Status of Brachytherapy Dosimetry and Need for Computational Improvements

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Background

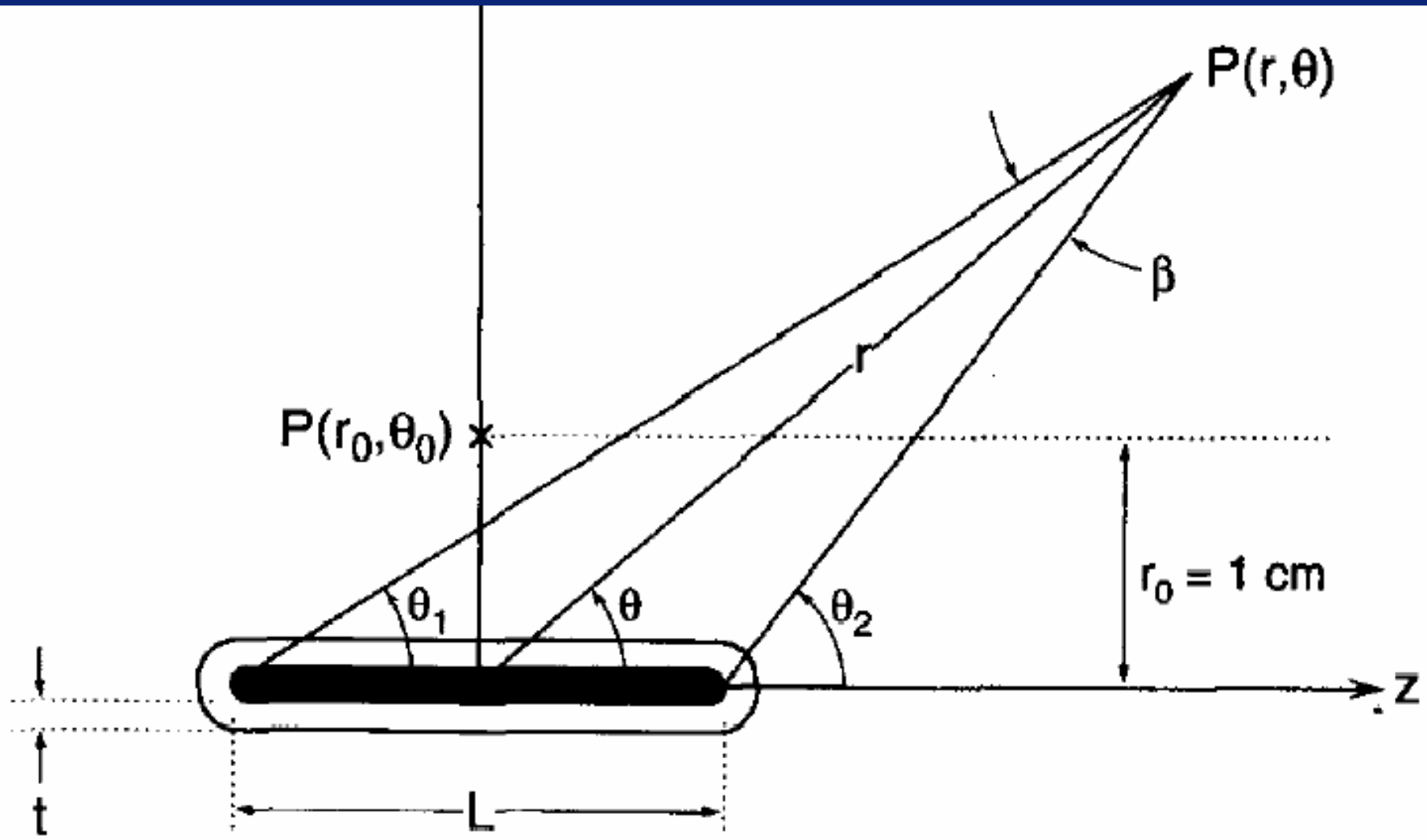
BRACHYTHERAPY [Latin]

Application of radiation therapy at short distances. Radiotherapy surface application (plesiotherapy) or within the human body.

Current radiotherapy treatment planning algorithms model source-specific parameters.

Need to model patient-specific parameters, and more complex effects.

Brachytherapy Dosimetry Geometry

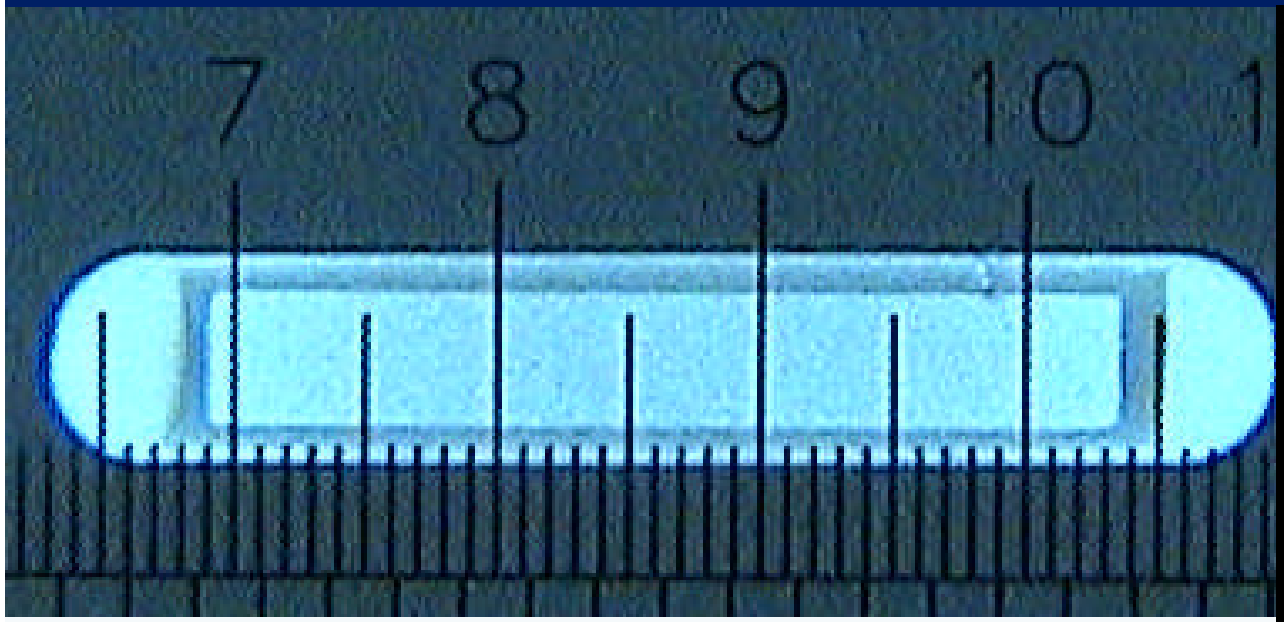


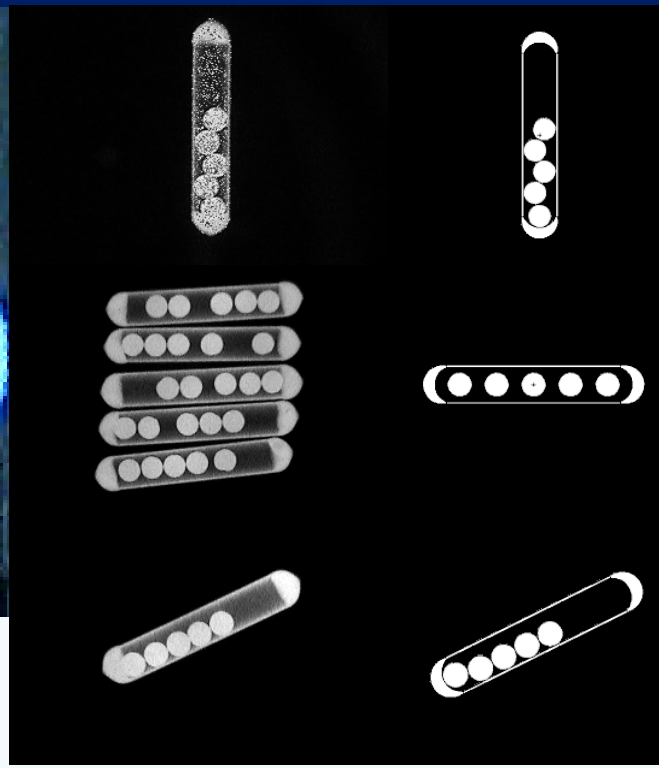
2-D Brachytherapy Dosimetry Formalism, AAPM TG-43U1 (2004)

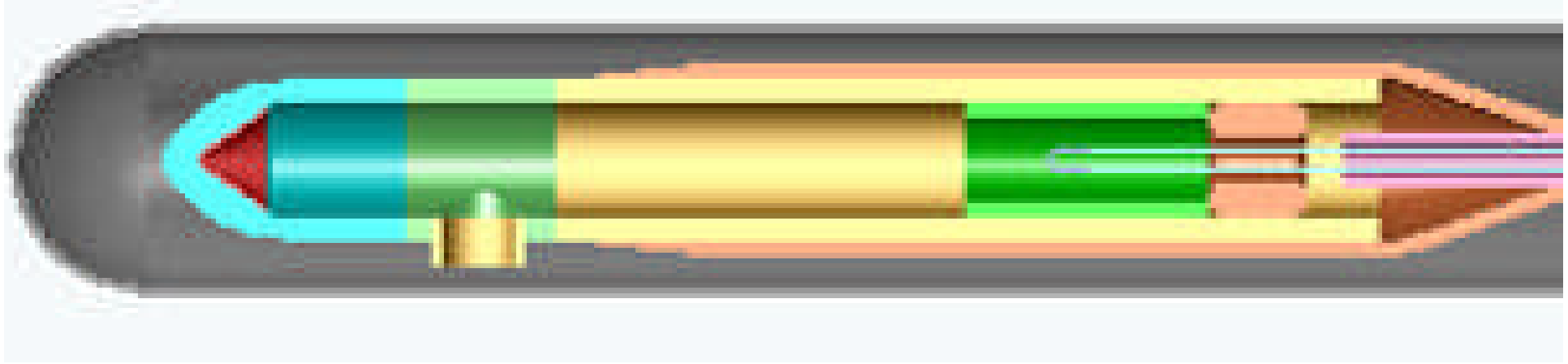
$$\dot{D}(r,\theta) = S_K \, \Lambda \, g_L(r) \, \frac{G_L(r,\theta)}{G_L(r_0,\theta_0)} \, F(r,\theta)$$

$\dot{D}(r,\theta)$	dose rate to water at point $P(r,\theta)$
S_K	air kerma strength
Λ	dose rate constant
$g_L(r)$	radial dose function
$G_L(r,\theta)$	geometry function (line source approximation)
$F(r,\theta)$	2-D anisotropy function

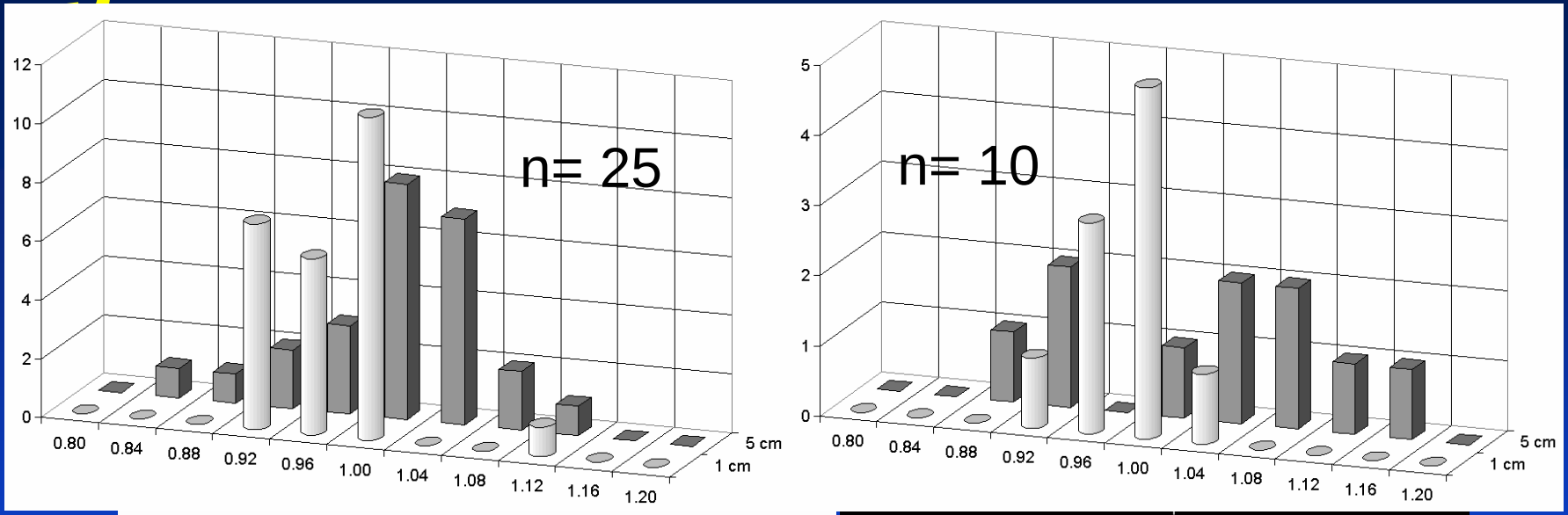
Geometric Characterization

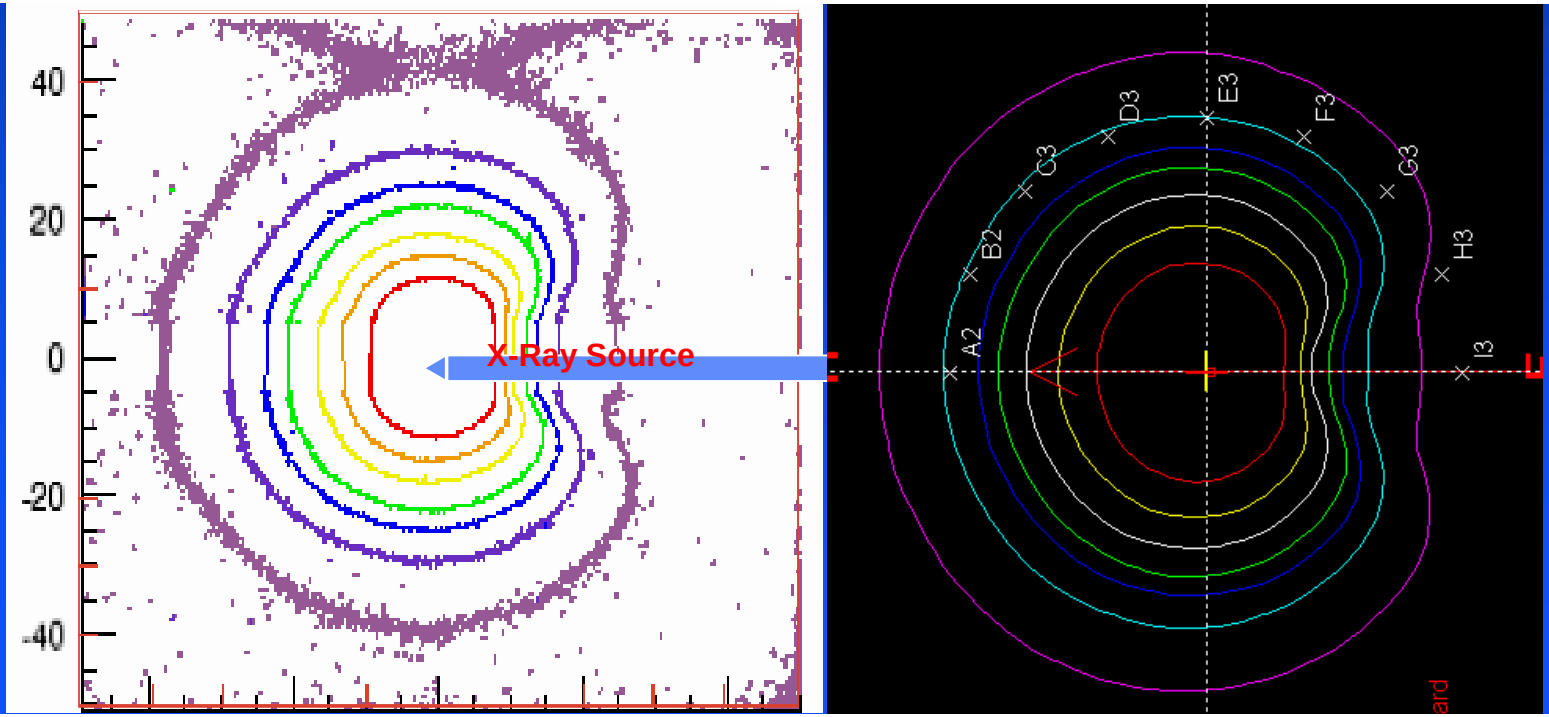




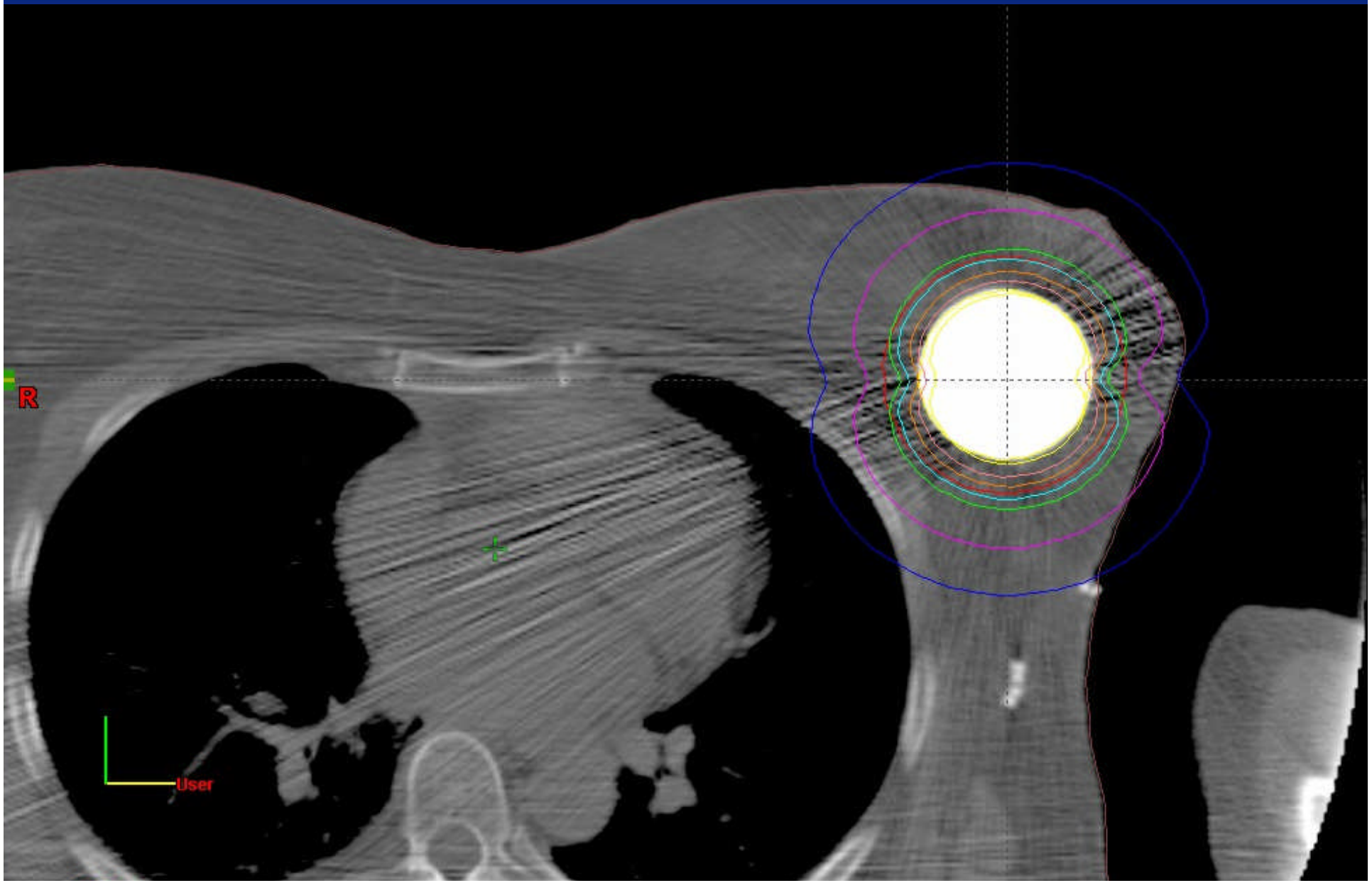


Agreement Between Meas. & Calcs.

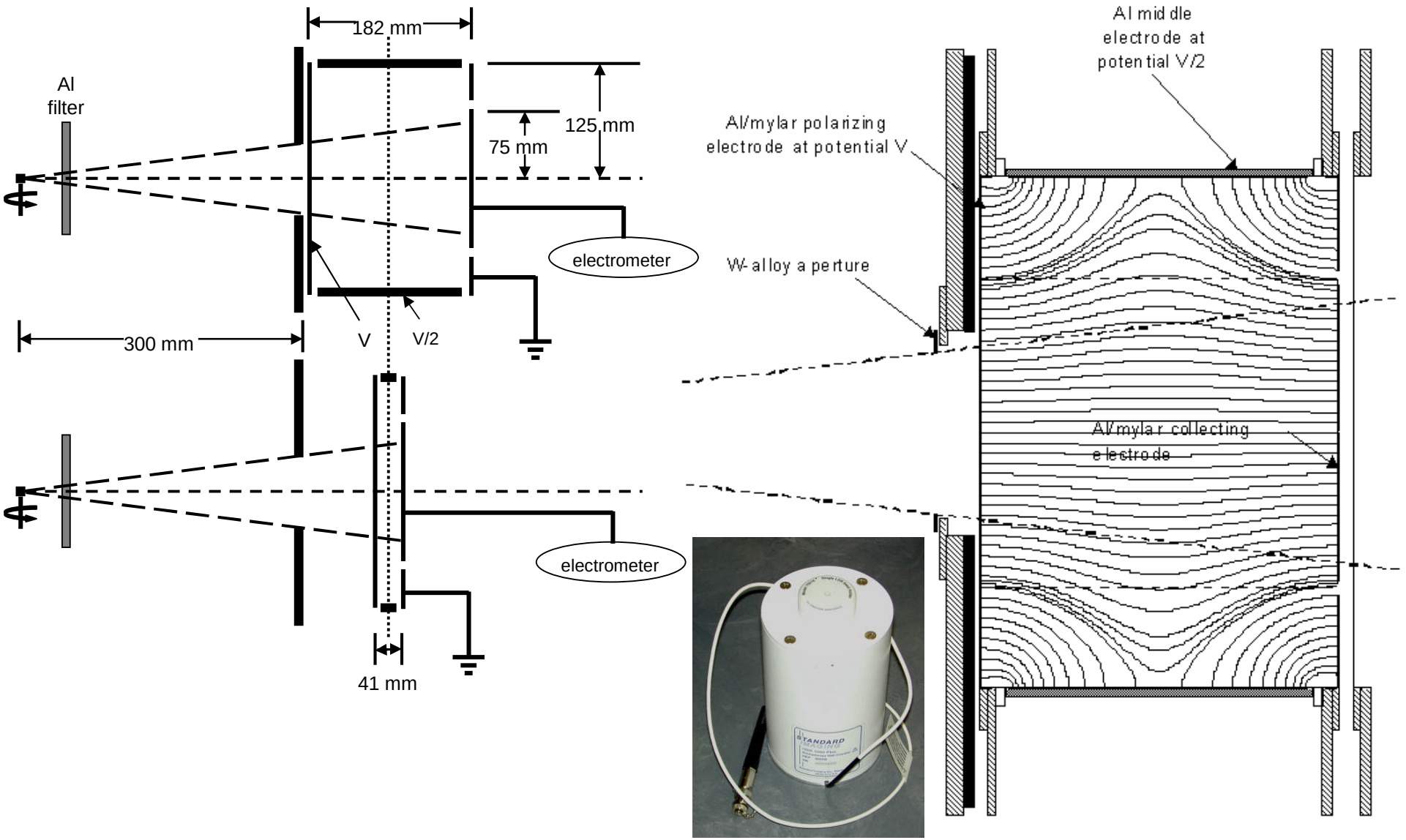




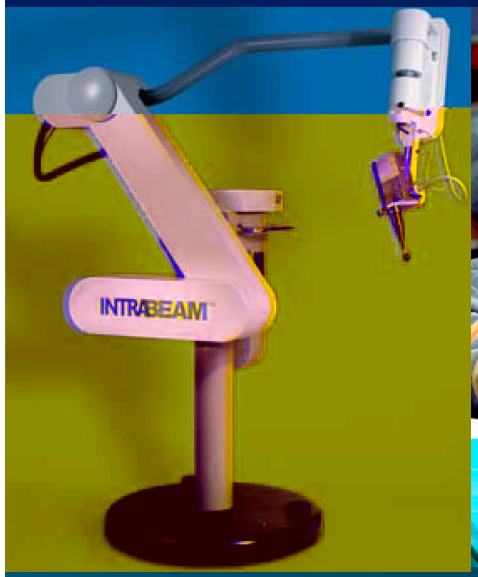
Backscatter and Attenuation ?!

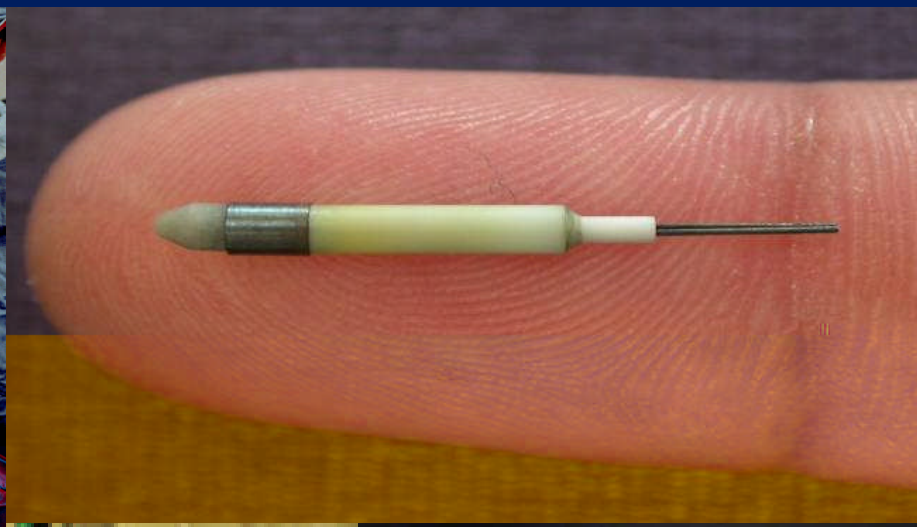


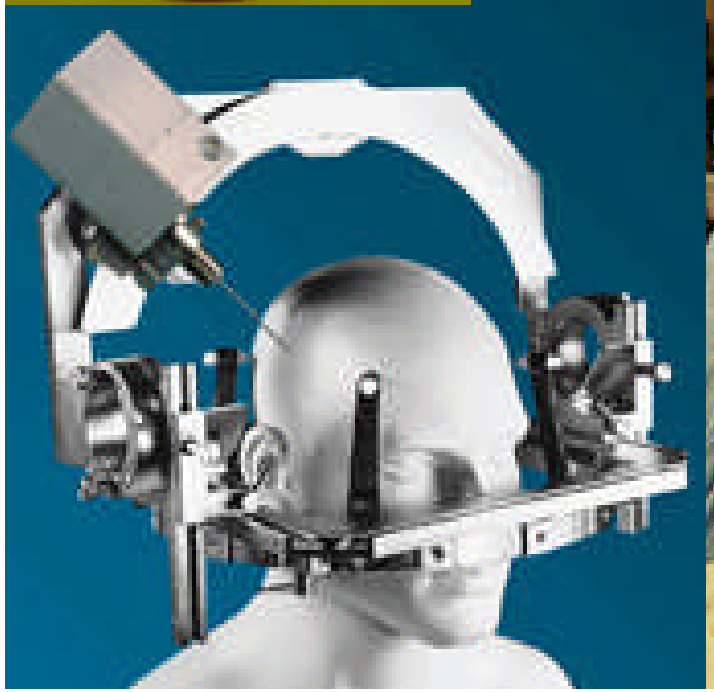
Electromagnetic Modeling for Source Strength Calibrations

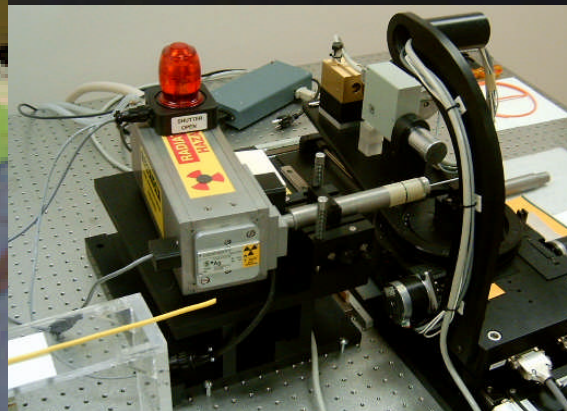


Electronic Brachytherapy









Parallel Computing Applications

Anatomic sites not readily modeled with analytical solutions or conventional for brachytherapy formalism

Environments impacted by mass density heterogeneities

Environments impacted by backscatter variability

Environments not well-suited for superposition of single-source dosimetry parameters

Curved sources (r_{CURVE} ~ r), long sources (L >> r), or mixed-field sources e.g., ^{252}Cf with (n,γ) and (γ,n)

Roadmap for Clinical Implementation

Identify appropriate applications and computational tools

Single-site preliminary results evaluating clinical utility

Publications citing multi-institutional results

AAPM / ABS / ANS proposal for retrospective analysis

Corporate collaboration for consistent ease-of-use

Consideration by societal committees for new approach

Large scale analysis ~ Phase IV post-market study

Summary

Hospital environment is not generally interested in radiation dosimetry scientific endeavors.

However, improvements of > 10 % in patient-specific radiation dosimetry calculations are clinically relevant based on clinical outcomes.

Dosimetry improvements $\propto$ Clinical improvements.

Keys to future success of brachytherapy are:

image-guide therapy, target delineation,

large scale coordination, and code development.