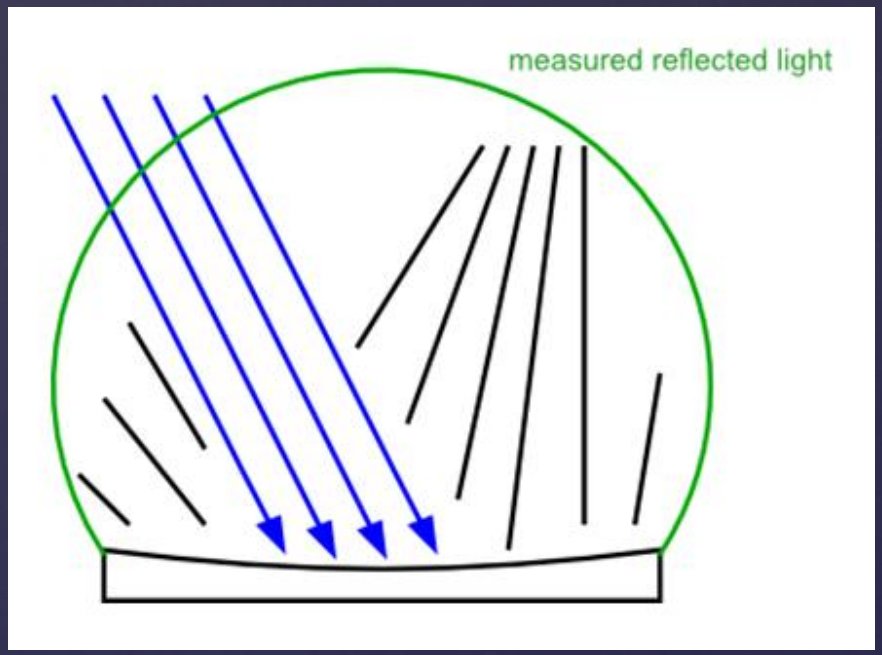
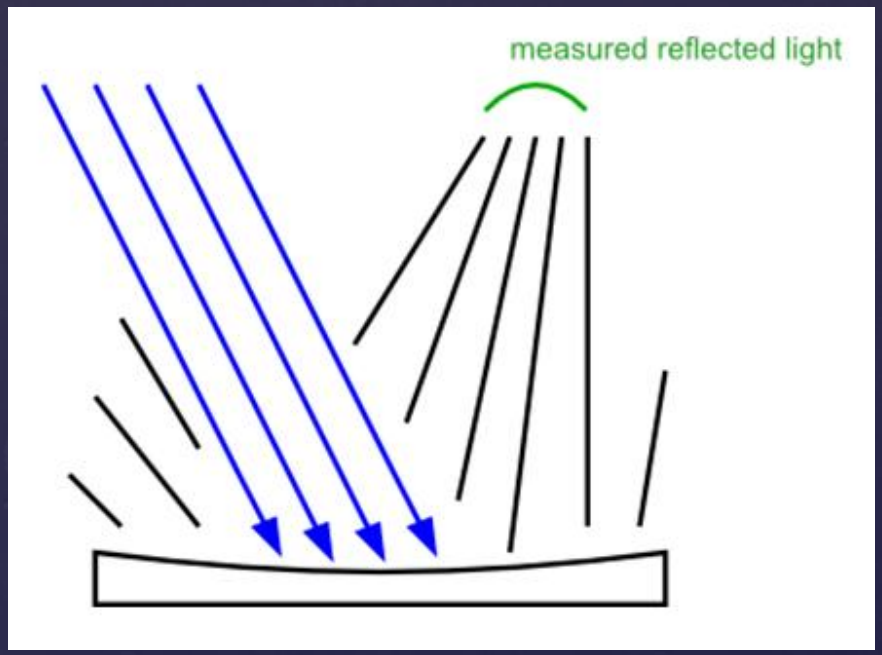
Messung der absoluten Reflektivität von konkav Spiegeln in der Fokalebene

Hanna Kellermann, Markus Garczarczyk, Razmik Mirzoyan

There is a differnece between the reflectivities

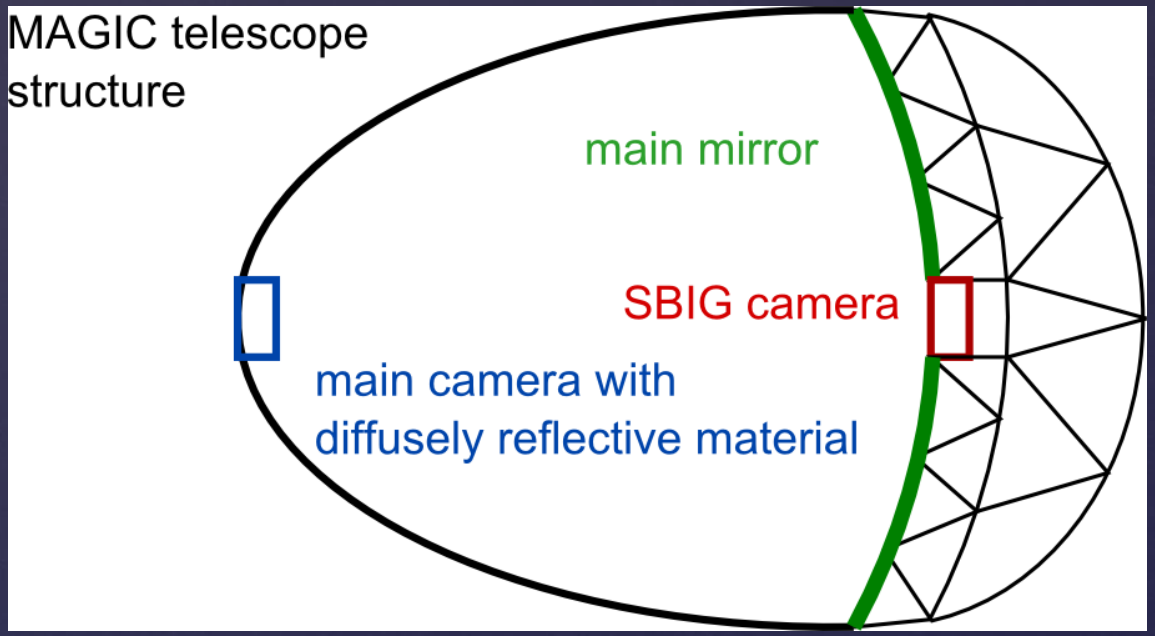


surface reflectivity

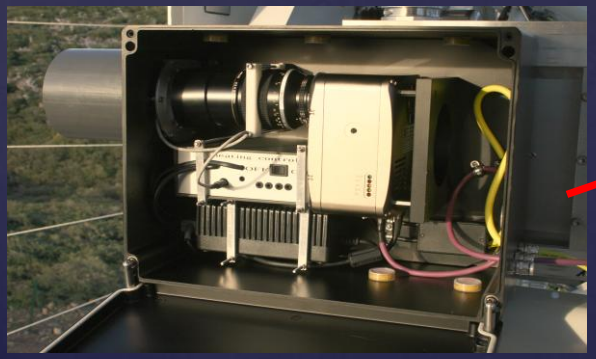


focused reflectivity

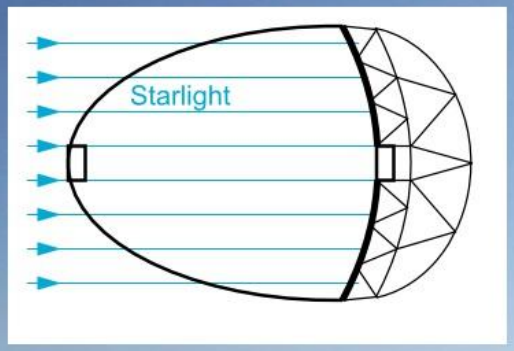
Measurement Setup



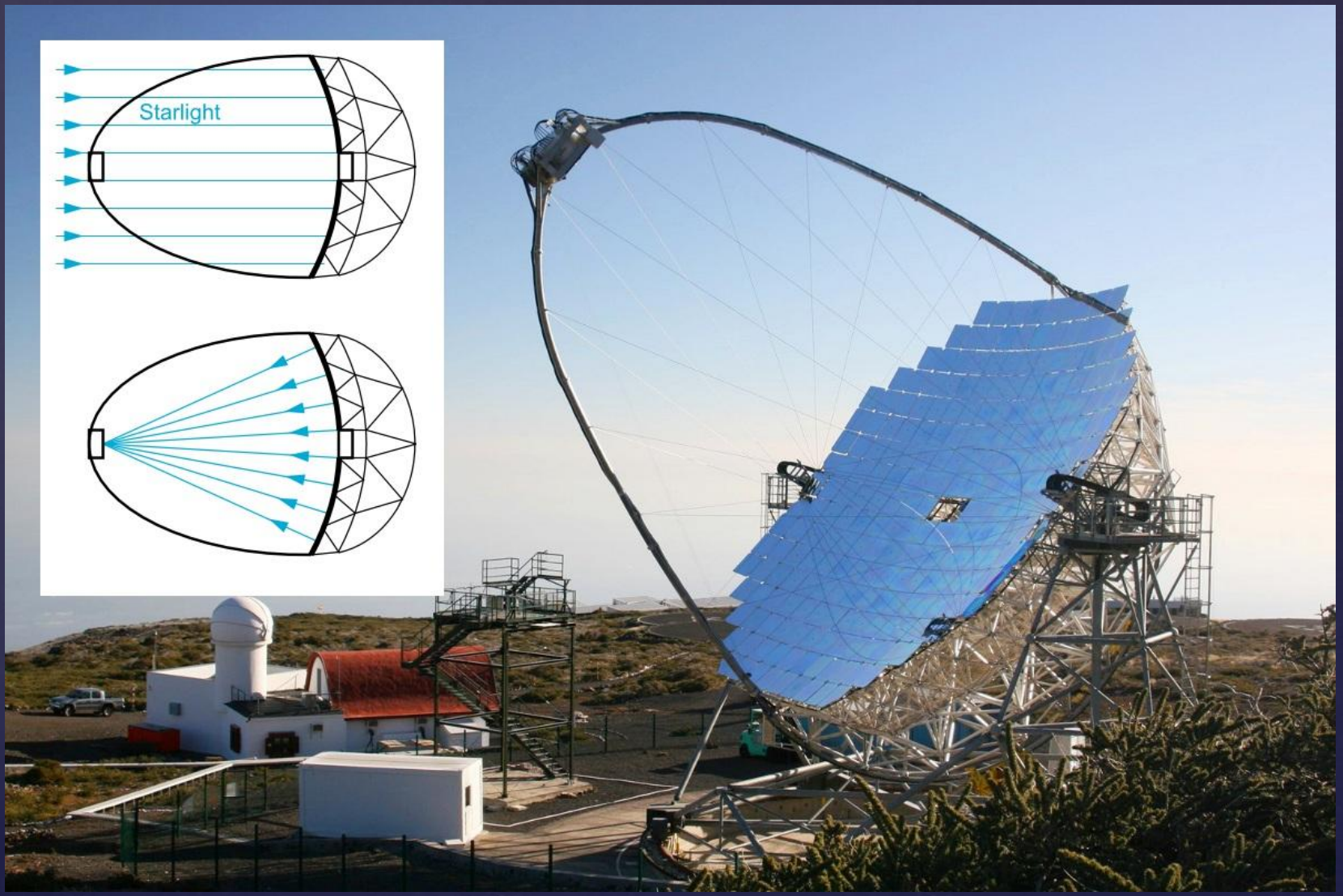
Measurement setup in detail



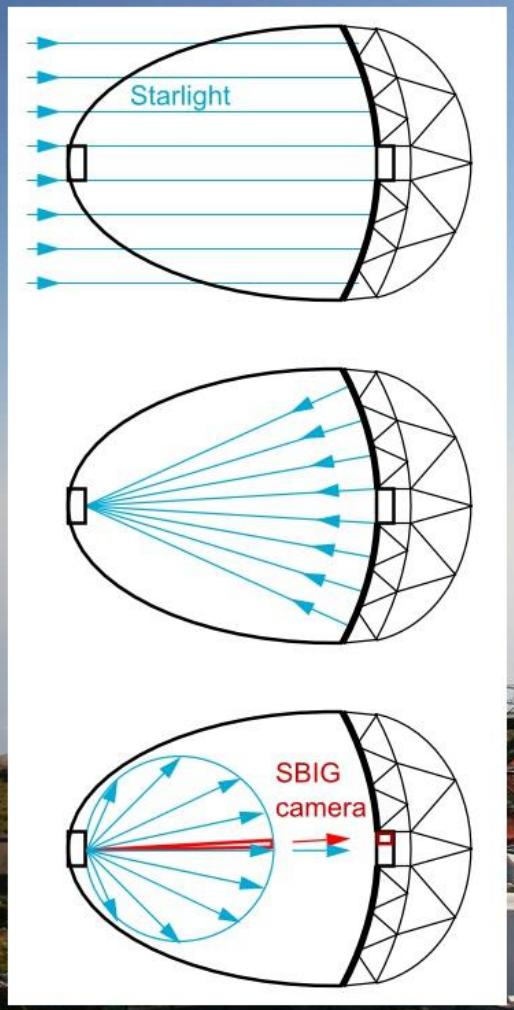
Measurement technique



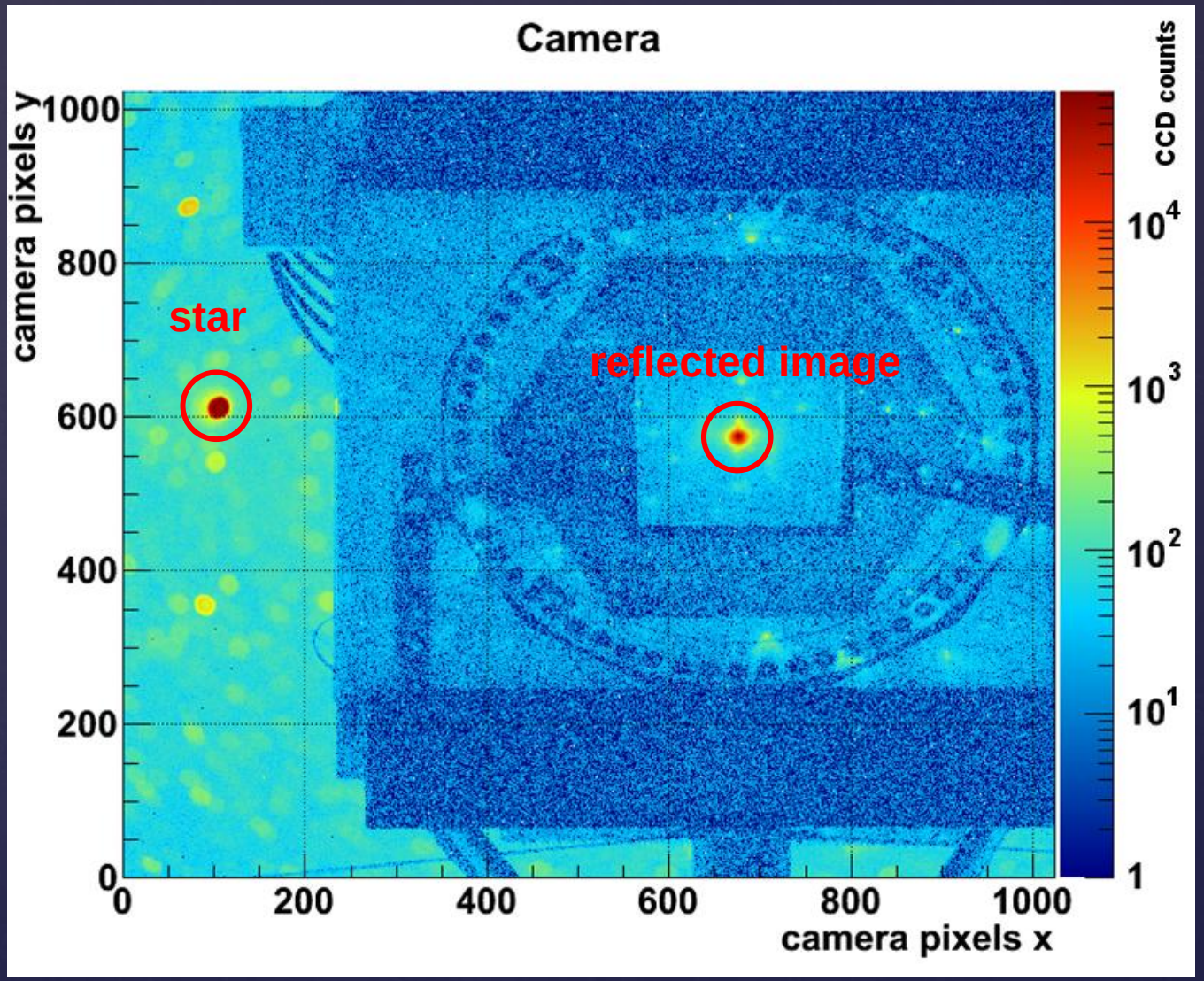
Measurement technique



Measurement technique



Picture taken with the SBIG-Camera



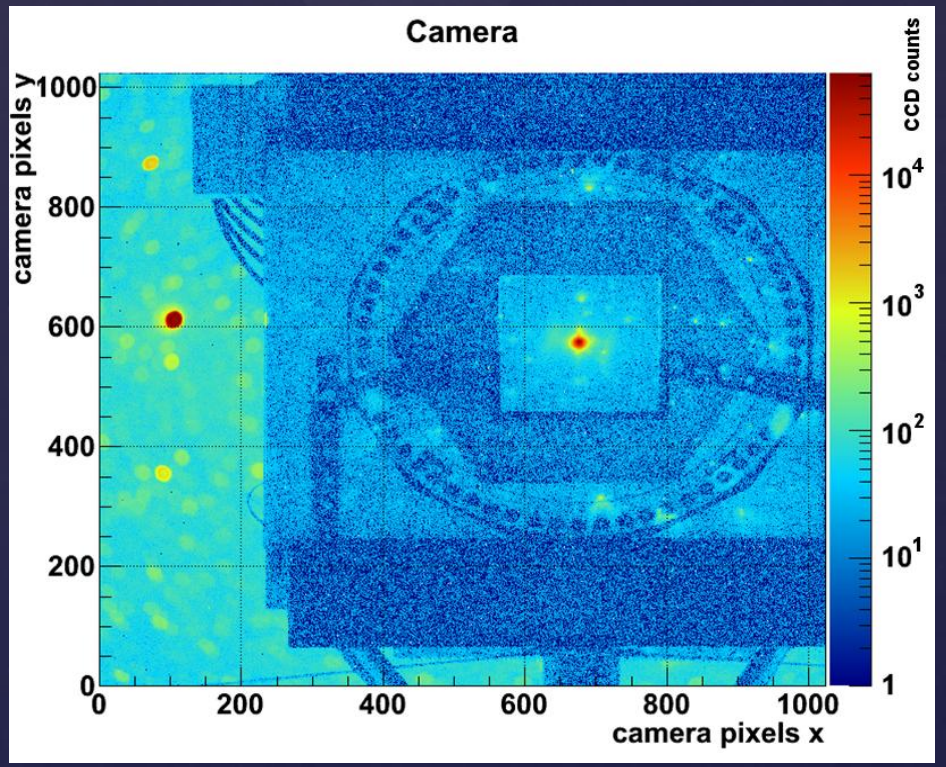
How to calculate the focused reflectivity

$$R_{fok} = \frac{\phi_{indirect}}{\phi_{direct}} \cdot C_{geom.}$$

ϕ_{direct} = sum of counts in the region of the reflection

$\phi_{indirect}$ = sum of counts in the region of the star

$C_{geom.}$ = geometrical factor

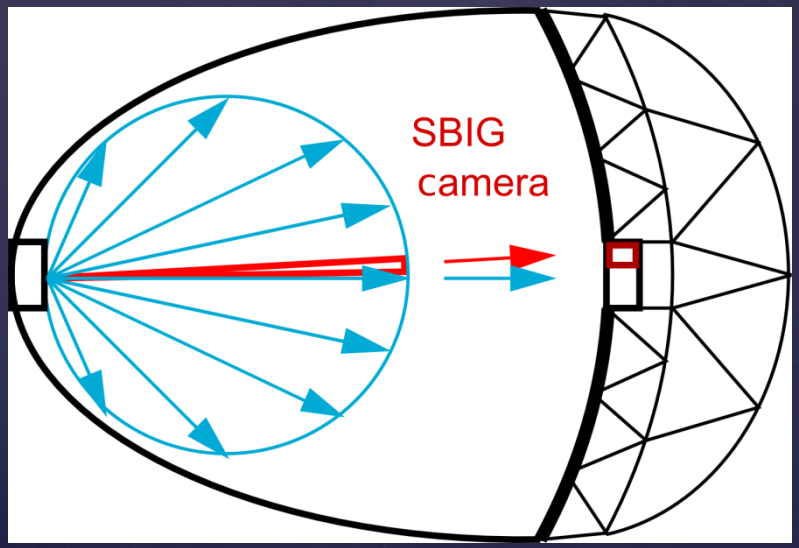


How to calculate the focused reflectivity

a little bit more detailed…

$$R_{fok} = \frac{\phi_{indirect}}{\phi_{direct}} \cdot \frac{r^2}{A_{mirror}} \cdot \frac{1}{R_{diffusor}} \cdot \frac{\Omega_{eff}}{\alpha}$$

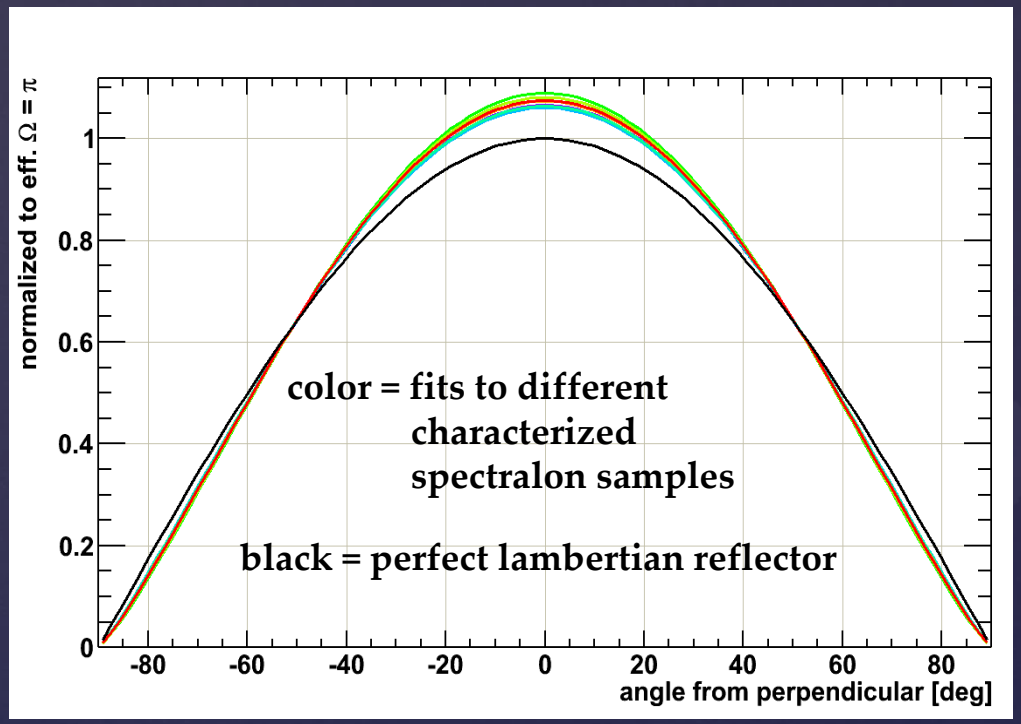
Mirzoyan, et al., 2007

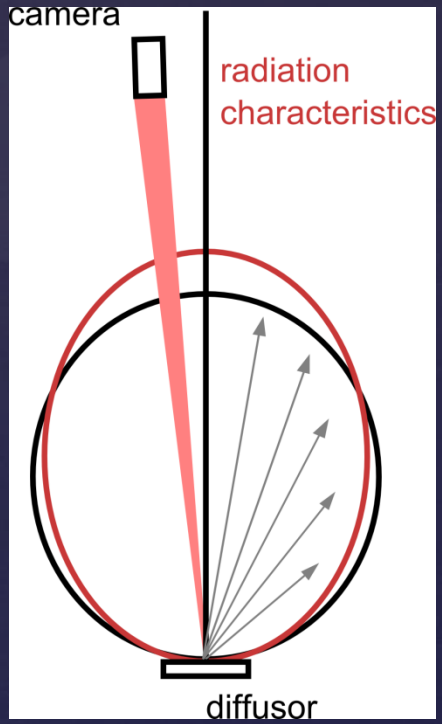


Ω_{eff} = a measure for how the light is reflected

α = angular correction

scattering characteristics of real spectralon samples and an ideal diffuse (Lambertian) reflector





How to calculate the focused reflectivity

$$R_{fok} = \frac{\phi_{indirect}}{\phi_{direct}} \cdot \frac{r^2}{A_{HSP}} \cdot \frac{1}{R_{Sp}} \cdot \frac{\Omega_{eff}}{\alpha}$$

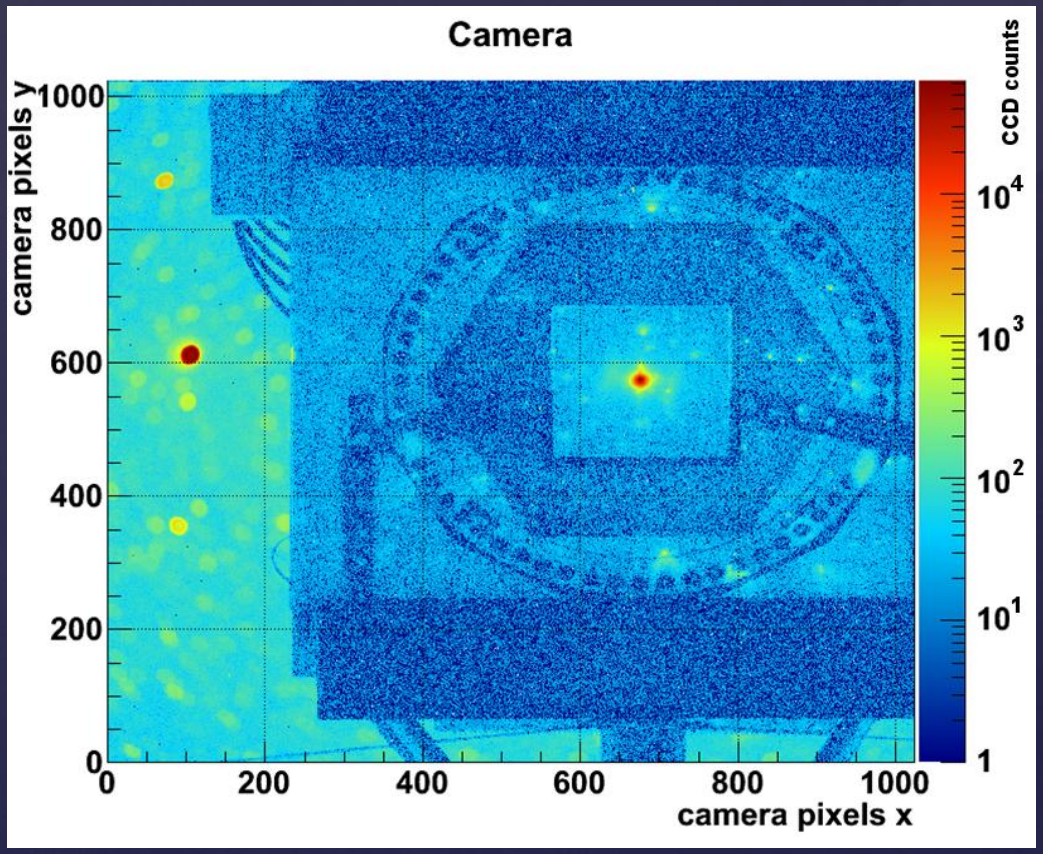
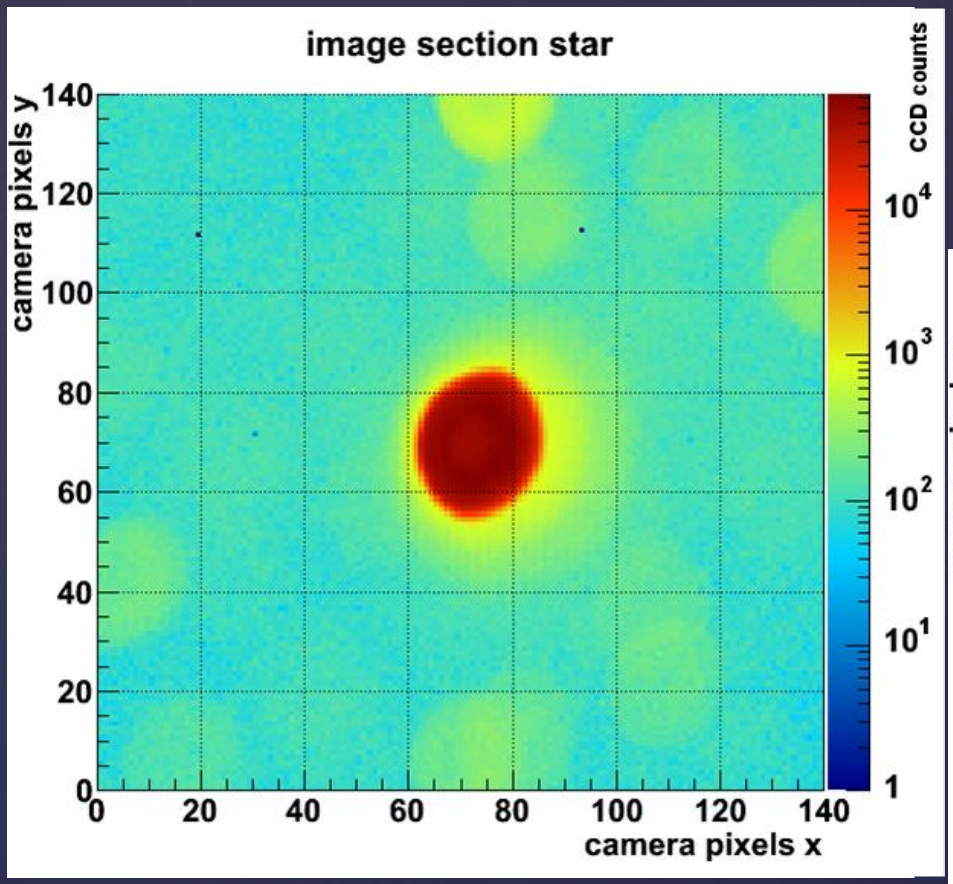


Image sections



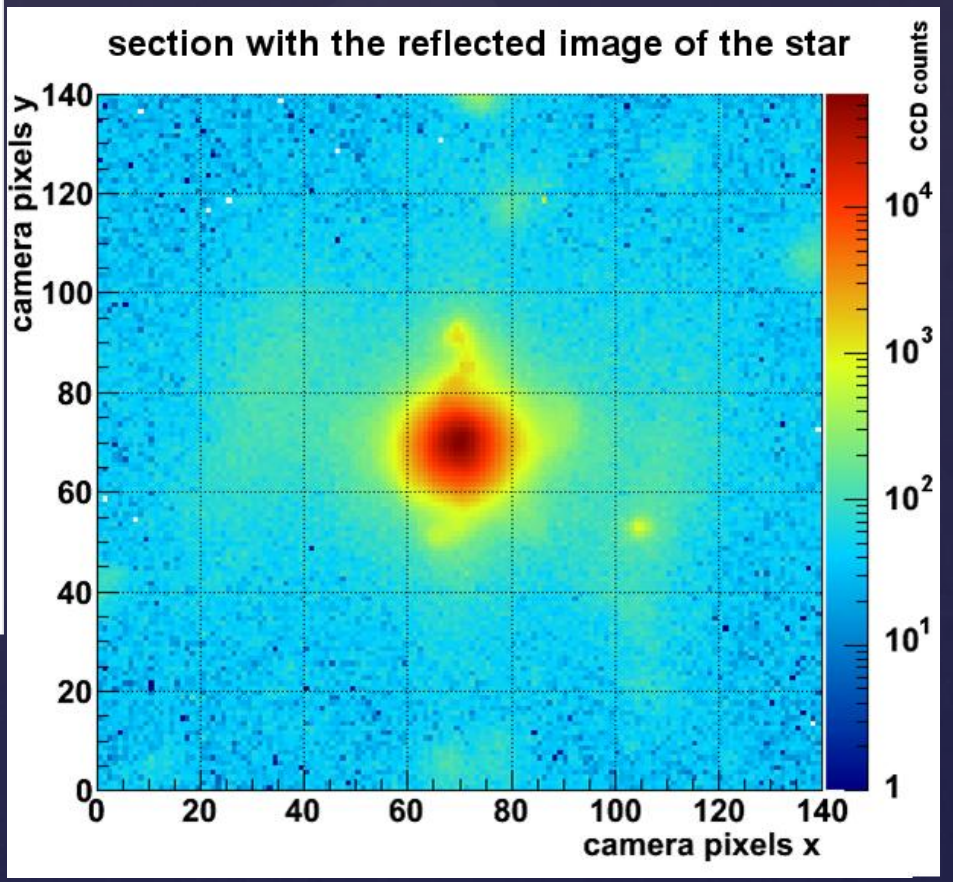
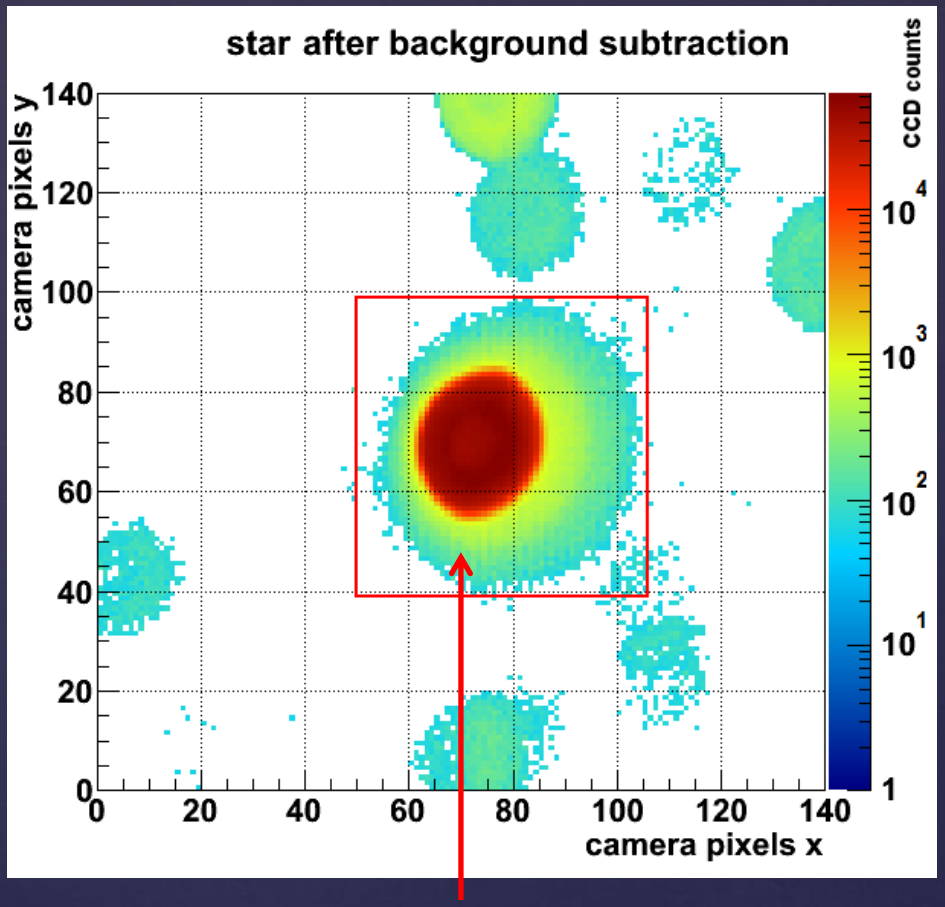
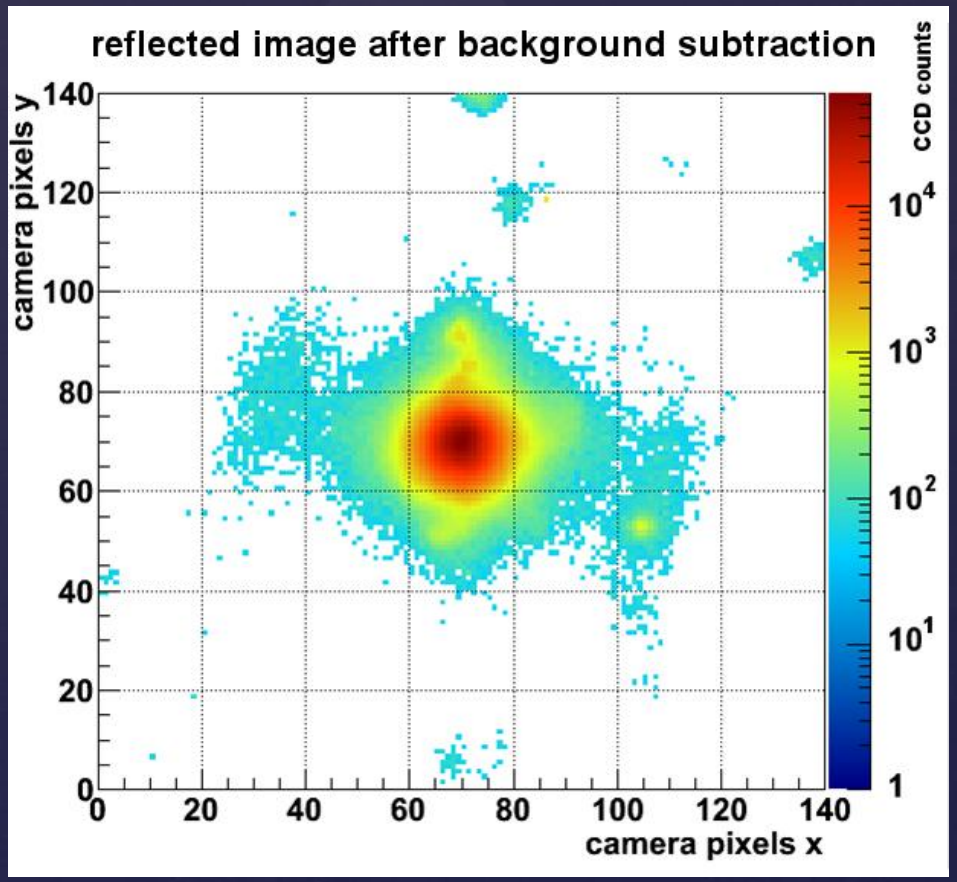


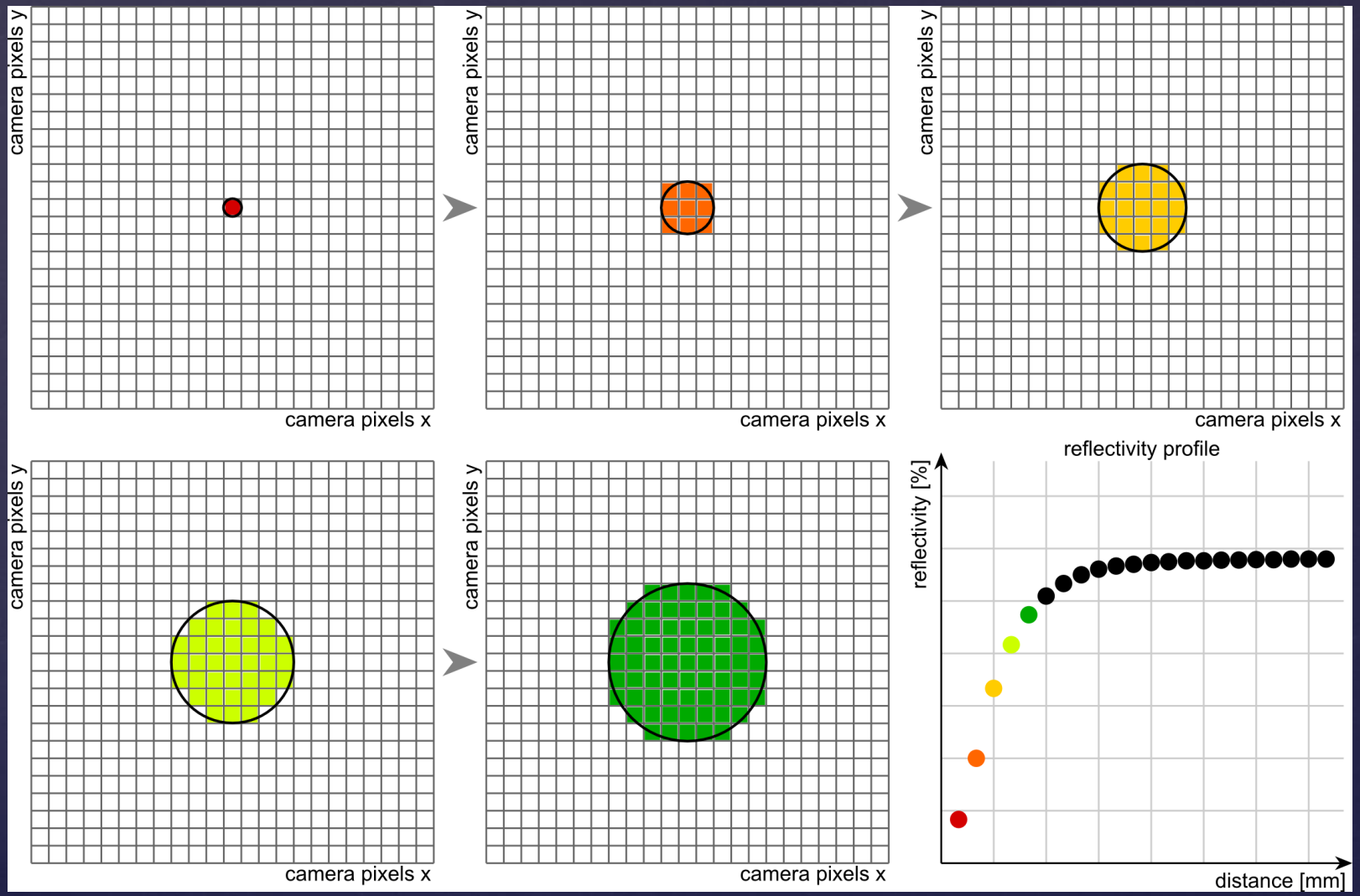
Image sections after background subtraction



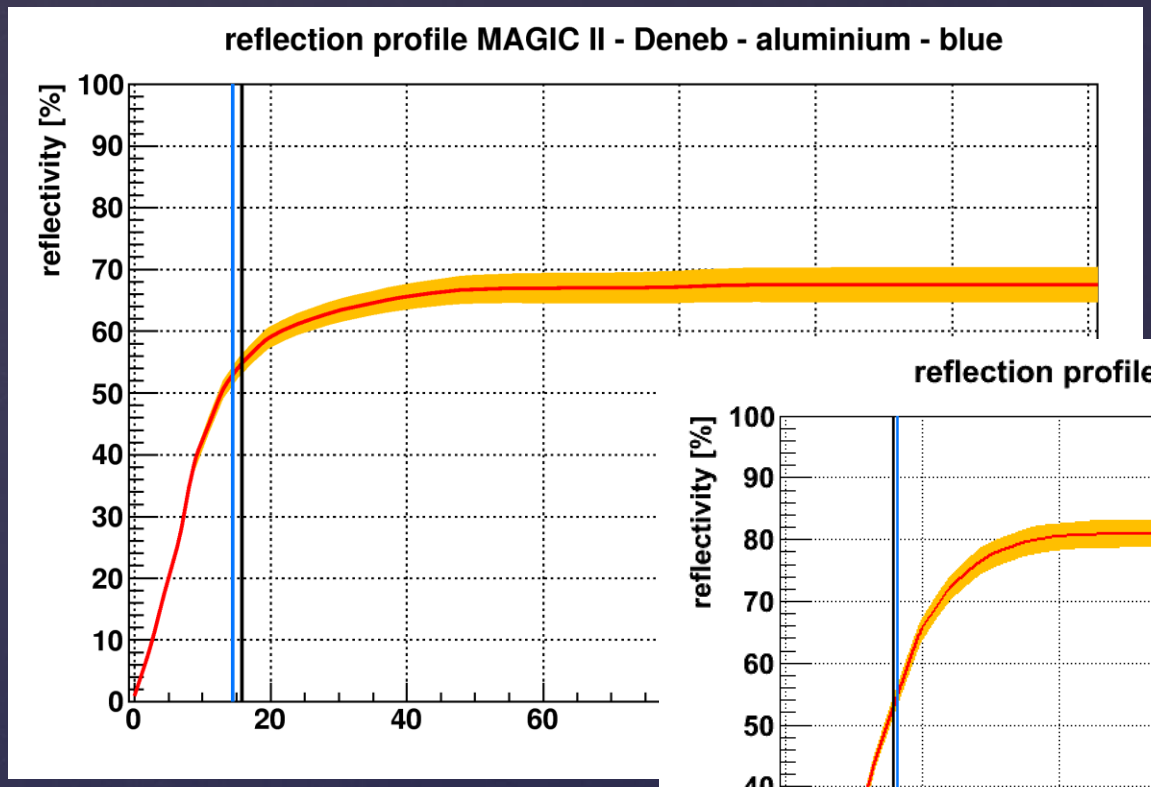
ϕ_{direkt}

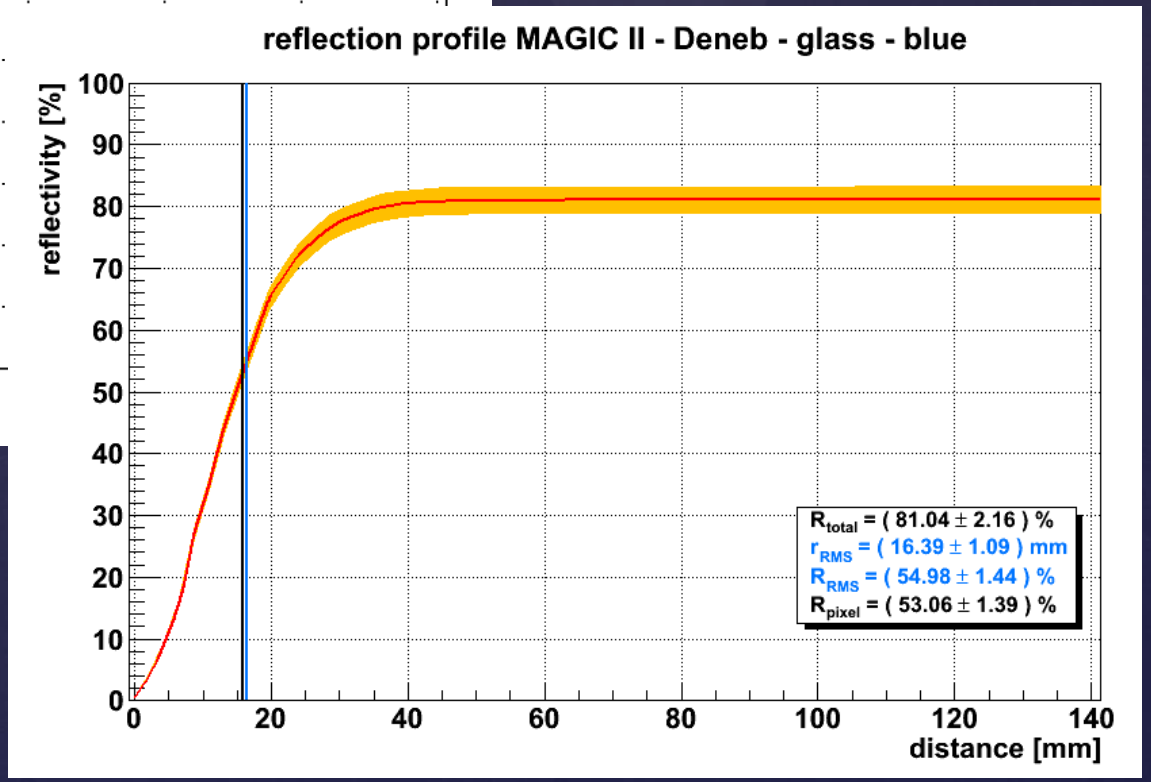


How to dervive the profile of the focused reflectivity



Examples of some reflectivity profiles





Some selected results (blue filter)

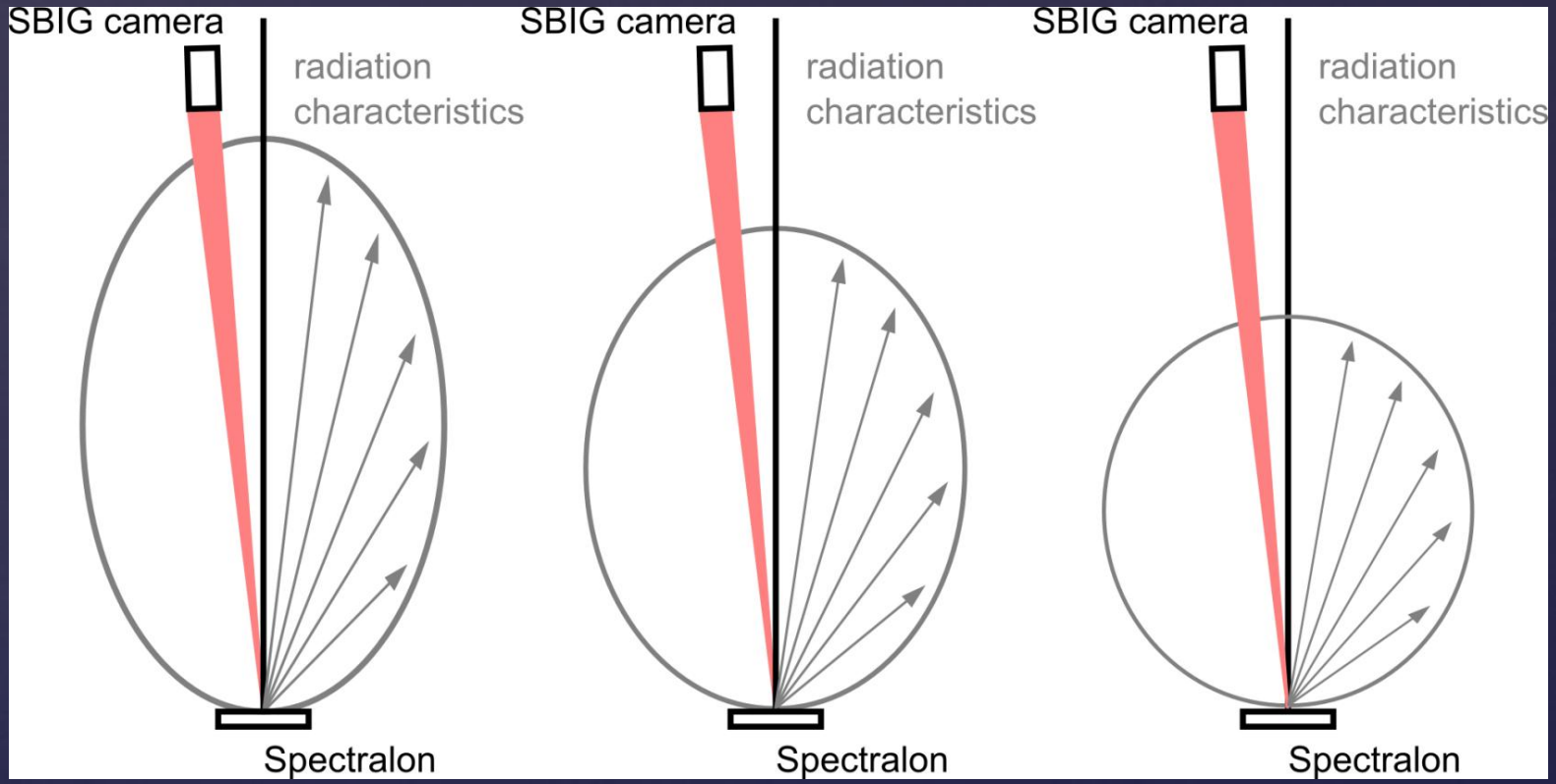
telescope/mirror	r_{RMS} [mm]	R_{RMS} [%]	R_{Pixel} [%]	R_{Total} [%]
MAGIC I	19.25 ± 0.61	55.01 ± 0.78	48.91 ± 1.83	71.21 ± 0.72
MAGIC II all	16.06 ± 0.73	55.21 ± 2.11	54.61 ± 1.53	74.68 ± 0.58
MAGIC II *Al*	14.42 ± 0.58	54.28 ± 1.07	55.93 ± 1.46	67.16 ± 0.74
MAGIC II glass	16.22 ± 0.15	56.31 ± 1.64	54.90 ± 2.05	81.36 ± 0.28

- The mirrors of MAGIC II have a better reflectivity R_{Total} as those of MAGIC I.
- PSF of MAGIC II is better, resulting in more light going to one pixel.
- The glass mirrors of MAGIC II have higher reflectivity R_{Total} than the Al mirrors.
- However Al mirrors focus better than glass mirrors

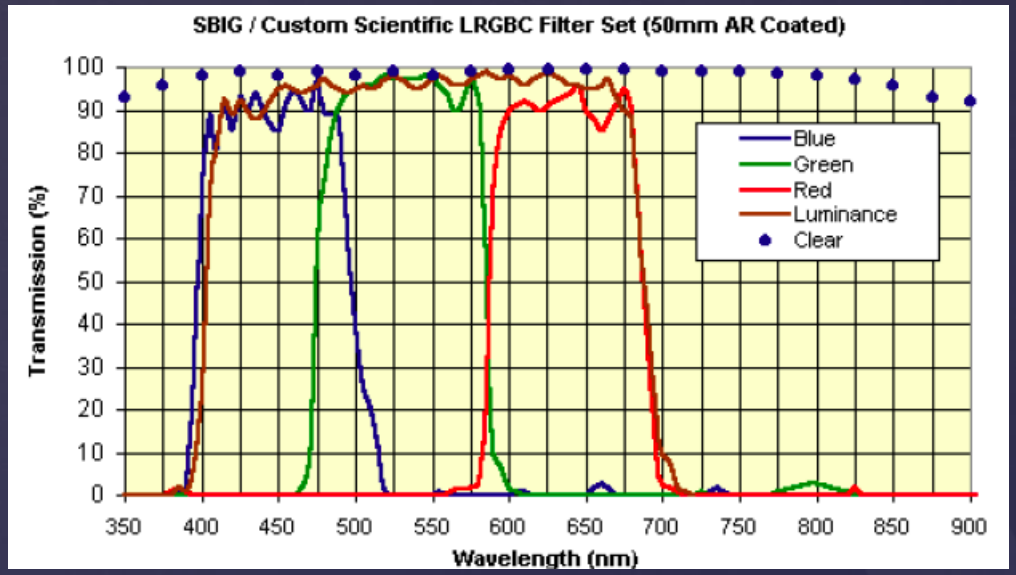
picture: Robert Wagner

Backup

Examples of different radiation characteristics



filters in the filter wheel



filter	wavelength λ [nm]
Clear	-
Luminance	380-700
Blue	380-520
Green	430-580
Red	580-700

SBIG camera and optics

SBIG camera

CCD: **KAF-1001E**
peak QE: **72%**
total pixels: **1.0 million**
array: **1024 x 1024 pixels**
pixel size: **24 microns**

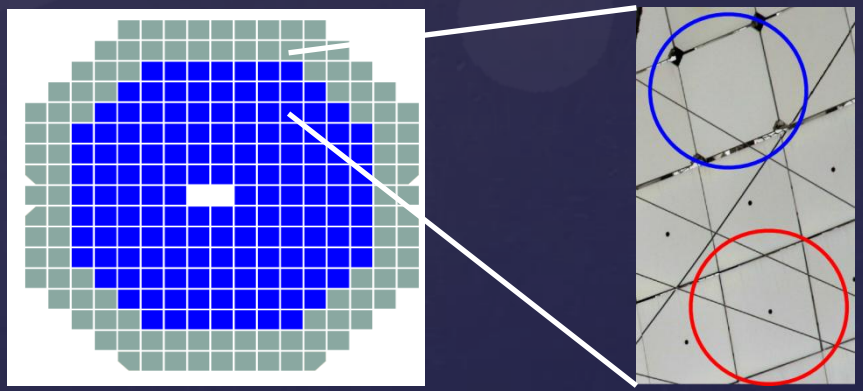
Nikon 108.2

focal length: **180mm**
camera aperture: **F/2.8**

Characterization of mirrors

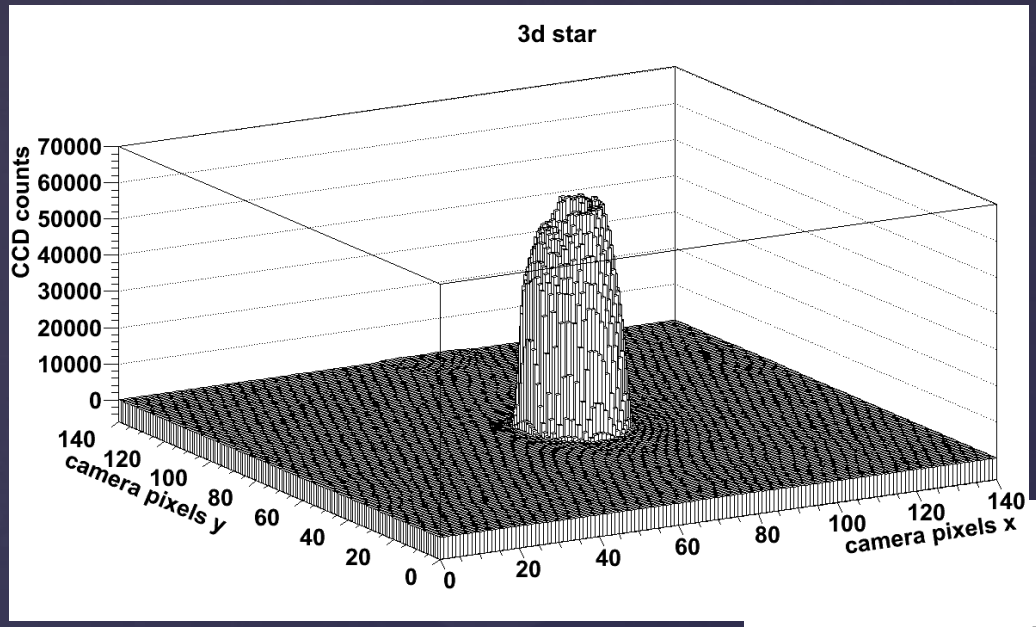
- MAGIC I reflector
- MAGIC II reflector

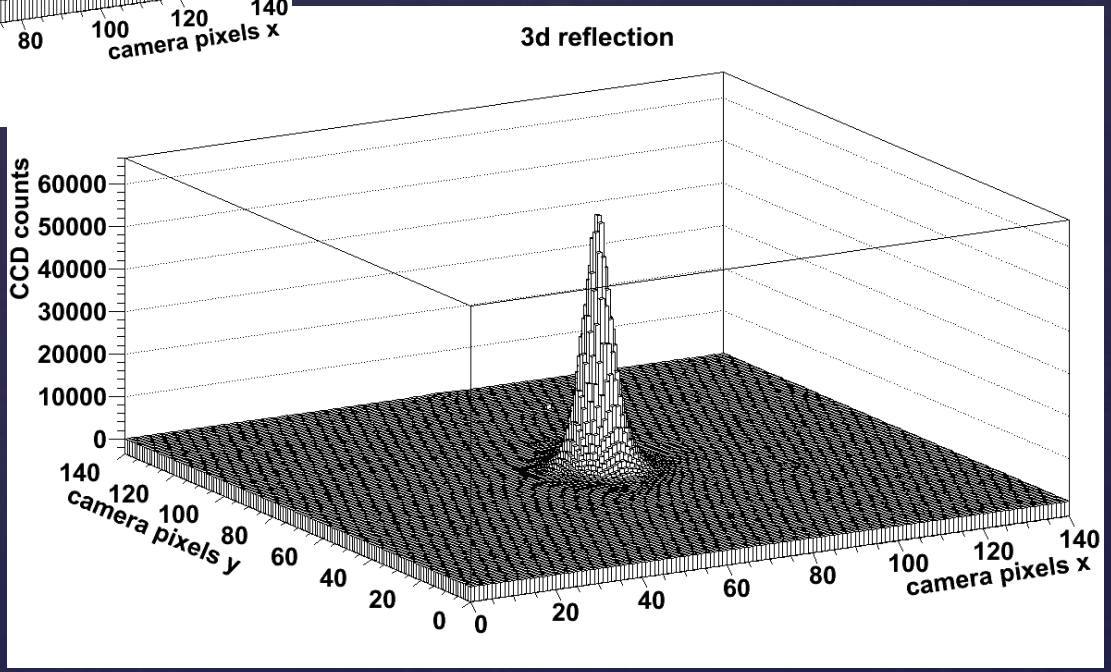
In MAGIC II, two types of mirrors are used: all Al and glass



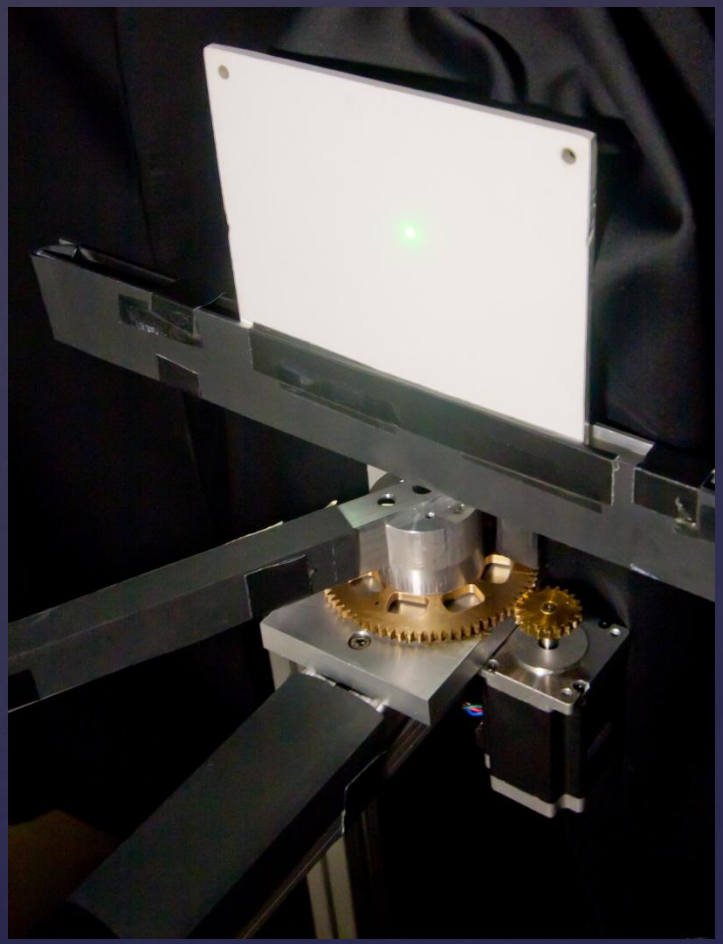
- difference between aluminum and glass mirrors

Shape of the star and the reflected image

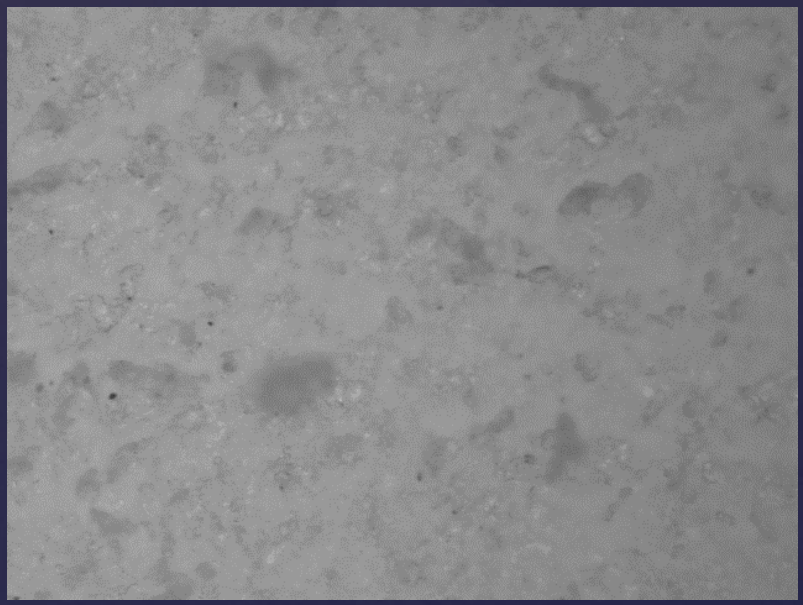




Characterisatzion of the Spectralon samples

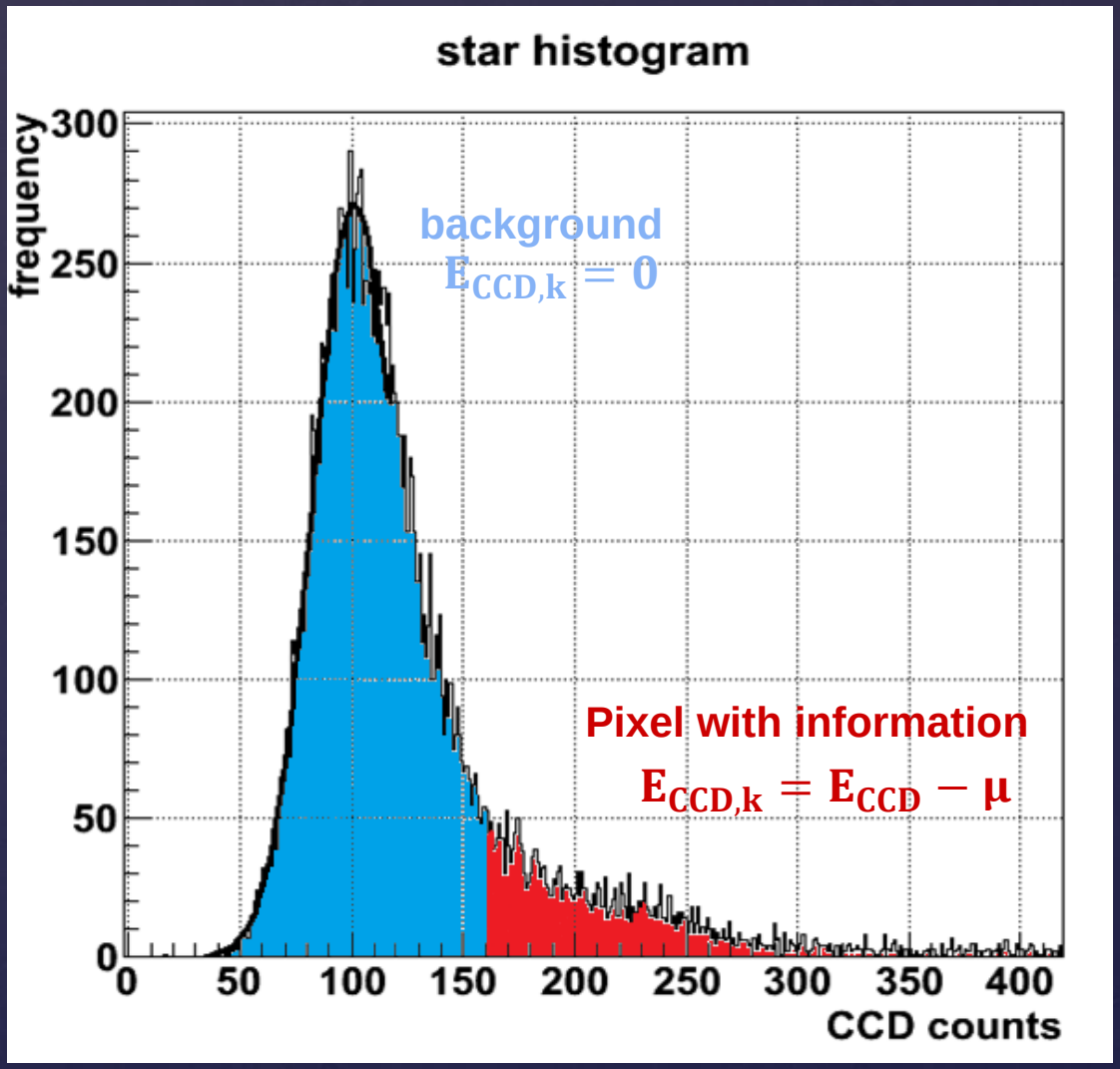


Spectralon sample in the mesurement setup



Spectralon surface under the microscope

Background subtraction

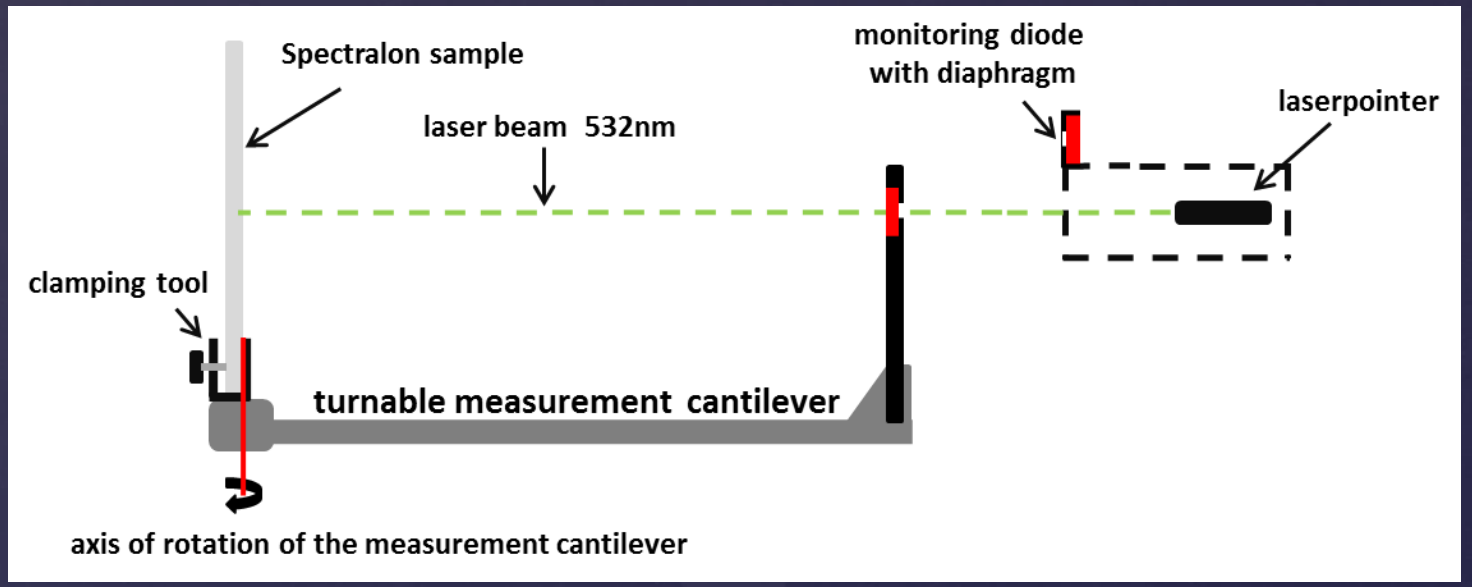


Stars used for the measurements

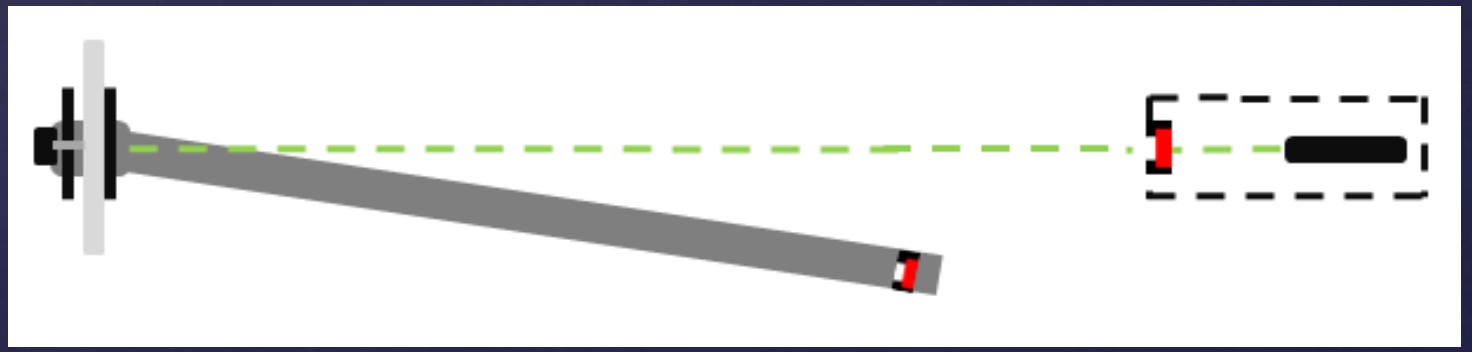
name	spectral type	surface tempera-ture	apparent magnitude
Polaris (α UMi)	F7	6000K - 7600K	1.97^m
Deneb (α Cyg)	A2	8400 K	1.25^m
Enif (ε Peg)	K2	3600K - 5100K	2.38^m
Fomalhaut (α PsA)	A3	8500	1.17^m
Alderamin (α Cep)	A7	7600	2.45^m
Caph (β Cas)	F2	6000K - 7600K	2.28^m
Nunki (σ Sgr)	B3	10000K - 25000K	2.00^m

Measurement setup for the characterization of the diffuse reflector

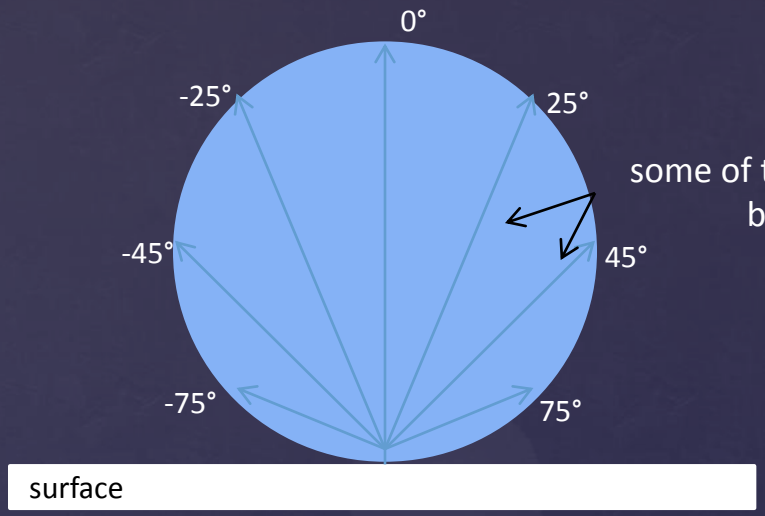
side view



top view



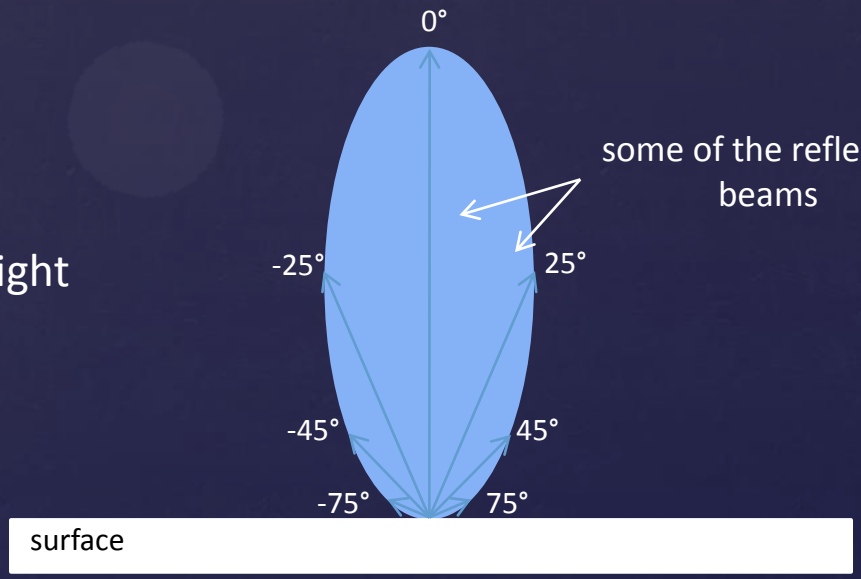
Diffuse and specular reflection



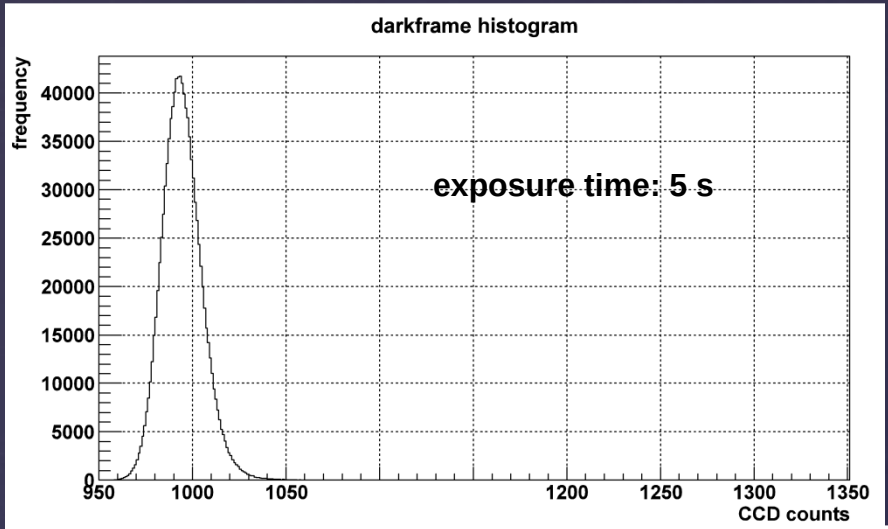
some of the reflected beams

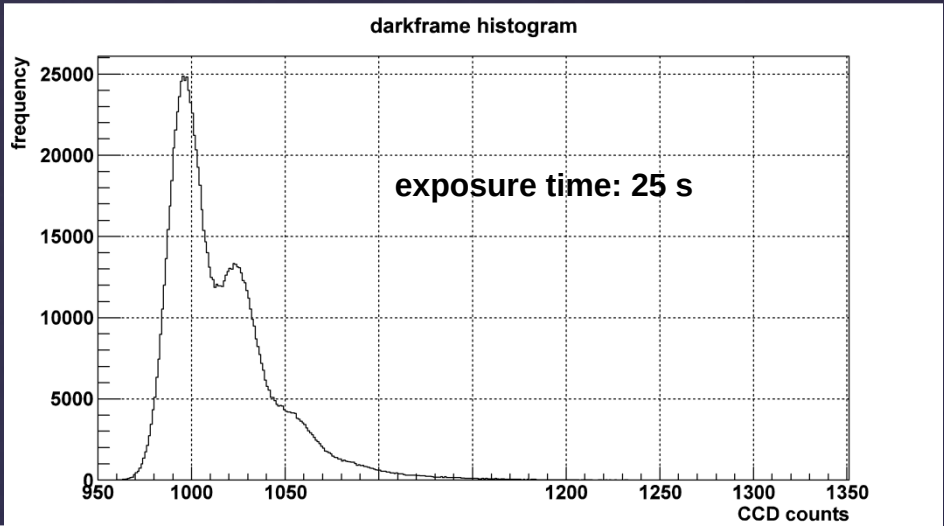
diffuse reflected light

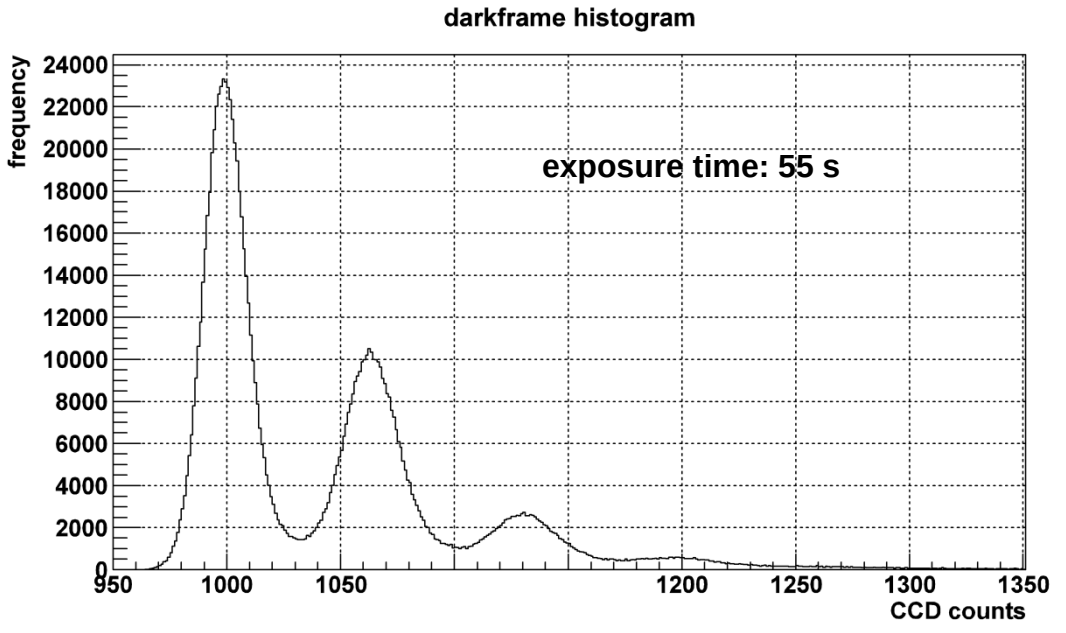
not so diffuse, more specular reflected light



Strange behavior of the CCD chip







Example of scattering characteristics of real spectralon sample