
Physics Group Activities – 2003

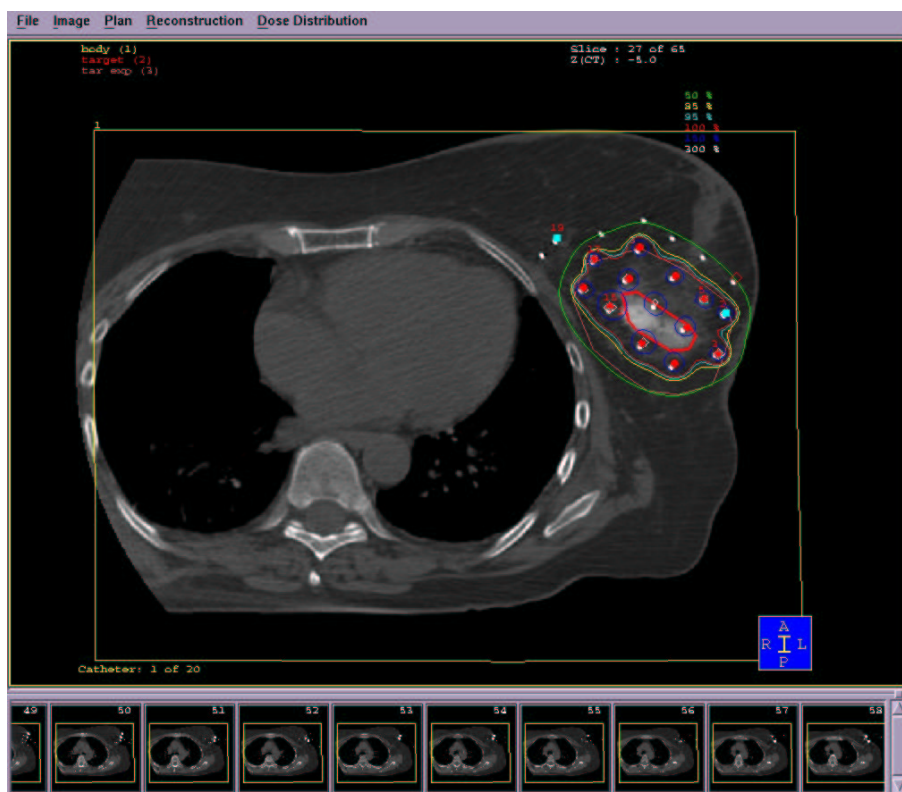


Figure 1: Image of treatment plan for HDR breast brachytherapy.

Group Members

Paul Cho, Ph.D.
Rob Emery, M.S.E.E.
Eric Ford, Ph.D.
Robert Giansiracusa, M.S.
Ira Kalet, Ph.D.
Homayon Parsai, Ph.D.
Mark Phillips, Ph.D.

Alina Popescu, Ph.D.
Dave Reid, B.S.
Ruedi Risler, Ph.D.
Karen Singer, M.S.
Mark Wagner, B.S.
Peter Wootton, B.Sc.
Lori Young, Ph.D.

Transitions

Newly hired: Eric Ford
Work-study student: Joanne Kang
Left: Dalong Pang, Juergen Meyer

Clinical Program

- Breast Brachytherapy: HDR breast brachytherapy was introduced for post-lumpectomy therapy. Michelle Yao, Paul Cho and Tom Arbuckle designed and implemented this program that brings together resources at SCCA and at UWMC.
- IMRT: Intensity modulated radiation therapy was brought into routine clinical use. An IMRT team of Mary Austin-Seymour, Mark Phillips, Evan Chapman, and Homayon Parsai helped shepherd the procedure into the clinic.
- CT Sim: The GE CT scanner and virtual simulator were integrated into the treatment planning process of the department with great improvement in efficiency.
- HDR Capabilities: Upgraded Nucletron HDR planning system to include DICOM capability to import CT and MR images.
- Pediatric TBI: Implemented pediatric TBI procedure on SL20B and SL20C.
- FSRT QA: We developed and implemented QA phantom test for the FSRT program.
- Prism: During this past year, a number of enhancements were included in Prism including
 - Development and clinical use of DICOM-RT capabilities for communication with virtual simulation programs and Elekta linacs
- Real-time prostate planning: Paul Cho helped implement a real-time treatment planning for prostate implants for Kent Wallner's program at VA-Seattle.
- ADAC Pinnacle: Philips/ADAC provided a research Pinnacle workstation which we have started to commission.
- 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
 - Gliasite 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):
 - Provided neutron beam for ongoing neutron therapy.
 - Provided alpha beam for 211-Astatine production. This program was
 - somewhat impeded by the seismic upgrade construction this year.
 - Operated and maintained the clinical cyclotron with no scheduled
 - patient sessions cancelled for technical reasons.
 - Completed the controls for the new zero degree beam line.
 - Maintained full therapy operation during the seismic construction
 - performed by an outside contractor on weekends over a time period of
 - five months. Main areas of concern were the cyclotron, the neutron
 - therapy gantry and the shielding doors.
 - Continued the upgrade of analog programmable power supplies to
 - digitally controllable supplies. Upgrade of on of the RF drive
 - amplifiers to a new and more powerful unit.
 - Replaced the last of the original programmable logic controller
 - components with the latest versions available.
 - Developed a test stand for the development of the future control
 - system software and hardware.
 - Supported the group from INEEL during beam experiments designed to
 - improve the information of the neutron spectrum.

Research Program

- 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.

- Development of a comprehensive DICOM software tools library

(Ira Kalet and Robert Giansiracusa)

Building on the unique new approach to designing software for the DICOM medical imaging protocol and DICOM-RT, its extension to radiotherapy, we are developing additional functionality for the Prism DICOM Server (PDS) software system, and adding other components, which will transform the Prism DICOM software from a local proprietary facility to a comprehensive toolkit that other research groups can use. The components will include a server which supports most of the major DICOM functions including query and retrieve, a client support library that will enable researchers to write their own DICOM applications that store or retrieve data from other systems (including most vendor provided implementations). We are also investigating implementation of a security profile that will provide end to end transparent encryption of data using the TCP/IP Secure Socket Layer (SSL) standard.

- Intraoperative Dose Optimization For Prostate Brachytherapy

(Paul Cho)

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.

- Advanced Inverse Planning Algorithm For IMRT

(Paul Cho)

It has been shown that the inverse problem in IMRT is severely ill-conditioned. The mathematical limitation inherent in inverse planning algorithms has not yet been quantified and properly regulated. The present research exploits the power of singular value decomposition to characterize and regulate the dose matrices for optimal convergence to a feasible solution. Tikhonov method combined with convex projection is being investigated.

- Image Guided Therapy
(**Mark Phillips, Paul Cho, Homayon Parsai, Juergen Meyer**)
Advances in imaging physiological processes, e.g. hypoxia, are an important development in targetting tissues for radiation therapy as well as assessing response to treatment. A collaboration with the Nuclear Medicine/PET group at UWMC is working to develop and apply deformable image registration for two separate clinical studies. The first is to use PET-FDG to reduce the size of target volumes in head and neck cancer, and thus reduce morbidity. The other is to use PET-FMISO to image hypoxia in head and neck tumors and to use the information to design IMRT treatments and to assess the response of the hypoxic regions to radiation therapy. This work is being performed in conjunction with the Nuclear Medicine Department (Paul Kinahan, Joseph Rajendran) and VA-Puget Sound (Eric Ford, David Schwartz).
- 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.
- Improved Seeds for Permanent Seed Implants for Prostate Cancer
(**Mark Phillips**)
Classic radiation biology has always categorized tumor response as having a high alpha/beta ratio, similar to that of acutely responding tumors. This has resulted in treatment strategies that make use of prolonged fractionation schedules in order to achieve the most separation between the tumor response and dose-limiting late responding tumors. Recent clinical results have indicated that for prostate tumors the alpha/beta ratio is probably less than 3, similar to late responding tissues. In addition, recently published data indicate that repair is much slower than previous thought. In a project done in collaboration with IsoRay, Inc., a company designing and developing novel isotope-seed combinations, I am investigating the potential advantages that would result from a shorter half-life isotope for permanent seed implants in light of the profound changes in the radiobiological modelling of prostate cancer.

Journal Articles

1. Cho P, Meyer J, Yee D, Phillips MH, Parsai H, Numerical instability and conditioning in IMRT optimization, *Med Phys*, 30: 1489, 2003.
2. Tutar IB, Managuli R, Shamdasani V, Cho PS, Pathak SD, and Kim Y, Tomosynthesis-based localization of radioactive seeds in prostate brachytherapy, *Medical Physics*, 30: 3135-3142, 2003.
3. Kalet I.J., Giansiracusa, R., Jacky, J., Avitan, D. A Declarative Implementation of the DICOM-3 Network Protocol. *Journal of Biomedical Informatics*, 36: 159–176, 2003.
4. Parsai H,Phillips MH, Cho PS,Giansiracusa R, Axen D, Influence of systematic and random errors in dynamic intensity modulated photon fields, *Phys Med Biol*, 48: 1-13, 2003.
5. Phillips MH, Cho PS, Parsai H,Douglas JG, Use of Intensity Modulation for Missing Tissue Compensation of Pediatric Spinal Fields, *J Appl Clin Med Phys*, 4: 274-281, 2003.
6. Kippenes H, Gavin PR, Parsaei H, Phillips MH, Cho PS, Leathers CW, Sande RD. Spatial accuracy of fractionated IMRT delivery studies in canine paraspinal irradiation. *Vet Radiol Ultrasound*, 44(3):360-6, 2003
7. Popescu A and Risler R. Wedge Factor Dependence with Depth and Field Size for Fast Neutron Beams, *Phys Med Biol*, 48: 1-9, 2003.
8. Young L. Contributed chapters to the Stanford Dosimetry online training project.

9. Ford E, Mageras G, Yorke E, Ling CC, Respiration-correlated spiral CT: a method of measuring respiratory-induced anatomic motion for radiation treatment planning, *Med Phys*, 30(1): 88-97, 2003.
10. Sidhu K, Ford E, Spirou S, Yorke E, Chang J, Mueller K, Todor D, Rosenzweig K, Mageras G, Chui C, Ling CC, Amols H, Optimization of conformal thoracic radiotherapy using cone-beam CT imaging for treatment verification, *Int J Rad Oncol Biol Phys*, 55(3): 757-767, 2003.

Proceedings

1. J Meyer and M Phillips, "Beam direction optimization for anatomy-based IMRT using beam's-eye-view-metric ", *UK Radiation Oncology Conference 2003*, University of Bath, Bath, UK, 2003.

Abstracts

1. Schwartz D, Ford E, Meyer J, Rajendran J, Lewellen B, Yueh B, Coltrera M, Virgen J, Yoshimi A, Kinahan P, Phillips MH, Krohn K. Co-registered FDG-PET/CT Imaging for staging and IMRT treatment planning for squamous cell carcinoma of the head and neck. *Annual Meeting of American Society for Therapeutic Radiology and Oncology* Salt Lake City, UT , Oct. 19-23, 2003.
2. Rajendran JG, Meyer J, Schwartz DL, Kinahan PE, Hummel SM, Lewellen BL, Phillips M, Krohn KA. Imaging with [F-18] FMISO-PET permits hypoxia directed radiotherapy dose escalation for head and neck cancers. *Society of Nuclear Medicine's (SNM) 50th Annual Meeting*, New Orleans, Louisiana, USA, 21-25 June 2003. (submitted)
3. Phillips M, Meyer J, Cho PS, Kalet I. Bayesian belief networks applied to inverse planning. *American Association of Physicists in Medicine (AAPM) 45th Annual Meeting*, San Diego, CA, USA, 10-14 August 2003.
4. Meyer J, Ford E, Kinahan P, Lewellen B, Phillips M. Deformable image registration for IMRT of head and neck cancer. *American Association of Physicists in Medicine (AAPM) 45th Annual Meeting*, San Diego, CA, USA, 10-14 August 2003.
5. Cho P, Meyer J, Yee D, Phillips M, Parsai H, Jones N. Numerical instability and conditioning in IMRT optimization. *American Association of Physicists in Medicine (AAPM) 45th Annual Meeting*, San Diego, CA, USA, 10-14 August 2003.
6. Rajendran G, Meyer J, Schwartz DL, Kinahan PE, Hummel SM, Lewellen BL, Phillips M, Krohn KA. Imaging with [F-18] FMISO-PET permits hypoxia directed radiotherapy dose escalation for head and neck cancers. *Society of Nuclear Medicine's (SNM) 50th Annual Meeting*, New Orleans, Louisiana, USA, 21-25 June 2003.
7. Kinahan P, Cheng P, Lewellen B, Schwartz D, Ford D, Phillips M, Meyer J, Rajendran J, Krohn K, Mankoff D. PET/CT+IMRT radiation treatment planning for head and neck cancer. *Academy of Molecular Imaging (AMI) 2003 International Symposium, Institute for Clinical PET Program*, Madrid, Spain, 26-27 September 2003.
8. Ford EC, Lutz W, A block design for split-field tests of accelerator alignment, *American Association of Physicists in Medicine (AAPM) 45th Annual Meeting*, San Diego, CA, USA, 10-14 Aug 2003.
9. Meyer J, Ford E, Kinahan P, Lewellen B, Phillips M. Deformable image registration for IMRT of head and neck cancer. *American Association of Physicists in Medicine (AAPM) 45th Annual Meeting*, San Diego, CA, USA, 10-14 Aug 2003.
10. Mageras G, Yorke E, Rosenzweig K, Ford E, Lovelock M, Pham H, Measurement of Lung Tumor Motion Using Respiration-Correlated CT, *Radiological Society of North America*, Chicago, IL, USA, 3-7 Dec 2003.

Invited Talks

1. Mark Phillips, Physics of IMRT, *Continuing medical education course, Seattle Cancer Care Alliance*, Sept, 2003.
2. Popescu A, Risler R. Dosimetric Measurements for Total Skin Electron (TSE) Treatments, *25th National Annual Conference*, Kochin, Kerala, India, Nov. 20yh-23th, 2003.

Academic Milestones

- Promoted to Professor: Mark Phillips was promoted to Professor in the Departments of Radiation Oncology and Neurological Surgery.
- Study Section Member: Mark Phillips was appointed to the NCI Radiation Study Section, 2003-2007.
- Regional Editor: Alina Popescu was appointed as a regional editor for the *Austral-Asian Journal of Cancer*.

Grants

- Intra-operative Dose Optimization for Prostate Brachytherapy, P.I. Paul Cho: Department of Defense, 2/1/2003-1/31/2006.
- Introduction of an Improved Brachytherapy Seed, P.I. Mark Phillips: Washington Technology Center and IsoRay, Inc., 2003.
- Resources for Lisp Programming in Biomedical Informatics, P.I. Ira J. Kalet, Publication grant to National Library of Medicine, pending.