PROTON
THERAPY
CO-
OPERATIVE
GROUP

Notes from Accelerator Subgroup Meeting
PTCOG XII, Loma Linda, CA
May 9, 1990

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Approximately thirty people participated in the Accelerator Subgroup meeting, making for a morning of lively discussions. Primary concentration was on the Loma Linda machine, its design philosophy and commissioning status. Following a break, we ranged over many different topics, from the status of accelerator technology to the optimum size of a treatment facility. Our discussions will be summarized below.

Loma Linda Accelerator

Strong vs Weak focusing. The choice of a weak focusing design for the Loma Linda Accelerator was brought up once again. Frank Cole defended the design choices, stating that a high dispersion had been purposely built into the machine to minimize the microwave instability. However, the large beam losses and inefficient capture are a definite price, which must be paid for the large dispersion. Weak focusing does allow one to avoid accelerating the beam through transition, undoubtedly a positive factor. In all, there are good and bad things that can be said about any lattice design, to paraphrase Tom Collins, a well-known Fermilab accelerator theorist, lattice design boils doen toa matter of personal taste of the designer.

Chromaticity problem. Beam studies at Fermilab uncovered a non-zero chromaticity of the synchrotron, with insufficient means for correcting this. Some of the beam loss can definitely be attributed to this factor. Following the dismantling of the ring at Fermilab, all magnets were measured and shims were fabricated to correct this problem. The shims were all installed prior to shipment. Calculations of the expected chromaticity in the ring based on the magnet measurement data agreed very well with the measured chromaticity, lending faith that the shimming would cure the problem. In transit, one set of shims in one magnet was damaged, it was decided that for expediency instead of taking the time to repair this shim package it would be simpler to remove all of the shims from all of the magnets. During our discussions a strong point was made that this should not have been done, and that the shims should be replaced in the magnets as soon as possible. This argument was resisted by the Loma Linda, SAIN and FNAL representatives, the counter argument being that at this stage of the commissioning it was more important to get some beam out to the treatment area, to test out all components of the system. Even if the intensity were low, valuable commissioning tests could take place. After a first round of testing, all areas would welcome a shutdown to fix problems found, this would be a perfect time to reinstall the shims.

Intensity Issue. Space charge has not been an issue to date at all. At this point it appears that design decisions driven on space charge arguments may have been a bit conservative. The feeling from the SAIC, Fermilab contingent is that the present system is capable of producing “adequate” beam intensity for the treatment programs. To increase the intensity, it is felt that a rebuild of the beam transport line between the source and the RFQ is necessary. Matching into the RFQ is not optimal now, but transmission beyond this point appears to be good. As space charge at injection does not appear to be a problem at this time, the Fermilab and SAIC folks felt that a higher injection energy would not increase the overall beam intensity.

Controls and system integration. There is a real problem with integrating the controls of the accelerator with the treatment control system. These two systems have evolved independently, and little or no effort has been made to establish links between them. This is of concern in several areas. First, there is no provision for the experimenter to control the beam intensity as it enters the treatment area. While not terribly important for a passive delivery system, it is vital for any kind of scanning. Second, there is no direct link to basic accelerator control points to shut off the beam when the full dose has been delivered and beam cutoff is desired. The cutoff techniques employed all rely on ancillary systems, primarily magnets and stops in the switchyard.

What will the next machine look like? Based on the experience with the present accelerator, it was felt that a designer starting with a fresh piece of paper would probably go in a slightly different direction. The emphasis on the smallest-possible accelerator seems to be unnecessary, as the footprint for the facility is dominated by the beam transport and gantry areas. In fact, allowing the ring to grow by as much as 20% in circumference will produce good beam-dynamics paybacks without an appreciable cost increase. Cost would probably not be a factor until the machine size doubled.

Other topics

Optimum facility size. A discussion took place about how many treatment rooms a single accelerator could service. Monte Carlo simulations for the Loma Linda facility, with 4 treatment rooms and 5 ports indicated that typical waits for beam following a request would be 4 to 7 minutes. Some people felt this was too long, and would lead to inefficiencies, and hence lower revenues. Ives Jongen argued strongly that no more than 4 rooms should be built in a single facility.

Economic calculations. The question was asked as to whether the extra costs of proton therapy would be "socially acceptable". The consensus of our group was that even if the improvements in treatment success were only very slight the extra costs would be clearly acceptable. [Somehow I don't think we can be totally objective on this subject.] During the discussions the surprising figure was given that typical cost to the patient in Europe for a full course of photon therapy was be around $2,000. This exceedingly low figure makes it very difficult to provide economic justification for a charged-particle treatment center.

Cyclotrons vs. Synchrotrons vs Linacs. Having partisans for all three technologies in the same room would of course eventually lead to a discussion of the relative merits of each accelerator. Advances in technologies for all three types of machines have been rapid, and will continue to be so. One could advance strong arguments for building any one of the three machines for dedicated medical purposes, and one would need to look at the specific needs of each customer, his site, the planned use, and funding to make the beast decision. Again, it was brought out that simplicity and reliability were by far the overriding considerations in a facility design. A strong recommendation was made that a machine should be single-purpose, and one should not, for instance, plan to produce isotopes or do physics experiments in the off-shifts.