Beam Dynamics Design of A Synchrotron Injector with Laser-Accelerated Ions

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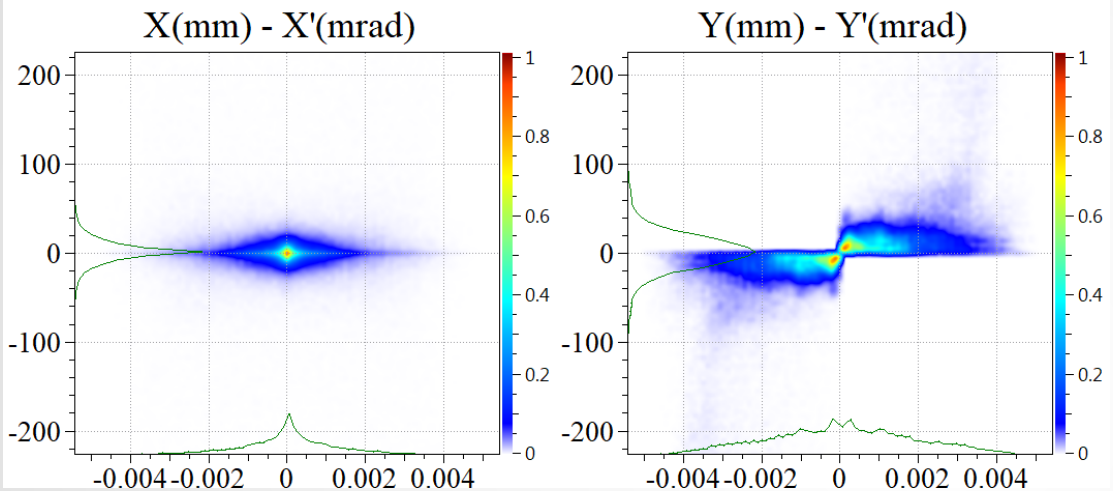
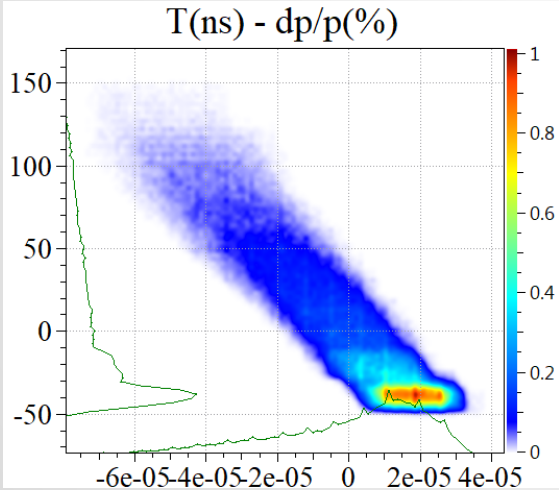
Abstract

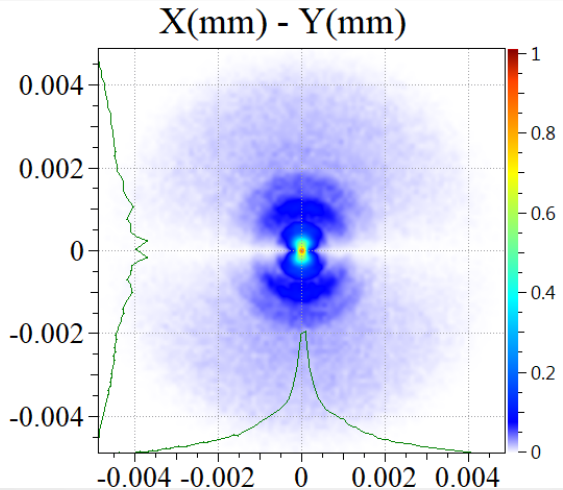
We present, in this paper, the beam dynamics design of a linac injector with laser-accelerated carbon-ions for a medical synchrotron. In the design, the initial transverse divergence is reduced by two apertures. The beam is focused transversely through a quadrupole triplet lens downstream the apertures. The output energy spread of the extracted beam at the exit of the injector is com-pressed from ±6% to ±0.6% by a debuncher and a bend magnet system to meet the injection requirement for the synchrotron. By changing the width of imaging slit of the bend magnet system, the beam with energy of 4±0.024 MeV/u is extracted, and the particle number per shot and transverse emittances of the beam at the exit of the injec-tor can be regulated through adjusting the slit height. The dynamics design can pave the way for the future concept research of the synchrotron injector.

Input Beam Parameters

Laser-accelerated ions:

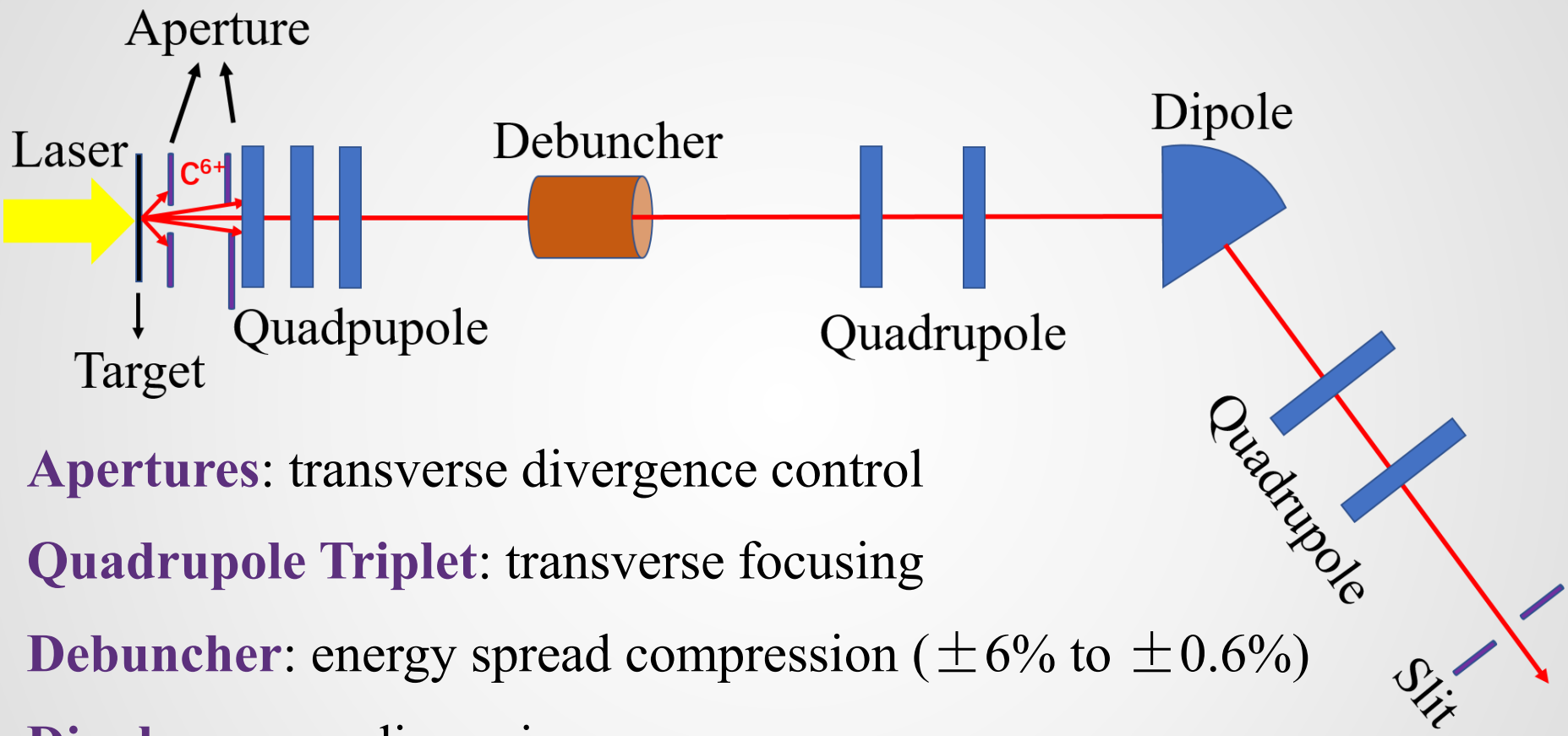






- Broad energy spread
- High current
- Low emittance
- Transverse divergence

Linac Injector Layout



Apertures: transverse divergence control

Quadrupole Triplet: transverse focusing

Debuncher: energy spread compression ($\pm 6\%$ to $\pm 0.6\%$)

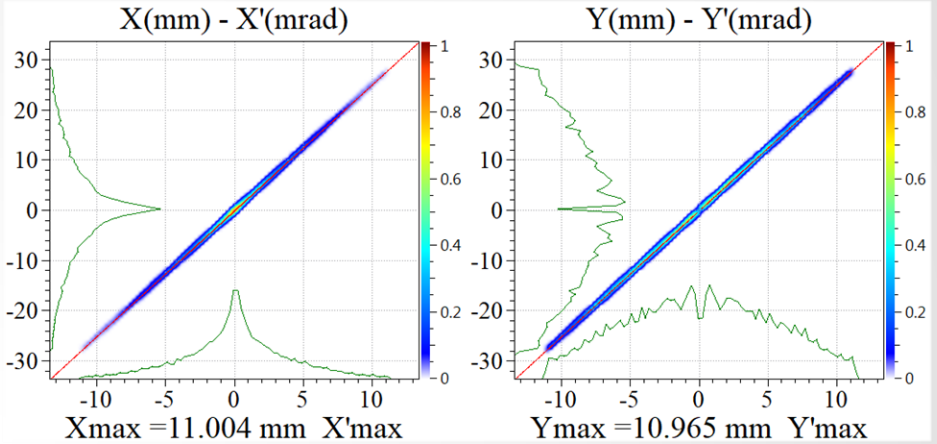
Dipole: energy dispersion

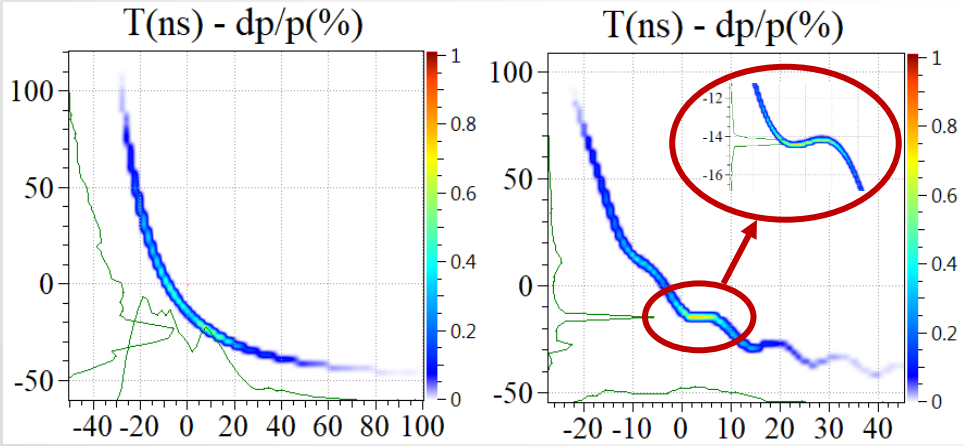
Slit: energy selection & transverse emittances, particle number adjustment

Beam Dynamics Design

- Transverse divergence control with two apertures with variable bore diameter

✓ Transverse divergence < 30 mrad

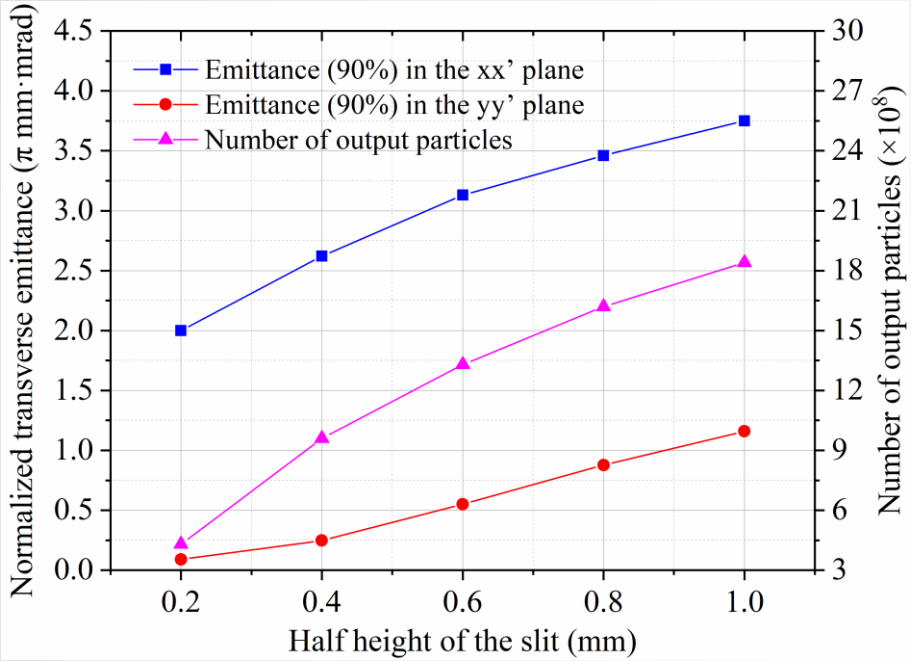


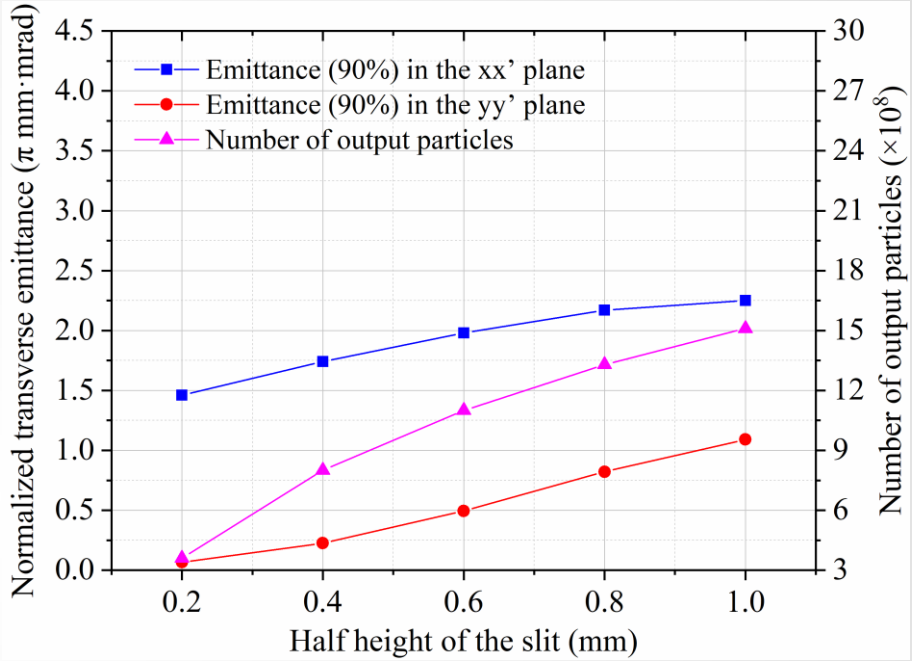


- Energy spread compression with debuncher (700 kV, 80 MHz)

✓ Energy spread ($\pm 6\%$ to $\pm 0.6\%$)

Beam Dynamics Design

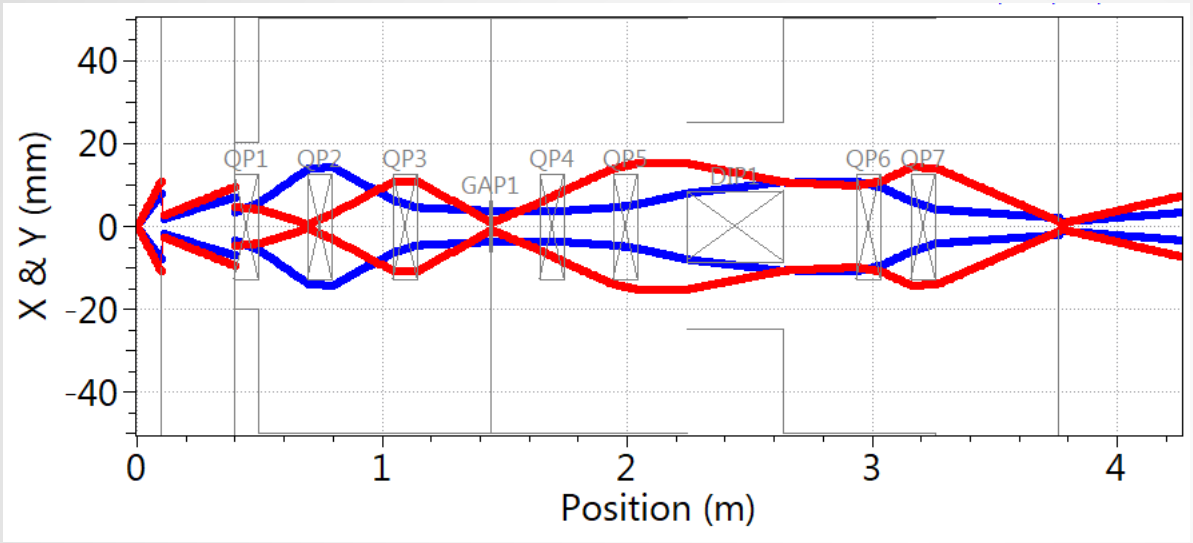


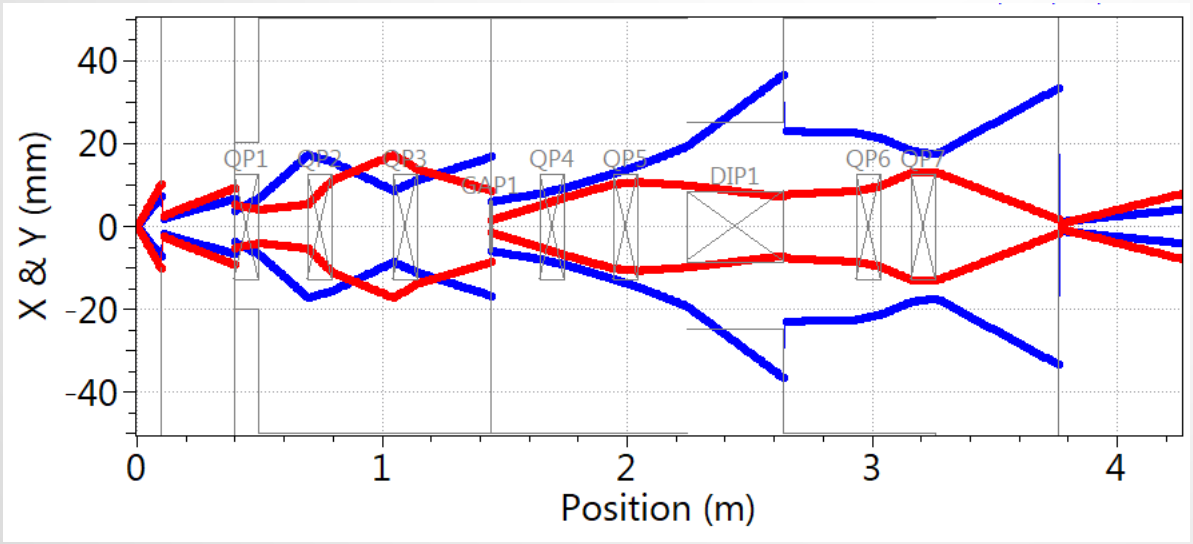


Output particle number and transverse emittances on the half height of the slit. The half width of the slit in the horizontal direction is 6 mm (left) and 4 mm (right)

- **The results provide part of research basis for the synchrotron injection, and further optimization for matching is feasible because the size of the slit is adjustable. .**

Beam Dynamics Design





RMS transverse envelopes (blue: X; red: Y) along the overall injector (top: the ions with initial energy spread within ±6%; bottom: the ions with actual energy spread).