PTCOG41 PROGRAM and ABSTRACTS

10 – 13 October 2004

Bloomington Convention Center, Bloomington, IN, USA

Table of Contents

PTCOG41 PROGRAM		**October 9 - 13, 2004,**	**Bloomington, INDIANA, USA**	
Saturday October 9, 2004				
Fall School in basic proton therapy Physics – Coordinator: Dr Jonathan Farr				
9:00	-	17:00	Fall School by Bernie Gottschalk @ IUCF	Bernie Gottschalk
Sunday October 10, 2004				
Fall School in basic proton therapy Physics - Coordinator: Dr Jonathan Farr				
9:00	-	13:00	Fall School by Bernie Gottschalk @ IUCF	Bernie Gottschalk
START of PTCOG 41: Registration + Opening at Convention Center				
15:00	-	18:00	Registration at the Convention Center	
16:00	-	18:00	*Steering Committee meeting; Cook Room at the Bloomington Convention Center*	Al Smith
18:00	-	20:00	Opening Ceremony + Community Welcome at the Bloomington Convention center; Welcoming address by Bloomington Mayor Mark Kruzan at 19:00	Rob de Cleene

Monday October 11, 2004				
Registration + Breakfast at convention center				
7:30	-	9:00	Breakfast + Registration	
OPENING ADDRESS				
9:00	-	9:15	**Chair: Dr.Allan Thornton**	
9:00	-	9:05	Opening address by Mr Mark Long, President IURTC	
9:05	-	9:15	Opening address by Dr.Paul Sokol, Director IUCF	
Session I: CLINICAL ASPECTS				
9:15	-	10:25	**Chair: Dr.Allan Thornton + Dr.Tom DeLaney**	
9:15	-	9:45	Partial Breast Irradiations	Simon Powell
9:45	-	10:05	LLUMC Breast protocol	Leslie Yonemoto
10:05	-	10:25	Current Indications for Proton therapy	Allan Thornton
10:25	-	11:00	Tea / Coffee Break	
Session II: TECHNICAL ASPECTS				
11:00	-	12:30	**Chair: Dr. Jay Flanz + Dr.George Coutrakon**	
11:00	-	11:30	A perspective on Proton Therapy Technology	Jay Flanz
11:30	-	11:45	An automated control system to streamline patient throughput in Proton Therapy	Phillipe Thirionet

Monday October 11, 2004

11:45	-	12:00	Spill-to-spill and daily energy consistency for new accelerator control system	Michael Moyers
12:00	-	12:15	Design toward the smaller sized facility for heavy ion therapy	Fuminori Soga
12:15	-	12:30	The Choice of Design for the MPRI Gantry Nozzle	Dmitri Nichiporov
12:30	-	12:45	A Proton Therapy Facility with Simultaneous Treatment Capability	Andreas Weber
12:45	-	14:00	LUNCH	
FOCUS Session I : Regional Based proton Therapy facilities				
14:00	-	16:00	**Chair: Dr.John Cameron + Dr.Jerry Slater**	
14:00	-	14:15	The development and establishment of MPRI as a Regional Facility.	Allan Thornton
14:15	-	14:30	Contractual obligations for a regional/non-hospital based facility	Herschel Workman
14:30	-	14:45	Establishing Daily Fractionated Pediatric Anesthesia Support	Allan Dunn
14:45	-	15:00	The History and the Development of the M.D. Anderson Proton Therapy Facility	James Cox
15:00	-	15:15	Fraction of proton beam treatment in radiotherapy at Shizuoka Cancer Center	Hiroshi Fuji
15:15	-	15:30	Update of the Clinical Program at the PSI Spotscanning Gantry	Gudrun Goitein
15:30	-	15:45	Shielding Estimates for a Proton Therapy Center	Vladimir Anferov
15:45	-	16:00	Overview of the IUCF and MPRI Facilities	Paul Sokol
16:00	-	16:25	Tea / Coffee Break	
16:25	-	16:45	Bus transport to IUCF	
16:45	-	18:15	TOUR of MPRI/IUCF	John Cameron
18:15	-	18:45	Bus Transport to Oliver Winery	
18:45	-	21:45	Barbecue at Oliver Winery	

Tuesday October 12, 2004				
Registration + Breakfast at convention center				
7:00	-	8:45	Breakfast + Registration	
Refresher Courses				
7:30	-	9:00	Clinical: **Cook** Room at the Bloomington Convention Center	
7:30	-	8:50	Paraspinal Sarcomas	Tom De Laney
7:30	-	9:00	Physics: Image Guided Radiotherapy : **Bank One** room at convention Center	
7:30	-	8:10	The current use of IGRT techniques in Photon Radiotherapy	Jatinder Palta
8:15	-	8:55	IGRT techniques in Proton Radiotherapy	Ale Mazal
FOCUS Session II: Extra cranial Treatments - Clinical				
9:15	-	10:30	**Chair: Dr.Skip Rosenthal + Dr.Jatinder Palta**	
9:15	-	9:30	Compensation of target motion during ion radiotherapy	Sven Oliver Groezinger
9:30	-	9:45	Clinical Treatment Technique Based on Proton Beams for Therapy of Intact Breast	Bijan Arjomandy
9:45	-	10:00	Granulomatous slack skin disease; An innovative treatment approach using protons	Jonathan Farr
10:00	-	10:15	A theoretical study of the effect of respiratory lung motion on IMPT treatment Plans	Tae Kyu Lee
10:15	-	10:30	CT Metal Artifact reductions and its effect on treatment planning	Jikun Wei
10:30	-	11:00	Tea / Coffee Break	
FOCUS Session II: Extra cranial Treatments - Technical				
11:00	-	12:45	**Chair: Mr Ed Dickey + Dr.Ale Mazal**	
11:00	-	11:15	Digital Imaging Automation for Patient Set Up	Stanley Rosenthal
11:15	-	11:30	Registration Strategies for Image Guided Radiotherapy.	Sanjiv Samant
11:30	-	11:45	Analysis of stereo photogrammetry for patient setup in partial breast irradiation	Christoph Bert
11:45	-	12:00	The Robotic Patient Positioner at MPRI	Chris Allgower
12:00	-	12:15	Automation Technology for PPS	Alexander Ferro
12:15	-	12:30	The IBA Patient Alignment System	Caterina Brusasco
12:30	-	12:45	Gantry and Patient Positioning System	Hugo Schar
12:45	-	14:00	LUNCH	

Tuesday October 12, 2004

Session III: Radiation Biology

14:00	-	16:00	**Chair: Dr.Susan Klein + Dr.Fred Vernimmen**	
14:00	-	14:30	Biological systems and dose-effect relationships after irradiation .	John Guelette
14:30	-	15:00	High LET effects of heavy charged particles	Gerard Kraft
15:00	-	15:15	RBE of the MPRI proton beam for crypt regeneration in mice	John Guelette
15:15	-	15:30	Proton RBE at low energies .	Gerard Kraft
15:30	-	15:45	Alpha/Beta values for arteriovenous malformation obliteration	Fred Vernimmen
15:45	-	16:00	A Solar Flare Simulation Using a Scan Beam System	George Coutrakon
PTCOG Business Feedback				
16:00	-	16:15	PTCOG business: Feedback from steering Committee	Al Smith
16:15	-	16:45	Tea / Coffee Break	
Session IV: Poster Viewing				
16:45	-	18:00	**Coordinators: Mr. Niek Schreuder + Mr. Anthony Mascia**	
Poster #		1	Solid Gel Dosimetry with 70 MeV Proton Beam	Kambiz Shahnazi
		2	Status of the M. D. Anderson Proton Therapy Center	Al Smith
		3	Study of Formation of Flat Field by Particle Radiations	Yoshihisa Takada
		4	Proton Therapy at the Wakasa Wan Energy Research Center	Kyo Kume
		5	Adaptive response induced by pre-exposure mouse pituitary with low-dose 60Co gamma-ray on growth hormone (GH) and body mass.	Hong Zhang
		6	How to manage positioning, immobilising and planning without a proton gantry - a recurrent Ependymoma of the sacrum - a case report	Daphne Commin
		7	Status of MedAustron	Erich Griesmeyer
		8	Status of the ACCEL Proton Therapy System installation at RPTC	Juergen Heese
		9	Carbon Ion Injector Linac for a Heavy Ion Medical Synchrotron	Donald Swenson
		10	BNCT Neutrons from Carbon Ion Injector Linacs	Donald Swenson
		11	The RPTC in Munich, Germany – fall 2004 update	Jörg Hauffe
		12	Fast switching of the proton beam between two treatment rooms and setup of a real-time control of the beam	Samuel Meyroneinc
		13	High-resolution proton beam tracking detector	Steve Ebstein
		14	Correcting a Skewed SOBP Produced with the Energy Stacking Technique	Mark Wolanski

Tuesday October 12, 2004				
18:00			Buses leave for Hotels	
18:45			Buses leave from hotels to IU Auditorium for conference dinner	
19:00	-	22:00	Conference Dinner	

Wednesday October 13, 2004				
Registration + Breakfast at convention center				
7:00	-	8:45	Breakfast + Registration	
Refresher Courses				
7:30	-	9:00	**Clinical**: **Cook** Room at the Bloomington Convention Center	
7:30	-	8:50	Prostate Treatments	Carlo Rossi
7:30	-	9:00	**Physics:** IT + RT PACS: **Bank One** room at convention Center	
7:30	-	8:10	DICOM draft standard for ion beam therapy	Michael Moyers
8:15	-	8:55	The RCET System - a working RT PACS system	Vincent Frouhar
Session V: Dosimetry				
9:15	-	10:30	**Chair: Dr.Chuck Bloch + Dr.Michael Moyers**	
9:15	-	9:30	The IBA Proton Therapy System In Wanjie	Thomas Canon
9:30	-	9:45	Uniform Scanning, a safe path towards PBS	Yves Claereboudt
9:45	-	10:00	Implementation of the Wobbling delivery mode	Roelf Slopsema
10:00	-	10:15	Performance of a fluorescent screen and CCD camera in 3He and 12C beams	Jacob Naumann
10:15	-	10:30	An ultra fast CVD beam monitor	Erich Griesmeyer
10:30	-	11:00	Tea / Coffee Break	
Session VI: General				
11:00	-	12:30	**Chair: Dr.Vladimir Anferov + Dr.Jonathan Farr**	
11:00	-	11:15	Minimally Perturbing head and neck registration and immobilization devices	Michael Moyers
11:15	-	11:30	Proton Pencil Beam Dose Kernel Simulation by Monte Carlo Method	Yaxiang Yang
11:30	-	11:45	Basic dosimetric data for a proton TPS	Ale Mazal
11:45	-	12:00	Emission of light fragments produced by nuclear fragmentation in thick water phantoms	Konstanze Gunzert-Marx
12:00	-	12:15	The impact of interplay between respiratory motion and C-12 beam scanning on the dose deposition	Christoph Bert
12:15	-	12:30	MPRI overview - operational statistics for the first 9 months.	Niek Schreuder
12:30	-	13:00	Open Forum Discussion on "Where do we go from here ?".	Al Smith
13:00	-	13:05	Closure	Allan Thornton

Partial Breast Irradiations

Simon Powell

Department of Radiation Oncology, Washington University School of Medicine in St. Louis, St. Louis, MO 63130

snpowell@wustl.edu

LLUMC Breat protocol

Leslie Yonemoto

Loma Linda University Medical Center, Loma Linda, CA

lyonemoto@verizon.net

Current Indications for Proton therapy

Allan Thornton

Midwest Proton Radiotherapy Institute, 2425 N Milo B Sampson lane, Bloomington, IN, USA

ATHORN5644@aol.com

A perspective on Proton Therapy Technology

Jacob Flanz, Ph.D.

Northeast Proton Therapy Center, Massachusetts General Hospital

flanz@hadron.mgh.harvard.edu

The field of proton therapy has enjoyed a marked growth in the past decade. The technical options available for these facilities have also grown. It is interesting to remember the questions one asked about Proton Therapy Technology a dozen years ago, after the major inno-ventions of Harvard, Berkeley and Sweden, and compare them to the questions one has now.

- Have the questions been answered, or have more questions arisen?
- Have we learned new things?
- Given the increase in for-profit groups involved in the fabrication of Proton Therapy technology - have the options increased or diminished?
- How best can one influence the growth of technology to be consistent with the treatment modalities being considered?

These questions and many more will not be answered to anyone's satisfaction in this talk

An automated control system to streamline patient throughput in Proton Therapy

Ph. THIRIONET, D. DUPREY, J-F. DE LE HOYE , D. LEYMAN, F. GENIN
Ion Beam Applications, Rue du Cyclotron 3, 1348 Louvain-la-Neuve, Belgium
Email: philippe.thirionet@iba.be

IBA is a Belgian company developing and producing Proton Therapy Systems for Proton Therapy Centers. Such a system is now running at the Massachussetts General Hospital since 3 years. During daily patient treatments, a need to streamline patient throughput and to reduce production costs has been identified. A Proton Therapy Center consists of more than one Treatment Room. In order for Patient Treatment to run smoothly and efficiently, it is of utmost importance to have the ability to schedule beam allocation to the Treatment Rooms, to effectively allocate the beam, to set up all parameters of the system (Energy selection system, magnet settings, etc.) and to tune all these parameters for correct beam delivery to the target Treatment Room. It is with this goal in mind that IBA has developed both an Automatic Beam Scheduler (ABS) and an Automatic Beam Operation (ABO). The ABS system provides an automatic rule-based selection of the sequence for processing multiple beam requests. In the earlier version of the system, the arbitration of more than one beam request had to be done manually by the operator. The ABS is designed and built as an additional module to be superposed to the existing system, and can be switched off for going back to manual mode if required. The ABS has the advantage of offering the possibility for the Therapist to request beam directly to the operator in the Main Control Room; with this request comes all the necessary beam parameters (range, beam intensity, etc.) The therapist then has a view upon where his request is situated in the beam scheduler queue and he is also able to see the approximate waiting time before the beam is allocated to his Treatment Room.For critical patients (for example pediatric cases), the therapist can make out a High Priority Beam request and will therefore receive beam allocation before the other Treatment Rooms, which are the in the Waiting queue. Once the Beam request (request given by the ABS) is the next one to be processed, the ABO automatically sets up all the system parameters (accelerator settings, energy selection, magnet settings, etc.) and then tunes these parameters for correct beam delivery to the allocated Treatment Room. The operator has the ability to connect or disconnect the ABO at any time should the need arise. An alarm system is available that can be connected to the control system in order for the operator to be called should the system fail to operate in full automatic mode (ABS & ABO). If this comes about, the operator will have to fix manually the problem that engendered the alarm and then put the system back into automatic mode. The ABS feature is now in its final version and is used on a daily basis by therapists and operators. The ABO feature required several prototyping phases to study the characteristics of the beam delivery system. The difficulty in this project was to keep full automation of the beam production independently from drifts of many physical parameters in time. The combination of these two systems (ABS & ABO) allows for a faster, smoother operation of the IBA Proton Therapy System and also allows for an operator free process. An overview of these two features and technical achievements will be presented.

Spill-to-spill and Daily Energy Consistency with a new Accelerator Control System

M. F. MOYERS, A. GHEBREMEDHIN, B. ARJOMANDY, R. SIMPSON, F. PISKULICH

Loma Linda University Medical Center

m.moyers@att.net

The Loma Linda University proton accelerator has had several upgrades installed including synchrotron dipole power supplies and a system for monitoring the beam energy. The consistency of the energy from spill-to-spill has been tested by measuring the depth ionization at the distal edge as a function of time. These measurements have been made with a minimally equipped beamline to reduce interference from confounding factors. The consistency of the energy in a treatment room beamline has been measured over several months using an ion chamber based daily quality assurance device. The results show that the energy of protons delivered from the accelerator (in terms of water equivalent range) is consistent from spill-to-spill typically within ± 0.010 mm (maximum deviation of 0.018 mm) at 70, 155, and 250 MeV and that the energy check performed each day in the treatment room over a several month period is within ± 0.1 mm at 149 MeV. These results are within the tolerances required for the energy stacking technique.

Design toward the smaller sized facility for heavy ion therapy

Fuminori SOGA

National Institute of Radiological Sciences4-9-1 Anagawa, Inage-ku, Chiba 263-8555, JAPAN

soga_f@nirs.go.jp

The clinical trial of treatment for cancer patients using the carbon beam has been conducted in the HIMAC for 10 years. The total number of the patients treated so far goes over 1900 covering various sites. Statistics show very good results with respect to local control as well as 5 years-survival in treated patients. The second heavy ion facility in Hyogo prefecture started the carbon beam treatment last year. However, both facilities are very big and required high cost of construction.

We want to propagate the heavy ion facilities in Japan. In order to promote these systems at various districts in our country, the optimized design for the smaller size of the facility has long been studied in our institute. Main specifications are the following. The final energy of the accelerator is 400 MeV/n and three treatment rooms are provided. Those are for horizontal beam port, vertical beam port and both beams ports directed in each room.

In the conceptual design, we adopt various kind of improvement in each part of accelerator to squeeze the dimension. Those are ECR ion source with use of permanent magnet, interdigital horizontal type linear accelerator instead of Alvarez type and the irradiation system with shorter distance of 6 meters between source and isocenter.

Integration of these ideas combined with the detailed design partly supported by the companies which have already constructed therapy facilities, results in the smaller sized design of facility which occupies about one third of area of the HIMAC facility. Moreover, the cost evaluation shows also roughly about one third of HIMAC.

The Choice of Design for the MPRI Gantry Nozzle

D. Nichiporov, Ph D

Indiana University Cyclotron Facility, Bloomington IN 47408-1398

nichipor@indiana.edu

The design of the MPRI gantry nozzle became a result of the continued development effort by the IUCF team using some of the earlier accomplishments. The starting conditions for the nozzle design in Treatment Room 2 were the following;
- clinical performance requirements defined,
- operating experience in Treatment Room 1 gained,
- gantry vendor chosen.

A number of design solutions for beam delivery were considered, including double scattering, ridge filters, active beam spreading and energy superposition. A combination of active beam spreading (beam wobbling) and dynamic depth dose delivery (energy stacking) has been chosen for the MPRI gantry-equipped Treatment Rooms 2 and 3.

Advantages and disadvantages of different beam delivery methods will be discussed. The chosen nozzle design will be presented along with preliminary dosimetry results that demonstrate proof of principle of wobbling and energy stacking as applied to the chosen design.

Among the topics of our future work are: development of a real-time depth-dose detector and algorithms of absolute dose calibration for energy stacking.

A Proton Therapy Facility with Simultaneous Treatment Capability

A. Weber, D. Cordini, J. Heufelder, H. Homeyer, H. Kluge,
I. Simiantonakis, R. Stark

Hahn-Meitner-Institut Berlin GmbH, Germany, 14109 Berlin, Glienicker Strasse 100
andreas.weber@hmi.de

andreas.weber@hmi.de

The number of patients to be treated per year in a hospital based therapy facility is becoming an issue with increasing importance. In this study we propose a setup allowing parallel treatment of patients using a single accelerator. With a beam distribution technique realized at the MPRI in Bloomington/Indiana the continuous beam is split by kickers and Lambertson-dipoles in the beam distribution line and transported in bunches to the patient. The adequate high beam intensity what is shared between the rooms can be delivered by a cyclotron. The beam line system, together with two possible layouts of a facility will be presented and the operational benefit will be discussed.

The development and establishment of MPRI as a Regional Facility.

Allan Thornton

Midwest Proton Radiotherapy Institute, 2425 N Milo B Sampson lane, Bloomington, IN, USA

ATHORN5644@aol.com

Proton therapy, while not a new irradiation modality, has long been regarded as a relatively exotic form of radiation therapy, resigned in the US to one of two coastal based centers, Harvard University Cyclotron (at Massachusetts General Hospital, Boston, MA) and Loma Linda University Medical Center (Los Angeles, CA). The cost of the accelerator and beam-line systems, along with the personnel necessary to maintain the equipment, has made this highly effective, proven, therapy available only to a limited number of centers.

These financial and technological constraints have changed greatly over the past decade, thanks in large part to the integration of microcomputer processing in 1) image-guided treatment planning systems 2) accelerator control systems 3) beam delivery systems 4) patient-positioning systems. With the lifting of these constraints several large commercial vendors willing to produce these centers, along with the construction, financing, and technological support have emerged. Paralleling this vendor entry came the development of CPT codes, Medicare approval, and carrier pricing appropriate for this nascent form or irradiation therapy.

The story of the creation of the Midwest Proton Radiotherapy Institute (MPRI) on the campus of Indiana University in Bloomington, Indiana, is one reflecting all of these changes of the past decade. IUCF performed its first medical treatment in 1993, and MPRI received approval to treat patients a decade later, in December of 2003. MPRI is a collabortion of individuals from a nuclear physics laboratory (Indiana University Cyclotron Facility), and a core of particle therapy medical staff and therapists recruited from Massachusetts General Hospital in Boston, Harper General Hospital in Detroit, and iThemba Labs (formerly the National Accelerator Centre) near Capetown, South Africa.

The MPRI concept development, funding, transformation from a research laboratory into a medical clinic, development of FDA-approved beam-delivery systems, and development of robotic patient positioning systems represents a decade of effort and innovation.

Contractual obligations for a regional/non-hospital based facility

H. WORKMAN, CPA

Midwest Proton Radiotherapy Institute, 2425 N Milo B Sampson Ln, Bloomington, IN, 47408, USA

heworkma@indiana.edu

The decision to construct a free-standing, non-hospital based Proton Therapy center in Bloomington, Indiana has created many opportunities for the local medical community.
All of the local health care providers have the potential to benefit from the increased technological acumen that a Proton Center brings to a community and many may respond by increasing their own technological proficiency. We conclude that there is a technological "halo" effect that accompanies the introduction of a Proton Center into a local community. This is good for the community as it begins to give it a very favorable identity in its own region, raising the awareness of Physicians in neighboring communities of the availability of these technologies, ultimately resulting in increased referrals into the community.

Selling the Community on the idea that a new, advanced form of Radiation Therapy would benefit, rather than injure, the local medical community has been an important activity. We recommend to others who are intent on placing a free-standing Proton Therapy Center into a community that you first understand the dynamics of the community and its resources, and then dedicate yourself and your staff to become a true partner of the community.

Unlike a hospital-based facility, the free-standing clinic must be self-reliant. We have contracted with the Bloomington Hospital for many services. For other services we have contracted with medical groups, administrative service companies, accountants and attorneys.

While the need to obtain direct services to the Clinic is great, so are those services that are provided directly to the patients where MPRI acts as a coordinator, but not a contractor. For example, one of the greatest needs of patients who come for treatment is that of housing. Other services include education for children, religious and social choices, entertainment, arts and sports, social workers, general practitioners, pediatricians and others.

Contracting, negotiating, coordinating and sticking our nose into every nook and cranny of the community on behalf of our patients is rewarding for the patients, for the Clinic and for Bloomington. We recommend this activity receive very high priority when establishing a new free-standing Proton Therapy Center.

Establishing Daily Fractionated Pediatric Anesthesia Support.

Allan Dunn, MD

Bloomington Anesthesiologists PC, 908 North Walnut Street, Bloomington, IN 47404

famdunn@aol.com

The History and the Development of the MD Anderson Proton Therapy Facility

James Cox

UT M. D. Anderson Cancer Center; Radiation Oncology; 1515 Holcombe; Houston; TX, 77030

jcox@mdanderson.org

Fraction of proton beam treatment in radiotherapy at Shizuoka Cancer Canter

Hiroshi Fuji[1], Shigeyuki Murayama[1], Hideyuki Harada[2], Minoru Kamata[2], Tetsuo Nishimura[2]

Proton Therapy Division and Radiation Oncology Division ,Shizuoka Cancer Center, Shizuoka, Japan

h.fuji@scchr.jp

Background: Excellent dose-distribution of the proton beam is thought to be beneficial for the treatment of a variety of malignant tumors. However the expected contribution of proton beam treatment (PBT) to radiotherapy is still unclear because the criteria for PBT to be preferred to conventional photon beam treatment (CPT) is not widely accepted in Japan.
Purpose: To investigate the contribution of proton beam treatment in radiotherapy at a cancer center in Japan.
Materials and Methods: At Shizuoka Cancer Center (SCC), the eligibility of the patients for proton beam treatment was determined by case physicians including the surgeon, the medical oncologist and the radiation oncologist. The character of the patients who underwent PBT in our referring system was analyzed in comparison with patients treated by CPT.
Results: Ninety seven patients - 5% of all patients undergoing radiotherapy - were enrolled into proton beam treatment from July 2003 to September 2004. The patients with prostate cancer predominated the subject group. Mean distance from SCC to hometown of the patients who underwent PBT was longer than that of CPT.

Conclusion: A considerable fraction of the patients treated by irradiation underwent PBT. However most patients suffered from a specific disease and were provided from a wider medical services area than where CPT is provided.

Update of the Clinical Program at the PSI Spotscanning Gantry

G. Goitein, H. P. Rutz, B. Timmermann, D. Weber, A. Lomax, A. Bolsi, O. Stadelmann,
Team Radiation Medicine

Division of Radiation Medicine, Paul Scherrer Institute,CH – 5232 Villigen PSI, Switzerland

gudrun.goitein@psi.ch

Since December 1996, a total of 201 patients have been irradiated for deep seated tumors, using the PSI spot scanning gantry. Patients are referred from outside centers, as PSI has but an ambulatory treatment facility. Clinical work-up is done outside PSI by referring clinics and doctors, evaluation for proton therapy takes place at PSI (in discussion with referring doctors), irradiation is performed 4 times weekly during yearly treatment periods of 6 – 9 months. There were 98 female and 103 male patiens, age ranged from 1 to 80 years with a med. of 49 and a mean of 44.5 years. Proton therapy was given for various histologies and groups of tumors with chordomas/chondrosarcomas being the by far largest one (n=94), followed by sarcomas (ST & B, n=28) and meningiomas (n= 23).

Recent analyses have been made and are published or about to be submitted: For 16 meningiomas, treated between 1997 and 2002, 3-year local control, progression-free survival and Overall survival were 91.7, 91.7 and 92.7%, respectively. Observed toxicity to the optic apparatus was dose-related. 1 necrosis occurred centrally within a lesion, causing surrounding oedema and severe neurological symptoms. 29 patients with chordomas and low-grade chondrosarcomas of the skullbase, treated between 1998 and 2003, have been analyzed. The actuarial local control rates are 87.5% for chordoma and 100% for chondrosarcoma. No regional failure was observed, but 1 failure occurred in the surgical pathway and 1 marginal (chordomas). No treatment related brain stem or optic pathway necroses are found. Pituitary dysfunction was diagnosed in 4 cases (14%). Age <39 years had favourable impact on progression-free survival. Twenty-six patients were irradiated for paraspinal chordomas with 72 CGE (59.4 – 74.4). 18 patients had undergone macroscopically compelte tumor resection, 2 had <30ml tumor left, and six patients presented with >30ml. At three years, overall actuarial control is 90%, disease specific survival is 86%. 3 patients developed distant metastases..

Though the follow-up time is only three years, these first results are promising and support proton radiotherapy with spot scanning and IMPT to be effective and well tolerated. Since summer 2004, proton therapy is feasible for small children under anaesthesia. The team of the Paediatric University Hospital Zurich has taken charge of this specific medical work. Radiation treatment is planned at PSI, in close collaboration with referring clinics and study centers for paediatric malignancies. So far, 2 children finished therapy: 1 boy with ependymoma and 1 with alveolar RMS, both children 2 years old. Fixation was done with bite block and the child laying in a whole body mold. Three to four more children will undergo proton treatment at PSI until December 2004. During 2003 and 2004, the tendancy for younger and pediatric patients was see as well as a concentration of tumor entities towards sarcomas and chordomas/chondrosarcomas of the skullbase and spinal axis. The irradiation of small infants under anaesthesia is only possible with the dedicated engagement of the Paediatric University Hospital Zurich and it's team under guidance of PD Dr. M. Weiss. Also, the Hospital's Oncology Department supports the proton treatments with close collaboration and excellent patient care.

Weber, DC., Lomax, AJ. et al (2004) *Radiother Oncol. 2004 Jun;* **71(3)**:251-8.

Shielding design for a proton therapy clinic – a practical approach.

V. ANFEROV

Indiana University Cyclotron Facility, Bloomington IN 47408-1398

vanferov@indiana.edu

The main goal of a Proton Therapy Clinic (PTC) is to administer proton radiation treatments safely and reliably. While delivering prescribed amount of radiation to a patient, the treatment facilities must be designed to minimize radiation exposure to the general public and to the personnel. This talk will consider a practical approach to designing shielding walls around the PTC.

We start with description of the applicable federal and state regulations regarding radiation safety. Then we define radiation areas in the PTC facility and establish radiation limits for each area. These limits guide the radiation shielding design of the PTC.

While proton radiation is administered to the patient, it is the neutron radiation that shielding walls must attenuate to the established limits. The neutrons are created whenever proton beam interact with materials during the treatment beam delivery process. Typical sources of neutron radiation may include energy setting devices, beam diagnostics elements, beam scattering foils, range modulators, collimators and the patient himself.

Knowing the expected beam loss at each potential source of neutrons, one must define the source strength for the shielding calculation. We show that empirical estimates (SULLIVAN, 1992) can be validated with Monte-Carlo simulations (MCNPx ver.2.4j). Moreover, these estimates work well for estimating radiation attenuation in shielding walls as well. Thus, this approach allows one to calculate the required shielding wall thickness in order to meet the radiation level limits established above.

We will illustrate this approach using shielding design for MPRI.

SULLIVAN, A.H., (1992) *A guide to radiation and radioactivity levels near high energy particle accelerators*, Nuclear Technology Publishing.

Overview of the IUCF and MPRI Facilities

Paul Sokol

Indiana University Cyclotron Facility, Bloomington IN 47408-1398

pesokol@indiana.edu

The Indiana University Cyclotron Facility (IUCF) is a multidisciplinary center supporting a variety of research and service activities. IUCF's origins date back to the early 70's when it was one of the premier nuclear science facilities in the country. The cyclotron at the facility, from which it derived its name, provides intense beams of protons used by nuclear physicists, both at IU and from around the nation, to study the fundamental structure of the nucleus and the fundamental interactions between subatomic particles. The early years of the facility were devoted entirely to nuclear physics and accelerator physics research.

The scope of programs at IUCF has greatly expanded since those early days and there are now active programs in the medical applications of accelerators, condensed matter physics, materials science and biological physics. One of the most important activities for IUCF is to provide development activities and operational support for the Midwest Proton Radiation Institute. IUCF also supports an active radiation effects program that is extensively used by NASA for it shuttle and space station efforts. In the future IUCF will be the home to the first university based pulsed neutron source in the country.

This talk will briefly review the history of IUCF, describe the current modes of operation and outline new projects for the future.

Paraspinal Sarcomas

Thomas DeLaney, MD

Massachusetts General Hospital; Northeast Proton Therapy Center; 32 Fruit Street, Boston, MA, 2114, USA

TDelaney@Partners.org

The current use of IGRT techniques in Photon Radiotherapy

Jatinder Palta

University of Florida, Radiation Oncology Physics, P.O. Box 100385, 2000 SW Archer Road, Gainesville, FL, 32610, USA

paltajr@ufl.edu

IGRT techniques in Proton Radiotherapy

Ale Mazal

Institut Curie, Service de Physique Médicale, 26, rue d'Ulm, , Paris, , 75005, France

alejandro.mazal@curie.net

Compensation of target motion during ion radiotherapy

S. O. GROEZINGER[1], C. BERT[2], E. RIETZEL[1], T. HABERER[2] and G. KRAFT[2]

[1] *Siemens Medical Solutions, 91052 Erlangen, Germany*
[2] *Gesellschaft fuer Schwerionenforschung (GSI), 64291 Darmstadt, Germany*

svenoliver.groezinger@siemens.com

Combined with fully active beam application techniques, radiotherapy with ion beams allows a close conformity of applied dose to the prescribed volume. As long as target position and geometry are precisely known at any time of the irradiation, a high dose can be applied even to targets close to critical structures and the contribution to the surrounding normal tissue can be minimized. Sophisticated positioning protocols and immobilization strategies are followed to guarantee precise positioning of tumors in the head, neck, pelvic or spinal region. On the other hand, the precision of dose delivery in the thoracic and abdominal region, on the other hand, is limited by intra-fractional organ motion, e.g. respiration. Due to the sequential dose application to single volume elements of the target, active beam delivery is highly sensitive to target displacement during irradiation. The interplay between beam scanning and target motion can cause strong distortions in the effective dose distribution.
Motion-related distortions can be reduced by gating the irradiation, delivering dose only if the target is located within a pre-defined position window. The remaining amount of distortions in the final dose distribution depends on the size of the position window. Extension of treatment time is inevitable and strongly correlated with the desired precision. To increase the time inside the position window, active and passive breath-hold techniques can be used.
In order to avoid treatment time elongation, two alternative approaches are possible: A statistical approach of scanning the target volume several times in an uncorrelated manner (rescanning) and a direct approach of following the target motion with the ion beam in three dimensions (3D online motion compensation, 3D-OMC).
For rescanning the dose of each fraction is delivered in several scans. By starting each scan in a random motion state, differently distorted dose distributions are superimposed, averaging out motion-related distortions. Experimental and theoretical studies for rescanning with scanned ion beams showed that, depending on the irradiation conditions, significant inhomogeneities can remain in the final dose distribution.
3D-OMC exploits the flexibility of fully active beam delivery to account for target motion in real-time. Motion-related shifts of the target voxel position are compensated on a point-to-point basis with a feed-back loop to the beam scanning magnets in lateral direction and a fast, passive energy modulator for longitudinal corrections. At GSI, a prototype setup for 3D-OMC was realized. A feasibility study showed, that precisely online measured target motion can be compensated with sub-millimeter precision.

Clinical Treatment Technique Based on Proton Beams for Therapy of Intact Breast

B. Arjomandy, D. Miller, D. Bush, M. Moyers

Loma Linda University Medical Center, Loma Linda, CA

arjomandy_2000@yahoo.com

Introduction:
Some 215990 new women will be diagnosed with breast cancer in 2004. About 40000 of this population will die according to the American Cancer Society. The most common techniques for treating breast cancer are surgery, chemotherapy, and radiation with x-ray, electrons, and brachytherapy or a combination of these modalities.
Proton radiation therapy offers an alternative technique in treating these patients.

Material and Method:
A technique is introduced for treatment of breast cancer using 155 MeV proton beams at Loma Linda Medical Center. This technique is restricted to partial breast tumors typically 3cm in diameter or less. A tissue equivalent breast and torso phantom were used to mimic the human body. The prone position was chosen for beam delivery. Dose calculations were performed using the Optirad® [(1)] treatment planning system. A bolus target was created for each beam to control and optimize the dose coverage and tissue sparing. Two or three coplanar beams were used to treat the breast. A set of TLDs was used to measure the dose to the skin.

Results:
The technique offers reduction in lung dose and heart, especially when left breast is treated. One of the important advantages about this technique is the skin sparing. Use of the bolus targets reduced the skin dose to about 70% of the prescribed dose.

1) Permedics, Inc. Loma Linda, CA. USA.

Granulomatous slack skin disease; An innovative treatment approach using protons

J. B. FARR[1], A. O'RYAN-BLAIR[1], C. A. ALLGOWER[1], A. L. SCHROETER[2], A. F. THORNTON[1], A. N. SCHREUDER[1]

[1]Midwest Proton Radiotherapy Institute, Bloomington, Indiana, [2]Mayo Clinic, Rochester, Minnesota USA

jbfarr@indiana.edu

An innovative application of proton therapy (PT) for Granulomatous slack skin disease (GSSD) is described. The treatment involved an abdominal lesion of cutaneous T-cell lymphoma. Although there is not currently a standard treatment for GSSD, various modalities including topical, localized, and systemic treatments have been used singly and conjunctively to treat the disease. Radiotherapy treatment for GSSD typically involves skin electron beam irradiation. Electron beam irradiation, however, contributes dose to underlying structures due to its attendant x-ray production. The basis for PT in this case was then to take advantage of the ranged property of PT to spare the underlying bowel and renal parenchyma from unnecessary irradiation. This had to be accomplished with the limitations of a fixed horizontal beam line as well as a maximum field size of 12 cm diameter. In order to develop an optimal distribution of dose to the abdominal skin under these conditions, including treatment of the underlying fascia to a depth of 2-4 cm without excessively irradiating bowel and kidney, a total of four patched proton fields were required at an extended source to surface distance. This technique was therefore challenged by the difficulties of both manually abutting multiple adjacent fields on a daily basis, and the desire to determine the dosimetry of the gap junctions. A unique solution was developed to minimize these uncertainties. Using the sub-millimeter precision of a robotic patient positioning system (PPS), coupled with a fixed range compensator attached to the patient immobilization, rather than the treatment nozzle, full coverage of the intended curved abdominal surface was obtained. An inter-comparison between miniature ionization chamber scans in a water phantom, radiographic film, and treatment planning dose calculations was completed to verify that the dose levels in the field matching junctions were clinically acceptable. The combined system of the field-matching precision of the PPS, coupled with the distal range compensation of the protons, and verification dosimetry of the field matching has resulted in a technique that may be applicable to other more common malignancies such as mycosis fungoides of the scalp, pulmonary mesothelioma, and breast chest-wall therapies.

The authors would like to thank Miles Wagner of the Northeast Proton Therapy Center for fabricating the large custom compensator used for this treatment.

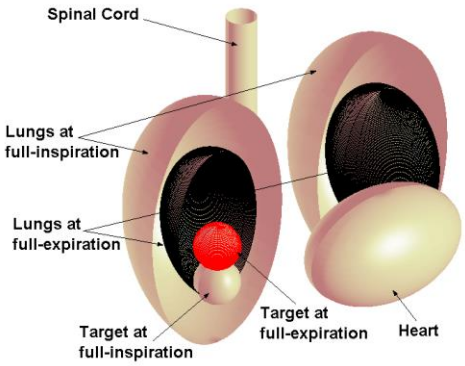
A theoretical study of the effect of respiratory lung motion on intensity modulated proton therapy treatment plans

TAE KYU LEE and GEORGE A. SANDISON
School of Health Sciences, Purdue University, 550 Stadium Mall Drive, West Lafayette, IN 47907, USA
lee50@purdue.edu and sandison@purdue.edu

Most optimized plans are generated based on an assumption of static anatomy. Target movement due to respiratory motion therefore introduces treatment plan dose plan errors.
In addition, for lung cancer treatment, the centimeters penetration range of the beam will be dependent upon the density of lung in the respiration cycle. In this study, a 3-dimensional mathematical homogeneous phantom was defined to simulate the motion of a spherical target tumor as lung size changes during the breathing cycle from full inspiration to full expiration. The target diameter was set to be comparable to the 2 cm amplitude of breathing. Target motion was move in the superior-inferior direction during the lung volume change (Figure 1.). We assumed that lung density at full-expiration is the same as that of water (1.00 g/cm^3) and at full-inspiration is 0.3 g/cm^3. The dose sensitivity to lung motion of both the target and lung, as an organ at risk (OAR), was studied for intensity modulated proton therapy (IMPT), and compared to intensity modulated x-ray therapy (IMXT). The relative dose error due to breathing was defined as the ratio of the mean dose at full inspiration (planned dose) minus the mean dose at full expiration to the planned dose. The mean relative dose error was defined as the mean value of the relative dose error during the first half-period. Proton dose calculations were performed using the proton loss model (Sandison and Chvetsov 2000), modified for use in heterogeneous media (Lee and Sandison 2004).

IMPT was found to be more sensitive to target movement in lung compared to IMXT. This may be explained by the fact that IMPT has better physical ability to localize the radiation dose on the assumed static position of the target and that fewer beams are typically used compared to IMXT (Yeboah and Sandison 2002). It was also found that the change in average density of lung significantly affects the proton beam's range causing geometric misses of the target. Target motion has a large negative impact on IMPT target dose and OAR dose when plans are designed assuming static anatomy.

Figure.1. The simulated mathematical phantom with respiratory lung motion. Spinal cord, heart and lungs were defined in simple elliptical geometry. The cardiac motion was not introduced.



References:

SANDISON G A and CHVETSOV A V (2000) *Med. Phys.* **27**: 2133–2145
LEE TK and SANDISON GA (2003) *Phys. Med. Biol.* **48**: 259-273
LEE TK and SANDISON GA (2004) *Med. Phys.* **31** 1864-1865
YEBOAH C and SANDISON G A (2002) *Phys. Med. Biol.* **47**: 1–15

CT METAL ARTEFACT SUPPRESSION FOR PROTON AND OTHER RADIATION THERAPY PLANNING

Jikun Wei[1], George A. Sandison[1], Laigao Chen[1], Yun Liang[2], Michael Ringor[3]

[1]*School of Health Sciences, 550 Stadium Mall Drive, West Lafayette, IN 47907-2051*

[2]*Department of Radiology, Indiana University Medical School, Indianapolis, IN 46202*

[3]*Faith, Hope and Love Cancer Care, 1425 Unity Place, Lafayette, IN 45709-5657*

weij@purdue.edu

Abstract: This paper presents a novel method of reducing x-ray CT high-density artefacts generated by metal objects when abundant bone structures are present in the region of interest. The method of suppression requires that bone pixels are isolated and segmented by thresholding. Then artificial CT numbers are assigned to the bone pixels so that their projection profiles are smooth and thus can be properly simulated by a polynomial interpolation. The projection profile of the metal object is then removed to heavily suppress the artefacts. The resulting processed profile is fed to a reconstruction routine and the previously preserved bone pixels added back. The new method utilizes two important features of the CT image with metal artefacts: (a) metal and bone pixels are not severely affected by the high density artefacts and (b) the high density artefacts can be located in specific projection channels in the profile domain, although they are spread out in the image domain. This suppression method solves the problem of CT image artefacts arising from metal objects in the body and field of view. It has the potential to greatly improve proton and other radiation beam treatment planning that utilizes CT-based inhomogeneity corrections for patients with metal implants, e.g. dental prostheses, Fletcher-Suit applicators, artificial femoral heads, etc. This CT metal artefact reduction technique is especially important for proton therapy planning as the correct density information in CT images is critical for calculating proton dose deposition and penetration depth of the Bragg peak. Some preliminary imaging and treatment planning results are demonstrated.

An Automatic Method of Anatomical Landmark Localization for Daily Patient Positioning

G. C. SHARP*, **S. KOLLIPARA, T. MADDEN, S. J. ROSENTHAL**

Department of Radiation Oncology; Massachusetts General Hospital

Harvard Medical School

e-mail srosenthal@partners.org

High precision alignment of patient anatomy to beam isocenter is essential for most protocols being treated with particle beams. The dominant tool for assuring this alignment is radiographic x-rays taken just before each treatment. While there are several techniques for analyzing the x-rays and determining required patient moves, the approach of identifying and tracking anatomic landmarks has been used extensively for over twenty years at the Massachusetts General Hospital and other centers worldwide.

The advent of online imaging, such as flat panel image arrays, and computer software has improved the efficiency of this process markedly over the last decade. The next generation of set up tools will use the computer to analyse the images and recommend moves without user input.

We describe our approach to this step forward in treatment efficiency. We have developed an algorithm for matching user defined anatomic points in a reference image with the same points on daily radiographs. In order to optimize the parameters used in the matching algorithm, a retrospective test bed of 348 images was studied. The performance is now quite robust for typical landmarks found in the head and neck images.

A production version of the algorithm has been incorporated in the software used at the MGH for patient set up called DIPS. It performs the matching calculation in less than ½ second, and provides a means for therapists to identify and improve reference images off line. A preliminary trial of the matching tool for a month in the clinic show good acceptance by radiation therapist with an reduction in the time required to analyze each image from about 50 seconds to 30 seconds. The analysis time includes the period in which the user reviews and corrects the automated identification of landmarks.

Details of the algorithm will be presented and future directions to reach 100% accuracy will be discussed.

*Gregory Sharp was supported by a grant from Varian Medical Systems Inc.

Registration Strategies for Image Guided Radiotherapy

Sanjiv Samant

Jude Children's Research Hospital, 332 N. LauderdaleMemphis, TN 38105

Sanjiv.Samant@STJUDE.ORG

With the advent of digital imaging, image registration has become a valuable tool in radiotherapy. Though traditionally performed visually, it can now be performed using automated registration algorithms for precise computer assisted patient positioning, which is especially important in conformal, IMRT and proton based radiotherapies. However its clinical implementation has been limited due to the need for fast and robust algorithms, and the need for a human observer to validate acceptability of the registration. The use of flat panel imagers in megavoltage and kilovoltage imaging has allowed for both better visually based registration and improved performance of automated registration algorithms. Here we present several image registration strategies. For 2D image registration (i.e. EPID-EPID and DRR-EPID), we present several registration algorithms. For intensity-based image registration, a new optimization algorithm, **variable step-size grid search (VSGS)** used in conjunction with mutual information (MI) similarity measure, which is faster and more robust and of same subpixel accuracy compared to the conventional quasi-Newton and Powell optimization algorithms. For feature-based image registration, generated using standard edge detection algorithms, the **Hausdorff metric is used in conjunction with a branch-and-bound (BB)** algorithm. BB is faster than the MI, and of pixel accuracy. Results from phantom and clinical data are presented. For 3D imaging, mutual information in conjunction with Powell's method has been used to register imaging data sets (MR-CT, MR-MR and PET-CT) with subpixel accuracy. A "**2D/3D**" registration strategy is being developed whereby 2D portal images are registered to digitally reconstructed radiographs (DRRs) using VSGS and a fast DRR generator to achieve registrations in a clinical setting. The novel concept of **registration quality evaluator (RQE)** is presented to evaluate the validity of a registration, which could be adversely affected by out-of-plane rotations in 2D imaging, the existence of local optima, and changes in patient anatomy in 2D and 3D imaging. An application of RQE to 2D portal imaging is presented, and a general methodology for the performance evaluation of a registration algorithm based on receiver operating characteristic (ROC) is presented.

Analysis of stereo photogrammetry for patient setup in partial breast irradiation

Christoph BERT[1/2], Katie METHEANY[2], Alphonse TAGHIAN[2/3], Simon N. POWELL[2/3], George T.Y. CHEN[2/3]

[1]Gesellschaft für Schwerionenforschung, Darmstadt, Germany, [2]Massachusetts General Hospital. Boston, Ma, [3]Harvard Medical School, Cambridge, Ma

c.bert@gsi.de

At MGH we have used both protons and photons for partial breast irradiation (PBI). With this technique accurate setup is more critical because of smaller field sizes, tighter margins, and, for protons, range. The PBI protocol at MGH includes daily acquisition of lateral and anterior-posterior radiographic films before treatment to bring the chest wall into alignment, with the expectation that this will relocalize the PTV accurately.

Recently we installed a stereo photogrammetry system to measure the patient's surface in 3D (VisionRT, London England). A user selected reference surface region is compared with daily surface images. The software calculates treatment couch translations and rotation to maximize the congruence of the pre-treatment topology with the reference image.

We have acquired surface images prior to photon treatment for 7 PBI patients, over 43 fractions in total. For each fraction, surface data were acquired 1) after patient setup by lasers 2) after setup by port films and 3) at the end of treatment. The analysis examined the distance from the reference surface to the daily treatment surface in direction of the reference surface normal. To assess the potential of the 3D camera system as a patient setup device, we also analyzed the virtual setup by transforming the surface after laser setup according to the calculated couch movement.

Distance differences between the reference surface and daily conventional setup surfaces were sometimes greater than 10mm with laser or port film alignment. Combining the results of all fractions and all patients, the surface difference histogram showed an absolute mean ± standard deviation of 3.7±5.9mm (laser), 4.3±6.7mm (port film), and 1.7±3.8mm for the virtual alignment using stereovision.

Changes in the patient surface from intra- and interfraction images were observed in the limited number of cases done so far. The central question is the appropriateness of skin surface as a surrogate for tumor position and the dosimetric consequences of observed surface mis-positionings, especially for proton treatments.

C. Bert is partially supported by a DAAD Doktorandenstipendium.

The Robotic Patient Positioner at MPRI

Chris Allgower, Niek Schreuder, Jonathan Farr, Anthony Mascia

Midwest Proton Radiotherapy Institute, 2425 N Milo B Sampson lane, Bloomington, IN, USA

callgowe@indiana.edu

The Midwest Proton Radiotherapy Institute chose to use a robotic patient positioner rather than conventional patient beds. The robot, a model UP200 made by Motoman, has six degrees of freedom, rather than the four of a traditional bed, and it is currently the only such robot in the US being used for patient positioning. Aspects of the robot's software implementation will be discussed, and conclusions drawn based on the promising clinical experiences at MPRI so far.

Control System for Patient and Gantry Positioning systems

Alexander Ferro

Alexander Ferro, ipg ltd., head of Automation Engineering

alexander.ferro@ipg-ag.com

Based on the experience to build control systems for the proton therapy this presentation will contain information, how theses projects have been realized.

The main features of an Position Control System

The positioning control system, further on called PCS, features to the superior control system, often called the therapy control system, an accurate and secure positioning subsystem.

Following main functionalities are provided:

The patient table, the gantry and the nozzle can be moved to the desired position if no security rule is infringed. The PCS controls the acceleration and deceleration of the motion and the motion itself.

The PCS provides a high accuracy, which is required for the therapy. The required corrections are done within the PCS. In the PCS the necessary mathematics models are implemented and it is equipped with the required sensors.

The PCS itself provides the functionalities to get a safe system to avoid damages and injuries. Therefore a Safety Control Unit (SCU) is integrated into the PCS, which fulfils the corresponding standards. Redundant sensors are mounted on the mechanic to avoid the risk of a single point of failure.

The second part of the presentation contains details about what is important to manage such a project and what is crucial to be successful.

Aspects covered by the presentation:

Details about the technical concept of the PCS

- Involved technologies

The major milestones of the RPTC project

Crucial considerations for the Project Management

- List of main risks to build such a system

- Measures to take to be successful

Status of the RPTC project from the PCS view point

The IBA Patient Alignment System.

BRUSASCO, Caterina

Ion Beam Applications s.a.

Caterina.Brusasco@iba.be

In this talk, we describe the newly developed IBA Patient Alignment System, which has been recently installed and validated in the fixed beam treatment room of the Wanjie International Hospital in China. The hardware is based on standard commercial products and the alignment corrections are computed by the software DIPS developed by MGH. The development of the system has been largely based on the previous development done by MGH for the two gantry rooms of NPTC, but it presents some original solutions linked to the IBA's stringent requirements on positioning precision and to the adaptation of the system to a fixed beam line.

Patient Positioning System

HUGO SCHÄR

CEO SCHÄR ENGINEERING Ltd.

h.schaer@schaer-engineering.ch

Robot or patient positioning system

More and more proton therapy projects consider the realisation of a robot instead of a patient positioning system for positioning and laying the patient during the therapy.

Some projects, especially in research institutes, have already realised projects using robots. Other therapy projects, which have ordered robots, have, as far as we are aware of what, still to be finalised and tested outside the therapy plants.

All these projects have caused us to question our part in constructing patient positioning systems carefully and thoroughly so not to miss the changes and developments in the market, respectively not to invest power and money in an area which can be handled more efficiently and delivered cheaper by other suppliers.

We would like to present the technical conclusions and results comparing the two possibilities: robot or patient positioning system with the following aspects:

Stability of the machines

Measuring-systems
Undesired grades of liberty
Deflection corrections
Emergency safety
Steering
Design
Safety
Costs

Biological systems and dose-effect relationships after irradiation

J. GUEULETTE

Université catholique de Louvain (Bruxelles, Belgium)
gueulette@rbnt.ucl.ac.be

The concept of "biological system" refers to the set of experimental conditions that have been adopted to study a particular biological phenomenon. Beside biology related conditions (type of animal, tissue, cells ; physiological status, pre- and/or post-treatment procedure, timing, etc.), *radiobiological* systems call for an accurate definition of the irradiation conditions. Indeed, factors such as geometry, fractionation, dose rate, type of radiation, etc. might interfere with the element under study (e.g. drug) or even govern the biological response.

In many radiotherapy oriented radiobiological studies, the primary set of data consists in dose-effect relationships whose shape and position are the main subject of analysis and the basis of the resulting hypothesis and conclusions. In this respect, "cell survival curves" take a preferential place as the response to radiation of most organs or tissues can be interpreted on the basis of the lethality of the corresponding target cells. Determinations of cell survival curves "in vitro" are usually the first experiments, which orient the elaboration of the protocols for further animal studies "in vivo" and, ultimately, clinical trials.

Different dose-effect relationships for high-energy photons (reference) will be discussed. The influence of biology related characteristics (e.g. animal, tissue, endpoint, oxygenation, cycle phase, etc.) will be reviewed as well as the influence of different irradiation conditions (e.g. fractionation, dose rate, geometry, etc.), except the radiation quality. Some insights into the experimental procedures will be given, in order to enhance the significance of the experiments and/or to comply with the scientific, technical or ethical constraints.

High LET effect of heavy charged particles

G. KRAFT

GSI Biophysics and Tech. University Darmstadt, Germany

g.kraft@gsi.de

The use of ions heavier than protons is mostly motivated by the difference in the radiobiological response. With increasing linear energy transfer LET in general an increase of the biological effectiveness RBE is observed. But it is not possible to correlate the RBE with one single physical parameter alone. RBE depends on the dose level, atomic number of the particles, on the particle velocity or energy and most important on the repair capacity of the tissue. The biological response to particle irradiation can be qualitatively understood with the assumption that on a nanometer scale at high local ionisation densities, clusters of DNA damage are produced that are difficult to repair.

Particles produce tracks with local doses ranging from many kilo Gray in the track center to a fraction of a Gray at the radial border at a few micrometer distance from the center. In the transition region of elevated doses of approximately 100 Gy and less Gy, clustered damage predominates that is irreparable and causes the higher RBE. This microdosimetric picture of particle action also explains the correlation of RBE with the repair capacity: For repair proficient cells the general repair suppression yields a greater increase in efficiency than for cells that have a diminished repair capacity already for photon radiation. The repair capacity can be characterized according to the α/β ratio. Small α/β ratios correspond to a large repair capacity which is expressed in a pronounced shoulder in the x ray dose effect curves and vice versa. Systems with small α/β ratios should have therefore large RBE values. This general behaviour can be found in cell culture work, as well for tissues and tumors in the experiments and in model calculations like LEM that follows the principles explained before.

RBE of the MPRI proton beam for crypt regeneration in mice

J. GUEULETTE[1], S.B. KLEIN[2], B.M. DE COSTER[1] and AN. SCHREUDER[3]

[1]*Université catholique de Louvain (Bruxelles, Belgium)*
[2]*Indiana Ubniversity Cyclotron Facility, Bloomington, Indiana, USA*
[3]*Midwest Proton Radiotherapy Institute, Bloomington, IN, USA*

gueulette@rbnt.ucl.ac.be

The RBE (reference high-energy photons) of the proton beam produced at MPRI (Bloomington, USA) was determined using intestinal crypt regeneration in mice as biological system. Four beam depths were tested : the initial plateau, the beginning, the middle and the end of a 7-cm SOBP. Reference photon irradiations were performed with a nearby 7 MV accelerator at the depth of the peak dose. The mice were irradiated to the whole body in a single fraction, with a dose rate of 0.85 Gy/min for protons and 2.5 Gy/min for photons. All the animals (total of 120 mice) came from the same lot and were randomized according to radiation quality and dose level. RBEs were determined at the level of 20 regenerated crypts (corresponding photon dose = 12.4 Gy) and were found equal to 1.03, 1.05, 1.03 and 1.11 for the plateau, the beginning, middle and end of the SOBP, respectively. However, a separate photon experiment showed that the dose rate of 2.5 Gy/min (i.e. the dose rate used for reference photons) was 9 % more effective than 0.85 Gy/min (i.e. the dose rate used for protons). This led to raise the latter RBEs accordingly, yielding corrected RBE values of 1.12, 1.14, 1.12 and 1.21, respectively. These values are in accordance with those obtained at PSI (Switzerland) and especially with those of NAC (South Africa) where the proton beam meets the same physical characteristics as at MPRI.

Proton RBE at low energies

G. KRAFT

GSI Biophysics and Tech. University Darmstadt, Germany

g.kraft@gsi.de

The alpha/beta ratio for cerebral arteriovenous malformations treated with proton beam therapy.

F. VERNIMMEN[1] and J. P. SLABBERT[2]

[1] Department of Radiation Oncology, Stellenbosch University and [2] iThemba LABS, Cape Town, South Africa

fv@sun.ac.za

Radiosurgery is an established treatment modality for cerebral arteriovenous malformations (AVMs), whereby the total radiation dose is given in a single session. For small AVMs this is an appropriate method. Large unresectable AVMs pose a challenge to treat with radiosurgery because of the increased risk of late side effects if the dose is not reduced. Dose reductions lead to a lower obliteration rate. Hypo-fractionation has been used as a way to circumvent this problem. In order to estimate the dose needed to be given per fractionated treatment and remain iso-effective, the alpha/beta ratio for obliteration has to be known.

In our series we treated 64 patients with proton stereotactic radiation. AVM volumes ranged from 1.7 -110 cc (median 16.25cc). Patient population was divided by fractionation schedule. Patients (n=38) with large AVMs (median vol = 19.8cc) received 3 fractions for a single fraction equivalent of 17.3 Gy. Treatment was given twice a week on Mondays and Fridays. Patients with small AVMs (median vol = 10cc) were treated with radiosurgery (one fraction) with a single dose of 18 Gy. The dose given per fraction for various schedules were calculated assuming an α/β ratio of 3 Gy.

The patients have been followed for up to 10 years with a median of 5 years. By grouping the patients according to different fractionation schedules, the clinical data obtained in this study allow us to follow the influence of fractionation on obliteration rate and late side effects. No major differences in obliteration rates were seen. Analyzing our data using an F/E plot resulted in estimating an α/β ratio for AVM obliteration of 9 Gy (95 % CI 8 Gy to 11 Gy). This is in accordance with the work of Wigg who found values of between 10 Gy and 14 Gy by analyzing data from the literature. Other researchers have found very different values ranging from less than 1 Gy, 3 to 4 Gy and even up to 49 Gy.

The finding of an α/β ratio for AVM treatments that is higher than that of the normal surrounding brain would indicate that fractionated proton radiotherapy could be beneficial in the management of cerebral AVMs.

A 36 hour Solar Flare Simulation Using a Scanned Proton Beam at LLUMC

G. Coutrakon, J. Hubbard, P. Koss, K. Shahnazi, Eric Benton*

Loma Linda University Medical Center; 11234 Anderson St.; Loma Linda, CA 92354

coutrak@proton.llumc.edu

A simulation of a 36 hour solar flare was delivered this year in the research room at LLUMC using a proton beam on a one square meter target. The goal for the NASA radiobiology program was to deliver a large uniform field size with a controlled dose rate and energy spectrum for a "typical" solar event. Scanning magnets and a 5.5 mm thick Pb foil were used to enlarge the beam size on the target. A total dose of 1.3 +/- 0.1 Gy was delivered to the entrance region of the target. Beam intensity was controlled at the accelerator using six discreet values of injected beam current to the ring. The beam energy was controlled with a dynamic range shifter allowing 19 energies between 30 and 210 MeV. This presentation focuses on the dosimetry measurements for the 36 hour exposure.

* Presently at Eril Research, San Rafael, CA

Solid Gel Dosimetry with 70 MeV Proton Beam

Kambiz Shahnazi, Yaxiang Yang, Dan Miller, Andy Obenaus, and John Adamovics

Loma Linda University Medical Center, Loma Linda, and Rider University

kambiz@dominion.llumc.edu

Abstract:
Lecuodye solid gel is a new material for possible dose verification. It can be molded into almost any shape for irradiation.

Method:
Lecuodye solid gel was studied with 70 MeV proton beam. Water equivalent depth and dose linearity was measured using Alpha Imager an optical device.

Results:
70 MeV proton beam modulated and un-modulated can be observed in both plate and cylindrical cast. Approximate distance measured is the same as the calculated distance +/1mm. The unmodulated beam has a longer range by about 1 mm which is expected. Geant (Monte Carlo) simulation shows the same expected results. Dose linearity per counts is very linear, but it seems that it does not respond to low dose. From 6 Gy up to 24 Gy, it is linear.

Conclusion:
This dosimeter can be used for dose verification. It still needs to be studied further for sensitivity to different energies.

Aknowledgements
Tamaka Jones

Status of the M. D. Anderson Proton Therapy Center

Al Smith

M. D. Anderson Cancer Center

alsmith@mdanderson.org

Study of Formation of Flat Field by Particle Radiations

Y. TAKADA, R.KOHNO [1], K.TAKIZAWA, T.HIMUKAI, Y.TERASHITA, S.KAMIMURA, T.KANAI [1]

Institute of Applied Physics, University of Tsukuba,
[1] National Institute of Radiological Sciences
takada@pmrc.tsukuba.ac.jp

Insertion of a range compensator disturbs the dose distribution when a fixed modulation method is used for large field formation. This induces hot spots and cold spots of the dose distribution in the target region if we use a complex-shaped range compensator. This is due to the different lateral spreads of dose distributions of pencil beams passing through the different thicknesses of the range compensator at the same water-equivalent depths. A bi-material range compensator is used to control the lateral spreads at the same water-equivalent depths while keeping the range losses at the design values. It consists of a low-Z material (Chemical wood) and a high-Z material (Pb-Sb alloy). While the low-Z material mainly defines the range loss, the high-Z material mainly defines the lateral beam spread due to multiple Coulomb scattering. The thicknesses of the low-Z and high-Z materials at various lateral positions of the range compensator are determined so that the lateral spreads of the pencil beams traversing the range compensator are the same at some water-equivalent depth in the target volume. Using the bi-material range compensator, overlap of dose distributions formed by pencil beams traversing various parts of the range compensator become smoother, which results in the reduction of dose inhomogeneity induced by the single-material range compensator. We designed and manufactured a number of bi-material range compensators together with corresponding single-material range compensators. We measured the dose distributions formed by a carbon beam in water using the range compensators by a 96 channel one-dimensional array of parallel plate ionization chambers immersed in water vessel and moved in the depth direction. The experiments were done in HIMAC. Improvement of the field flatness has been observed for a 290MeV/u carbon beam.

This work is supported in part by a grant of Ministry of Education, Culture, Sports, Science and Technology.

Proton Therapy at the Wakasa Wan Energy Research Center

K.KUME, S.FUKUDA, S.FUKUMOTO, S.HATORI, G.KAGIYA, M.KONDO, T.KURITA, I.MARUYAMA, N.OHTANI, K.YAMAMOTO and N.YOKOHAMA

The Wakasa Wan Energy Research Center, Tsuruga 914-0192, Japan

kkume@werc.or.jp

The Wakasa Wan Energy Research Center (WERC) was founded by collaboration among a Japanese local government, a national nuclear agency, and three private electricity companies. A main aim of WERC is to utilize specialized techniques used at nuclear power reactors, 15 of which locate in this region, for general industrial purposes to contribute to regional welfare and industrial promotion. A multi-purpose ion accelerator complex was built at WERC as one of the tools for the nuclear techniques utilization. Clinical trials of the proton therapy at WERC are now carried out with this accelerator.

The WERC accelerator facility consists of the accelerator system, a medical beam line, and other beam lines for non-clinical purposes. The accelerator system is composed of two negative ion sources (one of which is to produce pulsed proton beam), a 5 MV tandem accelerator and a 200 MeV proton synchrotron. The tandem is used as an injector to the synchrotron on occasions when this system delivers high energy ion beams for the clinical purpose. The medical beam line consists of two fixed ports. A flat irradiation field of ϕ100 mm x SOBP (Spread Out Bragg Peak) 80 mm with 200 MeV proton beam has been achieved, using tungsten scatterers and a couple of wobbler magnets for lateral directions and a brass ridge filter for distal direction in each port. Beam is delivered to a patient with a dose rate of approximately 1 Gy/min/nA. Beam intensity for the medical use is at present achieved up to 3 nA with certain quality in time structure of beam itself. A patient positioning system consists of an X-ray CT, a common couch with rails between the X-ray CT and the irradiation port, and a DR system. This positioning system was shown to achieve a positioning precision of 1 mm through clinical treatments.

There have been 19 patients altogether who have been treated at WERC since June 2002, when an official clinical trial was started. 17 patients among them were suffered from prostate cancers, while rest were suffered from liver cancers and were treated with a respiration gating system. The number of patients in one certain period is limited since the WERC accelerator is dedicated not only to the clinical use but also to other purposes such as biology, ion implantation, ion beam analysis and so on. Further improvements of the accelerator system and the medical beam line are planned for more efficient use of the accelerator.

Adaptive response induced by pre-exposure mouse pituitary with low-dose ^{60}Co γ-ray on growth hormone (GH) and body mass

H. ZHANG, W.J.LI, X.D.JING, B.LIU, F.L.MIN, X.DUAN, Q.M.ZHOU, Y.XIE

(*Institute of Modern Physics, The Chinese Academy of Sciences, Lanzhou 730000, P.R.China*)

zhangh@impcas.ac.cn

Irradiation has been widely reported to damage organism by attacking on proteins, nuclei acid and lipids in cells. However, many studies have shown that low dose of irradiation can produce stimulating effects on the immune systems and induce adaptive responses to the harmful effects of subsequent high-dose radiation exposure. The pituitary of the $B6C3F_1$ hybrid strain mice were irradiated with 0.05 Gy of ^{60}Co γ-ray as the pre-exposure dose (D_1), and were then irradiated with 2 Gy of ^{60}Co γ-ray as challenging irradiation dose (D_2) at 4 h after per-exposure. Body weight and serum growth hormone (GH) were measured at 35th day after irradiation. The results showed that irradiation of mouse testes with 2 Gy of ^{60}Coγ-ray significantly diminished mouse body weight and level of serum GH (Table). Pre-exposure with a low-dose (0.05 Gy) of ^{60}Coγ-ray significantly alleviated reductions of mouse body weight and level of serum GH induced by subsequent a high-dose (2 Gy) irradiation (Table). The data suggested that low-dose ionizing irradiation can induce adaptive responses to the harmful effects of pituitary by subsequent high-dose exposure.

Table Effects of pre-exposure of mouse pituitary with low-dose ^{60}Co γ-ray on growth hormone (GH) and body mass induced by subsequent high-dose irradiation

Group (Gy)	Body mass (g)	Mass loss (%)	Serum GH (ng/ml)	Percentage decrease (%)
0	36.20±1.25	0	73.93±0.50	0
0.05	36.01±1.57	0.5	73.69±0.59	0.3
2	26.05±1.09[(a)]	28.0	50.65±0.61[(a)]	31.5
0.05+2	34.77±1.78[(b)]	4.0	73.13±0.88[(b)]	1.1

Data represent mean±SEM, n=7. The differences among data of individual group were performed with the analysis of variance (ANOVA). (a) P <0.001 vs 0 Gy group; (b) P <0.001 vs 2 Gy group.

How to manage positioning, immobilising and planning without a proton gantry - a recurrent Ependymoma of the sacrum – a case report

Daphne Commin

iThemba LABS, Medical Radiation, PO Box 722, Somerset West, W Cape, , 7129, South Africa

daphne@tlabs.ac.za

Status MedAustron

E. Griesmayer*

Fotec; Forschungs- und Technologietransfer GmbH; Viktor Kaplan-Strasse 2; A-2700 Wiener Neustadt; Austria

www.fotec.at

eg@fotec.at

The design study of the MedAustron project has been published in June 2004. The status of the project with respect to medical, medical-physics and technical developments will be presented.

* For the MedAustron Project Group

Status of the ACCEL Proton Therapy System installation at RPTC

Juergen Heese

ACCEL Instruments GmbH, Friedrich-Ebert-Str. 1, Bergisch Gladbach, D-51429, Germany

heese@accel.de

Carbon Ion Injector Linac for a Heavy Ion Medical Synchrotron

Donald A. SWENSON

Linac Systems, Albuquerque, NM

DASwenson@linac.com

The design of a Carbon Ion Injector Linac for a heavy ion medical synchrotron will be presented. The linac is designed to accelerate quadruply-ionized carbon ions ($^{12}C^{+4}$) with a charge/mass ratio (q/A) of 0.333, and all other ions with the same or higher charge/mass ratios, such as H^{+1}, H_2^{+1}, H_3^{+1}, D^{+1}, $^{3}He^{+1}$, $^{4}He^{+2}$, $^{6}Li^{+2}$, $^{10}B^{+4}$, and $^{16}O^{+6}$ to an output energy of 7 MeV/u. The 200-MHz linac consists of an Radio Frequency Quadrupole (RFQ) linac to accelerate the ions from an input energy of 0.008 MeV/u to an intermediate energy of 0.800 MeV/u, and an Rf-Focused Interdigital (RFI) linac to accelerate these ions to the output energy. The combined linac structures have a total length of 7.8 meters and a total peak rf power requirement of about 600 kW. The RFQ linac employs a radial-strut, four-bar design that is about twice as efficient as the conventional four-bar RFQ design. The RFI linac, which is basically an interdigital drift tube structure with rf quadrupole focusing incorporated into each drift tube, is about 5 times more efficient than the conventional Drift Tube Linac (DTL) structure. Details of the linac structures and their calculated performance will be presented.

BNCT Neutrons from Carbon Ion Injector Linacs

Donald A. SWENSON

Linac Systems, Albuquerque, NM

DASwenson@linac.com

The option to generate intense beams of neutrons for BNCT with the same linac that is supplying carbon ions for carbon therapy, without limiting either application, will be described. The Rf Focused Interdigital (RFI) linac structure, under development at Linac Systems, is well suited for accelerating different ion species (carbon ions for the carbon therapy application and protons for the BNCT application). As all of the forces on the charged particles (accelerating and focusing) are rf electric, the only change needed to accommodate different ion species is to change the rf excitation of the structure. The peak rf power for proton acceleration is down by an order of magnitude from that required to accelerate carbon (+4) ions. The pulse duty factors for the two applications are quite different. The duty factor of the carbon ion application is very low (<0.1%), whereas the pulse duty factor for the BNCT application needs to be very high (~100%). The optimum solution is to have two rf power systems, one for the high-power, low-duty operation for the carbon beam, and one for the low-power, cw operation for the proton beam. When carbon ions were needed for injection into the carbon synchrotron (<0.1% of the time), the high-power, low-duty rf power system would establish the proper conditions for acceleration of carbon ions. The rest of the time (>99.9% of the time), the low-power, high-duty rf power system would establish the proper conditions for the acceleration of protons to produce intense fluxes of epithermal neutrons for the BNCT application. A description of the additional hardware and cost for this mode of operation will be estimated.

The RPTC in Munich, Germany – fall 2004 update

Jörg HAUFFE, Peter-Michael RÜCKER, Markus RINECKER, Gerd DATZMANN, Udo PETER, Manfred HERBST, Hans RINECKER

ProHealth AG, Hans Pinsel Str. 10 a
85540 Haar bei München, Germany

joerg.hauffe@prohealth-ag.de

The Rinecker Proton Therapy Center (RPTC), currently under construction in Munich, Germany, is expected to treat its first patient in March 2005; thus in less than 5 months.

The facility will operate a 250 MeV proton beam, provided by an ACCEL superconducting cyclotron, in four gantries. Each gantry will be equipped with an automatic patient table positioning system with six degrees of freedom. Scanning beam nozzles, which cover 300 x 400 mm treatment fields and have two orthogonally mounted targeting X-ray systems with digital image processing are installed in all the gantries. Additionally, one fixed beam room will be optimalized for eye and head treatment with up to 160 MeV.

The diagnostic department for in-house staging and targeting will consist of an endoscopic facility, ultrasound, lab, two 1,5 Tesla MRIs and two 16-slice CTs, one of which is combined with a PET-scan for fusion imaging.

Our presentation will discuss the most important issues accruing in the pre-opening phase and also the specifics of Munich's Rinecker Proton Therapy Center.

Fast switching of the proton beam between two treatment rooms and setup of a real-time control of the beam.

S. MEYRONEINC [1] representing the ICPO technical team[1]

L. Guérin[1], C. Nauraye[1], R. Ferrand[1] B. Laune[2], M. Malard[2] ,Y. GEORGET[3], R. BEUNARD[3,] R. CIRIO[4], M. DONNETI[4]

[1] *ICPO, Centre de Protonthérapie d'Orsay / Institut Curie, BP65, 91402 Orsay Cedex-France*
[2] *IPNO, Institut de Physique Nucléaire d'Orsay – IN2P3/CNRS- 91406 Orsay Cedex–France*
[3] *GANIL – IN2P3/CEA- 14076 CAEN–France*
[4] *INFN Torino- Italy*

meyronei@ipno.in2p3.fr

During February-March 2004, CPO has installed new magnets, which can achieve a fast switching system between two treatment rooms. The new technology relies on three new laminated magnets instead of one old massive magnet. Inside the new magnets the time of stabilisation of the magnetic field is short and allows to expect time of the switching less than 2 minutes instead of 20 minutes before. This upgrade will enable to parallelize the treatments in the two treatment rooms. This project has been done in collaboration with IPNO/IN2P3/CNRS.

IPNO has managed the studies, the design and the engineering integration of the three magnets. IPNO was also the expert in beam optics. The alignment has been studied and managed by the surveyor of GANIL.

The work has been validated to the require of standard of quality. In order to achieve this goal, CPO has added detectors: a small cylindrical Wellhöfer Ionization Chamber 0.1CC, beam profilers, and a Cross Ionization Chamber.

This work was financially supported by a LA LIGUE CONTRE LE CANCER

High-resolution proton beam tracking detector

S.M. Ebstein

Lexitek, Inc.
14 Mica Lane #6
Wellesley, MA 02481

ebstein@lexitek.com

Current and future proton beam facilities require instrumentation to monitor the proton beam in real time for control and safety. Current developments in dynamically controlled scanned proton beams are expected to further improve the therapeutic advantage of protons. These developments, and the comparable developments in conventional X-ray radiotherapy, further increase the need for accurate and fast detector instrumentation.

Lexitek is developing a new, patent-pending, scintillator-based detector for the real-time monitoring of a scanned, narrow-focused, proton beam during the irradiation of a patient. This detector will track the position of the proton beam with millimeter and microsecond resolution in real-time in order to verify the relevant spatial and dosimetric beam parameters. The detector can provide feedback into the control system of the scanning beam to dynamically correct for any deviations in the beam parameters. The use of a scintillator minimally affects the proton beam and ensures that delicate instrument components are not unduly exposed to primary or scattered radiation. The only component in the beam, the scintillator, is inherently radiation robust and should show little aging due to radiation exposure, and is inexpensive to replace if needed.

We present our development plans and limited initial work testing the detector in collaboration with the Northeast Proton Therapy Centerat the Massachusetts General Hospital.

Support of this work by an SBIR grant from the National Institutes of Health is gratefully acknowledged.

Correcting a Skewed SOBP Produced with the Energy Stacking Technique

Mark Wolanski

Indiana University Cyclotron Facility, Bloomington IN 47408-1398

wolanski@iucf.indiana.edu

The energy stacking technique will be used to produce SOBPs over the clinical range of interest (2 cm – 15 cm) in Treatment Room 2 at MPRI. The weights of the individual Bragg peaks composing the SOBP are calculated given the depth-dose distribution of the pristine peak and an experimentally determined flux-reduction factor accounting for beam loss and multiple scattering in the variable range degrader. The prescribed SOBP will be verified before treatment. An algorithm has been developed to correct the SOBP if its flatness is outside clinical specifications due to a simple "skewness", i.e. a linear change in the plateau dose with depth. Representative results will be given.

Prostate Treatments

Carlo Rossi

Loma Linda Medical Center, Radiation Medicine, 11234 Anderson Street, Room B-124, Loma Linda , CA, 92354, USA

CRossi@Dominion.llumc.edu

REFRESHER COURSE: Physics - Part I

Overview and Status of DICOM Draft Standard for Ion Beam Therapy

M. F. MOYERS and ION BEAM SUB-COMMITTEE of DICOM WORKING GROUP 7

m.moyers@att.net

During the first thirty years of ion beam therapy, almost all devices involved with patient treatments were "home grown" and specific to each institution. During the last ten years, many of the devices and procedures previously found only in ion beam therapy have made their way into x ray and electron beam therapy. Apertures and boluses are now produced by computer controlled cutters and more departments are venturing into daily image guided therapy. Beam delivery systems have become more versatile to treat a larger variety of patient conditions. The commercial sector is now showing public interest in ion beam therapy and new facilities being built have a choice of vendors from which to pick and choose various combinations of equipment. Multi-segmented treatments, such as intensity modulated beams, require large amounts of data to be transferred from the treatment planning system to the beam delivery system and device manufacturing equipment and later from the beam delivery system to the patient record. Regional treatment centers require transfer of patient plan data between cities for optimization and approval. Protocol centers require plan data for evaluation of treatments. Transfer of information between the large variety of devices and facilities without developing many proprietary datalinks requires a communication standard. Since 1999, a sub-committee of Working Group 7 of DICOM, the group that deals with radiation therapy extensions, has been working to support light ion beams. A draft communication standard is now finished and awaiting approval. This course will provide an overview of this new standard including basic concepts, history, solutions, and contact information.

The RCET System - a working RT PACS system

Vincent Frouhar

University of Florida, Radiation Oncology Physics, 200 SW Arch Road Rm 1211, P.O. Box 100385, Gainesville, FL, 32610, USA

vfrouhar@ufl.edu

The IBA Proton Therapy System in Zibo

CANON, Thomas

Ion Beam Applications s.a.

Thomas.Canon@iba.be

IBA sold in 2001 a Proton Therapy System to Wanjie Irradiation Co LTD. The Wanjie Proton Therapy Center, Zibo (China) is built around 4 treatment rooms: one fixed beam room and three gantry rooms, of which one is installed in the frame of the present contract.

The present paper will review the present status of the project which is now entered in its final validation phase as summarized below:

The Fixed Beam Room is now being validated and is on track for acceptance by October 2004.

- Patient alignment subsystems are validated
- Beam clinical options are calibrated
- Beam data collection for Treatment Planning algorithms was performed

The validation operations are running nominally thanks to a high beam production system availability. It will be followed in October by the clinical commissioning to be performed by Wanjie.

The gantry room is now completely integrated and is in the final phase of calibration, consisting of:

- Patient Positioning System calibration
- Beam Tuning calibration
- Isocenter tests of the gantry were passed successfully.

These integration tests will be followed by the calibration of the clinical options and the validation phase to be started end October 2004

Uniform Scanning, a safe path towards PBS

Yves CLAEREBOUDT

Ion Beam Applications s.a.

Protontherapy - R&D – Louvain-La-Neuve – Belgium

ycl@iba.be

After several months within which our Research & Development Team has been working on the further improvement of our system reliability, the uniform scanning development project was resumed in January 2004. After a first phase spent on the validation of the installed equipment and thereby verification of the operations and robustness at our NPTC – MGH site in Boston, several prototype iterations have been built in order to validate the final Uniform Scanning design.

The first iteration, which synchronizes the software data acquisition from the ionization chambers and range verifier on the scanning magnets, was delivered in May. This software allows for the acquisition of data on lateral uniformity.
The second iteration, which allows for a full irradiation delivery in Service Mode, was delivered in June.
This software allowed MGH to validate the mechanism that gives each layer a certain weight in order to obtain a flat SOBP (Spread Out Bragg Peak).
These prototypes allowed us to get a clearer view on what is required to deliver a uniform scanning irradiation and to finalize the documentation of the to-be built system, namely: risk analysis, Failure Mode & Effect analysis, operation scenarios, user interface prototypes, conversion algorithms and cyclic checks. The IBA Research & Development teams are now working hard in order to be able to submit a “SPECIAL 510K” to the FDA before the end of 2004.

Moving towards to PBS will be carried out using the same prototyping techniques and the risks associated with this project have been reduced, as we know that our system is already able to perform uniform layered irradiations using scanning techniques.
This work was made possible thanks to the close collaboration between both MGH & IBA team members.

Implementation of the Wobbling delivery mode

R. SLOPSEMA[1], H. KOOY[1], J. FLANZ[1], Y. CLAEREBOUDT[2], D. PRIEELS[2], V. BREEV[2], J. HUBEAU[2]

[1]Northeast Proton Therapy Center, Massachusetts General Hospital, Boston MA,
[2]Ion Beam Applications Ltd., Louvain-la-Neuve, Belgium

rslopsema@partners.org

In wobbling mode, a large beam spot is scanned using two orthogonal orientated magnets at fixed frequencies of 3 Hz and 30 Hz respectively. Large uniform dose distributions can be obtained of up to 30 cm x 40 cm in the lateral plane. Compared to double-scattering mode, with a maximum field diameter of about 25 cm, this has the advantage that no, or less matching of fields is needed in case of large treatment volumes. In addition both the lateral and distal penumbra are better, and the number of secondary neutrons is lower.

The spread-out Bragg peak is delivered using a layering strategy. For a single energy the beam is scanned multiple periods until sufficient dose is delivered at the distal end of the SOBP. Subsequent layers are delivered by inserting absorbing material in the beam path, providing a pullback in range, and adjusting the weight, or relative contribution of the peak to the uniform SOBP. In our implementation the weight is defined by the number of Monitor Units measured by an ionization chamber upstream. Due to the energy-dependence of the optimal weights, a weight set is valid for a limited range span. We show that a set of 24 weight files is sufficient to cover ranges from 6.0 g/cm^2 up to 33.0 g/cm^2.

We present our wobbling conversion algorithm, i.e. the algorithm converting the required field parameters into equipment settings. On one hand the magnetic field amplitude and beam spot size have to optimized to get a uniform and efficient lateral dose distribution, on the other hand the correct pullback and weighting of the pristine peaks must result in a uniform SOBP with desired modulation width. Measurement results are given, showing the feasibility of our implementation.

Performance of a fluorescent screen and CCD camera system in ^{3}He and ^{12}C beams

J. NAUMANN, L. CESANNE and S. O. GRÖZINGER

Gesellschaft für Schwerionenforschung (GSI), Darmstadt

j.naumann@gsi.de

An increasing number of dedicated medical proton and ion therapy facilities are being planned, built or actually coming into operation. Such facilities require accurate methods to determine the beam properties and the absorbed dose to water phantoms. In principle, a variety of such methods for dosimetry and for diagnostic purposes exist that can be used for proton and ion beams.
However, many of these require a complicated set-up which is neither suitable for a clinical environment nor for a daily routine. Therefore, for a lot of applications standard x-ray films remain the method of choice. While films are comparatively easy to handle the non-linear response of films with respect to the absorbed dose makes a quantitative analysis difficult.
The combination of a fluorescent screen and a CCD camera is a very promising candidate to replace x-ray films. Such systems are being used routinely for beam diagnostics at the Gesellschaft für Schwerionenforschung (GSI) in Darmstadt and were successfully employed in the tests of the gantry magnets for the Heidelberg ion therapy facility (HIT). These applications have been restricted to low LET regions.
While fluorescent screens are in use at proton facilities and their response to high LET proton radiation was investigated (SCHIPPERS *et al.*, 2002) little is known about the performance of such screens in ion beams.
At GSI several measurements were conducted in ^{3}He and ^{12}C beams to determine the response of a P43 screen with respect to dose, intensity and other parameters. In particular, the signal quenching was measured for the first time in a carbon ion beam using a movable water column. The quenching was found to be significant in the Bragg peak region.

SCHIPPERS, J. M., BOON, S. N. and VAN LUIJK, P., *Nucl. Instr. and Meth. A* **477**:480-485

An ultra fast CVD beam monitor

Author: E. Griesmayer*

Fotec; Forschungs- und Technologietransfer GmbH; Viktor Kaplan-Strasse 2; A-2700 Wiener Neustadt; Austria

www.fotec.at

eg@fotec.at

An ultra fast radiation hard CVD beam monitor has been developed during the last 2 years in the frame of the MedAustron project. The detector was tested at the Indiana University Radiation Facility, at MGH in Boston and at GSI Darmstadt with protons and carbon ions, respectively. The detector provides single particle counting rates approaching the GHZ range at an efficiency close to 100%. Results of the beam tests will be presented

* For the MedAustron Project Group

A - 2700 Wiener Neustadt, Viktor Kaplan- Straße 2 | Tel. (+43-2622) 90333-0, Fax (+43-2622) 90333-99 | E-mail: office@fotec.at Internet: www.fotec.at
ATU 46032608 FN 176224 d Landesgericht Wr. Neustadt DVR 1036475

Minimally perturbing head and neck registration and immobilization devices

M. F. MOYERS

Loma Linda University Medical Center

m.moyers@att.net

When treating a patient with beams of ionizing radiation, multiple beams enter the patient at different locations and from different directions. During treatment, the patient is placed at a designated location on a patient positioner utilizing a registration device. The patient is also immobilized with additional devices to maintain alignment of the radiation beam to the diseased target while missing critical normal tissues. Current registration and immobilization devices limit the optimization of beam entry locations and directions because they perturb the radiation beam and cause regions of the patient to receive more or less dose than prescribed. The purpose of this work was to determine if registration and immobilization devices could be fabricated that reduce perturbations in the radiation fields to acceptable levels from all desired entry directions without raising the cost of treatments prohibitively.

Characterization of the radiological properties of various potential composite materials was performed. The properties characterized for each material included: the proton linear stopping power, the x ray linear attenuation coefficient, the XCT number, imaging of the fibers within the composite material with a proton beam, imaging of the fibers with an x ray beam, and the perturbation of the proton beam dose distribution in patients produced by variously shaped and thickness edges. A prototype head and neck registration pod with immobilization facemask was designed and produced. The design allows for attaching the mask material to the pod in a fashion that allows quick, unassisted egress by the patient while not significantly perturbing the proton beam dose distribution. Results of the radiological characterization will be presented.

Dose Distribution Calculations of Proton Pencil Beams using the Geant4 Monte Carlo Program

Yaxiang YANG, Ning WNG, George COUTRAKON, Dan MILLER, Michael MOYER

Medicine Radiation Department, Medical Center, Loma Linda University

In developing a treatment planning system for proton beam scanning systems, it is crucial to have accurate dose distributions of small proton pencil beams for any required beam energy. However, it is very difficult to measure these beams' 3D dose distributions accurately for all energies. For this paper, we used the Geant4 toolkit to simulate the proton transmission in water and to obtain dose kernels for realistic pencil beams. The Geant4 pencil beam dose calculations were verified by comparing them with measured depth dose curves and beam sizes at various depths. Good agreement was achieved between Geant4 results and experiment measurements for several energies. Next, we used Geant4 to obtain the 3D dose distributions (or kernels) of pencil beams for energies ranging from 70MeV-250MeV in 10MeV steps.

These nineteen 3D dose distributions were then made into normalized dose kernels in units of dose/(peak-dose) vs. depth/(peak-depth). From these normalized dose kernels, any other energy's dose kernel can be linearly interpolated. The interpolation calculations were then compared with new Geant4 simulations performed at the interpolated energies that we wished to test. These results are also discussed in this paper.

Basic dosimetric data for a proton TPS

Ale Mazal

Institut Curie, Service de Physique Médicale, 26, rue d'Ulm, , Paris, , 75005, France

alejandro.mazal@curie.net

Emission of light fragments produced by nuclear fragmentation in thick water phantoms

K. Gunzert-Marx[1], D. Schardt[2], H. Iwase[2], R. S. Simon[2]

[1] *Siemens Medical Solutions, 91052 Erlangen, Germany*
[2] *Gesellschaft für Schwerionenforschung mbH, 64291 Darmstadt, Germany*

konstanze.gunzert-marx@siemens.com

The nuclear fragmentation of high-energy heavy-ions penetrating tissue leads to an attenuation of the primary beam and a build-up of secondary lighter fragments. Since these fragments have in general longer ranges than the primary ions ($R \propto A/Z^2$) and in addition different RBE's, the nuclear fragmentation has to be included in the therapy treatment planning program (KRÄMER *et al.*, 2000). To improve the experimental database, the energy and angular distribution of light fragments emitted from a thick tissue equivalent phantom was investigated in the framework of the carbon-therapy project of GSI in continuation of former experiments (SCHALL *et al*., 1996, GOLOVKOV *et al.*, 1997). Carbon ions with an energy of 200 AMeV were stopped in a 12.78 cm thick water target. The light fragments escaping from the target were measured 3 m downstream of the phantom using a ΔE-E-telescope consisting of a 9 mm thin NE102- and a 14 cm thick BaF_2-scintillation-detector. The neutron and proton energy spectra obtained from time-of-flight measurements show a broad maximum close to the entrance energy of the primary ions and the spectra extend to about twice this energy. The energy spectra of heavier fragments are broadly distributed around half the primary ion energy, their maximum energies are near to the entrance energy of the ions. The angular distributions were measured from 0° to 30°. The angular spectra for all fragments are forward peaked, especially for heavier fragments. Similar investigations were performed during patient treatments at GSI. Only slight differences are observed compared to the angular distributions and yields at the water target. Referring to the obtained data the dose contribution of neutrons and charged fragments was determined and it was shown that the neutron dose is less than 1% of the dose in the tumour volume. The presented data are compared to calculations with the PHITS code and to literature data concerning the neutron emission in proton and photon irradiations.

KRÄMER, M., JÄKEL, O., HABERER, T., KRAFT, G., SCHARDT, D., WEBER, U., (2000) *Phys. Med. Biol.* **45**: 3299-3317
SCHALL, I., SCHARDT, D., GEISSEL, H., IRNICH, H., KANKELEIT, E., KRAFT, G., MAGEL, A., MOHAR, M.F., MÜNZENBERG, G., NICKEL, F., SCHEIDENBERGER, C., SCHWAB, W., (1996) *Nucl. Instr. and Meth. in Phys. Res. B* **117**: 221-234
GOLOVKOV, M., ALEKSANDROV, D., CHULKOV, L., KRAUS, G., SCHARDT, D., (1997) *Adv. in Hadrontherapy:* 316-324

The impact of interplay between respiratory motion and C-12 beam scanning on the dose deposition

Christoph BERT, Eike RIETZEL, Sven Oliver GRÖZINGER, Thomas HABERER, Gerhard KRAFT

Gesellschaft für Schwerionenforschung, Darmstadt, Germany

c.bert@gsi.de

Since 1997 more than 230 patients have been treated with C-12 ions at GSI. For dose delivery a particle pencil beam is scanned in 3D with the intensity controlled rasterscanner technique[1], allowing for a very conform and homogeneous dose deposition. Longitudinally dose is deposited slice by slice by changing the beam energy between particle spills from the synchrotron; laterally magnetic deflection is used for beam scanning within each iso-energy slice. Treatment planning is performed with the in-house software TRiP[2], that biologically optimizes the number of particles at each scan position.

Up to now, only static tumors are treated in anatomic regions where stereotactic fixation devices can be used. Then an extreme conformity between target and irradiated volume can be achieved. To overcome the restriction to treat static tumors only, a 3D online motion compensation system was developed. The prototype system allows fast and precise adjustments of the Bragg peak position during dose delivery[3]. For a future clinical use of such a system, target motion will have to be measured online e.g. by fluoroscopy. In addition dedicated treatment planning e.g. based on tumor motion information from 4D computed tomography[4] is necessary and links the information from motion tracking with the actual anatomy.

The presented work will focus on extensions of the treatment planning system TRiP. New modules have been added to facilitate dose calculations in the presence of target motion. The modules have been successfully tested in comparison to experiments measuring motion trajectories in temporal correlation to the rasterscanned beam delivery. Distinct dose patterns resulting from interplay between detector motion and scanned beam were used to validate the extension of the treatment planning system. Comparisons between calculated and measured dose distributions showed excellent qualitative agreement and good quantitative agreement within the accuracy of the film detector responses.

C. Bert is partially supported by a DAAD Doktorandenstipendium.

[1] HABERER et al, *Nuc. Instr Meth Phys Res* **A330** (1993) 296-305.
[2] KRÄMER et al, *Phys. Med. Biol.* **45** (2000) 3319-3330.
[3] GRÖZINGER, S.O., PhD-Thesis, TU Darmstadt, 2004.
[4] RIETZEL et al, *Int J Radiat Oncol Biol Phys* **57** (2003) S232-3.

MPRI overview - Operational Statistics for the First 9 Months.

Niek Schreuder, Ed Dickey, David Long, Leia Fanelli, Lisa Taylor, Anthony Mascia, Jonathan Farr, Avril O'Ryan-Blair, Mary-Beth Sullivan-Dickey, John Smith, Herschel Workman and Allan Thornton

Midwest Proton Radiotherapy Institute, 2425 N Milo B Sampson lane, Bloomington, IN, USA

aschreud@indiana.edu

The MPRI facility became operational in February 2004 when the first patients were treated. The MPRI facility has currently one fixed horizontal beam line in operation while two additional treatment rooms, equipped with IBA gantries, are currently under construction. The MPRI facility uses the high energy (208 MeV) proton beam produced by the cyclotrons of the Indiana University Cyclotron Facility (IUCF). The IUCF cyclotrons were refurbished and upgraded as part of the MPRI construction project and prior to the first human treatments.

The MPRI facility operates at this stage under an Investigative Device Exemption (IDE) from the USA Food and Drug Administration (FDA). Operating under an IDE requires additional efforts from the therapy team. The fixed horizontal beam has also some limitations that the MPRI team must overcome. The use of a 6 axis robotic patient positioner adds another dimension to the use of a fixed horizontal beam line for proton treatments.

The operational statistics of the MPRI facility for the first 9 months of clinical operations will be discussed using the following categories;

- Beam availability.
- The efficiency of the existing treatment process.
- The Quality Assurance process.
- Manpower requirements.
- Clinical Challenges to date.

"Where Do We Go From Here?"

Al Smith

M. D. Anderson Cancer Center

alsmith@mdanderson.org

Particle therapy is slowing entering the mainstream of radiation oncology. The technology for particle therapy is in a transition from prototype or "first-generation" beam delivery systems to "second-generation" systems. There are two general features that divide the first and second generations. First-generation systems tend to be research accelerator-based and primarily use passive scattering nozzles while second-generation systems tend to be hospital-based and use either combinations of passive scattering and beam scanning nozzles or beam scanning alone. There are, of course, facilities that do not fall neatly into either category. Also, second generation systems may tend to be more standardized as vendor products rather than prototypes and function more like photon therapy facilities in terms of technology integration and clinical practice. Particle therapy is evolving and maturing into a more stable and universal state. This seems to be a good time to ask the question, "Where do we go from here?" What are the things we must do to promote the growth of particle therapy, make it affordable to a broader range of facilities, and optimize its efficiency (patient throughput) and utility (ease of use)? After a short introduction by the session chair, a general discussion will be held with participation from the audience.

Attendees: PTCOG41 Bloomington, Indiana 10 – 13 October 2004

Index	Lastname	Firstname	Institution	Country	Email
1	Algranati	Carlo	AtreP	Italy	carlenzo@yahoo.com
2	Allgower	Chris	Midwest Proton Radiotherapy Institute	USA	callgowe@indiana.edu
3	Alonso	Jose	Lawrence Berkeley National Laboratory	USA	JRAlonso@lbl.gov
4	Anferov	Vladimir	IUCF	USA	vanferov@indiana.edu
5	Arjomandy	Bijan	Loma Linda University Medical Center	USA	arjomandy_2000@yahoo.com
6	Arzt	Leonard	Nat. Asso. for Proton Therapy	USA	lenarzt@proton-therapy.org
7	Avery	Steven	University of Pennsylvania	USA	avery@xrt.upenn.edu
8	Balakin	Vladimir	Physical-Technical Centre	Russia	balakin@protom.ru
9	Barnes	Robert	M W Zander	USA	robert.barnes@mw-zander.com
10	Bedda	Sam	UT MD Anderson Cancer Center	USA	sbeddar@mdanderson.org
11	Bert	Christoph	GSI	Germany	c.bert@gsi.de
12	Bertinatti	Alain	Ion Beam Applications s.a.	Belgium	swi@iba.be
13	Bloch	Charles	UT MD Anderson Cancer Center	USA	cbloch@mdanderson.org
14	Brusasco	Caterina	Ion Beam Applications s.a.	Belgium	swi@iba.be
15	Buettner	Kathy	Northern Illinois University	USA	kbuettner@niu.edu
16	Cameron	John	Indiana University	USA	cameron@iucf.indiana.edu
17	Canon	Thomas	Ion Beam Applications s.a.	Belgium	swi@iba.be
18	Cappello	Vito	Hitachi America Ltd.	USA	vito.cappello@hal.hitachi.com
19	CARB	SAUL	Proton Development N.A.	USA	saulprotondev@yahoo.com
20	Chandler	Chris	Ion Beam Applications s.a.	Belgium	swi@iba.be
21	Chu	James	Rush University Medical Center	USA	jchu@rush.edu
22	Claereboudt	Yves	Ion Beam Applications s.a.	Belgium	swi@iba.be
23	Cleveland	Earl	Ion Beam Applications (IBA)	Belgium	ECleveland@iba-group.com
24	Closset	Michel	Ion Beam Applications s.a.	Belgium	swi@iba.be
25	Collins	JOHN	IUCF	USA	collins@iucf.indiana.edu
26	Combs	Stephanie E.	University of Heidelberg	Germany	Stephanie.Combs@med.uni-heidelberg.de
27	Commin	Daphne	iThemba LABS	South Africa	daphne@tlabs.ac.za
28	Coutrakon	George	Loma Linda Univ. Med. Ctr.	USA	coutrak@proton.llumc.edu
29	Cox	James	UT M. D. Anderson Cancer Center	USA	jcox@mdanderson.org

Index	Lastname	Firstname	Institution	Country	Email
30	DeLaney	Thomas	Massachusetts General Hospital	USA	TDelaney@Partners.org
31	Dickey	Edward	MPRI	USA	eddickey@indiana.edu
32	Dobler	Natalie	M W Zander	Germany	natalie.dobler@mw-zander.com
33	Ebert	Matthias	Siemens AG	Germany	matthias.ebert@siemens.com
34	Ebstein	Steven	Lexitek, Inc.	USA	ebstein@lexitek.com
35	Falkenstein	Dennis	Siemens Medical Solutions	USA	dennis.falkenstein@siemens.com
36	famiglietti	Robin	UT MD Anderson Cancer Center	USA	rfamigli@mdanderson.org
37	Fanelli	Leia	MPRI	USA	lfanelli@indiana.edu
38	Farr	Jonathan	Midwest Proton Radiotherapy Institute	USA	jbfarr@indiana.edu
39	Ferro	Alexander	ipg ag	Switzerland	monika.lang@ipg-ag.com
40	Fitzek	Markus	Tufts-New England Medical Center	USA	mfitzek@tufts-nemc.org
41	Flanz	Jacob	Massachusetts General Hospital	USA	flanz@hadron.mgh.harvard.edu
42	Folberth	Walter	Siemens AG, Medical Solutions	Germany	walter.folberth@siemens.com
43	Ford	Rhonda	NIU	USA	remaxrhonda@yahoo.com
44	Friesel	Dennis	IUCF	USA	Friesel@iucf.indiana.edu
45	Frouhar	Vincent	University of Florida	USA	vfrouhar@ufl.edu
46	Fuji	Hiroshi	Shizuoka Cancer Center	USA	h.fuji@scchr.jp
47	Gaza	Razvan	M.D. Anderson Cancer Center	USA	razvangaza@yahoo.com
48	Genin	Frederic	Ion Beam Applications s.a.	Belgium	swi@iba.be
49	Ginion	Jean-Marie	Ion Beam Applications s.a.	Belgium	swi@iba.be
50	Giorgio	Gene	Optivus Technology, Inc.	USA	ggiorgio@optivus.com
51	Goebel	Holger	ACCEL Instruments GmbH	Germany	goebel@accel.de
52	Goitein	Gudrun	Paul Scherrer Institute	Switzerland	gudrun.goitein@psi.ch
53	Goldner	Gerard	Hitachi America Ltd.	USA	gerard_goldner@pis.hitachi.co.jp
54	Grecula	John	Ohio State University	USA	grecula-1@medctr.osu.edu
55	Griesmayer	Erich	Fotec GmbH	Austria	eg@fotec.at
56	Groezinger	Sven Oliver	Siemens Medical Solutions	Germany	svenoliver.groezinger@siemens.com
57	Gueulette	John	Université catholique de Louvain	Belgium	gueulette@rbnt.ucl.ac.be
58	Gunzert-Marx	Konstanze	Siemens Medical Solutions	Germany	konstanze.gunzert-marx@siemens.com
59	Hansmann	Thomas	M W Zander	Germany	thomas.hansmann@mw-zander.com
60	Harada	Hisashi	Mitsubishi Electric Corporation	Japan	qchan@pic.melco.co.jp

Index	Lastname	Firstname	Institution	Country	Email
61	Hauffe	Joerg	ProHealth AG	Germany	joerg.hauffe@prohealth-ag.de
62	Heese	Juergen	ACCEL Instruments GmbH	Germany	heese@accel.de
63	Herbst	Manfred	ProHealth AG	Germany	manfred.herbst@rptc-1.de
64	Herrmann	Klaus	Siemens Medical Solutions	Germany	klaus.herrmann@siemens.com
65	Homeyer	Heinrich	Hahn-Meitner-Institut	Germany	Homeyer@hmi.de
66	Hsi	Wen	Rush University Medical Center	USA	whsi@rush.edu
67	Hubeau	Jonathan	Ion Beam Applications s.a.	Belgium	swi@iba.be
68	ITO	Toshimitsu	Mitsubishi Electric Corporation	Japan	Toshimitsu.Ito@hq.melco.co.jp
69	Jaekel	Oliver	German Cancer Reserach Center	Germany	o.jaekel@dkfz.de
70	Jermann	Martin	Paul Scherrer Institute (PSI)	Switzerland	martin.jermann@psi.ch
71	Johnson	Steve	Varian Medical System	USA	steven.johnson@varian.com
72	Jongen	Yves	Ion Beam Applications s.a. (IBA)	Belgium	jongen@iba.be
73	Juentgen	Petra	Hitachi Europe GmbH	Germany	Petra.juentgen@hitachi-eu.com
74	Kawachi	Kiyomitsu	NIRS	JAPAN	k.kawachi@sunny.ocn.ne.jp
75	Khattabi	Christine	Hitachi America Ltd.	USA	christine.khattabi@hal.hitachi.com
76	Kiyama	Yoko	Hitachi America Ltd.	USA	yoko.kiyama@hal.hitachi.com
77	Klein	Susan	IUCF	USA	sbklein@indiana.edu
78	Klein	Hans-Udo	ACCEL Instruments GmbH	Germany	klein@accel.de
79	Kluge	Heinz	Hahn Meitner Institut	Germany	kluge@hmi.de
80	kossuri	Narendra	Keck graduate institute	USA	nkossuri@kgi.edu
81	Kraft	Gerhard	GSI	Germany	G.Kraft@gsi.de
82	Krishnan	Sunil	MD Anderson Cancer Center	USA	skrishnan@mdanderson.org
83	Kuboniwa	Takao	Hitachi Ltd	Japan	takao_kuboniwa@pis.hitachi.co.jp
84	kumada	masayuki	National Institute of Radiological Science	Japan	kumada@ama.po-jp.com
85	Kume	Kyo	The Wakasa Wan Energy Research Center	Japan	kkume@werc.or.jp
86	Labarbe	Rudi	Ion Beam Applications s.a.	Belgium	swi@iba.be
87	Langen	Katja	MD Anderson-Orlando	USA	klangen@orhs.org
88	Langenegger	Armin	Varian Medical Systems	USA	armin.langenegger@varian.com
89	Latinkic	Mitch	The University of Texas M. D. Anderson Cancer Center	USA	mlatinkic@mdanderson.org
90	Lee	Andrew	U.T. - M.D. Anderson Cancer Center	USA	aklee@mdanderson.org

Index	Lastname	Firstname	Institution	Country	Email
91	Lee	Tae Kyu	Purdue University	USA	lee50@purdue.edu
92	Leonardi	Renzo	ATreP	Italy	renzo@ect.it
93	Lesyna	David	Optivus Technology, Inc.	USA	lesyna@optivus.com
94	Leyman	Didier	Ion Beam Applications s.a.	Belgium	swi@iba.be
95	Liebsch	Norbert J.	Massachusetts General Hospital	USA	nliebsch@partners.org
96	Litzenberg	Dale	University of Michigan	USA	litzen@umich.edu
97	Lombardi	Augusto	ATreP	Italy	augusto.lombardi@lnl.infn.it
98	Ma	Charlie	Fox Chase Cancer Center	USA	charlie.ma@fccc.edu
99	Marc	Marcel	Varian Medical Systems	USA	marcel.marc@varian.com
100	Mascia	Anthony	Midwest Proton Radiotherapy Institute	USA	amascia@indiana.edu
101	Masser	Veronika	Fotec GmbH	Austria	masser@fotec.at
102	Mathot	Gilles	Ion Beam Applications s.a.	Belgium	swi@iba.be
103	Mazal	Alejandro	Institut Curie	France	alejandro.mazal@curie.net
104	McDonough	James	University of Pennsylvania	USA	mcdonough@xrt.upenn.edu
105	McKellar	Joyce	Siemens Medical Solutions	USA	joyce.mckellar@siemens.com
106	McMurry	Harris	Siemens Medical Solutions USA	USA	harris.mcmurry@siemens.com
107	Meedt	gustav	CMS	Germany	gustav.meedt@cms-europe.com
108	Mendenhall	Nancy	University of Florida	USA	mendenan@shands.ufl.edu
109	Merrifield	Charles	UT M. D. Anderson Cancer Center	USA	cmerrifi@mdanderson.org
110	Mesoloras	Geraldine	Purdue University	USA	gmesolor@purdue.edu
111	Metz	James	University of Pennsylvania	USA	metz@xrt.upenn.edu
112	Meyroneinc	Samuel	Institut Curie	France	meyronei@ipno.in2p3.fr
113	Mihalcea	Daniel	Northern Illinois University	USA	mihalcea@fnal.gov
114	Morse	Richard	Varian Medical Systems	USA	richard.morse@varian.com
115	Moyers	Michael	Loma Linda University Medical Center	USA	m.moyers@att.net
116	Nakane	Naoko	Hitachi Ltd	Japan	naoko-a_nakane@pis.hitachi.co.jp
117	Naumann	Jakob	Gesellschaft für Schwerionenforschung (GSI)	Germany	j.naumann@gsi.de
118	Nerbun	Claire	MD Anderson Cancer Center	USA	ctnerbun@mdanderson.org
119	Nichiporov	Dmitri	IUCF	USA	nichiporov@iucf.indiana.edu
120	Nielsen	Bjarne R.	DANFYSIK A/S	Denmark	brn@danfysik.dk
121	Noser	Hans	ipg ag	Switzerland	monika.lang@ipg-ag.com

Index	Lastname	Firstname	Institution	Country	Email
122	O`Connell	John	Walter Reed Army Medical Center	USA	John.OConnell@NA.amed.army.mil
123	O`Ryan-Blair	Avril	Midwest Proton Radiotherapy Institute	USA	aoryanbl@indiana.edu
124	Ogino	Takashi	National Cancer Center Hospital East	Japan	togino@east.ncc.go.jp
125	Palta	Jatinder	University of Florida	USA	paltajr@ufl.edu
126	Penmetsa	Rakesh	Keck Graduate Institute Of Applied Life Sciences	USA	rpenmets@kgi.edu
127	Pepmiller	Phil	CMS	USA	Phil.Pepmiller@cms-stl.com
128	Prado	Karl	UT M.D. Anderson Cancer Center	USA	kprado@mdanderson.org
129	Prieels	Damien	Ion Beam Applications s.a.	Belgium	swi@iba.be
130	Roberts	Rebecca	UT M. D. Anderson Cancer Center	USA	rerobert@mdanderson.org
131	Rosenthal	Stanley	Massachusetts General Hospital	USA	srosenthal@partners.org
132	Rossi	Carl	Loma Linda Medical Center	USA	CRossi@Dominion.llumc.edu
133	Samant	Sanjiv	SJCRH	USA	sanjiv.samant@stjude,org
134	Schaffner	Barbara	Varian Medical Systems	Switzerland	barbara.schaffner@varian.com
135	Schär	Hugo	Schär Engineering AG	Switzerland	h.schaer@schaer-engineering.ch
136	Schier	Howard	Hitachi America Ltd.	USA	howard.schier@hal.hitachi.com
137	Schmidt	Stefan	ACCEL Instruments GmbH	Germany	stefan.schmidt@accel.de
138	Schneider	Andrew	Schneider	USA	deltamlk@aol.com
139	Schreuder	Niek	MPRI	USA	aschreud@indiana.edu
140	Sewchand	Wilfred	Walter Reed Army Medical Center	USA	wilfred.sewchand@na.amedd.army.mil
141	Shahnazi	Kambiz	Loma Linda Medical Center	USA	kambiz@dominion.llumc.edu
142	Sinwell	MaryANn	Mitsubishi Electric Power Products, Inc.	USA	maryann.sinwell@meppi.com
143	Slater	Jerry	Loma Linda Univ. Medical Center	USA	jdslater@dominion.llumc.edu
144	Slopsema	Roelf	MGH	USA	rslopsema@partners.org
145	Smith	Alfred	M. D. Anderson Cancer Center	USA	alsmith@mdanderson.org
146	Smith	John	MPRI	USA	js6@indiana.edu
147	Soga	Fuminori	National Institute of Radiological Sciences	JAPAN	soga_f@nirs.go.jp
148	Sokol	Paul	Indiana University Cyclotron Facility	USA	pesokol@indiana.edu
149	Sullivan-Dickey	MaryBeth	MPRI	USA	sullivam@indiana.edu
150	Suzuki	Kazumichi	Hitachi America Ltd.	USA	kazumichi.suzuki@hal.hitachi.com
151	Sweitzer	Michael	Varian Medical Systems, Inc.	USA	michael.sweitzer@varian.com

Index	Lastname	Firstname	Institution	Country	Email
152	Swenson	Donald	Linac Systems, LLC	USA	daswenson@linac.com
153	Taing	Lina	MD Anderson Cancer Center	USA	lctaing@mdanderson.org
154	Takada	Yoshihisa	University of Tsukuba	JAPAN	takada@pmrc.tsukuba.ac.jp
155	Taylor	Lisa	MPRI	USA	ldtaylor@indiana.edu
156	Thirionet	Philippe	Ion Beam Applications s.a.	Belgium	swi@iba.be
157	Thornton	Allan	Midwest Proton Radiotherapy Institute	USA	ATHORN5644@aol.com
158	Turlapati	Sumant	Keck Graduate Institute of Applied Life Sciences	USA	sturlapa@kgi.edu
159	Valencia	Dennis	Medical Marketing Enterprises	USA	dennis.valencia@att.net
160	Vernimmen	Frederik	Tygerberg Hospital	South Africa	fv@sun.ac.za
161	Vogel	Richard	Kathy's House	USA	mail@kathys-house.org
162	Weber	Andreas	Hahn-Meitner-Institut Berlin	Germany	andreas.weber@hmi.de
163	Wedekind	Moira	IUCF	USA	moira@iucf.indiana.edu
164	Wicha	Roman	Varian Medical Systems	USA	roman.wicha@varian.com
165	Wolanski	Mark	IUCF	USA	wolanski@iucf.indiana.edu
166	Workman	Herschel	MPRI	USA	heworkma@indiana.edu
167	Yang	James	UT M.D. Anderson Cancer Center	USA	JamesYang@mdanderson.org
168	Yang	Yaxiang	Loma Linda Univ. Med. Ctr.	USA	yyang@dominion.llumc.edu
169	Yoder	Neil R	IUCF	USA	yoder@iucf.indiana.edu
170	Yonemoto	Leslie	Loma Linda Unviersity	USA	lyonemoto@verizon.net
171	Zhang	Yunkai	Rush Univ. Medical Center	USA	Yunkai_Zhang@rush.edu
172	Zhang	Ziaodong	UT MD Anderson Cancer Center	USA	xizhang@mdanderson.org
173	Zhang	Hong	Institute of Modern Physics, CAS	P.R.China	zhangh@impcas.ac.cn
174	Zhu	X. Ronald	UT M.D. Anderson Cancer Center	USA	xrzhu@mdanderson.org
175	Zhu	mengping	UT M.D. Anderson Cancer	USA	mpzhu@mdanderson.org
176	Zook	Bryan	Optivus Technology, Inc.	USA	zook@optivus.com