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**Response to ERR Charge**

1. **What are the running conditions for the experiment? Please state clearly the target and beamline configurations and operation.**

We run with GlueX in standard configuration using the standard diamond radiator with the coherent peak at approximately 9 GeV (energy range 8.4 - 9.1 GeV), but we also note that we are flexible to run at somewhat lower energy and are not as precisely sensitive to the machine energy.

The photon flux in the experiment is 2.5 times smaller than the flux of the high-luminosity GlueX II experiment, E12-12-002, (and about 5 times smaller than the GlueX designed flux) and constitutes to about 2x107 photons/sec in the coherent peak region. The photon beam will be produce on a 4⋅10-4 R.L. diamond radiator by an electron beam with the current of about 140 nA. The experiment will collect data using 3 targets: 7 days on 12C (7% R.L.), 4.5 days on liquid D (4.1 % R.L.), and one day liquid 4He (4 % R.L.). The experiment will also acquire calibration data using an empty target run. The run plan of the SRC experiment is presented in Table I.

1. **What is the operational status/performance requirements of the target system needed by the experiment? If not completed, what are the completion/commissioning schedules, tasks and user commitment?**

We will run with a 30 cm-long cell that has a copper heat shield installed around the outside for both the deuterium and 4He running (both ~4% radiation length). We will run an 8-foil carbon foil target in total 7% radiation length (each foil is 0.24 cm). The carbon foils will span the 30 cm target length.

1. **Has the spectrometer, detector configuration been defined, including ownership, maintenance and control during beam operations?**

Spectrometer and detectors will be in standard GlueX configuration. Detector support will come from Hall D staff members and responsible parties have confirmed (see <https://halldweb.jlab.org/level-1/manpower.pdf>).

1. **What is the impact of the expected neutron radiation on GlueX detector components such as the SiPMs? Is any local shielding required? Are the radiation levels expected to be generated in the hall acceptable?**

Neutron background is critical for the performance of silicon photomultiplier, which are used for the instrumentation of the Barrel Calorimeter and Start Counter of the GlueX experiment. Neutron radiation results in the degradation of the SiPM performance, specifically the increase of the dark current. BCAL design allows for a factor of 5 increase of the dark noise. The start counter is less sensitive to the SiPM dark current and can be operated at at least a factor of 10 larger dark noise (due to the relatively large signal amplitude > 100 pixels, and large readout thresholds applied). During the design phase of the GlueX experiment, radiation hardness properties of SiPMs have been measured using an AmBe neutron source and beam tests in the experimental Hall A. In order to compare damage effects to Silicon caused by neutrons with different energies, it is convenient to convert the particle fluence to the equivalent fluence of 1-MeVneutrons using the so-called damage function. Radiation tests demonstrated that SiPMs with the accumulated neutron dose of 32 rem (which corresponds to the fluence of about 1.1x109 nEQ/cm2) increased the dark current by about a factor of 5. Backgrounds and radiation level in Hall D was estimated using FLUKA and GEANT simulations provided by the Radiation Control group. Expected lifetimes of the BCAL and ST SiPMs of the GlueX experiment are about 8 and 5 years, respectively.

The beam photon flux of our experiment is 5 times smaller than that proposed for GlueX design. The largest neutron background will be produced on a liquid deuterium target. Recently, neutron background produced on the deuterium target was simulated by the RadCon group (Pavel Degtiarenko) using FLUKA and Geant programs. Projected lifetime of SiPMs for runs on helium and deuterium targets are listed in the table below (neutron background produced on the C target is expected not to increase the 4He background). Degradation of the SiPM performance due to the neutron radiation, i.e., the dark current increase, is expected to be negligibly small (< 20% for

the ST SiPM, where the effect is the largest) even for the deuterium target. The dark rate of SiPMs will be measured during the experiment using special runs with the random trigger; this is important for planning future experiments in Hall D.

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|  | **GlueX Design** | **SRC/CT** | |
|  | LH target | LHe4 target | LD target |
| BCAL | 8 years | 25 years | 7.7 years |
| ST | 5 years | 6.2 years | 1.6 years |
| Run Time of our experiment | | 3 days | 13.5 days |

Table II. Expected SiPM lifetime for run conditions of the SRC/CT experiment.

Experimental Hall D was designed to handle the photon flux about two times larger than the GlueX designed flux (corresponding to 108 photons/sec in the energy range between 8.4 GeV and 9.1 GeV). Based on the Monte Carlo simulation, the radiation level in Hall D will not exceed the GlueX designed level. The estimated neutron dose equivalent rate in Hall D at the ceiling and walls induced by the deuterium target is conservatively estimated to be 4 - 5 times larger than the hydrogen target and therefore, should not present any issues as we run at x5 less flux. Additionally, we are coordinating with RadCon to install TLDs close to the target and implement Bonner spheres to determine the energy spectrum of the neutrons close to the target. The radiation level during run is continuously monitored by the RadCon group, specifically with the rapid access CARMs (a few detectors have been installed for the PrimEx experiment, which took data on He4 target).

1. **What is the expected data rate for the experiments?**

Nominal GlueX trigger rate at a photon flux of 5x107 photons/s, is a trigger rate of about 80 kHz, 90% live time, and a corresponding data rate of 1.1 GB/s. For our experiment, we will lower the ECAL and BCAL thresholds so that we are sensitive to minimum ionizing particles, and we will include the start counter in the trigger. This configuration was tested in Feb 2020 (see https://halldweb.jlab.org/level-1/src) with the 5x107 photon flux. The tested trigger required a hit in the start counter and reduced the energy thresholds in the BCAL and FCAL to 180 and 250 MeV, respectively. These thresholds are set below the minimum ionizing particle threshold so that we accept proton and pion final states. This configuration yields a trigger rate of 78 kHz, 90% live time, and a corresponding data rate of approximately 1 GB/s (albeit at nominal GlueX photon flux as stated above). Our experiment will run with a photon flux of 2x107, but our carbon target will be double the radiation lengths of the nominal hydrogen GlueX target. We expect that the hadronic backgrounds from the nuclear target will be smaller due to larger attenuation effects (scaling approximately as *A2/3*) and the electromagnetic backgrounds should scale with the radiation length.

1. **Are the responsibilities for carrying out each job identified, and are the manpower and other resources necessary to complete them on time in place?**

We have adequate manpower from our group to cover shifts, calibrations, and analyses (TAU/MIT/ODU/GWU). We invite the GlueX collaboration to join in shifts and analysis.

1. **Are the beam commissioning procedures and machine protection systems sufficiently defined for this stage?**

Yes. This is all standard GlueX calibration and procedures. All basic calibrations done with PrimEx prior to start of experiment.

1. **What is the simulation and data analysis software status for the experiment? Has readiness for expedient analysis of the data been demonstrated? What is the projected timeline for the first publication?**

We will use standard GlueX calibration and software, and analysis will be completed within the GlueX framework. Our group already has a dedicated Monte Carlo event generator. We anticipate that our first publication will be achieved within a year of data taking. Our group has an abundance of experience analyzing short range correlations with electron beams in other experiments and a strong track record of rapid publications. The strategy is to first analyze channels for np-dominance:

* γ + p → π0 + p and γ + n → π- + p: 2 particle final state, lowest cross section
* γ + p → ρ0 + p and γ + n → ρ- + p: 3 particle final state, highest cross section

1. **What is the status of the specific documentation and procedures (COO, ESAD, RSAD, ERG, OSP’s, operation manuals, etc.) to run the experiments?**

Assigned PDL is Lubomir Pentchev. Documents are initiated at https://halldweb.jlab.org/wiki/index.php/Experiment\_Readiness\_Review\_2020#ERR\_Agenda

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| **Condition** | **Scheduled Work**  **(Activities)** | **Total Time** | **Beam Conditions** |
| **Pre-experiment** | **Install C target** | **3 shifts** | **no beam** |
|  | Disassemble beam pipe.  Retract target.  Remove Start Counter (ST).  Remove vacuum snout.  Remove GlueX cell.  Mount carbon foils (survey). Attach vacuum snout.  Attach ST.  Target in place.  Assemble beam pipe.  Pump vacuum.\* Ramp magnet\* | 1 shift assembly  1 shift for survey & align  1 shift for pumping vacuum |  |
|  |  |  |  |
| **Detector checkout** |  | **2.5 shifts** | **140 nA** |
|  | Establish typical tagged photon beam, check/calibrate sub-detectors, Trigger, and DAQ  (some tests can be done during pumping vacuum) |  |  |
| **Run with C target** |  | **7 days** | **140 nA** |
| **Target change** | **Install liquid D target** | **5 shifts** | **no beam** |
|  | Ramp magnet down | 1 shift |  |
|  | Disassemble beam pipe.  Retract target.  Remove ST.  Remove vacuum snout.  Remove carbon foils.  Mount GlueX cell.  Survey. Mount heat shield (needed for helium).  Attach vacuum snout.  Attach ST.  Target in place.  Assemble beam pipe.  Pump vacuum\*. Ramp magnet.\* | 1 shift assembly  1 shift for survey & alignment |  |
|  | Ramp Magnet\* Pump vacuum\* | 1.5 shifts  (1 shift for pumping vacuum) |  |
| **Run with empty target** |  | **0.5 days** | **140 nA** |
| **Target preparation** | Cool target\*. | **1 shift** |  |
| **Run with D target** |  | **4.5 days** | **140 nA** |
| **Target change** | Switch to liquid He target | **1.5 shifts** |  |
|  | Boil LD2\*.  Pump D2 from tanks.  Replace with helium.  Cool target\*. |  |  |
| **Run with He target** |  | **1 day** | **140 nA** |
|  |  |  |  |
| Total |  | **13 days**  **data taking**  9.5 shifts overhead |  |

Table I. Run plan of the SRC/CT experiment.

(\*) means Hall D can be in beam permit.