Monte Carlo GATE Simulation of Linac and Radiotherapy

Darshana Suresh - Shalini Nath - Saai Lakshmi

WORK DONE

1. Literature Study

-> Understood the application of Monte Carlo simulation in beam production.

-> Understood the methods used for improving the simulation time.

-> Studied the output parameters of the simulation - Percentage depth dose, dose profile, and their statistical uncertainties.

WORK DONE

1. Literature Study
2. Additions to the Code

-> Geometry of MLC and Secondary Collimators.

-> Code to remove straying beams to improve simulation time.

-> Code to detect and record the details of beam particles reaching the phantom.

-> Code to display the dose output files (3D images) in GATE.

WORK DONE

1. Literature Study
2. Additions to the Code
3. Output Analysis

-> Installation of ROOT (s/w for particle physics data analysis). Used for analyzing phase space files.

-> Installation of VV (2D and 3D image viewer). Used for viewing 3D image of dose deposition on phantom.

-> Plotted graphs of depth dose and dose profile in python along with its statistical uncertainty.

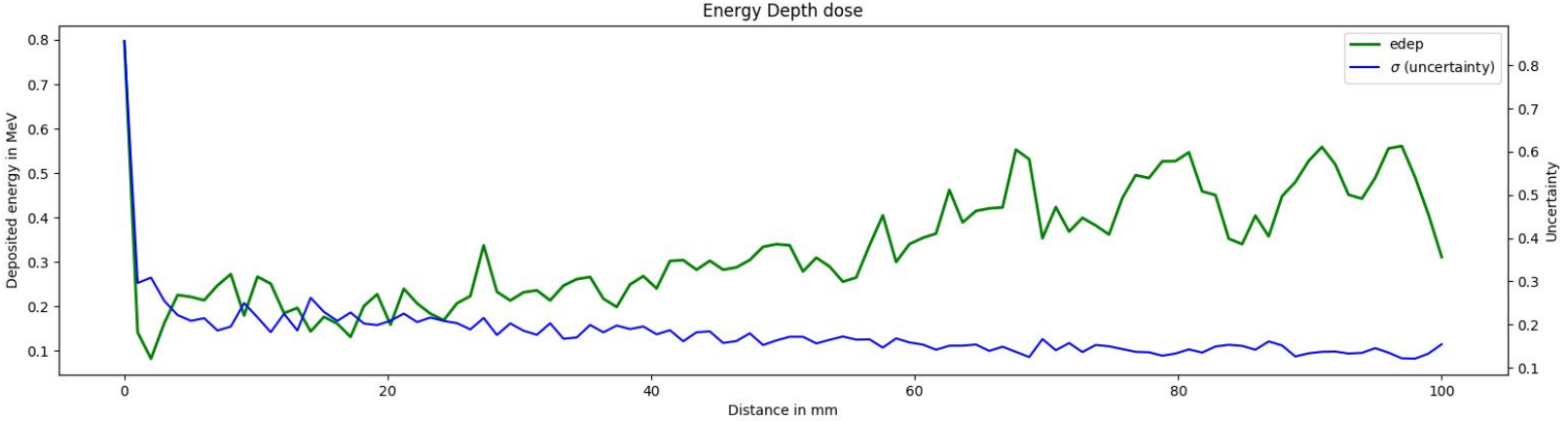
RESULTS

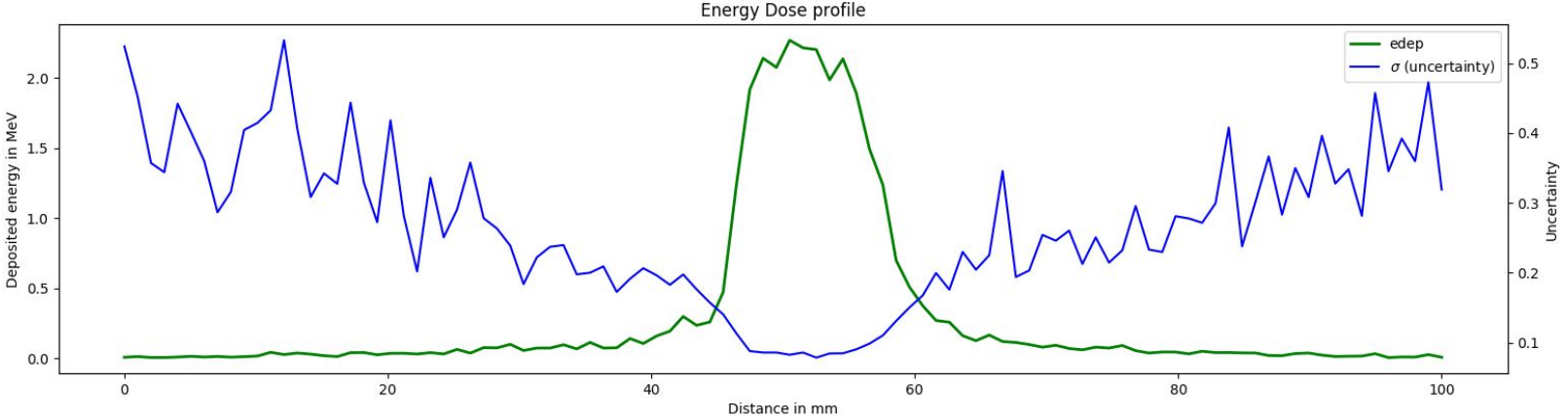
OUTPUTS OBTAINED

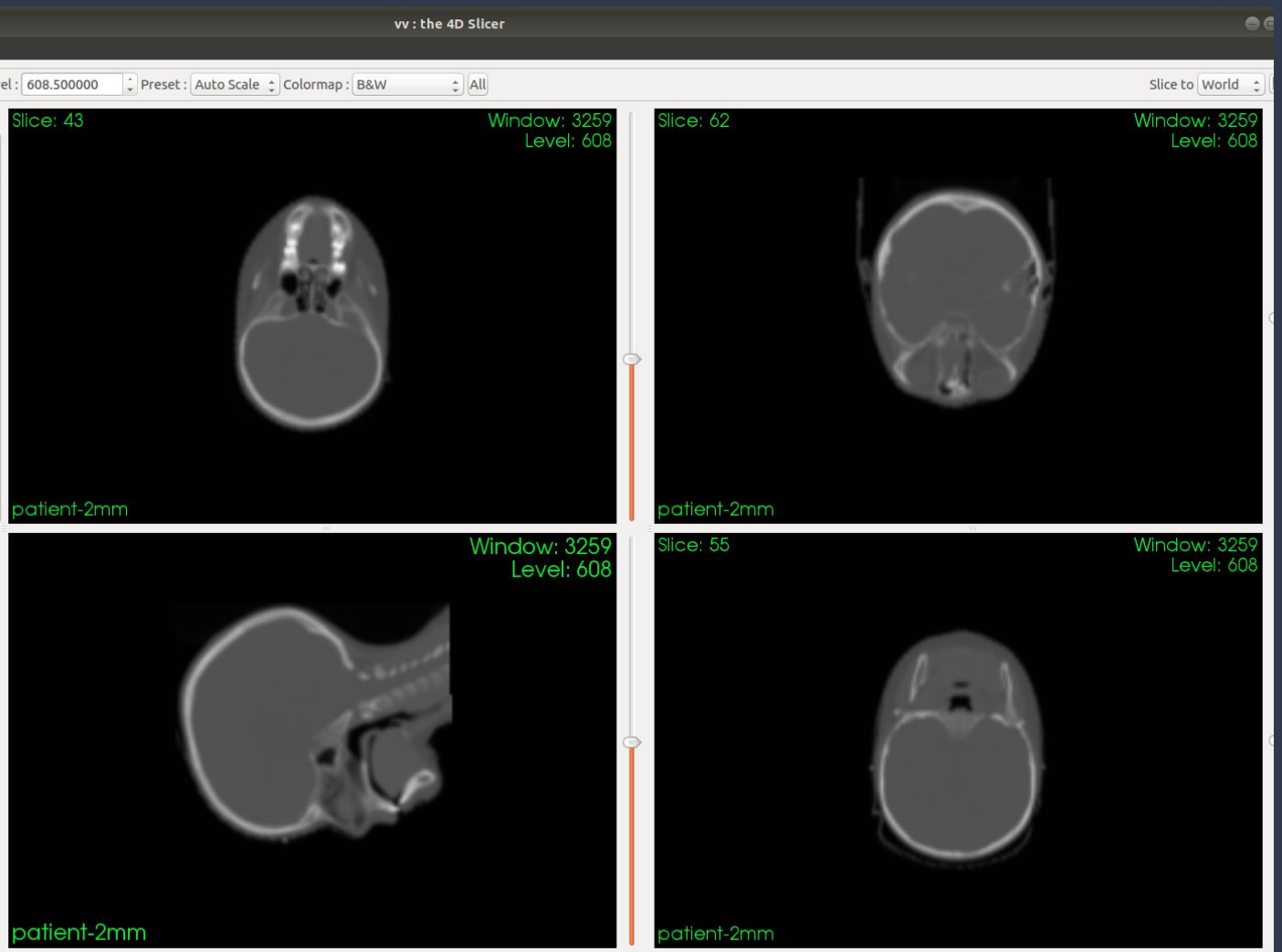
- Values for **depth dose** and **dose profile** for the specified regions in the phantom. These are used to plot the required graphs.
- **Statistical uncertainties** of the dose depositions in each point.
- 3D images of the **dose depositions** on the phantom.

MEAN VALUES OF

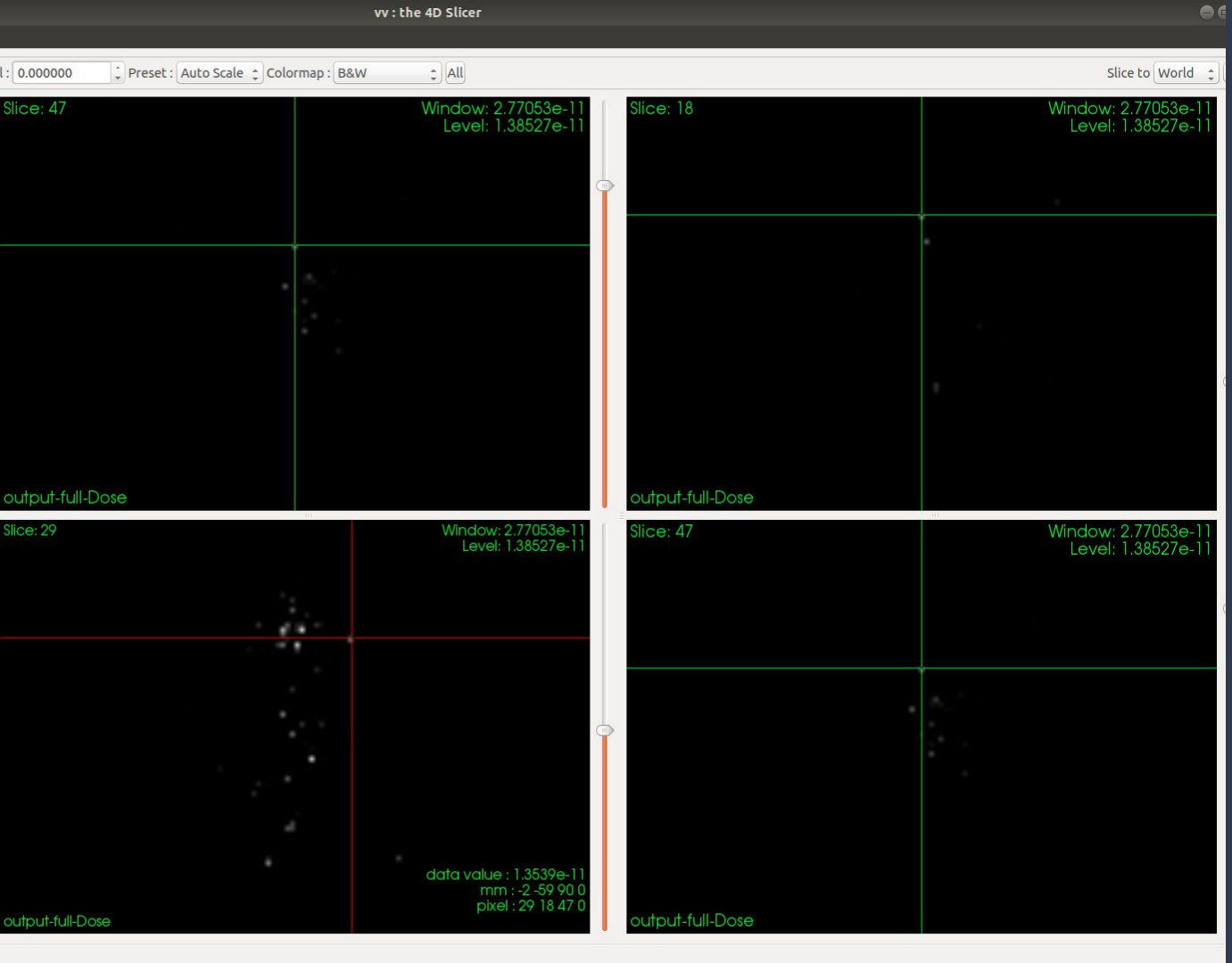
- Depth Dose
  - Statistical Uncertainty : 0.1418223092548
- Dose Profile :
  - Statistical Uncertainty : 0.1635915781939


Energy Depth dose
edep
σ (uncertainty)
Deposited energy in MeV
Uncertainty
Distance in mm
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
20
40
60
80
100


Energy Dose profile
edep
σ (uncertainty)
Deposited energy in MeV
Uncertainty
Distance in mm
2.0
1.5
1.0
0.5
0.0
0.5
0.4
0.3
0.2
0.1
0
20
40
60
80
100

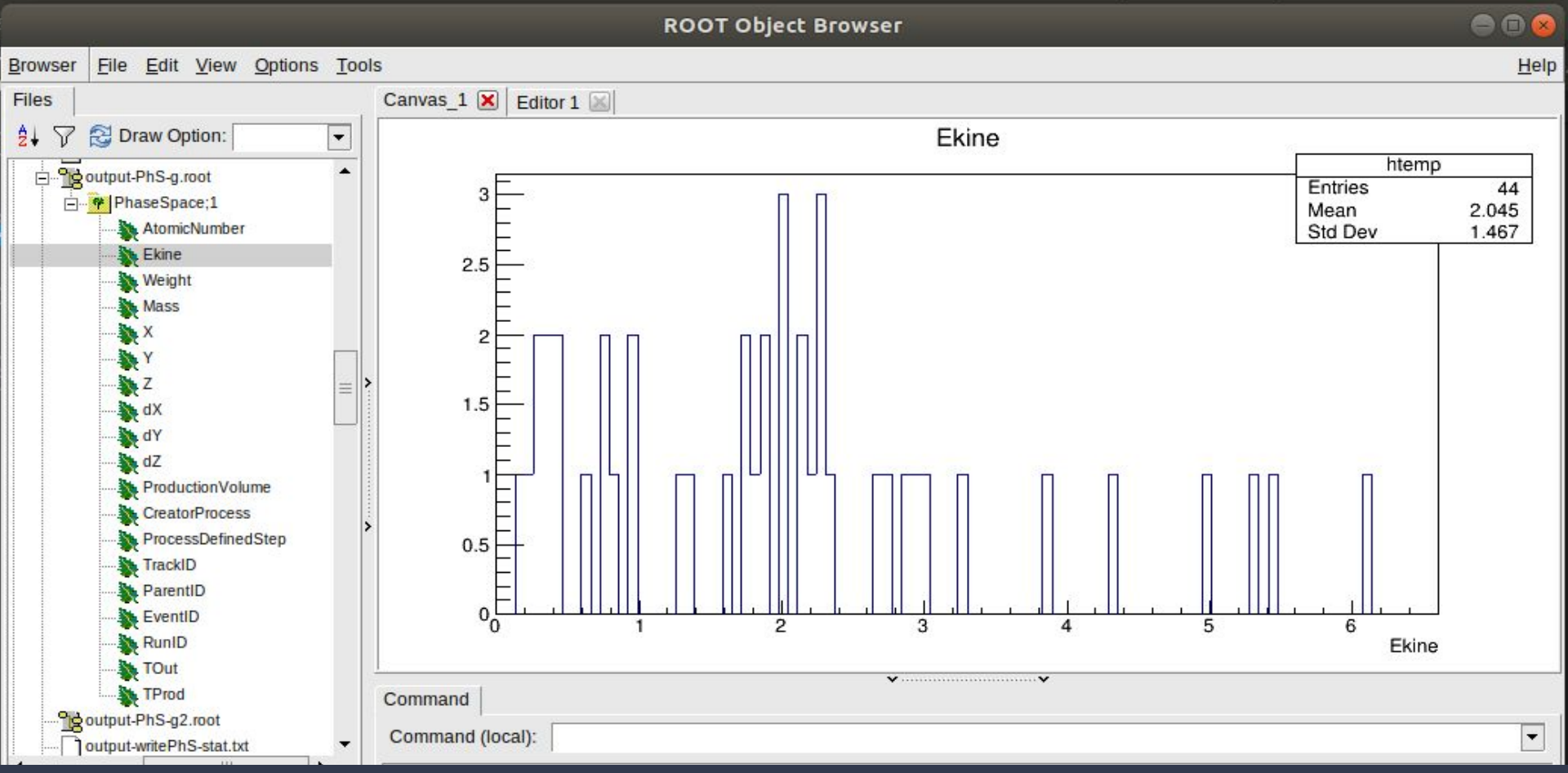


3D Image of Patient head in vv software <-



3D Image of Dose deposition in a region of the phantom <-

Phase Space file in ROOT Software



Conclusion & Future Work

- Carried out a simulation of a LINAC head, photon beam production and transportation in radiotherapy.
- Input values for the simulation were taken from research papers on Monte Carlo linac simulations using GATE.
- Dosimetric values with an average **relative statistical uncertainty** of 14.18% for depth dose and 16.36% for dose profile were obtained. (50k primaries)
- Input values specific to the medical team’s requirement can be set in the code to compare the experimental results with the simulated ones and further required changes can be made in the future.

Report Contents

- **Introduction**: Radiotherapy, Linac internals, intro to GATE.
- **Literature Survey:**
  - Background : Radiotherapy process, Monte Carlo simulation, Dosimetry, Photon interactions, perks of using GATE
  - Related papers
- **Problem definition:** Monte Carlo simulation of LINAC and radiotherapy for cancer treatment planning,
- **Methodology**
  - Design (flow chart of code and explanation)
  - Software requirements (GPU, Gate, geant4, ROOT etc.)
  - Implementation
- **Results**
  - Dose output graphs and images
  - Relative uncertainty measure
- **Future Work**: Extension of project to simulate a specific linac machine and use for dosimetric analysis.

(relative uncertainty = absolute error / measured value)