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The influence of transverse distribution of electron beam on the distribution of proton beam in the process of electron cooling

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Background

- High brightness.
- Long lifetime of proton beam in the storage ring.
- High quality of proton beam.
- High experiments efficiency.

Motivation

- Control of the proton beam distribution under cooling in order not to overcool the beam core.
- Higher peak currents of protons.
- Prolong the lifetime of proton beam.
- Increase the efficiency of experiments.

Key point

Low proton density without cooling.
proton loss with cooling.

Compromise ：

Cooling + less proton loss

Problem ：

The distribution of proton beam deviate from the initial Gaussian type under the electron cooling. A dense core and a long tail formed during the cooling.

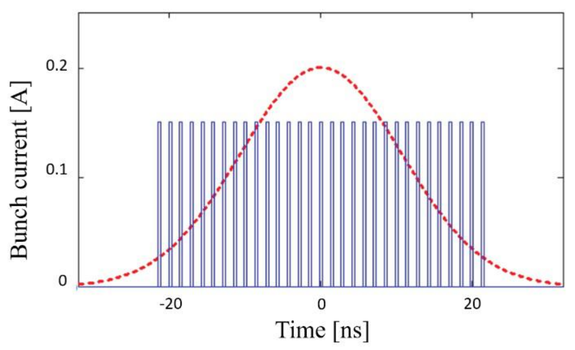

Figure 1: The LEReC beam structure. Thirty electron bunches (blue) spaced by 1.4 ns placed on a single ion bunch (red), with ion bunch repetition frequency of 9 MHz.

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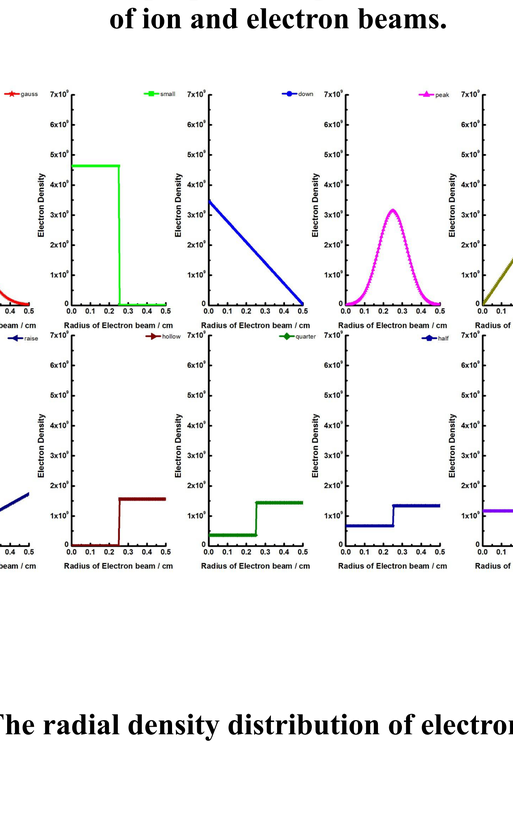

Figure ： Longitudinal distribution of ion and electron bunches

Figure 2: The proposed longitudinal distribution of ion and electron beams.

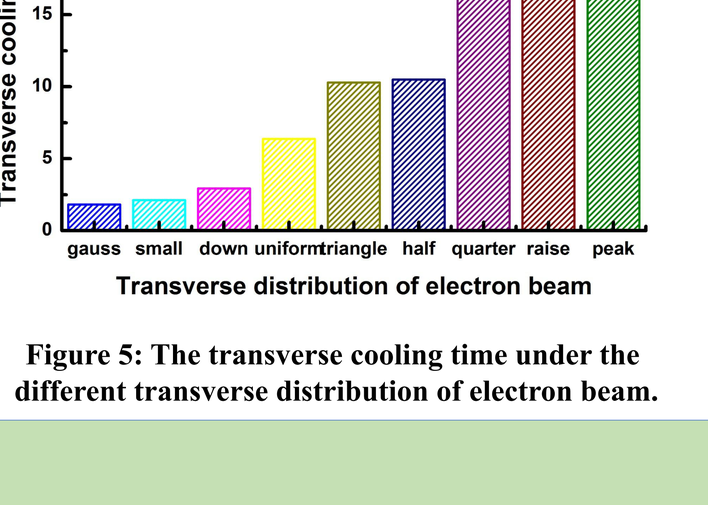

Figure 3: The transverse distribution of electron beam.

Transverse distribution of Elctron Beam

- Uniform
- Gauss
- Down
- Peak
- Triangle
- Raise
- Hollow
- Quarter
- Half
- Small

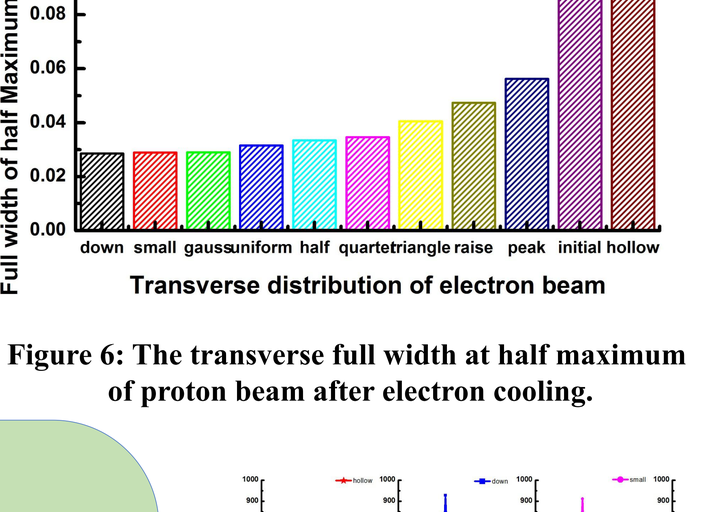

Figure 4: The radial density distribution of electron beam.

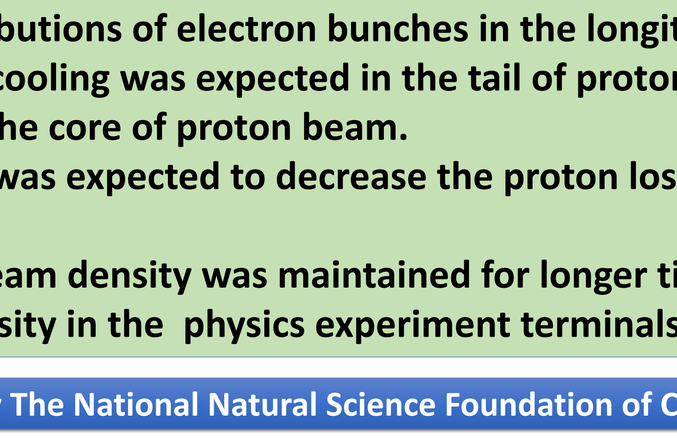

Figure 5: The transverse cooling time under the different transverse distribution of electron beam.

Transverse Elctron Cooling

- Transverse Elctron Cooling time
- Final transverse full width at half maximum of proton beam after electron cooling
- Final transverse distribution of proton beam after cooling

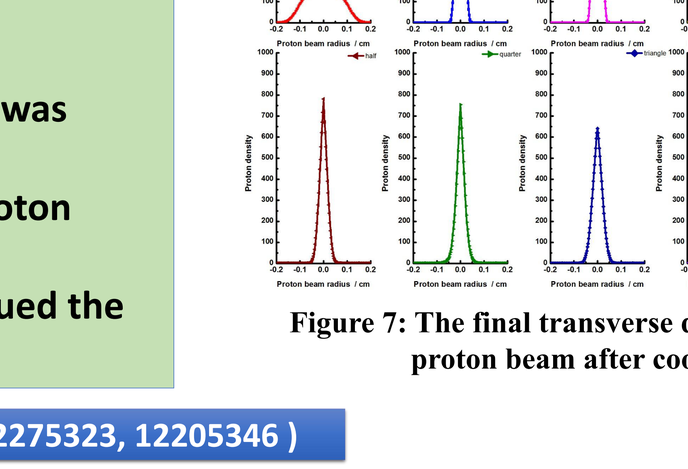

Figure 6: The transverse full width at half maximum of proton beam after electron cooling.

Summary

- eight kinds of transverse distribution of electron beam were attempted in the simulation.
- The distribution of proton beam has been influenced by the transverse distribution of electron beam in the process of electron cooling.
- The proton beam bunch with Gaussian distribution was expected to be cooled by the different distributions of electron bunches in the longitudinal direction.
- The stronger cooling was expected in the tail of proton beam and the weaker cooling was performed in the core of proton beam.
- This solution was expected to decrease the proton loss and prolong the lifetime of proton beam.
- The proton beam density was maintained for longer time in the storage ring, and ensued the certain luminosity in the physics experiment terminals.

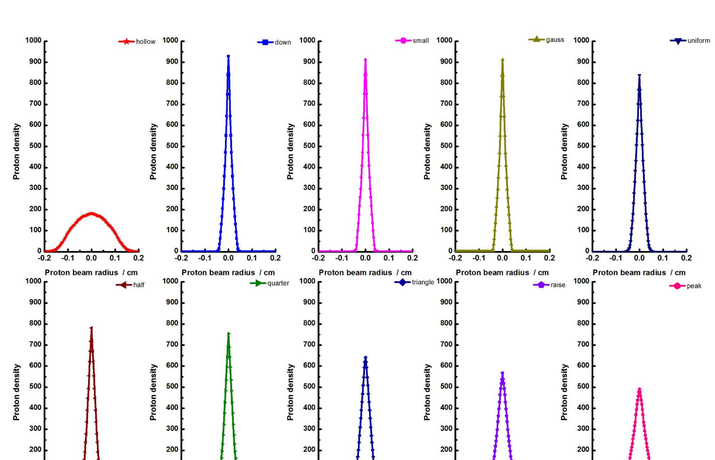

Figure 7: The final transverse distribution of proton beam after cooling.

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