
Longitudinal Bunch Position Update

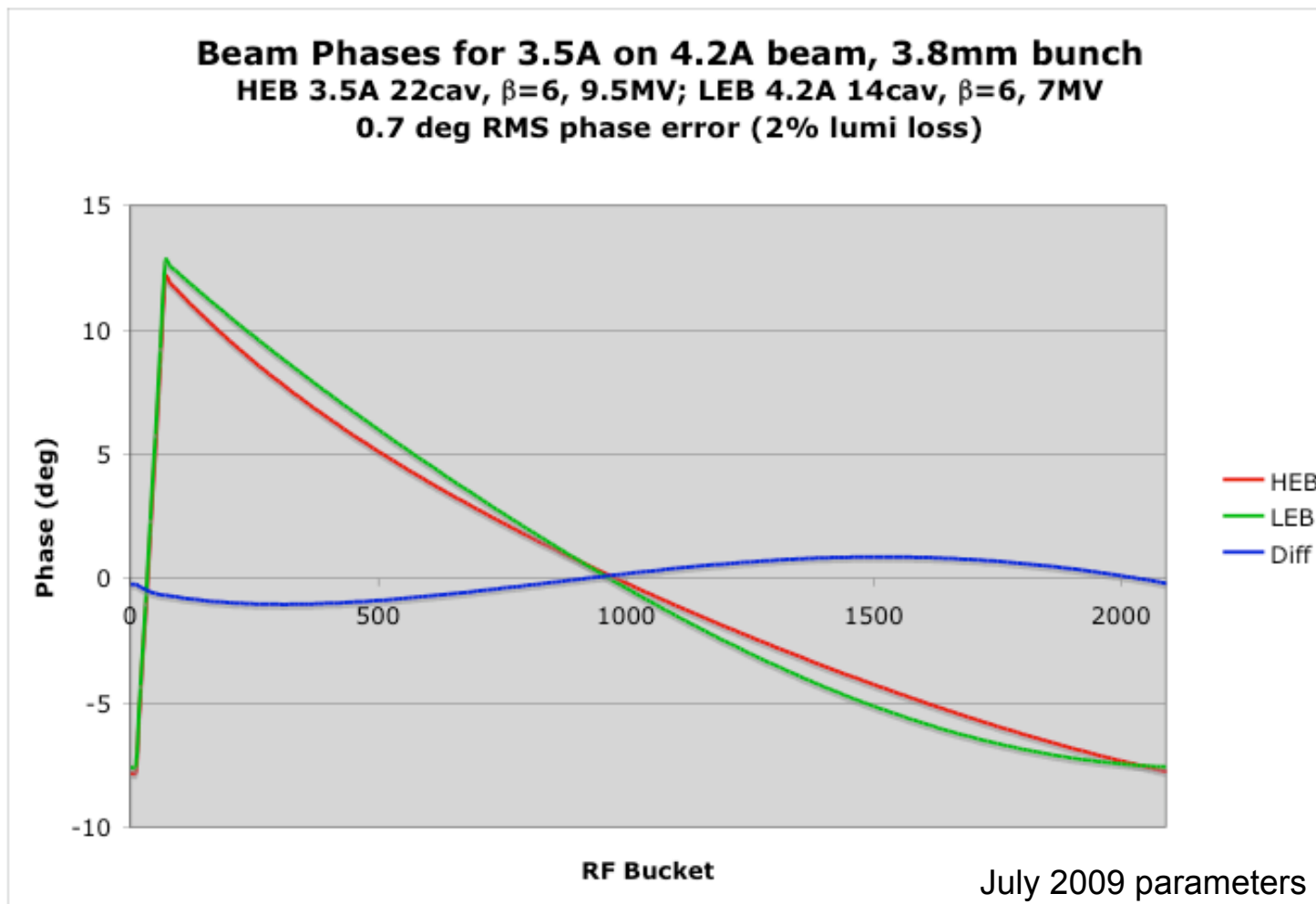
Super-B Workshop
Annecy, France
March 17, 2010

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- e^+ and e^- bunches must overlap at crab waist
 - For 5 mm (1σ) bunch, 0.5 degrees RF phase difference (1.0 mm) between HER and LER decreases luminosity by 1%
 - Want RMS error < 0.5 deg
- Phase transient
 - Due to ion-clearing gap and heavy beam loading of cavities
 - About 10x the 0.5 degree requirement
 - Generally different for HER and LER

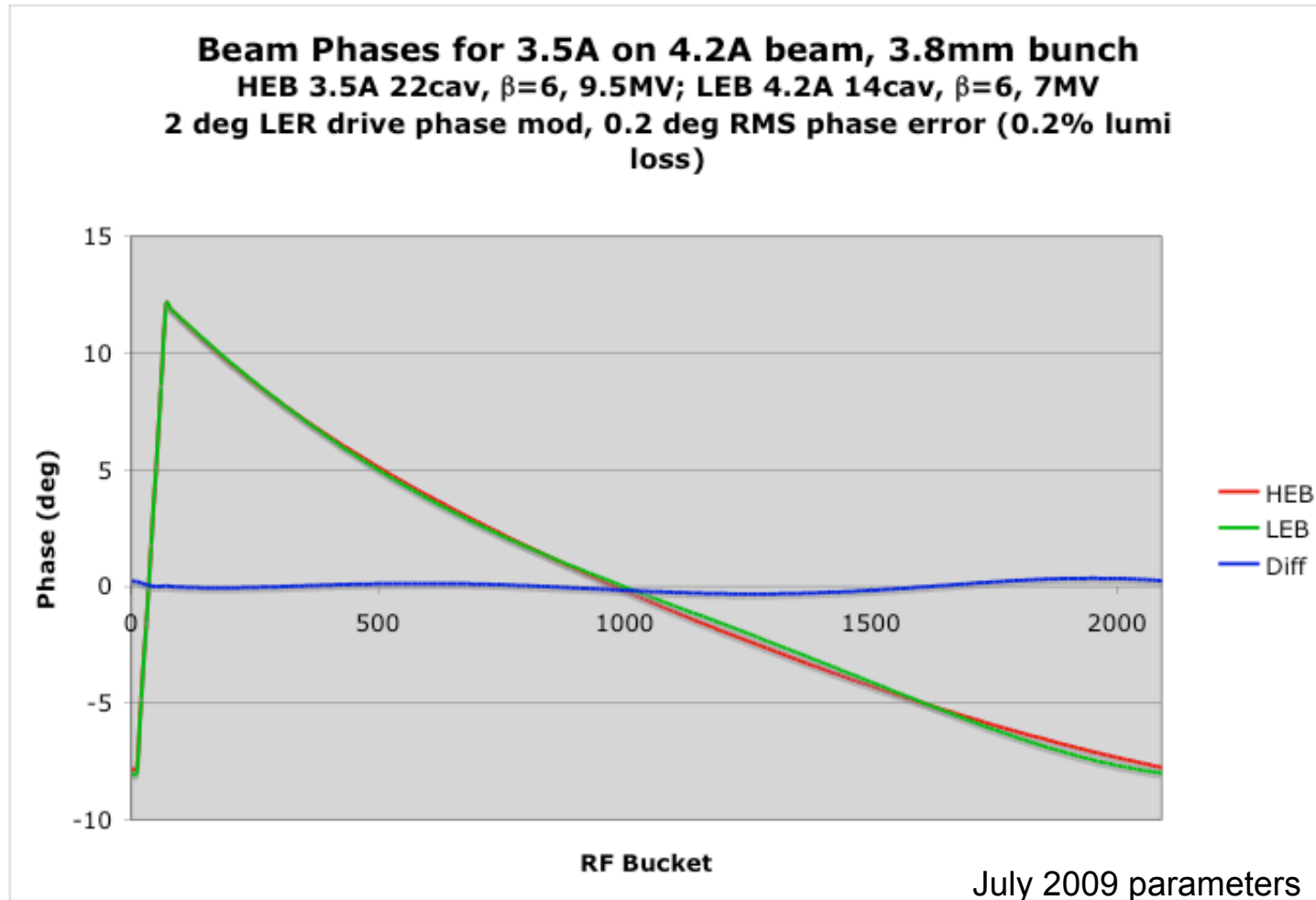
- Perfect matching
 - Requires identical beam currents in HER and LER
 - Requires identical ratio of beam/cavity power
 - May require more RF stations than otherwise needed
 - > installed RF power not well-utilized
- Imperfect matching
 - With unequal beam currents, other parameters can be adjusted to approximately match overall phase transient
 - If necessary, the residual quasi-sinusoidal error can be fixed by modulating RF drive phase

Example: Imperfect matching



- Overall phase change is well-matched
- Quasi-sinusoidal difference: 2% lumi loss if uncorrected

Correction of Phase Error

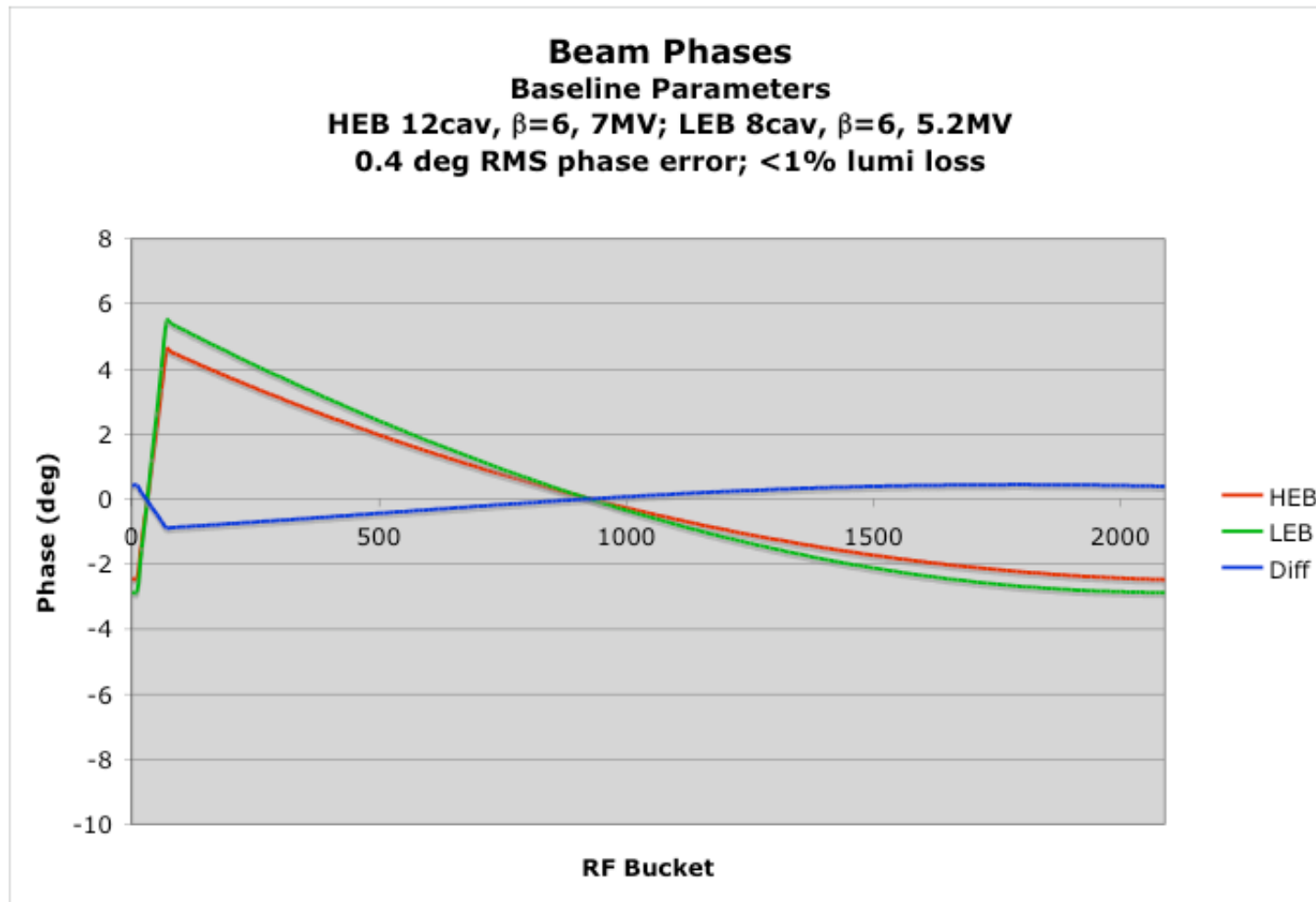


- ± 2 deg sinusoidal phase mod of LER klystron drive at revolution frequency corrects phase error
- System bandwidth (5 MHz) should allow $\sim \pm 90$ deg modulation

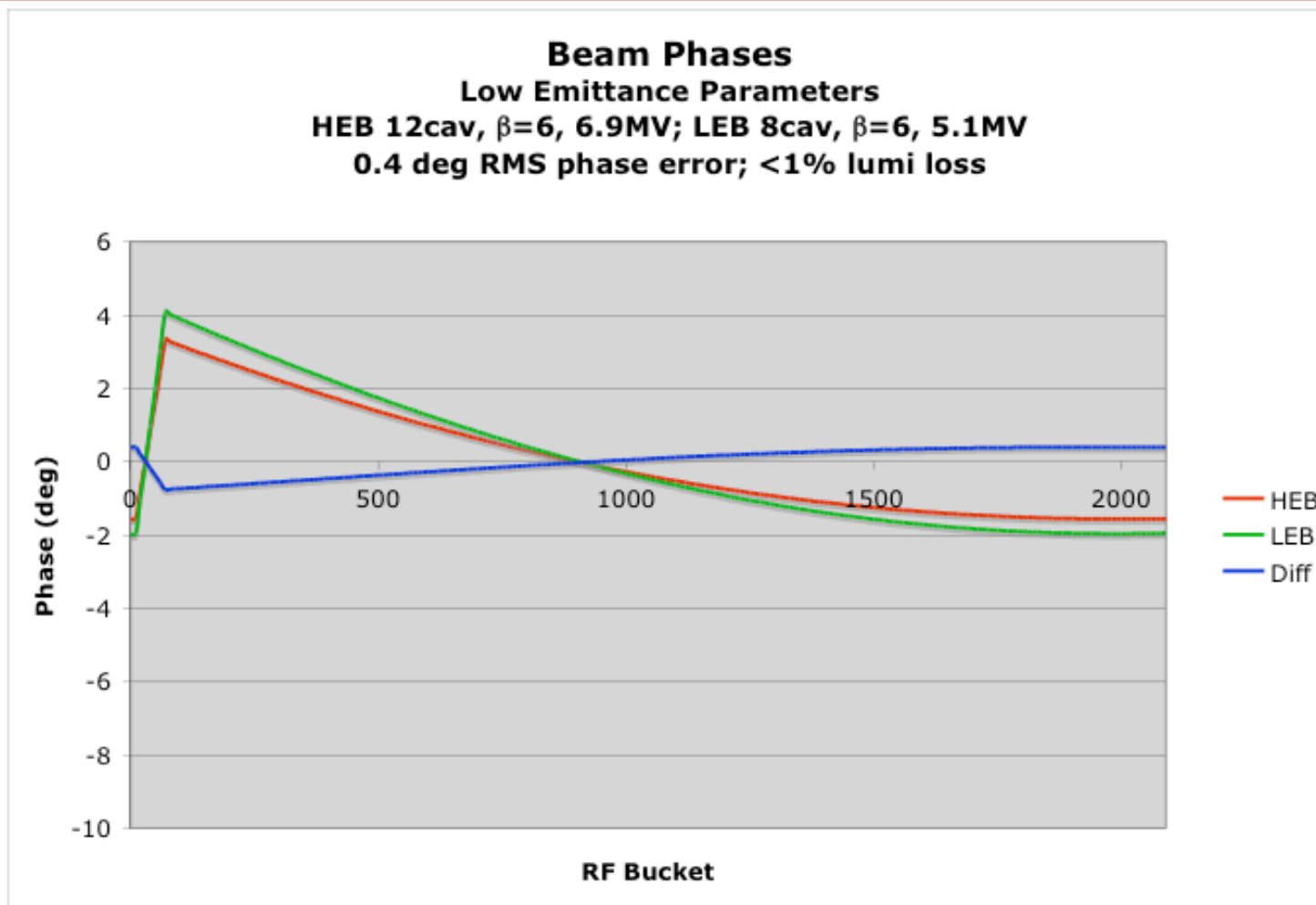
Feb 23, 2010 Parameters (v.12?)



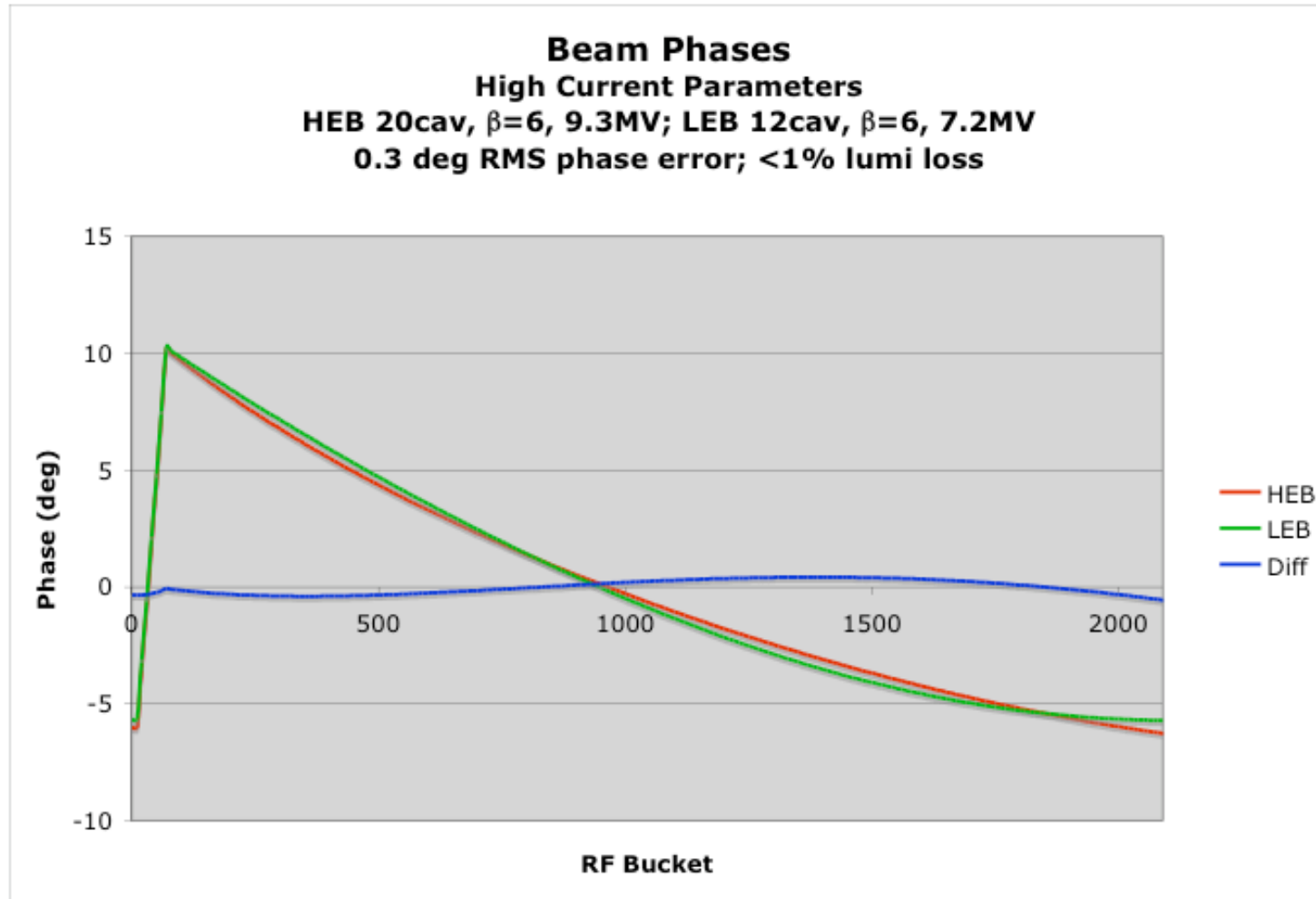
Parameter	Units	Base Line		Low Emittance		High Current		Tau/Charm (prelim.)	
		HER (e+)	LER (e-)	HER (e+)	LER (e-)	HER (e+)	LER (e-)	HER (e+)	LER (e-)
LUMINOSITY	cm²s⁻¹	1.00E+36		1.00E+36		1.00E+36		1.00E+35	
Energy	GeV	6.7	4.18	6.7	4.18	6.7	4.18	2.58	1.61
Circumference	m	1258.4		1258.4		1258.4		1258.4	
X-Angle (full)	mrad	66		66		66		66	
β _x @ IP	cm	2.6	3.2	2.6	3.2	5.06	6.22	6.76	8.32
β _y @ IP	cm	0.0253	0.0205	0.0179	0.0145	0.0353	0.0286	0.0658	0.0533
Coupling (high current)	%	0.25	0.25	0.25	0.25	0.5	0.5	0.25	0.25
Emittance x (without IBS)	nm	1.97	1.82	1.97	1.82	1.97	1.82	1.97	1.82
Emittance x (with IBS)	nm	2.00	2.46	1.00	1.23	2.00	2.46	5.20	6.4
Emittance y	pm	5	6.15	2.5	3.075	10	12.3	13	16
Bunch length	mm	5	5	5	5	4	4	5	5
Beam current	mA	1892	2447	1460	1888	3094	4000	1365	1766
Buckets distance	#	2		2		1		1	
Ion gap	%	2		2		2		2	
RF frequency	Hz	4.76E+08		4.76E+08		4.76E+08		4.76E+08	
Revolution frequency	Hz	2.38E+05		2.38E+05		2.38E+05		2.38E+05	
Harmonic number	#	1998		1998		1998		1998	
Number of bunches	#	978		978		1956		1956	
N. Particle/bunch	#	5.08E+10	6.56E+10	3.92E+10	5.06E+10	4.15E+10	5.36E+10	1.83E+10	2.37E+10
α _x @ IP	microns	7.211	8.872	5.099	6.274	10.060	12.370	18.749	23.070
α _y @ IP	microns	0.036	0.036	0.021	0.021	0.059	0.059	0.092	0.092
α _{x'} @ IP	microrad	277.4	277.3	196.1	196.1	198.8	198.9	277.4	277.4
α _{y'} @ IP	microrad	140.6	173.2	118.2	145.6	168.3	207.4	140.6	173.3
Piwinski angle	rad	22.88	18.60	32.36	26.30	13.12	10.67	8.80	7.15
α _x effective	microns	165.22	165.30	165.14	165.18	132.43	132.63	166.12	166.63
Σ _x	microns	11.433		8.085		15.944		29.732	
Σ _y	microns	0.050		0.030		0.084		0.131	
Σ _x effective	microns	233.35		233.35		186.68		233.35	
Hourglass factor		0.950		0.950		0.950		0.950	
Tune shift x		0.0021	0.0033	0.0017	0.0023	0.0053	0.0081	0.0052	0.0081
Tune shift y		0.0970	0.0977	0.0891	0.0892	0.0827	0.0828	0.0909	0.0910
Longitudinal damping time	msec	13.4	20.3	13.4	20.3	13.4	20.3	26.8	40.6
Energy Loss/turn	MeV	2.11	0.865	2.11	0.865	2.11	0.865	0.4	0.166
Momentum compaction		4.36E-04	4.05E-04	4.36E-04	4.05E-04	4.36E-04	4.05E-04	4.36E-04	4.05E-04
Energy spread without IBS	dE/E	6.31E-04	6.68E-04	6.31E-04	6.68E-04	6.31E-04	6.68E-04	6.31E-04	6.68E-04
Energy spread with IBS	dE/E	6.43E-04	7.34E-04	6.43E-04	7.34E-04	6.43E-04	7.34E-04	6.94E-04	7.34E-04
CM energy spread	dE/E	5.00E-04		5.00E-04		5.00E-04		5.26E-04	
Energy acceptance	dE/E	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
SR power loss	MW	3.99	2.12	3.08	1.63	6.53	3.46	0.55	0.29
Touschek lifetime	min	35	16	17	8	70	32	17	8
Luminosity lifetime	min	4.81	6.23	3.71	4.80	7.87	10.17	34.69	44.88
Total lifetime	min	4.23	4.48	3.05	3.00	7.07	7.72	11.41	6.79
RF plug power + SR	MW	12.22		9.43		19.98		1.68	
Total power	MW	16.5		12.5		26		2.9	



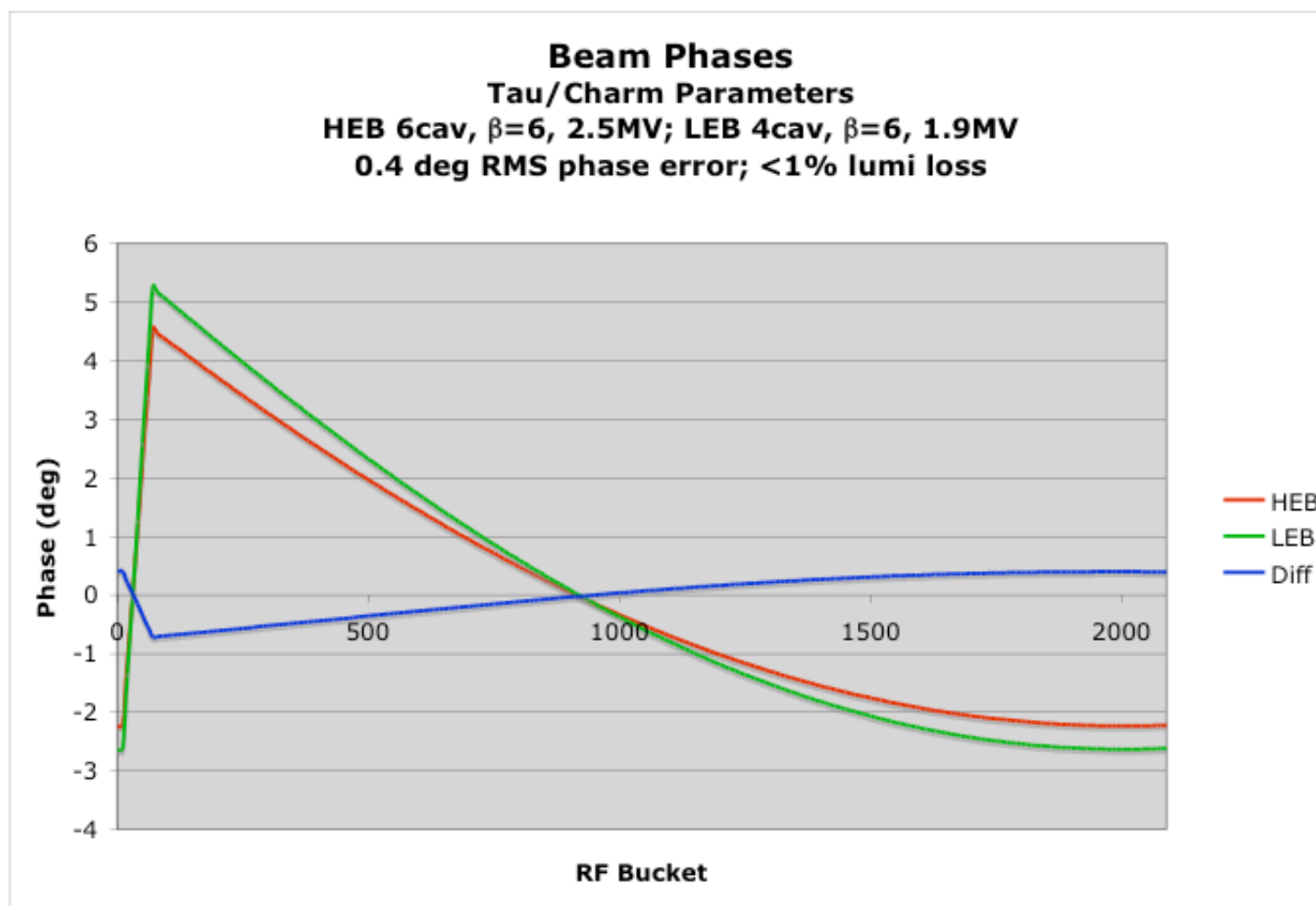
- HER 12 cavs 7MV $\beta=6$, LER 8 cavs 5.2MV $\beta=6$
- Lose <1% of lumi due to gap transient mismatch



- HER 12 cavs 6.9MV $\beta=6$, LER 8 cavs 5.1MV $\beta=6$
- Lose <1% of lumi due to gap transient mismatch



- HER 20 cavs 9.3MV $\beta=6$, LER 12 cavs 7.2MV $\beta=6$
- Lose <1% of lumi due to gap transient mismatch



- HER 6 cavs 2.5MV $\beta=6$, LER 4 cavs 1.9MV $\beta=6$
- Lose <1% of lumi due to gap transient mismatch

- RF system likes new parameters
 - LER current 20-30% higher than HER
 - Gap transients can be fairly well matched without adding extra RF cavities
 - Sinusoidal phase errors can be corrected if necessary (not necessary at present)
- Cavities
 - Must increase coupling constant to ~ 6 to get power into cavities
 - Minimum: 12 HER and 8 LER cavities
 - High Current operation: 20 HER and 12 LER cavities
 - Recommend 1 additional RF station (2 cavities) in each ring for reliability