Simulation of Electron Cooling and IBS at EicC

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EicC Plan and Its Physics Goals

Based on the HIAF (the Heavy Ion High Intensity Accelerator Facility, approved in 2015 in China), the IMP is proposing to build a high luminosity polarized EIC facility in China, EicC, to carry out the frontier research on nucleon structure studies.

The EicC will be constructed in two stages, i.e. EicC-I and EicC-II.

EicC-I and EicC-II accelerator design parameters.

Accelerator	Electron beam	Proton beam	$\sqrt{S}$	Luminosity ($cm^{-2}s^{-1}$)
EicC I	3 ~ 5	12 ~ 30	12 ~ 24	4×10^{33}
EicC II	5 ~ 10	60 ~ 100	35 ~ 63	1×10^{35}

Energy unit in GeV. Both electron and ion beams are polarized.

Electron Ion Collider in China

Electron Cooling

The cooling time depends on not only the storage ring lattice parameters, the Betatron function, dispersion of the cooling section, initial emittance and momentum spread, energy and charge state of ion beam, but also on the construction of electron cooling device, the strength of magnetic field, the parallelism of magnetic field in the cooling section, the effective cooling length, and the parameters of electron beam, such as radius, density and transverse temperature of electron beam. These parameters are determined by the storage ring and the technology limitation, on the other hand, they are influenced and restricted each other.

$$IBS \rightarrow \frac{Z^4}{A^2 m^2}\frac{N_i}{\varepsilon_{xN}^{3/2}\sigma_s}$$

- more important for heavy ions than protons due to Z^4/A^2
- more important for electrons than protons due to m^2
- becomes more important for higher beam densities

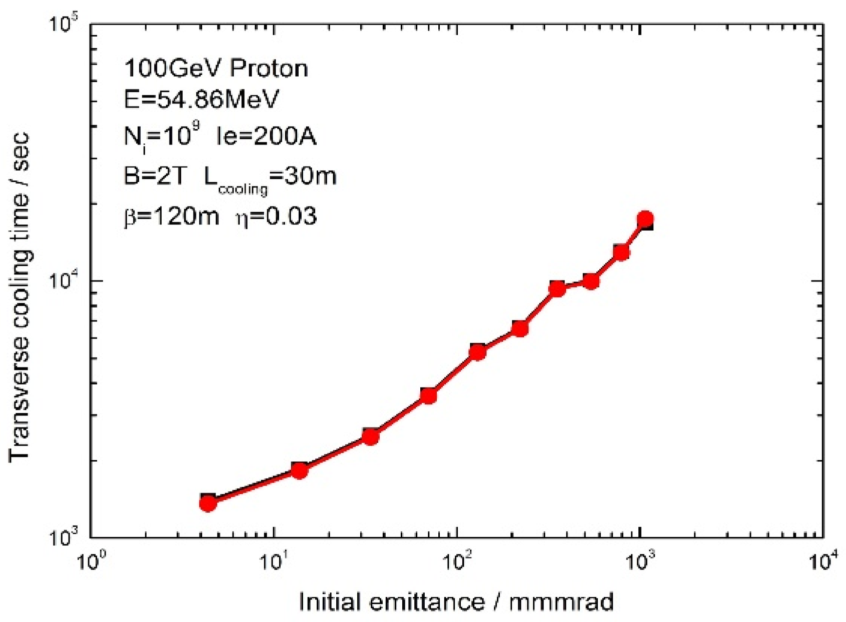

Figure 1: The transverse cooling time as a function of the initial emittance.

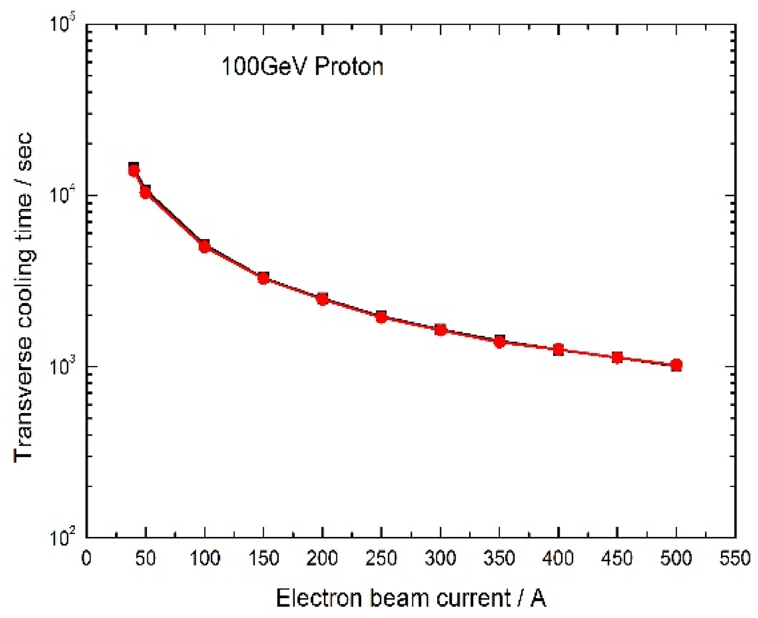

Figure 2: The transverse cooling time as a function of the electron beam current.

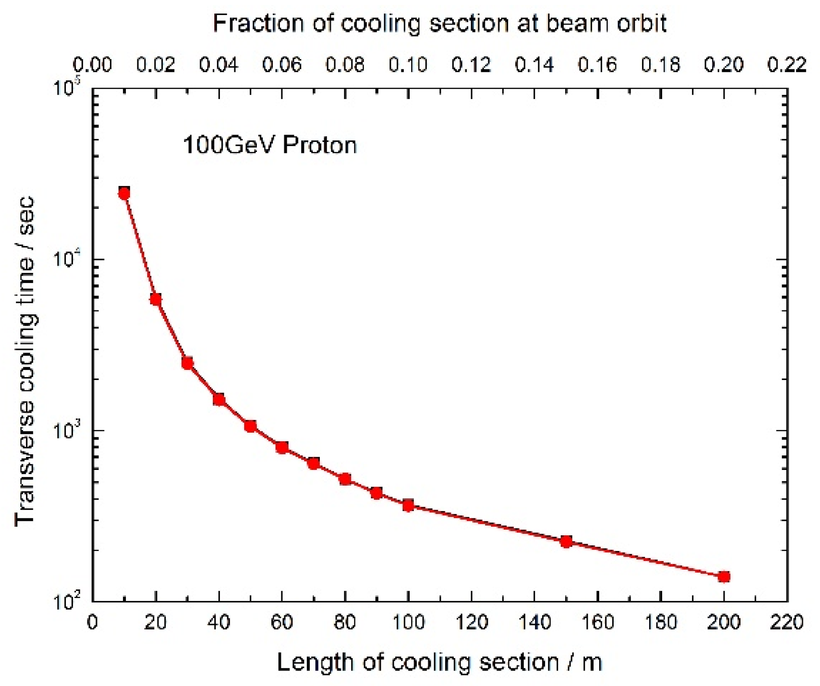

Figure 3: The transverse cooling time as a function of the length of the cooling section.

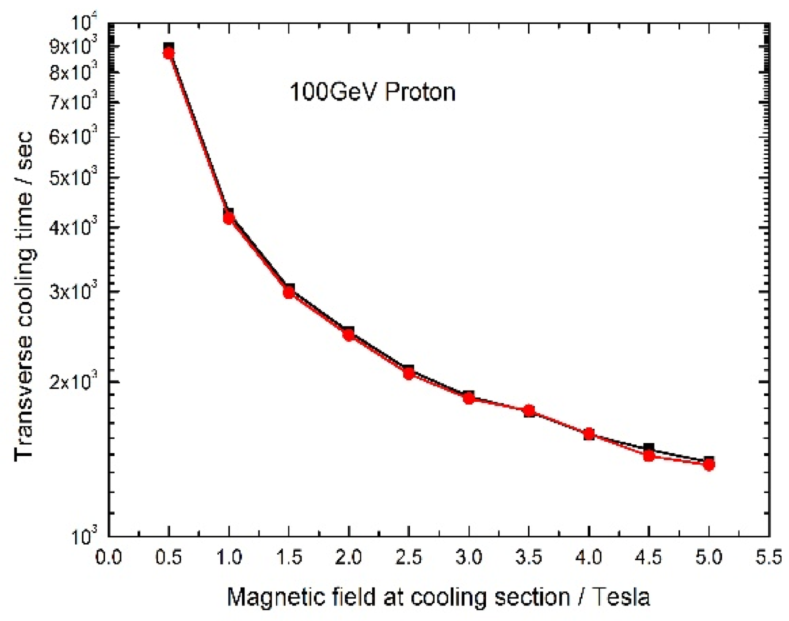

Figure 4: The transverse cooling time as a function of the magnetic field strength in the cooling section.

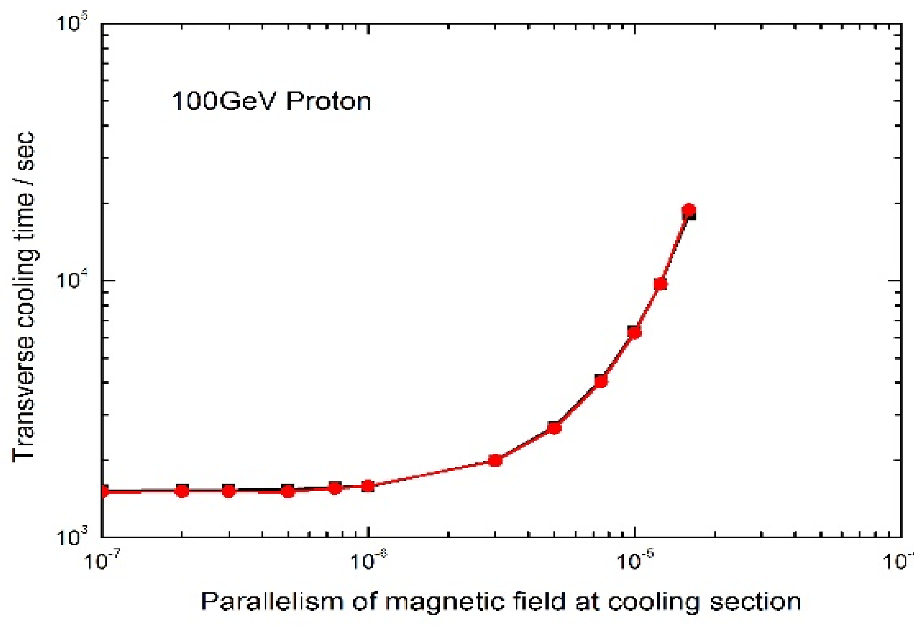

Figure 5: The transverse cooling time as a function of the parallelism of magnetic field in the cooling section

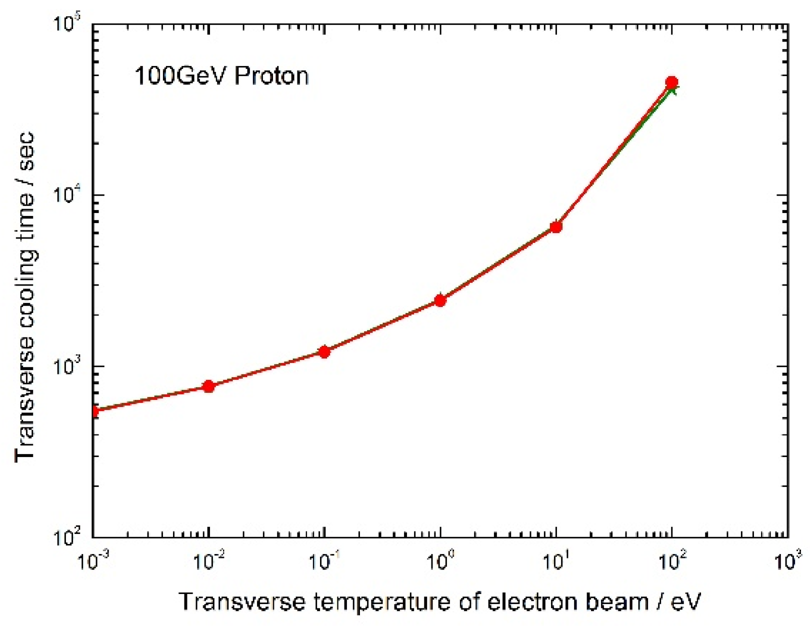

Figure 6: The transverse cooling time as a function of the transverse temperature of electron beam.

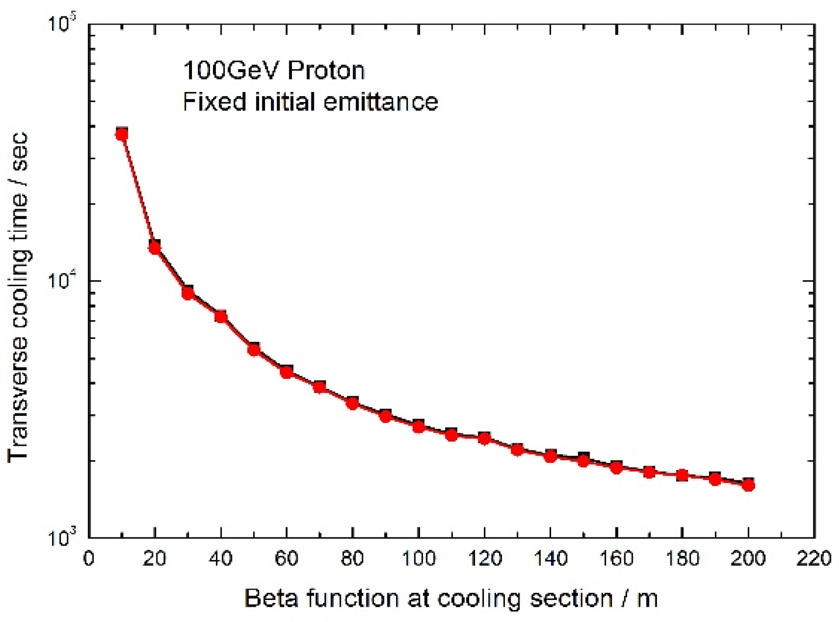

Figure 7: The transverse cooling time as a function of the Betatron function in the cooling section.

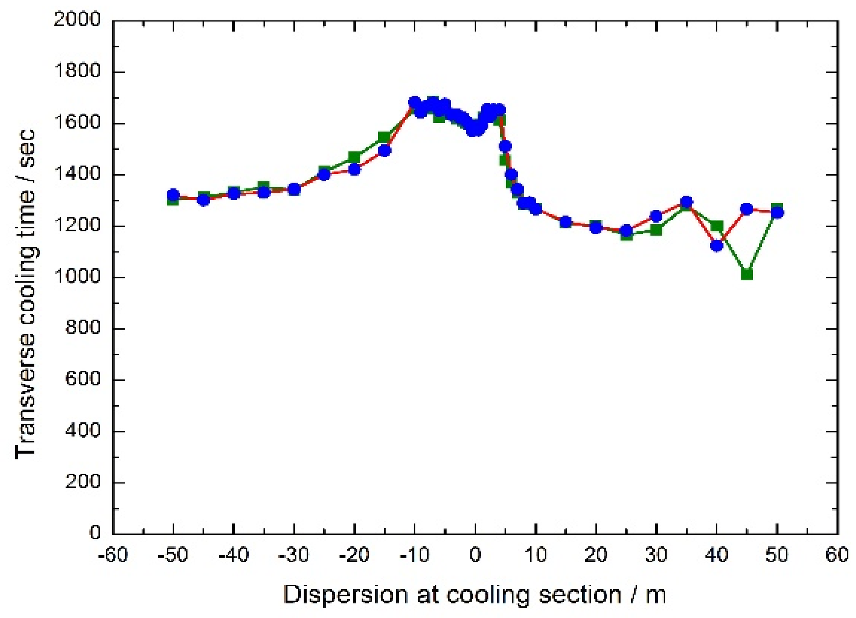

Figure 8: The transverse cooling time as a function of the dispersion function in the cooling section.

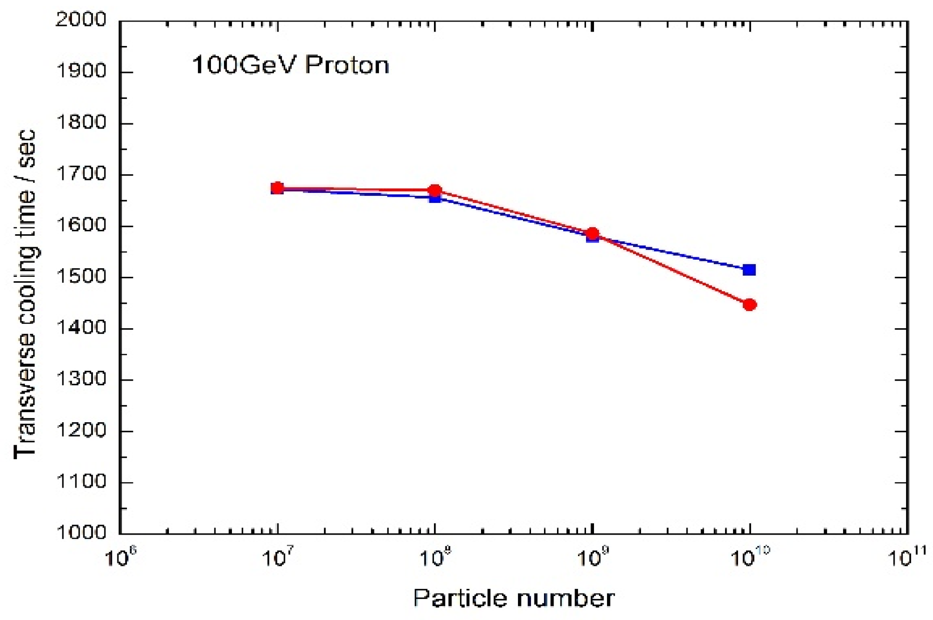

Figure 9: The transverse cooling time as a function of the particle number in the ion beam.

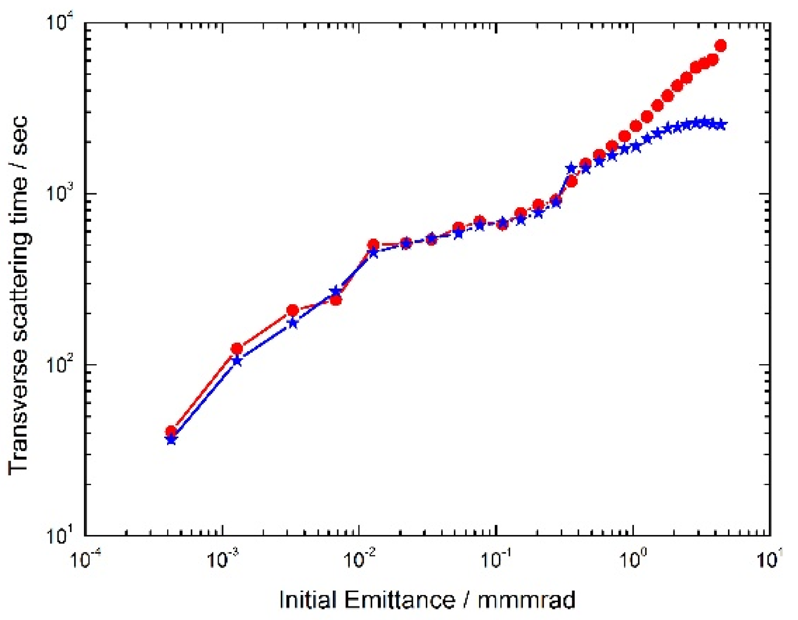

Figure 10: The transverse scattering time as a function of the initial emittance In the proton beam.

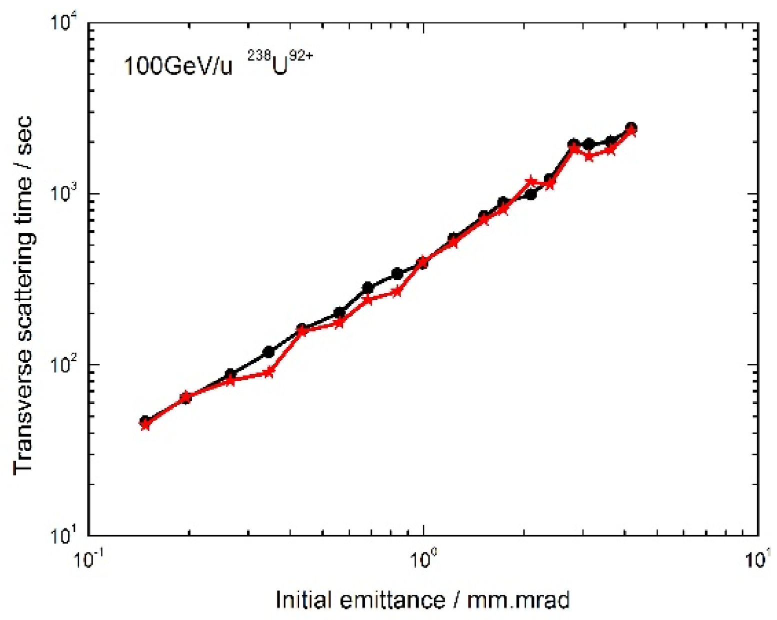

Figure 11: The transverse scattering time as a function of the initial emittance in the uranium ion beam.

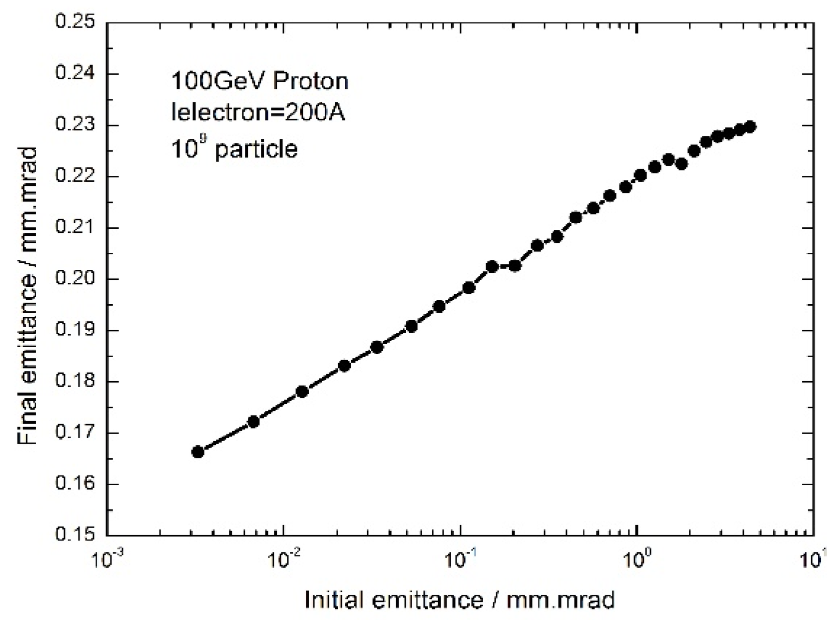

Figure 12: The final equilibrium emittance as a function of the initial emittance in the case of 200A electron beam cooling.

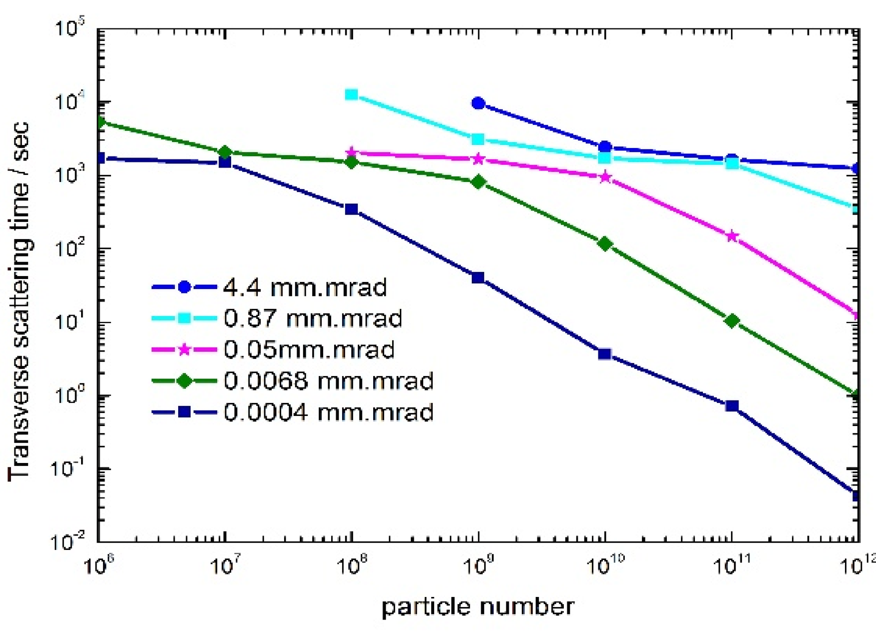

Figure 13: The transverse scattering time as a function of the particle number in the ion beam.

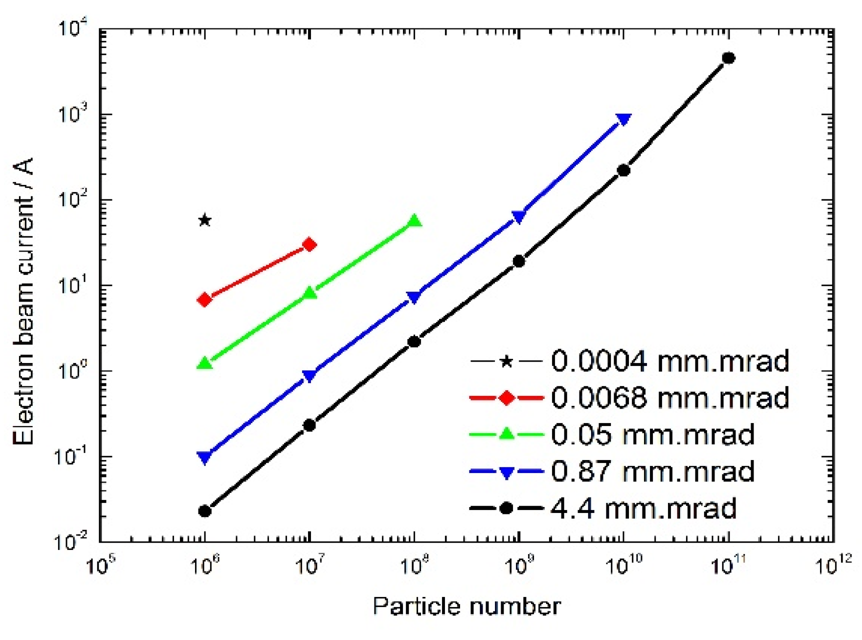

Figure 14: The necessary electron beam current as a function of the particle number in the ion beam in order to keep the emittance constant in the case of different initial emittance.

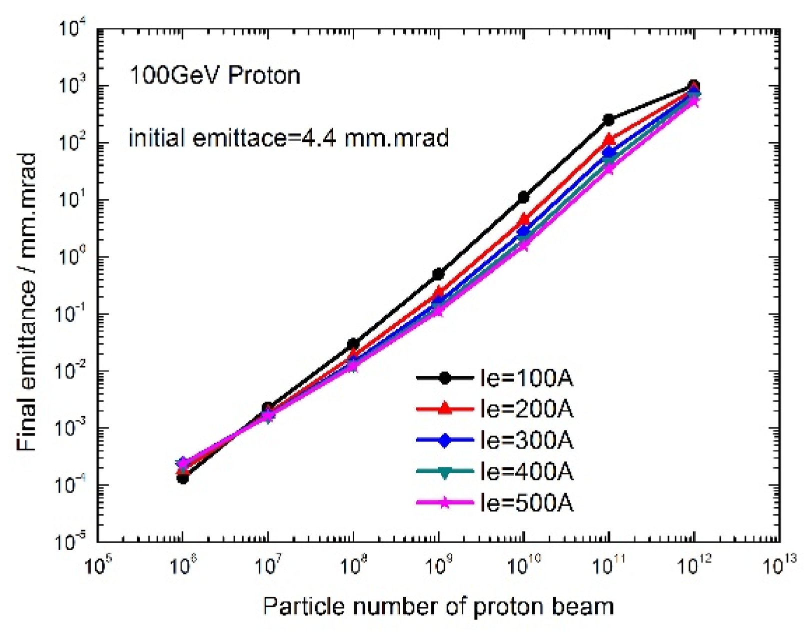

Figure 15: The final equilibrium emittance as a function of the particle number in the ion beam in the case of different electron beam cooling.

Summary

- **From the simulated results, the transverse cooling time of proton beam with 100GeV is over 1000 seconds. The transverse cooling time can be shorten with the help of proper configuration of the parameters, such as smaller initial emittance and electron transverse temperature, higher magnetic field strength, parallelism of magnetic field in the cooling section, longer length of electron cooling section, stronger electron beam current, and bigger beta function and dispersion function in the cooling section.**
- **In order to achieve the required luminosity from physics experiments, the parameters of ion beam, electron cooling device and storage ring should be optimized carefully and compromised each other, and attempt the different configurations from the point of view of realizable technical solutions.**