additive appearance

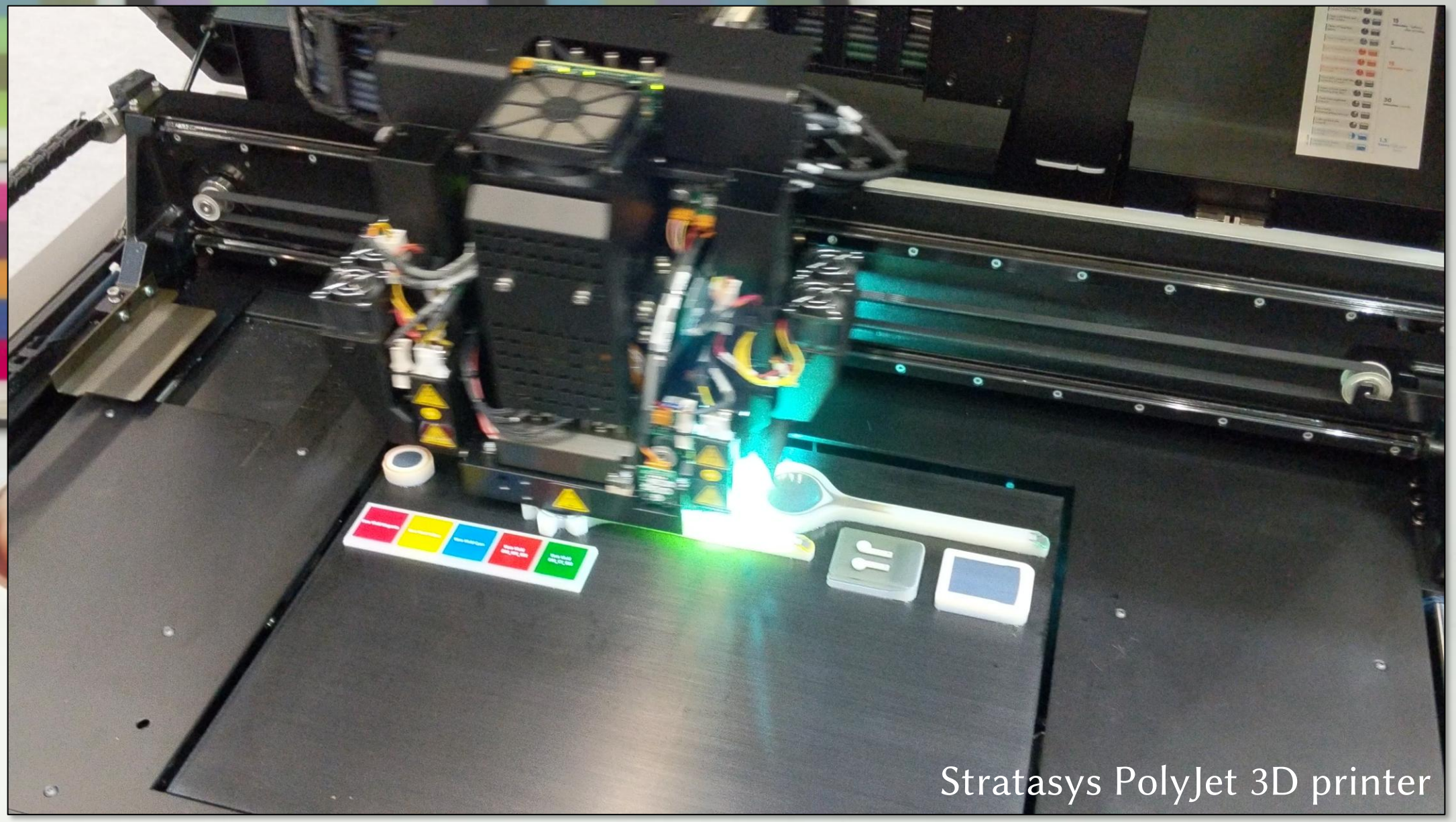
Computer Graphics Charles University

SIGGRAPH ASIA 2025 HONG KONG 香港

Scattering-Aware Color Calibration for 3D Printers Using a Simple Calibration Target

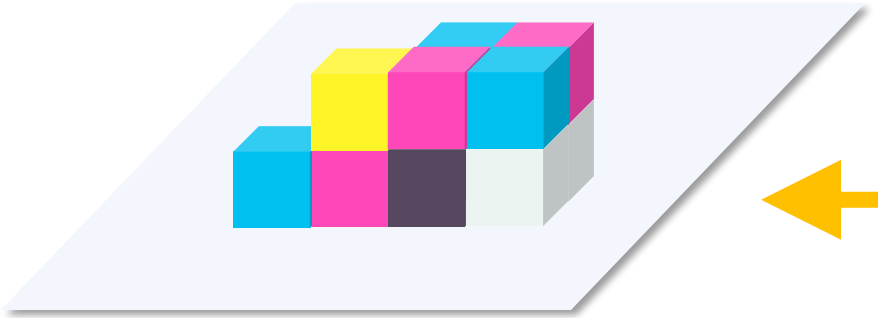
Tomáš Iser, Tobias Rittig, Alexander Wilkie


additive appearance
Computer Graphics Charles University
SIGGRAPH ASIA 2025 HONG KONG 香港



Stratasys PolyJet 3D printer

Forward and inverse process



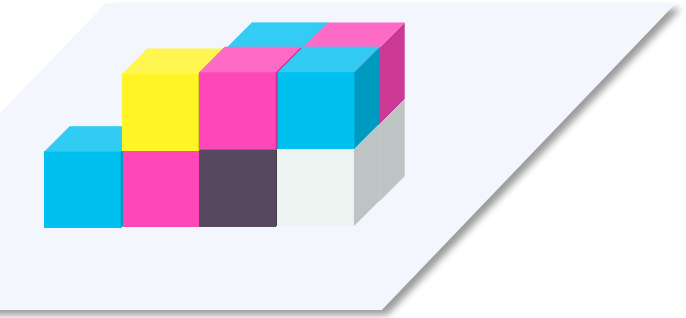
discrete 3D grid

forward process
(printing or rendering)

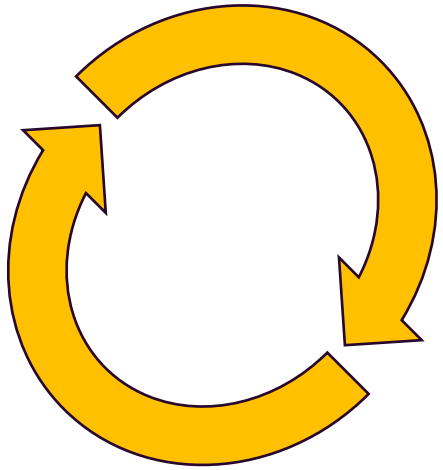
inverse process
(halftoning, contoning, ...)

3D printout

Brunton et al. [2015], Babaei et al. [2017],
Brunton et al. [2018], Shi et al. [2018], *and others*



rete 3D grid



iterative optimization
(e.g., differentiable rendering)

Elek et al. [2017], Sumin et al. [2019],
Rittig et al. [2021], Nindel et al. [2021]

3D printout
(initial iteration)

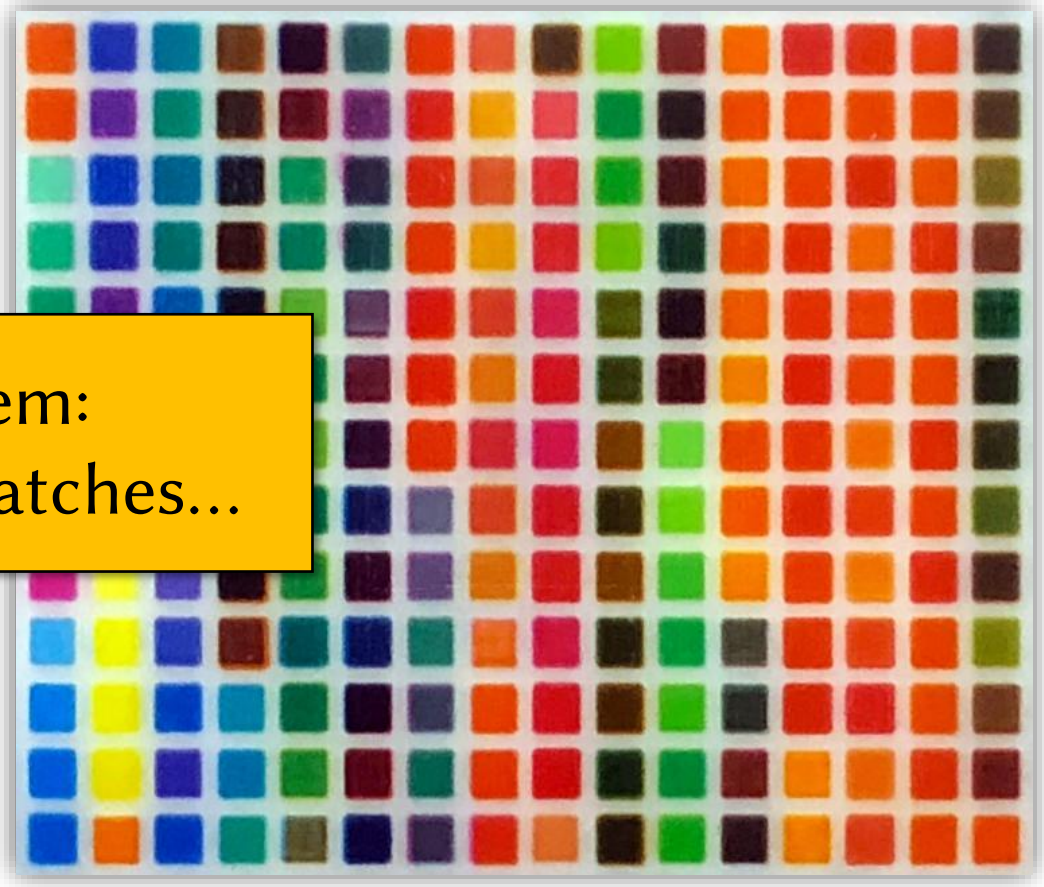
3D printout
(later iteration)

Early color models

- Forward & inverse mapping via **color lookup tables**

Brunton et al. [2015]

1st problem:
Too many swatches...



Shi et al. [2018] *and others*

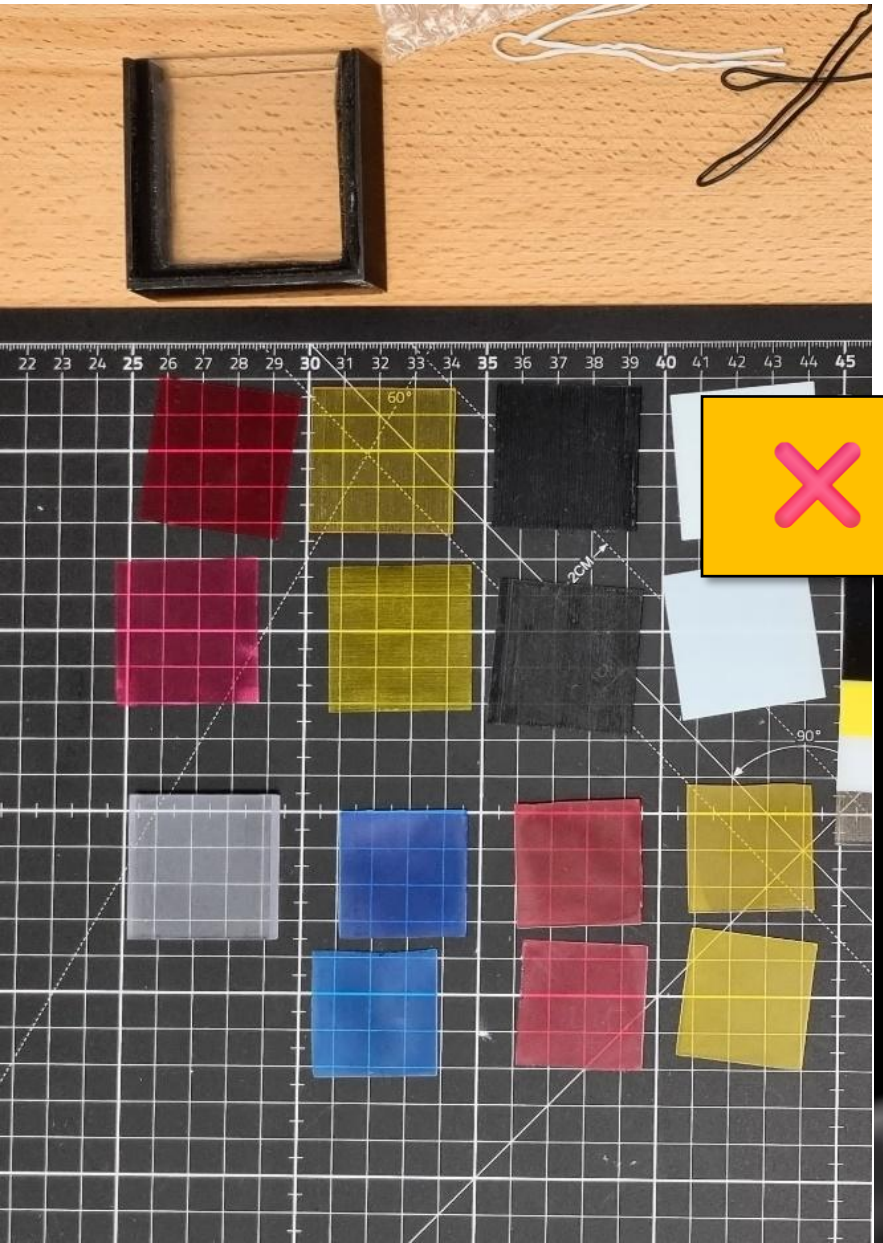
2nd problem with lookup tables

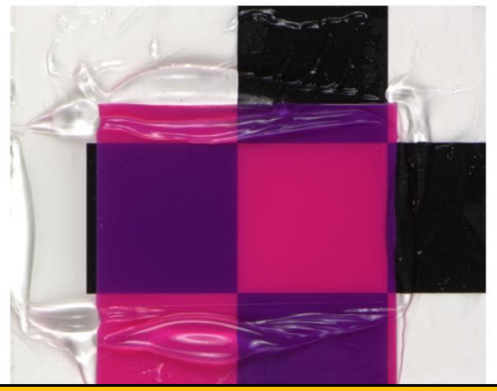
Expectations 😊

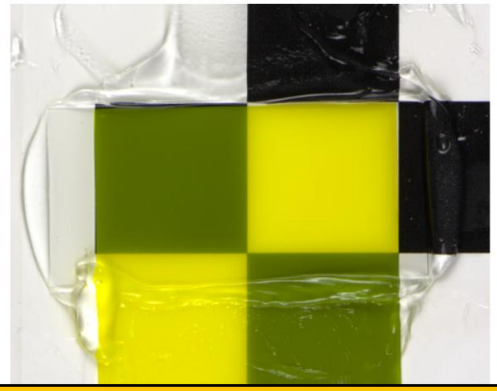
Loss of contrast due to light scattering

Reality 😢

Calibrating the scattering



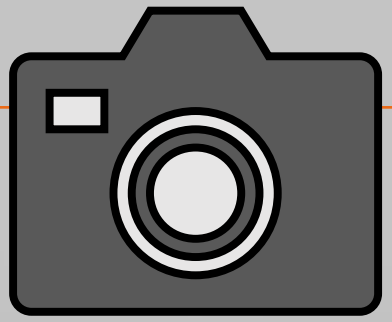


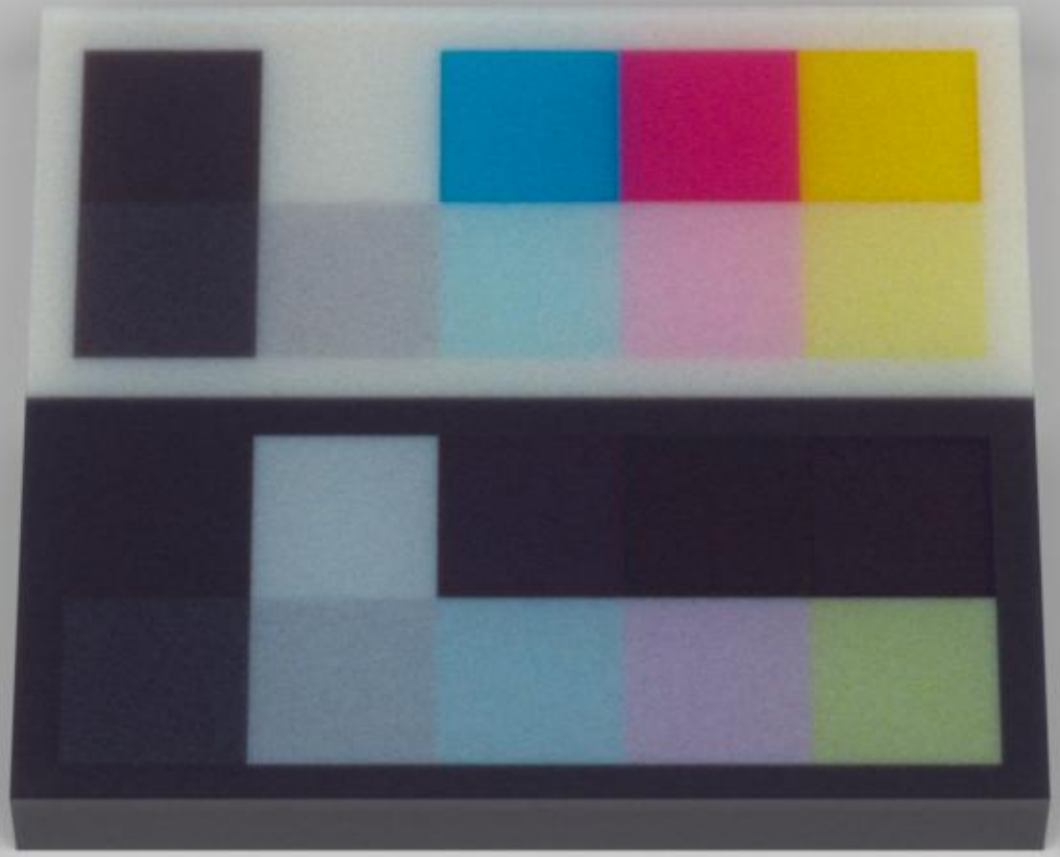


Elek et al. [2017]
Elek et al. [2021]
Iser et al. [2022]
Pranovich et al. [2024]
Abu Rmaileh et al. [2025]
and others

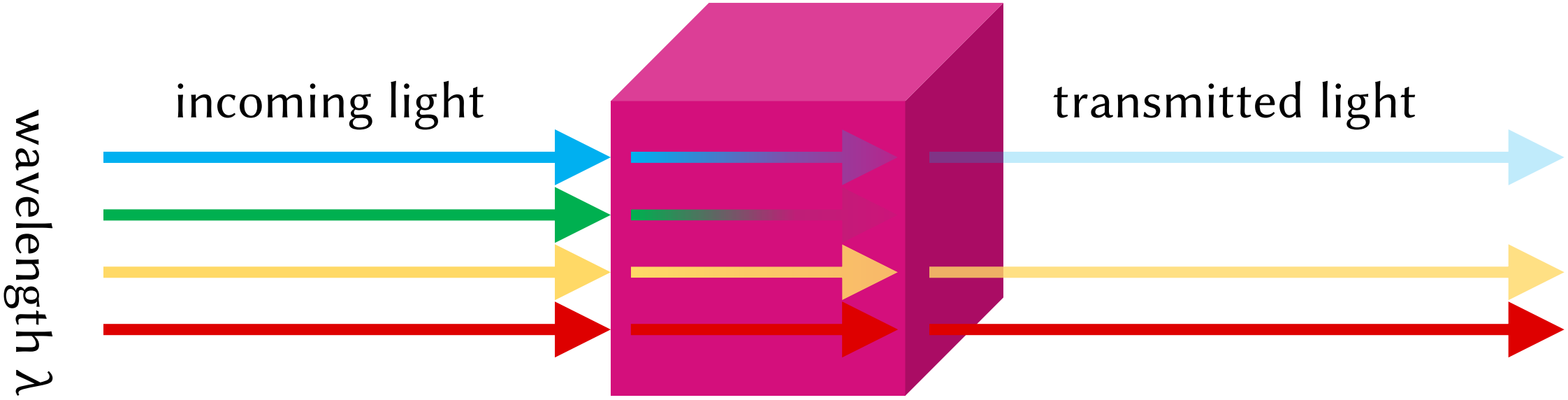
❌ Lots of manual work! ❌

Our solution



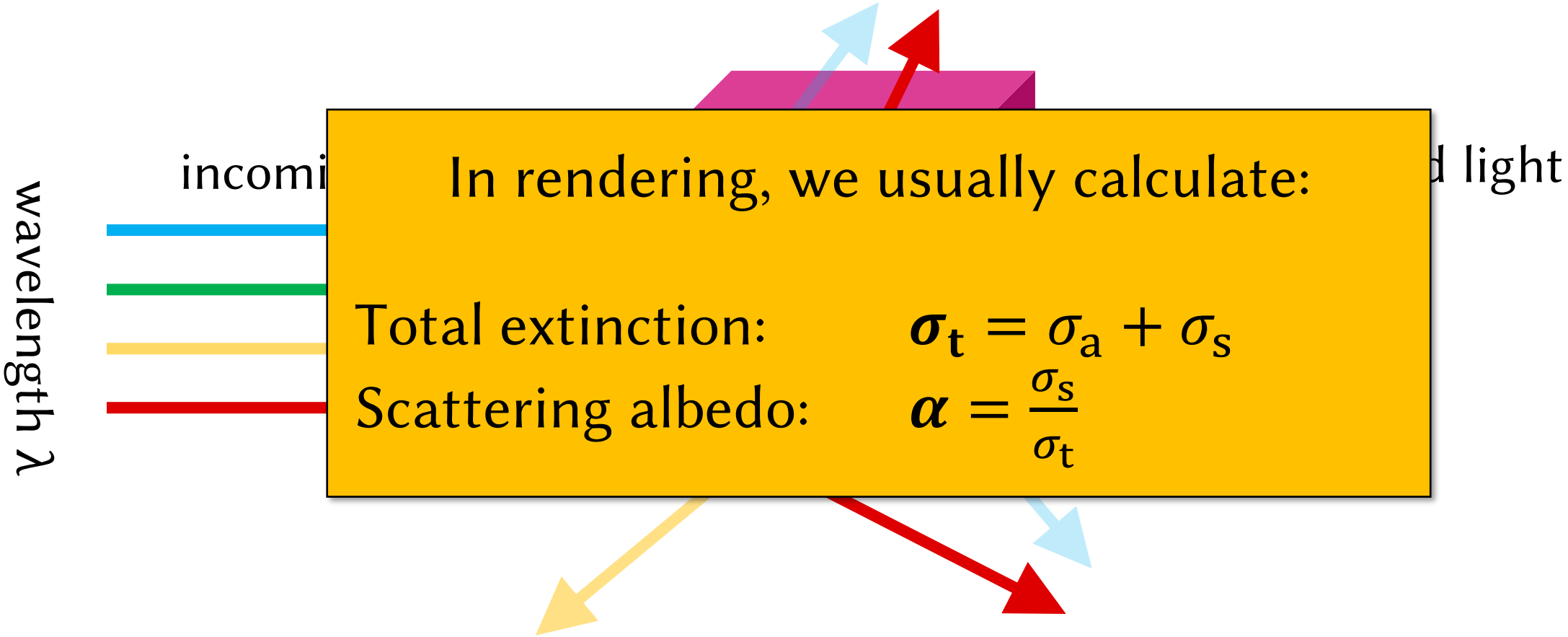


Absorption in a 3D printed slab

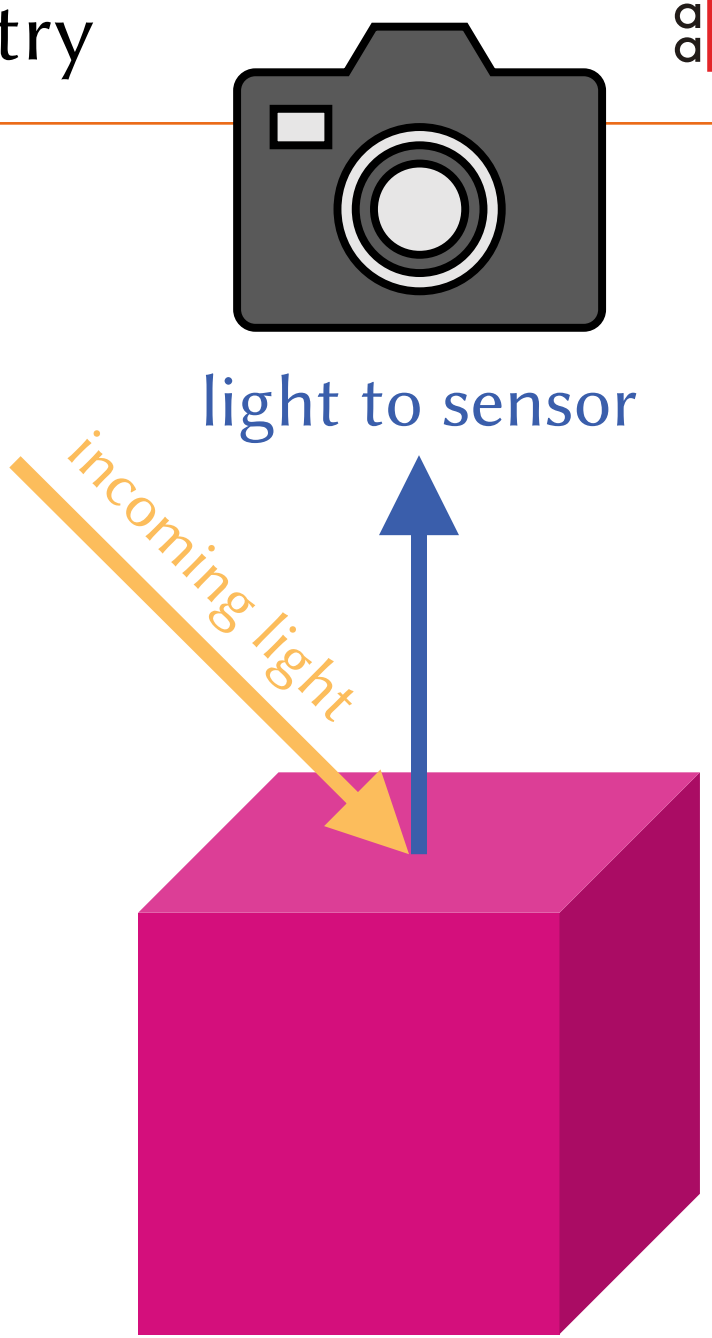


absorption coefficient $\sigma_a(\lambda)$

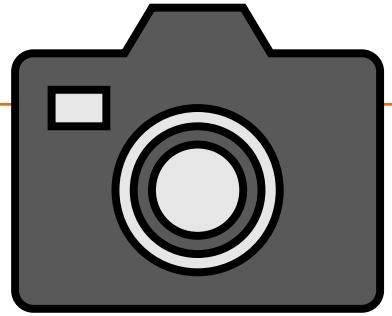
Scattering in a 3D printed slab



Measurement geometry



Reflectance vs. thickness

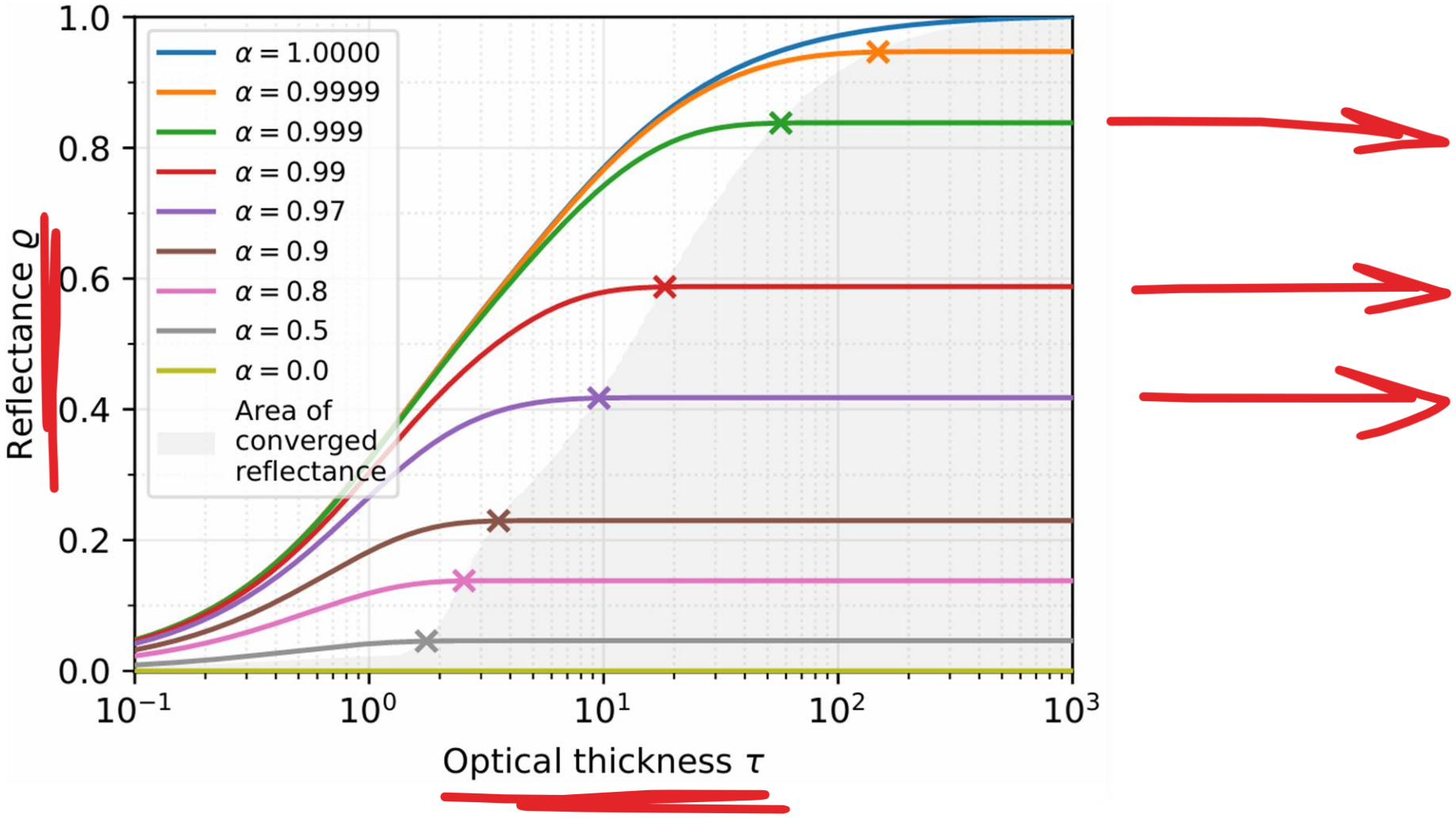


light to sensor

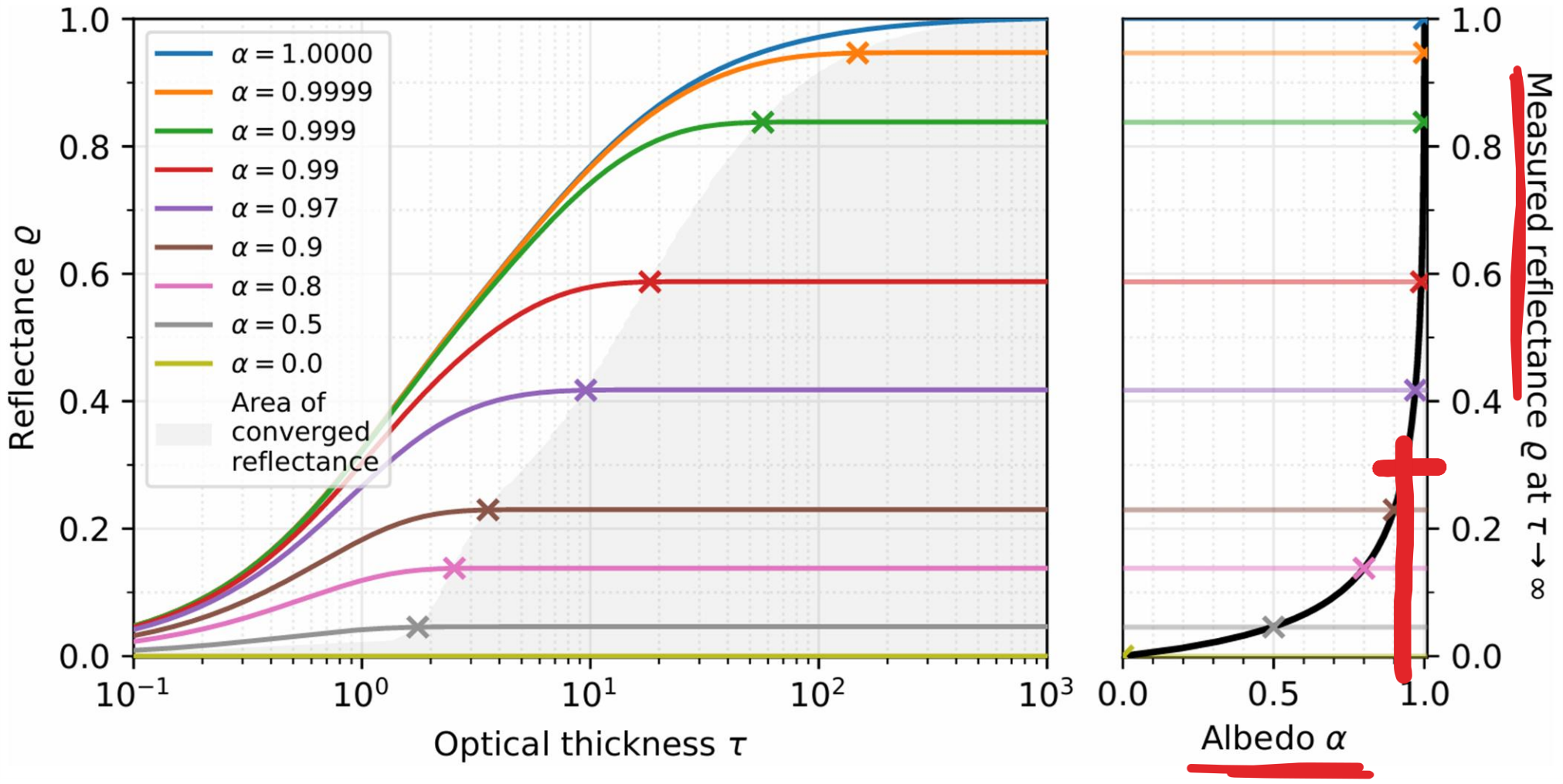
incoming light

thickness

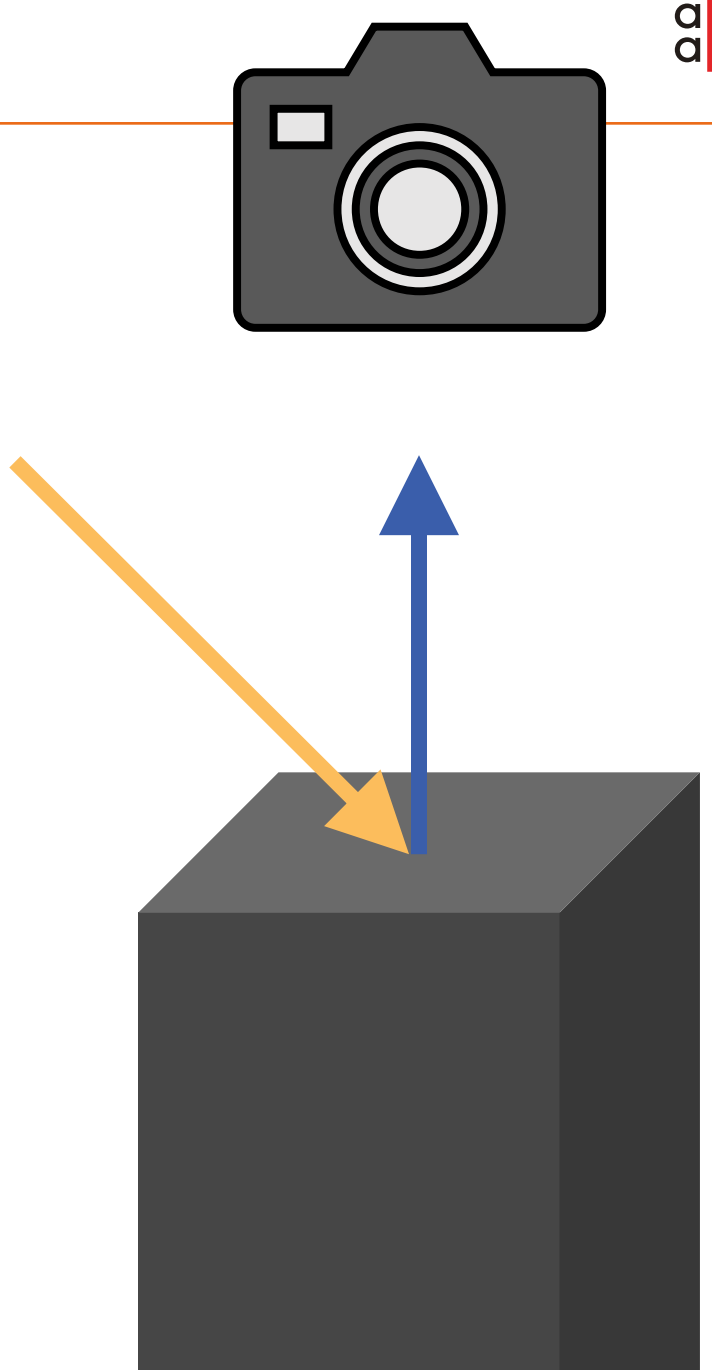
Reflectance vs. thickness



Estimating α when $\tau \to \infty$

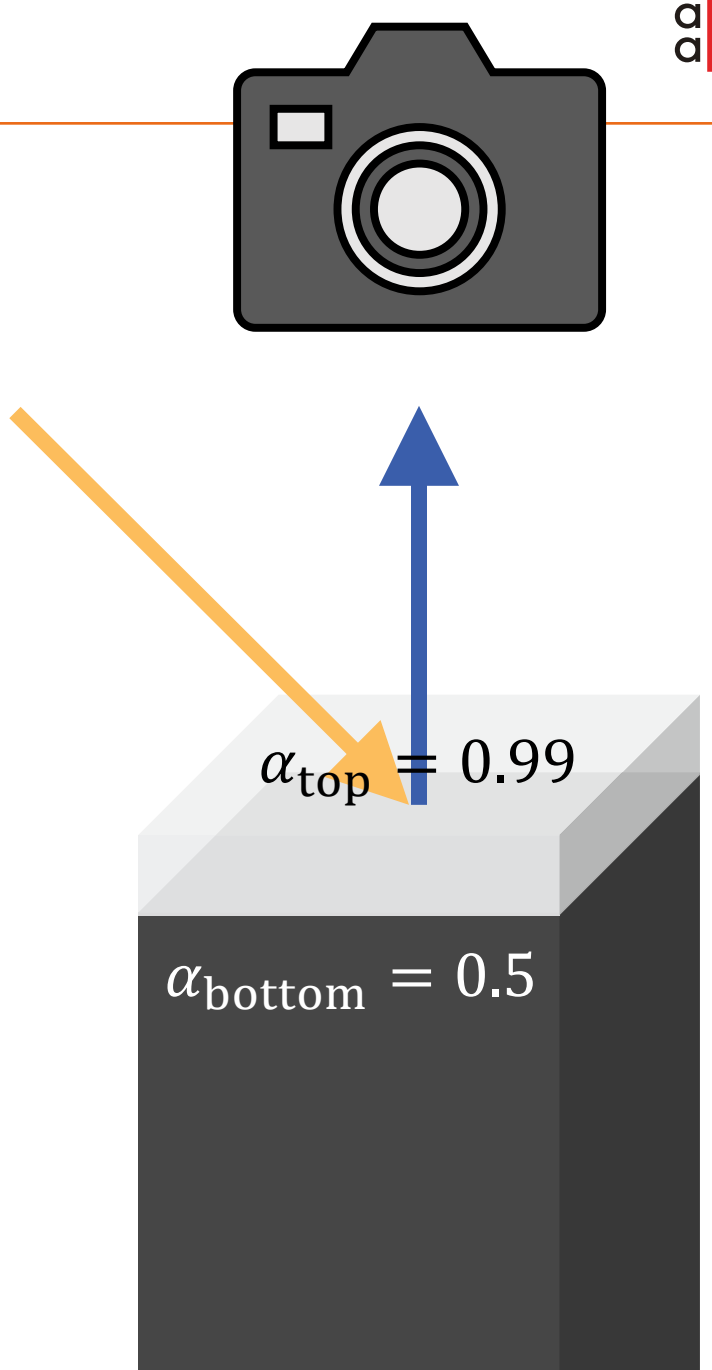


Stacking two layers



thick layer
(known α,
unknown σ_t)

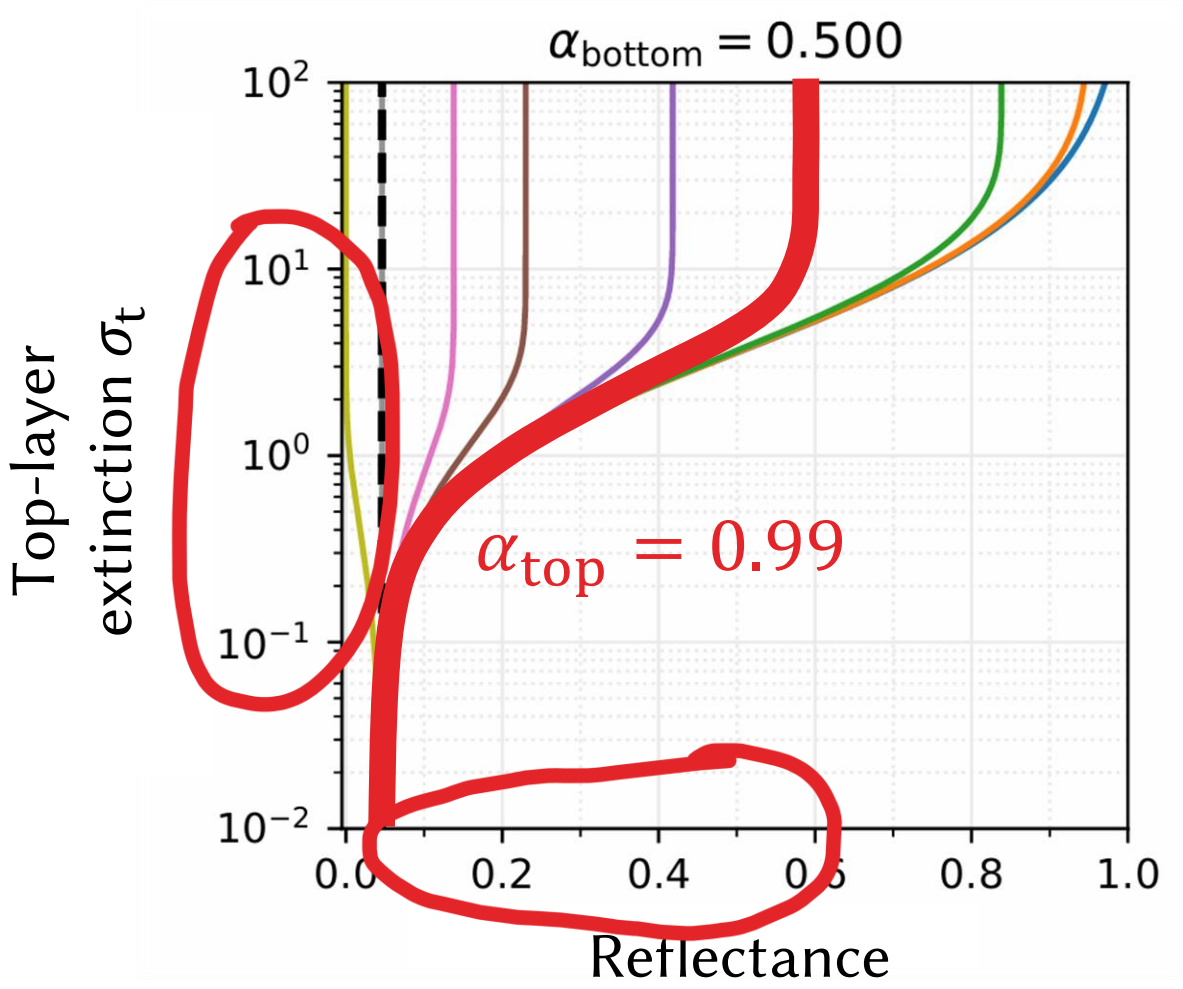
Stacking two layers

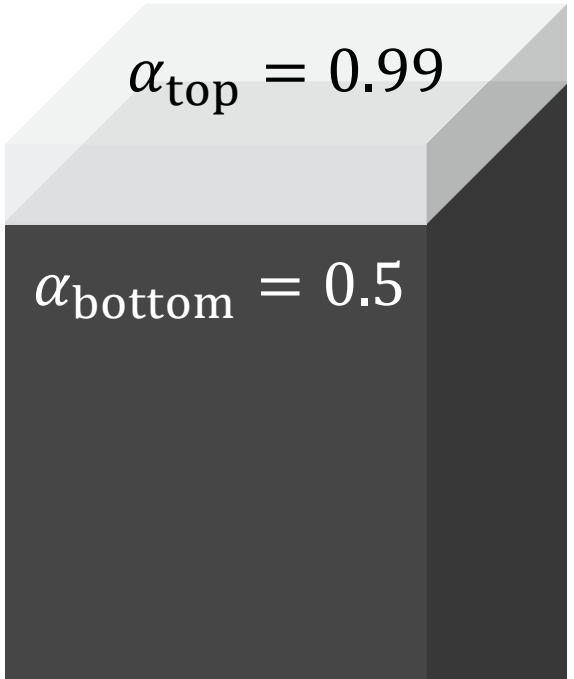


thin layer
(known α,
unknown σ_t)

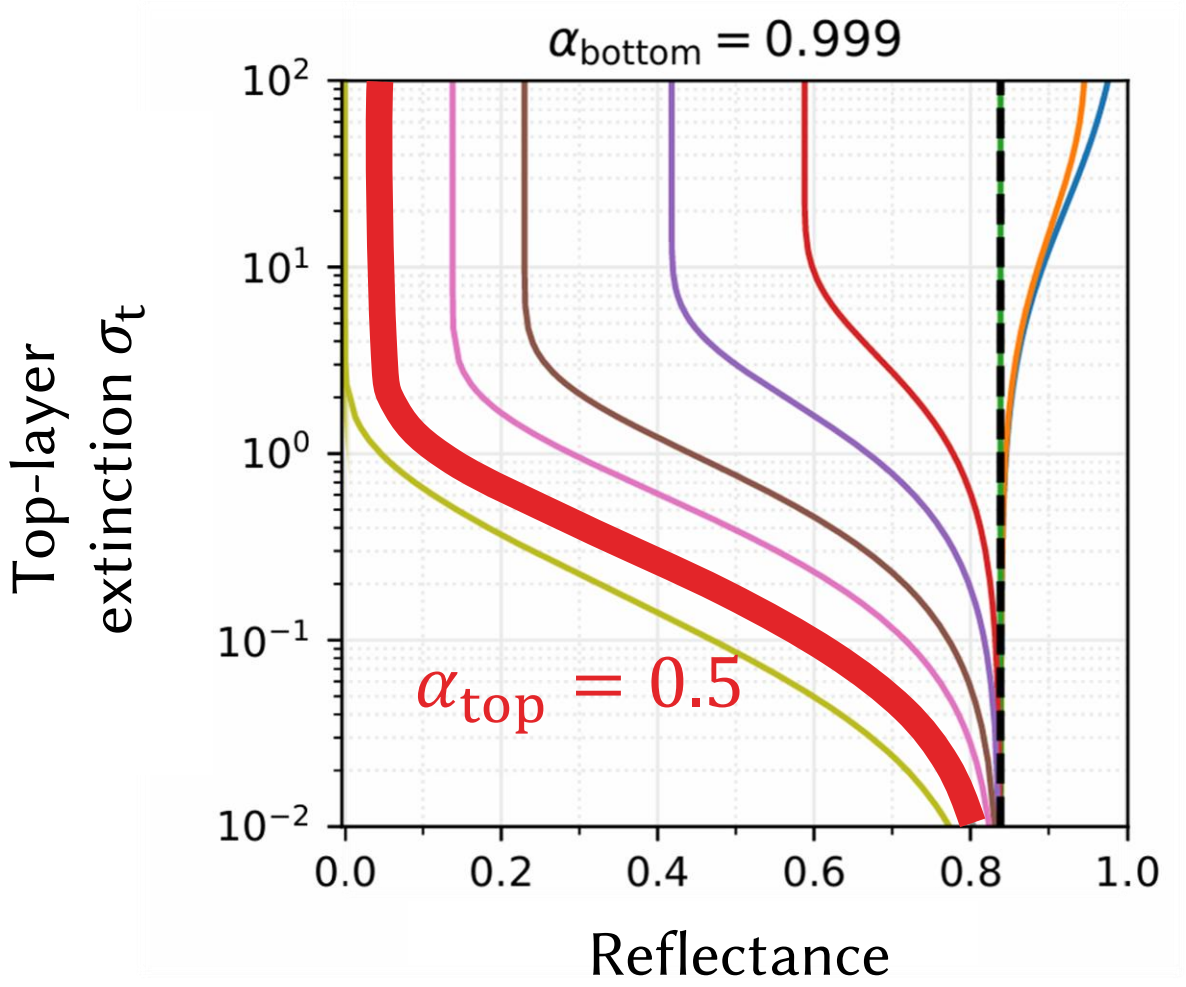
thick layer
(known α,
unknown σ_t)

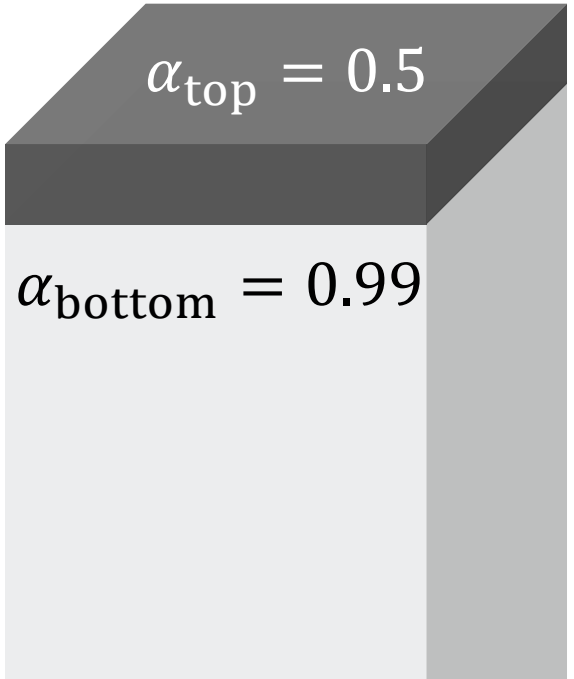
Top-layer extinction vs. reflectance



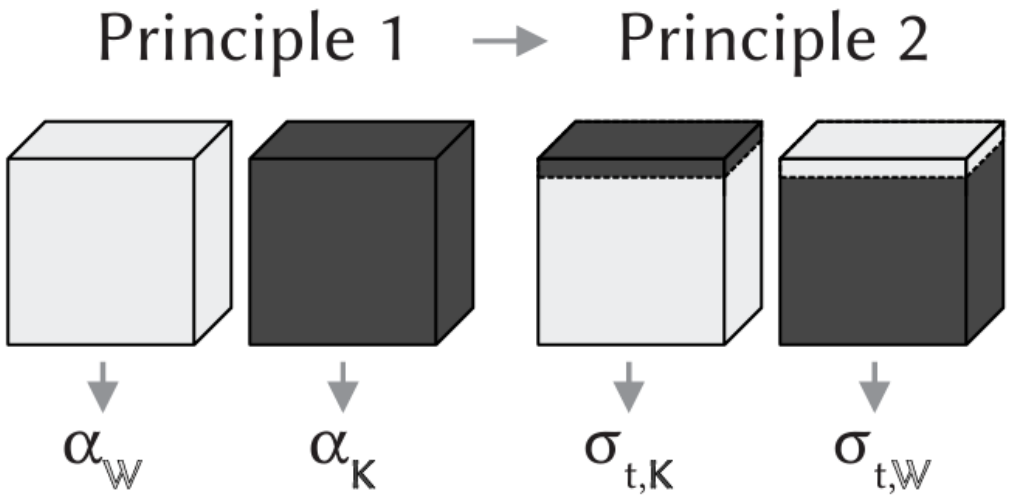


Top-layer extinction vs. reflectance



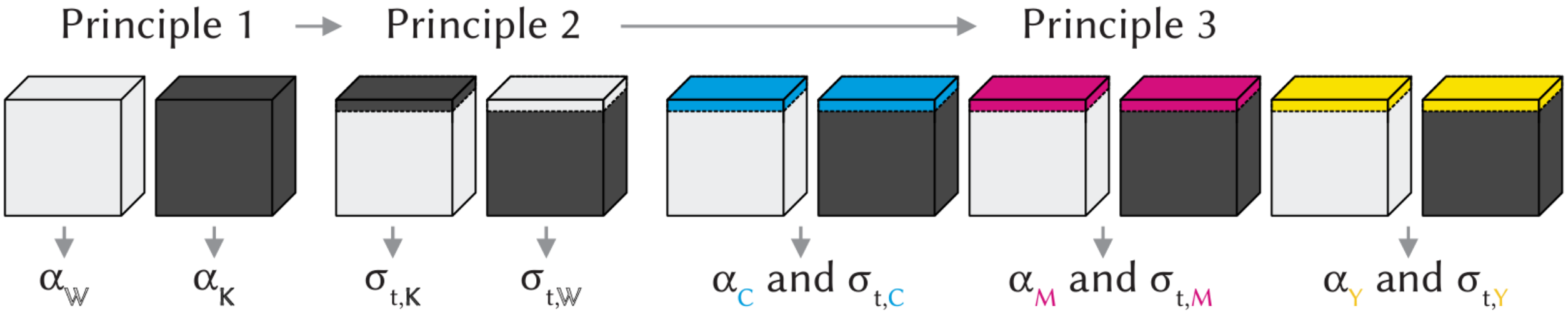


Two principles

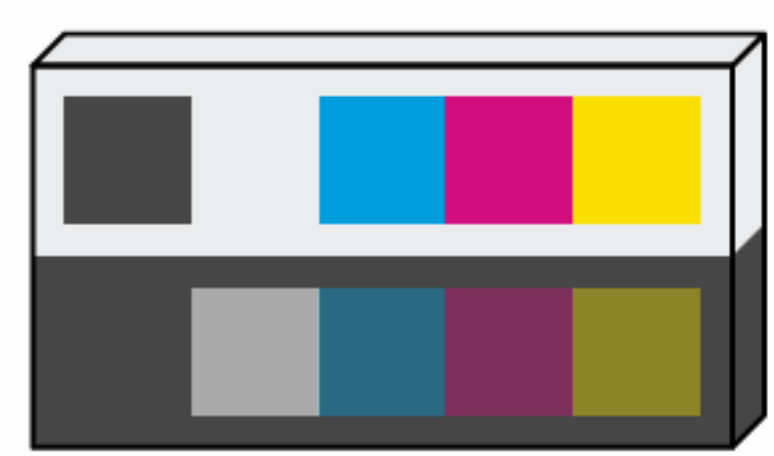


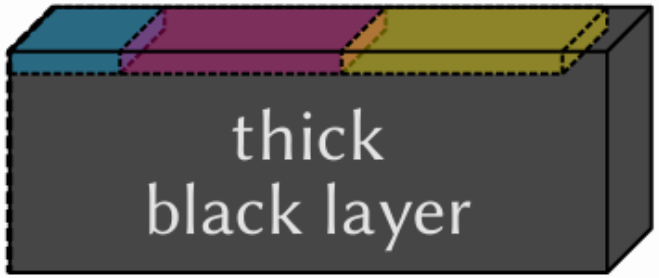
White & black resins done ✅

Three principles

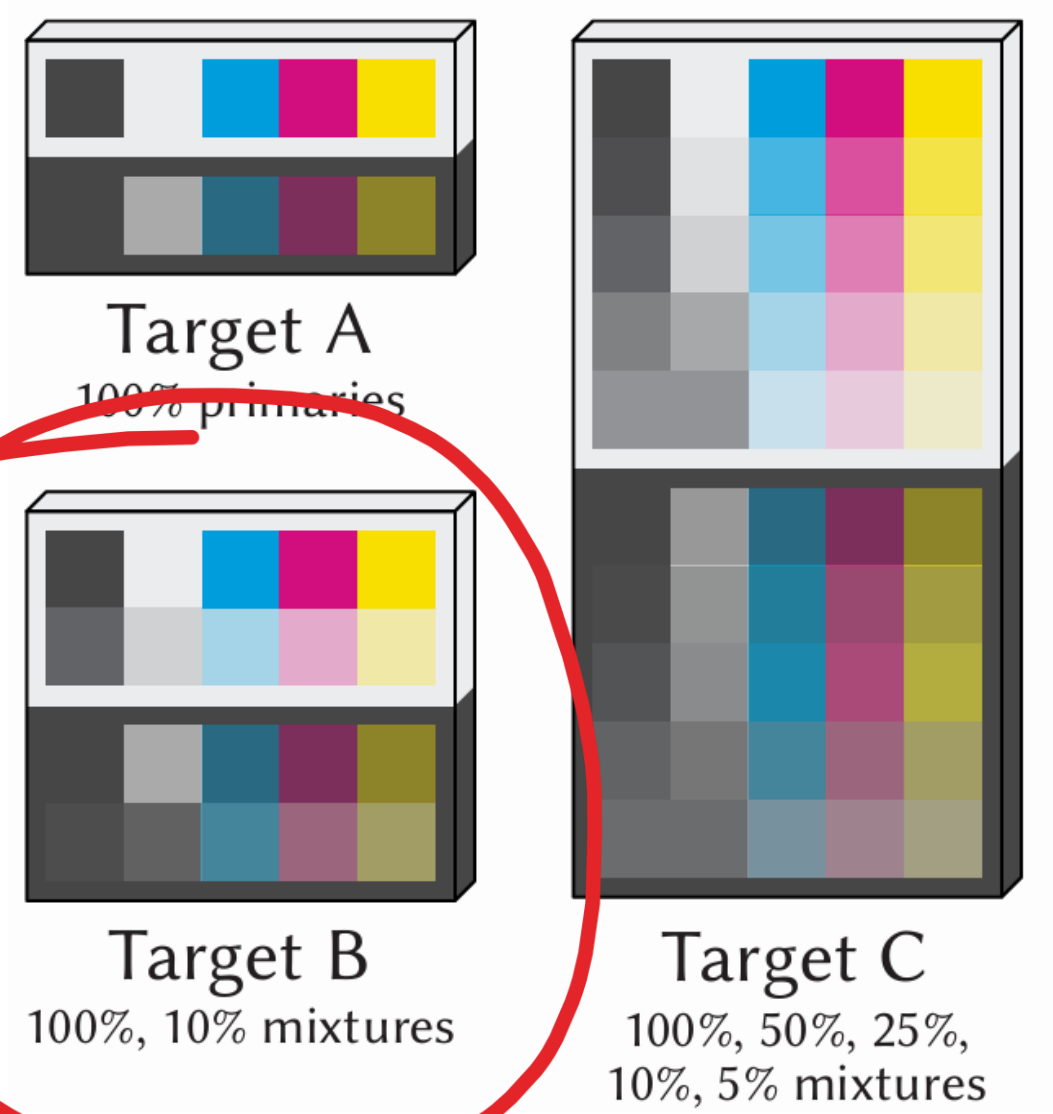


Designing the calibration targets





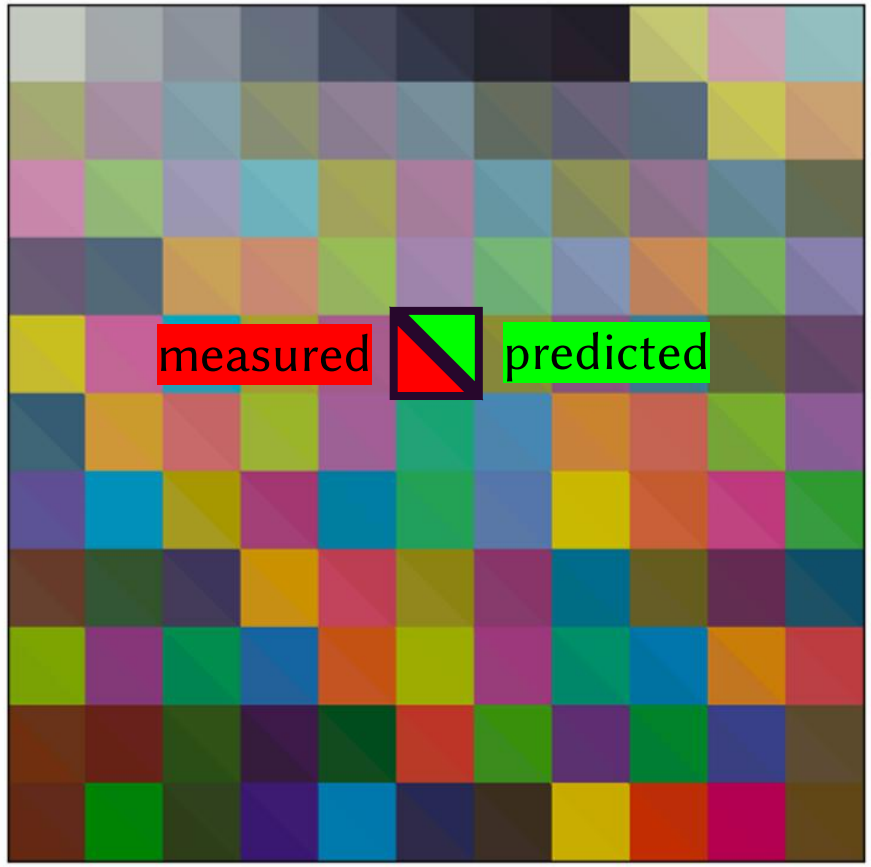
Designing the calibration targets



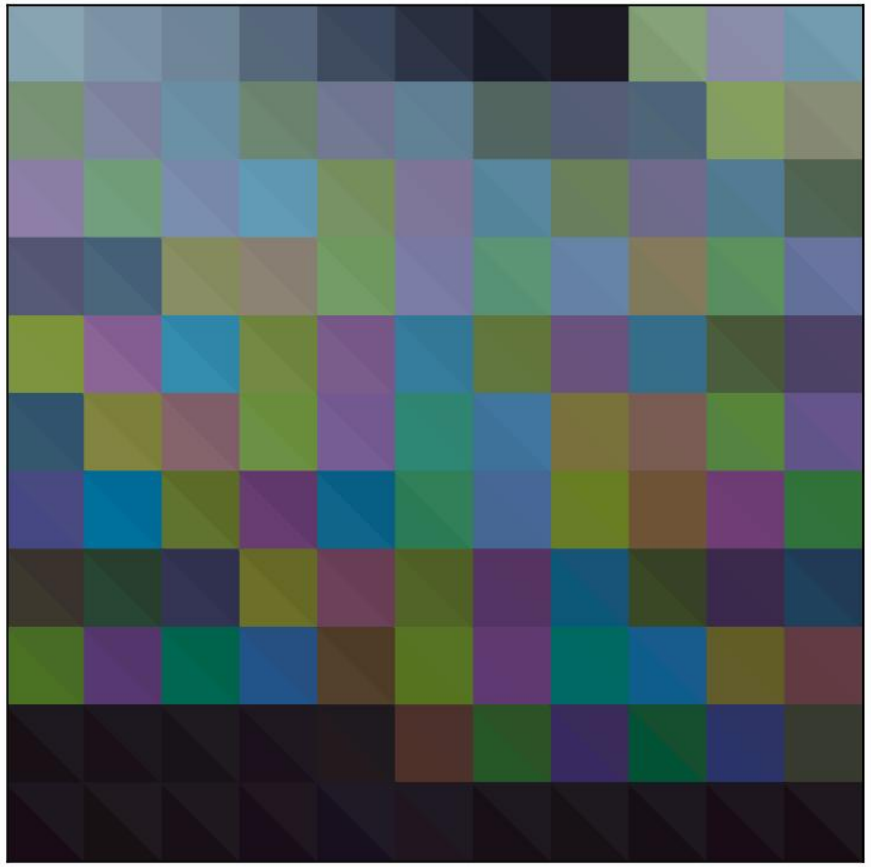
Validations

Validation on 242 resin mixtures

Resin mixtures on white

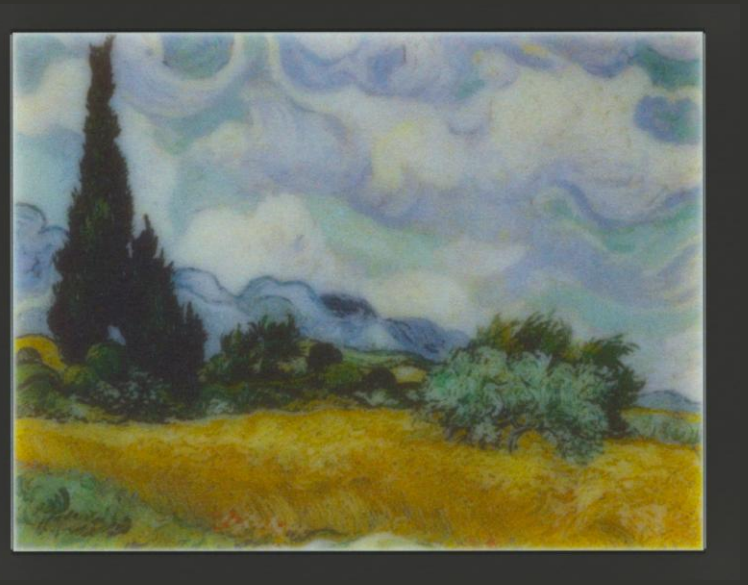


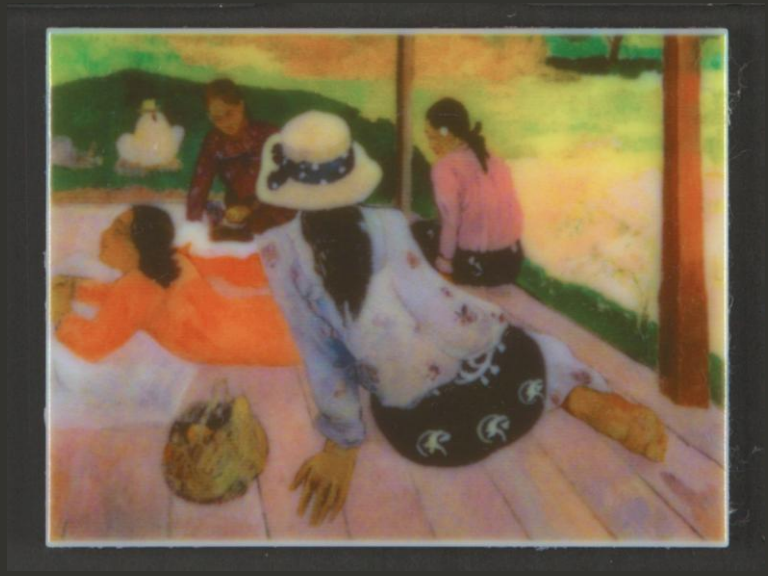
The same resin mixtures, on black

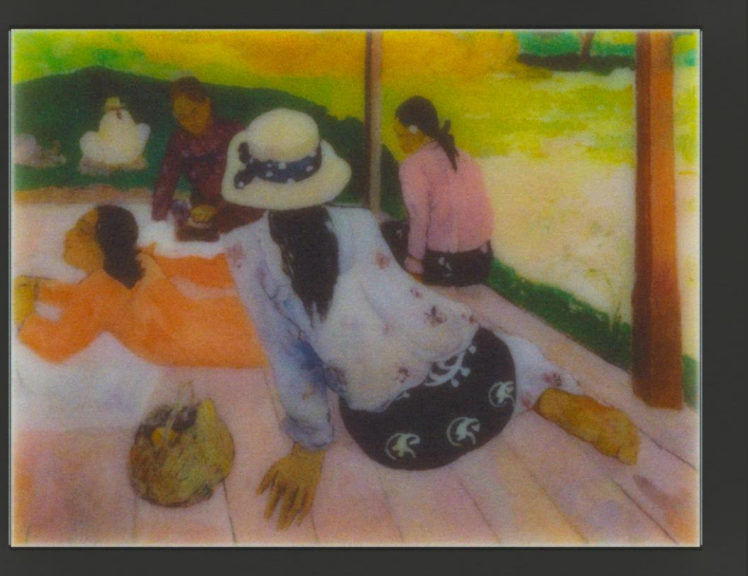


Photographs

Our renders



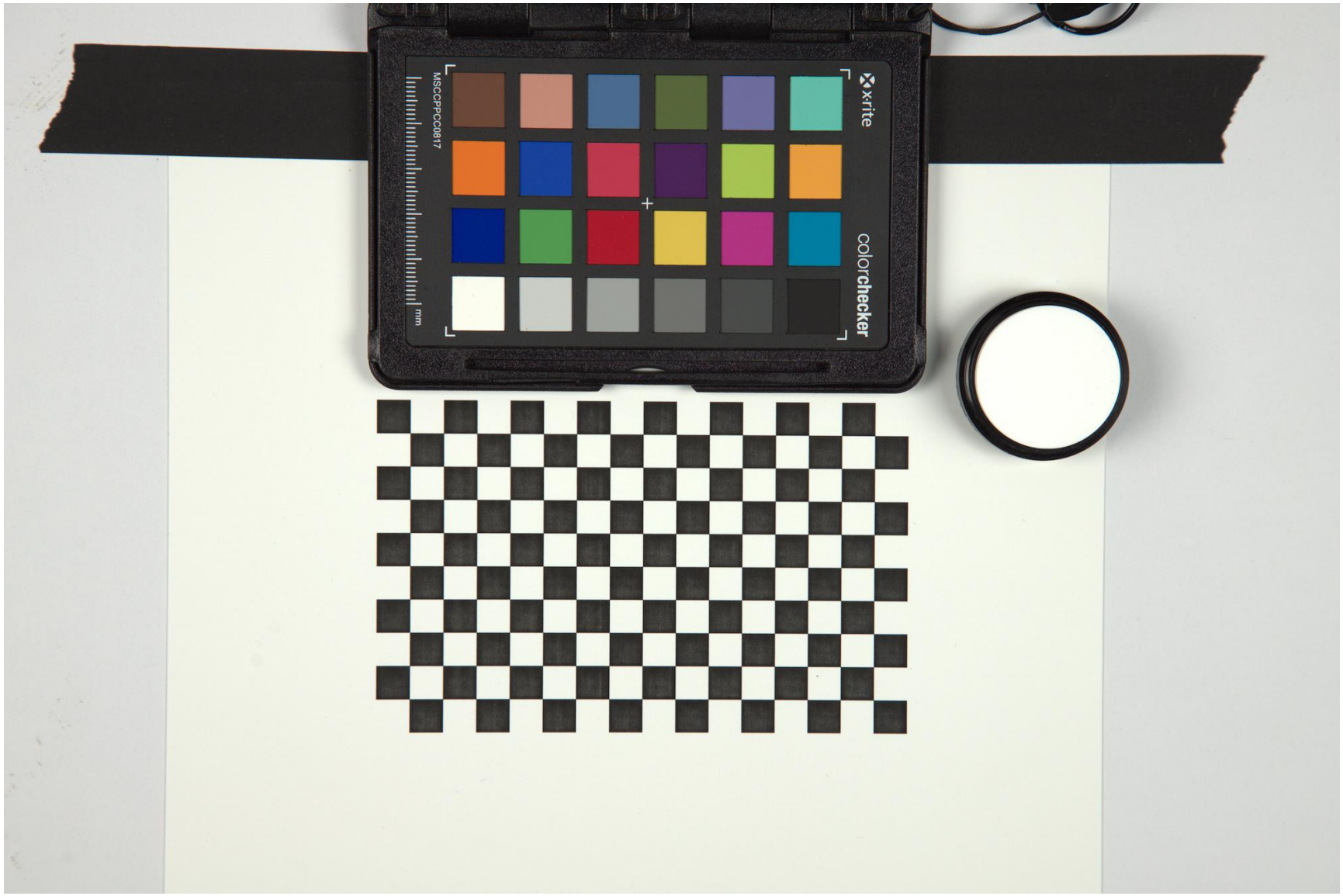




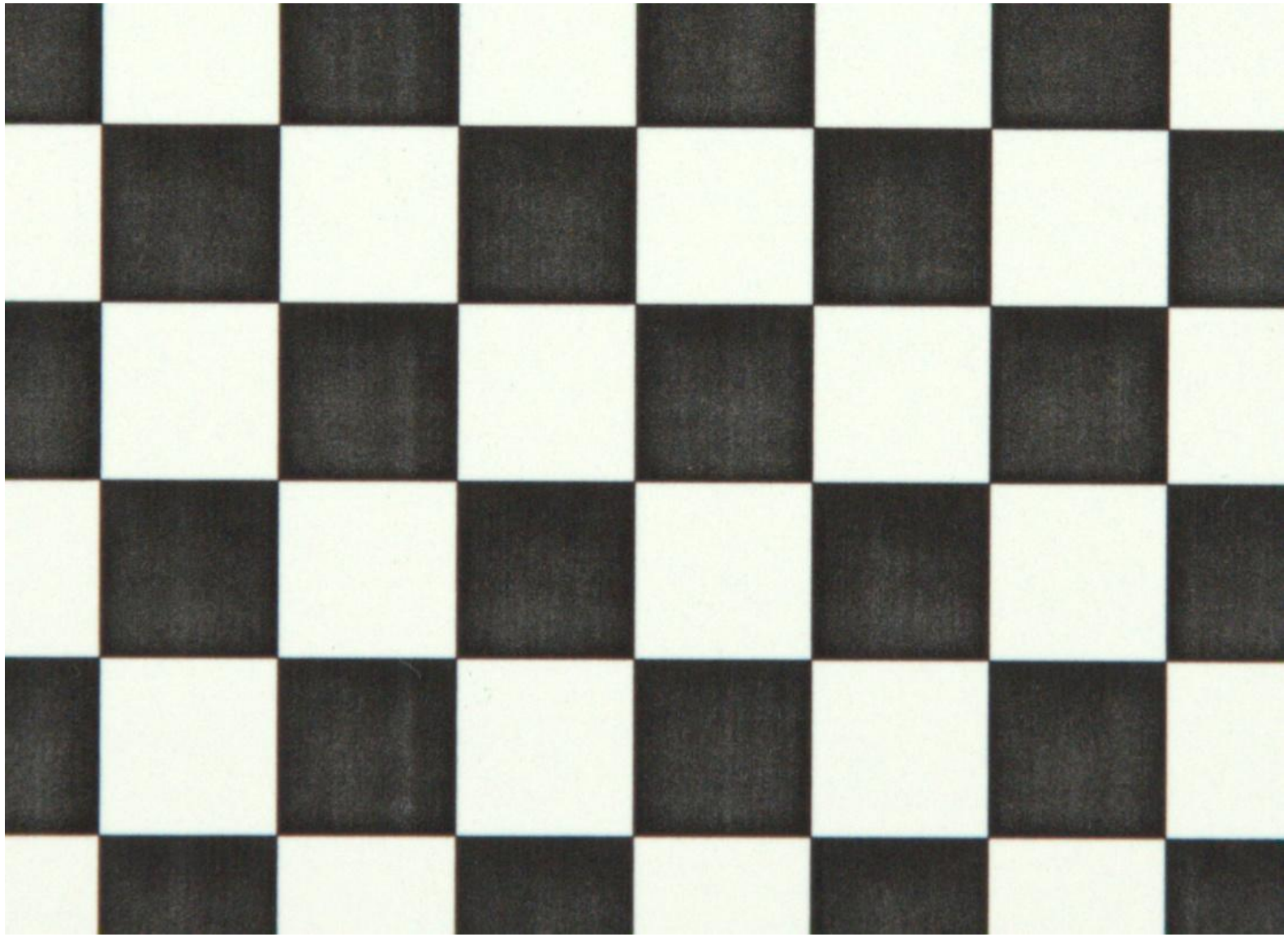
Photographs

Our renders

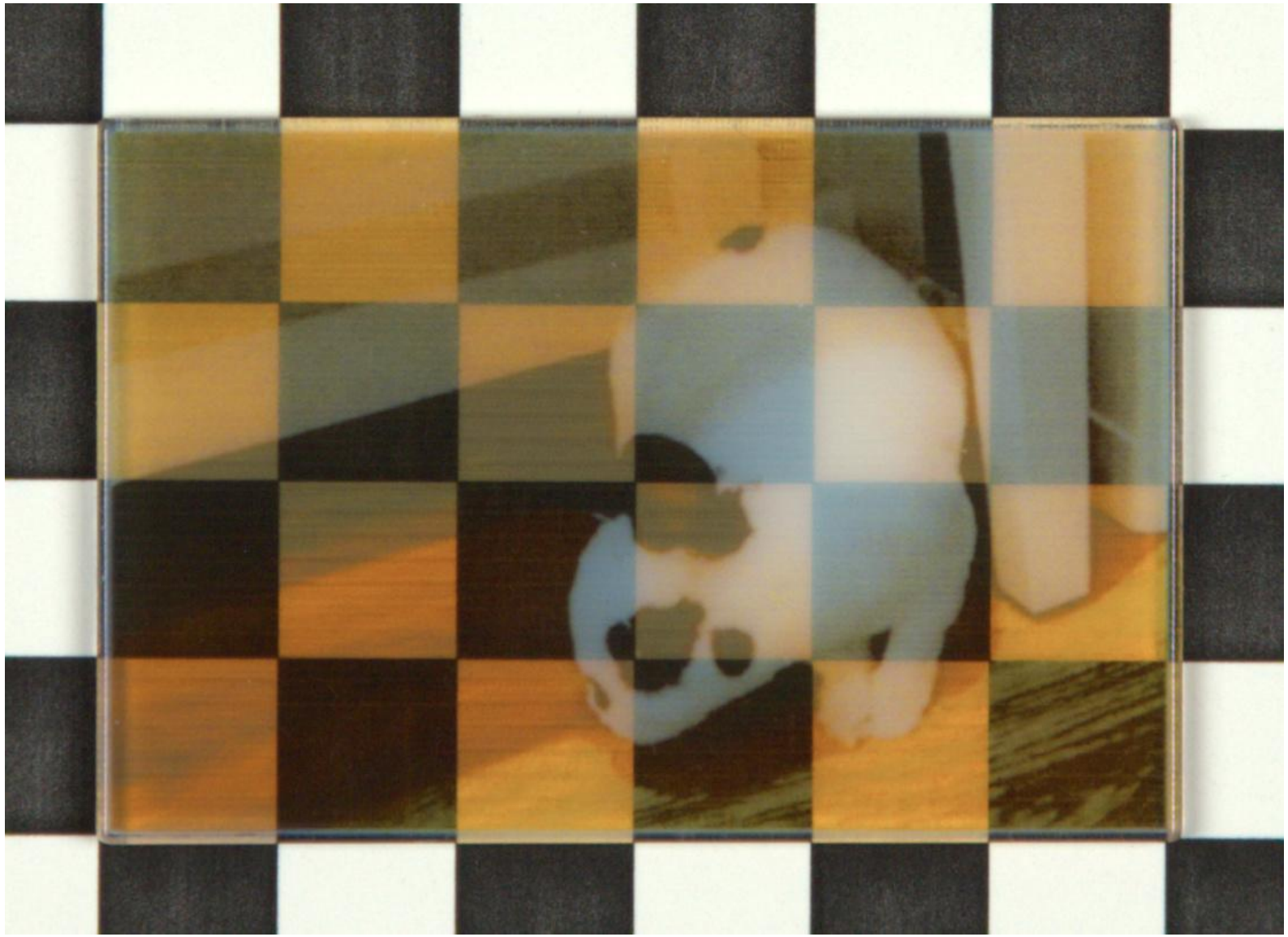
Translucency validation



Translucency validation



Translucency validation



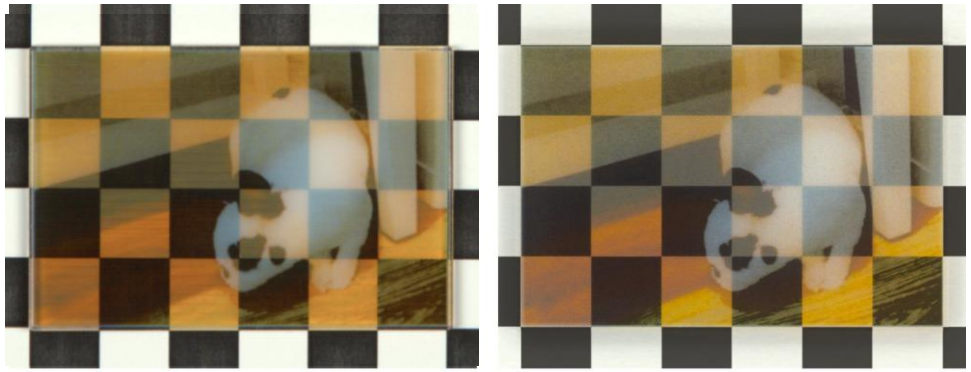
Thickness:

0.25 mm

Translucency validation

Photograph | Our render

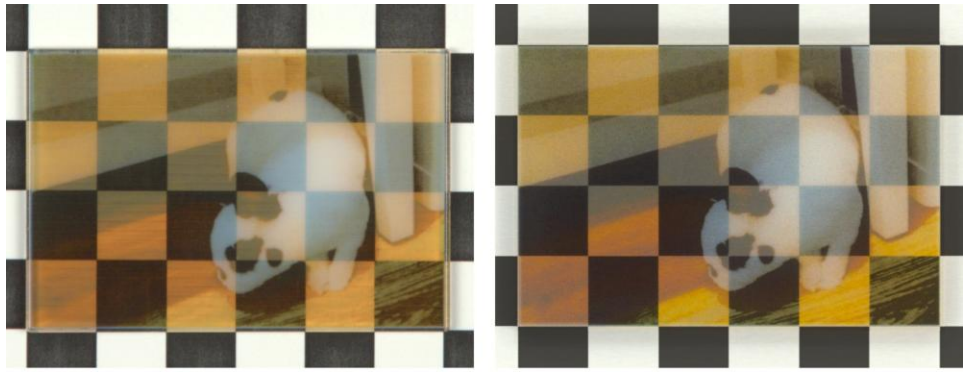
Thickness:
0.25 mm



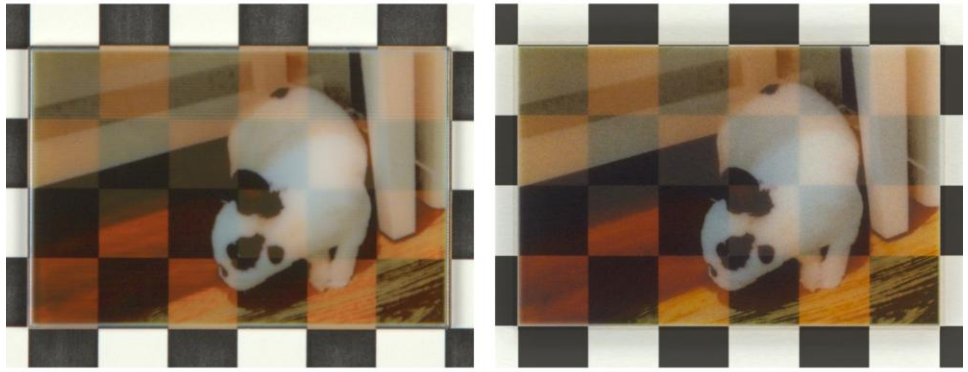
Translucency validation

Photograph | Our render

Thickness:
0.25 mm



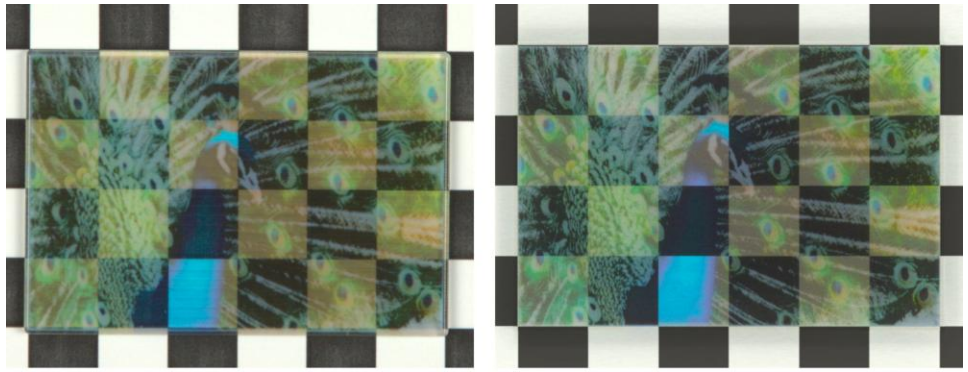
Thickness:
0.50 mm



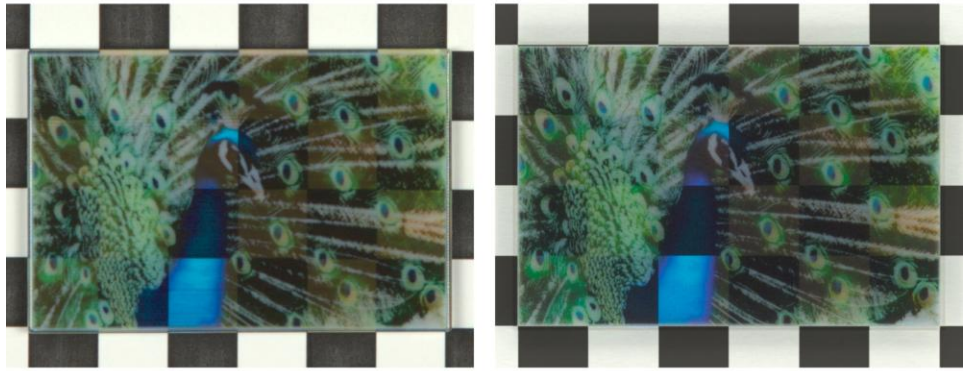
Translucency validation

Photograph | Our render

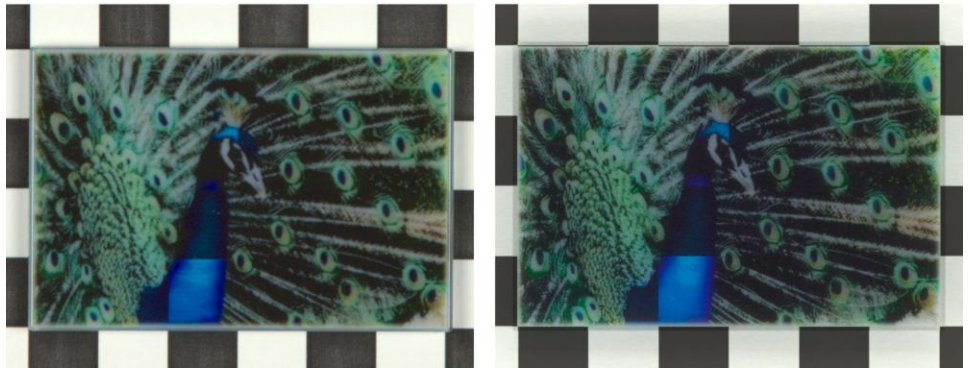
Thickness: 0.25 mm



Thickness: 0.50 mm



Thickness: 1.00 mm



Some of the 3D printouts in the slides are based on the following 3D models:
"Full body 3D scan" (https://skfb.ly/EK8o) by **fablabbudapest**
"Graffiti Railway Tank" (https://skfb.ly/o9noM) by **Yaroslav Dubovikov**
"Realistic Human Eye" (https://skfb.ly/6wByQ) by **Alexander Antipov**
All of the above are licensed under Creative Commons Attribution (http://creativecommons.org/licenses/by/4.0/)

additive appearance

Computer Graphics Charles University

SIGGRAPH ASIA 2025 香港 HONG KONG

Scattering-Aware Color Calibration for 3D Printers Using a Simple Calibration Target

Tomáš Iser, Tobias Rittig, Alexander Wilkie