ANL-HEP-TR-02-067

HIGH ENERGY PHYSICS DIVISION SEMIANNUAL REPORT OF RESEARCH ACTIVITIES

July 1, 2001 – December 31, 2001

ARGONNE NATIONAL LABORATORY

Argonne, Illinois

Operated by THE UNIVERSITY OF CHICAGO for the

U.S. DEPARTMENT OF ENERGY

under Contract W-31-109-Eng-38

Argonne National Laboratory, with facilities in the states of Illinois and Idaho, is owned by the United States government, and operated by The University of Chicago under the provisions of a contract with the Department of Energy.

Available electronically at http://www.doe.gov/bridge

Available for a processing fee to U.S. Department of Energy and its contractors, in paper, from:

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
phone: (865) 576-8401
fax: (865) 576-5728
email: reports@adonis.osti.gov

ANL-HEP-TR-02-067

Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

HIGH ENERGY PHYSICS DIVISION
SEMIANNUAL REPORT OF
RESEARCH ACTIVITIES

July 1, 2001 - December 31, 2001

Prepared from information gathered and edited by
The Committee for Publications and Information:

Members: P. Malhotra
J. Norem
R. Rezmer
R. Wagner

July 2001

Abstract

This report describes the research conducted in the High Energy Physics Division of Argonne National Laboratory during the period of July 1, 2001 through December 31, 2001. Topics covered here include experimental and theoretical particle physics, advanced accelerator physics, detector development, and experimental facilities research. Lists of Division publications and colloquia are included.

Table of Contents

I. EXPERIMENTAL RESEARCH PROGRAM

I.A. EXPERIMENTS WITH DATA

I.A.1. Medium Energy Polarization Program

During the period July - December, 2001, a number of papers were published with authors from the spin group, and preparations were made for the upcoming polarized proton run at RHIC. Extensive work on construction of a shower maximum detector for the STAR endcap electromagnetic calorimeter is described in another section of this report.

The final experimental paper from the Saclay nucleon-nucleon elastic scattering program was published (C. Allgower et al., Phys. Rev. C64, 034003 (2001)). This paper was written by an ANL physicist, and the results are shown in a previous semiannual report. This paper probably completes the program, though an additional article may still be written by a Saclay collaborator on interpretation of some of the data.

The final paper on Brookhaven experiment E925 was submitted for publication in Phys. Rev. D. ANL physicists were the primary authors. Inclusive $\pi^{\pm}$ and proton analyzing powers were measured by scattering polarized protons off solid carbon and liquid hydrogen targets at 22 GeV/c. This is close to the extraction momentum (24 GeV/c) from the AGS to RHIC. Sizeable $\pi^{\pm}$ asymmetries were observed, suggesting that this process can be used for high energy proton beam polarimeters. Knowledge of beam polarization in RHIC is also presently tied to E925, through an absolute pp elastic scattering polarimeter that was part of the E925 apparatus.

There were five papers published on STAR results. Two deal with particle correlations: "Pion Interferometry of $\sqrt{S_{NN}}$ = 130 GeV Au + Au Collisions in RHIC," (C. Adler et al., Phys. Rev. Lett. 87, 082301 (2001)) and "Identified Particle Elliptic Flow in Au + Au Collisions at $\sqrt{S_{NN}}$ = 130 GeV," (C. Adler et al., Phys. Rev. Lett. 87, 182301 (2001)). For the first paper, correlations of the 3-momenta of pairs of outgoing, like-sign, charged pions were measured via a Hanbury Brown-Twiss (HBT) interferometry technique. No sudden jumps in the HBT parameters are observed with energy, although there is a sizeable gap between the older data and the RHIC results. The measurements suggest that the source of pion emission is more rapidly expanding at RHIC than at lower energies. The second paper describes a measure of the azimuthal anisotropy of the transverse momentum p_T distribution, the elliptic flow parameter v_2. It was found that v_2 differs significantly for charged pions, kaons, and protons+antiprotons as a function of p_T and centrality of the collision. Comparison of both results are made to various hydrodynamical model predictions of heavy ion collisions.

Three other papers report yields and spectra for various particles. Unidentified negative hadron yields are reported in "Multiplicity Distribution and Spectra of Negatively Charged Hadrons in Au + Au Collisions at $\sqrt{S_{NN}}$ = 130 GeV," (C. Adler et al., Phys. Rev. Lett. 87, 112303 (2001)). About 300 antideuteron and 14 anti-^{3}He events are reported in "Antideuteron and Anti-^{3}He Production in $\sqrt{S_{NN}}$ = 130 GeV Au + Au Collisions," (C. Adler et al., Phys. Rev. Lett. 87, 262301 (2001)). The antideuteron yields are ~50 times larger than at $\sqrt{S_{NN}}$ = 17 GeV from the CERN SPS data, but suggest little or no increase in antinucleon freeze-out volume. The anti-^{3}He are found to be produced from a smaller volume than the antideuterons, and also to have a large enhancement in production rate. Antiproton production is studied in "Measurement of Inclusive Antiprotons from Au + Au Collisions at $\sqrt{S_{NN}}$ = 130 GeV," (C. Adler et al., Phys. Rev. Lett. 87, 262302 (2001)). Fig. 1 shows the invariant yield of inclusive antiprotons as a function of transverse mass at midrapidity (|y| < 0.1) for various centrality bins. These distributions for the most central events are significantly flatter

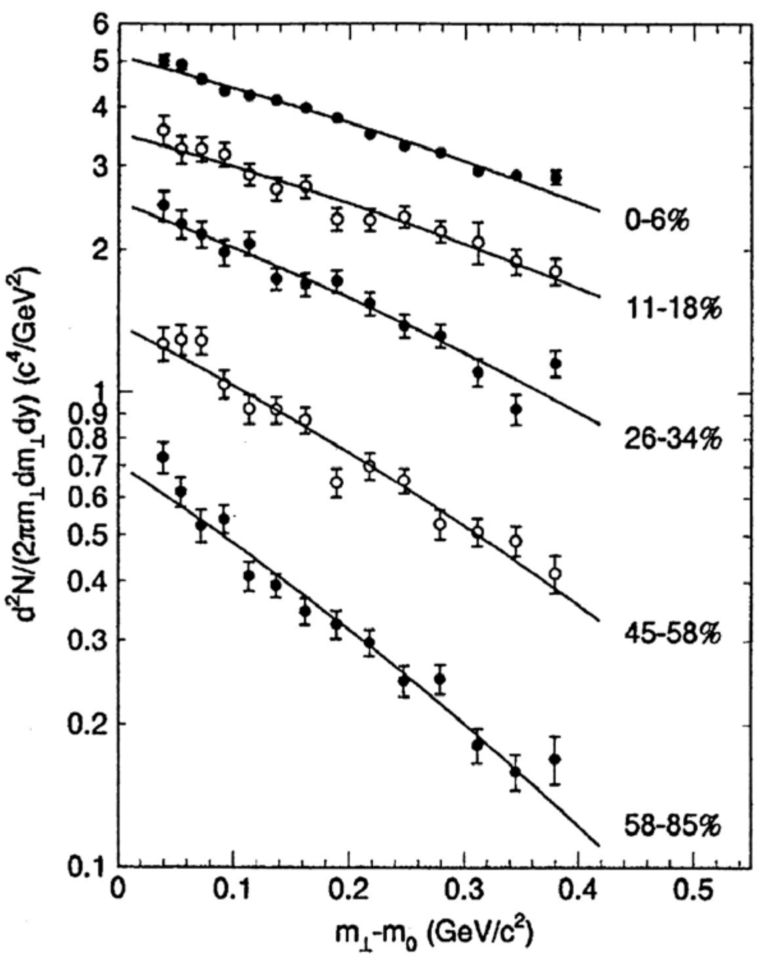


Figure 1. Transverse mass distributions of inclusive antiproton invariant yield at midrapidity. The errors shown are statistical only. The solid lines are fits to the distributions with Gaussians in p_T.

than in Pb + Pb collisions at the SPS. Extrapolating the yields to all p_T, it is estimated that there are 9.5 +/- 1.0 antiprotons produced per unit rapidity at RHIC.

Two papers were published from Crystal Ball experiments at the AGS. The process $\pi^- p \rightarrow n\eta^\circ \rightarrow n3\pi^\circ \rightarrow n6\gamma$ was studied in "Determination of the Quadratic Slope Parameter in $\eta \rightarrow 3\pi^\circ$ Decay," (W.B. Tippens et al., Phys. Rev. Lett. 87, 192001 (2001)). When the total kinetic energy of the final state particles is small (in the η° frame), the decay amplitude, A, can be expanded as $|A|^2 \sim 1 + 2\ \alpha\ z$, with z the distance from the center of the Dalitz plot (0 <= z <= 1), and α the quadratic slope parameter. The result is α = -0.031 +/- 0.004, consistent with the previous world average of α = -0.039 +/- 0.015, but considerably larger in magnitude than Chiral perturbation theory predictions. ANL physicists assisted this analysis by evaluating a contribution to the systematic error on α.

The second Crystal Ball paper was "Measurement of $K^- p \rightarrow \eta\Lambda$ Near Threshold," (A. Starostin et al., Phys. Rev. C64, 055205 (2001)). Differential cross sections at fifteen momenta between 724 and 770 MeV/c and Lambda polarizations near 735 and 765 MeV/c were measured; see Figs. 2, 3, and 4. The angular dependence near threshold (722 MeV/c) is consistent with s-wave production dominance. Well above threshold, the shape indicates a small d-wave component, perhaps from the excitation of Lambda*(1690) 3/2-. These data are a considerable improvement over earlier results. A paper is being prepared on the interpretation of these measurements.

During most of this six month period, STAR was running with Au + Au collisions at the design energy, $\sqrt{S_{NN}}$ = 200 GeV per nucleon pair. Polarized proton studies began in the AGS in November; these alternated with periods of heavy ion acceleration to fill RHIC. ANL physicists were responsible for checking out the AGS polarimeter and operating it during polarized proton tests. Six new scintillation counters were built at ANL and added to the AGS polarimeter in the forward direction to allow forward-recoil coincidences and to reject inelastic backgrounds at low momenta. These counters permitted measurements for an absolute calibration of the polarimeter at P_lab ~ 3.8 GeV/c. The results suggested little depolarization between the ion source and this momentum. Polarized proton collisions in RHIC began in mid December.

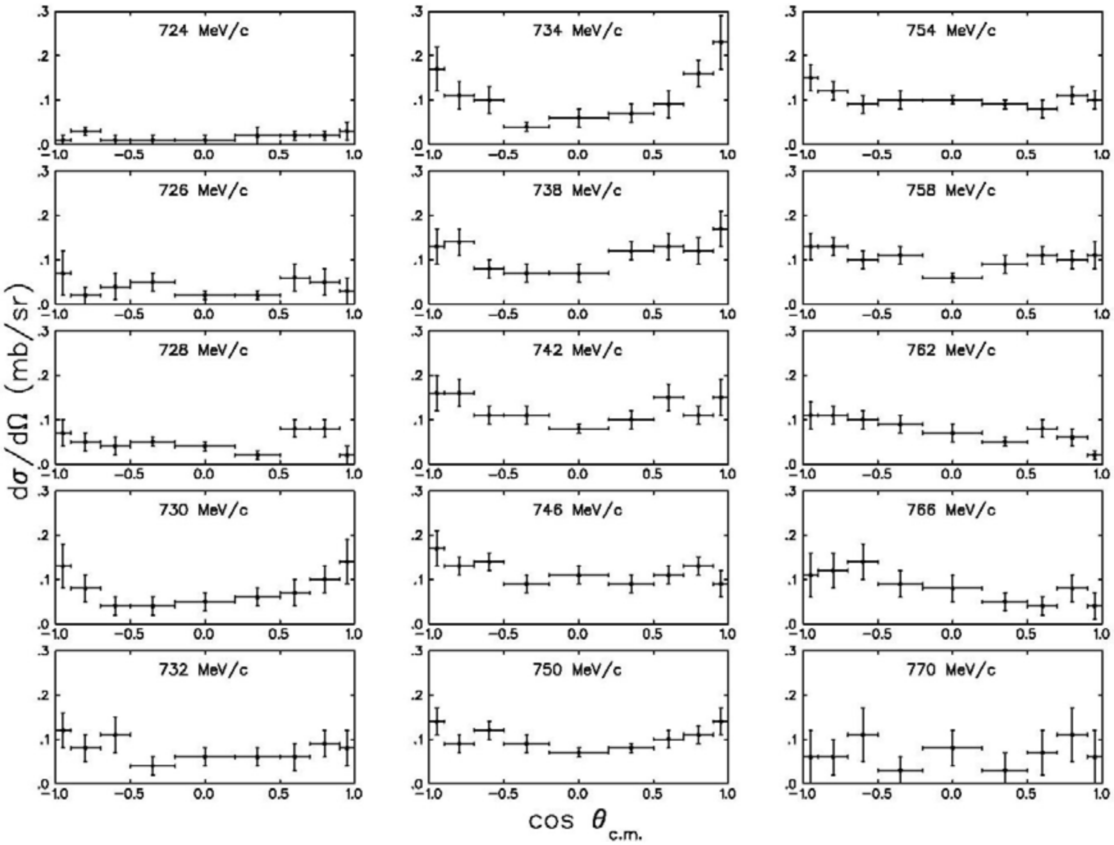


Figure 2. Differential cross sections for the $K^- p \rightarrow \eta^\circ \Lambda^\circ$ reaction from Crystal Ball data at the AGS.

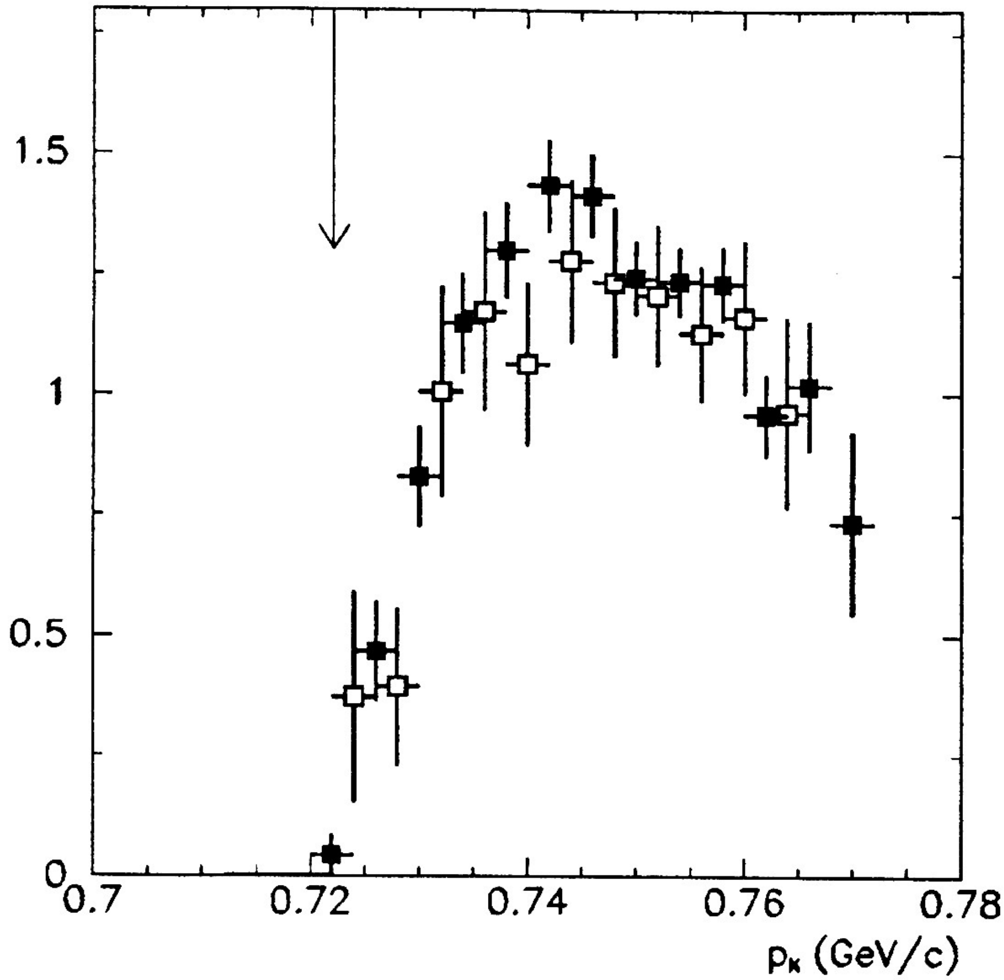


Figure 3. Total cross sections for the $K^- p \rightarrow \eta^\circ \Lambda^\circ$ reaction as a function of kaon momentum from Crystal Ball measurements. The solid squares are from the $\eta^\circ \rightarrow \gamma\gamma$ decay, and the open squares are from the $\eta^\circ \rightarrow 3\pi^\circ$ decay. The arrow indicates the threshold for this reaction.

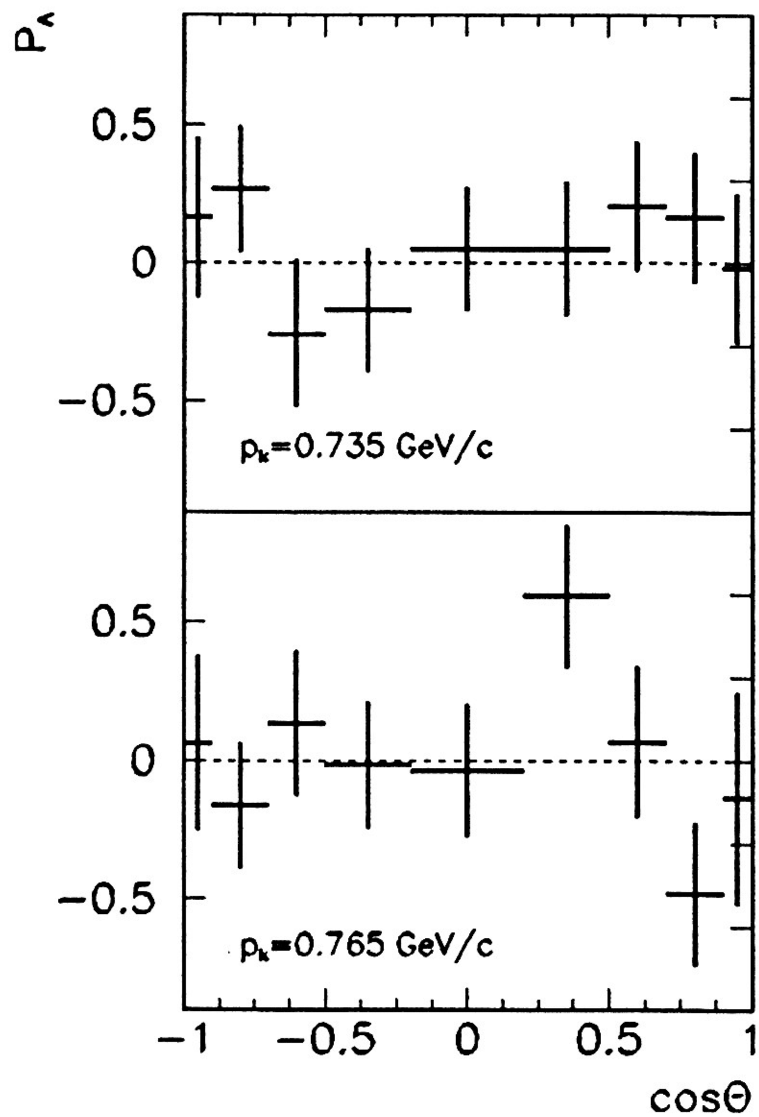


Figure 4. The Λ° polarization for the $K^{-}p \rightarrow \eta^{\circ}\Lambda^{\circ}$ reaction as a function of angle. The results were from data summed in the two K- momentum bins of 720 - 750 and 750 - 770 MeV/c.

(H.Spinka)

I.A.2 Collider Detector at Fermilab

a) Physics Results

The emphasis of the collaboration has largely shifted to getting Run 2 going. Some Run 1 analyses remain to be completed and submitted for publication. Will Bell completed his thesis analysis limit on the branching fraction for $B_s \rightarrow \psi\eta'$ and went off and got a job. Bob Blair continued as QCD physics convener, where a few analyses remain pending. Steve Kuhlmann with students submitted the photon muon and inclusive photon analysis and the inclusive photon analyses for publication.

As the higher than predicted cross section for B production has stirred some new interpretations, Tom LeCompte completed his b cross section analysis using displaced vertex muons with the 630 and 1800 GeV data. At 1800 his analysis agrees well with our many other measurements, and at 630 it is compatible with the UA1 results as seen in Figure 1. The ratio of cross sections seems well predicted as seen in Figure 2.

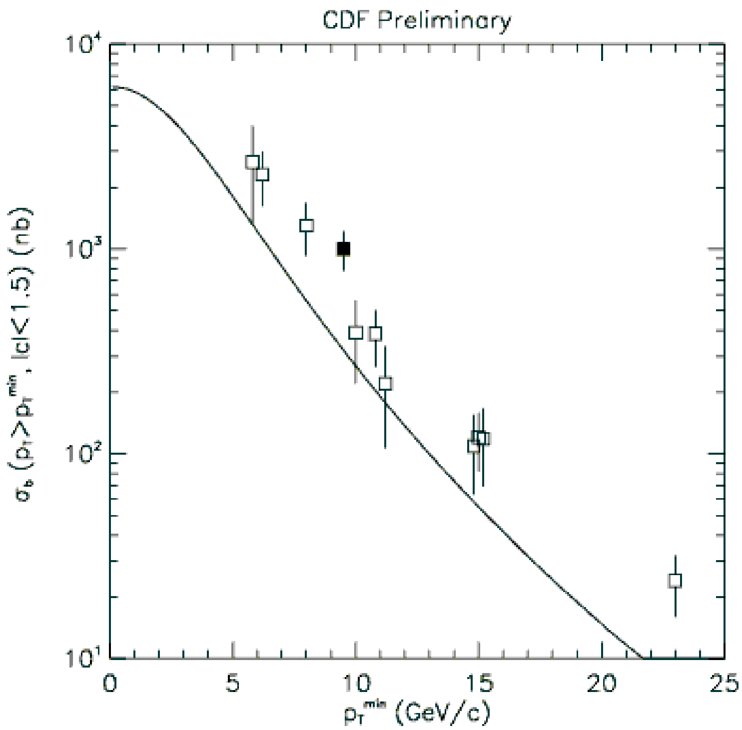


Figure 1. B cross section at 630 GeV as a function of minimum p_T, the solid point is CDF and the rest are UA1.

Several papers which we have been involved with reached publication, including the W mass (Larry Nodulman and Barry Wicklund) and the diphoton search (Bob Blair).

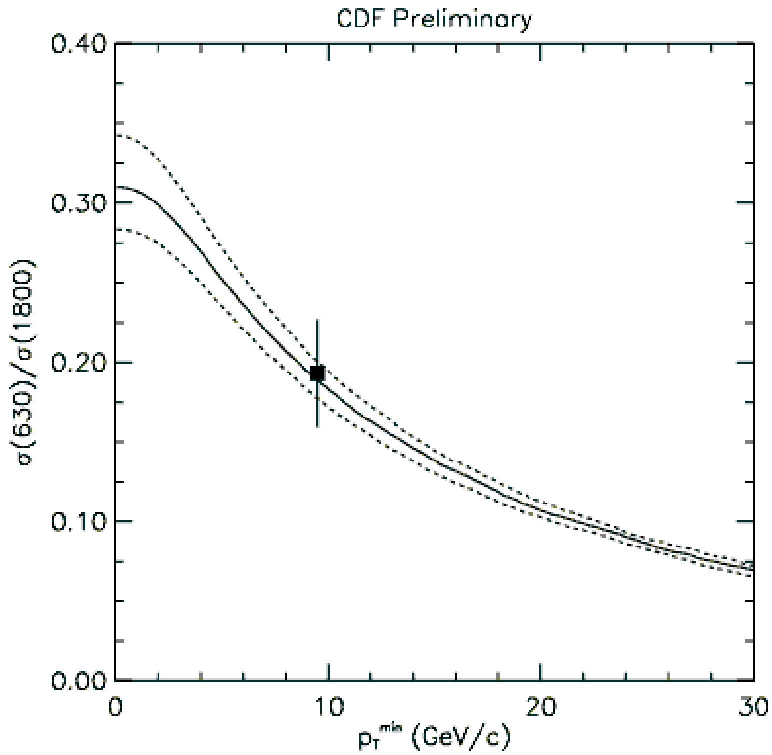


Figure 2. Cross section ratio as a function of minimum p_T, the band is the prediction and the point the CDF measurement.}

b) The CDF Run 2 Commissioning

Shower max calorimeter readout continues to be a major project for us; Karen Byrum has become one of the calorimeter subproject leaders for operation. The basic installation was completed, and Gary Drake developed a diode protection scheme which has been demonstrated to prevent the local recurring preamplifier burn-out. Enough diode boards were assembled to protect a quarter of the detector, and they were installed where the problem was noted. After the problems showed signs of spreading, Fermilab ordered parts so we can complete the protection; no loss of signal or increase in noise is associated.

Jimmy Proudfoot, Steve Kuhlmann, Karen Byrum, and Larry Nodulman, continued to develop software to handle the hardware within the B0 online system, providing for stand-alone diagnostics, diagnostics in the data, coherent noise suppression and zero suppression in normal data-taking. Karen continues working with Gary and Mike Lindgren to develop and put into practice the plan for a stable operating configuration. Additional spare digitizer cards are being made for the plug.

Since the CDF detector was rolled into the hall in April, turn on of both the collider and the detector have been agonizingly slow. By the end of the year the luminosity had reached a mere $10^{31}\sec^{-1} cm^{-2}$. For CDF, most systems reached an operational status; notable exceptions are silicon, where the fraction of the part of detector which has plumbing which is in operation is both growing and needing to grow, the level 2 trigger, where lack of luminosity has made the slow commissioning livable, and muons, where older systems are having beam background problems and the new systems are slowly being commissioned. The silicon trigger shows great promise for the part of the silicon detector which is usable.

Jimmy Proudfoot has taken on a large operational role, taking over Young Kee Kim's CDF operations job.

Karen Byrum, Steve Kuhlmann, Bob Blair, Masa Tanaka, and John Dawson and company continue working with the Michigan group to integrate the Level 2 trigger hardware for shower max and calorimeter isolation. Masa in particular has been actively working on general Level 2 problems, writing diagnostic code including emulators and helping to make the Level 2 trigger system work.

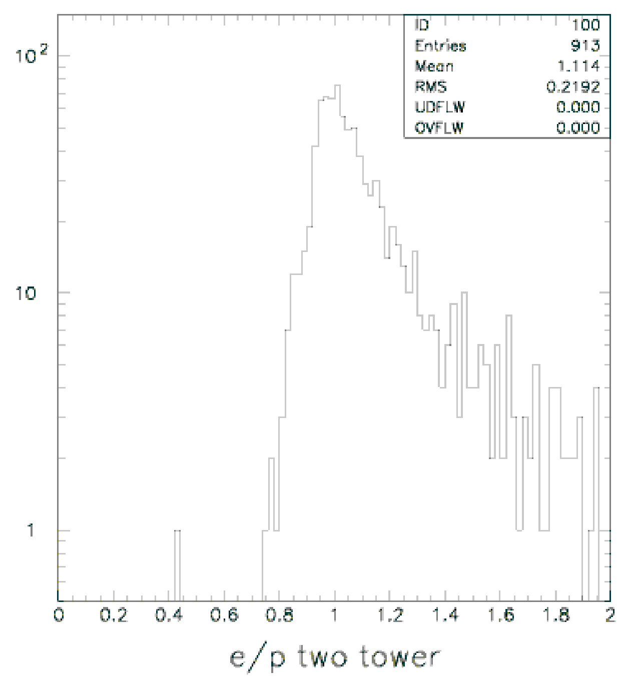


Figure 3. E/P for and the momentum is beam constrained COT measurement.

Larry and Barry are physics group delegates to the trigger dataset working group for top/electroweak and b physics respectively; top/ewk involves lepton and jet triggers while b physics involves strategy for track triggers at level 1 and silicon triggers at level

2, and understanding bandwidth limitations. One unfortunate result is that due to the much increased material in the silicon tracker, the dielectron J/ψ trigger has not yet been viable, despite considerable effort by Masa, Barry and others.

Bob Wagner continues developing offline software for calorimeter reconstruction with emphasis on electron code. Bob, Steve and Barry Wicklund are involved in code for the wire chamber data reconstruction. Sufficient data has been taken so that problems with the code can be found and fixed. The data itself is now the best detector monitor. The central EM calorimeter is holding up well, with reasonable light yield and attenuation.

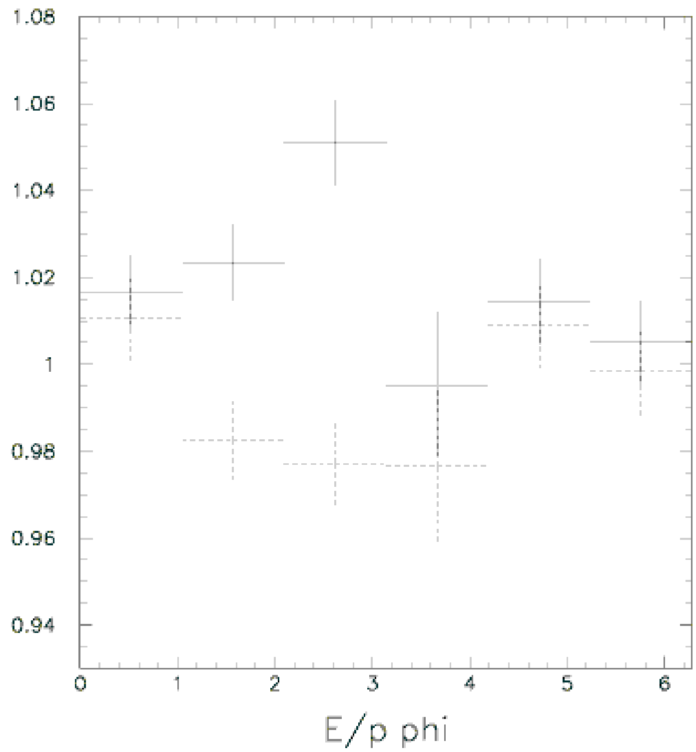


Figure 4. Charge asymmetry in E/P for W electrons as a function of azimuth; solid points are for positrons, dashed are electrons.

An electron *W* sample (as well as a small Z sample) shows that the gain settings by the Fermilab/Penn/Korea group using sources before the commissioning run did a reasonably good job, as shown be E/P in Figure 3. The charge asymmetry of E/P has become a useful diagnostic in tracking alignment, as seen Figure 4, which illustrates an apparent beam-line offset. We are working with Eva Halkiadakis from Rochester to develop tower gains and other response tuning from the 8 GeV inclusive electron "calibration" sample.

(L. Nodulman)

I.3. The CDF Upgrade Project

a) Run IIb Planning

Limited resources are being put into Run 2b upgrades, and the main emphasis will be silicon. Steve Kuhlmann, along with Joey Huston, has taken charge of replacing the preradiator chambers, which would lose function at high luminosity, for Run 2b. This project is surviving internal CDF as well as Fermilab reviews and has attracted foreign participation and substantial support. Jim Grudzinski is becoming involved in design issues as the planning progresses.

(L. Nodulman)

I.A.4 Non-Accelerator Physics at Soudan

In July 2001, the Soudan-2 experiment completed the taking of data using its fine-grained iron tracking calorimeter of total mass 963 tons. The total data exposure was 5.9 fiducial kiloton-years (kTy). Results presented here are based upon the full 5.9 kTy exposure.

Topologies for contained events in Soudan 2 include single track and single shower events (mostly ν_μ and ν_e quasi-elastic reactions) and multiprong events. Flavor-tagging proceeds straightforwardly: An event having a leading, non-scattering track with ionization dE/dx compatible with muon mass is a candidate ν_μ charged current (CC); an event having a prompt, relatively energetic shower prong is a candidate ν_e CC event. Recoil protons of momenta greater than approx. 350 MeV/c are imaged by the calorimeter, allowing a much-improved measurement of the incident neutrino direction, especially for sub-GeV quasi-elastic reactions.

We measure the atmospheric neutrino flavor ratio-of-ratios R using single track and single shower events which are fully contained within the calorimeter (all hits more than 20 cm from the nearest surface). These samples contain mostly quasi-elastic neutrino reactions, but include a background of photon and neutron reactions originating in cosmic ray muon interactions in the surrounding cavern rock. The latter “rock events" are mostly tagged by coincident hits in the active shield, however some are unaccompanied by shield hits and constitute a background. The amount of zero-shield-hit rock background in a neutrino event sample is estimated by fitting event vertex-depth distributions to a combination of tagged-rock and ν Monte Carlo distributions. As expected, the fits show the background to be mostly confined to outer regions of the calorimeter.

The track and shower event samples have been analyzed for our 5.9 kTy exposure. Our full detector Monte Carlo simulation of atmospheric neutrino interactions is based on the 1996 Bartol flux for the Soudan site. After correction for cosmic ray muon induced background, the number of single track events observed in data is less than the number of single shower events, whereas the null oscillation Monte Carlo predicts the relative rates to be other-way-round. Consequently the flavor ratio-of-ratios obtained is less than 1.0 and is anomalous. For the full data set, we obtained: $R = 0.768 \pm 0.098$.

The phenomenology for ν_μ to ν_τ oscillations is quite specific; neutrinos of muon flavor can “disappear" according to the equation:
$P(\nu_\mu \rightarrow \nu_\tau) = \sin^2(2\theta) \sin^2(1.27)\Delta m^2[eV^2] L[km]/E[GeV])$.
Consequently it is optimal to analyze for neutrino oscillations using the variable L/E. With the Soudan 2 calorimeter, measurement of event energy for charged current reactions is straightforward; we do this with resolution $\Delta E/E$ which is 20% for ν_μ CC's and 23% for ν_ε CC's. To determine the neutrino path length L however, the zenith angle θ_z of the incident neutrino must be reconstructed with accuracy. The path length can be calculated from the zenith angle knowing the Earth’s radius, the depth of the detector, and the mean neutrino production height. The latter is a function of ν flavor, ν energy, and zenith angle. We select from our data an event sample suited to this measurement. We use a quasi-elastic track or shower event provided that the recoil proton is measured and that P_{lept} exceeds 150 MeV/c; otherwise, if the recoil nucleon is not visible, we require the single lepton to have E_{vis} great than 600 MeV. We also select multiprong events, provided they are energetic (E_{vis} greater than 700 MeV) and have vector sum of P_{vis} exceeding, the final state lepton momenta are required to exceed 250 MeV/c. For the selected sample, flavor tagging is estimated to be correct for more than 92% of events. The resolution for recovering the incident neutrino direction is evaluated using the mean angular separation between “true" versus reconstructed neutrino direction in Monte Carlo events. The mean separations are 33.2^o for ν_μ CC's and 21.3^o for ν_e CC's . The resolution in log(L/E) (L in kilometers, E in GeV) is better than 0.5 for the selected sample. Hereafter we refer to these events as “HiRes events". The other events are “lowres.”

The zero-shield-hit rock background, as estimated by the fits to event vertex depth distributions, comprises 6.8% (5.1%) of the ν_μ (ν_e) flavor sample of HiRes events. With just these HiRes events, we calculated the ratio-of-ratios to be $R = 0.681 \pm 0.096$, which is also significantly less than 1.0. Separately analyzing the lowres tracks and showers, we obtain
$R = 0.807 \pm 0.278$. The lowres multiprongs yield $R = 0.826 \pm 0.224$.

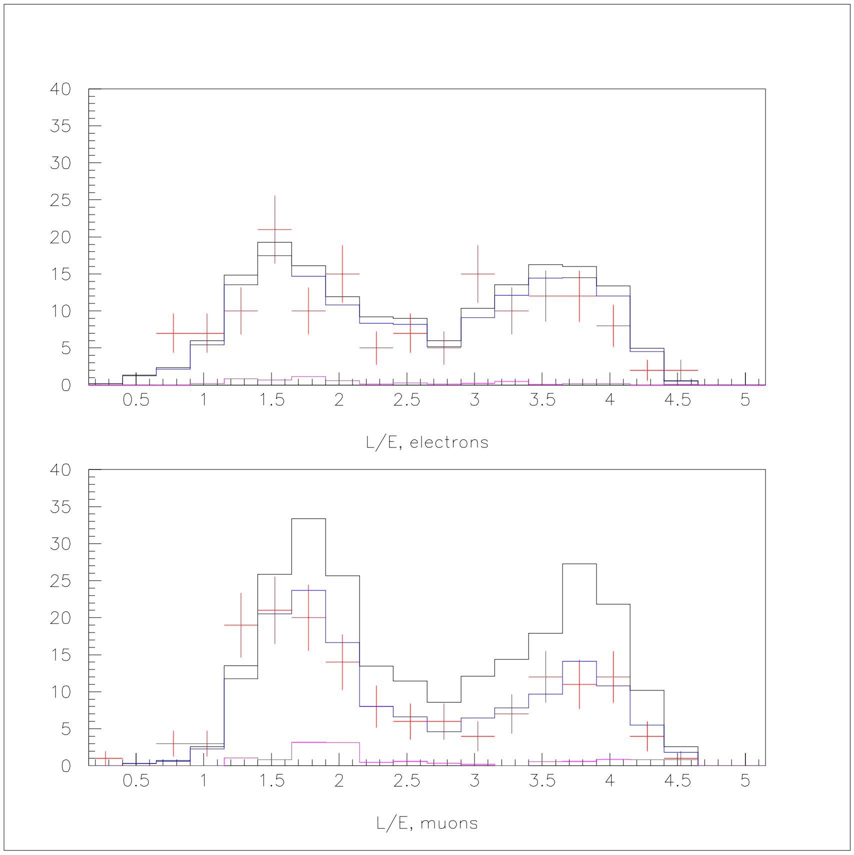
The atmospheric Monte Carlo (MC) sample represents 28.2 kiloton years of exposure. The MC event rates have been normalized to the ν_e data sample. The assumption implicit with this adjustment is that the ν_e sample is devoid of oscillation effects For ν_e events, the shape of the distribution coincides with that predicted by the

Monte Carlo for null oscillations. The distribution of ν_μ data however, falls below the MC prediction in all bins with the relative dearth being more pronounced for ν_μ's incident from below horizon. Distributions in Log(L/E) for HiRes events are shown in the next figure. For null oscillations this variable distributes according to a `phase space' which reflects the neutrino points-of-origin throughout the spherical shell volume of the Earth's atmosphere. That is, down-going ν's populate the peak at lower log(L/E) from 0.0 to 2.0. Neutrinos incident from/near the horizon occur within the dip region extending from 2.0 to 2.6, while upward-going neutrinos populate the peak at higher values. Allowing for statistical fluctuations, the ν_e data follows the shape of the null oscillation MC distribution. In contrast, the ν_μ data falls below the null oscillation MC for all but the most vertically down-going flux. To convert results of our atmospheric neutrino simulation generated under the no-oscillation hypothesis into simulated neutrino oscillation data, we apply to every MC event an L/E-dependent weight representing the probability of muon flavor survival for a given Δm^2 and $\sin^2(2\theta)$.

To determine the neutrino oscillation parameters Δm^2 and $\sin^2(2\theta)$ from our data, we construct a χ^2 function over the plane-of-parameters. For points (i,j) in the physical region of the $\sin^2(2\theta)$ -log(Δm^2) plane, we fit the MC expectation to our data at each point. The MC flux normalization, f_ν as well as $\sin^2(2\theta)$ and log Δm^2, is a free parameter:
$(\chi^2_{\text{data}})_{ij} = \chi^2(\sin^2(2\theta),\Delta m^2,f_\nu) = \sum_{k=1}^{8} [N_k(\text{data-bkgd}) - f_\nu N_k(MC)]^2/\sigma_k^2$
We assume that the oscillation affecting our data is purely ν_μ into ν_τ and that the ν_e data is unaffected.

The $\chi 2$ is summed over data bins containing our selected (HiRes) ν_μ and ν_e samples, where k = 1-7 are ν_μ log(L/E) bins, with k = 8 containing all the ν_e events. The denominator $\sigma\{k\}^2$ accounts for finite statistics in the neutrino Monte Carlo and for uncertainty in the rock background in the ν data. Not yet included are error terms which address systematic errors in the analysis, however preliminary examination shows statistical errors to be the dominant error source in the analysis. The MC counts $N_k(MC)$$ for the kth bin are constructed using oscillation weight factors.

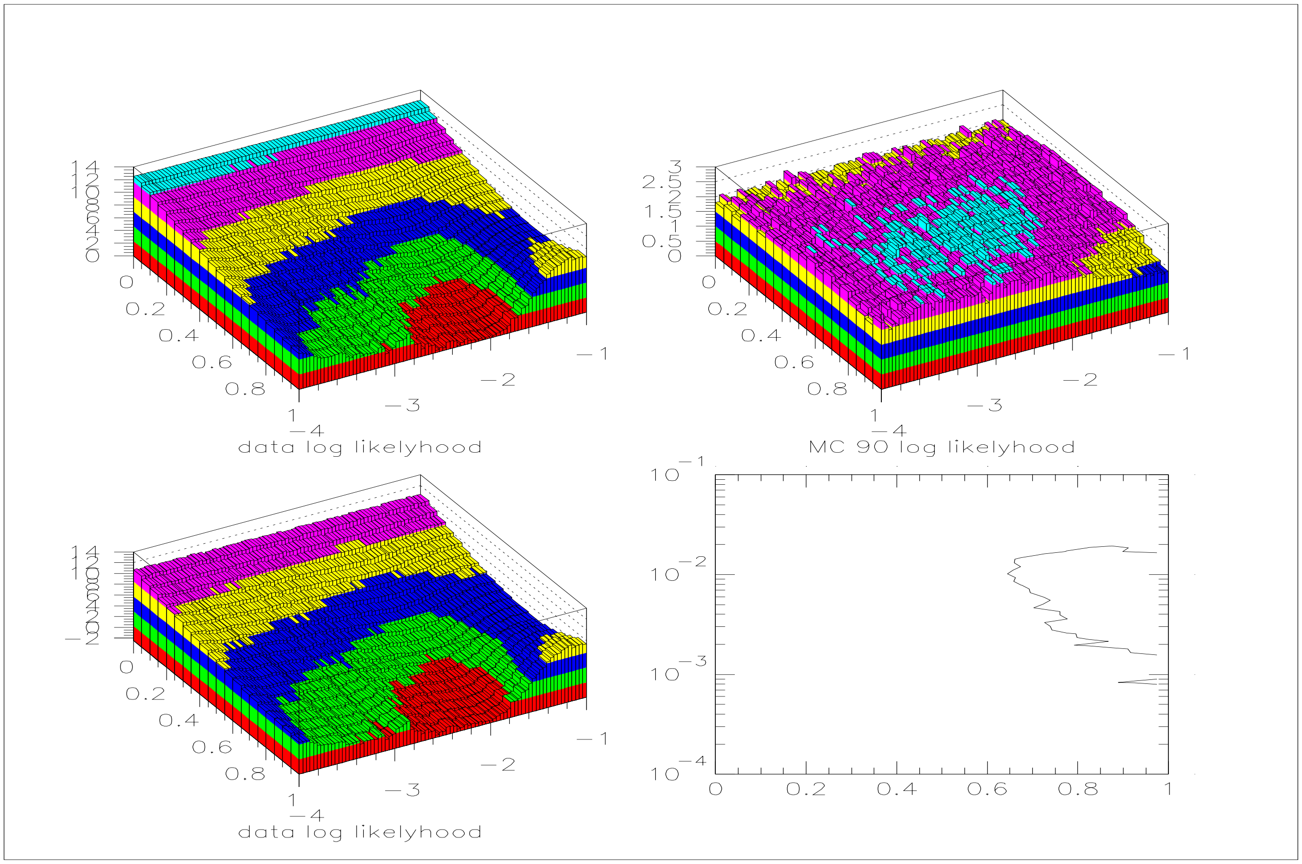
We find the location of minimum χ^2_{data}, and plot $(\Delta\chi^2_{\text{data}})_{ij}$ which is $(\chi^2_{\text{data}})_{ij}$ - $(\chi^2_{\text{data}})_{\text{min}}$. A crater region of low χ^2 values is discerned, at the bottom of which is a relatively flat basin. The lowest point χ^2_{min} occurs at values $\sin^2(2\theta) = 0.975$, $\Delta m^2 = 10.0$ 10^{-3}, with flux normalization $f_\nu = 0.150$ compared to the nominal 0.164 (or 91% of the Bartol 95 flux).



An additional structure is the $\Delta\chi^2$ ridge which occurs at large mixing angle and for Δm^2 above 10^{-2} eV^2. For oscillation solutions in this regime, depletion in the downward-going ν_μ neutrino flux with sub-GeV energies is predicted for ν_μ to ν_τ oscillations arising from the first oscillation minimum. Our HiRes events have sufficient resolution to show such an effect if it would be present. However, no pronounced depletion is observed, and so the χ^2 has a high value there.

To find the region allowed for the oscillation parameters by our data at 90% confidence level (CL), we use the method of Feldman and Cousins. At each of 2500 points (i,j) = $\sin^2(2\theta)_i$, Δm^2_j on a grid spanning the physical region of the plane parameters, we run 1000 simulated experiments. For each of the simulated sets, we find $\Delta\chi^2_{ij}$ such that $(\Delta\chi^2_{sim})_{ij}$ is less than for 90% of the simulated experiments at (i,j). The surface defined by local $(\Delta\chi^2_{90})_{ij}$ over the oscillation parameters plane is then plotted. Note that the surface is not a plane at $(\Delta\chi^2_{90}) = 4.61$, but rather has a concave shape. The central shaded portion is approximately $\Delta\chi^2 = 4.6$, however the outlying regions have $\Delta\chi^2$ values which are lower. At each point over the physical region, if $\Delta\chi^2_{(data)ij}$ is less than $(\Delta\chi^2_{90})_{ij}$ then (i,j) belongs to the allowed region of the 90% CL contour.

The region allowed by our data at 90% CL is shown by the shaded area in the figure below. Although the χ^2 minimum occurs at the location depicted by the solid circle, the relatively flat basin of our $\Delta\chi^2$ surface extends to lower Δm^2 values.



(M. C. Goodman)

I.A.5. ZEUS Detector at HERA

a) Physics Results

Four papers were published in this period and seven additional papers were submitted for publication. We briefly summarize some of the new results.

- *Measurement of the Photon-Proton Total Cross Section at a Center-of-Mass Energy of 209 GeV at HERA*: The photon-proton total cross section has been measured in the process $e^+p \rightarrow e^+\gamma p \rightarrow e^+X$ with the ZEUS detector. Events were collected with photon virtuality $Q^2 < 0.02$ GeV^2 and average γp center-of-mass energy $W_{\gamma p} = 209$ GeV in a dedicated run, designed to control systematic effects, with an integrated luminosity of 49 nb^{-1}. The measured total cross section is $\sigma^{\gamma p}_{tot} = 174 \pm 1$ (stat) ± 13 (syst) μb and is shown together with the result from

H1 and lower energy experiments in Fig. 1. The energy dependence of the cross section is compatible with parameterizations of high-energy pp and $p\bar{p}$ data.

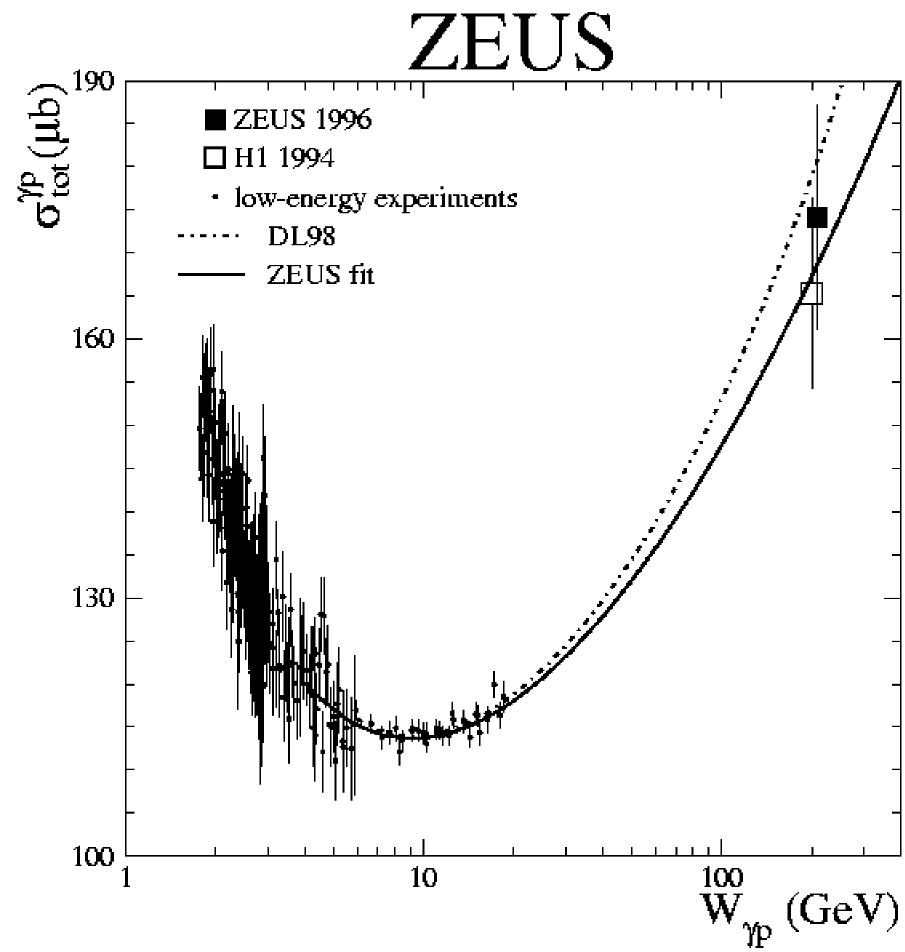


Figure 1. The photon-proton total cross section as a function of the photon-proton center-of-mass energy. The present result is shown with measurements by H1, low-energy experiments and parameterizations by ZEUS and DL98.

- *Dijet Production in Neutral Current Deep Inelastic Scattering at HERA*: Dijet cross sections in neutral current deep inelastic *ep* scattering have been measured in the range $10 < Q^2 < 10^4$ GeV^2 using an integrated luminosity of 38.4 pb^{-1}. The cross sections, measured in the Breit frame using the k_T jet algorithm, are compared with next-to-leading order perturbative QCD calculations using a selection of different proton parton distribution functions. The jets were selected with asymmetric E_T cuts in order to avoid an infrared singularity of the calculation related to the use of symmetric E_T cuts. Figure 2 shows the dijet cross section $d\sigma/d\log_{10}\xi$, where ξ is the reconstructed fraction (in leading order QCD) of the proton's momentum carried by the struck quark. The results are in excellent agreement with theoretical calculations based on next-to-leading order QCD. However, the comparison is plagued by large uncertainties, in particular of the theoretical prediction. Improved calculations including either higher order terms or resuming leading logarithms and larger data sets, as will be provided by the upgraded HERA machine, will lead to more stringent confrontations between data and theory.

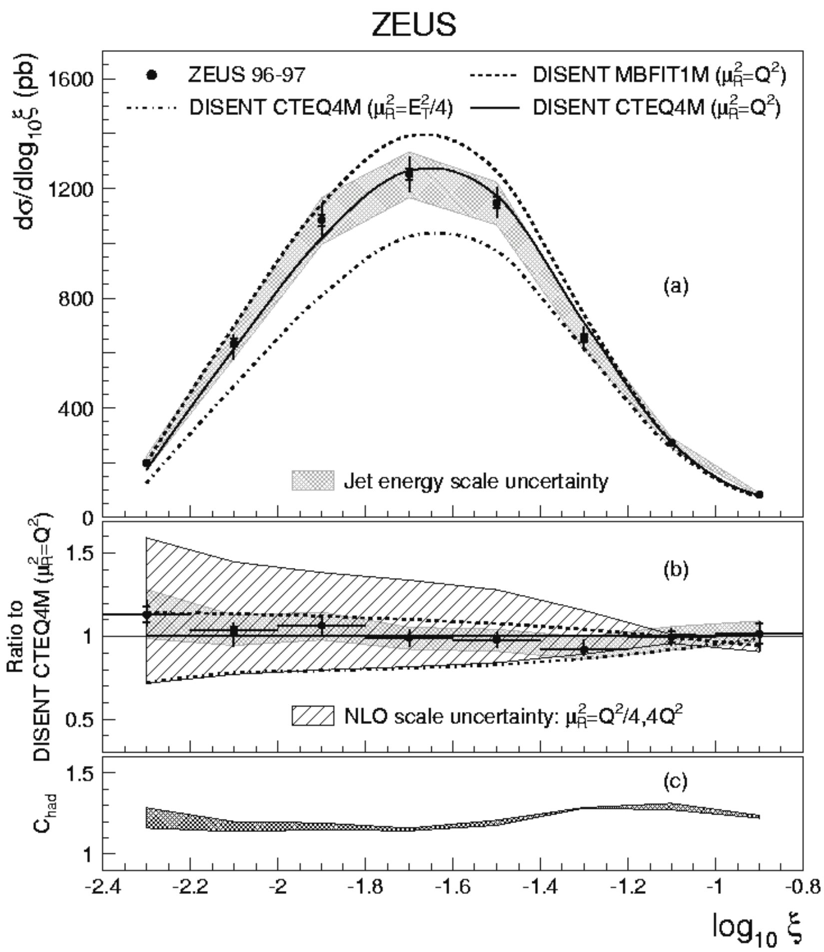


Figure 2. Dijet cross section, $d\hat{u} = d\log_{10} \emptyset$, for jets of hadrons in the Breit frame selected with the inclusive k_T algorithm. The ZEUS results are shown in comparison with NLO QCD calculations obtained with DISENT.

- *Dijet Photoproduction at HERA and the Structure of the Photon*: This paper reports the measurement of dijet cross sections in photoproduction. The events are required to have a virtuality of the incoming photon, Q^2, less than 1 GeV^2 and a photon-proton center-of-mass energy in the range 134 < W < 277 GeV^2. Each event contains at least two jets satisfying transverse-energy requirements of E_{T1} > 14 GeV and E_{T2} > 11 GeV and pseudorapidity requirements of $-1 < \eta_{1,2} < 2.4$. Figure 3 shows the measured cross section as a function of the cut on the lower transverse energy jet, E_{T2}^{cut}, for a fixed range of transverse energies of the leading jet, $25 < E_{T1} < 35$ GeV. The results for the data samples with enhanced direct and resolved photon contributions are also shown in the figure. The measurements are compared to NLO predictions, corrected for hadronization effects, using the GRV-HO and CTEQ5M1 parton density functions for the photon and the proton, respectively. The predictions using the AFG-HO photon parton density functions for the photon are also shown.

The NLO predictions do not describe the data very well, for E_{T2}^{cut} close to 25 GeV or the lower bound on E_{T1}. The calculations show the well-known infrared singularity related to the choice of symmetric cuts on the transverse energy of the jets. For E_{T2}^{cut} between 20 and 25 GeV, the predictions are clearly above the measurement, while for E_{T2}^{cut} below 20 GeV the inverse is true. This poor agreement between data and theoretical prediction is being blamed on the fact that in the calculation the transverse momentum of the jets is calculated only in leading order, thus introducing large-scale uncertainties. Again higher order calculations are expected to improve the situation.

- *Exclusive Photoproduction of J/ψ Mesons at HERA*: The exclusive production of J/ψ mesons, $\gamma p \rightarrow J/\psi p$, has been studied in *ep* collisions in the kinematic range $20 < W < 290$ GeV. The J/ψ mesons were reconstructed in the muon and the electron decay channels using integrated luminosities of 38 pb^{-1} and 55 pb^{-1}, respectively. The helicity structure of J/ψ production shows that the hypothesis of s-channel helicity conservation is satisfied at the two standard-deviation level. The total cross section and the differential cross section, $d\hat{u} = dt$, where t is the squared four-momentum transfer at the proton vertex, are measured as a function of W, for $|t| < 1.8\ GeV^2$. The t distribution exhibits an • exponential shape with a slope parameter increasing logarithmically with W with a value b = 4.15 ± 0.018 (stat.) $^{+0.008}_{-0.015}$ (syst.) GeV^{-2}. The effective parameters of the Pomeron trajectory as a function of t is shown in Fig. 4. Also shown are the results of the H1 collaboration and the DL soft-Pomeron trajectory. The values for the intercept $\alpha_P (0) = 1.200 \pm 0.009$ (stat)$^{+0.004}_{-0.010}$ (syst) and the slope $\alpha_P' (0) = 0.115 \pm 0.018$ (stat)$^{+0.008}_{-0.015}$ (syst) are inconsistent with those expected from the exchange of a soft Pomeron. The data indicate that α_P' is different from zero but smaller by a factor of two than the value measured in soft hadronic interactions. Clearly therefore, the description of J/ψ production lies within the realm of perturbative QCD. A quantitative description comparable to the precision of the current data requires further theoretical progress.

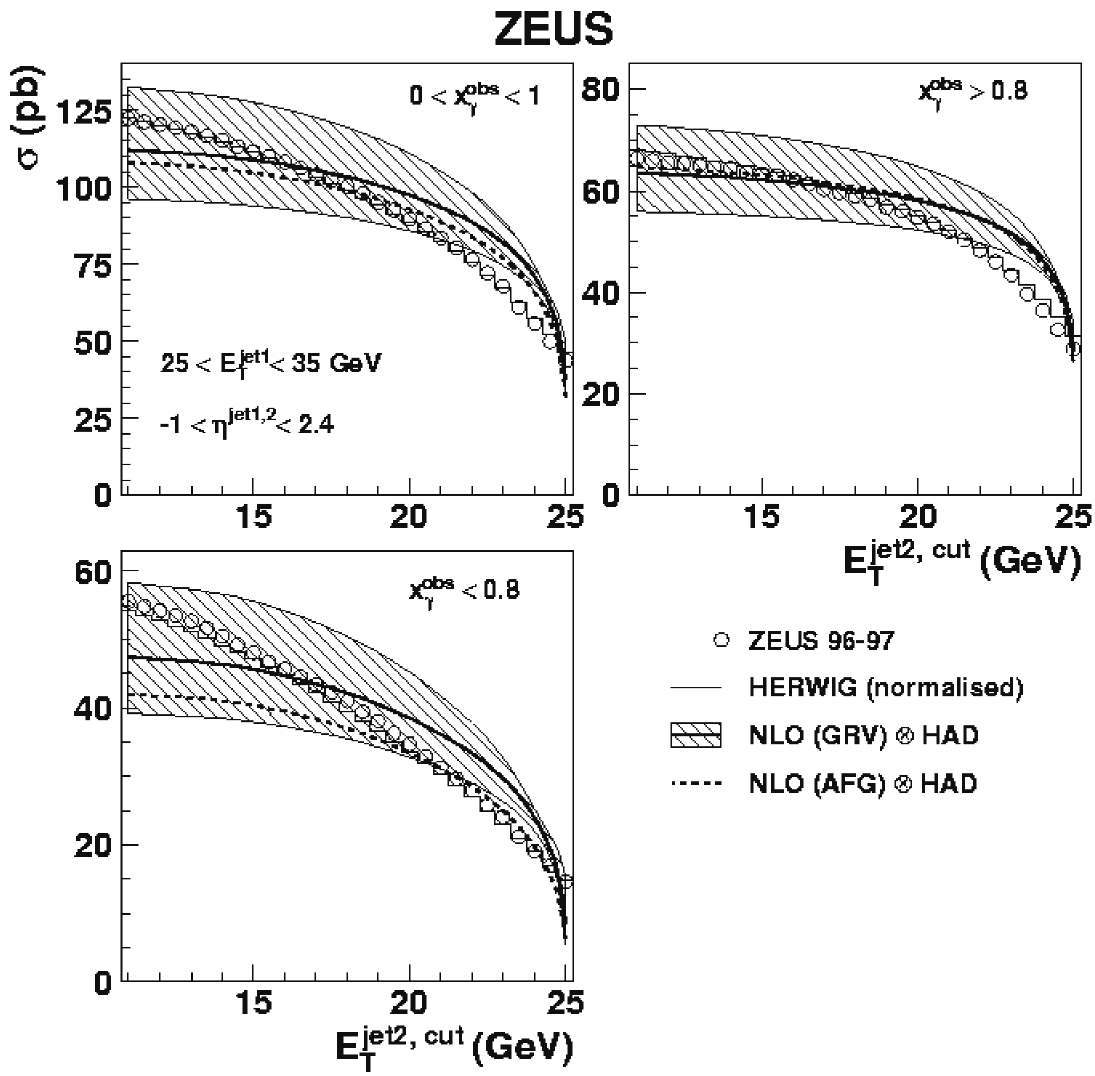


Figure 3. Measured dijet cross section in photoproduction as function of the cut on the lower transverse energy jet for a fixed range of transverse momenta of the leading jet: a) all xγ, b) xγ > .8, and c) xγ,<0.8. The NLO predictions, corrected for hadronization effects, using two different photon parton density functions are also shown. The results of HERWIG normalized in magnitude to match the data are shown as histogram.

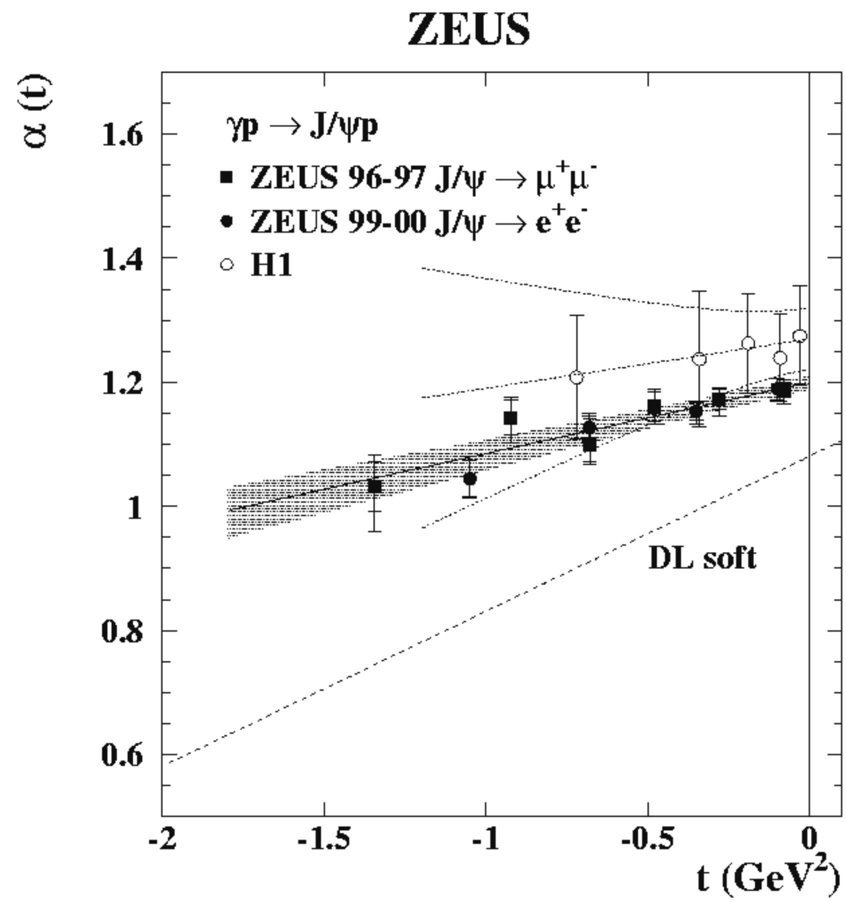


Figure 4. Pomeron trajectory as a function of t as obtained in the two leptonic decay channels. The results from the H1 collaboration are also shown. The solid and dotted lines are the result of linear fits to the ZEUS and H1 data, respectively. The one standard deviation contour is indicated for the ZEUS (shaded area) and H1 (dotted lines) measurements. The dashed line shows the DL soft Pomeron trajectory.

b) HERA and ZEUS Operations

The luminosity upgrade at HERA continued in this period. The detector, with their new components, was closed in July. Installation of new elements in HERA, including the strong focusing magnets and spin rotators were finished, and commissioning of the accelerator began. In November, a specific luminosity of $1.68 \cdot 10^{30}$ cm^{-2} s^{-1} mA^{-2} (design is $1.82 \cdot 10^{30}$) was reached.

Several problems with limited apertures and synchrotron radiation background were identified and plans were made to modify some absorbers and collimators in a short shutdown in early 2002.

The re-commissioning of the ZEUS detector proceeded without problems. The new Microvertex detector consisting of barrels of silicon detectors in the central regions and wheels in the forward region were tested with cosmic rays in July and were shown to function as expected.

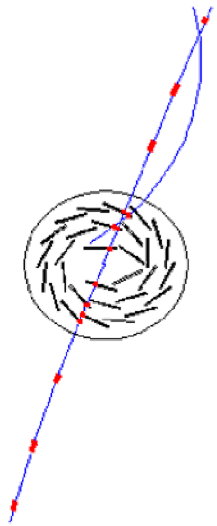


Figure 5. A cosmic ray signal in the silicon Microvertex detector in the ZEUS detector. The signals in the Microvertex detectors are those within the circle. Those outside the circle are signals in the Central Tracking Detector.

The new Straw Tube Tracker, which provides improved forward tracking, has also been successfully commissioned, and tested with halo muons accompanying the proton beam. The other components of the ZEUS detector are all working as expected.

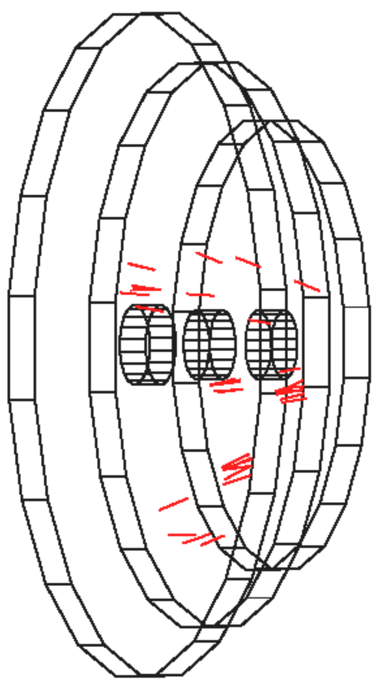


Figure 6. Hits in the Straw Tube Tracker from a halo muon run taken in December 2001.

(R. Yoshida)

I.B. EXPERIMENT IN PLANNING OR CONSTRUCTION

I.B.1. The Endcap Electromagnetic Calorimeter for STAR

The Spin Physics group is focusing primarily on the polarized proton program which will be carried out using the Solenoidal Tracker At RHIC (STAR). The group is heavily involved in the construction of the Endcap Electromagnetic Calorimeter (EEMC) which will be installed during RHIC shutdowns in 2002 and 2003. The ANL group is responsible for the construction of a shower-maximum detector (SMD) for the EEMC. The EEMC is crucial to the STAR Collaboration's goals for the spin program, because it is needed to measure the direct photons produced in the parton-level process $qg \rightarrow q\gamma$. The SMD is required to distinguish these isolated photons from the pair of photons produced in the decays of the π° and η mesons. The production of SMD modules began in July 2001 after a "production readiness" review committee approved the SMD design. During the second half of 2001, work continued on a cosmic ray test facility for calibration of the SMD modules.

The SMD consists of planes of extruded triangular scintillator strips located roughly 5 radiation lengths into the EEMC. The SMD is built in 30 degree modules, and each 30 degree sector of the calorimeter will have two modules with strips running perpendicular to each other. The scintillation light is transported to phototubes using wavelength-shifting (WLS) optical fibers which are threaded through a hole running down the center of each strip. This design was endorsed by the committee which met at Argonne to review the project on July 2-3, 2001. Some minor changes to the SMD module construction procedures were proposed by the committee and have since been implemented.

With the construction procedures approved, the efforts of the ANL group began to focus on the construction of the 30 modules (including some spares) which will eventually be needed for the complete calorimeter. During the summer, we were grateful for the help of Jeff Rylander, a physics teacher at Maine East High School in Park Ridge, IL, and of two undergraduate students, Meghan Gagliardi from Loyola University and Michael Bates from Indiana University. In the fall, three visitors from JINR in Dubna, Russia came to Argonne to assist with the construction. Thanks largely to these visitors, 14 modules were glued by the end of 2001. Of these, five had been shipped to Indiana University for machining, and two had been machined to the proper dimensions. The first machined module has been returned to Argonne. It has been used to test the lengths of prototype WLS fiber bundles and for some preliminary cosmic ray tests. An example of a completed module with fibers is shown in Figure 1.

Meghan Gagliardi completed the studies of the light yield of individual strips using 2-3 MeV electrons from a ruthenium source. Her most significant finding was a 10% variation in light output associated with the details of how the strips are wrapped in aluminized mylar. This variation was observed when the mylar wrapping was removed and the test strips were rewrapped. It is believed that the strips were wrapped identically both times, and so this variation appears to defy explanation. It does not significantly increase the expected strip-to-strip variation in light output.

As part of the quality control procedures for the SMD, a cosmic ray test facility has been built at Argonne. This facility is used to compare the light output caused by muons passing through the SMD to benchmarks determined from Monte Carlo simulations of direct photons and mesons in the EEMC. A complete set of clear optical fibers and multi-anode photomultiplier tubes (MAPMT's) was finally assembled in the test facility during the summer of 2001, and so for the first time it became possible to read out an entire SMD module at once. The optical fibers and photomultiplier tubes are calibrated using an LED system as described in the previous semiannual report. Calibrations of these optical components were completed and studied by Jeff Rylander. Later the visitors from Dubna repeated some of the measurements. It is expected that further repetition of the calibration will be necessary to monitor variations in the gains of the MAPMT's.

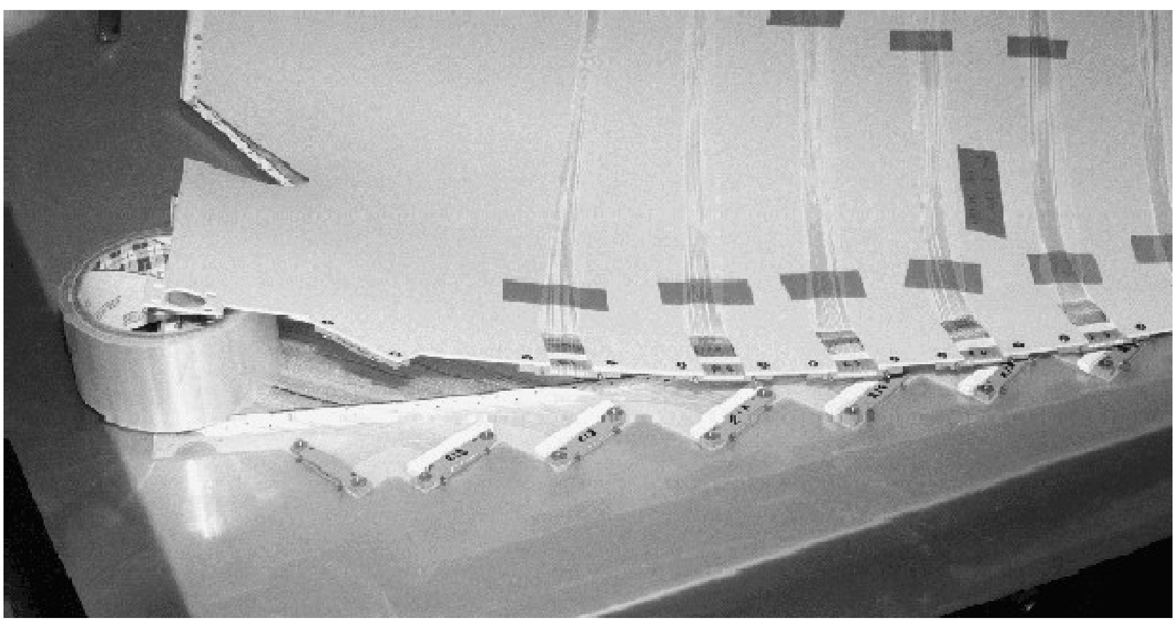


Figure 1. A corner of a completed module without its aluminum cover. The polystyrene fiber-routing layer which holds the fibers that exit their strips at the side of the module is lifted up to allow the triangular scintillator strips to be seen. Fibers from strips that end at the large-radius edge of the module proceed directly to connectors as shown. The left-most connectors on both the top and bottom layers are part of a system which will inject laser light into each bundle for calibration purposes. The light is transmitted into the WLS fibers at the clasps which can be seen adjacent to the other connectors.

The cosmic ray facility was improved by the addition of tagging counters which were built from scintillator strips borrowed from ANL colleagues working on the MINOS project. The MINOS strips are arranged parallel to and above the SMD strips. Each MINOS strip covers about eight SMD strips. These counters were added to suppress single-photoelectron noise observed in the MAPMT's. The noise is believed to come from some combination of light leaks and cross talk. The acceptance of the test facility's trigger scintillators can accommodate nearly 200 strips, so each particular strip only has a small chance of being struck by a muon in any one trigger. The tagging counters are used in software to effectively reduce the trigger area used for any given scintillator strip. A significant noise reduction was observed.

In summary, the SMD construction project passed an important milestone (the production readiness review) and made significant progress during the second half of 2001. The most immediate goal of the SMD production is to finish the construction and calibration of the eight modules and one or two spares needed for installation in the summer of 2002.

The group also will continue to work towards an understanding of the calibration results obtained from the cosmic ray test facility.

(R. Cadman)

1.B.2 MINOS - Main Injector Neutrino Oscillation Search

The phenomenon of neutrino oscillations allows the three flavors of neutrinos to mix as they propagate through space or matter. The MINOS experiment will use a Fermilab muon neutrino beam to study neutrino oscillations with higher sensitivity than any previous experiment. MINOS is optimized to explore the region of neutrino oscillation parameter space (values of the Δm^2 and $\sin^2(2\theta)$ parameters) suggested by atmospheric neutrino experiments: IMB, Kamiokande, MACRO, Soudan 2 and Super-Kamiokande. The study of oscillations in this region with an accelerator-produced neutrino beam requires measurements of the beam after a very long flight path. This in turn requires a very intense neutrino beam (produced for the MINOS experiment by the Fermilab Main Injector accelerator) and massive detectors. The rates and characteristics of neutrino interactions are compared in a "near" detector, close to the source of neutrinos at Fermilab, and a "far" detector, 735 km away in the underground laboratory at Soudan, Minnesota. The neutrino beam and MINOS detectors are being constructed as part of the NuMI (Neutrinos at the Main Injector) Project at Fermilab.

The MINOS detectors are steel-scintillator sandwich calorimeters with toroidally magnetized 1-inch thick steel planes. The combination of alternating active detector planes and magnetized steel absorber planes has been used in a number of previous neutrino experiments. The MINOS innovation is to use extruded plastic scintillator with fine transverse granularity (4-cm wide strips) to provide both calorimetry (energy deposition) and tracking (topology) information. The 5,400 metric ton MINOS far detector is also much more massive than those used in previous accelerator-based neutrino experiments. Advances in extruded scintillator technology and in pixilated photomultipliers during the past decade have made such a detector feasible and affordable for the first time.

Results from the Super-Kamiokande, Soudan 2 and MACRO experiments provide evidence that neutrino oscillations are taking place within the region of parameter space that MINOS was designed to explore. The current value of Δm^2, around $3.5 \times 10^{-3} eV^2$, has motivated the design of a lower energy beam for MINOS than was initially planned in order to improve sensitivity at low Δm^2. Argonne physicists and engineers are involved in several aspects of the preparations for MINOS: scintillator-module factory engineering, near-detector scintillator-module fabrication, near-detector front-end electronics, far-detector installation and, most recently, engineering and construction of neutrino beamline components. The Argonne group's work on the use of the Soudan 2 detector as part of MINOS has been suspended, pending a possible decision to restart the detector when the NuMI beam is ready in 2005. The 960-ton Soudan 2 detector was shut down in July 2001 after a 12-year run to study proton decay and atmospheric neutrinos.

One major focus of work by the Argonne MINOS group is scintillator module construction. ("Modules" are subassemblies of 20 or 28 extruded plastic scintillator strips.) Scintillator module assembly for MINOS is taking place at assembly facilities at Argonne, Caltech and the University of Minnesota in Minneapolis. The Argonne group designed and built the assembly machines and tooling for all three module factories. Argonne physicists and engineers serve as NuMI Project WBS Level 3 Managers for the design and construction of the machines needed to construct scintillator modules and for the operation of the three factories. Previously, an Argonne physicist served as the Level 3 manager for scintillator strip fabrication and was responsible for the introduction of several important strip design innovations.

In early 2001 the Argonne group commissioned the assembly facility for near detector modules in Building 369 at Argonne. The preparation of Building 369, which has air conditioning and more floor space than Building 366, was made possible by substantial financial and logistical assistance from the Laboratory administration. By the end of 2001 the group had completed the assembly of 280 near detector modules (out of the total 573 required) and had shipped over 100 of these to Fermilab, where they will be mounted on near detector steel planes prior to installation in the underground detector hall. Figure 1 shows the first trial fitting of near detector scintillator modules on a steel detector plane in the New Muon Laboratory at Fermilab.

The second major focus of the Argonne MINOS group is electronics and data acquisition for the experiment. Argonne physicists and engineers continued to serve as the Level 2 manager for electronics and the Level 3 manager for the near-detector front-end electronics in 2001. The near detector must have fast front-end electronics with no dead time because of the high instantaneous rate of neutrino events. This is accomplished using a special MINOS modification of the Fermilab QIE ASIC chip. All

Figure 1. Photograph of the first trial assembly of MINOS near-detector scintillator modules onto a steel detector plane at Fermilab. A strongback fixture supports the 1-inch thick steel plane to prevent bending when the plane is raised to a vertical orientation. A high-current coil, installed through the square holes in the 280 detector planes after they are assembled, is used to magnetize the steel planes. All near-detector modules are being constructed at Argonne's Building 369 assembly facility.

MINOS QIE chips were fabricated during the first half of 2001. Most components of the near-detector front-end electronics, along with protocols for communication among the various boards, are the responsibility of the Argonne electronics group. All front-end electronics components, including QIE chips from Fermilab and clock boards from IIT, were installed and operated together in the "small system test" setup at Argonne during the fall of 2001. As part of this effort the Argonne group developed software to operate and study the performance of the readout electronics chain. The group also performed simulations of electronics response to evaluate the physics impact of the choices made in the final stages of QIE-chip and board design.

During December 2001 the Argonne and Fermilab electronics groups completed performance studies with the small system test setup and began assembly of the "vertical slice test" setup at Argonne. This setup will eventually include enough front-end channels to read out all 128 pixels of two M64 near-detector photomultiplier tubes and will be interfaced to the MINOS data acquisition system. The DAQ hardware and software is being provided by the Rutherford Laboratory MINOS group and is very similar to the Rutherford DAQ system already in operation for the far detector at Soudan. By the end of December most of the hardware, along with DAQ and Run Control software, had been installed and the integration of front-end software was under way. In parallel with this effort the Argonne electronics group continued work on final versions front-end boards and on control and performance testing software for the vertical slice test setup. The vertical slice test involves close collaboration among physicists and engineers at Argonne, Fermilab, IIT and the Rutherford Lab.

An Argonne physicist is also the Level 2 manager for far-detector installation at Soudan. During 2001 the outfitting contractor completed installation of the underground laboratory utilities and infrastructure, including the detector support structure. The contractor granted beneficial occupancy of the far detector hall in the Soudan underground physics laboratory in July. Intensive planning during the first half of the year, involving close interaction with MINOS collaborators building detector and electronics components, allowed installation of detector planes and electronics to begin immediately after beneficial occupancy. The first steel plane was erected at the end of July and the first detector planes (with scintillator modules) were installed in August. The first cosmic-ray muon track was recorded and reconstructed at the end of August By the end of the year the first 85 detector planes had been installed and 76 planes were reading out. Figures 2 and 3 show front and side views of the installed detector planes at Soudan.

Figure 2. Photograph of the MINOS far detector at Soudan in December 2001. This “front” view of the detector looks towards Fermilab, into the direction of the neutrino beam. Steel planes are mounted on the detector support structure after scintillator modules have been attached. The scintillator side of each plane faces inwards so that only the back of the last steel plane installed is seen in this view. The hole for the magnet coil is in the center of the 8-meter wide octagonal planes. Racks containing photomultipliers, front-end and data-acquisition electronics are visible in the background on the right side.

Figure 3. Side view of the installed MINOS far detector planes in December 2001. This view shows the edges of the steel detector planes, scintillator modules and the fiber optics cables that carry light from the scintillator strips to the photomultiplier tubes. The neutrino beam direction is from left to right in the photograph. The edge of the plane shown in the previous figure is at the far right.

As Argonne work on scintillator module fabrication and far detector installation became routine at the end of 2001, Argonne physicists began to shift some effort to work on NuMI neutrino beam components at Fermilab. Initially this work focused on neutrino beam horn testing, target hall instrumentation readout and integration planning for installation of beam components in the target hall. The Argonne group plans to increase its level of effort on NuMI neutrino beam work at Fermilab during 2002.

(D. S. Ayres)

I.B.3 ATLAS Detector Research & Development

(a) Overview of ANL ATLAS Tile Calorimeter Activities

The TileCal subsystem continued making excellent progress in the second half of 2001. Both submodule and module mechanical construction is proceeding on schedule. 197 submodules and 48 modules have been constructed. Module instrumentation is continuing at a rate of 1 module per month and we are continuing to test (and repair where necessary) modules instrumented at MSU. 38 completed modules have now been shipped to CERN. In addition, we now routinely run the cesium source in all modules instrumented at MSU and replace tiles and repair fibers as needed. For all recent modules, we typically have no tile-fiber couplings outside the design goal of having a response less than 75% of the average.

(J. Proudfoot)

I.C. DECTECTOR DEVELOPMENT

I.C.1 ATLAS Calorimeter Design and Construction

The ATLAS Tile Calorimeter construction effort is now fully into the production phase. The areas of ongoing work comprise: submodule construction; module assembly; instrumentation and testing; testbeam measurement of detector performance; engineering support of work at US collaborating institutes; continued engineering evaluation of specific elements of the detector and final design of areas in the detector where special constraints, such as the support of the liquid argon cryostats, must be accommodated.

a) Submodule Construction

Submodule production continued at the scheduled production rate. At the close of this reporting period, 200 submodules were stacked and welded and 197 fully completed and stored for mounting into modules. The height envelope for all submodules constructed to date at Argonne is generally well within the tolerance envelope. This completes the production of our assigned quota of 192 submodules. We will continue production into early 2002 in order to fabricate a number of spares in addition to 9 submodules to be used in the construction of a 65^{th} module. The repair of defective submodules is also complete.

Submodule production has been completed at the University of Illinois, where 193 submodules were constructed. No major problems have been encountered in this production.

The design of the special submodules required in the region of the endcap cryostat supports was completed in the 1st half of 2001. We envisage commencing full scale production of the submodules in January 2002.

b) Module Assembly and Shipping

Module production is also proceeding smoothly and at a somewhat higher rate than planned in the baseline schedule. A cumulative total of 48 modules have been constructed to date and we routinely construct one module every 2 calendar weeks. Girder production is now complete at the vendor, with a total of 65 girders being constructed. We expect delivery of the final shipment in January 2002. The timely delivery of the special ITC submodules from the University of Texas at Arlington continues to be a modest concern, but so far we have not been forced to halt production while waiting for the delivery of the next series.

c) Module Shipping

Shipping of modules to Michigan State University and CERN has continued with no problems. 38 modules have now been sent to CERN and 26 have been shipped to MSU (23 of these have been instrumented and returned to Argonne). We are at present behind our scheduled shipping plan by 2 modules. However, this simply reflects the scheduling of shipments and not any intrinsic problem.

(J. Proudfoot)

d) Instrumentation and Testing

Module instrumentation and testing is now a routine activity and two full crews of technicians are trained in the procedures. We made some modest changes in tooling and module storage to facilitate testing and repair of modules from MSU. At the present time, 20 modules have been instrumented at Argonne and 23 at Michigan State University, out of a total of 32 to be instrumented at each location (N.B. there was an error in the June 2001 report). We are meeting our planned schedule and routinely complete the instrumentation and testing of a module in less than 28 calendar days. Our procedures are working well and typically we repair only a handful of fibers on any given module and on occasions have no repairs to make following the initial instrumentation.

We continue to closely monitor the variation in light output with tile pack. Our sorting procedures are working and we continue to get an average layer uniformity which is of order 6% (c.f. the specification of <10%). In addition, the variation in light output from the scintillator appears to be somewhat better. As a consequence, the recent modules are showing a significant improvement over the early ones, as shown in Fig. 1.

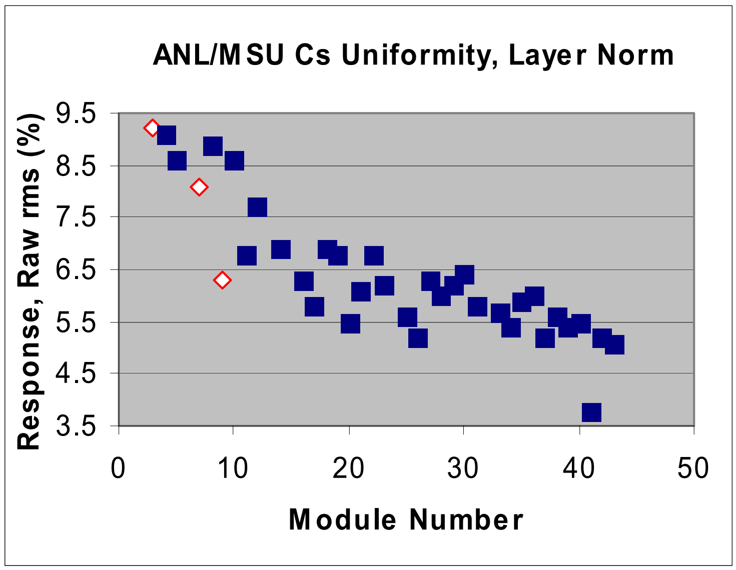


Figure 1. Instrumentation uniformity as a function of module number

The repairs of modules instrumented at MSU have had one positive side-effect. We now have several techniques available for the repair of the early production modules, as well as trained technical staff to carry them out. This repair work will be undertaken in the fall of 2002.

(J. Proudfoot and R. Stanek)

e) Test Beam Program

An Argonne staff physicist continues to be the coordinator of the Tile Cal testbeam program. In addition, a Division computer scientist continued to develop readout code for the online data acquisition system. Three testbeam periods were allocated to the Tile Calorimeter in July, August, and September. This period was devoted to developing a calibration program, ascertaining that the drawer electronics will be reliable and functional, and verifying timing of the trigger cables.

(R. Stanek)

f) Engineering Design and Analysis

Substantial progress has been made in several areas of the engineering work in which Argonne staff have major responsibilities. Argonne has agreed to take responsibility for several of the engineering tasks associated with assembly of the calorimeter as a whole and its support system. These tasks include: engineering analysis, in which V. Guarino is responsible for the summary of engineering calculations, finite element analysis of the cylinder, and the design of the barrel and extended barrel saddle supports. A solid model of this saddle, as used for the extensive finite element calculations that were carried out, is shown in Figure 2.

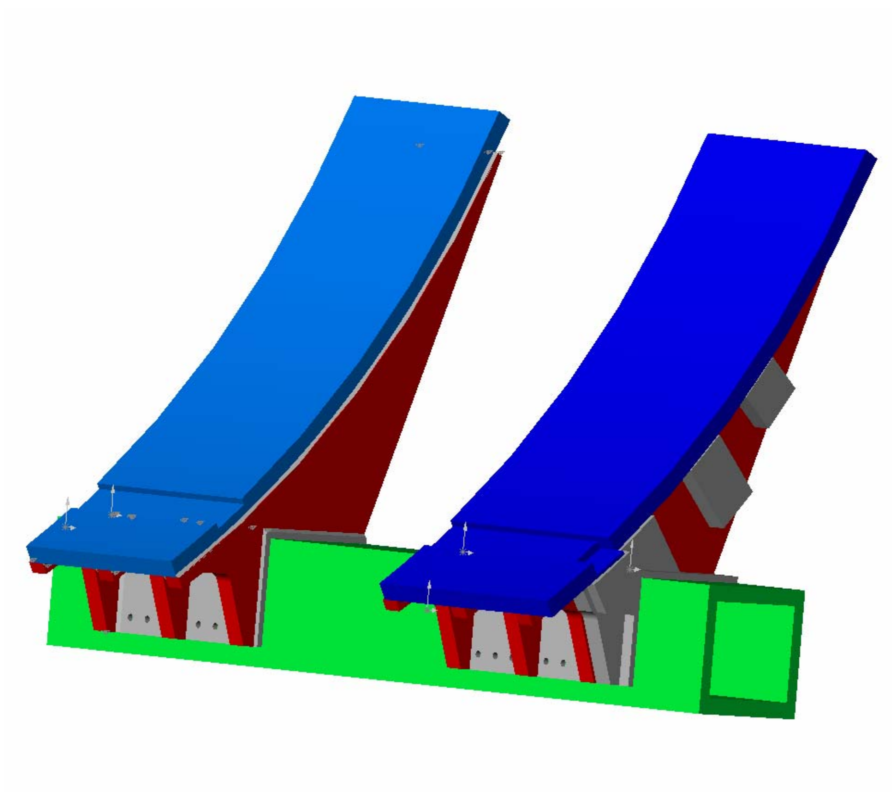


Figure 2. Solid Works FEA model of Extended Barrel Saddle.

The design and analysis of the endcap calorimeter support saddle was reviewed by Atlas Technical Coordination in December 2001. Unfortunately, the review committee did not approve the design for construction, but rather asked that some of the calculations be re-visited and reformulated in terms of Eurocode norms. This work was started in late December and will be completed early in 2002. We expect to commence procurement of the first set of saddles in the spring of 2002.

In addition, ANL engineers have proposed to contribute to work within the area of ATLAS Technical Coordination. A first task in this is the design of the x-brackets used to guide the calorimeters into position on the Atlas main rail system. Some initial conceptual work was done in the last quarter of 2001 and we expect to begin detailed design of the bracket in January 2002.

(J. Proudfoot and V. Guarino)

I.C.2. Computational Projects

a) ATLAS Computing

Argonne (through David Malon) continued to lead the ATLAS-wide database effort in the 2nd half of 2001. In this time period, triggered by a similar decision by CMS and the ATLAS policy to use common tools, ATLAS decided to move away from Objectivity/DB and towards a new, as-yet-unspecified common persistence tool. We also delivered the ATLAS database architecture document and began the first of a series of data challenges, Data Challenge 0.

Significant U.S. effort during the quarter was devoted to adaptation of the Objectivity conversion service to the new StoreGate data store model, as the "new" StoreGate backend entered ATLAS software releases in October. User support for persistency in event generation and fast simulation continued to consume much more effort than the database effort should reasonably have been expected to provide, diverting development time into support for a product that was intended only to be a demonstration that Athena could, in fact, use multiple storage technologies. In this time frame, we changed the ATLAS release from SRT to CMT. While CMT is more maintainable in the long-term, substantial effort was expended in making this conversion.

ATLAS has always had as its strategy the adoption of LHC wide common tools. Our own evaluation of Objectivity/DB was scheduled for late 2002, but after CMS has abandoned it, it is no longer viable to be the only experiment using it. Our database design insulates user code from the persistency technology, so this new direction should not impact user code. It will, of course, impact core database code.

A principal focus of the U.S. ATLAS database effort was the elaboration of a draft ATLAS database architecture for the event store. Greg Chisholm of ANL with Ed Frank of the University of Chicago spearheaded this effort. We planned to deliver a draft document by the end of the summer, and this milestone was met, with the draft delivered in mid-September and presented in the database session of the September ATLAS

Software Week. Several meetings were held within ATLAS to guarantee collaboration input, particularly with the BNL team to insure that this architecture did not inadvertently bias us towards any particular persistency technology. In 1Q02, specific implementations of this architecture will be developed and documented.

The first ATLAS data challenge is beginning this year. DC0 is intended to be a small continuity test (100,000 events) before generating the millions of events in DC1. This will give ATLAS the opportunity to test its software on a larger scale than previously possible. As the scale of the data challenges grow, so will the need for database support.

Prototype scenarios for grid-enabled data access from Athena, the ATLAS experiment's control framework, were investigated. Two approaches, in particular, were explored, one involving registration of files containing event collections with the Globus replica catalog, the other involving use of GDMP 1.2.2. The latter approach was exercised on EU Data Grid testbed nodes in Geneva and Milan, using the ATLAS fast simulation program Atlfast running under Athena, with the object database product Objectivity/DB as the underlying storage technology.

This work was described at the CHEP'01 conference in Beijing:

Malon, May, Resconi, Shank, Vaniachine, Youssef, "Grid-enabled data access in the ATLAS Athena framework," Proceedings of Computing in High Energy and Nuclear Physics 2001, Beijing, China, September 2001.

(T. LeCompte)

I.C.3. Electronics Support Group

CDF: We are involved with the development of front-end electronics for the Shower Max Detector of the CDF Upgrade at Fermilab. For this project, we have major responsibilities for the electronics engineering of the system. The system has 20,000 channels of low-noise electronics, and services two detector subsystems. The primary responsibilities involve the coordination of the design engineering and system integration for the entire system, overseeing the production of all components, and ensuring that the overall system meets performance requirements. The development work is a collaborative effort between Argonne and Fermilab.

In the last reporting period, we completed the production work for the electronics. All electronics were installed on the detector and commissioned for operation. We were successful in meeting the schedule goals in getting ready for Fermilab Run II, which is now in progress.

In this period, we continued our participation with the experiment by providing technical support for the maintenance and repair of all of the electronics for this subsystem. This includes those projects that were the responsibility of Fermilab. We anticipate providing this support through the life of the experiment. The system includes 100 VME read-out boards called SMXR Modules, 600 front-end boards called SMD Modules, 6000 front-end daughter cards called SQUIDs, 100 front-end crate controllers called SMC Modules, 600 preamp boards, 15,000 preamp SIPS (Single In-line Package), and 60 crate monitor boards.

In addition to the Shower Max front-end electronics, we have also built electronics for the CDF Level 2 Trigger. One project is called RECES. The modules in this subsystem receive trigger information from the Shower Max front-end electronics, and provide information to the Level 2 Trigger. This project has been completed, with all electronics installed and working. We also provide technical support and maintenance for this project.

Another project for the Level 2 Trigger System is the Isolated Photon Trigger. This subsystem receives information from the calorimeter, and triggers on isolated photons in the detector. The subsystem consists of three types of modules. This project is also completely installed and functional. Like the other projects, we provide long-term support and maintenance.

ATLAS: We have major responsibilities in the development of electronics for the Level 2 Trigger of the ATLAS Detector at CERN. Working with colleagues from Michigan State University, we are responsible for the development of two parts of this system: the Level 2 Trigger Supervisor, and the Region of Interest (ROI) Builder.

The ROI Builder is the interface between the first level trigger and the second level trigger. When an event occurs in the detector, signals are sent from the front-end electronics to the Level 1 Trigger. The Level 1 Trigger collects event fragments from the front-end electronics over the entire detector, and stores them in a Readout Buffer. It evaluates the data, and identifies regions of the detector that could have an interesting event. The Level 1 Trigger boards then sends a list of addresses called pointers to the ROI Builder, identifying where the event data from the "Region of Interest," can be found. The ROI Builder collects the pointers for the event, and "builds" the event using the pointer list. It then sends the result to the Trigger Supervisor for distribution to Level 2 processors. The selected Level 2 Processor then executes algorithms using the pointers, and can request information to be sent from the Readout Buffers as needed. The ROI Builder is highly complex, using fast, high-density Field programmable Gate Arrays (FPGAs) to implement the functionality.

We have a working system at CERN, called the Atlas Test Bed, where system tests are being performed. In the early part of 2001, the prototype ROI Builder was used in integration tests for different detector subsystems. The tests were largely successful. In this period, testing continued on the prototype system. We are providing much of the software development and support for this phase of the project.

Development efforts for the ROI Builder continued during his period. A particular accomplishment during this period was the completion of a prototype run of Gigabit Ethernet Link Source cards. These are intended to lay the groundwork for the use of Gigabit Ethernet as a protocol to transfer information into and out of the ROI Builder. The cards make extensive use of large programmable logic arrays. They also have a large, fast synchronous memory that might allow their use as an intermediate data storage element. A proposal under consideration is to implement an architecture in the Readout Buffers that is similar to the Gigabit Ethernet Source Link Card. This has several advantages in how the networking is configured. It is planned to use these cards in the Atlas Test Bed to investigate the merits this proposal.

Another project for ATLAS is the development of an interface card for the clock system, called the TTC Mezzanine card (TTCPR). Clock and control information is passed to different parts of the detector on optical fiber in an encoded format. Engineers at CERN have developed a custom integrated circuit called the TTC. The device receives the serial data, and converts it to the appropriate control signals needed by the various subsystems. The card designed at Argonne hosts the device, which is implemented using ball grid array (BGA) technology. The card itself has a PCI format, which is a standard used by digital processors to interconnect auxiliary data streams. The first version was designed in 2000. A new version was designed in early 2001 that uses a new version of the TTC. In this period, we produced several of the cards for use in various test stands and applications at CERN. In particular, we provided cards for the Atlas Test Beam, where portions of the detector are undergoing tests. Other experiments at CERN have expressed interest in using this card.

<u>MINOS</u>: We are involved with the development of electronics for MINOS, the Neutrino Oscillation Experiment at Fermilab and the Soudan mine. We have major responsibilities for the design, development, and production of electronics Near Detector, one of the two major detectors for this experiment.

The heart of the front-end electronics for the Near Detector is a custom integrated circuit designed at Fermilab, called the QIE. The QIE digitizes continuously at 53 MHz. The operations are pipelined so that there is no deadtime due to digitization. The digitized data will be stored in a local memory during the entire period of the beam spill. The data will be sent from the local memory to a read-out board after the spill is over. In between spills, the electronics will record data from cosmic rays.

The QIEs and associated circuitry will be built on small daughter boards called MENU Modules, which resemble memory SIMMs. The boards contain a high density of surface mount parts. The MENU Modules plug in to a motherboard called the MINDER Module. The MINDERs reside in front end crates called MINDER Crates, which are a semi-custom design. There is a crate controller in the MINDER Crates called the KEEPER, which controls all activity in the crate. When data is acquired, it is stored on the MENU Modules. After data is acquired, the MINDER then initiates a readout operation, where the data is sent from the MENUs to a VME readout board, called the MASTER Module. The MASTER resides in a 9U VME crate located some distance away from the MINDER Crates. All of the board designs contain a high level of programmable logic to do the complex processing of data and control of operations.

The chip design, and the development of the QIE daughter board, are responsibilities of Fermilab. Argonne is responsible for the design the MASTER Module, the MINDER Module, the KEEPER, and the MINDER Crate. We also have overall responsibility for the design of the rest of the system for the Near Detector, including the specifications for the QIE performance.

The first prototype MASTER Module was designed and built in latter part of 2000. In this period, we continued testing the MASTER. We also designed and built the first prototypes of the KEEPER and the MINDER. These were tested with the first prototypes of the MENU, which were built at Fermilab. System tests are in progress. We plan to develop a complete "Vertical Slice" of the system by the early part of 2002. We also plan to build 200 channels for use at a test beam at CERN by the summer of 2002.

ZEUS: We are involved with the development of front-end electronics for the new Straw Tube Tracker Detector of the ZEUS experiment at DESY. The new detector uses straw tubes, rather than the older-style wire chamber technology. The detector produces a pulse in response to a charged particle passing through the detector. The front-end electronics is situated directly on the detector. It uses a custom integrated circuit designed at PENN, called the ASDQ. The device receives charge pulses from the detector, and sends a digital signal to the “back end” electronics located off the detector in a counting room, where a timestamp for the signal is recorded. The back end processors then use the timestamps to reconstruct the trajectory of the particle through the tracking detector. There are ~12,000 channels in the detector in total, although the front end electronics multiplexes 6 detector channels into each readout channel to reduce the number of signal wires between the front end and the back end.

In the last period, we completed the production of 200 front end boards for the experiment. The boards were checked out at Argonne, and sent to ZEUS for installation onto the detector. We were successful in meeting the production schedule, and ZEUS is now taking data. We intend to provide support as needed for the life of the experiment.

(G. Drake)

II. THEORETICAL PHYSICS PROGRAM

II.A. THEORY

II.A.1. The Puzzle of the Bottom Quark Production Cross Section and a Possible Supersymmetry Explanation

A long-standing puzzle in heavy flavor production is the excess hadronic production of bottom (*b*) quarks recorded by the CDF and D0 collaborations. The measured cross section is a factor of two or three larger than the central value of predictions in perturbative quantum chromodynamics (QCD). In Physical Review Letters 86, 4231-4234 (2001), Ed Berger, Brian Harris, David Kaplan, Zack Sullivan, Tim Tait, and Carlos Wagner suggest that this discrepancy signals a contribution from "new physics". They postulate the existence of light gluinos and light bottom squarks. Light gluinos of mass between 12-16 GeV are pair-produced strongly by $q\bar{q}$ and gg fusion subprocesses. The gluinos then decay into a bottom quark and a bottom squark, $\tilde{g} \rightarrow b\tilde{b}_1^*,\ \bar{b}\tilde{b}_1$, where the bottom squark mass is in the range 2-5.5 GeV. The bottom squark remains relatively stable or decays promptly into other light hadrons (e.g. via *R*-parity violating couplings). The gluino and bottom squark masses are adjusted to reproduce the magnitude of the transverse momentum distribution of the *b*-quark and to be consistent with data on the time-averaged $B^0 - \bar{B}^0$ mixing.

Ed Berger continued to work during the second half of 2001 on the theory and phenomenology of light gluinos and light bottom squarks. In Argonne report ANL-HEP-CP-01-118 (hep-ph/0112062), the written version of his invited talk at the 9th International Symposium on Heavy Flavor Physics, Pasadena, California, 10-13 Sep 2001, and in Argonne report ANL-HEP-PR-02-001 (hep-ph/0201229), to be published in Int. J. Mod. Phys. A, he discusses constraints on this scenario from other data and explores implications of the proposal. Contrary to first impressions, the scenario is consistent with cosmological constraints, with precision data in $Z^0 -$boson decays, and with other low energy data. The scenario survives since (i) all previous limits on light gluinos are not applicable because the postulated mass range is different or the decay channel of the gluino is different, and (ii) the mixing angle of $\tilde{b}_L$ and $\tilde{b}_R$ can be tuned to a value such that the tree-level coupling of the light bottom squark $\tilde{b}_1$ to the *Z* boson is negligible.

The light gluino and light bottom squark scenario gives rise to many other interesting possible signals. Decay of the $\Upsilon(nS)$ states into a pair of light bottom squarks is explored by Berger and Lou Clavelli in Physics Letters **B**512, 115-120 (2001), and decays of the bottomonium χ_{bJ} states into light bottom squarks is calculated by Berger and Jungil Lee in Argonne report ANL-HEP-PR-02-021 (hep-ph/0203092), published in Physical Review **D**65, 114003 (2002). Among other implications are an enhancement of $\bar{t}t \quad \bar{b}b$ production at hadron colliders, flavor-changing effects in radiative decays of *B* mesons, and enhanced $\bar{q}q \quad \bar{b}b$ at both LEPI and LEPII. Results on Higgs boson decays into bottom quarks and on radiative decays of bottomonium states will be reported in semi-annual reports for calendar year 2002. According to the SPIRES database, over 25 subsequent papers have thus far cited the original paper of Berger, *et al*.

(E. L. Berger)

II.A.2 2001 Snowmass Summer Study

Ed Berger was an active participant in the activities of the APS / DPF / DPB Summer Study on the Future of Particle Physics (Snowmass 2001), 30 Jun - 21 Jul 2001. Among the subsequent written reports to which he made substantial contributions are Snowmass 2001: Jet Energy Flow Project, by C. F. Berger, E. L. Berger, *et al* (hep-ph/0202207) and Working Group on QCD and Strong Interactions: Summary Report, by E. L. Berger, *et al* (hep-ph/0201146). Both of these papers appear in the proceedings of the Summer Study.

(E. L. Berger)

II.A.3. Decay Matrix Elements from Lattice Measurements

This research was presented in the report for July 1--December 31, 2000. During the current reporting period, G. Bodwin, S. Kim, and D. K. Sinclair completed a paper describing that research (ANL-HEP-PR-01-026, hep-lat/0107011). It has been published in Phys. Rev. D **65**, 054504 (2002).

(G. T. Bodwin)

II.A.4 B Physics at the Tevatron Run II and Beyond

The proceedings of the Workshop on B Physics at the Tevatron Run II and Beyond have been published as Fermilab-PUB-01/197. G. Bodwin and B. Harris contributed the section "Fragmentation in the Nonperturbative Regime". This contribution contains several original results, which were described in the report for July 1--December 31, 2000.

(G. T. Bodwin)

II.A.5 Relativistic Corrections to Gluon Fragmentation to J/ψ

At the Tevatron, J/ψ production at the largest values of p_T is dominated by the mechanism of gluon fragmentation into J/ψ. The fragmentation contribution to the quarkonium production cross section may be computed in the Non-Relativistic QCD (NRQCD) factorization formalism (Bodwin, Braaten, Lepage) as an expansion in powers of the heavy-quark-antiquark relative velocity v. At leading order in v, an analysis of the Tevatron data leads to the conclusion that the fragmentation proceeds predominantly through production of a heavy-quark-antiquark pair in a color-octet state. That result, taken together with the NRQCD rules for the scaling of spin-flip and non-spin-flip interactions with v, leads to a prediction that the produced $J/\psi's$ should have a substantial transverse polarization (Cho, Wise). Current CDF data do not confirm this expectation, although the error bars are large.

It is known in the case of J/ψ decays that relativistic corrections (relative order v^2) are very large ($\approx$ 100%). Motivated by this fact and by the importance of the fragmentation mechanism for the interpretation of the Tevatron data, G. Bodwin and J. Lee have undertaken a calculation of the relativistic corrections to the color-singlet and color-octet fragmentation functions for gluon fragmentation to J/ψ.

The correction to the color-octet fragmentation function involves diagrams with an outgoing heavy-quark-antiquark pair and only two external gluons. Hence, it is relatively simple to compute. On the other hand, the correction to the color-singlet fragmentation function involves diagrams with an outgoing heavy-quark-antiquark pair and three external gluons. The rather tedious, but straightforward, algebra for this computation was handled by making use of symbolic-manipulation computer routines. In addition, it was necessary to carry out some of the phase-space integrations analytically and to make some subtle changes of variables in order to put the remaining integrations over the final-state gluon energies into a form that is suitable for numerical evaluation.

Preliminary results are that the corrections are $2.5v^2$ for the short-distance coefficient of the color-singlet fragmentation function and $-1.8v^2$ for the short-distance coefficient of the color-octet fragmentation function. In the case of the J/ψ, $v^2 \approx 0.3$. Therefore, the color-singlet correction is about +74%, and the color-octet correction is about -54%. The large correction to the short-distance coefficient of the color-singlet fragmentation function reduces the predicted polarization of the J/ψ by about 10% at the largest measured value of p_T. The large correction to the short-distance coefficient of the color-octet fragmentation function will not immediately change the predicted size of the color-octet contribution to J/ψ production at the Tevatron, since the unknown color-octet matrix element that multiplies the short-distance coefficient is determined, at present, by fitting to the Tevatron data. However, the large correction will ultimately be important in evaluating the consistency of the fitted matrix element with the NRQCD velocity-scaling rules and with determinations of the matrix element from other processes and, eventually, lattice computations.

A paper describing this work is in progress.

(G. T. Bodwin)

II.A.6 New Regulator for NRQCD

G. Bodwin, E. Braaten (Ohio State), and J. Lee have begun investigations of a new method for regulating divergences in operator matrix elements in Non-Relativistic QCD (NRQCD). The method expresses the NRQCD matrix elements in terms of matrix elements in full QCD and, then, regulates the matrix elements in full QCD dimensionally. This method, in effect, regulates ultraviolet divergences in NRQCD operator matrix elements with a cutoff of the order of the heavy-quark mass. However, unlike momentum-cutoff methods, it is gauge and Lorentz invariant. NRQCD operator matrix elements that are defined with this regulator include power-ultraviolet-divergent contributions. This is to be contrasted with the situation for dimensionally regulated matrix elements, in which the power-divergent contributions vanish.

It is known in a number of examples in quarkonium decay that the leading power-divergent contribution to the NRQCD operator matrix element is correlated in magnitude and sign with the order-a_s correction to the corresponding short-distance coefficient. Therefore, one might hope that a cutoff regulator would reduce the sizes of the order-a_s corrections to the short-distance coefficients by incorporating the power-divergent parts of those corrections into the NRQCD operator matrix elements. Preliminary investigations for the case of *S*-wave quarkonium decays indicate that that is the case.

One problem with this method that remains to be addressed is the possibility that the order-a_s corrections to the short-distance coefficients might change substantially as one introduces full-QCD operators of higher dimension into the computation. Dimensional analysis suggests that operators of arbitrarily high dimension can yield comparable contributions.

Work on this topic is in progress.

(G. T. Bodwin)

II.A.7. New Tools for Fermion Masses from Extra Dimensions

The paper "New Tools for Fermion Masses from Extra Dimensions", by David E. Kaplan (SLAC) and Tim Tait (Argonne), published in JHEP 0111, 051 (2001), considers models in which the patterns of both quark and lepton masses and mixings can be explained by the existence of one or more small extra dimensions. The fermions are localized on domain walls formed by non-trivial vacuum expectation values of a scalar field that vary along the extra dimension. This results in all of their interactions in the four-dimensional effective theory being suppressed by the overlap of their profiles in the extra dimension. Thus, the up quark may be explained to be very light, because its right- and left-handed components are localized far from each other, whereas the top is heavy, because its right- and left-handed components are localized close to one another. Flavor-changing neutral currents mediated by Kaluza-Klein modes of the gauge bosons and contributing to phenomena such as Kaon oscillations are considered and found to result in strong constraints on the allowed size of the extra dimensions. Supersymmetric versions are also constructed, and a powerful 5-dimensional superfield formalism is exploited in order to analyze field configurations that preserve one, four-dimensional supersymmetry. Mechanisms that utilize the extra dimension to communicate supersymmetry breaking to the gauginos, squarks and sleptons in a flavor-safe way (including gaugino mediation and Scherk-Schwarz supersymmetry breaking) are considered and the resulting pattern of super-partner masses is computed.

(D. E. Kaplan and T. Tait)

II.A.8 Lattice Gauge Theory

During this time frame, we have extended our work on simulations of Lattice QCD and related theories at finite temperature and/or densities. Because the introduction of finite baryon number density into QCD leads to sign problems, which are not adequately handled by current simulation methods, we are studying related finite density systems that do not have such difficulties. In particular, we have been considering 2-colour QCD at finite quark-number density and QCD at finite isospin (I_3) density.

We have extended our simulations of 2-colour QCD at finite chemical potential μ for isospin on 8^4 and $12^3 \times 24$ lattices, to smaller quark masses (m = 0.025, down from m = 0.01). These simulations are probing the chiral limit of this theory and its spectrum of light scalar/pseudo-scalar excitations. As for the heavier mass case, we see evidence for a phase transition to a state with a diquark condensate at $\mu = \mu_c \sim m_\pi / 2$ (Fig. 1). Such a superfluid state is the analogue of the colour-superconducting state, predicted for QCD at high baryon-number density. We are also extending our simulations to weaker coupling on a 16^4 lattice with m = 0.05, to study critical scaling at this transition. In addition, we are performing simulations at finite temperature as well as finite μ on a $12^3 \times 6$ lattice to verify our observations from simulations on an $8^3 \times 4$ lattice.

We have almost completed our simulations of QCD with a finite chemical potential μ_I for isospin (I_3) on an 8^4 lattice. Since nuclear matter is at finite (negative) I_3 density, as well as baryon-number density, we are probing a surface in the phase diagram for nuclear matter. Here we see clear evidence for a phase transition to a state with a pion condensate, which breaks I_3 and parity spontaneously. We are also studying how this condensate behaves as we heat the system on an $8^3 \times 4$ lattice. It is interesting to speculate whether such a state is present when the system is also at finite baryon-number density, i.e. whether nuclear matter might exhibit some of these properties.

We are interested in extending our zero-mass finite temperature lattice QCD simulations, which have proved very revealing in determining the quantitative properties of the phase transition from hadronic matter to a quark-gluon plasma, to larger lattices with smaller lattice spacings. With this in mind, we have produced MPI versions of our simulation codes for QCD with extra 4-fermion interactions, which allow such zero-mass simulations.

Our simulations have been performed on IBM SP's at NERSC and NPACI, and CRAY SV1's at NERSC.

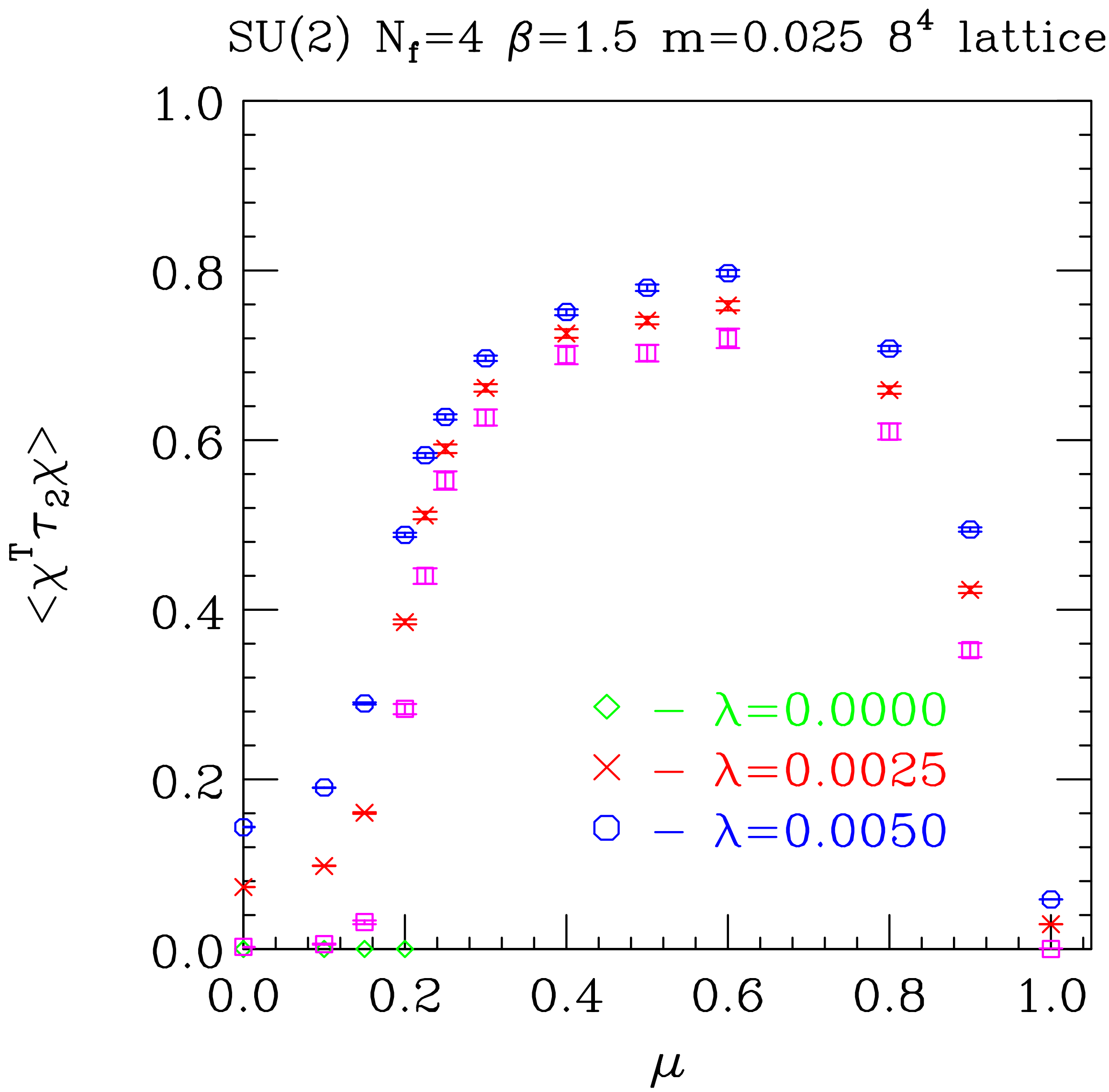


Figure 1. Diquark condensate as a function of μ .

(D. K. Sinclair)

II.A.9 Top Quark Seesaw, Vacuum Structure, and Precision Electroweak Constraints

The paper "Top Quark Seesaw, Vacuum Structure, and Precision Electroweak Constraints", by Hong-Jian He (U. Texas, Austin), Christopher T. Hill (Fermilab) and Tim Tait (Argonne), to be published in Phys. Rev. D, is a critical analysis of the Top Seesaw model of electroweak symmetry breaking. This model is a well-motivated dynamical scenario that manages to generate the W and Z boson masses, as well as explain why the top quark has a huge mass with respect to the light fermions. It predicts the existence of composite Higgs bosons, and heavy colored matter that is vector-like with respect to the weak interactions. Our paper rigorously computes the predictions of the model, and extracts the phenomenologically sound regions of parameter space both in terms of predictions for the W and Z masses, the mass for the top quark, and complete consistency with precision measurements. Extensions that explain the bottom quark mass either through additional, vector-like matter or from Topcolor instanton effects, are proposed and analyzed and, it is shown that this scenario is likely to naturally arise in a theory including compact extra dimensions.

(T. Tait)

II.A.10 Beautiful Mirrors and Precision Electroweak Data

The paper "Beautiful Mirrors and Precision Electroweak Data", by D. Choudhury (Harish-Chandra Research Institute, India, and also visiting Argonne while this work was carried out), Tim Tait, and Carlos Wagner (Argonne), to be published in Phys. Rev. D, examines the current data from LEP on the structure of bottom quark (right- and left-handed) couplings to the Z boson. The data deviates from the Standard Model prediction for these couplings by roughly three standard deviations, possibly hinting at the effects of physics beyond the Standard Model. Furthermore, the data from bottom quarks plays an essential role in the fit to the Higgs mass, revealing a tension between different sets of measurements in the fit, and further suggesting the presence of nonstandard physics. We examine the data from LEP and also from higher and lower energy measurements in order to assemble a comprehensive picture of the bottom couplings to Z. We then propose a specific model of new physics in which we introduce nonstandard quarks--"Beautiful Mirrors"--that mix with the bottom, affecting its coupling to Z and successfully reproducing the observed data. We perform a fit to the data including our beautiful mirrors (see Fig. 1) and find that in one case the mirror quarks are light (about 250 GeV) and thus observable at Run II of the Fermilab Tevatron, and the Higgs is heavy (about 300 GeV). A second scenario has heavier quarks (about 1 TeV) and a light Higgs of about 100 GeV. The effects of the mirrors on gauge coupling unification are examined and it is found that they can improve the unification of couplings with respect to the Standard Model.

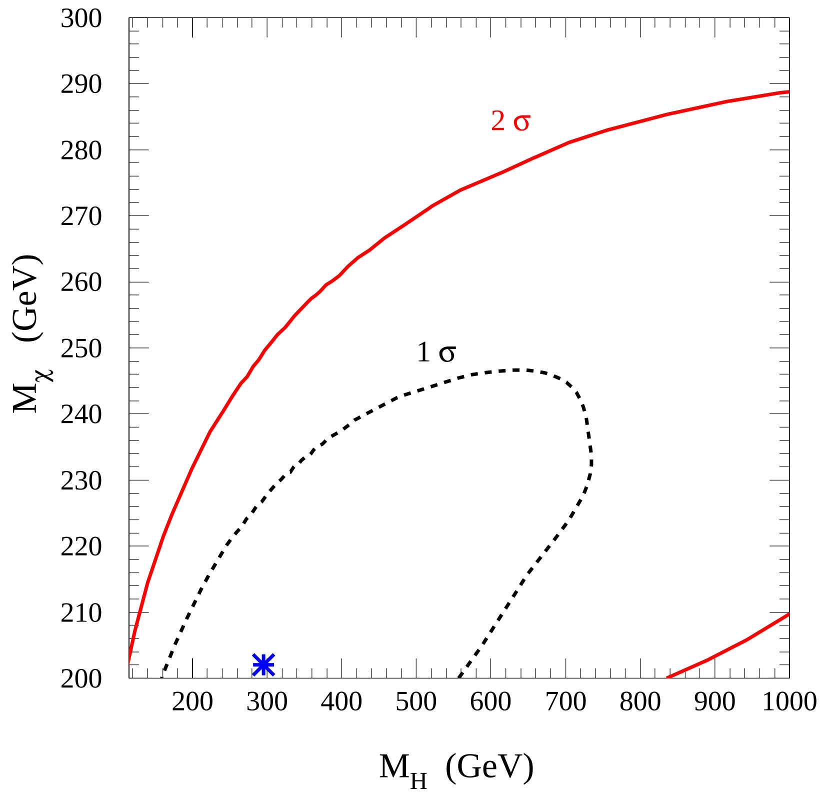


Figure 1. The result of the fit to electroweak precision observables in the beautiful mirror model. The central value of the fit in the plane of the Higgs mass (M_H) and the exotic quark mass (M_χ) is indicated by the asterisk (*) and the 1- and 2σ contours are indicated by dashed and dotted lines, respectively.

(C.E.M. Wagner and T. Tait)

II.A.11 The Chiral Anomaly And High-Energy Scattering In QCD

Any solution of the full Regge limit of QCD must, almost certainly, involve a resolution of the unsolved problem of matching perturbation theory with confinement. In two, recent, long papers by Alan White, both of which are soon to be published in Physical Review D, it is shown that a transition from perturbation theory to confinement can indeed occur in the Regge region. The chiral anomaly plays a crucial role and is the only "non-perturbative"' element involved.

In the first paper (hep-ph/0202169), infra-red properties of the triangle anomaly and the "anomaly pole" are first elaborated and then applied to the study of Regge limit scattering when the gauge symmetry is partially broken to SU(2) (color superconducting QCD). White shows that, when the gauge symmetry is broken, the chiral flavor anomaly provides a wee-gluon component for Goldstone bosons (pions) that combines with interactions due to the U(1) anomaly to produce an infra-red transverse momentum scaling divergence in scattering amplitudes. After the divergence is factorized out, as a wee gluon condensate in the infinite momentum pion, the remaining physical amplitudes have confinement and chiral symmetry breaking. A lowest-order contribution to the pion scattering amplitude is calculated in detail. Although originating from very complicated diagrams, the amplitude has a remarkable (semi-)perturbative simplicity. The momentum structure is that of single gluon exchange, but zero transverse momentum quarks inject additional spin and color structure via anomaly interactions.

In the second paper (hep-ph/0205036), White studies, in detail, how chirality transitions occur in the effective triangle diagram Reggeon interactions that are obtained by placing quark lines on-shell in large quark loops. These interactions appear in the Reggeon vertices that couple different Reggeon channels (in a general multi-Regge limit). In particular, they occur in the triple-Regge vertices that couple three distinct Reggeon channels. Such vertices include the couplings of bound-state pions and nucleons together with their couplings to the physical pomeron and, effectively, determine the bound-states of the theory and their Regge limit scattering amplitudes. In the dispersion relation formalism developed by White, the anomaly must be due to the contributions of unphysical triple discontinuities. Therefore, he applies an asymptotic discontinuity analysis to high-order Feynman diagrams to show that the anomaly occurs only in sufficiently high-order Reggeized gluon interactions. Gluon combinations with the quantum numbers of the anomaly (winding-number) current must be involved and so a direct connection with the well-known U(1) problem is established. Amongst the diagrams discussed are those that contribute to the pion/pomeron and triple pomeron couplings that appear in the first paper.

(A. R. White)

II.A.12 Area Potentials And Phase Space Quantization

C. Zachos has completed a review article on Deformation Quantization [ANL-HEP-PR-01-095, Int. J. Mod. Phys. A **17**, 297-316 (2002)] that he was invited to write by World Scientific for that designated showcase slot. This is a formulation pioneered by Moyal (who worked at ANL for a decade), which furnishes a third alternative, independent of the conventional Hilbert Space, or Path Integral formulations. In this logically complete and self-standing formulation, one need not choose sides—coordinate or momentum space: It works in full phase-space, accommodating the uncertainty principle. The review provides a self-contained, coherent, and applications-oriented introduction to an HEP audience that has been showing signs of dissatisfaction with extant partial reviews intended for other fields, and thus not optimized for utilization in particle physics. It is also likely that the new and old technical tricks displayed there will find new uses by the noncommutative geometry physics community.

In collaboration with T. Curtright (U. Miami) and A. Polychronakos (Rockefeller U.), Zachos has introduced and analyzed area potentials involving ≥ 3-body interactions [ANL-HEP-PR-01-111, Phys. Lett. A **295**, 241-246 (2002)]. The authors investigate and stabilize the spectra of these new models and their maximally superintegrable symmetry charges. Finally, they quantize them in phase space (constructing their Wigner Functions—the density matrices in deformation quantization), providing extensions to many-body theory.

(C. Zachos)

III. ACCELERATOR RESEARCH AND DEVELOPMENT

III.A. ARGONNE WAKEFIELD ACCELERATOR PROGRAM

III.A.1. The Argonne Wakefield Accelerator Facility Status

The new AWA RF photocathode gun has been installed on the gun test stand and the waveguide for delivering RF power has been routed to the gun. The new gun underwent a high temperature (> 300^{o}F) vacuum-bakeout for one week and reached a final pressure of 3x10^{-10} Torr. After the bakeout the gun was high-power RF conditioned. The diagnostics monitored during conditioning were: (1) the vacuum pressure; (2) the dark current with a Faraday Cup; and (3) the cathode area for sparks with an intensified camera. During the test, very little dark-current was observed compared to the old AWA drive gun and, as a result, the field in the gun will not be loaded down. At the end of the test we had successfully conditioned the gun to accelerating fields greater than 80 MV/m (the design goal). Figure 1 shows the new gun on the test stand and Figure 2 shows one of the arcs in the gun that occurred during the RF conditioning process.

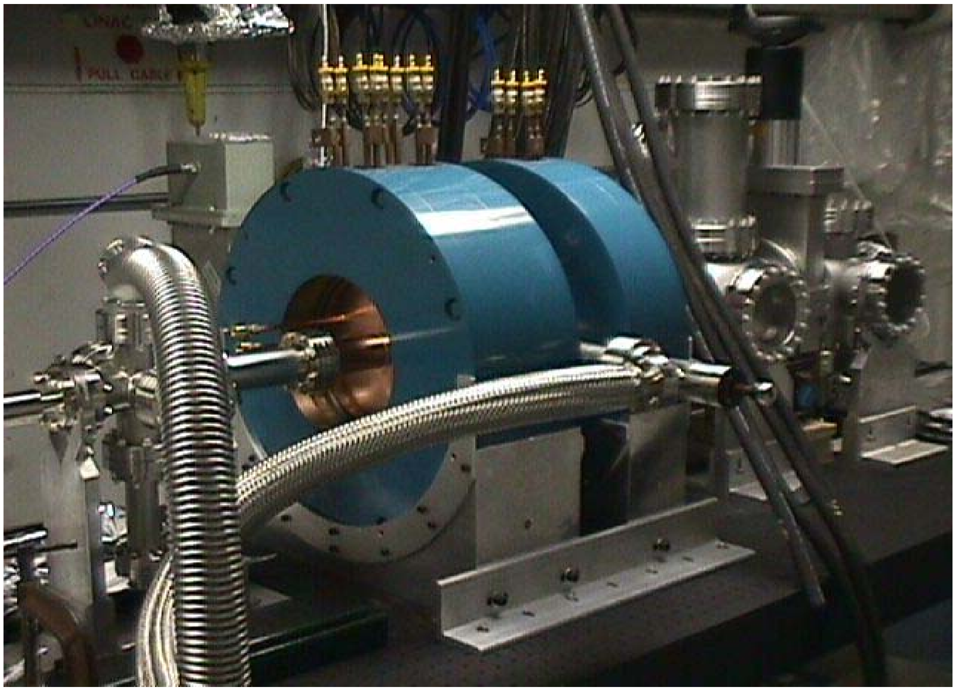


Figure 1. The new AWA gun on the test stand. The gun has been RF conditioned to the designed field strength of 80 MV/m with very low dark current measured.

We re-specified the new AWA laser. After a long period of investigation, we decided to purchase a Ti:Sapphire based laser system that is capable of producing 2 mJ UV @ 248 nm and 3mj @ 266nm with a repetition rate of 10 Hz. The laser was delivered to the Building 366 and will be installed in the spring.

The process to replace the existing OS9/HP-based control and data acquisition systems is underway. For this upgrade we ordered and installed: (1) a new PC-based control computer (PIII, 1.0 GHz); (2) a PCI-to-CAMAC interface card (2915); and (3) two CAMAC parallel bus crate controllers (3922-B). We have developed a new NT-based control programs using National Instruments's LabWindow/CVI system. We are

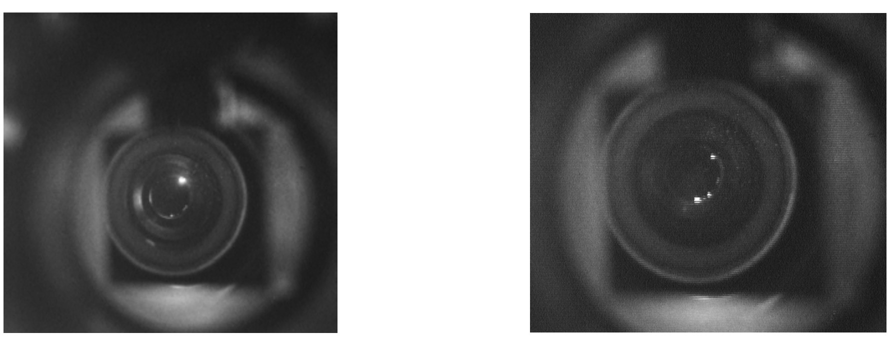


Figure 2. Observed Occasional arcing during the RF conditioning. The right picture shows RF breakdown at 70 MV/m and left is 80 MV/m.

currently migrating all of the AWA operations to a new control and data acquisition system within the next year. Modifications to the data-acquisition system include a new frame grabber that was installed on the data acquisition PC during this period.

III.A.2. Dielectric Standing-Wave Accelerator Development

An 11.424 GHz standing-wave dielectric structure has been constructed. The copper housing and waveguides were brazed with the SLAC hydrogen-brazing furnace. Cold test measurements showed that an unloaded Q of 2200 was achieved. This implies that for a 10 MW input power level we should achieve a gradient of 40 MV/m allowing

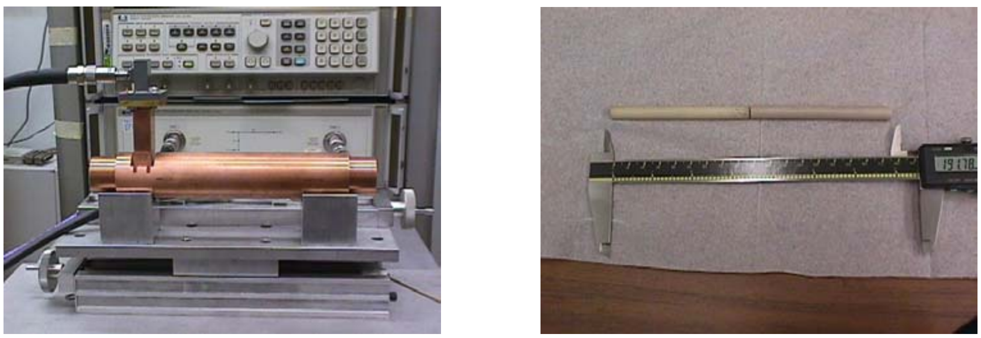


Figure 3. 11.4 GHz standing wave accelerator under the cold test. Right figure shows the two sections of dielectric accelerator are used.

for a meaningful test of the dielectric breakdown phenomena.

III.A. 3 The AWA Accelerator Concepts Developed

We continued our work on dielectric-loaded, rectangular accelerating structures. We did analytic and numerical work on wakefields in these structures with a strong emphasis on the transverse wakefields. It was found that our approach could easily identify all the excited modes and their relative strengths.

Another important work we pursued during this time was the high-power, 21-GHz RF extractor for CLIC-type applications. This work is being done in collaboration with DULY Research. We have simulated an RF extraction device based on our previous work and the schematic is shown in Figure 3. The structure parameters are $l= 30$ cm, $a=5$ mm, $b=6.4$ mm, $\varepsilon=4.98$, and $R/Q=19$ kΩ/m. With an expected current of $I = 20$ A, we expect a power level $P \geq 150$ MW to be produced by and extracted from this device. All the materials have been ordered and the device is now being fabricated by DULY research. A high power test is expected to be conducted at CERN in Fall 2002.

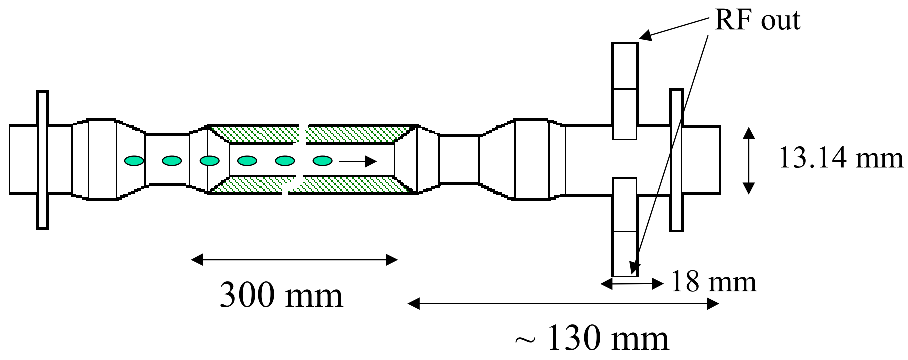


Figure 4. Schematic diagram of a high power RF extractor (PETS) for CLIC applications.

(W. Gai and J. Power)

III. B. MUON COLLIDER RESEARCH

a) Dark Current Measurements in Lab G at Fermilab

There are two experimental efforts leading to operational muon cooling components and a demonstration of cooling, the MUCOOL experiment centered around Fermilab which is primarily aimed at demonstrating components, and the Muon Ionization Cooling Experiment (MICE) which wants to cool muons by more than 10%. The MICE experiment is a European/American/Japanese effort, essentially formed at SNOWMASS 01. The MICE group will be submitting a proposal to Rutherford Lab in December 02, and Rutherford has an area in ISIS and an internal target that can be used, and are already providing an engineer. The Argonne part of these efforts is to determine the backgrounds of dark currents and x rays that will interfere with detectors and limit the accelerating gradient that can be used in the rf cavities.

A group at Argonne, Fermilab, IIT and the Univ. of Cincinnati have systematically measured the parameters of the dark currents produced in a six cell 805 MHz cavity and compared these results with new

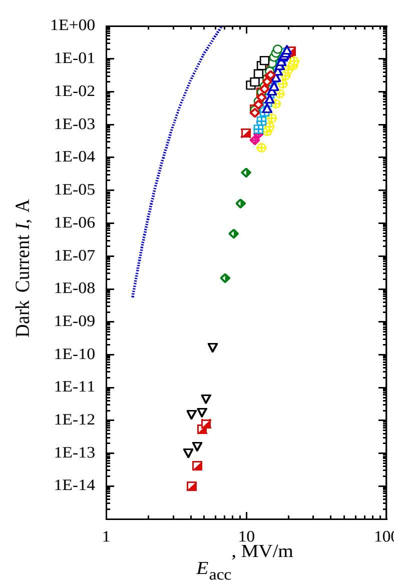


Figure 1: Dark currents vs E_{acc} for an rf cavity, compared with a W probe.

measurements on proton and electron linacs and a variety of superconducting cavities. Our measurements of the dark current production Figure 1, show Fowler Nordheim emission over 14 orders of magnitude. We have also measured the electron energy spectrum, micropulse length, magnetic field dependence, spatial and angular distribution and a variety of other effects. The data also show the effects of different methods of conditioning. We have also seen ring beams formed due to ***E*** x ***B*** drifts during acceleration, perhaps for the first time in high energy physics environment.

The radius of the ring beams depends on the electric and magnetic fields at the point of emission. Measurements have shown that the radii depend on the magnetic and electric field like E/B^2, as shown in Figure 2.

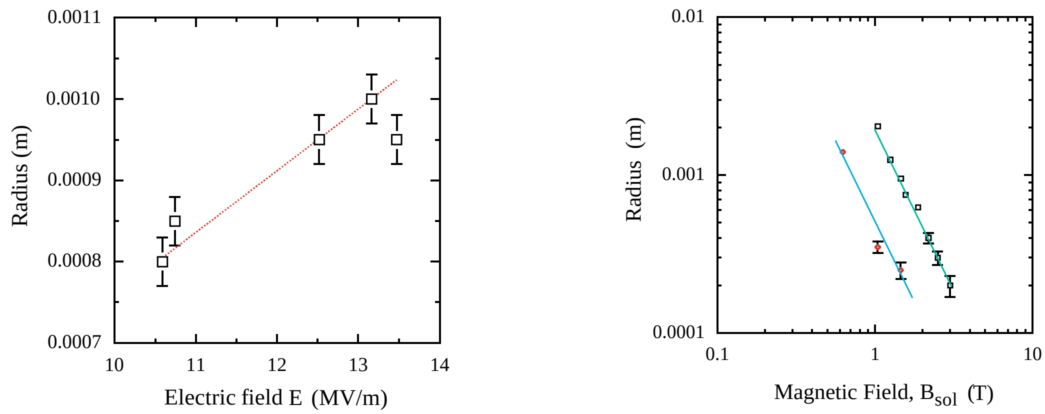


Figure 2: Dependence of ring radius on electric and magnetic fields. The two lines on the graph r(B) refer to beams from different irises in the cavity.

Measurements of the magnetic field dependence of the dark currents have turned out to be unexpectedly difficult since the diagnostics used, the electron orbits and the copper itself are strongly affected by the 2-5 T fields produced.

Most of this data was presented at a Muon group meeting at CERN in October. The data show that it should be possible to produce useful measurements at accelerating field gradients of 10 - 15 MV/m in pillbox cavities, which should be higher than the fields produced by the power supplies we can initially afford.

We have also seen effects which are unexplained and previously unreported, such as the narrow peak in the dark current at the lowest fields, which were seen on one day and did not appear when the data was repeated the next. This peak may be some sort of multipacting effect and we are continuing to acquire data on these phenomena.

b) Electrons in the VLHC Tunnel

Tanaji Sen (Fermilab) and Norem presented the design of a large e^+e^- collider ring at SNOWMASS 01. There was spirited discussion about what sort of polarization could be usefully generated in the machine and what the ultimate Luminosity limits of the machine were. These were finally resolved and papers summarizing the design and possible R & D issues were sent to the SNOWMASS proceedings and Physical Review Special Topics.

(J. Norem)

IV. PUBLICATIONS

IV. A. BOOKS, JOURNALS AND CONFERENCE PROCEEDINGS

A Hybrid Dielectric and Iris Loaded Periodic Accelarating Structure
Peng Zou, Liling Xiao, Xiang Sun, Wei Gai (ANL); Thomas Wong (IIT)
Applied Physics **90**, 4, 2017-2023 (August 2001).

A Laser Strain Gauge for Accelerator Targets
A. Hassanein, J. Norem
In: *Conference Proceedings - Particle Accelerator Conference,* Chicago, IL, June 18-22, 2001, (PAC2001) TPAH121 pp. 1494.

An e^+e^- Collider in the VLHC Tunnel
J. Norem, K. Thompson, et al
In: *Conference Proceedings - Particle Accelerator Conference,* Chicago, IL, June 18-22, 2001, (PAC2001) RPPH112 pp. 3493.

Angular Dependence of the pp Elastic Scattering Spin Correlation Parameter A_{00nn} Between 0.8 and 2.8 GeV. II. Results for Higher Energies
C. E. Allgower, M. E. Beddo, D. P. Grosnick, T. E. Kasprzyk, D. Lopiano, H. M. Spinka
Phys. Rev. C Vol. **64**, 034003 (September 2001)

A Precise Measurement of 180 GeV Muon Energy Loss in Iron
J. Dawson, L. Price, J. Proudfoot, R. Stanek
Eur. J. Phys. C **20**, 487-495 (2001).

A Study of $B^\circ \rightarrow j\psi K(*)^\circ \eta + \eta -$ Decays with the Collider Detector at Fermilab
R. E. Blair, K. L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte, L. Nodulman, J. Proudfoot, R. Thurman-Keup, R. G. Wagner, A. B. Wicklund
Phys. Rev. Lett. **88**, 071801 (2002).

Anomalous $W^+W^- t\bar{t}$ Couplings at the LC
T.M.P. Tait
In: Batavia 2000, Physics and Experiments with Future Linear e+e- Colliders (AIP, Melville, NY, July 2001) pp. 560-563.

Argonne Wakefield Accelarator Facility Upgrade
M.E. Conde, W. Gai, R. Konecny, J. G. Power, P. Schoessow, X. Sun
In: *Conference Proceeding, 2001 Particular Accelerator Conference* Chicago, IL June 18-22, 2001, (PAC 2001) FPAH122, pp. 3957.

Brane Effects on Extra Dimensional Scenarios: A Tale of Two Gravitons
M. Carena, A. Delgado, J. Lykken, S. Pokorski, M. Quiros, and C.E.M. Wagner
Nucl. Phys. B **609**, 499-517 (August 2001).

Charged Particle Multiplicity in Jets in $p\overline{p}$ Collisions at $\sqrt{s}$ = 1.8 TeV
R. E. Blair, K L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte, L. Nodulman, J. Proudfoot, R. Thurman-Keup, R. G. Wagner, A. B. Wicklund
Phys. Rev. Lett. **87**, 211804 (2001).

Cross Section and Heavy Quark Composition of $\gamma + \mu$ Events Produced
R. E. Blair, K L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte, L. Nodulman, J. Proudfoot, R. Thurman-Keup, R. G. Wagner, A. B. Wicklund
Phys. Rev. D **65**, 012003 (2002).

$\overline{d}$ and $^{3}\overline{He}$ Production in $\sqrt{s_{NN}}$ = 130 GeV Au + Au Collisions
R. V. Cadman, T. LeCompte, H. M. Spinka, D. G. Underwood, A. Yokosawa, K. Krueger
Phys. Rev. Lett. **87**, 262301 (December 2001).

Deconstructing Gaugino Mediation
H.-C. Cheng, D. E. Kaplan, M. Schmaltz, and W. Skiba
Phys. Letts. B **515**, 395-399 (August 2001).

Determination of the Quadratic Slope Parameter in $\eta \rightarrow 3\pi^{\circ}$ Decay
C. E. Allgower, H. Spinka
Phys. Rev. Lett. **87**, (November 2001).

Dijet Photoproduction at HERA and the structure of the photon
S. Chekanov, M Derrick, D. Krakauer, S. Magill, B. Musgrave, A. Pellegrino, J. Repond, R. Yoshida
Eur. Phys. J. C **23,** 4, 615-631 (December 2001)

Dijet Production in Neutral Current Deep Inelastic Scattering at HERA
S. Chekanov, M Derrick, D. Krakauer, S. Magill, B. Musgrave, A. Pellegrino, J. Repond, R. Yoshida
Eur. Phys. J. C **23**, 1 13-27 (2001)

Diquark Condensation at Nonzero Chemical Potential and Temperature
J. B. Kogut, D. Toublan, and D. K. Sinclair
Phys. Letts. B **514**, 77-87 (August 2001).

Experimental Demonstration of Two Beam Acceleration Using Dielectric Step-Up Transformer
Wei Gai, M.E. Conde, R. Konecny, J.G. Power, P. Schoessow, J. Simpson, X. Sun, and P. Zou
In: *Conference Proceeding, 2001 Particular Accelerator Conference*
Chicago, IL June 18-22, 2001, (PAC 2001) TPPH090, pp. 1880**.**

Field Analysis of a Dielectric-Loaded Rectangular Waveguide Accelerating Structure
Liling Xiao, Wei Gai, and Xiang Sun
In: *Conference Proceeding, 2001 Particular Accelerator Conference* Chicago, IL June 18-22, 2001, (PAC 2001) FPAH124, pp. 3963.

Fragmentation in the Nonperturbative Regime
G. T. Bodwin and B. W. Harris
In*: Proceedings of the Workshop on B Physics at the Tevatron Run II and Beyond*, Fermilab-PUB-01/197 (December 2001) 517-519.

Field Analysis of a Dielectric-Loaded Rectangular Waveguide Accelerating Structure
Liling Xiao, Wei Gai, Xiang Sun
Phys. Rev. Lett. E **65**, 016505, 1-9 (December 2001).

Fully Differential QCD Corrections to Single Top Quark Final States
B. W. Harris, E. Laenen, L. Phaf, Z. Sullivan, and S. Weinzierl
Int. J. Mod. Phys. A **16S1A**, 379-381 (October 2001).

Global Conformal Anomaly in N=2 String
G. Chalmers and W. Siegel
Phys. Rev. Lett. D **64**, 026001 (July 2001).

Grid-Enabled Data Access in the ATLAS Athena Framework
D. Malon, E. May, A. Vaniachine
In: *Conference Proceedings of CHEP 2001, International Conference on Computing in High Energy and Nuclear Physics*, September 3-7, 2001, Beijing, China.

Higgs-Bosons
J. Lee
In: *Particle Physics Experiments at JLC* (KEK Report 2001-11; hep-ph/0109166) pp. 391-404.

High-Mass Dijet Cross Sections in Photoproduction at HERA
S. Chekanov, M Derrick, D. Krakauer, S. Magill, B. Musgrave, A. Pellegrino, J. Repond, R. Yoshida
Phys. Lett. B **531** 2-28 (December 2001).

High Power Test of the First S-Band RF Gun at SRRC
W. Gai, R. Konecny et al
In: *Conference Proceeding, 2001 Particular Accelerator Conference* Chicago, IL June 18-22, 2001, (PAC 2001) WPAH310, pp. 2423.

High-Power Testing of 11,424 GHz Dielectric-Loaded Accelerating Structures
S. H. Gold, Wei Gai
In: *Conference Proceeding, 2001 Particular Accelerator Conference*

Chicago, IL June 18-22, 2001, (PAC 2001) WPAH132, pp. 3984.

Identified Particle Elliptic Flow in Au+Au Collisions at $\sqrt{S_{NN}}$ =130 GeV

R. V. Cadman, K. Krueger, T. LeCompte, H. M. Spinka, D. G. Underwood,
A. Yokosawa

Phys. Rev. Lett. **87**, 182301 (July 2001).

Instrumentation for the Muon Based Neutrino Source

J. Norem, C. X. Wang, N. Solomey

In: *Conference Proceeding, 2001 Particular Accelerator Conference* Chicago, IL June 18-22, 2001, (PAC 2001) ROAB003, pp. 522, August 2001.

Longitudinal and Transverse Wakefield Analysis in a Multi-Mode Cylindrical Structure

L. Xioa, W. Gai, J. G. Power

In: *Conference Proceeding, 2001 Particular Accelerator Conference* Chicago, IL June 18-22, 2001, (PAC 2001) FPAH123, pp. 3960.

M-Theory and Automorphic Scattering

G. Chalmers

Phys. Rev. Lett. D **64**, 046014 (August 2001).

Magnets and Vacuum Chamber, Workshop on an e^+e^- Collider in the VLHC Tunnel

J. Norem, L. Teng, S. Sharma

In: *Workshop on an e^+e^- Collider in the VLHC Tunnel* held at IIT, Chicago, IL. Fermilab-Conf-01-107-T (2001).

Measurement of Dijet Production in Neutral Current Deep Inelastic Scattering at High Q_2 and Determination of α_s

J. Breitweg, S. Chekanov, M. Derrick, D. Krakauer, S. Magill, B. Musgrave, A. Pellegrino, J. Repond, R. Stanek, R. Yoshida and the ZEUS Collaboration

Phys. Lett. B**507**, 70-88 (October 2001).

Measurement of Dσ/DM Forward-Backward Charge Asymmetry for High Mass Drell-Yan e+e Pairs from $p\overline{p}$ Collilsions at $\sqrt{s}$ = 1.8 TeV

R.E. Blair, K.L. Byrum, E. Kovacs, S.E. Kuhlmann, T. LeCompte, L. Nodulman, J. Proudfoot, R. Thurman-Keup, R.G. Wagner, A.B. Wicklund

Phys. Rev. Lett. **87**, 131802 (June 2001).

Measurement of Inclusive Antiprotons from Au+Au Collisions at $\sqrt{s_{NN}}$ =130 GeV

R. V. Cadman, K. Krueger, H. M. Spinka, D. G. Underwood,

Phys. Rev. Lett. **87** 262302 (December 2001).

Measurement of the B^+ Total Cross-Section and B^+ Differential cross-Section $d\sigma/d_{pT}$ in $p\overline{p}$ Collisions at $\sqrt{s}$ =1.8-TEV

R. E. Blair, K. L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte, L. Nodulman, J. Proudfoot, R. Thurman-Keup, R. G. Wagner, A. B. Wicklund

Phys. Rev. D **65**, 052005 (November 2001).

Measurement of the Inclusive Jet Cross Section in $p\overline{p}$ Collisions at $\sqrt{s}$ =1.8 TeV

R. E. Blair, K. L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte, L. Nodulman, J. Proudfoot, T. Thurman-Keup, R. G. Wagner, A. B. Wicklund

Phys. Rev. D **64**, 0232001 (October 2001).

Measurement of the Photon-Proton Total Cross Section at a Center –of-Mass Energy of 209 GeV at HERA

S. Chekanov, M. Derrick, D. Krakauer, S. Magill, B. Musgrave, A. Pellegrino, J. Repond, R. Yoshida

Nucl. Phys. B **627**, (2002) 3-28 (December 2001).

Measurement of Open Beauty Production in Photoproduction at HERA

J. Breitweg, C. Chekanov, M. Derrick, D. Krakauer, S. Magill, B. Musgrave, A. Pellegrino, J. Repond, R. Stanek, R. Yoshida

Eur. Phys. J. C **18**, 625 (2001).

Measurement of the Strong Coupling Constant from Inclusive Jet Production at the Tevatron $p\overline{p}$ Collider

R. E. Blair, K. L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte, L Nodulman, J. Proudfoot, R. Thurman-Keup, R. G. Wagner, A. B. Wicklund

Phys. Rev. Lett. **88**, 042001 (August 2001).

Negative Probability and Uncertainty Relations Haber,

T. Curtright and C. Zachos

Mod. Phys. Letts. A **16**, 2381-2385 (December 2001).

Next-to-Leading Order Calculation of Associated Production of Gauginos and Gluinos

E. L. Berger, T.M.P. Tait, and M. Klasen

In*: Proceedings of the 5th International Symposium on Radiative Corrections* (RADCOR 2000), Carmel, CA, 11-15 September 2000, edited by H. Haber, eConf C000911 (electronic proceedings) pp. 7-15. *[not previously reported]*

New Tools for Fermion Masses from Extra Dimensions

D. E. Kaplan and T.M.P. Tait

JHEP **0222**, 051 (December 2001).

Observations of Diffractive J/ψ Production at the Fermilab Tevatron

R. E. Blair, K. L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte, L Nodulman, J. Proudfoot, R. Thurman-Keup, R. G. Wagner, A. B. Wicklund

Phys. Rev. Lett. **87**, 241802 (July 2001).

Physics Goals for the Planned Next Linear Collider Engineering Test Facility

W. Gai, J.G. Power, et al.

In: *Conference Proceeding, 2001 Particular Accelerator Conference* Chicago, IL June 18-22, 2001, (PAC2001) FPAH048, 3783, 2001.

Pion Interferometry of $\sqrt{S_{NN}}$ =130 GeV Au+Au Collisions at RHIC

R. Cadman, T. LeCompte, K. Krueger, H. M. Spinka, D. G. Underwood, A. Yokosawa

Phys. Rev. Lett. **87**, 082301 (2001).

Parameters of an e^+e^- Collider in the VLHC Tunnels

J. Norem, S. Sharma, L. Teng

FermiLab -Conf. 01/107-T, 67-73 (July 2001).

Proceedings of the 27th Int'l Cosmic Ray Conference (ICRC), Hamburg, Germany, Aug. 7-15, 2001

M. Goodman

In: *Proceedings of the 27th Int'l. Cosmic Ray Conference ,* Hamburg, Germany (ICRC 2001) edited by Kampert et al Vol. HE, 1085, (August 2001).

Properties of Hadronic Final States in Diffractive Deep Inelastic ep Scattering at HERA

S. Chekanov, M. Derrick, D. Krakauer, S. Magill, B. Musgrave, A. Pellegrino, J. Repond, R. Yoshida

Phys. Rev. Lett. D **65**, 052001 (July 2001).

γ Production and Polarization in $p\bar{p}$ Collisions at $\sqrt{s}$ = 1.8 TeV

R. E. Blair, K. L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte, L Nodulman, J. Proudfoot, R. Thurman-Keup, R. G. Wagner, A. B. Wicklund

Phys. Rev. Lett. **86**, 3963-3968 (2001).

Resummation of QCD Corrections to the η_c Decay Rate

G. T. Bodwin and Y.-Q. Chen

Phys. Rev. D **64**, 114008 (December 2001).

R-Parity-Violating Production of Single Top Squarks with R-Parity-Conserving Decays

E. L. Berger, B. W. Harris, and Z. Sullivan

In: *Proceedings of the XXXIVth Rencontres de Moriond: '99 QCD and High Energy Hadronic Interactions*, edited by J. Tran Thanh Van (The Gi'oi, Hanoi, 2001) p. 399.

Scaling Behaviour at the N_t=6 Chiral Phase Transition for 2-Flavour Lattice QCD with Massless Staggered Quarks, and an Irrelevant 4-Fermion Interaction

J. B. Kogut and D. K. Sinclair

Phys. Rev. D **64**, 034508 (August 2001).

Search for Gluinos and Scalar Quarks in $p\overline{p}$ Collisions at $\sqrt{s}$ =1.8 TeV Using the Missing Energy Plus Multijet Signature

R.E. Blair, K.L. Byrum, E. Kovacs, S.E. Kuhlmann, T. LeCompte, L. Nodulman, J. Proudfoot, R. Thurman-Keup, R.G. Wagner, A.B. Wicklund

Phys. Rev. Lett. **87**, 251803 (2001).

Search for Quark-Lepton Compositeness and a Heavy W' Boson Using the *ev* Channel in $p\overline{p}$ Collision at $\sqrt{s}$ =1.8 TeV

R. E. Blair, K. L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte, L. Nodulman, J. Proudfoot, R. Thurman-Keup, R. G. Wagner, A. B. Wicklund

Phys. Rev. Lett. **87**, 231803 (July 2001).

Search for Lepton-Flavor Violation in e+p Collisions at HERA

S. Chekanov, M. Derrick, D. Krakauer, S. Magill, B. Musgrave, A. Pellegrino, J. Repond, R. Yoshida

Phys. Rev. Lett. D **65**, 092004 (December 2001).

Search for New Heavy Particles in the WZ$^{\circ}$ final state in $p\overline{p}$ Collisions at $\sqrt{s}$ =1.8 TeV

R.E. Blair, K.L. Byrum, E. Kovacs, S.E. Kuhlmann, T. LeCompte, L. Nodulman, J. Proudfoot, R. Thurman-Keup, R.G. Wagner, A.B. Wicklund

Phys. Rev. Lett. **88**, 071806 (August 2001).

Search for New Physics in Events with a Photon and B-Quark Jet at CDF

R. E. Blair, K. L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte, L. Nodulman, J. Proudfoot, R. Thurman-Keup, R. G. Wagner, A. B. Wicklund

Phys. Rev. D **65**, 052006 (2002).

Solving QCD Using Multi-Regge Theory

A. R. White

In: *Proceedings of the Third Workshop on Continuous Advances in QCD 1998*, edited by A. V. Smilga (World Scientific, Singapore, 1998) pp. 97-108. *[not previously reported]*

Study of the Heavy Flavor Content of Jets Produced in Association with W bosons in pp Collisions at $p\overline{p}$ Collisions at $\sqrt{s}$ =1.8 TeV

R. E. Blair, K. L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte, L. Nodulman, J. Proudfoot, T. Thurman-Keup, R. G. Wagner, A. B. Wicklund

Phys. Rev. D **65**, 052005 (September 2001).

Systematics of Large Axial Vector Meson Production in Heavy Flavor Weak Decays
H. J. Lipkin
Phys. Letts. B **515**, 81-88 (August 2001).

The New L-Band 1-1/2 Cell Photocathode RF Gun at Argonne
M. E. Conde, W. Gai, R. Konecny, J. G. Power, P. Schoessow, and X. Sun
In: *Conf. Proceedings Workshop on Photo-Injector for Energy Recovery Linac*, Upton, New York (Brookhaven National Laboratory) Jan.22 - 23, 2001.

The Radiation Environment in and Near High Gradient RF Cavities
L. Ducas and J. Norem
Nucl. Instrum. and Meth. **A** 472, 600-605 (2001).

The Muon Anomalous Magnetic Moment – Significance of the New Measurement
J. L. Uretsky
Phys. Letts. B **523**, 299-303 (December 2001).

Thermoelestic Tespons of Suddenly Heated Liquid Targets in High-Power Colliders
A.Hassainein, I. Konkashbaev, J. Norem
In: *Conference Proceeding, 2001 Particular Accelerator Conference* Chicago, IL June 18-22, 2001, (PAC 2001) RPAH071, pp. 3009.

The Shape and Experimental Tests of the Q^2-Invariant Polarized Gluon Asymmetry
G. P. Ramsey
In: *Proceedings of the 14th International Spin Physics Symposium* (SPIN 2000), edited by K. Hatanaka et al. (AIP, Jan 2001) pp. 437-441. *[not previously reported]*

Three-Jet Production in Diffractive Deep Inelastic Scattering at HERA
S. Chekanov, M. Derrick, D. Krakauer, S. Magill, B. Musgrave, A. Pellegrino, J. Repond, R. Yoshida
Phys. Lett. B **516**, 273-292 (July 2001).

Transformer Ratio Enhancement Using a Ramped Bunch Train in a Collinear Wakefield Accelerator
J. G. Power, W. Gai and X. Sun
In: *Conference Proceeding, 2001 Particular Accelerator Conference* Chicago, IL June 18-22, 2001, (PAC 2001) MOPC005, pp 114.

Two-Colour QCD at Non-Zero Quark-Number Density
J. B. Kogut, D. K. Sinclair, S. J. Hands, and S. E. Morrison
Phys. Rev. D **64**, 094505 (November 2001).

Upsilon Decay to a Pair of Bottom Squarks
E. L. Berger and L. Clavelli
Phys. Letts. B **512**, 115-120 (July 2001).

What is Coherent in Neutrino Oscillations. The Analog with a Two-Slit Experiment
H. J. Lipkin
In: *Proceedings of the Carolina Symposium on Neutrino Physics,* edited by J. Bahcall et al. (World Scientific, Singapore, 2001) pp. 115-119.

IV.B. MAJOR ARTICLES SUBMITTED FOR PUBLICATION

A Feasibility Study of a Neutrino Source Based on a Muon Storage
D. Ayres, M. Goodman, A. Hassanein, T. Joffe-Minor, D. Krakauer, J.H. Norem, C.B. Reed, P. Schoessow, D. Smith, R. Talaga, J. Thron, L.C. Teng, C. Wagner, C.X. Wang
ANL-HEP-PR-01-120

A Way to Reopen the Window for Electroweak Baryogenesis
G. Servant
JHEP
ANL-HEP-PR-01-120

Angular Dependence of the pp Elastic Scattering Spin Correlation Parameter A_{00nn} Between 0.8 and 2.8 GeV. II. Results for Higher Energies
C. E. Allgower, M. E. Beddo, D. P. Grosnick, T. E. Kasprzyk, D. Lopiano, H. M. Spinka
Phys. Rev. C

Area Potentials and Deformation Quantization
T. L. Curtright, A. P. Polychronakos, and C. K. Zachos
Phys. Letts. A
ANL-HEP-PR-01-111

Axions and a Gauged Peccei-Quinn Symmetry
H.-C. Cheng and D. E. Kaplan
Phys. Rev. Letts.
ANL-HEP-PR-01-021

Beautiful Mirrors and Precision Electroweak Data
D. Choudhury, T.M.P. Tait, and C.E.M. Wagner
Phys. Rev. D
ANL-HEP-PR-01-085

Charged Jet Evolution and the underlying Event in Proton-Antiproton Collisions at 1.8 TeV
R. E. Blair, K. L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte, L Nodulman, J. Proudfoot, R. Thurman-Keup, R. G. Wagner, A. B. Wicklund
Phy. Rev. D
ANL-HEP-PR-01-080

Deformation Quantization: Quantum Mechanics Lives and Works in Phase-Space
C. Zachos
Int J Mod Phys A
ANL-HEP-PR-01-095

Diffractive Dijet Production at $\sqrt{s}$ = 630 and 1800 GeV at the Fermilab Tevatron
R. E. Blair, K. L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte,
L Nodulman, J. Proudfoot, R. Thurman-Keup, R. G. Wagner, A. B. Wicklund
Phys. Rev. Lett.
ANL-HEP-PR-01-100

Extraction of a Weak Phase from $B \rightarrow D^{(*)}\pi$
D. A. Suprun, C.-W. Chiang, and J. L. Rosner
Phys. Rev. D
ANL-HEP-PR-01-086

Final-State Phases in Doubly-Cabibbo-Suppressed Charmed Meson Nonleptonic Decays
C.-W. Chiang and J. L. Rosner
Phys. Rev. D
ANL-HEP-PR-01-098

Higgs-Boson Pole Masses in the MSSM with Explicit CP Violation
M. Carena, J. Ellis, A. Pilaftsis and C.E.M. Wagner
Nucl. Phys. B
ANL-HEP-PR-01-112

N=2 6-Dimensional Supersymmetric E_6 Breaking
C.-S. Huang, J. Jiang, T.-J. Li, and W. Liao
Phys. Letts. B
ANL-HEP-PR-01-114

New Tools for Fermion Masses from Extra Dimensions
D. E. Kaplan and T.M.P. Tait
JHEP
ANL-HEP-PR-01-081

Properties of the $\Lambda(1670)1/2^-$ Resonance
C.E. Allgower, H. Spinka
Phys. Rev. Letts.
ANL-HEP-PR-01-082

Radion Mediated Supersymmetry Breaking as a Scherk-Schwarz Theory
D. E. Kaplan and N. Weiner
Phys. Rev. Letts.
ANL-HEP-PR-01-074

Search for the Decay $B_s \rightarrow \mu + \mu - \Phi$ in $p\overline{p}$ Collisions at $\sqrt{s}$ = 1.8 TeV
R. E. Blair, K. L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte,
L Nodulman, J. Proudfoot, R. Thurman-Keup, R. G. Wagner, A. B. Wicklund
Phys. Rev. Lett.
ANL-HEP-PR-01-101

Searches for Excited Fermions in ep Collisions at HERA
S. Chekanov, M. Derrick, D. Krakauer, S. Magill, B. Musgrave, A. Pellegrino,
J. Repond, R. Yoshida
Phys. Rev. Lett. B
ANL-HEP-PR-01-092

Search for New Physics in Photon-Lepton Events in $p\overline{p}$ Collisions at $\sqrt{s}$ = 1.8 TeV
R. E. Blair, K. L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte,
L. Nodulman, J. Proudfoot, R. Thurman-Keup, R. G. Wagner, A. B. Wicklund
Phys. Rev. Lett. D
ANL-HEP-PR-01-102

Soft and Hard Interaction in $p\overline{p}$ Collisions at $\sqrt{s}$ = 1.8 TeV
R. E. Blair, K. L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte,
L Nodulman, J. Proudfoot, R. Thurman-Keup, R. G. Wagner, A. B. Wicklund
Phy. Rev. Letts. D
ANL-HEP-PR-01-115

Simple Relations for Two Body B Decays to Charmonium and Tests for $\eta - \eta'$ Mixing
A. Datta, H. J. Lipkin, and P. J. O'Donnell
Phys. Letts. B
ANL-HEP-PR-01-109

The STAR Endcap Electromagnetic Calorimeter
R. V. Cadman, K. Krueger, H. Spinka, D. Underwood, A. Yokosawa
Nuclear Instruments and Methods
ANL-HEP-PR-01-087

Top Quark Seesaw, Vacuum Structure and Electroweak Precision Constraints
H.-J. He, C. T. Hill, and T.M.P. Tait
Phys. Rev. D
ANL-HEP-PR-01-047

Updated Analysis of Some Two-Body Charmless *B* Decays
C.-W. Chiang and J. L. Rosner
Phys. Rev. D
ANL-HEP-PR-01-119

IV.C PAPERS OR ABSTRACTS SUBMITTED TO CONFERENCE PROCEEDINGS

A Hybrid Dielectric and Iris Loaded Periodic Accelerating Structure

Peng Zou, Liling Xiao, Xiang Sun and Wei Gai

In: *Conference Proceedings - Particle Accelerator Conference* (PAC2001), Chicago, IL. June 18-22, 2001

ANL-HEP-CP-01-064

Determination of tan β at a Future e^+e^- Linear Collider

J.F. Gunion, T. Han, J. Jiang, S. Mrenna, and A. Sopczak

In: *Proceedings of the 2001 APS/DPF/DPB Summer Study on the Future of Particle Physics, Snowmass* (SNOWMASS 2001), CO, 30 June – 21 July 2001.

ANL-HEP-CP-01-121

Heavy-Quark Parton Distribution Functions and their Uncertainties

Z. Sullivan and P. M. Nadolsky

In: *Proceedings of the 2001 APS/DPF/DPB Summer Study on the Future of Particle Physics, Snowmass* (SNOWMASS 2001), CO, 30 June – 21 July 2001.

ANL-HEP-CP-01-104

Horizontal Muons in Soudan 2 and Search for AGN Neutrinos

D. Demuth (Univ. of Minnesota at Crookstron) and M. Goodman

In: *Proceedings of the 27th Int'l. Cosmic Ray Conference* (ICRC 2001), Hamburg, Germany, Aug. 7-15, 2001.

ANL-HEP-CP-01-039

Lattice QCD at Finite Isospin Density

J. B. Kogut and D. K. Sinclair

In: *Proceedings of LATTICE 2001*, Berlin, Germany, 19-24 (August 2001).

ANL-HEP-CP-01-094

Measurement of the Strong Coupling Constant from Inclusive Jet Production at the Tevatron $p\bar{p}$ Collider

R. E. Blair, K. L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte, L Nodulman, J. Proudfoot, R. Thurman-Keup, R. G. Wagner, A. B. Wicklund

Phys. Rev. Lett. 88, 042001 (August 2001).

PDF Uncertainties in WH Production at Tevatron

P. M. Nadolsky and Z. Sullivan

In: Proceedings of the 2001APS/DPF/DPB Summer Study on the Future of Particle Physics (SNOWMASS 2001), Snowmass, CO, 30 June – 21 July 2001.

ANL-HEP-CP-01-105

Soft and Hard Interactions in $p\bar{p}$ Collisions at $\sqrt{s}$ =1800 and 630 GeV

R. E. Blair, K. L. Byrum, E. Kovacs, S. E. Kuhlmann, T. LeCompte, L. Nodulman, J. Proudfoot, R. Thurman-Keup, R. G. Wagner, A. B. Wicklund

Phy. Rev. Lett. D

ANL-HEP-PR-01-116

Supersymmetry Explanation for the Puzzling Bottom Quark Production Cross Section

E. L. Berger

In: *Proceedings of the 9th International Symposium on Heavy Flavor Physics*, Pasadena, CA, 10-13 September 2001.

ANL-HEP-CP-01-118

The Shape and Experimental Tests of the Q^2-Invariant Polarized Gluon Asymmetry

G. P. Ramsey

In: *Proceedings of the Spin Physics Symposium* (SPIN 2000), Osaka, Japan, 16-21 October 2000.

ANL-HEP-CP-00-127 [*not previously reported*]

TTCRP: A PMC Receiver for TTC

John W. Dawson, William N. Haberichter, James L. Schlereth

In: *Conference Proceedings, 7th Workshop on Electronics for LHC Experiments*, University of Stockholm, Stockholm, Sweden, September 10-14, 2001.

ANL-HEP-CP-01-090

Young Physicists' Forum

T. Adams, …Z. Sullivan, *et al*.

In: *Proceedings of the 2001 APS/DPF/DPB Summer Study on the Future of Particle Physics* (SNOWMASS 2001), Snowmass, CO, 30 June – 21 July 2001.

ANL-HEP-CP-01-110

IV D. TECHNICAL REPORTS, NOTES

CDF Notes:

CDF-5457

Corrections to the Run 1B Photon Cross Section

Dana Partos, Steve Kuhlmann

CDF Note Number: CDF/ANAL/JET/CDFR/5457

CDFR-5691

Trigger Operations Review
W. Badgett, P. Wilson, P. Murat, J. Patrick, J. Proudfoot, N. Lockyer
CDF Note Number: CDF/DOC/TRIGGER/CDFR/5691

CDFR-5759

Measurement of the Ratio of b Quark Cross Sections at 630 and 1800 GeV
T. LeCompte J. Lewis S. Tkaczyk
CDF Note Number: CDF/ANAL/BOTTOM/CDFR/5759

CDF-5788

Level 2 Isolation Trigger Information
Steve Kuhlmann, Monica Tecchio, Bob Blair, John Dawson, Bill Haberichter
CDF Note Number: CDF/PUB/TRIGGER/PUBLIC/5788

CDFR-5803

A First Look at Run 2 High p_T Electrons
M. Coca, E. Halkaidakis, L.Nodulman, J.Proudfoot, P. Tamborello, M. Tanaka, E. Thomson, G. Veramendi
CDF Note Number: CDF/MEMO/ELECTRON/CDFR/5803

Technical Reports

Analysis of Low Energy AGS Polarimeter Data and Potential Consequences for PHIC Spin Physics
R. Cadman, K. Krueger, H. Spinka, D. Underwood, A. Yokosawa
Collider-Accelerator Note *(not for publication)*
ANL-HEP-TR-01-036

Extended Barrel Support Saddle Design and Analysis
V. Guarino, J. Grudzinski, and E. Petereit
ANL-HEP-TR-01-097

Effects of Beam Attenuation on the Slope Parameter for $\eta \to 3\pi^\circ$
R. Cadman and H. Spinka
ANL-HEP-TR-01-048

HEP Division Semiannual Report of Research Activities, July 1, 2000 to December 31, 2000

H.M. Spinka, L.J. Nodulman, M.C. Goodman, J. Repond, D.S. Ayres, J. Proudfoot, R. Stanek, T. LeCompte, G. Drake, E.L. Berger, G.T. Bodwin, D.K. Sinclair, C. Zachos, W. Gai, J. Norem

ANL-HEP-TR-01-050

Some Additions to the Crystal Ball Monte Carlo Program

C. Allgower, M. Bates, R. Cadman, R. Greene, R. Manweiler, H. Spinka, S. Wolf

ANL-HEP-TR-01-089

X-Band Dielectric Loaded RF Driven Accelerator Structures: Theoretical Experimental Investigations

Peng Zou

ANL-HEP-TR-01-035

V. COLLOQUIA AND CONFERENCE TALKS

Edmond L. Berger

The Puzzle of the Bottom Quark Production Cross Section
Invited plenary talk presented at the 3rd Circum-Pan-Pacific Symposium on High Energy Spin Physics, Peking University, Beijing, China, October 13, 2001.

Supersymmetry Interpretation of the Large Bottom Quark Production Cross Section and Implications for Other Processes
Institute for High Energy Physics, Beijing, China, October 8, 2001.

Supersymmetric Explanation for the Large Bottom Quark Production Cross Section
Invited plenary talk presented at the 9th International Symposium on Heavy Flavor Physics, California Institute of Technology, Pasadena, CA, September 13, 2001.

Geoffrey T. Bodwin

Inclusive Production of Heavy Quarkonium in Hadronic Collisions
Invited plenary talk presented at the Workshop on Hard Probes in Heavy Ion Collisions, CERN, Geneva, Switzerland, October 10-13, 2001.

John Campbell

W+2 Jet Production at the Tevatron to Next-to-Leading Order
Department of Physics, Michigan State University, East Lansing, MI, October 9, 2001.

Gordon Chalmers

Quantum Scattering in IIB Superstring Theory
ITP, Technical Universität Munchen, Germany, July 13, 2001.

Quantum Scattering in IIB Superstring Theory
Institut für Theoretische Physik, Hannover, Germany, July 2001.

Jing Jiang

Something About Extra Dimensions
ANL-HEP Division Theoretical Physics Seminar, Argonne, IL, October 29, 2001.

David Kaplan

Deconstructing Gaugino Mediation
Invited, 2-hour talk presented at the Summer Institute 2001: Session 2 (Phenomenology), Fujiyoshida, Yamanashi, Japan, August 19, 2001.

Supersymmetry Breaking and Extra Dimensions
Invited, 2-hour talk presented at the Summer Institute 2001: Session 2 (Phenomenology), Fujiyoshida, Yamanashi, Japan, August 16, 2001.

Parameterizing Supersymmetry Breaking
2001 APS/DPF/DPB Summer Study on the Future of Particle Physics (SNOWMASS 2001), Snowmass, CO, July 17, 2001.

Jungil Lee

Topics in Heavy Quarkonium Phenomenology
ANL-HEP Division Theoretical Physics Seminar, Argonne, IL, October 15, 2001.

Harry J. Lipkin

The Past and Future of QCD
TRIUMF, Vancouver, BC, October 22, 2001.

The Past and Future of QCD
ANL-HEP Division Seminar, Argonne, IL, October 17, 2001.

The Past and Future of QCD
Department of Physics, Yale University, New Haven, CT, October 12, 2001.

The Past and Future of QCD
Department of Physics, University of Connecticut, Storrs, October 11, 2001.

I Spin - U Spin - V Spin -- Forever
Meshkov Symposium, Aspen, CO, August 25, 2001.

Geraldine Servant

Supersymmetry Breaking by Gaugino Condensation in Effective Type I String Models
Department of Physics, Purdue University, West Lafayette, IN, October 30, 2001.

How is String Theory Connected to the Standard Model?
Department of Physics, University of Chicago, IL, October 26, 2001.

Donald K. Sinclair

Models at Finite Density and Temperature
XIX International Symposium on Lattice Field Theory (LATTICE 2001), Berlin, Germany, August 19-24, 2001.

Zack Sullivan

Young Physicists at Snowmass
ANL-HEP Division Lunch Seminar, Argonne, IL, August 21, 2001.

Balancing the Field
2001 APS/DPF/DPB Summer Study on the Future of Particle Physics (SNOWMASS 2001), Snowmass, CO, July 11, 2001.

What We Need in QCD (a pragmatic point of view)
2001 APS/DPF/DPB Summer Study on the Future of Particle Physics (SNOWMASS 2001), Snowmass, CO, July 9, 2001.

Timothy Tait

New Tools for Fermion Masses from Extra Dimensions
Physics Department, Yale University, New Haven, CT, December 4, 2001.

Beautiful Mirrors and Precision Electroweak Data
Department of Physics, University of Illinois at Chicago, November 26, 2001.

New Tools for Fermion Masses from Extra Dimensions
Physics Department, University of Wisconsin at Madison, November 16, 2001.

Beautiful Mirrors and Precision Electroweak Data
ANL-HEP Division Seminar, Argonne, IL, November 7, 2001.

Beautiful Mirrors and Precision Electroweak Data
Department of Physics, University of Illinois at Urbana-Champaign, November 5, 2001.

Anomalous Top Quark Interactions
2001 APS/DPF/DPB Summer Study on the Future of Particle Physics (SNOWMASS 2001), Snowmass, CO, July 10, 2001.

Jack Uretsky

Dispersive Deception and Hadronic Contributions to the Muon Magnetic Moment
ANL-HEP Division Seminar, Argonne, IL, August 1, 2001.

Carlos Wagner

Beautiful Mirrors and Precision Electroweak Data
Department of Physics, Michigan State University, East Lansing, MI, October 23, 2001.

Alan R. White

$\pi-\pi$-Scattering via Pomeron Exchange in QCD
Invited talk presented at the Meeting on QCD and the Deep Structure of Elementary Particles, Weimar, Germany, September 13, 2001.

Confinement in High Energy Scattering
Invited talk presented at the Trento Workshop on the Physics of Colour Confinement, Trento, Italy, September 21, 2001.

Cosmas Zachos

Deformation Quantization: Quantum Mechanics Lives and Works in Phase-Space
University of Illinois at Chicago, October 3, 2001.

Deformation Quantization: Quantum Mechanics Lives and Works in Phase-Space
Fermilab, Batavia, IL, August 1, 2001.

VI. HIGH ENERGY PHYSICS COMMUNITY ACTIVITIES

Edmond L. Berger

Member, International Advisory Committee, HADRON 2003, Aschaffenburg, Germany, August 31--September 6, 2003.

Scientific Program Committee, SPIN Symposium 2003, Nuclear Theory Institute, U. Washington, Seattle, August 4-7, 2003.

Member, Organizing Committee, 8th Conference on the Intersections of Particle and Nuclear Physics (CIPANP 2003), New York, May, 2003.

Convener, "Tests of QCD with Quarkonium", Quarkonium Physics Working Group, CERN, 2002

Member, CTEQ Collaboration

Member, International Advisory Committee, 9th International Conference on Hadron Spectroscopy (HADRON 2001), Protvino, Russia

Convener, QCD, Division of Particles and Fields Meeting, DPF 2002, Williamsburg, May, 2002.

Co-host (with Steve Kuhlman), CTEQ collaboration meeting, Argonne, IL, October 26–27, 2001.

Member, International Advisory Committee, Conference in Honor of Jean Tran Thanh Van, Paris, October 2002.

Adjunct Professor of Physics, Michigan State University, East Lansing, MI, 1997-present.

Member, High Energy and Nuclear Physics Advisory Committee, Brookhaven National Laboratory, 1995-2001.

Member, Scientific Program Organizing Committee, Rencontres de Moriond, QCD and High Energy Hadronic Interactions, France, every year from 1986 to the present.

Geoffrey T. Bodwin

Member, Working Group, Hard Probes in Heavy Ion Collisions, CERN, Geneva, Switzerland, 2001-present.

Member, Advisory Committee and Convenor, Heavy Quarks Session, Quark Confinement and the Hadron Spectrum, Gargnano, Italy, 2001-present.

Member, Organizing Committee, International Conference on Advanced Topics in QCD, Beijing, 2001-present.

Zack Sullivan

Member, Steering Committee of the Young Physicists Forum for Snowmass 2001, Snowmass, CO, June 30-July 21, 2001.

Chairman, Balancing the Field Working Group for Snowmass 2001, Snowmass, CO, June 30-July 21, 2001.

Carlos Wagner

Associate Professor, EFI, University of Chicago, Chicago, IL, 1999-present

Member, LEP Higgs Working Group, 1997-present

Cosmas Zachos

Member, Advisory Panel for J. Phys. A (Math. Gen).

VII. HEP DIVISION RESEARCH PERSONNEL

Administration

Price, L.
Hill, D.

Accelerator Physicists

Conde, M.
Gai, W.
Norem, J.
Power, J.
Schoessow, P.

Experimental Physicists

Ayres, D.
Blair, R.
Byrum, K.
Cadman, R.
Chekanov, S.
Derrick, M.
Fields, T.
Goodman, M.
Joffe-Minor, T.
Krakauer, D.
Kuhlmann, S.
LeCompte, T.
Magill, S.
May, E.
Musgrave, B.
Nodulman, L.
Pellegrino, A..
Proudfoot, J.
Repond, J.
Reyna, D.
Spinka, H.
Stanek, R.
Talaga, R.
Tanaka, M.
Thron, J.
Underwood, D.
Wagner, R.
Wicklund, A.
Yokosawa, A.
Yoshida, R.

Theoretical Physicists

Berger, E.
Bodwin, G.
Campbell, J.
Chalmers, G.
Chiang, C. W.
Harris, B.
Kaplan, D.
Lee, J.
Jiang, J.
Servant, G.
Sinclair, D.
Sullivan, Z.
Tait, T.
Wagner, C.
White, A.
Zachos, C.

Engineers and Computer Scientists

Dawson, J.
Drake, G.
Grudzinski, J.
Guarino, V.
Gieraltowski, J.
Hill, N.
Kovacs, E.
Mouser, C.
Schlereth, J.
Vaniachine, A.

Technical Support Staff

Adams, C.
Ambats, I.
Anderson, S.
Caird, A.
Cox, G.
Cundiff, T.
Franchini, F.
Haberichter, W.
Jankowski, D.
Kasprzyk, T.
Koeenko, L.
Konecny, R.
Matijas, Z
Nephew, T.
Reed, L.
Rezmer, R.
Skrzecz, F.
Wood, K.

Laboratory Graduate Participants

Bell, W.
Zou, P.
Jing, C.

Visiting Scientists

Choudhury, D. (Theory)
Crittenden, J. (ZEUS)
Kovacs, E. (Theory)
Krueger, K. (STAR)
Liu, W. (AWA)
Lipkin, H. (Theory)
Ramsey, G. (Theory)
Sun, X. (AWA)
Uretsky, J. (Theory)
Xiao, L. (AWA)