A Continuation Proposal

for the

EXPERIMENTAL STUDY
OF
HEAVY FLAVOR PHYSICS

A Proposal for Continued Support of the U.S. Department of Energy
Grant No. DE-FG02-91ER40622
for Research in Experimental High Energy Physics by
THE UNIVERSITY OF MISSISSIPPI

for the Period May 1, 2005 to April 30, 2006

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January 30, 2005
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Abstract

The Experimental High Energy Physics Group at the University of Mississippi requests continued support for studies in heavy flavor physics coupled with detector R&D and fabrication. The primary analyses will be continued studies in b-physics using the BABAR data set and implementing a large DØ Monte Carlo. Also of utmost importance is the commissioning of the CMS HCAL and Pixel detectors for the LHC. We also continue our studies of producing intense neutrino beams with refinement of muon cooling scenarios (MICE, Neutrino Factory) and are participating design of a next generation Muon Collider.

This proposal discusses the needs and describes the work of the High Energy Physics Group during the past year and outlines proposed work. Since a continuation, much of the detail on FY04 progress is in the form of web links to archival information.
1 Research Proposal and Developments

1.1 Introduction

The HEP group at the University of Mississippi has had an active FY04 year. We have continued our BABAR activities with research associates Dr. Johannes Bauer, Dr. Haiwen Zhao working full time at SLAC on BABAR and Dr. Romulus Godang splitting time in Mississippi on BABAR and future collider activities. Mr. Vance Eschenburg is located at SLAC and hopes to complete his dissertation by summer 05. Dr. Alex Melinchouk is working at Fermilab on DØ software and analysis, and Dr. Quinn with Mr. Michael Joy are working in Mississippi on commissioning a Linux farm for regionally-based offsite DØ computing (DØSAR). Drs. Summers, Kroeger, Sanders, and Cremaldi are splitting time on BABAR, CMS, and Muon Collider tasks.

Dr. Godang has written our first PRL, titled "First Measurement of the Branching Fraction $\Upsilon(4S) \rightarrow B^0\bar{B}^0$ with a Partially Reconstructed $B^0 \rightarrow D^*-\ell+\nu$. That and other BABAR highlights are given below:

• Dr. Godang prepared a PRL on the important branching fraction $\Upsilon(4S) \rightarrow B^0\bar{B}^0$ is nearly published. It is now in collaboration wide review.

• The PDG is considering the $\Upsilon(4S) \rightarrow B^0\bar{B}^0$ decay in calculation of b-decay rates.

• Dr. Bauer is preparing a PRL on the rare decay $\bar{B}^0 \rightarrow D^{*0}\gamma$.

• Dr. Bauer presented a paper for BABAR on calibration of the CSI calorimeter at IEEE-Portland.

• Three BABAR talks by Drs. Bauer, Godang, and Mr. Eschenburg were presented at DPF04 Riverside.

• Dr. Zhao will give a DPF05 on $B \rightarrow D^* n\pi$ decays

• 57 research papers were published by the BABAR collaboration.

Dr. Breese Quinn joined the faculty in January 04 and continued his top quark research on Fermilab experiment DØ. Ph.D. Michael Joy has passed his prelims joined our program. A large DØSAR computing facility is being commissioned in Mississippi to run DØ Monte Carlo. Dr. Quinn hired new research associate Dr. Alex Melinitchouk in June 04 with University matching funds. Dr. Melinchouk is located at Fermilab and is working on silicon tracker software support.

• Dr. Quinn was appointed to the DØ Standing Committee on Installation to Physics Commissioning as L0 Upgrade Working Group leader.

• Mississippi was unanimously approved to join the DØ collaboration.

• Mr. Michael Joy and Quinn are commissioning the DØSAR computing farm.

• Dr. Melnitchouck was appointed leader of the DØ L0/SMT Software Group.

• Two DØ talks were presented at DPF04 in Riveride by Melnitchouk and Quinn.

• 14 research papers were published by the DØ collaboration, and co-authored by U. Mississippi collaborators.
We have completed our hardware obligations to the CMS HCAL and are moving on to commissioning and software efforts on HCAL. We also have obligations to CMS Pixels. The Pixel effort is focused around Fermilab’s SiDet and Fermi test beams.

- All HCAL readout box fabrication was completed by Summer 04 and shipped to Fermilab.
- Analysis of $t\bar{t} \rightarrow Wb\bar{W}$ for jet-jet calibration is beginning.
- Dr. Cremaldi introduced the idea of Ti-quartz doping was introduced for SLHC calorimetry.

The Muon Collider/Neutrino factory effort has been very quite productive with 201 MHz RF cavity fabrication in our shop and muon cooling software design.

- Fabrication in support of a 201 MHz RF cavity to be tested with 400 MeV/c protons at Fermilab are nearly complete.
- Ionization cooling in a sector cyclotron software model was demonstrated as well as an injection scheme.
- Three Collider talks were presented at DPF 04 in Riveride by Godang and Summers. One talk introduced the idea of black hole detection at a future muon collider

Dr. David Sanders, et al. has completed our R&D in to high volume storage using RAID. Three 1TB systems and two 2TB systems were built in supporting our work at $\text{BABAR}$, Muon Collider, and CERN CMS.

- Two 2TB systems were built in FY04 for our work on $\text{BABAR}$, Muon Collider, and CERN activities.
- Dr. Sanders presented a paper at CHEP04 -Interlaken, on RAID systems.

Some ILC accelerator R&D was performed in FY04 continuing through September 05 when the grant expires. It focused on the warm technology RF cavities and will likely not be continued.

- Talks on detection of acoustic emissions in RF cavities and the instrumentation of beam halo absorbers in the LC beam delivery system were presented to the ALCPG community at SLAC.

Dr. Eric Aitala completed his Ph.D. requirements in Fall FY04 on Fermilab experiment E791.

- He is the University web master and is teaching Astronomy 104 this Spring.

### 1.2 Research on $\text{BABAR}$

$\text{BABAR}$ has made the first direct branching fraction measurement of the $\Upsilon(4S) \rightarrow B^0B^0$ final state through Dr. Godang’s analysis of $B \rightarrow D^{*-}\ell^+\nu$ decays. He implemented a new partial $D^*$ reconstruction algorithm, see Figure 1, and used doubly tagged events for the first time on $\text{BABAR}$ with the algorithm. Previously all $B$ branching fractions have only been able to use the $B^0/B^\pm$ ratio and should now be adjusted to include this isospin violating effect. The paper under collaboration wide review and will soon be submitted to Physical Review Letters. Dr. Godang and the $\text{BABAR}$ collaboration have given talks at DPF04 [1] and ICHEP04 on this important topic.

Dr. Bauer is completing his rare decay $\bar{B}^0 \rightarrow D^{*0}\gamma$ analysis, important to our full understanding of factorization and radiative penguin decays. This decay proceeding through W-exchange may
Figure 1: The $M_s^2$ (left) and $M_2^2$ (right) distributions of the on-resonance samples. The continuum background has been subtracted from the $M_s^2$ and $M_2^2$ distributions. For the $M_2^2$ distribution, the $M_2^1$-combinatorial, and the $M_2^1$-peaking have been subtracted. The levels of the simulated signal, peaking $B\bar{B}$ and combinatorial $B\bar{B}$ background contributions are obtained from the fit.

Figure 2: $\Delta E$ vs. $m_{ES}$ distribution for $\bar{B}^0 \rightarrow D^{*0} \gamma$ candidates and sideband regions. The signal box is presently blinded so not to bias selection cuts.

contribute to some radiative penguin decays and must be considered for completeness. If the branching fraction is $\geq 10^{-6}$ some new physics may be indicated. Dr. Johannes Bauer has performed a blind analysis, Figure 2, and has completed documentation and BABAR reviews. He will open the blinded box circa. February 11, 2005 [2].

Dr. Haiwen Zhao is studying the branching fraction and polarization in the $B$ meson decays to $B \rightarrow D^{*0}a1(1260)$ decays. [3] In FY04 the BRECO group requested that he extend this analysis to include the general $B \rightarrow D^{*0}n\pi(n = 1, 2, 3)$ phase space. After added months of coding and Monte Carlo preparation he has his first results forthcoming in Spring 2005. Dr. Zhao has completed a multivariate fit for separating resonance, nonresonance, and background in each channel, see Figure 3.

Mr. Vance Eschenburg is studying $B^- \rightarrow D_2^{*0}(2460)\pi^-$ and $B^- \rightarrow D_1^{0}(2420)\pi^-$ decays. These are p-wave charm mesons are members of a spin-symmetry doublet that possess a total angular momentum of $j = \frac{3}{2}$ in the heavy-quark limit (HQET). Vance will improve the branching fraction measurements of $D_1^{0}(2420)\pi^-$ and $D_2^{*0}(2460)\pi^-$. This analysis will also shed light on the wider $D_1^0$ and $D_1$ $j=1/2$ resonances also predicted by HQET.
Vance is completing a filter of the decays $B^- \rightarrow D_1(2420)\pi^-$ and $B^- \rightarrow D^*_s(2460)\pi^-$ for his dissertation. In Figure 4 we show the $D'(\ast)\pi$ FY04 signals. Some improvement is expected with the tuning of selection cuts and more data added from Run-4. Preliminary results were shown at DPF2004.[4] He is working in close association with the Iowa State group on BABAR. He hopes to complete his dissertation by May 2005.

Figure 3: The ML fit of (1) $m_{ES}$ and (2) $m_{\pi\pi}$ for mode $B^0 \rightarrow D^-\pi^+\pi^--\pi^+$. Red solid curve shows the signal of $B^0 \rightarrow D^-a_1^+(1260)$. Red dashed curve shows the signal of $B^0 \rightarrow D^- (p^0\pi^+)_{NR}$. Red dotted curve shows the signal of $B^0 \rightarrow D^- (\pi^+\pi^-\pi^+)_NR$. Blue dashed curve shows the $B\bar{B}$ background. Blue dotted curve shows the $q\bar{q}$ background.

Figure 4: Mass Spectrum of $D^*\pi$ and $D\pi$. Fitted curves of the narrow resonances and backgrounds are shown in the plots and a cut-away of the side-band regions.

Dr. Kroeger and Mr. Aruniva Roy have completed the first stage of their study of geometrical corrections to the calorimeter cluster energy assignment. Mr. Roy presented some results in Summer-04 at the July BABAR Collaboration Meeting. The algorithm is being tested on BABAR’s EMC $\pi^0 \rightarrow \gamma\gamma$ mass resolution. See Figure 5.

Dr. Godang serves as a BABAR Computing Model Expert. As a CM2 Expert he provides advice on physics skims and general optimization of BABAR computing operations. He is currently performing advanced CM2-Run4 skims of BABAR data.

Dr. Zhao serves on BABAR’s Data Quality Assurance Team representing the EMC. He has just completed the conversion of the OEP monitoring package to ROOT, and reports to Data Quality Group on a weekly basis. This is further discussed in Dr. Jeff Richman’s talk.[5]

Dr. Bauer and Mr. Eschenburg continue to be responsible for source calibrations at BABAR. Both are experts in the use of the neutron-activated circulating source for low energy calibration. Dr.
Bauer consults on the high energy calibration scheme for the calorimeter using radiative Bhabhas, which he participated in the past. Dr. Bauer leads our paper review committee as senior research associate on BABAR.

We are opening future research areas on BABAR, see 4.5. We will continue with research in to $B^0 \rightarrow X^+ \ell^- \nu_\ell$ decays to investigate small discrepancies in the predicted semileptonic branching fractions believed to be due to light quark interactions. Using $B^0 \rightarrow D^{**} \ell^- \nu_\ell$ decays under our partial reconstruction algorithm $|V_{cb}|$ will be measured to great precision allowing $|V_{td}|$ to be further constrained. Run(1-4) 230 $fb^{-1}$ has been skimmed. The INFN Sezione Di Padova group is sharing this research.

For the Charm AWG we are skimming for $D \rightarrow h^\pm + n\pi^0 + n\gamma$ decays. These are rare charm decays whose branching ratios are poorly measured. We are working closely with the INFN Bari group on the research. [6]

We have had long term interest in radiation damage studies to crystals, especially with new ultrasonic hardening and annealing techniques being developed for damaged BABAR CsI(Tl) crystals with extension to CMS-ECAL crystals. A proposal was sent to the DOE Materials Science division in FY04, and we are waiting award notification.

References


1.3 Research on D$\emptyset$

With the exceptional increased performance of the Tevatron, tremendous emphasis has been placed on maximizing the Run II physics potential for the D$\emptyset$ and CDF experiments prior to the LHC turn on. Dr. Breese Quinn has been a member of the D$\emptyset$ experiment since 2000, and through his leadership the University of Mississippi was recently unanimously approved as a new collaborating institution. Dr. Quinn was named to lead the installation and commissioning of the Layer 0 upgrade to the D$\emptyset$ Silicon Microstrip Tracker (SMT) and represented D$\emptyset$ at DPF04 to discuss the complete D$\emptyset$ Upgrade program[1].

Dr. Quinn has taken on the service responsibility of establishing a D$\emptyset$ Monte Carlo farm at the University. The Ole Miss farm will be incorporated into a regional GRID computing consortium known as D$\emptyset$SAR[2]. D$\emptyset$SAR currently provides offsite computing resources to the D$\emptyset$ experiment, but is evolving into a more broadly-based organization that will make major contributions to CMS, ATLAS, and other computing efforts as well. Dr. Quinn is joined in this effort by Ph.D. student Michael Joy, who has gathered bids, assembled Linux systems, etc. The startup system consists of 24 dual processor 2.2GHz Opteron nodes, rack mounted in the physics department computer room which has battery backup (Figure 6). Research Scientist, Dr. David Sanders, and Departmental Computer Manager, Mr. William Furr are helping with the installation. In addition, we feel there is great potential for new students to become involved in this endeavor. The D$\emptyset$SAR community will hold its Spring 2005 workshop at U. Mississippi. Dr. Quinn should have the farm completely operational at that time.

There are two upcoming demands for computing resources for which the farm would need to upgrade. D$\emptyset$ recently made the decision to reprocess the entire Run II data set collected so far. This project is required in order to take advantage of major improvement in calibration of the EM calorimeter, as well as other important technical improvements to data reconstruction. The optimistic estimate for completing this task with available resources is one year. An Ole Miss farm enhanced with additional nodes and storage would be equipped to take part in data reprocessing and significantly increase D$\emptyset$SAR’s contribution to accelerating and maximizing D$\emptyset$’s physics output.

It is a natural extension is to expand the D$\emptyset$SAR farm to possibly a CMS computing center. This would require additional manpower. There is a possibility of joining with Louisiana Tech to become a Tier-2 CMS center, leveraging the collaborative experience that we already share for D$\emptyset$SAR efforts. Dr. Quinn will submit an OJI in FY05 requesting support for a CMS postdoc and new hardware to upgrade and expand the farm.

Dr. Alex Melnitchouk from Brown University was hired in June ’04 on U.M. matching funds to maintain continuity and support the D$\emptyset$ Experiment at Fermilab. Dr. Melnitchouk has been working on the $h \rightarrow \gamma \gamma$ analysis at D$\emptyset$ and refining the photon selection with a neural net approach. An update was presented to the Higgs/Dilepton Working Group in June 17, 2004. [3]
Figure 6: The initial configuration of Ole Miss D∅SAR farm consists of 24 2.2GHz dual-processor Opteron nodes, 6 TB of data storage and 1 GBit fiber connection to the campus network, which has a 150 MBit connection to Internet 2. There are ample services and rack space to accommodate tripling the size of the farm.

In November 2004 he began working on the Layer Zero/Silicon Microstrip Tracker detector (L0/SMT) software. A new group has been organized at D∅ to support this effort, and Dr. Melnitchouk has been appointed to serve as leader of the D∅ L0/SMT Software Group.

Dr. Melnitchouk presented a number of reports to the D∅, FNAL, and wider physics community including his presentation at DPF2004 on his search for Higgs in diphoton final states[4], see Figure 7.
Figure 7: 95% CL limits on the Higgs decay branching fraction into photons as a function of mass (black curve). Left plot – fermiophobic Higgs scenario, bottom plot – topcolor Higgs scenario. On the left plot exclusion contours from DØ Run I (red) and LEP (blue) are overlaid. The region excluded by LEP is indicated with grey. Green points – theoretical curve for benchmark fermiophobic Higgs model Magenta lines show 2 fb$^{-1}$ Monte Carlo prediction for Tevatron Run II based on Run I DØ and CDF efficiencies and misidentification rates at decays at DØ.

References


1.4 Research on CMS

The University of Mississippi is a charter member of the CMS experiment. Our efforts concentrate on the HCAL(HB, HE, HF, HO) and Forward Pixel subsystems. Dr. Cremaldi presently serves as the Tracker Institutional Representative within US-CMS. Dr. Sanders and Dr. Summers have provided support to forward pixels, computing, and test beams. Drs. Cremaldi and Kroeger are becoming involved in HCAL calibration. We are presently committed to provide test beam and software support to the Forward Pixel effort working mainly in the area of Monitoring and Control. Drs. Cavaglia and Godang have made some beginning efforts on CMS physics. Drs. Quinn and Melanchouk are committed to DØ tasks in FY05, but some movement over to CMS is expected in FY06.

We have fulfilled our construction phase commitments to HCAL with producing over 200 RBX (readout boxes). These boxes were fabricated to ±2mil precision with machine plate in order to
satisfy strict spacial constraints for readout boxes in the HCAL. HCAL readout box production was completed in FY04 in a timely manner and in summer 04 shipped out. We show the first instrumented RBX HB readout box and last shipment of RBX HO, Figure 8. HO RBX installation began at CERN in Fall 04.

We are presently short of a dedicated post doc at CERN or Fermilab who could fully participate in LHC commissioning. In FY05 we are planning to rotate a BABAR post-doc (Bauer) to support of Fermilab (D0/CMS) activities (Melnitchouk). This may help at Fermilab, but will not satisfy our LHC startup commitments at CERN or future CMS Computing efforts in Mississippi.

![Figure 8: First outfitted RBX(HB) at Fermilab (left). Partial RBX (H0) shipment to Fermilab(right) in August 04. The RBX readout boxes are outfitted and checked at FNAL, then shipped to CERN for final check and installation.](image)

In FY04 we began R&D on quartz calorimeter for SLHC. HE and HF will receive added doses and new radiation hard technologies are sought. We are investigating the properties of Ti-doped quartz for enhanced light output. Dr. Cremaldi reported our first work at the Fall 04 HCAL Meeting. [1]

We have begun to look at the \( pp \rightarrow gg \rightarrow t\bar{t} \), \( Wb \ W\bar{b} \rightarrow jjb \ \ell^+\ell^-\ell^+\ell^- \) decays for jet calibration. This entails finding a clean sample of of \( W \rightarrow jj \) decays with b-tagging. Official samples are being prepared at Fermilab for our use as well as others. We show some \( t \rightarrow bj\ell \) decays with calorimeter smearing produced locally on G5 workstations purchased in FY04, Figure 9. A new student, Ms. Mohana Priya is expected to begin working in Spring-05 on this calibration.

We have also written an internal physics note (Godang, et al.)[2] on the study of the standard model higgs decay channel \( H^0 \rightarrow \ell^+\ell^-\nu\nu \). This channel is less favorable to detection in comparison to \( \ell^+\ell^-\ell^+\ell^- \) due to large missing energy, but has a larger branching fraction. Similar large missing energy decays may occur in black hole evaporation at the LHC also, a topic we are also interested in.

In collaboration with gravitational theorist Dr. Marco Cavaglia, we have made progress in modeling black hole production at the LHC. Dr. Cavaglia has applied for an OJI based on black hole research pursuits at the LHC and has interest in the Pierre Auger Observatory data. Dr. Cavaglia is working with our group on this physics and will attract a number of students to phenomenology. We see this as highly beneficial to the LHC physics effort.

In the CMS PIXEL program R&D studies were completed on temperature, humidity, and monitoring of the forward pixel detector. Through discussions with the CMS Si Tracker we have selected...
Figure 9: $t \rightarrow bW \rightarrow bjj$ mass used in HCAL calibration from Pythia events.

a Siemens SIMATIC S7-300 programmable logic controller (PLC) for processing sensor warnings and alarms. A system is being brought to the US for testing. We plan continued participation in the software development, relying on students in FY05.

Two interesting papers were published from CERN test beam data (FY03) which helped explain charge collection in out Si pixel detectors. Dr. Morris Swartz (JHU) [4] and Dr. Tilman Rohe (PSI) [5] were the lead authors. Sanders and Cremaldi joined the test beam effort at CERN.

Drs. Ostovskii and Cremaldi have written a short paper on annealing measurements in Si.[3] We are seeking funds to continue this work.

References


1.5 Neutrino Factory/Muon Collider Research

The University of Mississippi has been working on Neutrino Factory and Muon Collider R&D since 1994. Don Summers currently serves on the Neutrino Factory and Muon Collider executive committee. Summers, Godang, Bracker, and Cremaldi have made significant contributions to the project.

Mississippi has fabricated two 805 MHz copper RF cavities designed by LBL. The LBL design uses beryllium windows to increase the acceleration gradient. The cavities were successfully tested at LBL and Fermilab at room temperature and 77 °K. We are presently working on pieces of a larger 201 MHz copper cavity to be tested at Fermilab’s Muon Test Lab (MTL) located near the FNAL Booster. This device is being installed at MTL and tests should start soon in 05 with 400 GeV/c protons.

Mississippi is committed to build the upstream cerenkov counter for the Muon Ionization Cooling Experiment (MICE) at RAL. This device will perform $\pi-\mu-e$ separation of the incoming 200 MeV/c beam. We are using a fluorocarbon radiator. Some prototyping has been done in FY04. We will try to furnish a first device in FY05 pro bono. We are seeking DOE/NSF support for MICE.

In order to achieve a future design for neutrino factory or muon collider, we are performing detailed simulations of ionization cooling with a novel “inverse cyclotron technique”. Summers et al. describes progress on six dimensional cooling with small rings in his DPF 04 paper [3] "6D IONIZATION MUON COOLING WITH TABLETOP RINGS" In the paper he describes how ionization cooling can be provided by high pressure hydrogen gas which removes both transverse and longitudinal momentum, see Figures 10 and 11, later longitudinal momentum being restored with RF. A novel scheme for injection in to the ring is also described, see Figure 12.

![Table for Muon in Hydrogen](image)

**Figure 10:** Plot of $\mu^+$ energy loss (MeV/cm) in liquid hydrogen versus kinetic energy (GeV) generated using GEANT3. The default value of the GEANT3 variable “CUTMUO” was decreased from 10 MeV to 10 eV to permit the propagation of slow muons. The energy turnover at 8 keV corresponds to a momentum of 1.3 MeV/c. $p = \sqrt{2mE} = \sqrt{2 \times 105.7 \times 0.008}$. Liquid helium, aluminum, copper, and iron show similar results.
Dr. Godang also provided a strong motivation for a Muon Collider also at DPF 04. Briefly, in the s-channel Higgs production process to a narrow resonances energy resolution is very important consideration. [1] A muon collider with sufficient energy resolution (R = 0.01% and/or 0.06%) might be the only possible means for separating the two higher mass Higgs bosons, \( H^0 \) and \( A^0 \). The s-channel Higgs resonance would be found by scanning in \( \sqrt{s} \) using a small step (\( \sigma \)).

Our group began work with Dr. Marco Cavaglia in investigating the issue of Black Hole (BH) production at colliders. The cross section will depend on the value of the fundamental Planck scale \( M_{Pl} \), which determines the energy where the gravitational interaction becomes strong. If this fundamental energy scale is as low as the TeV scale, BHs can be produced in future colliders such as the LHC, CLIC, and the muon collider. A signature will be a large cross section of events with high missing \( E_T \). Dr. Godang’s talk at DPF 04 discussed these issues. [1]
1.6 High Density Storage Project - RAID

Mississippi has provided two 1-TB RAID arrays to accommodate FY02-03 GEANT production runs and trigger studies at CERN. These RAID arrays were used in the Monte Carlo production and analysis of data for the CMS Trigger/DAQ TDR.

Two new arrays 2TB arrays were built and tested in FY04 in Mississippi. The tests compared Hardware and Software RAID arrays and measured the CPU-overhead of Software RAID arrays in dual-CPU systems. One array went in support of BABAR physics analysis at SLAC and the second array remains in our local computer system in support of CMS/D or Muon Collider computing. Dr. Sanders describes these endeavors in a talk at CHEP04 [1]. He rightfully concludes that the home built RAID is still marginally cheaper, but commodity arrays systems are finally becoming attractive.

The Monitoring and Control and Calibration of the CMS Pixel Tracker will require large storage arrays. We have provided some expertise on the matter, but primarily remain interested in RAID for analysis and backup of large L3 data sets at BABAR and CMS.

References


1.7 Future Activities - ILC/Pierre Auger/NNN/DUSEL

In May 2003 we were funded to perform two accelerator R&D studies for the US-LC effort targeting ”warm machine” issues. These involved (1) detecting acoustic emission (AE) in Cu RF cavities with standard transducer technology. Dr. Ostrovskii, an expert in acoustic waves in solids participates in these studies pro bono. (2) Study of beam halo monitoring in the LC final transport lines by instrumenting the collimators with radiation hard sensors of diamond pads, quartz rods, etc. Our first report was given in Jan-04 and followed in September-04.

Our accelerator LC R&D proposals were not funded as 3-yr extensions in FY04, but present funding was rolled over as a ”no cost extension” through Fall-05 by Dave Sutter at DoE. Dr. Sutter encouraged us to finish our studies even though the ”warm machine” is not in favor. We plan...
to finish these studies by Fall-05. Mr. Peter Sonnec is working on the AE project through mid-January-05. With no extra manpower anticipated in the near future our participation in the ILC is dubious at this time, although we remain encouraged about its progress.

Drs. Cavaglia and Cremaldi remain interested in the Pierre Auger Project and remain in close contact with U. Chicago collaborators and affiliates.

We remain interested in Next Generation of Nucleon Decay and Neutrino Detectors (NNN). We have visitors coming from the U.S. Deep Underground Science and Engineering Laboratory (DUSEL), Dr. B. Sadoulet et al. and interest in the NNN05 European Conference - http://nnn05.in2p3.fr. We strongly feel that an underground detector laboratory is needed to advance neutrino physics soon in this century.

1.8 QuarkNet Progress and Developments

We have completed the fourth year of outreach under the auspices of QuarkNet. We have produced a number of PMT base hardware in our physics department machine shop and shipped to Fermilab (Tom Jordan). A number of a cosmic ray apparatus were commissioned on by our teachers. Local teacher Mr. J. Reidy Jr. was awarded a CMS teacher fellowship which allowed him to work at the University and CERN during the summer-04. We are planning a meeting and workshop in spring summer 05 at the University.

A novel simulation of quarks in a proton and meson are shown on our web site, , Figure 13, part of a quarknet initiative with junior high student.

http://www.phy.olemiss.edu/HEP/QuarkNet/Proton.mov

Figure 13: Three quarks built by junior high students moving inside a proton.
2 Talks and Publications

Table 1: Mississippi Ph.D. Dissertations

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Table 2: Mississippi Conference Talks

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<td>L. Cremaldi</td>
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<td>Vertex</td>
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Table 3: CERN CMS Papers Co-Authored by UMiss

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Table 4: Muon Collider/Neutrino Factory Papers Co-Authored by UMiss

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<th>1st Author</th>
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<tr>
<td>C. Albright</td>
<td>ν Factory/β Beam Development</td>
<td>physics/0411123</td>
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<td>D. Li</td>
<td>201/805 MHz RF Development</td>
<td>J. Phys. 29 (2003) 1683</td>
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<td>M. Alsharoa</td>
<td>ν Factory/μ Collider Progress</td>
<td>PRSTAB 6 (2003) 081001</td>
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Table 5: 14 Fermilab D0 Papers Co-Authored by UMiss

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<td>A. Abazov</td>
<td>H⁺⁺ H⁻⁻ → μ⁺μ⁺μ⁻μ⁻ Search</td>
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<td>A. Abazov</td>
<td>Supersymmetry Search in γγ Events</td>
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<td>B° Lifetime using B° → J/ψ φ</td>
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<td>A. Abazov</td>
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<td>B⁺/B° Lifetime Ratio</td>
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<td>Search for $B \to \rho^+ \gamma$, $\rho^0 \gamma$, $\omega \gamma$</td>
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<td>$B \to D_{sJ} \overline{D}^{(*)}$</td>
<td>PRL 93 (2004) 181801</td>
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<td>FCNC and LFV Search in $D^0 \to \ell^+ \ell^-$</td>
<td>PRL 93 (2004) 191801</td>
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<td>$B^0 \to \phi K^{*0}$ Amplitudes</td>
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<td>$B^0 \to \rho^+ \rho^-$ and the CKM angle $\alpha$</td>
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<td>$B \to \rho \pi$ Decays</td>
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<td>$D^0 \to \bar{D}^0$ Search using Leptons</td>
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<td>Moments in Semileptonic $B$ Decays</td>
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<td>Direct CP Search in $B^+ \to \phi K^+$</td>
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</table>
3 Request for FY05

3.1 FY04 Funding Profile

The University of Mississippi High Energy Physics group is primarily supported by the U.S. Department of Energy grant DE-FG05-91ER40622 with DoE supplements and by the University of Mississippi. The base funding from DoE in the current funding period 5/01-4/31 is $484,919. This covers the 2-month summer salary for each of the four faculty and one Scientist, salary for 3 postdoctoral associates, support for two graduate students, travel funds, and a modest amount of M&S.

Our grant has been supplemented in FY05 by CMS M&O funding in Fermilab MPOs of about $15K. Muon Collider R&D funding by DOE of 50K. An FY04 LC R&D grant of $51K which has been given no-cost extension through September-05. We received a substantial rollover amount from the DoE in FY04, which has been spent as previously described.

The University has provided about $50K in funds by way of a reduced overhead rate. Startup funds for Dr. Quinn have been supplied. Dr. Quinn has received a reduced teaching load while starting his research effort. Summer research support is available to junior faculty.

Dr. David Sander’s holds a University Research Scientist position, being paid by the department 10 months, and HEP 2 months. Dr. Sanders is able to spends significant time on research ≥ 50% in general but can not take extended leaves. He is allowed to travel on research projects, and supports our BABAR and CMS work at CERN. On those occasions his duties are covered by a graduate student who is supported by the department. Thus the department contribution is significant, about $40K to research.

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<th>Amount</th>
<th>Date</th>
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<td>DoE base</td>
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<tr>
<td>B.</td>
<td>DoE one-shot CMS machinist</td>
<td>60,319</td>
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<td>C.</td>
<td>DoE one-shot D0 Travel</td>
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<td>D.</td>
<td>DoE one shot Equipment</td>
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<td>F.</td>
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<td>9/30/04-10/1/05</td>
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3.2 FY05 Request

We are asking continued support of our post docs and students. in FY05.

BABAR On BABAR, Dr.’s Bauer and Zhao are preparing papers on (1) $\bar{B}^0 \to D^{*0}\gamma$, (2) $D^{*0}\alpha_1(1260)$ decays. Mr. Vance Eschenburg is studying p-wave $B^- \to D_2^{*0}(2460)\pi^-$ and $B^- \to D_0^-(2420)\pi^-$ decays and finishing his dissertation. Dr. Godang will perform further work with $B^- \to D^{*+}\ell^-\nu_\ell$ decays under partial reconstruction. $|V_{cb}|$ can be measured to greater precision
allowing $|V_{td}|$ to be further constrained. The loss of Dr. Bauer in Jan05 will be greatly felt by Mississippi and the ECAL on BABAR. He is one of the long-time experts providing continued service over the years.

**DØ** Dr. Melnitchouk will continue his investigation of $h \rightarrow \gamma\gamma$ on DØ and continue his software duties to lead DØ L0/SMT Software group. Mr. Joy will be supported 1/2 time by HEP to supply aide and expertise in the DØSAR farm effort. Some added burden may be taken on by using the system for DØ reprocessing of Run II data. We are asking for two additional work stations for CMS/DØ to support software development and analysis. One workstation will be placed at DØ and the second used by CMS.

**CMS** Our CMS efforts on software and help with commissioning are being hampered by lack of permanent research personnel (Fermilab or CERN). We will continue to work closely with the HCAL and Pixel groups to support these efforts at Fermilab and CERN. We are involved in HCAL calibration duties, Pixel monitoring and control software development, and some R&D in to Super Hcal. We plan to continue efforts with Dr. Cavaglia to study BH production and tagging at the LHC

**Muon Collider** The Muon Collider/Neutrino Factory has made great progress over the years. It has added a new dimension to our group, with added funding and novel projects. It has allowed us to bring in systems/computer expert Steve Bracker over the years which has benefitted all research programs. Our 1/2 machinist will be substantially supported by Muon funds in FY05. The RF cavity work will continue in to FY05, with rf cavity beam tests planned at Fermilab and target MUCOOL liquid-target tests at CERN.

We ask continued support of our four faculty for summer research.

We ask for adequate travel allowance to continue our research efforts in FY05. Dr. Kroeger spends one summer month at SLAC and Dr. Quinn and student will have duties on DØ for one summer month.

<table>
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<th>FY05 BUDGET</th>
<th>A. DoE base 400,000</th>
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In-kind

| A. University reduced overhead | 33,600              |
| B. University equipment       |                     |
| C. Department 1/2 comp manager | 31,400 (1/2 department cost) |
| D. Department 1/2 machinist-1 | 24,000 (1/2 salary by department) |
| E. Department 1/2 machinist-2 | 16,520 (2/5 salary by department) |
The present budget can not support the DØ and CMS activities. I have not been notified of any HCAL or Pixel supplements from Fermilab.

From: skuja@umd.edu
Subject: Re: HCAL travel thru Dan
Date: January 28, 2005 7:26:39 AM CST
To: cremaldi@phy.olemiss.edu

DOE has not agreed to distribute the $300K at this point. We are waiting for a decision from them.

Andris

Lab Service Accounts With two running experiments Mississippi should receive supplements lab for our service accounts on BABAR and DØ

1- $15K place in our SLAC lab service account for \babar running.
2- $15K place in our FNAL lab service account for \dz running.
A Short Progress Reports

A.1 Dr. Bauer

Rare Decay Search and Service
Johannes Bauer
Jan. 2005
The University of Mississippi
E-mail: bauerj@slac.stanford.edu

Search for Rare Decay $B^0 \to D^{*0}\gamma$  The physics analysis project of Johannes Bauer, the search for the rare decay $B^0 \to D^{*0}\gamma$, made big progress during 2004.

His main focus was the comparison of Monte Carlo with data. Since he discovered discrepancies between these data sets, he launched more detailed studies to determine the actual reason for this discrepancy, but found no “smoking gun.” In the end he decided to take this discrepancy into account as a systematic error on the background estimate. For this he determined the discrepancies for each of the six reconstruction modes ($D^0\pi^0, D^0\gamma) \times (K\pi, K\pi\pi^0, K3\pi)$ from two sources: The first source was a comparison of the number of events in the grand sideband region, the second was a comparison of the number of events in the signal region with cuts adjusted to select $B^0 \to D^{*0}\pi^0$ events instead of $B^0 \to D^{*0}\gamma$ events. Taking the maxima of these scaling factors with their errors into account changed the number of expected background events from $9.4 \pm 1.7$ to $9.4 \pm 4.8$.

Johannes Bauer then determined the complete systematic error on the efficiency and worked out possible calculations of the limit on the branching fraction including all systematic errors. With an average efficiency of 1.8%, the analysis may now expect to set a limit of about $2 \times 10^{-5}$ for the branching fraction of $B^0 \to D^{*0}\gamma$ at 90% confidence level, if no signal is seen.

The progress was regularly presented to the Radiative Penguin group, the analysis document (B.A.D. 94) was read and discussed in the meetings, and in July 2004, the analysis was signed off by the group. The review committee then reviewed the analysis document and provided suggestions, and by the end of 2004 Johannes Bauer submitted the “final” and complete version containing all required changes to the review committee, which is now reviewing the analysis a final time.

Since the review committee has already indicated that they have no more comments on the selection cuts, a speedy approval to un-blind the data may be expected. Once the data are unblinded, the analysis is essentially complete — except for anything requested during the subsequent collaboration-wide review. Johannes Bauer already wrote a complete draft of a Physical Review Letter on this analysis (save the final numbers) and is currently circulating it to solicit comments.

**Reports on $B^0 \to D^{*0}\gamma$ analysis**

At Collaboration Meetings:
- February 21, 2004
- May 5, 2004
- July 7, 2004

At Radiative Penguin Group Meetings:
- January 8, 2004
- May 27, 2004
- June 24, 2004

At Review Committee Meetings:
J. Bauer Service- Source Calibration  Johannes Bauer continued to be the manager for the EMC source calibration system, working with Vance Eschenburg (University of Mississippi), who serves as the regular operator of the system, and Tetiana Hryn’ova (Stanford University), who serves as backup when neither Vance nor Johannes are available.

During data-taking time, source calibrations are performed about once a month. It usually takes one hour to collect the data, which is followed by fitting of the spectra, checking the quality of the data, and loading the results into the database, Figure 14.

In November 2003, a new neutron generator arrived to replace the unit that had stopped working in Fall 2002 and that was later partially repaired to allow for low-intensity neutron beams. The installation of the new generator was preceded by a test in a special bunker at SLAC. Johannes Bauer was the overall manager of this work, ensuring that all necessary procedures and permits were signed for the tests and the installation, taking care that required work was scheduled and performed, testing the generator, and making sure the operators were all trained in the operation of the new generator. The performance of the new generator so far is flawless.

During the summer shutdown of BABAR, a pipe carrying Fluorinert for the source calibration was slightly damaged during work on other sub-systems, causing Fluorinert to leak out of the system. Johannes Bauer was again carrying the overall responsibility that the source of the leak was found and fixed, and he ran tests to ensure the integrity of the system after the repair.

Johannes Bauer regularly attended the weekly EMC operations meeting to be informed about any upcoming work that might affect the source calibration. He presented the status of the system at a collaboration meeting and regularly provides speakers with updated plots on the source calibration constants (like the figure shown below).

His article on the source calibration system was published in the August 2004 issue of IEEE Transactions on Nuclear Science.

Figure 14: Cesium Iodide light yield versus time.
Reports on source calibration work

At Collaboration Meetings:
   May 5, 2004

At EMC Operations Meetings:
   January 26, 2004
   April 26, 2004

Johannes Bauer is serving as resident supervisor to Vance Eschenburg for his dissertation work. He is meeting regularly with Vance and his advisor Rob Kroeger to discuss the status and provide guidance for Vance’s dissertation analysis, as well as for Vance’s talks and papers (like for the DPF conference in Riverside).

As part of BABAR’s internal review process, the collaboration asks institutions to review articles before they are being published. Since May 2002, Johannes Bauer collects and compiles the comments on these articles from the members of the OleMiss group. So far he has posted 32 such compilations to the collaboration.

Johannes Bauer serves as de-facto system manager of the two RAID arrays that are currently located at SLAC. Since these machines were built by OleMiss, they are not maintained by SLAC personnel. Johannes therefore handles all major problems that arise, like diagnosing and exchanging several malfunctioning RAID and system disks, as well as performing several system installations.

Johannes Bauer is serving as IEEE reviewer of Transactions on Nuclear Science, for example, for the edition with articles based on talks presented at the 2003 IEEE Nuclear Science Symposium in Portland, OR.

He is member of the “Conference and Promotion Committee” for the IEEE Nuclear Science Symposium (even though he was unable to join the latest such conference in Rome, Italy), attending monthly phone conferences and promoting the conference, for example, at SLAC and to the Young Particle Physicists group.

He volunteers as SLAC tour guide, providing 2-hour tours of SLAC to visiting groups, ranging from school classes to professional organizations to seniors.

Johannes Bauer regularly participates in the weekly meetings of the Radiative Penguin group, in the weekly EMC operations meeting, and in BABARcollaboration meetings. He frequently attends the weekly SLAC colloquia and SLAC experimental seminars. In January 2003, he also participated in a Linear Collider Workshop at SLAC in order to learn more about opportunities that this new project presents.

Publications and Presentations

In Summer 2004, Johannes Bauer’s article on the source calibration performance was published in the peer-reviewed journal IEEE Transactions on Nuclear Science. The article was based on his presentation October 2003 at the IEEE Nuclear Science Symposium in Portland, OR.

In August 2004, Johannes Bauer presented the talk “Radiative Penguin Decays of $B$ Mesons: Measurements of $B \to K^{*}\gamma$, $B \to K_{2}^{*}(1430)\gamma$, and Search for $B^{0} \to \phi\gamma$” on behalf of the BABARcollaboration at the DPF meeting in Riverside, CA. He submitted his contribution to the conference proceedings for publication in the International Journal of Modern Physics A.


A.2 Dr. Zhao

**Progress Report from BaBar**

Haiwen Zhao  
Jan. 2005  
The University of Mississippi  
E-mail : zhaohw@slac.stanford.edu

Study of Hadronic Decay $B \to D^{(*)}(n\pi)−$  
This analysis is a study of hadronic decays of $B$ meson to $D^{(*)}$ mesons and a charged $n$-pion final states ($n\pi$) where $n \leq 3$. The ($n\pi$) system can be $\pi^+, \pi^+\pi^0, \pi^+\pi^−\pi^+$ and the $D^{(*)}$ can be neutral or charged, depending on the charge of $B$ meson. The study are important in $CP$ violation study, test of the factorization hypothesis and Heavy Quark Effective Theory.

Based on the data set of an integrated luminosity of 59.0 $fb^{-1}$ taken with BaBAR detector at $\Upsilon(4S)$ resonance, hadronic decays of $B \to D^{(*)}(n\pi)^−$ are studied. There are totally 24 decays modes involved in this study making it a complicated analysis. Dr. Zhao implemented a two-variable maximum likelihood technique in the analysis. The progress is steady and currently the preliminary results on decay branching fractions of $B \to D^{(*)}\pi$ and $B \to D^{(*)}\pi^0\pi$ are obtained. The study of $B \to D^{(*)}\pi\pi\pi$ is at its final stage. We also expect to give the first measurement of the polarization of the decay $B^0 \to D^*-a_1^+(1260)$.

Selected presentations and documents on this work are given as the following:

  (links: http://xxx.lanl.gov/pdf/hep-ex/0409055)
- H.W.Zhao, *BaBar collaboration meeting talk, July 2004*.  
  http://www.slac.stanford.edu/ zhaohw/research/babar/PHYS01/presentation/talk_0402coll.pdf
BaBar Data Quality Assurance and Validation  In order to ensure the correctness and accuracy of experiment measurement results, data quality monitoring and assurance is very important.

Dr. Zhao has been playing a leading role on Electromagnetic Calorimeter (EMC) Data Quality Assurance. He was appointed to be in charge of BaBar EMC data quality monitoring and assurance as EMC expert for Run4 data taking period (2004) and continue in Run5 period (2005). His work includes the new Monte Carlo data validation, new software release validation and data format conversion monitoring and validation, monitoring of EMC online event processing data and EMC online prompt reconstruction data to validate the data after processing. Dr. Zhao implemented a tool codes for display the stripchart of important quantities for EMC data, report on any problems in the data processed in the preceding week on a weekly meeting of the Babar QA group, and cooperate with other EMC experts to fix the problem.

The following is examples of Dr. Zhao’s contribution in this field:

- EMC data quality monitoring strip chart:
- EMC data online prompt reconstruction monitoring plots:
  http://www.slac.stanford.edu/ zhaohw/research/babar/PHYS01/plot/emcopr.pdf
- Contribution to BaBar Data: page 3 in talk of
  http://www.slac.stanford.edu/ zhaohw/research/babar/PHYS01/presentation/richman.pdf
- Weekly report on EMC data quality (BaBar Data group meeting):
A.3 Dr. Godang

Progress Report
Romulus Godang
Jan. 2005
The University of Mississippi
E-mail: godang@phy.olemiss.edu

BABAR Analysis Status $\Upsilon(4S) \rightarrow B^{0}\overline{B}^{0}$ Dr. Godang is measuring the branching fraction of $\Upsilon(4S) \rightarrow B^{0}\overline{B}^{0}$ using partial reconstruction technique of $B^{0} \rightarrow D^{*+}\ell^{-}\overline{\nu}_{\ell}$. He introduces a novel technique for this analysis where he compared the single and the double tag samples of $B^{0} \rightarrow D^{*+}\ell^{-}\overline{\nu}_{\ell}$. This technique allow him to extract the result that does not depend on branching fractions of the $B^{0}$ and the $D^{*+}$ decays, on the simulated reconstruction efficiency, on the ratio of the charged and neutral $B$ meson lifetimes, or on the assumption of isospin symmetry. Using partial reconstruction of the decay $B^{0} \rightarrow D^{*+}\ell^{-}\overline{\nu}_{\ell}$ he obtains a result of $f_{00} = 0.486 \pm 0.010 \text{(stat.)} \pm 0.009 \text{(sys.)}$. This work is under collaboration-wide review and will be submitted to PRL in Spring-05.

Paper Review Committee Dr. Godang has been appointed by BABAR Publications Board to review an important physics analysis as a paper Review Committee. There are 3 analysis topics that he reviewed:

1. Search for $B^{0}$ to Invisible Final States and $\nu \overline{\nu} \gamma$.
This analysis is important for an existence of new physics especially with an asymmetric $B$ Factory at $10^{36}$ luminosity.
The primary editor for this analysis is Justin Albert (a postdoc from Caltech).
This analysis has published into Phys. Rev. Lett. 93, 091802, 2004.

2. Determination of the Partial Branching Fraction for $B \rightarrow X_{u}\ell\nu$ and of $|V_{ub}|$ from the Inclusive Electron Spectrum near the Kinematic Endpoint. This analysis is important for improving measurement of CKM element $|V_{ub}|$, the coupling of the $b$ quark to the $u$ quark that will enhance the sensitivity of CP asymmetries in $B$-meson.
The primary editor for this analysis is Vera Luth (a Principal Investigator from SLAC).
This analysis has been submitted to the 32nd International Conference on High-Energy Physics, ICHEP 04, 16 August–22 August 2004, Beijing, China. This conference paper is available at hep-ex/0408075: http://arXiv.org/pdf/hep-ph/0408075.

3. Measurement of the Ratio of Branching Fractions of $\Xi_{c}^{0}$ Decays to $\Xi^{-}\pi^{+}$ and $\Omega^{-}K^{+}$. This analysis is important for understanding charmed baryons with high precision from $B$-factory.
The primary editor for this analysis is Matthew Charles (a postdoc from University of IOWA).
This analysis has been submitted to the 32nd International Conference on High-Energy Physics, ICHEP 04, 16 August–22 August 2004, Beijing, China. This conference paper is available at hep-ex/0408056: http://arXiv.org/pdf/hep-ph/0408056.

Computing Model Expert Dr. Godang has been appointed as a New Computing Model Expert (CM2 Expert) at the Inclusive Hadronic $B$ Decay (IHBD) Analysis Working Group (AWG). The
New Computing Model is the major change in BABAR. It provides substantial and important advantages over the current system in BABAR both for online and offline physics analyses.

There are two urgent CM2 expert task for the physics analysis. Firstly it is to understand and exploit the capabilities of CM2 and to help any remaining problems in the CM2 implementation. Secondly it is to prepare skims from their AWG for the December 2004 skim production. Currently BABAR has proposed to have a collaboration skim plan for every 3 month instead of every year in the previous system.

**Ntuple production for RUN4 data set** Dr. Godang had produced ntuples for the newest data set (CM2-RUN4) that currently available at BABAR. These data contain of 103 $fb^{-1}$ for data plus about 200 $fb^{-1}$ Monte Carlo simulation events. The data have been used by INFN Sezione Di Padova group for their physics analysis topic: $B^0 \rightarrow \pi^- \ell^+ \nu$ using partially reconstructed $B^0 \rightarrow D^{\ast} \ell^- \nu$. These data ntuples can also be used for other analyses like determination of $|V_{ub}|$ using recoil technique.

**Research in to Black Holes** Dr. Godang is conducting research in to “Resolution of Nearly Mass Degenerate Higgs Bosons and Production of Black Hole Systems of Known Mass at a Muon Collider” working together with Don Summers, Marco Cavaglià, Lucien Cremaldi and Steve Bracker.

Dr. Godang presented this new anlysis result on behalf of BABAR collaboration at The DPF 2004: Annual Meeting of the Division of Particles and Fields of APS 26 August–31 August 2004, Riverside, CA, USA. The paper will be published soon at International Journal of Modern Physics A by World Scientific Publishing 2004. This paper is available at

Higgs to Gamma Gamma In June 2004, I completed $h \rightarrow \gamma\gamma$ analysis with 260 $pb^{-1}$ (largest D0 dataset available at the time) and set limits on $B(\gamma\gamma\gamma\gamma)$ as a function of Higgs Mass. Details of the analysis are at:


The limits were improved in comparison with those we submitted to Moriond 2004 conference. However, according to the D0 physics coordinator, the overall results were not competitive enough for a publication. The main reason was high photon background. I was suggested to perform Neural Net Photon ID studies in order to suppress the photon background, which would improve the sensitivity of $h \rightarrow \gamma\gamma$ analysis as well as other high Pt photon analyses at D0.

During July 2004 - October 2004, I worked on Neural Net Photon ID studies. Constructed a neural net (NN) based on variables similar to those that are currently in use by (linear) Photon ID D0 tool H-Matrix. Studied different training methods and parameter settings. Showed that the best NN performance is achieved with the Broyden, Fletcher, Goldfarb, Shanno (BFGS) method. Demonstrated that the NN is robust / not sensitive to

-- parameter settings
-- number of hidden nodes
-- training repetitions
-- reordering and renormalizing inputs.

I optimized the input variables using calorimeter cell information in the cone around the photon candidate, based on 1D distributions of input variables for background, $h \rightarrow \gamma\gamma$ Monte Carlo (MC), $-Z_{\ell}\ell ee$ MC, and $Z_{\ell}\ell ee$ data. Studied non-linear correlations between input variables. -Verified applicability of the variables that have discontinuities. -Considered several Neural Nets based on the training signal sample: $Z_{\ell}\ell ee$ data, $Z_{\ell}\ell ee$ MC, single electron MC. Despite good understanding of Photon ID variables and NNs that was gained during these studies, the improvement in photon background suppression with NN turned out to be only marginal. One possible explanation for such performance is that the data itself does not contain sufficiently detailed (shower shape) information that can be exploited by the non-linear multivariate tools. These studies are described in the notes and talks that can be found at:

In the end I have provided recommendations and code examples to the D0 Photon ID group to be used for continuation of Photon ID studies.

I gave Conference and Workshop talks:

"Search for Fermiophobic and Topcolor Higgs in the Diphoton Final States at D0", DPF 2004 Conference, Riverside, CA
http://physics.ucr.edu/~billdbrk/talks/talk121.pdf, August 30, 2004

**Silicon Microstrip Tracker / Layer Zero Detector**  In November 2004 I began working on the Silicon Microstrip Tracker / Layer Zero Detector (SMT/L0) software group has been organized at D0. I became a leader of the D0 SMT/L0 software group. The charge of this group includes:

- taking over the core SMT software maintenance
- adding Layer Zero of the Silicon Tracker to the SMT code
- coordinating efforts of software and hardware groups involved in the Layer Zero to ensure timely preparation of the software and successful technical and physics commissioning of the Layer Zero Detector in 2005.

More information about the SMT/L0 group and its responsibilities can be found at

http://www-d0.fnal.gov/~melnit/L0/L0SoftwareGroupDocument_V0_Nov10_2004.pdf

What I have done as a part of this group’s effort is described in the following presentations:

http://www-d0.fnal.gov/~melnit/L0/AM_L0meeting_111004.pdf
http://www-d0.fnal.gov/~melnit/L0/AM_TRKVTXmeeting_111804_Part1of2.pdf
http://www-d0.fnal.gov/~melnit/L0/AM_TRKVTXmeeting_111804_Part2of2.pdf
http://www-d0.fnal.gov/~melnit/L0/AM_TRKVTXmeeting_121604.pdf
A.5 Future BABAR Projects

A.5.1 Precise Measurement of $|V_{cb}|$ Determination

Dr. Godang’s semileptonic $\bar{B}^0 \to X^+ \ell^- \bar{\nu}_\ell$ analysis opens the way to two other interesting investigations which he describes below.

The other interesting physics analysis is to measure the matrix element of the Cabibbo-Kobayashi-Maskawa Matrix (CKM), $|V_{cb}|$, to a better precision using $\bar{B}^0 \to D^{*+} \ell^- \bar{\nu}_\ell$ measurement with Partial Reconstruction Technique. It is very important to measure the $|V_{cb}|$ determination to a better precision in order to understand the CKM unitary in the Standard Model. The precise measurement of $|V_{cb}|$ is also important in order to determine the other CKM matrix element, $|V_{td}|$.

The matrix element $|V_{td}|$ can be extracted from a measurement of $\mathcal{B}(K^+ \to \pi^+ \nu \bar{\nu})$ yet it depends on other parameters [1, 2, 3], especially on $|V_{cb}|$ and the mass of the charmed quark as appearing in Equations 1 and 2, respectively.

\[
\begin{align*}
\mathcal{B}(K^+ \to \pi^+ \nu \bar{\nu}) \bigg|_{SM} &= R_+ A^4 X^8 F(x_t) \frac{1}{\sigma} \left[ (\rho_0 - \rho)^2 + (\sigma \bar{\eta})^2 \right] \\
&= R_+ |V_{cb}|^4 F(x_t) \frac{1}{\sigma} \left[ (\rho_0 - \rho)^2 + (\sigma \bar{\eta})^2 \right] \\
&= (0.77 \pm 0.21) \times 10^{-10} \quad (1)
\end{align*}
\]

\[
\frac{\sigma(|V_{td}|)}{|V_{td}|} = \pm 0.04_{\text{scale}} \pm \frac{\sigma(|V_{cb}|)}{|V_{cb}|} + 0.7 \frac{\sigma(\bar{m}_c)}{\bar{m}_c} \pm 0.65 \frac{\sigma[\mathcal{B}(K^+ \to \pi^+ \nu \bar{\nu})]}{\mathcal{B}(K^+ \to \pi^+ \nu \bar{\nu})} \quad (2)
\]

A.5.2 Absolute Branching Fraction of $\bar{B}^0 \to X^+ \ell^- \bar{\nu}_\ell$

Semileptonic decays play an important role in heavy quark physics especially in $B$ mesons. The spectator model in heavy quark decay implies that the semileptonic branching fractions of hadrons containing a heavy quark should not depend on the number or kind of light quarks in the hadron [4]. Based on this model, the prediction of the semileptonic branching fraction of $B$ meson is generally above 12%. The inclusive semileptonic branching fraction has been theoretically predicted of $\mathcal{B}_{sl} = 16.5\%$ [5]. However, the inclusive semileptonic branching fraction measurement is $\mathcal{B}_{sl} = 10.45 \pm 0.21\%$ [6]. It is smaller than theoretical expectation.

The semileptonic decays of $\bar{B}^0 \to D^{*+} \ell^- \bar{\nu}_\ell$ is a very useful physics analysis that could address the question why the inclusive semileptonic branching fraction measurement is somewhat smaller than the theoretical prediction. This analysis can also be lead to measure the $R^{+}/R^{0} \equiv f_{+}/f_{00}$. Recently Ikaros Bigi [8] described the status of the Heavy Quark Parameters (HQP) in terms of the decay width in the inclusive semileptonic $B$ decays with 3% precision theoretically.

Based on Dr. Godang’s expertise on semileptonic $B$ physics analyses, he hope to answer the unresolved above question by measuring the absolute branching fraction of $\bar{B}^0 \to X^+ \ell^- \bar{\nu}_\ell$ using all available BABAR data set (RUN 1-4) with 230 $fb^{-1}$.

References


A.6 Future CMS Analysis Interest

A.6.1 $H \to \ell\ell\nu\nu$

The Higgs mechanism is an important step towards the discovery of the Standard Model (SM) and the Minimum Supersymmetry Standard Model (MSSM) Higgs bosons. In the SM mechanism, we only have a single neutral Higgs with its mass as a free parameter; however, in the MSSM as a result of adding a second complex Higgs doublets (to preserve supersymmetry) to the SM gives us five elementary Higgs particle bosons: one pseudoscalar boson $A^0$ (CP-odd scalar), two charged scalar bosons $H^+$ and $H^-$, and two neutral scalar bosons $H^0$ and $h^0$ (CP-even scalars).

If the Higgs bosons exist, their signature can certainly be seen at the LHC. The Higgs boson mass measurements at the Large Hadron Collider (LHC) are predicted at the level of $10^{-3}$ [1]. The measurements of the Higgs boson couplings are predicted at the 5-10% level [2]. At the LHC $pp$ collider, the production of the Standard Model Higgs boson is mainly dominated by the gluon-gluon fusion process: $pp \to gg \to H$ with the mass range of $100 \text{GeV/c}^2 < m_H < 1 \text{TeV/c}^2$.

The theoretical calculation at the leading order (LO) all the couplings and the masses of the MSSM Higgs sector are determined by two independent input parameters: the parameter $\tan \beta$ and the pseudoscalar Higgs boson mass $m_A$. The $\tan \beta$ is defined as $v_1/v_2$ where $v_1$ and $v_2$ are two vacuum expectation values.

At the leading order calculation the gluon fusion mechanism $gg \to H$ provides the dominant production of Higgs bosons in the relevant mass range up to $1 \text{TeV}$. This gluon fusion mechanism is mediated by heavy bottom, top and squark loops as seen in Fig. 15 [3].

The Next Leading Order (NLO) is based on the QCD correction that consists of two-loop virtual corrections and one-loop real corrections and will be important.

Based on the supersymmetric theoretical prediction that the cross section in the gluon fusion mechanism for the heavy Higgs production, $H^0$, with a small $m_A$, may be dominated by the bottom quark loops for a larger value of parameter $\tan \beta$. The range of $\tan \beta$ is larger than 10 to limit the
The Feynman diagram contributing to $gg \rightarrow H$ at the lowest order.

Figure 16: The relative error on the determination of cross section for several Higgs search channels at the LHC [2].

The channel of $gg \rightarrow H, H \rightarrow W^+W^-$ is one of the very important one for searching the Higgs masses since the branching fraction of heavy Higgs boson to W-pair is almost 100%, yet the background from the bottom-pair production is needed to be suppressed using the jet veto. This background is $t\bar{t} \rightarrow b\bar{b}W^+W^-$ where each W could go to lepton-neutrino pair.

In the full Next Next Leading Order (NNLO) calculation [4], there is an sizeable effect so called real gluon bremsstrahlung at NLO that could contribute to the gluon fusion process. This effect has been analyzed in applying the jet veto ($p_T > 15 \text{ GeV}/c$) by ATLAS Collaboration. [5]

We hope to begin investigating the details of the $H \rightarrow \ell\ell\nu\nu$ analysis sometimes in FY05.

References


B  Budget Justification

A.1-4. Three faculty supported for two summer months each and one faculty for one summer month to perform research full-time and to direct students. No cost of living adjustment was applied to salaries. The summer commitments are:

(a) L. Cremaldi: \textit{Babar}45\%, CMS 45\%, 10\% MUON
(b) R. Kroeger: \textit{Babar}90\% CMS 10\%
(c) D. Summers: \textit{Babar}45\%, CMS 10\%,MUON 45\%
(d) B. Quinn: D0 90\% CMS 10\%

\textit{( Academic year support, with reduced teaching loads, is provided by the University.)}

A.6. Two months summer salary for Dr. David Sanders, Research Scientist/Computer System Manager. Dr. Sanders is supported 10 months by the physics department. He spends greater than 50\% time on the UMHEP computing, RAID Arrays, supporting UMiss systems at SLAC, performing physics analyses. Two months support is requested so he can continue his support of \textit{Babar} (systems, RAID arrays, etc.), some software development for CMS, and bring up our D0/CMS computing. Sander’s also supports test beam operations at CERN for our group. In his absence for research purposes, the department pays a student for backup (13.2K per yr.). The Department contributes about 5 months of Dr. Sander’s salary, and with the student totals an in-kind contribution of \approx \$33K + 25.04\%. fringe.

B.1 Three postdoctoral associate are supported full-time. One is supported for 6 mos.

(a) J. Bauer (8 mos): 100\% \textit{Babar}
(b) H. Zhao (12 mos): 100\% \textit{Babar}
(c) R. Godang (12 mos): 90\% \textit{Babar}; 10\% MUON
(d) A. Melnitchouk (10 mos): 90\% D0; 10\% CMS

B.2 Machinist/Designer to fabricate and maintain HCAL/Pixel subsystems on CMS.

B.3 One graduate student, V. Eschenburg, is doing his dissertation in residence at SLAC and needs full support. Mr. Michael Joy is working 50\% department and 50\% DOE during the academic year. We will support 3 HEP students full time for the summer 05.

C. Fringe benefit rate: 25.04\% of salary for Senior Personnel and Post Doctoral Associates; 3\% of salary and wages for undergraduate and graduate students.

\textit{( All salaries and wages and fringe benefits are consistent with guidelines established by the University. )}

E.1 Domestic Travel (3 faculty, 1 research scientist, 3 postdocs, 2 students)

\textit{( All domestic travel costs are based on average cost of such trips in FY04 corrected for inflation and are consistent with university policy and regulations. )}
(a) One faculty for one summer months each at SLAC  
(b) Supplement for one student 12 months at SLAC  
(c) Faculty during academic year to run shifts, direct students and consult with postdocs at SLAC, FNAL  
(d) CMS related travel.

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
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<tbody>
<tr>
<td>One collaboration meeting at CERN or EPS Meeting for faculty.</td>
<td>2017</td>
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<tr>
<td>CMS related travel</td>
<td>6000</td>
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</tbody>
</table>

**E.2 Foreign Travel (4 faculty, 1 research scientist, 3 postdocs)**

(All foreign travel costs are based on average cost of such trips in FY04 corrected for inflation and are consistent with university policy and regulations.)

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
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<tbody>
<tr>
<td>One collaboration meeting at CERN or EPS Meeting for faculty.</td>
<td>2017</td>
</tr>
<tr>
<td>CMS related travel</td>
<td>6000</td>
</tr>
</tbody>
</table>

**G.1 Materials and Supplies**

<table>
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<tr>
<th>Description</th>
<th>Cost</th>
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</thead>
<tbody>
<tr>
<td>Materials (tapes, supplies, software, licenses) for BABAR analyses</td>
<td>1000</td>
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</table>

**G.2 Publication Costs**

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
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<tbody>
<tr>
<td></td>
<td>500</td>
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**G.6 OTI - Other Direct Costs**

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long distance charges – conference calls three a week for BABAR D0, CMS, MUON; Shipping and mailing charges.</td>
<td>1000</td>
</tr>
<tr>
<td>Tuition remission is requested for each graduate research assistant at the Universitys standard rate of $2055 per semester (1.5 students @ 2 semesters per student @ $2055 per semester = $6165)</td>
<td>6165</td>
</tr>
</tbody>
</table>

Indirect costs are calculated in accordance with The University of Mississippis rate agreement with DHHS, dated February 3, 1999. Indirect costs for research are calculated at 43.5% of Total Direct Costs less equipment, tuition remission, and the portion of each subgrant or subcontract in excess of $25,000. Under a special agreement with the University an indirect cost rate of 34% is applied on modified total direct costs except travel, on which a 10% rate is applied.