MPEG in the Digital Cinema Workflow, an ARRI point of view

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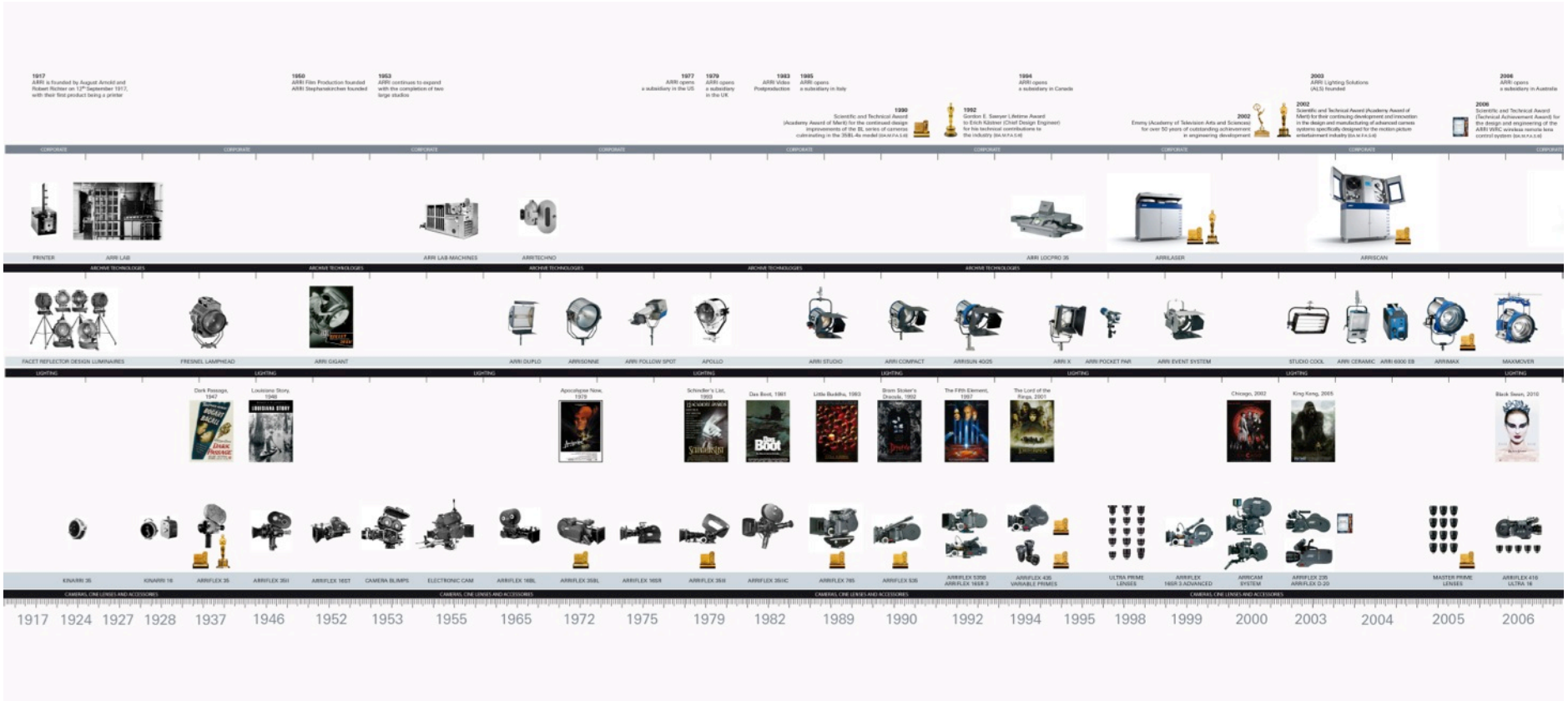
ARRI History

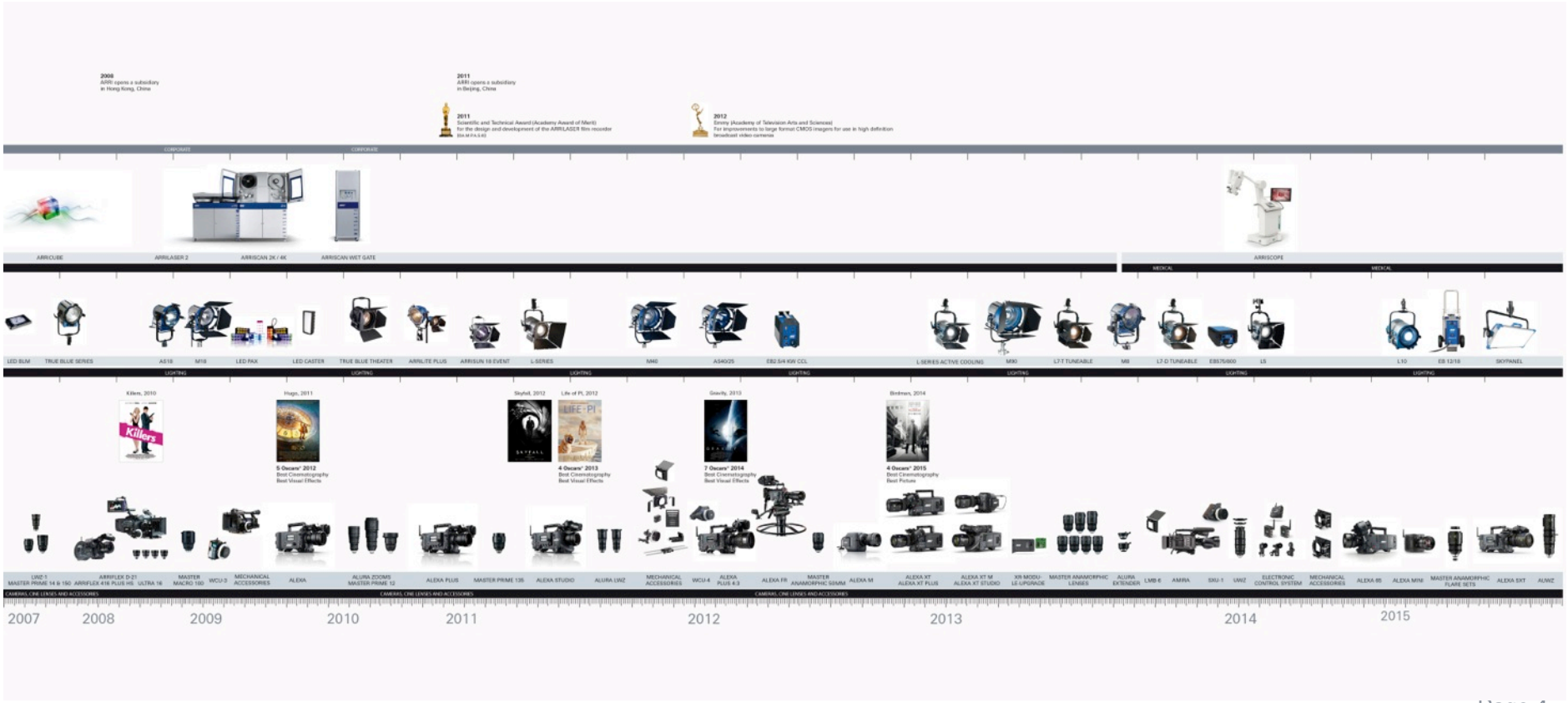
ARRI was founded September 12th, 1917 by August Arnold and Robert Richter, starting as film producers.

Today, ARRI is the largest manufacturer of professional motion picture equipment in the world.

ARRI History 1917 – 2006



ARRI History 2007 – 2015



ALEXA Family

ALEXA	ALEXA 65	ALEXA XT	ALEXA XT M	ALEXA XT Plus	ALEXA XT Studio	ALEXA Mini
						
ALEXA **The Original**	**ALEXA 65** **65 mm Reborn**	**ALEXA XT** **The Original – Updated**	**ALEXA XT M** **The Specialist**	**ALEXA XT Plus** **The Allrounder**	**ALEXA XT Studio** **The Flagship**	**ALEXA Mini**
Compact and affordable with an image quality akin to 35 mm film	65 mm sensor for unsurpassed image quality, with dedicated lenses and workflow	In-camera ARRIRAW recording, Lens Data system, 4:3 Super 35 sensor	Separate head and body for 3D rigs, action, Steadicam, aerial and underwater	Built-in wireless remote control, extra HD-SDI and RS connectors, included DNxHD license	Optical viewfinder, spinning mirror shutter, motorized ND filter slider, built-in wireless remote control, extra HD-SDI and RS connectors	Ideal for gimbals and drones; with lightweight carbon housing and integrated functions

Camera Systems

ALEXA 65

ALEXA XT

ALEXA Mini

AMIRA

Cine Lenses

PCA | Electronic Control System

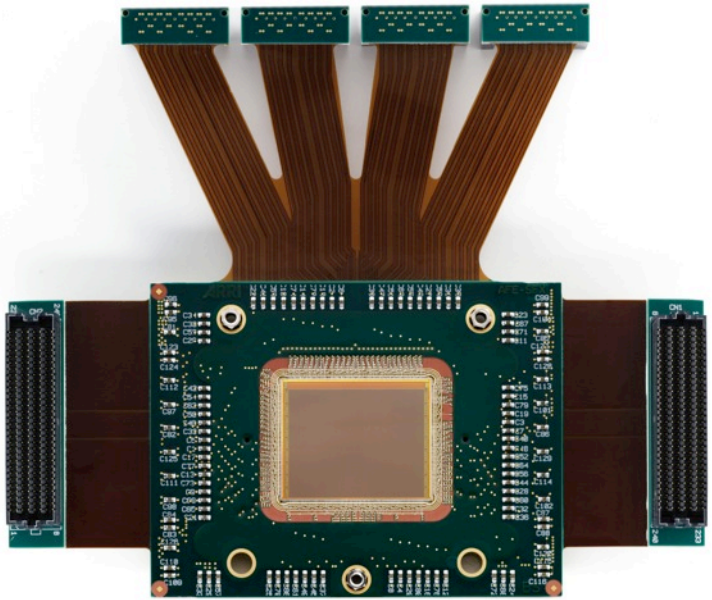
PCA | Mechanical Accessories

Film Cameras

ALEXA Sensor & Image Performance

The ALEXA 35 format ALEV III CMOS sensor is a custom design by ARRI, optimized for digital cinematography.

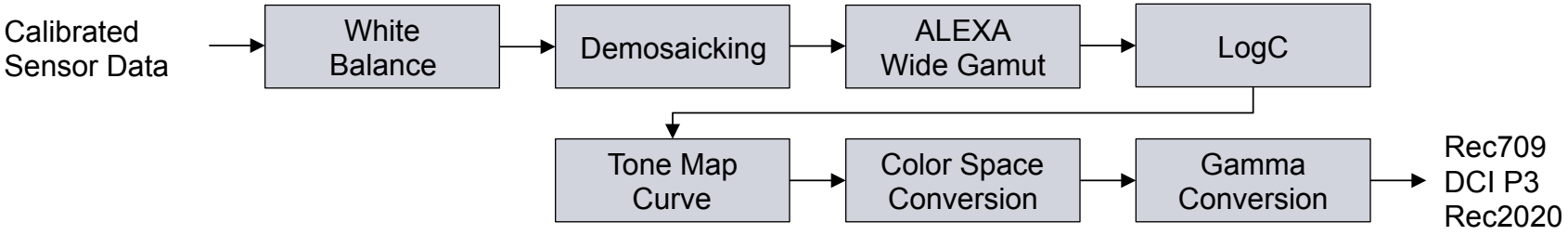
- Film-like, organic look
- Wide exposure latitude of over 14 stops
- Dual amplifier technology
- High sensitivity of EI 160 - 3200
- Natural color reproduction
- Sharp, natural images for HD, 2K or 4K deliverables
- Max Resolution in “Open Gate”: 3414x2198 (3.4K)
- Max Resolution for standard lenses: 3164x1778 (3.2K)



ALEXA Output Scheme

- 1 or 2x MON OUT
  - HD-SDI 16:9
    - HD-SDI with information overlay
- 2x REC OUT
  - HD-SDI 16:9
    - Clean image
- 1x XR Capture Drive
  - ARRIRAW (16:9, 4:3, 4:3 cropped or Open Gate)
    - uncompressed
- 1x XR Capture Drive or SxS PRO/PRO+ card or CFast 2.0 card
  - QuickTime 16:9 HD, 16:9/4:3 2K or 16:9 3.2K
    - ProRes 422
    - ProRes 422 HQ
    - ProRes 4444
    - ProRes 4444 XQ
  - MXF 16:9 HD
    - DNxHD 145
    - DNxHD 220x
    - DNxHD 444

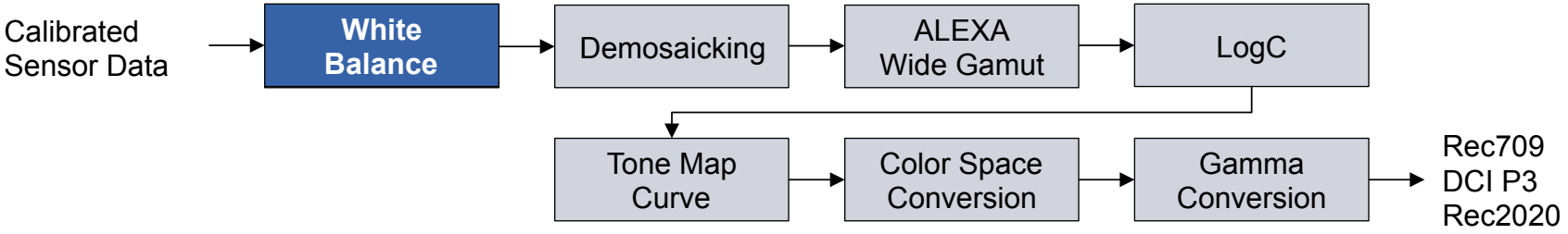
ARRI Workflow



- The calibrated sensor data are in linear domain
- Linear domain means the pixel values are linearly related to the amount of light

4x Amplified

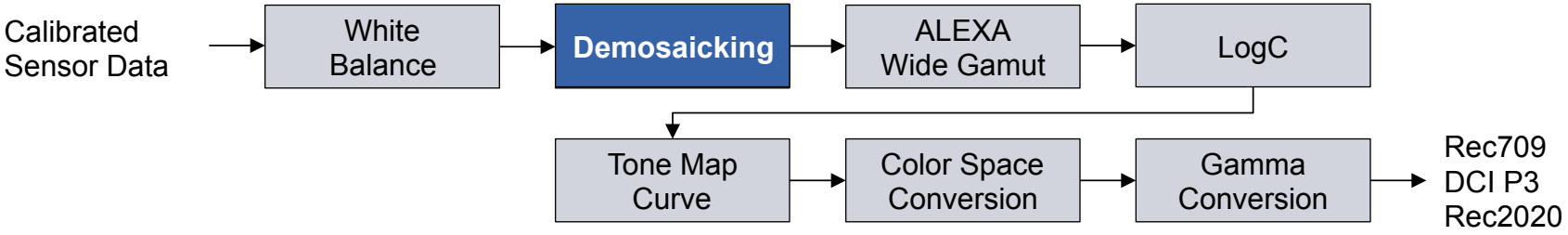
ARRI Workflow



- In the white balance the the red and blue components are multiplied by a value to adapt the image to the spectrum of the illumination

4x Amplified

ARRI Workflow

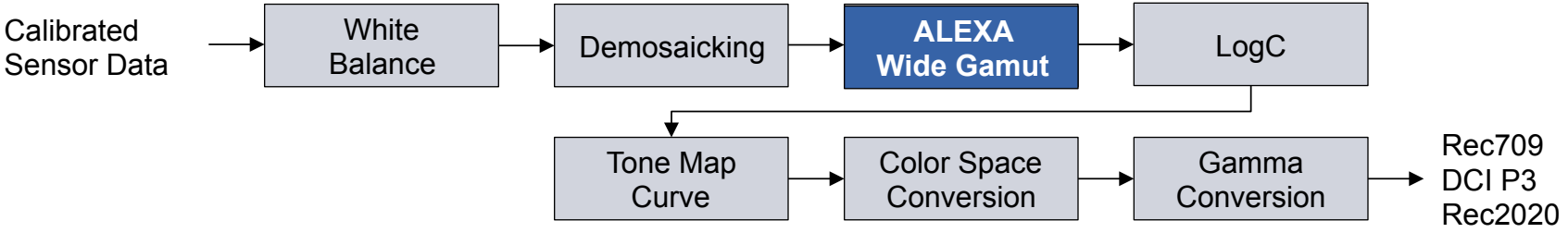


- The ALEVIII sensor is provided with a Bayer pattern color filter array, i.e. every pixel can capture only one component

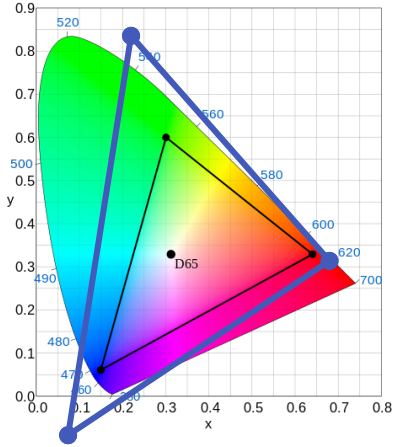
- The demosaicking reconstructs the full RGB image from the Bayer pattern sensor data

4x Amplified

ARRI Workflow



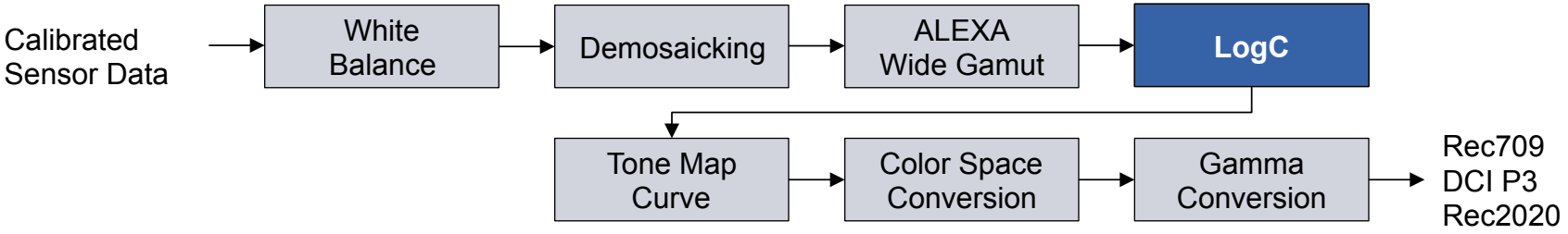
- A digital camera does not have RGB primary colors
- The encoding primaries for this color space are chosen to avoid clipping in all but the most extreme cases



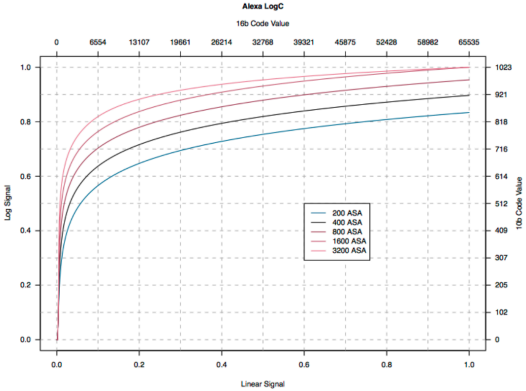
4x Amplified

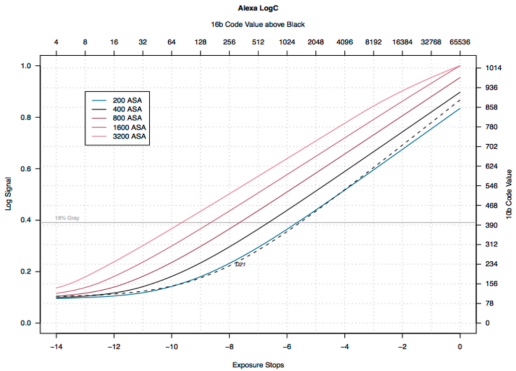
	x	y
White Point	0.3127	0.3290
Red	0.684	0.313
Green	0.221	0.848
Blue	0.0861	-0.1020

ARRI Workflow

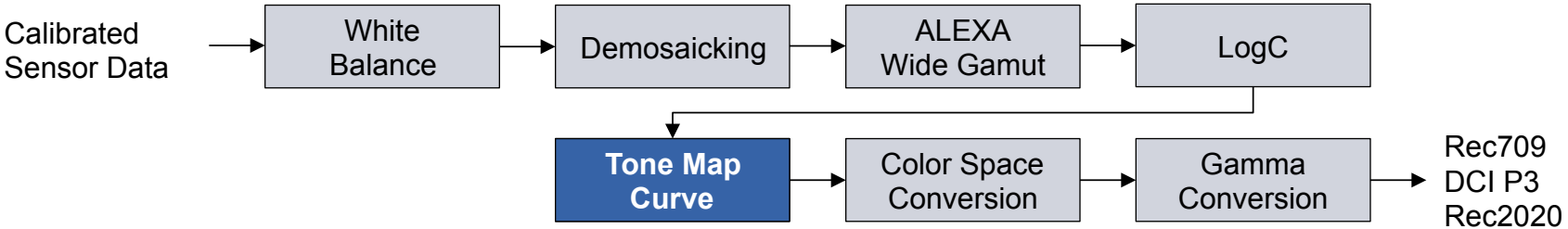


- The “C” in LogC is derived from “Cineon”, the digital film scanning, processing and recording system developed by Kodak in the 90s
- In this encoding the relation between the exposure measured in stops and the signal is linear (straight) over a wide range
- The toe occurs because the sensor can not see low light levels with the same quantization as higher levels

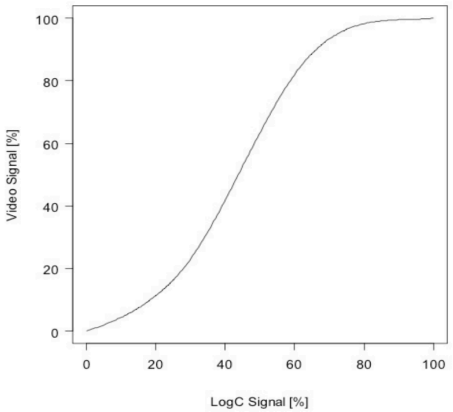




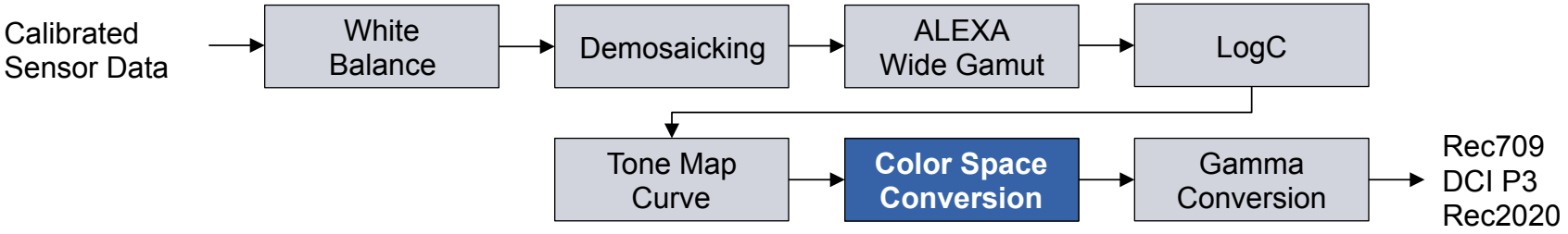
ARRI Workflow



- **Tone Map Curve** compresses the shadows and the highlights of the image that provides a nice image on video but it also means that some information is no longer available in the image

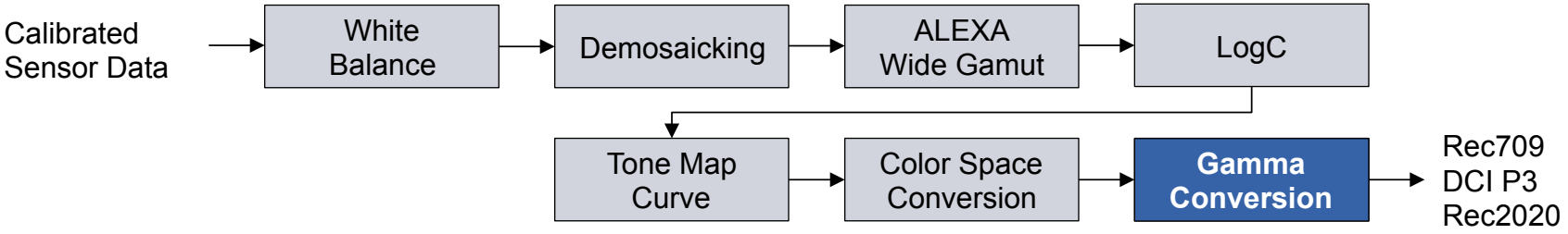


ARRI Workflow



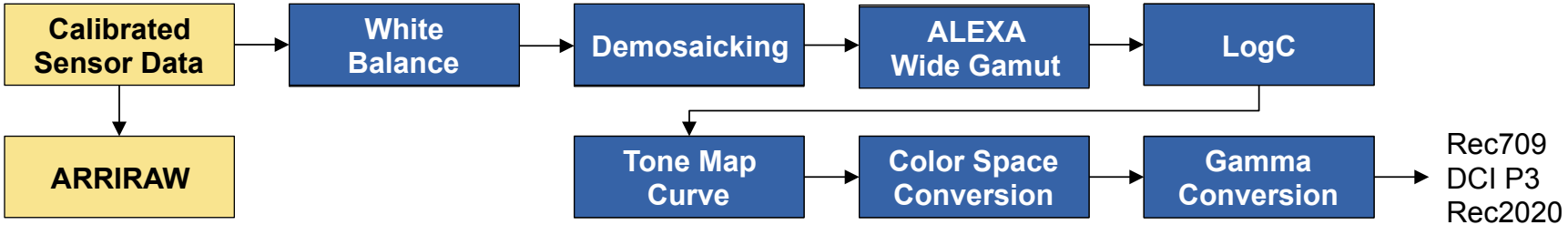
- **Color Space Conversion** allows to correctly represent the colors into the video color space, if the target gamut is smaller than the original one (Rec709 or DCI P3) there is a loss in color information

ARRI Workflow



- **Gamma Conversion** is necessary because displays use neither a linear nor a logarithmic encoding. The relation between signal and brightness is a power function where the exponent is traditionally called γ

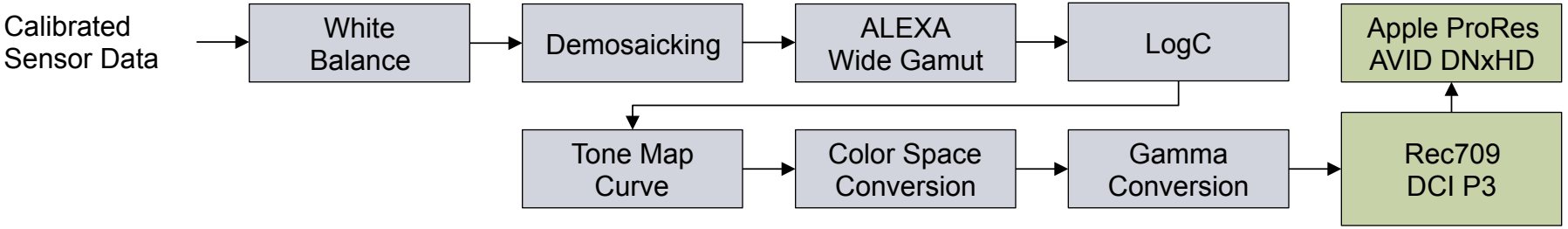
ARRI Workflow - ARRIRAW



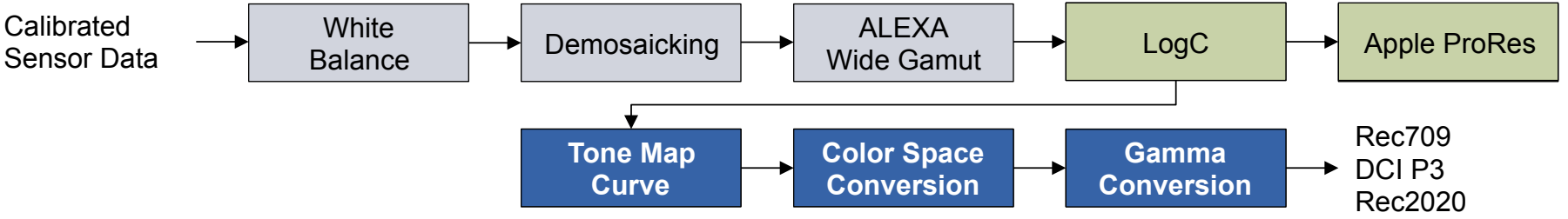
- ARRIRAW is the highest image quality output possible with ALEXA
- It stores, unencrypted, 12-bit log compressed raw sensor Bayer pattern data
- It has been made public in SMPTE RDD 30:2014 and RDD 31:2014

Format	Resolution	File Size	Data Rate @ 24fps	fps Range
16:9 2.8K	2880x1620	7 MB	1.34 Gbit/s	0.75-120
4:3 Cropped/2.6K	2578x2160	8.4 MB	1.61 Gbit/s	0.75-96
4:3 Full/2.6K	2880x2160	9.3 MB	1.79 Gbit/s	0.75-96
Open Gate 3.4K	3414x2198	11.3 MB	2.17 Gbit/s	0.75-75

ARRI Workflow – ProRes and DNxHD



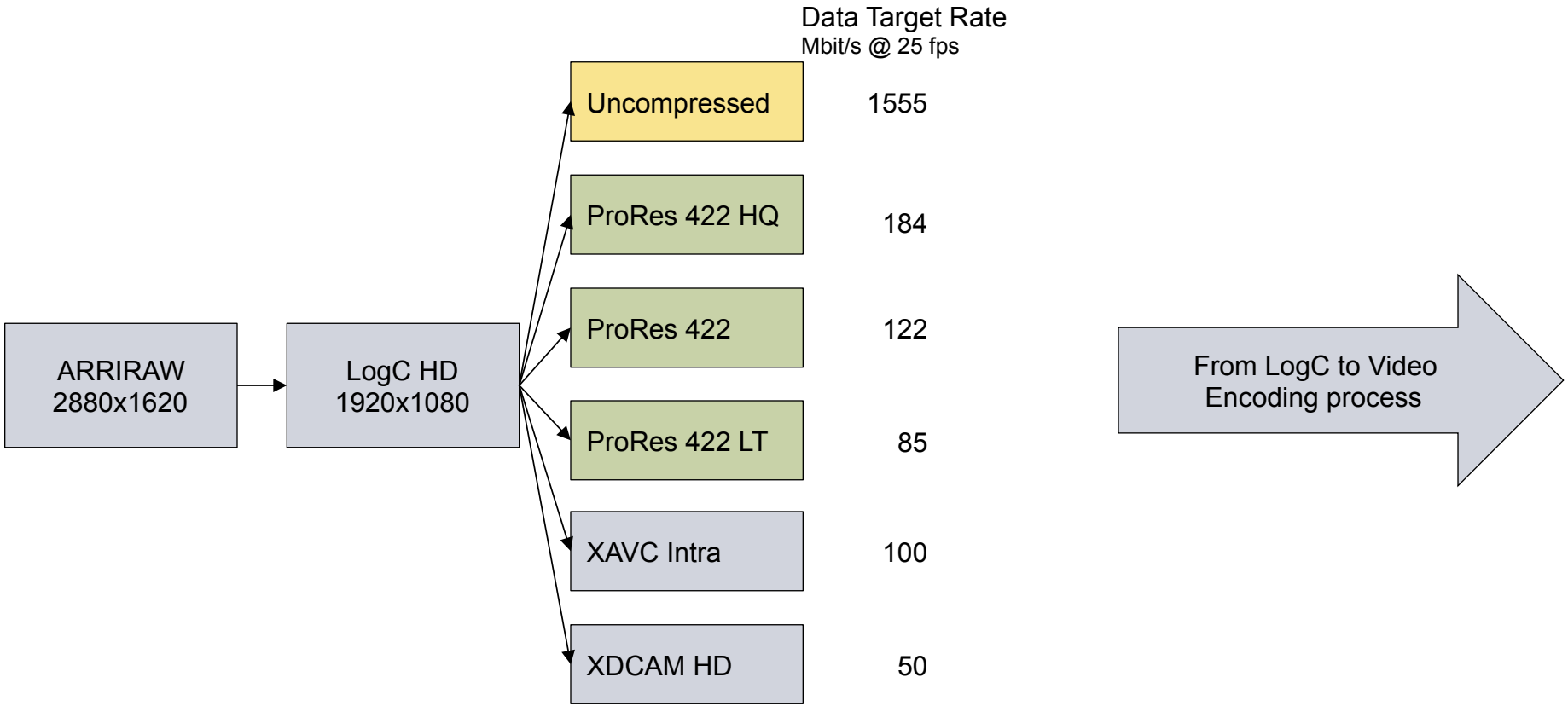
ARRI Workflow – ProRes and DNxHD



Video vs LogC

Color comparison: split image Video/Log C

LogC compression test workflow

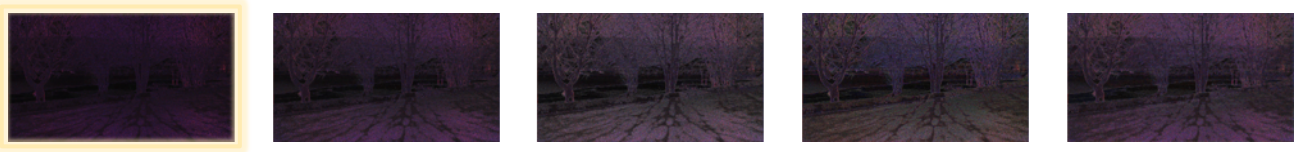


Scene 1 – LogC

Scene 1 – Rec709

Difference in LogC Images

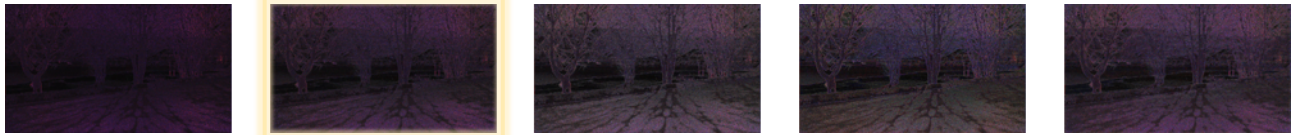
422 HQ | 422 | 422 LT | XAVC Intra | XDCAM HD



20x amplified difference of compressed to uncompressed image

Difference in LogC Images

422 HQ | 422 | 422 LT | XAVC Intra | XDCAM HD



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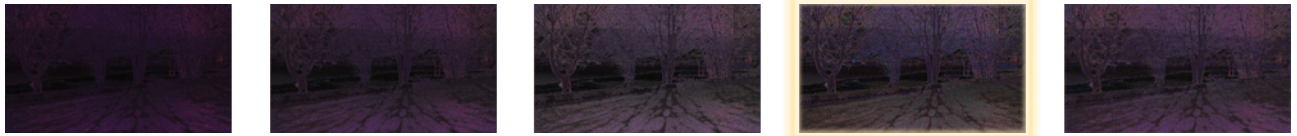

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Difference in LogC Images

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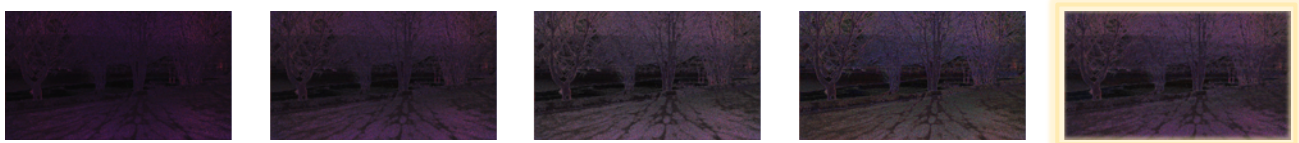
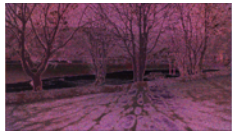


20x amplified difference of compressed to uncompressed image

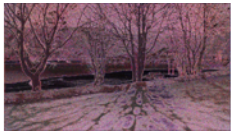
Difference in Rec709

422 HQ

422

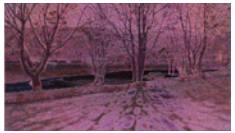


422 LT



XAVC Intra

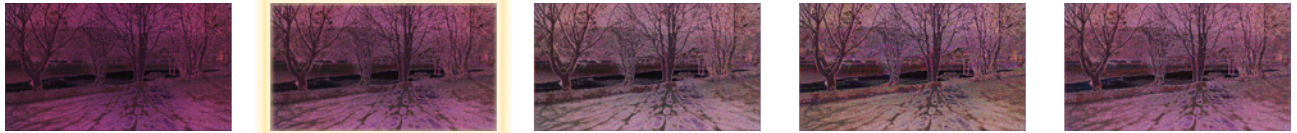
XDCAM HD



20x amplified difference of compressed to uncompressed image after color correction

Difference in Rec709

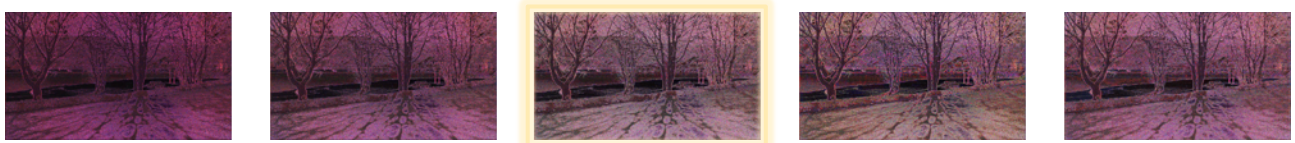
422 HQ | 422 | 422 LT | XAVC Intra | XDCAM HD



20x amplified difference of compressed to uncompressed image after color correction

Difference in Rec709

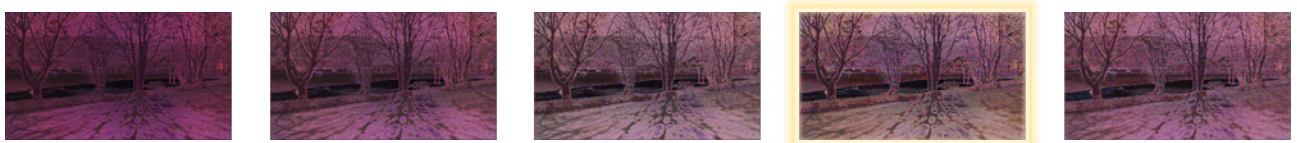
422 HQ | 422 | 422 LT | XAVC Intra | XDCAM HD



20x amplified difference of compressed to uncompressed image after color correction

Difference in Rec709

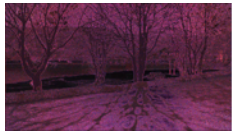
422 HQ | 422 | 422 LT | XAVC Intra | XDCAM HD



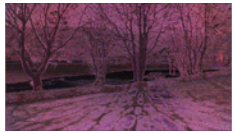
20x amplified difference of compressed to uncompressed image after color correction

Difference in Rec709

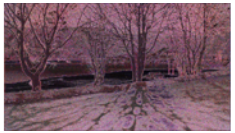
422 HQ



422



422 LT



XAVC Intra

XDCAM HD

20x amplified difference of compressed to uncompressed image after color correction

Side-by-Side ProRes 422HQ

20x amplified difference in LogC

20x amplified difference in Rec709

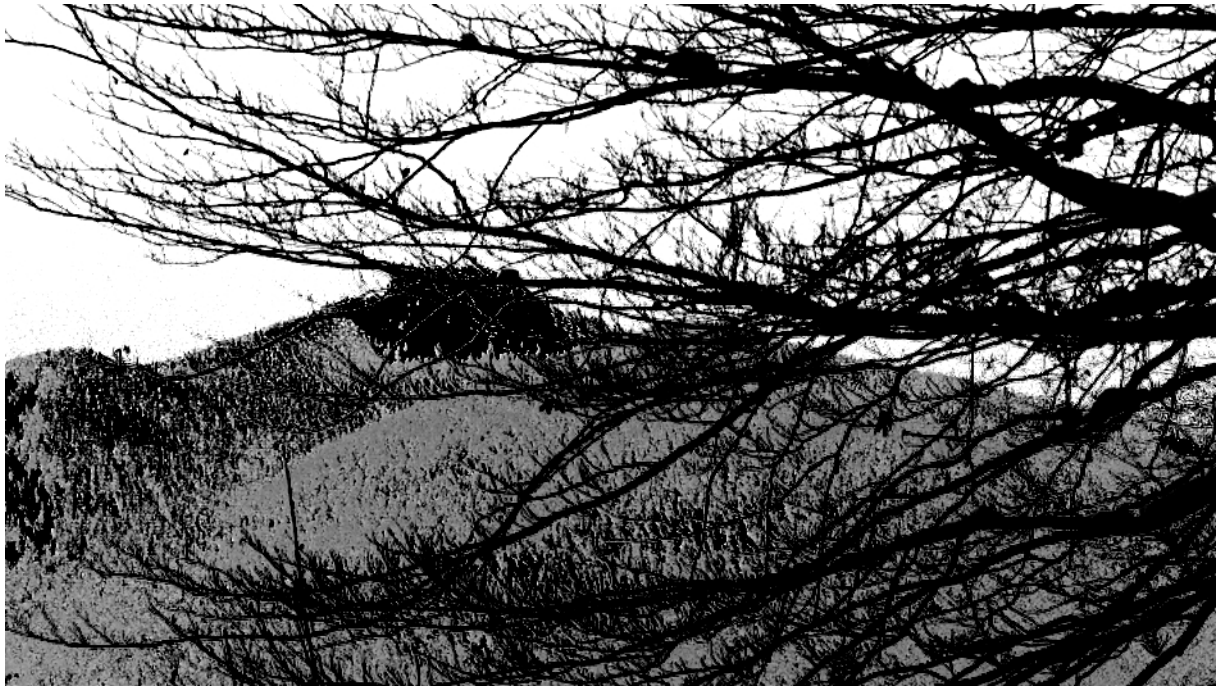
Keying

Keying

Matte for selective color correction of sky

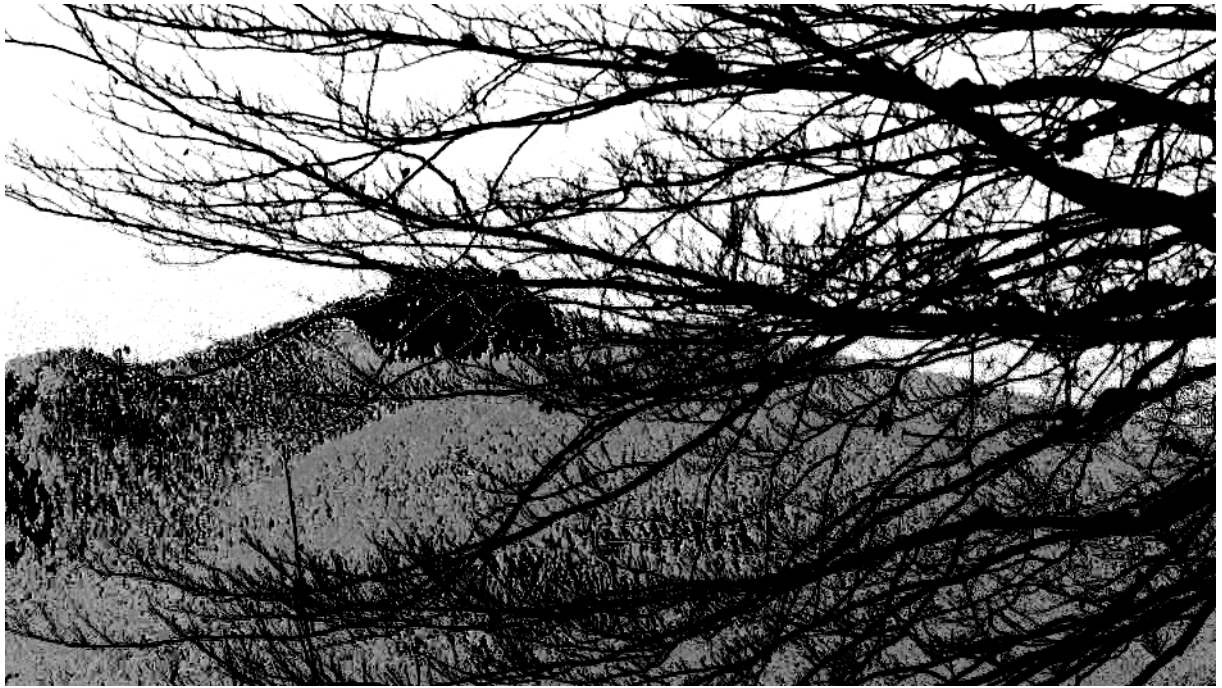
Matte Quality

Uncompressed | 4444 XQ | 4444 | 422 HQ | 422 | 422 LT



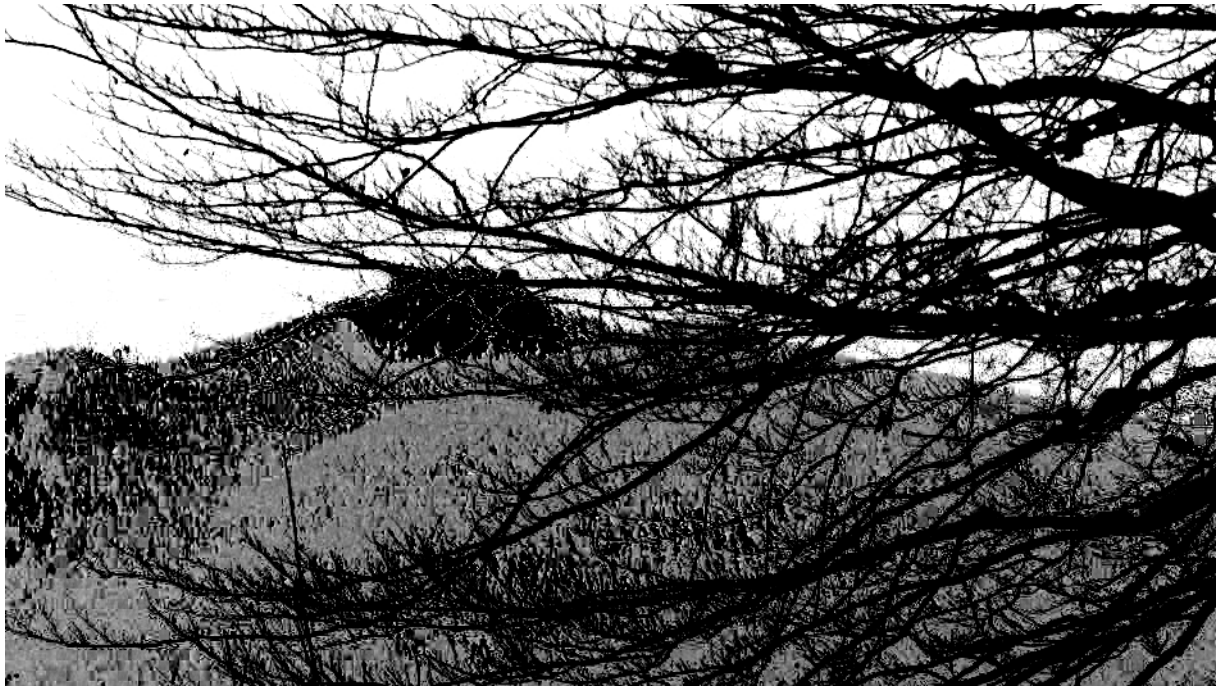
Matte Quality

Uncompressed | 4444 XQ | 4444 | 422 HQ | 422 | 422 LT



Matte Quality

Uncompressed | 4444 XQ | 4444 | 422 HQ | 422 | 422 LT



Matte Quality

Uncompressed | 4444 XQ | 4444 | 422 HQ | 422 | 422 LT

Matte Quality

Uncompressed | 4444 XQ | 4444 | 422 HQ | 422 | 422 LT

Matte Quality

Uncompressed | 4444 XQ | 4444 | 422 HQ | 422 | 422 LT

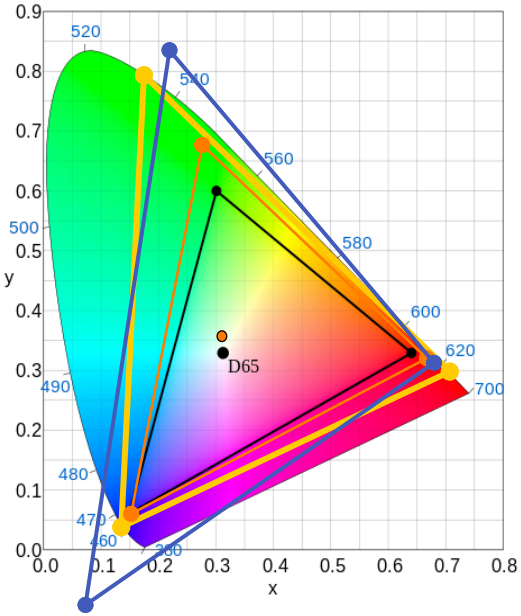
Apple ProRes vs HEVC

Compression Rate: 4444 – 12bit – Intra – [Mbit/s]								
Aspect Ratio	Resolution	Fps Range	Max Luma Sample Rate [sample/s]	Apple ProRes		HEVC – 6x Main10		
				4444	4444 XQ	5.1	5.2	6.1
16:9	1920x1080	0.75-120	414,720,000	1,320	1,980	240-960	360-1,440	720-2,880
16:9	2048x1152	0.75-120	471,859,200	1,508	2,262	240-960	360-1,440	720-2,880
4:3	2048x1536	0.75-48	150,994,944	816	1,224	240-960	360-1,440	720-2,880
16:9	3164x1778	0.75-30	168,767,760	900	1,350	240-960	360-1,440	720-2,880

Compression Rate: 422 – 10bit – Intra – [Mbit/s]								
Aspect Ratio	Resolution	Fps Range	Max Luma Sample Rate [sample/s]	Apple ProRes		HEVC – 3x Main10		
				422	422HQ	5.0	5.1	5.2
16:9	1920x1080	0.75-200	414,720,000	578	830	NA	120-480	180-720
16:9	2048x1152	0.75-200	471,859,200	660	940	NA	120-480	180-720
4:3	2048x1536	0.75-48	150,994,944	190	286	75-300	120-480	180-720
16:9	3164x1778	0.75-30	168,767,760	345	518	75-300	120-480	180-720

Wide Color Gamut

	Rec709	DCI P3	Rec2020
Resolution	1080i or 1080p	2K or 4K “flat” or “scope”	3840x2160 7680x4320
Bit Depth	8-10 bits	12 bits	10-12 bits
Frame Rate	23.976–60 fps	2K – 24 or 48 fps 4K – 24fps	23.976–120 fps
Coverage	35.9%	≅50%	75.8%
Gamma	2.2	2.6	10 bits: 2.2 12 bits: ---
YCbCr Conversion	K_B = 0.0722 K_R = 0.2126	XYZ color space	K_B = 0.0593 K_R = 0.2627
Used in:	HDTV	Almost all 2K and 4K cinema projectors	Christie CP42LH Laser projector, Dolby Vision



High Dynamic Range – Production

- Digital camera manufacturers are working hard to expand the dynamic range of their cameras
- 18 or even more stops dynamic range are still future but not so far away, i.e. more than 16 bits per channel will be necessary

- OpenEXR is a high dynamic-range image file format developed by Industrial Light & Magic
- It supports 16- or 32- bit floating point or 32 bit integer pixel. The 16-bit floating point is called “half” is compatible with the half type in NVIDIA’s CG graphics language
- It supports lossless and lossy coding.

More Information on OpenEXR: http://www.openexr.com/

- ACES is becoming the industry standard for managing color throughout the life cycle of a motion picture or television production
- It is a free, open, device-independent color management and image interchange system that can be applied to almost any current or future workflow
- ACES is currently being integrated in many of the hardware and software tools already in use
- ACES represents color components as 16-bit floating point number (IEEE P754)

	x	y
White Point	0.32168	0.33767
Red	0.73470	0.26530
Green	0.00000	1.00000
Blue	0.00010	-0.07700

More Information: http://www.oscars.org/science-technology/sci-tech-projects/aces

High Frame Rate

- In video production more than 48 fps are normal
- The maximum frame rate of ARRI cameras is 200 fps
- There are special cameras that can shot at much higher frame rate
  Phantom Flex 4K camera can: 4K @ 940 fps
  2K @ 1977 fps
- Apple iPhone6 can 200 fps
- The limit of 300 fps imposed at HEVC should be too restrictive

Very Low Delay Encoder

- This is useful for live view of the recorded material on wireless display directly on the set
- Most of the time the users look at the images on the display but audio comes directly from the live set

- In this situation, even small delays are detectable
- Just few lines delay is acceptable, but medium-low quality 4:2:0 8bit compression is enough

Digital Cinema Certificates

- ARRIRAW has a Certificate to ensure a given image quality if ARRIRAW is used to record the footage
- Every post-production program must, at least, deliver an image quality comparable or better than ARRI image quality.

- Apple requires image quality tests to certificate the implementation of a ProRes encoder
- AVID requires the same for its DNxHD coder

ProRes

DNxHD®

- MPEG standard is at the decoding side, i.e. every encoder that can write HEVC decodable and compliant bitstream is a HEVC encoder
- No image quality is guarantee
- What we suggest is a “Digital Cinema Certification” for encoder, i.e. an encoder is certified if it can guarantee a specified image quality at a certain rate

ARRI Footage for MPEG

Aspect Ratio	Lens	Resolution	Speed	Sync Audio
16:9	Spherical	2880x1620	Standard	Yes
			High – 120fps	No
4:3 Full	Spherical	2880x2160	Standard	Yes
			High – 90fps	No
4:3 Full	Anamorphic	2880x2160	Standard	Yes
Open Gate	Spherical	3414x2198	Standard	Yes

ARRIRAW Converter

ARC Webpage: https://www.arri.com/?id=5985

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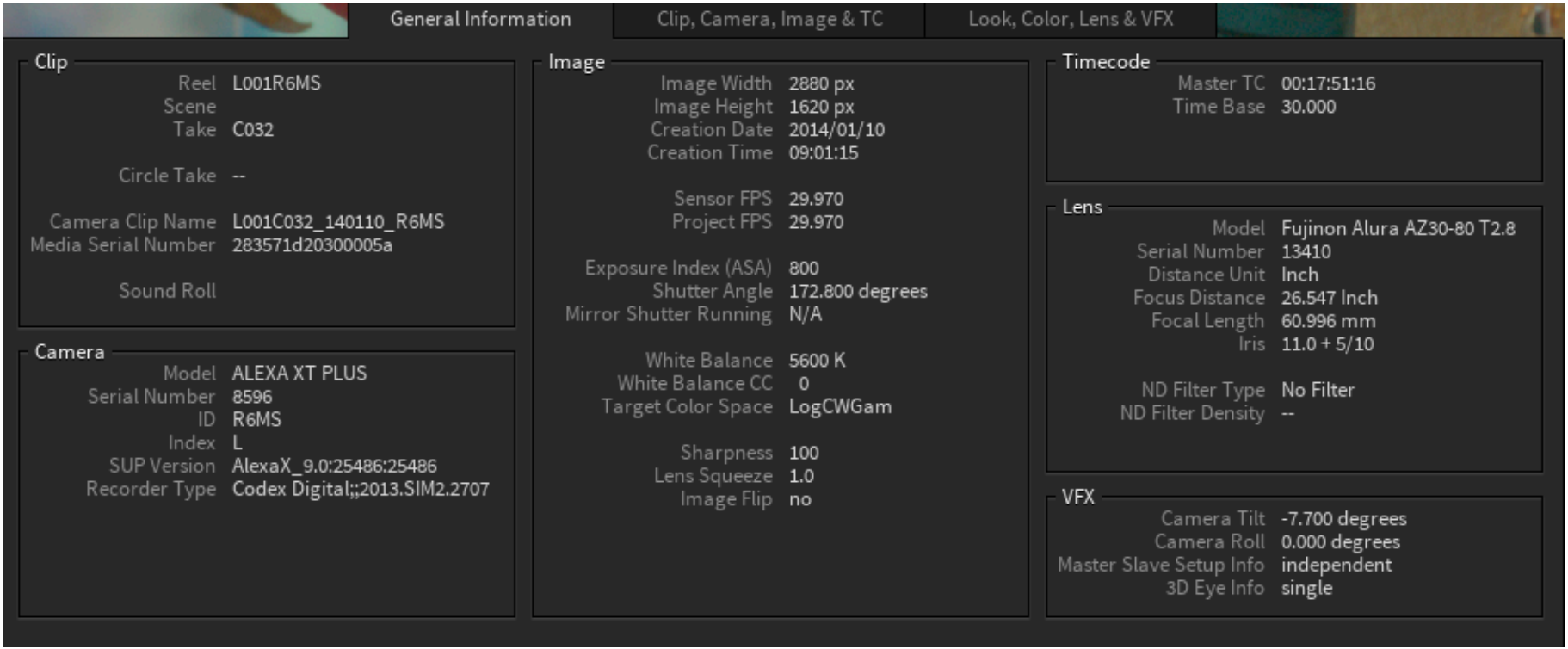
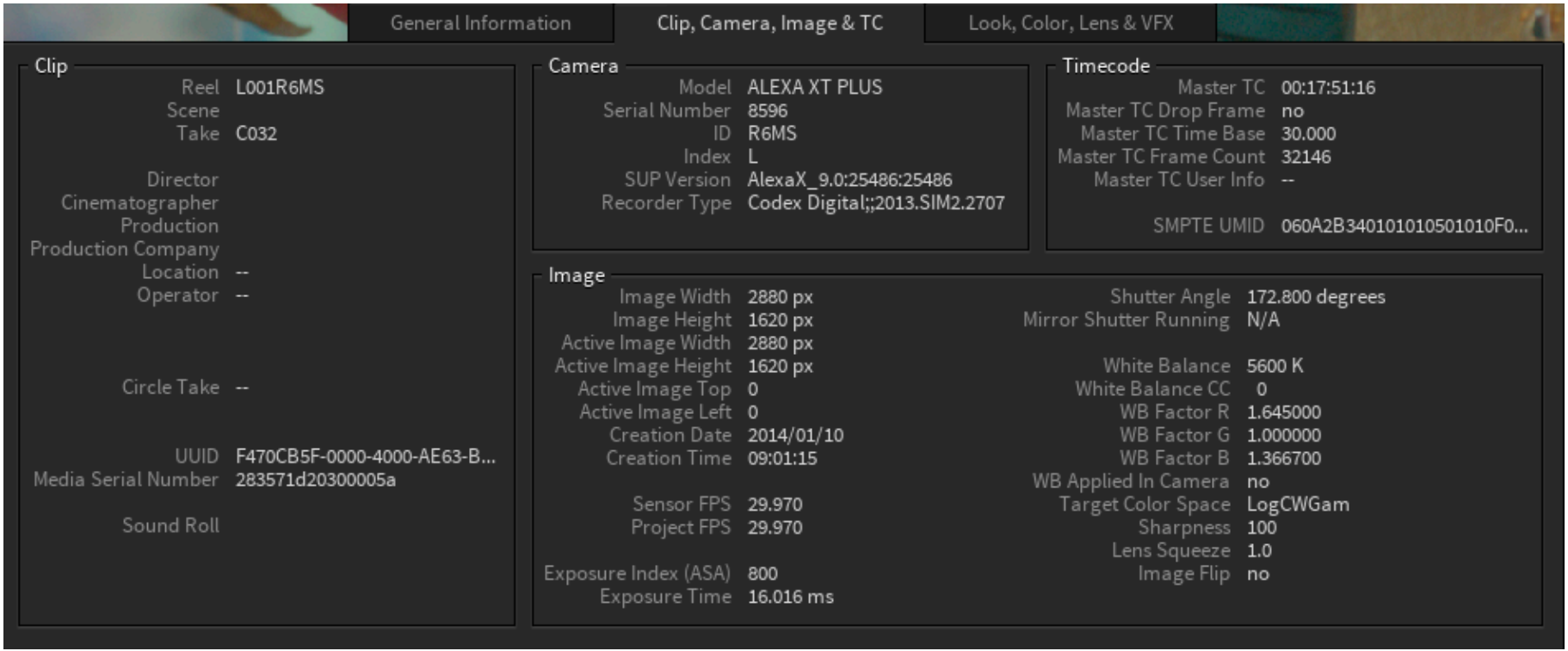
ARRI Footage Metadata



ARRI Footage Metadata



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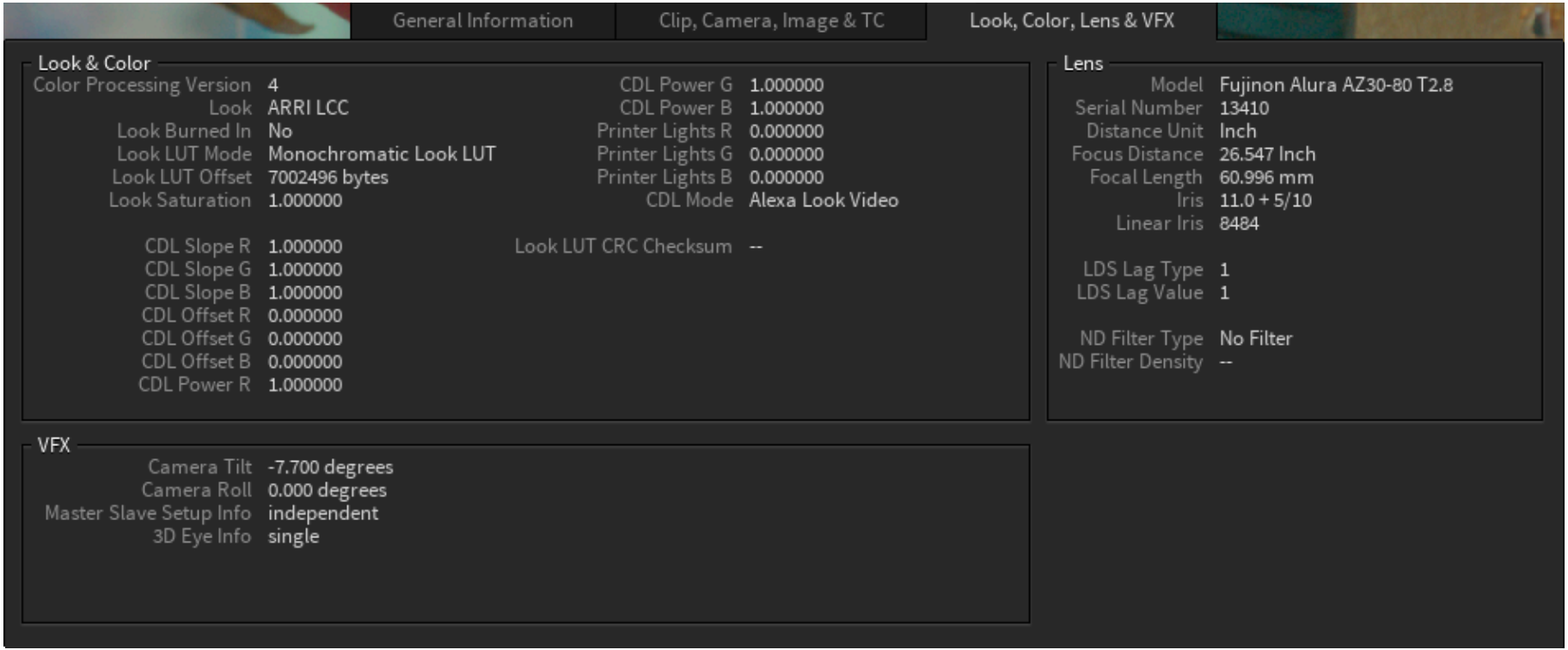

TRULY CINEMATIC