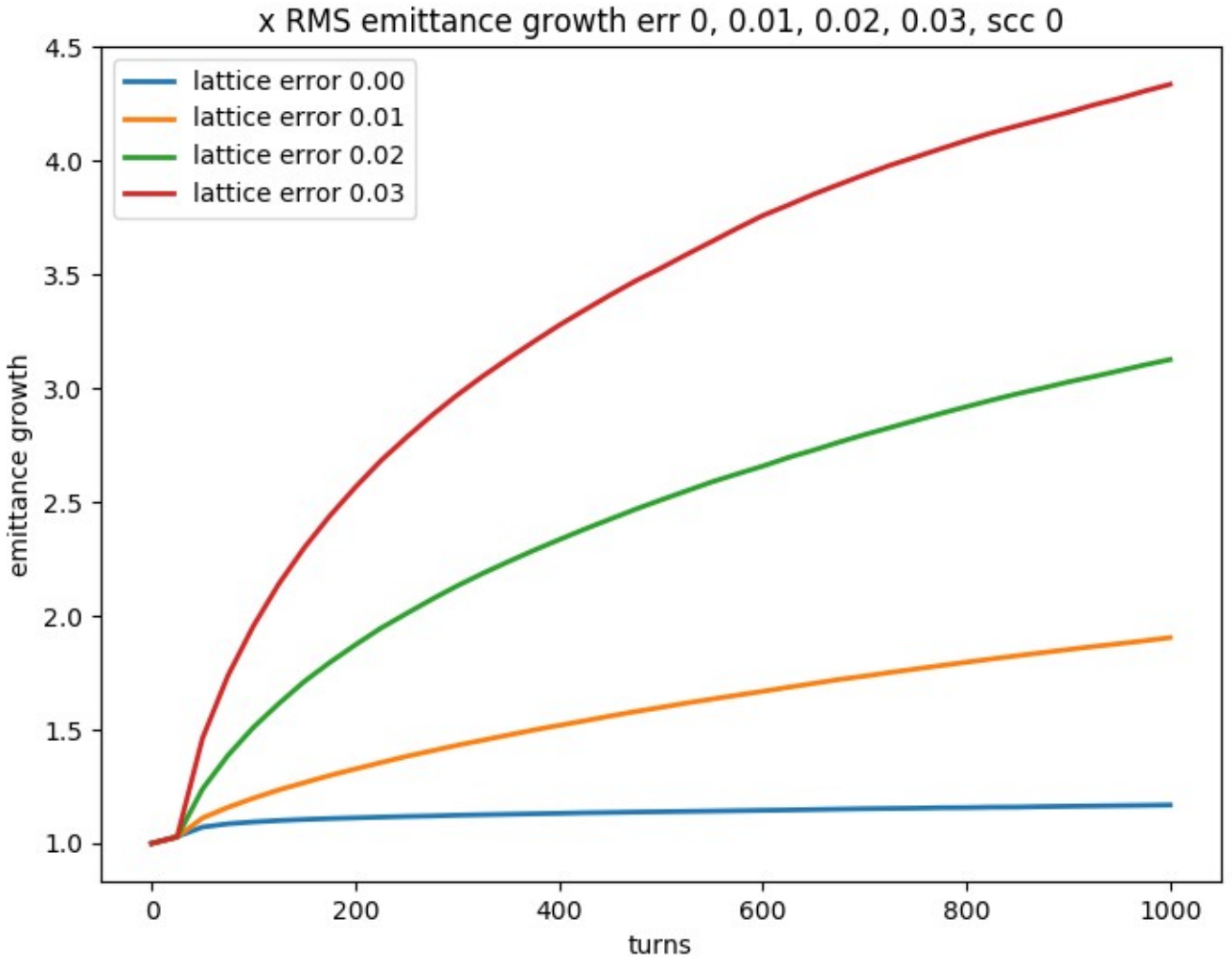
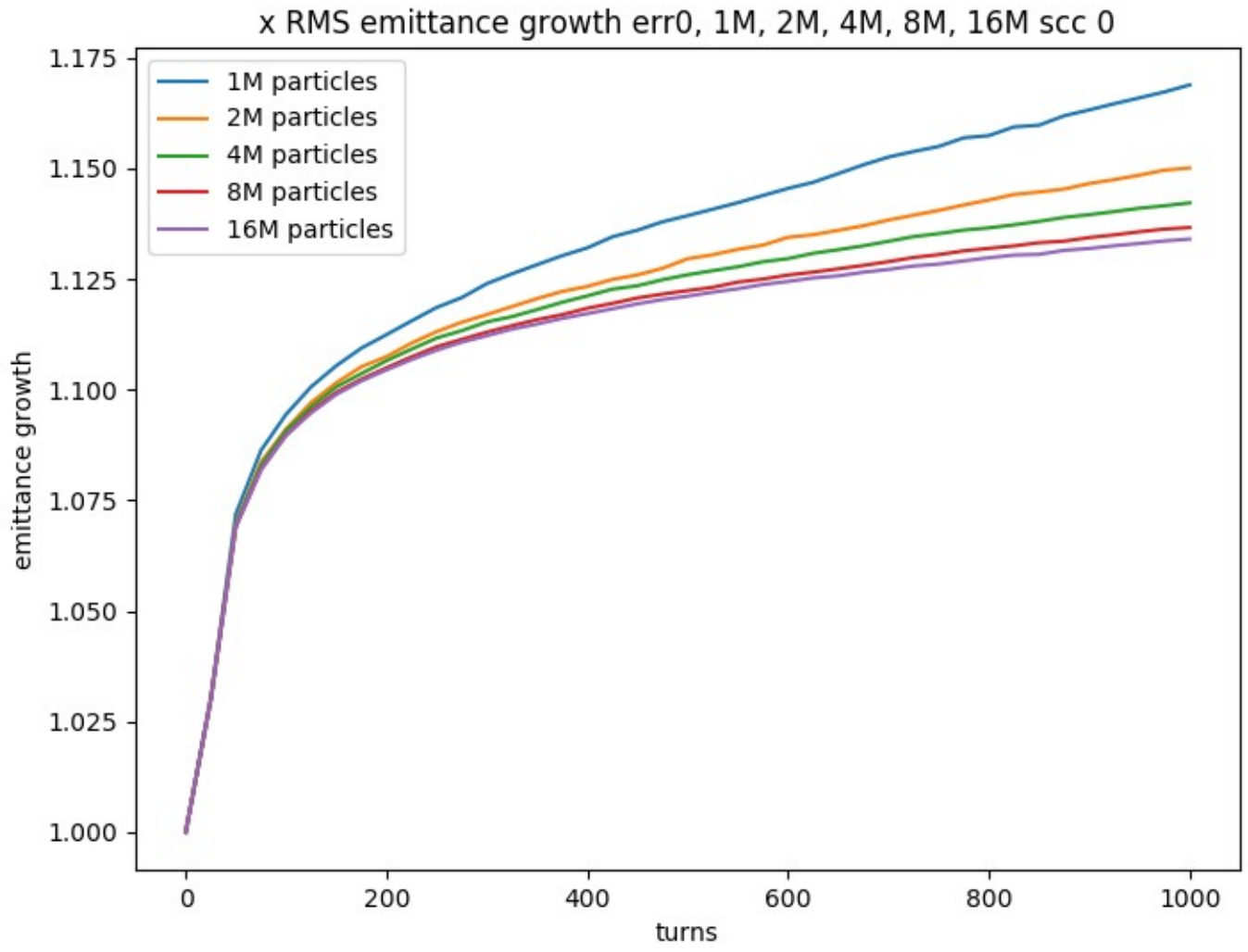
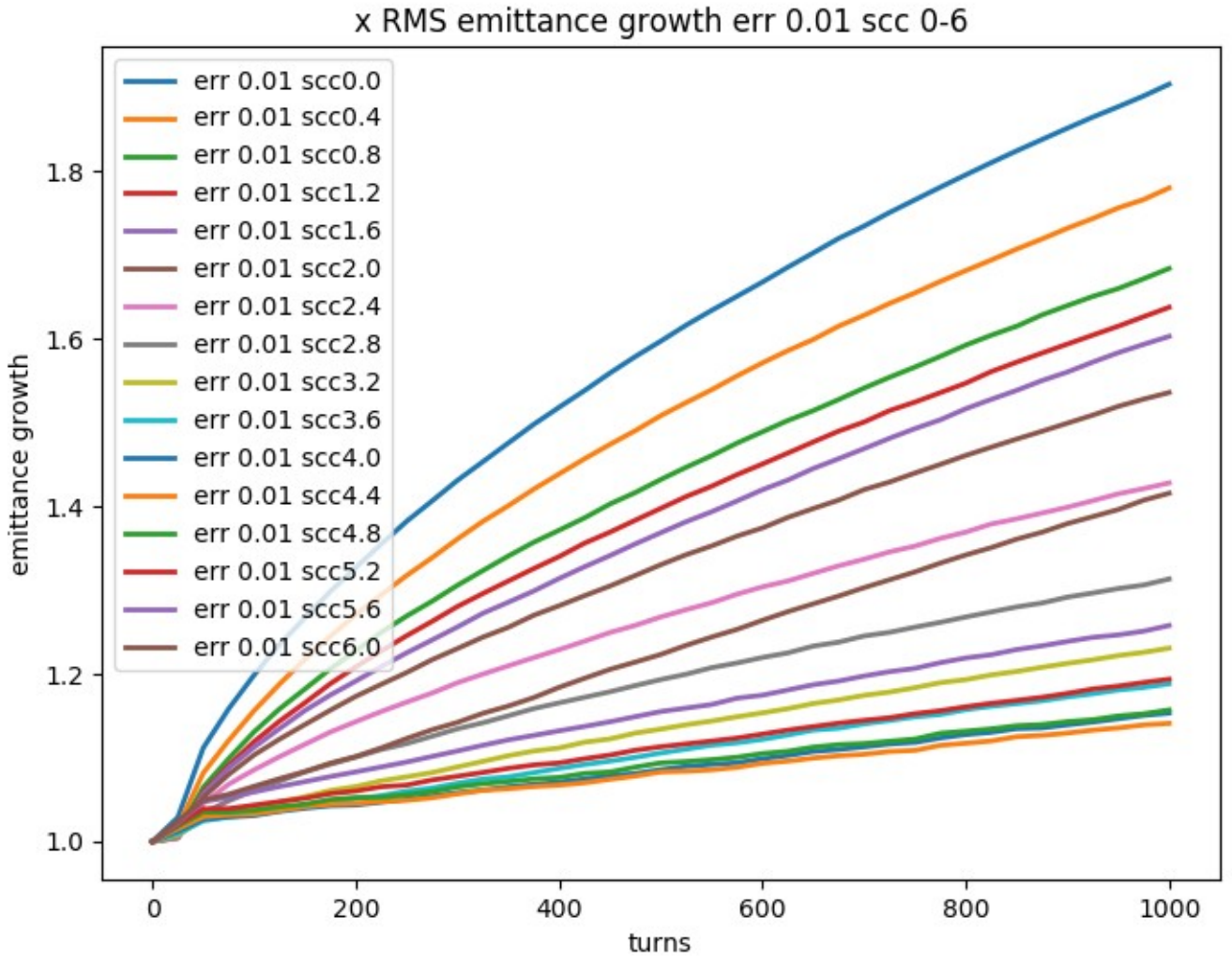


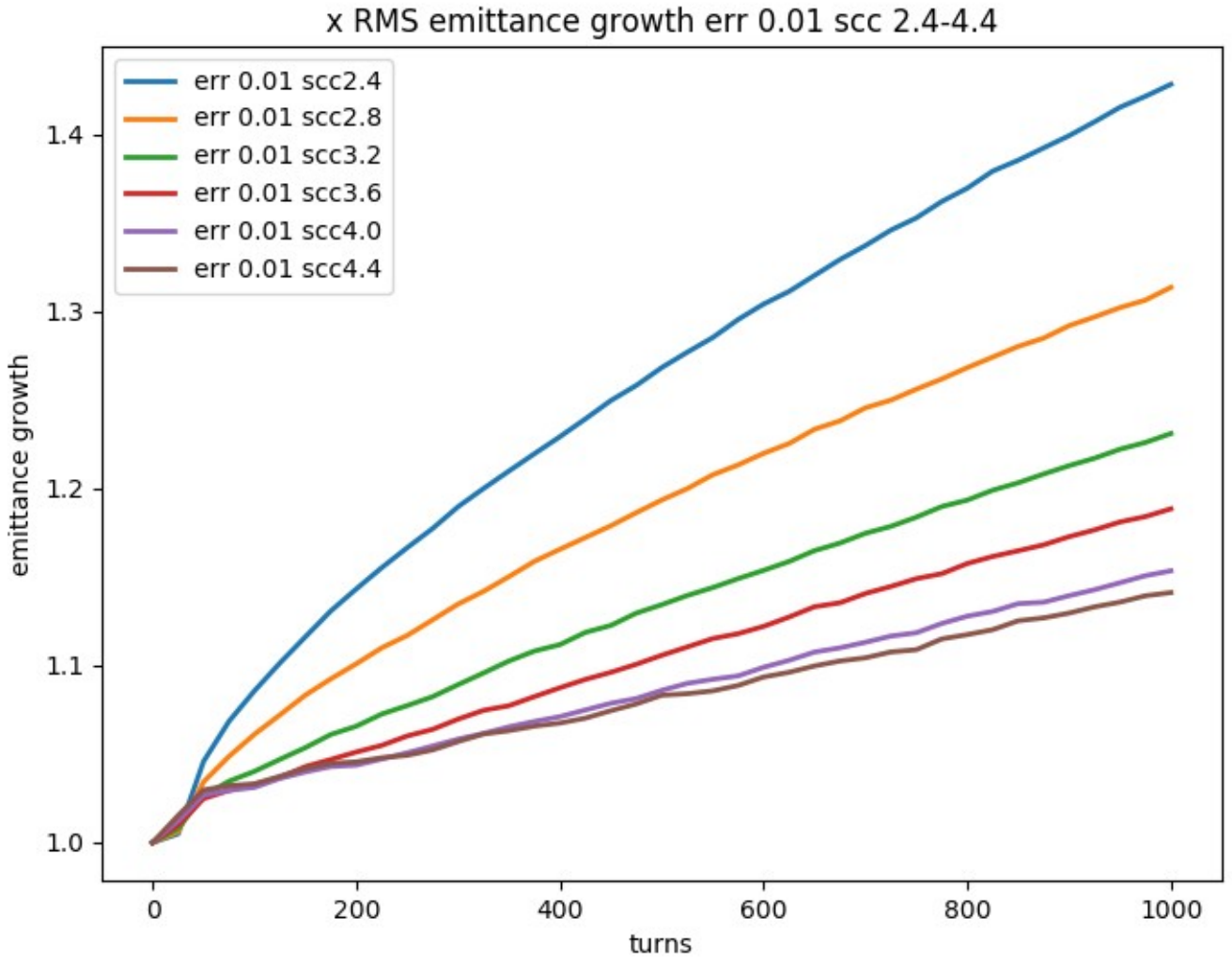
Lattice error	RMS emittance growth
0	1.169
0.01	1.904
0.02	3.126
0.03	4.335



Macro particles	Calculates RMS emittance growth
1M	1.169
2M	1.150
4M	1.142
8M	1.137
16M	1.134

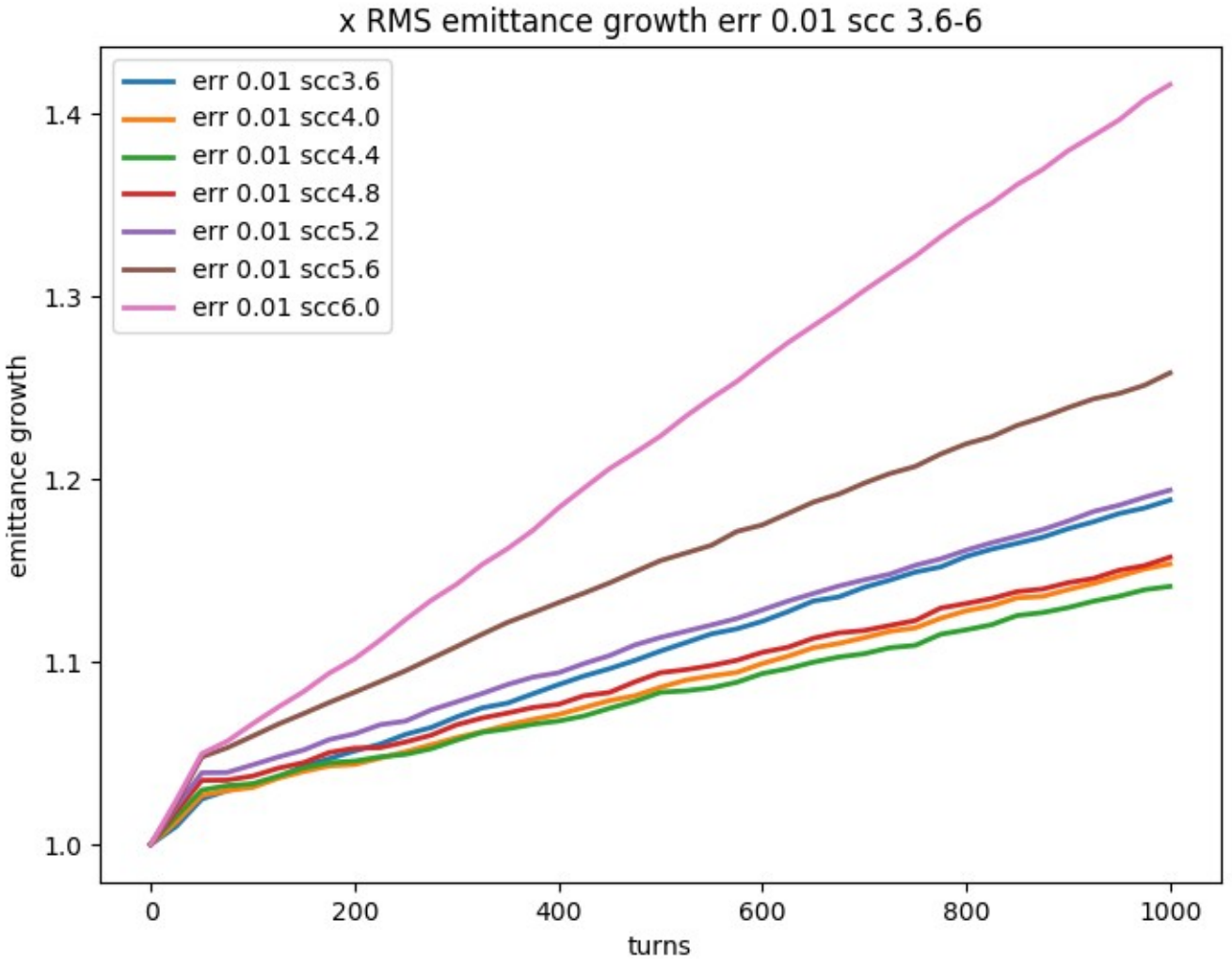


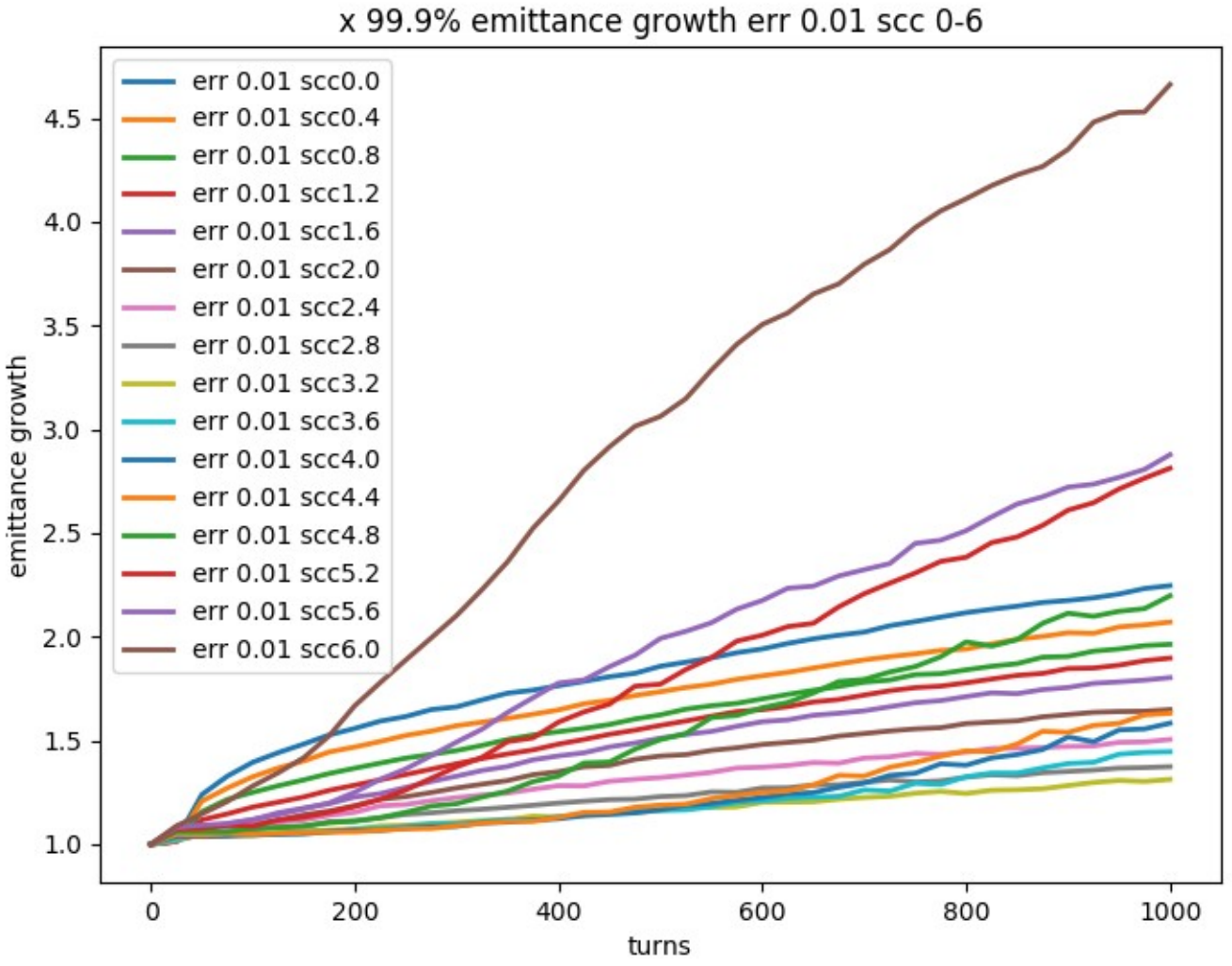
New runs with 1M macro particles instead of 100K (previous results)

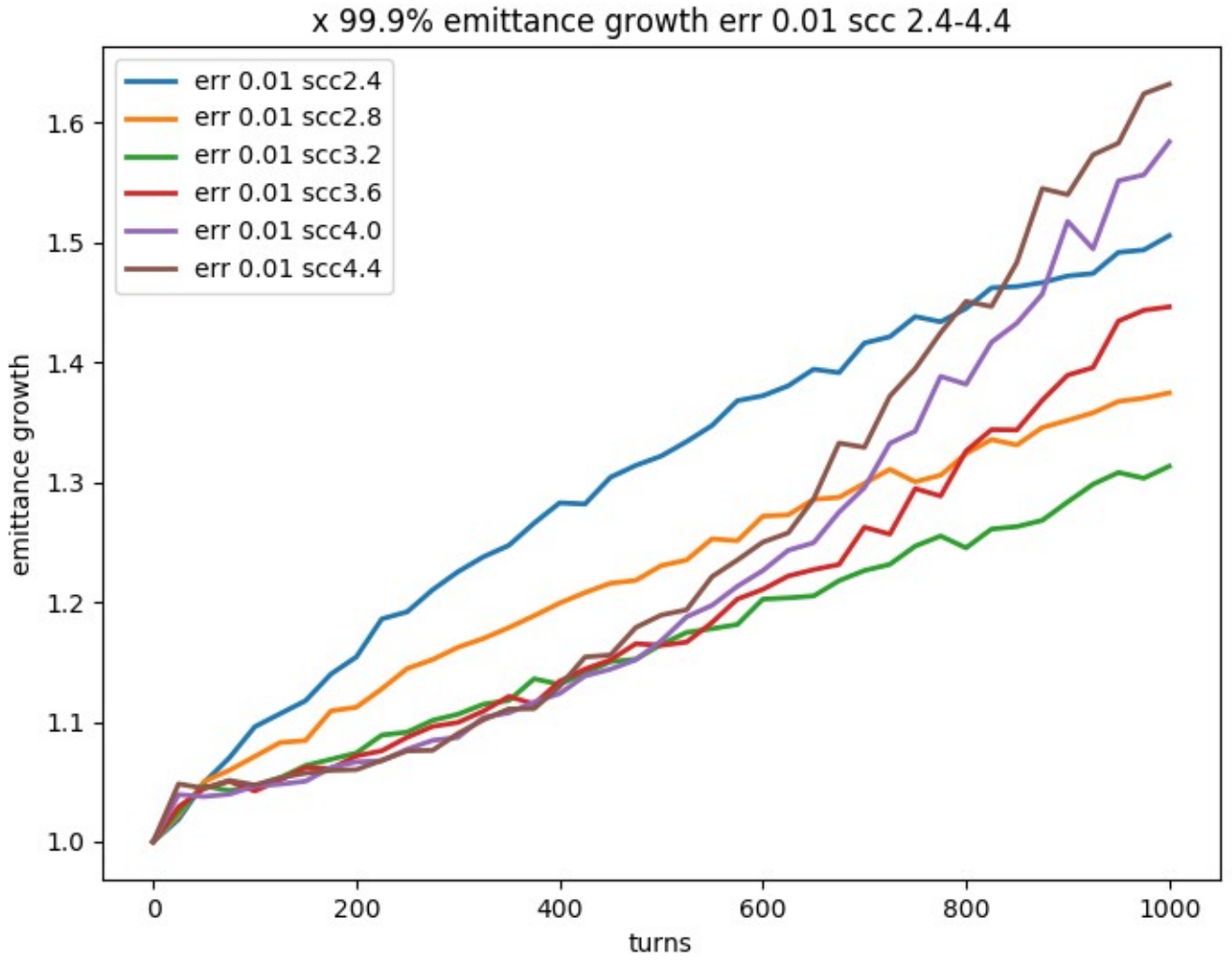


Best compensation occurs at scc 4.4 (unlike running with 100K macro particles)

See table at end

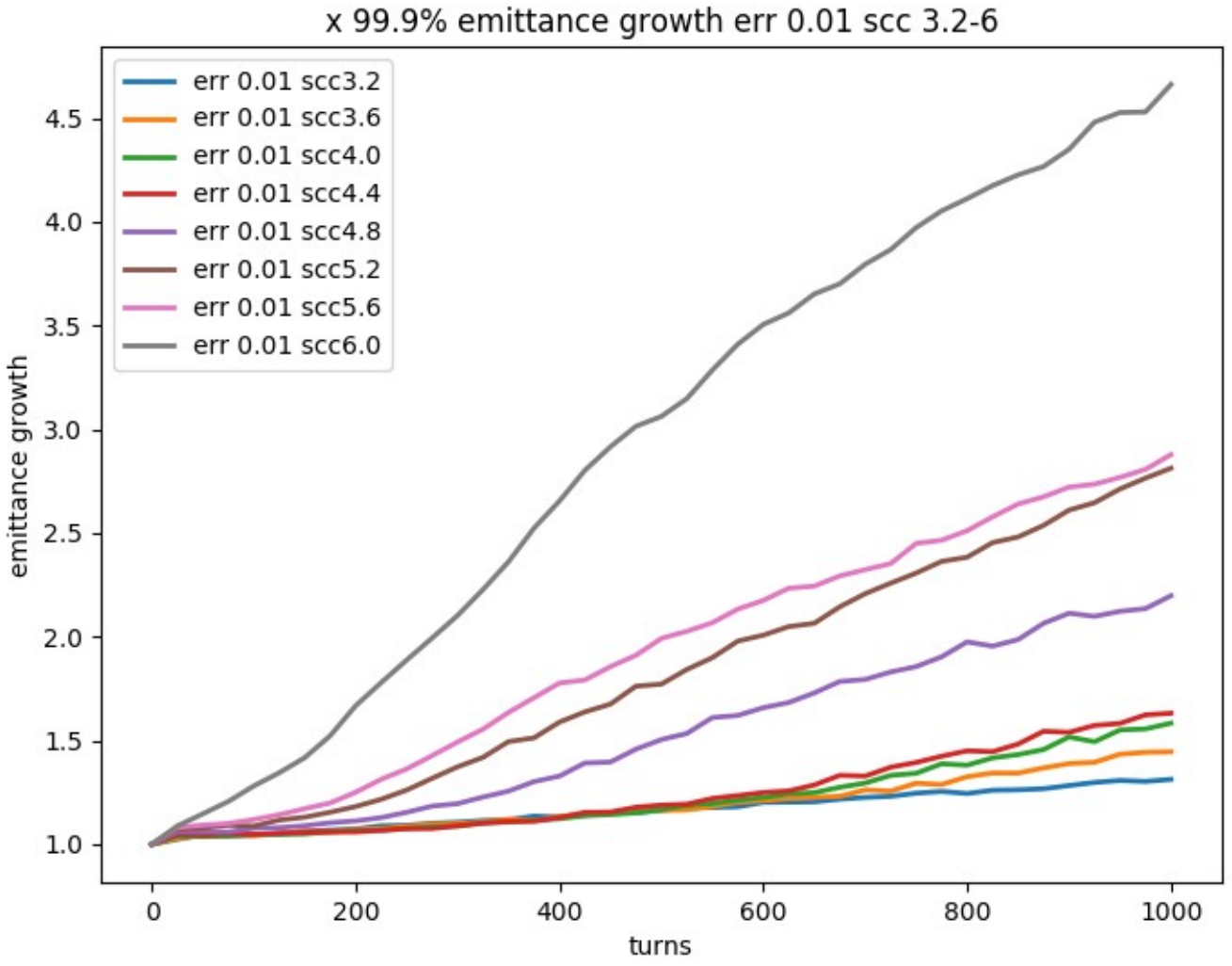

x RMS emittance growth err 0.01 scc 3.6-6
err 0.01 scc3.6
err 0.01 scc4.0
err 0.01 scc4.4
err 0.01 scc4.8
err 0.01 scc5.2
err 0.01 scc5.6
err 0.01 scc6.0
emittance growth
1.0
1.1
1.2
1.3
1.4
0
200
400
600
800
1000
turns

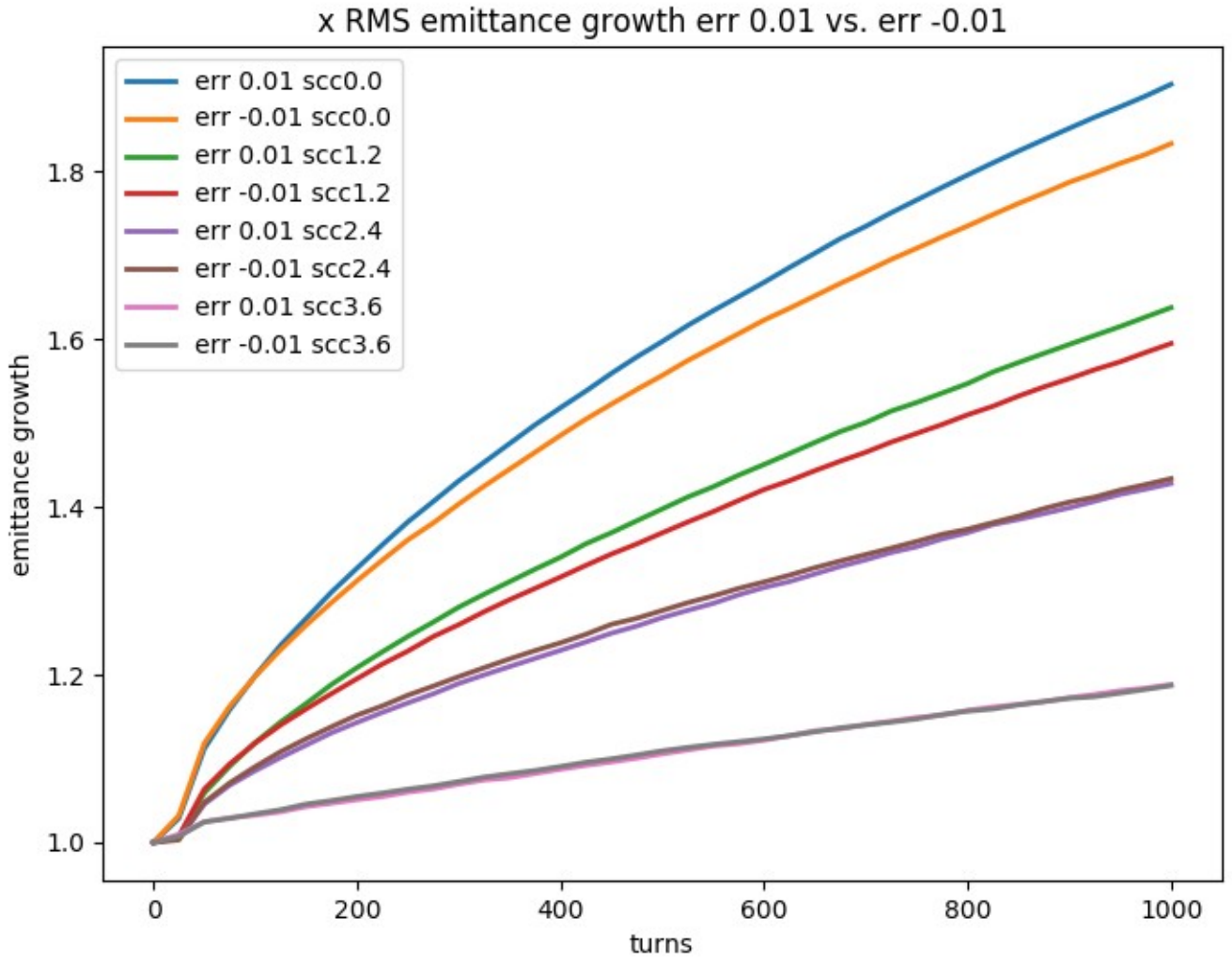

x 99.9% emittance growth err 0.01 scc 0-6
err 0.01 scc0.0
err 0.01 scc0.4
err 0.01 scc0.8
err 0.01 scc1.2
err 0.01 scc1.6
err 0.01 scc2.0
err 0.01 scc2.4
err 0.01 scc2.8
err 0.01 scc3.2
err 0.01 scc3.6
err 0.01 scc4.0
err 0.01 scc4.4
err 0.01 scc4.8
err 0.01 scc5.2
err 0.01 scc5.6
err 0.01 scc6.0
emittance growth
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
0
200
400
600
800
1000
turns



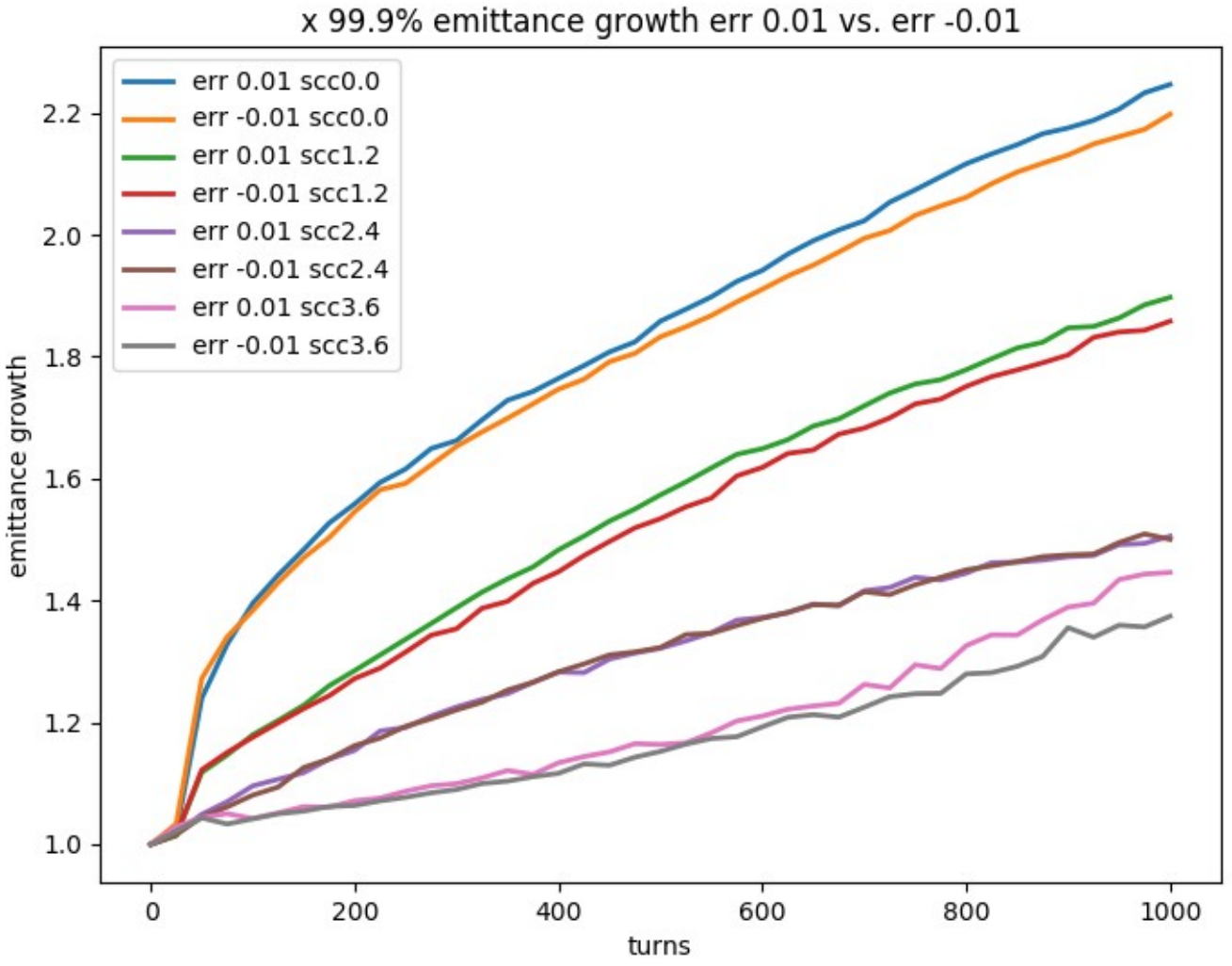
Best compensation of 99.9% emittance occurs at scc 3.2, unlike 100K macro particle running where it occurred at around 2.8

See table at end

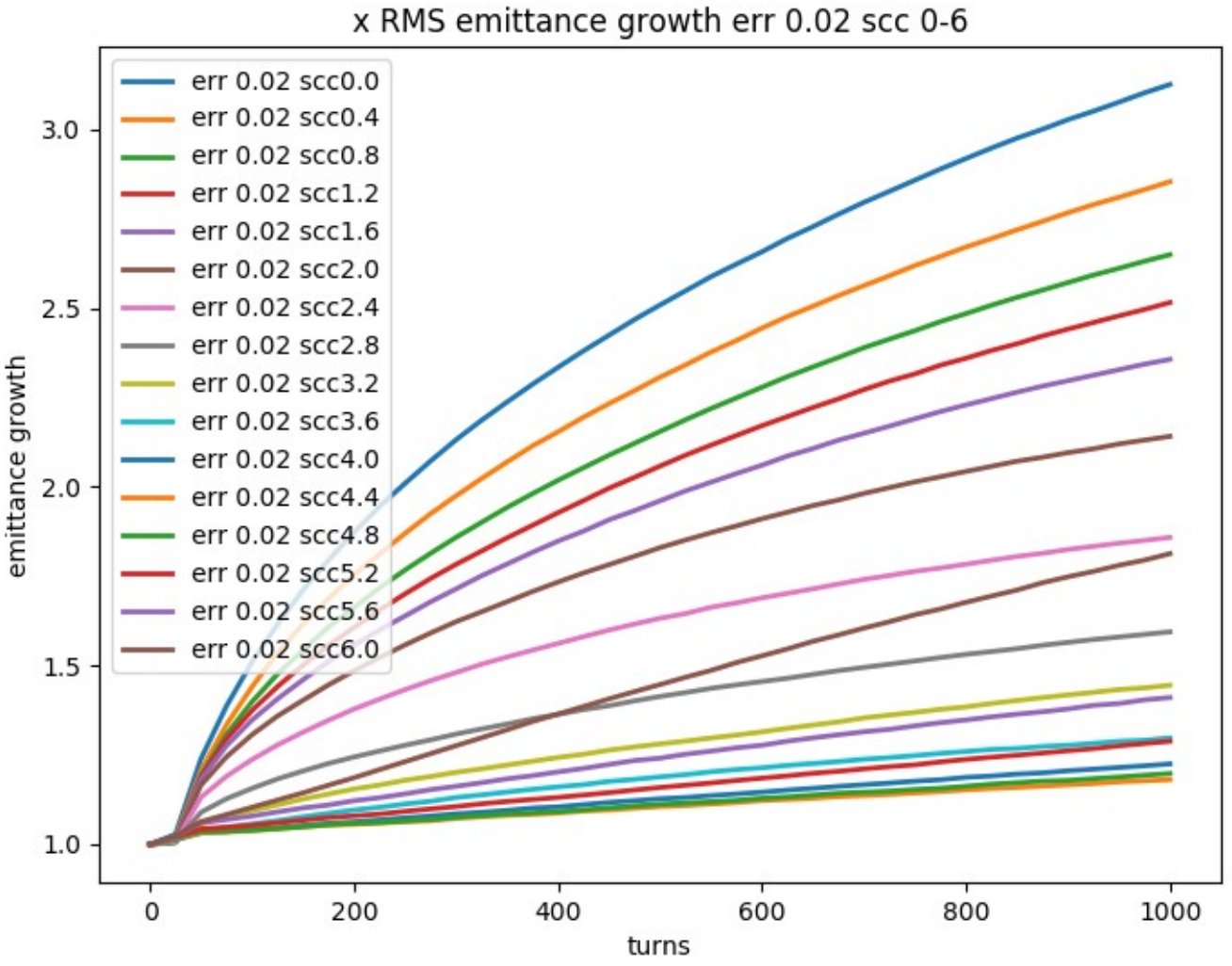

x 99.9% emittance growth err 0.01 scc 3.2-6
err 0.01 scc3.2
err 0.01 scc3.6
err 0.01 scc4.0
err 0.01 scc4.4
err 0.01 scc4.8
err 0.01 scc5.2
err 0.01 scc5.6
err 0.01 scc6.0
emittance growth
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
0
200
400
600
800
1000
turns

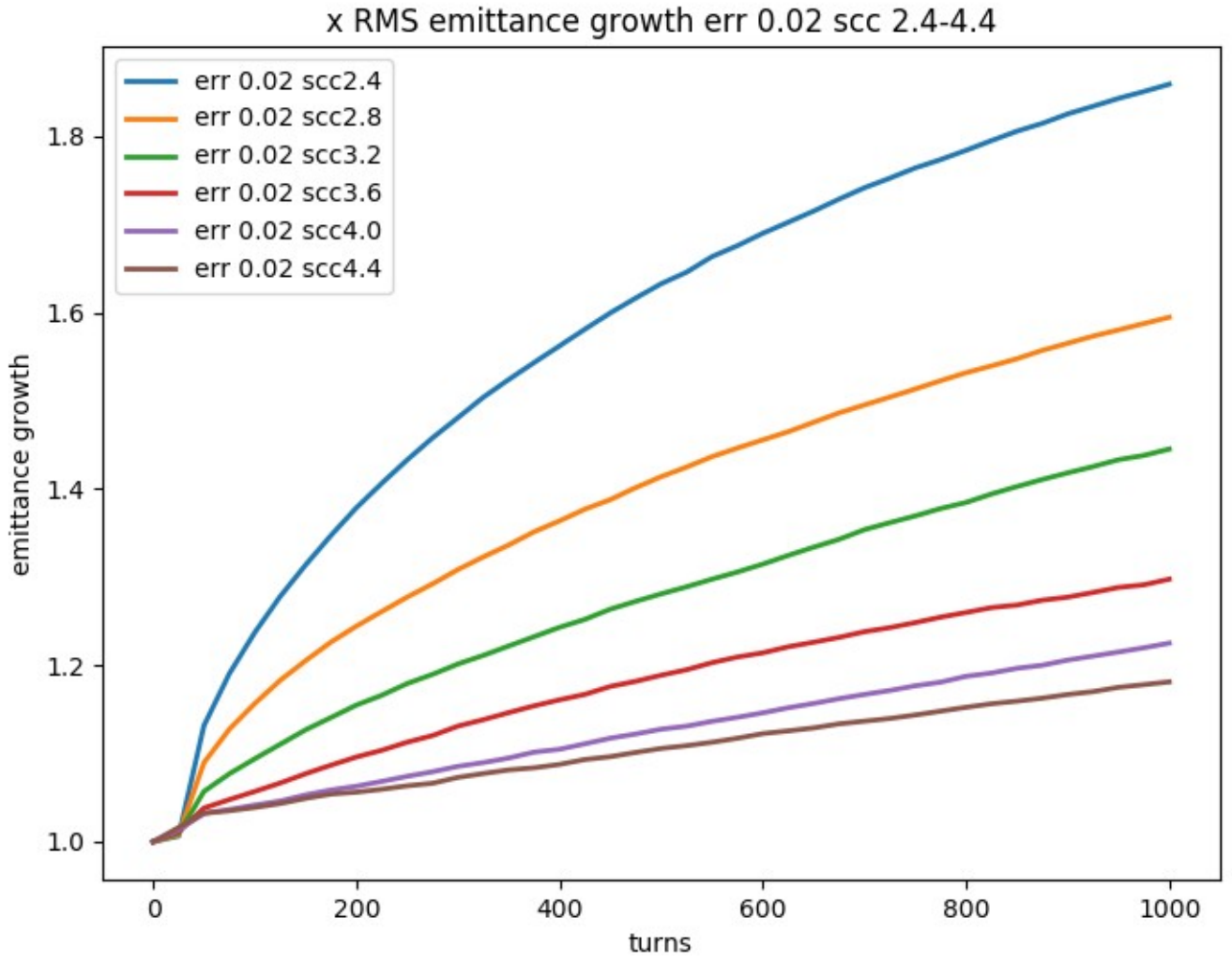


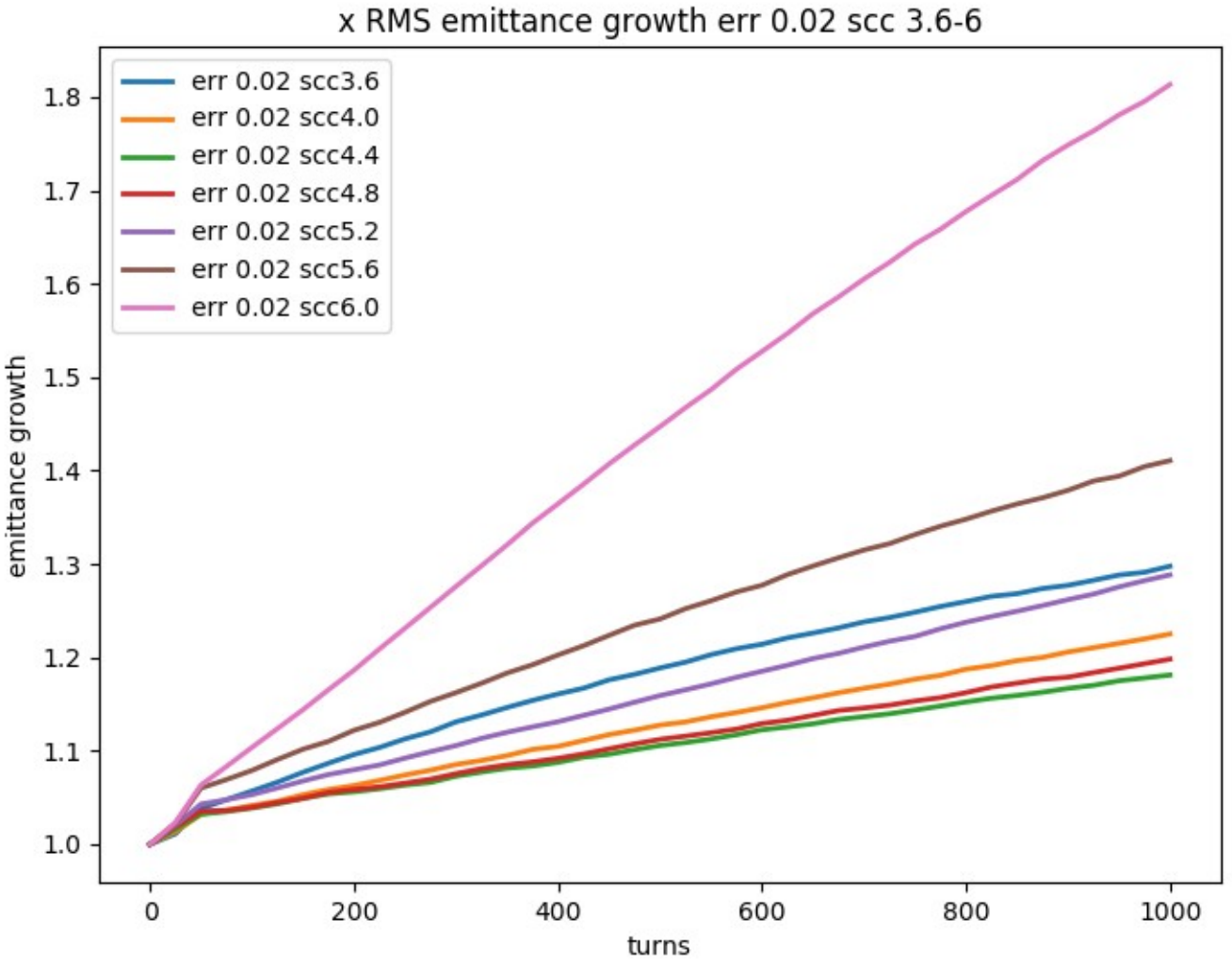
RMS emittance growth is not affected setting lattice element + error or – error when tunes are adjusted to remain the same in both cases.



99.9% emittance is not particular affected by sign of error

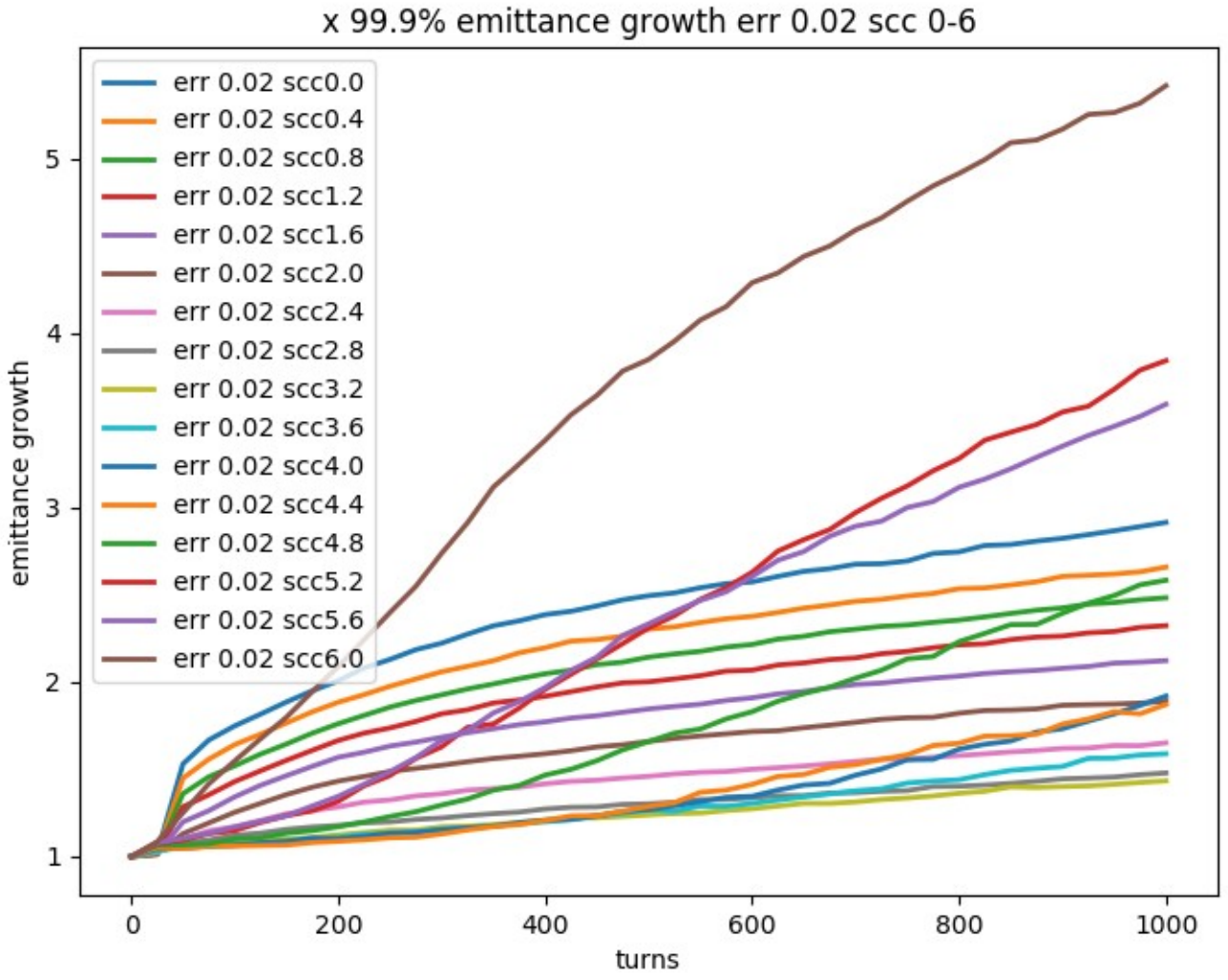

x RMS emittance growth err 0.02 scc 0-6
err 0.02 scc0.0
err 0.02 scc0.4
err 0.02 scc0.8
err 0.02 scc1.2
err 0.02 scc1.6
err 0.02 scc2.0
err 0.02 scc2.4
err 0.02 scc2.8
err 0.02 scc3.2
err 0.02 scc3.6
err 0.02 scc4.0
err 0.02 scc4.4
err 0.02 scc4.8
err 0.02 scc5.2
err 0.02 scc5.6
err 0.02 scc6.0
emittance growth
3.0
2.5
2.0
1.5
1.0
0
200
400
600
800
1000
turns

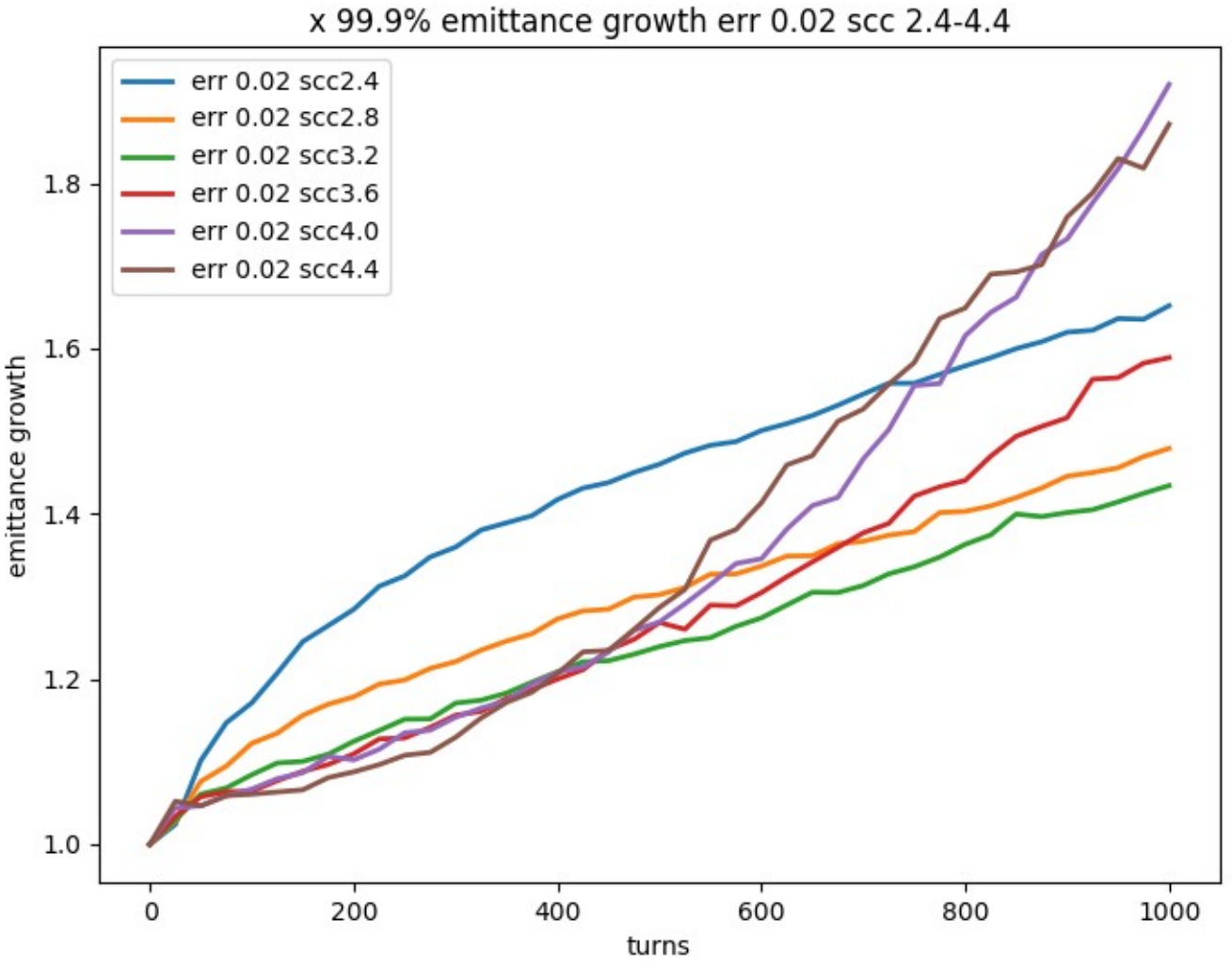

x RMS emittance growth err 0.02 scc 2.4-4.4
err 0.02 scc2.4
err 0.02 scc2.8
err 0.02 scc3.2
err 0.02 scc3.6
err 0.02 scc4.0
err 0.02 scc4.4
emittance growth
1.0
1.2
1.4
1.6
1.8
0
200
400
600
800
1000
turns

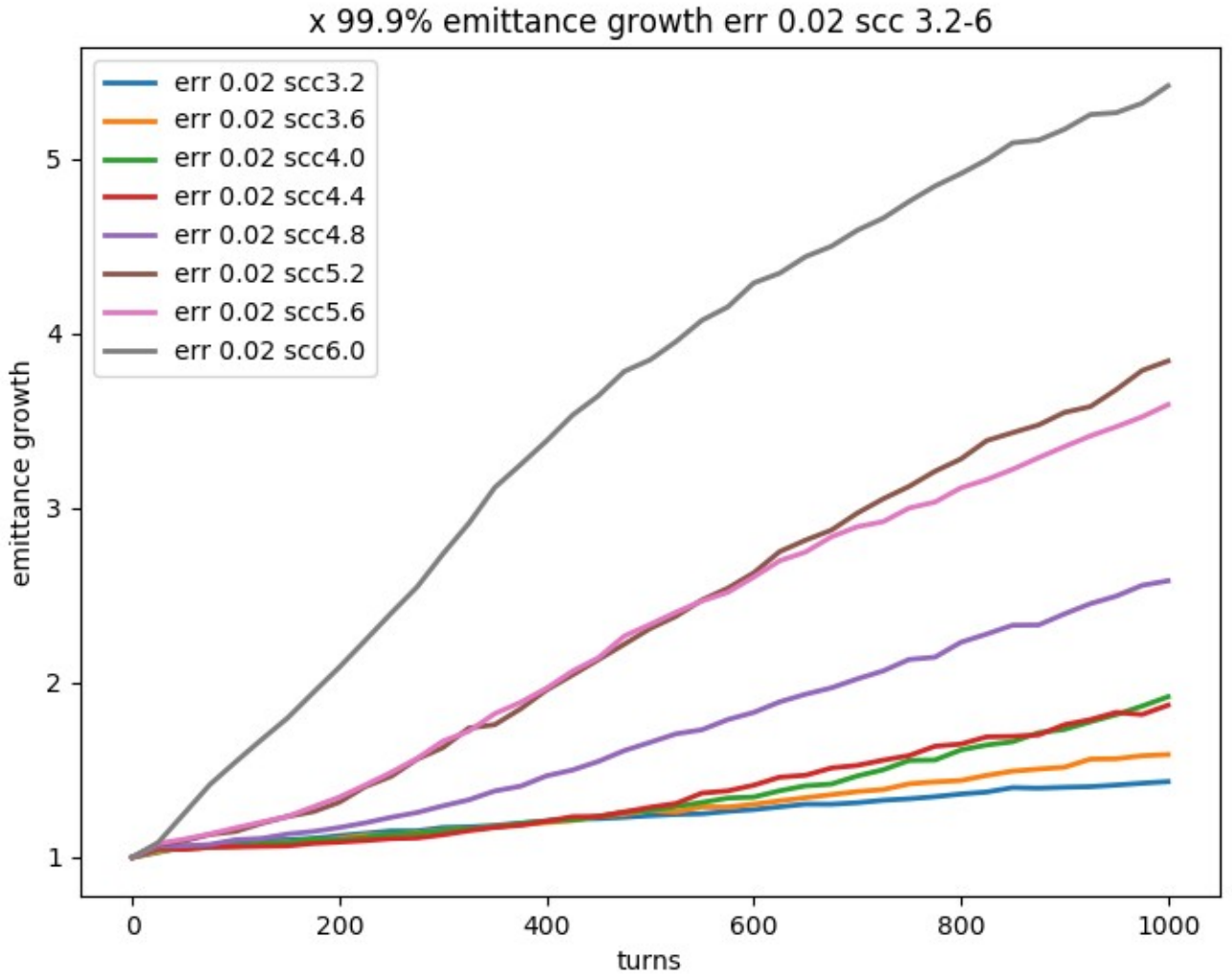


For 0.02 lattice error, best compensation for RMS emittance at 4.4, same as error 0.01.

See table at end

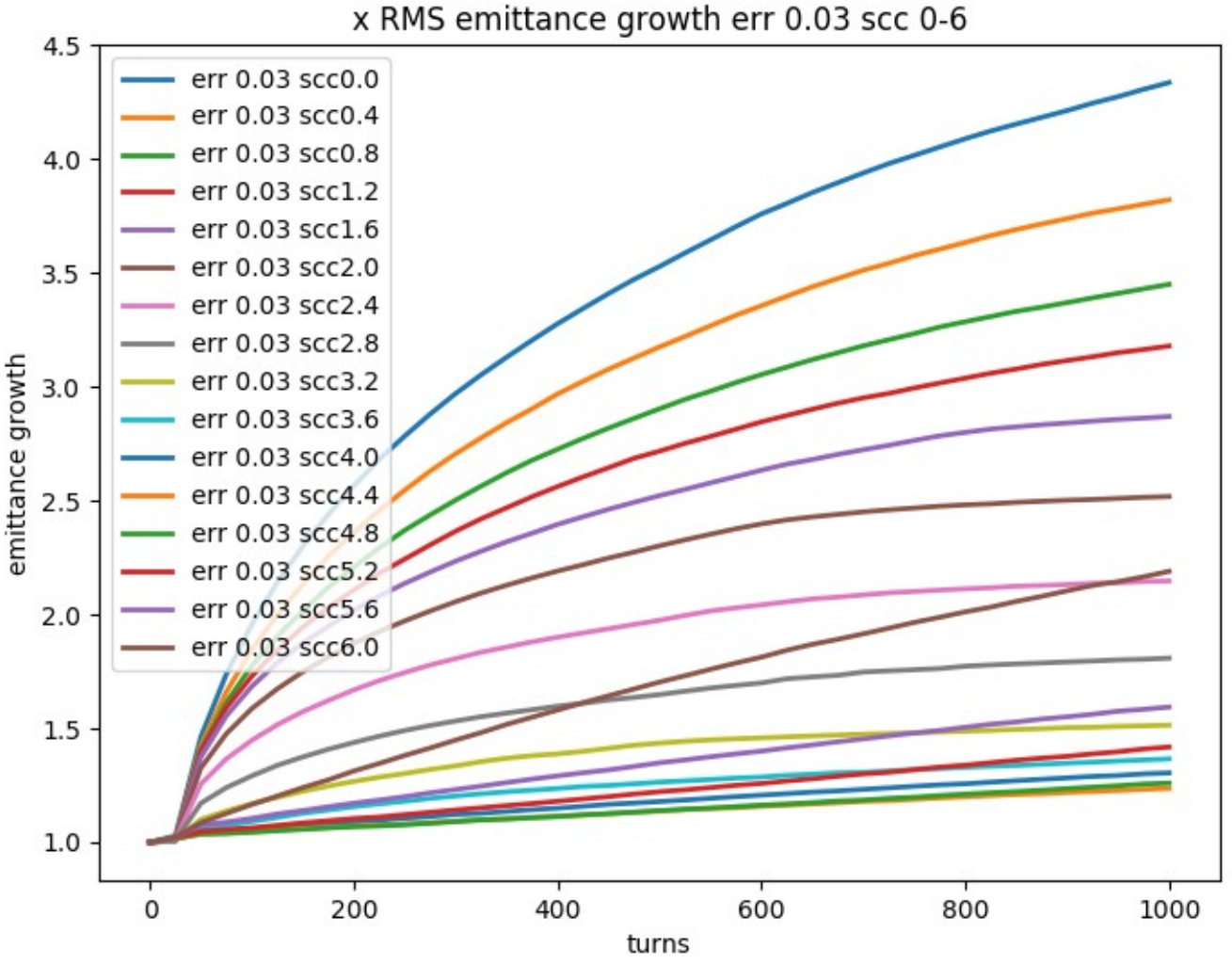

x 99.9% emittance growth err 0.02 scc 0-6
err 0.02 scc0.0
err 0.02 scc0.4
err 0.02 scc0.8
err 0.02 scc1.2
err 0.02 scc1.6
err 0.02 scc2.0
err 0.02 scc2.4
err 0.02 scc2.8
err 0.02 scc3.2
err 0.02 scc3.6
err 0.02 scc4.0
err 0.02 scc4.4
err 0.02 scc4.8
err 0.02 scc5.2
err 0.02 scc5.6
err 0.02 scc6.0
emittance growth
1
2
3
4
5
0
200
400
600
800
1000
turns

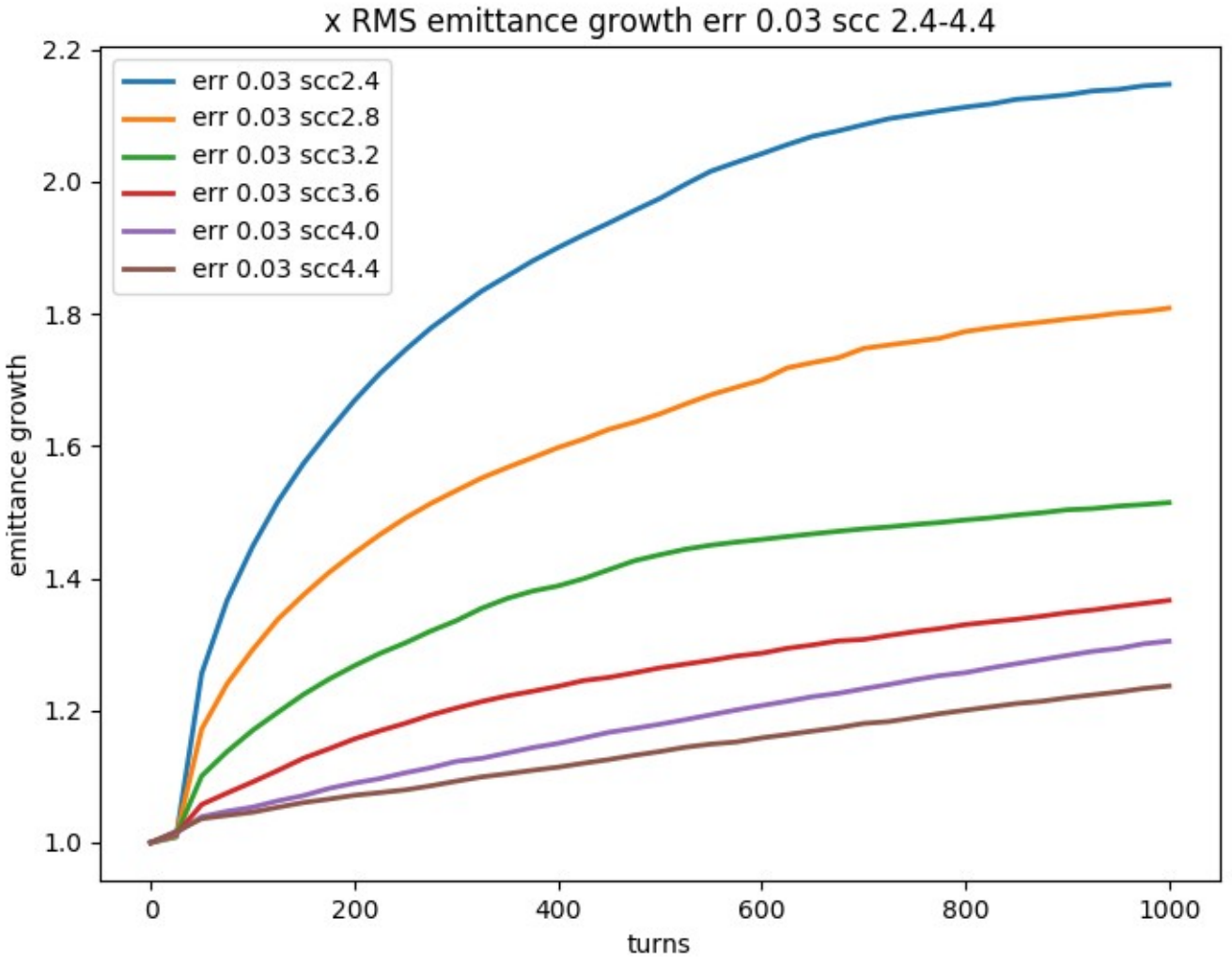

x 99.9% emittance growth err 0.02 scc 2.4-4.4
err 0.02 scc2.4
err 0.02 scc2.8
err 0.02 scc3.2
err 0.02 scc3.6
err 0.02 scc4.0
err 0.02 scc4.4
emittance growth
1.0
1.2
1.4
1.6
1.8
0
200
400
600
800
1000
turns

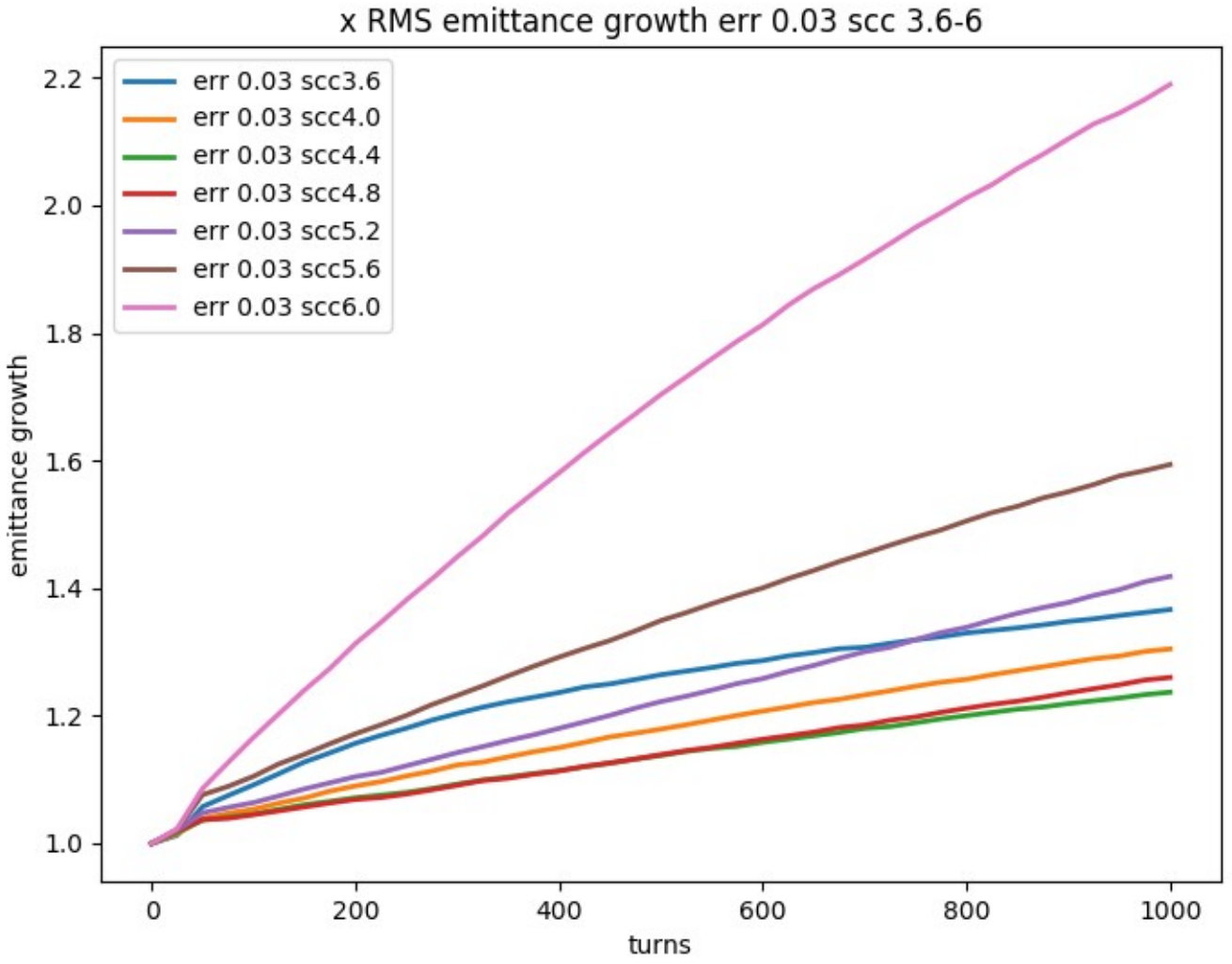


For lattice error 0.02, best compensation for 99.9% emittance growth occurs at scc 3.2, same as for error 0.01

See table at end.

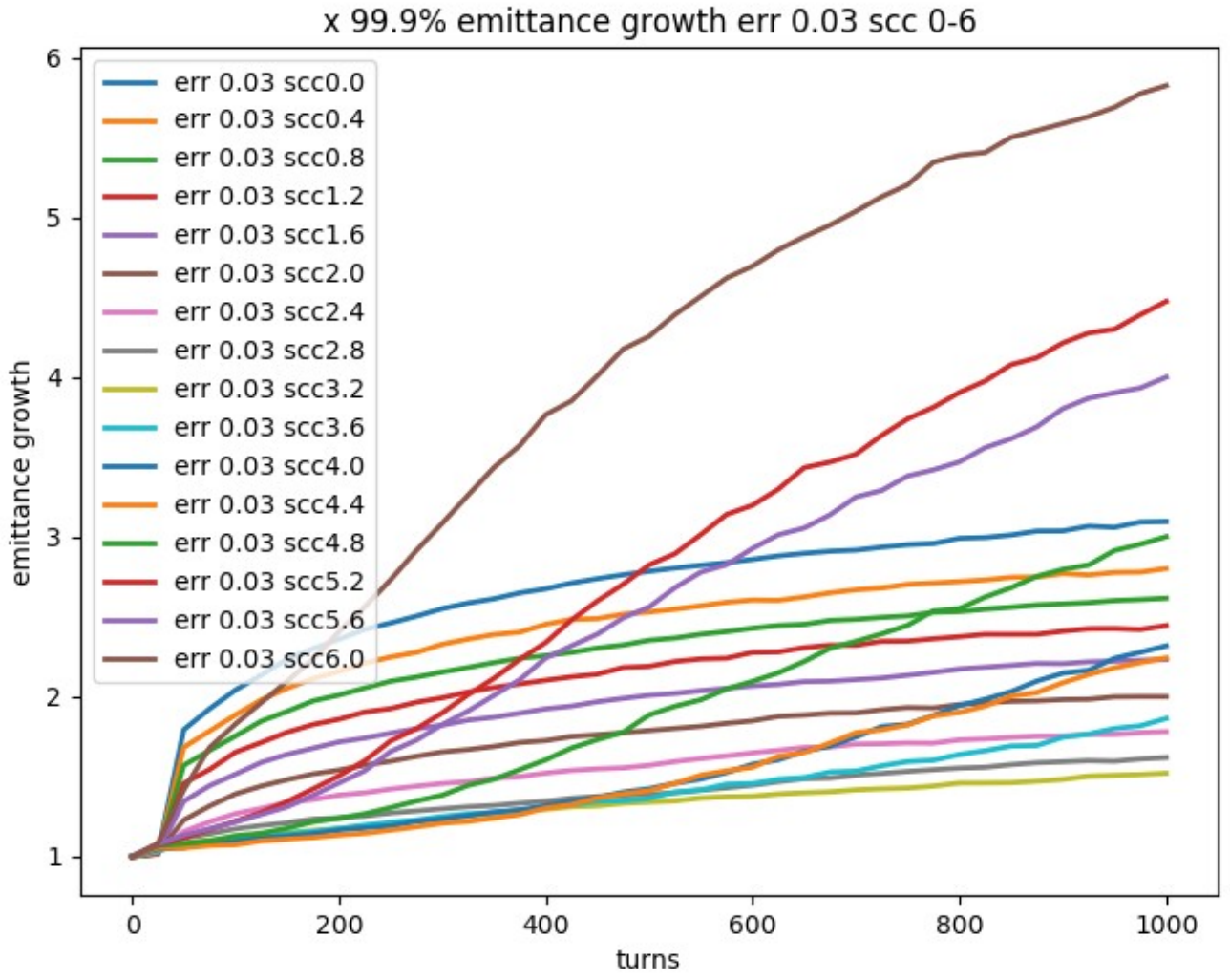

x RMS emittance growth err 0.03 scc 0-6
emittance growth
turns
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0
200
400
600
800
1000
err 0.03 scc0.0
err 0.03 scc0.4
err 0.03 scc0.8
err 0.03 scc1.2
err 0.03 scc1.6
err 0.03 scc2.0
err 0.03 scc2.4
err 0.03 scc2.8
err 0.03 scc3.2
err 0.03 scc3.6
err 0.03 scc4.0
err 0.03 scc4.4
err 0.03 scc4.8
err 0.03 scc5.2
err 0.03 scc5.6
err 0.03 scc6.0

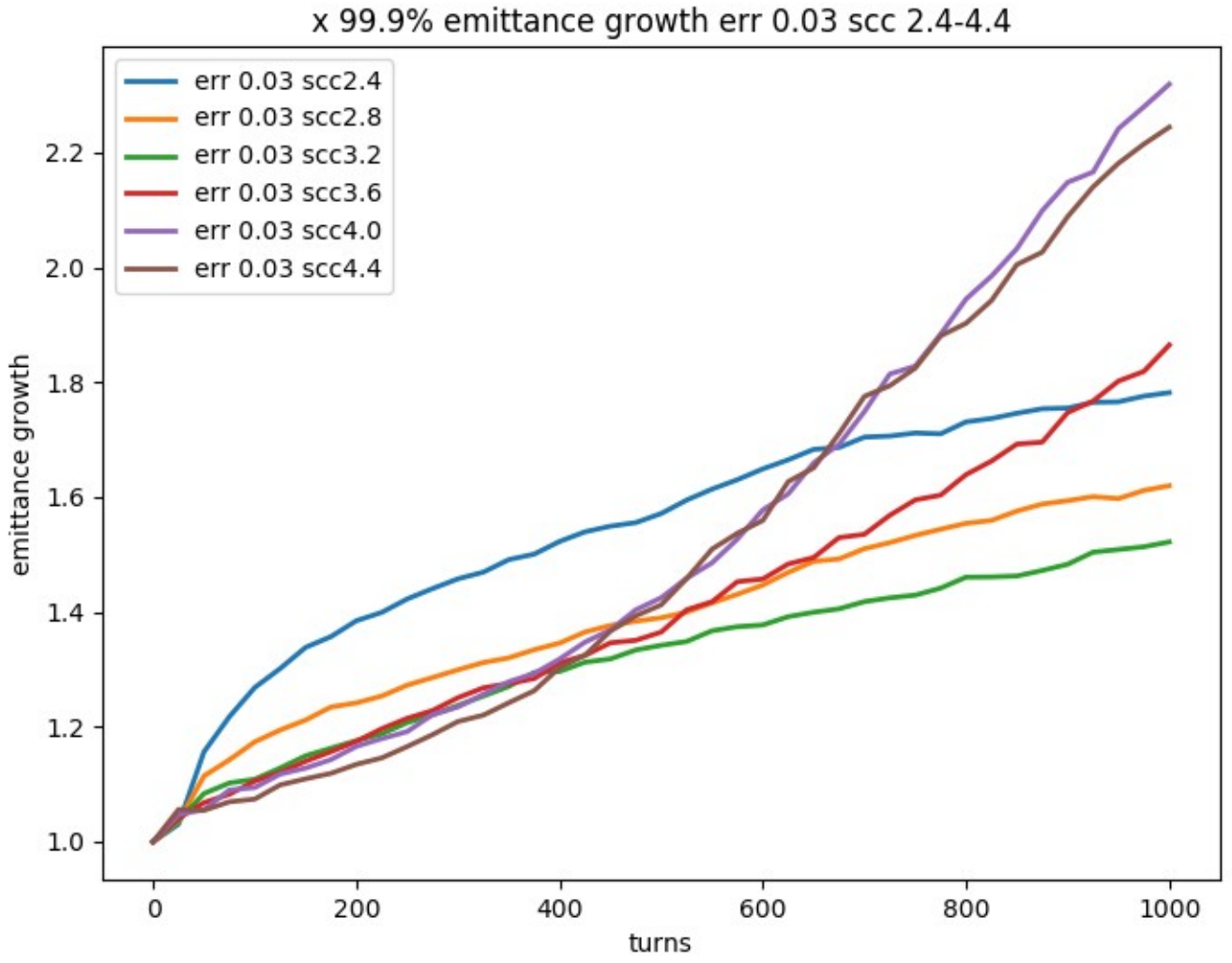

x RMS emittance growth err 0.03 scc 2.4-4.4
err 0.03 scc2.4
err 0.03 scc2.8
err 0.03 scc3.2
err 0.03 scc3.6
err 0.03 scc4.0
err 0.03 scc4.4
emittance growth
turns
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0
200
400
600
800
1000

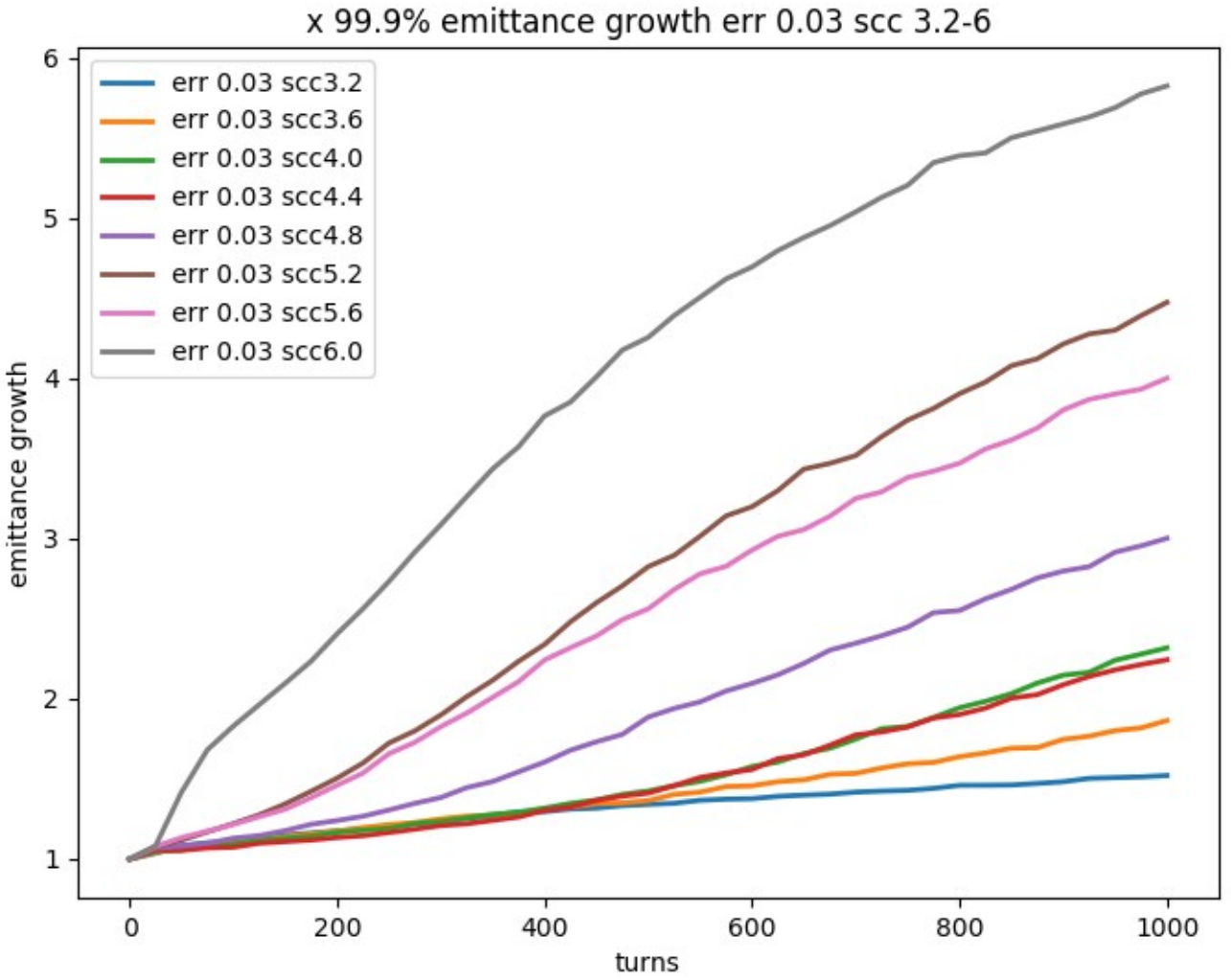


For 0.03 lattice error, best compensation for RMS emittance at 4.4, same as error 0.01.

See table at end


x 99.9% emittance growth err 0.03 scc 0-6
err 0.03 scc0.0
err 0.03 scc0.4
err 0.03 scc0.8
err 0.03 scc1.2
err 0.03 scc1.6
err 0.03 scc2.0
err 0.03 scc2.4
err 0.03 scc2.8
err 0.03 scc3.2
err 0.03 scc3.6
err 0.03 scc4.0
err 0.03 scc4.4
err 0.03 scc4.8
err 0.03 scc5.2
err 0.03 scc5.6
err 0.03 scc6.0
emittance growth
turns
1
2
3
4
5
6
0
200
400
600
800
1000


x 99.9% emittance growth err 0.03 scc 2.4-4.4
err 0.03 scc2.4
err 0.03 scc2.8
err 0.03 scc3.2
err 0.03 scc3.6
err 0.03 scc4.0
err 0.03 scc4.4
emittance growth
turns
1.0
1.2
1.4
1.6
1.8
2.0
2.2
0
200
400
600
800
1000



For lattice error 0.03, best compensation for 99.9% emittance growth occurs at scc 3.2, same as for error 0.01

See table at end.

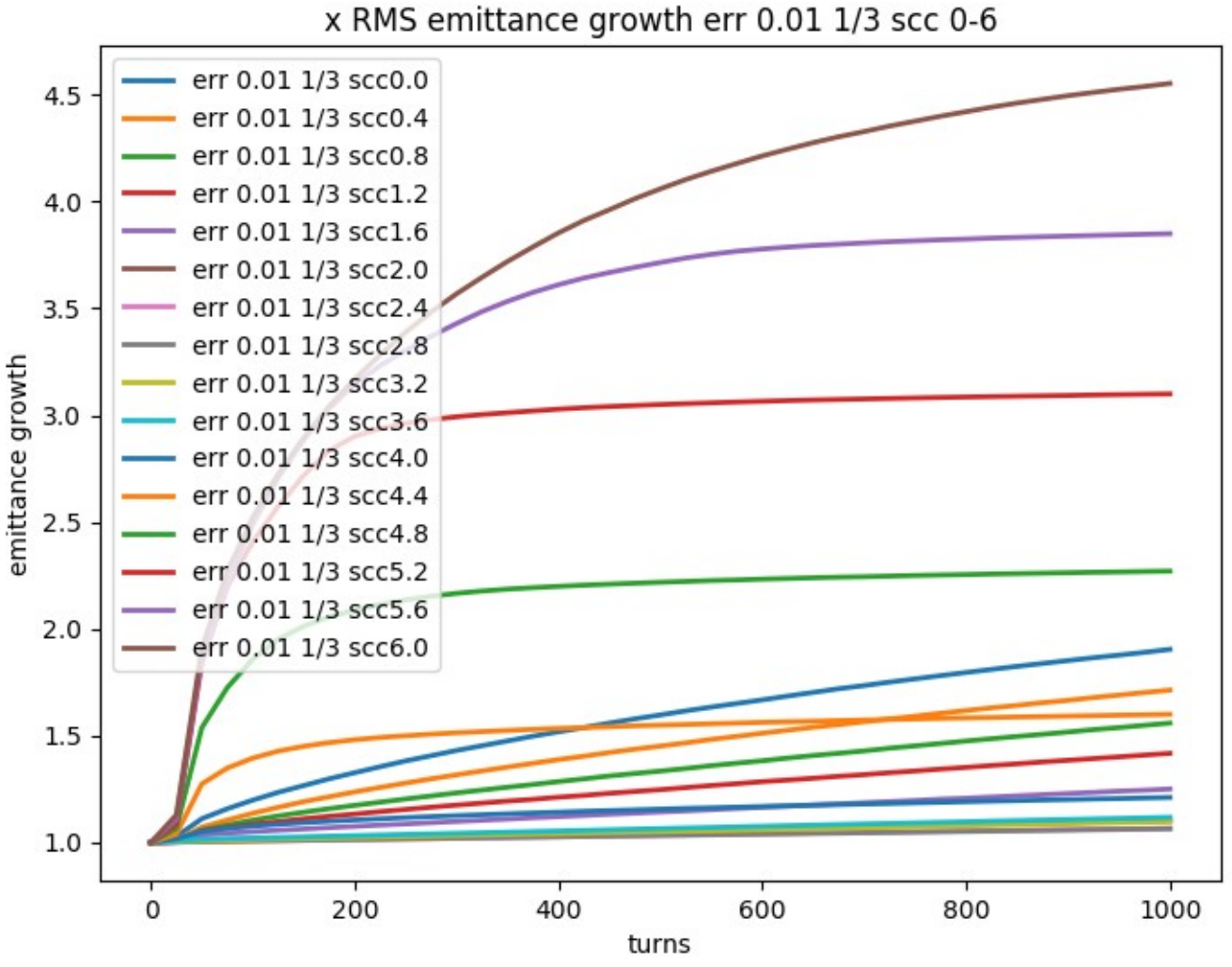
RMS emittance with lattice error and 1/6 SC compensation summary

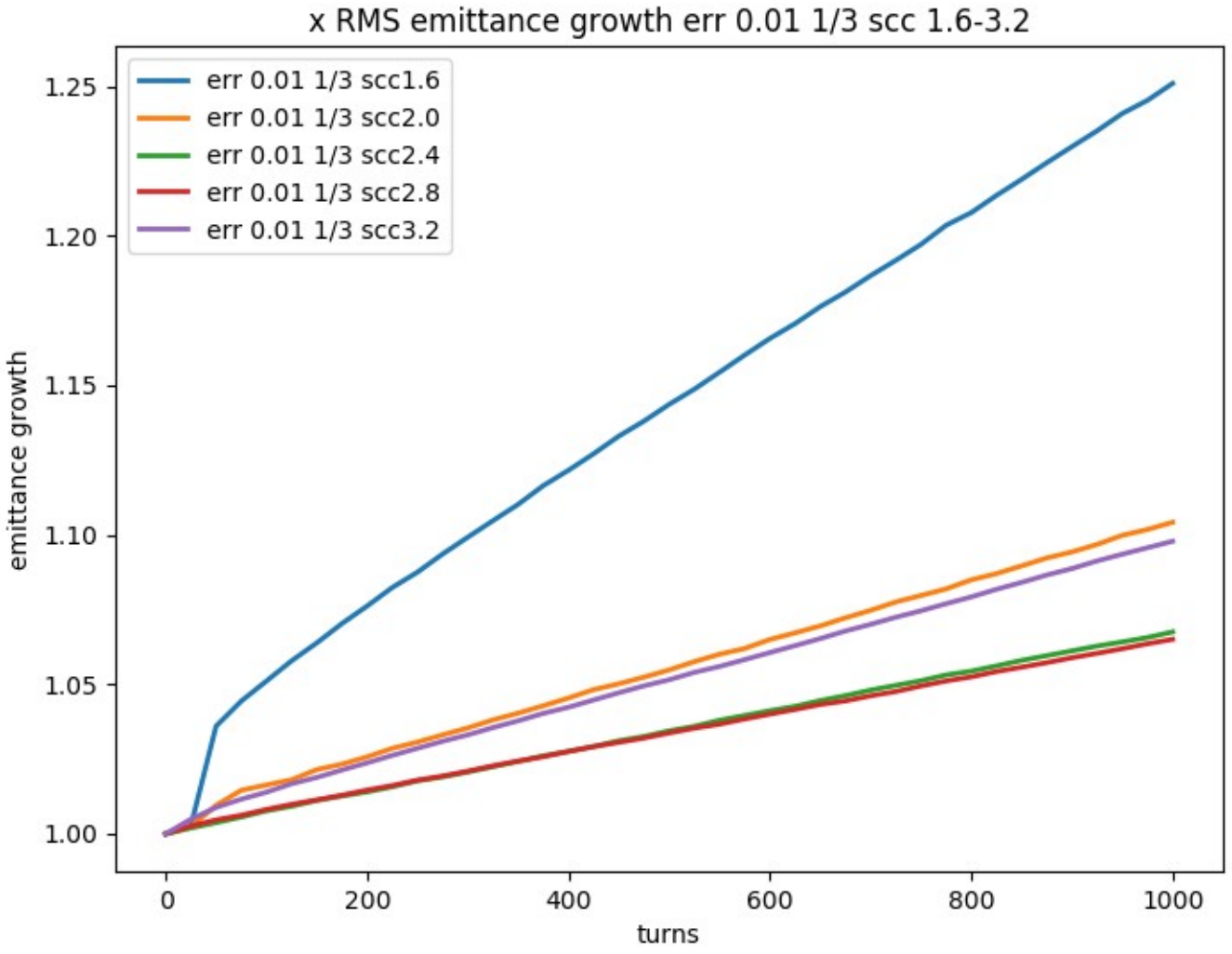
Lattice error	Optimal compensation factor	RMS emittance growth	Uncompensated emittance growth
0	0		1.169
0.01	4.4	1.141	1.904
0.02	4.4	1.181	3.126
0.03	4.4	1.237	4.335

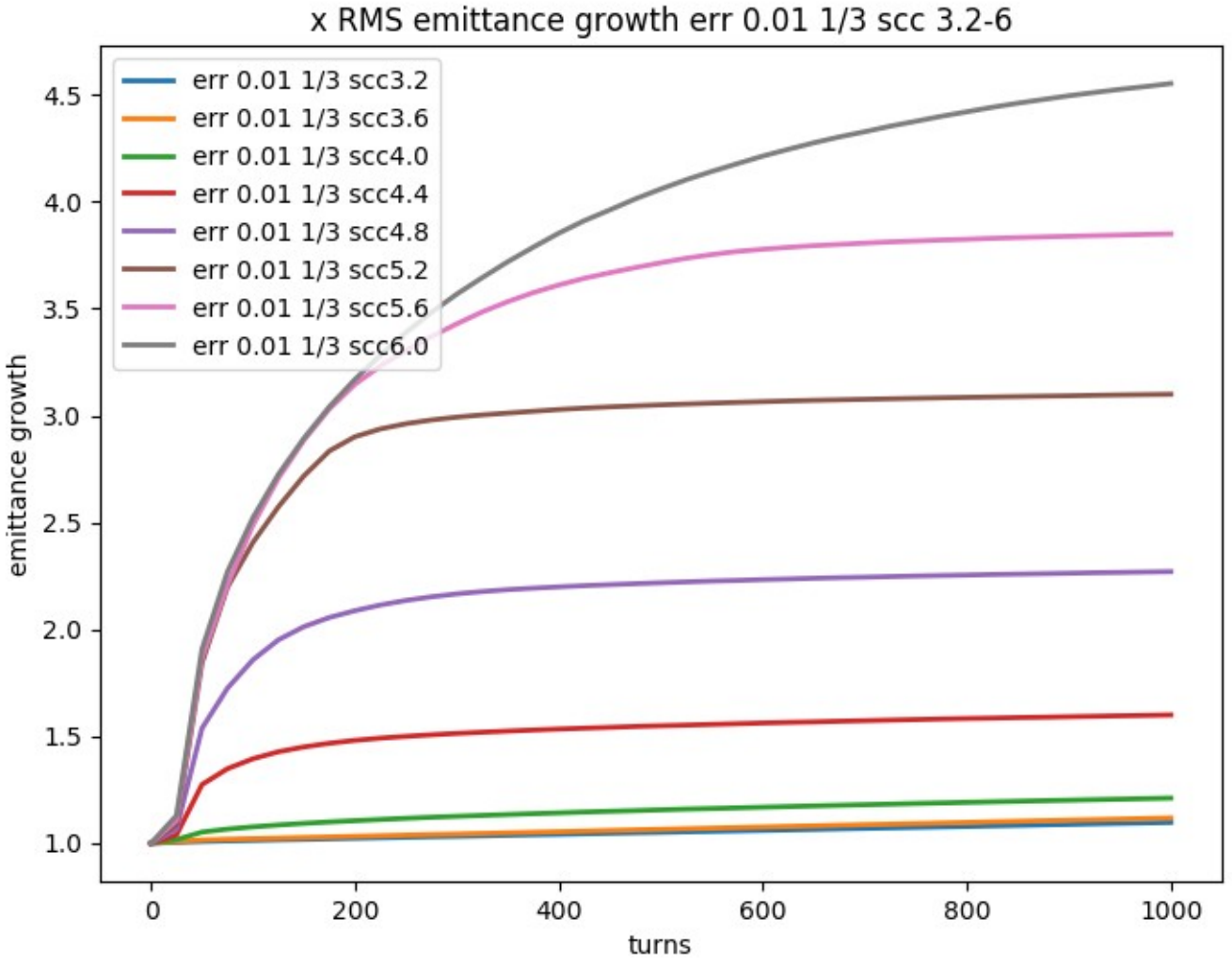
99.9% emittance with lattice error and 1/6 SC compensation summary

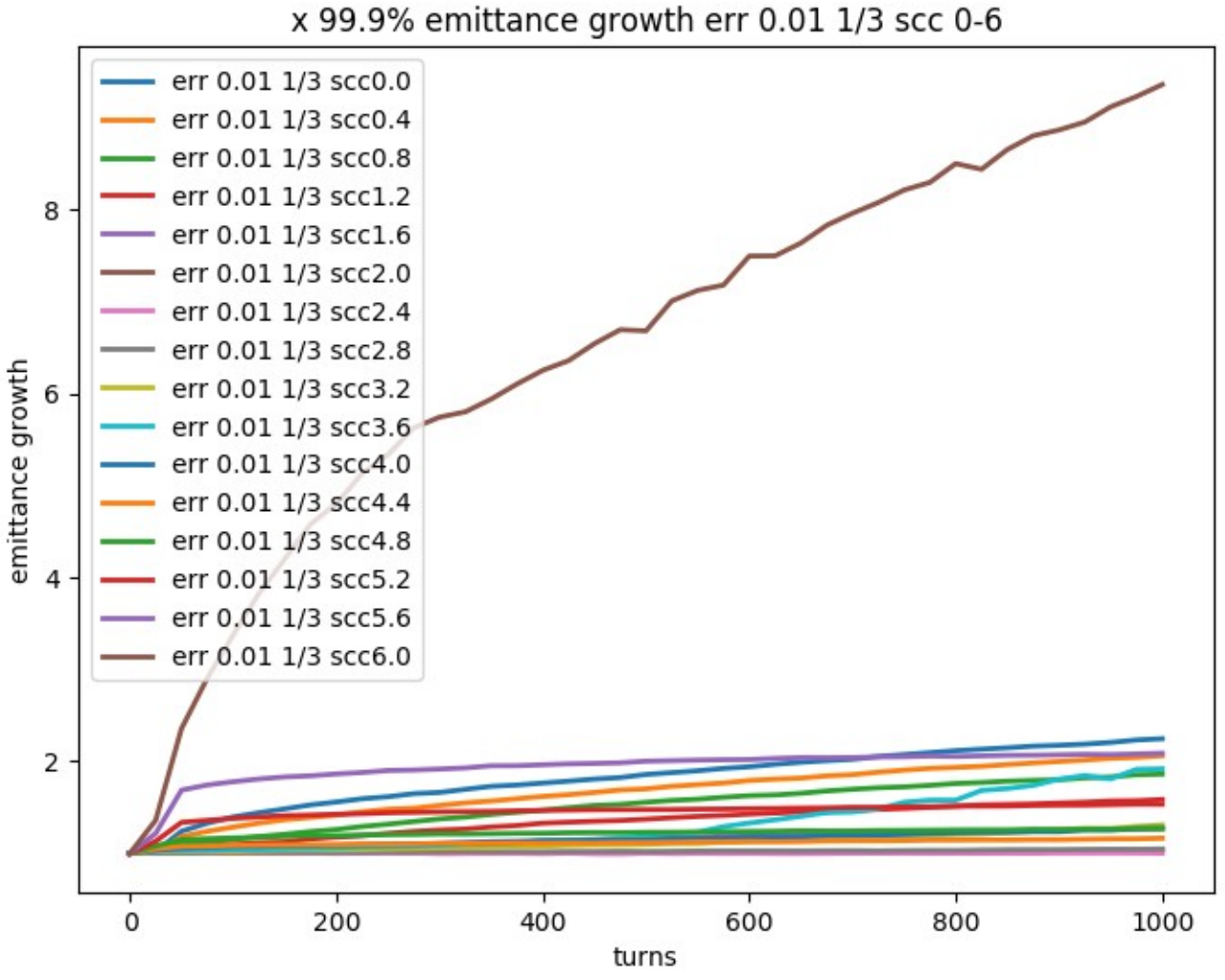
Lattice error	Optimal compensation factor	99.9% emittance growth	Uncompensated emittance growth
0	0		1.094
0.01	3.2	1.313	2.247
0.02	3.2	1.434	2.915
0.03	3.2	1.522	3.098

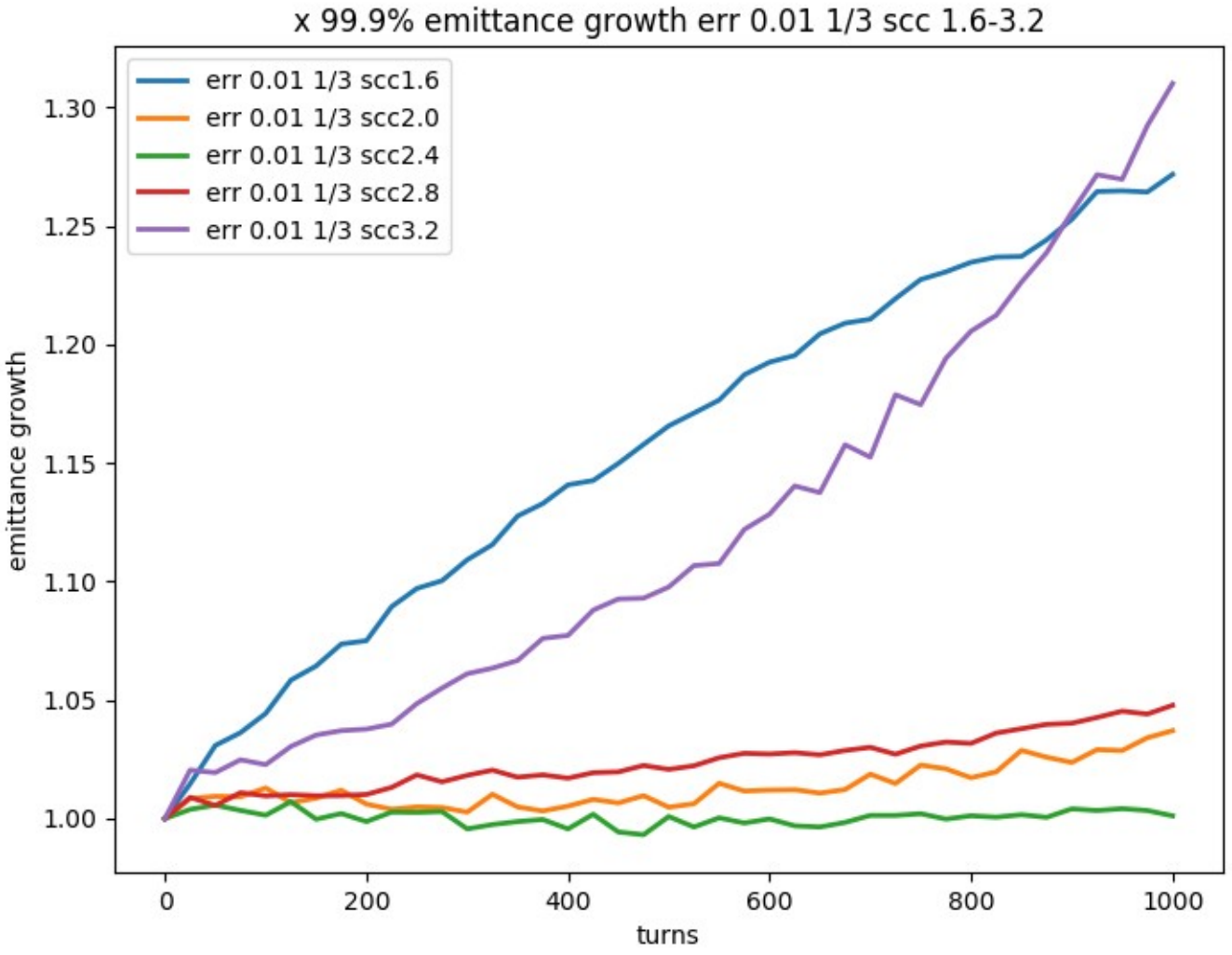
Next are results with 1/3 and 1/12 compensation locations.

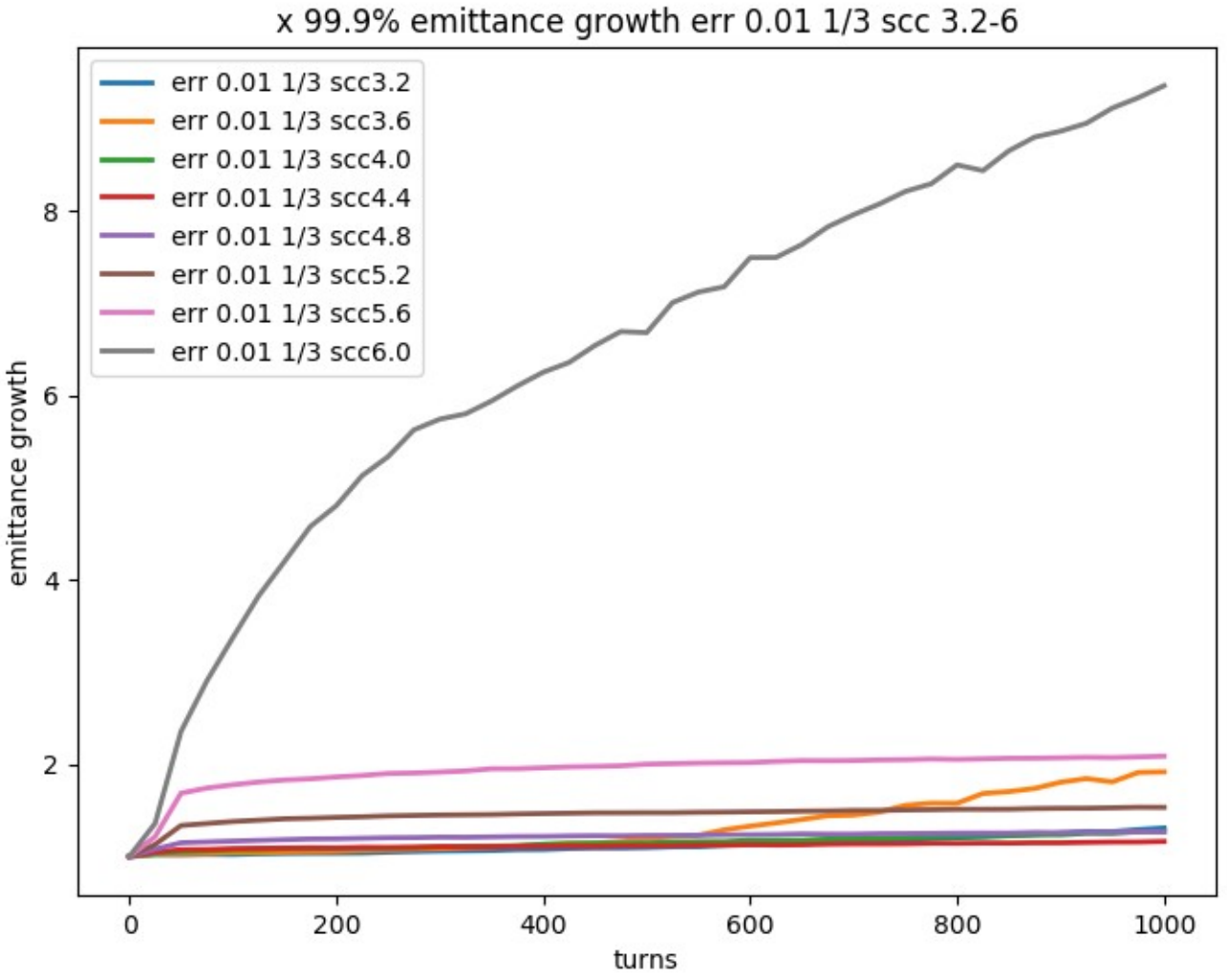

x RMS emittance growth err 0.01 1/3 scc 0-6
err 0.01 1/3 scc0.0
err 0.01 1/3 scc0.4
err 0.01 1/3 scc0.8
err 0.01 1/3 scc1.2
err 0.01 1/3 scc1.6
err 0.01 1/3 scc2.0
err 0.01 1/3 scc2.4
err 0.01 1/3 scc2.8
err 0.01 1/3 scc3.2
err 0.01 1/3 scc3.6
err 0.01 1/3 scc4.0
err 0.01 1/3 scc4.4
err 0.01 1/3 scc4.8
err 0.01 1/3 scc5.2
err 0.01 1/3 scc5.6
err 0.01 1/3 scc6.0
emittance growth
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0
200
400
600
800
1000
turns


x RMS emittance growth err 0.01 1/3 scc 1.6-3.2
err 0.01 1/3 scc1.6
err 0.01 1/3 scc2.0
err 0.01 1/3 scc2.4
err 0.01 1/3 scc2.8
err 0.01 1/3 scc3.2
emittance growth
1.25
1.20
1.15
1.10
1.05
1.00
0
200
400
600
800
1000
turns


x RMS emittance growth err 0.01 1/3 scc 3.2-6
err 0.01 1/3 scc3.2
err 0.01 1/3 scc3.6
err 0.01 1/3 scc4.0
err 0.01 1/3 scc4.4
err 0.01 1/3 scc4.8
err 0.01 1/3 scc5.2
err 0.01 1/3 scc5.6
err 0.01 1/3 scc6.0
emittance growth
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
0
200
400
600
800
1000
turns


x 99.9% emittance growth err 0.01 1/3 scc 0-6
err 0.01 1/3 scc0.0
err 0.01 1/3 scc0.4
err 0.01 1/3 scc0.8
err 0.01 1/3 scc1.2
err 0.01 1/3 scc1.6
err 0.01 1/3 scc2.0
err 0.01 1/3 scc2.4
err 0.01 1/3 scc2.8
err 0.01 1/3 scc3.2
err 0.01 1/3 scc3.6
err 0.01 1/3 scc4.0
err 0.01 1/3 scc4.4
err 0.01 1/3 scc4.8
err 0.01 1/3 scc5.2
err 0.01 1/3 scc5.6
err 0.01 1/3 scc6.0
emittance growth
2
4
6
8
0
200
400
600
800
1000
turns

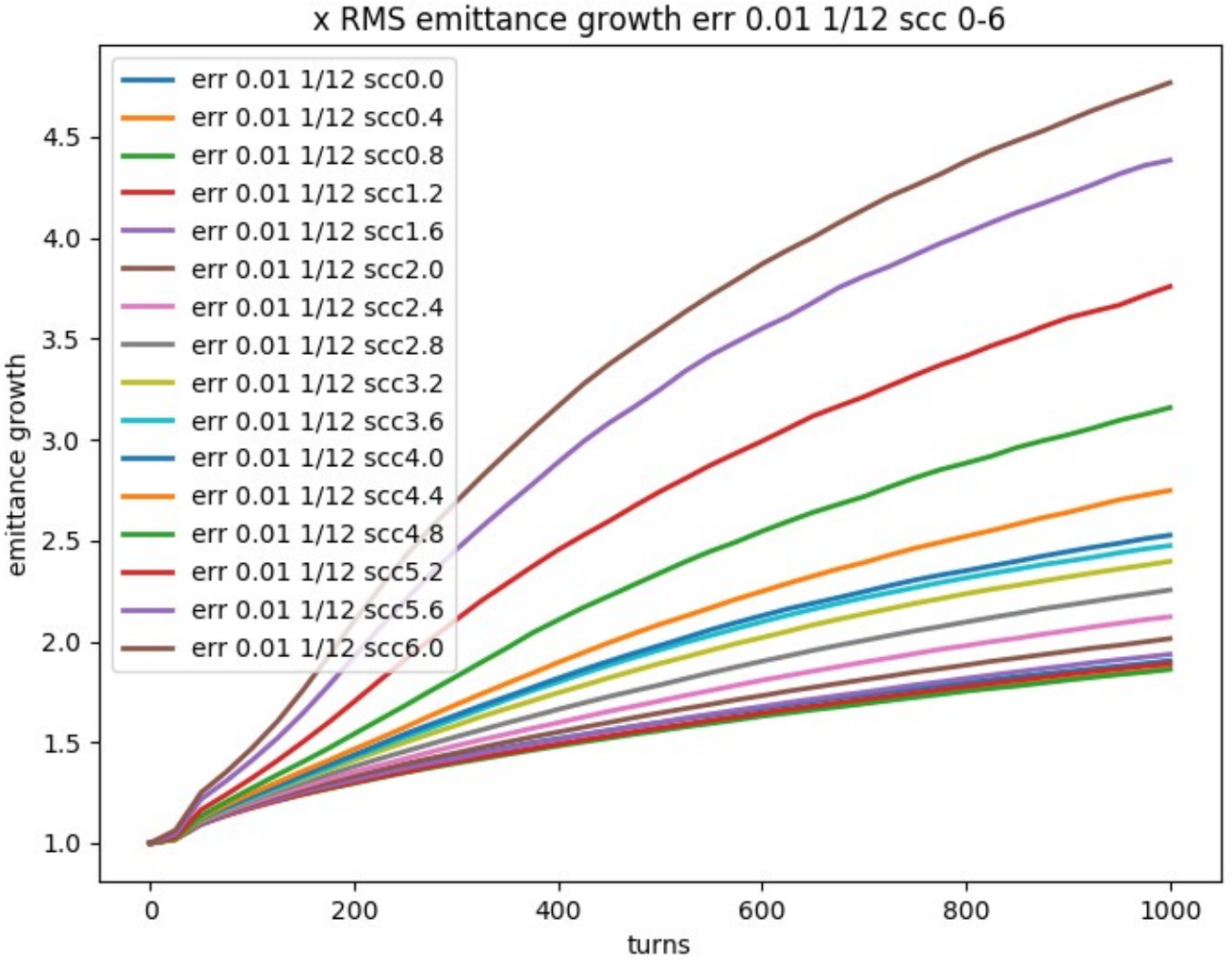

x 99.9% emittance growth err 0.01 1/3 scc 1.6-3.2
err 0.01 1/3 scc1.6
err 0.01 1/3 scc2.0
err 0.01 1/3 scc2.4
err 0.01 1/3 scc2.8
err 0.01 1/3 scc3.2
emittance growth
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0
200
400
600
800
1000
turns


x 99.9% emittance growth err 0.01 1/3 scc 3.2-6
err 0.01 1/3 scc3.2
err 0.01 1/3 scc3.6
err 0.01 1/3 scc4.0
err 0.01 1/3 scc4.4
err 0.01 1/3 scc4.8
err 0.01 1/3 scc5.2
err 0.01 1/3 scc5.6
err 0.01 1/3 scc6.0
emittance growth
2
4
6
8
0
200
400
600
800
1000
turns

1% lattice error, SCC 1/3 locations

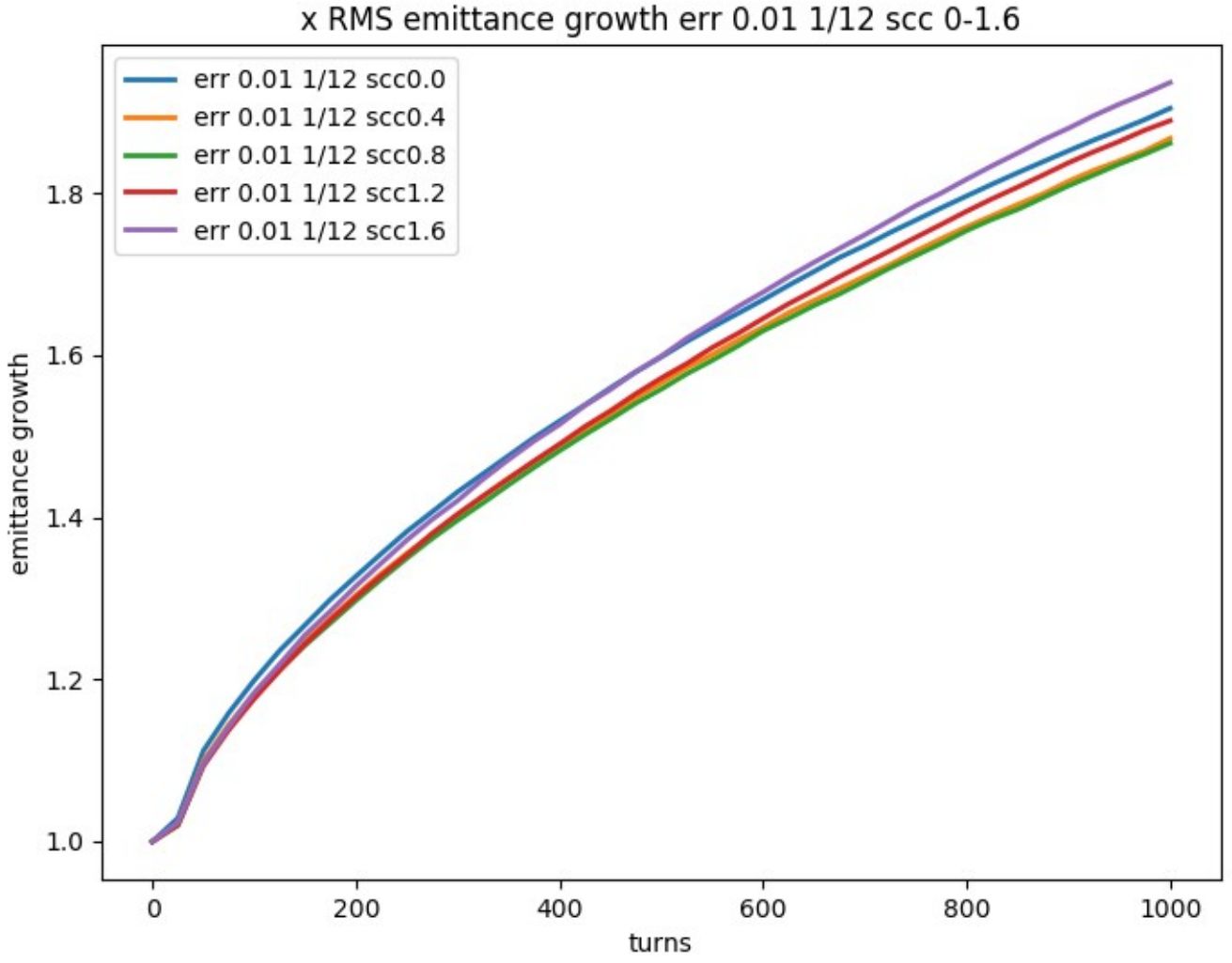
	Optimal compensation	emittance growth	Uncompensated emittance growth
X RMS emittance	2.8	1.065	1.904
X 99.9% emittance	2.4	1.001	2.247

With compensation at 2/6 space charge kicks (3 times/FODO cell) emittance growth may be almost all compensated.

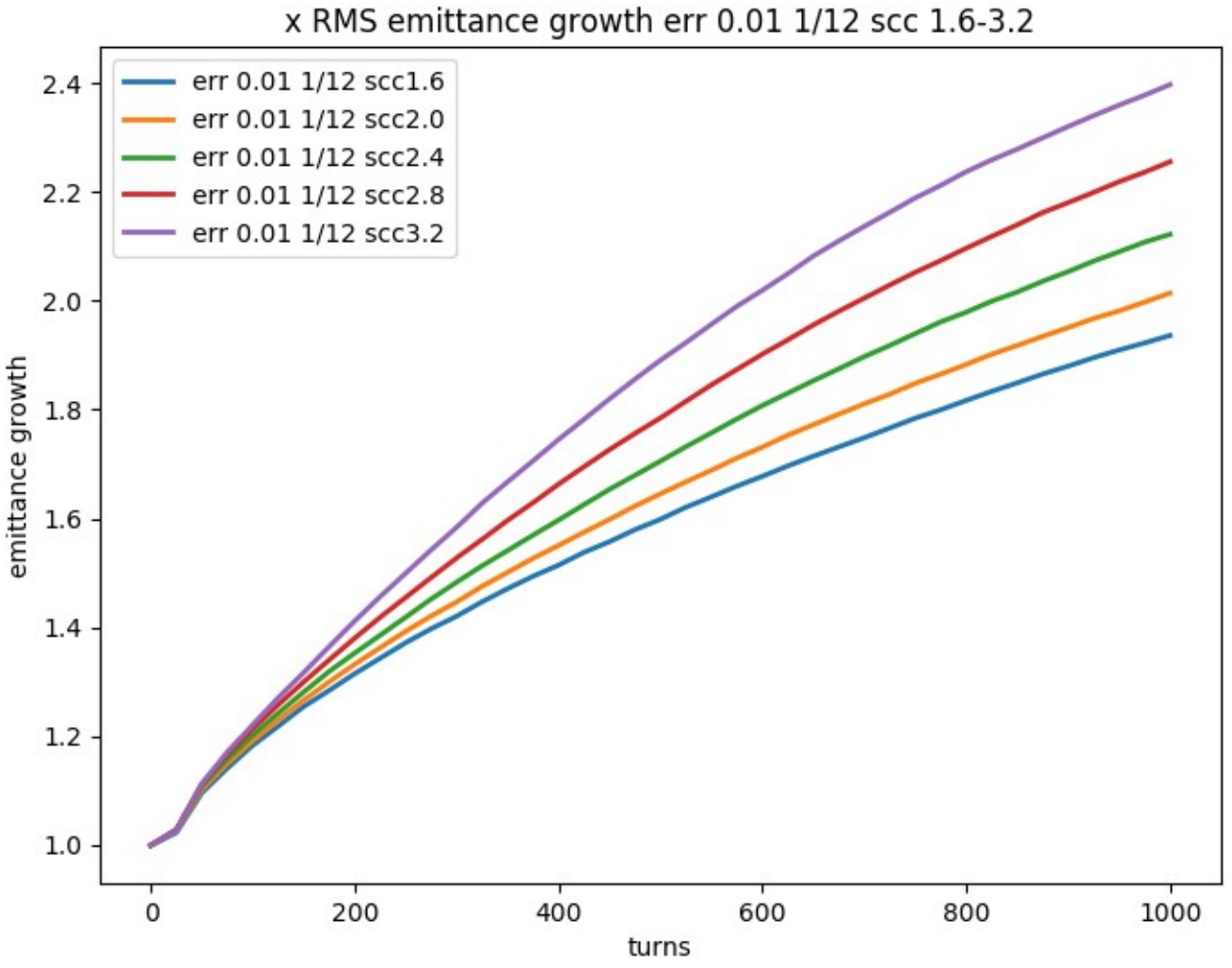


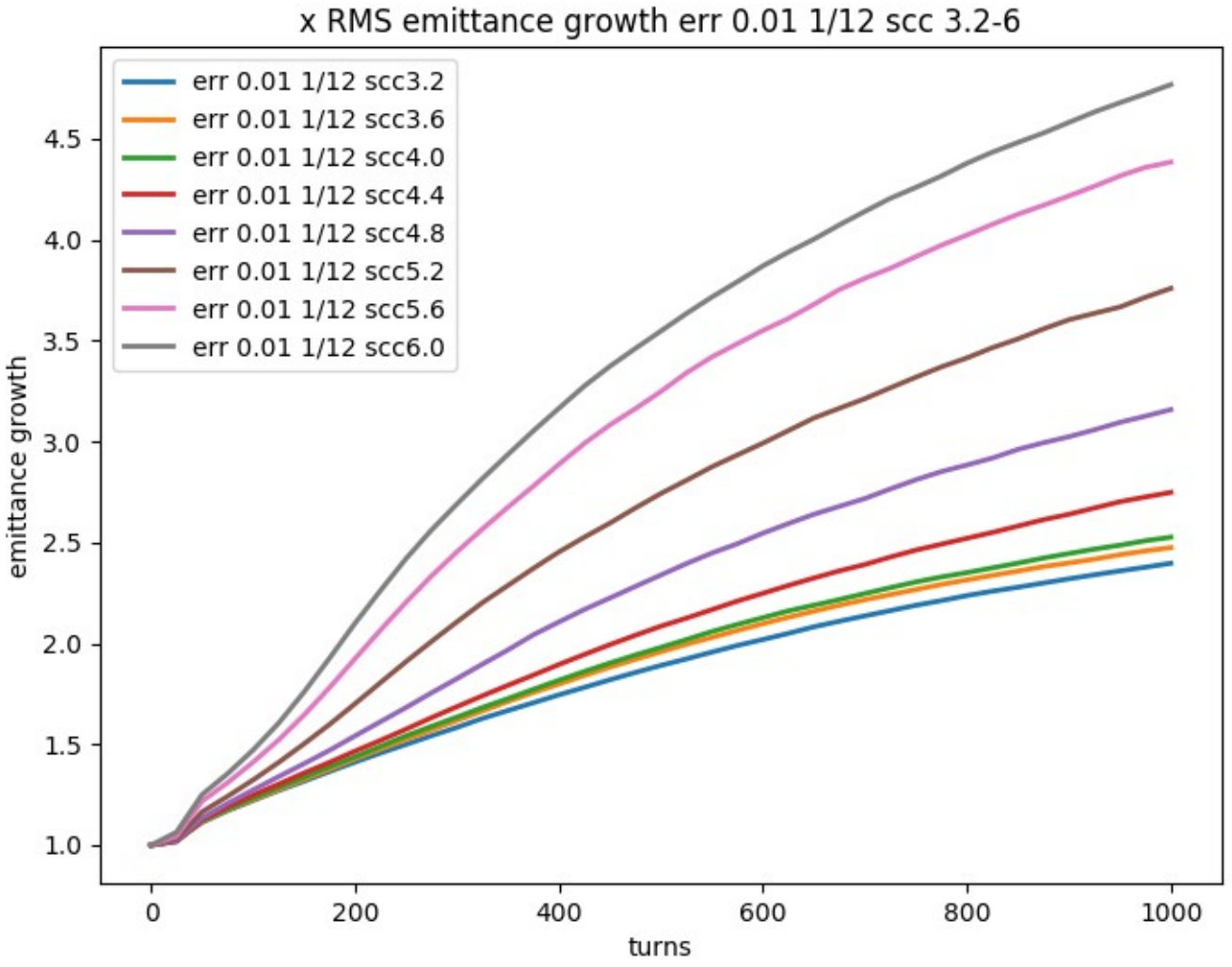
Compensation at 1/12 SC locations

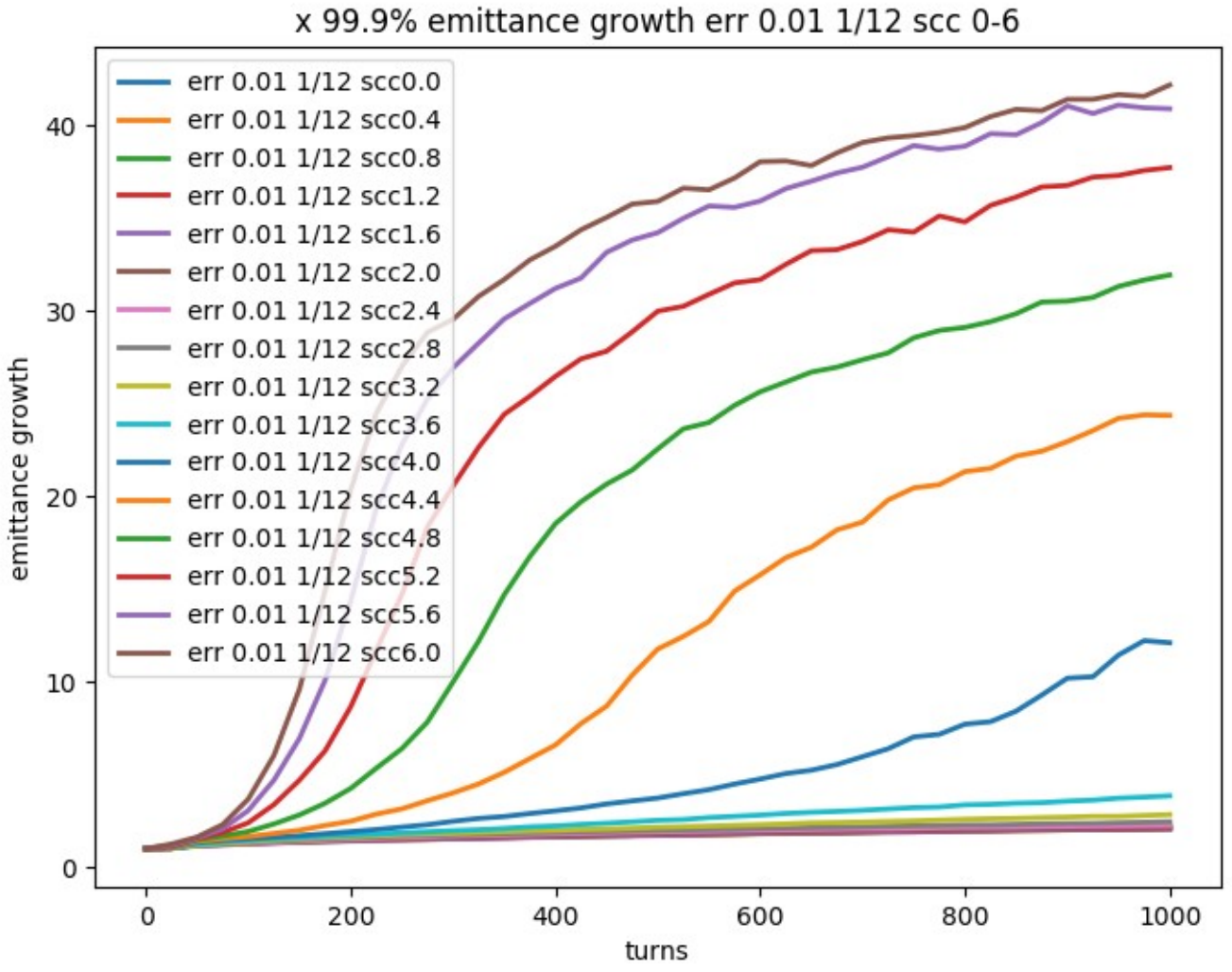
1% error

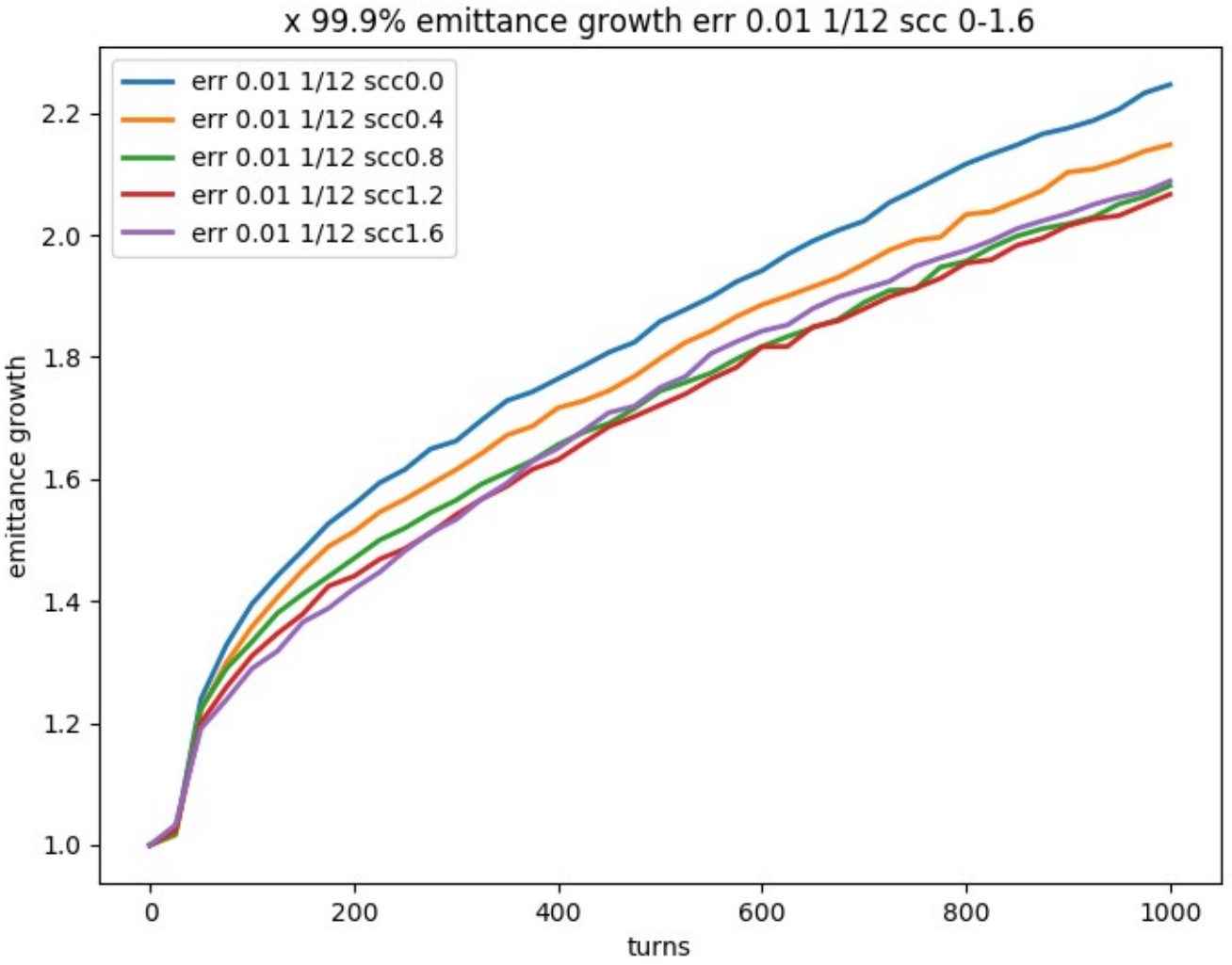


Optimal compensation at 0.8 which reduces emittance growth to 1.861 (uncompensated is 1.904).

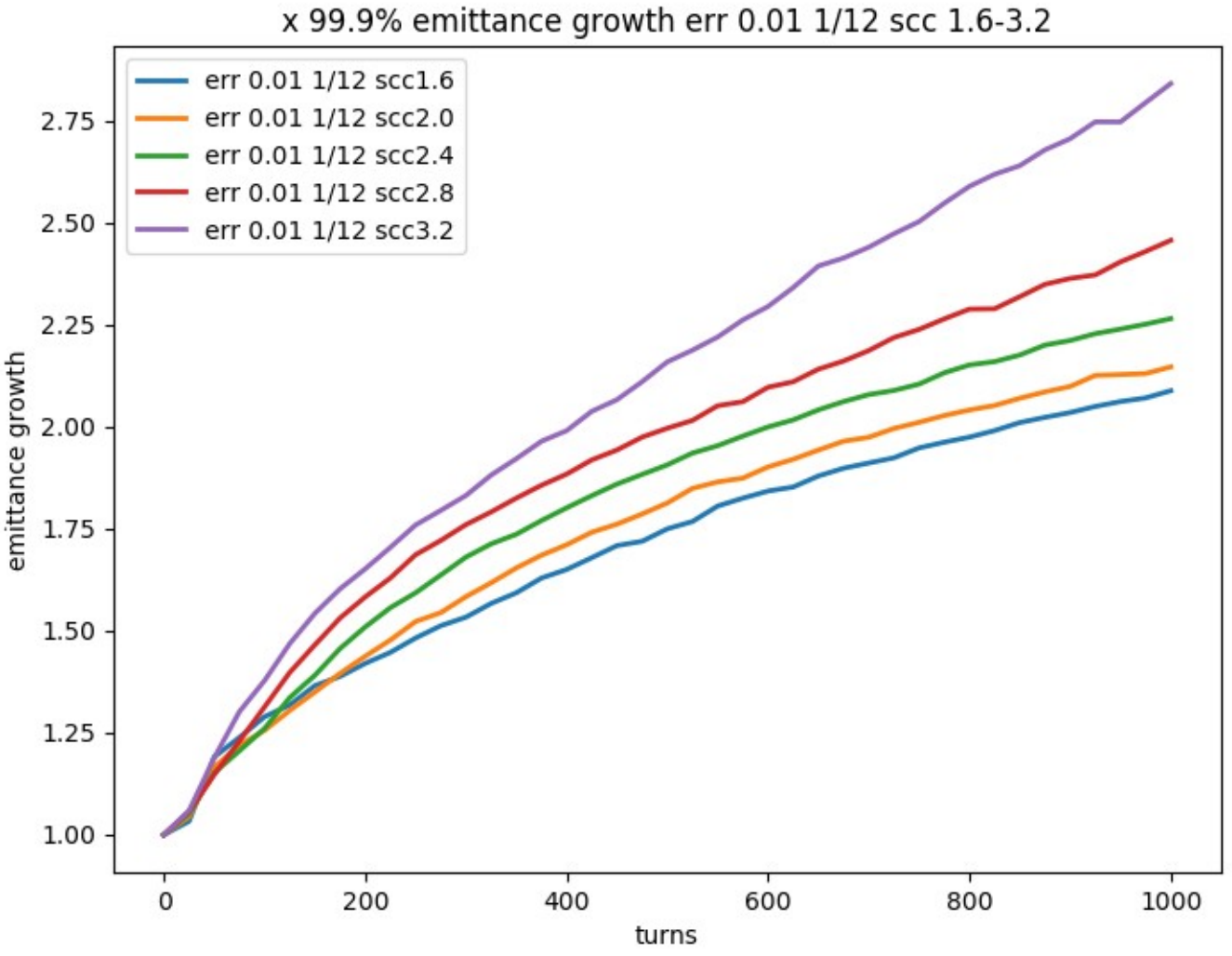

x RMS emittance growth err 0.01 1/12 scc 1.6-3.2
err 0.01 1/12 scc1.6
err 0.01 1/12 scc2.0
err 0.01 1/12 scc2.4
err 0.01 1/12 scc2.8
err 0.01 1/12 scc3.2
emittance growth
turns
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
0
200
400
600
800
1000

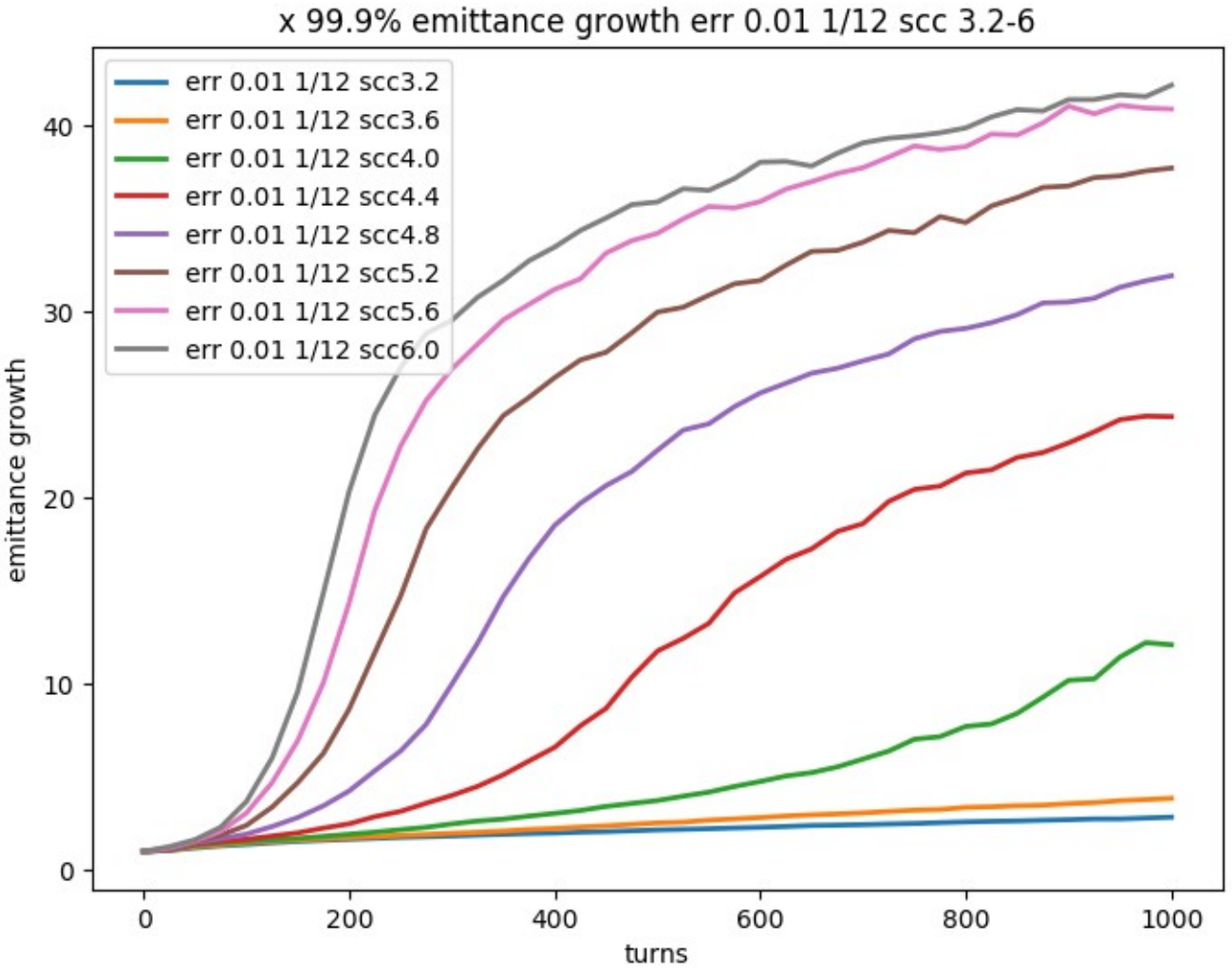

x RMS emittance growth err 0.01 1/12 scc 3.2-6
err 0.01 1/12 scc3.2
err 0.01 1/12 scc3.6
err 0.01 1/12 scc4.0
err 0.01 1/12 scc4.4
err 0.01 1/12 scc4.8
err 0.01 1/12 scc5.2
err 0.01 1/12 scc5.6
err 0.01 1/12 scc6.0
emittance growth
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
0
200
400
600
800
1000
turns

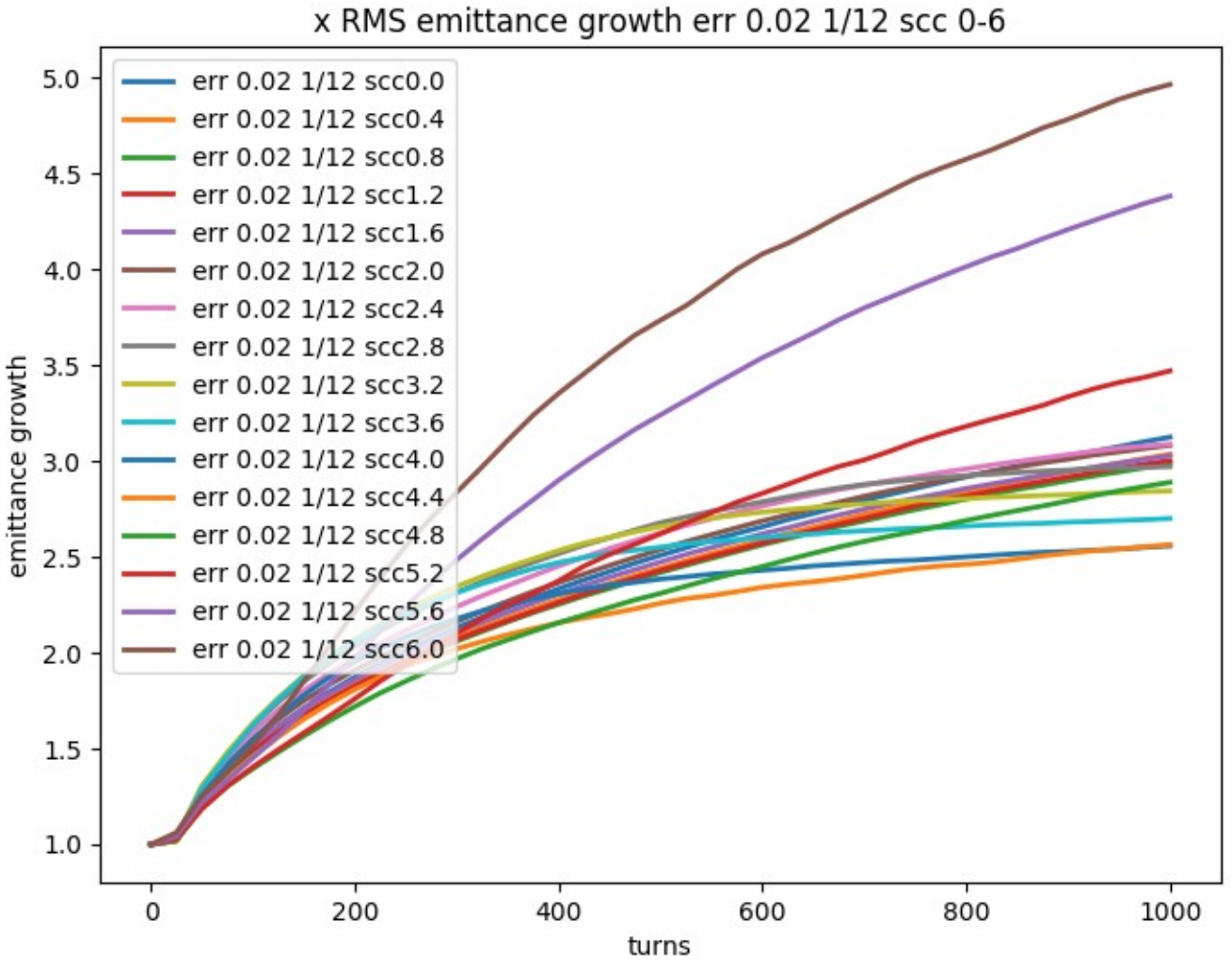

x 99.9% emittance growth err 0.01 1/12 scc 0-6
err 0.01 1/12 scc0.0
err 0.01 1/12 scc0.4
err 0.01 1/12 scc0.8
err 0.01 1/12 scc1.2
err 0.01 1/12 scc1.6
err 0.01 1/12 scc2.0
err 0.01 1/12 scc2.4
err 0.01 1/12 scc2.8
err 0.01 1/12 scc3.2
err 0.01 1/12 scc3.6
err 0.01 1/12 scc4.0
err 0.01 1/12 scc4.4
err 0.01 1/12 scc4.8
err 0.01 1/12 scc5.2
err 0.01 1/12 scc5.6
err 0.01 1/12 scc6.0
emittance growth
0
10
20
30
40
0
200
400
600
800
1000
turns

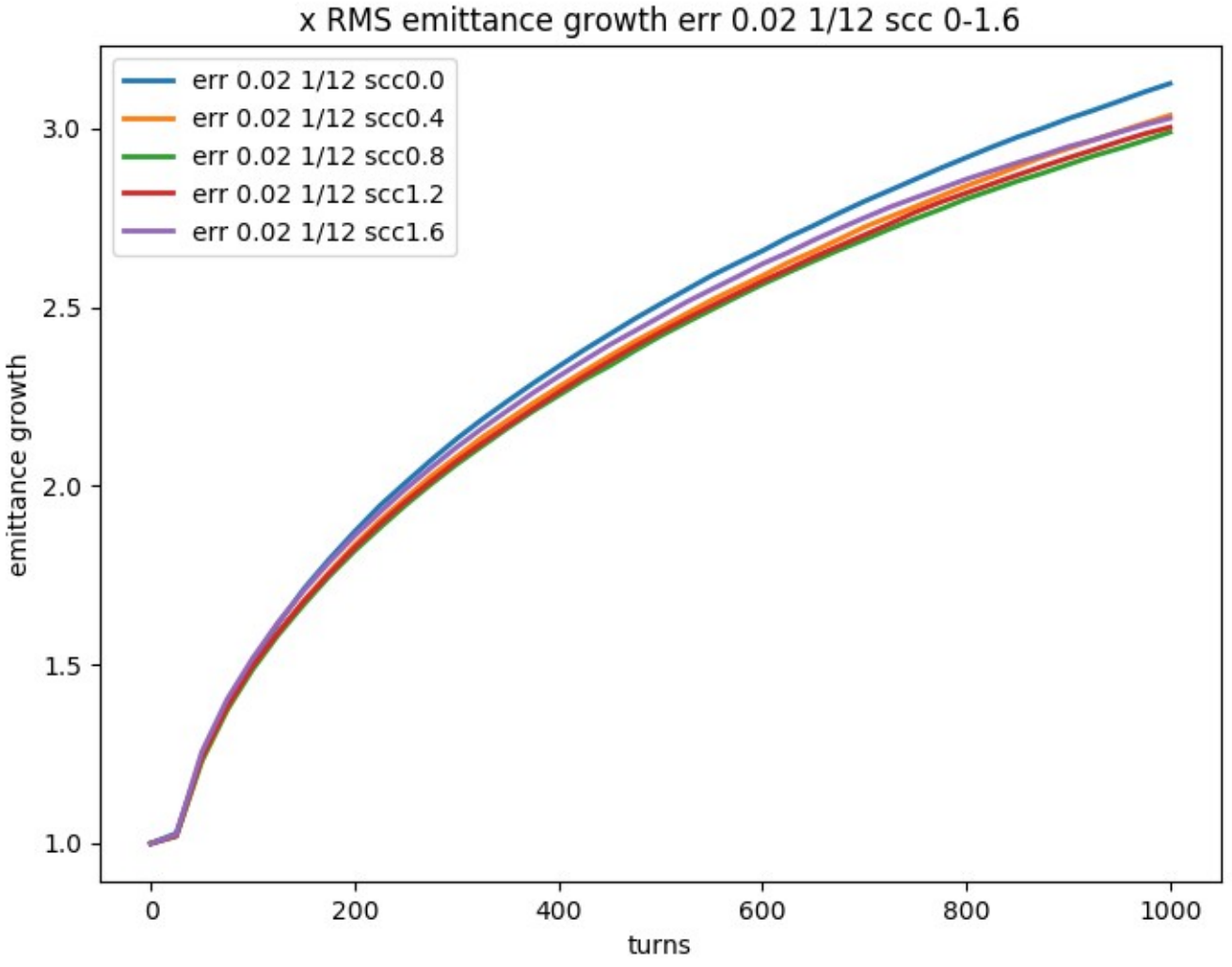


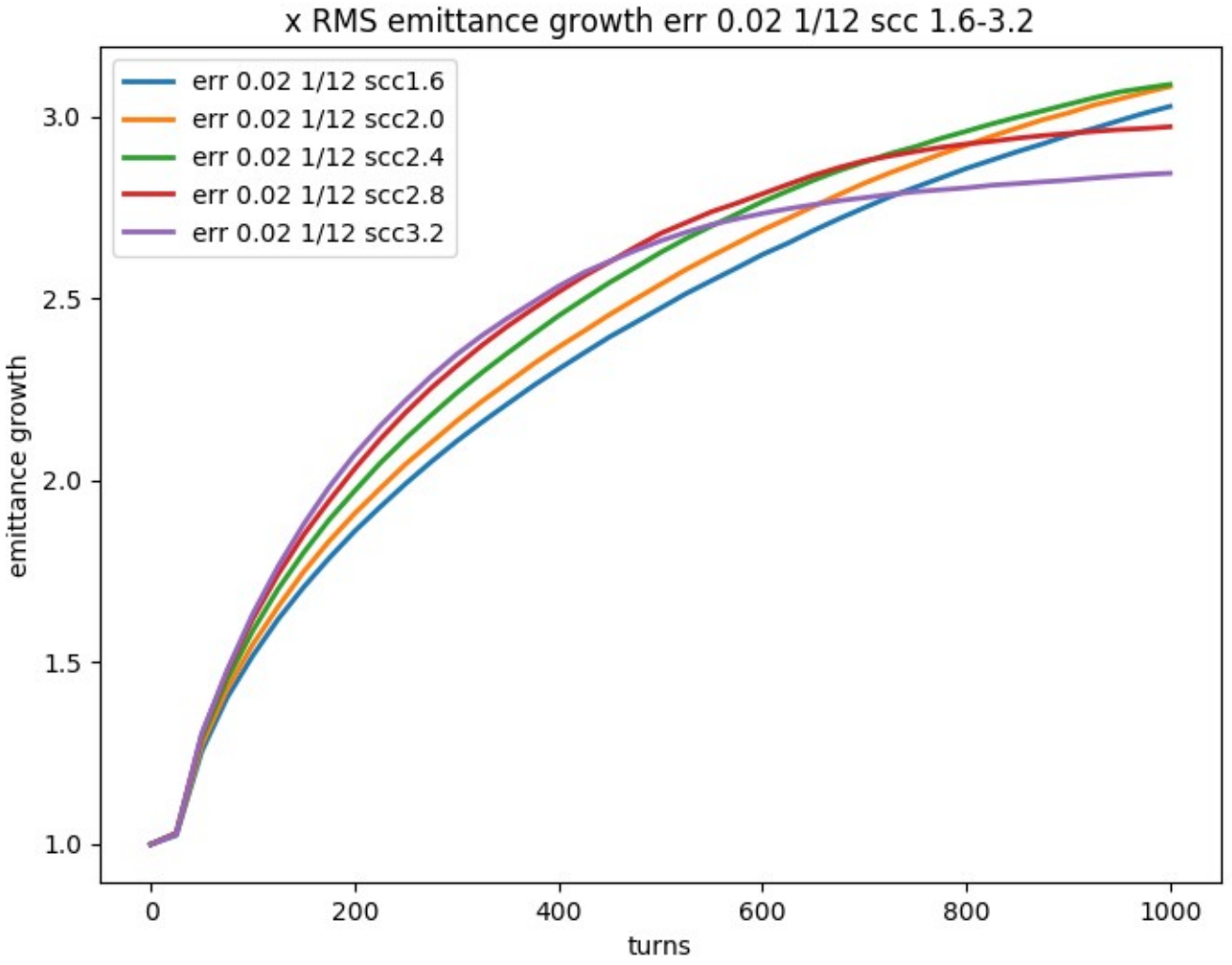
Optimal compensation for 99.9% emittance is 1.2

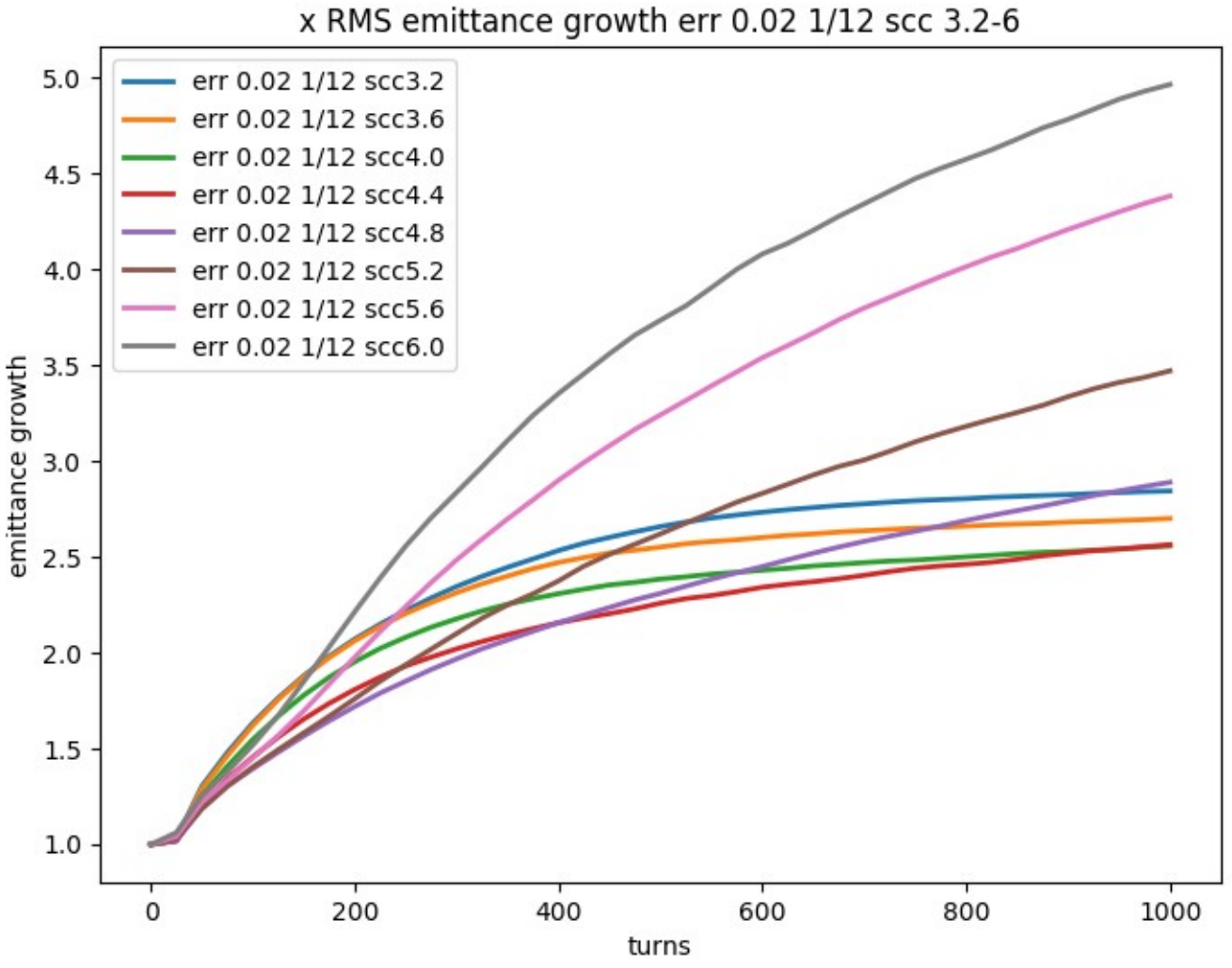

x 99.9% emittance growth err 0.01 1/12 scc 1.6-3.2
err 0.01 1/12 scc1.6
err 0.01 1/12 scc2.0
err 0.01 1/12 scc2.4
err 0.01 1/12 scc2.8
err 0.01 1/12 scc3.2
emittance growth
turns
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
0
200
400
600
800
1000

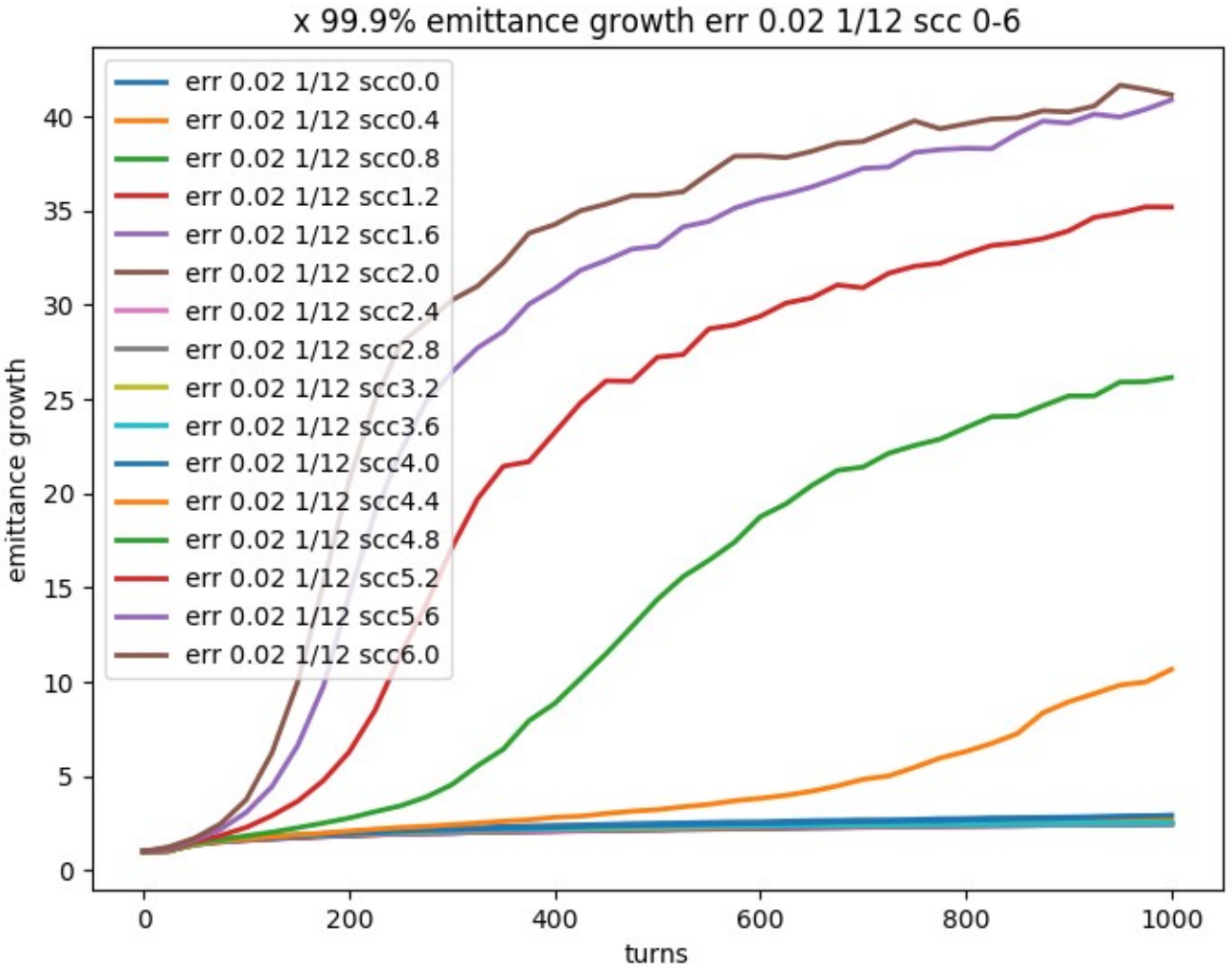

x 99.9% emittance growth err 0.01 1/12 scc 3.2-6
err 0.01 1/12 scc3.2
err 0.01 1/12 scc3.6
err 0.01 1/12 scc4.0
err 0.01 1/12 scc4.4
err 0.01 1/12 scc4.8
err 0.01 1/12 scc5.2
err 0.01 1/12 scc5.6
err 0.01 1/12 scc6.0
emittance growth
0
10
20
30
40
0
200
400
600
800
1000
turns

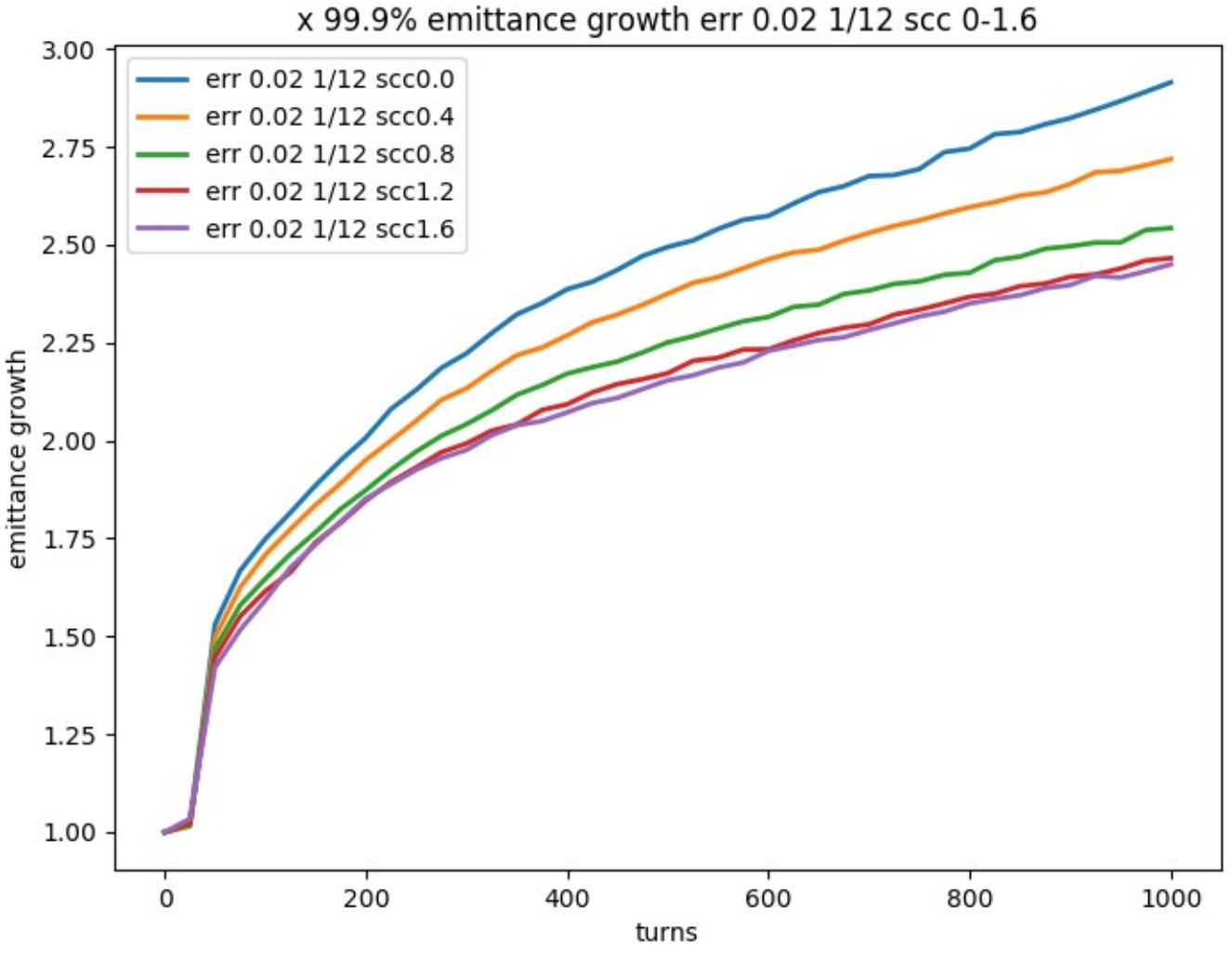

x RMS emittance growth err 0.02 1/12 scc 0-6
err 0.02 1/12 scc0.0
err 0.02 1/12 scc0.4
err 0.02 1/12 scc0.8
err 0.02 1/12 scc1.2
err 0.02 1/12 scc1.6
err 0.02 1/12 scc2.0
err 0.02 1/12 scc2.4
err 0.02 1/12 scc2.8
err 0.02 1/12 scc3.2
err 0.02 1/12 scc3.6
err 0.02 1/12 scc4.0
err 0.02 1/12 scc4.4
err 0.02 1/12 scc4.8
err 0.02 1/12 scc5.2
err 0.02 1/12 scc5.6
err 0.02 1/12 scc6.0
emittance growth
turns
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0
200
400
600
800
1000

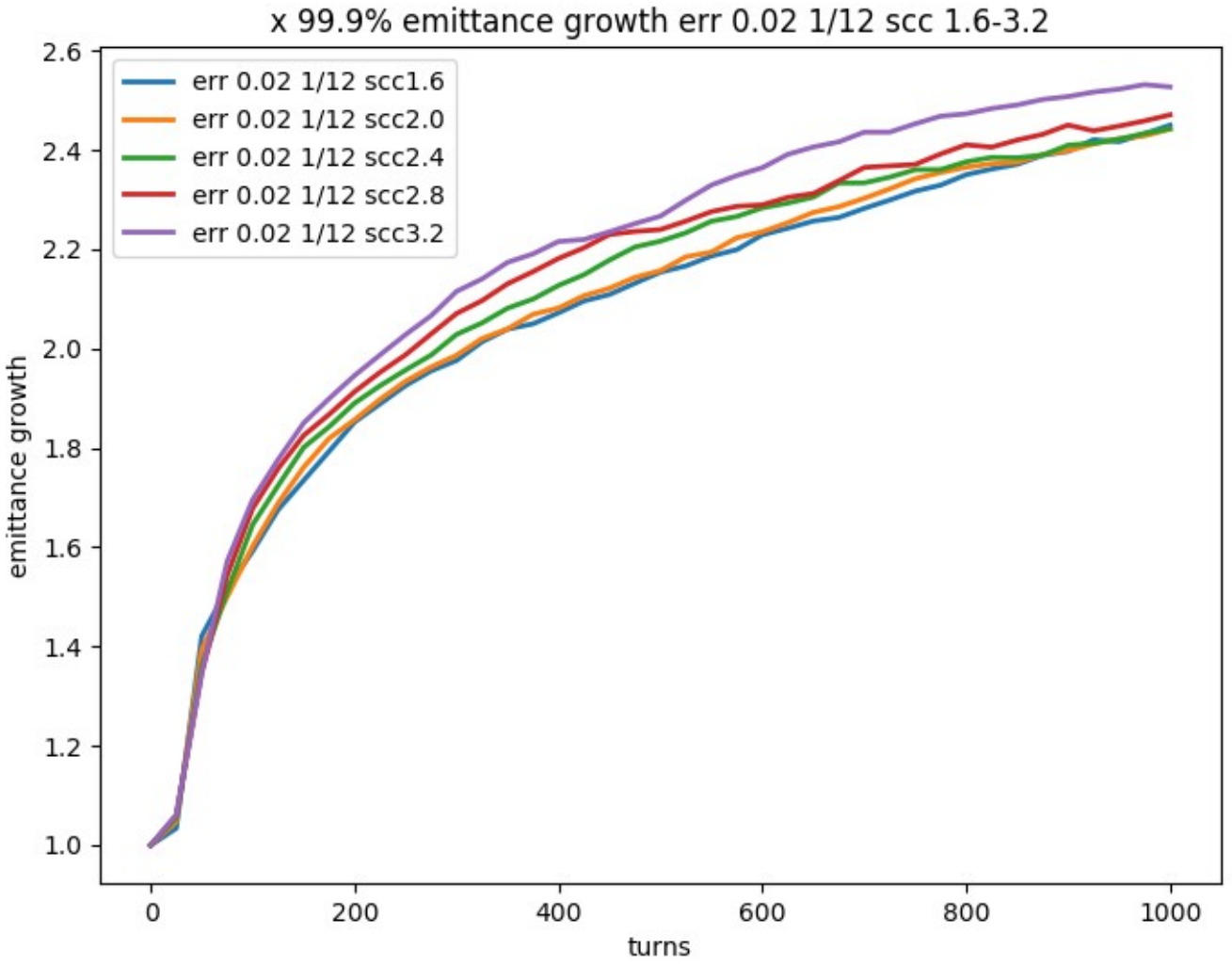

x RMS emittance growth err 0.02 1/12 scc 0-1.6
err 0.02 1/12 scc0.0
err 0.02 1/12 scc0.4
err 0.02 1/12 scc0.8
err 0.02 1/12 scc1.2
err 0.02 1/12 scc1.6
emittance growth
turns
1.0
1.5
2.0
2.5
3.0
0
200
400
600
800
1000

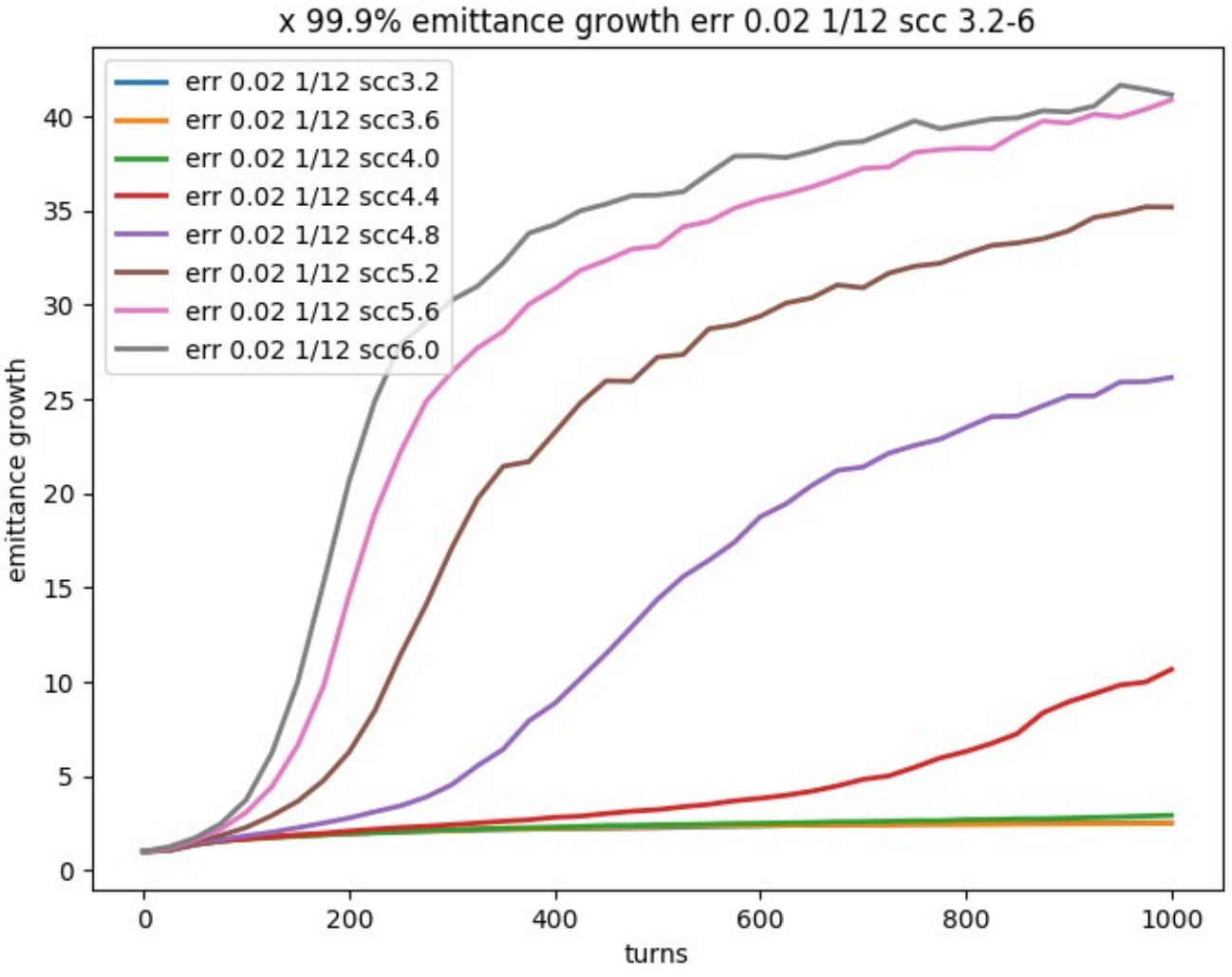

x RMS emittance growth err 0.02 1/12 scc 1.6-3.2
err 0.02 1/12 scc1.6
err 0.02 1/12 scc2.0
err 0.02 1/12 scc2.4
err 0.02 1/12 scc2.8
err 0.02 1/12 scc3.2
emittance growth
1.0
1.5
2.0
2.5
3.0
0
200
400
600
800
1000
turns


x RMS emittance growth err 0.02 1/12 scc 3.2-6
err 0.02 1/12 scc3.2
err 0.02 1/12 scc3.6
err 0.02 1/12 scc4.0
err 0.02 1/12 scc4.4
err 0.02 1/12 scc4.8
err 0.02 1/12 scc5.2
err 0.02 1/12 scc5.6
err 0.02 1/12 scc6.0
emittance growth
turns
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
0
200
400
600
800
1000


x 99.9% emittance growth err 0.02 1/12 scc 0-6
err 0.02 1/12 scc0.0
err 0.02 1/12 scc0.4
err 0.02 1/12 scc0.8
err 0.02 1/12 scc1.2
err 0.02 1/12 scc1.6
err 0.02 1/12 scc2.0
err 0.02 1/12 scc2.4
err 0.02 1/12 scc2.8
err 0.02 1/12 scc3.2
err 0.02 1/12 scc3.6
err 0.02 1/12 scc4.0
err 0.02 1/12 scc4.4
err 0.02 1/12 scc4.8
err 0.02 1/12 scc5.2
err 0.02 1/12 scc5.6
err 0.02 1/12 scc6.0
emittance growth
0
5
10
15
20
25
30
35
40
0
200
400
600
800
1000
turns


x 99.9% emittance growth err 0.02 1/12 scc 0-1.6
err 0.02 1/12 scc0.0
err 0.02 1/12 scc0.4
err 0.02 1/12 scc0.8
err 0.02 1/12 scc1.2
err 0.02 1/12 scc1.6
emittance growth
turns
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0
200
400
600
800
1000


x 99.9% emittance growth err 0.02 1/12 scc 1.6-3.2
err 0.02 1/12 scc1.6
err 0.02 1/12 scc2.0
err 0.02 1/12 scc2.4
err 0.02 1/12 scc2.8
err 0.02 1/12 scc3.2
emittance growth
turns
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0
200
400
600
800
1000


x 99.9% emittance growth err 0.02 1/12 scc 3.2-6
err 0.02 1/12 scc3.2
err 0.02 1/12 scc3.6
err 0.02 1/12 scc4.0
err 0.02 1/12 scc4.4
err 0.02 1/12 scc4.8
err 0.02 1/12 scc5.2
err 0.02 1/12 scc5.6
err 0.02 1/12 scc6.0
emittance growth
0
5
10
15
20
25
30
35
40
0
200
400
600
800
1000
turns

SC compensation 1/12 locations RMS emittance growth summary

Lattice error	Optimal compensation factor	RMS emittance growth	Uncompensated emittance growth
0	0		1.169
0.01	0.8	1.861	1.904
0.02	0.8	2.990	3.126

The improvement in emittance growth is not great here

SC compensation 1/12 locations 99.9% emittance growth summary

Lattice error	Optimal compensation factor	RMS emittance growth	Uncompensated emittance growth
0	0		1.094
0.01	1.2	2.067	2.247
0.02	1.6	2.450	2.915

The improvement in emittance growth is not great here either