

TABLE OF CONTENTS

LIST OF TABLES	ix
LIST OF FIGURES	x
Chapter 1 Introduction	1
1.1 Pion Production and the Symmetry Energy	1
1.2 Symmetry Energy and Astrophysics	1
1.2.1 Neutron Stars and Supernovae	1
1.3 Organization of Dissertation	1
Chapter 2 Theory	2
2.1 Density Dependence of the Symmetry Energy	2
2.1.1 Origin of Symmetry Energy	2
2.1.2 Paramaterization Models	2
2.1.3 Existing Constraints	2
2.1.4 Constraining at $2\rho_0$	2
2.2 Simulation Codes for Heavy-Ion Collisions	2
2.2.1 Molecular Dynamics Codes (IMQMD, AMD)	2
2.2.2 Boltzmann-Uehling-Uhlenbeck	2
2.3 Pion Production at Sub-Threshold Energy	2
2.3.1 Pion Production Through Δ Resonance Excitations	2
2.3.2 Predictions from Theory	2
Chapter 3 Development of the SπRIT Time Projection Chamber	3
3.1 General Design Considerations	5
3.2 Design Overview	7
3.3 Top Plate	8
3.4 Pad Size and Pad Plane Dimensions	10
3.4.1 Unit Cell	11
3.4.2 Layer Cross Section	12
3.4.3 ZAP and Adapter Boards	14
3.5 Wire Planes	16
3.5.1 Anode Plane	17
3.5.2 Ground Plane	19
3.5.3 Gating Grid Plane	21
3.5.4 Gating Grid Transmission Line	26
3.5.5 Wire Plane Repair	27

3.6	Field Cage	28
3.6.1	Field Cage Windows	33
3.6.2	Field Cage Gas	34
3.7	Target Ladder and Motion	36
3.7.1	Enclosure Windows	38
3.8	Shipping	39
3.9	TPC Upgrades	44
Chapter 4	Experimental Setup	48
4.1	RIBF Facility and Production of Primary Beam	48
4.2	BigRIPS fragment separator	49
4.2.1	BigRIPS Parallel Plate Avalance Counters	50
4.2.2	Beam Drift Chamber Detectors	52
4.3	$S\pi$ RIT Time Projection Chamber inside the SAMURAI Spectrometer	52
4.4	Trigger Detectors	53
4.4.1	Kyoto Multiplicity Array	53
4.4.2	Krakow KATANA Array	53
4.4.3	Active Veto Array	53
4.4.4	Trigger Selection	53
4.5	DAQ	53
Chapter 5	Data Analysis	54
5.1	Beam Analysis	54
5.1.1	Analysis of PPAC signals	56
5.1.2	Analysis of Beam Time of Flight	62
5.1.3	Determination of Charge	64
5.1.4	Beam Drift Chambers and Projection to Target	66
5.1.5	Reconstruction efficiency	67
5.1.6	Beam Purity	67
5.1.7	LISE and energy loss	67
5.2	$S\pi$ RITROOT	68
5.3	Data Corrections and Cuts	68
5.3.1	Geometrical Efficiencies	69
5.3.2	Cuts on Track Properties	69
5.4	Absolute Cross Section and Scaler Analysis	69
5.5	Impact Parameter Selection	76
5.6	Charged Particle Identification	77
5.7	Comparison to Theory	77
Chapter 6	Where do these topics belong?	78
6.1	Commisioning of the $S\pi$ RIT Time Projection Chamber	78
6.2	cosmics	78
6.3	VR/visualization project	78
Chapter 7	Summary and Outlook	79

APPENDICES	80
Appendix A An appendix?	81
A.1 appendix section	81
Bibliography	82