APS Autofocus Sensor

Lens: 26 mm f/2.8 ⇒ D = 9.3 mm

Negative: 16.7 × 25.0 mm

Blur: .004" on 4×6" print

Range: 4' ⇒ ∞

$$\text{Print mag} = \frac{-6''}{25.0\,mm} = -6.1$$

$$\text{Blur on film} = B' = \frac{.004'}{6.1} = .000656'$$

$$B' = 16.7\,\mu m$$

Autofocus Zones:

Start at ∞ and work in to 4'.

Determine L_H and its corresponding L_{NEAR}.

This L_{NEAR} becomes L_{FAR} for the next zone.

Determine L_o for each zone until L_{NEAR} for one zone is less than 4'

$$L_H = -fD/B' \qquad L_{NEAR} = \frac{L_o f D}{fD - L_o B'}$$

$$L_o = \frac{L_{FAR} f D}{fD - L_{FAR} B'} \qquad L_{FAR} = \frac{L_o f D}{fD + L_o B'}$$

Zone	L_o	L_{FAR}	L_{NEAR}	L_o (ft)
1	$L_H = -14600$	∞	-7300	47.9'
2	-4860	-7300	-3640	15.9'
3	-2920	-3640	-2430	9.6'
4	-2080	-2340	-1820	6.8'
5	-1620	-1820	-1460 (4.8')	5.3'
6	-1325	-1460	-1210 (4.0')	4.3'

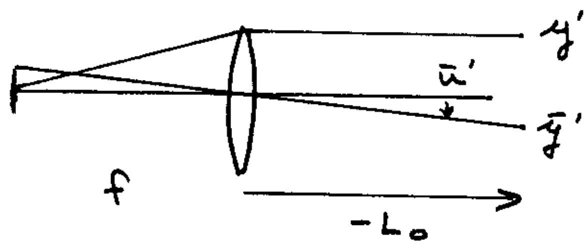
Required Autofocus Zones = 6

Autofocus System: LED 50μm × 50μm

Lenses 20mm f.l.

8mm × 8mm

Projected Spot size



$a = |y'| + |\bar{y}'|$

$y' = 4$ mm

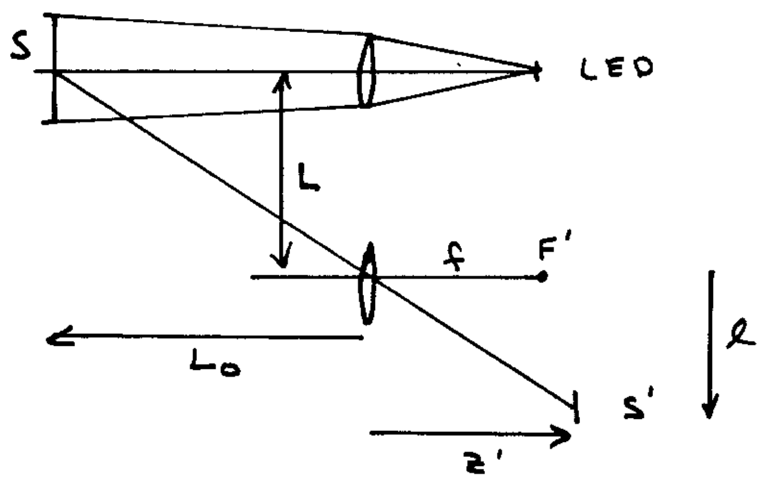
$\bar{y}' = -\bar{u}\, L_o$

$\bar{u} = -\frac{25\mu m}{f} = -.00125$

$S = 2a = 8\text{ mm} - .0025\, L_o$

Zone	L_o	S(mm)
1	-14600	44.5
2	-4860	20.2
3	-2920	15.3
4	-2080	13.2
5	-1620	12.1
6	-1325	11.3

Received Spots:



$L_o = z$

$$\frac{1}{z'} = \frac{1}{L_o} + \frac{1}{f}$$

$m = z'/L_o$

$S' = m\,S$

$$\ell = \frac{L z'}{L_o}$$

Zone	L_o	z'	m	S'	ℓ
1	-14600	20.027	-.00137	.061	-.00137 L
2	-4860	20.083	-.00413	.083	-.00413 L
3	-2920	20.138	-.00691	.106	-.00690 L
4	-2080	20.194	-.00969	.128	-.00971 L
5	-1620	20.250	-.0125	.151	-.01250 L
6	-1325	20.306	-.0153	.173	-.01533 L

By the Scheimpflug Condition, the returned spots must lie on a line going through F.'

Note: $\frac{z_i' - f}{l_i} = -20.0\,L$ for all zones

To determine the lens seperation L, we must use the condition that the returned spots do not overlap. The largest spots are from zones 5 and 6:

$$l_6 - l_5 = -\frac{S_6' + S_5'}{2}$$

$$-.01533\,L + .01250\,L = \frac{.173 + .151}{2} = .162$$

$$\underline{L = 57.24\,mm}$$

Detector tilt angle:

$$\tan\beta = f/L$$

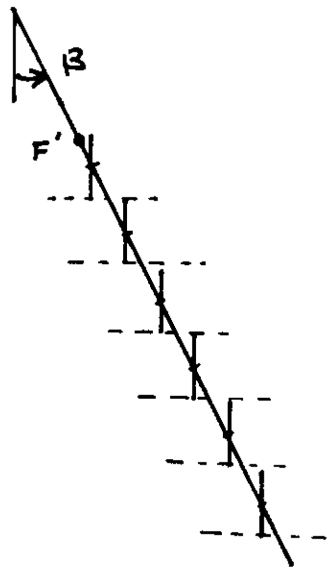
$$\beta = 19.3°$$

Note that Δl/zone is approx constant $= 162\,\mu m$

(some round-off errors)

Zone	l (mm)
1	-.078
2	-.236
3	-.395
4	-.555
5	-.715
6	-.877

Detector Geometry



The average limiting spot size is 162 μm

This determines the detector size when projected onto the tilted array:

$$d = S'/\cos\beta = 172\,\mu m$$

An array with 6 pixels – each 172 μm is needed.

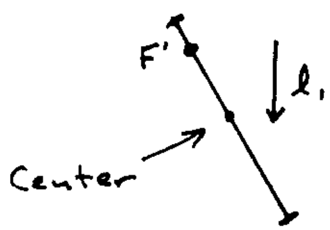
There is no need for "dead" space between the pixels.

Contiguous pixels are better to detect the intermediate object locations.

The detector is tilted at 19.3°.

Detector offset relative to F':

$$\text{offset} = l_1/\cos\beta = -82\,\mu m$$



Pixel 1

This is the distance from F' to the center of pixel 1

About 4 μm of pixel 1 will extend beyond F'.