SUMMARY REPORT OF THE WORKING GROUP B: BEAM DYNAMICS IN HIGH INTENSITY LINACS

A. Aleksandrov[1], I. Hofmann[2], J-M. Lagniel[3]

[1] Oak Ridge National Laboratory, Oak Ridge, TN 37830 USA,
[2] GSI, Planckstr.1, 64291, Darmstadt, Germany
[3] Jean-Michel Lagniel, GANIL, Caen, France

INTRODUCTION

The focus of the Working group B was to discuss the following questions:

1. Summarize the state of the art in linac simulation capabilities. What are the weaknesses? What developments are needed?
2. Summarize recent developments in benchmarking experimental data with simulations. What critical experiments are needed to further refine the theory and simulations?
3. Summarize the present understanding and limitations of linac beam dynamics in operating linacs.
4. Summarize the primary limitations to beam intensity in existing high-intensity linear accelerators.
5. Summarize the key open questions in the beam dynamics of high-intensity linacs and opportunities to advance the field.

There were 9 invited talks, 4 contributed talks and 2 posters, covering the above topics roughly uniformly, followed by 2 discussion sessions.

LINAC SIMULATION CAPABILITIES AND DEVELOPMENT

There has been tremendous progress in computing power of parallel computers. There are a number of linac beam dynamics codes capable of using that power. As a result more particles can be tracked in PIC simulations with more accurate space charge forces calculation on denser 3-D grids. An example of an RFQ simulation with 865 million particles in only 5 hours was presented. It appears that simulations have reached the number of particles in real bunches. However it was noted that even further increase could be beneficial for studying effects of correlations in 6-D distributions.

There is not an individual code preferred by the majority in the community. Usually developers trust and promote their own codes.

Defining realistic initial distributions remains a problem. It is not clear how to recreate 6-D distribution from measured 2-D or 1-D projections. There is no understanding of the importance of correlations between degrees of freedom in 6-D distributions. One interesting approach shown by Lars Groening is to use a phenomenological analytical formula with coefficients tuned to fit the measurements at one location in the linac. The resulting distribution is closer to the measurements than water bag or Gaussian but it is not clear how well it reproduces the real beam in other parts of the machine. Another common approach is to use output distributions from RFQ simulation. The 4-D distribution for the RFQ input is easier, in principle, to reconstruct from measured 2-D projections. The remaining question is confidence in the RFQ codes. More realistic boundary descriptions for RFQ simulations should be developed.

CODE BENCHMARKING

Dedicated benchmarking experiments are rare because they are quite time and resource consuming. One very thorough study was presented by the GSI group, where they compared predictions from 4 PIC codes with experimental measurements for different phase advances in the UNILAC DTL. Puzzling discrepancy between the codes was reported and sparked lengthy discussion. Differences in model set up was suspected and confirmed by authors in a follow up work. Still there is noticeable difference between the codes.

It was noted during the discussion that in many past cross-checks between various codes good agreement was observed. Typically cross checking is done close to the design set points for well matched beam. There are reports of non-discrepancies for non-matched beams but no systematic study has been done. As a first step codes should be cross-checked using a simple model and non-matched beam.

Also it was noted that part of the problem could be due to lack of information on longitudinal beam parameters.

UNDERSTANDING OF BEAM DYNAMICS IN OPERATING LINACS

Reports from two new linacs at SNS and at JPARC demonstrated that there is a good general understanding of beam dynamics, which allowed designing the machines so that they both perform close to the design parameters. However despite a steady progress in refining the models there is no complete understanding of all beam dynamics details in new linacs. Two examples were unexpected beam loss in the SNS SCL and transverse tail development in the JPARC linac.

LIMITATIONS TO BEAM INTENSITY IN EXISTING LINACS

The SNS linac is the most powerful to date. Loss limiting intensity has not been achieved yet. It is possible that design limitations other than beam dynamics will limit the maximum intensity (e.g., available RF power).

There is general agreement that with increasing beam power in the emerging projects beam loss caused by the intensity effects will ultimately limit the maximum power. Expected fractional losses are extremely small. Understanding of halo formation remains the most important problem at the intensity frontier.

NEW DEVELOPMENTS IN BEAM DYNAMICS OF HIGH INTENSITY LINACS

The most notable trend is extending use of superconducting cavities to lower energies and related new approaches to transverse focusing.

The Argonne group showed an example of using solenoids for transverse focusing at low energy. This allows stronger focusing per unit length, therefore higher accelerating gradients can be used. Also maintaining round beam cross sections at lower energy can reduce halo development

KONUS beam dynamics allows the use of H-mode cavities with higher shunt impedance. It has being around for some years, and now is extending to high beam intensity applications.

The finding of a 4:1 resonance in PIC simulations of the UNILAC DTL was reported. It could be a useful case for benchmarking of simulation codes and sheds new light on the 90^0 phase advance "barrier" in linac design.

The “tail emphasis” method presented by J. Rodnizki “tail emphasis” method allows large dynamic range calculation of longitudinal tail development in an RFQ with significantly less particles than conventional calculations.