

SPEAR 3 Kicker Overview

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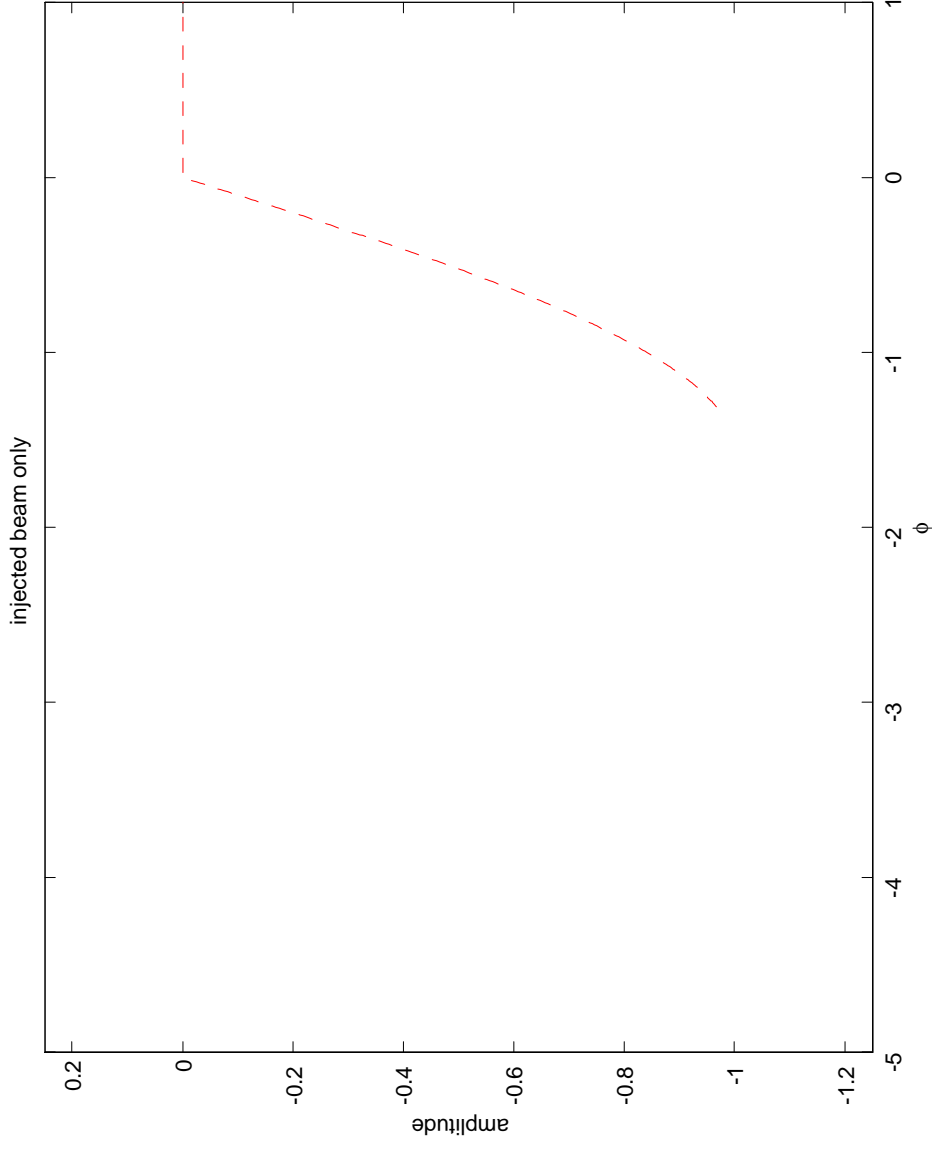
September 4, 2003

1 Outline

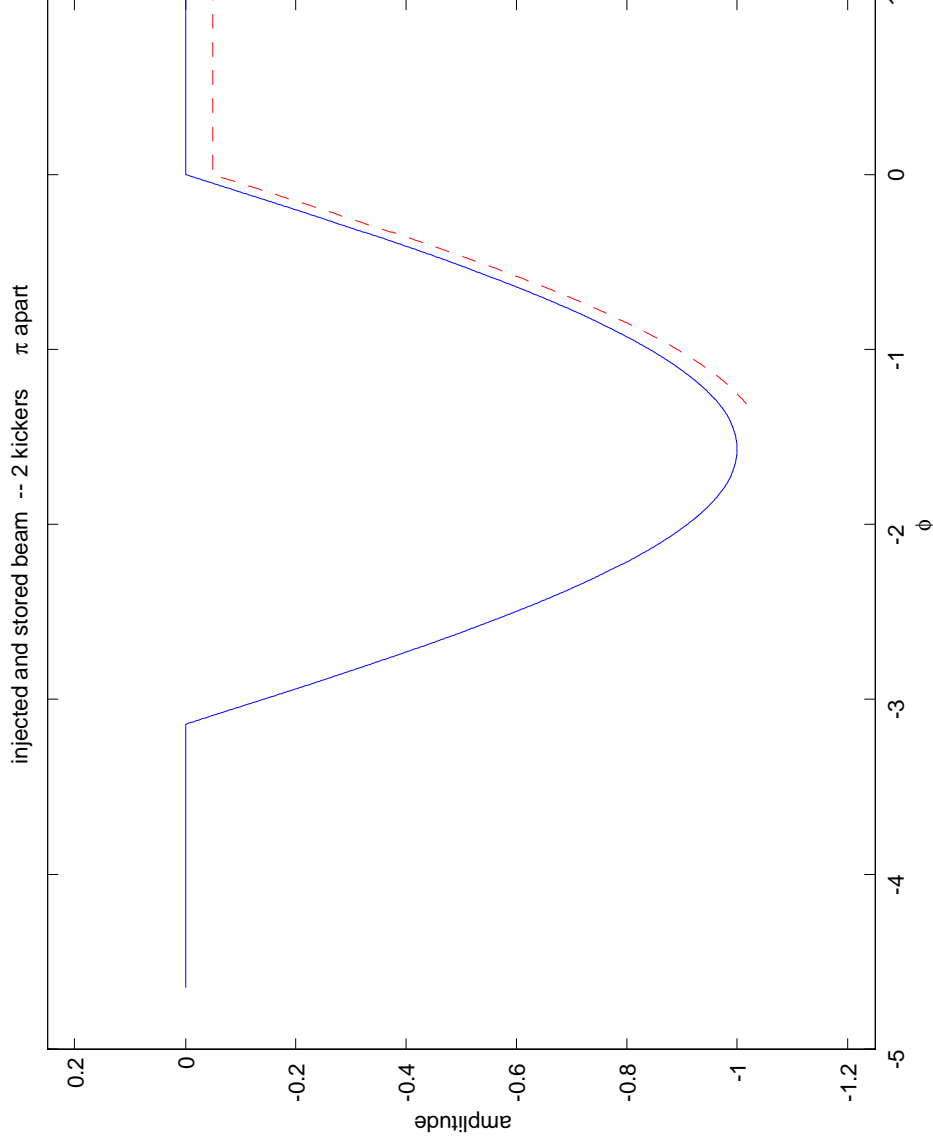
- Purpose of a kicker
- Desired kicker magnet characteristics
- Kicker magnet design
- Desired kicker pulser characteristics
- Kicker pulser design (brief)
- Kicker commissioning

2 Purpose

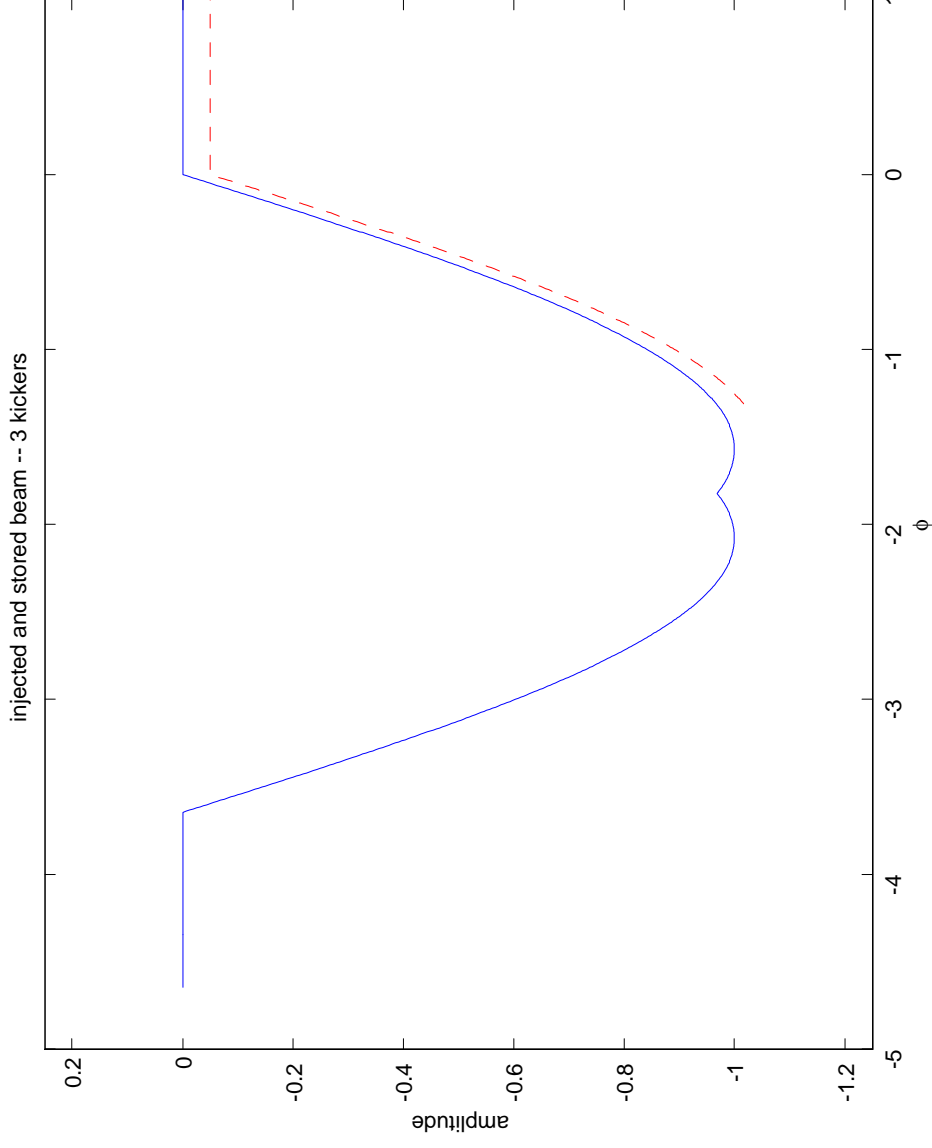
- Normal closed orbit determined by the lattice of static magnets (dipoles, quadrupoles, sextupoles)
- Injected beam does not follow the closed orbit
 - Septum, a static magnet, bends the injected beam close to closed orbit
 - Still far enough away from closed orbit that it is outside the aperture of the ring
 - Kicker gives a fast magnetic deflection to the injected beam to place it within the ring aperture



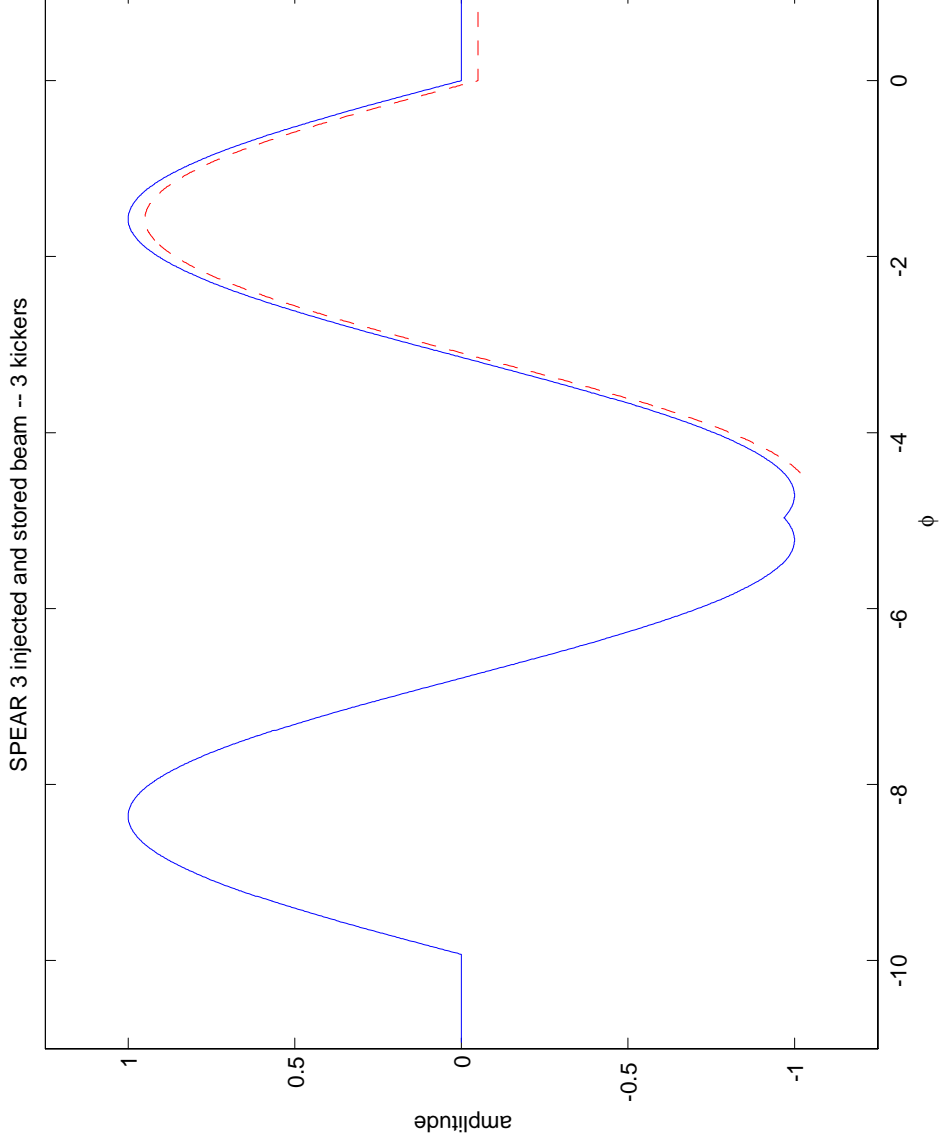
- Injection into Booster uses one kicker
 - Kicker magnet turns on before injection
 - Magnet is off before stored beam returns (440 ns later)
- Note trajectory is displayed in normalized coordinates, so it is sinusoidal



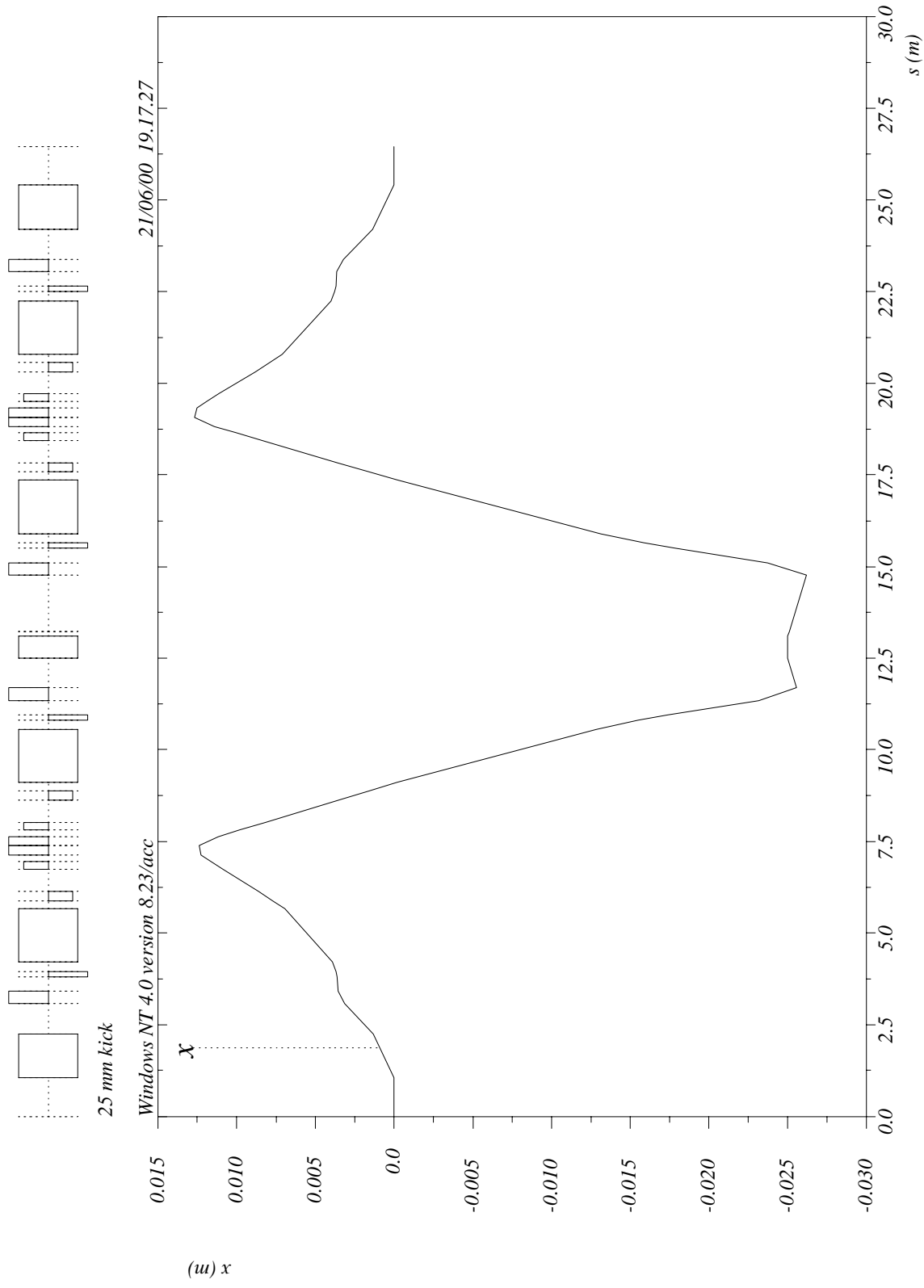
- Single kicker either stores injected beam or keeps stored beam, cannot do both
- Use two kickers placed π radians apart (in normalized coordinates)
 - First kicker displaces stored beam near trajectory of injected beam
 - Second kicker straightens both beams to within the machine aperture



- Cannot place kicker magnets exactly π radians apart
 - Physical constraints
 - Lattice flexibility
- Use third kicker as additional adjustment to “close the bump” for the stored beam



- SPEAR 3 cannot place kickers $\approx \pi$ radians apart because of physical limitation
- Kickers are placed $\approx 3\pi$ radians apart
- Beam returns to closed orbit within a few damping times ($\tau \approx 5$ ms)



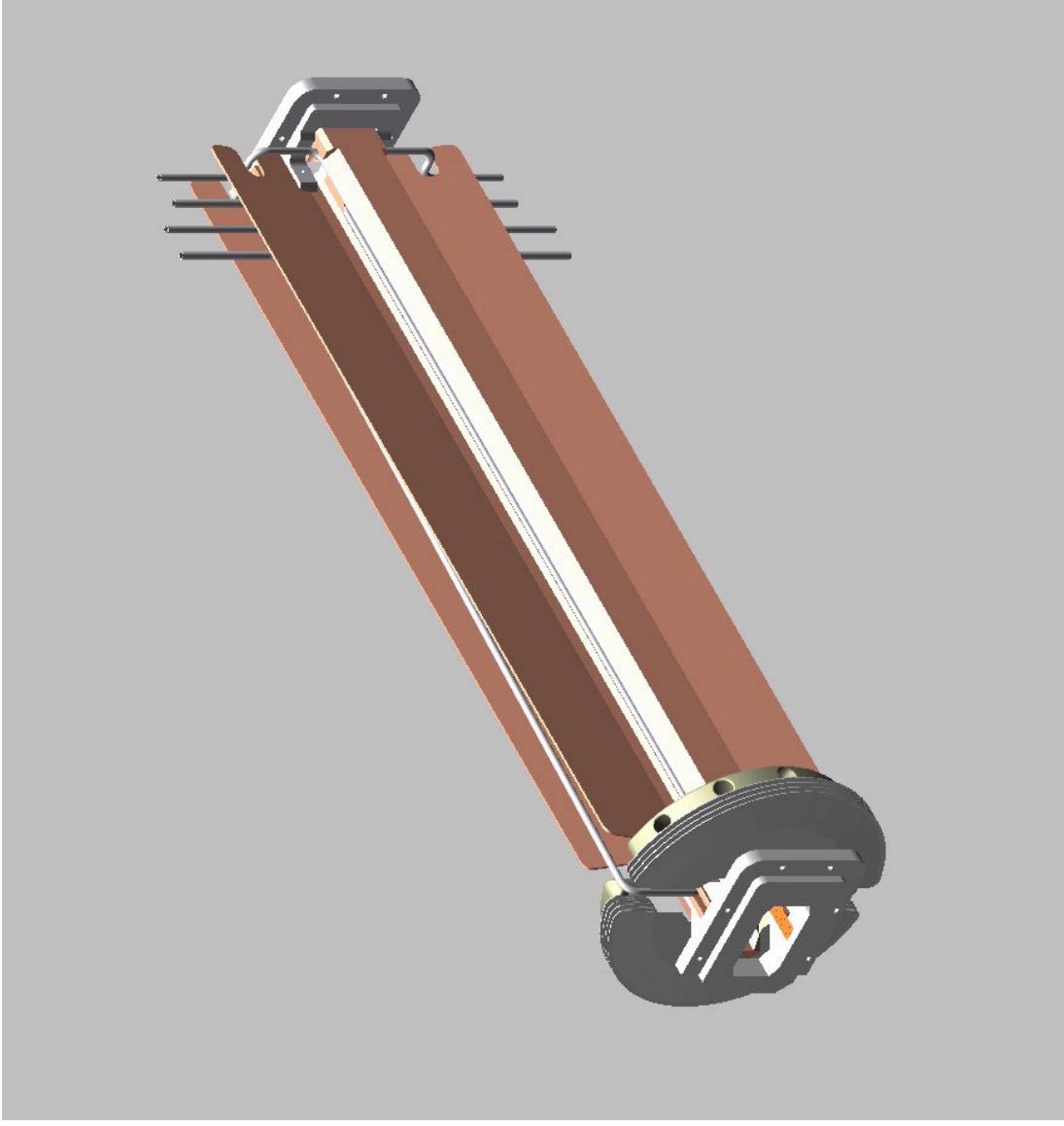
$\delta_e / p_{oc} = 0.$

Table name = TWISS

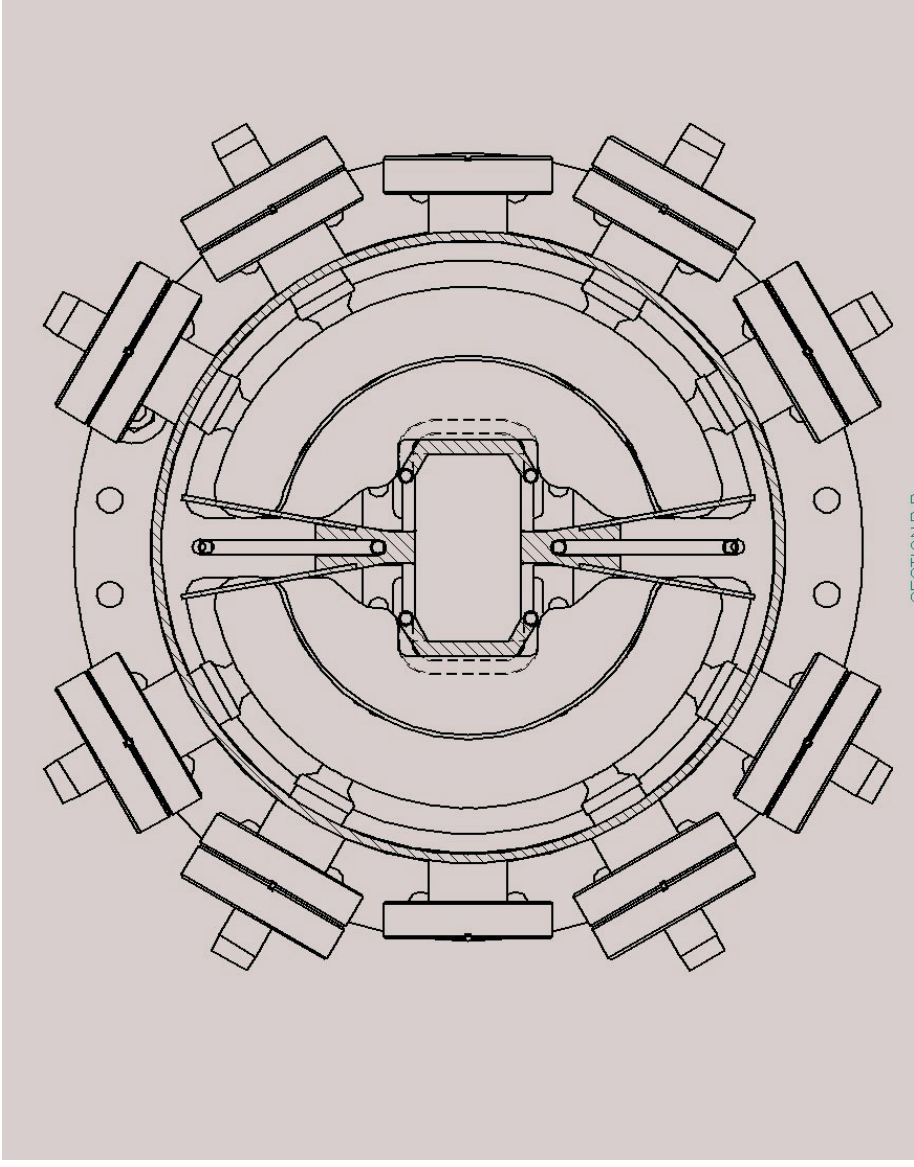
- MAD plot of SPEAR 3 25 mm kick trajectory of stored beam₈

3 Magnet Characteristics

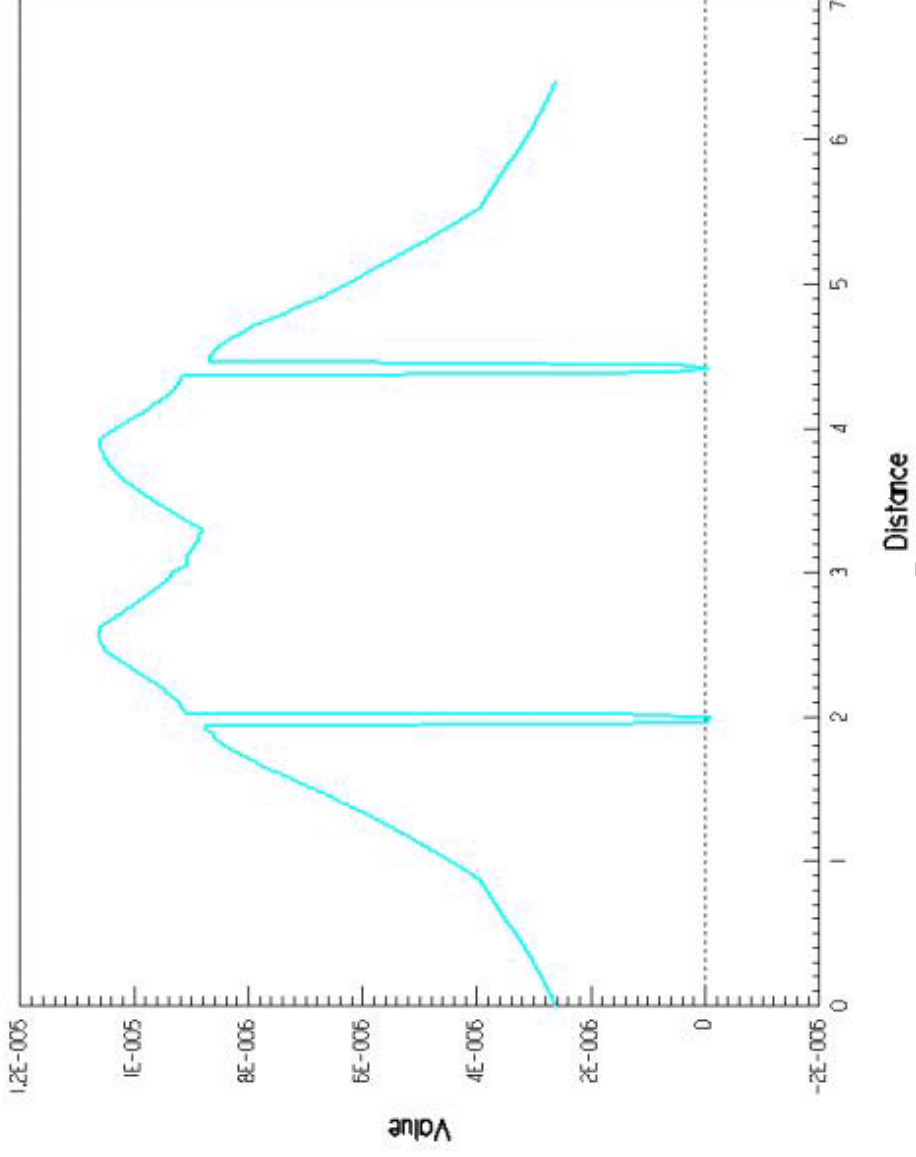
- Duty cycle of kicker extremely low
- Want it to be benign to stored beam after injection
- Beam impedance (Z)
 - High Z resonant structure can cause beam instabilities
 - High Z broadband structure degrades properties of bunch
- A student of K. Wille (DELTA) designed a low-impedance stripline kicker
 - Non-resonant
 - Low broadband beam impedance
 - No ferrites
 - Easy to fabricate



- Strips on top and bottom to carry image currents (minimize Z) at ground potential
- Current carrying conductors on sides



- Cross section similar to that of standard vacuum chamber
 - Slightly smaller to gain field strength
- Width of top and bottom ground strips compromise between
 - Beam Z
 - Magnetic field strength and uniformity

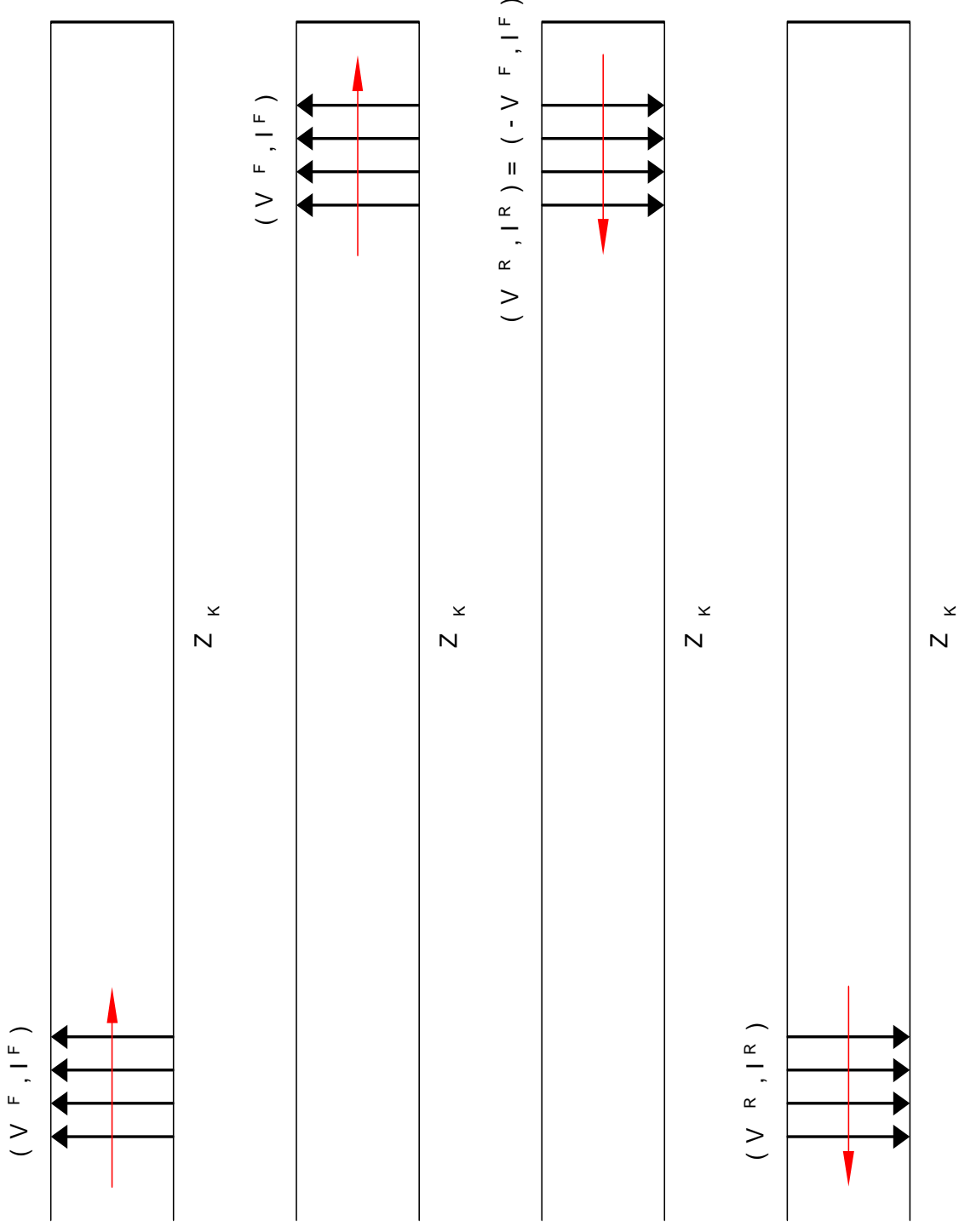


- Total field is the sum of that from the two electrodes
- All bunches of the beam at center of K1, K3
- Different bunches of the beam sweep through non-uniform field of K2

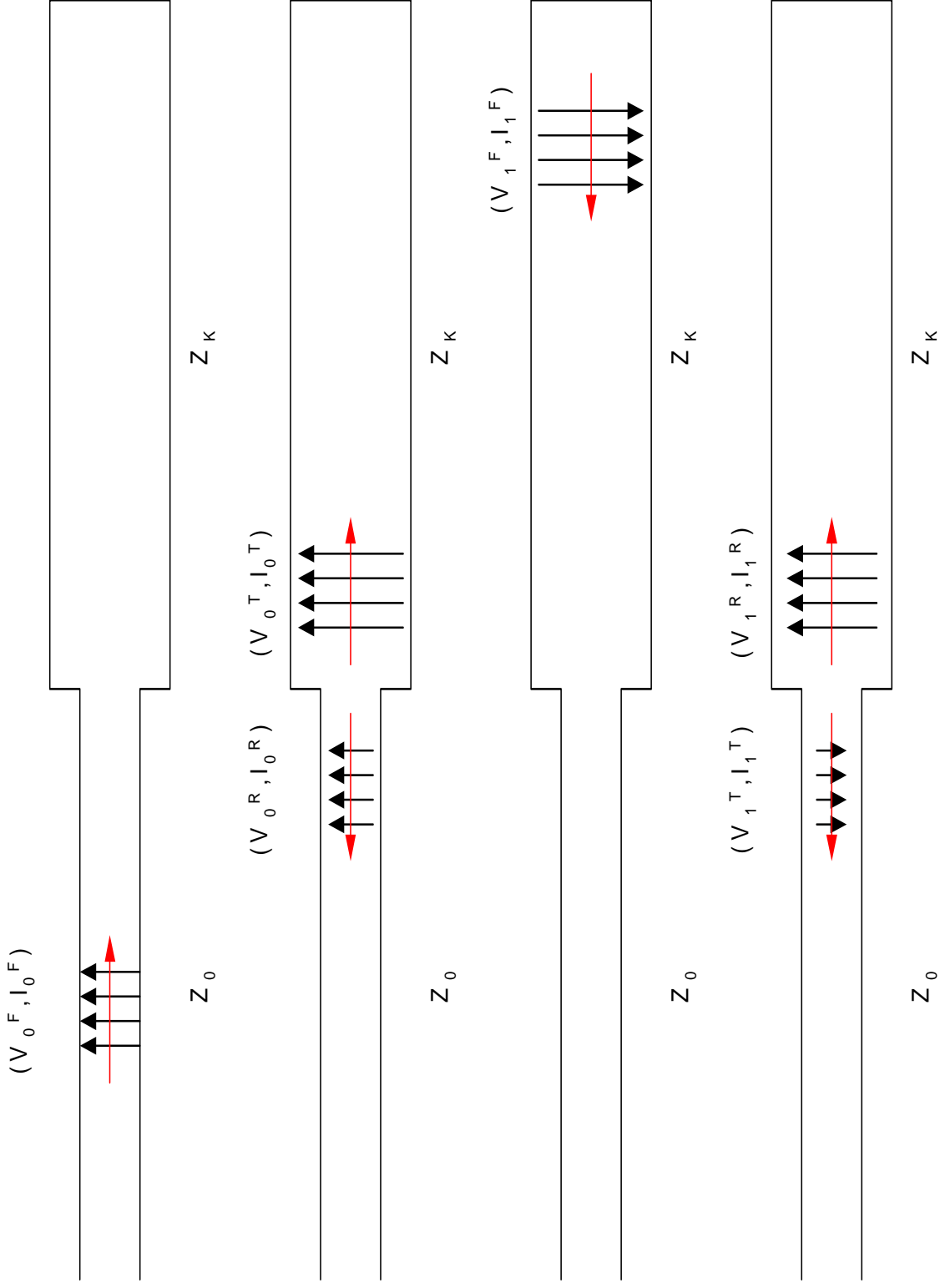
4 Magnet Operation

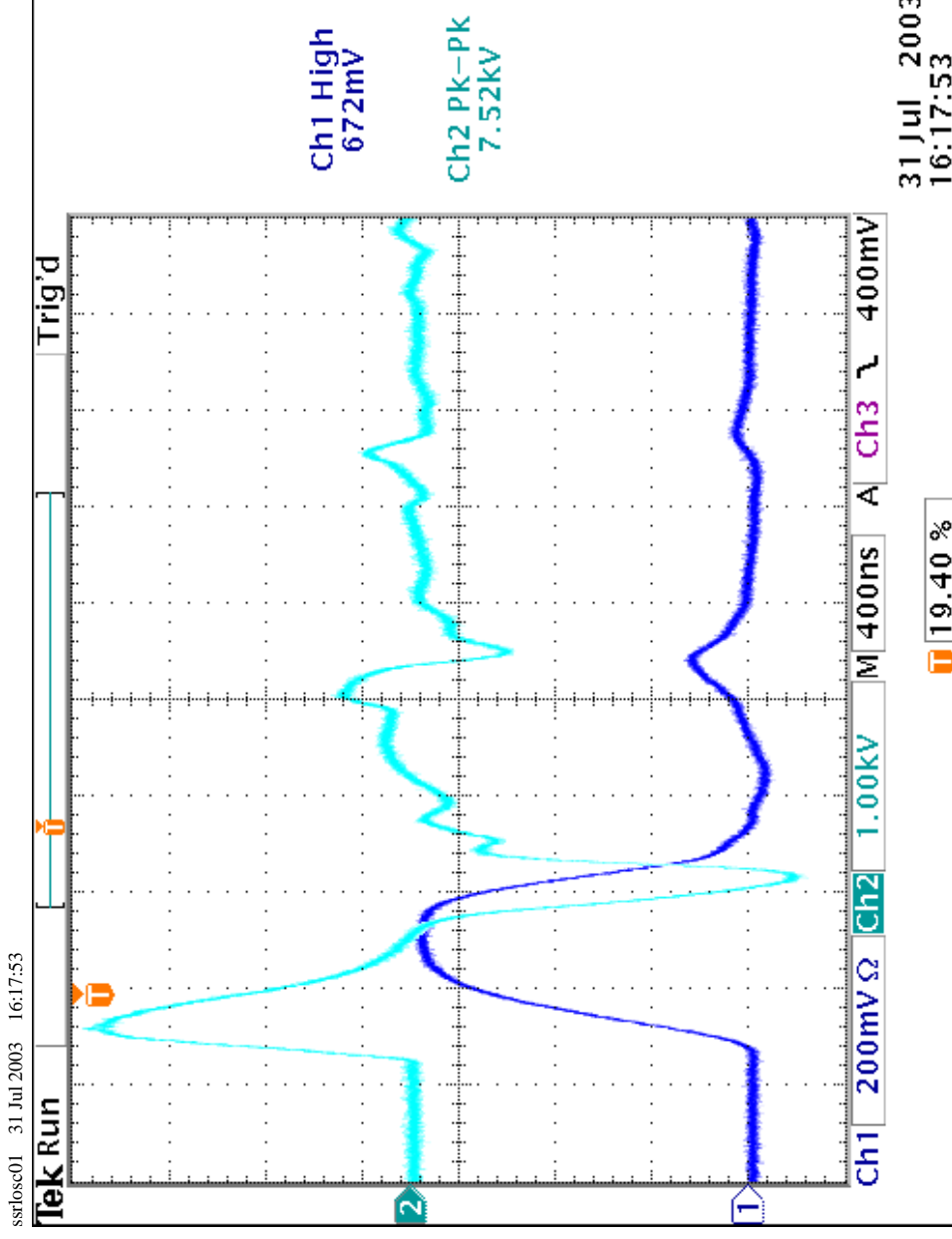
- Electrodes are shorted transmission lines ($Z_0 = 62\Omega$)
- Voltage pulse applied to transmission line carries current
- Pulse reflects off of the shorted end
 - Voltage of reflected pulse changes sign
 - Current of reflected pulse keeps sign

$$* (-Q)(-v) = Qv$$



- When pulse overlaps the length of the kicker ($K1$, $K3 = 1.2$ m; $K2 = 0.6$ m)
 - Voltage along kicker goes to zero
 - Currents double
- Magnetic field strength determined by total current in the two electrodes
- Ideal situation would be to match cable impedance to kicker impedance ($Z_0 = 62\Omega$)
- But 1500 A of pulser current are needed
$$1500 \text{ A} \times 62\Omega = 93000 \text{ V}$$
resulting in a voltage that is prohibitively high
- Feed current from pulser on lower Z cable
 - Reflections at the cable-kicker interface limit the rise time of the system
 - Important result of current doubling still holds if the rise time is short compared to the pulse length

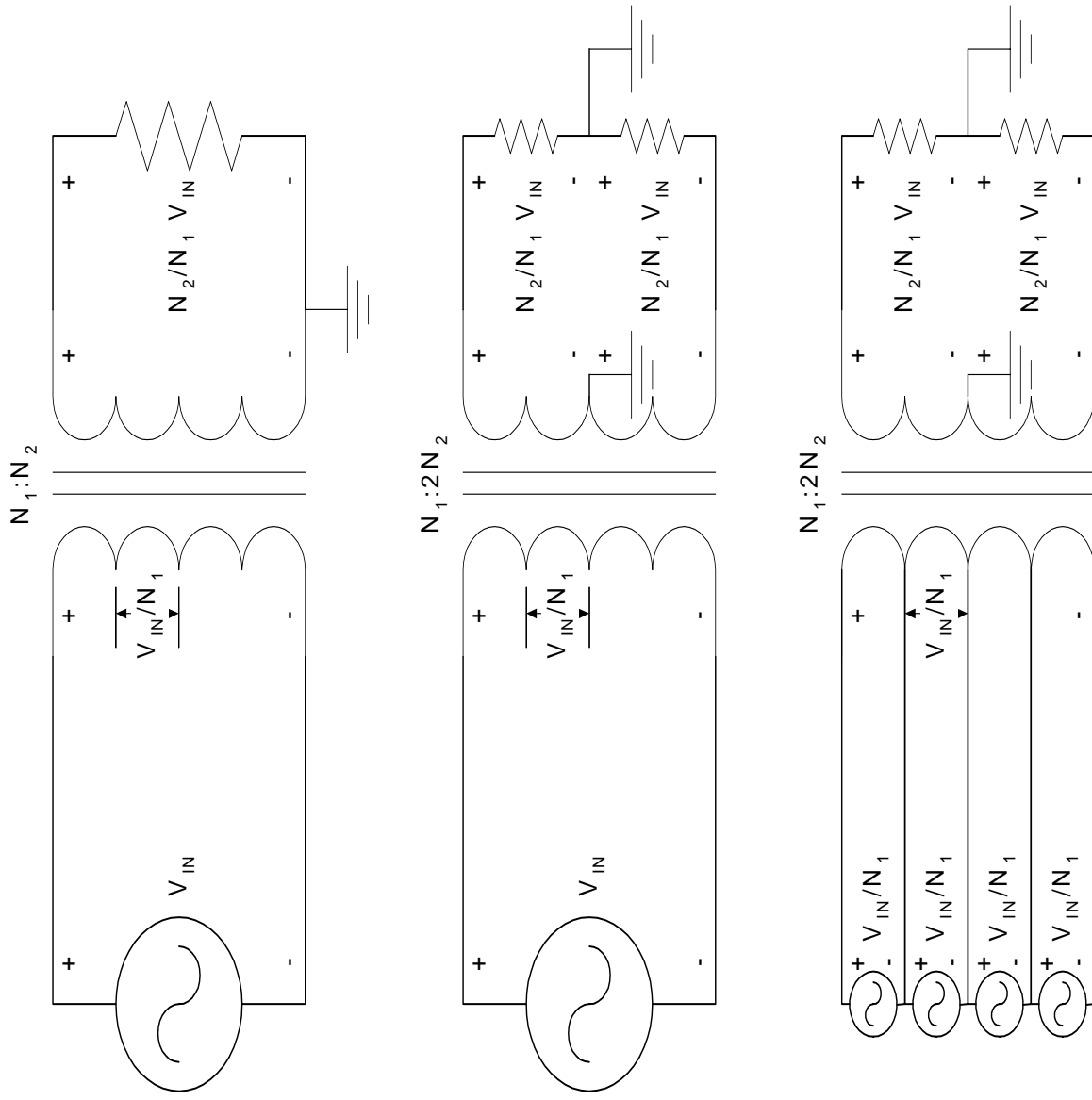




- Upper trace is the voltage at the K1 cable-kicker interface
- Lower trace is the current waveform on one electrode

5 Kicker Pulser

- Refer to talk of C. Pappas
- Past kickers used thyratrons to switch
 - Timing jitter
 - Stability with time, temperature
- SLAC PCD built high voltage pulser for NLC modulators using IGBT technology
 - Increased reliability
 - Increased stability
- Pulser properties
 - Needs to produce two equal and opposite pulses (one for each electrode)
 - Needs to produce close to 25000 V
- Use high voltage, high current transformer
 - Use two secondaries to create opposite voltage pulses
 - Add voltages of individual stages in series



6 Kicker Commissioning

- Have tested kickers with pulsers before final assembly
- Kickers will be retested after installation
- Current transformer on one cable of each kicker will monitor current through one cable
 - Monitor cable transit times will be measured to enable proper timing of kickers
- Pulse widths of the three independent kickers will be set via SRS units
- Appropriate delays will be calculated from transit time difference of beam at the kicker
- Delays will be adjusted using current monitor pulses
- Current amplitude vs kicker voltage will be calibrated for all kickers
- Set kickers for nominal strengths
- Adjust K3 until beam is acquired
- With one bunch, adjust three kickers so that stored beam is maintained in ring