What is Accelerator Physics?

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Accelerator Physicist

August 16, 2004

What are Particle Accelerators?

- Particle accelerators are machines that produce energetic particle beams for various applications:
  - High energy and nuclear physics
  - Material science
  - Isotope production
  - Cancer treatment
  - Fusion
- The physical properties of the beam produced depend on the requirements of its intended application:
  - Particle species, energy, polarization
  - Beam size, intensity, time structure, lifetime
- *Accelerator physics is the field that deals with all the physics issues associated with the production of energetic particle beams.*

Variety of Requirements

- Species:
  - electrons, positrons, protons, antiprotons, photons, neutrons, negative ions, heavy ions, muons, neutrinos
- Energy
  - keV -> TeV
- Beam Size
  - 100m -> submicron
- Intensity
  - watts -> Mwatts
- Time Structure
  - femtoseconds -> continuous
- Lifetime
  - nanoseconds -> days

Accelerator Physics: A Characterization

- Accelerator physics is a branch of applied physics. The goal is the production of particle beams for other applications.
- As a field, it is limited only by this goal. Because of the great variety of applications and associated beam requirements, accelerator physics is a broad field.
- Accelerator physics ranges from engineering and technology to diagnostics to experimental physics to computer science to computational and theoretical physics.
- Because it encompasses so many disciplines, accelerator physics supports a diverse community with a wide range of interests.
- There is a great deal of interaction between the various disciplines.

What Physics Subjects are Required?

- Classical mechanics and nonlinear dynamics
  - Single particle motion
  - Multi-particle and collective phenomena
- Electromagnetism
  - RF cavity design and analysis
  - Impedance and wakefield determinatons
- Statistical and plasma physics
  - Multi-particle and collective phenomena
- Quantum and nuclear physics
  - Beam - materials interactions
  - Quantum fluctuations in storage rings
- Other fields as required

Accelerator Physics Resources: Books and Websites

- Basic Texts
  - D.A. Edwards and M.J. Syphers, *An Introduction to the Physics of High Energy Accelerators*
  - H. Wiedemann, *Particle Accelerator Physics*, 2 Volumes
  - S.Y. Lee, *Accelerator Physics*
  - *CERN Accelerator School Notes*, Various subjects
- Handbook
  - A. Chao and M. Tigner, *Handbook of Accelerator Physics and Engineering*
- Beam Optics
  - D.C. Carey, *The Optics of Charged Particle Beams*
- Linear Accelerators
  - T. Wangler, *RF Linear Accelerators*
- RF Superconductivity
  - H. Padamsee, J. Knobloch, and T. Hays, *RF Superconductivity for Accelerators*

Accelerator Physics Resources: Books and Websites

- Collective Dynamics and Instabilities
  - A. Chao, *Physics of Collective Beam Instabilities in High Energy Accelerators*
  - M. Reiser, *Theory and Design of Charged Particle Beams*
  - N.S. Dikansky and D.V. Pestrikov, *The Physics of Intense Beams and Storage Rings*
- Websites
  - Journals
    - http://prst-ab.aps.org/
    - http://pre.aps.org/
  - Conferences
    - http://www-conf.slac.stanford.edu/pac03/, PAC 2003
    - http://www.epac04.ch/index.html, EPAC 2004
  - SNS
    - http://www.sns.gov//
    - http://www.sns.gov//APGroup/APGroup.html

Where do Accelerator Physicists Work?

- Major Laboratories, Accelerator Facilities, and Universities
  - United States
    - Fermilab, Stanford, Brookhaven, Berkeley, Los Alamos, Argonne, Jefferson Lab, Oak Ridge, Cornell, Michigan State, Indiana University, University of Maryland
  - Worldwide
    - CERN, KEK, GSI, DESY, JAERI, BINP, RAL, …
- Industry
  - Technology suppliers
  - Isotope separation
  - Cancer treatment centers

Potential Thesis Topics at SNS

- Computational, theoretical, and experimental, studies of the dynamics of high-intensity charged particle beams with emphasis on multi-particle and collective effects.
- Experimental investigations of charged particle measurement and control.
- Development of laser-based diagnostics and manipulation techniques for charged particle beams.
- Development of high-current H^- ion source technology.