MONTE CARLO-VALIDATED IN VIVO OPTICAL DOSIMETRY AND SOURCE TRACKING FOR HDR BRACHYTHERAPY

Kevin Willy, Megan Clark Ph.D., Shauna McVorran MD., Petr Bruza Ph.D, David Gladstone Sc.D

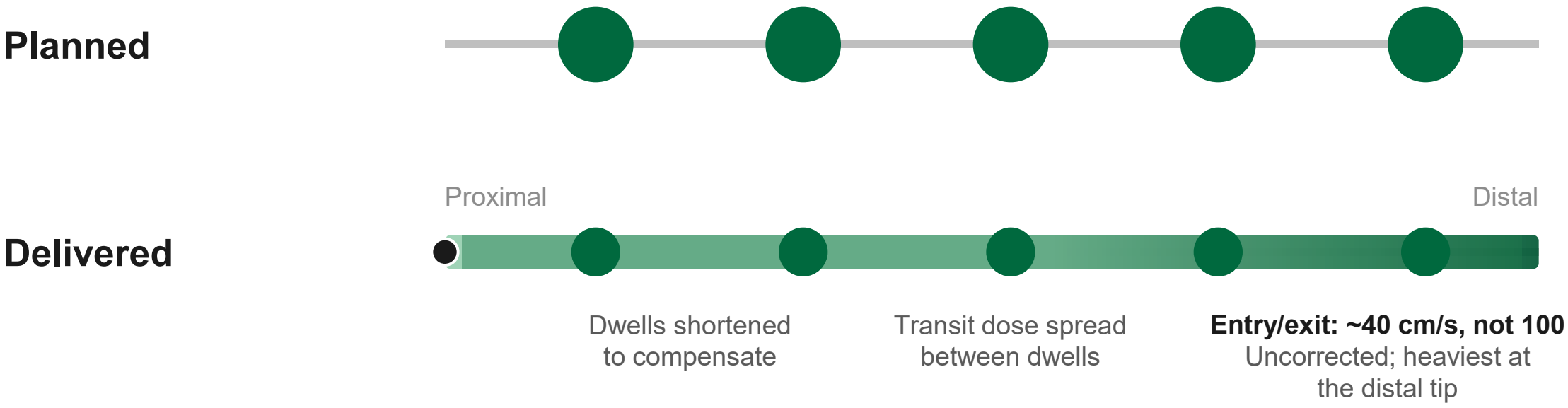
Hotter HDR sources make transit dose a bigger share of every treatment

- Ir-192 HDR sources are now delivered at **15 Ci**, shortening every dwell
- Dwell time scales with **1/activity**, but transit time is set by cable speed and **does not shrink**
- In our phantom, transit delivered **12.3%** of dose from a 10.3 Ci source; a new 15 Ci source raises that to **~17%**[1]

Our goal: *measure dwell and transit dose in vivo, independent of the afterloader.*

1. Estimate: same measured transit time; dwell times scaled by 10.3/15 to deliver the same planned dose.

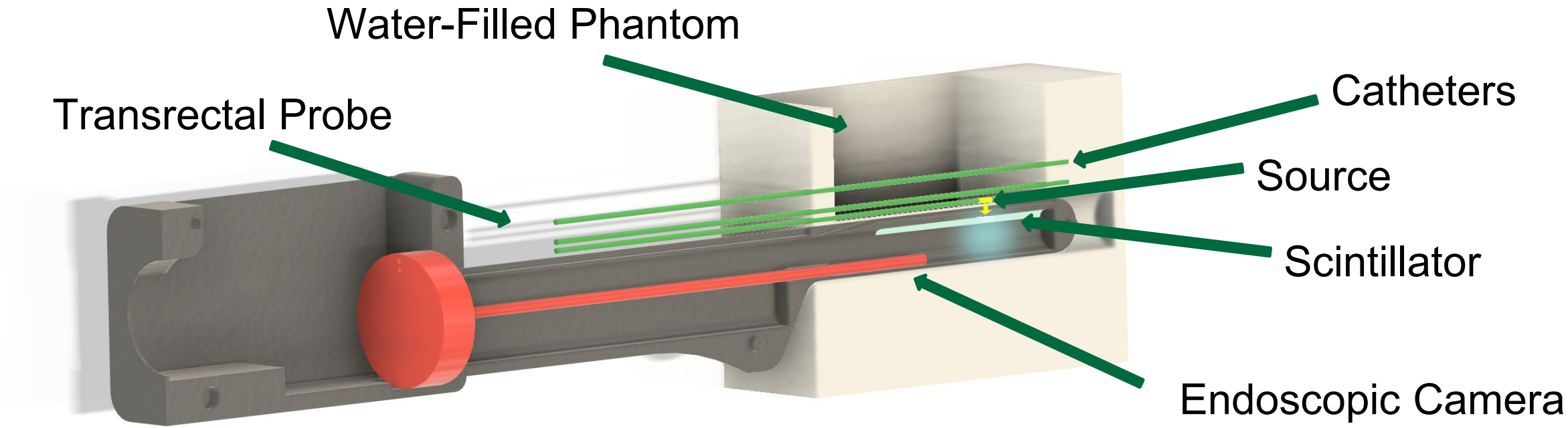
Afterloader transit correction reshapes the delivered dose, and nobody sees the result



The afterloader logs transit times, not the dose distribution they delivered.

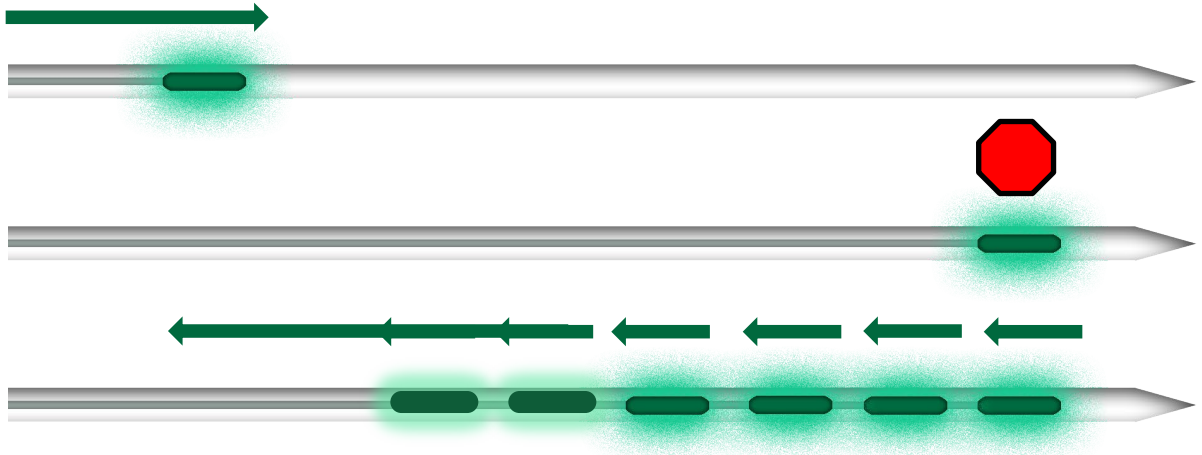
Schematic, not to scale. Source: manufacturer's afterloader reference guide, transit time correction section.

We built a transrectal scintillation dosimeter to image that distribution

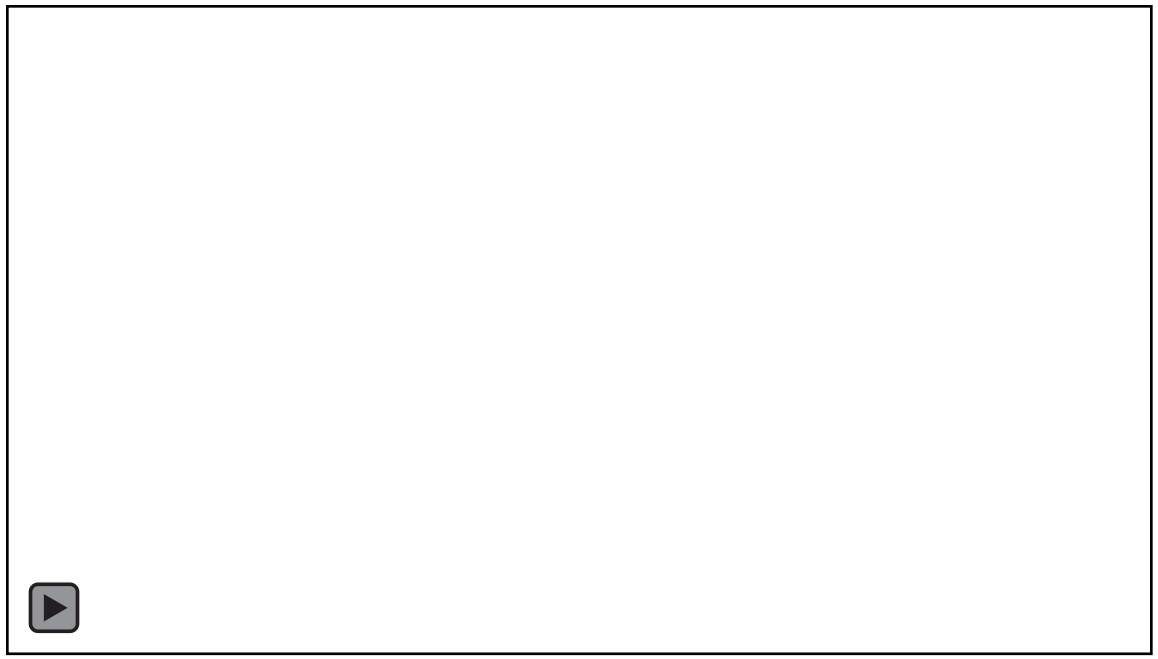


Catheters are placed at 7, 10, and 15 mm from the scintillator surface

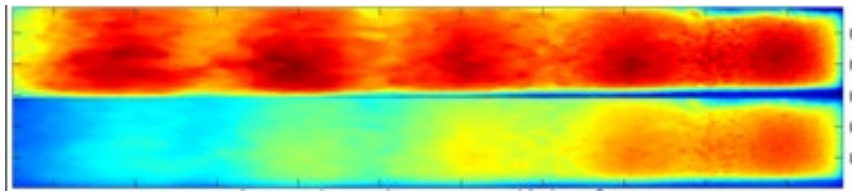
One probe tracks dwell position, dwell time, transit and dose

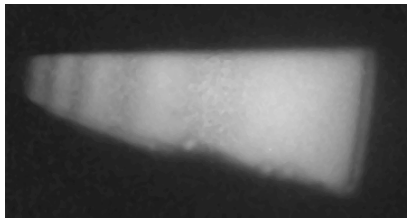


- Dwell position
- Dwell time
- Transit times
- Absolute dose



Video of treatment captured





Transit delivered 12.3% of measured dose, and source speed varied 15% between dwells

Plan: 3 channels, 5 × 5 s dwells, 1 cm apart

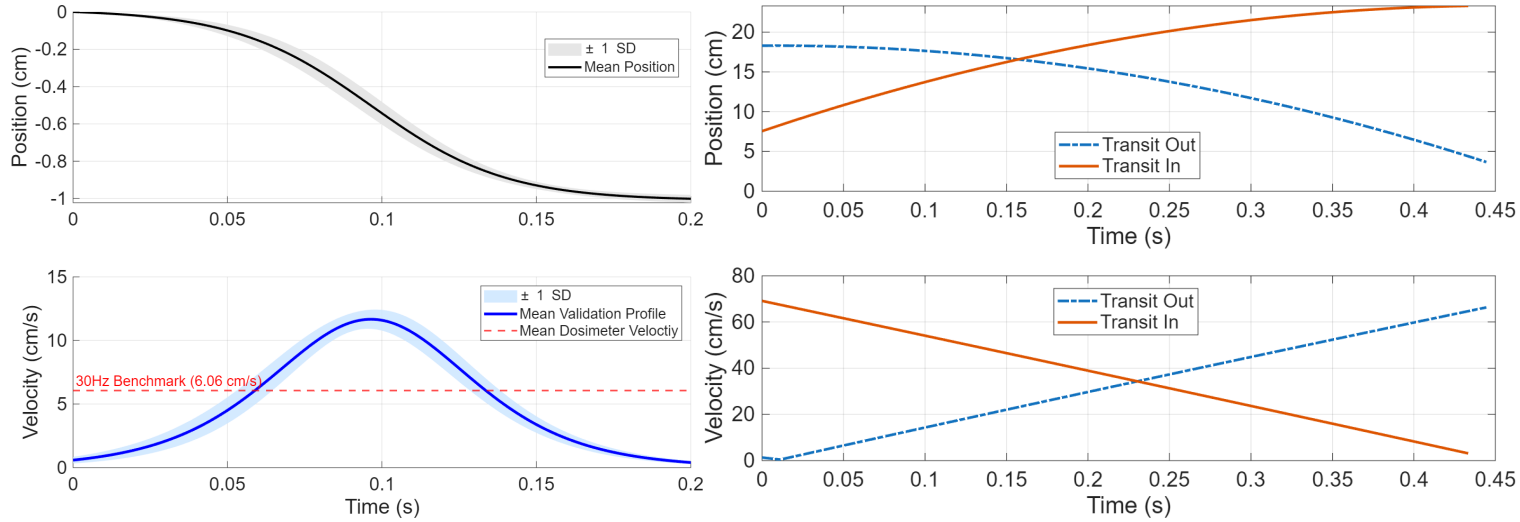
Transit share of total dose
12.3%

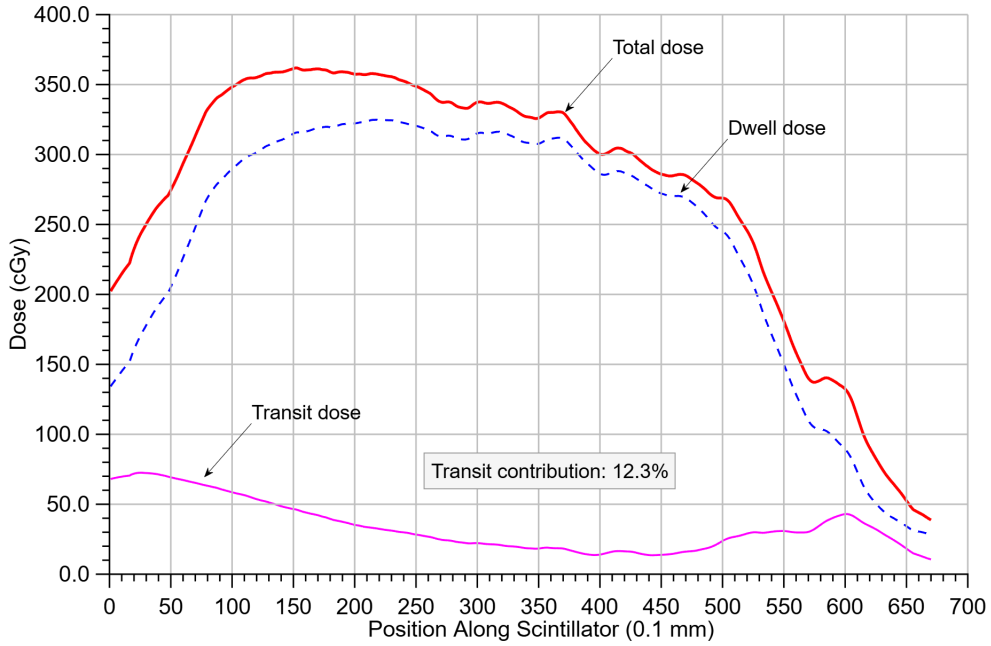
Entry/exit source speed
~40 cm/s mean, 70 cm/s peak (100 cm/s assumed)

Inter-dwell source speed
6.1 ± 0.92 cm/s (15% variation)

Dwell time
5.22 ± 0.2 s (planned 5 s)

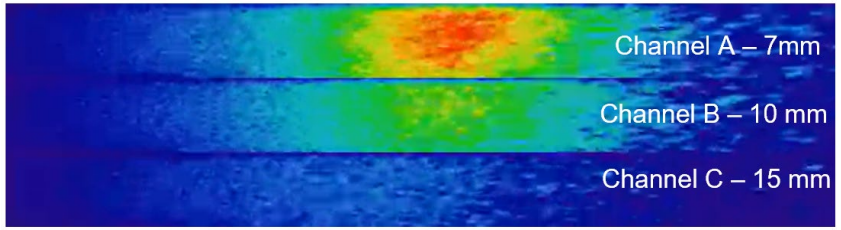
Total dose
14.08 Gy measured vs 14.16 Gy modeled (−0.6%)





Conclusions:

- A probe-mounted scintillator measured **dwell position, dwell time, transit and dose**, independent of the afterloader
- Total dose within **1%** of the Monte Carlo model; dwell position error **0.08 mm**
- Transit was **12.3%** of dose at 5 s dwells, and that share grows as sources get hotter



Future Work

- Integrate an ultrasound transducer to map measured dwell and transit dose onto anatomy
- Develop a next-generation clinical probe for in vivo dose QA