

**Verification of PLAQUE SIMULATOR
Dose Distributions Using
Radiochromic Film**

Amanda Krintz, William F. Hanson,
Geoffrey S. Ibbott, and David S. Followill

Department of Radiation Physics
The University of Texas M.D. Anderson
Cancer Center, Houston, TX 77030

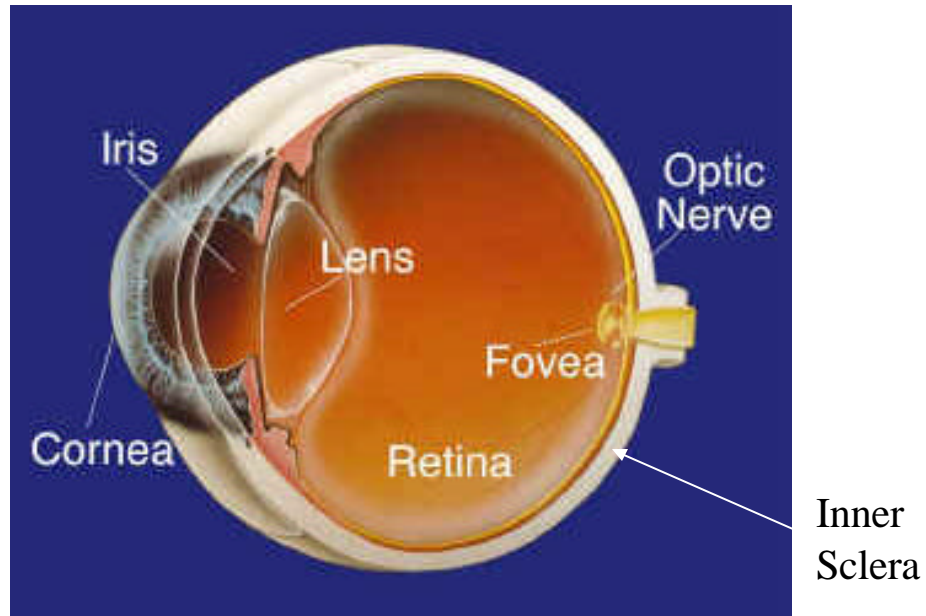
Introduction

The use of ^{125}I eye plaques to treat ocular melanoma is a common treatment modality as an alternate to surgery. (Finger et al, 1993) The Collaborative Ocular Melanoma Study (COMS) began a clinical trial in 1986 comparing enucleation and plaque therapy for medium sized tumors. The dosimetry formalism and parameters used to calculate the radiation doses received by patients in this trial have evolved during the trial as more accurate data became available. The original dosimetry calculations used for the COMS trial assumed point sources without incorporating any other dosimetry parameters such as line source approximation, anisotropy, silastic insert transmission and the effects of the gold shield. In 1996, the COMS trial incorporated the AAPM Task Group 43 (TG-43) formalism for interstitial brachytherapy dosimetry (AAPM, 1995) still without consideration of the dosimetry parameters omitted earlier in the trial.

In this work the standard COMS eye plaque is considered. (Earle *et al*, 1987) The plaque consists of a silastic insert notched to hold ^{125}I seeds, which is then inserted into a gold backing shield. While measurements have been performed previously to determine the effects of the gold and silastic on the calculation of dose, they have generally been done with only a single ^{125}I seed and with TLD. (Luxton *et al* 1988) This work, however uses GafChromic film type MD-55 from GafChromic Dosimetry Media (Nuclear Associates, Carle Place, NY) to investigate the use of radiochromic film for ^{125}I dosimetry and to validate Plaque Simulator (PS) (© BEBIG GmbH, Berlin, Germany), a treatment planning system for eye plaque dosimetry.

Eye Anatomy

- Macula (fovea) , Lens, Optic Disc (nerve), Sclera



COMS Eye Plaques

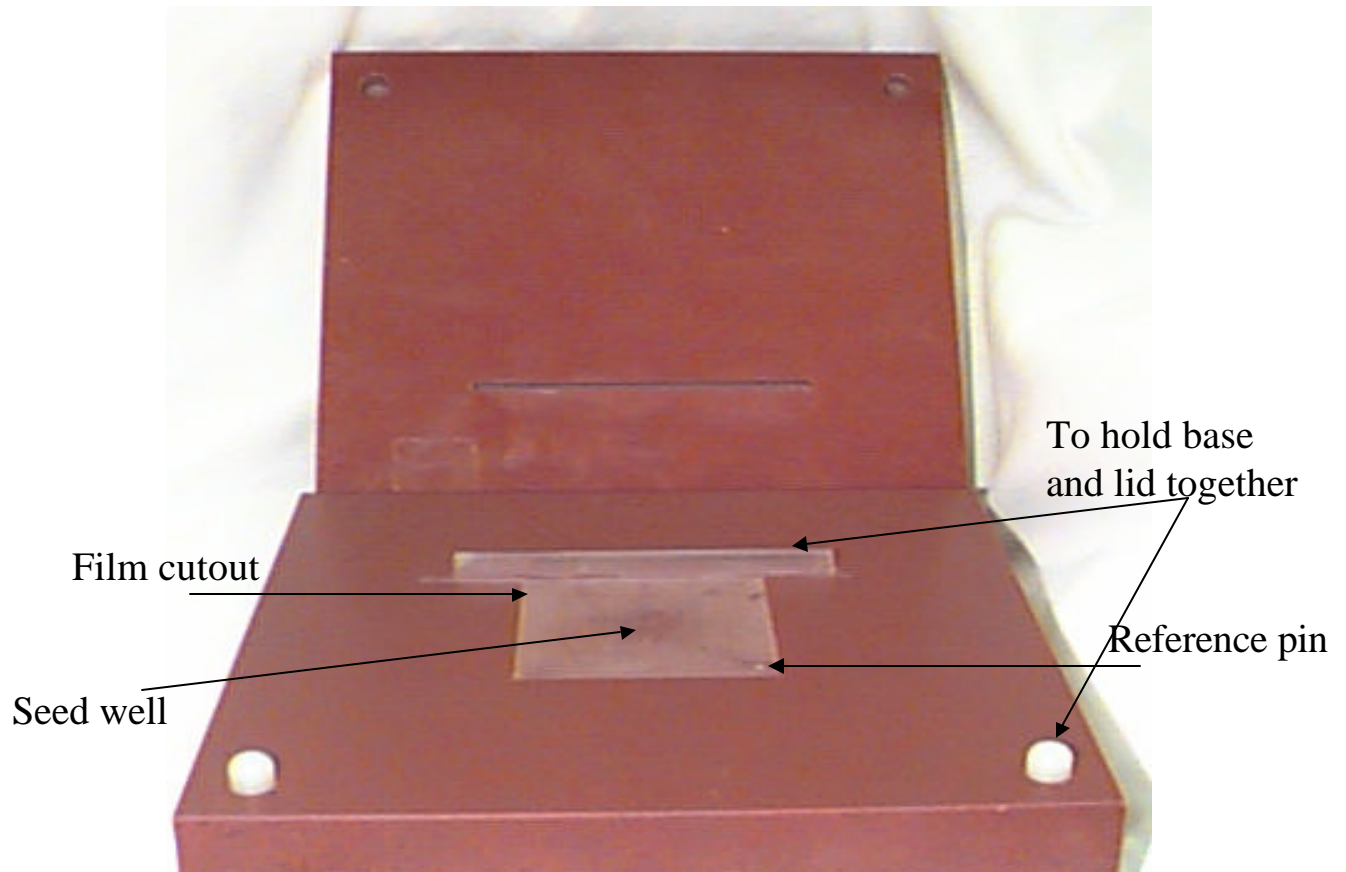
- 12, 14, 16, 18, and 20mm plaque sizes that hold 8 - 24 seeds.



Material and Methods

- Treatment Planning System
 - Plaque Simulator (PS) (©BEBIG)
M. Astrahan, USC
 - Standard COMS calculations or,
 - Updated dosimetry calculations
- Standard COMS eye plaques
 - 12, 14, 16, 18, 20 mm plaque sizes
 - points of dose calculations
 - macula, optic disc, lens, tumor apex,
inner sclera, 5mm pt., opposite retina
- Radiochromic film Type MD-55 (Nuclear Associates)
 - No processing / not light sensitive
 - High dose range (up to 70-100 Gy)
 - Scanned with a laser densitometer
 - 632.8 nm HeNe laser
 - 0.1 mm pixel size
- Phantoms
 - 2 RMI Solid Water phantoms
 - square phantom for film calibration
 - eye phantom for plaque measurements

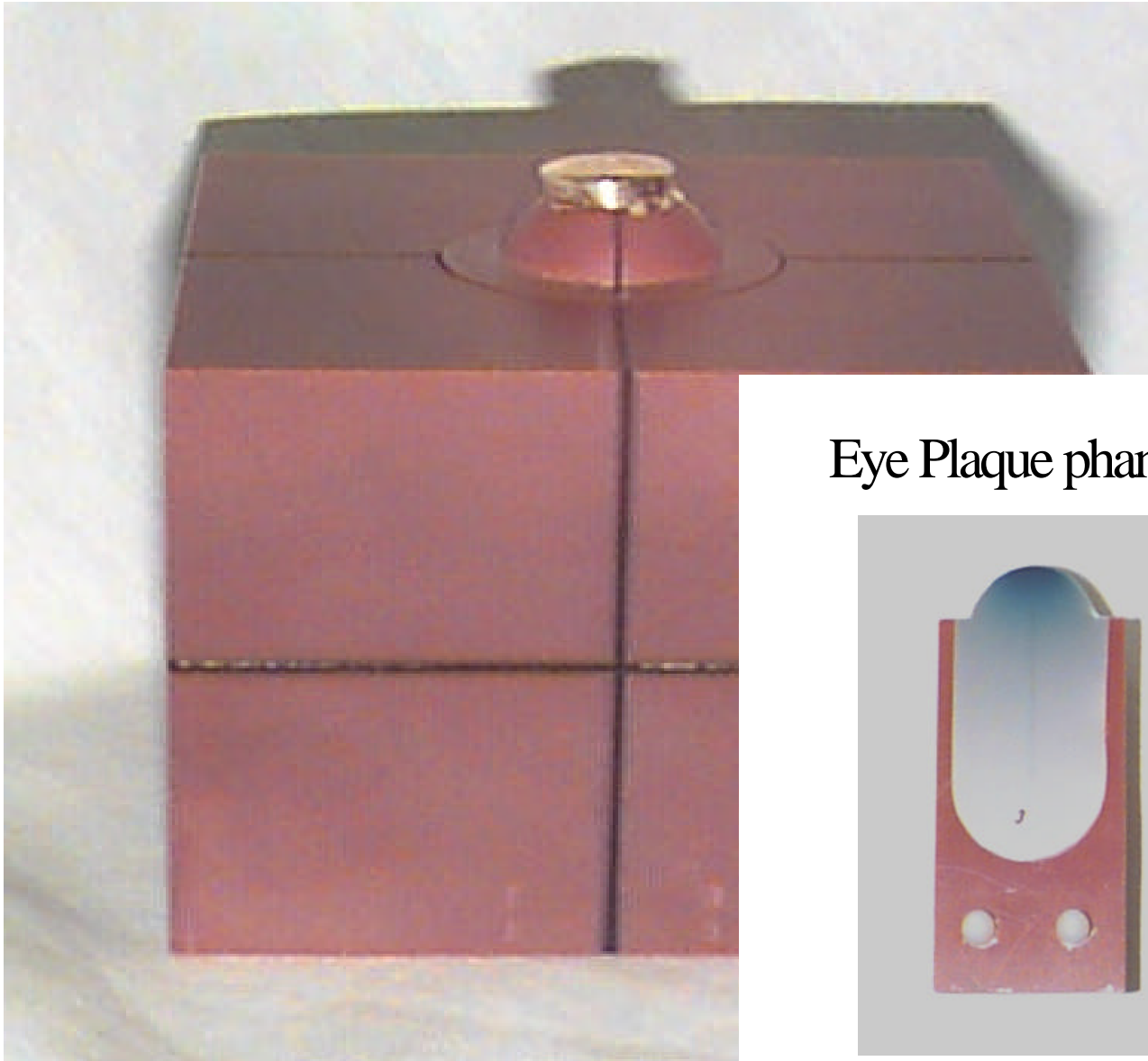
Single Seed Measurements



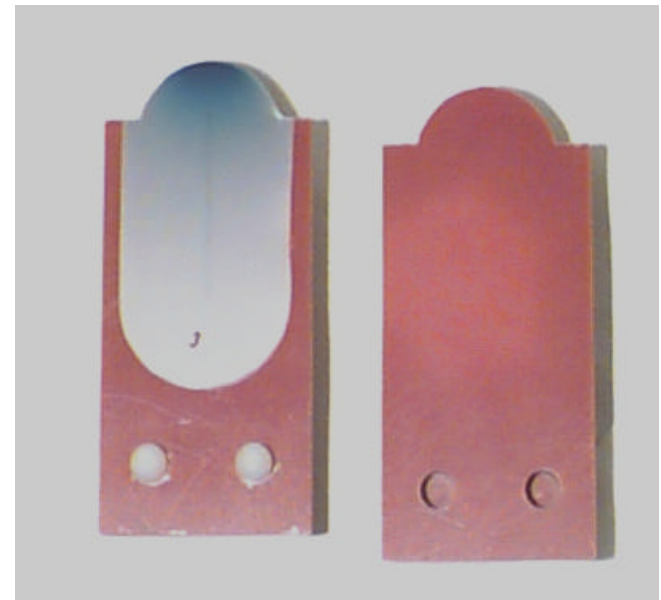
Film Calibration

- solid water film phantom
- single seed, Iodine-125, Model 6711
 - ADCL calibrated/ NIST traceable
- exposed films to a range of max. doses
500 Gy - 100 Gy at 1mm along the
film surface from the source

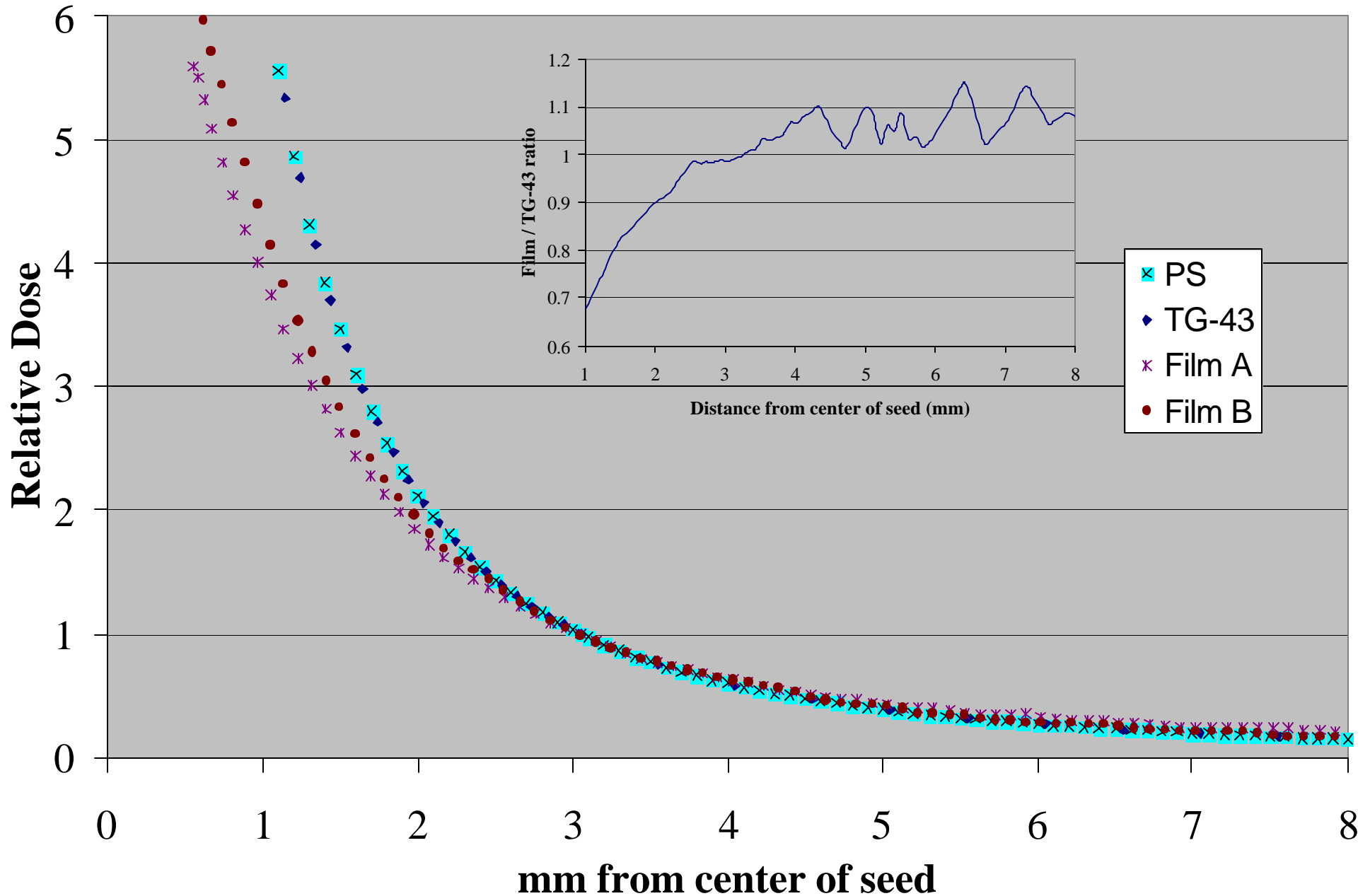
Eye Plaque Phantom



Eye Plaque phantom film insert



Single Seed Measurements

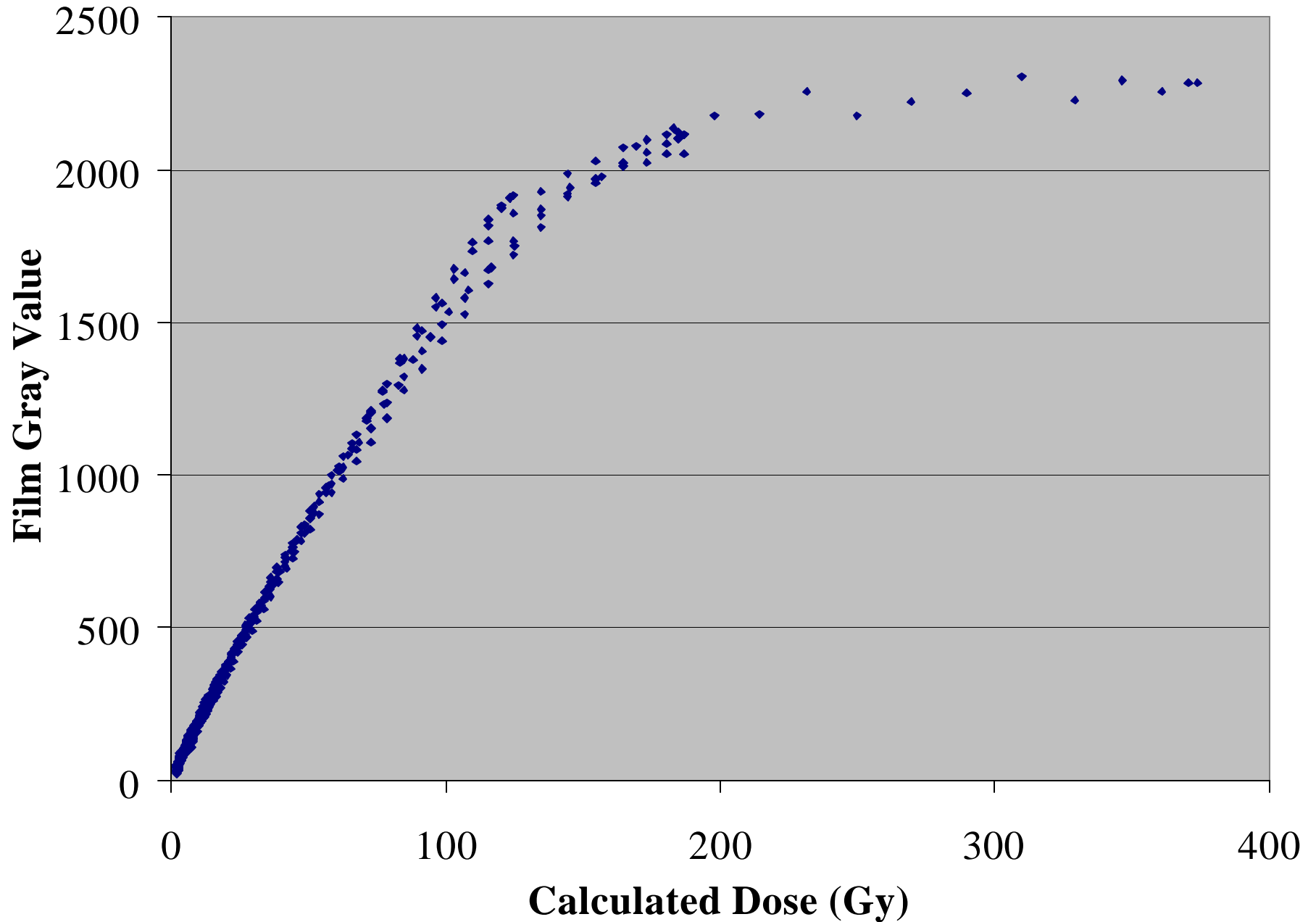


Film profiles were compared to TG-43 line source calculation and PS calculated dose. Comparison was performed by normalizing film and calculations to the same point (3mm from the center of the seed). Disagreement between film and PS at distances less than 2.5mm was not critical since seeds in a plaque are at least 2.4 mm from any critical structure.

The majority of the tumors were located in the posterior hemisphere of the eye, thus near the optic disk and macula.

The film was exposed to a single seed multiple times to generate a dose response curve. The film has a linear response up to 70 Gy and completely saturates at near 200 Gy.

Measurements



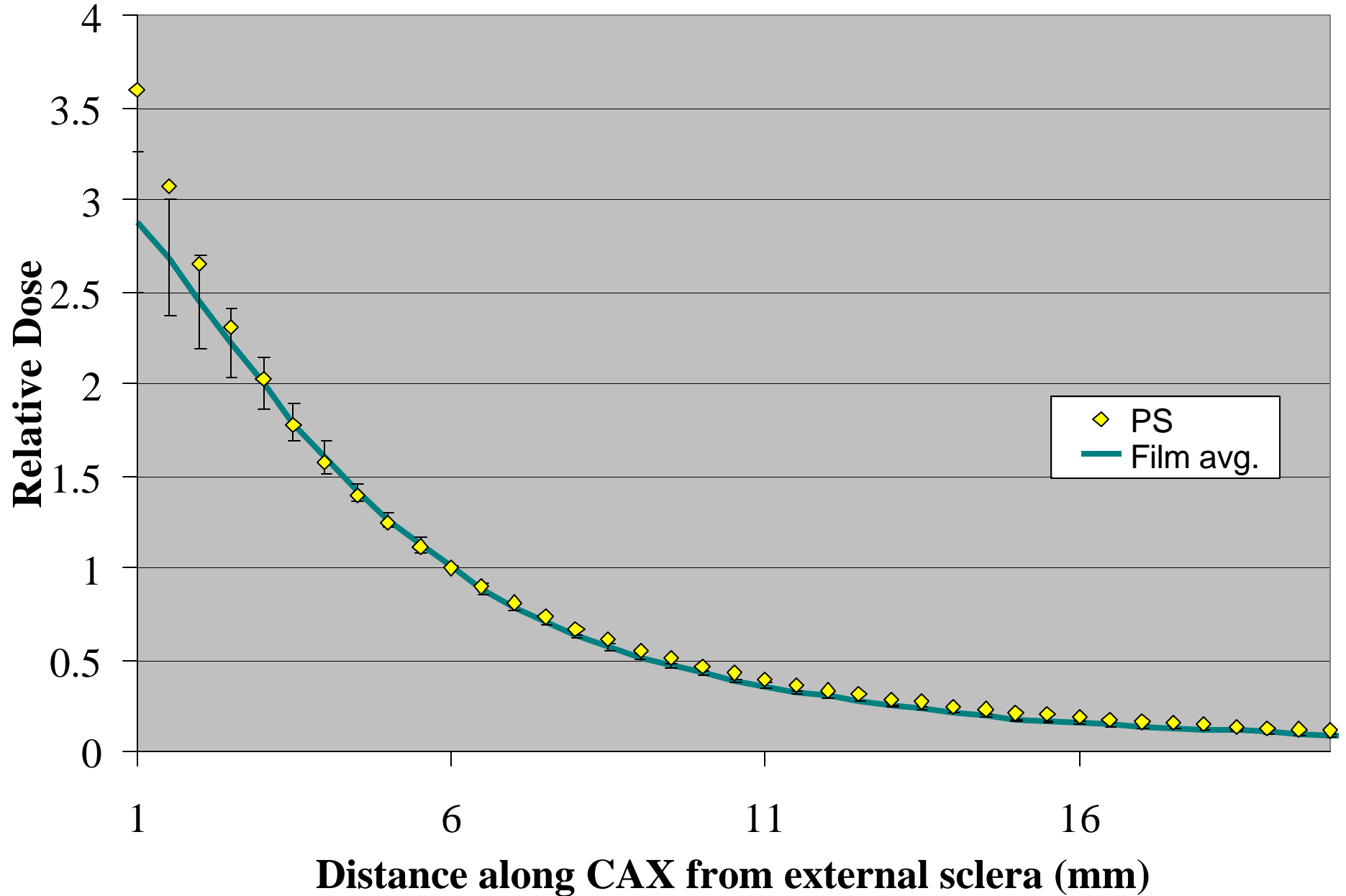
Eye Plaque Measurements

- Performed in solid water phantom for 14mm and 20mm plaque sizes, fully loaded (13, 24 seeds).
- Film profile compared to PS for central axis and along inner sclera
- The comparison was performed in two ways by normalizing the film data and PS:
 1. to a point 5 mm from the plaque for the on-axis comparison and to a point at a 5.25 mm arclength along the inner sclera for the scleral comparisons.
and
 2. to a point 5 mm on axis from the plaque for both the on-axis and scleral comparisons.

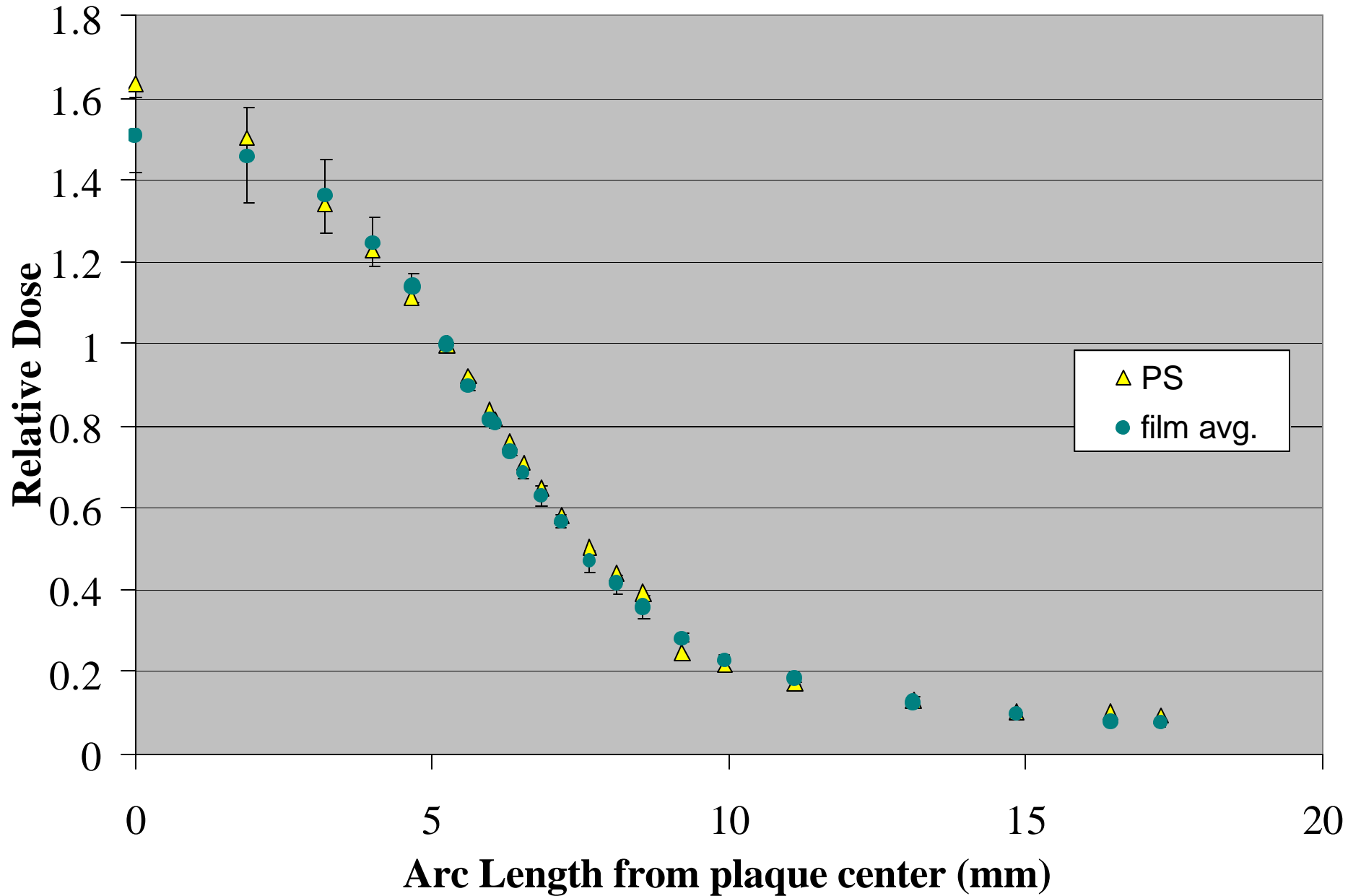
Updated Dosimetry in Plaque Simulator

- Allows for full rotation of the silastic insert
- Accounts for attenuation through silastic using a single factor of 0.90
- Accounts for gold backing by completely stopping any radiation that hits the gold
- Accounts for source anisotropy

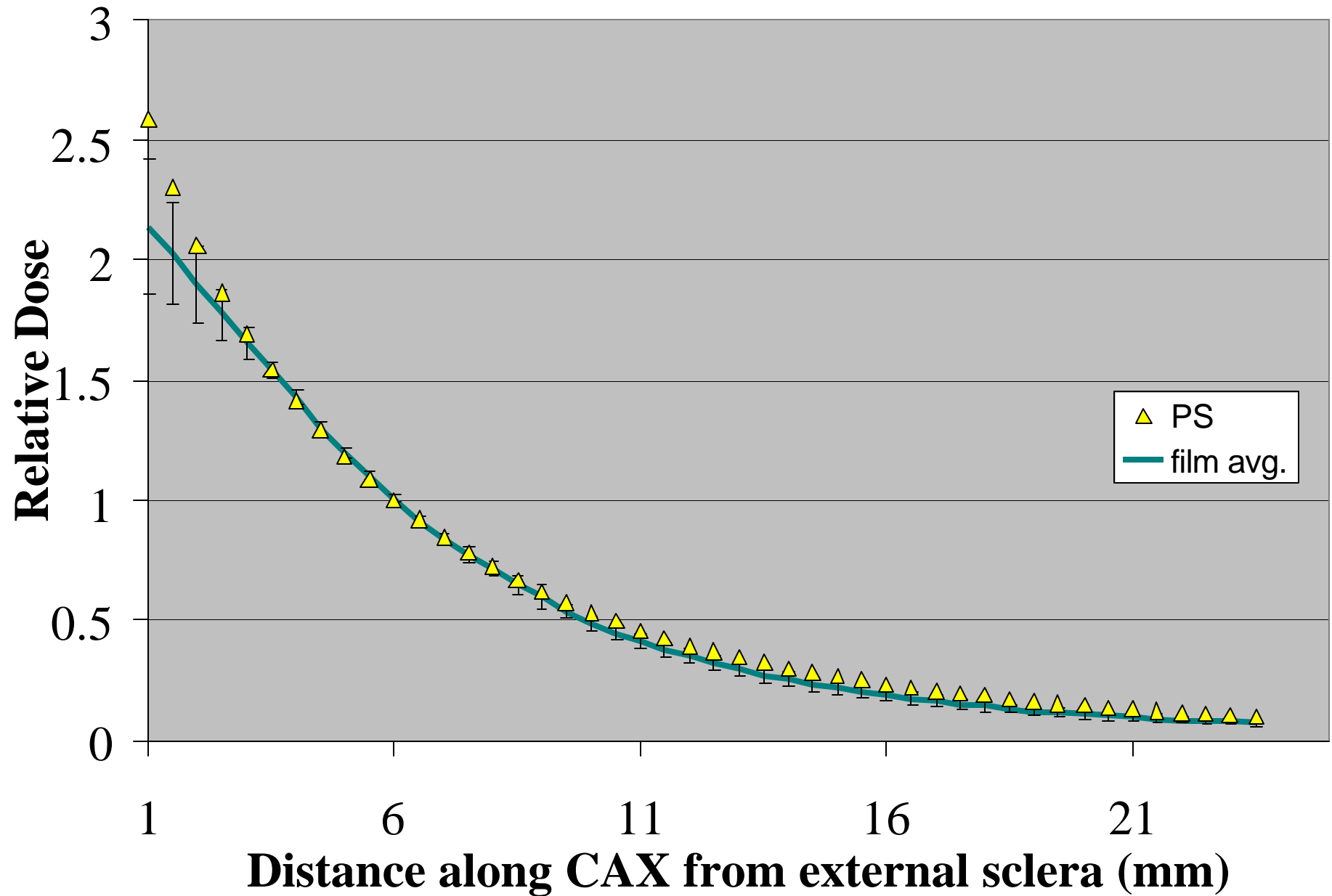
14mm central axis comparison



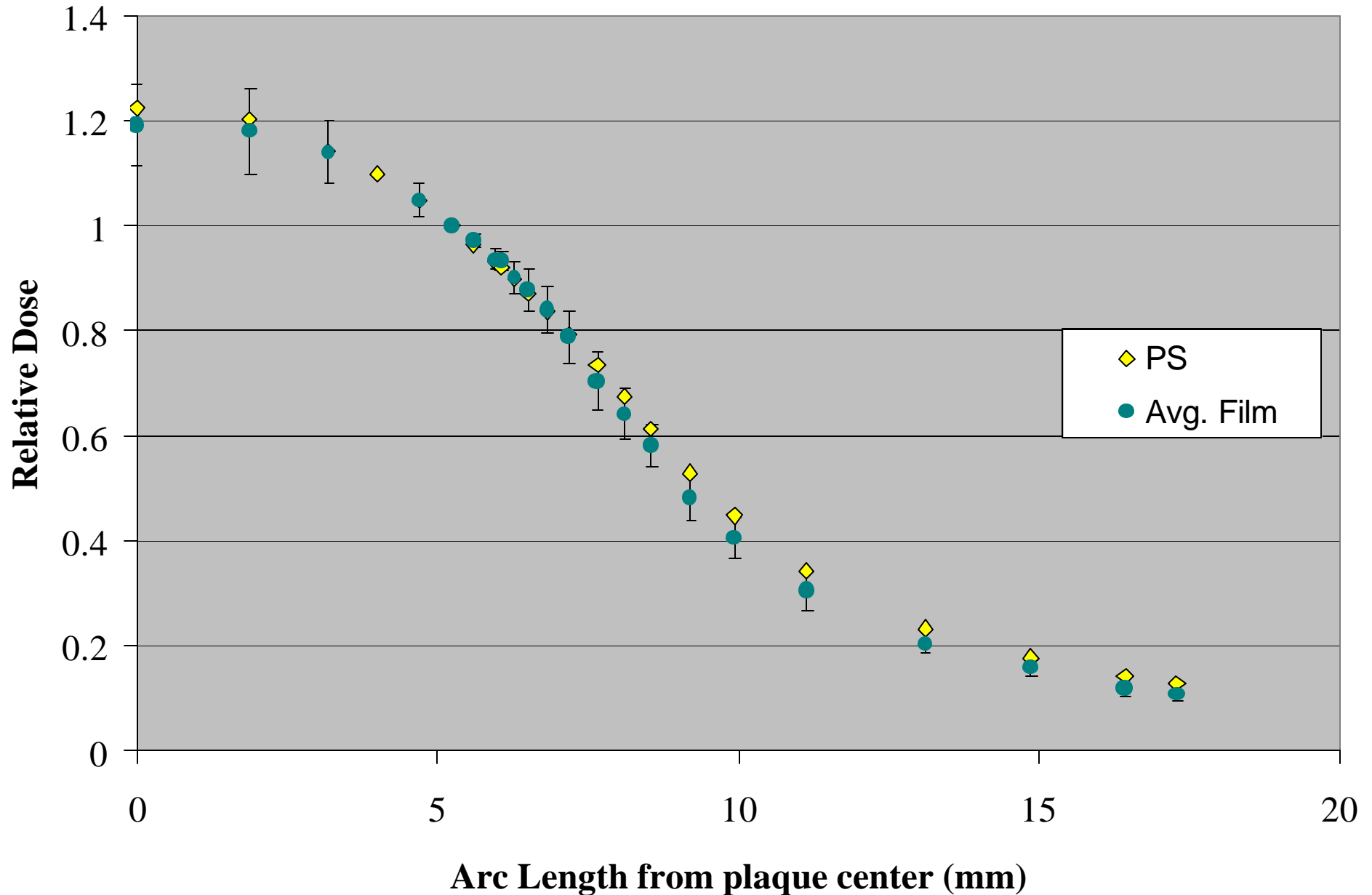
14mm inner sclera comparison



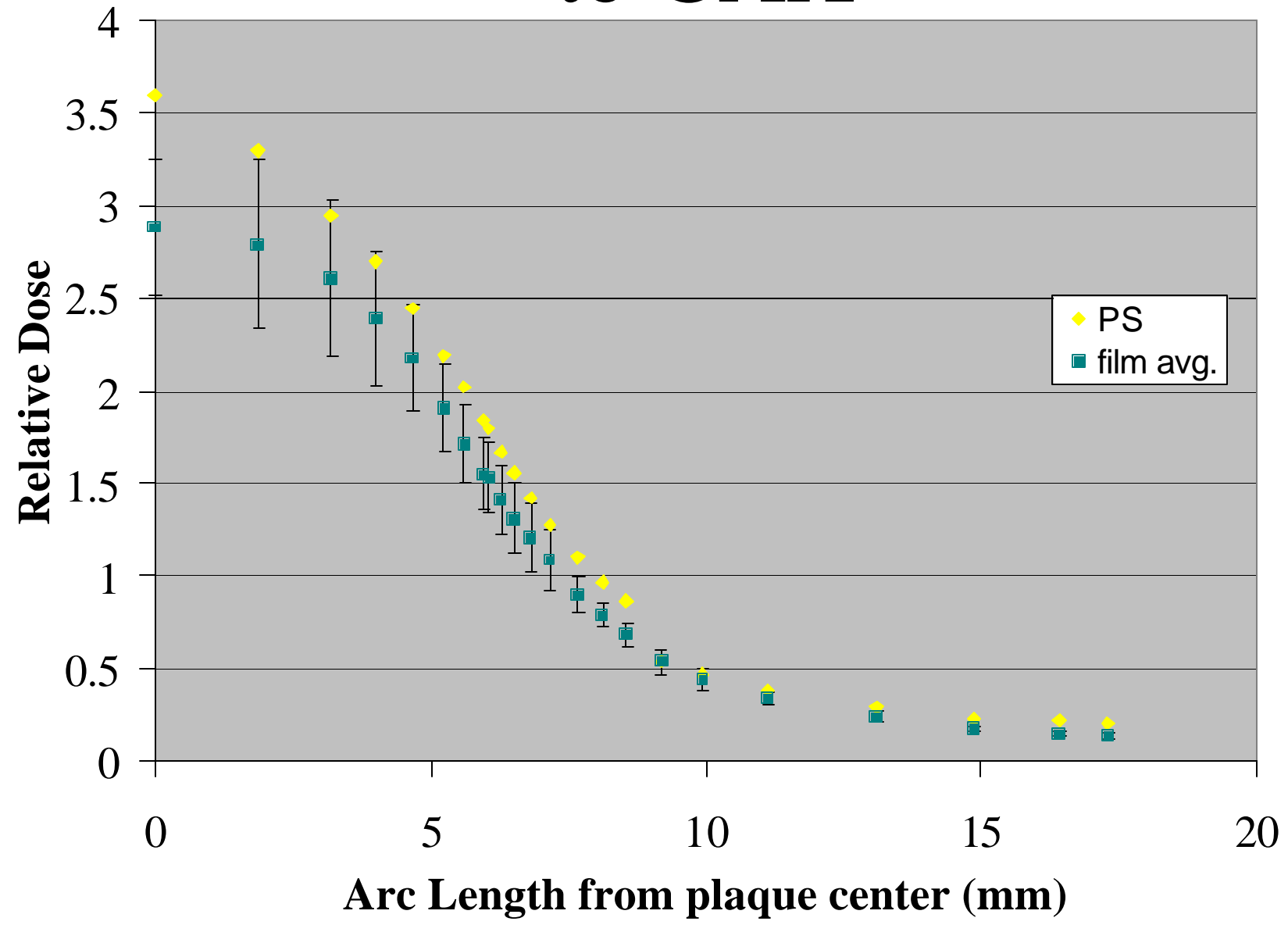
20mm central axis comparison



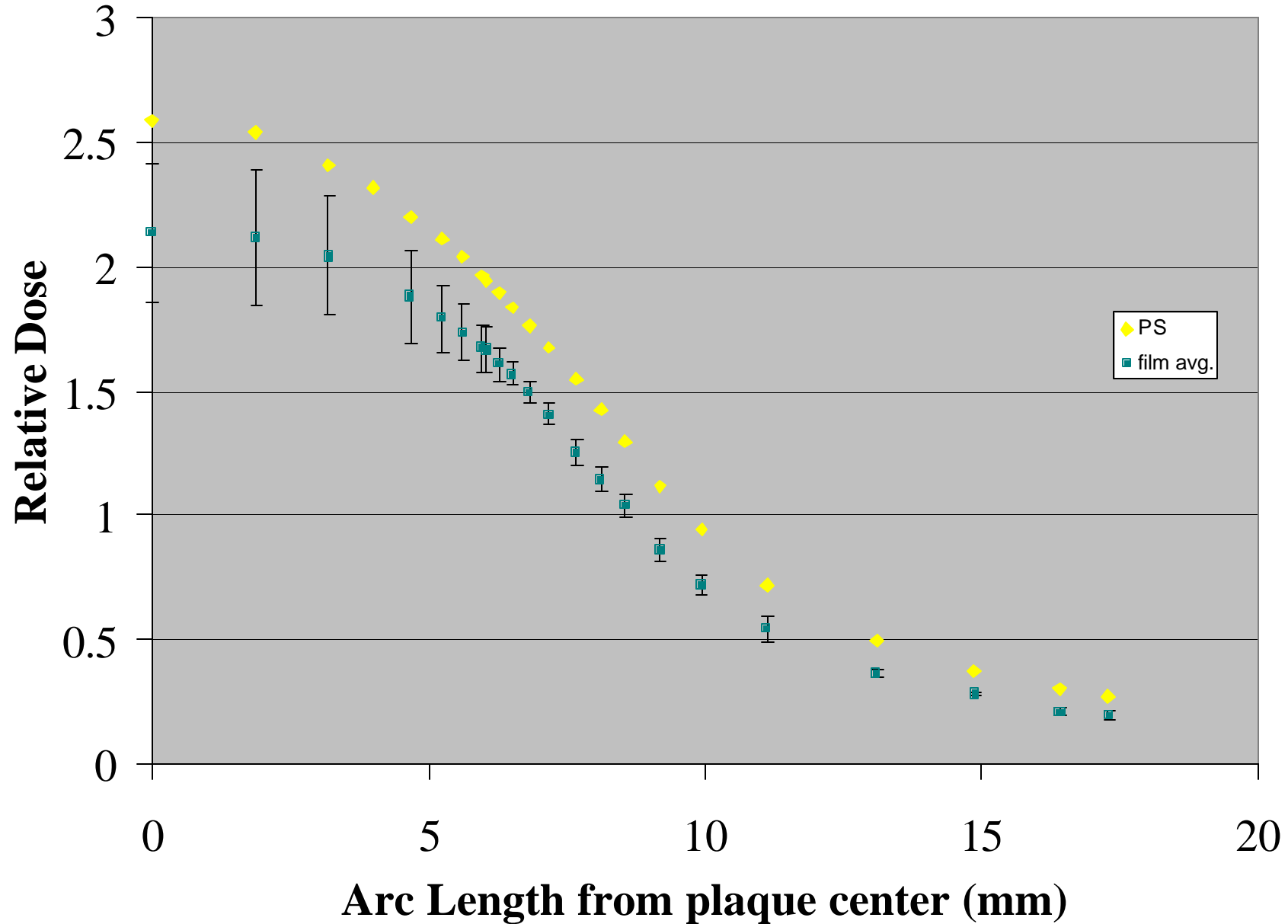
20mm inner sclera comparison



14mm inner sclera - Normalized to CAX



20mm inner sclera - Normalized to CAX



Normalization of film and PS to inner sclera point shows good agreement in relative dose distributions.

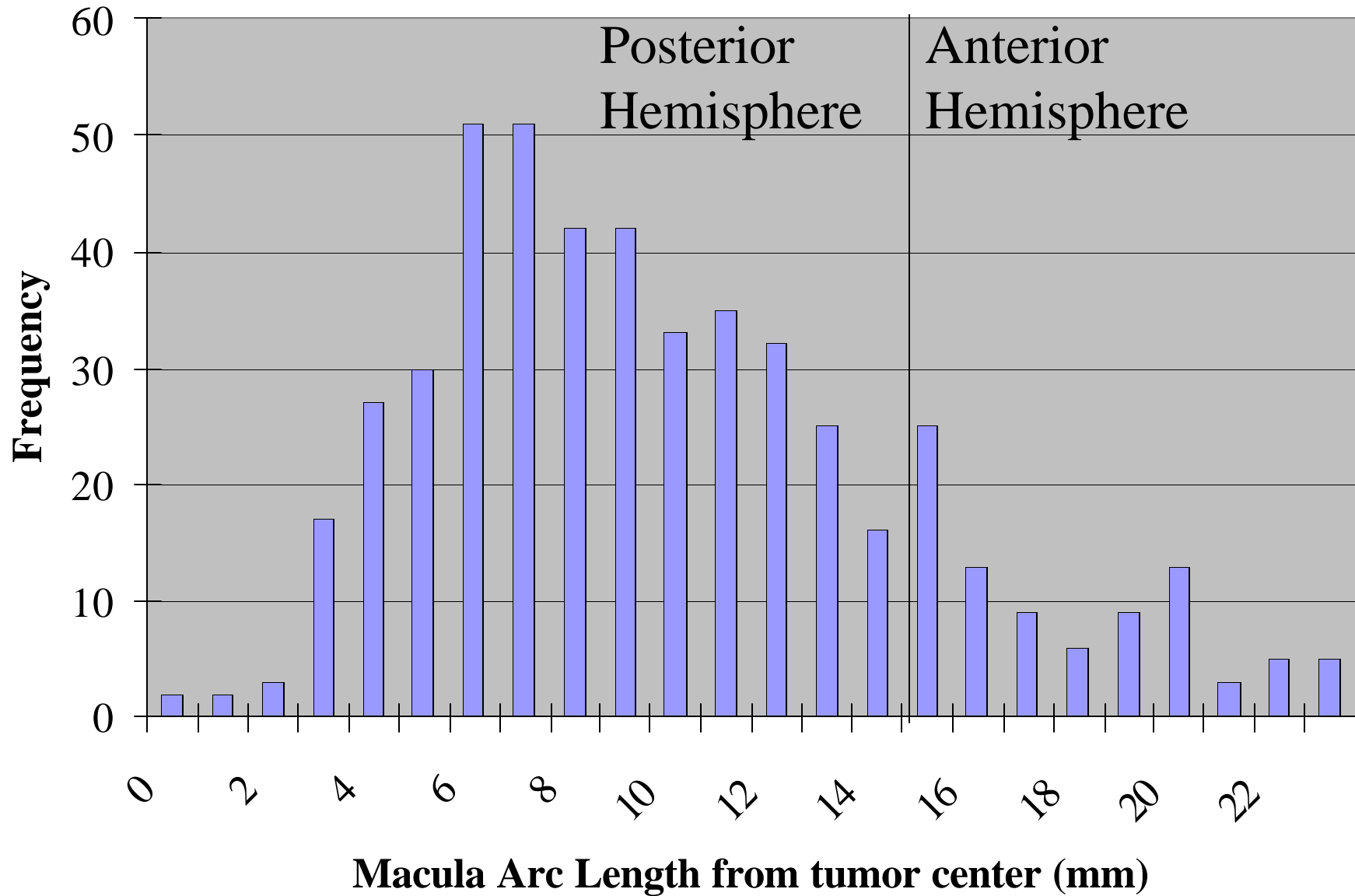
Normalization of film and PS to central axis point shows good agreement in relative dose distributions.

Normalization of film and Plaque Simulator scleral dose distributions to a point on CAX shows absolute dose disagreement between film and PS along the inner sclera, assuming the doses along the central axis are accurate. For 14mm and 20mm plaques, we see an ~15% dose reduction in dose with film at points near the edge of the plaque. The difference in dose is most likely due to fact that PS uses a single silastic insert attenuation factor that does not account for the obliquity of the radiations travelling through the silastic to points near the edge of the plaque.

Conclusions

- GafChromic film MD-55 is a suitable dosimeter for Iodine-125 brachytherapy within 2.5mm of the source.
- Plaque Simulator matches film measurements with a fully loaded plaque including line sources and plaque construction characteristics along the central axis from the plaque.
- Plaque Simulator dose not agree with the film dose distributions along the inner sclera most likely due to an inadequate silastic insert transmission factor. As a result, doses to the macula and optic disc may be lower than reported.

Tumor Localization



This investigation was supported by PHS grant EY 06266, The Physics Center for COMS, awarded by the NEI, DHHS.

References

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3. Luxton, Gary, Astrahan, Melvin A., Petrovich, Zbigniew, “Backscatter measurements from a single seed of ^{125}I for ophthalmic plaque dosimetry,” *Med. Phys.* 15, 397-400 (1988-a)
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