Collaboration Questionnaire -- Instrumentation for FRIB

To get firmer ideas about instrument packages that will be proposed at the FRIB Workshop, Feb, 20-22, 2010, we request that each collaboration to fill in the following questionnaire. These should be e-mailed to Kim Lister (Lister@anl.gov) and copied to Brad Sherrill at (Sherrill@frib.msu.edu) and Rick Casten (Rick@riviera.physics.yale.edu) *no later* than Feb 12, 2010. The recommended **length** is **2 pages**, plus two additional figures. One figure should present the instrument and the other should indicate its location, size, etc on the floor at FRIB by using the attached floor plan template.

Digital Gammasphere

1) What is the primary physics motivation and experimental capability of the proposed instrument and why is this important for FRIB science?

   Gammasphere is a Compton Suppressed Ge Array for the detection of gamma-rays. It's large efficiency and high signal to noise ratio makes it an ideal device for in-beam gamma-ray spectroscopy. It is currently the premiere device in the world for nuclear structure studies at high angular momentum. It has been used to study excited states throughout the periodic chart from A~10 to A~260. Currently, Gammasphere has limitations both in count rate capabilities and data throughput. By implementing a digital data acquisition system based on Gretina digitizers and trigger modules, both the count rate capability and data throughput rates can be increased by at least a factor of four. This would allow the processing in excess of 500,000 gamma-rays/sec. Such a device would be extremely powerful in studying excited states in nuclei using reaccelerated beams at FRIB.

2) What are the unique capabilities of this device that are not available in existing equipment? Is this instrument stand alone or is it to be used (solely or partially) in conjunction with other instruments. Could it be used at NSCL or other laboratories before FRIB?

   Gammasphere is still a unique device. It is able to process ~125,000 gamma-rays/sec and with the digital upgrade, this number will increase by a at least a factor of four. Its 4π geometry allows not only for discrete gamma-ray spectroscopy studies but calorimetric measurements as well. It can also be used in conjunction with other instruments as *e.g.* charged particle arrays like microball and recoil mass spectrometers like the FMA. It should be noted that Gammasphere is complimentary to GRETINA and both would prove to be a powerful duo at FRIB. Gammasphere is currently in operation at ATLAS but has also run successful campaigns at the 88" cyclotron at LBNL.

3) Describe the instrument in some detail – how does it meet the scientific requirements and what are the (estimated) performance specifications? Be brief but as detailed as you can. Is the design fixed or are multiple options still being discussed and encouraged?

   Gammasphere's detector geometry is fixed and consists of up to 110 Compton suppressed Ge detectors. A Gammasphere detector module consists of a HPGe detector surrounded by a BGO side shield and BGO backplug which serve to suppress Compton scattered events. With the

current analog electronics, individual Ge counters can run at ~10,000 counts/sec before pileup degrades detector throughput. Once an event is marked for readout, the DAQ is dead for a minimum of 25 μsec in order to process the event for readout. For in-beam experiments, this limits the event rate to ~15,000 events/sec. Even in experiments where the trigger rates are low, the 10k rate limit in individual Ge detectors can be extremely restrictive with regards to how much beam current can be placed on target. The redesign of the Gammasphere electronics will increase count rate capabilities of individual Ge detectors to ~40,000 counts/sec with no degradation in throughput when compared to the present 10k limit. In addition, the new DAQ is being designed to allow a data rate for in-beam measurements at 50,000 events/sec. The new data acquisition system will consist of Gretina digitizers. We envision a 10 channel digitizer will instrument 2 detector modules. Thus, the new DAQ will consists of ~55 digitizers distributed in 10 VME crates.

4) What is the current stage of development of your project ?

We are in the first phase of the project where we plan to only digitize the central contacts of the Ge detectors. This phase will require only 11 digitizers. The digital data acquisition system will run in parallel with analog Gammasphere. This implementation will allow us to run individual Ge detectors at count rates up to 40,000/sec, and an energy signal which is lost due to pileup in analog Gammasphere may be recovered in digital Gammasphere due to shorter shaping times implemented with the digital shaper algorithm compared to analog Gammasphere. For this phase of the project, all hardware has been either procured or is ordered and initial testing of the system should begin in the second half of 2010. Over the next 2-3 years, a transition to a fully functional digital data acquisition system for Gammasphere is planned.

5) What is the approximate cost of the project: discuss possible sources of funding.

We estimate the total cost of the project at $750,000 to $1,000,000. Phase I has currently been funded out of the ANL Physics division base budget. We believe 75% of the project can be funded this way; however, additional money may be needed to complete the project.

6) Please provide a brief list of collaborators and institutions. Spokesperson(s) provide contact info.

Gammasphere continues to be supported by the nuclear structure community. It is a collaboration between LBNL, ANL, ORNL and university groups. Argonne is leading the effort in the upgrade of the digital data acquisition system with strong support from the Gretina collaboration. Michael Carpenter at ANL is serving as contract person for this upgrade project.

7) Please can you outline how your collaboration has been developing your project and how you are growing your collaboration (How many meetings? Participants?, Circular mailings? Have you a web-site?)

Gammasphere has been operating for nearly 15 years and the collaboration is well established. The host laboratory takes responsibility for maintaining and operating the device. There is a user's executive committee which serves to update the community on the device as well as acting as a liaison between the users, the host laboratory and DOE. The Gammasphere users

group has in excess of 200 members. The device has a website and the user's executive committee updates the users community via periodic newsletters.

8) Did you consider alternative designs? What alternatives were considered? How did you arrive at a final design?

   The design of Phase I has been finalized. We presently have several options for Phase II which will depend to some degree on what we learn when implementing Phase I. The choice to use Gretina digitizers and trigger modules was made in order to leverage the development time and costs the gamma-ray community as already invested in digital electronics. We believe this choice has saved us significant time and money in realizing the projects goals. As we design the final system, we are trying to balance cost with functionality.

9) What existing equipment exists in the US Community that has similar goals and characteristics, even if inferior in performance.

   Other Compton-Suppressed Ge arrays in the U.S. include Yrast-Ball at Yale and Clarion at ORNL. Both are based on Ge clover detectors while Gammasphere uses individual co-axial detectors. The detection efficiency of these arrays is significantly less than Gammasphere. In addition, even smaller clover arrays exist at LBNL and Florida State. Gretina will have similar Ge efficiency to Gammasphere but will be limited in its angular coverage. As already mentioned, Gretina and Gammasphere will be complimentary devices.