Construction of a 12” Cyclotron

Clemson University SPS Chapter, Clemson SC, 29634

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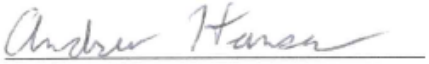
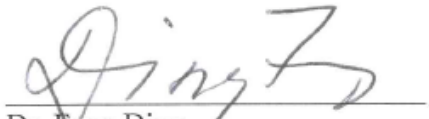


Andrew Hanson
Principal Proposer



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Abstract:

Our chapter proposes to design and construct a 12” cyclotron. The design and construction process will be split over multiple semesters to offset costs and allow more students the opportunity to participate. The final product will be a fixture of our physics department for future undergraduate research, education, and outreach.

Statement of the Activity:

Background and Relation to the Clemson SPS Chapter Objectives:

The cyclotron was one of the major workhorses of atomic physics in the mid-twentieth century and is still used in medicine due to its high ion energy relative to its size. Because of the spherical path it accelerates ions along, a 9" cyclotron can obtain maximum ion energies of 184 keV or more and a 12" can reach 800 keV [1]. Furthermore, a very barebones 6" cyclotron was able to be built from scratch for under $1000 using hand-made or second-hand components [2], showing that such an undertaking is possible on a limited budget.

The Clemson University physics department has a strong departmental background in atmospheric physics, astrophysics, and quantum physics but fewer opportunities in particle or accelerator physics. As such, the Clemson University chapter of the Society of Physics Students hopes to construct a 12" cyclotron. While mainly targeted at physics undergraduates, the opportunity would be available to any interested undergraduates through a Creative Inquiry research program over several semesters in the hopes that it will attract undergraduates from other majors to develop an interest in physics. The benefits of building a cyclotron from scratch are many. The designing of the device relies on the application of electromagnetism, particle physics, and quantum mechanics, allowing students to further their understanding of basic concepts and observe some of the difficulties in applying them in the real-world. The construction stage would teach many of the engineering principles and techniques necessary for experimental physics as well as electronics and computer programming. Throughout the entire undertaking, those involved would also learn about the field of accelerator physics. The final

product will also serve as a tool for further research as well as in teaching and demonstrating the principles of accelerator physics and electromagnetism.

Schedule of Planned Activity:

As mentioned, the plan is to develop the cyclotron in several phases with each phase spanning an academic semester. In the first phase (Spring 2013 semester), the focus will be on studying the theory behind the cyclotron construction and on determining the most cost efficient methods of obtaining materials and construction. Several aspects will go into this.

To keep costs minimal, the first goal will be to determine the minimal parameters required for each component in order for the overall system to work. During this time, the focus will be on the theory behind the mechanics of the cyclotron, and previous groups' attempts at cyclotron construction.

The next objective will be pricing components once the necessary working parameters are determined. A legitimate option for some components is to build them from scratch, so these options will be researched and heavily considered in regards to cost versus time [3].

There will be money set aside by Clemson University for the purchase of an electromagnet; however, we will only be able to afford to repurpose a used one or else acquire one through liquidation or surplus. As such, it is uncertain when a suitable magnet will be found and purchased. If we are awarded this grant, the money will be put towards the systems not directly based around the specific magnet. These systems include the vacuum system, the ion source, the water cooling system, the RF signal generator, and construction of the copper D's.

By the end of the spring 2013 academic semester, all the non-magnet-specific systems should be completed. If a magnet has or has not been located, then this will be noted in the interim report.

If no magnet has been found during the spring semester, the search will continue during the summer with one located and shipped by the beginning of the fall 2013 academic semester.

Upon returning in the fall, phase two will commence with the focus on the main assembly process. In the fall semester, a small sum of money will be provided by Clemson University towards the support structure for the overall rig and the components directly related to the electromagnet. After the electromagnet is operational, work will focus on the computer control systems necessary to have all the systems interact appropriately as well as the data acquisition system. Finally, a long stage of calibration should take a significant portion of the fall semester.

By then end of the fall 2013 academic semester, our goal is to have all of the individual systems operational and a control system in place. If all goes well, calibrations should be far enough along to carry out at some live test-runs, with the optimal scenario being that the cyclotron is fully operational.

Bibliography:

[1] “Rutgers Cyclotron.” Rutgers University, Web. 4 Nov 2012. <http://www.physics.rutgers.edu/cyclotron/welcome.shtml>.

[2] Niell, Fred. “Fred’s World of Science, Cyclotron I.” 20 Aug 2001. Web. 15 Nov 2012. <http://www.niell.org>

[3] Niell, Fred. “Effective Scientific Equipment Procurement Strategies: Building on a Budget.” Small Cyclotron Conference 2010. Houghton College, Houghton, NY. Web. 15 Nov 2012. <http://cyclotronconference.org/presentations/Scientific%20Equipment%20Procurement.pdf>

Budget:

Item/System	**Cost**
Sheet Copper (for copper D's)	$200
Ion Source	$200
Water Cooling System	$300
RF High Power Signal Generator	$1000
Vacuum Tubing	$50
Total	**$1750**