Colorado State University's
Accelerator and FEL Lab:

Internship Report

Chapter 1

What we're doing; Why we're doing it

The Colorado State University Accelerator and FEL Lab faculty consists of several graduate students working under the leadership of Dr. Stephen Milton and Dr. Sandra Beidron, with the goal of developing an Accelerator-based program at Colorado State University (CSU). The program currently being developed is focused on preparing students in a field as complicated as accelerators, as well as bridging the gap between the use of accelerators in a laboratory, and their uses in manufacturing, medical, and military applications.

The Accelerator and FEL lab located on the Foot Hills Campus in the Engineering Research Center (ERC) is presently the site of this program. Students working in the ERC are given insights into the different fields of knowledge that contribute to accelerators. Due to the fact that the knowledge and expertise that contribute to accelerators involves several varieties of sciences and engineering, there are opportunities for students, with any knowledge background on both the undergraduate and graduate student level, to participate.

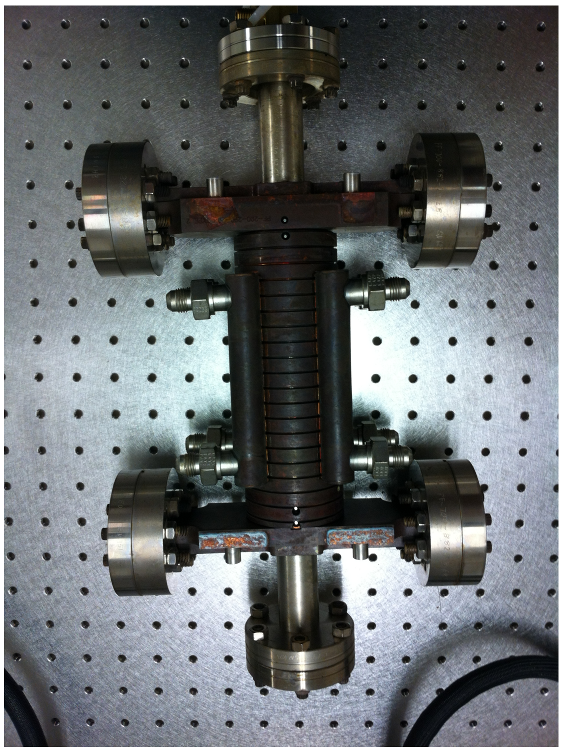
The Accelerator and FEL lab is being developed at the ERC, and will eventually include a six-MeV (Mega-electron volt) L-Band electron linear accelerator (LinAc), and a laser table with a microwave test stand and a magnetic test stand. Dr. Biedron, Dr. Milton, and their team of graduate students are working to procure and assemble the LinAc and laser table. The lab faculty is also designing and fabricating the necessary support equipment for the lab, and outlining lab procedures for future program participants.

Chapter 2

My assigned tasks; Progress, Test plans, Etc..

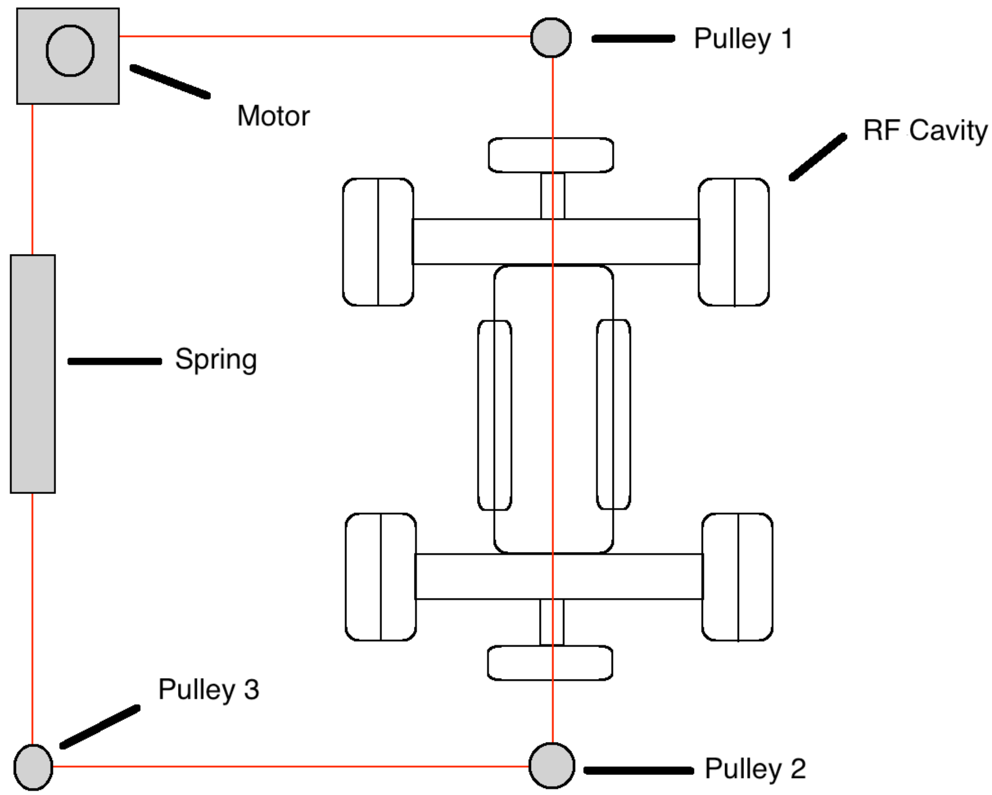
This report outlines my involvement with the Accelerator and FEL lab faculty during the summer of 2012. I was hired as one of three interns. Over the summer, we assisted in preparing the lab at the ERC in anyway possible, but our duties primarily concerned designing the two test stations.

The first test station, or the microwave test stand, is used to “map,” or gather data on the specifics of a radio-frequency (RF) cavity. The test station is based around a RF cavity donated to the lab by the Stanford Linear Accelerator Center (SLAC) (Figure 1).



(Figure 1: Donated Radio-Frequency Cavity)

This RF Cavity is mapped using a bead attached to a string. The bead is then pulled through the cavity’s vacuum tube (Illustrated in Figure 2) via a pulley system driven by a motor.



(Figure 2: Illustration of the Microwave Test Stand, The string is depicted with a red line)

As the RF cavity is powered, the motor is activated, and the bead is pulled through the length of the cavity by a string, which is represented by red. Wave-guide sensors and a network analyzer use the disturbance caused by the bead to map the inside of the cavity.

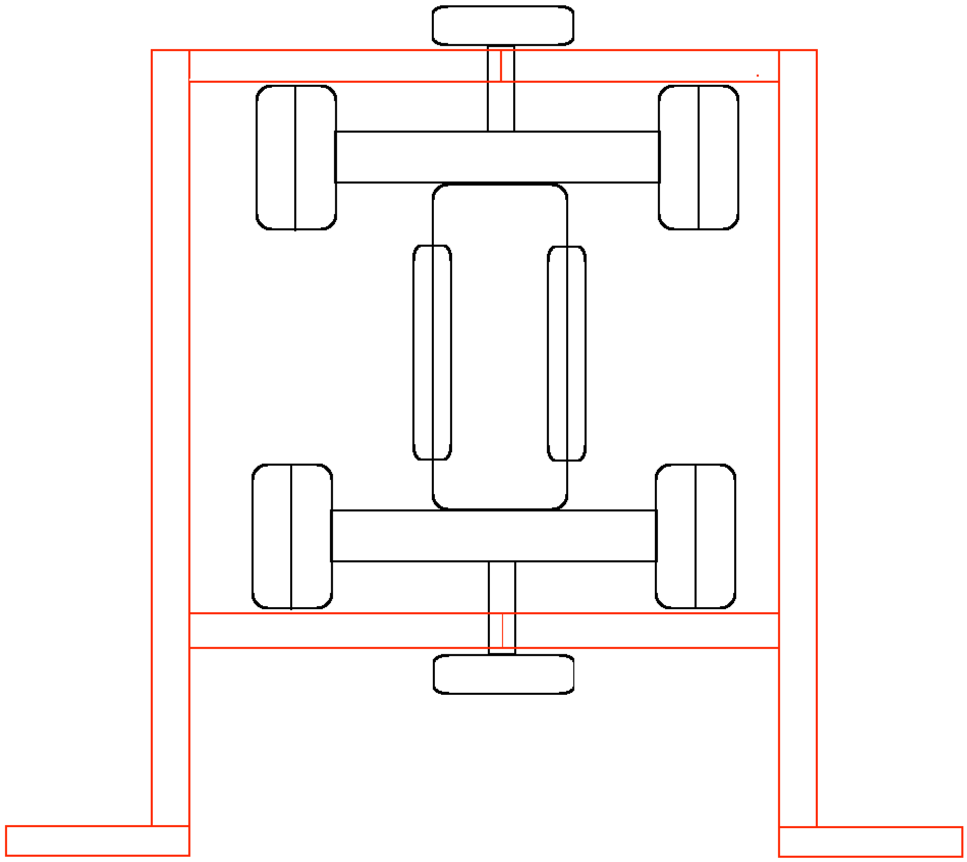
The design of the microwave test stand is based on pictures of a similar experiment carried out in a different lab. The RF cavity in the CSU lab is smaller then the cavity used in the original experiment, and some modifications were required to correct the size difference. I spent most of my time interpreting the pictures of the original experiment, and then modifying its design to suit the RF cavity in the CSU lab.

The RF Cavity needs to be positioned upright and raised off the ground to allow space for the pulleys and string to work properly. Therefore, the microwave test stand relies on an aluminum mount that secures the cavity in an upright position. A mount for the RF cavity in the CSU lab was designed to account for the size difference between the cavity in the CSU lab, and the cavity in the original experiment.

I designed and produced the new mount to function in the microwave test stand. I measured the dimensions of the RF cavity, sketched possible designs, and then considered several design constraints. These constraints included the stress of the RF cavity's weight being exerted on the aluminum, and the limited space available for the mount. After the constraints, and the limited capabilities of the equipment used in the machine shop were considered, a final design was produced. Solidworks, a 3D CAD program, was then used to produce technical drawings for the machine shop in the ERC.

I observed the machining and production of the parts from the mount's final design. During this period, several properties of my drawings were corrected from a manufacturer's point of view such as the units I measured in, the order in which I measured, and the tolerances I used. I gained valuable insight to the production portion of the design process. I changed my future drawings to match this understanding, and hopefully saved the lab and the machine shop time, money, and frustration.

The final design incorporated two aluminum stands that mated to the table using screws and an L-bracket style design. The stands hold the RF cavity at four points; at both the top and bottom of the cavity's vacuum tube, and on either side of the vacuum tube. The final design is illustrated in figure 3.



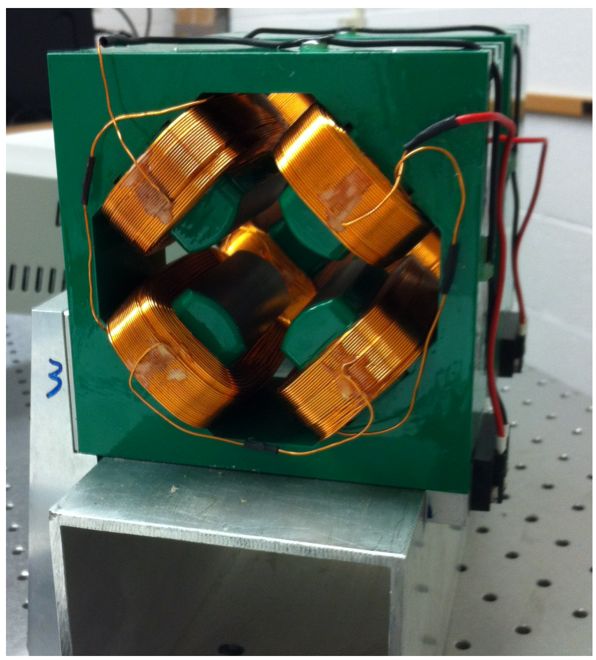
(Figure 3: The RF Cavity Stand depicted in red)

Several smaller changes were made to the design of the original experiment. I designed a mount to match the small motor already being used in the lab. This mount positioned the motor in place with the rest of the pulley system (Illustrated in Figure 1), but it is currently not being used in the microwave test stand because of a design miscommunication between the lab and machine shop.

The method to control the string's movements with the wheels was devised from the picture of the original experiment. Translation stages, or intermittent fastenings that are moved incrementally in two directions with dials, were used in pairs to permit controllable movement in the x and y-axis. These translation stages were used in pulleys one and two. In this way, the string going through the RF cavity can be accurately controlled

Minimizing the movements of the string outside the movements of the translation stages became a crucial part of the microwave test stand's design. Special wheels, with a "v-cut" groove were procured to eliminate the chance of the string moving in the groove of the wheel. These wheels were attached to the rest of the system using modified L-brackets from Home Depot. The spring in figure 2 was also added to the design to reduce movement. The spring increases the tension in the string, and this tension reduces the amount of movement in the pulley system.

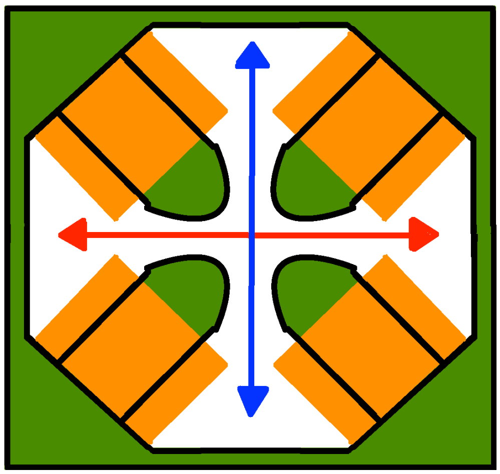
The second test station, the magnetic test stand, was designed to measure the magnetic field of a quadruple magnet. The magnetic test stand at the ERC was designed around and tested on two pairs of donated quadruple magnets (Figure 5).



(Figure 5: Quadruple Magnets)

The magnetic test stand functions using a Hall probe sensor that moves inside and around the magnet's magnetic field on several of the aforementioned translation stages. The Hall probe, in combination with the translation stages, accurately measures the magnetic field.

During testing, the magnets are powered, and then the Hall probe is moved using the translation stages in incremental points along the x and then y-axis of the magnet's magnetic field (Illustrated in Figure 6). Alysia Dong, another intern who was involved in the lab, developed the magnetic test stand. She designed the mount for the Hall probe, and developed a Labview program that automated the testing and recording of these x and y data points.



(Figure 6: X is depicted in red and Y is depicted in Blue)

When information about the strength of the magnetic field is recorded at each of these points, the data is compiled, and is then used to provide an accurate representation of the tested magnet's magnetic field.

Due to my previous experience with the RF Cavity mount, I had some familiarity with Solidworks. I used this skill to help produce the technical drawings for the Hall's probe's mount. The drawings were given to the machine shop, the Hall probe parts were produced, and then the parts were assembled in the lab.

Chapter 3

Progress, Test Plans, Etc..

The microwave test stand is still being completed. Complications involving the machine shop and the motor mount part have delayed progress with the lab's completion. There are also other difficulties involving the wheels and their compatibility with the mounts. Test plans are still being made for the microwave test stand. An adjustable RF cavity is being produced to test the system, and the appropriate Labview programs are being written to operate the network analyzer and wave-guide interfaces.

The magnetic test stand is complete, thanks to Alysia Dong's work. Test plans for the Hall probe set up are in progress. Before Alysia left the at the start of the 2012 fall semester, she explained the Labview program that recorded the results of the Hall probes measurements to me, wrote a detailed report that outline the testing procedures for the magnetic test stand, and began mapping the magnetic field of one of the quadruple magnets. Alysia prepared everything necessary to continue testing with the system she organized.

A new system is being developed to test an undulator magnet for the Accelerator and FEL lab. This magnet cannot be tested with the magnetic test stand, because of its size and design complicates the use of a Hall probe. I will be assisting Alex D'Audney with his designs for the system that tests the undulator.

Chapter 4

Conclusion

Overall, my internship of 2012 was successful. Colorado State University's Accelerator and FEL lab benefited from the work of me and the other interns. The results of our labor are very tangible; the results being one operational test stand, and one near operational test stand. The internship with Dr. Biedron, Dr. Milton, and their team of graduate students was very beneficial to me and the other interns as well. I studied materials about accelerator-based technology, accelerator's commercial and military uses, and the growing need for people trained in their uses extensively. I also learned about real-world practices; I gained valuable experience in a lab setting, worked with engineers and scientists who have been in the field, and I've witnessed the importance of "User" influence.

Fortunately, I am able to continue my internship into the school year as an independent study course, and I am looking forward to assisting in the continual development of Colorado State's Accelerator and FEL lab.