# Cooling efficiency of Bucked Lattice

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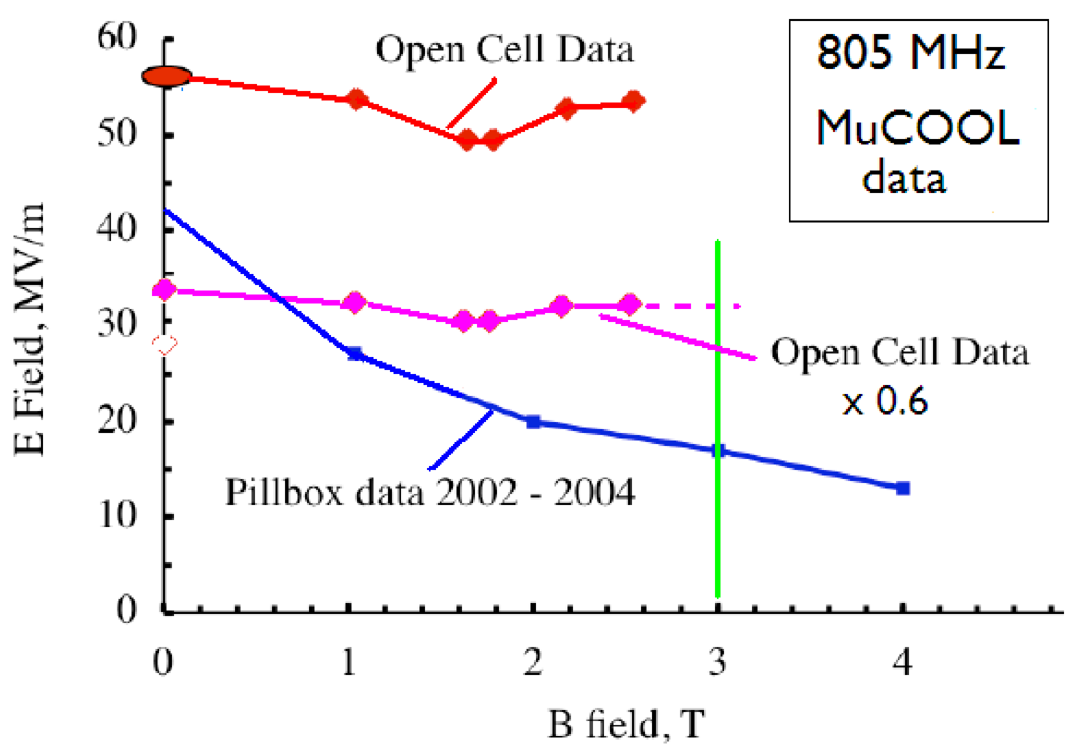


# Define a cooling efficiency Q

$$Q_6(z) = \frac{d\epsilon_6/\epsilon_6}{dN/N} \tag{1}$$

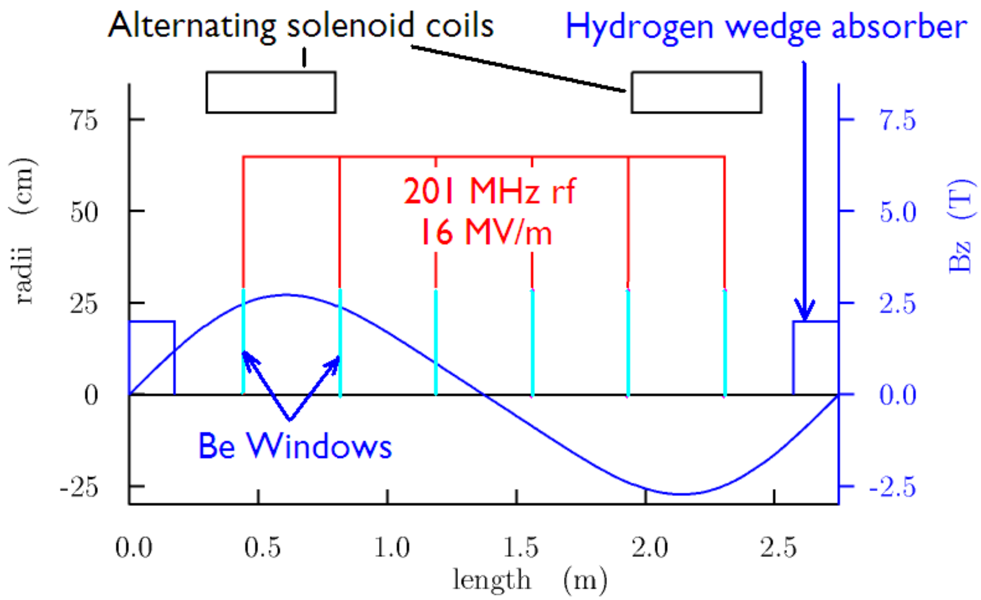
Note, if $Q_6(z)$=constant, then

$$\int_o^n \frac{d\epsilon_6}{\epsilon_6} = Q_6 \int_o^n \frac{dN}{N}$$

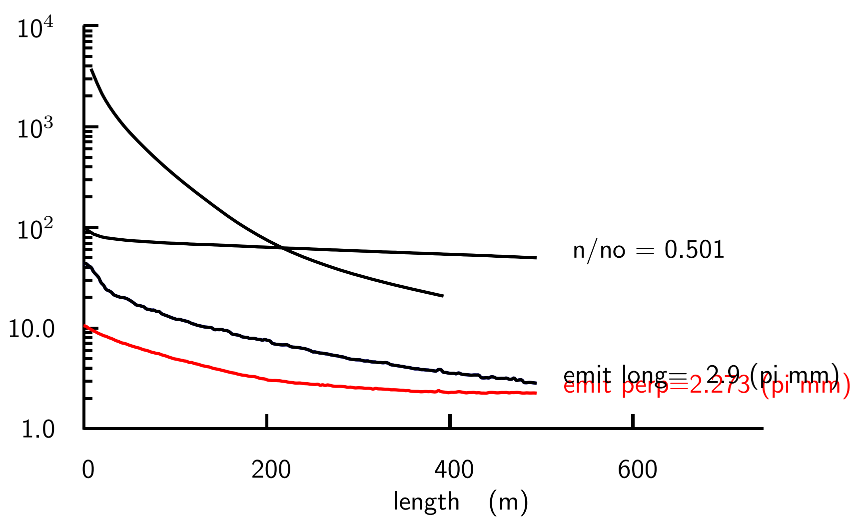
$$\mathrm{Ln}\left(\frac{\epsilon_6(n)}{\epsilon_6(o)}\right) = Q_6 \ \mathrm{Ln}\left(\frac{N(n)}{N(o)}\right)$$

$$\frac{N(n)}{N(o)} = \left(\frac{\epsilon_6(n)}{\epsilon_6(o)}\right)^{1/Q_6} \tag{2}$$

# Old RFOFO



Alternating solenoid coils
Hydrogen wedge absorber
201 MHz rf
16 MV/m
Be Windows
radii (cm)
Bz (T)
75
50
25
0
-25
7.5
5.0
2.5
0.0
-2.5
0.0
0.5
1.0
1.5
2.0
2.5
length (m)

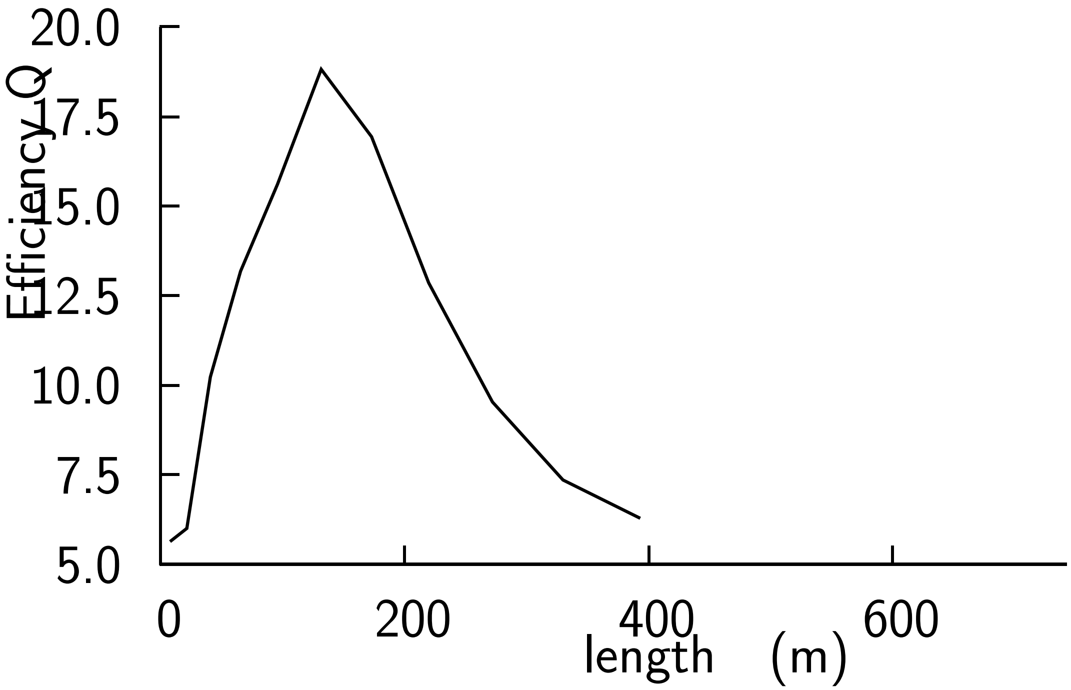



$10^4$
$10^3$
$10^2$
10.0
1.0
n/no = 0.501
emit long= 2.9 (pi mm)
emit perp=2.273 (pi mm)
0
200
400
600
length (m)

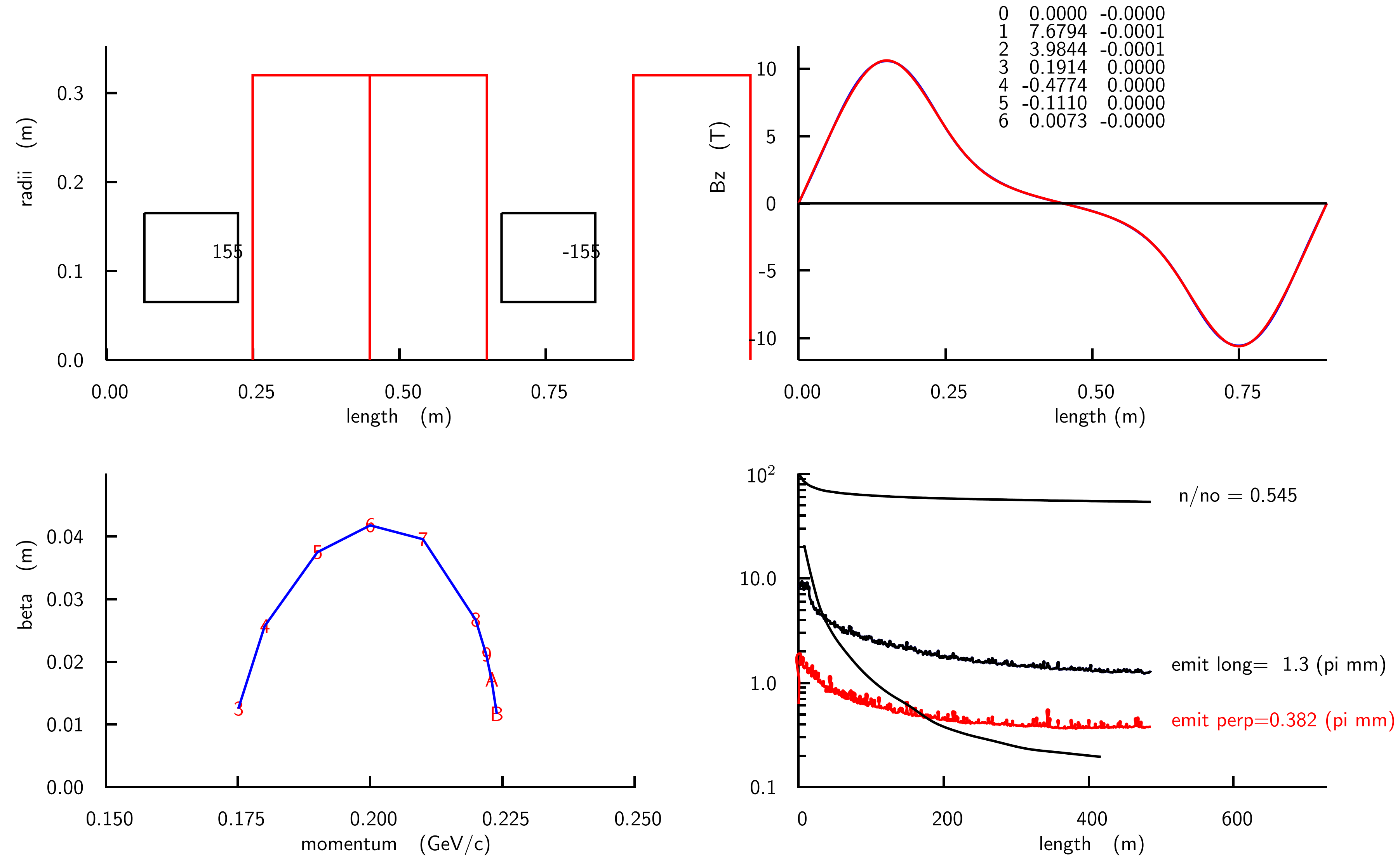
# Efficiency vs. length

- Mismatch and Scraping losses at start
- Decay losses as emittances approach eqilibrium at end
- Sweet region in between (Q≈ 15

- If tapered then the entire channel is operated in the sweet region

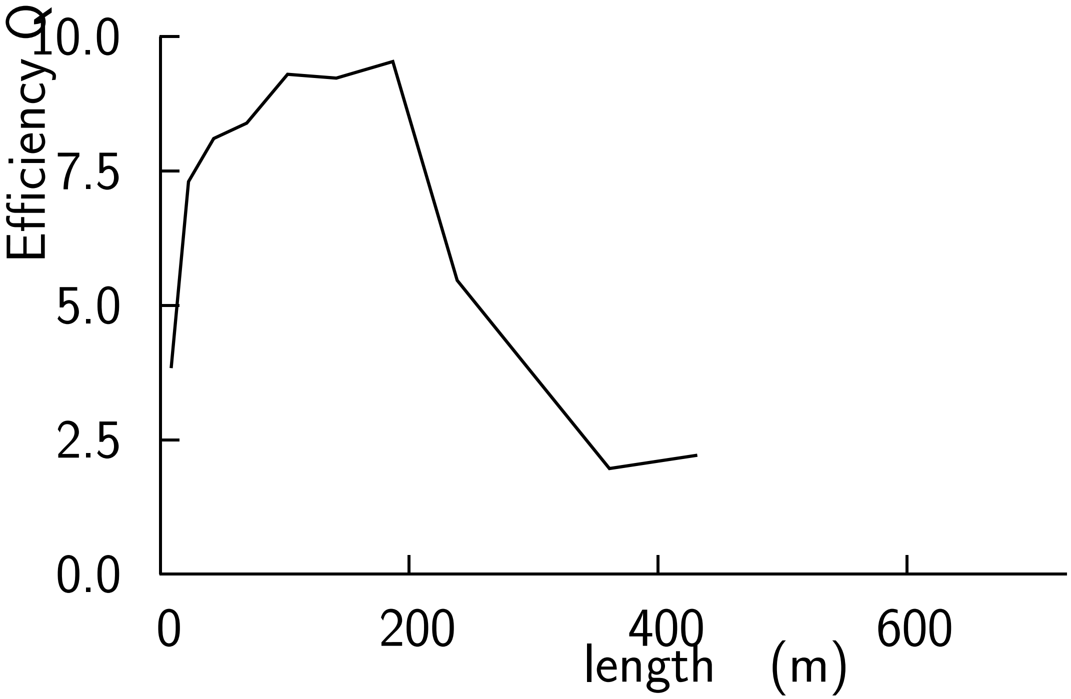


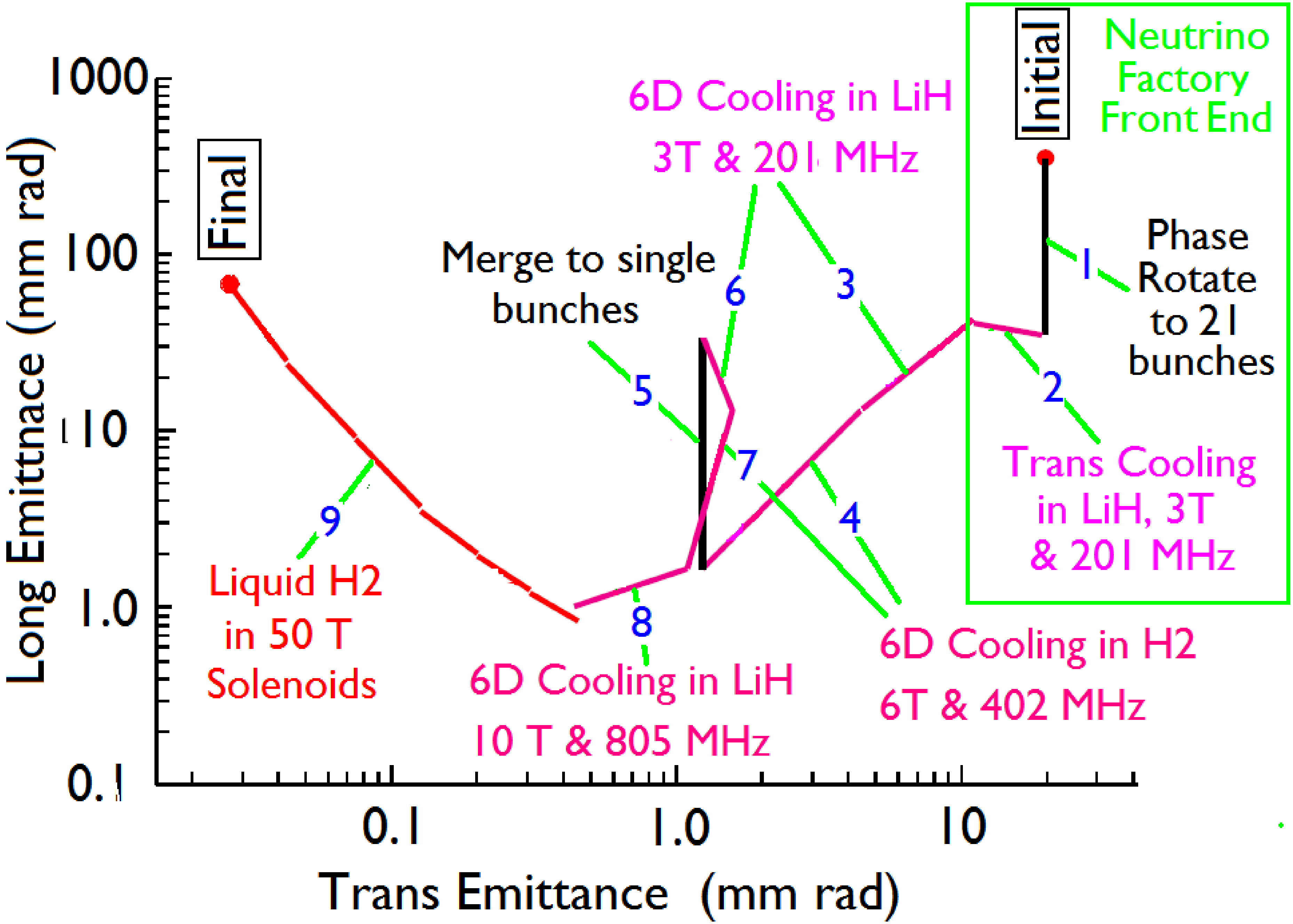
# Old 1/3 scale RFOFO



# Efficiency vs. length

- Sweet region in between (Q$\approx$ 8.5)




Final
Initial
Neutrino Factory Front End
6D Cooling in LiH 3T & 201 MHz
Merge to single bunches
Phase Rotate to 21 bunches
Trans Cooling in LiH, 3T & 201 MHz
Liquid H2 in 50 T Solenoids
6D Cooling in LiH 10 T & 805 MHz
6D Cooling in H2 6T & 402 MHz
1
2
3
4
5
6
7
8
9
1000
100
10
1.0
0.1
0.1
1.0
10
Long Emittnace (mm rad)
Trans Emittance (mm rad)

# What this means for overall survival

from start to end of 6D cooling $\frac{\epsilon_6(n)}{\epsilon_6(o)} = 0.6\ 10^6$

If $Q$=15

$$\frac{N(n)}{N(o)} \approx 0.4$$

If $Q$=8.5

$$\frac{N(n)}{N(o)} \approx 0.2$$

To this must be added estimated losses from merging (0.7), final cooling (0.5) and acceleration (0.7) giving

If $Q$=15

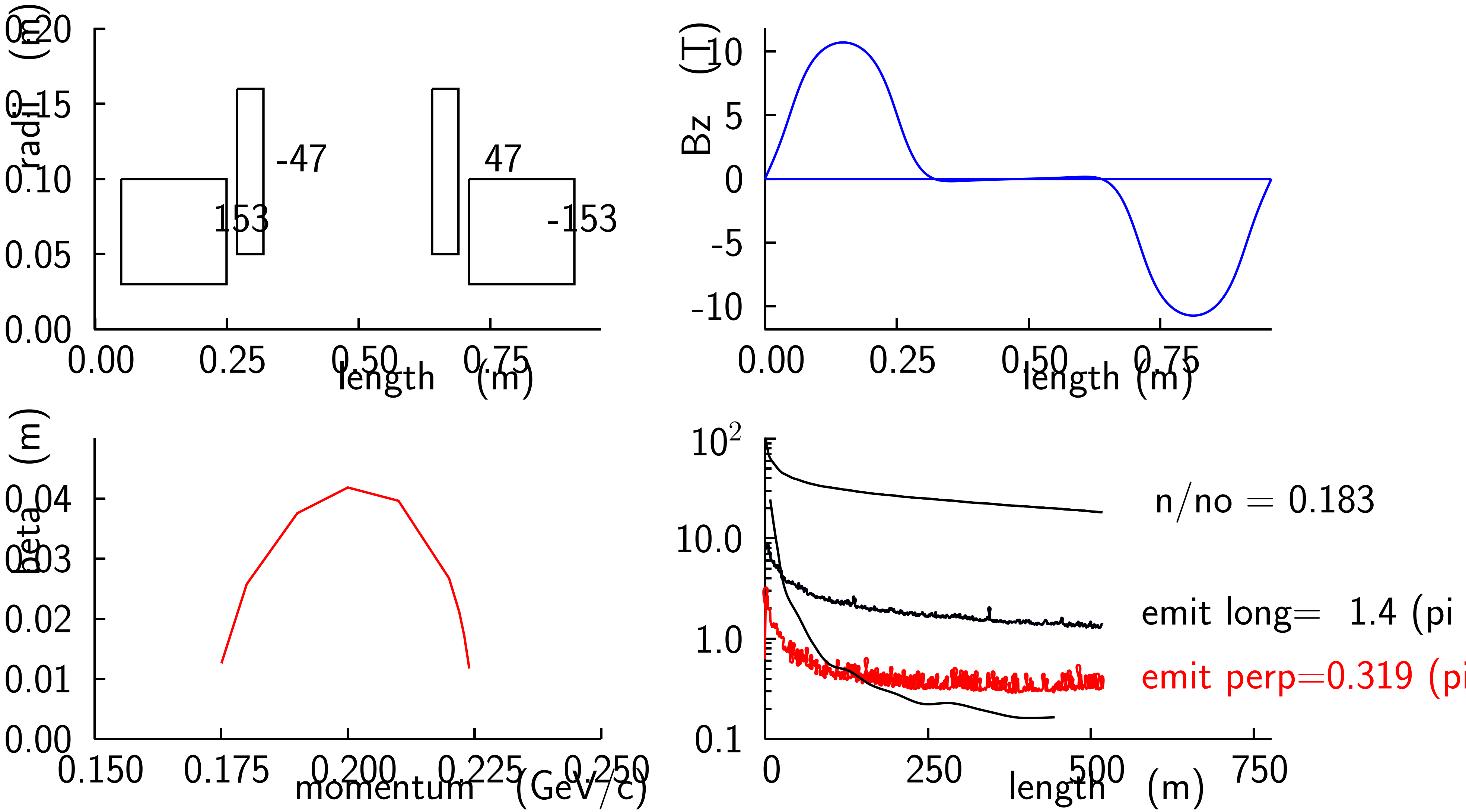
$$\frac{N(n)}{N(o)} \approx 0.1$$

If $Q$=8.5

$$\frac{N(n)}{N(o)} \approx 0.05$$

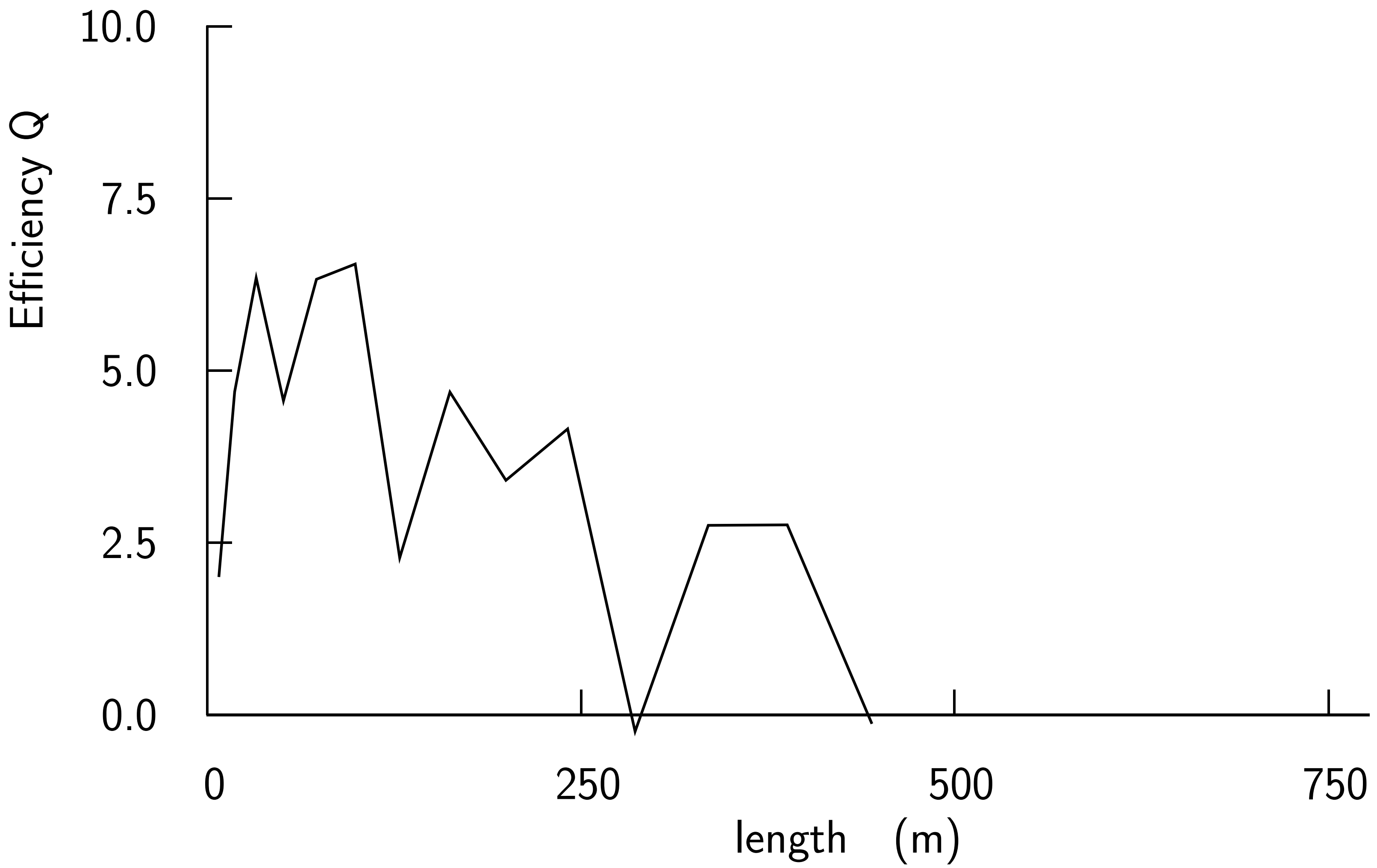
So the expected survival was between 0.1 and 0.04 which is consitent with our guess of 0.07

# Version with bucking coils



# Efficiency vs. length

- Sweet region in between only (Q$\approx$ 5)



# What this means for overall survival

from start to end of 6D cooling $\frac{\epsilon_6(n)}{\epsilon_6(o)} = 0.6\ 10^6$

If $Q$=5

$$\frac{N(n)}{N(o)}\ \approx\ 0.07$$

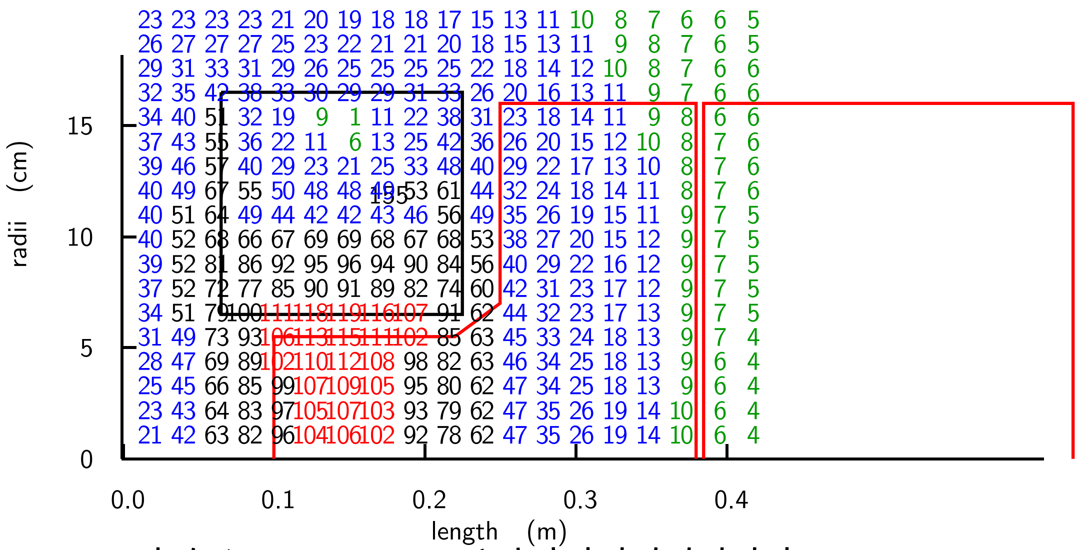
To this must be added estimated losses from merging (0.7), final cooling (0.5) and acceleration (0.7) giving

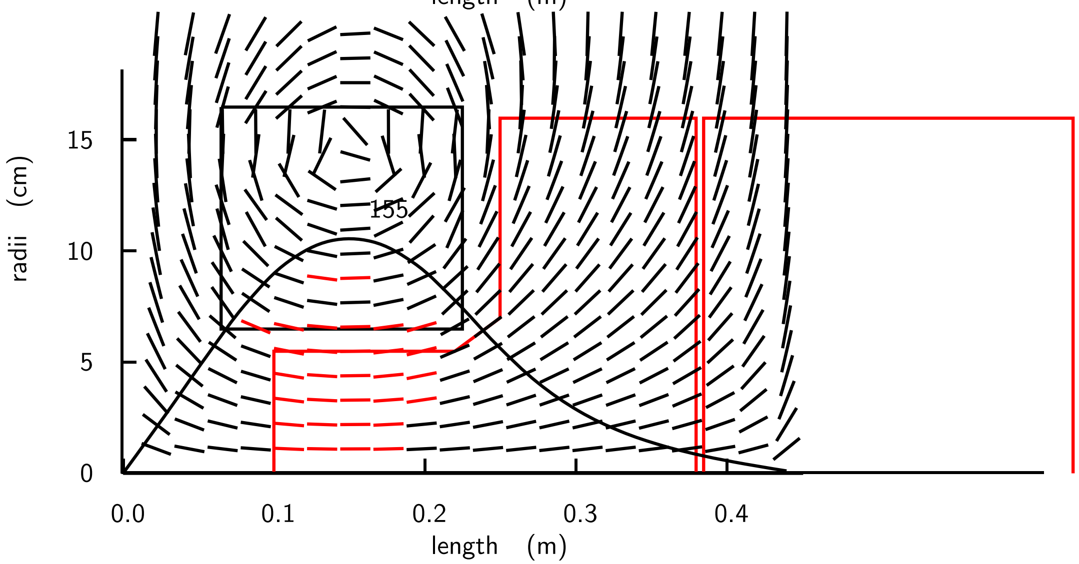
If $Q$=5

$$\frac{N(n)}{N(o)}\ \approx\ 0.017$$

This is not acceptable

# Old 1/3 lattice plus semi-open cavities




This could be used throughout

# What this means for overall survival

from start to end of 6D cooling $\frac{\epsilon_6(n)}{\epsilon_6(o)} = 0.6\ 10^6$

If $Q$=8.5

$$\frac{N(n)}{N(o)}\ \approx\ 0.2$$

To this must be added estimated losses from merging (0.7), final cooling (0.5) and acceleration (0.7) giving

If $Q$=7.5

$$\frac{N(n)}{N(o)}\ \approx\ 0.05$$

This is barely acceptable

I have not done this analysis with the open cavities with coils in irises that could be used for the earlier stages and might be better