Simulation of the Final Focus and Collimator of the Electron Beam for VHEE Therapy (50-200 MeV) and 5 MeV X-Ray Therapy with Geant4 / TOPAS

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Introduction

Monte Carlo simulation of radiation transport has been used to estimate dose distributions from radiotherapy linacs for more than 30 years.

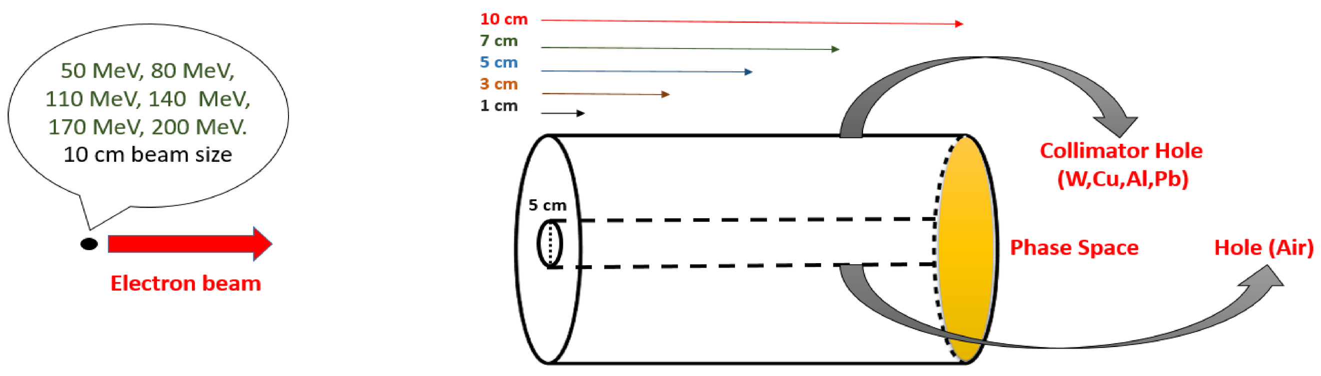
We present Monte Carlo simulation of the Final Focus and Collimator of the Electron Beam for VHEE Therapy (50-200 MeV) and 5 MeV X-Ray Therapy with Geant4 / TOPAS .

To compare a phase space resultant between two geometries X-Ray Therapy and VHEE Therapy.

Optimize target parameters to maximize dose to tumor for low energy electron beam.

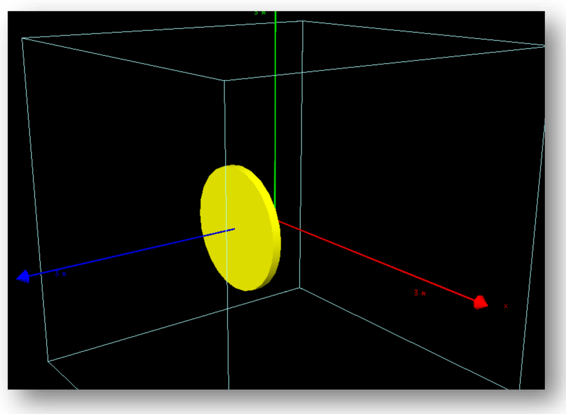
Very High Energy Electrons

- VHEE radiotherapy (VHEE-RT), the delivery of ultrahigh radiation doses in fractions of a second, is under investigation as a cutting-edge technology to improve cancer treatment.
- Irradiate collimator hole at various depths along the collimator and various energy and material .

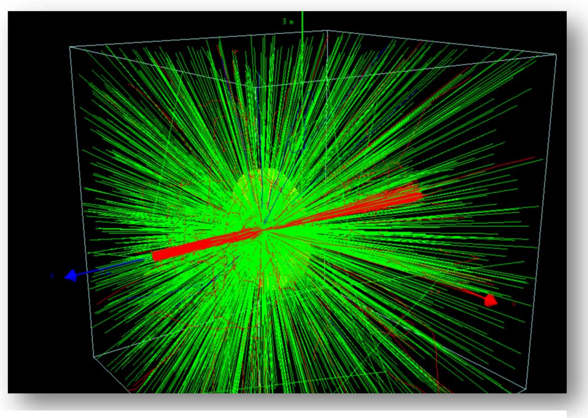


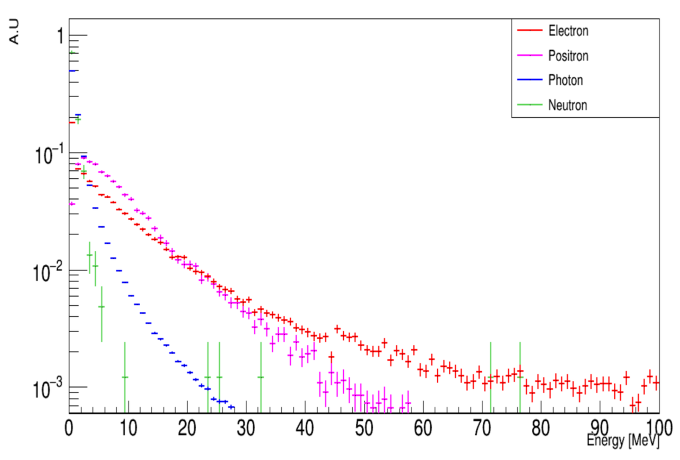
TOPAS simulation parameters:

- 140 MeV beam of incident electrons.
- 1-5 cm thickness collimator (W).

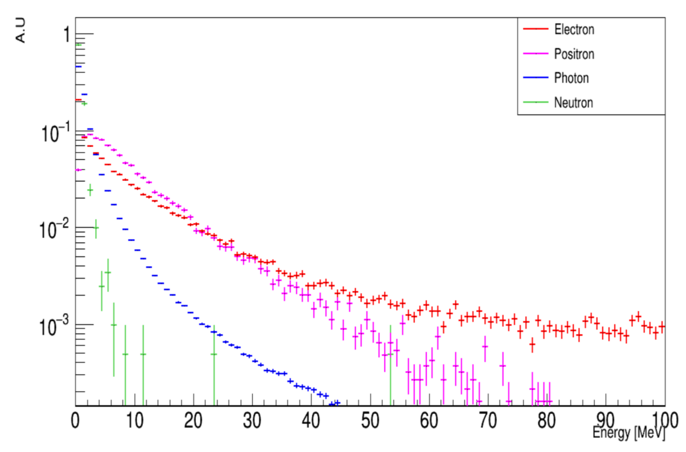


Nb = 10^6
Ee = 140 MeV



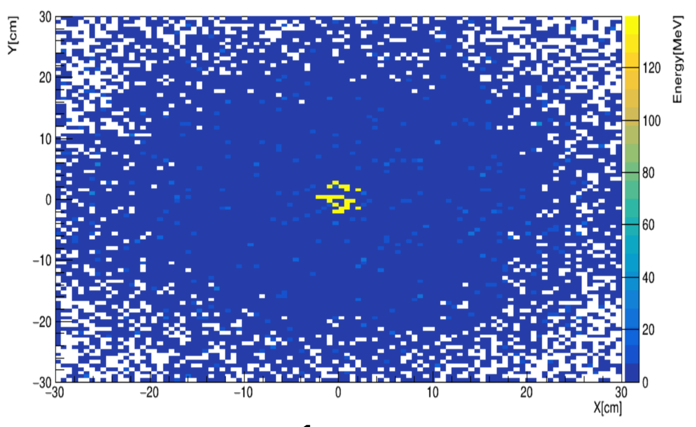


1 cm

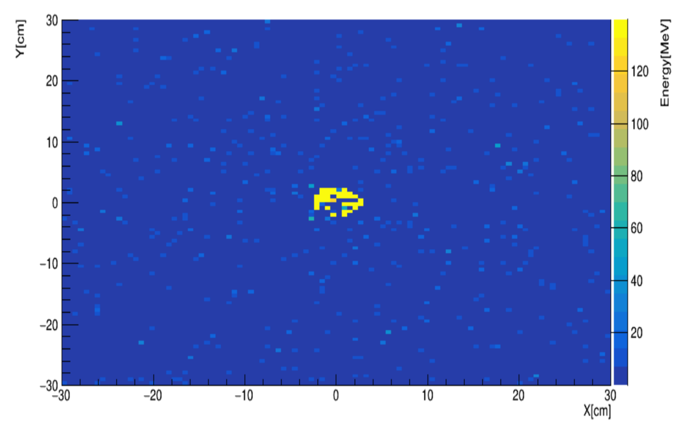


5 cm

Study the ratio of particles produced



1 cm



5 cm

Study energy deposit in XY-plane

Simulation studies have indicated several advantages of using very high energy beams for radiotherapy and next step is simulation of VHEE beams in water for measure dose in depth and dose profiles including :

- Improved dose deposition characteristics.
- Increased dose rate .
- Ease of beam steering and manipulation.

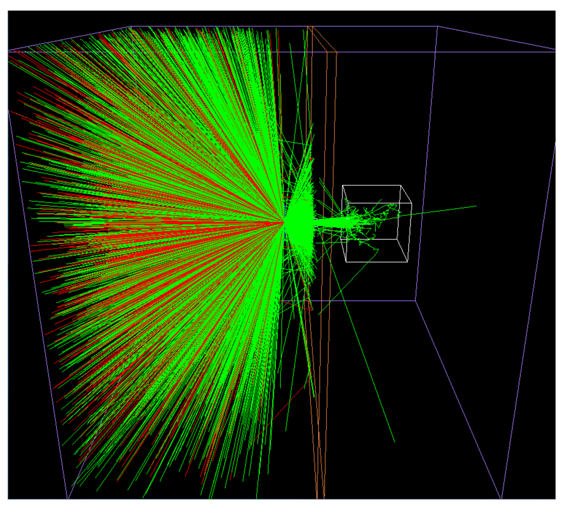
X-Ray Conversion Target

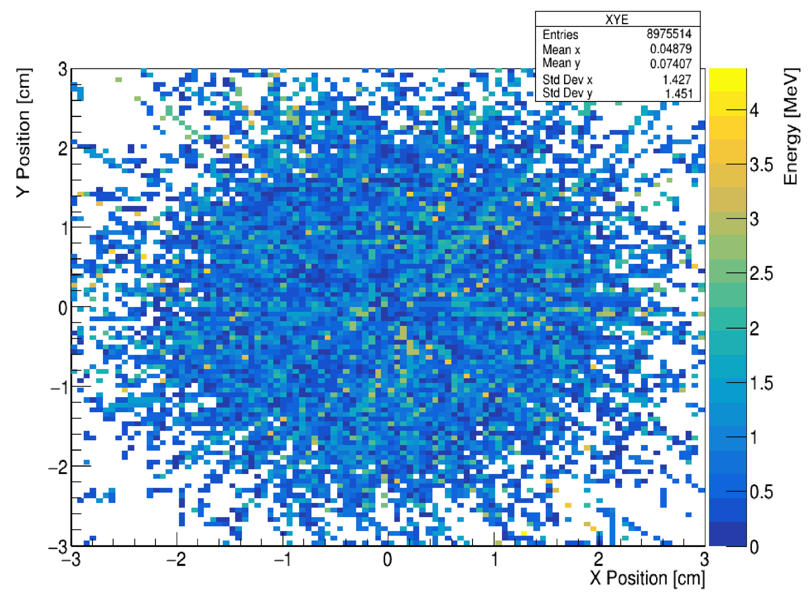
Current radiotherapy linacs are extremely expensive and unaffordable for many countries. In part to create more affordable linacs for these countries, I study conversion targets for classical radiotherapy.

Conversion target – a thin square of tungsten with a copper layer for cooling which converts the beam of incident low energy electrons into secondary electrons, positrons, and photons. Want to maximize dose of x-rays to tumor without harming the surrounding healthy tissue.

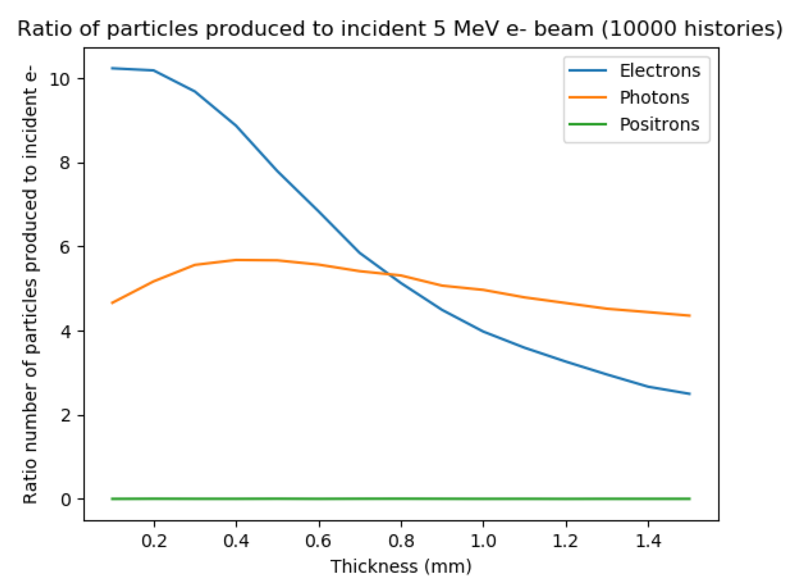
TOPAS simulation parameters:

5 MeV beam of incident electrons
5 cm^2 tungsten target
0 – 1.5 mm thickness range
1 mm thick copper layer for cooling
10 cm thick lead shielding 50 cm away
10 cm^3 tumor surrounded by 1 cm^3 healthy tissue

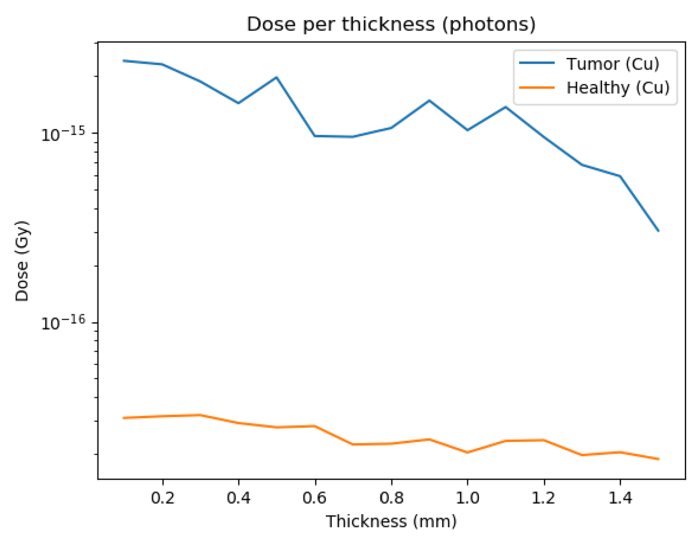




Study energy distribution from particle production over back end of target to ensure an even distribution of dose for treatment.



To maximize photons produced per electron, we select 0.4mm as the optimal thickness for the target for the given beam parameters



Study total dose to tumor and surrounding tissue for various target thicknesses.

Next Steps:
Optimization of copper layer for selected thickness to reduce affects of overheating and study impact and limitations of target from overheating.
Further investigate dose characteristics, including distribution and reduction per depth for chosen target thickness.
Compare studies at various other low energies.

Conclusions

Our results confirmed the potential advantage of VHEE-RT and provide a strong rational for further evaluating VHEE-RT, and this will be more evident in the next step in calculating the dose in water .
Found optimal target thickness for 5 MeV electron beam is 0.4 mm thick.
Next, study impact of collimator and target for delivering dose to patient.

References

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