F. Méot, BNL C-AD

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Course syllabus : Numerical Experiments with Particle Accelerators

The course is an introduction to the physics of particle accelerators, based on computer laboratory time during which students will manipulate/play with charged particle beams. Students will discover the main types of charged particle accelerators and their optical components, they will learn the basic principles they lean on, *via* numerical simulations using dedicated, popular, beam dynamics and beam optics computer programs.

Students will run these programs and manage the data they produce, using small sets of short, *ad hoc*, input data file and other data treatment computer tools which they will be provided. They will confront their experimental beam dynamics findings with theoretical expectations, they will interactively play with both : experimentation regarding particle beams in accelerators and accelerator components, and the underlying theory.

Purpose of the course : The course will prepare graduate students with no prior experience for the understanding of the physics, and the design, of particle accelerators. Running computer programs has a variety of goals : applying numerical methods to solve problems for which analytical methods have prohibitive limitations, analyzing or acquiring data from numerical simulations, analyzing and understanding these data, presenting and reporting results on appropriate media. This course will allow students to attain a level of knowledge needed to thrive in this field, it will navigate through the following list, as time allows : cyclotron and transverse stability, CW acceleration ; synchro-cyclotron and longitudinal stability, pulsed acceleration ; pulsed synchrotrons ; particle colliders ; light sources and synchrotron radiation damping, insertion devices ; electrostatic accelerators and linacs including space charge effects. Numerical experiments will include a variety of beam physics topics such as, phase space motion, optics defects, non-linear dynamics and resonances, synchrotron radiation Poynting and spectral brightness, spin dynamics and other siberian snakes, in-flight particle decay, beam purification, *etc.*

The course will introduce to a wide variety of applied mathematics and numerical methods, from interpolation to ODE solving to Fourier analysis. It will introduce to popular software tools as gnuplot (plotting), latex (writing), and most probably to program debugging as part of the lab time. It will develop system and computing skills, knowledge in computer languages. In a general manner, this course will require the students to carry out numerous programming or other computing tasks under linux environment.

A 2 hour session will be organized in the following way : underlying theoretical principles of the “topic of the day” (15-20 minutes) ; software tools for the session (10-15 min.) ; computer simulations and data analysis (1.5 hour).

Lecture notes will be provided *via* .pdf files produced under latex. Students are expected to turn in their computer lab time and home work assignments under the same environment. Preparation of lab time experiment sessions will be part of home work assignments.