UOIT
CHALLENGE INNOVATE CONNECT

UNIVERSITY OF ONTARIO
INSTITUTE OF TECHNOLOGY

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

Witold Matysiak (University of Florida Proton Therapy Institute)

A. Hanu (McMaster University)

A. J. Waker (UOIT)

Microdosimetry with Tissue Equivalent Proportional Counters (TEPC)

Energy deposition in gas and tissue:

$$E_g = E_t$$

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

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

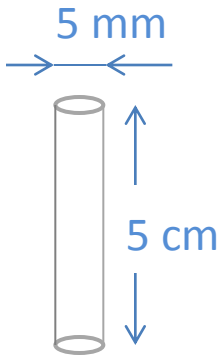
Set:

- X_g = 5 mm
- ρ_g = 0.0004 g/cm^3

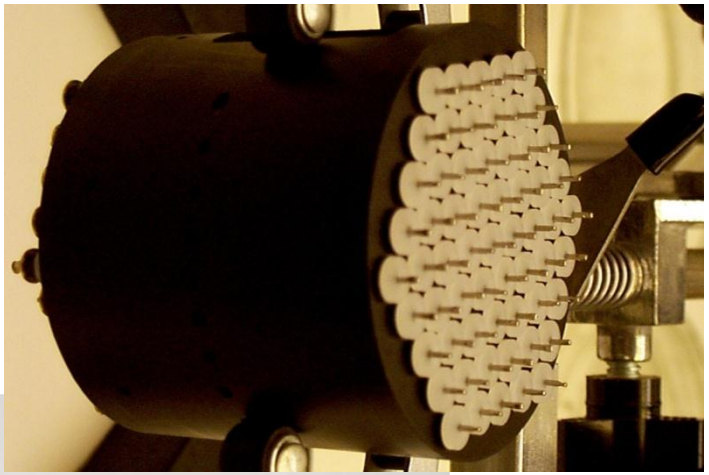
Simulated soft tissue site **X_t = 2 μm**

TEPC can measure **dose** in **micrometer** size soft tissue volume!

Multielement TEPC (METEPC)



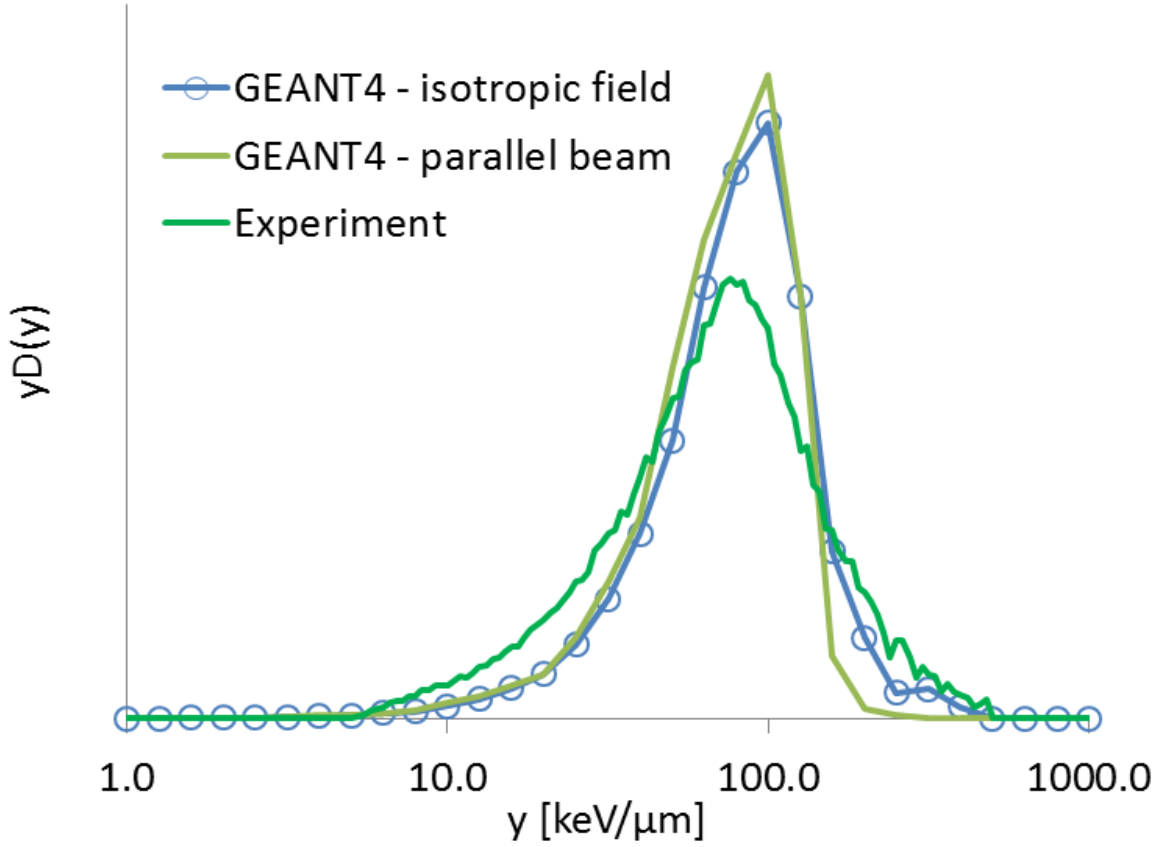
61 independent cylindrical cavities in a cylindrical block of A150 tissue equivalent plastic



- 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

Monte Carlo – Experiment

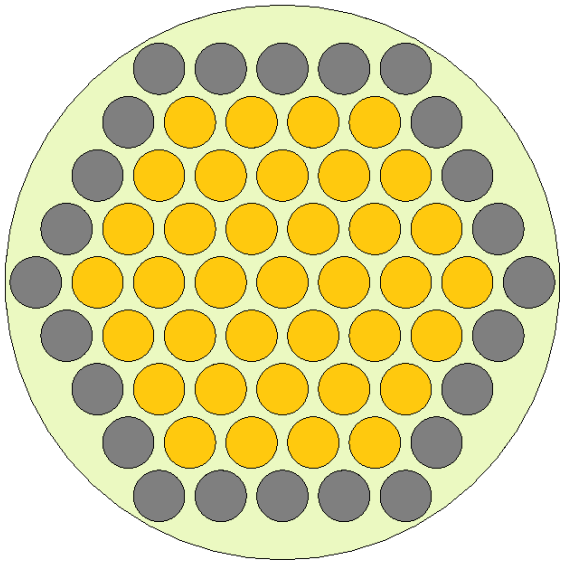
monoenergetic 727 keV neutrons



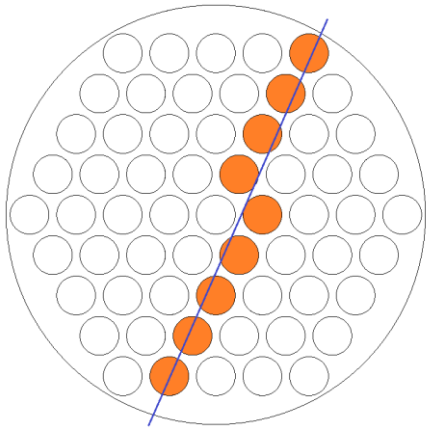
Coincidence/Anticoincidence Shield

Guard detector sensitive volumes

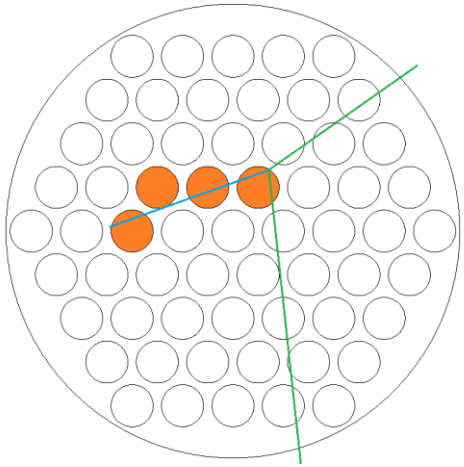
Central detector sensitive volumes



Coincidence/Anticoincidence Shield (CACS) configuration

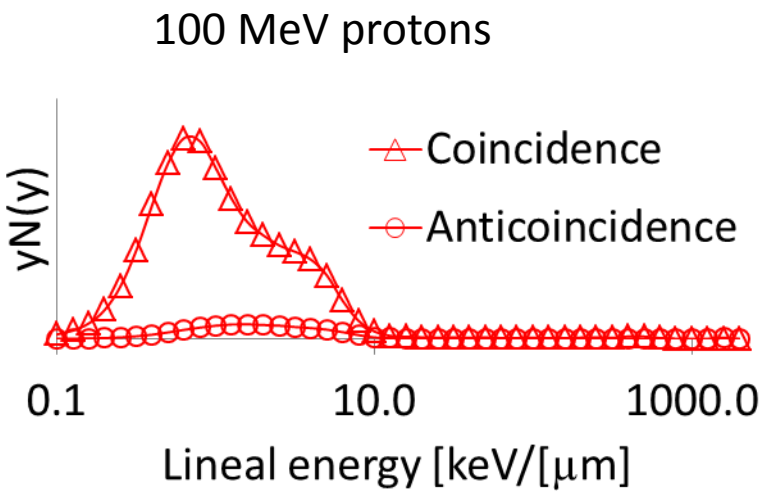


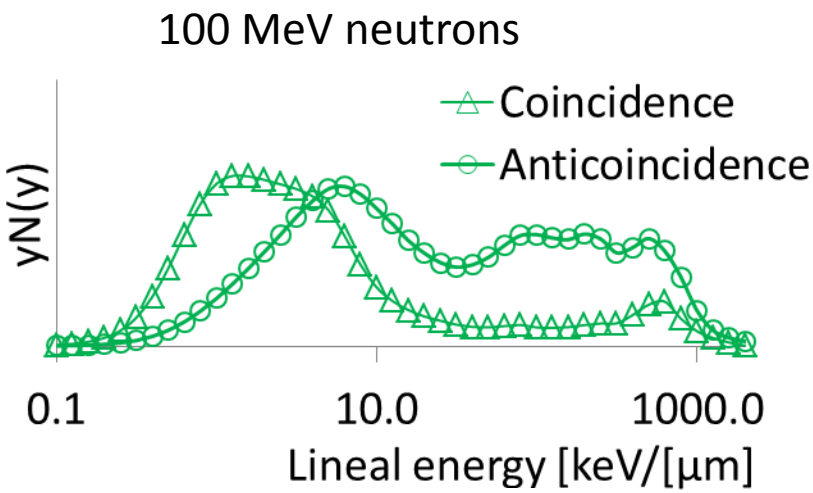
Coincidence event

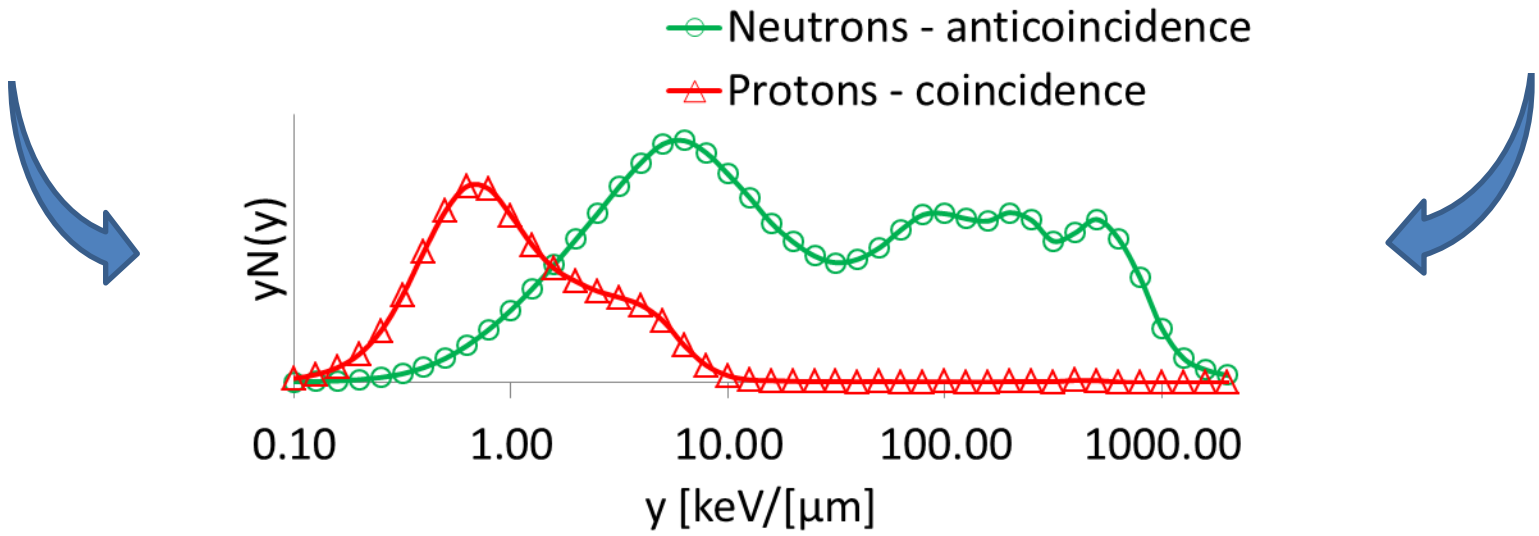


Anticoincidence event

Monte Carlo


100 MeV protons
yN(y)
Coincidence
Anticoincidence
0.1
10.0
1000.0
Lineal energy [keV/[µm]


100 MeV neutrons
yN(y)
Coincidence
Anticoincidence
0.1
10.0
1000.0
Lineal energy [keV/[µm]


Neutrons - anticoincidence
Protons - coincidence
yN(y)
0.10
1.00
10.00
100.00
1000.00
y [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