Beams and Dreams – Transfer Lines for VHEE Therapy

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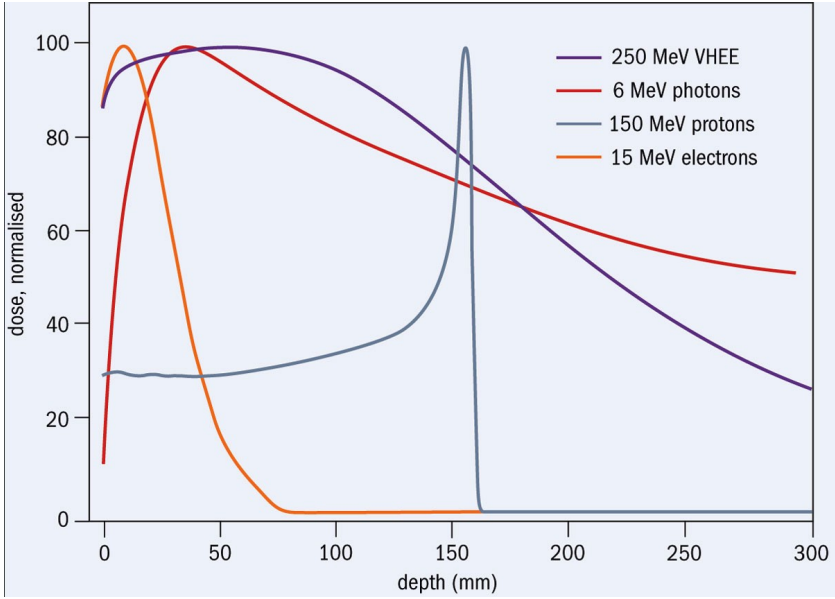
VHEE

- Very High Energy Electrons (>50MeV) can be superior to conventional RT for treatment of deep seated tumours
  - FLASH effect
- Acceleration of electrons to 200 MeV could be carried out in a short linac
  - Smaller required gantry than hadron therapy – electrons fully relativistic

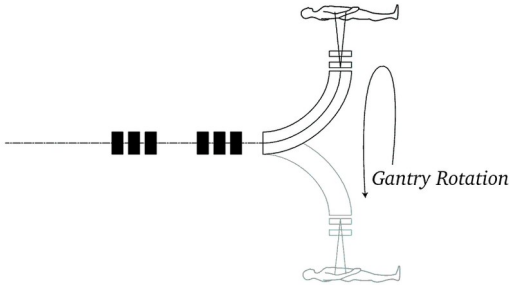


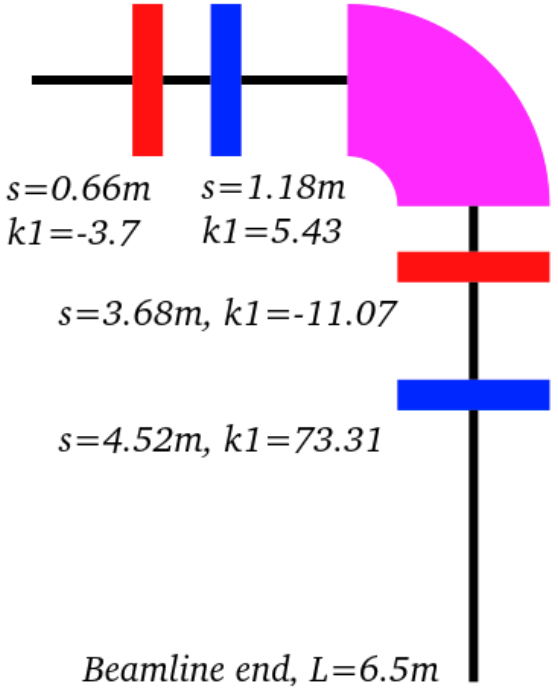
Motivation

- For any clinically viable VHEE treatment machine, a flat beam (constant transverse intensity distribution) is very desirable
  - Lateral penumbra would create uneven dose distribution and thus significant dose to healthy tissues
- Magnification also required
  - Up to 7.5cm radius for flat irradiation, less for scanning
- We achieve these requirements with a transfer line

Option 1: Optics

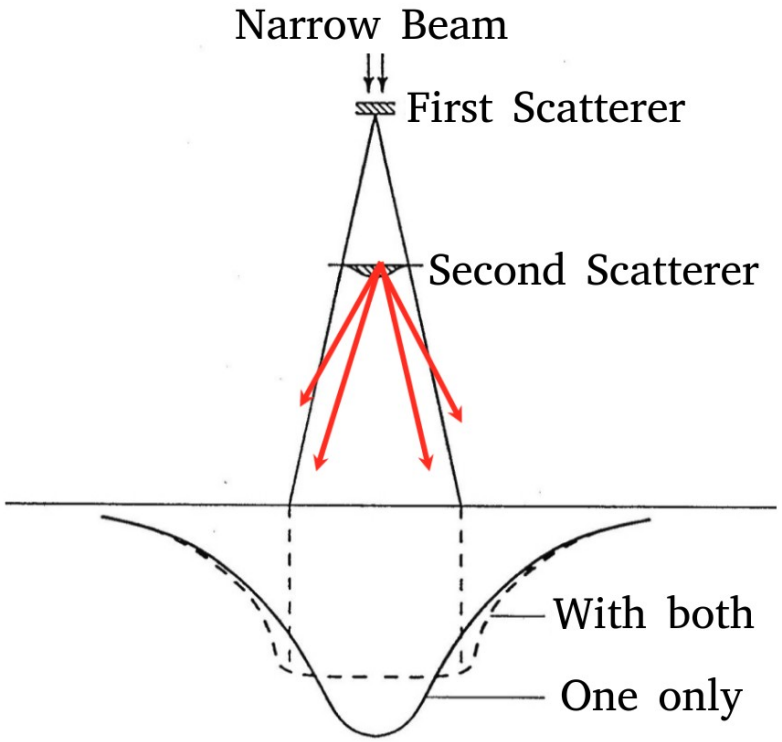
- Arrangement of quadrupoles (lattice) to magnify beam
  - Relies on initially flat beam
- Toy model of ‘Riesenrad Gantry’ used for this study





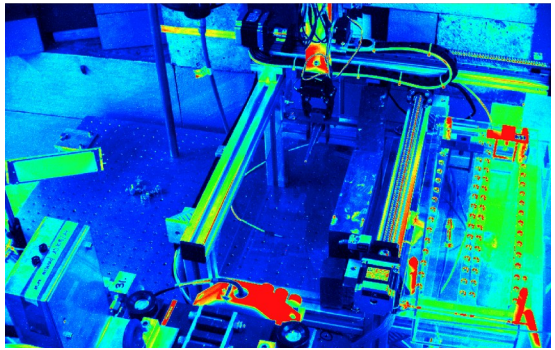
Option 2: Dual Scattering Foil

- Flat scatterer enlarges beam
  - ~random – beam has a Gaussian intensity distribution
- Second scatterer scatters centre of beam into constant intensity distribution



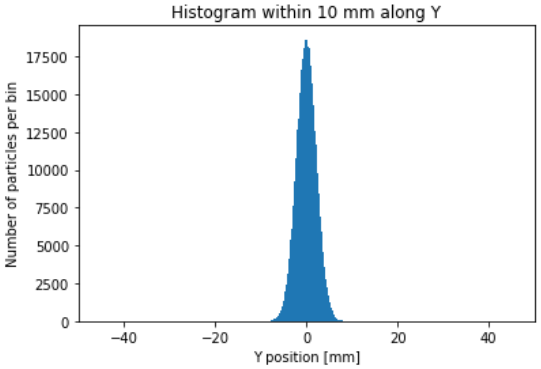
Verification of Principle at CLEAR

- Cern Linear Electron Accelerator for Research (CLEAR)
  - 200 MeV beam, in-air test stand at dump for experiments
- Scatterers inserted into beam using robot

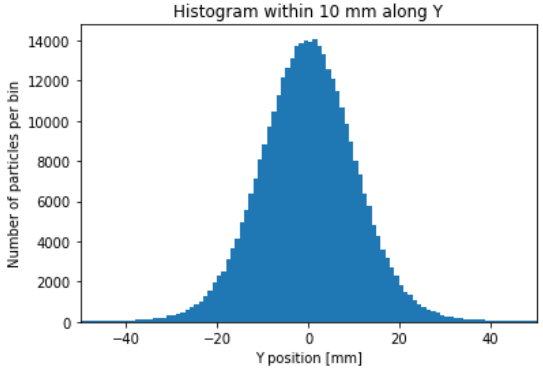


TOPAS Simulations

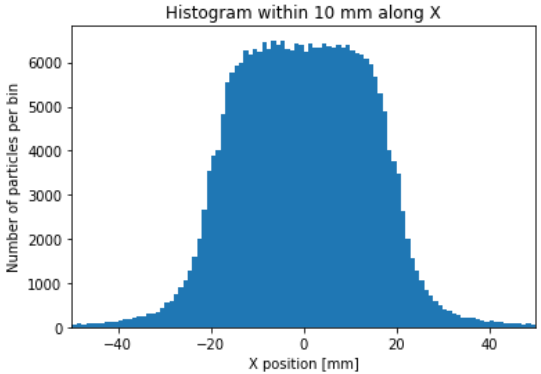
No scattering

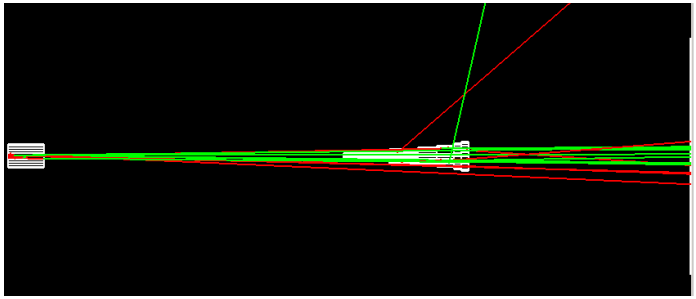


First Scatterer



Dual Scatterering



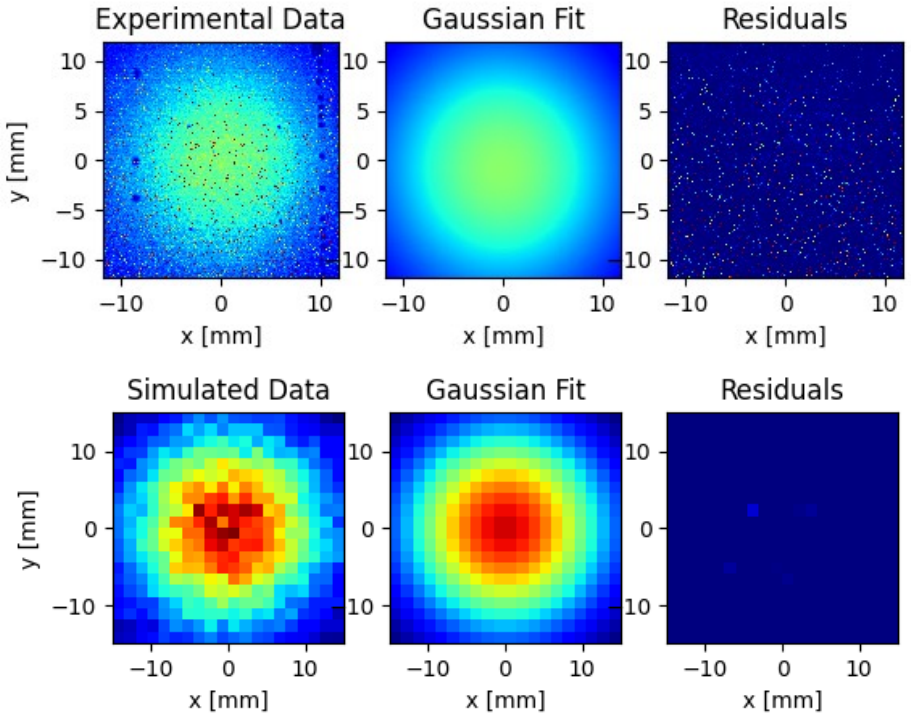


Beam composed of electrons and X-Rays (only electrons shown here)

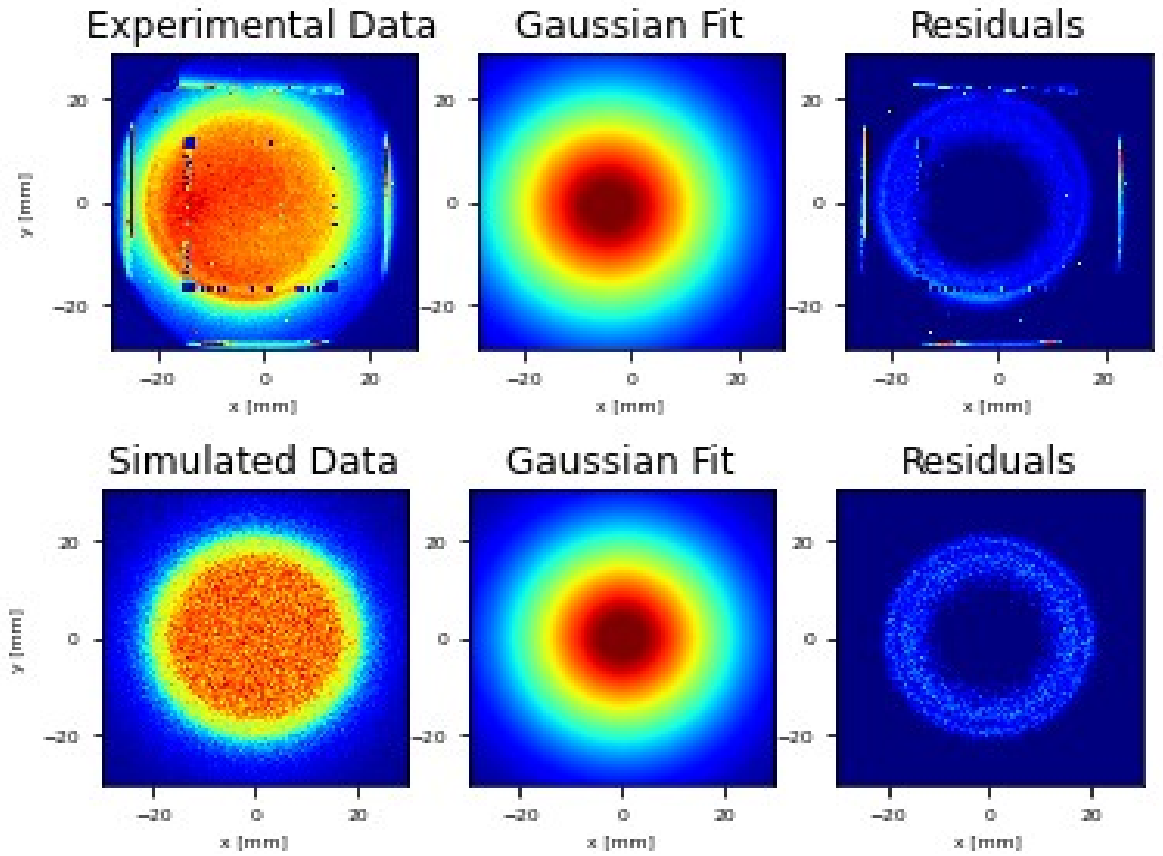
Experimental Tests

- First Experimental test
  - Single scatterer, 3D printed in PLA
- Gaussian beam produced as expected with successful fits
  - Very good agreement between experiment and MC simulation

E=200 MeV, L=30mm, foil 500mm upstream of YAG



- 2nd experimental test
  - Full dual scattering system implemented
- Similarly very good agreement between experiment and simulations
  - Only for electrons!



Looking Forward

- Electron distribution is not the full picture
  - Significant X-Ray production
  - YAG screen more sensitive to electrons
- Next experiment with aluminium scatterers being prepared
  - Dose distribution will also be investigated