

# MEETING AND 4K SCREENING AT ARRI MUNICH - JULY 13<sup>th</sup> 2015

WITH

## THE ARRI IMAGE SCIENCE DEPARTMENT ENGINEERS

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*Upgrade completed during IBC 2015 in Amsterdam by:*

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*Product Manager Camera Systems*

Report by:

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**Rolf Coulanges, BVK, Imago delegate**

## GENERAL INFORMATIONS

Page 3 to 15

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# This report is designed for filmmakers, cinematographers, camera teams, post-producers and colorists interested in the texture of the image

On monday, July 13<sup>th</sup>, thanks to Rolf Coulanges, cinematographer, BVK, Imago TC delegate, we have been invited to a meeting at ARRI Munich. Organized by Harald Brendel, Principal Engineer Image Science and Henning Radlein, Head Of Digital Workflow Solutions, the goal of this encounter was to show us the developments and tests on the new:

- DeBayer algorithms for the internal recording in the ALEXA/AMIRA cameras and for the process of the ARRIRAW in post
- Noise reduction parameters for the AMIRA
- Sharpness control & resolution parameters

Some of these new parameters were introduced at Cinec in Munich (sept 2014) and at Micro Salon (Feb 2015) but we had deep explanations, new presentations and a screening of new tests. We were the only cinematographers invited to this unique session.

The discussion was focusing on the texture - through deBayer sharpness for the ALEXA and the AMIRA and noise reduction for the ALEXA MINI & the AMIRA - and on the UHD and 4K rasters. We received informations allowing to understand the general philosophy of ARRI regarding how to create and treat the number of pixels.

According to Harald Brendel it was a kind of test to check the interest of doing such meetings for the future.

After that all engineers had introduced themselves, Rolf and I received a lot of explanation on the research ARRI put on the deBayer algorithms.

## IBC 2015 UPDATE (Version 2 on internet)

During last IBC (September 2015), thanks to Christian Grafwallner, Research & Development Supervisor Digital Workflow Solutions, we received informations on the **SXT Color Workflow** (page 11 to 14) and thanks to Michael Jonas, Product Manager Camera Systems, you will find these new informations on:

- The **ALEXA MINI**, which has the **same options of sharpness, detail and noise reduction than the AMIRA**. You will find these updates in this version.
- The **ALEXA SXT**, which will have the **denoiser in HD and UHD/4K** (but no adjustable sharpness and detail).
- The decisions, about if and when we will have the denoiser for HD in the AMIRA hasn't been decided yet by ARRI.

## INTRODUCTORY NOTE:

This is quite ambitious to report on such a meeting in which the screening was decisive, but the photos (pages 18 to 45) sent by Harald, should give a rough idea of the research and results led of the ARRI Image Science Department engineers.

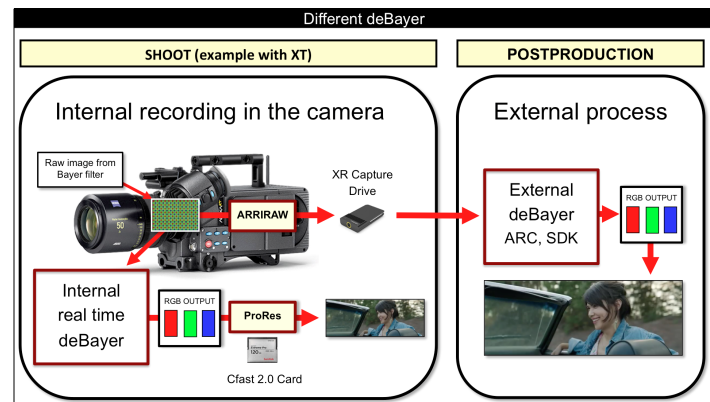
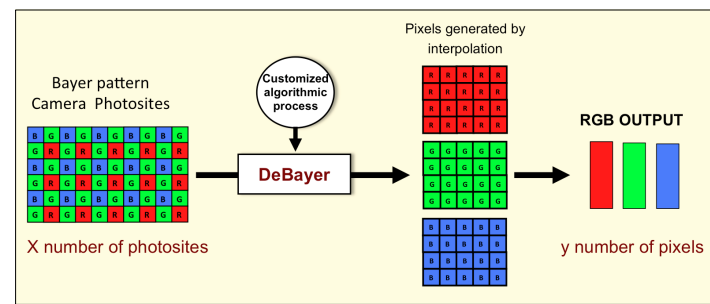
## REMINDER

Before giving all the informations, it is worth recalling some infos about the Bayer pattern located in front of almost all of the large sensors of digital cameras. These cameras like all the ALEXA cameras, the AMIRA, as well as RED cameras, SONY F55/F65 or CANON C300/C500 and PANASONIC VARICAM 35, use what it is called a Bayer color filter array. Essentially, it consists of a simple repeating pattern of four photosites, two of which are sensitive to green light, one to red and one to blue, in a square RGGG layout. But in order to provide a RGB output, the image need to be processed to be seen. This mathematicall process of paramount importance is called the deBayer (see upper right figure).

ARRI put a lot of emphasis on the improvements of these algorithms.

What is at stake in this proces is also  
the structure and the texture of the image.

In this report we have to take care on the difference between internal deBayer providing ProRes recording and monitoring, and the deBayer which is applied on the RAW image in postproduction (see lower right figure).



## ARRI DEBAYER COMPARISON 1/3 (see details pages 16 to 20).

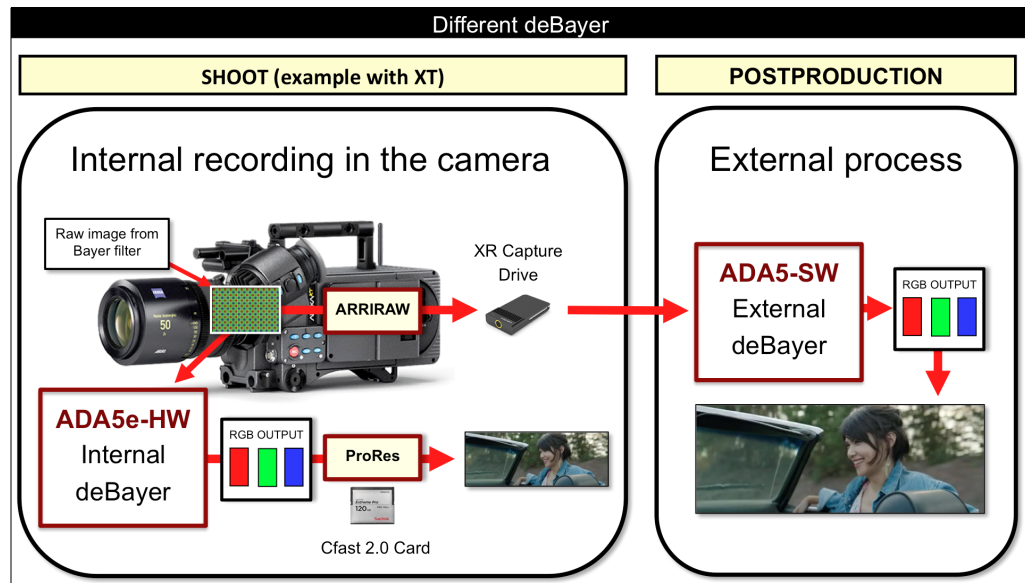
This new deBayer ADA-5 (for ARRI DeBayer Algorithm 5) is specified like this:

- **ADA5e-HW:** the current deBayer algorithm in the ALEXA (XT & Classic) Sup 11 and in the AMIRA Sup2 )
- **ADA5-SW:** in the ARRIRAW Converter (ARC) 3.1, in the ARRI SDK\*.

It is introducing less aliasing, much better keying and reduction of noise in the Red and Blue channels (green deBayer & sharpening stays similar to ADA-3).

Many people have been accustomed for years to calculate the number of pixels coming from a Bayer pattern with a ratio of 1:0.6 - 1:0.7. Meaning that for (x) 1000 photosites on the sensor we reached (y) 600 or 700 pixels to respect the quality of the real "resolution" of a camera, calculated with the MTF. (see pages 42 to 45) Of course it is not so simple, the lens and postproduction parameters can totally change the sharpness of an image.

\* SDK: Software Development Kit. In the case of ARRI, this software is designed for ARRIRAW processing and contains documentation and a library. It can be incorporated by example in a grading system.



## ARRI DEBAYER COMPARISON 2/3 *(see details pages 16 to 20)*

In fact from the beginning, ARRI deBayer was working on a 1:1 ratio: 1000 photosites=1000 pixels and was using a downscaling to arrive at a “natural” number of pixels.

ARRI has found the way to “push” the ratio to 1:1.2 meaning that with 1000 photosites, 1200 pixels are created. In the past, many manufacturers played with ratio over 1/0.7 but the result was more on the video look side.

ARRI showed us UHD and 4K images with the appropriate number of pixels but with an image which didn't try to compete on over sharpness with other competitors.

The result on screen was a combination of sharp but smooth image.

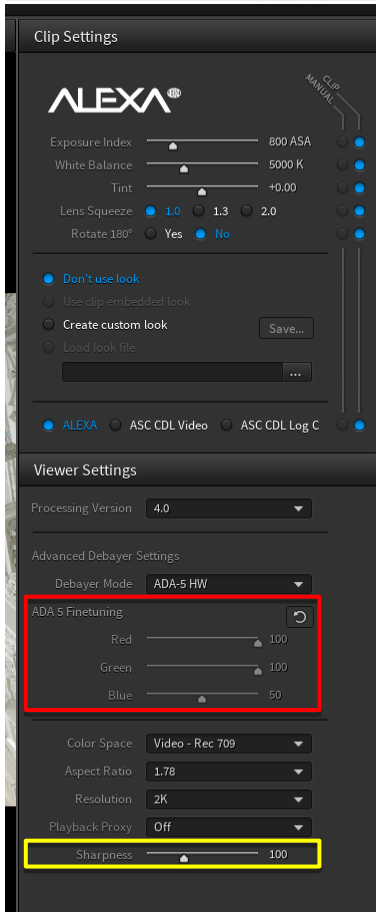
So we can say that the new deBayer version 5 is sharper but holds the organic look we are accustomed to meet with ARRI. Harald explained us that ARRI's philosophy want to respect its filmic roots without crossing the boundary of the video look.

**Harald and Henning put a lot emphasis on the importance, for all ALEXA and AMIRA owners, to update their cameras to this new version.**

You can find some explanations on the new ADA-5 deBayer on this presentation made by Henning at CINEC (Sept. 2014) in Munich.

<http://www.arri.com/videos/videos/arri-workflow-developments/>

## Internal recording in the camera ADA5-HW deBayer



## ARRI DEBAYER COMPARISON 3/3 (see details pages 16 to 20)

« In the ARRIRAW Converter Software (ARC), when you select **ADA5-HW**, the controls to fine tune the RGB channels is greyed out (red rectangle, image on the left). You can't control these parameters in the ADA-HW algorithm. And this is the algorithm running in the cameras.

When you select **ADA5-SW**, you can adjust the the R, G, and B channel. The default is 100/100/50 which helps with blue screen shots without scarifying overall image sharpness (green rectangle, image on the right).

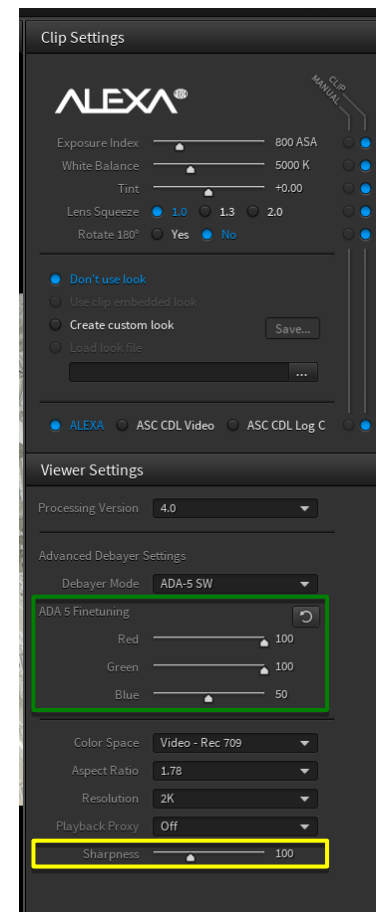
In any case you always have the control for sharpness of the rescaler filter. That is the parameter **S** (yellow rectangles).

We showed you an additional parameter **F** (or Detail) that is available in the AMIRA and will be available in the ARC software at a later time.

So there are two groups of controls:

- The one which fine tunes the relative sharpness of the R, G, and B channels in the deBayer process (only with ADA5-SW in post).
- The one that influences the sharpness of the image (all channels are treated equally) in the rescale filter, called "Sharpness" and "Detail" ».

## External process. ADA5-SW deBayer



## ARRI RESOLUTION TESTS *(see details pages 21 to 26)*

We saw a comparison test between three different rasters shot with the same camera the **ALEXA 65**.

- **3414** (ALEXA Open Gate),
- **4096** (4K) and
- **6560** (ALEXA 65 full resolution).



Writing about these tests is quite complex, so please have a look on the page notified above.

Harald Brendel wrote: “The goal of the test was to study the effect the increased resolution has on a “natural” image or, let’s say, on natural objects.

When one photographs a resolution test chart in three different resolutions like we did, it’s clear what you will see. You will be able to resolve higher spatial frequencies, unless you have some other limiting factors in your system.”

Harald sent us the explanations on how it was done:

“The camera position was changed such that the distance between the two red tapes on the wooden frame was either 3414, 4096, or 6560 pixels wide in the ALEXA 65.

Then, the 3414 pixels image was enlarged to 4096 pixels, using the same upsample filter that is used in the ARC or in the AMIRA with UHD output (default sharpness setting).

The 6560 pixels image was reduced to 4096 pixels, using the same filter that is used in the ARC when ALEXA 65 material is processed (default sharpness setting).

The 4096 pixels image was filtered to match the other two images in sharpness“.

ALEXA MINI & AMIRA SCALER NEW PARAMETERS *(see details pages 23 to 40)*

With the HD, 2K or UHD recording on the ALEXA MINI & the AMIRA you can now control the sharpness through two settings in: MENU>>System>>**Sensor**>>

- **Sharpness** controls the amplification of micro contrast in the image,
- **Detail** controls the smallest detail that is reproduced by the filter.

In 3,2K you have only the parameter of sharpness.

Below images of the ALEXA MINI viewfinder menu and images on the home screen extracted from the AMIRA Simulator updated with version 5.

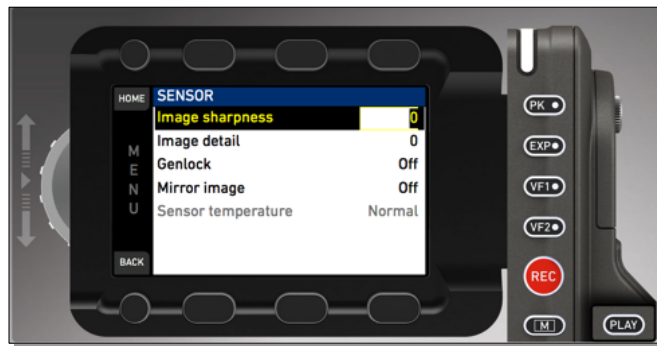
[http://www.arri.com/fileadmin/adapps/amira\\_simulator/index.html](http://www.arri.com/fileadmin/adapps/amira_simulator/index.html)

The screening showed us a lot of interesting subtleties, usefull for many fields: feature films, commercials, beauty, wildlife, etc. With Rolf, we had the same reactions: **why don't install these settings for the ProRes recording or in the ARC?** Harald Brenning and the engineers said us that they will consider this request for the ALEXA but it will done end of this year for the ARC.

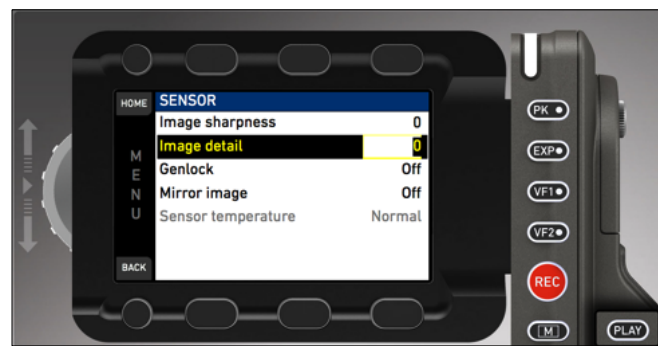
ALEXA MINI



AMIRA



AMIRA



## ALEXA SXT, ALEXA MINI & AMIRA NEW NOISE REDUCTION

(see details pages 41 to 45)

With the ALEXA MINI & the AMIRA you can now apply a noise reduction on the 3,2K & 4K resolution through a rescale filter.

The ALEXA SXT will have soon the denoiser in HD and UHD/4K .

You can find it in:

**MENU>>System>>Sensor>>Image denoising**

We saw the comparison between 3 settings:

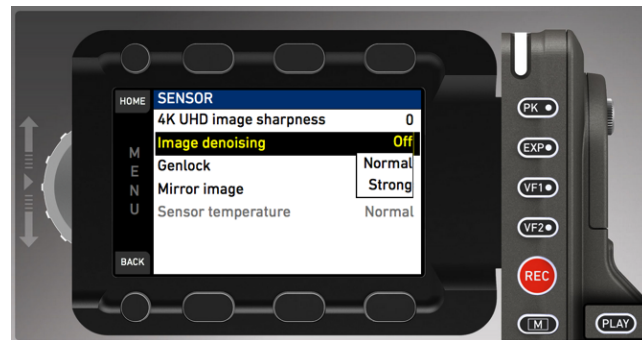
- **Off**
- **Normal**
- **Strong**

Many manufacturers have launched internal noise reduction camera systems. Examples: in the 4K internal recording of the new C300 MK II or in the F55.

In this screening we were pretty impressed by this new algorithm applied on a two stops underexposed footage. We had no point of comparison with what post-production could have given, but it was not the idea.

The goal was to give filmmakers/cinematographers, working on medium range budgets a quick, inexpensive, reliable in-camera tool. Tests with motion were not ready but we thought that the research was promising.

## ALEXA SXT, ALEXA MINI & AMIRA





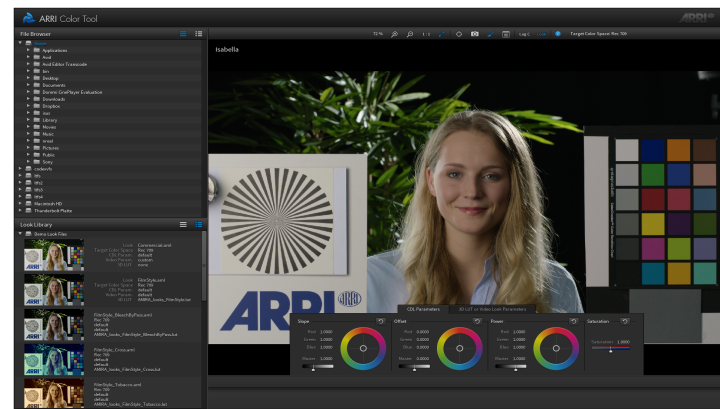
## ARRI COLOR TOOL

This report address all issues of texture of the image. We are particularly interested in all tools, delivered by manufacturers, allowing cinematographers, filmmakers, colorists to handle the parameters of structure and texture of the image.

LUT's and Looks managements belong to these tools.

The ARRI Color Tool, software able to create and store Look and 3D LUT's, is now the same for AMIRA & ALEXA cameras simplifying the way cinematographers work.

Rolf and I suggested to bring back, on the ALEXA cameras, the P3 color space (for DCI) output which has been disabled. With the new displays delivering P3, it could be a very usefull item. ARRI engineers didn't think it was a problem.



# ARRI LOOK MANAGEMENT (ALM)

This color management works only with a LUT box and the DIT has to take on the obligation to verify whether the LUT (blue arrows) are embedded in the dailies and in the final grading. This management doesn't work in the REC 2020 Color Space.

Christian Grafwallner  
ARRI presentation

## ALEXA CLASSIC/XT

## Typical Workflow Live Color - Before ALM-2



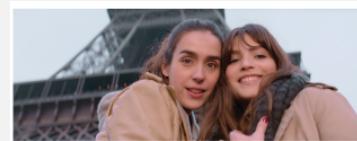
ALEXA Classic/XT

ARRIRAW

ungraded  
Log C image

LUT Box

graded  
Rec 709 image



On set monitoring

CDL & 3D LUT



CDL & 3D LUT

CDL & 3D LUT

Dailies Creation

Final grading



## ARRI LOOK MANAGEMENT 2 (ALM-2) - Only with the ALEXA SXT

During IBC, Christian Grafwallner, Research & Development Supervisor Digital Workflow Solutions, showed us the new look management (ARRI Look Management - ALM-2) working on the SXT cameras.

The ALM-2 comes from the AMIRA advanced color management system. It uses a new type of file, the ALF-2 (ARRI Look File 2). It contains an ASC CDL (Color Decision List) and 3D LUT (Look-Up Tables).

Some specificities of the ALEXA SXT that fit with cinematographers expectations to control their image:

- New looks and smoother workflow (ASC CDL & 3D LUTs)
- Three independent HD-SDI outputs
- New color management
- Matches current ALEXA images, but provides the basis for radically different looks
- 3D Look-up Tables, ASC Color Decision List
- Live in-camera grading on set
- Rec 2020 gamma
- Same tools for ALEXA SXT, ALEXA Mini & AMIRA



## ARRI LOOK MANAGEMENT 2 (ALM-2)

This color management deletes the LUT box and allows, through a direct link with the camera and the metadata (blue arrows), to embed the LUT directly in the dailies (even in the Rec 2020 Color Space) and in the final grading, but it only works on the ALEXA SXT.

Christian Grafwallner  
ARRI presentation

### Typical Workflow Live Color - With ALM-2



ALEXA SXT/SXR

ALEXA SXT/SXR

CDL & 3D LUT

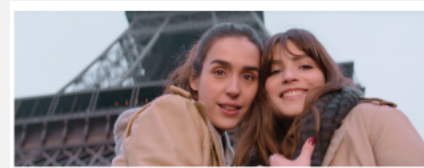
Ethernet



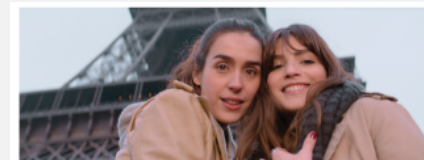
ARRIRAW  
CDL & 3D LUT

Dailies Creation

Final grading



On set monitoring



## CONCLUSION

I will quote Harald last e-mail:

« My colleagues found the workshop very interesting. I hope we can do something similar with a group of cinematographers and/or colorists. It's valuable for us to have a direct contact between our users and the engineers developing image processing algorithms. ».

During this workshop, we felt a real desire of transparency and a real will to work with cinematographers.

We enjoyed a very usefull meeting with a friendly and efficient discussion. We felt that this communication could lead to new tools and parameters to control the image.

Thanks to Harald, thanks to Henning, Rolf and all the engineers!

## NOTE FROM PHILIPPE ROS

This report was made with the precious help ...and great patience of Harald Brendel to which we pay tribute.

I think it was worthy to share with you these informations to be found from page 46 to help you to understand differences between resolution, sharpness, acutance, detail and MTF. These notes come from emails we exchanged with Harald Brendel, Rolf Coulanges and Marc Shipman-Mueller, ARRI Product Manager Cameras & Lenses.

A special thanks to Christian Grafwallner and to Michael Jonas from ARRI Munich who gave us their precious time.

The link to download the photos which are the core of this report is located page 50.

## ARRI DEBAYER COMPARISON

4K Screening

## ARRI DEBAYER COMPARISON

All ARRI digital cameras



A comparison of:

- **ADA3-HW** - The second generation deBayer algorithm in the ALEXA
- **ADA5e-HW** - The current deBayer algorithm in the ALEXA and in the AMIRA
- **ADA5-SW** - The deBayer algorithm used in the ARRIRAW Converter (ARC) software and in the ARRI SDK).

Harald Brendel: "The ADA5-SW is a more complex version of the deBayer algorithm that can't be implemented in hardware and is therefore available in the ARRIRAW software (ARC or SDK) only".





ADA3-HW



ADA5e-HW



ADA5-SW



ARRI DEBAYER COMPARISON

Harald Brendel comments

All ARRI digital cameras

ProRes

ADA3-HW is the second generation of deBayer algorithm in the ALEXA. It is the former version.



ADA3-HW

ARRI PRORES & ARRIRAW  
MASTER PRIME LENSES

ProRes

ADA5e-HW is the current deBayer algorithm in the ALEXA and in the AMIRA. This algorithm does not have adjustable sharpness in the ALEXA and in the AMIRA. ADA5e-HW is currently present in ALL ALEXA or AMIRA through their new Sup's versions.



ADA5e-HW

The photos below come from zoom in screen captures

RAW

The name of the deBayer algorithm used in the ARC software is ADA5-SW. The default of sharpness in RGB is 100-100-50 (See page 30) which means that the blue highpass is reduced compared to green and red. The ADA5-SW is a more complex version of the deBayer algorithm that can't be implemented in hardware and is therefore available in the ARRIRAW software (ARC or SDK) only.



ADA5-SW

## Rolf Coulanges & Philippe Ros comments

All ARRI digital cameras

During the screening it was obvious that the version 5 was giving a better result in terms of texture.

A bit more sharper than the former version without giving any video look. Still the smoothness of the ALEXA look.

The difference of sharpness between ProRes and Raw seemed more important than in version 3 (to be confirmed)



ADA3-HW



ADA5e-HW



ADA5-SW



ARRI RESOLUTION TEST

ARRIRAW

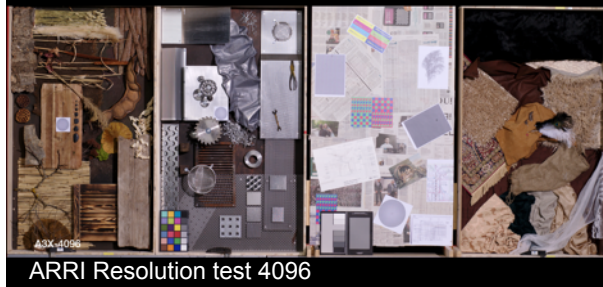
ALEXA 65

4K Screening



# ARRI RESOLUTION TEST

ALEXA 65



## Harald Brendel comments

All images were taken with the ALEXA 65 camera (RAW).

Three images captured in:

- **3414** (ALEXA Open Gate),
- **4096** (4K)
- **6560** (ALEXA 65 full resolution).

Default settings of sharpness were used on the ARC

A3X is the internal name for the sensor in the ALEXA 65.

Reminder:

« The goal of the test was to study the effect the increased resolution has on a “natural” image or let’s say on natural objects ».

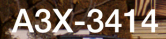
The camera position was changed such that the distance between the two red tapes on the wooden frame was either 3414, 4096, or 6560 pixels wide in the ALEXA65.

Then, the 3414 pixels image was enlarged to 4096 pixels, using the same upsample filter that is used in the ARC or in the AMIRA with UHD output (default sharpness setting).

The 6560 pixels image was reduced to 4096 pixels, using the same filter that is used in the ARC when ALEXA65 material is processed (default sharpness setting).

The 4096 pixels image was filtered to match the other two images in sharpness ».





V5 Page 23





A3X-4096





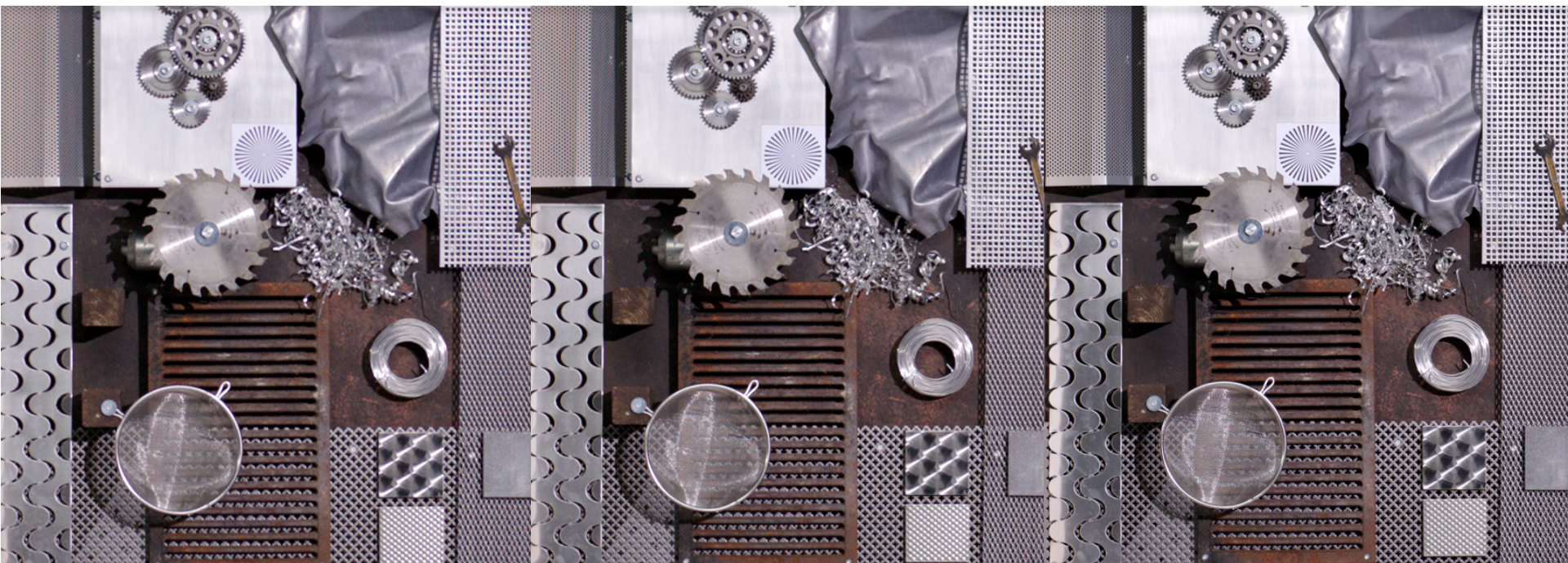




## Rolf Coulanges & Philippe Ros comments

A lot of informations were delivered by these tests and lead several immersive screenings to appreciate all the levels of subtleties and hues. In the 6560 raster (coming from more than 20 millions of photosites spread on the 65 mm large sensor), we had a very good feeling of ARRI's philosophy in terms of sharpness for this new definition: very sharp without aggressivity.

*The photos below come from zoom in screen captures*



ARRI Resolution test 3414

ARRI Resolution test 4096

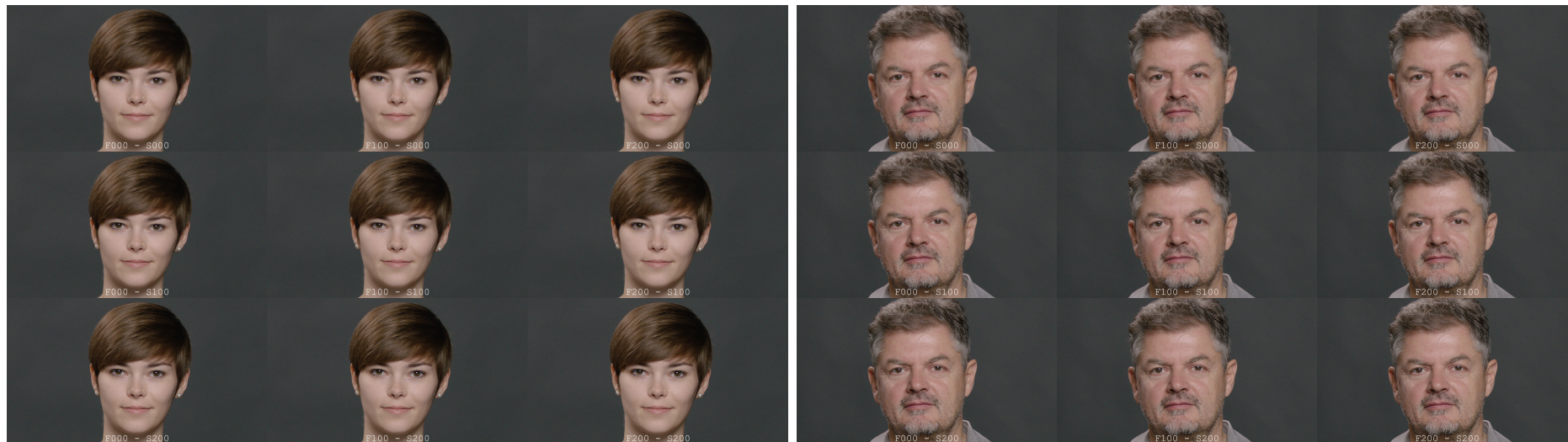
ARRI Resolution test 6560 v5 26





## ALEXA MINI & AMIRA SCALER NEW PARAMETERS: SHARPNESS AND DETAIL

4K Screening



Following pages: two examples showing the new scaler parameter Sharpness and Detail.

They are available in the ALEXA MINI & the AMIRA cameras  
in HD, 2K and UHD. In 3,2K, in the AMIRA, only the  
Sharpness is displayed

These parameters are not available in the other ALEXA camera models.

These parameters will be introduced in the ARC at the end of this year.





F000 - S000



F100 - S000



F200 - S000



F000 - S100



F100 - S100



F200 - S100



F000 - S200



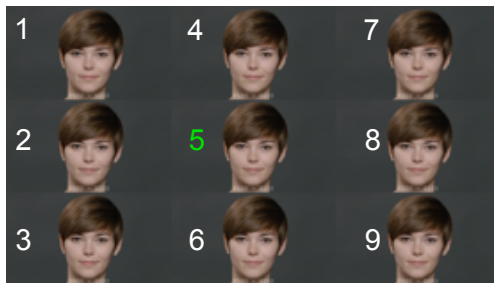
F100 - S200



F200 - S200

## Harald Brendel

comments



« For the following photos on Scaler parameters, even if we are speaking about the AMIRA or the ALEXA MINI IN ProRes, the tests were done using uncompressed ARRIRAW files. They have been processed in software without ProRes compression.

- **SHARPNESS** controls the amplification of micro contrast in the image,
- **DETAIL** controls the smallest detail that is reproduced by the filter.
- **S** is **SHARPNESS** and **F** is **DETAIL**

F means frequency but for the camera menu we decided to call it **DETAIL**.

You will find SHARPNESS & DETAIL in the AMIRA simulator on the ARRI website.

Please note that the parameters in the camera range from -5 to +5, while the image show numbers ranging from 0 to 200. The relation is as following:

$$-5 = 0 \quad 0 = 100 \quad +5 = 200$$

I hope this clarifies it:

F000 = Detail - 5

S000 = Sharpness - 5

F100 = Detail 0

S100 = Sharpness 0

F200 = Detail 5

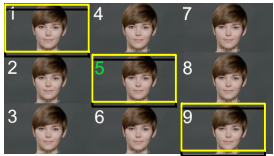
S200 = Sharpness 5

The default in the camera is 0 for both parameters, which is the center element “F100 - S100” (in the tableau face n° 5, number in green) ».



## With the minimum of Detail

The noise is due to the zoom in the image, but we can see the difference on the structure of the sharpness.



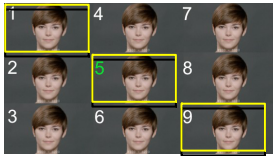
Sharpness →

*The photos below come from zoom in screen captures*



## Medium settings of Detail

The picture number 5 is the default in the camera, this is the level we are accustomed to find on an Alexa camera. Settings in the ARC (ARRIRAW Converter) are F=100 S=100



Sharpness →

4

5

6

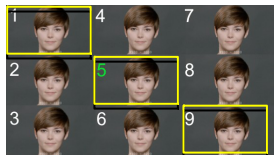
F100 - S000

F100 - S100

F100 - S200



## With the maximum of Detail



Sharpness →

7



F200 - S000

8



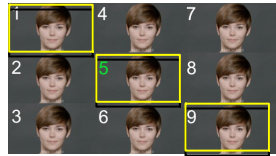
F200 - S100

9



F200 - S200

# From the minimum of Sharpness and Detail to the maximum

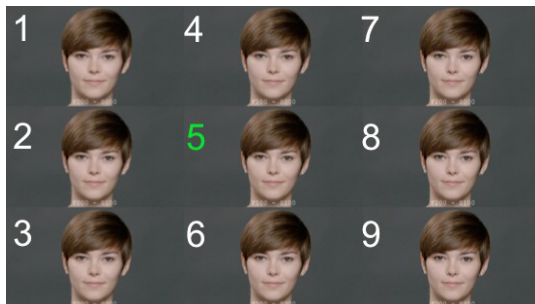


The picture number 5 is the default in the camera, this is the level that we are accustomed to find on an Alexa camera. Settings in the ARC (ARRIRAW Converter) are F=100 S=100

Sharpness →







## Rolf Coulanges & Philippe Ros comments

We saw these images in the ARRI's large theater. These photos can't give the richness of the variation in the structure of the image, but, from the minimum to the maximum, each cinematographer/filmmaker will find the appropriate settings for the drama.

The results were very interesting and we think that the range of setting was very well chosen.

### Some remarks:

- Minimum between 1 and 3: These settings could be very useful for close shots on faces. N°1 is close to be out of focus
- Medium range n°4 to 6: On a large screen the difference between the Sharpness and Detail settings are subtles and allow to give different structures to the image.
- Maximum between n°5 and 9: These settings could be very useful for large shots in the country side, n°9 is the limit where we feel it will be artificial to go over.

Of course we are entering in a subjective field but this is the real interest of these tests: to give cinematographers/filmmakers accurate settings to change the perception of the image.

These parameters are not available in the ALEXA camera models EXCEPT IN THE ALEXA MINI.

However Harald Brendel sent us an email in which he wrote: « We acknowledge your request of having these parameters in the ALEXA as well and we will discuss this ».

A very interesting news for the future collaboration between ARRI and cinematographers and colorists.



F000 - S000



F100 - S000



F200 - S000



F000 - S100



F100 - S100



F200 - S100



F000 - S200



F100 - S200



F200 - S200



# With the minimum of Detail



Sharpness →

*The photos below come from zoom in screen captures*



## Medium settings of Detail



———— Sharpness ———→





# With the maximum of Detail



Sharpness →



# From the minimum of Sharpness and Detail to the maximum



Sharpness →

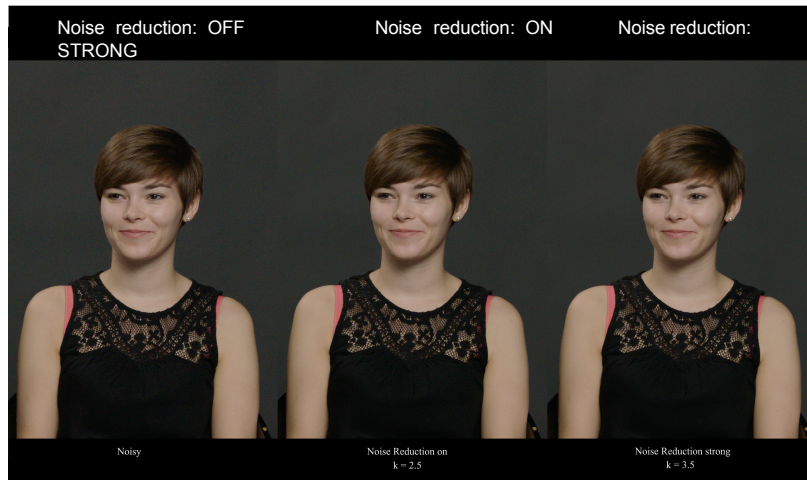




ARRI NOISE REDUCTION LEVEL  
IN 3,2K & UHD MODE ON ALEXA MINI & AMIRA  
IN HD, UHD/4K MODE ON ALEXA SXT

4K Screening





## Harald Brendel comments

« A comparison of images :

- **No denoise, OFF**
- **With Default denoise, ON**
- **With Extra strong denoise, STRONG**

The denoise algorithm is available:

- In the ALEXA MINI & the AMIRA in 3,2 K & UHD mode
  - Soon in the ALEXA SXT IN HD, 3,2K & UHD/4K mode
- ».

« The noise was generated by the Amira exposed @ 3200 ISO (normal exposure is 800 ISO).

- There are only three possibilities for the denoise: **OFF - ON - STRONG**.
- The filter settings (Sharpness and Detail) are the default (0/0).
- With strong denoise it's possible to have artifacts in fast motion. You may not see these artifacts in the mo they are visible when you look at still frames ».



## Reminder

The UHD (Ultra High Definition) is the "4K" definition for the 4K TV: 3840 x 2160 pixels

The 4K cinema (DCI) has a definition of:

4096 x 2160 pixels

Noise reduction: OFF

Noise reduction: ON

Noise reduction: STRONG



Noisy



Noise Reduction on  
 $k = 2.5$



Noise Reduction strong  
 $k = 3.5$



*The photos below come from zoom in screen captures*

Noise reduction: OFF



Noise reduction: ON



Noise reduction: STRONG





## Rolf Coulanges & Philippe Ros comments

On the large screen, given the fact its was UHD ProRes material with 2 stops underexposure, the result was amazing. It was a very accurate noise reduction level created by the R& D department and we will see in the future more tests with motion. We were wondering if we wouldn't need more settings in the future.

*The photos below come from zoom in screen captures*

Noise reduction: OFF

Noise reduction: ON

Noise reduction: STRONG

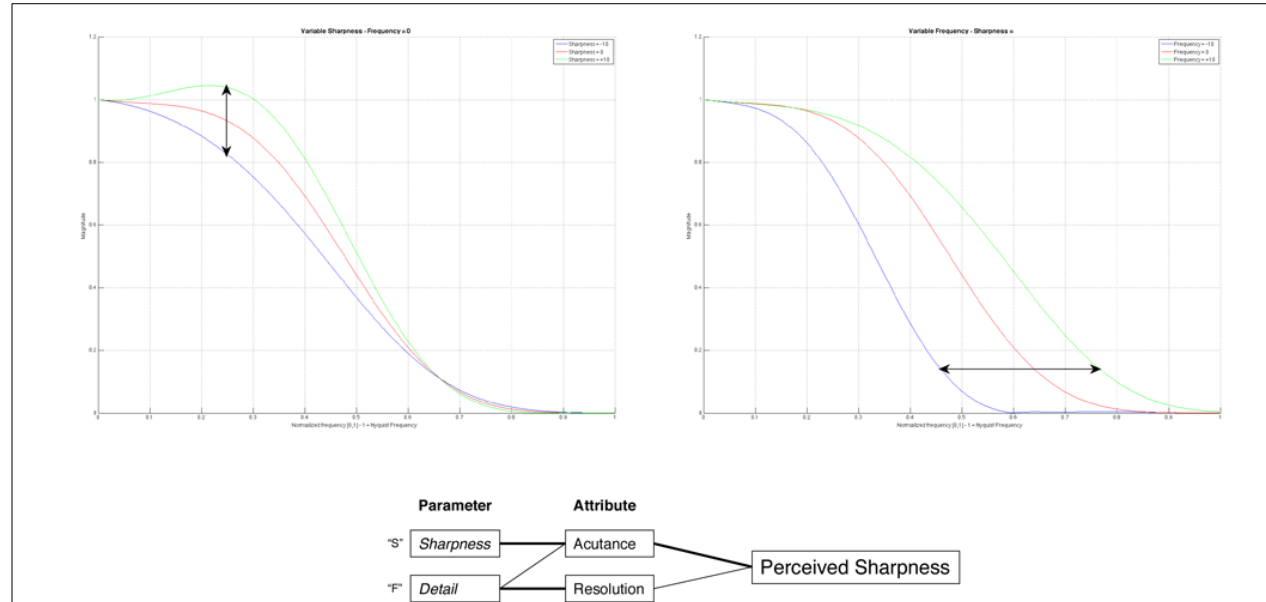


## REMINDER – GLOSSARY



# Harald Brendel comments on resolution, sharpness and perceived sharpness

« Resolution is a measure for the smallest spatial detail an imaging system can resolve. The *Detail* parameter of the scaler controls the resolution by adjusting the frequency where the transfer function of the filter becomes zero, or very small. This is shown in upper right figure. The perception of sharpness depends, to a lesser degree, on the resolution and more on the micro contrast in the image, which is called acutance (see here: <https://en.wikipedia.org/wiki/Acutance>). The acutance is controlled by the parameter *Sharpness*. This is shown in upper left figure. Even more confusing is the fact that the *Detail* parameter influences acutance too. You can't change the resolution without changing the overall shape of the transfer curve ».



« The diagram at the bottom summarizes the relationships. Thick lines represent a strong influence, thin lines a weaker influence.

There have been several proposals how to measure sharpness as a part of the image quality »

I had a question to Harald: « But how can we define the feeling of general sharpness in the images when F and S are increased? »

Answer:

« In your context, I would suggest to call it “Perceived Sharpness” to differentiate it from the parameter *Sharpness* ».

# Remarks on resolution and sharpness from Harald Brendel and Marc Shipman-Mueller, ARRI

**Resolution:** (European journal 2003):

means the smallest detail that can be discerned with a perceptual system, i.e. perceived as separate from the larger whole. The resolution of the human eye is indicated as ‘visual acuity’.

**Resolution of an image** from [Harald Brendel](#):

« Resolution is a measure for the smallest spatial detail an imaging system can resolve ».

Remarks & corrections from [Marc Shipman-Mueller](#), ARRI Product Manager Cameras & Lenses on P. Ros presentation at Micro Salon 2015:

## Resolution & sharpness

« We need to carefully distinguish between sharpness and resolution. **Sharpness is a perceived quality which is a combination of the measurable properties of resolution and contrast. Technically, the relationship of resolution to contrast is expressed as MTF, which is a curve that plots resolution vs. contrast,** but most humans, that are not image science engineers, feel more comfortable with the fuzzy term “sharpness” than with X% of contrast at Y line pairs per mm. However, sharpness can be deceiving, which is why engineers prefer MTF. A high resolution image with low contrast may look less “sharp” than a low resolution image with high contrast. This is because our human perception pays more attention to contrast at certain line pairs per mm than others. As a colleague of mine once said: ‘Our ancestors were the ones that saw that there was the shape of a the tiger in the grass, not the ones with the visual acuity to count his hairs ».

## Raster & Resolution:

Now here is where I think we all make a grave mistake in our lax ways of discussing this topic: resolution is NOT the number of pixels that the manufacturer says are in a file. **The number of pixels in a file define the ability of the container, but resolution defines the content,** i.e. what MTF can actually get through a camera system. If a manufacturer says that a camera records a 4K file, that only means that the file has a raster of 4K horizontally. It makes no claims to the resolution of the content. **The resolution, as measured in line pairs per millimeter (or image width)** could be well below 4K. Interestingly, most of the movies released in 4K in the last years have been posted in 2K and up-sampled to 4K later, only a small portion of all feature films are actually been shot and completely posted (including VFX) in 4K. This has been like that for years now and we do not see a change this year either.



## Reminder

Writing this report was not so easy because the terms “resolution”, “definition”, “sharpness”, “acutance” “detail” are quite complex. We tried to clearly define the technical terms because the semantical blurring lead to unintended consequences on artistic work and budgeting systems.

A lot of people use resolution instead of definition.

The french word “definition” means the total number of pixels in an image. But we are speaking about high resolution and high definition to define HD, 2K or 4K rasters.

So, we strongly recommend this tutorial, written by Dr. Hans Kiening: *4K+ Systems, Theory Basics for Motion Picture Imaging*:

[http://c-sideprod.ch/wp-content/medias/2012/10/4K\\_plus.pdf](http://c-sideprod.ch/wp-content/medias/2012/10/4K_plus.pdf)

You will find photos likes the ones below which perfectly illustrate Mark’s sentence: « A high resolution image with low contrast may look less “sharp” than a low resolution image with high contrast ». Dr. Hans Kiening explains: « Although the image on the left comprises twice as many pixels, the image on the right, whose contrast at coarse details is increased with a filter, looks at first glance to be distinctly sharper »..



You can download the images on:

<ftp://imago@ftp.arri.de/ARRI>

The password is:

[cine45%!](#)

In the directory you'll find the following images

- ARRI\_DeBayer-Comparison.jpg
- ARRI\_Denoise-Levels.jpg
- ARRI\_Resolution-Test\_3414.jpg - ARRI\_Resolution-Test\_4096.jpg - ARRI\_Resolution-Test\_6560.jpg
- ARRI\_Scaler-Parameter\_Female-Face.jpg
- ARRI\_Scaler-Parameter\_Male-Face.jpg