PARTICLES

sponsored by

PROTON THERAPY CO-OPERATIVE GROUP

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

Number 23 January 1999 Editor: Janet Sisterson Ph.D.,

Costs: At PTCOG XIX, the Steering Committee decided that part of the registration fee for PTCOG meetings would be used to help produce both Particles and the abstracts of the PTCOG meetings. Only part of the costs are covered in this way, so more financial help is needed from the community. PTCOG is always happy to receive financial gifts; 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 "Massachusetts General Hospital" and sent to Janet Sisterson at the address given below. We thank the organizers of PTCOG XXVII, Chiba, Japan for their generous contribution over and above the designated amount normally due to PTCOG for the support of Particles.

Facility and Patient Statistics: I continue to collect information about all operating or proposed facilities. Please send me your information. A recent published summary of the world wide patient statistics with detailed patient data through 1994 can be found in the following reference. "Proton therapy in 1996." J. M. Sisterson, CP392, Application of Accelerators in Research and Industry, eds. J. L. Duggan and I. L. Morgan, AIP Press, New York (1997), p1261-4. A new summary with patient data through 1997, "World wide proton therapy experience in 1997" is accepted for publication in the proceedings of the 1998 International Conference on the Application of Accelerators in Research and Industry. The publication date is expected to be April 1999.

Particles on the Internet: The URL for the Harvard Cyclotron Laboratory is:-

- http://neurosurgery.mgh.harvard.edu/hcl/ or http://brain.mgh.harvard.edu:100/hcl

This contains links to recent issues of Particles.

Other proton therapy links:

- Northeast Proton Therapy Center: http://www.mgh.harvard.edu/depts/nptc/nptc.htm
- LLUMC, California: http://www.llu.edu/proton
- U of California, Davis: http://crocker.ucdavis.edu/cnl/research/eyet.htm
- Midwest Proton Radiation Institute: http://nike.iucf.indiana.edu/ptherapy/
- TRIUMF, Canada protons: http://www.triumf.ca/welcome/proton_thrpy.html
- TRIUMF, Canada pions: http://www.triumf.ca/welcome/pion_trtmt.html
- NAC, South Africa: http://www.medrad.nac.ac.za/
- PSI, Switzerland: http://www.psi.ch/
- Proton Oncological Therapy, Project of the ISS, Italy: http://top.iss.infn.it

- TERA foundation, Italy: http://www.tera.it
- Tsukuba, Japan: http://www-medical.kek.jp/index.html
- Tsukuba, Japan - new facility plans: http://www-medical.kek.jp/devnewfac.html
- HIMAC, Chiba, Japan: http://www.nirs.go.jp/ENG/particl.htm (ENG case sensitive)
- National Association for Proton Therapy: http://www.proton-therapy.org/
- Prolit - database of particle radiation therapy: http://proton.llu.edu
- GSI homepage: http://www.gsi.de
- The Svedborg Laboratory, Sweden: http://www.tsl.uu.se/

ARTICLES FOR PARTICLES 24

May 30 1999 is the deadline for news for Particles 24, the July 1999 issue. I will send reminders by fax or e-mail.
Please note that I have moved from the Harvard Cyclotron Laboratory to the Northeast Proton Therapy Center at Massachusetts General Hospital. Address all correspondence for the newsletter to:

Janet Sisterson Ph.D.	Telephone:	(617) 724-1942
Northeast Proton Therapy Center	Fax:	(617) 724-9532
Massachusetts General Hospital	E-mail:	sisterson@radonc.mgh.harvard.edu
Boston MA 02114		

Articles for the newsletter can be short but should **NOT** exceed two pages in length. The best way to send an article is by computer. If you mail or fax an article, remember that I scan them into the computer so I need a good clean copy of any figures.

PLEASE, when you send me a file by computer GIVE IT AN UNIQUE TITLE that will indicate to me the source of the article. You have no idea how many files I have on my computer that are called ptles23.doc or something similar!!

PTCOG and FUTURE PTCOG MEETINGS

Chair: Michael Goitein
Department of Radiation Oncology
Massachusetts General Hospital
Boston MA 02114

Secretary: Janet Sisterson
Northeast Proton Therapy Center
Massachusetts General Hospital
Boston MA 02114

The PTCOG e-mail address is PTCOG@radonc.mgh.harvard.edu

Steering Committee Members

USA	Europe	Russia	Japan	South Africa
W. Chu	U. Amaldi	V. Khoroshkov	K. Kawachi	D. Jones
M. Goitein	H. Blattmann		H. Tsujii	
D. Miller	J.-L. Habrand			
J. Sisterson	G. Munkel			
James Slater	E. Pedroni			
A. Smith	A. Wambersie			
H. D. Suit				
L. Verhey				

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

PTCOG XXX	NAC, Cape Town, South Africa	April 12 - 15 1999
PTCOG XXXI	Bloomington, IN, USA	October 11 - 13 1999
PTCOG XXXII	Uppsala, Sweden	May/June 2000

COMBINED MEETING - PTCOG XXX / EHTG / ECHED
12-15 April 1999

PTCOG Proton Therapy Co-Operative Group
EHTG European Hadron Therapy Group
ECHED European Clinical Heavy Particle Dosimetry Group

Date: 12-15 APRIL 1999

Venue: MÖVENPICK ARTHUR'S SEAT HOTEL
SEA POINT, CAPE TOWN
SOUTH AFRICA

Organisers: Medical Radiation Group
National Accelerator Centre
P O Box 72
Faure
7131 SOUTH AFRICA

Contact:
Dr. Dan Jones
Tel: +27-21-843-3820
Fax: +27-21-843-3382
e-mail: jones@nac.ac.za

Latest Information: http://www.medrad.nac.ac.za/events.htm.

Full information with registration information was mailed in December to all those on the Particles mailing list as of October 1998. If you did not get the documentation, or require additional copies please contact Dan Jones by one of the means given above.

********** ERRATUM **********

KRUGER NATIONAL PARK TOURS

Regrettably GM Taylor Tours can no longer offer the tour to the Kruger National Park as specified in the mailed PTCOGXXX/EHTG/ECHED Meeting announcement. Talk Travel (the official travel agent for the Meeting) can however, offer a wide selection of Kruger National Park (and other) tours. Please contact Carol at Talk Travel, the correct phone and fax numbers are below.:

Tel: +27-21-797-1861
Fax: +27-21-797-7810
e-mail: CarolJ.talk@galileo.sa.co.za

NB. The fax number for Talk Travel in the mailed announcement was incorrect.

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Program: The meeting will cover all aspects of neutron capture, fast neutron, proton and heavy ion therapy. Eros Pedroni, who will chair the focus session on "patient motion and positioning", asks for your help in organizing this session. See his announcement below.

Cape Town is regarded as one of the world's most beautiful cities and April is a very pleasant time of the year - the average maximum temperature is 23°C/73°F and the average minimum temperature is 12°C/54°F. The Arthur's Seat Hotel is conveniently located in the suburb of Sea Point and is one block from the seafront. Downtown is easily accessible as the hotel is on the main bus and taxi routes and there is also a shuttle bus to the Waterfront shopping, hospitality and entertainment complex. Cape Town is easily reached from all major cities, either on South African Airways or on other international carriers. Flights terminate in Cape Town or Johannesburg, which is a 2-hour flight from Cape Town.

Announcement:
FOCUS SESSION ON "PATIENT MOTION AND POSITIONING"

Dear colleagues,
I received the task to organize and chair this session and I need therefore your help.

We should try to put together our present knowledge on these important topics. Here are just a few examples of possible contributions to the session:

a) How much do we know quantitatively about organ motion (for example using dual CT images, with inspiration and expiration)?
b) How much of it is taken into account in treatment planning (safety margins, acceptable homogeneity of the dose, quantification of the dose errors due to organ motion)?
c) Discussion of the sensitivity of the different beam delivery techniques: more critical for scanning than for scattering.

d) Strategies to cope with organ motion in the beam delivery: multiple painting of the dose, choice of the beam size allowable for scanning
e) Methods to reduce organ motion: synchronization with phase of breathing, external active breathing techniques, ventral compression ?
f) Misalignment of density heterogeneities due to organ movements and resultant wrong compensation of the range
g) Check of patient immobilization during treatment using external or internal sensors: for example distance sensors, stereotactic cameras, ultrasound, implanted magnetic dipoles.
h) Automated patient positioning setup: prior to treatment and during treatment
i) Active correction of target movements with the beam (tumor tracking) ?
j) and whatever else you think fits the subject.

Organ motion is probably one of the most important obstacles to precision radiotherapy in general. I expect therefore a strong interest in this topic and numerous contributions.

Anyone coming to the next PTCOG meeting and willing to give a presentation for this session, is invited to announce his contribution either to me (pedroni@psi.ch) or to the local organizing committee.

E. Pedroni, PSI, Switzerland.

FIRST ANNOUNCEMENT:

PTCOG XXXI
Bloomington, IN USA
October 11 - 13, 1999

Venue:	**Indiana University Campus** Indiana Memorial Union Bloomington, IN
Organizers:	**Indiana University Cyclotron Facility (IUCF)** 2401 Milo B. Sampson Ln. Bloomington, IN 47408
Contact:	**Dr. Susan B. Klein** Tel: (812) 856-4405 Fax: (812) 855-6645 e-mail: sklein@iucf.indiana.edu
Latest Information:	http://www.iucf.indiana.edu

Agenda:

- Clinical results
- New treatment protocols
- New facilities
- Accelerator developments
- Beam delivery systems
- Dosimetry
- Quality assurance
- Radiobiology
- Treatment planning

Bloomington, Indiana is the heart of mid-western United States. The Indiana University campus has been rated as one of the five most beautiful campuses in the United States by Thomas A. Gaines in his book, The Campus as a Work of Art. IU Bloomington, is applauded internationally for its musical arts program. The IU School of Music, one of the world's top-ranked music schools, offers more than 1,000 performances each year.

October is by far the most pleasant time of the year. Temperatures generally remain around 13C/60^{o} F until late in the month, and this part of the country is renowned for its beautiful autumn colors. Bloomington is an hour's drive south of Indianapolis, where the airport is located.

Hotel accommodations will be available at the conference site, and also at other locations within Bloomington. Nothing is beyond walking distance, if you have comfortable shoes and sufficient time, but motorized transportation will be available. Detailed information will be announced in the next Particles Newsletter, and located on the "latest information" web site noted above.

PROLIT: Culling The Heavy-Particle Radiation Therapy Literature

I am repeating this article from Particles 22, so that the many people who have asked me about a bibliography can have a better answer than the one I have been giving.

Prolit, a database of Medline abstracts related to particle radiation therapy, is now available on the Loma Linda Proton Treatment Center Web pages (http://proton.llu.edu). The database provides access to over 5000 particle therapy abstracts, enabling physicians, patients, and researchers to begin their search for information in one convenient site on the Web. A full description of Prolit is available on the Web site. The database will be updated regularly.

The first Prolit database was developed at LLUMC in the late 1980s; it was distributed to PTCOG members and others interested in particle radiation therapy via hard copy and diskettes. Prolit was discontinued in 1993, when it became apparent that the data-collection process was too labor-intensive and the mode of distribution limited. The current incarnation of Prolit can be updated quickly, and should reach a much larger audience via the Internet.

The Prolit development team anticipates refining the search engine and PubMed search strategy based on user feedback. Please direct any comments to Robert Kirby at rkirby@dominion.llumc.edu. *Robert Kirby, Dept. of Radiation Medicine, Loma Linda University Medical Center, 11234 Anderson Street, Loma Linda, CA 92354.*

PTCOG Information/News/Reports:

The following reports and articles were received by January 1999.

Status Report: Heavy Ion Therapy at **GSI**, Darmstadt, Germany:

After a machine shut down of six months, two therapy blocks of 4 weeks each were available from August 12 to September 12 and from October 23 to November 23. In each therapy block 9 patients have been treated, suffering from chordomas, chondrosarcomas and adenocystic carcinomas. Half of the patients received all fractions with carbon beam only, the other half had a carbon boost of at least 5 fractions combined with precision photon treatment.

The tumors were mostly located in the base of the skull. One patient having a chordoma in the pelvic region was treated also. Target volumes up to 300 ccm were dissected into range layers of 2 mm thickness resulting in up to 120 isoenergy slices and up to 20,000 treatment pixels.

Major problems at the beginning of each patient treatment period resulted from the many changes in the accelerator system and the beam line reconstruction. It took always a few days to obtain a stable beam having less than 1mm dislocation at the target point for all 250 energies between 88 and 430 MeV/u and the different intensity steps and beam diameters.

When the stability conditions were fulfilled the irradiation could be performed without major problems over the complete time course. For the second patient treatment period there were only a few hours of interruption mainly caused by defects in the oldest part of the accelerator system, the Alvarez tanks.

In such cases of longer interruptions the patients were released from their fixation mask and realigned after the problems were fixed. The treatment started at the same pixel at the same range layer and lateral position as it was stopped before.

The intensity and the spatial limits for each pixel were very narrow: in lateral position an error of 50 % of the half width and +/- 50 % in calculated intensity were allowed for a single pixel. Only a few interrupts occurred during irradiation mostly because of intensity fluctuations rather than because of lateral errors. The total agreement between planning volume and irradiated volume could be also tested using the positron emitting nuclides mainly ^{11}C and ^{10}C. The decay of these isotopes was monitored online by means of a PET camera. The comparison of planning contours and PET reconstruction were very useful and agreement within 2-3 mm was found which is the spatial resolution of the PET camera.

However in some cases the PET image was influenced by biological effects as for instance the fast wash out of C isotopes from soft tissue. For bones these wash out effects were not observed. This yields a biology weighted PET image depending on time after irradiation.

Another difference was found in measured and planned particle ranges when „mixed“ tissues are traversed by the beam: Volume elements consisting of bones and soft tissues showed Hounsfield numbers that represent an average of both tissues but do not reflect the local tissue density that is responsible for the energy loss of the beam, because range correction are based on CT images. Therefore calibration-experiments with fresh animal tissues have been carried out and animal experiments are in preparation.

During treatment these inaccuracies of the range correction were not expected to cause problems, because entrance channels were selected in such a way that possible range overshoots would not be directed towards critical organs.

For treatment planning the Voxelplan program was used in combination with TRIP that takes into account particle fragmentation as well as local variations in RBE.

The physical dose distribution (absorbed dose) could be verified in phantom irradiations and the distal fall off by PET analysis. For the RBE verifications the response of tumors and healthy tissue has to be waited for. Up to now no effects in the patients treated with carbon alone have been observed. Analysis of the first two patients treated in December last year yielded an unexpected fast tumor regression although these patients received a boost of 5 fractions with carbon ions only.

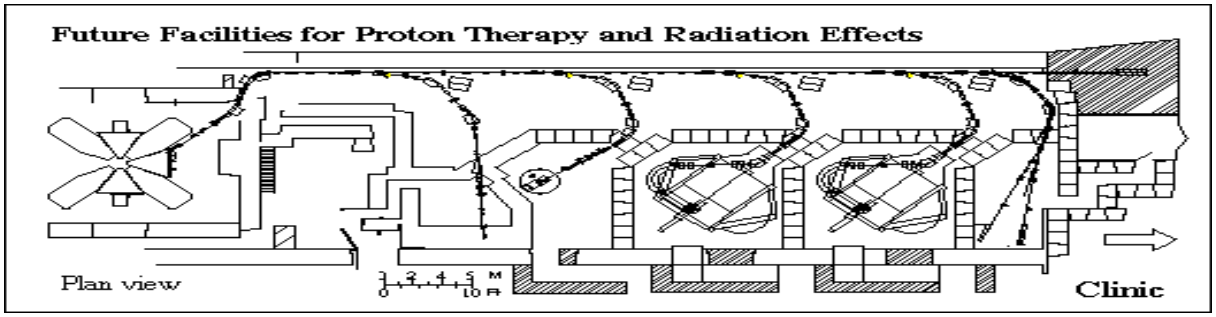
As a general conclusion it can be stated that the treatment of the first twenty patients with the intensity controlled rasterscan system went extremely well concerning the reliability of the accelerator, the precision of the dose distribution and online PET verification and also in the interplay of the four institutions at Darmstadt, Heidelberg and Dresden. This success supports the desire for a dedicated therapy machine, where carbon beam for treatment is available every day through out the year.

A proposal of a heavy ion treatment facility to be installed at Heidelberg has been completed and handed over to the minister for science and technology at an inauguration ceremony of the Heavy Ion Therapy at GSI at September 16 that was held in the connection with PTCOG meeting at Heidelberg. (This proposal written in English is available on request.) For the next year, three patient treatment periods are scheduled between February and end of September. *Gerhard Kraft, GSI, Planckstr. 1, Darmstadt D 64291, Germany.*

An Update from **IUCF,** Bloomington, Indiana:

INTRODUCTION: In 1996, a consortium of physicians and scientists throughout the Midwest collaborated to form the Midwest Proton Radiation Institute (MPRI) consortium. MPRI is an independent radiation therapy center which will be operated as a regional facility in association with physicians and scientists at a number of radiation oncology practices within a 300-mile radius of the institute. MPRI will be operated by one or more existing organizations which already operate radiation oncology facilities. The medical facility will purchase proton beam from the Indiana University Cyclotron Facility (IUCF). IUCF has two operational accelerators suitable for proton therapy: a 210 MeV cyclotron, and a 240 MeV synchrotron. The cyclotron is currently available and the synchrotron could be available for expansion.

FACILITY DESCRIPTION: A conceptual design for the proton therapy facility has been completed which utilizes the existing cyclotrons and their experimental facilities space, as well as much of the existing beam line equipment and services. The Main Cyclotron, which can deliver over one micro-amp of protons at 210 MeV, will be operated as a fixed energy machine at its maximum energy. The main beam line from the cyclotron will be reconfigured for fast switching between the treatment rooms and the other research activities, and equipped with a new control system. In addition to the eye-line there are four new rooms planned, each with their own energy selection system: a fixed horizontal beam line, two gantries and a research/radiation effects room. An adjoining clinical facility will be constructed to house treatment planning, patient care and staff support facilities. A schematic layout of the MPRI facility is shown in Figure 1.



CURRENT STATUS: MPRI has been granted one million dollars through a VA/HUD economic development initiative. The past year has been occupied with developing the clinical specifications and with the conceptual design of the facility to meet these specifications. The preliminary beam line design for beam transport and energy selection from the Cyclotron to the proposed treatment rooms was reviewed on December 4, 1998. Decommissioning of the cyclotron's nuclear physics experimental areas has begun, with the intention of keeping the eye-line operational as long as possible during the facility renovation. Planning is underway for upgrades to the accelerator systems to insure their long-term reliability.

PATIENT TREATMENT: The first AMD patient was treated at the Indiana University Cyclotron Facility on July 27, 1998. We have since treated a total of eight patients for a clinical trial evaluating proton therapy for the choroidal neovascular membrane in age-related macular degeneration. This study is being carried out in collaboration with the Department of Ophthalmology at the IU Medical School, the IU School of Optometry, and radiation oncologists from Methodist and IU Hospitals. The clinical trial is designed to be a randomized, double-blinded, controlled trial of patients who have been recently diagnosed with AMD and who are not candidates for conventional laser coagulation therapy. The treatment consists of a total dose of 16 Gy delivered in two equal fractions on consecutive days. The patient accrual rate has been steady, but not as high as the physicians expected.

ACKNOWLEDGMENTS: We have benefited from advice and assistance from many physicists and radiation oncologists in refining our plans. In particular, we acknowledge and thank members of the Harvard Cyclotron Facility, Loma Linda University Medical Center and the Northeast Proton Therapy Center. We have greatly benefited from advice from Dr. A. Mazal, C.P.O. and Dr. A. Thornton, M.G.H. Finally, we owe a great debt to the various members of our consortium and technical advisory boards who have given us much excellent counsel. G. P. Berg, C. Bloch, J. M. Cameron, S. B. Klein, M. K. Wedekind*, Indiana University Cyclotron Facility, 2401 Milo B Sampson Ln, Bloomington, Indiana 47408.*

The first treatment periods at the **Berlin Eye Treatment Facility**:

As reported earlier, the Berlin Eye Treatment Facility at the Hahn-Meitner Institute (HMI) started patient treatments in June 1998. Besides the experimental physics work at the accelerator department, patient treatments are now scheduled during one week per month. After seven therapy periods, 30 patients have been treated up to December 1998. The following eye diseases were treated:

- 21 choroidal melanomas
- 6 hemangiomas
- 2 iris melanoma
- 1 retinal angioma

Patient's ages varied from 10 to 85 years. Fractionation schedules of 60 CGE and 20 CGE delivered in 4 fractions on 4 days were applied for melanoma and hemangioma patients, respectively. The patients are prepared and treated in a close collaboration between ophthalmologists and radiation oncologists from university hospitals in Berlin and Essen where the patients are being prepared for the proton therapy (Ta clip surgery). For all treatment planning, EYEPLAN was used. Eye modeling and tumor localisation was assisted in most cases with CT and high-resolution MRT data. Treatment times could be reduced due to the new technical features of the HMI eye treatment beam line (X-ray image intensifiers, image processing of X-ray pictures and data link to the treatment chair). For the 2nd to 4th irradiations, a

patient treatment generally took not longer than 12 minutes including patient preparation and positioning procedure.

A follow-up of the first patient after 4 month revealed first signs for an overall tumor regression, no side effects and an increased visual acuity compared to the last measurements before the treatment in June. *Juergen Heese, Hahn-Meitner-Institut Berlin GmbH, Abt. Ionenstrahltechniken/Augentumortherapie, Glienicker Str. 100, D-14109 Berlin, Germany.*

PSI Spot Scanning Gantry: Review of the first beam periods for patient treatments:

After a first human patient treatment in November 1996, two beam periods of five months each allowed for the irradiation of 19 more patients in 1997/98. The treated lesions were located within the brain, retroperitoneum, sacral area, shoulder and orbita, target volumes varied between 30 and 3900 cc. Histologies were selected gliomas, meningiomas, sarcomas, chordomas and chondrosarcomas of the skullbase, chordomas of the sacrum, and two selected metastases. Out of 20 treatments, four were boost treatments or planned photon-proton combinations. Four patients received palliative therapy, though this will not be a main program in the future.

All treatments were well tolerated, medically as well as with respect to the logistics of the new therapy installation. None of the patients with brain tumors required steroid medication. During the short follow up period, no tumor progression was seen or reported. One patient suffers from grade 2 reaction of the rectal mucosa, in an area where the tumor was directly attached to the rectal wall. All other patients are free from treatment related toxicity.

Proton radiation therapy with spot scanning protons on the PSI gantry has been successful in two beam periods. Longer follow up time, increasing experience and improved logistics will be basis for further patient treatments within defined programs and protocols in close collaboration with the Swiss Proton Users Group and referring centers and doctors. *G. Goitein, L. Wisser, A. Lomax, E. Pedroni, Team Radiation Medicine, Division of Radiation Medicine, Paul Scherrer Institute, CH - 5232 Villigen PSI.*

First patient treatment at the **National Cancer Center**, Kashiwa, Japan:

The year of 1998 is commemorative for the National Cancer Center (NCC), JAPAN. The Project of Proton Treatment Facility of NCC, Kashiwa started in April 1996, when the building construction and machine manufacturing initiated. These construction and manufacturing completed in March 1997. Adjustments and tests of all the equipments have begun from April 1997. In November 1997, we had the pleasure to show our new facility to the participants of PTCOG XXVII meeting held at the National Institute of Radiological Sciences (NIRS), Chiba.

In February 1998, first proton beam was extracted from the cyclotron, and in March, beam tests have been started at gantry #2. Biological experiments to determine RBE were performed, in collaboration with NIRS, in May and June. After that, we have improved some hardwares and softwares of our proton therapy system until October. On November 24, 1998, first proton beam irradiation to a human was carried out. The first patient is a male with carcinoma of the maxillary sinus. We had made a 2 beams treatment planning for the patient at gantry #2. The system for patient set-up with real-time digital radiography worked very well. It is planned in our initial protocol for the head & neck malignancies to treat 2.5 GyE x 26 fr., total of 65 GyE by proton therapy alone. *Takashi Ogino, M.D., Div. of Radiation Oncology,National Cancer Center Hospital East 6-5-1 Kashiwanoha, Kashiwa, Chiba 277-8577, JAPAN*

Proposed NEW FACILITIES for PROTON & ION BEAM THERAPY

January 1999

INSTITUTION	PLACE	TYPE	1ST RX?	COMMENTS
NPTC (Harvard)	MA USA	p	1999	at MGH; 235 MeV cyclotron; 2 gantries + 3 horiz.
INFN-LNS, Catania	Italy	p	1999	70 MeV; 1 room, fixed horiz. beam
Hyogo	Japan	p, ion	2001	2 gantries; 2 horiz; 1 vert; 1 45 deg;under construction
NAC, Faure	South Africa	p	2001	new treatment room with beam line 30^{o} off vertical.
Tsukuba	Japan	p	2001	270 MeV; 2 gantries; 1 research room; funded
CGMH, Northern Taiwan	Taiwan	p	2001?	250MeV synchrotron or 230Mev cyclotron;3 gantry,1 fixed
Wakasa Bay	Japan		2002	multipurpose accelerator; building completed mid 1998
Bratislava	Slovakia	p, ion	2003	72 MeV cyclotron; p; ions; +BNCT, isot prod.
Shizuoka Cancer Center	Japan		2002?	synchrotron 230? MeV; 2 gantries; 1 horiz; funded.
Erlangen	Germany	p	2002?	4 treatment rooms, some with gantries.
CNAO, Milan & Pavia	Italy	p, ion	2004?	synchrotron; 2 gantry;1 fixed beam rooms;1 exp. room
AUSTRON	Austria	p, ion	?	2p gantry;1 ion gantry;1 fixed p;1 fixed ion;1 exp room
Beijing	China	p	?	250 MeV synchrotron.
Central Italy	Italy	p	?	cyclotron; 1 gantry; 1 fixed
Clatterbridge	England	p	?	upgrade using booster linear accelerator to 200 MeV?
TOP project ISS Rome	Italy	p	?	70 MeV linac; expand to 200 MeV?
3 projects in Moscow	Russia	p	?	
HIRFL,Lanzhou	PR China	C ion	?	
Krakow	Poland	p	?	60 MeV proton beam.
Moscow	Russia	p	?	320 MeV; compact, probably no gantry
Proton Development N.A. Inc.	IL USA	p	?	300 MeV protons; therapy & lithography

WORLD WIDE CHARGED PARTICLE PATIENT TOTALS

January 1999

WHO	WHERE	WHAT	DATE FIRST RX	DATE LAST RX	RECENT PATIENT TOTAL	DATE OF TOTAL
Berkeley 184	CA. USA	p	1954	— 1957	30	
Berkeley	CA. USA	He	1957	— 1992	2054	June-91
Uppsala	Sweden	p	1957	— 1976	73	
Harvard	MA. USA	p	1961		7942	Dec-98
Dubna	Russia	p	1967	— 1974	84	
Moscow	Russia	p	1969		3100	Dec-98
Los Alamos	NM. USA	π-	1974	— 1982	230	
St. Petersburg	Russia	p	1975		1029	Jun-98
Berkeley	CA. USA	heavy ion	1975	— 1992	433	June-91
Chiba	Japan	p	1979		96	Oct-96
TRIUMF	Canada	π-	1979	— 1994	367	Dec-93
PSI (SIN)	Switzerland	π-	1980	— 1993	503	
PMRC, Tsukuba	Japan	p	1983		593	July-98
PSI (72 MeV)	Switzerland	p	1984		2753	Dec-98
Dubna	Russia	p	1987		40	Dec-98
Uppsala	Sweden	p	1989		147	Feb-98
Clatterbridge	England	p	1989		817	May-98
Loma Linda	CA. USA	p	1990		3433	Apr-98
Louvain-la-Neuve	Belgium	p	1991	– 1993	21	
Nice	France	p	1991		1010	Jan-98
Orsay	France	p	1991		1219	July-98
N.A.C.	South Africa	p	1993		283	Nov-98
MPRI	IN USA	p	1993		9	Dec-98
UCSF - CNL	CA USA	p	1994		162	May-98
HIMAC, Chiba	Japan	heavy ion	1994		473	Sept-98
TRIUMF	Canada	p	1995		37	Jan-98
PSI (200 MeV)	Switzerland	p	1996		20	Dec-98
G.S.I Darmstadt	Germany	heavy ion	1997		20	Dec-98
Berlin	Germany	p	1998		30	Dec-98
NCC, Kashiwa	Japan	p	1998		1	Nov-98
					1100	pions
					2980	ions
					22929	protons
				TOTAL	27009	all particles

See Page 13.
for
The Proposed New Facilities Table