TABLE OF CONTENTS

Table of Contents.....i

List of Figures.....iv

Acknowledgements.....vii

Dedication.....ix

1 Introduction and Overview 1

1.1 Background.....3

1.1.1 Ionization Measurements.....3

1.1.2 Ionization Theory.....10

1.2 Overview.....13

2 Electron Imaging with Electron Time of Flight 16

2.1 Apparatus and Method..... 18

2.2 Results and Conclusions.....22

3 Electrons from Aligned Molecules 33

3.1 Molecular Dissociation.....33

3.2 Apparatus and Method.....36

3.3 Molecular Fragments..... ..39

3.3.1 Dissociation Energies..... ..42

3.3.2 Molecule Alignment..... ..44

3.4 Correlated Electron Momentum..... ..46

4 Kinematically Complete Single Ionization of He 55

4.1 Small Momentum Transfer.....57

4.1.1 Longitudinal Momentum & Q-value.....57

4.1.2 Transverse Momentum.....59

4.2 Related Work.....61

4.2.1 Low Velocity Collisions.....61

4.2.2 Ultra-high velocity collisions/ photoionization.....64

4.2.3 High velocity collisions.....68

4.2.4 Trends, intermediate case, our project.....70

4.2.5 Perspective.....74

4.3 Apparatus and Method.....76

4.4 Results.....81

4.4.1 Raw Data.....81

4.4.2 Longitudinal Momentum.....85

4.4.3 Uncorrelated Transverse Momentum.....89

4.4.4 Correlated Transverse Momentum.....96

4.4.5 Conclusion.....110

5 Conclusions **112**

Bibliography **115**

A. Measurement Resolution and Quality Control **122**

A.1 Determination of ΔP_{Rz} and ΔP_{Ry} 122

A.2 Recoil Ion Time Focusing and Determination of ΔP_{Rx} 128

A.3 Determination of ΔP_{ex} and ΔP_{ey}, and ΔP_{ez} 130

A.4 Tabulated Resolution Values 135

B. Spectrometer Dimensions **136**

C. Using the LINAC for Time Focusing **140**