ICOOL Acceptance Studies of PRISM

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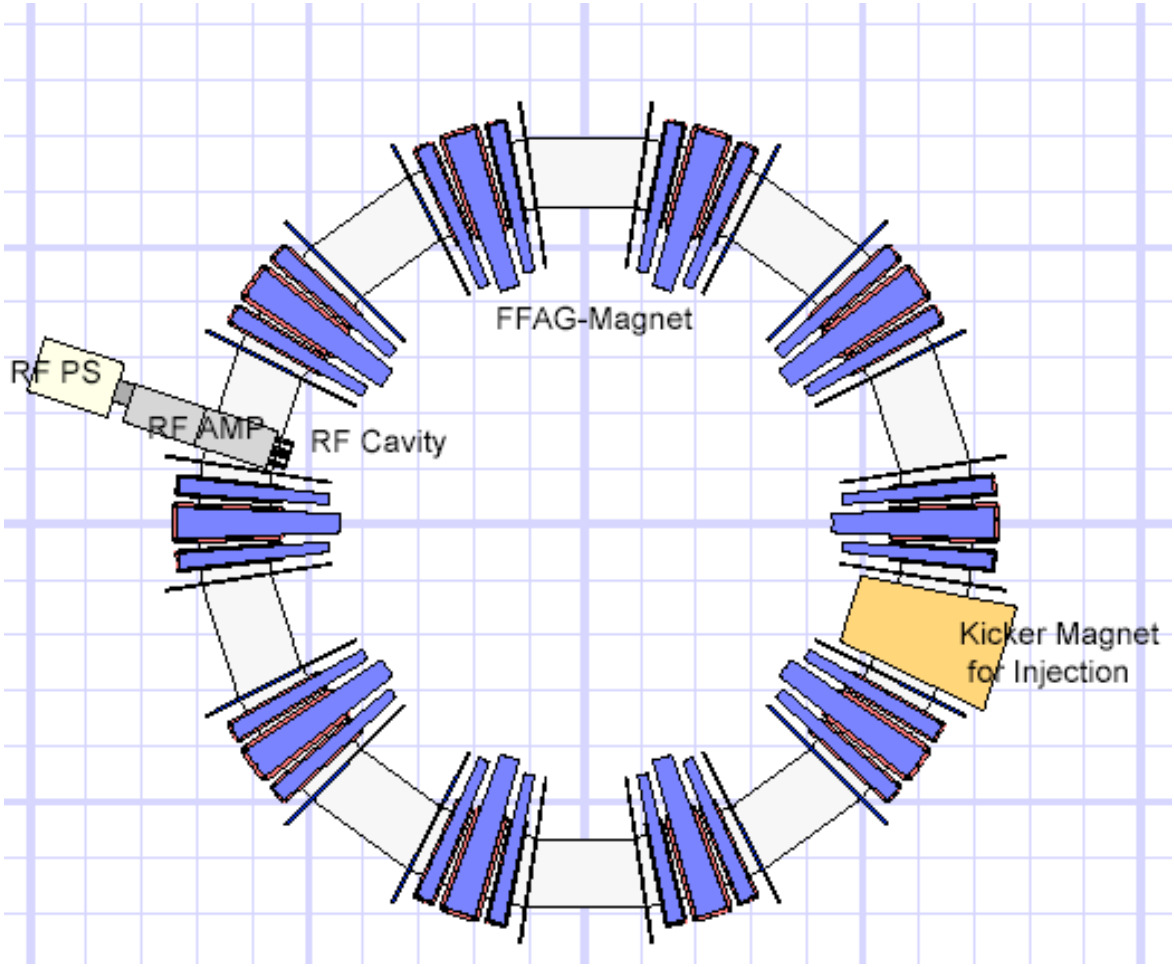
Friday meeting 9/10/04



ICOOL Method

Represent Scaling by sum of multipoles

Fields definen on a true circle that approximates the reference orbit

$$B_y(x) \;=\; B_o(x+R)^k \;\approx\; B_o\ \Sigma_{n=1}^{n=5} M_n\ r^n$$

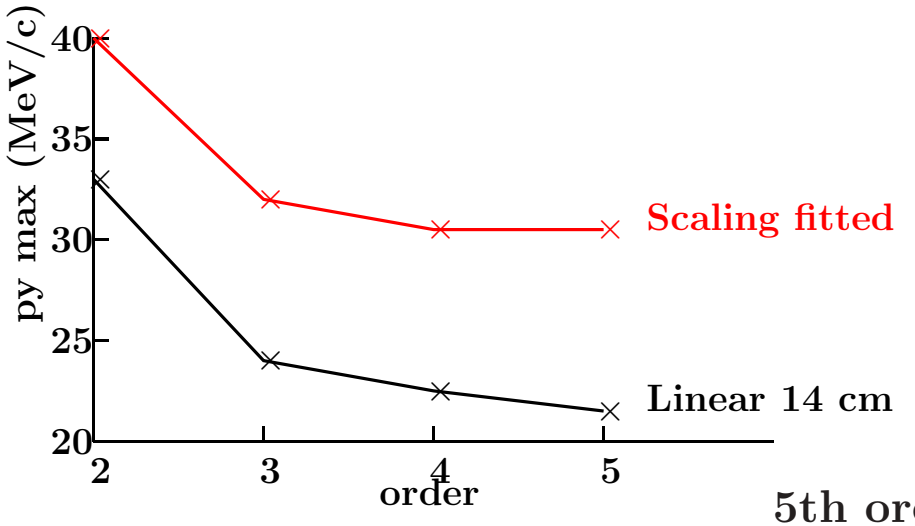
$$M_n = \frac{\Pi_{i=0}^{i=n-1} k^i}{n!}$$

Hyperbolic tangent approx to ends $dz = \frac{\text{Distance from end}}{\Gamma}$

$$B \;=\; B_o\ \frac{(e^{dz} - e^{-dz})}{(e^{dz} + e^{-dz})}$$

ICOOL Field Calculations

Using maxwell's equations fields off axis derived from multipoles on axis



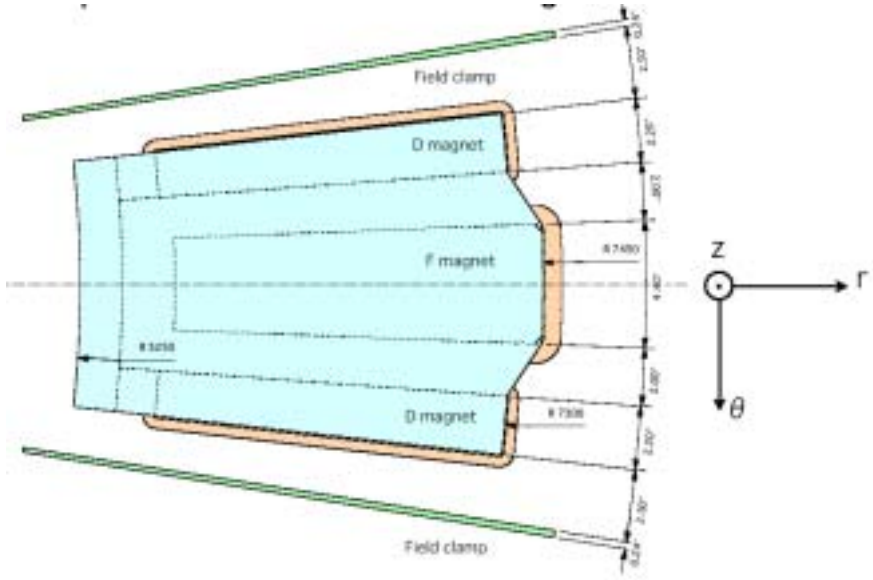
5th order calculations used

End Shapes Method 1

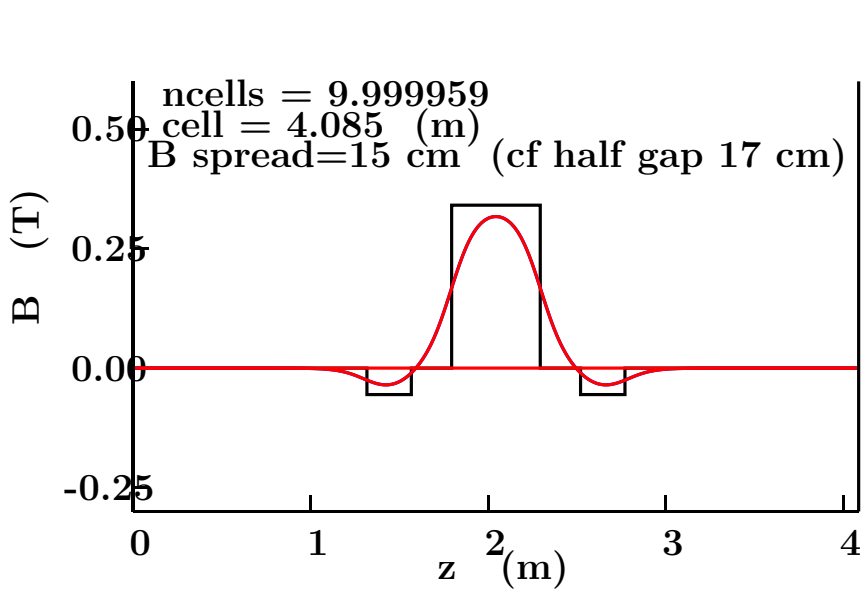
- magnet lengths from figure in Arimoto at Nufac04
- Shape parameter Γ =15 cm (typical for normal magnet)
- Adjust Fields to get tunes from Sato's talk at Nufac04

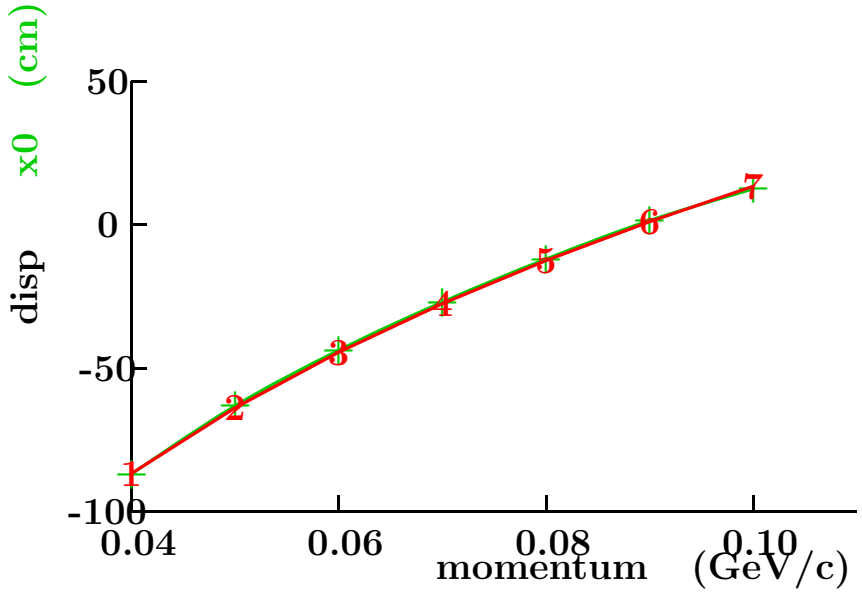
Table 1: Present parameters of PRISM-FFAG

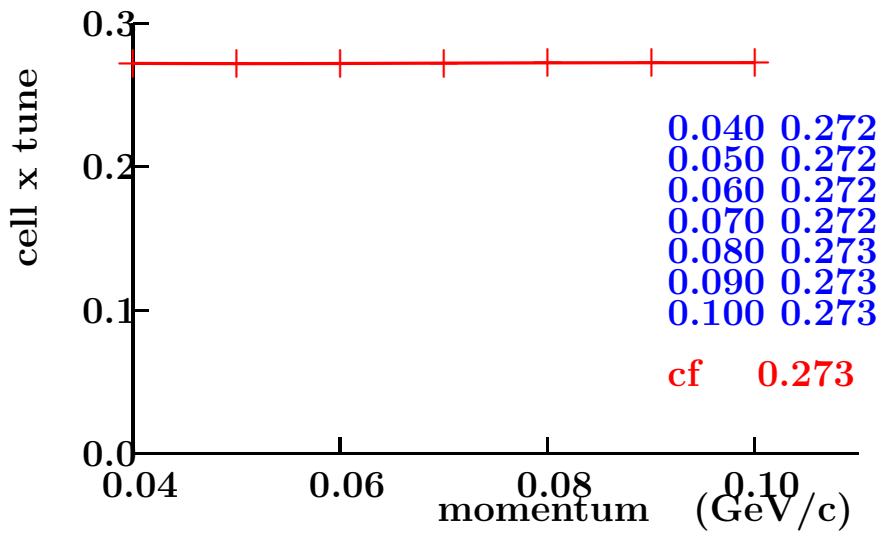
Number of sectors	10
Magnet type	Radial sector
	DFD triplet
Field index (k-value)	4.6
F/D ratio	6.2
Opening angle of magnets	F/2 : 2.2deg.
	D : 2.2deg.
Half gap of magnets	17cm
Maximum field	Focus. : 0.4 Tesla
	Defocus. : 0.065 Tesla
Average radius	6.5m for 68MeV/c
Tune	horizontal : 2.73
	vertical : 1.58

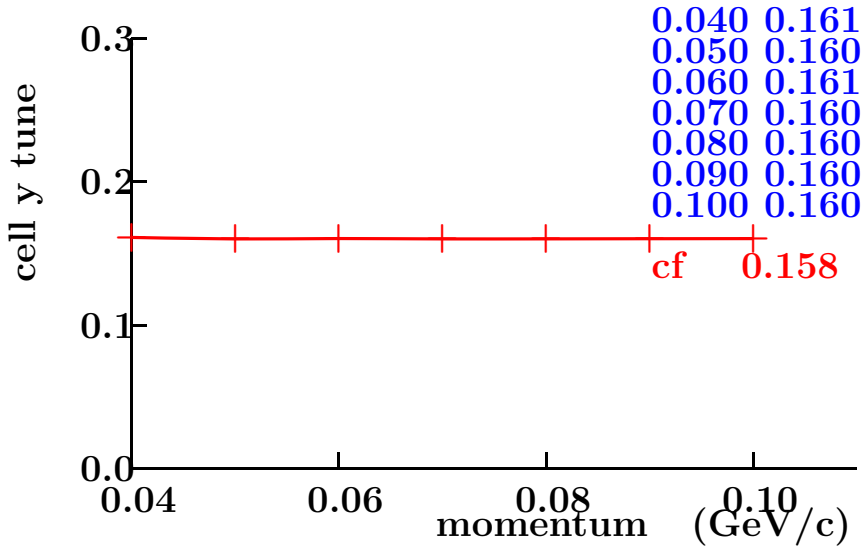


Momentum	MeV/c	68
Field Index k		4.6
beta x	m	1.75
beta y	m	3.8
momentum range for ± 40 cm		× 2.11
x tune at 68 MeV/c		.272 x 10 = 2.72
y tune at 68 MeV/c		0.160 x 10 = 1.60


ncells = 9.999959
cell = 4.085 (m)
B spread=15 cm (cf half gap 17 cm)
B (T)
0.50
0.25
0.00
-0.25
0
1
2
3
4
z (m)

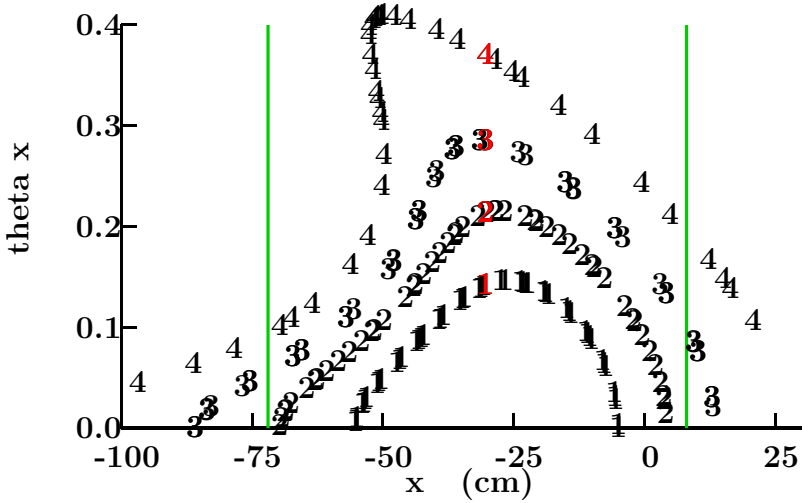

disp x0 (cm)
50
0
-50
-100
1
2
3
4
5
6
7
0.04
0.06
0.08
0.10
momentum (GeV/c)

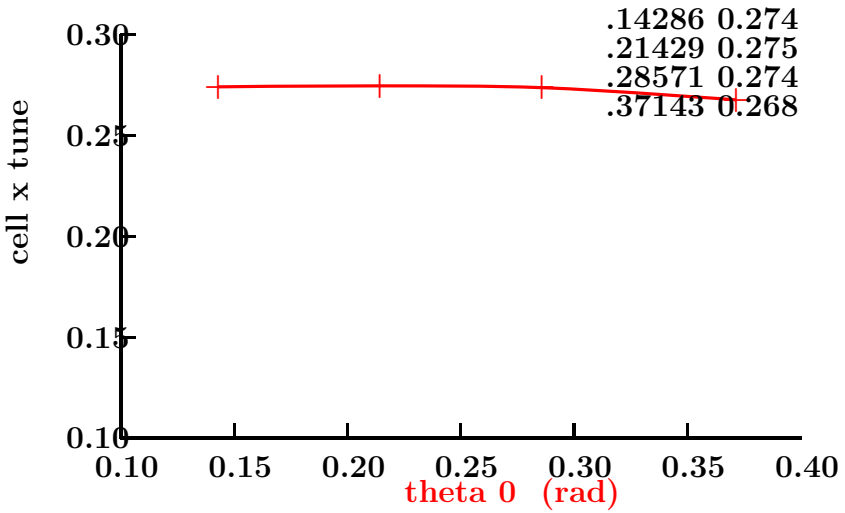

cell x tune
0.3
0.2
0.1
0.0
0.040 0.272
0.050 0.272
0.060 0.272
0.070 0.272
0.080 0.273
0.090 0.273
0.100 0.273
cf 0.273
0.04
0.06
0.08
0.10
momentum (GeV/c)


cell y tune
0.3
0.2
0.1
0.0
0.040 0.161
0.050 0.160
0.060 0.161
0.070 0.160
0.080 0.160
0.090 0.160
0.100 0.160
cf 0.158
0.04
0.06
0.08
0.10
momentum (GeV/c)

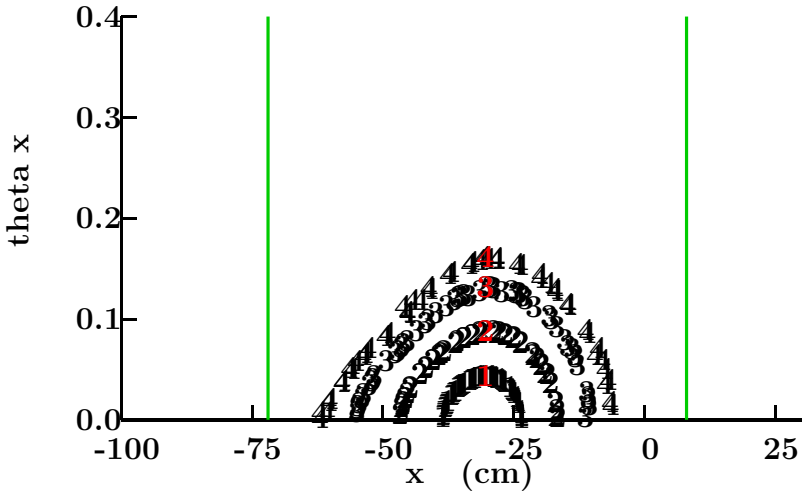
Dynamic aperture

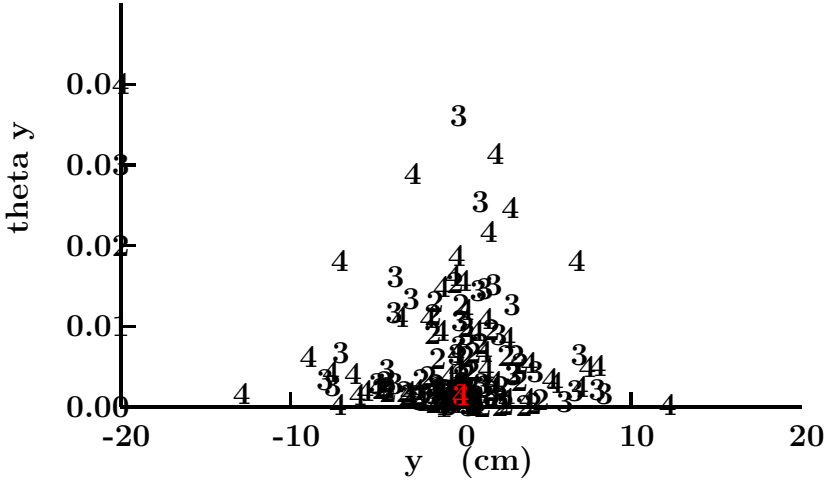
x motion with no initial y

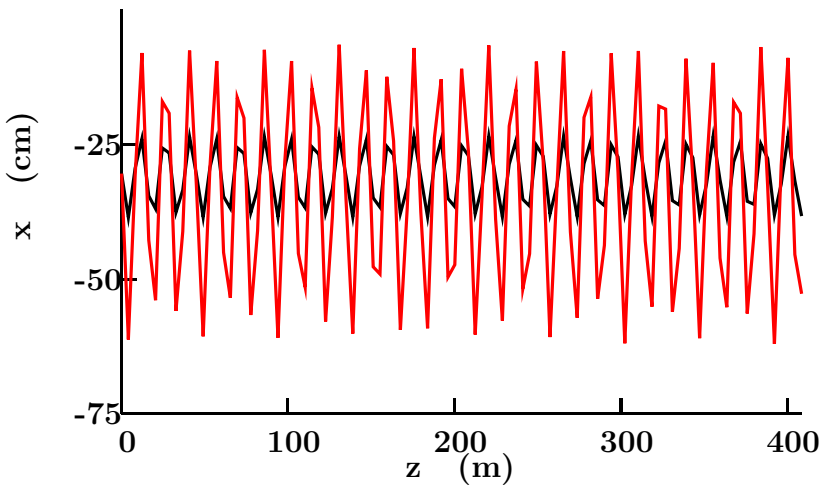


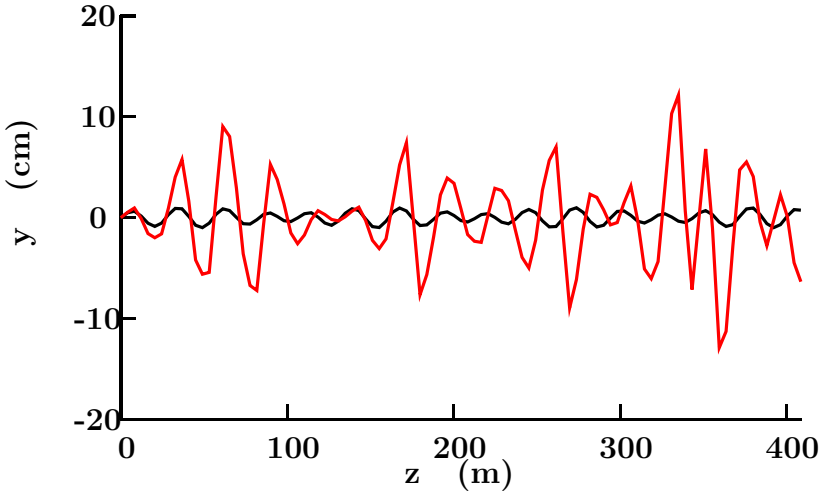


x motion with epsilon initial y

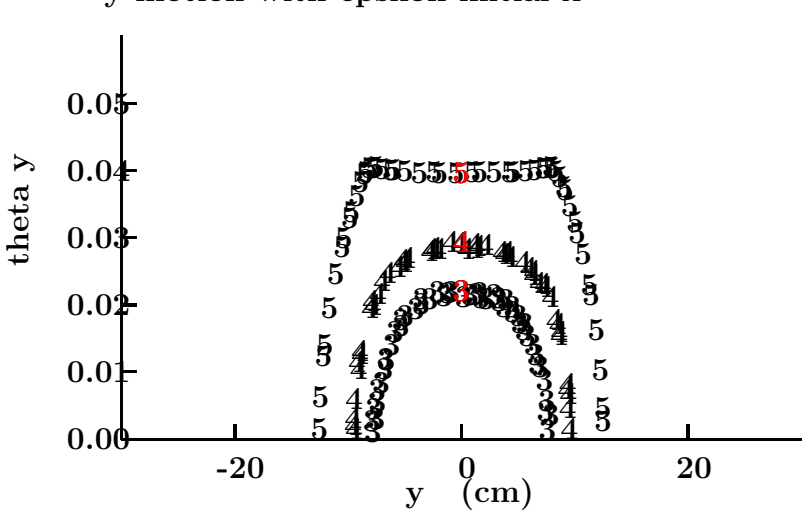


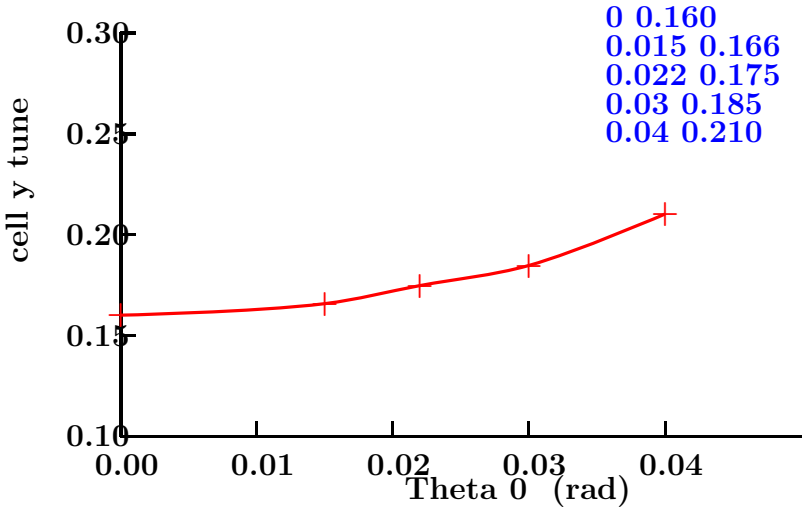




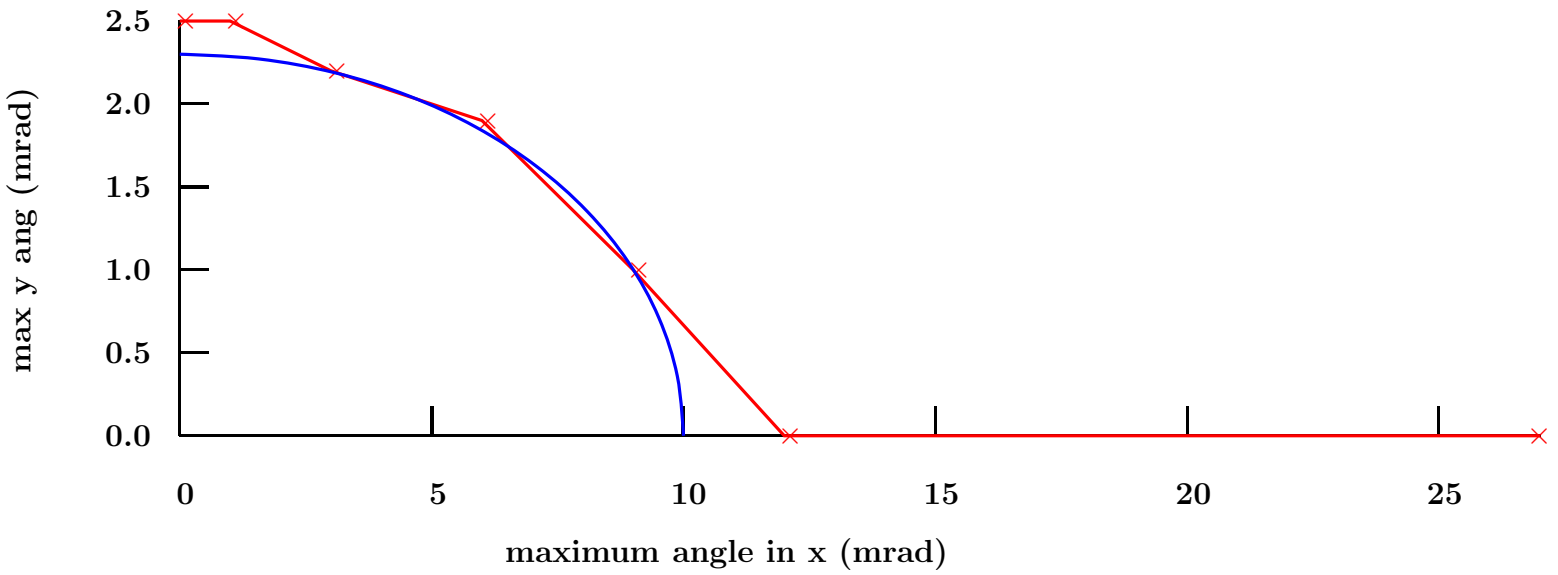


y motion with epsilon initial x



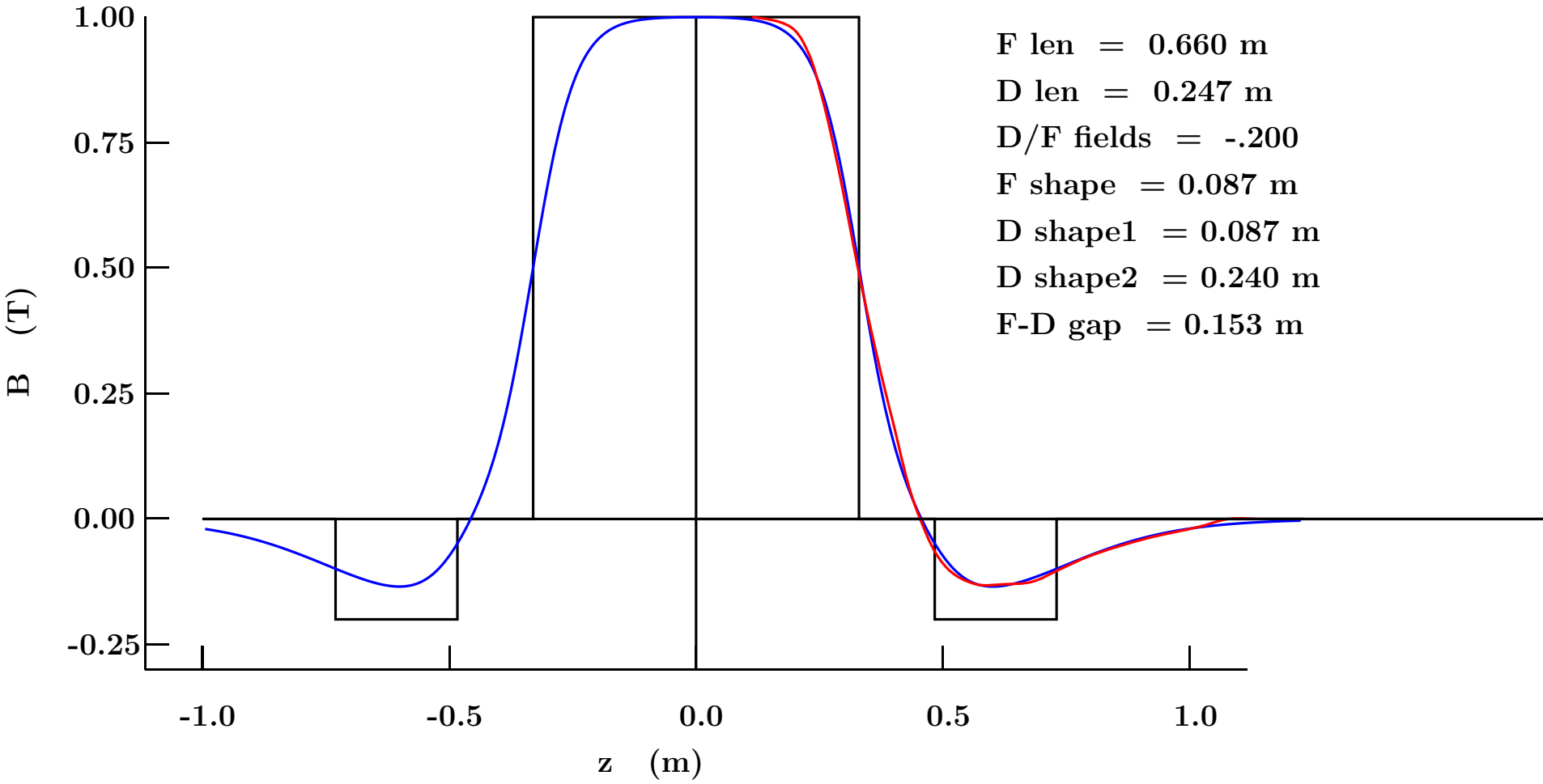


Acceptance with both x and y amplitudes

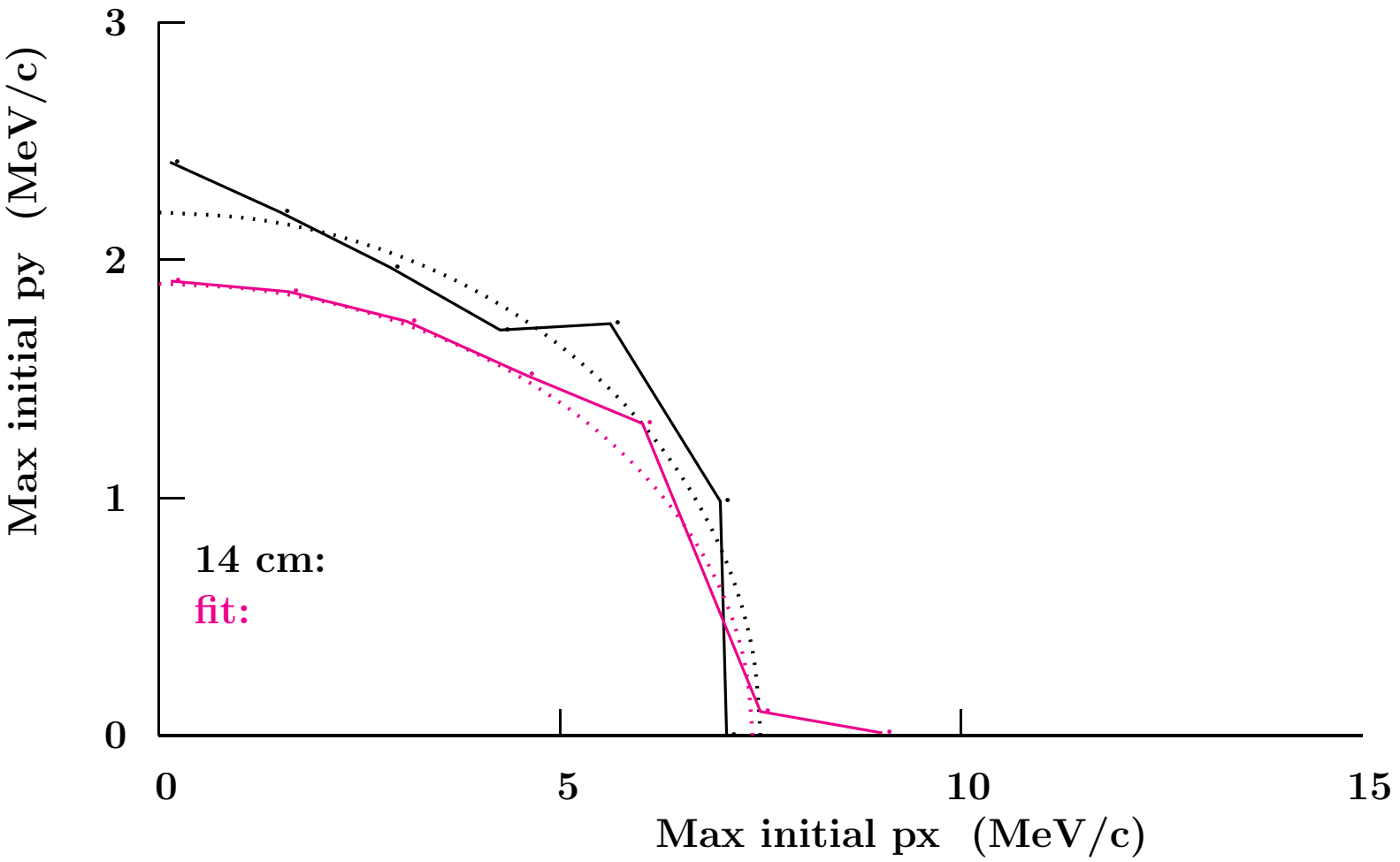


Values on axes give optimistic esstimate of acceptance

End Fields Method 2

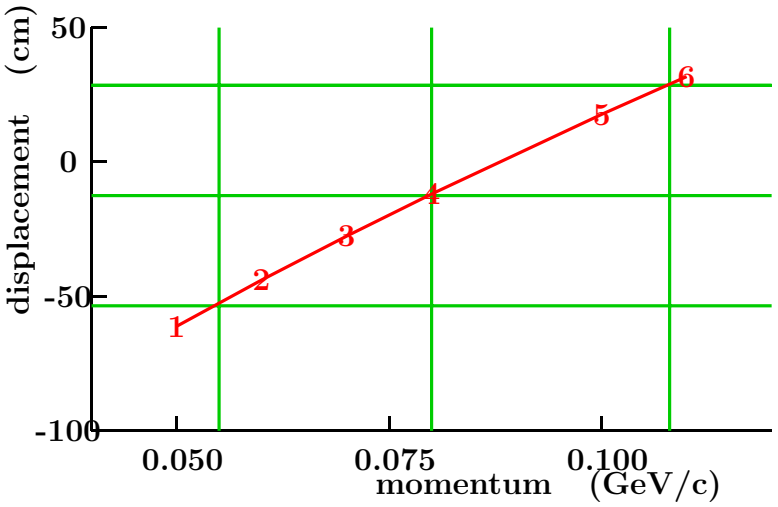


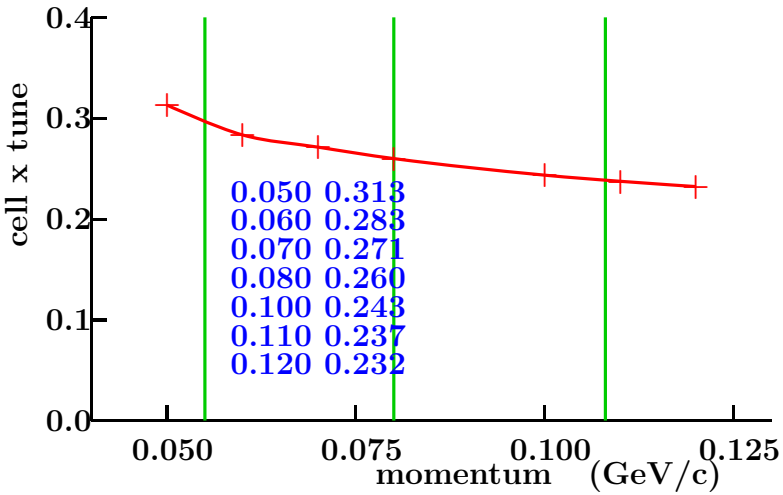
Compare Acceptances

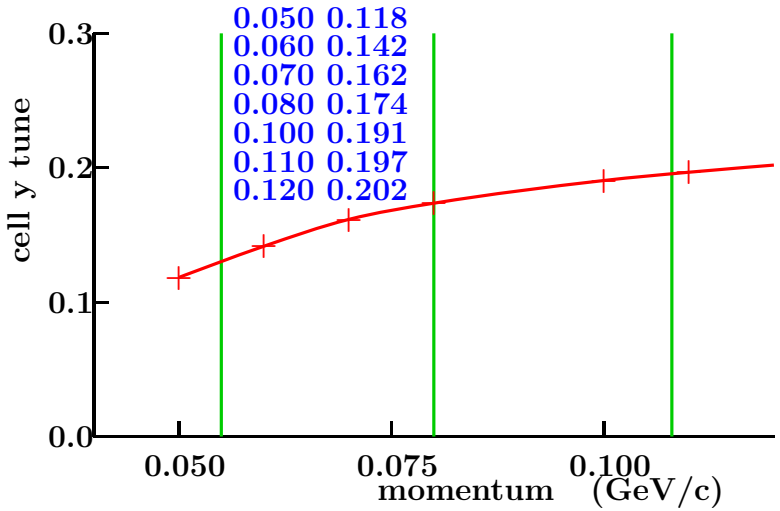


Acceptance in y worse probably because of steeper dB/ds

Linear Magnets i.e. Non-Scaling

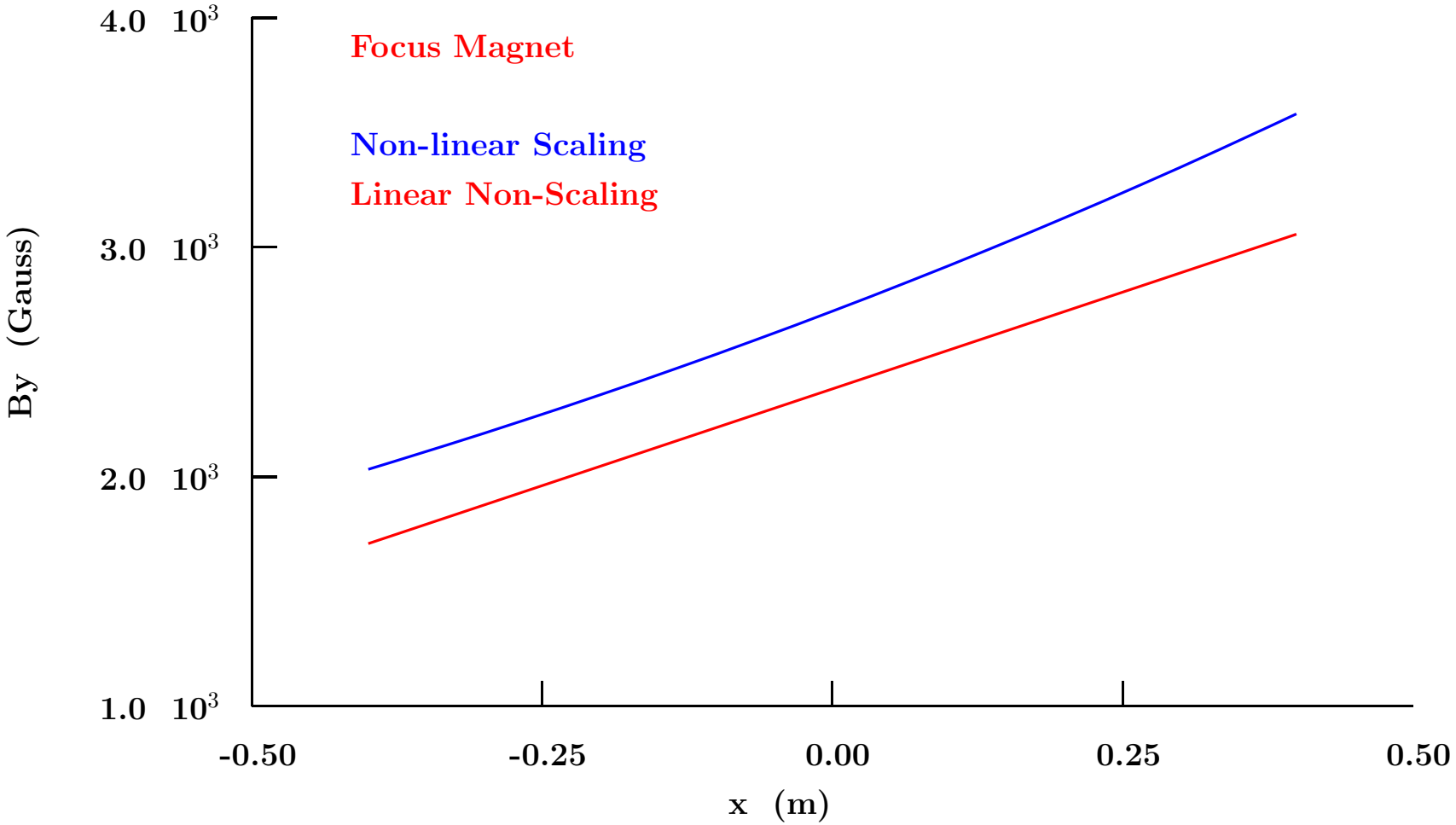




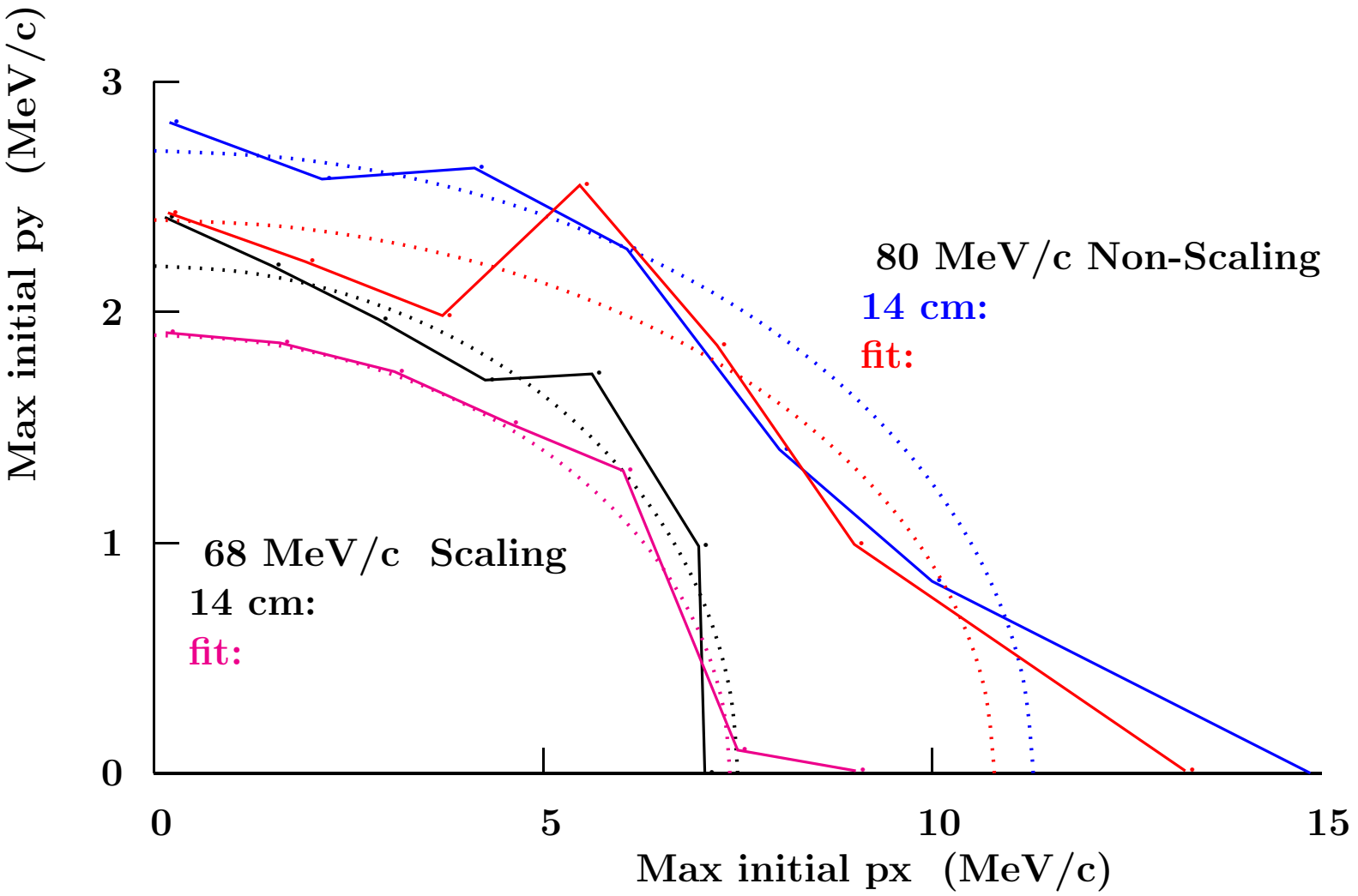


Move momentum range up to avoid 3rd order resonance at low end
Range remains approximarely the same: factor of 2

After recaling to 68 MeV/c Fields are lower



Compare Acceptances



Linear latices have larger acceptance

Best solution gain is more than 3 times

Summary and Conclusions

End shapes	B vs x	x	y	xy
fitted	scaling	12.58	2.04	25.6
14 cm	scaling	12.92	2.73	35.3
fitted	linear	21.66	1.95	42.3
14 cm	linear	23.71	2.47	58.6

- The ICOOL simulation using 5 multiploles to represent the exponent k, gives a good representation of a scaling lattice. Tracking a single particle through 100 cells takes approximately 6 seconds on a 2.4 GHz Pentium laptop.
- The observed x acceptances for zero perpendicular amplitudes agree qualitatively with Sato's report at NUFAC04, but other acceptances appear somewhat lower.
- Using a fit to the s field dependence in Arimoto'd NUFACT04 talk gave somewhat less acceptances than more gentle field shapes.
- Removing all higher moments, thus making the magnets simple combined function (dipole + quadrupole), gave almost the same momentum acceptance, and 2 times larger dynamic aperture at the chosen central momentum.
- But we have not studied the acceptance as a function of momentum, as is now required since different momenta have quite different tunes.