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Open Film Tools
-
Camera Characterization for Cinematographers

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Open Film Tools

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- a project initially funded by MFG Foundation Karl-Steinbuch Research Program at the „Medien- und Filmgesellschaft Baden-Württemberg“

Goal:

- Evaluation and development of camera characterization tools and methods, in order to ensure colour constancy and correct colour reproduction in cine and tv productions,

…and making this tools freely accessible

Current tools:

- Hardware and software to estimate camera spectral responses
- Software for computation of camera profiles
- Spectral database of commonly used cine lighting

Outline

- Introduction to Camera Characterization, the theoretical and practical background
- Building and using your own Open Film Tools hardware for camera characterization
- Measuring setup and steps for camera characterization with Open Film Tools
- Using Open Film Tools software to create camera profiles
- Current Open Film Tools results
- Another Open Film Tool at a glance: a spectral database for cine lighting

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Introduction to Camera Characterization

theoretical and practical background

Colour Reception and Reproduction in Movie Production – a Short Overview

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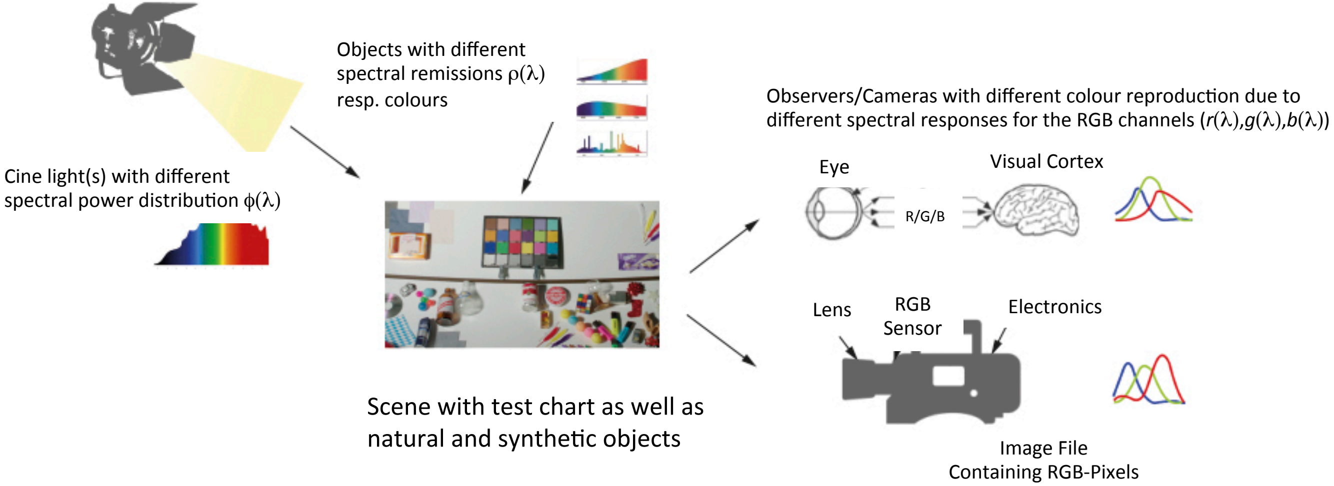


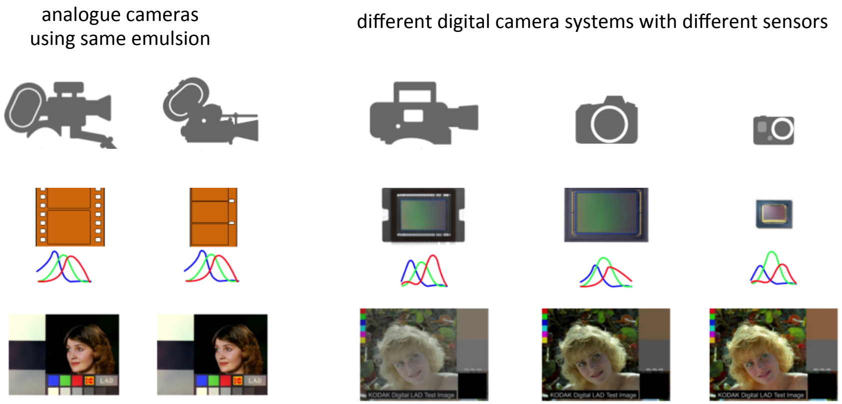
- The colour ***F*** with the *R/G/B* values in your images pixels depends on spectral characteristics of lighting, objects and used camera

- While ligthing and objects often are the same, the observers, i.e. the human eye versus different camera systems does not have same spectral responses *r/g/b*

$$\boldsymbol{F} = \begin{pmatrix} R \\ G \\ B \end{pmatrix} \sim \begin{pmatrix} \sum \left(\phi(\lambda_i)\rho(\lambda_i)r(\lambda_i)\right)\Delta\lambda \\ \sum \left(\phi(\lambda_i)\rho(\lambda_i)g(\lambda_i)\right)\Delta\lambda \\ \sum \left(\phi(\lambda_i)\rho(\lambda_i)b(\lambda_i)\right)\Delta\lambda \end{pmatrix}$$

From Different Cameras to Same Colour – the Motivation

- Past: different analogue cameras but same film and developing process with defined colour constancy



- Present: many different digital cameras with different sensors, electronics and postprocessing algorithms
- Problem: manual colour correction for each camera, in order to ensure colour constancy
- ***Motivation: ensure colour constancy without time consuming manual colour postprocessing***

How Can We Characterize a Camera System According to Colour Reproduction

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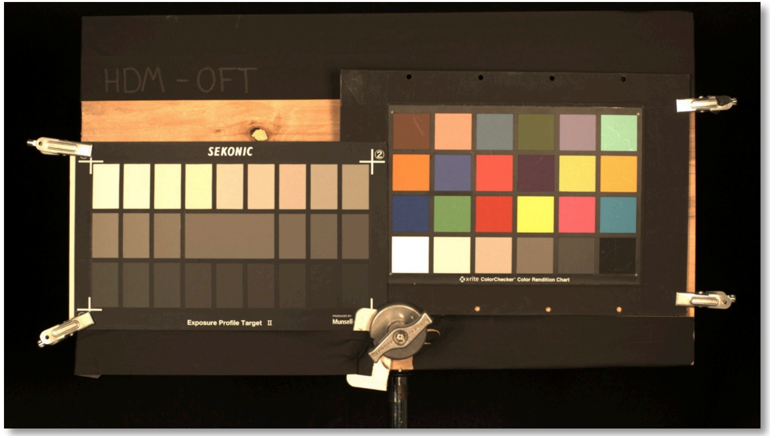
- The colour reproduction by a camera is mainly influenced by two different behaviours:
    - Non linearities, e.g. twice increasement of stop value or object reflectance does not result into doubled intensity values in your image pixels due to the non linear behaviour of optics, electronics but also because of logarithmic encoding
    - Different spectral responses for R/G/B channels in comparison to the human eye or other cameras mainly influenced by the spectral transmission of the R/G/B filters in front of the pixels
- Standardized colour reproduction means the removal of the non linearities by a linearization and computing standardized R/G/B intensities which are device independent



Linearize Your Movie Data First...

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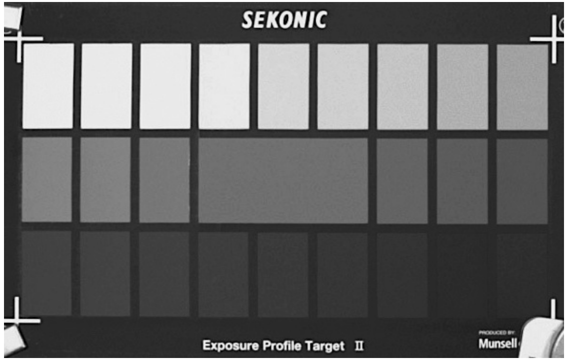
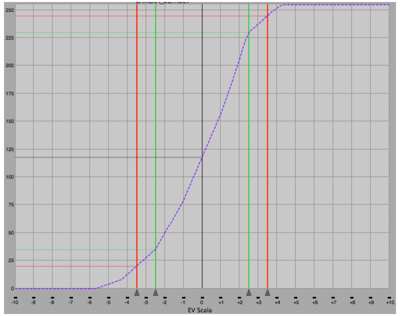
- The linearization is based on 1 linearization function or LUT which just inverts the non linearity
- a function are sometimes provided from the manufacturer
  e.g. http://strattoncamera.com/pdf/11-06-30_Alexa_LogC_Curve.pdf, http://community.sony.com/sony/attachments/sony/large-sensor-camera-F5-F55/12359/2/TechnicalSummary_for_S-Gamut3Cine_S-Gamut3_S-Log3_V1_00.pdf
- by applying your own linearization LUT created with a linearization chart, e.g. described at http://indiecinemaacademy.com/create-sekonic-dts-profile-light-meter-video/ using a SEKONIC chart



measure Patches

e.g. with Photoshop



Write LUT

e.g. cube LUT

TITLE ”Cube LUT sample for linearization"
LUT_3D_SIZE 33

0.001 0.001 0.001
0.002 0.002 0.002
0.0025 0.0025 0.0025
...

... and as a Second Step Do a Matrixing

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- For matrixing a colour transformation matrix must be created (How to create the matrix is part of later discussed Open Film Tools)
- Matrixing means, that you can change your Red/Green/Blue pixel values in a manner, which means that the new value of a channel is based upon the weighted sum of all three input channels

$$\boldsymbol{F}_2 = \begin{pmatrix} R_2 \\ G_2 \\ B_2 \end{pmatrix} = \begin{pmatrix} a R_1 + b G_1 + c B_1 \\ d R_1 + e G_1 + f B_1 \\ g R_1 + h B_1 + i B_1 \end{pmatrix} = \begin{pmatrix} a & b & c \\ d & e & f \\ g & h & i \end{pmatrix} \begin{pmatrix} R_1 \\ G_1 \\ B_1 \end{pmatrix} = \boldsymbol{M} \boldsymbol{F}_1$$

- The reference colors are given by applying the spectral sensitivity of the human observer, i.e. you have to calculate the matrix coefficients for that
- Having such a Matrix per device allows you also to convert device dependent colors into other device representation

$$\boldsymbol{F}_{S2} = (\boldsymbol{M}_{SN2})^{-1} \boldsymbol{M}_{SN1} \boldsymbol{F}_{S1}$$

Colourimetrical Camera Characterization - Existing Standards for Matrix Creation

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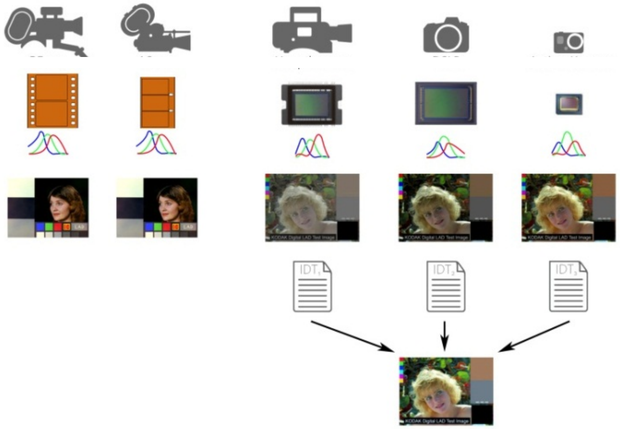
- Computation of camera profiles containing the colour transformation matrix is a standard method in order to ensure correct colour reproduction.



- One standard method for creating the color transformation matrix is defined by the „Academy of Motion Picture Arts and Sciences“ known as the creation of digital camera system input device transforms (IDTs).
- ***The Open Film Tools project will implement this kind of profile creation accessible for everyone.***
- Additional Benefits: Camera vendors ship only for a small set of new cameras such IDT profiles. Even this profiles does not take into consideration different lenses or filters. For low budget cameras no IDT profiles exist at all.

Standardized Colour by Matrixing – But Where?

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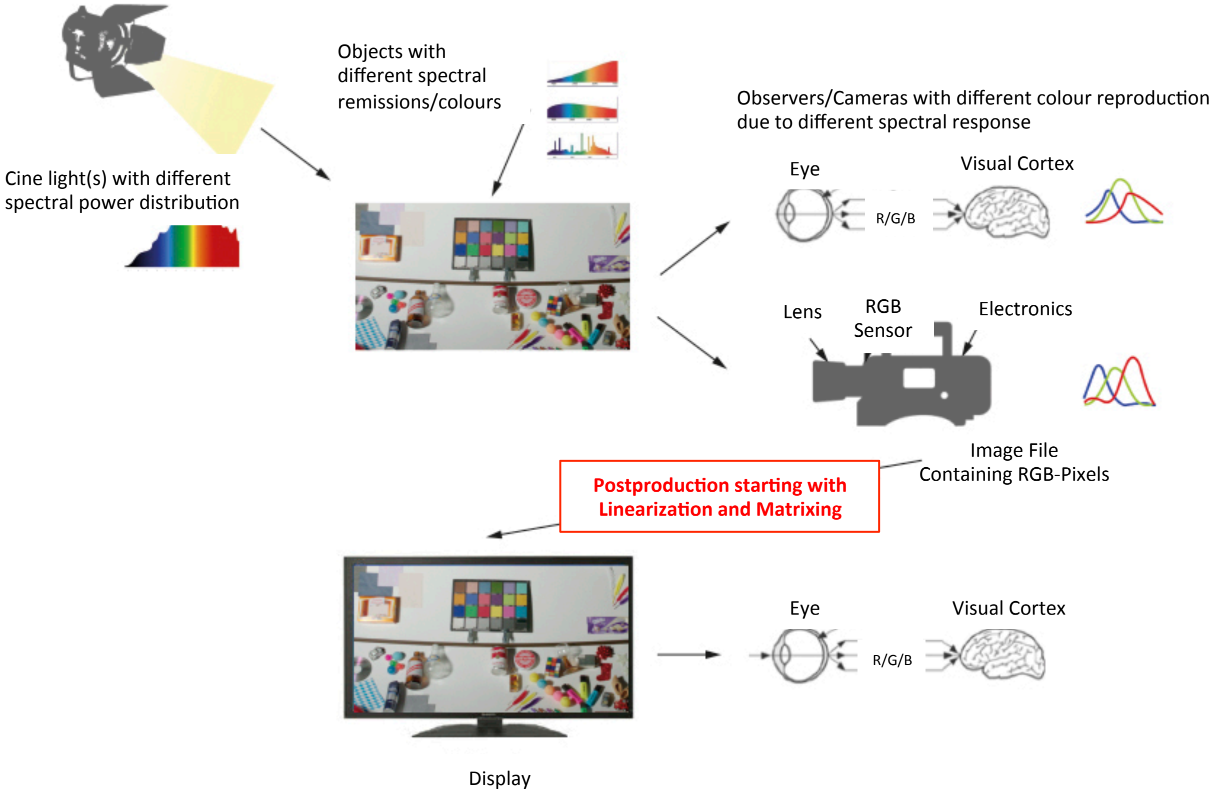

Creating Camera Profiles – User Requirements

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- *…but what additional invest for this IDT profile creation is accepted by the user?*

- We developed a questionnaire with following topics:

    - Requirements for correct colour reproduction
    - Problematic cine lighting, objects and cameras/lenses
    - Acceptance of additional time invest in current production workflow

- Using that questionnaire we did a opinion poll by German cinematographers

User Requirements – Answers from Cinematographers

- Colour reproduction requirements:
  - Lighting: LED and energy saving lights leading to unpredictable colour faults
  - Objects: skin tone reproduction is important
  - Camera systems: unknown old lenses and low end cameras have specific colour faults which must be corrected
- Acceptance of additional time invest:
  - Highly accepted at rental service with a time invest of approx. 30 min
  - Operator might be the cinematographers assistant or rental staff
  - No acceptance at all at the set before or during the shooting

IDT Camera Profile Creation

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- IDT profile creation means the computation of a colour transformation matrix

- The matrix is influenced by:

  - The spectral power distribution of used cine lighting
  - The spectral remission of objects
  - The spectral response of the camera system including the influence of used lenses and filters

Camera Profile Creation – The Created Profile

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- The created profile is a readable C like code text file, it uses a “CTL” standard file format, following excerpt shows an example of the core color transformation:

```
void main
(       input varying float rIn, input varying float gIn, input varying float bIn, input varying float aIn,
        output varying float rOut, output varying float gOut, output varying float bOut, output varying float aOut)
{

    // camera system white balancing and scaling factors
    const float b[] = { 0.017475, 0.017805, 0.033070 };

    // matrix converting white balanced scaled camera system RGB response values to ACES RGB relative exposure values
    const float B[][] =        {   { 0.767496, 0.596652, -0.224143 },
                                   { 0.269611, 1.170601, -0.410240 },
                                   { 0.037494, -0.259808, 1.541097 }    };

    const float b_min = min(b[0],min(b[1],b[2]));
    const float e_max = 1.0;
    const float k = 1.0;

    float normBE = b_min * e_max;

    float clippedRGB[3];

    clippedRGB[0]= clip((b[0] * gamma(rIn)) / normBE);
    clippedRGB[1]= clip((b[1] * gamma(gIn)) / normBE);
    clippedRGB[2]= clip((b[2] * gamma(bIn)) / normBE);

    rOut = k * (B[0][0]*clippedRGB[0]+B[0][1]*clippedRGB[1]+B[0][2]*clippedRGB[2]);
    gOut = k * (B[1][0]*clippedRGB[0]+B[1][1]*clippedRGB[1]+B[1][2]*clippedRGB[2]);
    bOut = k * (B[2][0]*clippedRGB[0]+B[2][1]*clippedRGB[1]+B[2][2]*clippedRGB[2]);
    aOut = 1.0;
}
```

Camera Profile Creation – The Created Profile

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- How to use an IDT Profile in postproduction:

  - Such profiles can be use in postproduction software as Nuke, e.g. the matrix values inside of a processing module.

- How the programmer of postproduction software can implement and test it:

  - It is C based and a OpenCL derivate, it can be compiled into OpenCL binary for certain GPUs in order to process pixels in parallel.
  - It is also used by the ctlrender reference implementation but only interpreted pixelwise and therefore very slow.

Camera Profile Creation – The Parameter Set

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- we are looking for the linear matrix $\boldsymbol{B}$ by a solution for following problem

$$\chi^2 = \sum \left\| f_{CAM}(\boldsymbol{x}_i', \boldsymbol{w}_{\mathrm{ACES}}) - f_{CAM}(\boldsymbol{MBv}_{\mathrm{i}}, \boldsymbol{w}_{\mathrm{ACES}}) \right\|$$

χ^2	Error to minimize, z.B. non linear optimization by Levenberg-Marquardt algorithm (defined)
f_{CAM}	Tristimuli transformation into physiological color domain (CIE Lab, CIE Luv, CIECAM02, …) (defined)
$\boldsymbol{w}_{\mathrm{ACES}}$	Tristimulus for ACES-White from IDT09 (defined)
$\boldsymbol{M}$	3x3 Transformationsmatrix from ACES to CIE XYZ Colour Domain (defined)
$\boldsymbol{x}_i'$	Standard Observer-Tristimuli for i colour patches for a given reference white (derived from measurement)
$\boldsymbol{v}_{\mathrm{i}}$	Camera-Tristimuli for i colour patches for a given reference white (derived from measurement)

- Standard Observer-Tristimuli are derived from spectral power distribution of lighting, spectral remission of patches and spectral sensitivity of the CIE Standard Observer
- Camera-Tristimuli are derived like tristimuli above but using Camera Spectral Response instead of Standard Observer

How We Can Get the Profile Creation Parameter Set the Chart Based Approach

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- IDT09 does allow the usage of directly measured Lab values, i.e. the classic chart image based method, but is not recommended.

- You need:

  - A chart of your choice
  - A colour (Lab) measurement device to measure chart patches

- For convenience our later presented IDT creation software supports the Color Checker chart.

How We Can Get the Profile Creation Parameter Set the Spectral Based Approach

- IDT09 recommends the spectral based approach, but where you get the spectral data for cameras, lighting and objects?
- The spectral response of the camera is very often unknown. Vendors do not publish them, or if published the influence of lenses is not taken into respect.
- The spectral power distribution (SPD) of cine lighting is published only as graphical presentation.
- Fortunately for objects there are several data sets available.

Building your own Open Film Tools hardware for camera characterization

Estimating the Camera Spectral Response – Using Low Cost Open Film Tools Hardware

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- Main problem: the spectral response of the camera is very often unknown. The measurement of the spectral response at a high end lab costs at lot of equipment and manpower.

- We developed a low cost measuring device using a a slit/grating combination attached in front of the cameras lens

- the case of the device will be published as 3D data file for a 3D printer. All other elements are also specified and available at a minimum additional amount of money or even still exist at rental services.

Open Film Tools – the Open Source Spectroscope Accessory

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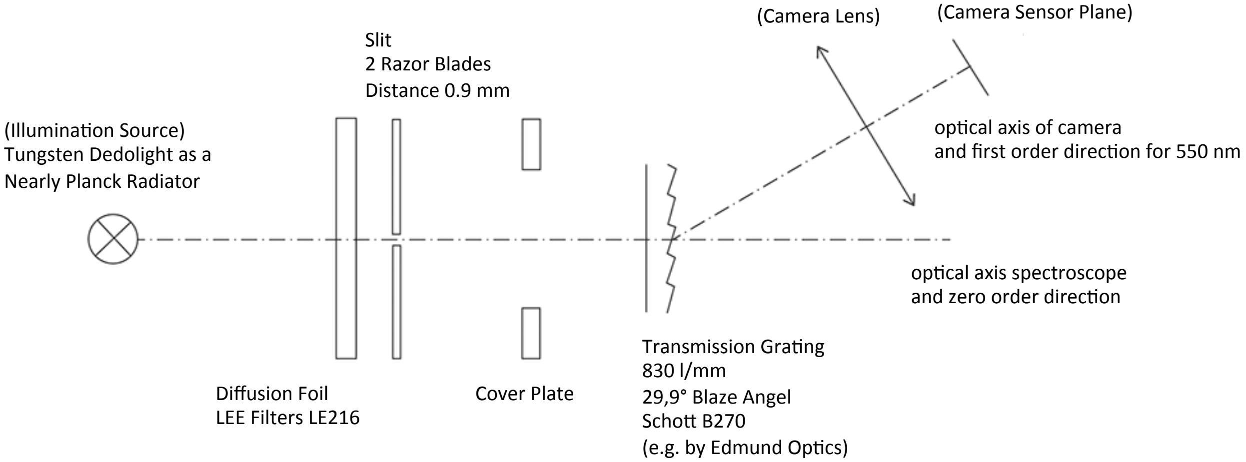
- The principal optical design with current configuration details is shown below



Open Film Tools – the Open Source Spectroscope Accessory

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- It has some additional simplification in comparison to a normal spectroscope:

  - No collimation in front of the slit, instead a common used diffusion foil from cine production is used, i.e. the used intensity is lower
  - No infinity focus enabling lens system between grating and camera lens, i.e. the camera lens must be focused to the slit distance

- The gratings efficiency curve is taken from manufacturer, it is in the opposite direction as Tungsten illumination ensuring almost equal signal to noise ratio

Open Film Tools – the Open Source Spectroscope Accessory

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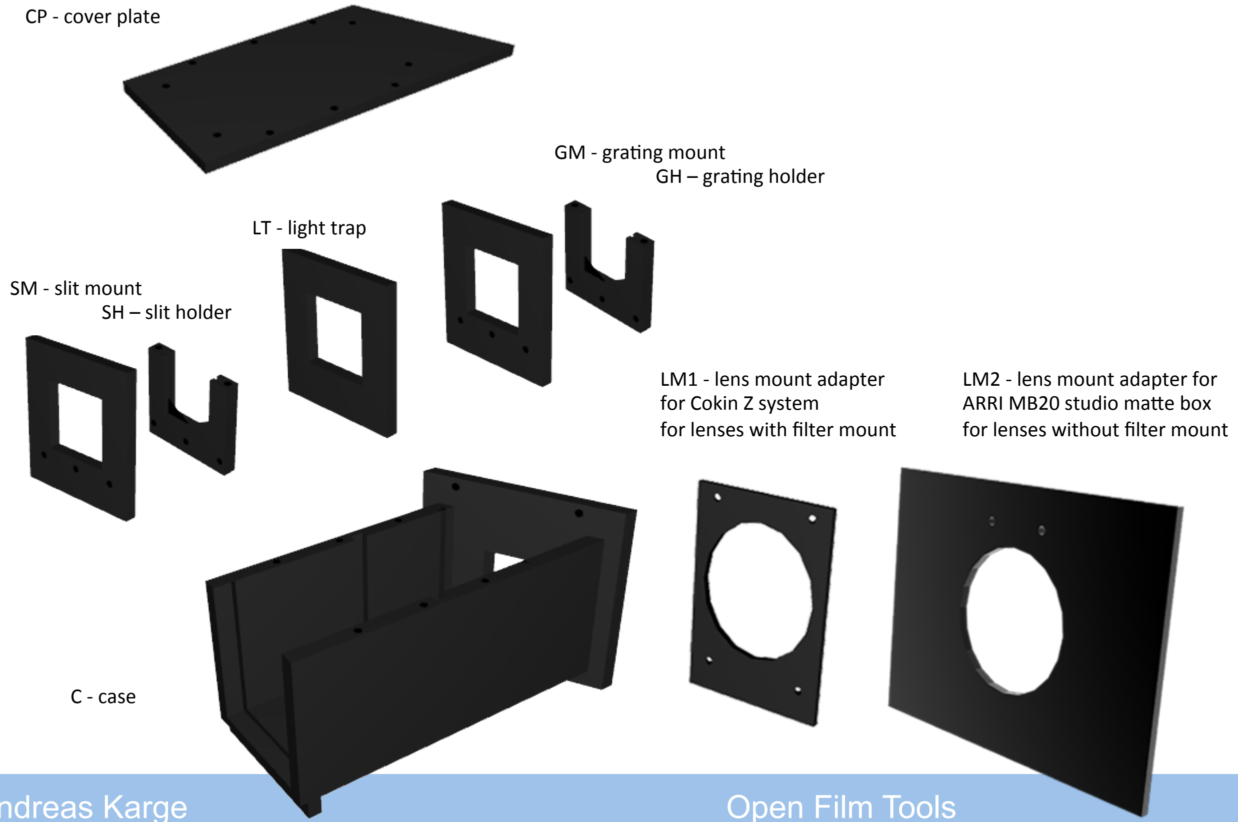
- The case can be printed (and even redesigned) by downloadable 3D files open-film-tools/english/camera_characterization/SpectroscopeCase.zip
- It contains:
  - 01_black-box_2016 file as an overview of all components (not intended to be printed)
  - 3 folders with origin files
- The subfolders are grouped into
  - 01_blackbox containing the outer case,
  - 02_opticalbench containing all components holding the optical components and
  - 03_cameramount with 2 adapters for mounting a compendium or a lens via lens filter mount

Spectroscope Accessory Components
Case Parts – Folders with Files to Print



1) Folder 01_blackbox

- C - 01_blackbox

2) Folder 02_opticalbench

- SM/GM 02_front_back-cover (i.e. print 2x)
- SH/GH 03_holder (i.e. print 2x)
- LT – 04_light-trap
- CP – 01_cover

3) Folder 03_cameramount

- LM1 - 01_film_camera_mount
- LM2 - 02_photo_camera_mount

Spectroscope Accessory Components – What Do You Need to Connect Case Components

- A set of M5x30, M5x50 and M5x80 screws, screw nuts, wing nuts and washers to connect the mounts with the holders and the case with the lens mount adapters

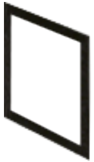
- A set of wood screws with 3 mm in diameter and 30 mm in length to connect the case with the cover plate

Spectroscope Accessory Components – What Do You Need to Build (Optics)

- Transmission grating: 50x50 mm sized, 830 l/mm, 29.9° Blaze Angel, Schott B270
  (e.g. http://www.edmundoptics.com/optics/gratings/transmission-gratings/49585/)

- Slit: buy a 1 mm slit 50x50 mm sized (e.g. http://www.leybold-shop.de/physik/geraete/optik/optische-aufbauteile/blenden-spalte-gitter/blenden-mit-schlitz-satz-2-46162.html)
  or built by your own with 2 rasor blades mounted inside of a 50x50 slide holder

- Diffusion Foil sheet: LEE Filters LE216, used in front of slit



Spectroscope Accessory
Assembling of Components

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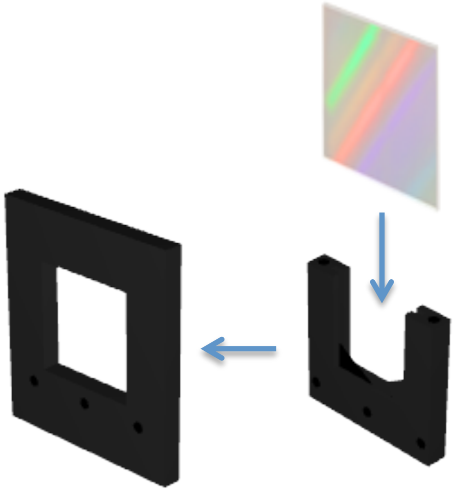

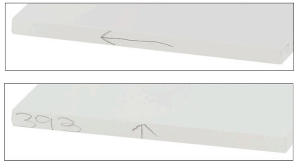

Top Image: Arrow indicating the blaze arrow.
Bottom Image: Arrow indicating the transmission direction.
(images by ThorLabs; http://www.thorlabs.de/newgrouppage9.cfm?objectgroup_id=1123)

- Insert grating into holder according to images above
- Fix mount and holder with screw set parts
- Use tape for avoiding stray light due to screw reflectance and slits between mount and holder

Spectroscope Accessory
Assembling of Components

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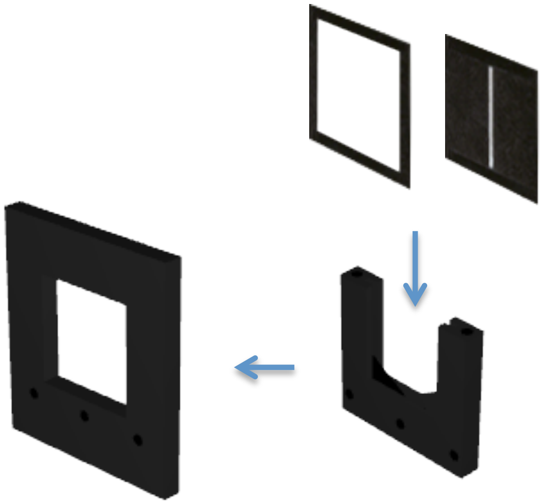
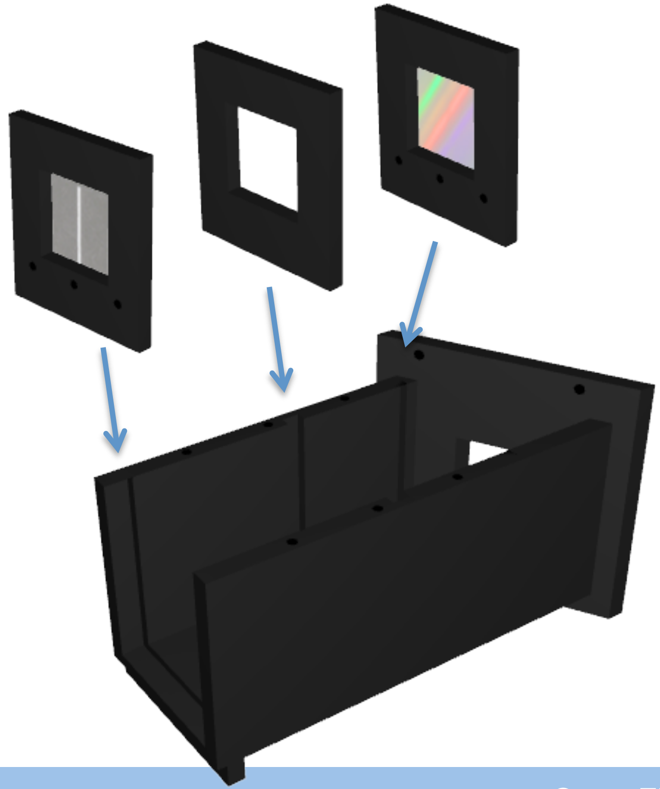


- Insert into holder the slit first and second the diffusion foil in front of slit
- Fix mount and holder with screw set parts
- Use tape for avoiding stray light due to screw reflectance and slits between mount and holder

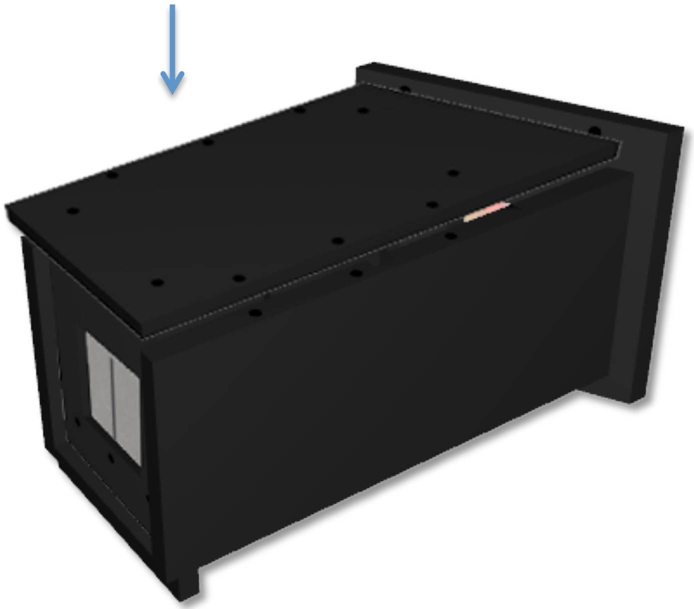
Spectroscope Accessory
Assembling of Components



- Insert grating mount, light trap and slit/foil mount into case (holders show into camera mount direction)
- Use tape for avoiding stray light due to screw reflectance and slits between mount and holder
- If your 3D printer filament has high reflectance, you should also tape/moleton for the inner parts of the case

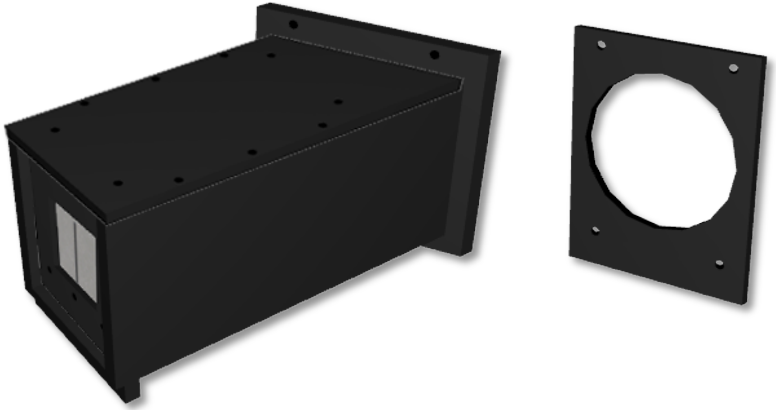
Spectroscope Accessory
Assembling of Components

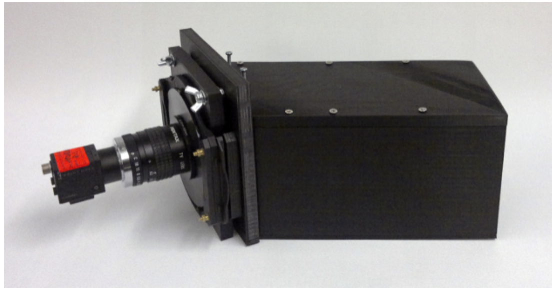
- Position cover plate on top of case
- Fix cover plate and case with wood screw set parts
- Use tape for avoiding stray light due to slits between cover plate and case



Spectroscope Accessory
Assembling of Components

Ready to use spectroscope attachment with one of the lens mount adapters





Attachment in front of a small camera

Using
your own Open Film Tools hardware
for camera characterization

Spectroscope Accessory Mounting Procedure
Mounting a Cinematographic Lens

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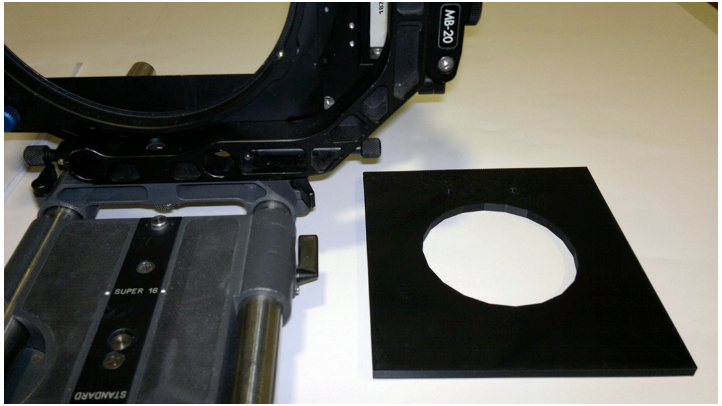
– You need:

- ARRI MB20 Studio Matte Box
- Spectroscope Matte Box Lens Mount
- M5x50 screw set

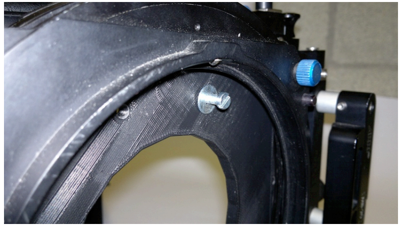


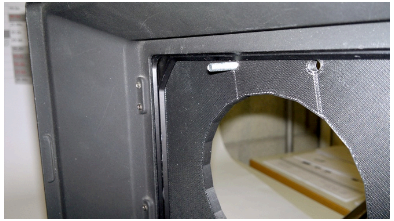
Spectroscope Accessory Mounting Procedure
Mounting a Cinematographic Lens

- Insert lens mount plate into front side filter holder (screw holes right)

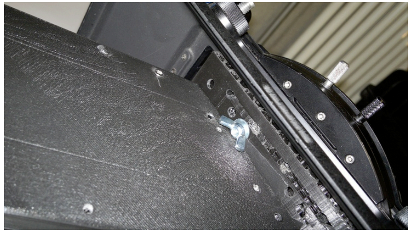
- Rotate filter holder 90 degrees ccw in order to have screw holes at upper position

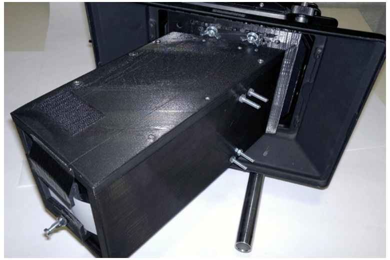
Spectroscope Accessory Mounting Procedure
Mounting a Cinematographic Lens





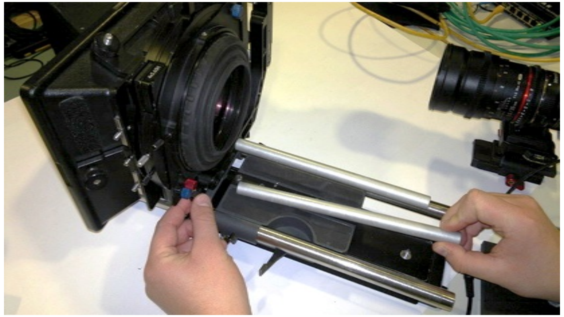
- Put 2 screws from camera side through screw hole using washers





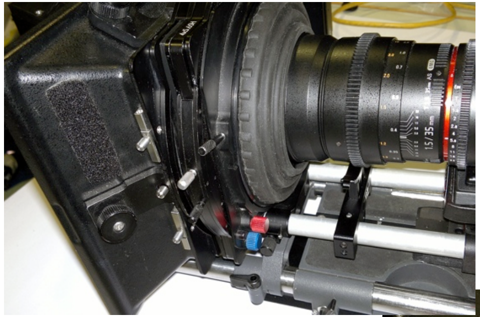
- Mounting the spectroscope in front using wing nuts and washers

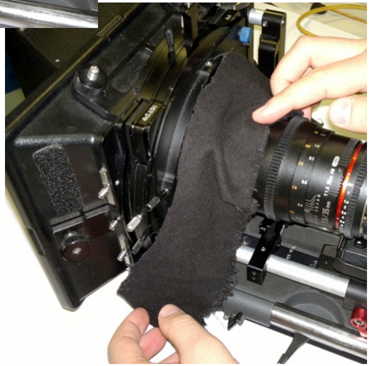
Spectroscope Accessory Mounting Procedure
Mounting a Cinematographic Lens



- Put in the rear most filter frame into the matte box, optionally with filter inside
- Mount the bellow
- Mount the rod system, either for mounted lens or mounted camera

Spectroscope Accessory Mounting Procedure
Mounting a Cinematographic Lens

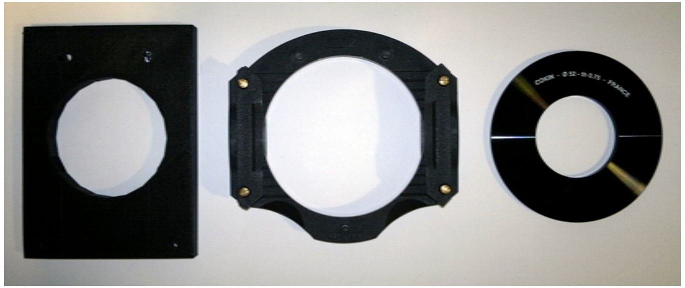




- Mount camera/lens on rods
- Fill gap between bellow and lens with molleton in order to avoid stray light

Spectroscope Accessory Mounting Procedure
Mounting a Photographic Lens

- You need:
  - Cokin Z pro filter holder and Cokin filter mount for the lens of your choice (optionally with adaptors)
  - Spectroscope photographic lens mount
  - M5x50 screw sets



Spectroscope Accessory Mounting Procedure
Mounting a Photographic Lens

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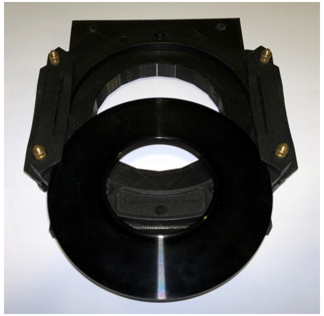
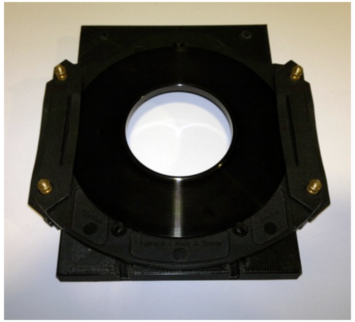
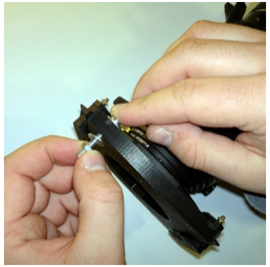




- Remove enough filter distance pieces according to spectroscope adaptor plate thickness
- Except the outermost distance piece, mount the other distance pieces with inside edge used as outside
- Insert adaptor plate in front till the Cokin holder pins are at same position as there counterpart holes in adaptor plate, fix the plate by moving the pins into the holes
- Insert filter mount adaptor and optionally additional adaptors at the camera side

Spectroscope Accessory Mounting Procedure
Mounting a Photographic Lens

- Mount lens (optionally via additional filter mount adaptors)
- Put screws with washers from the rear side trough the screw wholes of lens mount plate, fix the screws by nuts/washers from front side


Spectroscope Accessory Mounting Procedure
Mounting a Photographic Lens

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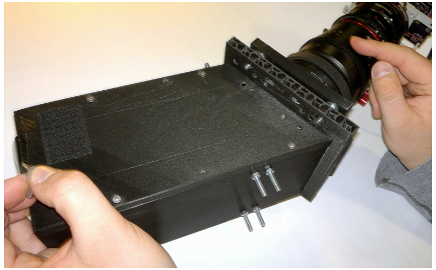
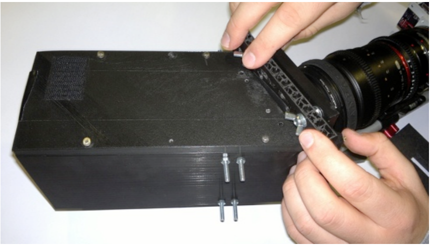
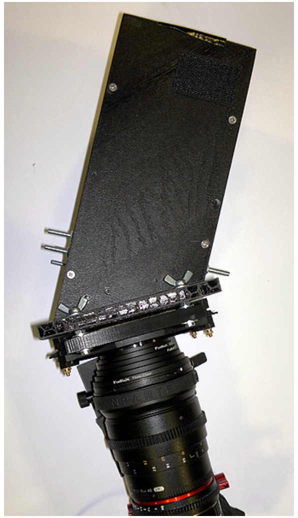




- Attach spectroscope at the front side and fix it with wing nuts/washers combinations



Measuring setup and steps for camera characterization with Open Film Tools

Capturing the Data for Camera Characterization the Measurement Setup

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– You need:

  - The camera system mounted with lens with horizontal angle above 30 degrees, (filter) and spectroscope attachement
  - Control display for live view
  - A Tungsten light, we test/recommend the Dedolight DLH1 X 150
  - A Kinoflo or alternatively OSRAM LUMILUX 20W energy saving light bulb
  - A spectrometer, we test Eye One with i1 Share Software and UPRTek Compact MK350D with Android/iOS App or µSpectrum
  - Software to store the images and spectrometer measurements

Measurement Setup
Case Example

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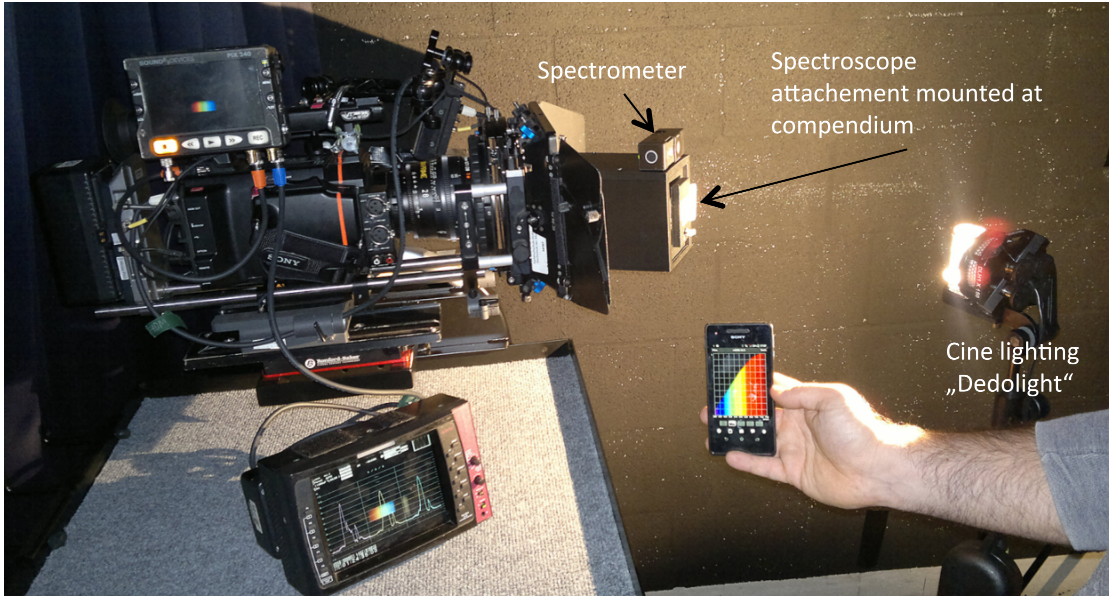
- Sony F Camera with spectroscope attachment and an additional reference spectrometer (UPRTek Compact MK350D), a Dedolight as light source. The reference measurement is triggered by a smart phone.



Capturing the Data for Camera Characterization the Measurement Procedure

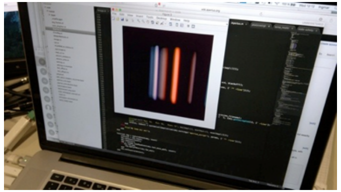
- Place the tree components: line lighting (Kinoflo or energy saving one) in front of spectroscope with a initial distance of 30 cm, place the spectrometer beside the spectroscope looking also at the lighting

- Fix a piece of the diffusion foil sheet in front of spectrometer

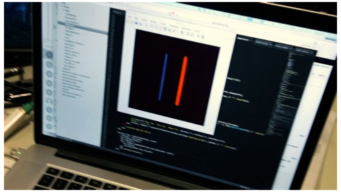
- Connect required hard/software for capturing images and measurements

- Adjust camera settings identically or as much as close to settings used on set

Capturing the Data for Camera Characterization the Measurement Procedure



- Open stop and focus the the lines, it might be a distance of approx. 0.37 m



- Close the stop to a value around 8, the peak intensity of lines might be 80% of maximum intensity, if not move lighting closer or farther

Capturing the Data for Camera Characterization the Measurement Procedure

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- Adjust distance for spectrometer that the maximum signal is also around 80 % of maximum, for that you might make test measurements

- Make final measurement and capture image, the lighting should be at least 10 min turned on

Capturing the Data for Camera Characterization the Measurement Procedure

- Replace line lighting by Tungsten lighting
- Adjust lighting distance according the 80 % intensity rule mentioned before
- Adjust spectrometer distance according the 80 % intensity rule mentioned before
- Make measurement and capture image

Measurement Procedures
Comparison of Spectral and Chart Based Method

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- For the spectral based method:
    - Pros: take the spectral characteristics into account, the recommended IDT creation, profiles can be recreated afterwards for different lighting
    - Cons: takes a bit more time to measure (approx. 20 min), might be placed at rental before production
- For the chart based method:
    - Pros: quick method at the set
    - Cons: only colour is measured for a certain lighting, not recommended IDT creation, ageing of chart (might be remeasured)

Measurement Procedure Output

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- For the spectral based method:
  - Two image files (8/16bit int or float tif, dpx):
    - one for Kinoflo or energy saving line source and
    - a second one for Tungsten lighting
  - Two spectrometer measurement files (i1 Share or UPRTek xls files):
    - one for Kinoflo or energy saving line source and
    - a second one for Tungsten lighting
- For the chart based method:
  - An image (8/16bit int or float tif, dpx) with a Color Checker chart
- For both chart based/spectral based optionally a reference image (8/16bit int or float tif, dpx)

Measurement Procedure Output Postprocessing for Linearization

- If image data is not linearized, then you have to linearize the image files before the calculation of the camera profile and save in same image format as before
- It is highly recommended that you use the same workflow as later on for your movie material
- E.g. in Nuke you can do so by
  - using implicit linearization during reading, Nuke has build in linearizations
  - using a predefined function after reading, function is given by manufacturer
  - using a linearization LUT after reading, LUT is created by yourself from a linearization chart image

Postprocessing for Linearization in Nuke

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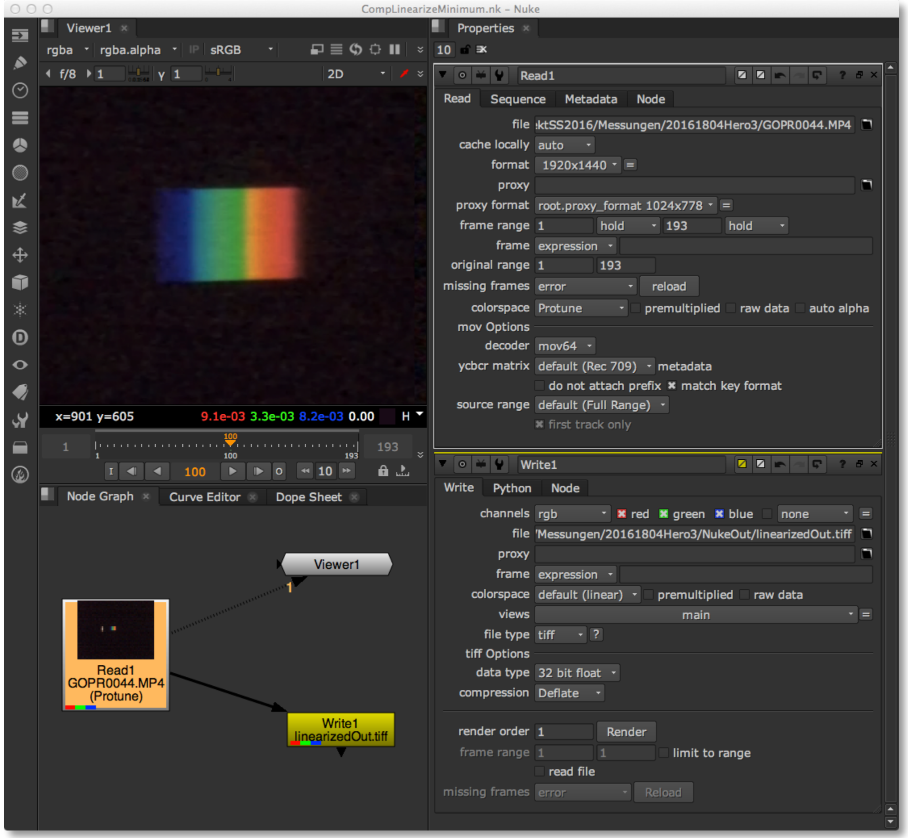
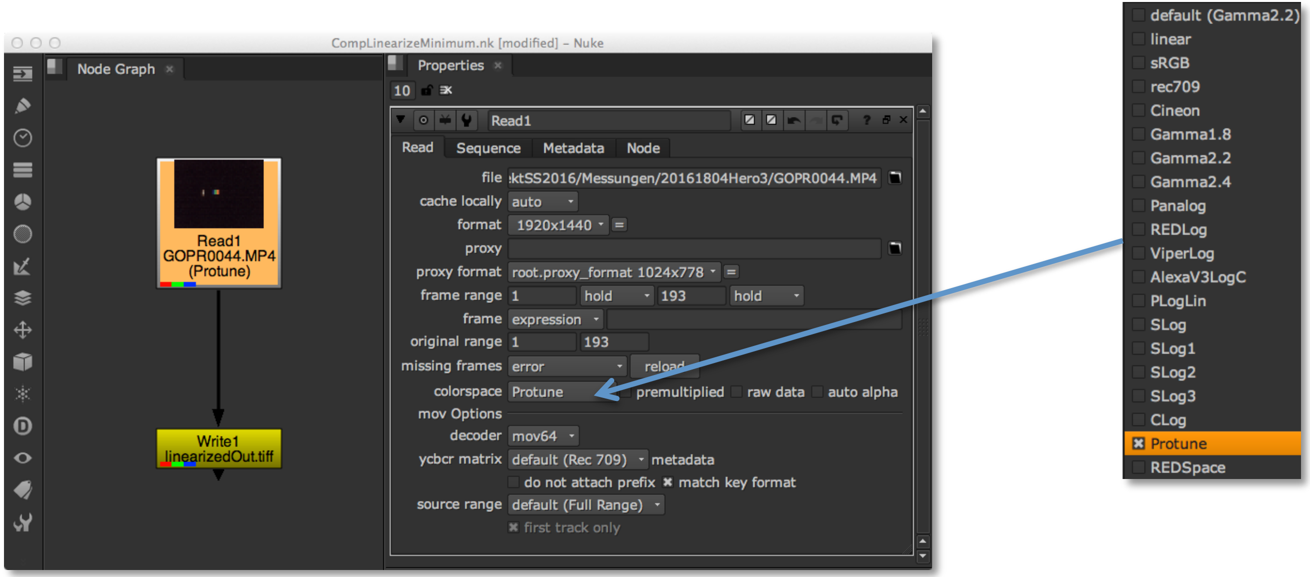


- The minimal linearization workflow contains a read and a write node
- It has to process the line spectrum image as well as the Tungsten spectrum image
- Be aware that your movie processing later on uses the same read settings

Postprocessing for Linearization in Nuke
Implicit Linearization during Read

– Nuke has build in linearizations for a set of camera side defined settings



Postprocessing for Linearization in Nuke
Write Linearized Data for Camera Characterization

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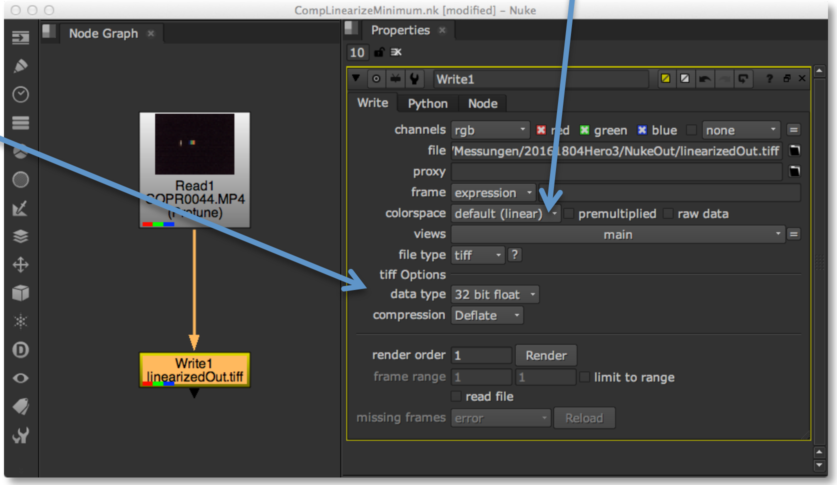
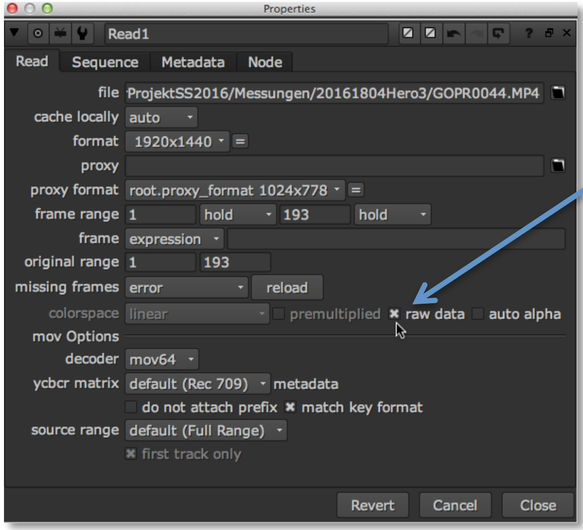
- In order to use the linearized spectral images inside of Open Film Tools Profile Calculation, you have to write a linear image in 32 bit float tiff format



Postprocessing for Linearization in Nuke Using Explicit Linearization



– modify read colorspace parameter to <u>raw data</u>

…and insert after read and before write a linearization node…

Measurement Procedure Output
Explicit Linearization by ColorLookup

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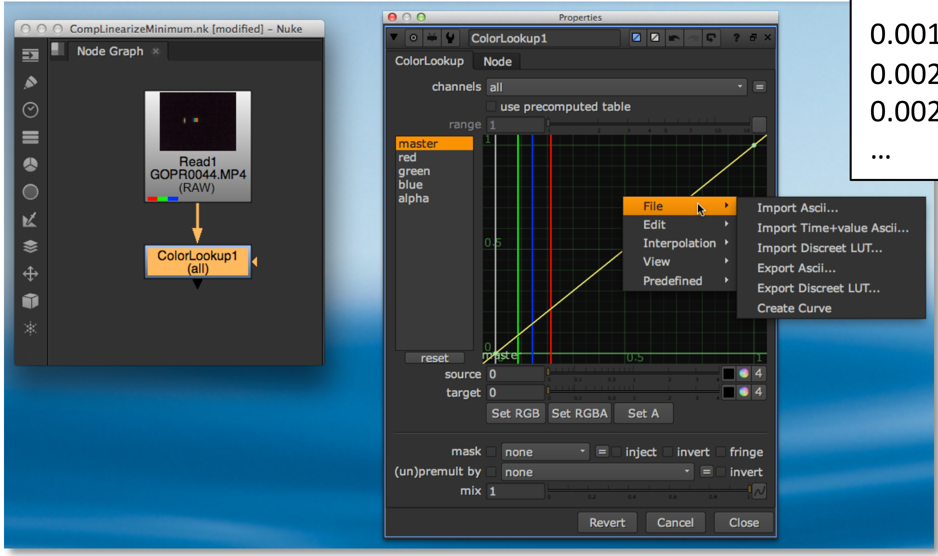
- you are able to import a linearization LUT created e.g. by using a linearization chart image

TITLE ”Cube LUT sample for linearization"
LUT_3D_SIZE 33

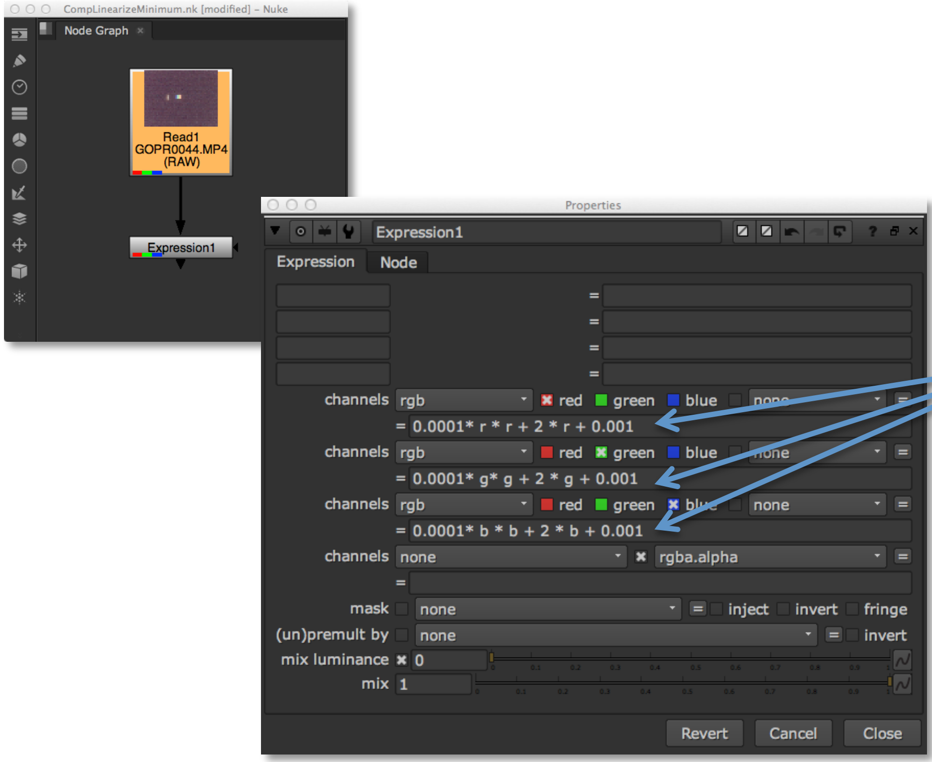
0.001 0.001 0.001
0.002 0.002 0.002
0.0025 0.0025 0.0025
...



- Be aware that your movie processing later on uses the same settings

Measurement Procedure Output
Explicit Linearization by Expression

HOCHSCHULE DER MEDIEN



- some manufacturers specify linearization functions with coefficients
- By using a expression node you can apply this linearization function to each color channel
- The function might be the same for every colour
- Be aware that your movie processing later on uses the same read settings

Measurement Procedure Output
Explicit Linearization by Expression

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e.g. from
http://strattoncamera.com/pdf/11-06-30_Alexa_LogC_Curve.pdf

Harald Brendel: ALEXA Log C Curve Usage in VFX

Conversions

ARRI provides lookup tables in different formats for the conversion between Log C and linear camera signal. Please go to http://www.arri.de/camera/digital_cameras/tools/lut_generator/lut_generator.html.

Alternatively, the formula described in the next section can be used for the conversion.

Formula

The encoding of linear data using the ALEXA Log C curves can be expressed by the following formula:

```
(x > cut) ? c * log10(a * x + b) + d: e * x + f
```

in which `x` denotes the linear data, `cut` and `a` through `f` denote parameters and `log10` denotes the common logarithm. For a particular image being encoded, the values of `cut` and `a` through `f` will depend on three factors:

- version of Log C encoding (SUP 3.x or SUP 2.x)
- type of linear data (normalized sensor value or relative scene exposure factor)
- exposure index (160 to 3200 for SUP 3.x, 160 to 1600 for SUP 2.x)

The appendix contains values of `cut` and `a` through `f` for all possible combinations of the above factors.

The decoding of ALEXA Log C-encoded data into linear data can be expressed by the following formula:

```
(t > e * cut + f) ? (pow(10, (t - d) / c) - b) / a: (t - f) / e
```

The above formulas can be easily implemented in programming languages like C or as expressions in software systems like Nuke or Shake.

Using Open Film Tools software to create camera profiles

But how the User Gets the IDT - A Web-Based Portal to Profile Creation

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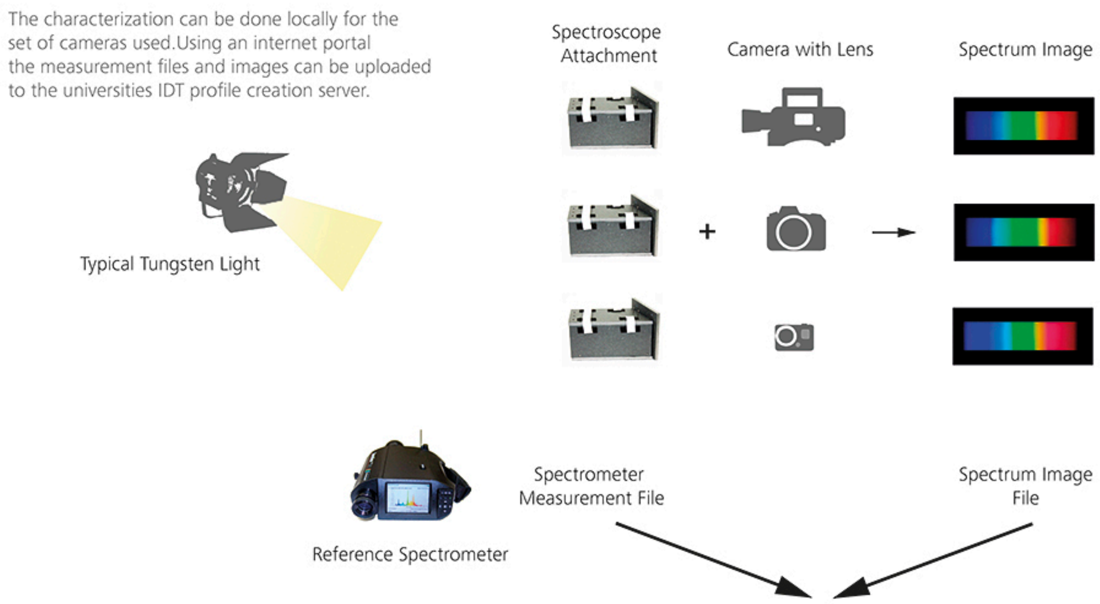


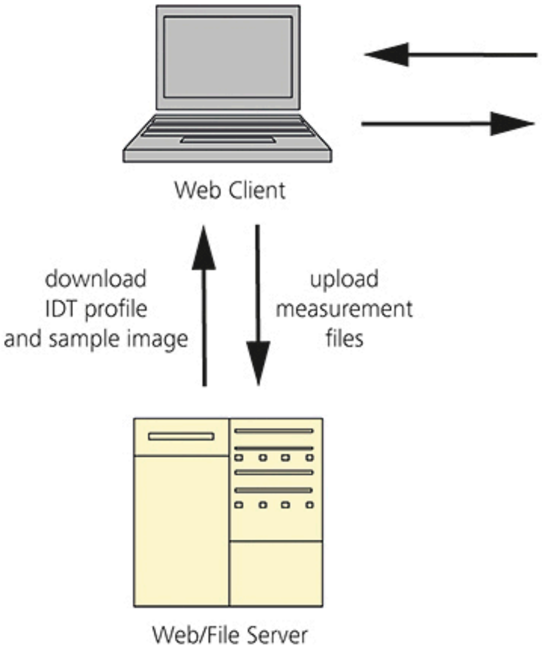
Data for web portal…

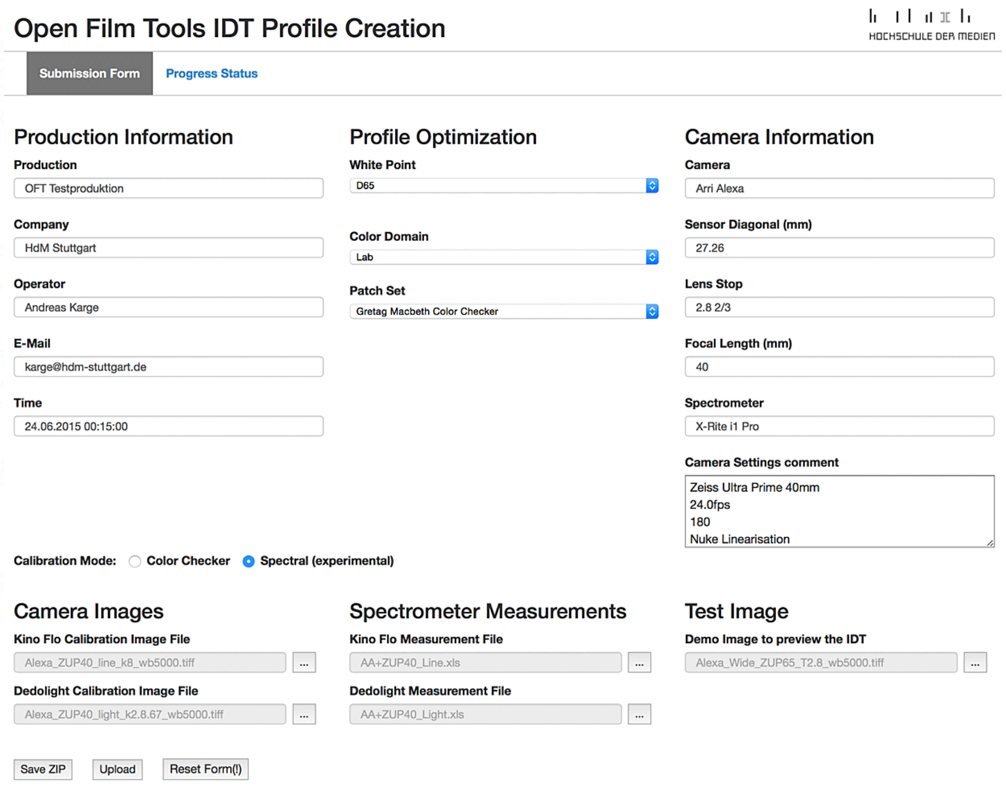
− A web browser based interface will allow the upload of required data

HOCHSCHULE DER MEDIEN

The Web Client Interface at cam-char.hdm-stuttgart.de

… input data





Open Film Tools IDT Profile Creation

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Submission Form | Progress Status

Production Information

Production: OFT Testproduktion

Company: HdM Stuttgart

Operator: Andreas Karge

E-Mail: karge@hdm-stuttgart.de

Time: 24.06.2015 00:15:00

Profile Optimization

White Point: D65

Color Domain: Lab

Patch Set: Gretag Macbeth Color Checker

Camera Information

Camera: Arri Alexa

Sensor Diagonal (mm): 27.26

Lens Stop: 2.8 2/3

Focal Length (mm): 40

Spectrometer: X-Rite i1 Pro

Camera Settings comment:
Zeiss Ultra Prime 40mm
24.0fps
180
Nuke Linearisation

Calibration Mode: ○ Color Checker ● Spectral (experimental)

Camera Images

Kino Flo Calibration Image File: Alexa_ZUP40_line_k8_wb5000.tiff ...

Dedolight Calibration Image File: Alexa_ZUP40_light_k2.8.67_wb5000.tiff ...

Spectrometer Measurements

Kino Flo Measurement File: AA+ZUP40_Line.xls ...

Dedolight Measurement File: AA+ZUP40_Light.xls ...

Test Image

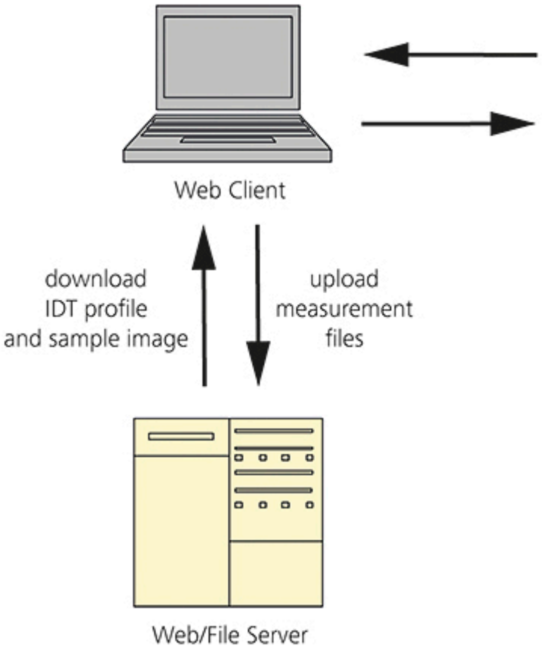
Demo Image to preview the IDT: Alexa_Wide_ZUP65_T2.8_wb5000.tiff ...

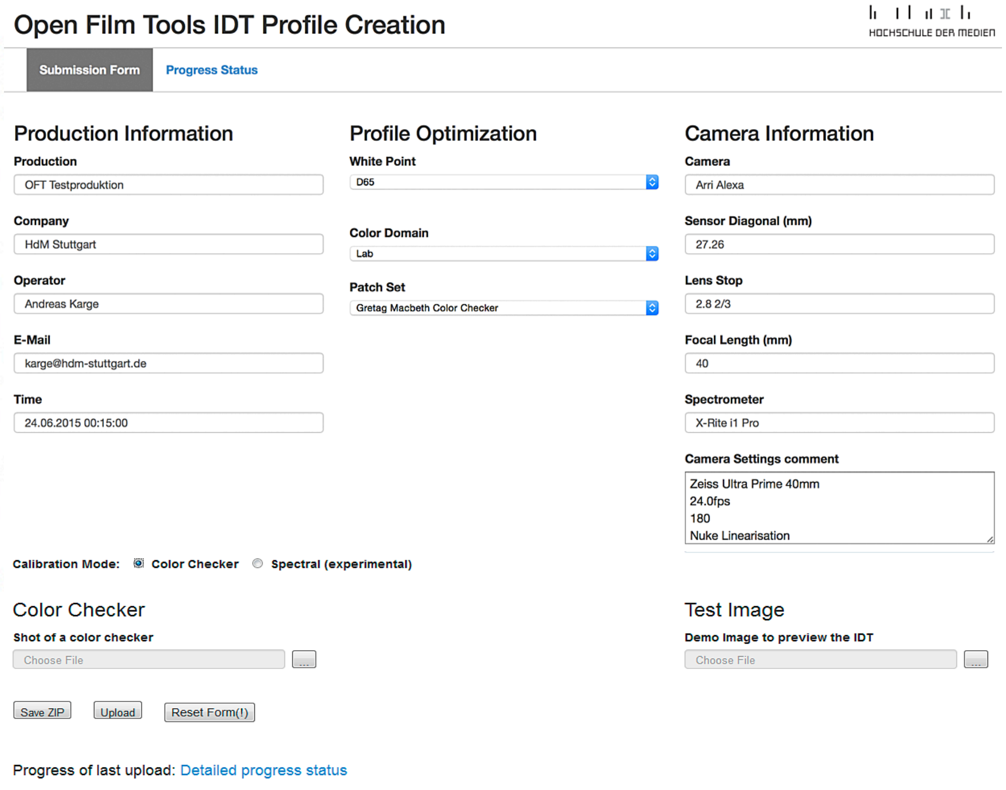
Save ZIP | Upload | Reset Form(!)

IDT profile computation …

The Web Client Interface
Chart Based IDT Profile Creation

… input data



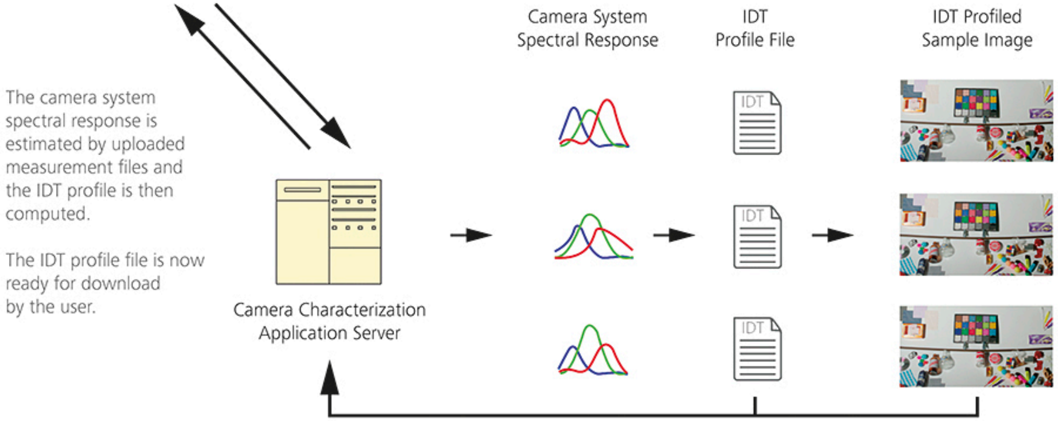


IDT profile computation …

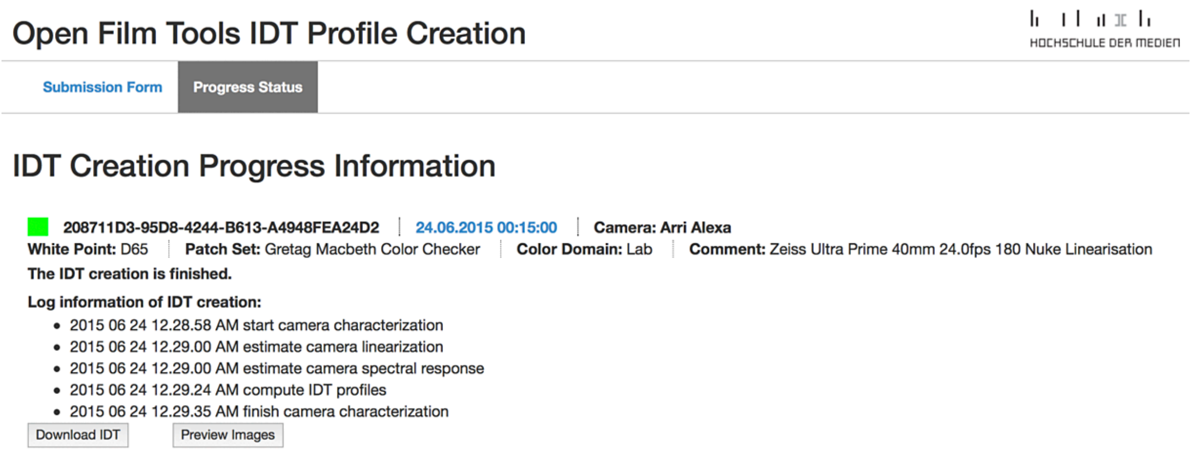
IDT Profile Creation – the Server Side

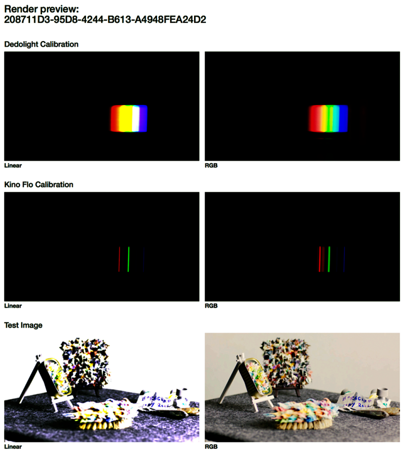
- The data is transferred from the web server to the HdM profile server:

… Web Portal / Web Server



IDT Profile Creation – the Output





- At the end a download link to a folder containing the profile, the spectral response and the production meta data is provided and an e-mail is sent to client

- Also the profiled test image is shown

The Algorithm Inside
Used Set of Colours and Lights for IDT Creation

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- For the chart based method:
  - Color Checker Patches Lab from Babelcolor
- For the spectral based method:
  - Color Checker Patches spectral reflection from Babelcolor
- IDTs for Standard D and C Illuminant for both methods, additionally for the spectral based method for the lighting used during measurements

The Algorithm Inside
Estimating the Camera Spectral Respons

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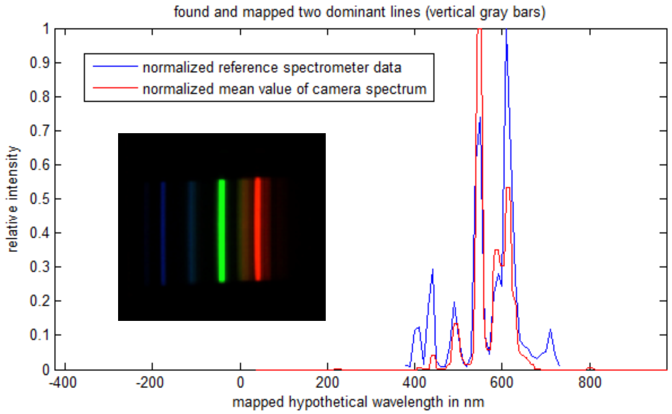
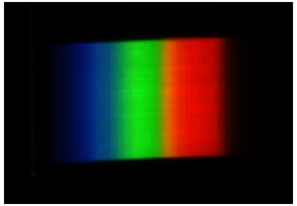
- Calibration of Spectroscope
  - Rotation Correction Using Cross Correlation
  - Estimating the pixel to wavelength mapping function by using distinct lines of fluorescence lighting mapped into reference spectrum
  - currently a linear function for two major lines, might be a 3th order polynomial using 4 lines in future taken distorsion also into account



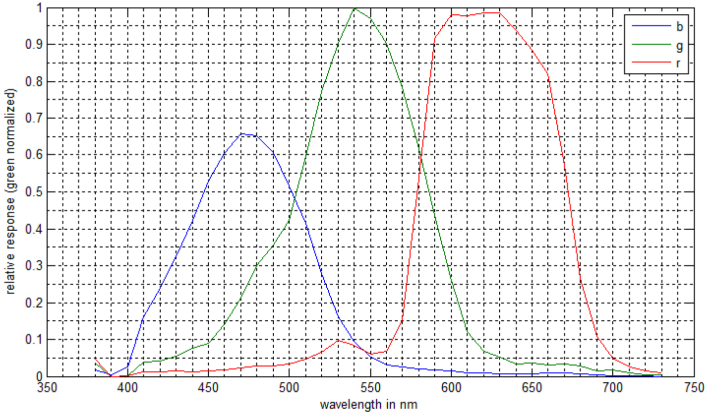
The Algorithm Inside
Estimating the Camera Spectral Response

- Estimation of Spectral Response
  - Radiometric Correction for Grating Efficiency (vendor given) and Spectral Power Distribution of Illumination (reference measurement)
  - Mean of several Rows in order to increase SNR



Uncorrected image data
(Tungsten illumination)

Correction



Current Open Film Tools results by Applying the Profile

Lets take a look of some Open Film Tools
estimated spectral responses of camera/lens combinations
and IDT profiled images…*

**(reference spectrometer EyeOne)*

First Results – Spectral Response for Arri Alexa

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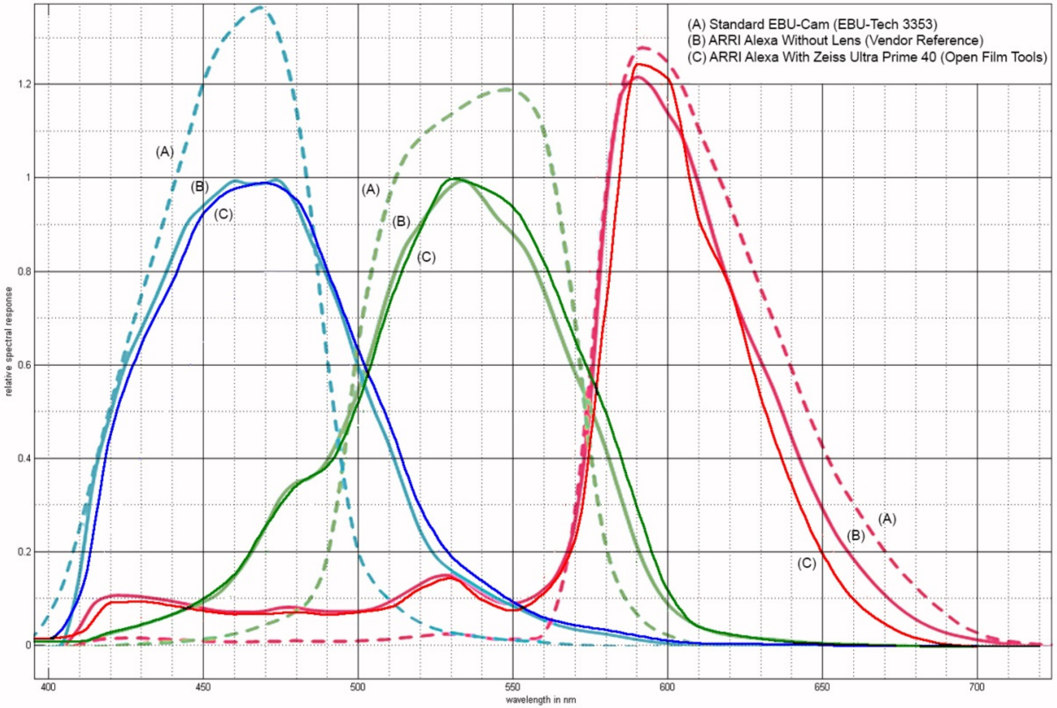
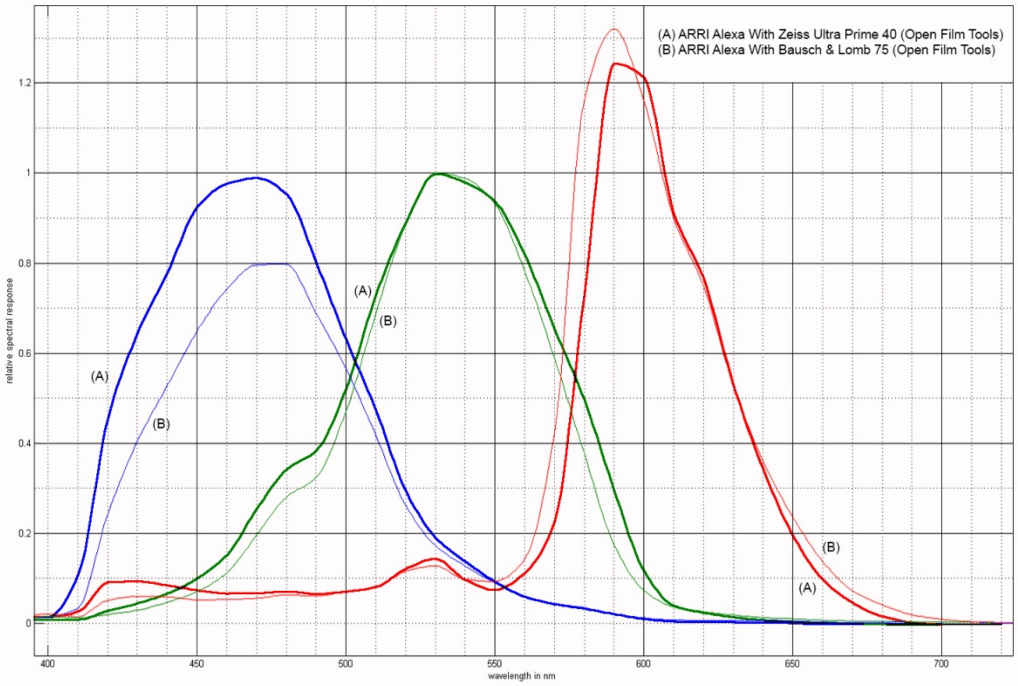


First Results – Influence Of Used Lenses



Applying the Profile in Nuke

- Be aware that your movie processing uses the same read and optionally expression or colorlookup settings which define the Linearization

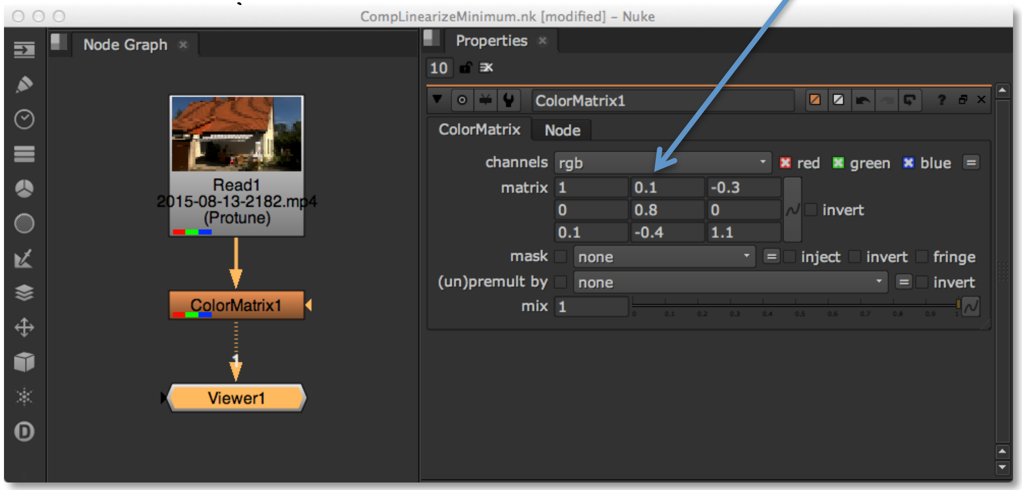
- Next a ColorMatrix node is used, where you can fill in the Matrix coefficients from the CTL file

```
void main
(       input varying float rIn, input varying float gIn, input varying float b
        output varying float rOut, output varying float gOut, output varying fl
{

    ...

    // matrix converting white balanced scaled camera system RGB response value
    const float B[][] =         {  { 0.767496, 0.596652, -0.224143 },
                                   { 0.269611, 1.170601, -0.410240 },
                                   { 0.037494, -0.259808, 1.541097 }   };

    ...
```



Normalize Lightness

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- After the ColorMatrix node a Lightness normalization must be done
- This means that all color values must be multiplied by a constant factor
- The factor f is defined by the pixel value v of the mid gray patch which must be 0.18, i.e. $f = 0.18 / v$
- And now you have your movie data with standardized color ready to use in your convenient workflow nodes

Profiled images using same IDT showing influence of used lens (ARRI Alexa with Zeiss vs. Bausch & Lomb)

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Profiled images using same IDT showing influence of used lens (ARRI Alexa with Zeiss vs. Bausch & Lomb)

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Better match with Lens specific IDT profiled images (ARRI Alexa with Zeiss vs. Bausch & Lomb)

Better match with Lens specific IDT profiled images (ARRI Alexa with Zeiss vs. Bausch & Lomb)

Open Film Tools – IDT Profile Creation
Spectral Based vs. old fashioned Lab value based

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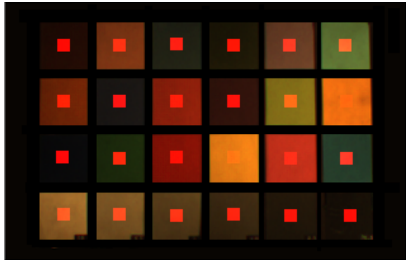
- A comparison between spectral (*using first protoytpe*) and classical chart based profile creation were done, below point gray industrial camera images are shown (very noise 8 bit integer using only approx. 7 bit)



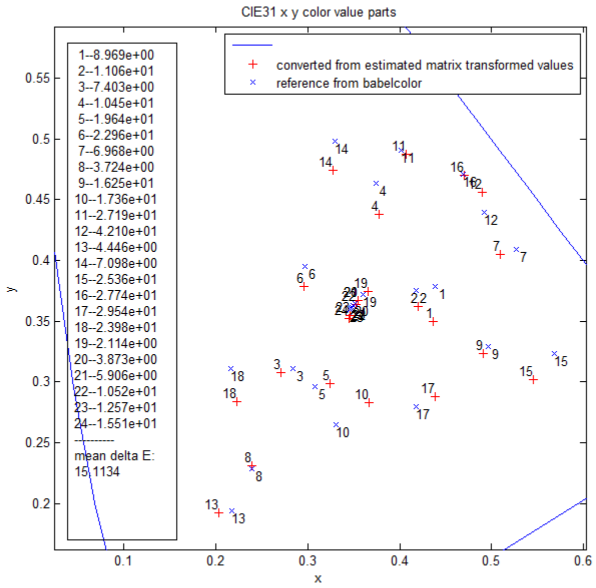
Color Checker raw image with detected patches

Profiled Image
(spectral based profile creation method)

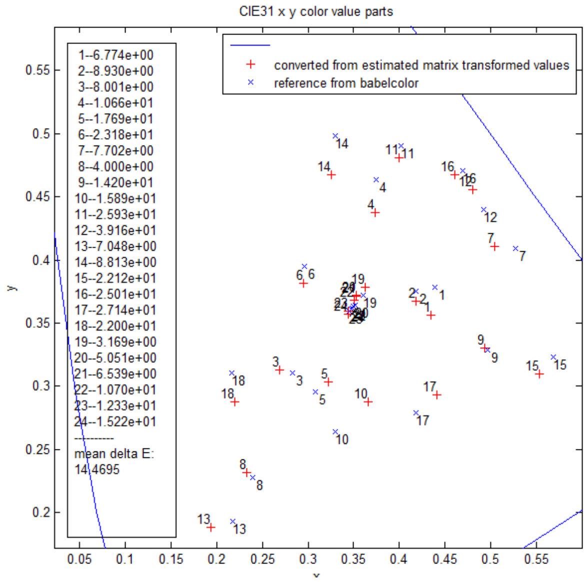
Profiled image
(chart based profile creation method)

Open Film Tools – IDT Profile Creation
Spectral Based vs. old fashioned Lab value based

- We got almost same delta E values (the illumination is not normalized), a delta C comparison shows spectral based delta C of 8 vs. Lab based value of 7.5



Spectral based estimation for Color Checker Loci



Lab based estimation for Color Checker Loci

Another Open Film Tool at a glance
-
a spectral database for commonly used cine lighting

Another Open Film Tool –
a Database of Commonly Used Cine Lighting

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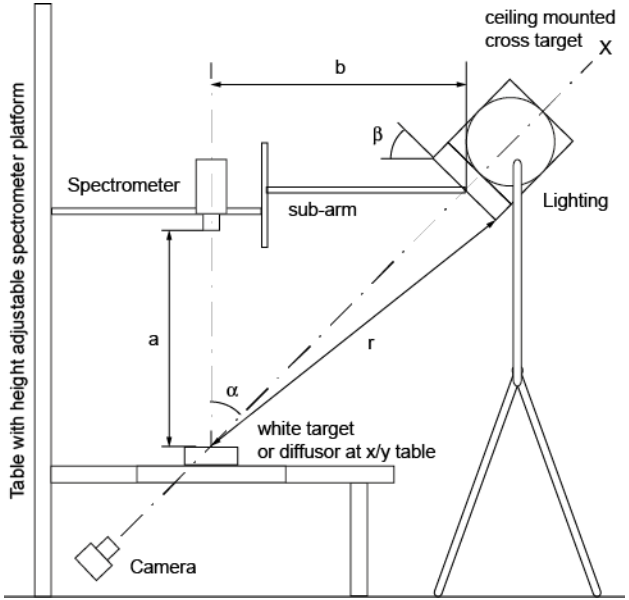
- ***Currently no public available numerical databases of commonly used cine lighting exist.***
- ***But for IDT profile creation we must have the spectral power distribution!***
- We measured commonly used Tungsten, fluorescence, HMI and LED lighting with a standardized illumination geometry.
- The database is available at www.hdm-stuttgart.de/open-film-tools/english/cinelight_spectra.
- This dataset have following benefits:
  - Comparison of different lighting
  - derivation of CCT and CRI and other colourimetrical relevant data
  - a certain light might be evaluated against samples of this dataset, in order to detect maladjustment or ageing effects
  - can be used for IDT profile creation as the spectral power distribution of illumination

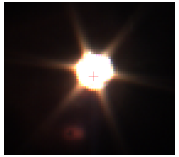
Database of Commonly Used Cine Lighting – Measurement Setup

- Based upon ISO 3664 45°/0° we propose a measurement setup and measurement procedure to ensure a quick and reproducible measurement process



Database of Commonly Used Cine Lighting – Measurement Setup Process

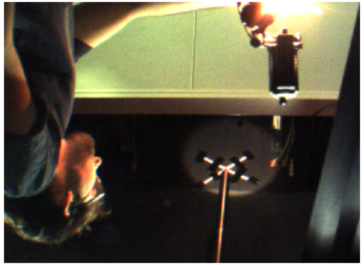
HOCHSCHULE DER MEDIEN

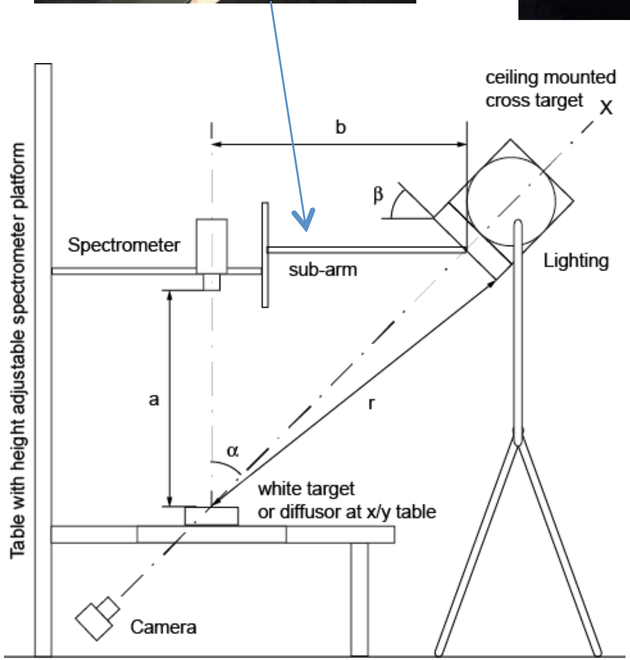


2) Adjust lighting

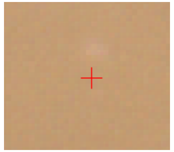
Iterative loop

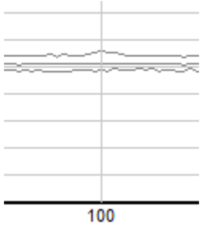
1) Define sub-arm position for given distance





3) horizontal/vertical adjustment (with diffusor in front of camera)

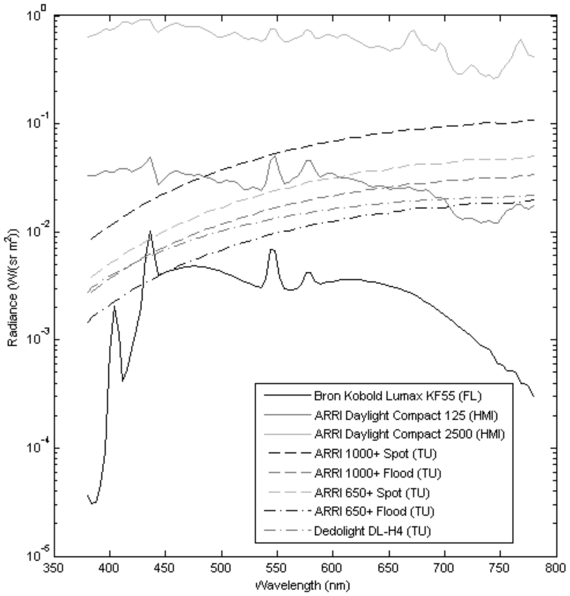




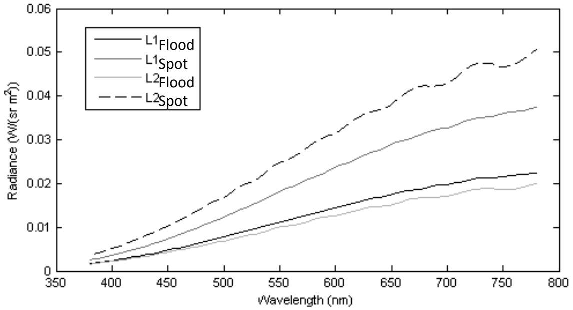
PhotoResearch PR650 Measured Cine Lighting Examples

HOCHSCHULE DER MEDIEN

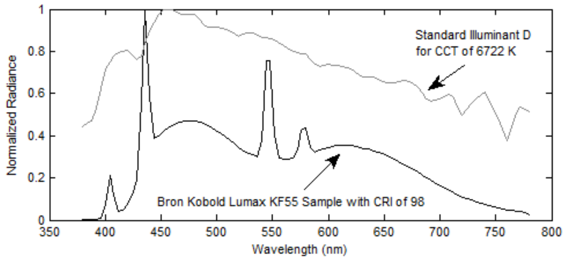
Overview



Sample for Well(L1)/Maladjustment(L2) Comparison



Comparison With Standard Illuminant Sample



Measured Lighting – Colourimetrical Evaluation Samples

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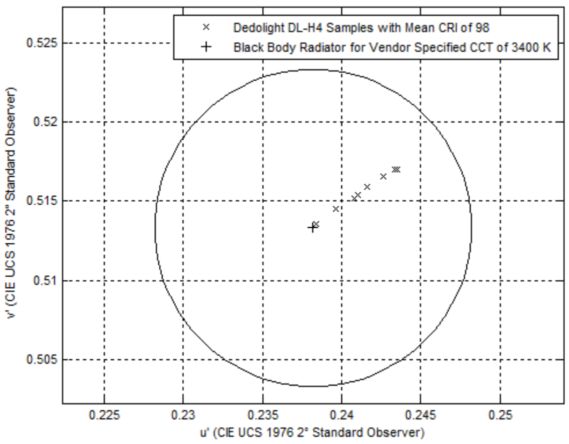
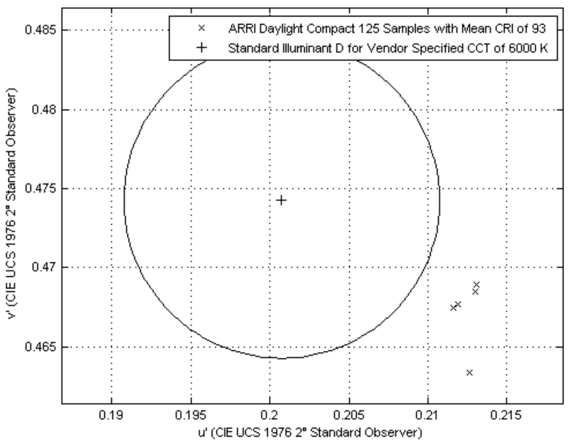
Tungsten sample nearly the vendor specified CCT and high CRI



HMI sample different to the vendor specified CCT but acceptable CRI



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www.hdm-stuttgart.de/open-film-tools