A PRELIMINARY COMPARISON OF SEXTUPOLE ARRANGEMENT FOR THE AC RING

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There are three straightforward ways of introducing sextupoles into a lattice: sextupole magnets, end shimming of dipoles or quadrupoles and suitable profiling of quadrupole pole faces. In this note we make a preliminary comparison between the following patterns of sextupole distribution, all based on the lattice 83-08.

i) Sextupole magnets, in two different distributions (S1, S2)
ii) Sextupole components in all quadrupoles (AQS)
iii) Some quadrupoles only with sextupole components (PQS)
iv) Sextupole shims on all bending magnets only (ABS)
v) Some quadrupoles and some dipoles with sextupole (PQBS)

Only two families of sextupoles are considered. We attach the beam stability outputs from the tracking program PATRICIA[1] for each pattern. A further study will use the program HARMON[2] to increase stability while minimizing the sextupole strengths.

In practice we will install sextupoles in the end shims of dipoles, in the pole profiles of quadrupoles and as separate elements in missing magnet sections. We may also need vacuum chamber windings to enhance or trim the sextupoles built into quadrupoles. The end shims of quadrupoles are best reserved for octupole shimming.

References

1. H. Wiedemann, PEP Technical Memo PTM-230.
2. M. Donald, PEP Note-311.

Table 1. Compare the different pattern of sextupole arrangement (1)

pattern		8308	8308S	8308AQS	8308ABS	8308PQS	8308PQBS
Strength	SF	−0.289	−0.281	−0.162	−0.414	−0.168	−0.127
	SD	0.424	0.407	+0.295	0.605	0.303	0.216
Number	SF_s	8	8				
	SD_s	8	9				
	SF_Q			14		8	8
	SD_Q			14		8	8
	SF_B				6		3
	SD_B				6		3
stability		✓				✓	✓

Two families and by end shims for all pattern.

Table 2. Preliminary Compare the different sextupol strength for different arrangement (1)

pattern	8308 AQS	8308 PQS	8308 PQBS
lK' SD m^{-2}	+0.295	0.303	0.216
lK' SF m^{-2}	-0.162	-0.168	-0.127
* S_{SD}	1.652	1.696	1.208
S_{SF}	0.9486	0.9838	0.7437
** $(B_s/B_Q)_{SD}$	0.1652	0.1696	0.1208
$(B_s/B_Q)_{SF}$	0.09486	0.09838	0.07437

All for lattice 8308 AC, every element with two sextupoles.

$$* \quad S = \left|\frac{G_2}{G_1}\right| = \left|\frac{K'l/l}{K}\right| = \left|\frac{K'l}{Kl}\right|$$

$$** \quad B_s/B_Q = \left|\frac{\frac{1}{2} G_2 X^2}{G_1 X}\right| = \left|\frac{G_2 X}{2 G_1}\right|$$

$K_F = -0.4879 \ m^{-2}$ $\quad K_D = 0.5105 \ m^{-2}$, $\quad l = 0.7 \ m$, $\quad X = 0.2 \ m$

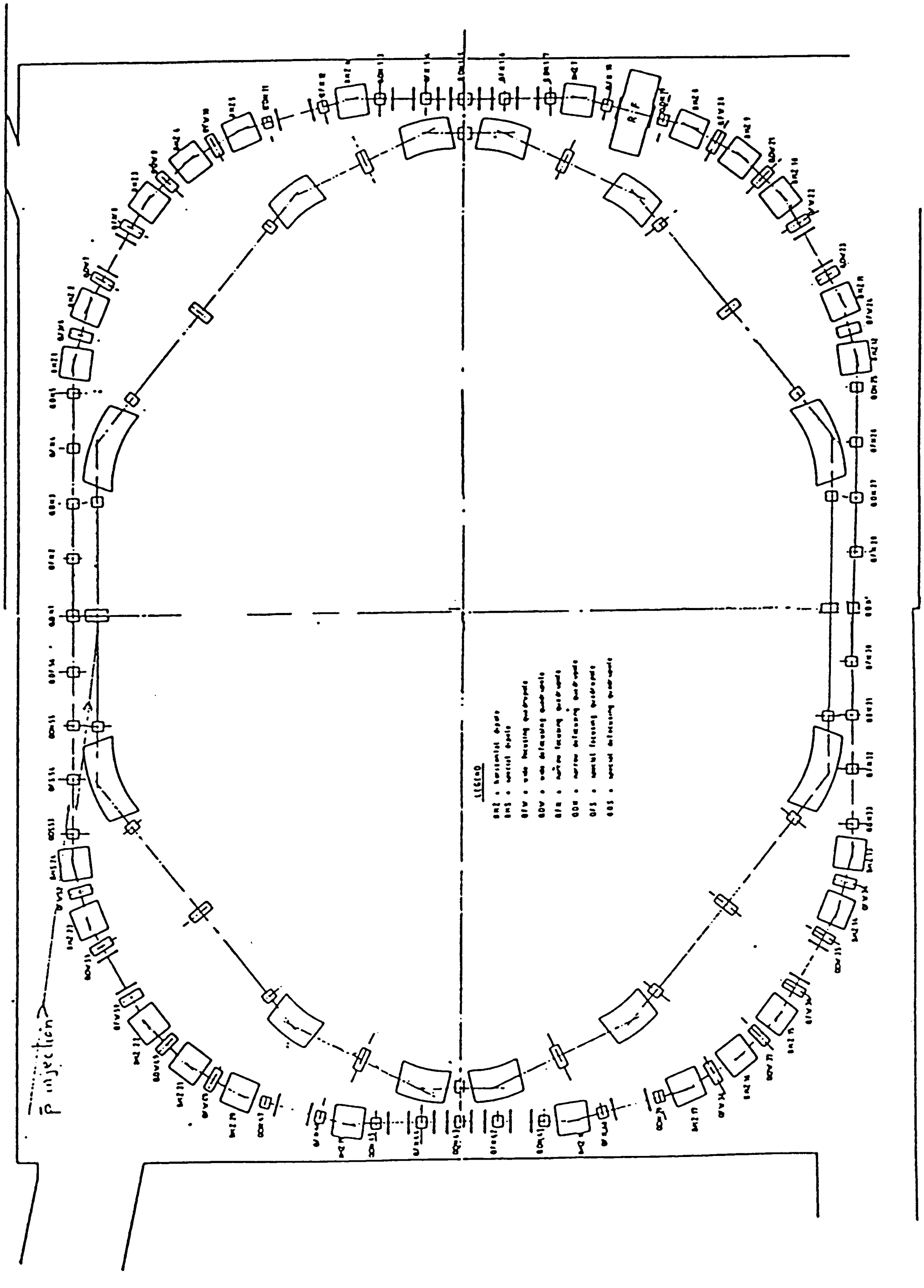


Fig 1.

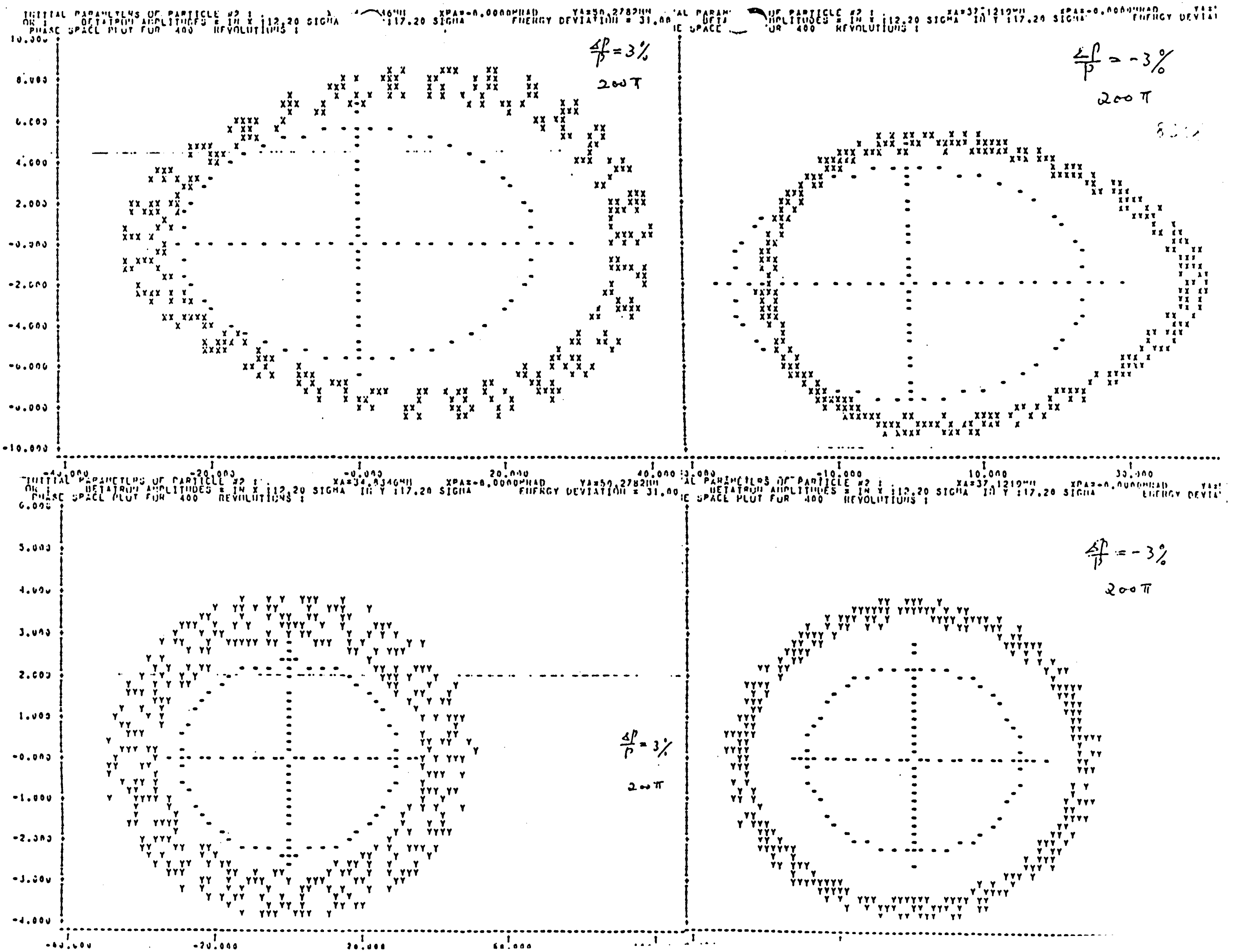

INITIAL PARAMETERS OF PARTICLE #2 :
BETATRON AMPLITUDES = IN X 112.20 SIGMA
PHASE SPACE PLOT FOR 400 REVOLUTIONS :
XPA=-0.0000MRAD
ENERGY DEVIATION = 31.00
Δp/p = 3%
200π
Δp/p = -3%
200π
Δp/p = 3%
200π
Δp/p = -3%
200π

Fig 2

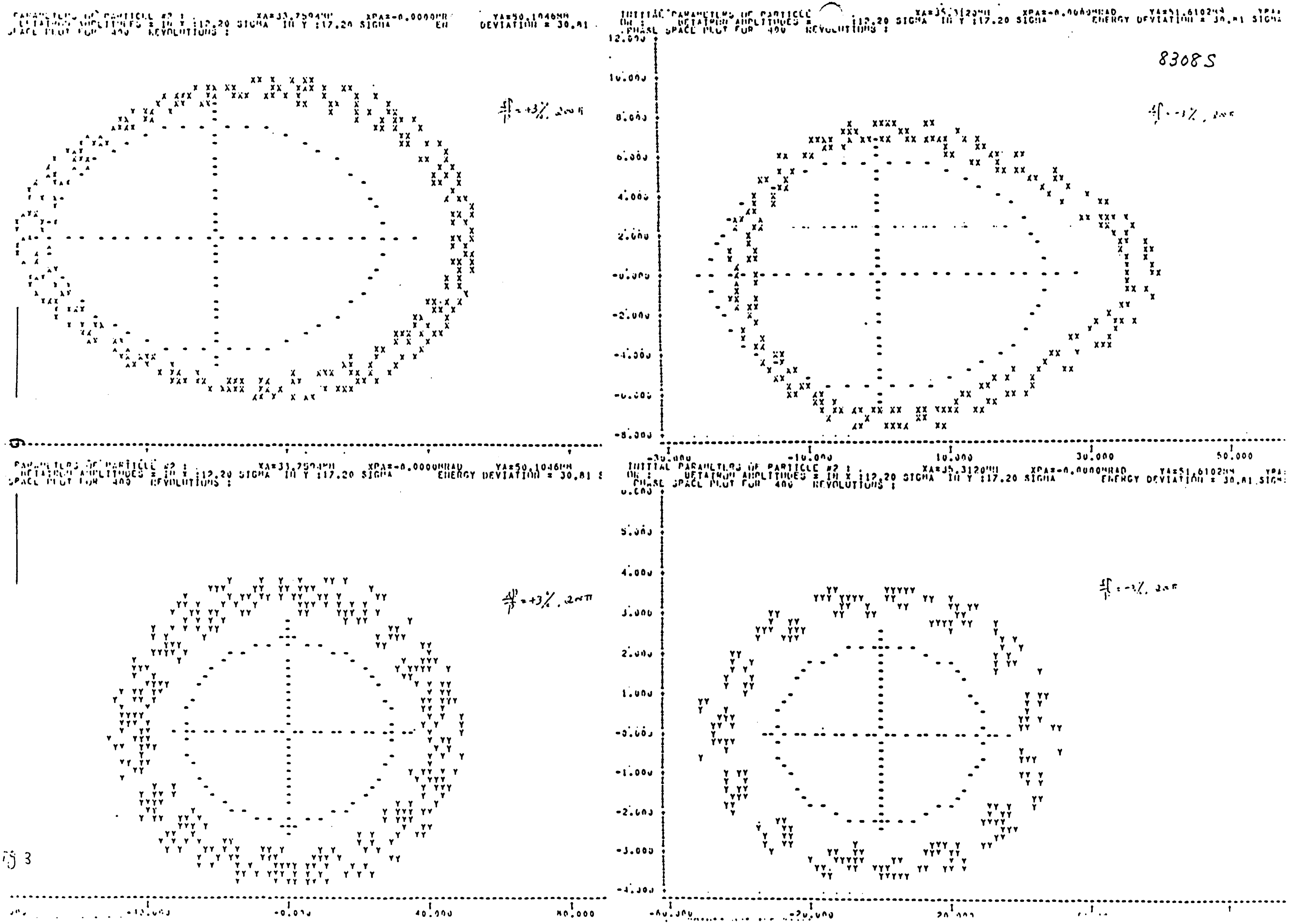
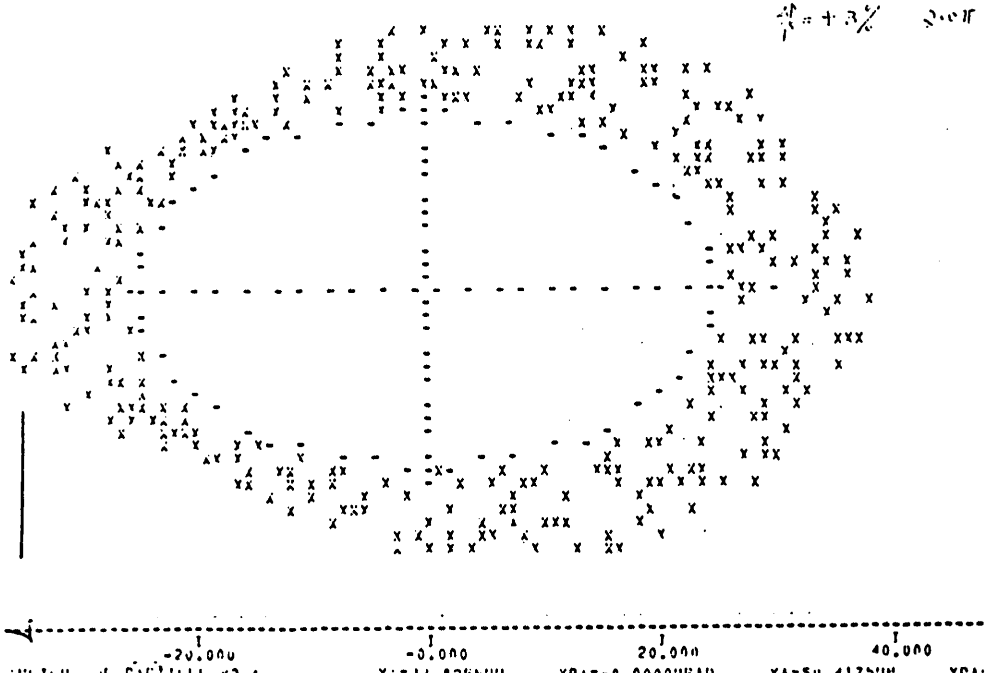
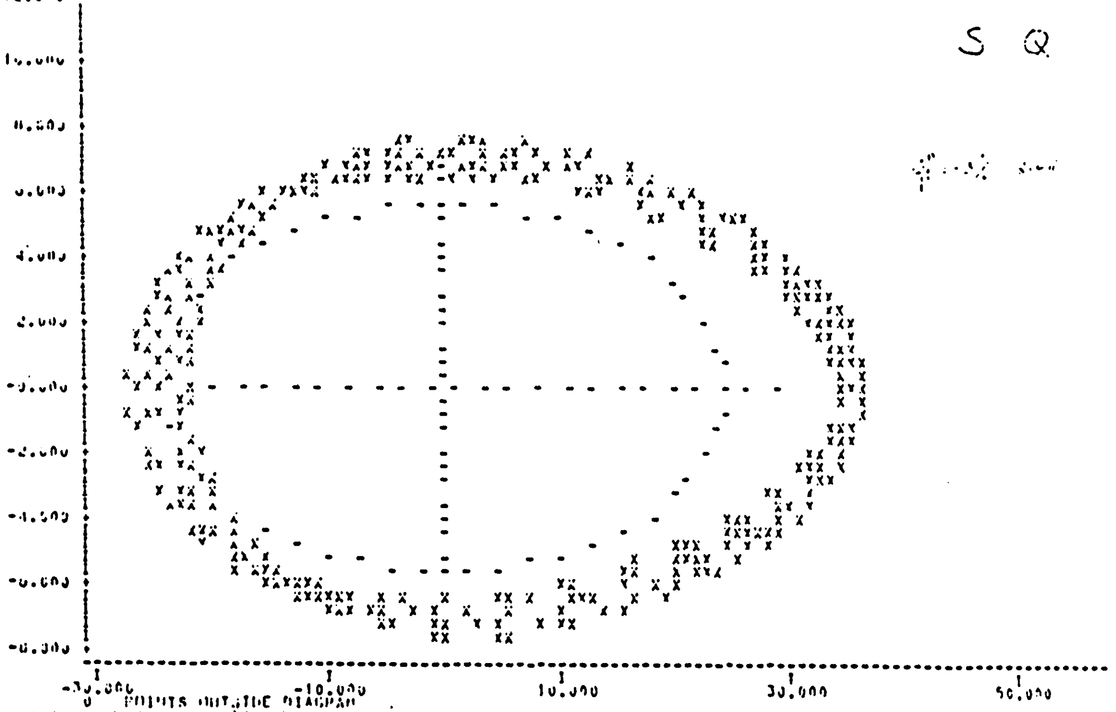

8308S
Δp/p = +3%, 2nπ
Δp/p = −1%, 2nπ
Δp/p = +3%, 2nπ
Δp/p = −1%, 2nπ
INITIAL PARAMETERS OF PARTICLE #2 :
BETATRON AMPLITUDES = IN X 112.20 SIGMA IN Y 117.20 SIGMA
PHASE SPACE PLOT FOR 400 REVOLUTIONS :
ENERGY DEVIATION = 30.81 SIGMA

Fig 3

ETERS OF PARTICLE #2 : XA=34.825500 XPA=-0.0000MRAD YA=50.417500 YPA=
ATRON AMPLITUDES = IN X :12.20 SIGMA IN Y :17.20 SIGMA ENERG VIATION = 30.81 SIGMA
PLOT FOR 400 REVOLUTIONS :



INITIAL PARAMETERS OF PARTI #2 : XA=36.511900 XPA=-0.0000MRAD YA=51.112900 YPA=
OF : BETATRON AMPLITUDES = IN X :12.20 SIGMA IN Y :17.20 SIGMA ENERGY DEVIATION = 30.81 SIGMA
PHASE SPACE PLOT FOR 400 REVOLUTIONS :



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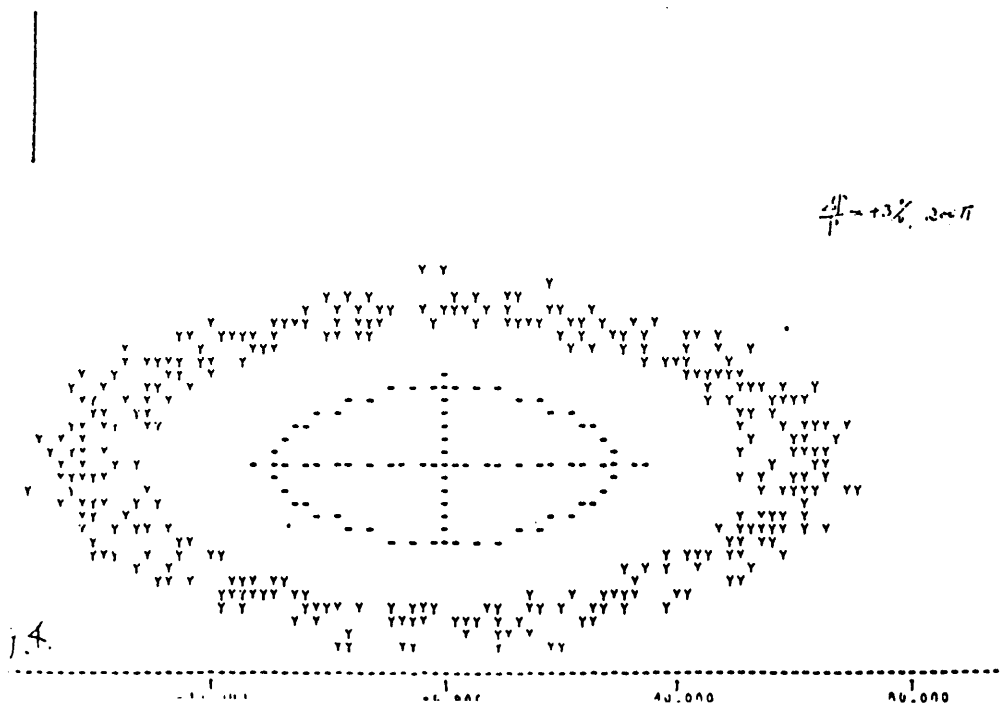

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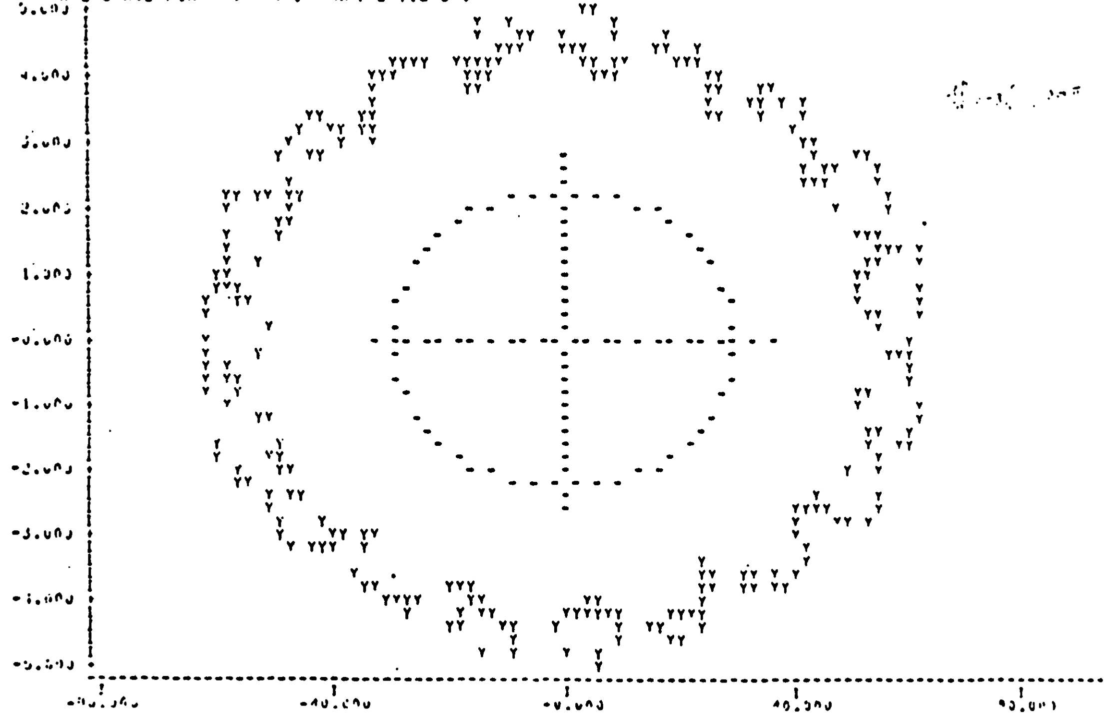

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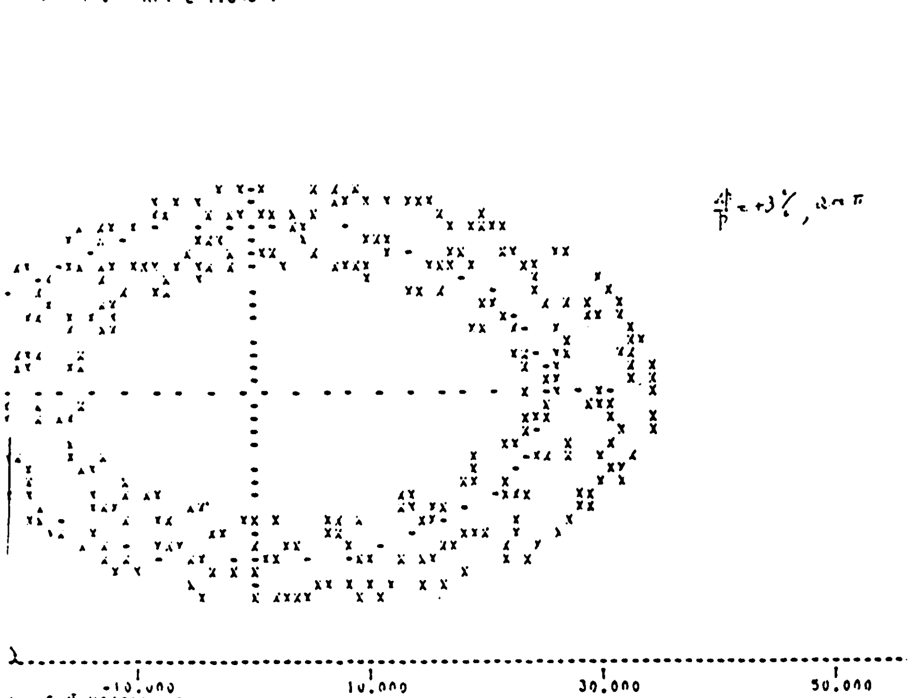
INITIAL PARAMETERS OF PARTICLE #2 : XA=35.2072MM XPA=-0.0000MRAD YA=54.1635MM
BETATRON AMPLITUDES = IN X 112.20 SIGMA IN Y 117.20 SIGMA ENERGY DEVIATION = 30.41 SIGMA
PHASE SPACE PLOT FOR 400 REVOLUTIONS :



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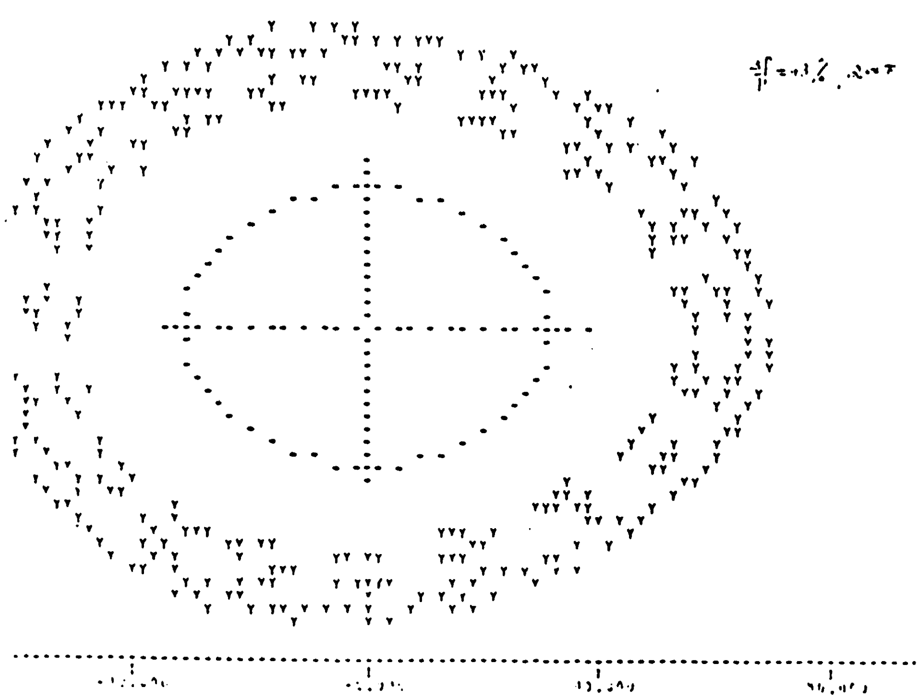
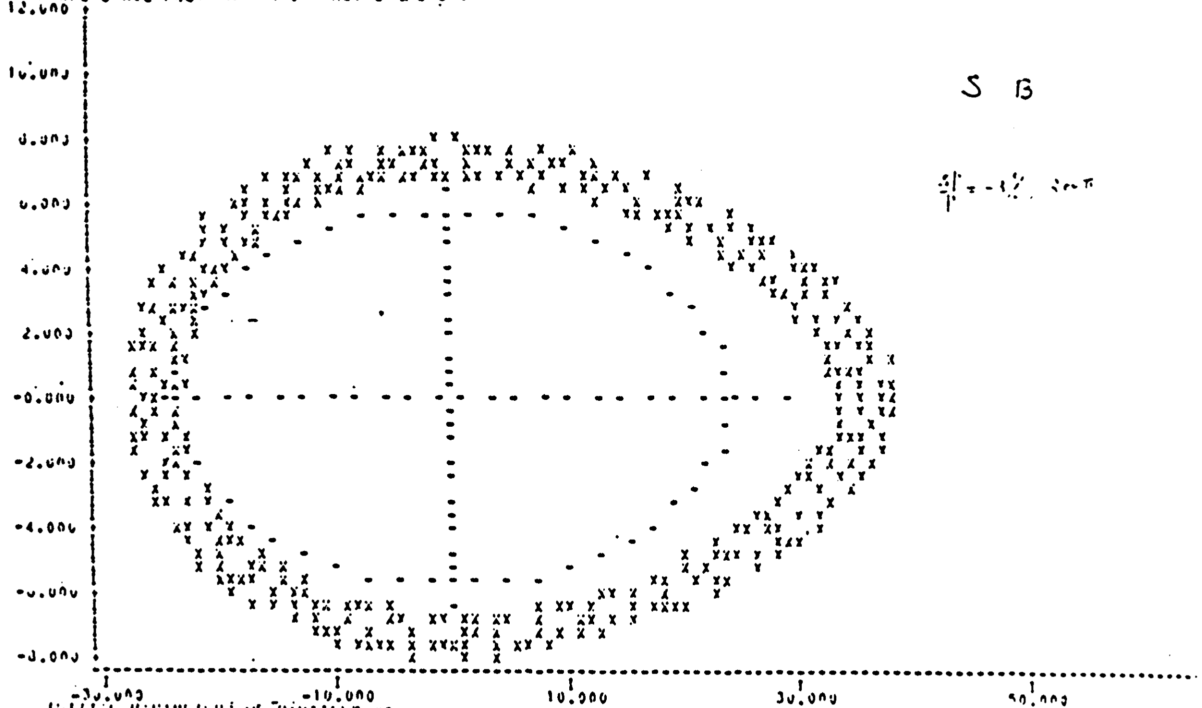


INITIAL PARAMETERS OF PARTICLE #2 : XA=33.2343MM XPA=-0.0000MRAD YA=10.4253MM
BETATRON AMPLITUDES = IN X 112.20 SIGMA IN Y 117.20 SIGMA ENERGY DEVIATION = 30.41 SIGMA
PHASE SPACE PLOT FOR 400 REVOLUTIONS :



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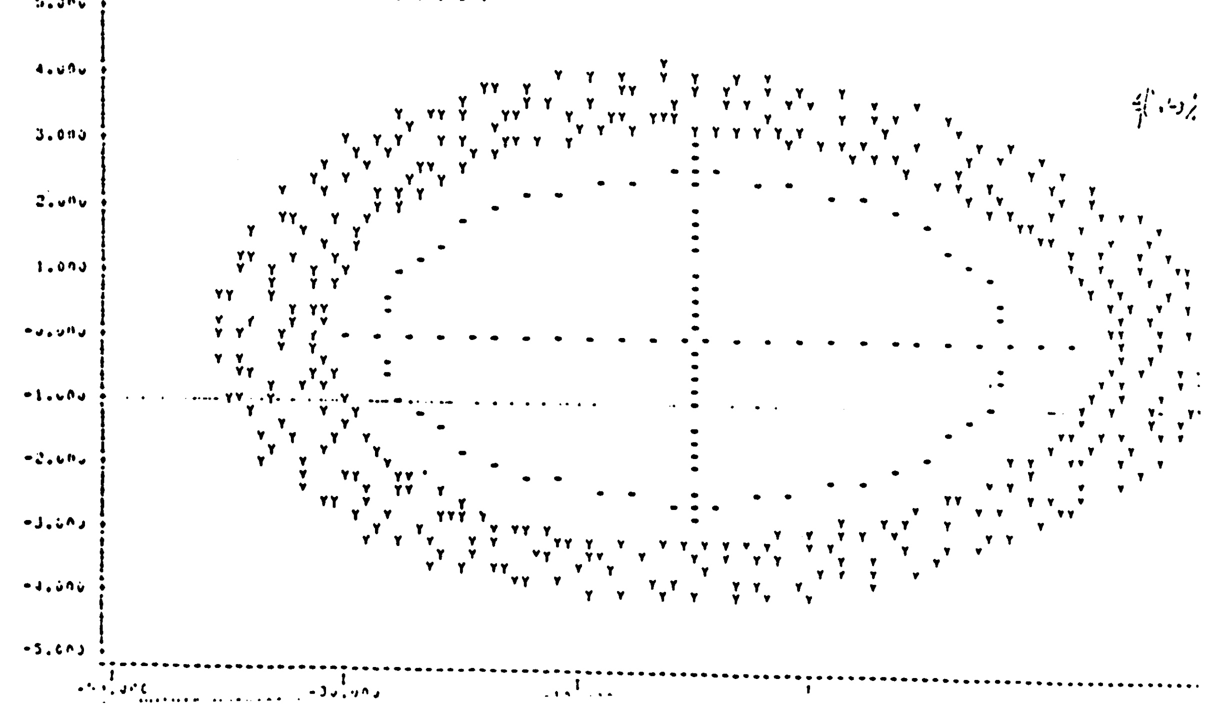

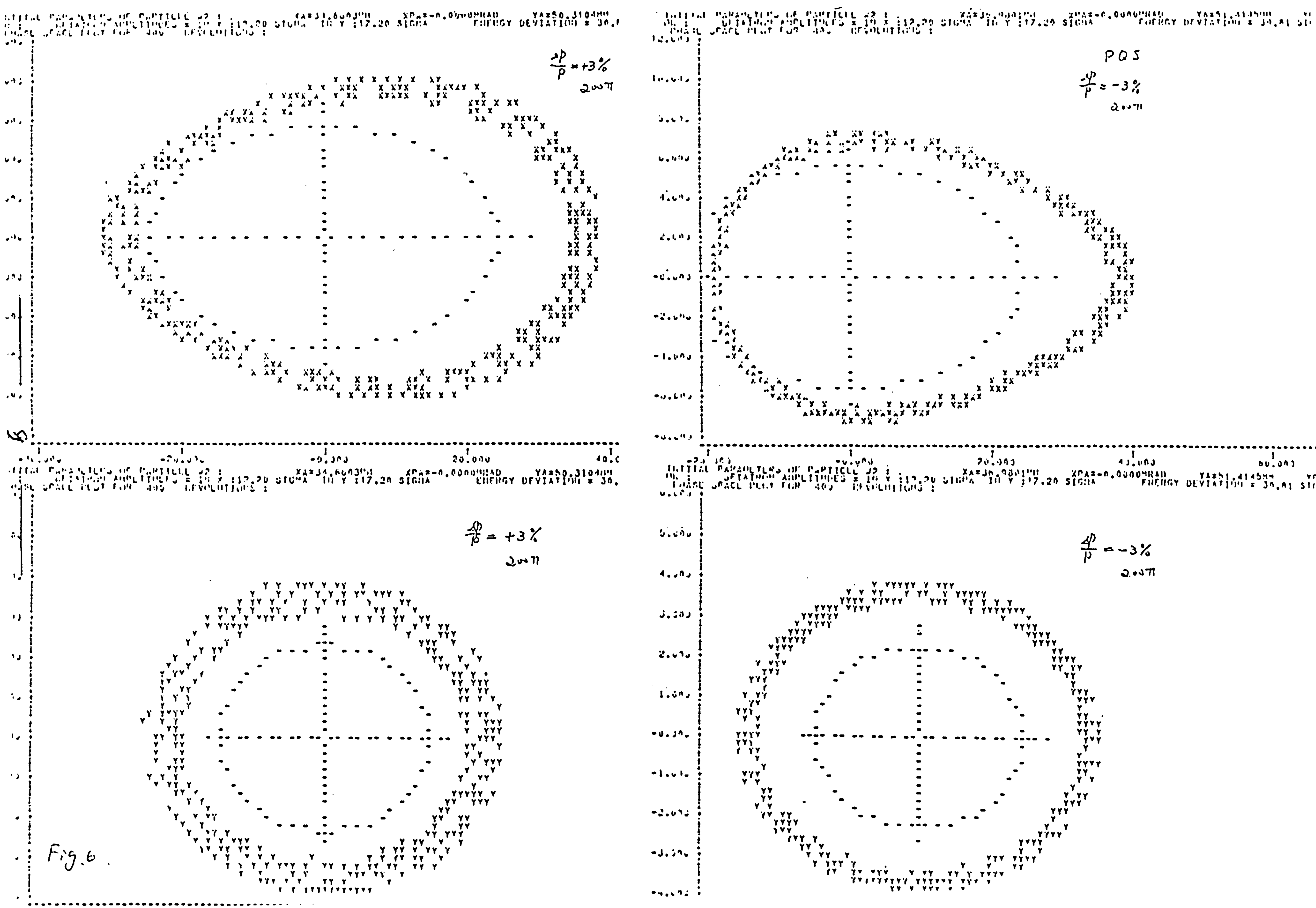

Fig. 6

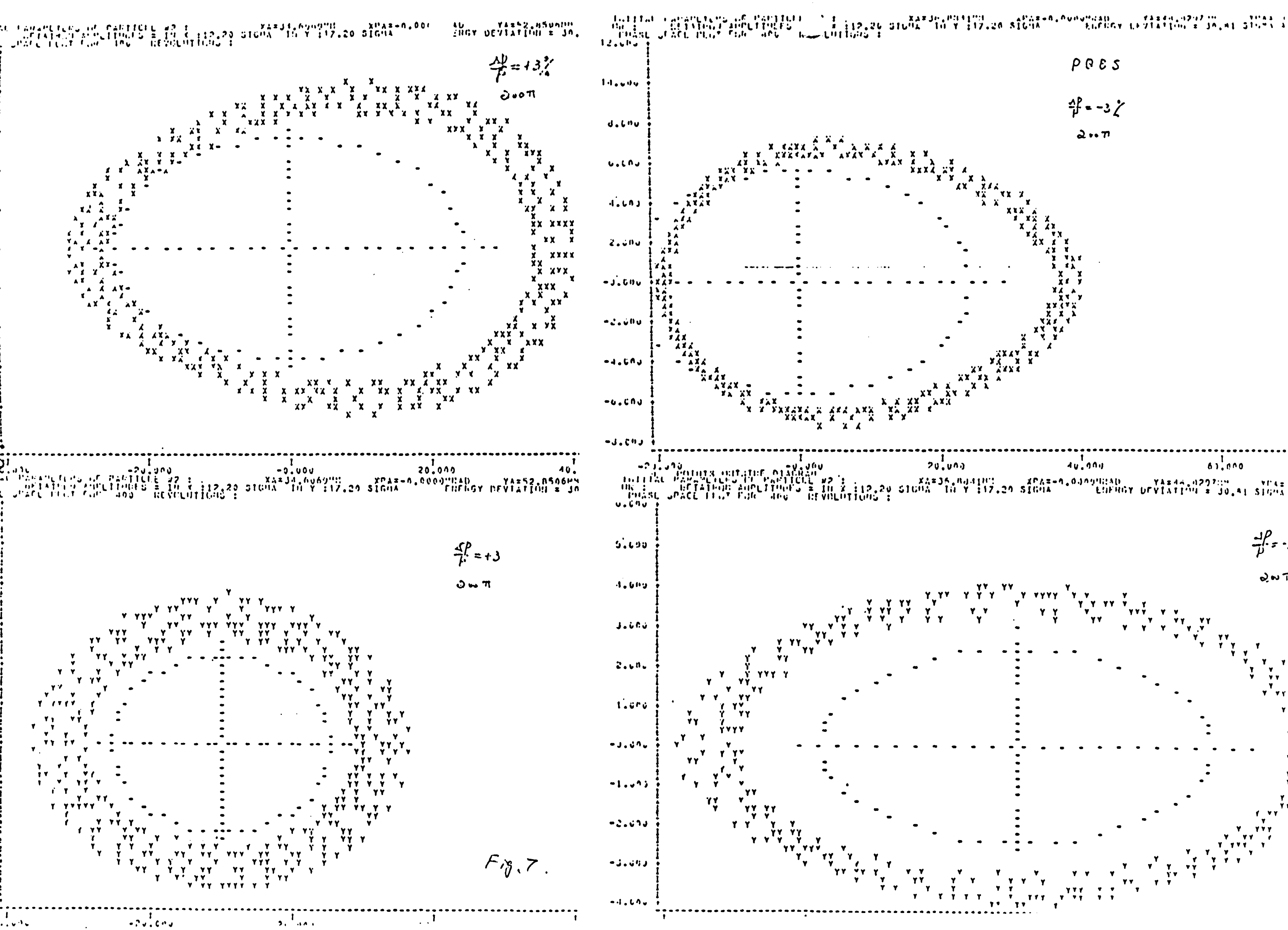

Fig. 7.

The Preliminary compare for the different pattern of sextupoles arrangement (2)

No.	Shims for bending magnet		special sextupoles in missing magnet sections		sextupoles with quadrupoles		field rate $R = B_s/B_Q$	
	SF1	SD1	SF2	SD2	SF	SD	R_F	R_D
1	−0.10	0.10	0.0	0.0	−0.1210	0.2506	0.0269	0.0980
2	−0.15	0.15	0.0	0.0	−0.1001	0.2284	0.0140	0.0858
3	−0.10	0.10	−0.10	0.10	−0.1041	0.2324	0.0170	0.088
4	−0.15	0.15	−0.15	0.15	−0.07486	0.2011	/	0.0706
5	−0.10	0.10	−0.20	0.20	−0.08727	0.2142	/	0.0779
6	−0.15	0.15	−0.30	0.30	−0.04955	0.1738	/	0.0553
7	−0.10	0.10	−0.40	0.40	−0.05351	0.1779	/	0.0576
8	−0.15	0.15	−0.50	0.50	−0.01579	0.1375	/	0.0350
9	−0.10	0.10	−0.60	0.60	−0.01975	0.1415	/	0.0370
10	−0.15	0.15	−0.60	0.60	0.00108	0.1193	/	0.0248

1). for AC lattice 8308 only.

2). the unit of sextuple strength is m^{-2}, $(K'l)$.

3). R is the rate between sextupol and quadrupole field components from pole profile.

$R = \frac{B_S}{B_Q} = \frac{1/2\, G_2 x^2}{G_1 x} = \frac{x K' l}{2 K l}$, $K'l = 2\left(\frac{SF}{SD}\right) - 0.15$, 0.15 is by winding, $l = 0.7\,m$, $x = 0.2\,m$

Table 4. Preliminary Compare the sextupole strength for different arrangement (3)

Number of pattern	shims for bending magnets		special sextupoles in missing magnet sections		quadrupole with sextupole component: the strength		by winding	by profile
	SF1	SD1	SF2	SD2	SF	SD		
1	-0.4140	0.6050	0.0	0.0	0.0	0.0	0.0	0.0
2	-0.40	0.30	0.0	0.0	0.00938	0.1755		
3	-0.35	0.30	0.0	0.0	-0.01414	0.1686		
4	-0.30	0.25	0.0	0.0	-0.03498	0.1909		
5	-0.30	0.20	0.0	0.0	-0.03230	0.2199		
6	-0.2359	0.4342	0.0	0.0	-0.075	0.075	0.15	0.0
7	-0.1351	0.3330	0.0	0.0	-0.117	0.120	0.15	0.025
8	-0.0315	0.2071	0.0	0.0	-0.159	0.175	0.15	0.050
9	0.0663	0.1324	0.0	0.0	-0.201	0.209	0.15	0.075
10	0.1675	0.0277	0.0	0.0	-0.243	0.256	0.15	0.100
11	-0.2956	0.4912	0.0	0.0	-0.050	0.050	0.10	0.0
12	-0.1949	0.3908	0.0	0.0	-0.092	0.0946	0.10	0.025
13	-0.0942	0.2906	0.0	0.0	-0.134	0.139	0.10	0.050
14	0.0066	0.1895	0.0	0.0	-0.176	0.184	0.10	0.075
15	0.1074	0.0883	0.0	0.0	-0.218	0.229	0.10	0.100
16	-0.3553	0.5484	0.0	0.0	-0.025	0.025	0.05	0.0
17	-0.2544	0.4472	0.0	0.0	-0.067	0.070	0.05	0.025
18	-0.1538	0.3477	0.0	0.0	-0.109	0.114	0.05	0.050
19	-0.0530	0.2466	0.0	0.0	-0.151	0.159	0.05	0.075
20	0.0871	0.1361	0.0	0.0	-0.211	0.204	0.05	0.100

Table 5. preliminary compare for sextupole strength (3. continue)

Number	SF1	SD1	SF2	SD2	SF	SD	winding	profile
21	-0.4048	0.5170	0.0	0.0	0.0	0.05	0.0 / 0.10	0.0
22	-0.3041	0.4165	0.0	0.0	-0.042	0.0946	0.0 / 0.10	0.025
23	-0.2034	0.3164	0.0	0.0	-0.084	0.139	0.0 / 0.10	0.050
24	-0.1026	0.2152	0.0	0.0	-0.126	0.184	0.0 / 0.10	0.075
25	-0.0017	0.1140	0.0	0.0	-0.168	0.229	0.0 / 0.10	0.100
26	-0.1144	0.3177	-0.30	0.30	-0.075	0.075	0.15	0.0
27	-0.0135	0.2105	-0.30	0.30	-0.117	0.120	0.15	0.025
28	0.0901	0.0846	-0.30	0.30	-0.159	0.179	0.15	0.050
29	0.1879	0.0099	-0.30	0.30	-0.201	0.209	0.15	0.075
30	0.2891	-0.0948	-0.30	0.30	-0.243	0.256	0.15	0.100
	SF1	SD1	SF2	SD2	SFQW	SDQW	winding	profile
31	-0.3095	0.5145	0.0	0.0	-0.050	0.050	0.10	0.0
32	-0.2205	0.4346	0.0	0.0	-0.0920	0.0946	0.10	0.025
33	-0.1315	0.3550	0.0	0.0	-0.1340	0.139	0.10	0.050
34	-0.0425	0.2746	0.0	0.0	-0.176	0.184	0.10	0.075
35	0.0466	0.1941	0.0	0.0	-0.218	0.229	0.10	0.100
36	-0.4063	0.5379	0.0	0.0	0.0	0.05	0.0 / 0.10	0.0
37	-0.3173	0.4580	0.0	0.0	-0.042	0.0946	0.0 / 0.10	0.025
38	-0.2284	0.3784	0.0	0.0	-0.084	0.139	0.0 / 0.10	0.050
39	-0.1393	0.2980	0.0	0.0	-0.126	0.184	0.0 / 0.10	0.075
40	-0.0502	0.2175	0.0	0.0	-0.168	0.229	0.0 / 0.10	0.100
41	-0.1352	0.3466	-0.30	0.30	-0.075	0.075	0.15	0.0
42	-0.0461	0.2660	-0.30	0.30	-0.117	0.120	0.15	0.025
43	0.0453	0.1668	-0.30	0.30	-0.159	0.179	0.15	0.050
44	0.1319	0.1066	-0.30	0.30	-0.201	0.209	0.15	0.075
45	0.2212	0.0235	-0.30	0.30	-0.243	0.256	0.15	0.100

$$R = \frac{B_S}{B_Q} = \frac{\frac{1}{2} G x^2}{G x} = \frac{x K' l}{2 K l}$$

$$(K'l)_{profile} = R \frac{2Kl}{x} = 7RK$$

$$\begin{matrix} SF \\ SD \end{matrix} = \frac{1}{2} (K'l)_{profile \, \substack{F \\ D}} + \frac{1}{2} W$$

$l = 0.7\ m$ $\quad x = 0.2\ m.$ $\quad K_F \doteqdot -0.48\ m^{-2}$ $\quad K_D \doteqdot 0.51\ m^{-2}$

then $\begin{matrix} SF \\ SD \end{matrix} - \frac{1}{2} W = 0.35\, R \cdot K_{\substack{F \\ D}}$

Table 6.

R	0.0	0.025	0.050	0.075	0.100
$SF - \frac{1}{2}W$	0.0	−0.042	−0.084	−0.126	−0.168
$SD - \frac{1}{2}W$	0.0	0.0446	0.08925	0.1338	0.1785

*) given the single winding (w) for calculation

**) SFQW. SDQW. , just wide quadrupole with sextupole component.