

C O N T E N T S

Page No.

Preface

Chapter 1	An evaluation of the theories of direct electron pair production (DPP) by muons	
1.1	Introduction	1
1.2	Theory of DPP process	2
1.3	The calculation of Bhabha	3
1.4	Treatment of Muroto, Ueda Tanaka(MUT)	10
1.5	Treatment of Ternovskii	13
1.6	Treatment of Kel'ner(1967), Kel'ner Kotov(1968)	14
1.7	Treatment of Kokoulin and Petrukhin (1969)	21
1.8	Consideration of some other effects	
	a) Effect of DPP process in the coulomb field of the electrons	23
	b) Effect of multiple scattering in the target medium	24
	c) Effect of nuclear form factor	24
1.9	Other DPP theories	25
1.10	Numerical calculations	25
1.11	Discussion	
1.11.1	KP cross section with Bhabha cross section	26

1.11.2	KP cross section with MUT cross section	33
1.11.3	KP cross section with Kobayakawa cross section	33
1.11.4	KP cross section with Ternovskii cross section	33
1.11.5	KP cross section with Kel'ner cross section	34
1.11.6	Kel'ner Kotov cross section	34
1.11.7	KP cross section with Wright cross section	34
1.12	Conclusion	35
Chapter 2	A critical reanalysis of the past experiments on direct electron pair production by muons	
2.1	Introduction	37
2.2	The emulsion experiments with cosmic ray muons	40
2.3	The multiplate cloud chamber experiments	40
	a) Experiment of Roe and Ozaki(1959)	40
	b) Experiments of Stoker et al (1961, 1962, 1963)	41
	c) Experiments of Hazen et al(1961,1965)	41
	d) Experiment of Binns and Kearney(1972)	42
	e) Experiment of Chaudhuri and Sinha (1963)	43
	f) The experiment of Das and Sinha(1967)	43

	Page No.
2.4 Experiment of Grupen et al(1972)	44
2.5 Experiment of Wright(1975)	44
2.6 Experiment of Ashton et al(1968)	45
2.7 Accelerator experiment of Jain et al	46
2.8 Summary of experimental work	47
2.9 Procedure of reanalysis	47
2.10 Determination of underground spectrum	49
2.11 Sea level spectrum at large zenith angles	51
2.12 The result of reanalysis	51
2.12.1 The experiment of Binns and Kearney (1972)	51
2.12.2 The experiment of Chaudhuri and Sinha(1964)	53
2.12.3 The experiment of Das and Sinha(1967)	54
2.12.4 The experiment of Allkofer et al (1971, Private communication)	55
2.13 Conclusion	57

Chapter 3	Experimental study of direct production of electron pairs by high energy muons	
3.1	Introduction	58
3.2	Sea level measurements	60
3.2.1	Experimental set up	60
3.2.2	Method of triggering and other operational detail	61
3.3	Underground measurements	63
3.4	Selection and analysis of events	65
3.5	Estimation of energy transfer	65
3.6	Errors and corrections	70
	i) Error of the scanning process	70
	ii) Error in energy estimation	71
	iii) Effect of finite target thickness	71
	iv) Error from unresolved DPP tracks	72
	v) Uncertainties of the incident muon spectrum	73
	vi) Statistical error	74
3.7	Experimental results	74
3.8	Discussion	81
3.9	Conclusion	84
Chapter 4	Measurements of Absolute vertical intensity of cosmic ray muon	
4.1	Introduction	86
4.2	Apparatus for intensity measurements	87

a) Telescope aperture	87
b) Arrangement for exclusion of incident shower particles other than muons	88
c) Evaluation of the effect of multiple scattering	89
d) Multiple scattering correction for range	91
e) Correction for the instrumental errors	93
4.3 Methods and measurements	93
4.4 Experimental results	95
4.5 Comparison with previous measurements and recent data	99
4.6 Conclusion	104
Bibliography	108