Fast Bus ADC (which during the course of two runs was expanded from two to four crates to facilitate a faster read out time for the data acquisition). This task include writing code to include the ADC's in the data acquisition system, and code to decode the ADC information in the analysis package. In addition our group was responsible for the computerized high voltage power supply system that powered all photomultiplier tubes for the experiment. Our group helped in the data collection of this experiment. The USA group also worked on the online software to monitor the electromagnetic calorimeter.

Off-line work done for the analysis of E-771 concentrated on the elec-

tromagnetic reconstruction package. We used the Cray supercomputer to generate new shower pattern tables for the electromagnetic calorimeter from the EGS monte carlo. We also parameterized the electron and photon energy deposition in the calorimeter again from the EGS monte carlo. We also parameterized the time vs energy deposition inside the main array glass blocks of the electromagnetic calorimeter.

Other work done in conjunction with E-771 included the development of a tracking program that used the Hough Transformation. This algorithm was also easily expanded into a vertex algorithm too. Although this algorithm was developed and tested with Pythia generated monte carlo events it was not used to process data.

Our group was also part of the P-876 proposal which requested for more beam time for E-771. The original runs of E-771 resulted in very little data as readouts for the silicon vertex detector were late. This request was subsequently turned down by Fermilab.

Our group was also part of a letter of intent for a Fixed target B experiment to the Superconducting Super Collider Laboratory. However in August of 1992 we withdrew from the Fixed target experiment and were accepted into the SDC collaboration. This realignment was in response to the State

of Alabama EPSCORE call for proposals where we would be part of a state wide consortium including the University of Alabama High Energy Group. The EPSCORE proposal was one of six proposals accepted but was later cut due to insufficient funding. Our group and University hosted an group of representatives from the SSC laboratory in 1992.

When the SSC Laboratory was terminated, our group applied for equipment that was being distributed to High Energy Physics and Nuclear Physics groups supported by the Department of Energy. Our group applied for equipment and received several computer systems and other laboratory electronics.

In March of 1994 our group joined Fermilab Experiment E-871 (the HyperCP experiment). This experiment is a search for CP violation in the decay sequence of  $\Xi^- \rightarrow \Lambda\pi^- \rightarrow p\pi^-\pi^-$  and the anti-particle decay sequence of  $\Xi^+ \rightarrow \bar{\Lambda}\pi^+ \rightarrow \bar{p}\pi^+\pi^+$ . Our group took responsibility for the scintillation trigger hodoscopes to be used by the experiment. This included monte carlo simulations to determine the placement of the trigger hodoscopes and the design of the scintillator counters. We submitted a supplemental equipment proposal to the Department of Energy to obtain funding to build the scintillation counters and hodoscope stand.

Our group tested a large number of photomultiplier tubes and bases to

select the best ones to use in the trigger hodoscope. With the supplemental funding, our group procured the scintillator, light guides and wrapping material for the counters. Fifty scintillator counters were subsequently assembled at the University of South Alabama and tested. The hodoscope stand was designed and constructed again at the University of South Alabama. These components were shipped to the experiment and installed by the our group in the spectrometer. Our group was brought up the computerized high voltage power supply that powers all photomultiplier tubes used by the experiment (this includes re-writing the software to interact via CAMAC).

Once beam was delivered to the HyperCP experiment, our group helped in the spectrometer commissioning. We plateaued the scintillation hodoscope counters with beam and timed in the counters. We helped in setting up the trigger logic for the experiment. We took shifts to collect data and to monitor the spectrometer.

During the run, we wrote the on-line monitoring software for the scintillation trigger hodoscope. We also converted an event display program that was not satisfactory into the event display package that is now standard for the experiment (in fact the standard release used by the experiment is a total re-write of the code).

In 1994 we were invited by the University of Alabama to help organize the Southern Association for High Energy Physics Meeting on the Gulf. The organizers wanted to expand this meeting from a purely Theory Meeting into a joint Experimental-Theory meeting. We organize the Experimental Section from 1994 and 1995.

## Appendix A

### Publications

The following is a list of publications that members of the University of South Alabama High Energy Physics Group are on the authors list.

- 1) L. Spiegel et al., "Performance of a lead radiator gas tube calorimeter", IEEE Trans. on Nucl. Sci., NS36(1989)86.
- 2) S. Conetti et al., "Performance of a 0.75 mm pitch MWPC's operating at high rate", IEEE Trans. on Nuc. Sci., NS36 (1989) 112.
- 3) C. M. Jenkins et al., "Results from the E-705 Electromagnetic Shower Position Detector", IEEE Trans. on Nuc. Sci., NS36(1989) 117.
- 4) G. Zioulas et al., "An on-line trigger processor for large transverse energy events", IEEE Trans. on Nuc. Sci., NS36(1989)375.

- 5) S. W. Delchamps., "Precision charge amplification and digitization system for a scintillating and lead glass array", IEEE Trans. on Nuc. Sci. NS36(1989)680.
- 6) C. M. Jenkins and R. K. Clark, "Lifetime Extension of Gas Calorimeters at the SSC", Proceedings of the SSC Workshop on Calorimetry, (1989) 695.
- 7) C. M. Jenkins et al., "Results from the E-705 Electromagnetic Shower Position Detector", Fermilab Pre-print: TM-1591, April 1989.
- 8) M. Rosati et al., "Production of Charmionium States from Experiment E-705 at Fermilab", Submitted to the Proceedings of the 1991 meeting of the Division of Particles and Fields. Vancouver, Canada.
- 9) L. Fortney et al., "High  $p_T$  production of  $\pi^0$  and  $\eta$  at 300 GeV/c", Submitted to the Proceedings of the 1991 meeting of the Division of Particles and Fields. Vancouver, Canada.

- 10) C. M. Jenkins et al., "A Fixed Target Experiment at the Superconducting Super Collider", Journal of the Alabama Academy of Sciences, 63 (1992) 32.
- 11) T. Alexopoulos et al., "B physics at FNAL E771", Nucl. Phys 27B (1992) 257.
- 12) S. E. Anassontzis et al., "The Super Fixed Target Beauty Facility at the SSC", Nucl. Phys 27B (1992) 352.
- 13) L. Spiegel et al., "A Combination Drift Chamber/Pad Chamber for Very High Readout Rates", IEEE Nuclear Science Symposium and Medical Imaging Conference, November 2-9, 1991, Vol. 1, page 381.
- 14) L. Spiegel et al., "A Combination Drift Chamber/Pad Chamber for Very High Readout Rates", Fermilab Pre-print TM-1765, November 1991.
- 15) L. Antoniazzi et al., "Production of  $J/\psi$  via  $\psi'$  and  $\chi$  Decay in 300 GeV/c Proton and  $\pi^\pm$  Nucleon Interactions", Fermilab Pre-print 92/140-E (1992).

- 16) L. Antoniazzi et al., "A Measurement of  $J/\psi$  and  $\psi'$  Production in 300 GeV/c Proton, Antiproton, and  $\pi^\pm$  Nucleon Interactions", Phys. Rev. D46 (1992) 4828.
- 17) L. Antoniazzi et al., "A Measurement of  $J/\psi$  and  $\psi'$  Production in 300 GeV/c Proton, Antiproton, and  $\pi^\pm$  Nucleon Interactions", Fermilab-Pub-92/141E (1992).
- 18) L. Antoniazzi et al., "Production of  $J/\psi$  via  $\psi'$  and  $\chi$  Decay in 300 GeV/c Proton and  $\pi^\pm$  Nucleon Interactions", Phys. Rev. Lett. 70 (1993) 383.
- 19) L. Antoniazzi et al., "The Experiment E705 Electromagnetic Shower Calorimeter", Nucl. Inst. and Meth. A332 (1993) 57.
- 20) L. Antoniazzi et al., "The Experiment E705 Electromagnetic Shower Calorimeter", Fermilab Preprint: Fermilab:Fermilab-pub-93/001, 1993.
- 21) W. Selove et al., "Di-Muon and Single-Muon Events from a Beauty Experiment", Proceedings of the Fermilab Meeting, Seventh meeting of the Division of Particles and Fields, Batavia, Illinois, (1993) 701.

- 22) L. Fortney et al., "Measurement of Localized Efficiency Loss in a Silicon Microstrip Detector Operated at High Intensity", Proceedings of the Fermilab Meeting, Seventh meeting of the Division of Particles and Fields, Batavia, Illinois, (1993) 1684.
- 23) S. Delchamps et al., "Production of States with Hidden Charm in 300 GeV/c  $\pi^+$ ,  $\pi^-$ , p and  $\bar{p}$  Collisions with Nuclei", Proceedings of the Fermilab Meeting, Seventh meeting of the Division of Particles and Fields, Batavia, Illinois, (1993) 711.
- 24) L. Antoniazzi et al., "Production of Chi Charmonium via 300 Pion and Proton Interactions on a Lithium Target", Fermilab Pre-print: Fermilab-Pub-93/083-E(1993).
- 25) L. Antoniazzi et al., "Production of  $\chi$  Charmonium via 300 GeV/c pion and proton interactions on a lithium target", *Phys. Rev. D* 49 (1994) 543.
- 26) S. Conetti et al., "Fixed Target B Physics at Fermilab and the SSC", *Nucl Inst. and Meth* A333 (1993) 142.

- 27) L Antoniazzi et al., "Search for Hidden Charm Resonance States Decaying into  $J/\psi$  or  $\psi'$  Plus Pions", Fermilab Pre-print: Fermilab-Pub-92/265-E (1993).
- 28) L Antoniazzi et al., "Search for Hidden Charm Resonance States Decaying into  $J/\psi$  or  $\psi'$  Plus Pions", Phys. Rev. D50 (1994) 4258.
- 29) A. McManus et al., "A Search for New Charmonium States Decaying into  $J/\psi$  Plus Charged Pions", Proceedings of the Albuquerque Meeting, Eighth Meeting of the Division of Particles and Feilds, (1994) 547.
- 30) G. Cori et al., "High Mass Dimuon States produced in 800 GeV/c pSi Interactions", Proceedings of the Albuquerque Meeting, Eighth Meeting of the Division of Particles and Feilds, (1994) 1272.
- 31) G. H. Mo et al., "Search for Flavor Changing Neutral Current Decay  $D^0 \rightarrow \mu^+\mu^-$  in 800 GeV/c Proton-Silicon Interactions", Proceedings of the Albuquerque Meeting, Eighth Meeting of the Division of Particles and Feilds, (1994) 956.

- 32) T. Alexopoulos et al., "The Fermilab E771 Spectrometer a Large Aperture Spectrometer to Study Charm and Beauty States as Detected by Decays into Muons", Nucl. Inst. and Methods A376 (1996) 375.
- 33) T. Alexopoulos et al., "Search for Flavor Changing Neutral Current Decay  $D^0 \rightarrow \mu^+ \mu^-$  in 800 GeV Proton-Silicon Interactions", Phys. Rev. Lett. 77 (1996) 2380.

## Appendix B

### Presentations

Presentations by members of the High Energy Physics Group at the University of South Alabama.

- 1) C. M. Jenkins et al., "A Fixed Target Experiment at the SSC", Gulf Shores SAHEP Theory Meeting, January 5, 1991, Gulf Shores, Alabama.
- 2) C. M. Jenkins et al., "A Fixed Target Experiment at the SSC", Invited talk given at the Sixty-Eighth Meeting of the Alabama Academy of Sciences, March 8, 1991, Jacksonville, Alabama.
- 3) C. M. Jenkins et al., "Preliminary Results from a Photodiode Light Detector for Scintillator", Sixty Ninth Annual Meeting of the Alabama Academy of Sciences, University of Alabama, Tuscaloosa, Alabama, April 15-18, 1992.
- 4) C. M. Jenkins et al., "Presentation of Preliminary Results from Fermilab Experiment E-771", Departmental Colloquium given at the University of Southern Mississippi, April 23, 1993.

- 5) R. K. Clark et al., "Using the Hough Transform for Offline Tracking", Meeting of the Southeast Section of the American Physical Society, Oak Ridge, Tennessee, November 13, 1992.
- 6) R. K. Clark et al., "On image processing, Hough transforms and particle tracking", Departmental Colloquium given at the University of Alabama, Tuscaloosa, Alabama, April 1991.
- 7) R. K. Clark et al., "Tracking Particles with Hough Transformation", Alabama Academy of Sciences, University of Alabama, Tuscaloosa, Alabama, April 1992.
- 8) C. M. Jenkins et al., "Hidden Charm States in Fermilab Experiment E-705 and E-771", Third Annual Southern Association for High Energy Physics Meeting on the Gulf. January 3-5, 1994, Gulf Shores, Alabama.
- 9) R. K. Clark et al., "The Hough Transform and Tracking and Vertexing", Third Annual Southern Association for High Energy Physics Meeting on the Gulf. January 3-5, 1994, Gulf Shores, Alabama.
- 10) R. K. Clark, "The Hough Transform and High Energy Physics

and Image Processing”, Departmental Colloquium, Naval Research Laboratory, Stennis Space Center, Mississippi, November 16, 1993.

- 11) C. M. Jenkins et al., “Fermilab Experiment E-871: Search of CP Violation in  $\Xi^-/\bar{\Xi}^+$  and  $\Lambda/\bar{\Lambda}$  Decay”, Fourth Annual SAHEP Meeting on the Gulf, January 3-5, 1995, Gulf Shores, Alabama.
- 12) R. K. Clark, “Finding Line Intersections Using Hough Transforms: An Application to High Energy Physics”, 72<sup>nd</sup> Meeting of the Alabama Academy of Science, March 15-17, 1995, Birmingham, Alabama.