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EXPERIMENT : Measurement of Emittance Increase in Transferring the 3.5 GeV/c Test Proton Beam from the PS to the AA

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Summary

Beams of known transverse size were transferred to the AA where their sizes were remeasured. The results for the vertical plane are more reliable. Depending on the fraction of the beam intensity considered, the results were:

	Fraction of beam in PS(%)	Fraction of beam in AA(%)	$\varepsilon_{AA}/\varepsilon_{PS}$
vertical plane	100	100	3.6
	100	95	1.5
	95	95	$\approx$ 2.0
horizontal plane	100	100	4.3
	100	95	1.1

1. Introduction

This note explains the method of arriving at the results given in the summary and gives the assumptions and machine paramameters used.

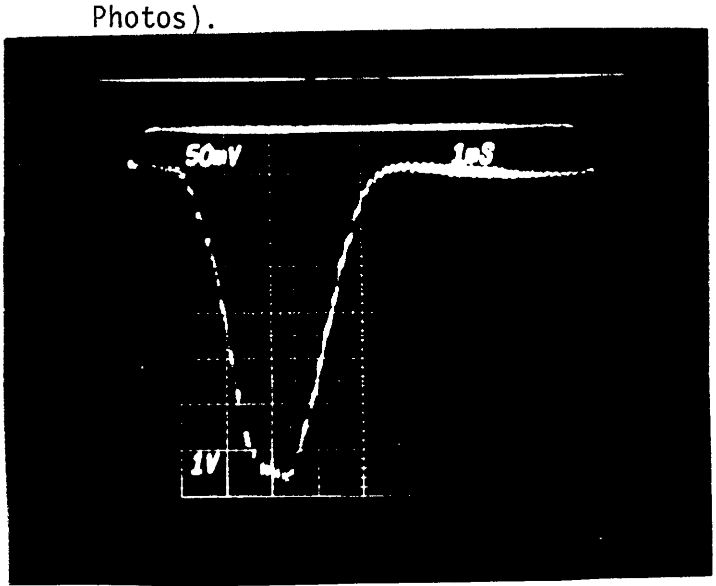
The beam size was limited in the PS using the measuring targets which are forks with independent position adjustment of the two sides.

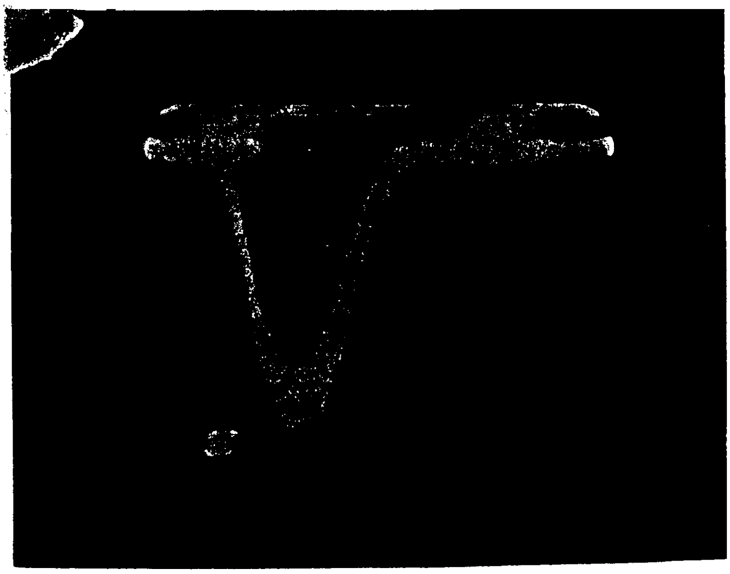
This enables a maximum emittance to be defined. In the case of the vertical a beam profile was obtained after the insertion of the target.

2. Vertical Plane

The target was flipped in on the flat top just before ejection (20 ms). The position of each side was adjusted separately to cause a 10% beam loss. The width set was 8.6 mm. For β_V = 21.7 at the target this gives an emittance of 0.85 mm.mR. This emittance is an upper limit for 100% of the beam.

The vertical beam profile was also measured with the wire scanner (see Photos).





Wire velocity is 1.84 m/s

The total width estimated to be between 3.3 and 3.7 mm corresponding to an emittance of 0.9 to 7.7 mm.mR.

Only the first half of the scan was used since at 3.5 GeV/c scattering leads to a broading of the profile. Even so the estimate of the emittance with the wire is likely to be enhanced by about 0.1 to 0.2.

3. Horizontal Plane

Here the situation was more complicated. First we had on the flat top a period during which 5 bunches are circulating followed by the loss of 4 bunches using the full aperture kicker, then stabilization of the remaining bunch at h = 6. It was then found that there was insufficient time to insert the target before ejection. As a compromise the target was inserted during the period when 5 bunches were in the ring. Later manipulation may have contributed to the long tail seen in the AA. The beam before the target was flipped in and had a width of about 40 mm. This was reduced to 17.3 mm with the target and the loss of beam compensated by increasing the vertical emittance (Booster scrappers). In determining the radial emittance the effect of momentum spread has to be allowed for. The measured width ω is taken as

$$\frac{\omega^2}{4} = \beta_H \ \varepsilon_H + \left(\alpha_p \frac{d_p}{p}\right)^2$$

$\beta_{H_{PS}} = 21.7$, $\alpha_p = 3.65$, $d_{p/p} = 1.2 \times 10^{-3}$ (longitudinal emittance = 75 mR, bunch length 60 ns, bucket height 0.39 eV, h = 6 at ejection).

For ω 17.3, $\varepsilon_H = 2.6$ mm.mR.

This estimate for ε_H is less accurate than ε_V and furthermore no substantiating wire scan could be made at the time of the ME.

4. Measurements of Beam Width in the AA

Beam profiles were measured with the scrappers in ss 13 ($\alpha p = 0$, $\beta_V = 9.7$, $\beta_H = 8.6$) and coherent oscillation amplitudes measures at BLG23 pick-up ($\beta_V = 10.9$, $\beta_V = 17.9$). The ejection path was such that nearly all beam passing through the last part of the ejection line was captured. (Measurement fraction 100% but this could be perhaps only 90% since the intercalibration of the ejection line transformer and ring transformer is not properly known.)

The following results were obtained; the measured radii were corrected for the measured coherent oscillations measured at the BLG23 pick-up ($\beta_V = 10.9$, $\beta_H = 17.9$).

Shot	Scraper	Radius (100% of beam) mm		$\varepsilon_{100} \cdot 10^6$	Radius (95% of beam)		$\varepsilon_{95} \cdot 10^6$	Coherent Oscillation
		Measured	Corrected	mm mR	Measured	Corrected	mm mR	mm
1	V top	6.4	5.6	3.3	4.0	3.2	1.1	0.8
2	V bottom	6.6	5.8	3.5	4.2	3.4	1.2	0.8
3	V bottom	6.6	5.8	3.5	4.1	3.3	1.2	0.8
4	V top	7.4	5.7	3.4	6.2	4.5	2.1	1.8
5	V bottom	8.1	6.4	4.2	5.7	4.0	1.7	1.8
6	H inside	10.0	9.8	11.1	5.4	5.2	3.1	0.3
7	H outside	11.3	11.1	14.3	5.1	4.9	2.8	0.3
8	H inside	10.0	9.1	9.6	5.9	5.0	2.9	1.3
9	H outside	very long tail		---	5.7	4.8	2.7	1.3

Reported by R. Sherwood