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# Aperture Study of the AGS Booster with and without Eddy Current Multipoles

G. F. Dell

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Collider Accelerator Department

**Brookhaven National Laboratory**

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*HIGH ENERGY FACILITIES*
*Brookhaven National Laboratory*
*Upton, N.Y. 11973*

# APERTURE STUDY OF THE AGS BOOSTER WITH AND WITHOUT EDDY CURRENT MULTIPOLES

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The aperture of the AGS Booster with the 1,2,4,7 sextupole configuration set for a chromaticity of zero and with or without eddy current multipoles has been studied by particle tracking (1) at four different tunes (Fig. 1) and five different momenta. The eddy current multipoles are those of Morgan (2) and are listed in Table I. In all cases the particles tracked had equal emittances in the horizontal and vertical directions.

| n | Strength $m^{-n}$ |
|---|---|
| 2 | $7.8 \times 10^{-1}$ |
| 4 | $-2.4 \times 10^{1}$ |
| 6 | $-1.6 \times 10^{3}$ |

Table I. Eddy current multipoles $b_n$ (Morgan[1]).

## A. TRACKING AT THE REQUIRED EMITTANCE

Particles were tracked for 400 turns with emittances of $30/\pi$ to $60/\pi$ mm mradians in steps of $10/\pi$ mm mradians for the following cases: a). SF and SD sextupoles only, b). case "a" plus $b_2$, c). case "a" plus $b_2$ and $b_4$, and d). case "a" plus $b_2$, $b_4$, and $b_6$. The particles were stable at all tunes and all momenta. In addition, 2500 turn runs were made for case "d" at the design emittance of $50/\pi$ mm mradians for three of the tunes (The fourth was inadvertently omitted). Again all particles were stable. These results as well as the particle tunes, derived from a Fourier analysis of the tracking data, are listed in Table II. The apertures listed are the radial dynamic aperture $A(r) = ((\beta_x + \beta_y)\,\epsilon)^{1/2}$ with $\epsilon$ being the emittance.

## B. DYNAMIC APERTURE

The dynamic aperture of the booster was determined for case "d". A preliminary aperture was obtained from tracking runs of 600 turns. Then the initial amplitudes were decreased by approximately 5mm and 2500 turn runs were made to assure that the motion was stable at these amplitudes. The radial dynamic aperture and the associated particle tunes are listed in Table III.

## C. TRACKING OF THE EJECTION LATTICE

During ejection, the strengths of four dipoles in one region of the booster are reduced by approximately one percent to introduce a radial excursion to the particles. this configuration was tracked for case "a", and again stability was observed. Based on 400 turn runs, the radial dynamic aperture is greater than 80 mm for $-0.5 \leq \Delta P/P \leq 0.5\%$.

## SUMMARY

1. Except for the operating point of $\nu_x = 4.735$, $\nu_y = 4.740$, all radial dynamic apertures are at least 75 mm throughout the momentum range mentioned above. At (4.735, 4.740), the radial dynamic aperture is ~55 mm.

2. The most significant feature in the shape of the phase plots is the indication of coupling between the horizontal and vertical motion. This appears in Fig. 2 as the radial width of of the plot. Even with this coupling, the dynamic aperture is significantly greater than what is needed.

## REFERENCES

1. H. Wiedemann, PEP-220, SLAC, 1976.
2. G. Morgan and S. Kahn, Booster Tech Note #4.

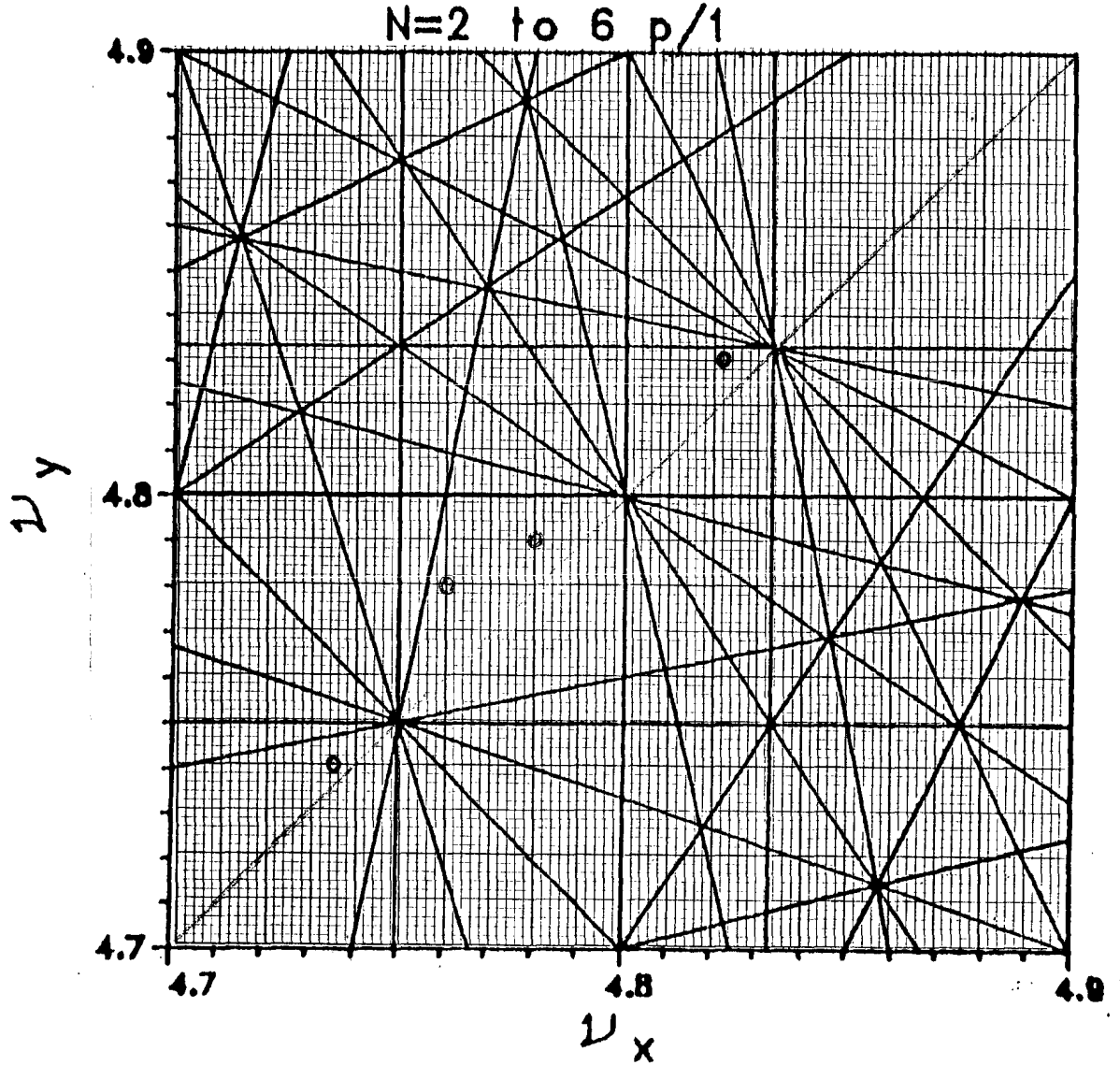


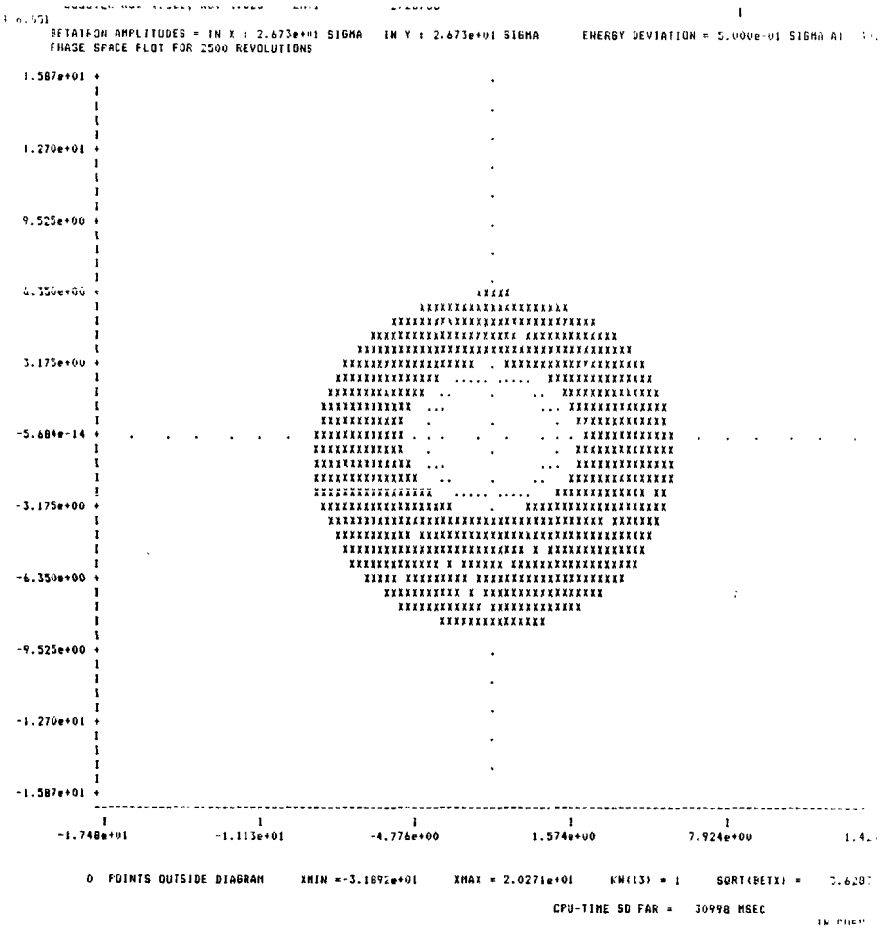

Fig. 1 Four operating points at which tracking was done for the AGS Booster. Tunes are: (4.735, 4.740), (4.760, 4.780), (4.780, 4.790) and (4.822, 4.830) with ($\nu_x$, $\nu_y$)

| | ΔP/P(%) | | | | |
|---|---|---|---|---|---|
| TUNE | -0.5 | -0.25 | 0.0 | 0.25 | 0.5 |
| 4.822/ | S | S | S | S | S |
| 4.830 | 4.8216 | 4.8220 | 4.8228 | 4.8220 | 4.8216 |
| | 4.8372 | 4.8380 | 4.8380 | 4.8380 | 4.8372 |
| 4.780/ | S | S | S | S | S |
| 4.790 | 4.7836 | 4.7796 | 4.7804 | 4.7796 | 4.7792 |
| | 4.7972 | 4.7968 | 4.7968 | 4.7964 | 4.7964 |
| 4.735/ | S | S | S | S | S |
| 4.740 | 4.7348 | 4.7372 | 4.7360 | 4.7352 | 4.7348 |
| | 4.7472 | 4.7476 | 4.7480 | 4.7476 | 4.7472 |

Table II. Tracking results for case "d" (all eddy current multipoles) for 2500 turns runs with $\epsilon_x = \epsilon_y = 50/\pi$ mm mradians $\rightarrow$ A(r) = 26.9 mm. Entry "S" denotes stable particle.

| TUNE | ΔP/P(%) | | | | |
|---|---|---|---|---|---|
| | -0.5 | -0.25 | 0.0 | 0.25 | 0.5 |
| 4.822/ | 81.6mm | 87.0mm | 81.6mm | 87.0mm | 76.2mm |
| 4.830 | 4.8304 | 4.9188 | 4.8228 | 4.8340 | 4.8492 |
| | 4.9068 | 4.9188 | 4.8380 | 4.9196 | 4.8988 |
| 4.780/ | 92.5mm | 92.5mm | 92.5mm | 92.5mm | 87.0mm |
| 4.790 | 4.7836 | 4.7888 | | 4.7996 | 4.7840 |
| | 4.8804 | 4.8788 | | 4.8876 | 4.8688 |
| 4.735/ | 49.0mm | 54.5mm | 54.5mm | 54.5mm | 49.0mm |
| 4.740 | 4.7400 | 4.7404 | 4.8000 | 4.7444 | 4.7452 |
| | 4.7636 | 4.7712 | 4.8840 | 4.7712 | 4.7640 |

Table III. Radial dynamic aperture plus particle tunes. 2500 turn runs. Case "d" (all eddy current multipoles).



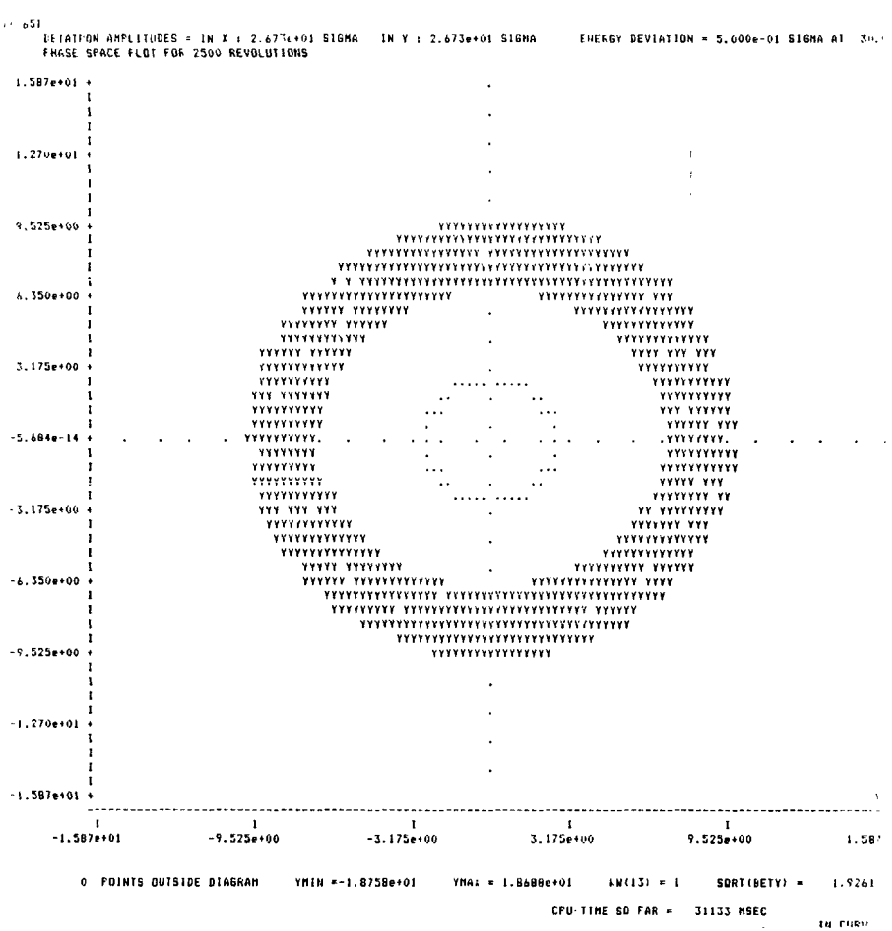




Fig. II X and Y phase plots at $\Delta P/P = -0.5\%$ with $\nu_x(0) = 4.822$, $\nu_y(0) = 4.830$. 2500 Turn runs.

$\epsilon_x(0) = 50/$ mm mradians
$\epsilon_x(\max) = 51.9/$ mm mradians

$\epsilon_y(0) = 50/$ mm mradians
$\epsilon_y(\max) = 94.3/$ mm mradians