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ABSTRACTS

of the
PTCOG XVI MEETING

held in

Vancouver, British Columbia, Canada

March 30, 31 1992

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Dosimetry and Treatment Planning **Page**

Proton rat brain model

Marie-Helene Archambeau, John 0. Archambeau,
Loma Linda University Medical Center, Loma Linda CA.

In an ongoing study, a rat brain model is being used to assess changes produced by single dose fractions of 100 MeV protons.

The left hemibrains of 27 Sprague-Dawley female rats are irradiated with a modulated 100 MeV proton beam using single-dose fractions of 25, 30, 35, 40 and 50 Gy. The beam penumbra is 0.12 cm. The rats are weighed weekly and observed daily for behavioral and neurological deficits.

Interim (13 months) results show that the proton dose distribution is confined to the intended volume. Unlike animals receiving brain irradiation with x-rays, the rats did not develop an oral mucositis, and continue to gain weight proportionally to controls. There are no signs of behavioral or neurological deficits. T2 weighed MR images at monthly intervals document progressive, dose dependent periventricular changes. Histological assessment documents microvessel dilatation, periventricular demyalinization and necrosis. Computer assisted 3-dimensional reconstructions show microvessel dilatation, loss and an altered configuration. Using stereologic techniques the microvessel length density decreases from 535 mm/mm^3 to 390 mm/mm^3 following 30 Gy, but remains only slightly changed following 40 Gy. The changes produced in the left hemibrain occur at the same time and at the same dose level as those produced by x-rays, indicating a dose equivalence.

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Patient positioning: - PGI PPS prototype: MGH/HCL STAR. - linac derivative. - gantry concepts

Matthew Haggerty and Brian Vogel, Product Genesis Inc., Cambridge MA.

The PGI representatives provided an update of the Patient Positioner prototype developed for the MGH STAR unit now in operation at HCL. This update included a brief system description and development history, a report on current status, a discussion regarding continuing development activities and a videotape presentation of the machine used during actual treatment of an anesthetized child patient and a fully conscious adult patient. This video and its narrative explained the key steps in the treatment including patient installation, alignment, x-ray confirmation, bolus and water column adjustments and actual treatment.

Derivative design concepts for a positioner for linear accelerator applications were described next. This discussion addressed the differences in the design constraints imposed by the LINAC including the reduced treatment envelope, due to the LINAC itself and its existing couch, and the need for pitch and roll motions. This section closed with a discussion about the likely next steps including securing a partnership with a medical equipment manufacturer to continue the development and implementation.

The last segment of the presentation addressed patient positioning design concepts developed by PGI for the proposed MGH proton medical facility gantry application. This presentation included a brief discussion of the requirements and constraints imposed by a gantry beam delivery system, a sample of the positioning concept designs, and a more in-depth review of the recommended design approach noting its advantages over other concepts. This section closed with a discussion of next actions including exploration of an "internal gantry" between the large gantry and the patient bed (to permit a "relative" position system and a much less robust positioner) and exploration of patient "pod" devices.

The presentation closed with a question and answer session with the attendees.

Computer-assisted patient immobilization and repositioning system forfractionated small volume irradiation and radiosurgery - application to protontherapy

James G. Schwade, Pavel V. Houdek, Vincent Pisciotta, Xiaodong Wu, Jeffrey Fiedler, Arnold Markoe, Dept. of Radiation Oncology, University of Miami Medical School, Miami, Florida

The majority of cancer patients cannot benefit from the application of precision radiotherapy techniques unless a system for accurate and rapid patient positioning is available. We have developed a system that is based on low frequency magnetic field technology. A space digitizer, attached to a stereotaxic halo, is used to determine three target point coordinates and three Euler angles associated with target volume location and orientation. These six parameters are used for the original and subsequent patient set-ups as well as for monitoring of patient position during each treatment session. Although the system is currently used in an accelerator facility, we feel that its principles can easily be transferred to proton therapy applications.

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A Cranial Immobilization and Repositioning system for combined Proton and Photon Irradiation of Paranasal Sinus Tumors

S.J. Rosenthal, A. Thornton, Massachusetts General Hospital, Boston, MA

A new clinical implementation of hyperfractionated, accelerated radiation therapy employing combined photon and proton beams in the treatment of paranasal sinus tumors and other advanced head and neck malignancies has required the development of an immobilization system capable of sub-millimeter patient alignment. This new system which is currently in use at MGH was described in detail. It incorporates a prosthedontic device for dental fixation, a universal joint which rigidly locks to the natural angle of the patients head, and a thermoplastic mask for securing the patient to the dental device, The system is used to reproduce patient head position during simulation, CT and MR imaging and proton/photon radiotherapy treatments. Data was presented which used digitized pre-treatment and post-treatment radiographs and a computerized position analysis based on 3 implanted radio-opaque fiducial markers. The immobilization system repositions the patient to within 3 mm and 1 degree of rotation in the initial set-up step. Then the patient is brought to the prescribed position using the 3 implanted seeds as fiducial guides. Intratreatment motions was measured to be 0.6 ± 0.3 (S.D.) mm of isocenter translation and 0.4 ± 0.3 (S.D.) degrees of rotation about isocenter. This is an improvement over current immobilization without dental fixation.

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Automating Proton Therapy Patient Positioning I, REPOman

Kenneth Gall, Lynn Verhey, Massachusetts General Hospital, Boston MA, Miles Wagner, Harvard Cyclotron Laboratory, Cambridge MA

Alignment of radiotherapy patients with a proton beam is most often accomplished by radiographic means. Making hand measurements from radiographs and confirming the moves can be the rate-limiting step for patient throughput. We have developed a method for aligning patients based on stereoscopic localization of surgically implanted fiducial markers. The stereoscopic localization of the fiducials from plane film radiographs is facilitated with the use of a backlit digitization tablet. The repositioning algorithm directs output to the computer interfaced patient couch. This method permits fast (approximately 15 minutes) and accurate (< 1 mm, a, <1 degree, a) patient set-up. The system has been clinically implemented in the MGH/HCL proton therapy treatment program and is now in routine use for set-up of patents treated for base of skull and other cranial lesions.

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Automating Proton Therapy Patient Positioning II, Digital Radiography

Kenneth Gall, Massachusetts General Hospital, Boston MA.

When patients are aligned with treatment beams radiographically, as is the case with most proton therapy patients, **a** great deal of time can be taken processing and interpreting plane film radiographs. Some proton therapy centers have installed digital radiographic systems based on Image Intensifier (II) tubes to facilitate the instant acquisition of set up radiographs. However II systems are massive, expensive, and may impart significant geometric image distortion. A digital radiography system based on a cooled CCD camera and a Gd x-ray *intensifying* screen overcomes these problems. The system optical, electronic, and mechanical design is presented. The spatial and contrast resolution of the device is more than adequate to resolve radiographic anatomy needed to verify treatment alignment. These imagers are to be deployed in the proton therapy treatment rooms at the Harvard Cyclotron Laboratory.

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A stereophotogrammetric system using multiple digital cameras for the accurateplacement of patients during proton stereotactic radiosurgery.

G. van der Vlugt & H. Ruther (1), F. Vernimmen, (2), Dept. of Surveying University ofCape Town(1), Dept. of Radiotherapy Tijgerberg Hospital, Tijgerberg (2), South Africa.

To achieve the necessary immobilization and position accuracy for radiosurgery, mechanical devices have been used up till now; these however are not "patient friendly" and influence the dose/fractionation of the irradiation. A new near real time photogrammetric method has been developed to replace these techniques and improve patient comfort.

By way of CT-scan the coordinates of the tumor center and of markers placed on the head of the patient can be determined. These markers are also visible on the MRI, on angiography and have a reflective surface making them visible to the digital cameras. The vector between beam entry point and tumor must be aligned with the proton beam. It is therefore necessary for the CT-scan coordinates to be transformed into a new "desired" set of values reflecting the position of the head in its correct treatment position. This new set of "desired" coordinates is used as the goal when moving the patient into the beam line. When the patient is first seated in the special computer controlled chair, it is manually moved into the provisional treatment position. Then using digital photogrammetry with three cameras, the markers are coordinated. These values are then used to calculate the translations and rotations necessary to move the patient into the "desired" position. The chair's computer transforms these parameters into mechanical movements of the chair. After the movements are completed the markers are coordinated again to check that the patient is in the correct position. When this is checked the beam is switched on and the patient is closely monitored by the cameras for any movements until treatment is ended. If too big a movement is detected, the beam will be automatically switched off.

The basic photogrammetric routines for solving this application have been developed and the majority already programmed and tested. In-situ tests of the system will be required and minor changes to the user interface may be necessary for final optimization.

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Proton Beam Stereotactic Radiation Therapy with STAR, the PGI Patient Positioner - First Year Experience

S. J. Rosenthal, Massachusetts General Hospital, Boston, MA

A new clinical program for the treatment of brain lesions with single or few fraction stereotactic proton radiation therapy began treatments in April 1991. This is a joint program of the Departments of Neurosurgery and Radiation Oncology of the Massachusetts General Hospital. Treatments are delivered at the Harvard Cyclotron Laboratory in the small field beam line. A new patient positioner (STAR) was developed and built by Product Genesis Inc. (PGI) of Cambridge, MA to include 5 degrees of motions, 1/4 mm position accuracy and portability of the entire device. This report outlined the task of integrating the STAR positioner and the new program with existing and modified equipment. Areas of immobilization, *repositioning*, treatment planning, positioner to beam alignment, and treatment delivery required major work and innovation to get all components working together. The problems which arose and were solved during this year were discussed. This year has provided the necessary shake-down of a prototype patient positioner and a new therapeutic program. Currently 19 patient treatments have been completed with treatment times below 1 hour for three fields in some cases. The integration effort of this year has led to a practical clinical program using this novel positioning device.

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Quality control at the Centre A-Lacassagne proton facility, Nice, France.

N. Brassart, P. Chauvel, J. Herault

1. Reliability and accuracy of the treatment chair.

The technology of eye's treatment was already improved in other facilities and the treatment chair in Nice is, particularly, similar to those used in Villigin and Clatterbridge.

Six movements are possible: rotations of the chair, inclination and height (h) of the head, x, y, z displacements. The precision of the h, x, y, z displays of the control box is ± 0.1 mm. The patient is positioned as usual and immobilized by a bite block and a mask. To appreciate the implication of the mechanical accuracy and reliability of the chair, in the daily variation of the x, y, z coordinates necessary to obtain the exact positioning of the patient for each session, we first studied the movements of the chair under a mass of almost 60 kg. For each position of x,y,z indicated on the control box, we measured the exact position with an optical level. As a conclusion, for a small variation of 0.2 mm step in ± 1 mm range around different fixed positions, the linearity default is equal to the precision of the lecture, that means ±0.1 mm. We also studied the maximum difference observed between the four values accepted for the treatment of one patient and this for each of the three directions x, y, z and for all patients treated. These deviations are mainly included between 0 and 2 mm. Some larger differences are sparsely observed, mainly in the y and z directions. As the accuracy of the chair is ± 0.1 mm, for little variations around fixed positions, the largest differences observed in the daily positioning of the patients, are mainly due to the patient himself (sliding on the chair, dental status).

2. Quality assurance of the proton beam before treatment.

Since June 17 1991, we started ocular melanomas treatment with a 65 MeV proton beam. By April 92, 80 patients have been treated. The machine and the beam line have been previously described (Particles No. 9). The accuracy of the proton dose deposition and the possibilities offered by the 3D treatment *planning* need very well defined beam quality control criteria. The quality and the stability of the beam are verified each day before starting the treatments by studying: - the beam profile in air, without modulator and range shifter, which allows us to adjust the slope of the profile, - the Bragg peak - a half range modulated Bragg peak and profile, - the dose measurement at a fixed position to check the monitoring system of the beam. The homogeneity of the beam is tested by measuring the 95 to 90% width ratio on the profile. Dosimetry is performed following the "Code of practice for proton dosimetry". An intercomparison *including* a A.150 calorimeter was held in April 1991 in Orsay. Dosimetry intercomparisons between the centers of Clatterbridge, Louvain-la-Neuve, Orsay and Nice were held in Clatterbridge and Orsay. Presently the dose per unit monitor is measured before each fraction for every patient. The maximum difference from one day to another is, for 80% of the patients, <1.5% and, for 10%, between 1.5 and 2%. The largest differences observed correspond to one treatment week and are linked to a large variation of pressure during one day, the plate parallels chambers, even free air, lacking to achieve a correct equilibrium.

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A Monte Carlo Method for Predicting Loss of Tumor Control Due to Random Field Placement Uncertainties

Brian J. McParland, Department of Clinical Physics, Ontario Cancer Institute and Department of Medical Biophysics, University of Toronto

Patient motion, random field misalignments and changes in patient contour over the course of treatment can contribute to temporally-varying dose distributions within the tumor volume. This random nonuniformity of dose in space and in time can result in the loss of tumor control. In this work, the random and inhomogeneous dose distributions throughout a tumor volume due to field placement variations were calculated with Monte Carlo simulations and a biophysical model of tumor dose response used to estimate the resulting loss in tumor control probability (TCP). For a simple beam profile model, it is shown that this Monte Carlo method can predict the dependence of the TCP upon field margin, beam penumbra and magnitude of field placement uncertainty. An optimum field margin about the tumor yielding maximum tumor control can be specified using these Monte Carlo data, accounting for the effects of both tumor dose nonuniformity and the reduction in dose required to maintain normal tissue complications at a constant level. By selecting appropriate beam models and radiobiological parameters, this Monte Carlo method can be used to predict variations in local control for a wide variety of scenarios.

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Charged-particle radiosurgery for intercranial vascular malformations: Clinicalresults, sequelae and current directions*

JZ.P. Levy, J.I. Fabrikant, G.K. Steinberg[1], K.A. Frankel, M.H. Phillips, M.P. Marks[1], D.AForce.
Lawrence Berkeley Laboratory, University of California, Berkeley, and [1]Stanford University Medical Center, Stanford, CA

More than 450 patients with surgically-inaccessible intracranial AVMs have been treated with stereotactic helium-ion radiosurgery at LBL since 1980. Neuroradiologic follow-up indicates that the rates for complete angiographic obliteration 3 y after treatment are: 90-95% for treatment volumes < 4 cm3; 80-85% for volumes 4-14 cm3; and 60-70% for volumes > 14 cm^3. The rate and extent of AVM obliteration is a threshold phenomenon directly related to treatment volume and dose.

There have been no serious immediate complications, and no deaths have occurred from the radiation procedure. However, several distinct categories of delayed radiation injury have been identified, including vasogenic edema, occlusion of functional vasculature, and radiation necrosis. The rate of serious complications was about 11% (about half fully or partially reversible), but confined almost completely to patients in the earlier high-dose group treated with 28-45 GyE; the rate of delayed sequelae at current dose schedules (15-25 GyE) has been reduced to about 2-3%. Radiation injury is more likely when central brain structures are in the radiation field, or with increasing treatment volume.

Current research directions described include: (1) tailoring the distal edge of the Bragg peak on *a slice-by-slice* basis by means of individually fabricated computer-designed 3-D compensators for orthogonal or oblique beamports; and (2) application of charged-particle radiosurgery to the treatment of medullary-cervical AVMs.

*Research supported by the Office of Health and Environmental Research, U.S.
Department of Energy Contract DE-AC03-76SF00098

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Calculations of Proton transport in Water with Monte Carlo Program PTRAN,

Martin J. Berger, National Institute of Standards and Technology, Gaithersburg, MD.

The PTRAN code, currently under development, is designed to treat proton beams with initial energies from 50 to 250 MeV, and takes into account energy-loss straggling, multiple scattering deflections, and the absorption of protons in nonelastic nuclear reactions. Results are presented pertaining to 1-D and 3-D spatial distributions of the energy lost by proton beams in an unbounded water target. Proton energy spectra have also been calculated as functions of depth. Calculated depth-dose curves agree with measurements at the Harvard Cyclotron (158.6 MeV) and at PSI (214.3 MeV beam). Best agreement with experiment is obtained with the assumption that approximately half of the proton energy lost by protons in nuclear reactions is deposited locally via secondary charged particles.

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Beam characteristics of energy degraded protons at PMRC

Y. Takada, K. Takikawa, S. Suwa, T. Kusano, A. Tachikawa, K. Kurosawa, Y. Hayakawa,
and T. Inada, University of Tsukuba, Japan

Medical proton beam line using carbon energy degrader was constructed and successfully used for proton therapy for ten years. 500 MeV primary protons from KEK booster synchrotron are incident on the carbon degrader where the beam energy is degraded to 250 MeV. After the broad beam is collimated by 1 m-long iron collimator, it was momentum-analyzed by the magnetic system. The large energy spread of the
degraded beam is limited to 6p/p=±1.35% by the momentum slit. The beam is branched to two areas, the horizontal beam port and the vertical beam port, by switching on and off the bending magnet. Only a small portion of the beam (0.6%) is transported to the end of the beam line. We expand the beam using scatterers and obtain the necessary dose rate of 1-2 Gy/min at the patient position. Using the wedge placed at the momentum-dispersed position behind the 90° vertical bending magnet, the Bragg curve of the vertical beam has been improved.

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Routine Quality Assurance for a Proton Radiation Therapy Facility.

J.V. Siebers, D.W. Miller, M.F. Moyers, Loma Linda University Medical Center, Loma
Linda, CA.

Prior to first patient treatment each day, calibration and quality assurance procedures are completed to ensure treatment quality and dose delivery. Patient treatment calibration factors for each patient portal are derived from a patient calibration measurement, performed on a day prior to first portal treatment, and daily calibration measurements completed each treatment day.

$$TXcf = \textit{Patient Calibration CFx Da} \; \frac{\textit{Daily Calibration CF Tx Day}}{\textit{Daily Calibration CF Patient Calibration Day}}$$

This modifies the calibration factors to account for changes in detector sensitivity. Daily calibration factors are checked with respect to a reference calibration, and patient calibration factors are checked with respect to a simple calibration model. The percent standard deviation in the daily calibration factors for the primary and backup dose monitors are 0.78 and 0.80 respectively.

The beam range is verified at each energy by measuring the dose per monitor unit at several locations along a modulated peak. The maximum range deviation observed is 1.13 mm, and the standard range deviation, averaged over all beamlines, is 0.28 mm. Future daily calibration and quality assurance procedures will be simplified to allow the daily calibration and full beam range check to occur simultaneously. With development of a full calibration model, patient calibration measurements in most cases, will be unnecessary.

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Commissioning of Site Specific Treatment Planning Tools

M. F. Moyers, D. W. Miller, J. V. Siebers, R. Galindo, D. Ruotolo, D. Bobrow, P. Liu, Loma Linda University, Loma Linda CA.

Treatment planning for proton patients at Loma Linda University Medical Center is currently accomplished using the Massachusetts General Hospital's treatment *planning* system. Although this system has been in use in Boston for several years, Loma Linda has had to make several modifications to fit the local environment. These local modifications required testing in addition to that normally considered when commissioning a commercially available two-dimensional planning system. Specifically, seven major areas of testing were addressed: CT input, depth dose, heterogeneities, boluses, apertures, patient immobilization, and digitally reconstructed radiographs. This report briefly describes the tests performed on each of these items to ensure accurate and safe patient treatments.

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Recent Developments at the Loma Linda Accelerator

G. Coutrakon,, Loma Linda University Medical Center, Loma Linda CA.

Several upgrades have been achieved in the accelerator operations to improve patient throughput as well as beam quality for phase 2. In particular, the proton beam can be switched between treatment rooms at different energies in less than three minutes. This allows patient alignments to proceed simultaneously in both treatment rooms with no interruption for beam tuning. In addition, beam tunes have been performed in 5 MeV increments between 100 MeV and 250 MeV with greater than 80% extraction efficiency or a 2 x 10^{10} protons per pulse. Results of spread out Bragg peaks created by varying the energy from the accelerator are also presented.

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Pre-conceptual Design of a proton Therapy Accelerator

C. Ankenbrandt, T. Kroc, A. Lennox, L. Michelotti, S. Peggs, and C. Schmidt, Fermilab, P.O. Box 500, Batavia, IL.

Design concepts for a particle medical facility centered on a rapid-cycling, strong-focusing proton synchrotron for radiation therapy are presented, with emphasis on the accelerator physics aspects of the synchrotron called the Proton Therapy Accelerator (PTA). The accelerator and its ancillary beam delivery systems are simple and robust, leading to a safe, reliable, economical and easily maintained machine capable of meeting high beam performance specifications. The injector can also produce neutrons for boron neutron capture therapy (BNCT) and isotopes for positron emission tomography (PET). The design presented here is "pre-conceptual" in the sense that a final optimization of the *nominal* parameters has not been carried out.

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An improved isocentric gantry with reduced diameter for proton therapy byscanned beam.

Yves Jongen, IBA, chemin du Cyclotron, 2 - B-1348 Louvain-la-Neuve - Belgium

The isocentric gantry previously proposed by IBA to be used in beam scanning proton therapy has been revised to address some of the concerns expressed about this design (and about beam scanning in general).

Linking the beam scan to the integral of the beam current, selecting carefully the scan frequencies and introducing a large amount of pixel to pixel overlapping (each spot is re-irradiated more than 30 times) guarantees a very high field uniformity, despite possible beam current fluctuations or organ motions.

Locating the main energy degrader at the entrance point of the gantry allows a very easy and effective uncoupling between the gantry optics and the upstream beam transport system optics.

Designing the gantry to accommodate large beam emittances allows to achieve the energy degradation without having to sacrifice a lot of beam intensity.

Including an energy analyser in the gantry allows to maintain the distal fall-off similar to a monochromatic beam.

Designing a slot-shaped collimator with two fast, servo-actuated jaws allows to obtain the equivalent of a multi-leaf collimator with sharp lateral fall-off.

The other advantages (mostly the reduced radius of 2.5 m) of the earlier version of this compact gantry design have been maintained.

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An isocentric gantry of reduced diameter using the large field, beam scattering method for proton therapy.

Yves Jongen, IBA, chemin du Cyclotron, 2 - B-1348 Louvain - Belgium

We propose the design of a compact (radius = 2.80 m), isocentric gantry for large field (35 x 20 cm), scattered beam proton therapy. The large, uniform, fields are obtained by the double scattering method developed by B. Gottschalk and the Harvard/MGH group. However, in this gantry, the two scatterers are located inside the gantry optical system. Taking advantage of the magnifying properties of the gantry optics, it is possible to reach those large fields with smaller scattering angles, thinner scatterers and, finally, reduced energy loss (less than 10 MeV at 230 MeV). Locating the energy degrader at the entrance point of the gantry allows a very good uncoupling from the upstream beam optics. Unlike previous IBA designs, the large acceptance of the gantry allows to perform the energy degradation, and the beam flattening while preserving a fair proportion of the total beam intensity. The transmitted beam ratio is calculated to be approximately 20% for a beam degraded to 140 MeV and 10% for a beam degraded to 70 MeV. Including an energy analyzer in the gantry allows to obtain a distal fall-off quite similar to the distal fall-off of a mono-energetic beam. The design of the exit part of the gantry, and mainly of the last 90° magnet, is probably the most critical part of the study. The design of this last 90° magnet featuring an exit pole gap of 15 cm and width of 40 cm is described. This gantry can be used with the now classical energy modulating wheel and a patient specific fixed collimator. Alternatively, dose conformation would be possible using a step by step energy degrader and a fast, servo actuated, multileaf variable collimator.

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Update of the PMRC plan for proton therapy

Y. Takada, S. Fukumoto, H. Tsujii, T. Inada, A. Maruhashi, Y. Hayakawa, J. Tada, and H. Tsuji,
University of Tsukuba, Japan

PMRC is planning to construct the proton facility dedicated to cancer therapy. Our main target is to treat the deep-seated tumors. The original plan had the proton synchrotron as an accelerator and two rooms with fixed beam ports. In order to reduce the cost and incorporate recent developments, the plan has been updated. The new plan has an IBA-SHI cyclotron as an accelerator, a rotating gantry and the second treatment room with vertical and horizontal fixed beams. To reduce the size of the gantry, excentric gantry is proposed. To access the patient at the final position freely without rerotation of the gantry, an elevator room covering all the rotational positions is placed adjacent to the rotating treatment capsule. We propose a double scattering method using the dual-ring second scatterer to form a large uniform field in short length for the reduction of the nozzle length. It was found that this method requires relatively strict alignment of the beam axis (-1 mrad).

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The LBL/UC Davis Proton Therapy Project*

Jose R. Alonso, Lawrence Berkeley Laboratory, Berkeley CA.

The National Cancer Institute has issued grants to the Lawrence Berkeley Laboratory and the Massachusetts General Hospital to perform design studies for proton therapy facilities to be located in a hospital setting. LBL and MGH have been working in a collaborative manner to develop plans and specifications for these facilities. It is our intention that selection of the final contractor for construction of accelerator and beam delivery components will be based on clinical specifications developed jointly by LBL and MGH. LBL has formed a partnership with UC Davis, so that now LBL's design studies will be focused on developing the UC Davis Proton Therapy Facility (PTF) on a site adjacent to the new Cancer Center in the UC Davis Medical Center in Sacramento, California. During this year UC Davis is identifying the issues associated with construction of the PTF: building site and space requirements, environmental and regulatory problems, and is developing a financial plan for construction of the PTF. LBL is concentrating on studies relating to the technical components of the PTF. "Critical Technology" issues have been identified, areas where performance of presently-operating proton therapy projects have fallen somewhat short of the most desirable specifications, or where design optimization studies might contribute to significant performance and/or cost improvements. Contracts are being prepared to perform studies in these areas. Industry will be heavily involved in these studies, it is LBL's intention to subcontract most if not all of these studies to the private sector. The final design process will begin early in the next calendar year, actual construction is anticipated to start in late 1993 or early 1994. Enthusiasm level is *very* high throughout UC Davis and LBL, exemplified by the recent signing of a Memorandum of Agreement by the LBL Director and the UC Davis Chancellor to jointly work towards making the PTF a reality.

*Work supported by the National Institutes of Health, National Cancer Institute, under Grant CA 56932

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Progress of the joint Sumitomo-IBA cyclotron based proton therapy system.

Yves Jongen, IBA, chemin du Cyclotron, 2 - B-1348 Louvain-la-Neuve - Belgium

The cyclotron-based proton therapy system initially proposed by IBA is now the subject of a joint development effort between Sumitomo Heavy Industries of Japan (SHI) and IBA. According to the agreement, signed on October 17, 1991 the development of the system is shared between the two companies.

Marketing and production for America and Europe will be mainly the responsibility of IBA, while for Asia it will be mainly the responsibility of SHI.

The physical design of the magnet is now completed, and the mechanical design is in progress. Requests for quotations are now issued to steel foundries and to coils manufacturers. An interesting new feature has been proposed by the IBA team leader Andre Laisne. The magnet gap, which in this cyclotron follows radially an elliptical pattern, is now completely closed in the hills at extraction. This patented configuration allows to maintain a very isochronous field up to the maximum pole radius. Extraction, central region and RF system design is also underway.

Two isocentric gantries, one using the scanned beam method and the other using the large field, scattered beam method are developed and are the subject of other presentations at this meeting.

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The North Carolina Storage Ring Project.

J.R. Mowat and D.E. Sayers, Dept. of Physics and College of Physical and Mathematical Sciences, North Carolina State University (Raleigh), E. Chaney and J.E. Tepper, Dept. of Radiation Oncology, University of North Carolina School of Medicine (Chapel Hill).

North Carolina State University is presently sponsoring feasibility studies for a regional storage ring laboratory to be constructed in Raleigh during the mid-to-late 1990's. Serious consideration is being given to incorporating proton therapy as a major component of the laboratory's program, one which will co-exist with synchrotron radiation components. This will be done in collaboration with the Department of Radiation Oncology at the UNC School of Medicine and will offer service to the entire Southeastern US region. We will present a status report, including a timetable for development, a brief discussion of the main programs envisioned that fall within the broad scientific scope of the storage ring project, and the management challenges they present.

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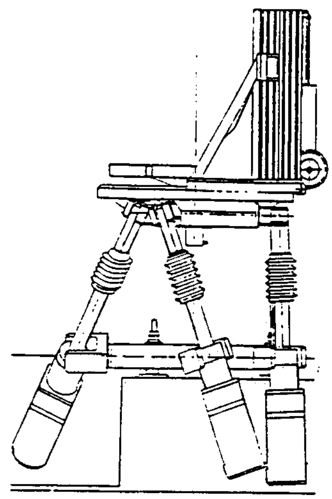
CPO patient contention system
A. Mazal, Centre de Protontherapie d'Orsay, Orsay, France.

6 actuators, PC driven,
step by step motors, 6 degrees of freedom.
$\Delta x = \Delta y = \pm 200$ mm; $\Delta z = 300$ mm;
$\Delta\theta x = \Delta\theta_y = \Delta\theta z = \pm 15°$.
Additional rotation (vertical axis): 360°.
Resolution = 1/10 mm;
reproducibility = 1/10 mm;
speed = 1 cm/s.

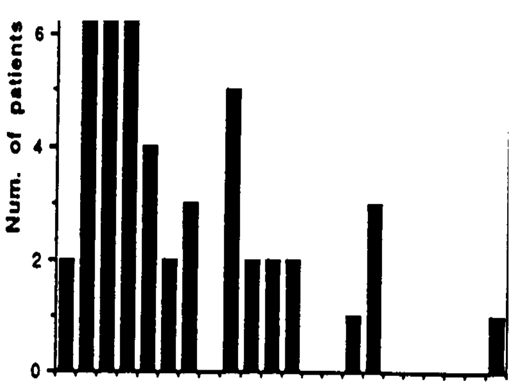


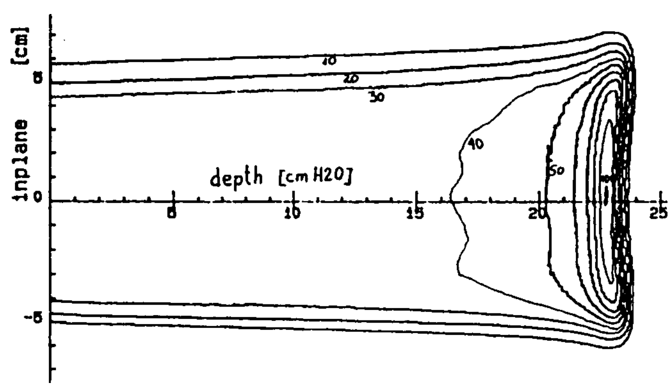
CPO status report
A. Mazal, Centre de Protontherapie d'Orsay, Orsay, France.

Synchrocyclotron, 200 MeV, completely devoted to medicine.
First patient (uveal melanoma): Sept. 1991. Patients treated (march 1992): 48
Present treatment scheme: 4 fractions x 15 GyE (RBE 1.1), 1 week/month, 12 pat./week
Under development: a) 200 MeV, $\phi = 10$ cm, brain tumors, same line; b)2nd room shielding, scattering models; c) intercomparisons, radiobiology, microdosimetry.

CPO n° of patients: 48 (March 1992)

Max is 7 patients: graph is truncated





Tumour volumes (cc)