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PARTICIPATION IN HIGH ENERGY PHYSICS TASK D

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PROGRESS REPORT

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MASTER

PROGRESS REPORT ON DOE DE F602 290ER 40560 TASK D

Leon M. Lederman

This grant was initiated in December of 1989. My request for DOE funds (July 7, 1989) listed three activities which would require support from DOE. These were (1) communication of HEP and Basic Research activities via lectures, articles, TV, etc., (2) science education activities and (3) participation in E789, a fixed-target research on beauty physics at Fermilab. The DOE grant received was mostly consumed in connection with E789 although valuable help was given in travel and secretarial help which furthered goals (1) and (2).

A. Communication and Advancement of HEP

I append (Appendix I) a list of lectures given over the past year on high energy particle physics, as well as articles of a general nature. Most of these are to general audiences. Several other activities serve to advance the state of the subject and are listed here.

1. Member, SSC Science Policy Committee

Advises the Director on policy issues related to the SSC laboratory. In addition to three meetings in Dallas of two days each I have written several times to the Director on various issues of SSCL management.

2. Member, URA Board of Trustees

Holds the contract for the management of Fermilab and SSCL. Responsible for the management of both Laboratories.

3. Member, Secretary of Energy Advisory Board

SEAB advises the Secretary on all issues related to the DOE.

4. Member, Program Planning Committee of APS

Responsible for the development of a strategic plan for the advancement of research in physics.

These and other activities are given substance by virtue of active involvement in HEP research. Senior statesman can quickly get out of touch with the rapidly changing technology and scientific issues unless they are in fairly intimate contact with the frontier of research activities.

In connection with SSC, I have visited India, Mexico and Brazil with a specific agenda item related to collaboration and contribution to SSCL. India seems essentially on board with very promising indicators from Brazil and Mexico.

B. Science Education

These are carried out through the Education Section of Fermilab and involve participation in the educational activities of the Laboratory. One of these is of special interest to DOE and involves the creation of the Academy for Mathematics and Science Teachers in Chicago (AMST). This large program is supported by DOE and has the special role of involving Fermilab and Argonne in the improvement of the Chicago Public Schools. I cite here only the value of connecting the management and organizational skills of Fermilab to the important problem of science education in a large, inner-city system.

Through the Education Office of the DOE Secretariat, \$2M was awarded to AMST for FY 1991.

C. Experiment E789: Study of Beauty Quarks

1. Overview

The goal of E789 is to detect the production and decays of B^0 's, mesons made of a b-quark and a light quark e.g., $b\bar{d}$, $b\bar{s}$, $b\bar{u}$ or B_d^0 , B_s^0 .

The number of B's seen in hadronic interactions is very small: a few events seen at CERN in a fixed target run, indirect evidence in UA1 and better, very recent data from CDF. The problem is that $\sigma(pp \rightarrow B^0)/\sigma_T \sim 10^{-6}$ and although huge numbers of hadronic collisions can be obtained, the backgrounds are also huge. The 789 approach makes use of an existing high resolution two-particle spectrometer which was designed in 1978 by my group (Columbia, Fermilab, Stony Brook) for E605, for dimuon and dihadron studies. It was later used (E772) by a group from Los Alamos to study the nuclear effects on very small Bjorken-x distributions of quarks. E789 is a collaboration

of Los Alamos, Fermilab, Chicago, LBL, NIU, University of Southern Carolina, Taiwan to make use of the very high mass resolution (0.2%) of this spectrometer to look for

$$\begin{aligned}
 B^0_d, B^0_s &\rightarrow \pi^+\pi^- \\
 &\rightarrow K^+\pi^- \\
 &\rightarrow K^+K^- \\
 &\rightarrow p\bar{p} \\
 &\rightarrow \mu^+ + \mu^- \\
 &\rightarrow \mu^+ + e^- \\
 &\rightarrow J/\psi + x \\
 &\text{and } \Lambda_b \rightarrow p\pi^-, pK^- \\
 \bar{\Lambda}_b &\rightarrow \bar{p}\pi^+, \bar{p}K^+
 \end{aligned}$$

Whereas a spectrum of dihadrons in the mass range of the B^0 would completely mask the B^0 , if it can be established that the dihadron vertex is in vacuum, the background should be drastically reduced, ($\sim 10^{-4}$).

The goals of the research are to observe some or all of the above decays, to determine the masses and lifetimes of B_S, Λ_B (these are as yet unobserved), to study the dynamics of b-quark production e.g., cross-sections, p_t distributions, X_F distributions. Some by products are the leptonic decays (for which only upper limits exist) and to see dihadron decays of bb bound states e.g., $\eta_b \rightarrow p\bar{p}, \gamma \rightarrow \pi^+\pi^-$ etc. Finally, we view the research as a learning process.

If we can learn and improve, a few thousand $\pi^+\pi^-$ events with a crude muon tag may be enough for CP violation!

2. Important questions concerning the feasibility of the proposed measurements

DATA ACQUISITION

- 1.) Can silicon detectors survive the high rate environment?
- 2.) Is the di-hadron trigger rate too high?

DATA ANALYSIS

- 1.) What is the expected signal/background ratio?
- 2.) Efficiency for silicon vertex detectors to reject dihadron backgrounds originating from the target (direct QCD pair)
- 3.) Background due to decays of long-lived particles (D, K, Λ ...)

3. Plan and Status

The E605 spectrometer is well-tested at high rates in the open geometry of dihadrons and of electron pairs. It has successfully operated at a proton intensity of $\sim 2 \times 10^{11}$ ppp which implies an interaction rate of 10^9 interactions/sec (a 10% target and a 20 second spill). This produces about 10^4 $B^0\bar{B}^0$ pairs which have about a 1% detection probability (mostly acceptance) and there is an estimated branching ratio of 10^{-5} for two body decays, yielding 10^{-3} detected B^0 's in each hadronic decay channel per minute. A run of 20 weeks at 100 hours/week yields a very pleasant 100 events in each channel that has a 10^{-5} BR. The problem is that there are 5×10^7 buckets/sec so we are looking at 20 events/bucket.

Now in order to distinguish events from the target from events from vacuum, we must add a vertex detector to the E605 spectrometer. Clearly silicon microstrip is the detector of choice and since this must be located close to the target, the question of 20 events/bucket (average of 5 tracks in the silicon per event) is clearly the crucial issue.

The E789 experiment began operations without the silicon in March of 1990. By the time the run paused in late August, eight planes of silicon (pitch 50μ) had been installed. (This is four in each arm.) Most of the run was occupied in bringing up all the systems.

Much of the electronics is ten years old, some even dates back to the NEVIS (Sippach) system brought to Fermilab in 1973. New electronics was required for the silicon and these are essentially home built. A new Station 1 drift chamber array was constructed in the high rate region just downstream of the large magnet.

All systems have been debugged and have operated in data-taking modes and at intensities up to about 3 interactions/RF bucket. Since only 4 planes in each arm were in (out of a total of 8 planes) and the read-out electronics is still not final and capable of only 3 bucket resolution, this was the highest intensity at which the system was exercised.

At this writing we have some preliminary results from the experience and from a glimpse of the 250 tapes of data taken.

1) The experimental trigger is accidentals limited and the rate goes as I^2 (not higher).

2) The beam line collimation must be improved for higher intensity running.

3) A mass resolution, using the silicon, of 25 MeV FWHM for the J/ψ is just what is expected.

4) The silicon spatial resolution (target impact parameter) is also what is expected from a 50 μ pitch.

5) Silicon radiation damage as observed from increase in noise is what was predicted from data taken at Los Alamos.

Improvements since the shutdown is attributed to room temperature annealing.

6) Whereas the surveying that enables matching of downstream tracks to silicon has been made satisfactory, there are still problems in matching slopes in order to refine the road in the silicon as defined by extrapolation of downstream tracks.

7) A-dependence of single and di-hadrons has been observed and is being analyzed.

8) Some 30 tapes are being used to find a "D" meson peak to begin to see if we have interesting charm data.

4. Tasks During the Pause

The second half of the 1990/91 run will begin in December (no Gramm-Rudman) and end in May-June 91. In the pause we will

1) Install 8 planes of SI in each arm

2) Install new discriminator and CR's to secure 1 bucket resolution. Financial constraints are such that we will not replace electronics for all strips.

3) Our venerable PDP11 will be supported by a SUN workstation.

4) Various shielding improvements

5) A vertex processor is being constructed.

The goal of the second half is to find B's!

5. Long Range Prospects

Let us suppose that the fall run indeed yields a few hundred B^0 events, gives data on Branching Ratios, cross-sections, lifetimes, etc. How can this be improved? The time scale is the run which will begin one year or so from June 1991 - let's say September 1992.

There are two possibilities:

1) A method can be found to gain a factor of 10-30 using essentially the same apparatus. What will be needed is: i) tagging on muons such that the sign of the muon can be determined, ii) an analogue trigger which is a new level zero determination that the event origin is off-target, iii) general hardening of counters, PWC's for ~ 100 interactions/RF bucket.

Since the largest part of the acceptance involves two charged particles crossing over before Station I, it is possible (some loss of acceptance) to make an effective new target way downstream along the general lines of an idea of Bjorken to image the target area magnetically.

2) Based upon the 789 experience and that of the 3 or 4 other fixed target experiments that are currently engaged in Beauty physics, a composite effort may be formed that combines the strengths and experience of the many practitioners.

From: FNAL::CHUCKB "CHUCK BROWN X3202 MS122 WH10W" 19-SEP-1990 14:58:06.76
To: CHILDRESS, MONT, GARBINCUS, KAPLAN, PENQ, OB0E, MHS
CC: CHUCKB
Subj: Liaison's summary of E789 Test Run

CNBrown, September 19, 1990

SUMMARY OF E789 TEST RUN: APR-AUG 1990

4/22-6/23: INITIAL BEAM ON TARGET:

Two months were spent tuning up the beamline, installing the new Station 1 drift chambers, plateauing and timing hodoscopes, debugging the existing chambers and calorimeters, and debugging the Data-acquisition system.

6/23-7/17: J/Psi A-DEPENDENCE DATA

Four weeks were spent studying the J/Psi yield from tungsten, carbon, and beryllium targets. The kinematic range $-1 < X_f < 1.2$ was emphasized in order to complete and complement the results of E772. Over 10,000 J/Psi dimuon decays were recorded at an average intensity of $1.5E10$ on 5 gm/cm² targets.

During this period, 8 planes of SSD detectors were also installed, plateaued, and timed into the DAQ system.

7/17-8/8: D->K-pi DATA

Dihadron triggers were recorded at an average intensity of $3E9$ on a 200 micron Pt wire and with 4 upper Y-SSD and 4 lower Y-SSD planes operational. The data should contain a few hundred D->K-pi events depending on the efficiency of our decay finding algorithms and the A-dependence of the charm yield. The data-taking rate was much lower than expected due to a larger than anticipated direct dihadron rate from the target. We had not managed to complete the construction of our vertex processor which would have helped to reject this background online. This data is currently being analysed on the LANL ACP-system installed in MEat.

8/8-8/24: D->dilepton DATA

During this period we decided to prescale the copious dihadron triggers in order to increase our sensitivity to dilepton D-decays. Two more U-SSD planes were added. Data was recorded at an average intensity of $1.5E10$ on a 250 micron high by 1mm long Pt target.

8/23-8/24: SINGLE AND DIHADRON A-DEPENDENCE DATA

Hadron yields were recorded from Beryllium, Iron, and Tungsten targets at a variety of magnet currents. This data will provide confirmation and extension of the measurements of E357 and E805 as well as provide us with valuable engineering rates for the FY91 run.

8/24-8/27: B->h+h- TEST DATA

During this period we studied the rate dependence of various triggers at nominal magnet settings for B-decays. We also took some data at the highest intensities we could ($\sim 8E10$ on a 1mm Pt target, limited by trigger rates and problems with the beam) in order to have events that can be run through a simulated vertex processor before the FY91 run.

SUMMARY:

Although we hope to publish some of the results from the FY90

E789 run, it was definitely a test run in a reduced E789 configuration. We hope to get the full 16-plane SSD detector with improved electronics, the full RICH detector, the vertex processor, and an upgraded DAQ system working before the FY91 run. If so, we should be able to make the measurements on D-decays outlined in our director's review of 2/10/90 and also establish the cross-section for B-production at 800GeV. Time and monetary uncertainty are not in our favour!

END

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