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Preliminary Chromatic Correction

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U.S. Department of Energy

USDOE Office of Science (SC)

DISCLAIMER

Preliminary Chromatic Correction

for the RHIC2

Lattice Design

Armando Antillon
BNL, July 3, 1984

ABSTRACT

A lattice with the name of RHIC2 has been considered as a candidate for the Relativistic Heavy Ion Collider. In this note we study its chromatic properties in two cases: 1) when two families of sextupoles are included, 2) when special families of sextupoles are placed in the arcs of the ring in order to diminish higher order resonance effects and chromatic effects.

1.- Description of the RHIC2 lattice.

This lattice consistes of 6 arcs and 6 insertions with supersymmetry 3. Each arc is made of 12 cells with the next structure

$$\text{Cell} = C = \frac{QF}{2} \overset{1}{|}\ B \overset{2}{|}\ \frac{QD}{2} \overset{3}{|}\ SD \overset{3}{|}\ \frac{QD}{2} \overset{2}{|}\ B \overset{1}{|}\ \frac{QF}{2} \overset{3}{|}\ SF \overset{3}{|}$$

where 1, 2 and 3 mean three different drift spaces.

One of the insertions has the next arrangement

Insertion = I = Q7I Q6* Q6I BS Q5I BS Q4I Q3I Q2I Q1I BC2I BC1I
CR BC1O BC2O Q1O Q2O Q3O Q4O BS Q5O BS Q6O Q6O* Q7O

where BS is dispersion suppresor dipole and the dipoles BC1I, BC1O allow head-on colisions.

Each superperiod is made in the following way

$$6 \times C_I + I_1 + 12 \times C_o + I_1^{-1} + 6 \times C_I$$

where I_1^{-1} means mirror of I_1 and the cells C_I differ from Co in the drift spaces between bending magnets and quadrupoles.

Some of the machine functions are

in the arcs

	β_x	β_y	η_x
QF	51.5	7.4	1.38
QD	7.4	51.5	0.69

in the insertions

$$\beta_x^* = 17.7\text{m}$$
$$\beta_y^* = 2.99\text{m}$$
$$\beta_{x\,max} = 267.3\text{m}$$
$$\beta_{y\,max} = 667.4\text{m}$$

The natural chromaticity has values

$$\xi_x = -51.0 \quad , \quad \xi_y = -69.9$$

and the nominal tune is $\nu_x = 31.61521$, $\nu_y = 31.61399$

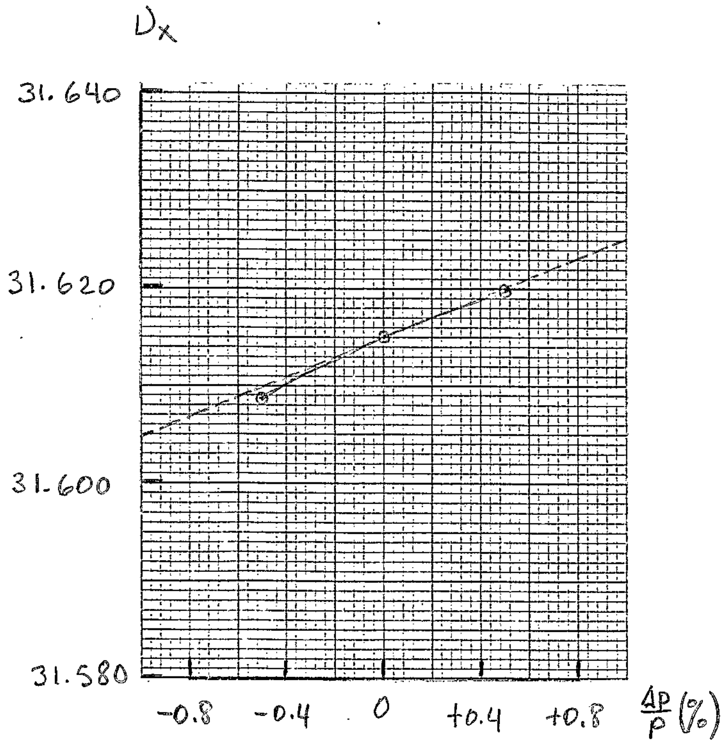
2.- Chromatic Properties with two families of sextupoles.

In order to avoid the main resonances near the nominal tune, the chromaticity has been chosen to be 1, even without knowing if this value is compatible with head-tail instabilities. Next tables show the momentum dependence of some machine functions. The integrated strenghts of the sextupoles $\left(\frac{B'' \ell_{sex}}{B\rho} \, m^{-2} \right)$ are in this case:

SF = -.14352

SD = +.42412

All calculations have been done for $\left| \frac{\Delta p}{p} \right| \leq 0.5\%$.



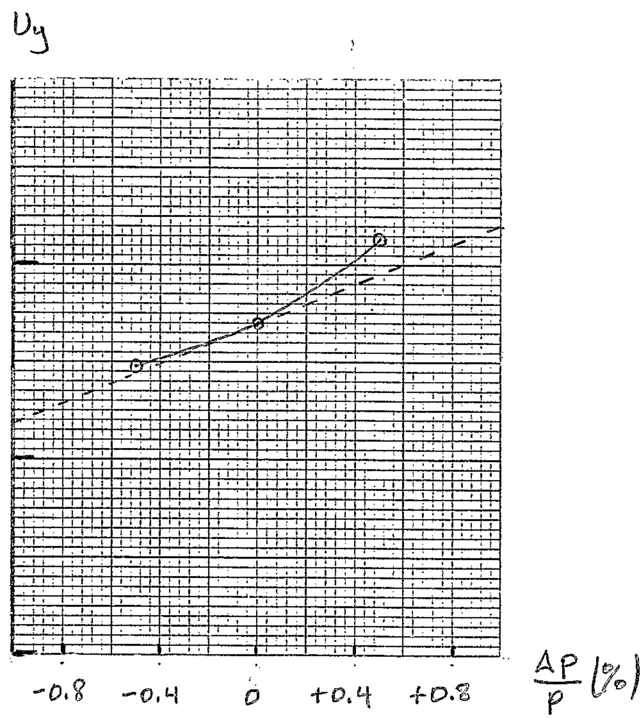
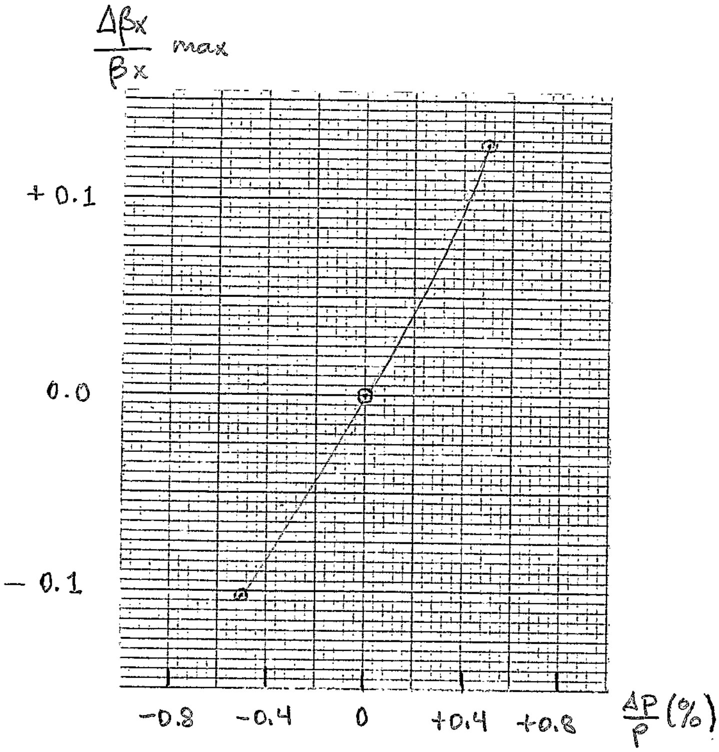


Table I.- Tune variations with momentum. Two families of sextupoles are considered. Straight line is chromaticity 1. ν_x = 31.61521, ν_y = 31.61399.



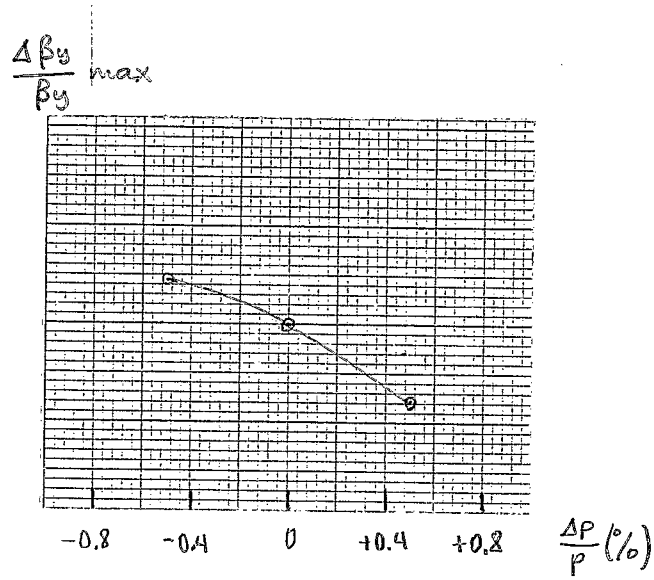


Table II.- Variation of max in insertions. β_{ox} = 267.322m and β_{oy} = 667.463m.

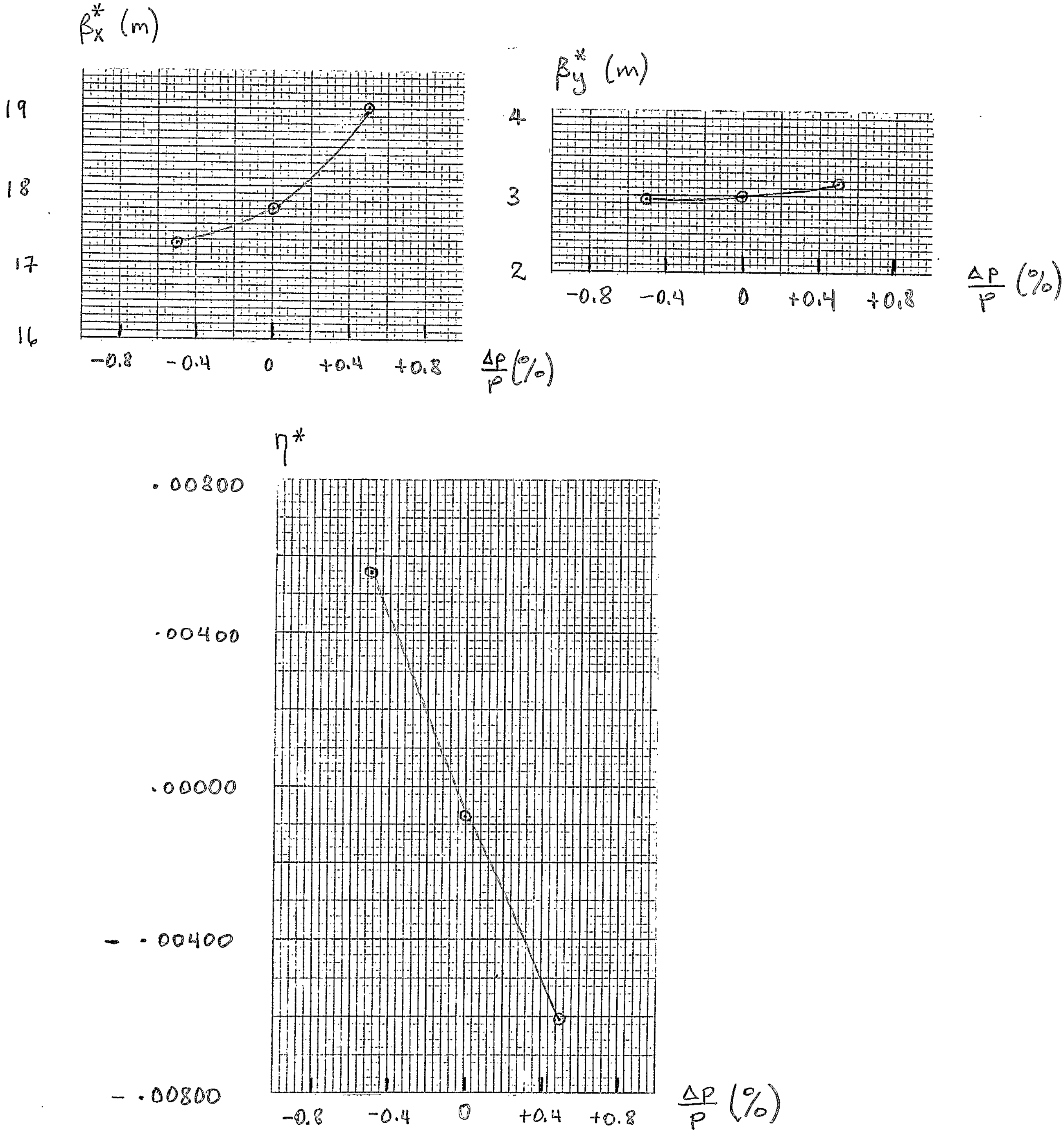


Table III.– Behavior of β_x, β_y, η in the crossing point.

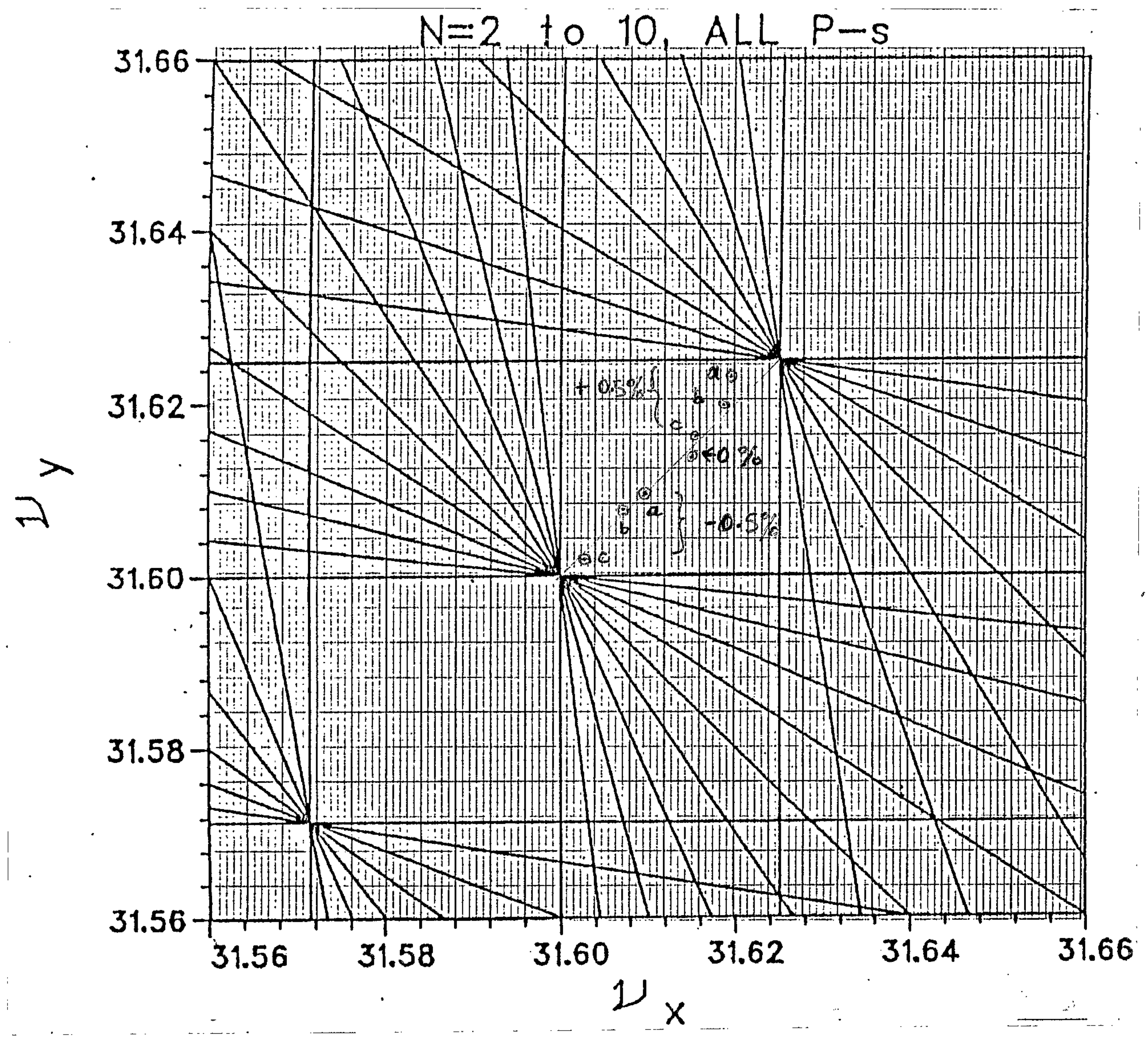


Table IV.- Variation of momentum with amplitud with resolution of 100 turns. Points a, b, c represent emittances 0, $1.5\pi \times 10^{-6}$ m -rad, $3\pi \times 10^{-6}$ m -rad respectively. We kept chromaticity 1 in order to avoid 8th and 10th order resonances.

With the previons characteristic, the phase space shows the next structure for 100 turns. When the number of turns is smaller it is possible to identify high order resonances.

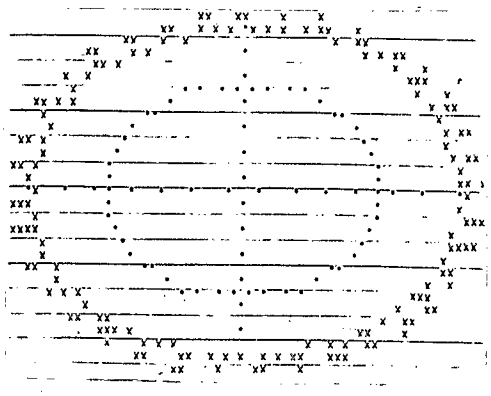
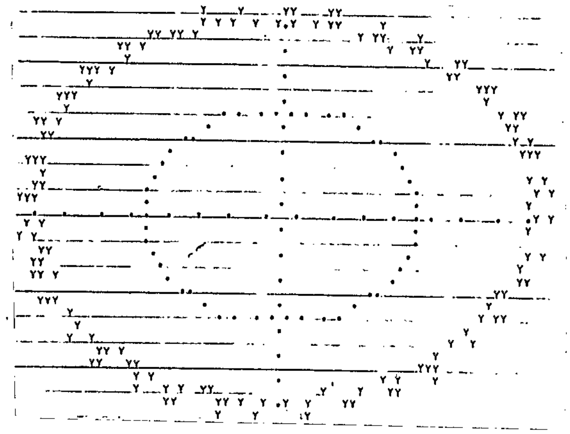
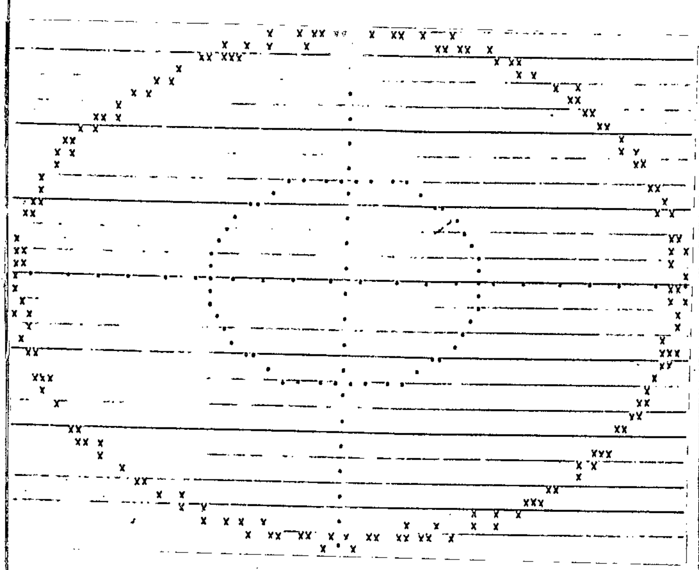
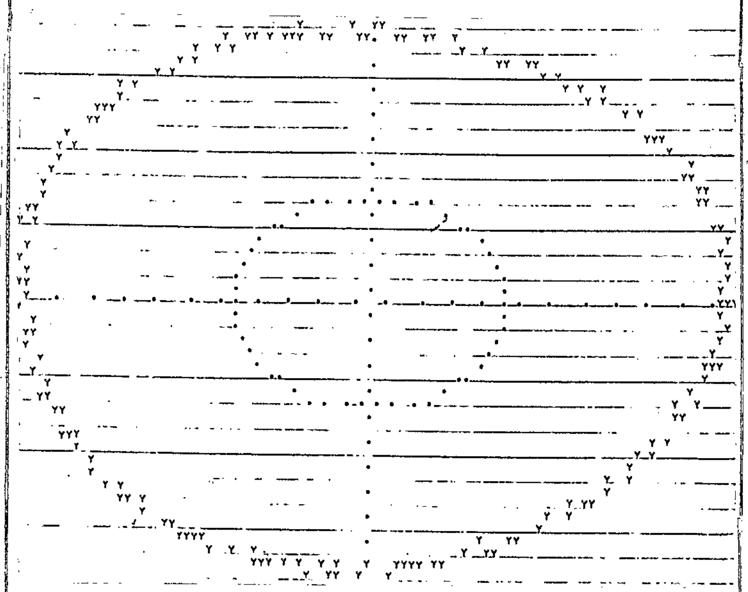
EMITTANCE	X DIRECTION	Y DIRECTION
$1.5\pi \times 10^{-6}$ m-rad		
$3\pi \times 10^{-6}$ m-rad		

Table Va.

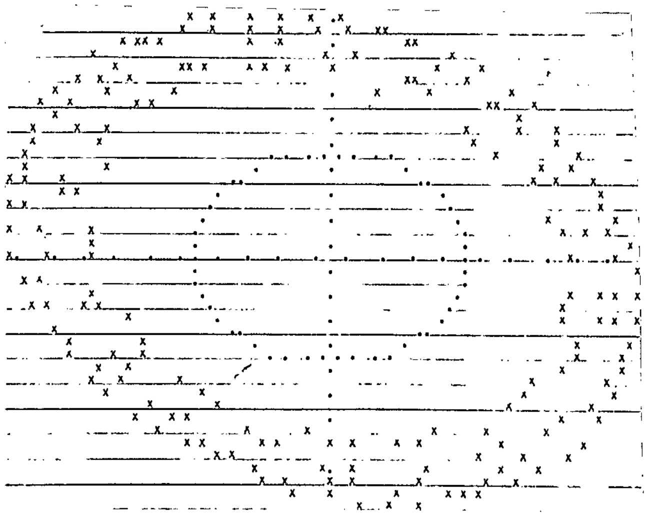
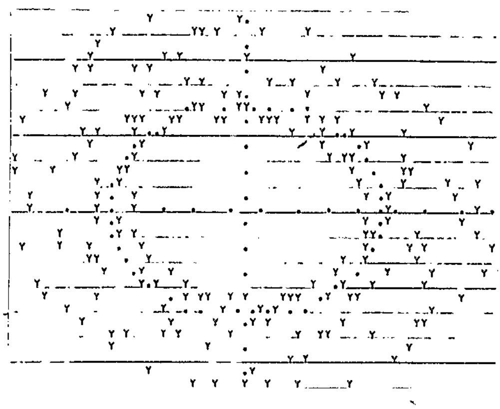
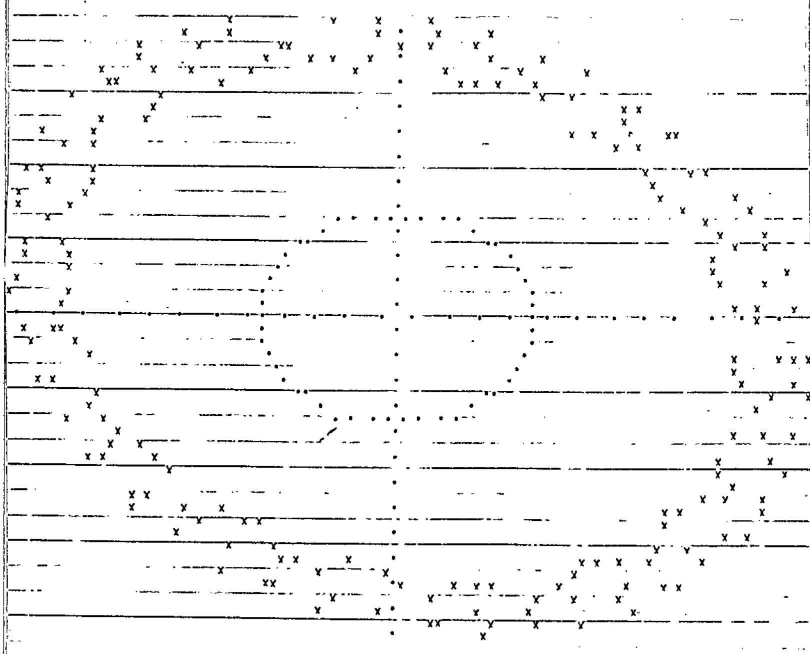
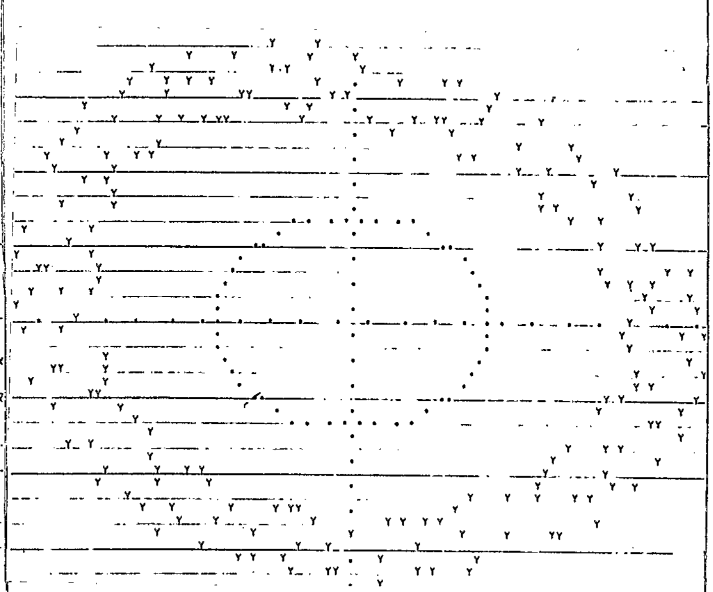
ϵ	X DIRECTION	Y DIRECTION
$1.5\pi \times 10^{-6}$ m-rad		
$3\pi \times 10^{-6}$ m-rad		

Table Vb.

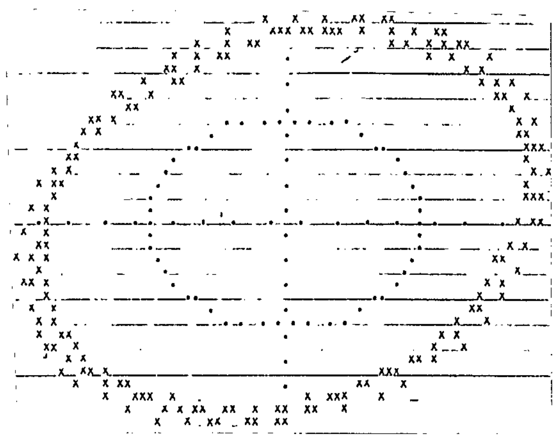
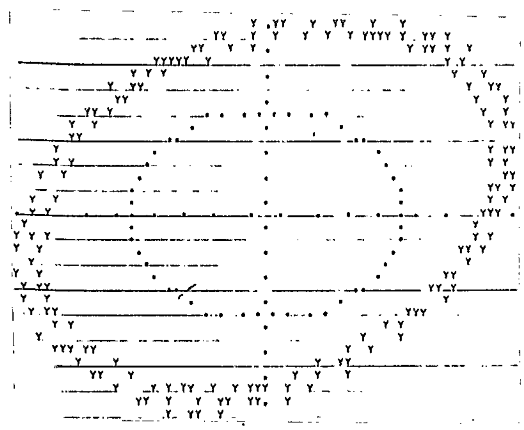
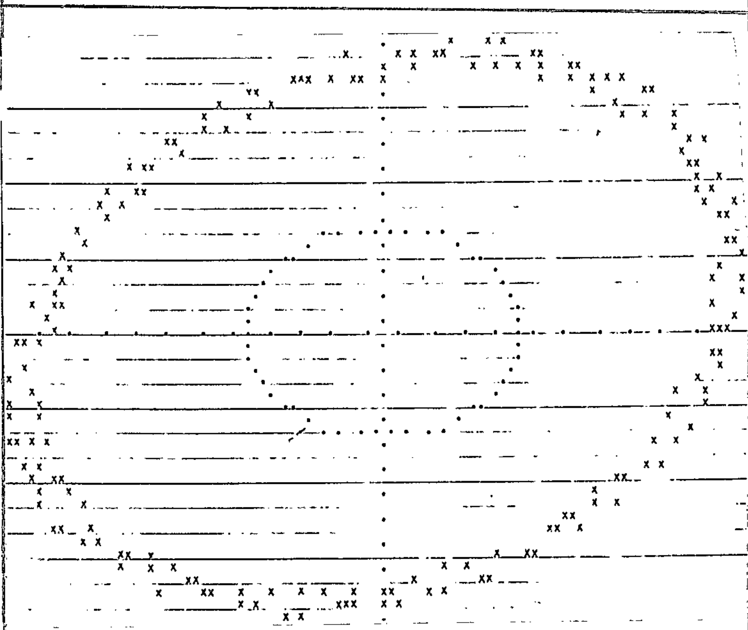
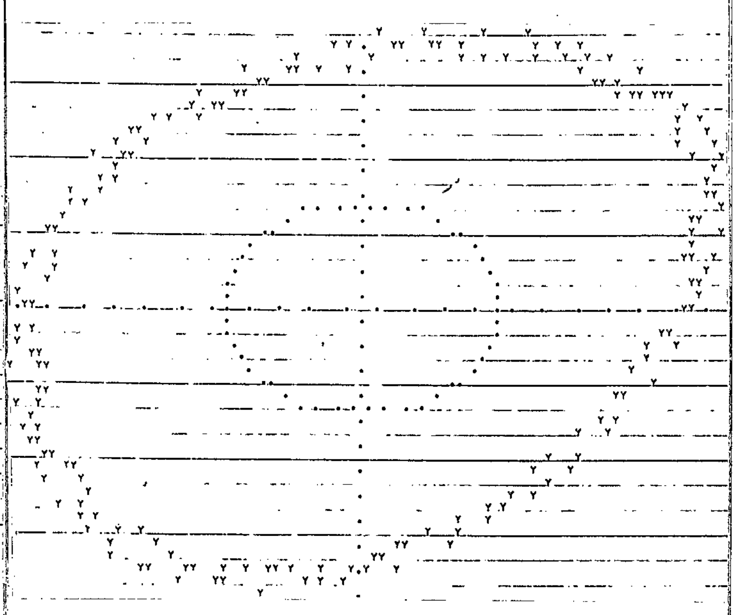
ε	X DIRECTION	Y DIRECTION
1.5π $\times 10^{-6}$ m-rad		
3π $\times 10^{-6}$ m-rad		

Table Vc.

Table V.- a) x and y phase spaces for 100 turns. Momentum 0%. b) Momentum 0.5%. The diffusion of the satates in phase spaces are consequence of higher order resonances. c) Momentum -0.5%. Direction of phase space is also affected by higher order resonances.

3.- Chromatic Properties with special families of sextupoles.

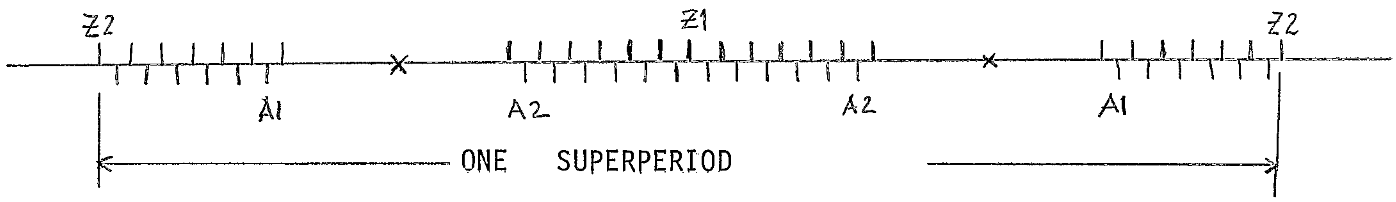
The phase spaces of table V and the large tune dependence with amplitud, shown in table IV, have been suggested that the higher order resonance effects appear as consequence of aberration phenomena[2]. In order to correct phase spaces without changing the chromatic bahavior of part 3, we have tried to put some special sextupoles in insertions, in places where dispersion is practically zero. The attempt was no successful.

Another attempt to disminish the higher order resonance effects has been made by improving the chromatic behavior. This has been done as we now describe.

We know[3,4] that $\Delta\beta/\beta$ change with $\Delta p/p$ as

$$\frac{\Delta\beta}{\beta}\left(\phi,\frac{\Delta p}{p}\right) = 2\zeta^{1}(\phi)\,\frac{\Delta p}{p} + \left(\zeta^{1\,2}(\phi) + 2\,\zeta^{2}(\phi)\right)\left(\frac{\Delta p}{p}\right)^{2} + \cdots$$

We will assume that $2\zeta^2 << \zeta'^2$. With this, $(\Delta\beta/\beta)_{max}$ will decrease if ζ'_{max} is minimized. This has been done, in both x and y direction, by changing the SF, SD sextupoles, to vaues Z,A in places indicated.



The new values for SF, SD are lightly different from part 3.

SF = -.14109	,	SD = +.42894 and
Z1 = -.34524	,	Z2 = .00007
A1 = .2	,	A2 = .6

With this special sextupoles, the machine functiones are

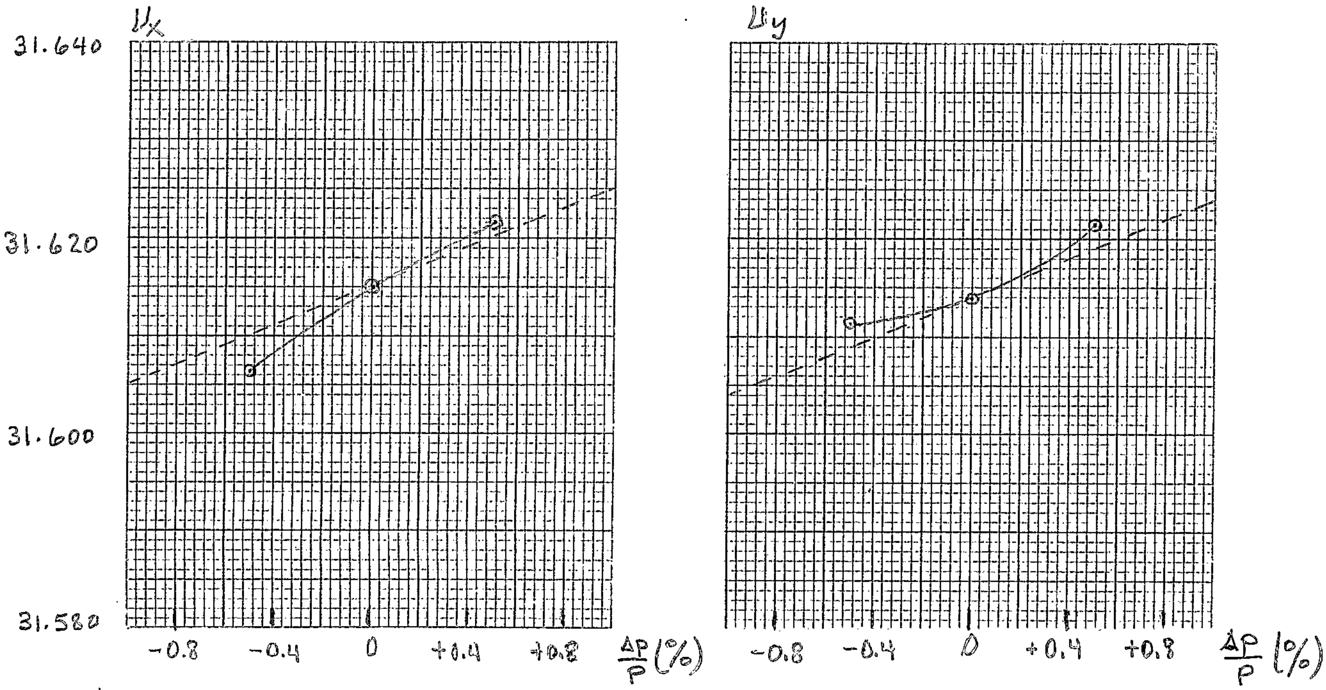


Table VI.- Behavior of tune with momentum when special sextupoles are placed in the arcs. SF and SD have to change lightly in order to keep chromaticity 1.

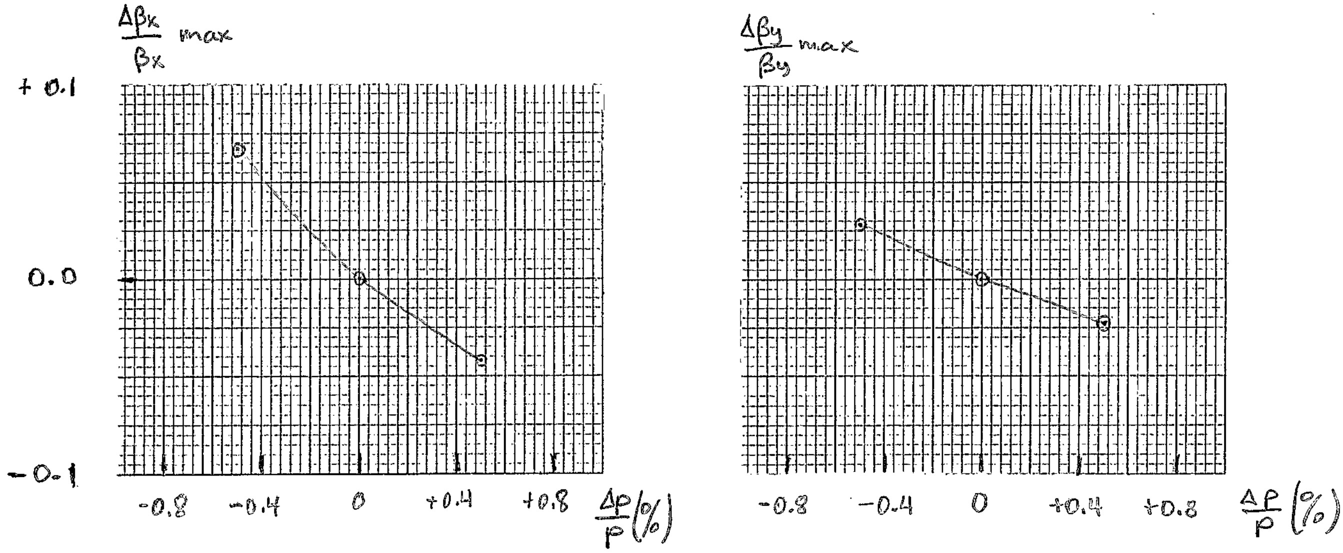
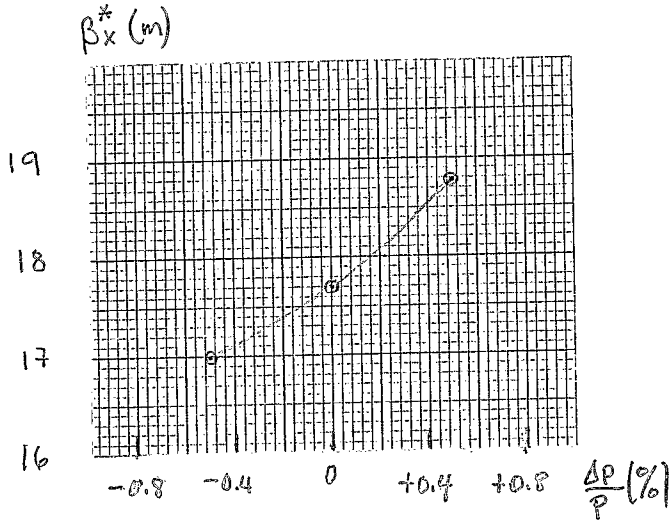
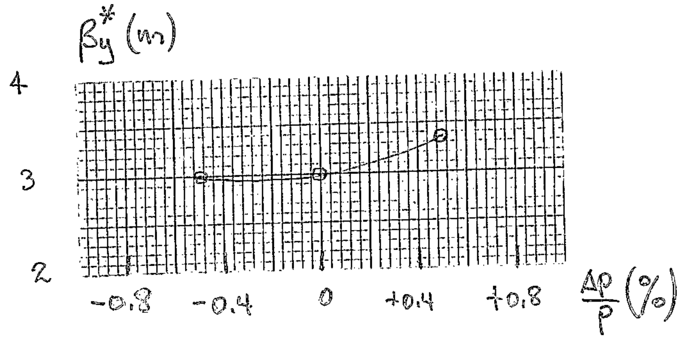


Table VII.- β_{max} in insertions is better with special sextupoles.
β_x = 267.322 and β_y= 667.463.





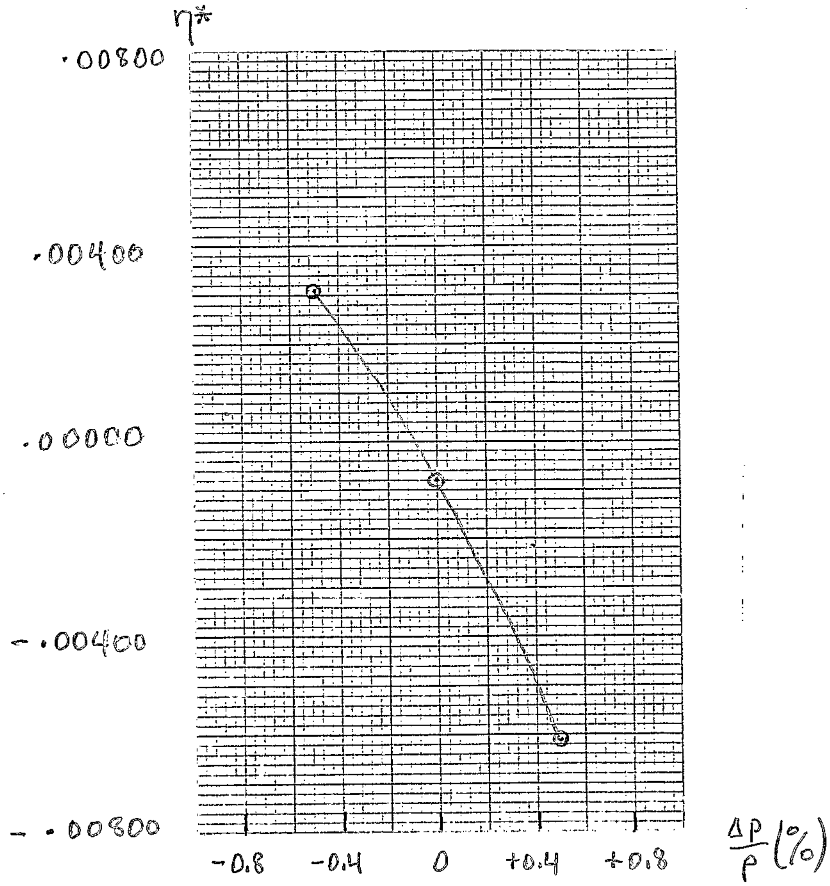


Table VIII.- In the crossing points β and η remain basically the same with and without special sextupoles.

The tune diagram still shows large tune dependence with amplitude, but smaller than in the previous case.

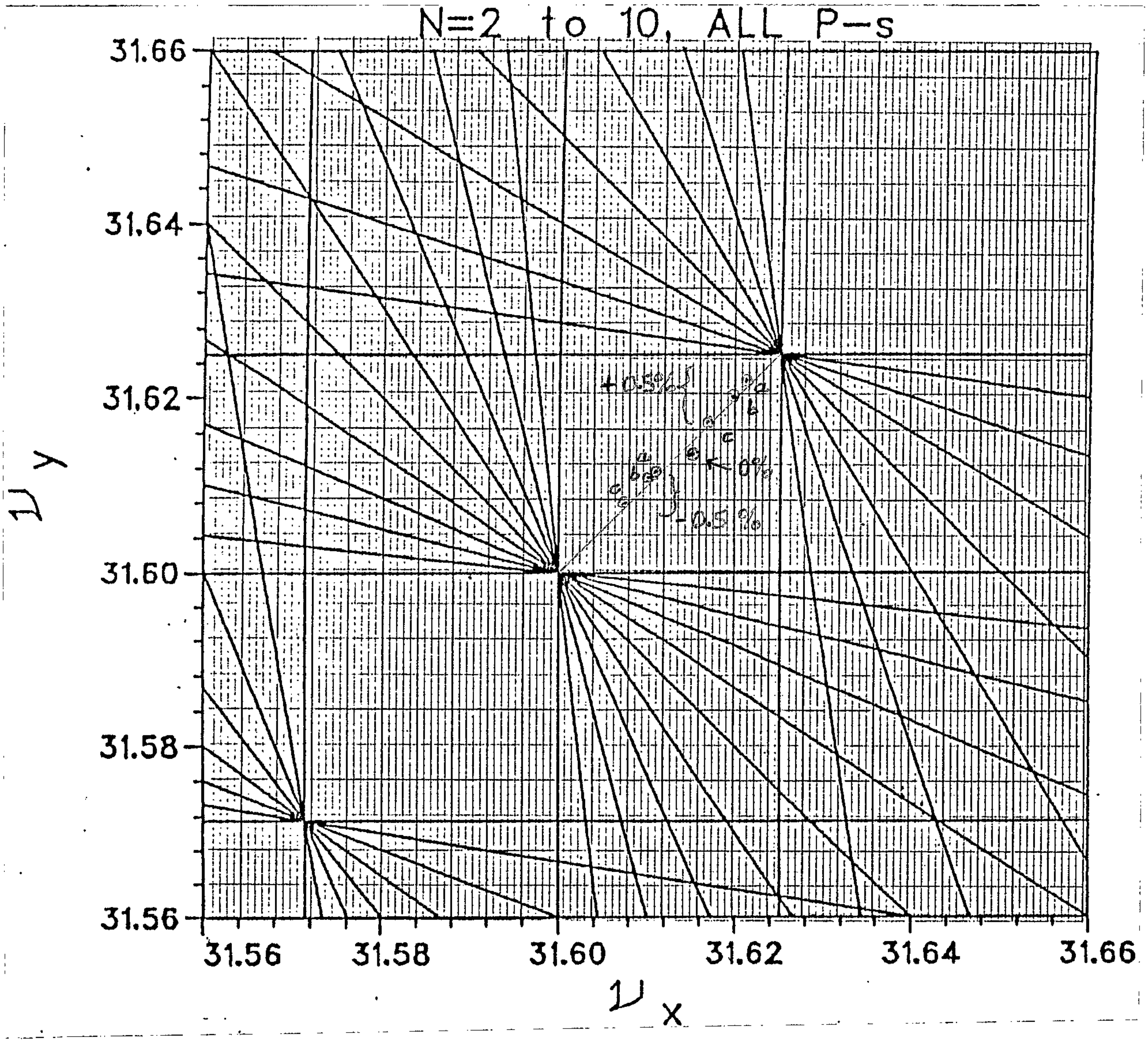


Table IX.- Tune variation with amplitud is a little bit better. Points a, b, c represent emittances 0, $1.5\pi \times 10^{-6}$ m -rad, $3\pi \times 10^{-6}$ m -rad. respectively.

Finally, phase space is much better with special sextupoles than only with SF, SD.

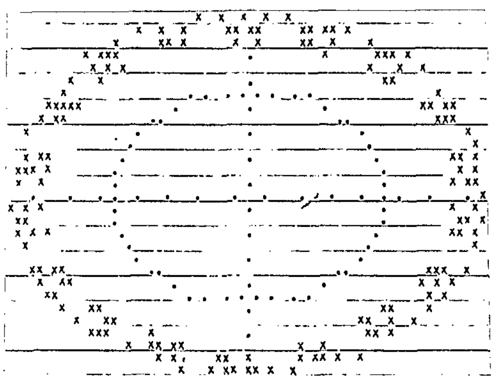
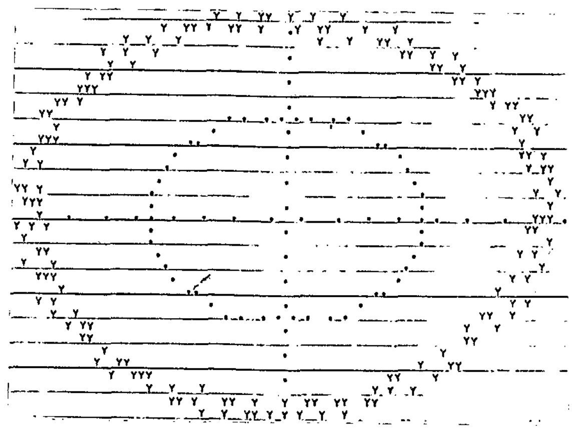
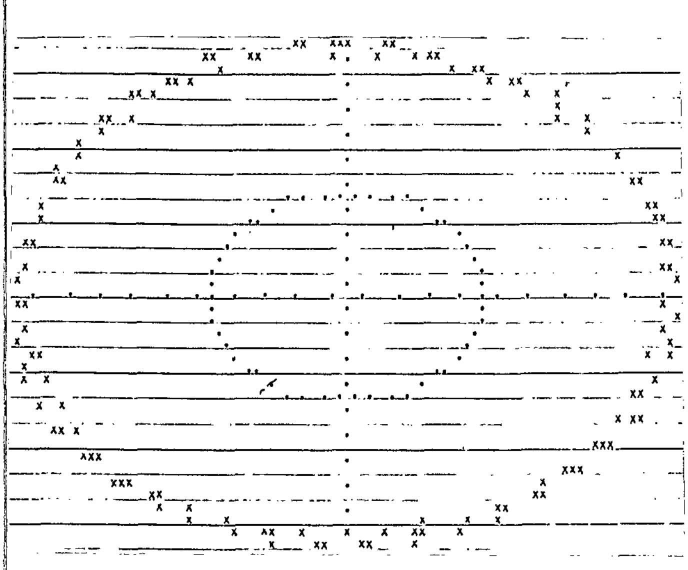
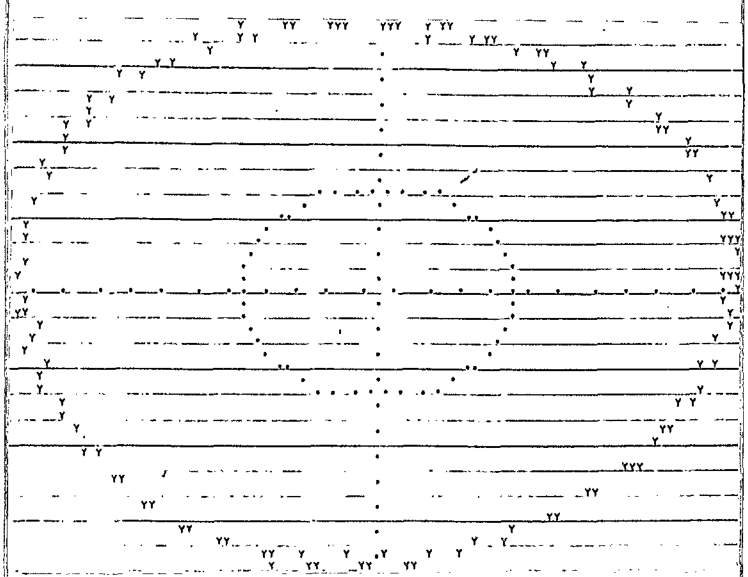
EMITTANCE	X DIRECTION	Y DIRECTION
1.5 π x 10^{-6} m-rad		
3 π x 10^{-6} m-rad		

Table Xa.

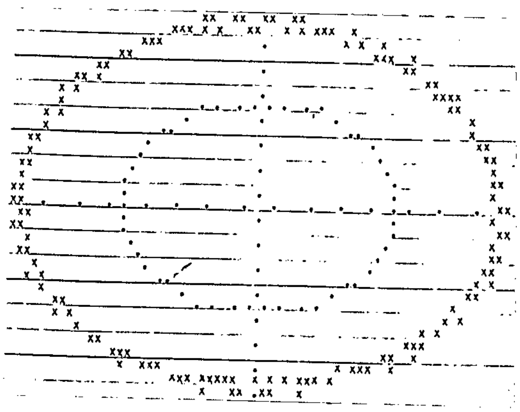
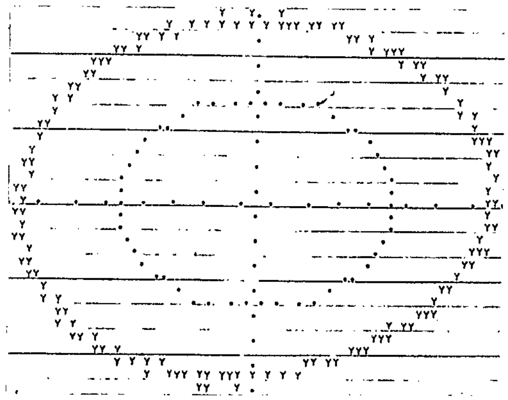
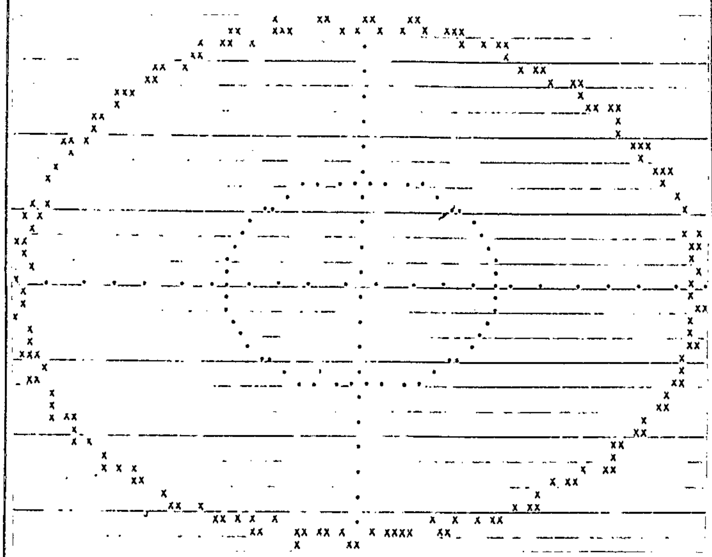
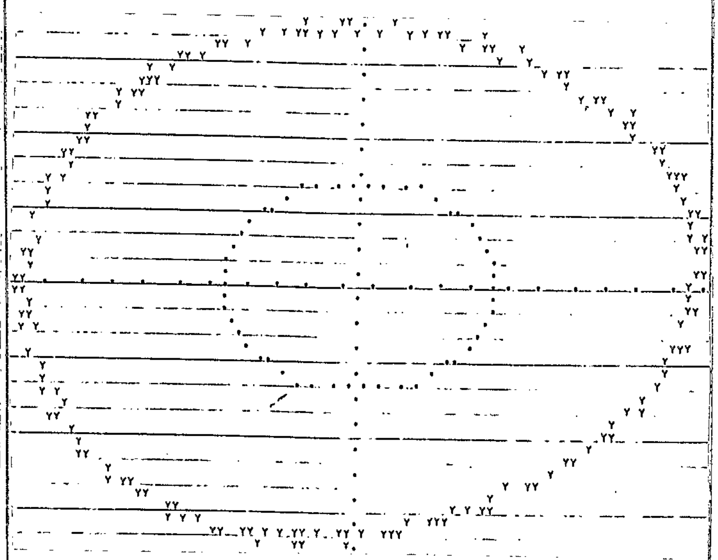
EMITTANCE	X DIRECTION	Y DIRECTION
$1.5\pi \times 10^{-6}$ m-rad		
$3\pi \times 10^{-6}$ m-rad		

Table Xb.

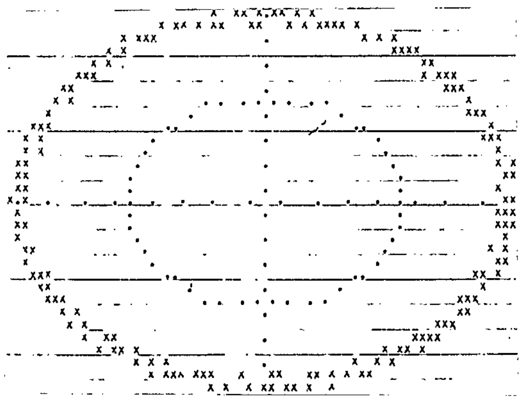
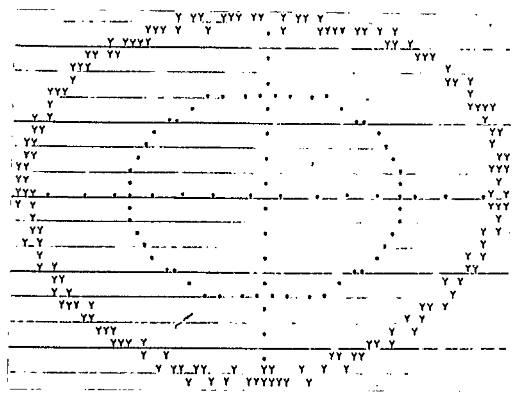
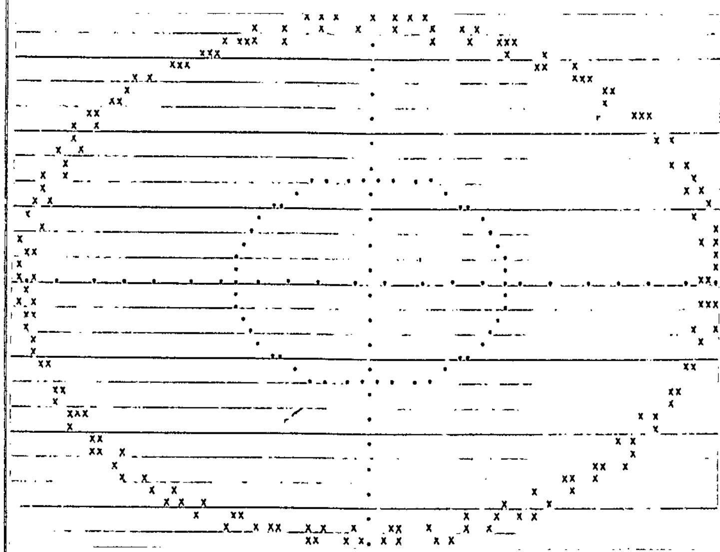
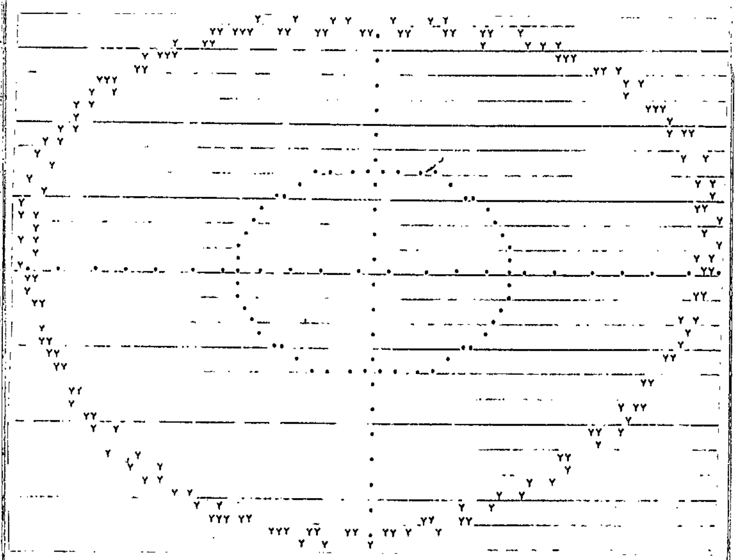
EMITTANCE	X DIRECTION	Y DIRECTION
1.5π $\times 10^{-6}$ m-rad		
3π $\times 10^{-6}$ m-rad		

Table Xc.

Table X.- a) x and y phase spaces for 100 turns and special sextupoles. Momentum 0%. b) Momentum 0.5%. Diffusion of points of phase space have been partially corrected. c) Momentum -.05%. Direction of phase space have been also partially corrected with special sextupoles.

4.- Summary.

We have used special families of sextupoles in the arcs of RHIC2 in order to reduce discomfort in phase space of higher order resonances. In general, chromatic behavior is better than with two families of sextupoles.

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