GlueX DIRC

Program Management Plan

October 2015

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1. Introduction

The GlueX experiment will provide the data necessary to construct quantitative tests of non-perturbative QCD by studying the spectrum of light-quark mesons and baryons. The primary goal of the GlueX experiment is to search for and study the spectrum of so-called hybrid mesons that are formed by exciting the gluonic field that couples the quarks. QCD-based calculations predict the existence of hybrid meson states, including several that have exotic quantum numbers that cannot be formed from a simple quark/anti-quark pair. To achieve its goal, GlueX must systematically study all possible decay modes of both conventional and hybrid mesons, including those with kaons.

Charged kaon identification in the baseline GlueX detector is provided in the forward direction by the Time-of-Flight system for momentum below 2 GeV/c. In 2013 the GlueX collaboration submitted a proposal to the Program Advisory Committee (PAC) for running at the design intensity with the baseline detector. This proposal was approved by the PAC, and the collaboration was encouraged to pursue a dedicated particle identification (PID) system to extend the kaon identification to higher momentum.

In late 2013, the collaboration made a proposal to SLAC for reusing four of the BaBar DIRC (Detection of Internally Reflected Cherenkov) bar boxes as the central element of a forward kaon-identification system in GlueX. This proposal was approved in the late spring of 2014 by SLAC and DOE. A subsequent proposal to the PAC in 2014, demonstrated that the addition of a Cherenkov-based PID system utilizing the BaBar DIRC components dramatically increases the number of potential hybrid decay modes that GlueX can access, and will reduce the experimental backgrounds from mis-identified particles in each mode. This enhanced capability will be crucial for the GlueX experiment to realize its full discovery potential.

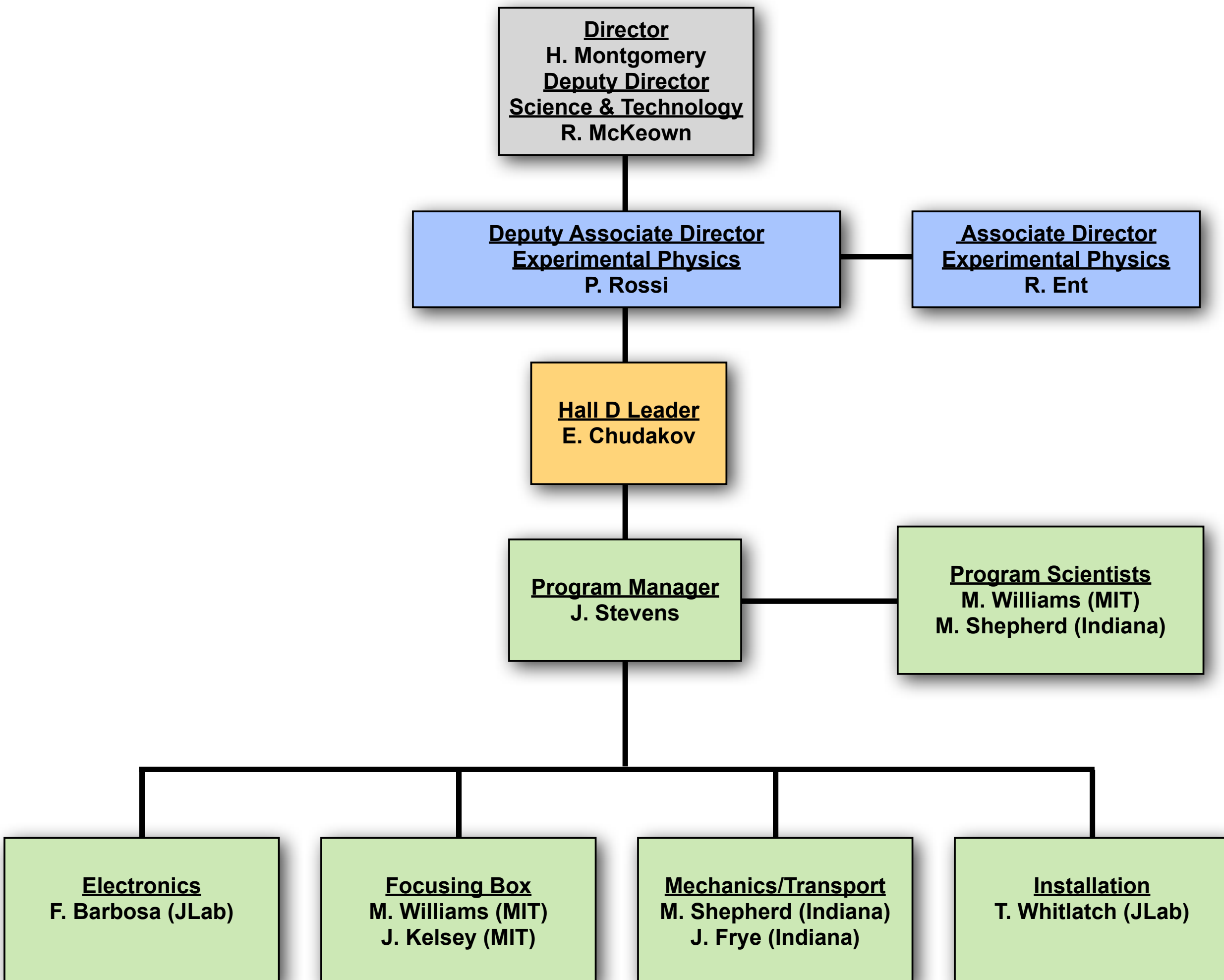
The technical design for the GlueX DIRC was developed as a joint collaboration between MIT, Indiana University and Jefferson Lab. The optics design is based on a prototype developed by SLAC for the SuperB experiment and studied in a detailed simulation. Cherenkov light exiting the BaBar bar boxes are directed to a plane of photosensors by a set of planar mirrors in an expansion volume filled with distilled water. The photosensors and electronics requirements for the DIRC are very similar to those of the CLAS12 RICH program at JLab. Therefore, to reduce technical and design risk, the DIRC will utilize the design for the CLAS12 RICH MAPMT readout and Front-End Electronics already developed and tracked by that program.

The GlueX experiment collected it's first commissioning beam in the Fall of 2014. A subsequent run in the Spring of 2015 allowed the experiment to start commissioning polarized photon beams, and to continue work on calibration of the detector. More commissioning is expected in late 2015 and/or early 2016, with first physics data taking in late 2016. In this document, we present our design for a DIRC-based forward PID system in GlueX using components from the BaBar DIRC. The proposed schedule assumes a staged installation beginning in late 2017 when GlueX is expected to reach its design intensity.

2. Program Organization

The DIRC Program will be executed as a joint collaboration between Indiana University (IU, USA), Jefferson Lab (JLab, USA) and Massachusetts Institute of Technology (MIT, USA).

A clear definition of the roles and responsibilities that individuals and their organizations play will be critical to the success of the DIRC Program. We show below the DIRC Organization Chart. The different colors used in the chart refer to the different levels of the Program: Director and Deputy Director (grey), structure within the Physics Division (blue), DIRC Program Organization (within the Physics Division) (green).



Program Management Team:

The Program Management Team (PMT) will monitor overall developments within the program and provide advice as needed. Membership of the PMT will consist of the JLab Deputy Associate Director of Experimental Physics, the Program Manager, the Hall D Leader and the Program Scientists. Outside the formal structures of the organization chart above, the PMT will monitor overall progress and meet monthly to discuss issues and progress. The Program Manager will convene these meetings.

Director and Deputy Director: (Hugh Montgomery and Robert McKeown, respectively – JLab)

- Primary interface with DOE Office of Nuclear Physics.
- Provide overall guidance.

Associate Director, Experimental Physics: (Rolf Ent – JLab)

- Provides project specific guidance.

Deputy Associate Director, Experimental Physics: (Patrizia Rossi – JLab)

- Gives final approval for initiation of any project in any given year.
- Reports status and progress (milestones achieved and problems encountered) to the Director and Deputy Director.
- Convenes external review panels in consultation with the Program Manager and Program Scientists as needed.
- Receives and evaluates documented findings of convened external reviews.

Hall D Leader: (Eugene Chudakov – JLab)

- Coordinates with the Program Manager the allocation of resources in Hall D to ensure that the project is completed in a timely fashion and at the same time to not interfere with other developments and the beam schedule in the Hall.
- Appoints, in close collaboration with the Program Scientists, internal review panels as needed and helps to implement the guidance provided by such reviews.
- Reports to the Deputy Associate Director of the Physics Division the developments and year-to-year resource needs of the DIRC program as integrated in Hall D.
- Negotiates with higher management regarding the development of an overall Hall D schedule that includes the DIRC project.

Program Manager: (Justin Stevens – JLab)

Is the central coordinator of all DIRC program activities. His responsibilities include:

- Oversight of the project:
  - Convenes regular meetings
  - Monitors progress and reports to the JLab Deputy AD, Experimental Physics
  - Documents progress
- Sees that money spent on each sub-project is appropriate for that project. (**i.e.** approves all JLab expenditures).

Program Scientists: (Mike Williams – MIT and Matt Shepherd – Indiana University).

- As the intellectual leaders of the program, they are responsible for defining the detailed technical specifications of the DIRC detector.
- Work with the Program Manager to ensure all projects meet the necessary technical standards.
- Monitor progress on each subsystem.
- Initiate, in close collaboration with the Program Manager, informal meetings and

discussions to facilitate communication among the members of the program.
- Initiate, in close collaboration with the Hall Leader, internal project and subsystem reviews.
- Provide the Program Manager with timely, expert advice on technological issues.

Subsystem managers: Have technical and schedule responsibility for each of the technical subgroups. The subgroups include:

- Electronics
- Focusing Box
- Mechanics/Transport
- Installation

Each subsystem manager is responsible for:

- Overseeing the day-to-day work on his or her subsystem.
- Reporting developments to the Program Manager and Program Scientists.

3. Program Assumptions, Constraints and Dependencies

Assumptions

Program assumes that funding will be made available from the JLab Capital Equipment annual base budget. The DIRC Project will start in FY16 and continue until FY18.

Dependencies

The DIRC project requires the successful commissioning and operation of the GlueX detector in Hall D. The electronics were developed as part of the RICH detector project in Hall B and the DIRC project requires the successful validation of those components, which is being tracked by the RICH program.

The DIRC project relies on the availability of manpower at MIT and Indiana University, including contributed labor from the Indiana University College of Arts and Sciences.

4. Program Risk Management

The project risk will be managed by the Program Manager according to the plan described below. Levels of risk are identified for each element by the Program Manager in concert with the relevant subsystem managers.

Cost contingency is evaluated based on Risk Factors and Weighting Factors as described in Section 5.

5. Program Methodology for Estimating Cost Contingency:

For each subsystem of the DIRC Project, a list of expenditures was developed. These lists include cost estimates based on various inputs that included catalog prices, vendor quotes, estimates based on previous experience, and technical estimates.

This section describes how the cost contingency for a given DIRC subsystem was calculated. Risk is a function of the following factors: the sophistication of the technology, the maturity of the design effort, the accuracy of the cost sources, and the impact of delays in the schedule.

Risk analysis was performed for each subsystem. Results of this analysis are related to a contingency, which is listed for each costed element.

Definitions

Base Cost Estimate – The estimated cost of doing things correctly the first time. Contingency is not included in the base cost.

Cost Contingency – The amount of money, above and beyond the base cost, that is required to ensure the Project's success. This money is used only for omissions and unexpected difficulties that may arise. Contingency funds are held by the Associate Director of the JLab Physics Division.

Risk Factors

Schedule Risk

No schedule risk has been assigned to this project since a delay in the completion of the DIRC will not put the schedule of the GlueX run plan at risk. The beam time for the GlueX high-intensity run (Phase IV) was approved by the JLab PAC without the DIRC and therefore may begin before the DIRC project is completed. In addition, other approved experiments, which do not require the DIRC (*eg.* η Primakoff), may run in Hall D before Phase IV of the GlueX run program.

Cost Risk

Cost risk is based on the data available at the time of the cost estimate. For elements for which there is a recent price quote from a vendor or a recent catalog price, we assign a 10% contingency. If the items are not "off-the-shelf" of a single vendor we will discuss the contingency under the technical risk. Some special cases are the MA-PMTs, ASICs and Front-End Electronics for which we have recent price quotes, however the contingency is set somewhat higher at 20% to reflect possible changes in the exchange rate.

Technical Risk

Based on the technical content or technology required to complete the element, the technical risk indicates how common the technology is that is required to accomplish the task or fabricate the component. If the technology is so common that the element can be bought "off-the-shelf", i.e. there are several vendors that stock and sell the item, it has very low technical risk, therefore we did not assign additional contingency. The fabrication of the aluminum mirrors uses common technology, but as these are custom items we assigned a 20% contingency.

Design Risk

It is directly related to the maturity of the design effort. When the element design is nearly complete, quantity counts and parts lists finished, the risk associated with design is nearly zero; therefore a risk factor of 0 is applied. When the element design is still being finalized, we assign 30% contingency. This is applicable to elements of the focusing boxes, mechanics, transport and installation.

6. Program Change Control

Once the baseline for the DIRC Project has been established and approved, a formal baseline change control process will be followed.

- The DIRC PMT will act as Change Control Board (CCB) to evaluate proposed (see Table below) changes to the project baseline. Membership of the CCB will consist of the Program Manager, the Hall Leader, the Program Scientists, and the Associate Director when needed.

Change Control approval will be handled in accordance with the table below:

Table 6.1 Project Change Control Approval Authority

	Associate Deputy Director Experimental Physics	**Program Manager, Scientists & Hall D Leader**
Scope / Technical	Any change in scope and/or performance that affects the science	Any change that affects the Deliverables or Key Performance Parameters
Schedule	Any change at WBS Level 1 that delays project completion by > 6 months	Any change to a Level 1 milestone or any change to a Level 2 milestone > 2 months
Cost	Any cumulative change at WBS Level 1 that increases the TPC by > 100K$	Any cumulative change at WBS Level 1 > 25K$ and < 100K$

7. Program Environment, Safety, Health, & Quality

All phases of the DIRC Program will be carried out in accordance with the Jefferson Lab Environment, Health and Safety (EH&S) policies and procedures as documented in the Jefferson Lab "EH&S Manual" including obeying all local, state and federal regulations. The laboratory has as one of its guiding principles the protection of the health and safety of its employees, contractors and the public. The environmental, safety, and health risks/issues are considered small and manageable within current standard processes.

DIRC Program work will be conducted under the laboratory's existing Integrated Safety Management (ISM) Program. ISM is an integral part of Jefferson Lab's management structure spelled out in detail in the "EH&S Manual", the "Quality Assurance Manual", and various management manuals and training documents. Particular attention and planning will be given to those items that have the greatest potential to impact the project cost, schedule, and performance. Extensive testing and evaluation will be carried out for all of the critical components whether purchased or fabricated and assembled in house. DIRC Project work will be performed under the standards and codes set forth in the TJNAF DOE JSA contract, Federal Occupational Safety and Health Act (OSHA), 29 Code of Federal Regulations (CFR) 1926, 10 CFR851, and Virginia OSHA as supplemented by Jefferson Lab work rules.

Prior to the use of any hardware built under the DIRC Program in an experiment, the Physics Division at JLab will require completion of a "Readiness Review". The "Readiness Review" focuses on the technical readiness of all the experiment's components and their safe operation.

Training

Principal players are Ph.D. physicists, their students, engineers, and qualified technicians. No additional training beyond what is already required to work safely and effectively at their respective institutions is required. Naturally, all work done at JLab will be done in accordance with the procedures and training requirements spelled out in the JLab EH&S manual. Work done at the Universities/Institutions will be done in compliance with the rules and procedures spelled out at each Institution.

8. Program Communications

Program communications must be proactive and timely, responding to accomplishments and emerging issues or activities. Communications will focus on disseminating information regarding program objectives, strategies, problems/issues, and status. Due to the collaborative nature of the DIRC Program team, use of phone calls and e-mails will be the central mode of communication among participants. The Program Manager will convene regular bi-weekly meetings by BlueJeans conference connections available for those off-site.

DIRC Project and Reviews

Progress on each component will be monitored by the Program Scientists and reported to the Program Manager.

The JLab DIRC Program Manager will provide a monthly status update to the Associate Director of Experimental Physics via a short written report and a monthly meeting.

JLab will convene external review panels to evaluate progress on an as needed basis. In the event of any serious problems in the interim, e.g. a detector performance issue, additional appropriate reviews would be convened by JLab.

9. The DIRC Program

a. Scope

WBS	**DIRC Project**	**WBS 1**	Project Management
		WBS 2	MAPMT
		WBS 3	Electronics
		WBS 4	Focusing Box
		WBS 5	Mechanics
		WBS 6	Transport
		WBS 7	Installation

b. High Level Deliverables

1. A DIRC detector providing GlueX with the capability to identify kaons for momenta up to 4 GeV/c with a selection efficiency greater than 50% and a pion mis-identification probability below 1%
2. 4 BaBar fused silica bar boxes
3. 216 MAPMTs and associated electronics
4. 2 focusing boxes

c. Roles and Responsibilities

Person	**Responsibility**
Mike Williams (MIT) Matt Shepherd (Indiana University)	Project Scientists
Justin Stevens (JLab)	Project Management
Jim Kelsey (MIT Bates)	Focusing Box Tech. Oversight
Fernando Barbosa (JLab)	Electronics Tech. Oversight
John Frye (Indiana University)	Mechanics/Transport Tech. Oversight
Tim Whitlatch (JLab)	Installation Tech. Oversight

d. Schedule

The DIRC Program schedule covers approximately 3 years.

e. Project Cost

The cost of the DIRC detector is reported in the three tables below. In Table 9.1, the base cost (including procurement and labor) for each subsystem is listed together with the percentage applied contingency, the cost contingency in K$ and the total cost (base cost + cost contingency). Percentage FTEs of the JLab Project Manager is reported in the Project Management row. Both the Direct and Burdened costs are listed, where the burdened cost includes G&A applied to the base cost. Table 9.2 shows the flow of the expenditure through FY16-FY17-FY18 for the **base cost** of the project. Table 9.3 shows the items that contribute to the cost of each subsystem.

Table 9.1

WBS	Name	Base Cost ($K)	Cont. (%)	Cont. Cost ($K)	JLab Direct Cost ($K)	JLab Burdened Cost ($K)	Contributed Labor ($K)
1	Project Management	24.0			24.0	48.6	
2	MAPMTs	450.3	20	90.1	540.4	590.4	
3	Electronics	292.5	16	48.1	340.6	523.9	
4	Focusing Boxes	243.1	28	57.7	300.8	392.4	
5	Mechanics	59.5	30	17.8	77.3	107.0	35.7
6	Transport	32.5	30	9.7	42.2	58.4	34.5
7	Installation	27.0	30	8.1	35.1	62.8	
	Total	**1128.8**	**21**	**231.6**	**1360.3**	**1783.5**	**70.2**

Table 9.2: Base cost of the project by fiscal quarter

		FY2016				**FY2017**				**FY2018**				**Base Cost Total**
WBS	**Name**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	
1	Project Management	8.0				8.0				8.0				**24.0**
2	MAPMTs						205.2				245.1			**450.3**
3	Electronics				56.8		172.1	16.0				47.7		**292.5**
4	Focusing Boxes			161.3	53					28.8				**243.1**
5	Mechanics				59.45									**59.5**
6	Transport					16.5	16.0							**32.5**
7	Installation						3.0	8.0	8.0			8.0		**27.0**
		Q1	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	
	Base Quarterly	**8.0**	**0.0**	**161.3**	**169.2**	**24.5**	**396.3**	**24.0**	**8.0**	**36.8**	**245.1**	**55.7**	**0.0**	
		FY2016				**FY2017**				**FY2018**				
	Base Yearly	**338.5**				**452.7**				**337.6**				**1128.8**
	Burdened Yearly	**590.7**				**694.1**				**498.7**				**1783.5**

Table 9.3

Project Management	- 10% FTE: Project Manager - The total cost of the Project Management includes Fringe and G&A.
MA-PMTs	- The cost of the MAPMT procurement
Electronics	- Procurement and testing of ASICs, Front End, FPGA and SSP boards - Integration tests of readout chain - Installation and cabling of readout components including low and high voltage modules, crates, chassis, etc.
Focusing Box	- Stainless steel box design and fabrication - Flat glass mirrors for focusing optics - Fused silica window interface to MAPMTs - Water system
Mechanics	- Bar box and focusing box support structure design and fabrication
Transport	- Shipping crate design and fabrication - Transportation of BaBar bar boxes from SLAC to Jefferson Lab
Installation	- Labor for mechanical installation of bar boxes and focusing boxes in Hall D

f. Institutional Responsibilities

In Table 9.4, the responsibilities of each collaborating institution to the DIRC Program is reported.

Table 9.4

INSTITUTION	RESPONSIBILITY
Indiana University, USA	• Bar box transportation to Jefferson Lab • DIRC support structure
Thomas Jefferson National Accelerator Facility, USA	• Project Management • MAPMTs • Electronics and DAQ • Installation of the DIRC in Hall D
Massachusetts Institute of Technology, USA	• Focusing optics box design and fabrication • Optical mirrors • Fused silica window

g. Project Milestones

Table 9.5 Level 1 and Level 2 milestones for the DIRC Program.

	Milestone Name	Level	Date
1	Start of DIRC project	1	1/1/16
2	Support structure design finalized	1	5/2/16
3	Focusing box design finalized	1	6/1/16
4	Start support structure fabrication	2	7/1/16
5	MAROC order for procurement submitted	2	7/1/16
6	Adapter & ASIC board order for procurement submitted	2	7/1/16
7	Start focusing box 1 fabrication	2	8/1/16
8	Bar box shipping crate design finalized	2	10/3/16
9	First article MAROC delivery	2	11/2/16
10	First article adapter+ASIC board delivery	2	11/2/16
11	MAPMT contract awarded	2	1/2/17
12	FPGA board order for procurement submitted	2	1/2/17
13	Delivery of support structure	1	3/1/17
14	First article FPGA board delivery	2	4/3/17
15	First article MAPMT delivery	2	5/3/17
16	Delivery of bar boxes to JLab	1	5/1/17
17	Delivery of focusing box 1	1	5/1/17
18	Assembly of support structure completed	2	6/1/17
19	First article MAPMT acceptance testing complete	2	7/3/17
20	Start bar box and focusing box 1 mechanical installation	2	7/3/17
21	Start electronics installation for focusing box 1	2	8/1/17
22	Start focusing box 2 fabrication	2	11/2/17
23	Delivery of focusing box 2	1	5/1/18
24	Start focusing box 2 mechanical installation	2	6/1/18
25	Start electronics installation for focusing box 2	2	7/3/18
26	MAPMT production completed	1	7/2/18
27	MAPMT characterization completed	2	8/1/18
28	DIRC project completed	1	10/1/18