

Modelling of a novel x-ray source for MR-guided Radiotherapy

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Monte Carlo Techniques for Medical Applications, October 2017



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Introduction

The Australian MRI Linac Program

Transforming the Science and Clinical Practice of Cancer Radiotherapy

THE UNIVERSITY OF SYDNEY
Personalised disease targeting
Real time treatment adaption

THE UNIVERSITY OF QUEENSLAND AUSTRALIA
Medical device innovation
Superconducting magnet design

Ingham Institute
Cancer biomarker discovery
Physiological targeting

WESTERN SYDNEY UNIVERSITY
Nano-scale contrast agents
Pre-clinical high field NMR

STANFORD UNIVERSITY
Simulate beam transport
Experimental accelerators

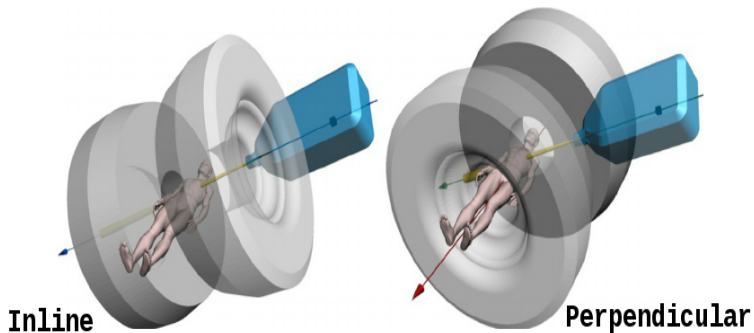
POLITECNICO DI MILANO
Automatic feature extraction
4D image processing

UNIVERSITY OF WOLLONGONG
MRI compatible detectors
Treatment head simulation
MRI-guided Hadron therapy

CSIRO
Computer science
Deformable Image registration

THE UNIVERSITY OF NEWCASTLE AUSTRALIA
MR only planning
Epid Dosimetry

Collaborators of Australian MRI-linac program

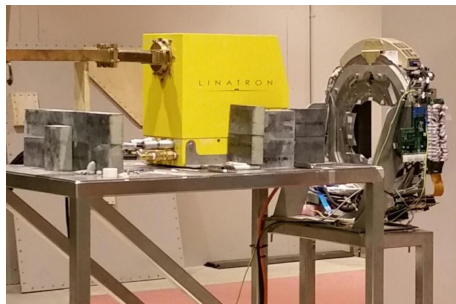


Clinical Linear Accelerator



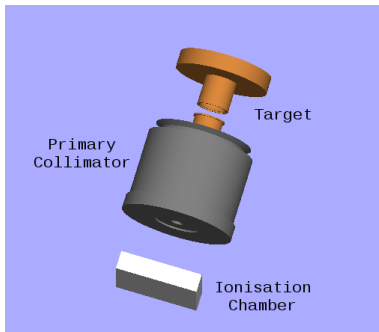
Varian Clinac, Varian Medical Systems

Linear Accelerator and MLCs for MRI-Linac



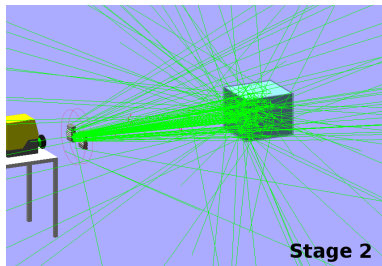
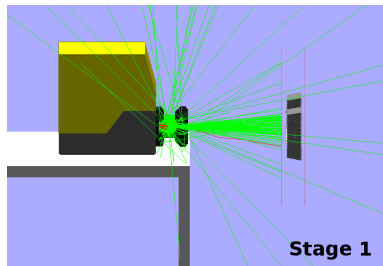
Varian Linatron MP and Millenium 120-leaf MLC

- To develop a Monte Carlo model of the Australian MRI-linac using Geant4
- Develop Monte Carlo Treatment Verification System
 - Model magnetic field
 - Methods of calculating dose to a moving/deforming tumour



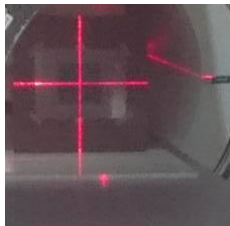
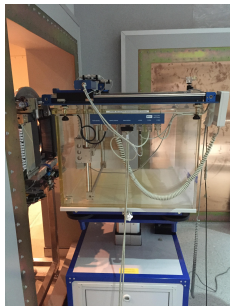
Geant4 Simulations:

- Version 10.2.p01
- Physics List: G4EmLivermorePhysics
- 2 stage simulation:
 - Stage 1:** electron beam simulated above target and phase space scored above MLCs
 - Stage 2:** read in phase space from above MLCs, read in MLC positions and score dose in phantom



Setup:

- Modelling high energy beam (6MV)
- No magnetic field
- Measurements taken using:
 - CC13 ion chamber in water phantom (open field)
 - EBT3 film in solid water (MLC field sizes)
- Source-to-Isocentre Distance variable
1.8-3.2m
- Open Field and MLC defined field sizes

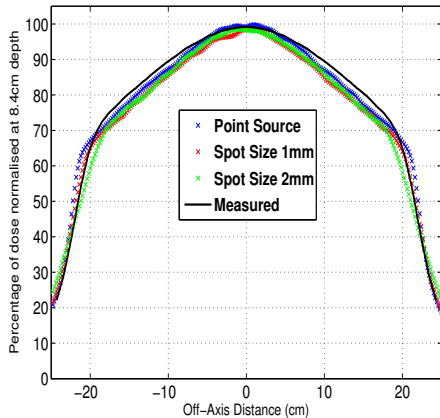


Simulation Parameters Varied:

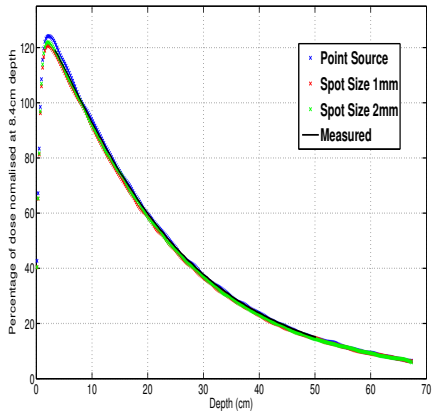
- Spot Size
- Energy

Variations in Electron Beam Size

Open field measured with CC13 ion chamber in water tank



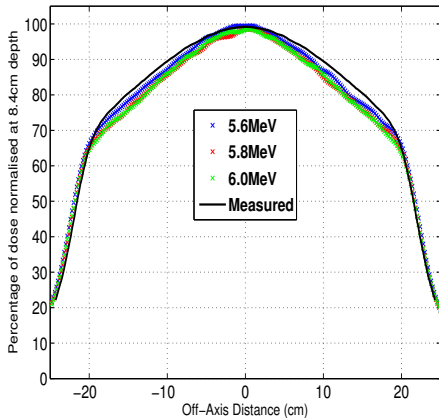
X Profile, Depth 8.4cm in Water Tank



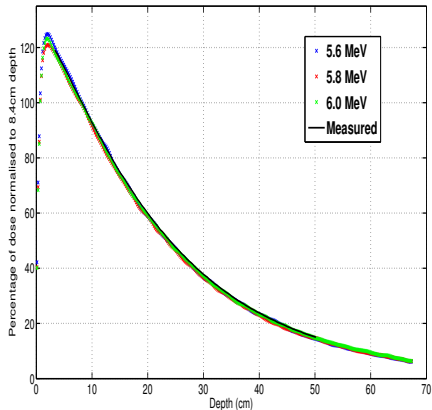
Percentage Depth Dose in Water Tank

Variations in Electron Beam Energy

Monoenergetic electron beams displayed, open field measured with CC13 ion chamber in water tank

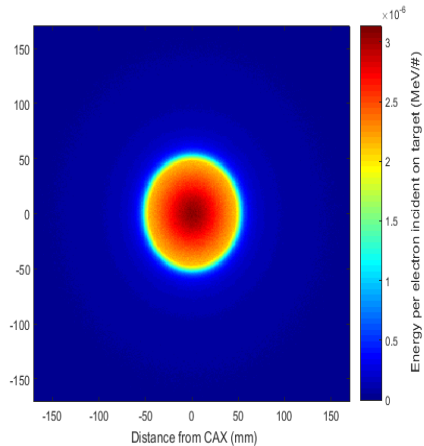
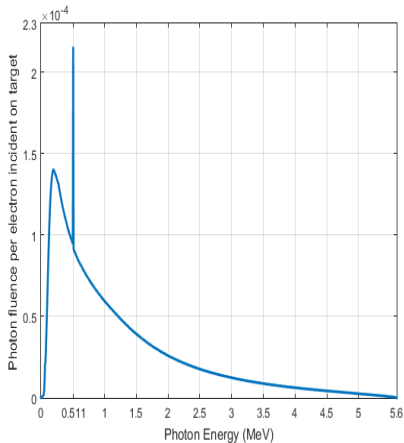


X Profile, Depth 8.4cm in Water Tank



Percentage Depth Dose in Water Tank

Energy Spectrum of current model

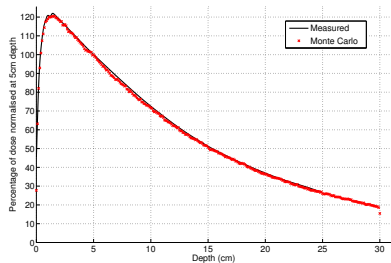
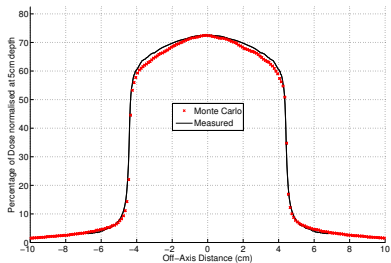
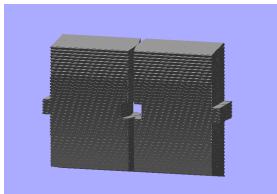


Energy 5.6MeV, Spot size 1mm

Results

MLC defined field size data

Measured with EBT3 film in solid water



Conclusions & Future Work

- Energy of beam approximately 5.6-6.0MV
- Electron spot size approximate to 1mm
- Close match between MC data and measurements for open field data
- MLC defined field sizes in good agreement

- Model magnetic field from MRI and compare to measured results

Acknowledgements

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Thahabah AlHarthi



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