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<u>EXPERIMENT</u>: Measurement of antiproton accumulation rates versus transverse aperture.

<u>DATES</u>: 6 & 7 August 1983

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Purpose

Transverse antiproton amplitude distributions measured in a zero dispersion region of the AA have fewer particles at large amplitudes than expected. This is thought to be mainly due to non-linear and some residual linear coupling within the machine.

Another distribution equally important in determining the usefulness of transverse acceptance, is that of the antiproton accumulation rate versus aperture.

Antiproton depletion at large transverse amplitudes during precooling, RF capture and deposit has already been observed (AA/ME/Note 52) but the aperture dependence of the entire cooling and stacking process, involving amplitude redistribution at all stages, has not hitherto been measured.

Method

During stable machine conditions the normalised antiproton stacking rates, given by the reciprocal of the missing factor, were measured for various apertures determined by single scrapers in section 1302. Between each measurement at reduced aperture a full-aperture measurement was made. The missing factors were averaged over 150 cycles. As this study was done during operational stacking, we imposed the condition that the overall 24-hour stacking rate should not be decreased by more than 5% on account of these measurements. We expect through a better understanding of the machine to gain back much more than this amount in the long term.

Results

Horizontal distributions were measured during the night of the 5/6 August when the full-aperture stacking rate was exceptionally stable (missing factor 6 +/-.05). The stack intensity was 7 Exp+10 and the AA was taking 4/5 cycles. Vertical distributions were examined during the following night but due to a PSB fault they had to be abandoned after only four measurements. The normalised stacking rates with respect to the horizontal half-aperture using inner or outer scraper and the vertical half-aperture using the top scraper are shown in Figure 1. Owing to the limit imposed on the reduction of AA performance we did not explore the region below the half-aperture of 16mm. The accumulation rate is 50% of the full-aperture value when the horizontal aperture is 40 pi mm mrad.

Differential stacking rates are shown in Figure 2. Antiproton amplitude distributions in the injection region are also plotted and roughly normalised to fit the differential stacking rate to facilitate comparison of the shapes of the two distributions. This fit is crude since in neither the horizontal or the vertical case did we clearly measure the maximum of the distribution. However, it seems that the shape follows that of the antiproton amplitude distribution with slightly greater weight towards large amplitudes. This is at first sight somewhat surprising since horizontally the maximum beta-function and acceptance are in the injection region and so transverse amplitudes in stack or stack-tail should be less than those around injection.

However, we observed on inserting the scraper an immediate loss from the stack or stack-tail and on removing the scraper the stacking rate improved by a few percent compared to the rate under stable conditions. About 5 minutes was required to re-establish equilibrium conditions. G.Carron has pointed out that this latter effect is probably due to the greater efficiency of the stack tail cooling after a period of stacking at reduced rate, but the loss on inserting a scraper indicates the presence of a large amplitude tail presumably due to some partial heating by one or more of the cooling systems.

We did not measure antiproton loss rates at each scraper position, but it may well be that the loss rate rises as the aperture is reduced. Then the decrease of stacking rate with aperture would be a combined effect of increased stack loss rate together with a reduction in the antiproton yield as the scraper cuts into the injection aperture. Then we would expect the initial fall-off in stacking rate (Fig.1) to be steeper than the fall-off of yield with aperture, and this is just what we see in Fig. 2a where the two gradients are plotted.

Conclusion

Under present conditions a marginal increase in AA horizontal aperture gives slightly greater benefit in accumulation rate than in yield alone. This may also be the case vertically. These findings depend upon stack loss rate, which will itself depend on adjustment of the cooling systems and the stack intensity.

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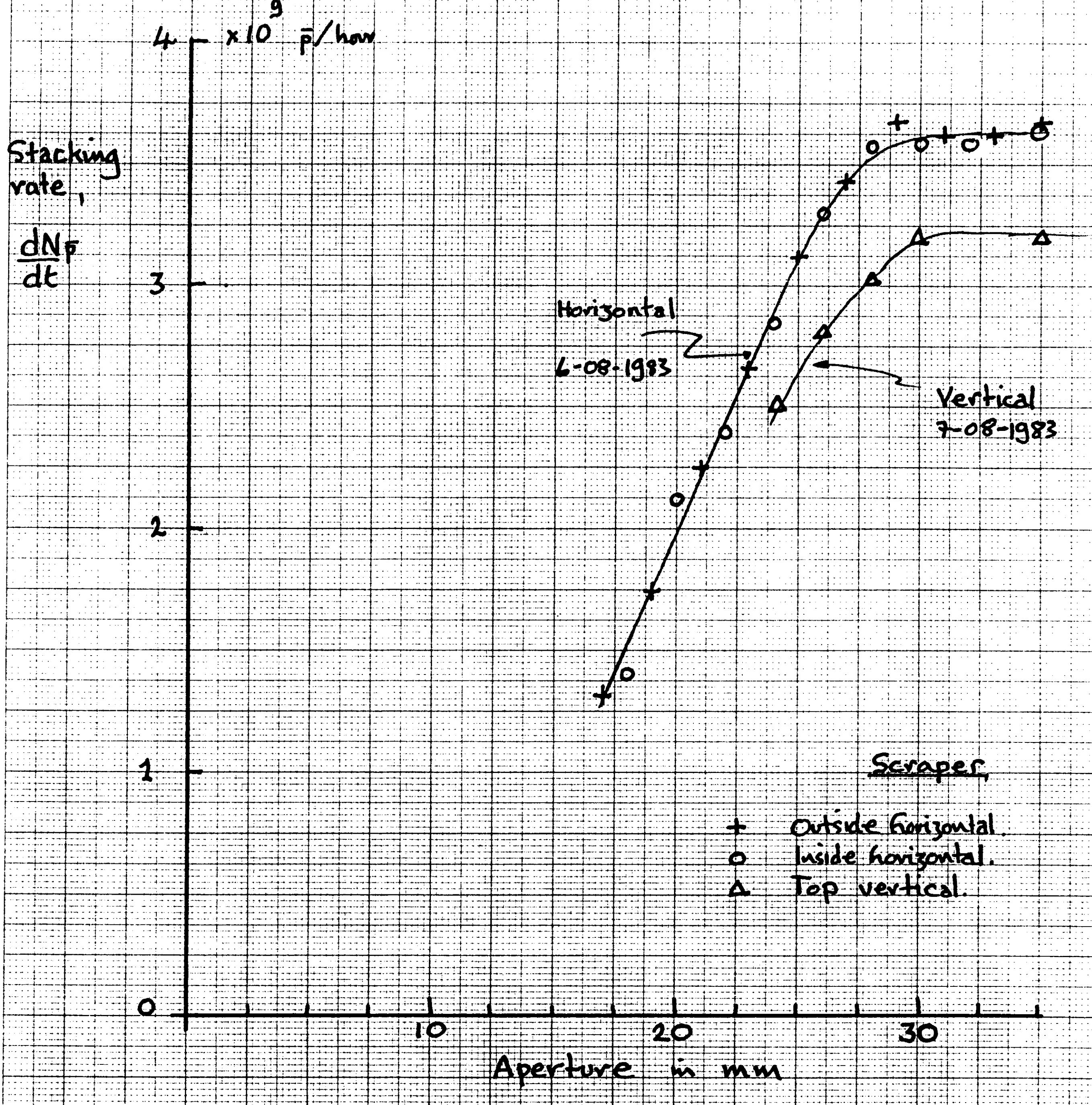

FIG. 1 AA accumulation rate, $\frac{dN_{\bar{p}}}{dt}$, versus aperture in section 13-02, normalised to 10^{12} ppp and full cycle rate.

Experimental conditions : 4/5 Cycles

$I_p \simeq 1120$ ppp

6-08-1983 Stack = 70×10^9 $\bar{p}$

7-08-1983 Stack = 140×10^9 $\bar{p}$

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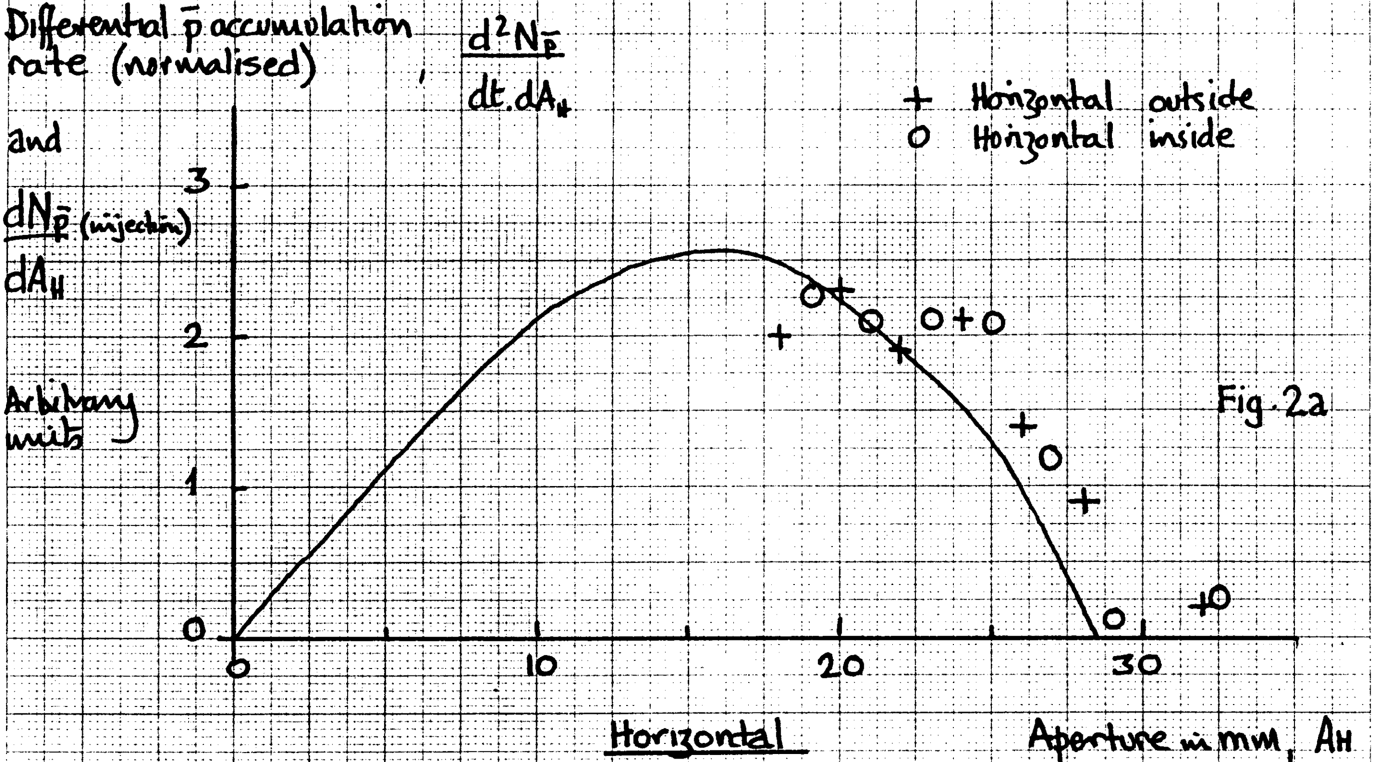

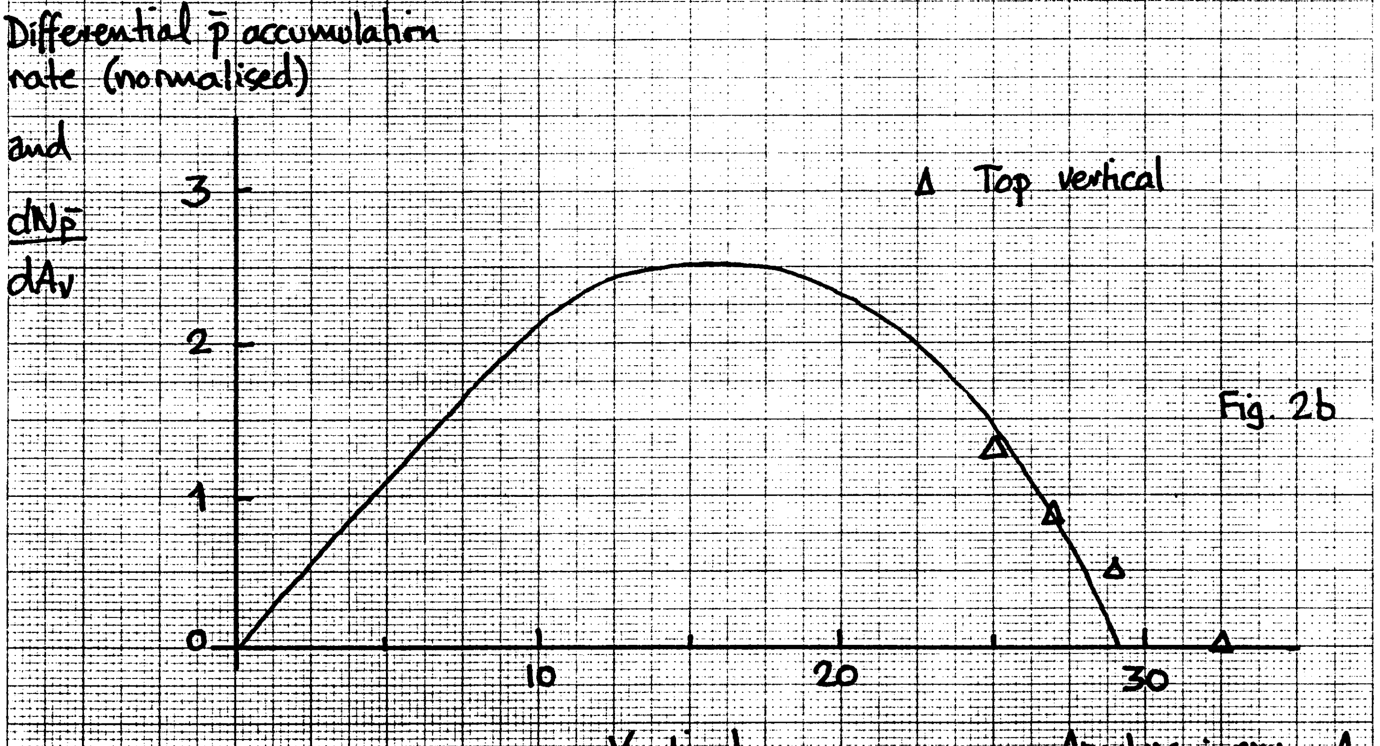

FIG. 2 A comparison between the $\bar{p}$ amplitude distributions measured in the $\alpha_p = 0$ region of the AA (full curves), and the differential $\bar{p}$ accumulation rates versus aperture in horizontal and vertical planes (experimental points). The vertical scales have been adjusted to allow comparison of the shapes of the distributions.

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