Multi-element Tissue Equivalent Proportional Counter (METEPC) for Dosimetry in Particle Therapy

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Microdosimetry with Tissue Equivalent Proportional Counters (TEPC)

Energy deposition in gas and tissue:

\[ E_g = E_t \]

\[ \left( \frac{S}{\rho} \right)_t X_t = \left( \frac{S}{\rho} \right)_g \rho_g X_g \]

if:

\[ \left( \frac{S}{\rho} \right)_t = \left( \frac{S}{\rho} \right)_g \]

then:

\[ X_t = \frac{\rho_g}{\rho_t} X_g \]

Mass stopping power of the material and gas have to be equal:
• Gas: tissue equivalent propane
• Material: A150 plastic

Set:
• \( X_g = 5 \text{ mm} \)
• \( \rho_g = 0.0004 \text{ g/cm}^3 \)

Simulated soft tissue site \( X_t = 2 \text{ \( \mu \)m} \)

TEPC can measure dose in micrometer size soft tissue volume!
Multielement TEPC (METEPC)

- Efficiency of TEPCs is proportional to the wall cavity surface area
- Building a detector consisting of multiple cavities increases sensitivity
- Tissue equivalent propane-based gas simulating 2 µm tissue site

61 independent cylindrical cavities in a cylindrical block of A150 tissue equivalent plastic
Monte Carlo – Experiment

monoenergetic 727 keV neutrons

Graph showing comparison between GEANT4 simulations and experiment results for isotropic field and parallel beam conditions.
Coincidence/Anticoincidence Shield

Guard detector sensitive volumes

Central detector sensitive volumes

Coincidence event

Anticoincidence event

Coincidence/Anticoincidence Shield (CACS) configuration
Monte Carlo

100 MeV protons

100 MeV neutrons

$y N(y)$

Lineal energy [keV/μm]
Summary

• A multielement TEPC developed for radiation protection dosimetry can measure:
  – Absorbed dose; Mean Quality factors and Dose-Equivalent

• With more sophisticated signal processing the device has potential for discriminating between charged and neutral component of a radiation field
  • Monte-Carlo study suggests this is feasible
  • Experimental verification required
Summary contd.

• Signal processing has to be developed

• Similar measurements have been carried out in the past by others (PTB instrument) but not with such a compact instrument as the METEPC

• Count-rate limitations will prevent in-beam use, however, the study of fields out of the main beam are valuable for radiation protection measurements and the assessment of hazards to patients due to neutron contamination of the beam