PROTON THERAPY CO-OPERATIVE GROUP

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8/11/87

PTCOG VI

MINUTES OF THE SIXTH PTCOG MEETING HELD AT FERMILAB ON April 13th and 14th 1987

More than 40 people attended the PTCOG meeting hosted by Fermilab. A copy of the agenda of the meeting is appended as Appendix VI/A.

New Officers

Since there had not been a change of leadership of PTCOG since its inception, the steering committee thought it would be appropriate to have an election of new officers. The steering committee accordingly presented a slate of officers to the member at the meeting which was unanimously adopted. As a result, your new officers are:

Chair	PTCOG	Jim Slater	Loma Linda
Co-chair	PTCOG	Richard Wilson	Harvard
Secretary	PTCOG	Michael Goitein	MGH
Chair	accelerator group	Jose Alonso	LBL
Co-chair	accelerator group	Henry Blosser	Michigan State
Chair	facility group	Bill Chu	LBL
Co-chair	facility group	Dan Miller	LL
Chair	clinical group	Mary Austin-Seymour	MGH
Co-chair	clinical group	Jo Castro	LBL

Up until now, the PTCOG steering committee has been comprised of the PTCOG chair & co-chair, the PTCOG secretary, and the chairs and co-chairs of the three working groups. In order to maintain continuity while keeping the steering committee manageably small, it was decided to change this arrangement. From now on the steering committee will be made up of: the current chair, co-chair and secretary, the current chairs of the three working groups, the immediate past chair, co-chair and secretary and the immediate past chairs of the three working groups. In case you have lost track, this means that the steering committee will now be comprised of the following 10 people: Jose Alonso,

John Archambeau, Mary Austin-Seymour, Bill Chu, Frank Cole, Michael Goitein, Stan Schriber, Jim Slater, Herman Suit and Dick Wilson.

Meeting Highlights

The meeting followed the Agenda of Appendix VI/A; only a few comments are offered here as, obviously, a great deal of material was covered.

Jim Slater reviewed the goals and state of the Loma Linda project – which is proceeding apace. The machine design report has been completed and circulated. Phil Livdahl has agreed to become the LL project manager. He described the organization and schedule which seeks to have the fabrication at Fermilab complete in early to mid '88, transfer to Loma Linda in mid '89 and a clinically commissioned machine by the start of 1990. The Loma Linda group issued a blanket invitation to researchers to collaborate with them. Interested persons should contact Phil Livdahl.

Hank Blosser described the status of the Harper Grace superconducting machine. The gantry is operating, the dewar vessel can rotate, and they are in the middle of working out a quenching problem likely due to a problem with some weldments.

Ken Thomas reviewed aspects of the Brobeck machine which has not had much active development since the last PTCOG meeting; Ron Marin discussed some interesting ideas he is working on regarding the beam delivery system.

A group of Harvard Cyclotroneers and collaborating colleagues (Andy Koehler, Harald Enge (MIT), Bernie Gottschalk, Monroe Rabin (U Mass. & MGH) and Bruce Bailey) presented to the group the fairly detailed design study they are engaged in. Named the "corkscrew gantry", the device they are working on is an isocentric beam delivery system in a geometry intended to minimize shielding and space requirements. Contact Andy Koehler for details.

Science Application International Corporation (SAIC) is an engineering firm doing business with the federal government and others – including Loma Linda for whom they are doing design work. Members of SAIC presented a number of aspects of their company and of the beam delivery system, based on the HCL corkscrew concept, on which they were working.

An interesting review of the current state of the art in RFQ design and fabrication was provided by John Staples from LBL. Techniques are being developed to reduce fabrication costs and experience with the units already in the field is considered very promising. Developments at Westinghouse Corporation were presented which offer hope for a less expensive approach to providing rf power to the RFQ.

A new phase of PTCOG activity was ushered in with a half day being devoted to presentation and discussion of clinical plans and applications. These included:

- A presentation by John Archambeau (LL) of an analysis, using data in the literature, of the indications for improved local therapy (i. e. proton therapy!) in the treatment of cancer of the rectum.

- A presentation by Christopher Willet (MGH) of the possible advantages of the use of protons in treatment of retinoblastoma, comparing external photon and proton beam distributions.

- A presentation by Gerry Slater (MGH/LL) of the possible role for protons in the treatment of carcinoma of the lung – using techniques of comparative treatment planning analysis developed at MGH and with the NCI contract for high energy external photon beam treatment planning.

- A presentation by Mary Austin-Seymour (MGH) of the possible role for protons in the treatment of carcinoma of the nasopharynx, using techniques of comparative treatment planning analysis.

- An analysis presented by Chris Inouye (LL) of the optimal approach to the diagnostic workup of patients in cancer therapy.

- A review by Jim Slater of the very preliminary stages of a cost analysis of proton therapy being conducted for Loma Linda by the firm of CPAs, Laventhol & Horwath.

Previous two PTCOG meetings

Your secretary has been delinquent in failing to compile and circulate minutes of the last two meetings. The following remarks, and the associated attachments, are in partial restitution.

The penultimate meeting was held on December 1st and 2nd, 1986. This was a joint meeting of PTCOG and an "International Workshop on Biomedical Accelerators" hosted by Lawrence Berkeley Laboratory. The agenda is attached (Appendix V/A). LBL have put together the proceedings of that meeting, and it has been mailed to attendees and the PTCOG membership. If you have not received a copy and would like one, contact Dr. W. T. Chu, Building 64-227, Lawrence Berkeley Laboratory, Berkeley, CA 94720. The three working groups met during the meeting and the minutes of their deliberations are appended (Appendix V/B).

The ante-penultimate meeting was held at Fermilab on June 26th and 27th 1986. The agenda of that meeting is appended (Appendix IV/A). A summarizing session was held at the end of that meeting, and the unedited remarks of the three working group chairmen are appended (Appendix IV/B).

Next PTCOG meeting

The next PTCOG meeting (PTCOG VII) will be held at Loma Linda University, in conjunction with the "Second International Charged Particle Dosimetry Workshop" on October 12th (Monday), 13th and 14th, 1987.

The preliminary agenda for the meeting is attached as Appendix VII/A. As you will see, the meeting features a number of formal presentations – primarily of material submitted to the dosimetry workshop. In addition, three are blocks of time for discussion of broad topics which will follow the more casual PTCOG format. In addition, a parallel session has been scheduled for the PTCOG clinical working group on Tuesday morning.

Topics which were mentioned for possible discussion at the next meeting included:

1) Radiobiology
2) Treatment planning comparisons
    a) along the lines of the PTCOG VI presentations
    b) a session on theoretical issues such as dose-volume effects
3) Control & safety systems for accelerator and facility (including dosimetry)
4) Patient positioning
5) Dosimetry
6) Nozzle design (that which comes after beam transport)

As you can see, topics (2), (3), (5) and (6) are covered in the proposed agenda, so we are doing fairly well. If you have nay comments concerning additions, deletions or expansions of this list, or any

proposals concerning speakers (yourself included) you would like to have on or off the program, please contact your secretary.

PTCOG VII Meeting Arrangements

The meeting will be held at the Loma Linda University Medical Center. A block of rooms have been held at the Inland Empire Hilton, 285 E. Hospitality Lane, San Bernadino, CA 92408 in the name of "PTCOG". Call them at (714) 889-0133, or detach and mail the form on the next page (*not included in this document in 2005*), to make reservations (rooms held to 6pm only unless guaranteed using credit card). Hotel reservations must be made by September 18th.

If you are flying in, try to go to the Ontario Airport. The Hilton has limousine service to this airport. Transportation will be provided each day between the hotel and meeting. Plan not to drive your car to the Loma Linda Medical Center as parking there is harder than building a proton accelerator.

There will be a $50 registration fee which will cover the cost of lunch each day, coffee breaks, and a banquet on Tuesday night.

At the beginning of September you will receive a reminder of the Loma Linda meeting, and a form to indicate if you plan to attend.

APPENDIX VII/A

PRELIMINARY PROGRAM

SECOND INTERNATIONAL CHARGED PARTICLE THERAPY WORKSHOP
AND MEETING OF THE
PROTON THERAPY CO-OPERATIVE GROUP

October 12, 13, 14
Loma Linda University Medical Center
Loma Linda, California

Alfred R. Smith, Ph. D.
Director, Medical Physics
Department of Radiation Therapy
Hospital of the University of Pennsylvania
3400 Spruce Street
Philadelphia, PA 19104

PROGRAM

OCTOBER 12, MONDAY

7:30 – 8:15 am	Registration	
8:15 – 8:30 am	Opening Remarks	Jim Slater John Lyman Mike Goitein
	Plenary Session Al Smith, Moderator	
8:30 – 9:00 am	"Heavy charge Particle Therapy: An Overview" M.R. Raju – Los Alamos National Laboratory	
9:00 – 9:30 am	"Fast Neutron Radiation Therapy: Implications For Heavy Charged Particle Treatment" Tom Griffin – University of Washington Hospital	
9:30 – 10:00 am	"Antiprotons As Simulators Of Charged Particle Therapy T.E. Kalogeropoulos – Syracuse University	
10:00 – 10:15 am	Coffee Break	
	Treatment Planning Session Mike Goitein, Moderator	
10:15 – 10:30 am	"Experience With 3-D Conformation Therapy With Pions And Intercomparison With Other Techniques" Blattmann, Greiner, Karasawa, Coray – Swiss Institute for Nuclear Research	
10:30 – 10:45 am	"A Precision Correlation Technique For Mulit-Modality Imaging Studies Of The Brain" Chen, Pelizzari, Spelbring, Halpern, Awan, Weischelbaum – Michael Reese/University of Chicago	
10:45 – 11:00 am	"Treatment Plan Optimization: Determination Of Beam Weights" Lyman – Lawrence Berkeley Laboratory	
11:00 – 11:15 am	"Treatment Planning Program Requirements For Clinical Implementation Of The Raster Scanner Beam Delivery System" Henderson, Lyman, Collier, Petti, Renner, Chu, Blakely, Curtis, Rodrigues – Lawrence Berkeley Laboratory	
11:15 – 11:30 am	"Treatment Planning Of Juxtaspinal Tumors With Helium Ions" Collier, Henderson, Petti, Pitluck, Kessler, Castro, - Lawrence Berkeley Laboratory	

11:30 – 11:45 am	"Patient Immobilization for Particle Therapy: Historical Perspective" Zink – National Cancer Institute
11:45 – 12:00 noon	Discussion
12:00 – 1:30 pm	Lunch
	Clinical Reports Jim Slater, Moderator
1:30 – 1:50 pm	"Proton Therapy In Moscow Medical Centers" Minakova – Burdenko Neurosurgical Institute Academy of Medical Science of the USSR
1:50 – 2:10 pm	"Results Of Pion Dose Escalation Studies At TRIUMF" Goodman – Cancer Control Agency of British Columbia
2:10 – 2:30 pm	"Clinical Results Of Helium And Heavy Ion Therapy" Castro – University of California Lawrence Berkeley Laboratory
2:30 – 2:50 pm	"Development Of Adjuvant Treatment In Support Of Proton Therapy" Larsson – Uppsala University, Sweden
2:50 – 3:10 pm	"Experience With Proton Therapy At MGH/Harvard" Mary Austin-Seymour – Massachusetts General Hospital
3:10 – 3:30 pm	"Clinical Status of SIN Pion Project" Greiner – Swiss Institute for Nuclear Research
4:30 – 3:45 pm	Coffee Break
	Facility Progress Reports Dan Miller, Moderator
3:45 – 5:00 pm	Progress on Loma Linda Machine Progress on Other Machines

OCTOBER 13, TUESDAY

8:00 – 12:00 noon	PTCOG Clinical Working Group Comparative Planning Studies Protocol Design
8:00 – 8:20 am	"Physical And Biological Characterization Of The Heavy Charged-Particle Beams Delivered By The Wobbler System" Renner, Blakely, Chu, Rodriguez – Lawrence Berkeley Laboratory

8:20 – 8:40 am	"Use Of The Uppsala Synchrocyclotron In Radiotherapy And Radiosurgery" Larrson – Uppsala University
8:40 – 9:00 am	"Proton Radiotherapy Nozzle" Gottschalk, Harvard Cyclotron Laboratory
9:00 – 9:20 am	"Effects of Beam Scanner and Accelerator Pulse Structure on Proton Treatment Times" Dan Miller – Loma Linda University
9:20 – 9:40 am	Discussion
9:40 – 10:00 am	Coffee Break
10:00 – 12:00 noon	Treatment Control & Safety Systems Bill Chu, Lawrence Berkeley Laboratory Mike Shea, Fermi Laboratory
12:00 – 1:00 pm	Lunch
1:00 – 2:00 pm	PTCOG Business Meeting
2:00 – 3:00 pm	Commissioning the Loma Linda Accelerator
3:00 – 3:30 pm	Coffee Break
3:30 – 4:00 pm	Loma Linda Proton Medical Facility Assembly Plans
4:00 – 5:00 pm	PTCOG Accelerator Working Group PTCOG Facility Working Group

OCTOBER 14, WEDNESDAY

	Basic Physics Peter Fessenden, Moderator
9:00 – 9:15 am	"Toward A Better Understanding Of The Penetration Of Protons In Matter" Bichsel – Seattle, Washington
9:15 – 9:30 am	"Thick Target Proton Multiple Scattering Angles" Koehler, Sisterson, Schneider* Harvard Cyclotron Laboratory and *American Science and Engineering
9:30 – 9:45 a,	"Studies Of The Multiple Coulomb Scattering Of Heavy Charged Particle Beams" Schimmerling, Wong, Phillips, Ludewigt, Curtis, Tobias –

	University of California Lawrence Berkeley Laboratory
9:45 – 10:00 am	Discussion
10:00 – 10:30 am,	Coffee Break
	Beam Characterization John Lyman, Moderator
10:30 – 10:45 am	"AAPM Microdosimetry Intercomparison Of Clinical Facilities Using Heavy Charged Particles" Dicello, Lyman, Fessenden, Koehler, McDermott, McDonald, Verhey – Clarkson University, Lawrence Berkeley Laboratory, Stanford University, Harvard University, Batelle Northwest Laboratory, and Massachusetts General Hospital
10:45 – 11:00 am	"Autoradiographic Detection Of Pion Star Distribution" Shirato, Kornelsen, Harrison, Lam*, Goodman – Cancer Control Agency of British Columbia and *TRIUMF
11:00 – 11:15 am	"Proportional Counter Dosimetry and Microdosimetry in Negative Pion Beam" Menzel, Schuhmacher, Blattman – Universitat des Saarlandes
11:15 – 11:30 am	Discussion
11:30 – 1:00 pm	Lunch
	Dosimetry Sandra Zink, Moderator
1:00 – 1:15 pm	"Treatment Technique And Dosimetry For Dynamic Therapy with Pion at Sin" Coray, Blattman, Pedroni – Swiss Institute for Nuclear Research
1:15 – 1:30 pm	"Determination of Dosimetric Parameters In Medical Beams From Dubna Phasotron" Zielczynski, Savchenko, Molokanov, Cherevatenko – Joint Institute for Nuclear Research
1:30 – 1:45 pm	"Physical And Technical Aspects Of Proton Therapy At The ITEP Synchrotron" Lomanov – Institute for Theoretical and Experimental Physics
1:45 – 2:00 pm	"Absolute Dosimetry In A Clinical Proton Therapy Beam Using Calorimetry, Ionization Chambers And a Faraday Cup" Verhey, Lyman, McDonald – Massachusetts General Hospital, Lawrence Berkeley Laboratory, Batelle-Northwest Laboratory

2:00 – 2:15 pm	Discussion
2:15 – 2:30 pm	Coffee Break
2:30 – 3:00 pm	"Commissioning The Loma Linda University Medical Center Proton Therapy Facility: Dosimetry Plans" Awschalom, DeLuca, DiCello, Robertson – Fermilab, University of Wisconsin, Clarkson University
3:00 – 4:00 pm	Discussion & Concluding Remarks
4:00 pm	Adjourn Meeting

Appendices relating to:

PTCOG VI

Fermilab
April 13th & 14th, 1987

VI/A Agenda of PTCOG VI held at Fermilab on April 13th & 14th, 1987

Agenda
For the VIth meeting of PTCOG

All meetings in Curia II of the Wilson building (high rise) at Fermilab unless otherwise noted.

Wednesday May 13th

8:30 am *registration*

8:45 Review of existing projects
- Loma Linda
- Status of Michigan State studies – H. Blosser
- Any others

9:45 Gantry design
- Harvard Cyclotron Lab. Design of a "corkscrew gantry"
- SAIC presentation of Loma Linda plans
- "Is there an alternative?" – Ron Martin
- patient positioner issues
- Radiographic alignment

10:45 *break*

11:00 Gantry design (continued)

12:45pm *break for lunch*

1:45 Control system
- Discussion of design criteria

3:45 *break*

4:00 New Developments affecting Accelerator design
- Fermilab comparison of superconducting vs. conventional synchrotron
- New superconductors
- Experience with RFQs

5:00 Parallel sessions of the 3 working groups *rooms announced at previous session*

Topics to be decided by working groups, but likely to include:
- Accelerator group
  - Fermilab presentation of measurements on prototype magnet
- Facility group
  - Review of file of working papers
- Clinical group
  - Dose-volume relationships

6:30 *dinner at Fermilab with informal discussions*

Thursday May 14th

8:30am Clinical applications session
- Clinical indications – Loma Linda group
- Comparative treatment planning for several sites – MGH group
- Clinical specification of beam intensity – Michael Goitein
- Use of, and support for, diagnostic imaging – Joe Thompson
- Confidence limits on target volumes – John Archambeau

10:45 *break*

11:00 Clinical applications session (continued)

12:00 noon Facility Staffing & Financing
- Staffing needs
- Operating costs
- Reimbursement

12:45pm Organizational matters
- Selection of new PTCOG officers
  - Chair
  - Secretary
  - Chairs & co-chairs of 3 working groups
- Future meetings
- Other business

1:30 adjourn

Appendices relating to:

PTCOG V

LBL

December 1st & 2nd 1986

A Agenda of PTCOG V held at LBL on December 1st & 2nd 1986

B Minutes of working groups at PTCOG V

Appendix V/A

Vth PTCOG Meeting
&
International Workshop on Biomedical Accelerators

Lawrence Berkeley Laboratory
University of California, Berkeley, California
December 1 and 2, 1986

The International Workshop on Biomedical Accelerators is jointly sponsored by the Proton Therapy Cooperative Group and the Accelerator and Fusion Research Division and Biology and Medicine Division of Lawrence Berkeley Laboratory.

Monday a.m. December 1, 1986, 8:00 a.m. – noon.

8:00 Registration, Building 50 Auditorium, LBL

Opening Session Chair: Paul H. Silverman, LBL.

8:30 Welcome by Director David A. Shirley of LBL

Session I. Biomedical Aspects of Therapy Delivery.

Radiobiology and radiation therapy: Chair: Herman D. Suit, Harvard.

8:45 Progress in proton and helium-ion therapy,
Joseph R. Castro, LBL

9:20 Rationale for the light-ion accelerator for medical research and treatment,
Jack F. Fowler, Gray Laboratory, England

10:00 Properties and some biological effects of light ions,
Eleanor A. Blakely and C. A. Tobias, LBL.

10:40 Coffee

Optimization of therapy planning: Chair: Sandra R. Zink, NCI.

11:00 What is needed to plan therapy? Michael Goitein, MGH.

11:30 Therapy planning optimization, John T. Lyman. LBL.

Monday p.m.

December 1, noon – 2:00 p.m.

Lunch and PTCOG working-group meetings. (Room assignments in back page.)
Optional visits to the Bevalac Biomed Facility and to the Research Medicine Building.

December 1, 2:00 – 5:30 pm.

Session II: New Biomedical Accelerators. Chair:Klaus H. Berkner, LBL.

2:00 Design and use of the Loma Linda proton synchrotron,
Lee C. Teng, Fermilab

2:45 The 230 MeV AVF cyclotron dedicated to proton therapy at Tsukuba,
Noriyuki Takahashi, Sumitomo Heavy Industries, Japan.

3:00 Current heavy particle medical accelerator programs in Japan,
Kiyomitsu Kawachi, National Institute of Radiological Sciences, Chiba

3:45 Coffee

4:00 The European light-ion medical accelerator (EULIMA) project,
Pierre Mandrillon, PS Division, CERN

4:45 The light-ion biomedical research accelerator (LIBRA),
Richard A. Gough, LBL.

Monday Evening December 1. Banquet at the Faculty Club.

6:30 Social hour, no-host cocktail

7:30 Dinner

8:30 "Accelerators and Medicine at Berkeley," Director David A. Shirley, LBL.

Tuesday a.m. December 2, 8:30 – noon.

Session III. Facilities. Chair: James M. Slater, Loma Linda

Loma Linda University proton accelerator facility (LLUPAF):

8:30	The plan for LLUPAF, James M. Slater, Loma Linda.
8:45	Modern proton therapy facility, Miguel Awschalom, Fermilab.
9:10	Shielding calculations for LLUPAF, Daniel W. Miller, Loma Linda
9:25	Justification for LLUPAF shielding calculations, Miguel Awschalom, Fermilab.
9:40	Corkscrew gantry, Andreas M. Koehler, Harvard Cyclotron Laboratory.
9:55	Gantry design for LLUPAF, Daniel W. Miller, Loma Linda.
10:10	Capabilities of passive beam-spreading techniques, Bernard Gottschalk, HCL.
10:25	Discussions on LLUPAF.
10:45	Coffee
11:00	Performance of the LBL Wobbler, Tim R. Renner, LBL.
11:30	Quantitative limitations of dynamic beam delivery, William T. Chu, LBL.

Tuesday p.m.

December 2, noon – 2 p.m.

Lunch and PTCOG working-group meetings (Room assignments in back page.)
Optional visits to the Bevalac Biomed Facility and to the Research Medicine Building.

December 2, 2:00 – 5:30 p.m.

Session IV. Beam localization and Status Reports.

Imaging in relation to beam localization. Chair: Thomas F. Budinger, LBL.

2:00	NMR and PET imaging in charged particle therapy, Peter E. Valk, LBL.
2:25	Correlating NMR and XCT images for therapy planning, Marc L. Kessler, LBL.
2:50	Diagnostic applications of radioactive beams, Aloke Chatterjee, LBL.
3:15	Coffee

Status reports and contributed papers. Chair: Michael Goitein, MGH.

3:30	Permanent magnet wobbler for proton therapy, Francis C. Younger, Brobeck Corp.
3:50	Report on International Working Meeting on Proton Therapy, Leningrad, October 14-17, 1986, M. R. Raju, Los Alamos National Laboratory.
4:10	(Other titles and speakers to be announced.)

Summary Session. Chair: Herman D. Suit, Harvard.

4:30	Reports by PTCOG working groups. Clinical Applications Working Group: John O. Archambeau, Loma Linda Accelerator Design Working Group: Stanley O. Schriber, Los Alamos Facility Design Working Group: Richard Wilson, Harvard
5:00	Summary of the workshop, Herman D. Suit, Harvard.
5:30	Adjourn.

APPENDIX V/B

PROTON THERAPY CO-OPERATIVE GROUP

Lawrence Berkeley Laboratory
December 1-2, 1986

FACILITIES COMMITTEE SUMMARY
James M. Slater, M.D.

The Facilities Committee, comprised of approximately forty attendees, met at noon on December 2, 1986 in one of the conference rooms at Lawrence Berkeley Laboratory to discuss the requirements and specifications of a proton therapy facility.

The PTCOG Facilities report of December 4, 1985 was discusses as to its relevance today using the following outline:

PTCOG –Facilities report 12/4/85

Items identified in RW outline of 10/17/85	WHO primary	secondary	size (pp)	first version
1. Effect of energy degradation	CHU		0.5	
2. Energy selection after degradation	MILLER			
3. Can gantry & accelerator be decoupled?	ENGE			
4. Need for >1 beam direction &/or gantry….	VERHEY			
5. Scanning & wobbling	CHU			
6. Control System	AWSHALOM			
7. Lateral beam shaping	CHU			
8. Beam modulation	AWSHALOM			
9. Position verification (x,y&z)	KRAMER	CHU/GOITEIN		
10. Planning Rx (programs, imaging….)	GOITEIN			
11. Facility design (buildings,…)	KOEHLER	WILSON		
12. Shielding	AWSHALOM	GABRIEL/WILSON		
13. Patient Positioning	CASTRO	AWSHALOM/ZINK		
14. Personnel requirements	GOITEIN			
15. Beam switching	AWSHALOM			
16. Specification of E, I, Size, Uniformity, a/p	VERHEY			
17. Financial issues	THOMAS			
18. Criteria for Evaluation	GOITEIN	WILSON		

The consensus of the committee indicated that these items remain relevant today. Many of the topics listed have been discussed at length and decisions regarding specifications and/or goals to be achieved have been stated in previous committee reports. A brief summary of the points of consensus arrived at since the December 4, 1985 report as compiled by Lynn Verhey are as follows:

DRAFT REPORT OF THE PTCOG FACILITIES WORKING GROUP

By L. Verhey, September 1986

Although little new work had been submitted since 1/86, this is an attempt to summarize all work, which has been done by members of the facilities group specifying the parameters of a proton therapy facility. This draft of the report is an update of the draft of 6/30/86, including discussions from the Fermilab IV meeting of 6/26/86. Where obvious work remains to be done, it is so designated. The category numbers refer to the items in Richard Wilson's memo of 10/17/85.

1. & 2. Energy Degradation

This is only an issue with a fixed energy machine such as a cyclotron. In most of the deliberations, which have taken place since 1/86, there has been an assumption that the machine will be a synchrotron with energy easily selectable. If a cyclotron is used then energy degradation will be necessary and the distal falloff of the stopping proton beam will be somewhat degraded. The 90 to 10% falloff of beam is approximately 1.2% of the range of particles as they are extracted from the machine. Needed: A calculation of the degradation in distal falloff produced by degrading the beam from 250 MeV to 100 MeV.

3. & 4. Gantry: How necessary and can it be decoupled from accelerator design?

Although much work needs to be done on gantry design, early calculations indicate that in a typical synchrotron design, the beam emittance is not a limiting problem for gantry design. Some work has been done in the past 6 months in looking at two different extreme gantry designs. One, of the Harold Enge type which delivers a full beam of 40x20 cm at isocenter with a scatterer being included in the gantry, and the second, a simpler system which transmits only an unscattered beam and then scattered the beam in the 2-3 m between the last magnet and isocenter. This latter design is certainly less expensive but has the disadvantage of delivering a beam with more divergence. Andy Koehler has worked on a modification of the smaller gantry, which he calls the "corkscrew". With an extra bend, it decreased the width of the gantry plane to about 18", thus decreasing significantly the weight and the shielding requirements. It generally is felt by most potential proton users that a gantry is very useful for some small, but important, fraction of proton treatments. Our own estimate from Harvard is that about 1 out of 6 treatments could not be delivered effectively with beams of fixed horizontal or fixed vertical variety. Needed: a calculation of the increase in entrance dose as SAD decreased from infinity down to 2 meters. A discussion of the technical problems of treating with a divergent beam is needed. Also, do we want to rotate the gantry with the beam on?

5. Scanning & wobbling

The Berkeley group now has a wobbler for the Bevelac, which uses about 50% of the extracted particle beam and delivers field sizes up to about 20 cm in diameter. This system is about a factor of 2 more efficient that passive scattering which tends to use about 25% of the extracted beam. (Harvard experience and B. Gottschalk calculations.) Bill Chu claims that the system at Berkeley costs about $150,000. An option, which allows one to use even more of the beam, is a beam scanning system, in particular a spot scanning system, which could use almost 100% of the extracted beam. This system is thought to be rather expensive and precautions must be taken so that the instantaneous dose distribution will remain uniform if the patient moves slightly or if the magnetic steering systems go slightly out of alignment. The plans at Loma Linda at the moment include passive scattering initially followed by wobbling or scanning in the future. Needed: More careful thought about the advantages of wobbling or scanning. If efficient use of beam is the primary reason for scanning or wobbling, longer treatment times of higher beam intensity might be preferred. Bill Chu's report of 12/1/85 discusses the

advantages and disadvantages of scanning and wobbling very well. We should all read this report carefully. Also needed are calculations of beam properties obtained by wobbling over a small diameter and then scattering the beam passively. This might permit large, homogenous beams at considerable less expense than pure wobbling.

6. Control System

Miguel Awshalom has done a considerable amount of thinking about the control system as part of his involvement in the LLUMC proton therapy machine project. He envisions a single IBM PC or equivalent computer in each beam line which is very user friendly and which keeps track of the patient-specific information thus assuring a safe treatment for each patient. These individual computers will all talk to a main computer which will keep track of the beam required for the various beam lines. Redundancy is also critical. Needed: someone to think about the priority system which determine how to handle conflicting requests in several areas.

7. Lateral beam shaping

Although the construction of individual patient apertures made out of brass or cerrobend is a simple way of beam shaping there is considerable interest in designing and constructing a multileaf collimator, which is capable of defining irregular shapes dynamically. It is assumed that each of these fingers would have about 1 cm width and could move across the beam center line in order that irregular fields not including the center of the beam could also be treated. Bill Chu from Berkeley is now designing such a system for the Bevelac and Miguel Awshalom is considering a similar design for the Loma Linda machine. One should think carefully about this since it is a very expensive option and simpler patient specific apertures may in fact be both less expensive and safer to use than the dynamic collimator. A multileaf collimator is, of course, necessary for dynamic treatments. Needed: to resolve several questions: (1) What are the real reasons for wanting such a collimator; (2) What is the largest field size desired? Should it be remotely controllable; (3) How does one deal with a divergent beam (Awshalom has a design); (4) What is the closest distance from collimator to patient?; (5) What will the beam edges look like at the patient?

8. Beam Modulation

In a passive scattering system, with a fixed-energy beam, the use of plastic variable-thickness wheels at Harvard or ridge filters at LBL, has been a very effective way of spreading the dose uniformly in depth. With a synchrotron, the possibility of changing the beam energy rapidly, opens up the possibility of programming the accelerator to deliver a uniform dose in depth. In practical terms, this may be very difficult due to the very narrow energy width of the beam. Awshalom and Miller have suggested a “micromodulator” which would spread the Bragg peak to about 5 mm, thereby decreasing the number of energy steps needed to give a uniform dose. Needed: to calculate the uniformity achievable with and without a micromodulator, to determine the feasibility of operating the synchrotron in this way, to clearly state the required dose uniformity.

9. Position verification

No information on this subject has been submitted.

Steve Kramer volunteered to write a document on determining the stopping point by detection of induced radioactivity. For transverse position, MGH and others are working on digital fluoroscopy.

10. Planning treatement

Michael Goitein has summarized the need in terms of hardware and software in planning proton therapy. In addition to a VAX or MicroVAX type computer there is a need of from two to four planning stations for a two treament room facility. This is expected to cost approximately $300,000 in

1986 money. In addition there is a need for CT studies at very fine resolution in the treatment position for patients being considered for proton therapy and auxiliary imaging capabilities such as MRI scans with considerable input from the proton therapy physicists as to position and technique. If a gantry is not available for the treatment beam, the CT machine must be capable of scanning the patient in more than the conventional horizontal position.

11. Facility Design

Nothing specific has been submitted in writing at this point but several individuals have expressed interest in having the proton facilities part of a full medical facility. At Loma Linda and at Massachusetts General Hospital plans are currently under way to fully integrate the proton facility with a full scale medical facility. Andy Koehler has a design which was commissioned in 1980, for a stand-alone proton therapy facility, which included all cost estimated for the buildings and associated facilities.

12. Shielding

Although nothing specific has been submitted to PTCOG relative to shielding some work has been done by Miguel Awshalom considering the Loma Linda facility. In addition, other Fermilab shielding experts are beginning to work on this problem. Some things are clear as, for instance, for a facility of 250 MeV protons the main particle of concern in shielding calculations are high energy neutrons which are generated by primary protons in gas or material surrounding beam lines. If space is not a particularly important parameter then concrete represents the lowest cost material for shielding, something in the neighborhood of 10'-16' of concrete being required in the forward direction to shield direct beams down to 0.25 mR/hr or less which is required for shielding the general public. If space is at a premium then combination steel and concrete could be used to give the same shielding for much less thickness of material. Detailed shielding calculations await the use of a computer program which can predict a full range of secondaries produced by proton collisions with other materials. Deach facility must look at their individual local regulations to guide their shielding designs. Also, one must decide how the beam is tuned – if beam position is affected by intensity, tune-up may need to be done at full intensity, and this impacts on shielding design.

13. Patient positioning

All potential proton users agree to the importance of secure patient positioning. Miguel Awshalom believes that the Loma Linda facility can use a seat in what the calls the head and neck room for irradiation of AVM, pituitary and eye tumors, and a couch for treatment of almost all other tumors in the other treatment rooms. He believes that these should all be remotely controllable and remotely monitored so that the patient's positioning can be done from a remote location using digital radiography to monitor the patient's position. If one assumed that a gantry beam delivery system will be available in at least one room of the proton treatment facility then the seated position will probably not be necessary for anything except the head and neck treatment. This would also imply that a conventional CT scanner could be used for planning of patients in supine or prone positions. For seated patients with tumors above the base of skull, planning can be done from a supine scan.

14. Personnel requirements.

M.G.

15. Beam switching

Again Miguel Awshalom has written a document on beam switching philosophy. This philosophy depends on simplicity of operation and centers around a computer which receives and satisfies requests form the various beam lines for beam at a particular energy. This computer also is responsible for starting and monitoring the operation of the accelerator, for performing beam diagnostics and for calibrating beam energy and beam intensity monitors. All of this will be done with a minimum of intervention from physicists and other personnel. He believes that it is possible to operate four or five treatment rooms at one accelerator without great difficulty.

16. Specification of Beam Parameter

Not very much has changed since the Verhey document in 12/85 which was written in preparation for the 1/86 PTCOG meeting. A review of that document is as follows:

Energy. Probably 250 MeV maximum proton energy but as little as 225 MeV would be considered if this was beneficial in terms of machine design. A variable energy machine is preferred although a fixed energy machine could be considered again if other advantages were outweighing the disadvantage of having to degrade the beam.

Intensity. It is generally felt that 1-2 minute treatment time is acceptable, although there is a strong desire for shorter treatment times if possible. This corresponds to an intensity of about 3.5×10^{12} protons delivered to isocenter for the largest treatment volume of approximately 40x40 cm. Loma Linda's design is based on this number.

Beam size. It is usually stated that at least one field dimension should be as large as 40 cm. A field size of 40x40 would be desirable or a 40 cm circle but maximum fields as small as 40x20 or 40x35 cm might be acceptable if the financial cost of larger fields were too high.

Beam uniformity. Numbers as small as ±1% and as large as ±5% have been discussed. It is very difficult and expensive to achieve real uniformities of ±1% though most would believe that ±2% to even ±3% inside a target volume is acceptable.

Particle type. Most discussions have centered around protons as opposed to any heavier ion such as helium or high-Z nuclei. The advantages of the sharp lateral falloff of a helium beam is attractive, however, and would still be considered by some if the price tag were not too high.

Reliability. It is generally felt that the reliability of these machines could be similar to that of linear accelerators, that is roughly 98%.

Penumbra. Penumbra is hopefully no worse that that which is achievable from linear accelerators: in the range of 6-8 mm for 80-20%.

Scanning. Most potential users feel that facilities should be able to accommodate scanning if the future requires it. Nonetheless the Loma Linda facility and the Harvard/MGH facility are being planned initially using passive scattering techniques.

Rooms. The Loma Linda facility is probably going to have 4 treatment rooms and the MGH machine is expected to start with 2 treatment rooms. Most seem to feel that 2 treatment rooms is the minimum for a proton facility.

Gantry. There is some disagreement as to the need for gantry but most would agree that it is strongly desired for treating certain types of tumors particularly when a conventional CT machine is used for treatment planning.

More parameters were discussed in the 12/85 document which should be referred to for further details.

17. & 18. Financial issues and Criteria for Evaluation – M. G.

Neither of these issues has been directly addressed by any members of the PTCOG. However, the financial estimates for the Loma Linda projects are now available and should be used as a baseline for considering other proton therapy facilities.

Item 14 regarding personnel requirements were suggested as follows: a) 1 physician/10 patients under treatment; b) 1 physicist/15 patients under treatment; c) 1 dosimetrist/10 patients under treatment; d) 2-3 technologists/treatment room; e) 1 machine operator and f) 1 engineer.

Two additional issues were discussed as follows:

19. Facility safety system. The system is being designed at Fermilab for LLUPAF under the direction of Miguel Awshalom and will be discussed in detail at a future meeting.

20. Gantry designs and specifications were discussed by Andreas Koehler and Daniel Miller at the PTCOG general session. Each institution may have constraints or desires leading to the selection of a particular gantry design, however, performance specifications and guidelines from this Committee were expected to be of value for future developing facilities. Chicago Bridge and Iron, Inc. has contracted with LLUPAF for the engineering design of a gantry which will be discussed, after its completions, at a later meeting.

CONCLUSION:

A summary report of the above subsystems and specifications in tabular format was felt to be a desirable addition to this report by many committee members.

Utilization Committee Meeting
Summary of discussions held at LBL on December 2-3, 1986.

Agenda

1) Is there a need to make a greater effort to locate, obtain and distribute information on proton therapy of interest to potential clinical users?

There was felt to be no pressing need for a newsletter or other written communication that would be distributed on a regular basis. The consensus was that the PTCOG format, with its input form a wide cross section of professional involvement in particle therapy and related fields, the willingness to share data and information, plus the frequency of the meetings was sufficient to assure that data of clinical interest would become known and distributed.

However, it was suggested that the report form the treatment planning contract group at NCI being prepared by Sandra Zink be widely distributed. Sandra has agreed to make this material available to PTCOG for distribution.

2) How to address the manpower needs for future clinical investigations, increases in the number of patients being treated and new installation commissioning?

The future manpower demand for clinicians and technologists is recognized. The issue is really one of where and how to obtain the appropriate training. The representatives of LBL, Harvard (HCL and MGH) and Vancouver (Triumph) pointed out that they would welcome staff to come and work with them for varying periods, e.g. for a month or for a year. The consensus is that an year of training is necessary and desirable both for clinicians and technologists.

It is recognized that salary support would be required from the home institution. This may become a factor limiting the time spent at a host institution.

There was no interest expressed in submitting a training grant request for salary support from NCI.

An alternative solution would be to have a “team” come to the new institution to hold workshops to train the staff. Workshops at PTCOG meetings and treatment planning simulation optimization are other resources to be evaluated.

The consensus is that training is a high priority item and that planning for training should be started early, and secondly, that an adequate budget be allotted a year or more in advance to support the program.

3) Review of a tentative scenario selecting patients with cancers of a known type, stage and location for clinical application when the Loma Linda Proton Treatment Center becomes operative.

The scenario selecting patients for therapy accepted the premise that it was sufficient to document that proton therapy produced results equivalent to results obtained using current therapy. Patients were to be treated using established treatment guidelines. These included workup, cancer volume definition, treatment planning, time dose schedules and total doses. The difference in approach would be to utilize

treatment plans that reduced the volume of normal tissues treated by utilizing the improved dose distribution of the proton beam.

After demonstrating equivalent results, dose escalation would be evaluated. The approach would treat essentially all cancers. Initially, emphasis would be on metastatic lesions and late stage disease, advancing to other types and locations of cancer as the guidelines were established.

Questions about beam localization and verification were not addressed. It was assumed that by using the gantry, set-up time and complexity would be similar to the present approach.

The approach was voted. The scenario of general application with phased extension to earlier staged lesions had few supporters. There were eighteen voting: six physicians and six physicists had previous experience with proton therapy, four others had experience with neutrons and two had no previous experience. There were sixteen votes to focus on a large number of cancers from a few very selected sites rather than to use the general approach. The same number voted that the comparison of treatment results should determine whether proton therapy produced results superior to those obtained with current techniques.

4) Agenda for the meeting in May (or there-about)

a) The group requested that a treatment planning workshop be held for the next meeting. John Lyman will present his approach to determining selection of the optimal treatment plan. Those coming to the workshop should prepare a detailed treatment plan for a selected site; these plans will be reviewed.

b) Presentation describing the control systems that are expected to be used for operating the accelerator and for beam transport will function.

c) Presentation on dose-volume relationship.

Contents of a letter addressed to Michael Goitein from Stan Schriber, Los Alamos National Laboratory, dated February 9 1987.

Dear Michael,

Attached are several paragraphs for the minutes of the last PTCOG meeting>

Accelerator Design Group

In the future the working group feels that it would be worthwhile to discuss aspects of LIBRA (Light Ion Biomedial Research Accelerator, LBL) once the design is further along. Other topics to be considered at future PTCOG meetings include controls, stability, ion sources, and activities of other interested groups such as TRIUMF (with the BC Cancer Institute) and the University of Washington (50 MeV proton machine for neutron therapy).

Discussion concerning the Loma Linda University Proton Accelerator Facility (LLUPAF) are summarized in the following:

Gantry and Focus at Patient

- Looking at focal point with respect to scatterer location and parallel beams
- Design should incorporate flexibility

Controls

- A philosophy is being adopted that permits changes as necessary by developments in the future
- Controls will remain flexible
- More discussions would be worthwhile
- Important to continue machine/hospital interfaces
- One button turn-on will be a challenging and interesting work project – the ion source as one item is an example of the interesting challenges ahead

Installation , Commissioning and Operation

- Being looked after very professionally and encouraged to continue

RF Cavity

- Investigating control to keep beam spill a constant. Some initial misunderstandings about concerns of rf microstructure on beam the user implications. At 10 MHz this is not considered a difficulty based on past accelerator experience.
- Experience of our colleagues from Japan on their cyclotron shows that one has to have good control on the ion source output

Impact

- In the light of future proton therapy activities, the LLUPAF machine no doubt will set some precedents. Fortunately a good team has been assembled with discussion, input, and assistance from members of PTCOG.

Appendices relating to:

PTCOG IV

Fermilab
June 26th and 27th, 1986

IV/A Agenda of Fermilab IV held at Fermilab on June 26th and 27th, 1986
IV/B Unedited summarizing remarks of the working group chairs.

Appendix IV/A

FERMILAB IV AGENDA

Thursday, June 26th (meetings in Wilson Hall, Curia II – all day)

8:30-9:00am	Registration (second floor lobby outside Curia II)	

Fermilab Design Study for Loma Linda Medical Center

9:00-9:45	Introduction, discussion of clinical objectives	J. SLATER, Loma Linda
9:45-10:45	Accelerator design	Fermilab design team
10:45-11:00	*coffee break*	
11:00-12:30	Accelerator design (continued)	
12:30-1:30	*Lunch* (second floor lobby)	
1:30-3:30	Facility design	Fermilab design team
3:30-3:45	*coffee break*	
3:45-4:45	Cost estimates	Fermilab design team

Presentations by PTCOG members of current activities (15 min each)

4:45	ACCTEK progress	R. MARTIN
5:00	Superconducting synchrocyclotron studies	H.BLOSSER, Mich. State
5:15	progress	K. THOMAS, Brobeck
5:30	Comparison of small Carbon & proton beams	W. CHU, LBL
5:45	Experience with conformation radiotherapy with pions and its relevance to the proton project at SIN	H. BLATTMANN, SIN

Second floor lounge, west side of central building:

6:00pm	*Cocktails*
6:30pm	*Dinner*
7:30-9:30pm	*Informal discussions*

Working groups

8:30-11:30	Parallel sessions of the three working groups:		Location
	Accelerator	Detailed review of Loma Linda design study with members of the Fermilab design team	Snake pit
	Facilities	Review of draft report of the working group and discussion of the Loma Linda design with members of the Fermilab design team	Comitium
	Clinical	Discussion of clinical utilization of a proton medical facility, with special reference to the Loma Linda proposed facility	15th floor conference room (east side)
11:30	coffee (second floor lobby, west side)		

Whole group reconvenes in the Curia II

12:00-12:45	Brief reports from the three working groups to the membership
12:45-1:30+	Whither PTCOG? – a discussion of the members' wishes for the future activities and emphasis of the group
by 2:00 pm	*meeting adjourns*

I had written up a draft report from the previous meeting in January which summarized all the work which the Facilities Committee had done up to that point. And so what we did was basically go through the report that I'd made and critique it. In the process of doing that, a number of elements, which were controversial in January (most of which are still controversial) were hit upon again, some of which we talked about yesterday. I'm not going to go through he whole report at all, but I just thought I'd mention a couple of the points we had talked about that, in my opinion at least, remain controversial. Like I said, you know about most of them. One of the things we talked about was the idea of beam spreading; we talked about scanning, wobbling and passive scanning techniques for beam spreading. We discussed the relative efficiencies of those (that came up yesterday), and we think that there are factors of somewhere between two and four to be gained in going from the passive scattering technique to a full scanning technique with wobbling being somewhere in the middle. Then we concentrated on what this meant, what was driving the considerations for either some future machine that we might be thinking about of for the Loma Linda machine. The things we came up with were, of course, efficiency of proton use as one possibility and the ability to do dynamic treatments was certainly another thought. And this brought up the whole issue of intensity. Again we tried to pull ourselves away from the Loma Linda design specifically, then we would go back to it because obviously we've been talking about it. We reviewed Michael Goitein's document on beam intensity which he presented in March, in which he went through and looked at how much time it would take to treat various kinds of tumors using various assumptions about beam intensity. I believe it was the feeling of our committee that, first of all, we would like to make the statement that we wish the machine had an intensity of factor two higher than what the working intensity was. In fact, in one sense the more intensity the better is always the rule. We looked back and talked about our oldest deliberations in which we talked about twenty nanoamps came down to ten or twelve nanoamps, and at least under some considerations, it looks like there wasn't very much safety factor even in the twelve nanoamps. I think one of the things we wanted to say was simply to reiterate that the more intensity the better, and that if in fact a relatively straight forward modification of power supplies would allow this machine to be designed with a factor two more intensity than this twelve nanoamps then I think we felt it was something that should be strongly considered. It would mean that we were working from a more or less one minute treatment time for a vast majority of the tumors, instead of a two minute treatment time for a vast majority of the tumors. This impacts on decisions about scanning, for instance, which we at Harvard feel is a very complicated issue. If one had this extra factor of two it might just be the thing that would allow you to go with a passive spreading technique initially and have the freedom of time to consider the more difficult wobbling and scanning issues later on. We also talked about lateral beam shaping to some extent. We talked about the multi-leaf collimator idea and again this was somewhat controversial in the sense that some of use felt that it was more complicated that I needed to be to use multi-leaf collimators in the beginning, but that again you would like to be able to use a multi-leaf collimator when you want to do dynamic treatments. Again that is something that you might want to consider for the future instead of in the beginning. Beam uniformity was something that we didn't spend very much time talking about but that's because we ran out of time. Miguel has been telling us for a long time that we need to tell him and every body at least two things. One is what intensity we really have to have. The second is what uniformity do we absolutely require in the three dimensional volume that we are irradiating. This impacts on a lot of decisions about beam spreading and that sort of thing needs to be considered very seriously. I have heard numbers as small as plus or minus one percent and I have heard numbers approaching plus or minus five percent from various people at various times. I think that our committee has not come up with a recommendation for what this should be, how we should be designing beam delivery systems. I think we are pointing out at this point that this is a controversial item and we need to make a recommendation, and then try to design a

beam delivery system that can meet it. I'm sure I've left out a lot of things but it's touched on what we spent a good fraction of our time discussing. Anyone from our facility section please feel free to add, correct or subtract from what I've said.

We felt that there were two compromises that were being made that we didn't necessarily need to make. One of them was beam throw and the other was beam intensity. If we could, in fact, push hard on both these numbers, it would considerably simplify the issue of beam delivery, which is for the facilities group the most difficult issue to solve, the crux of what we're doing.

MACHINE DESIGN COMMITTEE

I guess that the most impressive thing was the amount of work that's been done by everybody involved in either designing machines, using the machines or looking at facilities. I think that a lot of credit is due to the fact that people are working together very effectively and that we as a community have some concerns and we are providing our services to help out a number of individuals and hopefully this will continue for some time. I was quite impressed by how much work Fermilab have been able to do very quickly in putting a design together. And obviously because they were working very quickly, they couldn't have all the questions answered. Since we only had a couple of hours to talk in the group, it was decided that we would only address some of the issues in the Fermilab report and would consider this similar to a conceptual design review, where we could provide information back to the Fermilab people about things that they should be considering and things that they could be looking at for some future time where we would hold another design review on the machine itself. We started off considering the entire system, looking at what is an impact on the accelerator from the total operation and ran into some difficulty very quickly because we didn't understand some inputs as was just mentioned by the previous speaker, that is the uniformity that is required during the pulse. What is the biological effectiveness of the RF structure? There were a number of different issues that we as a group don't understand completely, and hopefully some time in the future we will get some of this type of information so that we can then look at the machine in a little more detail. It was recommended that diagnostics are a very important part of the system and this is in the beam transport line as well, the value of redundancy can't be overstressed. It is awfully important that there be good diagnostics that are not just intercepting type diagnostics, but non-intercepting type diagnostics to tell you what is happening with the machine. Another concern was the fact that the hyata? value for the machine places a good deal of emphasis on current stability during the flat top extraction. The beam can jump around a little bit and I can change the current that is being extracted. You have to be worried a little bit about the mechanism for pulling the beam out of the separatrix and what effect that has, and also if you have the bucket uniformly filled what effect that has. You look at this entire almost part doughnut that is going around the system. I'm not going to go through in detail everything that was discussed: I'm just going to give a few highlights. The uniformity of spill was expressed that it was less demanding than present type systems, say on the tevetron? and it was felt that putting adequate effort and time into this one could have some reasonable confidence that there will be a reasonable uniformity in the current coming out from each spill. It is felt that in each two-second type of operation that the uniformity of charge that is put into one of the buckets, this is the cycle where you do the rise and then the flat top of the extraction and the other half-second fall down in the field, if you look at the total repeatability of that total two-second time one could fill those buckets within five percent uniformity from bucket to bucket. This was felt to be fairly good. The extraction over a long period of time, say a millisecond, was felt that one could have rather uniform extraction in that sort of time period. You can have

feedback to maintain the current stability over millisecond time periods to within one percent to have a very good beam stability. But that's with the RF off, we never really addressed what it would be like with the RF on. The philosophy that we adopted in the discussions was that we should consider during a complete treatment time that the energy was fixed and that we were considering a scattered beam. These comments that I make are related to fixed energy and a scattered beam rather than a scan beam. If you address those issues then you are in very good shape to start understanding some of the problems when you have to then start scanning a beam. Since we had not too long a time to spend to discuss these different issues, it was felt that that was the more appropriate thing to talk about. If you put my comments about the flat top and the current variability, you will get an idea of how well one could do if one was then put into a mode of trying to do variable energy between pulses. Even variable energy during the pulse which I think is getting very complex. I understand that the system is going to be designed to take into account all of these issues from the beginning rather that tying to do this as an add-on. But I presume the initial operation would be with fixed energy and scattering. One other comment about beam diagnostics was that there could be a need for better???? on the detection system so that you could get down to the ten megahertz or fifteen megahertz sort of type operation. With some types of detectors that are being designed these days, one can get to that sort of level and look at each individual pulse and see what the characteristics are for each individual pulse that is being extracted. These are some convoluted type strip line detectors that would be sensing beam on the sides of the beam pipes rather than out of something that is actually in the beam. There is a strong recommendation that we have a look at some of the data from operation here at Fermi Lab and some other rings, just to see what the stability is like during extraction and to see what is happening in terms of the overall operation. There is a lot of data that is available and it would be worthwhile looking back at some of this data to see how other machines have operated, Then Bernie gave us a few preferences that he has; I will just mention his preferences, I won't say whether the Committee or the Group agreed with him. Obviously, some of his points we agree with and there is still a fair amount of discussion to be had on some of his preferred points. He preferred a standard room temperature magnet over superconducting magnet and there is a fair amount of discussion on that. There are some advantages superconducting magnets have. Fermi lab are going to do still a lot of work on looking at the different options superconducting to room temperature, to decide what is the best route to take. There is still a fair amount of work to be done there. That's why I said this more like a conceptual design review. Bernie would also prefer an RFQ injector. I think that almost everybody would agree with him on that as long as the costs would work out to an advantage for an RFQ system. He also would prefer to see a high rep rate, something on the order of five hertz. With the injector it is now felt that there is an easier way to do the chopping so you don't have to worry about the 700 nanosecond pulse and neutralization if you do the shopping at some other location other than what was talked about yesterday. You could get around this difficulty if you're using the Peletron or DC type injector system. I guess in terms of overall on the injector, again there is a lot of work to be done by Fermi lab. They intend to document the details of the different injector options and reasons why a particular selection would be made and there is an action item also on Berkeley to provide some costing information on a higher energy RFQ that could be an add-on or a DTL that could add on to the RFQ so that we know what the cost of this device really would be. It's awfully important to have simple-type systems that are less complex. The less complexity the more reliable the system is and it is felt that an RFQ might be less complex than a Peletron or a DC system. If the cost increase were something on the order of 250-400 k, then that would be reasonable justification for long term operation to go to an RFQ over a DC column system. The same is true on the transport line from your ion source to the injector, that you should try to keep that as simple as possible. If for some reasons, certain people prefer solenoids to quadropoles because of the reduction of the number of handles required from the semitry point of operating solenoids with respect to quadropoles. In terms of the control system, there is still a fair amount of work to be done on that to make sure that it is compatible with operating the machine in a hospital environment as well as

operating as a machine. The last comment that came up just before we closed and came down here was that, in terms of operations, some components would be left on all the time, there wouldn't be a total shutdown because it takes a long time to stabilize some of the systems. One example is the H minus sign source would be left in sort of a pseudo running mode, where it's on ready to operate but not at full power. The only time it would be shut down is for maintenance. Other that that, I think that is a complete summary, I think that the machine looks fairly nice and that there's a lot of hope that we're going to be to get moving on with this device and also the other systems that are proposed will obviously in the future provide some advantages in particular areas and I think that as a group we could provide some assistance to people who are working either with the Loma Linda/Fermi Lab group or on other types of systems. That was essentially all we discussed. If I've left out anything, I'm sure that the people who feel that I haven't adequately covered what we discussed will make a comment.

CLINICAL COMMITTEE

The Clinical Committee had, in previous sessions, looked at current possible and probable uses of protons, had made some suggestions globally as to the things that were needed – the idea of dose rate, the need for a gantry and other facility conveniences – and I think that now these have been met., or at least a model presented., the meeting that was held today focused primarily on commenting on these and how treatment would be utilized. We had prepared a list of tentative Phase I/Phase II protocols and these had been looked at by the members, and particularly in the light of what was presented yesterday, we had requested that they comment on the facilities available and comment on this as it regards to therapy. I think that I shall give the summary, or at least my interpretation of the summary, and then come back to specific comments. The summary as I've worded it is that we need to know the treatment plan that's going to be used, the patient load anticipated in order to modify or define the facility design. Based on the available experiences, there were a series of questions raised possibly in way of a comment. One was that in assigning rooms and with anticipated treatment, should there not be special facility rooms in which maybe there would be anterior/posterior vertical beams rather than have just the single AP beam. In light of the current needs, if there are going to be a large number of angular fields as in any large patient load such as in treating of lung, should we not give consideration to having two gantries. The question of need of the design and apportionment of the rooms was brought up and how these would be assigned and utilized and questions raised as to whether, as had been mentioned yesterday, there should be two synchrotrons, whether the accelerator could not be placed at ground level and brought down. The premise that I wrote down was that simplest is best and there was concern for complicating factors. Another concern was in assignment and apportionment of the room whether we had given due consideration to the beam defining devices. These would be heavy and difficult to move if they are large; if they are not appropriately designed, the beam edges could be fuzzy. Specifically, there were comments on treating of different areas – lung – what could be accomplished and other locations – pancreas was mentioned and children were other possibilities. There was not specific detailed treatment plan available and other suggestion that came out of this was that we should prepare treatment planes, working together with the contract groups as necessary, and specifically assign or at least estimate patient loads and how these would be apportioned and how we would attempt to accomplish the treatment plan.