SLAC
NATIONAL ACCELERATOR LABORATORY

SuperB

Longitudinal Bunch Position

Super-B Workshop
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Problem

- e+ and e- bunches must overlap at crab waist
  - For 6 mm (1σ) bunch, 0.6 degrees of RF phase difference (1.2 mm) between HER and LER will decrease luminosity by 1%
- Phase transient
  - Due to ion-clearing gap and heavy beam loading of cavities
  - About 10x the 0.6 degree requirement
  - Generally different for HER and LER

Steady-State Phasor Diagram

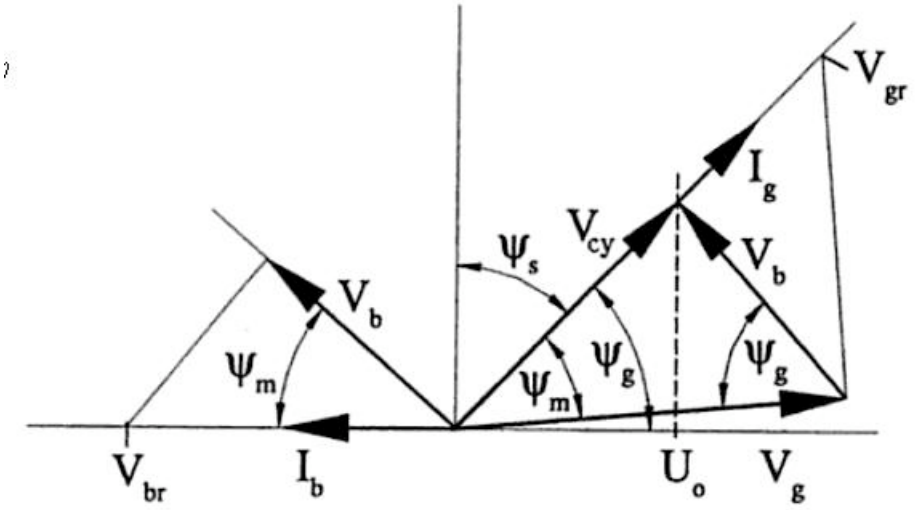
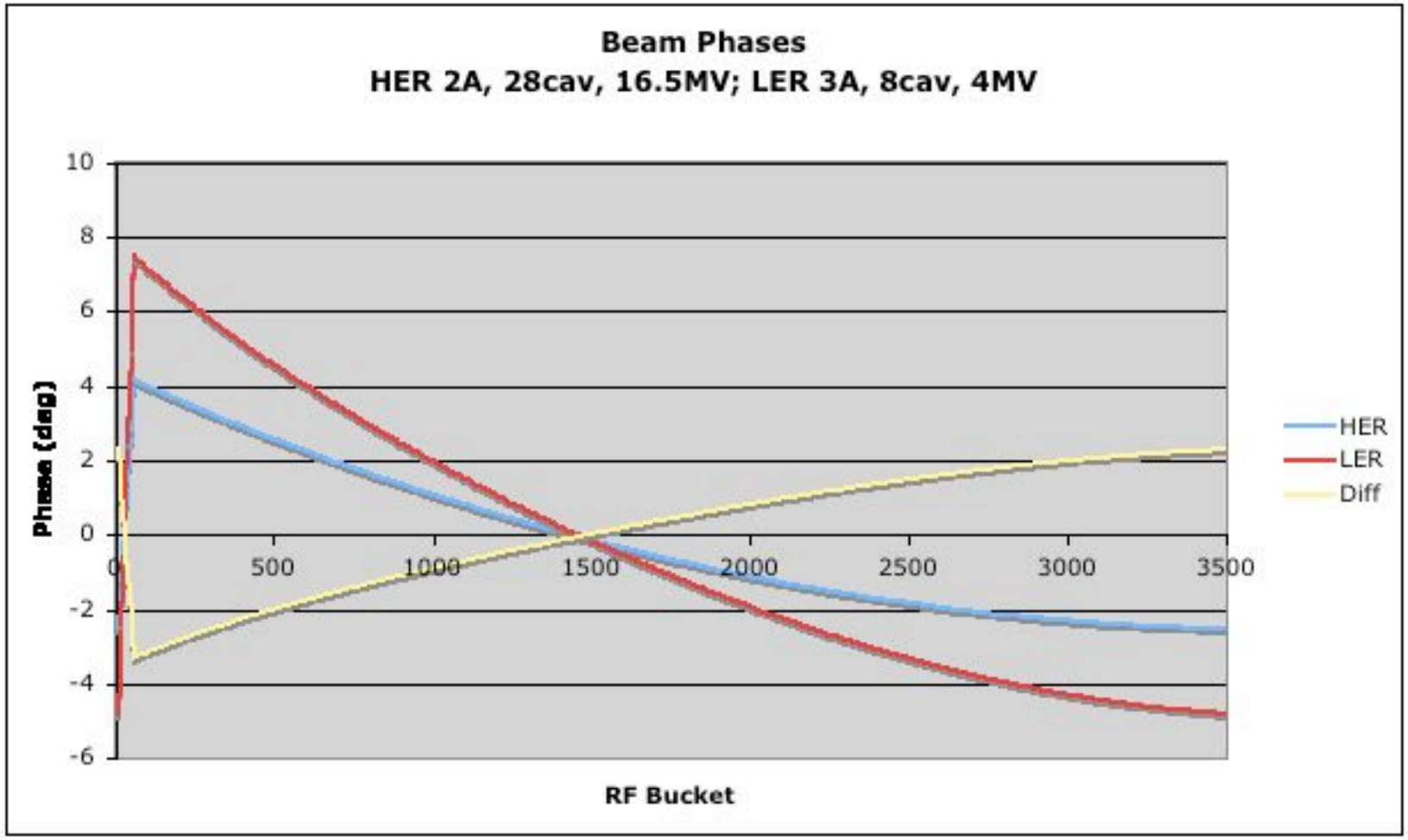


Fig. 6.9, H. Wiedemann, *Particle Accelerator Physics II*

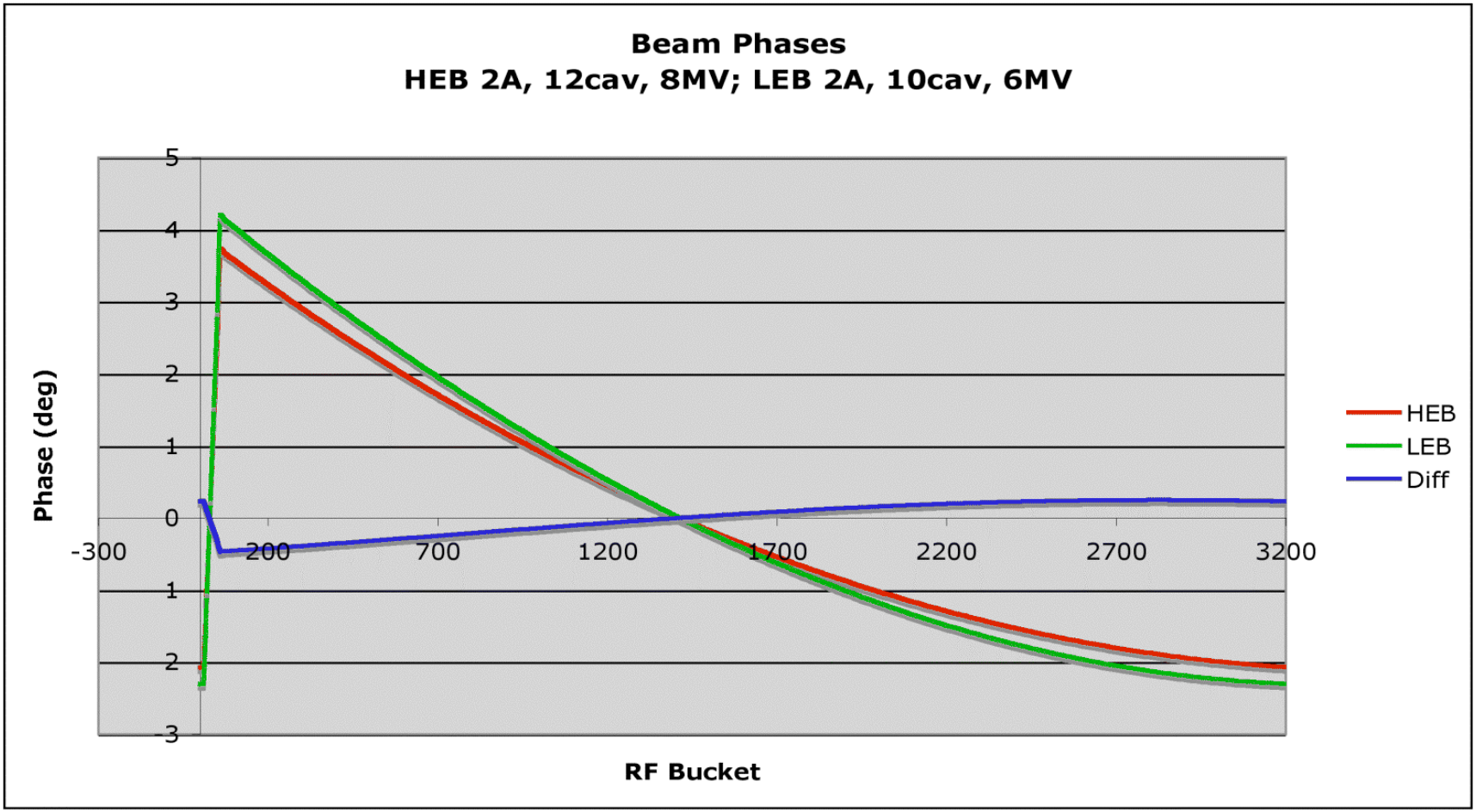
- Beam current I_b placed along neg real axis (consumes power)
- Generator current I_g in phase with cavity voltage V_{cy} (maximizes power transfer to cavity)
- ψ_s is synchronous phase; ψ_m is cavity detuning angle
- Heavy beam loading: I_b is larger than I_g
- Beam gap: beam disappears, cavity voltage and phase evolve, begin to move back toward steady-state when beam returns

PEP-II Phase Transient



- Phase transient different for two rings
  - ~12 degrees for LER, 7 degrees for HER
  - Due to different beam loading and synch phase

Super-B Phase Transient

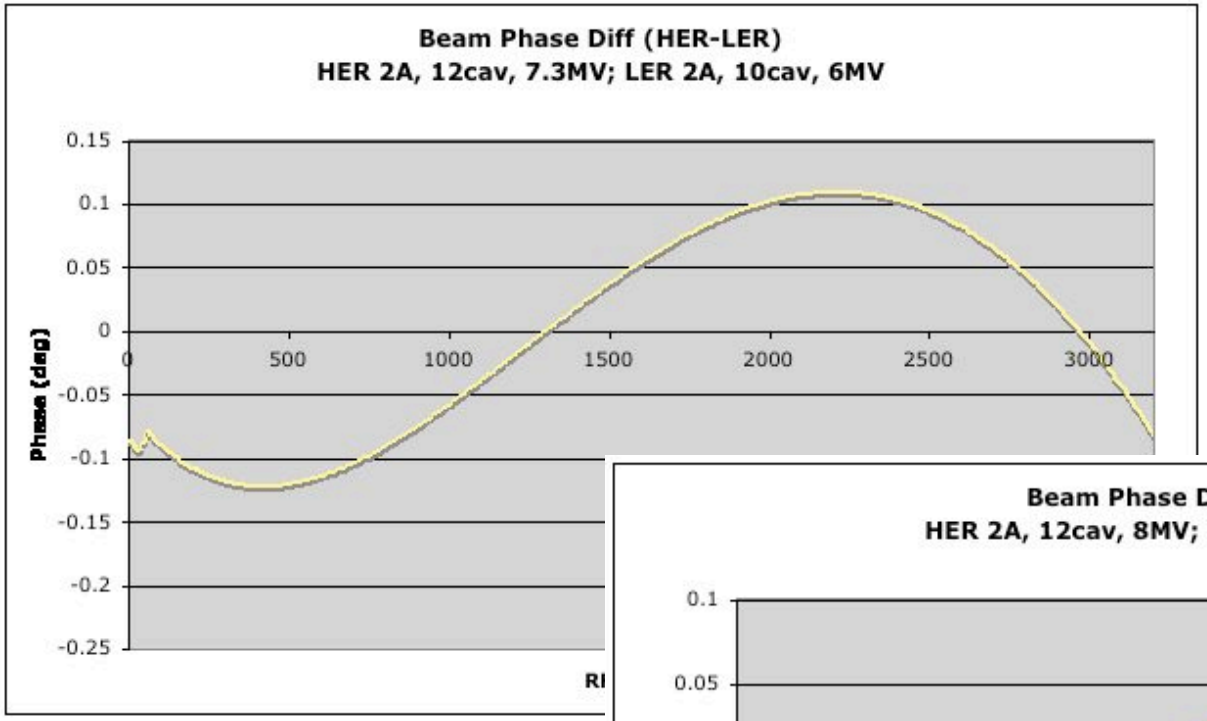


- Nominal parameters OK (0.5 deg max error)
- Phase transients better matched than PEP-II
  - Beam loading and synch phase more similar

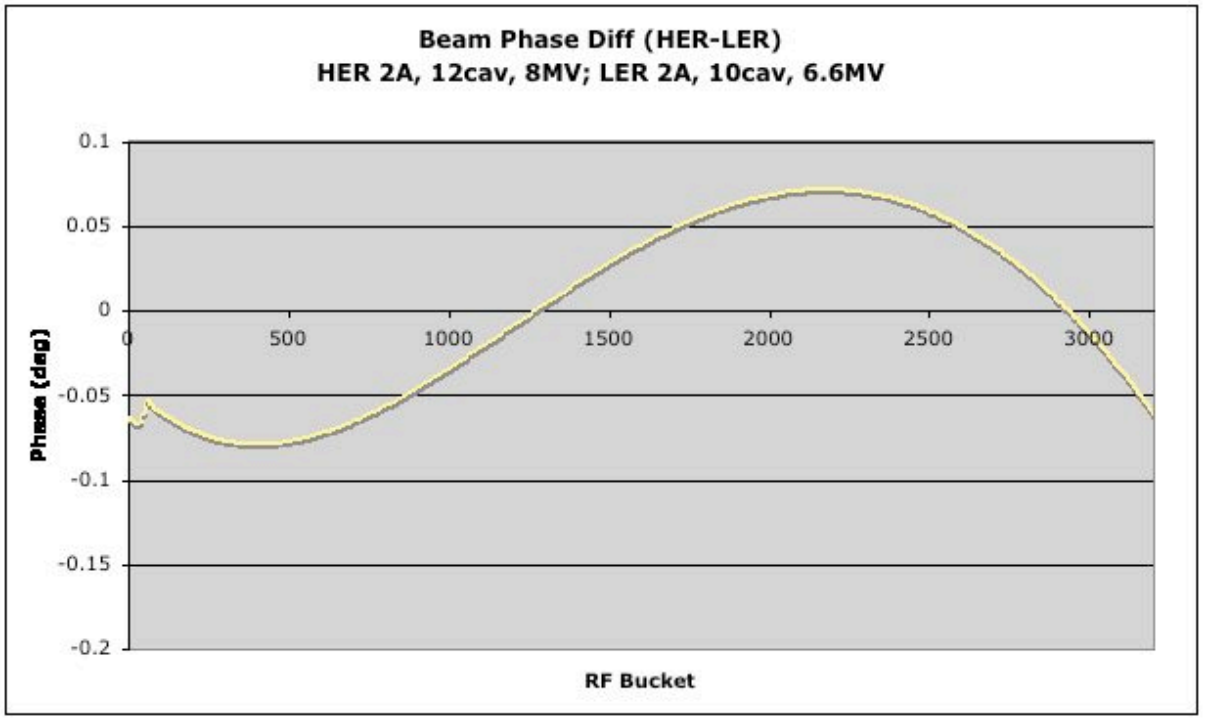
Possible Improvements

- Shift gap voltage ~10% from nominal to better match overall phase transients in LER and HER
  - Then if desired, vary klystron phase along bunch train to fix residual mismatch in phase transients (probably unnecessary)
- Apply feedback techniques?
  - “Magic tuning”?
  - Modulation of klystron phase?
  - Simulations: no significant improvement to date without significantly more RF power

Super-B Phase Transients



- ~10% change in gap voltage from nominal values matches phase transients well



- Klystron phase is kept constant for these simulations

Parameter Comparison

	PEP-II		Super-B	
	HER	LER	HER	LER
Beam Energy	8.97 GeV	3.12 GeV	7 GeV	4 GeV
Beam Current	2 A	3 A	2 A	2 A
Ring Voltage	16.5 MV	4 MV	8 MV	6 MV
Energy Loss	3.6 MV	0.6 MV	1.95 MV	1.13 MV
# Cavities	28	8	12	10
Cav Voltage	589 kV	500 kV	667 kV	600 kV
SynchLoss/Cav	129 kV	75 kV	162 kV	113 kV
Wall Loss/Cav	47 kW	34 kW	60 kW	48 kW
Beam Loss/Cav	265 kW	243 kW	333 kW	235 kW
Sync Phase	13 deg	9.3 deg	14.5 deg	11.3 deg
Cav Detuning	-184 kHz	-328 kHz	-161 kHz	-181 kHz

- Super-B gap transients match better because of:
  - More similar beam loading (seen in cavity detuning)
  - More similar synchronous phase

Comments

- Nominal parameters are OK
- Should be possible to better match phase transients with ~10% shift in gap voltage from nominal values
- Matching of phase transients restricts operational space for gap voltage and beam current
  - Change of nominal parameters may affect matching
  - Mismatch will hurt luminosity (slowly)