Linear Beam Dynamics
and
Ampere Class Superconducting RF Cavities
@RHIC

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by

Rama R. Calaga

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Rama R. Calaga

We, the dissertation committee for the above candidate for the Doctor of Philosophy degree, hereby recommend acceptance of the dissertation.

Dr. Ilan Ben-Zvi (Advisor)
Adjunct Professor of Physics and Astronomy
Stony Brook University

Dr. Stephen Peggs (Co-Advisor)
Adjunct Professor of Physics and Astronomy
Stony Brook University

Dr. Thomas Hemmick (Chairperson)
Professor of Physics and Astronomy
Stony Brook University

Dr. George Sterman
Distinguished Professor of Physics and Astronomy
Stony Brook University

Dr. Thomas Roser
Accelerator Division Head
Brookhaven National Laboratory

This dissertation is accepted by the Graduate School.

Dean of the Graduate School

Abstract of the Dissertation

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The Relativistic Heavy Ion Collider (RHIC) is a hadron collider designed to collide a range of ions from protons to gold. RHIC operations began in 2000 and has successfully completed five physics runs with several species including gold, deuteron, copper, and polarized protons. Linear optics and coupling are fundamental issues affecting the collider performance. Measurement and correction of optics and coupling are important to maximize the luminosity and sustain stable operation. A numerical approach, first developed at SLAC, was implemented to measure linear optics from coherent betatron oscillations generated by ac dipoles and recorded at multiple beam position monitors (BPMs) distributed around the collider. The approach is extended to a fully coupled 2D case and equivalence relationships between Hamiltonian and matrix formalisms are

derived. Detailed measurements of the transverse coupling terms are carried out at RHIC and correction strategies are applied to compensate coupling both locally and globally. A statistical approach to determine BPM reliability and performance over the past three runs and future improvements also discussed.

Aiming at a ten-fold increase in the average heavy-ion luminosity, electron cooling is the enabling technology for the next luminosity upgrade (RHIC II). Cooling gold ion beams at 100 GeV/nucleon requires an electron beam energy of approximately 54 MeV and a high average current in the range of 50-200 mA. All existing e^- coolers are based on low energy DC accelerators. The only viable option to generate high current, high energy, low emittance CW electron beam is through a superconducting energy-recovery linac (SC-ERL). In this option, an electron beam from a superconducting injector gun is accelerated using a high gradient ($\sim$ 20 MV/m) superconducting RF (SRF) cavity. The electrons are returned back to the cavity with a 180° phase shift to recover the energy back into the cavity before being dumped. A design and development of a half-cell electron gun and a five-cell SRF linac cavity are presented. Several RF and beam dynamics issues ultimately resulting in an optimum cavity design are discussed in detail.

Dedicated To My Mother

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