

S A A R B R Ü C K E N

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Luminance-Preserving and Temporally Stable Daltonization

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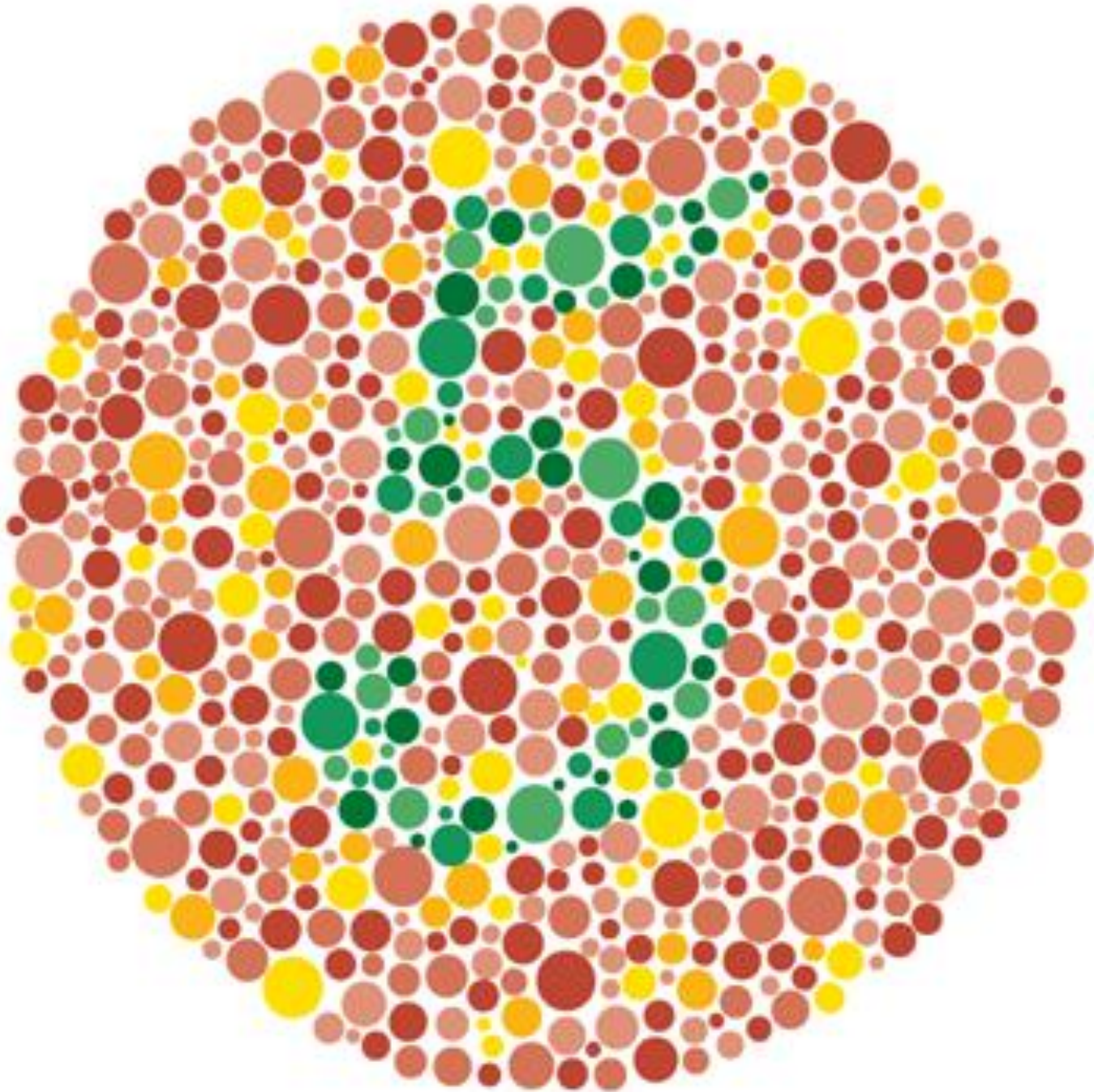
¹NVIDIA

²The Perse School Cambridge

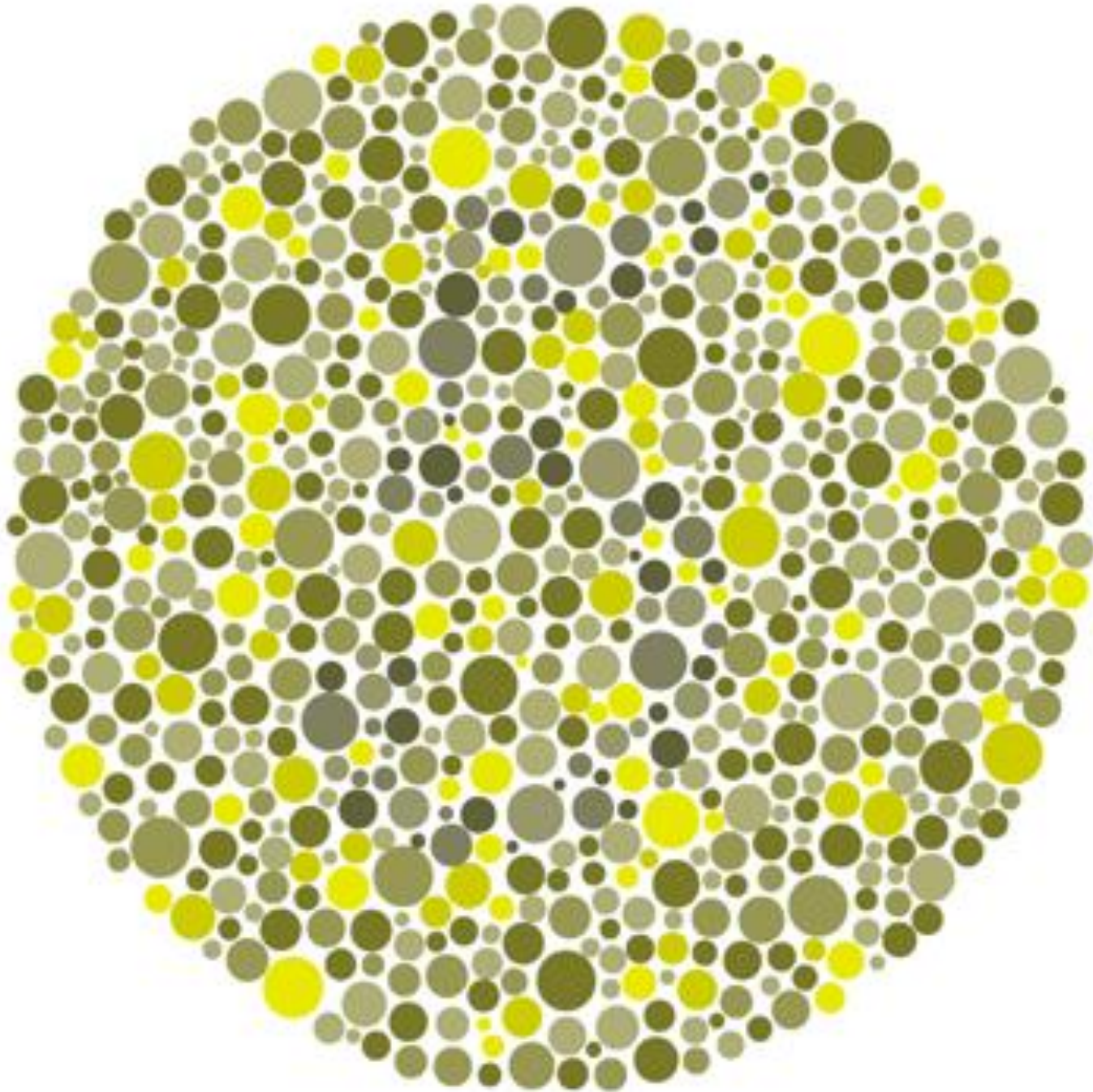
³University of Cambridge

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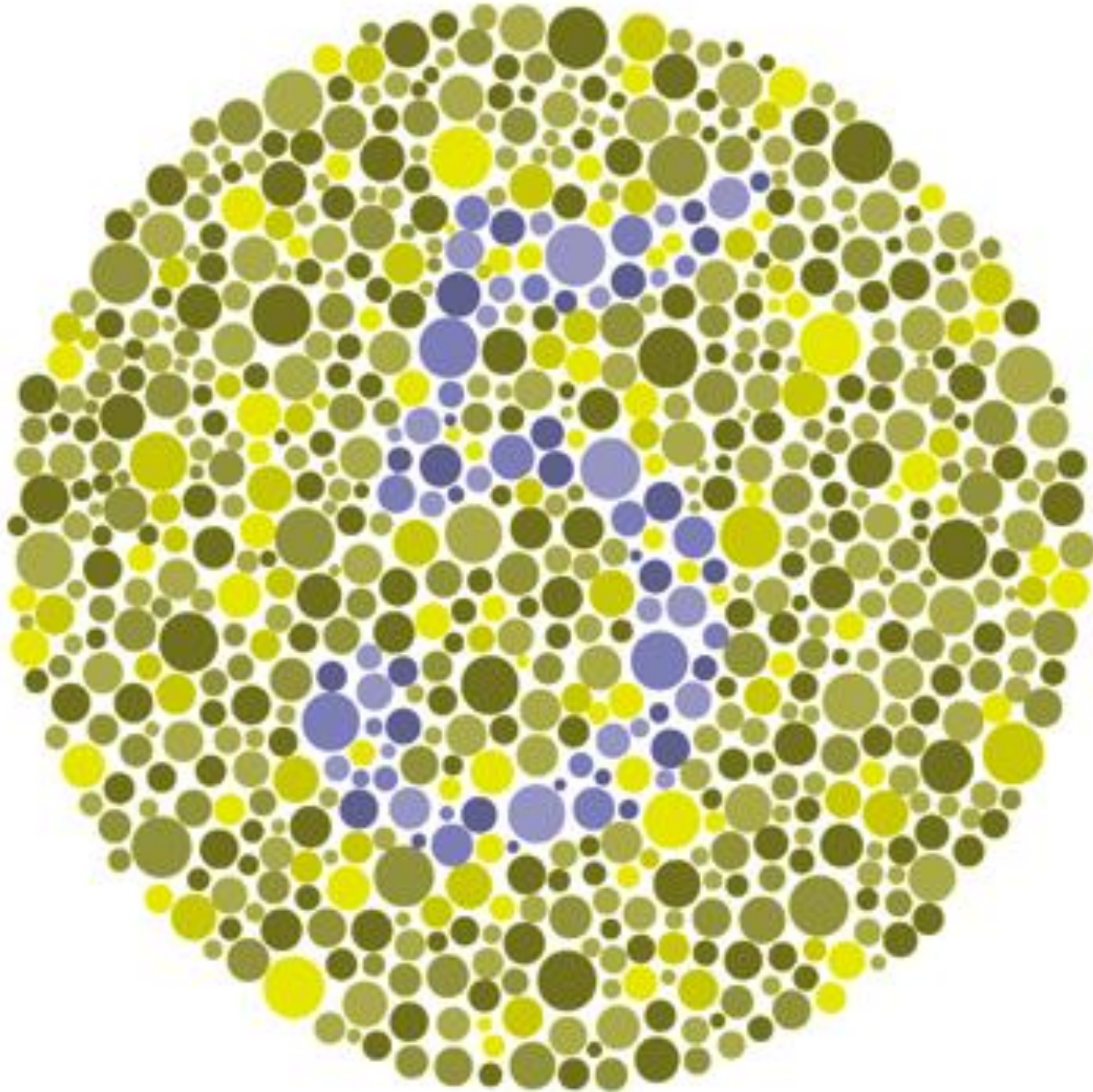
Daltonization: Improving Images for People with Color Vision Deficiencies (CVDs)



Normal vision perspective

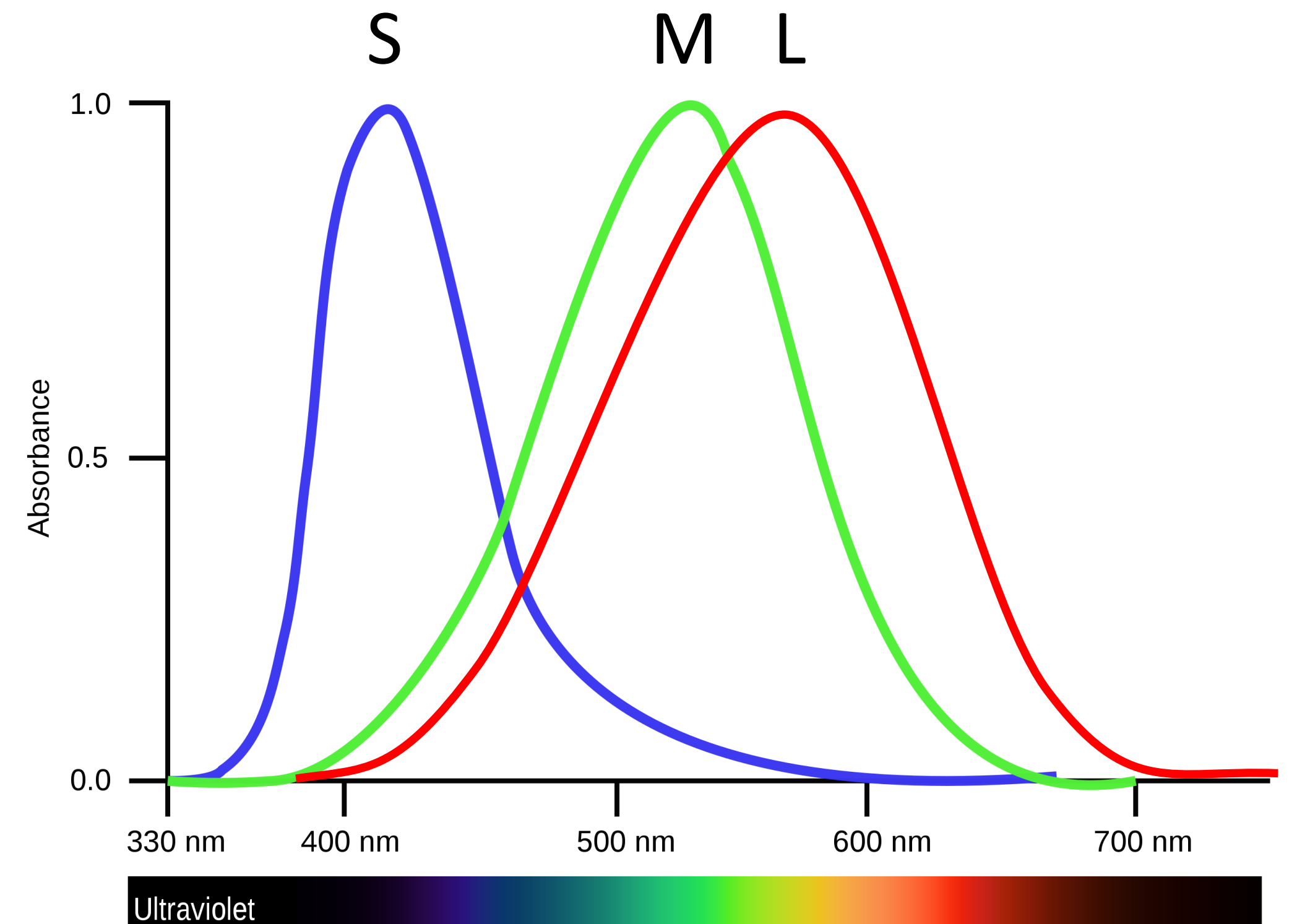


CVD perspective before daltonization



CVD perspective after daltonization

Dichromacy

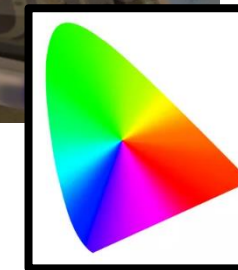


Not an idiosyncrasy
Sensitivity of the LMS cones

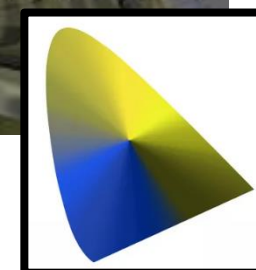
CVD Simulation



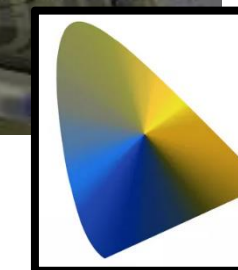
Normal vision



Protanopia



Deuteranopia



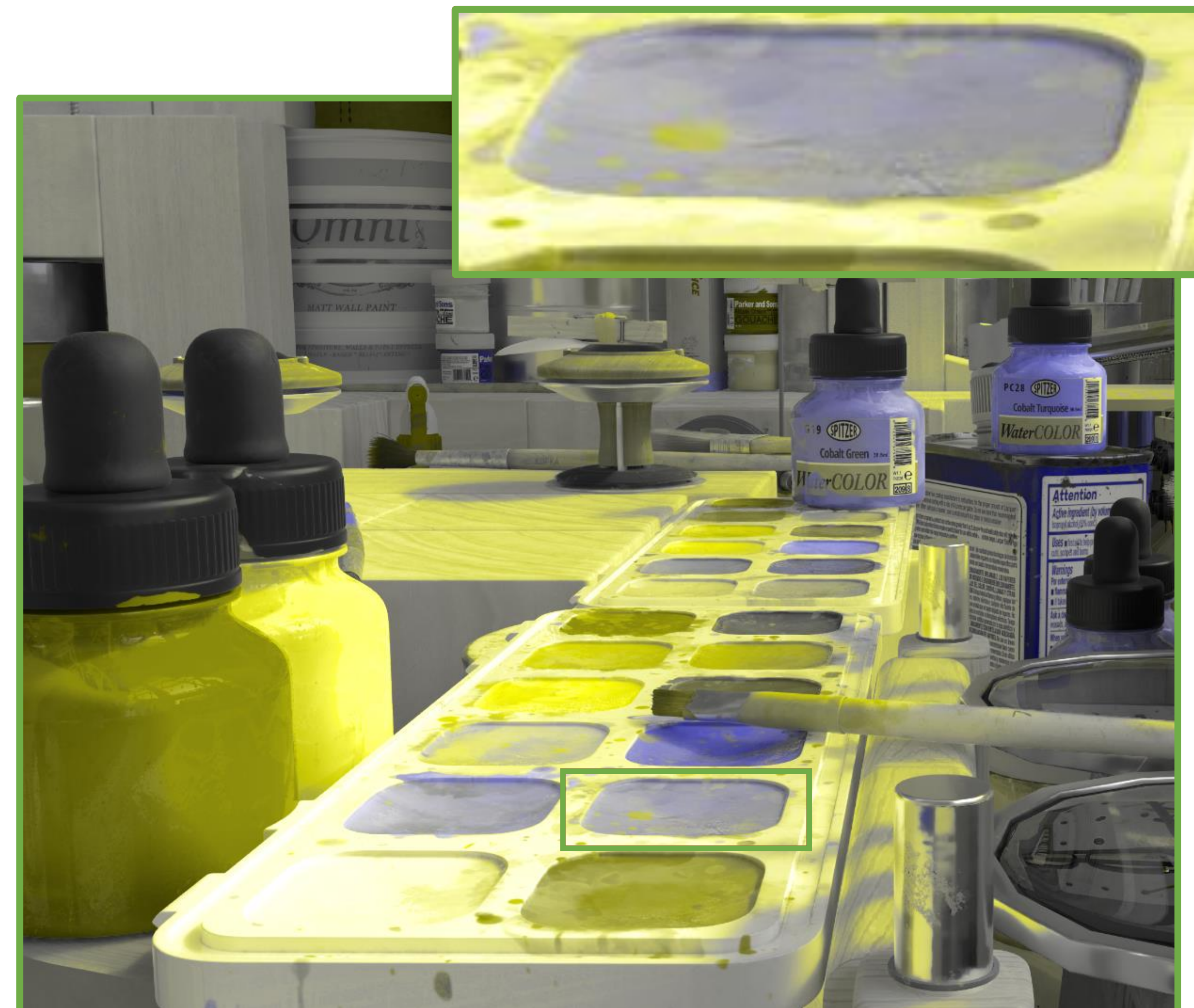
Tritanopia



Daltonization



Normal vision perspective



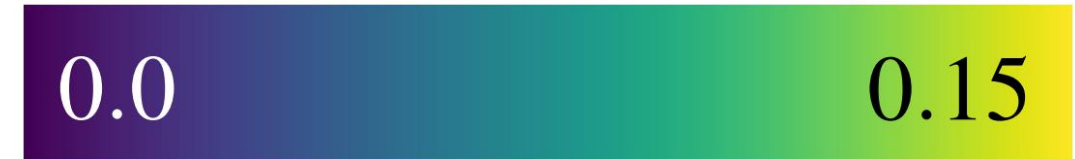
Protanopia CVD perspective

+ Our Daltonization

(~0.2 ms / frame – RTX 4090)

Luminance Preservation

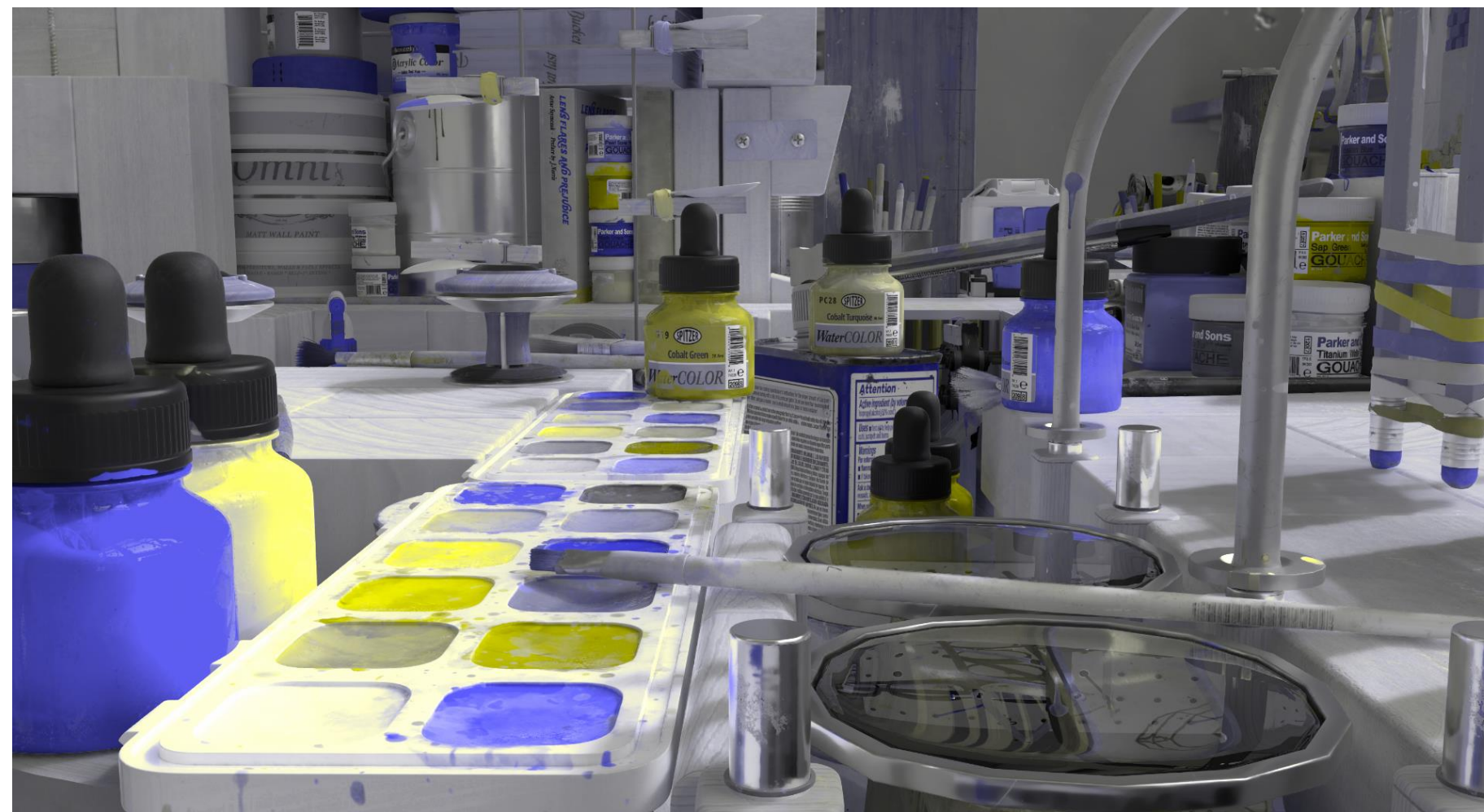
Luminance difference compared to original



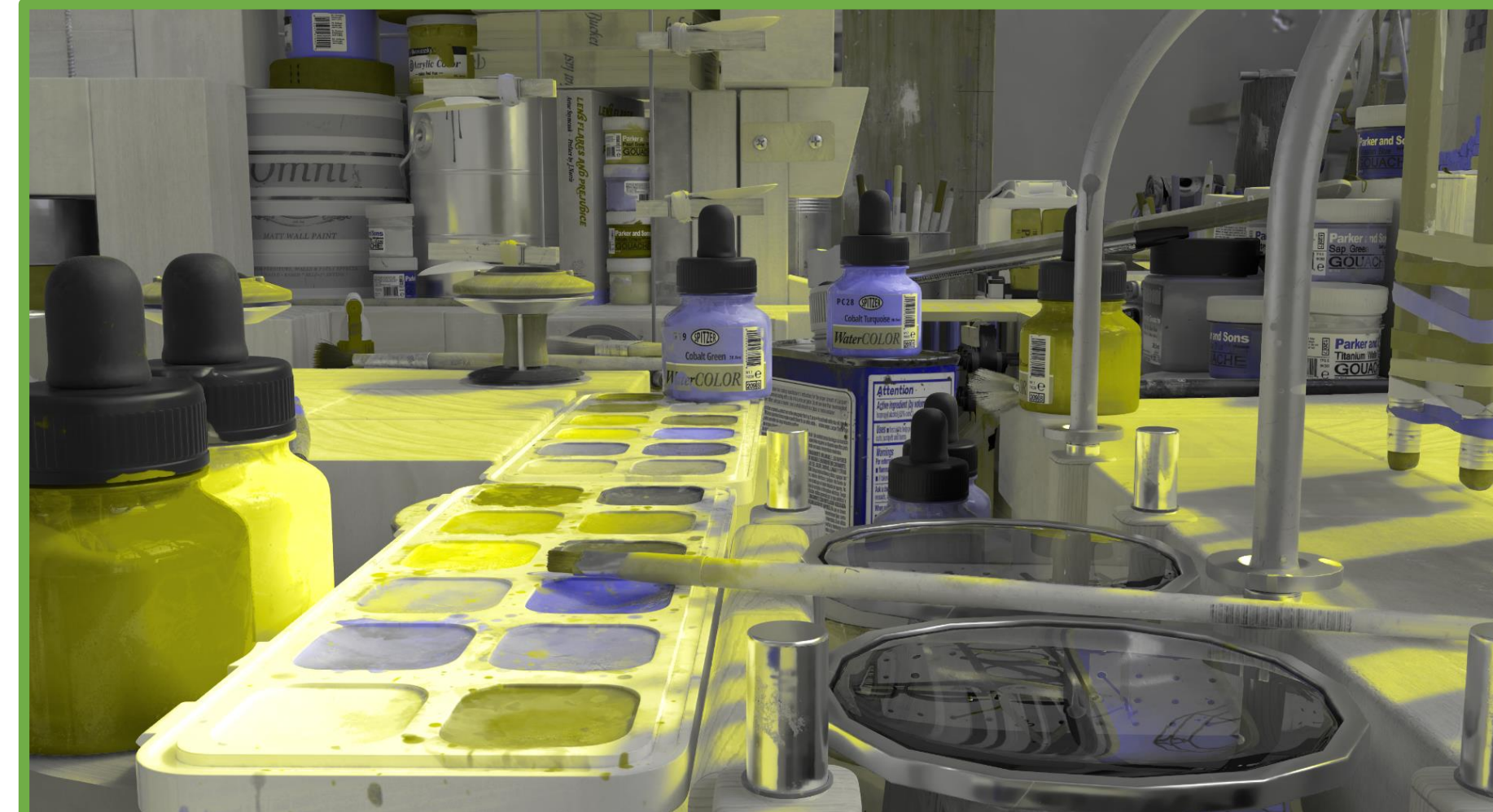
Original



CVD



CVD + Farup [2020]



CVD + Ours



Daltonization without Temporal Stability



**Normal vision
perspective**



**CVD perspective
+
Daltonization
(Machado and Oliveira [2010])**

Our approach: Temporal Stability



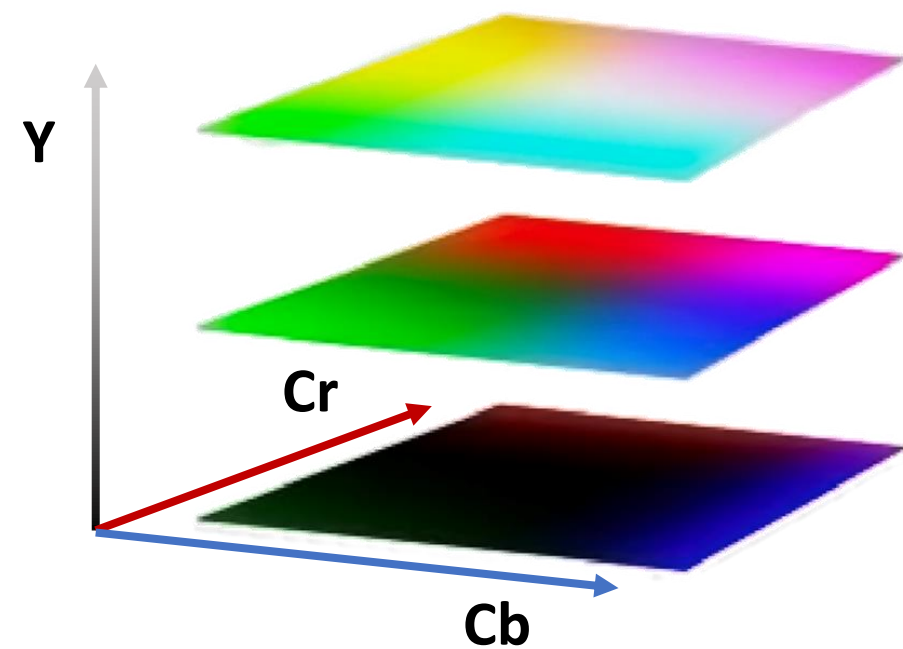
Normal vision
perspective



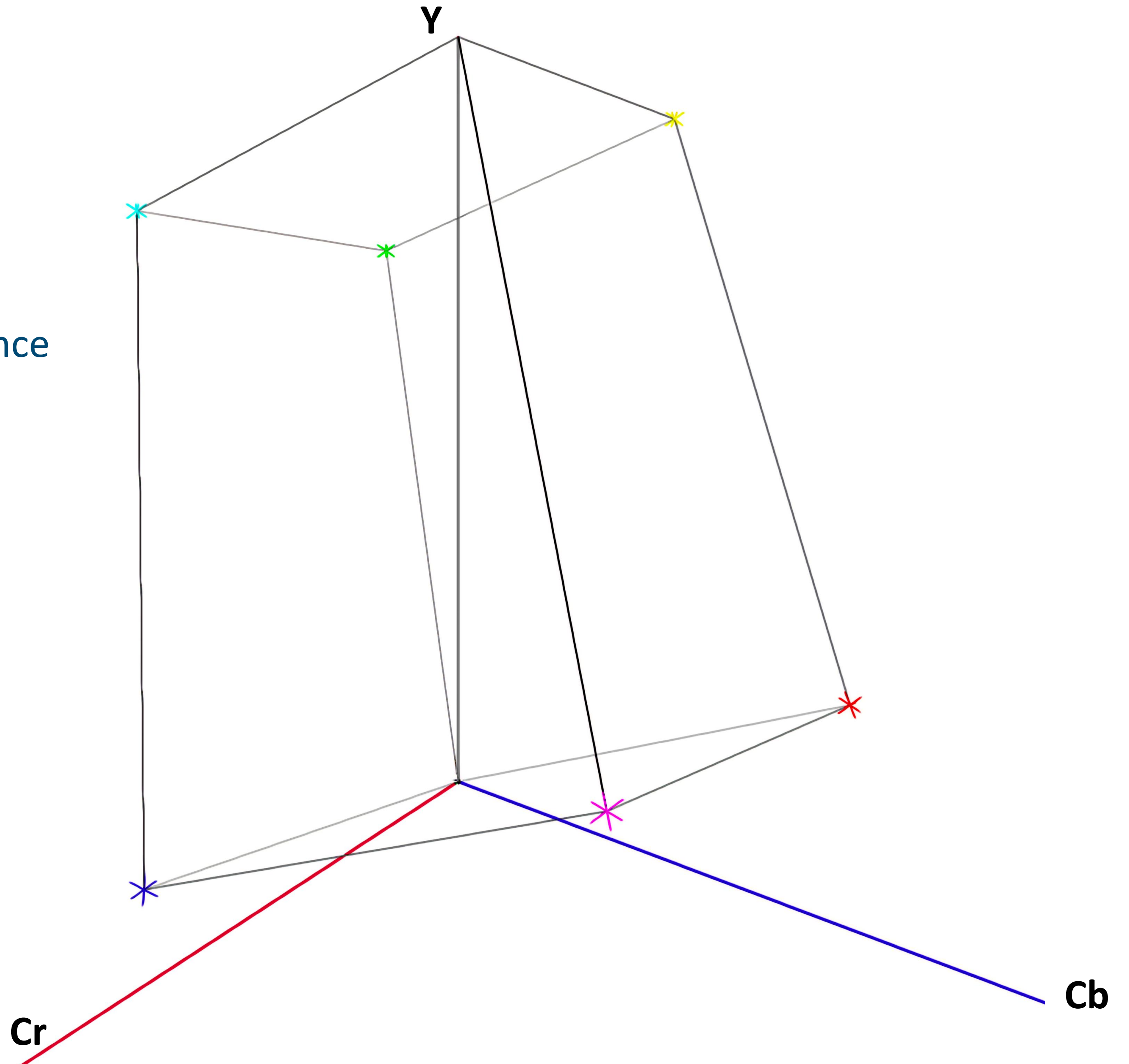
CVD perspective
+
Daltonization
(Ours)

RGB Cube in YCbCr

- **Color transform to *linear* YCbCr**
 - Linear luminance
 - Separates luminance and chrominance

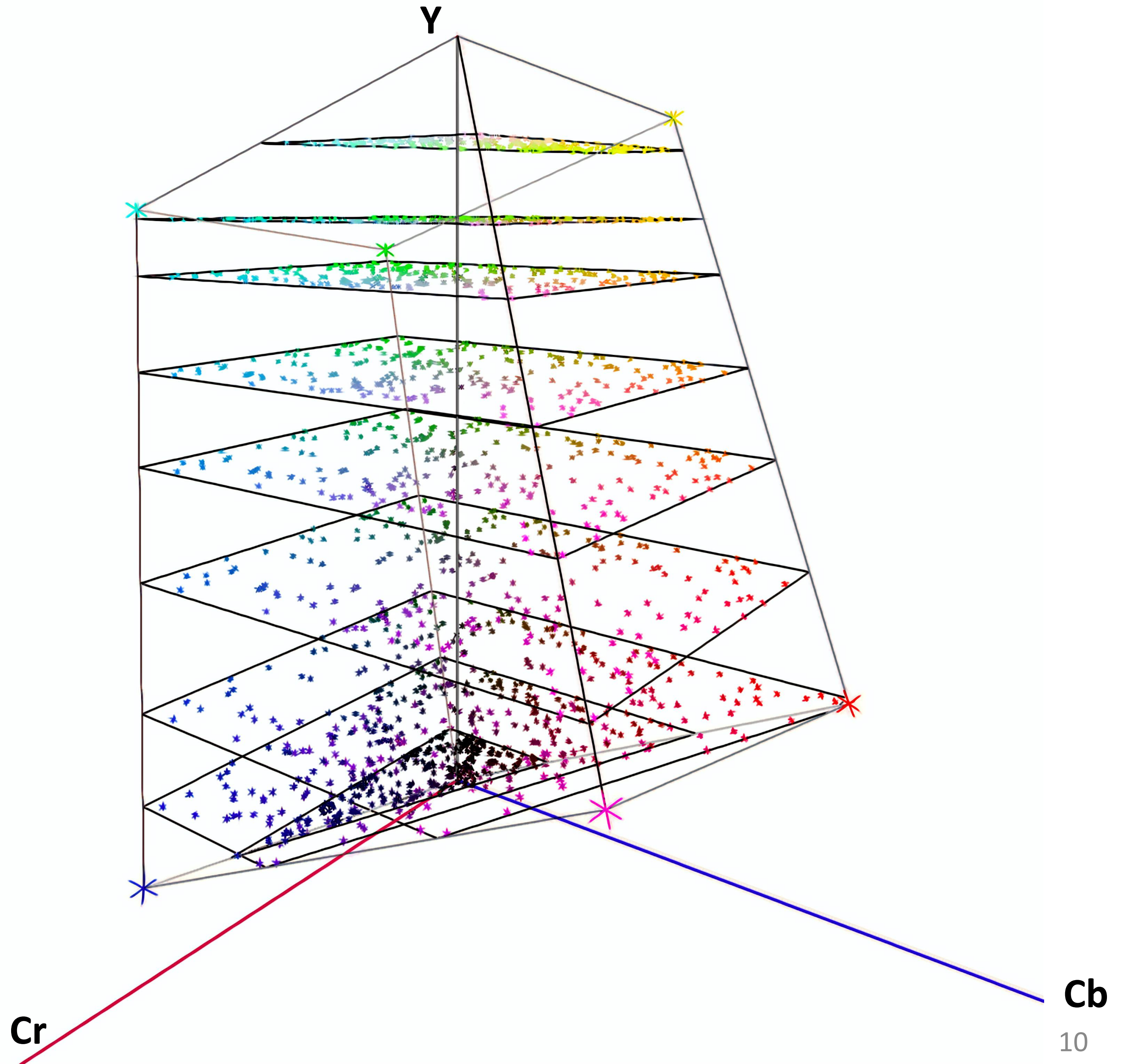


- **Transformed RGB cube**
 - Generates an RGB parallelepiped



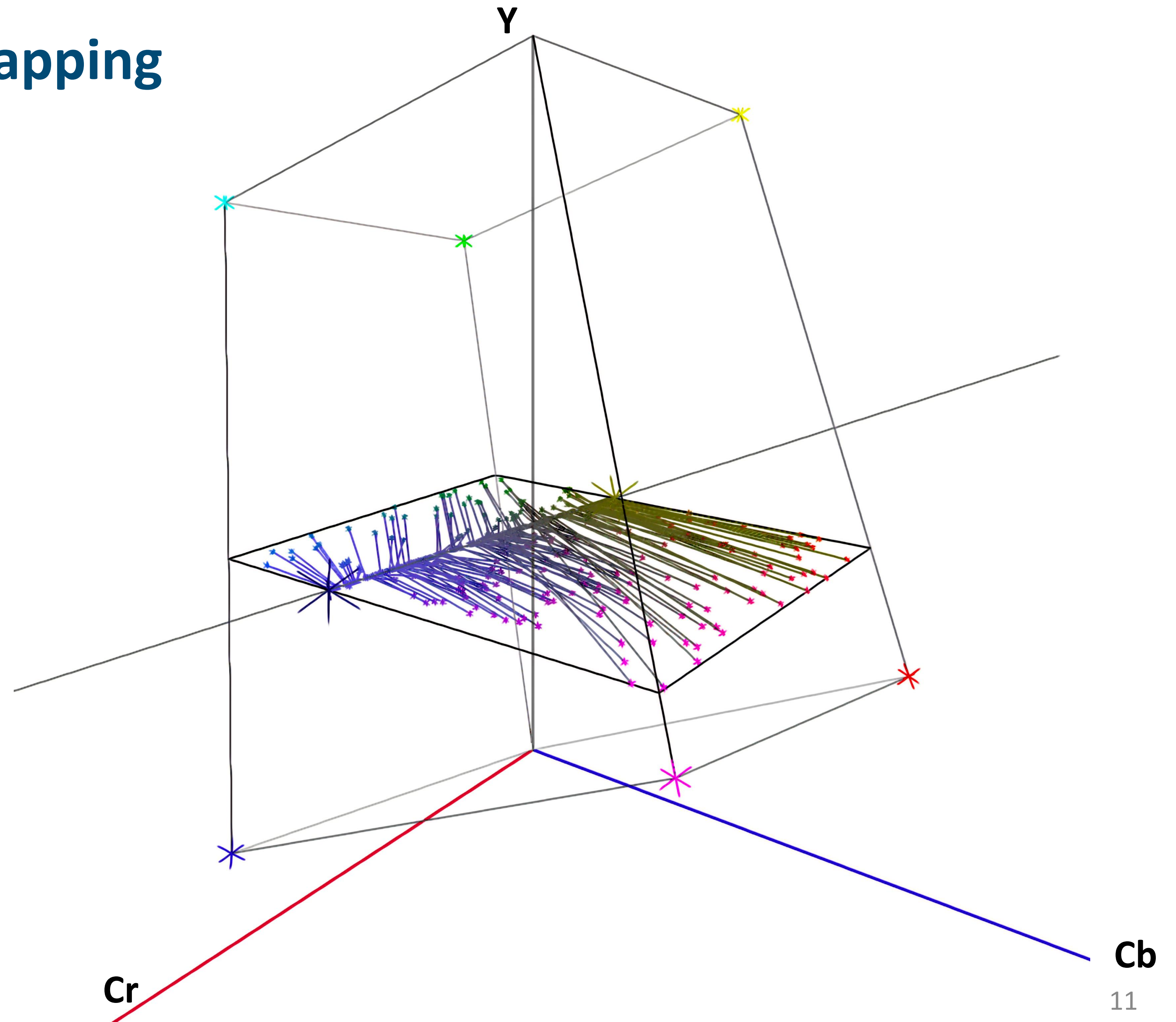
Luminance planes

- Equiluminance planes crossing the RGB parallelepiped
 - Luminance polygons



Per-polygon color mapping

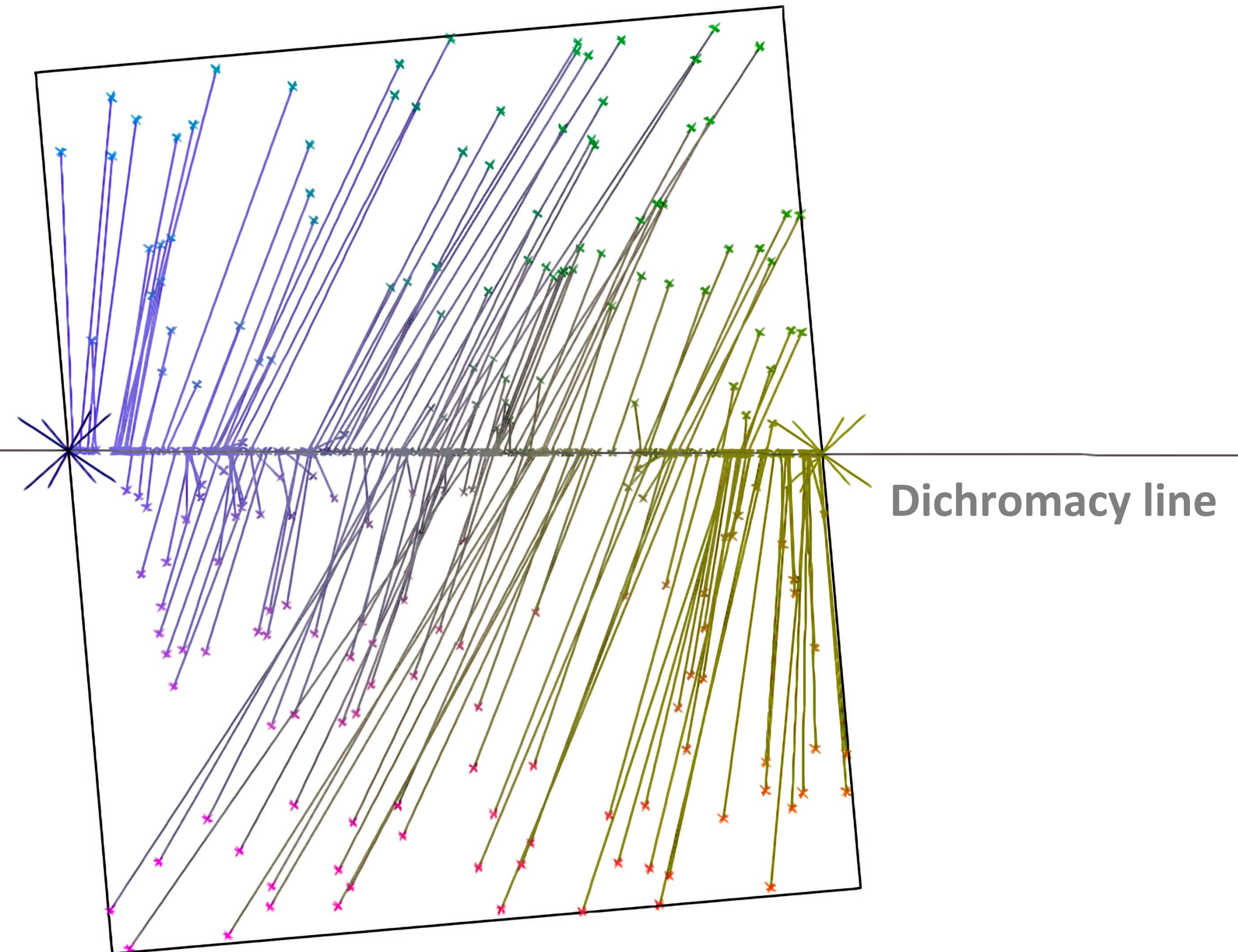
- **Final Daltonization**
 - Luminance-preserving transformation



Daltonization: Optimized color mapping

Goal: Map all colors onto the **Dichromat's line of visibility**

- 1. Initial projection:**
Project colors to the dichromat's line of visibility
- 2. Linear remapping:**
Inside available gamut + preserving grey point
- 3. Red-green differentiating remapping**
- 4. Interpolation:**
Preserving colors close to the dichromacy line
- 5. Weighted histogram equalization**
Increase the use of available colors



Remapped colors result



Original Image



Remapped Color Image
(Ours)

Color back-projection



Original Image



Presented Image
After back-projection (Ours)

(No change in how a dichromat sees the image)

Color back-projection



Original Image



CVD Perspective



Presented image

Evaluation

Original

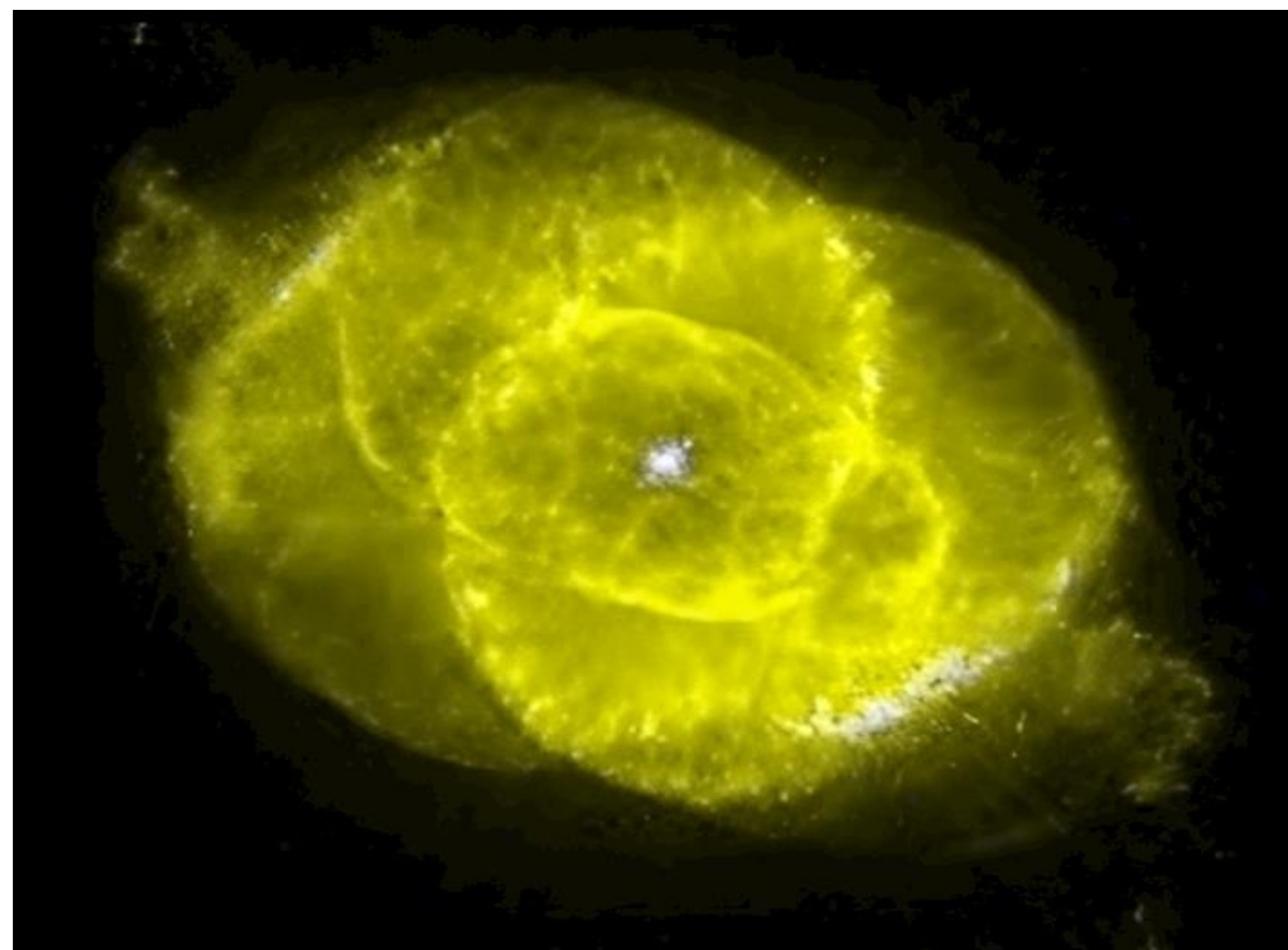
Daltonization: Ours

Daltonization: Farup [2020]

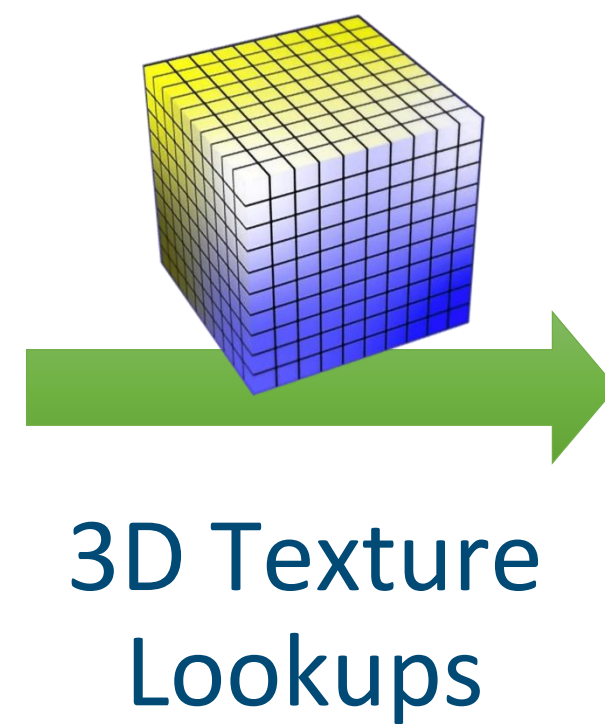
Normal
vision
perspective



CVD
perspective
(Protanopia)

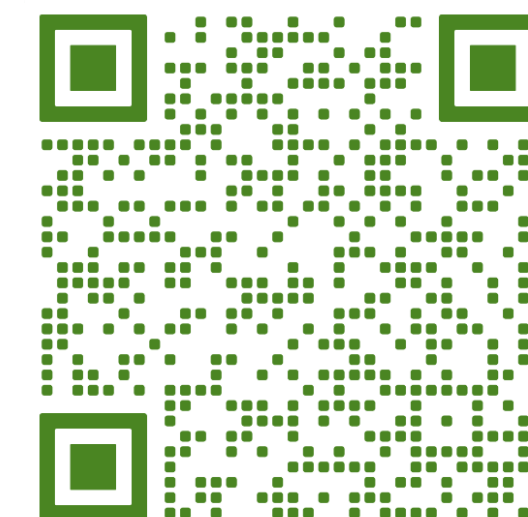


Real-time implementation



3840x2160 image : ~ 0.2 ms / frame

Follow the QR code to find our paper and supplemental material:
(https://research.nvidia.com/publication/2023-05_daltonization)





Original sequence

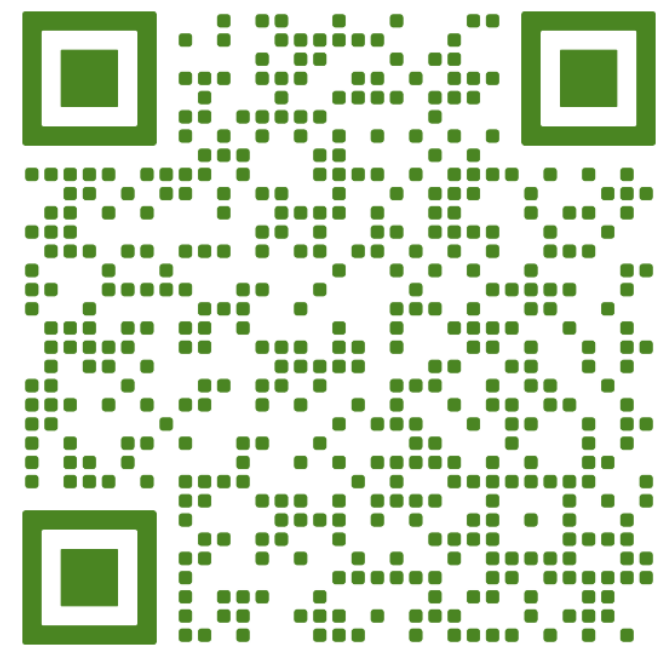
CVD simulation



CVD + Daltonization (Ours)



Thank You



https://research.nvidia.com/publication/2023-05_daltonization