Possible 200 MHz Cooling Experiment Design

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Abstract

I give details of a measurement solenoid with good flat field, together with its stray field. I also give details of an improved cooling lattice, but I do not yet have them matched together.

1 Specification of measurement Solenoid

1.1 Highest momentum track to be measured

Mean momentum in SFOFO lattice = momentum in center of absorber = 214 MeV/c

Momentum loss in one absorber = 12 MeV/c

Mean momentum to be measured before first absorber:

$$p_{\rm mean} = 214 + 12/2 = 220{\rm MeV/c}$$

Momentum acceptance = +/− 22 % = 48 MeV/c

Maximum momentum to be measured

$$p_{\rm max} = 220 + 48 = 268{\rm MeV/c}$$

1.2 Maximum required muon energy from beam

Maximum energy in measurement solenoid = 183 MeV (268 MeV/c)

Loss in lead scatterer ≈ 40 MeV

Maximum required KE before lead = 183 + 40 =**223 MeV**

1.3 Detector Solenoid length and field

Field for same beta as Janot's study in which the mean muon momenta were assumed to be 300 MeV/c:

$$B_{220} \;=\; B_{300}\,\frac{p_{220}}{p_{300}} \;=\; \frac{220}{300}\,5 \;\approx\; 3.6{\rm T}$$

Longest cyclotron wavelength (for maximum momentum=268 MeV/c)) is:

$$\lambda_{\rm cyclotron} = \frac{p\ 2\ \pi}{c\ B} = \frac{.268\ 2\pi}{0.3\ 3.6} = 1.56\text{m}$$

Minimum good field region required=2/3 $\lambda\ \approx 1$ m

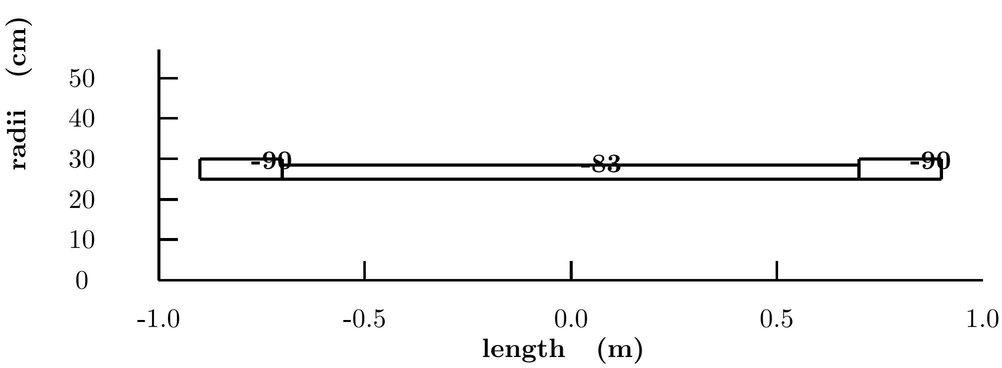
Thus the specified good field region of 1.2 m allows the addition of one or more redundant planes prior to the minimum required measurement planes. The specified good field radius is 15 cm. The specified field uniformity within this length is $+/-$ 1 %

2 Solenoid design

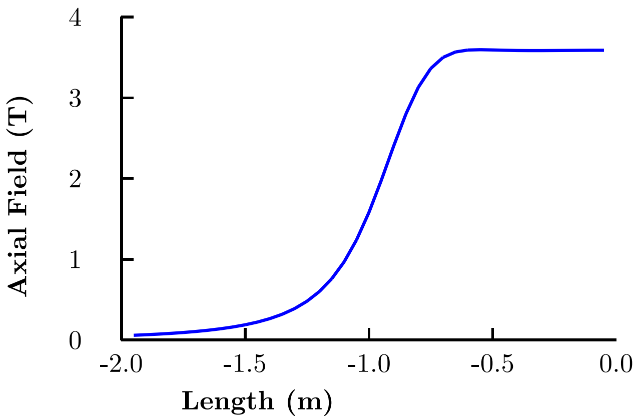
The dimensions and current densities in a preliminary 1.8 m long, 50 cm diameter, solenoid design are:

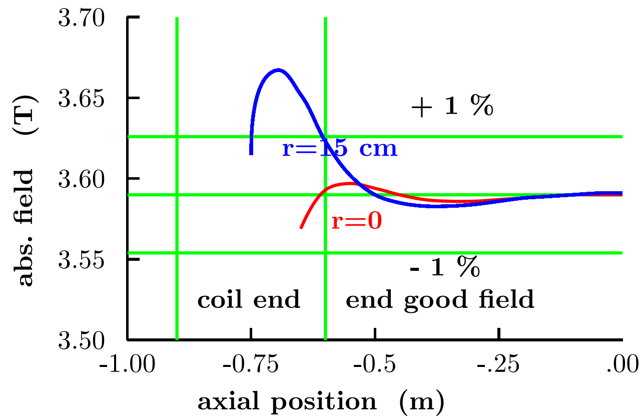
len1 m	gap m	dl m	rad m	dr m	I/A A/mm^2	n I A	n I l A m
-0.9	1.100	0.200	0.250	0.050	-90.80	0.91	1.57
0	0.000	1.400	0.250	0.035	-83.84	4.11	6.90
0.9	0.000	0.200	0.250	0.050	-90.80	0.91	1.57

amp turns 5.924 (MA)
amp turns $\times$ length 10.04235 (MA m)

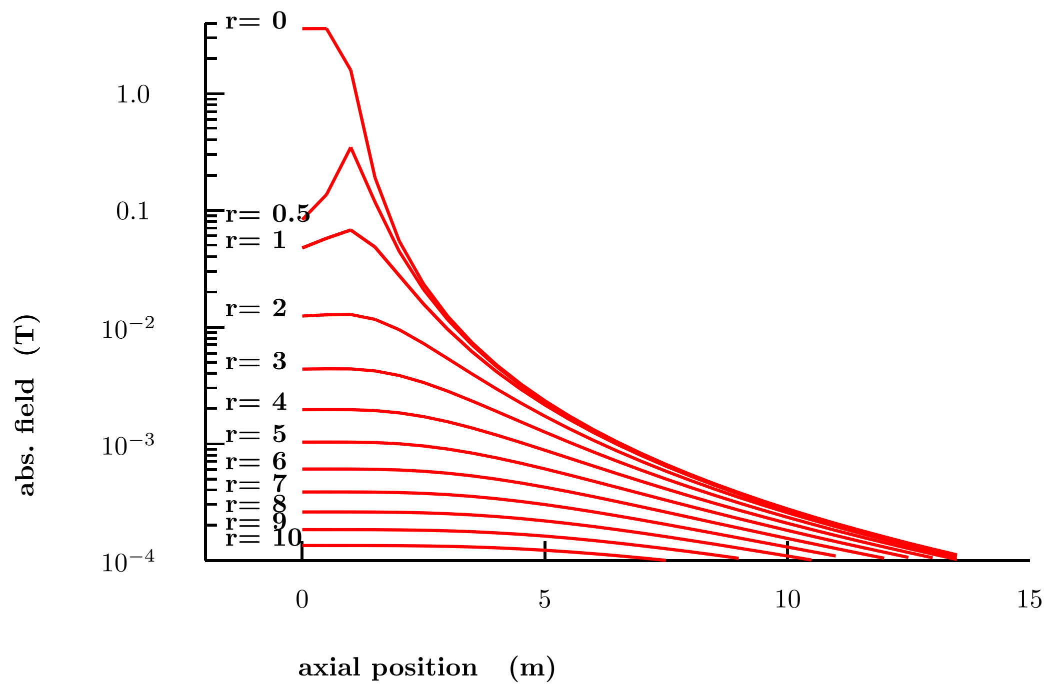


The fields in the solenoid are shown below. Tey are seen to meet the specification over the 1.2 m length, and are significantly better than specified over 1 m.





The stray fields outside the solenoid are plotted below. It is seen that at 4 m (approximate outside of shielding wall) the maximum fields are approximately .; at 10 m the fields are of order 1 gauss and are essentionally negligible.



3 New lattice

This lattice has the focus coils brought in to a smaller radius, on the assumption that the absorber boddy will be incorporated in the coil assembly, but keeping the ability to change the windows. The maximum field, maximum current density, stored energy and cost are all reduced and, surprisingly, the performance improved: the loss for cooling in 12 stages was reduced from 13 to 8 %.

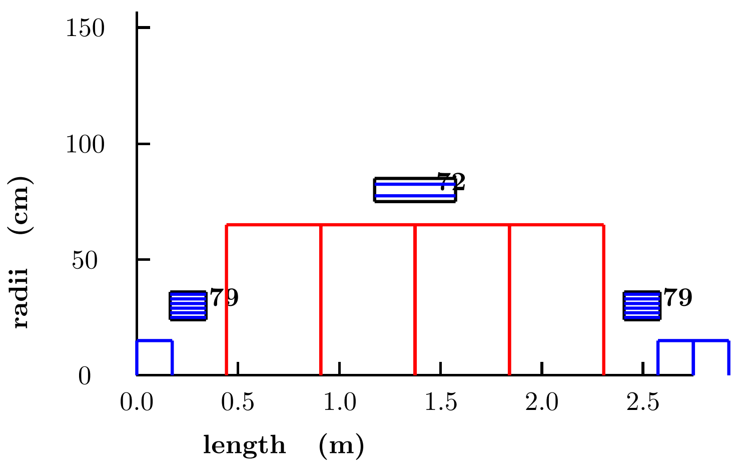
len1	dl	rad	dr		I/A
m	m	m	m		A/mm^2
0.165	0.177	0.240	0.120	6	79.10
1.175	0.400	0.750	0.100	2	73.00
2.408	0.177	0.240	0.120	6	79.10

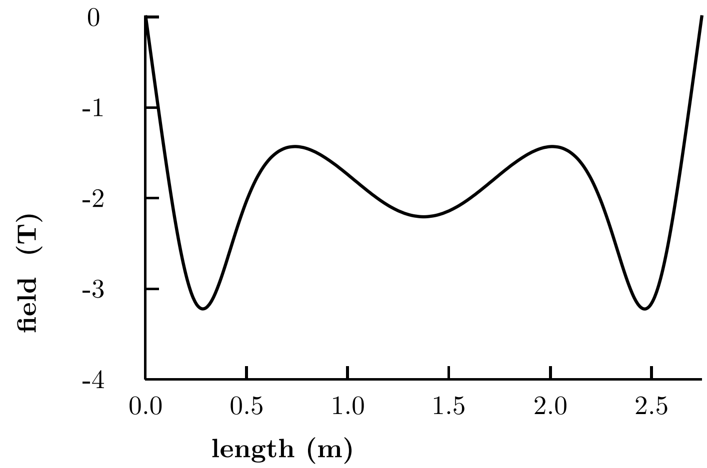
amp turns 6.28 (MA)
amp turns length 21.01096 (MA m)
cell length 2.750001 (m)
Stored Energy 465.933
maximum B (t) 5.578113
For comparison, the study 2 lattice was:

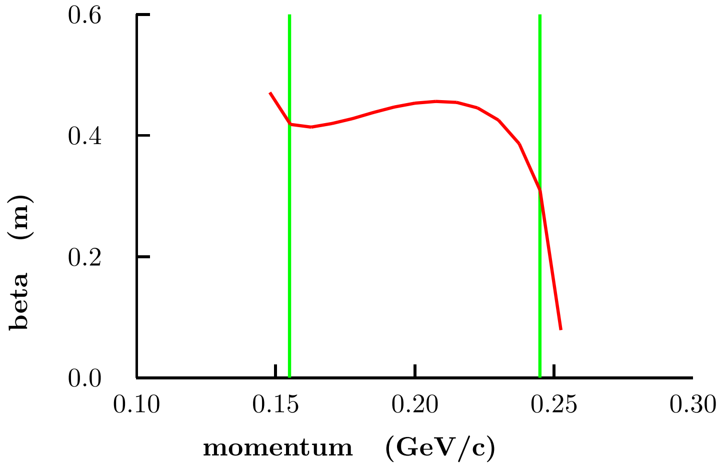
len1	dl	rad	dr		I/A
m	m	m	m		A/mm^2
0.175	0.167	0.355	0.125	12	105.20
1.294	0.162	0.729	0.162	16	99.07
2.408	0.167	0.355	0.125	12	105.20

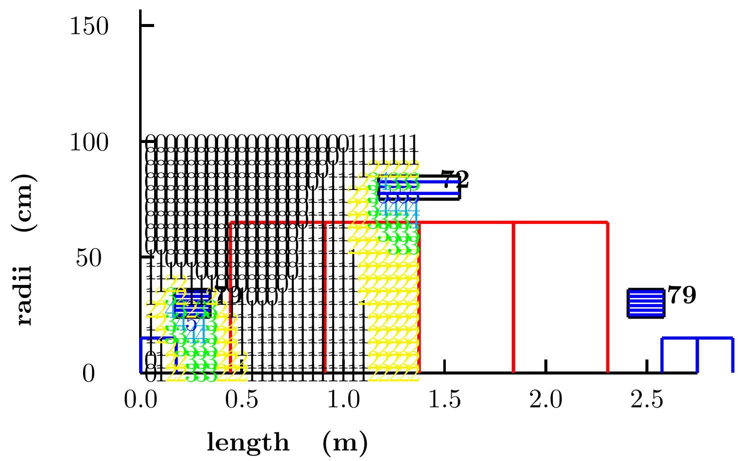
amp turns 6.992 (MA)
amp turns length 24.75359 (MA m)
cell length 2.750001 (m)
Stored Energy 549.9368
maximum B (t) 6.307168

Figures follow









4 status

I am currently having problems matching the new lattice with the solenoids. It is, in fact, the same problem I had before with the 'geometry B'. I also looked at the full system with lead plates. As Jim Norem noted, the entry into the solenoid from the field free beam will need work. More later in the week.