ANL-HEP-TR-02-117

HIGH ENERGY PHYSICS DIVISION SEMIANNUAL REPORT OF RESEARCH ACTIVITIES

January 1, 2002 – June 30, 2002

ARGONNE NATIONAL LABORATORY

Argonne, Illinois

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RESEARCH ACTIVITIES

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January 2002

Abstract

This report describes the research conducted in the High Energy Physics Division of Argonne National Laboratory during the period of January 1 through June 30, 2002. 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.

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I. EXPERIMENTAL RESEARCH PROGRAM

I.A. EXPERIMENTS WITH DATA

I.A.1. Medium Energy Polarization Program

During the period January - June, 2002, there was polarized proton running at RHIC and a number of papers were published with authors from the spin group. Extensive work on construction and testing of shower maximum detector modules for the STAR endcap electromagnetic calorimeter continued, and this effort is described in another section of this report.

Data collection with polarized protons at RHIC began late in December 2001 and continued to the second half of January 2002. Argonne physicists were heavily involved in data taking shifts at STAR and monitoring beam polarimeter performance during this time. A calibration of the AGS polarimeter at p_{lab} = 3.8 GeV/c ($G\gamma$ = 7.5) was performed, indicating little depolarization from the ion source to slightly above the injection energy for the AGS. However, significant losses were observed during both AGS and RHIC acceleration. It was demonstrated by Argonne physicists that the RHIC coulomb-nuclear interference (CNI) polarimeters had significant systematic errors, comparable to the statistical uncertainties, but of unknown origin. Data analysis at ANL also found evidence for beam depolarization during RHIC flattop, which was unexpected; see Fig. 1.

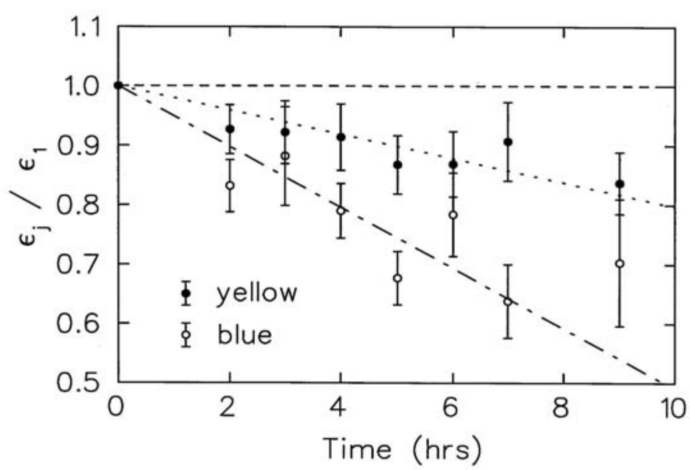


Figure 1. The average of the ratios of the asymmetry measured at least 1.5 hours into flattop to the asymmetry at the beginning of flattop is plotted as a function of time since the start of flattop for the blue and yellow RHIC rings. At least three CNI polarimeter measurements were required on flattop in the same beam and fill, with the magnitude of the initial asymmetry exceeding 1.0×10^{-3}. Fills with special conditions or with known hardware problems were excluded. It had been expected that these ratios would be consistent with 1.00.

The final experimental paper on Brookhaven experiment E925 was published ("Measurement of Analyzing Powers of π^+ and π^- Produced on a Hydrogen and a Carbon Target with a 22 GeV/c Incident Polarized Proton Beam," Phys. Rev. D**65**, 092008 (2002)). Knowledge of beam polarization in RHIC is presently tied to E925. Work on this experiment is now complete.

A paper on Brookhaven experiment E950 was submitted for publication in Phys. Rev. Lett. with an Argonne author. This experiment calibrated a CNI polarimeter in the AGS at the extraction energy, using the results from the E925 experiment that ran at about the same time. A very thin carbon ribbon target was used. The data indicate a sizeable hadronic spin-flip contribution exists for very small angle p + carbon elastic scattering, which is surprising. These results are being used to transfer the polarimeter calibration to RHIC at the injection momentum of p_{lab} = 24 GeV/c.

There were several papers submitted for publication on STAR results, and one was published ("Midrapidity φ Production in Au + Au Collisions at $\sqrt{s_{NN}}$ = 130 GeV," Phys. Rev. C**65**, 041901 (RC, 2002)). The φ's were detected via their $K^+ K^-$ decays in the rapidity and transverse momentum ranges $|y| < 0.5$ and $0.46 < p_T < 1.74$ GeV/c, respectively. The yields as a function of transverse mass, for three total charged multiplicity bins, are shown in Fig. 2. Within statistical uncertainties, there is no variation in the slope as a function of transverse mass for the different multiplicities. This slope, and the ratio of the φ to negative hadron yields at mid-rapidity are both observed to increase from AGS to RHIC energies.

A paper was published on the interpretation of data from Crystal Ball experiments at the AGS ("Properties of the $\Lambda(1690)\frac{1}{2}^-$ Resonance," Phys. Rev. Lett. **88**, 012002 (2002)). The $K^- p \rightarrow \eta^0 \Lambda^0$ cross sections near threshold and other data were fit in a unitary multichannel framework to obtain the mass M = 1673 ± 2 MeV, width Γ = 23 ± 6 MeV, and elasticity x = 0.37 ± 0.07. These parameters are in excellent agreement with quark-model predictions of Koniuk and Isgur (Phys. Rev. D**21**, 1868 (1980)).

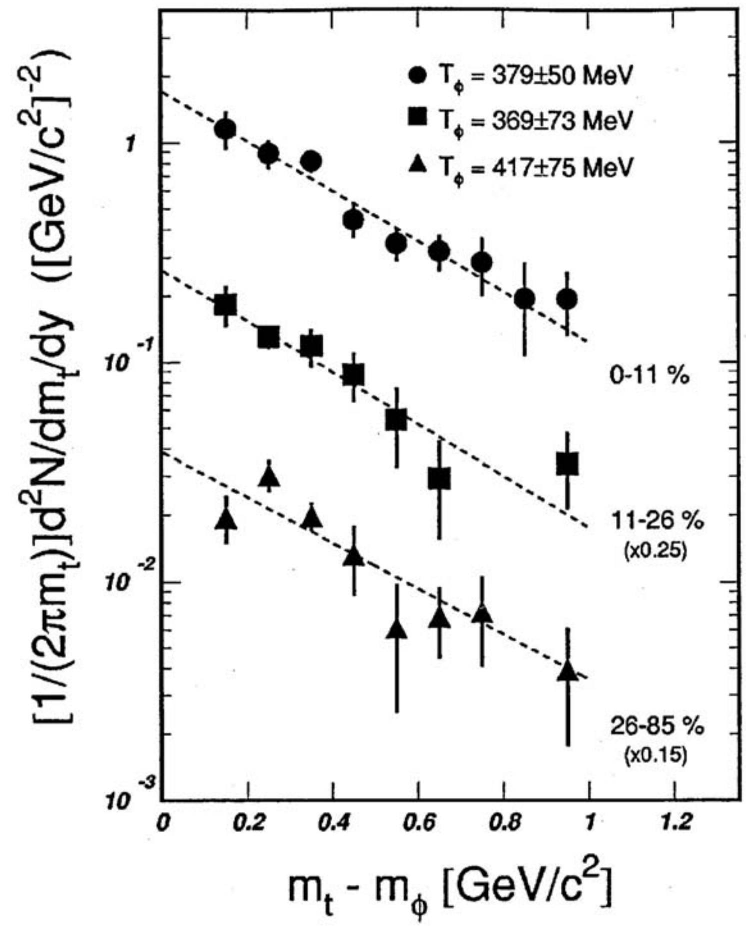


Figure 2. Transverse mass ($m_t^2 = p_T^2 + m_\varphi^2$) distributions of inclusive φ meson production from Au + Au collisions at $\sqrt{s_{NN}}$ = 130 GeV for three charged particle multiplicity bins. Dashed lines are exponential fits to the data. For clarity, data points from the 11 – 26% and 26 – 85% bins are scaled by 0.25 and 0.15, respectively. The errors shown are statistical only.

Data analysis continued at Argonne and Valparaiso University on the reaction $K^- p \rightarrow \pi^\circ \Sigma^\circ$ at eight momenta between 500 – 750 MeV/c from the Crystal Ball. Both differential cross sections and Σ° polarizations are being derived. It is hoped to have a letter submitted on the cross sections within a year. The data sample is approximately an order of magnitude larger than obtained previously with bubble chambers.

(H. Spinka)

1.A.2. Collider Detector at Fermilab

a) Physics

The quality of the new data being taken was decreed to be good enough for physics in January, new and samples of about 15 pb^{-1} were created for analyses aimed at the summer conferences. As the sample size is rather disappointing, many of the analyses were literally exercises for the students, but a few had some physics interest beyond demonstrating at some low level that the program is alive again.

One analysis of some interest is to measure the W boson cross section with electrons. The cross section should rise predictably, and there are plenty of W candidates so that the result will not be statistically limited. Essentially repeating the run 1 analysis, a reasonably clean W sample is readily obtained, as shown in Fig. 1, and the electron W cross section is measured to be 2.60 ±0.13 ±0.26 nb where the first uncertainty is statistics and the second is systematic, dominated by absolute luminosity determination. The NNLO predicted cross section is 2.73 nb, and perhaps we should normalize to that; luminosity is now determined using Cerenkov counters instead of the old beam-beam scintillators, so that canceling systematics in the 1.96/1.8 TeV ratio will require some work. It is noteworthy that the data, except for the increased high tail in the electron E/P distribution, is very much the same as run 1, including acceptance and efficiencies associated with the shower max detectors.

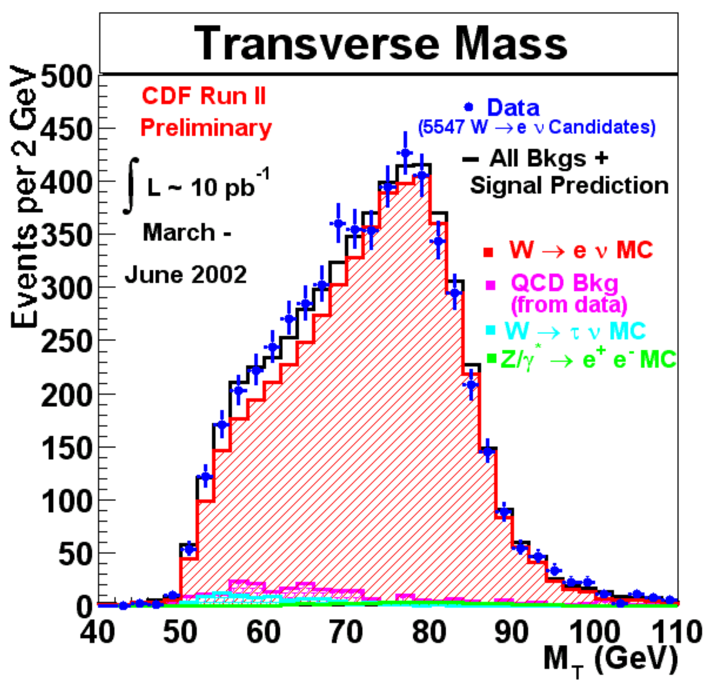


Figure 1. Transverse mass distribution from the Run II electron W sample.

Although the silicon commissioning has gone slowly, the all hadronic trigger has been implemented. In this data, silicon coverage has been partial and infrequent, so that competitive b physics is not yet possible. On the other hand, large samples of hadronic charm have been obtained. We looked at the mass difference between the D^+ and the D_s^+, shown in Fig. 2. We measured the difference to be 99.3 ±0.4 ±0.3 MeV/c^2 (statistics, systematic) and discovered that PDG, from CLEO2 and E679 had 99.2 ±0.5.

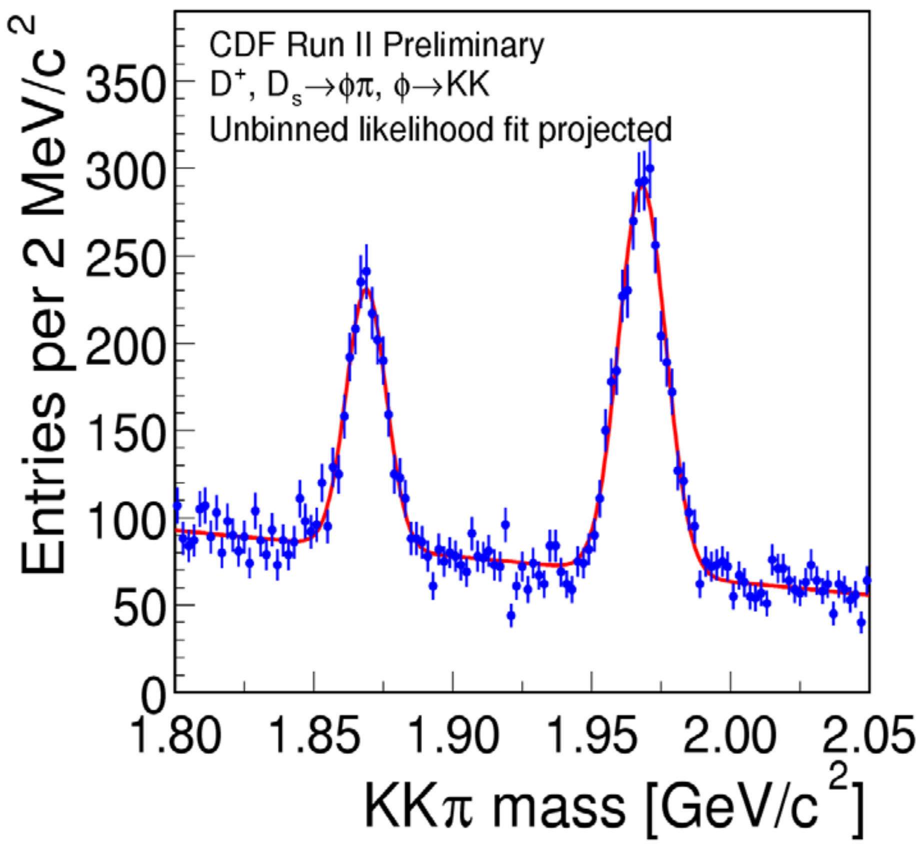


Figure 2. Three particle masses assuming KKπ from the all hadronic silicon vertex trigger.

The hadronic B program is not yet world class but it is alive, with fully reconstructed B signals. The most flagship signal, which goes under the name "B→ππ" is shown in Fig. 3. Efficiencies and measurement quality have to be improved in order to

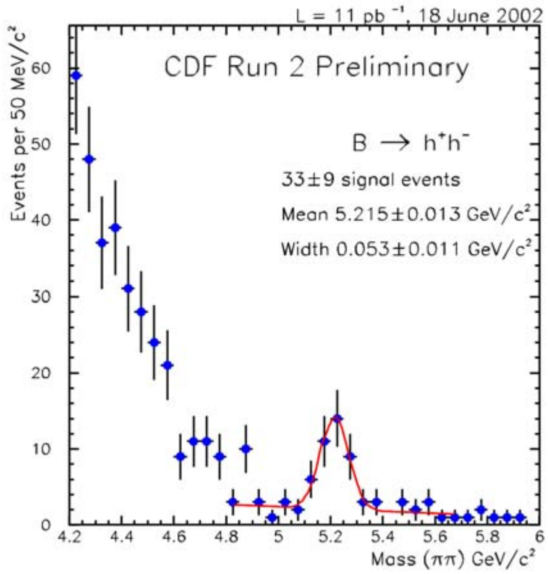


Figure 3. Two particle vertex trigger vertex offline mass spectrum.

project to an interesting CP measurement any time soon, but the signal is there, even if it isn't ππ as seen in Fig. 4.

Most of our effort was devoted to improving the understanding of calorimeter data to eventually enable a top mass measurement, and optimizing the hadronic b trigger strategy to get the b physics program going. We hope to have samples comparable to run 1 for the winter conferences.

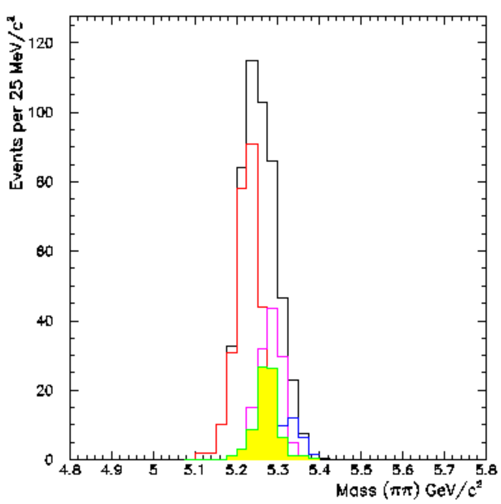


Figure 4. Expected B dihadron signal; the sum is made up of Kπ (left), B_s(KK) right and the real ππ signal (solid).

b) **CDF Operations**

With most of the problems of muon chambers holding high voltage with beam backgrounds behind us, and the silicon detectors slowly being commissioned, and the Level 2 trigger gradually being put into service, the data was declared to be of physics quality in January. Jimmy Proudfoot's operational concerns as Deputy Head of CDF Operations included data quality, operational efficiency, and robustness of the trigger for increasing luminosity. Unfortunately increasing luminosity remained an academic issue, and a path dependence was put into the Level 3 (farm) trigger such that electron candidates would always be rejected if the event happened to satisfy a low level diphoton trigger. The Level 3 strategy had to be reconsidered to avoid such problems. Karen Byrum, Tom LeCompte, Larry Nodulman, Jimmy Proudfoot and Bob Wagner served as shift leaders.

Karen Byrum, with help from Steve Kuhlmann, Jimmy Proudfoot and Larry Nodulman and Gary Drake and company, continued working on support for shower max readout operations. The diode protection installed on chambers which had repeated preamp burnout worked fine, and when burnout seemed likely to spread, diode boards for remaining three fourths of the detector were made and installed in the June shutdown. Coherent noise was sometimes worse than the onboard noise suppression code could deal with, so the code was upgraded and it was discovered that putting a ferrite core on the high voltage of particularly noisy shower max chambers would quiet it down. Gradually during this period the hardware and online software were improved so that shower max got out of the mode of making use of any access available and got into a reasonable operational equilibrium.

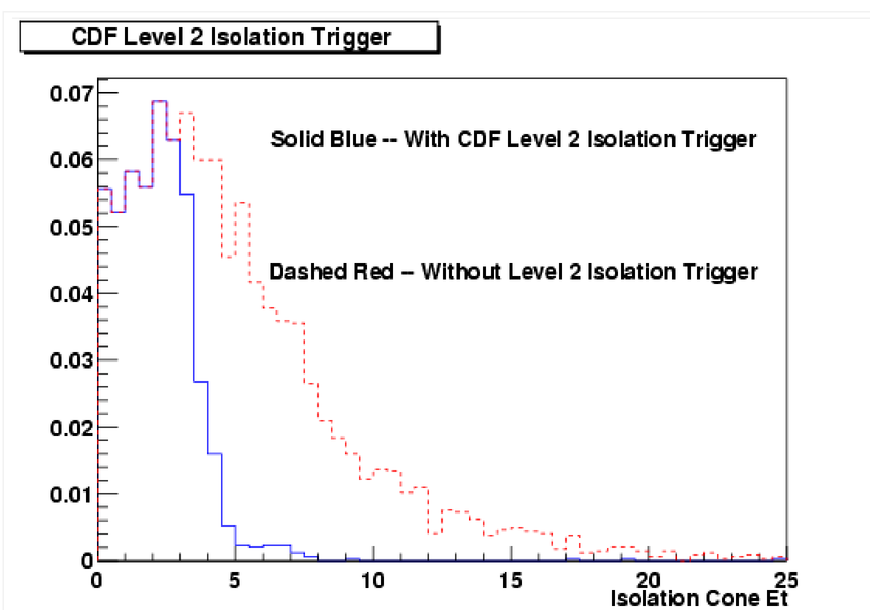


Figure 1. Reconstructed isolation cone energy (GeV) for photon candidates and the subset of photon

candidates which satisfies the Level 2 hardware isolation trigger.

Our electronics show has also been involved with the Level 2 trigger, with Karen Byrum developing the shower max trigger and Bob Blair and Steve Kuhlmann the isolation trigger. Masa Tanaka has graduated from helping to get these going to becoming an invaluable support to the Level 2 trigger system overall. The isolation trigger is illustrated in Fig. 1 and the shower max ("RECES") trigger is illustrated in Fig. 2.

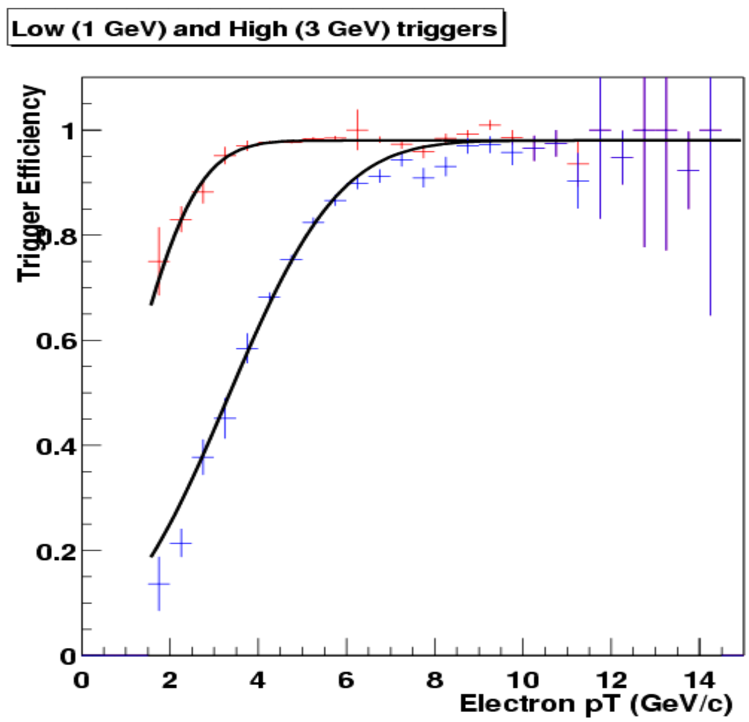


Figure 2. Efficiency for offline electrons of the shower max Level 2 triggers.

Larry Nodulman worked with members of the Electron Task Force to monitor the performance of the central EM calorimeter. The overall scale was reasonable and fell slowly during the period. The gains for individual towers showed a considerable dispersion, larger than 5% rms, and offline corrections were developed. Also, individual PMT gain factors were determined and during the June shutdown the individual PMT online gain factors were revised to reduce the tower dispersion, now <1% rms, and improve PMT pair balance. Using the offline corrections as well as tracking corrections determined by studying electron charge asymmetry, the E/p distribution for W electrons shows resolution almost as good as Run 1, with a larger Bremmstrahlung tail as seen in Fig. 3.

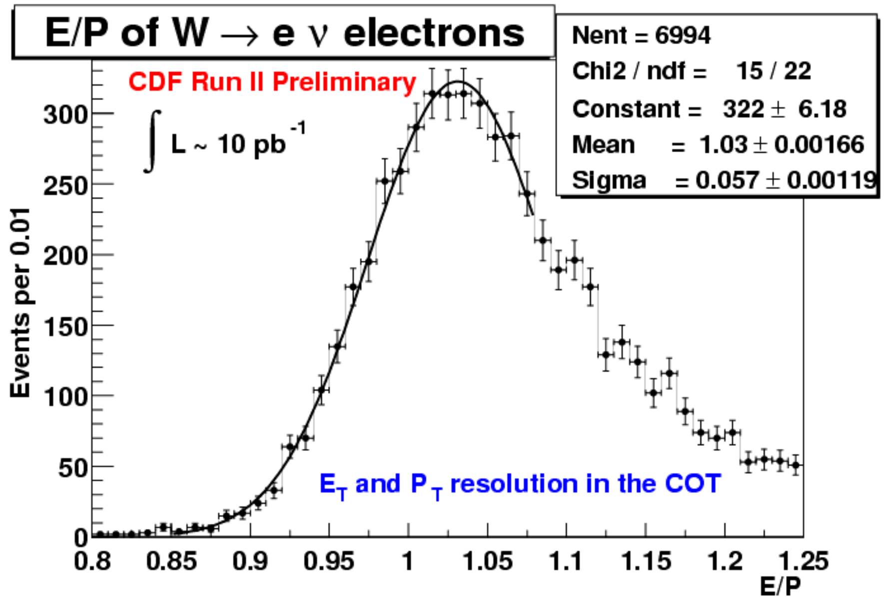


Figure 3. E/p for W electrons demonstrates the convolution of tracking and EM calorimeter resolutions. The best results from Run 1 got a fit sigma of 5%.

Bob Wagner continued to head the offline electron and photon software effort. He also, along with Barry Wicklund and Larry Nodulman, worked with the Electron Task Force to define electrons correctly and develop Level 3 trigger strategy for electron datasets. Barry Wicklund was also a leader of the B physics trigger strategy group.

Tom LeCompte continues working with the muon group. Gary Drake came up with a preamp design which avoids the oscillations which did not allow the CMX miniskirt muon chambers to be turned on.

(L. Nodulman)

I.A.3. The CDF Upgrade Project

a) Run 2b Preparation

The overall efforts for Run 2b were organized for a baseline Lehmann review. As part of the reorganization, Steve Kuhmann went from heading the preradiator upgrade to Level 2 manager for calorimeters which also includes the EM timing upgrade. Considerable support for the preradiator upgrade has been generated in Japan, Italy and Russia, and we will be using sigma tile scintillator rather than MINOS bars, to make logical towers more reasonably mapped onto fibers. The light yield of the Dubna scintillator was tested on the MINOS test stand at Argonne and is quite adequate, as seen in Fig. 1. Some design work is in process now at Argonne and some assembly of scintillator packages is anticipated. We are investigating possible involvement in trigger/DAQ issues, making use of ATLAS technology.

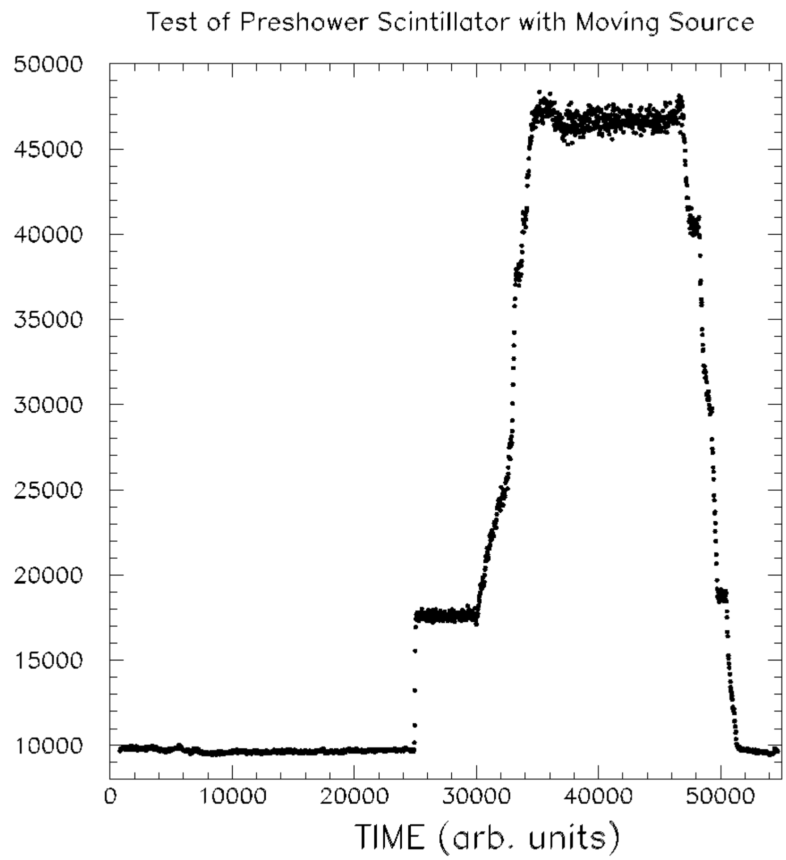


Figure 1. Scan results for a Dubna 2 cm thick sigma tile as measured on the MINOS mapper. The plateau level is about 2.2 times higher than typical MINOS 1 cm strips.

(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. A variety of topics in underground physics have been analyzed and presented based on data which was accumulated in Soudan 2. These include:

1) Search for slow moving magnetic monopoles
2) Search for nucleon decay, and the setting of upper limits in many modes
3) Search for n-anti-n oscillations

4) Search for astrophysical sources of underground muons
5) Measurement of atmospheric neutrino contained events and partially contained events, and the use of the flavor ratio and zenith angle distribution to measure the parameters of neutrino oscillation
6) Measurement of the moon shadow in the direction of underground muons
7) Measurement of the sun shadow and correlation with parameters of the solar cycle and the interplanetary magnetic field
8) Study of seasonal variation of the trigger rates due to radon in the mine
9) Study of seasonal variation of muon rates correlated with temperatures in the upper atmosphere
10) Measurement of coincidences between cosmic ray air showers on the surface and underground muons and the implications for cosmic ray composition
11) Measurement of multiple muon rates and implications for cosmic ray composition
12) Measurement of the atmospheric neutrino flux using horizontal muons and upward stopping muons
13) Search for very high energy neutrinos from Active Galactic Nuclei

Final analyses are continuing on neutrino oscillation parameters and a few nucleon decay channels. It is also likely that new ideas for Soudan 2 data analyses, such as a new category of rare events, could lead to further analyses in the near future.

(M. C. Goodman)

I.A.5. ZEUS Detector at HERA

a) Physics Results

Eight papers were published in this period and four more manuscripts were submitted for publication. In the following, we shall summarize some of the papers published in this period of time.

i) *Measurement of High Q^2 Charged Current Cross Sections in e^-p Deep Inelastic Scattering at HERA.*

Cross sections for e^-p charged current deep inelastic scattering have been measured at a centre-of-mass energy of 318 GeV with an integrated luminosity of 16.4 pb^{-1}. Differential cross-sections versus the kinematical variables Q^2, x and y were presented for Q^2>200 GeV. In addition, double differential cross sections versus Q^2 and x were measured in the kinematic range 280 $GeV^2 < Q^2 <$ 30 000 GeV^2 and 0.015 < x <

0.42. The predictions of the Standard Model were found to agree well with the measured cross sections, as can be seen from Figure 1. However, the measurements are completely dominated by statistical uncertainties. With the advent of HERA II the precision of the data will be sufficient to impose strong constraints on the d and s quark contents of the proton.

An electroweak analysis, performed by fitting the differential cross sections versus Q^2 with G_F fixed at the PDG value of $1.6639 \cdot 10^{-5}$ GeV^{-2} and M_W, the mass of the W boson, treated as free parameter gives

$$M_w=80.3 \pm 2.1(\text{stat.}) \pm 1.2(\text{sys.}) \pm 1.0(\text{PDF}) \text{ GeV}.$$

This mass determination, in the space-like region, is in good agreement with the more precise measurements of the W–boson mass in the time-like region obtained at LEP and at the Tevatron.

ii) *High-mass Dijet Cross Sections in Photoproduction at HERA*

Dijet differential cross sections for the reaction $e^+p \rightarrow e^+ + \text{jet} + \text{jet} + X$ in the photoproduction regime have been measured using an integrated luminosity of 42.7 pb^{-1}. The cross sections are given for photon-proton centre-of-mass energies in the range $134 < W < 277$ GeV. The differential cross sections as a function of dijet mass and of dijet angular variables have been measured. Figure 2 shows a comparison of the measured differential cross section versus the dijet mass and QCD calculations to next-to-leading order. The results for the sub-sample of events enriched in direct photon interactions are plotted separately. Within the large uncertainty due to the choice of renormalization scale the calculations are able to reproduce the measured cross sections.

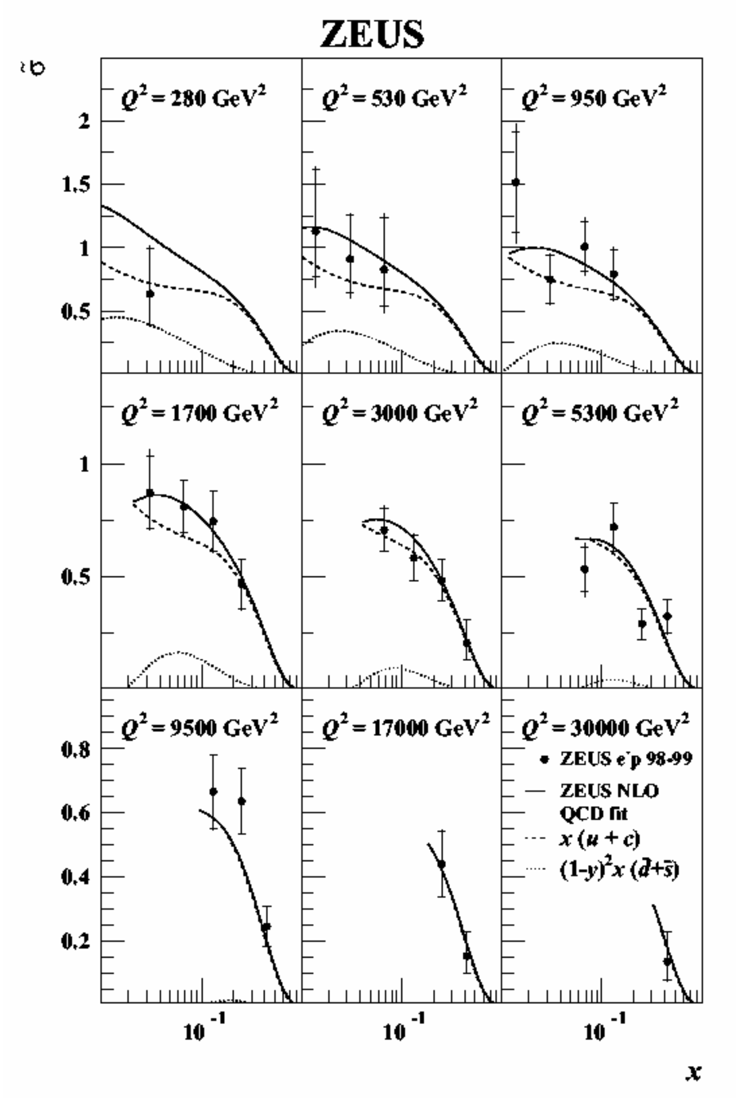


Figure 1. The reduced cross section as a function of x for different values of Q^2. The points represent the ZEUS data, while the expectation of the Standard Model evaluated using the ZEUS NLO QCD fit is shown as a solid line. The separate contributions of the PDF combinations $x(u+c)$ and $(1-y^2)(\bar{d}+\bar{s})$ are shown by dashed and dotted lines, respectively.

The data have been used to search for new heavy resonance states decaying into a pair of jets. Upper limits on the photoproduction cross section of such states in the mass range of 60 GeV to 155 GeV have been obtained.

iii) *Properties of the Hadronic Final States in Diffractive Deep Inelastic ep Scattering at HERA*

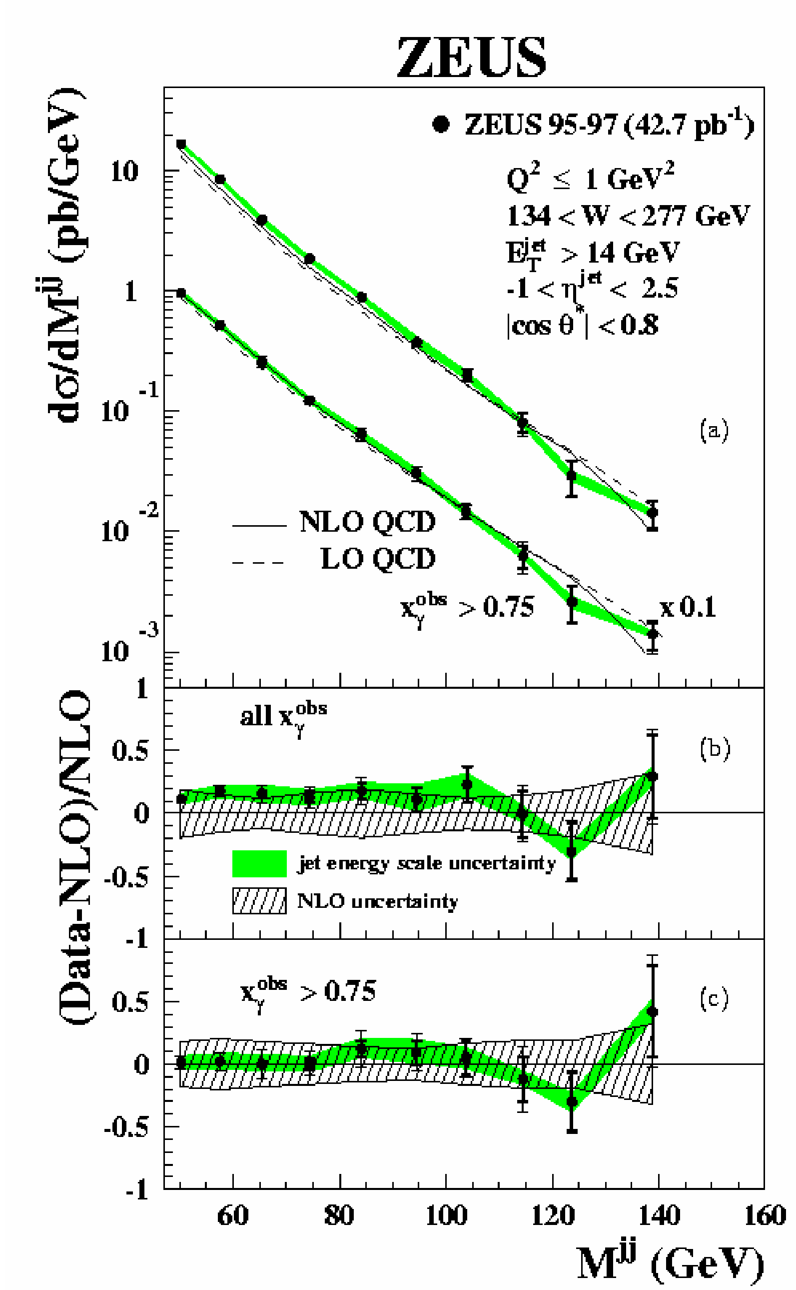


Figure 2. a) Dijet cross-sections versus dijet mass; the upper data points are for the full region in x_γ and the lower points are for the region $x_\gamma > 0.75$. The LO and NLO QCD parton-level calculations are shown as lines. b) the fractional difference between the measurement and the NLO calculation for the full range of x_γ. c) same as b), but for $x_\gamma > 0.75$.

Characteristics of the hadronic final state of diffractive deep inelastic scattering events, ep → eXp, were studied in the kinematic range $4 < M_X < 35$ GeV, $4 < Q^2 < 150$ GeV^2, $70 < W < 250$ GeV and $0.0003 < x_P < 0.03$ using an integrated luminosity of 13.8 pb^{-1}. The events were tagged by identifying the diffractively scattered proton using the leading proton spectrometer. The properties of the hadronic final state, X, were studied in its center-of-mass frame using thrust, thrust angle, sphericity, energy flow, transverse energy flow and 'seagull' distributions. Figure 3 shows the average squared transverse momentum of particles measured as a function of x_F, the Feynman x of the particles. Positive x_F is defined as the direction of the virtual photon. Also shown are the results from the EMC experiment at an average hadron center-of-mass energy similar to the average M_X of the ZEUS measurement. The EMC data indicate a suppression of the average p_T^2 associated with the proton remnant which is not as apparent in the diffractive data in the same mass range. The observed asymmetry is well reproduced by Monte

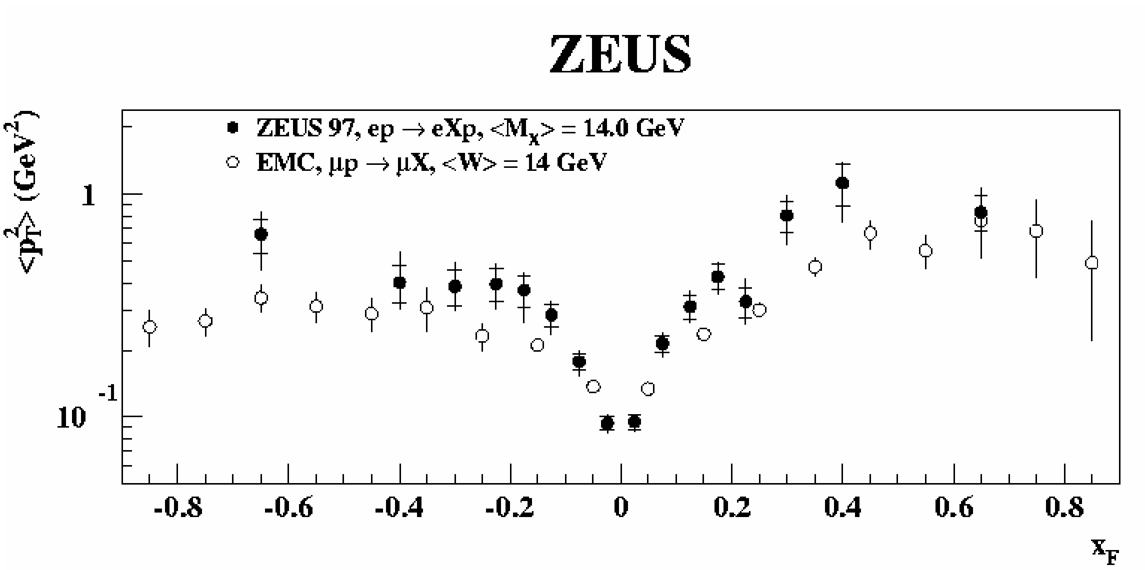


Figure 3. Average squared transverse momentum of particles measured in the center-of-mass frame of the system X as a function of x_F for diffractive events with an average M_X of 14 GeV. Also shown is the same quantity for inclusive DIS $\mu p \rightarrow \mu X$ data from the EMC collaboration at W = <M_X>. Positive x_F is in the direction of the virtual photon.

Carlo models which include a significant fraction of $q\bar{q}g$ states at the parton level.

iv) *Search for Lepton-Flavor Violation in e^+p Collisions at HERA*

A search has been made for lepton-flavor-violating interactions of the type $e^+p \rightarrow \ell X$, where ℓ denotes a μ or τ with high transverse momentum, using a data sample corresponding to an integrated luminosity of 47.7 pb^{-1}. No evidence was found for lepton-flavor violation and constraints were derived on leptoquarks LQ that could mediate such interactions. For LQ masses below √s, limits are set in $\lambda_{eq1}\sqrt{\beta_{lq}}$, where λ_{eq1} is the coupling of the LQ to an electron and a first-generation quark q_1 and β_{lq} is the branching ration of the LQ to ℓ and a quark. For LQ masses exceeding √s, limits are set on the four-fermion contract-interaction term $\lambda_{eq\alpha}\lambda_{lq\beta}/M^2{}_{LQ}$ for LQs that couple to an electron and a quark q_α and also to ℓ and a quark q_β. Some limits are also applicable to lepton-flavor-violating processes mediated by squarks in R-parity-violating supersymmetric models. In some cases involving heavy quarks and especially for $\ell = \tau$, the ZEUS limits are the most stringent published to date.

b) HERA and ZEUS Operations

The first half of 2002 was used to investigate the reasons for the high machine backgrounds as observed by the colliding beam detectors. Three different backgrounds have been identified: positron-gas interactions, proton-gas interactions and synchrotron radiation. Currently the background rates are such that the tracking detectors can not be operated in the presence of larger positron or proton beam currents. The studies involve the tracking systems as well as the calorimeter. In addition, detailed Monte Carlo studies of the beam lines are used to redesign the set of collimators employed to reduce the rate of synchrotron radiation entering the detectors.

Despite the problems with the machine this period is being used to commission the newly installed tracking detectors, the Microvertex Silicon tracker and the Straw Tube Tracker in the forward direction. Recently, several problems have surfaced with the operation of the Straw Tube Tracker, which will require a prolonged access to be mended.

(J. Repond)

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. During the first half of 2002, the group was focused on preparations for the installation of four 30 degree sectors of the detector at Brookhaven during the access period which lasts until late in the fall of 2002. Outstanding issues surrounding the calibration of the detector with a cosmic ray test facility at ANL were largely resolved.

A number of SMD design issues were resolved during the first half of 2002. The appropriate lengths of the wavelength-shifting (WLS) optical fibers used to read out the scintillators were determined based on the installation of prototype fiber bundles.

Polystyrene angle stock was chosen to shield the fibers along the sides of the modules. In consultation with other collaborators, the ANL group chose to use a 0.016 inch aluminum sheet to cover the 0.052 inch polystyrene layer that routes the optical fibers from the side of the module to the top. This decision was controversial due to thickness limitations in the calorimeter, however large sheets of thinner aluminum could not be obtained. These aluminum covers are bent over at the sides so that they also cover the polystyrene angles.

An important part of the Quality Control procedures in the SMD construction is the testing of each module in a cosmic ray test facility at ANL. This apparatus consists of trigger scintillators approximately 1.5 m above and below the SMD plus a set of tagging scintillators 10 cm above the SMD. The tag scintillators are aligned parallel to the triangular scintillator strips which make up the SMD. They are used in software to suppress noise by restricting the analysis of each event to the 10-15 SMD strips near the particular tag scintillator in which a signal was observed. A spectrum was generated for each SMD strip with the requirement of a signal in an appropriate tag scintillator and no signal in the two adjacent SMD strips. The resulting spectrum should be that of a muon traveling from the peak to the base of the triangle, plus extra events in the pedestal due to muons which pass through the tag scintillator but miss the relevant SMD strip and its two neighbors. These spectra could not be fit by a model of Gaussian photoelectron peaks with Poisson-distributed areas. It was found that when a more stringent cut was applied, to require no signal in 11 strips on either side of the strip of interest, the single-photoelectron peak was greatly suppressed and the Poisson distribution could be fit to the spectra. The average number of photoelectrons derived from this fit was reasonably consistent with the number obtained by averaging the spectrum and dividing the result by the single-photoelectron centroid obtained from an LED calibration. Light yield results for an SMD module are shown in Figure 1. The average number of photoelectrons produced by a muon traversing 7 mm of scintillator, calculated for each strip individually, should be compared to a required minimum of 2 photoelectrons. This requirement is based on assumptions used in Monte Carlo studies of the EEMC, and represents the minimum light output necessary to distinguish single photons from neutral mesons with adequate efficiency. For the module shown, all measured strips met the requirement.

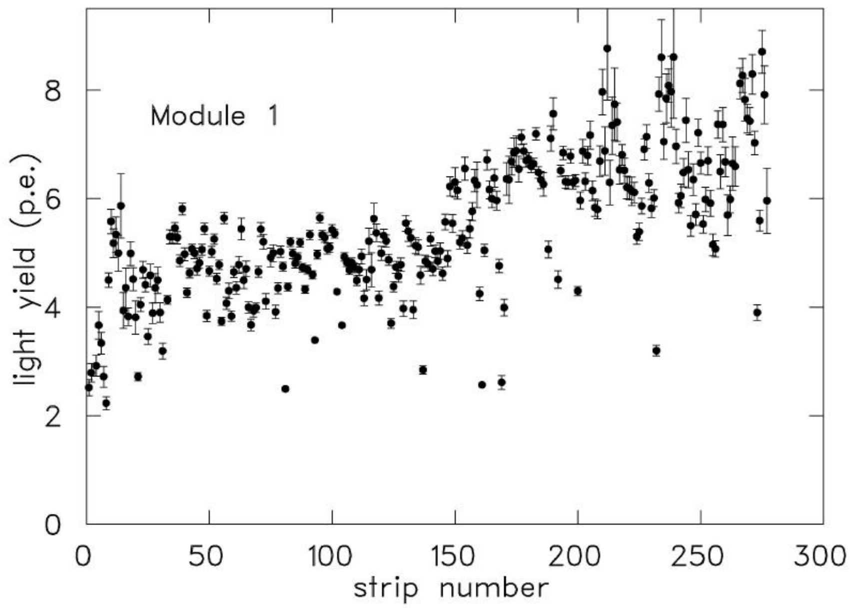


Figure 1. Quality Control results for module 1. The light yield of each strip, expressed as the average number of photoelectrons (p.e.) produced when a cosmic ray muon passes through the full height of the triangular strip, is plotted against strip number. The overall features of the plot are consistent with an inverse relationship between light output and the length of the WLS fiber. Low-lying strips are generally correlated with cases of visible damage in the clear fibers used to transport light from the module to the multi-anode photomultiplier tube.

With these issues resolved, the group's main focus was on assembly and testing of the SMD modules. The scintillator strips had been glued together during the second half 2001, and they were machined to the proper dimensions at Indiana University late in 2001 and early in 2002. After machining they returned to ANL for fiber installation and testing. The cosmic ray testing is intended to take two weeks per module, but some hardware problems have caused delays. As of June 30, 7 modules had been fully tested and were ready to be installed in the calorimeter, and testing of the last module needed to complete four sectors was in progress. Some modules had been shipped to Indiana University for cosmic ray testing with the calorimeter towers and to check the dimensional tolerances. Preparations were underway to begin regularly gluing the modules which will be needed for the second half of the calorimeter.

(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.

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 best value of Δm^2, around $3.5 \times 10^{-3} eV^2$, has motivated the use 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.

Several important MINOS detector milestones were achieved during the first six months of 2002. The first atmospheric neutrino event, an upward going muon from a neutrino interaction in the rock beneath the detector, was recorded in the partially completed far detector in March. This is illustrated in Figure 1. The assembly of the first half of the far detector, Supermodule 1, was completed at the end of June. The installation of the Supermodule 1 magnet coil was well under way at the end of the month. As the far detector installation became routine, the Argonne physicist who had served as the WBS 2.4 Level 2 co-manager for this task since 1998 gradually shifted his effort to neutrino beam-related work. He resigned as far detector installation manager in early 2002 in order to have more time for work on the neutrino beam.

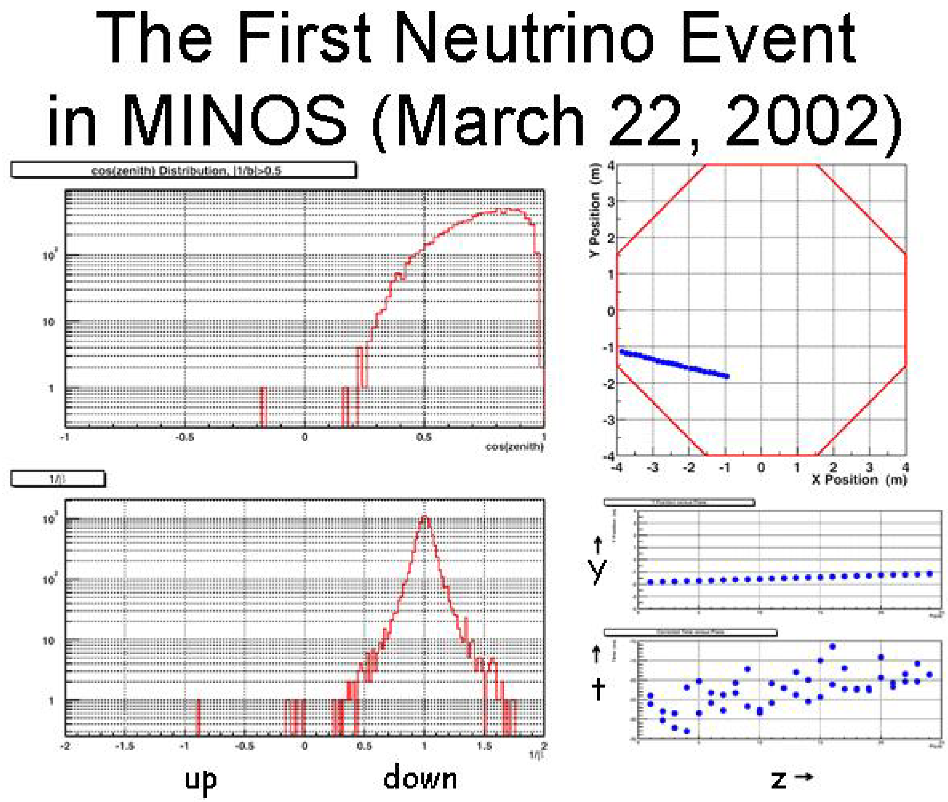


Figure 1. The first atmospheric neutrino event recorded in the MINOS far detector. The graphs show selection criteria applied to identify the upward going muon event in the presence of a large background of downward going cosmic-ray tracks. At Soudan, any upward going muon has a high probability of originating from a charged current muon neutrino interaction in the rock beneath the detector. The plots on the right side of the figure show the reconstructed x (horizontal), y (vertical) and z (detector axis) coordinates of the track, which enters the face of plane 1 and exits the side of the detector at plane 24. The lower right graph shows that the time delay of the scintillator strip pulses increases as the track moves upward from plane 1 to 24. The graphs on the left show that the signal event is cleanly separated from the background of downward going cosmic ray muons, with cos(zenith) > 0 (top) and a $1/\beta$ value near -1 (bottom). Several other candidate atmospheric neutrino interaction events have been identified in subsequent data.

The magnetization of the MINOS far detector gives it the capability of performing a unique atmospheric neutrino measurement. The bending of charged particles in the magnetic field distinguishes positive from negative muons up to 70 GeV/c. This allows the detector to measure charged-current muon neutrino and antineutrino interactions separately. A difference in the oscillation parameters of neutrinos and antineutrinos would constitute a violation of CPT symmetry, which could not have been observed in earlier experiments. Initial attempts to isolate a sample of atmospheric neutrino events in early MINOS data (with unmagnetized steel) found backgrounds from downward going cosmic-ray muon interactions to be higher than expected. This motivated the design of a veto shield covering the top and sides of the detector, to flag the presence of cosmic-ray muons in candidate neutrino events. During the summer of 2002 the MINOS Collaboration plans to install a prototype shield around the top and upper sides of one quarter of the far detector. The shield would use standard MINOS scintillator modules as its active elements and would determine if a shield over the entire far detector would reduce backgrounds sufficiently. It is anticipated that the full shield will be needed to ensure that this very important search for CPT violation is not compromised by background events.

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.

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 assistance from the Laboratory administration. By the end of June 2002 the group had completed the assembly of 501 near detector modules (over 80% of the total required) and had shipped most of these to Fermilab. The modules are being mounted on near detector steel planes at Fermilab prior to installation in the underground detector hall in 2004. At the end of June, 40% of the near detector planes had been assembled. Figure 2 shows a completed detector plane being placed in a storage rack 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 2002. The near detector must have fast front-end electronics with no dead time because of the high instantaneous rate of neutrino events at Fermilab. This is accomplished using a special MINOS modification of the Fermilab QIE ASIC chip. Most components of the near-detector front-end electronics, along with protocols for

Figure 2. Photograph of a completed MINOS near detector plane at Fermilab. The three light-colored panels attached to the steel detector plane on the left are Argonne built scintillator modules, with the fiber optics connectors visible near the top. The completed plane is being rigged into the rack where it will be stored until the underground detector hall is ready for installation to begin in 2004. The edges of four additional detector planes already in the storage rack can be seen on the right side of the photograph.

communication among the various boards, are the responsibility of the Argonne electronics group. All front-end electronics components, including QIE chips from Fermilab, clock boards from IIT, and the DAQ system from the Rutherford Lab, were installed and operated together in the "vertical slice test" setup at Argonne in early 2002. The Argonne group developed software to operate and study the performance of the readout electronics chain and performed simulations of electronics response. Figure 3 shows the vertical slice test setup in operation.

Figure 3. Photograph of the MINOS near detector vertical slice test stand at Argonne. The test stand electronics is located in the relay racks in the middle background and the operator's terminal is visible on the far left. Argonne physicists and engineers in the photograph are, from left to right, Dave Reyna, John Dawson and Gary Drake.

Physicists and engineers from Argonne, Fermilab, IIT and the Rutherford Lab completed their certification of the vertical slice performance during the first few months of 2002. In parallel with the completion of this work the group assembled and tested a nearly identical system of front-end and data acquisition electronics for the MINOS Calibration Detector (CalDet) run in a CERN test beam in September 2002. The main goal of this run is to compare directly the responses of the near and far detector electronics, which will be used to read out opposite ends of the same scintillator strips in the calorimeter. The CalDet system will include enough near detector front-end channels to read out all 128 pixels of two M64 near-detector photomultiplier tubes. The first components were shipped to CERN at the end of June.

As Argonne work on scintillator module fabrication and far detector installation became routine in late 2001, four Argonne physicists began to shift their effort to work on NuMI neutrino beam components, WBS 1.1.2, at Fermilab. This work focused on neutrino-beam horn testing and magnetic field mapping, target hall instrumentation readout and integration and the construction of facilities to repair or replace highly radioactive beam components. The Argonne group substantially increased its effort on NuMI neutrino beam work at Fermilab during the first half of 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 first half of 2002. Submodule construction was completed with the exception of some modifications to 6 special submodules, and module mechanical construction is proceeding on schedule. A total of 209 submodules were constructed at Argonne, and 58 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. 48 completed modules have now been shipped to CERN. In addition, we continue to routinely run the cesium source in all modules instrumented at MSU and replace tiles and repair fibers as needed.

(J. Proudfoot)

I.C. DETECTOR DEVELOPMENT

I.C.1. Atlas Calorimeter Design and Construction

The ATLAS Tile Calorimeter construction effort is now approaching the completion of module production. 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 must be accommodated. In addition, the engineering staff is now collaborating with Atlas Technical Coordination to specify and design components, which must be integrated with the calorimeter supports.

a) Submodule Construction

Submodule production was completed in March 2002. 144 standard submodules and 65 "special" submodules were constructed. Six submodules must be cut to provide for the supports of the endcap liquid argon cryostat and four of these have been completed. The height envelope for all submodules constructed at Argonne is generally well within the tolerance envelope.

b) Module Assembly

Module production was somewhat less smooth in this period due to personnel problems, which included medical leave for one key individual. A cumulative total of 58 modules have been constructed to date and we now expect to complete module construction in the fall of 2002 (about 1 month behind schedule). The module envelope distribution, as obtained from QC measurement made on each module, is shown in Figure 1. The design specification calls for no point to light outside of 0.030in of the module plane.

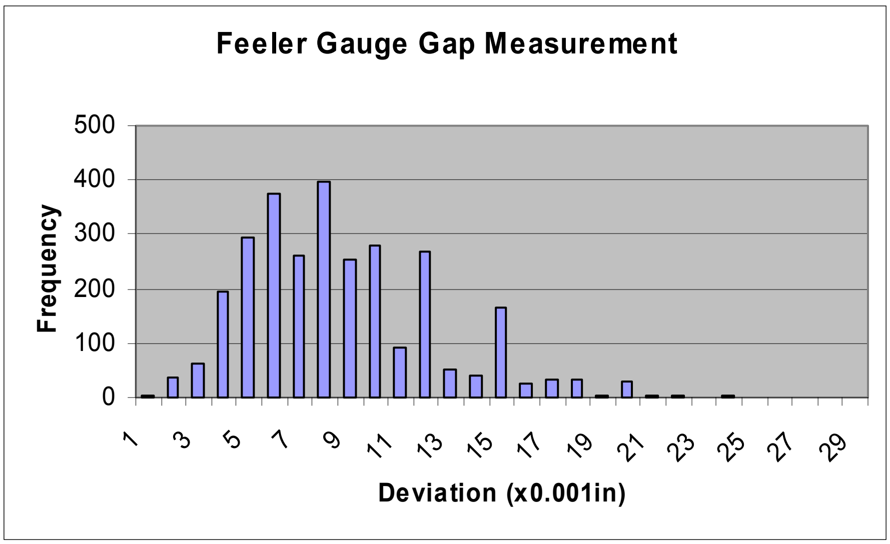


Figure 1: Module azimuthal envelope deviation from the module surface.

More detailed analysis of this data show that the deviation from the plane is a function of radial position. On average, the points with the largest deviation lie at the inner radius, where the average deviation is typically 0.012in. At the outer radius, the average variation is smaller and typically 0.006in. This result is consistent with being driven by the angular alignment of modules during mounting.

c) Module Shipping

Shipping of modules to Michigan State University and CERN has continued with no problems. 32 modules have been shipped to MSU, which represents the full complement of modules to be instrumented by that group. 28 of these have been instrumented and returned to Argonne. 48 modules have now been sent to CERN. Despite efforts to correct this, we continue to lag behind the scheduled shipping plan by 2 modules. However, this is not expected to be a problem for the preassembly schedule.

(J. Proudfoot)

d) Instrumentation and Testing

Module instrumentation and testing is continuing routinely with module non-uniformities of 5.5% being typical. Normally, following the initial instrumentation of a module with tiles and fibers, only a few fibers require replacement (as based on their response to the cesium source). At the present time, 25 modules have been instrumented at Argonne and 28 at Michigan State University out of a total of 32 to be instrumented at each location. We are approximately 1 module behind our planned schedule and, since it is unlikely that we can instrument a module in much less than 4 working weeks, do not expect to recover this slippage. However, we do not expect this to have any impact on the pre-assembly schedule for EBA.

The quality of module instrumentation, as measured by the number of fiber couplings whose response is lower than a minimum of 75% of the average, is shown in Figure 2 for all modules in which the cesium was run at Argonne. For many of the recent modules, no such coupling was detected. The early production modules do, however, show a large number of such low couplings and rework will be carried out on these modules at CERN in the fall of 2002. The techniques, which have been developed during the production, will be used to correct as many of the poor couplings as is possible.

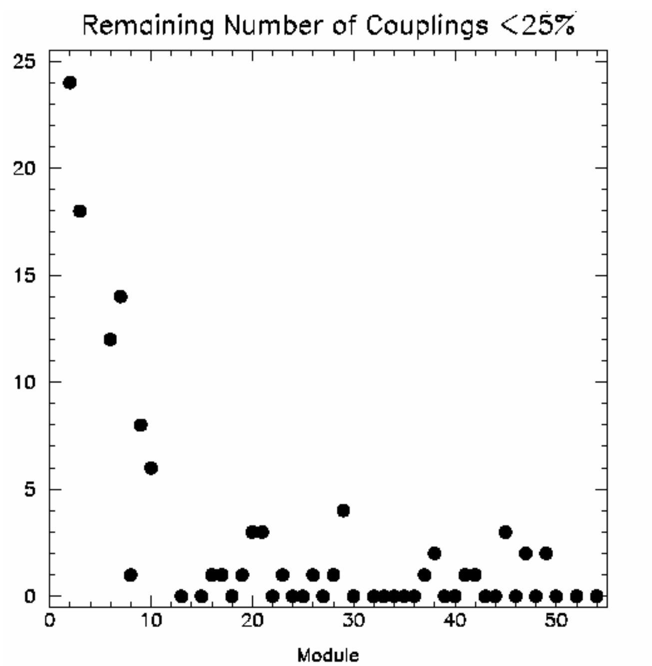


Figure 2. Module instrumentation quality as measured by the number of fibers whose coupling lies below a minimum value of 75% relative to the average response.

(J. Proudfoot and R. Stanek)

e) Test Beam Program

The testbeam program is now beginning to show that the operation of the calorimeters is as expected. The goals of the calibration program are such that all modules will be scanned with a cesium source at CERN on all the production modules. The Cs will allow for the gains of each cell to be set, we expect, to about 5%. Of these modules, 12% will be scanned in the testbeam and the response to electrons and muons will be measured. Thus, the testbeam will answer the obvious question of whether the Cs itself can carry the gain calibration to ATLAS.

On the scanning table at CERN, there is a stack of modules, as shown in Figure 3, with a bottom layer of Module 0, and the upper two layers of production modules.

Data are taken with electrons in all of the outer cells; the inner radius cells are checked with projective electrons and electrons at 20°, while other cells are scanned at 90°. Muon data are also recorded at 90° for inner cell to Cs comparison, and projective muon data recorded for future *in situ* experience.

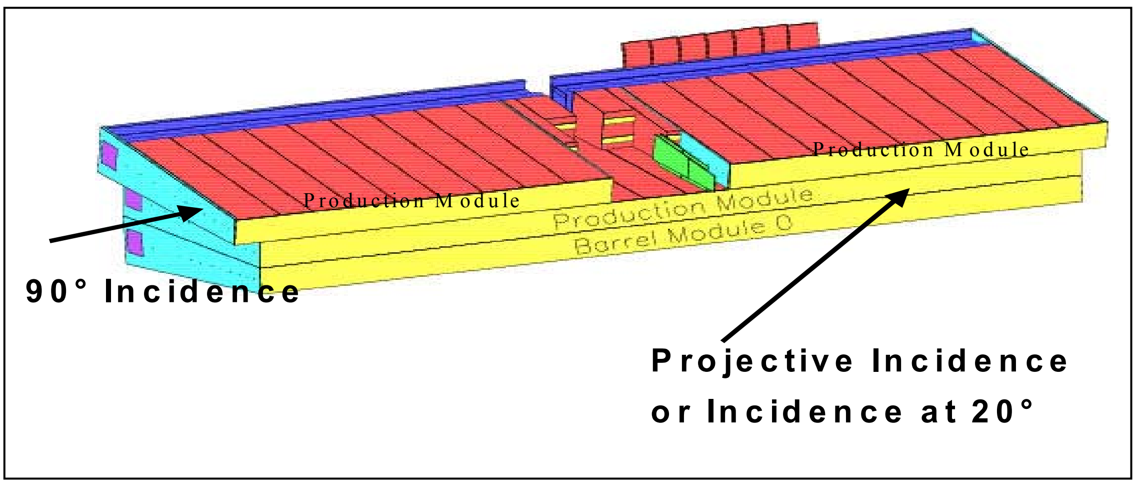


Figure 3. The setup of calorimeters on the scanning table at the CERN testbeam.

Although laser and charge injection triggers are used, Cs is the primary calibration tool to set the initial absolute electromagnetic scale. The gain to which we set is a tradeoff between electronics designs and saturation at high energies. With some experience, we set the high voltage such that each cell has a mean gain of 1.2 pC/GeV (electrons). The Cs response is very precise when averaging over tiles within a cell, and depending on the module's generation, also uniform to typically better than 3% percent over all tile-row segments. In practice, no offline Cs correction is applied to the electron or pion response. However, a correction of few percent can be made to the muon response.

We take electron data at both high energies and at 20 GeV in order to check the response of both high and low gain electronics. In Figure 4, we see the resultant pC/GeV for data taken in September 2001, and recent data taken in June 2002. The response to muons is equally as good as the electron response. Figure 5 shows the ratio of muon signal to Cs signal for muons at 90° for six modules, which have been already calibrated.

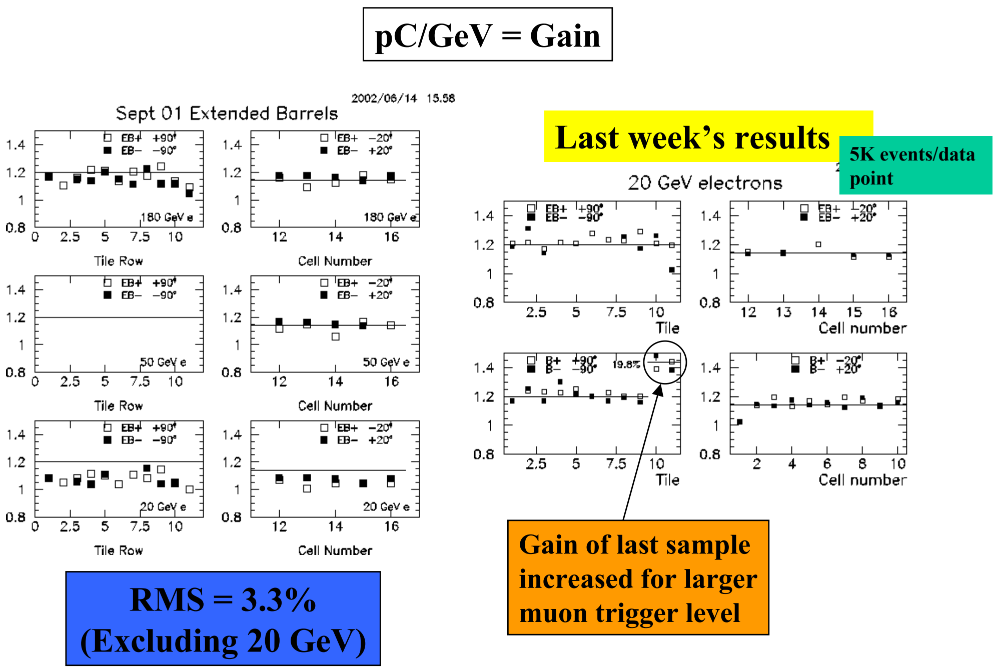


Figure 4. The response to electrons for 20, 50 and 180 GeV electrons. The results for 20 GeV electrons from September 2001 have an incorrect beam setting.

The various data points are for each cell in a given tile row, i.e. a tile-row segment. The RMS for all modules is 1.8%.

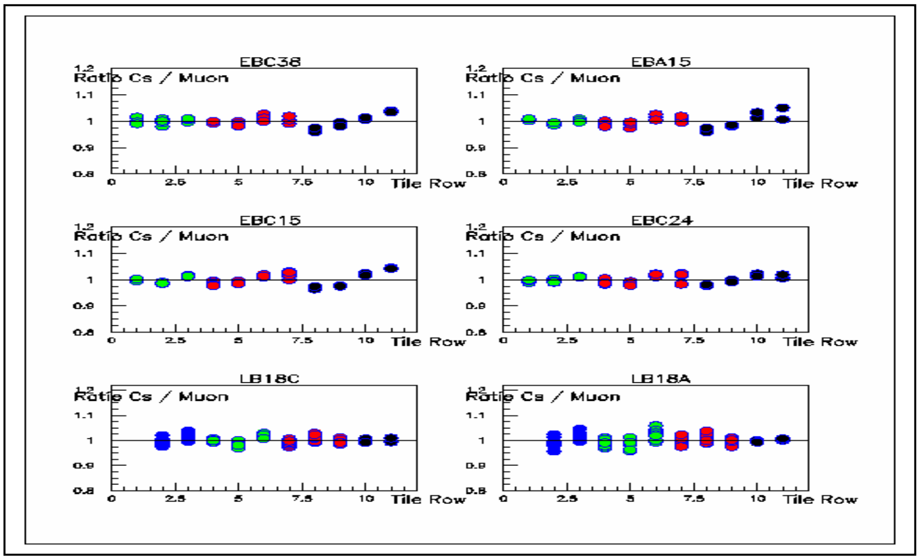


Figure 5. The response of tile-row segments normalized to respective Cs signal for six modules exposed to muons at 90°. The RMS for all modules is 1.6%.

(R. Stanek)

f) Engineering Design and Analysis

Argonne engineering staff have 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.

The design and analysis of the endcap calorimeter support saddle has been completed and the procurement placed by CERN with a company in the Czech Republic. An ANL engineer (V. Guarino) will continue to have the responsibility for vendor inspection of the saddles to ensure that they meet specification. Delivery is expected in October. The engineering calculations for the Extended Barrel are complete and have been documented. In addition, work has now begun on analyzing the stresses and module deflections during the assembly of the calorimeter cylinder. Two of the many assembly cases studied have been shown to be unstable and additional fixtures have been

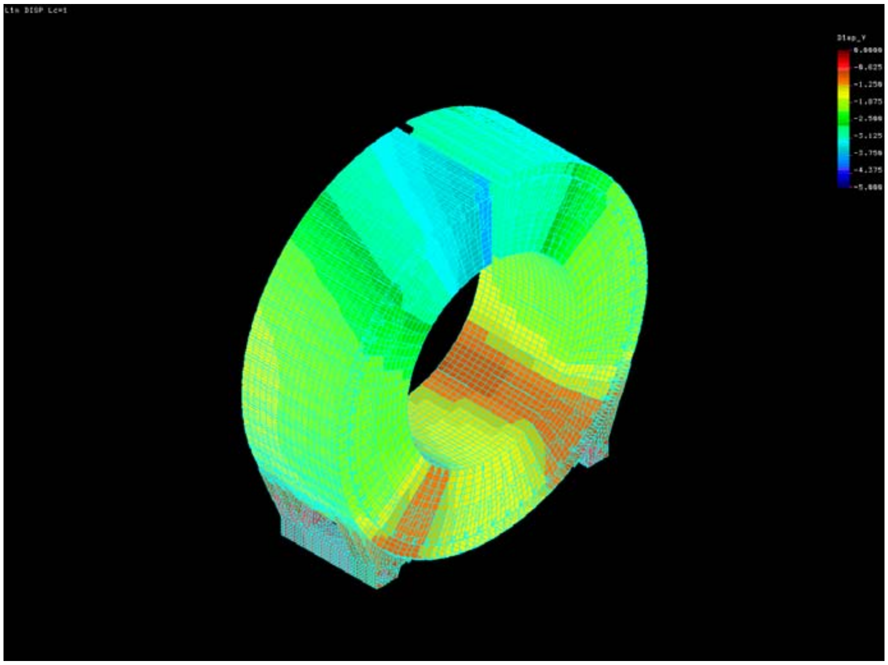


Figure 6. Vertical deflections (mm) calculated by finite element analysis of the calorimeter cylinder during assembly.

designed to ensure stability during this period of the cylinder assembly. The deflections, obtained from a 3-dimensional finite element analysis of the cylinder and saddles, are shown in Figure 6. Of note is that due to the non-uniform loading of the endcap cryostat there is a difference of ~3mm in the deflections between the front and back of the extended barrel cylinder.

(J. Proudfoot and V. Guarino)

g) Work in Collaboration with ATLAS Technical Coordination

Argonne engineering staff has now taken on new responsibilities in collaboration with ATLAS Technical Coordination for parts of the calorimeter and toroid magnet moving systems. The tasks currently assigned to Argonne engineering staff are shown in Table 1. The calorimeter x-brackets are used to guide the calorimeters into position on the Atlas main rail system. A preliminary design shown in Figure 5 is complete and being reviewed by other relevant ATLAS subsystems (in particular by the muon group).

ATLAS Technical Management Board – 2 May 2002

Project Brake-down Matrix

MOVEMENT SYSTEM						
Moving Detector Systems		**Barrel Cal**	**End-cap Cal**	**Small Wheel**	**End-cap Toroid**	**HF Truck**
System Lay-out inside ATLAS		Nyman				
Movement specs		Nyman Miralles Hott	Nyman Miralles Hott	Nyman Hooton	Nyman RAL	Nyman
Equipment						
X move	**X-brackets** **Shims** **(Temporary Jacks)**	ANL	ANL	ANL	ANL	CERN
Y move	**Air-pads** **Blocking Jacks**	CERN ANL	CERN ANL	CERN CERN	CERN RAL	CERN CERN
Z move	**Traction Cylinder** **Z-Brackets** **Z-Stoppers**	ANL	ANL	ANL	ANL	CERN
Hydraulics & Pneumatics ?	**Power pack** **Valves** **Pipes, hoses** **Air supply**	COMMON FOR MOVING SYSTEMS				
Control ?	**Sensors** **Controller**	COMMON FOR MOVING SYSTEMS				

Table 1. Task responsibility breakdown agreed to with Atlas Technical Coordination.

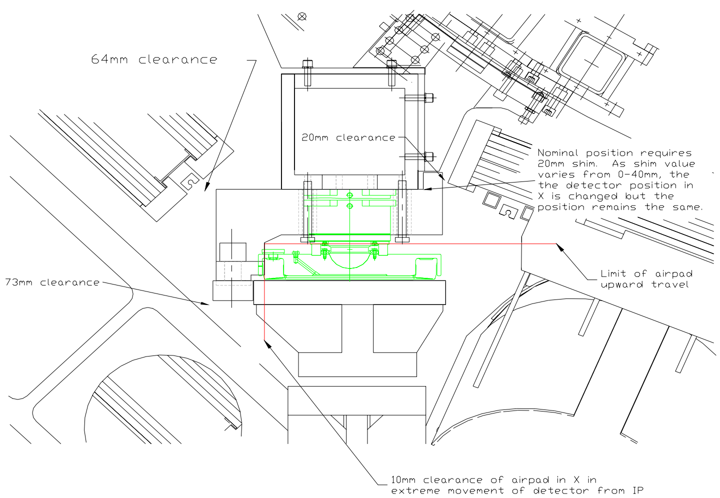


Figure 5. Integration drawing showing preliminary design of calorimeter x-bracket.

(J. Proudfoot and J. Grudzinski)

I.C.2. Computational Projects

a) ATLAS Computing

Argonne (through David Malon) continued to lead the ATLAS-wide database effort in the 1st half of 2002. In the last half of 2001, 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. The implementation of this began in the first half of this year, with the release and enhancement of a service that will enable Athena, the ATLAS software framework, to read and write ROOT files. As a first step in the transition from an object database, ANL supported Phase I of ATLAS Data Challenge 1 using the U.S.-developed AthenaRoot conversion service instead of Objectivity/DB, the previous baseline.

The U.S. database effort, led by ANL, has been integrally involved in the LHC-wide effort to define a common hybrid persistence strategy, and ATLAS shows perhaps the most detailed thinking in any of the LHC experiments about both common and experiment-specific components of a hybrid event store: using ROOT as a data streaming layer, and a relational database like MySQL as a file management layer. Based on this, ANL has played a leading role in the LHC experiments' efforts to define a common data management infrastructure, as David Malon was invited to convene the LHC Computing Grid Project's first Requirements Technical Assessment Group (RTAG), charged with establishing consensus among the experiments' architects on the specifications for a common approach to persistence. Design of this future tool is beginning now.

While there are substantial differences in philosophy and architecture among the four LHC experiments, The RTAG has been successful nonetheless in reaching agreement among the experiments on the essential components of a persistence infrastructure. To better focus the ATLAS effort on defining our needs and determining what adaptations may be necessary to use a common product, an ATLAS database workshop was held in Orsay in April, in which specific ATLAS directions were discussed and decided.

The successful Data Challenge 0 wound down in this period. Because DC0 used Objectivity/DB as its persistence technology, ANL provided not only the conversion services and specific converter packages for generator and fast simulation output, but also the production database support for the Data Challenge's event generation and fast simulation chains as well as production database support for Phase 0 of Data Challenge 1. These data challenges have provided an opportunity and a context for virtual data prototyping by the U.S. database group, based upon ideas from the U.S. grid project Graphing ("Grid Physics Networks"). Sashay Vaniachine of the U.S. group delivered the ATLAS invited talk at the ACAT 2002 workshop in Moscow, and described some of this work at that forum.

The ATLAS detector description group met at Brookhaven in early April, with Tom LeCompte as the ATLAS/TileCal representative. An outcome of that meeting was a request to the database group to provide access to "primary numbers"--numbers that parameterize the ATLAS geometry description--from a MySQL database based upon technology developed by Sasha Vaniachine. Development was begun on a conversion service to provide access to these numbers from the Athena offline control framework.

(T. LeCompte)

I.C.3. Detector Development for the Linear Collider

A group of physicist from the division has initiated an effort to develop the design of the hadron calorimeter (HCAL) for the linear collider. The main challenge of this design effort is to obtain a detector with a jet energy resolution of 30%/√E or better. This type of resolution is necessary to properly disentangle different Higgs mechanisms responsible for the generation of massive particles.

So far, the best jet energy resolution, of the order of 50%/√E, has been obtained by the ZEUS experiment. A novel approach, named Energy Flow Algorithms (EFAs), is being evaluated to improve this performance further. EFAs utilize both the tracking and the calorimeter information to measure the energy of hadronic jets. Their optimal performance requires a calorimeter with extremely fine segmentation, of the order of 1 cm^2 laterally and layer-by-layer longitudinally. This segmentation leads to a large number of readout channels, about 50 million for the HCAL. This large number of channels can only be read out digitally. The favored technology for the active medium of such a calorimeter is based on the use of Resistive Plate Chambers (RPCs).

In Monte Carlo studies the performance of calorimeters with different geometrical parameters has been simulated. The energy resolution obtained with a HCAL with digital and analog readout has been compared. In particular, the response to neutral hadrons (K_L^0, neutrons) of varying energy has been investigated.

On the hardware side, a cosmic ray test stand and a gas mixing system has been built to test RPCs. Figure 1 shows a photograph of the test set-up. In order to gain some initial experience with the technology, RPCs obtained from a group at Fermilab were investigated in excruciating detail. The charge spectra in avalanche and streamer mode were recorded, the noise rate and single particle efficiencies were measured and the cross-talk between adjacent pads was determined. The measurements were performed with different gas mixtures.

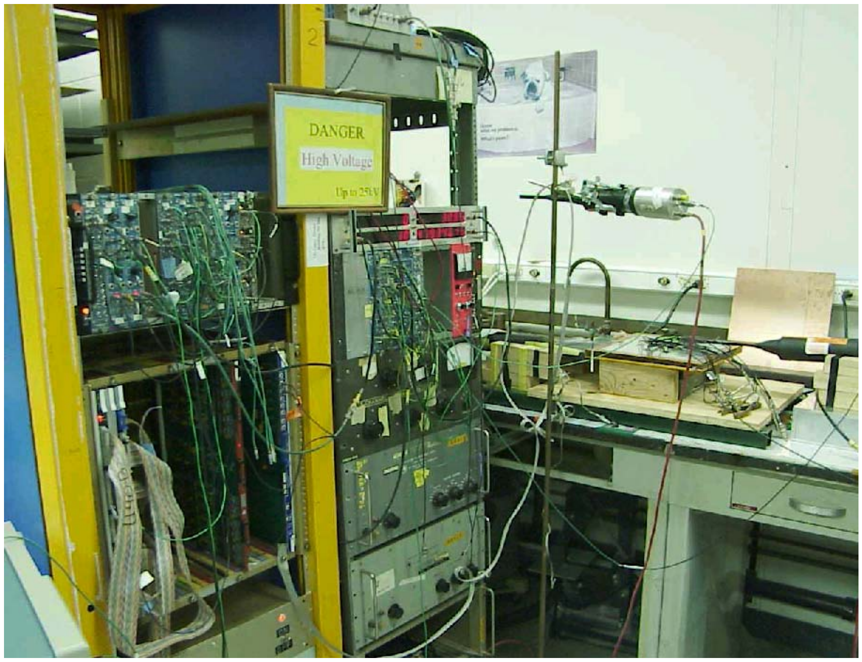


Figure 1. Photograph of the ANL cosmic ray test stand

(J. Repond)

I.C.4. 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 spring of 2001, 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.

There are several upgrades being planned for the detector for Run IIB, the second part of Run II. One of these is the replacement of the Central Preradiator Chambers (CPR). They currently are wire chambers, similar in construction and performance to the Shower Max detector. The plan is to replace them with scintillator and phototubes. We are working with division physicists who are involved with this project, to provide support for interfacing the new detector to the existing front-end electronics. Planning for this work is in progress.

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. In the fall of 2001, we built a card called the Gigabit Ethernet Link Source card. This card receives information from the front-end electronics, buffers it, and then sends it to the ROI Builder using Gigabit Ethernet protocol. 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. Testing of the prototype occurred at Argonne and at CERN in the winter of 2001-2002. The tests were highly successful. In February 2002, the ROI Builder was reviewed by an internal ATLAS review committee. The merits of using the Link Source card as a front end to the ROI Builder were discussed. While the general features were deemed acceptable, there were certain issues identified associated with error reporting and data slow control. We agreed to work out the details, and prepare a document that describes how the card would work in the system.

MINOS: 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.

In this period, we staged a small production of 200 read-out channels, to be used in a test beam at CERN. This included the production of 200 MENU Modules, 20 MINDERs, 4 MASTERs, 4 KEEPERs, and timing modules. The small system was first tested in the Vertical Slice test stand, and included tests with photomultiplier tubes. As part of this effort, significant work was done on developing the data acquisition program and calibration routines. The tests were highly successful, and demonstrated the system could meet design performance. All tests were completed by the end of May. The system has now been taken apart and shipped to CERN. We have made preparations to travel to CERN in July to reassemble the system and prepare for the test beam.

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 in a running mode. 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. Higgs Boson Decay Into Hadronic Jets

Searches for experimental manifestations of the Higgs boson are a central motivation for the experimental programs at the Fermilab Tevatron and the CERN Large Hadron Collider (LHC), with experimental detection techniques guided by theoretical expectations about the anticipated properties of these states. In weakly interacting extensions of the standard model (SM), it is natural to assume that the light Higgs boson has decay branching ratios similar to those in the SM. This expectation may be modified easily under the presence of light particles, weakly coupled to the *W* and *Z* gauge bosons, but strongly coupled to the Higgs field. The resulting Higgs boson decay properties will depend on the rates for decay to these new particles.

A Higgs boson with a dominant effective decay branching ratio into hadronic jets may be obtained within the minimal supersymmetric standard model (MSSM), under the assumption of light bottom squarks in the spectrum. This possibility is explored in detail by Ed Berger, Cheng-Wei Chiang, Jing Jiang, Tim Tait, and Carlos Wagner in a major paper, "Higgs Boson Decay into Hadronic Jets", Argonne report ANL-HEP-PR-02-022 (May 2002), hep-ph/0205342, published in Physical Review D 66, 095001 (2002). The existence of bottom squarks with low mass was proposed earlier in Phys. Rev. Lett. 86, 4231-4234 (2001) by Berger, Harris, Kaplan, Sullivan, Tait, and Wagner in order to address the observed excess production of bottom quarks at the Tevatron. This earlier work has since garnered over 40 citations.

Within supersymmetry (SUSY) theories, a light bottom squark is obtained most readily for large values of $\tan\beta$, the ratio of neutral Higgs field vacuum expectation values, and Berger *et al* work in this limit. They also work in the decoupling limit in which the mass of the pseudo-scalar Higgs boson is large compared to the *Z* boson mass and the couplings of the Higgs boson with SM particles approach their SM values. In particular, the coupling of the light scalar Higgs boson to bottom quarks is not enhanced. Within this light bottom squark scenario, the dominant Higgs decay is into a pair of bottom squarks that, in turn, manifest themselves as jets of hadrons. The total width of the Higgs boson is predicted to increase by a factor of ten to several hundred from its SM value, depending upon the value of $\tan\beta$. Since the couplings to SM particles remain approximately unchanged, the upshot is that branching fractions into conventional decay modes $\left(b\bar{b},\ WW^*,\ ZZ^*,\ gg,\ \tau\bar{\tau},\ \gamma\gamma,\ \ldots\right)$ are all reduced by a corresponding factor.

Berger *et al* compute the Higgs boson width for decay into a pair of bottom squarks as well as the influence of bottom squarks in loop processes that describe decay into other final states. The decay width into the gluon-gluon final state is enhanced as is the partonic cross section for the inclusive gluon fusion Higgs boson production subprocess. Except for the gluon fusion process, the Higgs boson production rates are not enhanced in hadron collisions and in electron-positron annihilation processes.

The authors study detection of the Higgs boson at LHC energies and show that dominant decay into bottom squarks that materialize as hadronic jets makes it much more difficult, if not impossible, to discover the Higgs boson. The more standard decays are suppressed, and the principal decay mode into jets suffers from large QCD backgrounds. They also examine possibilities at electron-positron linear colliders, demonstrating that it remains possible to discover the Higgs boson and to measure its mass and several of its coupling strengths. While details of the approach depend on the existence of bottom squarks, the conclusions are illustrative of the challenges to be faced if the dominant decays of a light Higgs state are into hadronic jets without specific flavor tags.

(E. L. Berger)

II.A.2. Radiative Decay of Υ (*nS*) into *S*-wave Sbottomonium

E. Berger, G. Bodwin, and J. Lee have calculated the branching fraction for the decay of an Υ state into *S*-wave sbottomonium. Sbottomonium is a bound state of a bottom squark and a bottom antisquark. (The bottom squark and antisquark are the scalar supersymmetric partners of the bottom quark and antiquark, respectively.) This study is motivated by the suggestion of Berger, Harris, Kaplan, Sullivan, Tait, and Wagner that the discrepancy between theory and experiment in *b* production at the Tevatron can be explained by a light bottom squark and a light gluino with masses in the ranges 2 GeV < $m_{\tilde{b}}$ < 5.5 GeV and 12 GeV < $m_{\tilde{g}}$ < 16 GeV. In this proposal, it is possible that the bottom squark and antisquark are stable enough to form sbottomonium. In that case, the scenario can be tested experimentally by searching for the radiative decay of an Υ state into sbottomonium.

The calculation extends, to the case of scalar squarks, the Nonrelativistic QCD (NRQCD) factorization approach to heavy-quarkonium decays. The required sbottomonium nonperturbative matrix elements are estimated from a lattice computation of the corresponding Υ decay matrix element [Bodwin, Sinclair, and Kim (Sejong Univ.)]. The estimate makes use of spin-symmetry relations to relate bottomonium and sbottomonium matrix elements, invokes the vacuum-saturation approximation to relate production and decay matrix elements, and employs an extrapolation in the squark mass that is motivated by potential-model scaling.

Predictions are provided of the branching fraction as a function of the masses of the bottom squark and the gluino. Branching fractions as large as several times 10^{-4} are obtained for supersymmetric-particle masses in the range suggested by the analysis of bottom-quark production cross sections. The authors examine and bound various uncertainties in the calculation. A comparison of the calculated branching fraction with CUSB data from the search for $\Upsilon \rightarrow X + \gamma$ narrows the permitted ranges of bottom squark and gluino masses, under the assumption that the bottom squark and antisquark are stable. Higher statistics data from CLEO and analyses of decays from the Υ (*3S*) and the Υ (*4S*) states will probe larger values of the masses.

Berger, Bodwin, and Lee also calculated the width of the lowest-lying sbottomonium state, obtaining a somewhat larger result than did Nappi in a previous potential-model calculation. However, the new value for the width is still much less than the experimental resolution over the interesting range of the bottom-squark mass.

A paper describing this work (ANL-HEP-PR-02-035, hep-ph/0206115) has been published in Physics Letters, B 552, 223 (2003).

(E. L. Berger, G. T. Bodwin, and J. Lee)

II.A.3. Order-v^4 Corrections to *S*-wave Quarkonium Decay

G. Bodwin and A. Petrelli have completed a calculation of higher-order relativistic corrections to the rates for the decays of *S*-wave heavy-quarkonium states into light hadrons and leptons or photons. Specifically, they have computed the short-distance coefficients for the relative-order-v^4corrections to these decays, where v is the heavy-quark-antiquark relative velocity.

This is the first calculation of a relative-order-v^4 correction involving operators with the same quantum numbers as the leading-order operator, and it is considerably more difficult technically than previous calculations of relative-order-v^2 corrections. Much of the detailed algebra was carried out by making use of the symbolic manipulation package Mathematica and the program FeynCalc. In the case of the $^3S_1$ decays into light hadrons, an infrared divergence appears. It must be subtracted from the Feynman amplitude for the decay process and absorbed into appropriate matrix elements of color-octet operators. This procedure, which is prescribed in the condition for the matching of full QCD and NRQCD, renders the expression for the physical decay rate finite.

The relative-order-v^4 calculation lays the groundwork for a new level of precision in the phenomenology of *S*-wave quarkonium decays. It also provides information about the convergence of the v expansion. Large coefficients that appear in relative-order v^2 had cast some doubt upon that convergence. However, the new calculation shows, at least for the color-singlet channel, that the expansion is well-behaved in order v^4.

A paper describing this work (ANL-HEP-PR-02-031, hep-ph/0205210) has been submitted to Physical Review D.

(G. T. Bodwin)

II.A.4. Lattice Gauge Theory

During this period we have continued our studies of hadronic matter in extreme environments using lattice gauge theory simulations. Because of the sign problems associated with systems at finite baryon-number density, we have limited our finite density studies to QCD at finite isospin density and 2-flavour QCD at finite quark-number density. For our finite temperature studies we have continued to use a modified action which allows us to work at zero quark mass.

We completed our simulations of 2-flavour QCD with a finite chemical potential μ_I for isospin (I_3) on an 8^4 lattice at 2 different masses. Here we identified the phase transition at $\mu_I = \mu_c = m_\pi$ to a state where I_3 is spontaneously broken by a pion condensate and determined that the transition was second order with mean-field critical exponents (Fig. 1). Using an $8^3 \times 4$ lattice we determined that the nature of the transition remained unchanged at low but finite temperatures. When the system was heated with $\mu_I > \mu_c$, the system was seen to undergo a transition where the condensate evaporates and the I_3 symmetry is restored. For μ_I sufficiently large this transition appears to be first order. We are now following the position of the finite temperature crossover from hadronic matter to a quark-gluon plasma for $\mu_I < \mu_c$ as a function of μ_I, and observe it to be slowly varying. In this regime the dependence of the transition temperature on μ_I and on the quark-number chemical potential are believed to be identical.

Our studies of 2-colour QCD with a finite chemical potential μ for quark number are aimed at studying some of the phenomena suggested for true (3-colour) QCD at finite quark/baryon number chemical potential, in a model which lacks its sign problems. In particular we can study diquark condensation, which in true QCD would lead to colour superconductivity. We have now extended our simulations to larger (16^4) lattices and weaker couplings $(4/g^2 = 1.85)$. We have observed the phase transition to a state with a diquark condensate which spontaneously breaks quark-number, and see evidence that this is a second order transition with mean-field critical exponents. We have simulated this system at finite temperature on $12^3 \times 6$ lattices and have observed the finite temperature phase transition where the condensate evaporates. This is confirmed to be first order at high μ and second order at lower $\mu > \mu_c$. Finally, we are simulating the system at stronger coupling $(4/g^2 = 1.5)$ and small quark mass $m = 0.025$ on 8^4 and $12^3 \times 24$ lattices. The larger of these lattices will enable us to study the spectrum of Goldstone and pseudo-Goldstone excitations.

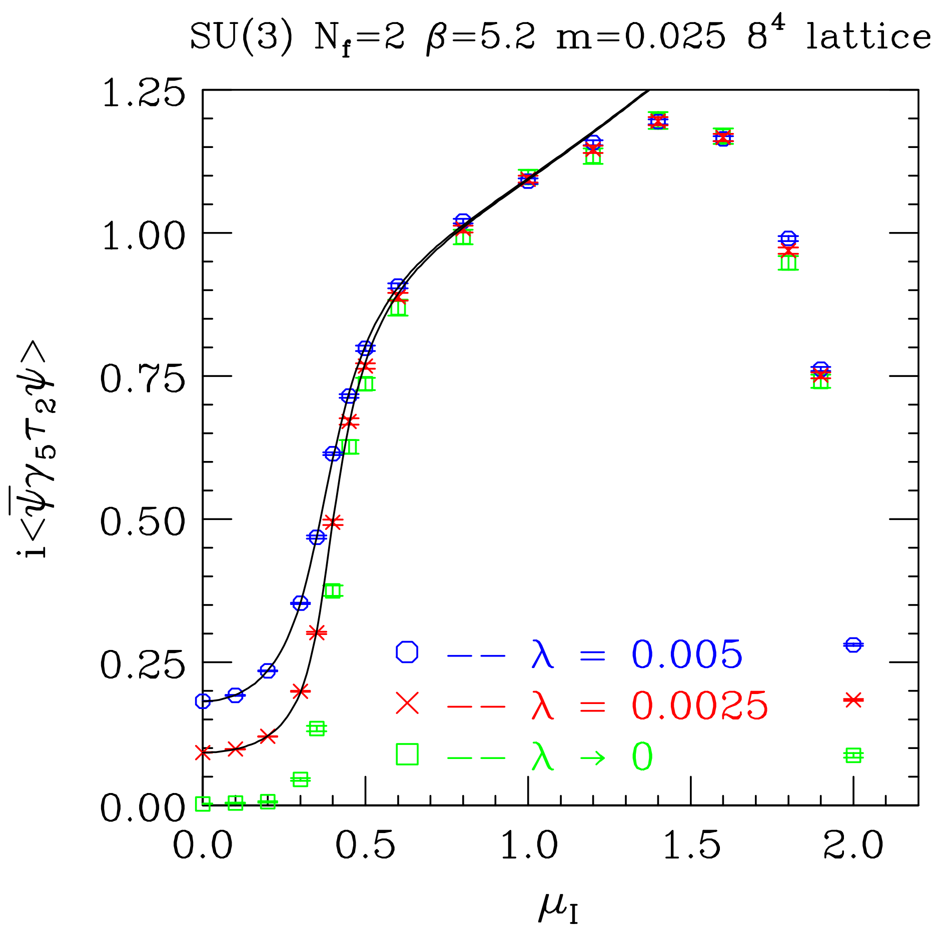


Figure 1. Charged pion condensate as a function of μ_I. The fit is to a mean field scaling function.

We studied quenched versions of both the above theories at finite chemical potential, and found that they behave very similarly to the unquenched theories. This contrasts with the case of QCD at finite baryon-number chemical potential. In both cases we confirmed the mean-field nature of the zero temperature phase transition with high precision.

We are extending our finite temperature simulations of QCD with extra 4-fermion interactions at zero quark mass to $N_t = 8$ lattices ($16^3 \times 8$ and $24^3 \times 8$) to study the universality class of the finite temperature phase transition hopefully free of the lattice artifacts which plagued the $N_t = 4$ and $N_t = 6$ simulations.

(D. K. Sinclair)

II.A.5. Deformation Quantization of Superintegrable Systems And Nambu Mechanics

In an extensive project, C. Zachos and collaborators have been configuring deformation quantization (quantization in phase-space) into a workable and practical tool. An application has been introduced by Curtright and Zachos [hep-th/0205063, ANL-HEP-PR-02-030], in which this quantization is distinctly superior to conventional operator quantization (as well as path integral quantization), and thus yields new results for chiral models and the quantization of Nambu brackets (NB).

Highly symmetric quantum systems are often integrable and, in special cases, superintegrable--they possess more invariants than degrees of freedom. In the case of velocity-dependent potentials, when quantization of a classical system presents operator ordering ambiguities involving x and p, in the conventional operator formulation, the general consensus has been to (painfully) select those orderings in the quantum Hamiltonian that maximally preserve the symmetries present in the corresponding classical Hamiltonian. In contrast, phase space is the framework best suited for quantizing superintegrable systems, naturally preserving the symmetry algebras of the respective Hamiltonian invariants. The power and simplicity of the method of Zachos and Curtright is illustrated through new applications to nonlinear σ-models (specifically for de Sitter N-spheres and chiral models), where the symmetric quantum Hamiltonians amount to remarkably compact and elegant expressions. Moreover, classically, such maximally superintegrable models have their symmetries accounted for in a unified way through NBs. The quantization of these systems then has an unexpected application: it facilitates explicit testing of NB quantization proposals, through direct comparison to the conventional quantum answers thus found. (The quantization of NBs has been problematic ever since their inception.) It is shown that Nambu's early quantization prescription does not always fail, as had been often superficially assumed. Comparison to the deformation quantization results found in this project vindicates Nambu's quantization prescription (and invalidates other prescriptions), for systems such as S^2, S^N, in a large class, and argues against unrealistic desiderata broadly held.

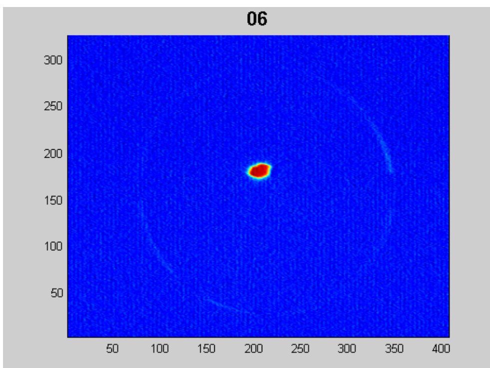
(C. Zachos)

III. ACCELERATOR RESEARCH AND DEVELOPMENT

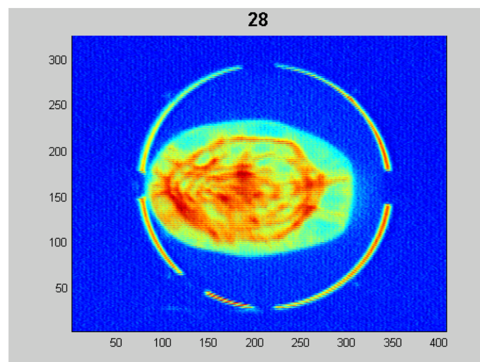
III.A. ARGONNE WAKEFIELD ACCELERATOR PROGRAM

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

During this period, the new AWA RF photocathode gun was fully installed at the gun test stand and commissioned. RF waveguides were rerouted to deliver the high RF power to the gun area. The new gun was baked at high temperature (> 300 F) for a week and, as a result, the gun vacuum reached 3×10^{-10} torr after the gun cooled down. A high charged (> 20 nC) beam was produced using the old AWA laser system. Initial measurements of the beam spot indicate that the beam is in the Laminar flow regime.



Electron beam focused with solenoid to a ~ 1 mm spot .



Measured larger electron beam image from screen has the same image as input laser beam.

Figure 1. Measured electron beam profiles from the newly commissioned AWA RF photocathode gun.

Figure 1 shows the electron beam profiles measured about one meter from the gun. The Figure on the right shows that the beam profile matches well with the input laser profile. This indicates that the electron beam flow between the gun and screen is Laminar and that the emittance has not thermalized.

Figure 2. The newly installed AWA Laser System.

We have continued the upgrade to our laser system including the commissioning of: (1) The Spectra Physics Tsunami oscillator; and (2) The TSA-50: Spitfire Regenerative Amplifier and two Ti:Sapphire Amplifiers. The system produces 1.5 mJ at 248 nm, 6 - 8 ps FWHM, 1 - 10 Hz with improved stability on laser pulse *timing* (< 1ps rms); *amplitude* (± 3% rms at high energy and ±1% at low energy) and transverse beam profiles. We have also greatly improved the AWA Laser Room environment by installation of a new HEPA air filter and a heavy-duty air conditioner.

The project to replace the existing AWA Control System is underway. A new PC based control computer was ordered and two PC compatible CAMAC crate controllers were installed. We also developed a new NT based control program using National Instrument's LabWindow/CVI system. All system software and hardware (including the AWA video Sync Generator built by the HEP electronics group) have been tested and we are now ready for switch over.

III.A.2. High power testing of the Dielectric traveling and standing wave Accelerators

We have performed several high power tests of the X-band traveling and standing wave dielectric structures. The experiments went well initially, we conditioned the traveling wave tube up to 5 MeV/m gradient. However, higher power caused RF breakdown at the RF coupling apertures for both structures, although at a much lower level for the standing waves. Experimental setup for the traveling wave structure test is shown in Figure 3.

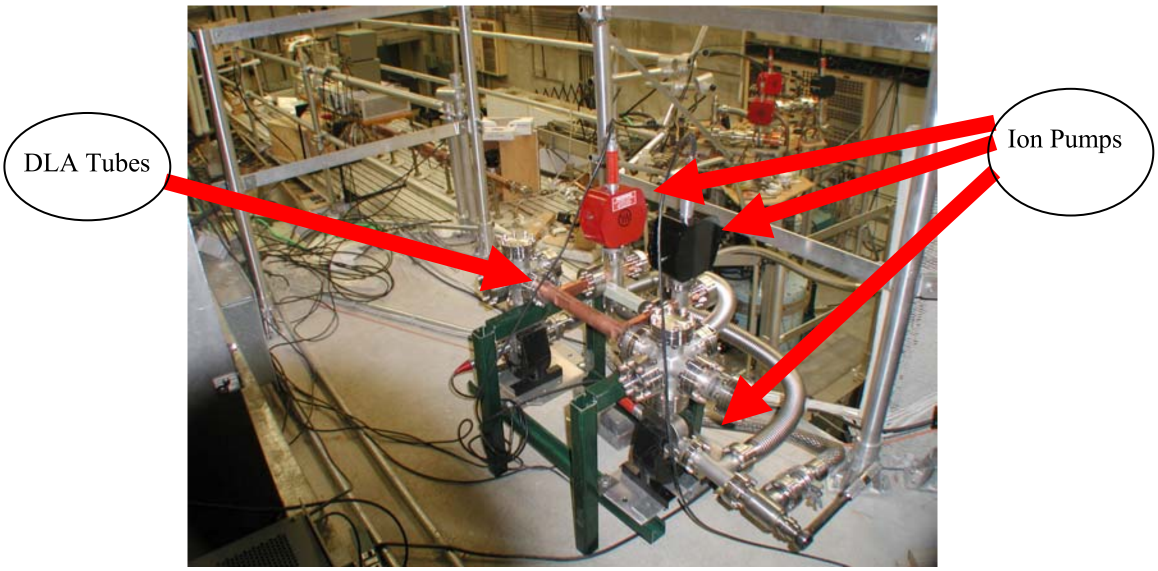


Figure 3. Traveling Wave Structure installed at the NRL for high power test.

III.A.3. Dielectric Accelerators Developments

In order to address the problems observed during the first series of high power test conducted at NRL, the dielectric loaded accelerating (DLA) structure was totally redesigned. We have developed a new modular DLA structure as shown in Figure 4. This scheme has several advantages: separation of coupling issues from acceleration; good coupling does not depend on the location of the dielectric taper with respect to the aperture; copper residue on outside of dielectric won't be harmful; larger coupling-aperture lowers the power density. The structures are already fabricated and will be cold and high power tested in the near future.

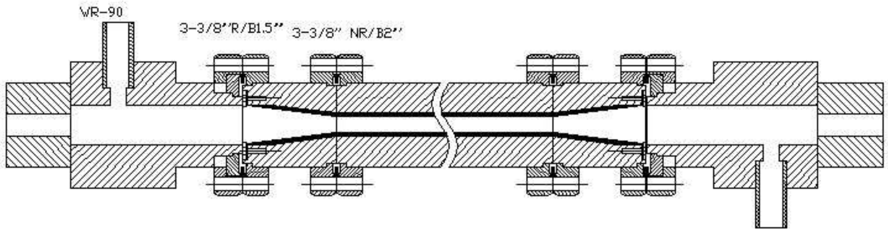


Figure 4. Design of a modular traveling wave Dielectric Structures.

We have continued our work on the high power, 21 GHz, RF extractor for the CLIC application in collaboration with DULY Research. We purchased and performed the initial machining of the device. It was then sent to DULY Research for final preparations before undergoing experimental testing at CERN. A high power test is expected to be conducted at CERN in the fall.

(W. Gai)

II. B. MUON COLLIDER RESEARCH

a) Studies of Dark Current at Lab G

At the end of the year, the open cell cavity was removed from the lab G facility and the experimental program switched to the single cell pillbox cavity designed and built at LBL. During the period from January to June, the pillbox cavity was installed and conditioned, and its operating characteristics were measured. This cavity, with a very low stored energy and field enhancement very close to 1.0, did not produce much dark current, had a very low breakdown rate and very little internal damage was seen when it was disassembled.

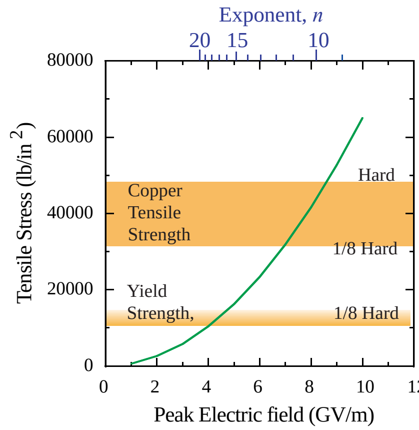


Figure 1. Electric fields on copper

While measuring the properties of the pillbox cavity we continued to understand more about dark current and breakdown in the open cell cavity. Two interesting properties of breakdown events were noticed. First, breakdown seemed to occur when the surface electric field at the emitter tips produced a tensile stress equal to the tensile strength of the bare copper. The electric field in this case was measured by fitting the Fowler-Nordheim emission curve to the measured dark current, over 14 orders of magnitude. This would imply that breakdown consisted of the sharpest emitter tips simply breaking off with the fragments producing arcs. We were also able to establish that the dark current emission seemed to be due to simple enhancements of field emission due to splashes of copper on the interior walls of the cavity. The fitted values of emitter area, combined with the measured density of the emitters implied dimensions for individual emitters (10^{-7} m) which were confirmed by SEM images of splashes on the window. This seems to be in contradiction with current theories of breakdown in normal cavities, which involve ionization of adsorbed gas. The paper summarizing these results was finished and submitted to Phys. Rev. Special Topics / Accel. and Beams. The arguments on tensile stress, tensile strength and mechanical perturbations being responsible for high field enhancements should be applicable to any

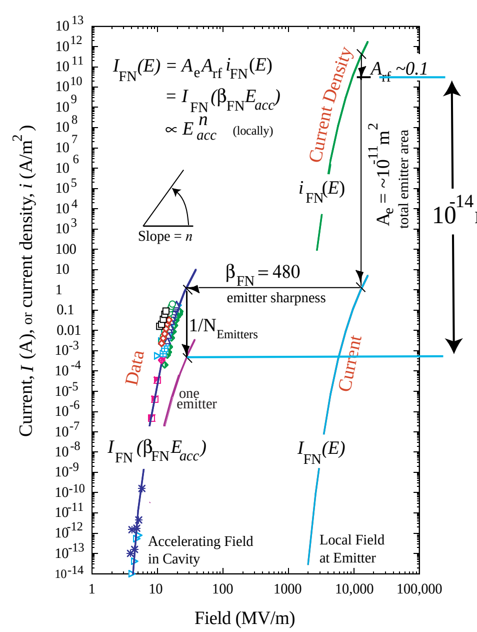


Figure 2. Field Emission in cavities

environment where breakdown occurs, such as DC, normal copper rf cavities, superconducting cavities and dielectrics.

Insight gained in the study of the open cell and pillbox cavities has been used to develop arguments about the xray and electron backgrounds which should be present in the Muon Ionization Cooling Experiment. This experiment is presently being designed by a large international collaboration to be installed at the ISIS facility at the Rutherford/Appleton Laboratory in England. Preliminary estimates imply that the cavities will be power limited and not able to produce dangerous levels of high energy dark current background at the 8 MV/m gradients produced by the 1 MW/cell presently planned for the experiment. On the other hand we have seen significant levels of multipactoring even at low power levels and this could be a problem.

(J. Norem)

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IV. A. BOOKS, JOURNALS AND CONFERENCE PROCEEDINGS

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E. L. Berger, J.-W. Qiu, and X.-F. Zhang
Phys. Rev. **D65**, 034006 (2002).

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. **D65**, 111101, (2002).

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. Lett. **B549**, 32-47 (2002).

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. **D66**, 012004 (2002).

Search for Single-Top-Quark Production 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. **D65**, 091102 (May 2002). *not previously sited*

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. **B529**, 93 (2002).

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
Phys. Rev. **D65**, 072005 (2002).

Snowmass 2001: Jet Energy Flow Project
E. L. Berger, …S. Magill, *et al.*
In: *Proceedings of the APS/DPF/DPB Summer Study on the Future of Particle Physics* (Snowmass 2001), edited by R. Davidson and C. Quigg, eConf C010630, P512 (June 2002).

Summary: Working Group on QCD and Strong Interactions

E. L. Berger, …S. Magill, *et al.*

In: *Proceedings of the APS/DPF/DPB Summer Study on the Future of Particle Physics* (Snowmass 2001), edited by R. Davidson and C. Quigg, eConf C010630, P5001 (June 2002).

Supersymmetry Breaking and Extra Dimensions

D. E. Kaplan

In: *Proceedings of the Summer Institute 2001: Session 2 (Phenomenology)*, pp. F35-F51.

Supersymmetry Explanation for the Puzzling Bottom Quark Production Cross Section

E. L. Berger

In: *Proceedings of the 9th International Symposium on Heavy Flavor Physics*, edited by A. Ryd and F. C. Porter (AIP, Melville, NY, 2002) pp. 371-380.

Theory of Quarkonium Production

E. Braaten, S. Fleming, J. Lee, and A. Leibovich

In: *Report of the Workshop on B Physics at the Tevatron: Run II and Beyond,* (FERMILAB-PUB-01/197; hep-ph/0201071) pp. 457-471 (2002).

The Past and Future of S-Matrix Theory

A. R. White

In: *Scattering*, edited by E. R. Pike and P. Sabatier (Academic Press, San Diego, Feb 2002) pp. 1483-1504.

The Snowmass Points and Slopes: Benchmarks for SUSY Searches

B. C. Allanach, …C.E.M. Wagner, *et al.*

In: *Proceedings of the APS/DPF/DPB Summer Study on the Future of Particle Physics* (Snowmass 2001), edited by R. Davidson and C. Quigg, eConf C010630, P125 (June 2002).

The Two Cutoff Phase Space Slicing Method

B. W. Harris and J. F. Owens

Phys. Rev. **D65**, 094032 (2002).

Top Quark Seesaw, Vacuum Structure and Electroweak Precision Constraints

H.-J. He, C. T. Hill, and T.M.P. Tait

Phys. Rev. **D65**, 055006 (2002).

Updated Analysis of Some Two-Body Charmless *B* Decays

C.-W. Chiang and J. L. Rosner

Phys. Rev. **D65**, 074035 (2002).

Young Physicists' Forum

T. Adams, …Z. Sullivan, *et al*.

In: *Proceedings of the APS/DPF/DPB Summer Study on the Future of Particle Physics* (Snowmass 2001), edited by R. Davidson and C. Quigg, eConf C010630, I003 (June 2002).

IV.B. MAJOR ARTICLES SUBMITTED FOR PUBLICATION

Azimuthal Anisotropy of K_s° and Λ and $\overline{\Lambda}$ Production at Mid-Rapidity from Au+Au Collisions at $\sqrt{s_{NN}}$ = 130 GeV

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

Phys. Rev. Lett.

ANL-HEP-PR-02-034

$B \rightarrow D_s \pi$ And the Tree Amplitude in $B \rightarrow \pi^+ \pi^-$

C.-W. Chiang, Z. Luo, and J. L. Rosner

Phys. Rev. D

ANL-HEP-PR-02-037

Branes and Orbifolds are Opaque

M. Carena, T.M.P. Taits, and C.E.M. Wagner

Acta Phys. Polonica B

ANL-HEP-PR-02-043

Chiral Anomaly and High-Energy Scattering in QCD

A.R. White

Phy. Rev. D

ANL-HEP-PR-019

Chirality Violation in QCD Reggeon Interactions

A. R. White

Phys. Rev. D

ANL-HEP-PR-02-033

Coherent ρ° Production in Ultra-Peripheral Heavy-Ion Collisions
R. V. Cadman, K. Krueger, H. M. Spinka, D. G. Underwood
Phys. Rev. Lett.
ANL-HEP-PR-02-049

Deformation Quantization of Superintegrable Systems and Nambu Mechanics
T. L. Curtright and C. K. Zachos
New J. Phys.
ANL-HEP-PR-02-030

Elliptic Flow from Two- and Four-Particle Correlations in Au+Au Collisions at $\sqrt{s_{NN}}$ = 130 GeV
R. V. Cadman, K. Krueger, H. M. Spinka, D. G. Underwood
Phys. Rev. C
ANL-HEP-PR-02-040

Exclusive Photoproduction of J/ψ Mesons at HERA
S. Chekanov, D. Krakauer, S. Magill, B. Musgrave, A. Pellegrino, J. Repond, R. Yoshida
ANL-HEP-PR-02-015

Hadronic Decays of χ_{bJ} into Light Bottom Squarks
E. L. Berger and J. Lee
Phys. Rev. D
ANL-HEP-PR-02-021

Higgs-Boson Decay into Hadronic Jets
E. L. Berger, C.-W. Chiang, J. Jiang, T.M.P. Tait, and C.E.M. Wagner
Phys. Rev. D
ANL-HEP-PR-02-022

Higgs-Boson Production in Association with a Single Bottom Quark
J. M. Campbell, R. K. Ellis, F. Maltoni, and S. Willenbrock
Phys. Rev. D
ANL-HEP-PR-02-027

Improved Results in Supersymmetric Electroweak Baryogenesis
M. Carena, M. Quiros, M. Seco, and C.E.M. Wagner
Nucl. Phys. B
ANL-HEP-PR-02-041

Is the Lightest Kaluza-Klein Particle a Viable Dark Matter Candidate?
G. Servant and T.M.P. Tait
Nucl. Phys. B
ANL-HEP-PR-02-032

Kaon Production and Kaon to Pion Ratio in Au+Au Collisions at $\sqrt{s_{NN}}$ = 130 GeV
R. V. Cadman, K. Krueger, H. M. Spinka, D. G. Underwood
Phys. Rev. Lett.
ANL-HEP-PR-02-047

Lattice QCD at Finite Isospin Density at Zero and Finite Temperature
J. B. Kogut and D. K. Sinclair
Phys. Rev. D
ANL-HEP-PR-02-016

Limits on Extra Dimensions and New Particle Production in the Exclusive Photon and Missing Energy Signature in pp(bar) 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-02-046

Measurement of the Q^2 and Energy Dependence of Diffractive Interactions at HERA
S. Chekanov, D. Krakauer, S. Magill, B. Musgrave, A. Pellegrino, J. Repond, R. Yoshida
Eur. Phys.
ANL-HEP-PR-02-026

Measurement of Proton-Dissociative Diffractive Photoproduction of Vector Mesons at Large Momentum Transfer at HERA
S. Chekanov, D. Krakauer, S. Magill, B. Musgrave, J. Repond, R. Yoshida
Eur. Phys. J.
ANL-HEP-PR-02-038

Mid-rapidity Λ and $\overline{\Lambda}$ Production in Au + Au Collisions at $\sqrt{s_{NN}}$ =130 GeV
H. M. Spinka, D. G. Underwood, R. V. Cadman, K. Krueger
Phys. Rev. Lett.
ANL-HEP-CP-02-029

Order-v^4 Corrections to *S*-wave Quarkonium Decay

G. T. Bodwin and A. Petrelli

Phys. Rev. D

ANL-HEP-PR-02-031

Physics Opportunities at $\mu^+\mu^-$ Higgs Factories

C. Blöchinger, …C.E.M. Wagner, and G. Weiglein

In: *Report of the Higgs Factory Working Group of the ECFA-CERN Study on Neutrino Factory and Muon Storage Rings at CERN*

ANL-HEP-PR-02-023

Quenched Lattice QCD at Finite Isospin Density and Related Theories

J. B. Kogut and D. K. Sinclair

Phys. Rev. D

ANL-HEP-PR-02-004

Radiative Decay of Upsilon(*nS*) into *S*-wave Sbottomonium

E. L. Berger, G. T. Bodwin, and J. Lee

Phys. Rev. Letts.

ANL-HEP-PR-02-035

Search for New Physics in Photon-Lepton Events 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 and A. B. Wicklund

Phys. Rev. Lett.

ANL-HEP-PR-02-025

The Chiral Anomaly and High-Energy Scattering in QCD

A. R. White

Phys. Rev. D

ANL-HEP-PR-02-019

The Phase Diagram of Four Flavor SU(2) Lattice Gauge Theory at Nonzero Chemical Potential and Temperature

J. B. Kogut, D. Toublan and D. K. Sinclair

Nucl. Phys.

ANL-HEP-PR-02-005

The Puzzle of the Bottom Quark Production Cross Section
E. L. Berger
Int. J. Mod. Phys. A
ANL-HEP-PR-02-001

Top-Squark Searches at the Tevatron in Models of Low-Energy Supersymmetry Breaking
M. Carena, D. Choudhury, R. A. Diaz, H. E. Logan and C.E.M. Wagner
Phys. Rev. D
ANL-HEP-PR-02-042

Uncertainties on the Measurements of the Top Mass at a Future e+e- Collider
S. Chekanov
Eur. Phys. J.
ANL-HEP-PR-02-044

IV.C PAPERS OR ABSTRACTS SUBMITTED TO CONFERENCE PROCEEDINGS

Design of Dielectric Accelerator Using TE-TM Mode Converter
W. Liu, W. Gai
In: *Advanced Accelerator Concepts 2002*, Oxnard, CA, June 22-28, 2002.
ANL-HEP-CP-02-069

Description of EM Fields & Wakefields in Dielectric-Loaded Rectangular Waveguide Acclerating Structures
L. Xiao, W. Gai, C. Jing and T. Wong
In: *Advanced Accelerator Concepts 2002*, Oxnard, CA, June 22-28, 2002.
ANL-HEP-CP-02-065

E-Flow Optimization of the Hadron Calorimeter for Future Detectors
S. Magill
In: *Proceedings of the DPF/DPB Summer Study on the Future of Particle Physics,* Snowmass, CO (July 1-20, 2001).
ANL-HEP-CP-02-013

Experimental Challenges for QCD—The Past and the Future
H. Lipkin
In: *Proceedings of the Symposium and Workshop, "Continuous Advances in QCD 2002/Arkadyfest"* Minneapolis, MN, May 17-23, 2002.
ANL-HEP-CP-02-079

Hard QCD and Structure Functions

R. Yoshida

In: *Proceedings of the European Physical Society (HEP2001)*, Budapest, Hungary (July 2001). *(not previously sited)*

ANL-HEP-CP-02-006

High Power Testing of ANL X-Band Dielcetric-Loaded Accelerating Structures

John Power, Wei Gai, Chunguang Jing, Richard Konecny, Steven H. Gold and Allen K. Kinkead

In: *Conference Proceedings to Advanced Accelerator Concepts 2002*, Oxnard, CA, June 22-28, 2002.

ANL-HEP-CP-020-076

Multi-Hadron Final States

J. Repond

In: *Proceedings of the X International Workshop on Deep Inelastic Scattering (DIS2002),* Krakow, Poland (April 30-May 4, 2002).

ANL-HEP-CP-02-066

Other Atmospheric Neutrino Experiments

M. Goodman

In: *Proceedings of the XXth International Conference on Neutrino Physics and Astrophysics*, May 2002, Munich Germany.

ANL-HEP-CP-02-075

Physics at Future Hadron Colliders

T.M.P. Tait, *et al.*

In: *Proceedings of the APS/DPF/DPB Summer Study on the Future of Particle Physics* (Snowmass 2001), edited by R. Davidson and C. Quigg, eConf C010630, E4001 (June 2002).

ANL-HEP-CP-02-060

Polarization of Prompt J/ψ and $\Upsilon(nS)$

J. Lee

In: *Proceedings of the X International Workshop on Deep Inelastic Scattering* (DIS 2002), Krakow, Poland, 30 April - 4 May 2002.

ANL-HEP-CP-02-045

Puzzles in Hyperon, Charm and Beauty Physics

H. J. Lipkin

In: *Proceedings of the 5th International Conference on Hyperons, Charm and Beauty Hadrons,* Vancouver, BC, June 25-29, 2002.

ANL-HEP-CP-072

Snowmass 2001: Jet Energy Flow Project
E. L. Berger, …S. Magill, *et al.*
Proceedings of the APS/DPF/DPB Summer Study on the Future of Particle Physics (Snowmass 2001), edited by R. Davidson and C. Quigg, eConf C010630, P512 (June 2002).
ANL-HEP-CP-02-003

Suggestions for Benchmark Scenarios for MSSM Higgs Boson Searches at Hadron Colliders
M. Carena, S. Heinemeyer, C.E.M. Wagner, and G. Weiglein
In: *Proceedings of the Workshop on Physics at TeV Colliders* (Les Houches 2001), Les Houches, France, May 21-June 1, 2001.
ANL-HEP-CP-02-017

Summary: Working Group on QCD and Strong Interactions
E. L. Berger, …S. Magill, *et al.*
In: *Proceedings of the APS/DPF/DPB Summer Study on the Future of Particle Physics* (Snowmass 2001), edited by R. Davidson and C. Quigg, eConf C010630, P5001 (June 2002).
ANL-HEP-CP-02-011

Summary: Working Group on QCD and Strong Interactions
E. L. Berger, …S. Magill, *et al.*
In: *Proceedings of the APS/DPF/DPB Summer Study on the Future of Particle Physics* (Snowmass 2001), edited by R. Davidson and C. Quigg, eConf C010630, P5001 (June 2002).
ANL-HEP-CP-02-011

The Higgs Working Group: Summary Report (2001)
D. Cavalli, ...C.E.M. Wagner, et al.
In: *Proceedings of the Workshop on Physics at TeV Colliders* (Les Houches 2001), Les Houches, France, May 21 - June 1, 2001.
ANL-HEP-CP-02-024

Theory of Quarkonium Production
E. Braaten, S. Fleming, J. Lee, and A. Leibovich
In: *Report of the Workshop on B Physics at the Tevatron: Run II and Beyond*, (FERMILAB-PUB-01/197; hep-ph/0201071) pp. 457-471. (January 2002).
ANL-HEP-CP-02-063

The Snowmass Points and Slopes: Benchmarks for SUSY Searches
B. C. Allanach, ….C.E.M. Wagner, et al.
In: *Proceedings of the APS/DPF/DPB Summer Study on the Future of Particle Physics* (Snowmass 2001), Snowmass, CO, June 30 - July 21, 2001.
ANL-HEP-CP-02-020

Wakefield Acceleration in Structures
Manoel E. Conde
In: *Conference Proceedings to Advanced Accelerator Concepts 2002*, Oxnard, CA, June 22-28, 2002.
ANL-HEP-CP-02-078

IV D. TECHNICAL REPORTS, NOTES

CDF Notes:

CDF-5909

Ntuple for Studying Run 2 High pt Electrons
L. Nodulman
CDF/MEMO/ELECTRON/CDFR/5909

CDF-5990

Online Track Processor for the CDF Upgrade
E.J. Thomson, C. Ciobanu, J.Y. Chung, J. Gerstenslager, J. Hoftiezer, R.E. Hughes, M. Johnson, P.Koehn, C. Neu, C. Sanchez, B.L. Winer, J. Dittmann, J. Freeman, S. Holm, J.D. Lewis, C.J. Lin, T. Shaw, T. Wesson, K. Bloom, D. Gerdes, N. Goldschmidt, J. Dawson, W. Haberichter
CDF/DOC/TRIGGER/PUBLIC/5990 (IEEE proc. FERMILAB-CONF-02/144-E)

CDF-5999

Event Selection in the CDF Run I V+gamma Analysis
D. Benjamin, L. Christofek, D. Errede, S. Errede, K. Hara, M. Lindgren, T. Muller, D. Neuberger, H. Sato, M. Shimojima, R.G. Wagner
CDF/ANAL/ELECTROWEAK/CDFR/5999

CDF-6000

A Comparison of Run I CDF W+gamma Candidates from The Diboson Group
D. Benjamin, L. Christofek, D. Errede, S. Errede, K. Hara, M. Lindgren, T. Muller, D. Neuberger, H. Sato, M. Shimojima, R.G. Wagner
CDF/ANAL/ELECTROWEAK/CDFR/6000

Technical Reports

Analysis of EB Support Saddles and Forces Between Modules During Assembly *(not for publication)*
V. Guarino
ANL-HEP-TR-01-058

HEP Division Semiannual Report of Research Activities, July 1, 2001 to December 31, 2001 *(not for publication)*
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-02-067

Simulation Studies and Information Pertaining to STAR EndCap Strip SMD Primarily for Cosmic Ray Response *(not for publication)*
D. Underwood
ANL-HEP-TR-02-012

V. COLLOQUIA AND CONFERENCE TALKS

Edmond L. Berger

The Puzzle of the Bottom Quark Production Cross Section and a Possible Supersymmetry Explanation

Annual Meeting of the Division of Particles and Fields of The American Physical Society (DPF2002), Williamsburg, VA, May 26, 2002.

Higgs Boson Decay into Hadronic Jets

Annual Meeting of the Division of Particles and Fields of The American Physical Society (DPF2002), Williamsburg, VA, May 25, 2002.

Collider Bottom Quark Cross Section, Bottom Squarks, and Higgs Boson Decay

CTEQ Collaboration Meeting, Fermilab, Batavia, IL, April 27, 2002.

The Puzzle of the Bottom Quark Production Cross Section and a Possible Supersymmetry Explanation

American Physical Society General Meeting, Albuquerque, NM, April 22, 2002.

The Puzzle of the Bottom Quark Production Cross Section and a Possible Supersymmetry Explanation

Thomas Jefferson National Accelerator Facility, Newport News, VA, February 22, 2002.

Robert Cadman

Design and Calibration of the EEMC Shower Maximum Detector for STAR

American Physical Society General Meeting, Albuquerque, NM, April 20, 2002.

John Campbell

W, Z+2 Jet Production at the Tevatron

ANL-HEP Division Seminar, Argonne, IL, March 6, 2002.

W+2 Jet Production at Next-to-Leading Order

Department of Physics, University of Illinois at Urbana-Champaign, February 25, 2002.

Chengwei Chiang

Resumming Sudakov Logarithms in Radiative Upsilon Decay
Second International Workshop on B Physics and CP Violation, National Taiwan University, Taipei, June 7, 2002.

Resumming Sudakov Logarithms in Radiative Upsilon Decay
Department of Physics, Purdue University, Lafayette, IN, April 2, 2002.

Wei Gai

Inivited talk presented at Electron Beam Driven Wakefield Accelerators,
DPF 2002, Williamsburg, VA

Invited talk presented at Two Beam Accelerators, University of Chicago, 2002.

Jing Jiang

Higgs Boson Decay Into Hadronic Jets
LoopFest, BNL, Upton, NY, May 9-10, 2002.

Jungil Lee

Quarkonium Physics in the Light Bottom Squark Scenario
Annual Meeting of the Division of Particles and Fields of The American Physical Society (DPF2002), Williamsburg, VA, May 24-28, 2002.

Relativistic Corrections to Gluon Fragmentation into J/ψ
Annual Meeting of the Division of Particles and Fields of The American Physical Society (DPF2002), Williamsburg, VA, May 24-28, 2002.

1. Relativistic Corrections to Gluon Fragmentation into J/Psi
2. Quarkonium Physics in the Light Bottom Squark Scenario

ANL-HEP Division Lunch Seminar, Argonne, IL, May 21, 2002.

Polarization of Prompt J/Psi and Upsilon(ns)
Invited talk presented at the International Workshop on Deep Inelastic Scattering (DIS 2002), Krakow, Poland, May 1, 2002.

The Polarization of Prompt J/Psi at the Tevatron and Theoretical Problems
High Energy Theory Seminar, Purdue University, West Lafayette, IN, March 19, 2002.

Harry J. Lipkin

Puzzles in Hyperon, Charm and Beauty Physics
Invited talk presented at the 5th International Conference on Hyperons, Charm and Beauty Hadrons, Vancouver, BC, June 25-29, 2002.

Some Puzzles in Charm and B Decays
ANL-HEP Division Lunch Seminar, Argonne, IL, May 28, 2002.

Experimental Challenges for QCD—The Past and the Future
Symposium and Workshop, "Continuous Advances in QCD 2002/Arkadyfest, Minneapolis, MN, May 17-23, 2002.

What is Beyond Postmodernism?
Invited talk presented at the Workshop on Beyond Postmodernism, Vancouver, BC, May 16-18, 2002.

Jim Norem

Dark Currents in Rf Cavities
Lunchtime Seminar, Argonne HEP, March 29, 2002.

Dark Currents
Fermilab Accelerator Physics and Technology Seminar, April 25, 2002.

Geraldine Servant

Is the Lightest Kaluza-Klein Particle a Viable Dark Matter Candidate?
5th European Meeting "From the Planck Scale to the Electroweak Scale", Kazimierz, Poland, May 24-29, 2002.

On Universal Extra Dimensions
Centre de Physique Theorique de Marseille, France, May 6, 2002.

Reopening the Window for Electroweak Baryogenesis in Cosmologies with Non-Standard Friedmann Equation

Department of Physics, Indiana University, Bloomington, April 15, 2002.

How to Rescue Electroweak Baryogenesis with Non-Standard Cosmology?

Department of Physics, University of Wisconsin at Madison, March 29, 2002.

Tester l'Equation de Friedmann au LHC (Tevatron?) ou Comment Sauver la Baryogenese Electrofaible avec une Cosmologie Non Standard

Service de Physique Theorique, CEA Saclay, Paris, France, March 19, 2002.

Reopening the Window for Electroweak Baryogenesis with Non-Conventional Cosmology

Department of Physics, University of Wisconsin at Milwaukee, February 29, 2002.

On the Electroweak Phase Transition, Sphalerons, Baryon Asymmetry…. And Cosmology

Department of Physics, University of Chicago, IL, January 30, 2002.

On the Electroweak Phase Transition, Sphalerons, Baryon Asymmetry…. And Cosmology

Fermilab, Batavia, IL, January 17, 2002.

On the Electroweak Phase Transition, Sphalerons, Baryon Asymmetry…. And Cosmology

ANL-HEP Division Theoretical Physics Seminar, Argonne, IL, January 14, 2002.

Donald K. Sinclair

Lattice QCD at Finite Isospin Chemical Potential and Temperature

20th International Symposium on Lattice Field Theory (LATTICE 2002), Boston, MA, 24-29 June 2002.

Timothy Tait

Beautiful Mirrors

PHENO 2002, Madison, WI, April 22-24, 2002.

Fermion Masses and Supersymmetry in Five Dimensions

Department of Physics, Harvard University, Cambridge, MA, April 9, 2002.

Fermion Masses and Supersymmetry in Five Dimensions
Department of Physics, MIT, Cambridge, MA, April 8, 2002.

New Tools for Fermion Masses from Extra Dimensions
Los Alamos National Laboratory, NM, March 18, 2002.

Beautiful Mirrors and Electroweak Precision Data
Department of Physics, Southern Methodist University, Dallas, TX, January 28, 2002.

Robert Talaga

Presented a poster (specifically, an electronic poster) OMNIS Project for COSMO 02
International Conference in Chicago, September 2002.

Carlos Wagner

Electroweak Baryogenesis in the MSSM
Invited talk presented at the 10th International Conference on Supersymmetry and Unification of Fundamental Interactions, DESY, Hamburg, Germany, June 17-23, 2002.

Introduction to Supersymmetry
Series of four invited talks presented at TASI-2002, Boulder, CO, June 3-9, 2002.

Beautiful Mirrors, Unification of Couplings and Precision Electroweak Data
2002 Aspen Winter Conference, "Current and Upcoming Discoveries in Particle Physics", CO, February 3-9, 2002.

Summary of the Electroweak Physics Session
Invited plenary talk presented at the 18th International Workshop on Weak Interactions and Neutrinos, Christchurch, NZ, January 20-26, 2002.

Beautiful Mirrors and Electroweak Precision Data
Invited parallel talk presented at the 18th International Workshop on Weak Interactions and Neutrinos, Christchurch, NZ, January 20-26, 2002.

Alan R. White

The Chiral Anomaly and High-Energy Scattering in QCD
ANL-HEP Division Theoretical Physics Seminar, Argonne, IL, March 11, 2002.

The Critical Pomeron in QCD and the Chiral Anomaly
Invited talk presented at The XXXVI PNPI Winter School on Nuclear and Particle Physics, Repino, Russia, February 25—March 3, 2002.

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.

Organizing Committee, 8th Conference on the Intersections of Particle and Nuclear Physics (CIPANP 2003), New York, May 19-24, 2003.

Convener, "Tests of QCD with Quarkonium", Quarkonium Working Group, 1st meeting to be held at CERN, November 8-10, 2002.

Co-organizer, Greater Chicagoland Particle Theory Meeting, Argonne, IL, October 21, 2002.

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

Organizing Committee, Theory Institute on Supersymmetry, Higgs, and Extra-Dimensions, Argonne National Laboratory, September 9-13, 2002.

Convener, QCD, Annual Meeting of the Division of Particles and Fields of the American Physical Society, Williamsburg, VA, May 23-28, 2002.

Member, Andrew Gemant Award Committee, American Institute of Physics, 2002 -- .

Member, American Linear Collider Working Group, 2002 -- .

Member, CTEQ Collaboration.

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

Scientific Program Organizing Committee, Rencontres de Moriond, QCD and High Energy Hadronic Interactions, France, March 16-23, 2002 and March 22-29, 2003 and every year from 1986 to the present.

Geoffrey T. Bodwin

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

Member, Advisory Committee and Convenor, Heavy Quarks Session, Quark Confinement and the Hadron Spectrum, Gargnano, Italy, September 2001-September 2002.

Member, Organizing Committee, International Conference on Advanced Topics in QCD, Beijing, November 2001-August 2002.

Member, Quarkonium Working Group, CERN, March 2002-present.

John Campbell

Organizing Committee, Theory Institute on Supersymmetry, Higgs, and Extra-Dimensions, Argonne National Laboratory, September 9-13, 2002.

Cheng-Wei Chiang

Organizing Committee, Theory Institute on Supersymmetry, Higgs, and Extra-Dimensions, Argonne National Laboratory, September 9-13, 2002.

Wei Gai

Member, Scientific Organizing and Advisory Committee, Advanced Accelerator Concept Workshop 2002, Oxnard, CA.

Jing Jiang

Organizing Committee, Theory Institute on Supersymmetry, Higgs, and Extra-Dimensions, Argonne National Laboratory, September 9-13, 2002.

Jungil Lee

Organizing Committee, Theory Institute on Supersymmetry, Higgs, and Extra-Dimensions, Argonne National Laboratory, September 9-13, 2002.

Geraldine Servant

Organizing Committee, International Workshop on Particle Physics and the Early Universe (COSMO-02), Chicago, IL, September 18-21, 2002.

Organizing Committee, Theory Institute on Supersymmetry, Higgs, and Extra-Dimensions, Argonne National Laboratory, September 9-13, 2002.

Tim Tait

Organizing Committee, Theory Institute on Supersymmetry, Higgs, and Extra-Dimensions, Argonne National Laboratory, September 9-13, 2002.

Carlos Wagner

Organizing Committee, Theory Institute on Supersymmetry, Higgs, and Extra-Dimensions, Argonne National Laboratory, September 9-13, 2002.

Convener, Electroweak Session of the 18th International Workshop on Weak Interactions and Neutrinos, Christchurch, New Zealand, January 20-26, 2002.

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.
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Accelerator Physicists

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Gai, W.
Norem, J.
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Experimental Physicists

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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.
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.
Chiang, C. W.
Jiang, J.
Lee, J.
Servant, G.
Sinclair, D.
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.
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

Loizides, J.
Jing, C.

Visiting Scientists

Bamberger, A (ZEUS)
Kovacs, E. (Theory)
Krueger, K. (STAR)
Liu, W. (AWA)
Lipkin, H. (Theory)
Ramsey, G. (Theory)
Schoessow, P. (AWA)
Uretsky, J. (Theory)