s2e simulation of FLASH with 3rd harm. section + coupler kicks

Igor Z.: s2e simulation of FLASH with 3rd harm. section without coupler kicks

simulation on the way: cpu time

model for rf coupler kicks

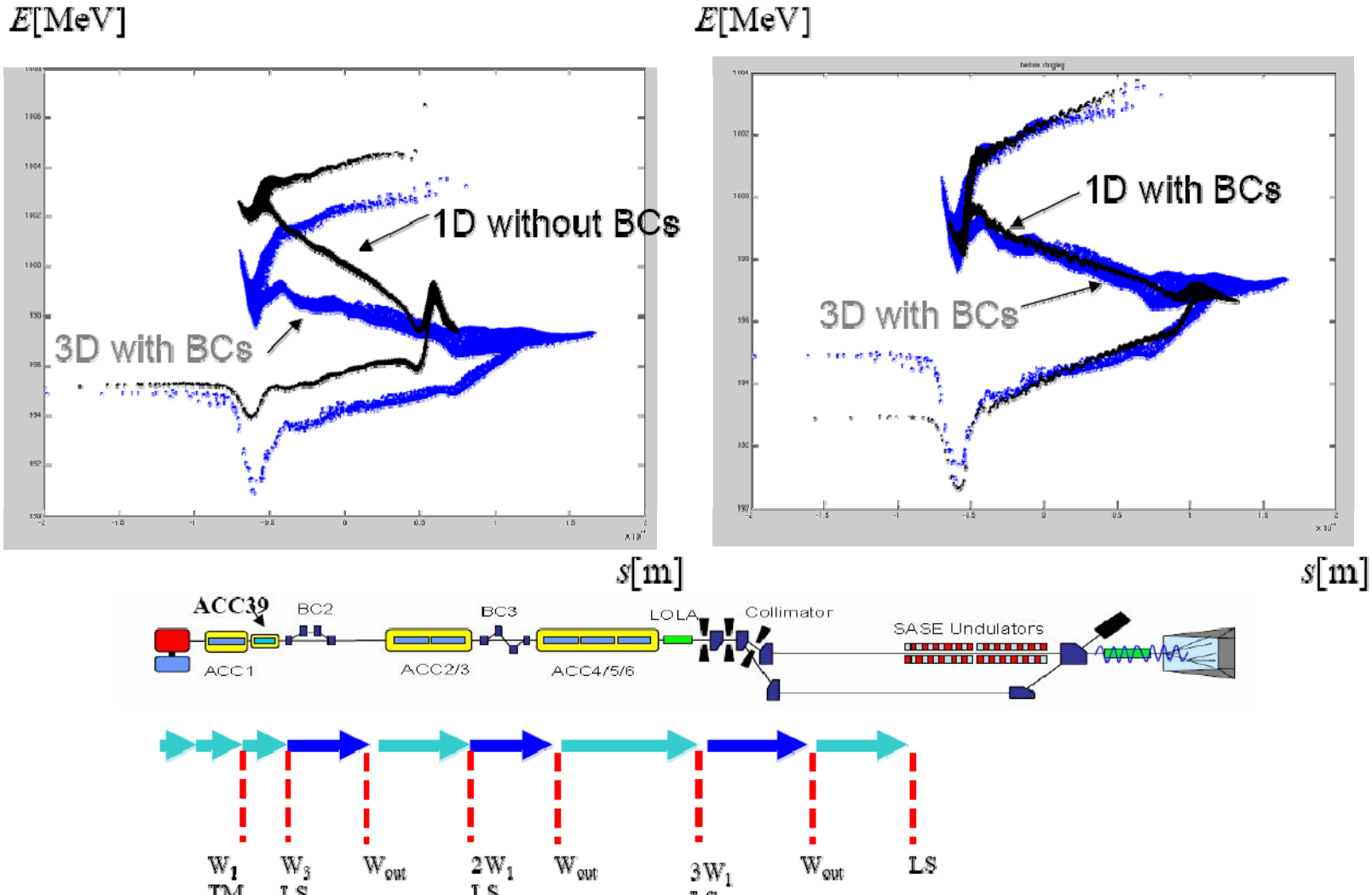
extra ASTRA loop

simulation:

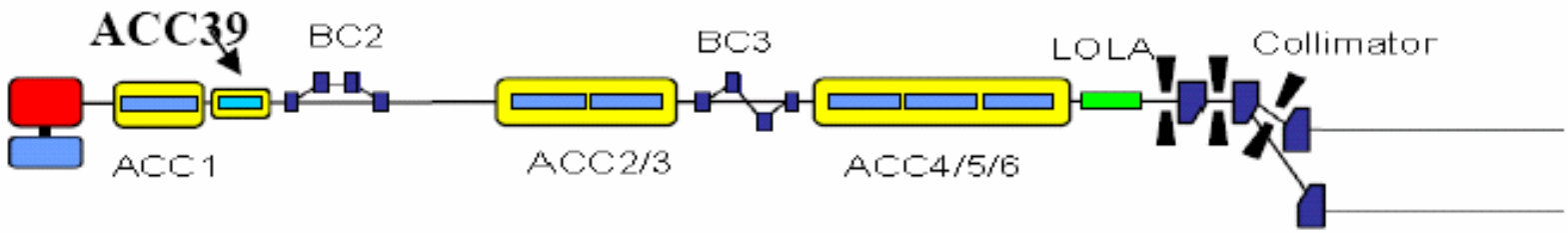
- trajectory
- after BC3
- after DOGLEG (with 20000 particles)

preliminary conclusion

3D simulation with space charge + cavity wakes+self fields in BCs.



8. March 2009
CPU time (mafia-2)



	L/m	L/m	L/m	L/m	L/m	L/m	L/m	L/m	L/m	
	2.6	11.2	7.3	6	42.3	16	70.5	9	44.1	
	t/h	t/h	t/h	t/h	t/h	t/h	t/h	t/h	t/h	
	0.75	3.33	1.97	0.02	12.32	0.04	22.47	0.12	13.25	
	8.52	10.13	6.13	0.10	37.58	0.35	65.36		39.00	
(A)	6.27	31.25	18.55	0.10	118.28	0.35	189.9 (B - 61.5m)		39.00	(C)

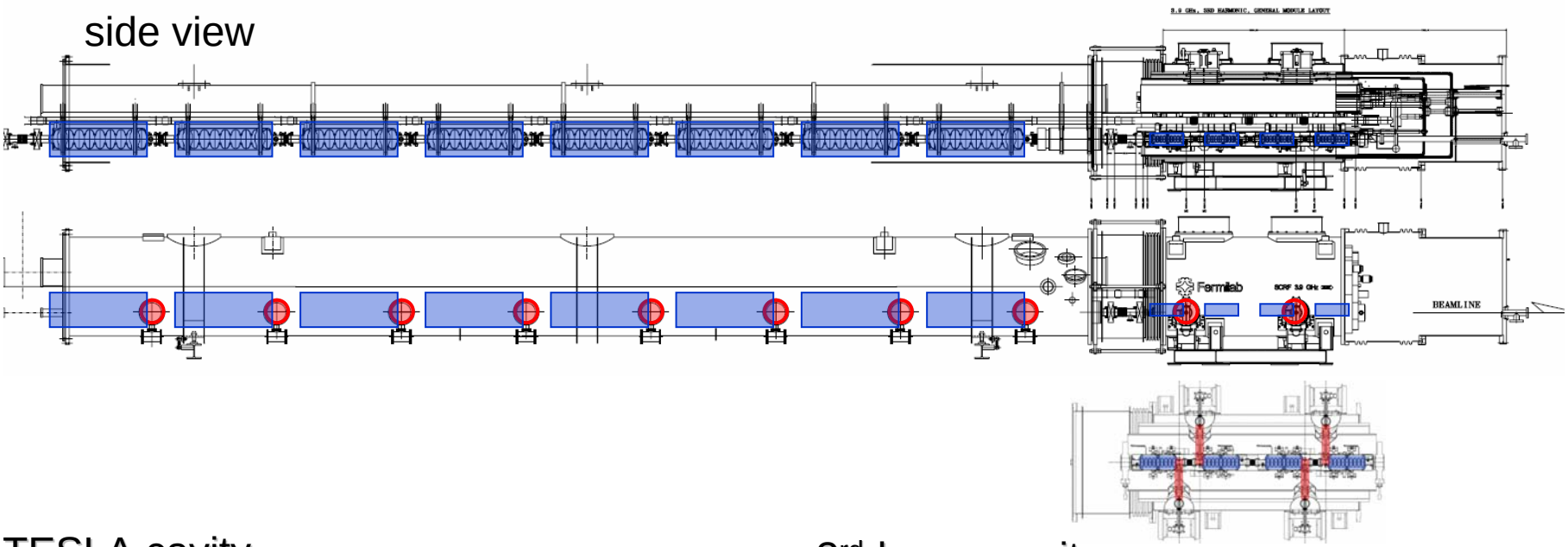
A = 22. Feb 14:30
B= 8. Mrz 8:00
C= 11. Mrz 2:45

	total ASTRA cpu time	
20000 particles with couplers	54.09 h = 2 d 6.09 h	
200000 particles without couplers	166.72 h = 6 d 22.72 h = 0.99 w	Igor's run
200000 particles with couplers	392.02 h = 16 d 8.02 h = 2.33 w	

most of CPU time required for coupler kicks ?!!?

rf coupler kicks
(3.9 GHz = estimated)

side view



TESLA cavity

upstream

$$\frac{1}{V_z}\begin{pmatrix}V_x\\V_y\end{pmatrix}=\begin{pmatrix}-57+j6.7\\-42-j3.5\end{pmatrix}\cdot 10^{-6}$$

$$\frac{1}{V_z}\frac{\partial}{\partial x}\begin{pmatrix}V_x\\V_y\end{pmatrix}=\begin{pmatrix}1.0-j0.7\\3.4+j0.2\end{pmatrix}\cdot\frac{10^{-3}}{\mathrm{m}}$$

$$\frac{1}{V_z}\frac{\partial}{\partial y}\begin{pmatrix}V_x\\V_y\end{pmatrix}=\begin{pmatrix}3.4+j0.2\\-1.1+j0.6\end{pmatrix}\cdot\frac{10^{-3}}{\mathrm{m}}$$

downstream

$$\frac{1}{V_z}\begin{pmatrix}V_x\\V_y\end{pmatrix}=\begin{pmatrix}-23+j52\\30+j5.3\end{pmatrix}\cdot 10^{-6}$$

$$\frac{1}{V_z}\frac{\partial}{\partial x}\begin{pmatrix}V_x\\V_y\end{pmatrix}=\begin{pmatrix}-3.7-j2.0\\3.0+j0.5\end{pmatrix}\cdot\frac{10^{-3}}{\mathrm{m}}$$

$$\frac{1}{V_z}\frac{\partial}{\partial y}\begin{pmatrix}V_x\\V_y\end{pmatrix}=\begin{pmatrix}3.0+j0.5\\3.8+j1.9\end{pmatrix}\cdot\frac{10^{-3}}{\mathrm{m}}$$

3rd-harm. cavity

calculation with MWS kicks

upstream

$$\frac{1}{V_z}\begin{pmatrix}V_x\\V_y\end{pmatrix}=\begin{pmatrix}-496+j202\\-96+j222\end{pmatrix}\cdot 10^{-6}$$

$$\frac{1}{V_z}\frac{\partial}{\partial x}\begin{pmatrix}V_x\\V_y\end{pmatrix}=\begin{pmatrix}-44-j34\\28-j67\end{pmatrix}\cdot\frac{10^{-3}}{\mathrm{m}}$$

$$\frac{1}{V_z}\frac{\partial}{\partial y}\begin{pmatrix}V_x\\V_y\end{pmatrix}=\begin{pmatrix}28-j66\\44+j34\end{pmatrix}\cdot\frac{10^{-3}}{\mathrm{m}}$$

downstream

$$\frac{1}{V_z}\begin{pmatrix}V_x\\V_y\end{pmatrix}=\begin{pmatrix}-267-j672\\45+j340\end{pmatrix}\cdot 10^{-6}$$

$$\frac{1}{V_z}\frac{\partial}{\partial x}\begin{pmatrix}V_x\\V_y\end{pmatrix}=\begin{pmatrix}-3.5-j53\\33+j75\end{pmatrix}\cdot\frac{10^{-3}}{\mathrm{m}}$$

$$\frac{1}{V_z}\frac{\partial}{\partial y}\begin{pmatrix}V_x\\V_y\end{pmatrix}=\begin{pmatrix}33+j75\\3.5+j53\end{pmatrix}\cdot\frac{10^{-3}}{\mathrm{m}}$$

it is an estimation !!!

generate artificial coupler fields + geometry transformations + …

http://www.desy.de/xfel-beam/data/talks/talks/dohlus_-_kick_of_3rd_harm_20080317.pdf

extra ASTRA loop
(autophasing & phasing)

pre processing:

- distribution = offset + slice-offset + input-distribution
- match to design optics

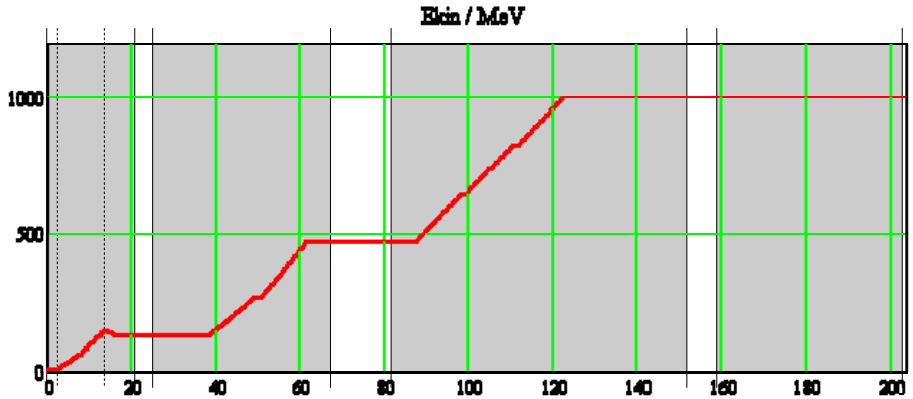
ASTRA processing:

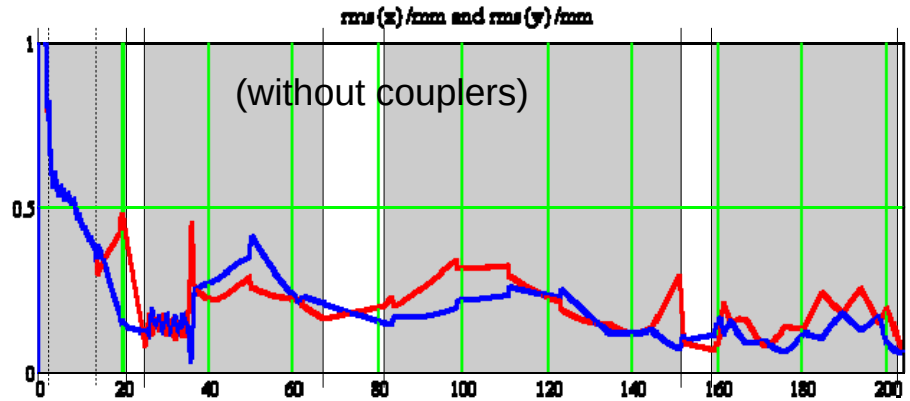
- prepare ASTRA template
- extract particle # 1
- auto phasing (run ASTRA with 1 particle without space charge)
- auto phasing = off; add “auto-phases”+”set-phases”
- run ASTRA with distribution

post processing:

- manage offset and slice-offset
- add wakes

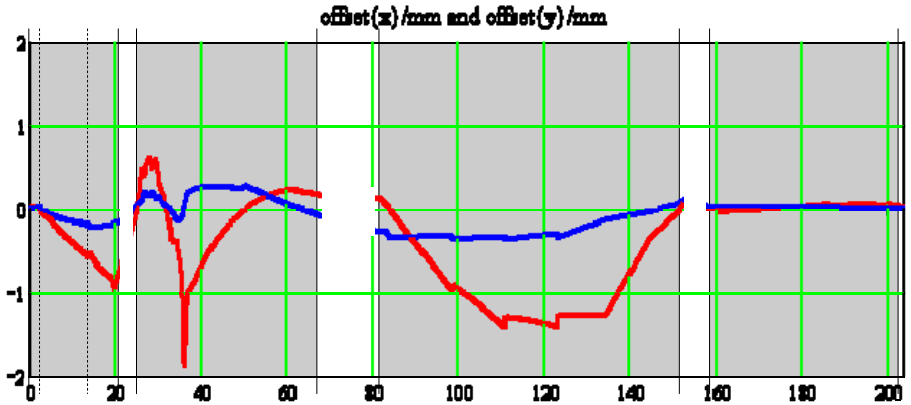
trajectory





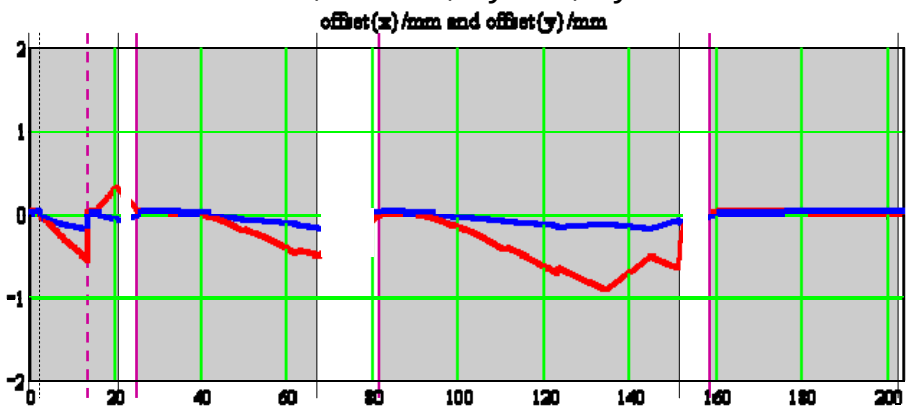
(without couplers)

without corrections



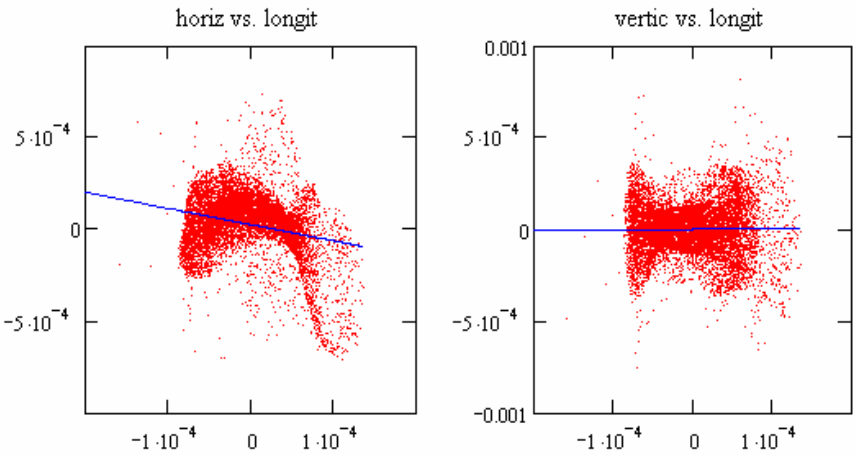
with corrections

<x>=0, <x'>=0, <y>=0, <y'>=0

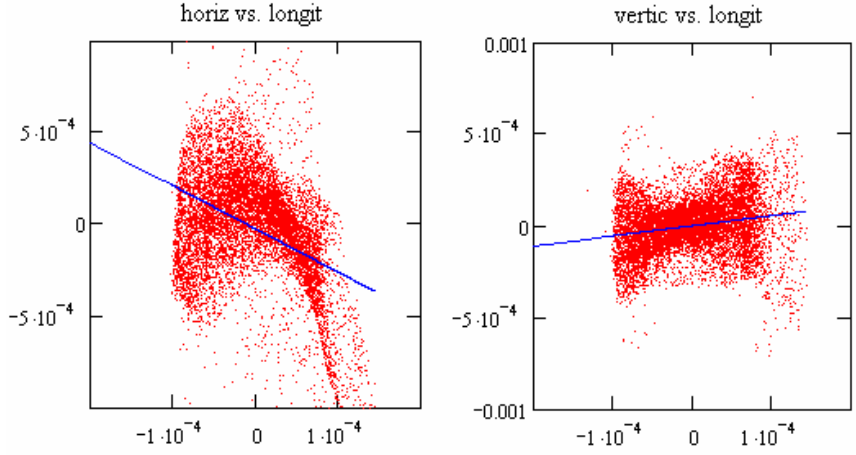


after BC3

NO coupler kick



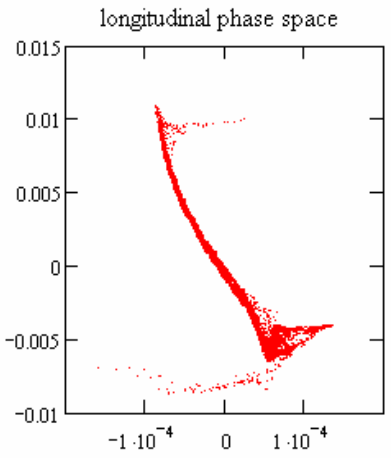
with coupler kick

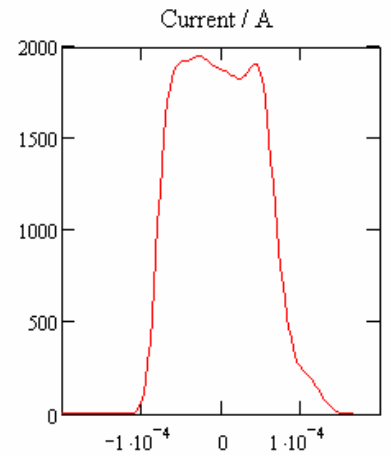


not quite the same plane!

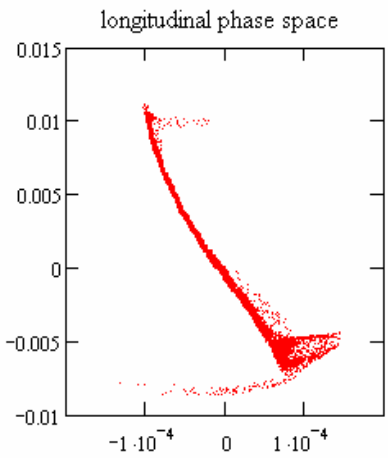
after BC3

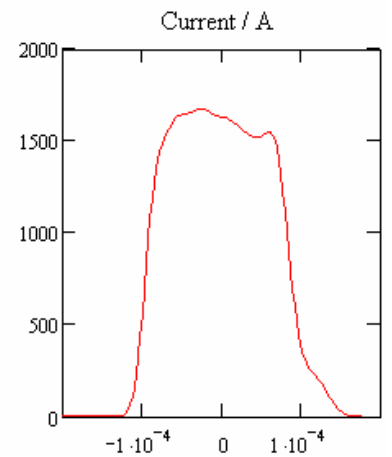
NO coupler kick





with coupler kick





… either modified auto-phasing (ASTRA) or sensitivity to kick

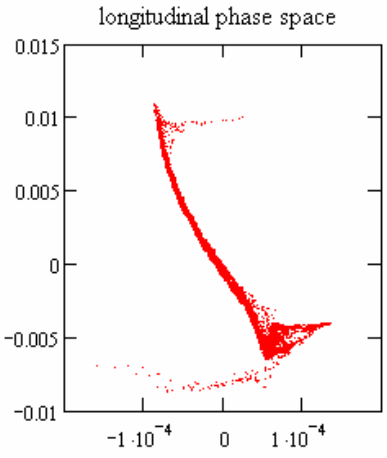
after BC3

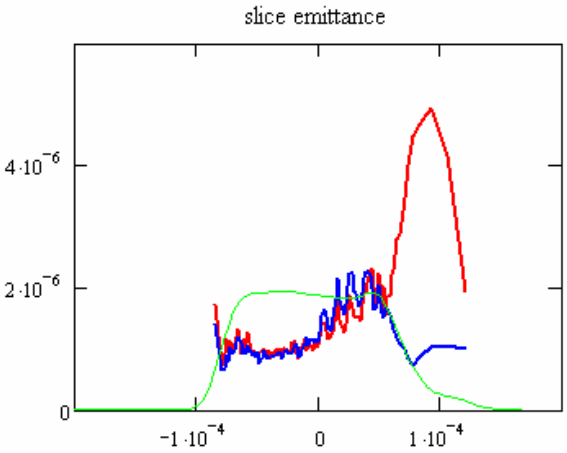
NO coupler kick

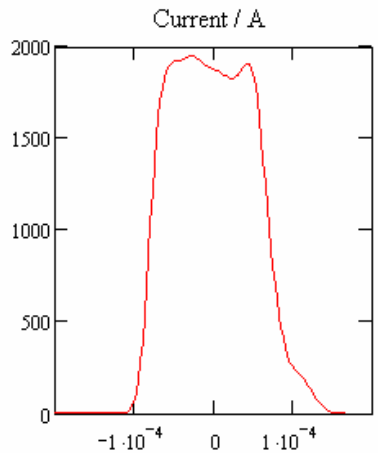
projected emittance

$$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & \gamma_{ref} \end{pmatrix} \cdot \begin{pmatrix} \alpha x \\ \beta x \\ \gamma x \\ \varepsilon x \end{pmatrix} = \begin{pmatrix} -0.072 \\ 6.244 \\ 0.161 \\ 3.752 \times 10^{-6} \end{pmatrix}$$

$$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & \gamma_{ref} \end{pmatrix} \cdot \begin{pmatrix} \alpha y \\ \beta y \\ \gamma y \\ \varepsilon y \end{pmatrix} = \begin{pmatrix} 0.163 \\ 11.249 \\ 0.091 \\ 1.627 \times 10^{-6} \end{pmatrix}$$





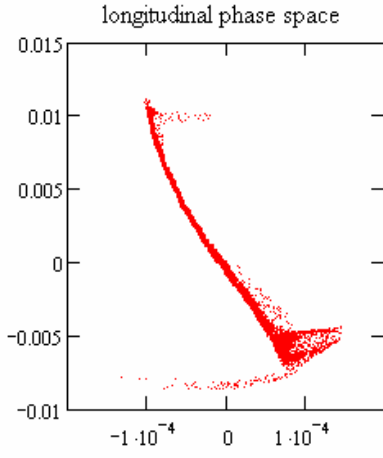


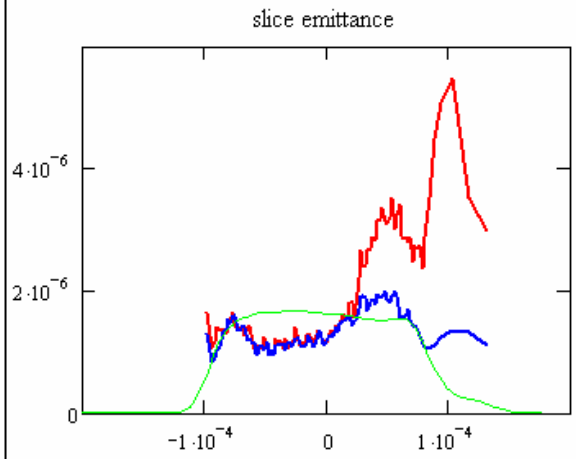
with coupler kick

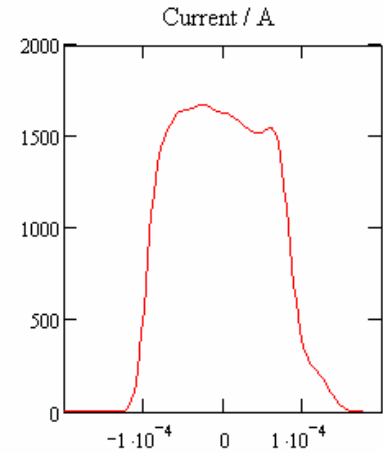
projected emittance

$$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & \gamma_{ref} \end{pmatrix} \cdot \begin{pmatrix} \alpha x \\ \beta x \\ \gamma x \\ \varepsilon x \end{pmatrix} = \begin{pmatrix} -0.829 \\ 16.268 \\ 0.104 \\ 5.868 \times 10^{-6} \end{pmatrix}$$

$$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & \gamma_{ref} \end{pmatrix} \cdot \begin{pmatrix} \alpha y \\ \beta y \\ \gamma y \\ \varepsilon y \end{pmatrix} = \begin{pmatrix} 0.175 \\ 11.338 \\ 0.091 \\ 1.799 \times 10^{-6} \end{pmatrix}$$

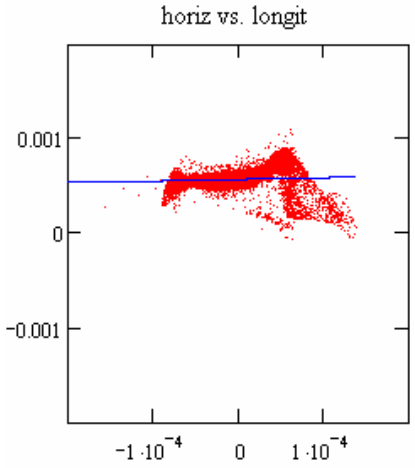


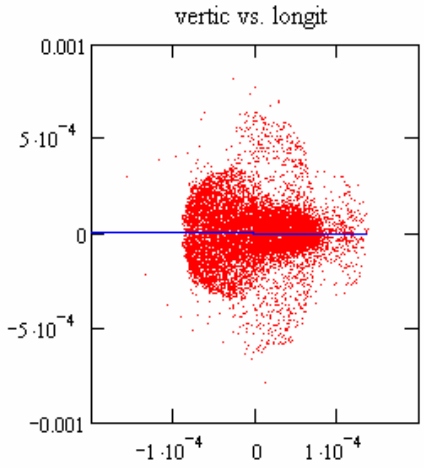


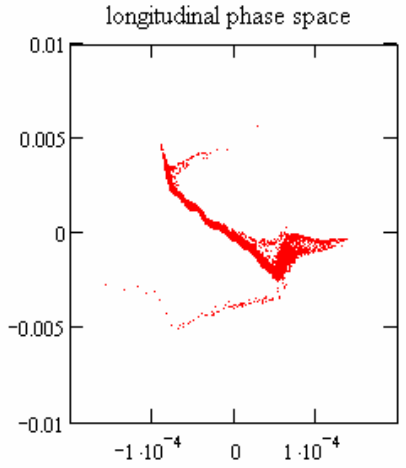


after DOGLEG

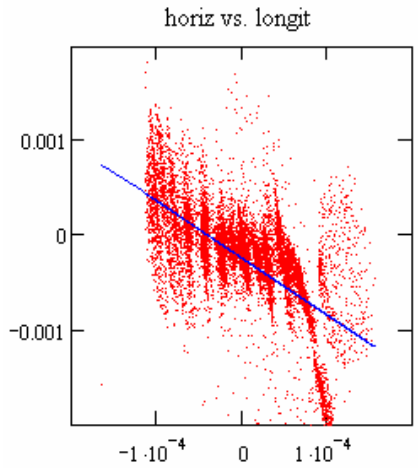
NO coupler kick xav = −0.406 200000 particles

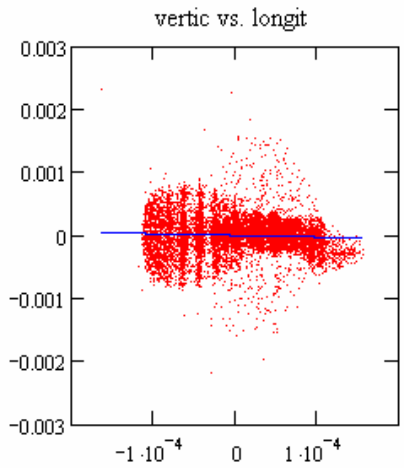


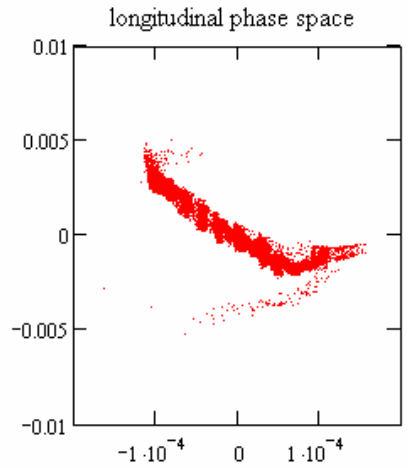




with coupler kick xav = −0.352







20000 particles → numerical μ-bunch instability !

preliminary conclusion

weak differences (slice emittance & long. phase space) after BC2

time dependent part of rf-kick should be negligible after BC2!

differences even in longitudinal phase space after BC3

possible reasons: ASTRA auto phasing;

slightly different reference planes (more additional length after BCs for CSRtrack runs);

real effect

tuning required

rf coupler kick is not quite trivial; system is sensitive !

numerical µ-bunch instability → more particles / other smoothing methods

CPU time → wait / parallel computing / no coupler kicks after BC2 /
other model (f.i. space charge impedance instead of ASTRA)