Considerations of Internal Reflections in the ADC

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Simple calculations of likely "ghost" reflections in the linear ADC are discussed. The worst case comes from the inner two surfaces, where it is estimated to be less than 10^{-4}, and falls rapidly as the prism separation increases.

There are 4 surfaces (referred to as S1, S2, S3 and S4, in the order that light passes though the two prisms), leading to 6 surface pairs that could produce ghosts. In the following, α is the prism angle of the individual prisms, and we assume 70mm total thickness for the combined prisms. We consider each surface pair:

S1/S2: Internal to the first prism. Using the design orientation of the prism, light entering this prism vertically (approximately true) is emitted at an angle α(n-1). Light reflected off surfaces S1 and S2 is emitted at an angle of α(3n-1), that is, different by 2nα from the direct pass. For prism angles of 5°, this angle is over 14°. Since angles over about 4° completely miss the grating/mirror, this surface pair is deemed innocuous for ghosts.

S1/S3: Since surfaces S2 and S3 are parallel, this pair behaves the same as S1/S2 except that there is additional defocus due to the increased pathlength of prism separation.

S3/S4: equivalent to S1/S2.

S2/S4: equivalent to S1/S3.

S2/S3: These are the parallel inner surfaces of the prisms, and are the most problematic. The difference in pathlength (2Δz) results in a defocus depending on prism separation. For an order-of-magnitude effect, we consider the defocus spot size compared to a 0.5-arcsecond disk in estimating an intensity difference. The ghost/parent contrast (per given area) is then

$$\left(\frac{2\Delta z/15}{0.363}\right)^2 r_1 \cdot r_2$$

or

$$\left(\frac{2\Delta z/15}{0.363}\right)^2 r_1 \cdot r_2$$

where $d = 2\,\Delta z/15$ is the defocused spot diameter, r_1 and r_2 are the reflectance at each surface, and Δz is measured in mm. We adopt reflectance of 0.01 for each surface. For a minimum separation of 4 mm, we see a maximum value ghost/parent ratio of 6×10^{-5}; at 10 mm, this becomes 10^{-6}.

The location of this ghost will be somewhat offset from the primary image. The rays will be parallel to the parent beam, so the offset is simply the translation of the rays,

$$□x = 2\ □z\ \tan □$$

where □ ranges from about 0.5 -- 1.3 degrees. Thus, at 10mm prism separation, the offset is 0.64 arcsec at maximum -- this will still be in the wings of the typical seeing-profile PSF.

S1/S4: This is equivalent to S2/S3, but with the overall addition of 2 □ (70/n) mm of defocus. Thus, surface pair S2/S3 will dominate over this pair (except at large prism separation where ghost effects are negligible from either pair).

In conclusion, only the inner surface pair is of any concern. The maximum contrast of ghost/parent is given by $r_1 \cdot r_2$ (at which point the ghost falls on top of the parent) and rapidly declines as the prisms separate.