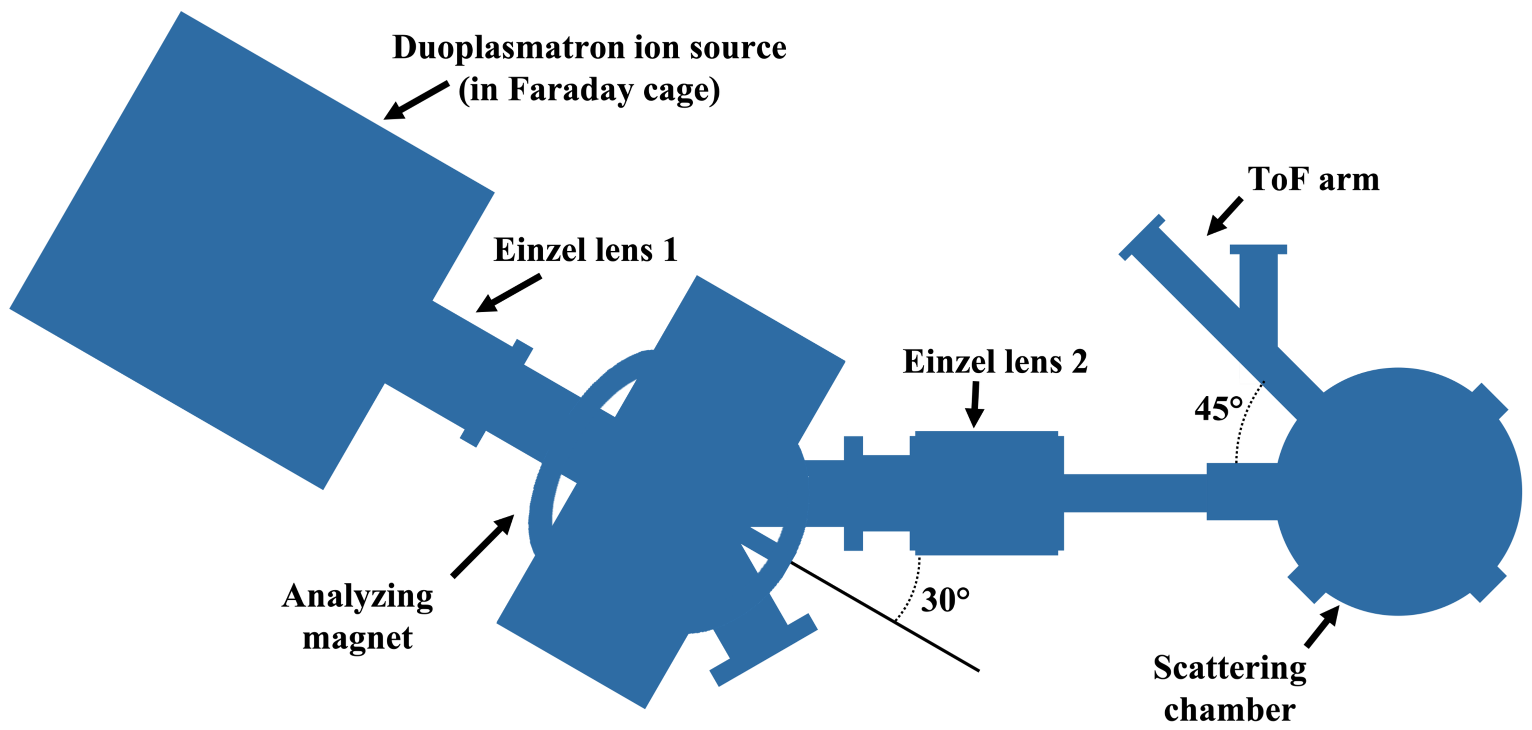
Time-of-Flight Spectrometer Experimental Campaign

Noah Helburn, Michael Fabrizio, Kurt Fletcher

State University of New York at Geneseo

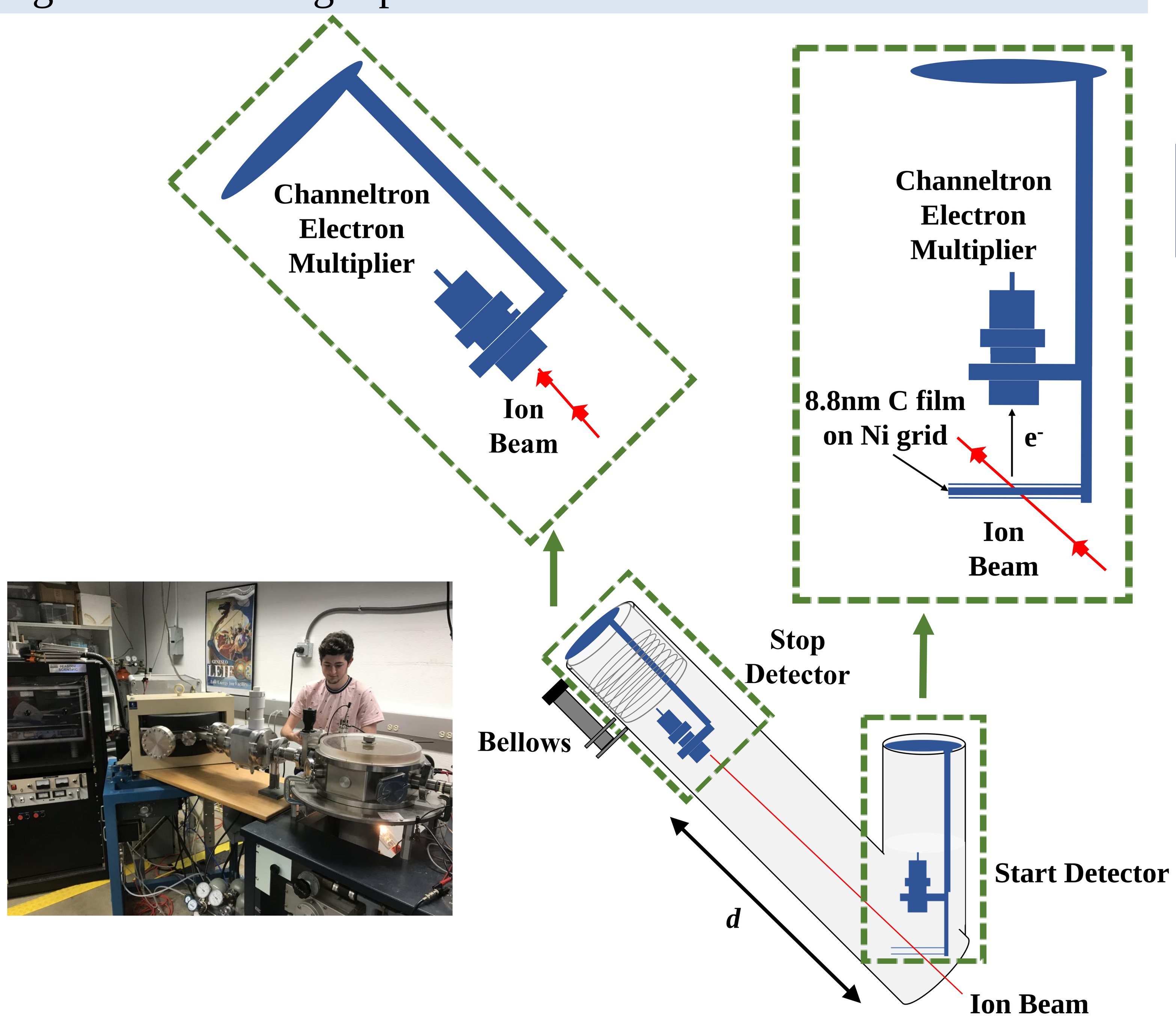
Introduction

A Peabody Scientific PS-100 Duoplsmatron ion source at the Low Energy Ion Facility (LEIF) is being used to improve the accuracy of a Time-of-Flight Spectrometer using low energy (~50 keV) ions via Rutherford backscattering at SUNY Geneseo. Surface analysis of target materials are currently being anyalyzed.



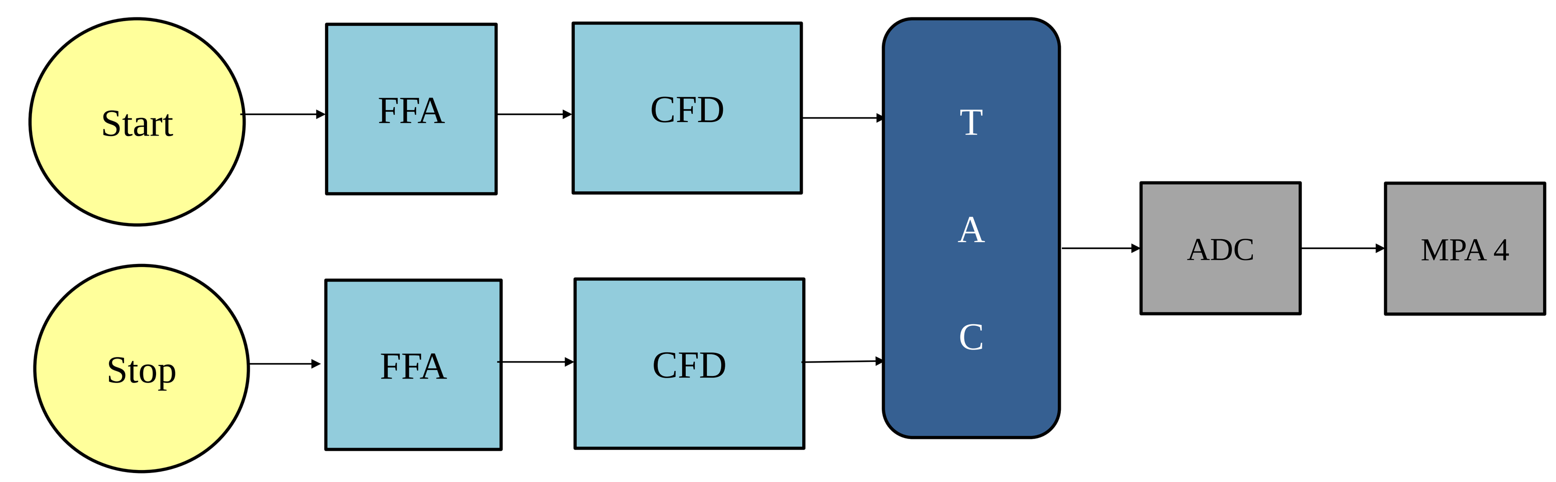
ToF Arm

Elastically scattered ions pass through a biased 5 μg/cm^2 carbon foil, causing the foil to emit electrons, which are then detected by a Channeltron electron multiplier (CEM), producing a "start" signal. The ions then propagate a certain distance, or flight path, before striking another CEM, producing a "stop" signal. The time between the start and stop signals is the time-of-flight for the ion. The modular design of the spectrometer allows one to modify the length of the ion flight path.

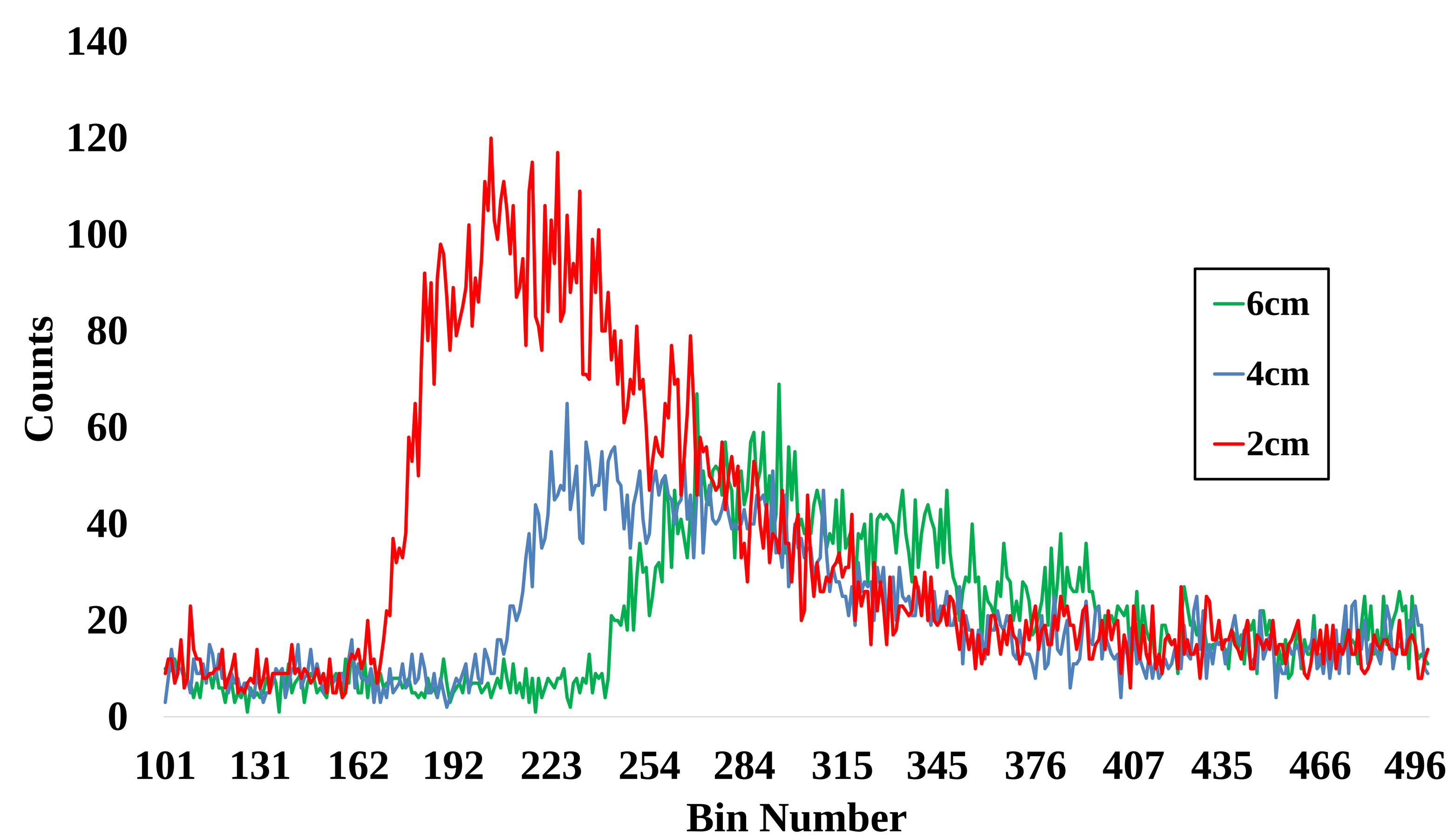


Electronics

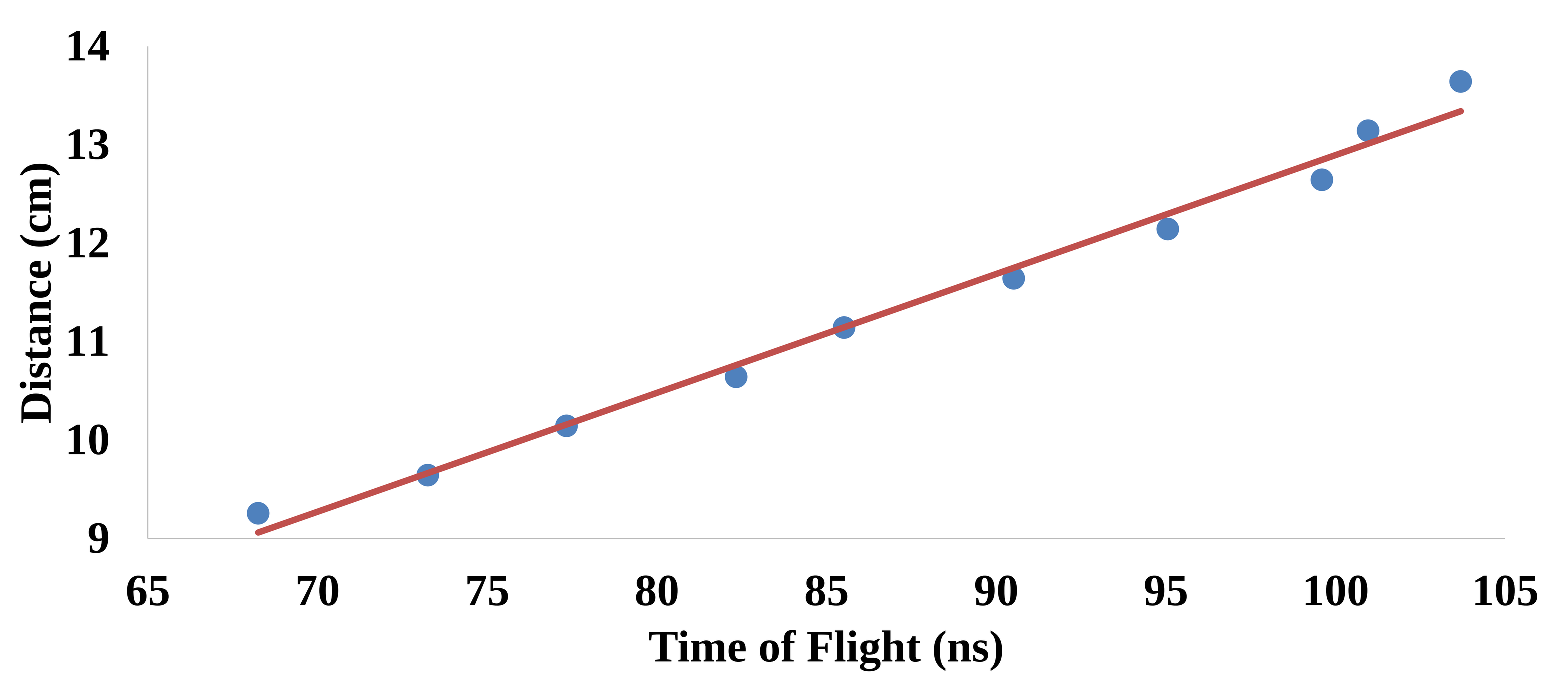
Electrons produced from the carbon foil are used to create the "Start" signal, while the alpha particles are used to create the "Stop" signal. These signals are amplified and converted into a single timing signal in the Time to Amplitude Converter (TAC). An Analog to Digital Converter (ADC) is used to convert the signal to binary that the computer can read.



Data



Results



Multiple bellows extensions were used to take Time-of-Flight data to obtain a distance vs time graph. The slope of this line represents the velocity of the maximum energy alpha particles. The slope is equal to $1.207 * 10^6\ m/s$.

Grid Thickness Measurments

Using a program called SRIM (Stopping and Ranges of Ions in Matter) we can see how much energy the alpha particles lose when going through the carbon foil. Looking at the maximum energy alpha particle for multiple grid thicknesses, an experimental value for the carbon foil thickness could be obtained.

Input Thickness (Ang)	Output Energy (keV)
1000	34.197
1100	31.692
1200	31.299
1300	30.242

$$E = \frac{1}{2}mv^2 \longrightarrow E = 30.258\ keV$$

This Energy most closely matches to 1300 Angstroms which is strong evidence that the thickness of the foil is within a few angstroms of there.

Predicted Times

Research over the semester has led to the discovery of Time-of-Flight (ToF) equations. These describe the electron ToF from the grid to the start detector and the alpha particle ToF from the grid to the stop detector.

Electron ToF

$$t_e = \frac{-\sqrt{\frac{2T_0}{m_e}} \pm \sqrt{\frac{2T_0}{m_e} - 4\left(\frac{q_eV}{2m_ed}\right)(-d)}}{2\left(\frac{q_eV}{2m_ed}\right)} + \frac{d}{c\sqrt{\frac{2(T_0+V)}{m_ec^2}}}$$

Alpha Particle ToF

$$t_\alpha = \frac{L}{\sqrt{\frac{2(E_0-\Delta E)}{m_\alpha}}}$$

Bellows Extension (cm)	Data Time (ns)	Predicted Time (ns)
2	73.253 ± 2	73.476
3	82.343 ± 1.5	81.361
4	90.52 ± 2.5	89.245
5	99.603 ± 3	97.130