STUDIES REGARDING SUPER-B LATTICE

N. Monseu

F. Méot

Laboratoire de Physique Subatomique et de Cosmologie, Université Joseph Fourier Grenoble 1, CNRS/IN2P3 , Institut Polytechnique de Grenoble, 53 avenue des martyrs, 38026 Grenoble France

Super-B Workshop, Frascati, 1-4/12/2009

1 Introduction

• This presentation will review the work done last two month, by F. Méot and me, from the beginning of my PhD thesis.

• Our long term goal is to contribute on spin dynamics, and specially on the rotator.

• We first try to understand the main parameters of the lattice, tune, dynamic aperture (on & off momentum), and check results obtained with MAD8 with ray-tracing methods yielding more accurate high order dynamics.

2 LER

2.1 Lattice parameters

• The purpose here is to show that ray-tracing starts from paraxial conditions identical to MAD hypothesis.

• Ray-tracing includes fringe fields in all bends and in solenoids, hard edge otherwise.

LER parameters.

			MAD8	Ray-tracing
Circumference[4]		(m)	1323.018	1323.031[5]
Qx, Qy	obs. at IP		45.53951, 20.56969	[45].5365, [20].5539[2]
	obs. at MDL		*45.54141, 20.56655*	*[45].5390, [20].5616*
Q'x, Q'y	obs. at IP		-6.492674, -7.666569	-6.4672, -15.963
	obs. at MDL		*-6.49278, -7.667717*	*-5.4900, -9.6662*
Max β x, y	obs. at IP	(m)	366.06, 1570.56	
	obs. at MDL		*366.22, 1563.01*	
Max D x, y			0.4853, 0	
$\alpha, \sqrt{1/\alpha}$			0.00042308, 48.6174	0.00042365, 48.5844
Periodic functions at IP :				
$\beta_x,\ \beta_y$		(m)	0.02, 0.002	0.020, 0.0020
$\alpha_x,\ \alpha_y$			∼0, 0	∼0, 0
D_x, D'_x		(m,-)	0, 0	∼0, 0
horiz. closed orbit, $x_{co},\ x'_{co}$		(m, rad)	0, 0	∼0, 0
rms and max. quantities, over circumference :				
horiz. closed orbit[6], $x_{co},\ x'_{co}$	rms, max	(m, rad)	0, 0	$2\,10^{-6}$, $2\,10^{-5}$
vertic. closed orbit[6], $y_{co},\ y'_{co}$	rms, max	(m, rad)	0, 0	$6\,10^{-6}$, $7\,10^{-5}$

[2] Obtained from multiturn Fourier analysis.

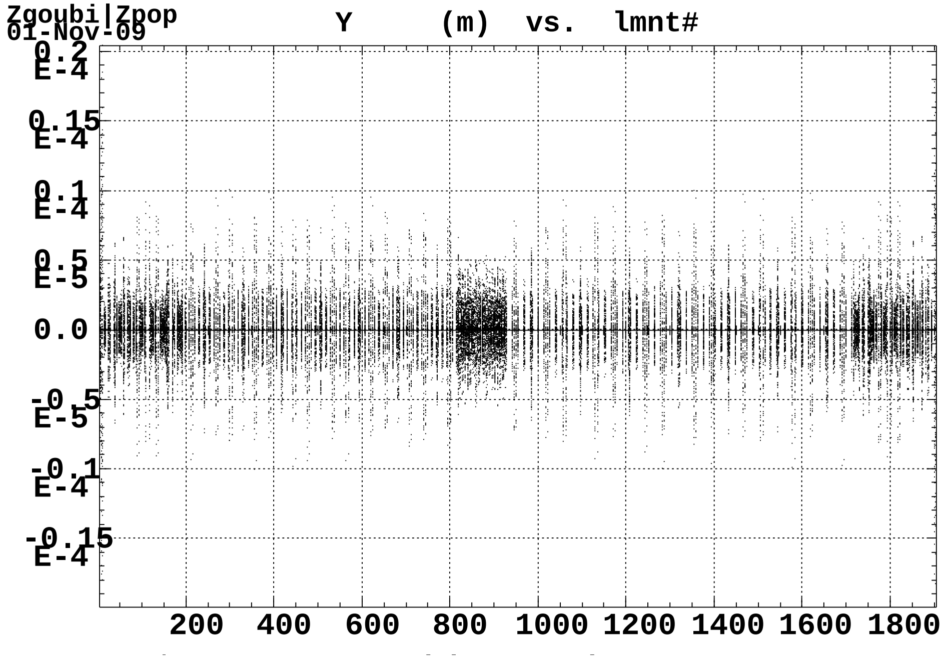
[3] Quasi-zero c.o., induced by dipoles' fringe fields.

[4] The origin of the difference between circumference values remains to be determined.

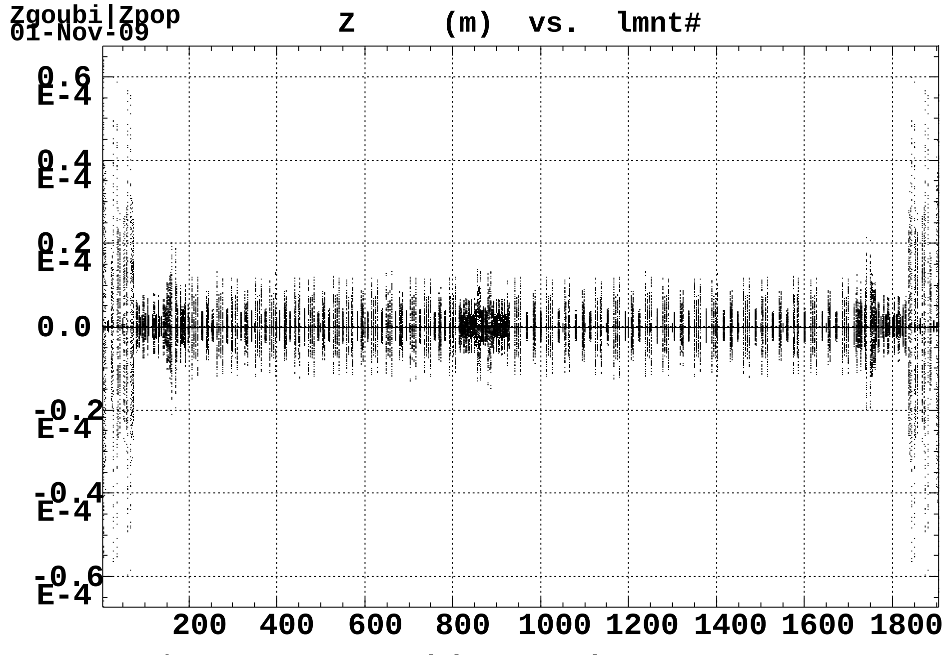
[5] The circumference in the ray-tracing case is the length of the on-momentum closed orbit.

[6] Arising from residual coupling in the solenoids.

Residual closed orbits, H and V



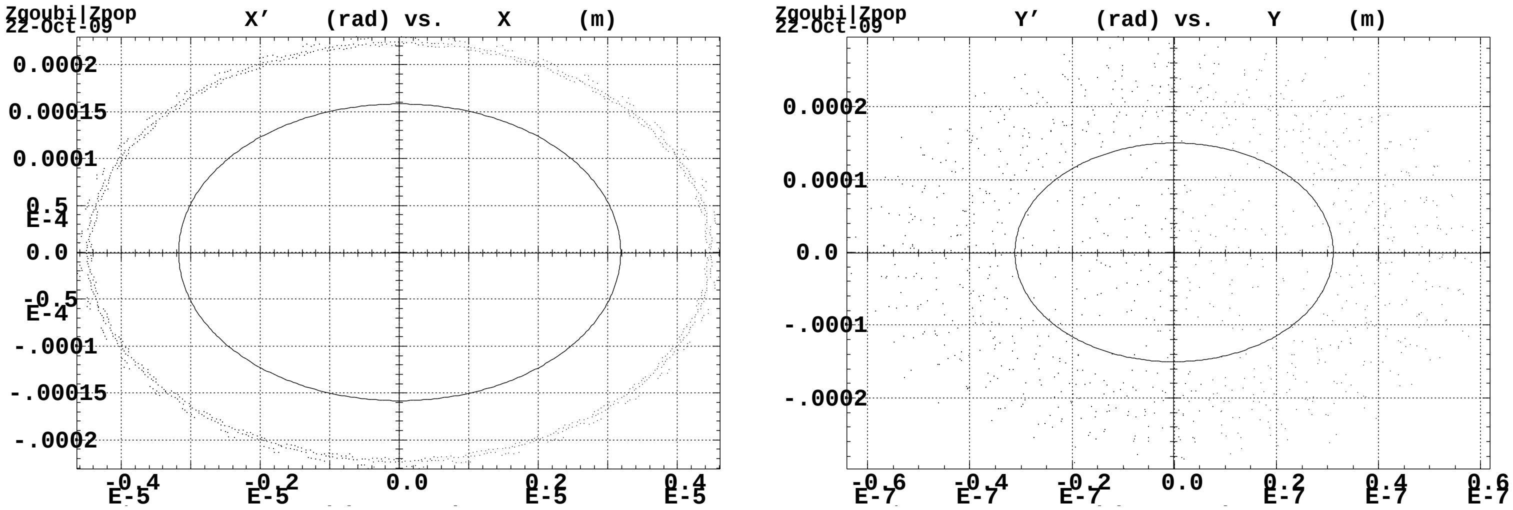
Residual H closed orbit, induced by dipoles’ fringe fields.



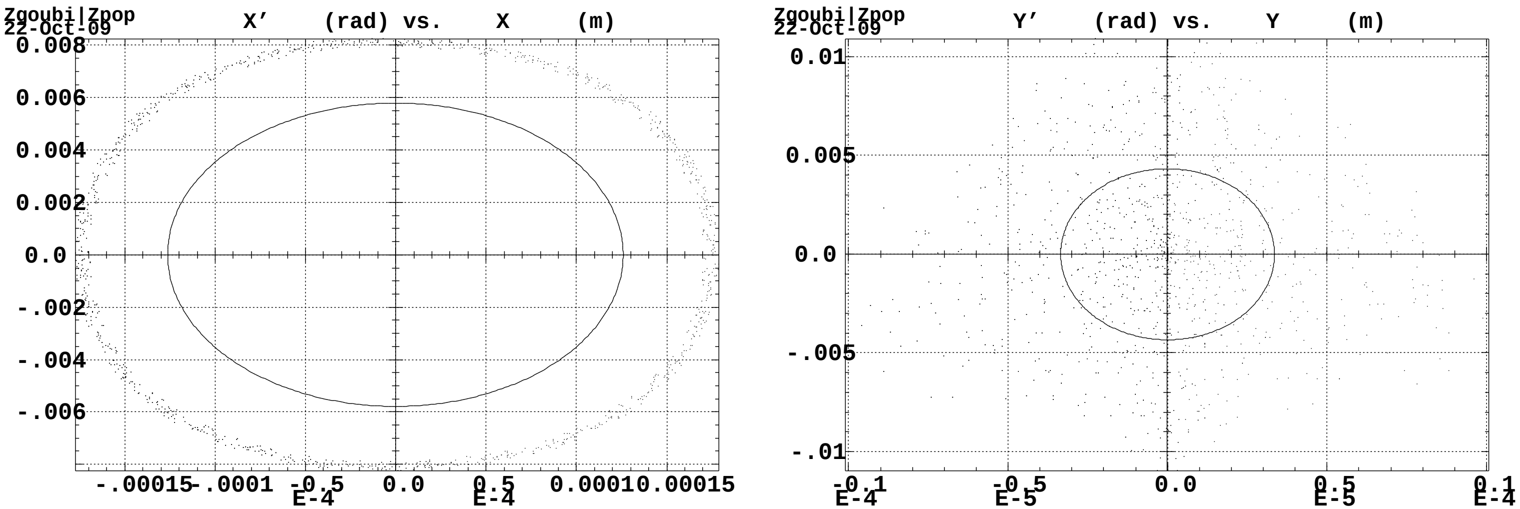
Residual V closed orbit, induced by solenoids.

Residual H and V closed orbits are negligible at IP (<< beam size).

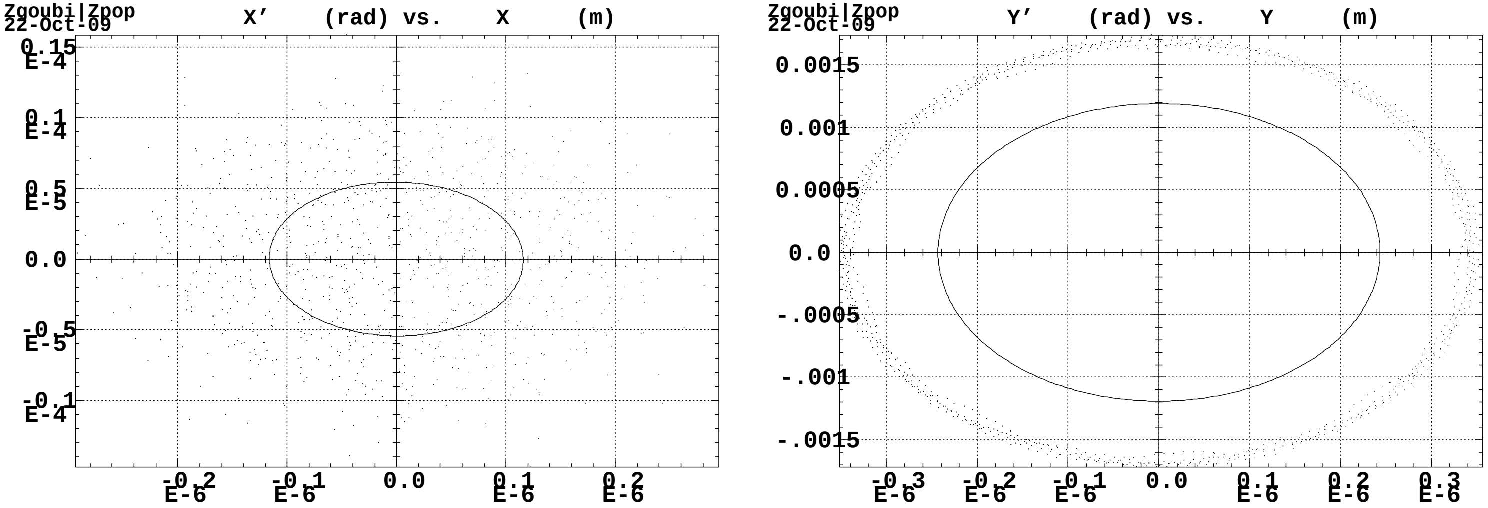
2.2 Typical H and V phase spaces at IP



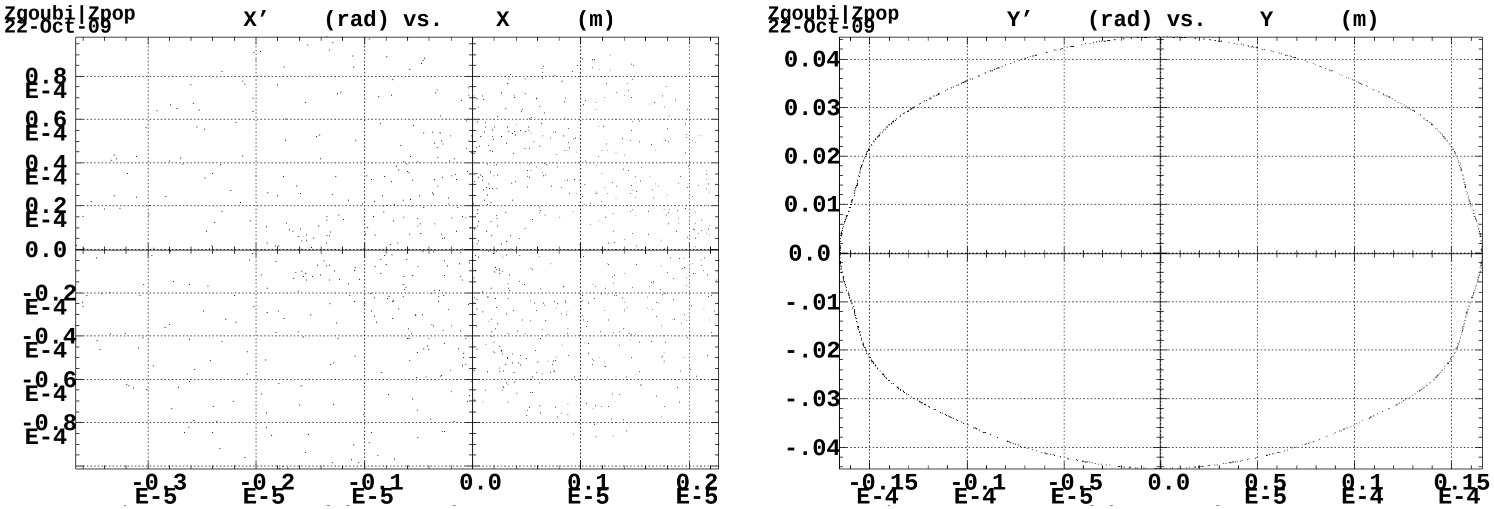
Left : 1000-turn (x, x') phase-space at σ_x ($\epsilon_x/\pi = 10^{-9}$ m.rad) ; right : induced (y, y') motion



Leftt : 1000-turn (x, x') phase-space at 40σ_x ($\epsilon_x/\pi = 1600 \times 10^{-9}$ m.rad) ; right : induced (y, y') motion.



Right : 1000-turn (y, y') phase-space at σ_y ($\epsilon_y/\pi = 0.5\,10^{-9}$ m.rad) ; left : induced (x, x') motion.



Right : 1000-turn (y, y') phase-space at 50σ_y ($\epsilon_y/\pi = 1250 \times 10^{-9}$ m.rad) ; left : induced (x, x') motion.

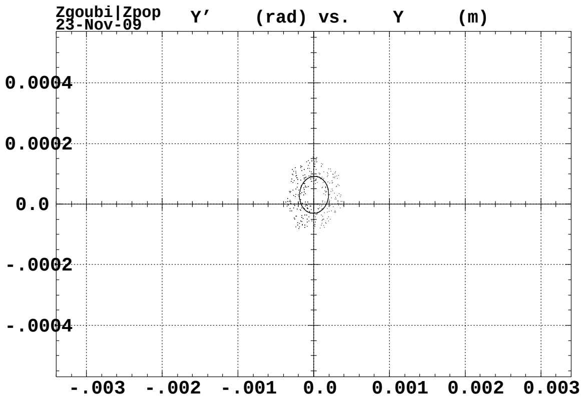
To summarize : residual coupling by solenoids contributes to less than $< 0.1\times$beam size, H & V

2.3 LER Maximum stable amplitudes

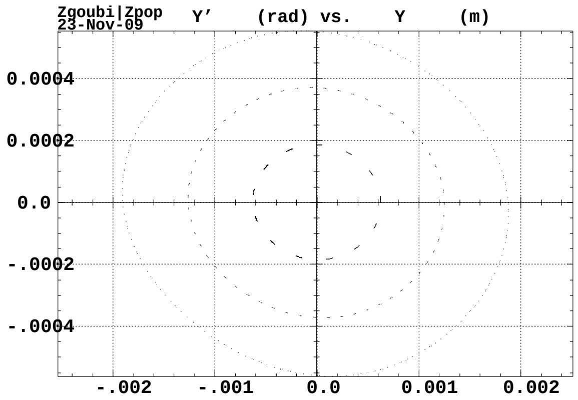
- **Goal : now we are satisfied with starting hypothesis, we produce DAs (and compare with MAD for reference).**

LER Maximum stable H amplitudes at DL

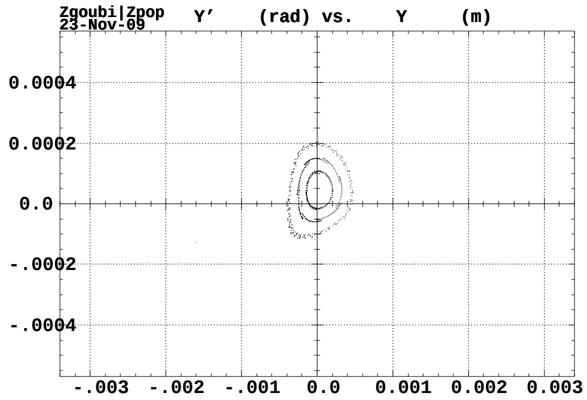
RAY-TRACING



4σ_x

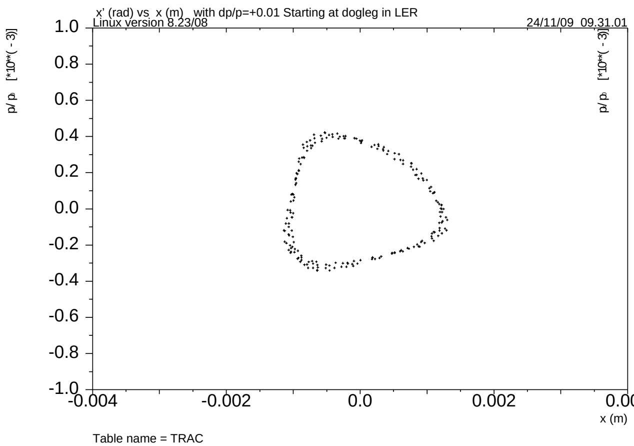


22.7σ_x**,** $\beta_x = 3.40$**,** $\alpha_x = 0.043$

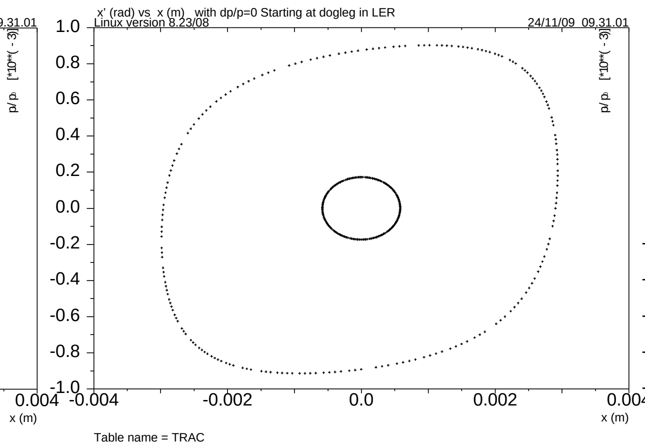


8σ_x

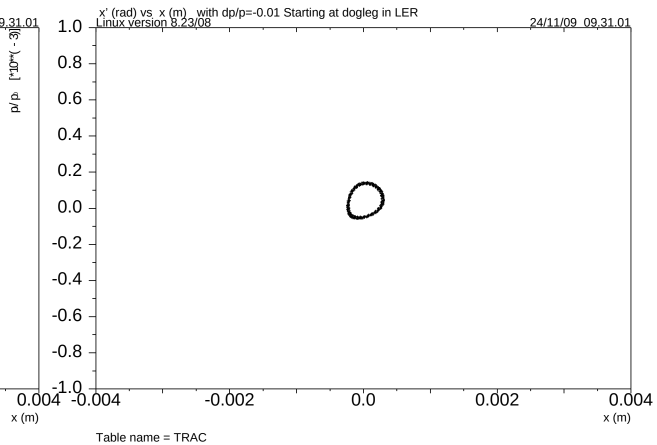
MAD



21σ



50σ

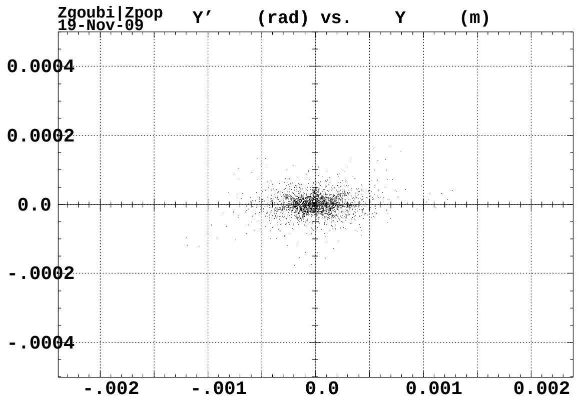


4.5σ

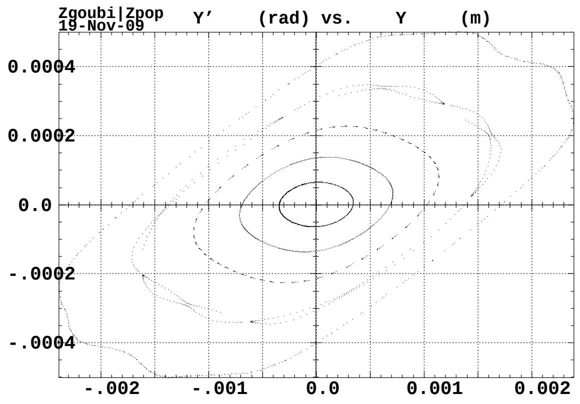
Maximum horizontal stable amplitudes ($x_{max} = n * \sigma_x$ where $\sigma_x = \sqrt{\epsilon_x * \beta_x}$ at DL, taking $\epsilon_x/\pi = 10^{-9}$)
1000-turn for ray tracing, 200-turn for mad ; $dp/p = +1\%,\ 0,\ -1\%$, from left to right.
Test particles are launched at DL and observed at DL.

LER Maximum stable V amplitudes at DL ($1\sigma_y$ taken for $\epsilon_y/\pi = 10^{-9}$)

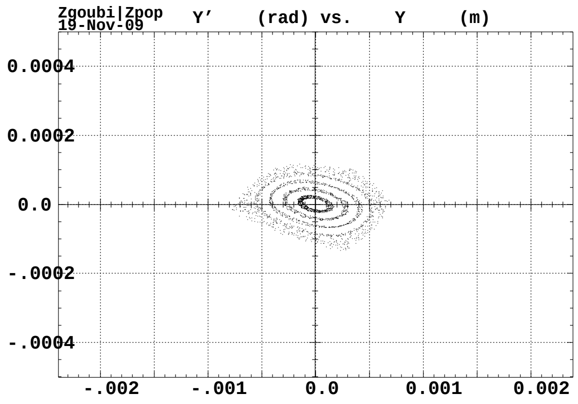
RAY-TRACING



4.7σ_y

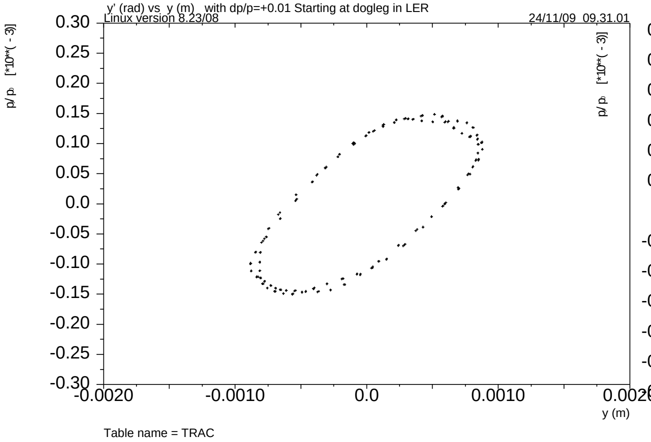


30σ_y**,** $\beta_y = 5.33$**,** $\alpha_y = -0.105$

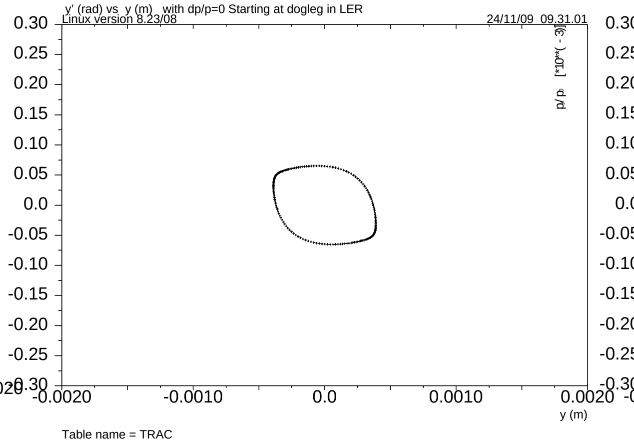


8.4σ_y

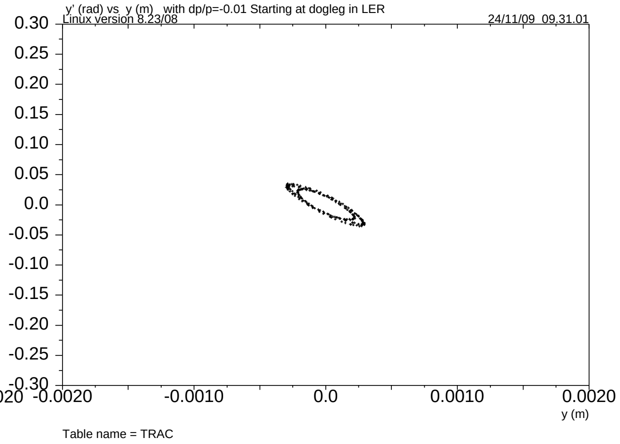
MAD



8σ_y



5σ_y**,** $\beta_y = 5.53$**,** $\alpha_y = +0.047$



1.5σ_y

Maximum vertical stable amplitudes

1000-turn for ray tracing, 200-turn for mad ; $dp/p = +1\%,\ 0,\ -1\%$, from left to right.

Test particles are launched at DL and observed at DL.

2.4 LER Dynamic aperture and momentum de-tuning

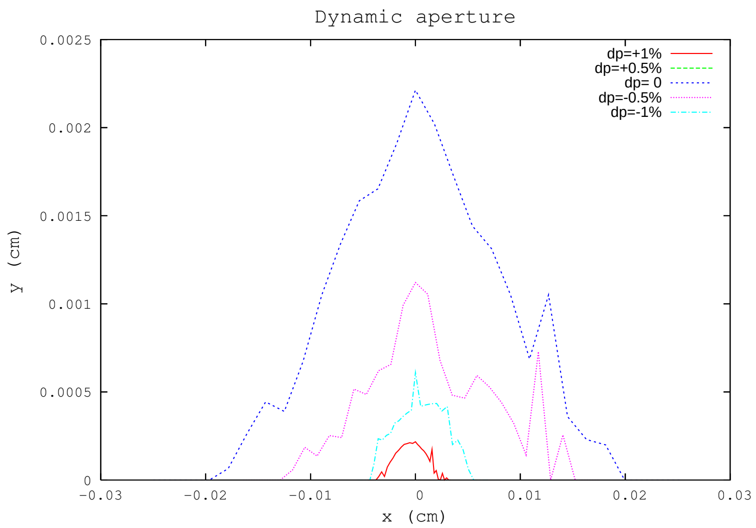


Figure 1: Dynamic aperture observed at IP.

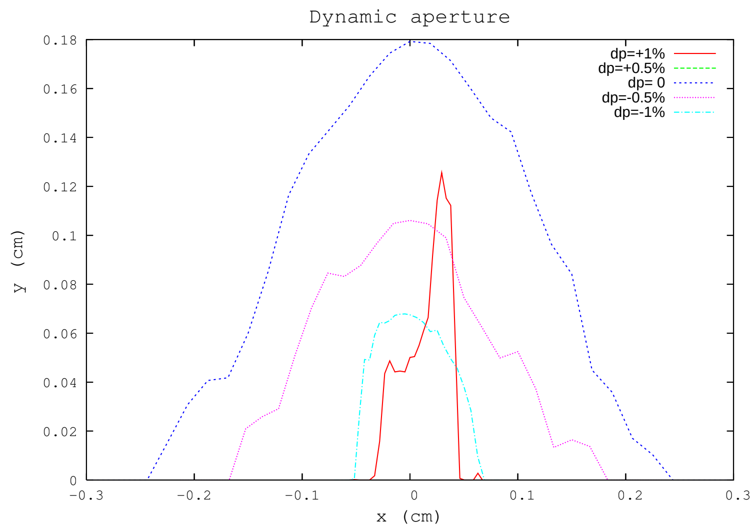


Figure 2: Dynamic aperture observed at DL.

Particles in the region $1.007 \leq dp/p \leq 1.004$ **are lost, whatever** z_0**.**

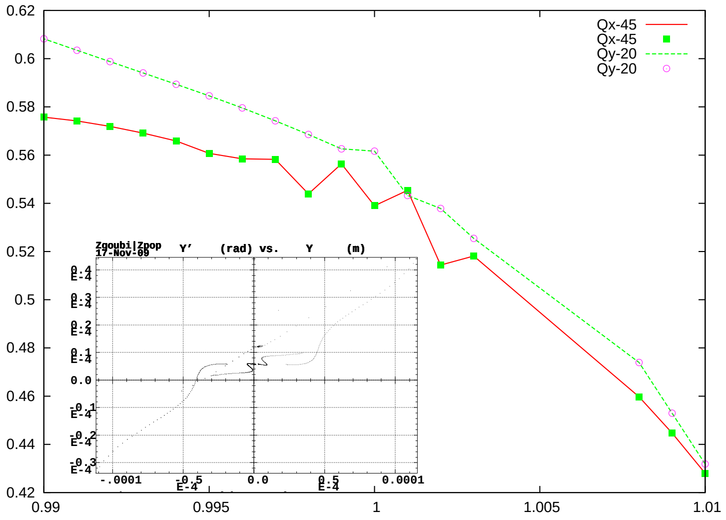


Figure 3: momentum detuning.

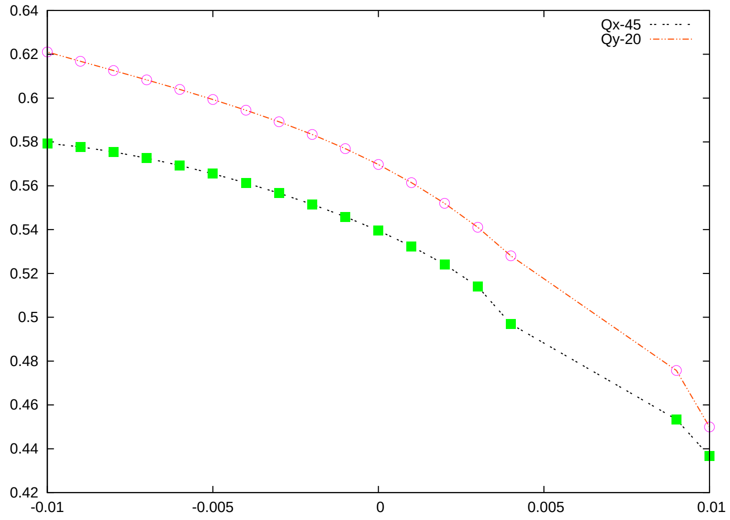


Figure 4: from MAD

2.5 Checking spin behavior

Single turn, IP to IP

Spin components of five particles at $dp/p = 0, \pm 0.5\%, \pm 1\%$, observed at IP, after a full turn, starting pure $\vec{S}_X$ (longitudinal).

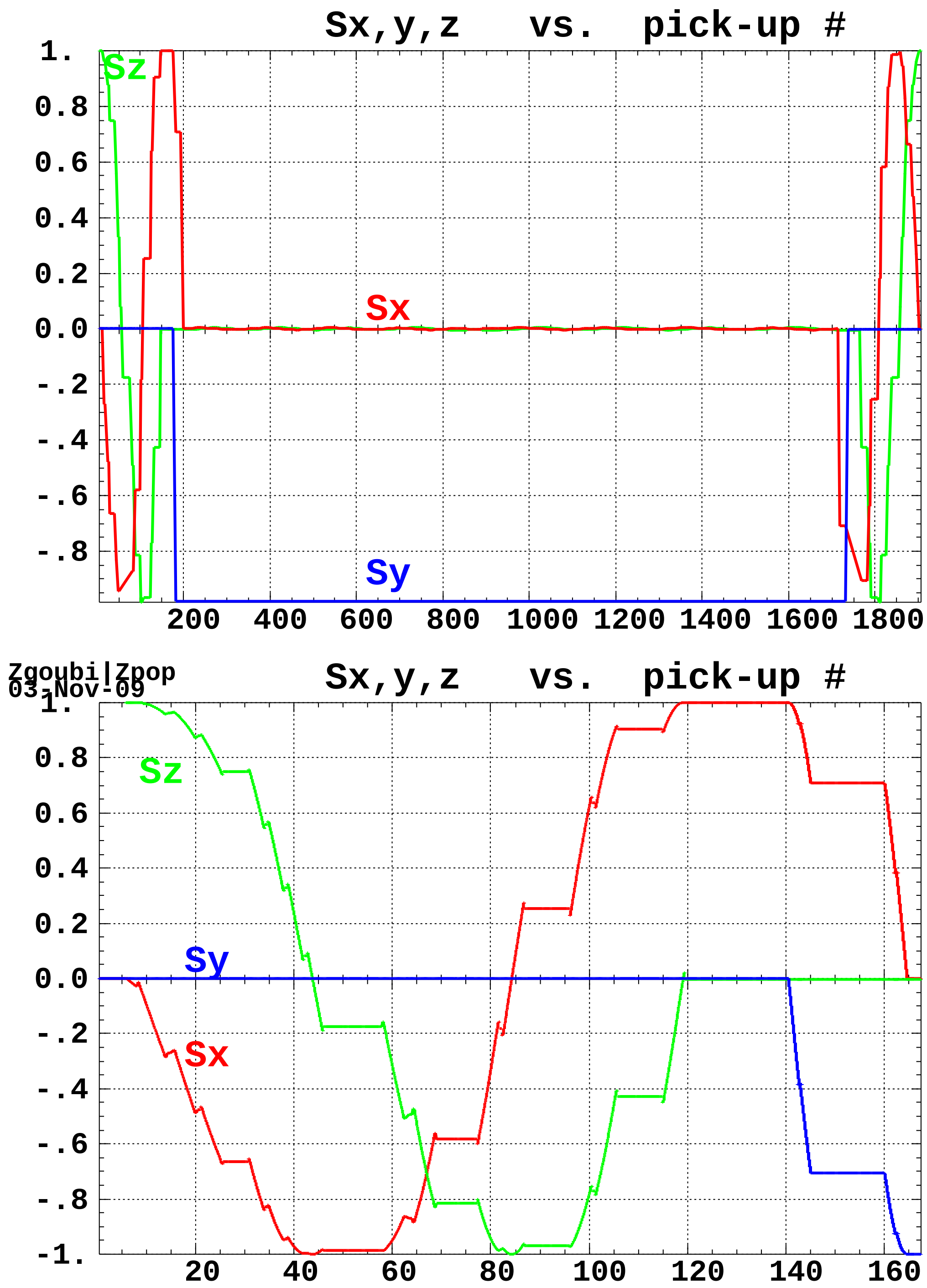
		INITIAL				FINAL				
		SX	SY	SZ	S	SX	SY	SZ	S	GAMMA
p	1	1.0000	0.0000	0.0000	1.0000	0.9999	0.0022	-0.0152	1.0000	8262.849
o	1	1.0000	0.0000	0.0000	1.0000	0.9999	0.0012	-0.0130	1.0000	8221.944
o	1	1.0000	0.0000	0.0000	1.0000	1.0000	-0.0000	-0.0006	1.0000	8181.039
m	1	1.0000	0.0000	0.0000	1.0000	0.9997	0.0039	0.0230	1.0000	8140.133
m	1	1.0000	0.0000	0.0000	1.0000	0.9983	0.0168	0.0561	1.0000	8099.228

Matching spin orbit vector $\vec{n}$ at IP

We consider the on-momentum, zero-closed orbit particle. Initial components of $\vec{S}$ at IP (the fit variables) are varied so to get (constraints :) identical components after a turn, and $|S| = 1$.

```
Xi2 =         8.69910E-18

 STATUS OF VARIABLES  (Iteration #    29)
 LMNT  VAR  PARAM  MINIMUM     INITIAL         FINAL          MAXIMUM      STEP
    3   Sx     10   0.891        1.00       0.9999999389       1.09      8.699E-16
    3   Sy     11  -0.100       7.826E-08   7.8264406325E-08  0.300      1.311E-15
    3   Sz     12  -0.100      -3.410E-04  -3.4099938123E-04  0.300      1.311E-15
 STATUS OF CONSTRAINTS
  TYPE     I   J  LMNT#      DESIRED    WEIGHT       REACHED         KI2         *  Parameter(s)
 Sx-Sx_0   1   1  1909      0.0000000   1.0000    2.9494193E-09   1.0000E+00     *  0 :
 Sy-Sy_0   1   2  1909      0.0000000   1.0000    1.1601682E-12   1.5473E-07     *  0 :
 Sz-Sz_0   1   3  1909      0.0000000   1.0000    4.1513054E-12   1.9810E-06     *  0 :
   |S|     1   4  1909      1.0000000   2.0000    1.0000000E+00   5.6768E-07     *  0 :
```



Components of the $\vec{n}$ vector over a turn and in the rotator.

Static behavior

S_X **(longitudinal) is recorded at IP over a few hundred turns. Nine particles with** $dp/p = 0, \pm 0.01,\ step \pm 0.02$ **(apart from particles with** $p/p_0 = 1.004,\ 1.006$ **which are not stable, see Sec. ??), and with** $\epsilon_y > 10^{-9}$ **nm (Fig. 5).rad are launched. Results in Fig. 6, no intrinsic resonance effects are observed.**

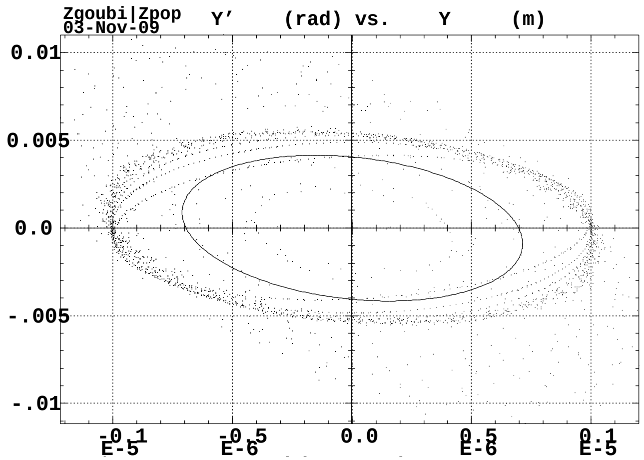


Figure 5: Vertical invariant at IP of nine particles launched for search of possible intrinsic resonance effects.

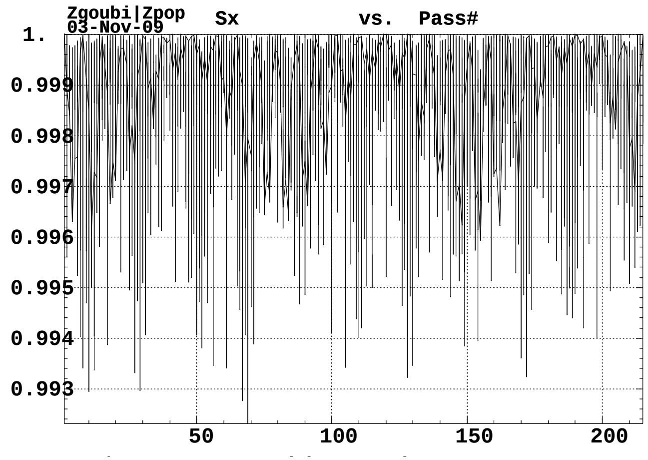


Figure 6: Longitudinal spin component at IP for the nine particles with $dp/p = 0, \pm 0.002, -0.004, -0.006, \pm 0.008, \pm 0.01$.

3 HER

3.1 lattice parameter

Table 1: HER parameters.

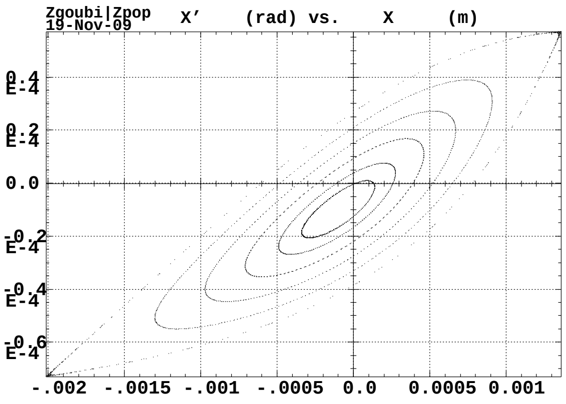
			MAD8	Ray-tracing[1]
Circumference[4]		(m)	1322.949337	1323.03[5]
Qx, Qy	obs. at IP *obs. at MDL*		45.53912, 20.57044 *45.53996, 20.56999*	[45].54350, [20].57357[2] *[45]54350, [20].57342*
Q’x, Q’y	obs. at IP *obs. at MDL*		-5.7722, -30.6157 *-5.7671, -30.8482*	-5.8311, -32.2510 *-5.8311, -32.2579*
Max β x, y	obs. at IP *obs. at MDL*	(m)	364.1857, 1525.0676	
Max D x, y		(m)	0.5983, 0	
α, $\sqrt{1/\alpha}$			0.00040590, 49.6355	0.00038548, 50.9330
Periodic functions at IP :				
$\beta_x, \ \beta_y$		(m)	0.02, 0.002	0.020, 0.0020
$\alpha_x, \ \alpha_y$			$\sim$0, 0	$\sim$0, 0
D_x, D'_x		(m,-)	0, 0	$\sim$0, 0
horiz. closed orbit, $x_{co}, \ x'_{co}$		(m, rad)	0, 0	$\sim$0, 0

(5) The circumference in the ray-tracing case is the length of the on-momentum closed orbit.

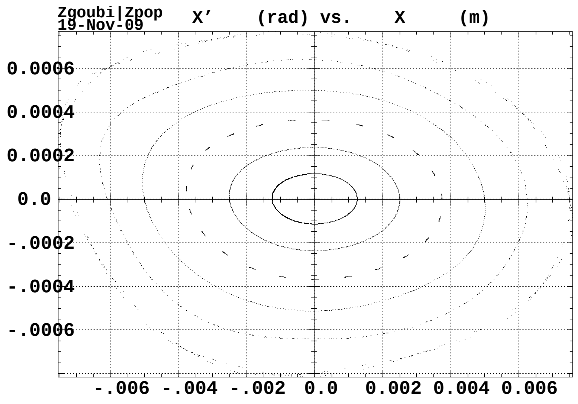
3.2 HER Maximum stable amplitudes

HER Maximum stable H amplitudes at DL

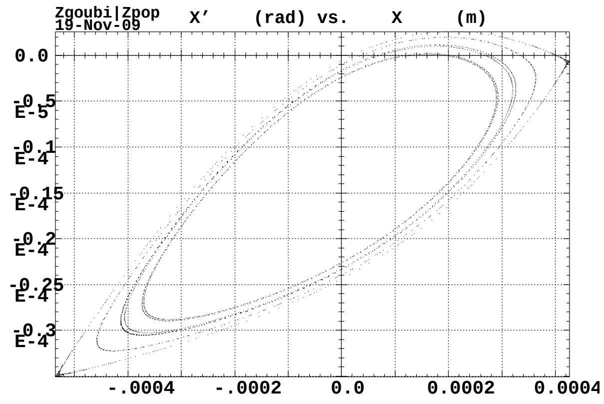
RAY-TRACING



$\mathbf{6.5}\sigma_x$

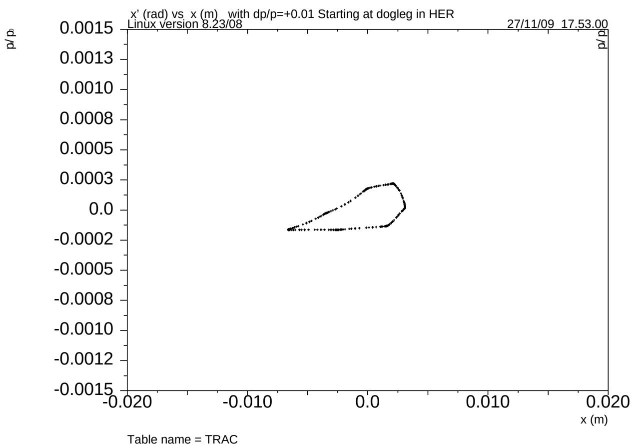


$\mathbf{25}\sigma_x$

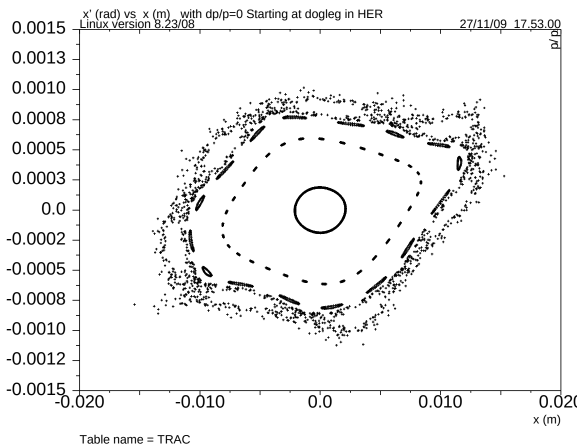


$\mathbf{2}\sigma_x$

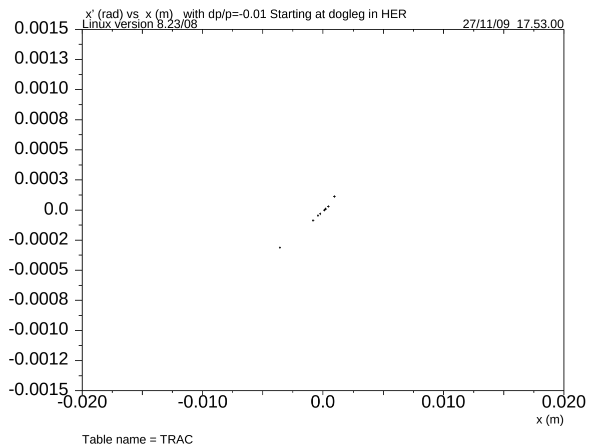
MAD



$\mathbf{28}\sigma_x$**,**
$\beta_x = 34.688, \alpha_x = -1.230$



$\mathbf{112}\sigma_x$**,**
$\beta_x = 11.013, \alpha_x = 0$

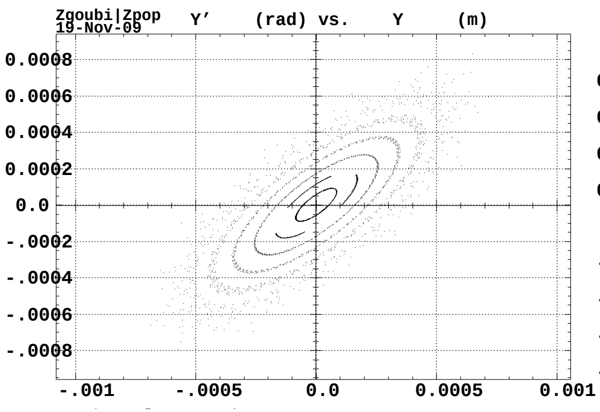


$\mathbf{0}\sigma_x$**,**
$\beta_x = 32.351, \alpha_x = -1.054$

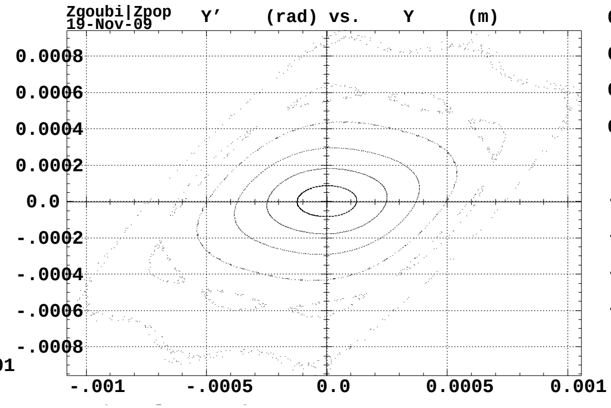
Maximum horizontal stable amplitudes
1000-turn for ray tracing, 200-turn for mad ; $dp/p = +1\%,\ 0,\ -1\%$, from left to right.
Test particles are launched at DL and observed at DL.

HER Maximum stable V amplitudes at DL

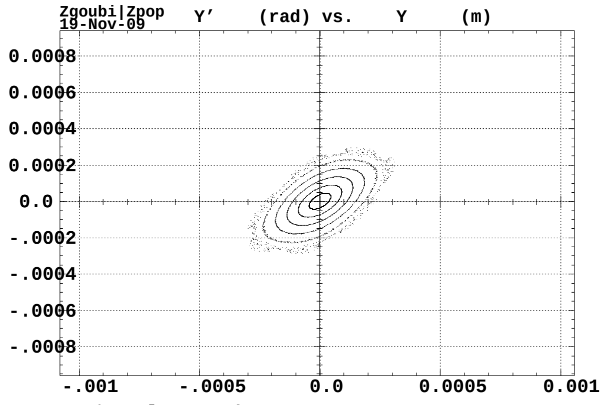
RAY-TRACING



$20\sigma_y$



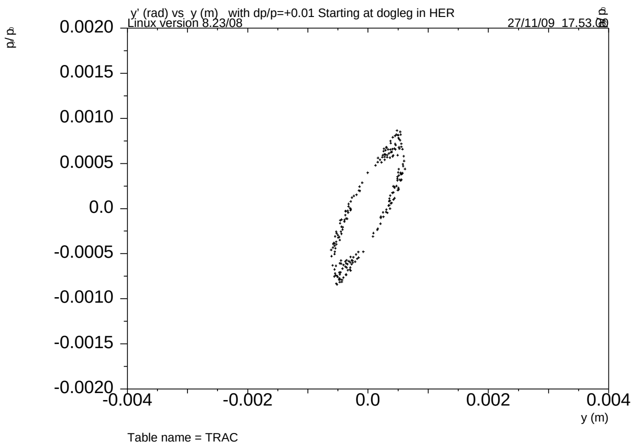
$30\sigma_y$



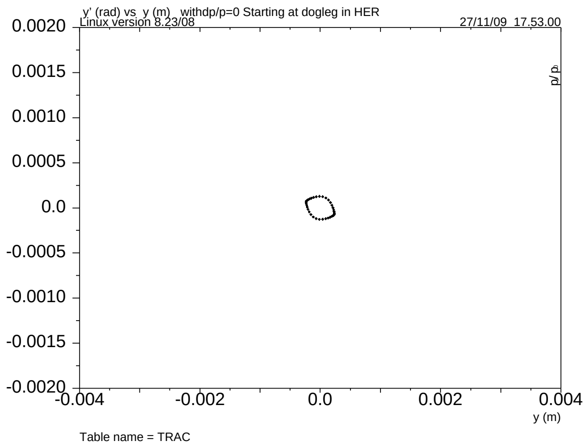
$6\sigma_y$ dp/p=-0.5%

(dp/p=-1% has 0 DA)

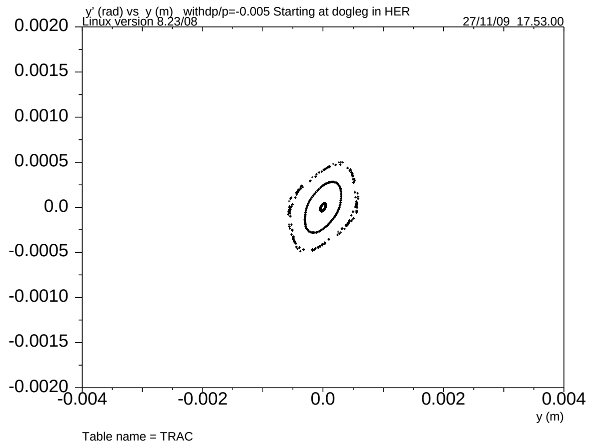
MAD



$9.5\sigma_y$



$5.5\sigma_y$



$14.5\sigma_y$

Maximum vertical stable amplitudes

1000-turn for ray tracing, 200-turn for mad ; $dp/p = +1\%,\ 0,\ -1\%$, from left to right.

Test particles are launched at DL and observed at DL.

3.3 HER Dynamic aperture and momentum de-tuning

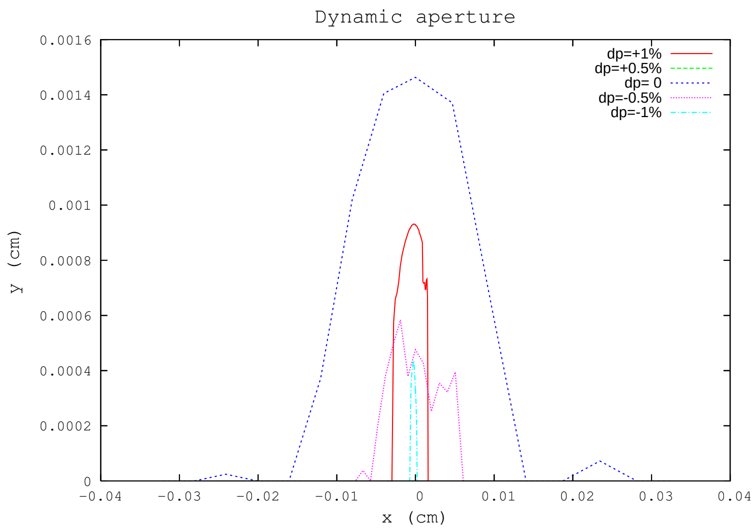


Figure 7: Dynamic aperture observed at IP.

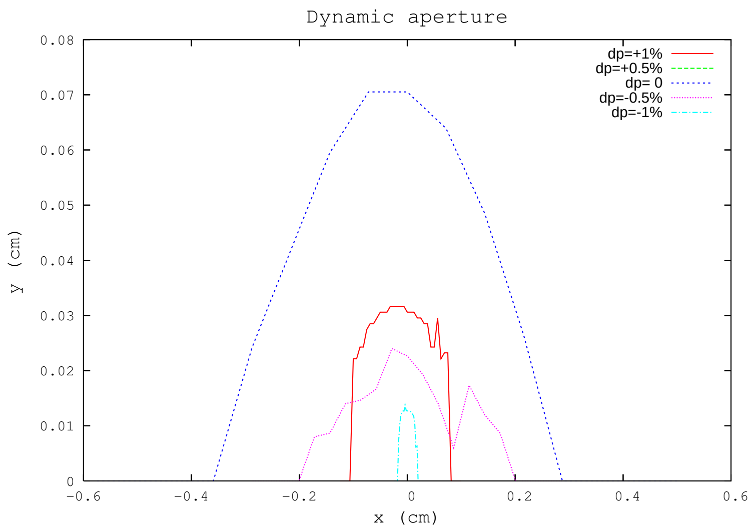


Figure 8: Dynamic aperture observed at DL.

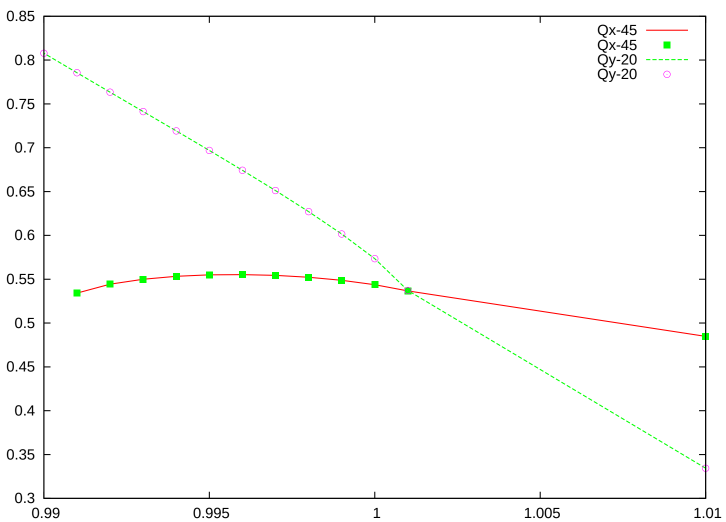


Figure 9: Tunes vs. momentum obtained with Zgoubi.

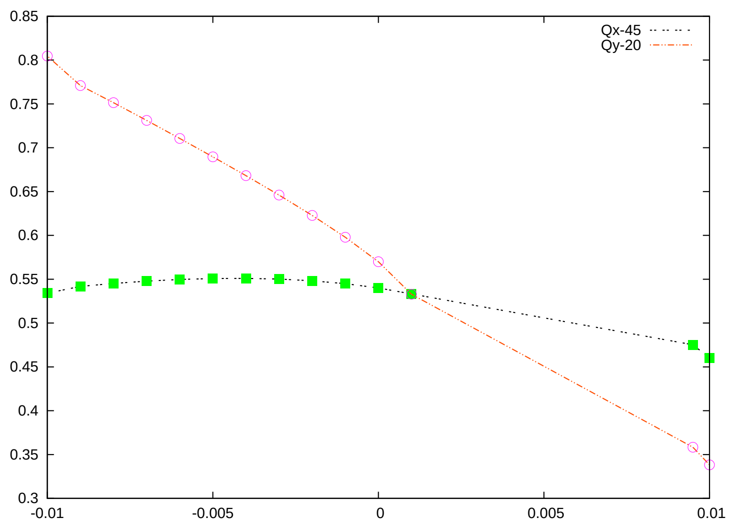


Figure 10: Tunes vs. momentum obtained with MAD.

Thank you for your attention