# Physics Group Activities – 2002

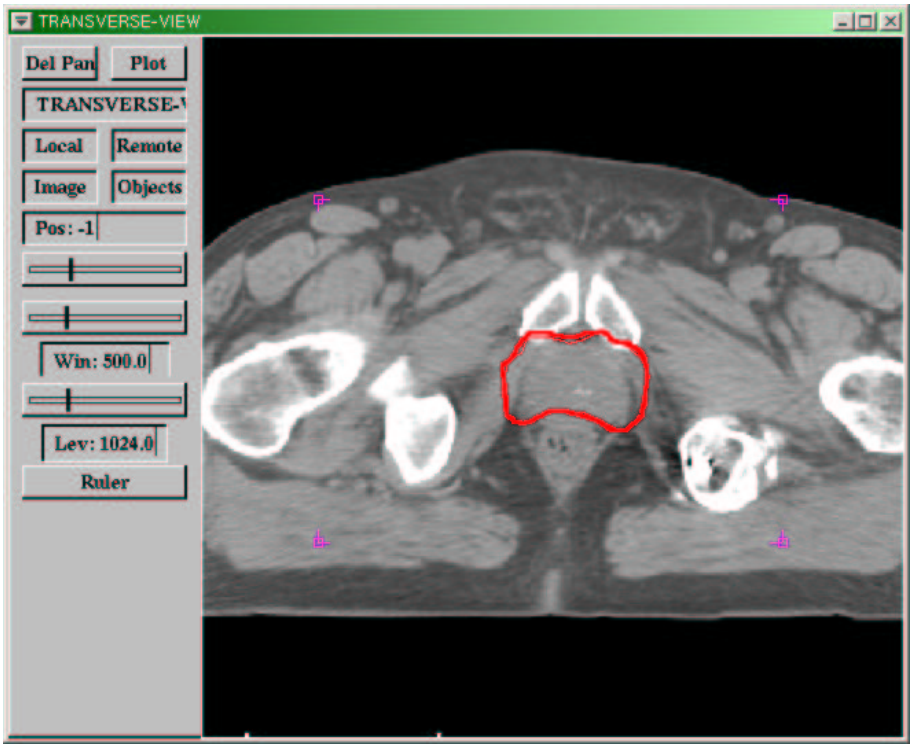


Figure 1: Prism image of a prostate IMRT treatment with the isodose curve shown sparing the rectum.

**Group Members**

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

**Transitions**
Left: Jon Jacky

**Clinical Program**

- IMRT: Intensity modulated radiation therapy was brought on-line. Using direct aperture optimization, two different inverse planning algorithms were implemented: Projection Onto Convex Sets and Fast Simulated Annealing. IMRT was primarily applied to prostate cancer.

- IMRT Compensators: A subset of IMRT, using intensity modulation to act as missing tissue compensators, was implemented. It first use was for breast tissue compensator on breast tangents, but has found its most regular application in spinal field compensation.

- Direct Treatment Data Transfer: The DICOM-RT protocol for transferring data from Prism to the Elekta linacs was implemented in Prism. The software made use of the programming innovations that arose from our earlier development of the DICOM image transfer protocol that was implemented in Prism. In addition to increasing the quality of data transfer, it also paved the way for the introduction of more complex treatment techniques, such as compensated fields and IMRT.

- Prism: During this past year, a number of enhancements were included in Prism including

  - electron dose
  - calculations
  - IMRT
  - multislice auto-contouring
  - library plans
  - Completed a low dose rate brachytherapy facility for the Prism RTP system, to replace the old UWPLAN system, which terminated operation because of a failed disk in an unmaintainable VAX computer.

- Total Skin Electrons: An extensive set of measurements was performed and analyzed to determine the optimum settings and clinical recommendations for total skin electron irradiation. This work has resulted in very detailed values to help the physician choose the appropriate irradiation parameters for a given patient's disease.

- Monte Carlo for Neutrons: Developed a collaboration with INEEL to benchmark and extend their Monte Carlo code for fast neutrons and boron neutron capture therapy. Installed workstation and Monte Carlo code and began modelling the CNTS.

- Provided clinical support. As part of our routine work, we provided clinical support for the following programs at UWMC and at the Seattle Cancer Care Alliance.

  - External beam therapy (x-rays, electrons, neutrons)
  - Intra-operative radiation therapy with electrons
  - 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
  - Brain tumor brachytherapy using liquid I-125 and balloon system
  - Permament implant brachytherapy for other sites

- Provided quality assurance and maintanence support. As part of our routine work, we provided quality assurance and maintanence support for the following UWMC and/or SCCA systems:
  - Linear accelerators
  - Cyclotron
  - 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
  - Departmental computers for research and treatment planning
- Operations and upgrades of the CNTS (with Ruedi Risler, David Reid, Robert Emery James Kuan, Eric Dorman, Jon Jacky):
  - Provided neutron beam for ongoing neutron therapy.
  - Provided proton beam for PET radionuclide production in the first half of the year until the Nuclear Medicine Department took their own cyclotron into operation.
  - Provided alpha beam once a month for 211-Astatine production
  - Operated and maintained the clinical cyclotron with only 1.1scheduled patient sessions cancelled for technical reasons.
  - Installed a new beam line and target station for Astatine production. Controls for the beam line and target are still being worked on.
  - Completed the hardware part of the change-over from the original relay controls to a new combination of Modicon and relay controls for the therapy motions.
  - Completed the preparations for the seismic upgrade of the cyclotron facility. Construction will start early 2003.
  - Continued the upgrade of analog programmable power supplies to digitally controllable supplies.
  - Continued preparation work for a future move of the cyclotron and beam line controls away from the PDP 11/23.
  - Changed the development environment for the therapy control software from the departmental HPUX based cluster which is being phased out to a Windows NT workstation.
  - Upgraded the functionality of the therapy control software. Added a display with patient set-up information inside the therapy room.
  - 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.
- Intraoperative Dose Optimization For Prostate Brachytherapy
  **(Paul Cho)**
  While brachythearpy 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 severly 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, 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).
- Improvements in Radiation Therapy Plan Optimization
  **(Mark Phillips, Juergen Meyer, Ira Kalet)**
  Treatment planning optimization has recently received much attention due to the advent of inverse planning techniques for IMRT. As useful as these algorithms are, they all have difficulty in handling the predominant situations in radiation therapy. These problems include decisions

based on models formulated with incomplete data, incomplete and qualitative presriptions, and mutually contradictory constraints/objectives. Our project is aimed at using belief nets (also known as Bayes' nets) to provide better methods at guiding the optimization process and choosing the most clinically appropriate solution.

– 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. Narayanan S, Cho PS*, and Marks II RJ, "Fast Cross-projection algorithm for reconstruction of radioactive seeds," Medical Physics, 29:1572-1579, 2002. (*corresponding author)
2. Gong L, Cho PS*, Han BH, Wallner KE, et al, Ultrasonography and fluoroscopy fusion for prostate brachytherapy dosimetry. Int. J. Radiation oncology Biol. Phys. 54:1322-1330, 2002. (*corresponding author)

**Proceedings**

1. Gong L, Cho P., Han B, Pathak SD, Haynor D, Wallner K, Sutlief S, and Kim Y, "Registration of prostate brachytherapy seeds with prostate anatomy for improved patient dosimetry," SPIE Medical Imaging, vol. 4681, pp. 567-575, 2002.
2. Lam S, Cho PS, and Marks RJ, "Reconstruction of superposed brachytherapy seeds using Hough transform," International Symposium on Optical Science and Technology, 47th Annual Meeting, 2002. (in print)
3. Ira J. Kalet, Ph.D., Mark Whipple, M.D., M.S., Silvia Pessah, M.D., M.Ph., Jerry Barker, M.D., Mary M. Austin-Seymour, M.D., Linda G. Shapiro, Ph.D., A Rule-based Model for Local and Regional Tumor Spread. Proceedings of the American Medical Informatics Association (AMIA) Fall Symposium, pp. 360–364, Isaac S. Kohane, ed., Hanley & Belfus, Inc., 2002.
4. Chia-Chi Teng, Mary M. Austin-Seymour, M.D., Jerry Barker, M.D., Ira J. Kalet, Ph.D., Linda G. Shapiro, Ph.D., Mark Whipple, M.D., M.S. Head and Neck Lymph Node Region Delineation with 3-D CT Image Registration. Proceedings of the American Medical Informatics Association (AMIA) Fall Symposium, pp. 767–771, Isaac S. Kohane, ed., Hanley & Belfus, Inc., 2002.

**Abstracts**

1. Cho PS, Narayanan S, Marks RJ II, Gong L, Han BH, and Wallner KE, "A fluoroscopy based intraoperative seed localizer for prostate brachytherapy," Proceedings of American Brachytherapy Society 23rd Annual Meeting, Orlando, May 22-24, 2002, p. 58.
2. Cho PS, Gong L, Han BH, Wallner KE, Narayanan S, and Marks RJ, "Prostate brachytherapy dosimetry with dual modality imaging," 44th Annual Meeting of the American Society for Therapeutic Radiology and Oncology, New Orleans, LA, Oct 6-10, 2002.
3. Yee D, Phillips M, Cho P, Parsai H, Meyer J, Hummel S, Austin-Seymour M. The Comparison of Three-Dimensional Conformal with Intensity-Modulated Radiation Treatment Plans for Nasopharyngeal Carcinoma. Poster presentation at the 16th Annual Scientific Meeting of the Canadian Association of Radiation Oncologists, Toronto, Ontario, Canada, October 25-27, 2002

4. Pang D, Phillips MH. IMRT of Lung Cancer. 44th Annual Meeting, American Association of Physicists in Medicine. Montreal, July 14-18, 2002.

**Technical Reports**

1. Cho PS, "Validation of Prism Electron Beam dose Computation," Technical Report 2002-05-01, Department of Radiation Oncology, University of Washington, May 2002.

**Invited Talks**

1. Ira Kalet. Anatomy, Biomedicine and Computing: the ABC's of Informatics in Cancer Treatment. Distinguished Lecture Series, Faculty of Computer Science, Dalhousie University, Halifax, Nova Scotia, April 18, 2002.
2. Mark Phillips. "Imaging in Diagnostic Radiology", Washington State Radiological Society, 28 Jan 2002.
3. Mark Phillips, "Validation of an IMRT Program", Northwest Chapter of AAPM, April, 2002.
4. Mark Phillips, "Physics of High Dose Rate Brachytherapy", Seattle Prostate Institute, Dec. 2002.

**Academic Milestones**

- Study Section Member: Mark Phillips was appointed to the NCI Radiation Study Section starting in 2003.
- Graduate Faculty: Paul Cho was elected to the Graduate Faculty with endorsement to chair doctoral supervisory committees. July 2002.

**Awards**

- Judith Stitt Award for Best Poster Presentation: Awarded to Paul Cho, American Brachytherapy Society 23rd Annaul Meeting, Orlando, Florida, May 22-24, 2002.

**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.