Bunch Compressor Design in the Full Energy Linac Injector for the Southern Advanced Photon Source*

Biaobin Li †, Xingguang Liu, Yi Jiao, Sheng Wang
China Spallation Neutron Source Science Center, Dongguan, China
Institute of High Energy Physics, Chinese Academy of Science, Beijing, China

Abstract

- A mid-energy fourth generation storage ring light source, named as the Southern Advanced Photon Source (SAPS), has been considered to be built neighboring the China Spallation Neutron Source (CSNS)[1].
- A full energy linac has been proposed as an injector to the storage ring, with the capability to generate high brightness electron beams to feed a Free Electron Laser (FEL) at a later stage[2].
- To achieve the high peak current in FELs, space charge, RF structure wakefield, coherent synchrotron radiation (CSR), RF curvature, and the second order momentum compaction factor should be carefully considered and optimized during the bunch compression processes.
- In this paper, physic design and simulation results with IMPACT-Z[3] of the bunch compressors are described.

Phase Space Linearizing

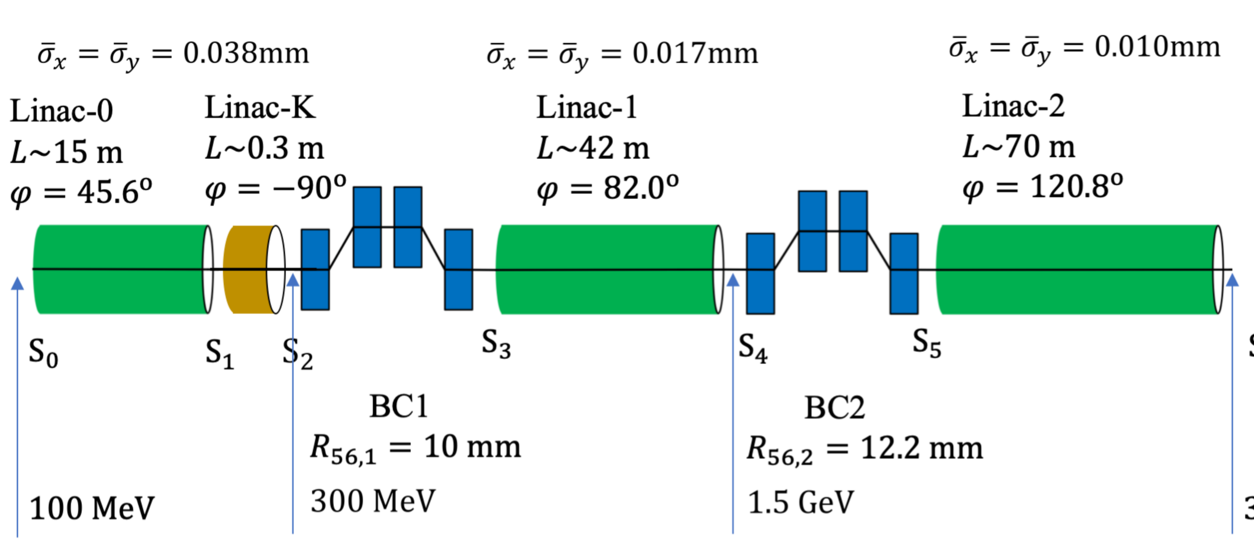

Figure 1: Scheme Layout of the full energy linac injector.

K-band RF cavity located at the decelerating crest ($\varphi_2 = -\pi/2$) is arranged before BC1 for phase space linearizing[4]. The voltages and phases of Linac-0 and Linac-K could be determined by:

$$V_2 = -\frac{(E_1 - E_0)k_1^2 + (3a^2 - 2b_0)E_1}{e(k_1^2 - k_2^2)},$$

$$\varphi_1 = \arctan\frac{k_1(E_1 - E_0 + eV_2)}{E_1(a - \Delta h)},$$

$$V_1 = (E_1 - E_0 + eV_2)/(e\sin\varphi_1).$$

where Δh is the linear energy chirp induced by longitudinal space charge (LSC) and longitudinal wakefield, and could be determined by simulation.

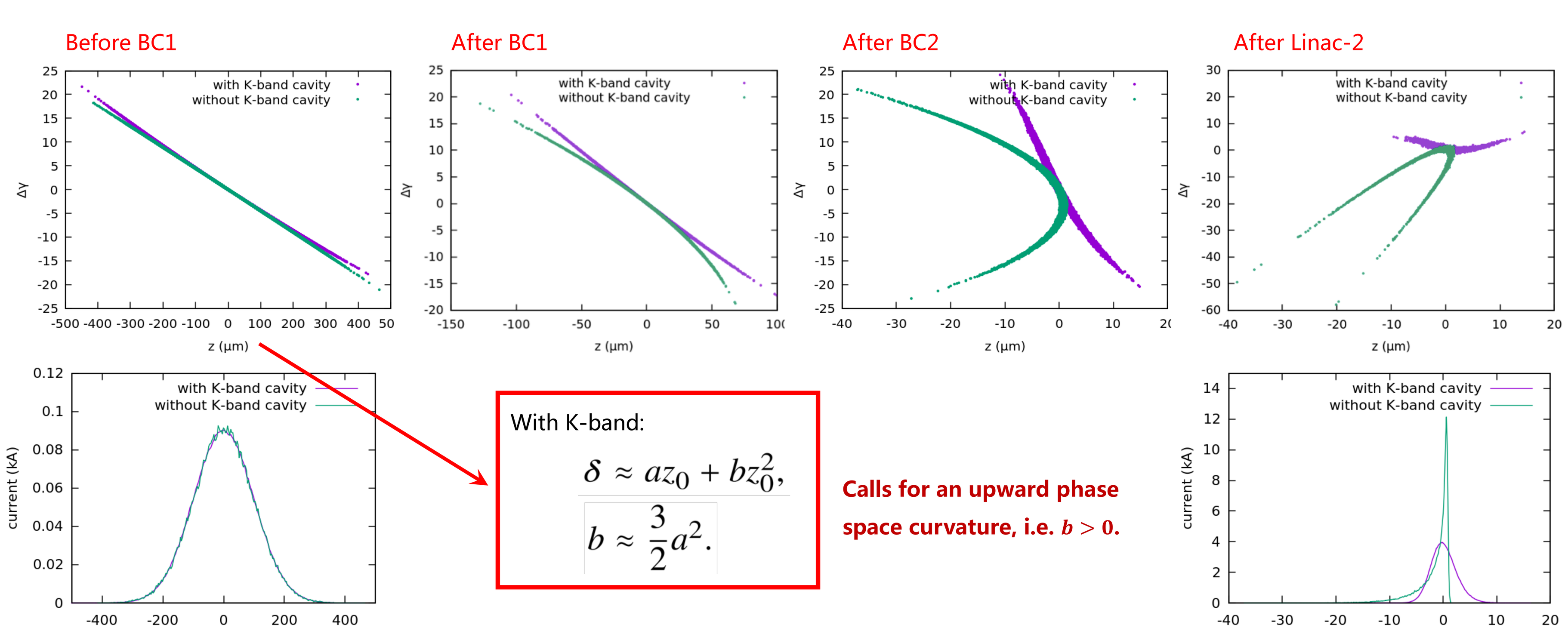

Figure 2: Phase space evolution when collective effects are not included ($\Delta h = 0$).

MBI Suppression

Microbunching instability (MBI) gain $\left(Gain = \left|\frac{b[k(s_6); s_6]}{b_0}\right|\right)$ at different initial energy spreads in our current scheme of the injector[5]:

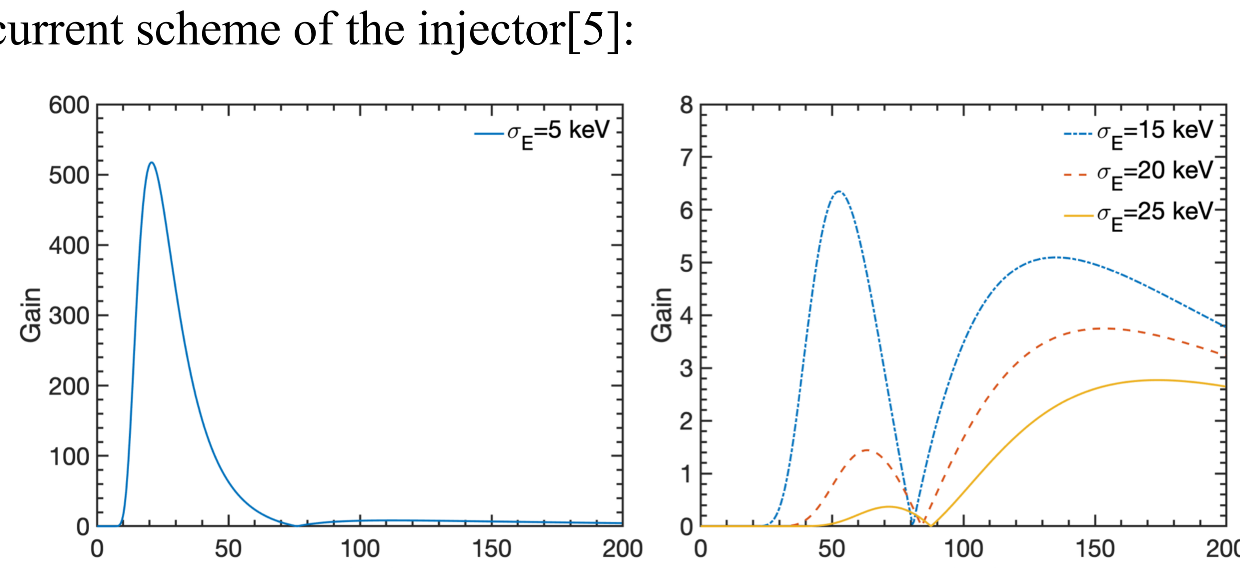

Figure 3: Microbunching gain. Only LSC is included.

Results show that a laser heater[6] before Linac-0 to increase the energy spread up to 25 keV is essential for suppressing the MBI.

Multiparticle Simulation with Collective Effects

Main parameters when collective effects are included:

Table 1: Main parameters of the linacs.

	φ (degree)	V (MV)	f_{rf} (GHz)
Linac-0	45.6	312.36	5.712
Linac-K	−90	23.35	35.983
Linac-1	82.0	1211.94	5.712
Linac-2	120.8	2327.61	5.712

Table 2: The injected electron beam parameters.

Parameter	Symbol	Value
Bunch energy	$\gamma_0 mc^2$	100 MeV
Bunch charge	Q	75 pC
Normalized emittance	$\epsilon_{x,n}, \epsilon_{y,n}$	0.15 μm
Beta function	$\beta_{x,y}$	8 m
Uncorrelated energy spread	σ_E	25 keV
Bunch length (rms)	σ_z	0.1 mm
Bunch 2nd order curvature	b_0	-7165

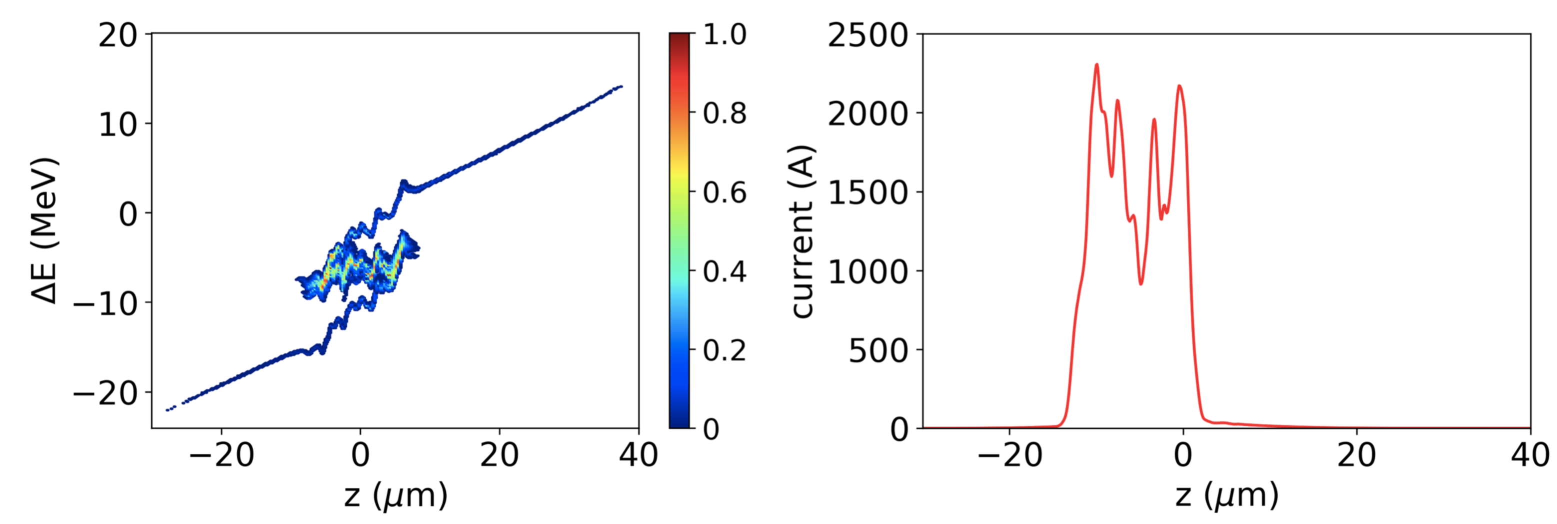

Figure 4: Simulation results of the longitudinal phase space and current profile after Linac-2 when initial rms uncorrelated energy spread is 5 keV. Np=64 million, grid=64×64×1024, ~1 hour @512 processors.

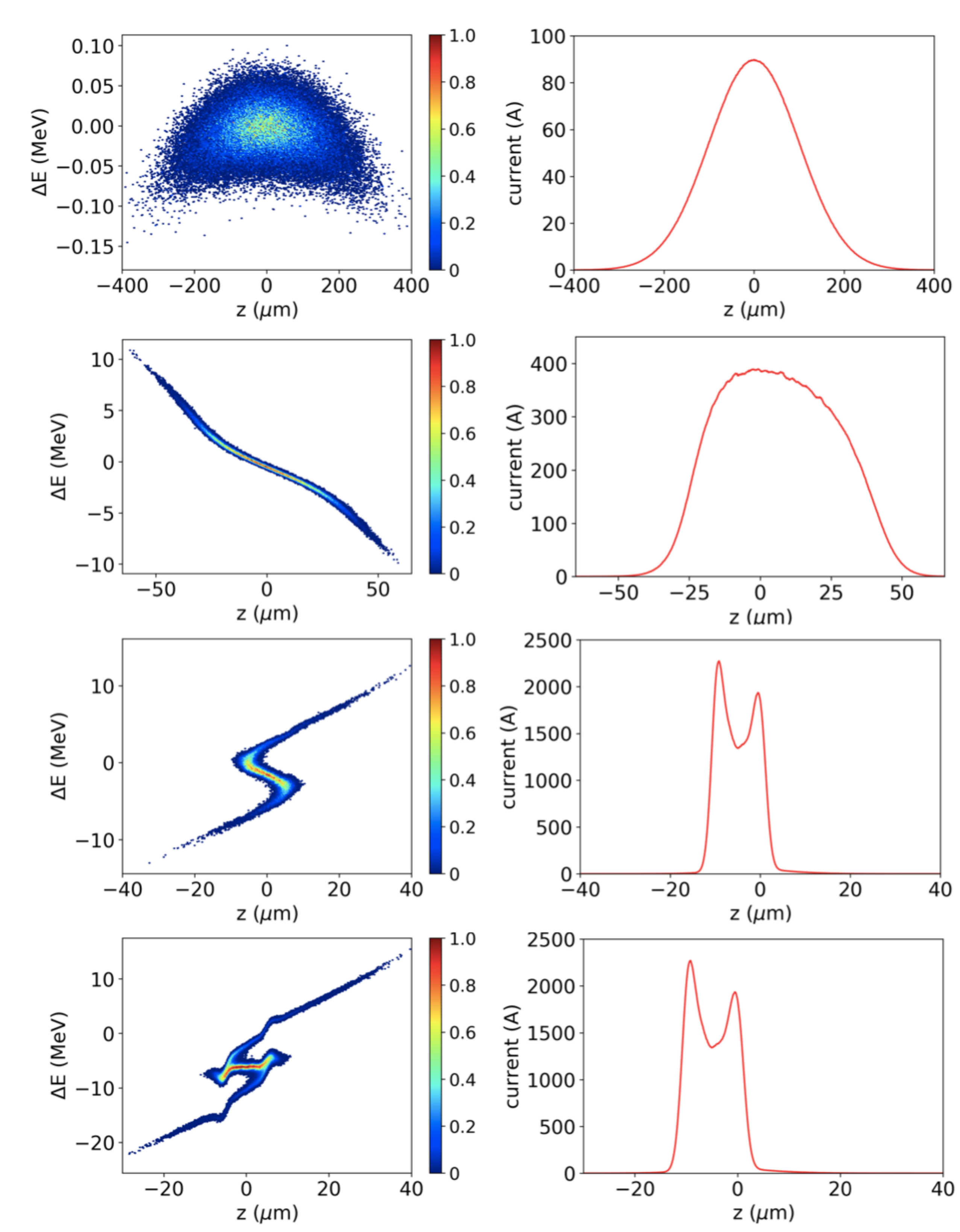

Figure 5: Simulation results of the electron beam longitudinal phase space (left) and current profile (right) at the entrance of Linac-0 (top), after BC1 (2nd row), after BC2 (3rd row), and after Linac-2 (bottom) when initial rms uncorrelated energy spread is 25 keV..

References

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†Email address: libb@ihep.ac.cn

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