Current developments

At the Medical University of Vienna

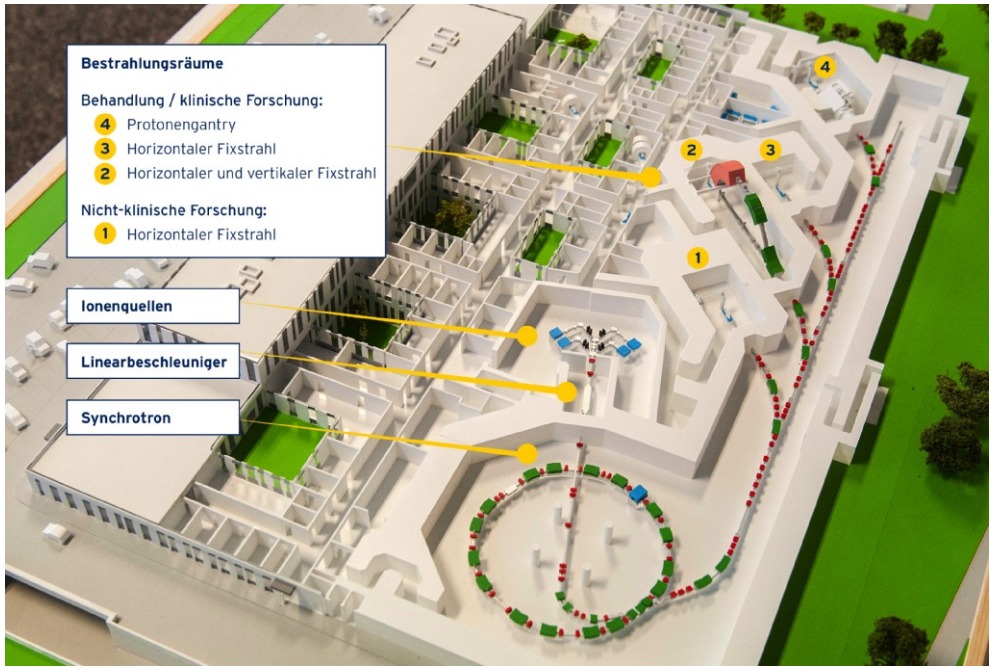
H. Fuchs, Medical University of Vienna

Overview

- Neutron measurements and simulation
- Cross section evaluation
- Implementation of microdosimetric calculation function

Neutrons production during ion beam therapy

- Neutron production during ion beam therapy
  - Increasing interest of community
  - Pregnant patients, etc.
- Experimental measurements
  - Water phantom @ isocenter
  - Central beam of P, C12, He ions
- Cross-comparison MC tools
  - Fluka
  - Geant4/OpenGATE

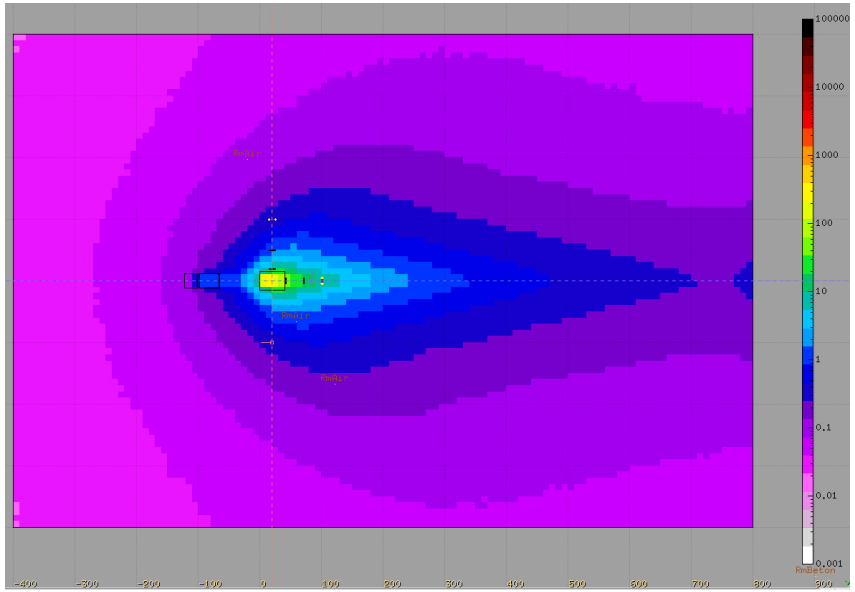


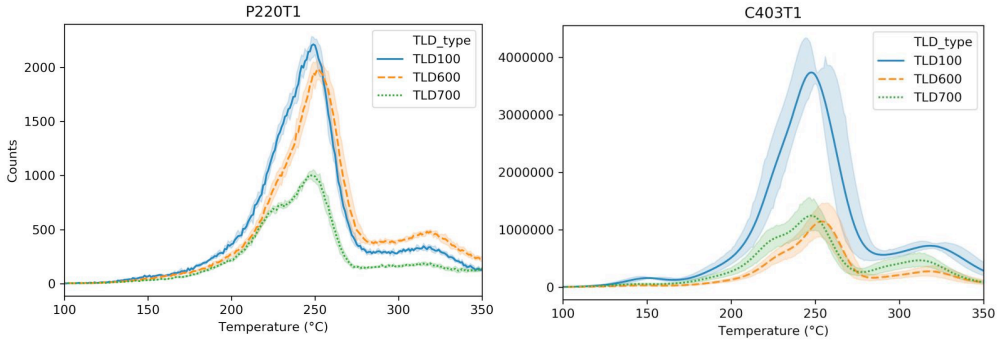
Experimental Set- Up

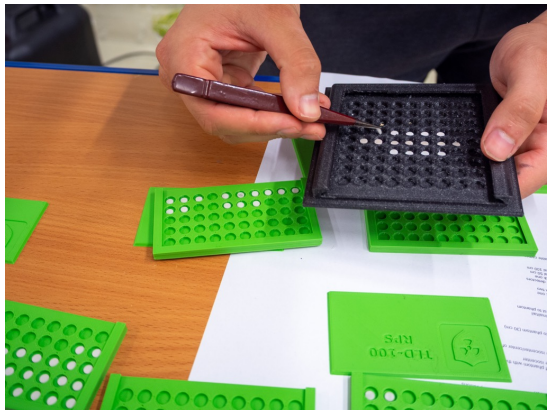
- Multiple particles and energies
  - P 142.5, 220 MeV
  - He 140, 220 MeV/u
  - C12 273, 402 MeV/u
- Detectors
  - WENDI 2 (Thermo Fisher)
  - TLD 100 + 600/700
    - calibrated for thermal neutrons
    - Nuclear reactor @ Vienna
- Positions
  - Lateral (15, 50, 100 cm)
  - Tail (40, 70, 120 cm)

Preliminary comparison

- Similar results for experimental measurements and simulations
  - For WENDI 2
  - Lateral only
- Issues:
  - TLD in tail unreliable
  - Not only neutrons…







Cross sections

- Helium ions available at MedAustron
- Cross Section Data limited
  - Helium ions in clinical energy range
- Evaluation of influences on clinical parameters
  - Dose distribution
  - Particle flux
  - Neutron flux
  - LETd
- GOAL: Modify individual Cross Sections for Sensitivity Analysis
  - Mainly interested in projectile fragments of ^{4}He

$$^{4}He + A \rightarrow \begin{pmatrix} ^{3}He + n + X \\ t + p + X \\ d + d + X \\ d + n + p + X \\ n + n + p + p + X \end{pmatrix}$$

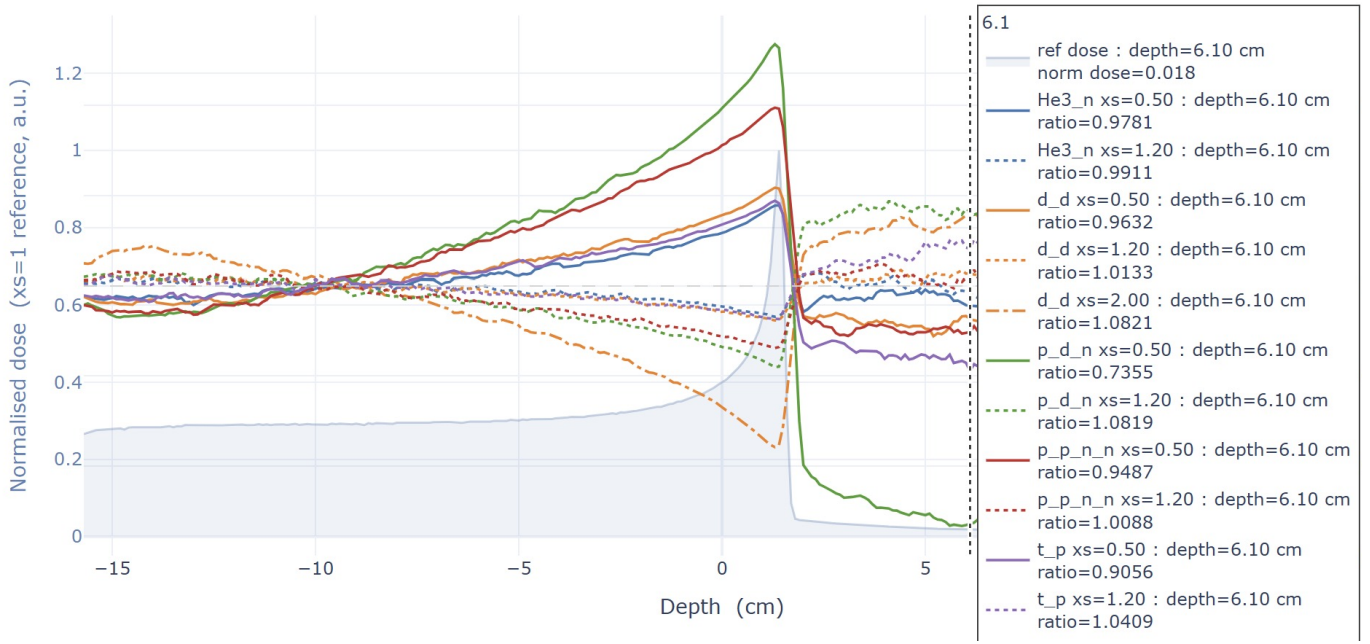
Physics Wrapper

- Developed a physics wrapper
  - Scale cross sections

- Choose a channel (e.g. 4He + X → t + p + X) to scale by choosing:
  - Nuclear process to scale → alphaInelastic
  - Channel signature in the format [[Z,A],[Z,A],…] → [[1,3],[1,1]]
  - Cross Section Scaling factor can be either <1 or >1
  - Optionally: Set channel definition to exclusive (default is inclusive)
  - Define energy range of specific secondaries [E_min, E_max] to be scaled → useful to only scale projectile or target fragments

Physics Wrapper II

- Replaced methods:
  - PostStepGetPhysicalInteractionLength → Mean Free Path is scaled in order to increase process cross section if needed
  - PostStepDoIt → look at the proposed particle change → accept/rollback depending on conditions set
- Currently working on test cases



Microdosimetric calculations

- Calculation of microdosimetric spectra
  - Time consuming
  - Very small step/voxel sizes
- Hybrid approaches exist
  - Using MC to calculate particle flux
  - Using analytical formula from there
    - Sato et al, PMB 2023

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Physics in Medicine & Biology

IPEM Institute of Physics and Engineering in Medicine

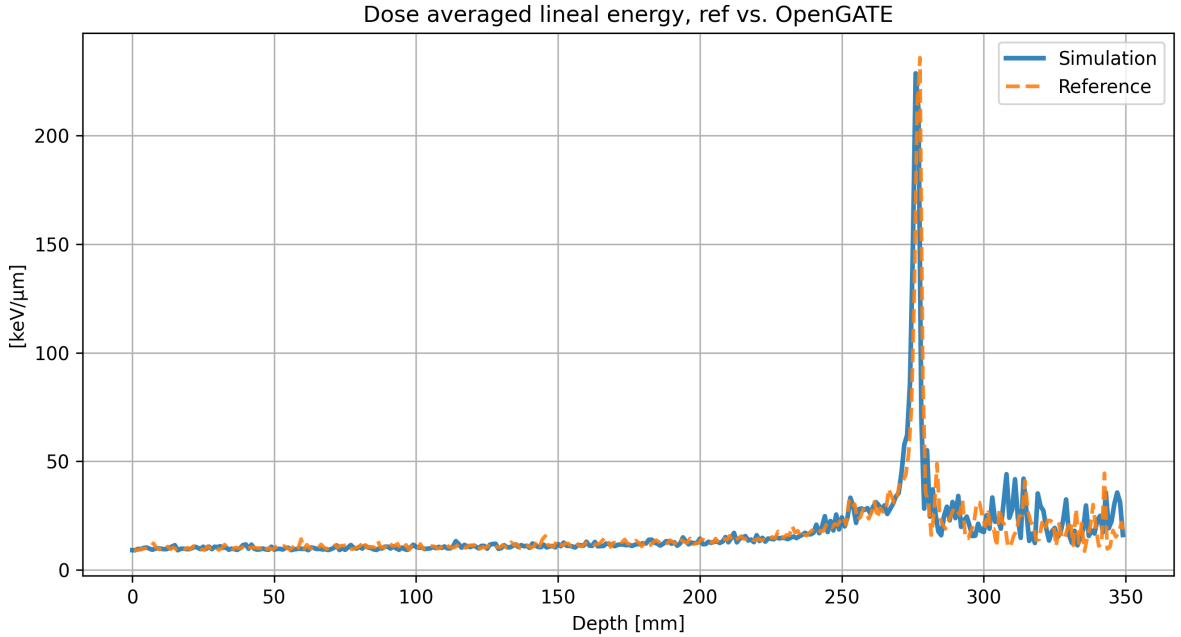
PAPER

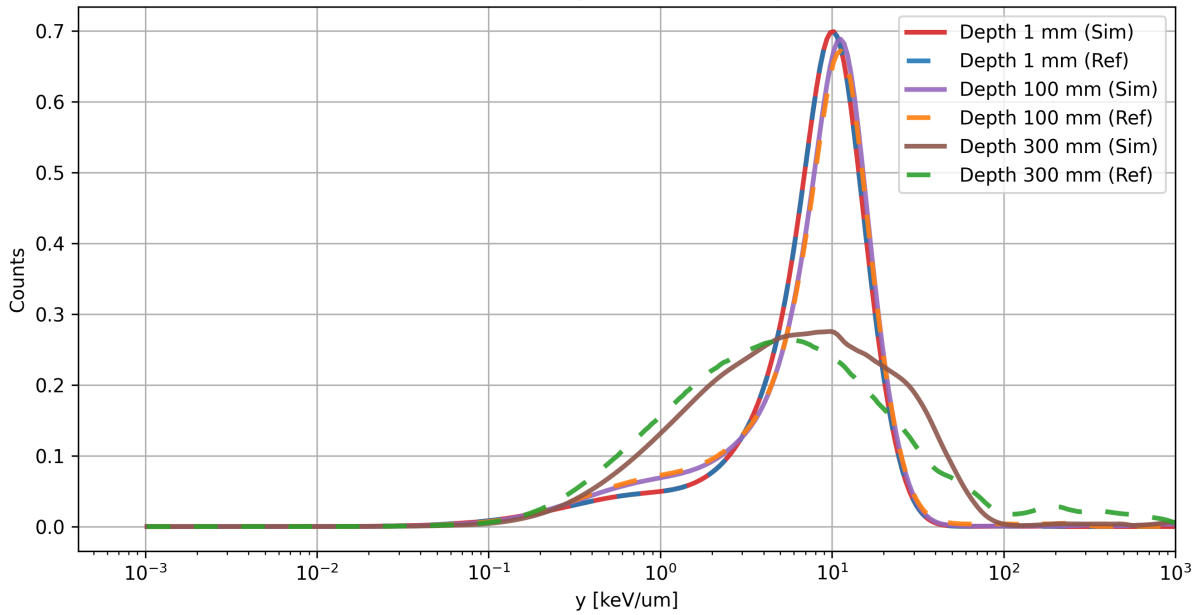
Improvement of the hybrid approach between Monte Carlo simulation and analytical function for calculating microdosimetric probability densities in macroscopic matter

Tatsuhiko Sato[1,2,*], Yusuke Matsuya[1,3], Tatsuhiko Ogawa[1], Takeshi Kai[1], Yuho Hirata[1], Shuichi Tsuda[1] and Alessio Parisi[1]

Microdosimetric calculations

- Implementation into OpenGATE
- New dose actor
  - AMF – Abridged Microdosimetric Formula
- Good agreement with full simulation
- Outlook:
  - Perhaps to calculate biological models
- Working on test cases





Summary & Outlook

Summary

- Neutrons
  - Comparison simulation – experiments promising
  - Unsolved tail measurement problems
- Cross sections
  - Impact of cross section on clinical parameters
  - Ongoing
- Microdosimetric functions
  - Faster way to get spectra with MC
  - Input for biological modelling