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Centro Ricerche Portici

UNSW

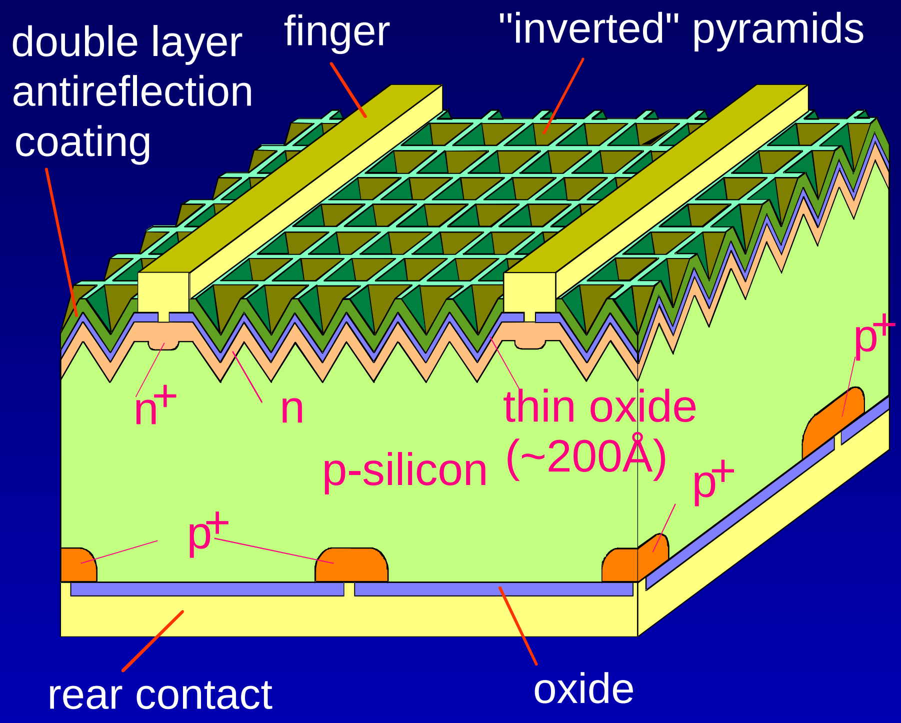
Analysis of light backscattered from textured silicon surfaces

<u>A. Parretta</u>, E. Bobeico, L. Lancellotti and P. Morvillo
ENEA Research Centre, Portici (Na), Italy

A. Wang and J. Zhao
Photovoltaics Special Research Centre, UNSW, Sydney, Australia

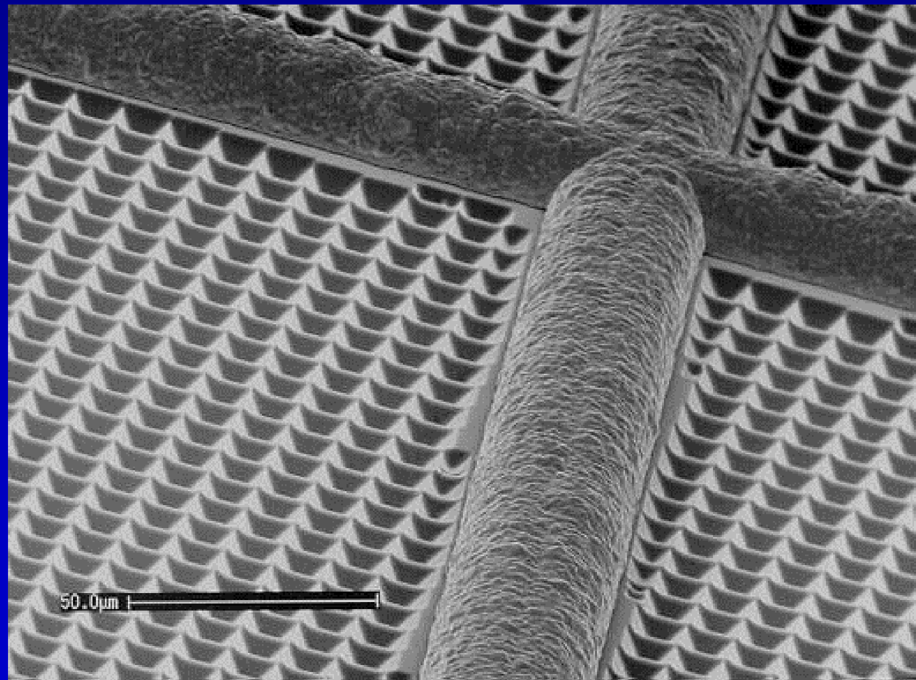
INTRODUCTION

TEXTURED SILICON IN PHOTOVOLTAIC DEVICES

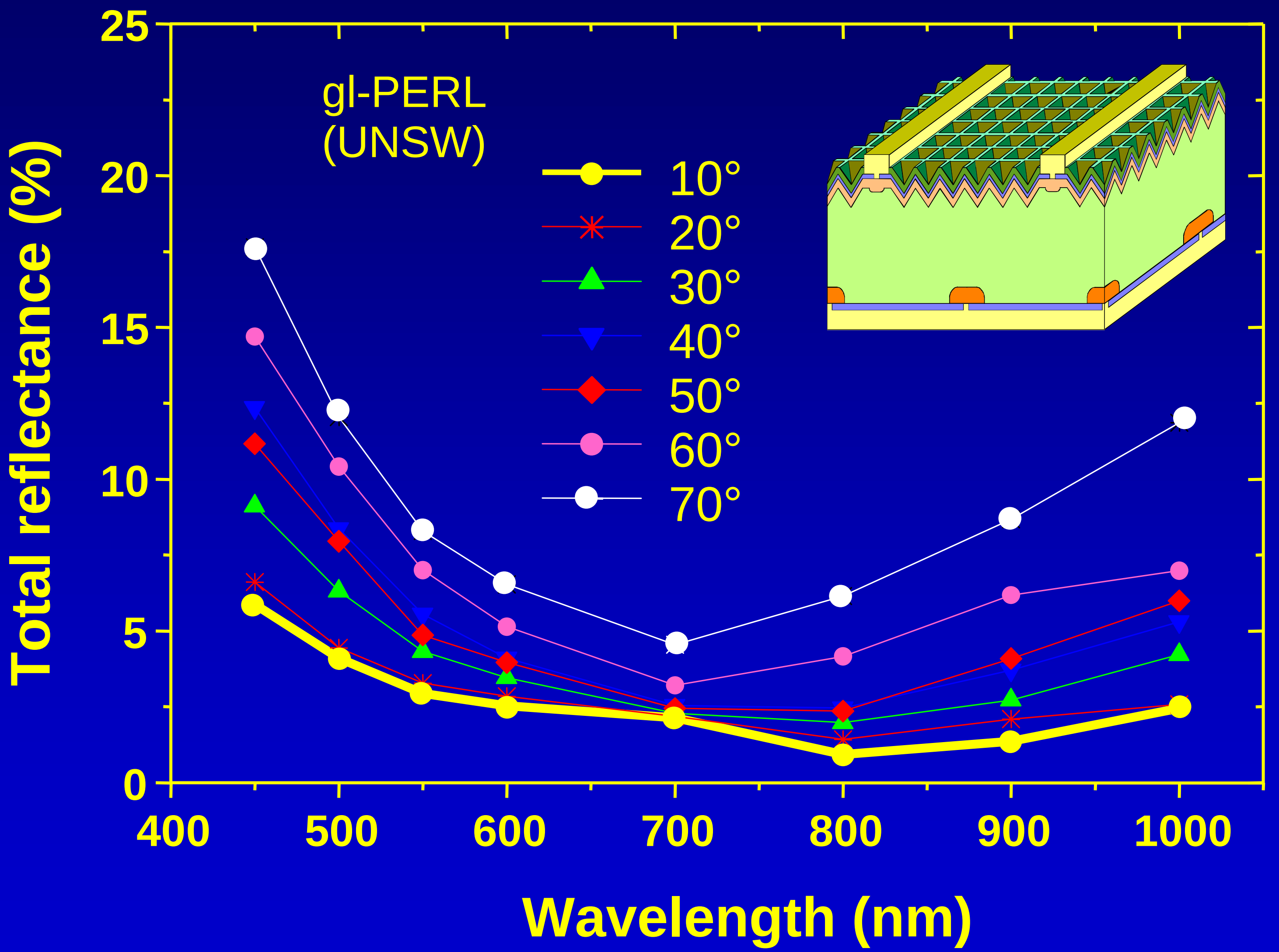


Inverted pyramids on single-Si
“PERL” cell (η = 24.4 %)
(UNSW)
Anisotropic etching of (100) Si surface.

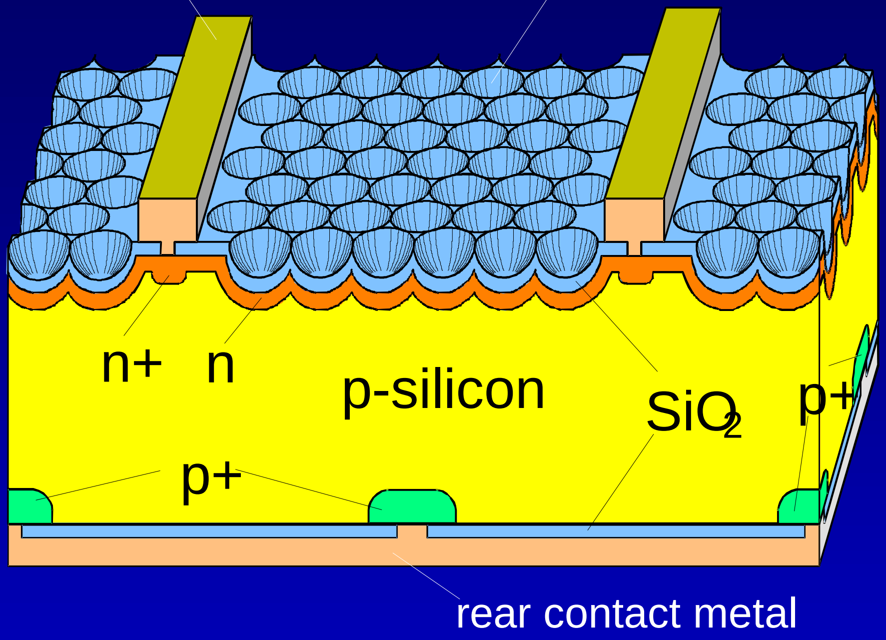
SEM photo of the
“PERL” cell (UNSW)



ANGLE-RESOLVED REFLECTANCE OF PERL CELL

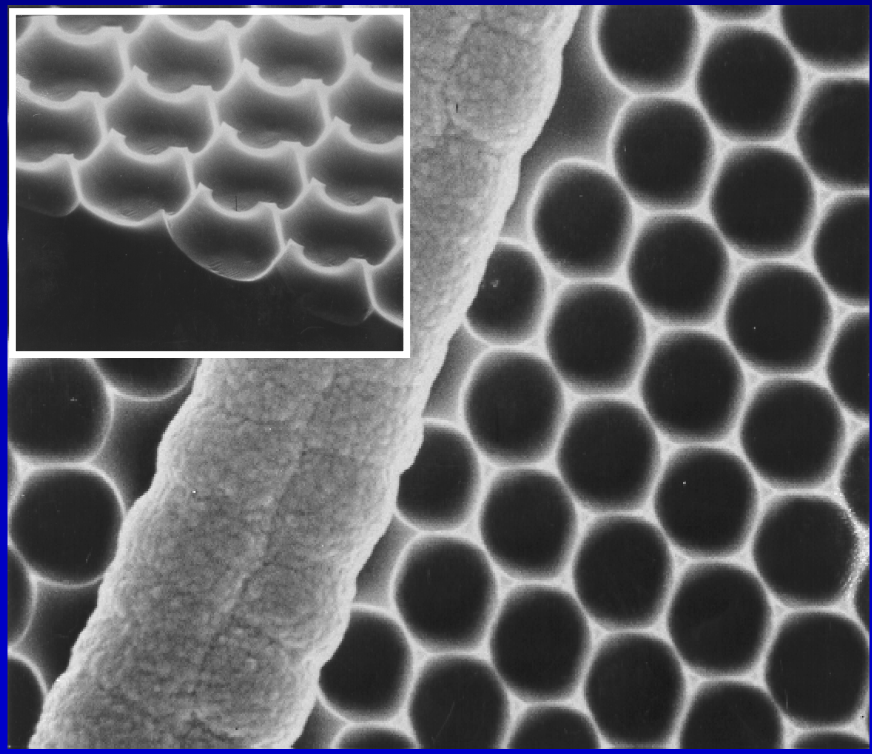


TEXTURED SILICON IN PHOTOVOLTAIC DEVICES

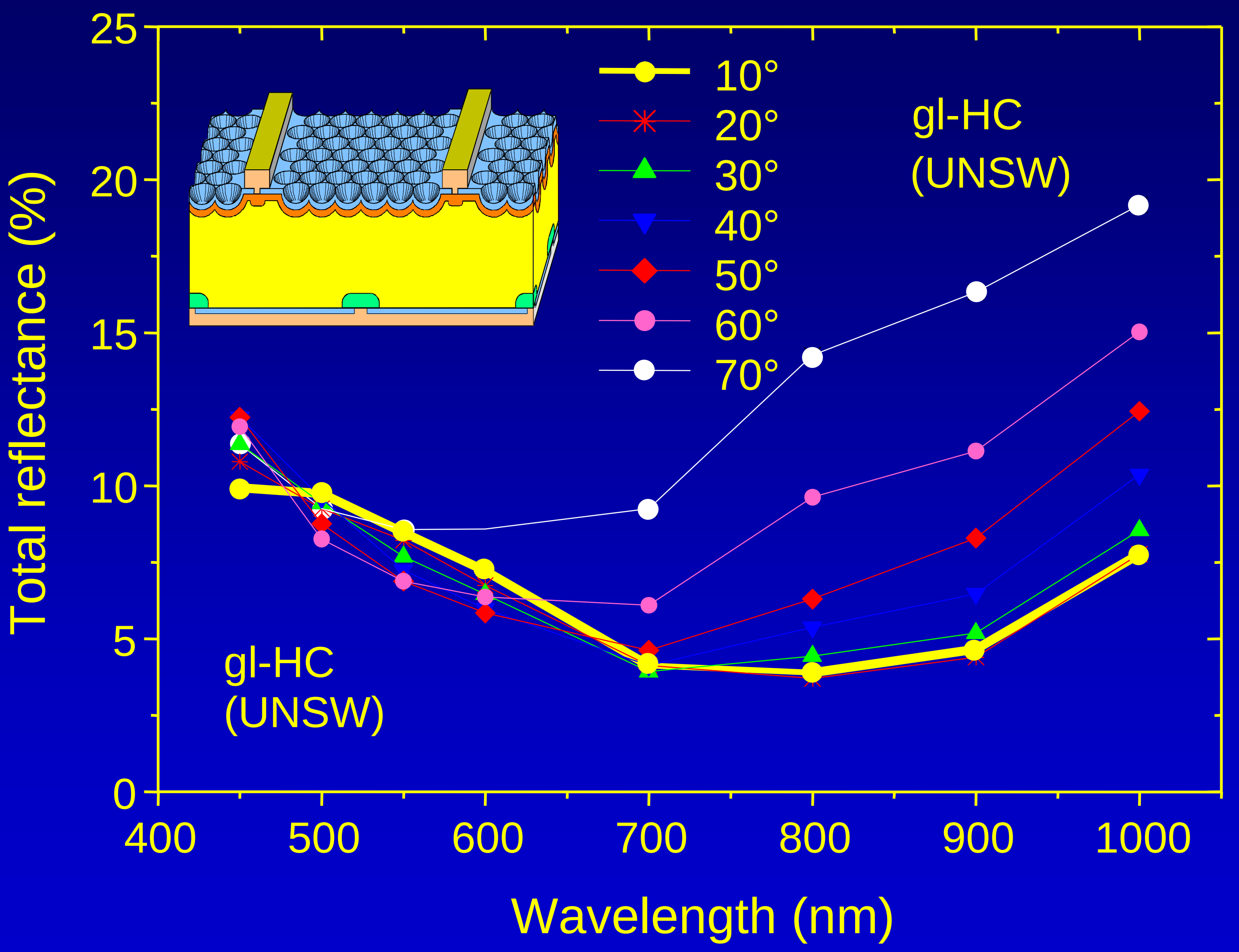


Hemispherical wells on multi-SI
"Honeycomb" cell (η = 19.8 %)
(UNSW)
Isotropic etching of multi-Si surface.

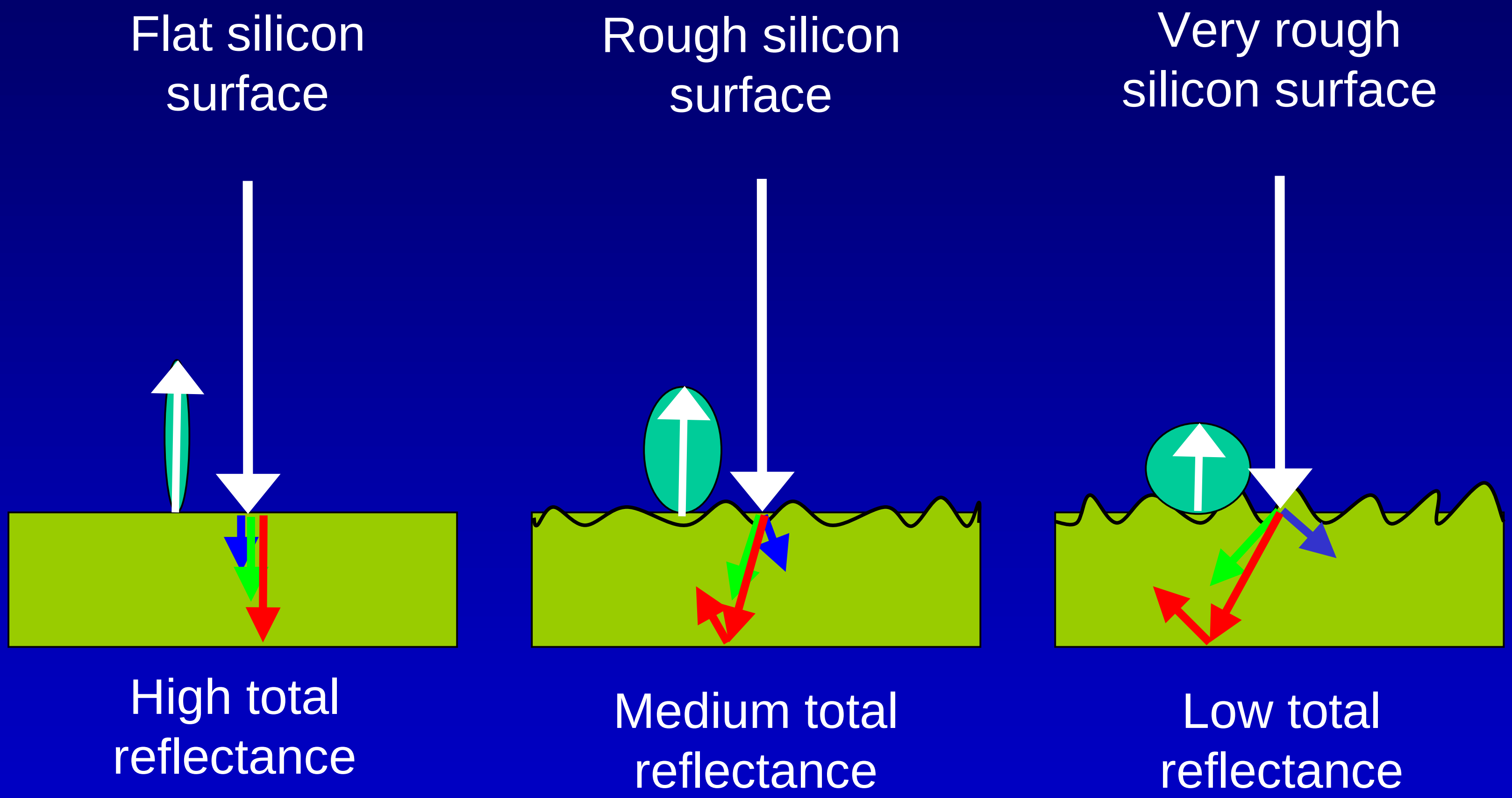
SEM photo of the
"Honeycomb" cell (UNSW)



ANGLE-RESOLVED REFLECTANCE OF HONEYCOMB CELL



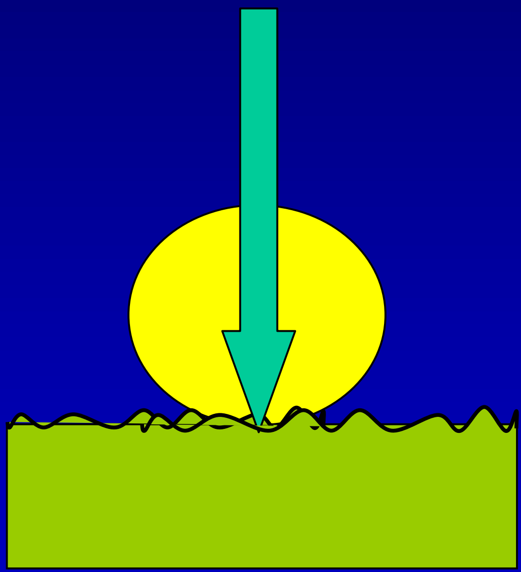
LIGHT BACKSCATTERING FROM TEXTURED SILICON SURFACES



Surface roughness promotes light trapping and produces spatially distributed reflected light

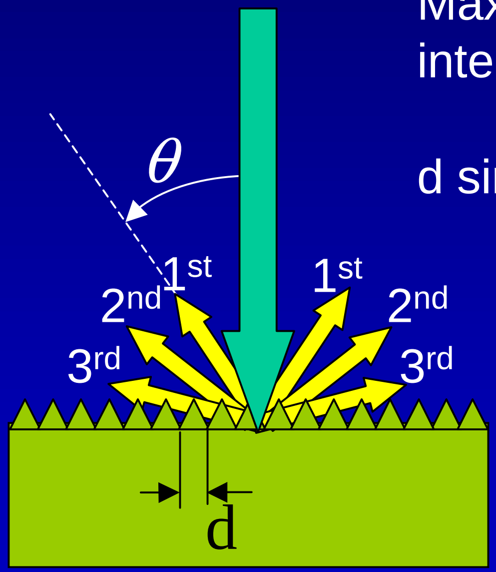
LIGHT BACKSCATTERING FROM TEXTURED SILICON SURFACES

Light diffusion



Randomly textured surface

Light diffraction

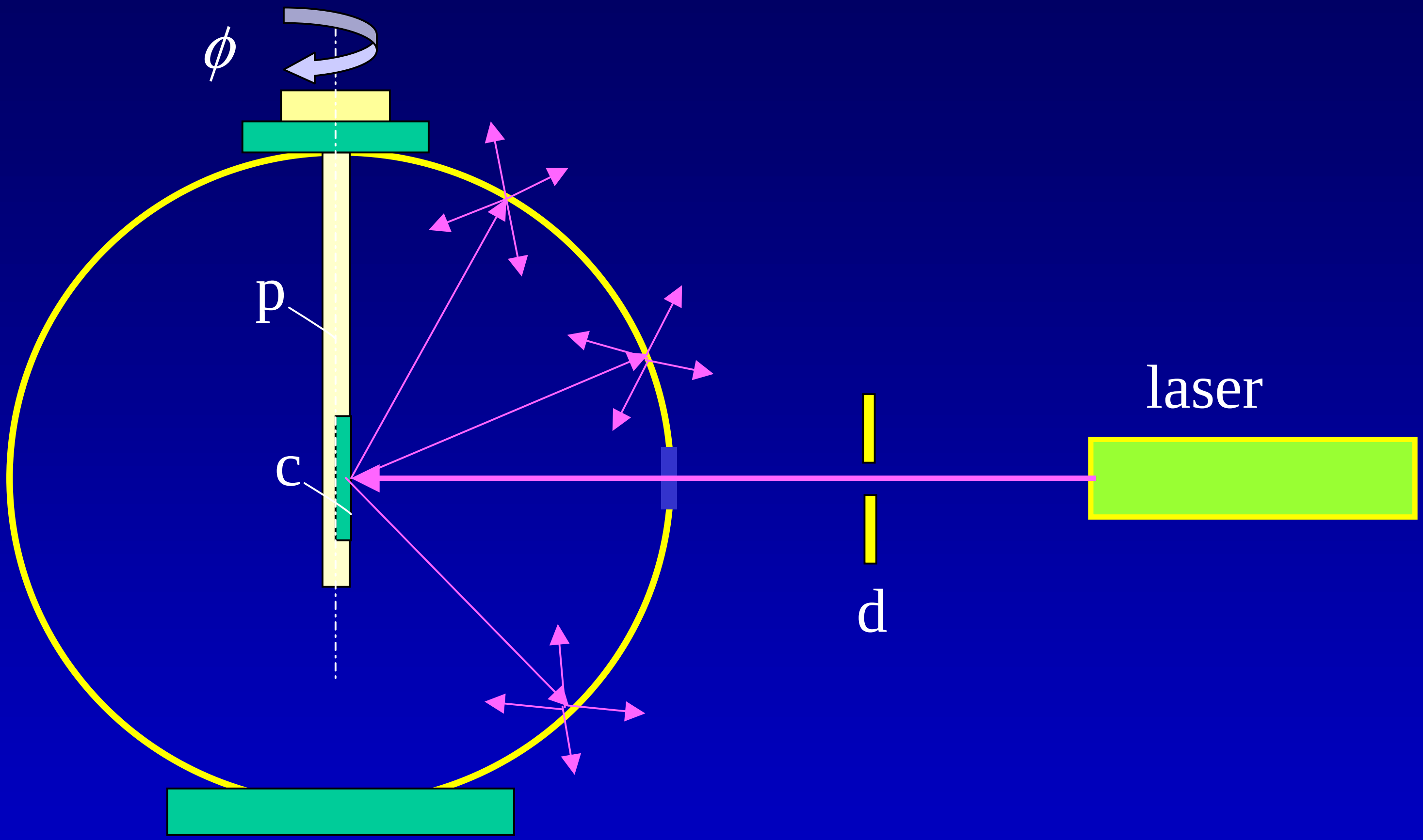


Maxima of intensity:

$d \sin\theta = k\,\lambda$

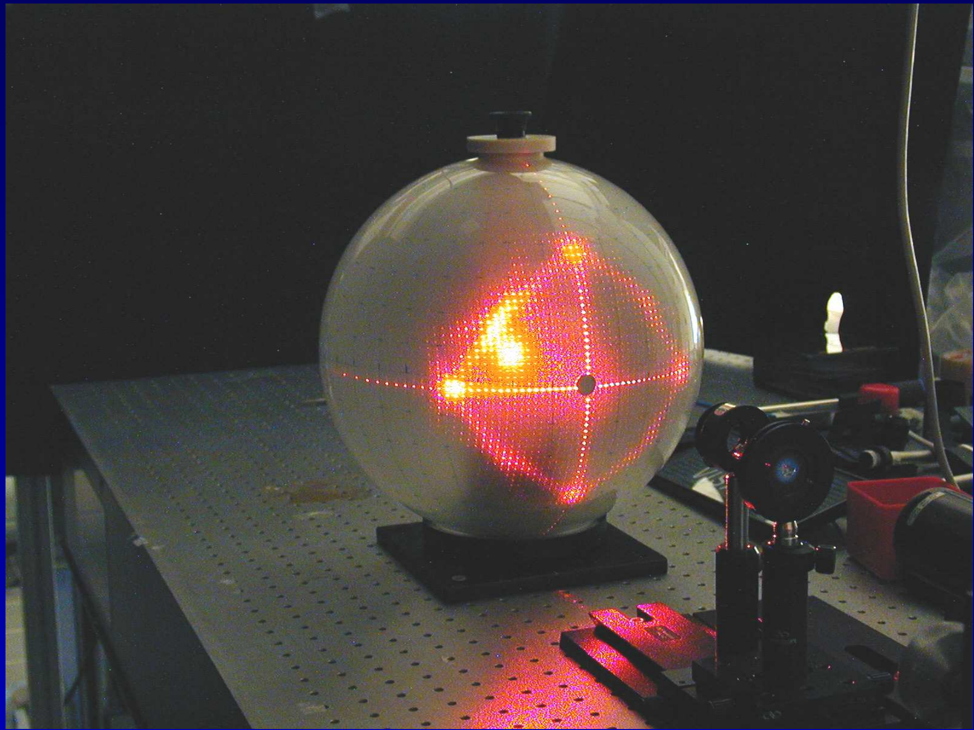
Regularly textured surface

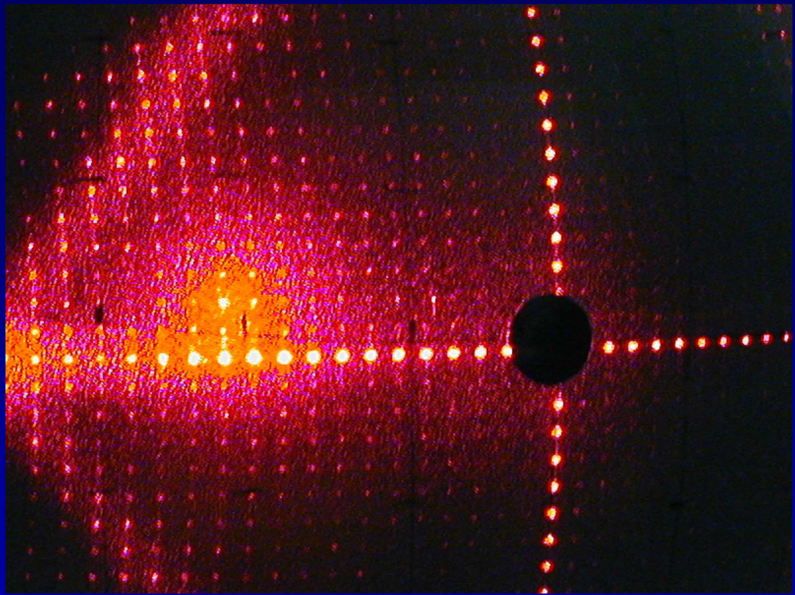
VISUALIZING GLOBE

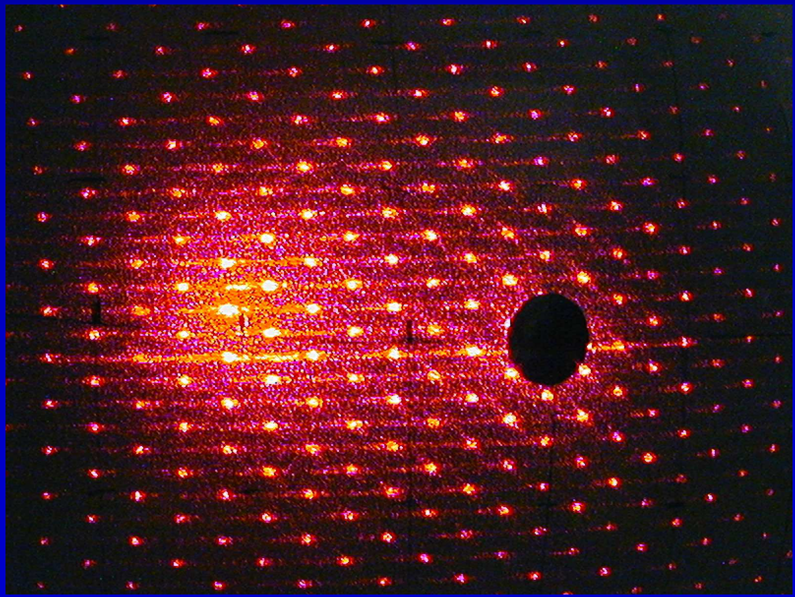


The plastic globe is internally sand-blasted in order to scatter, and then visualize, the light backscattered by the sample.

VISUALIZING GLOBE

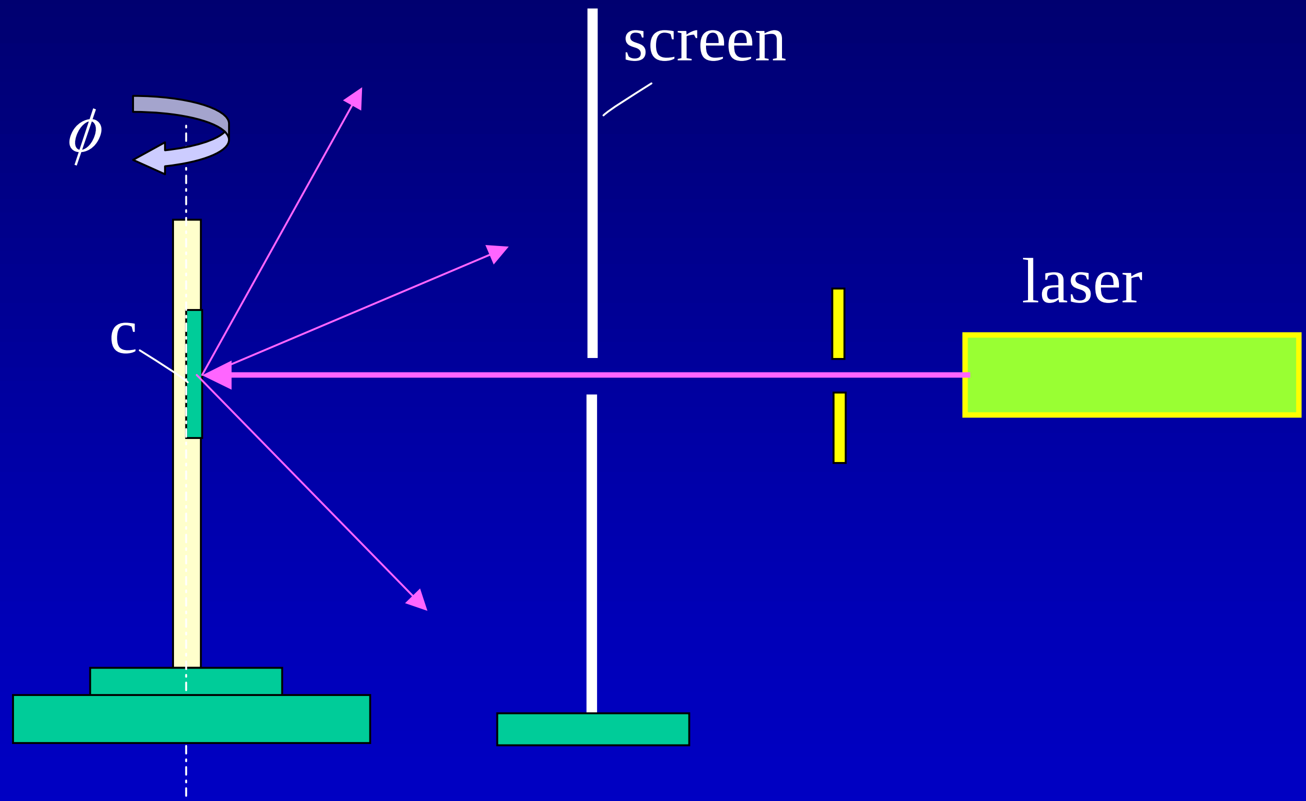


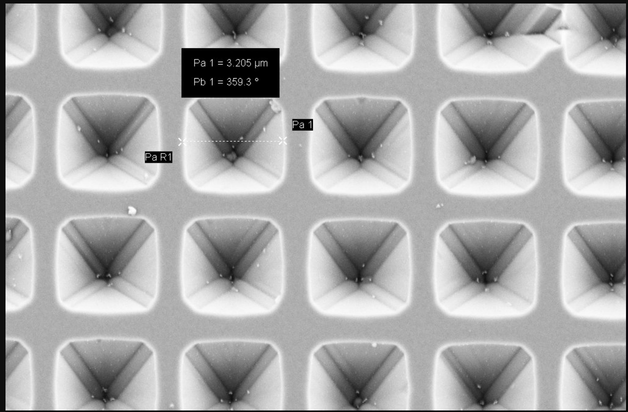


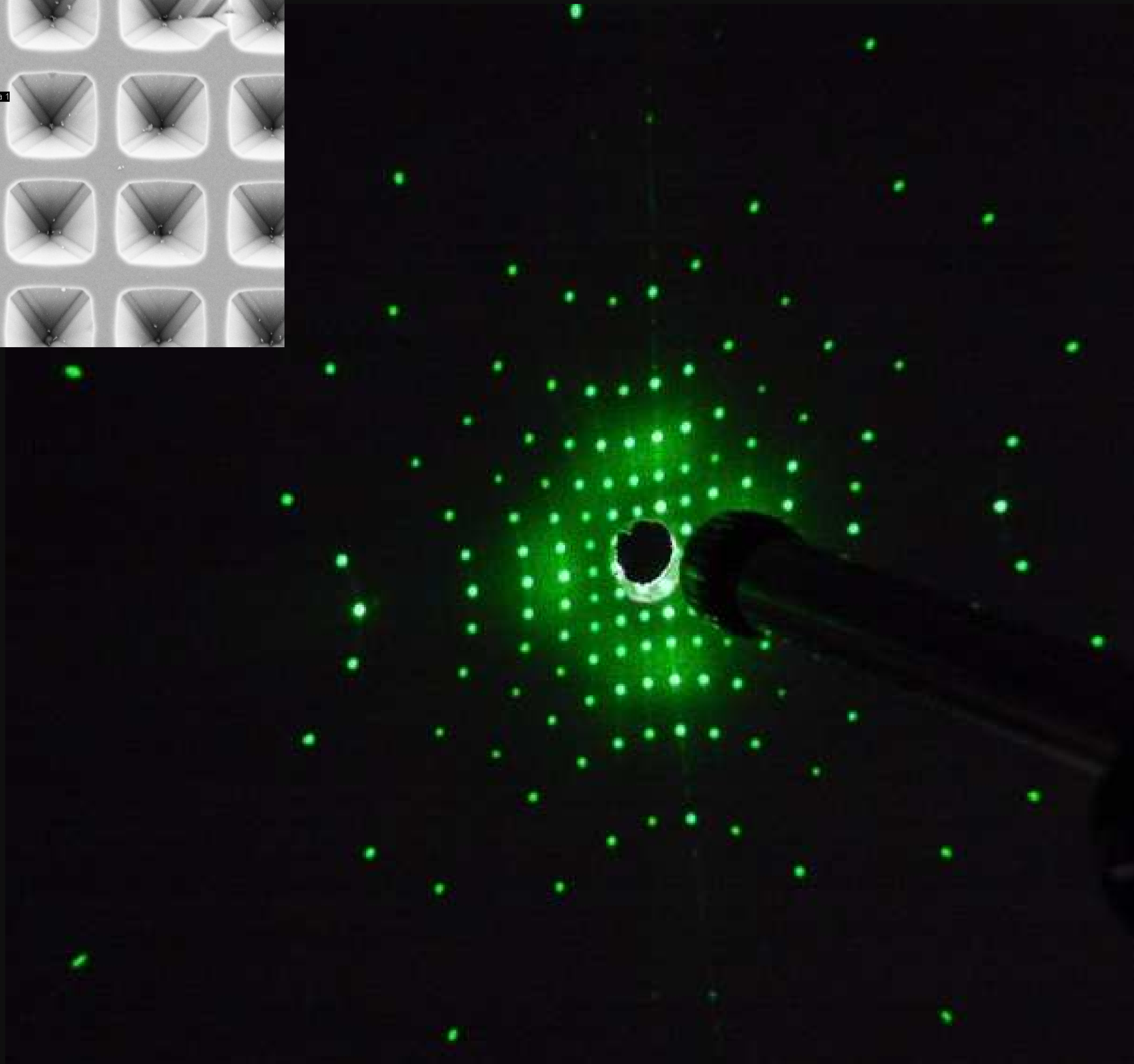


Backscattering figure produced by a solar cell textured by inverted pyramids (Fraunhofer).

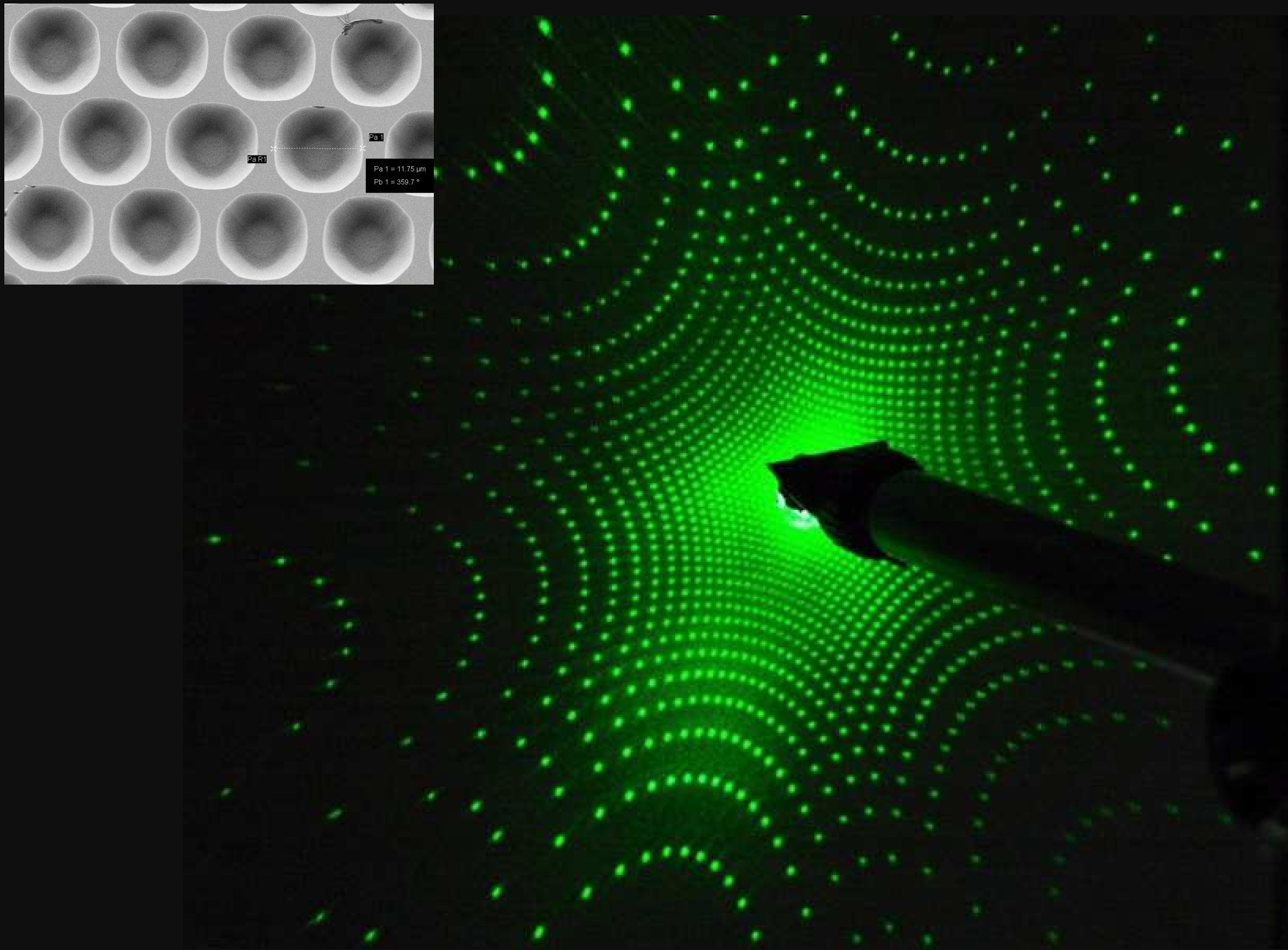
PIERCED SCREEN



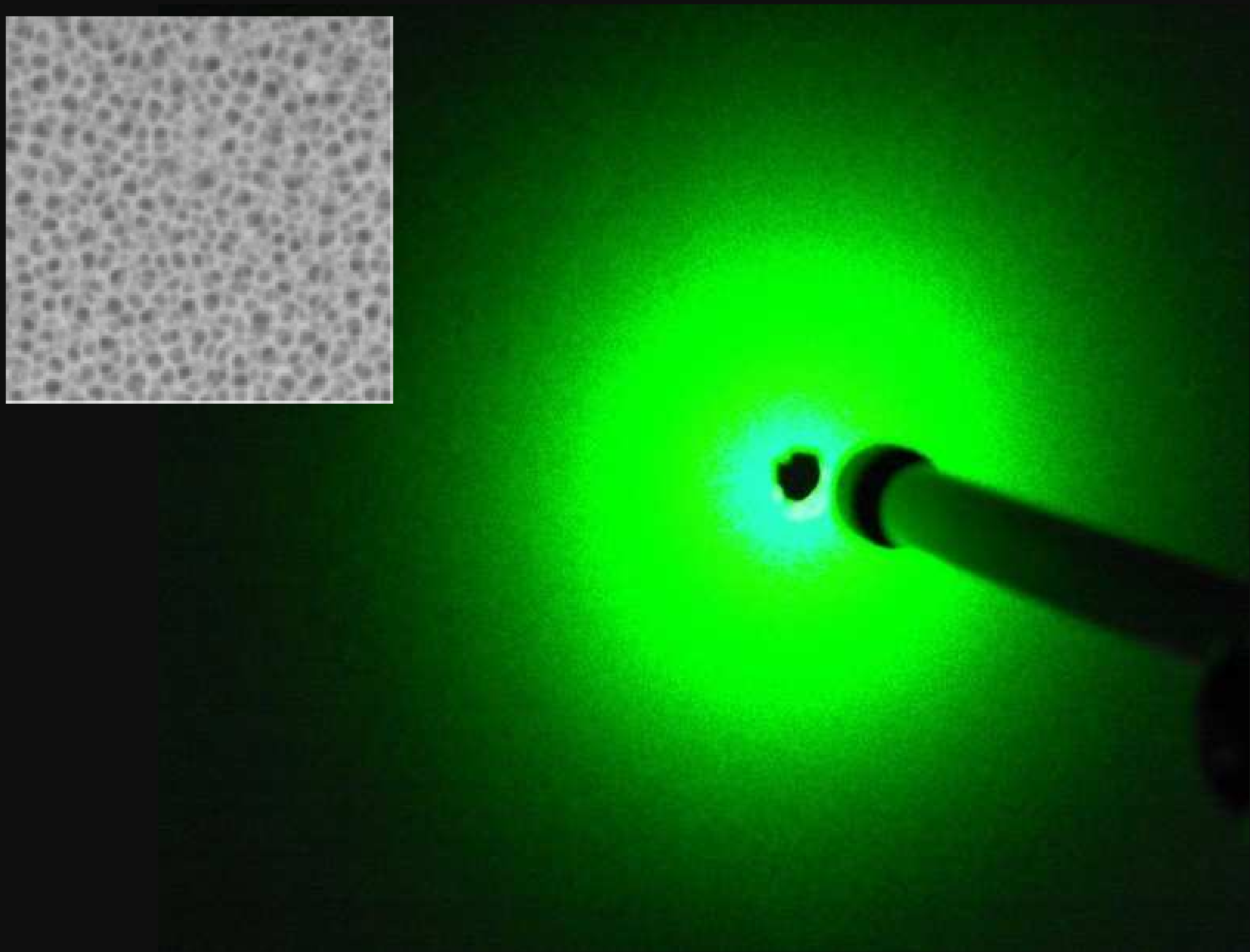




Inverted pyramids in a square lattice (IP)

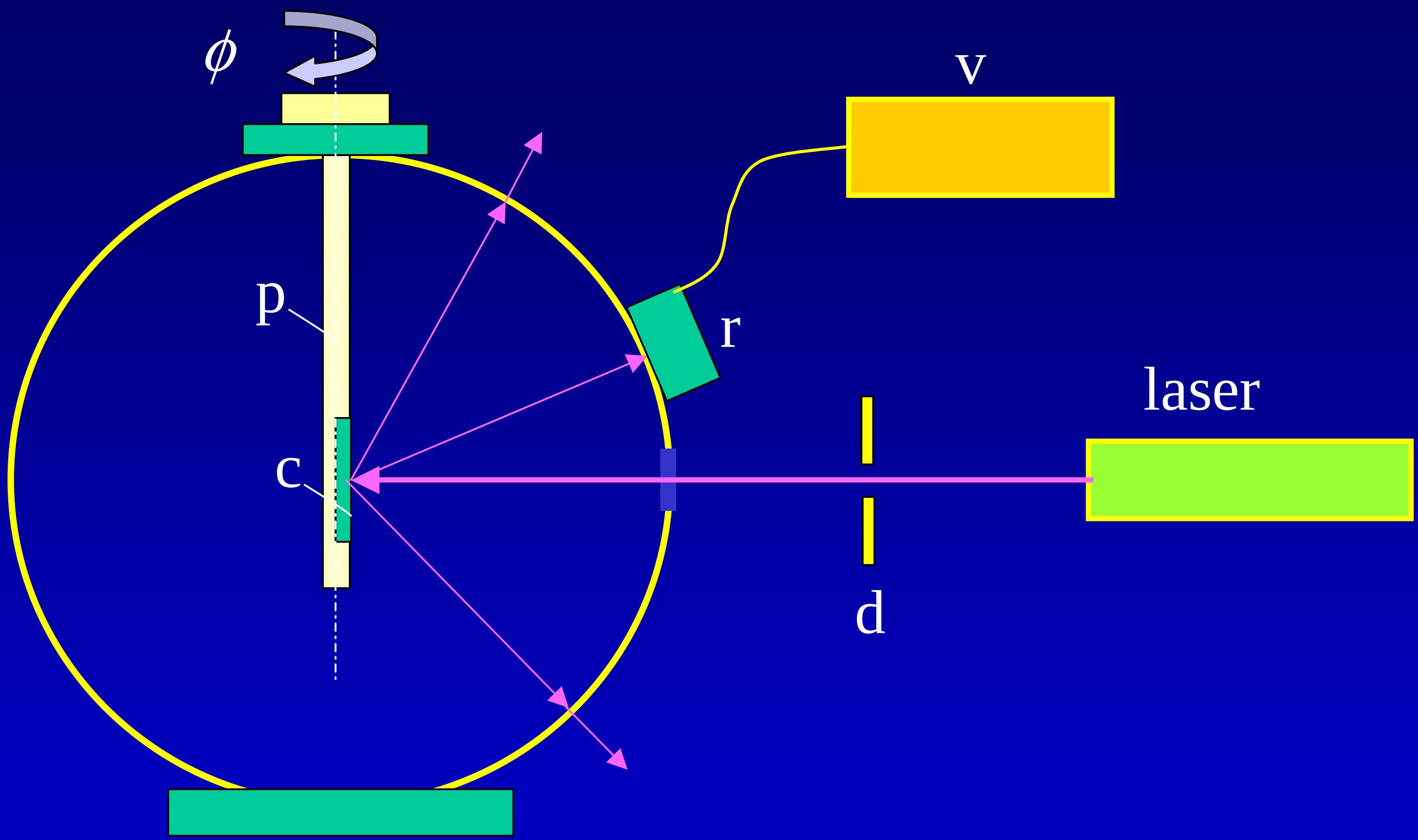


Hemispherical wells in a honeycomb lattice (HC)



Porous silicon (PS)

SEMITRANSPARENT GLOBE



Simple apparatus for backscattered light measurements.
The photodetector is moved over the globe surface.

SEMITRANSPARENT GLOBE

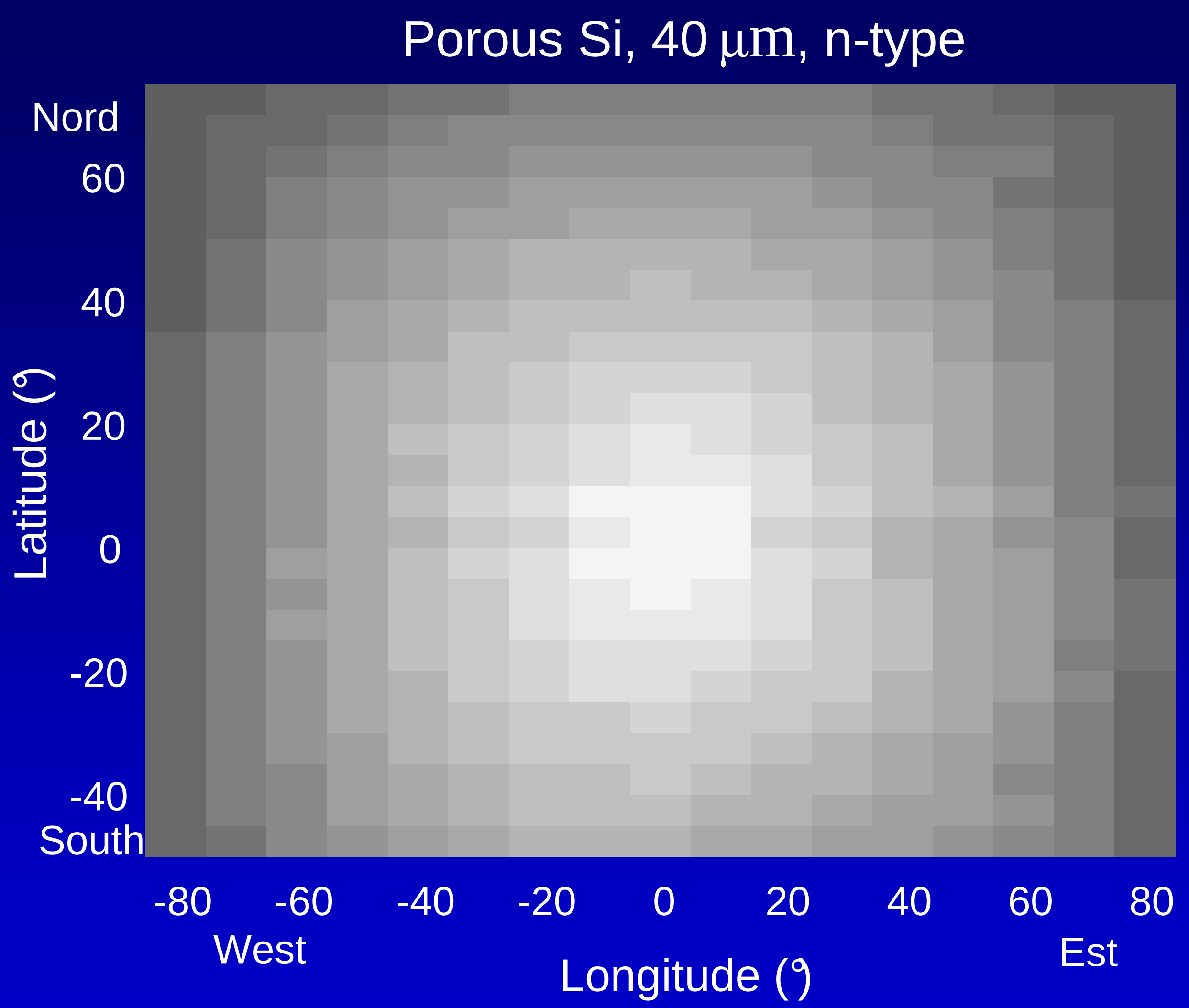
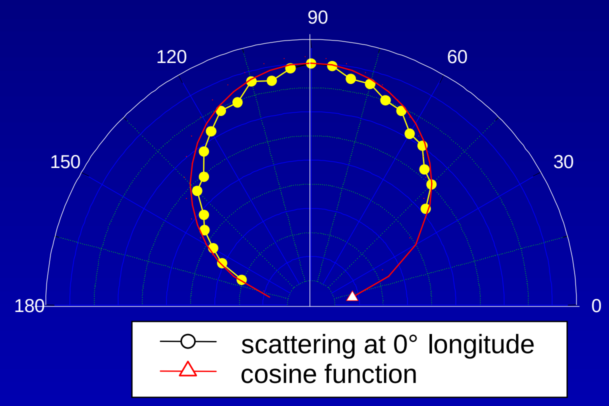
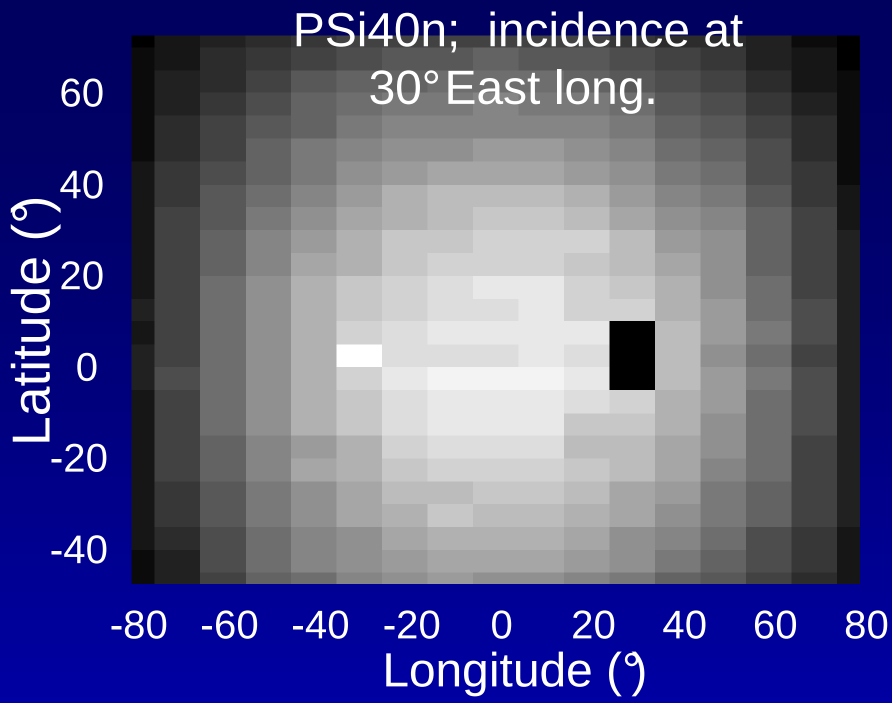


Diagramma polare dell'intensità

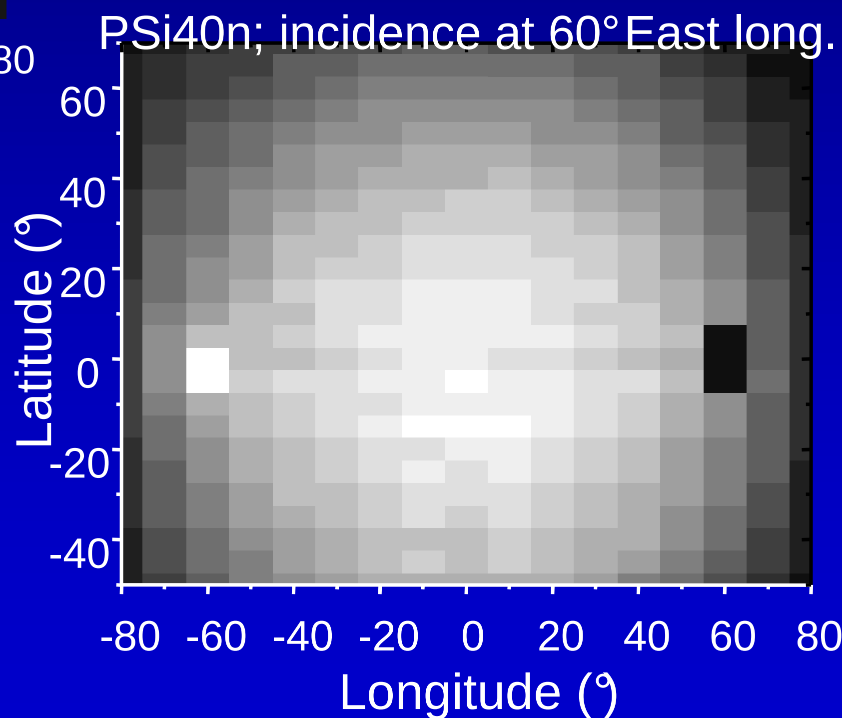


Laser light λ=633 nm; 0° incidence.

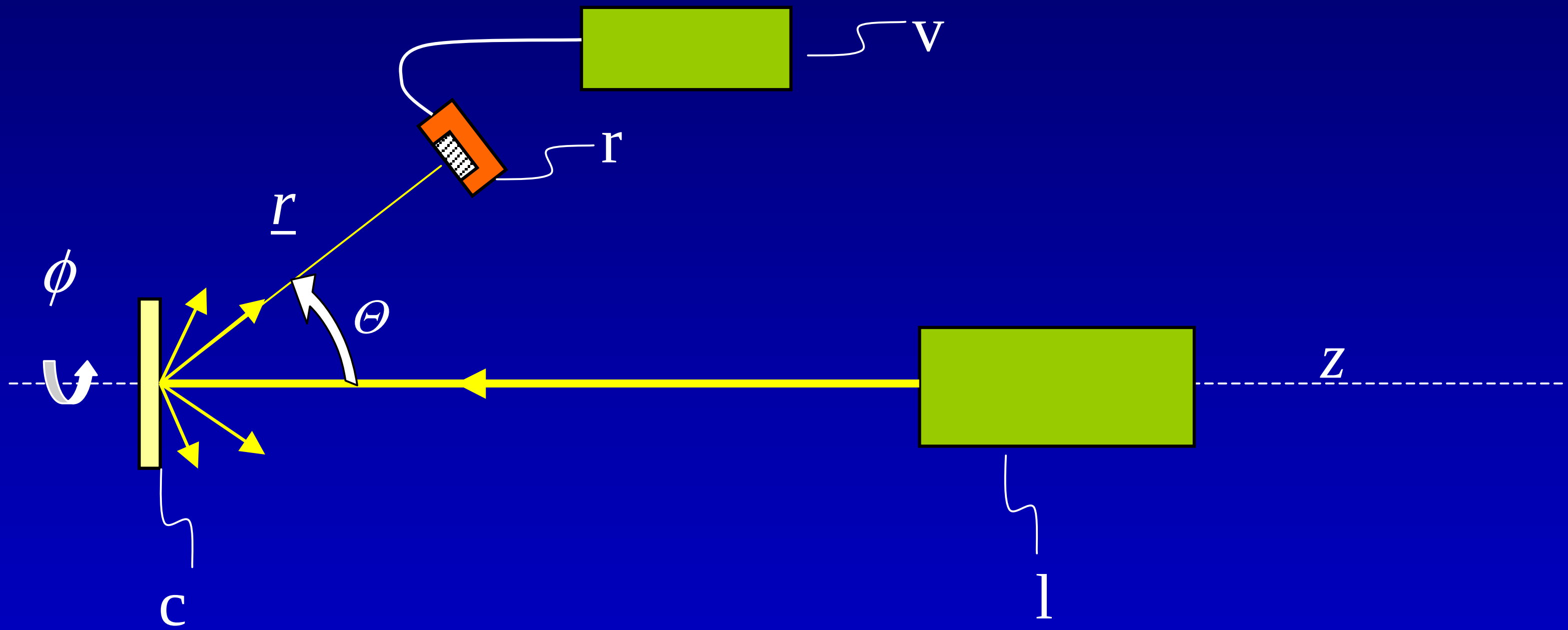


60° incidence

30° incidence



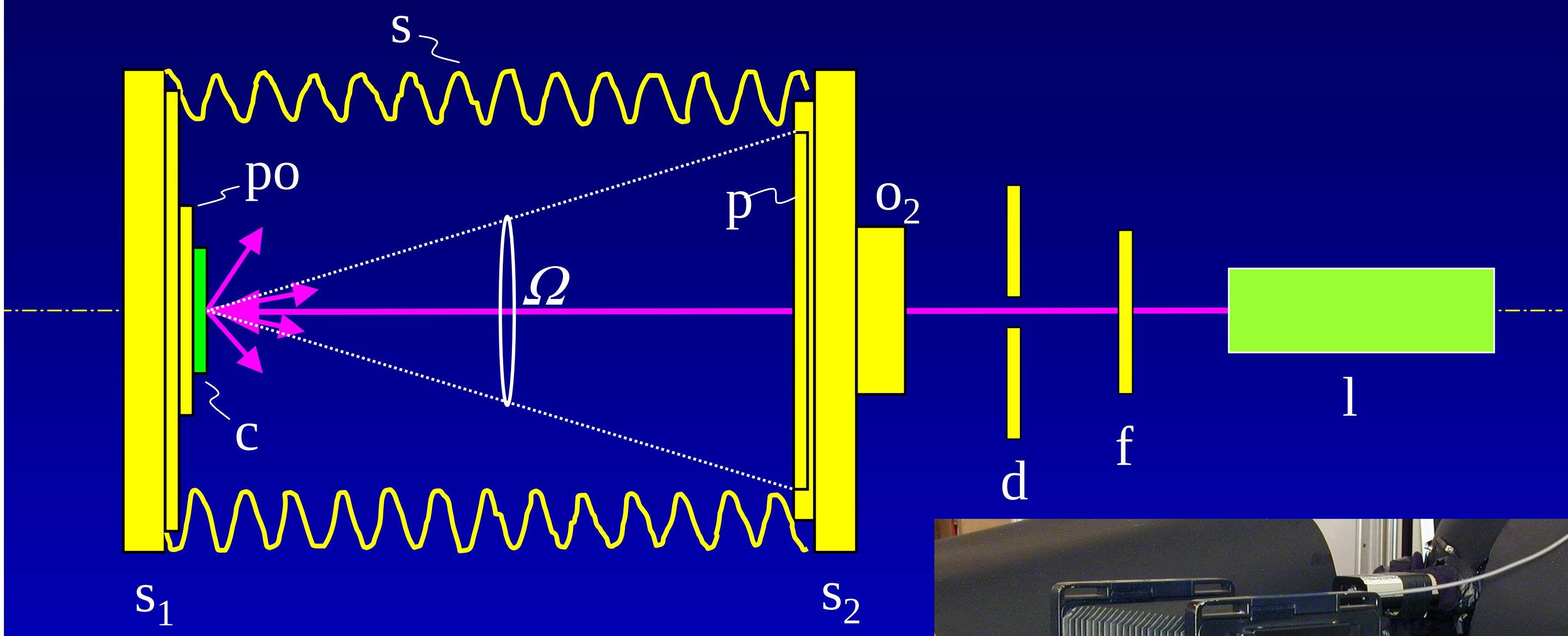
TWO-AXIS ROTATION STAGE APPARATUS

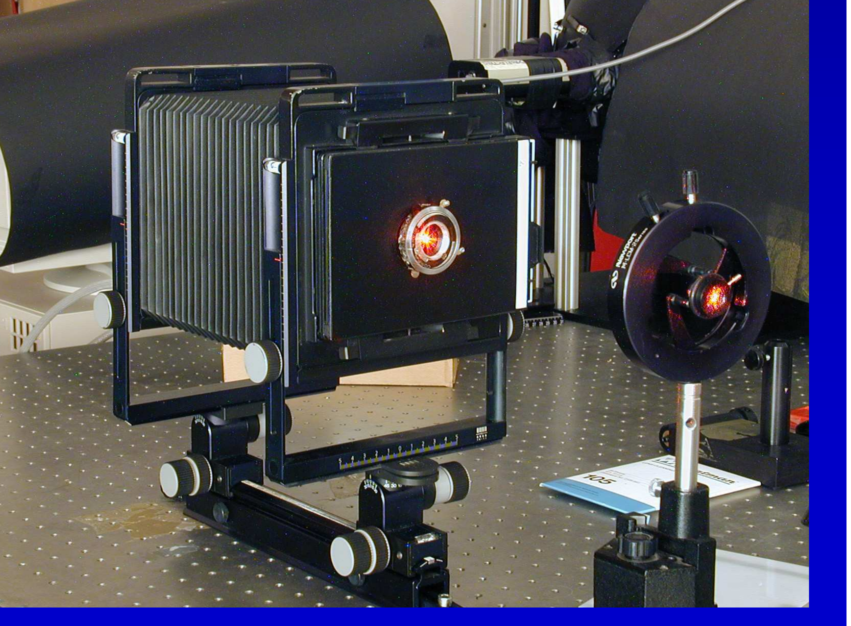


The detector is moved in front of the sample, at constant distance, changing angles Θ and ϕ by two goniometers.

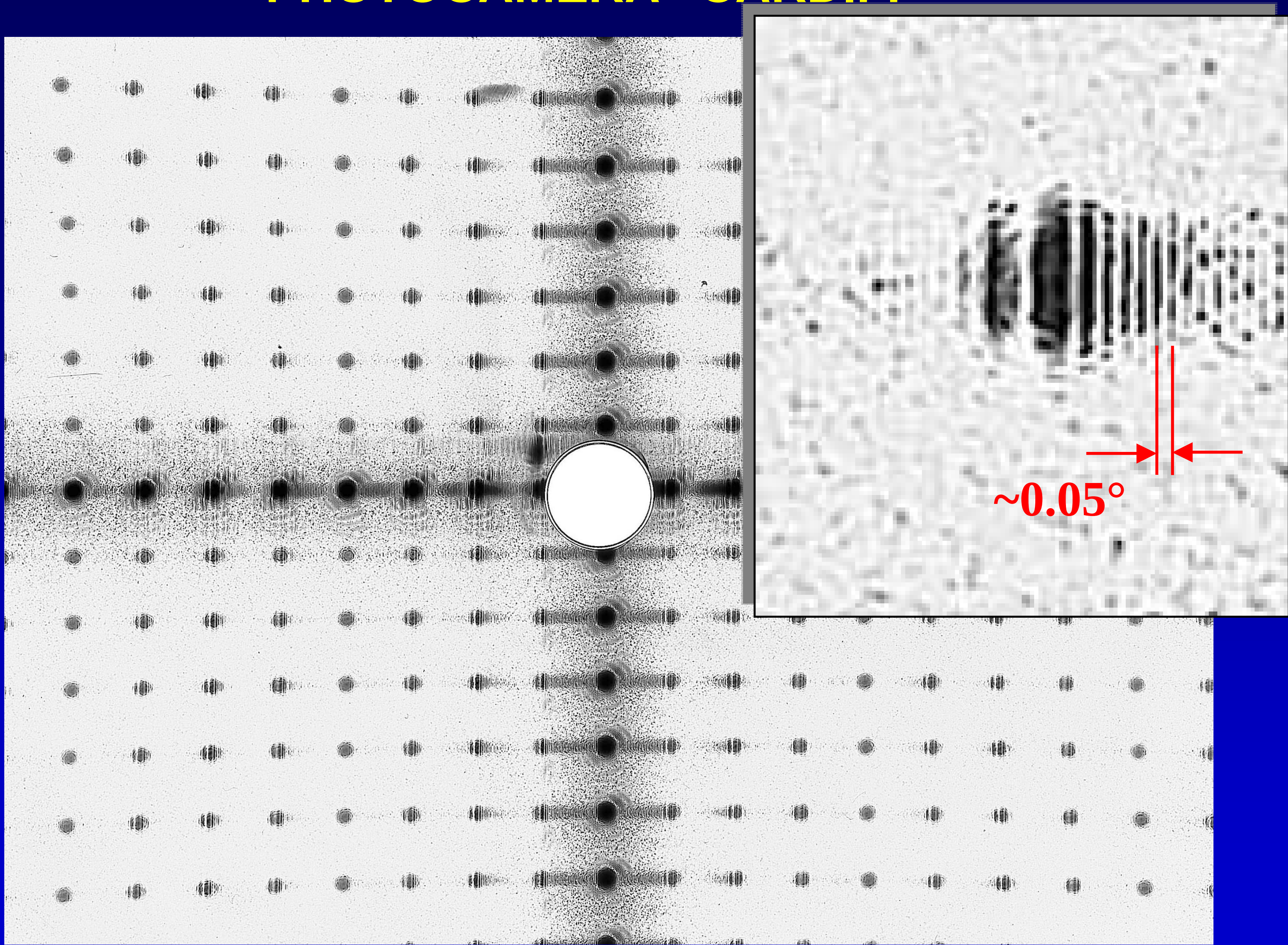
PHOTOCAMERA "CARDIFF"

(*__CA__*mera for* __R__*ecording* __DIFF__*used and* __DIFF__*racted light)





PHOTOCAMERA “CARDIFF”

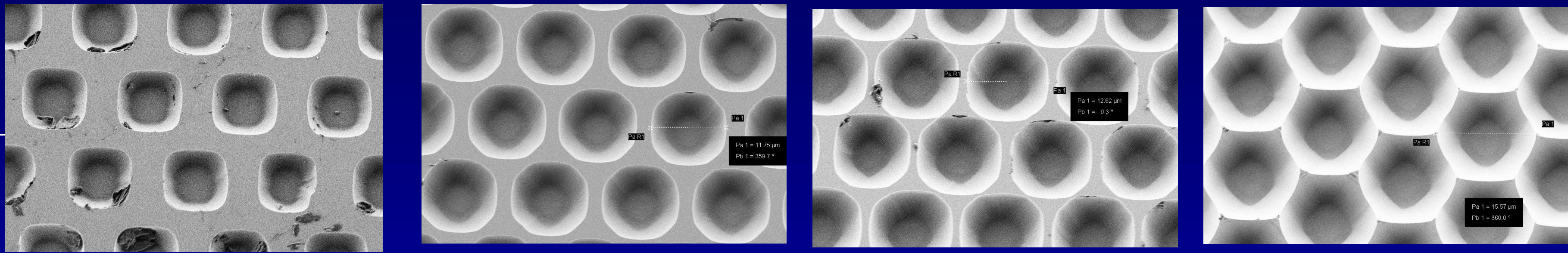


Inverted pyramids texture

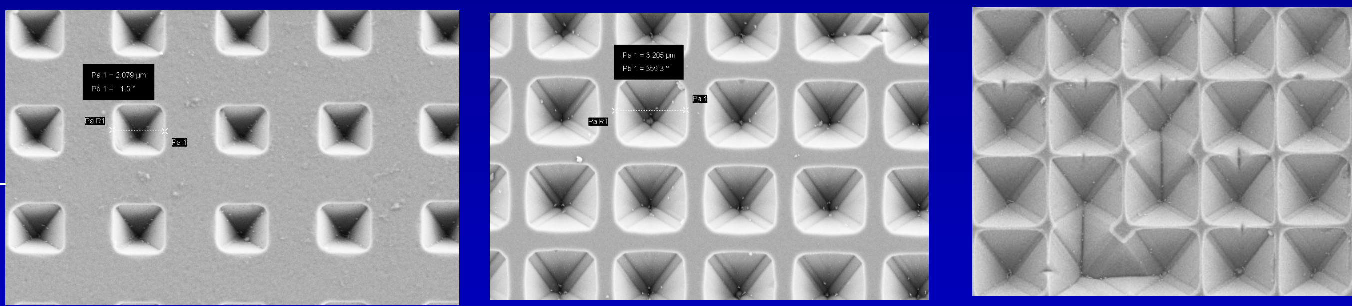
Does light backscattered from textured Si surface bring information about light collection process? …

SAMPLES

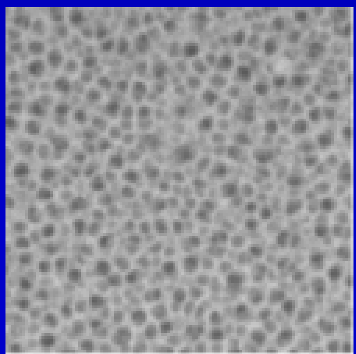
Surface coverage



HEMISPHERICAL WELLS (HC)



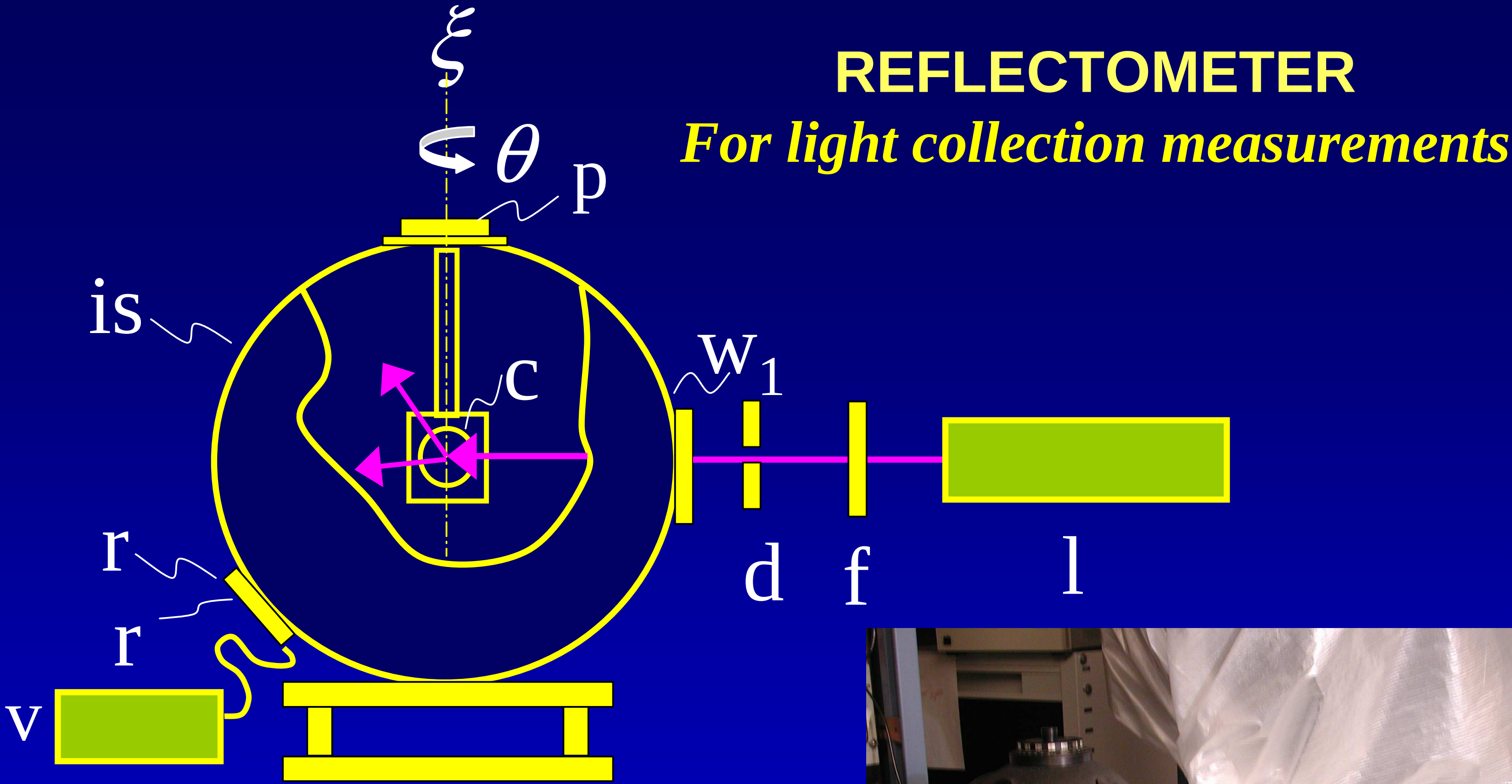
INVERTED PYRAMIDS (IP)

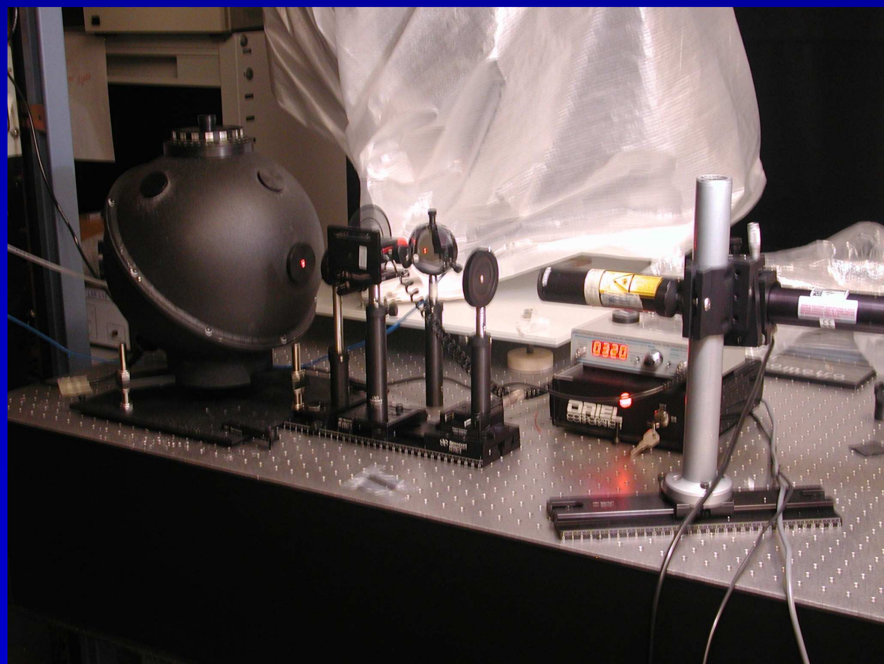


POROUS SILICON (PS)

REFLECTOMETER

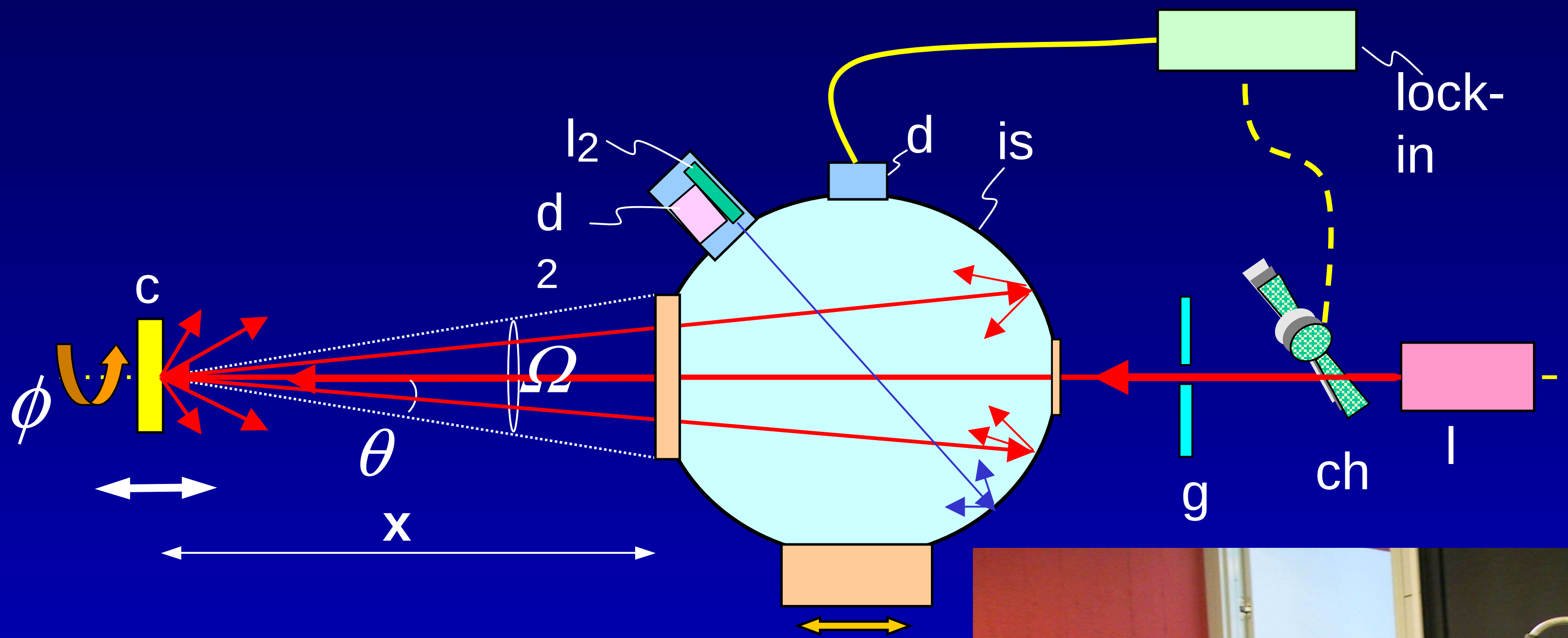
For light collection measurements

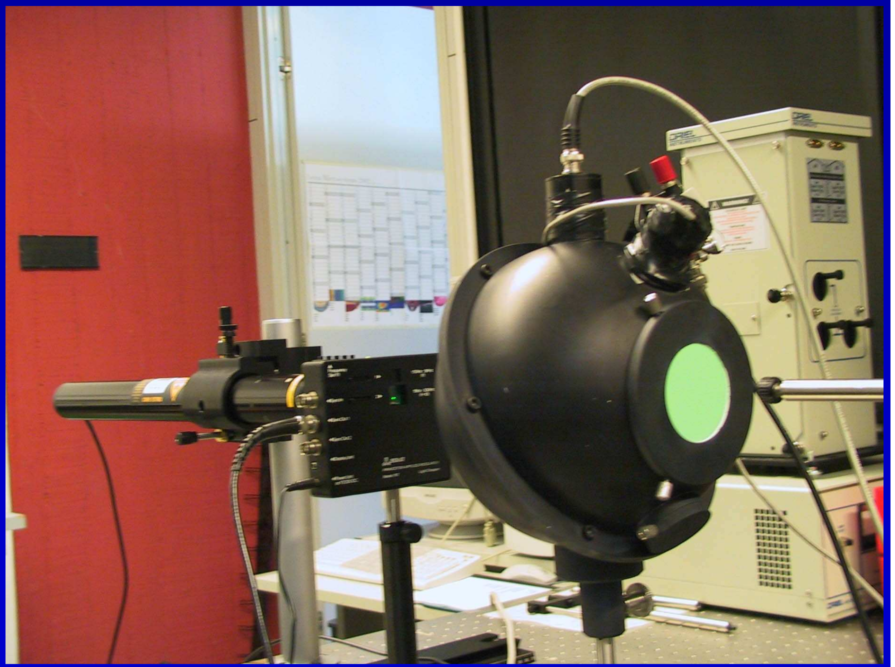




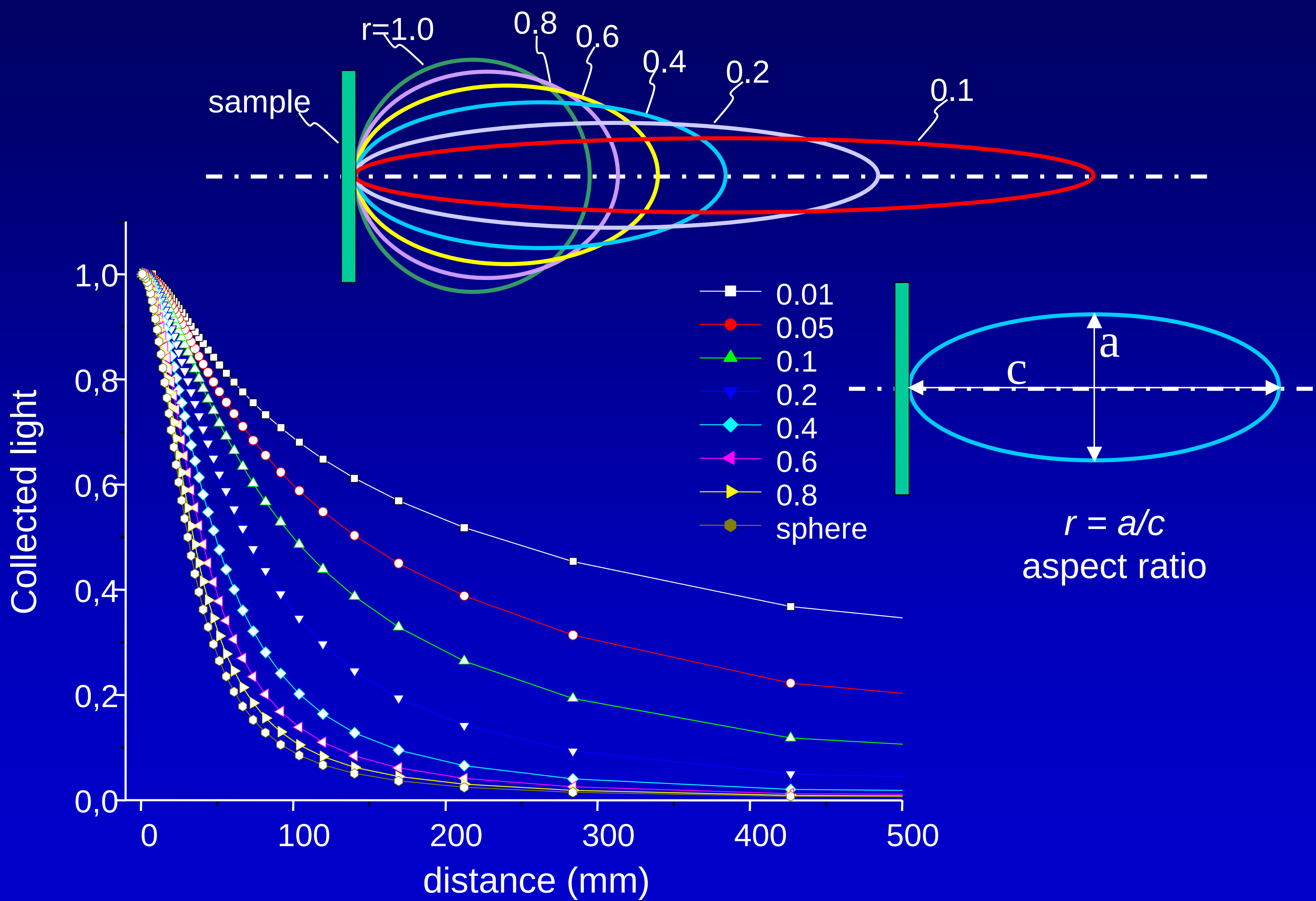
SCATTEROMETER "BASALT"

(Backscattered Light Topographer)

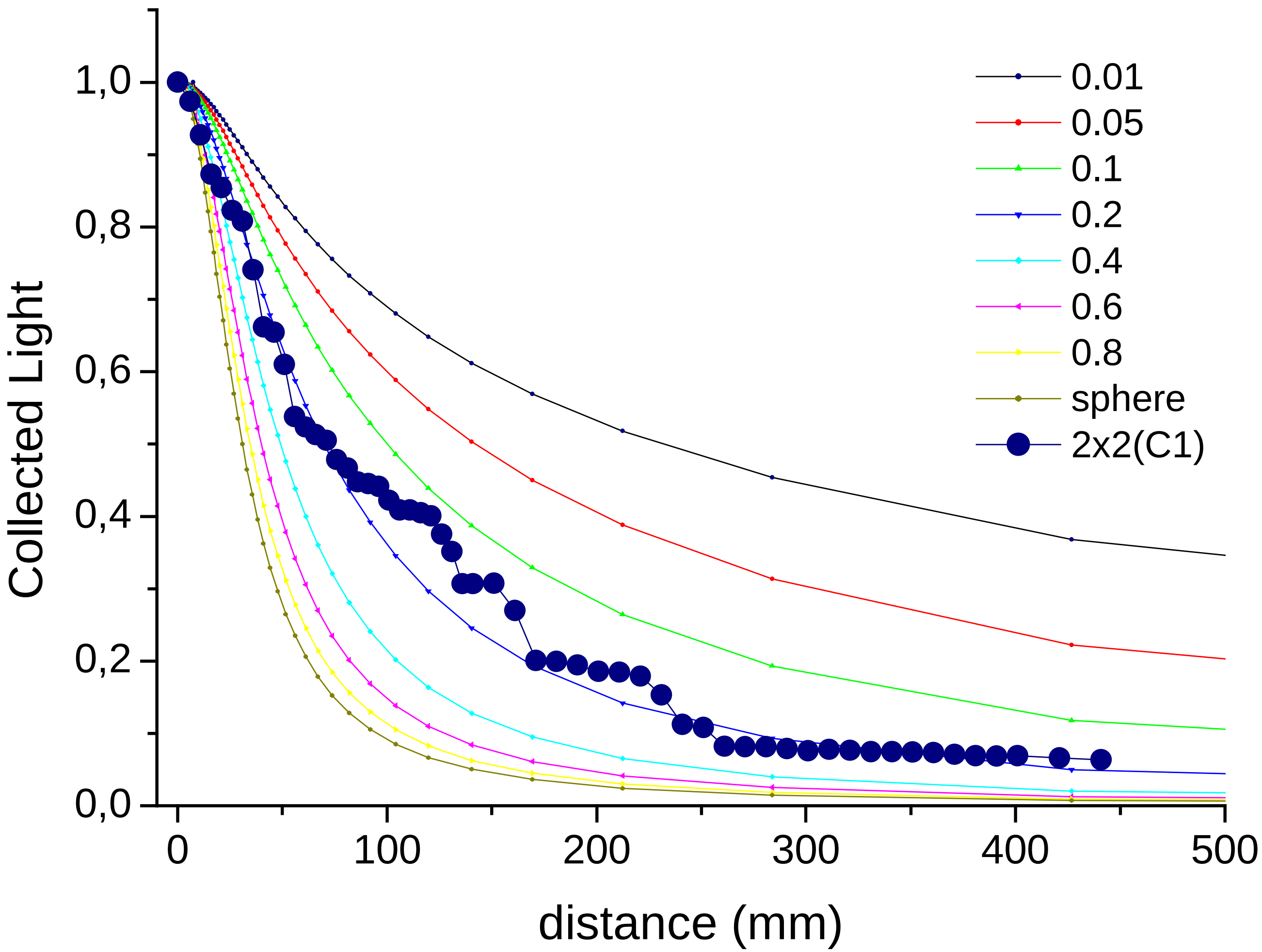


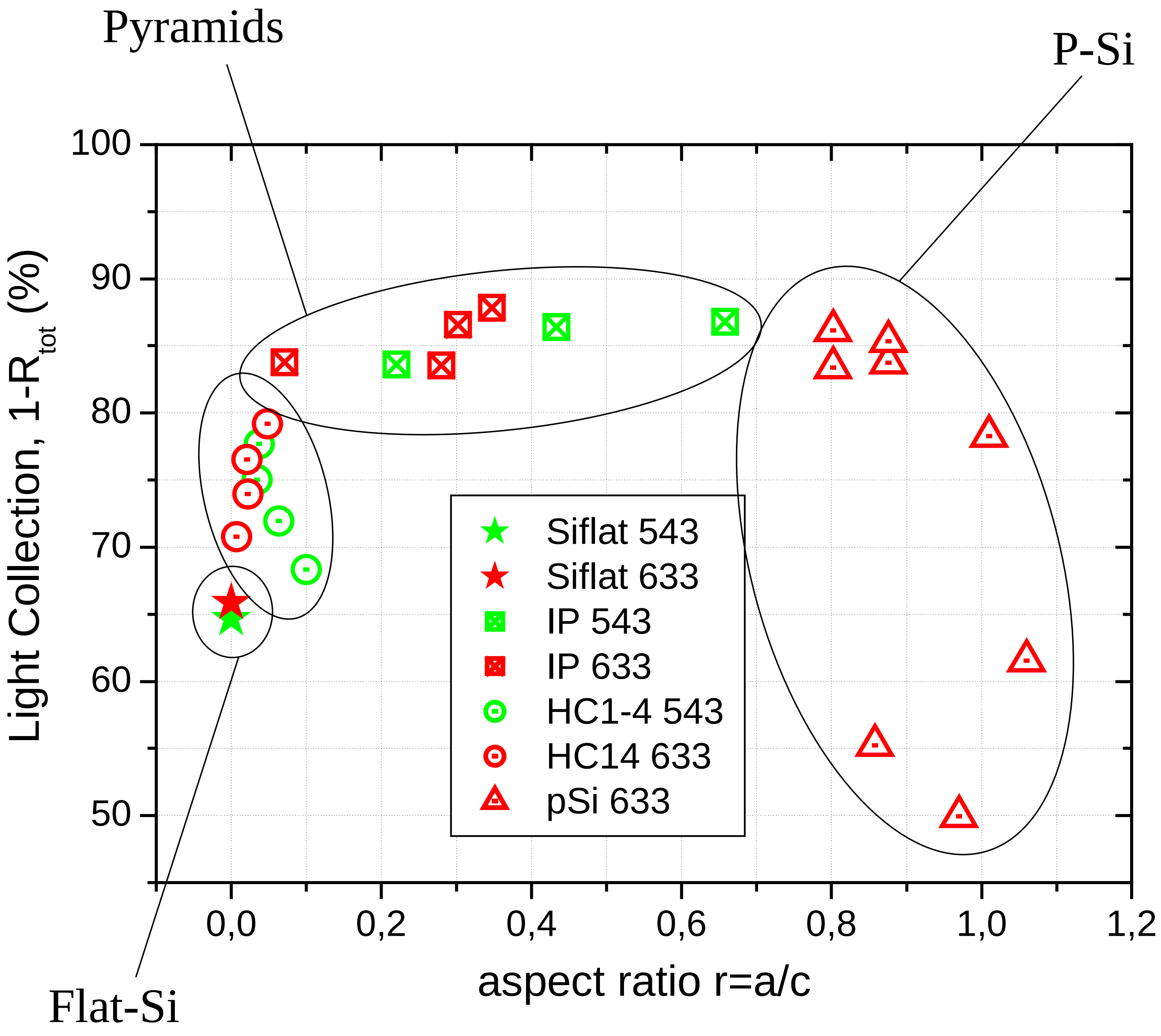


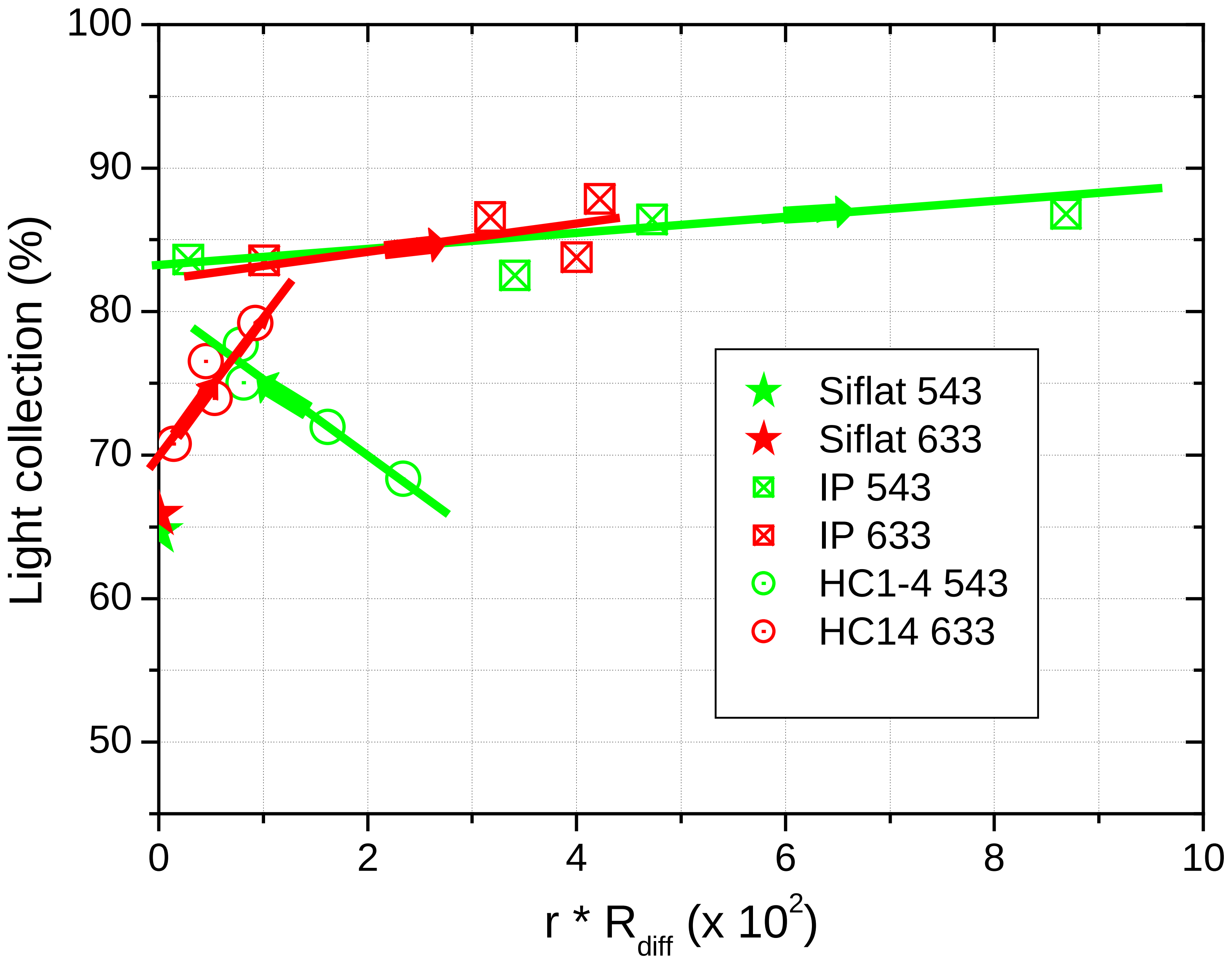
MODELS OF LIGHT BACKSCATTERING



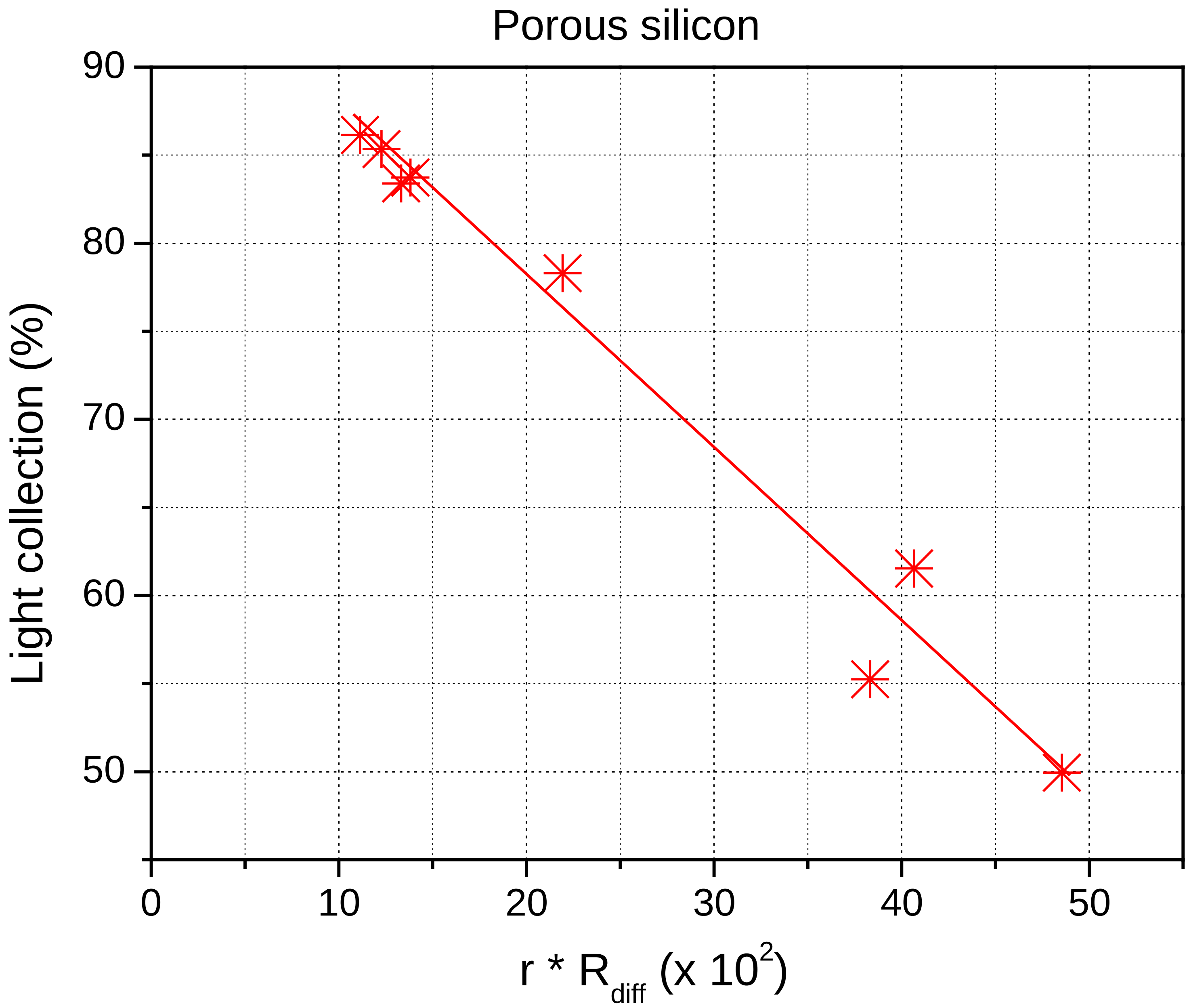
LIGHT BACKSCATTERING MEASUREMENTS




Pyramids
P-Si
Flat-Si
Light Collection, 1-R_tot (%)
aspect ratio r=a/c
100
90
80
70
60
50
0,0
0,2
0,4
0,6
0,8
1,0
1,2
Siflat 543
Siflat 633
IP 543
IP 633
HC1-4 543
HC14 633
pSi 633



100
90
80
70
60
50
0
2
4
6
8
10
Light collection (%)
r * R_diff (x 10^2)
Siflat 543
Siflat 633
IP 543
IP 633
HC1-4 543
HC14 633



Porous silicon
90
80
70
60
50
0
10
20
30
40
50
Light collection (%)
r * R_diff (x 10^2)

CONCLUSIONS

☻Methods and apparatus for visualizing, measuring and recording the light backscattered from textured silicon samples have been presented.

☻ The angular distribution of backscattered light could play a role in the light collection process.

☻ The investigation made on different types of texturisations on c-Si substrates (pyramids, wells, porous silicon) has shown that a sort of linear correlation exists between light collection and distribution and weight of the backscattered light.

☻ Work is in progress to confirm this type of correlation.