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Injection machine parameter measurement

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OBSERVATIONS AND CONCLUSION

As part of the injection steering instrumentation, signals from a few sets of "conversion" pick up electrode pairs are amplified in the ring and available in the MCR in analogue form for forming difference signals using scope amplifiers and hence give position information for injected beam pulses of less than one turn duration. The resulting wave form is primarily used to tune the injection steering by nulling the observed oscillations; but to better understand the information a particular unsteered radial situation (C2 PUE) was photographed (Fig. 1) and the first 35 passes measured by hand and then fit to a certain hypothesis. The reduced data and fit are shown in Fig. 2.

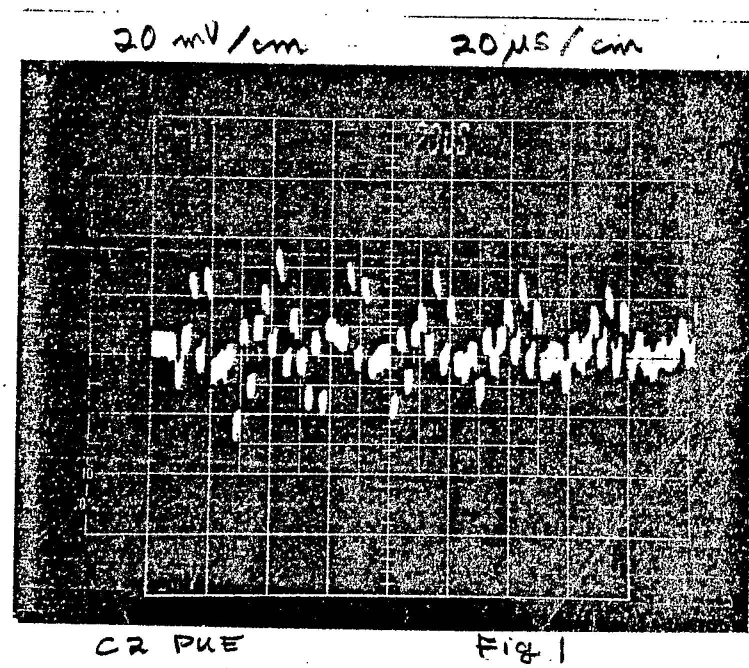


Fig. 1. C2 PUE

The function fit was:

$$A \cos\,[2\pi k\,(B + Ck) + D]\,\left(\frac{\sin 2\pi kE}{2\pi kE}\right) + F + kG$$

B is the initial radial tune

C the change in tune per turn

D the initial phase

E the tune spread in the beam which causes the signal to decrease with time

F an offset

G the radial shift per turn.

The naive interpretation of the results from the fit are as follows:

1. The initial tune is 8.809 ± .0005
2. The tune spread is .011 ± .0005
3. The tune charge/turn is $(5.3 \pm .15) \times 10^{-4}$
4. The radial shift/turn is -(.014 ± .002) cm/turn.

The last uses the PUE sensitivity of 6 cm $\left(\frac{V_1 - V_2}{V_1 + V_2}\right)$ and the observation that the sum for the above situation was 100 mV.

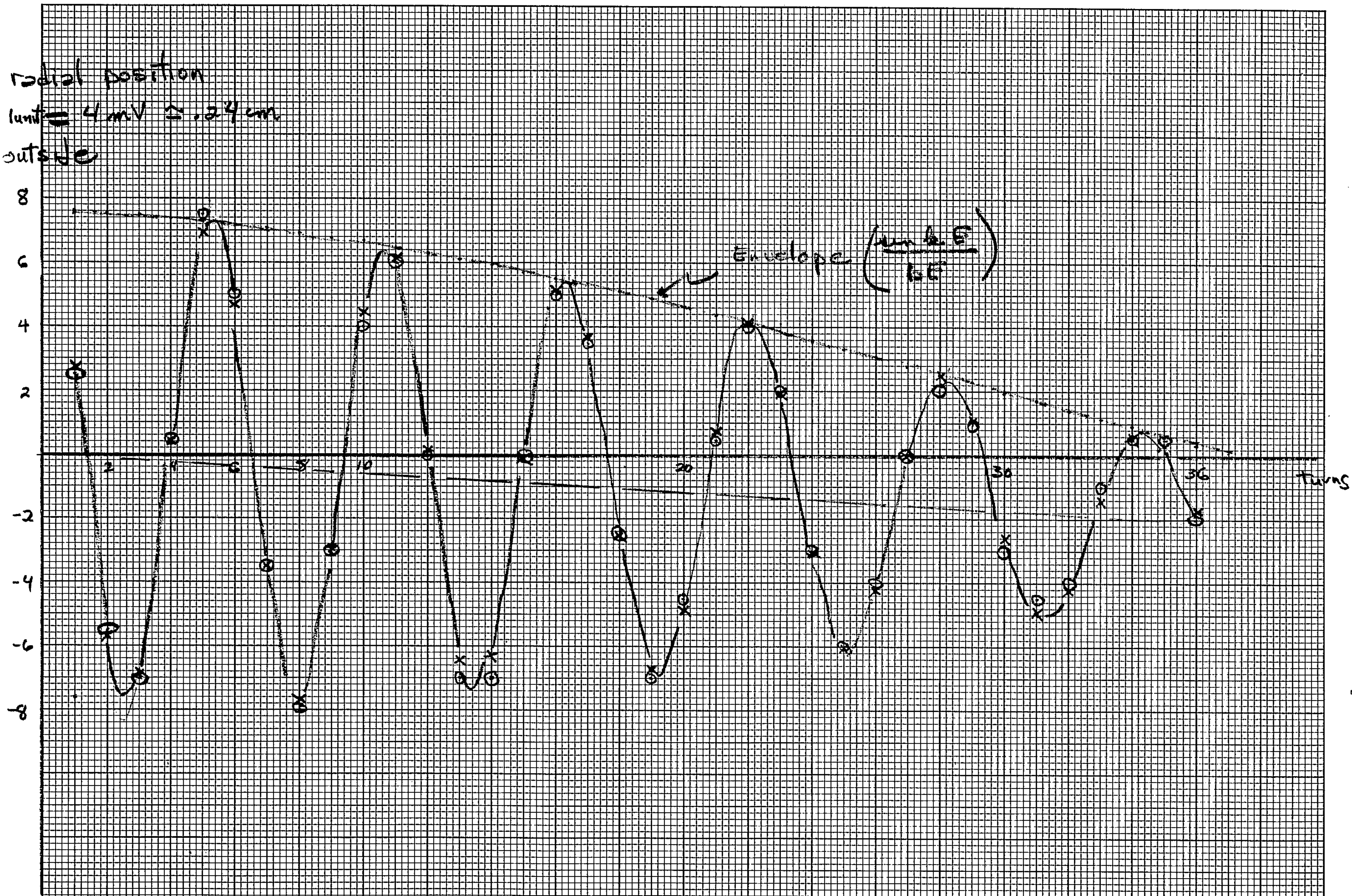
Point 4 is explained by the $\dot{B}$ at injection, (4.5 kG/sec) B at injection (250 Gauss) so $\frac{\Delta B}{B}$/turn = 8.6×10^{-5}/turn; $\frac{\Delta R}{R} = \alpha \left(\frac{\Delta p}{p}\right) = \alpha \left(\frac{\Delta B}{B}\right)$; $\alpha \approx \frac{1}{\nu_x^2}$; $\rightarrow \frac{\Delta R}{R} = -1.1 \times 10^{-6}$/turn or ΔR/turn = $-\ 1.43 \times 10^{-2}$ cm then 3 and 4 together give $\Delta\nu/\Delta R$ = (.038 ± .007) cm^{-1} or if we use the $\dot{B}$ calculation = (.037 ± .001) cm^{-1} and a horizontal chromaticity $\xi = \frac{\Delta\nu}{\Delta p/p} = \left(\frac{\Delta\nu}{\Delta R}\right) \Delta p = -\ 6.4 \pm 1$.

Alternately (2) taken with a value for $\frac{\Delta p}{p}$ = .2% from the Linac gives $|\xi| = \frac{(.011)}{2\times10^{-3}} = 5.5 \pm 2$. The tune spread is deduced from the attenuation of oscillations--which could be "faked" by a real beam loss (none seen).

The value of chromaticity is very near that expected for a pure linear machine ($\xi \approx -\nu$).

The fit χ^2 per degree of freedom was 1 for a measurement error (RMS) on the points of Fig. 1 of .3 units ~ 1 mV.

As a check, the fit was applied to the first 18 points (half the sample) with little change in the parameters.



C2 horizontal PUE

Fig 2