



Electron Transport
in Photon and Electron
Beam Modelling

Paul J. Keall, M.Sc.

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Supervisors:

Dr Peter W. Hoban

Dr John R. Patterson

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Contents

Abstract	ix
Statement	xi
Acknowledgements	xiii
Symbols and Abbreviations	xv
Preface	xix
1 Photon and Electron Physics at Therapeutic Energies	1
1.1 Introduction	1
1.2 Photon interactions	2
1.2.1 Introduction	2
1.2.2 Compton scattering	2
1.2.3 Photoelectric absorption	3
1.2.4 Pair production	4
1.2.5 Attenuation coefficients	6
1.2.6 Fluence	7

1.2.7	Kerma	8
1.2.8	Terma	9
1.3	Electron interactions I. Energy losses	10
1.3.1	Introduction	10
1.3.2	Ionisation and excitation energy losses	10
1.3.3	δ -ray production	11
1.3.4	Bremsstrahlung production	11
1.3.5	Collisional stopping power	12
1.3.6	Restricted collisional stopping power	14
1.3.7	Radiative stopping power	15
1.3.8	Restricted radiative stopping power	15
1.4	Electrons interactions II. Scattering	16
1.4.1	Introduction	16
1.4.2	Single scattering	17
1.4.3	Multiple scattering	19
1.5	Absorbed dose	22
1.5.1	Primary and scatter dose	23
1.5.2	Measurement of absorbed dose	23
1.6	The main components of a linear accelerator	24
1.7	Clinical photon beams	26
1.7.1	Introduction	26

1.7.2	Photon beam depth dose curves	27
1.7.3	Photon beam dose profile curves	28
1.7.4	Photon beam isodose curves	29
1.8	Clinical electron beams	31
1.8.1	Introduction	31
1.8.2	Electron beam depth dose curves	31
1.8.3	Electron dose profile curves	33
1.8.4	Electron isodose curves	33
1.9	Electron density	34
1.10	Radiological depth	35
2	Current Dose Calculation Methods	37
2.1	Introduction	37
2.2	Photon beam dose calculation algorithms	39
2.2.1	The Effective Pathlength method	39
2.2.2	The Equivalent Tissue-Air Ratio method	40
2.2.3	The Delta Volume method	42
2.2.4	The Monte Carlo method	44
2.2.5	The Superposition/Convolution method	51
2.2.6	Variations of superposition	57
2.3	Electron beam dose calculation algorithms	59
2.3.1	Introduction	59

2.3.2	The Effective Depth method	60
2.3.3	The Pencil Beam method	61
2.3.4	The 3-D Pencil Beam method	65
2.3.5	The Pencil Beam Redefinition algorithm	67
2.3.6	The Multi-ray model	72
2.3.7	Perturbative theoretical methods	74
2.3.8	The Phase Space Evolution model	76
2.3.9	The Monte Carlo method	79
2.3.10	The Superposition/Convolution method	79
2.3.11	The Macro-Monte Carlo algorithm	83
2.3.12	The Voxel-based Monte Carlo method	87
2.4	Summary	88
3	Superposition Incorporating Fermi-Eyges Theory	89
3.1	Introduction	89
3.1.1	Fermi-Eyges electron scattering theory	90
3.1.2	The Photon-Electron Cascade model	90
3.2	Method	91
3.2.1	The Fermi-Eyges theory scaling method	91
3.2.2	Superposition calculations	95
3.2.3	Monte Carlo calculations	95
3.2.4	Phantoms	95

3.3	Results	97
3.3.1	Single interaction site results	97
3.3.2	Depth dose results	98
3.3.3	Dose profile results	102
3.3.4	Computation time	103
3.4	Conclusion	103
4	Super-Monte Carlo for X-ray Beam Planning	105
4.1	Introduction	105
4.2	The Super-Monte Carlo photon beam dose calculation method	107
4.2.1	Calculation of the primary dose using pre-generated electron track data	107
4.2.2	Calculation of the scatter dose by superposition	113
4.2.3	Superposition calculations	114
4.2.4	Monte Carlo calculations	114
4.2.5	Phantoms	115
4.3	Results	117
4.3.1	Single interaction site results	117
4.3.2	Depth dose curves in a water-lung-water phantom	118
4.3.3	Profile curves at mid-lung in a water-lung-water phantom	119
4.3.4	Isodose curves in a two lung-block phantom	119
4.3.5	Computation time	126
4.4	Conclusion	126

5	Super-Monte Carlo for Electron Beam Planning	129
5.1	Introduction	129
5.1.1	The problems with electron beam superposition	130
5.2	The Super-Monte Carlo electron beam dose calculation method	132
5.2.1	Electron track data generation	132
5.2.2	Stopping power, scattering power and radiation yield ratios	133
5.2.3	Transport of electron tracks	136
5.2.4	Monte Carlo	142
5.2.5	Phantoms	143
5.3	Results	143
5.3.1	Pencil beam dose distributions in homogeneous phantoms	144
5.3.2	Broad beam dose distributions in water	149
5.3.3	Broad beam dose distributions in heterogeneous phantoms	150
5.3.4	Statistics and computation time	156
5.4	Conclusion	159
6	Conclusions, Discussion and Future Research	161
6.1	Conclusions	161
6.2	Extension of the current research	163
6.3	Application of the current research	164
6.4	Epilogue	165
A	Users Manual for the Fermi-Eyges Scaling Convolution and Super-Monte	

Carlo Suite of Software C_CONVOLUTION	167
A.1 Introduction	168
A.1.1 Fermi-Eyges scaling convolution	169
A.1.2 Super-Monte Carlo	170
A.2 Description of programs	172
A.2.1 c_input.h	172
A.2.2 c_convolution.h	174
A.2.3 c_main.c	174
A.2.4 c_input_kernels.c	174
A.2.5 c_elec_dens_grid.c	175
A.2.6 c_calc_terma.c	175
A.2.7 c_input_tracks.c	175
A.2.8 t_calc_prim_dose.c	175
A.2.9 t_calc_scatter_dose.c	176
A.2.10 c_calc_dose.c	176
A.3 Changes	176
B Using Restricted Stopping Powers to Vary Electron Step Length	179
C Changing the Electron Step Scattering Angle in Non-waterlike Media	181

Abstract

To address the deficiencies of currently available dose calculation algorithms for radiotherapy planning, two rigorous dose calculation methods have been devised.

The first method incorporates Fermi-Eyges multiple scattering theory into the primary dose calculation of the superposition method for external X-ray beam radiotherapy. The inclusion of scattering theory into the superposition technique accounts for the density *distribution* between the primary photon interaction and energy deposition sites, whereas conventional superposition methods only consider the average density between these two points. This method gives depth dose curves which show better agreement with Monte Carlo calculations in a lung phantom than a standard superposition method, especially at high energies and small field sizes where lateral electronic disequilibrium exists. For a $5 \times 5 \text{ cm}^2$ 18 MV beam incident on the lung phantom, a reduction in the maximum error between the superposition and Monte Carlo depth dose curves from 5% to 2.5% is obtained when scattering theory is used in the primary dose calculation.

The second method developed is the Super-Monte Carlo (SMC) method. SMC calculates dose by a superposition of pre-generated Monte Carlo electron track kernels. For X-ray beams, the primary dose is calculated by transporting pre-generated (in water) Monte Carlo electron tracks from each primary photon interaction site. The length of each electron step is scaled by the inverse of the density of the medium at the beginning of the step. Because the density scaling of the electron tracks is performed for each

individual transport step, the limitations of the macroscopic scaling of kernels (in the superposition algorithm) are overcome. The scatter dose is calculated by superposition. In both a lung-slab phantom and a two lung-block phantom, SMC dose distributions are more consistent with 'standard' Monte Carlo generated dose distributions than are superposition dose distributions.

SMC can also be applied to electron beam dose calculation. Pre-generated electron tracks are transported through media of varying density and atomic number. The perturbation of the electron fluence due to each material encountered by the electrons is explicitly accounted for by considering the effect of variations in stopping power, scattering power and radiation yield. For each step of every electron track, these parameters affect the step length, the step direction and the energy deposited in that step respectively. Dose distributions in a variety of phantoms show good agreement with Monte Carlo results.

SMC is an accurate, 3-dimensional unified photon/electron dose calculation algorithm.