MGH Department of Radiation Medicine Letterhead.

MEMORANDUM

TO: PTCOG Facility Committee

FROM: Lynn Verhey

SUBJECT: Summary of Contributions to PTCOG Facilities Report

At Michael Goitein's suggestion, I have read all the contributions to date from members of the Facilities Working Group and have attempted to summarize them for your consideration before the Fermilab III meeting on January 22nd. My apologies in advance for the authors of the individual reports if my summaries are either incomplete or misleading. I have used the categorization called up by Richard Wilson's outline of October 12, 1985 and have included those items on which no written reports have yet been received.

I would hope that this summary does not substitute for reading the actual reports, which have been circulated to you in an earlier mailing. For your consideration, I am also including a copy of the consensus proton beam specification report, which I included in the earlier mailing which needs to be discussed at our next subcommittee meeting on January 22nd. Please read it quickly and come prepared to suggest changes where appropriate. I have taken the liberty of sending this report to members of the Accelerator Design Working Group with a cover letter indicating that it is not the final approved document. See you all at Fermilab on January 22nd.

SUMMARY OF FACILITIES REPORT CONTRIBUTIONS PTCOG
1/13/86

1. The Effect of Energy Degradation – B. Chu.

Bill has calculated the increase in penumbra due to the presence of a preabsorber, which reduces the energy of the beam from 30 cm of water equivalent range to 5 cm of water equivalent range. He determines a sigma from the multiple scattering distribution of 5.3 mm which implies an increase in penumbra of 8.9 mm due to the presence of this preabsorber. He defines the penumbra as the 90 to 10% dose fall-off distance. This calculation is qualitatively confirmed by some measurements by Lyman et al in the alpha particle beam, which shows that the beams with the smallest residual range have the smallest penumbra. In addition, the data indicate a significant advantage to having the final collimation of the beam as close as possible to the patient surface. Clearly, a variable energy machine such as a synchrotron would have some advantages in keeping the penumbra to a minimum.

2. Energy Selection After Degradation – M. Awschalom

Miguel points out the advantage of having a beam delivery system running off the same power supply as the accelerator. He showed that energy selection in the synchrotron and in the beam transport should be no problem in that power supplies are available off the shelf, which are precise enough to deliver a 250 MeV proton beam with a stopping point uncertainty of ±1 mm. He also points out that beam losses due to nuclear interactions and multiple coulomb scattering in the variable absorber can be reduced by placing the absorber in front of the first scattering foil in the Andy Koehler-type scattering arrangement. It would also be possible to replace the first scattering foil by the variable absorber.

3. Can Gantry and Accelerator be Decoupled? – H. Enge

Report forthcoming at meeting.

4. Need for >1 Beam Direction and/or Gantry – L. Verhey

Report forthcoming at meeting.

5. Scanning and Wobbling – B. Chu

Bill describes the various advantages and disadvantages of beam spreading methods including the double scattering passive system, the wobbler magnet system, and both raster and pixel scanning techniques. Clearly the major advantage of the double scattering technique is its simplicity whereas the major advantages of the wobbler and scanning techniques are the versatility and the ability to shape dose distributions in three dimensions. Bill lists the difficulties with the sophisticated techniques in some detail and finishes the section with a discussion of the high dose rate effects in beam scanning and concludes that even at dose rates in excess of the 120,000 rad/sec which one would need for beam scanning a 40 x 40 x 15 volume with 1 cm^3 volumes that the oxygen depletion effect should be unimportant due to the small overall dose per fraction.

6. Control System – M. Awschalom

Miguel discusses mostly the philosophy of the control system in which he embraces the concept of simplicity, reliability and human engineering of all programs with a large number of console computers and computer parts available for rapid repair. In addition, he discusses the desirability of connecting al console computers to a local area network, such as the IBM TOKEN network, and the need to use a central computer for treatment planning which is capable of supporting Mike Goitein's treatment planning program. This presumably would be a DEC MicroVAX II.

On the subject of beam line instrumentation, Miguel included a note about the advantage of using SEM's instead of gas-filled chambers for monitoring the treatment beam. He calculates conservatively that in a choroidal melanoma beam it should be possible to measure the lowest charge with about 1% using SEM's. These devices would have to be frequently calibrated since they age with time but this is not thought to be a problem.

7. Lateral Beam Shaping – B. Chu

Bill has discussed the advantages and disadvantages of a multileaf collimator. In terms of beam shaping, it is a bit of a compromise as even a large number of jaws do not allow one to shape the fields as precisely as an individually machined beam aperture. On the other hand, the versatility and speed with which the field shape can be changed and the ability to use the collimator for dynamic treatments makes the use of a multileaf collimator and attractive possibility.

8. Beam Modulation – M. Awschalom

Miguel discusses the advantage of placing the variable absorber upstream of the first scattering foil to reduce beam loss due to multiple scattering and nuclear interactions.

9. Position Verification – B. Chu

Bill discusses the limitations of the verification of beam stopping regions using Oxygen-15 measurements. In particular, he discusses the uncertainty in the stopping point taking into account the threshold of the Oxygen-16 to Oxygen-15 reaction, the energy of the proton secondaries, and the sizes of the detector elements. He concludes that the uncertainty in position is comparable to that which is in the therapy planning itself, namely about 5 mm in a 15 cm range. Bill also discusses the possibility of using a proton beam CT to verify the treatment plans. Although this is certainly a possibility, it is obviously a technically advanced area of development.

10. Planning R_x – M. Goitein

No written report received.

11. Facility Design – A. Koehler, R. Wilson

No written report received.

12. Shielding – M. Awschalom

No written report received.

13. Patient Positioning – M. Awschalom and S. Zink

Miguel Awschalom proposes to use a system not unlike that which they are using at Fermilab's neutron facility. This corresponds to a sitting position for radiation of the head and neck area and a couch for radiation of patient sin the supine, seated or kneeling positions. He claims this would be adequate for a facility with a fixed horizontal, fixed vertical, or a combination of fixed horizontal and vertical beams. He mentions that snouts could be developed on a ball-bearing system, which would allow one to quickly and reproducibly change hardware from eye treatments to larger field treatments. He does not address the problem of getting CT scans in the treatment position on these patients. Sandra Zink also addresses the question of patient positioning and concludes that in order to scant patients in the treated positions using a conventional CT machine, it is necessary that most patients be treated either supine or prone, positions in which patients can be rather easily and securely immobilized. Such a facility would require a gantry or multiple, fixed beams to allow the treatment of all desirable angles.

14. Personnel Requirements – M. Goitein
No written report received.

15. Beam Switching – M. Awschalom et al.
Miguel describes two possible designs of beam switchyards, which will carry the beam from the accelerator to the several external treatment beam areas. Both designs consist of magnets, which are synchronized in design wit the magnets of the synchrotron so that the same power supplies, which energize the synchrotron, will also energize the switchyard magnets. He also claims this design requires no quadrupoles. He discusses the cost of warm core vs. superconducting magnets and concludes that the cost of construction is similar but that the significant savings in power consumption of the superconducting coils leads to a preference for that design. He concludes with a discussion of general considerations of switchyard designs which emphasized the need for reliability, redundancy, and simplicity of design.

16. Specification of Proton beam – L. Verhey
Lynn Verhey has summarized the report of the Clinical subcommittee as well as the Facilities subcommittee in an attempt to produce a consensus proton beam specification. Although a true consensus is not possible at this early date, this should be considered a document for discussion purposes. Miguel Awschalom has also made his own simplified specifications for a proton accelerator.

17. Financial Issues – K. Thomas
No report received.

18. Criteria for Evaluation – M. Goitein, R. Wilson
No report received.