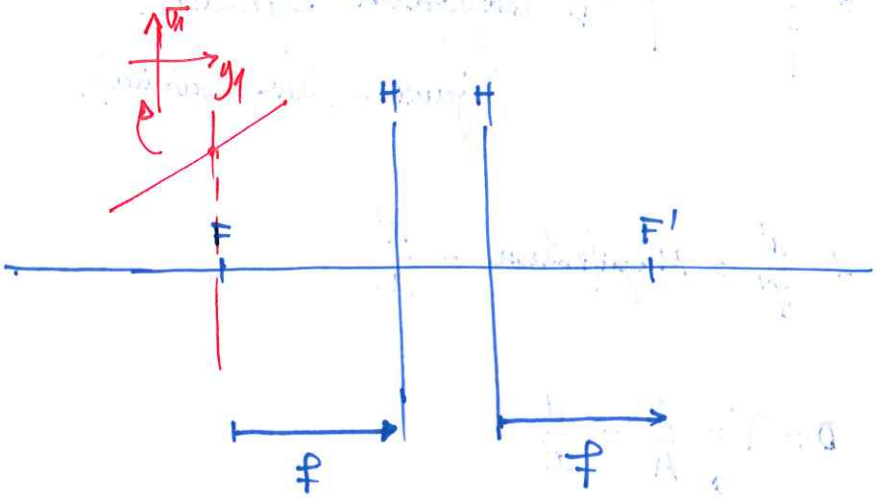
| 13/09/2016 |

1.8.2 - Correspondence matrix between F and F'

NOTE: F and F' are not conjugated planes since F' is not the image of F. F' is the image of a point objet at infinity (far from the optical system)

F is the ~~obj~~ ect for an image ~~fo re~~ formed at infinity.

¿Which is the relation between F and F' planes?



$$\bullet\ M_{FF'} = \begin{pmatrix} 1 & -f \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 1/f & 1 \end{pmatrix} \begin{pmatrix} 1 & -f \\ 0 & 1 \end{pmatrix} = \begin{pmatrix} 0 & -f \\ 1/f & 0 \end{pmatrix},$$

so:

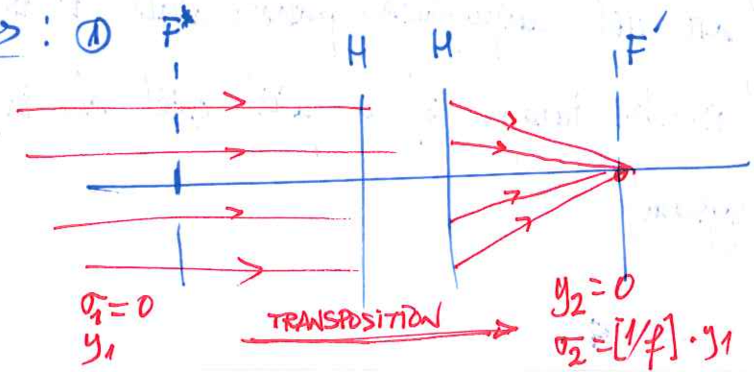
$B \neq 0$ (F and F' are not conjugated).

~~A≠~~

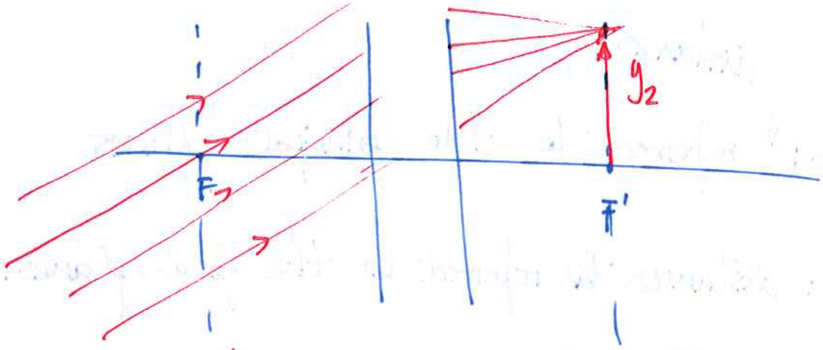
$A = 0 \longrightarrow M = 0\,? \longrightarrow$ NOT.

$$\begin{pmatrix} y_2 \\ \sigma_2 \end{pmatrix} = \begin{pmatrix} 0 & -f \\ 1/f & 0 \end{pmatrix} \begin{pmatrix} y_1 \\ \sigma_1 \end{pmatrix} \longrightarrow \underbrace{\left.\begin{aligned} y_2 &= -f\sigma_1 \\ \sigma_2 &= \frac{1}{f} y_1 \end{aligned}\right\}}_{\text{TRANSPOSITION RELATION.}}$$

Examples: ①



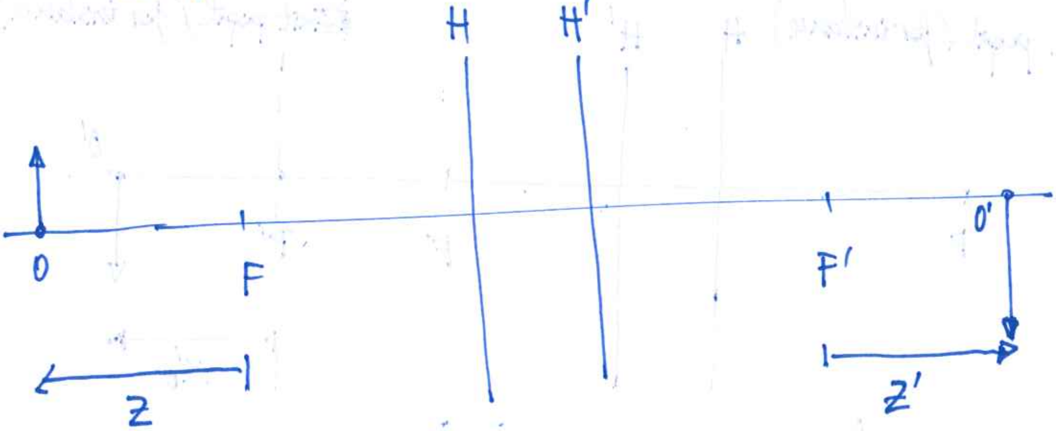
(2)



$\sigma_1 \; \forall y_1 \longrightarrow y_2 = -f/\sigma_1$

*

1.8.3.- Correspondence matrix for any points O - O'



$$M_{OO'} = \begin{pmatrix} 1 & -z' \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 0 & -f' \\ 1/f & 0 \end{pmatrix} \begin{pmatrix} 1 & +z \\ 0 & 1 \end{pmatrix} = \begin{pmatrix} -z'/f & -f' - \frac{z'z}{f'} \\ 1/f & z/f \end{pmatrix}$$

Image:

$B = 0 \longrightarrow \boxed{zz' = -f^2}$ ⇒ Newton lens equation.

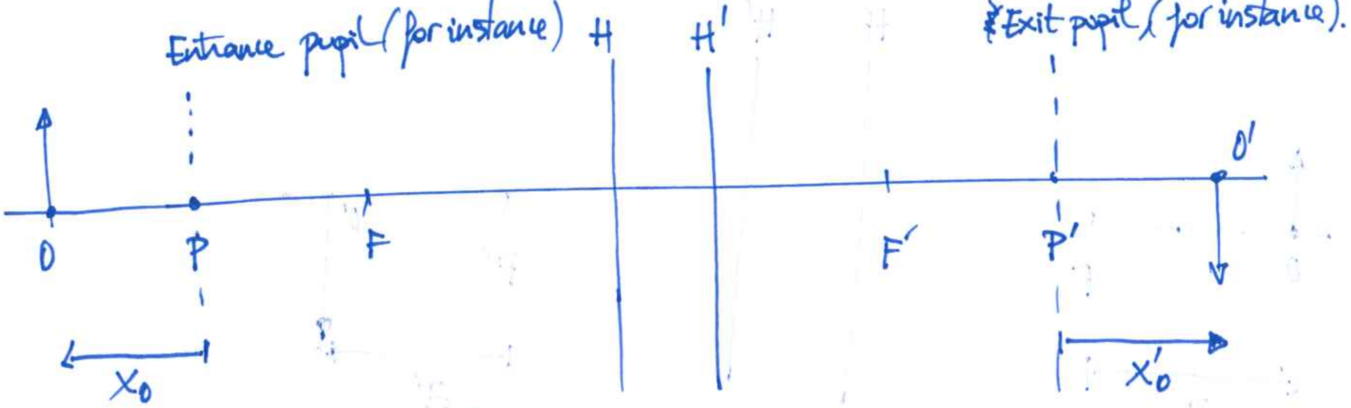
Magnification

$A = \boxed{M = -\frac{z'}{f'} = \frac{-f}{z}}$ ⇒ Newton magnification

Summary:

- Gauss equations: distances referred to the principal planes
- Newton equations: distances ~~to~~ referred to the focal planes.

1.9.- GENERAL CORRESPONDENCE EQUATIONS:



- I know $\rightarrow f$, $\rightarrow M_p$

- $$M_{OO'} = \begin{pmatrix} 1 & -x'_0 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} M_p & 0 \\ 1/f & 1/M_p \end{pmatrix} \begin{pmatrix} 1 & x_0 \\ 0 & 1 \end{pmatrix} \overset{(1)}{=}$$

$$\overset{(1)}{=} \begin{pmatrix} M_p - \dfrac{x'_0}{f} & \left(M_p - \dfrac{x'_0}{f}\right) x_0 - \dfrac{x'_0}{M_p} \\ 1/f & \dfrac{x_0}{f} + \dfrac{1}{M_p} \end{pmatrix}$$

* **Image** : $B=0 \longrightarrow B\cdot\frac{M_p}{X_0 X_0'}=0$

$$\boxed{-\frac{1}{X_0}+M_p^2\cdot\frac{1}{X_0'}=M_p\frac{1}{f}} \rightarrow \text{General equation lens}$$

* Magnification

$$\boxed{A=M_0=\frac{1}{M_p}\frac{X_0'}{X_0}} \longrightarrow \text{General magnification:}$$

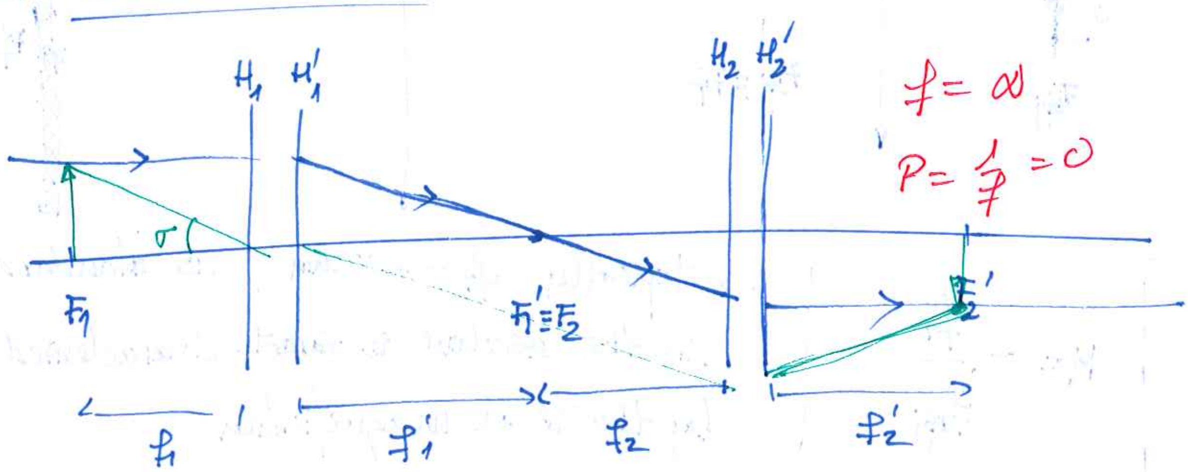
NOTE : When we choose HH' as correspondence points, $M_p=1$, so the general equation will be:

$$-\frac{1}{X_0}+\frac{1}{X_0'}=\frac{1}{f}$$

$$M_0=\frac{X_0'}{X_0}$$

being X_0 and X_0' the distance from ~~the~~ H to the objet plane and H' to the image plane ;

1.10.- AFOCAL SYSTEMS



Afocal systems do not focus parallel beams, but they can focus ~~diverg~~ divergin ~~or con~~ rays.

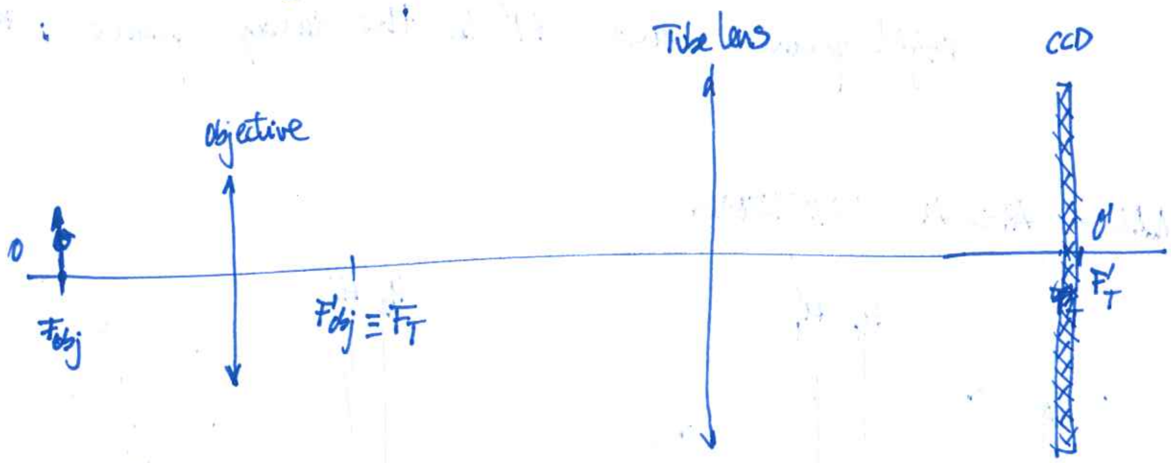
$$\circ\ M_{F_1F_2'} = \underbrace{\begin{pmatrix} 0 & -f_2 \\ 1/f_2 & 0 \end{pmatrix}}_{\text{TRANPOSITION (2)}} \underbrace{\begin{pmatrix} 0 & -f_1 \\ 1/f_1 & 0 \end{pmatrix}}_{\text{TRANSPOTTION (1)}} = \begin{pmatrix} -f_2/f_1 & 0 \\ 0 & -f_1/f_2 \end{pmatrix}^{(*)}$$

(*) We see as we have not image point B=0 nor ~~magnification~~ ~~C=0~~ optical power C=0

(*) We have lateral magnification and angular magnification.

1.10.1 - Applications

a) Optical microscopy:



$$\boxed{M = -\frac{f_T}{f_{obj}}}$$

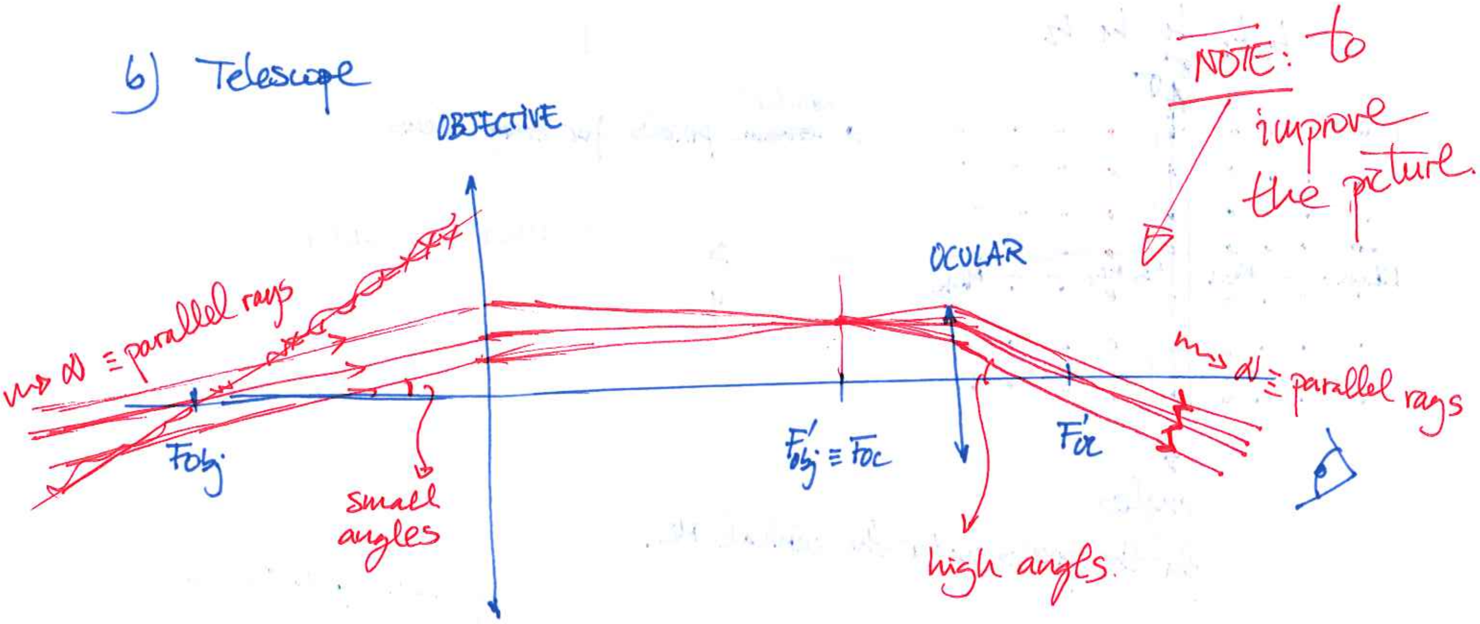
→ tipically $f_T = 200$ mm, as standard, so the objective is ~~caracte~~ characterized by the total magnification

Example

Objective 40 x , so :

$$40 = -\frac{200}{f_{obj}} \longrightarrow f_{obj} = 5 \text{ mm.}$$

b) Telescope

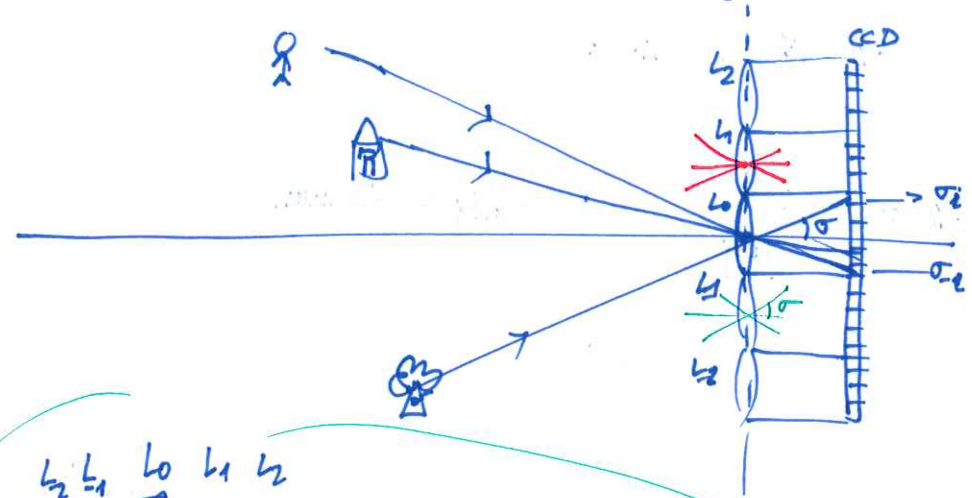


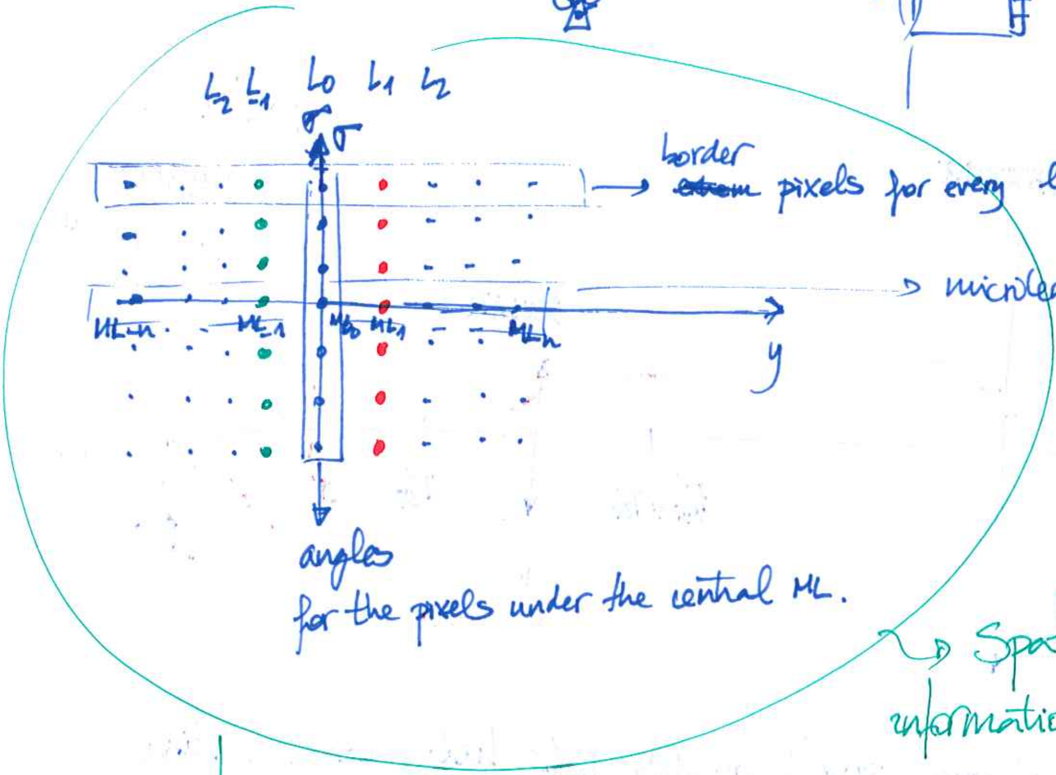
A telescope transforms small angles into high angles. High angles are «converted» into big images at the retina by the optical system of the eye.

$$\boxed{\gamma = \frac{f_1}{f_2} = \frac{f_{obj}}{f_{oc}}}$$

↳ typically . $f_{ob} = 250$ mm. $f_{oc} = 10$ mm $\longrightarrow \gamma = -25$ radians.

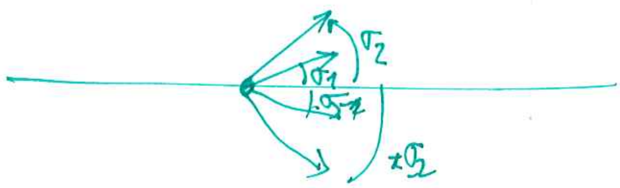
1.11 - INTEGRAL IMAGING SYSTEMS.





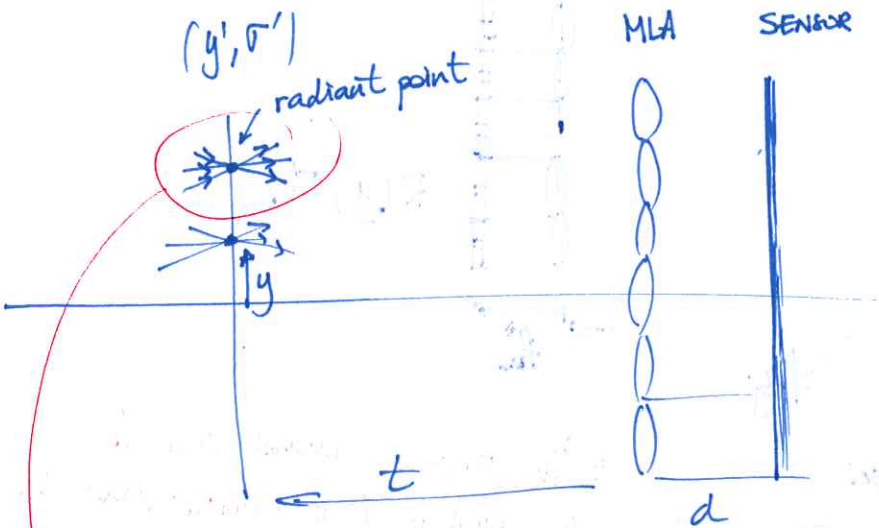
→ Spatial/angular information of the scene.

→ This is a map of the radiance (energy) arriving to the sensor! A radiant poin:



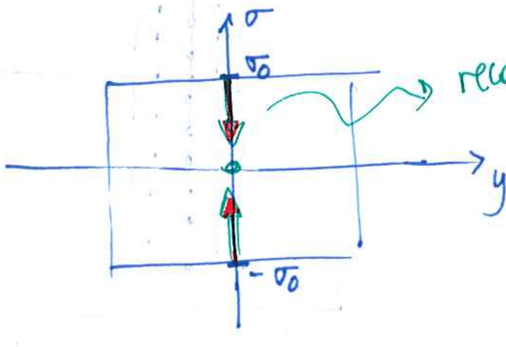
$R(y,\sigma)$ → to know the value of the radiance at any plane we need to propagate it.

$$T = \begin{pmatrix} 1 & -t \\ 0 & 1 \end{pmatrix} \longrightarrow R(y,\sigma) \longrightarrow R(y-\sigma t, \sigma)$$

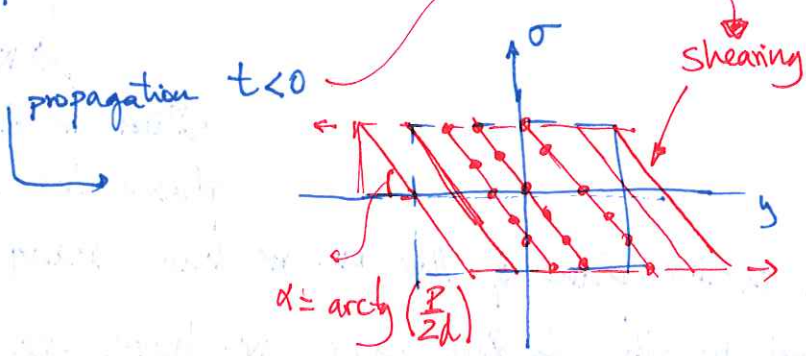


to know the total intensity we need to sum the « energy » of every rays.

$$I(y) = \int_{-\sigma_0}^{\sigma_0} R(y - t\sigma, \sigma)\, d\sigma$$

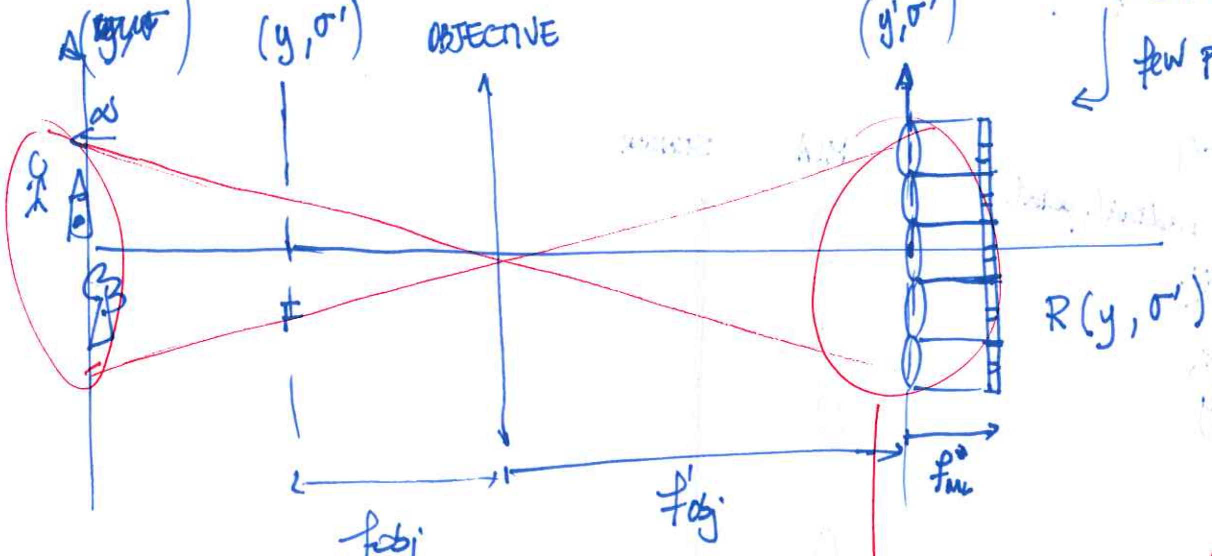


reconstruction in the plane of the MLA: sum of the intensity of the pixeles.



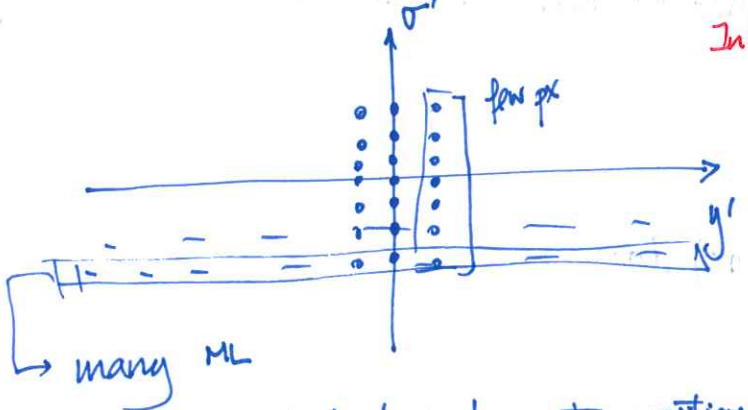
1.12 - PLENOPTIC IMAGING.

We have many ML but few pixels (angles).



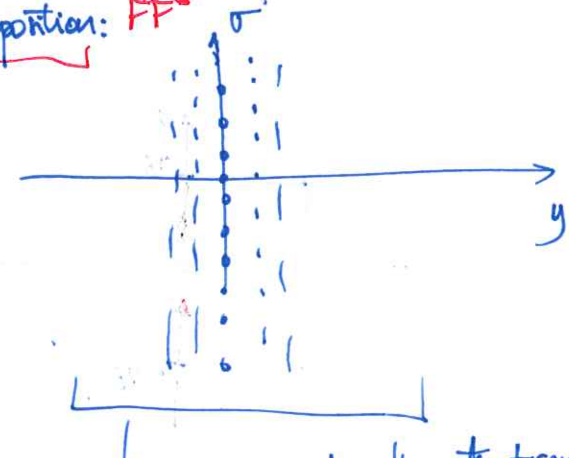
TRANSPOSITION

the scene is imaged close to the MLA so t is shorter than in InIm.



Reconstruction ≡ equivalent to make a transposition: FF'

$$M^{-1}_{FF'} = \begin{pmatrix} 0 & f \\ -1/f & 0 \end{pmatrix} \longrightarrow$$



When we do the ~~tra~~transposition we obtain in the object focal plane the same configuration as Lippmann.

So, in the plane of the ML we have many micro-image (ML) and few px, but in the ~~p~~ F_{obj} plane we have few cameras with many px.

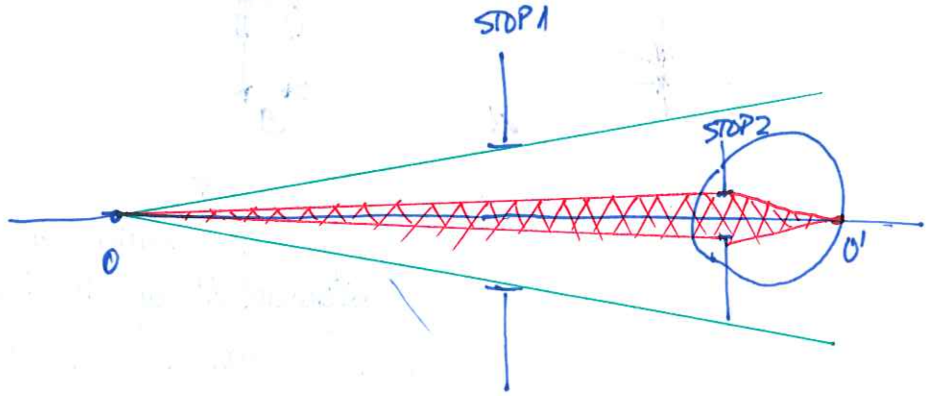
⇒ After transposition Plenoptics is equivalent to InIm

1.13.- FIELD LIMITATION :

a) Aperture (or irradiance) limitation

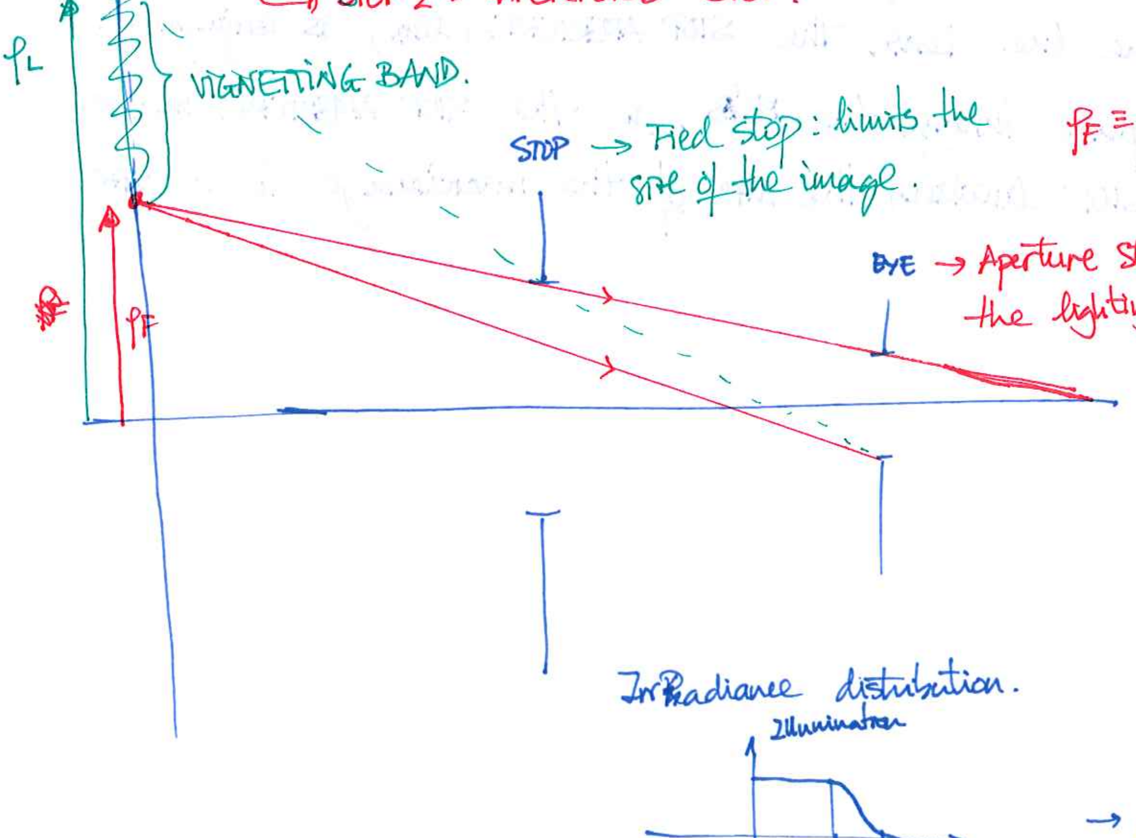
b) Field limitation.

Example: Eye + stop ~~aperture~~:

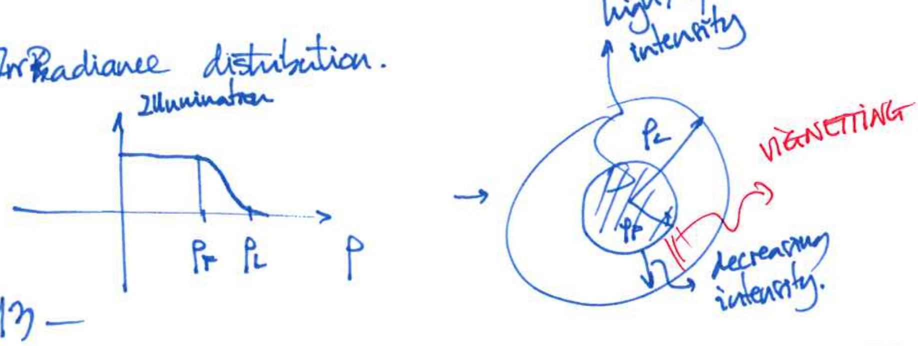


STOP 2 ≡ limites the amount of light (the cone of the radiance) arriving to the retina

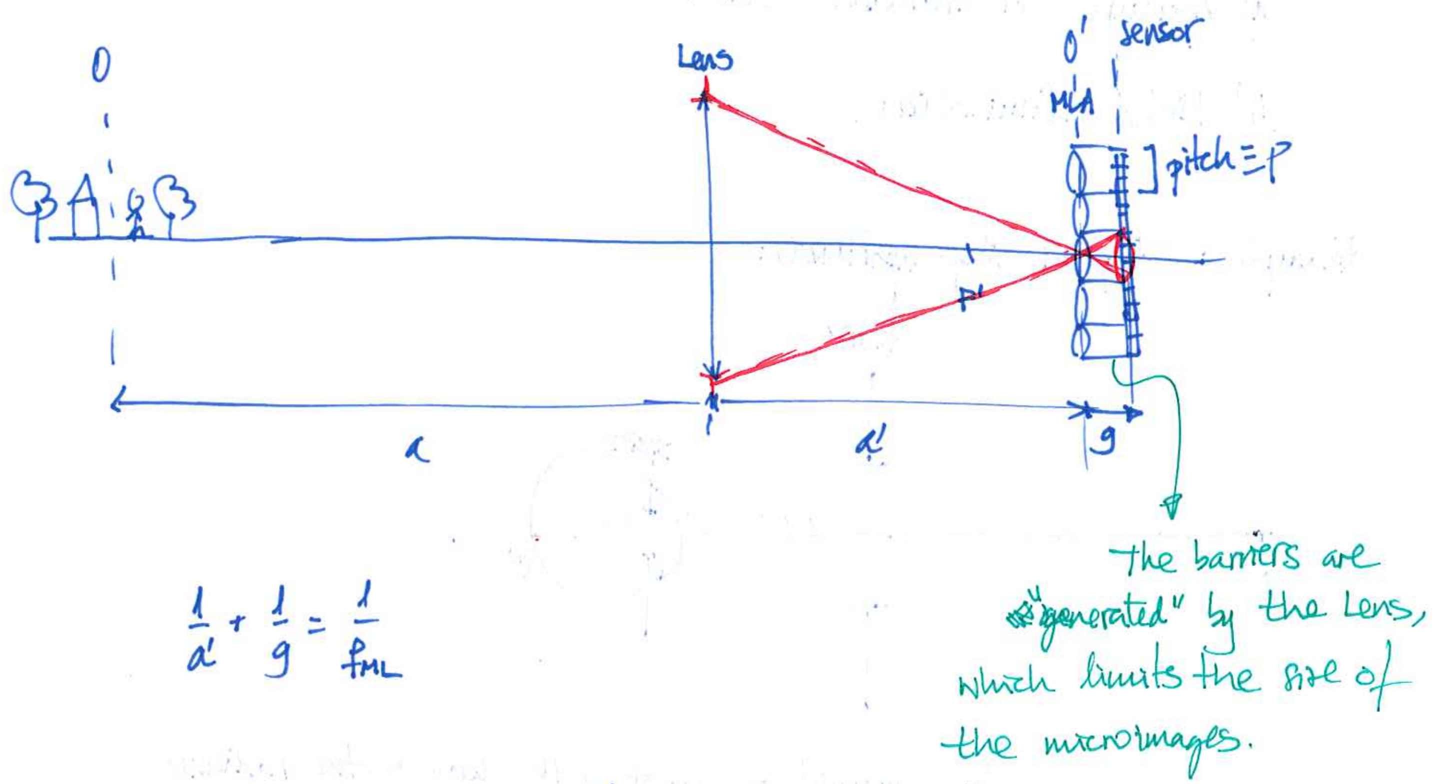
→ STOP 2 : APERTURE STOP.



~~Ir~~Irradiance distribution.



1.14 - PLENOPTICS 1.0 (LYTRO, R. Ng)

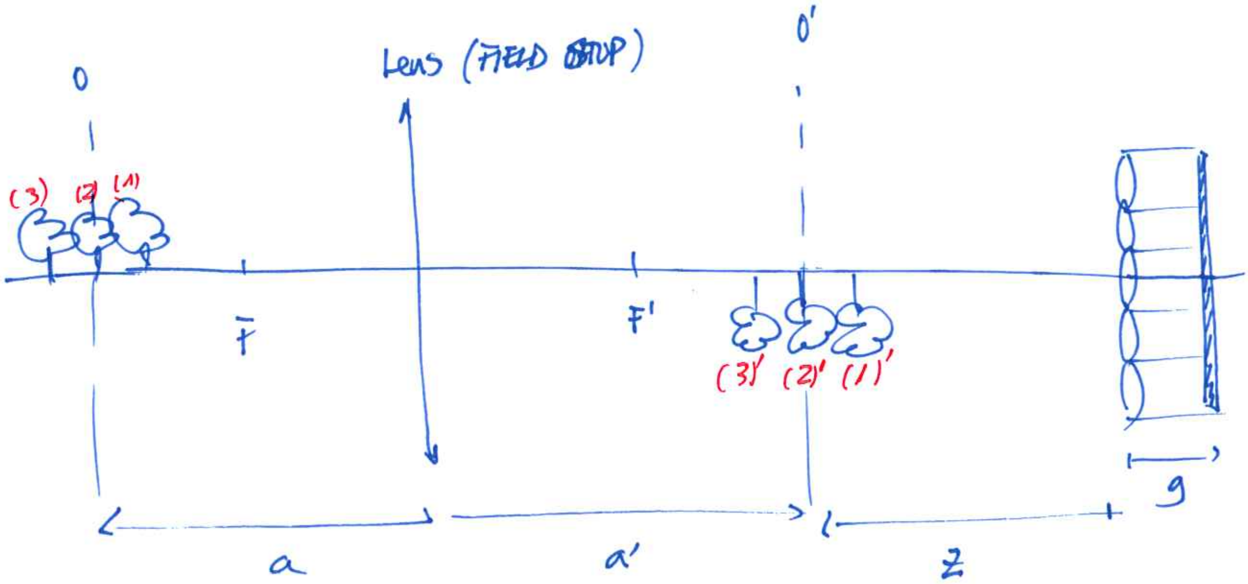


$$\frac{1}{a'} + \frac{1}{g} = \frac{1}{f_{ML}}$$

In Pleno 1.0, the image O' of O is on the plane of the MLA; therefore, on the sensor plane the image is blurred (out of focus). Pleno 1.0 images on the sensor plane the Lens. The STOP APERTURE (lens) is conjugated with the sensor plane through the ML's, so the STOP APERTURE makes as a FIELD STOP limiting the size of the microimage to a size $\phi \lesssim$ pitch.

1.15.- PLENOPTICS 2.0 (RAYTRIX, Perwass (o como se escriba))

This is between the ~~Ky~~ Pleno 1.0 and the InIm techniques.



$$\frac{1}{a} + \frac{1}{a'} = \frac{1}{f_L} \qquad \frac{1}{z} + \frac{1}{g} = \frac{1}{f_{ML}}$$

The Lens is not focused on the sensor given ~~rise to~~ rise to vignetting effects. Vignetting effects ~~does~~ affects the quality of the image at the edge.