

SPEAR-3 Lattice for Chicane Upgrade

Y. Nosochkov

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Lattice Modifications

- Double waist low β_y with a chicane in the East 7.6 m straight for future IDs.
- Low β_y in the four 4.8 m matching straights for IDs.

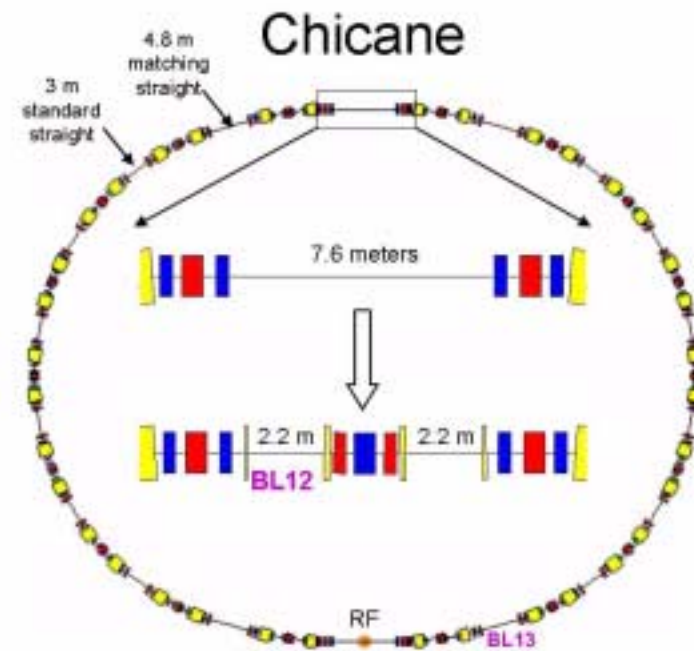
Table 1: Chicane bend parameters.

L, cm	8	15	16	10
B, kG	2.50	2.94	9.01	8.01
θ , mrad	2.0	4.4	-14.4	8.0

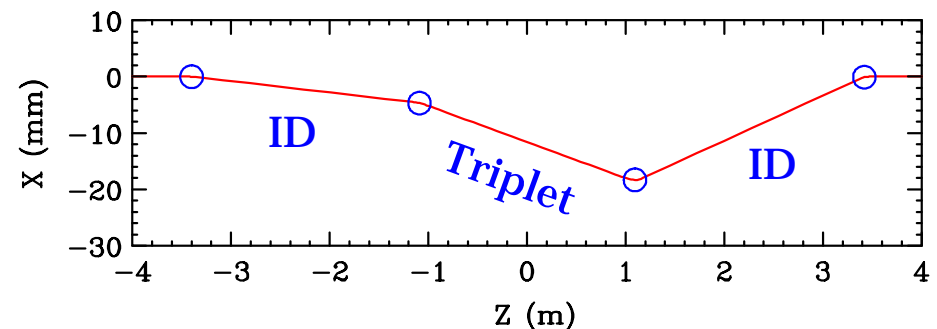
- Beam path increase 120 μm .
- Maximum beam offset -18.3 mm.
- Space between bends 2.195 m.
- Expected undulator length 1.505 m.
- Angle between two ID lines 10 mrad.

Table 2: Triplet quad parameters.

L, cm	35.34	61.05	35.34
K, m^{-2}	1.453	-1.993	1.439

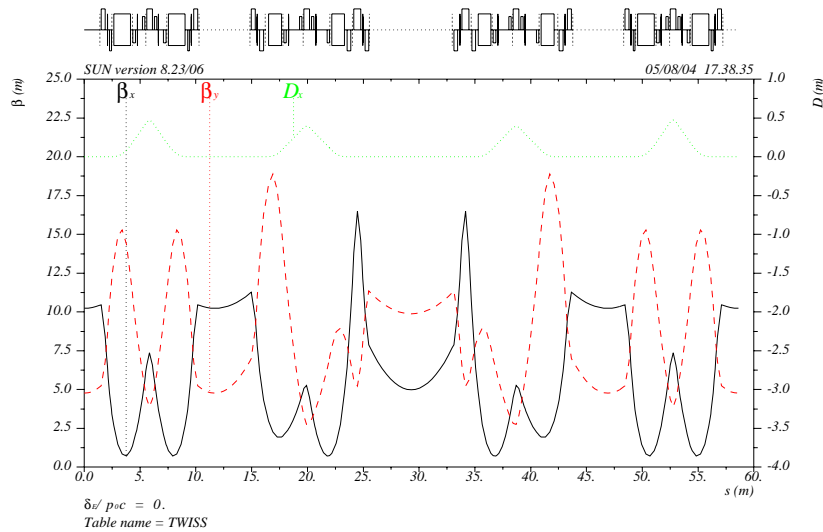


Chicane Orbit
(circles show locations of chicane bends)

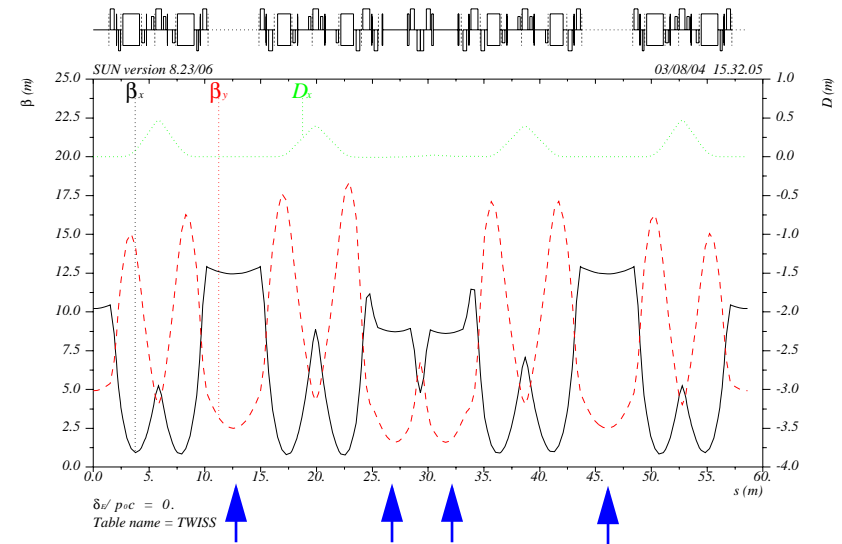


East Pit Optics with Chicane and Low β_y

Baseline



Chicane and low β



Focusing in the East Pit with chicane

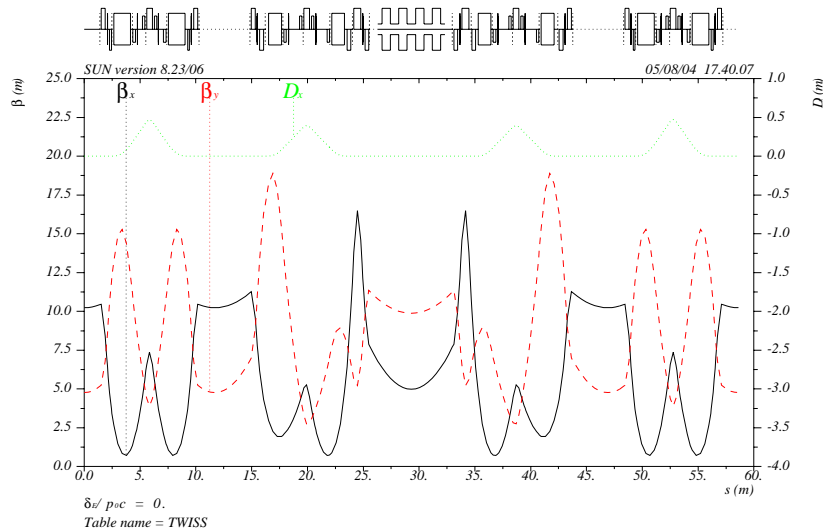
- Asymmetric focusing due to asymmetric chicane -> left/right quad families.
- Strengths of 4 quads in standard cells next to the matching cells adjusted.
- Vertical phase advance in the matching optics increased by $0.54 \cdot 2\pi$.
- Low β is limited by the quad strength limit of $K = 2$.

Table 1: Parameters at low β locations.

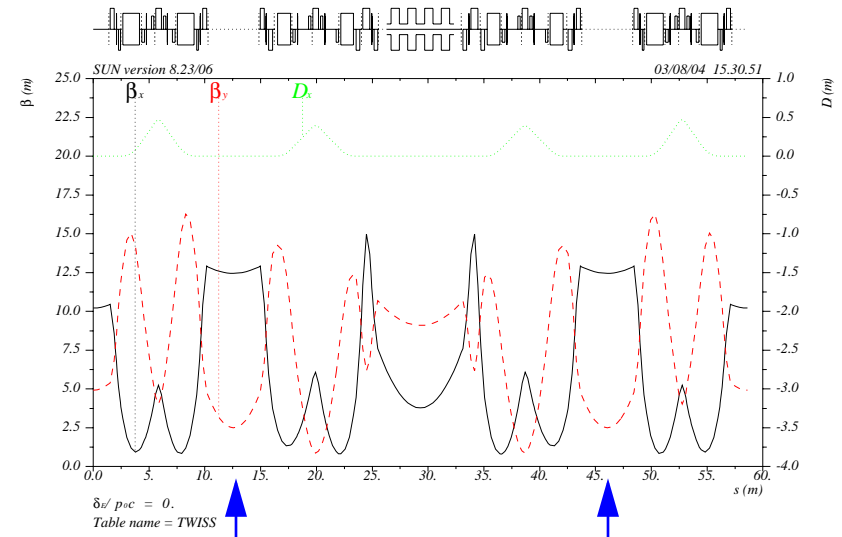
	Double waist		4.8 m straights	
β_y , m	1.6	1.6	2.5	2.5
β_x , m	8.73	8.62	12.45	12.45
η_x , cm	-0.36	1.20	0	0
η'_x , 10^{-3}	3.1	-7.6	0	0

West Pit Optics with Low β_y in 4.8 m Straights

Baseline



Low β



Focusing in the West Pit with low β

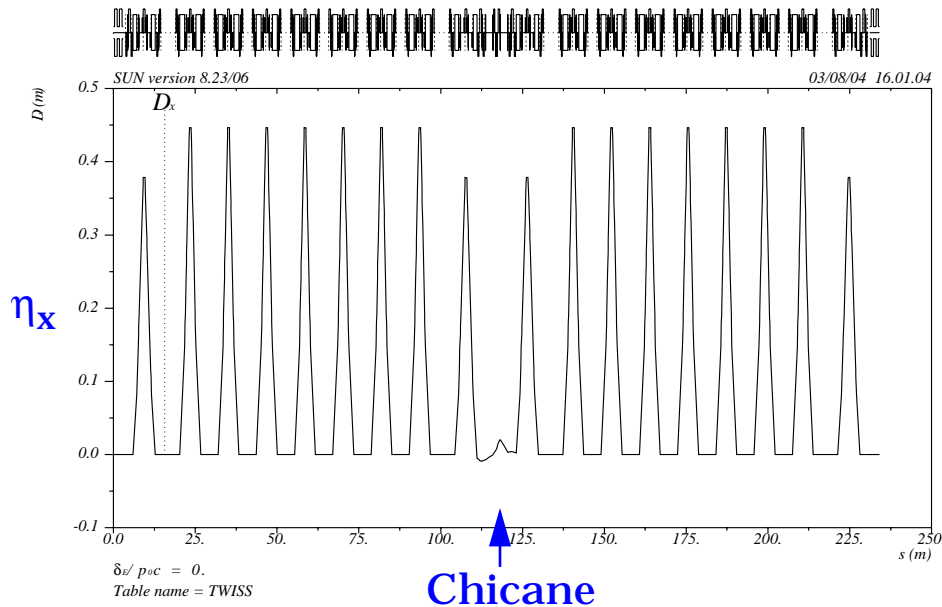
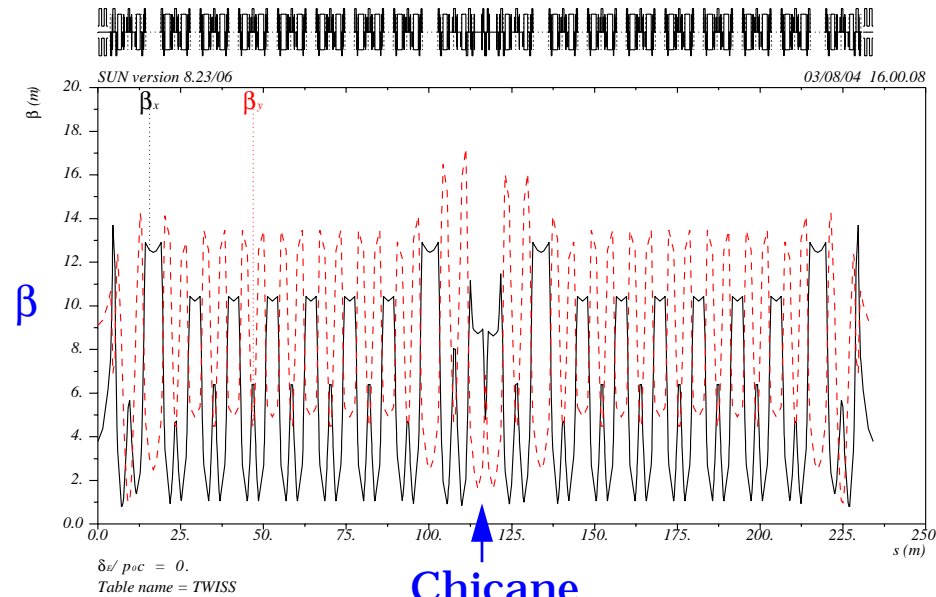
- Symmetric optics.
- Same phase advance and total matrix as in the East Pit.
- Strengths of 4 quads in standard cells next to the matching cells adjusted the same way as in the East pit.

Table 1: Parameters at low- β locations.

β_y , m	β_x , m	η_x , cm	η'_x
2.5	12.45	0	0
2.5	12.45	0	0

Full Ring Optics with Chicane and Low β_y

Comparison of parameters of the Baseline and Chicane lattices



	Baseline	Chicane
C, m	234.144012	234.144132
v_x / v_y	14.19 / 5.23	14.13 / 6.22
$\mu_{x/y}$, cell	282.6°/93.3°	281.1°/91.0°
$\beta_{x/y}^{\text{cell}}$, m	10.24 / 4.76	10.22 / 4.92
$\beta_{x/y}^{\text{RF}}$, m	4.99 / 9.89	3.78 / 9.10
ϵ_x , nm	18.0	18.3
α_c	1.187e-3	1.185e-3
v_s	0.0084	0.0084
σ_s , mm	4.9	4.9
σ_E , %	0.095	0.095

- (1) $\beta_{x/y}^{\text{cell}}$ are at center of 3 m straights.
- (2) Without IDs.

Emittance reduction in Chicane lattice with non-zero dispersion in ID straights

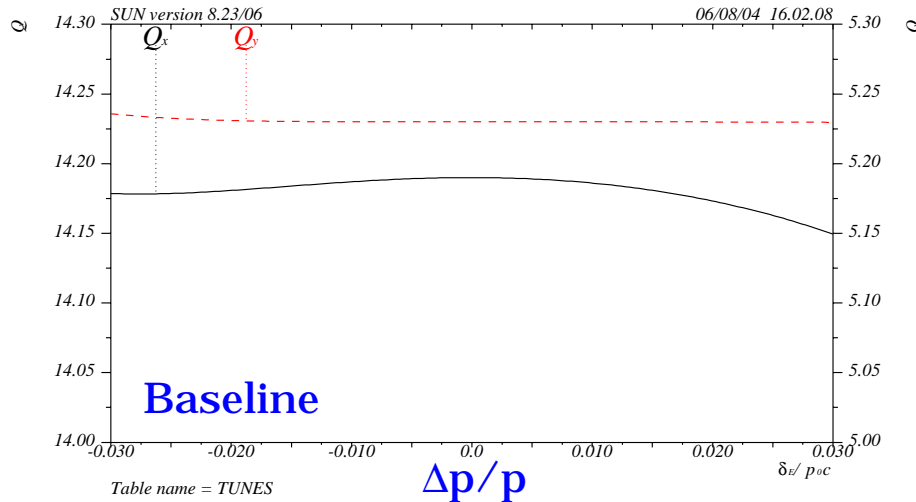
ϵ_x , nm (w/o IDs)	Dispersion in straights, cm				
	3 m	4.8 m	Double waist		7.6 m RF
18.3	0	0	-0.36	1.20	0
11.7	10	8.43	3.80	5.64	0

Minimum beam size at ID straights in the Baseline and Chicane lattices for $\epsilon_y/\epsilon_x = 1\%$

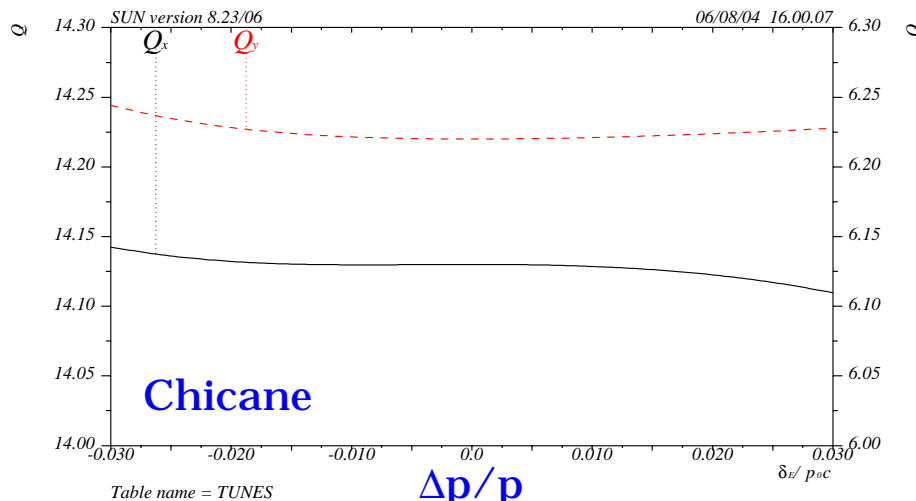
	Baseline ($\epsilon_x = 18.0$ nm)			Chicane ($\epsilon_x = 18.3$ nm)			
	3 m	4.8 m	7.6 m	3 m	4.8 m	Double waist	
β_x , m	10.24	10.24	4.99	10.22	12.45	8.73	8.62
β_y , m	4.76	4.76	9.89	4.92	2.5	1.6	1.6
σ_x , μm	429	429	300	432	477	400	397
σ_y , μm	29	29	42	30	21	17	17
$\sigma_{x'}$, μrad	42	42	60	42	38	46	47
$\sigma_{y'}$, μrad	6.1	6.1	4.3	6.1	8.6	10.7	10.7

Chromaticity Correction

Tune vs. $\Delta p/p$ for $\xi = 0$



$\Delta p/p$



$\Delta p/p$

Comparison of chromaticity correction in the Baseline and Chicane lattices

	Baseline	Chicane
ξ_x	-22.2	-21.9
ξ_y	-13.5	-15.3
K_{SF}, m^{-3}	31.96 ⁽¹⁾	34.12
K_{SD}, m^{-3}	-38.51	-41.01
K_{SFI}, m^{-3}	15.0	15.13 ⁽²⁾
K_{SDI}, m^{-3}	-17.0	-19.86
$dv_x/d\varepsilon_x, m^{-1}$	1023 ⁽¹⁾	1270
$dv_y/d\varepsilon_y, m^{-1}$	1936	2511
$dv_y/d\varepsilon_x, m^{-1}$	1157	1784

(1) K-values and tune shifts are for linear chromaticity = +1.

(2) SFI, SDI may need optimization.

Quadrupole Parameters

Quad	L, cm	K, m ⁻²	
		Baseline	Chicane
QF	35.3390	1.7687	1.7531
QD	16.3459	-1.5425	-1.5035
QFC	51.2380	1.7486	1.7486
QDXW	35.3390	-1.3865	-1.1674
QDXBE	35.3390	-1.3865	-0.4798
QDXAE	35.3390	-1.3865	-0.5888
QFXW	61.0531	1.5732	1.7620
QFXBE	61.0531	1.5732	1.4111
QFXAE	61.0531	1.5732	1.4303
QDYW	35.3390	-0.4606	-1.2679
QDYBE	35.3390	-0.4606	-1.3269
QDYAE	35.3390	-0.4606	-1.3203
QFYW	51.2380	1.4815	1.4815
QFYBE	51.2380	1.4815	1.4880
QFYAE	51.2380	1.4815	1.4785

Quad	L, cm	K, m ⁻²	
		Baseline	Chicane
QDZW	35.3390	-0.8782	-1.3841
QDZBE	35.3390	-0.8782	-0.9739
QDZAE	35.3390	-0.8782	-0.9615
QFZW	35.3390	1.4279	1.6928
QFZBE	35.3390	1.4279	1.6550
QFZAE	35.3390	1.4279	1.5964
QFBE	35.3390	0	1.4531
QFAE	35.3390	0	1.4390
QDE	61.0531	0	-1.9929
QFM1	35.3390	1.7687	1.7599
QDM1	16.3459	-1.5425	-1.9145
QFM2	35.3390	1.7687	1.6241
QDM2	16.3459	-1.5425	-1.3299

Summary

- A double waist optics with asymmetric chicane can be created in the East 7.6 m straight to accommodate two 1.5 m IDs.
- The low β_y values of 1.6 m and 2.5 m can be achieved at the double waist in the chicane and in all 4.8 m straights, respectively, for the quad strength limit of $K = 2$.
- The lattice upgrade requires 4 chicane bends, 3 triplet quads, and a number of new power supplies, BPMs, correctors (to be determined).