Open Cavity rf Experiment

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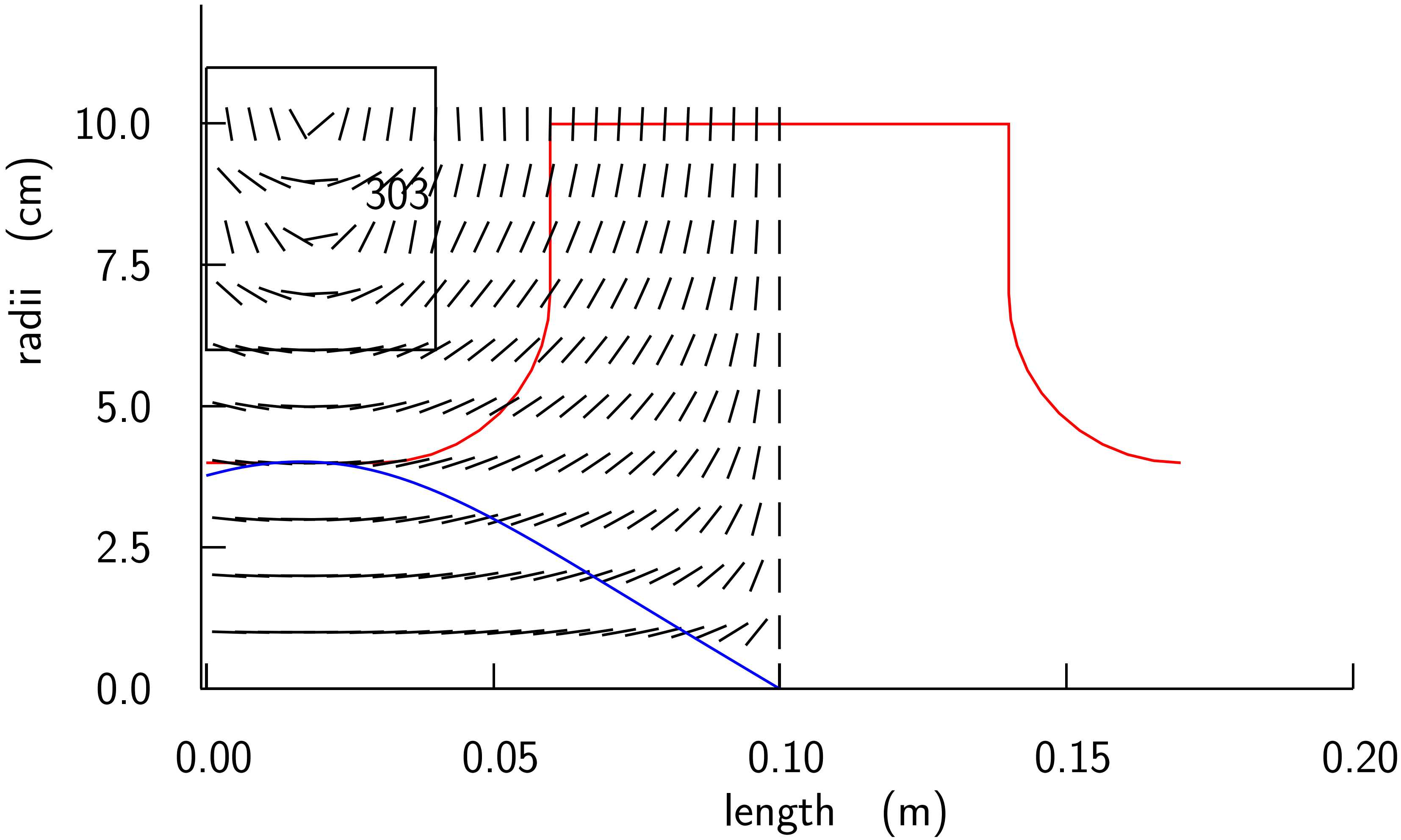
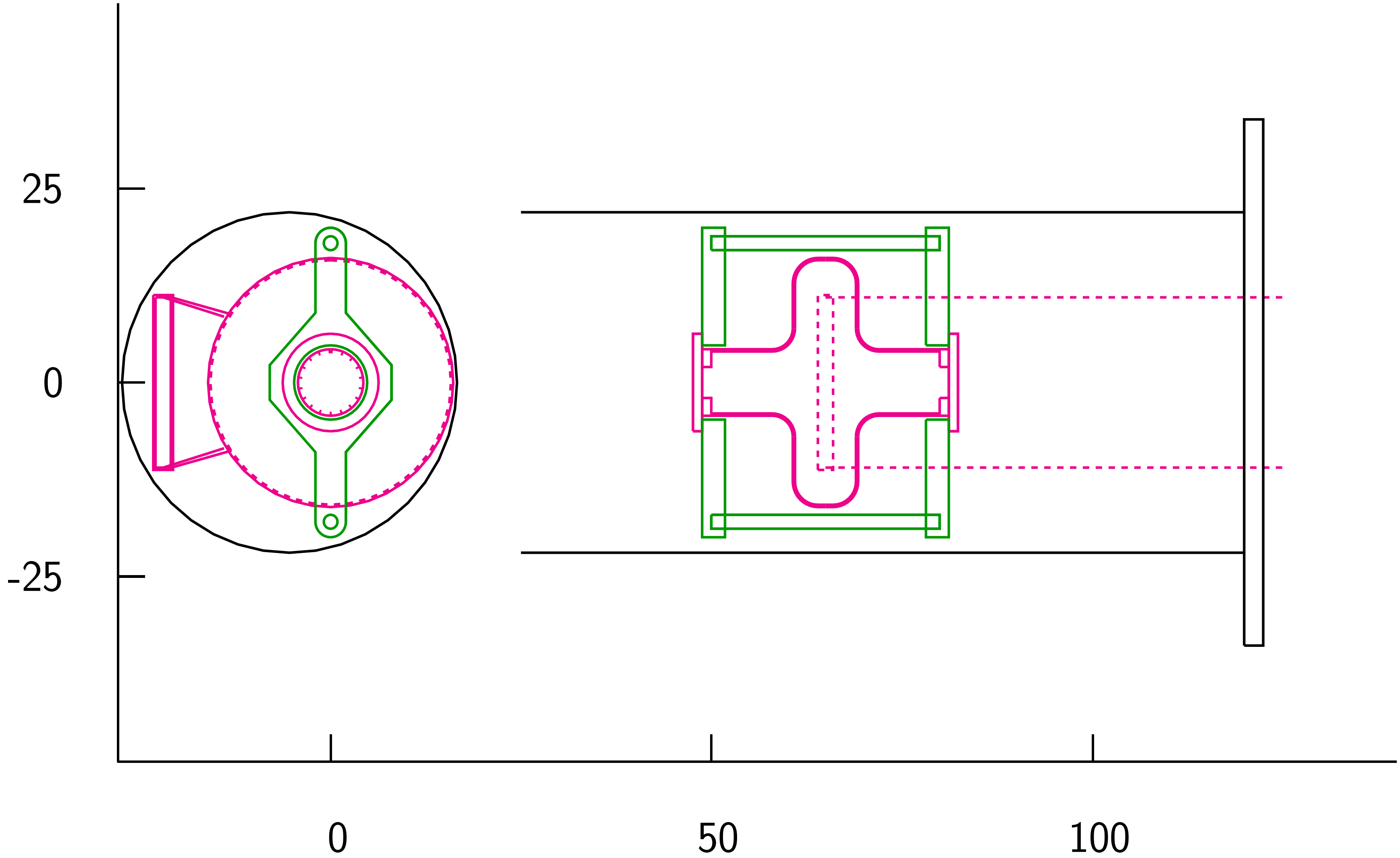
Questions

- Joints in exp 4
- tuner
- cooling in Nb3Sn case
- do we need a cold box?
- minimum gap for super insulation
- winding with ss strips together with sc

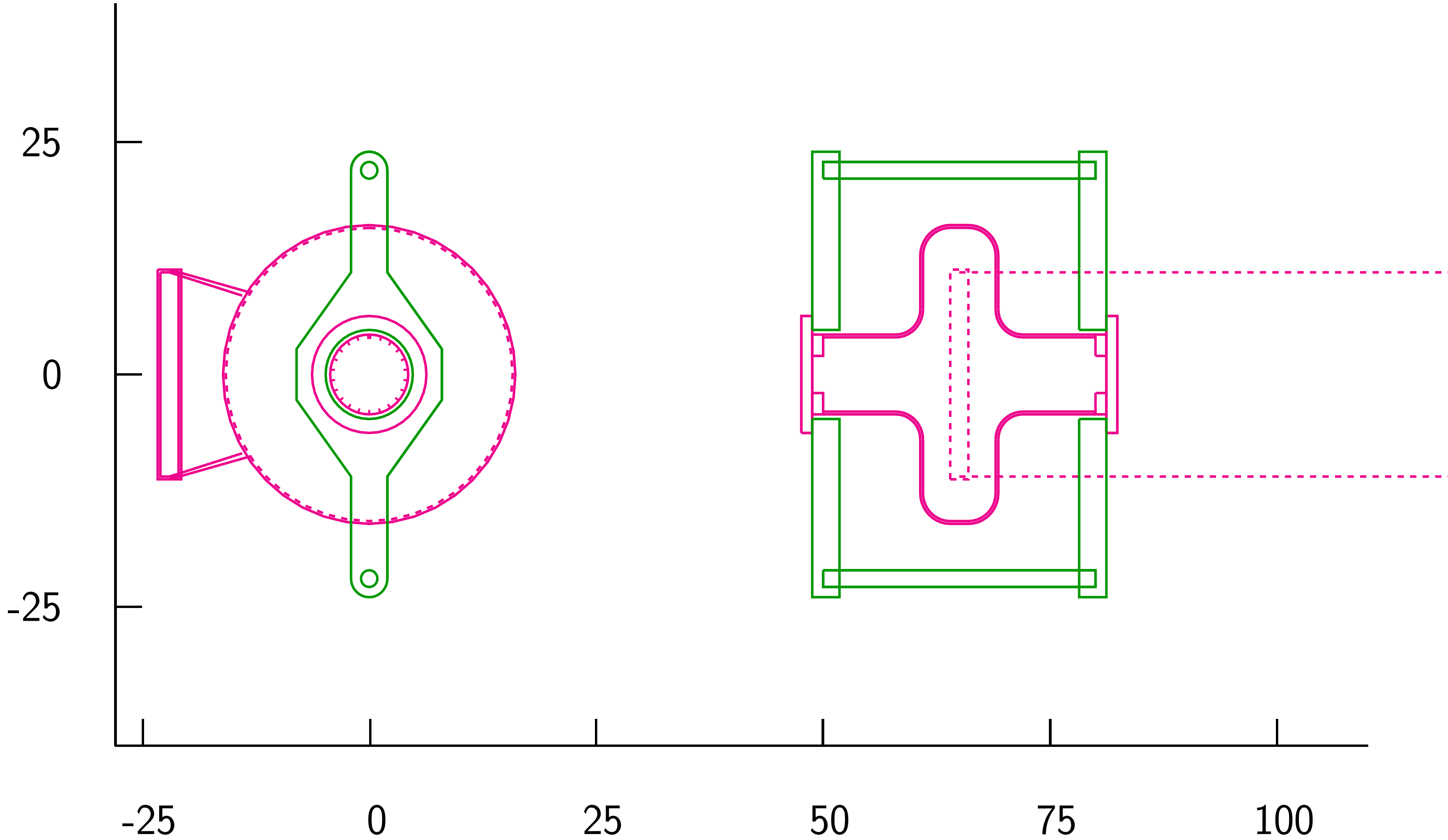
Experiment #1 Single cavity

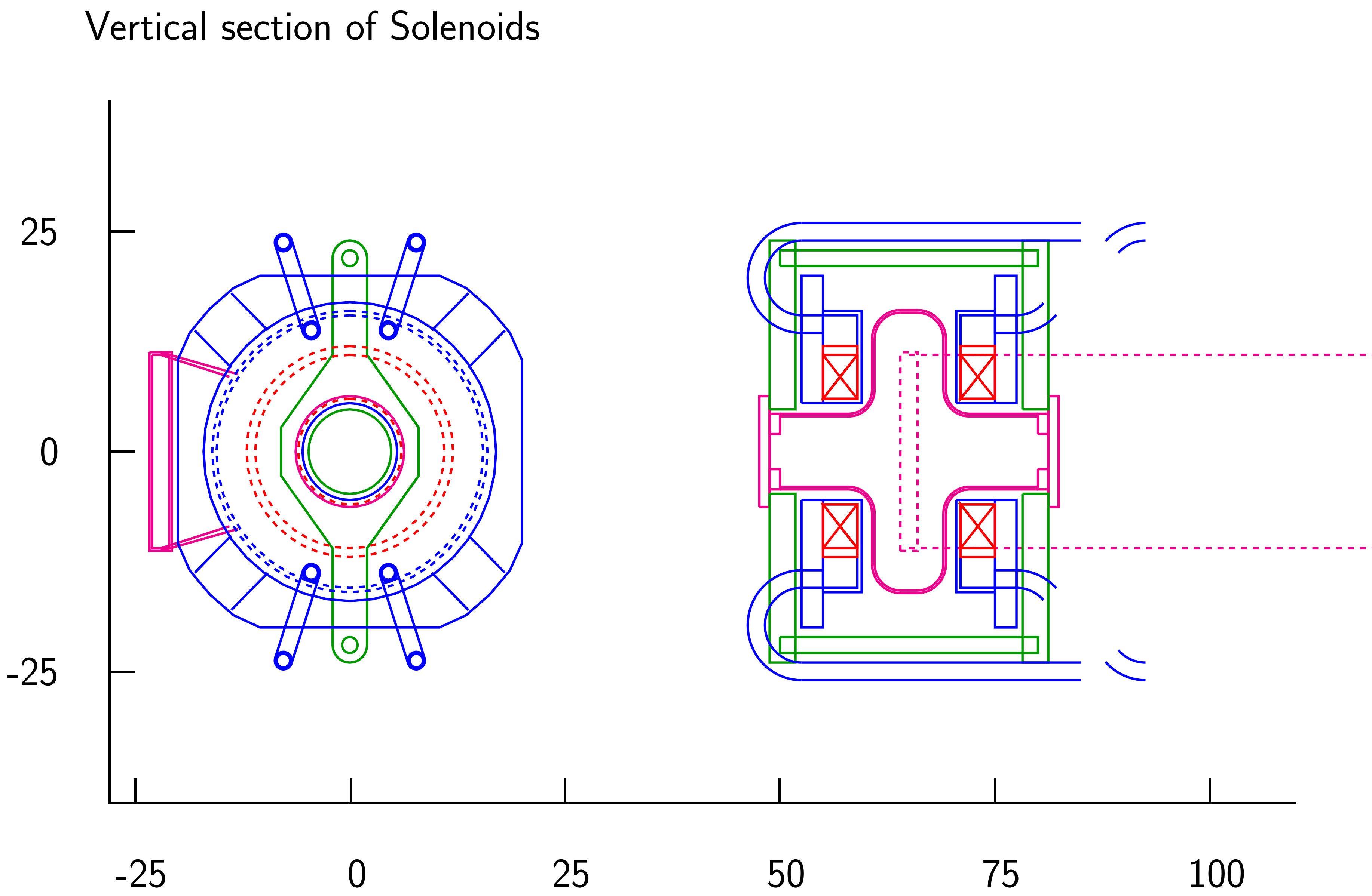


Test in Lag G magnet

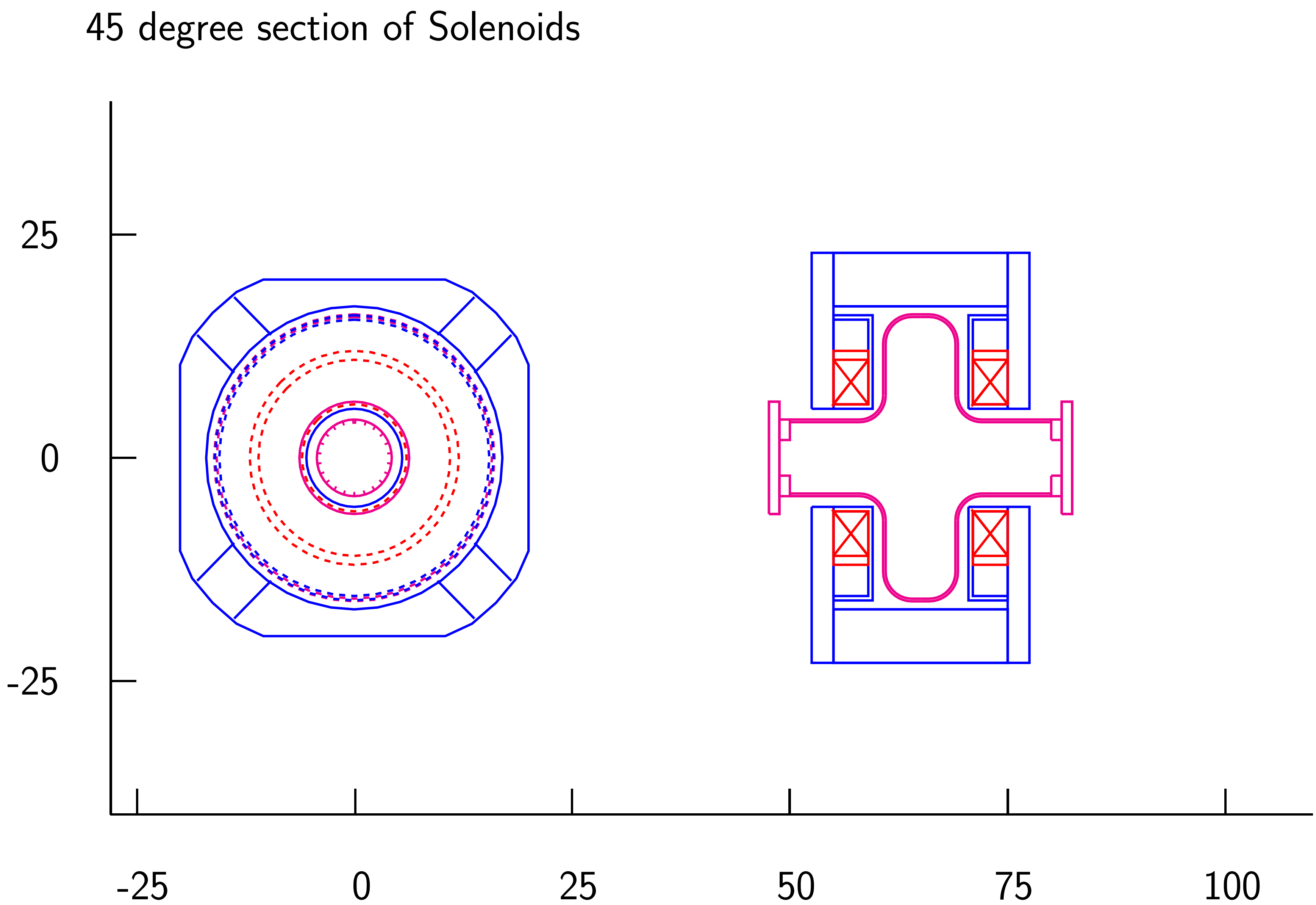


Cavity and Tuner



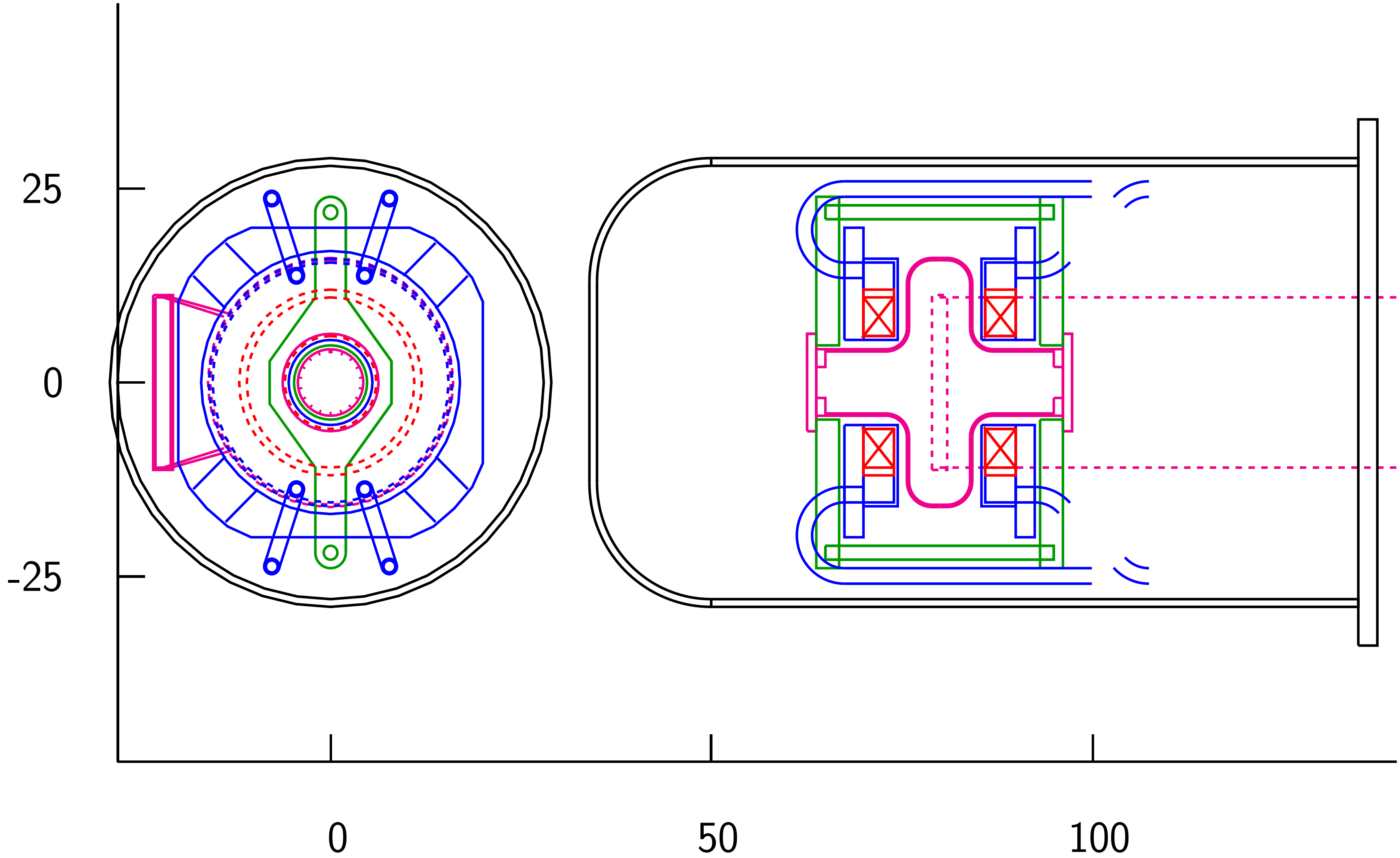


Vertical section of Solenoids
25
0
-25
-25
0
25
50
75
100

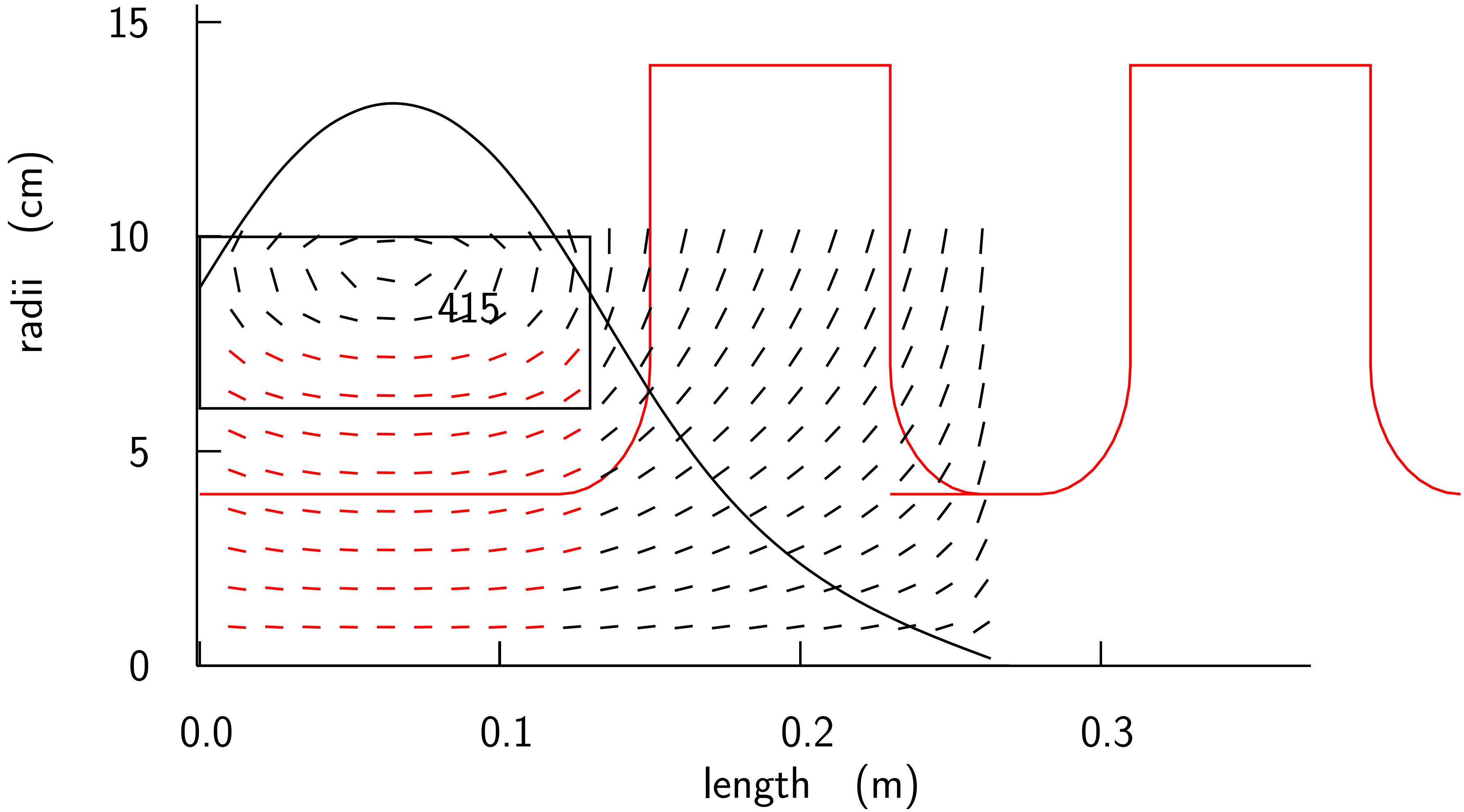


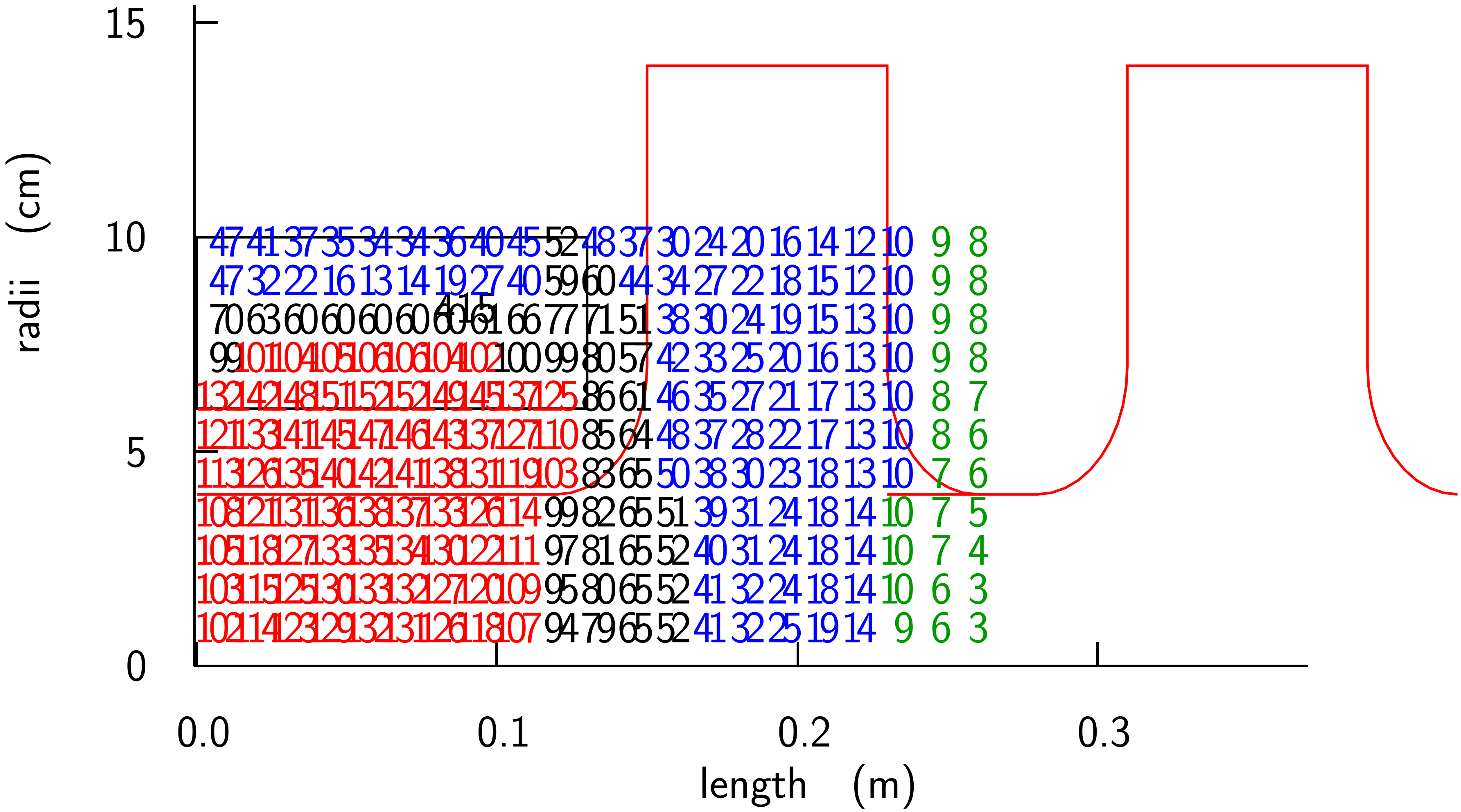
45 degree section of Solenoids
25
0
-25
-25
0
25
50
75
100

With Vacuum and Mounting Plate

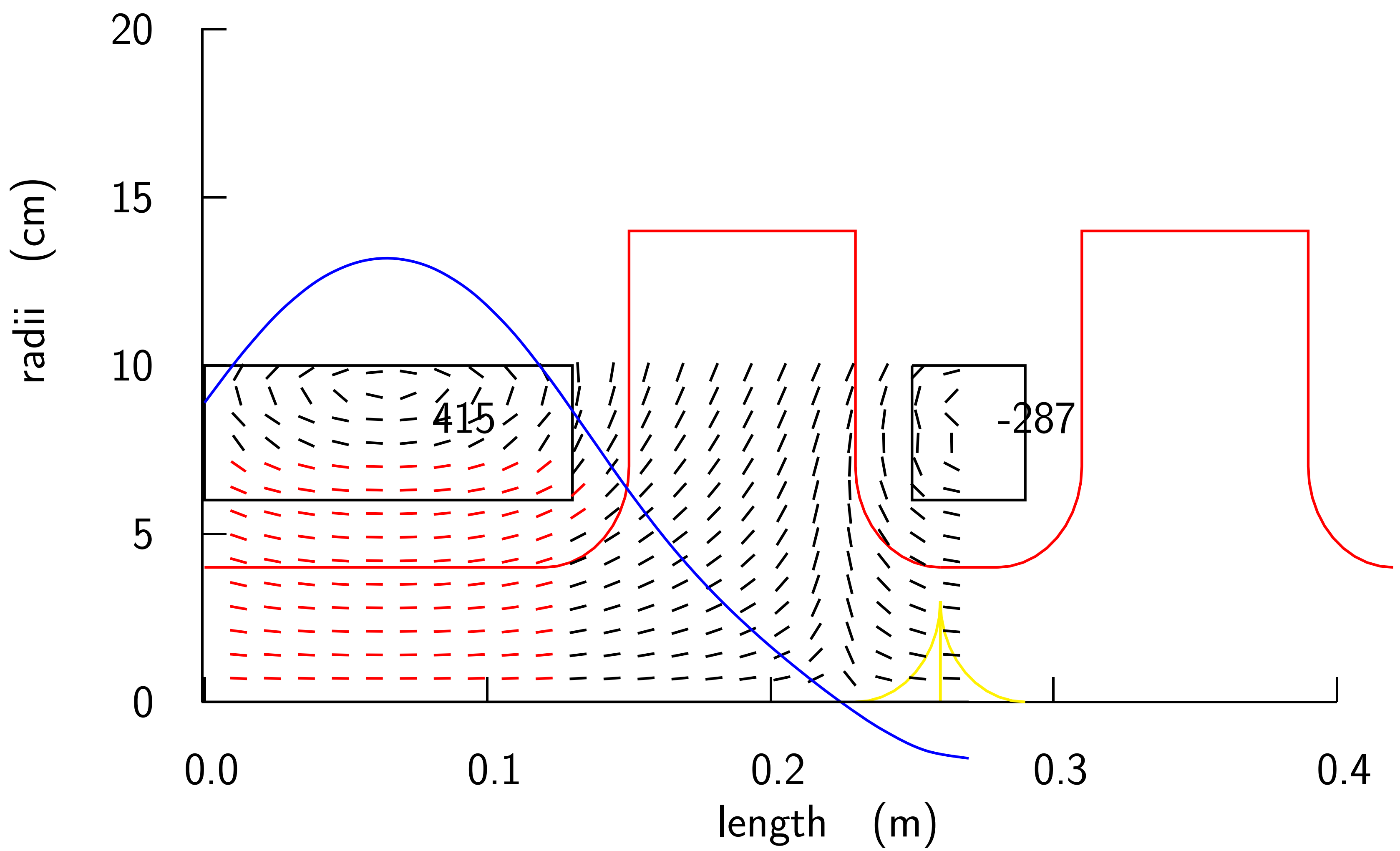


Experiment #2 Double cavity with no center coil

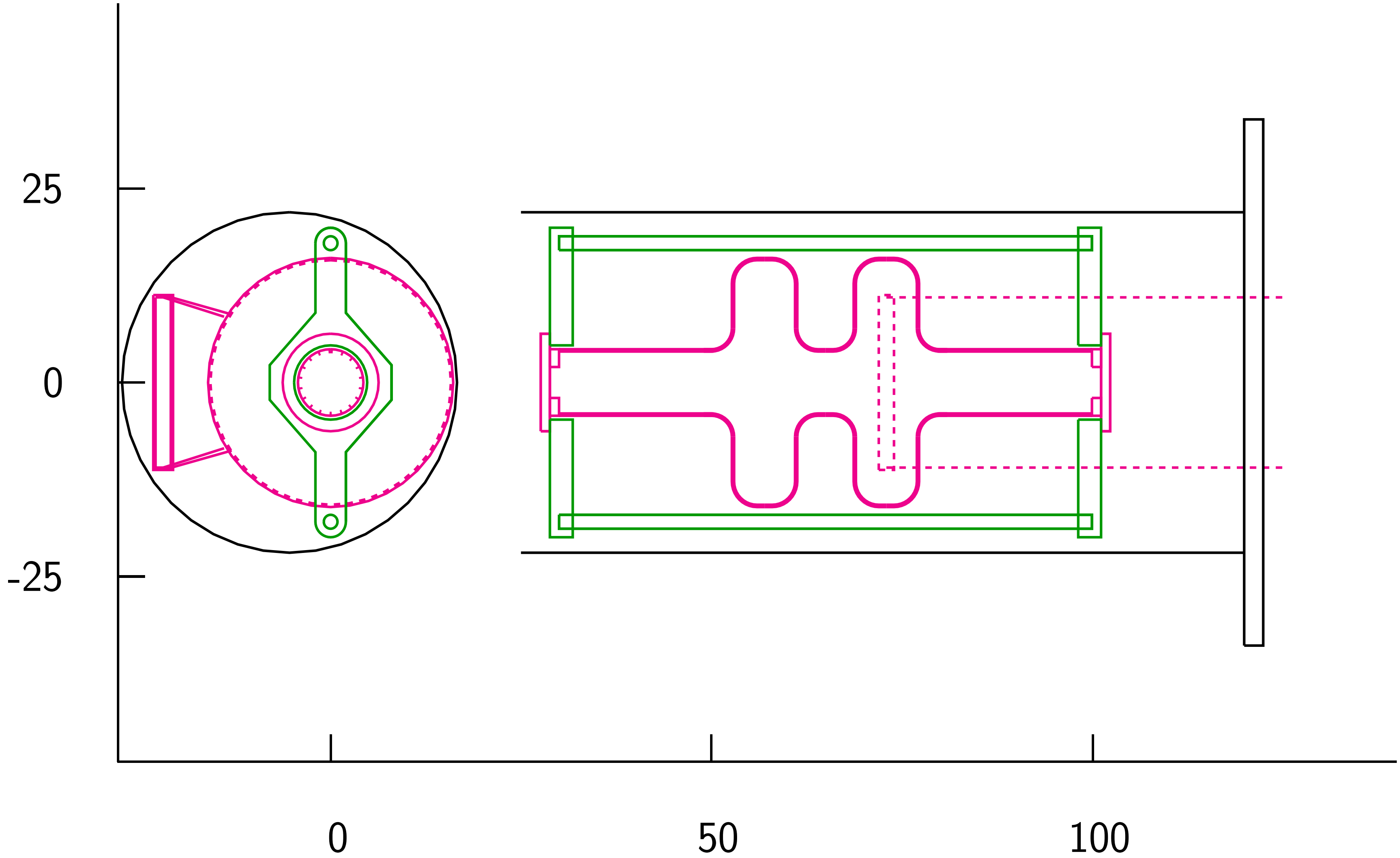



15
10
5
0
radii (cm)
0.0
0.1
0.2
0.3
length (m)

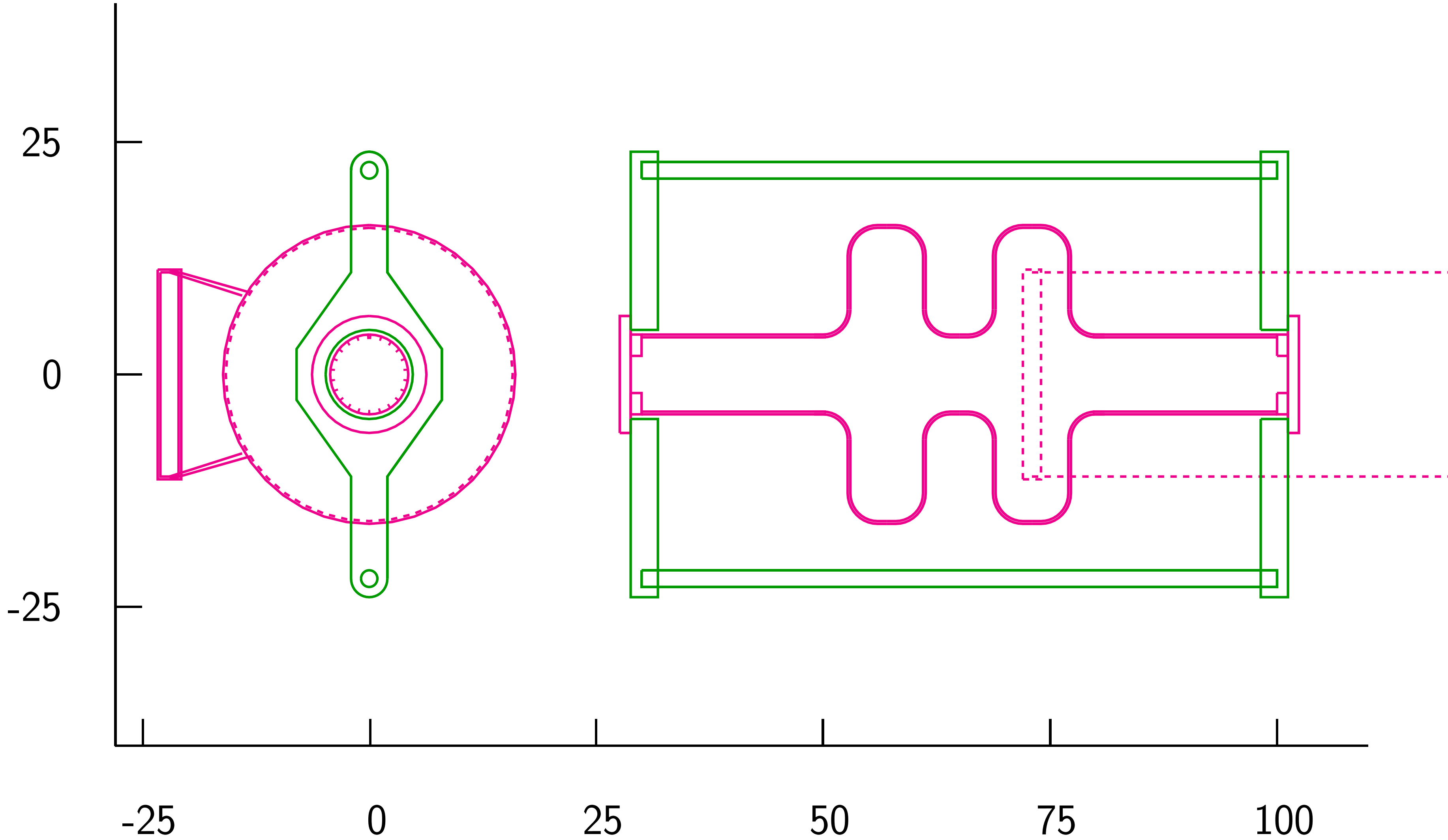
Experiment #4 with opposed center coil

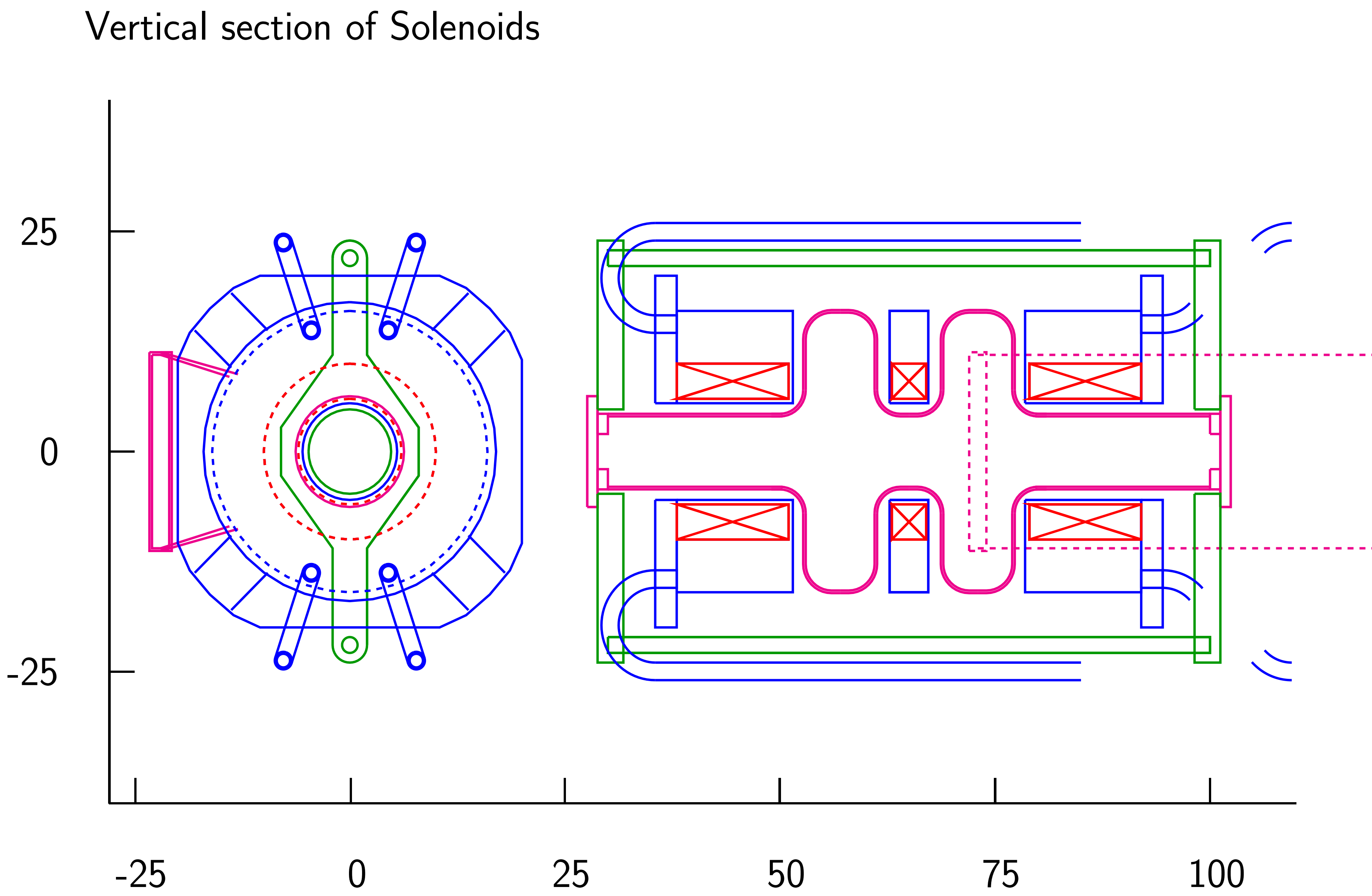


Test in Lag G magnet

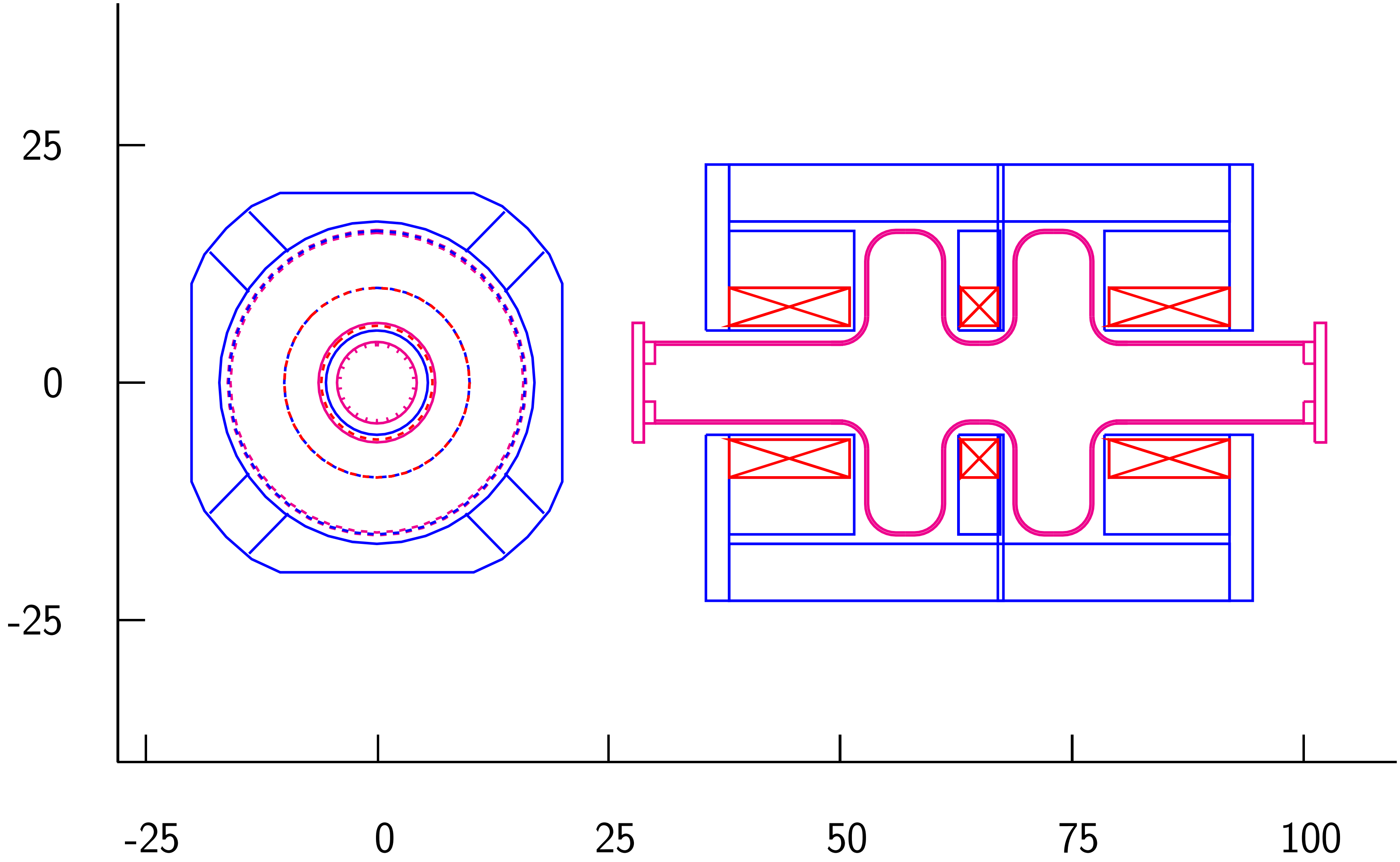


Cavity and Tuner

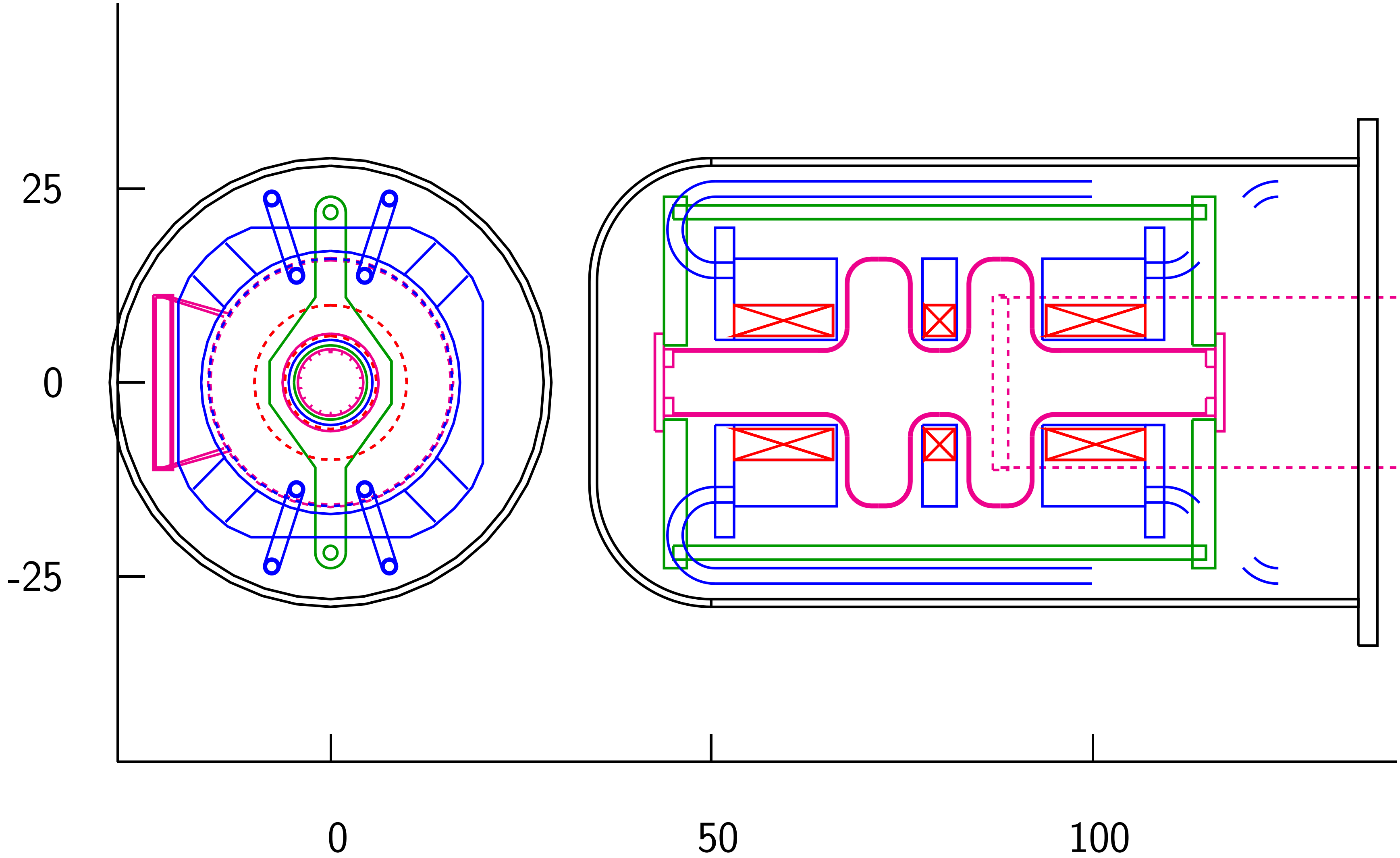



Vertical section of Solenoids
25
0
-25
-25
0
25
50
75
100

45 degree section of Solenoids

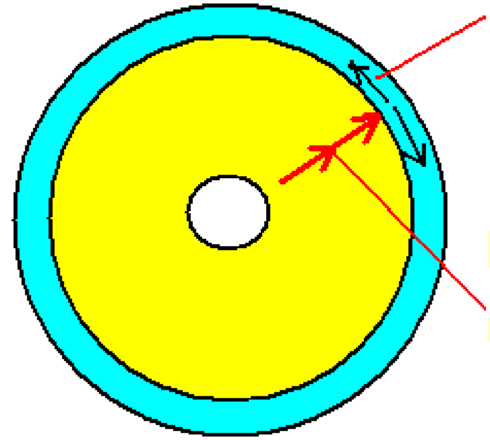


With Vacuum and Mounting Plate



Radial Force Constraint

If radial forces only constrained at outer radius t



$$\frac{dF_r}{dz}\max = \int B(r)\; j\; r\; d\phi\; dr$$

For a long solenoid $j = \dfrac{dB}{dr}\,\dfrac{1}{\mu_o}$

$$B = \left(\frac{r - r_o}{r_2 - r_1}\right)\frac{B}{B_2} \quad \text{so} \quad r = r_1 + (r_2 - r_1)\,\frac{B}{B_2}$$

$$\frac{dF_r}{dz} = \frac{d\phi}{\mu_o}\left(r_1\; B\; dB + (r_2 - r_1)\,\frac{B^2}{B_2}\,dB\right)$$

$$P_2 = \frac{\int dF_r}{r_2\; d\phi} = \frac{B_2^2}{\mu_o}\left(\frac{r_1}{2\; r_2} + \frac{1}{3} + \frac{r_1}{3\; r_2}\right)$$

For $B = 15,\; r_1/r_2 = 1/2$ and $\mu_o = 4\pi\; 10^{-7}$ $\qquad P_r\max = 75\; MPa$

Compared with the compression strength of epoxy filled superconductor stacks of about 130 MPa.

Strain in coil due to stretch of outer constraint

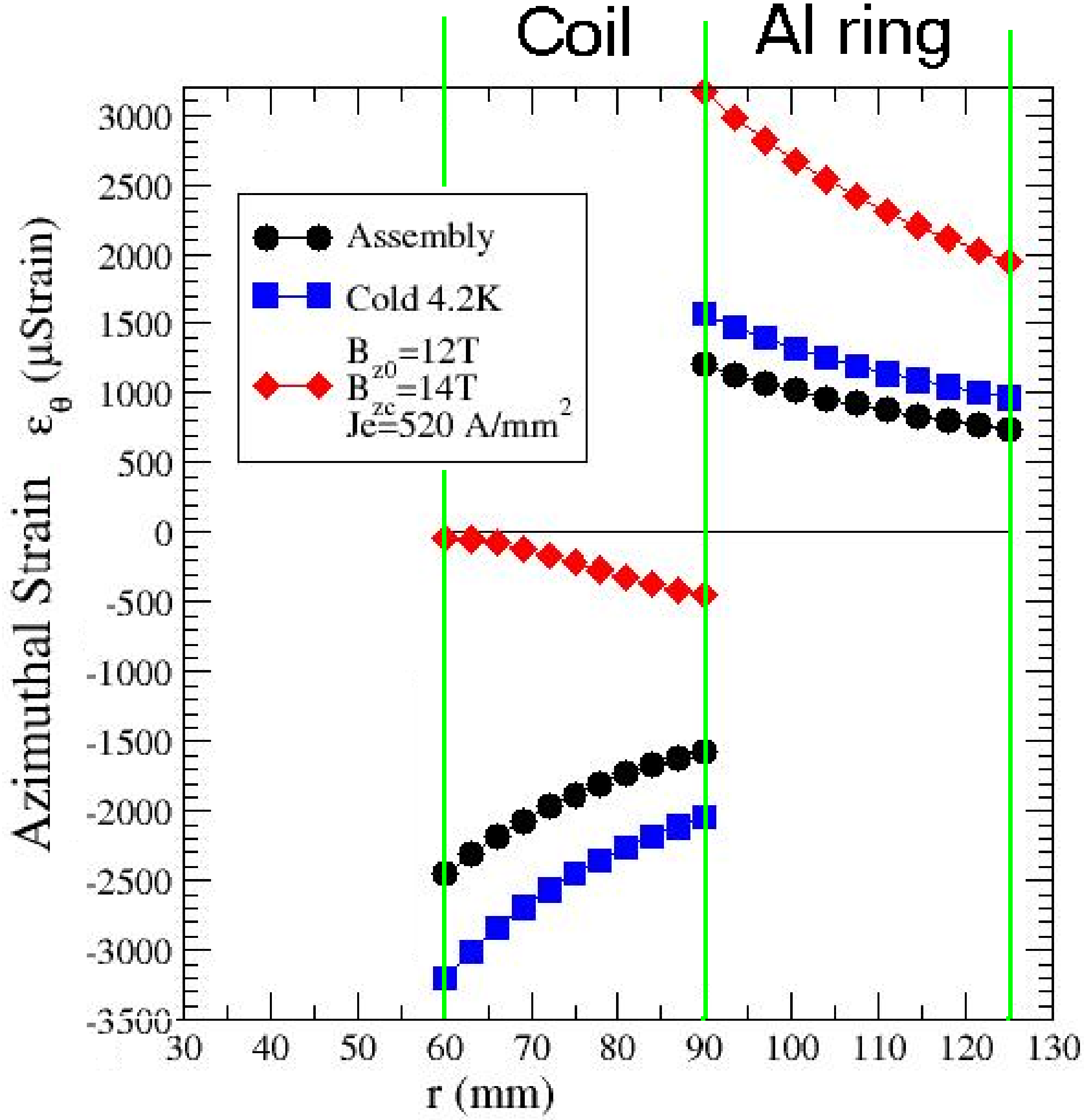
r=12 cm t=2.5 cm E=200 GP (ss)

$$S \ = \ P_r \, \frac{r}{t} \, \frac{1}{E} \ = \ 75 \; 10^6 \, \frac{12}{2.5} \, \frac{1}{200 \;\; 10^9} \ = \ 0.18 \ \%$$

but with low E coil material the inner layers will move out more and have more strain May need precompression by multiple ss rings, ss wound in with cable, or precomnpression in Al ring

Shlomo Caspi's analysis

With 100 micron radial premompression that can be supplied by inserting cold coil into warm ring



Coil does not go into tension when powered

Forces between end coils

exp1 single cavity

r=6 cm dr=5 cm l=4 cm c-c=16 cm Baxis=4 T Bmax=7 T j=300

Br=.2 T I= 300 x 40 x 50 = 0.6 MA A=2 $\pi(.1^2 - .06^2)$=.02 m^2

$F \approx IAB_r/\Delta r$=60,000 N integration gave F=51 kN

if 8 rods of .5 in dia then Tension= .051/(8 pi .006^2) 56 MP ok

Deflection of plate t=3.17 cm, span=15 cm, width 15 cm, load .051/4 uniform

$$\delta = \frac{5}{384}\frac{WL^3}{EI} = \frac{5}{384}\frac{WL^3\,12}{Et^3w} = \frac{5}{384}\frac{WL^3\,12}{Et^3w}$$

$$= \frac{5}{384}\frac{.051/4\ 10^6\ .25^3\ 12}{200\ 10^9\ .0317^3\ .15} = 32 \quad (\mu\mathrm{m})$$

exp2 Double cavity with no coil at center

r=6 cm dr=4 cm L=13 cm c-c=39 cm Baxis=13 T Bmax=15 T j=400 B at 3 cm=0.7 T

Br=.04 T I=400 x 130 x 40 = 2.1 MA F=.024 MN

easier than exp 1

Exp 4 Double cavity with coil at center situation needs calculation

Costs of Nb_3Sn Conductor

- D20 4 deg 12.8 T 5 cm radial thickness
- 12 T 2900 A/mm^2 47% Cu Oxford Hight Jc Nb3Sn
- 15 T 1500
- 1/3 for wire, 15% for space 100 microns for insulation wire 0.7mm cable 1.25 by 2mm (for 6 strand)
- 15$/m for sleave, 1100$/kg=295 m (3.7$ per m strand, 22.4 $/m for cable), 20,000$ for 500 m cable (40$/m)
- Young's of filled coil 42 GP

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