Project name

Flat beam generation in Photocathode and Advanced Beam Manipulations

Classification (accelerator/detector:subsystem)

Accelerator

Institution(s) and personnel

Department of Physics, Indiana University:
S.Y. Lee (professor), Shaoheng Wang (graduate student), Weming Guo (graduate student)

RF Engineering Group, LBNL
J.N. Corlett (scientist)

Accelerator Physics Group, ANL
Stephen Milton (scientist)

Contact person

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Project Overview

1. Flat beam production has already been verified by A0 facility in Fermilab. The RF gun of A0 facility can delivers electron with a kinetic energy of 3.8 MeV. The superconducting booster cavity raises the electron energy to 17 MeV. The photocathode is immersed in a solenoid field of about 800 Gauss. The emittances of the flat beam are reported as 0.9 μm and 45 μm. As for the Femtosource, we wish to obtain a flat beam of a smaller vertical transverse emittance less than 0.4 μm by this method.

2. The quadrupole-mode transfer function has been recently proposed to measure the beam emittances (see W. Guo and S.Y. Lee, Phys. Rev. E **65**, 066505 (2002)). We propose to study the feasibility of using the quadrupole mode transfer function for bunch compression in the damping rings for future linear colliders.

Description of first year (continuing) project activities

(1) Flat Beam Femtosource:

Mr. Shaoheng Wang, a fourth year graduate student at Indiana University, will continue to carry out his thesis research on the physics of flat beam production in a photocathode experiment carried out at the A0 facility in Fermilab. Experimentally, a cathode is immersed in the magnetic induction field of a solenoid to gain a finite initial canonical

angular momentum, and before the bunch enters the skew quadrupole triplet, the adaptor, the beam is accelerated and experienced some drift, and maybe longitudinally compressed as it does in A0 facility.

PARMELA simulation has been done with A0 setup, where the cathode B_z field equals 783 Gauss, 10 ns bunch length energy at adaptor entrance is 17.65 MeV. First, PARMELA generates an ideal uniform cold bunch of 2 mm radius, and pushes the bunch through the gun, booster 9-cell cavity and drift space until the bunch arrives at the entrance of the adaptor. We then calculate β, α and $\varepsilon_{\pm}$, at this position according to particles distribution from PARMELA, and vary the gradient of quadrupoles in the adaptor to satisfy the flat beam condition. Finally PARMELA pushes the bunch through the adaptor. So far, the effect of space charge has not been included in our calculation. We investigated the sensitivity of the final emittances to the quadrupole gradient. We find that final emittance is more sensitive to the first quadrupole. To obtain the smallest emittance, the accuracy of the quadrupole must be better than 0.2 Gauss/cm.

This research continues with PARMELA simulation for optimal flat beam generation, and prepares experimental condition at the A0 facility to test beam dynamics problems associated with flat beam photocathode. By measuring the σ-matrix before and after the adapter, one can verify the flat beam transformation theory.

This proposal requests fund for the support of one graduate student, one trip for the student to attend the International Accelerator School on "Linacs" to be held in Long Beach, California in November 6-14, 2002. The grant will also cover travel expenses for the student to participate experiments at the A0 facility. The student is expected to complete his thesis in two years. This proposal is in collaboration with J.N. Corlett at LBNL.

(2) Quadrupole-mode transfer function for bunch compression

Mr. Weming Guo, one of the fourth year graduate students at IU, will explore the feasibility of using the quadrupole-mode transfer function in the bunch rotation for the damping. The scheme includes the implementation of coherent bunch excitation in the longitudinal phase space. When the beam bunch is compressed to a small bunch length, it will be extracted to be accelerated in the linear accelerator.

The research proposal includes the following tasks: (1) Develop a computer program for numerical simulations including coherent rf voltage modulation, quantum fluctuation and radiation damping to study the quadrupole mode transfer function on bunch rotation; (2) carry out necessary experimental tests at the APS in Argonne National Laboratory or other electron storage rings; and (3) perform data analysis to compare all possible bunch compression schemes. Mr. Guo is expected to complete his thesis in 1 or 1.5 years. This proposal is in collaboration with Stephen Milton for possible beam experiments at the APS.

Budget

Institution	Item	Cost
Indiana	Annual graduate student stipend (2 students)	$41,640
Indiana	Tuition (2 students)	$10,594
Indiana	Health Insurance (2 students)	$1,612
Indiana	Travel (2 students)	$2,000
Indiana	Indirect cost (26% for off site rate)	$11,766
	Grand total	$67,612