SPS Undergraduate Research
FINAL REPORT
Department of Physics and Astronomy
Clemson University

Construction of a 12" Cyclotron

The Clemson University SPS chapter was awarded $1750 to initiate the design and construction of a 12" cyclotron. In this final report we detail the previous 11 months of effort on this project. The report is outlined as follows: Organization, Efforts, and Expenditures.

Organization: Work on this project has been coordinated by the SPS advisor, Dr. Chad E. Sosolik through the monthly chapter meetings, special topical meetings, and frequent group emails. The primary students involved in this project to date have been: Scott Davis, Michael Gagnepain, Andrew Hanson, Alexander Kerr, Scott Lindauer, and Jeremy St. John.

In order to tackle the complex project of designing, constructing, and modeling a demonstration level cyclotron, team members self-selected themselves into groups with focus on the following specific areas: vacuum, magnet, and simulation.

Efforts: As the Clemson University group had no prior expertise in cyclotrons, we began our work in the spring of 2013 by reaching out to the Rutgers University Cyclotron group. With some assistance from Dr. Sosolik, who provided travel funds from a South Carolina educational grant, four students from our team traveled to Rutgers University for a short visit. These students were able to examine and work with their cyclotrons, to make valuable contacts for future technical support, and to get a better sense of the technical aspects that this project will entail moving forward.

Site visit to the Rutgers University cyclotron
Clemson University students are (front row) Michael Gagnepain, Scott Davis, Taylor Kimmel, and Jeremy St. John. Students were hosted at Rutgers by Stoyan Lazarov and Dr. Timothy Koeth (back row).

On-campus efforts in own design have been focused in the areas listed below.

<u>Vacuum</u>: Efforts in this area involved securing space and equipment for an initial vacuum system. The Department of Physics and Astronomy has provided space within the main Kinard Laboratory of Physics for this project. This is an approximately 500 sq. ft. space located in

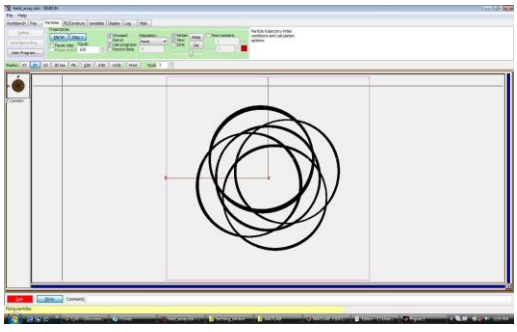
Room G03 of the building basement. Within this space, we have set up a laboratory bench with a computer for simulations and equipment interfacing. Both the lab bench and computer were obtained as surplus department equipment. Although a custom vacuum chamber was outside of our initial budget, we were able to secure a relatively large (24" diameter) cylindrical chamber that was donated to us by the Department of Electrical and Computer Engineering. The similarity of this chamber design to the ultimate cyclotron chamber we will use was fortuitous and has aided in setting up the proper pumping and gauging relative to our conductance calculations for ultimate chamber pressures. A large fraction of our budget went toward the purchase of a robust all-in-one vacuum gauge for the vacuum system. Pumping on this chamber is currently provided by a diffusion and mechanical pump donated to us by Dr. Sosolik's group.

Hands-on training at the Rutgers University cyclotron Clemson University students are from left to right are Scott Davis, Michael Gagnepain, and Taylor Kimmel (seated).

Magnet: To date we have yet to acquire a proper-sized magnet for use in this project. It was clear from our discussions with the Rutgers University group that they were able to obtain their magnets as surplus items from decommissioned experiments. Two candidate magnets within our own department here at Clemson University were identified in this regard, and one was temporarily loaned to our group. However, the magnet bore as well as field strength were both too small for our 12" cyclotron design. We hope to utilize recurring on-campus funds for student research (~$2000/semester) and some alumni donations to acquire a proper magnet within the next year.

Test Vacuum Chamber

Simulation: Information conveyed to us by the Rutgers University group made it clear that a reasonable simulation effort should be started alongside our design and construction of the cyclotron. Therefore, we have purchased a site license for the ion optical simulation package SIMION™. Dr. Koeth (Rutgers Univ.) has provided our group with a large collection of data files on



SIMION™ screenshot showing stable orbits for 250 keV protons within a cyclotron

cyclotrons, and Dr. Sosolik has agreed to teach a short course on how to use the software as well as the package POISSON/SUPERFISH starting in Spring 2014.

Expenditures: As noted above, the two primary expenditures on this grant were a vacuum gauge and a simulation package:

- Hot ionization guage (dual filament, built in controller, 2.75" CF)
    - Kurt J. Lesker (KJLC 354401YF): $1057.20
- SIMION 8.1 (Academic version)
    - Scientific Instrument Services (SIMION81A): $750.00

The combined cost of these items ($1807.20) exhausted our funds provided by this grant with the cost overrun covered by departmental funds.