Constructing and Commissioning a New Scattering Chamber for the Union College Ion Beam Analysis Laboratory

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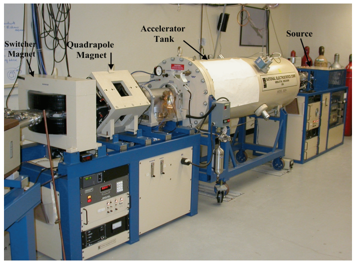

Figure 1: This is a photograph of the Union College Pelletron Accelerator.

Introduction

In the *Union College Ion Beam Analysis Laboratory* (UCIBAL), spectroscopic techniques such as *particle-induced X-ray emission* (PIXE) and *Rutherford back-scattering spectroscopy* (RBS) to analyze environmental samples using the Union College Pelletron Tandem Accelerator (shown in Figure 1). However, the old experimental setup shown in Figure 2 was rather inefficient. The chamber could not draw a vacuum better than 10^{-5} Torr. We could only run one sample at a time before we had to let the chamber up to air, replace the sample, and pump it down again. Due to the weak seal, this process could take up to a half hour or more, adding down time between experimental runs. The purpose of the new chamber is to increase the efficiency of our experiments. We also want to increase the range of elements detectable. By placing the detector inside the vacuum, there will be less attenuation of low energy x-rays, meaning the lighter elements invisible in our old setup may become visible. Ultimately, we wish to build a more complete elemental profile of our air and water samples.

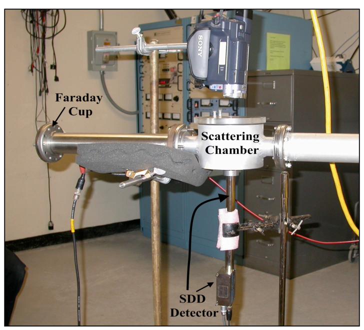

Figure 2: This is a photograph of the scattering chamber, SDD detector, and Faraday cup.

The New Chamber

For the new chamber, we settled on a ten-inch conflat seal multi-way cross pictured in Figure 3. Figure 4 shows the chamber after all the seals were closed off, but before we bolted a turbomolecular pump onto the chamber itself. After attaching the turbo pump onto the chamber, the system was pumped down over a week such that any moisture and oil in the chamber would be evaporated and get pumped out. A vacuum 10^{-8} Torr was achieved.

Figure 3: This is the new scattering chamber before assembly.

The Manipulator and Target Ladder

One of the biggest advantages to the new chamber is that the ability to mount several samples on a target ladder. This way, different targets may be placed in the beam without venting the chamber after each run. The first step was to mount a 3 axis target manipulator atop the scattering chamber, which can be seen in Figure 5. The manipulator allows us to move the targets with micrometer precision. The actual target ladder is shown Figure 6. It can hold up to three targets at a time, meaning we can run PIXE experiments before we have to vent the chamber and change out samples.

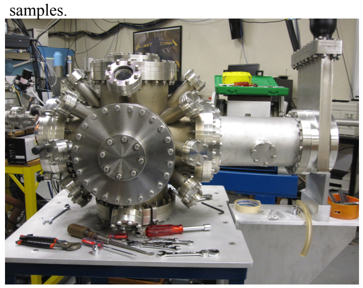

Figure 4: This is the scattering chamber with all the ports closed, but before the turbo pump was attached.

Figure 5: Here, we have the manipulator mounted atop the scattering chamber.

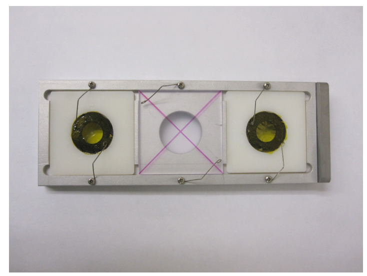

Figure 6: The target ladder with samples. The middle slot holds plastic scintillator, which is used to see precisely where the beam strikes the target.

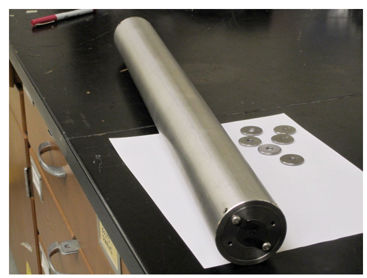

Figure 7: The two collimators sit at opposing ends of a two-foot stainless steel pipe. We have eight tantalum disks with apertures ranging from 1 mm to 8 mm. The beam first passes through the smaller aperture, which defines the beam, and then a slightly larger one, which cleans up the effects of diffraction from the first collimator.

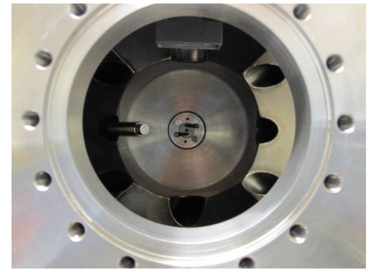

Figure 8: The collimator pipe is inside the beamline. The x-ray detector can be seen on the left, and the target ladder attaches to the top piece. The faraday cup attaches to this port.

Collimators

The proton beam has little use to us unless it is focused down to a small beam spot. To control the beam spot size, we use a set of collimators. We Built a full set of collimators (shown in Figure 7) out of tantalum. The collimator apertures range from 1 to 8 mm in diameter

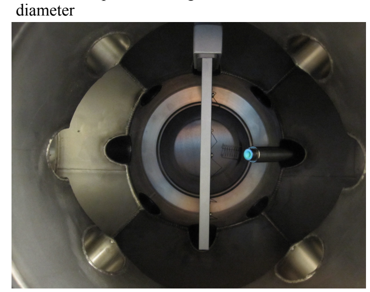

Figure 9: The target ladder is mounted inside the scattering chamber. The beam enters from the right and the faraday cup used to collect charge is to the left.

Preliminary Results

After all of the connections were made, we calibrated the detectors by taking data on a standard of known elemental concentrations. The lead standard is shown in Figure 10. Once calibrations were complete, we ran some sets of aerosol samples. One such run is displayed in figure 11.

Future Work

Now that our scattering chamber is operational, we will continue to run samples. Our next tasks will be to improve the signal to noise ratio of our silicon drift-detector and to acquire a better faraday cup. As seen in Figure 11, there is some noise in the high-energy end of our spectrum. The most likely cause is that charged particles produced in our experiments are interacting with the detector. Also, our final faraday cup measures a small current even when there is no beam, meaning there is a grounding issue in our circuit. We are in the process of attaching a better cup to eliminate these spurious measurements in the charge integrator. The ultimate goal is to be more accurate in measuring the elemental concentrations of our samples.

Acknowledgements

I wish to thank my lab partners Rob, Maria, and Chris, and my physics professors, Scott and Mike. I also wish to thank union college for the summer research grant.

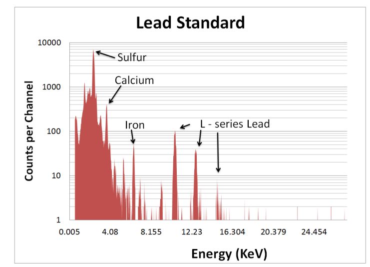

Figure 10: This is a PIXE spectrum of a lead standard on a Mylar backing. The three peaks show lead at a concentration of 44 µg per cm^2.

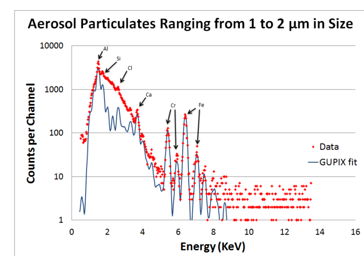

Figure 11: This spectrum is from an aerosol sample taken in a physics classroom. The blue line is a fit to the data by GUPIX. The spectrum includes the aerosol and the Kapton background.