RESULTS OF THE WORKSHOP

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The results given here are from notes and may not be complete. Although I have tried to reflect all viewpoints, the conclusions also include a measure of my own opinions and may not be agreed to by every participant.

1. Active therapy work is now being done with primary charged-particle beams (protons and heavier ions) at the Lawrence Berkeley Laboratory, KEK (The National Laboratory for High Energy Physics) and the University of Tsukuba in Japan, the Harvard Cyclotron Laboratory and Massachusetts General Hospital, and the Institute for Theoretical and Experimental Physics, Moscow, USSR, and at Gatchina (Leningrad), USSR. Work was done at the Gustav Werner Institute in Uppsala, Sweden during the years 1957-1968 and at Dubna, USSR. In all these hospitals, good clinical results have been obtained with tumors of the head, neck and genital areas. An extensive accelerator and facility improvement program is well along at Uppsala with extracted beam scheduled for late 1985. Planning for test on eye cancers is underway at Argonne National Laboratory using the existing 15-MeV proton linear accelerator and Fermilab has recently proposed a proton-beam facility using the existing 200 MeV accelerator.

2. Therapy was considered at the workshop to be the highest priority for the accelerator design. Diagnostic use is not an issue, because that work has been taken over by NMR. (It might be possible some day to improve resolution over NMR with proton radiography, but this is not now an active field.) Production of radionuclides complicates the design of synchrotrons and makes them more expensive than synchrotrons without radionuclide capability. Cyclotrons and linear accelerators inherently have high enough intensity that useful radionuclide production comes automatically. In fact, the cyclotron at Uppsala is planned to receive significant revenue by producing enough 123I for all Scandinavian medical needs. Radionuclide production is, even in these cases, considered to be significantly lower in priority than therapy.

3. The two lines of work, low-LET (protons and helium) and high-LET (heavy ions) are almost entirely separate. The high-LET work is all done at Lawrence Berkeley Laboratory, where a new medical accelerator is to be proposed for this work.

4. For low-LET accelerators, there was consensus on the following specifications:

<u>Energy</u>:	Protons 250 MeV
<u>Intensity</u>:	1 Gy/min over a sizeable area (perhaps 30 by 30 cm^2 or a little larger) (1 Gy = 100 Rad). This corresponds to an extracted current of the order of a nanoampere or more, or 10^{10} particles/sec.
<u>Repetition Rate</u>:	At least 1 Hz, preferably higher.
<u>Facilities</u>:	Several treatment rooms with expansion capabilities.

Very high reliability (better than 95%) and ease of repair were stressed by all speakers as a critical part of any accelerator for this purpose.

5. Linear accelerators inherently have much higher intensity than needed and are much more costly than other accelerators. It is believed that a linear accelerator should be considered for this application only if there is an existing, free accelerator.

6. Cyclotrons and synchrotrons can be compared as follows:

Cyclotron	Synchrotron
Fixed energy	Easily variable energy
Intensity 1 μA	20 nA
Proven Technology	Proven Technology
Detailed design: considerable	Not proven in detail;
experience with CW cyclotron	possibly cheaper

The Michigan State Laboratory has built and operated cyclotrons of directly applicable design. If one were ordering an accelerator today, one would choose a cyclotron.

7. R. L. Martin suggests that it is possible to make significant economies in a synchrotron that depends on scanning to cover the entire area, but whether the technology of scanning and monitoring is advanced enough to depend on it exclusively is controversial at this time.

8. The existing cyclotrons at Michigan State have superconducting magnets. Robert Wilson shoed an extremely attractive concept for a superconducting synchrotron, small enough to fit on a table top. Superconducting technology is advanced enough to be completely dependable and commercially available. It is interesting to consider building a superconducting accelerator directly into the gantry to achieve flexibility in movement.

9. The minimum cost of a low-LET accelerator appears to be 1 to 1.5 M$. The minimum cost for a facility, starting from scratch, with at least marginally adequate treatment rooms appears to be 8 M$. Economies may be possible in existing facilities. The cost of the accelerator is not a major fraction, but it is large enough to hope for significant savings through careful design. There are widely divergent views on costs of these facilities.

10. The workshop has performed a valuable function in getting medical people and accelerator people to talk and may be a beginning for new initiatives in charged particle beam therapy.