Monte Carlo Simulation of Linear Accelerator for Dosimetric Analysis

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Outline

Introduction

- Cancerous cells are formed when cells in the body fail to die and instead have an abnormal and uncontrollable growth.
- One of the major techniques for cancer treatment is radiotherapy.
- The most commonly used machine in radiotherapy is the Linear Accelerator (Linac).
- In this project, we try to simulate the LINAC head for radiation beam production, followed by the simulation of beam transport for dosimetric analysis.

Motivation

- Dosimetric analysis in radiotherapy need physical phantoms for experimentation, which are extremely costly.
- Furthermore, only proprietary software is available for phantom simulation.
- Our project utilises open-source simulation toolkit Geant4 for simulation and thus helps in cutting down the expenses of cancer patients.

Problem Statement

Monte Carlo simulation of a linear accelerator for treatment planning of cancer:

- Simulation of radiation beam production in LINAC.
- Simulation of beam transport from LINAC head to phantom.
- Dosimetric analysis of radiation.

Outline

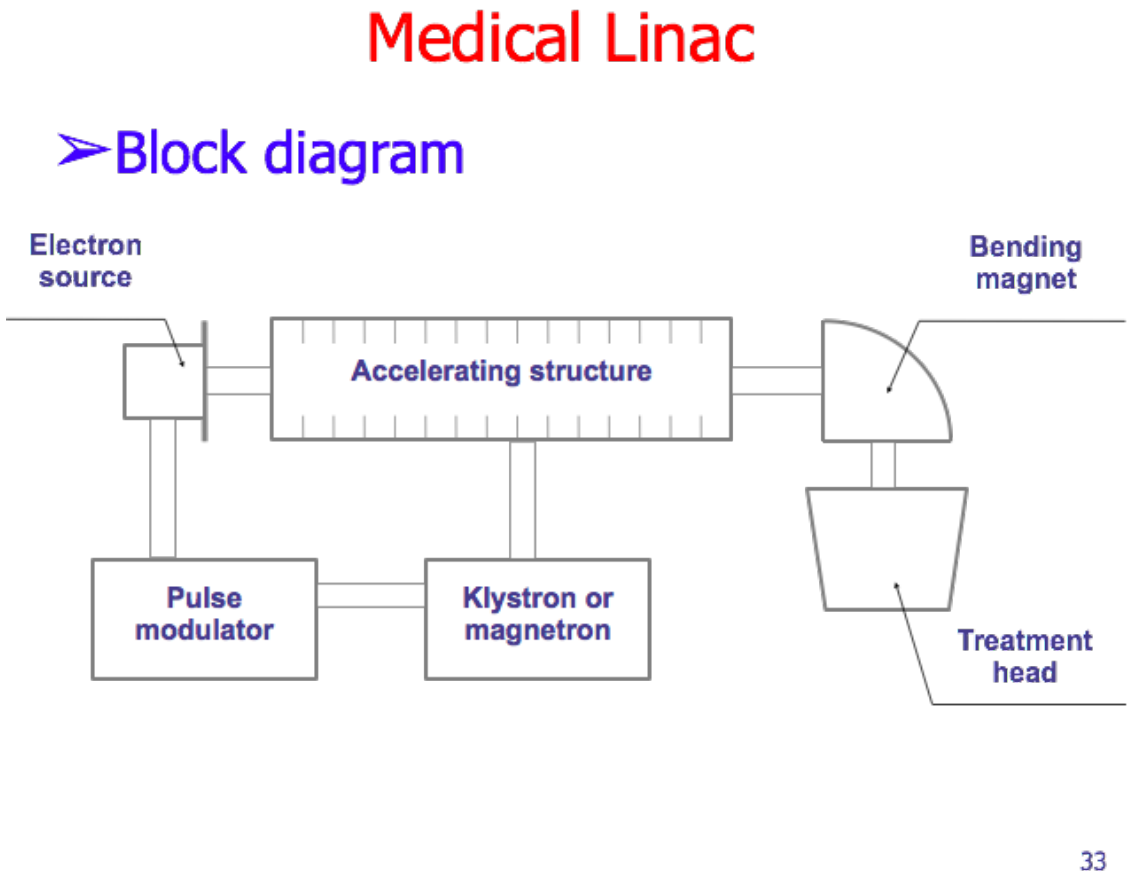

Figure: 1: Block Diagram of Medical LINAC electron acceleration structure.

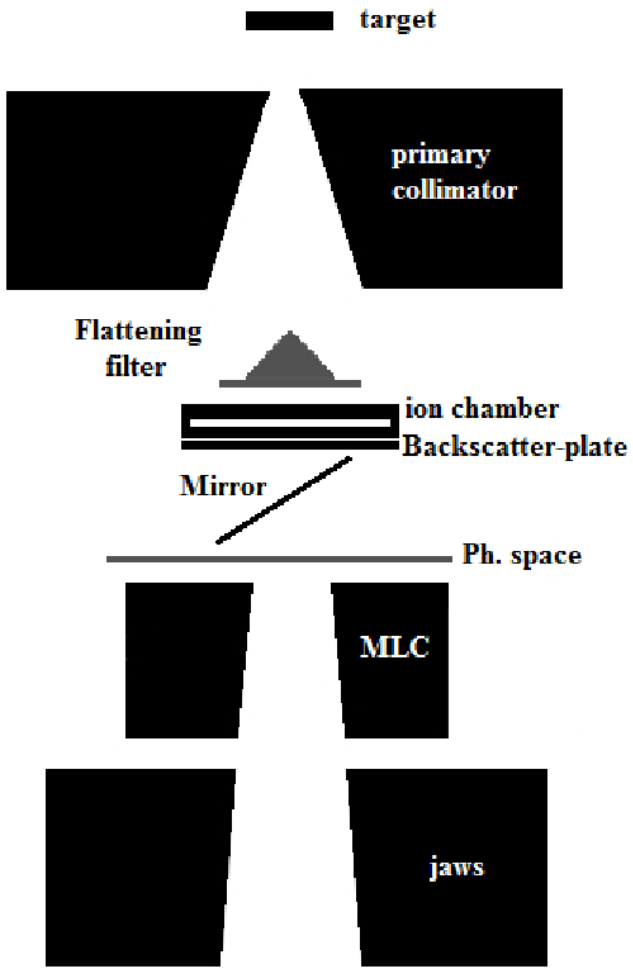

Figure: 2: Geometry of the Elekta linac gantry.

Literature Review

Background

- In this project, we try to simulate the LINAC head for beam production, for which phase space is generated.
- The particles which constitute the phase space are transported to the phantom and the dose distribution is calculated.
- For the simulation, Monte Carlo methods are used, which rely on repeated random sampling to obtain numerical results and can help us to acquire accurate results.

Outline

MC simulation of a LINAC for filtered and FFF systems.

In a work done by Kagri Yazgan and Yigit Cecen [1], Monte Carlo N-particle (MCNP) code was used to simulate a medical linear accelerator for filtered and FFF systems.

- The average photon energy was found to be 3.54 times higher in the filtered system than in the FFF system.
- The average photon dose was found to be 3.18 times higher for the FFF system than for filtered system.
- The errors in the comparison of simulation - experimental values were only 0.22%.

MC simulation for Neptun 10 PC LINAC

Mohammad Taghi Bahreyni Toossi et al. [2] used the MCNP-4C to simulate electron beams from Neptun 10 PC medical linear accelerator.

- Output factors for 6, 8 and 10 MeV electrons applied to eleven different conventional fields were calculated.
- Their findings revealed that output factors, acquired by MCNP-4C simulation and the corresponding values obtained by direct measurements were in a very good agreement.

MC SImulation of a medical LINAC for Radiotherapy Use

In a work done by B. Serrano et al. [3], an MC code MCNPX (Monte Carlo N-Particle eXtended) was used to model a 25 MV photon beam from a PRIMUS(KD2-Siemens) medical linac.

- The mean electron beam energy produced by the linac was stated to be 19 MeV. But the results showed the mean electron beam energy to be 15 MeV.
- In the near future, these results can help to validate the dose deposition on IMRT (Intensity-Modulated Radiation Therapy) treatment.

Simulation of the 6 MV Elekta Synergy Platform Linac

Yahya Tayalatia et. al [4] developed a computational model for 6MV Elekta Synergy Platform LINAC using GATE Monte Carlo software.

- The simulated depth dose profiles were in good agreement with the measured ones, with uncertainty less than 1.6%.
- The simulation of lateral dose profiles also fit accurately with the measurements with less than 1.8% of error uncertainties.

MC Simulation of a Medical LINAC for Generation of Phase Spaces

Alex C. H. Oliveira et al.[6] evaluated the dose distributions in radiotherapy planning.

- They aimed at creating a computational model of the head of a 6 MeV Linac using the MC code Geant4 for the generation of phase spaces.
- They also successfully simulated the transport of phase space in certain congurations of the irradiation eld to assess the dose distribution in the patient(phantom).

Work Plan

Work done so far:

- Literature Survey: Understood the working and components of a LINAC head.
- Visited the MVR Cancer Centre: Attended a talk on LINAC and its internals.

Work Plan for the semester:

- Understand the working of Geant4 code for Monte Carlo based particle simulation.
- Simulation of radiation beam production by the LINAC machine.

Conclusion

- The dose analysis in radiotherapy is one of the most crucial tasks in cancer treatment.
- Monte Carlo simulation helps to fulfill this task with great accuracy. For the process,the simulation of the LINAC head and the phantom are done.
- Through this project, we hope to simulate an Elekta LINAC at MVR Cancer Centre.

References

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Thank You