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Polarization and Radius

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Subject Polarization and Radius

Observations and Conclusion

A radial shift bracketing the $G\gamma=0+\nu$ intrinsic resonance was varied by 1 centimeter in several steps while recording the polarization measured by the high energy polarimeter (13.3 GeV/c D line), the rf frequency, and the beam transverse width just after the excursion. The polarization results are adequately explained in terms of the known relations among radius and vertical tune and momentum. Any effect on polarization due to the beam position in the quadrupoles is not significant at this energy.

A radial shift was added to the radial loop program which adequately bracketed the $0+\nu$ fast quad pulse (see figure 1). This, incidentally, meant the radius was shifting during the $G\gamma=8$ and $G\gamma=9$ imperfection resonances. By measuring the change in revolution frequency caused by the shift, the radial shift and momentum shift are directly calculable:

$$\frac{dB}{B} = \gamma^2 \frac{df}{f} + (\gamma^2-\gamma^2_{tr}) \frac{dR}{R} \quad \text{and} \quad \frac{dB}{B} = \gamma^2_{tr} \frac{df}{f} + \frac{\gamma^2-\gamma^2_{tr}}{\gamma^2} \frac{dp}{p}$$

$dB = 0$ since we measure at fixed Gauss Clock Counts (GCC) so:

$$\Delta R = \frac{-\gamma^2}{\gamma^2-\gamma^2_{tr}} R \frac{\Delta f}{f} \qquad \Delta P = \frac{-\gamma^2_{tr}\gamma^2}{\gamma^2-\gamma^2_{tr}} P \frac{\Delta f}{f}$$

the $(0+\nu)$ resonance is at $\gamma = 4.9$ ($p = 4.5$ GeV/c) the measured rf frequency is 4.35677 MHz; $\gamma_{tr} \sim 8.7$ so evaluating gives

$$\Delta R = \frac{1.37}{Hz} \times 10^{-3} cm$$

$$\Delta P = \frac{\pm 3.63}{Hz} \times 10^{-5}\ GeV/c \cong \frac{7.26 \times 10^{-2}}{Hz}\ GCC.$$

The momentum shift will have the additional relevant effect of shifting the vertical tune by the vertical chromaticity:

$$\frac{\Delta\nu}{\nu} = \xi \frac{\Delta p}{p}.$$

ξ (vertical) at 4.5 GeV/c is approximately -0.85 (AGS Studies Note 182) so $\Delta\nu_v = \frac{6 \times 10^{-5}}{Hz}$.

So both the momentum and tune are changed by radial shifts. These control the timing of the (0+ν) tune jump.

From figure 2 we can deduce the following, if ν_v is increased by $\Delta\nu$, the resonance will occur later by $\Delta\nu \times \frac{100\ counts}{.096}$.

If p is increased by Δp at a fixed Gauss Clock the resonance time will shift earlier (in GCC) by $\Delta GC = -\frac{2000}{\frac{GeV}{c}} \Delta p$ (this is the GC calibration).

To sum up, a radial shift Δr is equivalent to a Gauss Clock shift $\Delta GC = \frac{100}{.096} \Delta\nu - \frac{2000}{(GeV/c)} \Delta p$; $\Delta\nu = \frac{\xi\nu}{p} \Delta p$ and $\frac{\Delta p}{p} = \gamma_{tr}^2 \frac{\Delta r}{R}$.

Table 1 shows our data and the implied shifts.

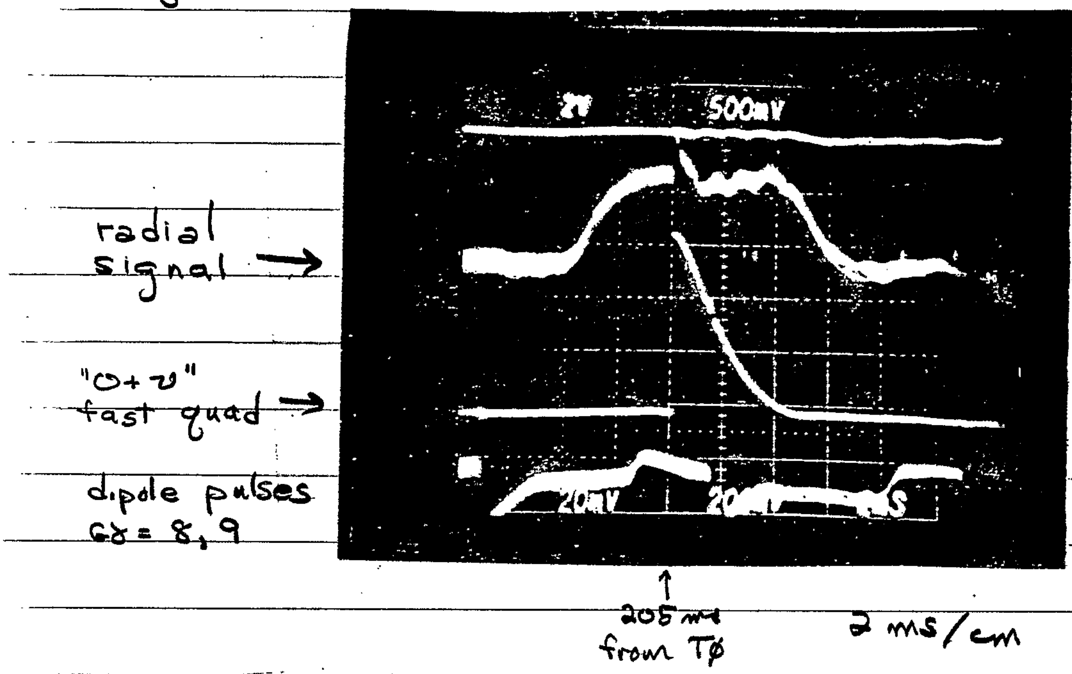
Table 1

Radial Cond.	Freq. Shift (Hz)	Radial Shift(mm)	Δ(Res.time) due to Δp = -Δp GCC	$\Delta\nu_v$	Δ(Res.time) due to Δν (GCC)
43	+210	2.9	-15	-.013	-14
13	0	0	0	0	0
-17	-210	-2.9	+15	0.013	14
-47	-430	-5.9	+31	0.026	27
-77	-660	-9.0	+48	0.040	42

In figure 3 we plot first (open circles) a typical resonance curve at 0+ν taken during this study, polarization @ 13.3 GeV/c vs the Gauss Clock setting of the tune jump. Next we plot (x's) polarization measured at a fixed GC as the radius is shifted, but we plot at the equivalent GC shift calculated by the above formula. Within errors all points lie on the same curve; hence, the conclusion: the observed dependence of polarization on radius simply reflects the same mechanism as that causing the variation of polarization in a normal Gauss Clock scan.

The shifting of radius at the resonance implies that the beam can not be always in the center of the 10 fast quadrupoles. One then expects to see some beam growth due to the fact that the fast quad kick is not adiabatic which then could affect the polarization in later resonances. Figure 4 gives the horizontal and vertical sizes (sigma) from IPM measurements 15 ms after the radial excursion is completed. The size change is small even for a variation of 1 cm. It is consistent with other studies of polarization at 13.3 GeV/c vs. beam size that this variation is not sufficient to affect the polarization at 13.3 GeV/c.

Fig 1 Radial excursion



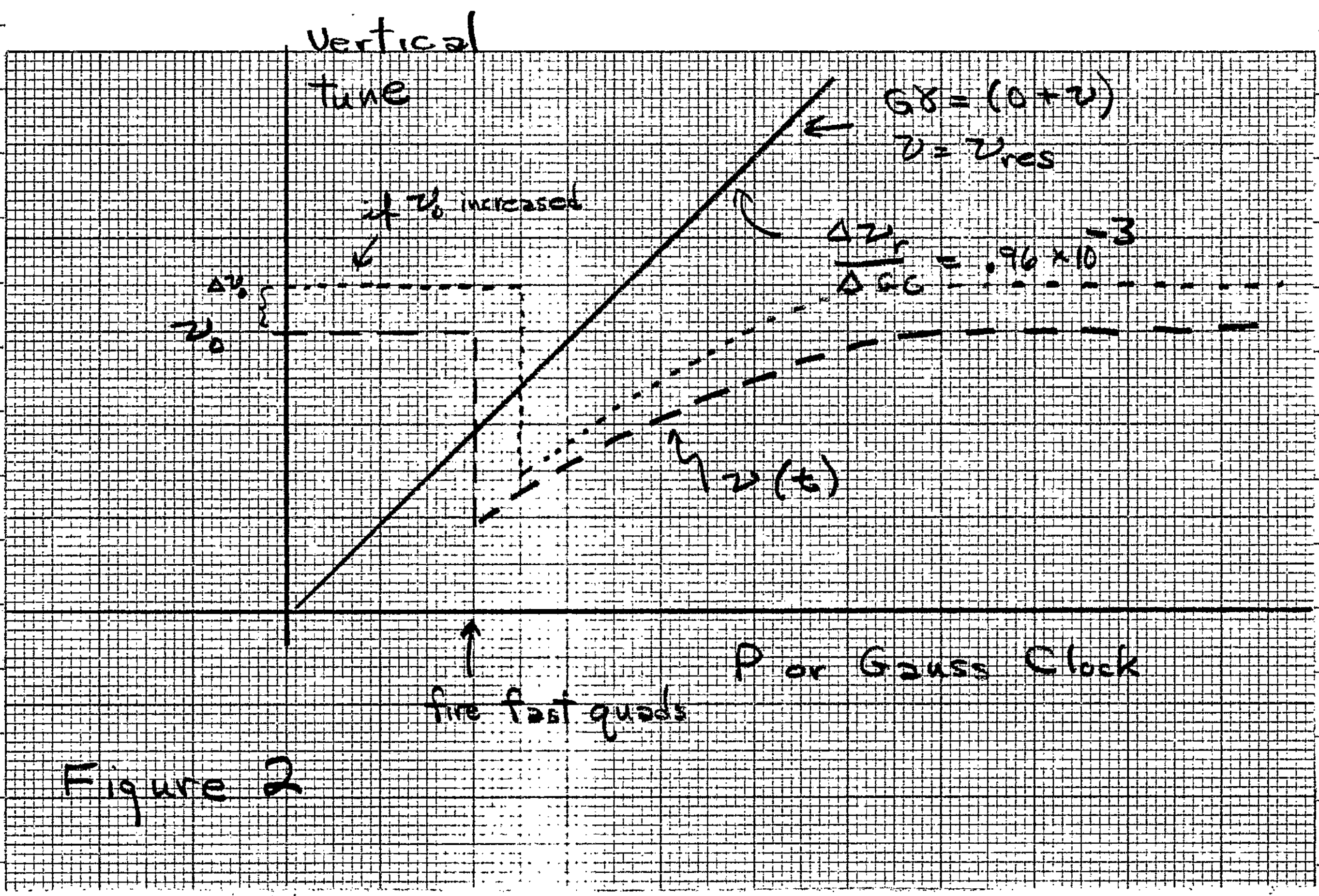


Figure 2

External Pol. (5.2%)   Gγ=0+ν resonance

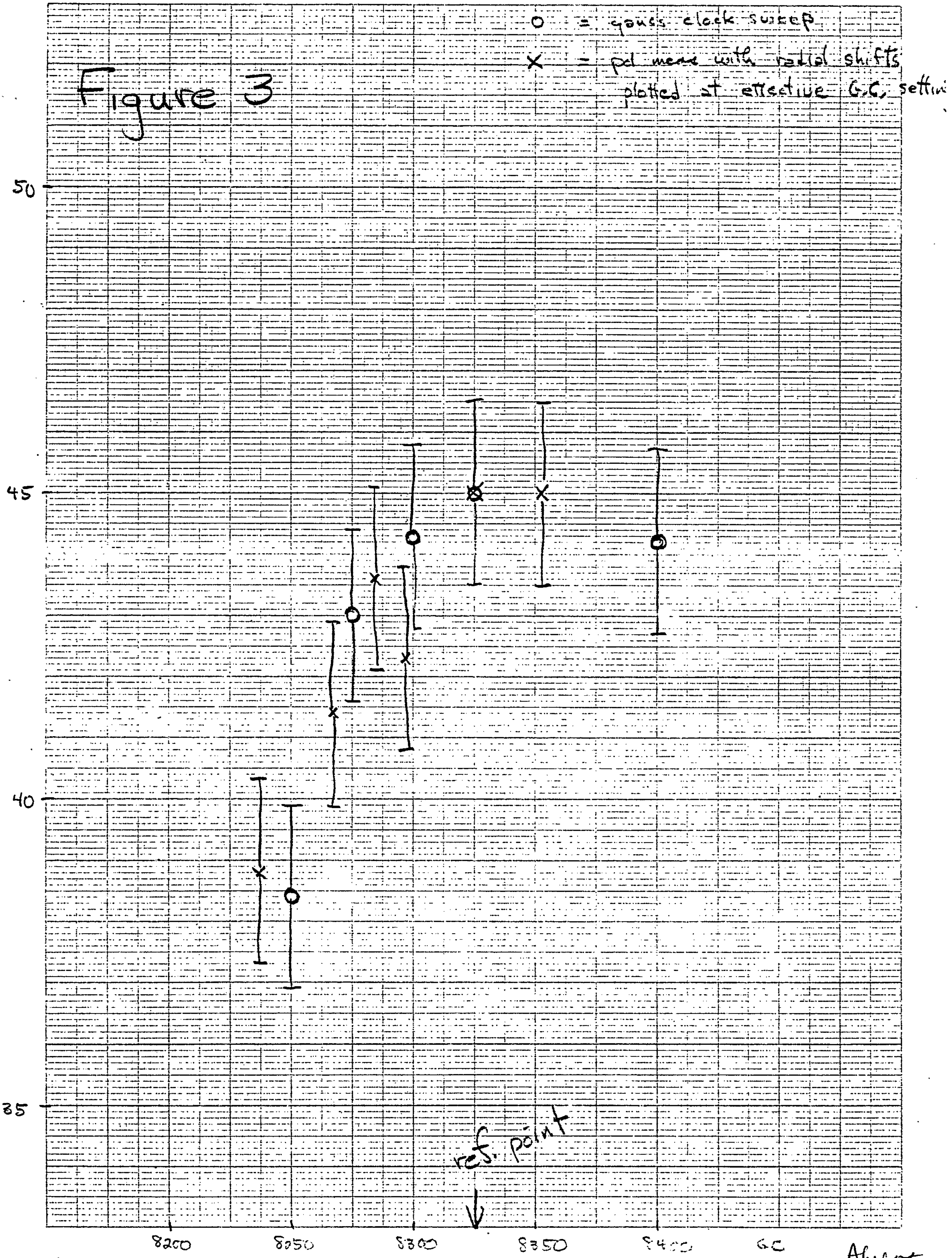


Figure 3

$\sigma_{H,V}$ (IPM) after radial excursion at (0+2)