Muon Collider Power Consumption

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FNAL Mini-Workshop
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- Required thicknesses of tungsten
- Inside open midplane
- Inside elliptical cos theta

Cryogenic Efficiency

LBL-30824
SC-MAG-341

ESTIMATING THE COST OF SUPERCONDUCTING MAGNETS AND THE REFRIGERATORS NEEDED TO KEEP THEM COLD*

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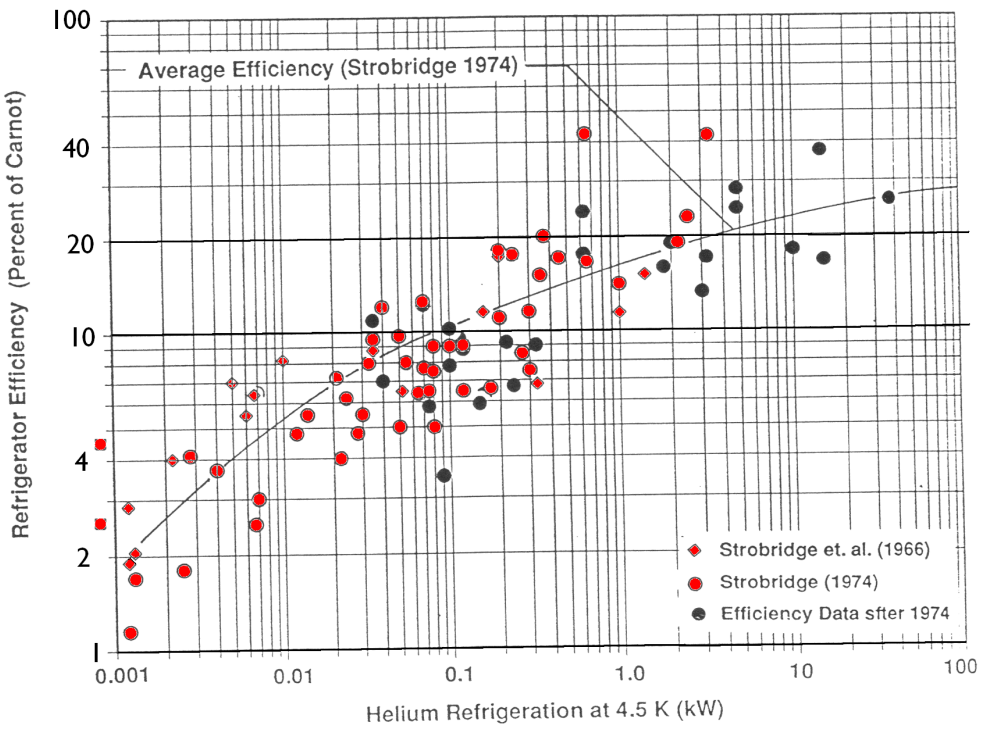


Figure 3. The Efficiency of Helium Refrigerators as a Function of 4.5 K Refrigeration

- Efficiency $\approx$ 20% of Carnot
- for 4 deg: $0.2 \times 4/300 \approx 1/375$
- for 70 deg: $0.2 \times 70/300 \approx 1/21$

Wall power consumptions

	Len	P_{peak}	Static	Dynamic	—	—	—	—	Tot
			4^o	rf	PS	4^o	20^o	70^o	
	m	MW	MW	MW	MW	MW	MW	MW	MW
p Driver (SC linac)									(20)
Target and taper	16				10.0	0.4			10.4
Decay and phase rot	95	220	0.1	0.8		4.5			5.4
Charge separation	14								
6D cooling before merge	222	1420	0.6	7.2		6.8	6.1		20.7
Merge	115	10	0.2	1.4					1.6
6D cooling after merge	428	1350	0.7	2.8			2.6		6.1
Final 4D cooling	78		0.1	1.5			0.1		1.7
NC RF acceleration	104	35	0.1	4.1					4.2
SC RF linac	140	50	0.1	3.4					3.5
SC RF RLAs	10400	570	9.1	19.5					28.6
SC RF RCSs	12566	790	11.3	11.8					23.1
Collider ring	2600		2.3		3.0	(5)		(5)	15.3
Totals	26777	4445	24.6	52.5	13.0	16.7	8.8	5	140.6

Required attenuation

- Allow 5 MW (wall) $\rightarrow$ 13 kW (4 deg) plus 240 kW at 70 deg.
- beam power 9 MW 3 MW to electrons Max leakage to 4 deg 0.43 %

What did we learn?

1. Narrow open mid-planes leak $\gg$ 0.43%
2. And Ding will show it is NOT from albido - using infinite widrh
3. We do not quite understand it, but doubt that it is not true

BUT

4. A tungsten pipe does allow the required attenuation

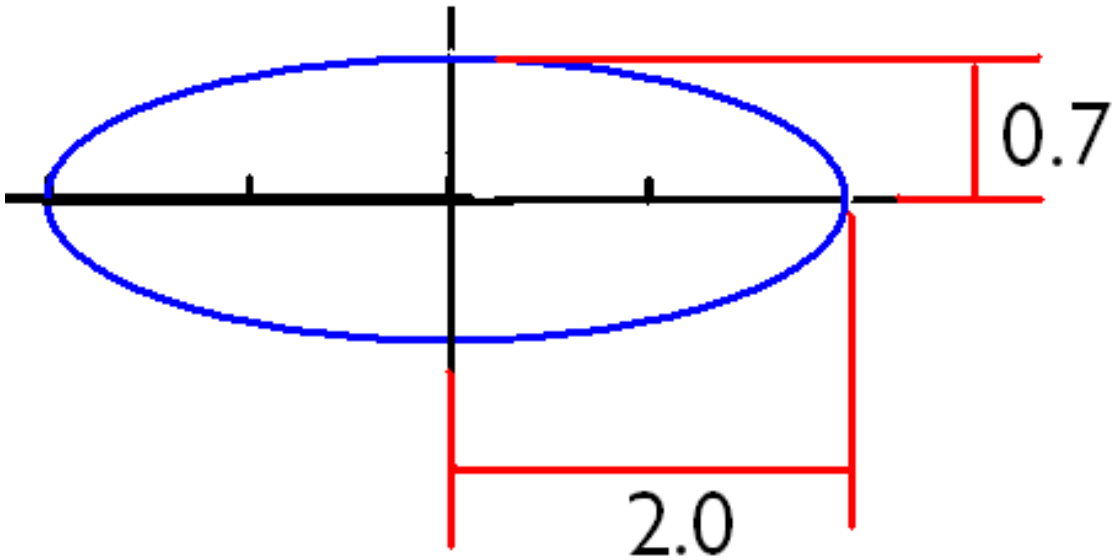
Beam pipe dimensions

$$\sigma_y = 0.7 \ mm \qquad \sigma_x = 4 \ mm$$

use $\pm$ 10 sigma in y use $\pm$ 5 sigma in x because it is mostly rfom dp/p

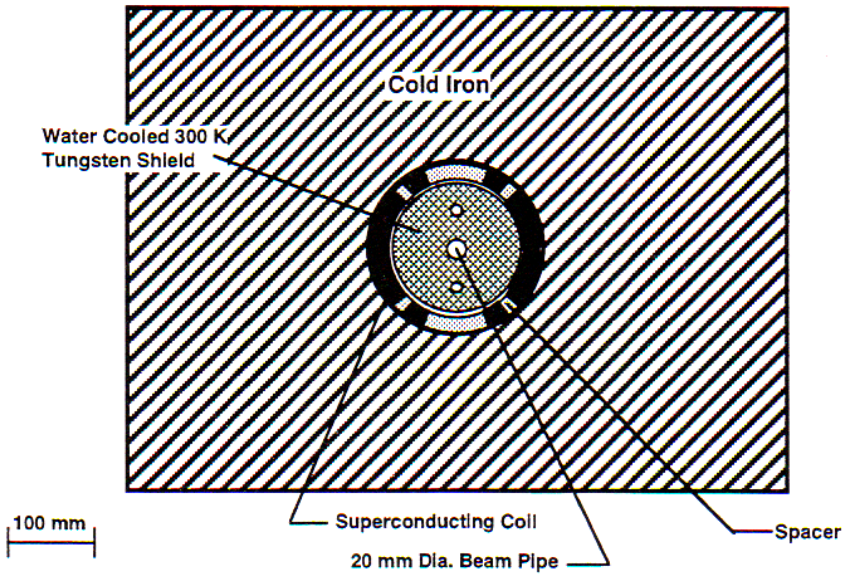
height = 2 x 0.7 x 10 = 14 mm

width = 2 x 4 x 5 = 40 mm



From 1998 Feasibility Study

Cos theta



- Most radiation in horizontal plane
- A factor of 10 less vertically

- Shielding and magnet could be ellipti
- At 2 TeV almost equal in & out

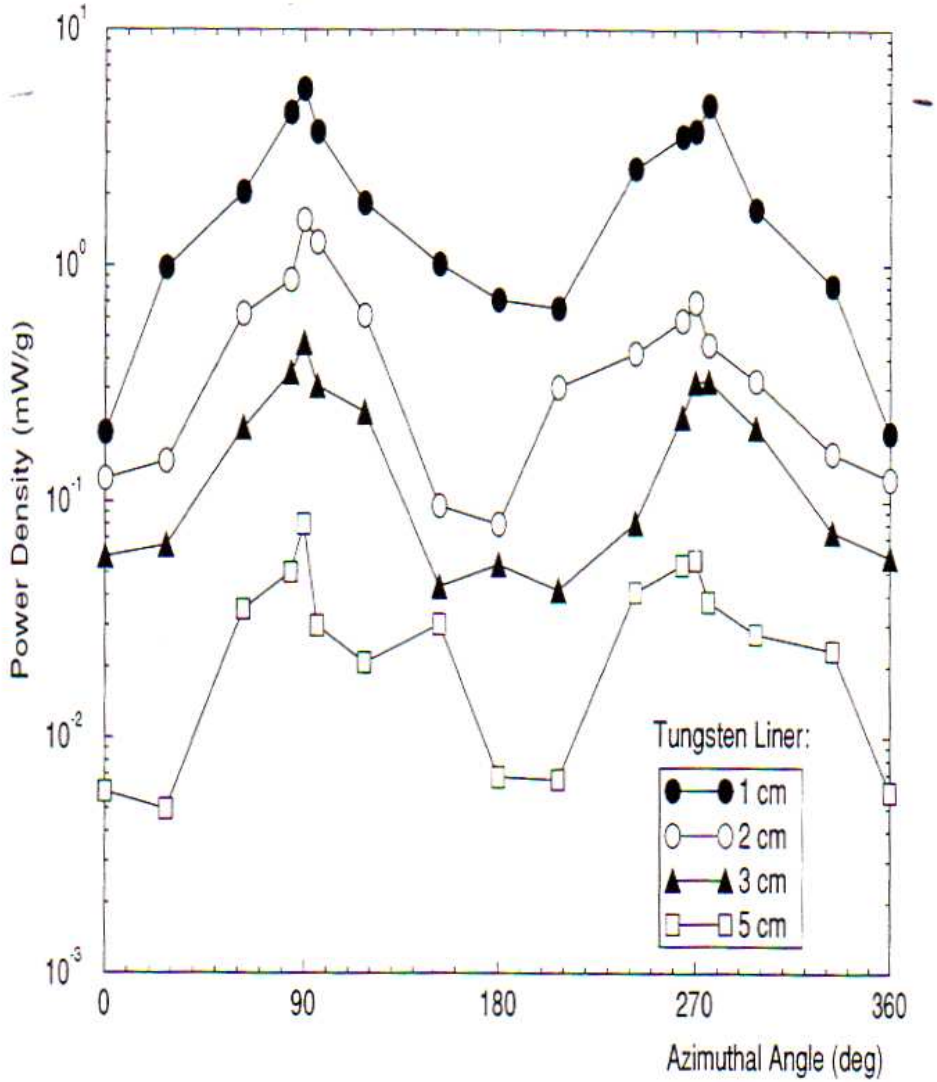
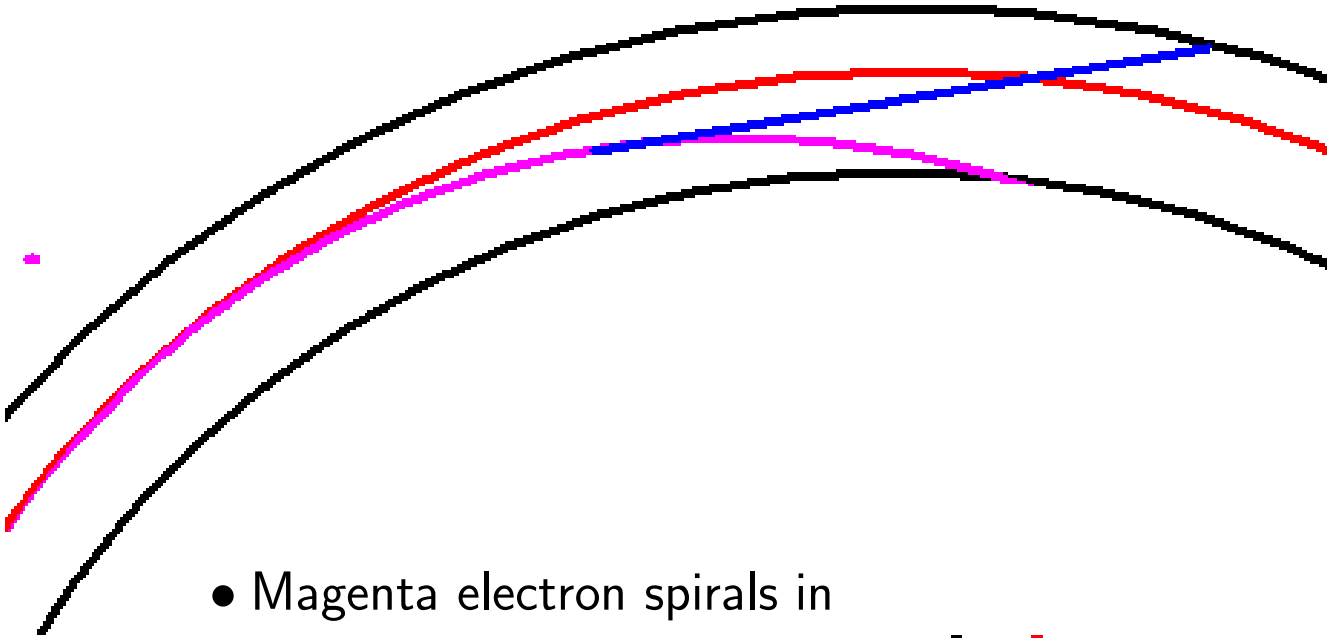


Figure 8.14: Azimuthal distribution of power density in the first SC cable shell in the collider arc for different tungsten liners inside the aperture for 2 TeV muon beam decays

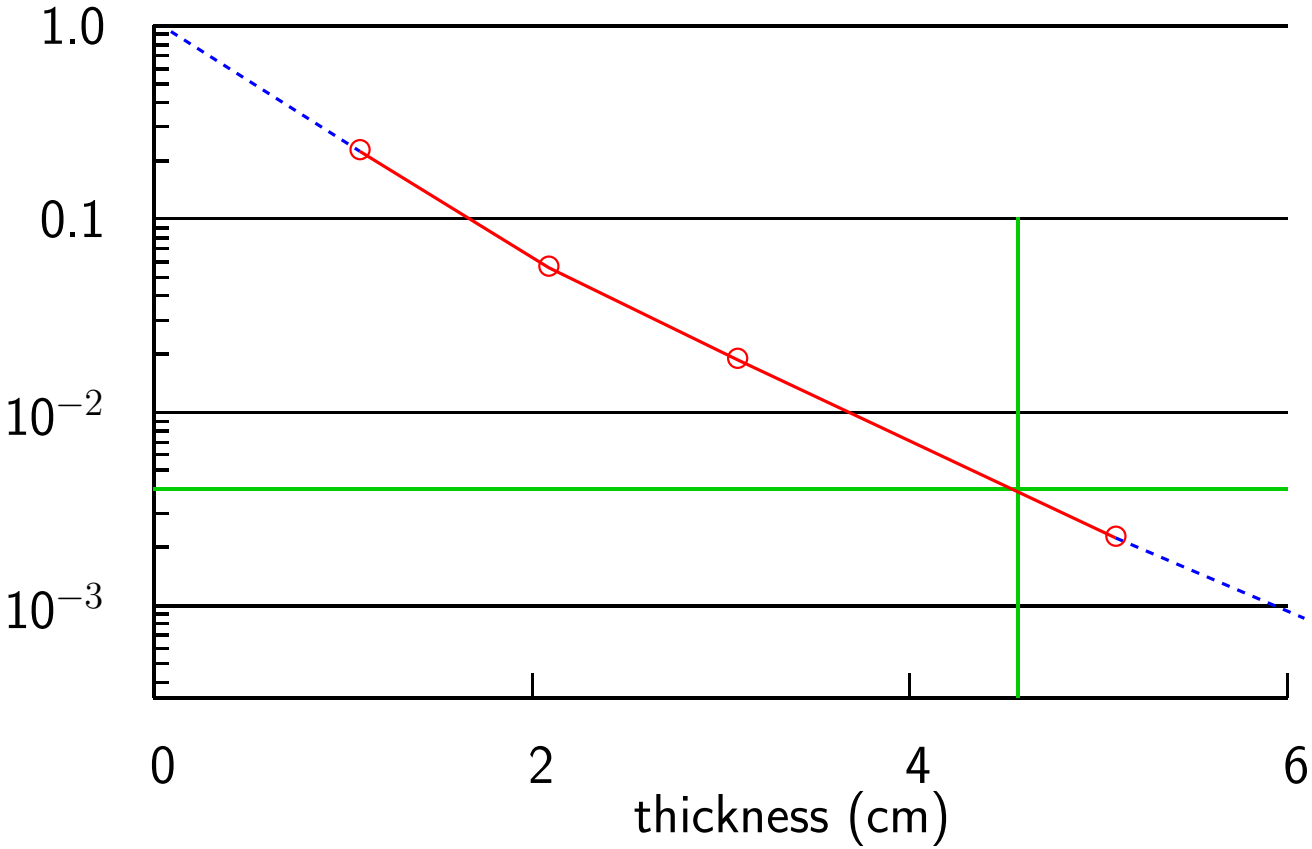
Why both in and out?



- Magenta electron spirals in
- Blue radiation crosses to outside
- At low energies there is less of this radiation

- Above was for 2 TeV muons
- For 0.75 TeV the synchrotron going out will be relatively less
- Assume it is a factor of 2 less - a guess

Required thickness of tungsten



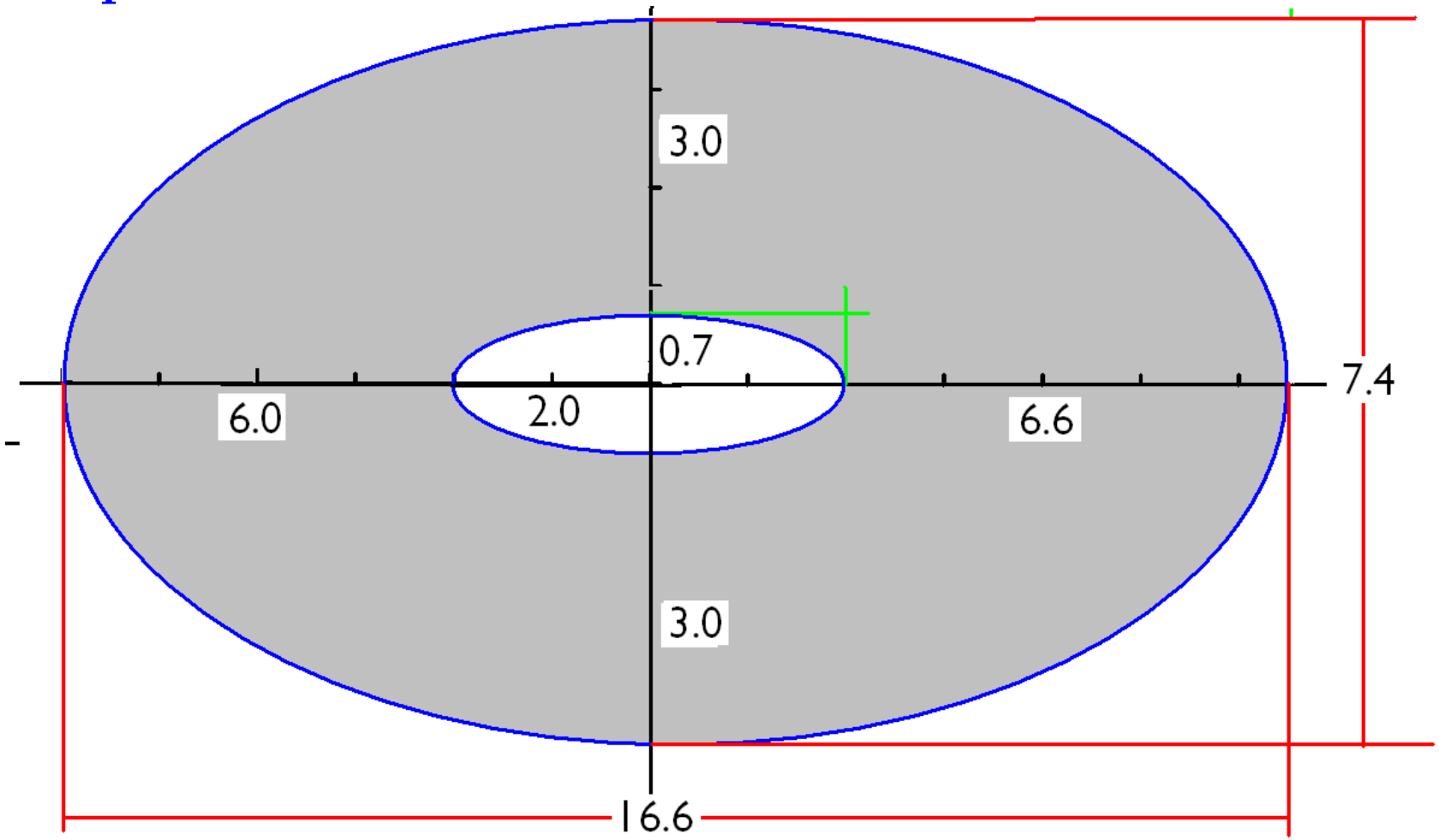
Factor 10 from 1.7 cm

Factor 2 from 0.6 cm

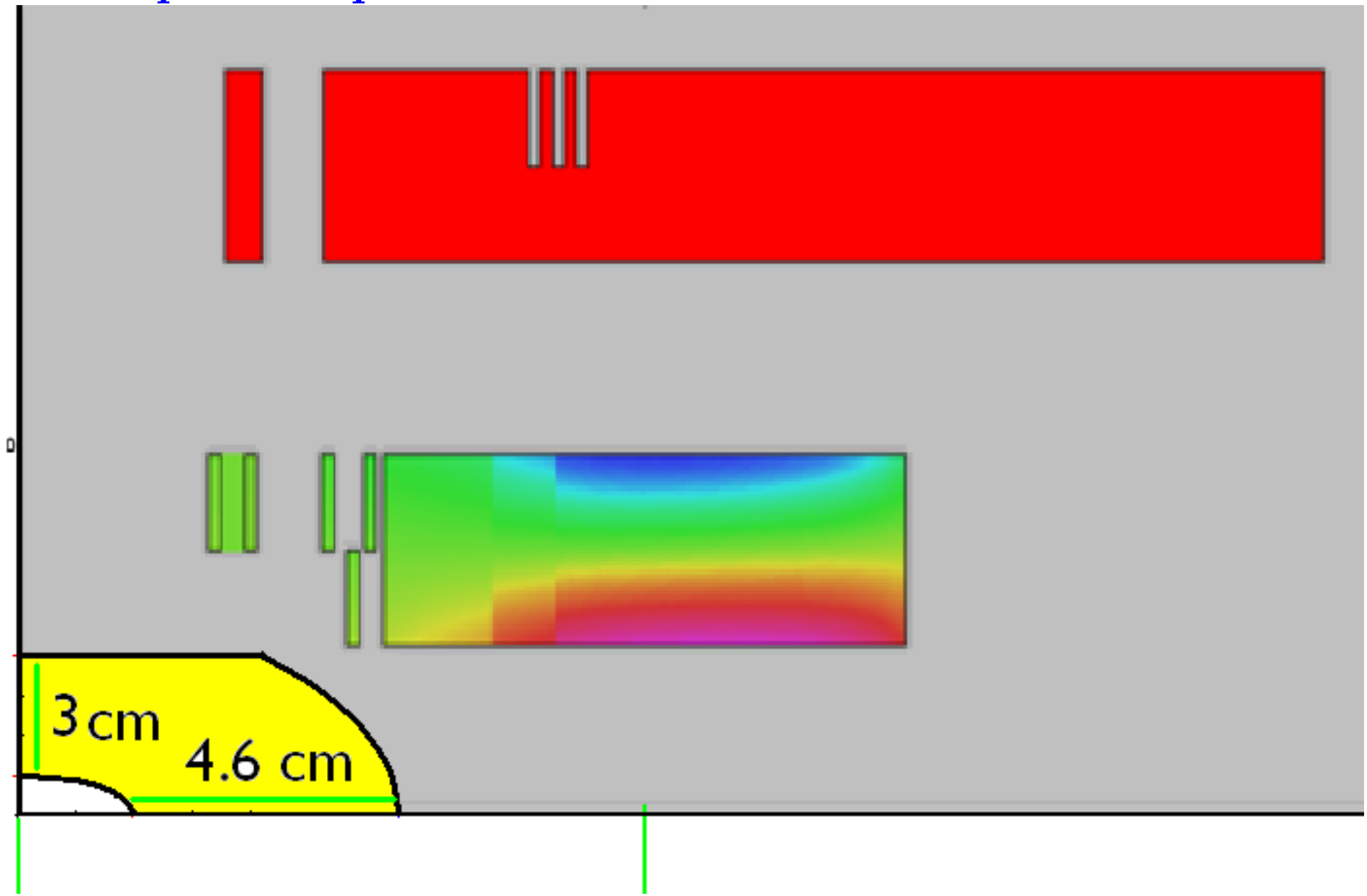
Factor 250 from 4.6 cm

- In worst direction inward: For 99.6% $\boxed{\text{L} = 4.6 \text{ cm}}$
- In outward direction if factor 2 less: L = 4.6 - 0.6 $\boxed{= \ 4.0 \text{ cm}}$
- for factor 10 less vertically: L=4.6 - 1.6 $\boxed{= \ 3.0 \text{ cm}}$

Required Shield



In Open midplane coils



In elliptical cos theta