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Chapter 1

Introduction

The primary goal of the GlueX/Hall D project is the definitive and detailed mapping of the spectrum of a new family of particles called *hybrid mesons* starting with those that carry exotic quantum numbers. Linearly polarized photons produced by electrons from an energy upgraded CEBAF will be the probe used to uncover this spectrum. This experimental information is absolutely critical in finding the answer to an outstanding and fundamental question in physics - a quantitative understanding of the confinement mechanism in quantum chromodynamics.

In addition to the GlueX detector, the project includes a beam line and an above-ground tagger building and detector building to be located off the stub at the east end of the north linac of the CEBAF accelerator. This project assumes that the electron energy of CEBAF will be increased to 12 GeV by about 2008.

1.1 History of the project

The GlueX plans have evolved over the last five years, starting with a workshop held in July 1997 at Indiana University and the formation of the *Eight+* working group. There then followed workshops at North Carolina State University (November 1997), Carnegie Mellon University (March 1998), Florida State University (October 1998), Rensselaer Polytechnic Institute (March 1999) and at the University of Adelaide (February 2000). At the Rensselaer meeting, the working group officially organized itself into a collaboration, selecting a spokesperson (Alex Dzierba - Indiana), deputy spokesperson (Cur-

tis Meyer - Carnegie Mellon) and Hall D JLab group leader (Elton Smith - JLab). Since that time, the collaboration has held between two and three collaborations meetings per year. The most recent was held at the University of Regina in September 2002.

A Preliminary Design Report appeared in January, 1999 and was presented to the JLab Program Advisory Committee (PAC-15) at its meeting in January, 1999 as a Letter of Intent (LOI). PAC-15 enthusiastically endorsed the physics and recommended the formation of a committee to review the project.

The second version of the Design Report [1] was prepared in August 1999 for the committee which met in December 1999 to review the GLUEX project. The review committee was chaired by David Cassel (Cornell) and consisted of Frank Close (Rutherford Lab), John Domingo (Jefferson Lab), William Dunwoodie (SLAC), Donald Geesaman (Argonne), David Hitlin (Caltech), Martin Olsson (Wisconsin) and Glenn Young (Oak Ridge). Their report provided an extremely strong endorsement for both the physics goal and the technical feasibility of the project. The committee also identified several areas of technical concerns and indicated that an R&D program would need to be carried out to move forward to a full CDR. The technical concerns were quickly resolved by the collaboration and using both University and JLab resources, an aggressive R&D program was started. The full text of the Cassel committee findings are reproduced in Appendix A, but of significance are the following comments on the uniqueness of JLab for this project.

> JLab, with the energy upgrade, will be uniquely suited for providing such a beam. In particular, the excellent emittance of the JLab electron beam allows for strong collimation of the coherent bremsstrahlung radiation to enhance the polarization and ratio of tagged to untagged photons in the tagged photon beam. No other facility in the world will be able to provide a beam of this quality, with this combination of energy, duty factor, and emittance. If such a project were pursued at other existing high-energy facilities, either the data taking rate would be dramatically reduced, compromising the physics goals, or a much more complicated detector would be required. We do not see any project at an existing accelerator complex (e.g., SLAC, CESR, DESY) which is likely to be able to compete with the Hall D initiative in this area.

The third version of the Design Report [2] was prepared in November 2000 as part of the NSAC Long Range Planning process. In the process of preparing this report, the collaboration developed a detailed management plan, (appendix B), and established a collaboration board to advise the executive management of the collaboration. The members of this board were elected to two year terms, with the board choosing its own chairperson, (George Lolos - University of Regina). In conjunction with version three of the Design Report, the GLUEX physics case was made at the Electromagnetic and Hadronic NSAC Town meeting held at Jefferson Lab in December of 2000. The JLab upgrade and the GLUEX project were made the top priority of this meeting, and summarized in the resulting white paper. The GLUEX case was then made to the NSAC Long Range Plan Committee at its meeting in Santa Fe in April of 2001. The result of the NSAC meeting was that the upgrade and GLUEX were one of the four recommendations presented to DOE and NSF by NSAC.

> We strongly recommend the upgrade of CEBAF at Jefferson Laboratory to 12 GeV as soon as possible.
> *The 12-GeV upgrade of the unique CEBAF facility is critical for our continued leadership in the experimental study of hadronic matter. This upgrade will provide new insights into the structure of the nucleon, the transition between hadronic and quark/gluon descriptions of matter, and the nature of quark confinement.*

The entire plan was published in March of 2002 [3], while a synopsis of the parts relevant to GLUEX are presented in Appendix C.

Since the NSAC meeting, the collaboration has continued to carry out R&D necessary to design and build the GLUEX experiment as well as to make the science case for GLUEX to the community at large. In addition, the collaboration has worked closely with the JLab management in discussions with the DOE and the NSF about moving forward quickly with the entire upgrade project.

1.2 Synopsis of R&D Efforts

Since the publication of the second version of this design report, the collaboration has been carrying out an aggressive R&D program that has been

supported both by JLab and individual universities. This program is detailed throughout this report, with more information available on line at `http://www.gluex.org/`. Significant achievements to date include the following.

- The superconducting solenoid will be moved from LANL to the Indiana University Cyclotron Facility (IUCF) by early November 2002 for refurbishment. The total cost of moving the magnet from LANL to IUCF and then to JLab along with the refurbishment is far less than the cost of a new magnet.

- The 3000-element lead-glass electromagnetic calorimeter along with associated electronics from the Brookhaven experiment E852 have been moved to JLab for use in GlueX.

- 20 μm thick diamond wafers to be used as part of the coherent bremsstrahlung source for GlueX have been prepared and tested . The wafers were also tested as part of the effort to provide a coherent bremsstrahlung source in Hall B at JLab.

- Prototypes of both the flash-ADC and TDCs necessary for GlueX have been built and tested. These non-commercial electronics are crucial for GlueX, but have already found uses in other experiments.

- Construction of prototype sections of the lead-scintillator barrel calorimeter. This work has involved detailed study of both fibers and high-magnetic-field photomultiplier tubes as well as substantial technology transfer from the KLOE collaboration.

- Parts of of a full-scale protoype straw-tube drift chamber have been built and tested for use as the central tracking device. Operation studies have also been caried out on a second protype chamber to understand the behavior of straw-tube devices.

- Prototype time-of-flight elements have been successfully tested using cosmic rays and later particle beams at the proton accelerator in Protvino, Russia. Based on these studies, a design that will achieve the requisite time resolution of 70 ps is in hand.

- Studies of fibers and construction of the infrastructure necessary to build and test the vertex detector have been carried out.

- Detailed studies of the design of the Cherenkov detector have been carried out.
- Development of a fast Monte Carlo has been completed and work on a detailed (GEANT based) Monte Carlo has begun.
- Work has begun on generalized data descriptions based on XML.
- A full scale effort on partial wave analysis (PWA) has been started, and many of the initial tools necessary to carry out this work have been implemented. A double blind study has been performed to demonstrate the ability to pull small signals out of the GlueX data. Studies have also been made on the effects of detector resolution on our ability to carry out a successful PWA.
- Members of the GlueX collaboration organized an international workshop on partial wave analysis held in June of 2002 at Carnegie Mellon. This effort has led to a broader interest in developing analysis tools relevant to PWA.
- The GlueX collaboration is in discussion with members of CLEO-c to identify aspects of PWA that are common to both efforts and attempt to develop a coherent set of tools for analyzing the data from these experiments.
- Work has been carried out to study and soon implement GRID based technology to facilitate data management and transparent access to data for all members of the collaboration.

1.3 Summary

The GlueX collaboration is ready to move forward quickly with the construction and commissioning of the GlueX experiment. A strong collaboration has been formed with sufficient expertise to accomplish this. An active R&D effort is quickly creating the knowledge, skills and infrastructure necessary for all tasks at hand, and a vigorous collaboration with theorists is leading to the necessary analysis and theoretical tools that will be necessary to extract timely physics results from the GlueX data. More information about the physics of the GlueX project can be found in articles in the

September/October 2000 issue of *American Scientist* [4] and in the September 2000 issue of the *CERN Courier* [5]. The collaboration also maintains a detailed web site at `http://www.gluex.org/` that provides detailed information on the project.

Bibliography

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[3] James Symons, *et al.* Opportunities in Nuclear Science, A Long-Range Plan for the Next Decade, April 2002. Available at `http://www.nscl.msu.edu/future/lrp2002.html`.

[4] A. R. Dzierba, C. A. Meyer and E. S. Swanson. The Search for QCD Exotics. *American Scientist*, **88**:406, 2000.

[5] A. R. Dzierba and N. Isgur. Mapping quark confinement by exotic particles. *CERN Courier*, **40 No. 7**:23, 2000.