Nuclear Astrophysics Working Group Report
Convenors: J. A. Clark (ANL) and C. M. Deibel (LSU)

The nuclear astrophysics session consisted of six invited talks and one contributed talk, which spanned a fairly large range of astrophysical processes from those involving nuclei close to or at stability to those far from stability over a variety of masses:

- A. A. Chen (McMaster University): *Classical Novae, Type I X-ray Bursts and ATLAS*
- S. Almaraz-Calderon (ANL): *Fusion Reactions in Nuclear Astrophysics: The MUSIC Approach*
- P. Collon (Notre Dame): *AMS for astrophysics, p-process work and other*
- H. Y. Lee (LANL): *Improving neutron capture rate predictions using Apollo + HELIOS*
- N. Scielzo (LBNL): *Neutron spectroscopy with ion traps for astrophysics*
- M. Mumpower (Notre Dame): *The r-process and nuclear masses near closed shells*
- G. Savard (ANL): *N = 126 Factory and the r-process* (contributed)

Alan Chen (McMaster University) discussed reaction rates important for explosive H and He burning in classical novae and Type I X-ray bursts (XRB's). Currently, there are three reactions that dominate the uncertainty in classical novae: ^{18}F(α,p)^{21}Ne, ^{25}Al(p,γ)^{26}Si and ^{30}P(p,γ)^{31}S. In XRB's the situation is much more uncertain, as there are many more reactions involved, most of which are far from stability. Currently, there are a number of programs to address these issues from direct reaction studies using HELIOS to indirect studies of nuclear structure with Gammasphere. The current and future program of the new MUSIC detector was discussed by Sergio Almaraz-Calderon. The successful measurements of ^{12}C fusion with several different C isotopes have shown the viability of this method and future studies will look farther from stability at fusion of very neutron-rich C, O, Ne and Mg isotopes, among others. Phillp Collon discussed the technique of Atomic Mass Spectroscopy (AMS) and recent results. There is currently very little known about the reactions involved in the *p*-process, and techniques such as AMS at ATLAS can be used in the future to address this, especially for the Dy and Hf isotopes. There was a considerable amount of discussion regarding the possibilities for studying the *r*-process at ATLAS. The current efforts with CARIBU and its predecessor studying masses have yielded a number of previously unknown masses, including those of nuclei, which are located on a possible *r*-process path. Nick Scielzo gave an overview of the neutron spectroscopy program at ATLAS, including previous results with the Beta Paul Trap (BPT) and plans for an upgraded BPT trap to be used in conjunction with CARIBU. The effects of the uncertainties in the probabilities of β–delayed neutron emission, as well as masses, β-decay rates and neutron separation energies were discussed by Matthew Mumpower. A series of sensitive studies completed by the Notre Dame group clearly show the need for more measurements, especially near closed shells, in order to put constraints on the site of the *r*-process. One of the findings of these studies was that the uncertainties of nuclei with N = 126 have a significant effect on the *r*-process. The capabilities of studying such nuclei at ATLAS with the new N = 126 factory were discussed by Guy Savard.

In addition to the above discussions several other areas were briefly mentioned, including studies of the very early stars, *s*-process studies and the possible addition of neutron detection capabilities at ATLAS. The option of bringing in an existing neutron detection system, such as VANDLE or 3Hen, was discussed as a possible option and was received favorably.

The above represents a number of developments that will allow a wide variety of stellar processes to be studied at ATLAS, including the αp and *rp* processes, fusion, *p*-process nuclei and data necessary to understand the *r*-process, such as masses, β-delayed neutron emission and "surrogate" reactions. The questions that we plan to address at ATLAS in the next 5 – 10 years are clearly well aligned with the questions of the nuclear physics community as a whole as outlined in the 2007 Long Range Plan. The nuclear astrophysics program at ATLAS also fits in nicely with the current and future priorities of the nuclear astrophysics community, such as the ongoing and planned activities of the Joint Institute for Nuclear Astrophysics (JINA), ReA3 and future plans for the FRIB facility.

There were several conclusions reached during the session regarding the future direction of the ATLAS facility. The consensus of the astrophysics working group was that there is very strong support for intense radioactive ion beams, such as those produced by AIRIS. The successful completion of AIRIS will provide radioactive ion beams of high intensity and purity that are vital to the needs of the astrophysics community, including reaction rate studies need to understand the αp and *rp* processes. High purity and intensity beams from CARIBU will also allow studies of neutron capture reactions via "surrogate" reactions, while low-energy beams from CARIBU are invaluable in studying masses and β–delayed neutron emission of importance to the *r*-process. In addition, the development of the N = 126 facility will allow the study of multiple nuclei of interest at the N = 126 shell closure, many of which have been shown to have significant effects on the *r*-process. Finally, the completion of a multi-user facility would significantly increase the possibilities for the study of reactions relevant to stellar processes. Given the low cross sections of many of the reaction of interest and the relatively low beam intensities of the needed radioactive ion beams, future experiments will likely require significant amounts of beam time, not feasible at the current ATLAS facility. The combination of the new AIRIS facility and N = 126 factory coupled with a multi-user capability will significantly enhance the already productive nuclear astrophysics program at ATLAS.