**Collaboration Questionnaire -- Instrumentation for FRIB**

1) What is the primary physics motivation and experimental capability of the proposed instrument and why is this important for FRIB science?
*Charged particle detection is critical to a number of sub-fields of rare isotope beam science including (but not limited to) direct reaction studies, equation-of-state studies, recoil-tagging methods, fusion and fusion/fission studies, and decay spectroscopy. A number of detector arrays are currently being designed or built. Additionally, development work to investigate new types of charged particle detectors as well as to improve the properties of current detector types (e.g. <100 ps timing for silicon detectors) is expected to yield critical improvements for arrays to be built specifically for FRIB. There are two time scales associated with development; 2-3 years for arrays using existing technology, and 5-10 years for work on developing semiconductor materials.*

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?
*Individual questionnaires give more details about each array. Under question 3) we have listed some arrays that are expected to be available for FRIB or other laboratories before that time. The last two projects listed are based in Europe. It is possible they could also be used at US laboratories.*

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?
***ANASEN:*** *Primarily for astrophysics experiments and experiments related to the structure of exotic nuclei, e.g. at ReA3. Detector has cylindrical geometry with position sensitive silicon strip detectors backed by CsI(Tl) scintillators (can stop up to 80 MeV protons). Has two modes: gas and solid target. In gas mode the detector will have active target capabilities with gas proportional counters providing tracking for charged recoils. The detector will be used for resonance reactions and transfer reactions.*
***Super-ORRUBA:*** *Primarily for transfer reactions. Comprised of 24 double-sided silicon strip detector telescopes. 75 strips on front and 4 strips on back of each detector, about 2000 channels of ASICs electronics required. Ideal for low-energy protons (down to 0.5 MeV) that are hard to detect with position sensitive silicon strips. Will initially be used at the HRIBF.*
***"Fission chips":*** *For fusion/fission studies. Gas-filled ionization chamber with a solid target. Tracking of both fragments is provided by drift time and position sensitive detectors at the anode. The walls of the chamber are paved with silicon detectors. Complete information, angle/energy/particle ID will be available for at least one fragment.*
***HiRA++:*** *For equation-of-state (and direct reaction) studies.*
***SiEFUS:*** *Elastic scattering and near/sub-barrier light-ion fusion with radioactive beams. SiEFUS consists of highly segmented, nTD (neutron Transmutation Doped) Si detectors utilizing TOF and pulse shape discrimination to isotopically resolve reaction products with $A < 60$. It will consist of 200 – 500 independent channels in the angular range $1° \leq \theta lab \leq 30°$. The time resolution for the device will be $\leq 200$ ps.*
***Decay Arrays:*** *Typically DSSD's are used as implantation detectors. Typically, the detector a has thickness of between 60 and 500 microns, strip pitch between 300 and 1000 microns, and the front and the back side are divided into between 40 and 160 strips.*

***GASPARD:*** *For direct reactions and resonant scattering. Light particle detection with low threshold. High gamma efficiency/resolution integrated in design. Time-of-flight, pulse shape discrimination and DE-E . Close to 4pi cover. Spherical geometry. Approx 15,000 channels of sampling electronics. Use of beam tracking for very low energy-high mass fission fragments, of CHYMENE solid H2/D2 windowless target, Magnetic spectrometer with large acceptance (VAMOS).*
***ACTAR:*** *Radio-activity studies (2p decay etc), molecular states, GMR, low cross-section direct reactions and resonant scattering where thresholds in the 150keV/nucleon is required. Active "square" gas volume employing TPC (20 liters). High granularity (20,000 pads). Electronics sampling with high through capabilities (10Gbit/sec). Electronics front end and DAC system is the same as employed for AT-TPC at FRIB/NSCL.*

4) What is the current stage of development of your project ?
***ANASEN:*** *Funded. Silicon detectors ordered. Final design stage.*
***Super-ORRUBA:*** *Funded. Detectors ordered. Finalizing design.*
***"Fission chips":*** *Detailed design of electrodes and tests of preliminary design in process.*
***HiRA++:*** *Unknown.*
***SiEFUS:*** *Construction of prototype detector (non-nTD Si) and new fast timing electronics is nearly complete. Prototype instrument will be taking data in Summer 2010.*
***Decay arrays:*** *The FRIB implantation-decay array is at the conceptual design stage and will consist of multiple high-granularity Si detectors with digital readout.*
***GASPARD:*** *Simulations and CAD studies in progress. Expected to be available in 2015.*
***ACTAR:*** *Developed Simulation Codes. CAO in progress. R&D financed (GET) and in progress.*

5) What is the approximate cost of the project: discuss possible sources of funding.
***ANASEN:*** *$760 k ($450 k for silicon)*
***Super-ORRUBA:*** *$500 k total*
***"Fission chips":*** *$400 k to $900 k depending on required granularity of silicon walls.*
***HiRA++:*** *Unknown.*
***SiEFUS:*** *Approximately 0.5 M$.*
***Decay arrays:*** *Varying depending on size. An 800-channel digital DSSD system approx $1M.*
***GASPARD:*** *Approx 3M€*
***ACTAR:*** *Approx Costs 1M€*

6) Please provide a brief list of collaborators and institutions. Spokesperson(s) provide contact info.
***ANASEN:*** *J Blackmon (LSU), G. Rogachev (FSU)*
***Super-ORRUBA:*** *D. Bardayan (ORNL), J Blackmon (LSU), M Smith (ORNL) J Cizewski (Rutgers), University of Tennessee, Tennessee Tech, University of the West of Scotland.*
***"Fission chips":*** *D. Shapira (ORNL), F. Liang (ORNL), J. Kolata (Notre Dame), W. Loveland (Oregon State), E. Chavez (UNAM).*
***HiRA++:*** *W Lynch (MSU), B Tsang (MSU), L Sobotka (Wash U).*
***SiEFUS:*** *R.T. de Souza (Spokesperson, IU), S. Hudan (IU), C.J. Horowitz (IU), M.A. Famiano (WMU), L.G. Sobotka (WashU).*
***Decay Arrays:*** *R. Grzywacz (UT), S. Liddick (NSCL/MSU), D. Seweryniak (ANL), and others*
***GASPARD:*** *IRFU/Saclay, IPNO, HUELVA Univ, GANIL*
***ACTAR:*** *IRFU/Saclay, CENBG, GANIL, RIKEN (GET) and NSCL(GET).*

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?)
*Conveners have had conference calls and communicate by email. Considering a workshop at some future date (to be discussed at the Users workshop).*
*Circular mail sent 02/05/10.*
*http://fsunuc.physics.fsu.edu/~SAWG/FRIB_workgroup/Welcome.html*

8) Did you consider alternative designs? What alternatives were considered? How did you arrive at a final design?
*Not applicable since likely there will be several arrays customized for broad experiment goals.*

9) What existing equipment exists in the US Community that has similar goals and characteristics, even if inferior in performance.
*The alternative to charged particle detector arrays for transfer reactions would be the HELIOS spectrometer. The advantage of a compact array for charged particles, such as Super-ORRUBA is that it can easily be coupled to auxiliary detectors, such as γ-detector arrays. In this way the two approaches are complimentary. For the other programs, charged-particle detector arrays are the most reasonable choice.*