

A cinematic still from a film. A man in a grey hoodie sits on a dark rooftop ledge, his back to the camera as he looks down at a small object in his hands. The background is a vast, dark cityscape at night, with numerous skyscrapers and a dense cluster of lights from windows and streets. The sky is a deep, dark blue. The overall mood is contemplative and solitary.

What you don't see

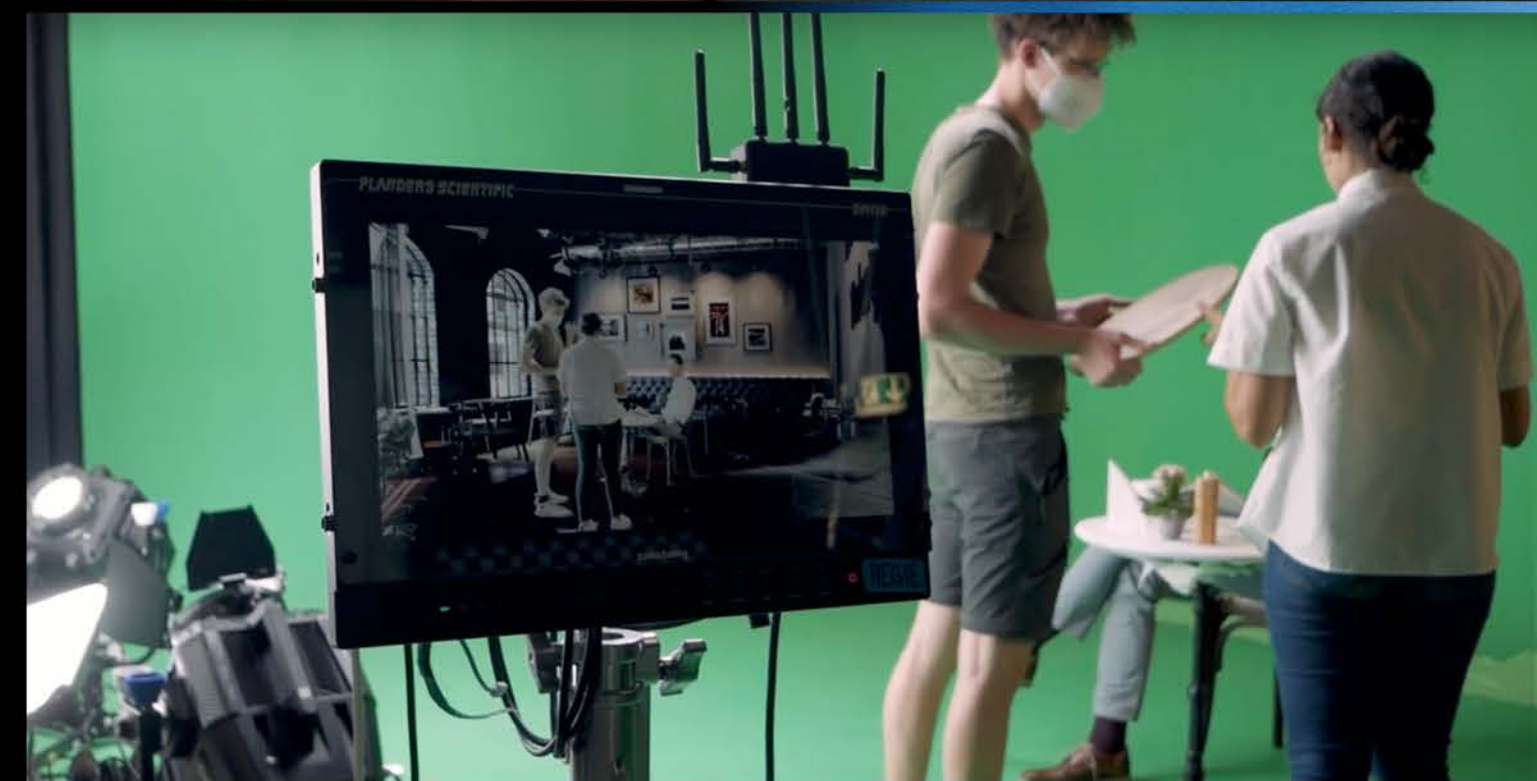
// 35mm-film in the LED-Volume

Sebastian Burk | Luis Zappel Prof. Dr. Jan Fröhlich

Who's talking?

Sebastian Burk

- Stuttgart Media University
- Ba. Eng. Audiovisual Media
- Currently Masterthesis in Audiovisual Media Creation and Technology
- Image Composition, Color, VFX
- Creative and Nerd
- Onset and Post



A cinematic still frame showing a man in a light blue hoodie sitting on a dark rooftop ledge. He is looking down at a small object in his hands. The background is a dense city skyline at night, with numerous skyscrapers and buildings illuminated by warm yellow and orange lights. The sky is a deep, dark blue. The overall mood is contemplative and urban.

Why should you shoot film in a LED-Volume?

Stillframe // 100% shot analog ICFVFX // graded

our goals

- simulate real Set conditions
- push the limits
- advantages & challenges
 - > Moiré, Colors, Workflow...

Stillframe // 100% shot analog in-camera // graded

Hard Facts

Studio: Hyperbowl Munich

- ROE Diamond LED Panels
- 2.6 mm Pixelpitch
- 1600 Nit maximum Brightness
- Nvidia Quadro RTX A6000
- OptiTrack Tracking-System
- Unreal Engine 5.2

**HYPER
BOWL**

Stillframe // 100% shot analog ICVFX // graded

Hard Facts

Analog

- Arricam ST, Kodak Vision3
- 35 mm 250d
- 24 fps
- Sync via Genlock with external speed box and manual phase adjustment
- Custom OCIO for Kodak Vision 3

Digital

- ARRI AMIRA
- UHD (3840 x 2160)
- 24 fps
- Sync via Genlock
- Custom OCIO
- Inner-frustum recording

Stillframe // 100% shot analog ICFVFX // graded

Color Calibration

//Considerations

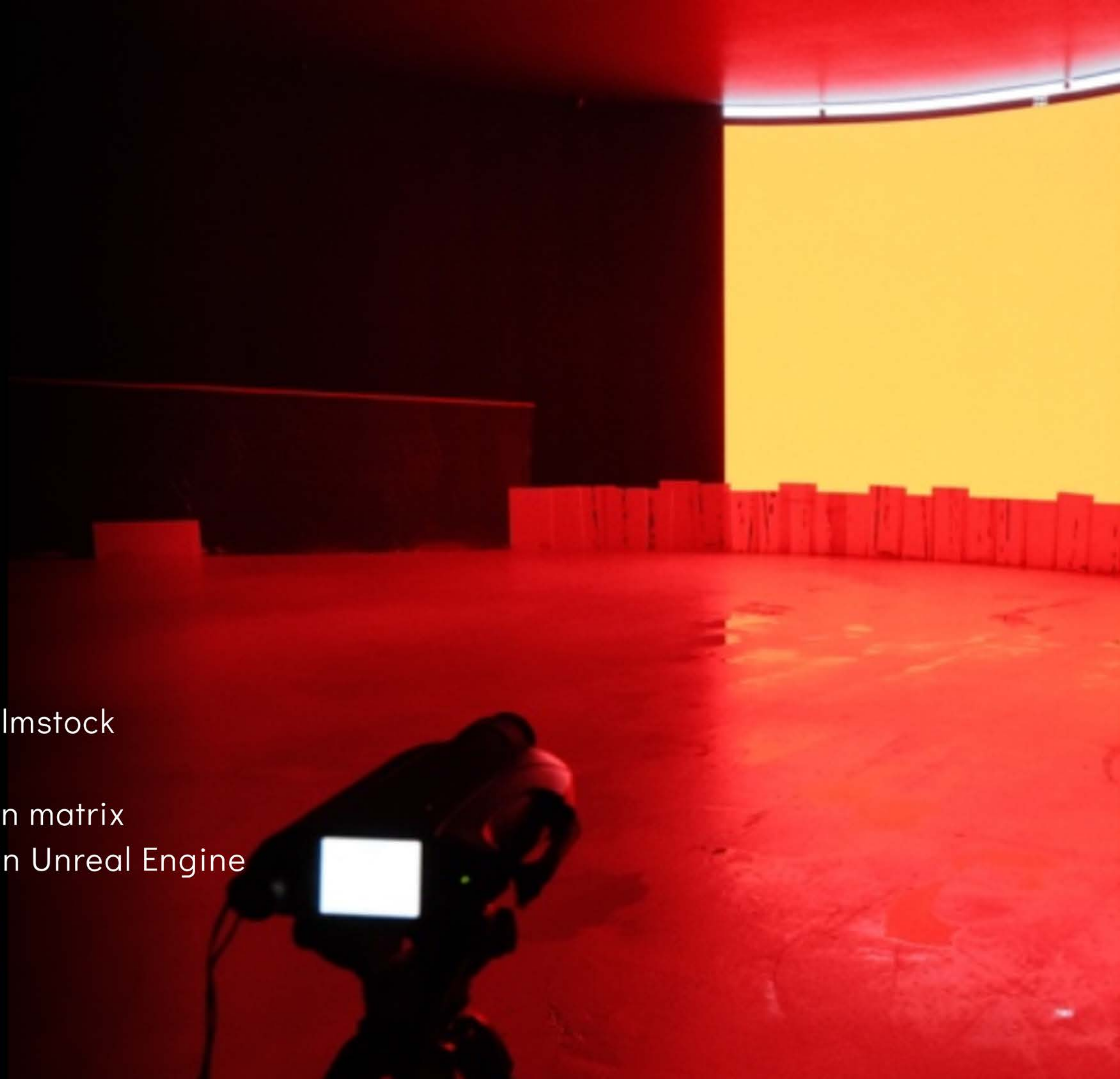
- calibration of LED-Wall to match filmstock is needed
- same workflow for analog and digital camera
- no ARRI ColorTool was used



Color Calibration

//Workflow

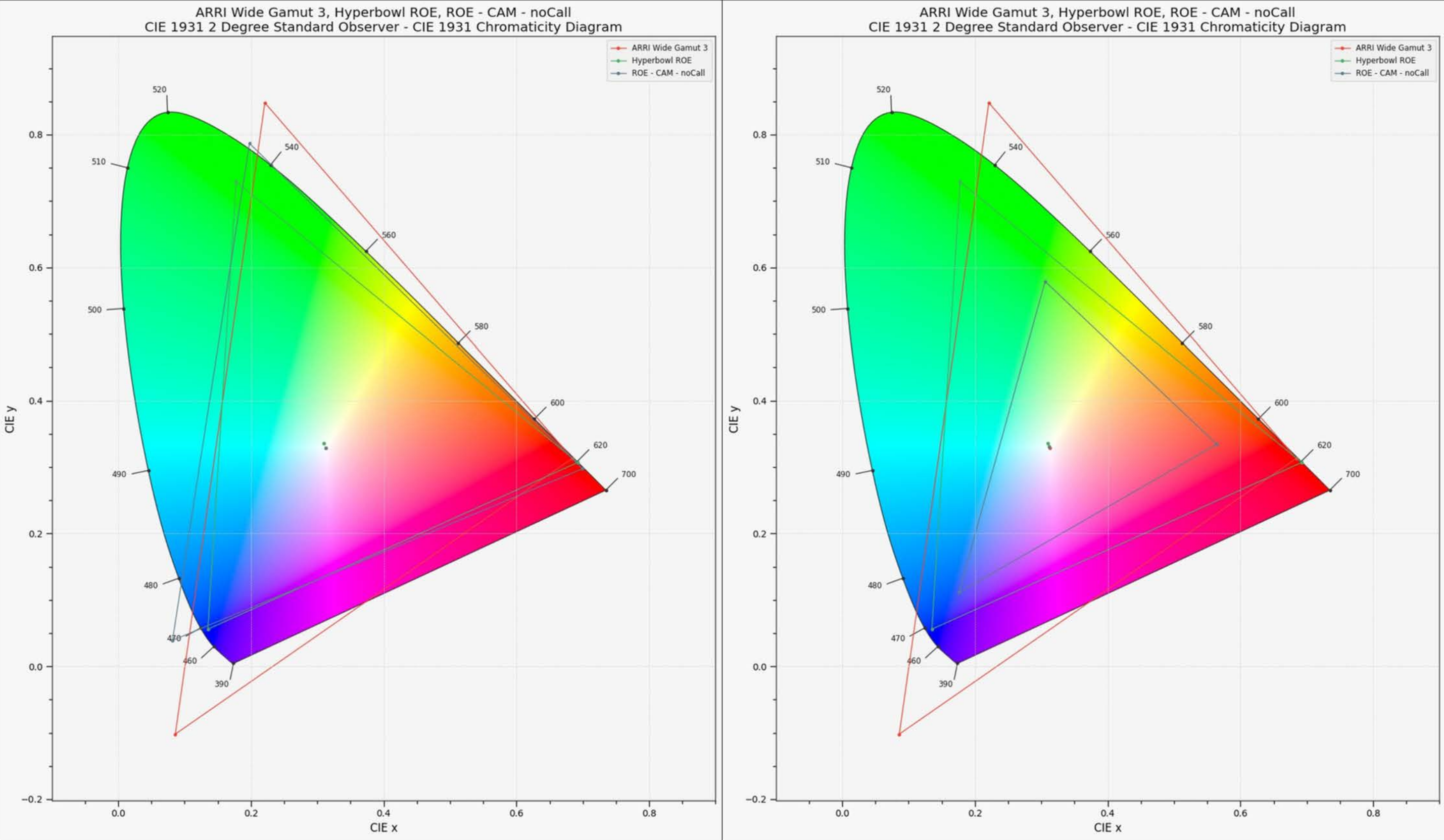
- measurement of LED Primaries
- capturing of the primaries with specific filmstock
- developing and scanning
- calculating $u'v'$ coordinates and correction matrix
- implementing correction matrix as OCIO in Unreal Engine



Color Calibration

//Results

MPTS 2025 | 15.05.2025



Color Calibration

//Workflow

- unexpected gammut results
- communication and timing challenges
- decision to shoot filmstock with same calibration as AMIRA for practical reasons
- footage in the end was scanned with ARRI scan



Synchronisation

//connecting digital and analog worlds

- in digital world precise sync is extremely important
- in analog context scanline artefacts are not to be expected
- doubleframes are visible if not synchronised
- sync source for camera with genlock via sdi and external speedbox
- sync pulse for Virtual System and ARRICAM ST is needed

Visual sync via red bars

Synchronisation

//manual syncing

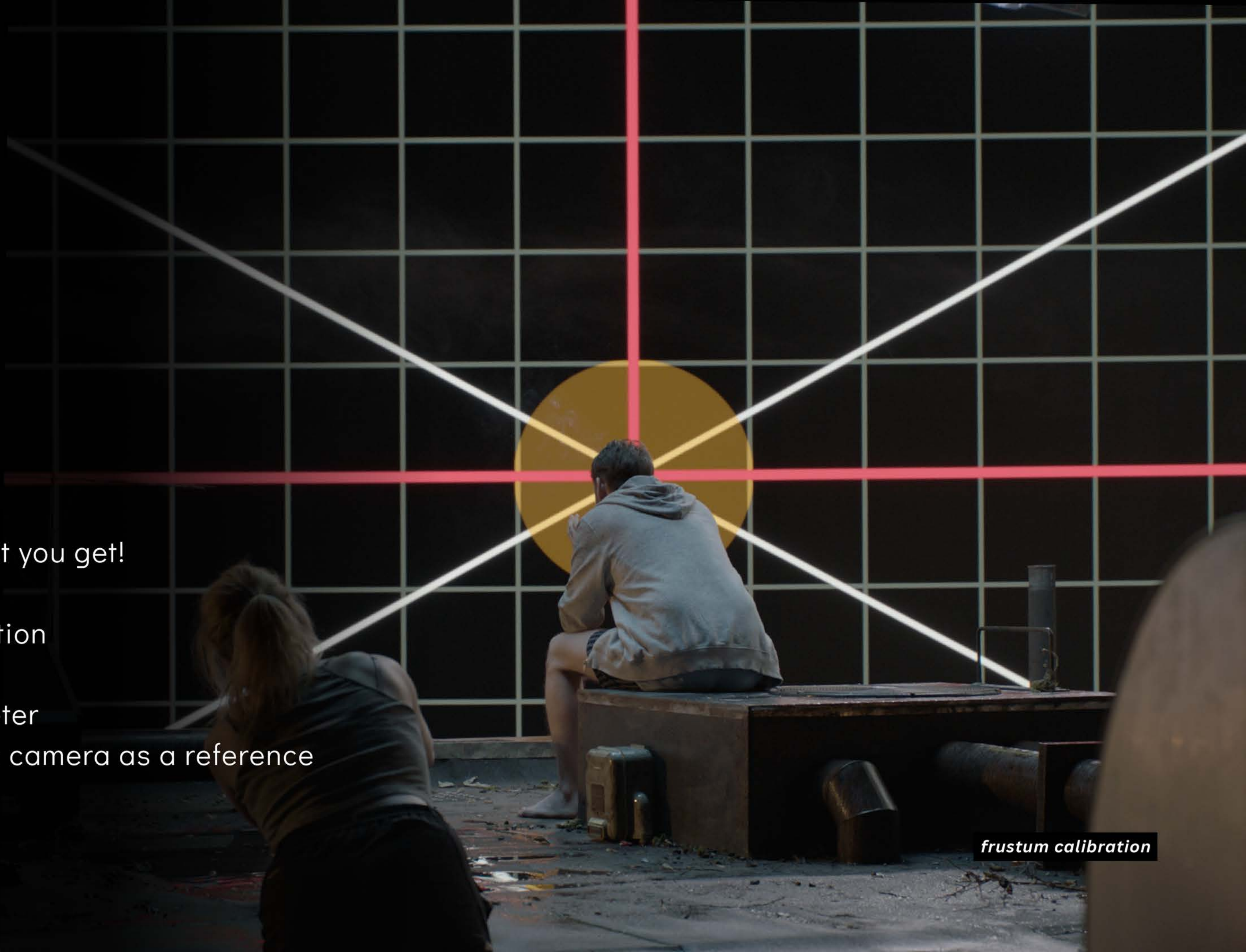
- checking optical with vertical moving bars
- manual adjusting the offset
- aiming for maximal doubleframes visible in the viewfinder (180° phase switch)
- camera speeds to offset to genlock -> solid sync

Visual sync via red bars

Monitoring

//What you see is not what you get!

- challenges & issues
 - filmstock & calibration
 - artifacts
- importance of light meter
- using a digital cinema camera as a reference



frustum calibration

Color Rendition

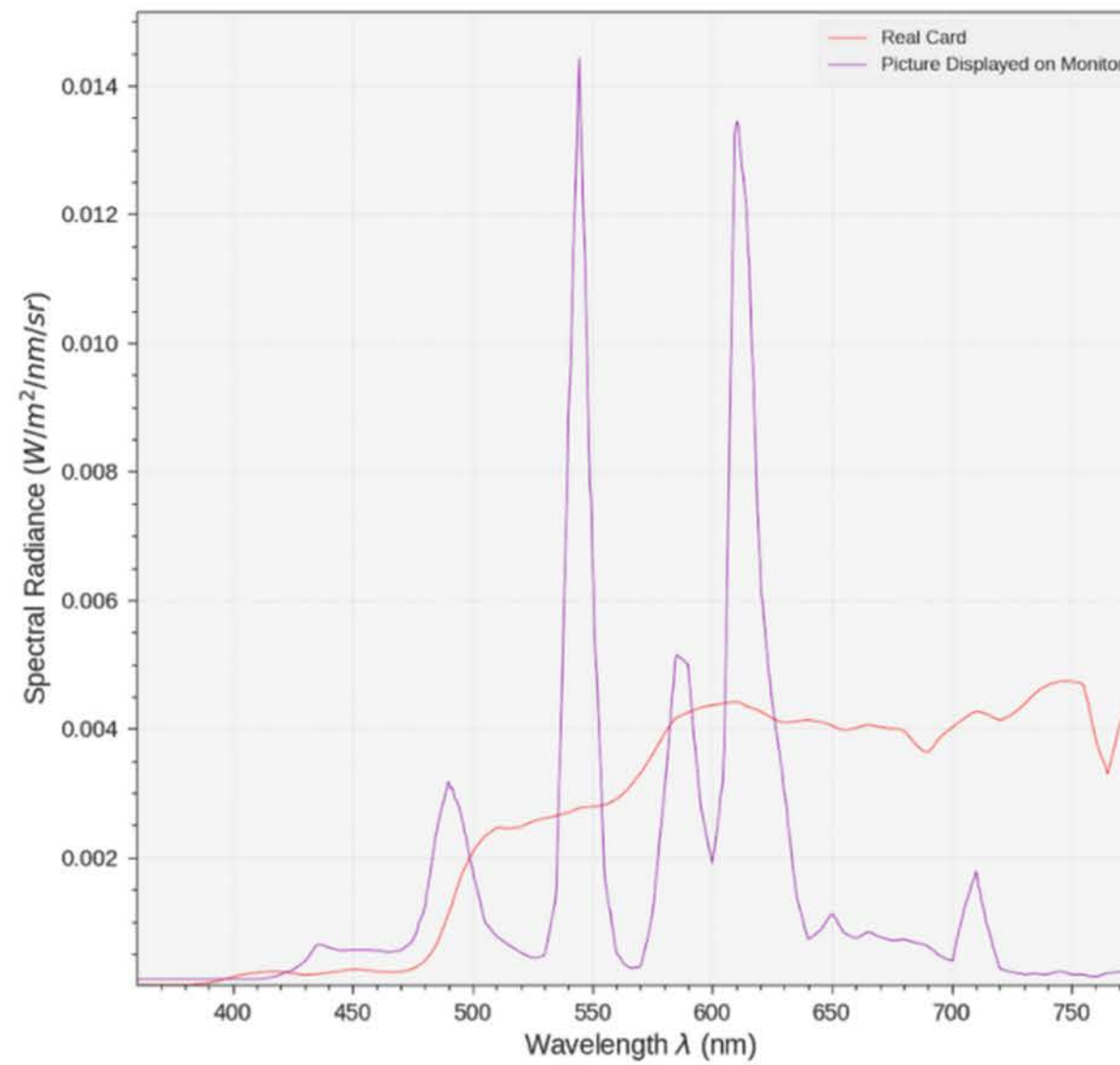
//Challenges of lighting in the volume

- LED-walls are not only a set extension but powerfull light source
- However, the LED panels are not designed for that purpose



Color Rendition

//Challenges of lighting in the volume



Yellow metamerism: two metameric spectral distributions producing the same color stimuli (metamers) even though the spectral distributions are radically different. The real card spectral distribution is relatively smooth while the spectral distribution of the picture of the card displayed on the monitor exhibits spikes from the monitor primaries.

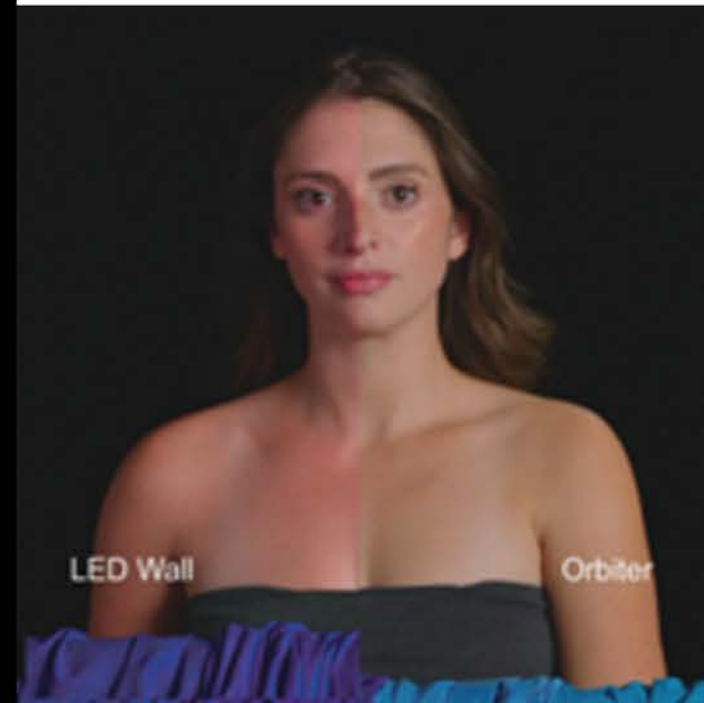
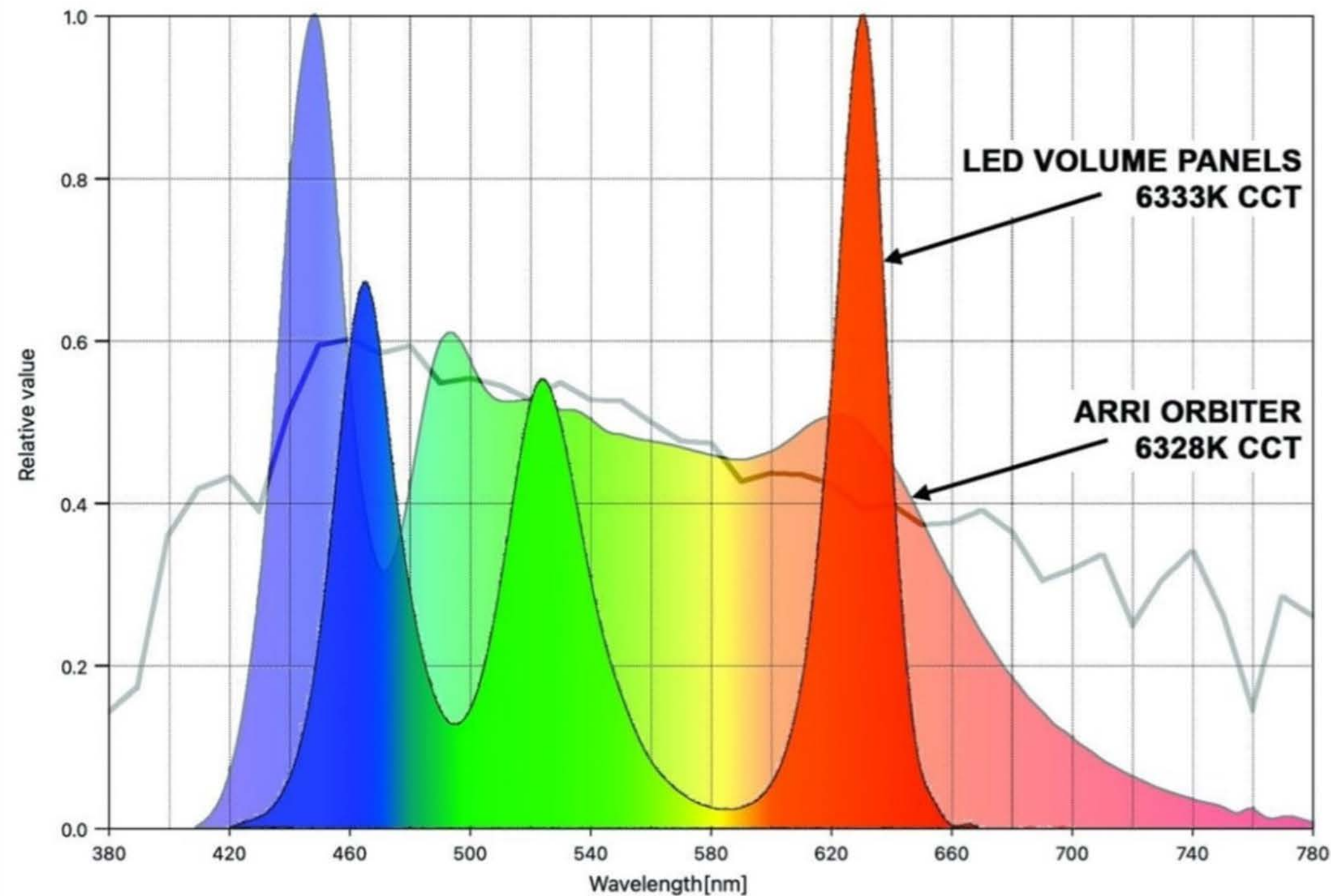
Spectral distributions and image courtesy of David Long (RIT).

- LED-walls used for VP typically only consist of red, green, and blue LEDs
- When the unreal scene emulates light sources like daylight the emitted spectrum differs from the spectrum of the physical equivalent
- two light sources can produce the same color stimuli to the observer even though they have differing spectral power distributions (they are metamers)

Color Rendition

//Metameric failure

- When reflecting off objects, the spectrum make a difference
- The spectrum of RGB-LED sources often causes metameric failures
- These color reproduction errors are especially noticeable in human skintones
- how would film handle these problematic spectrums?



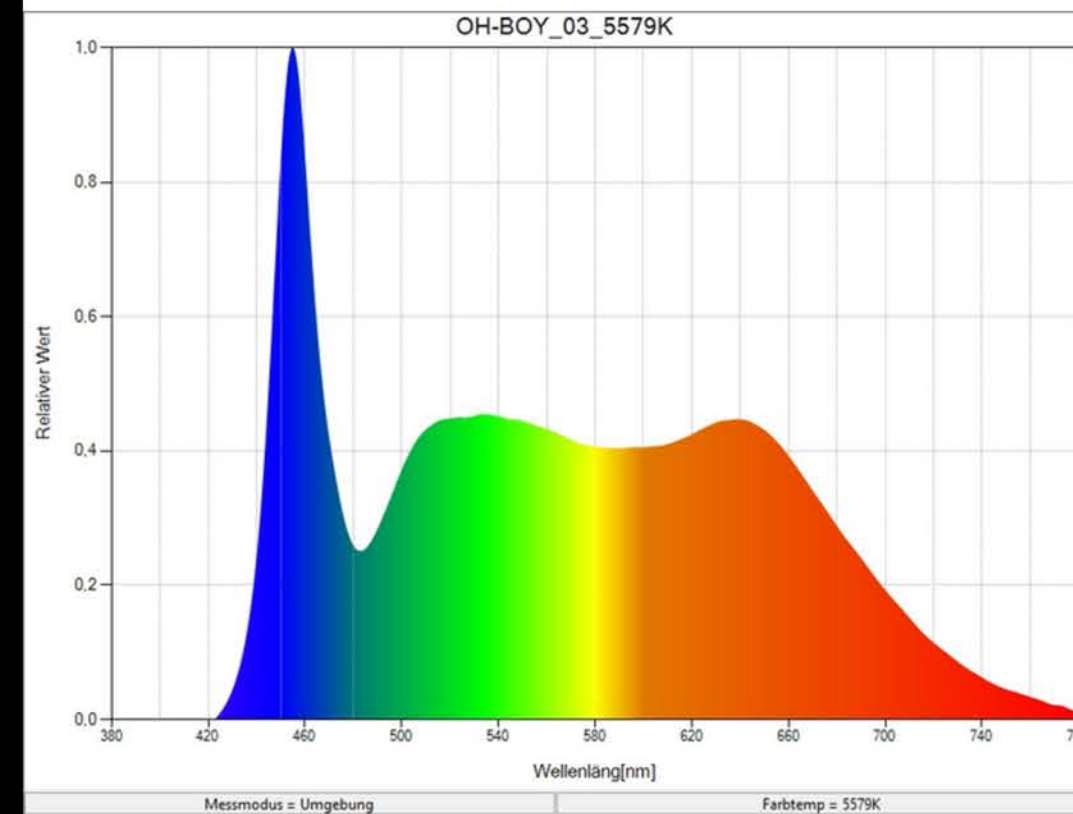
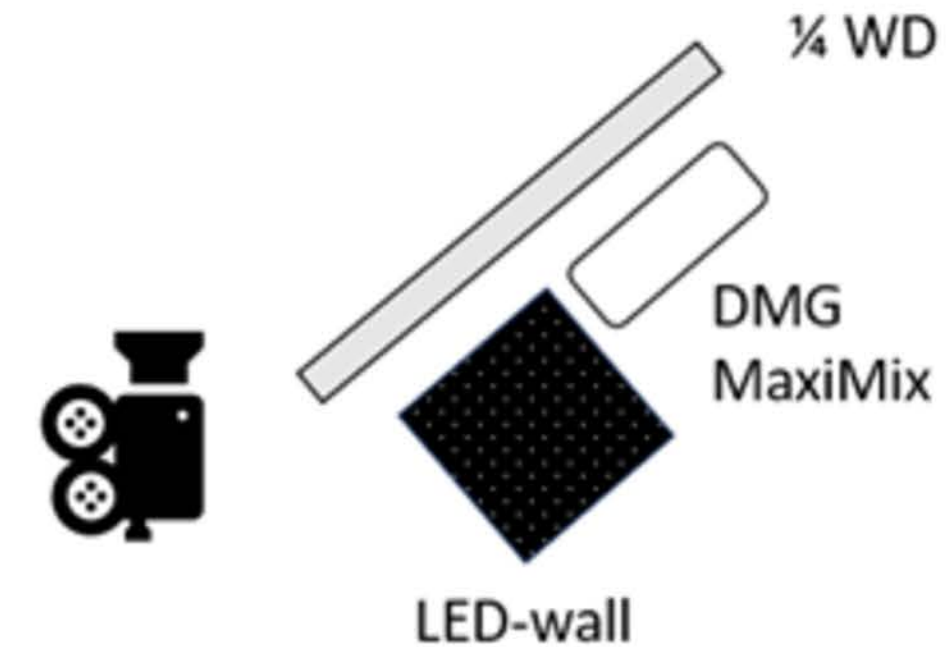
Kadner, N (2021). Color Fidelity in LED-Volumes. <https://theasc.com/articles/color-fidelity-in-led-volumes>

Color Rendition

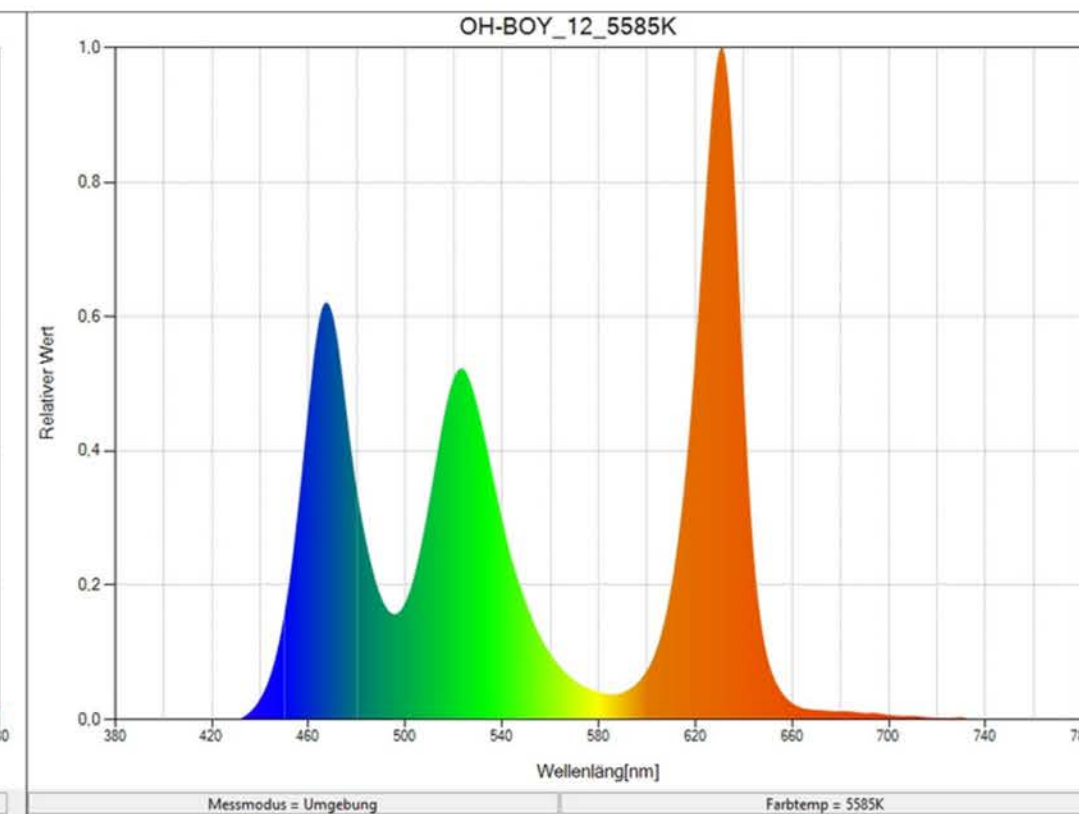
//Testing for Metameric failure on Film and digital

Test Setup:

- Kodak Vision3 250d vs ARRI Amira
- first lit by a full spectrum LED-panel giving the reference for “optimal”, natural color reproduction
- then lit by an RGB lightsource with narrow band spectrum, mimicing common LED-walls



Fullspectrum LED// Optimum

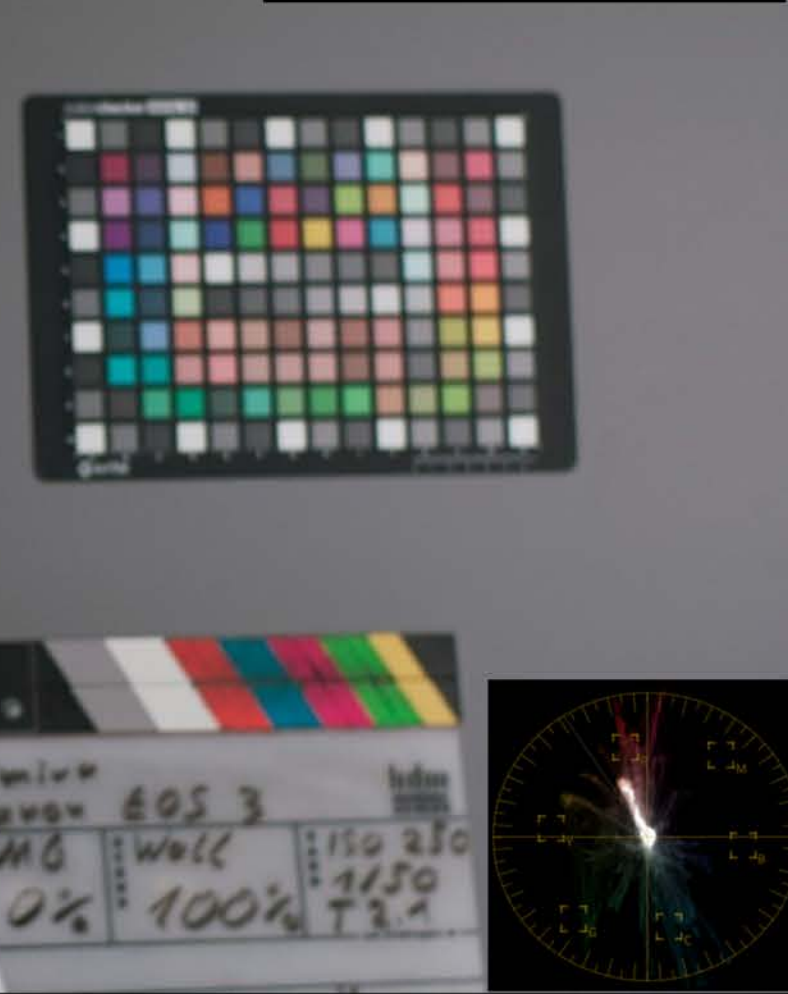


RGB LED// Volume

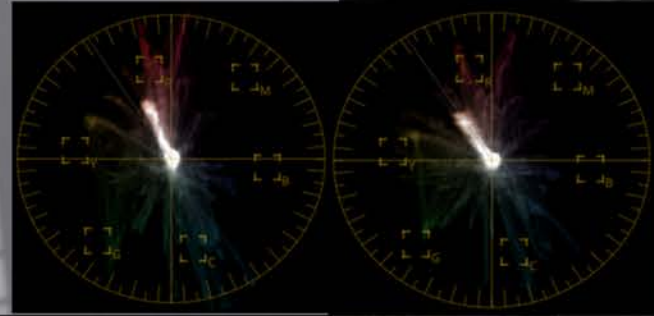
all stills white balanced only



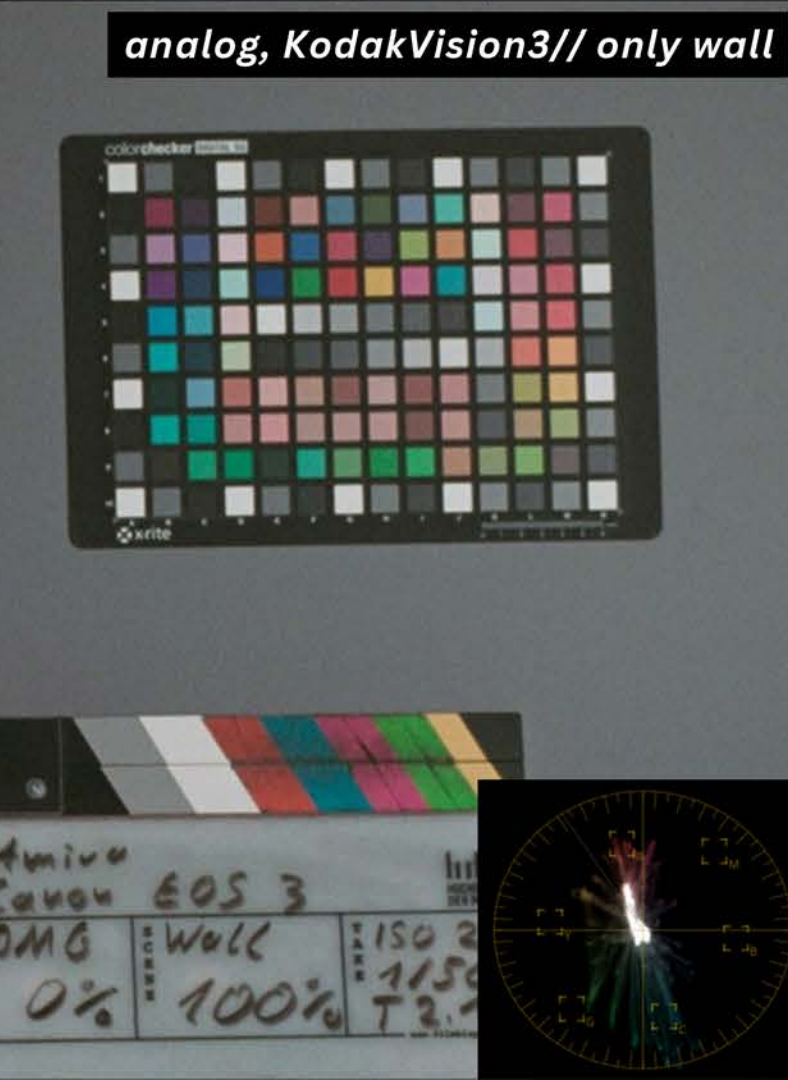
digital, Amira// only wall



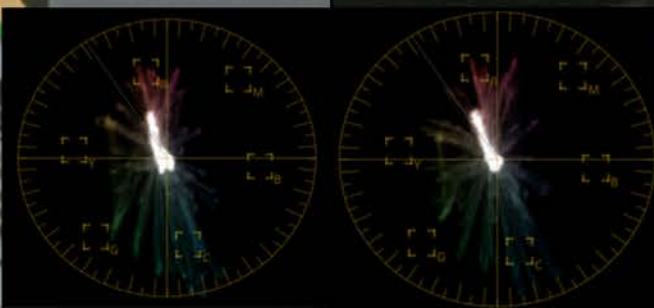
digital, Amira// fullspectrum LED



analog, KodakVision3// only wall



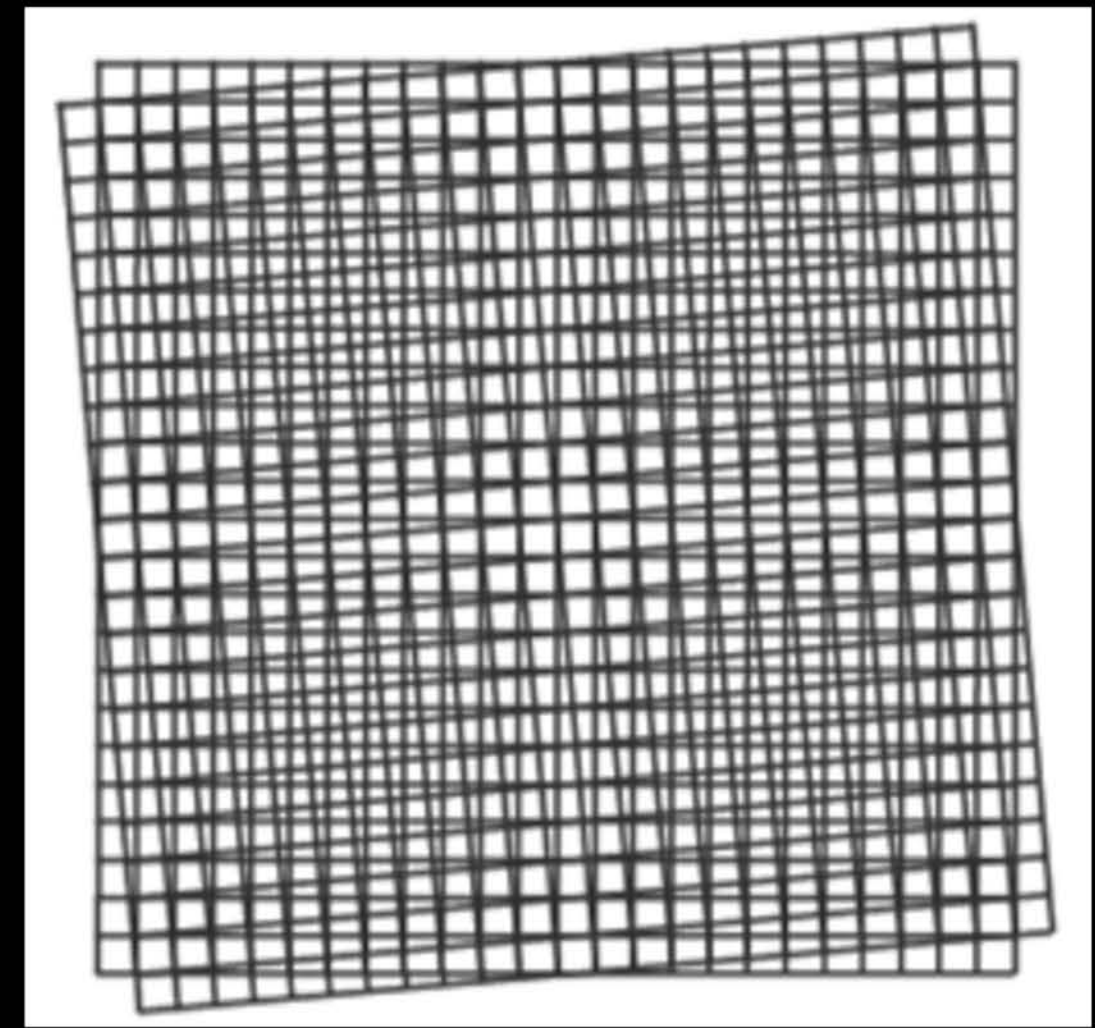
analog, KodakVision3// fullspectrum LED



Moiré

//What causes moiré

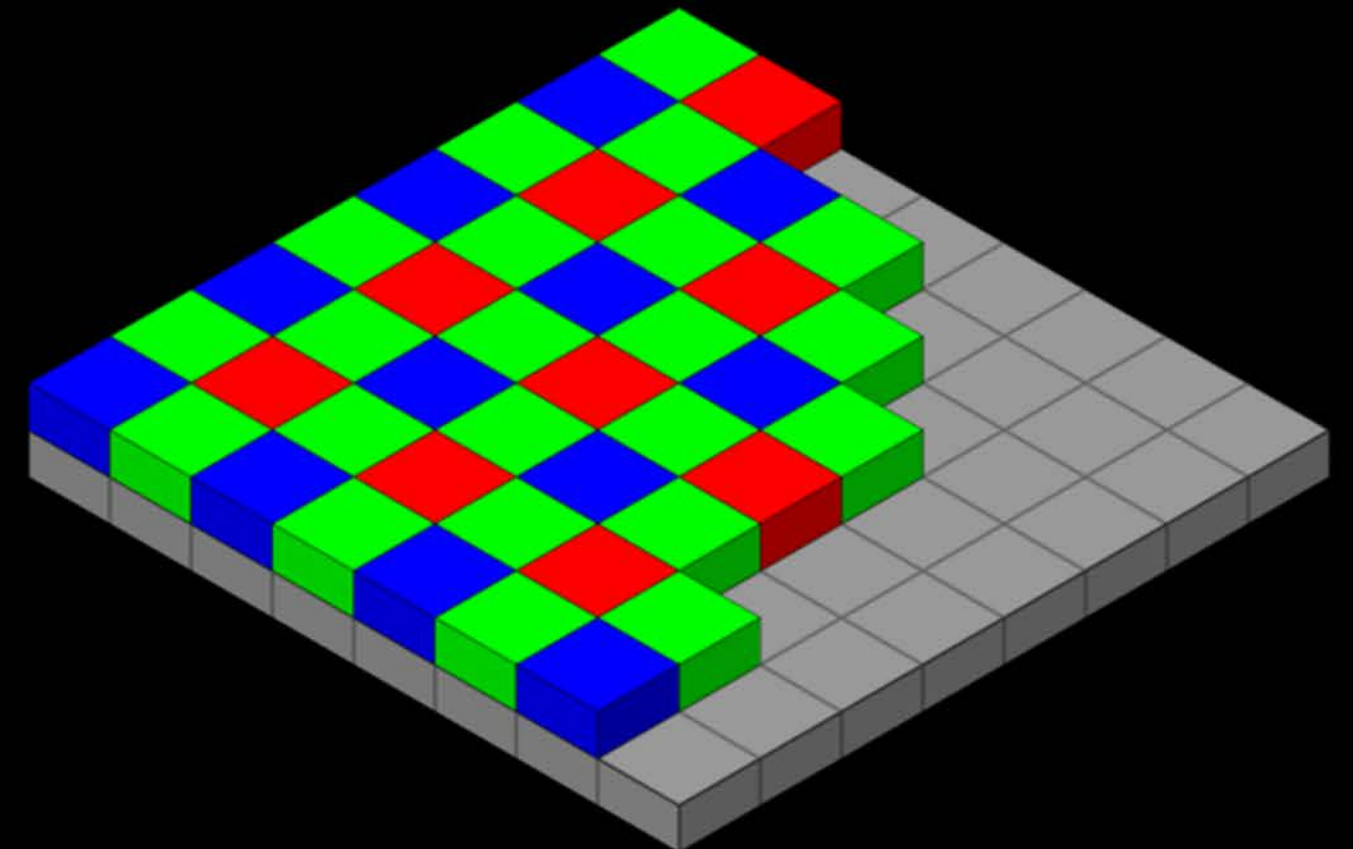
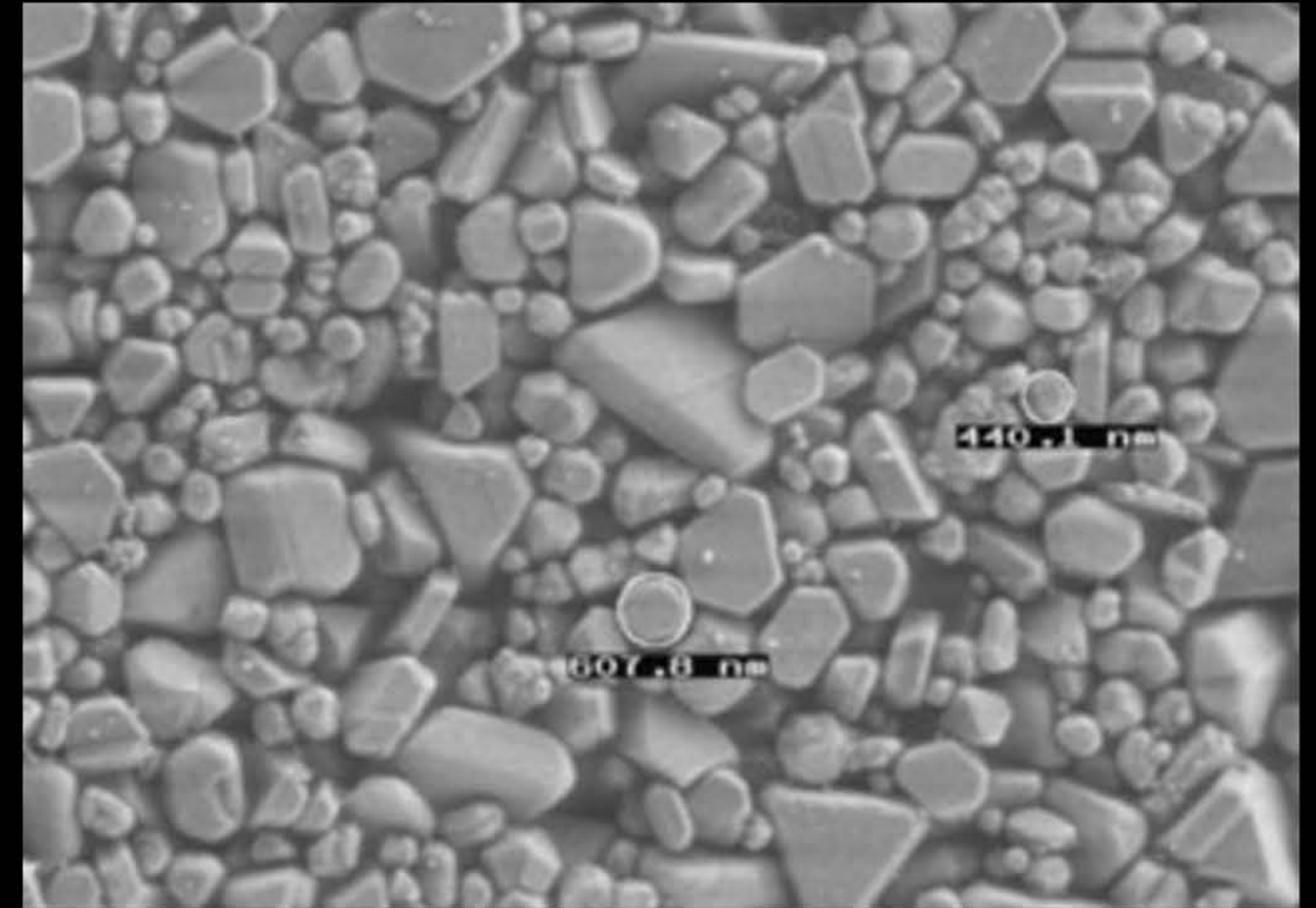
- image artifact caused by two overlaying periodic patterns
- Shooting in the volume heavily provokes moiré because of the grid pattern of the LED-wall
- Moiré occurs at insufficient sampling frequency (defined by Nyquist frequency)
- ratio of the samplefrequency (sensor) to the sampled frequency (LED-wall) also depends on Pixelpitch and focallength, distance to the wall ect.



Moiré

//Differences when shooting film

- celluloid crystals are distributed in irregular patterns on the negative
- moiré artifacts can't be captured on film by plainly filming the LED-Wall



Moiré

//Differences when shooting film

- However moiré can occur in the scan
- digital images naturally provide a second grid pattern
- when the pixel-grid of the LED-wall is resolved clearly enough in the negative so its “visible” to the CMOS scanner, the frequencies can interfere after the same principle
- depending on the scanner, sampling algorithms and potentially even the display in use moiré can occur
- Moiré is not prevented but postponed to the scanning process



analog, KodakVision3// 6k ARRISCAN

analog, KodakVision3// 3k ARRISCAN

Moiré

//Differences when shooting film

- **PRO:**

--> moiré is not baked into the image after capturing

--> the negative is an intermediate step which helps blur the grid before frequencies can interfere

- **CON:**

--> however, no feedback on set, whereas digital cameras give immediate feedback and allow for prevention on set



analog, KodakVision3// 6k ARRISCAN

analog, KodakVision3// 3k ARRISCAN

Workflow-engineering

//Postproduction Advantages

- in ICVFX there is no keying channel,
- alpha channel useful for postproduction adjustings, bug fixing, grading mattes
- searching for an easy way to reproduce an accurate background matte without rotoscoping
- Traditionally keying is realized with mathematical definable values (Chromakeying, Lumakeying)
- AI-based Depth Estimation lacks of detail needed for highend production
- What about difference keying?



Alpha-Channel

Workflow-engineering

//Postproduction Advantages

- different approaches tested in this production
- best working concept based on frustum capturing
- inner frustum is captured on a headless server running in the cluster
- synchronized with virtual colorchecker

Workflow-engineering

//Postproduction Advantages

- simulation of background by training a neural network in a supervised learning process
- Realised shot specific with Nuke's CopyCat
- Model contains optical and electronical system



learn
function



Workflow-engineering

//Postproduction Advantages

- A second pretrained model solves the background subtraction from Nuke's Cattery ¹
- accurate Alpha channel generated



*AI-Background
Subtraction*



1) Based on Lin et al. (2020)

Workflow-engineering

//Postproduction Advantages

- changes can be realized and rerendered in unreal
- trained model contains MTF -> reduces the need of comp adjustments
- dual model approach is useful for common workflows



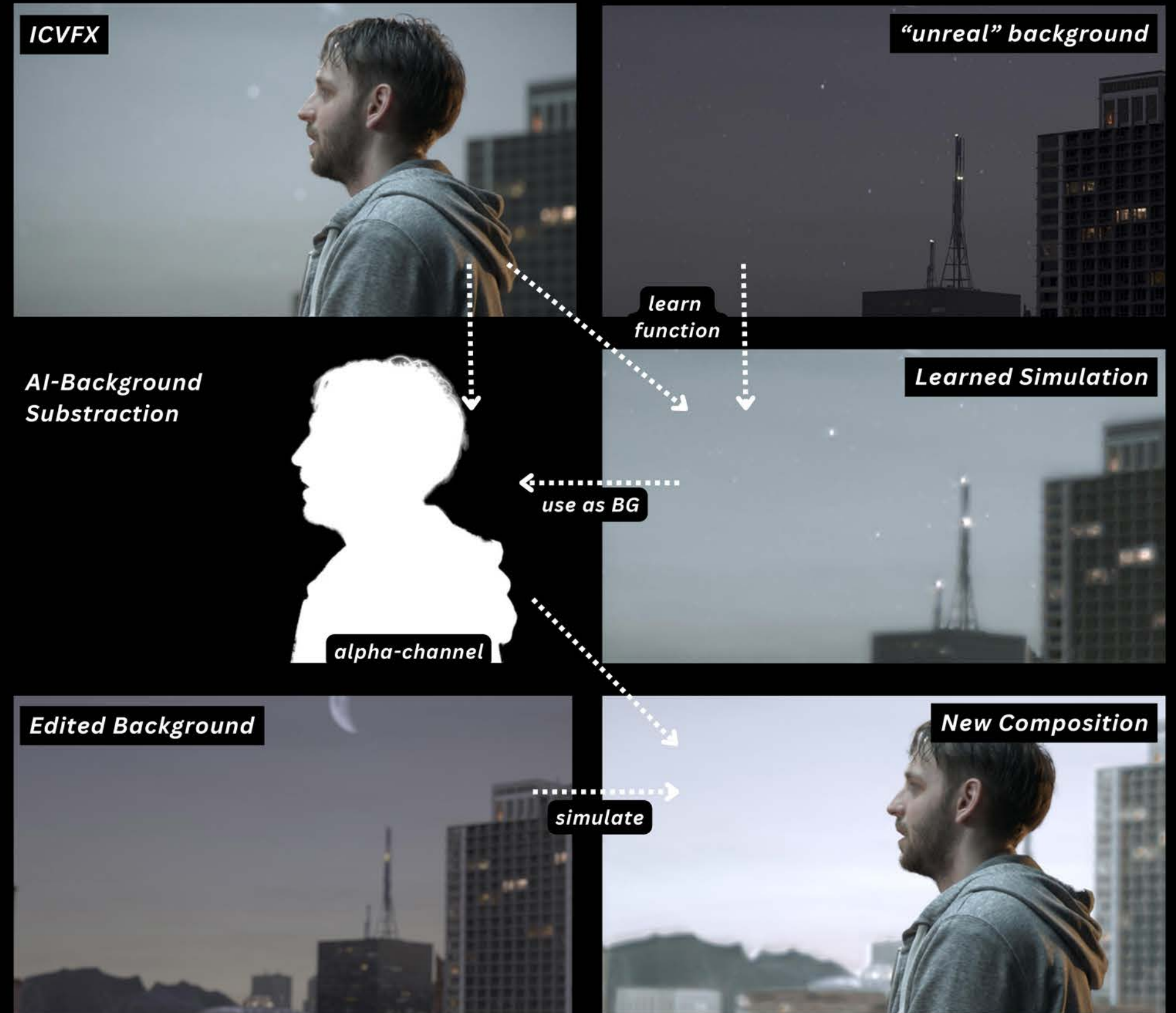
simulate



Workflow-engineering

//Postproduction Advantages

- overview
- has limits



Workflow-engineering

//Postproduction Advantages



Workflow-engineering

//Postproduction Advantages



Conclusion

//Practical implications

- shooting on film is less flexible, no plug and play --> more prep required
 - Decide for a filmstock- set up the according color calibration in advance
 - Test whether synchronization is required- set up a sync solution
 - what you see is not what you get- set up a reliable viewfinder
- Pleasing color rendition
- different results for moiré



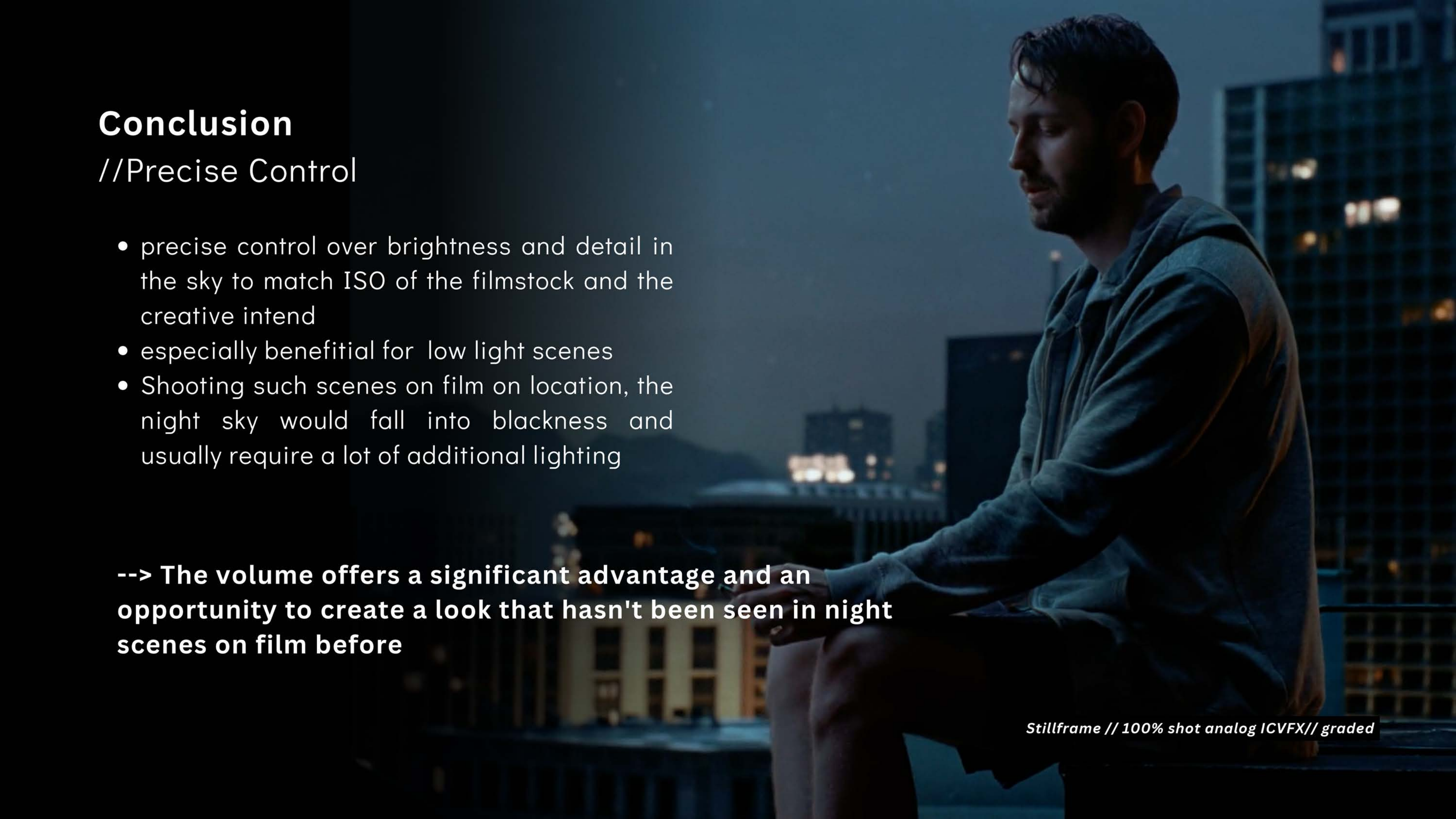
Conclusion

//Precise Control

- precise control over brightness and detail in the sky to match ISO of the filmstock and the creative intend
- especially beneficial for low light scenes
- Shooting such scenes on film on location, the night sky would fall into blackness and usually require a lot of additional lighting

--> The volume offers a significant advantage and an opportunity to create a look that hasn't been seen in night scenes on film before

Stillframe // 100% shot analog ICVFX// graded



A man in a grey hoodie sits on a rooftop ledge, looking down at a small object in his hands. The background is a dense city skyline at night, with numerous skyscrapers and glowing windows. The scene is dimly lit, with the city lights providing the primary illumination. The man is positioned on the right side of the frame, and the city extends to the horizon.

**Shooting on film doesn't hinder the capabilities
of the powerful Virtual Production tool - it
extends it!**





Special thanks to our partners!



oh, boy!

**HYPER
BOWL**



SILBERSALZ35

ARRI Rental

studio
L'EQUIPE
Bruxelles Wallonie

Special thanks to

Lauritz Raisch
Technical Director
@Hyperbowl

Bibliography

Lin, S., Ryabtsev, A., Sengupta, S., Curless, B., Seitz, S. & Kemelmacher-Shlizerman, I. (2020). Real-Time High-Resolution Background Matting. <https://arxiv.org/pdf/2012.07810v1.pdf>

Kadner, N (2021). Color Fidelity in LED-Volumes. <https://theasc.com/articles/color-fidelity-in-led-volumes>

De Waal (2012), p. 77

CONTACT

Luis Zappe
Director of Photography
luis_zappe@web.de
luiszappe.com

Sebastian Burk
Workflow Engineer
sb279@hdm-stuttgart.de

Prof. Dr. Jan Fröhlich
www.hdm-stuttgart.de/~froehlichj/



Sebastian Burk
Visual Storyteller | Virtual Production |
Postproduction

