Jefferson Lab
Thomas Jefferson National Accelerator Facility
Exploring the Nature of Matter

LABORATORY DIRECTED RESEARCH AND DEVELOPMENT LETTER OF INTENT

TITLE: LATTICE MITIGATIONS OF LUMINOSITY LIMITS FOR MEIC

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Date:	February 27, 2015
Department/Division:	CASA/Accelerator
Other Personnel:	new post-doctoral research associate (to be hired)
Proposal Term:	**From:** 10/2015 **Through:** 09/2017 **If continuation, indicate year (2nd/3rd):**

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Abstract

MEIC accelerator complex poses several lattice design challenges in order to reach its unprecedently high luminosity. As part of accelerator design process, exploration of innovative optics solutions is a key to mitigating performance limitations due to fundamental beam phenomena, such as space-charge and synchrotron radiation. Here, we address: beam loss and emittance degradation due to space-charge effects and transition crossing at various stages of ion acceleration, as well as, adverse effects of synchrotron radiation on electron beam emittance at final collision energy. We propose the following proof-of-principle lattice based mitigations of the above phenomena: Development of beam envelope matched transport optics for space-charge dominated sections of the ion linac; Design of novel Figure-8 lattices that avoid transition crossing for all ion species, based on negative momentum compaction optics (for the booster and ion collider ring), and finally; Study of extremely low emittance dispersion lattices for the electron collider ring to minimize emittance dilution due to quantum excitations.

1.0 Summary of Proposal

1.1 Description of Project

The proposed project will focus on the following three tasks:

- *Novel design of Figure-8 lattices that avoid transition crossing for all ion species, for the booster and ion collider ring. Large energy ranges covered by both rings: booster (285 MeV - 8 GeV) and ion collider ring (8 GeV - 100 GeV) make the design goal of no transition crossing quite challenging.*

  Present booster lattice, based on periodically perturbed FODO lattice, offers rather low momentum compaction resulting in a transition gamma of 10. The design is quite promising, however is needs to be further optimized by dynamic aperture studies via multi-particle tracking in the presence of magnet multipole errors.

  Present design of the ion collider ring, configured with simple FODO lattice, assumes transition during the course of acceleration. Additional pulsed quads would be needed to facilitate the so-called gamma transition jump - a system to alleviate beam loss at transition. However, they add significant cost and complexity to the system. Instead, we propose development of an alternative lattice for the ion collider ring based on negative momentum compaction optics, resulting in imaginary transition gamma, which eliminates transition crossing, per se, for all ion species. Cost-effectiveness of both design options will be assessed.

- *Study of ion beam envelopes along a linac in the regime where the space-charge de-focusing effects are comparable to focusing fields of RF cavities. The resulting beam envelope needs be optimized by adding focusing (quadrupoles) into the linac. Fully, compensated, matched transport optics would guarantee minimum emittance degradation for space-charge dominated sections of the ion linac.*
- *Study of extreme low emittance dispersion lattices for the electron collider ring to minimize emittance dilution due to quantum excitations. Such lattices, based on Flexible Momentum Compaction (FMC) cells, were studied earlier for LHeC [1], as return arcs of 60 GeV Energy Recovery Linac. They offer flexibility of emittance dispersion control, between DBA (Double Bend Achromat) and TME (Theoretical Minimum Emittance) optics, while maintaining ring isochronicity [2]. Here we propose to extend the FMC lattices for Figure-8 ring topology.*

1.2 Expected Results

- *Optimized design of Figure-8 lattice that avoids transition crossing for all ion species, validated by dynamic aperture studies via multi-particle tracking in the presence of magnet multipole errors.*
- *Alternative lattice for the ion collider ring based on negative momentum compaction optics, resulting in an imaginary transition gamma, which eliminates transition crossing, per se, for all ion species.*
- *Design of the ion linac transport, with compensated emittance dilution due to space-charge, through beam envelope matched optics.*
- *Extreme emittance preserving lattice for the electron collider ring based on flexible momentum compaction cells, offering superb flexibility of emittance dispersion control, while maintaining ring isochronicity.*

2.0 Proposal Narrative

Lattice design and numerical simulations will be done at Jefferson Lab, using existing computing resources. Results will be presented and discussed at local and international accelerator conferences.

The work will be performed by a new post-doctoral research associate (to be hired) under the PI's guidance.

3.0 Summary Budget

All budget numbers include estimated burden and overheads.

FUNDS USE	*YEAR 1*	*YEAR 2 (IF REQUESTED)*	*YEAR 3 (IF REQUESTED)*
Staff (FTE/$k)	*1.4/$225.061k*	*1.4/$231.813k*	___/___/
M&S ($k)			
Equipment ($k)			
Travel ($k)	*$20k*	*$20k*	
Services and Subcontracts			
Other (specify)			

1.4 FTE = 1 FTE (post-doctoral research associate) + 0.4 FTE (senior staff scientist)

References

[1] S.A. Bogacz et al, 'LHeC Energy Recovery Linac Design and Beam-Dynamics Issues', Proceedings of IPAC 2011 Conference, TUPC054 (2011)

[2] A Large Hadron Electron Collider at CERN: Report on the Physics and Design Concepts for Machine and Detector, The LHeC Study Group, arXiv:1206.2913 (June 2012), Ch 8.

Attachments

None