Towards a Higher Performance Frontend

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- **Work in Progress**
- **Based on PKJ Lyon Paper**
- **Basis for BNL sponsored Feasibility Study II**

http://pubweb.bnl.gov/people/palmer/nu/monterey/frontend.ps

Proton Driver

- e.g. AGS
- 6 bunches $\times \approx 2\ 10^{12}$
- 2.5 Hz (400 msec)
- Flat top for 75 msec
- Extract 6 bunches one every 15 msec

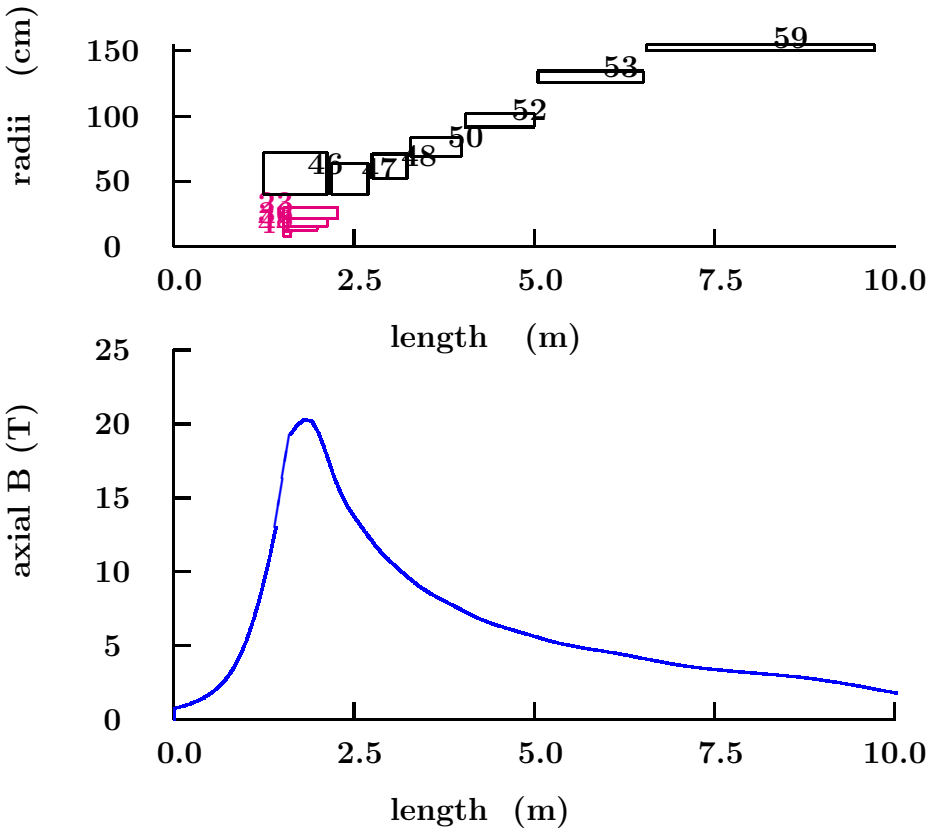
- Less target shock
- Single pulse Induction Linac
- less Acceleration Loading

Hg Target

- 5 mm diameter
- 30 cm long
- 150 mrad
- Optimized

Capture

- Aim for Long Life
- Lower field hollow Copper Insert
- Higher field Outsert
- Slower Taper
  20 T → 1.25 T
  over 18 m

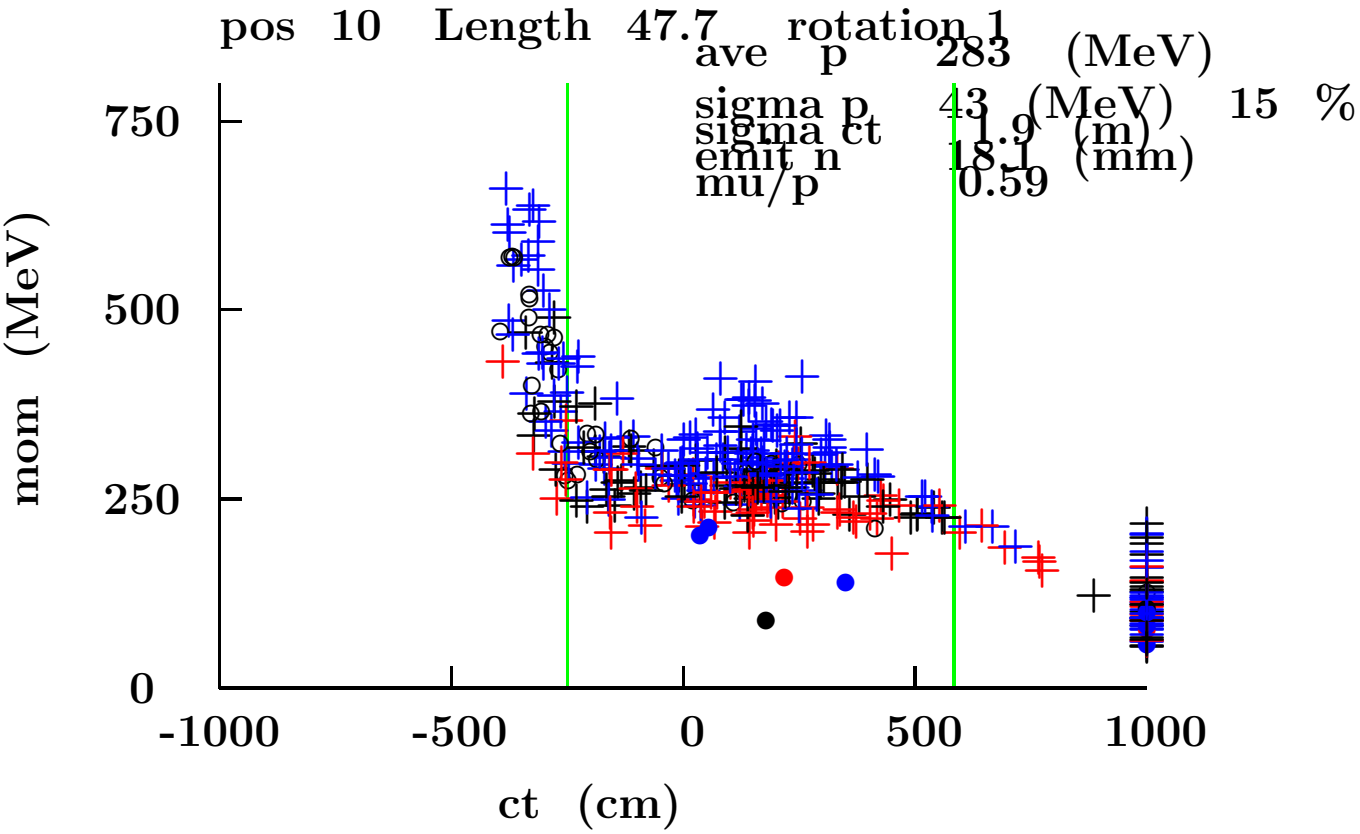


Phase Rotation 1

length m	frequency MHz	Gradient MeV/m
12	40	5
30	30	5
5	45	6

Non Distorting

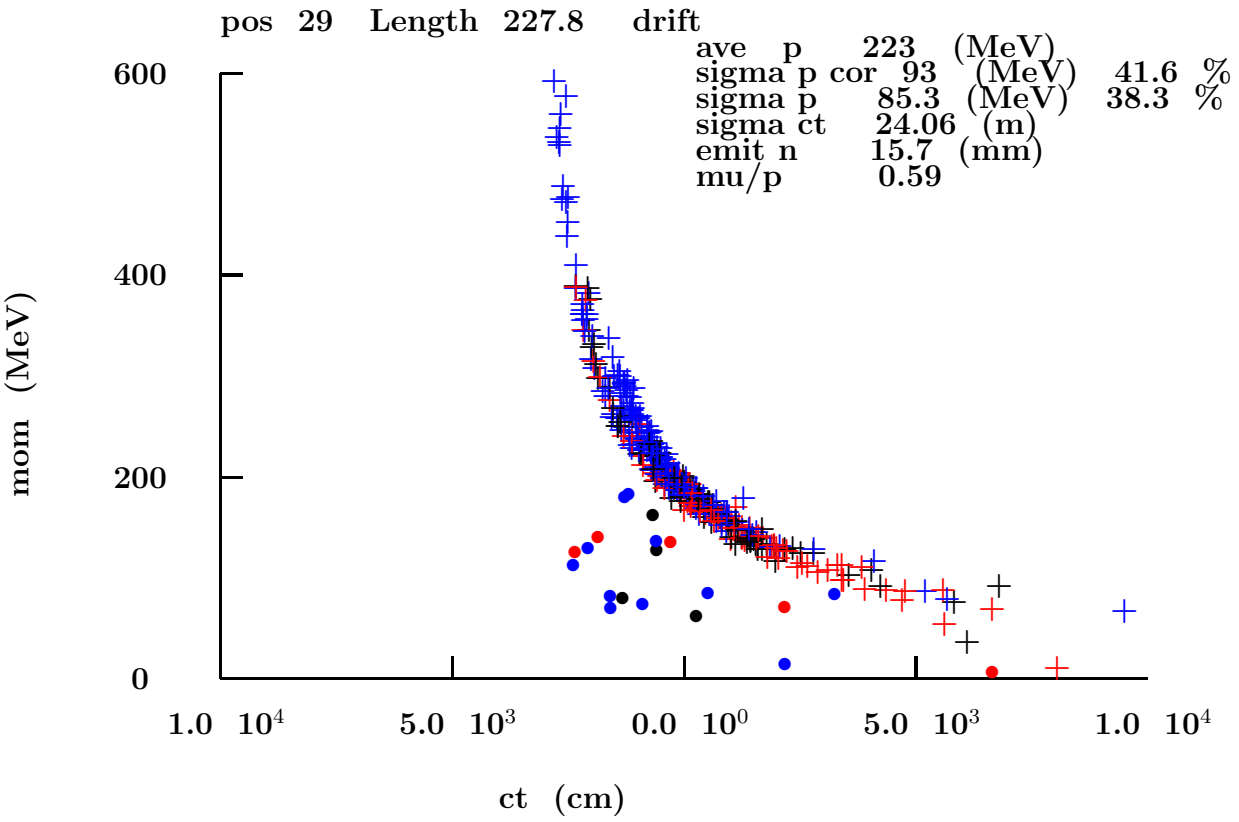
Designed to match 20 MHz Cooling

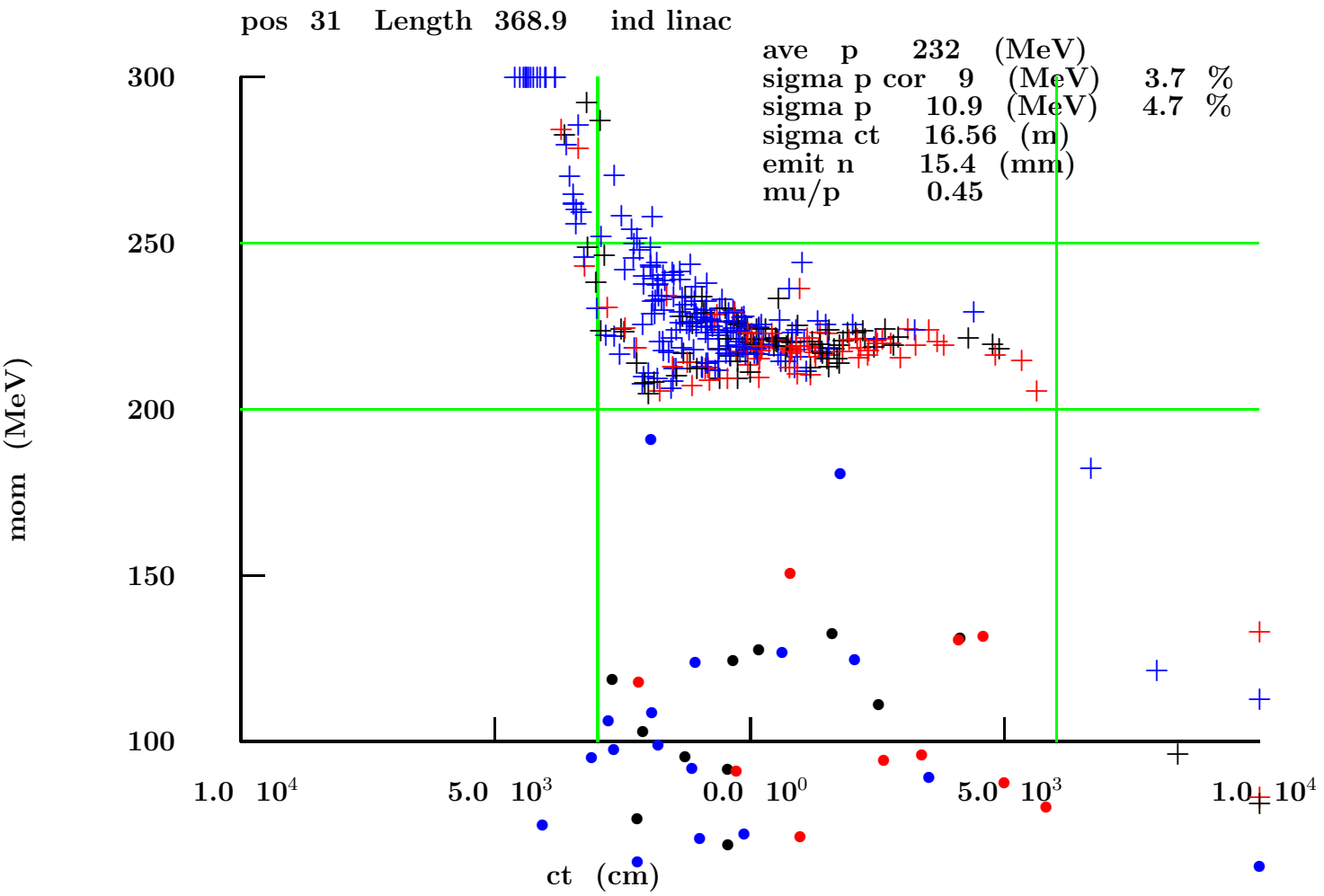


Phase Rotation 2

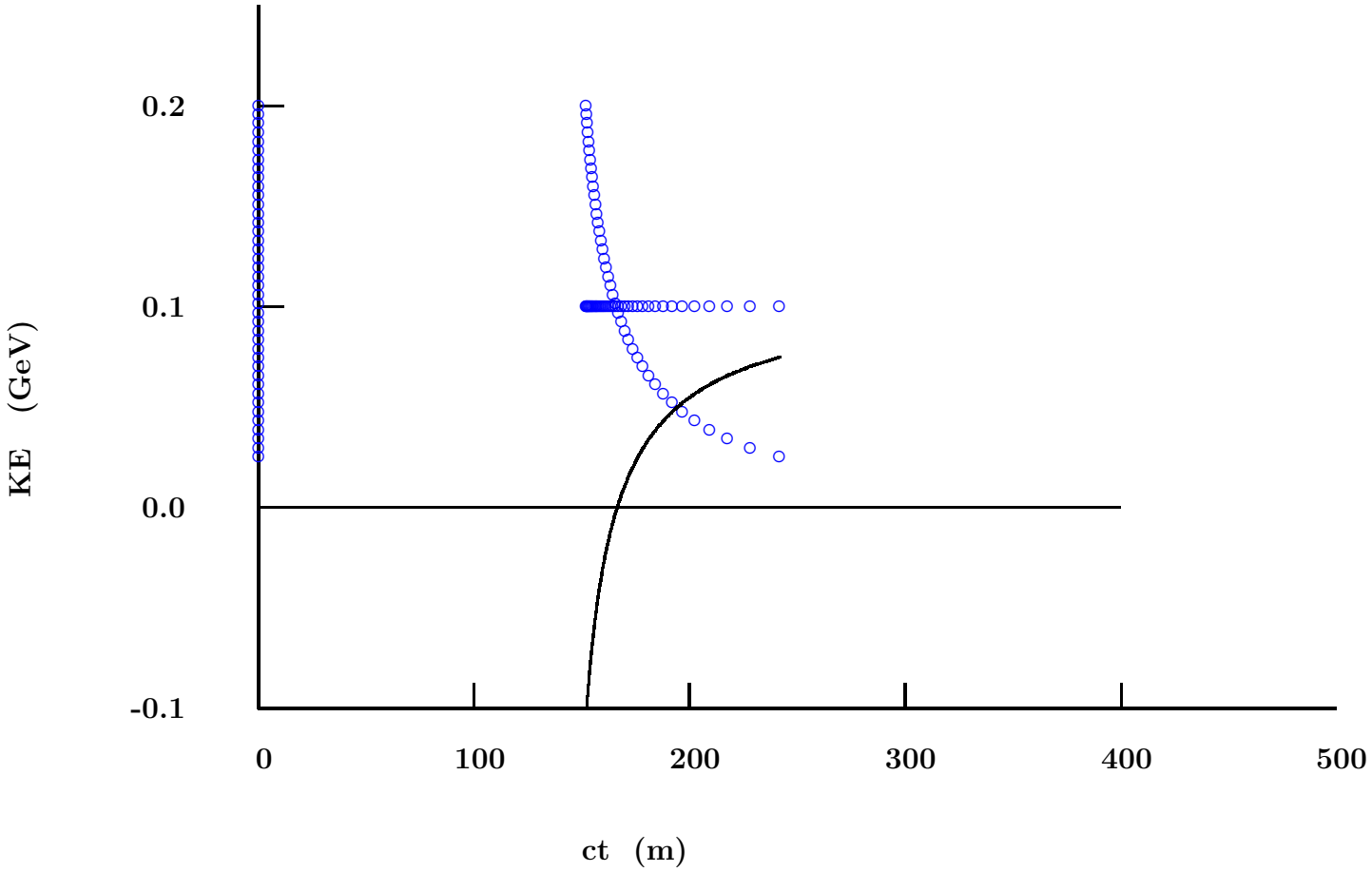
length m	frequency MHz	Gradient MeV/m
140	2.2	+/- 0.57

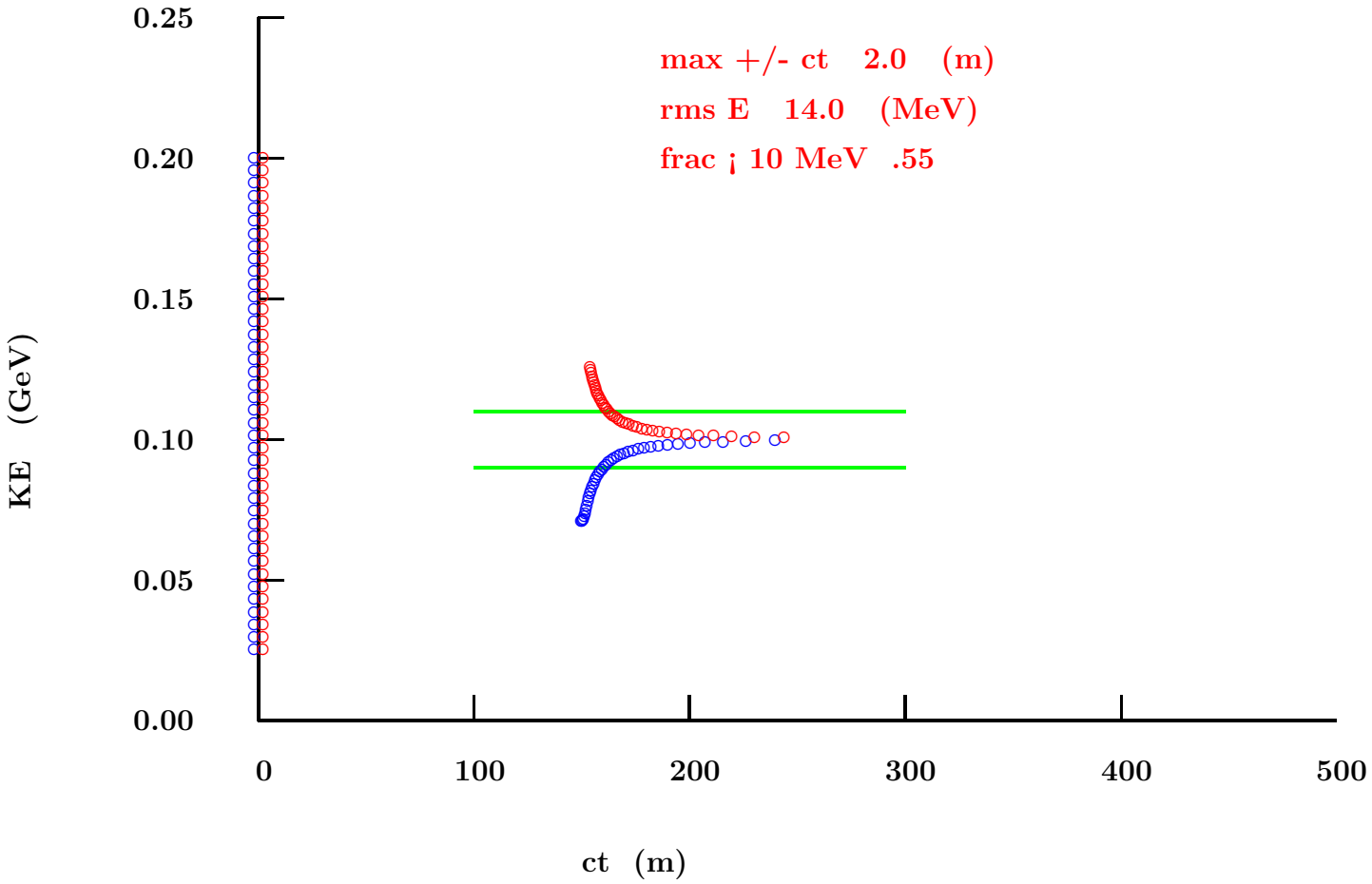
Distorting



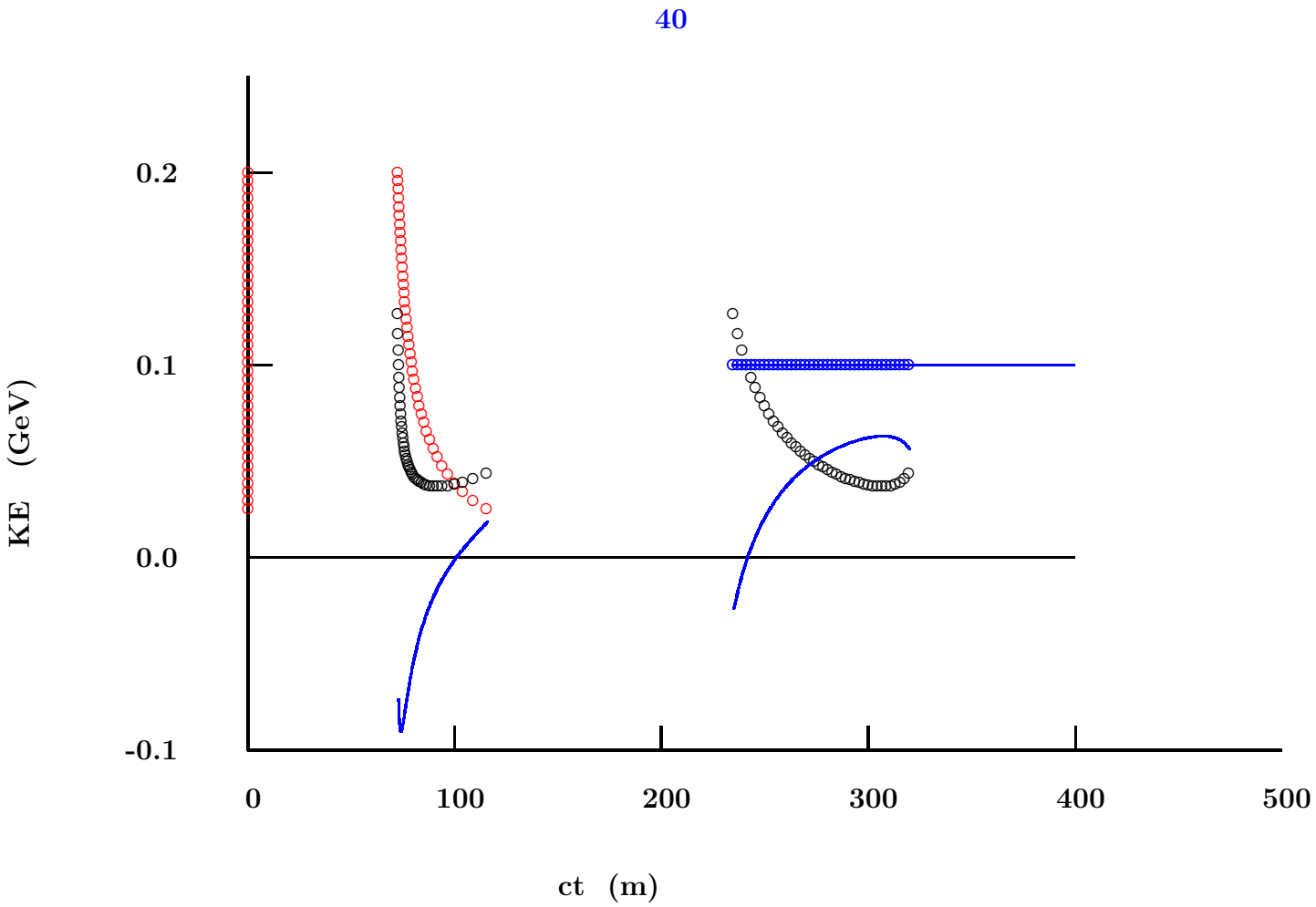

pos 31 Length 368.9 ind linac
ave p 232 (MeV)
sigma p cor 9 (MeV) 3.7 %
sigma p 10.9 (MeV) 4.7 %
sigma ct 16.56 (m)
emit n 15.4 (mm)
mu/p 0.45
300
250
200
150
100
mom (MeV)
1.0 10^4
5.0 10^3
0.0 10^0
5.0 10^3
1.0 10^4
ct (cm)

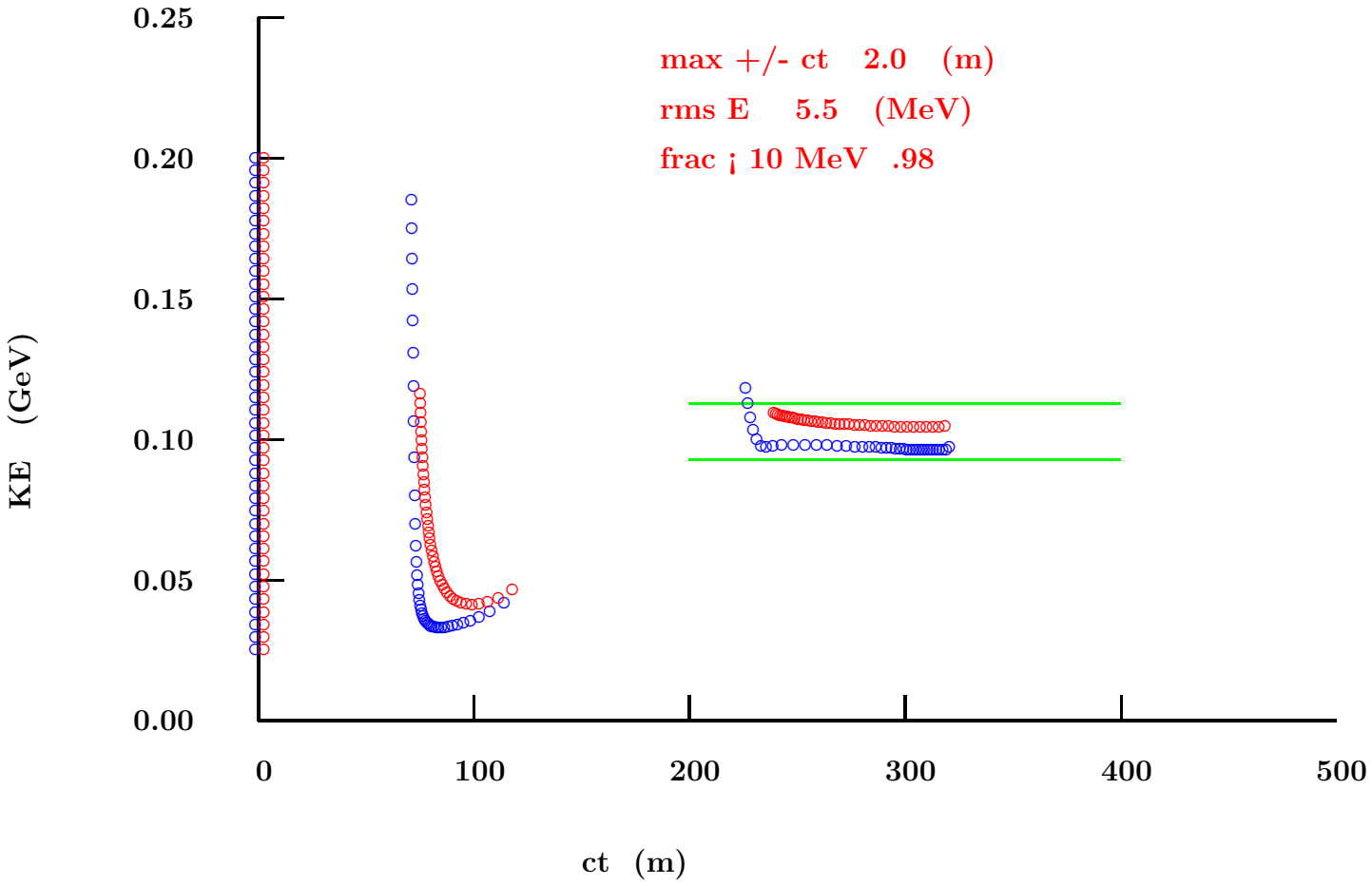
Normal Phase Rotation



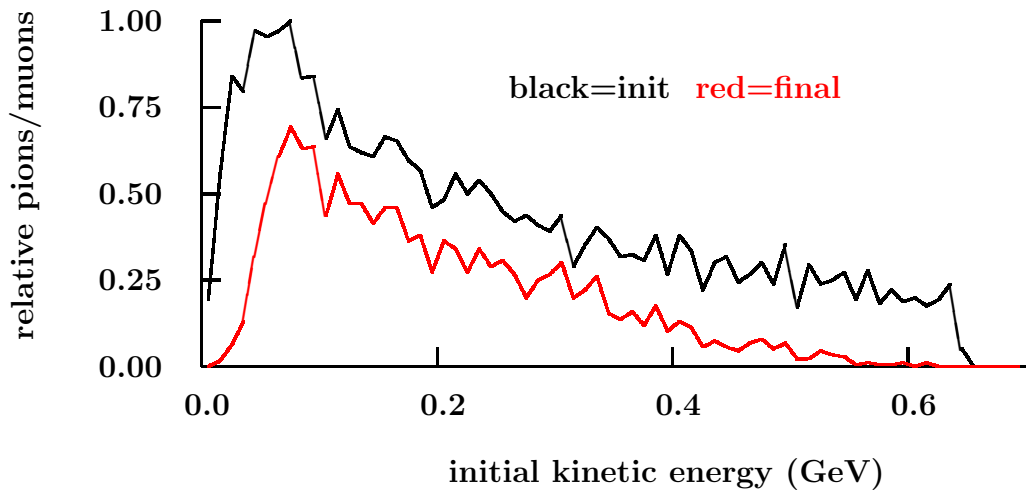

max +/- ct 2.0 (m)
rms E 14.0 (MeV)
frac ¡ 10 MeV .55
KE (GeV)
0.25
0.20
0.15
0.10
0.05
0.00
0
100
200
300
400
500
ct (m)

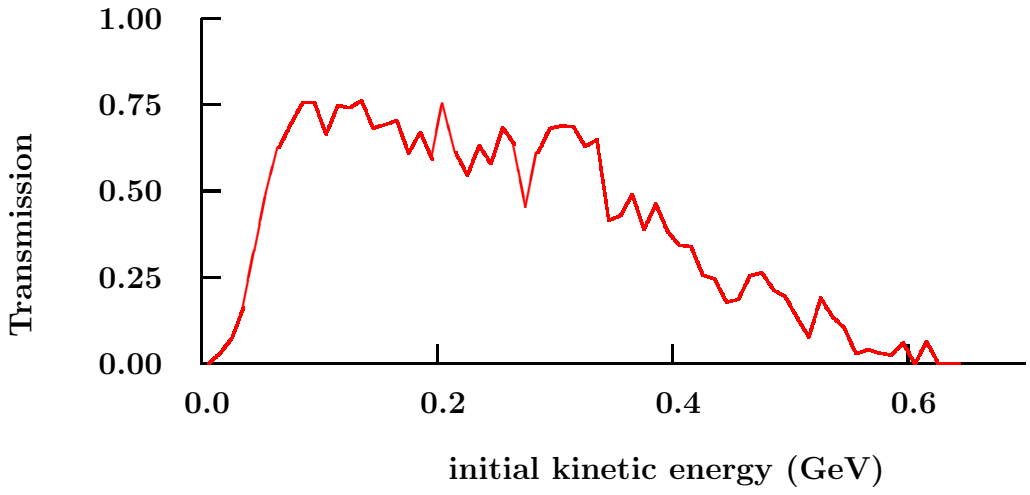
Non-distorting Phase Rotation



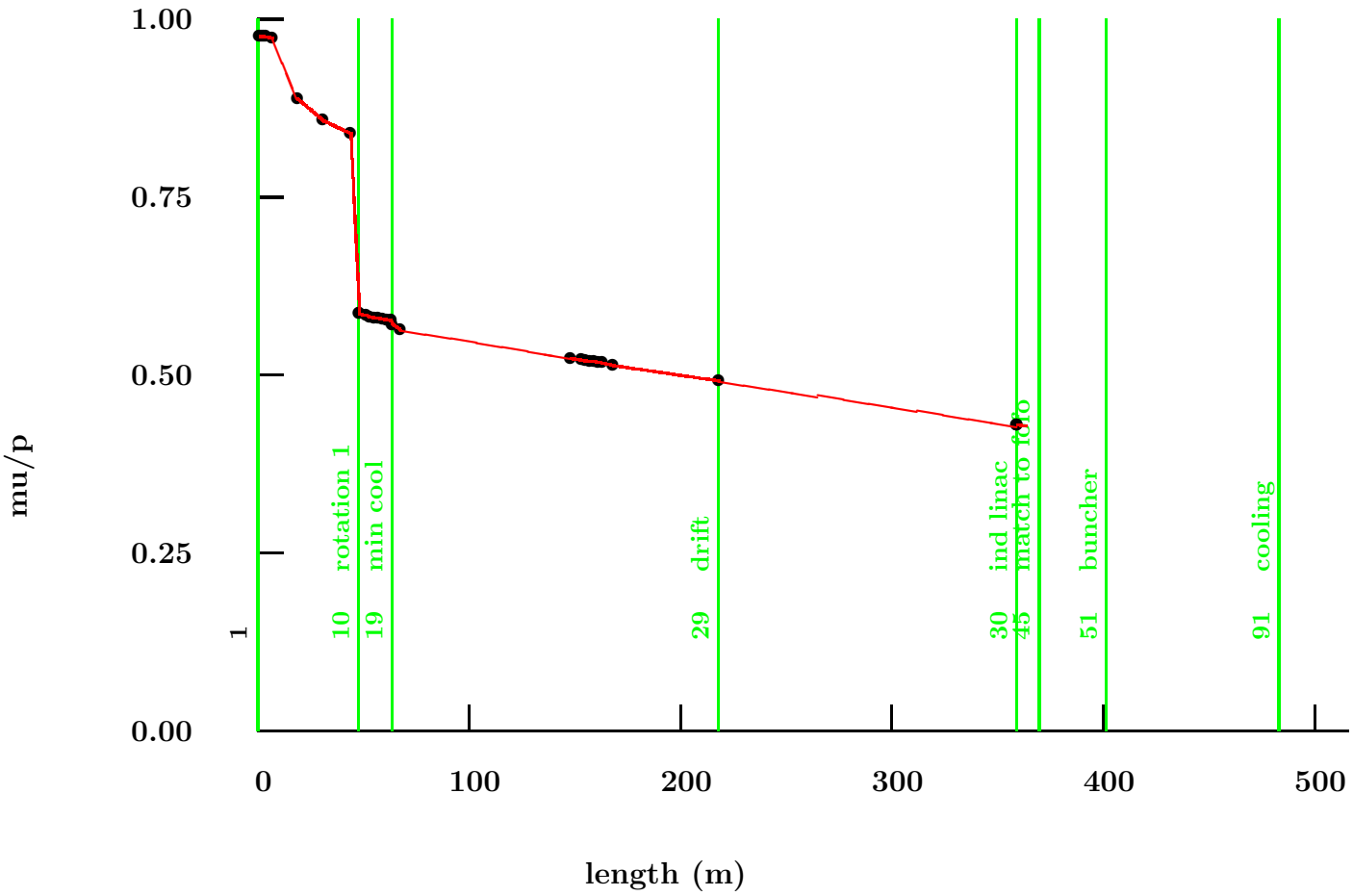

max +/- ct 2.0 (m)
rms E 5.5 (MeV)
frac ¡ 10 MeV .98
KE (GeV)
0.25
0.20
0.15
0.10
0.05
0.00
0
100
200
300
400
500
ct (m)

ICOOL Simulation of both Rotations





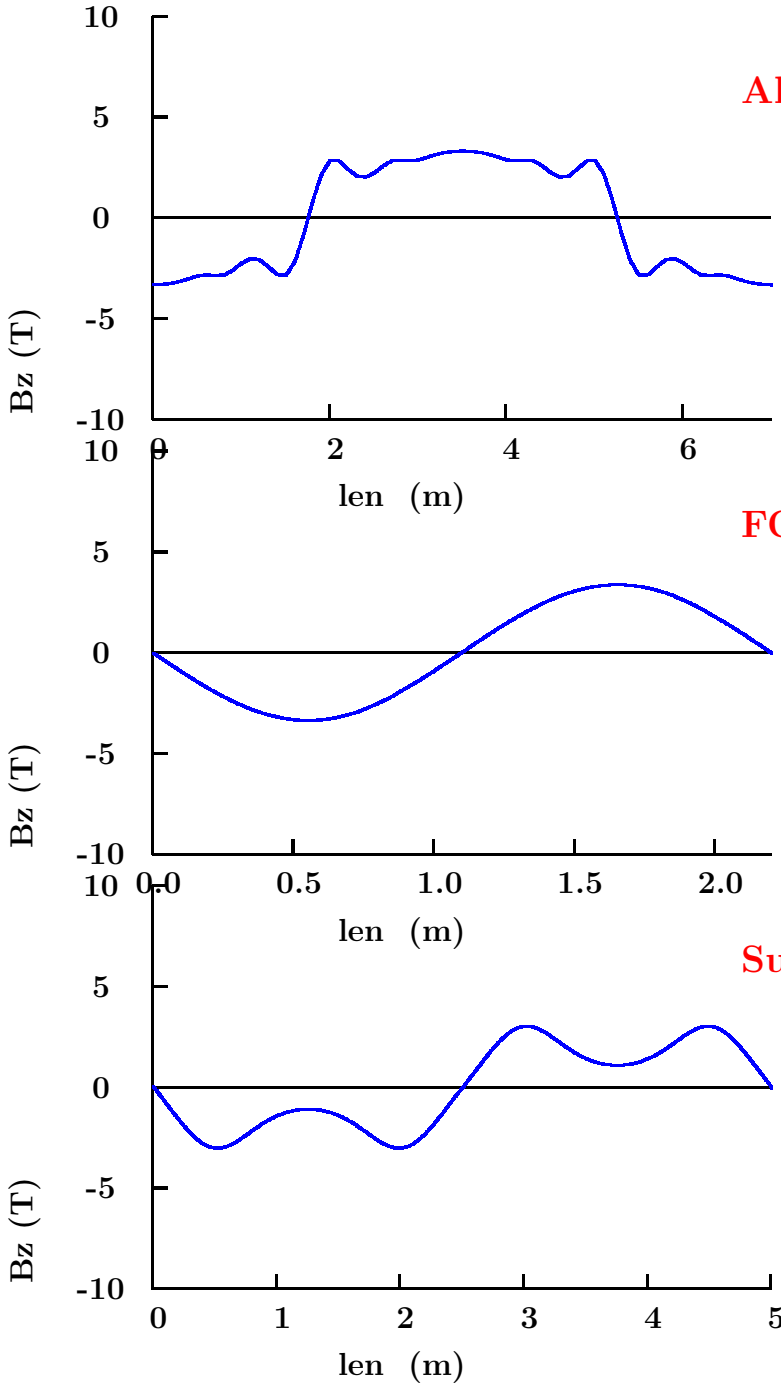
μ /p



At End:

- μ /p = **0.43**
- **dp/p = 3 %**
- σ_{ct} = **17 m**

Cooling Lattices



Alternating Solenoid

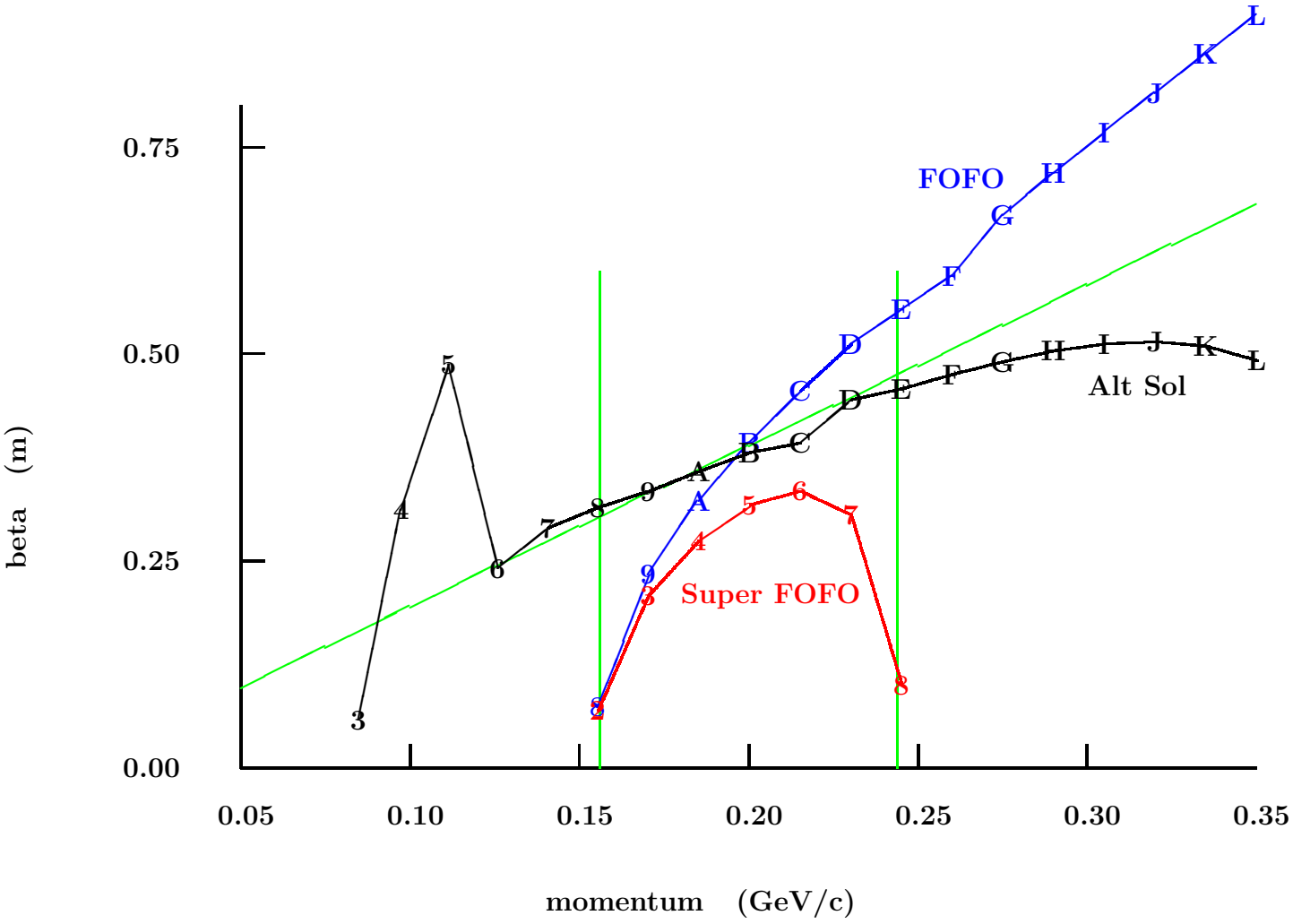
$B_z(\max) = 3.4$ (T)
$dB_z/dz(\max) = 15$ (T/m)

FOFO

$B_z(\max) = 3.4$ (T)
$dB_z/dz(\max) = 9.4$ (T/m)

Super FOFO

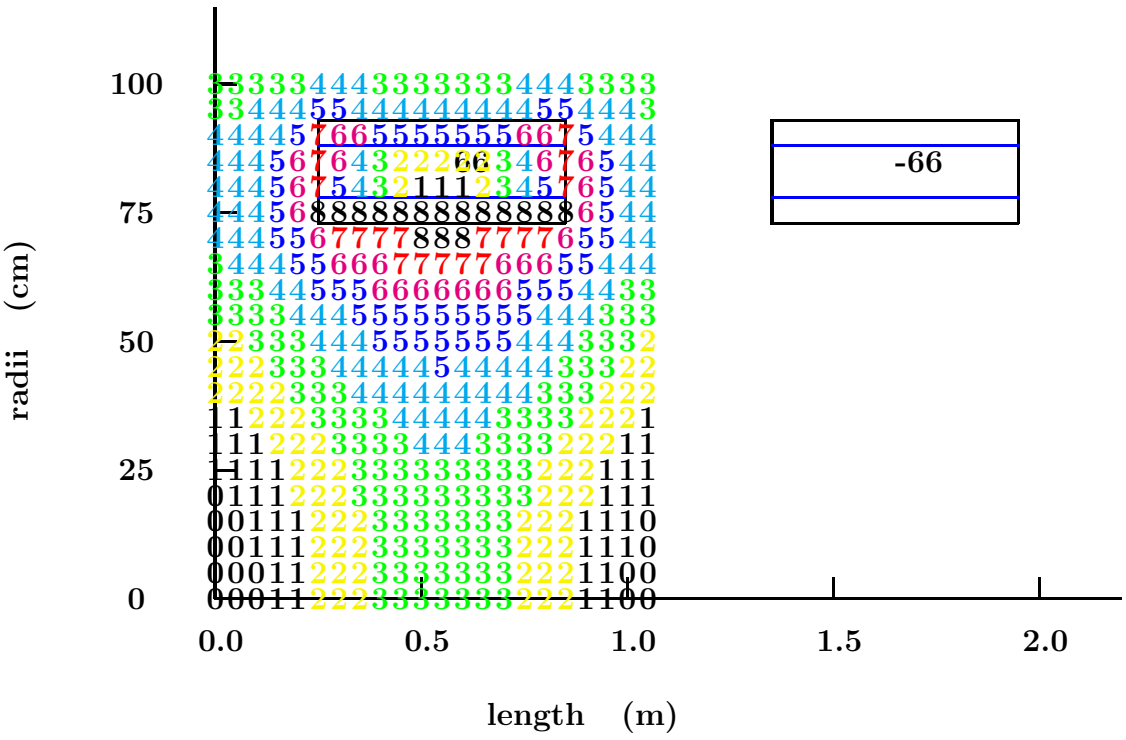
$B_z(\max) = 2.6$ (T)
$dB_z/dz(\max) = 7$ (T/m)


0.75
0.50
0.25
0.00
beta (m)
0.05
0.10
0.15
0.20
0.25
0.30
0.35
momentum (GeV/c)
FOFO
Alt Sol
Super FOFO

FOFO (for comparison)

len1 m	dl m	rad m	dr m		I/A A/mm^2
0.250	0.600	0.730	0.200	2	66.67
1.350	0.600	0.730	0.200	2	-66.67

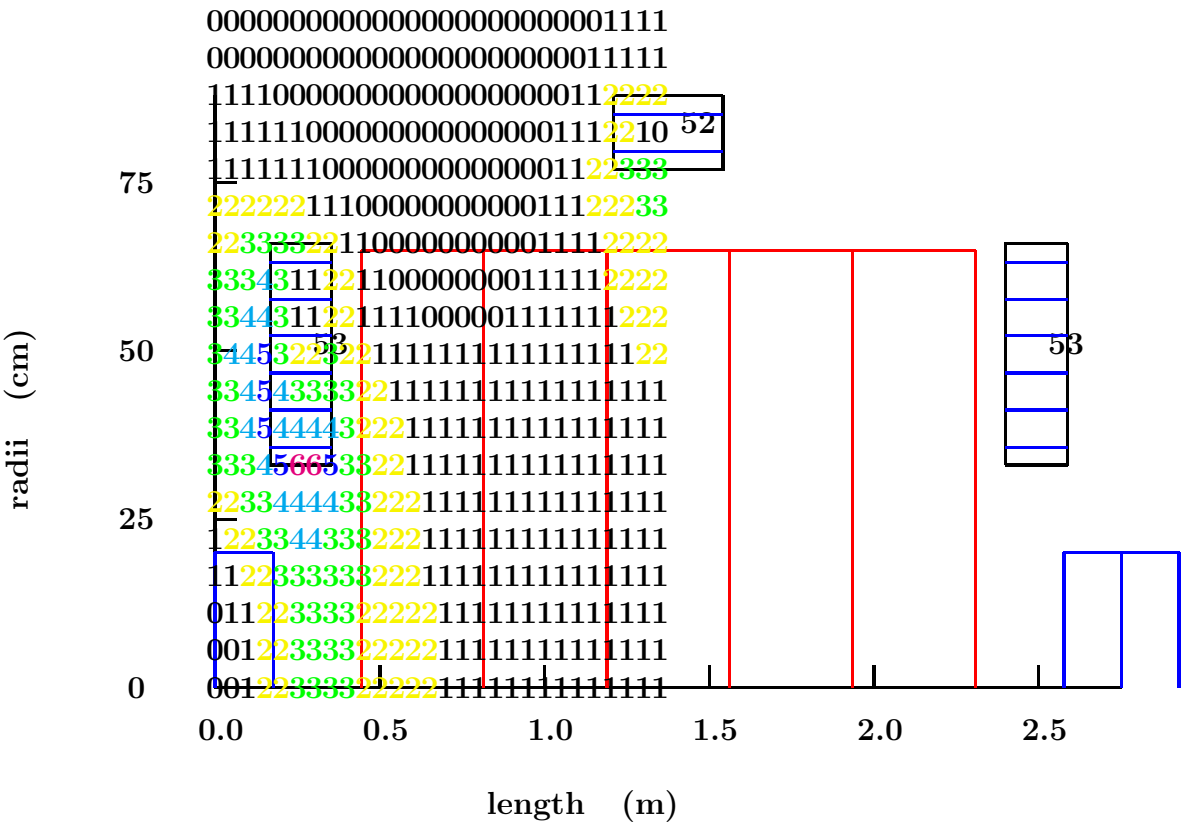
- full cell 2.2 (m)
- maximum B 8.9 (T)
- amp turns 7.3 (MA/m)
- amp turns * circ. 37.9 (MA m/m)



Super FOFO

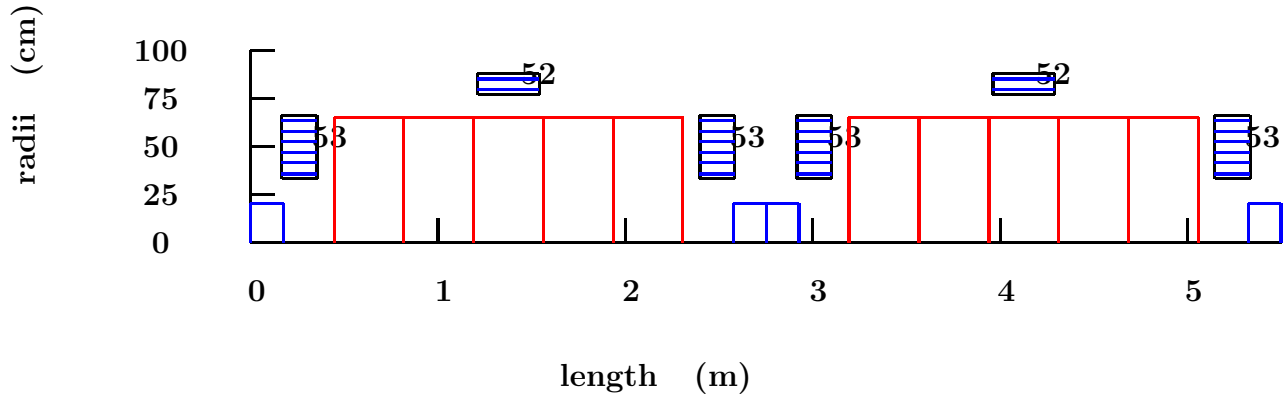
len1 m	dl m	rad m	dr m		I/A A/mm^2
0.165	0.187	0.330	0.330	6	53.48
1.210	0.330	0.770	0.110	2	52.34
2.398	0.187	0.330	0.330	6	53.48

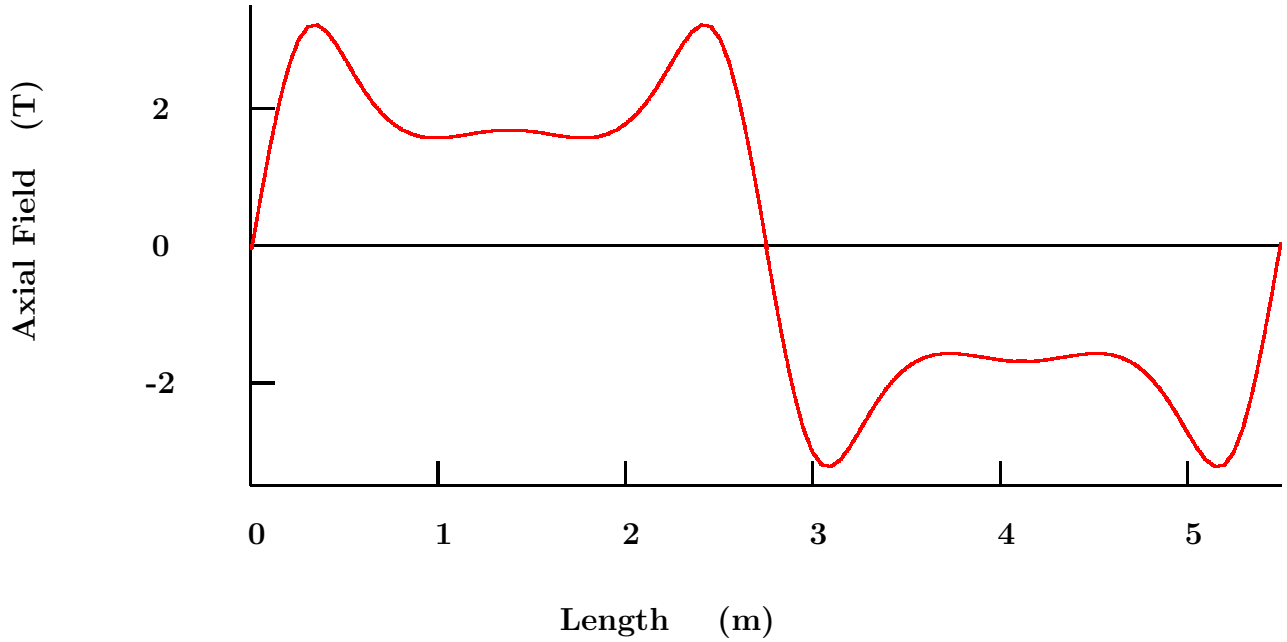
- 1/2 cell 2.75 (m)
- maximum B 6.24 (T) 8.9 for FOFO
- amp turns 3.09 (MA/m) 7.3 for FOFO
- amp turns * circ 11.0 (MA m/m) 37.9 for FOFO



Super FOFO

			c.f. FOFO
1/2 cell	2.75	(m)	1.1
maximum B	6.24	(T)	8.9
amp turns	3.09	(MA/m)	7.3
amp turns * circ	11.0	(MA m/m)	37.9
RBj	113	(MP/m^2)	432

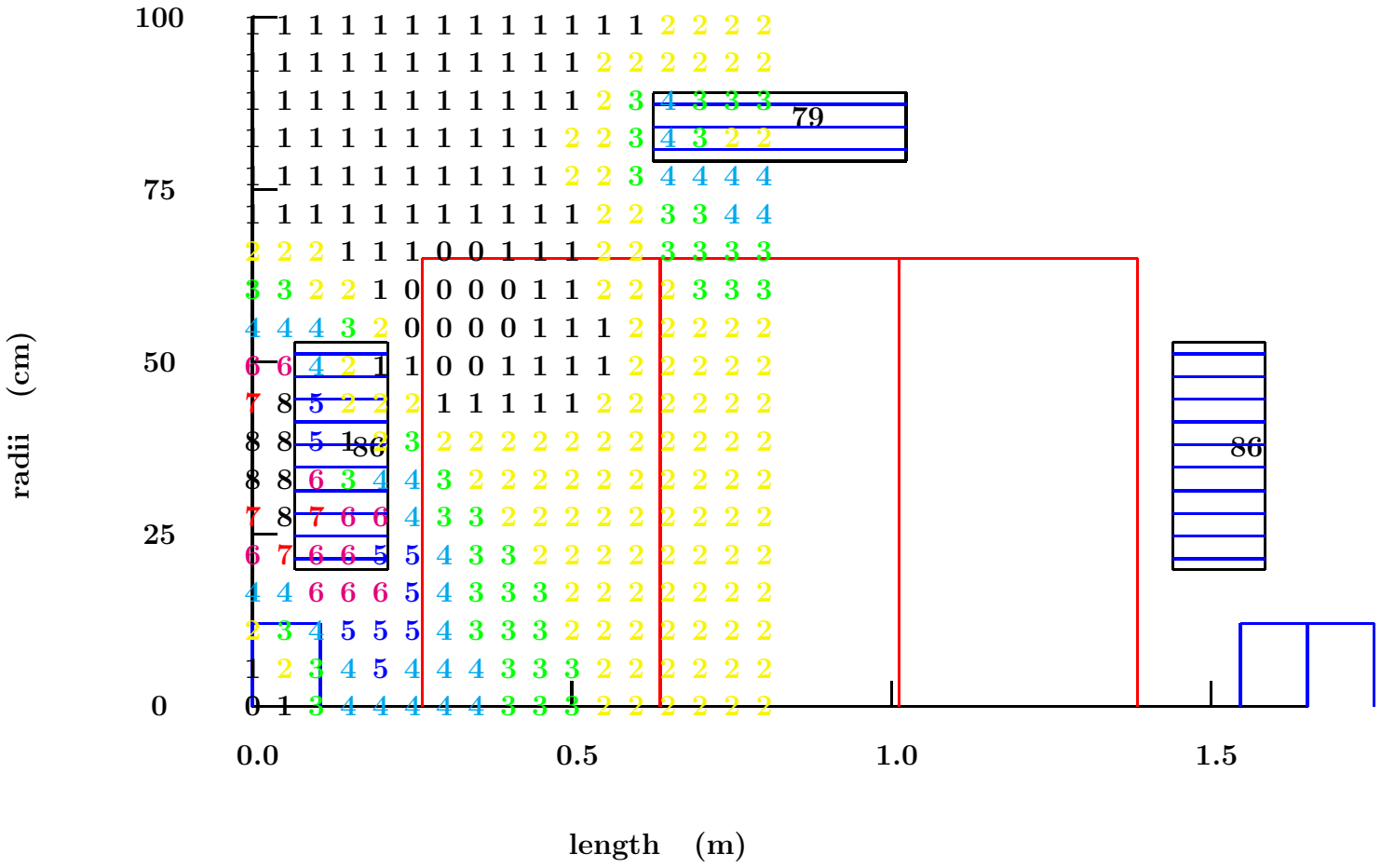




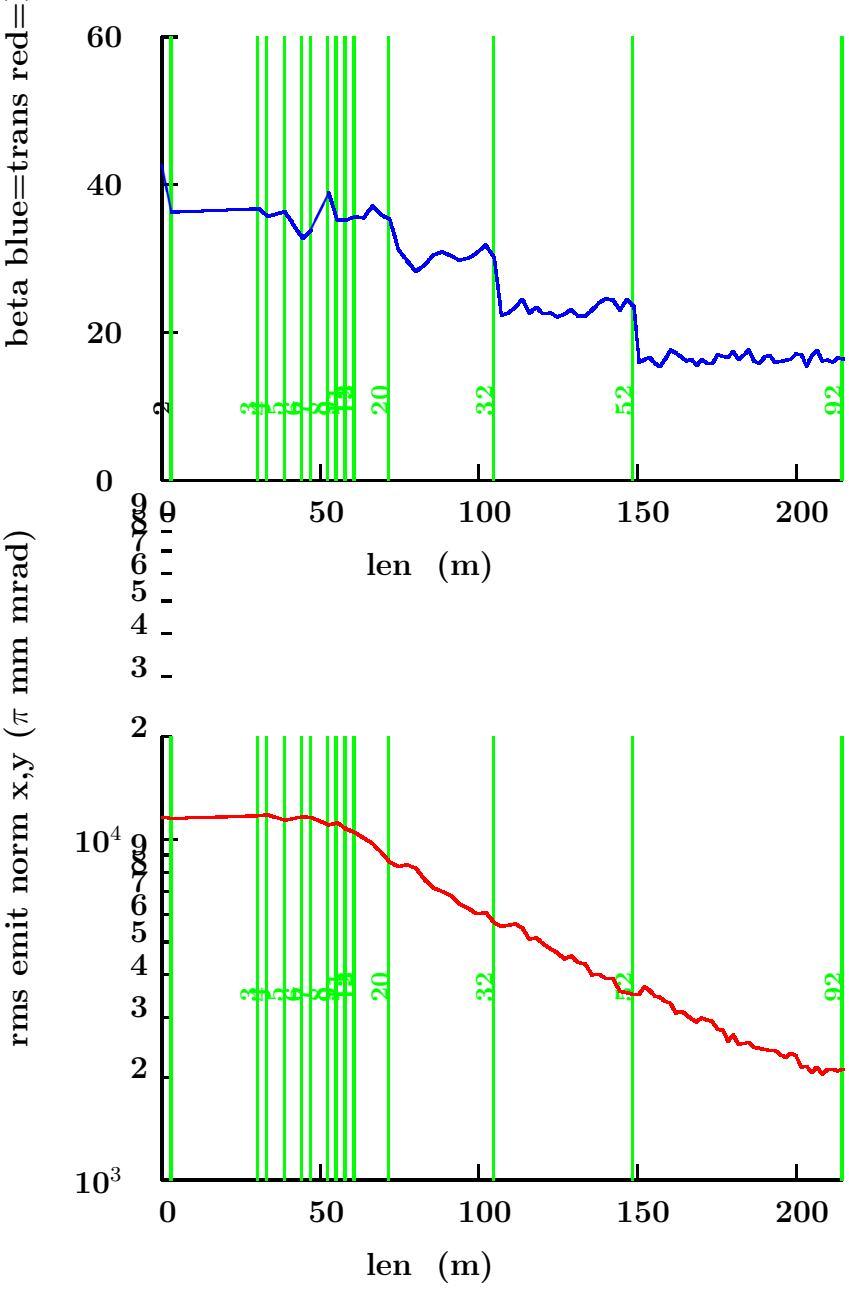
Scale down to 3 RF cavities

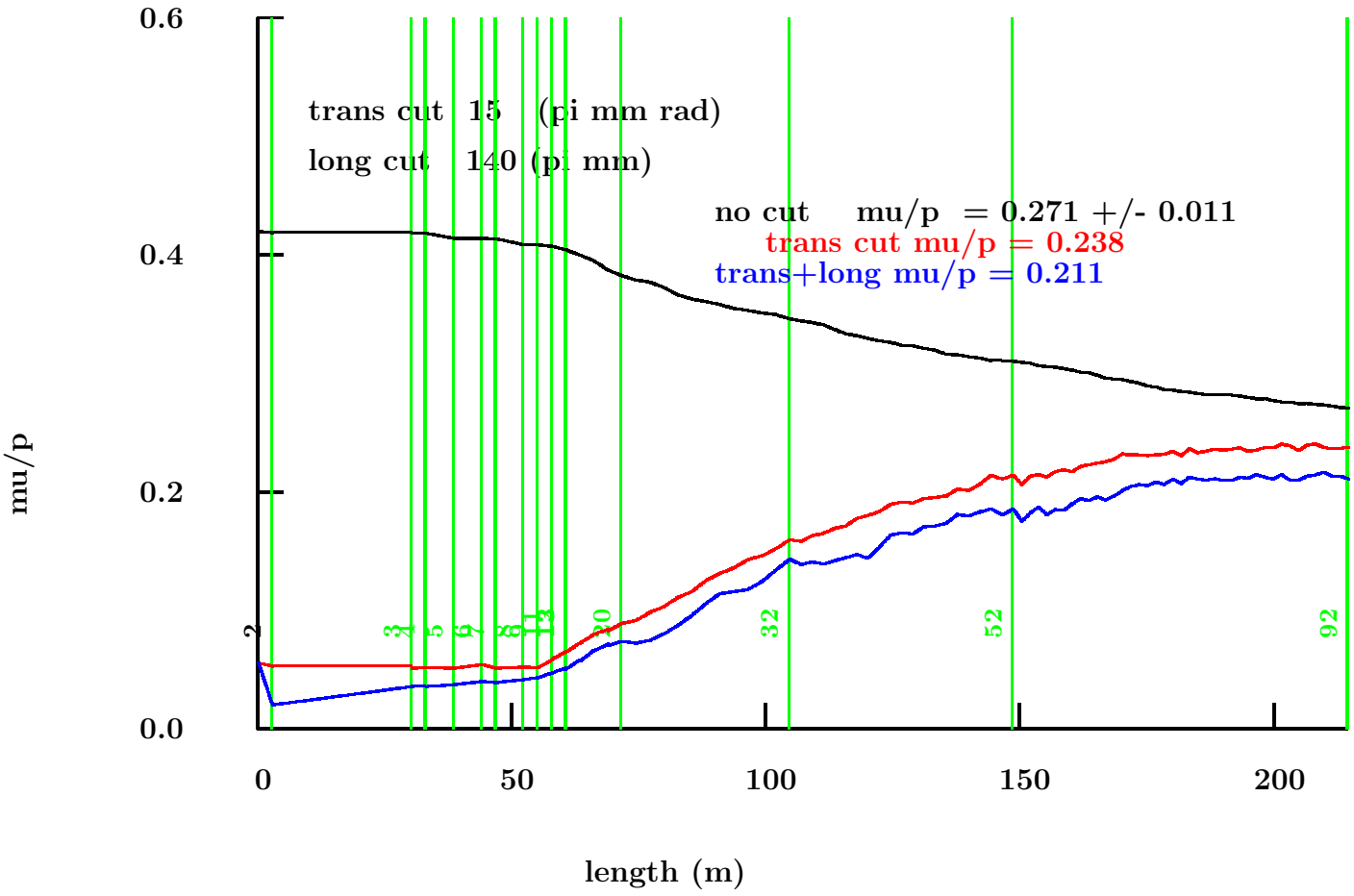
len1 m	dl m	rad m	dr m		I/A A/mm^2
0.066	0.145	0.198	0.330	10	86.82
0.627	0.396	0.792	0.099	3	79.58
1.439	0.145	0.198	0.330	10	86.82

cell 1.65 (m)
beta 0.2 (m)
amp turns 6.9 (MA/m)
maximum B 8.525572 (T)
RBj 146 (MP)



ICOOL Cooling with 4 stages




0.6
0.4
0.2
0.0
mu/p
trans cut 15 (pi mm rad)
long cut 140 (pi mm)
no cut mu/p = 0.271 +/- 0.011
trans cut mu/p = 0.238
trans+long mu/p = 0.211
2
3
4
5
6
7
8
10
13
20
32
52
92
0
50
100
150
200
length (m)

Conclusion

- **Much to be done**
  - **Match into Super FOFO**
  - **Include Correlator ?**
  - **Add non-distorting PR 2**
  - **Match between Cooling Stages**
  - **Add further cooling Stage ?**
  - **Try First Phase Rot with 2 MV/m**
  - **Optimize**

- **Expect $>$ 0.2 μ/p at 24 GeV**
  Exceeds PKJ 1.3 μ/p after cooling
- **$\approx$ 2 10^{20} $\mu/10^7$ sec year at 1 MW**
- **$\approx$ 8 10^{20} $\mu/10^7$ sec year at 4 MW**

- **Study II must answer:**
  - **Feasibility**
  - **Relative Cost**
  - **Needed R& D**
  - **Is BNL Site practical**

Summary Table

	len m	r_{max} cm	B_{axis} T	B_{coil} T	freq MHz	grad MV/m	$< p >$ MeV
Hg	.3	7.5	20	?			
Drift	6	20	20→ 3	?			
RF	42	30	3→ 1.25		30,45	5,6	→ 280
Mincool 1	1.8	30	1.25				→ 226
reversal	10	60	1.25→-1.25	?			226
Mincool 2	.7	30	-1.25				→ 202
Drift	167	30	-1.25 → 1.25				202
Induction	141	30	1.25		(300 ns)	+/− .55	→ 233
Match	-	-	-				
Buncher	43	30	3.3	6	175,350	6.6,6.6	233
Cooling	175	30→ 15	2.6 → 4.3	6.2 → 8.5	175	14	→ 208
Total	596						

Performance

Effective Polarization (rms)	36	%
Transverse acceptance cut	15	mm rad
Longitudinal acceptance cut	140	mm rad
μ /p per GeV	0.88	%

Note

- No Simulation of magnetic match from solenoid to Cooling