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A Newsletter for those interested in proton, light ion and heavy charged particle radiotherapy.

Number 13 January 1994 Editor: Janet Sisterson Ph.D., HCL

This is the **thirteenth** issue of Particles, a newsletter devoted to matters of interest to all those involved, or planning to become involved in proton, light or heavy ion and heavy charged particle radiation therapy.

Mailing Lists: The "PTCOG" mailing list and the "Particles" mailing list have been merged, so that all on the PTCOG mailing list should get Particles too. PLEASE help me keep this list up-to-date by sending me address corrections. If you no longer want to receive our mailings let me know.

At the PTCOG XIX meeting in Cambridge, the Steering Committee discussed methods of funding the newsletter. It was decided to continue as we have been doing and allocate a portion of the registration fee for PTCOG meetings to cover most of the costs of producing both Particles and the compilation of the abstracts from the PTCOG meetings. In addition, HCL is always happy to receive financial gifts to help cover the cost of producing Particles; all such gifts are deductible as charitable contributions for federal income tax purposes. The appropriate method is to send a check made out to the "Harvard Cyclotron Laboratory".

Facility and Patient Statistics: I am still collecting information about all facilities, both operating and proposed, regarding patient statistics, machine and treatment characteristics. Please send me up-dated information. The data are still not complete but I will be happy to share what I have with others. I hope that I can get to the point where the database only requires updating each year.

ARTICLES FOR PARTICLES 14

The deadline for news for Particles 14 is May 30 1994, for the July 1994 issue. I will send reminders by fax or e-mail. Address all correspondence for the newsletter to:

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Harvard Cyclotron Laboratory
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Cambridge MA 02138

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Articles for the newsletter can be short but should NOT exceed two pages in length. I **DO** need a good clean copy of your article and figures as I am using a scanner to get the text into the computer, but cut-and-paste the figures. If you FAX me an article, please indicate if a clean copy is in the mail. If I only get a single-spaced FAX copy, you may get typos! I think I can scan a double-spaced copy. As far as I am concerned, the very best way to receive an article is by using e-mail as then I only have to down-load it from the VAX to my MAC; I would like to see more people make use of this method.

FUTURE PTCOG MEETINGS

The times and locations of the next PTCOG meetings are as follows:-

PTCOG XX	Chester, England	May 16-18 1994
PTCOG XXI	Japan	Fall 1994
PTCOG XXII	North America	Spring 1995
PTCOG XXIII	South Africa ??	Fall 1995

If you wish **to join PTCOG**, please contact the secretary of PTCOG, Dan Miller, Department of Radiation Oncology, Loma Linda University Medical Center, 11234 Anderson Street, Loma Linda CA 92354. Telephone (909) 824-4378.

PTCOG XX; May 16-18 1994 Chester, England.

PTCOG XX will be hosted by the Douglas Cyclotron Unit, Clatterbridge Center for Oncology and will be held in the Moat House, Chester England.

PTCOG XX (Chester) Secretariat:-

Dr. Andrzej Kacperek (Chair)
Douglas Cyclotron Unit
Clatterbridge Centre for Oncology
Bebington, Wirral, L63 4JY
U. K.
Tel: (0)51 334 6366
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Mrs. Susan Nixon (Secretary)
Physics Department
Clatterbridge Centre for Oncology
Bebington, Wirral, L63 4JY
U. K.
Tel: (0)51 334 4000 ext 4164

There will be a welcoming reception in the Council Chamber of Old Chester Town Hall on Sunday 15 May between the hours of 6 pm and 8 pm where pre-registration will take place. Later arrivals can register at the Moat House on Monday 16 May from 8:30 am. The conference hotel has photocopying and international phone and fax facilities.

The provisional registration fee is set at £110. This includes lunch on Monday 16, Tuesday 17 and Wednesday 18 May; a Medieval Banquet and entertainment at Peckforton Castle, close to Chester on the evening of Monday 16 May; and a visit and buffet reception at the Cyclotron Unit and Radiotherapy

Centre, Clatterbridge on Tuesday May 17. A daily registration fee will be arranged. Guests are welcome but will be charged for the Medieval Banquet and the buffet reception at the Cyclotron.

The registration fee is payable in cash sterling or cheques made payable in English pounds to the **Clatterbridge Centre for Oncology**. No credit card facility is available.

HOTEL INFORMATION:

Block bookings have been reserved at hotels in Chester all within easy walking distance of the meeting venue. When booking a room mention the PTCOG XX meeting.

You must make your own reservation at the hotel by Monday April 18 in order to reserve a room in the PTCOG block.

All hotels are priced per night and include a full English breakfast. The hotels recommended are:

The Mill Hotel
Milton Street
Chester
CH1 3NF
Tel: 0244 350035
Fax: 0244 345635
Contact: Sarah
Room rate: £44.95 single/£54.95 double room

Blossoms Hotel
St. John's Street
Chester
CH1 1HL
Tel: 0244 323186
Fax: 0244 246433
Contact: Diane Randall
Room rate: £60 single/£90 double room

Moat House International (venue)
Trinity Street
Chester
CH1 2BD
Tel: 0244 322330
Fax: 0244 316118
Room rate: £70 single/£100 double room

Riverside Hotel
22 City Walls
Lower Bridge Street
Chester CH1 1SB
Tel: 0244 326580
Fax: 0244 311567
Room rate: £33 single/£44 double room

Contact the Chester Tourist Board for general information; Tel: (0)244 324324; Fax: (0)244 324338. A map of Chester and other information will be available with the next flyer.

FLIGHTS: There are direct British Airways flights to Manchester airport from the following airports: Chicago, New York, Amsterdam, Berlin, Dusseldorf, Frankfurt, Hanover, Munich, Brussels, Belfast, Dublin, Edinburgh, London, Geneva, Zurich, Madrid, Paris and Rome.

Trains leave frequently from Manchester to Chester. Pre-booked taxi-cabs can be arranged by the hotels.

Intercity train service is available form London (Euston) to Chester.

PRELIMINARY AGENDA

Subjects to be discussed include:-

- Latest research and clinical results in proton and charged particle radiotherapy.
- Problems in charged particle dosimetry including the results of intercomparisons.
- Charged particle radiobiology.
- 3D treatment planning including Monte Carlo and radiobiological data.
- Comparison of cyclotrons, proton linacs and linac boosters.
- Proton ophthalmology including clinical protocols, reviews, follow ups, planning improvements and beam line optimization.
- Suggestions and ideas from other groups and centres would be appreciated. It is planned to leave sufficient time for debate and discussion.

Abstracts for PTCOG XX

Speakers are invited and encouraged to submit an abstract of their presentation, which will be circulated AFTER the meeting with the next issue of Particles. These abstracts will be collected at the meeting or they may be sent to Janet Sisterson.

The abstract must include the title, authors and affiliation and not exceed 1/2 page in length. Line drawings and graphs are welcome.

PTCOG News

The following reports were received by December 1993.

News from the **Douglas Cyclotron Unit, Clatterbridge, Wirral, UK**:

We treated 140 eye patients in the last calendar year, which makes a total of 463 eye patients up to January 1994. All were uveal melanomas except for 3 choroidal haemangiomas and 2 conjunctival melanomas. We have been treating with protons since 1989 and a review of our clinical results will be presented at the Chester PTCOG meeting. Patient referrals from the three UK ophthalmological centres have shown a steady increase of about 15% per year.

Much of our present activities will be spent in organising the next PTCOG meeting, details of which appear elsewhere in this issue. *A. Kacperek, Douglas Cyclotron Centre, CCO, Bebington, Wirral, L63 4JY, UK.*

Status report of the proton therapy facility at the **Hahn-Meitner-Institute, Berlin, Germany**

Since 1992, great interest was issued to build a proton therapy facility for the treatment of uveal melanomas both from accelerator physicists at the Hahn-Meitner-Institute (HMI) and ophthalmologists of the Free University in Berlin.

The location of a therapy facility in Berlin is unique in Germany, since the Berlin ophthalmologists have gained large experience in treating patients with proton beams in collaboration with Nice and the VICKSI cyclotron at HMI is at the moment the only accelerator in Germany where a 72 MeV proton beam is available. In June 1993, a contract between HMI and the Klinikum Steglitz was signed to manifest the intention to install a proton therapy facility at HMI and fix a time schedule and financial support.

In the meantime, measurements of 72 MeV proton beam profiles and dose distributions have been carried out to guarantee a beam delivery with the required safety features for patient treatment. A beamline was re-constructed for experiments with the proton beam. A computer code for Monte-Carlo simulations of proton stopping and scattering was developed. However, the cyclotron building has to be modified to provide a waiting room and allow easy admittance to the irradiation room. The completion of this work and the treatment of the first patients is scheduled for 1995. *Juergen Heese, Bereich Schwerionenphysik, Hahn-Meitner-Institut Berlin GmbH, Glienicker Str. 100, D-14109 Berlin, Germany.*

First Patient treated at the **Indiana University Proton Therapy Center, Indiana, USA**

On September 28th, 1993 at 7:20 p.m. CDT the Indiana University School of Medicine became the 3rd active proton radiation therapy center in the United States. 200 MeV protons from the Indiana University Cyclotron Facility (IUCF) were delivered to a patient as part of the treatment for anaplastic astrocytoma of the brain.

A proton dose of 1500 cGy was delivered in five fractions (ending Sunday, Oct. 3rd) as a boost to photon therapy. Each fraction was equally divided among three ports. The protons treated the tumor plus 1 cm margin using a 4 cm spread out Bragg peak. Two novel features of this new treatment center are the dose monitor detectors and the control system. The dose was monitored by secondary electron emission monitors instead of more common ion chambers, and the proton dose was delivered by a computer controlled system.

Support for the creation of this proton radiation therapy center was provided by Indiana University, the Marion County Cancer Society, and the Lions Cancer Control Fund of Indiana, Inc. Special thanks are also due to the entire staff at IUCF for their cooperation and assistance over the past 3 years. *J. Morphis III, M.D. and Charles Bloch, Ph.D. Department of Radiation Oncology, Indiana University, 535 Barnhill Drive Indianapolis, IN 46202-5289 and Indiana University Cyclotron Facility, 2401 Milo B. Sampson Lane, Bloomington, IN 47408-0768.*

Update on the Ion Beam Therapy Project at **COSY-Julich, Germany**.

On April 1,1993 the cooler synchrotron and storage ring COSY-Julich was officially inaugurated. The wide range of energies (50-2500 MeV) provided by COSY and the possibility to change the energy actively from pulse to pulse in small steps without using beam degrading absorber materials has guided the considerations for the layout of the therapy site. A rotating gantry is intended to permit the same flexibility in choosing the treatment angle(s) as in conventional radiation therapy and a 3-D scanning system is foreseen to enable tumor conformal treatment. The release of a part of the COSY hall previously anticipated for a future extension has facilitated the idea to install a rotating beam line very much. Height restrictions in the originally assigned area (Site I) which would have permitted only a 'sector' gantry with partial rotation do not exist at the new site.

Site I can now be projected for pretherapeutic physical and biological studies and as test site for individual components of the medical beam line. It will be equipped with a horizontal beam line providing the same beam quality as at the actual therapy site (site II). At the beginning, however, the beam intensity at site I will be limited to only $2x10^7$ protons/s. We decided to accept this compromise to facilitate radiation protection measures and accelerate the commissioning. The official approval of the construction plan for site I has just been received. We hope to be able to start with the pretherapeutic dosimetry program in February of 1994. Beam characteristics, e.g. number of particles, beam profile, energy distribution, absolute dose, dose profile in air and tissue equivalent phantoms with (cooled) proton beams of 50 to 250 MeV will be measured.
In November we hosted a Workshop in Bonn for possible regional users, legislators and colleagues from the surrounding universities. Thanks again, in particular, to all the international speakers who joined us and made the meeting a success. U. *Linz, Forschungszentrum Julich (KFA), IKP, Postfach 1913, D-52425 Julich, Germany*

News from **Loma Linda University Medical Center, USA**

In 1993, proton-beam irradiation continued to expand. Treatments were administered via the gantry and the stationary beam lines, while the "uptime" of the synchrotron and these delivery systems continued to exceed 98%. Protons were delivered to patients having melanomas and other ocular and orbital malignancies; pituitary adenomas; acoustic neuromas, meningiomas, craniopharyngiomas, astrocytomas and other brain tumors; chordomas and chondrosarcomas; cancers of the head and neck; prostatic and other pelvic neoplasms; paraspinal tumors; and sarcomas of soft tissue. As of October 31st, 682 patients had received proton-beam irradiation since the Proton Treatment Center opened in October, 1990. Continuing a trend noted in previous years, most proton-beam patients, more than 400 by the end of 1993, were treated for adenocarcinoma of the prostate.

It was necessary to operate the gantry 12-15 hours a day to accommodate the demand for proton-beam therapy. During 1993, work aimed at alleviating this load continued, as LLUMC engineers activated the second and third gantries. By the end of the year, both gantries were carrying beam; gantry 2 was being commissioned in December, 1993, and gantry 3 will be undergoing commissioning in February, 1994. Both will be treating patients in early 1994. The research beam room was also being completed at the same time; it too will be available in 1994, thus providing dedicated space for radiobiological, physics and engineering research. Heretofore, researchers have been required to use the clinical beams when they were not being used to treat patients. Developmental work on the second and third gantries was aimed not merely at duplicating the capabilities of the first, but exceeding them. The gantries feature a new

beam-spreading system, which will be capable of delivering protons to fields as large as 40 x 40 cm, and will allow faster treatments of smaller fields. Many components on the new gantries are themselves new or redesigned, and will be retrofitted to the first gantry. As the gantries were being prepared, work proceeded on a control system which will permit rapid and, eventually, continuously variable energy changes and rapid switching of beam from one treatment room to another, as well as the use of a scanning beam.

Collaborative clinical research continued at LLUMC through participation in cooperative groups and in collaboration with other proton therapy investigators in the Proton Radiation Oncology Group (PROG). LLUMC investigators worked on several new protocols during 1993, including those for lung cancer, esophageal carcinomas, primary tumors of the liver, and bladder carcinomas.

The department of radiation medicine and LLUMC's departments of neurosurgery and neuroradiology are collaborating with investigators from Stanford University Medical Center and Lawrence Berkeley Laboratory in a study of proton treatment of arteriovenous malformations in the brain. Clinical evaluation of patients is performed at Stanford; therapy planning is done at LBL; and treatment is given at LLUMC, although all three components may be performed at LLUMC for local patients. A vacuum-assisted bite block, developed at LLUMC, is employed in the study, and instructional materials are being developed to extend that technology to the collaborating institutions.

During 1993 the Advisory Board of the National Cancer Institute indicated its interest in the Loma Linda University Cancer Institute (LLUCI) and the Proton Treatment Center's role in it. NCI personnel, including the Director of the Radiation Therapy Division, site-visited LLUMC and LLUCI in December, 1993 and will do so again in January, 1994.

Basic and applied research continued during 1993. LLUMC investigators continued work with scientists from East Carolina University, on the biological effectiveness of proton beams relative to conventional forms of radiation. Collaboration also continued with Clarkson University investigators into proton-beam microdosimetry. At LLUMC, physics research is being performed on calibration dosimetry for proton beams with a water calorimeter; this work should allow the establishment of national and international standards for proton-beam dose calibration. LLUMC physicists are also investigating new radiation detectors for proton-beam dosimetry, including a solid state detector that uses signals liberated from a diamond.

In addition to ongoing radiobiological studies of the effect of radiation on the microvasculature of the rat brain, and stereologic measurements of the late changes resulting therefrom, a joint NCI-sponsored radiobiological project with NASA and Lawrence Berkeley Laboratory is underway. The latter work employs proton beams to simulate outer-space radiation and helps define the human body's response to such radiation.

In recognition of the international interest in protons as a treatment modality and as a subject for basic radiobiological and physical research, the department continued efforts to expand its PROLIT literature database into an interactive vehicle for international working groups. *William Preston, Loma Linda University Medical Center, P. O. Box 2000, 11234 Anderson Street, Loma Linda, CA 92354.*

Cost comparison between proton and conventional photon facilities

As more hospital-based dedicated proton medical facilities are either planned or being constructed, criticizing opinions are heard from the conventional radiation therapy community as well as the medical community at large. There is really no debate on the clinical superiority of the proton beams over the photon beams; the main argument is that protons cost too much.

The proton opponents usually, and erroneously, compare the initial capital cost of a proton facility with that of one conventional linac facility. A correct way will be to analyze the capital costs of two kinds of facilities that can treat comparable number of patients to the same degree of cancer-cure efficacy. In other words, the cost of one proton facility should be compared with that of several linac facilities that can perform a comparable number of 3-dimensional conformal therapy deliveries within a given time. Such a comparison is made in the analysis below. Very conservative figures are assumed in comparing these costs. The conclusion is that one proton facility can treat the same number of conformal therapy patients as ten linac facilities. As the useful life of a proton accelerator is 25 ~ 30 years and that of linacs is 10 ~ 12 years, these ten linacs must be replaced at least once during the lifetime of a proton accelerator. The conclusion is that the capital cost of a proton facility is smaller than, or at least comparable to, that of photon facilities of comparable clinical capability.

Concerns have been expressed whether the health-delivery systems that need large capital investments, such as the proton facility, will do well under the new health-care paradigm of the US administration. Three arguments are presented here in support of proton therapy. First of all, as shown in the analysis, when spread out over 25-30 years, the capital cost of proton therapy is not any larger than that for conventional photon therapy. Also, the capital cost of conventional photon treatment is about 25% of the entire treatment cost; the delivery cost of (conventional) radiation therapy is dominated by the labor, and not by the facility cost

. The capital cost of proton facilities can be well absorbed if the clinical results are superior to that from photon treatment. When the costs are about the same for either proton or photon treatment modalities, it is clear that the one that gives you higher cancer cure with lower complication will win, and the protons will be the winner over photons in every clinical analysis. Secondly, if a treatment results in a local failure, the treatment is not cost effective however inexpensive is the cost of the treatment. About 20% - 30% of patients treated now by conventional photon therapy will definitely benefit from proton treatments. For these patients, proton treatments are surely more cost-effective than the conventional photon treatments. Finally, it is pointed out that the most active interests in proton therapy is in European countries where the socialized medicine is a norm. Similarly, the protons will fare well in the new US health-care environment of managed competition.

A comparison of the costs of conformal therapy delivery
by proton facility vs. photon facility

(The analysis is for treating the same number of patients in two types of facilities)

	Conformal therapy using a **proton** synchrotron	Conformal therapy using **photons from electron linacs**	Multiplicative factor for photon facilities to equal the capability of a proton facility
BASIC COST	Technical components (synchrotron, beam switch-yard, 3 gantries plus 1 fixed beam, and beam nozzle) ~ $25M Conventional facility ~ $25M	Technical components (a linac, adopted for conformal therapy delivery, such as Peacock)~ $2.5M Conventional facility ~ $2.5M	**Wrong conclusion:** The capital cost of a proton facility is 10 times that of a photon facility.
# of therapy rooms	4	1	× 4
# of ports for conformal therapy	2 ~ 3 ports	5 ~ 8 ports	The length of time to finish each course of treatments × 1.5 ~ × 3.0
Conformal therapy delivery per hour	2 ~ 3 tx/hour (capable now)	0.5 ~ 2 multiport tx/hour (eventually possible when developed)	
# of fractions per treatment	potentially fewer than 32 fx/tx	~ 32 fx/tx	× 1.2
Useful life of the accelerator(s)	Useful life of synchrotron facility ~25 ~ 35 years	Useful life of linacs ~ 10 ~ 12 years	× 2
NET MULTIPLICATIVE FACTOR			× 14 ~ × 28, take × 20 as a nominal figure

Conclusion: 1 proton facility can treat the same number of conformal therapy patients as 10 photon facilities, which must be replaced after ~10 ~ 12 years. The cost of the photon facilities equivalent to a proton facility is shown in the next page.

	Conformal therapy using a **proton** synchrotron	Conformal therapy using **photons from electron linacs**
COST COMPARISON OF PROTON VS. PHOTON FACILITY		
Cost of technical components in 25 years	Needs one synchrotron as its useful life is ~25 ~ 30 years $25M	10 linacs = $2.5M × 10 = $25M, to be replaced after ~10 ~ 12 years =$50M
Cost of conventional and ancillary facilities	$25M	to house 10 linacs $2.5M × 10 = $25M
Total cost of the therapy facility in 25 years	**$50M**	**$75M**
OPERATING COST		
Maintenance	Maintenance of 1 proton facility	Maintenance of 10 linacs, definitely more expensive
Conformal therapy planning	1 ~ 3 ports Proton Tx planning is easier than for photons as proton tx requires fewer ports.	5 or more ports, therefore more expensive
COST OF PATIENT PREPARATION		
Immobilization	Only 2 ~ 3 ports for conformal therapy, therefore immobilization is easier.	Probably longer tx times due to many ports, therefore immobilization is more difficult.
Variable aperture	Multileaf collimator	Multileaf collimator
Compensator	Not required	May require for each of >5 ports
CLINICAL IMPLICATIONS	No exit dose. There are some clinical cases that can be treated using protons but not by photons.	Always there is an exit dose — integral dose is larger; dose to normal tissues is larger

William T. Chu. Lawrence Berkeley Laboratory, University of California, Berkeley CA 94720.

Proton Therapy commences at **NAC, South Africa**

On 10 September 1993 the first patient was treated on the NAC's 200 MeV horizontal beam proton therapy facility. This beam is being used initially for small-field crossfire irradiations on Fridays only for the treatment of intracranial lesions. The strategy of starting in this manner is to allow personnel to get used to the equipment and techniques with a relatively simple beam set-up. The procedures for preparing the patient for treatment with our patient positioning system is labour-intensive and time-consuming and accounts for the relatively small number of patients treated to date. However, this aspect should become less demanding as experience is gained. The SPG (stereophotogrammetric) patient positioning system is working very well although there remain some areas where improvements can be made. The intrinsic accuracy of the SPG system itself is ±0.5 mm. A patient can typically be set up in 7-10 minutes.

Up to 30 November, 6 patients had been treated. All treatments consisted of 4-5 fields given in 1-3 fractions. The conditions treated were either brain metastases or arteriovenous malformations. It is planned to commence SOBP treatments early next year and later fractionated (3/week) treatments. A further treatment room is available for a possible additional proton beam configuration such as an isocentric gantry.

The neutron facility continues to run most reliably and 538 patients have now been treated. *Dan Jones, National Accelerator Centre, P.O. Box 72, Faure, South Africa.*

News from **Yale Medical School** and **Harvard Cyclotron Laboratory**:

Three dimensional dose distributions for 160 MeV protons using magnetic resonance imaging of the tissue-equivalent BANG polymer-gel dosimeter

We tested the response of the newly developed tissue-equivalent BANG polymer-gel dosimeter to high energy protons (Maryanski M. J., Schulz, R. J., Ibbott G. S., Gatenby J. C., J. Xie, Horton D. and Gore J. C., "Magnetic resonance imaging of radiation dose distributions using a polymer gel dosimeter", submitted to Physics in Medicine and Biology 1993). The gel is composed of an aqueous gelatin and, like its prototype BANANA gel, is infused with acrylic monomers (Maryanski M. J., Gore J. C., Kennan R. P. and Schulz, R. J., "NMR relaxation enhancement in gels polymerized and cross-linked by ionizing radiations: a new approach to 3-D dosimetry by MRI", Magn. Reson. Imaging 11 253-8, 1993). Absorption of ionizing radiation in the gel causes localized polymerization of the monomers which, in turn, reduces the transverse NMR relaxation times of water protons. The spatial distribution of relaxation times, which is permanent and depicts the dose distribution, can be measured with high resolution using clinical MRI scanners and standard pulse sequences. So far the dosimeter has been tested for response to low-LET radiations. Here we report preliminary results from a first experiment with 160 MeV proton beam, performed at Harvard Cyclotron Laboratory.

Two liter gels were prepared in glass Erlenmeyer flasks and were stored at room temperature for two weeks, then transported from New Haven, Conn. to Cambridge, Mass. for proton irradiation. All flasks containing gels were irradiated horizontally through the bottom, with circular fields modulated so that the plateau was 3.5 cm long and the maximum depth of penetration was 9 cm. Dose-response curves (1/T2 as a function of dose) were obtained in two Erlenmeyer flasks, each given doses in the plateau of 2, 4, 6 and 8 Gy using 4 cm diameter fields. Dose distributions were obtained in two Erlenmeyer flasks using 6.5 cm diameter fields. Following the irradiations, the gels were taken back to New Haven where magnetic

resonance imaging was carried out repeatedly over a two-week period using a research-dedicated 1.5 T GE Signa scanner at Yale Magnetic Resonance Center. All the data obtained from each pair of irradiations were essentially the same.

Figure 1a shows the dose map coplanar with the axis of the beam. The same dose map with superimposed isodose curves is shown in Figure 1b. Isodoses correspond to 4, 5, and 6.5 Gy ± 2%. The central axis depth dose profile (Figure 2) was also derived from Figure 1a. Figure 3 shows the visual appearance of the same BANG gel.

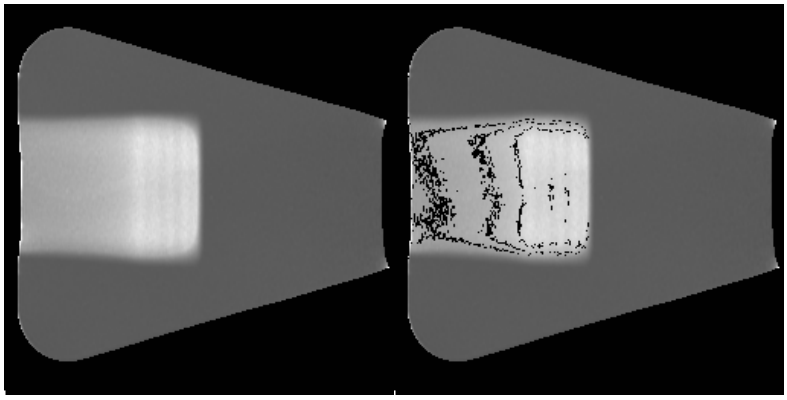
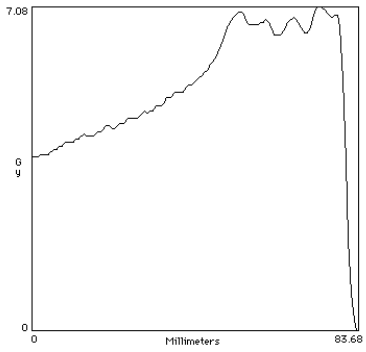


Fig. 1a Fig. 1b



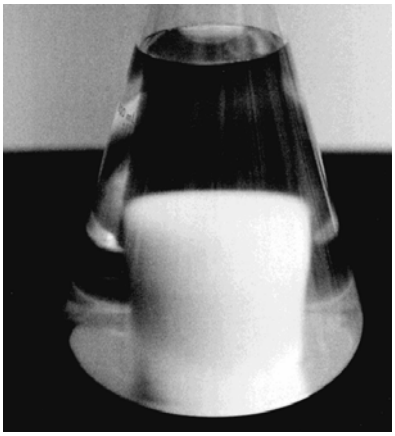


Fig. 2 Fig. 3

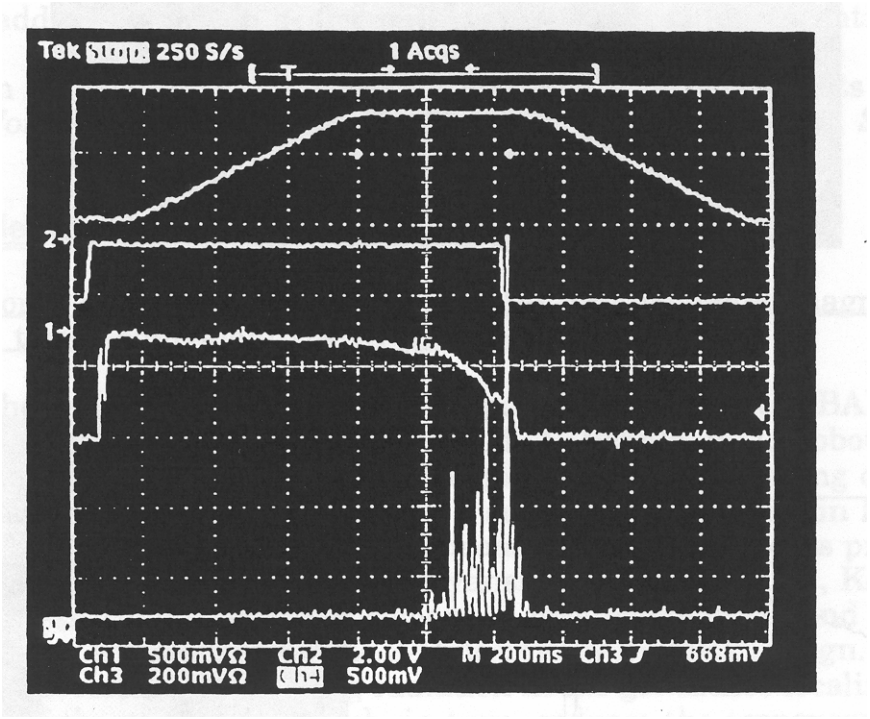
The results demonstrate the feasibility of the method, and more comprehensive studies of the BANG polymer-gel's performance for proton beam dosimetry are planned. *M J Maryanski[1], R J Schulz[1], J C Gore[1], A Koehler[2], C Mayo[2], [1]Yale University, 333 Cedar St, New Haven, CT 06510 and MGS Research, Inc., 25 Science Park, New Haven, CT 06511. [2]Harvard Cyclotron Laboratory, Cambridge MA 02138*

News from **HIMAC, Chiba, Japan**

Construction of the building and installation of all facilities of the HIMAC (Heavy Ion Medical Accelerator in Chiba) were completed at the end of September. Therefore, the celebration of the HIMAC completion was done on October 13th, inviting the Ex-Prime Minister Mr. Y. Nakasone who advocated "Comprehensive 10 year strategy for cancer control".

The injector beam commissioning has been done since last March. Most of the medically required ions have been accelerated as the specifications of the injector. The other area from the main accelerator synchrotron rings to treatment rooms were fixed as the radiation control area on November 15th. The beam injection to the synchrotron was started on Nov. 18th. After the successive success of multi-turn injection and rf-acceleration at the HIMAC synchrotron rings, we have succeeded in the slow beam extraction.

The first result of the 230 MeV/u helium ion beam extraction from synchrotron on December 10th is shown in a photograph.



1st line: Synchrotron quadrupole magnet current.
2nd line: rf-acceleration voltage.
3rd line: Circulating beam intensity, which decreases being coincident with the beam extraction.
4th line: Extracted beam intensity observed by a plastic scintillation counter.

The beam was transported to each irradiation room and the beam profiles were observed at just before the treatment rooms. We hope the physical dosimetry and biological experiments will start in early next year using 290 MeV/u carbon beam. *Kiyomitsu Kawachi, Division of Accelerator Physics and Engineering, National Institute of Radiological Sciences, 9-1, Anagawa 4-chome, Inage-ku, Chiba-shi 263, Japan.*

Status Report December 1993: **H**eavy **I**on **T**herapy **at GSI (HITAG), Germany**

For the heavy ion therapy project at GSI the design of the beam line and the medical cave (see Particles newsletter 12) has been finalized. Shielding blocks and the vacuum components, beam diagnostics and the magnets have been ordered. Presently the magnets and the power supplies of the scanning system are designed. The beam line between the scan magnets and the patient position will be designed within the next month.

A prototype of a fast position sensitive counter has been tested successfully with the SIS beam. This counter will monitor the intensity and position of the scanning beam in front of the patient. Experiments for the biological and physical characterization of carbon beams have been performed at various energies but are not yet fully analyzed. They will be reported later.

Using a 270 MeV/u C beam a sphere as an example of a 3D convex volume has been irradiated by magnetic beam scanning. The sphere has a diameter of 6 cm and was located in a depth between 9 and 15 cm in water. The depth was dissected in 30 slices of equal particle range. For energy variation a variable water column was used because at present the SIS has the capacity of 16 energy steps only. The area of each slice was covered by up to 1500 pixels which are covered by different beam intensities moving the beam in a raster like path over the area.

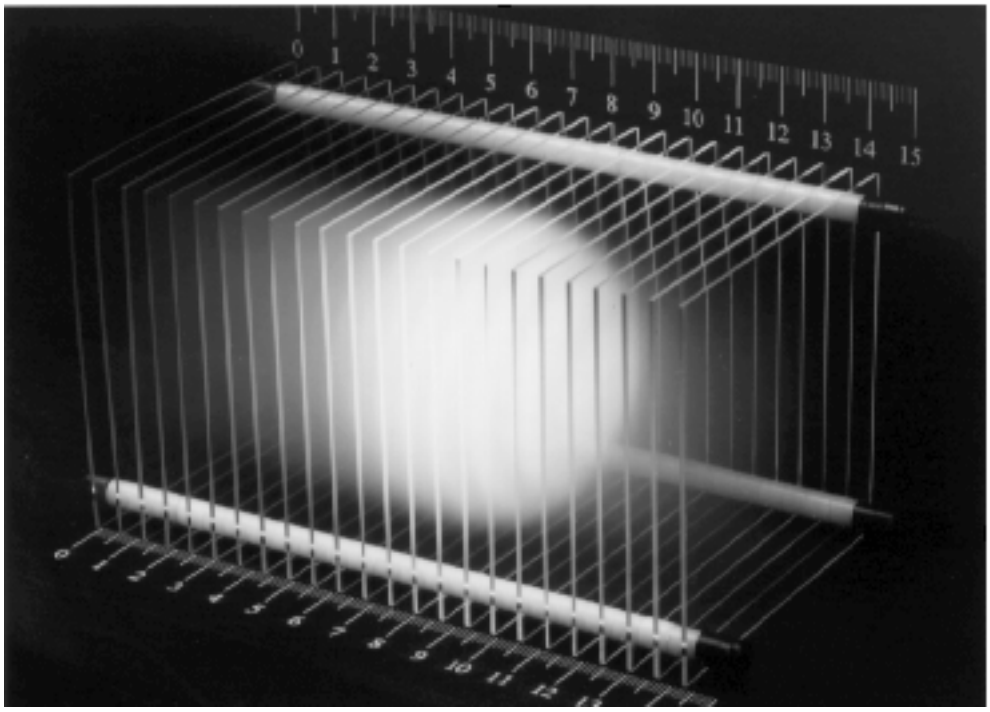


Figure: A spherical isodose volume of 6 cm in diameter and in a depth between 9 and 15 cm in water has been produced by scanning a carbon beam having a diameter of 5 mm. The target volume was dissected in 30 slices of equal particle range and in up to 1500 pixels per slice having different particle covering. The beam entered from left. At the right side of the sphere the halo caused by lighter fragments is visible.

Particles are recorded in a stack of CR 39 nuclear track detectors submersed in a water tank. Because the diameter of the developed tracks in the detector depends on the energy loss (LET) the region of

stopping particles is clearly visible in the photograph as well as the sharp cut off at the surface of the sphere. The sphere was irradiated to achieve a homogeneous dose distribution. In further experiments, the irradiation-procedure shall be extended to irregular shaped volumes and to the production of a biological isoeffect in a target volume. *G. Kraft for the biophysics group, GSI Darmstadt, Planckstr. 1, D-64291 Germany.*

Obituaries:

We note with regret the death of **Dr. Raymond N. Kjellberg** on 20 December 1993 at the age of 68. He died of cancer at the Massachusetts General Hospital after a hospitalization of several weeks. Beginning with preclinical investigations about 1959, Dr. Kjellberg developed a collaborative program of neurosurgical application of the proton beam from the Harvard University cyclotron, continuing to the time of his final illness. According to Harvard Cyclotron Laboratory records, this extended effort is documented by some 62 publications and presentations from 1961 to the present. Early papers (1961-64) described the development of the stereotactic technique for application of the Bragg peak. Application of the technique to pituitary suppression in the treatment of diabetic retinopathy was the focus of papers from 1965-69. Reports on the treatment of acromegaly started in 1968, followed soon after by reports on Cushing's disease and other pituitary adenomas. By 1977 the treatment of arteriovenous malformations in the brain (AVM's) had become the principal subject of his publications, some 12 years after starting his large series of AVM treatments. A special feature of Kjellberg's technique was his empirical estimate of the correlation between target volume and effective dose. A comprehensive paper describing the technique and the results seen in a large number of AVM cases was in preparation at the time of his death.

The stereotactic radiosurgery program he developed attracted patients not only from across the USA, but from around the world, and may have been responsible for allowing the Harvard Cyclotron to remain in operation for clinical applications after it had become largely obsolete as a physics research instrument in 1967. During his career he treated almost 3000 patients, as shown in Table 1.

Clinical experience in these patients, along with that in patients treated with radiosurgery at LBL and with gamma knife techniques in Sweden, has contributed to the establishment of the scientific basis for single fraction radiotherapy. Only two stereotactic radiosurgery programs, using protons and helium ions (the Harvard Cyclotron Laboratory, HCL, in Cambridge, Massachusetts and the Lawrence Berkeley Laboratory, LBL, in Berkeley, California) were operating less than a decade ago, compared to more than 163 centers with stereotactic radiosurgery capability at the present time. Possibly as a result of this increase, indications for stereotactic radiosurgery have expanded from benign conditions (Table 1) to include malignant tumors, specifically brain metastasis and high grade gliomas.

The resurgence of interest in stereotactic radiosurgery, using state-of-the-art technology, is due in no small measure to Dr. Kjellberg's clinical work with proton beam therapy at the Harvard Cyclotron spanning more than three decades.

Dr. Kjellberg was a strong, independent pioneer in exploring the field of single-fraction radiation treatment of lesions within the cranium. His influence on the development of clinical application of proton beams will be missed.

Table 1:
Numbers of patients treated by Dr. Kjellberg with the proton beam,
25 May 61 - 20 Dec. 93.

Arteriovenous malformation	1,487
Acromegaly	584
Other pituitary adenomas	519
Other intracranial targets	339
Total	2,929

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WORLD WIDE CHARGED PARTICLE PATIENT TOTALS

January 1 1994.

WHO	WHERE	WHAT	DATE FIRST RX	DATE LAST RX	RECENT PATIENT TOTAL	DATE OF TOTAL
Berkeley 184	CA. U.S.A.	p	1954	— 1957	30	
Berkeley	CA. U.S.A.	He	1957	— 1992	2054	Jun-91
Uppsala	Sweden	p	1957	— 1976	73	
Harvard	MA. U.S.A.	p	1961		6010	Dec-93
Dubna	Russia	p	1967	— 1974	84	
Moscow	Russia	p	1969		2550	Oct-92
Los Alamos	NM. U.S.A.	π-	1974	— 1982	230	
St. Petersberg	Russia	p	1975		719	Jun-91
Berkeley	CA. U.S.A.	heavy ion	1975	— 1992	433	Jun-91
Chiba	Japan	p	1979		86	Jun-93
TRIUMF	Canada	π-	1979		314	Jun-93
PSI (SIN)	Switzerland	π-	1980	— 1993	503	Jun-93
PMRC, Tsukuba	Japan	p	1983		354	Sept-93
PSI (SIN)	Switzerland	p	1984		1363	May-93
Dubna	Russia	p	1987		24	Aug-92
Uppsala	Sweden	p	1989		34	May-93
Clatterbridge	England	p	1989		463	Jan-94
Loma Linda	CA. U.S.A	p	1990		682	Dec-93
Louvain-la-Neuve	Belgium	p	1991		21	Nov-93
Nice	France	p	1991		216	Apr-93
Orsay	France	p	1991		235	May-93
N.A.C.	South Africa	p	1993		6	Nov-93
Indiana Cyclotron	IN USA	p	1993		1	Dec-93
					1047	pion beams
					2487	ion beams
					12951	proton beams
				TOTAL	16485	all particle beams

Proposed NEW FACILITIES for PROTON & ION BEAM Therapy

January 1994

INSTITUTION	PLACE	TYPE	1ST RX?	COMMENTS
P.S.I	Switzerland	p	1994	200 MeV, var. energy, gantry, dedicated line
HIMAC, Chiba	Japan	ion	1994	first ion beams extracted December 1993.
TRIUMF	Canada	p	1994	adapt existing proton beams for therapy use.
Berlin	Germany	p	1995	72 MeV cyclotron; eye treatment beam line.
Munich	Germany	p	1995?	64 MeV protons; eye treatments
Novosibirsk	Russia	p	1995?	180 - 200 MeV linear accelerator
Proton Development N.A.	IL U.S.A	p	1996	250 MeV accelerator; private facility.
G.S.I Darmstadt	Germany	ion	1996	new cave fortreatment has been designed.
ITEP Moscow	Russia	p	1996	3 horiz., 1 fix beams, 2 gantry, 1 exp., H- accel.
Jülich (KFA)	Germany	p	1997	Plans for a proton therapy beam line at COSY.
KVI Groningen	The Netherlands	p	1997?	plan:- 200 MeV accel.; 2 rms; 1 gantry; 1 fix.
NPTC (Harvard)	MA U.S.A.	p	1998	new facility to be built at MGH
TERA	Italy	ion	?	H- accel;60-250 MeV p; +BNC; isotope prod.
Clatterbridge	England	p	?	upgrade using booster linear accelerator.
Tsukuba	Japan	p	?	230 MeV ; 2 rms; 2 vert+1 h beam; 2 vert.
Krakow	Poland	p	?	60 MeV proton beam.