Geneseo's Ion Speedometer!

Dr. Kurt Fletcher
SUNY Geneseo
Physics & Astronomy
May 02, 2019

Image: https://www.yourmechanic.com/article/how-to-replace-a-speedometer-cable-and-housing-on-most-cars-by-ty-thompson

Acknowledgements

Many undergraduate researchers...

Most recently, Ethan Nagasing, Ethan Smith, Kallah Eddy

This work has been supported by U.S. Department of Energy through the Laboratory for Laser Energetics (SJP), Indirect Cost Recovery Funds, and the SUNY Geneseo Department of Physics and Astronomy

Sabbatical [*suh*-**bat**-i-*kuh* l] SHOW IPA

EXAMPLES | WORD ORIGIN

SEE MORE SYNONYMS FOR *Sabbatical* ON THESAURUS.COM

adjective

1 of or pertaining or appropriate to the Sabbath.

2 (*lowercase*) of or relating to a sabbatical year.

3 (*lowercase*) bringing a period of rest.

noun

4 (*lowercase*) sabbatical year.

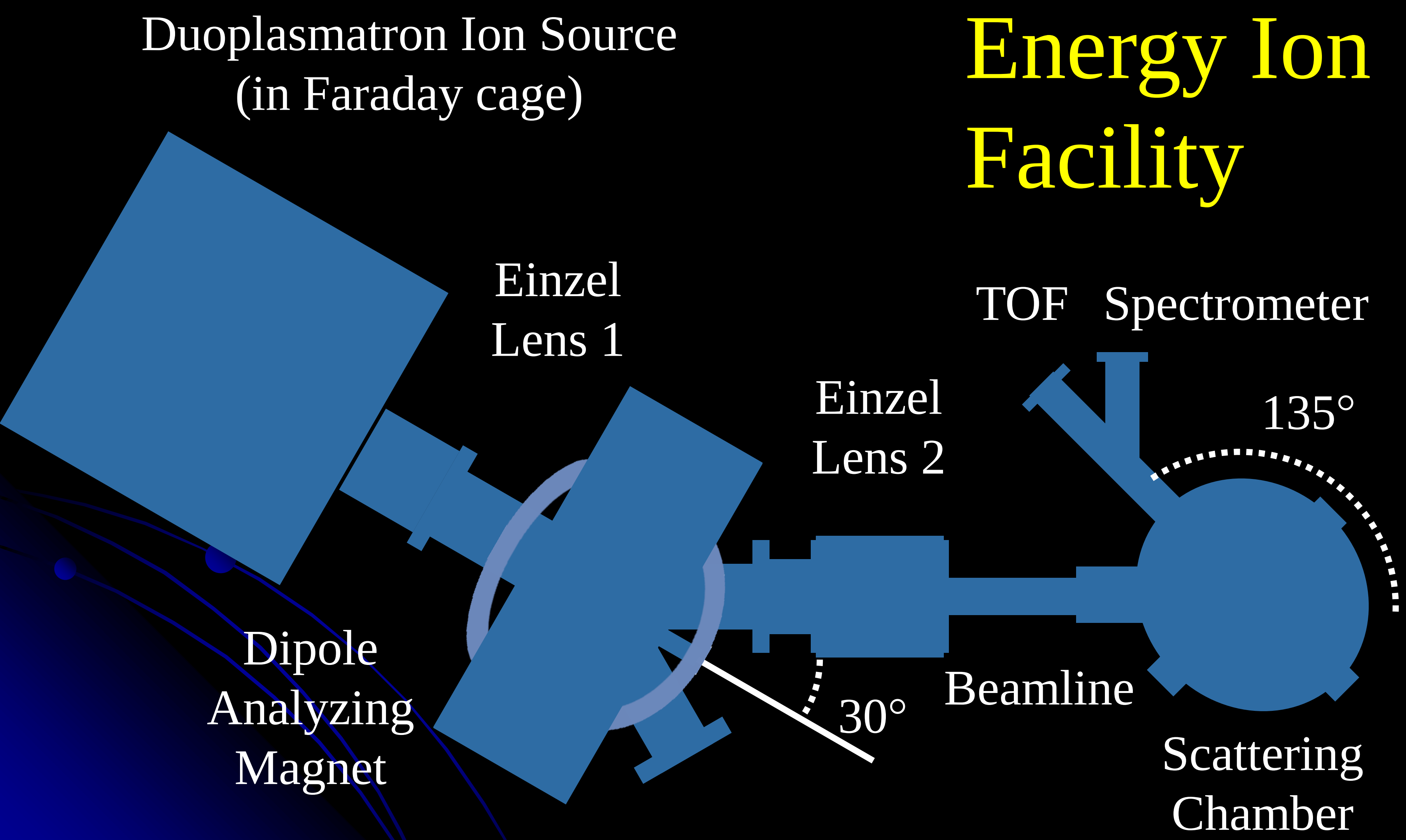
5 (*lowercase*) any extended period of leave from one's customary work, especially for rest, to acquire new skills or training, etc.

https://www.dictionary.com/browse/sabbatical

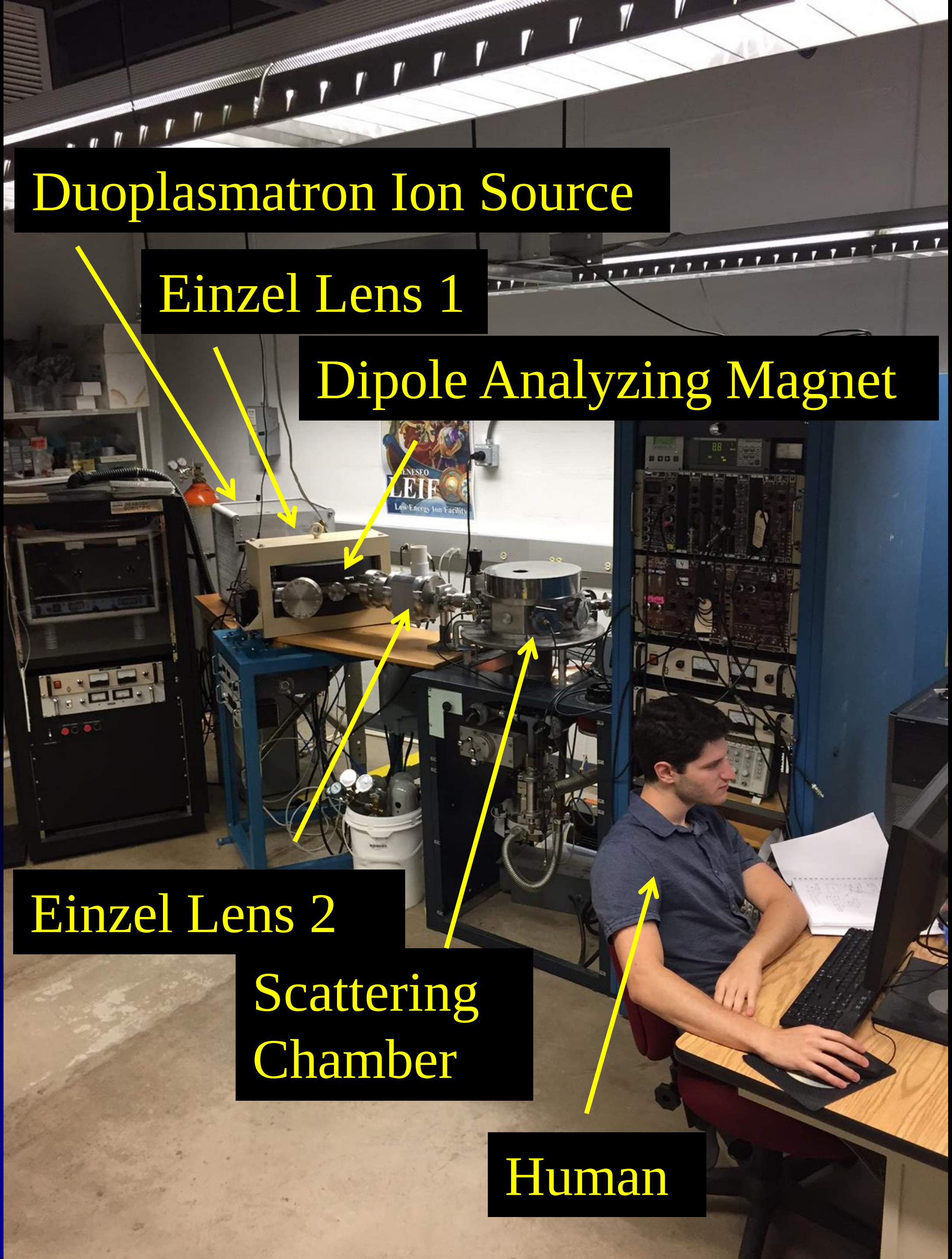
Outline

- The Low Energy Ion Facility
- Rutherford Backscattering
- The Time-of-Flight Spectrometer
- Time Trials
- Thin Film Analysis

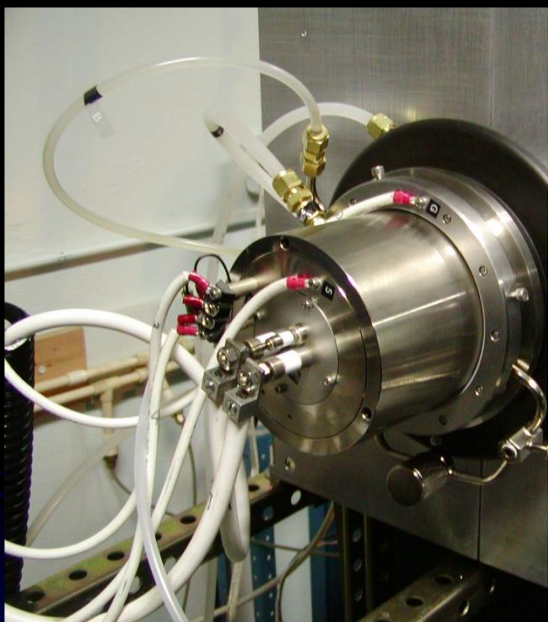
The Low Energy Ion Facility

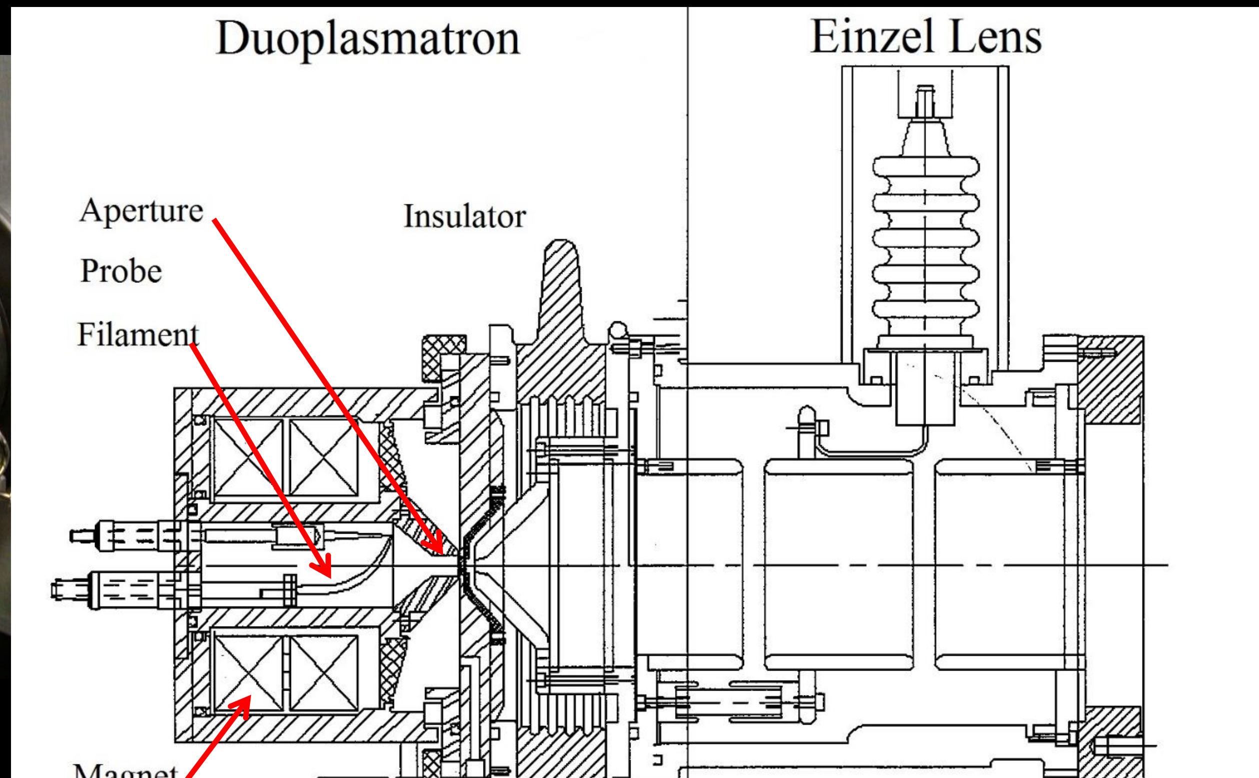


The Low Energy Ion Facility (LEIF)



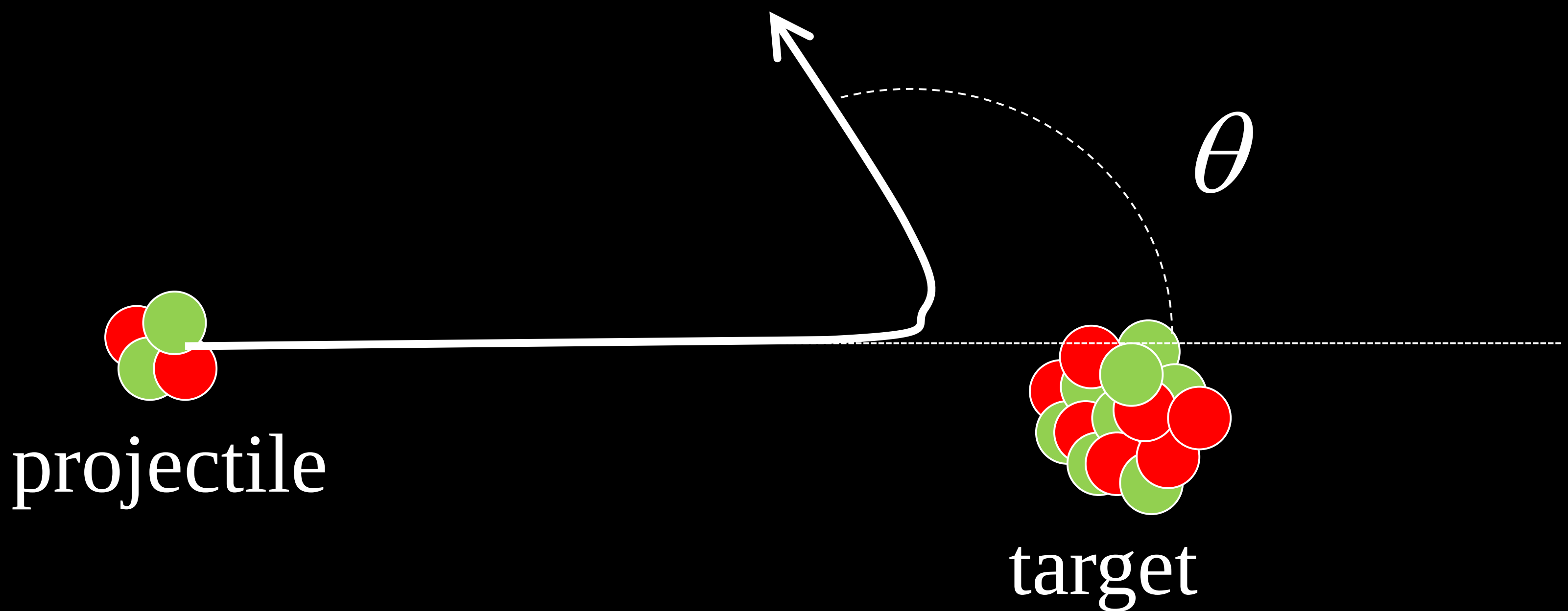
The Peabody Scientific Duoplasmatron Ion Source





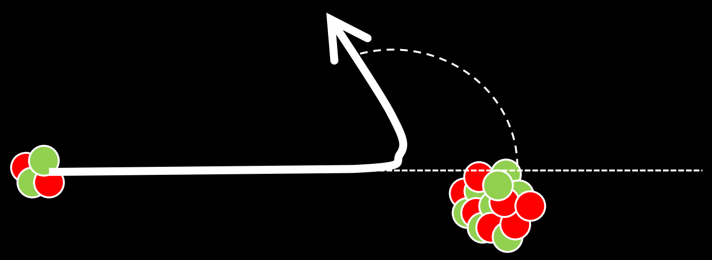
$$0\ kV < V_{source} < 30\ keV$$

Rutherford Backscattering (RBS)



$$N(\theta) = \frac{N_i n t}{16}\left(\frac{e^2}{4\pi\varepsilon_0}\right)^2 \frac{Z_1^{\,2} Z_2^{\,2}}{r^2 (K)^2 \sin^4\left(\frac{\theta}{2}\right)}$$

Rutherford Backscattering (RBS)



Elastic Collision $\boxed{P_i = P_f}$ $\boxed{KE_i = KE_f}$

$$KE_{recoil\ ion} < KE_{projectile}$$

For large M_{target} , $KE_{recoil\ ion} \approx KE_{projectile}$

"The fastest recoil ions bounced off the heaviest target nuclei"

Rutherford Backscattering (RBS)

Rutherford Backscattering (RBS)

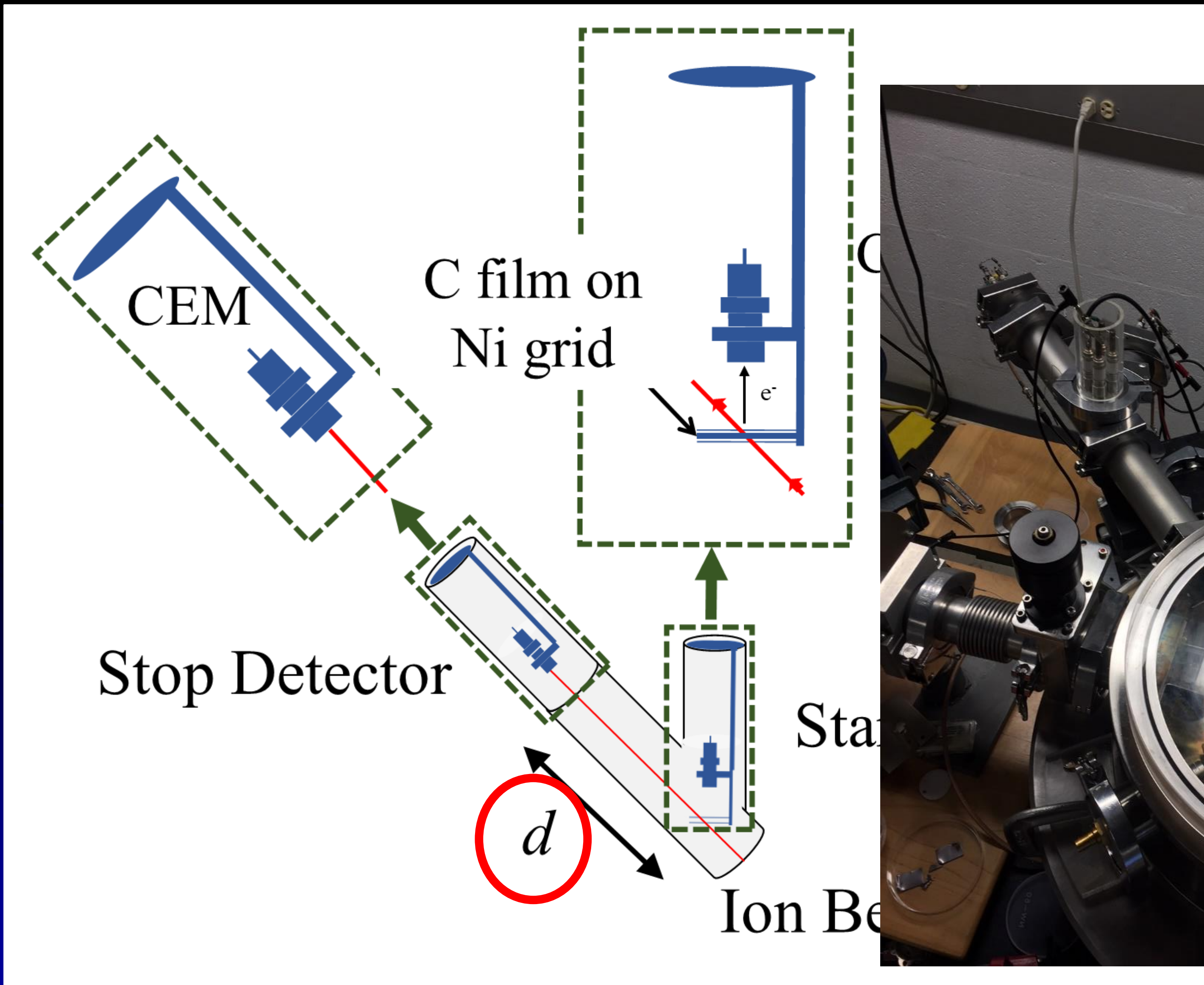
The Big Idea: Use low energy ions for RBS.

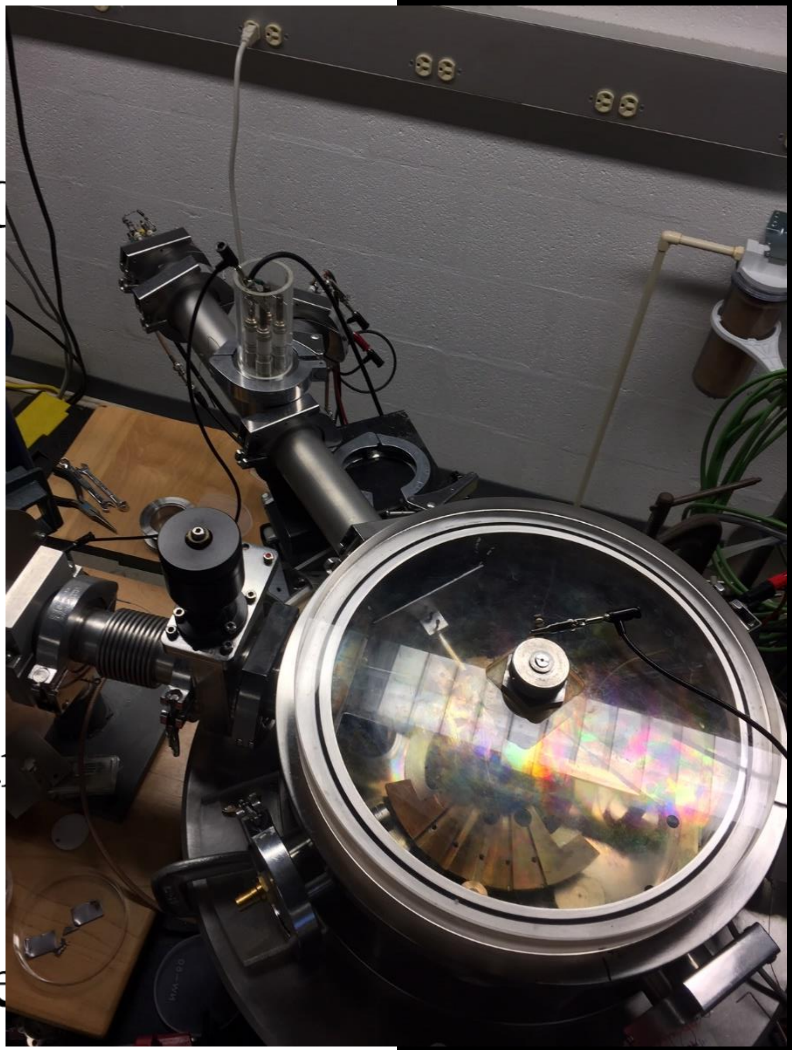
The Advantages

The Problem:
Determining the energy of the low energy ions

The Solution….

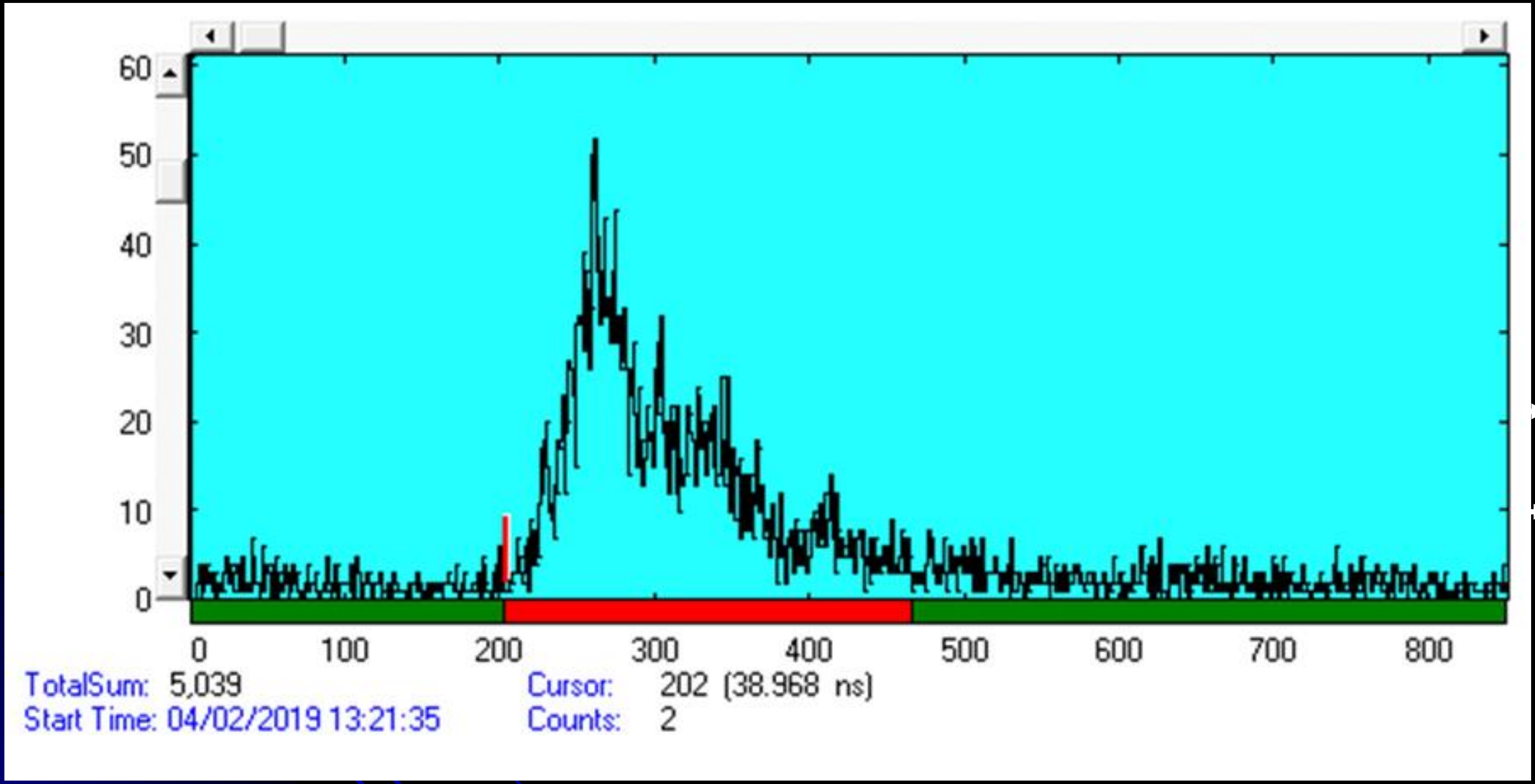
The Time of Flight Spectrometer





The Time of Flight Spectrometer

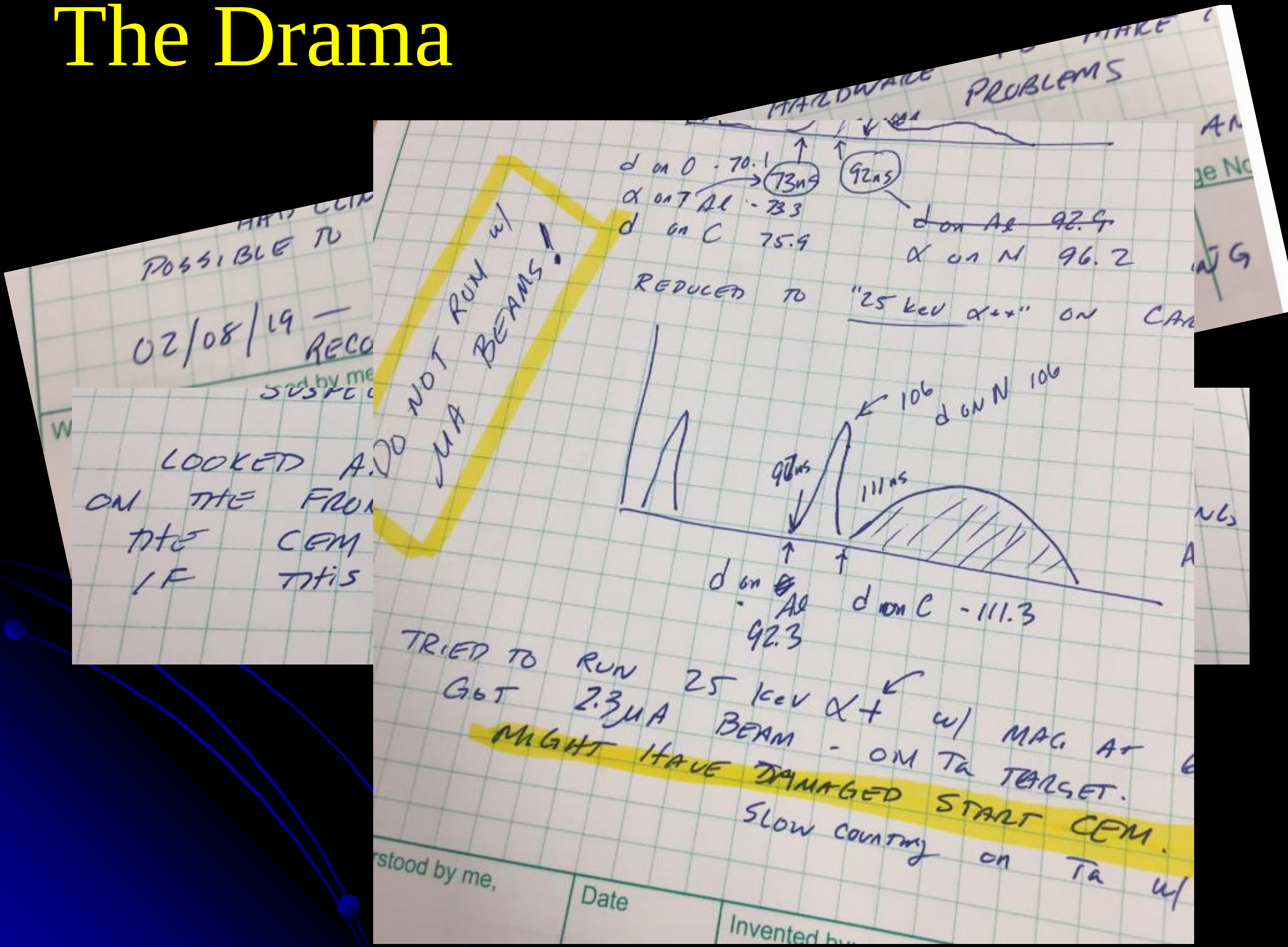
Signal Processing



Time to Amplitude Converter (TAC)

To MPA/Computer

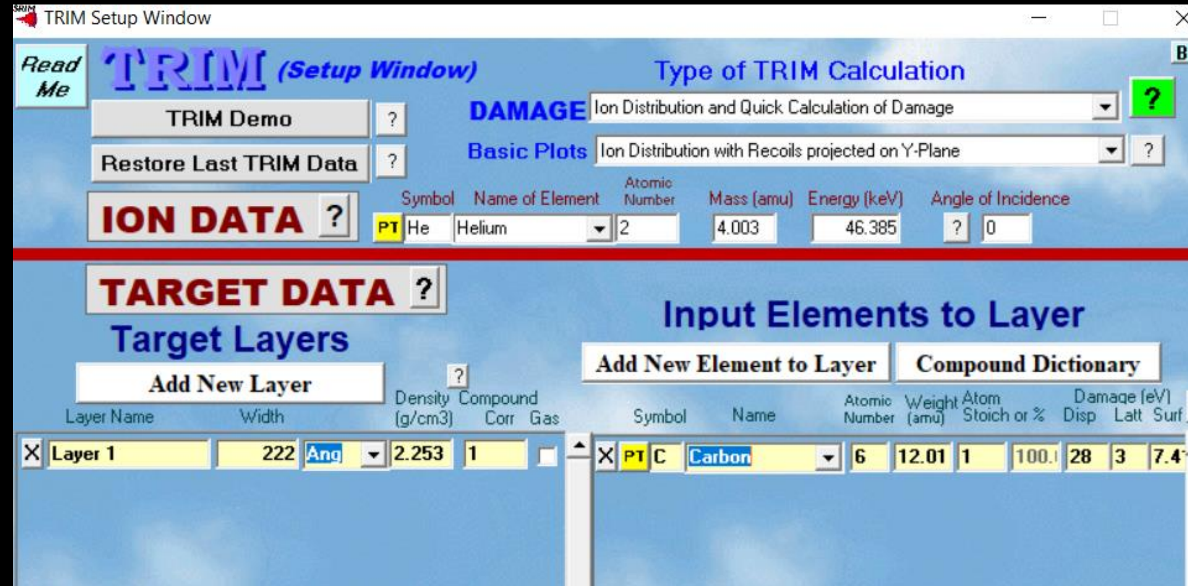
The Drama

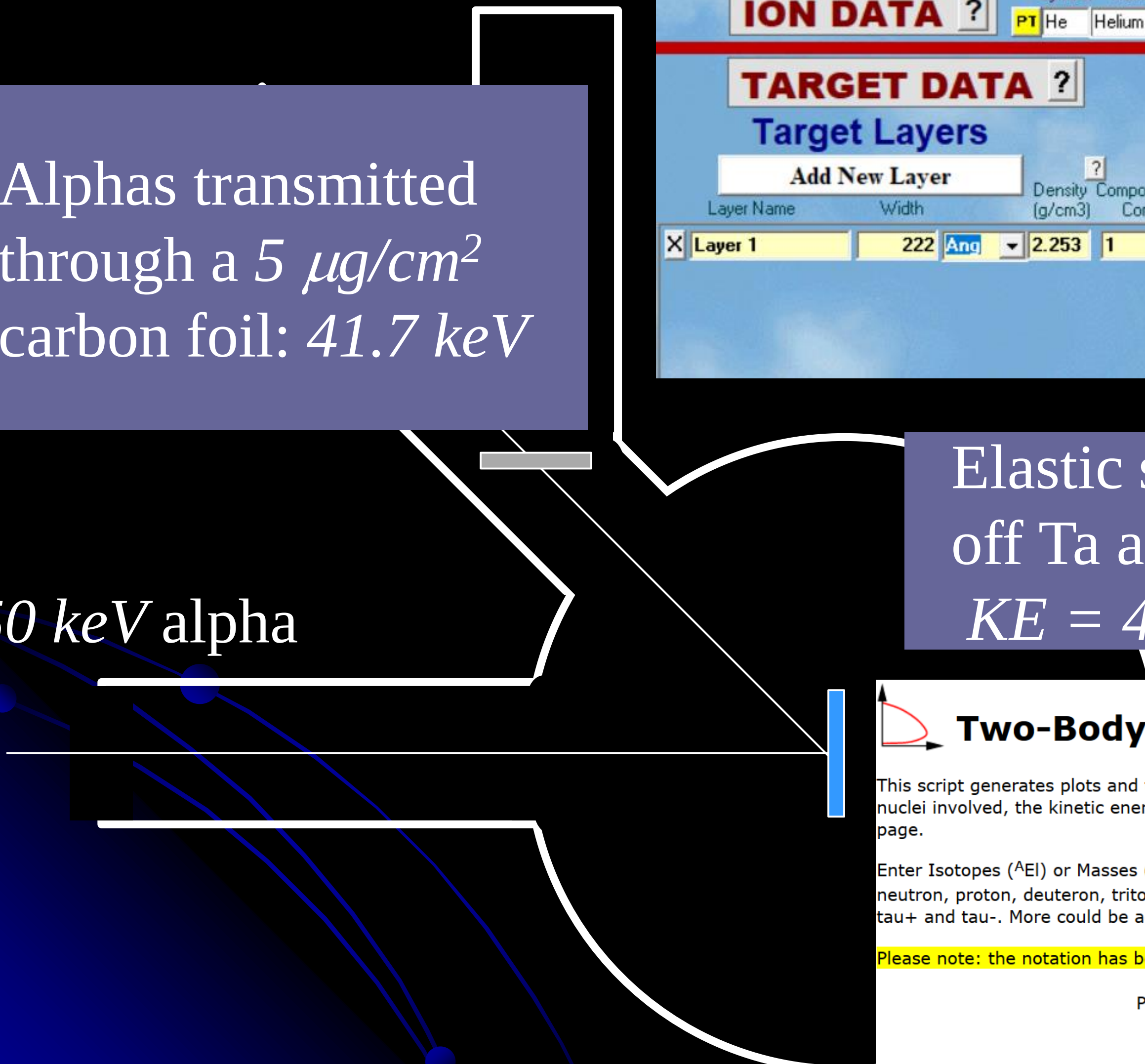


DO NOT RUN w/ μA BEAMS!
d on O - 70.1
α on ? Al - 73.3
d on C 75.9
73ns
92ns
~~d on Al 92.9~~
α on N 96.2
REDUCED TO "25 keV α++" ON
106
d on N 106
92ns
111ns
d on Al - 92.3
d on C - 111.3
TRIED TO RUN 25 keV α+ w/ MAG AT
GOT 2.3 μA BEAM - ON Ta TARGET.
MIGHT HAVE DAMAGED START CEM.
SLOW COUNTING ON Ta w/
HARDWARE
PROBLEMS
POSSIBLE TO
02/08/19 —
LOOKED AT
ON THE FRON
THE CEM
IF THIS
stood by me,
Date
Invented by

Time Trials -

Alphas transmitted through a $5\ \mu g/cm^2$ carbon foil: *41.7 keV*

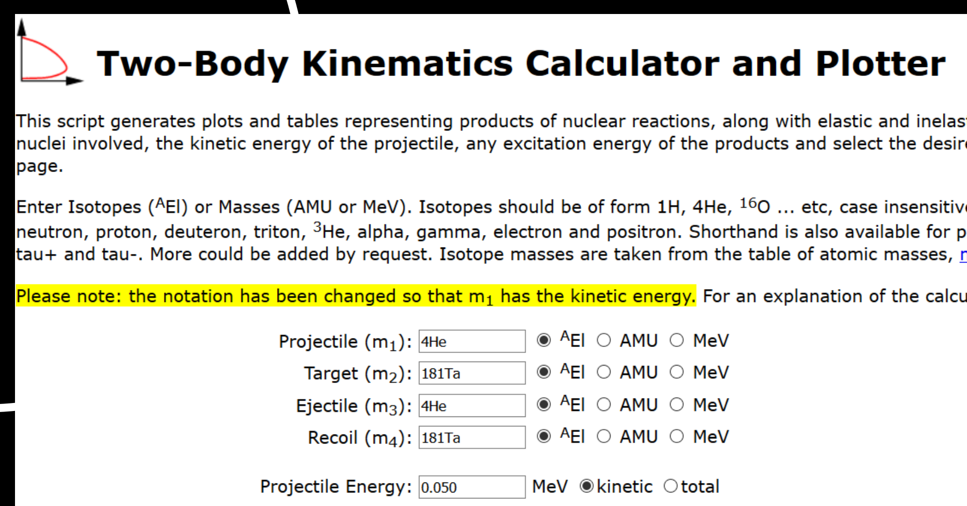




50 keV alpha

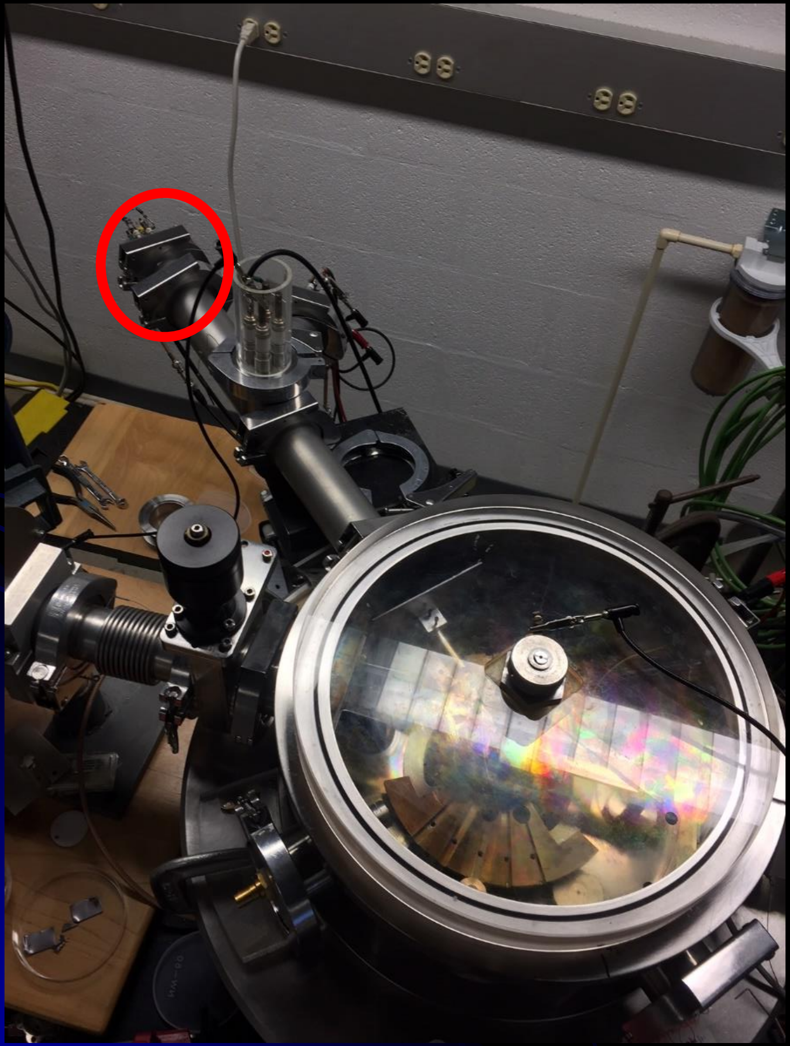
Elastic scattering off Ta at *135°*

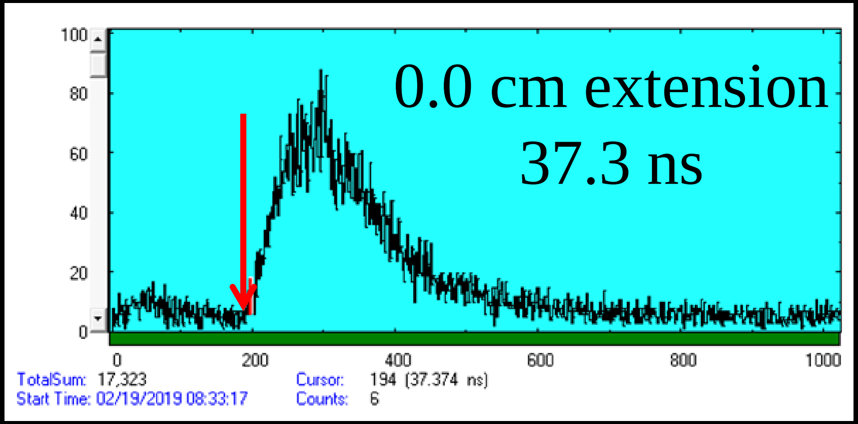
KE = 46.385 keV

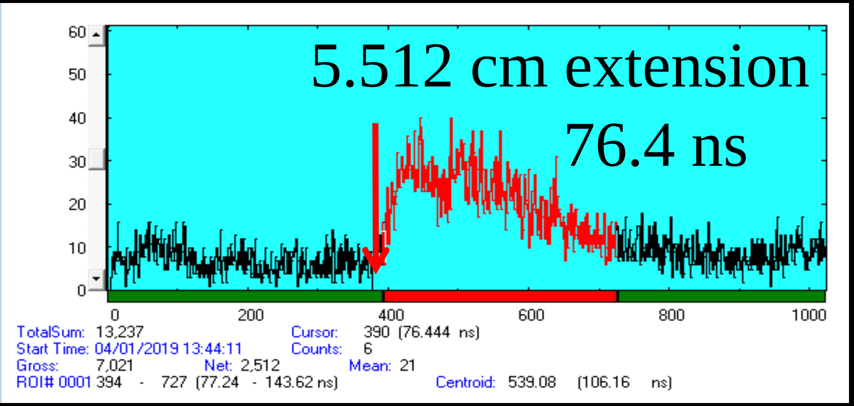


Time Trials - Experiment

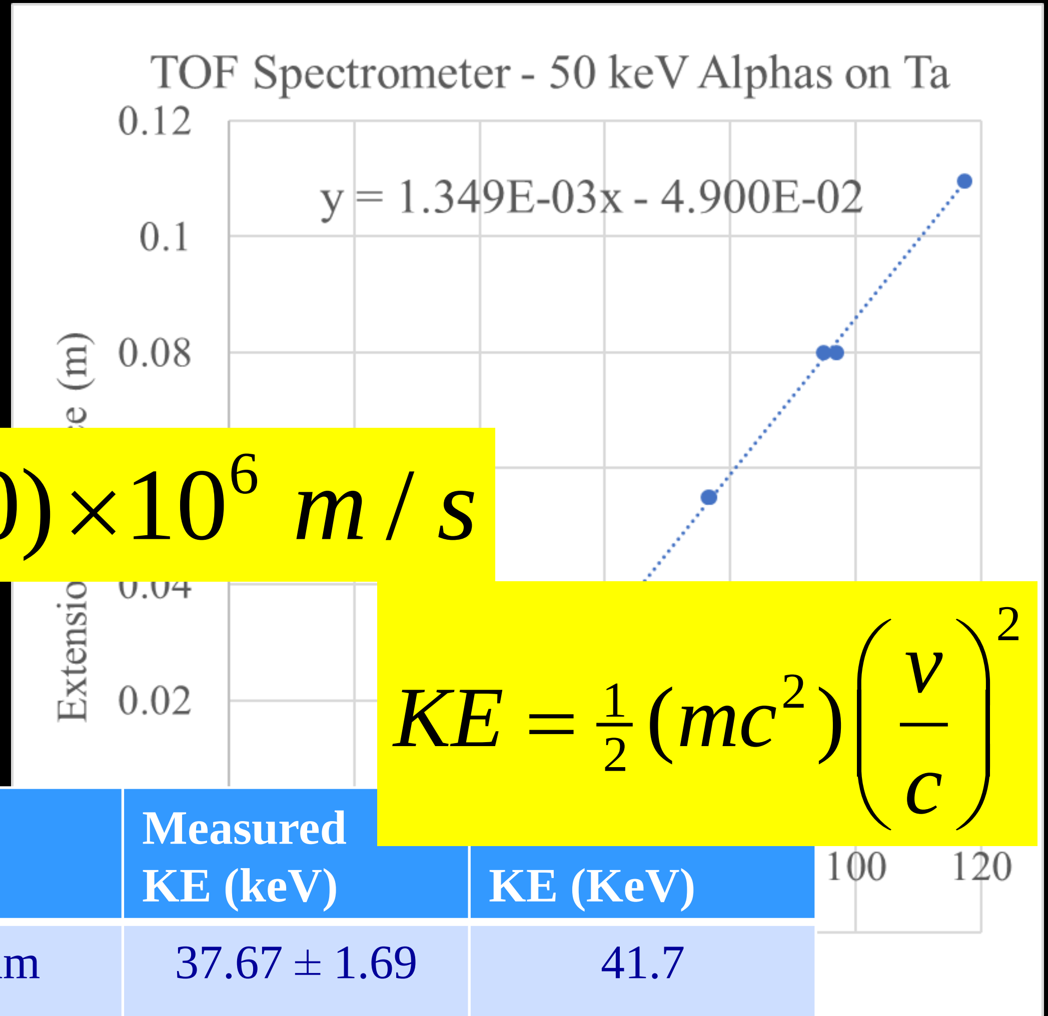
Vary *d* and measure *t*, compare to calculations







Time Trials – Results with Alphas

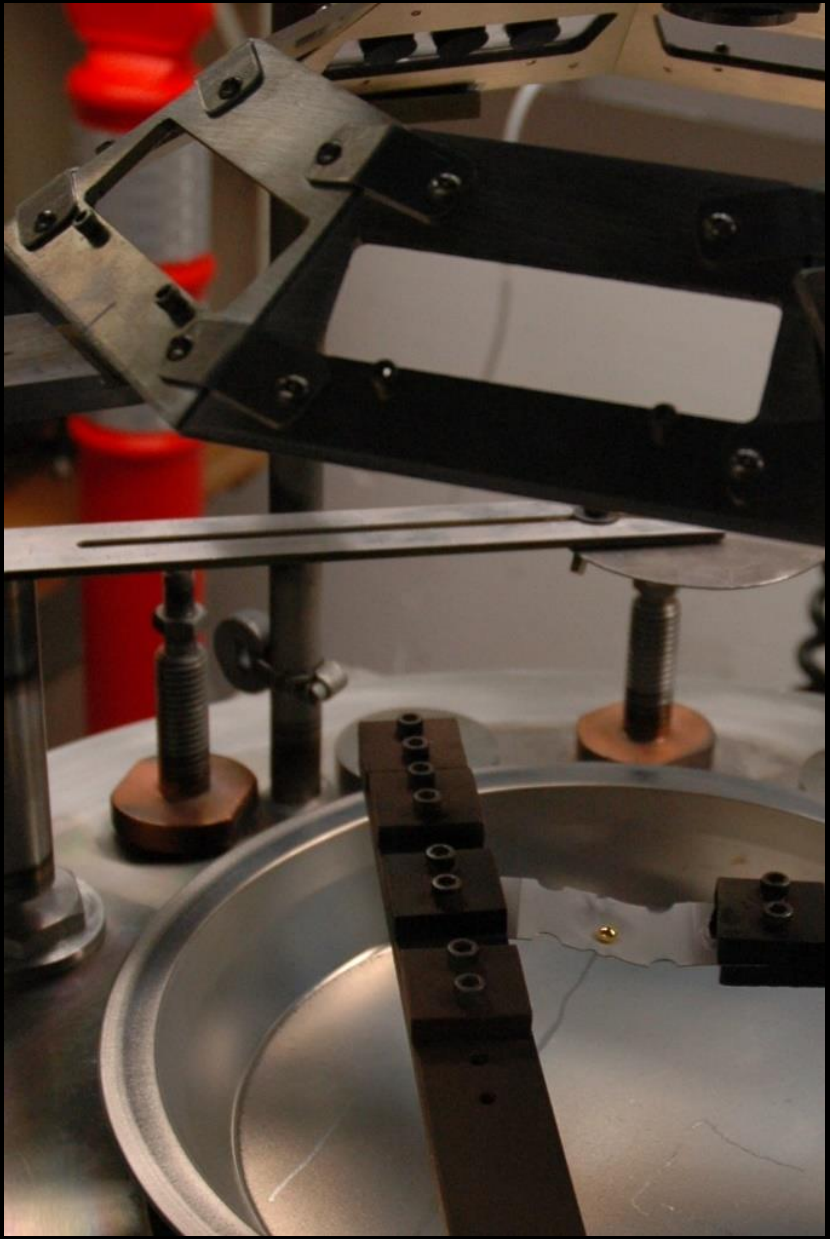


$$v = (1.349 \pm 0.030) \times 10^{6}\ m/s$$

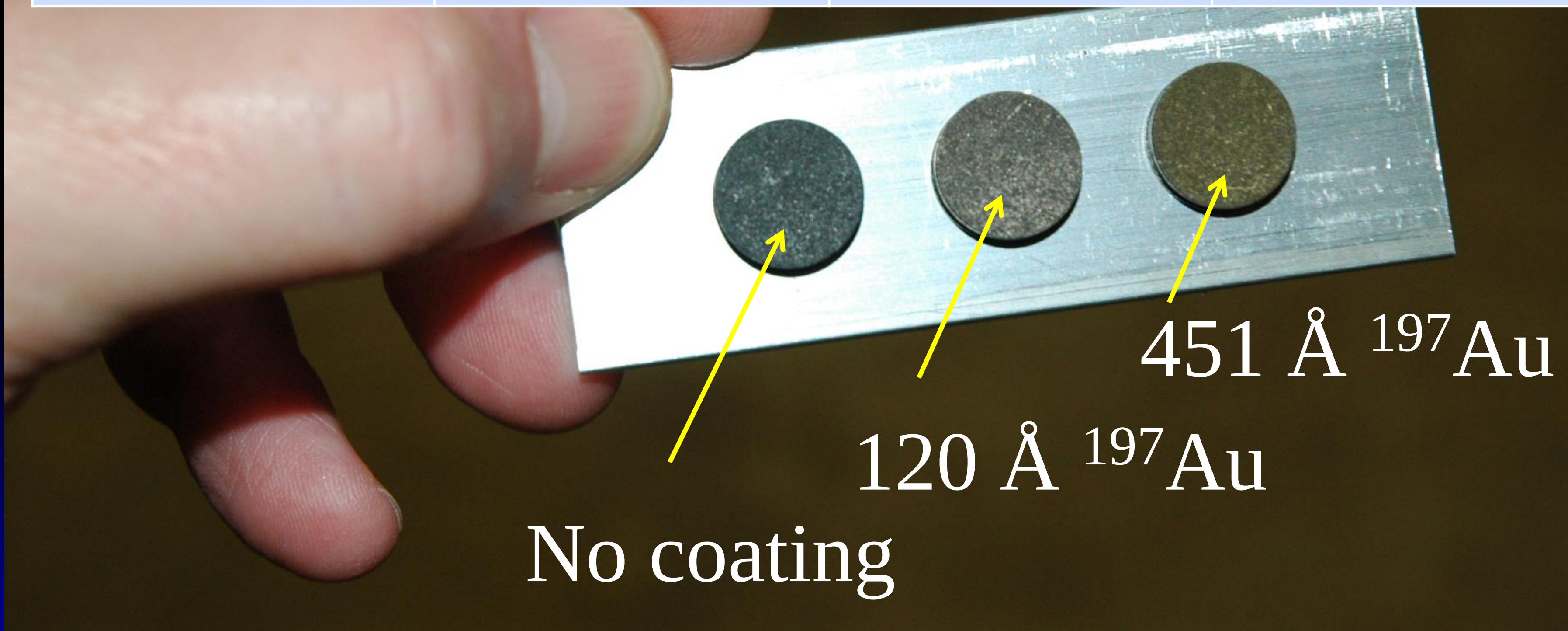
$$KE = \tfrac{1}{2}(mc^{2})\left(\frac{v}{c}\right)^{2}$$

Beam Energy (keV)	Target	Measured KE (keV)	KE (KeV)
50	Tantalum	37.67 ± 1.69	41.7
50	Aluminum	26.3 ± 2.9	26.1
25	Tantalum	19.9 ± 1.6	19.7

Thin Film Analysis Test

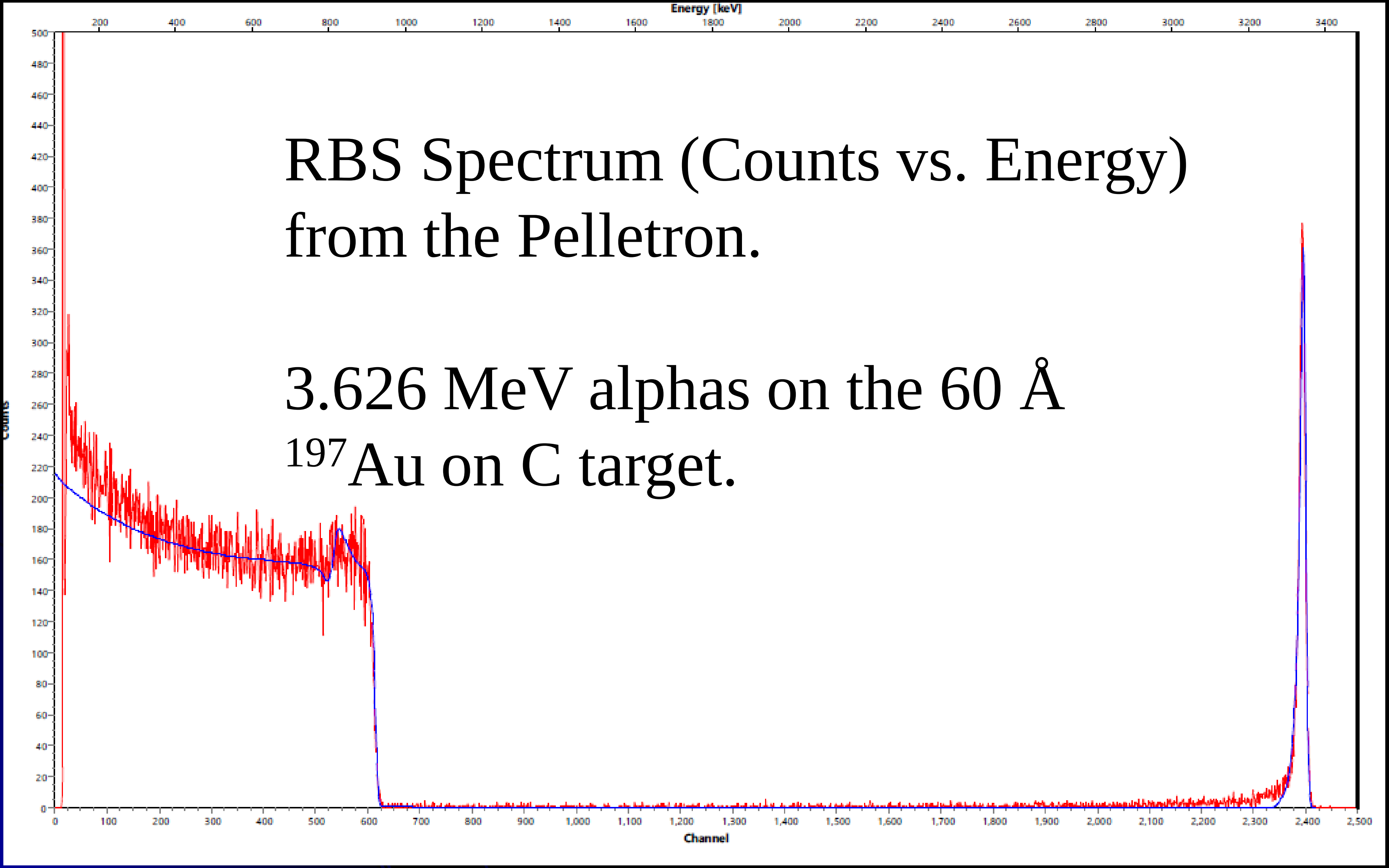


Date	2019-04-23	2019-04-29	2019-04-30
Thickness (RDM)	521 Å	138 Å	70 Å
RDM × Cos(30°)	451 Å	120 Å	60 Å
Thickness (Pelletron RBS)	(444.8 ± 2.2) Å	(101.77 ± 0.71) Å	(56.41 ± 0.60) Å



RBS Spectrum (Counts vs. Energy) from the Pelletron.

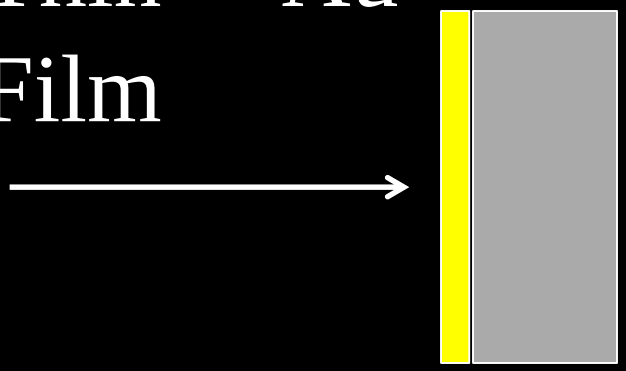
3.626 MeV alphas on the 60 Å ^{197}Au on C target.

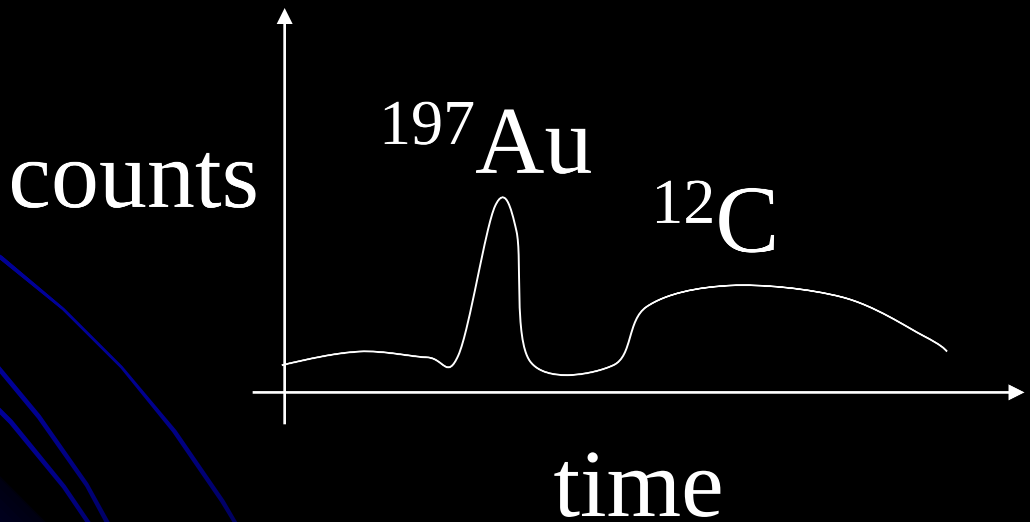


Thin Film Analysis Test   Expectations

Thin ^{197}Au Film

Thick ^{12}C substrate



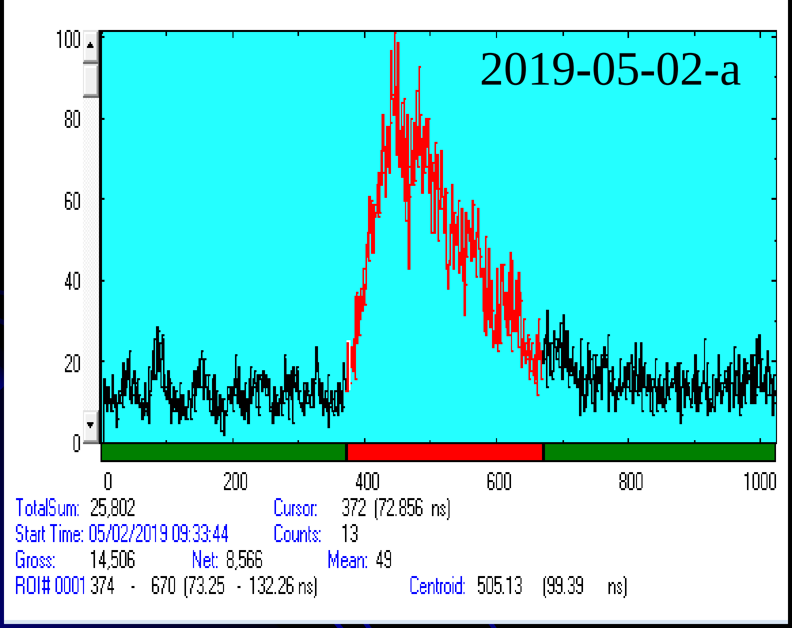


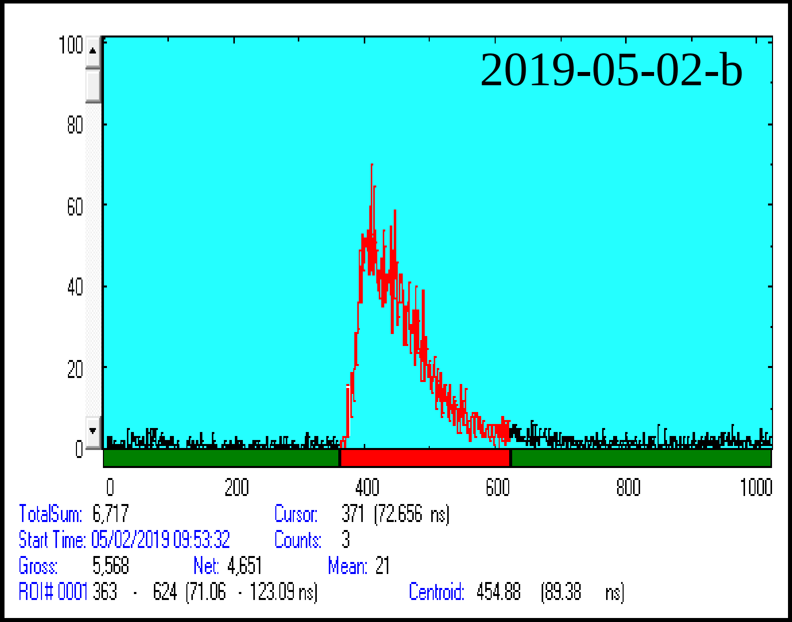
Thin Film Analysis Test

Results (with 5.51 cm extension)

445 Å layer
^{197}Au on ^{12}C

56 Å layer
^{197}Au on ^{12}C





Leading edge *predicted* at 75.7 ns

Same integrated beam current.

"Similar" detector conditions.

Future Work

- CEM Bias / Count rate
- Other ions (protons, deuterons)
- Improve time resolution
- Explore applications – surface science
- Everything's better when you add accordion bellows


PEABODY
SCIENTIFIC
GENESEO

Future Work

- Publish?
- Other ions (protons, deuterons)
- Improve time resolution
- Explore applications
- Everything's better when you add accordion bellows

Summary

A Time-of-Flight Spectrometer has been designed, built, and tested to measure the kinetic energy of low energy ions produced by the duoplasmatron ion source and elastically scattered from targets. The TOF spectra can be used to analyze the surfaces of such targets.

Thank you!