Half Flip 6D Lattice

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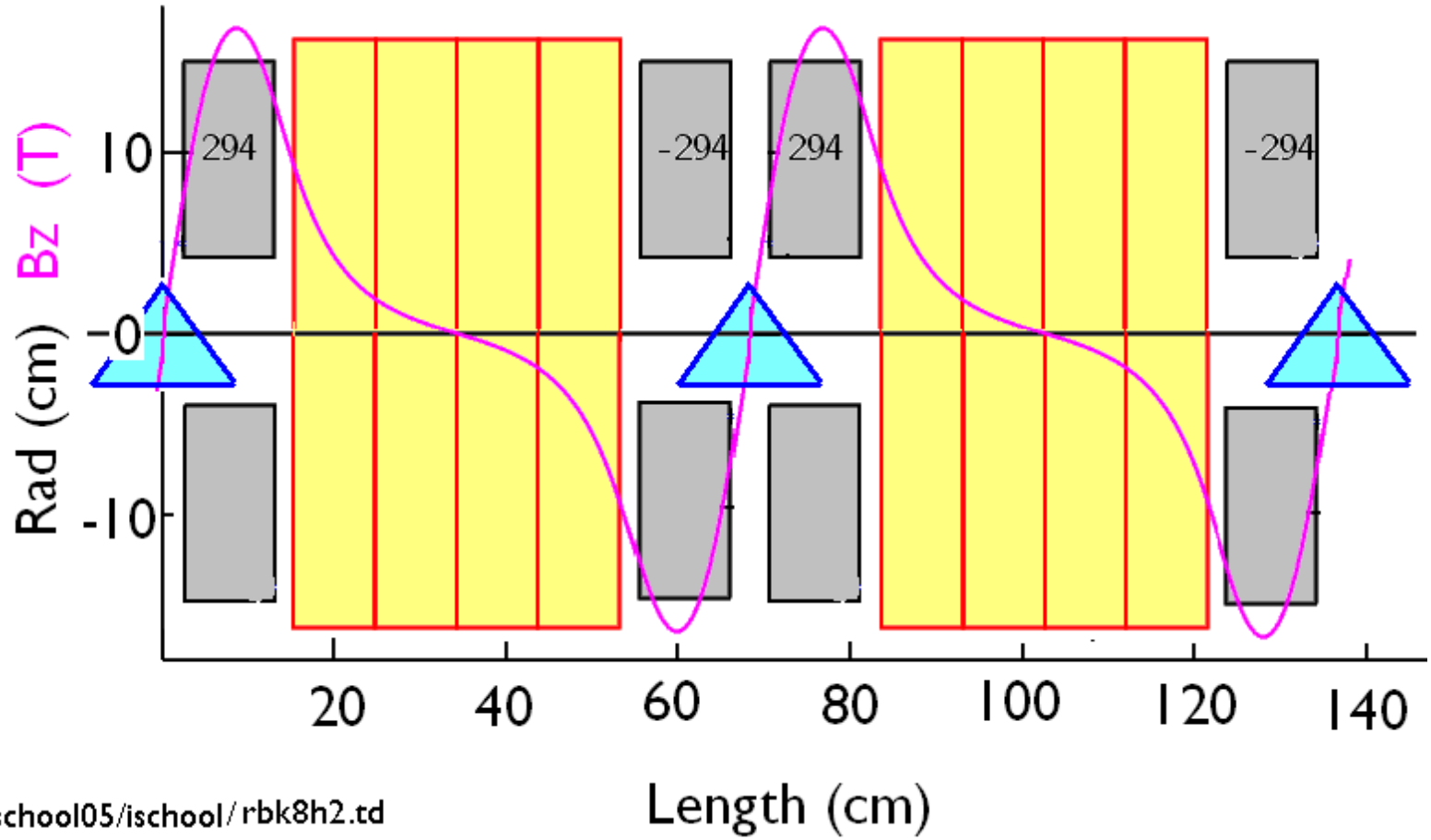
5/16/13

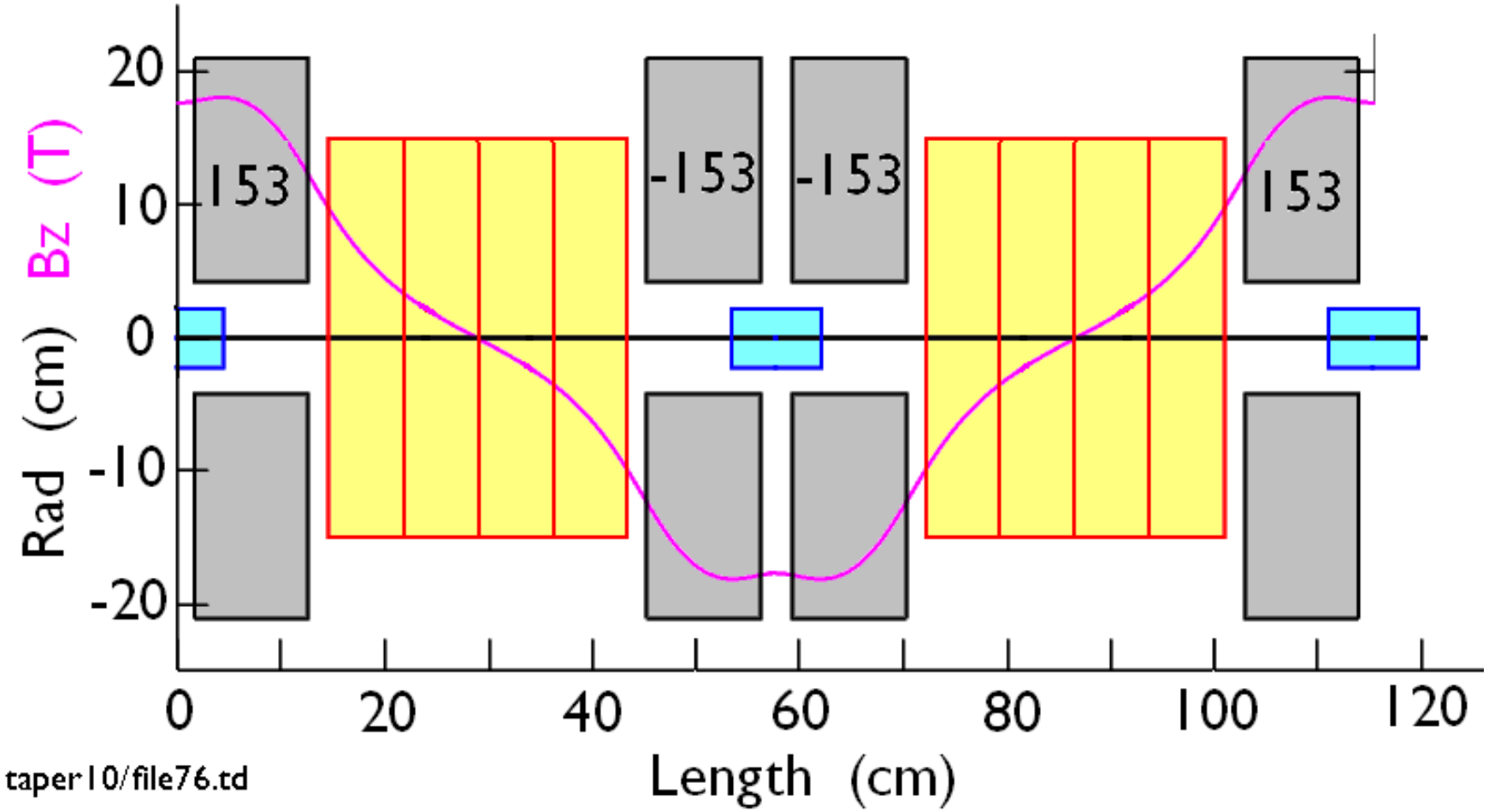
- Introduction
- Parameters of lattice
- Dynamic aperture, mean beam positions, & Dispersions
- Parameters vs. length in 2 cells
- Simulation of cooling
- Conclusion

A late stage RFOFO (Flip)



- All cells identical
- Coils on either side of absorber are bucking
- Requiring high current densities (294 A/mm^2) for a beta of 2.37 cm

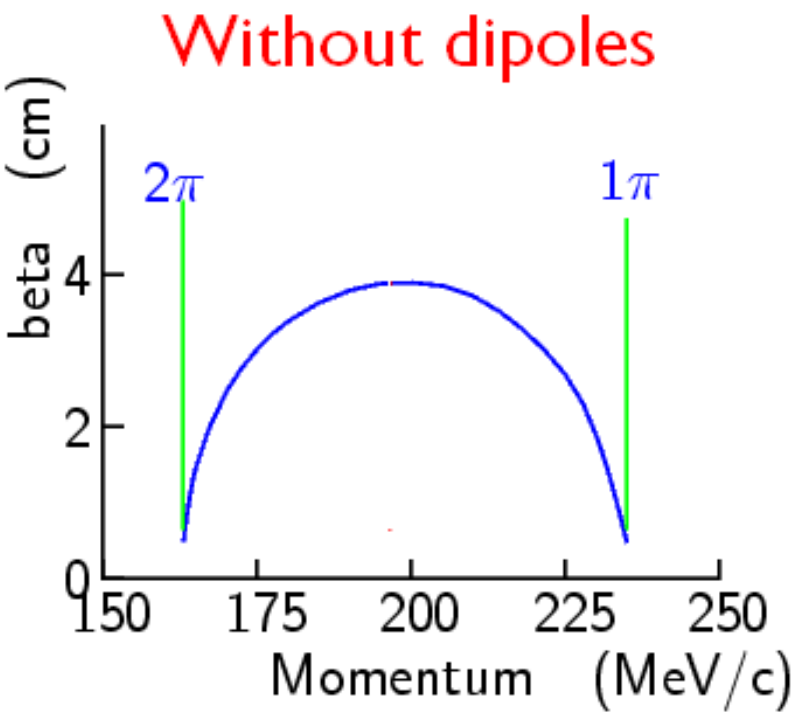
A late stage Half Flip

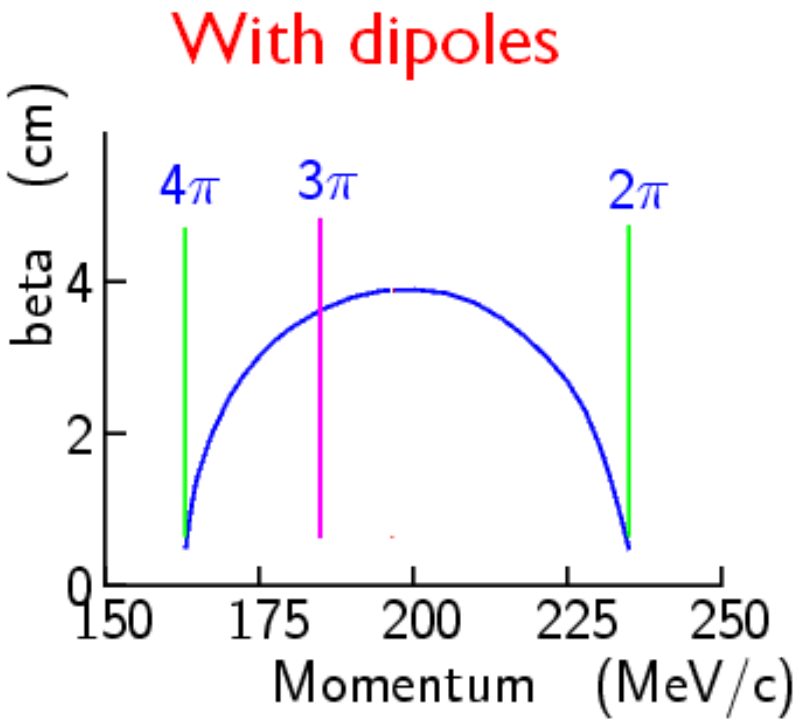


- All cells no longer identical
- Coils on either side of absorber are not bucking
- allowing higher fields with lower current densities (153 A/mm^2) for a smaller beta (2.1 cm)

A problem with half flip

- Without bending all cells have identical focusing ($\propto \ B^2$)
- With bending (required for dispersion) the symmetry is broken and a resonance exists in the center of the pass band
- We use the wider space 2pi to 3 pi: giving less momentum acceptance, but seems ok

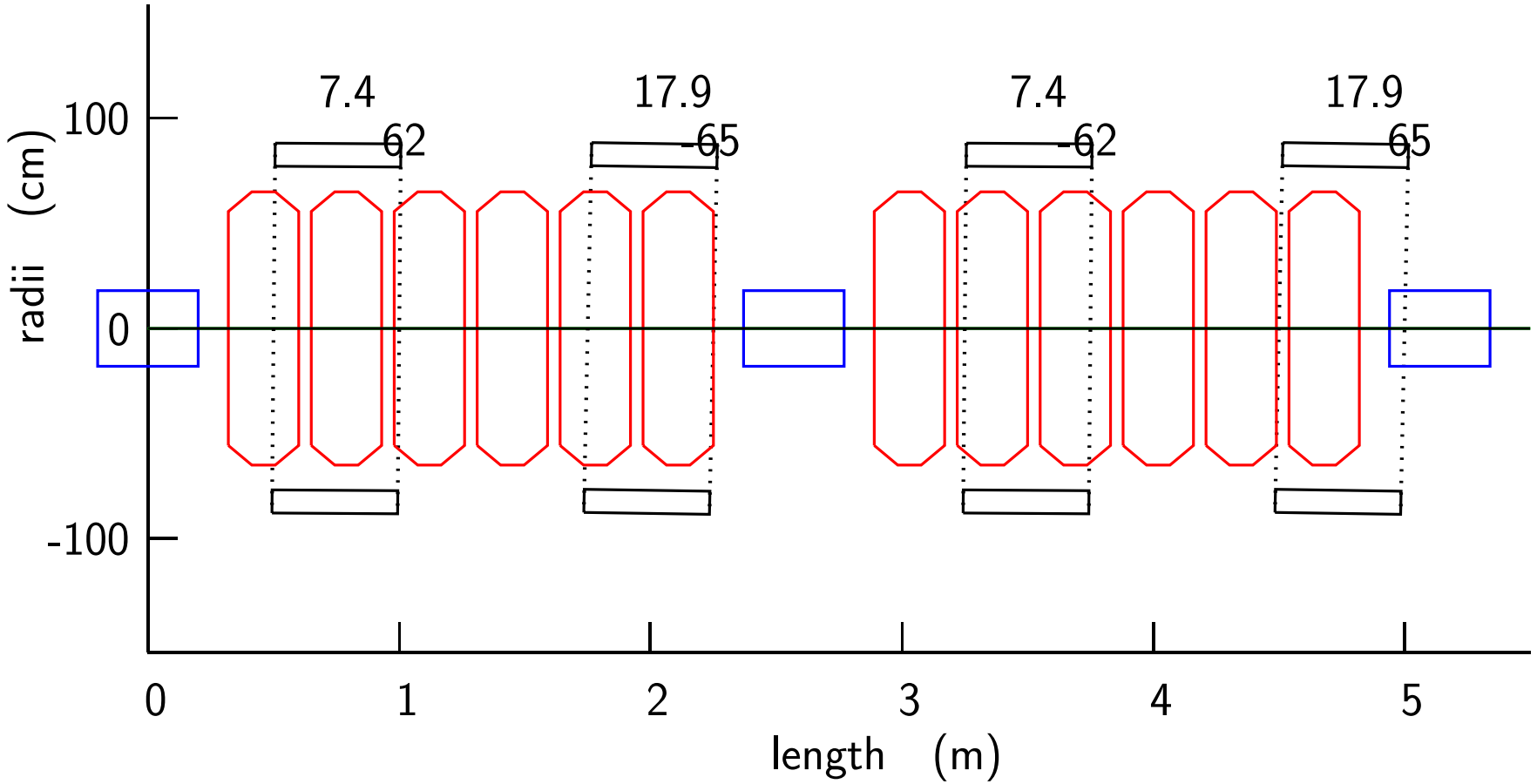


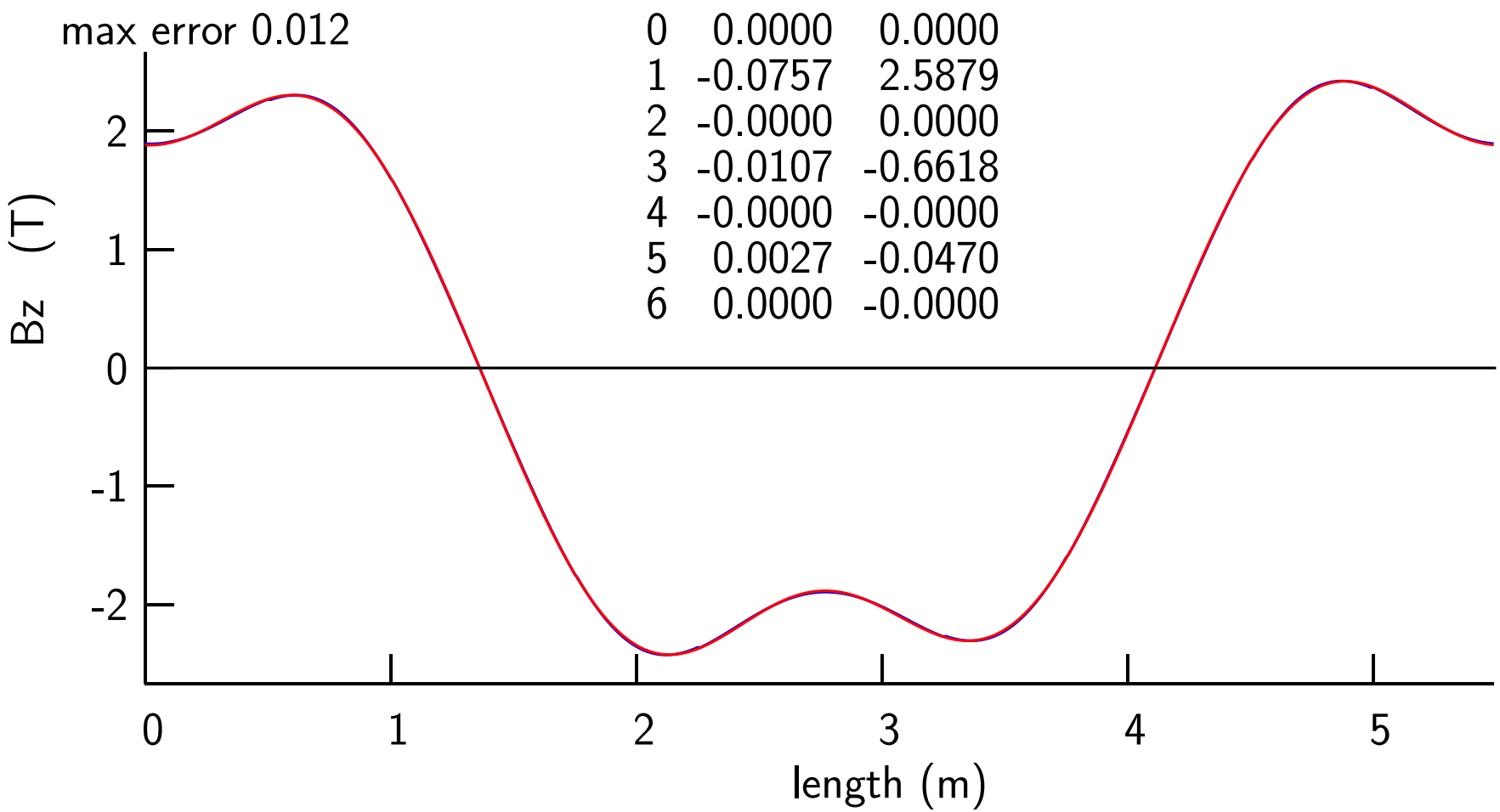


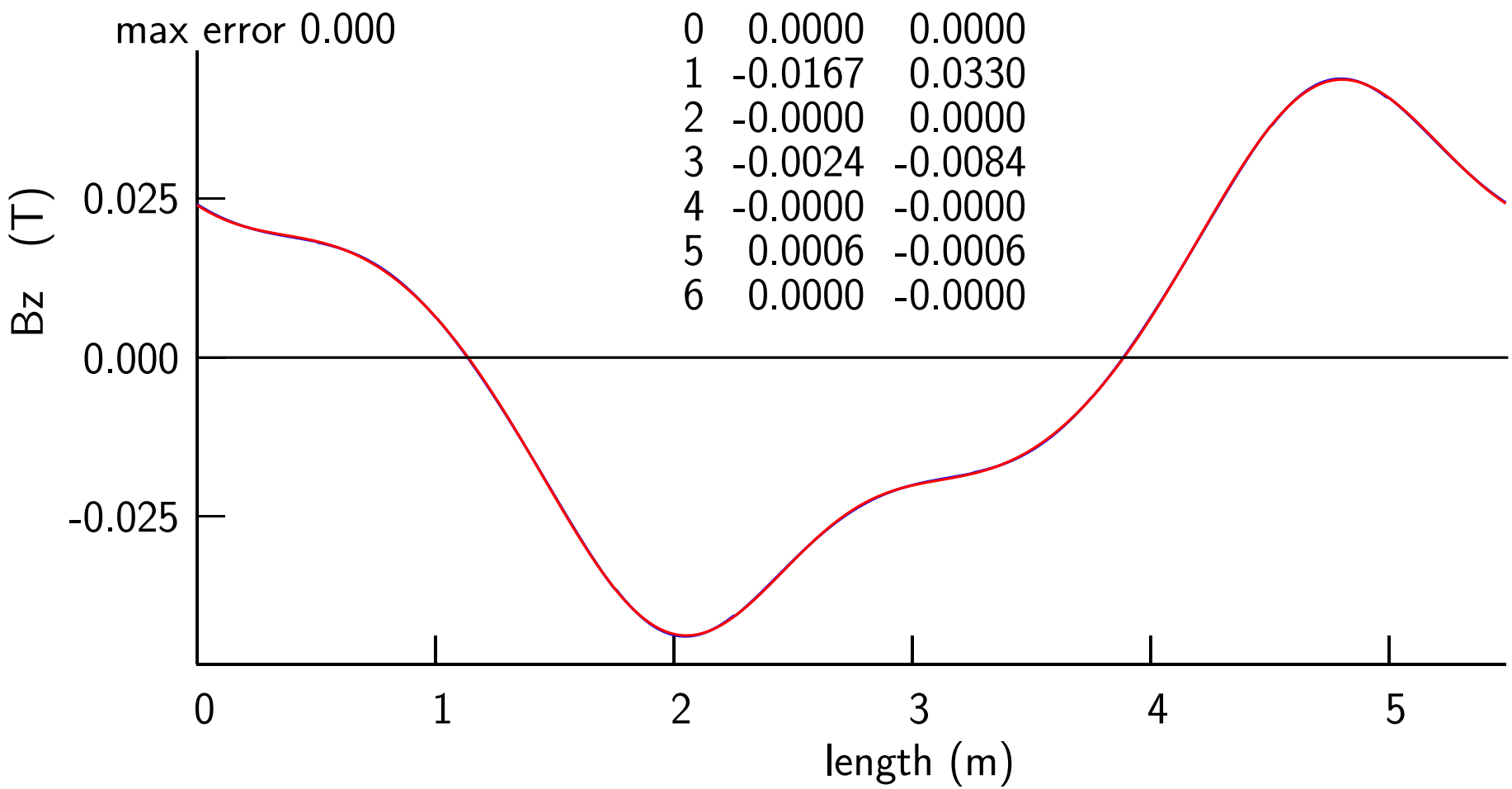
Scott Berg

Study of early stage 'Half Flip'

An early stage using 201 MHz




max error 0.012
0 0.0000 0.0000
1 -0.0757 2.5879
2 -0.0000 0.0000
3 -0.0107 -0.6618
4 -0.0000 -0.0000
5 0.0027 -0.0470
6 0.0000 -0.0000
Bz (T)
2
1
0
-1
-2
0
1
2
3
4
5
length (m)


max error 0.000
0 0.0000 0.0000
1 -0.0167 0.0330
2 -0.0000 0.0000
3 -0.0024 -0.0084
4 -0.0000 -0.0000
5 0.0006 -0.0006
6 0.0000 -0.0000
Bz (T)
0.025
0.000
-0.025
0
1
2
3
4
5
length (m)

Parameters

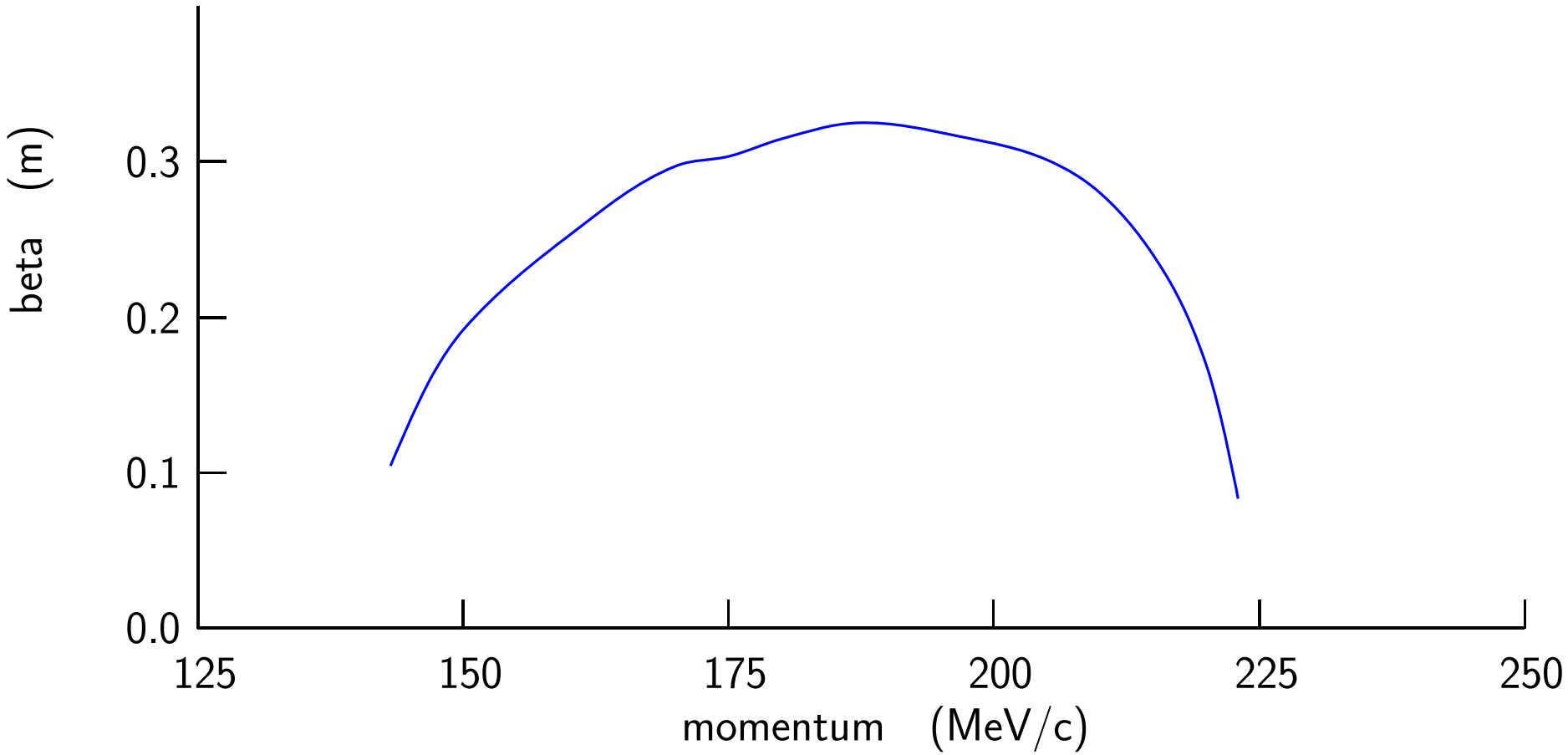
	start m	dl m	rad m	dr m	tilt rad	I/A A/mm^2
1	0.500	0.500	0.770	0.110	0.0179	62.22
2	1.750	0.500	0.770	0.110	0.0179	-65.45
3	3.250	0.500	0.770	0.110	0.0179	-62.22
4	4.500	0.500	0.770	0.110	0.0179	65.45

Hydrogen absorber 42.6 cm long, radius 18 cm

Hydrogen window of 0.5 mm aluminum

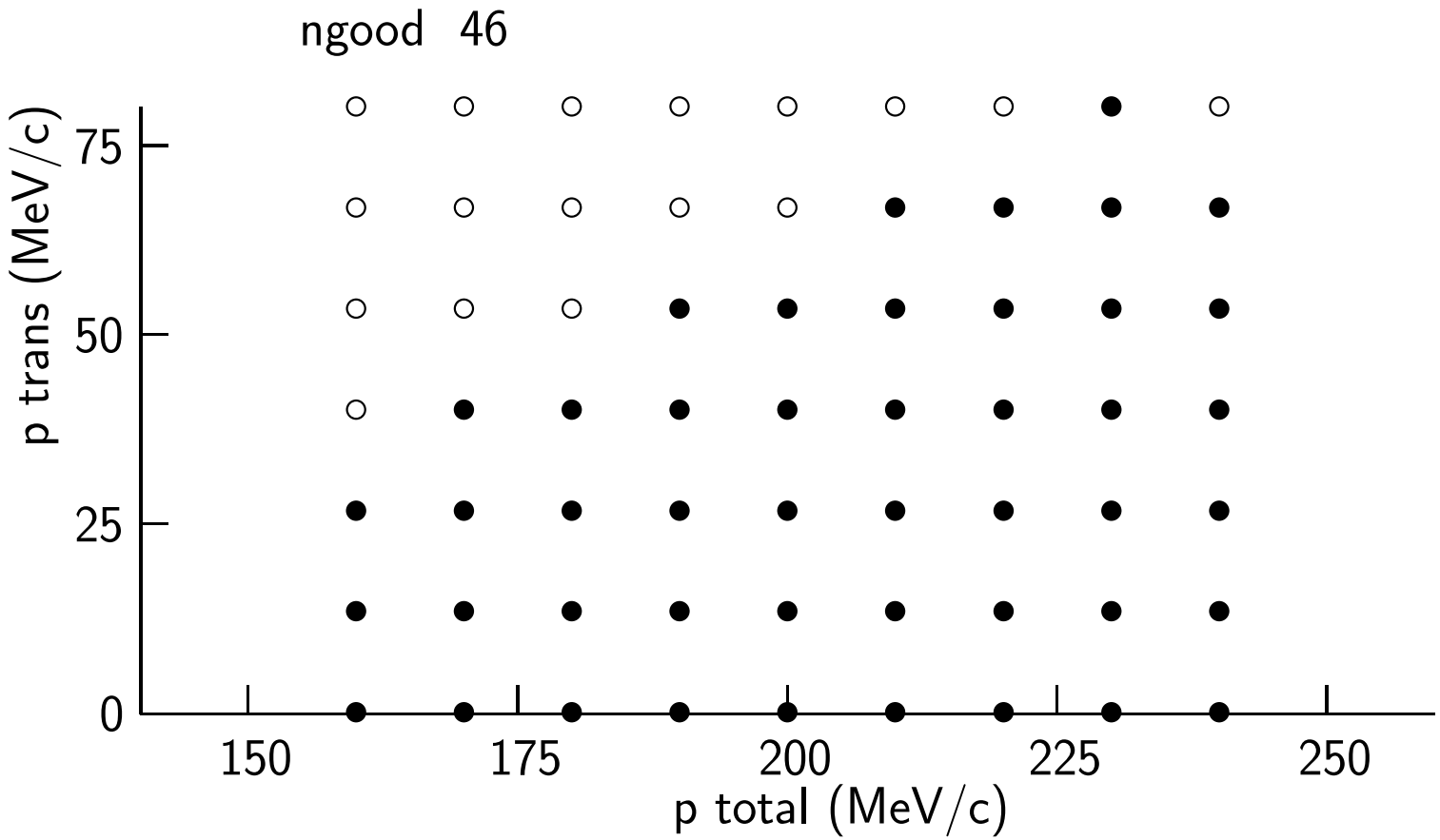
rf: 6 pillbox cavities, 33 cm long, 201.25 MHz, 17 MV/m, Initial phase 30 degrees (no rf windows)

Betas without tilts

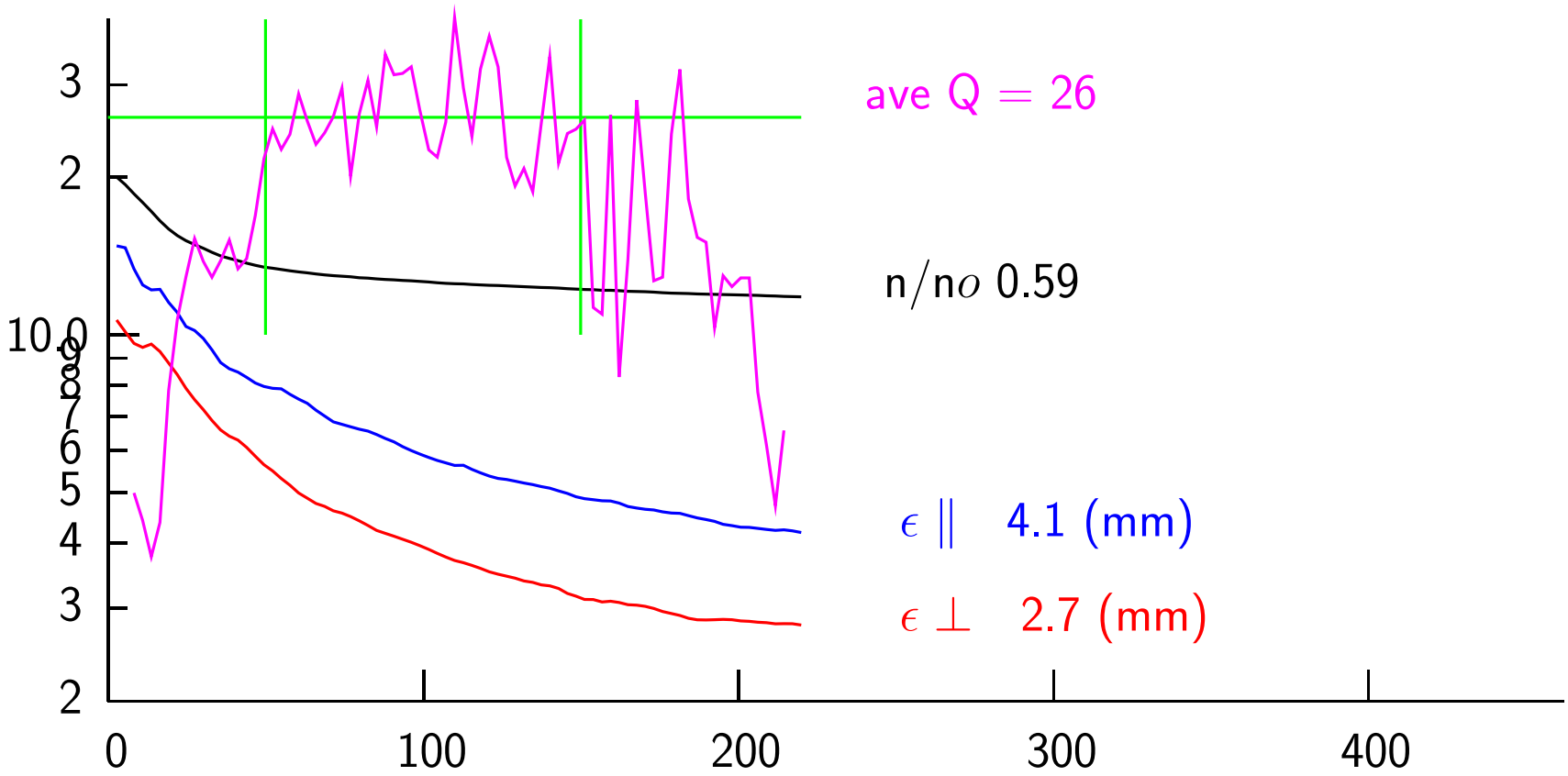


Acceptance with tilts

With no absorbers or rf, use ICOOL to propagate through 550 m
ICOOL using above Fourier description of fields on axis



ICOOL Simulation of cooling



- Cooling in all 6 dimensions
- Without a wedge
- This will work for both signs!

Scaling

$$\beta \propto L$$

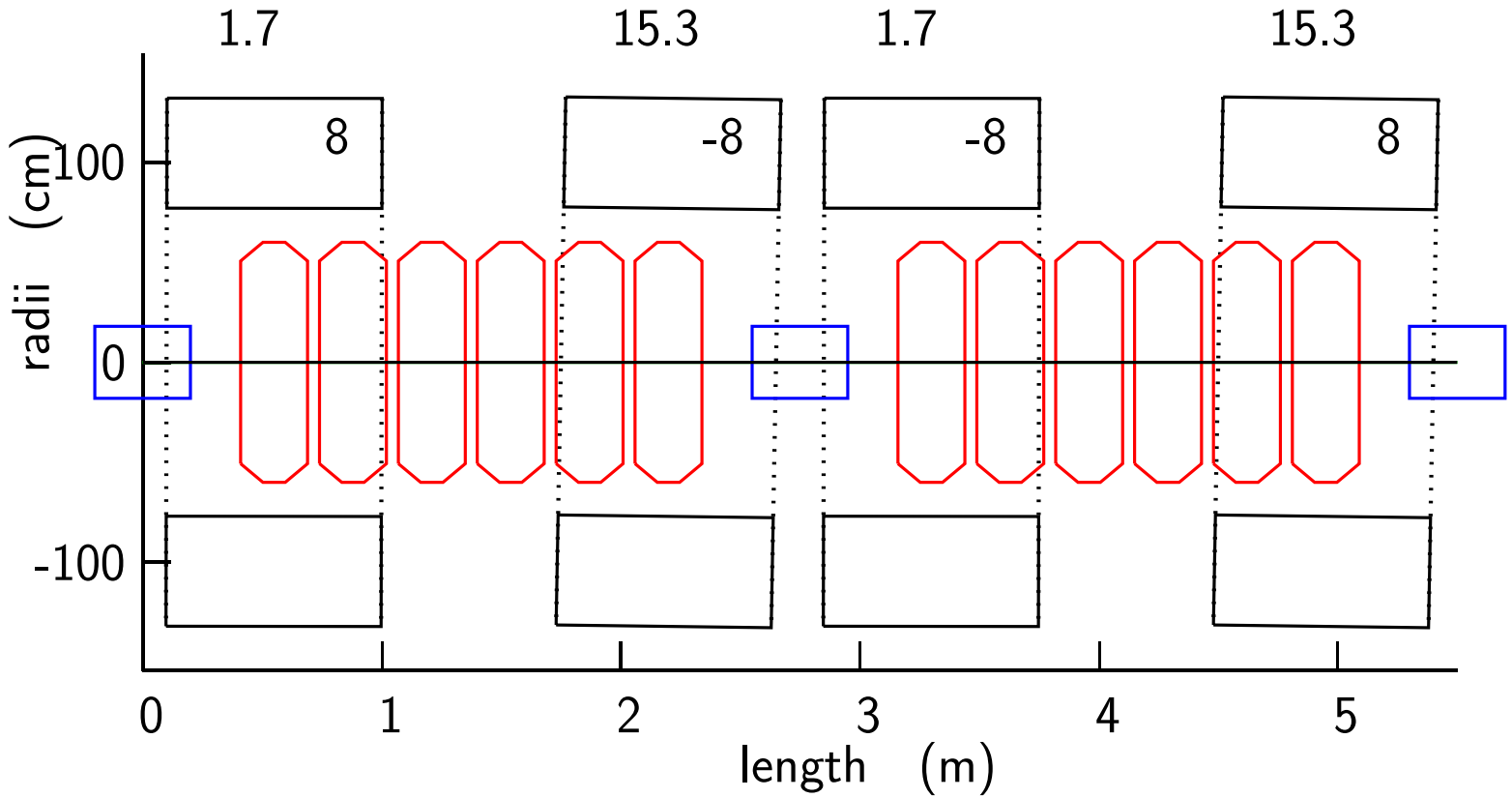
$$rf\ \ freq \propto 1/L$$

$$\epsilon_{\perp} \propto L$$

$$\epsilon_{\parallel} \propto L$$

$$j \propto \frac{1}{L^2}$$

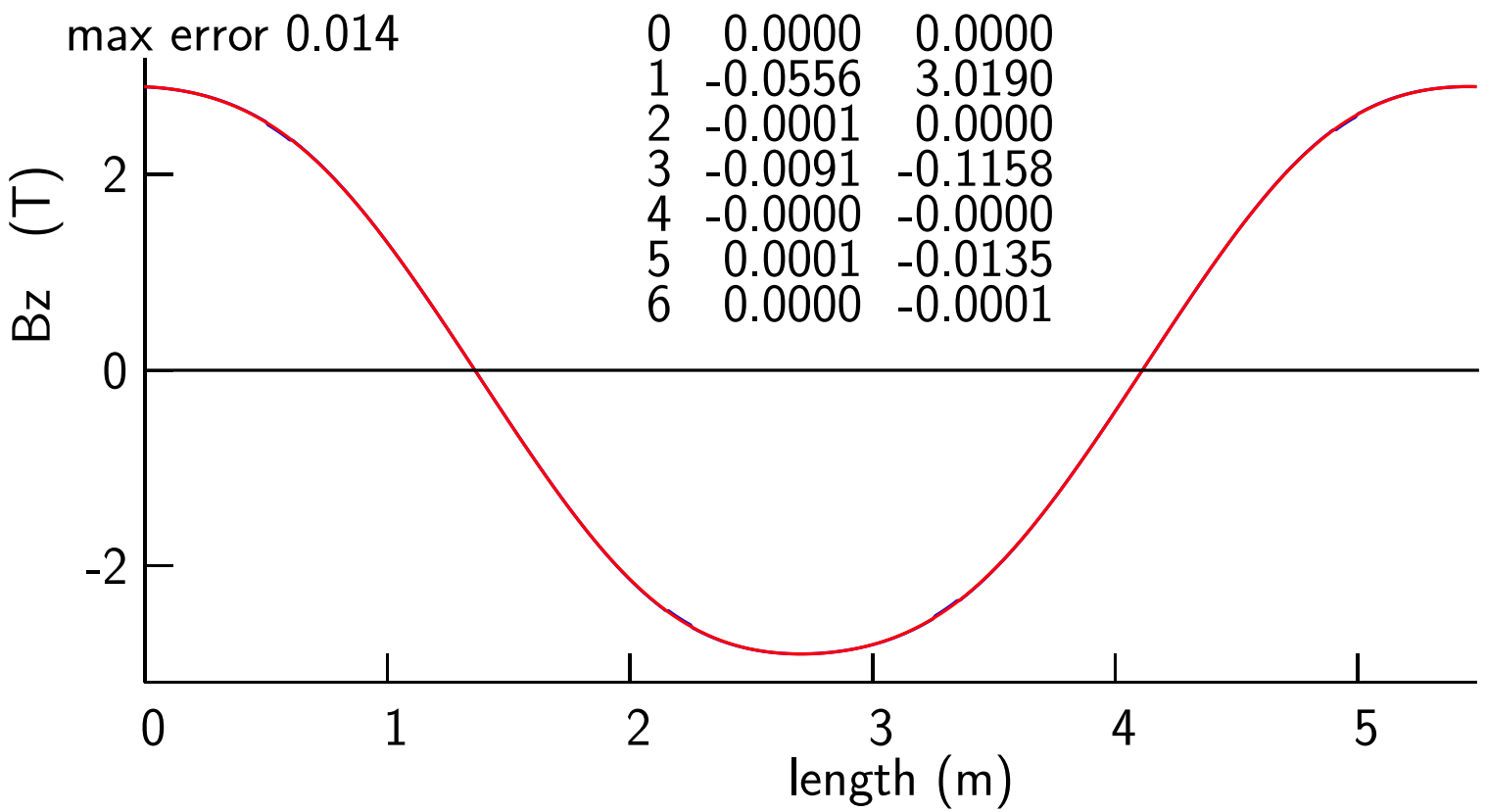
Try scaling down by a factor of 5

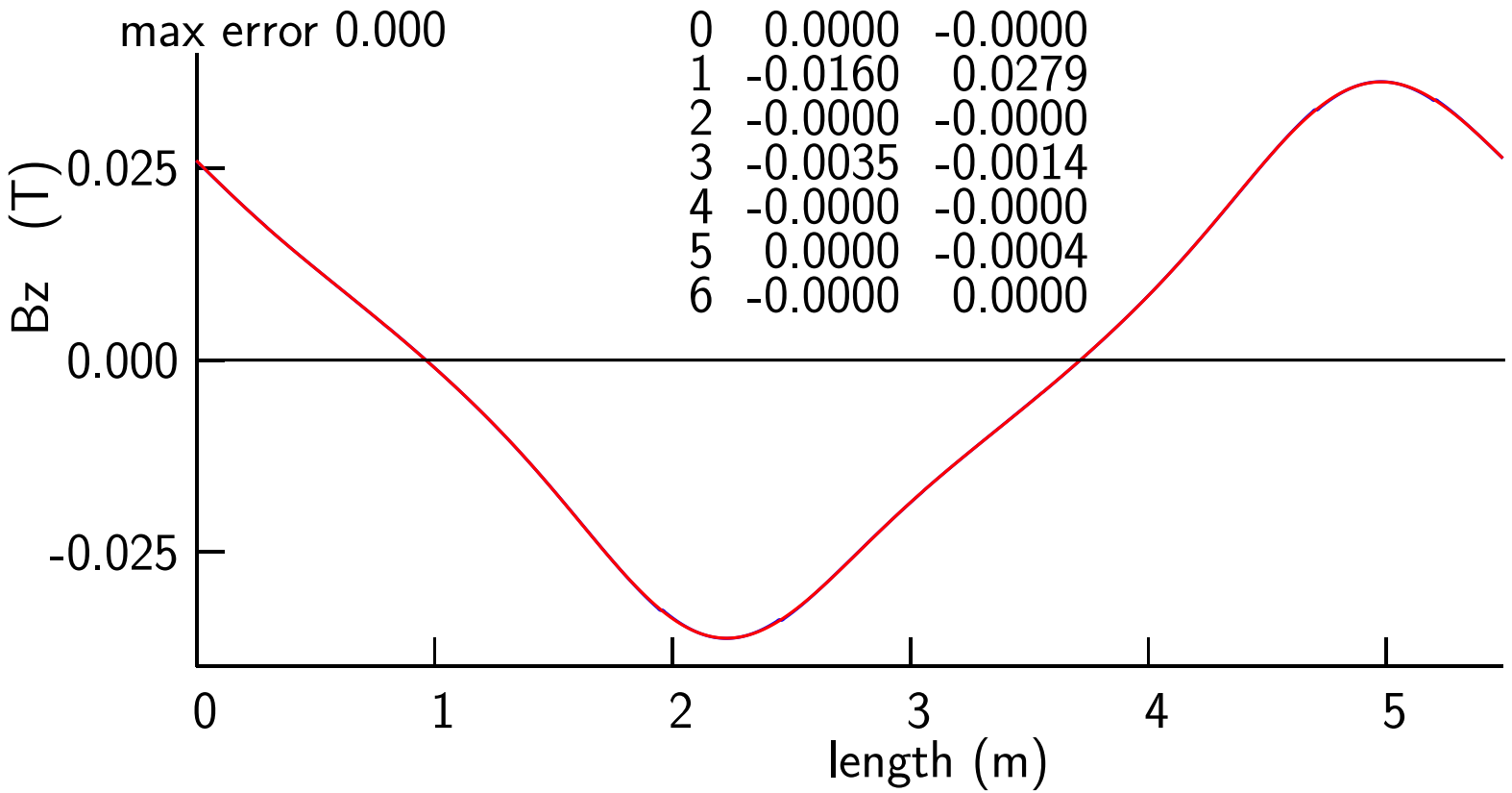


Equivalent to cell $5.5/5 \ = \ 1.1$ m

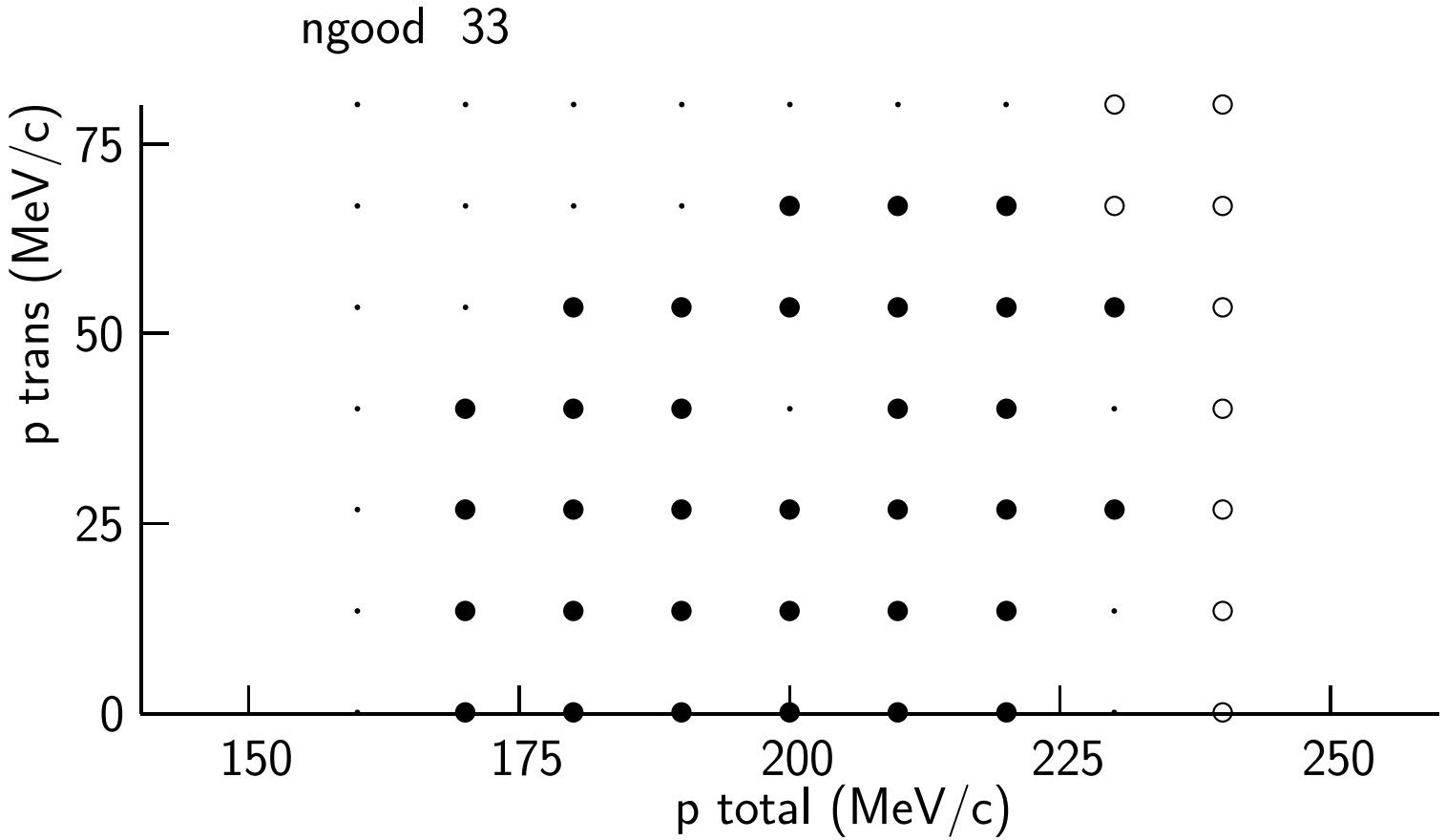
Current densities $8 \times 5^2 = 200 A/mm^2$

Fields and Fourier components



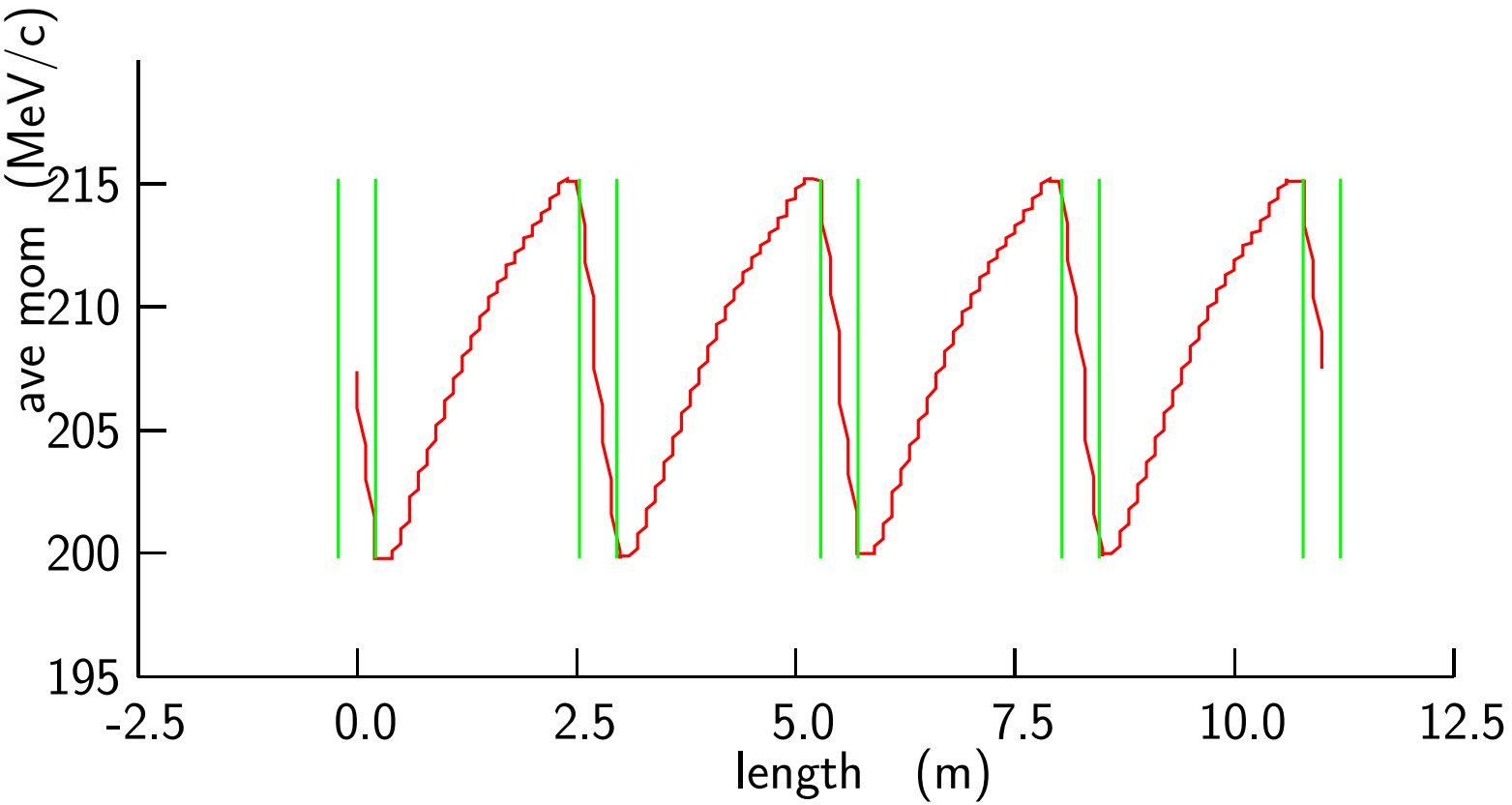

max error 0.000
0 0.0000 -0.0000
1 -0.0160 0.0279
2 -0.0000 -0.0000
3 -0.0035 -0.0014
4 -0.0000 -0.0000
5 0.0000 -0.0004
6 -0.0000 0.0000
Bz (T)
0.025
0.000
-0.025
0
1
2
3
4
5
length (m)

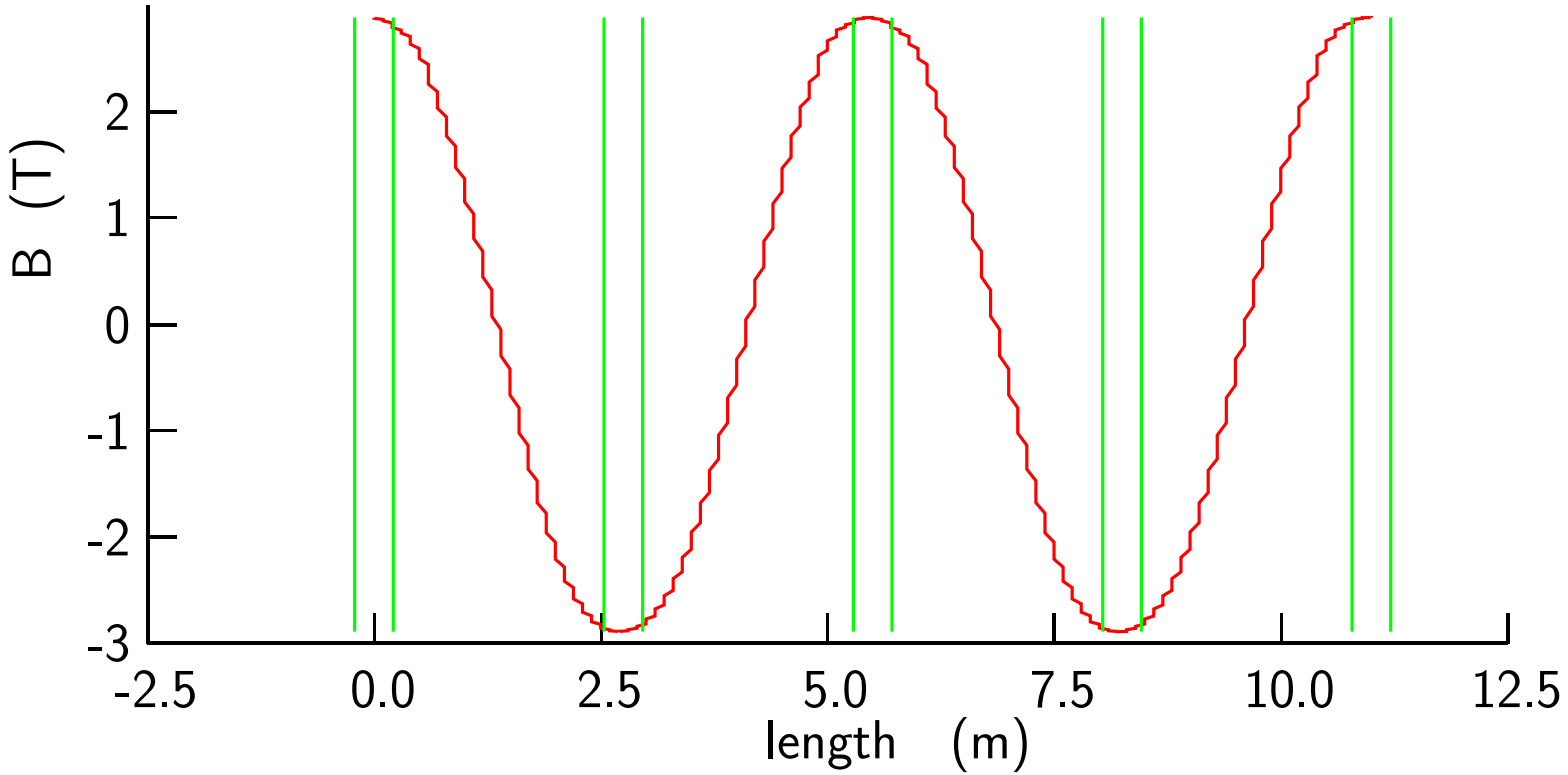
Acceptance

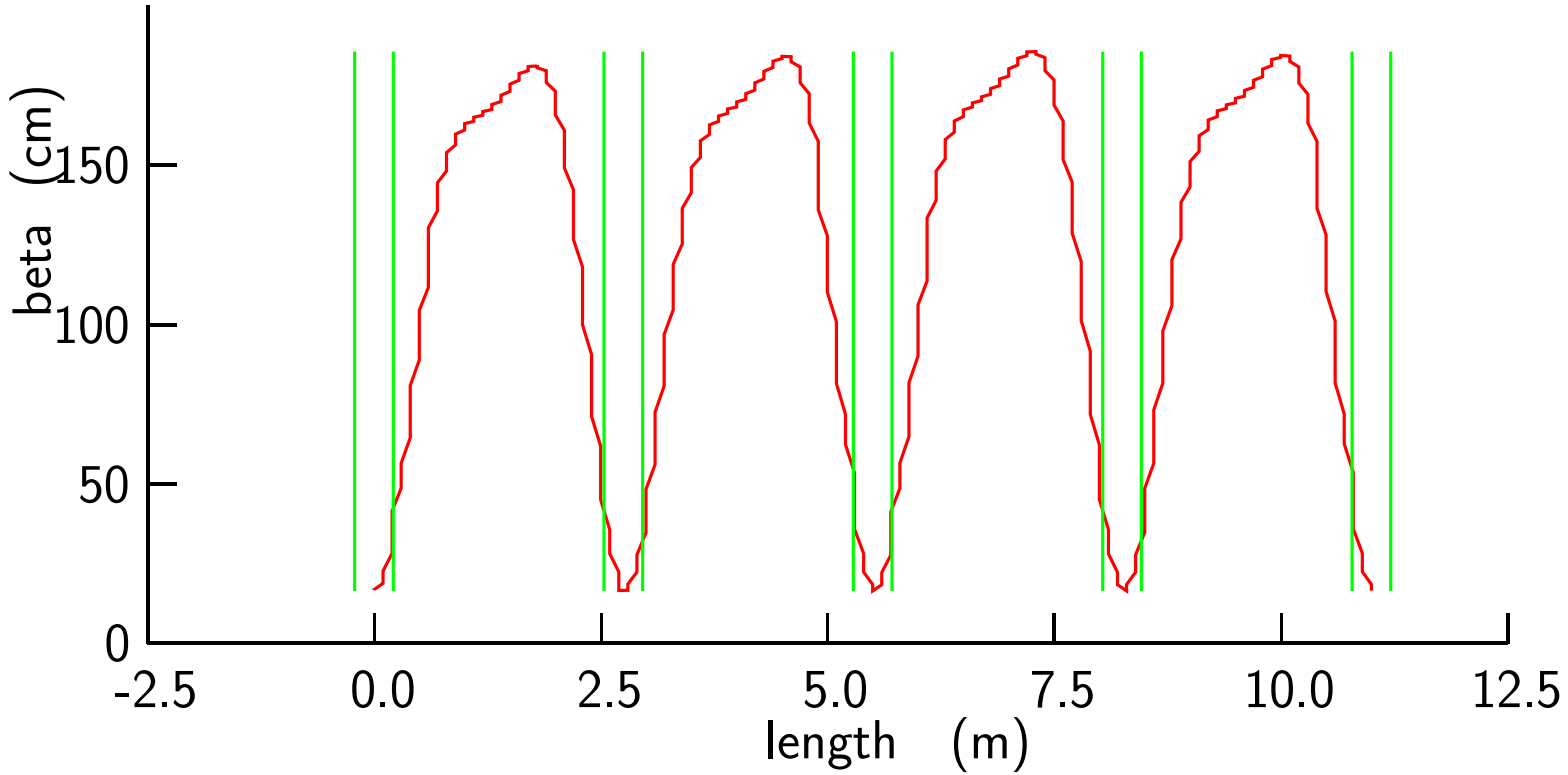


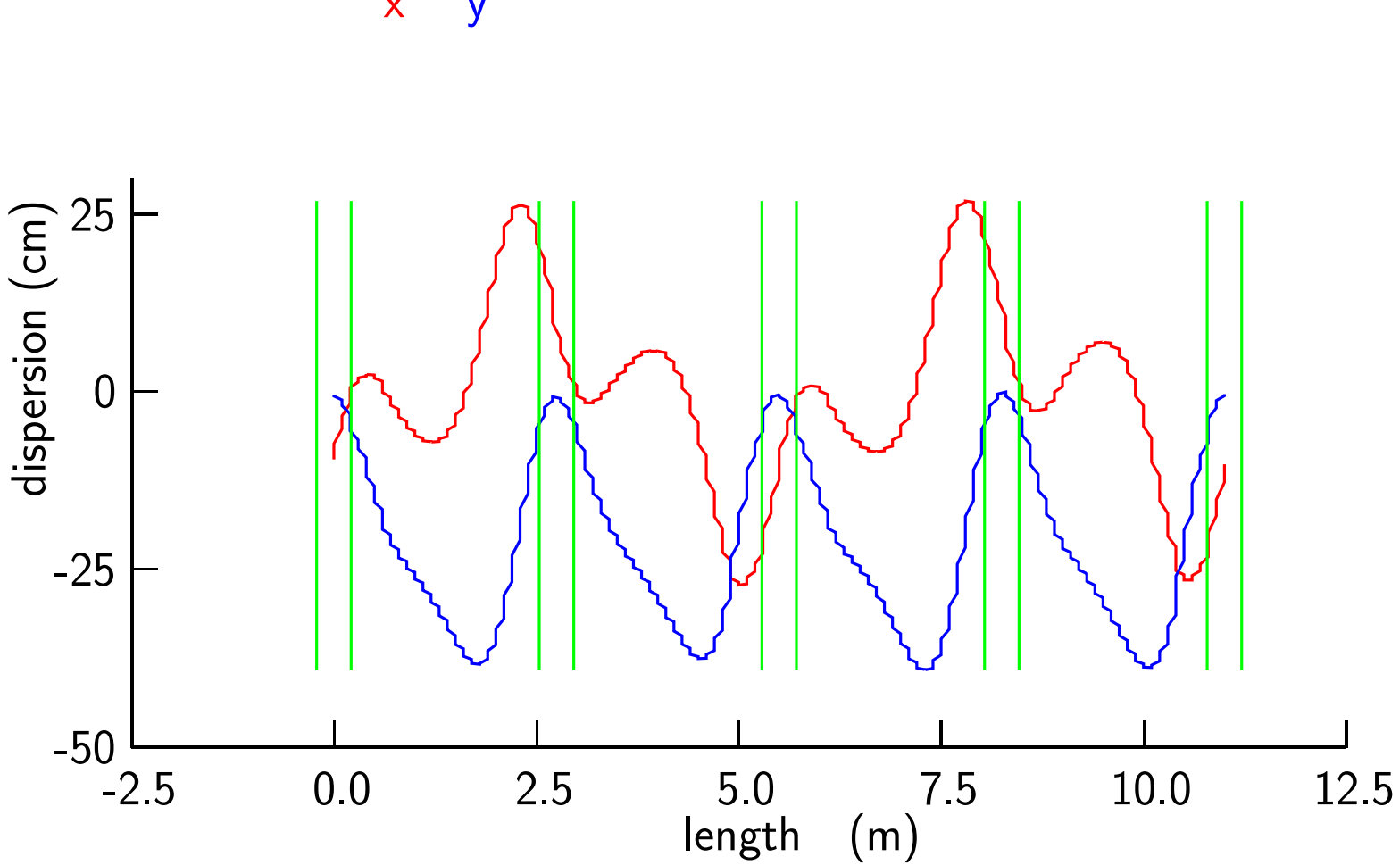
Not as good

Details vs length

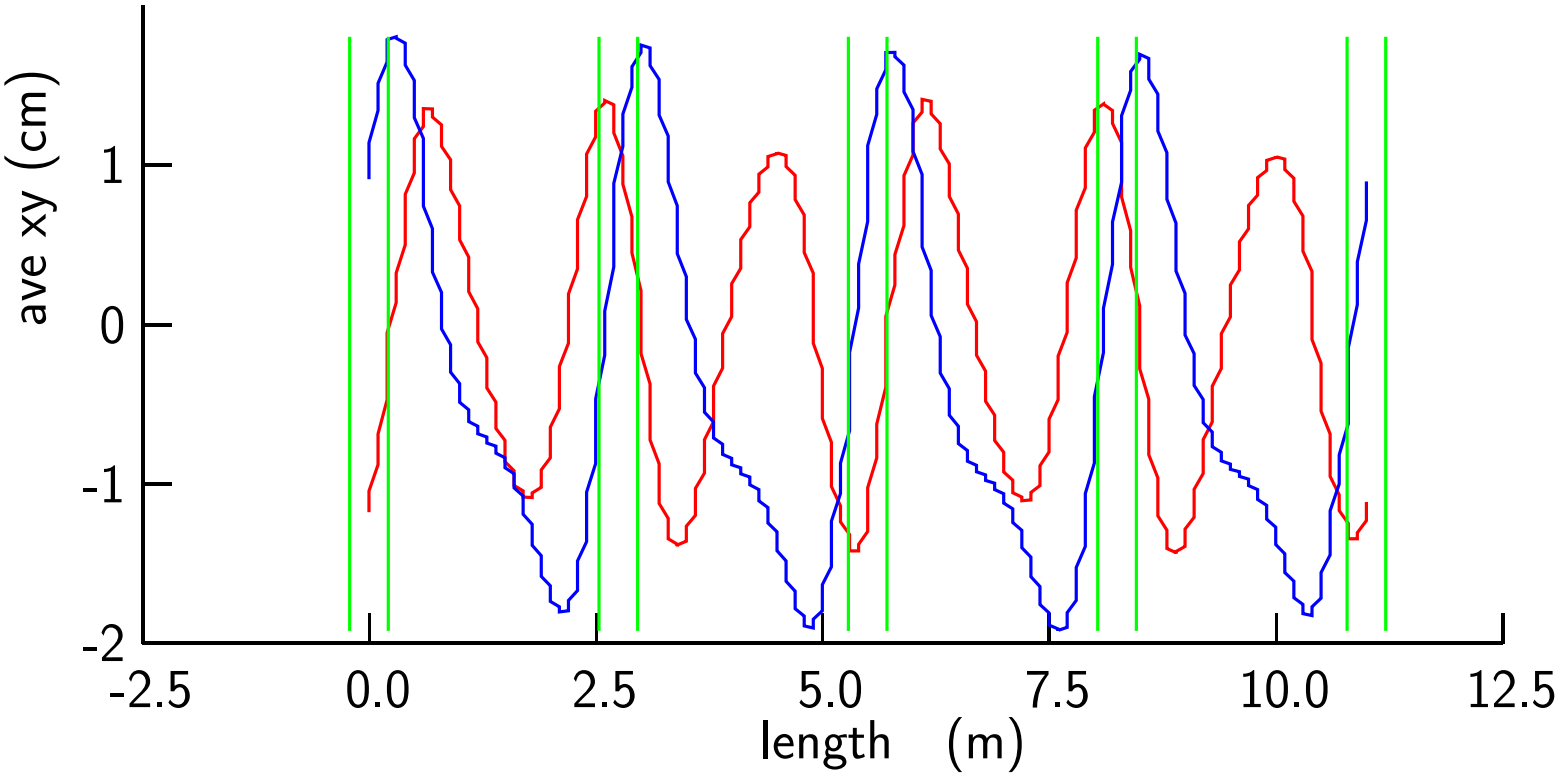



B (T)
2
1
0
-1
-2
-3
-2.5
0.0
2.5
5.0
7.5
10.0
12.5
length (m)


beta (cm)
150
100
50
0
-2.5
0.0
2.5
5.0
7.5
10.0
12.5
length (m)

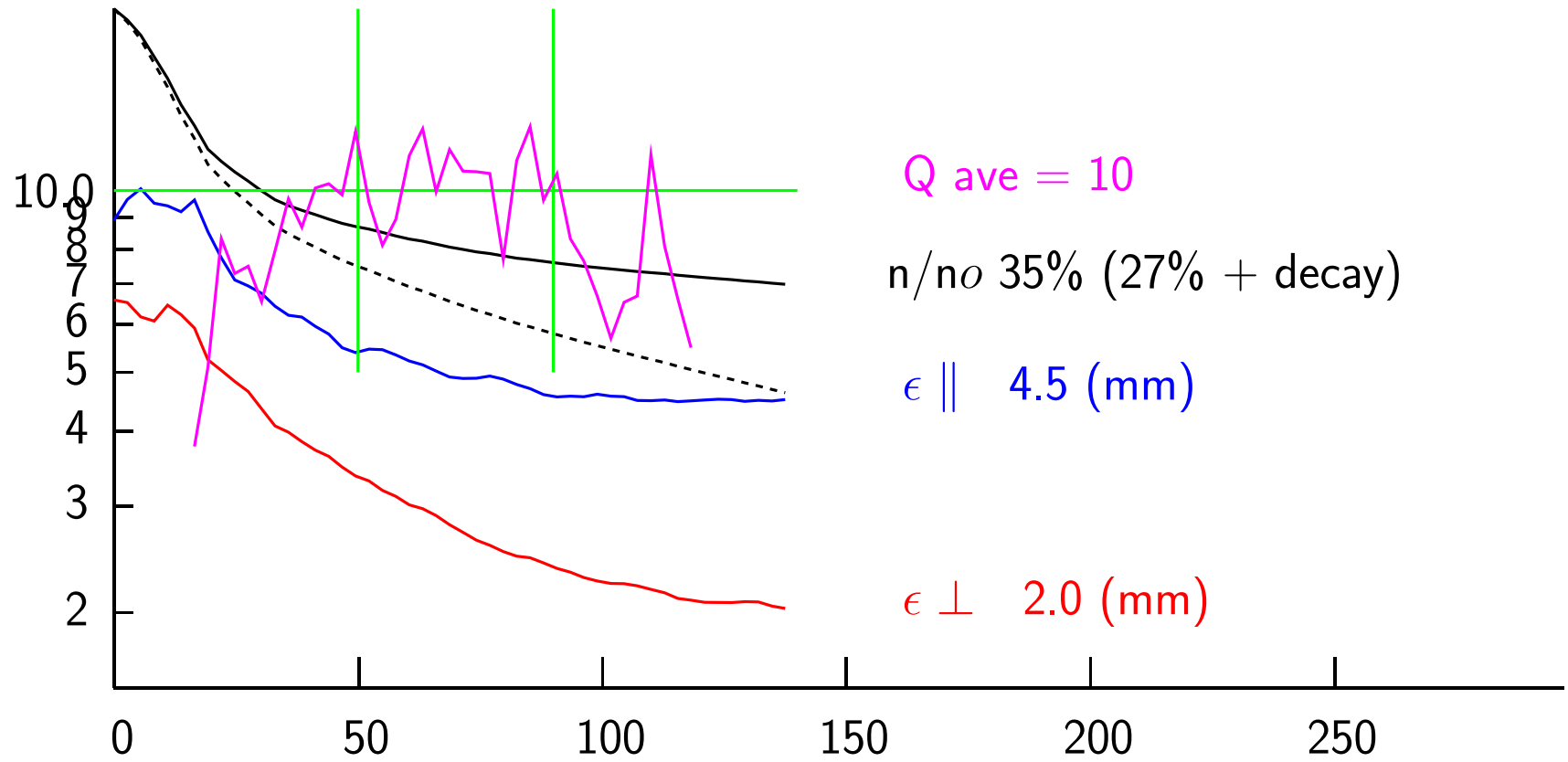

x
y
dispersion (cm)
25
0
-25
-50
-2.5
0.0
2.5
5.0
7.5
10.0
12.5
length (m)

x y



Similar

ICOOL Simulation



Cooling to 0.4 mm transverse

$\approx$ 1 mm longitudinal

which is too low for space charge

need less exchange that will held the transverse

Conclusion

- This lattice was conceived to reduce current densities for late stages
- But was tested first in an early 201 MHz stage
- Large dispersions (35 cm) are seen with small tilts (1 deg.) from the 2π resonance at the high momentum end
- The 6D cooling with a plane absorber was not expected
- But once seen has been pursued
- This cooling must arise from the strong angular dispersion at the absorbers combined with significant mean angles
- This is similar to Yuri's Helical FOFO Snake, but is here planar and SFOFO
- This result need confirmation
- And late stage designs