Origin 4K Camera

High Dynamic Range Workflow Considerations

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ORIGIN

WARNING: EXTREME RESOLUTION. UNPARALLELED EXPOSURE LATITUDE. MAY CAUSE SEVERE PERFORMANCE ENVY.

DESIGNED FOR CINEMATOGRAPHERS

Origin. The only 4K cinematography camera.

dalsa.com/dc
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DALSA technology with vision

Digital Cinema

Agenda

- Camera Overview
- On Set
  - 4K RAW data recording
  - visualization tools
- Data Back-up & Transport
  - getting from set to post
- Post Production: "The Digital Lab"
  - RAW to RGB processing
  - "log" vs. linear processing
  - data centric workflow environment
- Global Data Management
  - storage, processing and compression
  - asset archival

Camera Overview

## Designed specifically for cinematography

- Large format sensor
  - 4046 x 2048, 8.4um pixels, photo-gate architecture
- PL lens mount
  - accepts standard 35mm lenses (ARRI, Cooke, Angineux)
- Reflex viewing system
- High dynamic range, low noise
  - greater than 12 stops of exposure latitude
  - 4DN noise in 14 bit ADC (72dB), 16 bit word
- 4K primary image data output
  - 4K RAW recording to hard disk drive over quad fibre
  - auxiliary SMPTE 292, SMPTE 372 digital video later

On Set: Recording

RAW Linear Recording

- Uncompressed 16bpp ~16.7MBytes/frame
  - 16b RAW is the most compact high dynamic range (HDR) 4K image data format
  - metadata friendly DPX file format
- HDR "Digital Negative" philosophy
  - gamma/gain/color space parameters not "baked in"
  - recording media and display device independent
  - preserves downstream flexibility based on creative drivers, not technology limitations
- Preserves maximum scene latitude and detail...
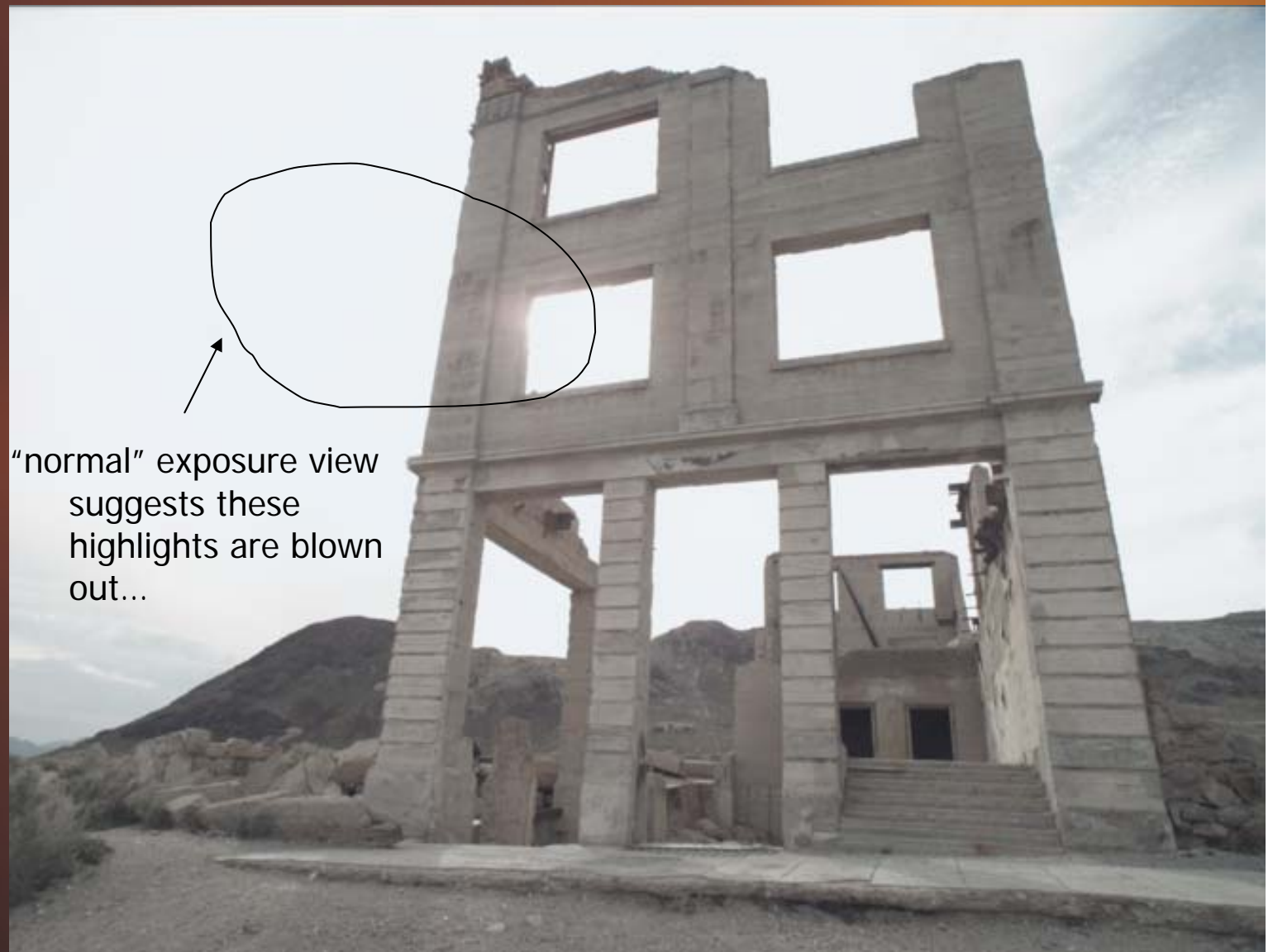
On Set: Recording

adjusting gain and gamma reveals the highlight detail captured in RAW data...

On Set: Recording

final image layered and mapped to the display to convey the full latitude

On Set: Recording
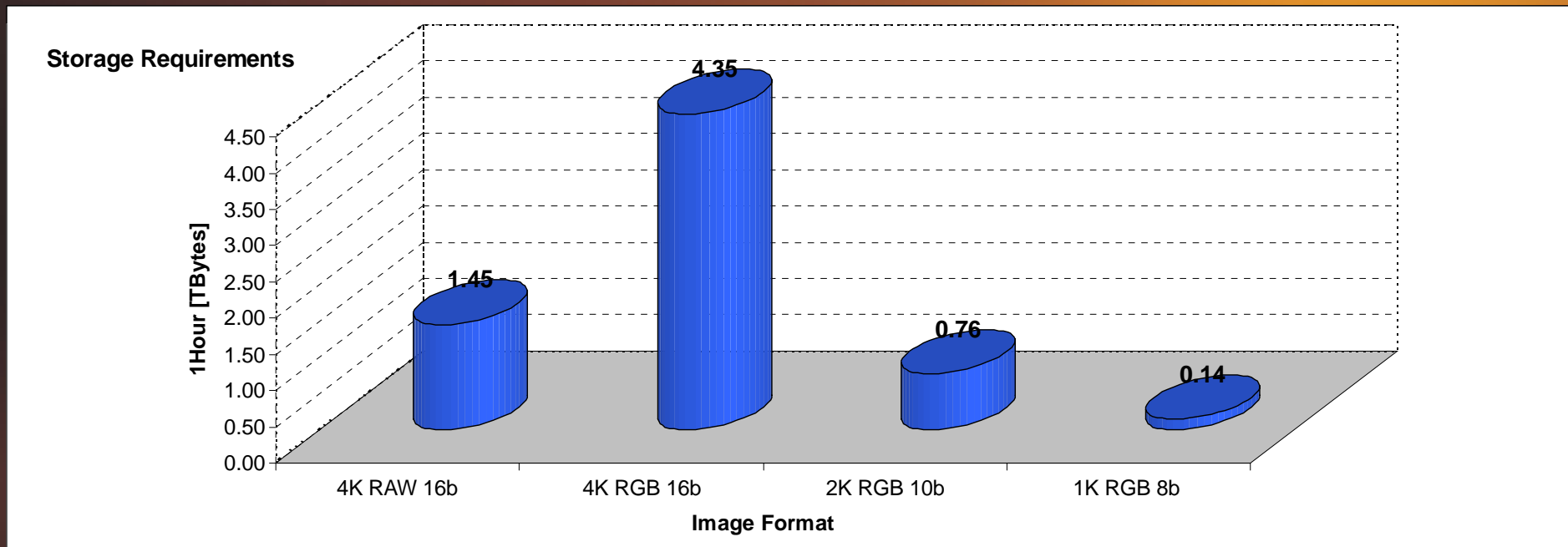
On Set: Recording

- Preservation of intent is critical throughout workflow
  - data centric recording enables use of DPX header to capture camera specific settings that can be exported to XML database
  - XML file used to integrate technical and creative parameters from multiple sources
- HDR 4K dictates recording hardware bandwidth
  - 420MB/sec at 24fps
- Tape based systems do not meet either requirement

www.codexdigital.com

On Set: Recording
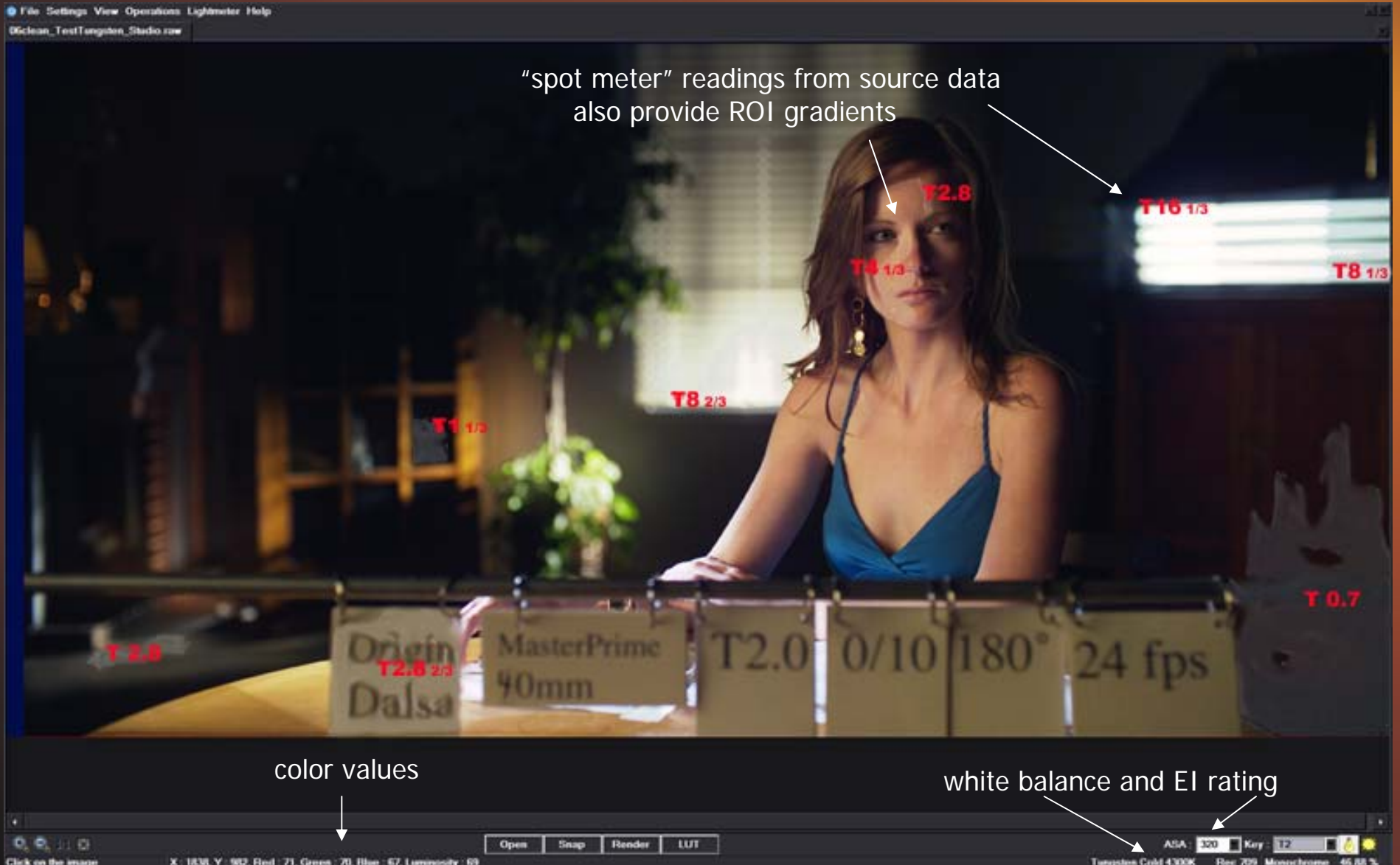

Storage Requirements

Chart: 1Hour [TBytes] vs Image Format

- 4K RAW 16b: 1.45
- 4K RGB 16b: 4.35
- 2K RGB 10b: 0.76
- 1K RGB 8b: 0.14

- **4K 16b RAW offers lossless data reduction**
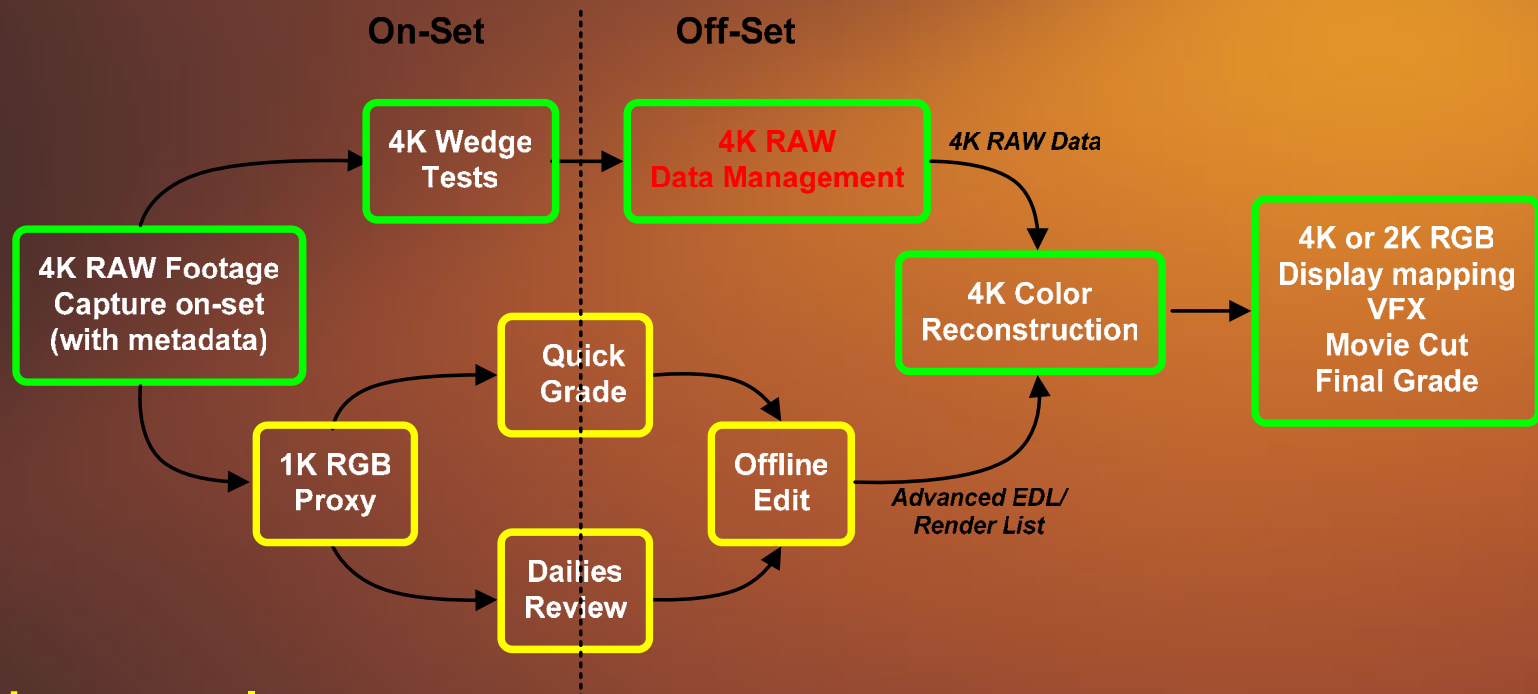 - 33% of 4K 16b RGB
  - only twice 2K 10b RGB

On Set: Visualization

- Immediacy of feedback is the primary benefit of digital production
  - requires accurate display and measurement
- Emerging suite of tools expand creative options
  - on-set color/look management systems increase confidence in end result
- RAW format enables fast, accurate results
  - full resolution, full range "digital wedge" < 20 sec
  - "soft mapped" through translator to target display
  - metadata embedded in wedge attached to sequence
  - <u>original image data unaffected</u>

On Set: Visualization

"spot meter" readings from source data
also provide ROI gradients

color values
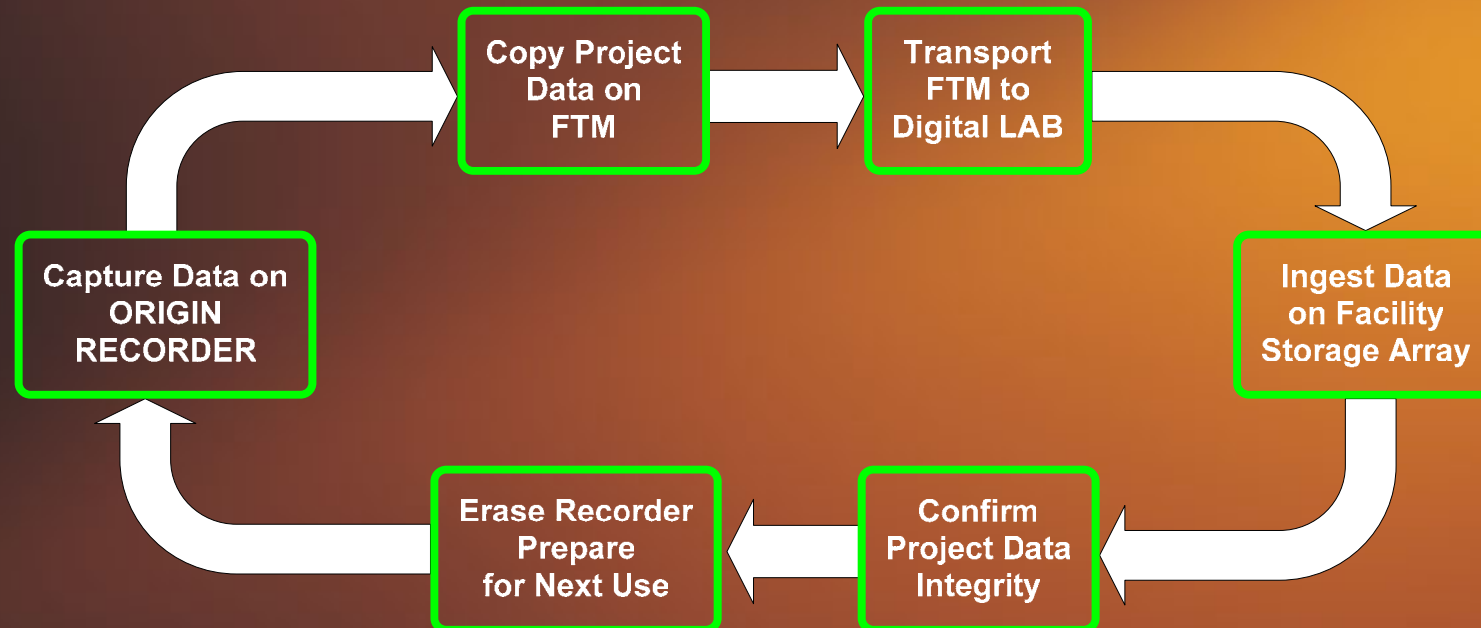
white balance and EI rating

On Set: Visualization

- **Other tools**
 - global and line profile histograms on wedge
  - 1K, 8b RGB proxies for reference grading and editorial

Data Back-up & Logistics

DALSA *technology with vision*

```
Copy Project        Transport
Data on      -->    FTM to
FTM                 Digital LAB
  ^                     |
  |                     v
Capture Data on     Ingest Data
ORIGIN              on Facility
RECORDER            Storage Array
  ^                     |
  |                     v
Erase Recorder  <-- Confirm
Prepare             Project Data
for Next Use        Integrity
```

- **Field Transport Magazine (FTM)**
  - RAID 5, removable drive bays or dedicated box
  - secure back-up, high bandwidth transport to post
  - data ingest options: SRPoIB @ 500MB/s, TCP/IPoIB @ 200MB/s, FTP: 70MB/s single GbE, 110MB/s dual bonded GbE
- **Recycled back to set after confirmation of receipt**
  - data "Offload Manager" reports file statistics

Data Back-up & Logistics
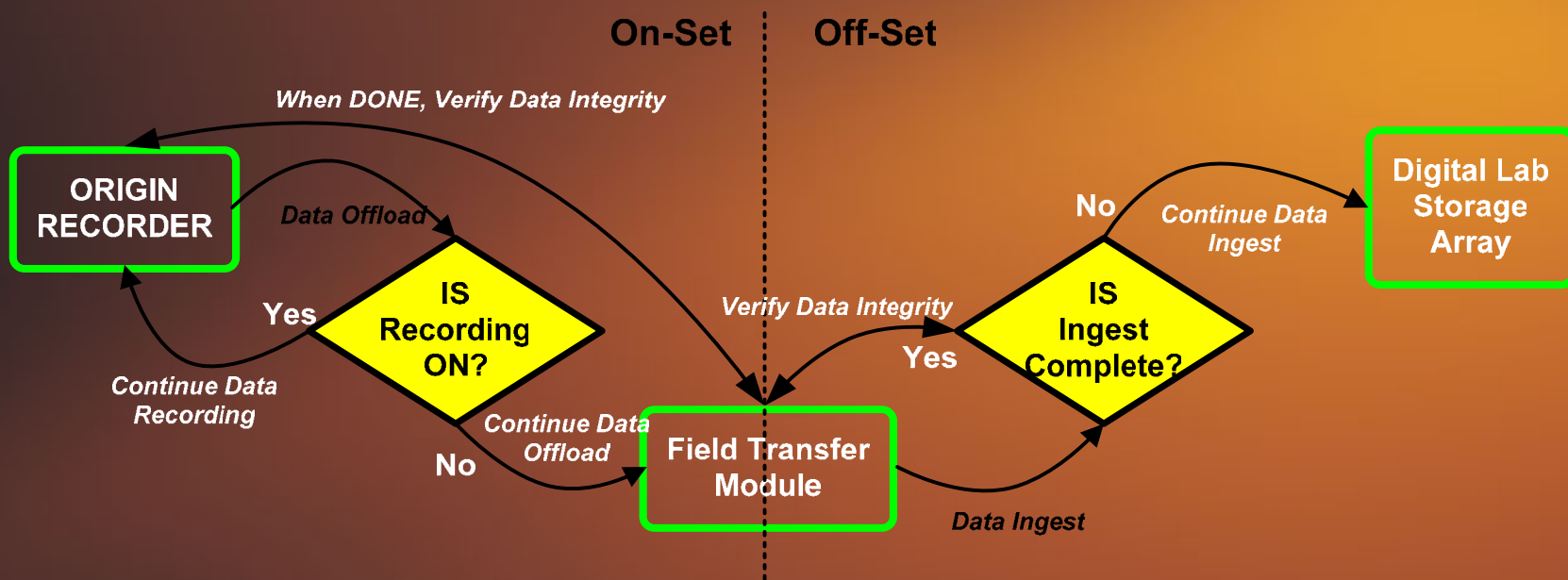
- **Offload Manager**
  - controls transfer from recorder to FTM & FTM to lab
  - tracks start/stop points of previous transfers to ensure continuity
  - performs MD5 verification and provides file statistics report to ensure data integrity throughout the process

The Digital Lab

Color Reconstruction

Four Pixel Cell of Bayer Pattern

G	B
R	G

Spectral Transmission
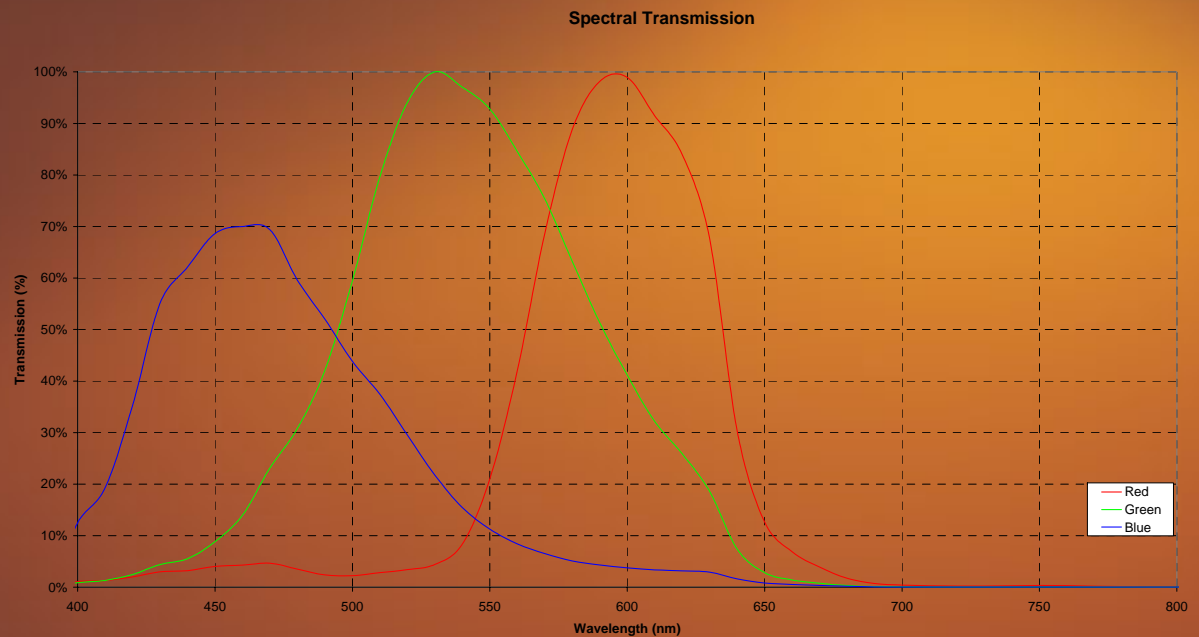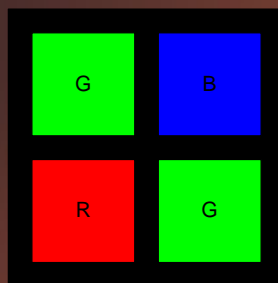
- Reconstruction ≠ interpolation
  - filter design and process control are critical to accurate, repeatable results
  - multi-pass, large kernel algorithm utilizes specific pixel and focal plane attributes to produce high quality RGB images

The Digital Lab
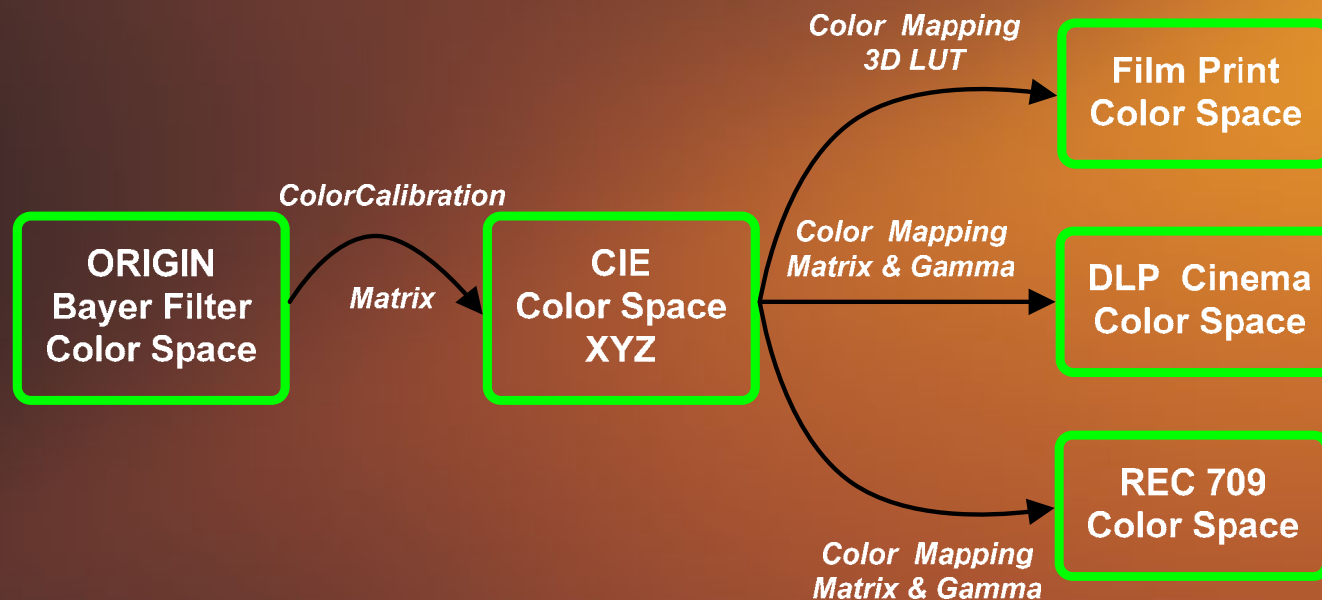
- **Detailed color calibration is critical**
  - native color space of each camera characterized
  - unique color mapping coefficients stored internally
- **Camera output mapped to CIE XYZ color space**
- **Mapping to target space happens as & when required**

The Digital Lab

- Resolution often confused with MTF
  - reconstructed RGB image <u>resolution</u> is 4046 x 2048 pixels
  - ability to resolve <u>image detail</u> determined by system MTF
- Reconstruction algorithm maximizes image detail
  - internal pre-filter spreads optical signal over known larger number of sampling elements (pixels)
  - algorithm makes intelligent decisions based on intra-frame correlation of scene content frequency and edge information
  - lens, imager characteristics and system noise determine fidelity of final image detail

The Digital Lab

12bit Linear vs. 10bit Log transfer function
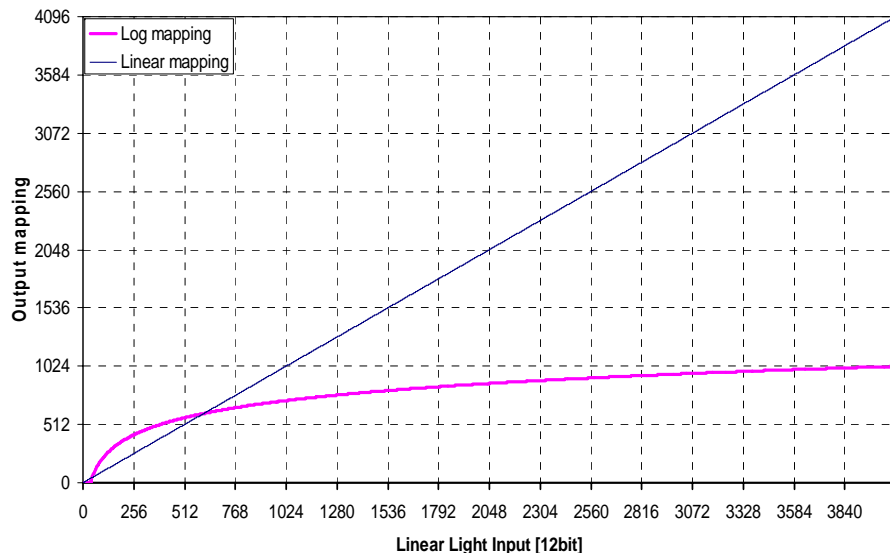
- **Bit assignment of scene**
  - linear assigns uniform distribution
  - log assigns bits based on approximation of HVS distribution
- **Mapped to suit display and processing pipeline at each step of the process**

- **Precision of end result affected by rounding errors introduced…**
  - at capture (to fit media)
  - each subsequent conversion from floating point processing to integer file format

12 to 10bit LogMapping - Rounding Error

The Digital Lab

Near-Line Image Library SAN
>200TBytes, SATA, RAID3/5, S.A.F.T.E.
Archive 4K RAW Camera Original
16bpp Bayer lin or 12bpp RGB gamma
8 or 10bit proxy all raw material
Back-up 4K WIP projects

Image Library Management Secure Server
Digital Asset Management Software
Offload Manager & Metadata Server
Search and Preview Proxy
Automated back-up and history tracking

Mastering
2K DLP Master encoding
*Color Matrix/3DLUT to Film gamut
2K/4K Laser Print-Film Master

"A grade" out-takes film print

InfiniBand / 10GbEthernet / Fibre Channel backbone

On-Line Storage Pool
>20 TBytes, FC/SCSI/SAS, RAID 3/5
High Speed, Intensive access
Storage pool for WIP projects
Storage pool for 1K/2K proxy
High Reliability and Availability

Editing Workstation(s)
Edit Final cut & "A grade" takes
1K/2K proxy off-line editing
Support 4K Real time NLE
Import/Export XML metadata
4K, RGB, 16bpp lin or 12bpp gamma

Color Grading Suite
2K Color Grading in Real time
Render graded 4K master
HDR exposure layering
Color Matrix/ LUT to Display Gamut
4K, RGB, 16bpp lin or 12bbp gamma

Processing Render Farm
>50 parallel processing nodes
Advanced render scheduling engine
Load balancing and TOE engine
Protected data sharing mode
32bit and/or 64bit CPUs

Compositing Workstation(s)
Multi layer compositing
Near/Non real time operation
Graphics, Animation, SFX
Motion tracking
4K, RGB, 16bpp lin or 12bpp gamma

Calibrated Grading Display
2K Cinema DLP

*use 2K CRT monitor & 4K LCD
monitor for verification

- Data centric model looks much like contemporary IT environment
  - high performance servers used for image processing, job scheduling and data management
  - combination of on-line, near-line and offline HDD storage
- Use of proxies mapped to given display environment maintains integrity of RAW source material through to final grading and mastering steps

Global Data Management

- Data management decisions required throughout the process
  - 4K, 16b RAW = 1.5TB per hour of material
  - appropriate resolution, bit depth and compression must be considered for each element
- Table illustrates impact on large 1,000,000 ft production
  - total RAW footage requires approximately 250TB
  - A Take Ratio = 5:1 (10 hours for 2 hour feature)
  - B Takes = all footage minus A Takes (approx 173 hours)

Total Storage Requirements [Tbytes]	Low	Medium	High
Master	2.6	6.44	8.59
	4K, 12bit log RGB, L3	*4K, 12bit log RGB*	*4K, 16bit lin RGB*
A Takes (per above)	9.43	15.27	50.91
	4K, 16bit lin RAW, L3	*4K, 12bit log RGB, L3*	*4K, 16bit lin RGB, L3*
B Takes (per above)	15.53	49.69	137.88
	2k,10bit log L3 bound	*2k,10bit log L3*	*4K,16bit RAW, L3 bound*
Proxy (entire OCN)	0.86	1.54	2.52
	8bit, 600x300MPEG	*8bit, 800x400MPEG*	*8bit, 1024x512MPEG*
Total Feature Film	28.40	72.94	199.90

$$L^3 = 2.5:1 \text{ lossless}, L^3 \text{ bounded} = 8:1, MPEG = 10:1 \text{ lossy}$$

Global Data Management

- Cost considerations
  - off-line HDD storage approx. $3K/hr of 4K RAW to purchase (including controller and RAID card)
  - lease/rental business models will be cheaper
  - end-to-end, full package pricing will be < 35mm process
- Archival considerations
  - archiving 4K RAW enables repurposing based on future image processing and display technologies
  - processing algorithms and metadata should also be archived
  - data facilitates multiple location disaster recovery plans
  - a 4K film neg. should also be struck to complete archival strategy

Summary & Conclusions

- 4K HDR RAW image capture <u>enables</u> highest quality end result
  - no irreversible baked in image processing preserves downstream flexibility
  - metadata rich files are best way to convey technical and creative intent
- Maintaining linear format deep into post preserves maximum detail
- Archiving 4K RAW files enables future repurposing
  - processing algorithms & metadata required too
- Data management strategy part of production planning
  - ideally end-to-end plan developed in consultation with camera supplier and post partners
- 4K HDR offers > 35mm quality at < 35mm costs