Final Report
on CP Violation in B Decays at $BABAR$

to

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for

Prairie View A&M University
High Energy Physics

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Chapter 1

Project Overview

The *BABAR* Collaboration, currently taking data at the PEP-II Asymmetric *B* Factory at the Stanford Linear Accelerator Center (SLAC), is conducting studies of *CP*-Violation in the *B*-system. The High Energy Physics Group at Prairie View A&M University is a member of the *BABAR* Collaboration and has been since 1994. The *BABAR* Collaboration is composed of 9 countries, 72 institutions, and over 550 physicists. Our high energy research group's participation and contributions to past research collaborations go back before 1994, to such national U. S. Department of Energy (DOE) supported basic research laboratories as Fermilab in the early 1980's and on experiments there such as E537, E647, and E771.

Prairie View A&M University (PVAMU) is located approximately 50 miles northwest of Houston, Texas. Prairie View A&M University is a Historically Black College or University (HBCU) with its founding in 1876. Prairie View A&M University is designated a University of the First Class in the state of Texas along with Texas A&M University, College Station (the flagship institution of the Texas A&M University System) and the University of Texas at Austin (which is also a flagship institution as well as being a Tier One institution in the United States). Texas A&M University and Prairie View A&M University are the first and second oldest public universities respectively in the state of Texas. With such a clear place in the history of our state, Prairie View A&M University recognizes the necessity of basic research that can come only through the interest and efforts of professors and researchers and which has contributed to the growth of all Tier One institutions. Our interest and efforts in particle physics and our contributions to this field have encouraged the interest of those students, particularly among the traditionally underserved, who want to seriously pursue their education and consider a career in the sciences by providing role members on campus with whom these students interact and research programs on which these students can actively participate. This has been proven to be a desirable and effective way to educate those students who want to be educated.

Our continuing interest in high energy physics research has over the years earned us support from the U. S. Department of Energy, the State of Texas, the Texas A&M University System, and U. S. DOE-supported national laboratories (Fermilab and Lawrence Livermore National Laboratory), as well as the interest of many undergraduate students at Prairie View. An infrastructure has developed within the Physics Department at Prairie View that has allowed for the development and encouragement of more than 14

“Ph.D. ready physics undergraduates”. Over the last decade six of these students have already earned Ph.D. degrees in physics, computer science, and other fields from such institutions as Rice University, the University of Texas at Austin, the University of Iowa, the University of Minnesota, Florida State University, and Hampton University.

Our own work on heavy quark physics began at Fermilab in the 1980’s, with the study of charmonium production in fixed-target hadron collisions (Fermilab experiment E705). This work continued in experiment E771, which produced both charm and bottom mesons. In all of our high energy physics work here at Prairie View, we have always encouraged and supported undergraduate student participation in our research. This has resulted in many of our Prairie View physics graduates going on to pursue their graduate degrees, some under full fellowships, and with several having already now completed their Ph.D.’s in Physics. This goal of encouraging Prairie View physics students to pursue further graduate studies and to consider a career in physics is one we take seriously, and our DOE-supported high energy physics research work is indispensable both for the physics knowledge gained and the positive influence it has had on our students.

Our initial work on *BABAR* focused on the Muon and Neutral Hadron detector, the Instrumented Flux Return (IFR) subsystem of the *BABAR* detector. We worked on simulation of the subdetector in GEANT3 and GEANT4, and assisted with the construction and installation of the IFR. This work was a natural outgrowth of our earlier work at Fermilab, which used the same type of hardware (resistive plate chambers) for muon detection.

Since completing the installation and initial cosmic ray test runs of the IFR, we have also joined the *BABAR* Quality Assurance/Quality Control team, which conducts tests of new releases of the experiment’s simulation, reconstruction, and analysis code. Concurrently, we have begun our own analysis work, beginning with charmed baryon analysis.

Information about Prairie View A&M University

Prairie View A&M University was established in 1876 and is the second oldest public university in Texas. Prairie View was made a Land Grant College and designated a Historically Black College or University (HBCU) in the 2nd Morrill Act of 1890. In 1984, the people of Texas in an amendment to the Texas Constitution established Prairie View as one of three “Institutions of the First Class” along with the University of Texas, Austin and Texas A&M University. Prairie View is also one of the member institutions of the Texas A&M University System. Prairie View's student enrollment exceeds 6000 students (including more than 500 graduate students) of whom 80% are African-American. More information about Prairie View can be found on the university home page on the web at <http://www.pvamu.edu/>.

The Texas A&M University System has also constructed for Prairie View A&M University a new state-of-the-art Science Building for the Physics, Chemistry, and Biology departments. Occupation of the New Science Building by the Physics, Chemistry, and Biology Departments occurred during January 2001, with the exception of Professors Judd and Wagoner and the High Energy Physics research group. Finally, after much discussion, the Prairie View A&M University administration during November 2001 moved Professors Judd and Wagoner and the High Energy Physics research group into their offices and spaces that had been sitting unoccupied in the New Science Building for 10 months. Figure B.1 below is a photograph of the New Science Building at Prairie View.

Figure B.1: New Science Building at Prairie View.

The Prairie View Physics Department has graduated over 30 physics majors from 1992–2001. Of these, 17 have been accepted into graduate programs at universities around the country. One of the latest graduates, Clayton Simien, was awarded the \$125,000 Packard Foundation Fellowship for his graduate studies in physics at Rice University. The table below details the status of these 18 Prairie View graduates. Of the other physics graduates, there are working in a number areas including as officers in the U.S. Navy, in industry, and on the staff of other universities. The High Energy Physics group at Prairie View was also among the first experimental high energy physics group supported at an HBCU. More information about High Energy Physics at Prairie View can be found on the High Energy Physics web page at <http://www.hep.pvamu.edu/>.

PVAMU Physics Graduates Entering Graduate Programs 1992–2001

PVAMU Graduate	Year Graduated	Graduate Program
John Calhoun*	1992	University of Iowa
Julius Barnes [†]	1993	Rice University
Eric Brass*	1993	Hampton University
Byron Freelon [†]	1993	University of Minnesota
Margaret Smith [#]	1993	University of Michigan
Temesgen Habtemariam [†]	1994	University of Minnesota
Christopher Johnson ⁺	1994	Texas A&M University
Eric Johnson	1994	University of Minnesota
Carlton Watson [†]	1994	University of Iowa
Althea Bluiett	1995	Michigan State University
Titania Dumas	1995	University of California, Davis
Mohamad Moghadassi ⁺	1995	Prairie View A&M University
Melynda Price [†]	1995	University of Michigan
Juba Watts-Cain ⁺	1995	University of California, Los Angeles
Kevin Storr [†]	1996	Florida State University
Clayton Simien	2000	Rice University
Merlyn Pulikkathara	2001	Prairie View A&M University

[†]Received Ph.D.

⁺Received M.S.

*Passed Ph.D. Qualifying Exam

[#]Withdrew from Program

Chapter 2

Progress Report: *BABAR* Work at Prairie View

The High Energy Physics group at Prairie View A&M University has been a member of the *BABAR* collaboration since September 1994. During this time we have worked on GEANT3 simulation and GEANT4 simulation of the Instrumented Flux Return (IFR), HP software support of *BABAR* code, software quality assurance, and charmed baryon analysis. We are presently involved actively in the latter two. We have also been manning *BABAR* shifts at SLAC since 1999 and have met or exceeded our shift quota during that time.

2001 was a banner year for the *BABAR* Collaboration. *BABAR* provided the first statistically significant observation of *CP*-violation in a non-Kaon system (as published in Phys. Rev. Lett. **87**, 091801 (2001)). In addition the *BABAR* Collaboration is publishing a large number of papers on a variety of *B* physics topics. *BABAR* and PEP-II have also been setting luminosity and efficiency records. This means that *BABAR* is collecting a large amount of high quality data for its ongoing analyses, and so is remaining highly competitive with Belle Collaboration at KEK in Japan. Prairie View High Energy Physics is pleased to be contributing to this *BABAR* effort.

It must also be noted that, due to actions by the Prairie View A&M University administration, the High Energy Physics research grant was frozen by the university from May 1, 2001 through August 1, 2001. This unfortunately resulted in there being no opportunity for student participation on our research work at the Stanford Linear Accelerator Center (SLAC) during Summer 2001. In addition this Prairie View A&M University administration action also caused DOE to terminate the present research grant effective March 14, 2002 and require re-submittal of this new proposal for funding of the High Energy Physics group at Prairie View.

Simulation

Software for simulation, reconstruction, and online data acquisition for the IFR was a very high priority in the early days of the *BABAR* experiment, since the IFR was scheduled to be built and installed in IR2 a year before the rest of the experiment was in

place. IFR installation was done in the summer of 1997, and it began taking data with cosmic ray muon triggers shortly afterward.

Prairie View was responsible for writing a large amount of the IFR simulation code. The code was written in C++ from the outset, with the expectation that the experiment would eventually move from GEANT3 to GEANT4. “Eventually” is now scheduled for the year 2001, but the IFR has been ready for the move for years. A simple version of the full simulation was done by Torre Wenaus and Doug Wright of LLNL before Prairie View joined the collaboration. Our work began with a more realistic layering system for the resistive plate chambers (RPCs). After this was completed, we wrote the geometry code for the barrel and endcap RPCs, incorporating gaps and spacers, and modified the strip readout for all the RPCs, since some of the chambers had a one-dimensional readout, and others a two-dimensional readout. (The initial plan was for all chambers to have a two-dimensional readout; budget constraints forced some of them to have only a one-dimensional readout.) The last component to be added to the model was the inner RPC cylinder, which was built at Livermore, and was the last part of the IFR to be installed.

Pictures of the IFR geometry can be found on the web at <http://www.hep.pvamu.edu/detector.html>. The postscript files and outer barrel RPC pictures were generated by GEANT3; the barrel steel, endcaps, and inner RPCs were done with GEANT4. GEANT4 pictures of some of the IFR detector geometry are shown below in Figures A.1, A.2, A.3, A.4, and A.5.

The original Quality Assurance tests of the IFR simulation, all done with GEANT3, were written at Prairie View. Some of the output of these tests is shown in <http://www.hep.pvamu.edu/mutest/mutestm.html>. The coverage gaps in the IFR barrel and forward endcap are clearly shown in the hit distributions in Figures A.6 and A.7 below.

All of the IFR simulation geometry code was originally in the `gnmuon` package. We became the package coordinators for this code in 1997, and remain so today. In 1998, immediately after the Inner RPC code was completed, the geometry code was moved to the `IfrSimGeom` package, for which our Italian collaborators took over responsibility. There has been no change to the geometry code since then. The `gnmuon` package retains only the GEANT3 interface routines and test routines, which are the only routines requiring maintenance when versions of CERNLIB are updated or problems occur with other packages. We hope that further maintenance will not be required after this year, when GEANT4 becomes the standard simulation.

Figure A.1: Front View of IFR Barrel RPC Envelopes.

Figure A.2: Front View of IFR Endcap RPC Envelopes.

Figure A.3: Some of the steel spacers in the IFR Barrel.

Figure A.4: The IFR forward endcap, with steel supports.

Figure A.5: Front View of IFR Endcap RPC Envelopes.

Figure A.6: Φ distribution of muon hits in the IFR barrel.

Figure A.6: Φ distribution of muon hits in the Forward IFR Endcap.

Computing

In the first year after joining *BABAR*, our group was involved with porting the simulation program BBSIM and its supporting utilities to our Hewlett-Packard HP9000/750 workstations. These utilities included the GNU gmake utilities, SLAC's CVS and rCVS, *BABAR* Software Release Tools, and AFS. In the case of the native C++ compiler, Prairie View was the lead institution in adapting the *BABAR* code to the HP platform. We selected the HP platform because it was the most commonly used workstation with our IFR collaborators at Lawrence Livermore National Laboratory and Genova.

However, there were significant problems with porting the Objectivity database to the HP platform, which required new code from the vendor. Eventually, Objectivity was successfully ported to the HP, but during the long wait for this to happen, HP users became accustomed to doing their computing remotely in SLAC. This has not been without problems. In particular, a change to the network configuration at Prairie View in 1999 resulted in lengthy network outages last year, and long delays in completing work. At the end of 1999, HP was dropped as a supported platform of the *BABAR* collaboration. (IBM AIX was also dropped in 1998.) At the beginning of the year 2000, only two platforms were officially supported within *BABAR*—Sun and DEC/OSF (now Compaq/OSF). RedHat Linux (ix86) was added as a supported platform a few months later.

In 1999, we borrowed one Sun workstation to test some software, and in 2000 we bought a Sun workstation and added two PCs running RedHat Linux. We plan to phase out work on the HPs, but they can continue to be used as X-window terminals (along with some of our Macintoshes) to access the SLAC computers for our *BABAR* work. Working remotely on the computers at SLAC is feasible for QA work and for Simulation maintenance, provided our network stays up, but is not very practical for doing analysis. Analysis at SLAC involves working around long database outages in addition to the normal AFS and network outages. Many of our collaborators are using the KANGA system, based on ROOT, to bypass these outages, but it is unclear at this time what the future of KANGA is within the collaboration. ROOT has been ported to one of our HP workstations, but the *BABAR* analysis software will not compile on HP.

All Prairie View HP workstations are accessible through the Internet—the HP workstations are called `hp71.pvamu.edu`, `hp72.pvamu.edu`, `hp73.pvamu.edu`, `hp75.pvamu.edu`, and `pv1babar.slac.stanford.edu`. Our web page is `http://www.hep.pvamu.edu/`. Our Sun workstation is `sun1.pvamu.edu`, and our Linux workstations are `red1.pvamu.edu` and `red4.pvamu.edu`. The Linux workstations are not readily accessible from outside the local network, (except for ssh access from SLAC) due to security concerns. Objectivity has been ported to the Linux boxes, and we intend to use one of them (namely `red4.pvamu.edu`) as our database server.

Software Quality

Prairie View A&M is the package coordinator for the `QaToolsUtils` routines which test our offline Simulation, SimApp, and Reconstruction (Reco) code. These routines can be run with either HBOOK or DHP (Distributed Histogramming Package) histograms. Package coordination involves maintaining compatibility of the package with any upgrades of compilers or changes in other parts of *BABAR* code. The latest change of note is the planned elimination of all Rogue Wave library routines from *BABAR* code and their replacement with C++ standard library routines.

Last year, the *BABAR* Collaboration replaced the GEANT3 simulation code with GEANT4. We are now running simulation production entirely with GEANT4. The SimApp (detector response) and Reconstruction Quality Assurance (QA) histograms are so far unchanged from what we used with GEANT3, but the Simulation QA will have to be different. At this time, the Simulation is being validated by the working groups, but routine Simulation QA for GEANT4 remains to be implemented.

The last reference plots for GEANT3 simulation runs, which were done with code release 8.8.0c, can be found at [“http://www.slac.stanford.edu/BFROOT/www/Computing/Programming/QA/QAHome.html”](http://www.slac.stanford.edu/BFROOT/www/Computing/Programming/QA/QAHome.html) under the heading “Production QA for SP3”.

The most recent references for GEANT4 SimApp and Reco QA runs can be found at [“http://www.slac.stanford.edu/BFROOT/QA/QaXxxTools/References”](http://www.slac.stanford.edu/BFROOT/QA/QaXxxTools/References) (Xxx = Reco or SimApp) with code release 10.3 or above.

A selection of reconstruction QA plots is shown in Appendix E—Quality Assurance Summaries and Plots.

Analysis

We began working on charmed baryon analysis over a year ago, within the Charm Analysis Working Group in *BABAR*. Prairie View wrote and tested a proton particle ID selector (`PidProtonGRLSelector`) and is now using it to select Λ_c decays to charged $pK\pi$. This proton selector was the default proton selector used by the *BABAR* Collaboration last year. Prairie View presentations have been made at *BABAR* CHID and Charm AWG meetings on this subject.

We have completed a first pass analysis of *BABAR* data produced up to the end of December 2001, tagging events with protons, events with $pK\pi$, events with Σ_c

candidates, and events with Λ_c^* candidates. This data set comprises about 60 fb^{-1} . The Λ_c resonances are of interest primarily for the light they may shed on the long standing puzzle surrounding the identity of the $\Lambda(1405)$. More generally, there has not yet been a definitive assignment of spin and parity to any of the Λ_c and Σ_c baryons.

Additional work on charmed baryons is being done by the Inclusive Spectra working group, and by several other members of the Charms Analysis Working Group. One of us (M. Haire) is on a collaboration review committee overseeing an analysis of the absolute branching fraction of Λ_c to $pK\pi$. Another analysis aims to find a doubly charmed baryon. The cross section for such a baryon is expected to be about 60 fb , and thus *BABAR* may already have produced one.

Figure A.8 shows the charged $pK\pi$ mass spectrum for the 1999 through 2001 *BABAR* data set. Roughly 100,000 Λ_c 's are in this plot, together with an enormous amount of background. It should be noted that most of the protons produced at *BABAR* are background protons. The ratio of protons to antiprotons in the initial particle selection is 3:1. With no vertexing restrictions, $p^+K^-\pi^+$ combinations are still nearly twice as numerous as their charge conjugates. Restricting all tracks to pass within a few millimeters of the primary vertex reduces the excess of protons to about 20%.

A 3.2 GeV cut on momentum and a requirement that the charged tracks pass within 3 millimeters of the primary vertex produces the $pK\pi$ mass plot shown in Figure A.9. Also noticeable in this plot, which uses loose proton selection, are some minor bumps in the vicinity of the lighter D mesons, and a bump at 2593 MeV, the mass of one of the Λ_c^* resonances. All these minor bumps vanish with a tight proton selection (Figure A.10), although it is unclear whether the tighter proton selection or the drop in statistics is responsible for the death of the 2593 MeV bump.

Choosing the $pK\pi$ mass in an interval around the Λ_c mass, and combining the resulting Λ_c candidate with a charged pion produces a collection of Σ_c^0 and Σ_c^{++} candidates (Figure A.11). The established $\Sigma_c(2455)$ and $\Sigma_c(2520)$ are prominent in any plot, although there is a great deal of background in their vicinity. There is obviously more structure in the Σ_c plots around 3 GeV and 3.3 GeV, where a large number of Σ_c resonances are expected (Figures A.12 and A.13).

Λ_c resonance candidates are found by combining Λ_c candidates with a pair of oppositely charged pions. The resulting mass plot (Figure A.14) shows the prominent $\Lambda_c^*(2625)$ with the $\Lambda_c^*(2593)$, another peak at 2750 MeV and at least one more peak above 2800 MeV. The latter structures have previously been seen by CLEO. The $\Lambda_c^*(2593)$ seen in $pK\pi(\pi^+\pi^-)$ survives a tight proton selection (Figure A.15), unlike the bump in the $pK\pi$ spectrum.

At this point, we have enough data to do a second pass over the interesting events from the above plots. Angular distributions and vertexing still need to be done on these

events. In addition, we have yet to include any neutral particles in our selections, although this has been started by the Inclusive Spectra group. In addition to $\Lambda_C^* \rightarrow \Lambda_C \pi^0 \pi^0$ and $\Sigma_C^+ \rightarrow \Lambda_C \pi^0$, the decays $\Lambda_C^* \rightarrow \Lambda_C \gamma$ and $\Lambda_C^* \rightarrow \Sigma_C \gamma$ should be checked, since there is a model suggesting that these are competitive with the strong decay of $\Lambda_C^*(2625)$ [P. Cho, Phys. Rev. D **50**, 3294 (1994)].

The performance of the current default *BABAR* proton selector developed by Prairie View (GRL) and the previously used proton selector (SMS) can be seen in the following plots of selected protons compared with Monte Carlo truth protons. Figure A.16 shows proton dE/dx in the Silicon Vertex Tracker, Figure A.17 shows dE/dx in the Drift Chamber, and Figure A.18 shows the measured Cerenkov angle, θ_C , of protons in the DIRC.

Figure A.8: Charged $pK\pi$ mass spectrum.

Figure A.9: Charged $pK\pi$ mass spectrum with 3.2 GeV momentum cut, vertex cut, and loose proton selector.

Figure A.10: Charged $pK\pi$ mass spectrum with 3.2 GeV momentum cut, vertex cut, and tight proton selector.

Figure A.11: $\mathcal{A}_c \pi^+$ mass spectrum.

SigmaC* mass $p > 2.5$ alldoca $< .05$ Lc $\pm .7$

Figure A.12: Σ_C^* mass spectrum.

Sc*-Lc mass p>2.5 Lc+/-7 alldoca<.07

Figure A.13: $\Sigma_C^* - \Lambda_C$ mass spectrum.

LambdaC* mass p>2.5 Lc+/-10

Figure A.14: $\Lambda_c \pi^+ \pi^-$ mass spectrum with loose proton selector.

Figure A.15: $\Lambda_c \pi^+ \pi^-$ mass spectrum with tight proton selector.

Figure A.16: Monte Carlo dE/dx vs $\log P$ distributions of protons in the SVT.

Figure A.17: Monte Carlo dE/dx vs $\log P$ distributions of protons in the DCH.

Figure A.18: Monte Carlo Cerenkov angle distributions of θ_C vs $\log P$ for protons in the DIRC.

Student Participation

One of our group's goals in the project is to provide an opportunity for our students to participate in the frontier of high energy physics research. Since the summer of 1995, a number of our students have participated in our group's research work at Prairie View, SLAC, and LLNL, in order to learn some of the basic concepts of particle physics and the methods of high energy physics research.

During the summer of 1995, one of our students, George Aduo, worked at LLNL for ten weeks, in the Physics and Space Science Section running simulation programs. He also spent time in the LLNL Resistive Plate Chamber (RPC) laboratory helping with the construction and testing of prototype chambers and learning how high energy physicists conduct experimental research and build detectors for a large experiment like *BABAR*.

In the summer of 1996, three students, Johnson Acheampong, Emmanuel Acheampong, and John Cooney, worked at the Prairie View campus, learning parts of the *BABAR* simulation software design.

Two students worked at SLAC during the summer of 1997—Clayton Simien and Shanneth Thomas—primarily on the electrical and mechanical installation of the RPCs in the IFR framework. Pictures of the installation can be found on the WWW at http://www.hep.pvamu.edu/pvhep_babar.html.

In 1998, two students spent a month at SLAC working on software and attending lectures at the SLAC summer school, while a third student worked for six weeks in the Theory Division with Dr. Helen Quinn. Another student, Clayton Simien, spent the summer of 1998 at Hampton University, Hampton, Virginia, working with experimentalists and theorists from that institution who are also working at the Thomas Jefferson National Accelerator Facility in Newport News.

In 1999, three Prairie View students—Clayton Simien, Gilbert Nyandoto, and Inez Sanderson—spent the summer at SLAC working on physics and software projects related to the running of the *BABAR* experiment, which finally commenced data-taking in 1999.

Finally we thank the U. S. Department of Energy for twenty years of continuous Support.

Chapter 3

1997–2005 Prairie View High Energy Physics Group Publications

The following is a list of some of the publications from the Prairie View High Energy Physics group contributed during 1997–2002.

1. B. Aubert *et al.*, “Measurement of branching fractions for exclusive B decays to charmonium final states”, Phys. Rev. D **65**, 032001 (2002).
2. B. Aubert *et al.*, “Measurement of the branching fractions for $\psi(2S) \rightarrow e^+e^-$ and $\psi(2S) \rightarrow \mu^+\mu^-$ ”, Phys. Rev. D **65**, 031101 (2002).
3. B. Aubert *et al.*, “Search for the Decay $B^0 \rightarrow \gamma\gamma$ ”, Phys. Rev. Lett. **87**, 241803 (2001).
4. B. Aubert *et al.*, “Measurement of the $B \rightarrow J/\psi K^*$ (892) Decay Amplitudes”, Phys. Rev. Lett. **87**, 241801 (2001).
5. B. Aubert *et al.*, “Measurements of the Branching Fractions of Exclusive Charmless B Meson Decays with η' or ω Mesons”, Phys. Rev. Lett. **87**, 221802 (2001).
6. B. Aubert *et al.*, “Measurement of the B^0 and B^+ Meson Lifetimes with Fully Reconstructed Hadronic Final States”, Phys. Rev. Lett. **87**, 201803 (2001).
7. B. Aubert *et al.*, “Measurement of J/ψ Production in Continuum e^+e^- Annihilations near $\sqrt{s} = 10.6$ GeV”, Phys. Rev. Lett. **87**, 162002 (2001).
8. B. Aubert *et al.*, “Measurement of Branching Fractions and Search for CP -Violating Charge Asymmetries in Charmless Two-Body B Decays into Pions and Kaons”, Phys. Rev. Lett. **87**, 151802 (2001).
9. B. Aubert *et al.*, “Measurement of the Decays $B \rightarrow \phi K$ and $B \rightarrow \phi K^*$ ”, Phys. Rev. Lett. **87**, 151801 (2001).

10. B. Aubert *et al.*, “Observation of CP Violation in the B^0 Meson System”, Phys. Rev. Lett. **87**, 091801 (2001).
11. B. Aubert *et al.*, “Measurement of CP -Violating Asymmetries in B^0 Decays to CP Eigenstates”, Phys. Rev. Lett. **87**, 2515 (2001).
12. The *BABAR* Collaboration, “The *BABAR* Detector”, *BABAR*-PUB-01/08, SLAC-PUB-8569, hep-ex/0105044, To appear in Nucl. Inst. and Methods, 2001.
13. B. Aubert *et al.*, “Measurement of $B \rightarrow K^* \gamma$ Branching Fractions and Charge Asymmetries”, *BABAR*-PUB-01/04, SLAC-PUB-8952, hep-ex/0110065, Submitted to Phys. Rev. Lett., 2001.
14. B. Aubert *et al.*, “Measurement of the ratio of the branching fractions $\mathbf{B}(B^\pm \rightarrow J/\psi \pi^\pm)/\mathbf{B}(B^\pm \rightarrow J/\psi K^\pm)$ ”, *BABAR*-PUB-01/14, SLAC-PUB-8942, hep-ex/0108009, Submitted to Phys. Rev. Lett., 2001.
15. B. Aubert *et al.*, “Study of CP -violating asymmetries in $B^0 \rightarrow \pi^+ \pi^-$, $K^+ \pi^-$ decays”, *BABAR*-PUB-01/21, SLAC-PUB-9012, hep-ex/0110062, Submitted to Phys. Rev. D, 2001.
16. T. Alexopoulos *et al.*, “Hadroproduction of the χ_1 and χ_2 states of charmonium in 800-GeV/c proton-silicon interactions”, Phys. Rev. D **62**, 032006 (2000).
17. B. Aubert *et al.*, “A study of time-dependent CP -violating asymmetries in $B^0 \rightarrow J/\psi K_s^0$ and $B^0 \rightarrow \psi(2S) K_s^0$ decays”, *BABAR*-CONF-00/01, SLAC-PUB-8540, hep-ex/0008048, Submitted to the XXXth International Conference on High Energy Physics, Osaka, Japan, 2000.
18. B. Aubert *et al.*, “Measurement of inclusive production of charmonium states in B meson decays”, *BABAR*-CONF-00/04, SLAC-PUB-8526, hep-ex/0008049, Submitted to the XXXth International Conference on High Energy Physics, Osaka, Japan, 2000.
19. B. Aubert *et al.*, “Exclusive B decays to charmonium final states”, *BABAR*-CONF-00/05, SLAC-PUB-8527, hep-ex/0008050, Submitted to the XXXth International Conference on High Energy Physics, Osaka, Japan, 2000.
20. B. Aubert *et al.*, “Measurement of the branching fractions for $B^0 \rightarrow D^{*-} \pi^+$ and $B^0 \rightarrow D^{*-} \rho^+$ ”, *BABAR*-CONF-00/06, SLAC-PUB-8528, hep-ex/0008051, Submitted to the XXXth International Conference on High Energy Physics, Osaka, Japan, 2000.

21. B. Aubert *et al.*, “A measurement of the charged and neutral B meson lifetimes using fully reconstructed decays”, *BABAR*-CONF-00/07, SLAC-PUB-8529, hep-ex/0008060, Submitted to the XXXth International Conference on High Energy Physics, Osaka, Japan, 2000.
22. B. Aubert *et al.*, “A measurement of the $B^0\bar{B}^0$ oscillation frequency and determination of flavor-tagging efficiency using semileptonic and hadronic B^0 decays”, *BABAR*-CONF-00/08, SLAC-PUB-8530, hep-ex/0008052, Submitted to the XXXth International Conference on High Energy Physics, Osaka, Japan, 2000.
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Appendix E

Quality Assurance Summaries and Plots

The following pages of this appendix show sample output from a QA analysis of a Simulation run. These summaries and plots are typical of the Quality Assurance (QA) work performed by Dr. Margaret Haire as a member of the *BABAR* Software Quality Assurance/Quality Control team.