Pbar Note: 489
Revised

DEBUNCHER APERTURE STUDY

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INTRODUCTION

Debuncher aperture studies made during 1987 and 88 (Ref.1) with stochastic cooling tank in and tank out revealed that the physical dimensions of the pick-up and kicker electrodes limit the transverse apertures of the debuncher. It was concluded that an optimum increase of the transverse gap between electrodes from 3.0 cm to 4.0 cm (tapered dimensions vary) would give debuncher apertures as high as 30.0π-mm-mr, and also give higher pbar yield. After 1988-89 collider run the electrode gaps in the debuncher stochastic cooling tanks have been increased to achieve the above goal.

This report presents the data on the debuncher apertures measured during January-March 1990 and a comparison with previous data.

THEORY OF MEASUREMENT TECHNIQUE

The transverse displacement of a beam particle resulting from the betatron oscillations in a storage ring is given by (Ref. 2)

$$x = \sqrt{\beta_x(s)\varepsilon_x}\cos(\psi(s)+\delta)$$

where $\beta_x(s)$ is beta function of the lattice and can be obtained from lattice calculations of the ring. The ε_x is the horizontal emittance of the beam. The ε_x increases by heating the beam and finally the beam occupies complete horizontal aperture of the ring. Thus, for a heated beam the maximum size of the beam at any point s in the ring is determined by a limiting device. Hence the limiting aperture of the ring A_x is related to the maximum transverse displacement of a beam particle by

$$x_{max}(s) = \sqrt{\beta_x(s)A_x}$$

The x_{max} can be measured using a scraper. Similar expression can be obtained for vertical displacement of the beam.

MEASUREMENTS

Proton beam pulse of about 2-5 $X10^{10}$ particles per batch was extracted from the Main ring and injected into the debuncher in the reverse injection mode. In this mode the accumulator and debuncher are operated in the normal pbar collection polarity. Hence the protons circulate in the reverse direction. The proton beam was injected into the accumulator via the AP1-AP3 beam line using A:EKIK and the beam is stored in the debuncher after extracting it from accumulator using kickers A:IKIK and D:EKIK. To get rid of off-momentum particles in the debuncher(which is <5% of the total intensity) the beam is scraped using momentum scrapers D:RJ410 and D:LJ410 . Then the beam is heated using D:IKIK and D:EKIK respectively for vertical and horizontal aperture measurements. These kickers generally operate at about 62kV. In the present study, to heat the beam without much loss (< 30%), the kickers were operated at lower voltages (7kV and 8kV for D:IKIK and D:EKIK respectively). The measurements on x_{max} and y_{max} have been made using the scrapers D:RJ306 (horizontal) and D:TJ308 (vertical) respectively. Finaly, β_x = 13.1 meter and β_y = 13.9 meter have been used to extract the limiting apertures.

The x_{max} and y_{max} can also be obtained by heating the beam using dampers, D:DPHAUX and D:DPVAUX respectively for horizontal and vertical cases. The aperture measurements with damper heated beam could be twice faster than with kickers. However, the apertures obtained by heating the beam using kickers are found to be more accurate than the one obtained by using dampers. This is because, in this method the beam is blown-up somewhat uniformly. Hence, the far edge of the aperture is distinct and can be located accurately. The beam without heating could be used to locate the core position precisely. And a combination of these two measurements determine the aperture. While dampers make use of only one measurement per data point. Generally the values with dampers are smaller than those obtained with kickers. In particular at dP/P =-2% the second method gave aperture to be about 30% smaller than the first method. Fig.1 shows a typical case of a comparison of horizontal aperture measurements at dP/P = 0.0 with kicker (solid curve) and with damper (dashed curve). These data have been taken with a similar amount of initial beam in the debuncher. We find that in this case, the values of the horizontal aperture obtained by two methods are the same within errors. However, in the case of vertical apertures, considerably large differences have been noticed. During this run we have observed that the D:DPVAUX was not responding as efficently as D:DPHAUX. This may have caused the large discrepency in the vertical aperture measurements. Therefore, here we present the data obtained only with the kickers.

To estimate the uncertainty in the measured values of aperture we used four different sets of measurements made at injection. A maximum deviation of 1.5π–mm-mr in horizontal aperture and 1.0π–mm-mr in vertical aperture have been obtained.

The apertures have been optimized at injection by moving movable tanks, applying closed orbit corrections. Finally momentum aperture measurements have been made by capturing the beam at injection frequency ($h = 90$, f_{RF} = 53.102976MHz) and selecting dP/P in the range -2.2% to 2.2%. The final values of apertures have been corrected for scraper calibraiton (Ref.3).

RESULTS AND DISSCUSSION

From the present measurements we have determined the apertures at injection to be,

$$A_x = 26.3\ \pi\ \text{mm-mr}$$

and $$A_y = 27.0\ \pi\ \text{mm-mr.}$$

Figs. 2 and 3 show a comparison of the present data as a function of dP/P with the data taken previously for stochastic cooling tanks out (June 1987) and for tanks in (Sept. 1987). In general we find that a considerable improvement has been achieved in both transverse planes by increasing the gaps between stochastic cooling plates. However, comparing the horizontal apertures obtained now and previous measurements (the one with tanks out) suggests that the aperture at injection could be at least 15% larger than we obtain. On the other hand vertical debuncher apertures are found to be larger than the previous values obtained without tanks which might have been the result of a number of improvements undertaken during past two years. These observations clearly show that at present the debuncher apertures are limited by other devices like horizontal and vertical bumps. These are under investigation.

We would like to thank Dr. J. Marriner for useful suggestions.

REFERENCES :

1) G. DUGAN, "Pbar yield measurement vs. debuncher acceptance and comparisons with predictions" PBAR NOTE 474.

2) D. A. Edwards and M.J. Syphers, "An introduction to the physics of particle accelerators" AIP Conference Proceedings Vol.184, Summerschool 1987 and 1988. ed M Month and M. Dienes p. 2

3) J. MARRINER, " Pbar scraper calibration" PBAR NOTE 471. We use new set of calibrations 1.2501 for D:RJ306 and 1.15747 for D:TJ308 which are obtained in a seperate measurements just before 1990 debuncher aperture studies.

CONSOLE LOCATION 08; AP1·

Fast Time Plot

8-MAR-1990 11:20

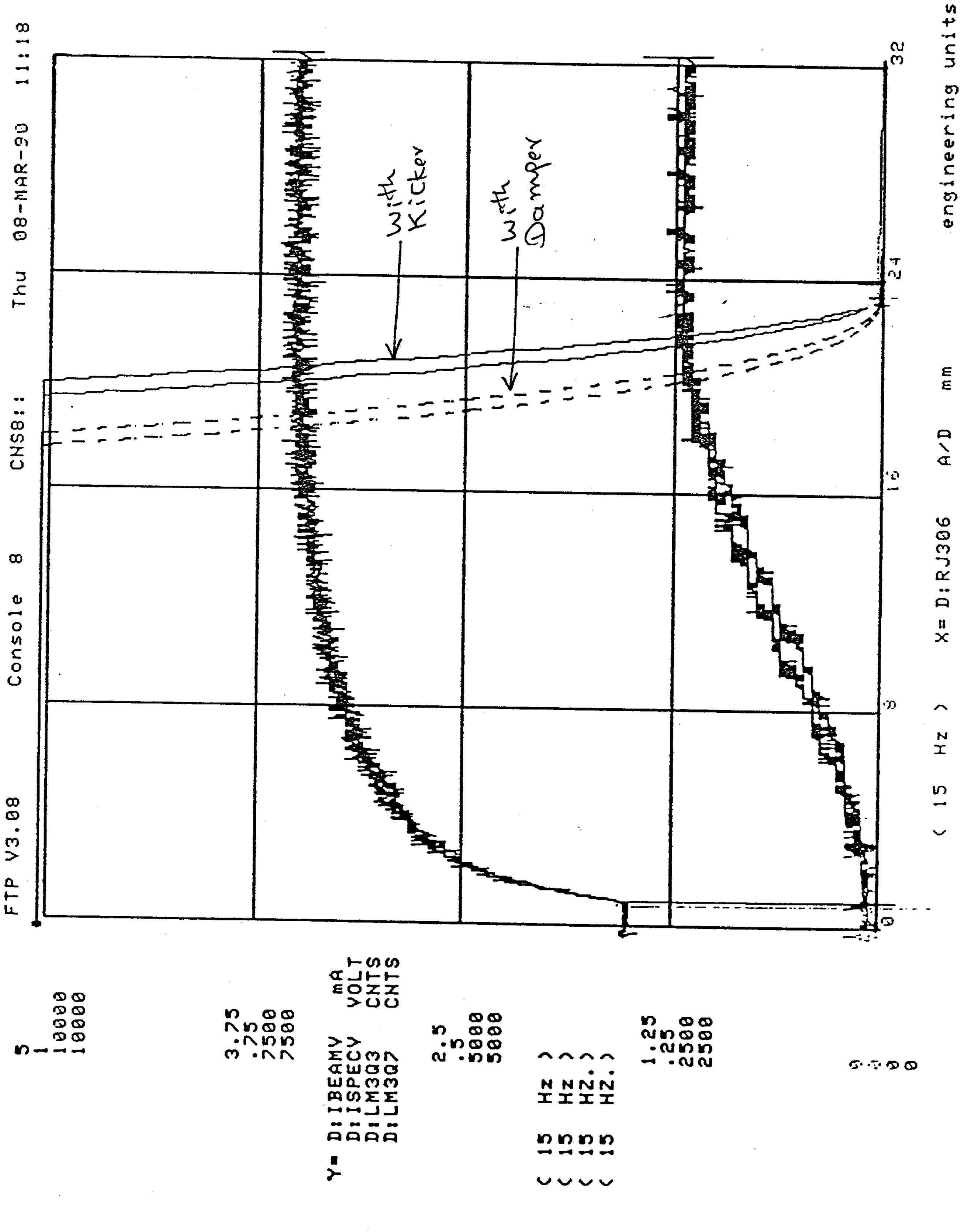
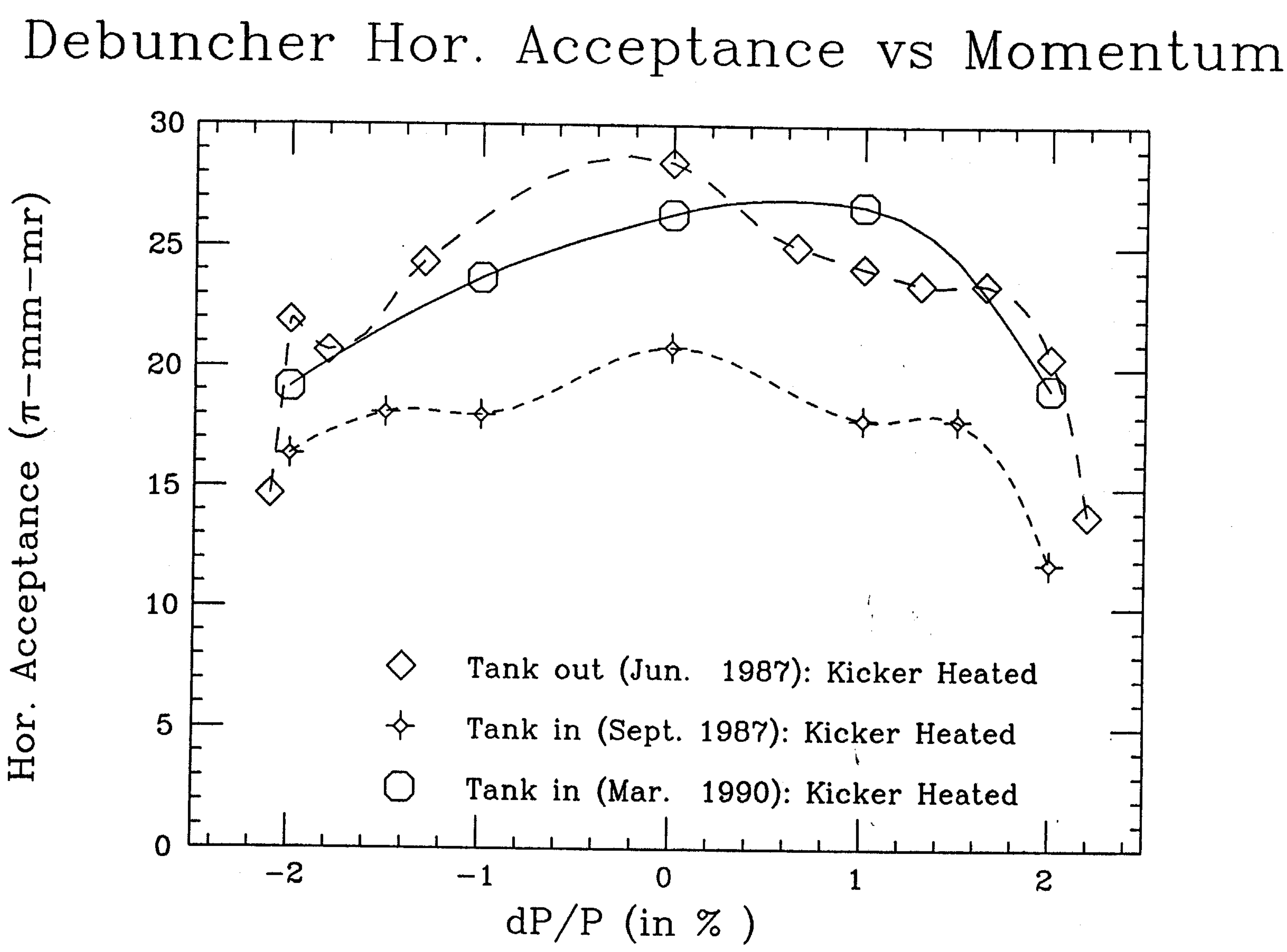


Fig - 1



Debuncher Hor. Acceptance vs Momentum
Hor. Acceptance (π−mm−mr)
30
25
20
15
10
5
0
−2
−1
0
1
2
dP/P (in %)
Tank out (Jun. 1987): Kicker Heated
Tank in (Sept. 1987): Kicker Heated
Tank in (Mar. 1990): Kicker Heated

Fig. 2

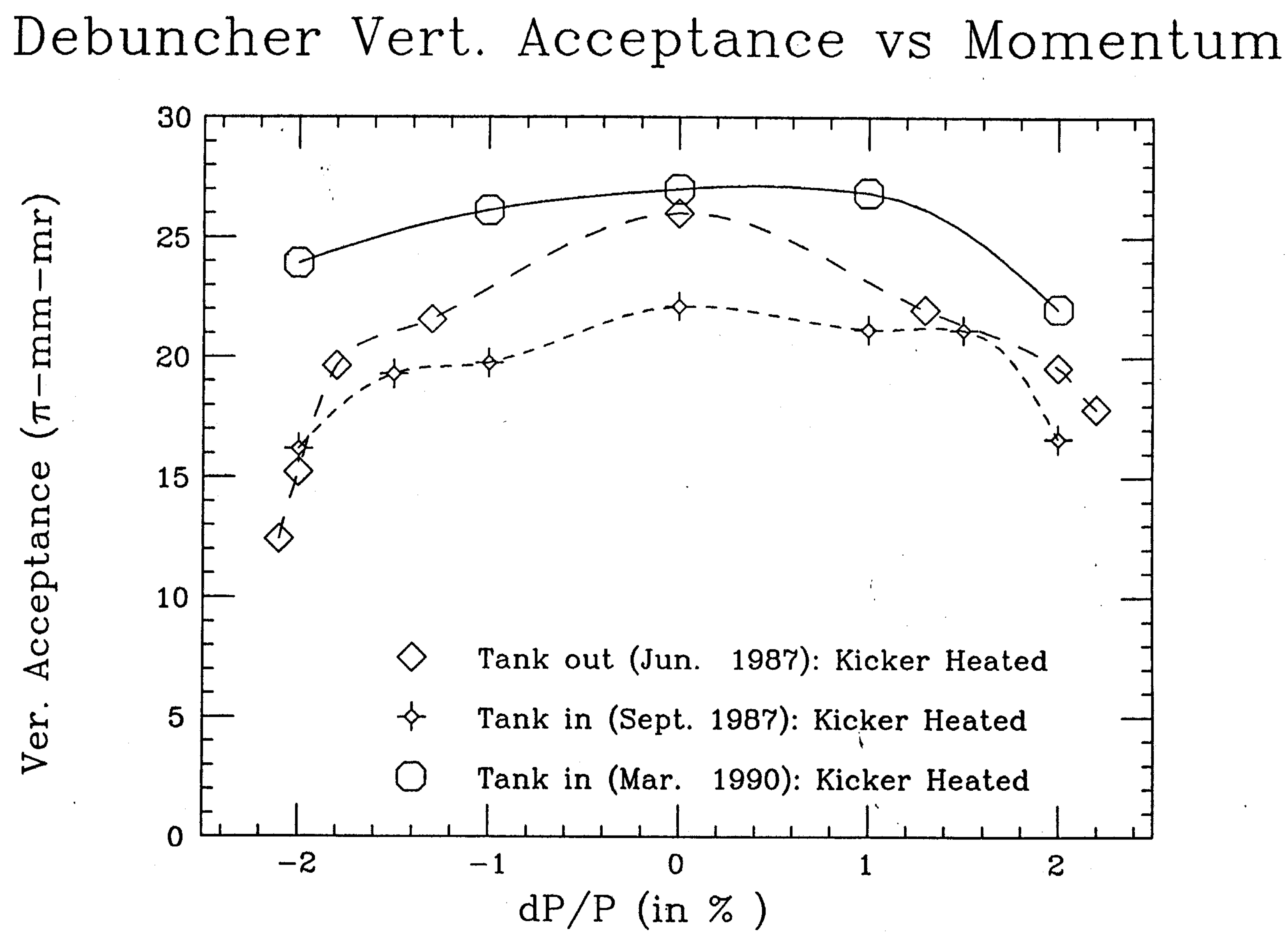

Debuncher Vert. Acceptance vs Momentum
30
25
20
15
10
5
0
−2
−1
0
1
2
Ver. Acceptance (π−mm−mr)
dP/P (in %)
Tank out (Jun. 1987): Kicker Heated
Tank in (Sept. 1987): Kicker Heated
Tank in (Mar. 1990): Kicker Heated

Fig. 3