Characterization of a miniature x-ray source for brachytherapy

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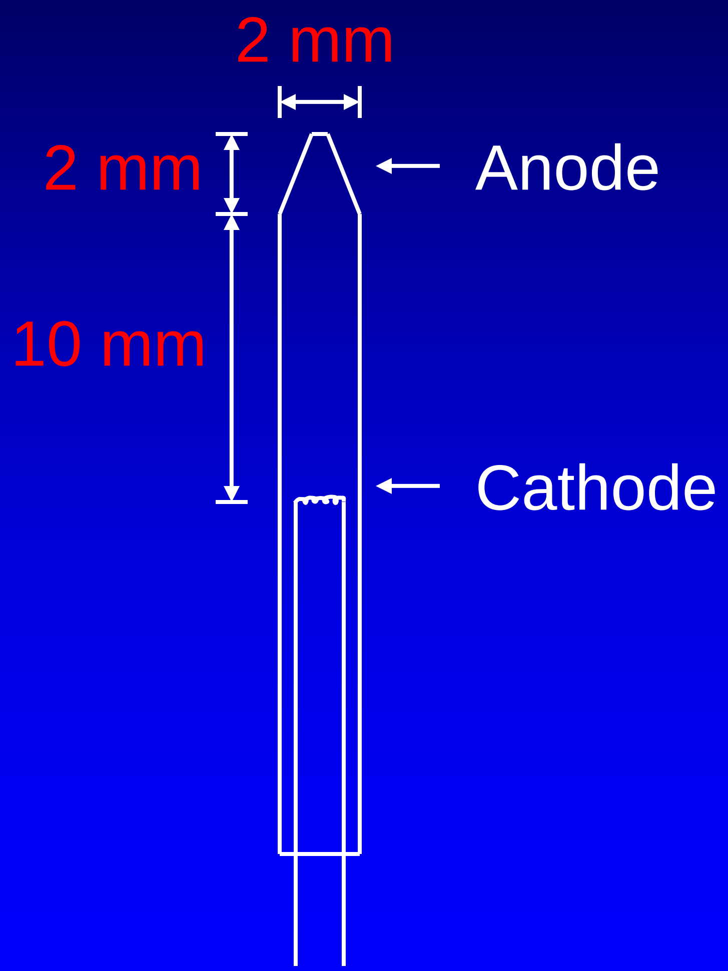
Source design

- X-ray source is ~ 2 mm diameter
- Placed in flexible cooling sheath
- Tube voltages from 30 kV to 50 kV
- Air kerma rates comparable to 10 Ci HDR ^{192}Ir



Advantages compared to HDR ^{192}Ir

- Low energy x-ray source, so minimal shielding is required
- Use of voltages between 30 kV – 50 kV allows for tunable depth-dose curves

Project goals

- Fully characterize the source in terms of TG-43 parameters (interstitial brachytherapy protocol)
- Monte Carlo modeling of source and comparisons with measurements
- Comparisons with TG-61 protocol (external kilovoltage x-ray beams)

TG-43 measurements

$$\dot{D}(r,\theta) = S_K \cdot \Lambda \cdot \left(\frac{G(r,\theta)}{G(r_0,\theta_0)} \right) \cdot g(r) \cdot F(r,\theta)$$

- Interim S_K measured using the modified 7-distance technique originally developed at the University of Wisconsin (Goetsch *et al*, 1991)
- A preliminary set of measurements gave an air kerma strength of 2.7 $cGy \cdot m^2 \cdot hr^{-1}$ for a tube current of 115 μA
  - treatment tube currents will be on the order of 300 μA
  - air kerma strength of 10 Ci ^{192}Ir is 4.1 $cGy \cdot m^2 \cdot h^{-1}$

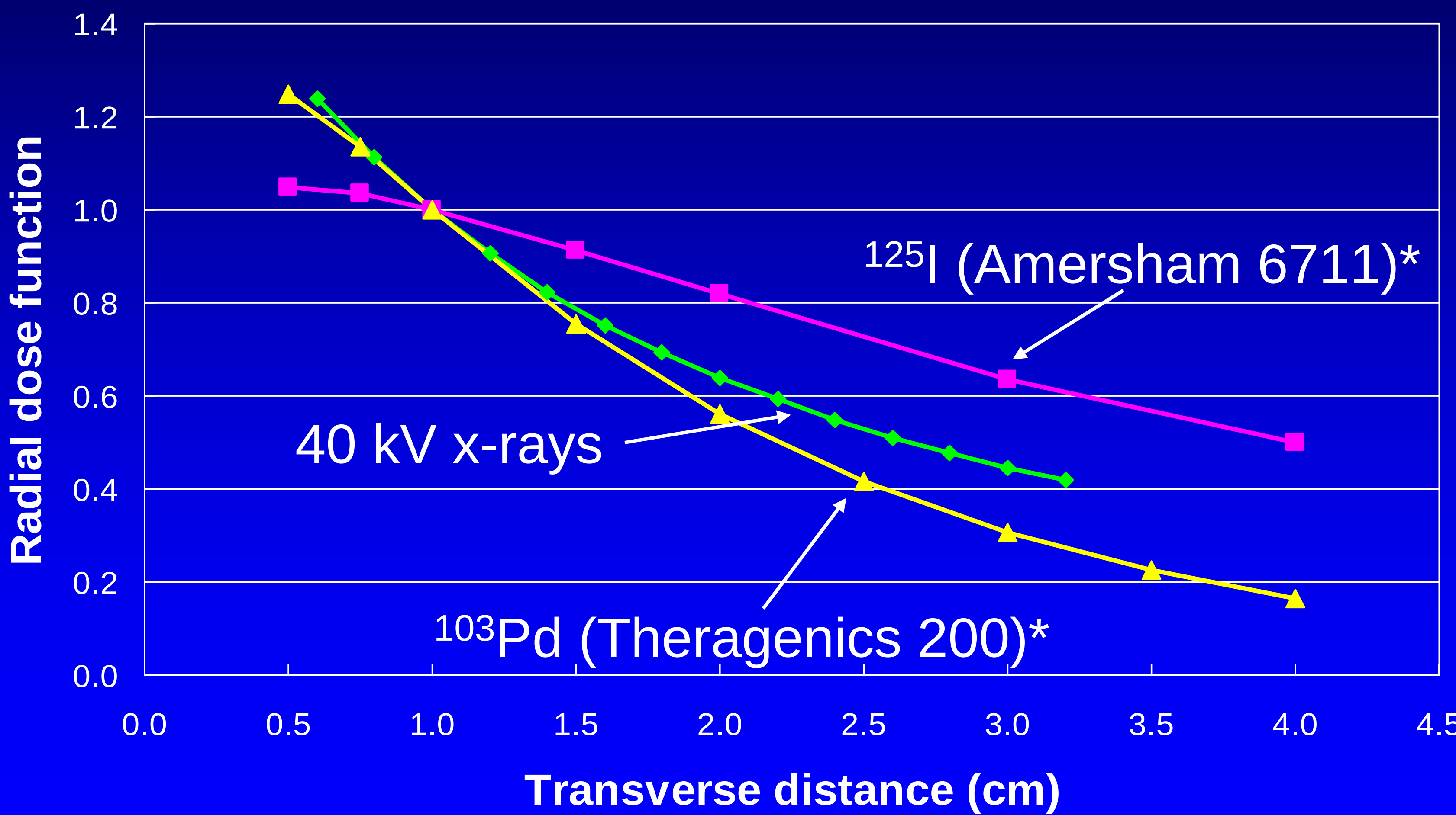
TG-43 measurements (cont.)

- Λ – will be measured using TLDs and also determined using Monte Carlo simulations
  - energy response of the TLDs is an issue at these low photon energies
  - TLD-100 and TLD-100H will be used

TG-43 measurements (cont.)

- Geometry factor – point source (i.e. $1/r^2$ dependence)
- g(r) – preliminary measurements have been made using a PTW 34013 0.005 cc chamber in a liquid water tank, additional measurements may be made using TLDs and radiochromic film

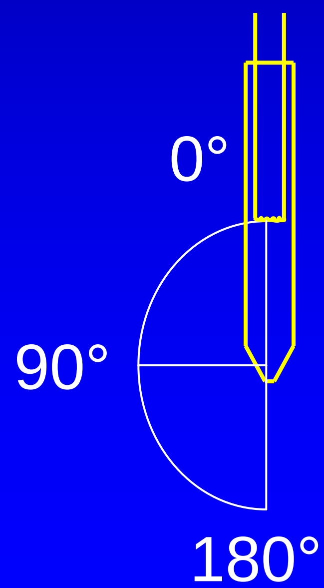
Radial dose functions – g(r)



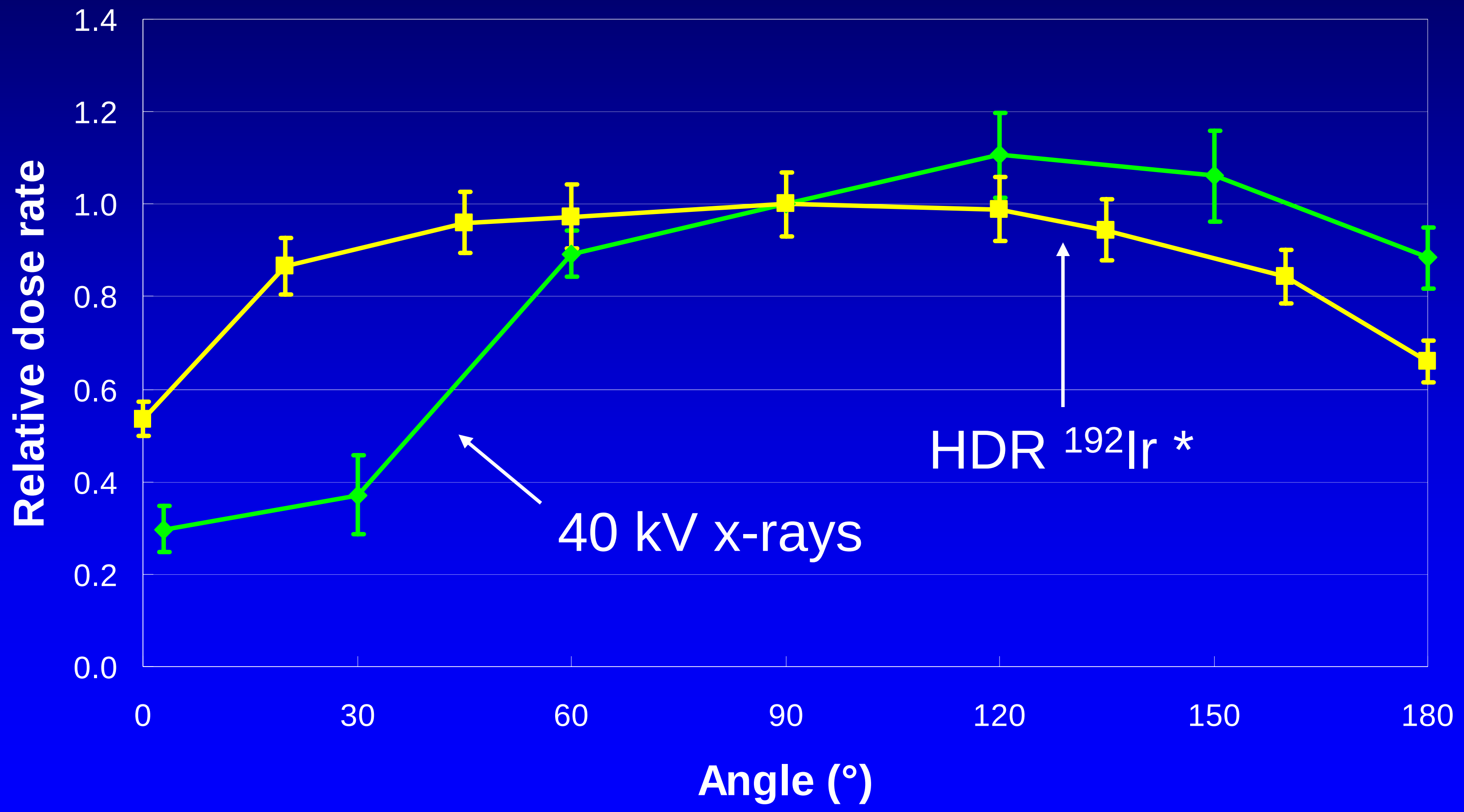
* Rivard *et al*, AAPM TG-43 update (2004)

TG-43 measurements (cont.)

- F(r,θ) – anisotropy function
  - preliminary measurements have already been performed using TLD-100 μcubes (1 x 1 x 1 mm^3) in liquid water with a Virtual Water™ support structure
  - radiochromic film may also be used

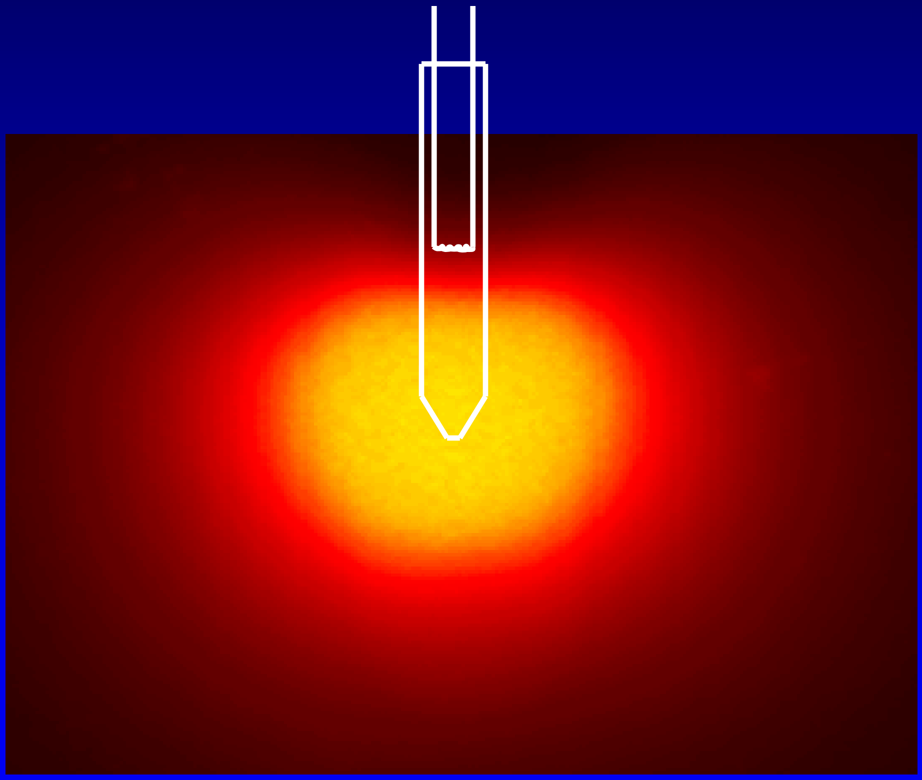


Anisotropy function - $F(r,\theta)$



* Kirov *et al* (1995)

Radiochromic film



Possible additional measurements

- Half-value layers
  - calculated from measured spectra
  - measured using Attix free-air chamber
- Air attenuation and air kerma rates using the free-air chamber
- Dose distributions around balloon-type treatment applicators using TLDs and/or radiochromic film

Acknowledgements

- Dr. Larry DeWerd
- Dr. Tom Rusch
- John Micka
- Ben Palmer
- Steve Beach
- Dr. Tim Bohm