



Russia IYPT

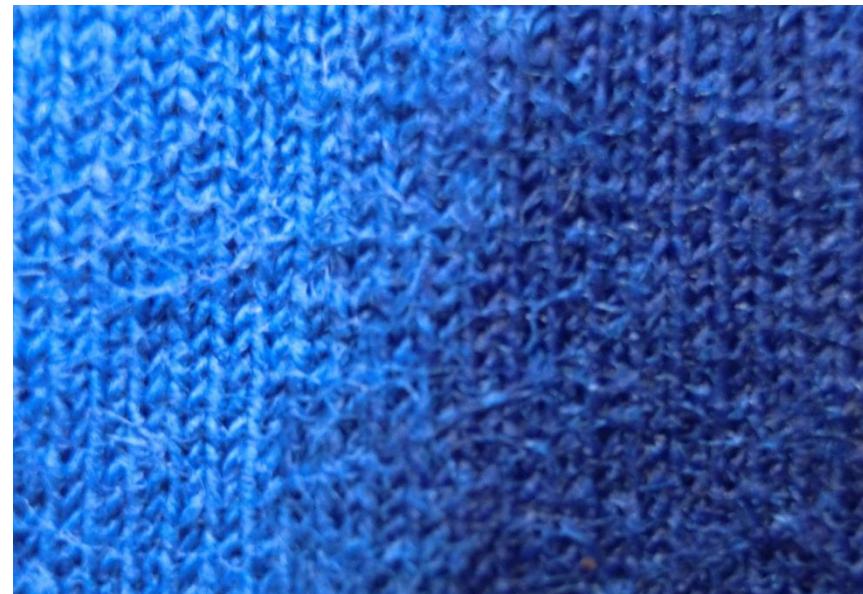
Wet and dark

Nikita Grushetsky

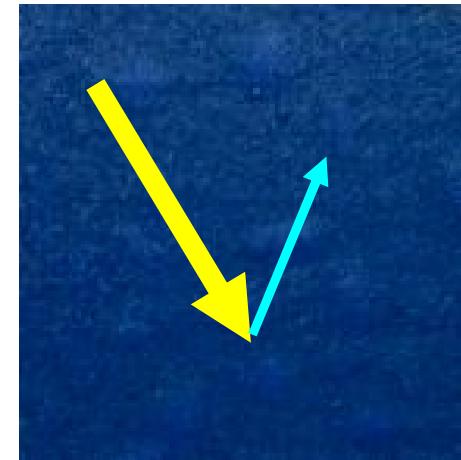
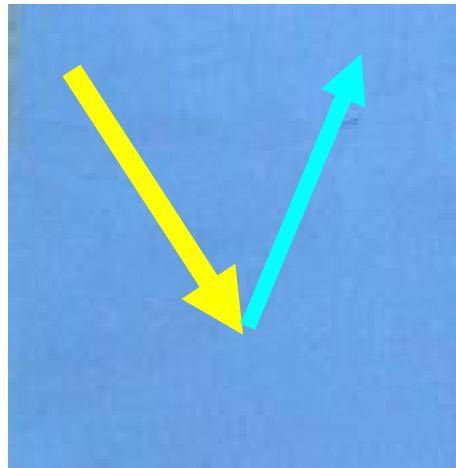
Maria Mukhina

Egor Shamanov

Clothes can look darker or change color when they get wet. Investigate the phenomenon.



In physical terms it means that cloth scatters back a smaller part of falling light.



- Luminance factor is the ratio of the luminance of a body to that of a perfect diffuser.

Standard perfect
diffuser

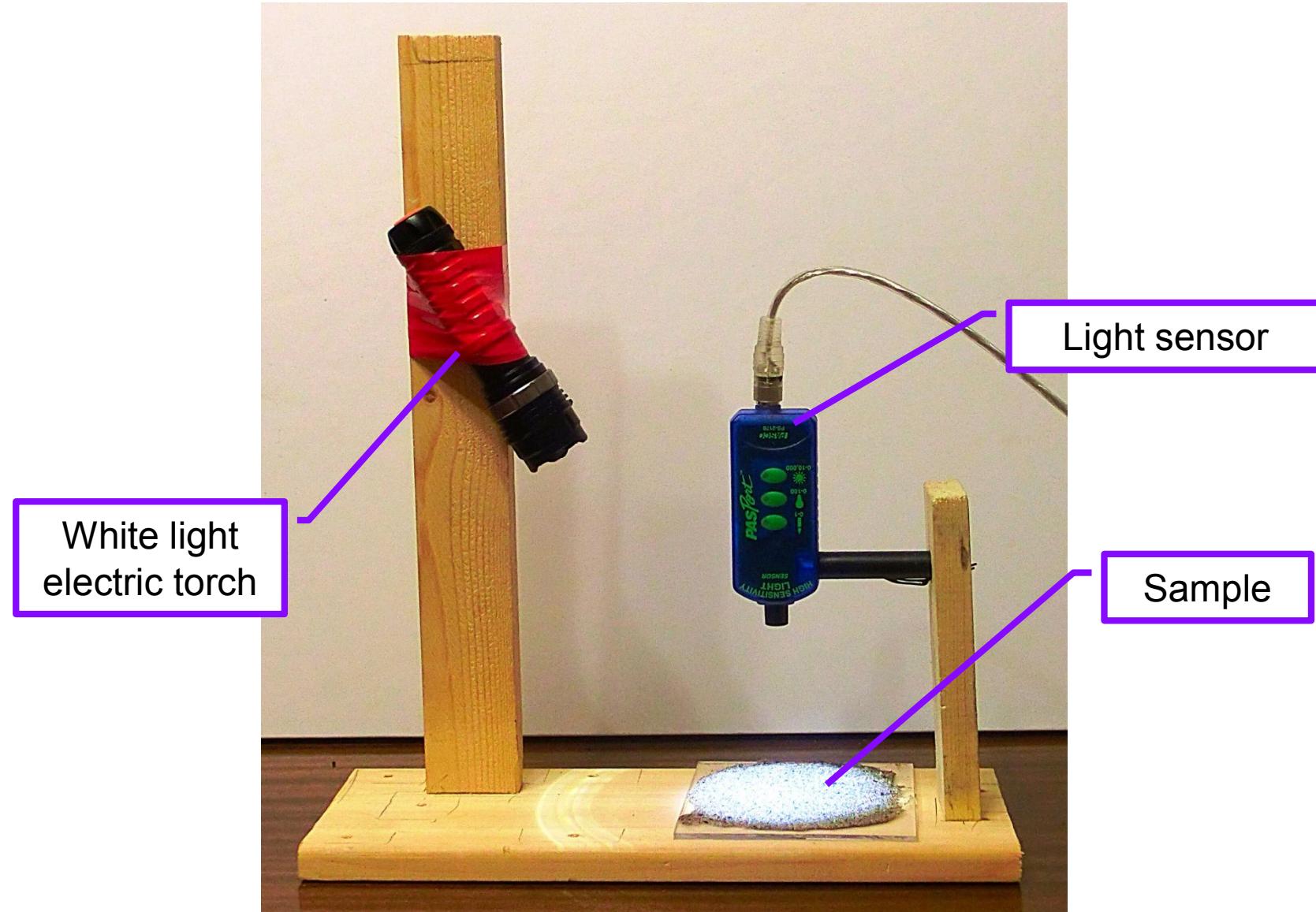
MgO ceruse

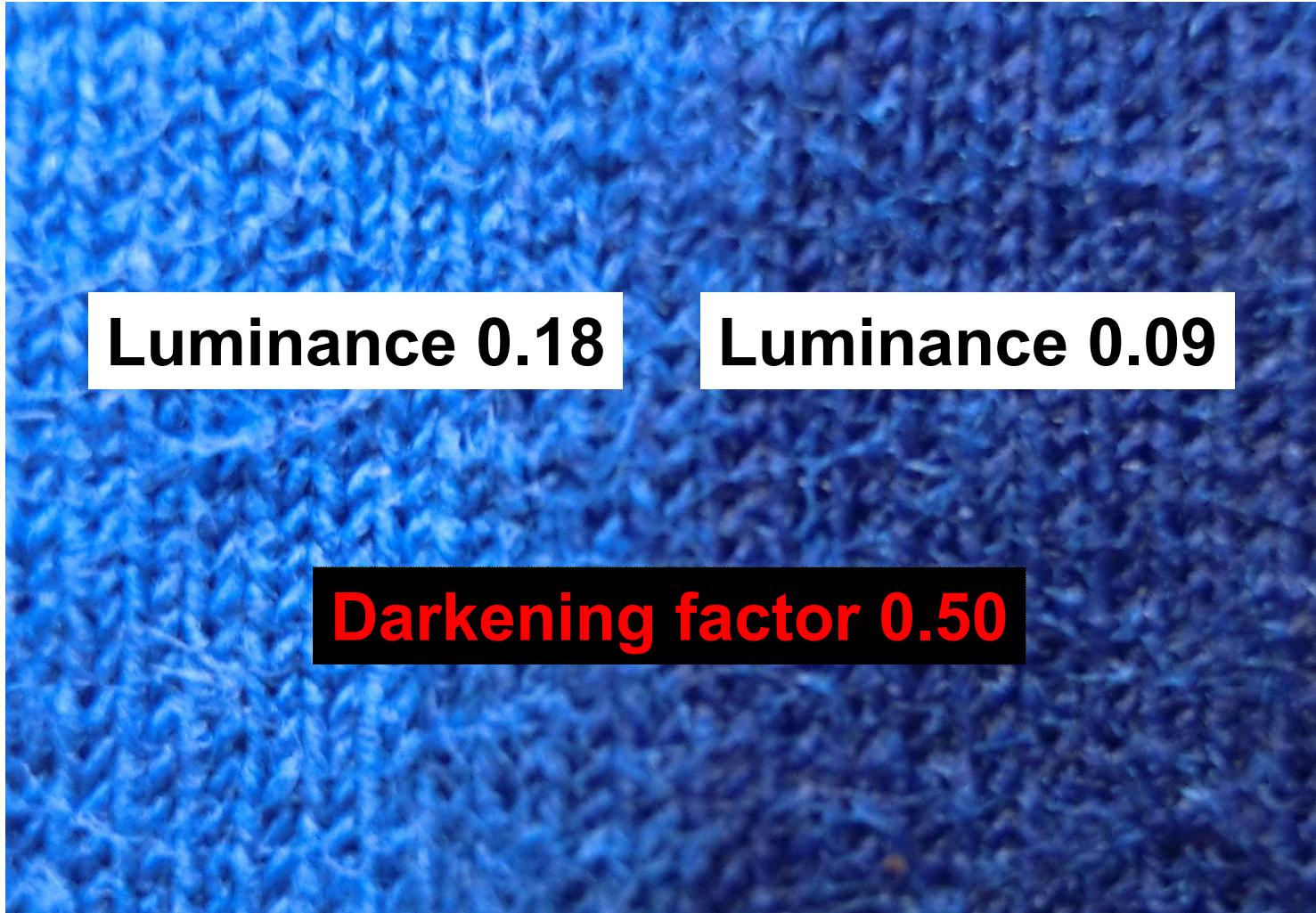
Our perfect
diffuser

white coated paper

Experimental setup

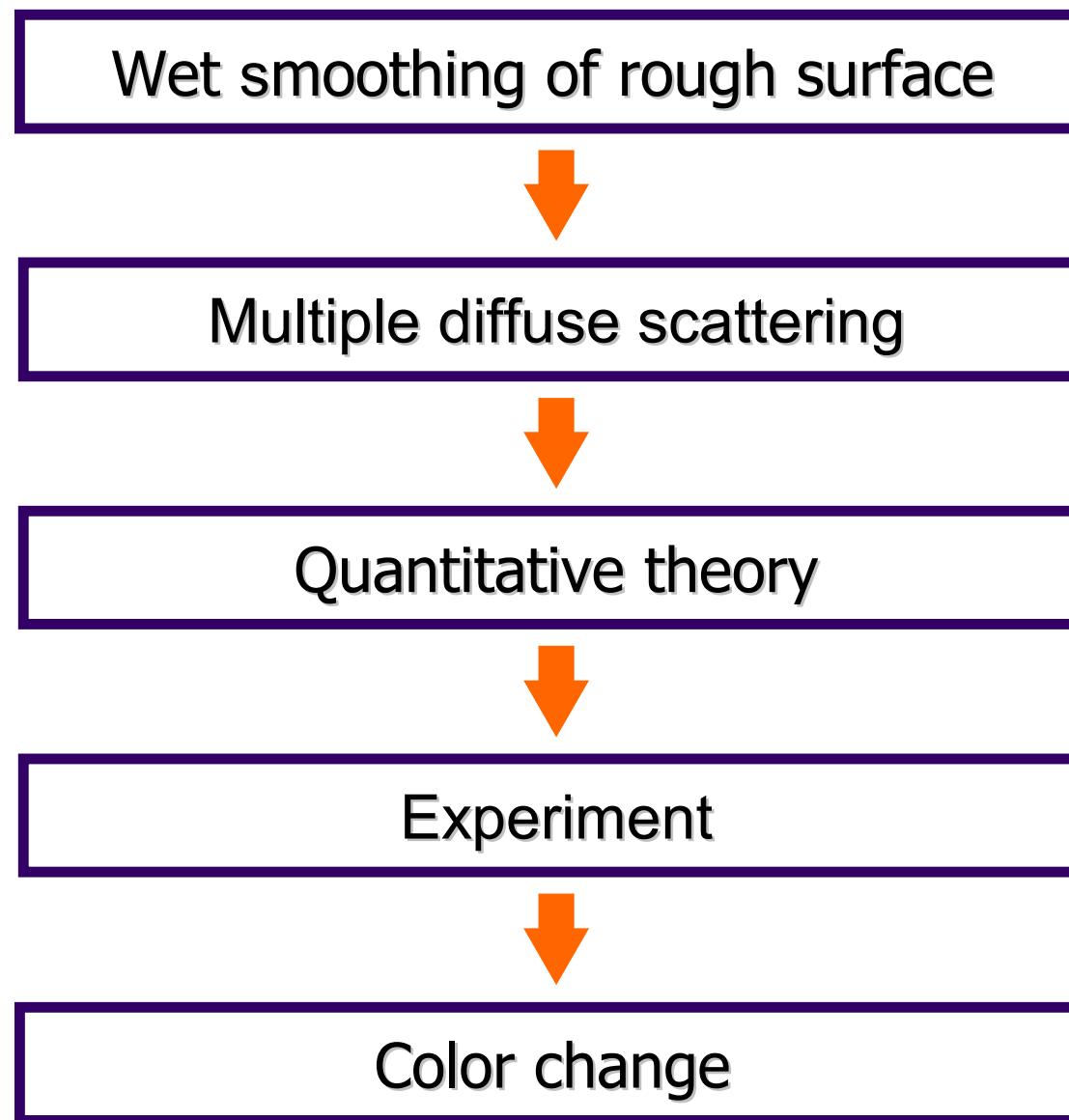
5





Measurement results

Material	Luminance of dry material	Luminance of wet material	Darkening factor
Light blue cloth	0.57	0.44	0.77
Light pink cloth	0.29	0.22	0.76
Sand	0.24	0.12	0.50
Dark blue cloth	0.18	0.09	0.50
Black cloth	0.052	0.048	0.92



1st effect:
wet smoothing
of rough surface

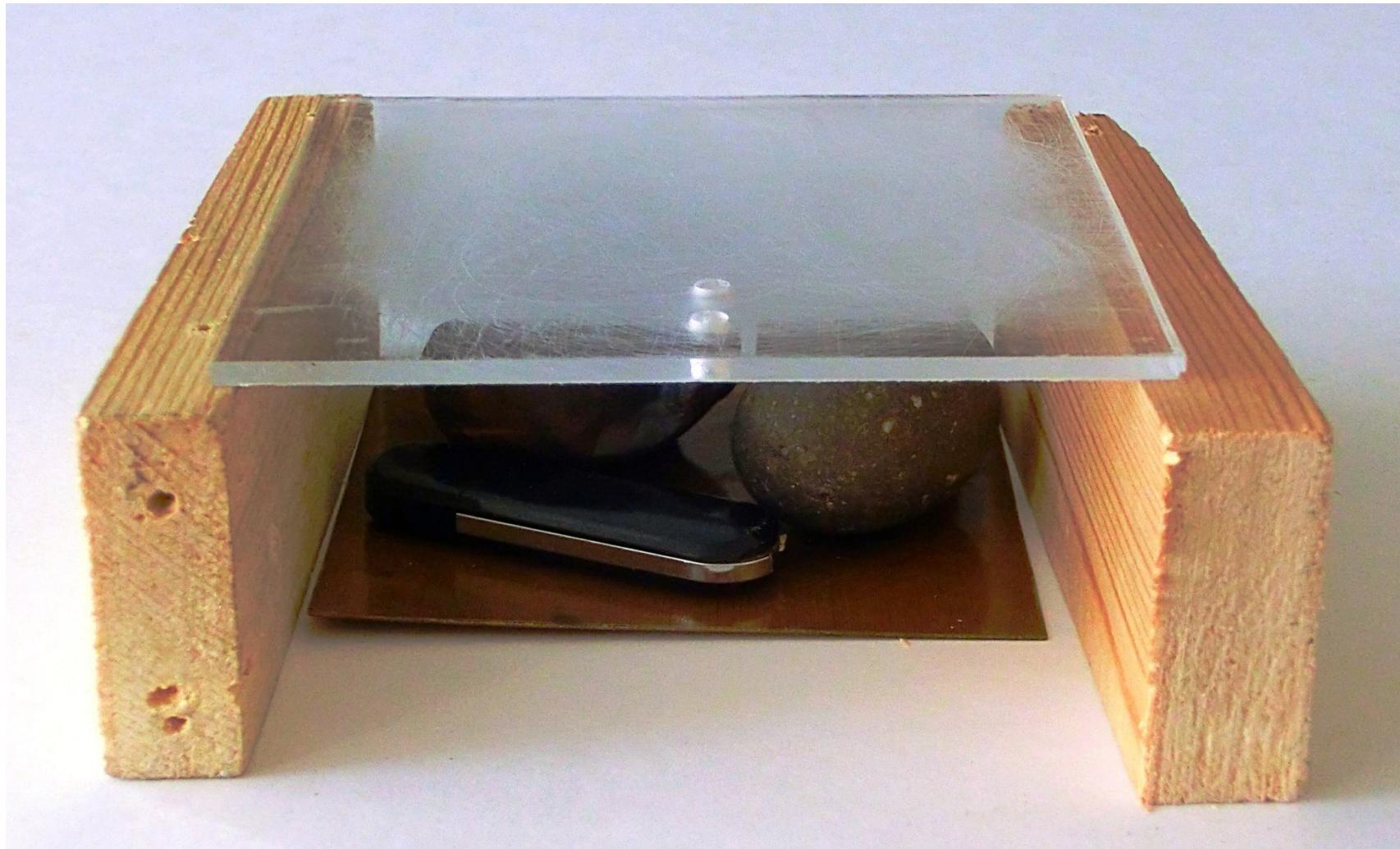
Dry and wet sand

10



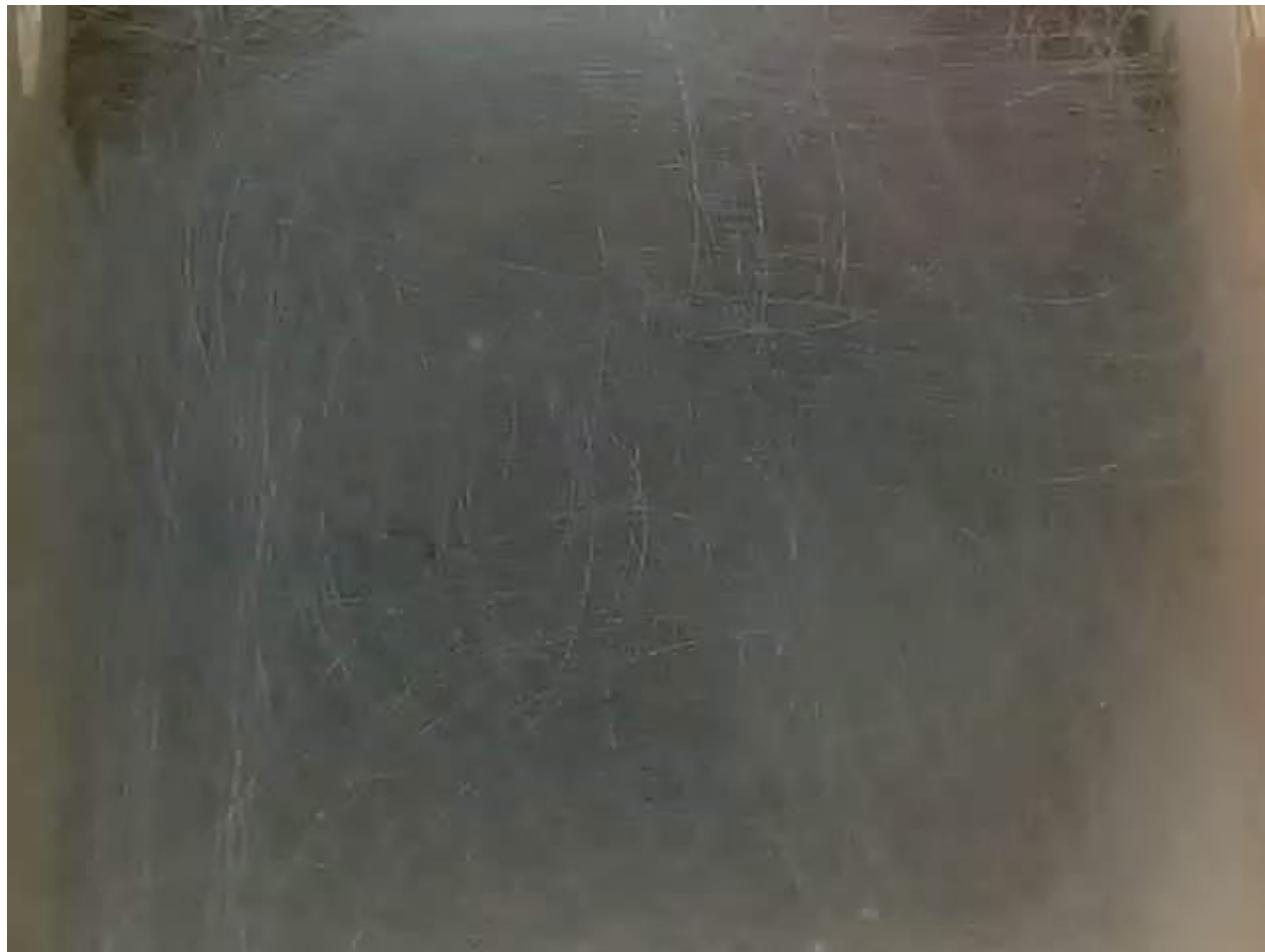
Rough plate

11



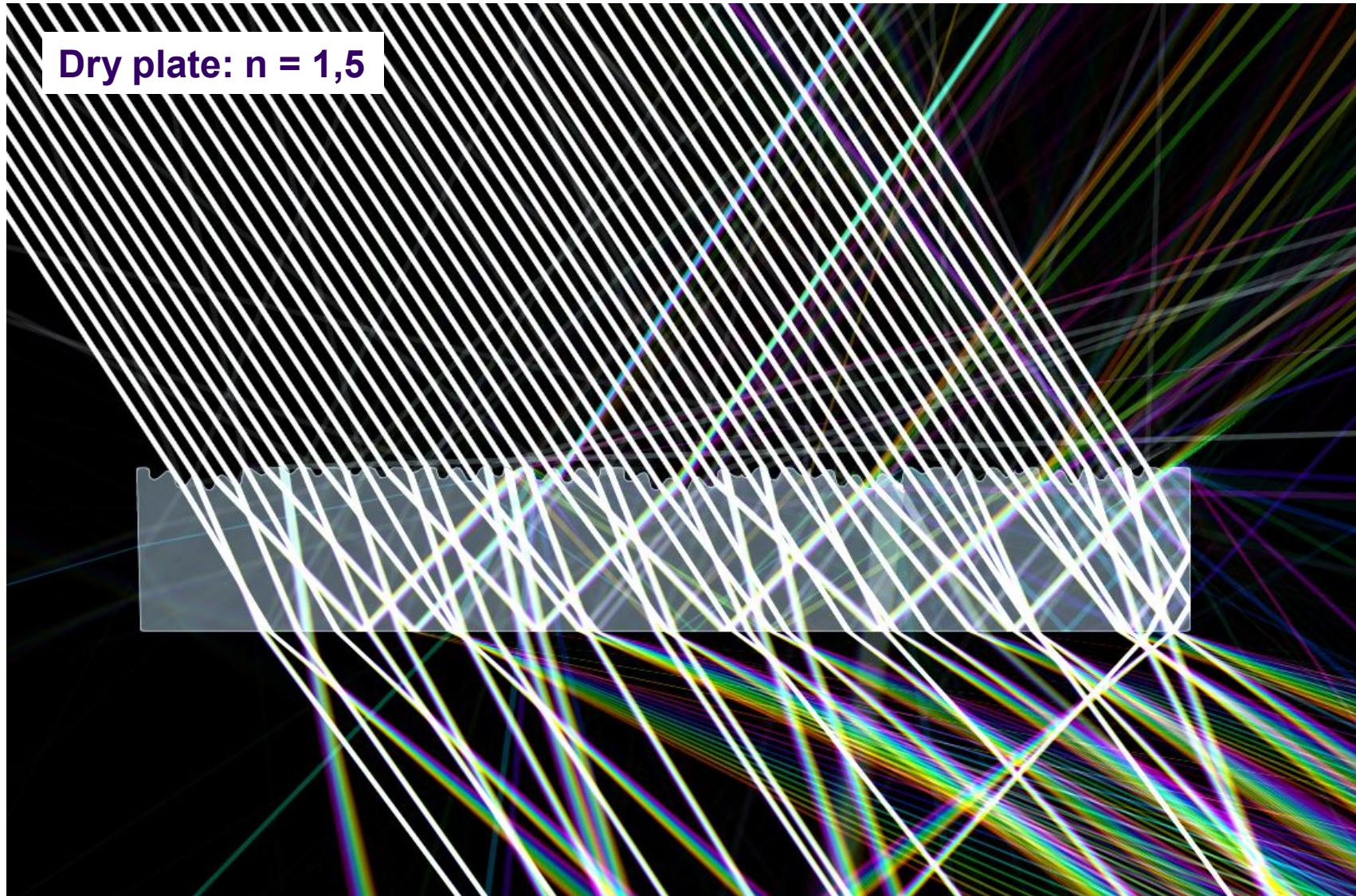
Rough plate (video)

12



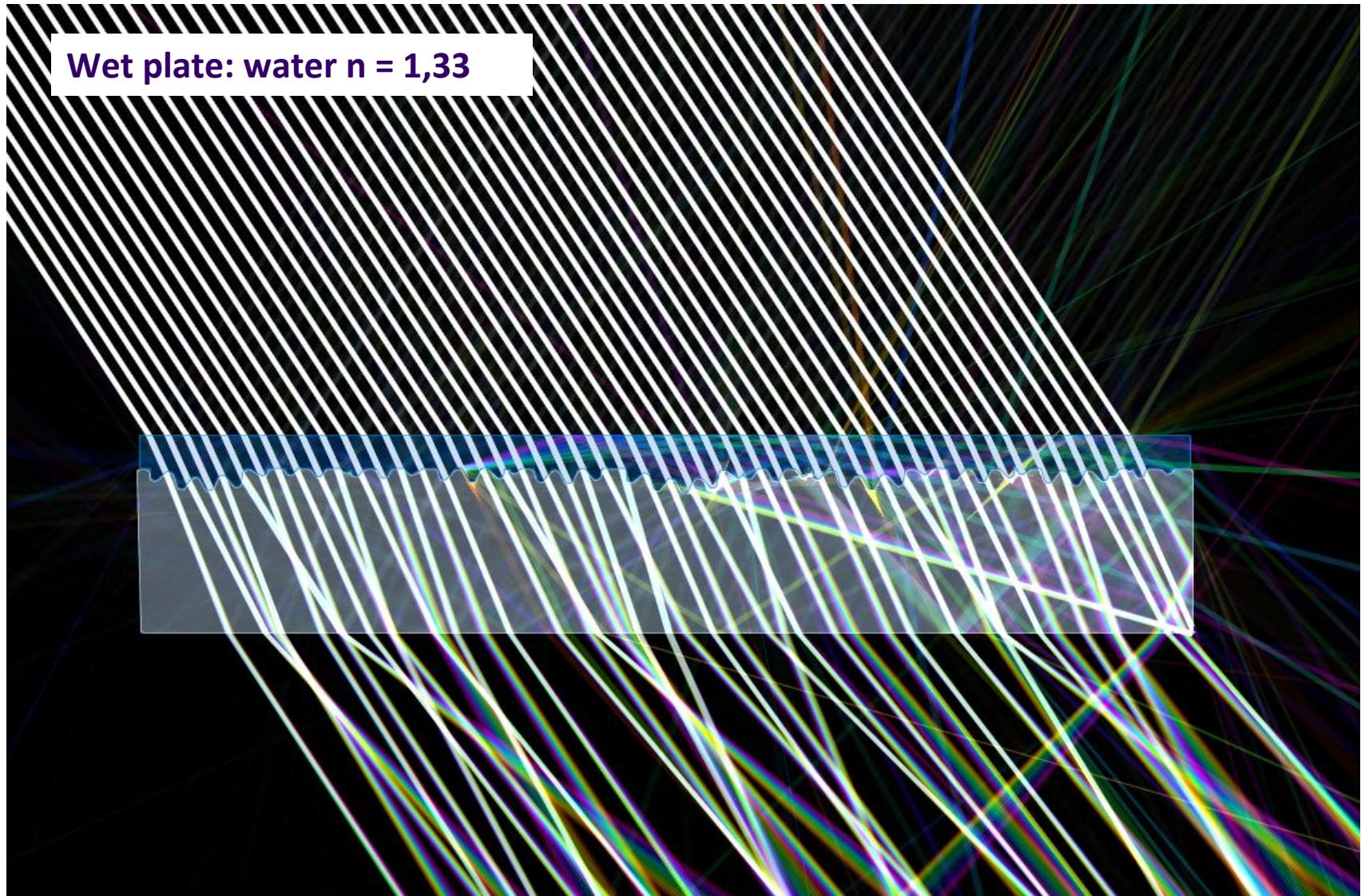
Algodox simulation

13



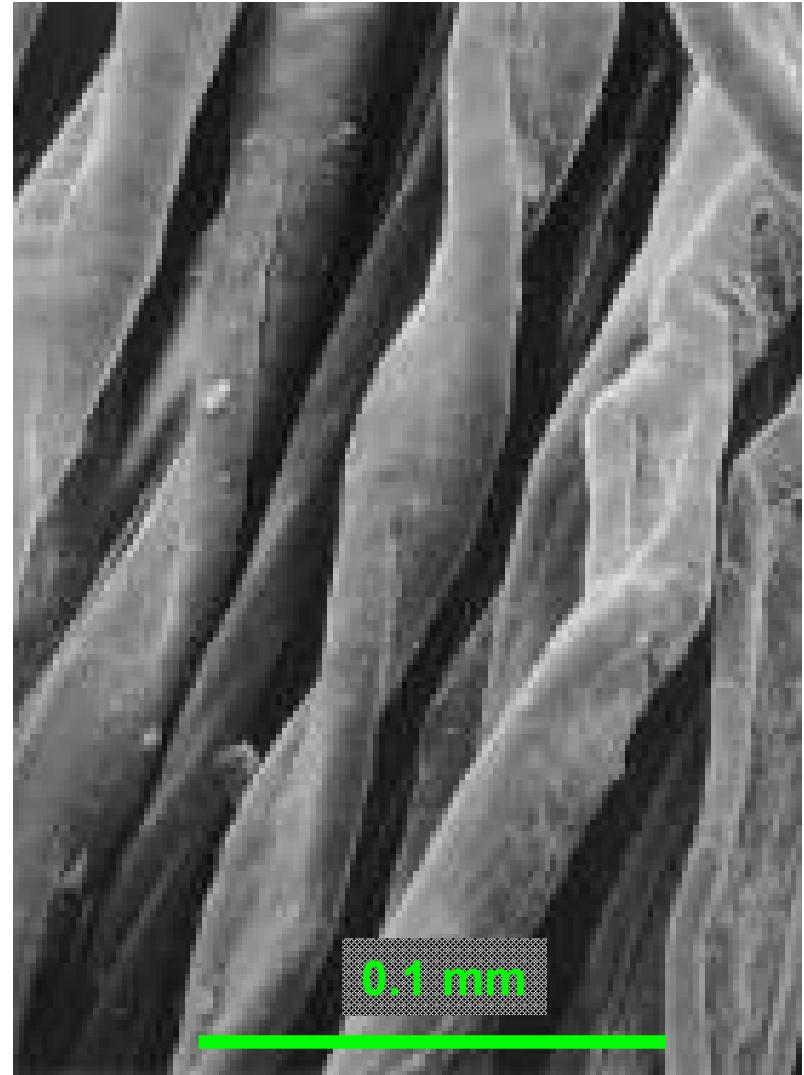
Algodox simulation

14



Cloth is not similar to glass plate

15



2nd effect:
multiple diffuse
scattering

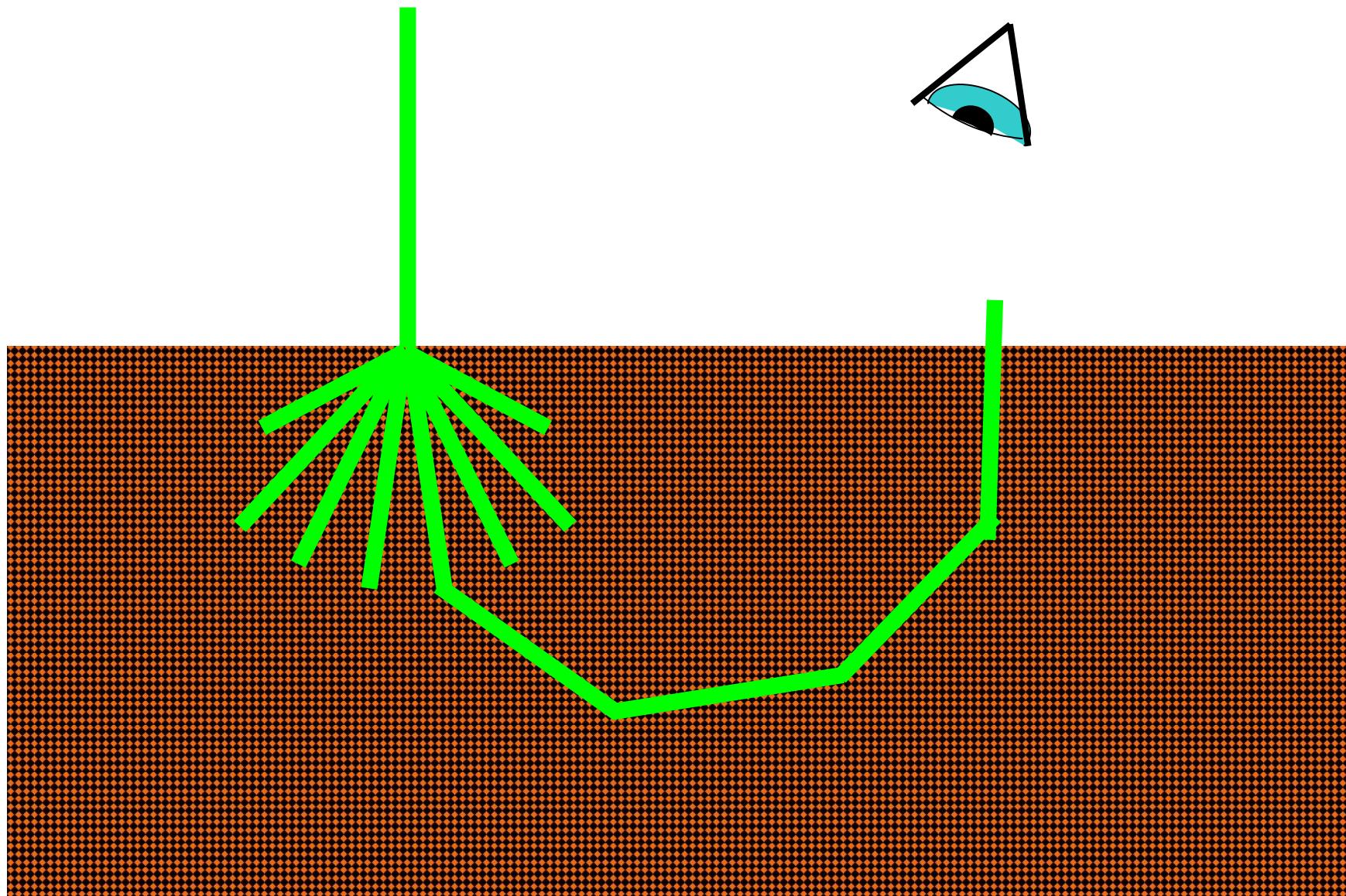
Laser and rice grains (video)

17



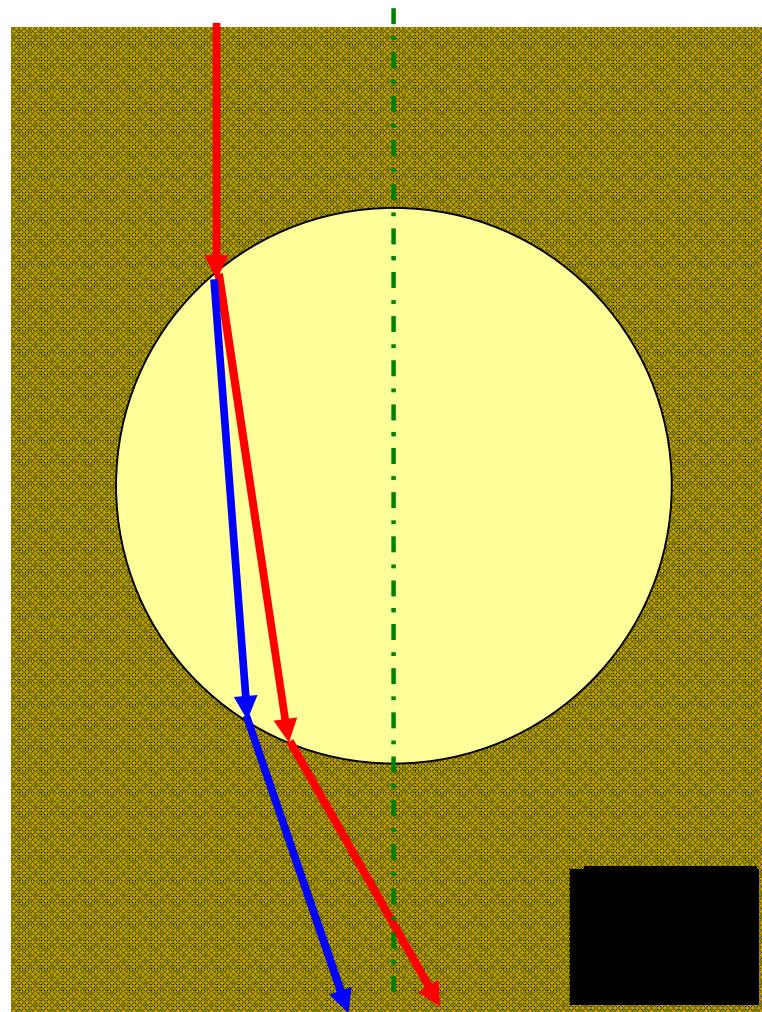
Multiple scattering

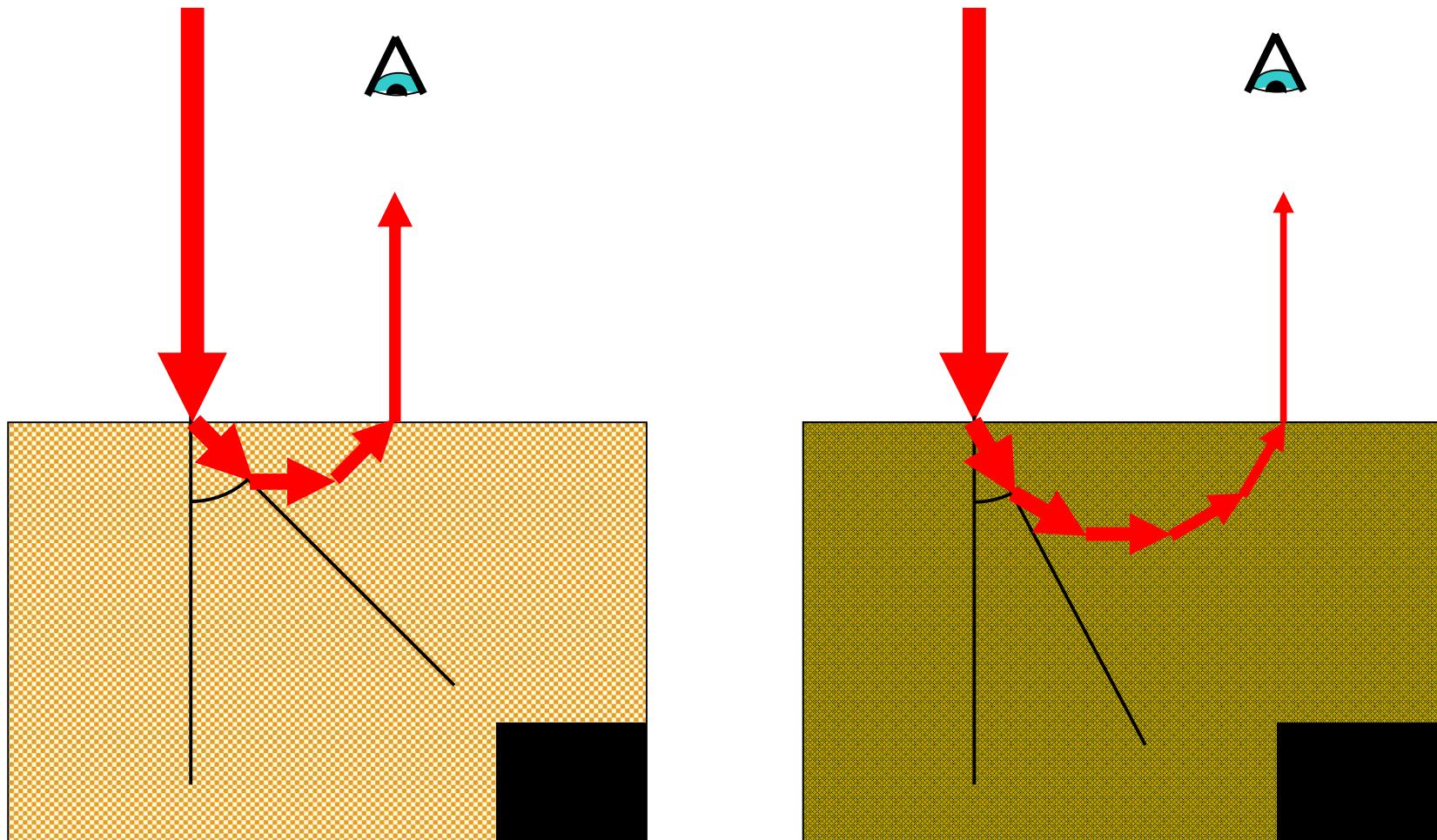
18



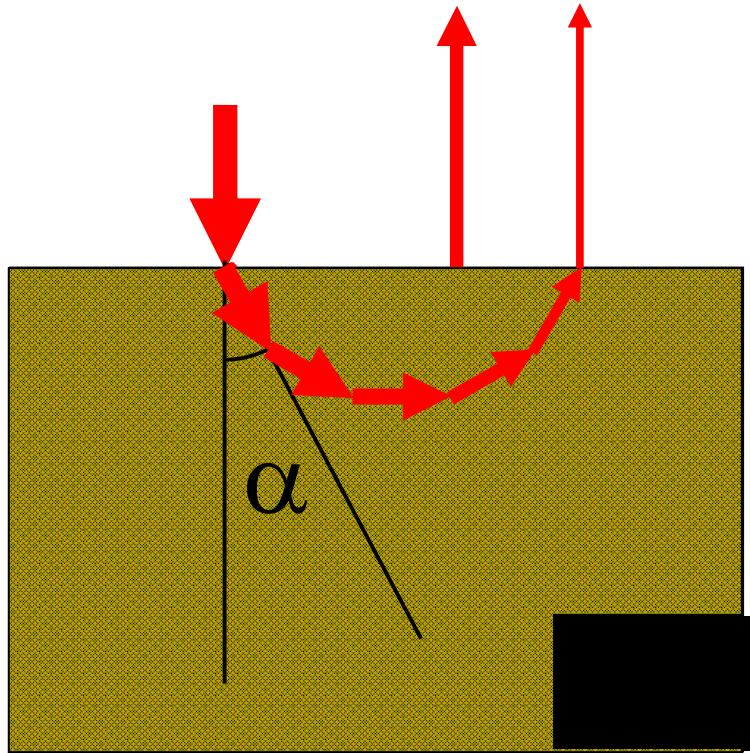
Effect of wetting on singular scattering

19





$$I_{back} \sim \exp(-kN)$$



Fiber Liquid

$$\alpha = \alpha_0 \frac{n_0 - n}{n_0 - 1}$$

Number of scatterings

$$N \simeq \frac{180^\circ}{\alpha} \sim \frac{1}{n_0 - n}$$

$$I_{back} \sim \exp(-kN)$$

$$I_{back} \sim \exp(-kN) \sim \exp\left(-\frac{A}{n_0 - n}\right)$$



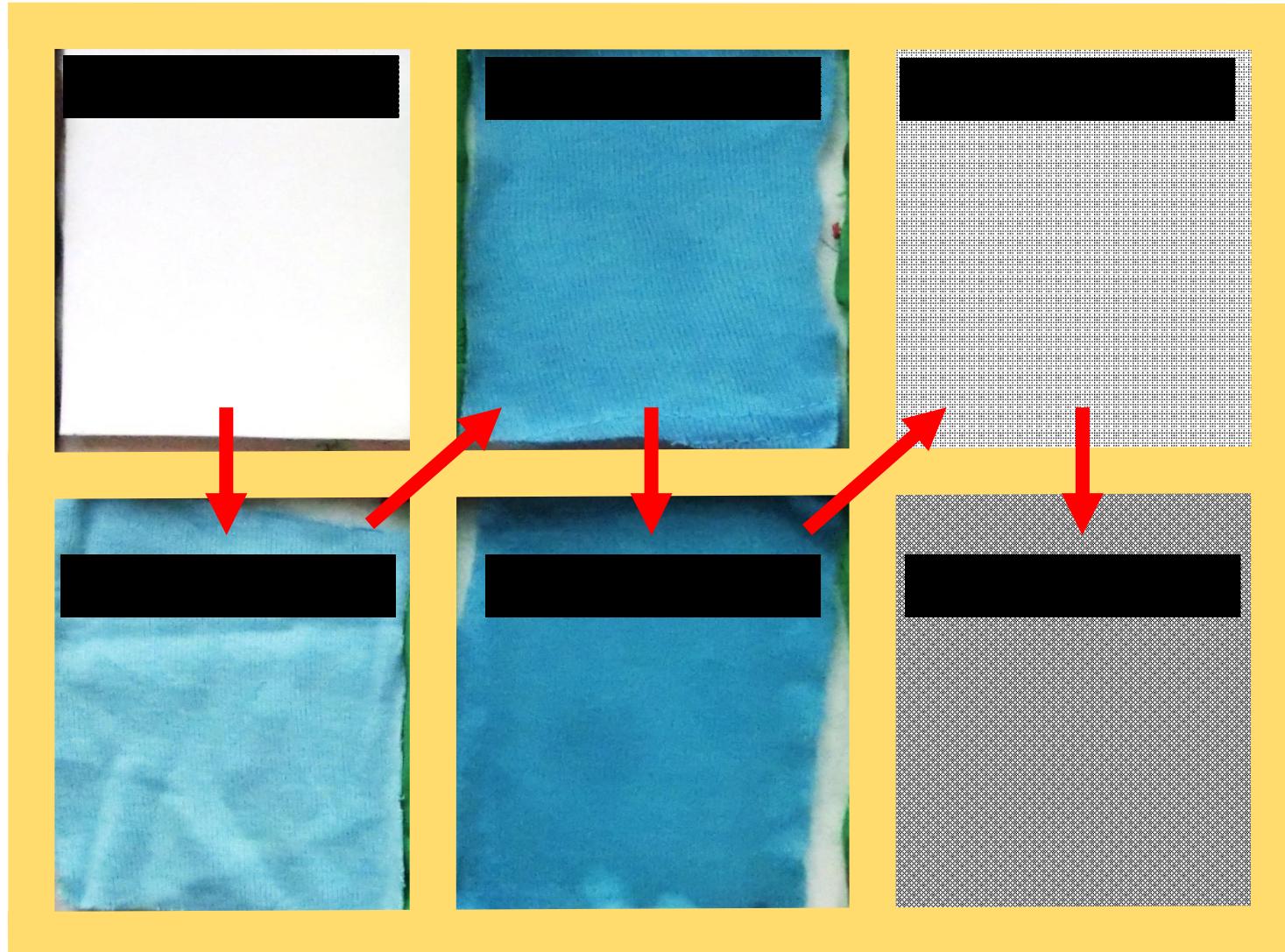
The higher refractive index of wetting liquid the darker is the cloth.

Experiment

Water	1.33
Silicon oil	1.40
Sunflower oil	1.47
Benzyl alcohol	1.54

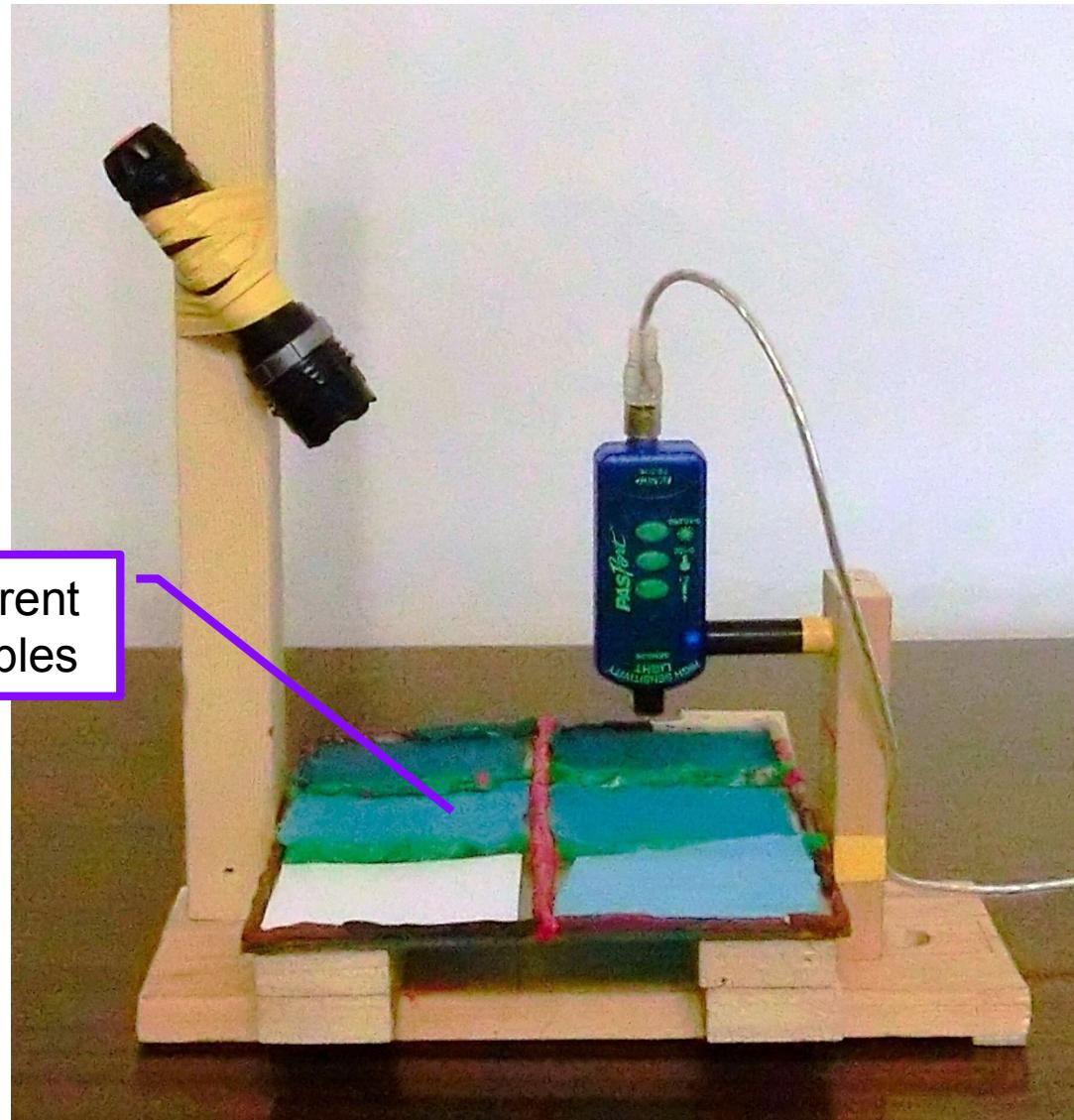
Cloth samples

25



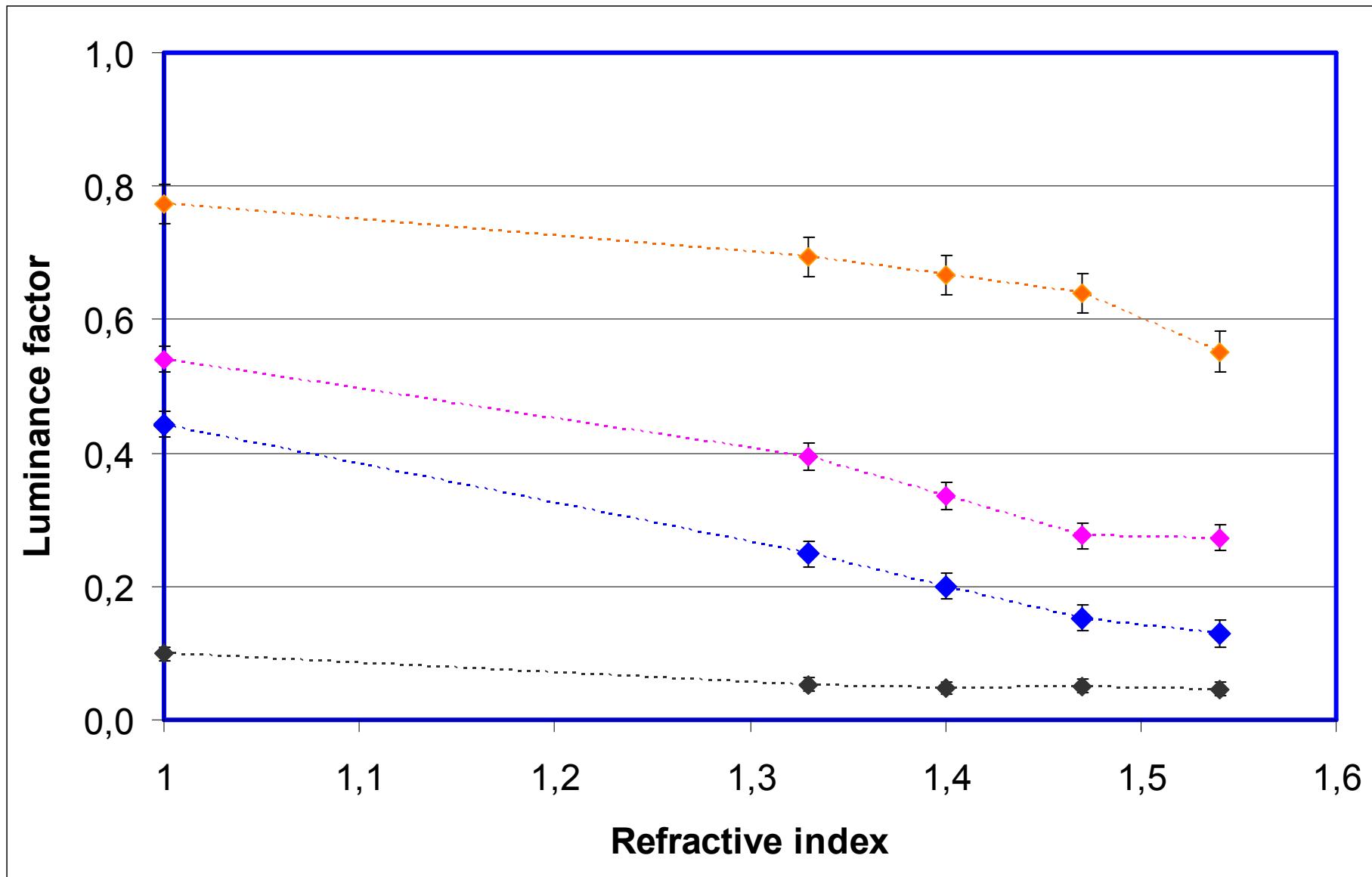
Experimental setup

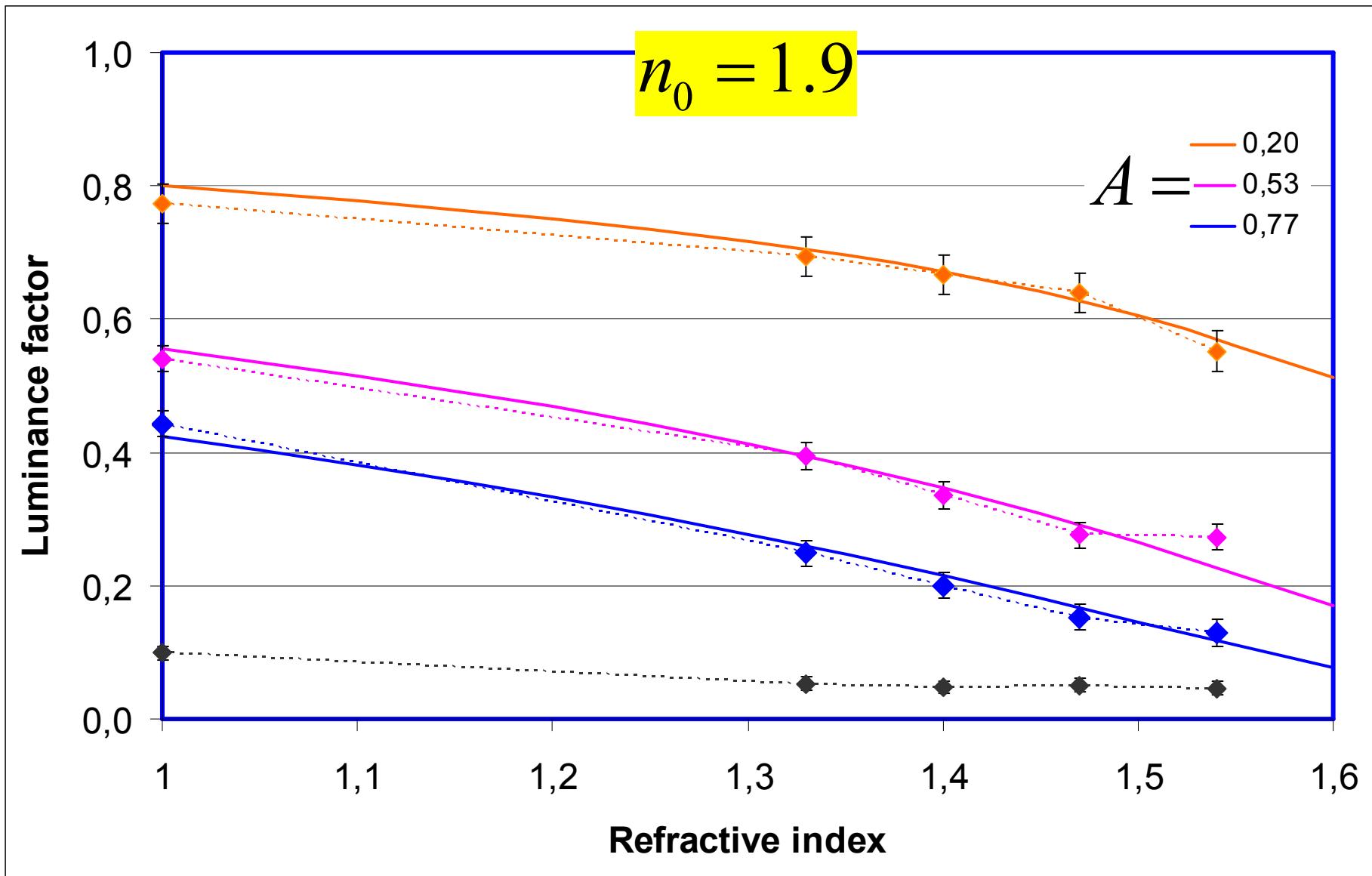
26

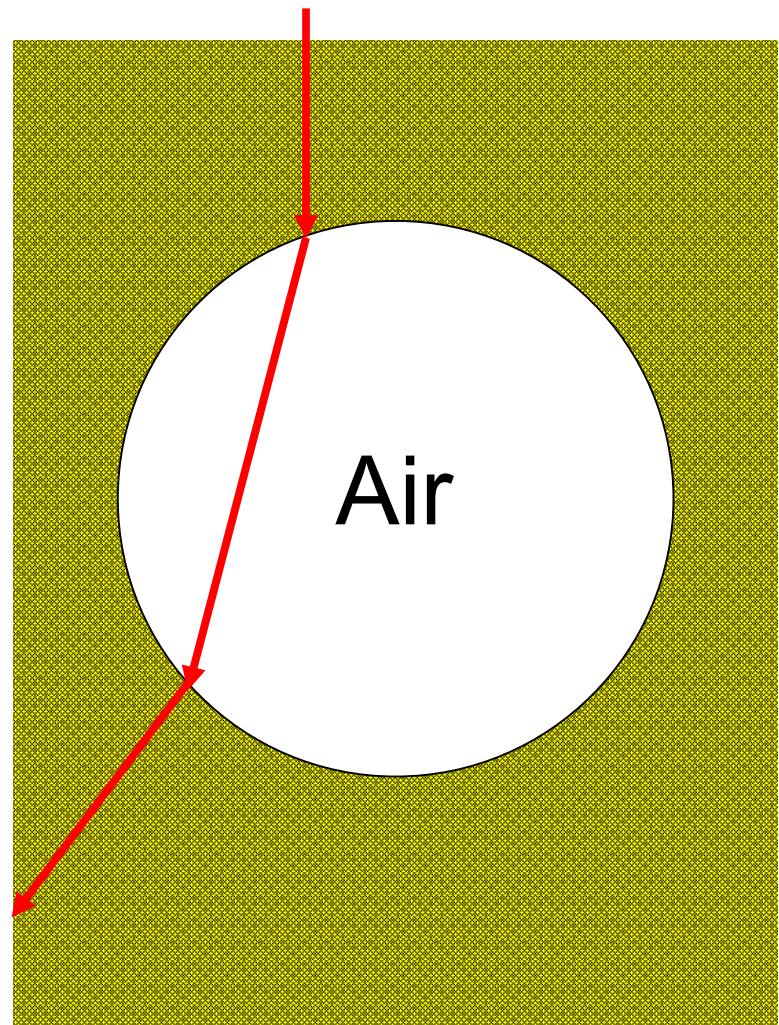
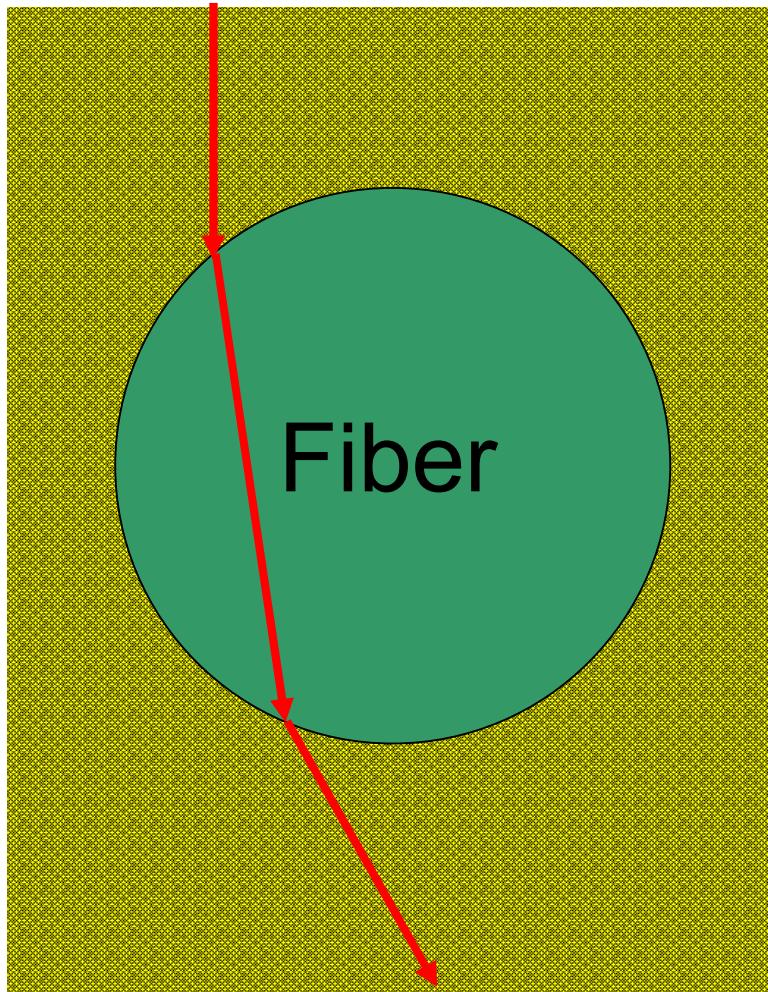


Luminance factor vs. refractive index

27



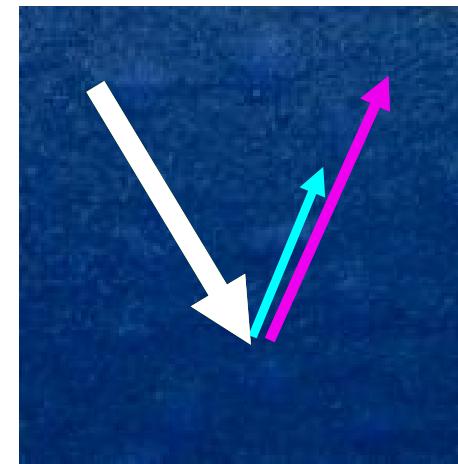
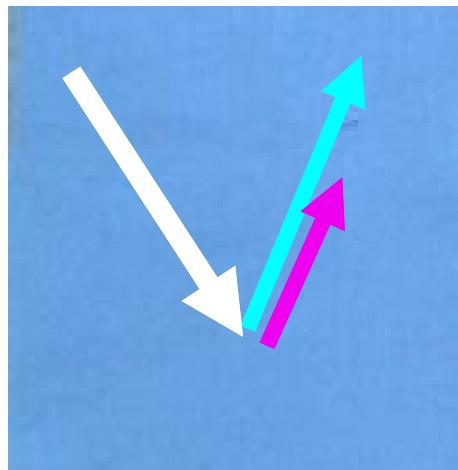




Colour change

«Clothes can look darker or change color when they get wet...»

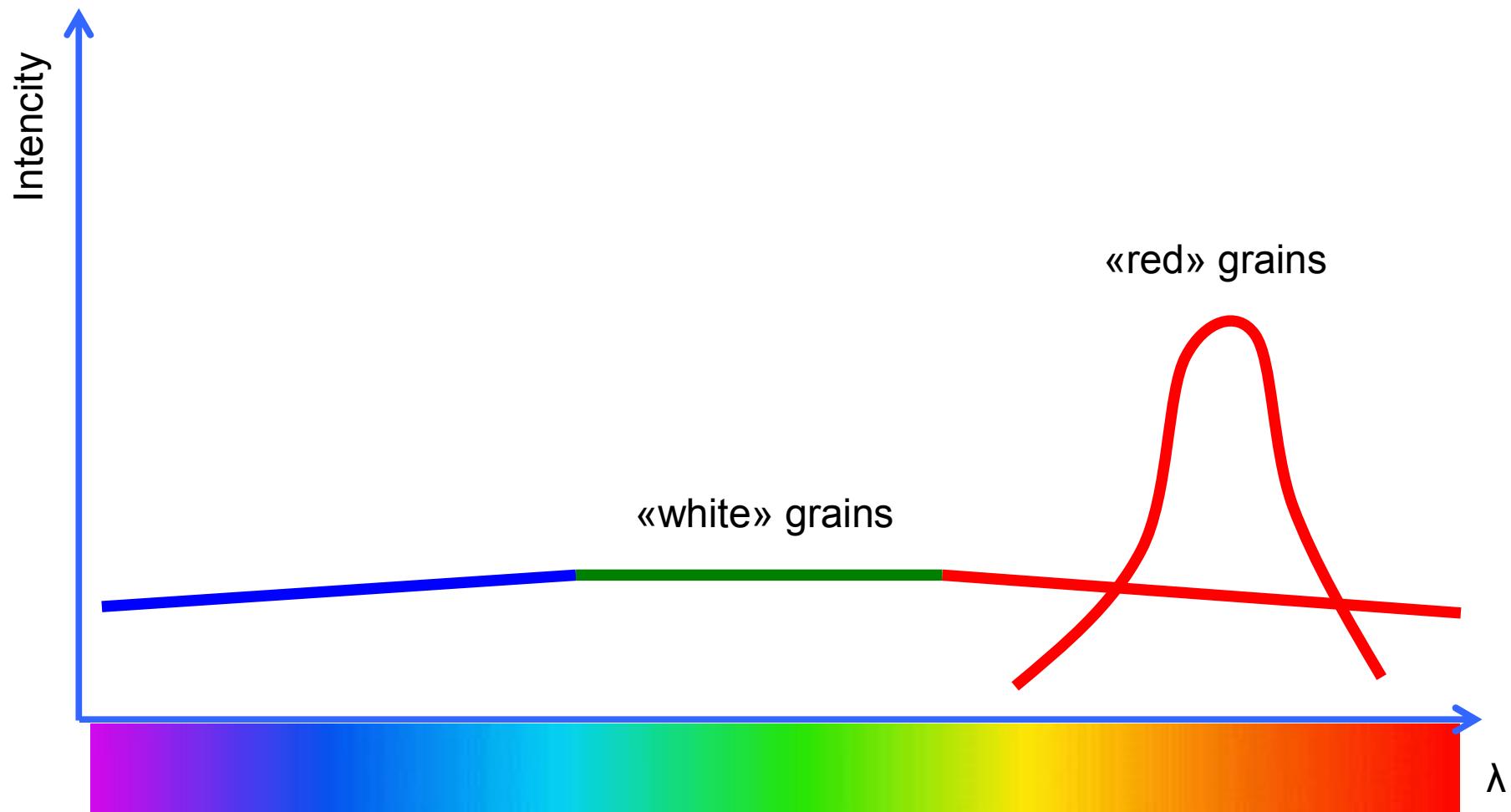
In physical terms it means that there are changes in a relative distribution of energy in light spectrum.



Dry and wet sand

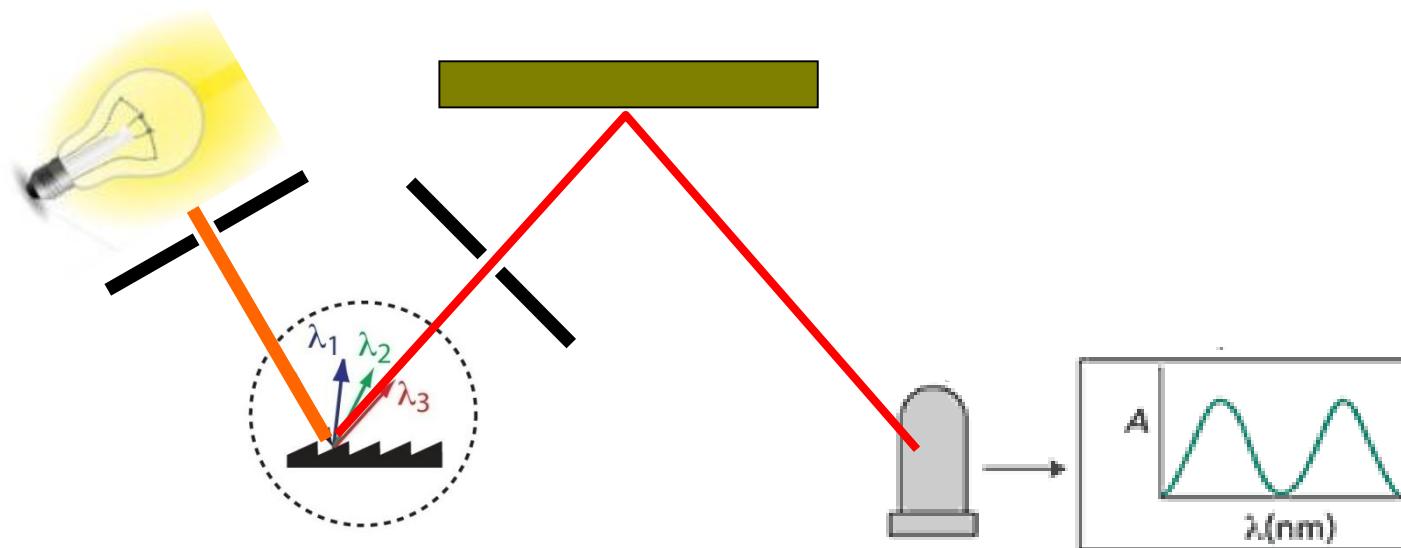
32





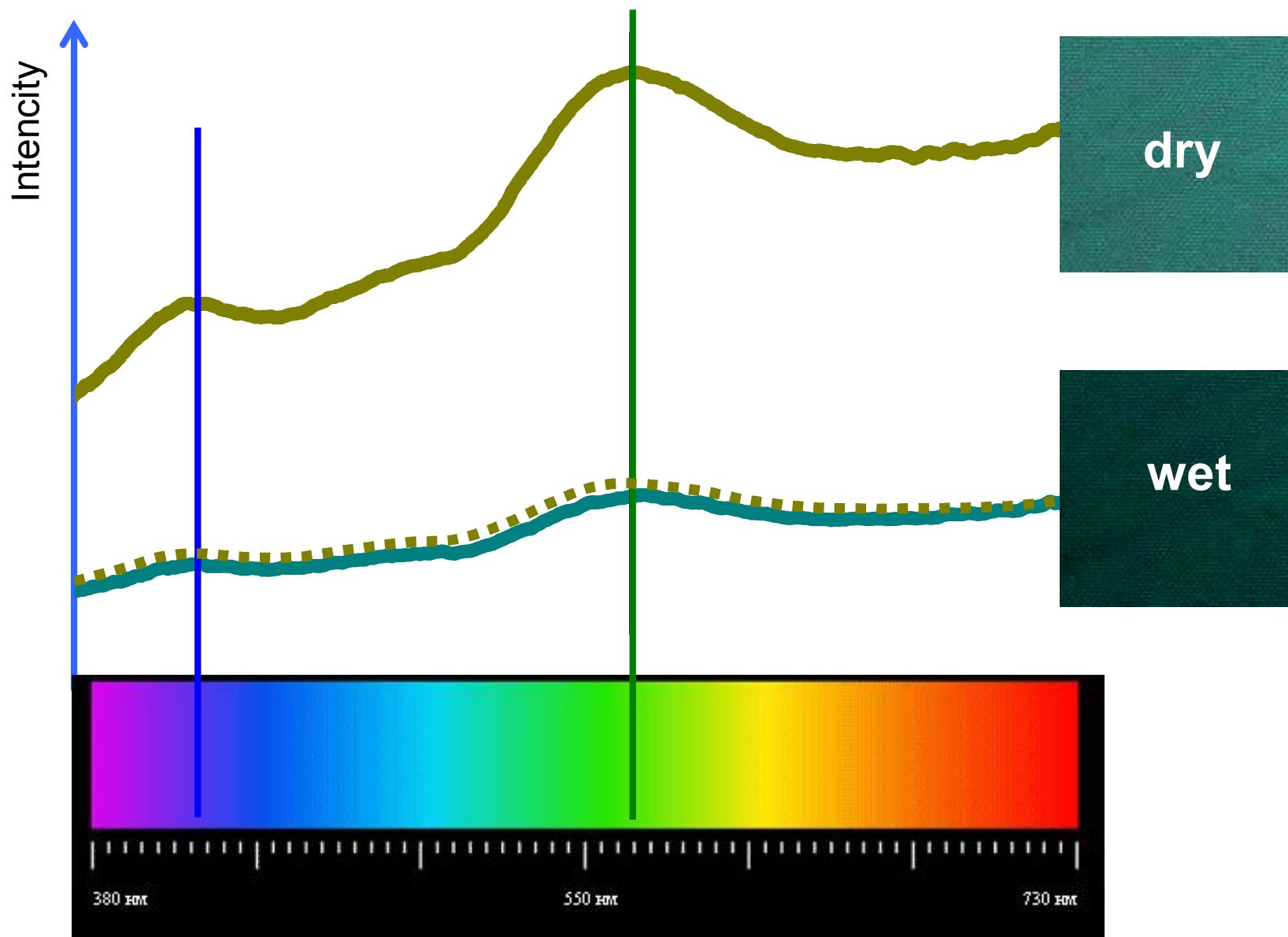
Spectrophotometer

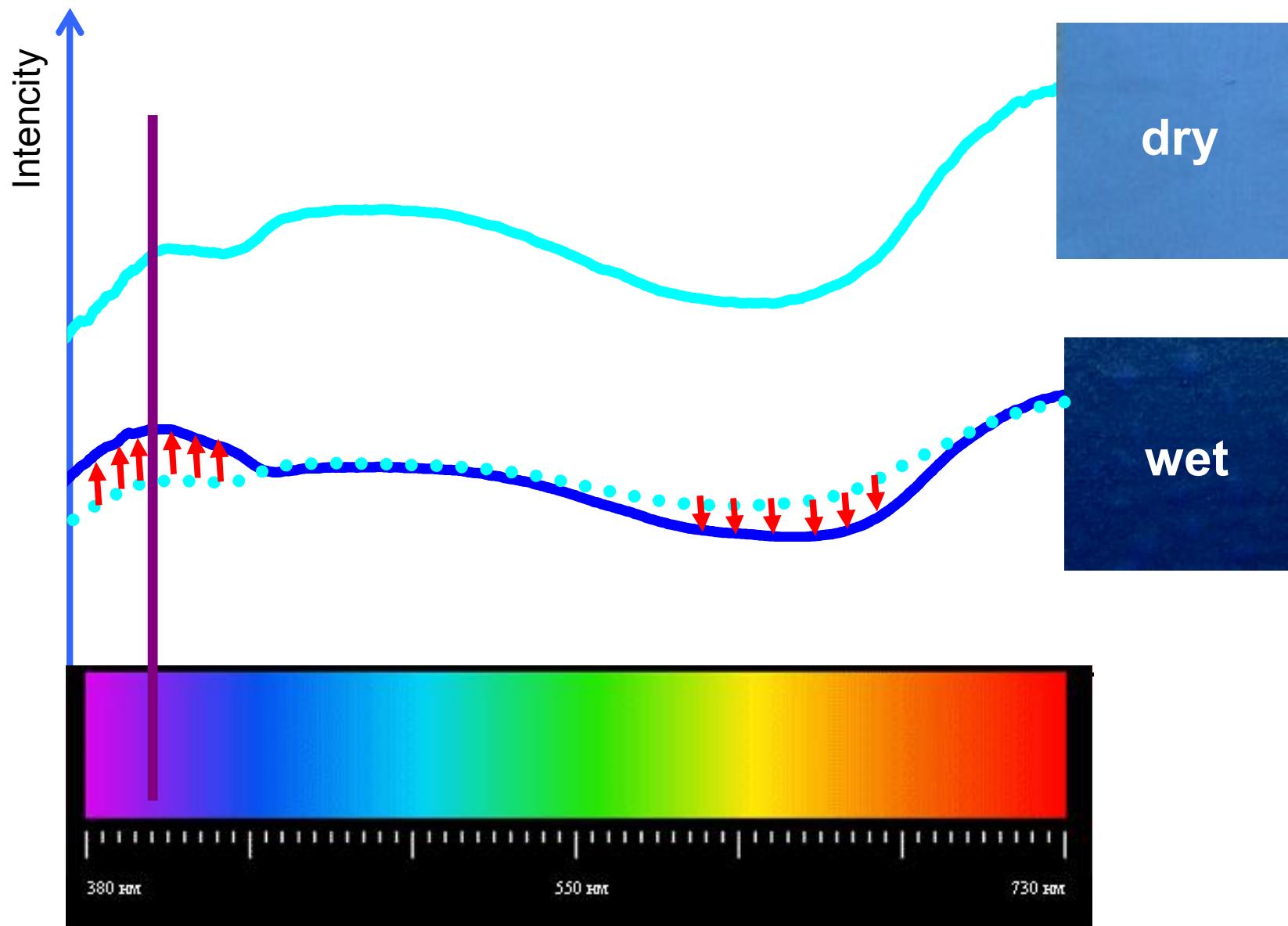
34



Dark-green cloth

35

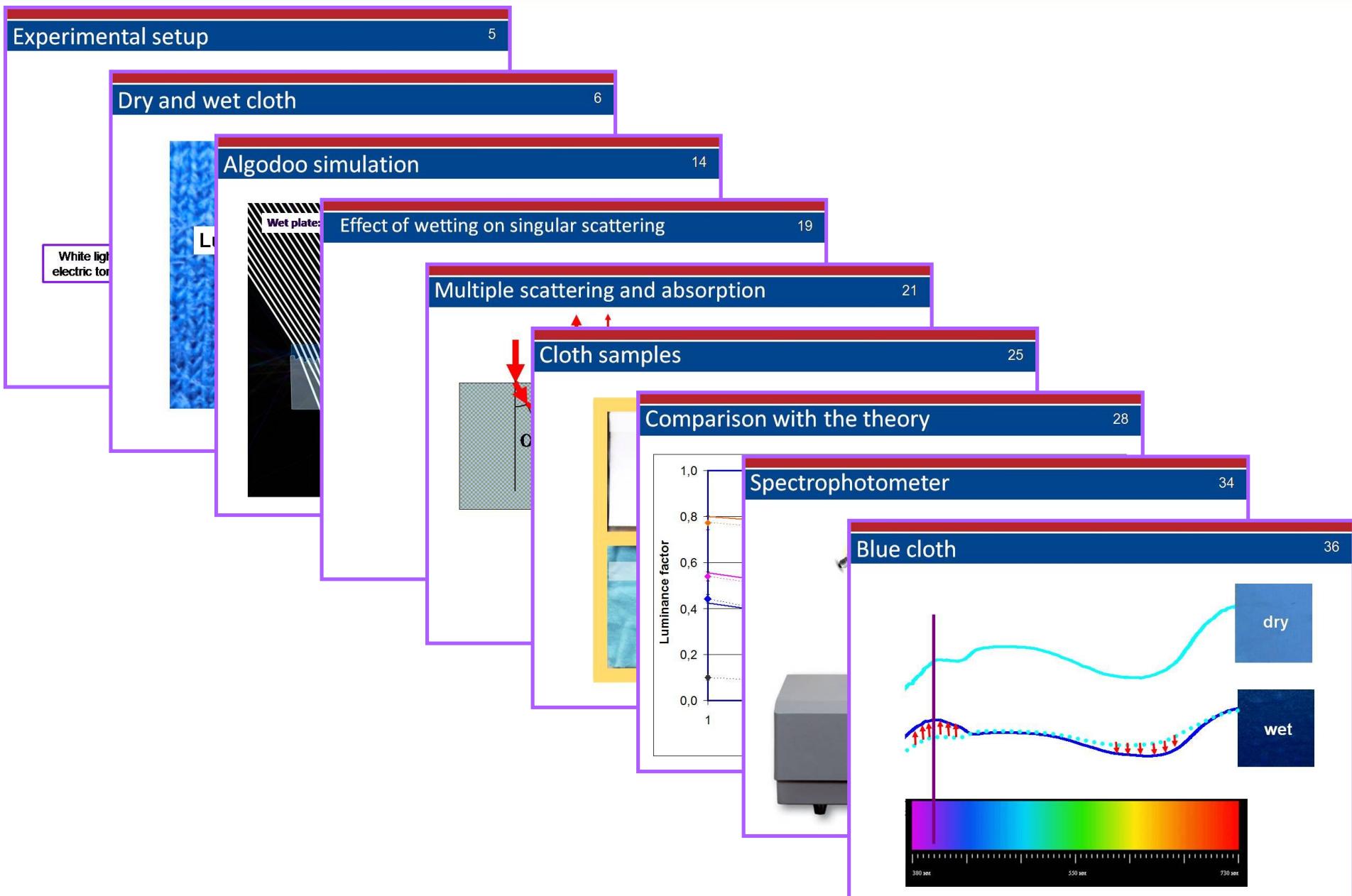




Summary

Summary

38



- Bohren C.F. (1983) “Simple experiments in atmospheric physics: Multiple scattering at the beach”. *Weatherwise*, **36**, 197–200.
- Twomey S.A., Bohren C.F., Mergenthaler J.L. (1986) “Reflectance and albedo differences between wet and dry surfaces”. *Appl. Optics*, **25**, 431–437.
- Lekner J., Dorf M.C. (1988) “Why some things are darker when wet”. *Appl. Optics*, **27**, 1278–1280.



**Thank you for
your attention!**