

MOSFET Dosimeter Response to Kilovoltage Radiation

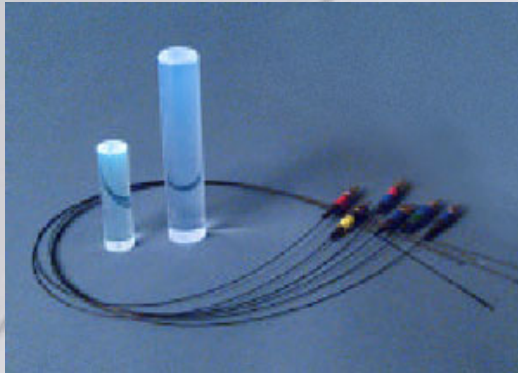
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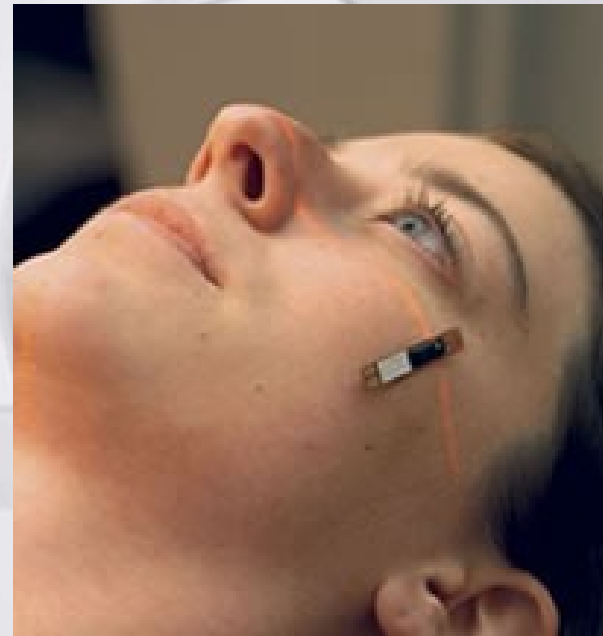
North Central Chapter AAPM meeting
Fairview Ridges Education Center, Burnsville, MN
May 4, 2007



Conventional *In Vivo* Dosimetry



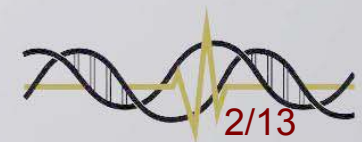
Photograph courtesy of Naval Research Laboratory



Photograph courtesy of Sichel Technologies, Inc.

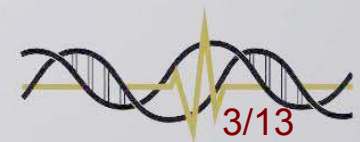


Photograph courtesy of Thomson Nielsen, Inc.



Dose Verification System[®]

- Sixel Technologies, Inc. developed a compact, implantable MOSFET Dose Verification System[®] (DVS[®]).
- Dosimeters are surgically implanted in or near irradiated areas of patient and are passive dosimeters until read by the reader.
- Dose is read telemetrically by a handheld antenna, which inductively powers the dosimeter.
- DVS[®] has FDA 501(k) approval for prostate and breast treatments.
- DVS[®] is currently characterized for MV radiation, but not kV radiation.
- The goal of this study was to determine the dose response of DVS[®] dosimeters to kilovoltage x-ray radiation compared to the response to irradiation from a ⁶⁰Co source.



Dose Verification System[®]



G. P. Beyer *et al.* , "An implantable MOSFET dosimeter for the measurement of radiation dose in tissue during cancer therapy," IEEE Sensors J. Submitted 2007.



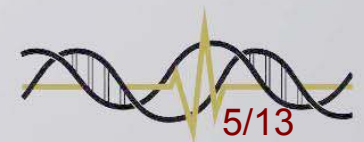
Photograph courtesy of Sichel Technologies, Inc.



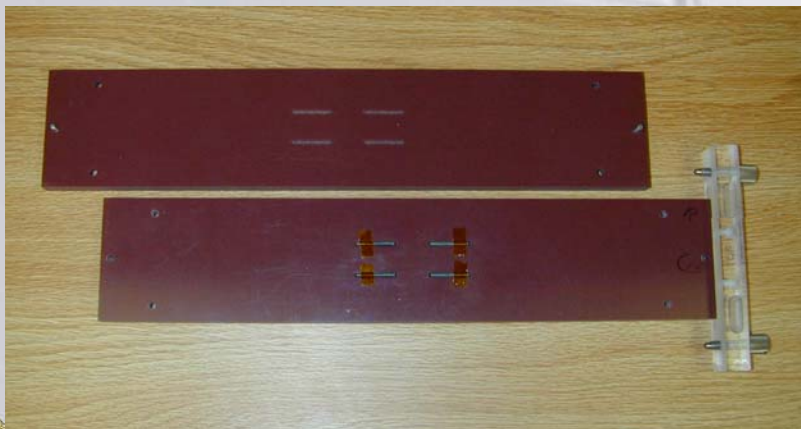
TG-61 Protocol

- Air-kerma-based protocol
- Reference dosimetry for low- and medium-energy x-rays (40-300 kV)
- In-air and in-phantom methods
- Corrections for Virtual Water™ were built into uncertainty of measurement

$$D_{water, z=2\text{ cm}} = MN_K P_{Q, cham} P_{sheath} \left[\left(\frac{\bar{\mu}_{en}}{\rho} \right)_{air}^{water} \right]$$



Experimental Procedure



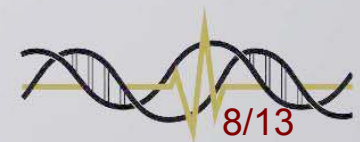
Experimental Procedure

- MOSFET dosimeters in Virtual Water™ cassette were irradiated by NIST-matched x-ray beams for 50 cGy.
- Dosimetry of x-ray beams was determined following TG-61 in-phantom method.
- Beams used were M80, L100, M100, M120, M150.
- kV cassette was also irradiated by ^{60}Co before and after x-ray irradiations to verify device stability.
- Control MOSFET dosimeters in Virtual Water cassette were irradiated with ^{60}Co source for five fractions of 200 cGy.

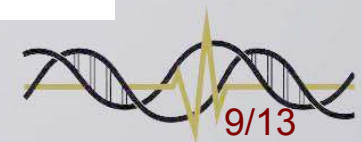
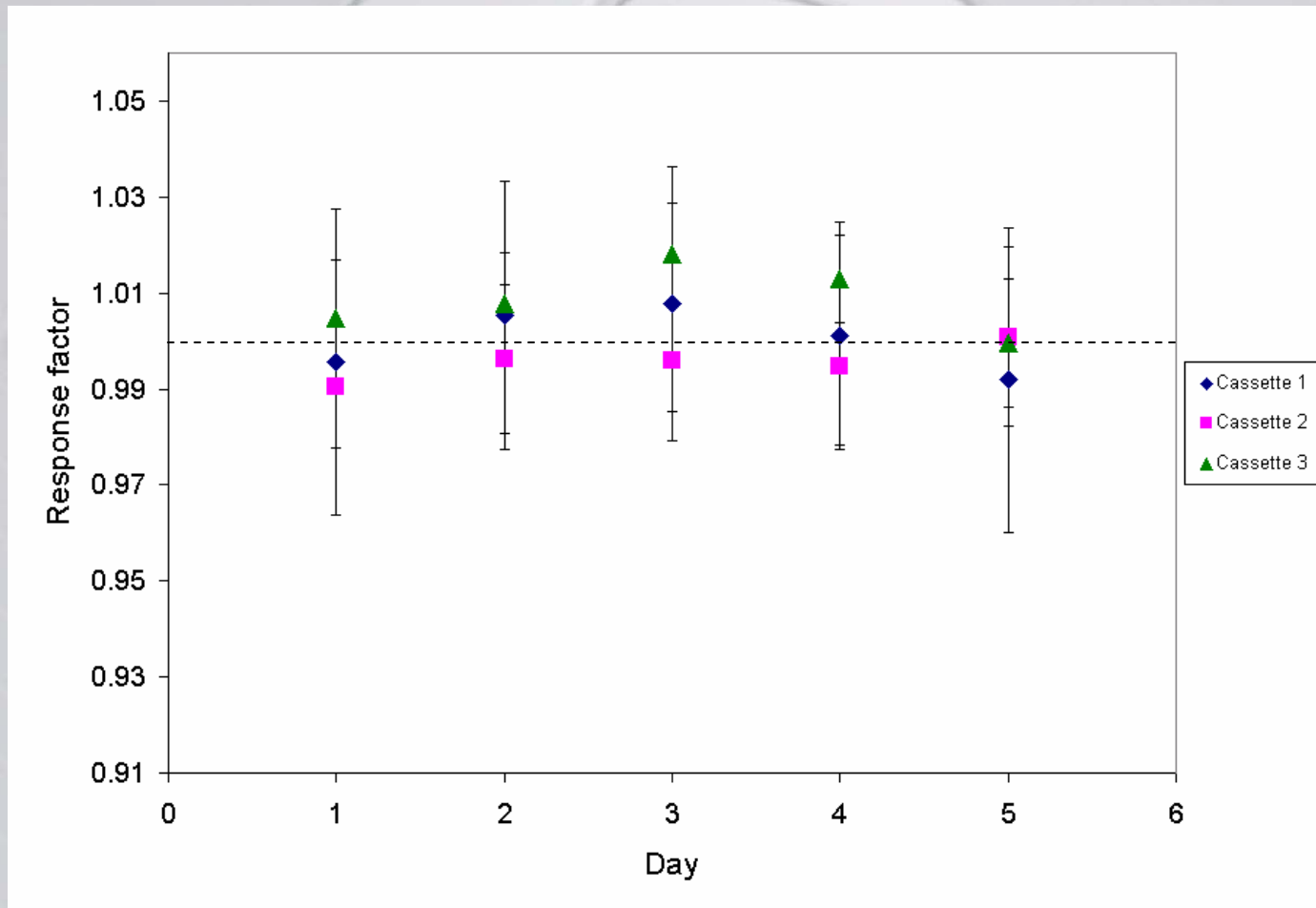


Measurement Results

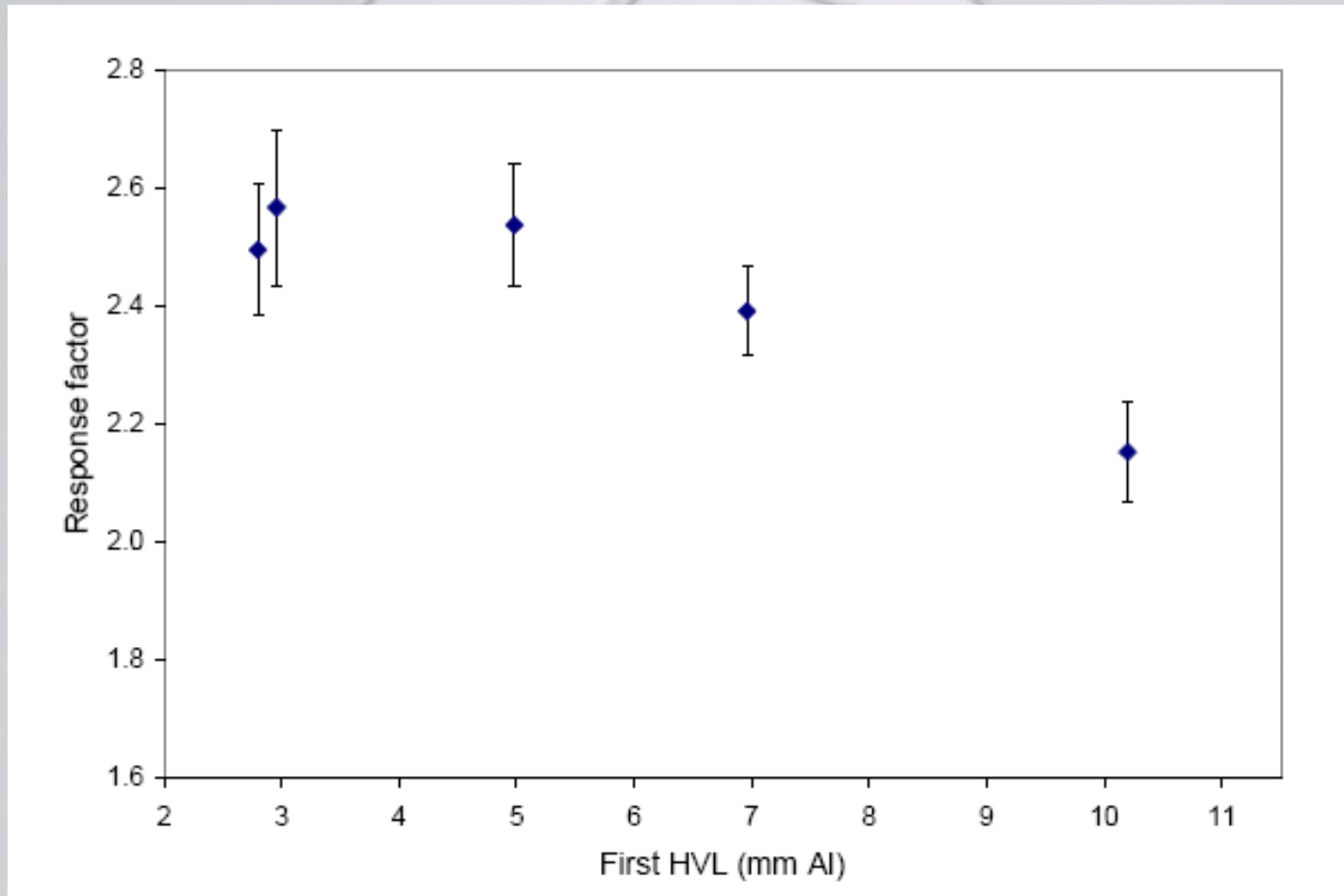
- Results include correction factors determined by Sichel Technologies to account for temperature (room temperature vs. body temperature), energy, and geometry.
- The corrected ratio of dose measured to dose delivered for the ^{60}Co cassettes was $1.002 \pm 0.4\%$
- The kV cassette ratio averaged over all measurements was:
 - $2.428 \pm 1.8\%$ for x-ray beams
 - $0.9755 \pm 1.2\%$ for ^{60}Co



Measurement Results: ^{60}Co



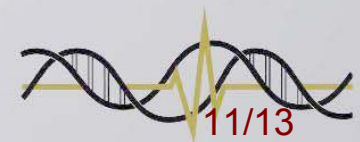
Measurement Results: x-ray



Conclusions

- kV results are consistent with previous MOSFET studies.^{1,2,3}
- ⁶⁰Co results are consistent with previous DVS[®] studies.⁴
- Compton scattering dominates mass energy-absorption coefficient at therapeutic energies.
- Photoelectric effect dominates in SiO₂ at kV energies.
- Dosimeter response to x-ray at 2 cm depth is ~2-3 times greater than to MeV energies.

- [1] S.L. Dong, T.C. Chu, G.Y. Lan, T.H. Wu, Y.C. Lin, and J.S. Lee, "Characterization of high-sensitivity metal oxide semiconductor field effect transistor dosimeters system and LiF:Mg,Cu,P thermoluminescence dosimeters for use in diagnostic radiology," *Appl. Rad. Iso.* 57, 883-891 (2002).
- [2] M. Lavalée, L. Gingras, and L. Beaulieu, "Energy and integrated dose dependence of MOSFET dosimeter sensitivity for irradiation energies between 30 kV and ⁶⁰Co," *Med. Phys.* 33, 3683-3689 (2006).
- [3] B. Wang, C-H. Kim, and X. G. Xu, "Monte Carlo modeling of a High-Sensitivity MOSFET dosimeter for low- and medium-energy photon sources," *Med. Phys.* 31, 1003-1008 (2004).
- [4] R.D. Black *et al.*, "An analysis of an implantable dosimeter system for external beam therapy," *Int. J. Rad. Oncol. Biol. Phys.* 63, 290-300 (2005).



Future Work: ^{192}Ir HDR Performance Testing

- Dose rate dependence
- Energy correction factor
- Dose per fraction calibration factor
- Angular dependence
- Response as a function of distance
- Reproducibility



Acknowledgements

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- UW ADCL customers
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