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COMPARISON SIMULATION RESULTS OF THE COLLIMATOR APERTURE IN HEPS STORAGE RING

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Abstract:
The High Energy Photon Source (HEPS) is a 6 GeV diffraction-limited storage ring light source, which is under construction and planned to be in operation in 2025. To protect the sensitive elements from being damaged and reduce the radiation level of the site, collimators will be installed in the storage ring to localize the particle losses. The Touschek scattering is the main cause of particle losses during daily nominal operations. Based on the elegant simulations, we evaluate the physical design of the collimators, especially analysis the collimator performance with different collimator apertures. The simulation results will be introduced in the paper.

INTRODUCTION

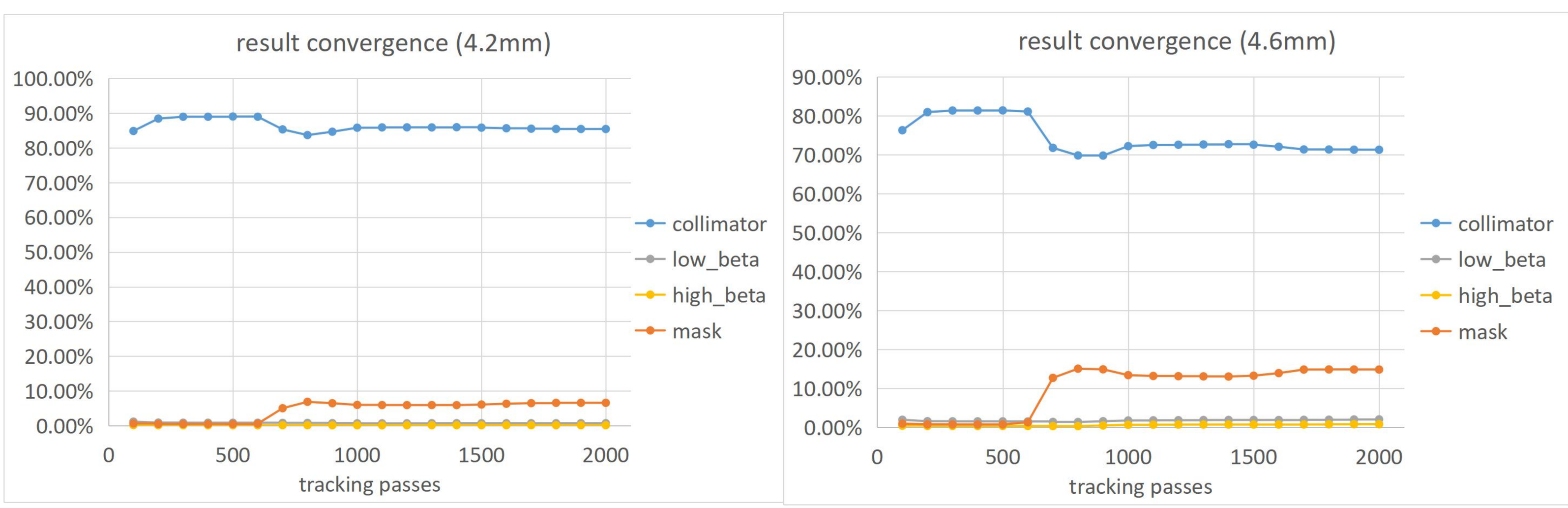
To secure the personal safety and ensure the proper operation of the facility, collimators will be installed in the storage ring to reduce the particle losses on the fragile elements. We use the elegant code to simulate the Touschek scattering process of the beam, and calculate the particle loss ratios at various locations with different collimator apertures. The design targets of the collimators are:
(1) over 70% lost particles collide on the collimators
(2) less than 20% particle losses take place in the straight sections
(3) the decrease of Touschek lifetime is well controlled, around 30% or less

BARE LATTICE

To balance the accuracy of simulation results and the cost of CPU time, we set the number of tracking passes to 2000, and insert the ``Tscatter'' element after each BLG magnet and every 4 quadrupole magnets. The 4.6 mm aperture can achieve the design target for bare lattice, over 71% scattered particles crash onto the collimators.

aperture	4.2 mm	4.6 mm	4.8 mm	5.0 mm
Collimator	85.41%	71.28%	60.69%	49.58%
Low-beta	0.72%	2.03%	3.42%	5.98%
High-beta	0.13%	0.80%	1.40%	2.52%
Mask	6.57%	14.83%	15.22%	16.40%
Others	7.17%	11.06%	19.28%	25.52%
Lifetime decrease	36.1%	30.73%	15.97%	0.45%

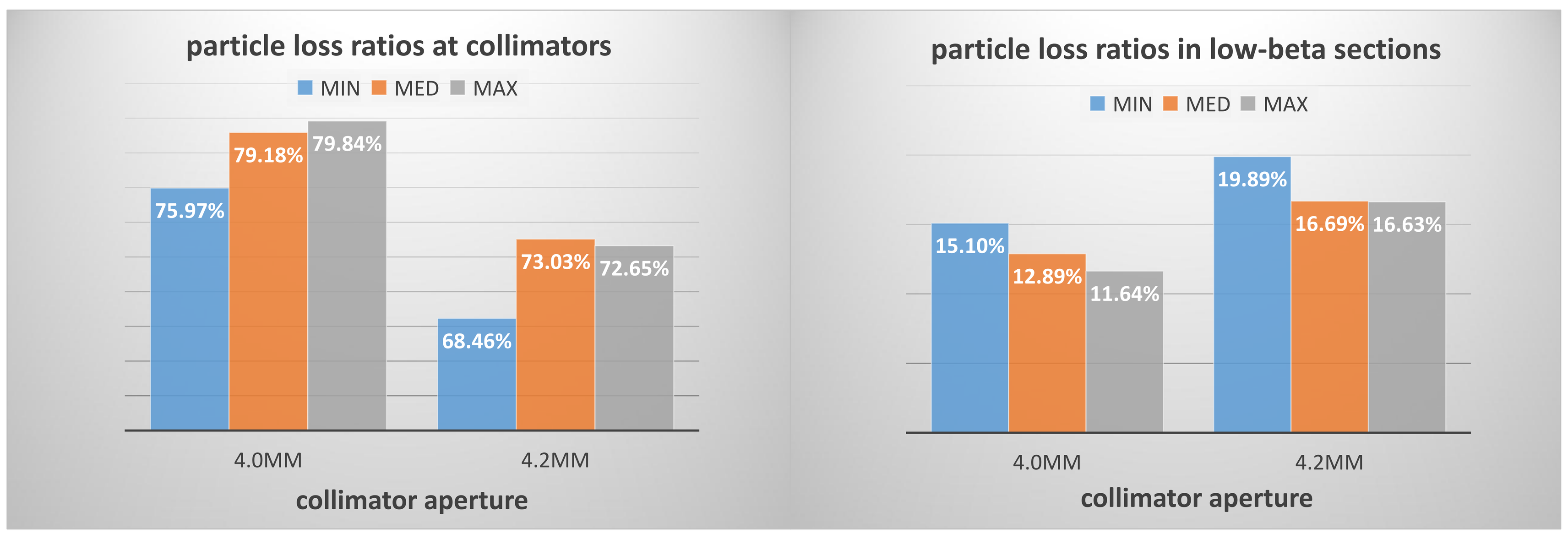
Particle loss ratio at various positions of the bare lattice.



The convergence of the simulation results: particle loss ratio versus tracking pass number.

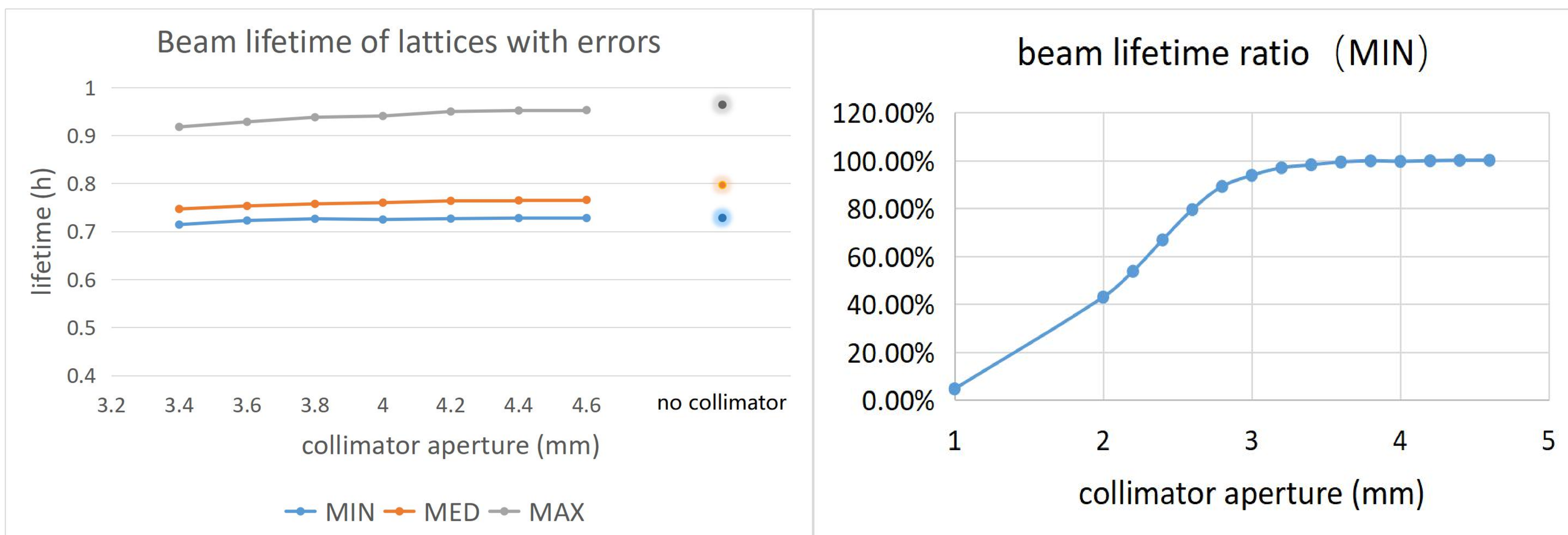
LATTICES WITH ERRORS

To evaluate the performance of collimators in the lattice with errors, we pick up three typical lattices from 100 random error seeds. We calculate the beam lifetime for every seeds, and pick up the lattices with maximal, medium and minimal beam lifetime as the typical lattices, labelled as ``MAX'', ``MED'' and ``MIN'' lattice.



The particle loss ratios in the three typical lattices with errors.

The 4.0 mm aperture can satisfy the requirements for all of the three typical lattices. Comparing to the results within the bare lattice, a larger percent of particles lost in the straight sections, especially in the low-beta sections, while almost no particle collides on the mask.



The beam lifetime for the three typical lattices with errors.

We find that for the lattices with errors, the decrease of collimator aperture barely affect the lifetime of beams, until it is smaller than 3.0 mm. However, a latter calculation show that the most stringent constraint on the aperture are not from the Touschek scattering, and the 4.0 mm aperture is already close to the critical value of beam instability induced by the synchrotron radiation. By these facts, we set the nominal collimator aperture to be 4.0 mm, and the minimal adjustable aperture is 3.5 mm.

Summary

The design of the collimators on the storage ring of HEPS was determined based on the simulation results of the latest lattice, including both bare lattice and lattices with errors. We set 4 collimators evenly distributed on the storage ring, placed in the upstream of the high-beta section. For bare lattice, we found that the 4.6 mm aperture meets the requirement, while for the lattices with errors, the 4.0 mm aperture can achieve the design target. Overall consideration, the nominal collimator aperture was determined to be 4.0 mm, and the minimal aperture was set to 3.5 mm to remain the space of adjustment.

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