RFOFO Ring Cooler

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WG 3 Wed 11.30 am

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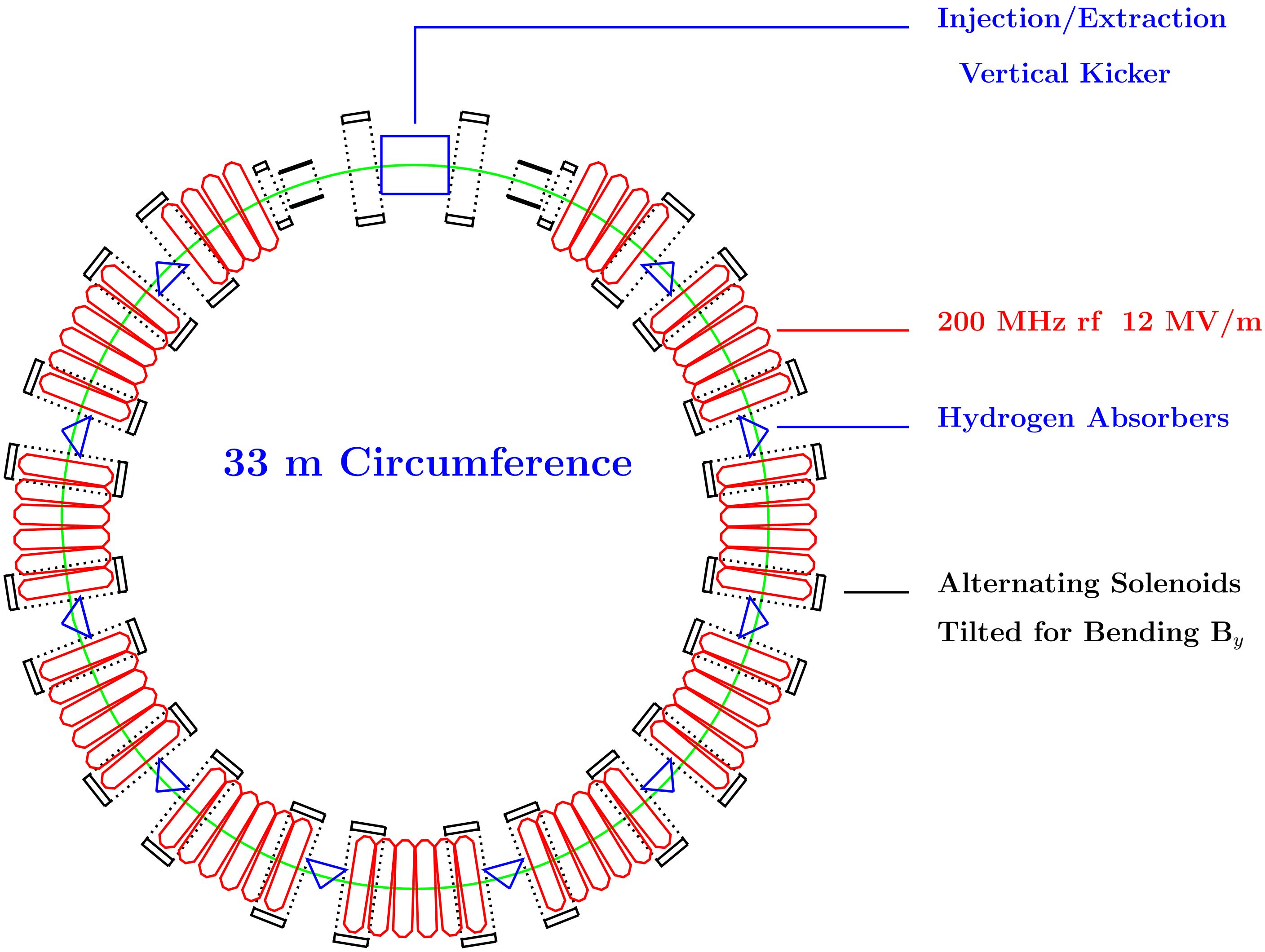
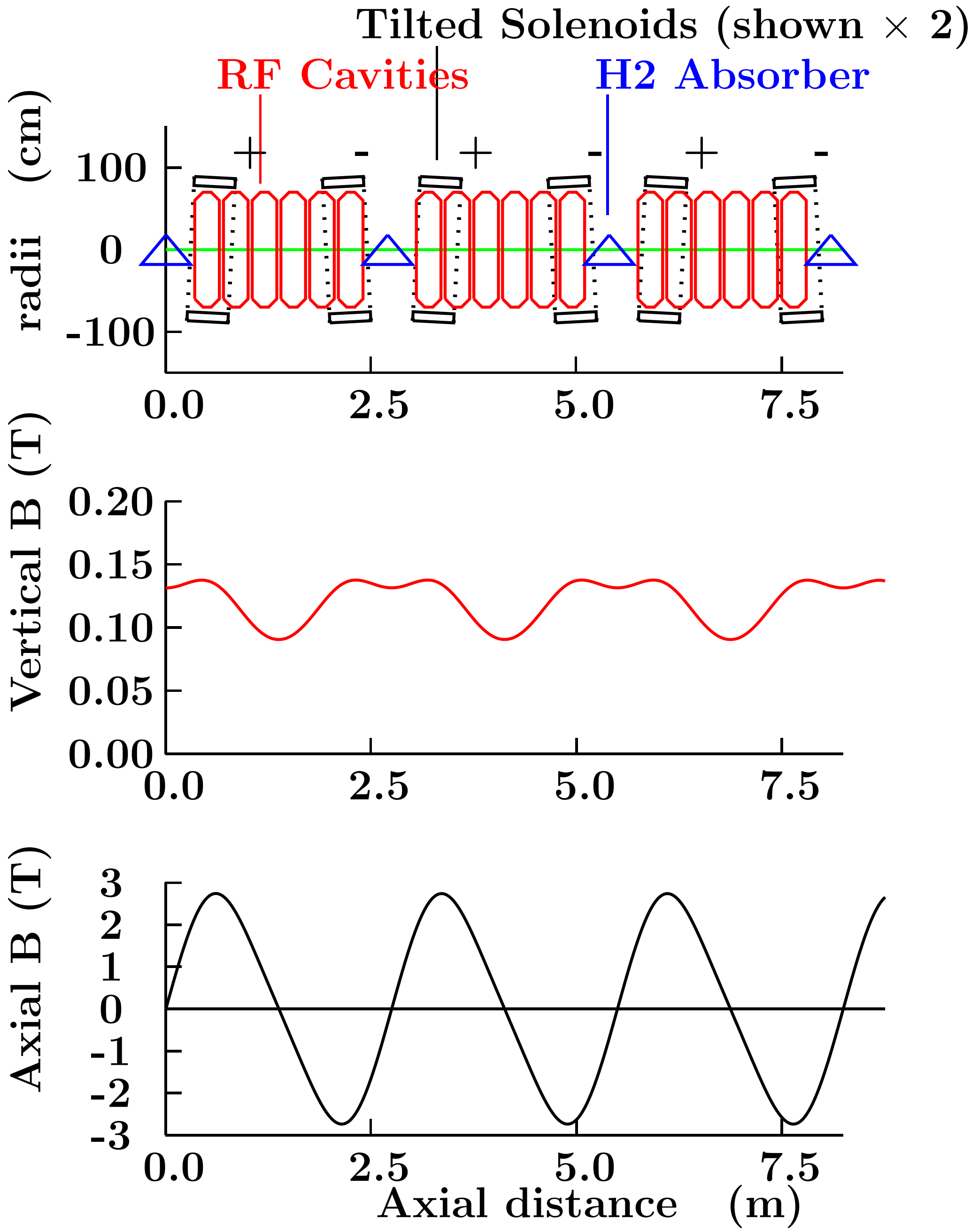
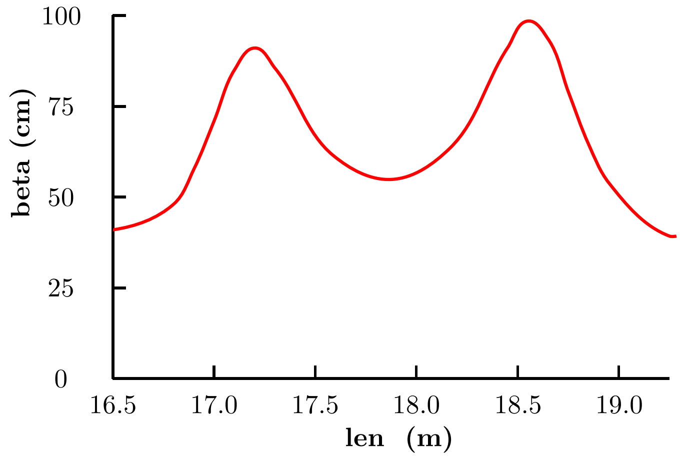
Layout of RFOFO Ring



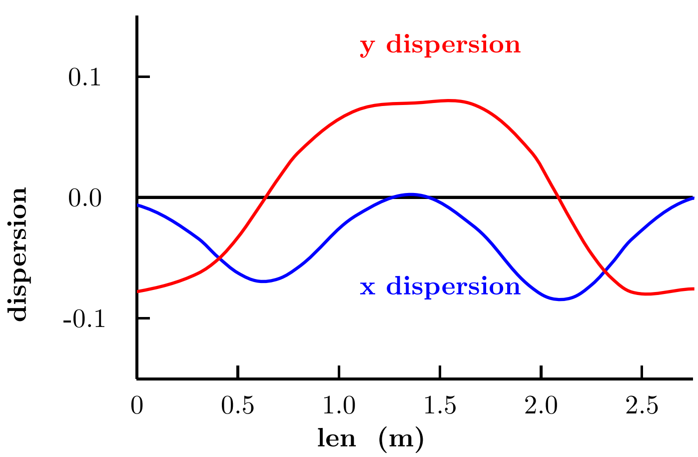
Tilt Focus Coils for Bend .



Beta and Dispersion .



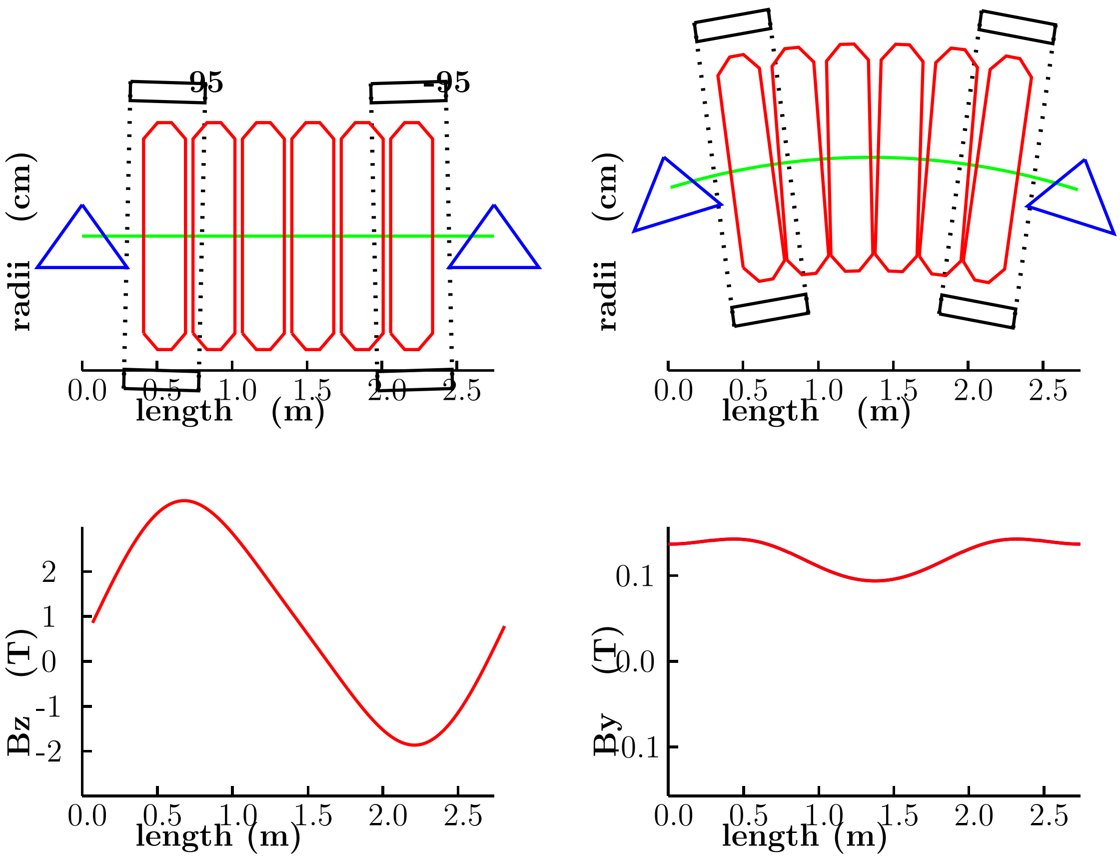
beta is ≈ straight case



Dispersion is rotating back and forth

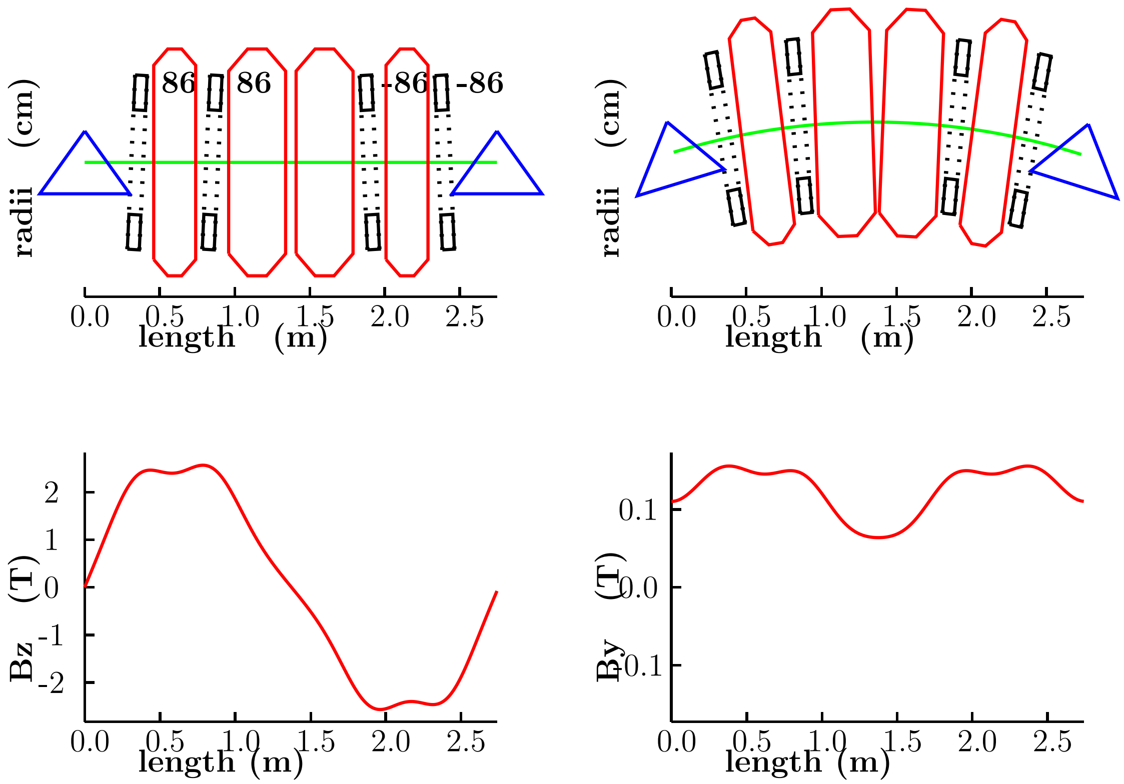
Cell Layouts

a) Coils outside RF



- Wedges shown 0 and 90 deg.
  true angle 30 deg
- Amp-turn-length = 54 MAm/cell
- RF Grad = 12 MV/m

b) Coils between Cavities



- Amp-turn-length = 14 MAm/cell
- RF Grad = 16 MV/m

- Performance the same
- Choice not yet made

Params for Simulation

Coils

gap m	start m	dl m	rad m	dr m	tilt rad	I/A A/mm^2
0.310	0.310	0.080	0.300	0.200	0.0497	86.25
0.420	0.810	0.080	0.300	0.200	0.0497	86.25
0.970	1.860	0.080	0.300	0.200	-.0497	-86.25
0.420	2.360	0.080	0.300	0.200	-.0497	-86.25

amp turns 5.52 (MA)

amp turns length 13.87326 (MA m)

cell length 2.750001 (m)

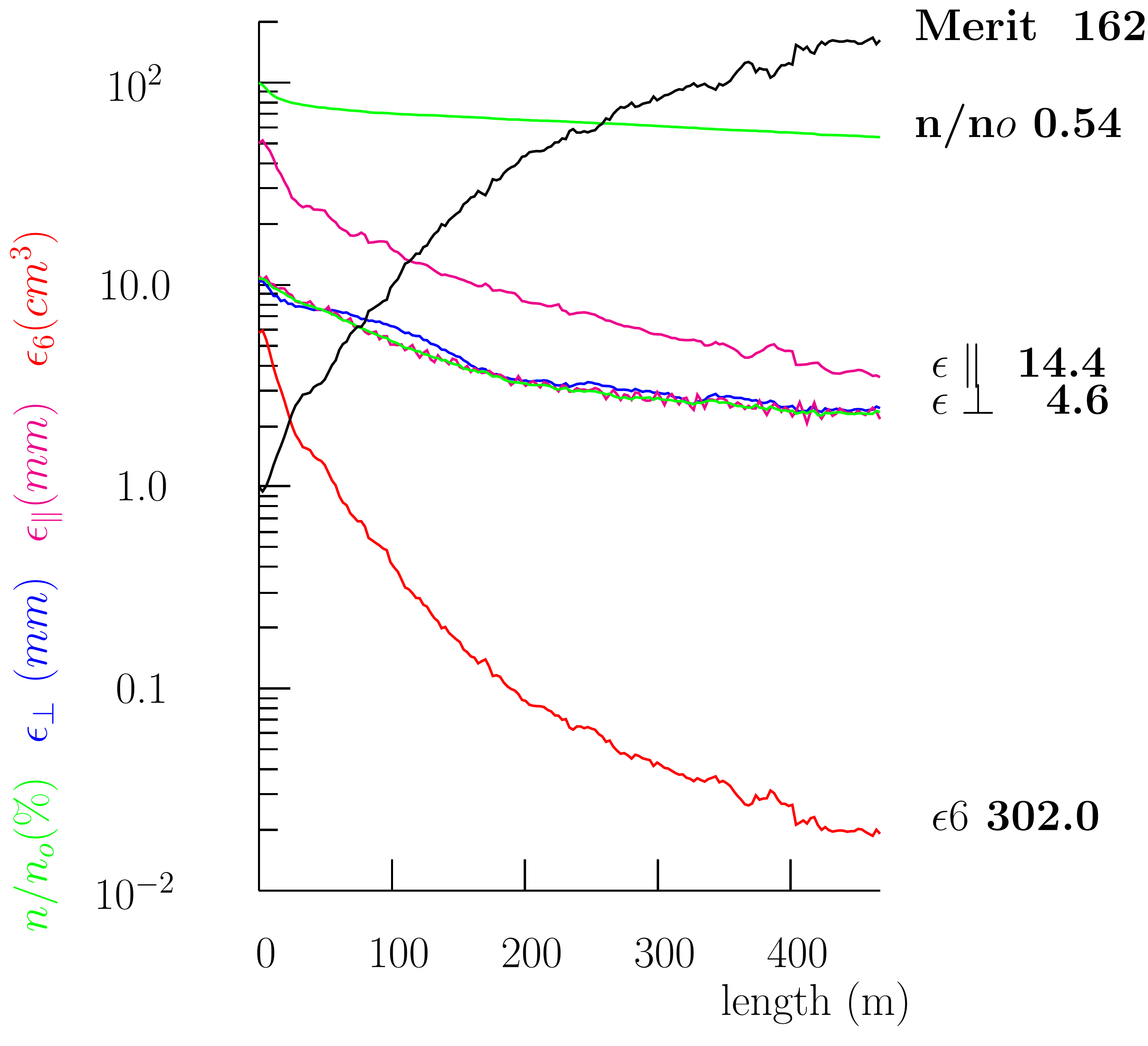
Wedge

Material		H2
Windows		none
Radius	cm	18
central thickness	cm	28.6
min thickness	cm	0
wedge angle	deg	100
wedge azimuth from vertical	deg	30

RF

Cavities/cell		4
Lengths	cm	28
Radial aperture	cm	25
Frequency	MHz	201.25
Gradient	MV/m	16
Phase rel to fixed ref	deg	25
Windows		none

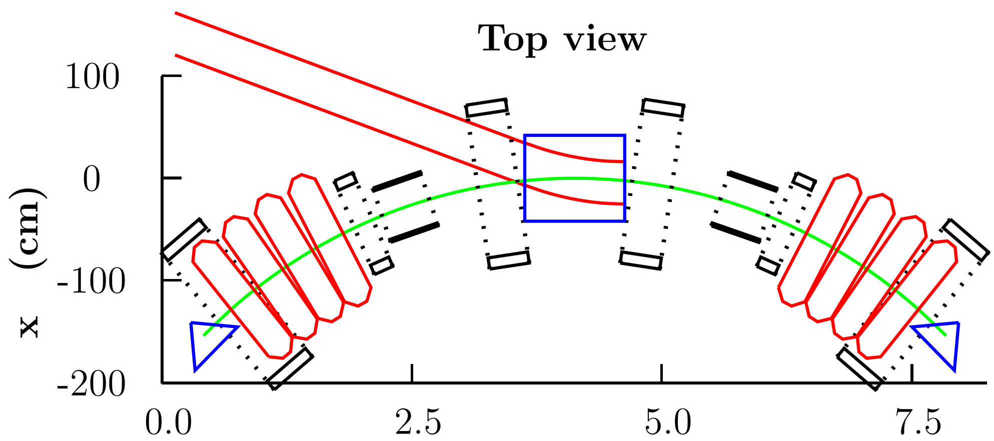
Performance



	len	trans	$\epsilon_\perp$	$\epsilon_\parallel$	ϵ_6	merit
	m	%	π mm	π mm	π^3cm^3	
RFOFO Ring						
initial			10.7	50.1	5.787	
final	468	**54**	**2.3**	**3.5**	0.019	**162**
ratio			4.6	14.4	302.0	
Study 2						
initial	108		10.7	50.1	5.787	
final		**50**	**2.3**	**38**	0.2	**15**
ratio			4.7	1.4	30	
Balbekov						
initial			12	15	2.16	
final	555	**48**	**2.1**	**6.3**	.028	**38**
ratio			5.7	2.38	79	

- Similar final transverse emittance
- Similat transmission
- RFOFO Ring has
  least final longitudinal emittance

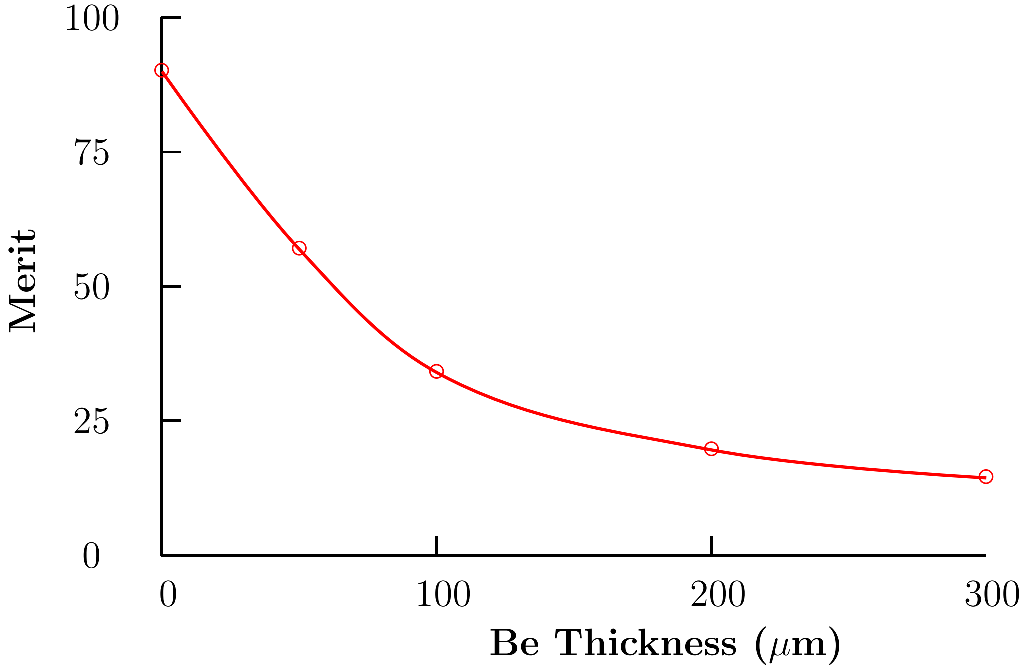
Insertion for Inject/Extract



- First Simulation gave Merit = 10
  Synchrotron tune = 2.0: Integer
- Increase energy, wedge angle, and add matching.
- Merit **160 → 110**
- Can probably be improved

Difficult Question 1

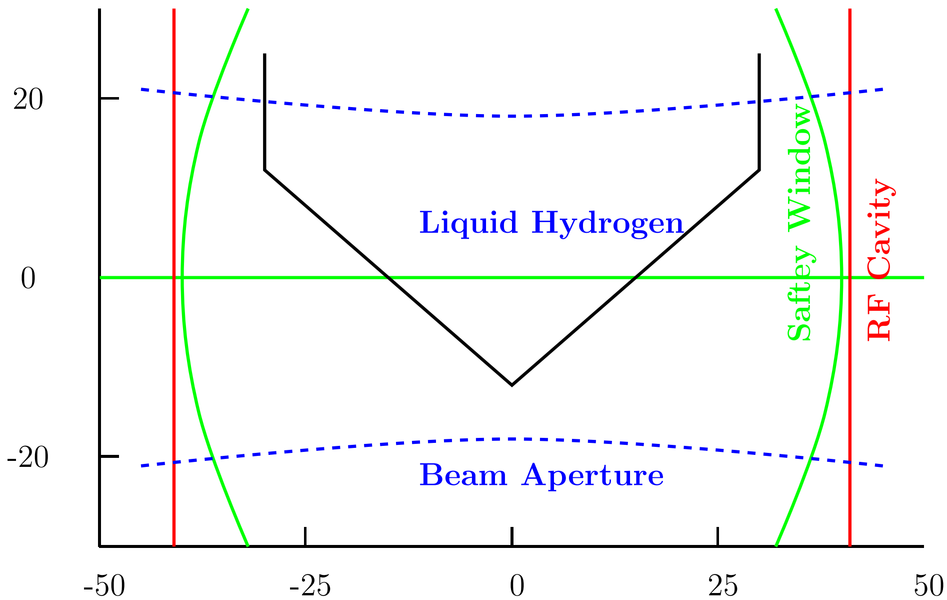
RF windows must be very thin



- Study 2: 200-300 microns
- Need ≈25 microns
- RF at 70 deg will help

Difficult Question 2

Design of wedge absorber



- Does not cross aperture
- Several kW Disipation
- Windows very thin

Difficult Question 3

Injection Kicker

Minimum Required kick

$$\text{for :} \qquad f_\sigma = \frac{\mathrm{Ap}}{\sigma} \qquad \mu \; = \; \mathrm{inf}$$

$$V \;=\; \left(\frac{4\ f_\sigma^2\ m_\mu\ R}{c}\right) \quad \frac{\epsilon_n}{\tau}$$

$$U \;=\; \left(\frac{m_\mu^2\ 8\ f_\sigma^4\ R}{\mu_o\ c^2}\right) \quad \frac{\epsilon_n^2}{L}$$

- muon $\epsilon_n \gg$ other ϵ_n's
- muon kicker Joules $\gg$ other kickers
- Nearest are $\bar{p}$ kickers

Compare with others

For $\epsilon_\perp = 10\ \pi$mm, $\beta_\perp = 1$m, & τ=50 nsec:

After correction for finite μ and leakage flux:

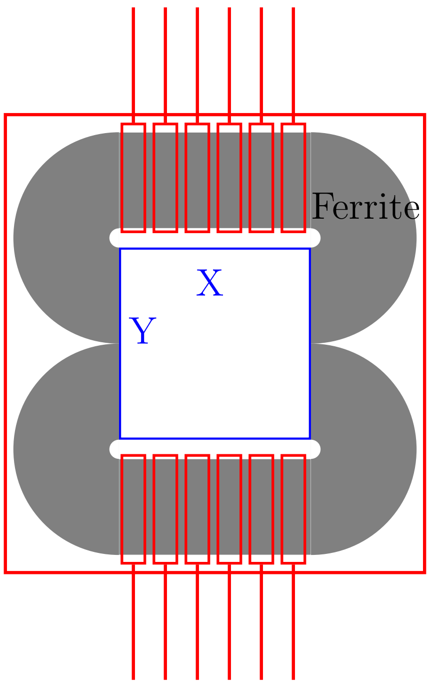
		μ Cooling	CERN $\bar{p}$	Ind Linac
$\int Bd\ell$	Tm	.30	.088	
L	m	1.0	≈5	6.0
t_{rise}	ns	**50**	**90**	**40**
B	T	**.30**	**≈0.018**	**0.6**
X	m	.42	.08	
Y	m	.63	.25	
V_{1turn}	kV	**3,970**	**800**	**6,000**
U_{magnetic}	J	**10,450**	**≈13**	**10,000**

Note

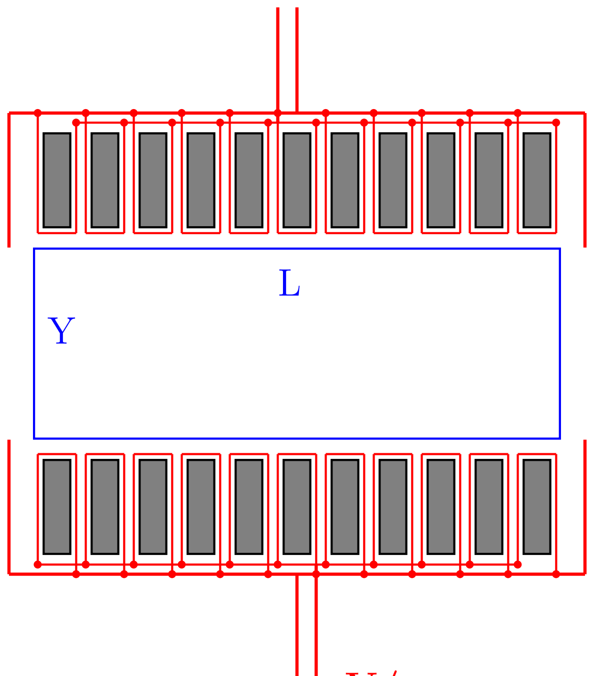
- U is 3 orders above $\bar{p}$
- Same order as Induction
- And t same order
- But V is too High

Induction Kicker

- As in an Induction Linac:
  Divide Yoke into slices
- Feed loops in parallel
  Solves Voltage Problem
- Conducting Box Removes
  Stray Field Return



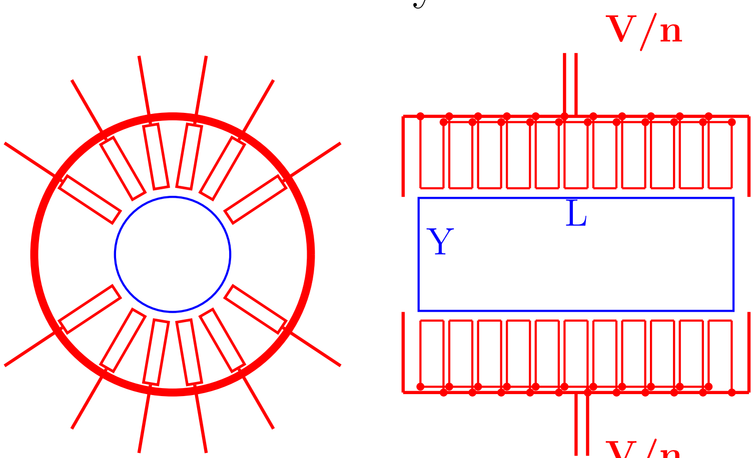
End View



Side View

Works with no Ferrite

- V = the same
- U≈ 2.25×
- I≈ 2.25×
- No rise time limit
- Not effected by solenoid fields



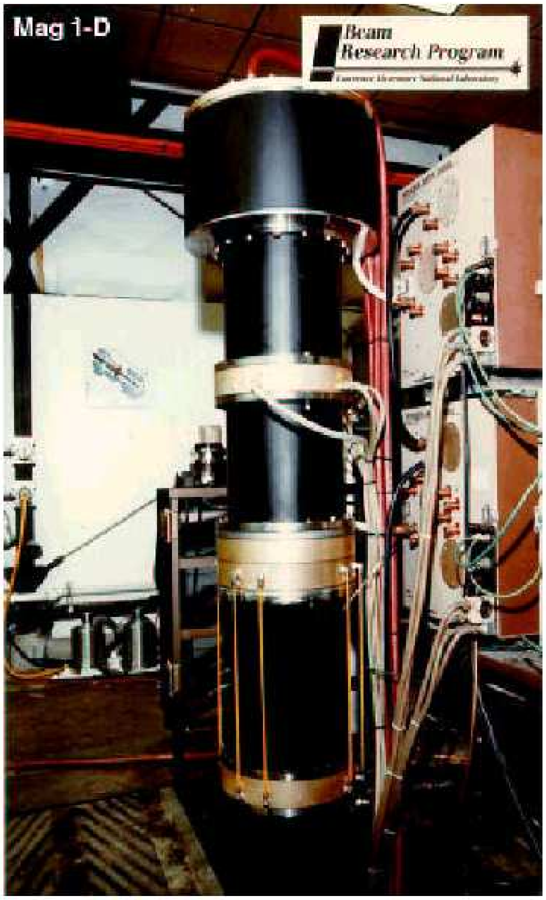
End View

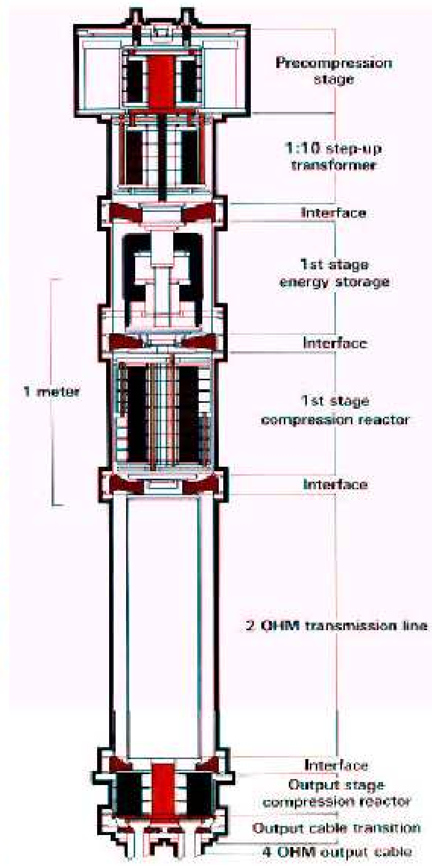
Side View

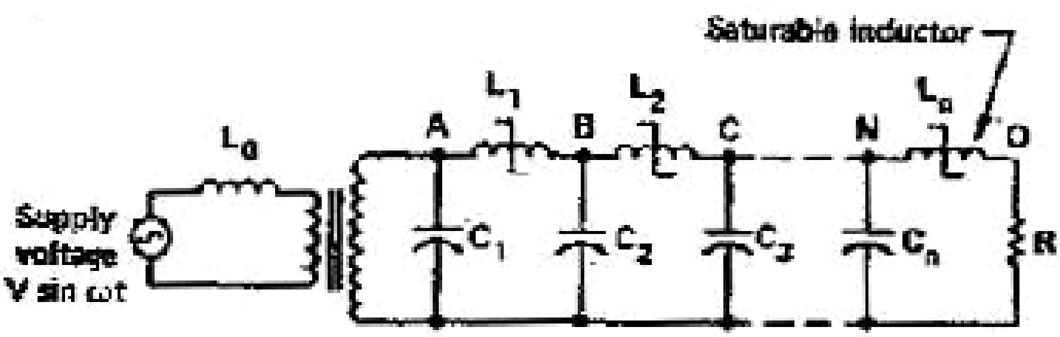
- If non Resonant: 2 Drivers
  for inj. & extract.
  Need 24 ×2 Magamps (≈ 20 M$)
- If Resonant: 1 Driver, 2×efficient
  Need 12 Magamps (≈ 5 M$)

Magnetic Amplifiers

- Used to drive Induction Linacs
- similar to ATA or DARHT
- switch low Amp long pulse
- Mag-Amp compresses pulse







Ring Cooler Conclusion

- Rapid Progress has been made.
  Merit 160 for ring vs 15 for Study 2
- Need for very thin windows
- Simulation done with Maxwellian Fields
  Exact coil positions need determining
- Work needed on H2 wedge design
- Work needed on Insertion
- The Kicker is the least certain
- Need pre-cooler or other ideas to match phase space into short bunch train

BUT

- Performance better than linear coolers
- Might lower acceleration cost
- Real hope that Collider requirements can be met