



Grading HDR material in Nucoda

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Grading HDR material in Nucoda

- ST 2084 PQ - This includes deliveries for the HDR10 specification - but currently we do not calculate the MaxFall and MaxCLL values.
- ST 2100 Hybrid Log Gamma - (BBC/NHK HDR BT.2100)
- Dolby Vision - based on ST2084 PQ it is a system that utilises 12 bit monitoring and dynamic metadata to map to different monitor brightness levels.
Setup and working in Dolby Vision is covered in a separate guide.
If you interested in working in Dolby Vision - please contact us for more detailed information.
Dolby Vision requires proprietary hardware and a license from Dolby and a Dolby Vision license for Nucoda.

Some things to remember about mastering material for HDR

- Although formats like HDR10 and HLG specify delivery in 10 bit, working with material that was captured on a camera with as much dynamic range as possible will dramatically increase your options while grading. Even moving to 12bit will make a difference in what you can achieve. Using material
- Mastering in HDR currently requires a monitor that is capable of applying the HLG and PQ EOTF (Electro Optical Transfer Function) in the monitor, the specification also requires the mastering monitor to be a rated to display a minimum of 1000 nits, and be able to display P3 and 2020 colour gamuts. Currently the only monitor capable of this is the Sony X300, it is able to display most of the P3 gamut but not all of the 2020 colour gamut.
- It is your choice whether to master the Rec.709 or HDR versions first and to derive the other master afterwards, but you should ensure that there is time allocated to do a trim pass for the second version as there is no way to just convert between the HDR and SDR versions.
- You should be aware, and bear in mind the requirement to convert between colour spaces for deliveries. While going between Rec.709 and P3 is a common conversion, the size of the 2020 gamut can cause issues if materials were graded and there are colours that fall outside the Rec709 or P3 gamut. This is where ACES could be a benefit.
- Online for final delivery should be done on a system capable of working with EXR files, such as Smoke or Flame
- Make sure that titles and supers are not at peak white - bear this in mind for GFX design.
- HDR standards are still changing and you should ensure that you double check the requirements for deliverables and ask questions if the requirements don't make sense or is confusing.
- It is advisable to have technical monitoring with CIE charts to help guide the process.

Note: PQ-2084 is not a color space - however it is more often than not referred to as PQ space.

Technical requirements for mastering at HDR

HDR Monitoring

The recommendation for HDR mastering is a monitor that can come close to displaying P3 and Rec.2020, and is capable of peak brightness level of at least 1000 Nits
Currently this is the Sony BVM X300 and some non commercially available displays from Dolby.

- Choose a monitor that is suitable for working in HDR and connect it to the Nucoda.
- Make sure the monitor is correctly set up - check your delivery specifications.
- For delivery in HLG the Sony X300 monitor should be set to HLG SG Variable in the menu.

VERY IMPORTANT

- Monitor setup must be **full range** for working in ACES and in HDR in general, to set the monitor to full range the output from the Nucoda must be 10 Bit 444 RGB or 12 bit 444 RGB - full range is not available in YUV 422.

Technical Monitoring (New PQ and P3 scopes are now in Nucoda 2017.1)

For technical monitoring, it is possible to use current scopes to work in HDR.

The signal will still fit within the 10 bit full range scale (4 to 1019 if you are being absolutely faithful to the SDI specification) - for the rest of us 0 - 1023 will do. If you are grading HDR the values will map to the waveform roughly as follows:

- 1023 = 10,000 nits - Theoretical peak luminance
- 920 = 4000 nits - peak luma on Dolby Pulsar (not commercially available)
- 844 = 2000 nits - peak luma on Dolby PRM 32FHD (not commercially available)
- 767 = 1000 nits - peak luma on a Sony BVM X300
- 711 = 600 nits - peak luma on a PRM 4220
- 528 = 108 nits - Dolby Cinema projector peak luminance
- 519 = 100 nits typical maximum for Rec.709 SDR monitor
- 447 = 48 nits - peak luma on a standard cinema projector
- 0 = 0 nits - black, corresponds to less than 0.05 nits on LCD, 0.0005 nits on OLED display

Working within these ranges when grading the HDR version should ensure that the SDR version has no clipping issues if you are going to try and conversion between PQ and rec.709

The following are some of the products available for 4K and HDR technical monitoring

- Omnitek - Ultra XR - 4K/UHD Waveform Analyzer - <http://www.omnitek.tv/ultra-xr>
- Leader - LV5490/LV5480* – Waveform Monitor for 4K Video - www.leaderamerica.com

Mastering and File delivery

Once the grade is complete you will require additional software to allow mastering of your content if a format such as IMF or HEVC is required. Proper mastering is essential.

For HDR10 deliveries masters must be delivered with MaxFALL and MaxCLL static metadata values (SMPTE ST 2086:2014) - currently Nucoda does not perform this calculation.

Mastering and file delivery systems include:

[DVS - Clipster](#) - [Colorfront TransKoder](#) - [Marquise Technologies - MIST](#) - [MTI Cortex Enterprise](#) - Adobe Media Encoder

Nucoda setup

Working in HDR in Nucoda is very similar to grading any other project. There will most certainly be a requirement for both HDR and SDR delivery. A decision will have to be made on which version should be created first. Whatever the outcome, time will be needed to do a trim pass or a partial re-grade on the other version.

This post from Alexis van Hurkman has some insights into creative grading in HDR and is well worth the read. [HDR, Resolve and Creative Grading](#)

HDR grading using ACES

The recommended workflow is to use ACES. ACES provides standardised transforms to ensure that all material is presented in a unified colour space, and also provides a standardised way of creating multiple colour space and display deliveries from a single master.

Using the ACES workflow it is possible to easily create different masters based on the ACES output transforms.

Material can also be exported and archived as linear scene referred images, making it easy to create other masters as required.

See the Nucoda ACES documentation [here](#). [Here](#) is a short description of ACES and the value of ACES in mastering HDR and WCG (Wide colour gamut) material

HDR grading using a Full Range project

If you do not want to grade in ACES it is entirely possible to grade in a full range project, with the project bit depth set to Half. There are two approaches that can be taken when preparing material for HDR grading.

Preparing material for grading - working with Log material

It is preferred that the source material is either RAW or in a Log space, such as Arri LogC, Slog2 or Slog3 or REDLog. This ensures that there is as much dynamic range available for the grade. Providing the Master display correctly displays PQ, normal grading to Dolby Vision is possible.

Any form of log source material can be graded using the Nucoda tools to look correct on the master display.

If the material is RAW, decode to Linear Gamma, then apply a PQ Matrix effect and set Input "to PQ" and the output to "None"

If the material is not RAW the Gamma Matrix and PQ Matrix should be used

This free LUT generator is very useful resource : <https://cameramanben.github.io/LUTCalc/LUTCalc/index.html>

Preparing Rec.709 or P3 material for grading

- It is possible to use a LUT to apply the PQ transfer curve to the material.
- If you are working in ACES - import the P3 or Rec.709 material and apply the Inverse IT to the material, that is Inverse P3D65 or Inverse Rec.709

Choosing a workflow

Option 1: ACES (Recommended)

Using the ACES workflow it is possible to create different masters based on the standardised ACES output transforms, or to save the material as scene referred linear images that can be archived and used to create other masters as required. The other benefit is that there are standardised input and output transforms that ensures you material is treated correctly .

The project will store files in half float, as EXR files. These files are larger than DPX 10bit files normally used and may require a more powerful workstation and fast storage, especially for UHD work.

Project setup

Add a project name in the dialog box

Select a resolution and frame rate for the project.

Create additional output formats set to the same resolution and frame rate as the main output format.

In the colour space menu, select *ACES* and select *V1.0*

Select *ACEScc* as the working colour space

In the CMS/ACES menu select Nucoda ACES output transform and then set the output transform that matches your mastering monitor, use the ST2084 transforms for the HDR grade. For SDR versions, select the matching output transform.

Likely transforms would be:

- Rec.2020-D65-ST2084-1000n - (HDR10 Amazon)
- P3-D65-ST2084-1000n - (HDR10 - Dolby Vision)
- Rec.2020-D65-HLG-1000n (BBC/NHK Hybrid Log Gamma)
- Rec709 or Rec.709 Clip

Each output format will have its own output transform set. Make sure to enable the “Apply CMS” button to ensure that the rendered image contains the required transform as part of the output.

The first, or main output format, cannot render the transform as part of the image, it is purely for monitoring and creating scene linear exports in the ST 2065-1 colour space.

Video Output scaling set to “Scale to SDI Legal”

Monitoring I/O

Setup for 4K or HD delivery

Use 444 10 bit RGB - 12 bit is only required for Dolby Vision - do not use the 12 bit PQ output

Creating other masters from the HDR master

After completing the PQ grade - make a copy of the composition and switch the output format to the Rec.709 version. Trim the SDR version to create the Rec.709 master.

Follow the same procedure for the HLG master, remember that the HLG master is used for both HLG and SDR, so during grading it may be prudent to regularly compare the HLG and SDR version to make sure the best look is achieved for both versions.

Option 2: Full Range

The workflow is display referred, that is, the material is graded to look correct on the mastering monitor, this means that if the image on the monitor is correct, the output files will be correct for the connected display.

Ensure that the display is set up correctly.

For HDR 10 or HLG it will be Rec.2020 D65 ST2084 or P3 D65 1000 Nits - see your project specifications.

If the material is in Log-C or S-Log3 it is possible to grade the content directly to the monitor.

Use a LUT to transform the material to Linear - a PQ matrix can then be applied in Nucoda.

Use a lut to go directly for Log-C to PQ2084

If the material is P3 or Rec.709 it has to be converted to Linear and the PQ Matrix added or could be converted directly to P3 D65 PQ2084.

Project setup

Add a project name in the dialog box

Add a project name in the dialog box

Select a resolution and frame rate for the project.

Set the bit depth to Half

Create additional output formats set to the same resolution, bit depth and frame rate as the main output format.

Video Output scaling set to "Scale to SDI Legal"

Monitoring I/O

Setup for 4K or HD delivery

444 10 bit RGB - do not use the 12 bit PQ output

Import material and grade as required.

Creating other masters from the HDR master

After completing the PQ grade - make a copy of the composition and switch the output format to the Rec.709 version. Trim the SDR version to create the Rec.709 master.

Follow the same procedure for the HLG master, remember that the HLG master is used for both HLG and 709, so during grading it may be prudent to regularly compare the HLG and 709 version. To make sure the best look is achieved for both versions.

Why is ACES particularly well suited for working in HDR?

Excerpt from the SMPTE document : Study Group On High-Dynamic-Range-HDR-Ecosystem

Appendix B: HDR Tone Mapping Technologies

B.1: Academy Color Encoding System (ACES) for HDR and WCG Mastering:

ACES is a color management and image interchange framework for production, mastering, and long-term archiving of digital content. It is designed to bring images from multiple sources into a common color space and provide a standard approach for viewing the images across a wide variety of output devices, including high-dynamic range and wide-color gamut displays. ACES images are used as a 'digital negative' allowing high fidelity manipulation while output tone curves that limit the dynamic range are deferred to a set of 'virtual prints' for different output display capabilities. ACES serves the purpose of a Digital Source Master feeding distribution of mastered content into digital cinema, film exhibition, broadcast, and home entertainment.

The ACES system preserves all of the information captured by cameras through use of 16 bit half-floating point values that cover 33 stops of dynamic range, more than double any existing camera encoding.

The ACES color space (ST 2065-1) covers the entire visible color gamut, and the primaries can be described as wide RGB primaries (not XYZ).

Images are converted into the linear-light ACES space with an input transform (IT: Input Transform) that converts colors from the native camera response to a colorimetric encoding (ACES: also the name of the color space).

Photographic exposures are referenced to a system design point – a mid-grey value of 0.18 in ACES – loosely representing the scene-referred color value of a properly-lit 18% grey card. ACES code values are equal to each other at the white point D60, a default which is considered more pleasing in theatrical presentations, but grading can change scene white balance to any value.

ACES images are viewed using an ACES Viewing Transform which provides an adjusted 'rendered' image appropriate for viewing in a dark-surround environment whether in the theater or at home. Production users may often select from a list of ACES Viewing Transforms that include other output devices (OT: Output Transforms) which can also be software customized for different signal encodings, transfer functions, color spaces, white points, viewing surrounds, and dynamic ranges devices at 100 cd/m², 600 cd/m², and 1000 cd/m².

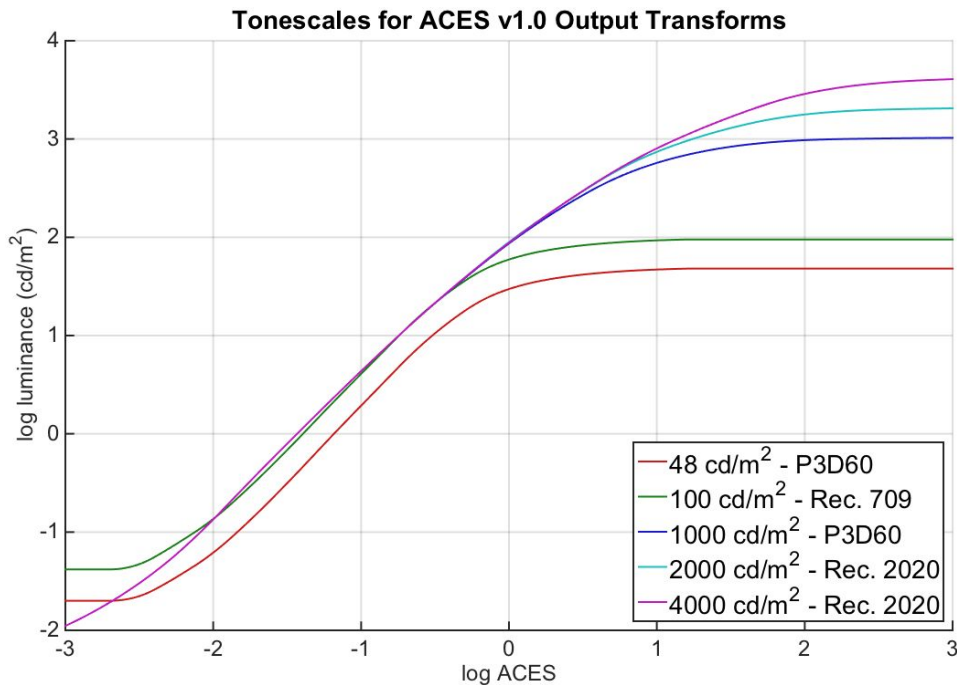


Figure B-1: ACES system tone curve

For HDR production, ACES has a consistent set of viewing transforms based on S-shaped tone curves as seen in Figure B-1:

HDR masters can be quickly created for different dynamic range displays using a colorist graded ACES master. OTs for different dynamic ranges have similar shapes, but the center of the curves are common to each other (though different for cinema than video), and content that is in the mid-tone region should look similar on different devices regardless of the extended highlight range or extended shadow range. Color space conversion from Rec.2020 to Rec.709 is handled in the OT where ACES uses fairly simple techniques using tone curve compression and saturation adjustments. Corrections for dim surround, chromatic adaptation to D65, and corrections for shadow colors and the Hunt effect are included in the transforms.

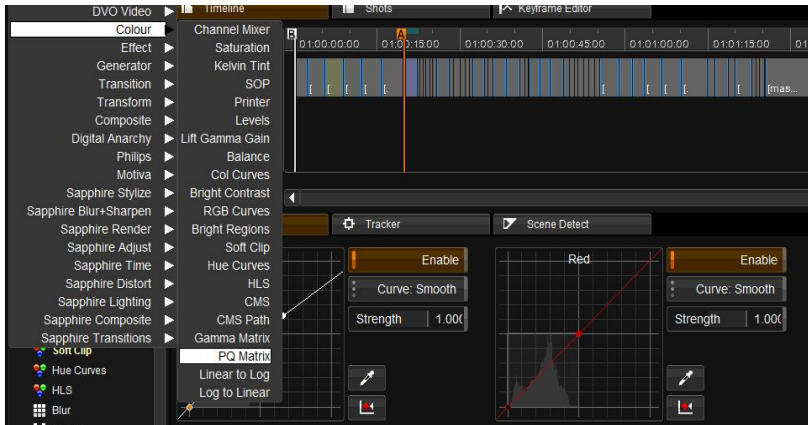
ACES ODTs for HDR at 1000 cd/m², 2000 cd/m² and 4000 cd/m² are present in the ACES v1.0 release distribution although tagged as 'for evaluation'. ACES preserves a lot of flexibility for HDR and WCG production since the original image can be manipulated without compromising the dynamic range or color space coverage.

ACES 1.0 is described in SMPTE standards:

- ST 2065-1:2012 Academy Color Encoding Specification
- ST 2065-2:2012 and ST2065-3:2012 Academy Printing Density and Academy Density Exchange Encoding (ADX)
- ST 2065-4:2012 ACES Image Container File Layout plus other features described at www.oscars.org/aces

Nucoda tools and options to make HDR easier

PQ Matrix Tool

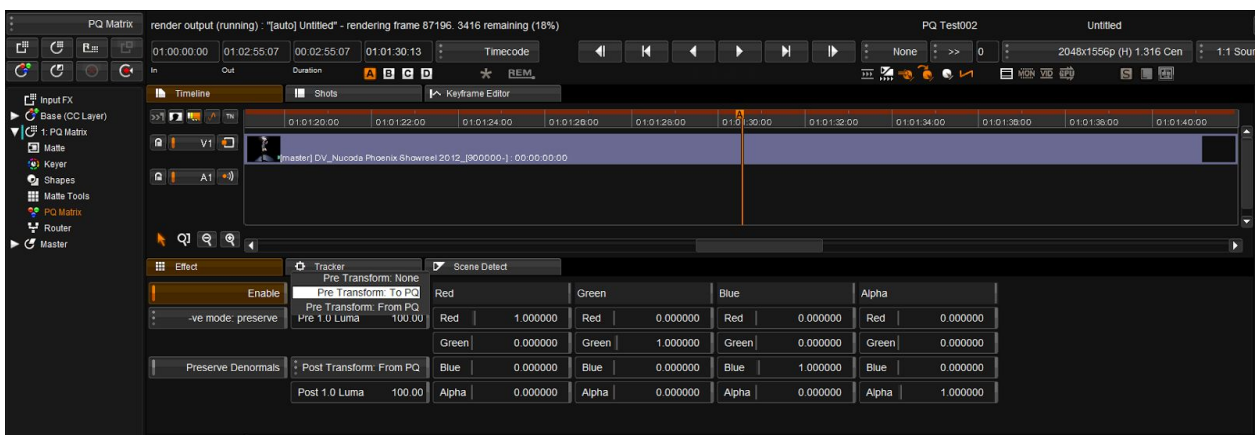


This new tool will allow users to add or remove the PQ Curve both before and during grading.

A typical scenario might be that you are working in a project with a PQ monitor as an output. If the monitor is set to apply the PQ EOTF, your material must have the PQ Curve applied. At this point you will need to apply a PQ Matrix (or LUT) both of which are designed to work in Linear space.

So the PQ Matrix would be added to the process tree.

- Pre Transform would be set: From PQ
- Apply Matrix
- Post Transform would be set: From PQ



The PQ Matrix could also provide an alternative workflow option to use SMPTE 2084 without having the project setup for HDR-ACES. For this you will need to have the project bit depth set to Half and scaling CGR. You can also use the tool to pre-convert material to PQ before delivering to VFX.

This transform is not needed if you are working in an ACES project or if you are using Log material you are grading directly to the PQ display, this is because PQ is display referred.

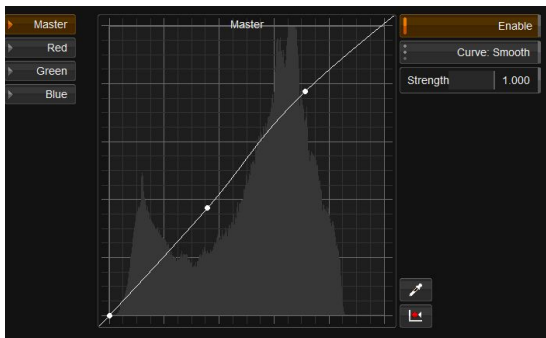
Colour tools updated for working in HDR

Certain colour tools have been updated to better support both HDR, PQ and ACES grading.

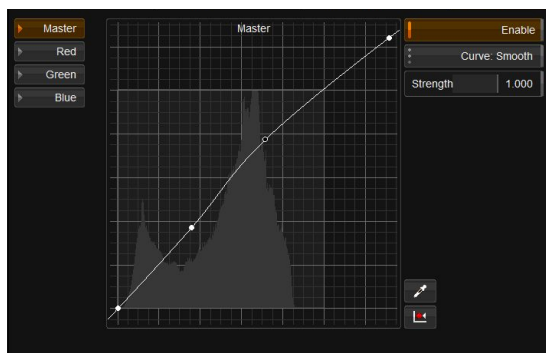
RGB Curves

The RGB Curves tool has been updated so that the graphs can be manually scaled and points can then be easily added beyond the normal 1.0 range.

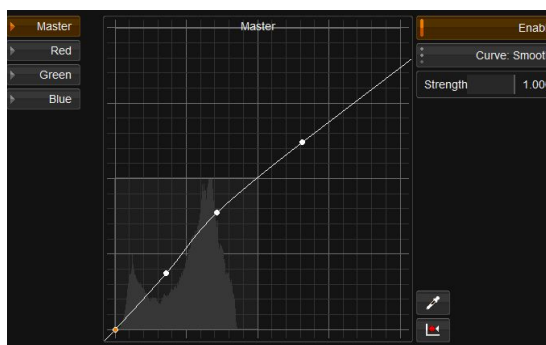
NOTE: Due to the changes that have been made to this tool it should be understood that if a project that utilised RGB Curves from an earlier version of software is attached in 2015.1 there could be a difference in the render result.



Shown here is the graph scaled to fit using the F hotkey. It fits to the default range which was set at 0-1



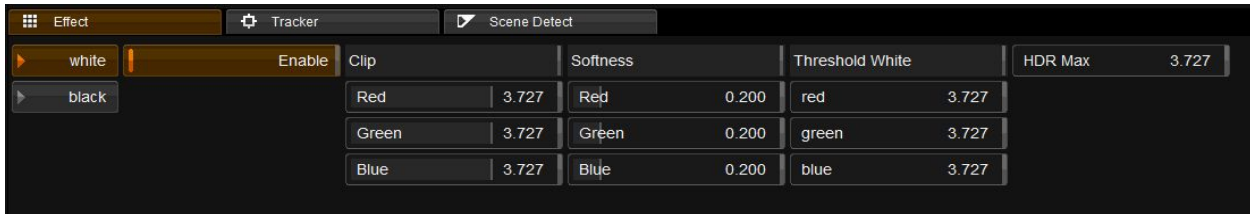
In this image the new Ctrl F hotkey is used to scale to Max value of the curve



This image shows the same graph as above but scaled to the 0-4 range

Soft Clip

The Soft Clip tool has been enhanced so that when the HDR Max value is adjusted the Clip value automatically scales to the same value.

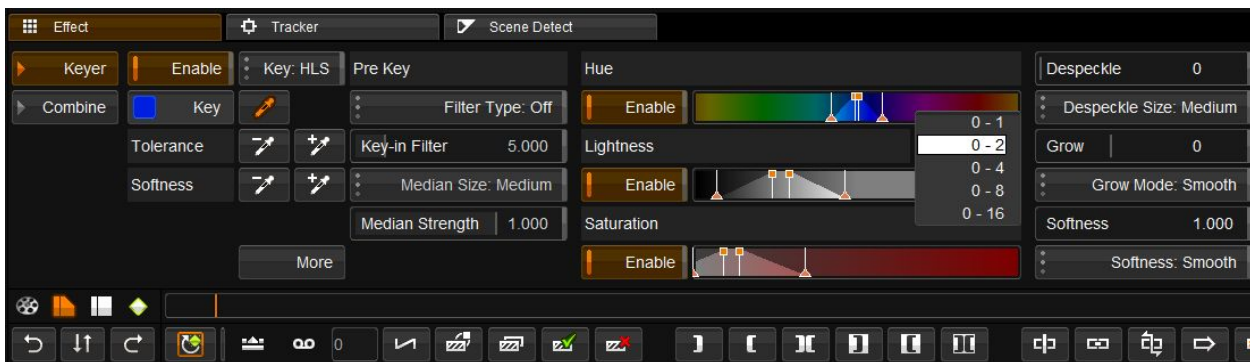


Isolation Tools

Isolation tools have been updated to better support both HDR, PQ and ACES grading.

HLS Keyer - With Lightness Range control

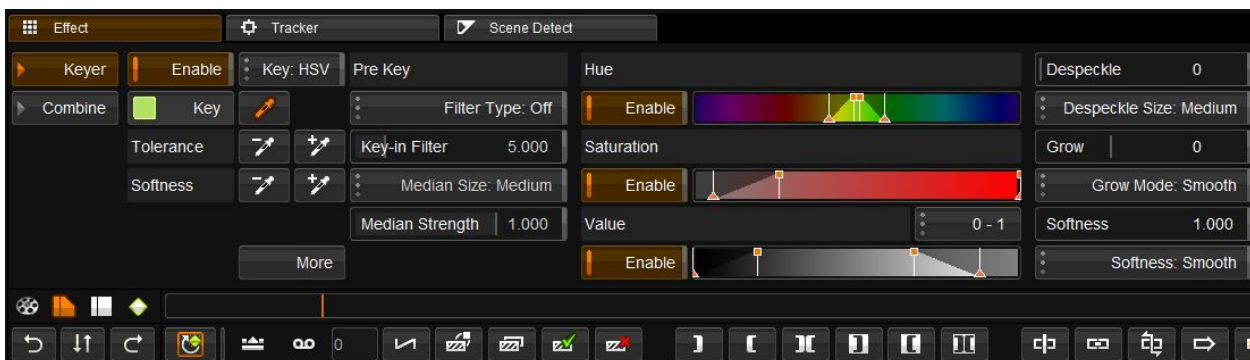
This new control allows the user to scale the Lightness control in the HLS keyer to be able to have better control when working with HDR imagery



HSV Keyer

A new keyer has been added - Hue, Saturation, Value.

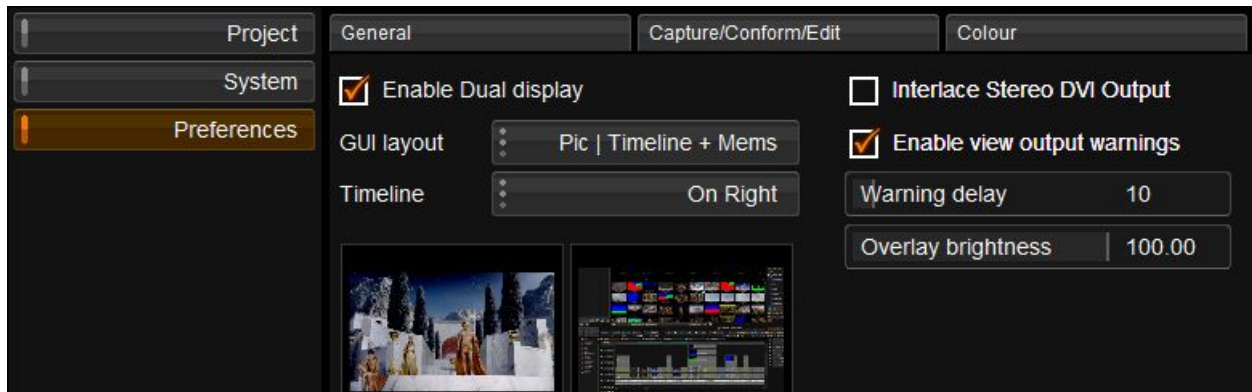
This is a much better tool for working with HDR images than the traditional HLS keyer. It also has a Value range control.



Application Preferences

Overlay Brightness

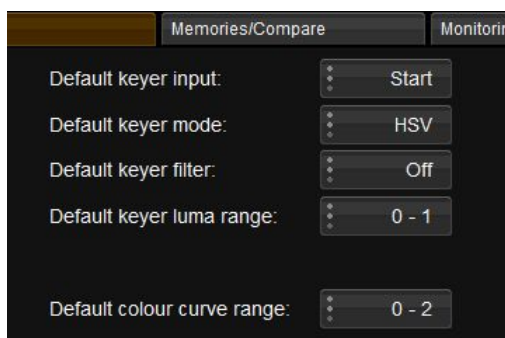
When working with HDR monitors the overlays used in the product (i.e. Grids, Borders, Keys, Mattes etc.) would all be at maximum brightness and could disturb the user.



A new Preference has been added to the Monitoring/Video IO tab that enables you to set the brightness of the overlays.



A new Preference has been added to select the default keyer and to select the default luma range.



A new Preference has been added to select the default colour curve range.

Links and documents for additional reading

HDR TV Standards

The following standards have so far been created by various organisations such as The Society of Motion Picture and Television Engineers (SMPTE), the Consumer Electronics Association (CEA), Motion Picture Experts Group (MPEG), The International Telecommunications Union (ITU), and the Blu-ray Disc Association (BDA)

SMPTE ST2084:2014 (and CEA-861-3)

Standard for an Electro-Optical Transfer Function (EOTF) for HDR that was developed by Dolby Laboratories. Used in HDR10, Dolby Vision and Technicolor/Philips

SMPTE ST2086:2014

Defines static metadata; metadata that does not change during playback of the video content.

SMPTE ST2094

Which is under consideration, along with CEA-861-G/HDMI 2.x, will define (dynamic) metadata.

ITU-R Rec BT.2020

Defines a wide gamut color space, among other aspects of a UHD TV system.

ITU-R Report BT.2381-0 (07/2015)

Requirements for High Dynamic Range Television (HDR TV) Systems, is a summary of performance criteria that should be met by a newly implemented HDR TV delivery system that includes the criterion of backward compatibility of HDR content with SDR displays.

ITU-R -Report-BT.2390-2016

High dynamic range television for production and international programme exchange

ITU-R-REC-BT.2100-0-201607

Image parameter values for high dynamic range television for use in production and international programme exchange - Recommendation for adopting PQ and HLG

[Study Group On High-Dynamic-Range-HDR-Ecosystem](#)

This is a very comprehensive document from the SMPTE Study Group and has a lot of information on HDR.
www.smpte.org

[HDR Demystified](#)

Created and maintained by the folks at www.spectralcal.com - please sign up for updates

[HDR_X300 Explained](#)

Document from Sony with information about the Sony X300

[Ultra High Definition Video Formats and Standardisation - BT Media](#)

BT Report on UHD and UHD formats <http://www.btplc.com/innovation>

[Understanding UHDTV Displays with HDR, HLG, and WCG](#)

Very informative technically accessible explanations

[HDR, Resolve and Creative Grading](#)

This post from Alexis van Hurkman is useful because it has some insights into creative grading in HDR and is well worth the read.