Towards the general application of water calorimetry as absorbed dose standard for radiotherapy dosimetry
Towards the general application of water calorimetry as absorbed dose standard for radiotherapy dosimetry
Towards the general application of water calorimetry as absorbed dose standard for radiotherapy dosimetry

- brachytherapy sources
- ion beams
- x-rays

- medium energy x-rays (70 kV, 100 kV, 150 kV)
- $^{192}$Ir-brachytherapy source
- scanned $^{12}$C ion beam (280 MeV)
Towards the general application of water calorimetry as absorbed dose standard for radiotherapy dosimetry

Brief overview: calorimetric infrastructure at PTB

- medium energy x-rays (70 kV, 100 kV, 150 kV)
- $^{192}$Ir-brachytherapy source
- scanned $^{12}$C ion beam (280 MeV)

heat conduction effects
Calorimetric infrastructure at PTB (water temperature: 4°C)

Primary standard water calorimeter

60Co-source

“Transportable” water calorimeter

60Co-source cooling unit

1 m

65 cm

high-energy photons
electrons
x-rays
carbon ion beams

“Brachytherapy” water calorimeter

192Ir-source

Detector

\[ D_W = \Delta T \cdot c_p \cdot (1 - h)^{-1} \cdot \Pi k_i \]
General application of water calorimetry (1)

medium energy x-rays
70 kV, 100 kV, 150 kV x-rays

> 500 measurements

SCD: 550 mm
depth: 50 mm
field size: > 12 cm Ø
dose rate: 0.19 – 0.31 Gy/min
General application of water calorimetry (1)

medium energy x-rays
70 kV, 100 kV, 150 kV x-rays

SCD: 550 mm
depth: 50 mm
field size: > 12 cm Ø
dose rate: 0.19 – 0.31 Gy/min

> 500 measurements

Heat conduction effect

PtIr-Cu$_{0.84}$Mn$_{2.16}$O$_4$
General application of water calorimetry (1)

- medium energy x-rays
  - 70 kV, 100 kV, 150 kV x-rays

- > 500 measurements

- SCD: 550 mm
- depth: 50 mm
- field size: > 12 cm Ø
- dose rate: 0.19 – 0.31 Gy/min

Graphs showing temperature changes over time for different energies.

- 150 kV
- calculation
medium energy x-rays
70 kV, 100 kV, 150 kV x-rays

> 500 measurements

SCD: 550 mm
depth: 50 mm
field size: > 12 cm Ø
dose rate: 0.19 – 0.31 Gy/min

General application of water calorimetry (1)

Calculation

Heat conduction correction (150 kV)
~ 3 %
General application of water calorimetry (2)

$^{192}$Ir-brachytherapy source
(352 GBq)

- depth: 29.4 mm (in water)
- dose rate: $\sim$ 0.75 Gy/min
- source: $\sim$ 1.1 mm Ø
General application of water calorimetry (2)

$^{192}$Ir-brachytherapy source (352 GBq)

depth: 29.4 mm (in water)
dose rate: $\sim 0.75$ Gy/min
source: $\sim 1.1$ mm Ø
General application of water calorimetry (2)

$^{192}$Ir-brachytherapy source (352 GBq)

- Depth: 29.4 mm (in water)
- Dose rate: ~0.75 Gy/min
- Source: ~1.1 mm Ø

- Needle 1.3 mm Ø
  (stainless steel)

- Teflon tube

- Turn by 180°
General application of water calorimetry (2)

$^{192}$Ir-brachytherapy source (352 GBq)

-90 s
-120 s
-200 s

$^{60}$Co

depth: 29.4 mm (in water)
dose rate: $\sim 0.75$ Gy/min
source: $\sim 1.1$ mm $\phi$
192\textsuperscript{Ir}-brachytherapy source (352 GBq)

depth: 29.4 mm (in water)
dose rate: ~0.75 Gy/min
source: ~1.1 mm Ø

Heat conduction effect

self-heating of source/needle:
~18.5 mW

General application of water calorimetry (2)
192Ir-brachytherapy source (352 GBq)

- self-heating of source/needle: \(~18.5\) mW
- heat conduction correction (120 s): \(~8\%\)
- depth: 29.4 mm (in water)
- dose rate: \(~0.75\) Gy/min
- source: \(~1.1\) mm Ø

General application of water calorimetry (2)
scanned $^{12}\text{C}$ ion beam (280 MeV/u)

GSI Darmstadt

- depth 50 mm
- spot size ~ 9 mm; raster ~ 4 mm
- $13 \times 13$ spots (~5 cm × 5 cm)
- each spot ~30 ms (~1 Gy/s)
- 12-times repeated

General application of water calorimetry (3)

~ 120 s
~ 2.4 Gy
scanned $^{12}$C ion beam (280 MeV/u)

GSI Darmstadt
- depth 50 mm
- spot size ~ 9 mm; raster ~ 4 mm
- 13 × 13 spots (~5 cm × 5 cm)
- each spot ~30 ms (~1 Gy/s)
- 12-times repeated

heat transport calculation
- time resolution $<<$ 30 ms
- “spill”-duration ~ 3.0 s
- pause ~ 2.5 s

General application of water calorimetry (3)
scanned $^{12}\text{C}$ ion beam (280 MeV/u)

GSI Darmstadt

- depth 50 mm
- spot size ~ 9 mm; raster ~ 4 mm
- 13 × 13 spots (~5 cm × 5 cm)
- each spot ~30 ms (~1 Gy/s)
- 12-times repeated

General application of water calorimetry (3)

Heat conduction correction ~ 1 %
Towards the general application of water calorimetry:

**Summary and Outlook**

...still a long way to go.....