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Accelerator Break-Out Group Summary

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Abstract. Interesting developments in accelerators have shown that they can be used as 'factory'-type systems with the choice of technology dependent on the specific requirements of the application. The status and future possibilities for cyclotrons and linear accelerators are compared briefly, based on discussions at a break-out session on accelerators. Only high power systems with beam powers in excess of a MW average power were considered.

INTRODUCTION

Schriber and Mandrillon co-chaired a break-out session on accelerators held during the ADTT Conference for about three hours on the fourth day of the conference. About twenty attendees participated in discussions of accelerator issues and future possibilities. Several high power accelerator concepts were discussed with an aim towards understanding similarities and differences in the technology, and understanding the directions that future applications would drive technical developments. High power accelerators were defined for this session as machines that could deliver more than a MW of average beam power to a suitable target, with a beam energy in excess of 500 MeV. Three basic points for high power accelerators were:

1) For applications requiring in excess of 10 MW of beam power, cw (continuous wave) linacs employing structures based on room-temperature copper cavities would be the preferred choice. Several decades of development in this field have been carried out at LANL (Los Alamos National Laboratory).

2) The increasing maturity of rf superconducting cavity technology provides an interesting option for high power linac applications.

3) The recent outstanding success of the PSI (Paul Scherrer Institute) ring cyclotron which extracted 0.6 GeV * 1.5 mA beam last year is a strong motivator for considering cyclotrons for applications requiring less than 10 MW of beam power.

Other than the accelerator developments at PSI, very little attention has been given to high power cw operation of cyclotrons; unlike the situation for linacs. Perhaps with more cyclotron development in the future, the conclusions of this break-out session would be changed towards more acceptance of cyclotrons in the 1-25 MW beam power regime. In fact, the following question can be posed now. For 10 MW average beam power, what is more difficult in terms of increasing beam power by a factor of ten above present day performance -- scaling power and considering a cyclotron, or scaling duty factor and considering a linac?

Applications requiring less than several MW of average beam power would find the cyclotron a very viable option, unless multiple uses of the facility imposed constraints that only a linac could fulfill. In the 10-100 MW average beam power regime, there are a number of choices that a linac designer can make -- including pulsed versus cw, room temperature versus superconducting, RFQ/CCDTL versus HIBILAC, and small versus large beam apertures. Above 100 MW average beam power a cw linac would be the choice.

A brief discussion of similarities and differences between cyclotrons and linacs follows for a 10 MW average beam power application.

10 MW CYCLOTRON AND LINAC SIMILARITIES

There are many similarities between the technologies and infrastructure supporting cyclotrons and linacs with average beam powers of about 10 MW. These similarities can be summarized as follows:

1) Although matching conditions are quite different, the design of the ion source and associated LEBT present similar problems and would look very similar in practice.

2) Fractional beam losses are expected to be at the same level, based on operations of MW output beam facilities at LANL and PSI where both have fractional losses of about 0.0002 of useful beam delivered to the target.

3) Improvements in ac to rf conversion efficiency for rf power systems would be very desirable and would have big impacts in costs as well as performance.

4) Diagnostics and feedback controls are important for operating both types of machines.

5) Higher order mode excitation and control are important considerations for operations.

6) RF coupling and couplers are important considerations; coupler sizes being considered are 500 kW for the cyclotron and 250 kW for the linac.

7) Beam halo is an important study consideration for understanding beam losses, possible activation and beam oscillations.

10 MW CYCLOTRON AND LINAC DIFFERENCES

There are also many differences between the technologies and infrastructure for these machines. These differences can be summarized as follows:

1) Although mentioned above as a similarity, rf couplers also have some differences. Cyclotrons benefit from a lower frequency and as such, should be able to attain higher power ratings than that for a linac.

2) Efficiency of conversion of total ac power to beam power is different. Existing machines show advantages for the cyclotron in some cases and advantages for the linac in other cases. The actual results depend on the application and the amount of beam loading within the rf cavity systems.

3) Transport between various sections of the machine is vastly different.

4) Detailed beam dynamics, including transverse-longitudinal coupling, for cyclotrons needs more development and investigation; and this is underway. Studies of emittance growth show significant differences between the two types of machines.

5) Collimators **DO** work and clean the beam for cyclotrons, thus improving operations.

NEXT STEPS

Researchers and investigators in the linac and cyclotron communities need to work together to determine realistic comparisons of the two types of machines. Proper comparisons between them would be extremely useful for an understanding of operations, costs and technology developments/capabilities. As is stated in many other fields, 'we want apples to apples comparisons, not apples to oranges'. Exchanging information relative to technology developments and future activities would benefit everyone.

We should develop tools, codes, capabilities and resources together in a manner that would assist sharing information, and reduce time and effort expended if done separately.

An example of one area of interest would be the development of high power beam dynamics codes that consider halo particles in enough detail to understand regions of beam loss. Other examples include beam-cavity interactions, related control measures, beam loss models and transport systems.

Front-end demonstrators are needed for both types of machines to understand aspects of initiating high power beams.

ACKNOWLEDGMENTS

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