TWO-ENERGY STORAGE RING COOLER DESIGN FOR ELECTRON-ION COLLIDER

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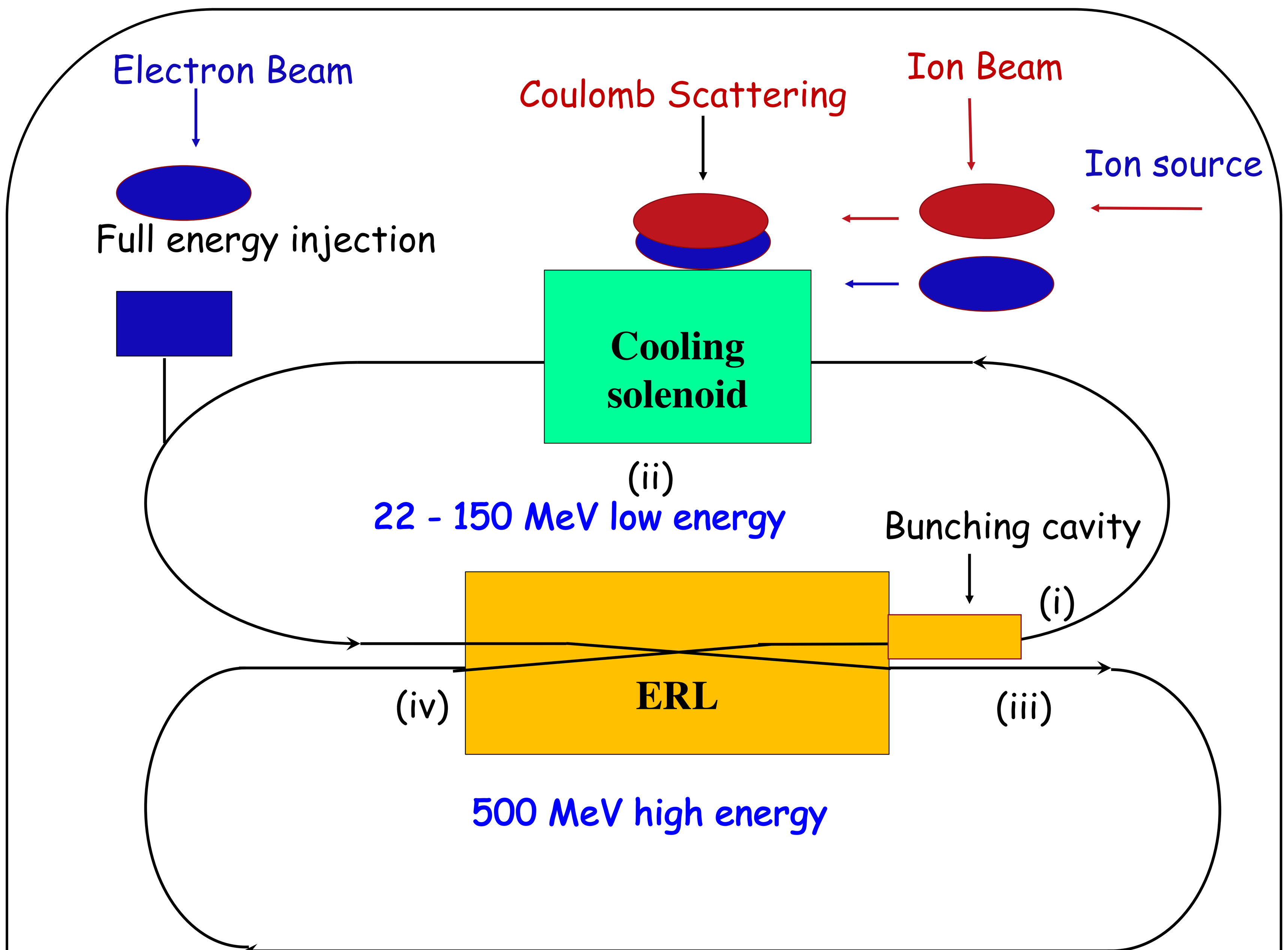
ABSTRACT

The desire to **increase the luminosity** in a collider motivates the search for highly efficient cooler design. Application of electron cooling at ion energies above a few GeV has been limited due to the **reduction of electron cooling efficiency** with energy and difficulty in producing and accelerating a **high-current high-quality electron beam**. **A high-current storage-ring electron cooler** offers a solution to both of these problems by maintaining high cooling beam quality through naturally-occurring synchrotron radiation damping of the electron beam. An appropriate design of the two-energy storage ring cooler may be useful to cool the ion beams resulting in a significant reduction of six-dimensional beam emittance, which is crucial to deliver high luminosities over a broad center of mass energy range in a collider. This presentation reports the development of a storage-ring based cooling design, which may provide the best possible solution to the emittance degradation due to the heating effects in ion storage rings in Electron-Ion Collider.

TWO-ENERGY STORAGE RING COOLER



Schematic diagram of a dual energy storage ring cooler

- ERL consists of set of accelerating, harmonic and decelerating RF cavities running on crest with 97.7 MHz RF frequency.

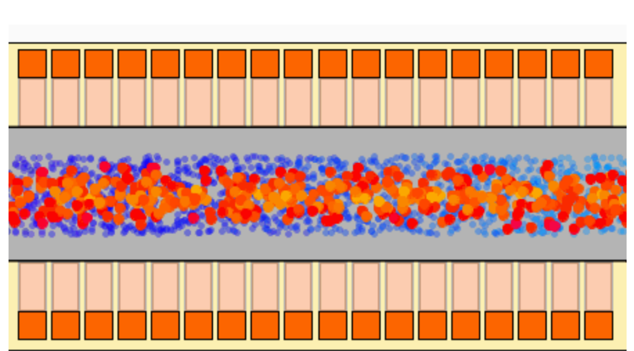
Luminosity $L = \frac{N_1 N_2 f}{4\pi\sigma_x\sigma_y}$

COOLING PROCESS: COULOMB'S SCATTERING

- Coulomb's scattering between electron beam and ion beam.
- Heat transfers from ion beam to electron beam through scattering.

Coulomb's scattering force

$$\vec{F} = -\frac{4\pi Q^2 e^4 n_e}{(4\,\pi\,\epsilon_0)^2 m_e} \int L_C(\vec{v}_{rel}) f(\vec{v}_e) \frac{\vec{v}_{rel}}{v_{rel}^3}\, d^3\vec{v}_e$$



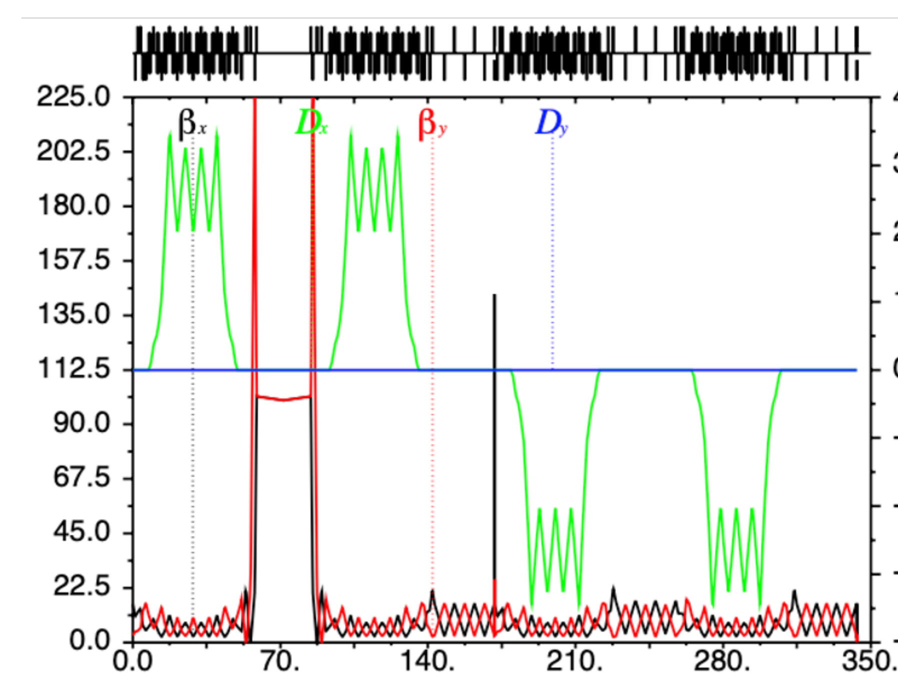
Schematic diagram for electron-ion scattering

SUMMARY AND FUTURE WORK

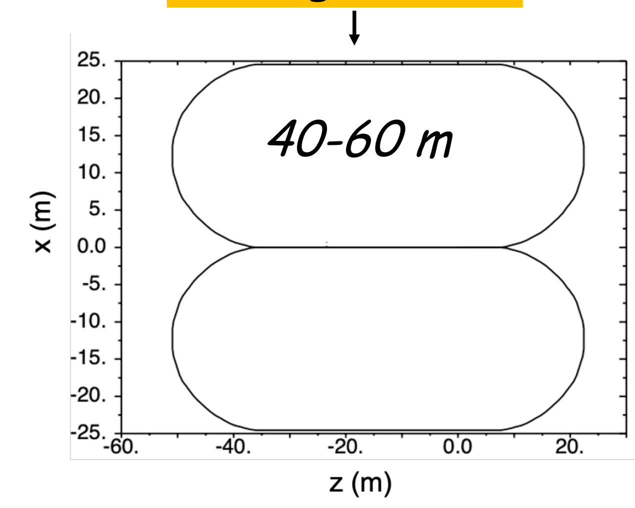
Scientists are looking forward to the appropriate design of the storage ring cooler that provides higher luminosity in collider experiments. Our cooler design, if successful, will significantly improve the collider performance. Accordingly, this design may be best suitable for the proposed Electron-Ion Collider. We have made significant progress in linear optics design, appropriately including aspects of cooling and synchrotron radiation damping. Intra-Beam Scattering (IBS) and damping times have been estimated. Single-particle tracking has been accomplished using ELEGANT particle tracking packages. The first results are very promising, which verifies the stability in a two-energy storage ring. Future work includes many-particle tracking and identification of potential issues such as coherent synchrotron radiation and beam break-up.

TWO-ENERGY STORAGE RING LATTICE DESIGN

- The total length is 343.4 m, each ring 171.7 m.
- Machine elements (Dipoles, Quadrupoles and Sextuples).



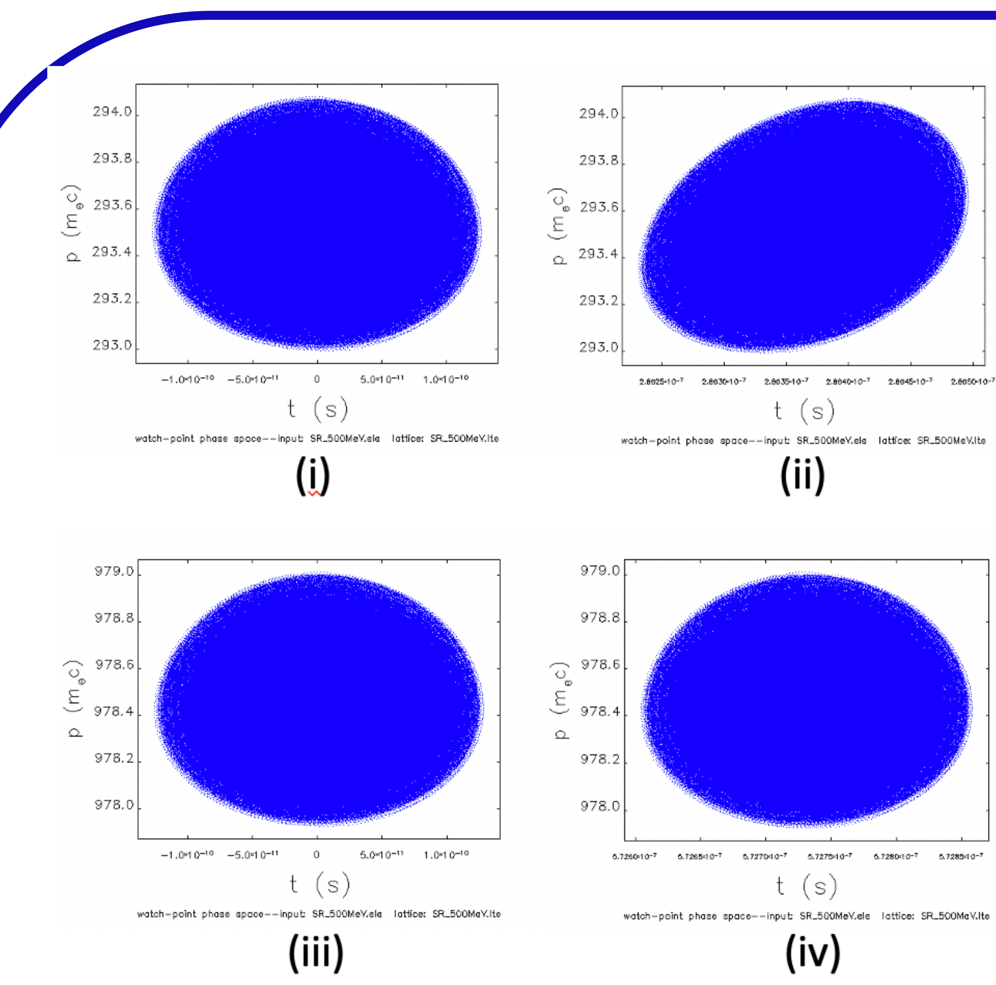
Cooling section



Optics design for two-energy storage ring

- Dispersion free straight sections : Cooling section and ERL section.
- Preliminary lattice design : Beam dynamics study.

STABILITY IN A TWO-ENERGY STORAGE RING



Longitudinal and transverse Phase-space stability using Elegant particle tracking simulation

Electron beam phase-space at different location of storage ring

Parameters in a two-energy storage ring		
Parameter	IBS time(s)	Damping time(s)
Horizontal	4.85	3.22
Vertical	8180	0.69
Longitudinal	0.45	0.25

Damping times and IBS times are in good agreements leading towards equilibrium

- Single particle tracking with and without synchrotron radiation has been performed which verifies the stability.
- Damped equilibrium emittance and energy spread are estimated.

APPLICATON OF TWO-ENERGY STORAGE RING

- Test of cryomodules, HOM couplers, and crab cavities at high currents.
- Dark matter search, low energy electron physics, and figure-8 test.
- Positron production tests and low-energy positron physics applications.
- High intensity CEBAF detector and target tests.
- Isotope production tests.
- Test for CEBAF luminosity increase, CEBAF energy increase.
- Ultra-short bunches for light source applications.
- Radiation effects study for NASA applications.

REFERENCES

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