



**Fermi National Accelerator Laboratory**

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**Talks on Fermilab Experiments  
at the 1992 APS Meetings**

submitted by S. Pordes

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SESSION A6: RARE DECAYS AND LIGHT QUARKS  
Monday morning, 20 April 1992  
Room 16 at 8:00  
P. Rapidis, presiding

9:00

**A6 6 Precision Determination of  $p\bar{p}$  Forward Angle Elastic Scattering Parameters** S. TROKENHEIM, for the E760 Collaboration (Northwestern - Fermilab - Ferrara - Genova - Irvine - Penn State - Torino) — The differential cross sections for  $p\bar{p}$  elastic scattering have been measured in the range of momentum transfer from 0.001 to 0.030  $(\text{GeV}/c)^2$  for  $\bar{p}$  momenta of 4.07, 5.61, 6.23, and 8.75  $\text{GeV}/c$  during the running of Fermilab experiment E760. A hydrogen gas jet intercepts the circulating  $\bar{p}$  beam in the antiproton accumulator. Precision measurements of elastic scattering cross sections are made by detecting recoil protons at angles between  $82^\circ$  and  $90^\circ$  in a bank of solid state detectors mounted on a movable carriage 1.5 meters from the target. The measured differential cross sections have been fit to the parametrization  $d\sigma/dt = |\sigma_t(\rho + i)\exp(-bt/2)F/(4\sqrt{\pi}\hbar c) + 2\sqrt{\pi}\alpha\exp(i\delta)/t|^2$ . The precision in the determination of the parameters  $\sigma_t$ ,  $b$ , and  $\rho$  is considerably better than achieved in previous experiments.

9:12

**A6 7 A technique for measuring the beam energy of the Fermilab Antiproton Accumulator and a determination of the proton electromagnetic form factor at  $|q^2| = 12.4 (\text{GeV}/c)^2$ .** D. R. BROEMMELSIEK for the E760 Collaboration (U.C. Irvine - Fermilab - Ferrara - Genova - Northwestern - Penn State - Torino) — The energy of a stochastically cooled beam of antiprotons at the Fermilab Antiproton Accumulator ring is measured with an accuracy of  $\sim 2 \times 10^{-4}$ . Using the E760 detector, the value of  $|G_M|$  for the proton, assuming  $|G_E| = 0$ , is measured in the time like region ( $q^2 < 0$ ) at  $|q^2| = 12.4 (\text{GeV}/c)^2$ .

9:12

**A9 7 Fermilab Booster to Main Injector Beamline Design** J. A. JOHNSTONE, A. D. RUSSELL, Fermi National Accelerator Laboratory\* - The Fermilab Main Injector will require construction of a 760m beamline for transporting 8 GeV protons from the Booster. In contrast to the severe constraints often encountered in beamline designs, the great length of the FMI 8 GeV line admits wide flexibility in the choice of physical and optical solutions. The adopted configuration comprises four distinct sections: Booster matching section, descent to the Injector altitude, 480m of periodic  $90^\circ$  FODO cells, and matching to the Injector. The main body of the beamline incorporates 51 recycled Main Ring B2's to produce  $112^\circ$  of horizontal bend and 2 B3's for the  $3^\circ$  vertical drop.

\* Operated by the Universities Research Association Inc., under contract with the U.S. Dept. of Energy.

\*\*Submitted by PHILIP S. MARTIN

9:24

**A6 8 Differential Cross Sections for  $p + \bar{p} \rightarrow$  Neutral Two Body Final States in the Range  $\sqrt{s} \approx 2.9-4.0 \text{ GeV}$ .** J.D. REID, E760 Collaboration (Penn State - Fermilab - Ferrara - Genova - Irvine - Northwestern - Torino) Fermilab experiment 760, which was designed for charmonium spectroscopy, has also taken a substantial amount of data of the type  $p + \bar{p} \rightarrow$  neutral two body final states. Data are presented showing the  $\sqrt{s}$  dependence of the differential cross sections for some of these final states including  $2\pi^0$ ,  $\pi^0 + \eta$ ,  $\eta + \eta$ . Data cover the range  $\sqrt{s} \approx 2.9-4.0 \text{ GeV}$ .

9:36

A6 9

**Observation of the Radiative Decay  $\Xi^- \rightarrow \Sigma^- \gamma$ .** T. DUBBS, (Fermilab E761 Collaboration<sup>1</sup>) University of Iowa. --- Hyperon radiative decays represent a class of baryon decays which require both weak and electromagnetic contributions. These decays allow us to test the interplay of electroweak and strong interactions as applied to the underlying quark structure of baryons. We have investigated the radiative decay  $\Xi^- \rightarrow \Sigma^- \gamma$  using a 375  $\text{GeV}/c$  polarized beam of  $\Xi^-$  produced at the Fermilab Proton Center charged hyperon beam line. Preliminary results will be presented.

\* Submitted by J. Lach

1. Fermilab; Institute of High Energy Physics, PRC; St. Petersburg Nuclear Physics Institute, Russia; Institute of Theoretical and Experimental Physics, Russia, U. of Iowa; U. of Sao Paulo, Brazil; Yale Univ; Centro Brasileiro de Pesquisas, Brazil; CNPq, Brazil; SUNY at Albany; U. of Bristol, UK

10:12

**A9 12 Performance of Full Length 50 mm Aperture SSC Dipole Magnets at Fermilab.** J. Strait, R. Bossert, J. Carson, S. Delchamps, S. Gourlay, R. Hanft, W. Koska, M. Kuchnir, M.J. Lamm, P.O. Mazur, D. Orris, J. Ozalis, and M. Wake, Fermilab; A. Devred, J. DiMarco, J. Kuzminski, T. Ogitsu, M. Puglisi, J. C. Tompkins, Y. Yu, Y. Zhao, and H. Zheng, SSC Laboratory. Thirteen 15 m long, 50 mm aperture SSC dipole magnets, designed jointly by Fermilab, Brookhaven Laboratory, Lawrence Berkeley Laboratory and the SSC Laboratory, are being built and tested at Fermilab. Seven of these magnets are being assembled jointly by Fermilab and General Dynamics Space Systems Division, and five of these will be used in the Accelerator Systems String Test (ASST) at the SSC Lab. The magnets are equipped with multiple voltage taps, which allow detailed study of quench phenomena, and strain gauges, which measure forces and deflections in the coil and its support structure. Quench performance, mechanical behavior, AC loss, and magnetic field measurement data will be presented and compared with the requirements for the ASST and for the Collider.

\*Work supported by the United States Department of Energy.

11:12

B9 2

**Resonant Extraction from the Fermilab Main Injector** J. A. JOHNSTONE, Fermi National Accelerator Laboratory\* - One requirement of the Main Injector is the capability to provide slow-extracted 120  $\text{GeV}/c$  test beams. In the proposed resonant half-integer extraction scheme control of the beam phase-space is provided by one family of 0-th harmonic octupoles and two orthogonal families of 53-rd harmonic quadrupoles. The extraction system details are discussed together with the results of Monte Carlo simulation of the process.

\* Operated by the Universities Research Association Inc., under contract with the U.S. Dept. of Energy.

\*\*Submitted by PHILIP S. MARTIN

11:12

**B6 2** A Measurement of QCD Scaling Violations from the Neutrino-Iron Structure Functions\* W. G. Seligman, C. Arroyo, K. Bachmann, R. Blair, C. Foudas, B.J. King, W. Lefmann, W.C. Leung, S. Mishra, P. Quintas, S. Rabinowitz, F.J. Sciulli, M. Shaevitz, Columbia U.; F.S. Merritt, M. Oreglia, H. Schellman, B. Schumm, U. Chicago; R.H. Bernstein, F. Borcharding, M. Lamm, W. Marsh, D. Yovanovich, FNAL; A. Bodek, H.S. Budd, P. de Barbaro, W.K. Sakumoto, U. Rochester; T. Kinne, P. Sandler, W.H. Smith, U. Wisconsin. — We present an analysis of the structure functions from neutrino-iron interactions. These structure functions were extracted from two experimental runs of the CCFR collaboration using the quadrupole-triplet neutrino beam at the Tevatron on an iron target. The data sample consists of roughly 1,050,000 neutrino-induced and 180,000 antineutrino-induced charged-current events after cuts. The structure functions from this high-statistics sample allow us to test the scaling violation predictions of perturbative QCD, and to measure  $\Lambda_{\overline{MS}}$ , the QCD scaling parameter.

\* supported in part by DOE and NSF

11:36

**B2 2** CP Violation in the Kaon System. BRUCE WINSTEIN, The University of Chicago.

12:00

**B6 6** Primordial  $p_T$  Measurements from Charged Current Neutrino Interactions at the Tevatron. T. Kinne, P. Sandler, W.H. Smith U. Wisconsin; P.Z. Quintas, C. Arroyo, K.T. Bachmann, R.E. Blair, T. Bolton, C. Foudas, B.J. King, W.C. Lefmann, W.C. Leung, S.R. Mishra, E. Oltman, S.A. Rabinowitz, F.J. Sciulli, W.G. Seligman, M.H. Shaevitz, Columbia U.; F.S. Merritt, M.J. Oreglia, B.A. Schumm, U. Chicago; R.H. Bernstein, F. Borcharding, H.E. Fisk, M.J. Lamm, W. Marsh, K.W.B. Merritt, H. Schellman, D.D. Yovanovitch, FNAL; A. Bodek, H.S. Budd, P. de Barbaro, W.K. Sakumoto, U. Rochester. We present preliminary results on measurements of primordial  $p_T$  in the nucleon for charged current events in  $\nu$ -N scattering. The data were collected in the CCFR iron-scintillator-calorimeter in the Fermilab Quadrupole Triplet Neutrino Beam with  $30 \leq E_\nu \leq 600$  GeV. Drift chambers with flash ADC readout, interleaved with the iron plates of the calorimeter, were used to reconstruct the hadron shower angle and energy. The reconstruction has been studied with momentum-analyzed hadron beams.

12:12

**B6 7** Photo-production of High  $p_T$  Jets. D. LINCOLN and the E683 Collaboration, Rice University, Ball State University, Fermilab, University of Maryland, University of Michigan, Vanderbilt University—Fermilab experiment E683 is designed to study high  $p_T$  jet production with a high energy photon beam. The QCD processes for high  $p_T$  jet photo-production are easier to calculate theoretically, and the jets produced are presumably cleaner than those in hadroproduction. E683 has just finished taking data from the most recent Fermilab Fixed Target Run. Preliminary results will be discussed.

12:24

**B6 8** The Inclusive Photon Spectrum from Proton-Antiproton Collisions at  $\sqrt{s} = 1.8$  TeV. C. A. LOOMIS, Duke Univ. for the E735 COLLABORATION—The E735 collaboration has measured the transverse momentum ( $p_T$ ) spectrum of inclusive photons with  $p_T < 5$  GeV. The goal was to look for photons produced by a quark-gluon plasma. The spectrum was measured with a NaI calorimeter which covered a solid angle of 75 msr at 90 degrees. The measured spectrum as well as the dependence of  $\langle p_T \rangle$  on charged-particle multiplicity will be presented. The results will be compared to several production models.

12:36

**B9 9** Spark Location in RF Cavities Q. KERNS, M. B. POPOVIC and C. KERNS, Fermilab\* — A spark detection system has been constructed at the test station for the Linac Upgrade at Fermilab. To locate sparks in RF Cavities we have placed five Ion Gauge Detectors along the accelerating module. The method used in detecting the spark location is based on the fact that sparks create pressure disturbances which travel throughout the cavity. Pressure signals from all five detectors are amplified using relatively fast amplifiers and then digitally recorded or monitored on the scope. The data recording is triggered by spark generation and data are recorded at a 15 Hz repetition rate. The system is also used to study different possibilities of preferential spark generation at the time least detrimental to the accelerator operations.

\* Operated by the Universities Research Association Inc., under contract with the U.S. Department of Energy.

12:48

**B6 10** Studies of Neural Networks for Quark-Gluon Separation in Jets from pp Annihilations M. DICKSON, (The CDF Collaboration\*), University of Rochester. — The use of neural networks as a method of quark/gluon jet separation has been investigated at CDF. Both Monte Carlo and real data taken at  $\sqrt{s} = 1.8$  TeV were used in the training and testing of networks derived using a back-propagation algorithm. The effect of this technique on the signal-to-noise ratio of the samples will be discussed.

\*Supported by the U.S. Department of Energy; the National Science Foundation; Istituto Nazionale di Fisica Nucleare, Italy; and Ministry Science, Culture and Education of Japan.

\* Supported by U.S. DOE under contract DE-AC02-76ER3085.

## MONDAY AFTERNOON

### SESSION C6: W AND Z

Monday afternoon, 20 April 1992

Room 16 at 14:30

C. Hargrove, presiding

14:30

**C6 1** Measurement of Weak Mixing Angle in Neutrino-Nucleon Scattering at Fermilab Experiment E770\* B.J. King, C. Arroyo, K. Bachmann, R. Blair, C. Foudas, W. Lefmann, W.C. Leung, S. Mishra, P. Quintas, S. Rabinowitz, F.J. Sciulli, W.G. Seligman, M. Shaevitz, Columbia U.; F.S. Merritt, M. Oreglia, H. Schellman, B. Schumm, U. Chicago; R.H. Bernstein, F. Borcharding, M. Lamm, W. Marsh, D. Yovanovich, FNAL; A. Bodek, H.S. Budd, P. de Barbaro, W.K. Sakumoto, U. Rochester; T. Kinne, P. Sandler, W.H. Smith, U. Wisconsin. — We report on a preliminary high-precision measurement of the weak mixing angle, determined from the ratio of charged-current to neutral-current deep-inelastic interactions in neutrino-nucleon scattering at the CCFR neutrino detector in the Fermilab quad-triplet neutrino beam. The approximately 100,000 neutral-current and 300,000 charged-current events after all cuts represents the highest statistics at the highest mean neutrino energy of any such data sample to date.

\* supported in part by DOE and NSF

16:18

C6 10  $Z\gamma$  Events at CDF.

M. Bellino (The CDF Collaboration<sup>\*</sup>), Tufts University<sup>†</sup> - The Standard Model involves no direct (*s*-channel) coupling between the  $Z^0$  and the *photon*. Yet if the  $Z$  is a composite particle, some theories suggest that  $Z\gamma$  events will deviate from the standard model predictions: giving, for example, higher event rates along with higher energy photons. This study describes a preliminary search of  $Z$  events for extra, isolated photons. These events are compared with the results expected from the standard (*t*-channel)  $Z\gamma$ -production mechanism and radiative  $Z$ -decay signal.

<sup>\*</sup>Supported by the U.S. Department of Energy; the National Science Foundation; Istituto Nazionale di Fisica Nucleare, Italy; and Ministry of Science, Culture and Education of Japan.

<sup>†</sup>Supported by DOE contract DE-AC0283ER40085

16:30

C6 11  $W\gamma$  and  $Z\gamma$  production from Events at CDF.\*

C. B. Luchini (The CDF Collaboration<sup>\*</sup>), University of Illinois<sup>†</sup> - We have studied the Di-Boson production of the  $Z^0\gamma$  and  $W^\pm\gamma$  vector bosons from  $p\bar{p}$  collisions at  $\sqrt{s} = 1.8$  TeV in the Fermilab TEVATRON. This analysis used the decay mode  $Z \rightarrow \mu\mu + \gamma$ ,  $W \rightarrow \nu_\mu\mu + \gamma$  where the muons were found in the central rapidity region ( $|\eta| < 1.0$ ) of the CDF detector.

<sup>\*</sup>Submitted by S. Errede.

<sup>\*</sup>Supported by the U.S. Department of Energy; the National Science Foundation; Istituto Nazionale di Fisica Nucleare, Italy; and Ministry of Science, Culture and Education of Japan.

<sup>†</sup>Supported by DOE contract DE-AC02-76ER01195.

16:42

C6 12 Angular Production Properties of  $W + \text{Jet}$  Events in  $p\bar{p}$  Collisions at  $\sqrt{s} = 1.8$  TeV R. DRUCKER, (The CDF

Collaboration<sup>\*</sup>), Lawrence Berkeley Laboratory<sup>†</sup> - We present preliminary results of a measurement of the scattering angle in  $W + \text{Jet}$  events in  $p\bar{p}$  collisions. The scattering angle ( $\theta^*$ ) is the angle between the  $W$  and the incoming proton beam in the center-of-mass frame of the  $W + \text{jet}$  system. The data are from collisions at  $\sqrt{s} = 1.8$  TeV, recorded with CDF. Both the electron and muon decay modes of the  $W$  are used. These events are produced in a regime in which perturbation theory is expected to be applicable to Quantum Chromodynamics. Comparisons with order  $\alpha_s$ , and (recently calculated) order  $\alpha_s^2$  predictions will be shown.

<sup>\*</sup>Supported by the U.S. Department of Energy; the National Science Foundation; Istituto Nazionale di Fisica Nucleare, Italy; and Ministry Science, Culture and Education of Japan.

<sup>†</sup>Supported by U.S. DOE under contract DE-AC03-76SF00098.

16:54

C6 13  $W - \text{jet}$  Background Estimates to  $W\gamma$  Events at CDF.

D. Benjamin (The CDF Collaboration<sup>\*</sup>), Tufts University<sup>†</sup> - The measurement of radiative  $W$ -production examines the gauge nature of the Standard Model  $WW\gamma$  vertex. A major background to  $W\gamma$  is  $W\text{jet}$  events, where the jet fragments into a leading and isolated  $\pi^0$ . This study uses CDF di-jet (1988-89) data to search for a third extra jet, and measure its fragmentation to isolated neutral pions. Isospin predicts a 2:1 ratio between charged and neutral pions in found in  $p\bar{p}$  collisions. So, as a further cross check, the fragmentation of isolated *charged* pions is measured using comparisons to test-beam  $\pi^+$  data.

<sup>\*</sup>Supported by the U.S. Department of Energy; the National Science Foundation; Istituto Nazionale di Fisica Nucleare, Italy; and Ministry of Science, Culture and Education of Japan.

<sup>†</sup>Supported by DOE contract DE-AC0283ER40085

17:06

C6 14 The Mean Charged Particle Multiplicity  $dN_{ch}/d\eta$  in Events with a  $W$  Boson S. EDNER, (The CDF Collaboration<sup>\*</sup>), University of Chicago<sup>†</sup> - The mean charged particle multiplicity per unit pseudorapidity,  $dN_{ch}/d\eta$ , is one of several quantities characterizing hadron production in  $p\bar{p}$  collisions. Using the data collected at  $\sqrt{s} = 1.8$  TeV by the CDF detector at Fermilab during the 1988-89 Tevatron Collider run, we have measured the ratio of  $dN_{ch}/d\eta$  in events associated with the production of  $W$  bosons to that in minimum bias events. We present our results and compare them to the predictions of several theoretical models.

<sup>\*</sup>Supported by the U.S. Department of Energy; the National Science Foundation; Istituto Nazionale di Fisica Nucleare, Italy; and Ministry of Science, Culture and Education of Japan.

<sup>†</sup>Supported by NSF Grant NSF-PHY-91-00690.

17:18

C6 15 Measurement of the Drell-Yan Cross Section at  $\sqrt{s} = 1.8$  TeV K. BLOOM, (The CDF Collaboration<sup>\*</sup>), University of Chicago<sup>†</sup> - The Drell-Yan process,  $q\bar{q} \rightarrow \gamma/Z^0 \rightarrow e^+e^-$ , is observed in  $p\bar{p}$  collisions using data taken with the Collider Detector at Fermilab (CDF) during the 1988-89 Tevatron Collider run. For electron pairs of low invariant mass,  $11 < M_{ee} < 30$  GeV, the cross section for this process is a probe of proton structure functions at low values of  $x$ . We present a measurement of the Drell-Yan cross section in this mass range, and a comparison with theoretical predictions.

<sup>\*</sup>Supported by the U.S. Department of Energy; the National Science Foundation; Istituto Nazionale di Fisica Nucleare, Italy; and Ministry Science, Culture and Education of Japan.

<sup>†</sup>Supported by NSF Grant NSF-PHY-91-00690.

## TUESDAY MORNING

9:36  
E6 9

Search for Beauty Production at  $\sqrt{s} = 21.7$  GeV.  
CHRIS L. DARLING, Yale University\* - Fermilab experiment E769 is a fixed target charm hadro-production experiment. Approximately 400 million transverse energy triggers were collected by E769 during the 1987-88 Fermilab fixed target run. Events were produced by a 250 GeV hadron beam incident on a target of 26 thin foils of Be, Al, Cu and W. A subset of this data is used in a search for high  $P_T$  electrons, from which a beauty production estimate is made. The result to be discussed is corrected for detector and trigger acceptances and comes from an analysis of the  $P_T$  distribution of electrons missing the primary vertex. The  $P_T$  distribution of electrons from charm, which is the main source of background to the beauty measurement, will also be discussed.

\* Representing the Fermilab E769 Collaboration.

9:48

E6 10 A Measurement of the b-Quark Cross Section using the Exclusive Decay  $B^0 \rightarrow J/\psi K^{*0}$  in  $\bar{p}p$  Collisions at  $\sqrt{s} = 1.8$  TeV  
S. VEJCIK, (The CDF Collaboration\*), The Johns Hopkins University<sup>†</sup>, - A measurement of the cross section for  $\bar{p}p \rightarrow bX$  from the exclusive decay  $B^0 \rightarrow J/\psi K^{*0}$  is reported. The data sample for this measurement was collected using the CDF detector at the Fermilab Tevatron Collider and contains the largest set of reconstructed neutral B mesons produced in  $\bar{p}p$  collisions to date. Comparisons are made to expected theoretical predictions for heavy quark production.

\*Supported by the U.S. Department of Energy; the National Science Foundation; Istituto Nazionale di Fisica Nucleare, Italy; and Ministry Science, Culture and Education of Japan.

<sup>†</sup> Supported by NSF Grant NSF-PHY-90-01887.

12:36

F4 6 Persistent Current Effects in Superconducting Accelerators.\*  
DAVID HERRUP, Fermilab.

Persistent currents in the superconducting cable in accelerator dipole magnets can have significant effects on the magnetic field quality. These currents create fields at all the harmonics allowed by the dipole symmetry, most notably the sextupole and decapole harmonics, and are most important at the injection energy. Observations indicate that the effects are time-dependent and also depend upon the magnet excitation history. Persistent current effects complicate considerably the operation and analysis of the accelerators. Both the Fermilab TEVATRON and HERA at DESY have dealt with these problems, and they are a major concern for future superconducting accelerators. I will discuss the problems introduced by persistent currents in the TEVATRON and HERA and the solutions that have been developed. I will also discuss these problems and possible solutions for future accelerators.

\* Operated by the Universities Research Association Inc., under contract with the U.S. Dept. of Energy.

13:00

F4 8 Emittances Control in Large Hadron Colliders.\*  
GERALD P. JACKSON, Fermilab.

Beginning at the moment of injection the beams in a hadron collider will evolve. The emittance delivered by the injector chain, diluted by steering and lattice mismatches at transfer, will determine the initial values of the longitudinal and transverse beam sizes. Mechanical, electrical, and seismic disturbances will try to dilute the emittances. Synchrotron radiation will provide limited damping in higher energy accelerators, whereas bunched beam stochastic cooling systems may provide substantial emittance control for all energy ranges. Predictions of the time dependence of the beam emittances, and hence the luminosity, are presented in this paper. Calculations and computer tracking simulations of the effectiveness of feedback systems to prevent emittance growth due to external excitations are described.

\*Operated by Universities Research Association Inc., under contract with the U.S. Department of Energy.

16:18

G2 4 Nucleon Structure Functions and Tests of QCD.  
SANJIB MISHRA, Harvard University.

16:54

G2 5 Formation of Charmonium States in  $p\bar{p}$  Annihilation.\*  
P. A. RAPIDIS, Fermi National Accelerator Laboratory.

We report results from Fermilab experiment<sup>1</sup> E760. We have studied charmonium states formed exclusively in the annihilation of medium energy antiprotons circulating in the Fermilab Antiproton Accumulator with the protons of an internal hydrogen gas jet target. The stochastically cooled beam of antiprotons has a very small momentum spread that allows for a center of mass r.m.s. resolution of  $\sim .25$  MeV/c<sup>2</sup>. We have measured the width of the  $\chi_1$ , the  $\chi_2$ , the  $\psi'$ , and the  $J/\psi$ . The branching ratio  $\chi_2 \rightarrow \gamma\gamma$  has been measured, and we have searched for the formation of the  $\eta_c$  and the  $\eta'_c$ . A search for the  $h_c(1P_1)$  in the mass region near the center of gravity of the  $\chi$  masses shows a signal in the  $J/\psi\pi^0$  channel.

\* Supported by the U.S. Department of Energy, the U.S. National Science Foundation, and the Italian Istituto Nazionale di Fisica Nucleare.

<sup>1</sup> E760 is a collaborative effort of Fermilab, U. di Ferrara, U. di Genova, U. C. at Irvine, Northwestern U., Penn State U., and U. di Torino.

3:36

12 2 Recent Charm Photoproduction Results from E687.\* \*\*  
J. WISS, University of Illinois.

INFN Bologna; University of California, Davis; University of Colorado; Fermilab; INFN Frascati; University of Illinois; INFN Milano; Northwestern University; of Notre Dame; INFN Pavia; Puerto Rico; University South Carolina.

Fermilab experiment E687, a high energy photoproduction experiment (average photon energy of 220 GeV), has reconstructed a large charm sample using a magnetic spectrometer with excellent vertexing, particle identification, and calorimetric capabilities. We will present new results on charm particle lifetimes, branching ratios, Dalitz amplitude analyses,  $D^*-\bar{D}^*$  mixing, charm particle semileptonic decays, and  $D^{**}$  spectroscopy.

\* Supported by the US DOE and NSF and by INFN

8:48

19 5 Studies of Coupled-Bunch and RF Cavity Modes in the Fermilab Booster. K. HARKAY, Purdue University, V. BHARADWAJ, P. COLESTOCK, and D. WILDMAN, Fermi National Accelerator Laboratory. \* --- A coupled-bunch instability has long been observed in the Fermilab Booster. The resulting longitudinal emittance growth is a major limit to beam brightness. Previous studies have indicated that the coupled-bunch oscillations are likely due to the influence of higher-order modes in the RF accelerating cavities. Out of 84 possible normal modes, spectral measurements indicate unstable growth of oscillations centered around modes 16 and 48. Calculations have been carried out of the linear growth rate for these modes based on detailed measurements of the cavity impedances using bench methods. The results are in qualitative agreement with the observations. Higher-order cavity mode dampers have been designed and installed. Experiments were performed to study the effects of the dampers and varying beam conditions, comparing the results with theoretical predictions.

\* Operated by the Universities Research Association under contract with the United States Department of Energy

9:00

19 6 Observation and Analysis of Parametric Coupling of Longitudinal Modes in the TEVATRON.\* P. L. COLESTOCK, G. P. JACKSON and L. KLAMP, Fermi National Accelerator Laboratory. Observations of coupling between longitudinal charge density modulation modes on a coasting beam have been made in the FERMILAB Tevatron. In these experiments, longitudinal modes are excited at a revolution harmonic ( $\omega_{\text{pump}}$ ) using an externally excited kicker. A beam response at neighboring revolution lines ( $\omega_{\text{beam}}$ ) below the pump frequency is observed, along with a set of low frequency lines, which follow the summation rule  $\omega_{\text{pump}} = \omega_{\text{low}} + \omega_{\text{beam}}$ . The coupling between revolution harmonics is observed to have a threshold which depends on both beam current and momentum spread. Moreover the coupling proceeds temporally from harmonics near the pump frequency to those further away in a cascade-like process. The qualitative structure of the response is consistent with a parametric, or three-wave, coupling phenomenon, which can be viewed as a scattering of the excited longitudinal charge density wave driven by low frequency oscillations at the first few longitudinal modes in the ring. The analysis of this phenomena in terms of weakly

9:12

19 7 Diagnosis and Cure of a Longitudinal Coupled Bunch Instability in the Tevatron. S. ASSADI, G. ANNALA, P. COLESTOCK, C. CRAWFORD, G. JACKSON, L. KLAMP, J. REID, D. WILDMAN, Fermi National Accelerator Laboratory. -- Using a realtime-response bunch length monitor, a slow extraction spill nonuniformity has been observed to be correlated with large and sudden growths of longitudinal emittance. We have identified the source of this emittance growth as a longitudinal coupled bunch instability using measurements of the beam current frequency spectrum. The character of the longitudinal impedance which caused this instability was defined by the facts that only one mode was excited and the coupled bunch mode frequency, nominally offset 2.1 MHz above and below harmonics of the RF frequency (53 MHz,  $h=1113$ ), moved over the course of months to other offset frequencies between 1.9 MHz and 2.2 MHz. In addition, the instability growth rate indicated a value for the impedance of approximately 100 k $\Omega$  at 53 MHz, corresponding to a dissipated power of 1 kW. Given these Q and power considerations, the 8 Tevatron RF cavities were considered to be prime suspects. This hypothesis was confirmed when a change of mode offset frequency was observed to occur at the time a power amplifier was replaced for one of the cavities. After further observations, a higher order cavity mode at 157 MHz was found to be the source of the impedance. Details of these measurements will be presented along with some means of suppression. † Operated by the Universities Research Association under contract with the U.S. Department of Energy.

**SESSION M9: LOW-ENERGY AND SPECIAL PURPOSE  
ACCELERATORS**

Thursday morning, April 23 1992

Room 3 at 8:00

E. Forest, presiding

9:00

**M9 6** An Improved Transitionless Lattice for the Main Injector  
D. TRBOJEVIC and K.Y. NG, Fermi National Accelerator  
Laboratory\* - The Fermilab Main Injector, 150 GeV accelerator,  
should be an injector for protons and antiprotons to the existing  
Tevatron. High energy accelerators are often confronted with the  
problem of having to cross transition energy during acceleration,  
due to relativistic beam energies. The design method for the lat-  
tice without transition was initially presented at the APS meeting  
in Washington 1990. A new lattice for the Main Injector without  
transition is presented. The main properties of this lattice are that  
the  $\gamma_t$  is an imaginary number, the fact that maxima of the dis-  
persion function are small, and the presence of two long-straight  
sections with zero dispersion. In addition, the latest design pro-  
vides a compaction factor of the ring very comparable to the usual  
FODO cell design.

\* Operated by the Universities Research Association Inc., under  
contract with the U.S. Dept. of Energy.

10:00

**M9 11** Design Concepts for a Particle Medical Facility  
C. ANKENBRANDT, T. KROC, A. LENNOX, L. MICHELOTTI,  
S. PEGGS, and C. SCHMIDT, Fermilab\*-- We have  
recently begun to design a new medical facility  
centered on a rapid-cycling proton synchrotron for  
radiation therapy. Design concepts for the accelerator  
and for the beam delivery systems will be described.  
The design calls for an injector which can also produce  
neutrons for boron neutron capture therapy and  
positron emitters for PET scanning.

\*Operated by the Universities Research Association,  
Inc. under contract with the U.S. Department of  
Energy.

**THURSDAY MORNING**

**SESSION N6: PARTICLE DETECTORS**

Thursday morning, 23 April 1992

Room 16 at 11:00

P. Fisher, presiding

11:12

**N6 2** Performance Studies of the DØ Inter Cryostat Detector.  
T. L. GELD, U. Michigan, for the DØ Collaboration. — The Inter  
Cryostat Detector (ICD) was designed to improve the energy resolu-  
tion in the transition region between the central and end calorimeters  
in DØ. The ICD consists of plastic scintillator tiles with a wave-  
length shifting fiber readout system to take the light to a 0.5 inch  
photomultiplier tube. It provides a single layer of energy sampling  
covering a pseudorapidity range of  $0.8 < \eta < 1.4$ , with a segmenta-  
tion of  $0.1\phi \times 0.1\eta$ . The recent DØ Test Beam run focused on this  
transition region between the calorimeters. Modules from the central  
calorimeter and from the end calorimeter were placed in a single cryo-  
stat filled with liquid argon (LAr). The cryostat walls were simulated  
by steel walls and placed between the modules. The ICD, situated  
between the cryostat walls in DØ, had to be placed in LAr in the  
Test Beam cryostat. The modifications necessary to use scintillator  
in LAr will be discussed. Preliminary results from the Test Beam  
showing the improvement in the calorimeter energy resolution due to  
the ICD will be presented.

11:24

**N6 3** The Liquid Argon Calorimeters for the DØ Experiment.  
T.C. HEURING, SUNY Stony Brook, for the DØ Collaboration. —  
The calorimeters for the DØ Detector consist of three large liquid ar-  
gon dewars with uranium/stainless steel/copper absorber plates. The  
devices cover a rapidity range of  $|\eta| < 4.1$  and are finely segmented in  
 $\eta$ ,  $\phi$ , and depth. The thickness of the calorimeters varies between 7  
and 10 nuclear absorption lengths. The calorimeters are critical com-  
ponents for the DØ trigger and the analyses of multi-particle final  
state transverse energy. Electron energy resolution, linearity, trans-  
verse and longitudinal shower profiles, and position resolution of the  
detector as well as a comparison to Monte Carlo generated data will  
be discussed.

**SESSION Q6: CHARM PRODUCTION**

Friday morning, 24 April 1992

Room 16 at 8:00

C. Boswell, presiding

8:00

**Q6 1** J/ψ Photoproduction at Fermilab E687. <sup>a</sup> B. O'REILLY, Northwestern University (for the E687 Collaboration.) <sup>b</sup> - Cross section measurements from Fermilab experiment E687 of J/ψ photoproduction at incident photon energies up to 400 GeV are compared to results from previous experiments. Measurements of the energy and t dependence of the cross section are presented.

<sup>a</sup>Supported by U.S. DOE and NSF and by INFN<sup>b</sup>INFN Bologna; University of California, Davis; University of Colorado; Fermilab; INFN Frascati; University of Illinois; INFN Milano; Northwestern University; University of Notre Dame, INFN Pavia; University of Puerto Rico.

8:12

**Q6 2** J/ψ Cross Section A. ETCHEGOYEN, T. FUESS, V. PAPPADIMITRIOU, (The CDF Collaboration\*), Fermi National Accelerator Laboratory<sup>†</sup>, - The J/ψ cross section as a function of p<sub>T</sub>, in the p<sub>T</sub> range 6-14 GeV/c<sup>2</sup>, is obtained using a dimuon data sample of luminosity ≈ 2.6 ± 0.2 pb<sup>-1</sup> taken with Collider Detector at Fermilab. The b quark cross section can be obtained from the J/ψ cross section. Work on the ψ' cross section is in progress.

\*Supported by the U.S. Department of Energy; the National Science Foundation; Istituto Nazionale di Fisica Nucleare, Italy; and Ministry of Science, Culture and Education of Japan.

<sup>†</sup> Supported by U.S. DOE Contract DE-AC02-CH03000.

8:24

**Q6 3** χ<sub>c</sub> Production in pp Collisions at √s = 1.8 TeV C. BOSWELL, (The CDF Collaboration\*), The Johns Hopkins University<sup>†</sup>, - Using the dimuon decay mode of the J/ψ, and γ identification from calorimeter information to reconstruct χ<sub>c</sub> → J/ψ γ, a measurement of the ratio of cross sections times branching fractions for pp → χ<sub>c</sub> X → J/ψ γ X and pp → J/ψ X is obtained. The cross sections and relative production of pp → χ<sub>c</sub> X → J/ψ X and pp → b X → J/ψ X are discussed. The data for this measurement in 1.8 TeV pp collisions at the Fermilab Tevatron Collider were collected using the CDF detector.

\*Supported by the U.S. Department of Energy; the National Science Foundation; Istituto Nazionale di Fisica Nucleare, Italy; and Ministry of Science, Culture and Education of Japan.

<sup>†</sup> Supported by NSF Grant NSF-PHY-90-01887.

8:36

**Q6 4** Inclusive Hadronic Production of χ<sub>c</sub> Mesons. L. DAUWE, C. THOMA (U. of Michigan at Flint); R. LI, R. CRITTENDEN, A. DZIERBA, A. GRIBUSHIN, S. KARTIK, T. MARSHALL, J. MARTIN, P. SMITH, T. SULANKE, A. ZIEMINSKI (Indiana U.); V. ABRA-MOV, Yu. ANTIPOV, B. BALDIN, S. DENISOV, A. DYSHKANT, V. GLEBOV, V. KORESHEV, A. KRIN-ITSYN, A. PETRUKHIN, V. SIROTENKO, R. SUL-YAEV (IHEP, Serpukhov); J. KRIDER (Fermilab); H. GOLDBERG, R. JESIK, S. MARGULIES, H. MENDEZ, J. SOLOMON (U. of Illinois at Chicago); C. DAVIS (U. of Louisville).— We report recent results on χ<sub>c</sub> meson production observed in the mode χ<sub>c</sub> → J/ψ + γ, with π<sup>-</sup> beam of 530 GeV/c incident on beryllium and copper targets. The fraction of J/ψ's produced via the χ<sub>c</sub> states as well as the relative yield of the production of χ<sub>c1</sub> and χ<sub>c2</sub> were measured and compared with QCD predictions.

\* Work supported by grants from NSF and DOE.

9:00

**Q6 5** Production Distributions of Proton-Produced D<sup>±</sup>. STEPHEN F. TAKACH\*, Yale University - The goal of fixed target experiment Fermilab E769 is to study charm hadroproduction. Using a 260 GeV/c hadron beam impinging on a multifoil target, E769 collected approximately 400M transverse energy triggers in the 1987-1988 fixed target run. This data set consists of roughly 240M triggers of positive beam data and 160M triggers of negative. Upstream of its multifoil target, the experiment used a differential Čerenkov counter and a transition radiation detector to identify beam particles. With this beam identification system and its downstream silicon microstrip detector, E769 is well-suited to study the beam dependence of charm production. From the positive beam data set, we extract the Feynman-x (x<sub>F</sub>) and transverse momentum (p<sub>T</sub><sup>2</sup>) distributions for the proton-produced D<sup>±</sup> sample.

\* Representing the Fermilab E769 Collaboration.

9:12

**Q6 7** Progress Report on Fermilab Experiment 687 Photoproduction of states containing heavy quarks\*,\*\* E68' COLLABORATION - INFN Bologna; University of California Davis; University of Colorado; Fermilab; University of Illinois INFN Frascati; INFN Milano; INFN Pavia; Northern Kentucky University; Northwestern University; University of North Carolina, Asheville; University of Notre Dame; University of Puerto Rico; Seoul National University; University of South Carolina; University of Tennessee; Vanderbilt University;— Fermilab Experiment 687 has recorded a very large number of hadronic interactions from photons with a mean energy of 250 GeV. From this sample, we have extracted large signals for charged and neutral D-mesons; charmed-strange mesons, and charmed baryons. With these signals, we have obtained high precision measurements of lifetimes, searched for rare decay modes and new states, studied in detail the decay properties of these particles, and explored the dynamics of charm photoproduction.

\*Supported by US DOE and NSF and by INFN

\*\*Submitted by J. Butler and J. Cumalat

9:24

**Q6 8** Observation of Excited Charmed Mesons\* S. Shukla for E68' COLLABORATION - University of Colorado; Fermilab University of Illinois; INFN Bologna; INFN Frascati; INFN Milano; INFN Pavia; Northwestern University; University of Notre Dame; University of Puerto Rico.—Observation of excited charmed mesons decaying to D<sup>++</sup> and π<sup>-</sup> is reported. The fraction of D<sup>+</sup> arising from the decay of these states is presented.

\*Supported by US DOE and NSF and by INFN

9:48

**Q6 10** Search for the charmonium state <sup>1</sup>P<sub>1</sub> (h<sub>c</sub>) through the decay channels J/ψπ<sup>+</sup>π<sup>-</sup> and η<sub>c</sub>γ. K. E. GOLLWITZER for the E760 Collaboration (Irvine - Fermilab - Ferrara - Genova - Northwestern - Penn State - Torino) — Fermilab experiment 760 uses p $\bar{p}$  annihilations to search for and study narrow charmonium bound states. We report results of a search for the charmonium <sup>1</sup>P<sub>1</sub> state through both hadronic and radiative decay channels. Presented are the results of the analyses searching for J/ψπ<sup>+</sup>π<sup>-</sup> (J/ψ → e<sup>+</sup>e<sup>-</sup>) and η<sub>c</sub>γ (η<sub>c</sub> → γγ).

10:00

**Q6 11** Search for the <sup>1</sup>P<sub>1</sub>(h<sub>c</sub>) in p $\bar{p}$  → J/ψ + π<sup>0</sup>. J. L. MARQUES for the E760 Collaboration (Irvine - Fermilab - Ferrara - Genova - Northwestern - Penn State - Torino) — We report results from Fermilab Experiment 760 which studies Charmonium states produced in p $\bar{p}$  annihilations. During the 1991 running period E760 conducted a search for the charmonium singlet P state. We present our results for the reaction: <sup>1</sup>P<sub>1</sub> → J/ψ + π<sup>0</sup> → e<sup>+</sup> + e<sup>-</sup> + γ + γ.

10:12

Q8 12

Search for the  $\eta_c$ . M. MASUZAWA for the E760 Collaboration (Northwestern - Fermilab - Ferrara - Genova - U.C. Irvine - Penn State - Torino) — The E760 experiment at Fermilab, which is designed to study resonant charmonium formation in  $p\bar{p}$  annihilations, has searched for the  $\eta_c$  resonance at two energy regions ( $E_{cm} = 3.59$  GeV and  $E_{cm} = 3.62$  GeV). We report the results of the measurement  $\eta_c \rightarrow 2\gamma$  and  $\eta_c \rightarrow$  other neutral channels such as  $\eta\pi^0\pi^0$ .

SESSION R6: CHARM DECAYS

Friday morning, 24 April 1992

Room 16 at 11:00

J. Krizmanic, presiding

11:12

R6 2 Cabibbo Suppressed Decays of Charm Mesons. P. D. SHELDON for the E687 COLLABORATION (INFN Bologna; University of California, Davis; University of Colorado; Fermilab; INFN Frascati; University of Illinois; INFN Milano; Northwestern University; University of Notre Dame; INFN Pavia; Puerto Rico; University of South Carolina; Vanderbilt University) -- Results from studies of Cabibbo suppressed and doubly Cabibbo suppressed decays of charm mesons are presented. The data was collected in the FNAL wideband photon beam by the heavy flavor photoproduction experiment E687.

R2 4 Present Status of the SSC.\*  
G. DUGAN, SSC Laboratory.

The present state of the SSC project will be described. The discussion will include a report on the current state of the design of the injector and collider accelerators. The status and current plans for the project's civil construction (with an emphasis on the collider tunnel and associated facilities) will be reviewed. An update on the superconducting magnet program (with an emphasis on the collider dipole magnet development) will be presented. A report on the status of the development of key accelerator components for the collider and injectors will be included. Finally, the status of preparations for the surface string test at the SSC site will be discussed.

\* Supported by the Department of Energy under contract DE-AC35-89ER40486

11:36

R6 4

Preliminary analysis on the  $D^0 \rightarrow K^-\mu^+\nu$  decay channel.\* D Hazan for E687 COLLABORATION - INFN Bologna; University of Colorado; Fermilab; University of Illinois; INFN Frascati; INFN Milano; INFN Pavia; Northwestern University; University of Notre Dame; University of Puerto Rico --We present a preliminary analysis of the decay  $D^0 \rightarrow K^-\mu^+\nu$  from Fermilab photoproduction experiment E687. High resolution vertex informations and  $D^*$  tag are used to reconstruct the missing neutrino momentum.

\*Supported by US DOE and NSF and by INFN

11:48

R6 5  $D^0 \rightarrow K_s$  Decays in 280 GeV/c Hadroproduction. D. PASSMORE\*, Tufts University. - We analyze data from Fermilab E769. Four hundred million interactions in a segmented target were reconstructed using a two magnet spectrometer with silicon microstrip vertexing, proportional wire chamber and drift chamber tracking, electron and hadron calorimetry and Čerenkov identification. A sample of events having both a  $K_s$  candidate and a short-range secondary vertex was examined. Selections were made to isolate and study the decays  $D^0 \rightarrow K^{*0}(892) + \pi^\pm$  and  $D^0 \rightarrow K_s + \pi^+\pi^-$ .

\* Representing the Fermilab E769 Collaboration

R6 6 Branching Ratio Measurements for  $D_s$  and  $D_s^*$  Decaying to  $K^+K^-\pi^0$  Final States.\*\* M.E. ZANABRIA, University of Notre Dame for the E687 Collaboration - INFN Bologna; University of Colorado; Fermilab; INFN Frascati; University of Illinois; INFN Milano; Northwestern University; University of Notre Dame; INFN Pavia; Puerto Rico. --- We present recent results from Fermilab E687 for amplitude analyses of the  $K^+K^-\pi^0$  decays of the  $D_s$  and  $D_s^*$  mesons. Interference effects, background and efficiency corrections are included in the measurement of the relative branching ratios for the  $D_s$  and  $D_s^*$  decaying to  $K^{*0}(892)K^+$  and  $K\bar{K}\pi$  (non-resonant) relative to the  $\phi\pi$  final state.

\*Supported by U.S. DOE and NSF and by INFN

\*\*Submitted by W.D. Shephard

12:12

R6 7

Amplitude analysis of the resonant substructures in the decay  $D_s \rightarrow K\bar{K}\pi^0$ .\*\* S. Malvezzi for the E687 COLLABORATION INFN Bologna; University of Colorado; Fermilab; University of Illinois; INFN Frascati; INFN Milano; INFN Pavia; Northwestern University; University of Notre Dame; University of Puerto Rico; Mayaguez -- The resonant substructures of the decay  $D_s \rightarrow K\bar{K}\pi^0$  are analyzed using the helicity formalism. The partial amplitude in  $\phi\pi$ ,  $K^{*0}K$  and Non-Resonant  $K\bar{K}\pi$  final states and their relative phases are presented.

\*Supported by US DOE and NSF and by INFN

\*\*Submitted by J. Butler

12:48

R6 10 Measurement of the  $J/\psi$  and  $\psi'$  widths. C. M. GINSBURG for the E760 Collaboration (Northwestern - Fermilab - Ferrara - Genova - Irvine - Penn State - Torino) — Fermilab Experiment 760 has been designed to do high-resolution charmonium spectroscopy in  $p\bar{p}$  annihilation. In earlier  $e^+e^-$  annihilation experiments, the best mass resolution obtained was FWHM  $\sim 5$  MeV; and total widths of  $\psi$  and  $\psi'$  resonances were obtained by measuring areas of resonances in the excitation curves for the  $e^+e^-$ ,  $\mu^+\mu^-$ , and hadronic decay channels. In the E760 experiment, the mass resolution due to beam width is FWHM = 400-600 keV, which permits direct measurements of  $\psi$  and  $\psi'$  widths. A special scanning technique ("Double Scan") has been developed, by which the momentum spread of the beam is determined precisely; and the total widths are obtained by analyzing the resonance shapes.

13:00

R6 11 Measurement of some exclusive decays of the  $\psi'$ . J. ZHAO for the E760 Collaboration (Northwestern - Fermilab - Ferrara - Genova - U. C. Irvine - Penn State - Torino) — Experiment E-760 at Fermilab, a study of charmonium produced in  $p\bar{p}$  annihilations, performed an energy scan of the  $\psi'$  in 1991 and a total of  $1 pb^{-1}$  of data were collected. We report results of the partial width of some exclusive decay channels containing  $J/\psi$ , such as  $\psi' \rightarrow J/\psi\eta$ .

13:12

R6 12 Angular Distribution in Radiative Decays of Charmonium  $\chi$  States. A. M. MAJEWSKA for the E760 Collaboration (Penn State - Fermilab - Ferrara - Genova - Irvine - Northwestern - Torino) — The E760 experiment at Fermilab is studying charmonium states formed in  $p\bar{p}$  annihilations. We have collected a large sample of radiative decays  $\chi_{1,2} \rightarrow J/\psi \gamma \rightarrow e^+e^-\gamma$  (approximately 500  $\chi_1$  and 3000  $\chi_2$  decays). From the angular distributions in these decays one can determine helicity amplitudes in the  $\chi$  formation process and the multipole structure of its radiative decay. Results of the angular distribution analysis will be presented. The accuracy of our measurement for  $\chi_2$  is the world's best so far. Our results will be compared with previous experiments<sup>1</sup> and with theoretical expectations<sup>2</sup>.

1) M. Oreglia et al., Phys. Rev. D 25 (1982) 2259;

C. Baglin et al., Phys. Lett. B 195 (1987) 85.

2) M.G. Olsson, C.J. Suchyta III, Phys. Rev. D 34 (1986) 2043;

K.J. Sebastian, H. Grotch, F.L. Ridener, (to be published).

13:24

R6 13 Measurement of the  $\gamma\gamma$  Decays of Charmonium J. E. FAST for the E760 Collaboration (U. C. Irvine - Fermilab - Ferrara - Genova - Northwestern - Penn State - Torino) — We report results from experiment E-760 at Fermilab, a study of charmonium produced in  $p\bar{p}$  annihilations. The two photon final state of the  $\chi_1, \eta_c$  and  $\eta_c'$  resonances have been studied. The partial width  $\Gamma(\chi_1 \rightarrow \gamma\gamma)$  has been measured and an upper limit placed on the product of the branching ratios,  $BR(\eta_c, \eta_c' \rightarrow p\bar{p})BR(\eta_c, \eta_c' \rightarrow \gamma\gamma)$ , for the  $^1S_0$  states.