Super-B: RF parameters and longitudinal issues.

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SLAC National Accelerator Laboratory

XI Super B Workshop

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INFN-LNF

High efficiency, cite independent project.

Super-B parameters. July 22, 2009

Bending radius	Super-B	PEP-II
HER	126 m	165 m
LER	10.5 m	13.8 m

Parameter	Units	Super-B
		LNF
		22-Jul-09
		with SR LER
E HER (positrons)	GeV	6.7
E LER (electrons)	GeV	4.18
Energy ratio		1.60
Bunch length HER	cm	0.5
Bunch length LER	cm	0.5
I HER	mA	2120
I LER	mA	2120
Circumference	m	1315
N. Buckets distance		2
Gap		0.97
Frf	Hz	4.76E+08
Fturn	Hz	**2.28E+05**
Fcoll	Hz	**2.31E+08**
Num Bunch		**1011**
N HER		**5.74E+10**
N LER		**5.74E+10**
Damping_long HER	msec	14.5
Damping_long LER	msec	22.0
Uo HER	MeV	2.03
Uo LER	MeV	0.83
alfa_c HER		4.04E-04
alfa_c LER		4.24E-04
sigma-EHER		6.15E-04
sigma-E LER		6.57E-04
CM sigma_E		**9.00E-04**
SR power loss HER	**MW**	**4.30**
SR power loss LER	**MW**	**1.76**

RF cavity limits

- Cavity voltage and forward power
  - Voltage in a cavity is limited by sparks and breakdowns
    - SLAC PEP-II experience: voltage should be less than 0.75 MV per cavity
  - Forward power into a cavity and reflected power are limited by sparks in RF windows
    - SLAC PEP-II experience: transmitted power should be less than 500 KW per cavity and reflected power less than 10%

Changing the coupling factor β of the PEP-II cavity for a better RF performance at Super-B

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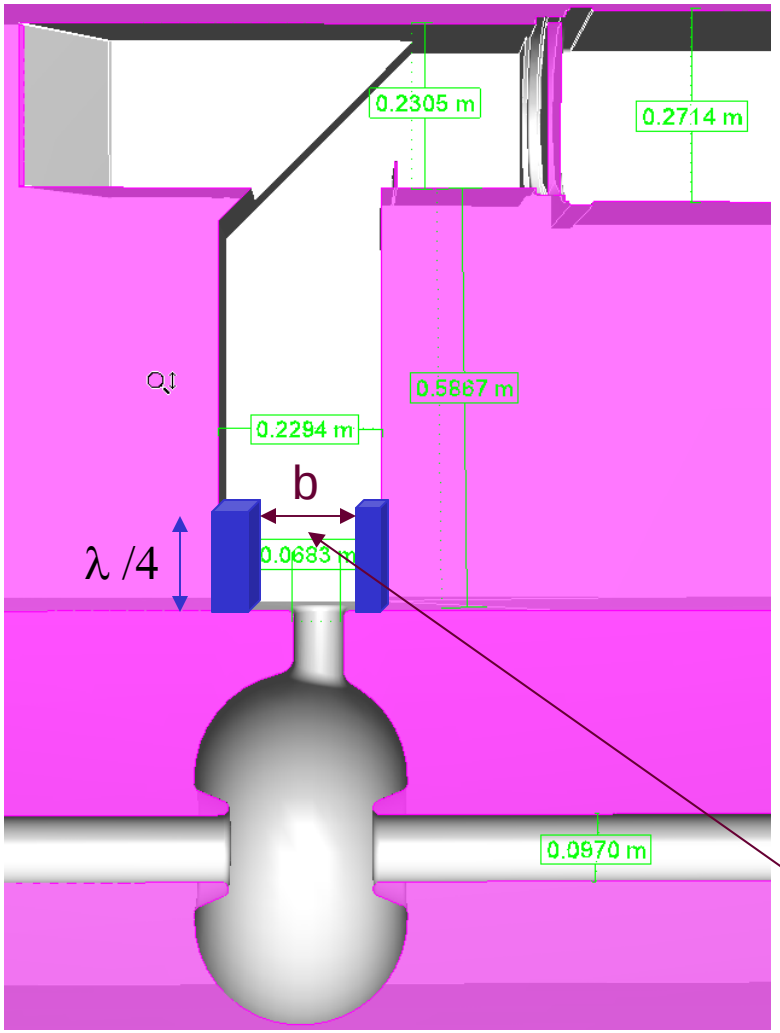

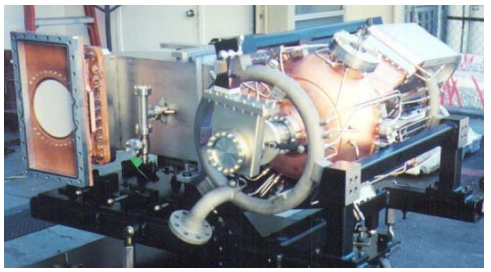

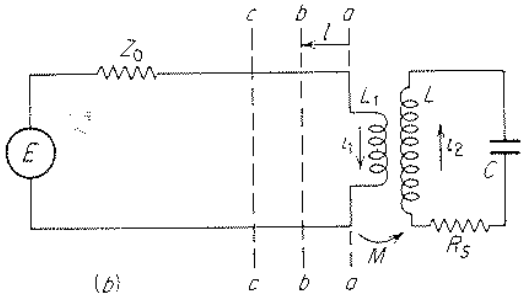

$$Q_L = \frac{Q_0}{1+\beta} \qquad Q_0 = \frac{\omega L}{R_s}$$

$$\beta = \frac{(\omega M)^2}{Z_0 R_s} \frac{1}{1+\left(\frac{\omega L_1}{Z_0}\right)^2}$$

$$Z_0 \sim b$$

Super-B RF plug power

Changing coupling from 3.6 to 6.0

HER	HER	HER	HER	HER	HER	HER	HER	HER	HER	HER	HER	HER+
Total	Zero I		Max	Number			Total	Total	Total	Power fo	reflected	LER
RF	Bunch	Bunch	voltage	of	S.R.	HOM	cavity	reflected	forward	to one	from	Total
voltage	length	spacing	er cavit	cavities	power	power	loss	power	power	cavity	one	forward
MV	mm	nsec	MV	klystron	MW	MW	MW	MW	MW	MW	MW	MW
5.78	5.00	4.20	0.51	12.00	4.30	0.45	0.37	1.30	6.41	0.53	0.11	9.03
				6.00								
												HER+
LER	LER	LER	LER	LER	LER	LER	LER	LER	LER	LER	LER	LER
Total	Zero I		Max	Number			Total	Total	Total	Power fo	reflected	Plug
RF	Bunch	Bunch	voltage	of	S.R.	HOM	cavity	reflected	forward	to one	from	Power
voltage	length	spacing	er cavit	cavities	power	power	loss	power	power	cavity	one	eff.~50%
MV	mm	nsec	MV	klystron	MW	MW	MW	MW	MW	MW	MW	MW
4.10	5.01	4.20	0.58	8.00	1.76	0.40	0.28	0.17	2.61	0.33	0.02	18.05
				4.00								

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Gap transient is small.
Kirk Bertsche. October SLAC Meeting

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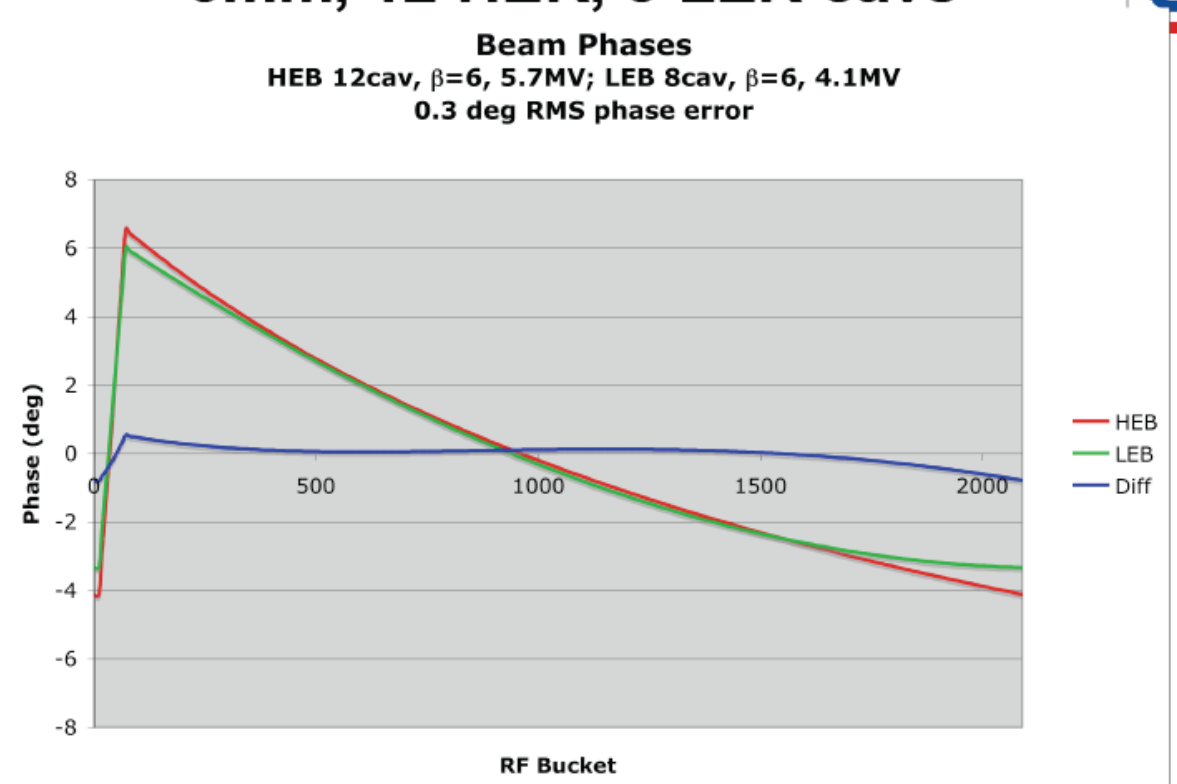
5mm, 12 HER, 8 LER cavs



- ~~Low gap voltages, HER 12 cavs β=6, LER 8 cavs β=6~~
- Lose <1% of lumi due to gap transient mismatch

Main mode Robinson Damping and optimal coupling factor

- Matching main mode

$$\beta = 1 + \frac{2 I_b Z_{sh}}{V_{total}} N_{cav} \frac{U_{S.R}}{V_{total}}$$

$$\Delta f = - f_{RF} \times \frac{Z_{sh}}{Q} \times \frac{I}{V_{total}} N_{cav}$$

PEP-II	cavity
f [MHz]	476
Z [MOhm]	3.8
Q	32000
Z/Q [Ohm]	118.75

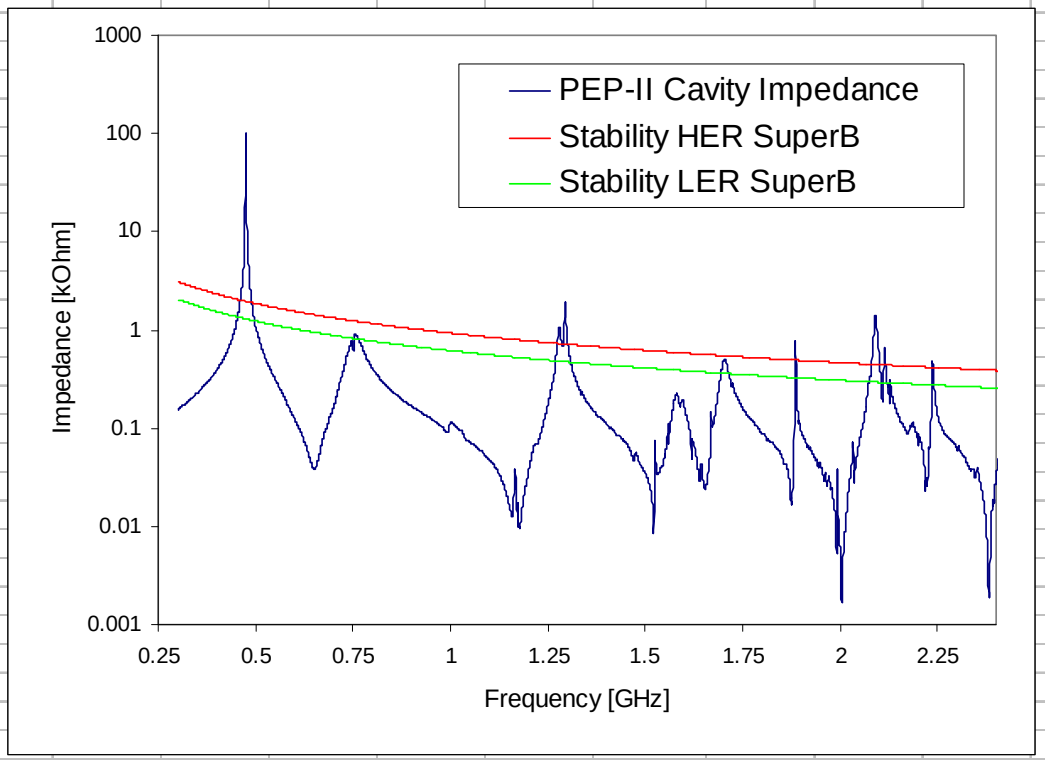
	PEP	-	II		Super	-	B
	LER		HER		LER		HER
Usr [MeV]	0.5		3.55		0.83		2.03
N cav	8		28		8		12
V [MV]	4.05		16.5		4.1		5.7
I [mA]	3000		2000		2120		2120
df [kHz]	-334.96		-191.84		-233.82		-252.28
f rev [kHz]	136.3		136.3		228		228
betta	6.56		6.55		7.36		13.08

Multi-bunch beam stability

- Threshold for a cavity impedance

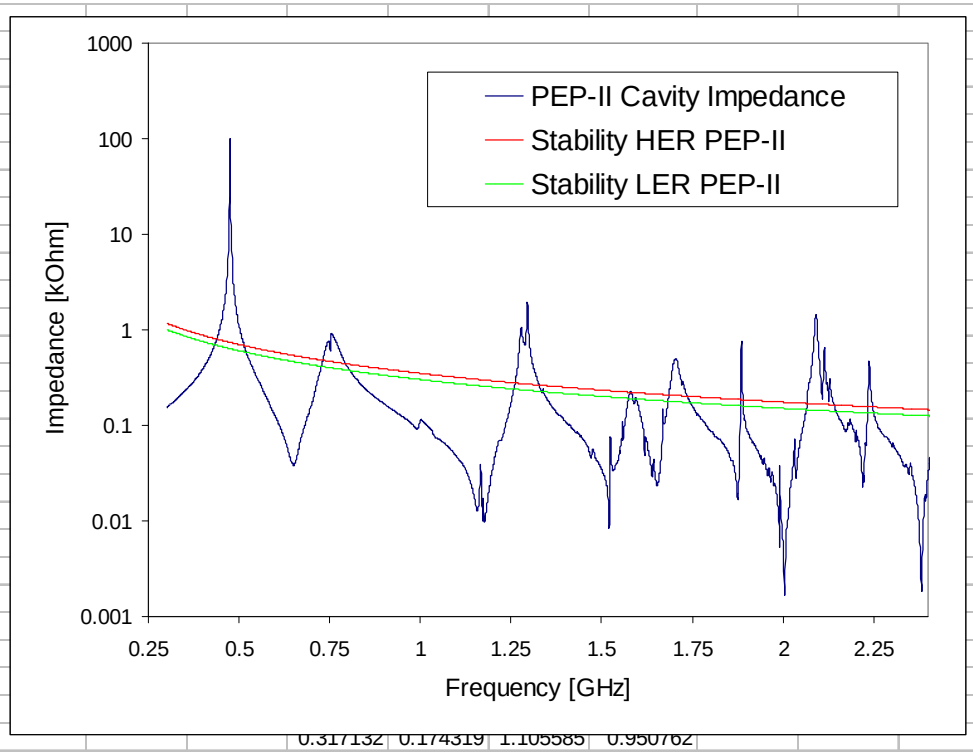
$$Z_{th}(\omega) = \frac{4\pi E \nu_s}{\alpha \tau_s N_c I \omega}$$

	HER	LER
Energy [GeV]	6.7	4.18
Current [A]	2.12	2.12
alpha	0.000404	0.000424
Freq RF[kHz]	476001.5	476001.5
Freq shift [kHz]	-252.2808	-233.82122
nu_s	0.0103309	0.0116337
R [MOhm]	3.8	3.8
Q	32000	32000
R/Q [Ohm]	118.75	118.75
Ts [msec]	14.5	22
Feedback gain	0	0
Ncav	12	8
Voltage [MV]	5.7	4.1
Amplitude	0.92892	0.6147672



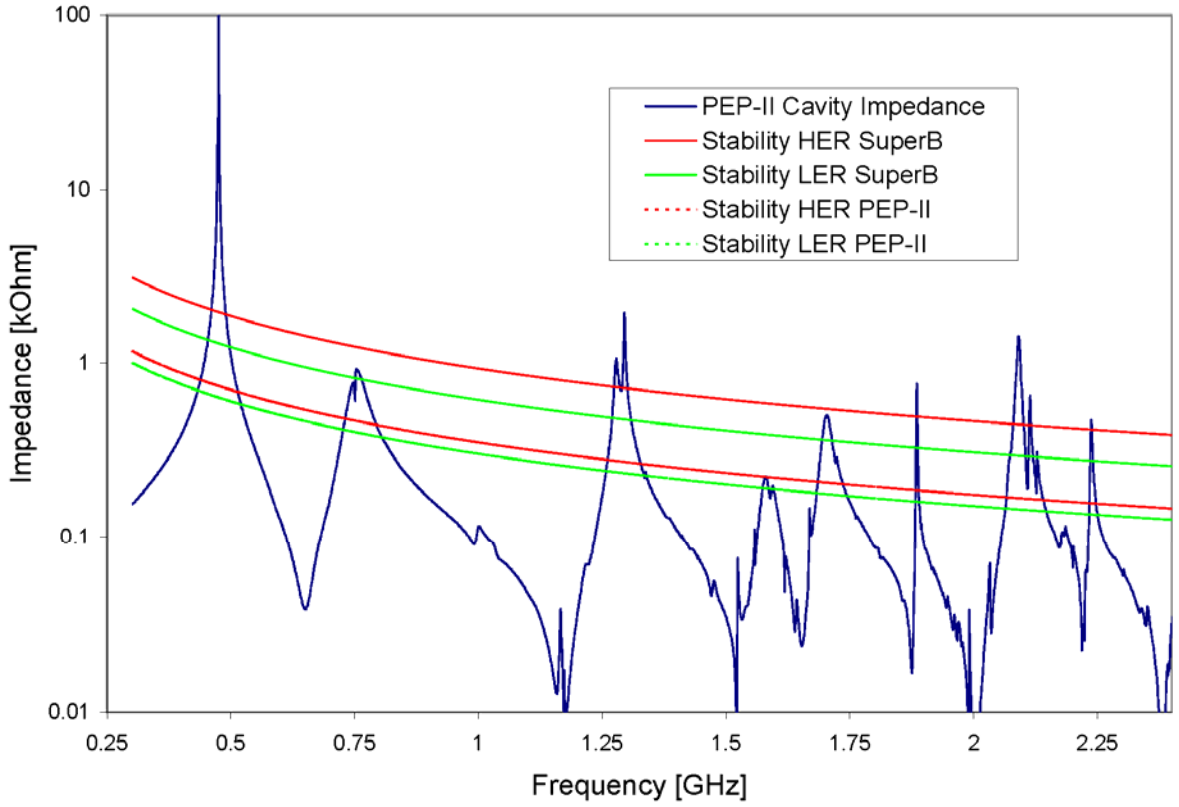
Beam stability for PEP-II. Effect of the feedbacks.

	HER PEP-II	LER PEP-II
Energy [GeV]	8.973	3.11
Current [A]	**2**	**3**
alpha	0.00241	0.00123
Freq RF[kHz]	476001.5	476001.5
Freq shift [kHz]	-191.84303	-330.87909
nu_s	0.0490437	0.0299078
R [MOhm]	3.8	3.8
Q	32000	32000
R/Q [Ohm]	118.75	118.75
Ts [msec]	18.6	20.9
Feedback gain	0	0
Ncav	28	8
Voltage [MV]	16.5	4.1
Amplitude	0.3506167	0.3015174



- PEP-II RF and bunch by bunch feedbacks overcome the instability threshold.

Super-B and PEP-II beam stability.



- Using similar to PEP-II feedback we can go to higher currents in Super B.

More currents in Super-B

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			LER	LER	LER		HER	HER	HER
	Usr [MeV]		0.83	0.83	0.83		2.03	2.03	2.03
	N cav		8	8	14		12	18	26
	V [MV]		4.1	4.1	5.8		5.7	8	10
	I [mA]		2120	3000	4000		2120	3000	4000
	df [kHz]		-221.51	-313.46	-517.03		-239.00	-361.46	-556.92
	f rev [kHz]		228	228	228		228	228	228
	opt betta		7.03	9.53	10.95		12.44	13.33	16.20

Super-B Higher currents. Each bucket is filled. Coupling factor is modified.

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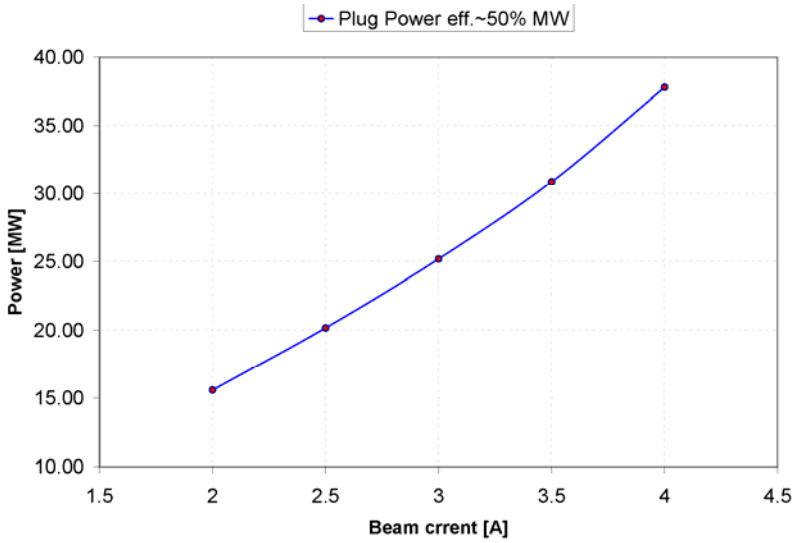
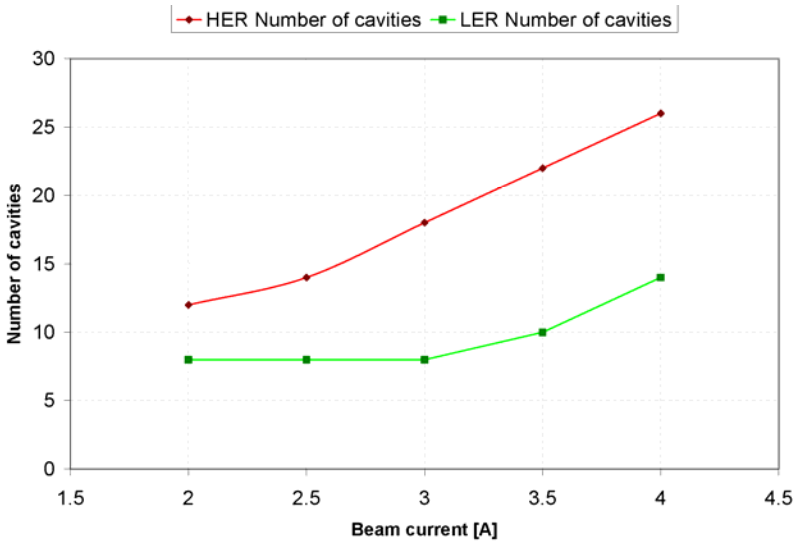
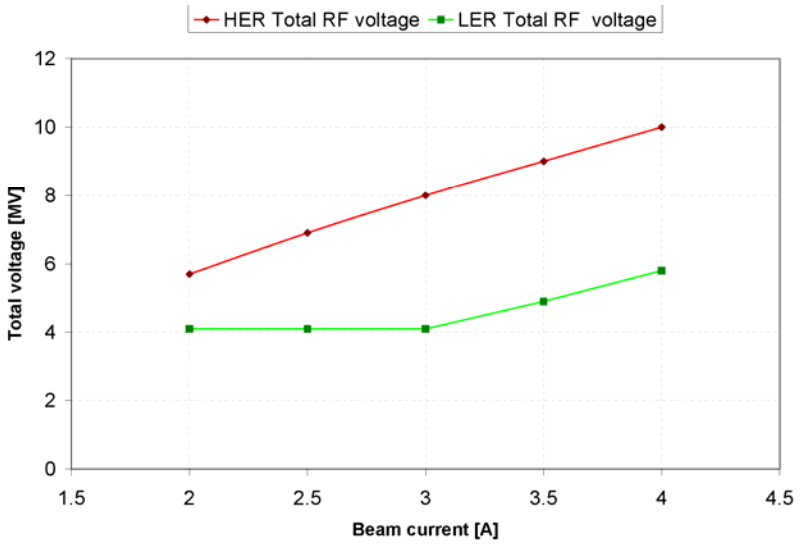
HER	HER	HER	HER	HER	HER	HER	HER	HER	HER	HER	HER	HER	HER	HER		HER+	
S.R. energy				Total	Zero I		Max	Number			Total	Total	Total	Power for	reflected	LER	
Beam	loss	Momen-	Momen-	RF	Bunch	Bunch	voltage	of	S.R.	HOM	cavity	reflected	forward	one	from	Total	betta
current	per turn	tum com-	tum	voltage	length	spacing	er cavit	cavities	power	power	loss	power	power	cavity	one	forward	
A	MeV	paction	spread	MV	mm	nsec	MV	klystro	MW	MW	MW	MW	MW	MW		MW	
2	2.03	4.0E-04	6.2E-04	5.7	5.0	2.1	0.51	12	4.06	0.1965	0.356	0.9879	5.60	0.47	0.08	7.80	6.00
								6									
2.5	2.03	4.0E-04	6.2E-04	6.9	4.5	2.1	0.51	14	5.075	0.372	0.447	1.3129	7.21	0.51	0.09	10.08	6.00
								7									
3	2.03	4.0E-04	6.2E-04	8	4.2	2.1	0.45	18	6.09	0.6442	0.468	1.7207	8.92	0.50	0.10	12.60	7.00
								9									
3.5	2.03	4.0E-04	6.2E-04	9	3.9	2.1	0.4	22	7.105	1.0189	0.484	2.2063	10.81	0.49	0.10	15.43	8.00
								11									
4	2.03	4.0E-04	6.2E-04	10	3.7	2.1	0.4	26	8.12	1.5197	0.506	2.7158	12.86	0.49	0.10	18.90	9.00
								13									
																HER+	
LER	LER	LER	LER	LER	LER	LER	LER	LER	LER	LER	LER	LER	LER	LER		LER	
S.R. energy				Total	Zero I		Max	Number			Total	Total	Total	Power for	reflected	Plug	
Beam	loss	Momen-	Momen-	RF	Bunch	Bunch	voltage	of	S.R.	HOM	cavity	reflected	forward	one	from	Power	
current	per turn	tum com-	tum	voltage	length	spacing	er cavit	cavities	power	power	loss	power	power	cavity	one	eff.~50%	
A	MeV	paction	spread	MV	mm	nsec	MV	klystro	MW	MW	MW	MW	MW	MW		MW	
2	0.83	4.2E-04	6.6E-04	4.1	5.0	2.1	0.58	8	1.66	0.1792	0.276	0.0836	2.20	0.27	0.01	15.60	6.00
								4									
2.5	0.83	4.2E-04	6.6E-04	4.1	5.0	2.1	0.58	8	2.075	0.2801	0.276	0.2449	2.88	0.36	0.03	20.17	6.00
								4									
3	0.83	4.2E-04	6.6E-04	4.1	5.0	2.1	0.58	8	2.49	0.4033	0.276	0.5051	3.67	0.46	0.06	25.20	6.00
								4									
3.5	0.83	4.2E-04	6.6E-04	4.9	4.6	2.1	0.48	10	2.905	0.6579	0.316	0.7332	4.61	0.46	0.07	30.85	6.00
								5									
4	0.83	4.2E-04	6.6E-04	5.8	4.2	2.1	0.4	14	3.32	1.0543	0.316	1.3484	6.04	0.43	0.10	37.80	6.00
								7									

Higher currents in Super-B







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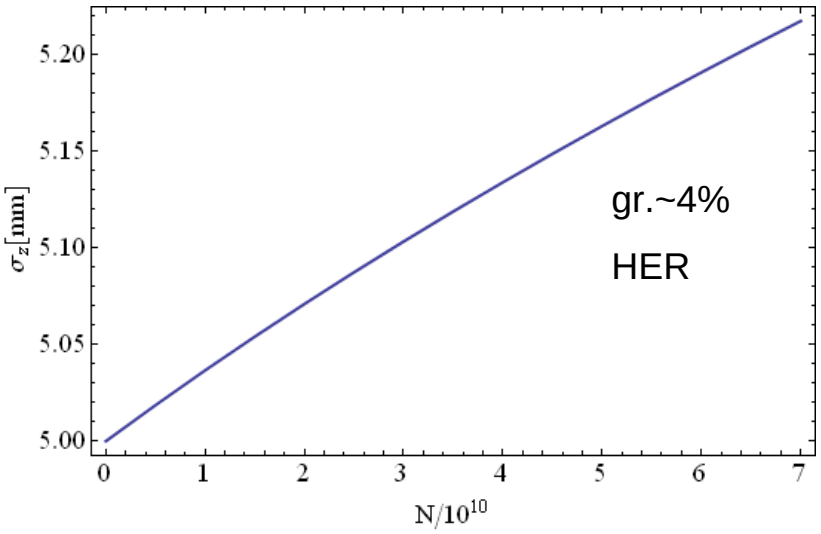
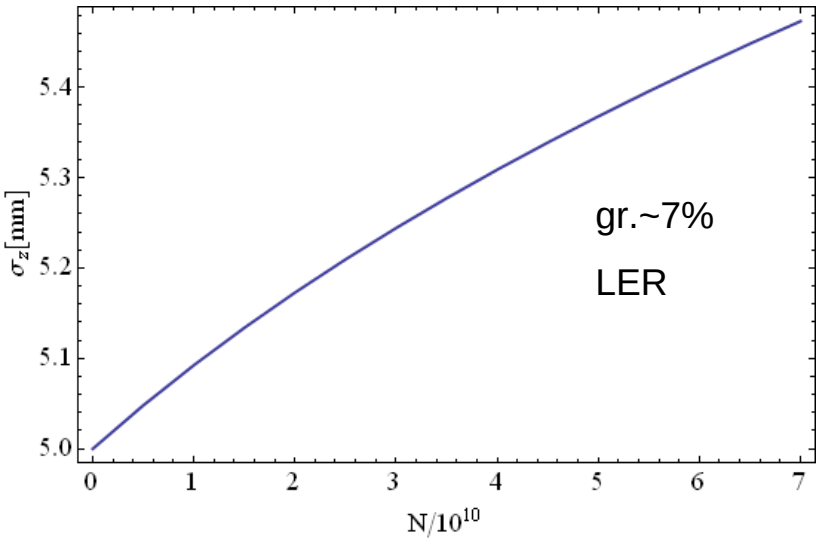
Electron Cloud & IBS Update

T. Demma, INFN-LNF

SuperB General Meeting
October 6-9 2009, SLAC





Bunch lengthening in Super-B. It could be very large.

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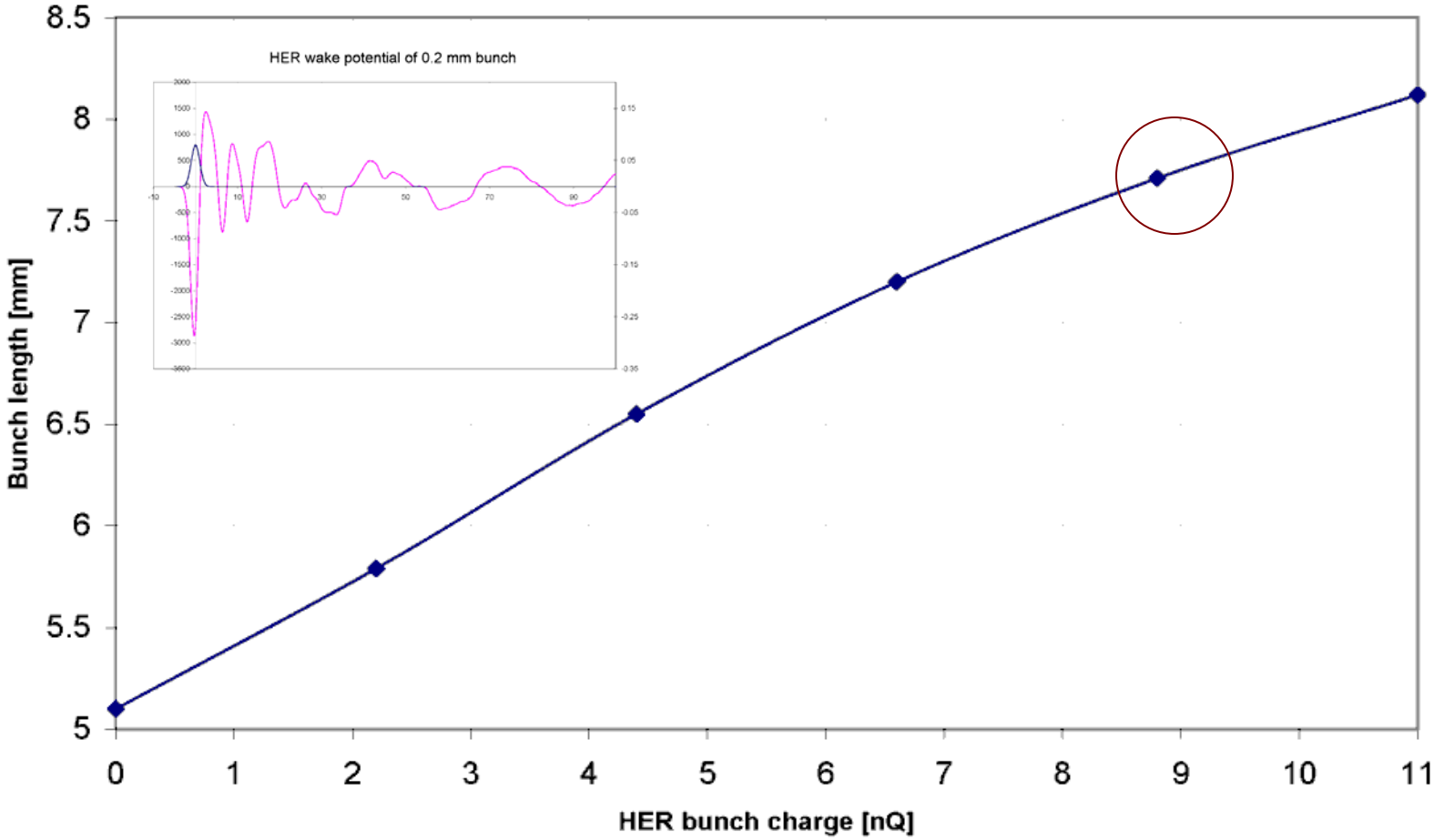
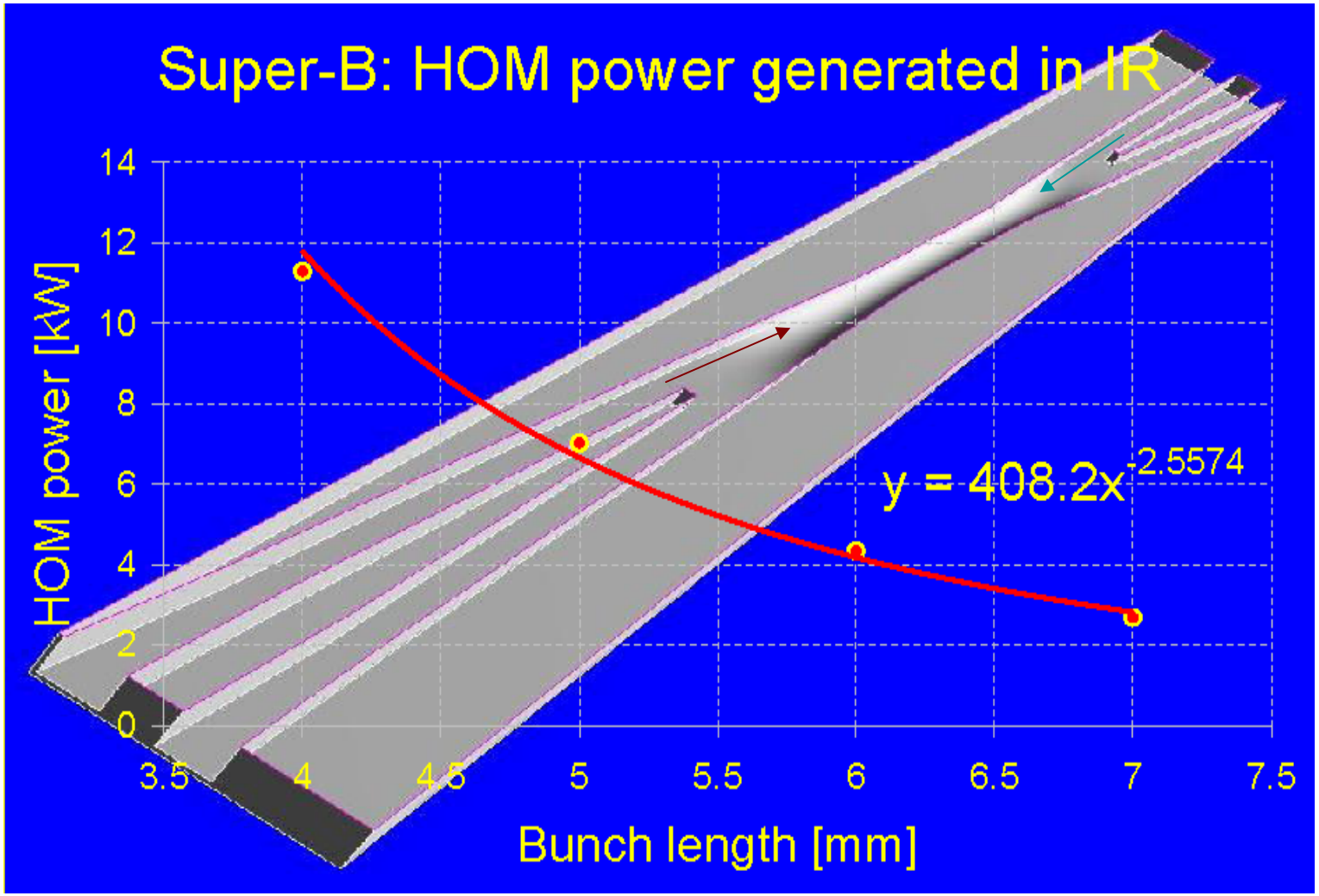
HER



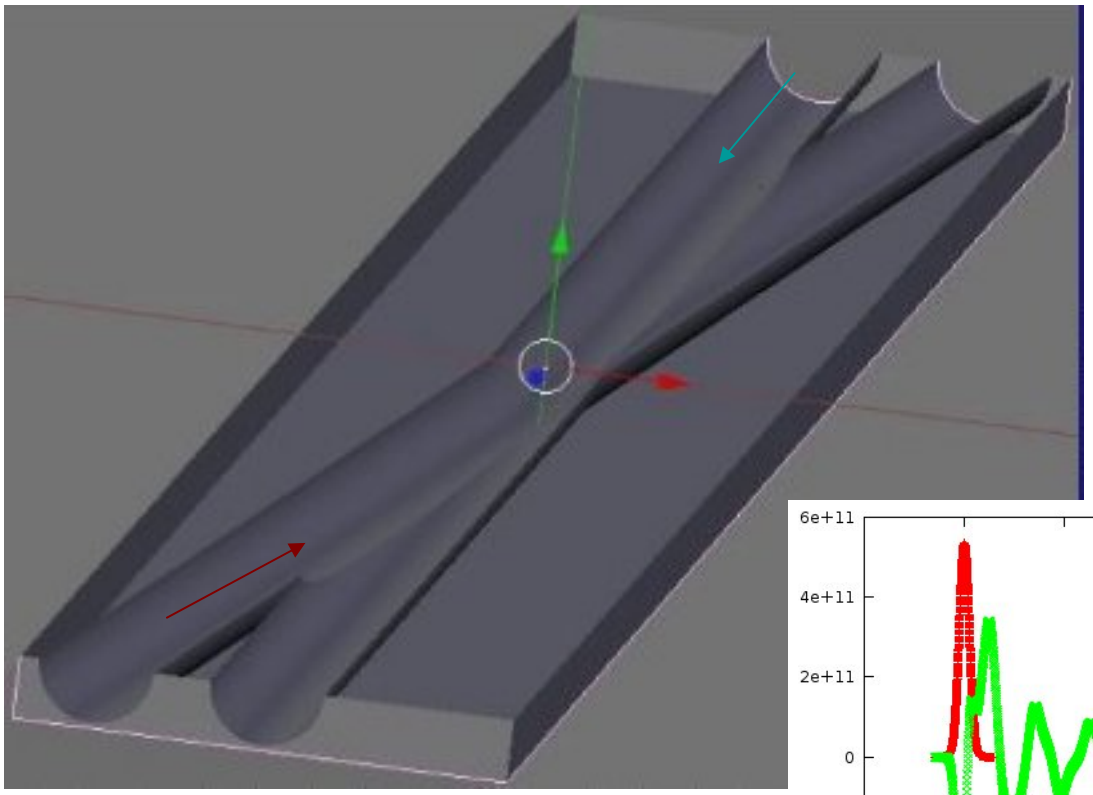
News from the wake field studies

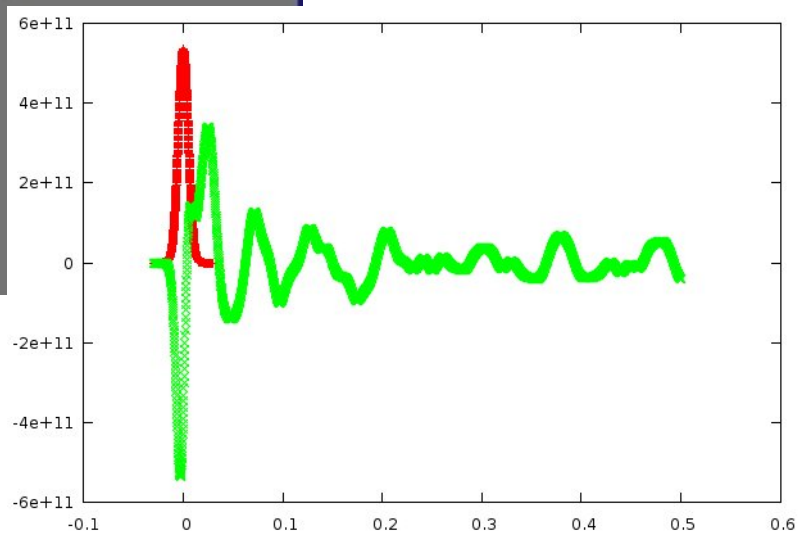
- IR study
  - attempting to understand the wake field structure for other geometry
  - detailed study of the fields penetrating through the thing IP walls
- Other beam chamber elements

Wake field simulations for the Super-B Interaction Region



Other shape of the Interaction Region. S.Weathersby





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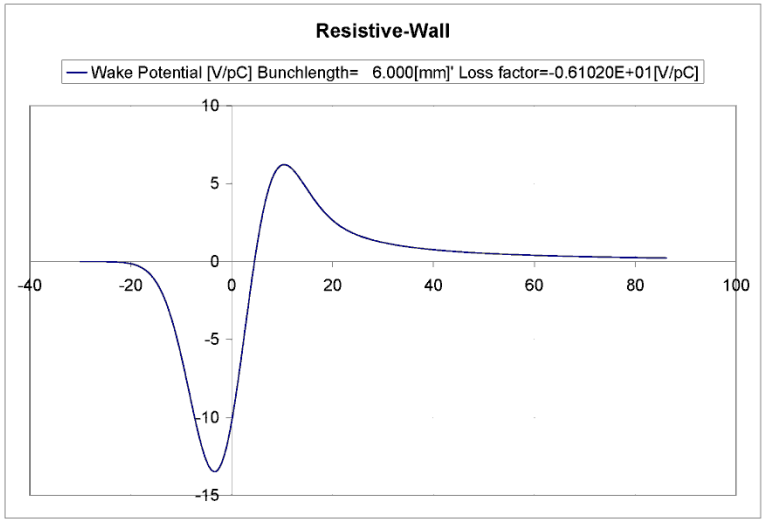
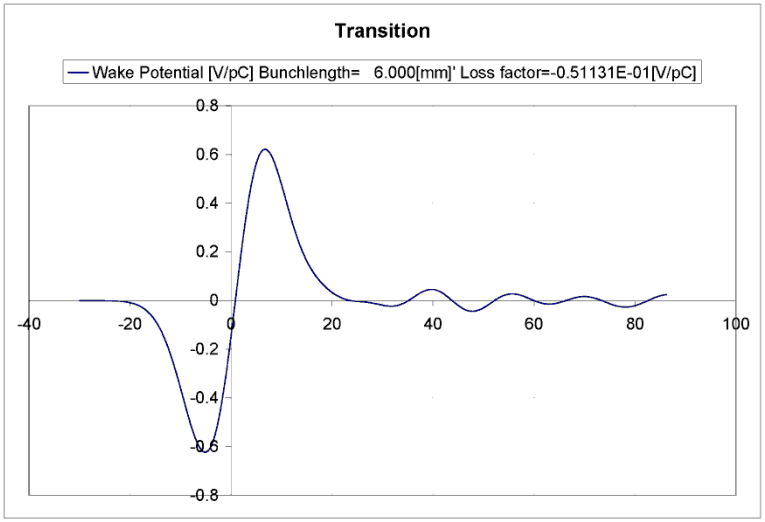
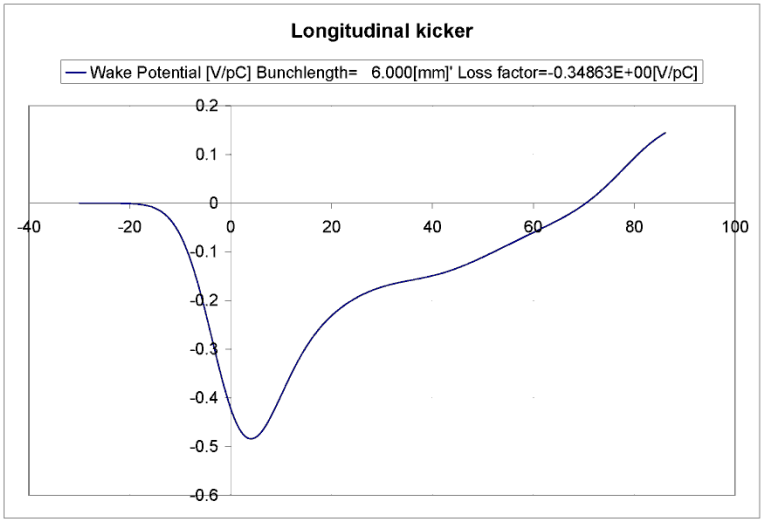
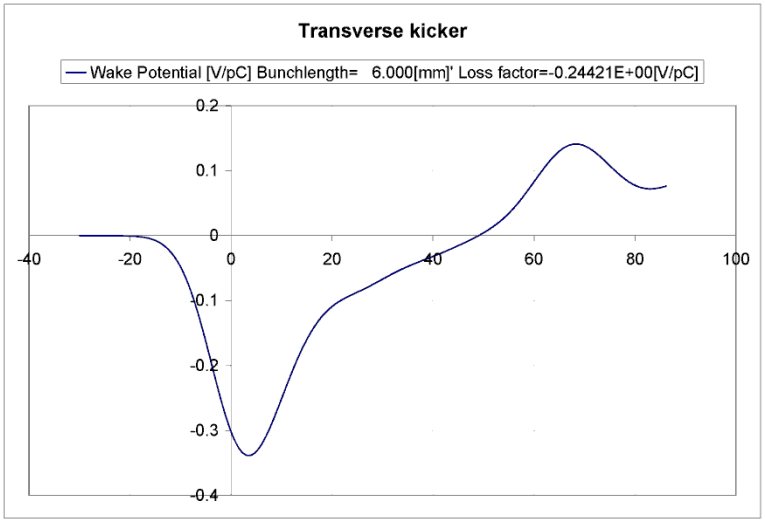
Resistive-wall and geometrical transitions



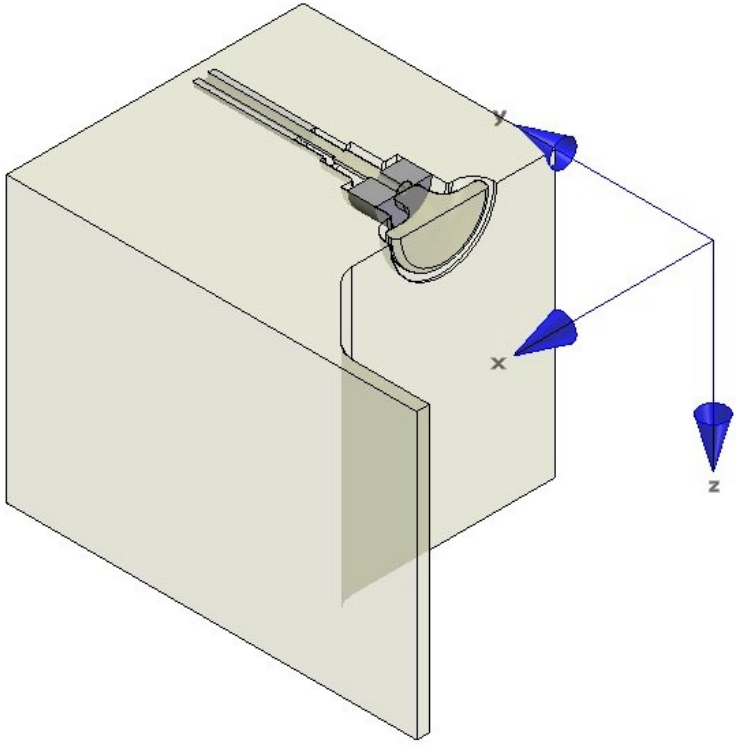


Kickers


Longitudinal kicker
Wake Potential [V/pC] Bunchlength= 6.000[mm]' Loss factor=-0.34863E+00[V/pC]
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-40
-20
0
20
40
60
80
100


Transverse kicker
Wake Potential [V/pC] Bunchlength= 6.000[mm]' Loss factor=-0.24421E+00[V/pC]
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-40
-20
0
20
40
60
80
100

BPMs

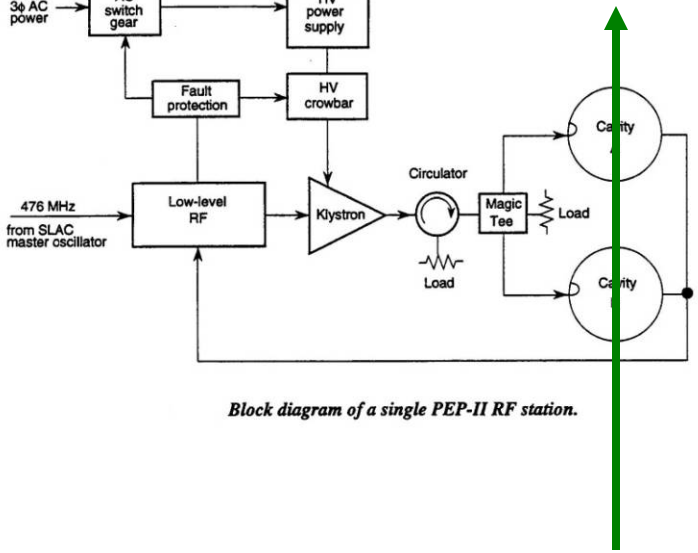


Loss factor = 0.003 V/pC

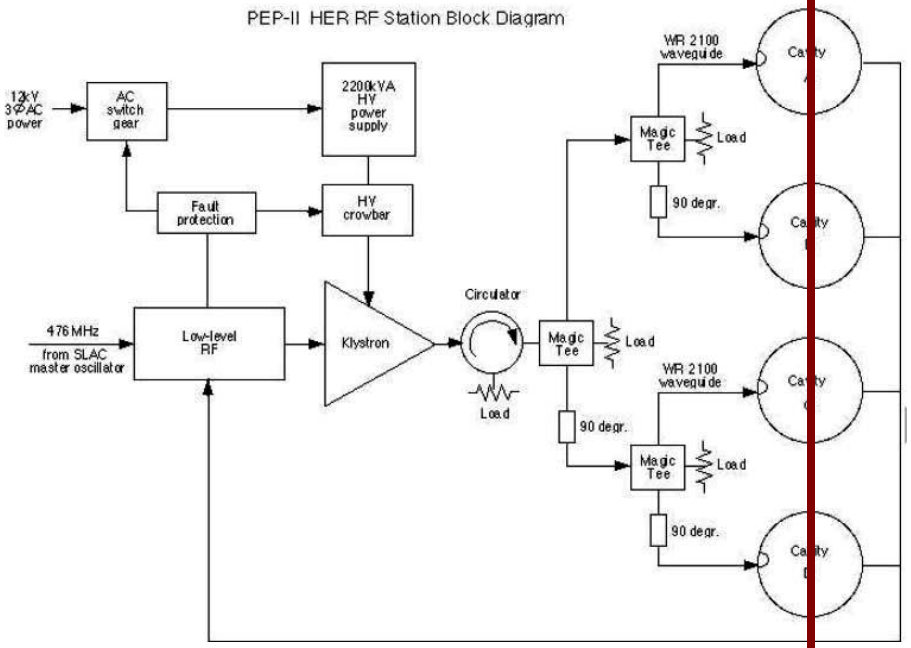
Summary

- A small modification of a coupler box of the PEP-II RF cavities will considerably improve the RF performance of the Super-B.
- RF and bunch by bunch feed-back may allow to go to higher currents adding more cavities.
- HOM studies are continued.

RF power distribution in PEP-II: 2 or 4 cavities per klystron



Block diagram of a single PEP-II RF station.



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