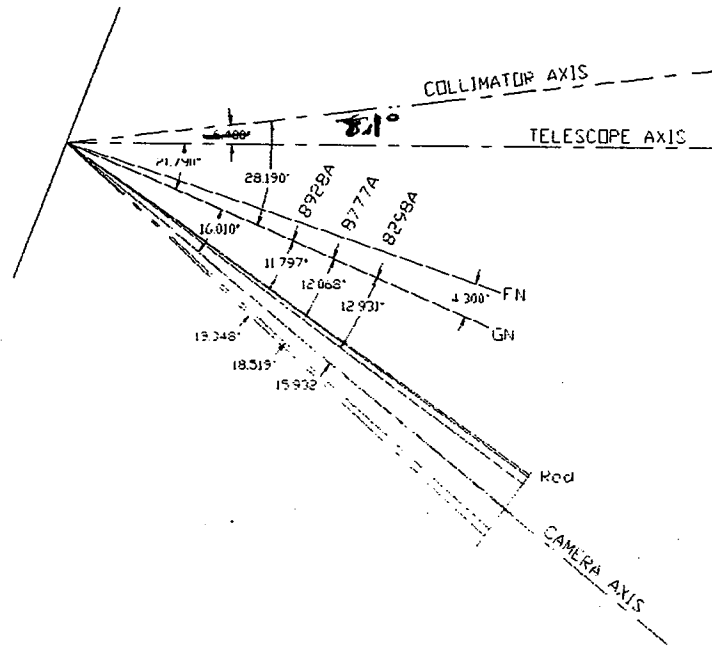


INTEROFFICE MEMORANDUM

6 December 1994

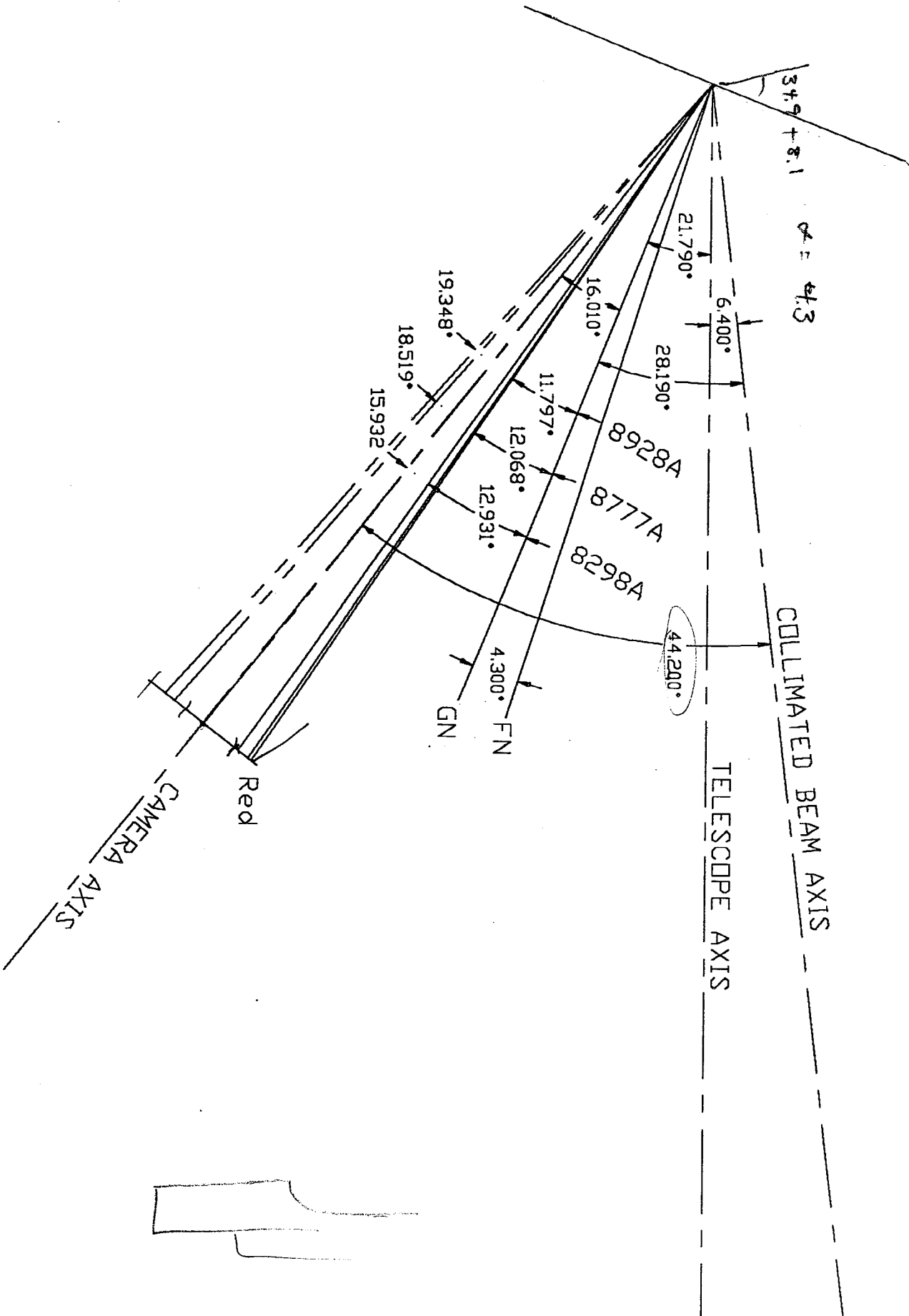
This memo is to pass along for your information and review my analysis of the ghosts measured by Judy Cohen and Neill Reid in LRIS spectra. With the help of additional information communicated by Judy Cohen in e-mail last night, I have put together the following AutoCAD (R12) drawing of the LRIS red grating geometry for the 300 gr/mm grating set to an angle of 21.790°:



I interpret the grating setting as the angle the grating is tilted from a "zero position" normal to the telescope axis (and therefore also normal to the axis of the grating turret, I imagine). The 6.4° angle which Judy said was "floating around the grating wavelength setting calculation" I take to be the angle from the telescope axis of the collimated light striking the grating; thus the grating incident angle α is:

in this example. Substituting this α into the grating equation with $\alpha^{-1} = N = 300$ gr/mm and order $m = 1$;

$$\frac{m\lambda}{q'} = \sin \alpha + \sin \beta$$



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with $\lambda = 8928, 8777, 8298 \text{ \AA}$, I find diffracted angles $\beta = -11.802^\circ, -12.067^\circ, -12.911^\circ$, respectively. With a camera-to-collimator angle of $\alpha - \beta = 44.2^\circ$, the angle β corresponding to the optical axis of the camera is $\beta_c = -16.01^\circ$ in this example (for which $\lambda_c = 6553 \text{ \AA}$), and the three near-IR wavelengths fall on the extreme "Red" end of the CCD detector, which I've shown to scale in Figure 1 at a distance of 12.0-inches (the EFL of the camera) from the grating. The angles shown in Figure 1, $11.797^\circ, 12.068^\circ, 12.931^\circ$, were drawn based on the measured pixel locations of the arc lines on the CCD, and [to within my round-off errors and the distortion of the Epps camera] are consistent with the angles derived from the grating equation. Notice that the negative angles beta are on the opposite side of the grating normal (marked GN in Figure 1) than the 28.190° angle alpha. I'm fairly certain (but without checking the LRIS blueprints, not 100% certain) that I'm reconstructing the LRIS grating geometry correctly with the information provided to me; someone (Bev ? Tom ?) should please confirm this, however. The blaze wavelength of the 300 gr/mm grating ($\lambda_B = 5000 \text{ \AA}$) gives a blaze angle $\theta_B = 4.30^\circ$, which when added to Figure 1 (the line marked FN, for facet normal) seems to roughly bisect the collimator-to-camera angle, and clearly $\alpha > \theta_B$ so my layout passes the simple "sanity checks."

Turning attention next to the ghosts, my contention has been that light which reflects off the CCD is "collimated" upon its return through the camera, strikes the grating, and is again diffracted. The angles α in the grating equations describing this second diffraction are equal (in absolute value) to the angles β for each wavelength in the first diffraction (note that α for the second diffraction is now wavelength-dependent, since the different wavelengths originate from different places in the camera focal plane). Since our interest is in finding solutions to the grating equation which return the light to the CCD, clearly α and β for the second diffraction of the ghosts will be on the camera side of the grating normal, I have adopted a sign convention in which both angles are negative.

With the same $N = 300 \text{ gr/mm}$ but now $m = -2$, I find (λ, α, β) solutions to the grating equation for the second diffraction as follows: $(8928, -11.802^\circ, -19.348^\circ)$, $(8777, -12.067^\circ, -18.519^\circ)$, and $(8298, -12.911^\circ, -15.932^\circ)$. The lines with two short dashes in Figure 1 show these $m = -2$ rays returning to the opposite side of the CCD after the second diffraction by the grating, and indeed the longest wavelength ghost lines are at the *bluest* extreme of the CCD, as observed by Judy and Neill. The separation in pixels is also $3 \times$ the original separation, which according to my explanation is to be interpreted as $(2 + 1) \times$ the original separation, since the second diffraction in order $m = -2$ has twice the dispersion of the first dispersion ($m = +1$), but added to this must be the separations of the original monochromatic arc line images on the CCD (the CCD "mulit-slits", if you will, as far as the second diffraction is concerned).

