Simulation of particle beam dynamics for Electron Beam Ion Source

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Project: The goal of the project is numerical simulation of various physical processes taking place in electron beam ion sources (EBIS) with special attention devoted to formation and evolution of different instabilities manifested in such kind of sources. Understanding of these processes could allow to improve efficiency of the sources. To perform the necessary simulation, it is planned to develop specialized software utilizing particle-in-cell (PIC) method. Such desired PIC code should allow to calculate all electron and ion trajectories in a self-consistent way, taking into account their local space charge dynamics in addition to external static electric and magnetic fields. A practical goal of the project should be simulation of real-time dynamics for EBIS-type ion sources, especially for EBIS working in reflex mode of operation (known as electron string ion sources, ESIS; ESIS invented and developed in JINR; KRION-6T ESIS (JINR) is a prototype of ion source for NICA project).

Learning experience: The candidate will learn to make simulation of particle dynamics using specialized software. You will get skills in bash, Python, Jupyter, Git and will learn how to perform computations on JINR supercomputer. For those interested in accelerator science the project is an excellent opportunity to become familiar with basic principles of low-energy beam dynamics taking place at ion sources of many high-energy accelerators. For students willing to advance their programming skills it is possible to participate in code development and get practice in C++ and Python programming.

Required skills: basic Python language, computer with linux operating system

Tasks

If you are willing to concentrate on physics and simulations:

- Install and configure Ef to perform simulations. Optionally: explore alternatives: Warp, PIConGPU, CST etc.
- For Ef, find and implement tests comparing numerical simulations with analytical models for low-energy beams in electromagnetic fields. Optionally: perform similar tests in different software.
- Optionally: for Ef, compare results of numerical simulations with available experimental data.

If you are willing to concentrate on programming:

- Understand code organization of Ef.
- Implement modules for various parts of Ef: different algorithms to solve Poisson's equation, different time integration schemes, various parsers for files with external fields, etc. Programming language is either Python, or C++, or both.
- Optionally: understand difference between MPI, OpenMP, CUDA, OpenCL and participate in GPU and/or CPU parallelization of Ef.

The number of project participants: 1-2

Website: https://github.com/epicf/ef/wiki

Period of practice: July