PTCOG-AO 2025
HONG KONG
NOV 7-9

PTCOG-AO

Theme: Physics

Abstract No: PTCOG-AO2025-ABS-0093

Therapeutic (RBE-weighted) Dose-Normalized Neutron Shielding Assessment for Multi-Ion (He, C, O, Ne) Radiotherapy

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Background / Aims:

- Heavy-ion radiotherapy is expanding from carbon to helium, oxygen, and neon ions.
- As multi-ion beams are not yet commercially implemented, existing heavy-ion therapy facilities have taken only carbon ions into account in their shielding design.
- While evaluating each ion individually is accurate, it is time-consuming and inefficient.
- AIM: To **assess the shielding effectiveness of various ion species based on RBE-weighted dose** and to **establish a practical multi-ion shielding calculation**

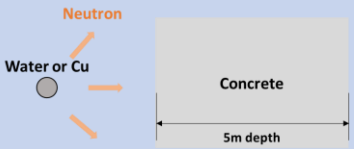
Subjects and Methods:

[1] Sato T et al. Radiat Prot Dosimetry, 143, 2-4, 2011

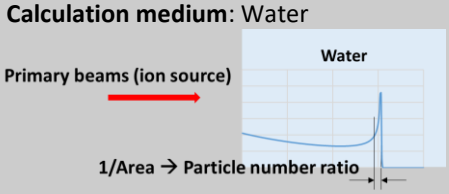
- **Monte Carlo: PHITS (ver.3.35)**
- **Beam energies**: 220 MeV/u for He, 430 MeV/u for C, O, Ne

$$\left(\frac{\text{Neutron dose}}{\text{Particle \#}}\right) \times \left(\frac{\text{Particle \#}}{\text{Physical dose}}\right) \times \left(\frac{\text{Physical dose}}{\text{RBE dose}}\right) = \frac{\text{Neutron dose}}{\text{RBE dose}}$$

Beam loss: Cu(beam dumper), water(isocenter)
Shielding material (calculation): Concrete, Fe
Neutron dose: Fluence-to-dose conversion (ICRP 116)



Calculation medium: Water



RBE calc.: mMKM[1] from lineal energy

Results:

- Neutron effective dose / RBE-weighted dose
  : **C > He > O > Ne** for Cu (beam dumper), **C > O > He > Ne** for water (isocenter)
- Neutron angular distribution in Cu is broader, being more influenced by heavier ions.
  - ➢ He ions produce a relatively higher neutron doses in the Cu medium.
- 50cm iron reduces the neutron effective dose to 1/4~1/5.
- Under the same max. energy, O and Ne require less shielding than C. However, He should be considered in shielding calculations, as its max. energy could be increased.

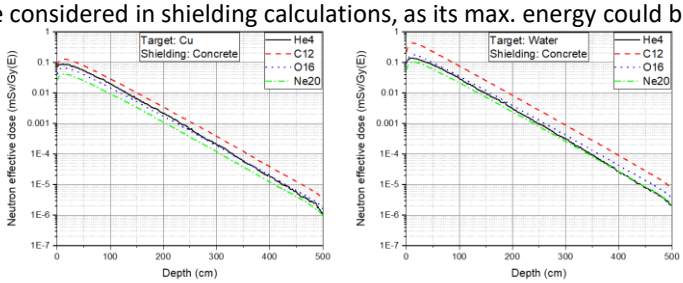


Fig. 1. Neutron effective dose versus concrete depth for Cu and water targets

➢ **Carbon ions provide a conservative basis for shielding assessment, while He ions deserve attention due to their potentially higher energy.**