PRELIMINARY DESIGN STUDY of a Pre-Booster DAMPING RING for the FCC e^+e^- INJECTOR

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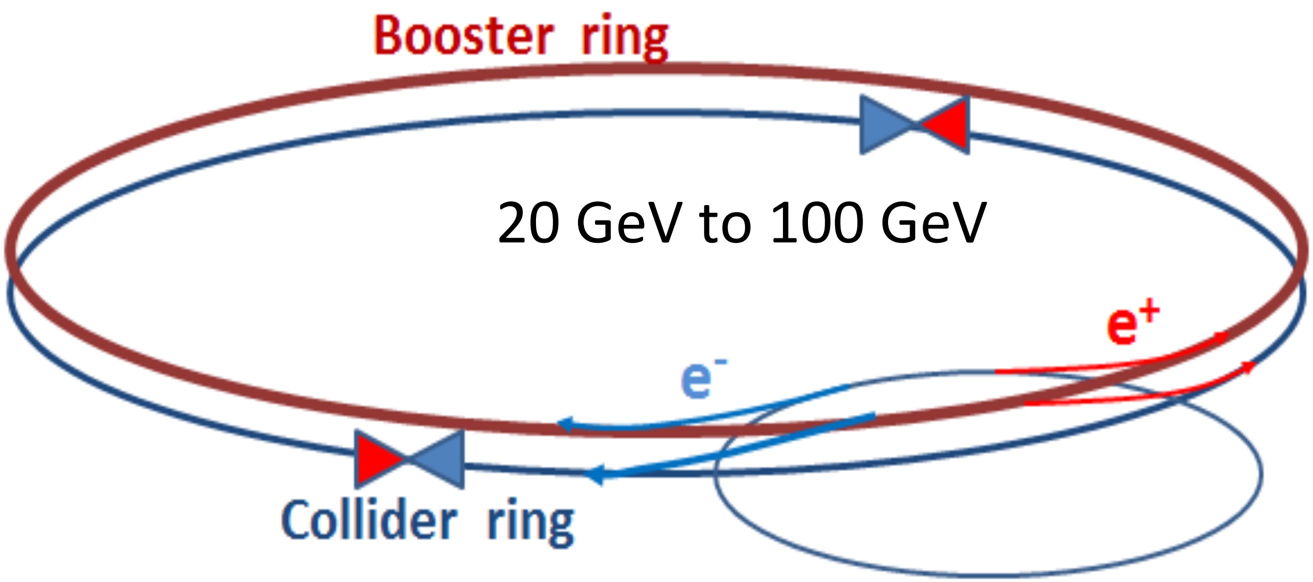
Outline

- Why an alternative Design?
- Parameter scaling
- Some Calculations for general design parameters
- Preliminary Lattice Design
- Future Plans

Alternative Damping Ring Synchrotron Design



- Linac,
- SPS as pre-booster,
- Alternative pre-booster design,
- Booster same tunnel with main ring,
- Collider ring.

around 10 Gev to 20 GeV

- Present design considers SPS as Pre-Booster Damping Ring (PPDR) but issues with:
  - machine availability, synchrotron radiation, new RF system…
- This is why a "green field" alternative design is interesting

Parameter space

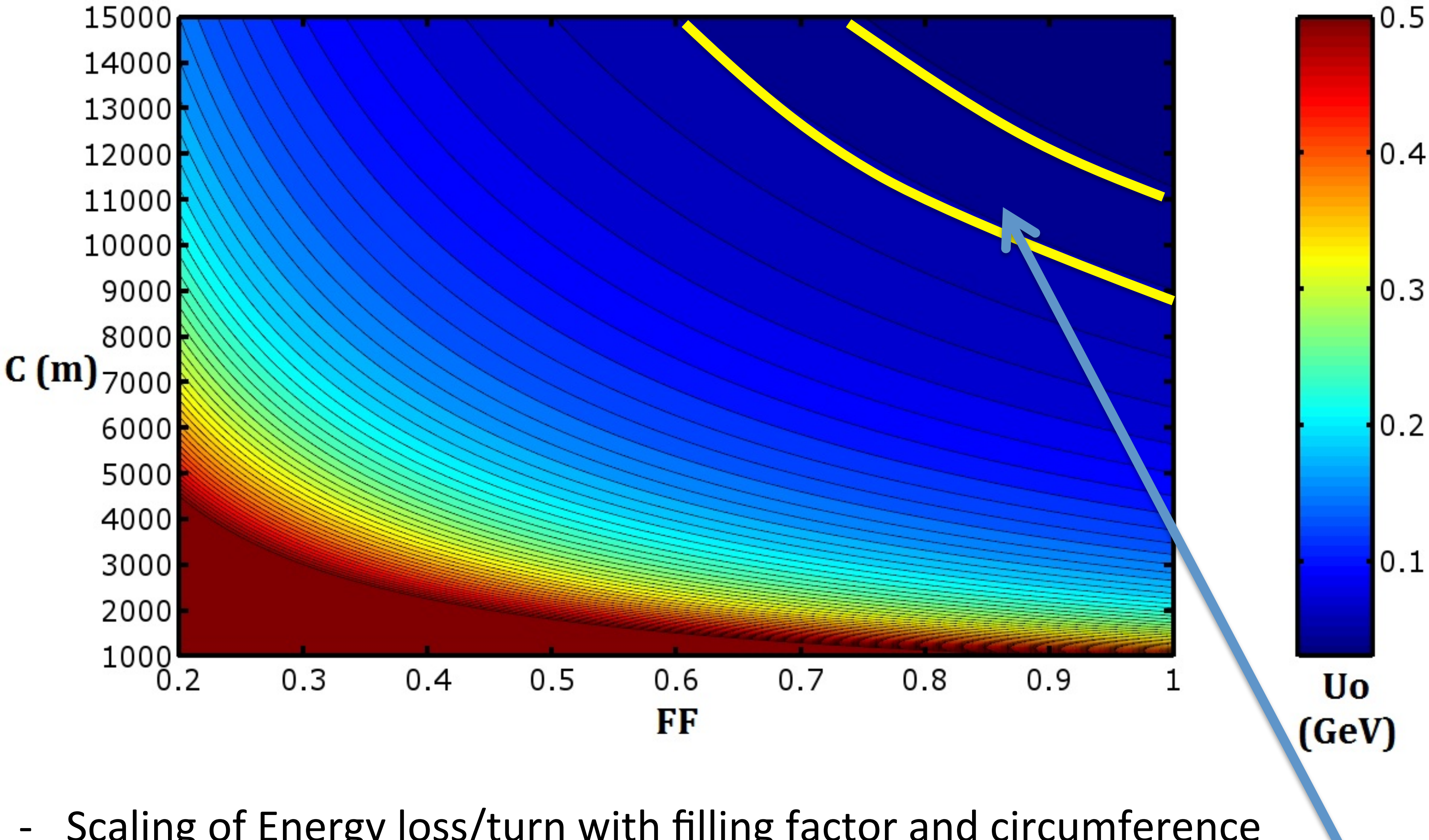
Scaling of important parameters impacting machine layout;

- Energy loss per turn → $$U_0 = \frac{2\pi . C_\gamma . E^4}{FF . C}$$
- Damping times → $$\alpha_s = \frac{E^3 . c . C_\gamma}{FF^2 . C^2}$$
- Energy spread → $$(\sigma_s)^2 = \frac{C_q . \gamma^2 . 2\pi}{FF . C}$$
- Emittance → $$\varepsilon_s = \frac{F_{lattice} . C_q . \gamma^2 . (2\pi)^3 . l^3}{FF^3 . C^3}$$

Filling Factor

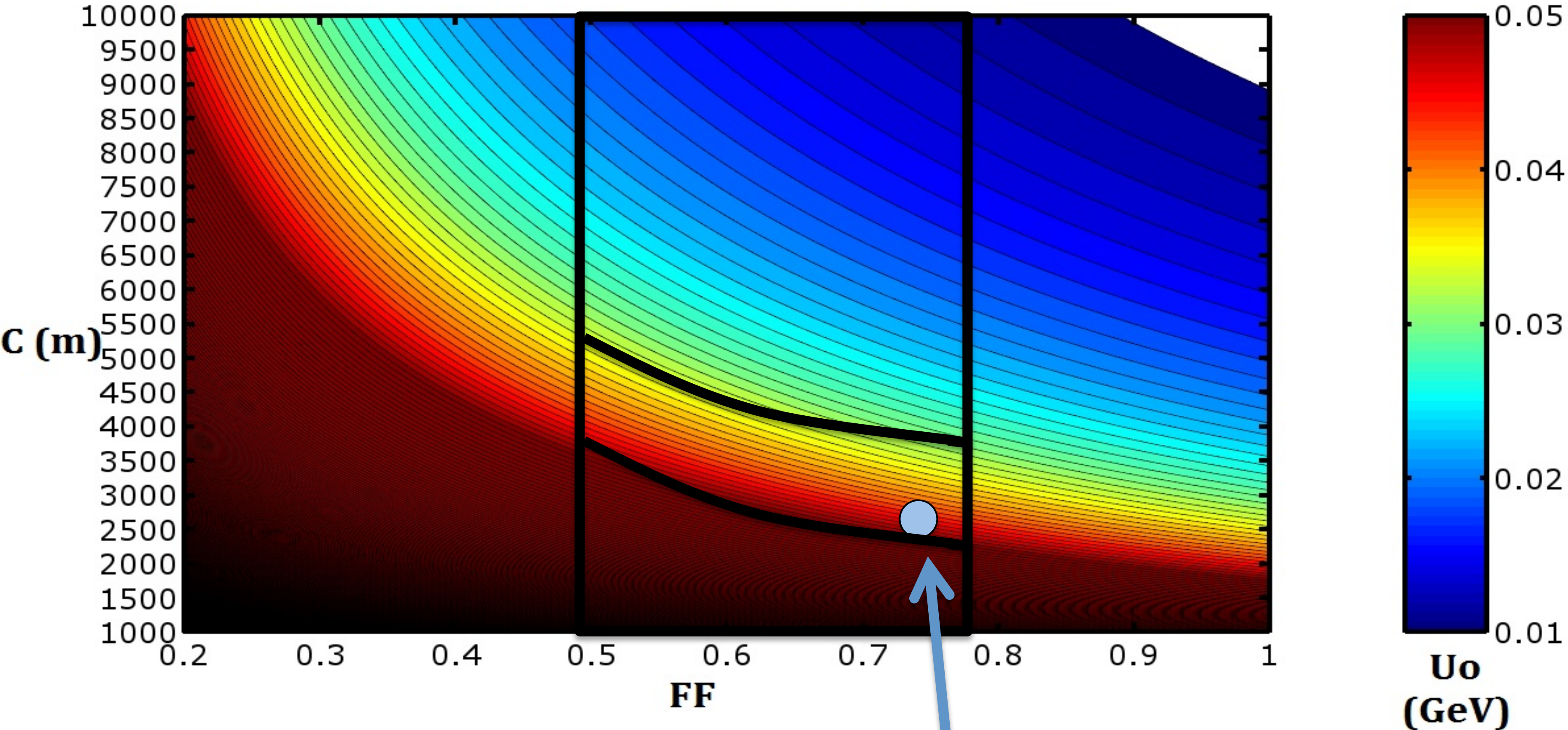
$$FF = \frac{N . l}{C}$$

Energy Loss Per Turn (30 GeV)



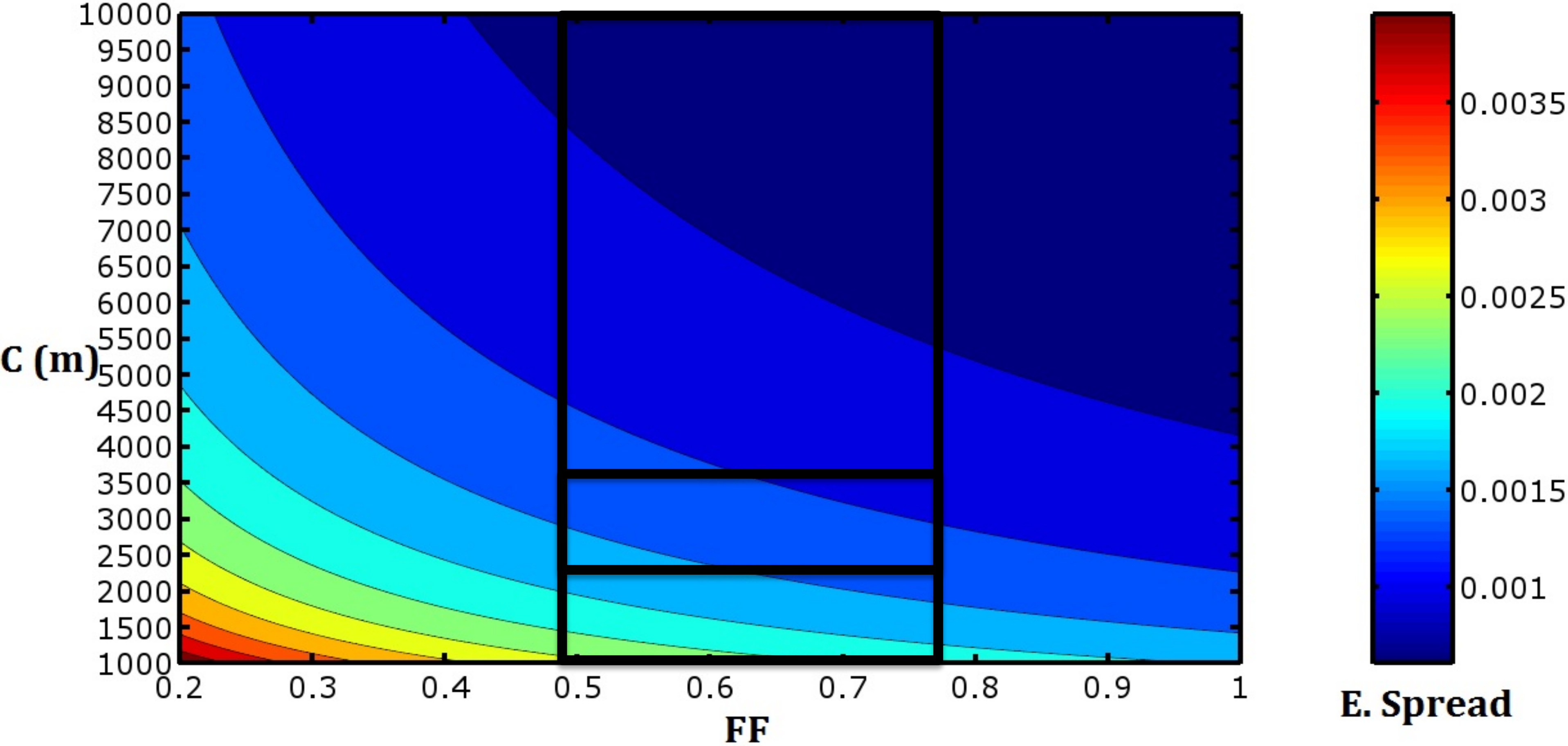
- Scaling of Energy loss/turn with filling factor and circumference
- For 30 GeV, the area below 50MeV/turn is for very high filling factors and circumferences

Energy Loss Per Turn (20 GeV)



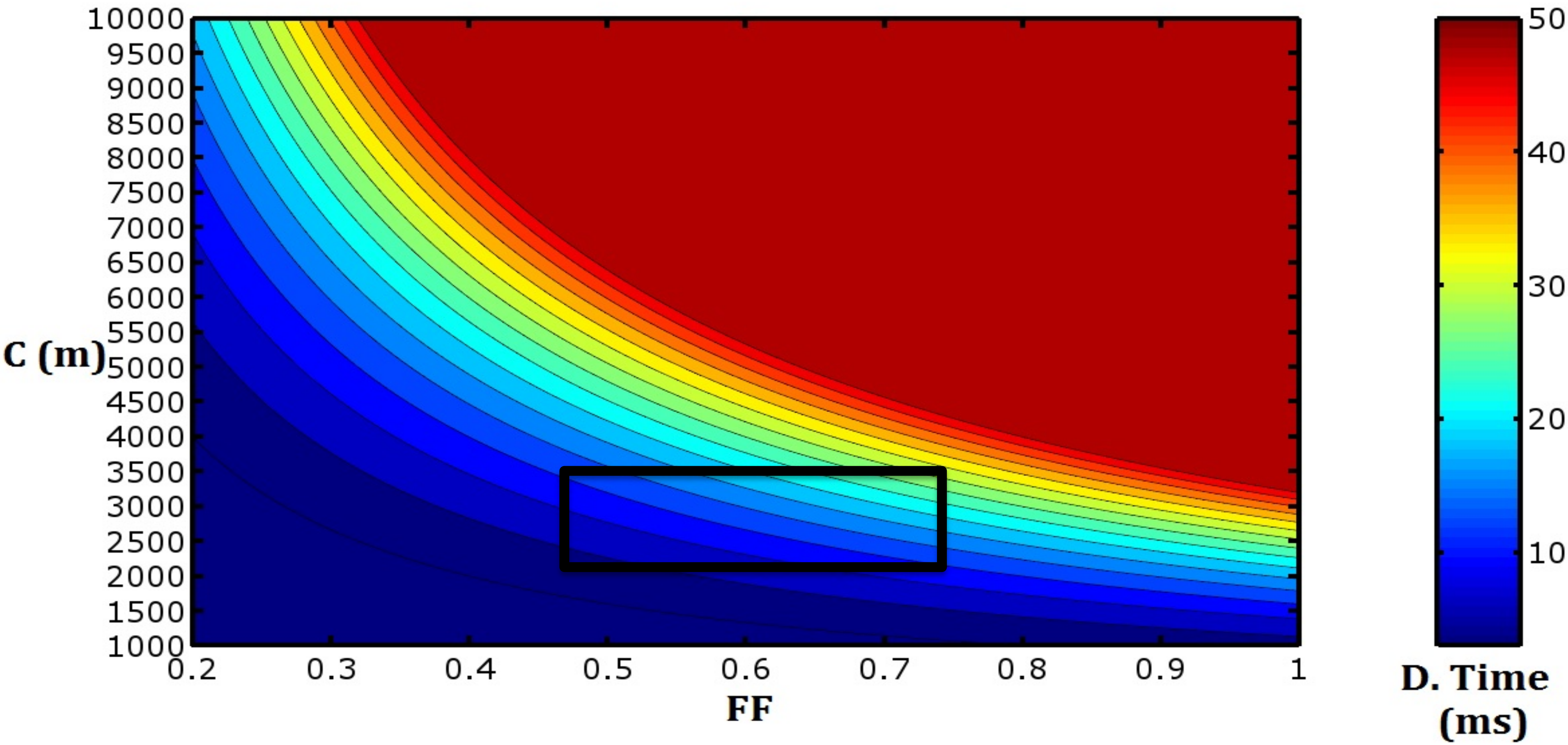
- Scaling of energy loss/turn with filling factor and circumference
- For 20 GeV, the area below 50MeV/turn is wide
- The lowest circumference of around 2.5km is for high filling factors of around 0.7

Energy Spread(20 GeV)



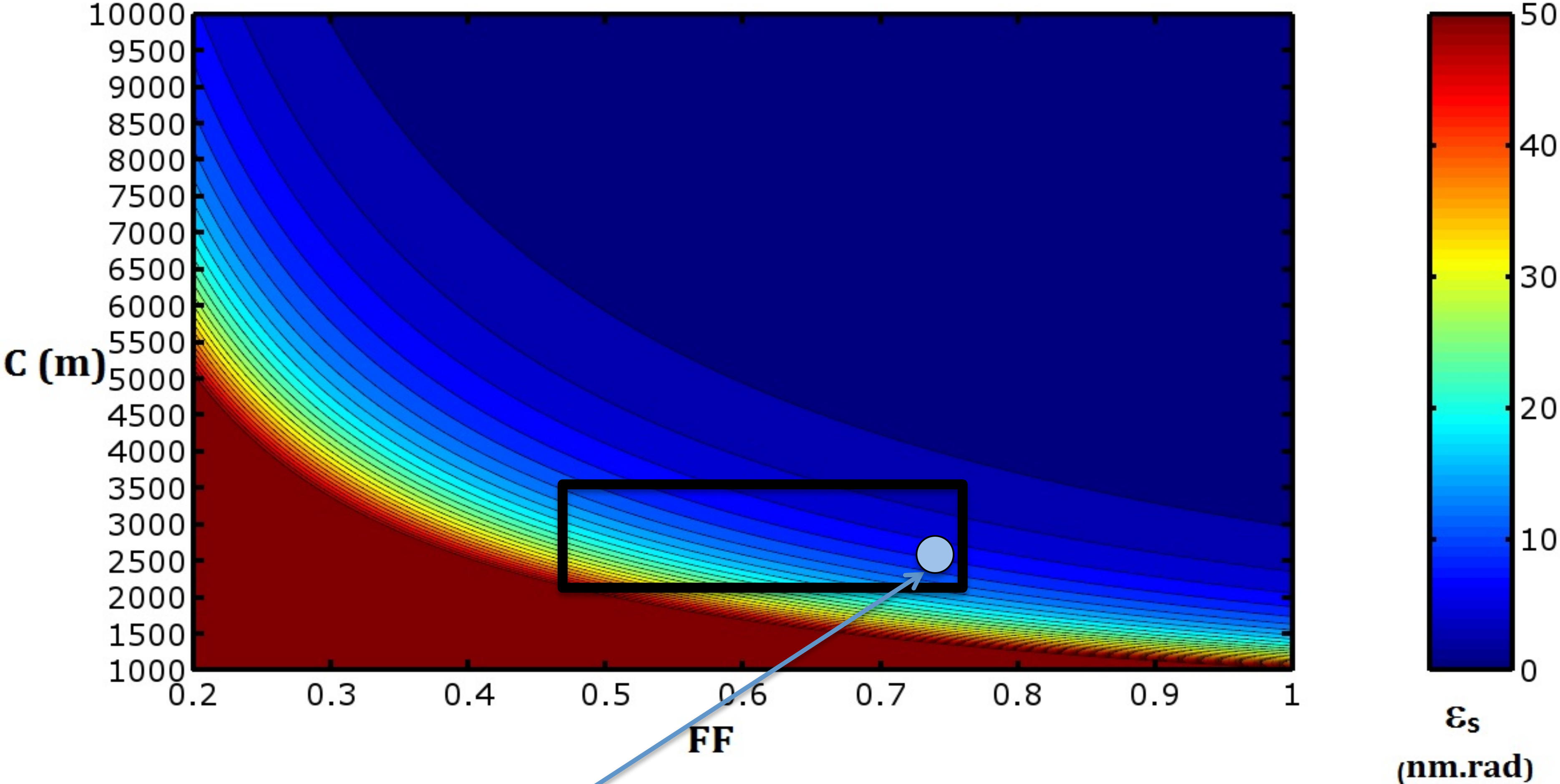
- Scaling of energy spread with filling factor and circumference
- For the area we remarked before, this does not vary so much.

Damping Time (20 GeV)



- Scaling of damping time with filling factor and circumference
- For the area we remarked before, the values are acceptable and does not vary so much.

Emittance (20 GeV)



- For the area we remarked before, the values are nice for emittance.
- It is around 10 nm.rad on the point for around FF:0.7 and C:2.5km

Assumptions and basic calculations for lattice

U=50 000 keV; max Uo for min. C
E= 20 GeV

$$U(keV) = 26{,}5.E^3(GeV).B(T)$$

B = 0.235 T;

FF.C= N.l_d = 1777.69 $$U_0 = \frac{2\pi.C_\gamma.E^4}{FF.C}$$

Sin(μ/2)=L_{cell}/4f , k=1/k.lq

μ=140^0
lq=0.3m

f= 4.7781
k=+-0.697627 m-2

ε_s= 10 nm.rad
E= 20 GeV

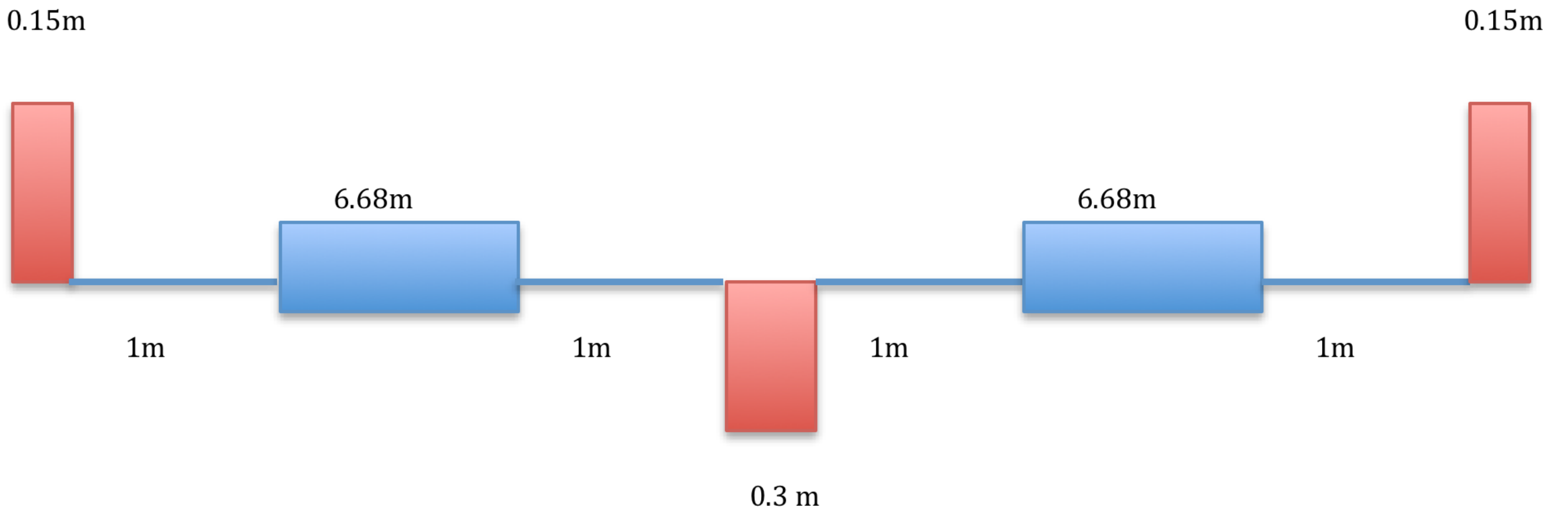
$$\mathcal{E} = 10^{-11}.E^2(GeV).\theta^3(\mathrm{deg})$$

Θ=1.357^0 → *N= 266*

$$N.l.B = 2\pi.\frac{P}{q}$$

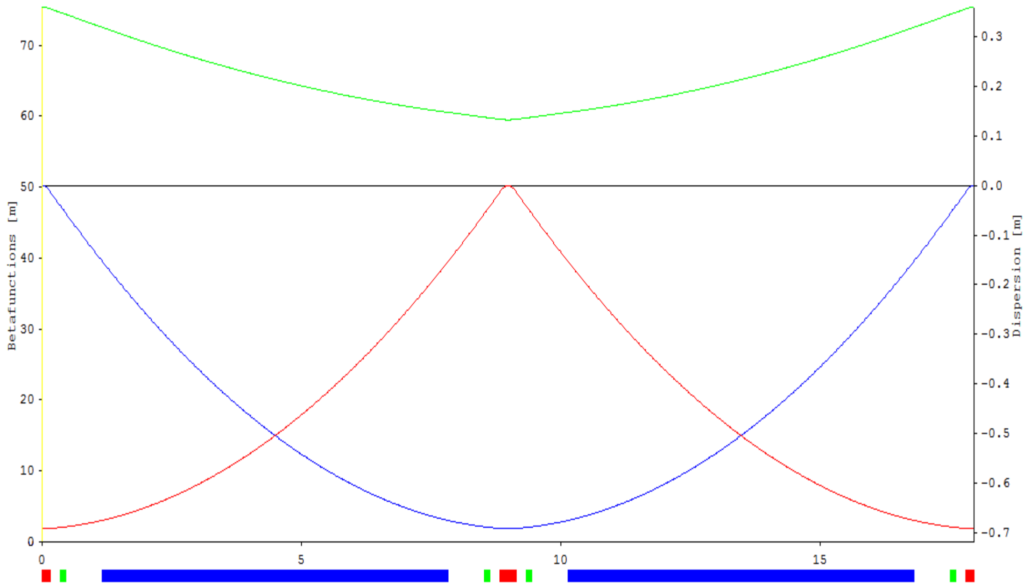
l_d= 6.68 m

FODO Lattice



L_{cell}	17.96 m
C	2388.68 m
FF	0.74
U_0	50 MeV
B_{max}	0.235 T
ε	10 nm.rad
Θ	1.35^0
l	6.68 m

Betatran Functions of FODO Cell



	6 GeV	20 GeV
C (m)	2388.68 m	2388.68 m
Emittance (nm.rad)	0.674	11.965
E. Spread	0.277	1.019
Chrom X	-124.487	-106.562
Chrom Y	-124.351	-106.402
Uo (keV)	331.9	50045.2
TauX (ms)	347.861	6.373
TauY (ms)	347.664	6.368
TauE (ms)	173.783	3.183

- Sextupole magnet need to be used,
- DA should be checked.

Future Studies

- Finalizing optic design:

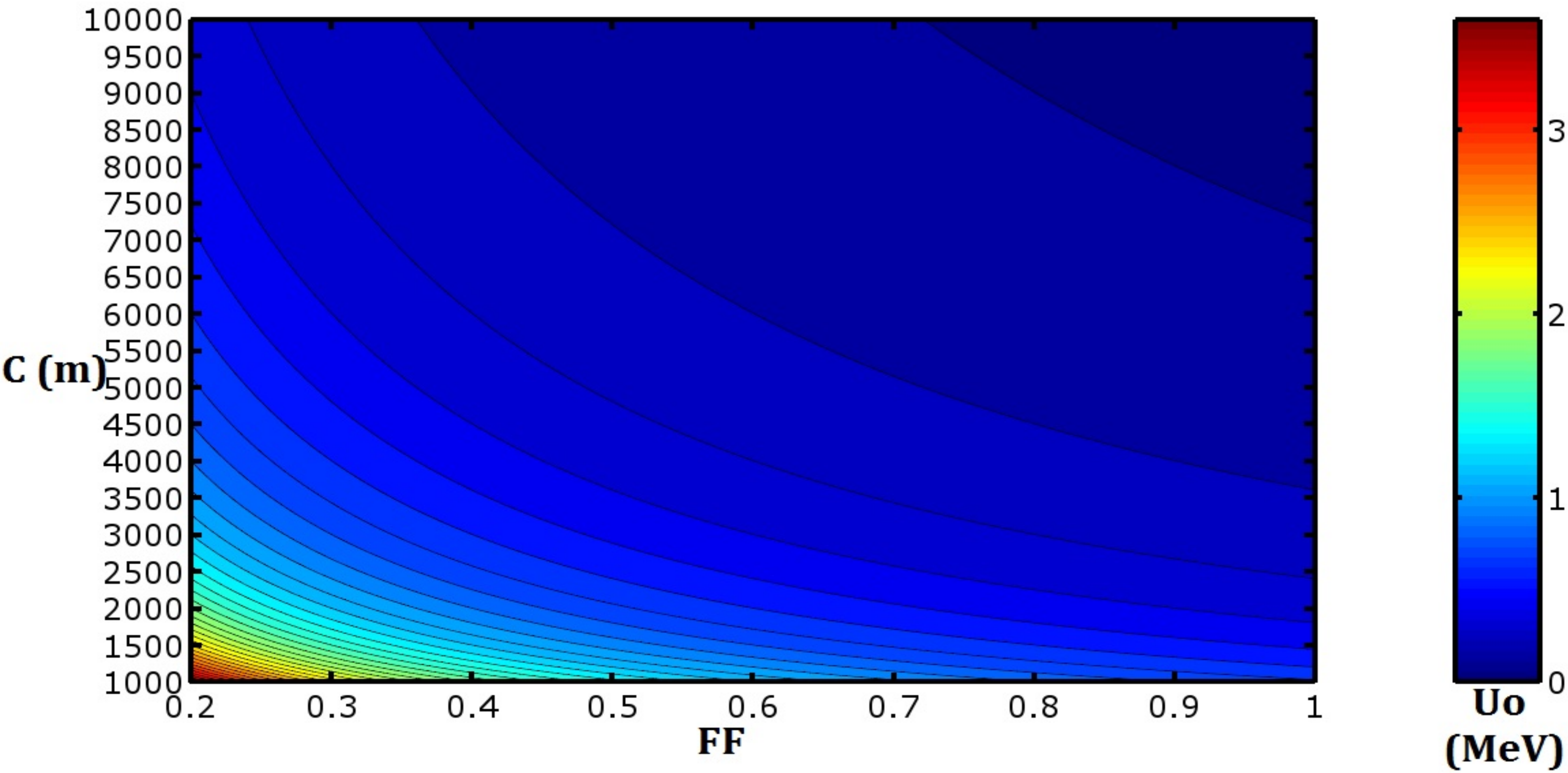
  - Having missing dipoles
  - Sextupole magnets
  - Dynamic aperture

- Injection and extraction design

- Collective effects

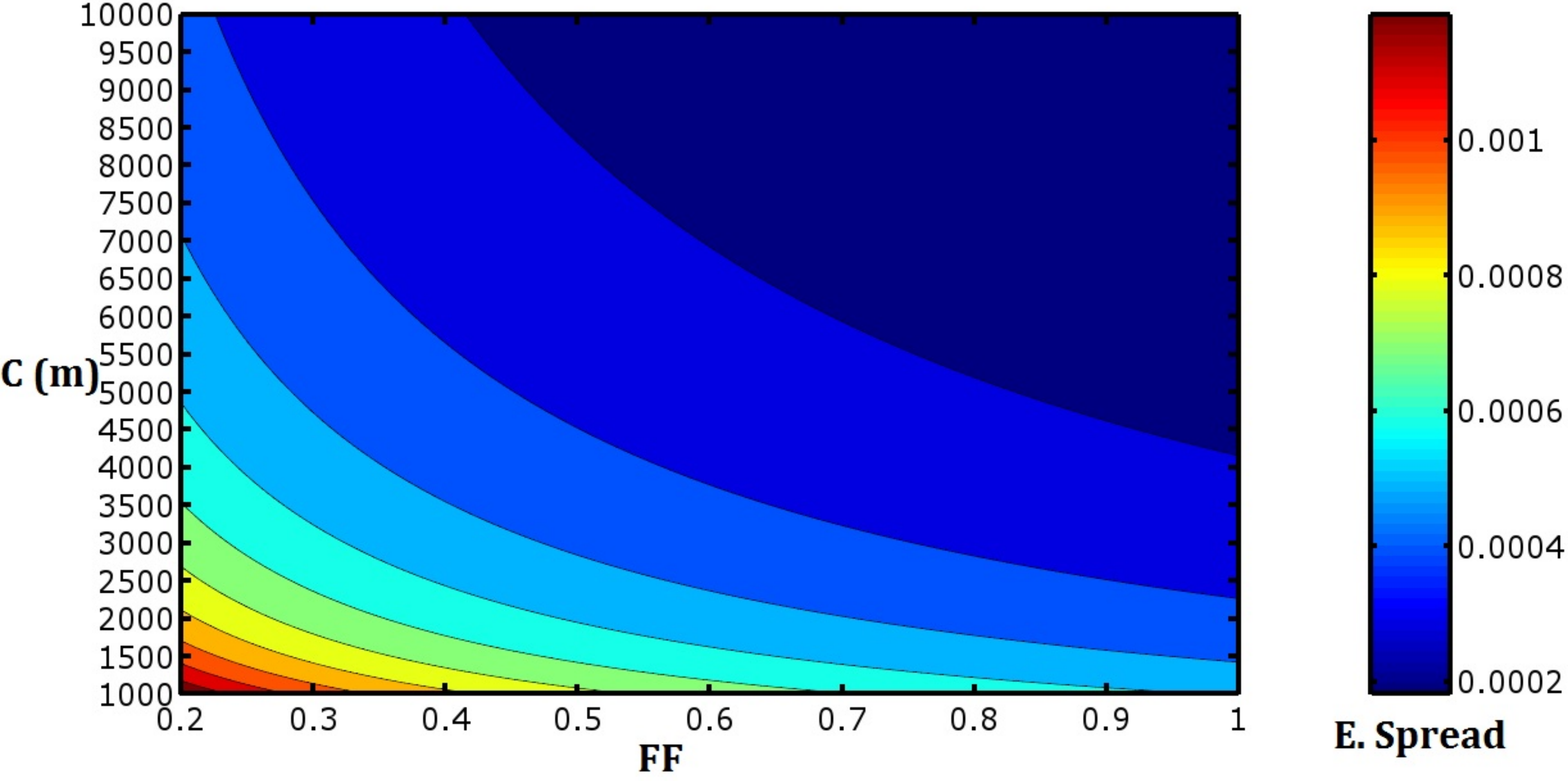
Thank you!

Appendix 1:



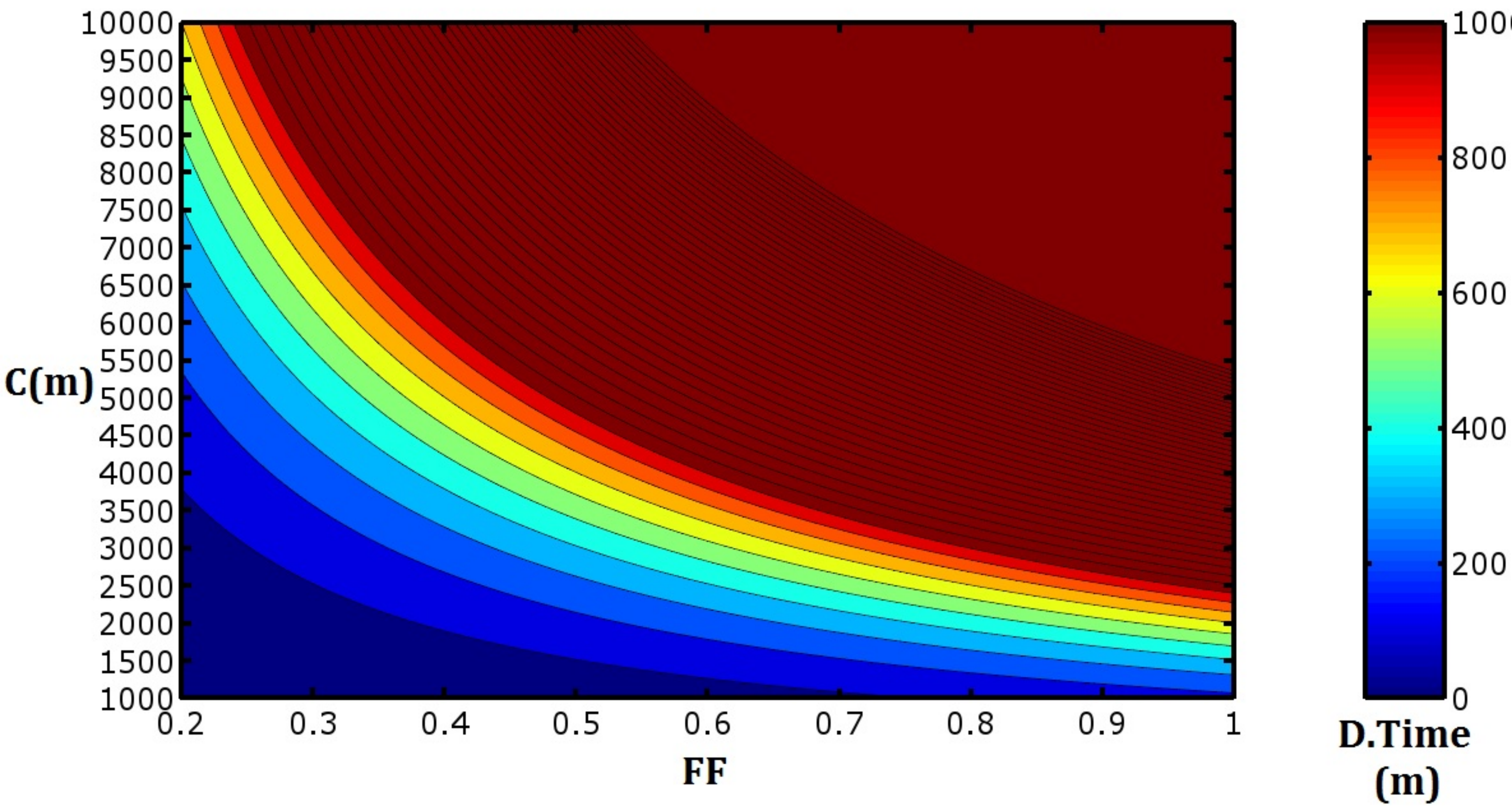
- Scaling of Energy loss/turn with filling factor and circumference

Appendix 2:



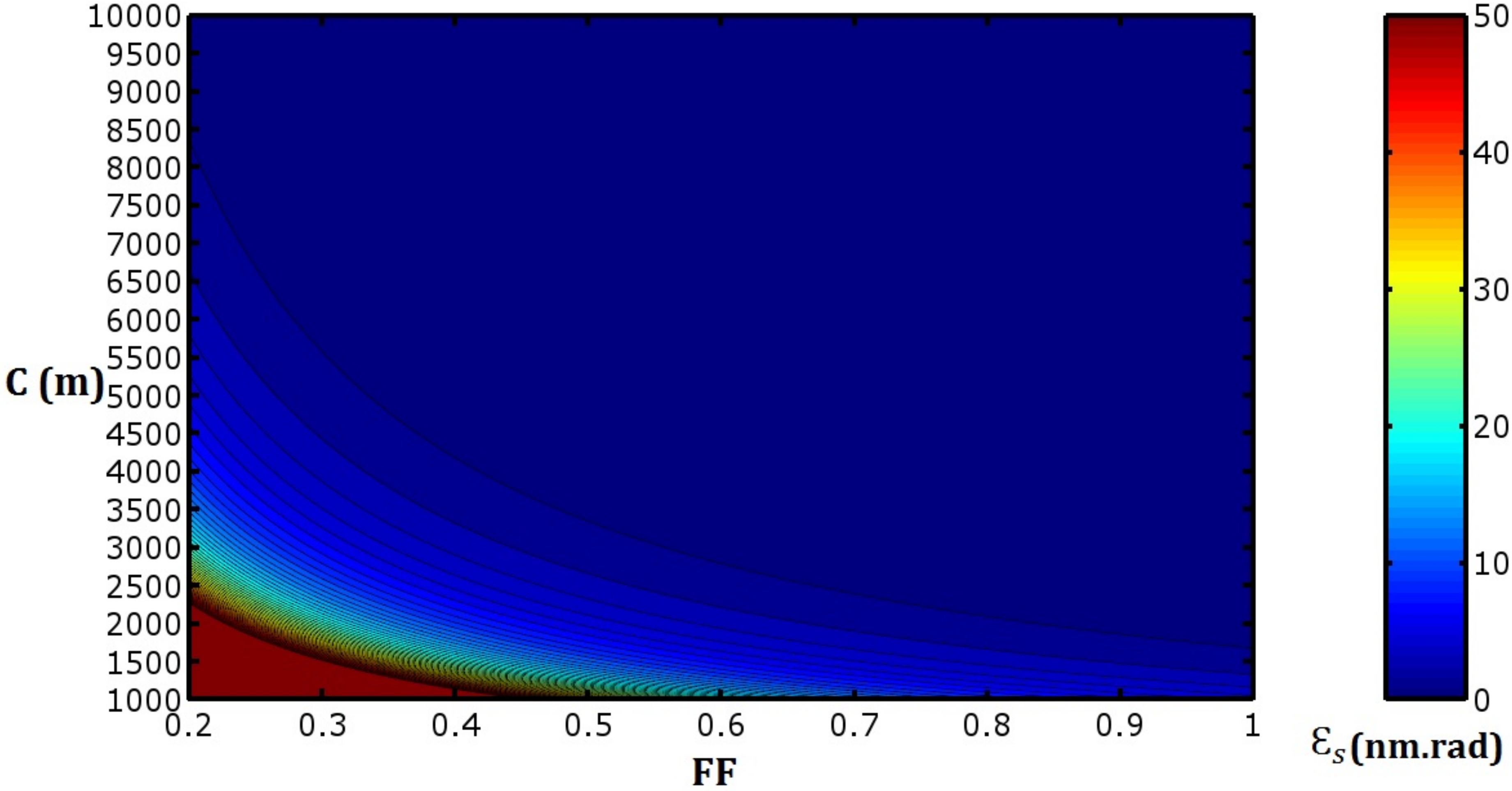
- Scaling of Energy spread with filling factor and circumference

Appendix 3:



- Scaling of damping time with filling factor and circumference

Appendix 4:



- Scaling of emittance with filling factor and circumference