Application of the Velocity Map Imaging Technique to Measure the Angular Distributions of Ultra-Low Kinetic Energy Photoelectrons

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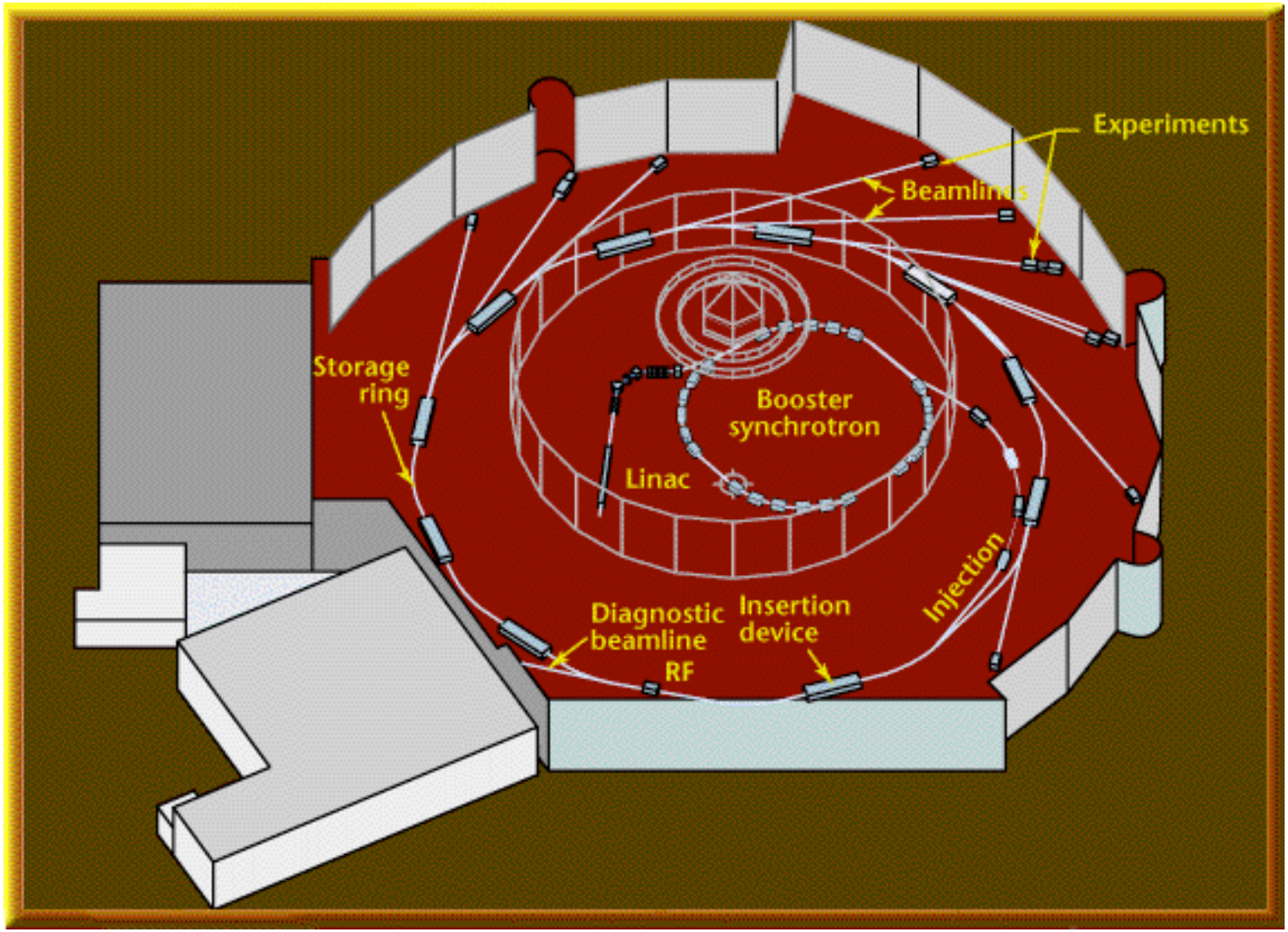
Viewgraph courtesy of LBNL

Layout of ALS



Viewgraph courtesy of LBNL

Motivation

What is the purpose of this project?

•Quantification of correlation effects associated with near-zero (from 100 meV down to 2 meV) kinetic energy photoelectrons.
•Measurement of near-zero photoelectron angular distributions over 4π steradians with minimum magnetic fields.

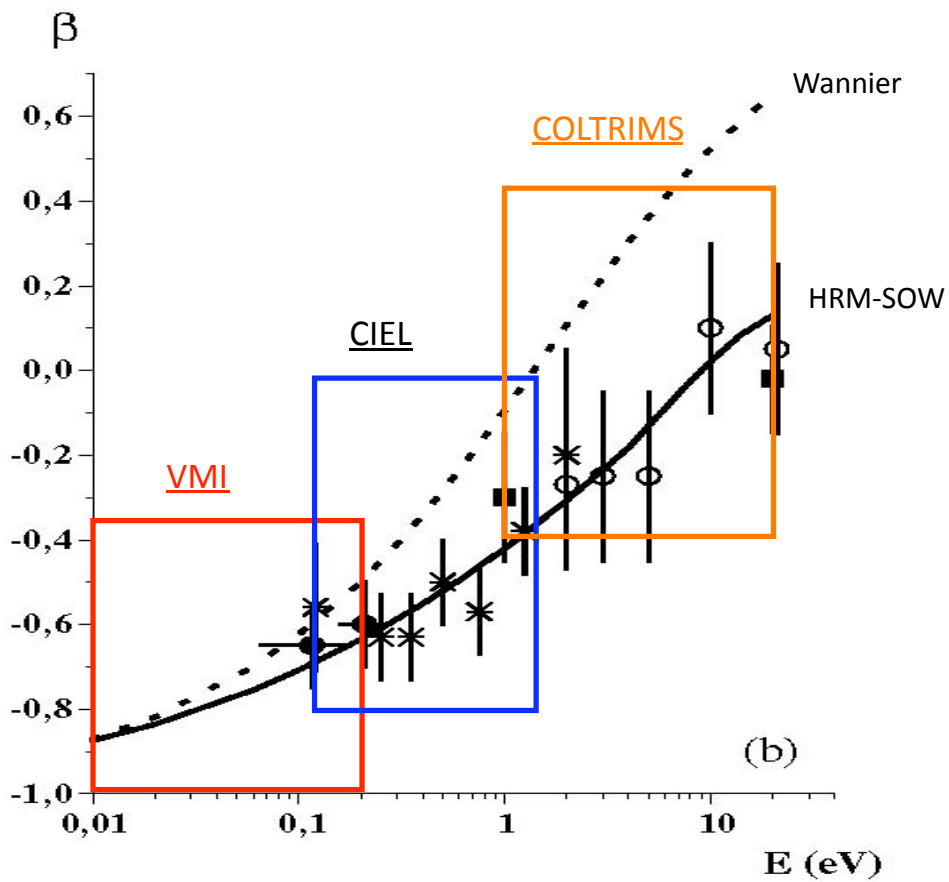
Why is this project important to physics?

•Will provide further understanding into correlation effects at energies where the effects are significant and even become dominant.
•Will provide direct measurement of near-zero photoelectron kinetic energy.

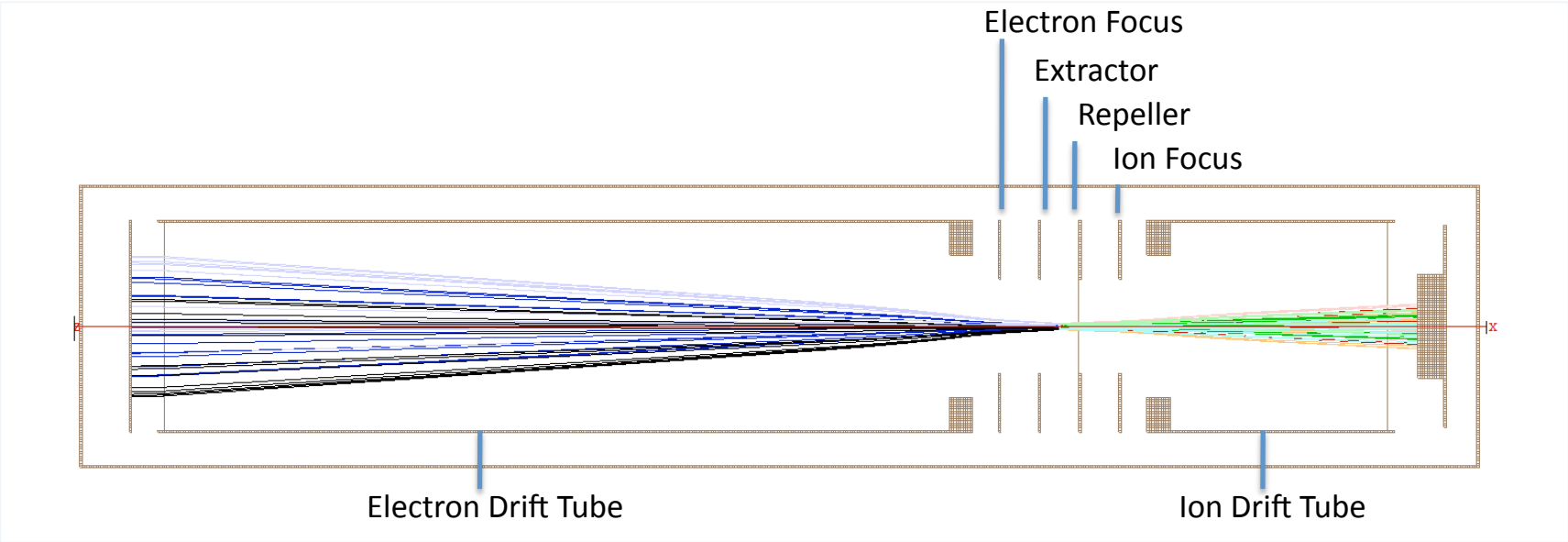
What has been accomplished with this project?

•Applied Velocity Map Imaging (VMI) technique to low K.E. photoelectrons.
•Measured β asymmetry parameters for helium and neon in proof of principle experiments.
•Explored limitations of the VMI technique.

Comparison of Available Techniques



Velocity Map Imaging Spectrometer



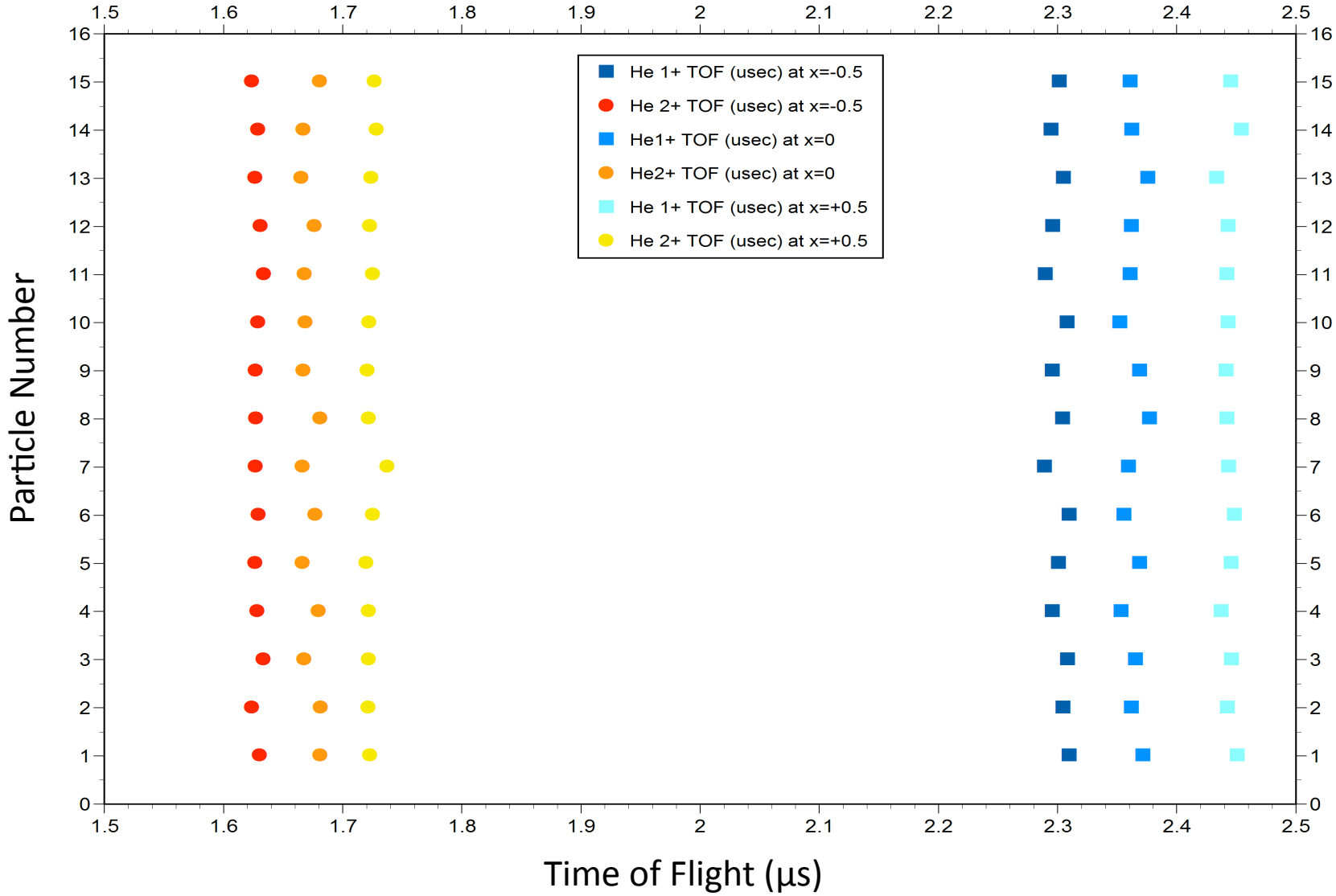
Dimensions

Electron Drift Tube (length): 340 mm
Electron Drift Tube (diameter): 88 mm
Ion Drift Tube (length): 215 mm
Ion Drift Tube (diameter): 88 mm
Electrostatic Lenses (outer diameter): 88 mm
Electrostatic Lenses (aperture diameter) : 40 mm

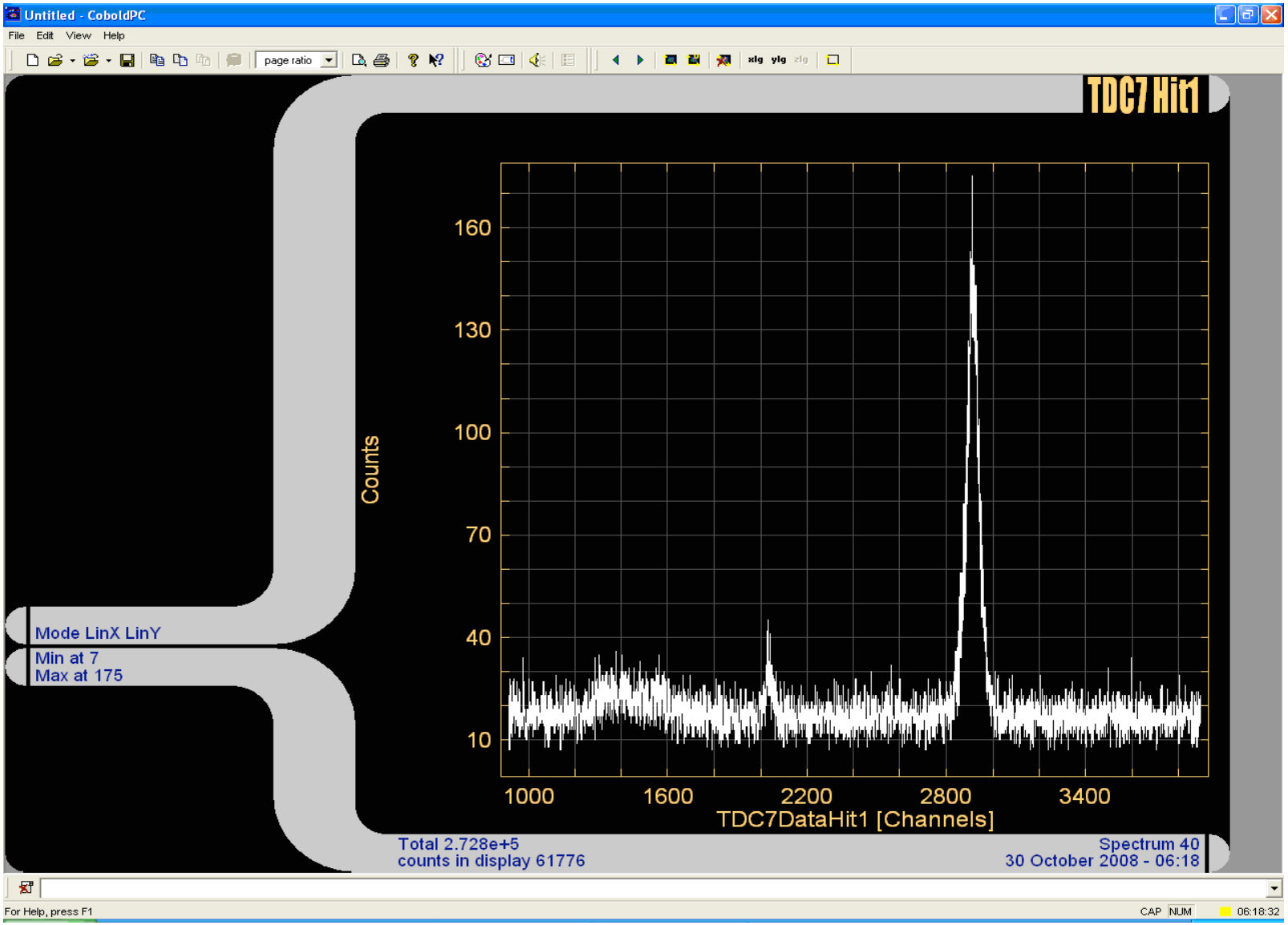
Voltages

Electron Drift Tube: -575 V
Ion Drift Tube: -640 V
Electron Focus: -438 V
Extractor: -534 V
Repeller: -651 V
Ion Focus: -775 V

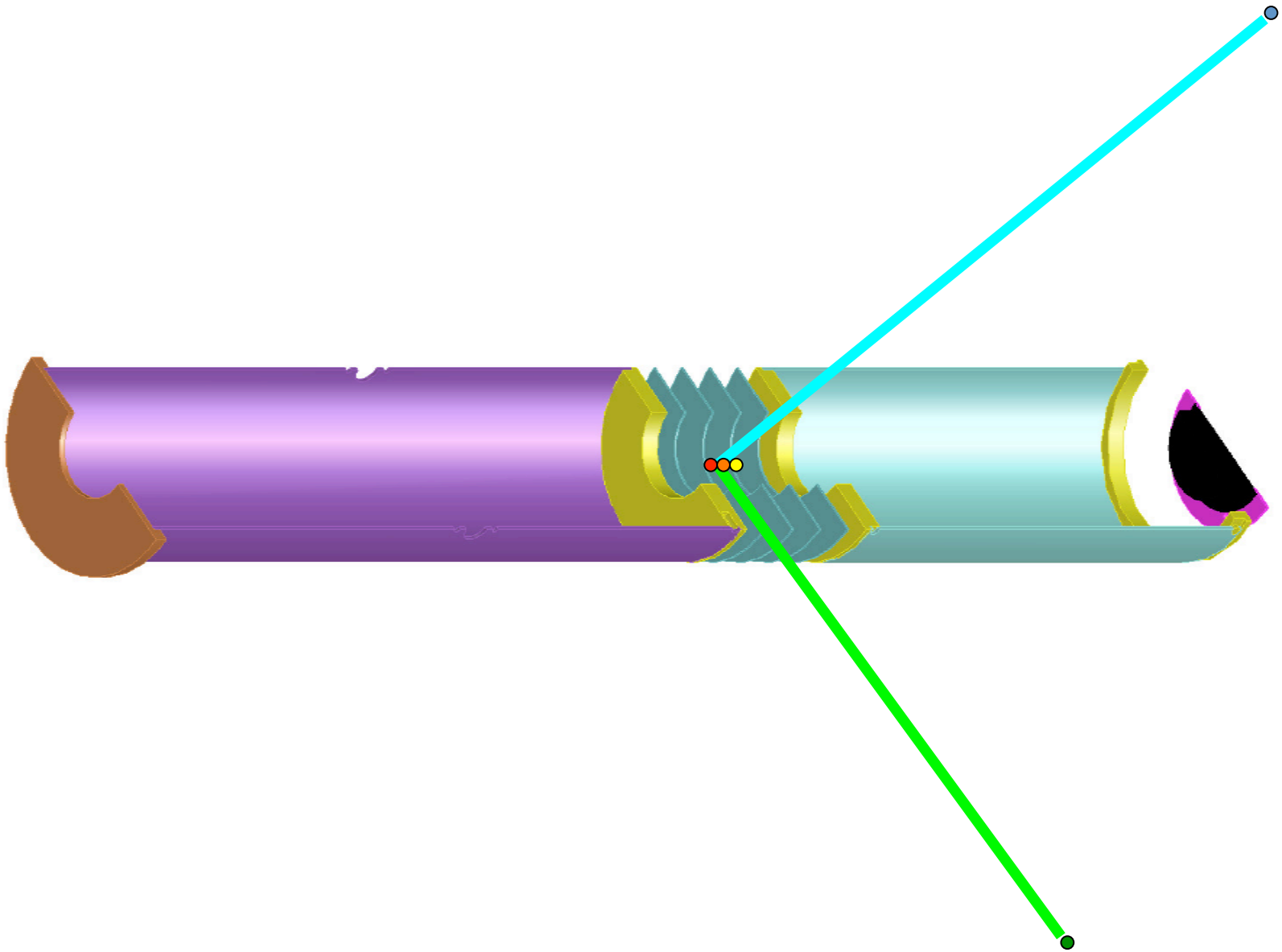
Sample Time of Flights (TOFs) at 100 meV



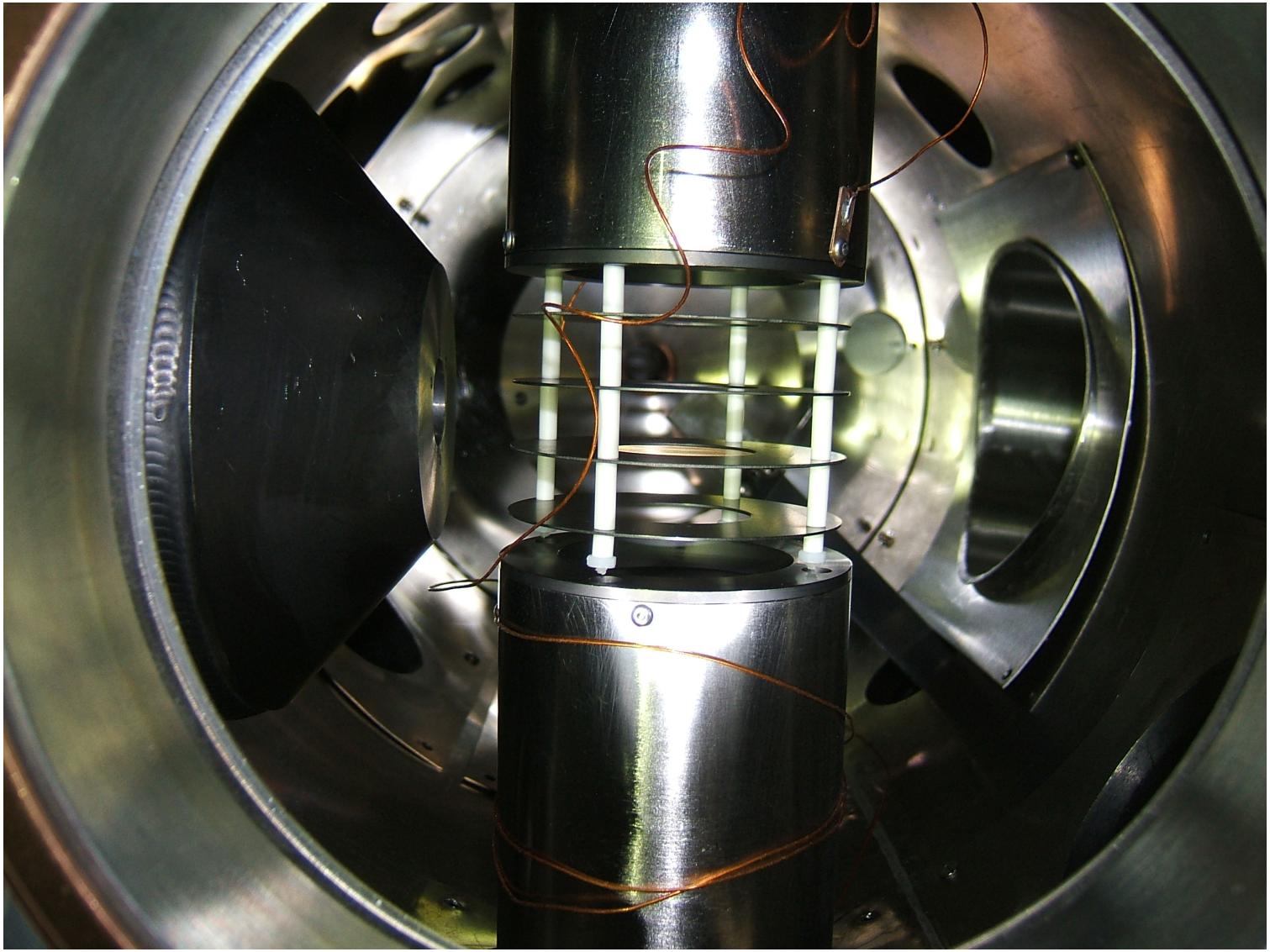
Sample He^{+} & He^{2+} TOF Spectrum



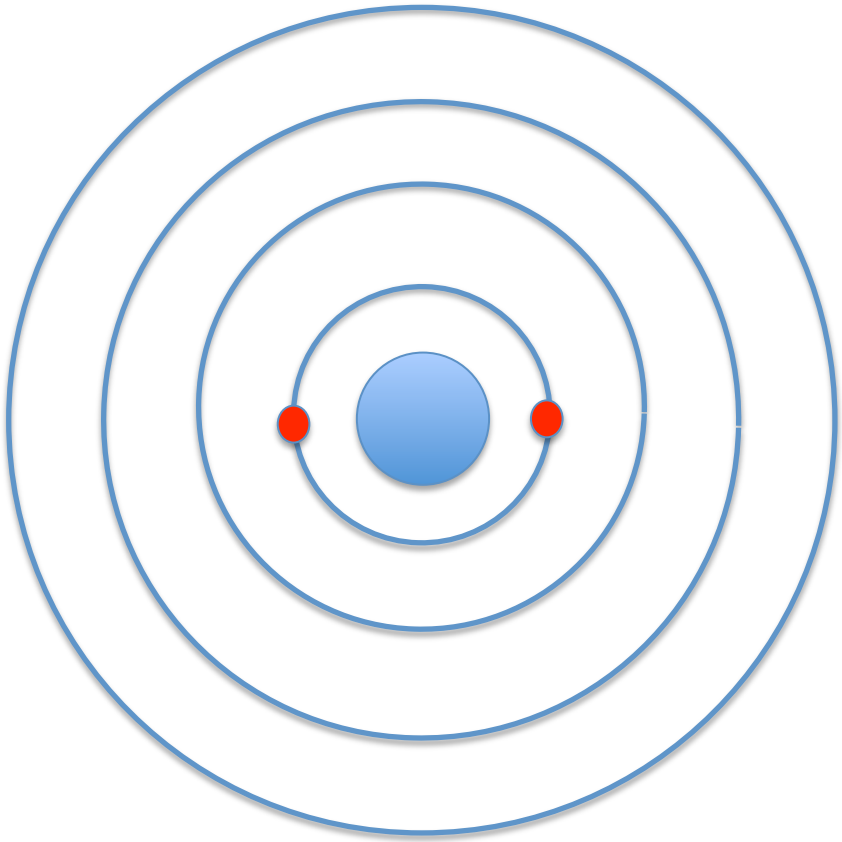
VMI Apparatus



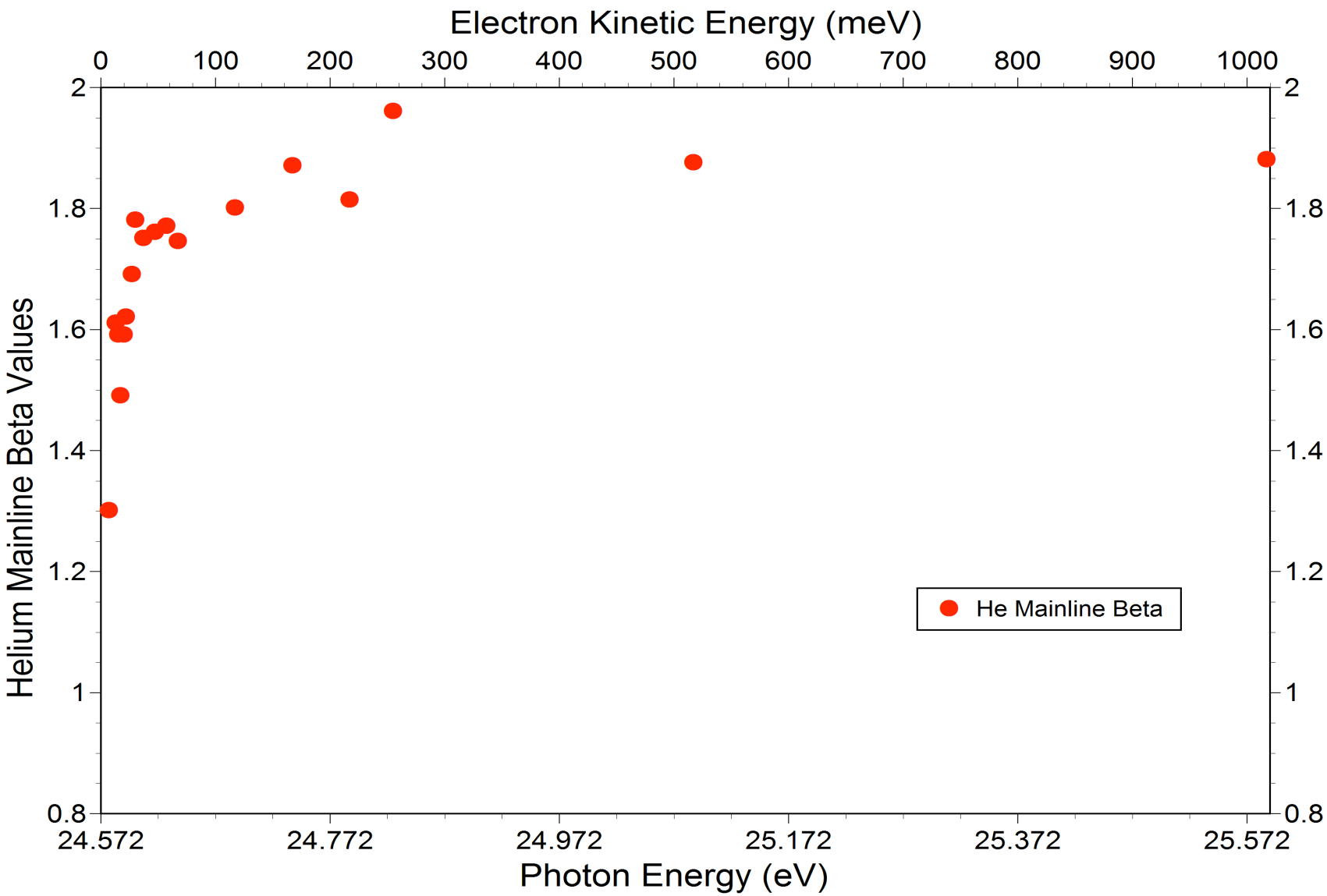
VMI Spectrometer Cont.



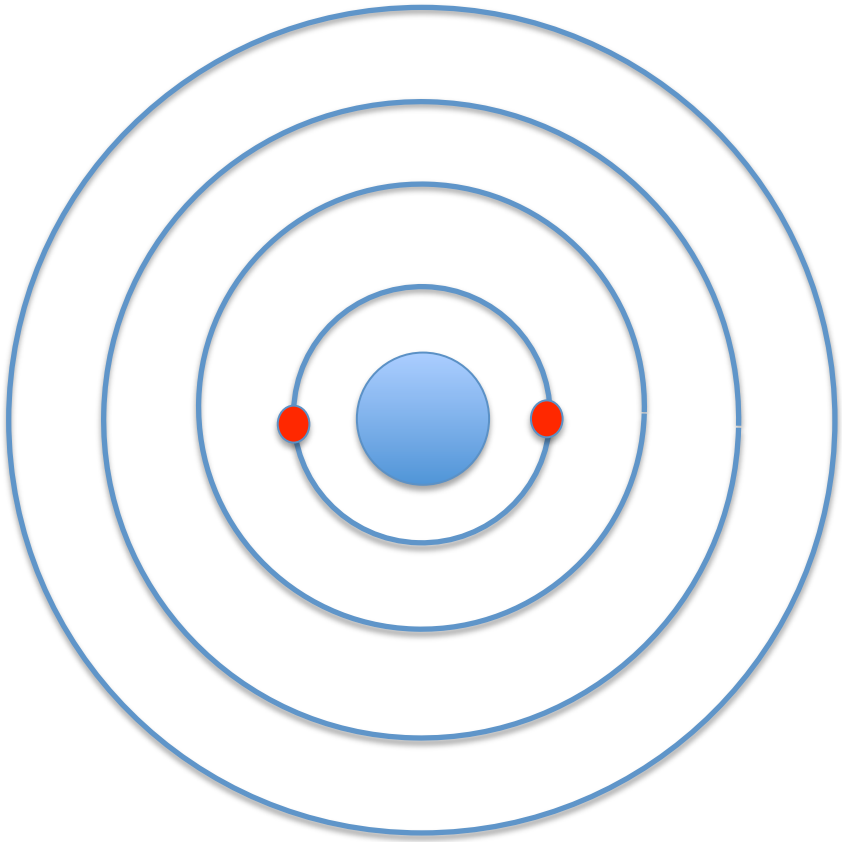
Case 1: Helium Mainline



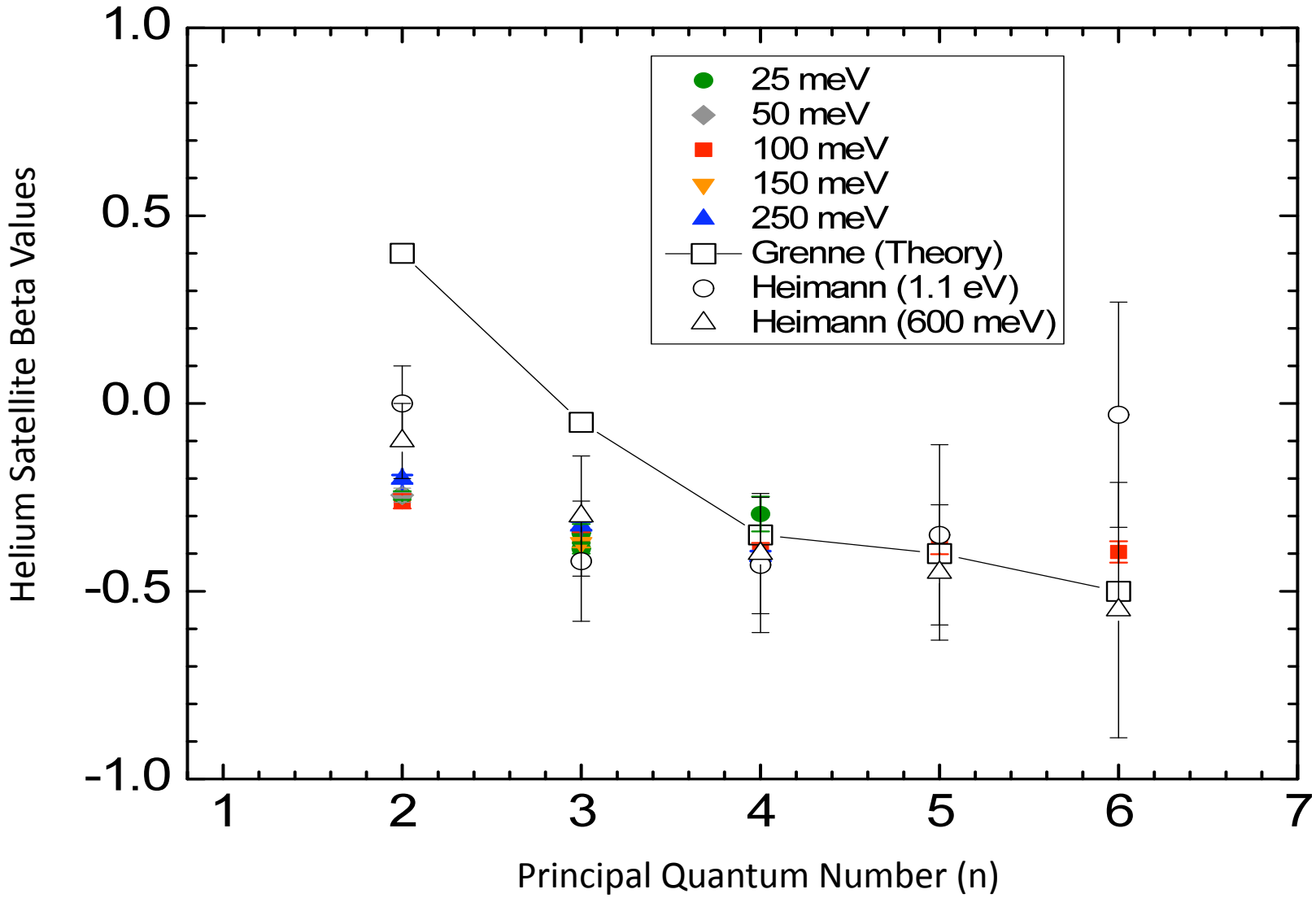
Helium Mainline Results



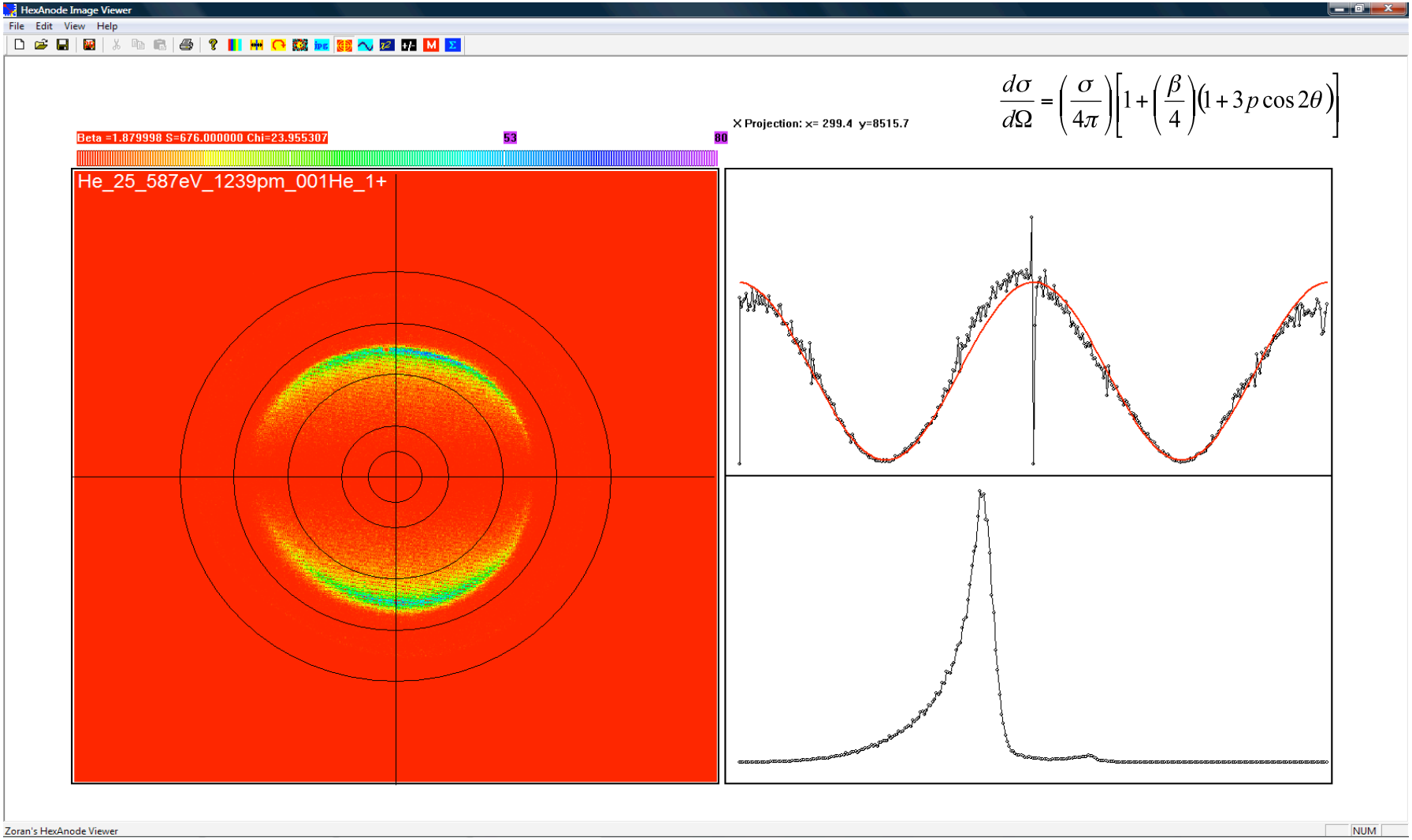
Case 2: Helium Satellites



Helium Satellite Results

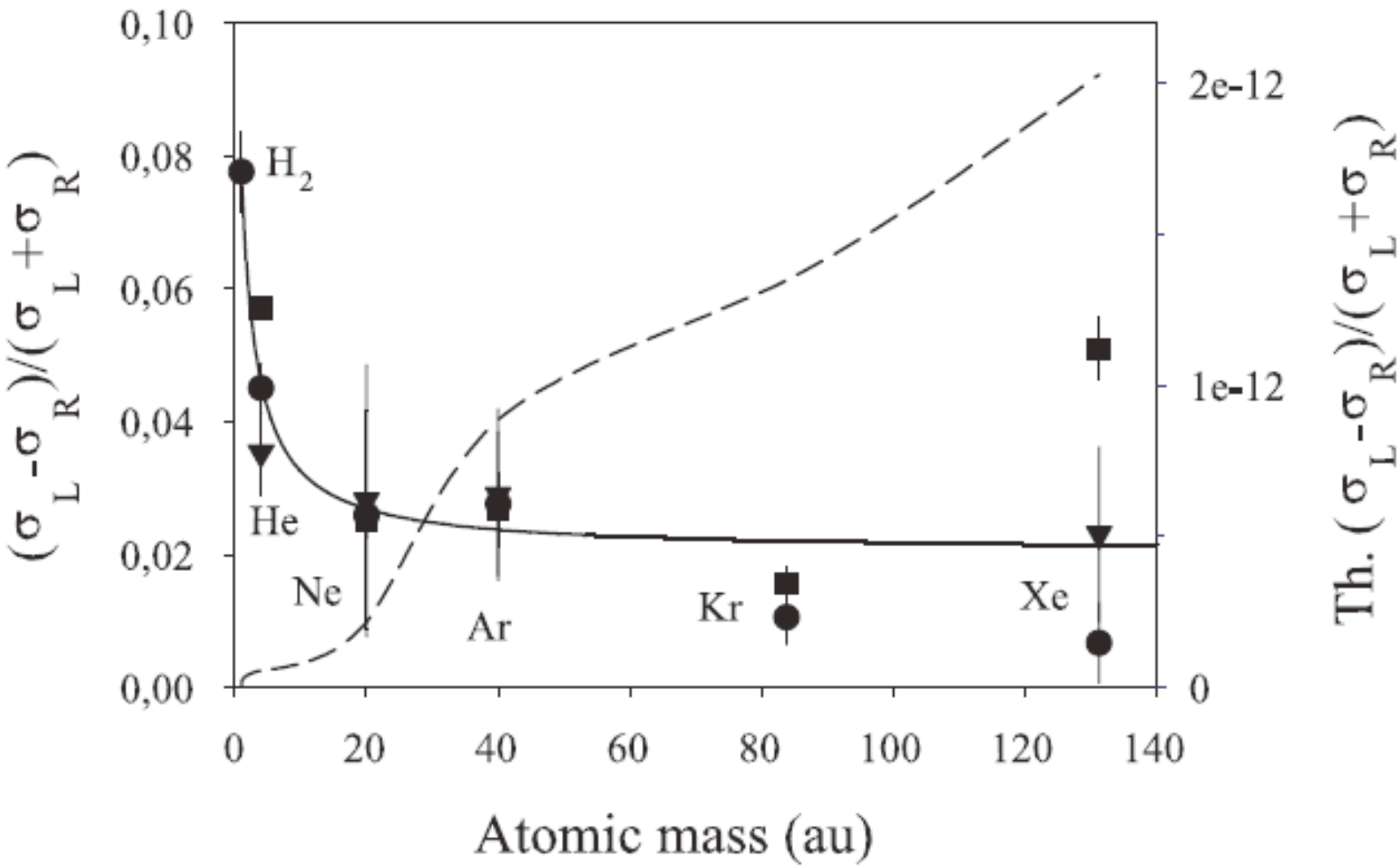


Sample Helium Analysis



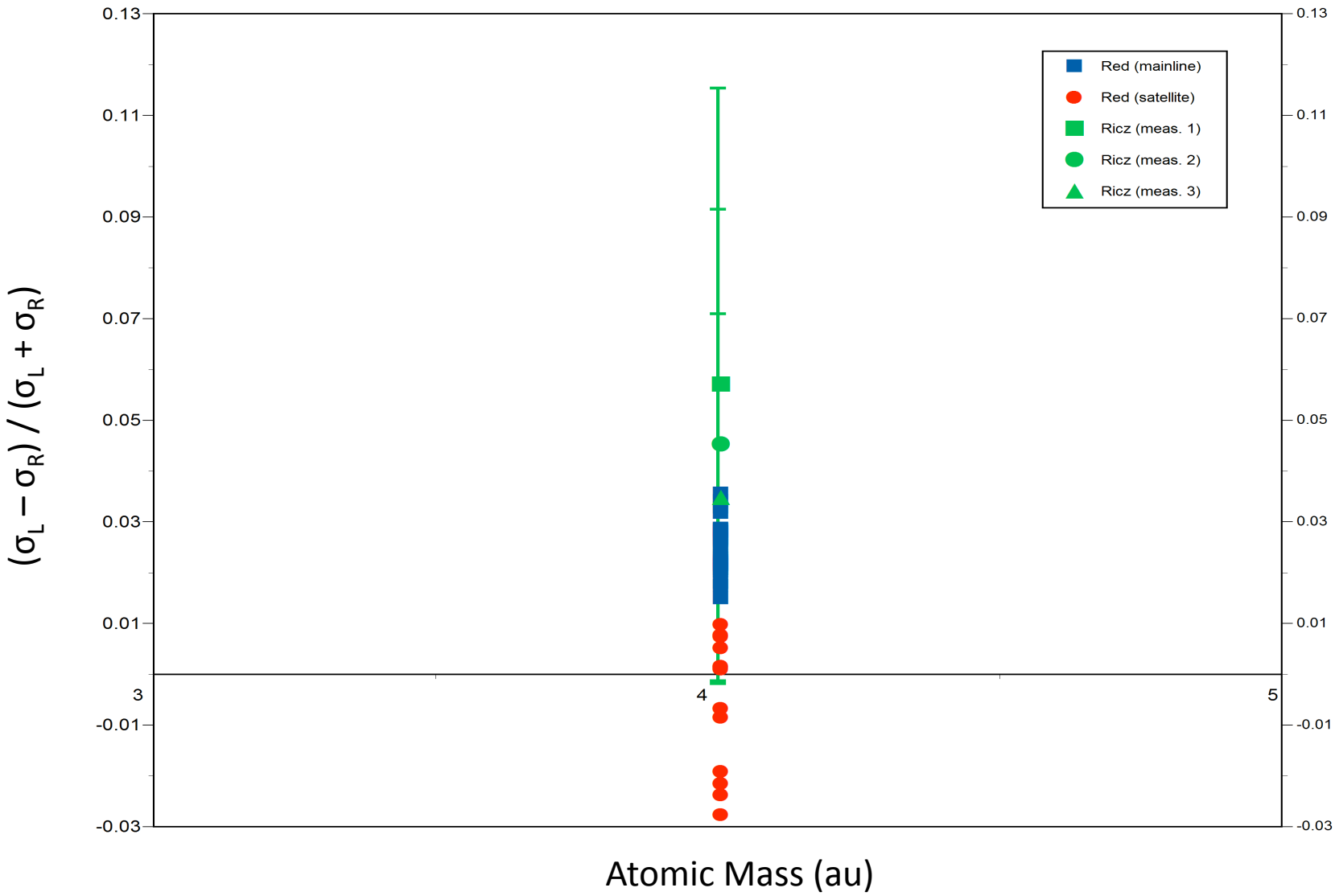
$$\frac{d\sigma}{d\Omega} = \left(\frac{\sigma}{4\pi}\right)\left[1 + \left(\frac{\beta}{4}\right)\left(1 + 3p\cos 2\theta\right)\right]$$

Asymmetry in Outer S-Shell Photoionization

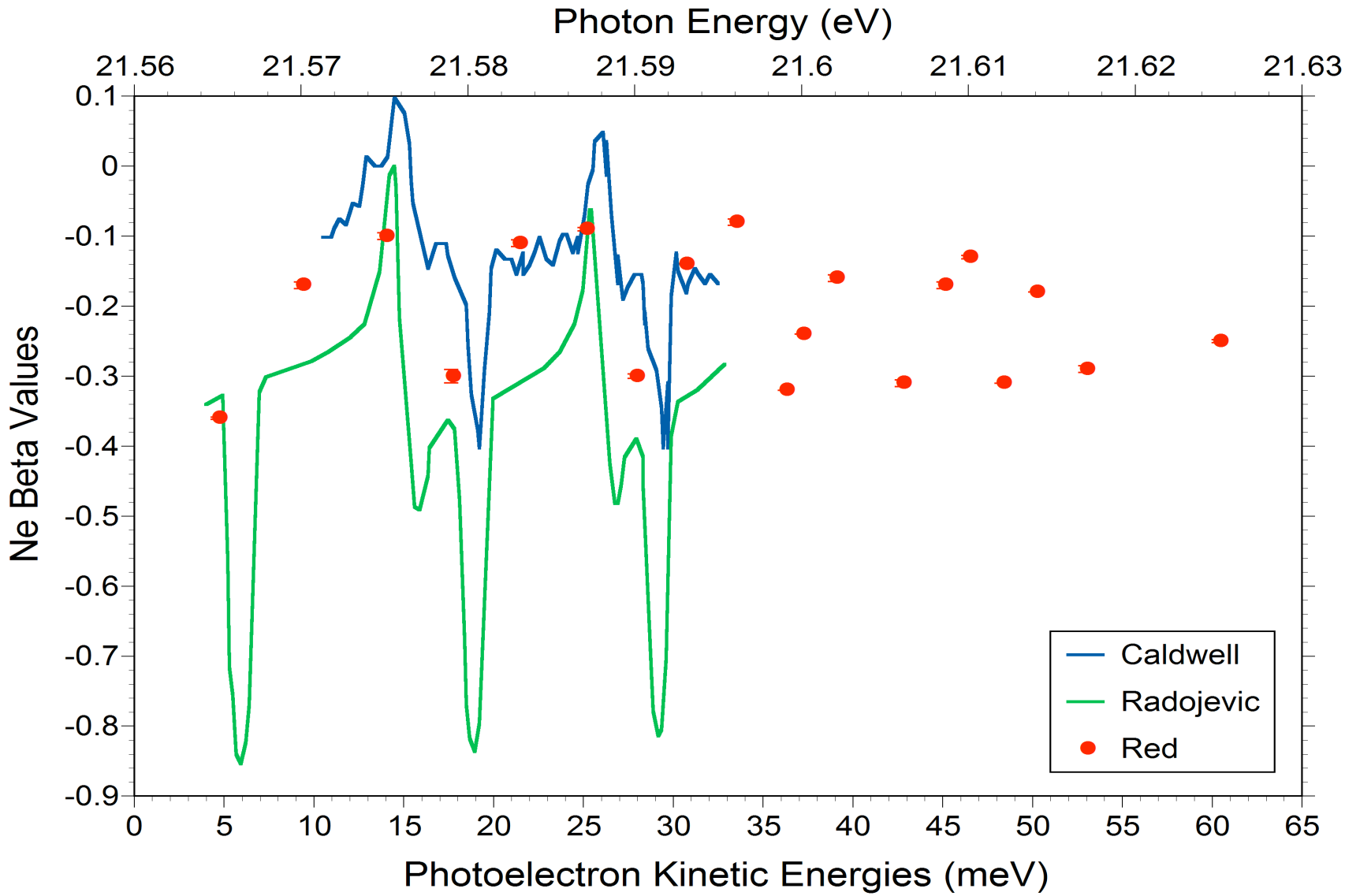


S. Ricz *et al.*, New J. Phys. 9, 274 (2007).

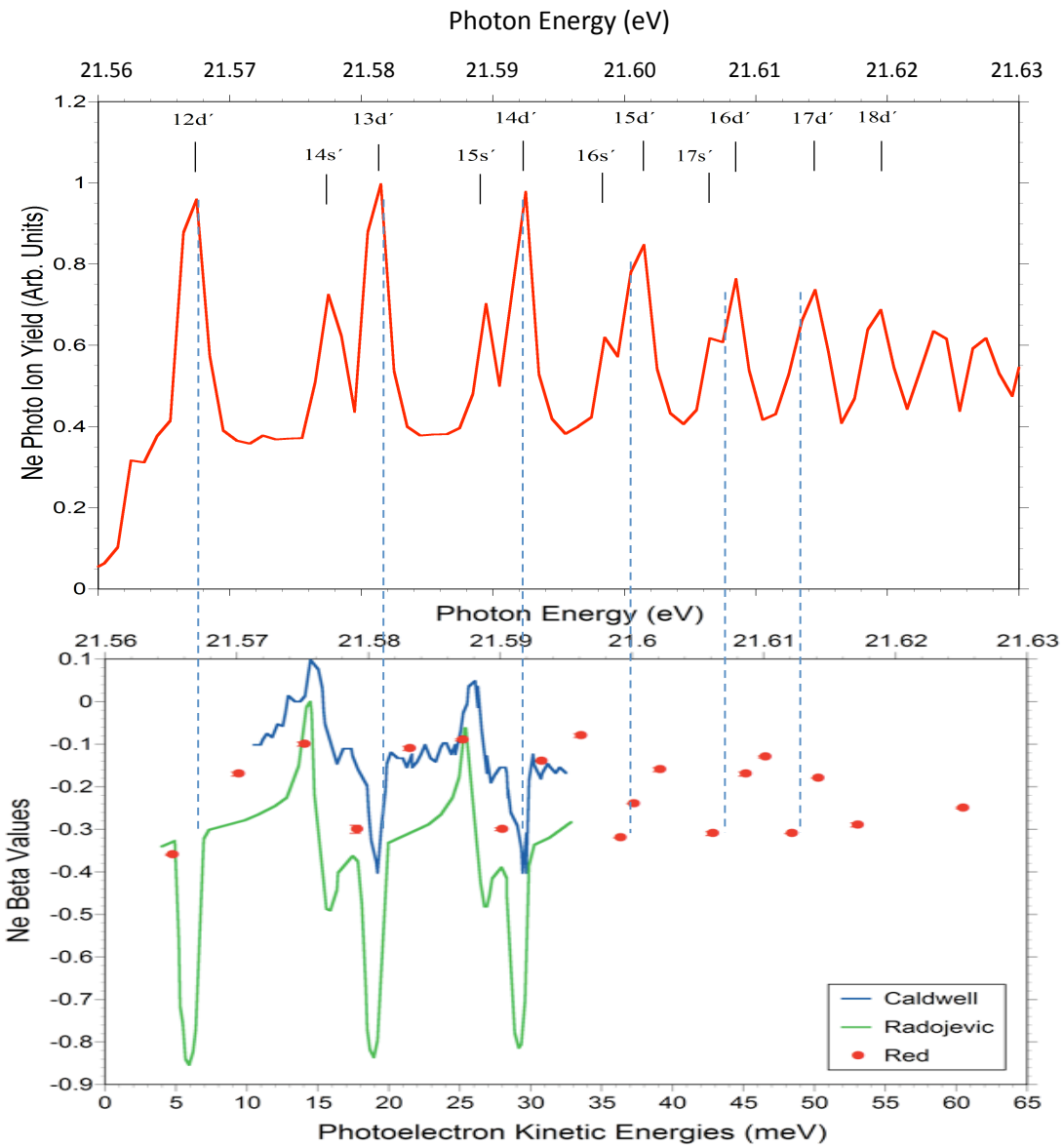
Helium Left-Right Asymmetry



Neon Beta Results



Neon Beta Results Cont.



Conclusions

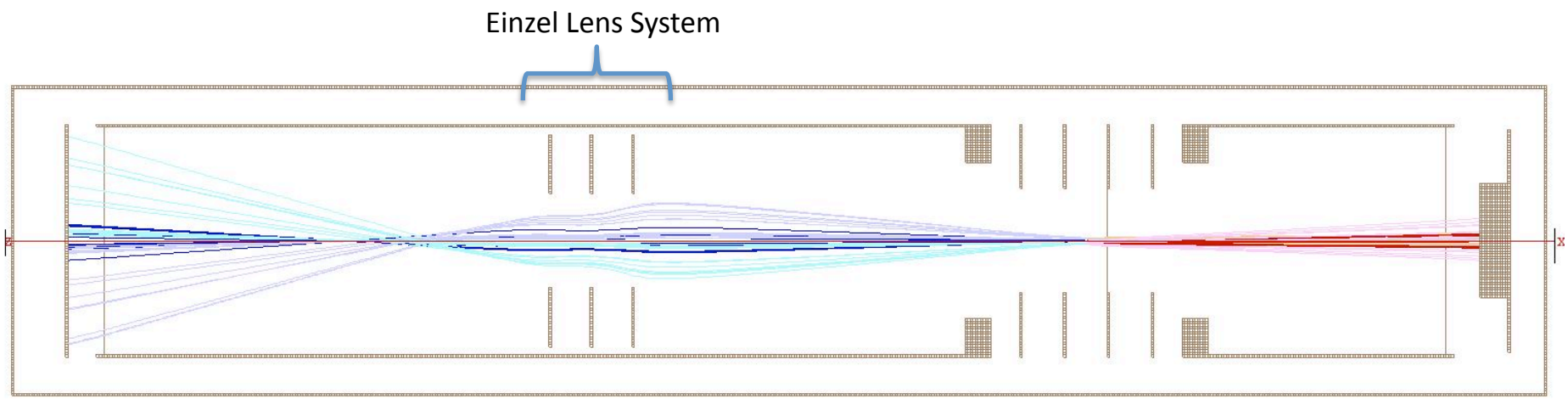
•The data demonstrates the suitability of the VMI technique for measuring the β asymmetry parameters of near-zero kinetic energy photoelectrons.

•These measurements were taken in coincidence with He^+ ions.

•A left-right asymmetry in outer s-shell photoionization has previously been observed.

•Our analysis supports the existence of left-right asymmetry in the photoionization of He with higher precision.

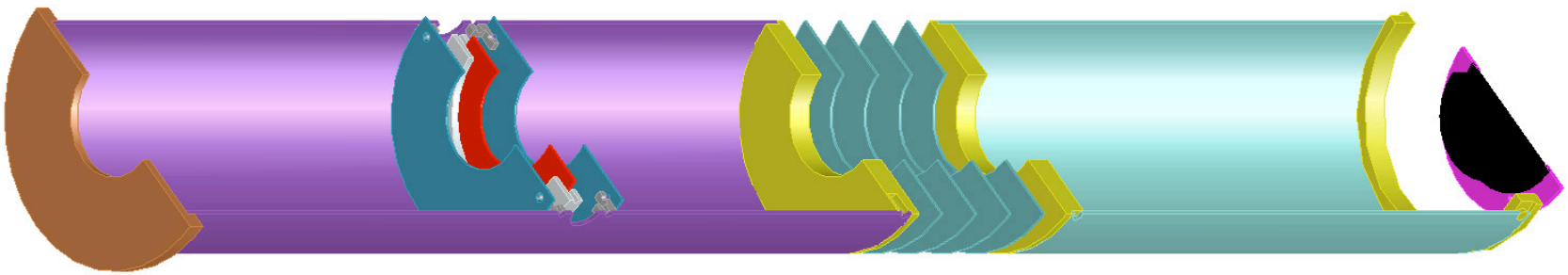
Future Work



Electron Drift Tube: -133 V
Middle Einzel Lens: -1544 V
Left/Right Einzel Lens: -133 V

Electron Focus: -550 V
Extractor: -920 V
Repeller: -1010 V
Ion Focus: -1344 V
Ion Drift Tube: -200 V

VMI with Einzel Lens System



Acknowledgements

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