Advanced Beam-Dynamics Simulation Tools for the RIA Driver Linac

Part 1: Low Energy Beam Transport and Radiofrequency Quadrupole

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Motivation: To develop computer simulation tools for calculation of small beam losses in the RIA driver-linac.

- Beam losses must be limited to very low values (~1 W/m) to avoid radioactivation of the accelerator components, which would prohibit hands-on maintenance.

- The first main objective for the beam physics is to design the driver linac for very low beam-losses.

- **A second main objective is to show from computer simulations, using a realistic model of the linac, that the beam losses will be acceptably small.**

Description of the Project

- To include random errors and a sufficient number of simulation particles per run, we need parallel-computing capability to obtain results with good statistical accuracy.
- The initial implementation will be at NERSC (National Energy Research Scientific Computing Center) at LBNL.
- This is a four Laboratory project (LANL, LBNL, ANL, MSU).
- Our proposals were submitted September, 02 and were approved April, 03. Our work began this summer.

The project plan is to develop tools and perform high-statistics beam-loss calculations for comparison with and optimization of candidate driver-linac designs.

- We are using well-established codes as the basis for the new simulation tools.
- Front-end code is based on the **PARMTEQ** Radiofrequency Quadrupole (RFQ) code.
- Main superconducting linac code is based on the **IMPACT code** (already parallel).

Description of the standard PARMTEQ code

- PARMTEQ has been used for more than 20 years for RFQ beam-dynamics design and simulation. It is a well-documented standard code of the DOE supported Los Alamos Accelerator Code Group.
- PARMTEQ provides an accurate model of the RFQ.
- LEBT (low energy beam transport before RFQ) and MEBT (medium energy beam transport after RFQ) are included.
- Space-charge subroutines are included.
- PARMTEQ has been benchmarked against beam measurements, beginning with the RFQ proof-of-principle experiment in 1979.

Development plan for RIA version of PARMTEQ

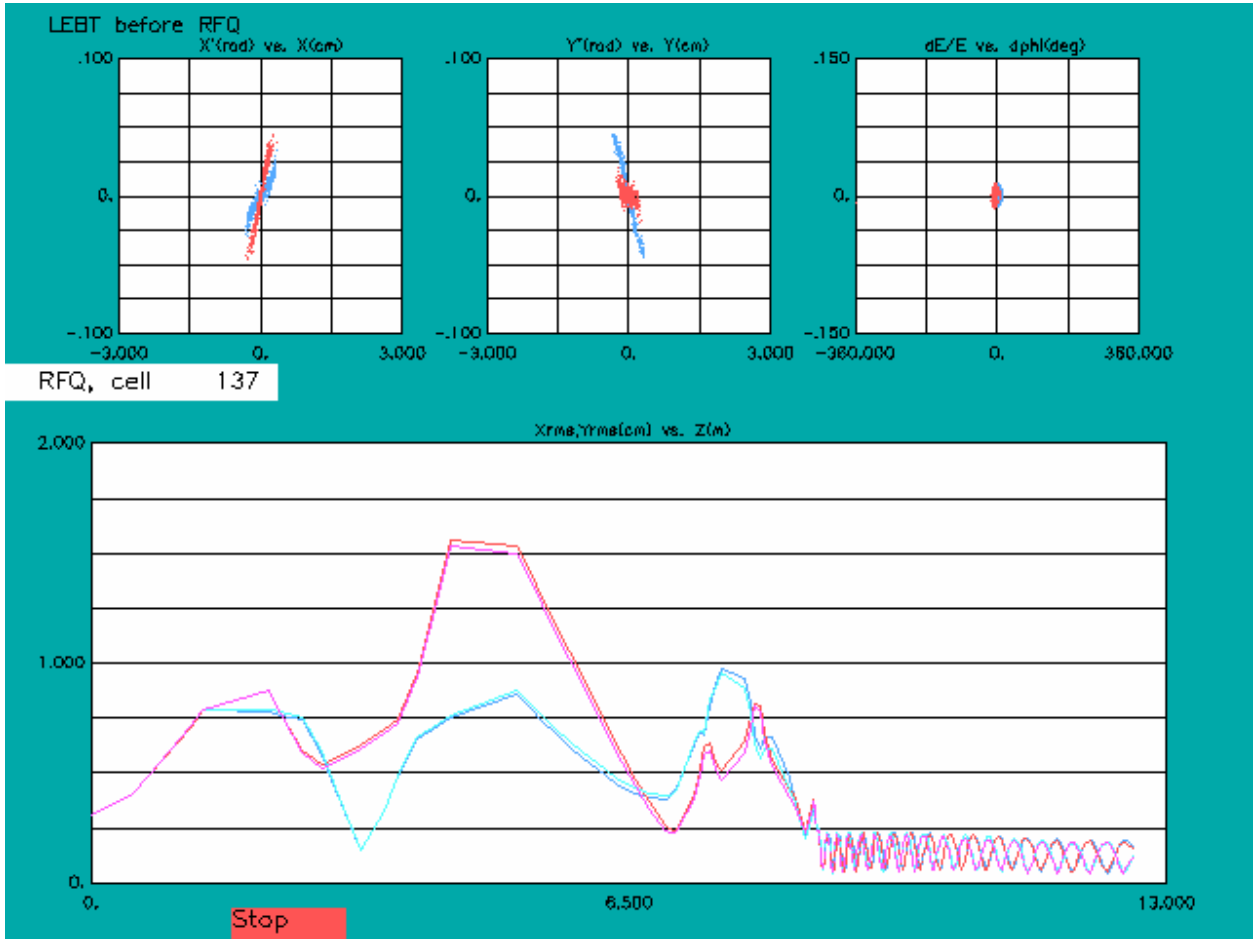
- Introduce multicharge dynamics beginning with 2-charge-state beam in LEBT/RFQ, first to desktop computer version, later at NERSC.
- Modify space-charge for multicharge beams in LEBT and RFQ.
- Introduce any non-standard beamline elements needed for RIA.
- Install standard PARMTEQ version at NERSC. Implement physics changes at NERSC.
- Implement parallel-computing algorithm at NERSC.
- Make low-statistics comparisons of results from RIA-PARMTEQ with other existing codes to identify and resolve any major differences, before high-statistics runs are made.

Status of RIA-PARMTEQ work

- Physics changes to PARMTEQ have been made to the standard desktop-computer version, providing a new 2-charge state simulation capability including space charge in the LEBT and RFQ.

- The standard PARMTEQ version has been installed and tested on the NERSC computing facility.

PARMTEQ simulation results with space charge for a RIA design from HV platform to end of RFQ with 2 charge states of uranium (q=28 and 29). Simulation includes transport, quadrupole focusing, multiharmonic bunching, and acceleration.



RIA-PARMTEQ jobs to be done

- Introduce additional beamline elements needed for RIA.
- Introduce the physics changes into PARMTEQ on NERSC machine.
- Implement parallel capability for PARMTEQ on NERSC machine.
- Make low-statistics comparisons of RIA-PARMTEQ results with other codes, prior to high statistics runs on NERSC.
- Combine PARMTEQ and IMPACT to perform high-statistics beam-loss computations including random errors for different designs.

Summary

- This is a project to develop parallel-computing simulation tools for high-statistics beam-loss calculations for the RIA Driver linac.

- We are using well-established codes as the basis for the new simulation tools (PARMTEQ for front end; IMPACT for main linac).

- Status:

  -PARMTEQ now has 2-charge-state capability including space charge forces in the desktop-computer version.

  -We have installed and tested the standard version of PARMTEQ on the NERSC computing facility, ready for 2-charge-state physics changes.