

Plastic scintillation dosimetry for measurement of age-related macular degeneration radiosurgery device

Age-related macular degeneration (AMD) is a chronic, progressive disease of the macula, the central part of the retina and is the leading cause of severe vision loss and blindness among those over age 65 in the developed world.(1) Oraya Therapeutics has developed the IRay™, a noninvasive, low-voltage, stereotactic radiosurgery device for the treatment of AMD which addressed limitations of radiological treatments (linear accelerators, brachytherapy, Gamma Knife), pharmaceutical treatments (Lucentis, Macugen), and photodynamic therapy.

The IRay™ delivers 100 kVp gamma rays to a macular target which is 15.0 cm from the source. Oraya Therapeutics has provided funding for this research in order to develop a dosimetry system which must be easily integrated into their current machine and provide real-time dose monitoring of the output of the IRay™. Furthermore, this dosimetry system must provide reliable retrospective measurement of actual dose delivered. Plastic scintillation dosimeters (PSDs) were chosen because of their unique combination of water equivalence, small volume, dose rate- and energy-independent response, and real-time capabilities.(2)

The PSD (BCF-12, Saint-Gobain Crystals, Nemours, France), 0.5µm diameter and 2 mm length, is polished and coupled to the waveguide (ESKA CK-20, Mitsubishi Rayon Co, Tokyo, Japan). The distal end of the PSD is coated with reflective paint to enhance capture. The uncoupled end of the waveguide was terminated in a female SMA 905 connector (SMA-505, Fiber Optic Center Inc, New Bedford, MA). A male SMA optical fiber adapter (E5776-51, Hamamatsu Corporation, Bridgewater, NJ) was used to enable connection with each of the two shielded PMTs (H7467, Hamamatsu Corporation, Bridgewater, NJ). The counting data was buffered and transferred through a hub (UPOINT 1610-8, Moxa Inc, Brea, CA). The entire system is shown in Figure 1a along with corresponding schematics in Figure 1b.

Figure 2 shows the percent depth dose curves of both the PSD and the ion chamber as measured with the portable x-ray generator (SR-115, Source-Ray Inc, Bohemia, NY). Figure 2 shows an increasingly important depth correction factor as depth increases. For example, it is around 6% at 1.5 cm. The correction factor for depths ranging from 0 to 2.0 cm is given explicitly in Table 1. The substantial deviation between the PSD and the ion chamber depth dose is attributed to the low beam quality of the portable x-ray tube which only has filtration of 4 mm Al (in comparison with a CT scanner's typical 6-8 mm Al HVL) and possible over response of the PSD to low-energy. For this specific application to SRS dose measurement, this is simply a correction factor which is applied to the PSD measurement in order to determine final dose delivered. However, for future dosimetry applications, this should be addressed.

Figures 3 and 4 show the PSD performance at high doses and high dose rates, respectively, as measured with a mobile c-arm fluoroscopy unit (OEC 9800, GE, United Kingdom). Figure 3 shows that the calibration factor of counts per R does not vary more than 1% over the entire range from 0.862 to 15.26 R. Figure 4 shows the linearity of counts to exposure over the entire range from 0 to 16 R.

References

- (1) H. Churei, K. Ohkubo, M. Makajo, H. Hokotate, Y. Baba, J. Ideue, K. Miyagawa, H. Nakayama, Y. Hiraki, T. Kitasato and N. Yabe, "External-beam radiation therapy for age-related macular degeneration: two years' follow-up results at a total dose of 20 Gy in 10 fractions," *Radiat Med* **22**, 398-404 (2004).
- (2) L. Archambault, J. Arsenaault, J. Gingras, A. S. Beddar and L. Beaulieu, "Plastic scintillation dosimetry: Optimal selection of scintillating fibers and scintillators," *Med Phys* **32**, 2271-2278 (2005).

PSD for measurement of AMD radiosurgery device

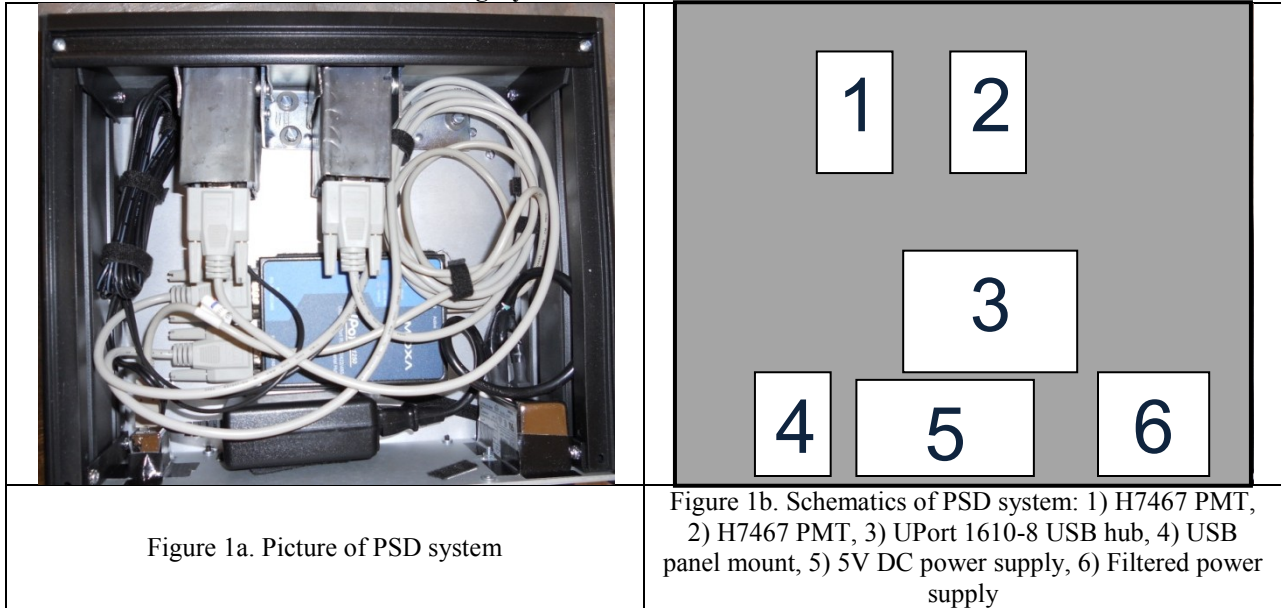


Figure 1a. Picture of PSD system

Figure 1b. Schematics of PSD system: 1) H7467 PMT, 2) H7467 PMT, 3) UPort 1610-8 USB hub, 4) USB panel mount, 5) 5V DC power supply, 6) Filtered power supply

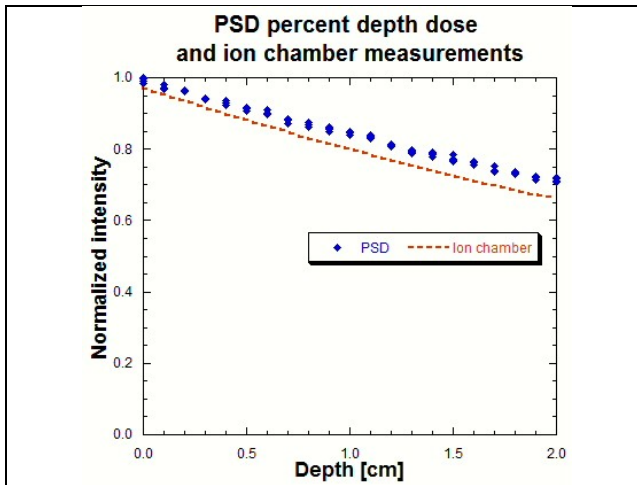


Figure 2. PSD and ion chamber depth-dose curves

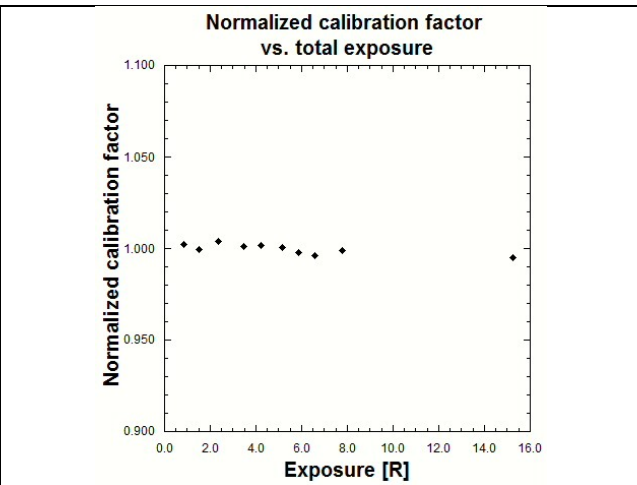


Figure 3. Calibration factor for counts to exposure for the PSD, normalized to average calibration factor

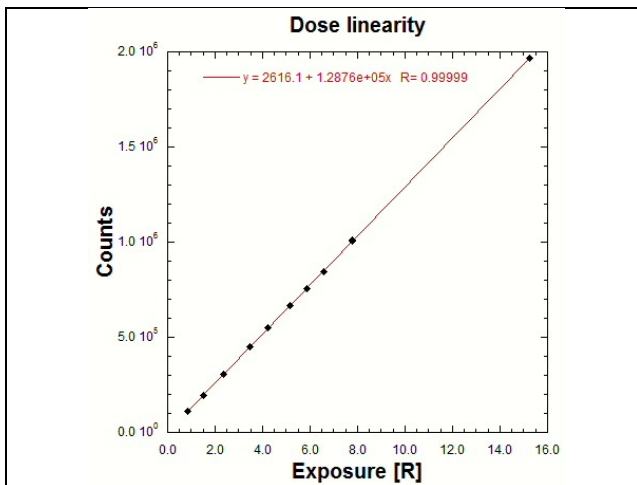


Figure 4. Dose linearity

<u>Depth [cm]</u>	<u>CF</u>	<u>Depth [cm]</u>	<u>CF</u>
0.1	1.0288	1.1	1.0706
0.2	1.0273	1.2	1.0577
0.3	1.0235	1.3	1.0550
0.4	1.0276	1.4	1.0601
0.5	1.0308	1.5	1.0634
0.6	1.0384	1.6	1.0758
0.7	1.0293	1.7	1.0541
0.8	1.0372	1.8	1.0683
0.9	1.0545	1.9	1.0636
1	1.0575	2.0	1.0825

Table 1. Correction factor between PSD PDD and ion

	chamber PDD
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