Short report on « 4WS emittance study » in the extraction line of ATF performed during the 6th december 2007 shift.

(Draft version)

J. Brossard, C. Rimbault.

I : Damping correction and emittance measurement

The first step was to perform DR orbit, dispersion and coupling correction. After this step, the vertical emittance has been measured using the SOR detector (place at location where theoretically the dispersion is zero : see Figure 1).

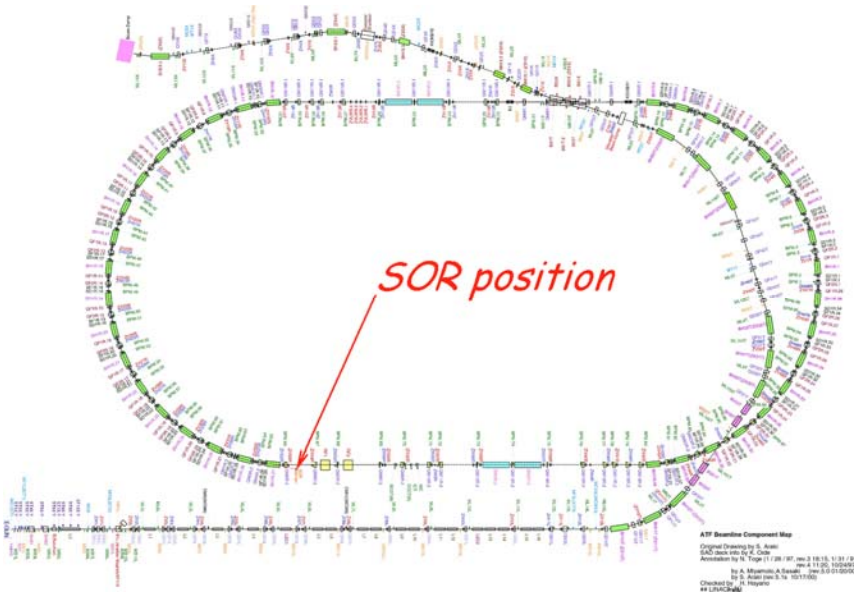

Figure 1 : ATF top view, and position of SOR.

The SOR vertical beam size is 12.43*1.2 =14.9 μm (1.2 is a correcting factor).
The beam shape at SOR location is tilted (see Figure 2).

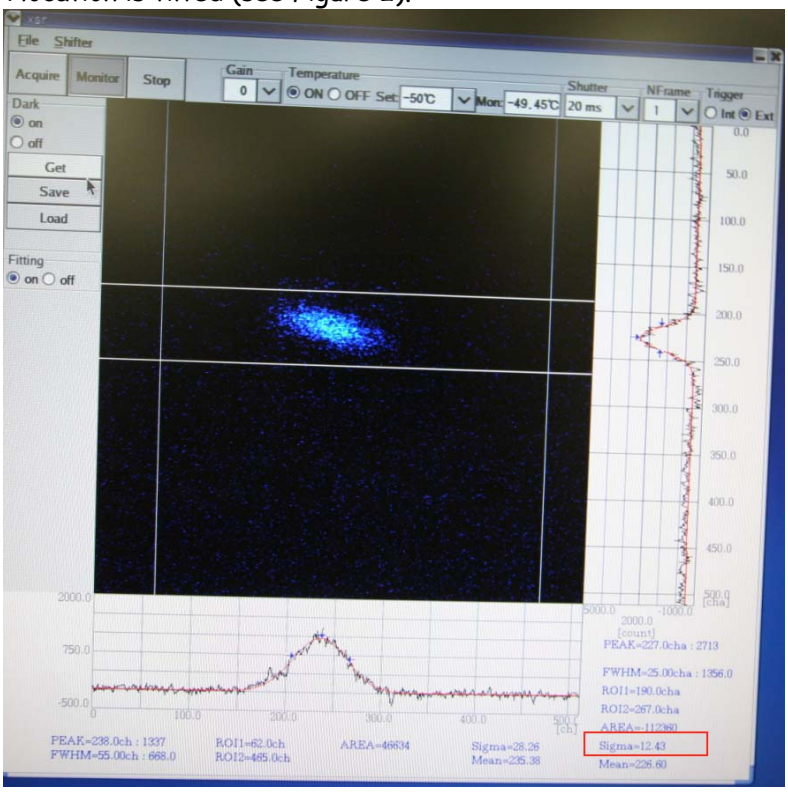

Figure 2 : Beam shape at OSR position in DR.

The x and y beta functions has been measured at SOR position. The results are : β_x= 0.39 m and β_y=3.09 m (see Figure 3).

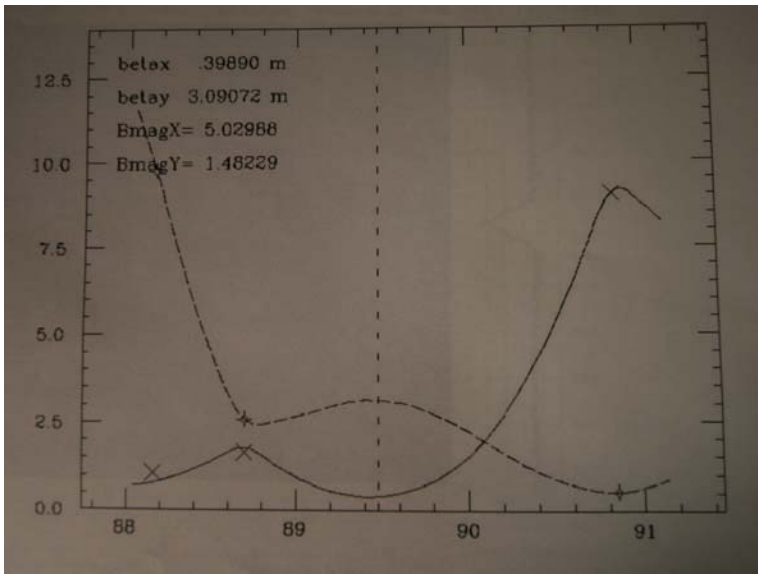

Figure 3 : Beta function measured at OSR position in DR.

With such data, the vertical emittance in the DR is estimated to be : 72 pm.rad.
(The nominal value is 20 pm.rad).

II : Extraction line correction and emittance measurement

After SOR measurement, we performed orbit and dispersion correction in the extraction line. The dispersion measurement gives :

	dispersion x (mm)	error	error (%)
MW0X	-31.9	1.34	-4.2
MW1X	10.5	0.52	5.0
MW2X	33.5	0.8	2.4
MW3X	63.1	1.6	2.5

	dispersion y (mm)	error	error (%)
MW0X	58.7	7.21	12.3
MW1X	-0.7	5.35	-764.3
MW2X	-26.6	8.94	-33.6
MW3X	-50.6	9.96	-19.7

Then, the status (magnet current values) of the machine has been stored in SET07DEC6_1638.dat file[1] and beam size measurement at wire scanner position started. The x, y and +10° beam size are shown in Figure 4 for all wire scanner station. From the first wire scanner station measurement, a rough estimation of the order of magnitude of the relative error level on beam size measurement can be estimate to reach 6%. The diameter of the wire scanner used are : 50 μm for x and 10° beam size measurement and 10 μm for y.

	MW0X	Meas 1	Meas 2	Meas 3	mean	rms	rms (in % of mean)
MW0X07DEC06_1833.dat	sig y	55.9	58.9	58.5	57.8	1.6	2.8
	sig x	132.4	146	131.9	136.8	8.0	5.8
	+10°	44.5	43.9	41.3	43.2	1.7	3.9
	-10°	77.9					

	MW2X	Meas 1
MW2X07DEC06_1905.dat	sig y	106.6
	sig x	66.4
	+10°	109.4

	MW1X	Meas 1
MW1X07DEC06_1852.dat	sig y	58.6
MW1X07DEC06_1923.dat	sig x	71.2
MW1X07DEC06_1852.dat	+10°	64.1

	MW3X	Meas 1
MW3X07DEC06_1919.dat	sig y	118.8
	sig x	109.8
	+10°	125

Figure 4 : Beam size (in μm) measurement done at 4 extraction line wire scanner station (and corresponding files).

[1] All the files (*.dat) could be download from atfcc0.kek.jp server using correct login and password (at present time only from KEK site).

For time reason, only one measurement at MW1X, MW2X and MW3X wire scanner station was taken. Some error level is given on the screen of the ATF control room (see Figure 5). At present time, we do not know the signification of this information. Each point of the red curve of Figure 5 is given for one single bunch (Naverage parameter equal 1).

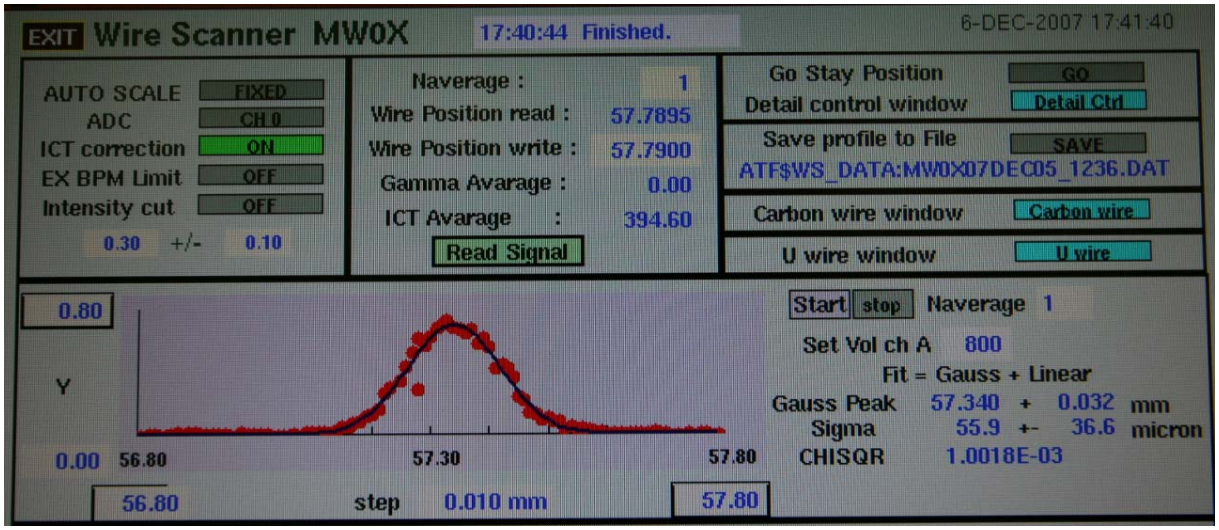

Figure 5 : Example of beam size measurement using wire scanner (MW0X, y beam size).

The dispersion was measured in the extraction line (see Figure 6).

	dispersion x (mm)	error	error (%)	dispersion y (mm)	error	error (%)
MW0X	-31.9	1.34	-4.2	58.7	7.21	12.3
MW1X	10.5	0.52	5.0	-0.7	5.35	-764.3
MW2X	33.5	0.8	2.4	-26.6	8.94	-33.6
MW3X	63.1	1.6	2.5	-50.6	9.96	-19.7

Figure 6 : Measured dispersion at wire scanner position.

Using these x and y dispersion and beam size measurement at the 4 wire scanner position, the 2d-emittance has been reconstructed using 2 different codes (assuming an energy spread of 8.10^{-4}). The internal ATF one (see Figure 7 for the emittance and Figure 8 for beam size fit in extraction line), and the one we presented during ATF preparatory shift meeting (in LAL). In this emittance estimation, the dispersion has been subtracted to the real beam size and the resolution of the wire scanner has been taken into account.

Extraction line "ATF" : $\varepsilon_y = 3.3.10^{-20}$ m.rad = $3.3.10^{-8}$ nm.rad
Extraction line "LAL" : $\varepsilon_y = 1.9.10^{-10}$ m.rad = 0.19 nm.rad = 190 pm.rad.

Using 3 wire scanner instead of 4, gives :

MW0X + MW1X + MW2X : 210 pm.rad
MW0X + MW1X + MW3X : complex emittance
MW0X + MW2X + MW3X : complex emittance
MW1X +MW2X + MW3X : complex emittance

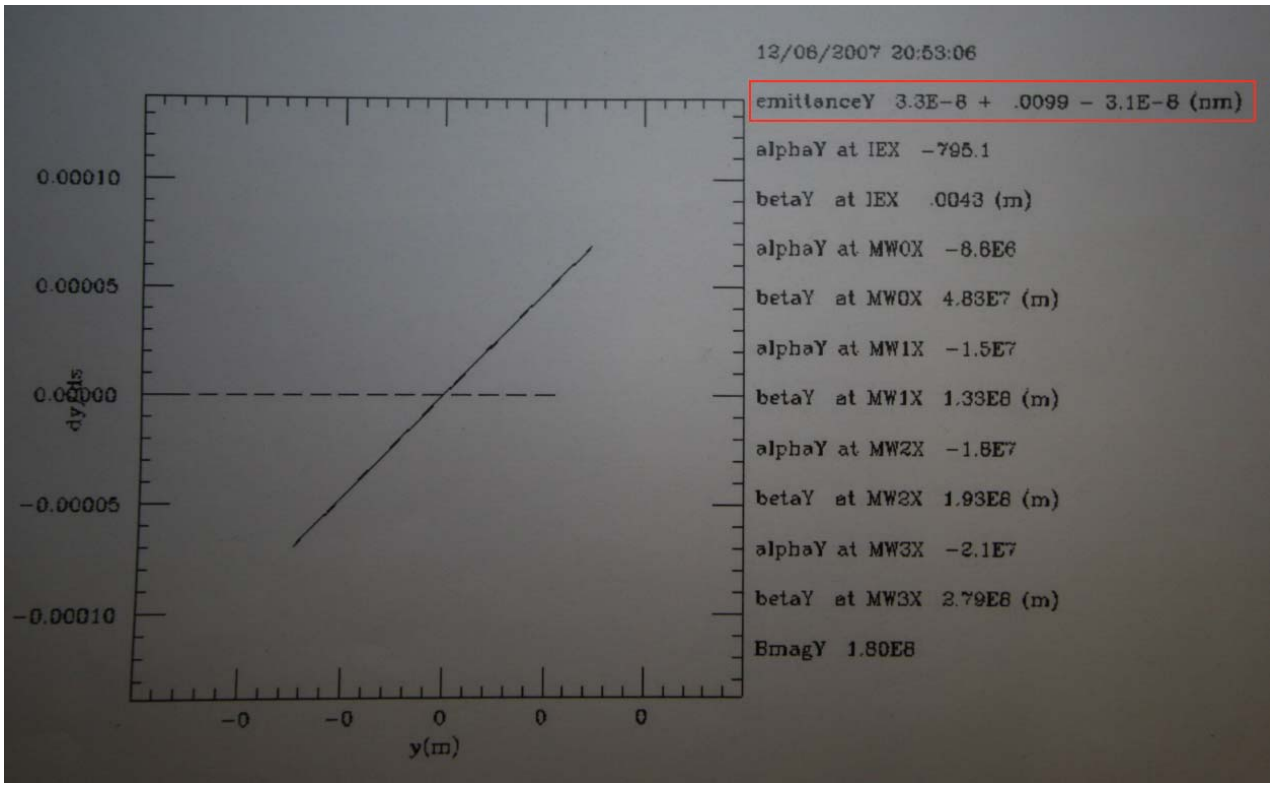

Figure 7 : Internal ATF emittance reconstruction outpout.

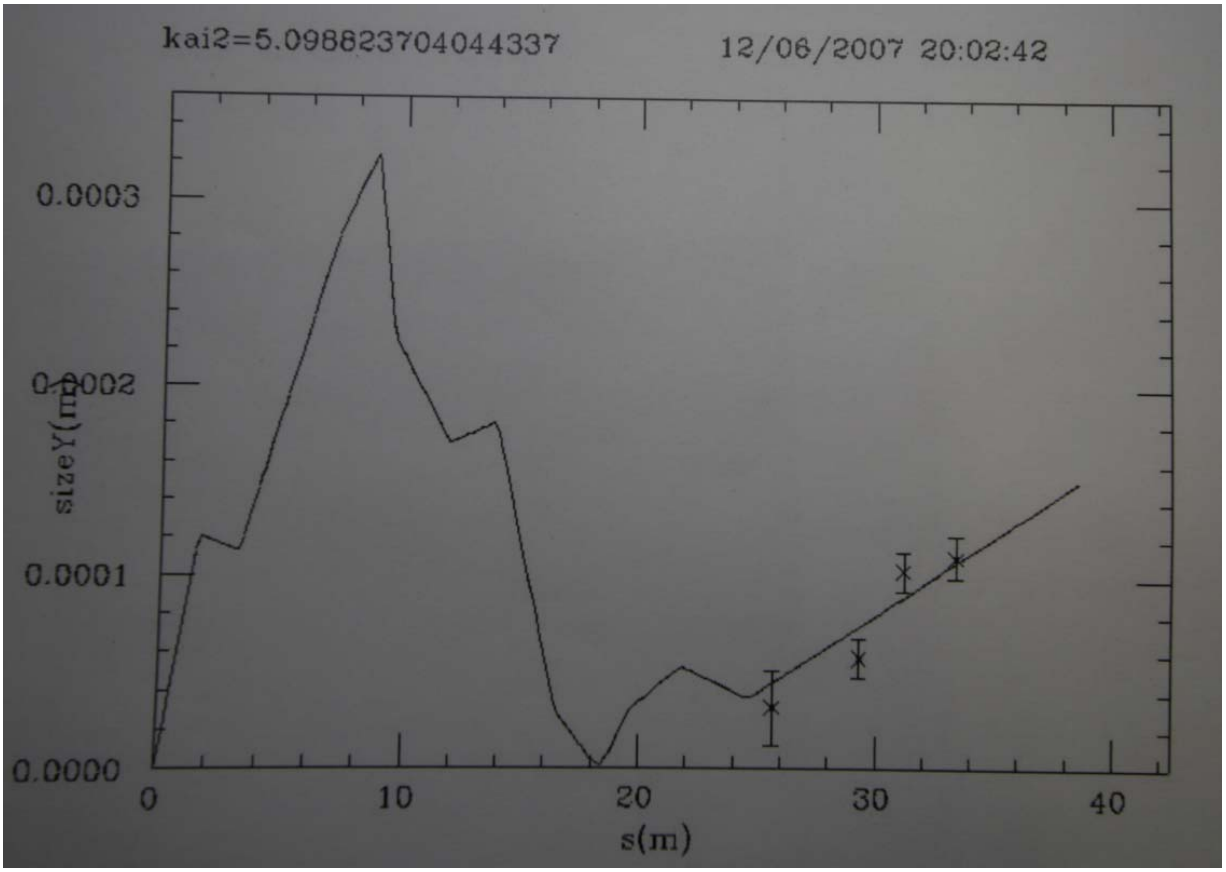

Figure 8 : Internal ATF beam size fitting.

III : Impact of error on the reconstruction

In order to estimate how this result could be affected by error on beam size and dispersion values, a matlab code has been written. This code use the initial values for dispersion and beam size, and try to compute the vertical and horizontal emittance for different level of error. As a baseline, the beam size error has been fixed to 6%, and the dispersion error level set to the one given by SAD results (see Figure 6).

The emittance reconstruction methods using such error levels are :

MW0X + MW1X + MW2X	:	473 +/- 195 pm.rad
MW0X + MW1X + MW3X	:	453 +/- 192 pm.rad
MW0X + MW2X + MW3X	:	always complex emittance
MW1X +MW2X + MW3X	:	891 +/- 182 pm.rad
MW0X+ MW1X +MW2X + MW3X	:	446 +/- 174 pm.rad