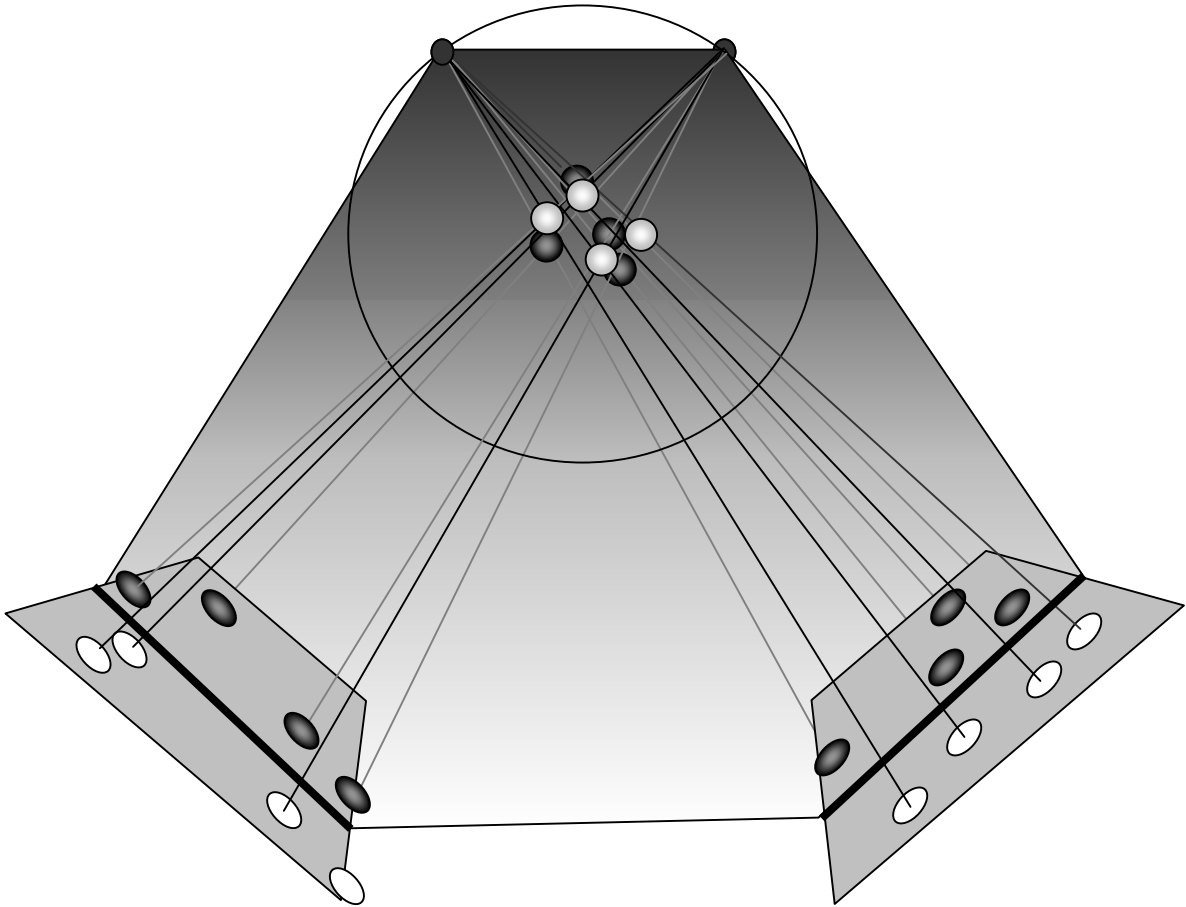
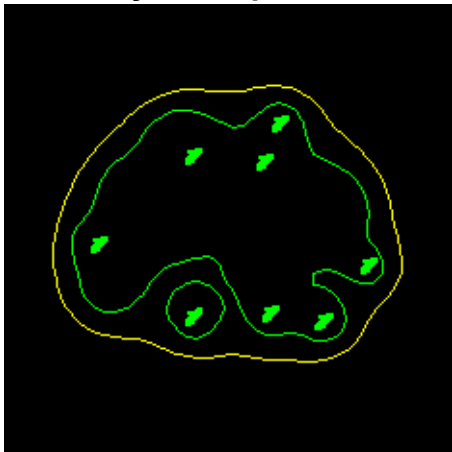


2004 Annual Physics Activity Report

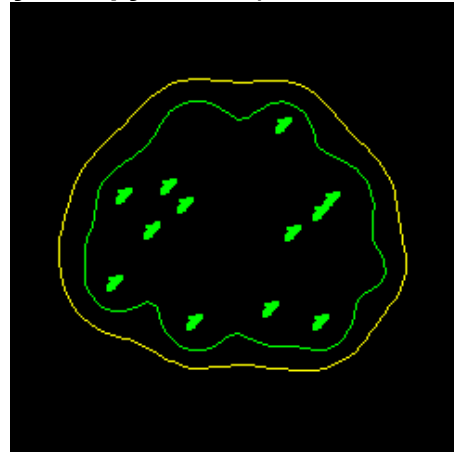
Department of Radiation Oncology
University of Washington



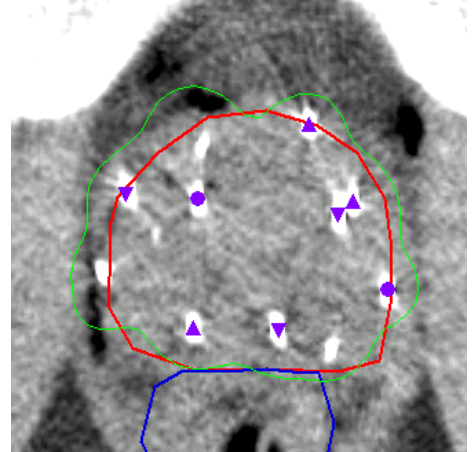
Dynamic prostate brachytherapy: *Intra-operative dosimetry and plan optimization*



Intra-operative evaluation



Remedial seeds added



Post-implant CT

Group Members

Paul Cho, Ph.D.	Sreeram Narayanan
Steven Crooks, Ph.D.	Mark Phillips, Ph.D.
Rob Emery, M.S.E.E.	Alina Popescu, Ph.D.
Eric Ford, Ph.D.	Dave Reid, B.S.
Robert Giansiracusa, M.S.	Ruedi Risler, Ph.D.
Lorraine Hanlon, Ph.D.	Karen Singer, M.S.
Kristi Hendrickson, Ph.D.	Mark Wagner, B.S.
Ira Kalet, Ph.D.	Lori Young, Ph.D.

Transitions

Newly hired: Steven Crooks (lecturer)

Research Associates: Kristi Hendrickson, Sreeram Narayanan

Visiting Faculty: Lorraine Hanlon, Ph.D. (University College of Dublin)

Left: Homayon Parsai

Deceased: Peter Wootton

Physics Retreat

On October 16, the physics group held a retreat on Whidbey Island to discuss future clinical and research programs. One major effort will be to become more involved in training in the department. This will involve the development of procedures and developing training sessions.

Clinical Program

- IMRT: Intensity modulated radiation therapy was brought into routine clinical use. In the latter part of the year, the IMRT program migrated from Prism to a research ADAC Pinnacle system.
- Direct DICOM transfer of MLC portals: Implemented direct transfer of beam portals from the AdvantageSim virtual simulator and ended the use of the Elekta MLP system.
- HDR Treatment Station: Upgraded Nucletron HDR treatment computer system to include DICOM-RT capability.
- Prism: Introduced routine DICOM-RT transfer of plans and dose monitoring points to the Elekta linacs.
- Provided clinical support. As part of our routine work, we provided clinical support for the following programs at UWMC.
 - External beam therapy (x-rays, electrons, neutrons)
 - intensity modulated radiation therapy
 - Intra-operative radiation therapy with electrons
 - Virtual simulation
 - Total body irradiation
 - Total skin electron irradiation
 - Intravascular brachytherapy
 - Stereotactic radiotherapy
 - Stereotactic radiosurgery
 - General brachytherapy

- Eye Plaques
- High Dose Rate brachytherapy
- Permanent prostate implant brachytherapy
- Permanent implant brachytherapy for other sites
- Provided quality assurance and maintenance support. As part of our routine work, we provided quality assurance and maintenance support for the following devices at UWMC and Harborview Hospital.
 - Linear accelerators
 - Cyclotron
 - CT scanner and virtual simulator
 - Gamma Knife
 - Radiocamera system
 - High dose rate afterloader
 - Intravascular brachytherapy system
 - Brachytherapy systems
 - Treatment planning systems:
 - * External beam therapy with x-rays and neutrons (Prism)
 - * Stereotactic radiosurgery
 - * Stereotactic radiotherapy
 - * High dose rate brachytherapy
 - * Permanent prostate implant brachytherapy
 - * ADAC Pinnacle
 - Departmental computers for research and treatment planning
- Operations and upgrades of the CNTS (with Ruedi Risler, David Reid, Robert Emery, James Kuan, Eric Dorman, Mark Wagner):
 - Provided neutron beam for ongoing neutron therapy.
 - Operated and maintained the clinical cyclotron with 2.5% of the scheduled patient sessions cancelled for technical reasons.
 - Provided alpha beam for 211-Astatine production. Presently the routine beam on target is 20 μ A. An additional charcoal filter was installed in the vault exhaust to monitor any potential air emissions from this operation.
 - Started a major upgrade of one of the programmable logic controllers in anticipation of a new accelerator and beam line control system.
 - Completed the replacement of all quadrupole power supplies by more versatile units, compatible with future digital controls.
 - Completed a demonstration program of the future control system. A set of harmonic coils was controlled by the new system under real operating conditions.
 - Improved the safety of the pit in the isocentric room by installing an elevated rubber tile catch platform.
 - Replaced the second RF drive amplifier by a more powerful unit.
 - Replaced the original ion source power supply with a commercial unit, which can handle both proton and alpha beams.

Research Program

- Journal Club
The physics group instituted a monthly journal club for all medical physicists in the Puget Sound area.
- Algorithms for automatic generation of clinical target volumes in head and neck cancer
(Ira Kalet, Mary Austin-Seymour)
The success of radiation therapy depends critically on accurately delineating the target volume, which is the region of known or suspected disease in a patient. Methods that can compute a contour set defining a target volume on a set of patient images will contribute greatly to the success of radiation therapy and dramatically reduce the workload of radiation oncologists, who currently draw the target by hand on the images using simple computer drawing tools. The most challenging part of this process is to estimate where there is microscopic spread of disease. We are developing methods for automatically selecting and adapting standardized regions of tumor spread based on the location of lymph nodes in a standard or reference case, together with image registration techniques. The best available image registration techniques (deformable transformations computed using “mutual information” optimization) appear promising but will need to be supplemented by anatomic knowledge-based methods to achieve a clinically acceptable match. This project also involves collaboration from Mark Whipple, Otolaryngology/Head and Neck Surgery, Linda Shapiro, Computer Science and Engineering/Electrical Engineering, and Chia-Chi Teng, Electrical Engineering graduate student.
- Intraoperative Dose Optimization For Prostate Brachytherapy
(Paul Cho, Sreeram Narayanan)
While brachytherapy has proven to be an effective treatment modality for early-stage prostate cancer, local failure and recurrence do occur. Based on the post-implant analysis correlating the PSA level and the principal dosimetric parameters, it is evident that the probability of cure increases with improved dose distribution. The primary objective of the proposed research is to develop an intraoperative method to measure and modify dose distribution for optimal outcome. Specific aims include: (1) automated detection and localization of seeds from multiple fluoroscopy projections, (2) semi-automated segmentation of prostate volume from ultrasound, (3) automated registration of seeds and prostate volume, (4) development of dose modification supervisor, and (5) clinical evaluation of the target system. The project is funded by NIH/NCI and DoD.
- Use of PET in drawing target volumes
(Mark Phillips, Eric Ford, Lorraine Hanlon)
Advances in imaging physiological processes, e.g. hypoxia, are an important development in targeting tissues for radiation therapy as well as assessing response to treatment. A collaboration with the Nuclear Medicine/PET group at UWMC is working to understand the interaction between imaging parameters and biological imaging. This is an important part of being able to quantitatively include PET information into treatment planning target volumes.
- Multivariate Decision Theory in IMRT
(Mark Phillips, Juergen Meyer, Ira Kalet)
Inverse planning of IMRT currently requires a tedious trial-and-error procedure for determining the clinically useful optimization parameters. In addition, the algorithms are black boxes which only provide the user with one final plan with no insight into the feasibility of other solutions. We have started a program for rationalizing this process by applying multivariate decision theory. Our implementation is based on influence diagrams, which are a combination of Bayesian belief networks and utility theory. Our objective is to improve and expand the decision making process that is an inherent part of inverse planning.
- Using IMRT to target hypoxic regions measured by PET
(Kristi Hendrickson, Joseph Rajendran (Nuclear Medicine))
Hypoxic tumor cells may be an integral part of radioresistance to therapy. Using the tracer F-MISO, PET images can be acquired that highlight those regions that are hypoxic. Viable tumor

cells have increased metabolism which is able to be imaged with FDG PET. Using both of these imaging types, in addition to the CT images, improved target volumes can be drawn. The objective of this project, done in conjunction with Nuclear Medicine, is to evaluate the differences in IMRT treatments between plans calculated with and without this added information. This project is funded by NIH.

– Biomedical Informatics Textbook

Ira Kalet

The field of biomedical informatics has undergone tremendous development and growth in the last decade. Building on the establishment of the Biomedical Informatics Department, Dr. Kalet has gotten a book contract to pull together the disparate concepts and methods into a comprehensive textbook.

Journal Articles

1. Ford EC, Lutz W. A block design for split-field tests of accelerator alignment, *Medical Physics*, 31(8), 2331-2334, 2004.
2. Gong L, Pathak SD, Haynor DR, Cho PS, and Kim Y. Parametric shape modeling using deformable superellipses for prostate segmentation. *IEEE Trans. Medical Imaging*, 23(3):340-349, 2004.
3. Lam ST, Cho PS, Marks II RJ, and Narayanan S. 3D seed reconstruction for prostate brachytherapy using Hough trajectories. *Phy Med Biol*, 49:557-569, 2004.
4. Mageras GS, Pevsner A, Yorke ED, Rosenzweig KE, Ford EC, Hertanto A, Larson SM, Lovelock DM, Erdi YE, Nehmeh SA, Humm JL, Ling CC. Measurement of lung tumor motion using respiration-correlated CT, *Int J Radiat Oncol Biol Phys*, 60(3): 933-941, 2004
5. Meyer J, Phillips MH, Cho PS, Kalet I, Doctor JN. Application of influence diagrams to prostate intensity-modulated radiation therapy plan selection. *Phys Med Biol*, 49: 1637-1653, 2004.
6. Mueller A, Wallner K, Merrick G, Ford E, Sutlief S, Cavanagh W, Butler W. Perirectal seeds as a risk factor for prostate brachytherapy-related rectal bleeding. *Int Journal Rad Oncol Biol Phys*, 59(4), 1047-1052, 2004.
7. Narayanan S, Cho PS, and Marks II R J. 3D seed reconstruction from incomplete data set in prostate brachytherapy, *Phys Med Biol*, 49:3483-3494, 2004.
8. Piper RK, Murphy MK, Greenwood LR, Lamperti PJ, Mitch MG, Seltzer SM, Bales MJ, Phillips MH. Characterization measurements and calculations of a new 131-Cs seed for use in low-energy x-ray brachytherapy. *Med Phys*, Med Phys, 31: 1529-1538, 2004.

Proceedings

1. Cho PS, Narayanan S, Lam ST, Pathak SD, Tutar IB, Gong L, Kim Y, and Wallner KE. Dynamic brachytherapy: intra-operative dose optimization using dual-modality imaging. (Invited Paper) in “Proceedings of the 14th International Conference on Computers in Radiation Therapy”, B. Yi, S. Ahn, E. Choi, and S. Ha, eds. Seoul, Jeong Publishing, pp. 10-13, 2004.
2. Parsai H, Phillips MH, and Cho PS. Clinical implementation of a computer-controlled step-and-shoot wedge technique. In “ Proceedings of the 14th International Conference on Computers in Radiation Therapy”, B. Yi, S. Ahn, E. Choi, and S. Ha, eds. Seoul, Jeong Publishing, pp. 731-733, 2004.
3. Phillips MH, Meyer J, Cho PS, Kalet IJ, and Doctor JN. Bayesian decision making applied to IMRT. in “ Proceedings of the 14th International Conference on Computers in Radiotherapy”, B. Yi, S. Ahn, E. Choi, and S. Ha, eds, Seoul:Jeong Publishing, pp. 108-111, 2004.

Abstracts

1. Phillips MH, Kalet IJ, Cho PS, Doctor JN, Austin-Seymour M, Korb L, Russell K, Rockhill J., Decision Making and Uncertainty in Inverse Planning, *Int J Radiat Oncol Biol Phys*, 60: S182, 2004.

Academic Milestones

- Promoted to Assistant Professor: Eric Ford was appointed to Assistant Professor in Radiation Oncology.

Grants

- Intra-operative Dose Optimization for Prostate Brachytherapy, P.I. Paul Cho: Department of Defense, 2/1/2003-1/31/2006.
- 2005 Frontiers in Biomedical Research Symposium, P.I. Ira Kalet: UW School of Medicine.