

PROGETTO SOLTERM-OTTICA

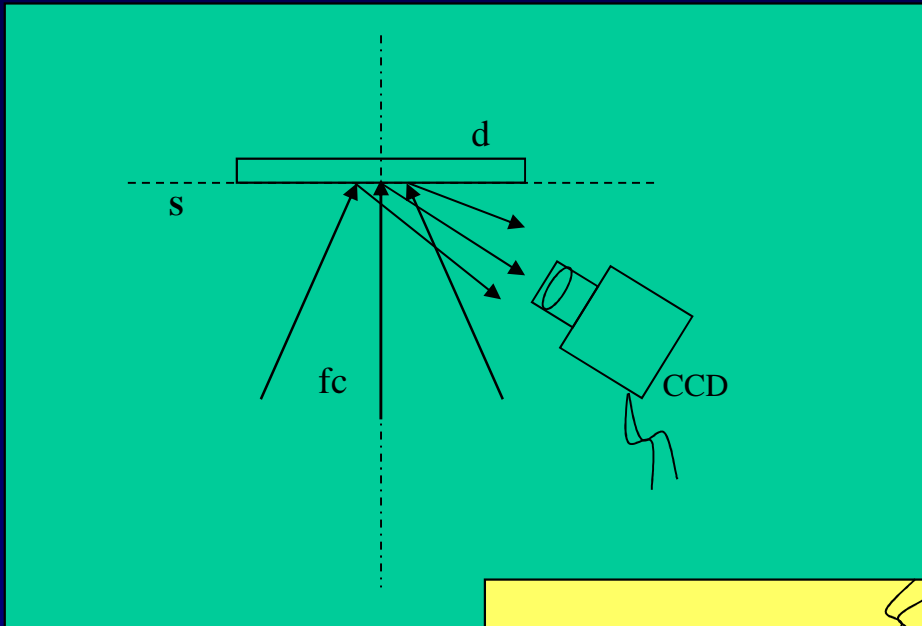
“Progettazione e realizzazione di radiometri
innovativi per impianti Solari Termodinamici”

A. Parretta e G. Nenna

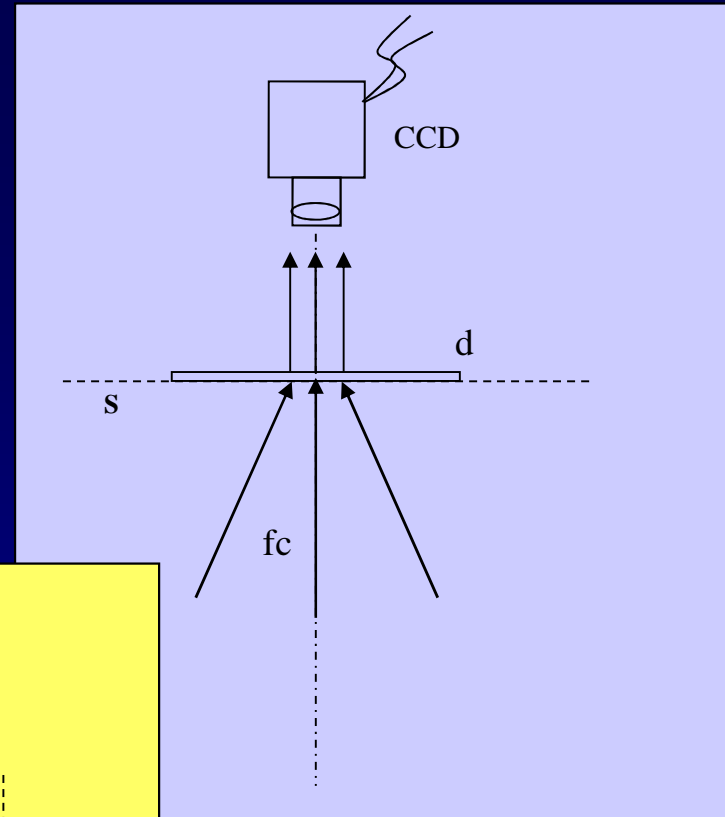
Linee di ricerca:

- A) Messa a punto del metodo LS-CCD
(Light Scattering-CCD)
- B) Progettazione e realizzazione di un radiometro FV
portatile e universale per medie-alte concentrazioni
- C) Progettazione e realizzazione di un radiometro FV
per concentratori termodinamici lineari

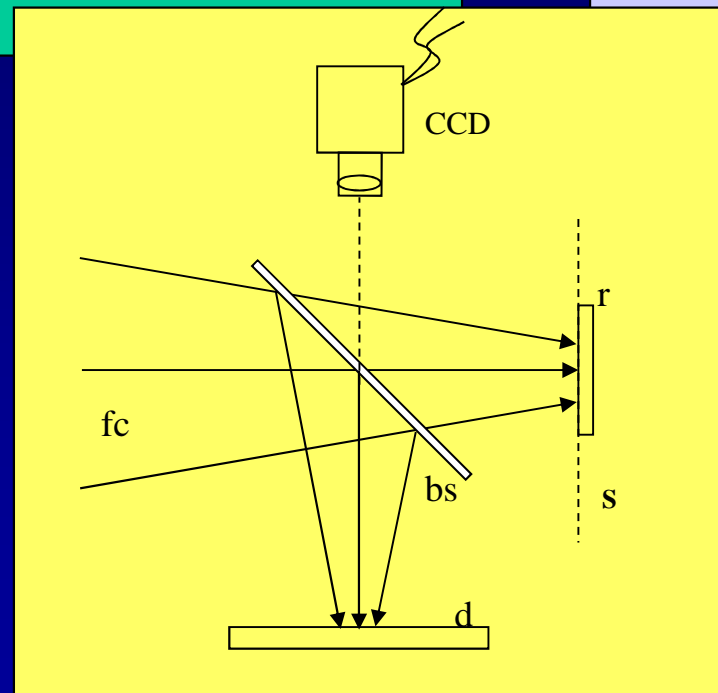
Metodo LS-CCD (Light Scattering and CCD recording)



Riflessione

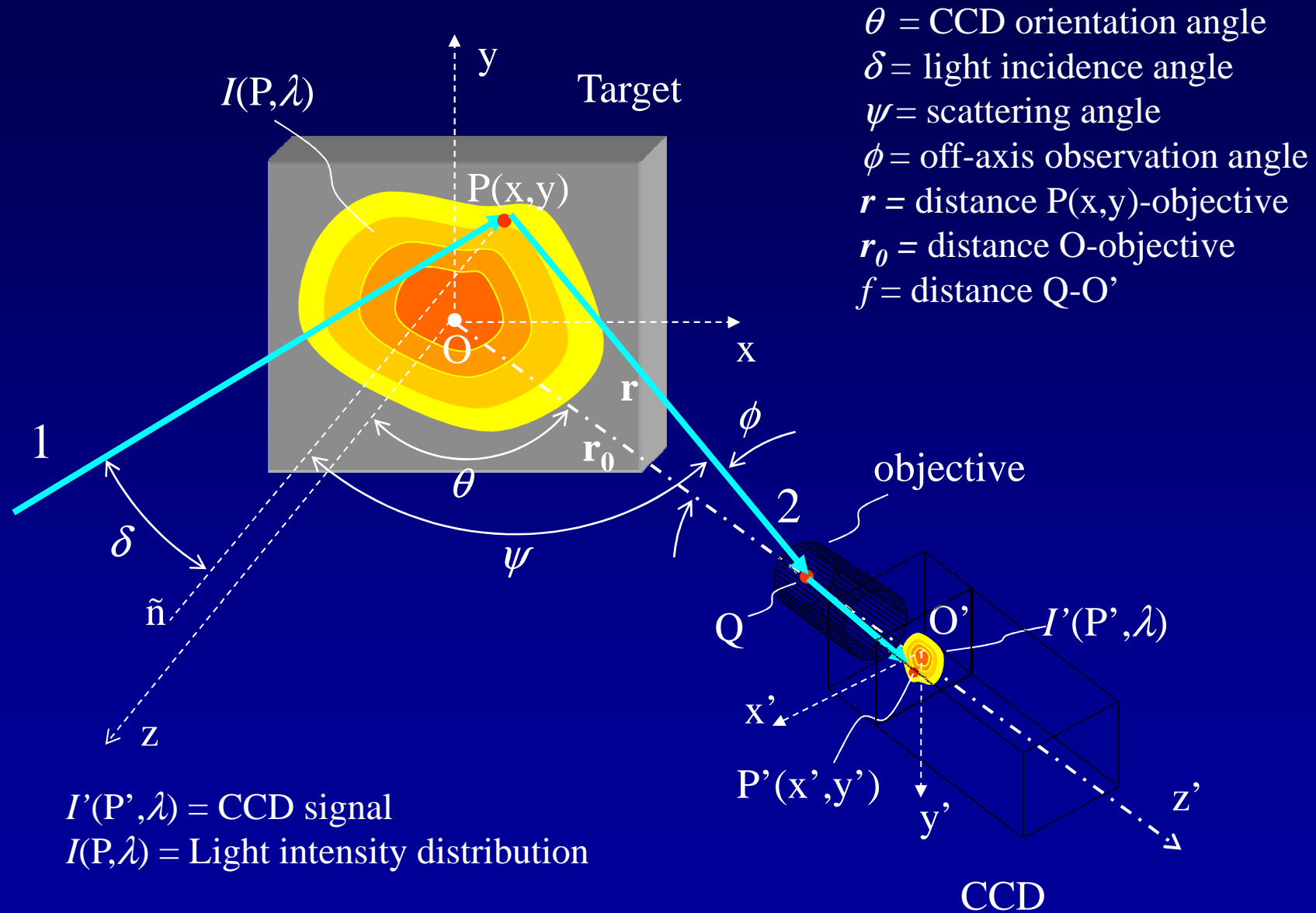


Trasmissione

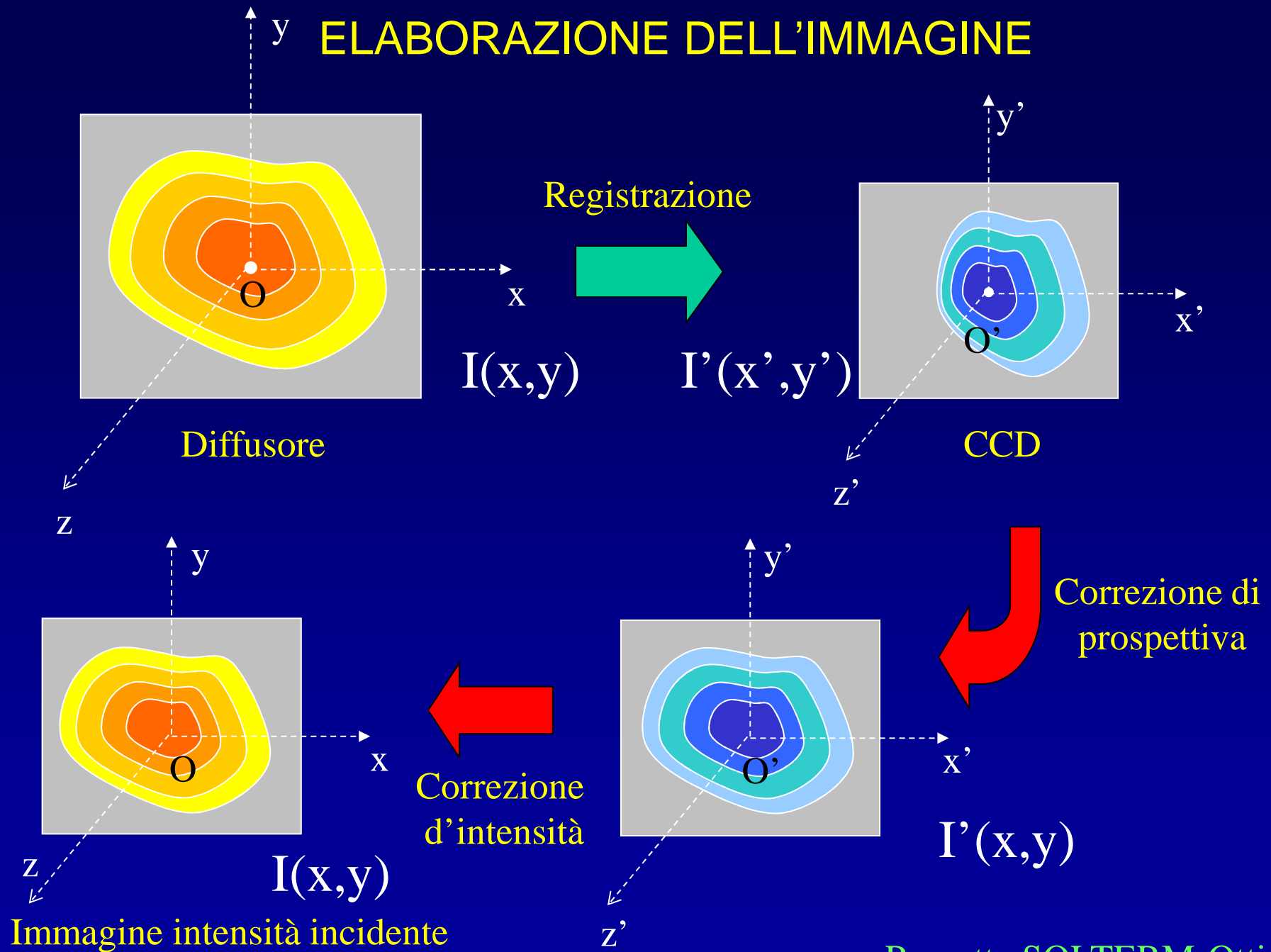


Riflessione non intrusivo

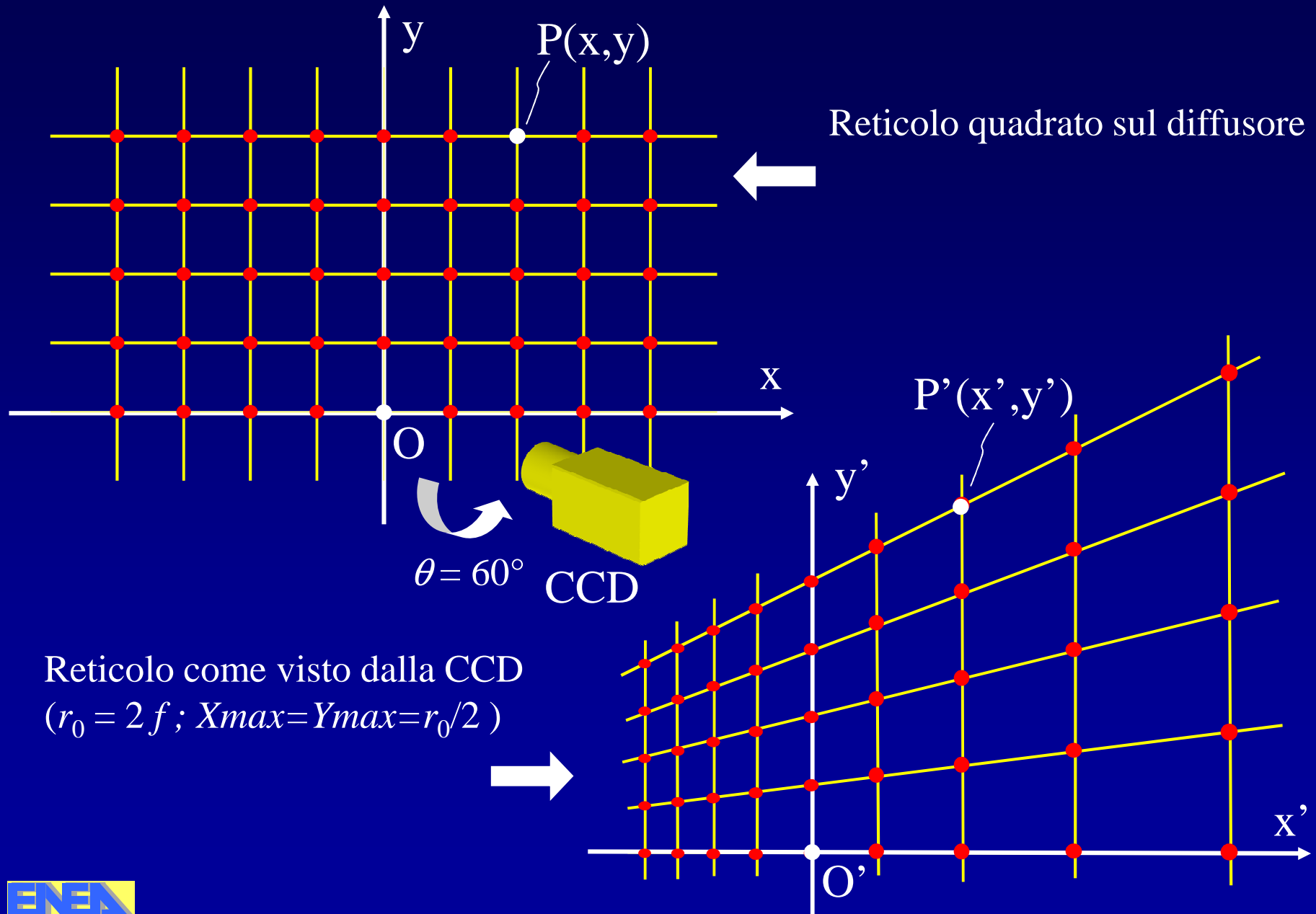
TEORIA (Riflessione)



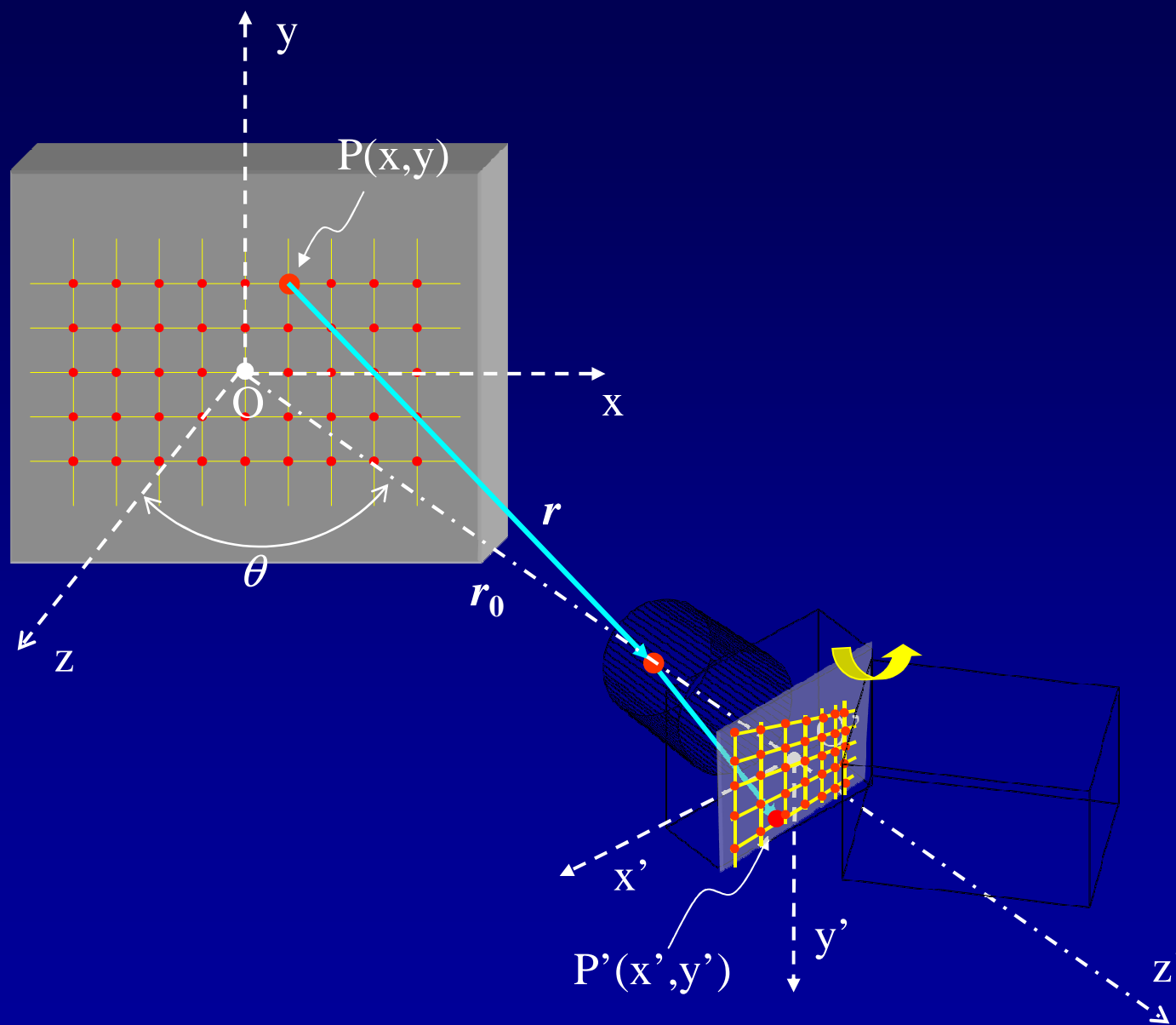
ELABORAZIONE DELL'IMMAGINE



EFFETTI DI PROSPETTIVA



EFFETTI DI PROSPETTIVA



(Teoria per la riflessione)

TRANSFORMAZIONE DELLE COORDINATE

$$x = \frac{r_0 \cdot x'}{(x' \cdot \sin \theta + f \cdot \cos \theta)} \quad ; \quad y = \frac{r_0 \cdot x' \cdot \cos \theta}{(x' \cdot \sin \theta + f \cdot \cos \theta)}$$

Formule generali
di trasformazione

$$x' = \frac{f \cdot x \cdot \cos \theta}{(r_0 - x \cdot \sin \theta)} \quad ; \quad y' = \frac{f \cdot y}{(r_0 - x \cdot \sin \theta)}$$

$$x \approx \frac{r_0 \cdot x'}{f \cdot \cos \theta} \quad ; \quad y \approx \frac{r_0 \cdot y'}{f}$$

Formule (lineari)
di trasformazione
per CCD lontana dal
diffusore

$$x' \approx \frac{f \cdot x \cdot \cos \theta}{r_0} \quad ; \quad y' \approx \frac{f \cdot y}{r_0}$$

(Teoria per la riflessione)

INTENSITA' SEGNALE CCD

$$I'(P', \lambda) \propto f_{scatt}(P) \cdot f_{lightcoll}(P) \cdot I(P, \lambda)$$

Segnale CCD

$$I'(P', \lambda) \propto R_d[\delta, \psi, \lambda] \cdot \left[\frac{R_o[\varphi, \lambda] \cdot \cos(\varphi) \cdot c_{focal}(P)}{r(P)^2} \right] \cdot I(P, \lambda)$$

Diffusore reale

$$c_{focal}(P) = \frac{(r_0 - x \cdot \sin \theta)^4}{r_0 \cdot f^2 \cdot \cos \theta \cdot [(y - x) \cdot \sin \theta + r_0]}$$

Fattore di focalizzazione

$$R_d(\delta, \psi, \lambda) = R_d(\psi, \lambda) = R_d(\lambda) \cdot \odot(\psi, \lambda)$$

Diffusore Lambertiano
o quasi-Lambertiano
(Funzione Lambertiana)

$$I'(P', \lambda) \propto [R_d(\lambda) \cdot \odot(\psi, \lambda)] \cdot \dots$$

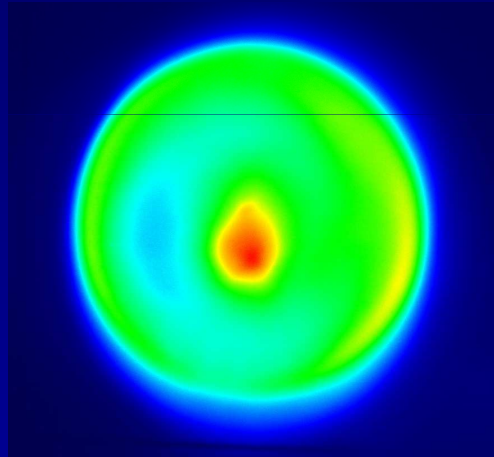
$$\dots \cdot \left[\frac{R_o[\varphi, \lambda] \cdot \cos(\varphi)}{r(P)^2} \cdot \frac{(r_0 - x \cdot \sin \theta)^4}{r_0 \cdot f^2 \cdot \cos \theta \cdot [(y - x) \cdot \sin \theta + r_0]} \right] \cdot I(P, \lambda)$$

Segnale CCD

FATTORE DI FOCALIZZAZIONE

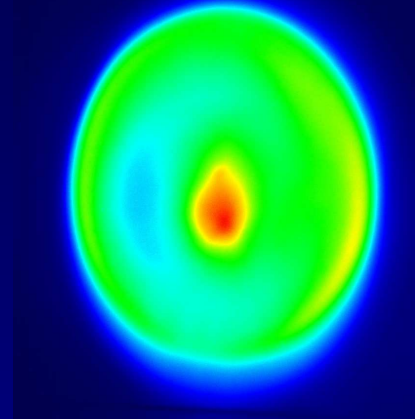
Differenze da una misura all'altra

$$C_{focal}(P) = \frac{(r_0 - x \cdot \sin \theta)^4}{r_0 \cdot f^2 \cdot \cos \theta \cdot [(y - x) \cdot \sin \theta + r_0]}$$



$\theta = 0^\circ$

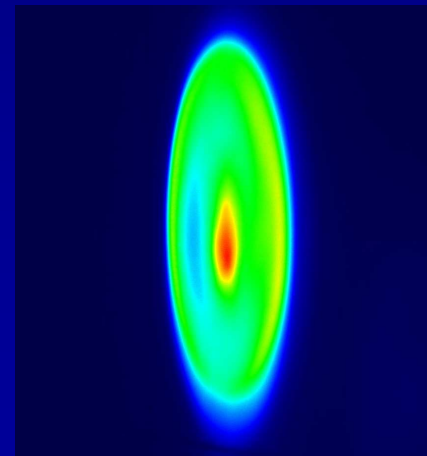
C'_{focal}



$\theta = 30^\circ$

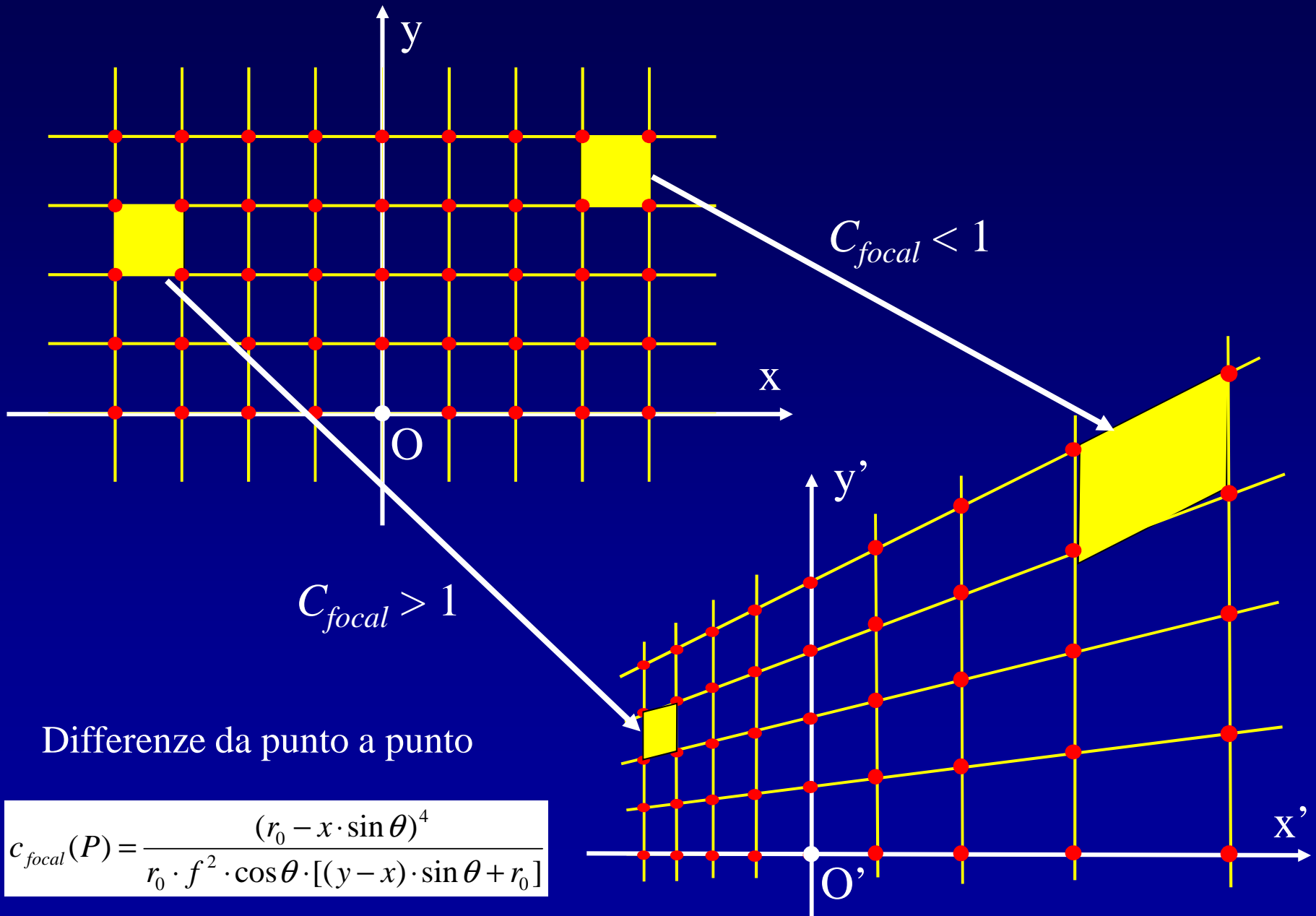
$C'_{focal} < C''_{focal}$

C''_{focal}



$\theta = 70^\circ$

FATTORE DI FOCALIZZAZIONE



INTENSITA' INCIDENTE (Riflessione)

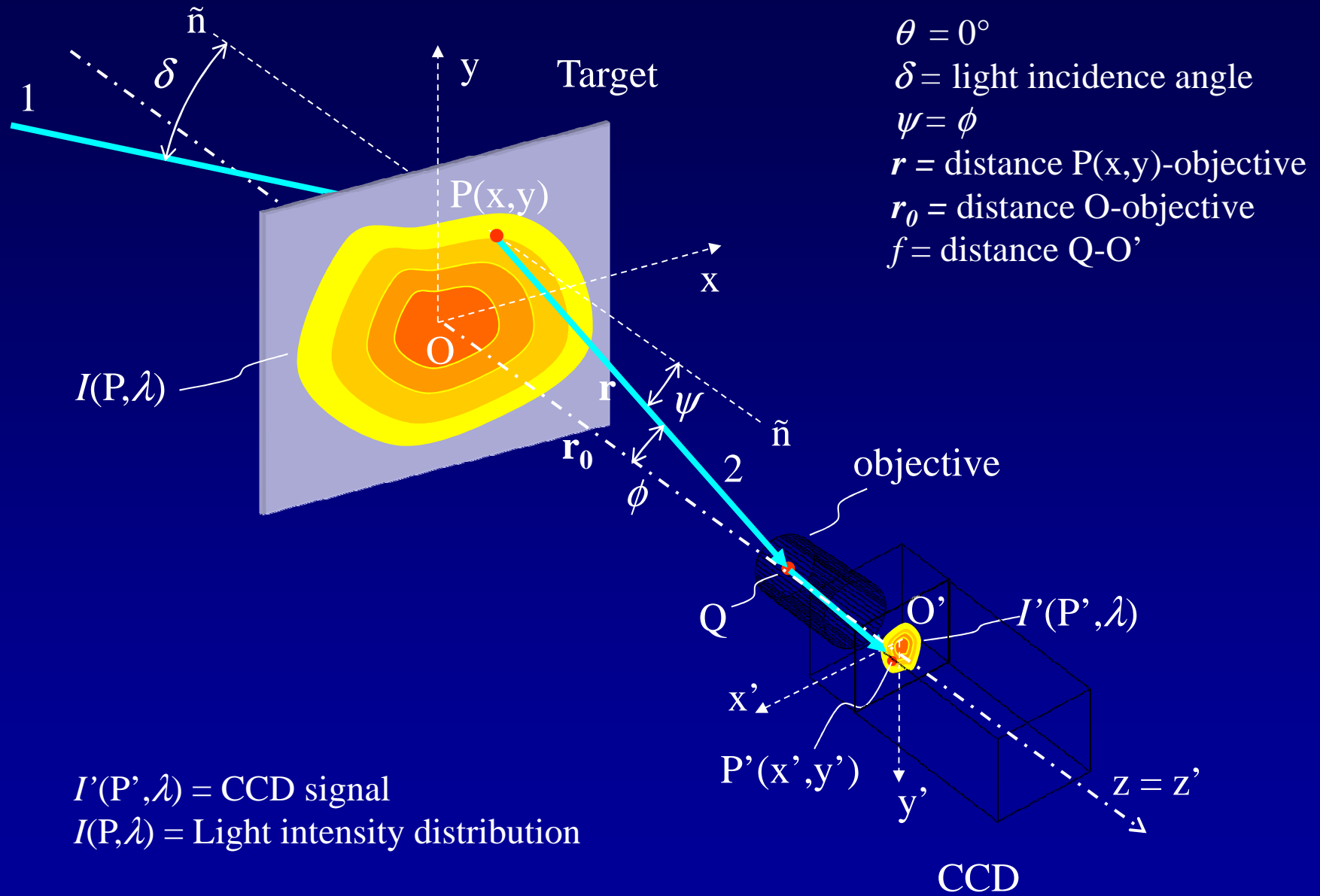
$$I(P, \lambda) \propto \left[\frac{r(P)^2}{R_d(\lambda) \cdot \odot(\psi, \lambda)} \right] \cdot \dots$$
$$\dots \cdot \left[\frac{r_0 \cdot f^2 \cdot \cos \theta \cdot [(y-x) \cdot \sin \theta + r_0]}{R_o[\varphi, \lambda] \cdot \cos(\varphi) \cdot (r_0 - x \cdot \sin \theta)^4} \right] \cdot I'(P', \lambda)$$

Intensità della luce
incidente

... approssimazioni per:

- i) CCD molto distante dal diffusore
- ii) CCD allineato sull'asse ottico

TEORIA (Trasmissione)



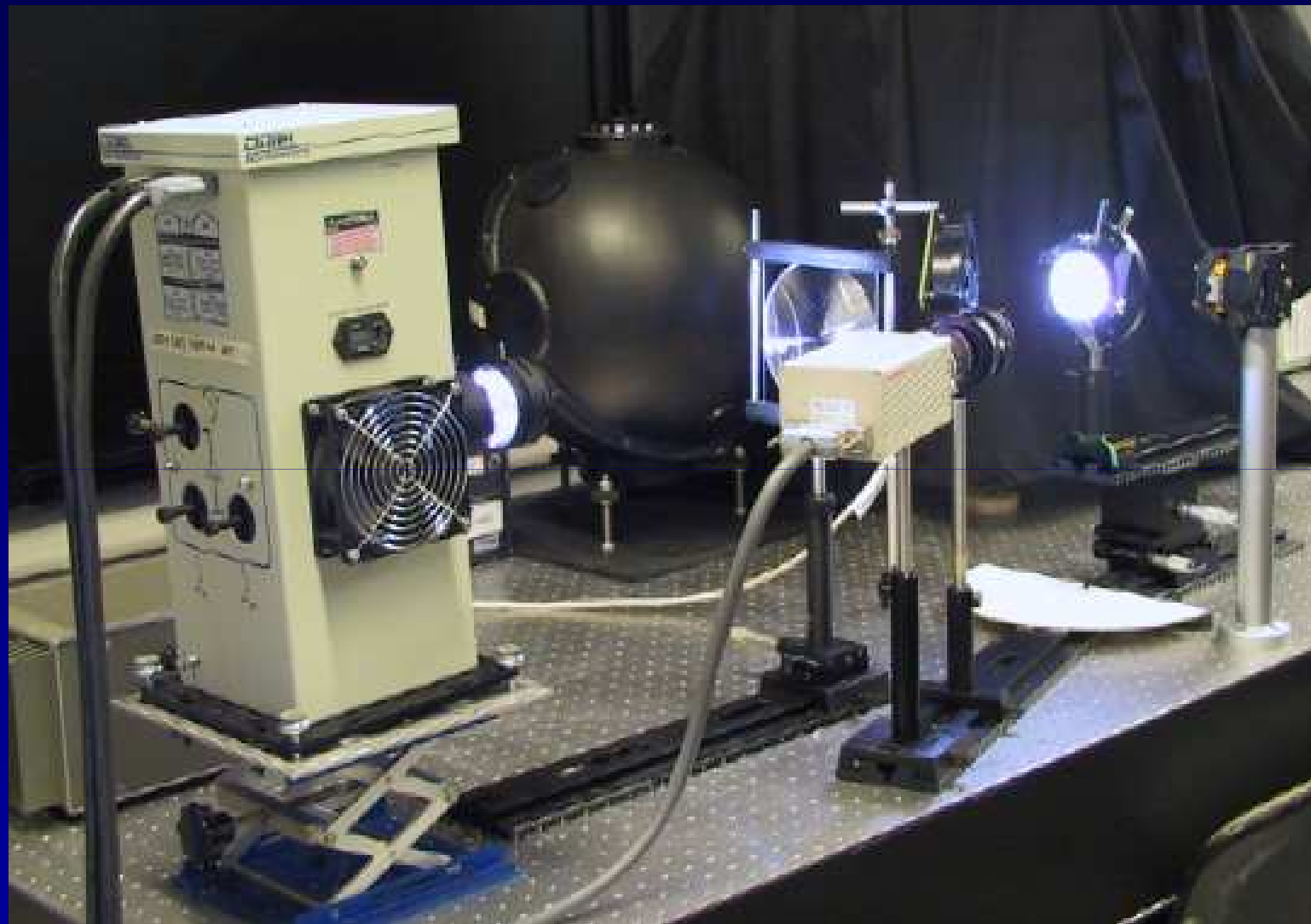
INTENSITA' INCIDENTE (Trasmissione)

$$I(P, \lambda) \propto \left[\frac{r(P)^2}{T_d(\lambda) \cdot \odot(\psi, \lambda)} \right] \dots$$
$$\dots \left[\frac{r_0 \cdot f^2 \cdot \cos \theta \cdot [(y-x) \cdot \sin \theta + r_0]}{R_o[\varphi, \lambda] \cdot \cos(\varphi) \cdot (r_0 - x \cdot \sin \theta)^4} \right] \cdot I'(P', \lambda)$$

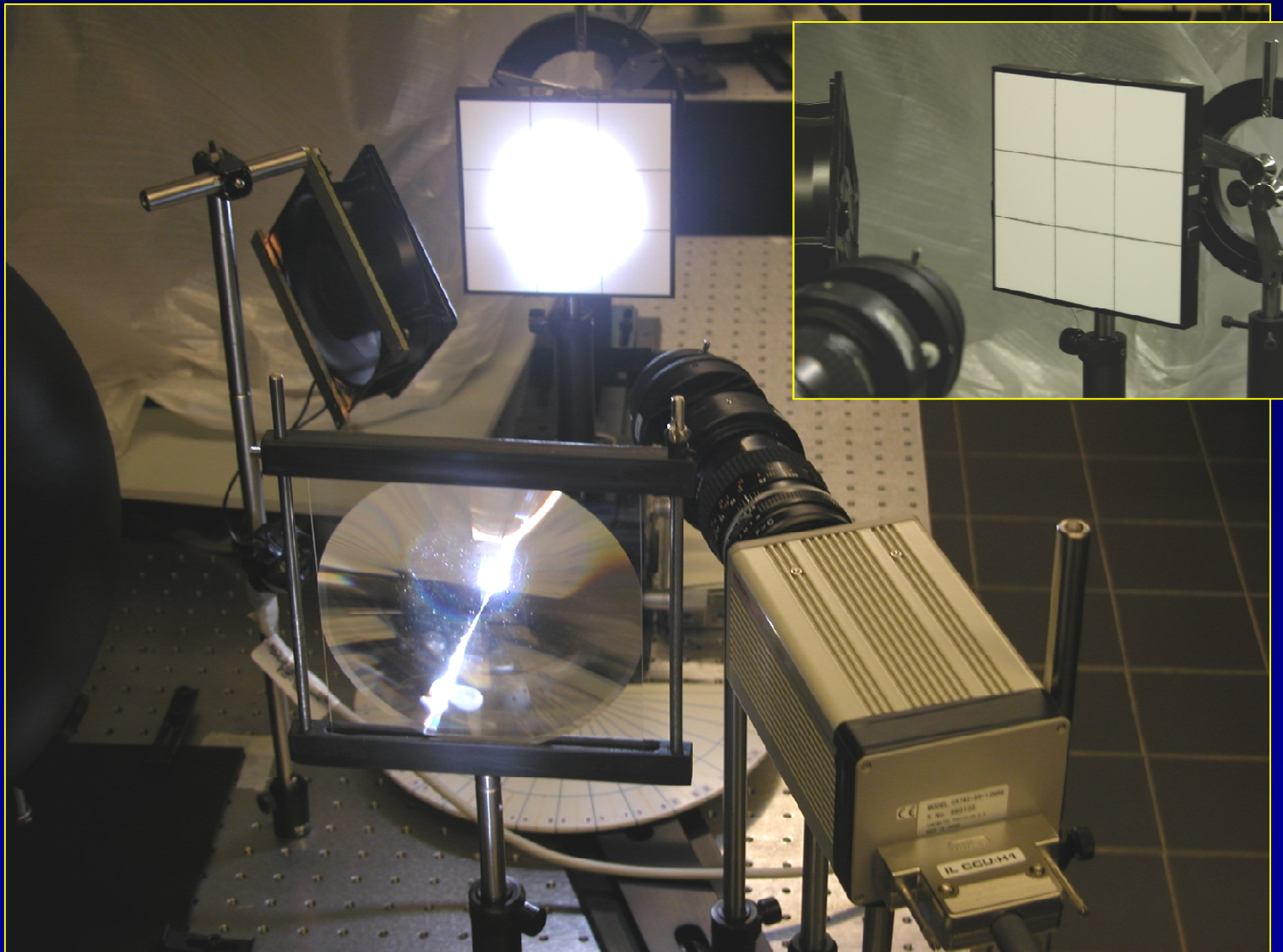
Intensità della luce
incidente

... approssimazioni per:

- i) CCD molto distante dal diffusore
- ii) CCD allineato sull'asse ottico

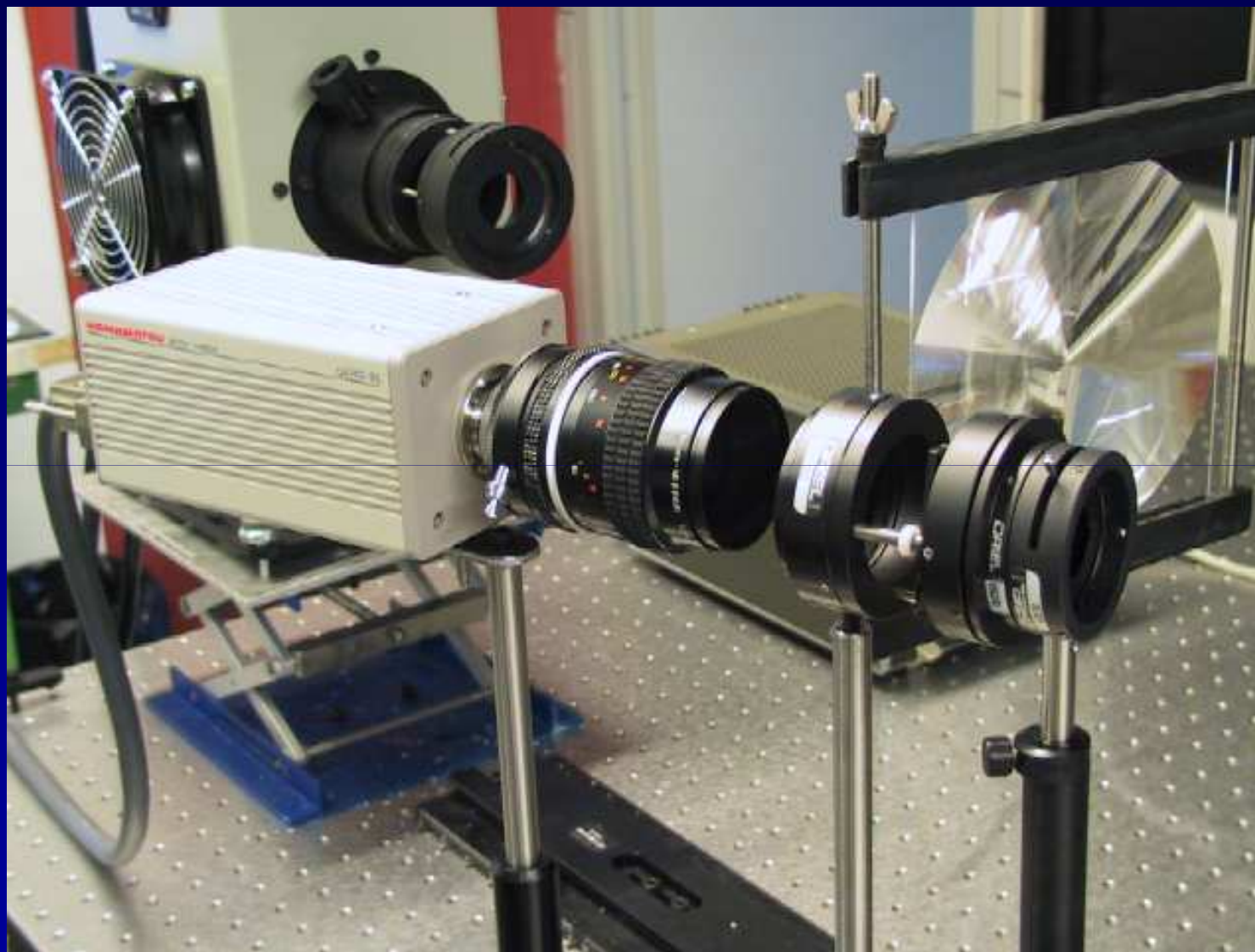


Metodo LS-CCD (riflessione)



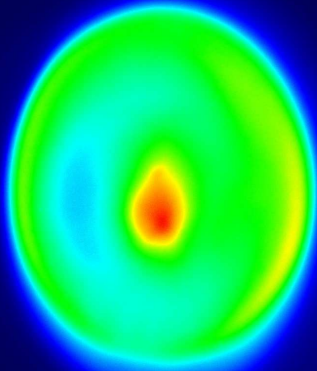
Progetto SOLTERM-Ottica

Metodo LS-CCD (riflessione)

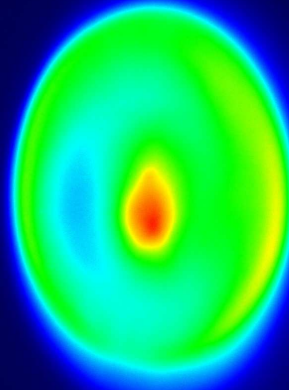


Progetto SOLTERM-Ottica

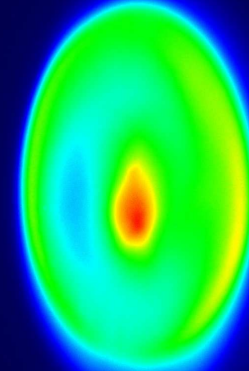
IMMAGINI CCD DI LUCE CONCENTRATA (Riflessione)



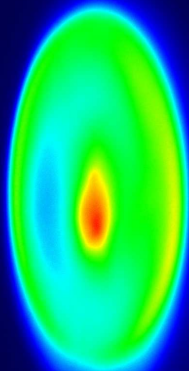
$\theta = 30^\circ$



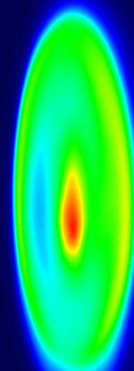
$\theta = 40^\circ$



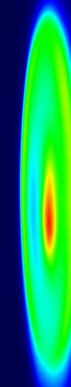
$\theta = 50^\circ$



$\theta = 60^\circ$

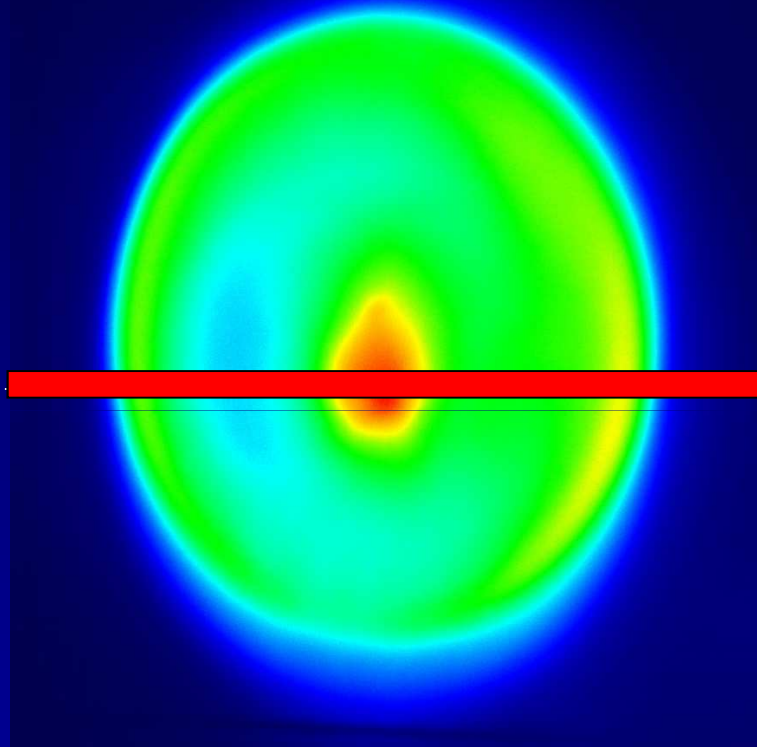


$\theta = 70^\circ$

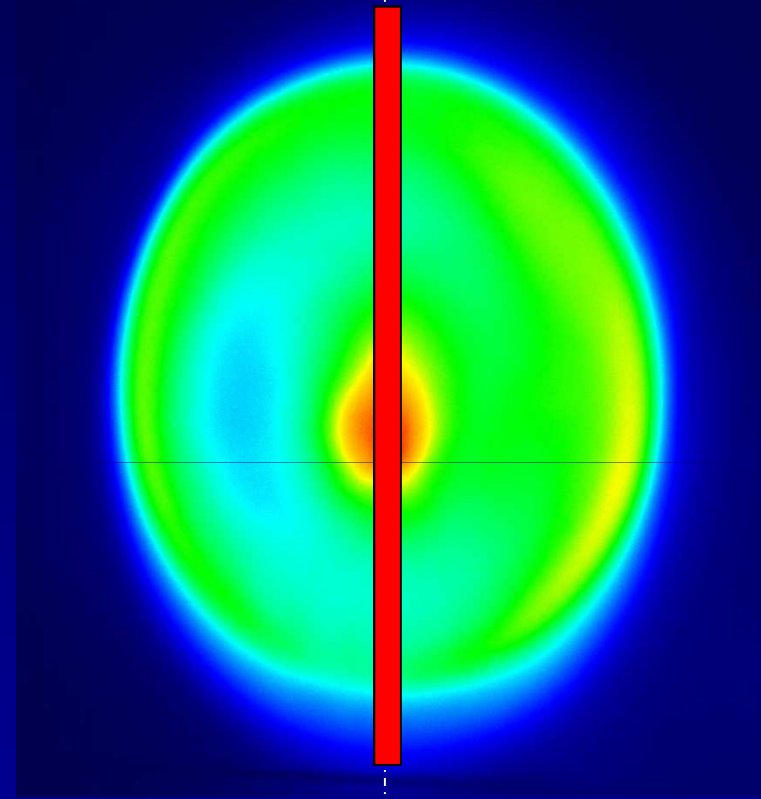


$\theta = 80^\circ$

ESEMPIO DI ELABORAZIONE (Riflessione)

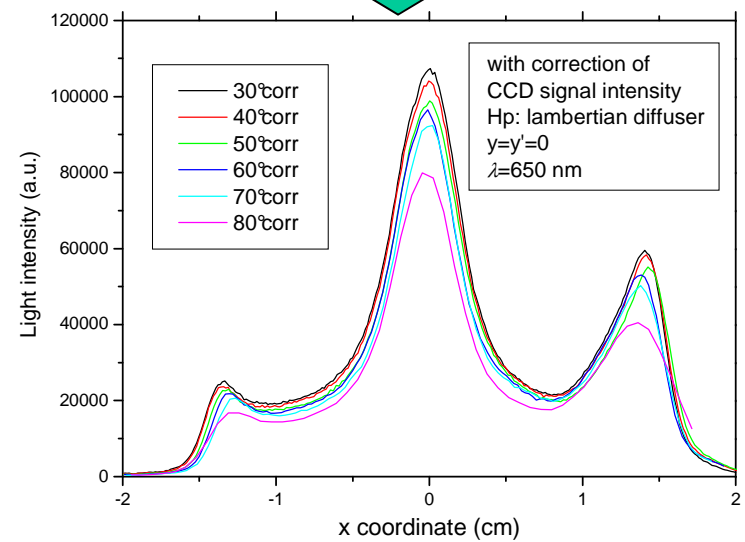
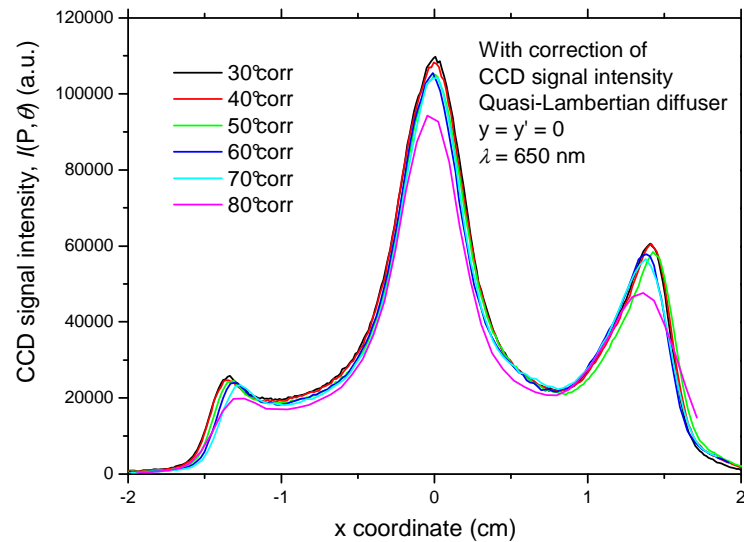
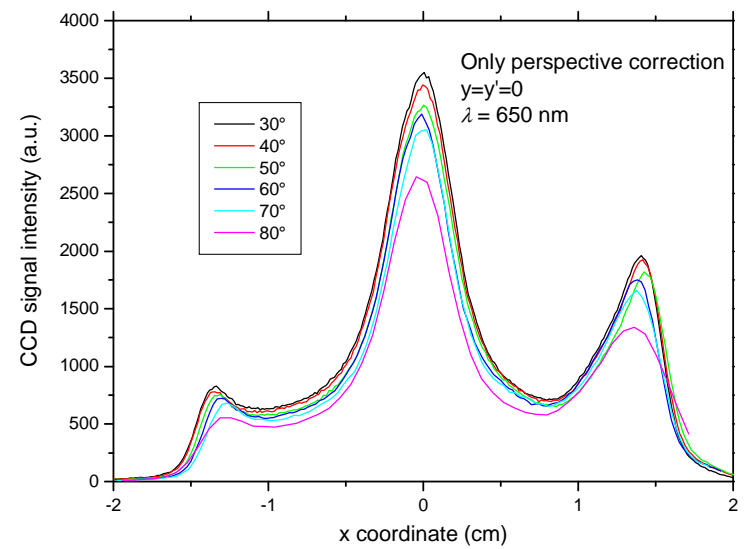
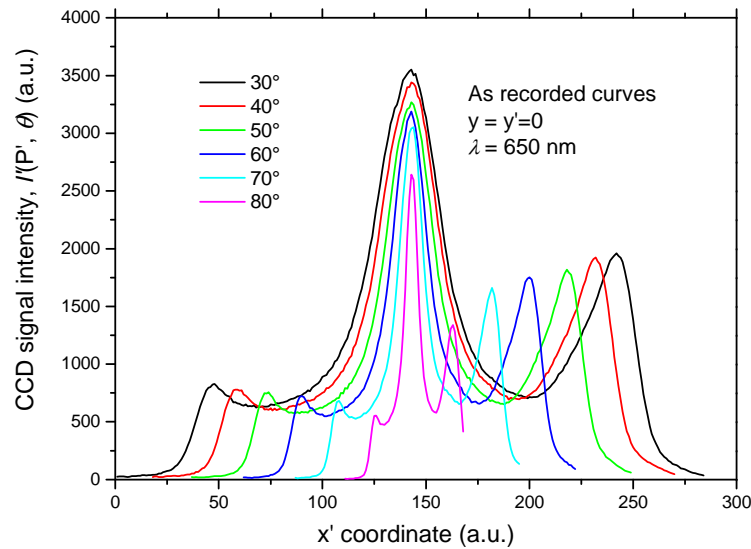


Profilo orizzontale

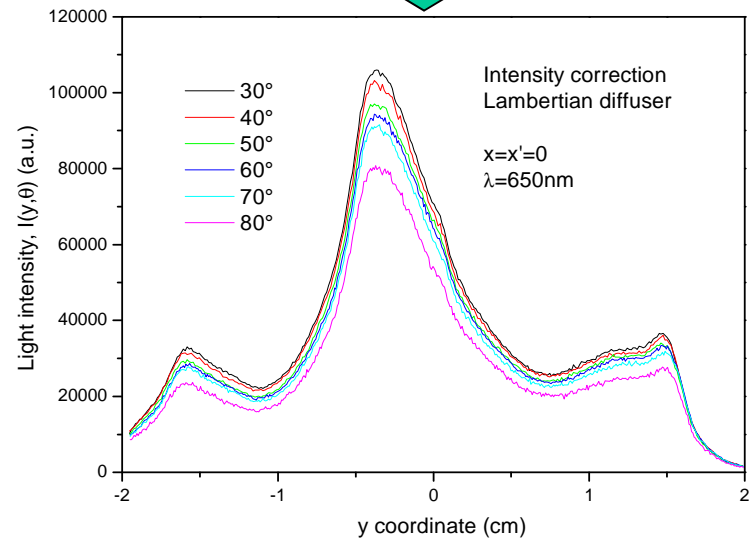
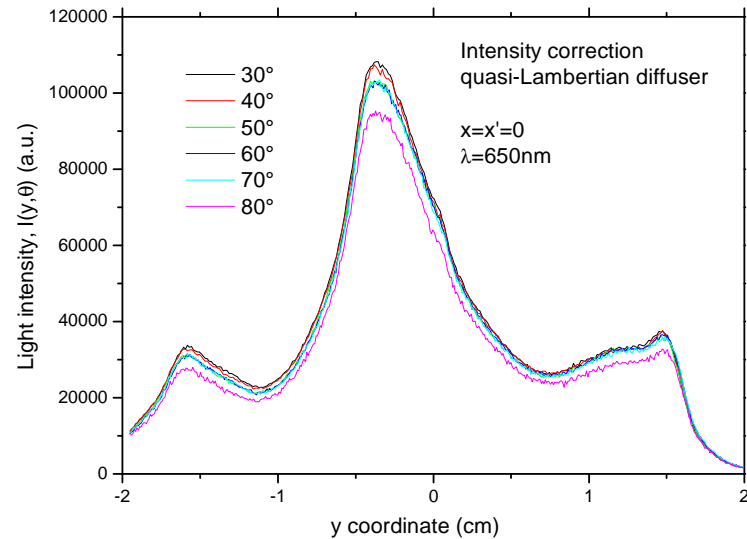
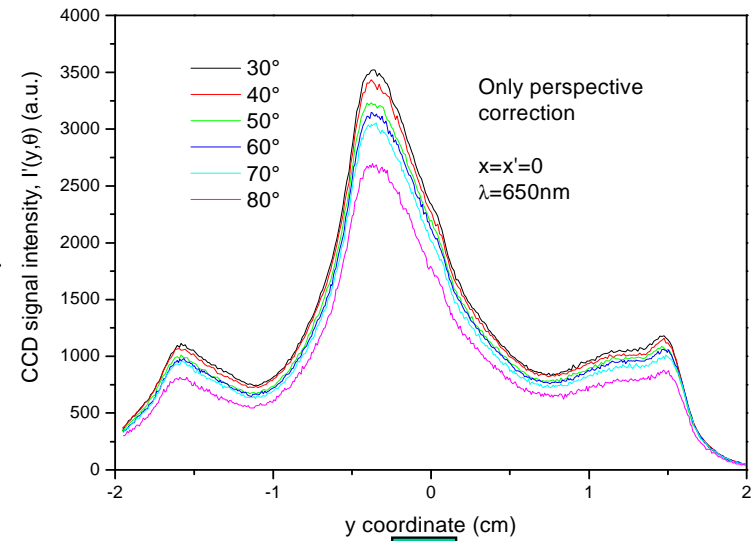
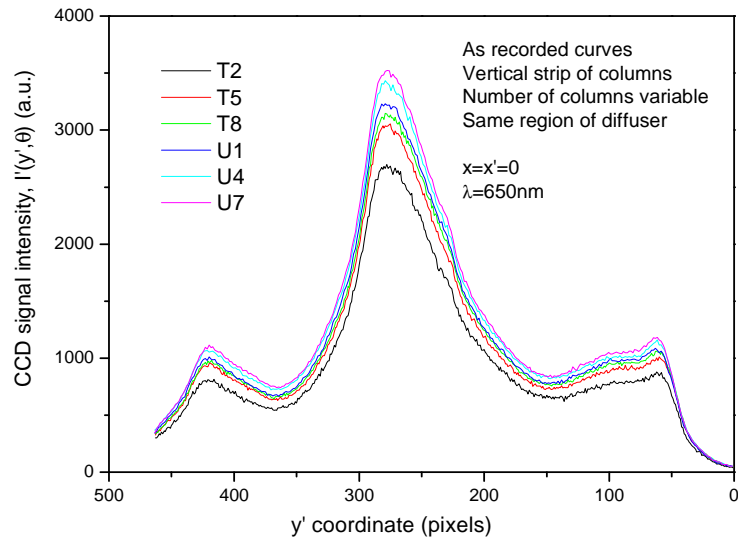


Profilo verticale

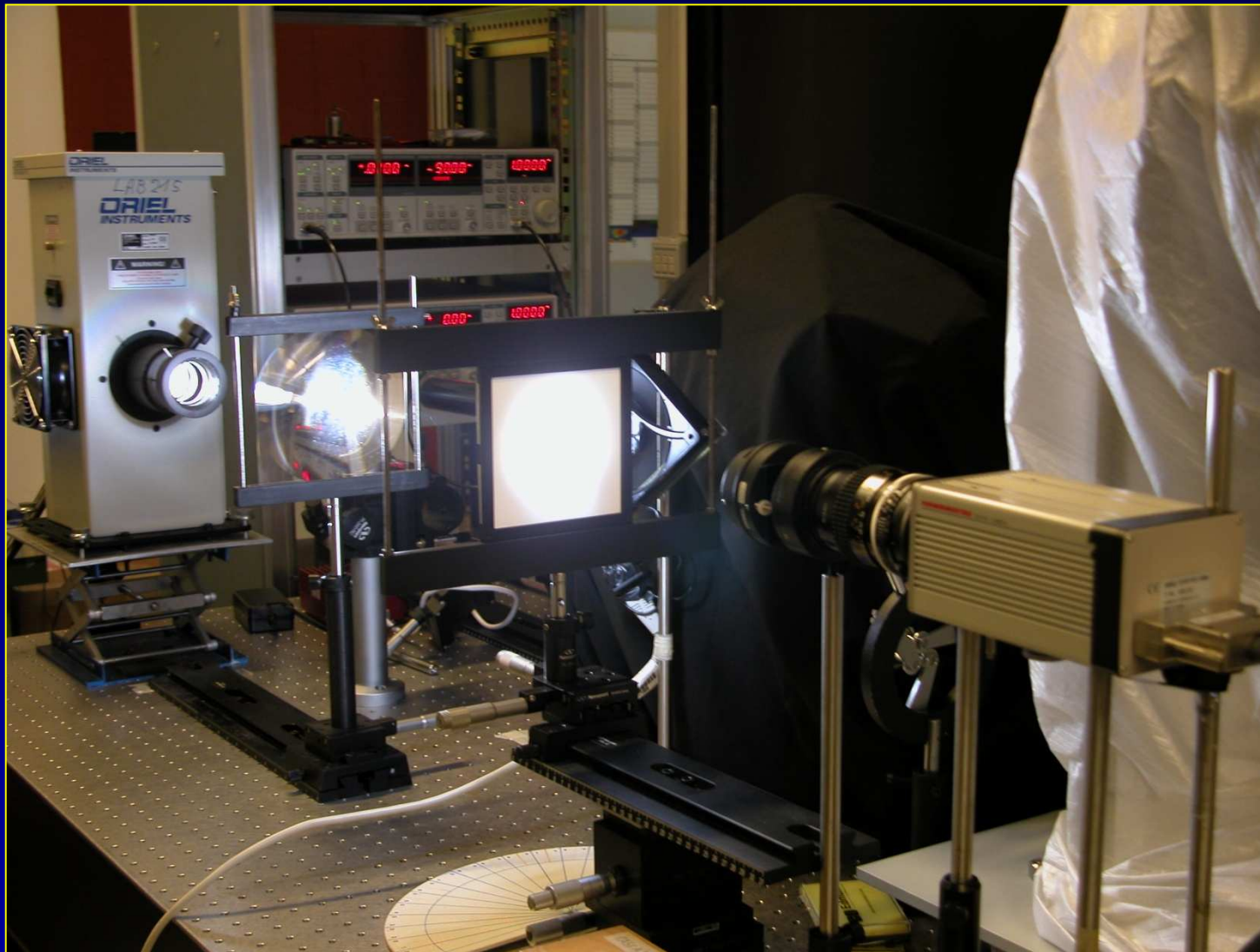
PROFILO ORIZZONTALE (Riflessione)



PROFILO VERTICALE

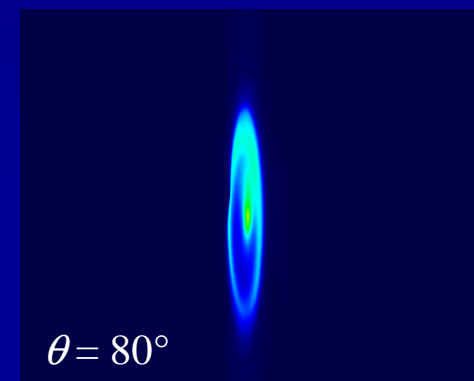
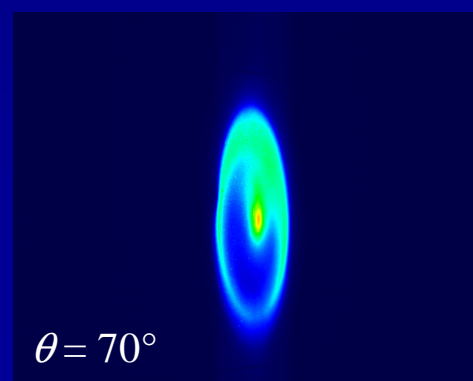
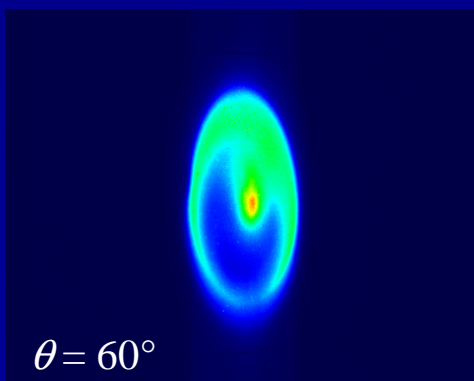
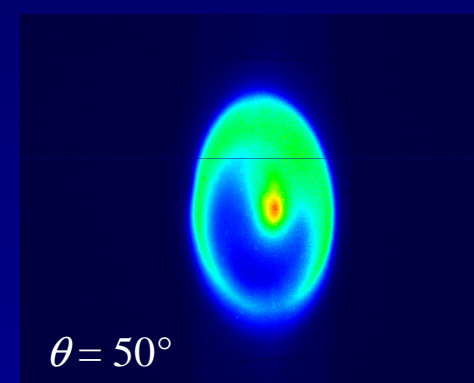
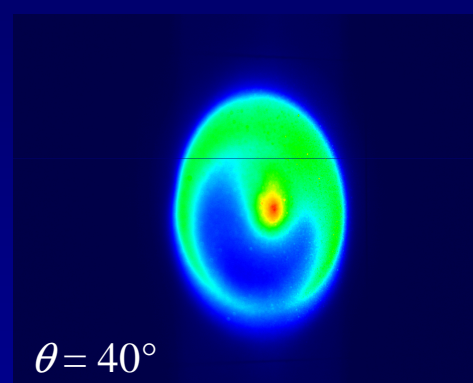
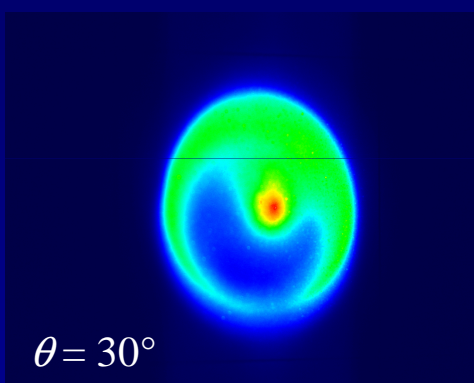
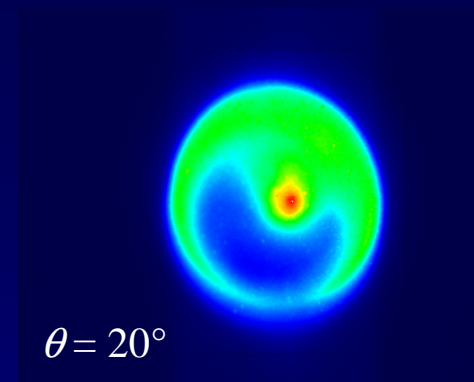
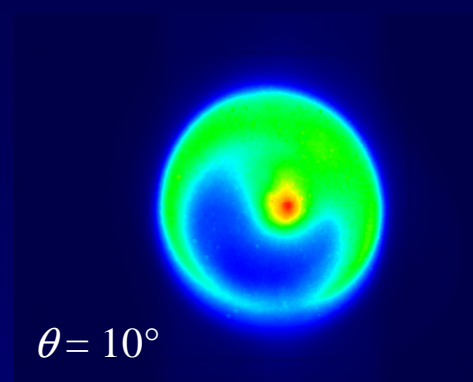
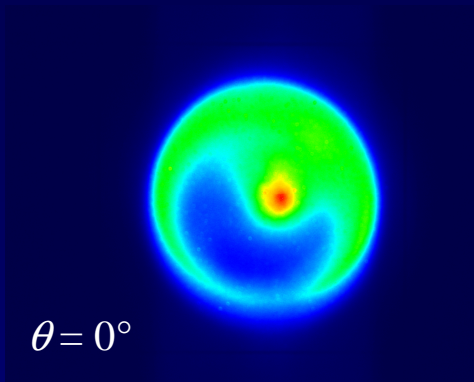


Metodo LS-CCD (trasmissione)

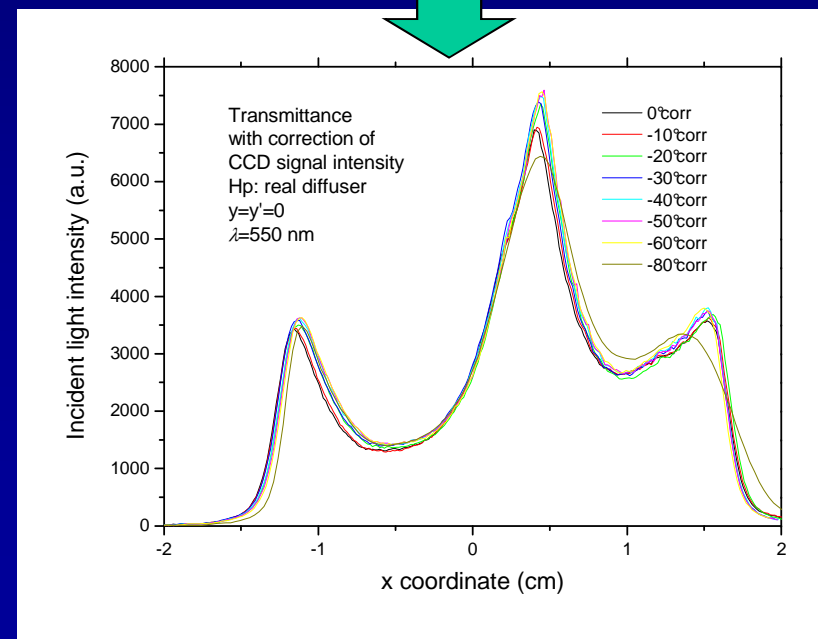
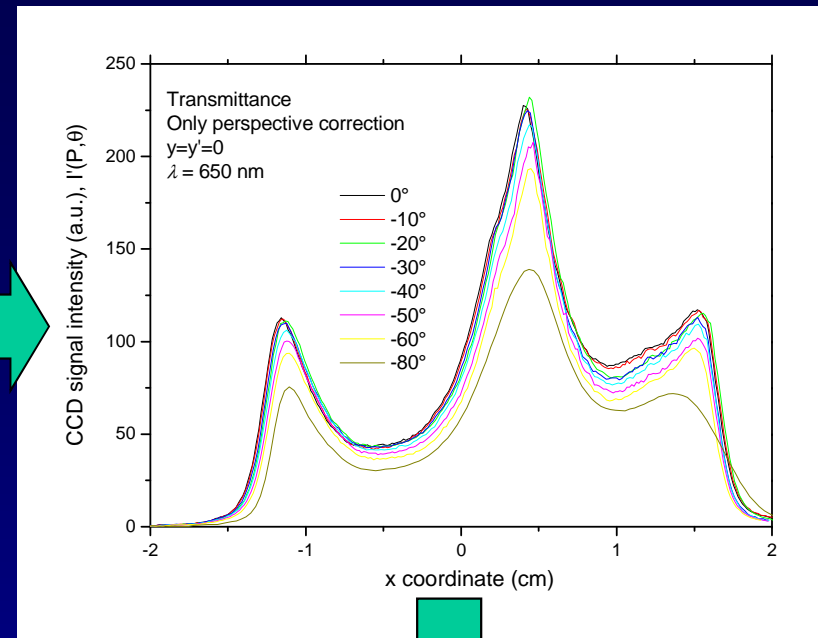
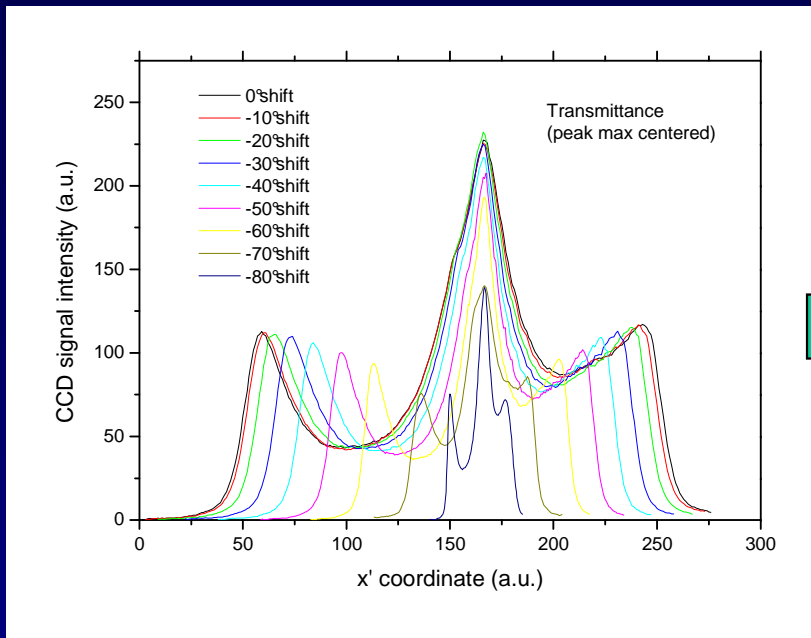


Progetto SOLTERM-Ottica

IMMAGINI CCD DI LUCE CONCENTRATA (Trasmissione)



PROFILO ORIZZONTALE (Riflessione)



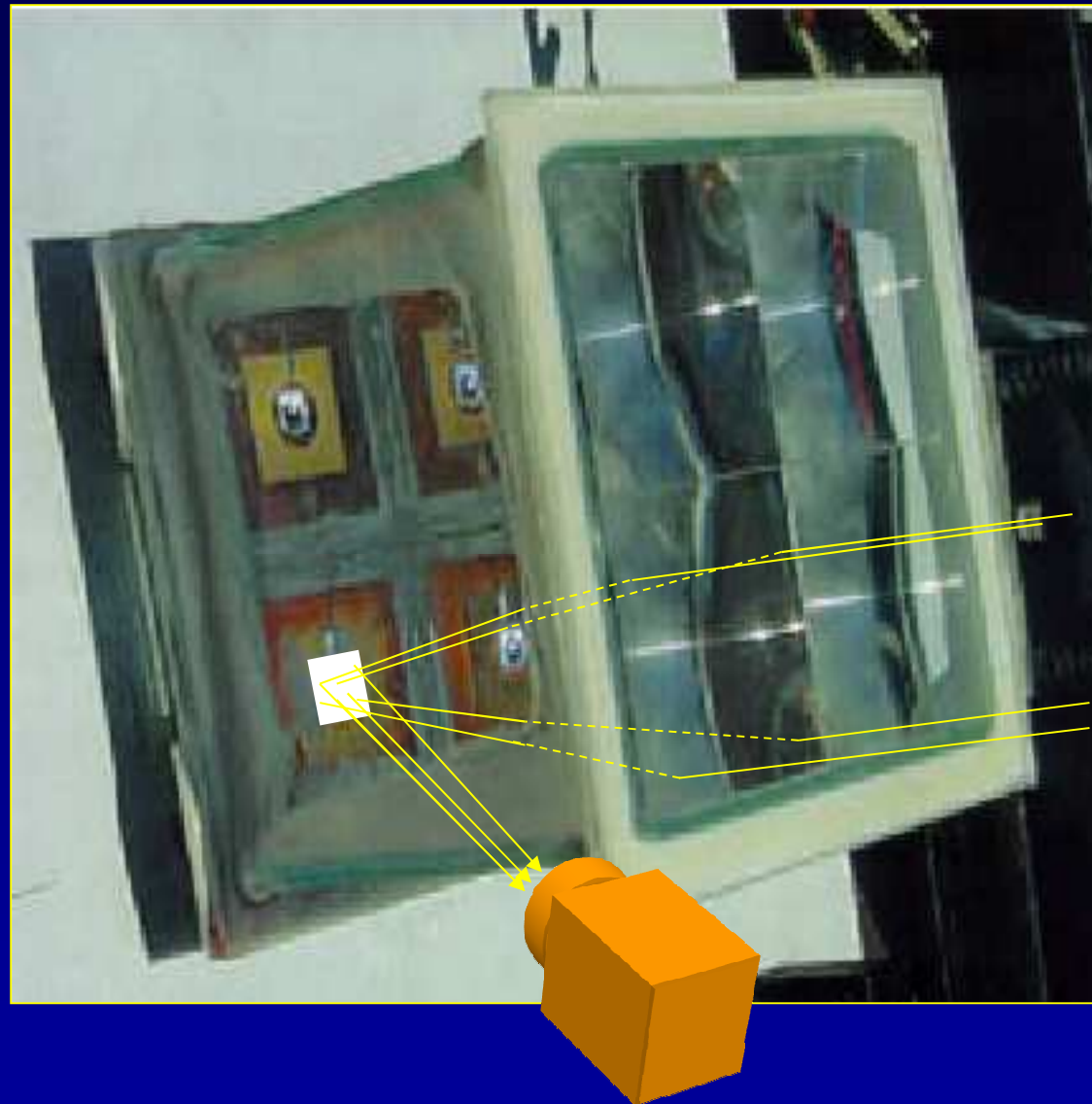
Concentratore a due assi con specchio parabolico



Progetto SOLTERM-Ottica

Università of Ferrara (I)

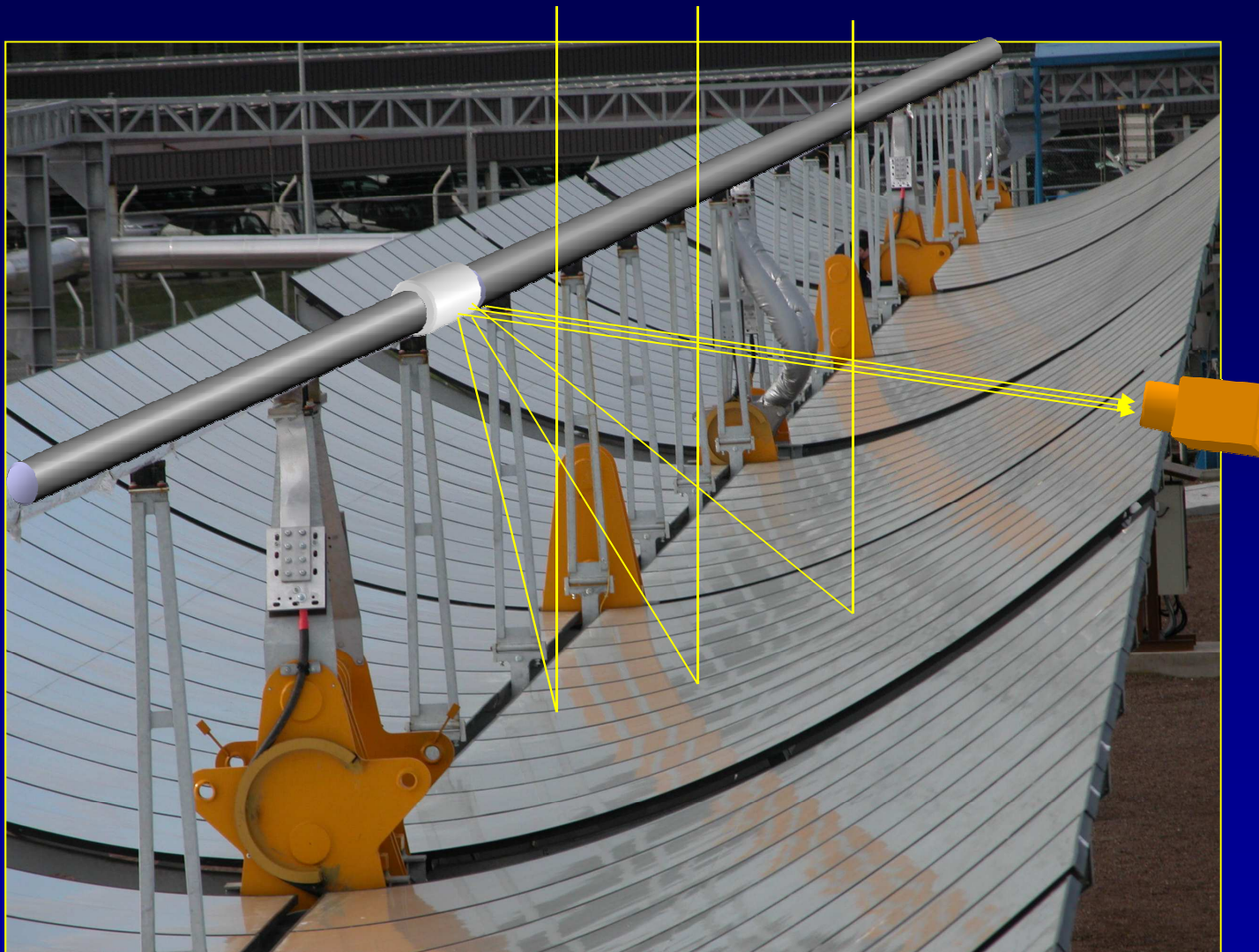
Concentratore a due assi con lente di Fresnel



Progetto SOLTERM-Ottica

Instituto de Energia Solar (ES)

Concentratore ad un asse con specchio parabolico

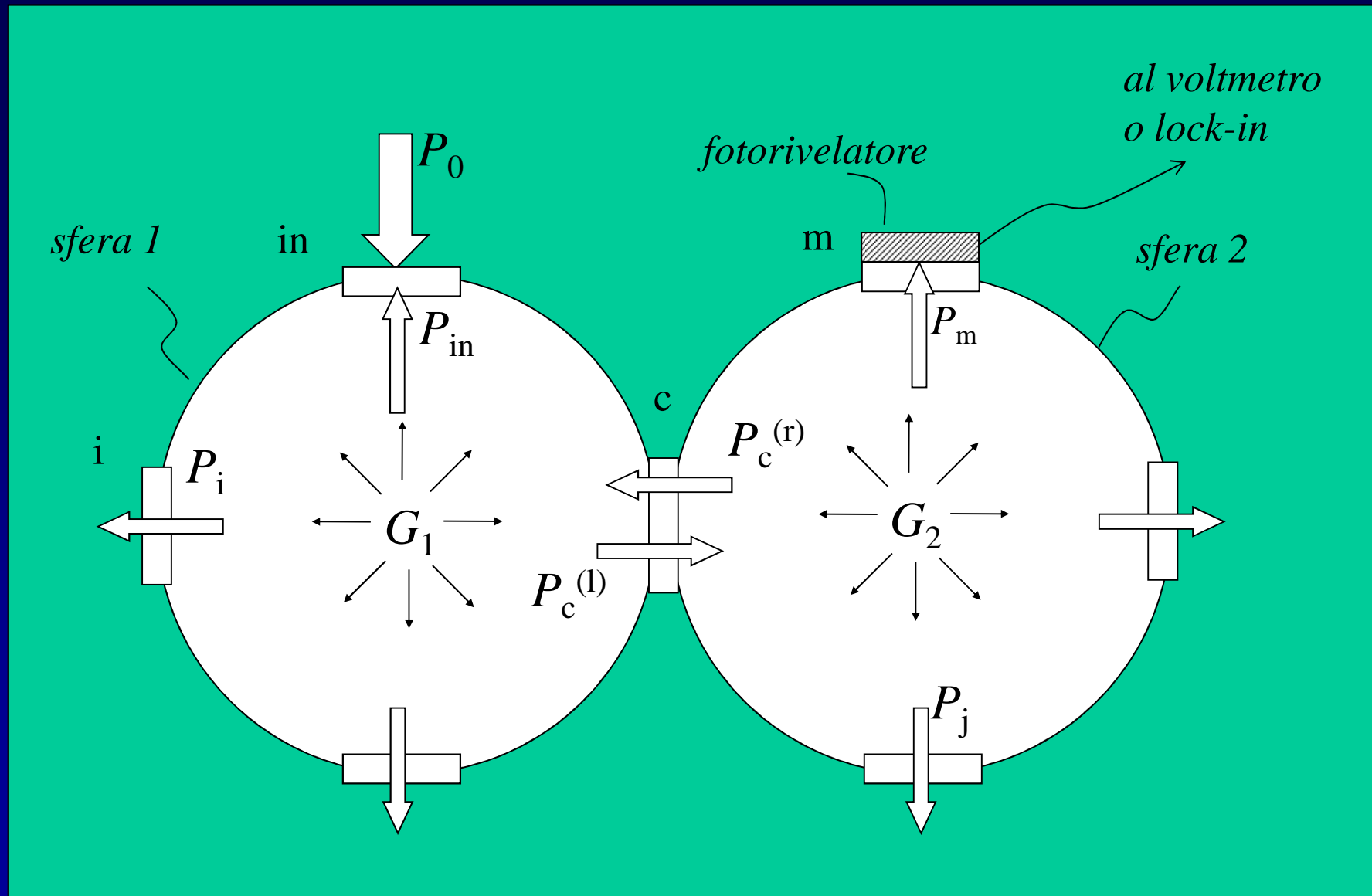


ENEA-Casaccia (I)- Progetto ARCHIMEDE

Progetto SOLTERM-Ottica

Radiometro per luce concentrata DCR1 (Double Cavity Radiometer)

Modello di radiometro a due sfere integratrici accoppiate



Progetto radiometro

Principio di conservazione dell'energia nella sfera 1:

$$P_0 + P_c^{(r)} = \sum_{i=1}^{N1} P_i + P_{p1}$$

$$P_0 + G_2 \cdot S_c = \sum_{i=1}^{N1} G_1 \cdot S_i \cdot (1 - R_i) + G_1 \cdot S_{p1} \cdot (1 - R_{p1})$$

Principio di conservazione dell'energia nella sfera 2:

$$P_c^{(l)} = \sum_{j=1}^{N2} P_j + P_{p2}$$

$$G_1 \cdot S_c = \sum_{j=1}^{N2} G_2 \cdot S_j \cdot (1 - R_j) + G_2 \cdot S_{p2} \cdot (1 - R_{p2})$$

Irradianza all'interno della sfera 1:

$$G_1 = \frac{P_0 \cdot \left[\sum_{j=1}^{N2} S_j \cdot (1 - R_j) + S_{p2} \cdot (1 - R_{p2}) \right]}{\left[\sum_{i=1}^{N1} S_i \cdot (1 - R_i) + S_{p1} \cdot (1 - R_{p1}) \right] \cdot \left[\sum_{j=1}^{N2} S_j \cdot (1 - R_j) + S_{p2} \cdot (1 - R_{p2}) \right] - S_c^2}$$

Irradianza all'interno della sfera 2:

$$G_2 = G_1 \cdot \frac{S_c}{\left[\sum_{j=1}^{N2} S_j \cdot (1 - R_j) + S_{p2} \cdot (1 - R_{p2}) \right]}$$

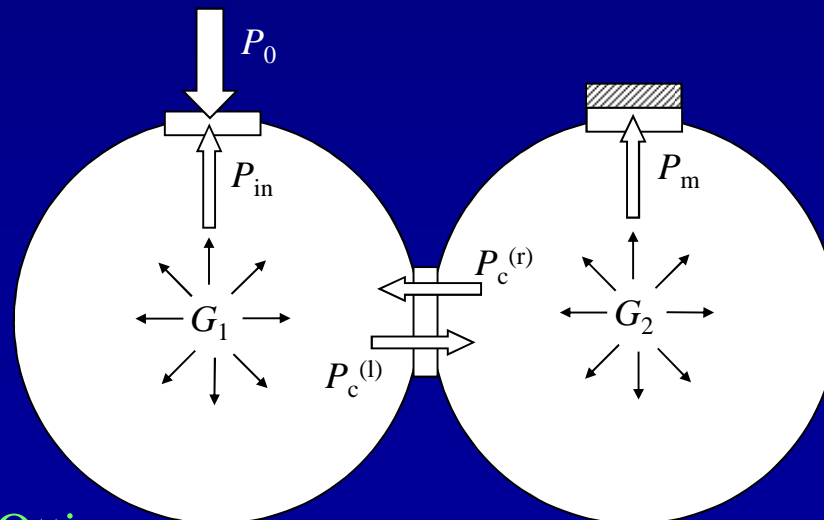
Progetto radiometro DCR1

Irradianza incidente sul fotorivelatore “m”:

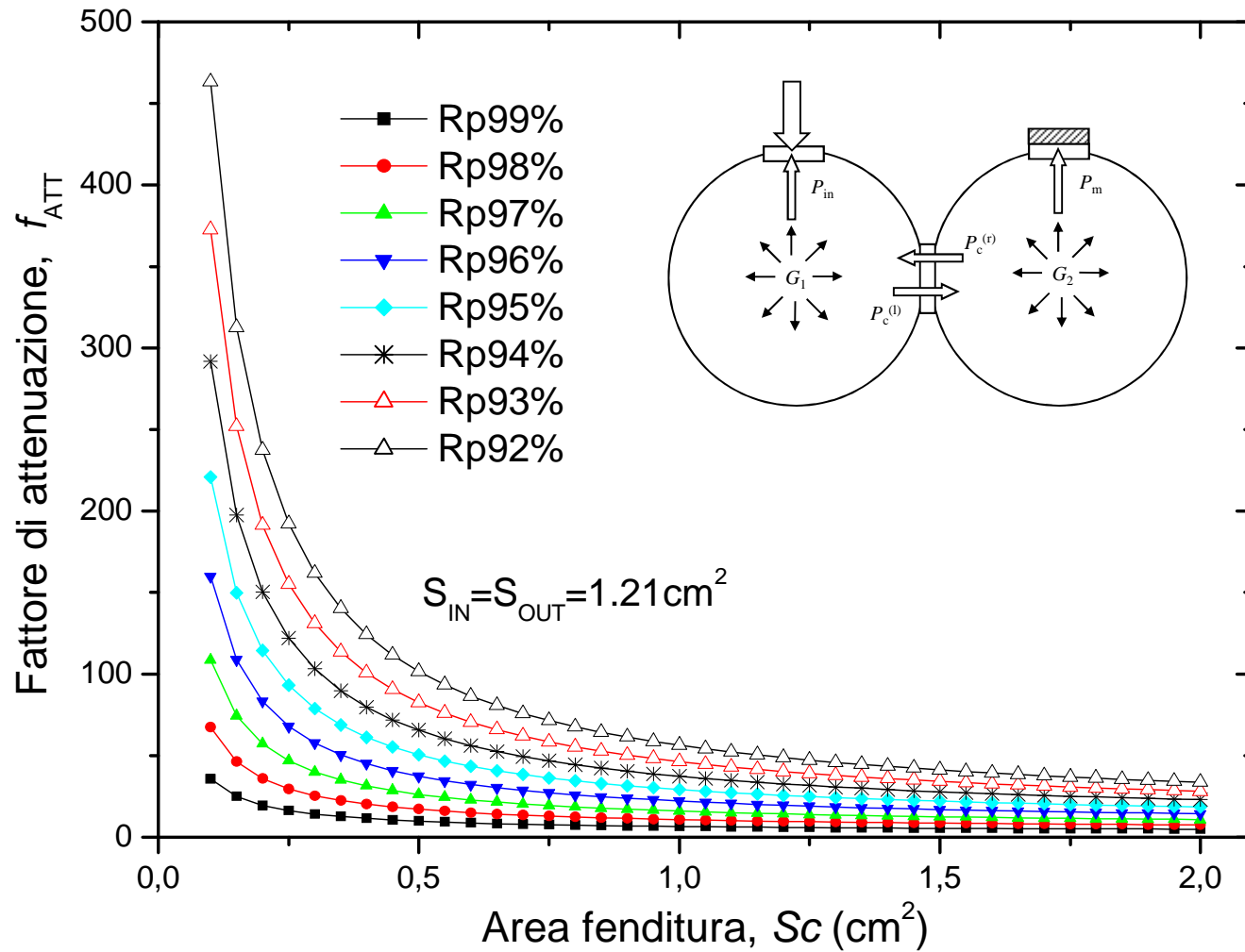
$$G_m = \frac{G_0 \cdot S_{in} \cdot S_c}{[S_{in} + S_c + S_{p1}(1 - R_p)] \cdot [S_m + S_c + S_{p2}(1 - R_p)] - S_c^2}$$

Fattore di attenuazione:

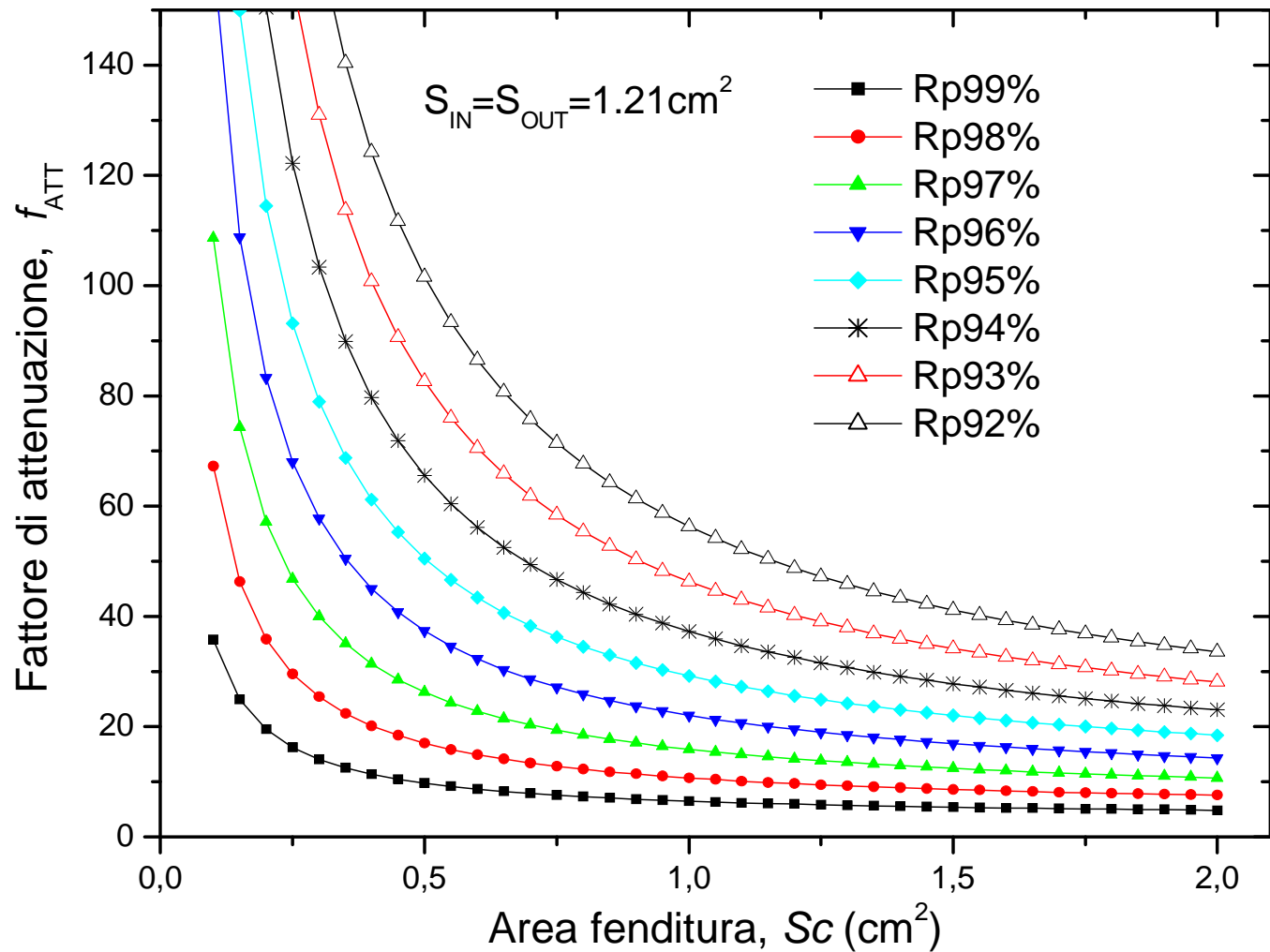
$$f_{ATT} = G_0 / G_m = \frac{[S_{in} + S_c + S_{p1}(1 - R_p)] \cdot [S_m + S_c + S_{p2}(1 - R_p)] - S_c^2}{G_0 \cdot S_{in} \cdot S_c}$$



Progetto radiometro DCR1



Progetto radiometro DCR1

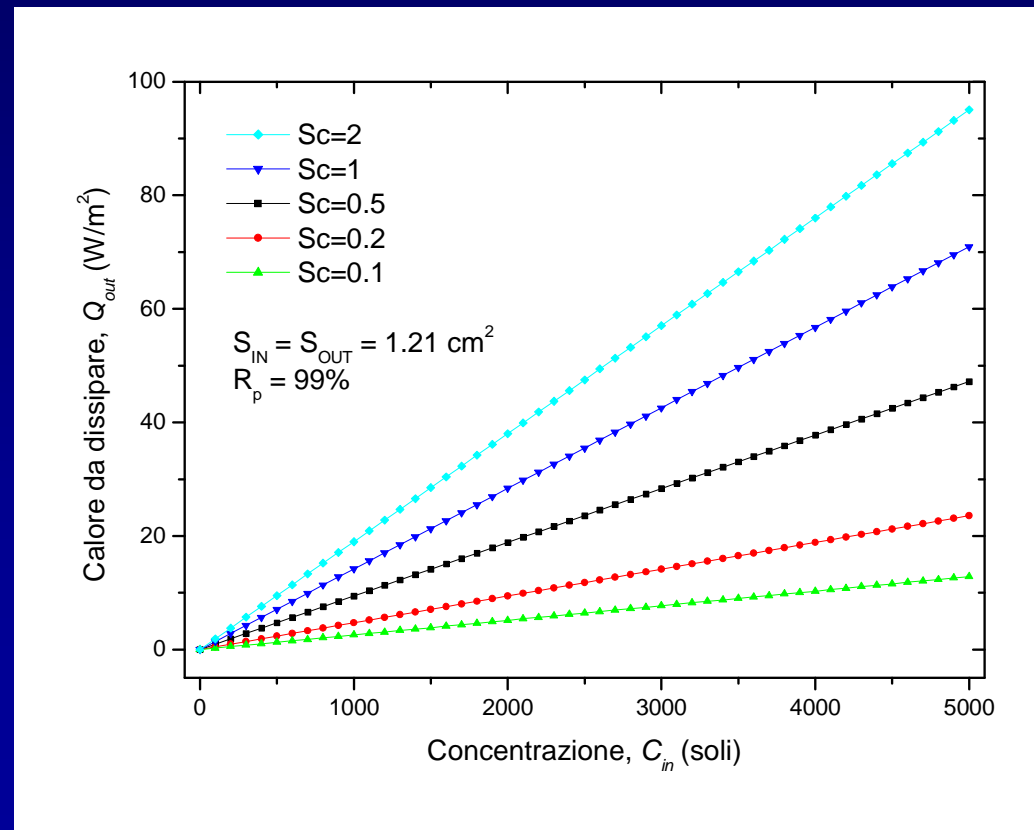


Progetto radiometro DCR1

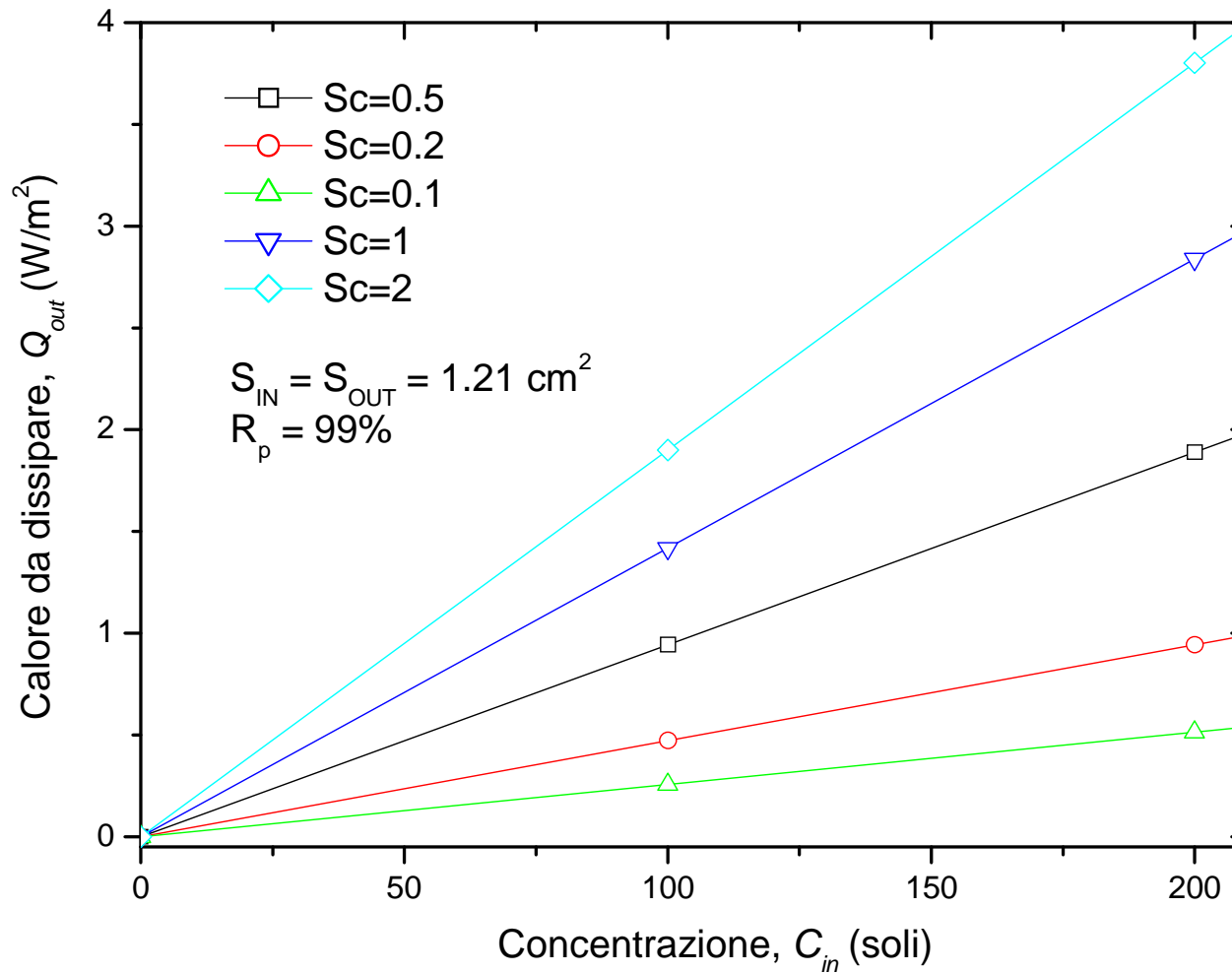
Calore da dissipare sulla cella SP:

$$Q_{out} = P_m \cdot [1 - \eta(C_m)] - P_m \cdot R_m$$

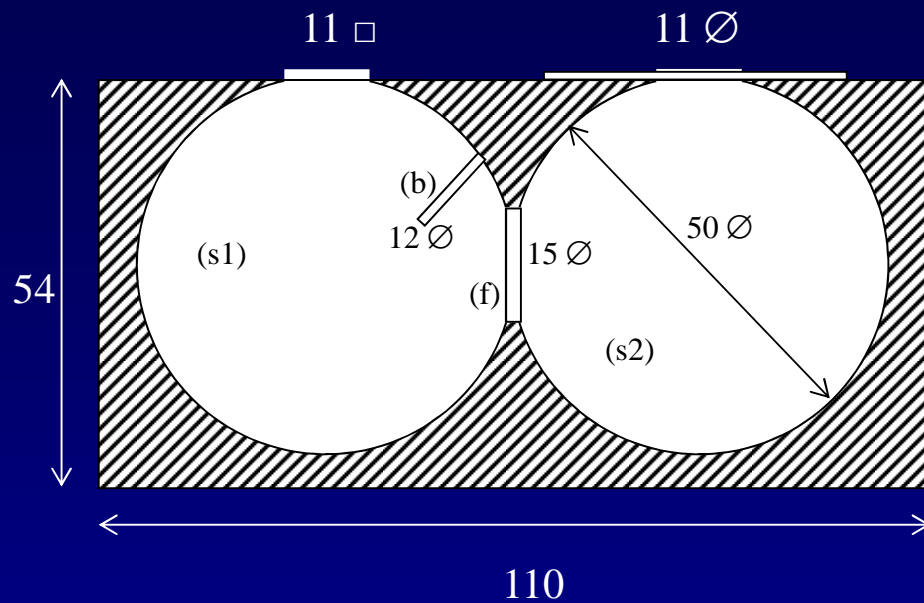
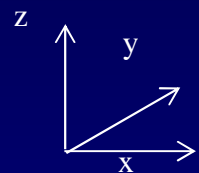
$$Q_{out} = \frac{S_m \cdot 0.1 \cdot C_{in} \cdot S_{in} \cdot S_c}{[S_{in} + S_c + S_{p1}(1 - R_p)] \cdot [S_m + S_c + S_{p2}(1 - R_p)] - S_c^2} \cdot [1 - \eta(C_m) - R_m]$$



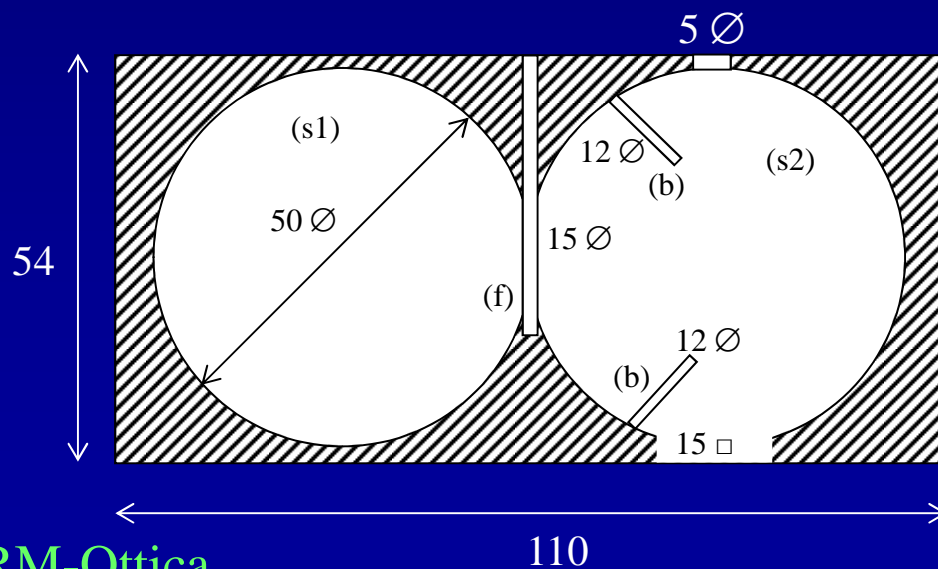
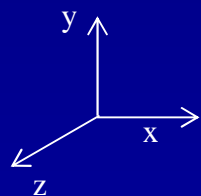
Progetto radiometro DCR1



Disegno radiometro

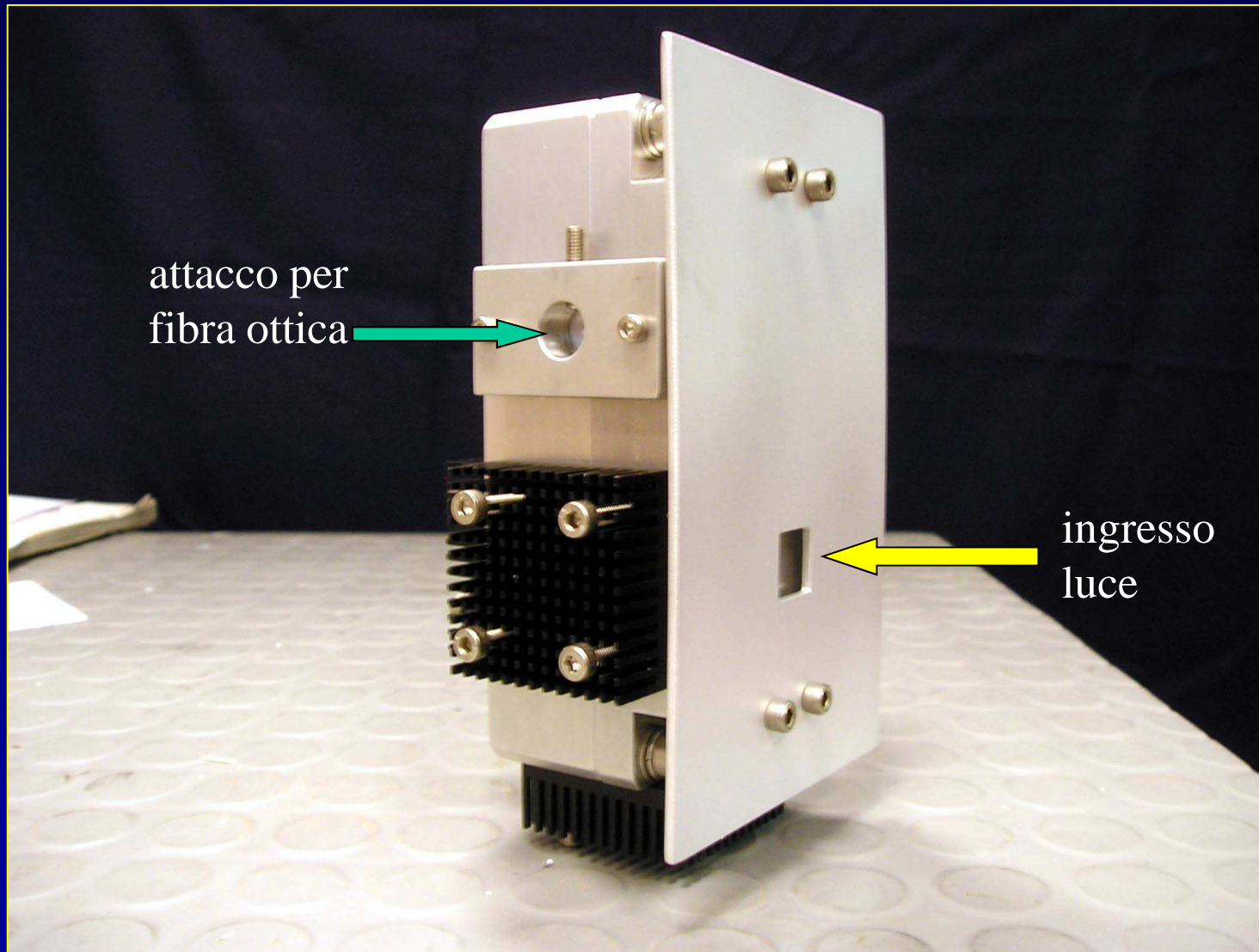


vista laterale



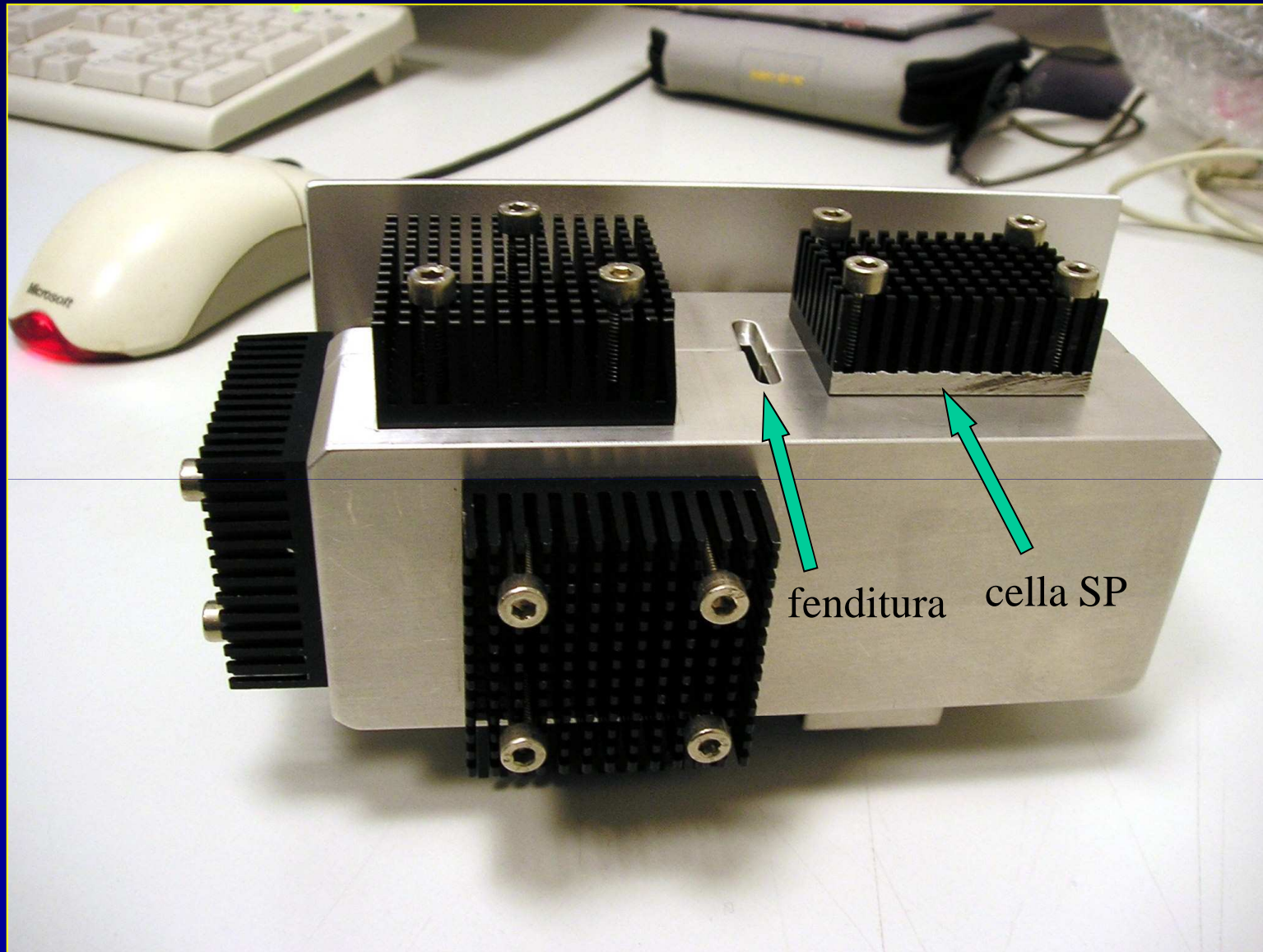
pianta

Radiometro DCR1



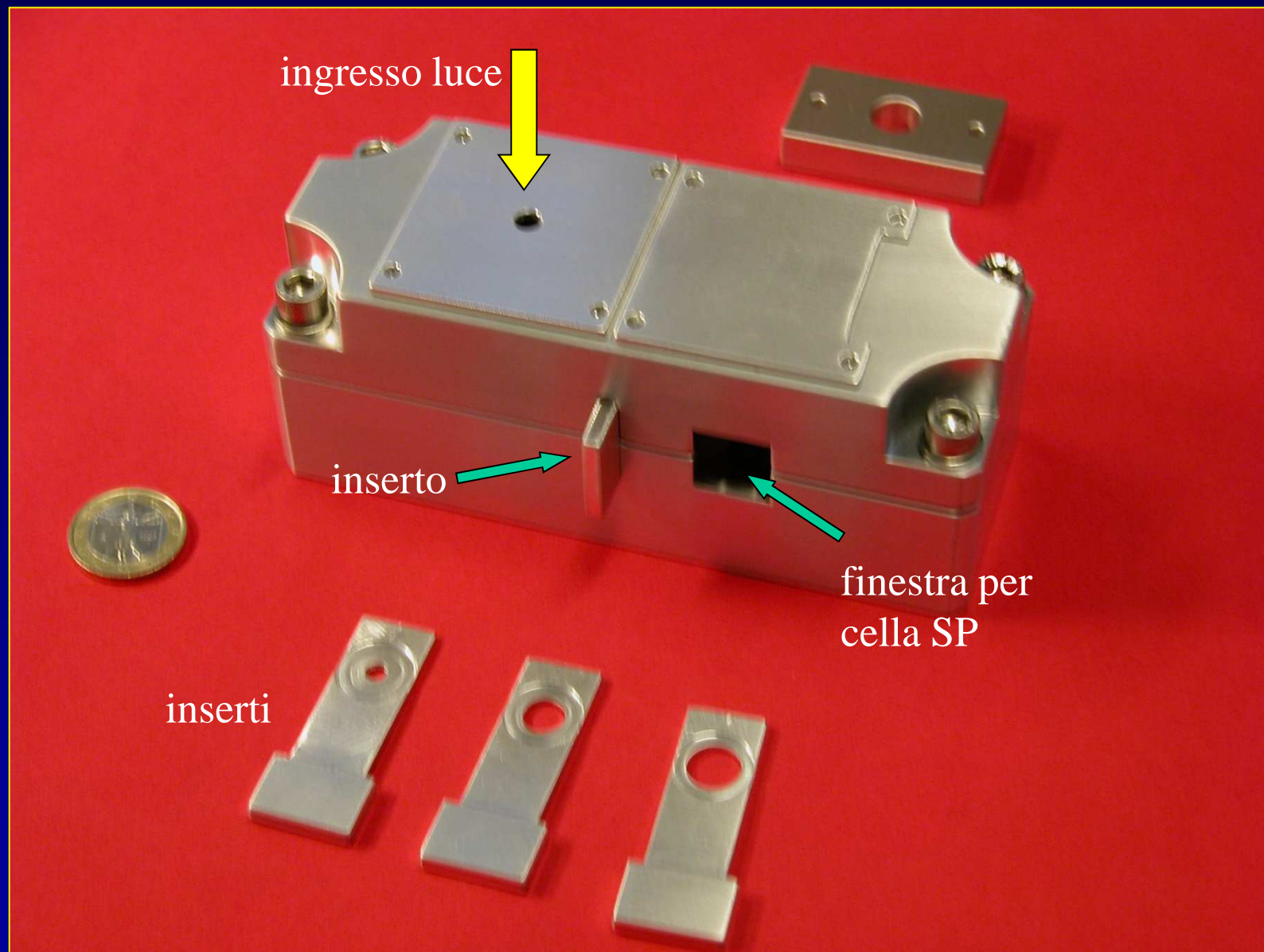
Progetto SOLTERM-Ottica

Radiometro DCR1



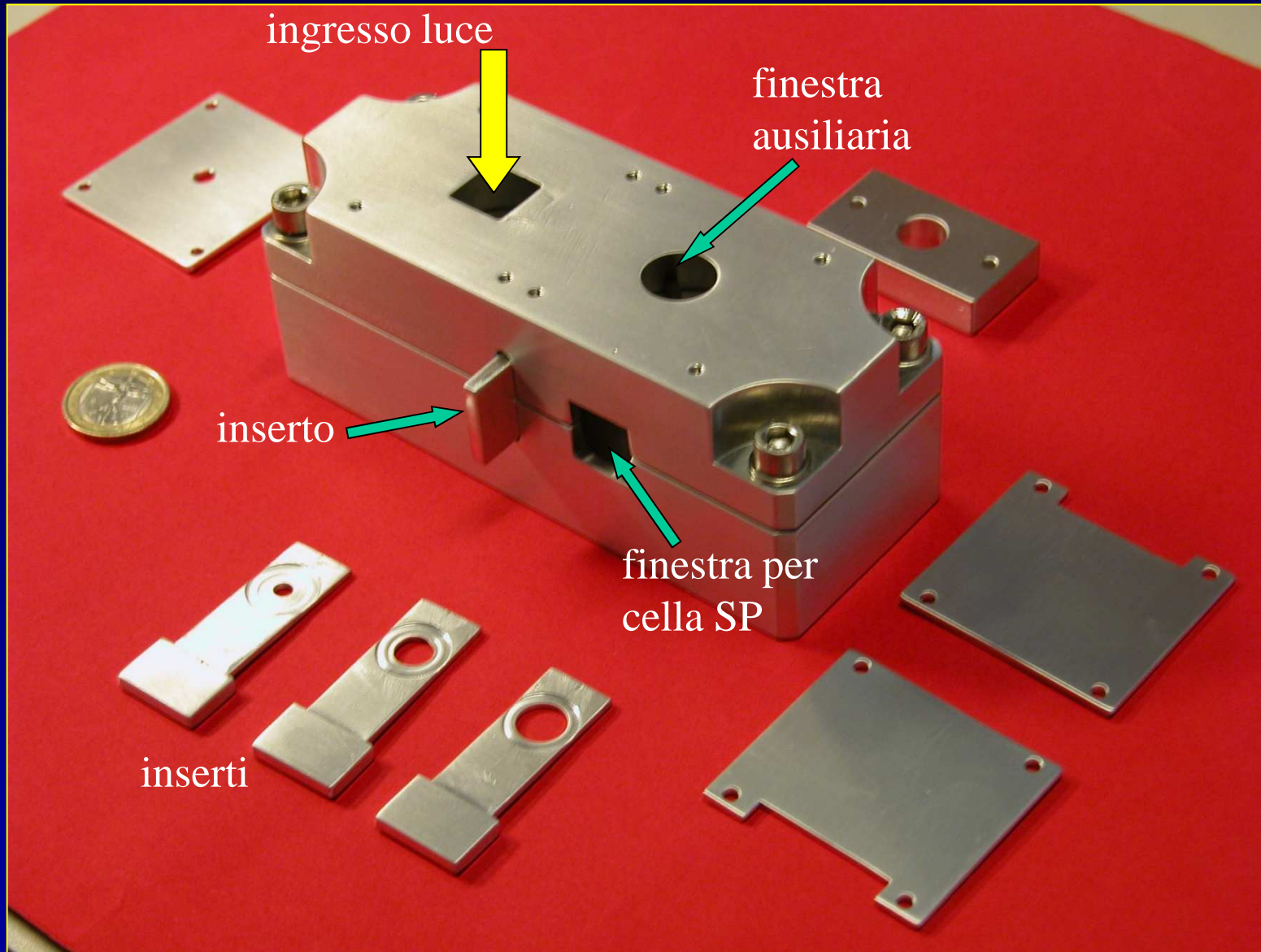
Progetto SOLTERM-Ottica

Radiometro DCR1

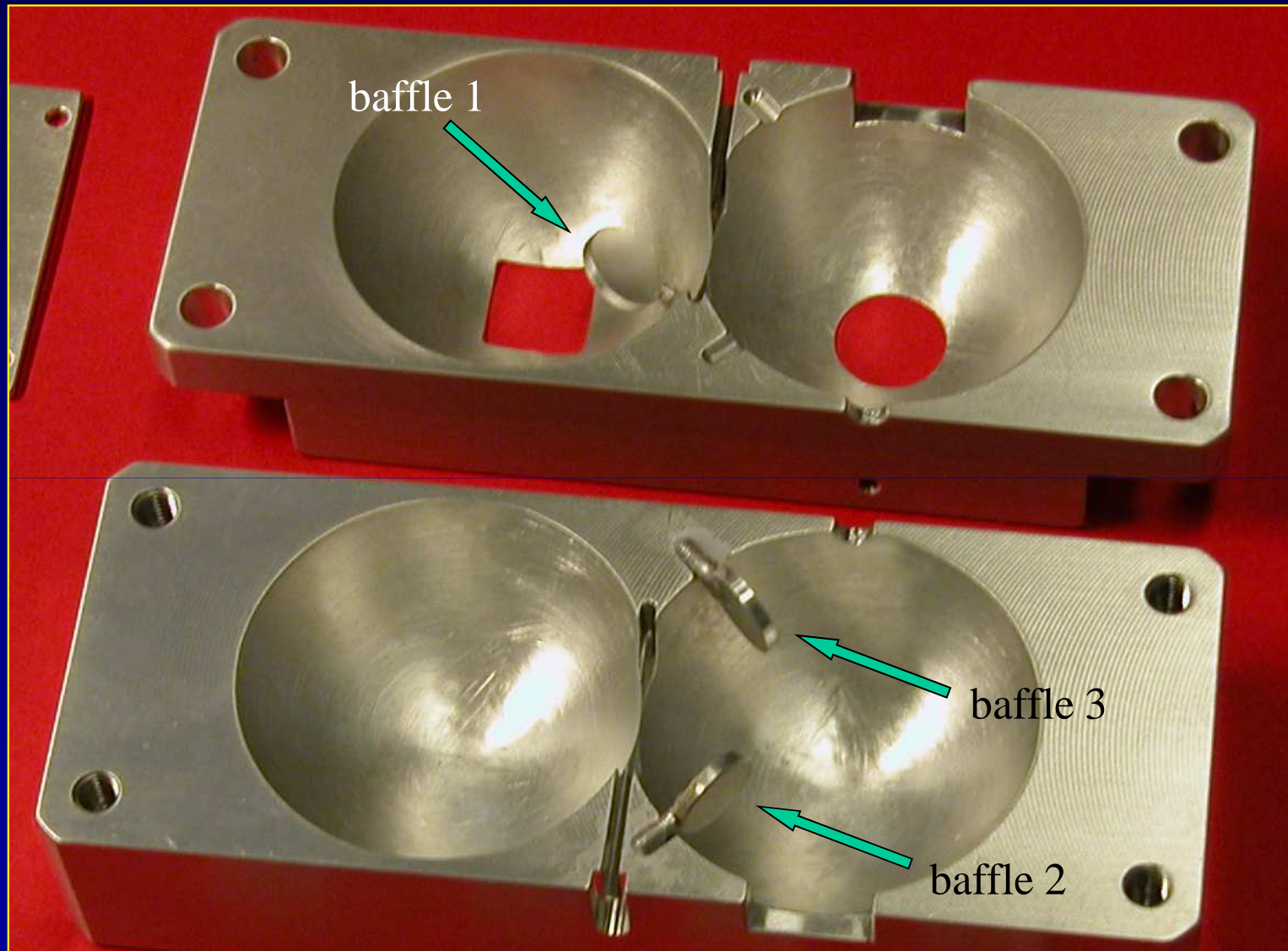


Progetto SOLTERM-Ottica

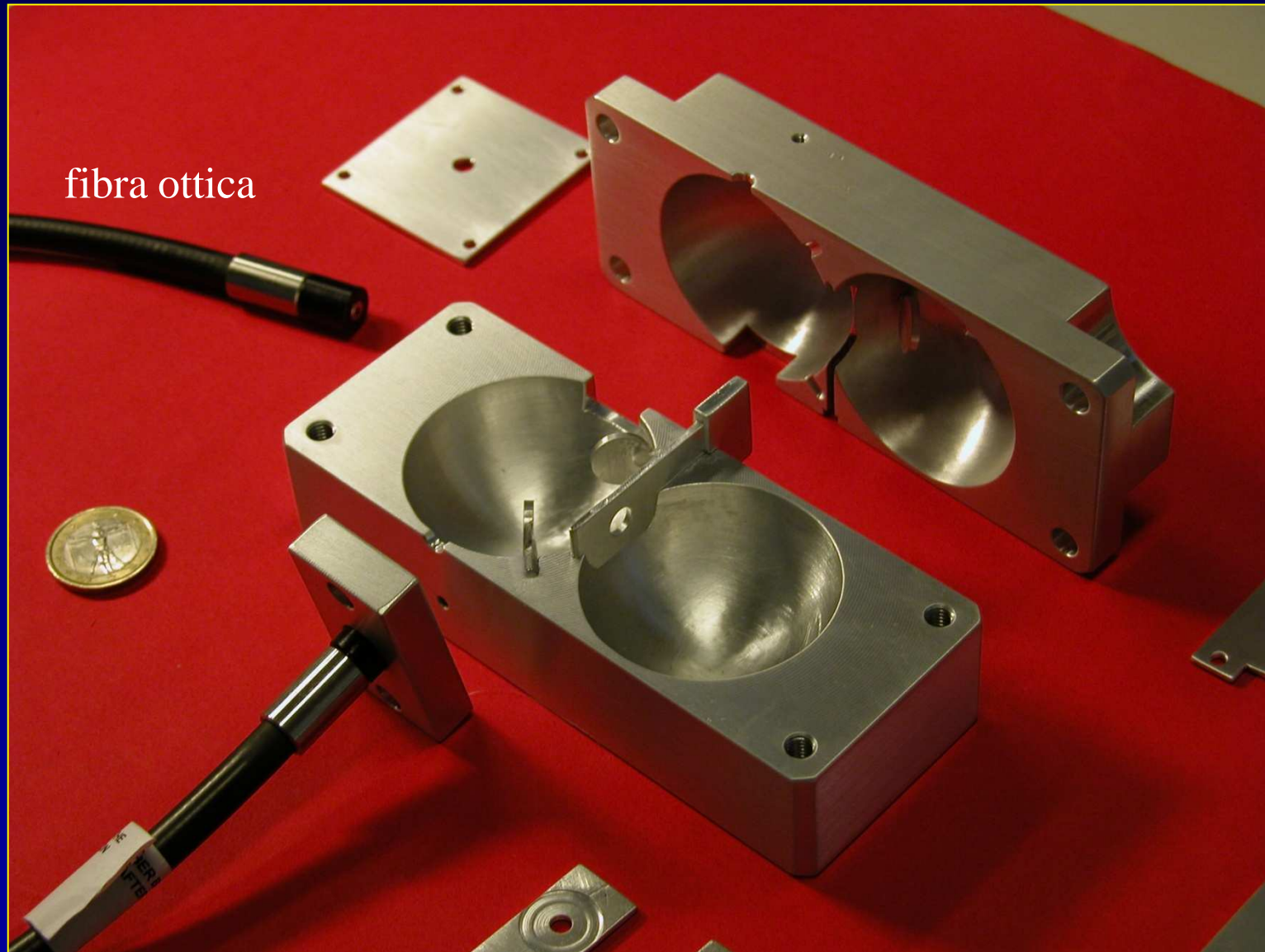
Radiometro DCR1



Radiometro DCR1

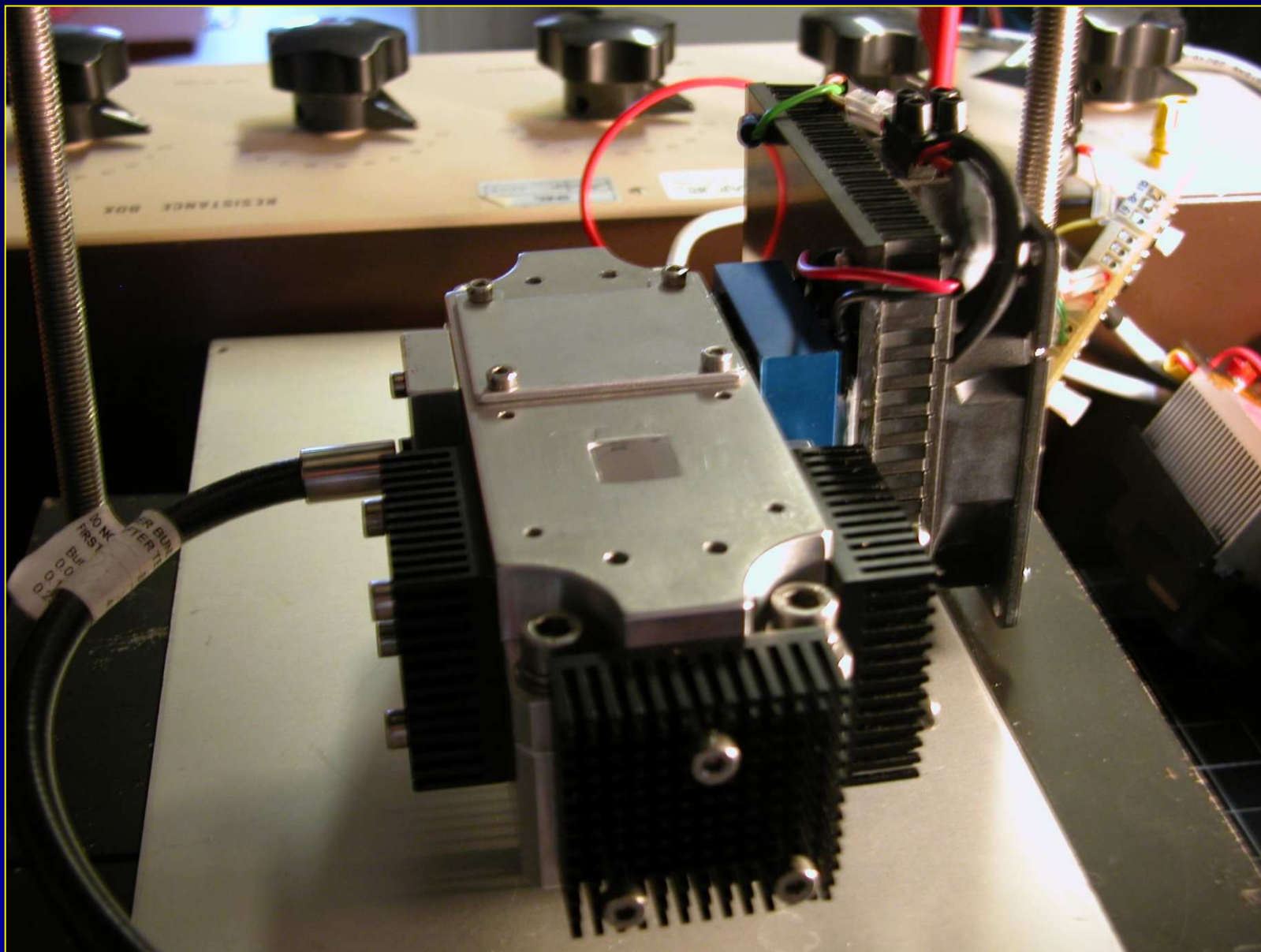


Radiometro DCR1



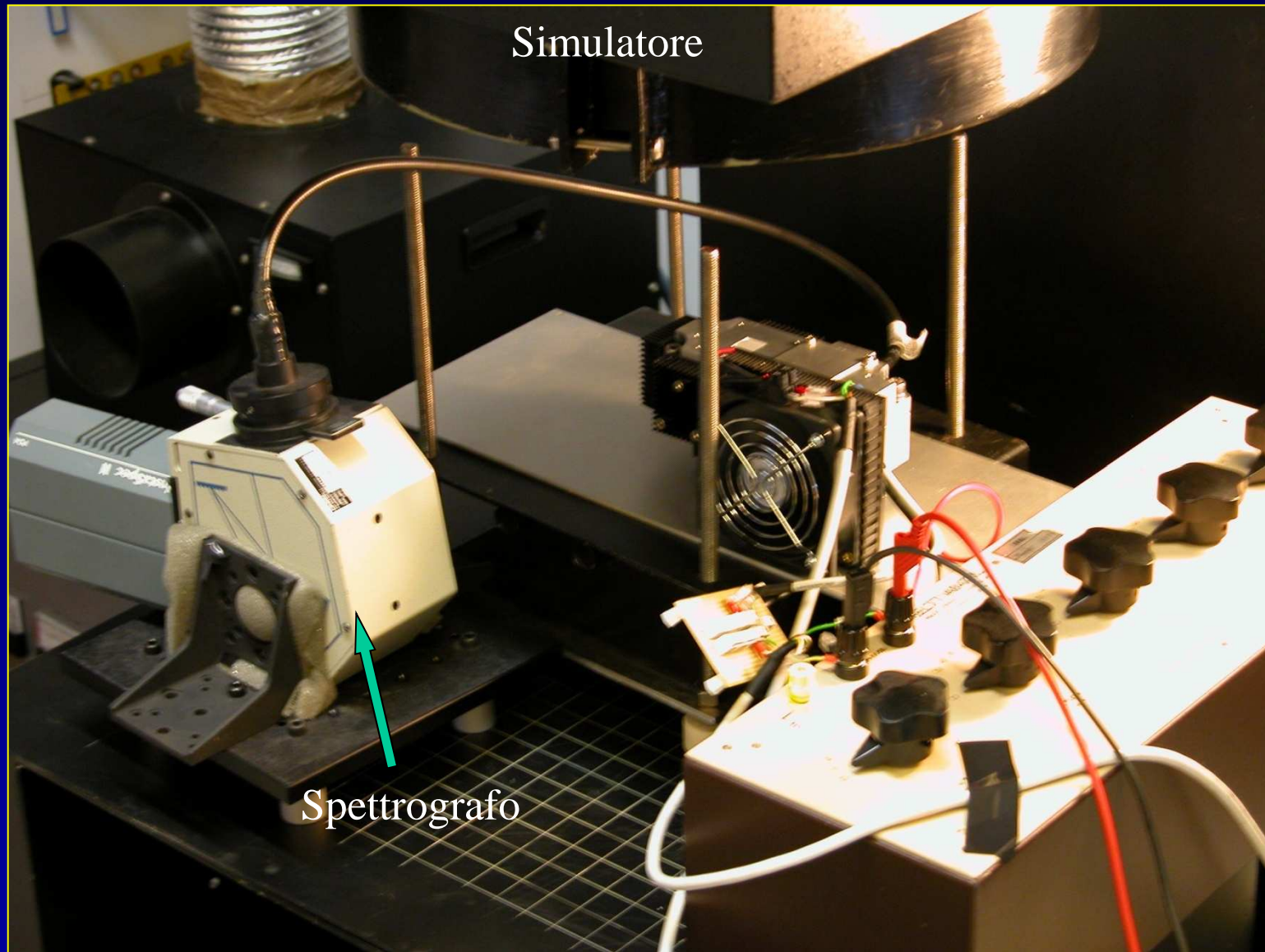
Progetto SOLTERM-Ottica

Radiometro DCR1



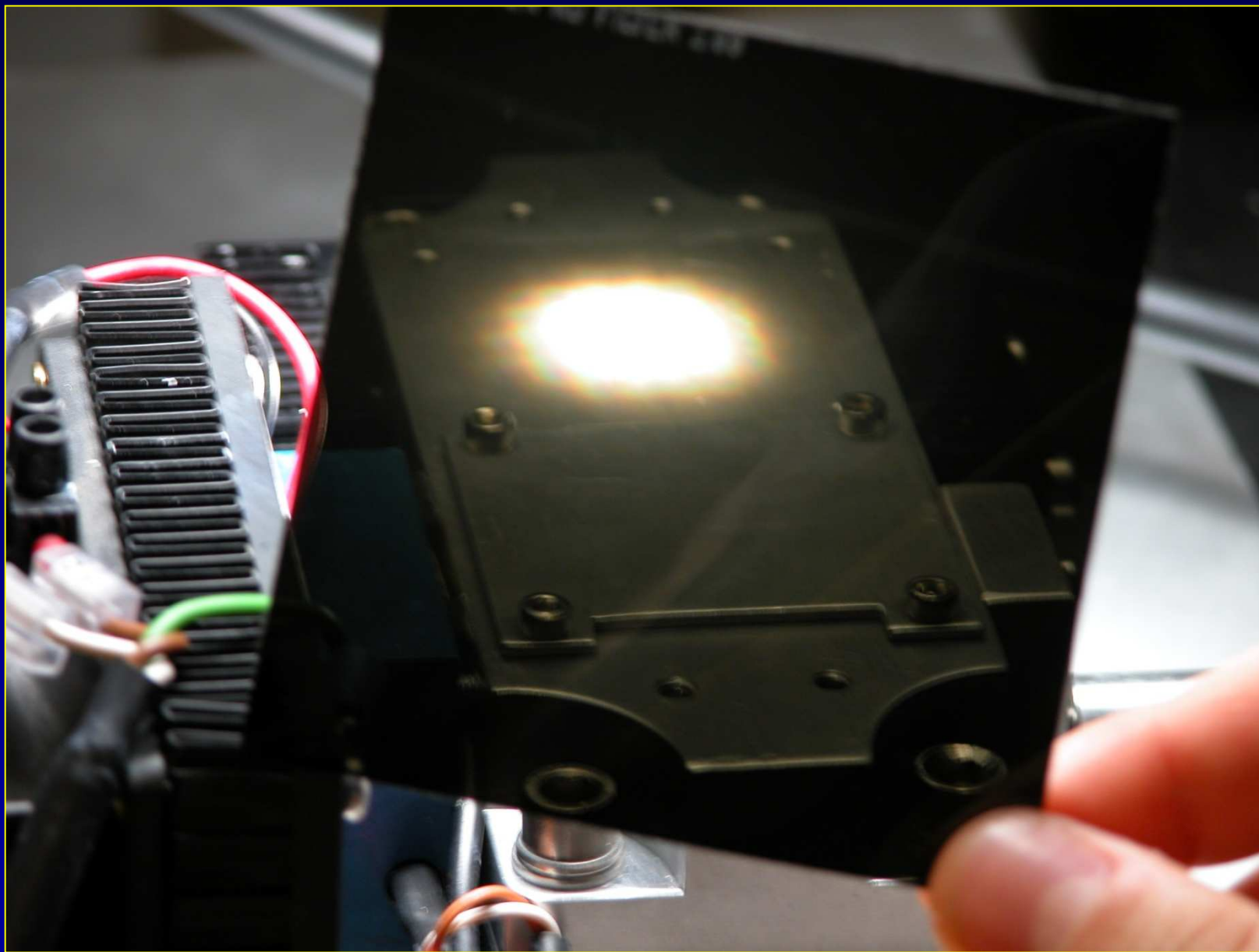
Progetto SOLTERM-Ottica

Radiometro DCR1



Progetto SOLTERM-Ottica

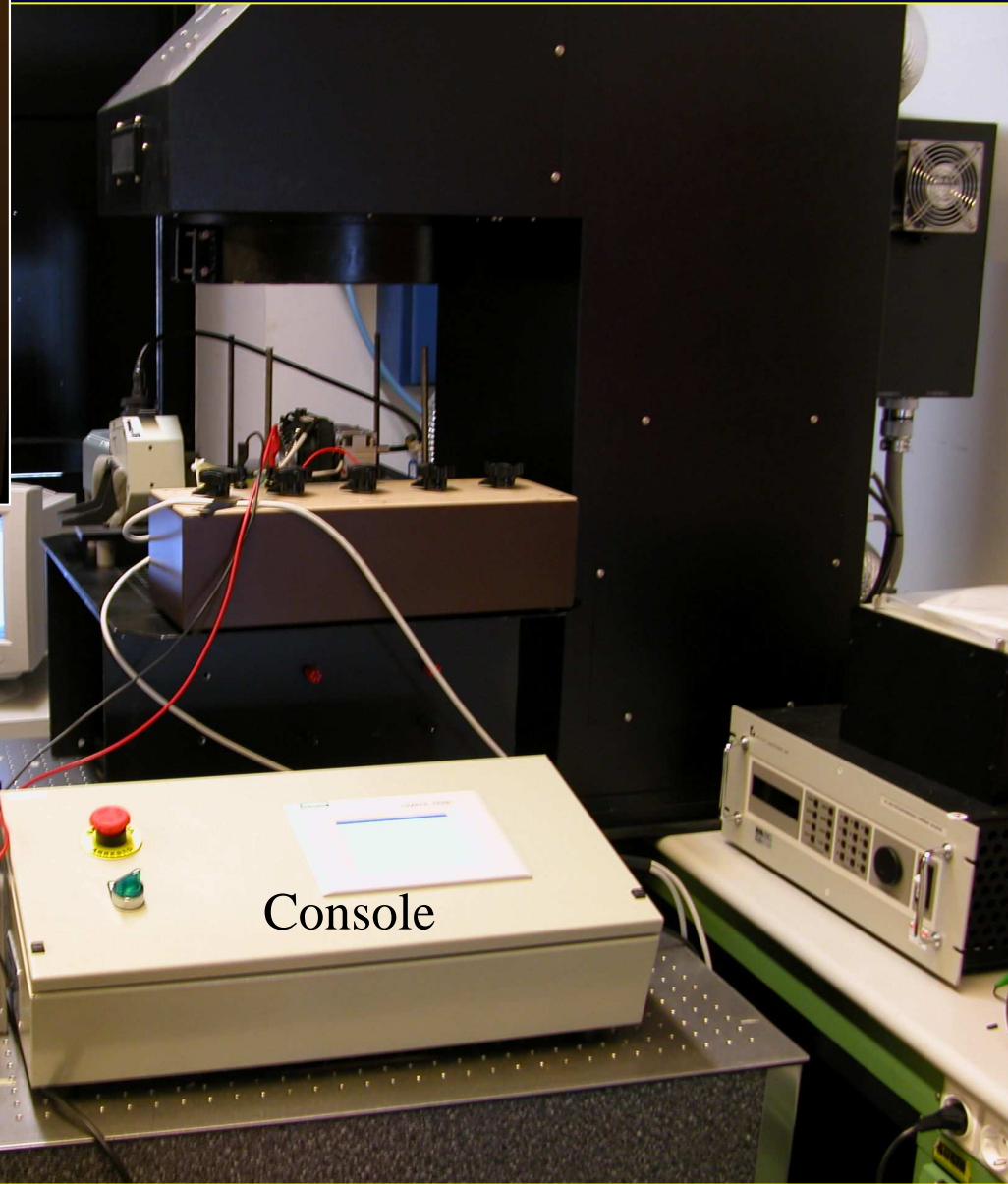
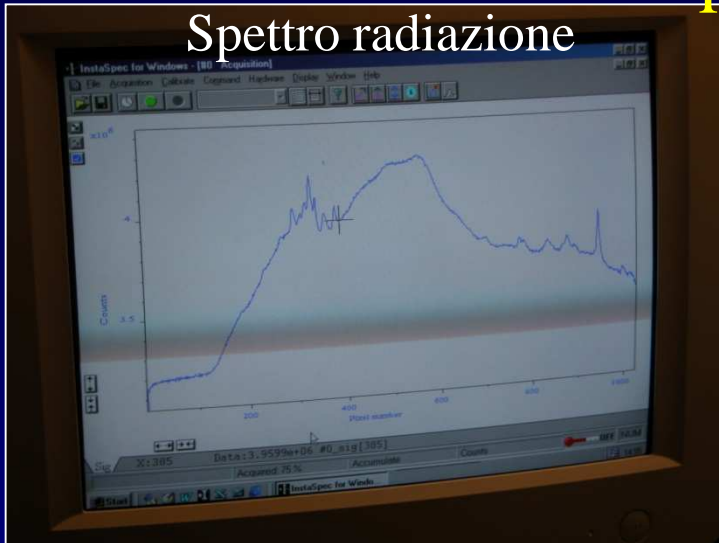
Radiometro DCR1



Progetto SOLTERM-Ottica

Radiometro DCR1

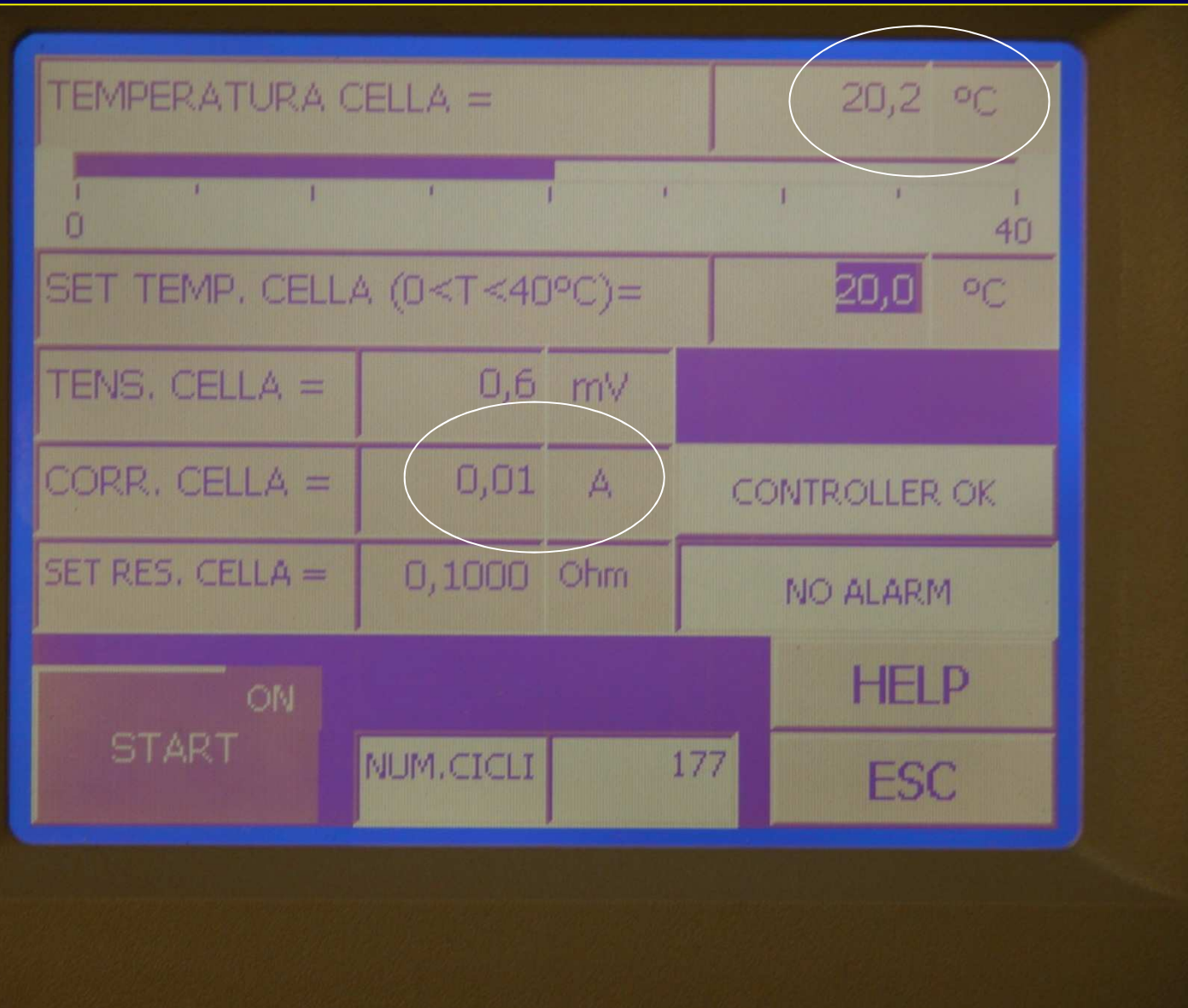
Spettro radiazione



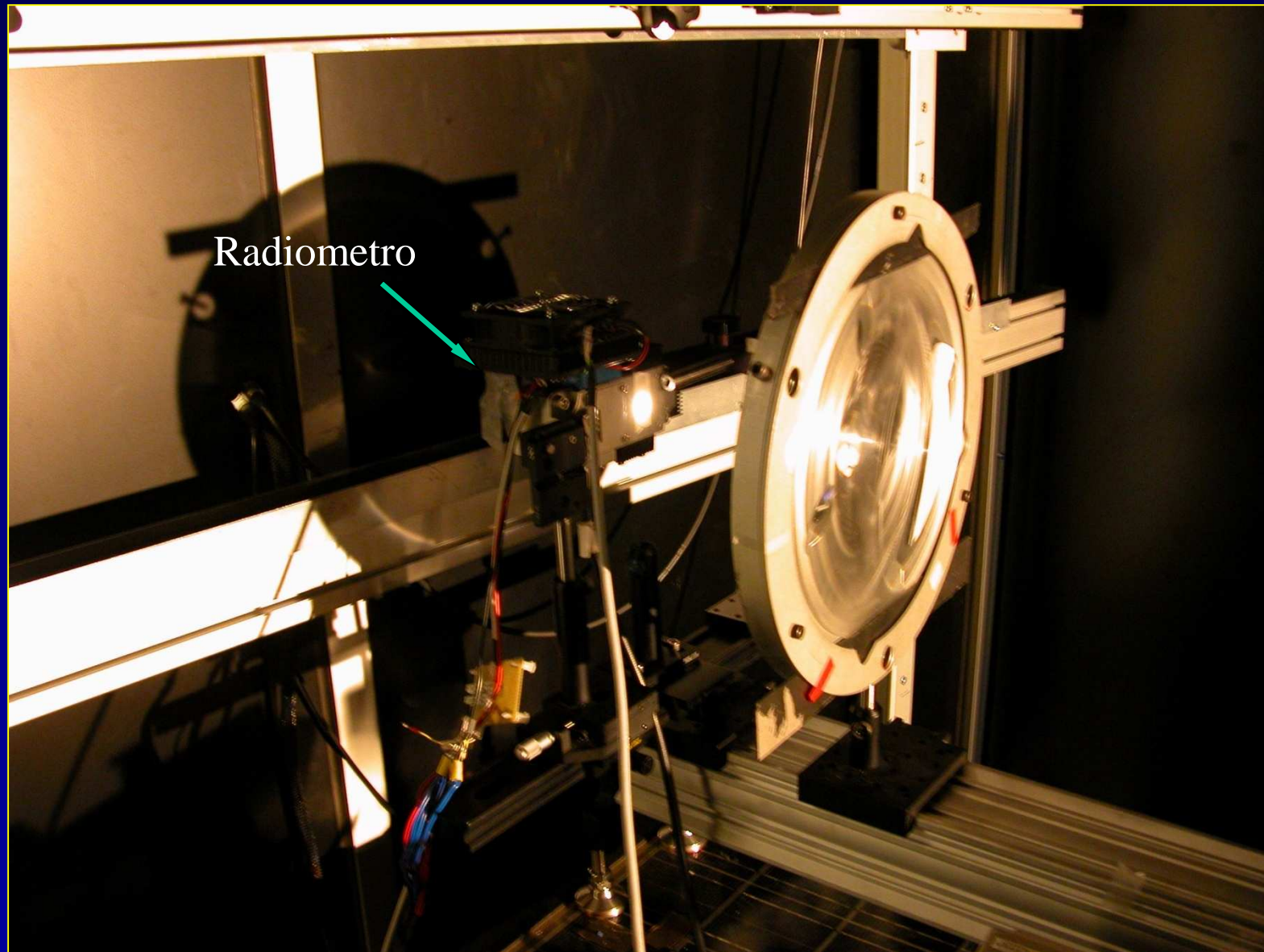
Console

Progetto SOLTERM-Ottica

Radiometro DCR1

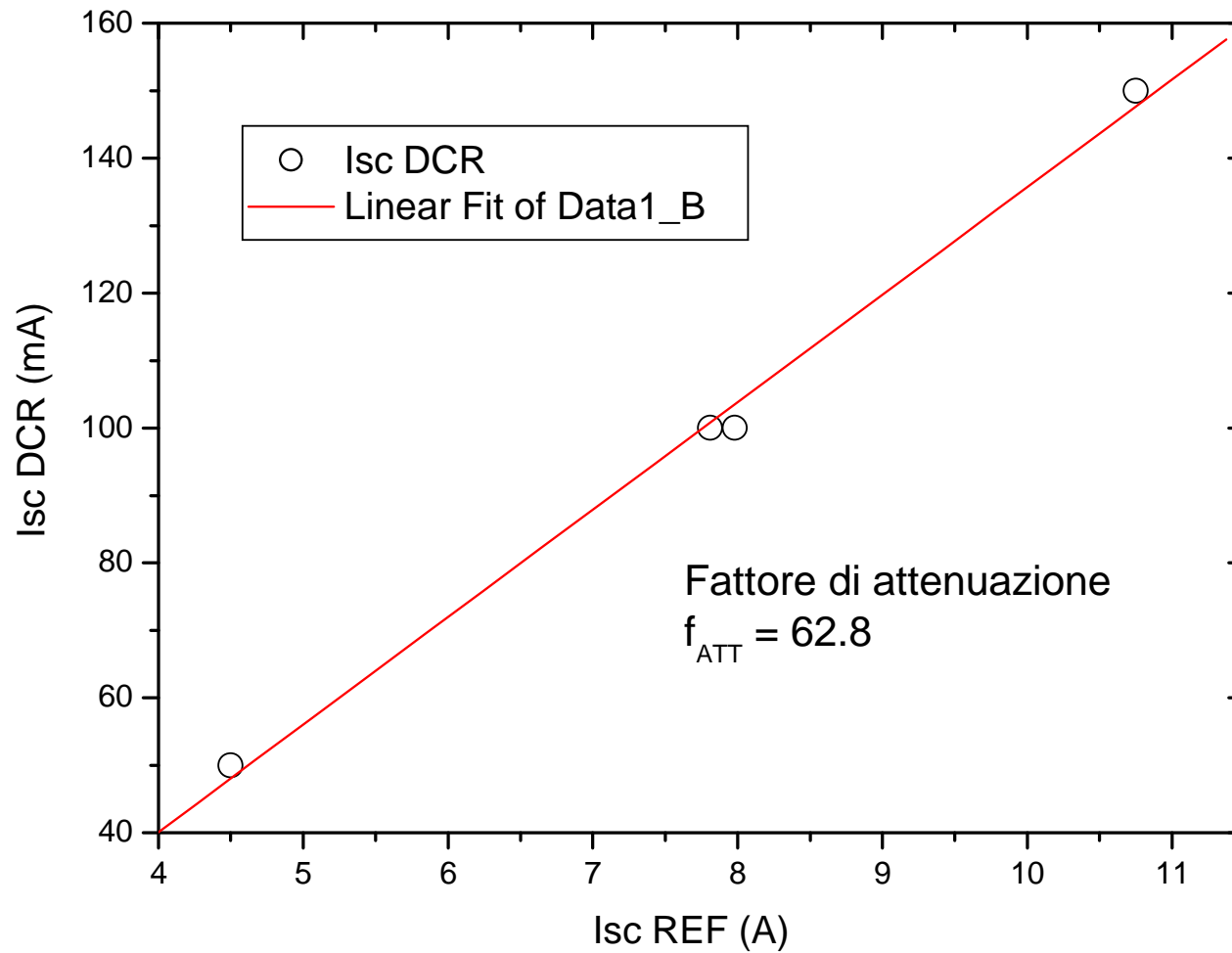


Calibrazione al Simulatore PASAN

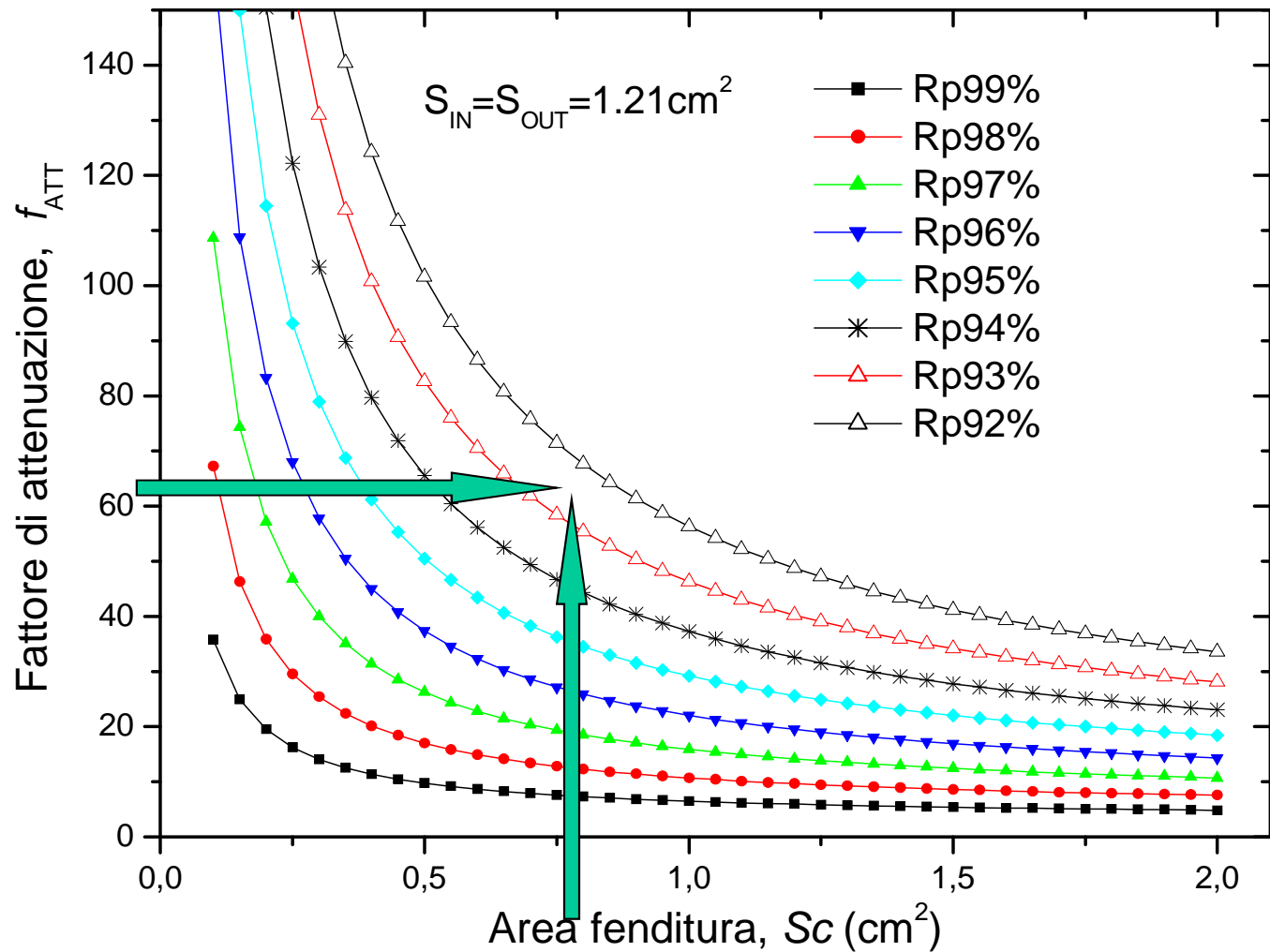


Progetto SOLTERM-Ottica

Calibrazione al Simulatore PASAN

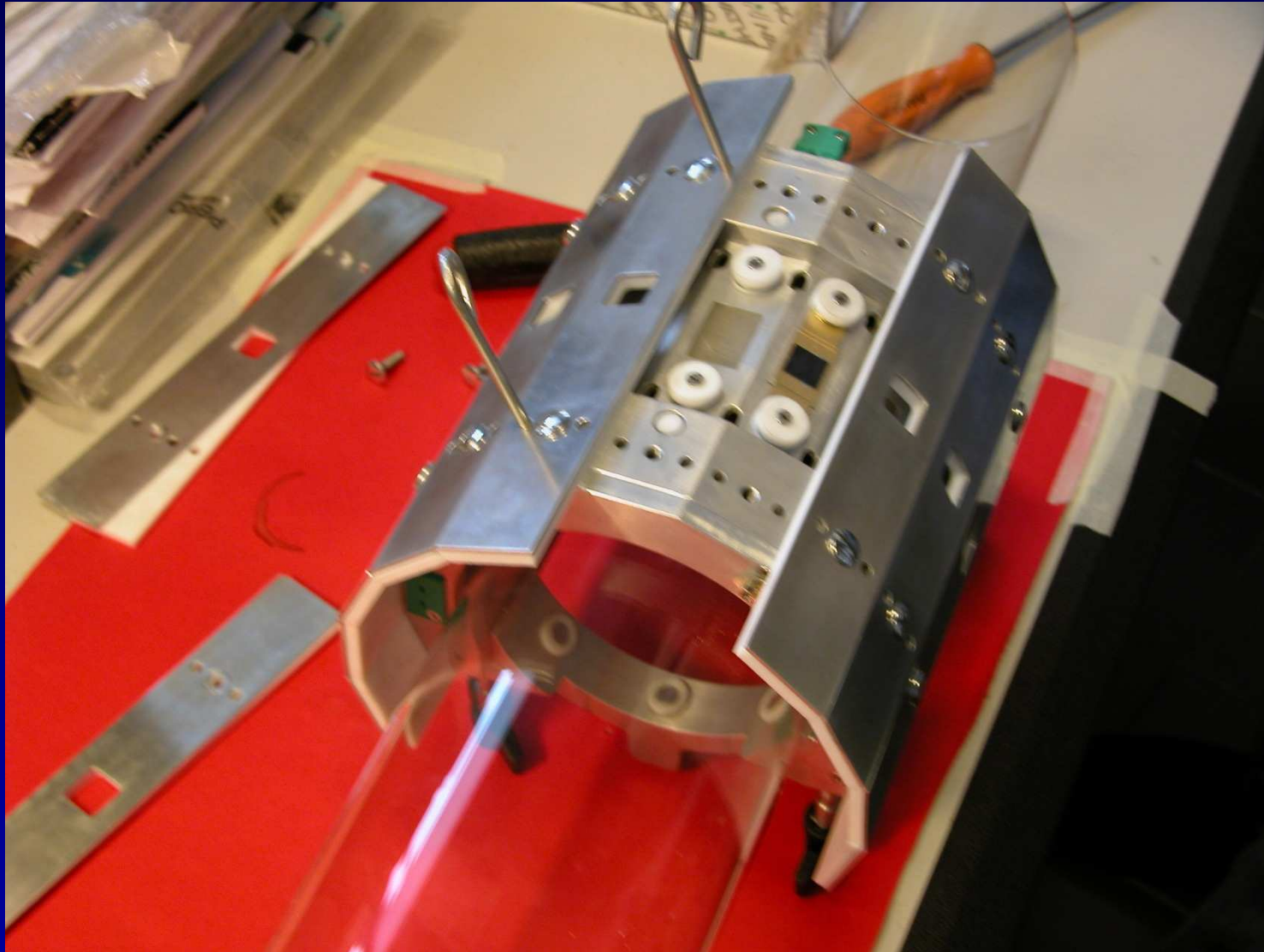


Progetto radiometro DCR1



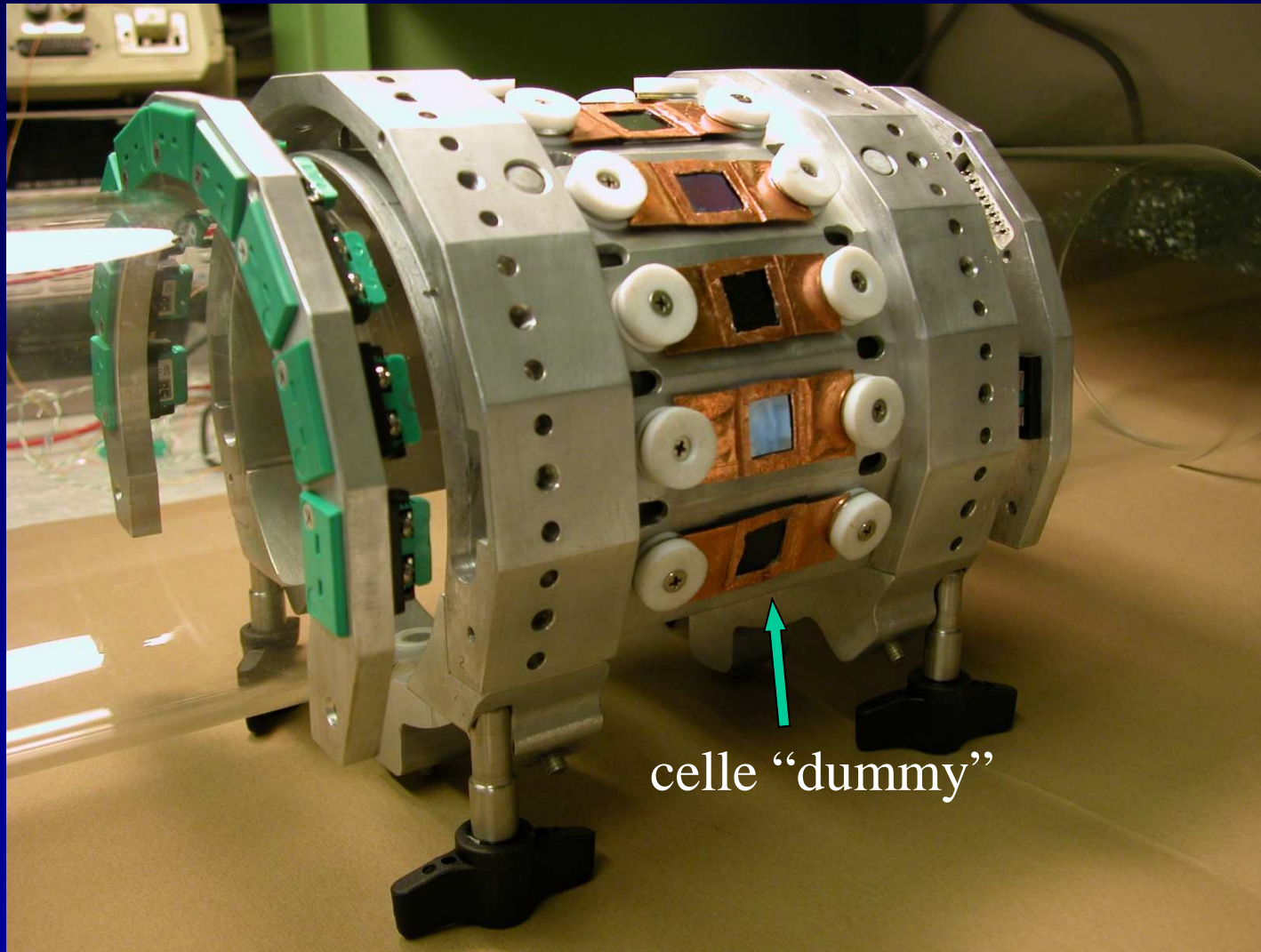
Collare fotovoltaico per concentratore termico lineare

Collare fotovoltaico



Progetto SOLTERM-Ottica

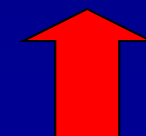
Collare fotovoltaico



celle "dummy"

Progetto SOLTERM-Ottica

	2003										2004										
	A	M	G	L	A	S	O	N	D	G	F	M	A	M	G	L	A	S	O	N	D
Obiettivo 2																					
Progettazione preliminare radiometri																					
Realizzazione prototipi																					
Verifiche sperimentali e messa a punto radiometri																					



oggi

Progetto SOLTERM-Ottica

The

En



The End

The End

