

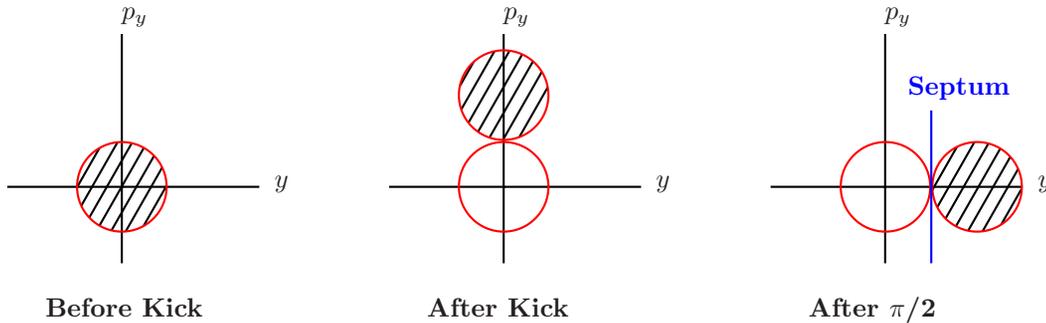
# Ring Cooler Kickers

R B Palmer

NUFAC03

Columbia U

# Minimum Required kick



$$I = \left( \frac{f_\mu \ 4 \ f_\sigma^2 \ m_\mu}{\mu_o \ c} \right) \frac{\epsilon_n}{L}$$

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

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

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

## Compare with others

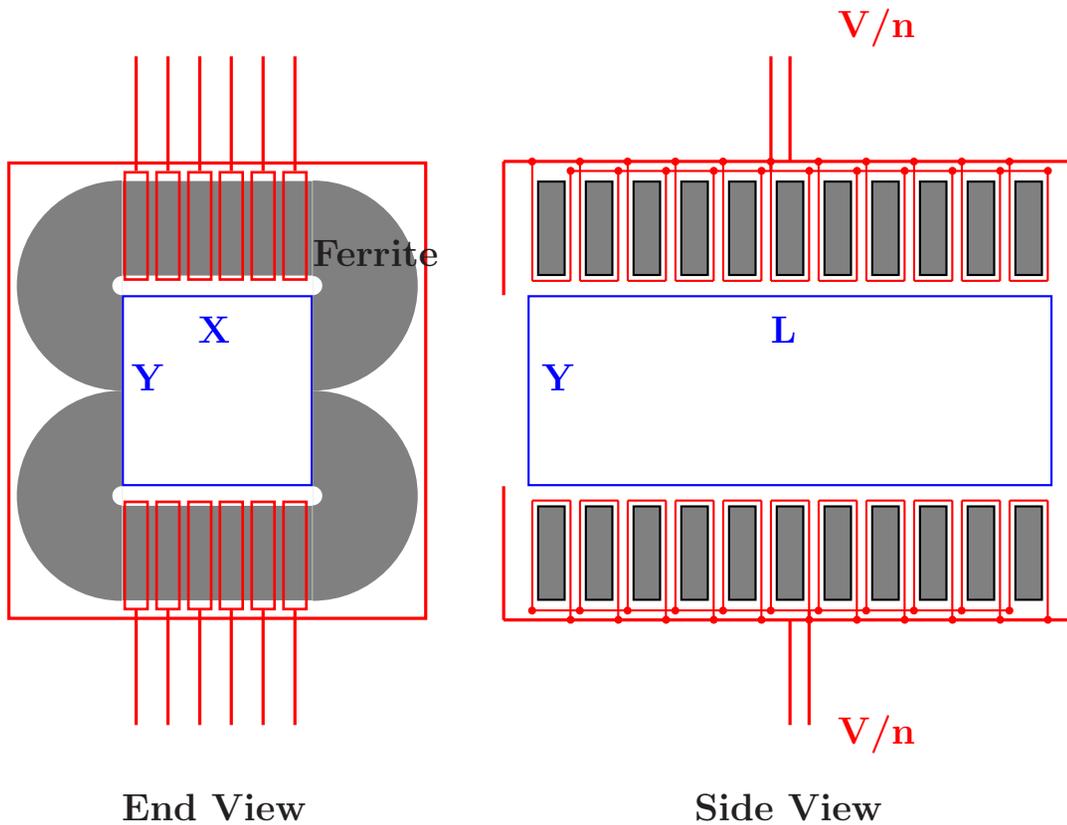
		$\mu$ Cooling Ring	CERN $\bar{p}$	5 m of Ind Linac
$\int Bdl$	Tm	.30	.088	
L	m	1.0	$\approx 5$	5.0
B	T	.30	$\approx 0.018$	0.6
X	m	.42	.08	
Y	m	.63	.25	
$t_{\text{rise}}$	ns	50	90	40
$V_{\text{1turn}}$	kV	3,970	800	5,000
$U_{\text{magnetic}}$	J	10,450	$\approx 13$	8000

## Note

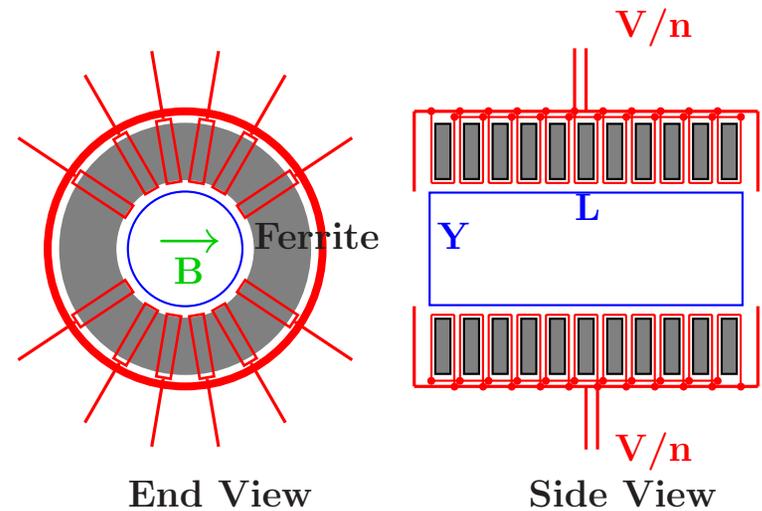
- J is 3 orders above  $\bar{p}$
- Same order as Induction
- And t same order
- But V is in wrong Direction

# Induction Kicker

- Drive Flux Return
- Subdivide Flux Return Loops  
Solves Voltage Problem
- Conducting Box Removes  
Stray Field Return

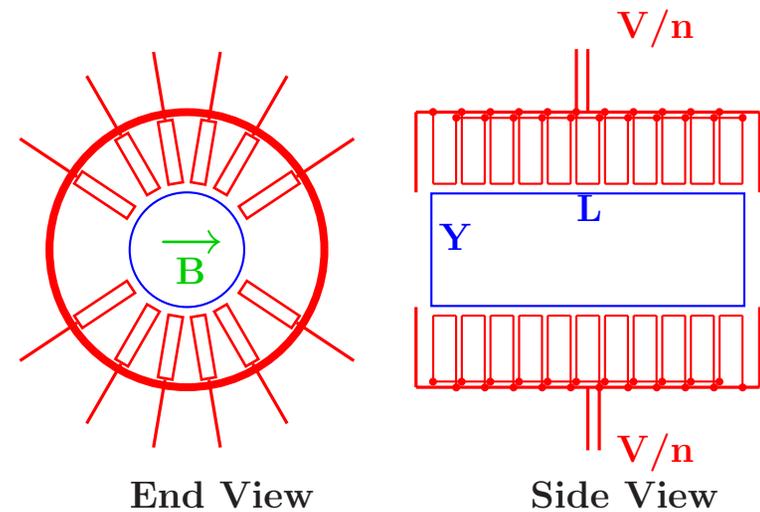


# Cos Theta Version



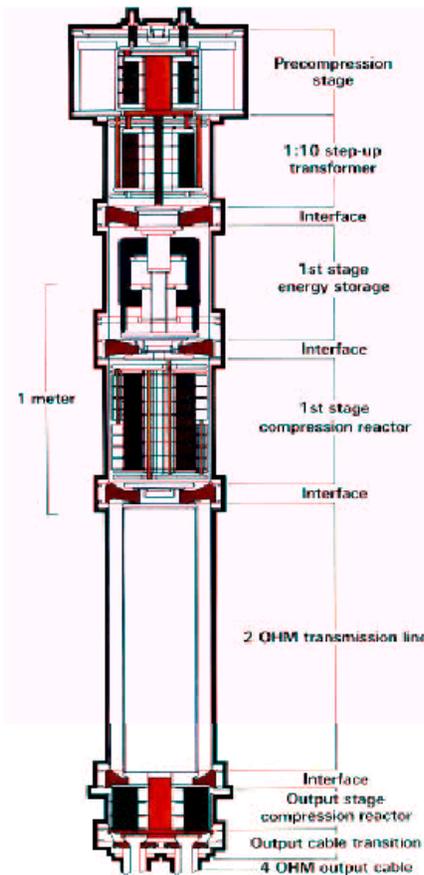
## Works with no Ferrite

- $V =$  the same
- $U 2.25\times$
- $I 2.25\times$
- No rise time limit
- Not effected by solenoid fields



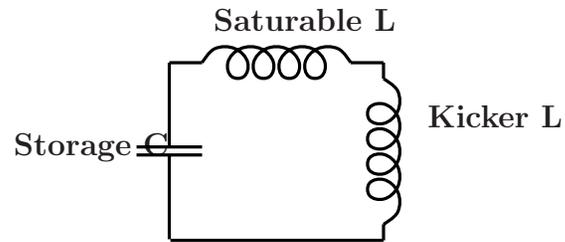
# Mag Amp Driver

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



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

# Magamp principle



Initially Unsaturated,  $L = L_1$  is large:

$$\tau_L = \sqrt{(L + L_1)C} \quad \text{is slow}$$

The current  $I$  rises slowly:

$$I = I_o \sin\left(\frac{t}{\tau_L}\right)$$

When the inductor saturates

$L = L_2$  is small:

$$\tau_S = \sqrt{(L + L_2)C} \quad \text{is fast}$$

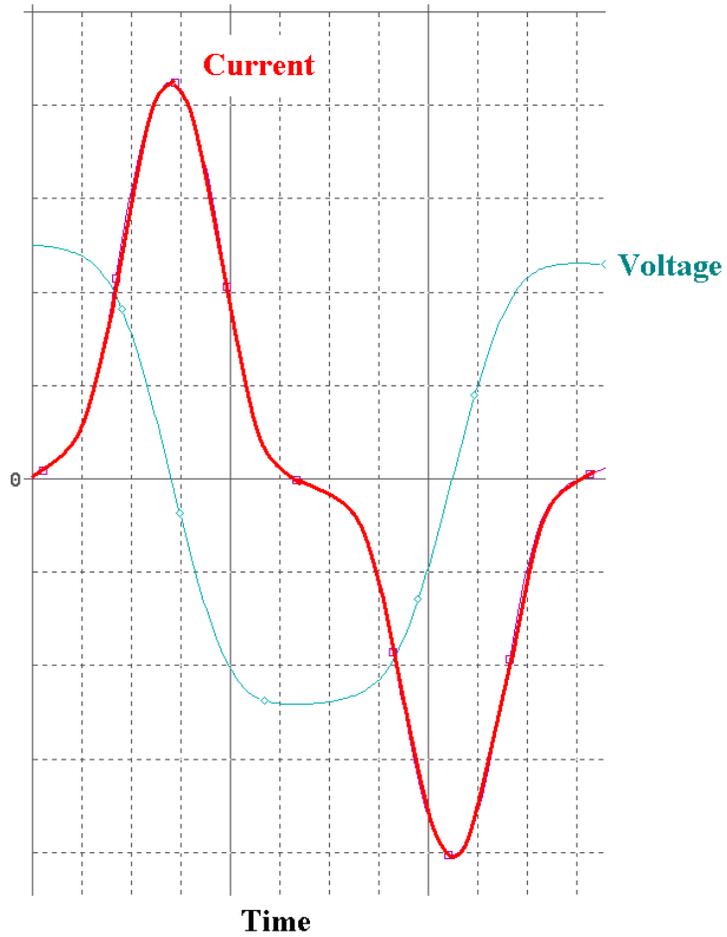
After approx  $\pi$  phase

Inductor regains its high inductance

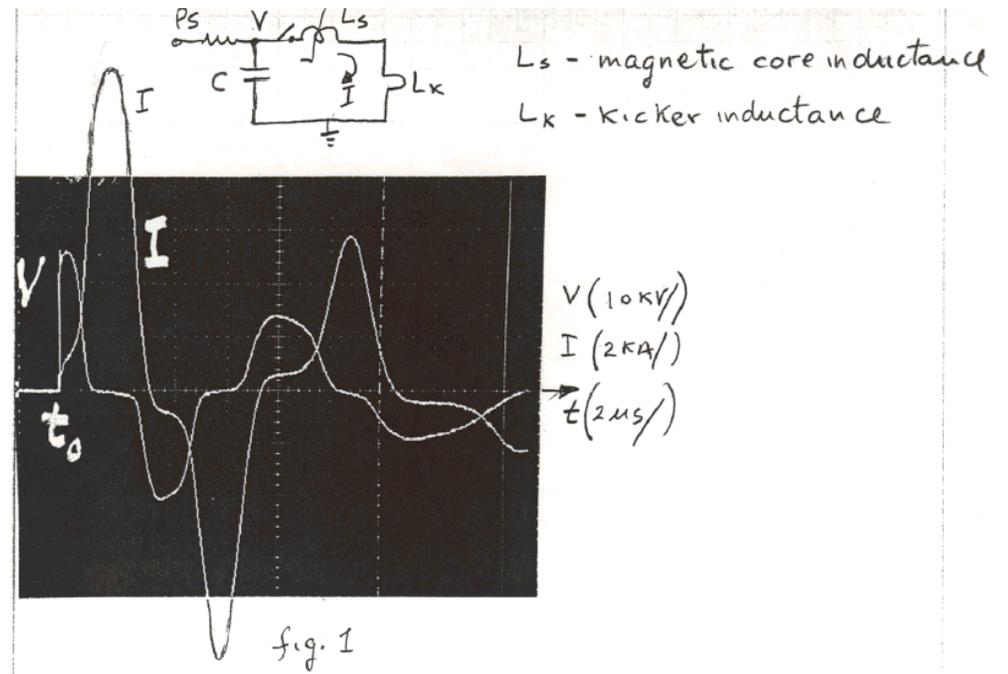
The oscillation slows before reversing.

# Pspice Simulation

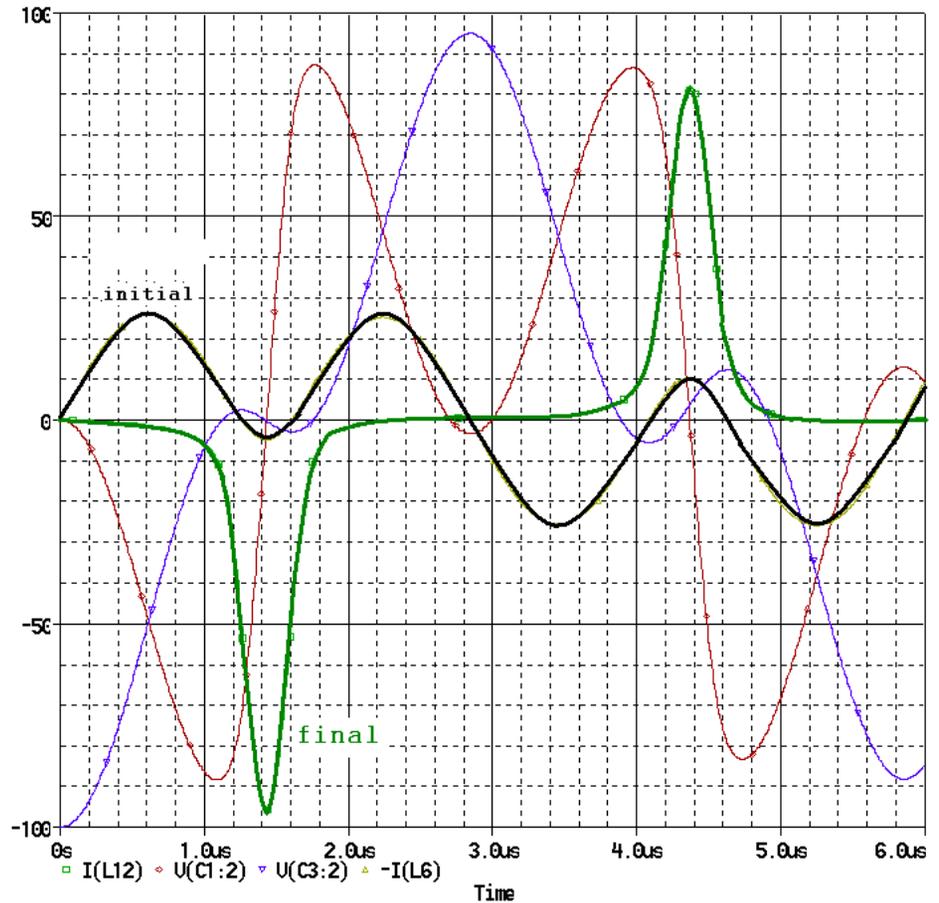
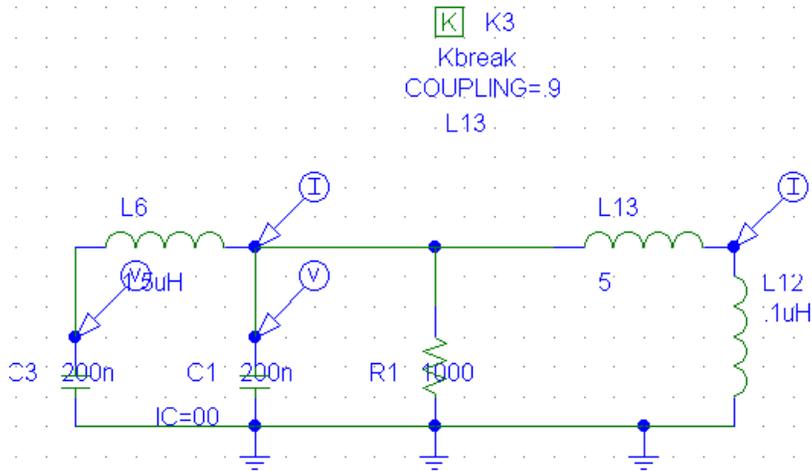
## a) Single stage



## Model (Reginato)



## a) 2 Stage



This example: Current "amplification" = 3.8

Many stages give large "amplification"

## Conclusion

- A Ring Cooler without Injection is Useless
- U is 3 orders more than conventional
- Induction Linac Drivers **may** be Solution
- **But this needs Real Study**
- Subject for University Study ?
- Can be Simulated (e.g. PSPICE)
- Can be Modeled (Lou's example)