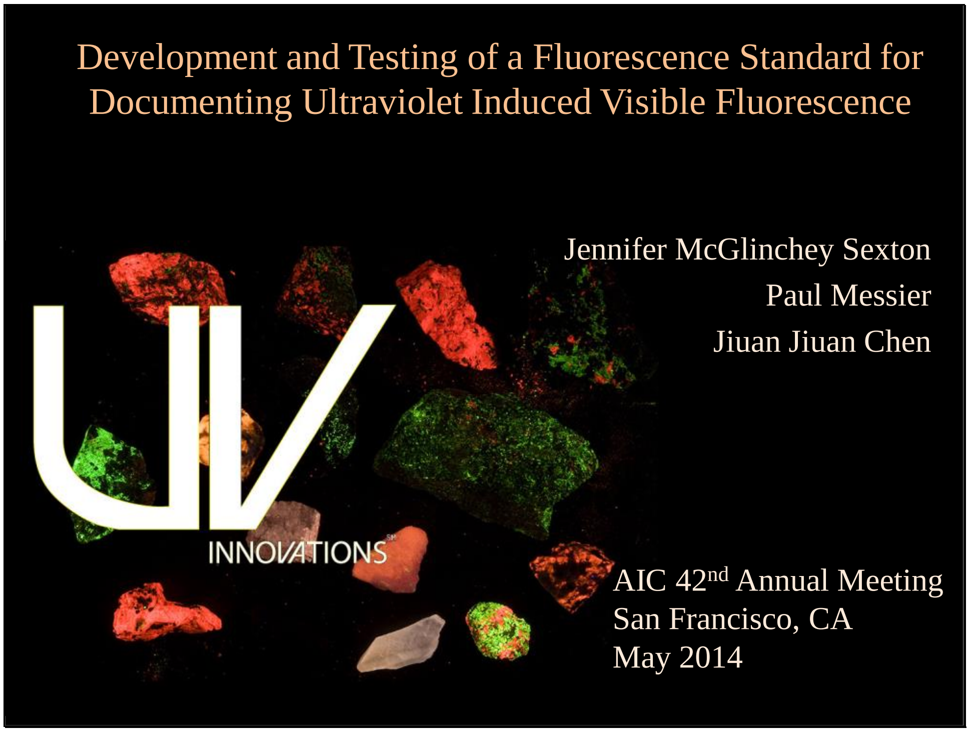
Slide 1

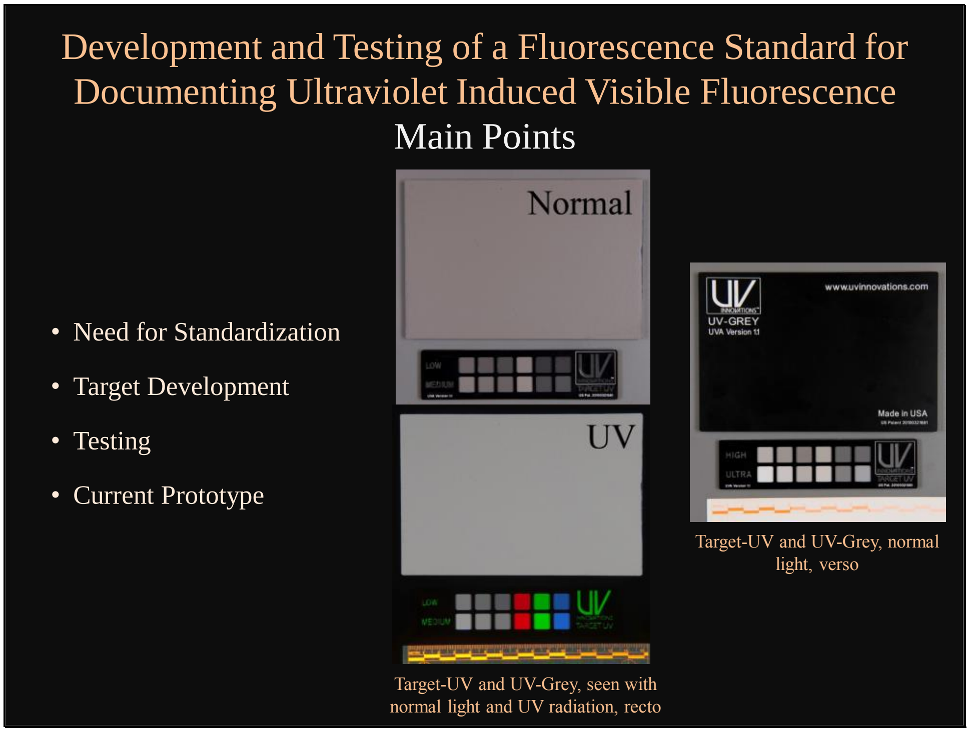


Jennifer McGlinchey Sexton[1] Paul Messier[2] and Jiuan Jiuan Chen[3]

[1] Conservator of Photographs, Paul Messier, LLC
[2] Head Conservator, Paul Messier, LLC
[3] Assistant Professor of Conservation Imaging and Technical Examination, Buffalo State College, Art Conservation Program

UV Innovations Inc. was established by Paul Messier and Jiuan-Jiuan Chen. It is a project of the Paul Messier Conservation Studio. This talk will present the final stages of development and beta testing of the target, over the last two years. This work built on the considerable efforts of co-authors JJ Chen and Paul Messier since this project began in 2008.

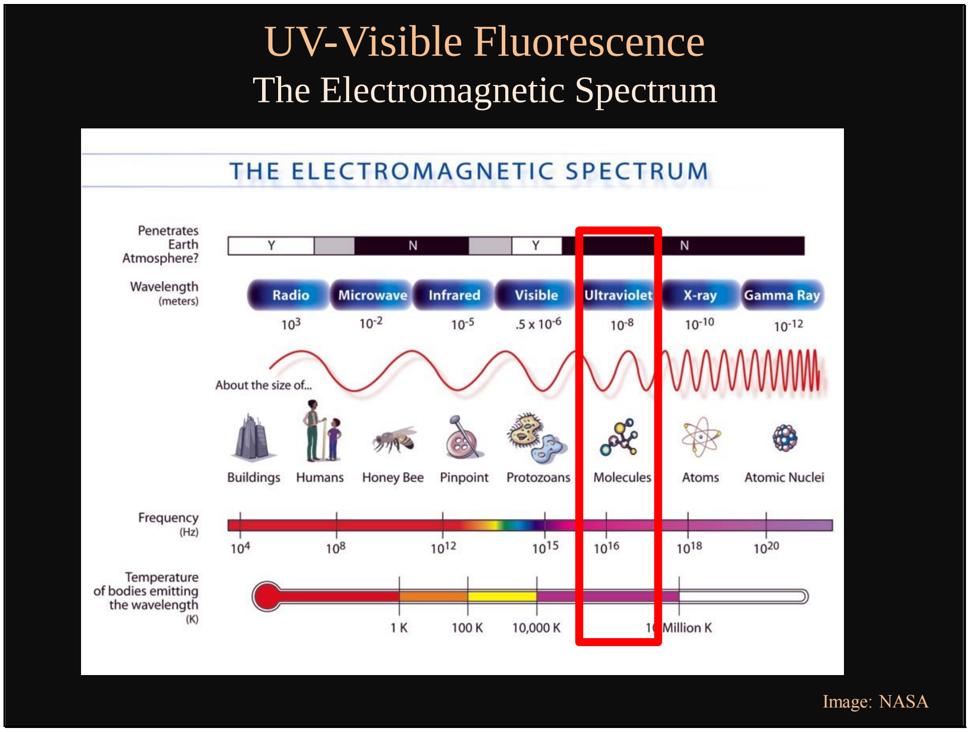
Slide 2



The Target-UV and UV-Grey are color references for achieving repeatable and consistent photographic documentation of UV visible fluorescence. White balance is set by the UV-grey, while the Target-UV provides consistent RGB levels for setting exposure.

The first major point of our talk today is a short discussion of why standardization is needed, particularly relating to this type of photo-documentation. From there we can get to the main focus of this talk, which is the general development of the Target, and the beta testing that we completed in 2013. To finish, I'll tell you a bit about the current design and what to expect.

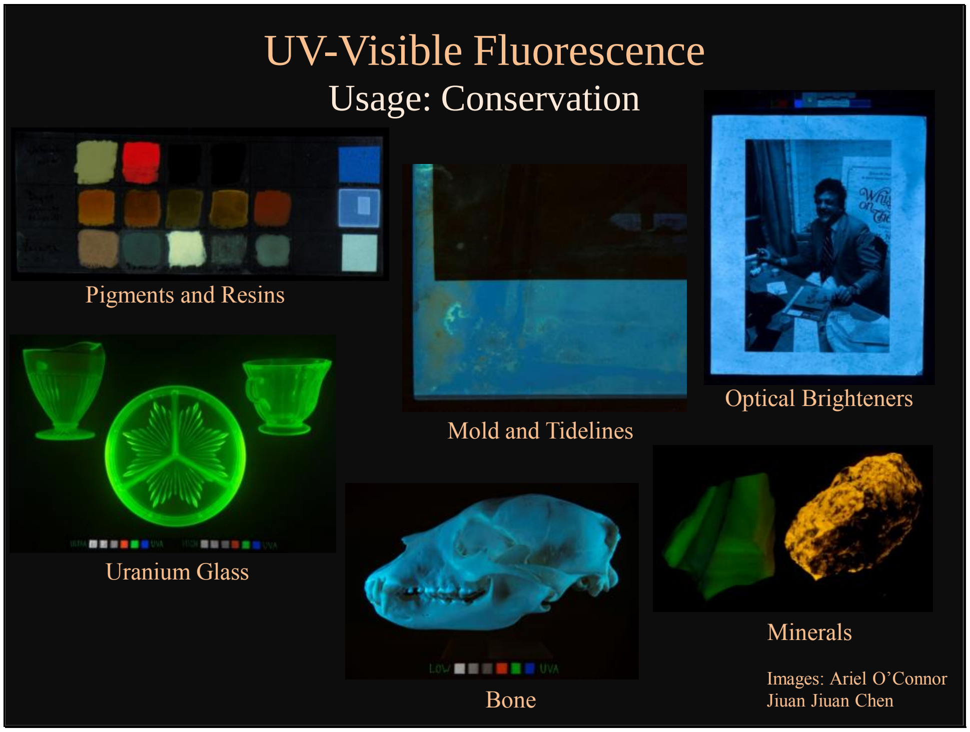
Slide 3



This Target is designed for use with ultraviolet induced visible fluorescence. More specifically UVA or longwave UV radiation. We hope to develop a future Target that focuses on UVC.

Image Credit: "EM Spectrum3-new" by NASA - http://mynasadata.larc.nasa.gov/images/EM_Spectrum3-new.jpg NASA. Licensed under Public domain via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:EM_Spectrum3-new.jpg#mediaviewer/File:EM_Spectrum3-new.jpg

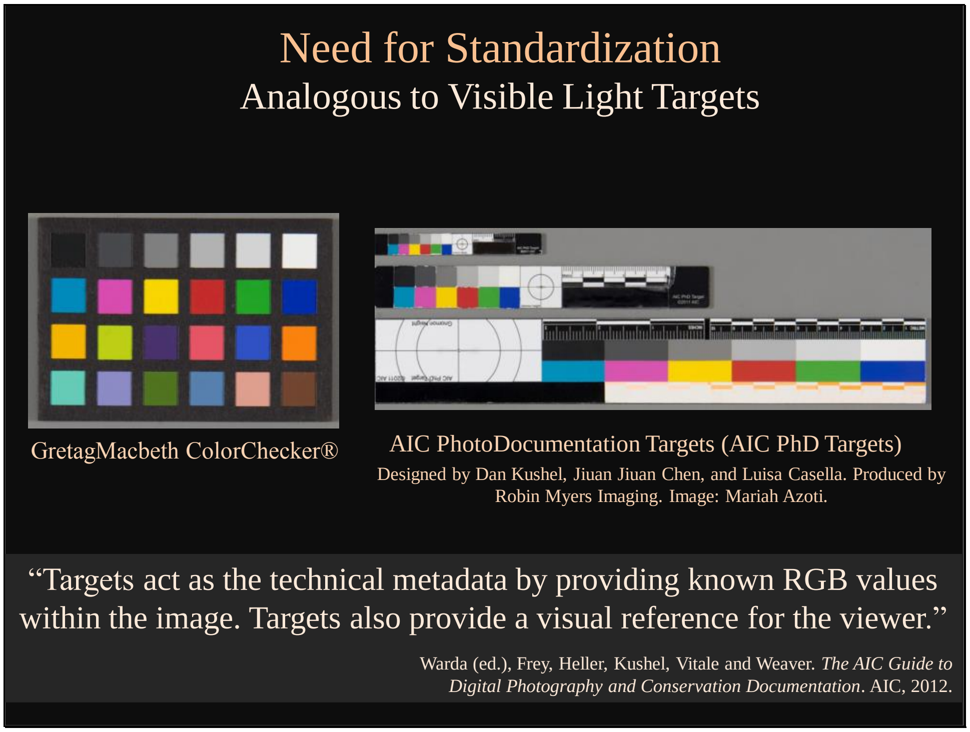
Slide 4



UV-visible fluorescence has been in use by art conservators since the 1930s. This imaging technique is valuable to all specialties and disciplines of art conservation.

Here are some examples of the use of uv-visible fluorescence to characterize pigments and resins, uranium glass, mold, tidelines, bone, optical brightening agents, and minerals.

Slide 5



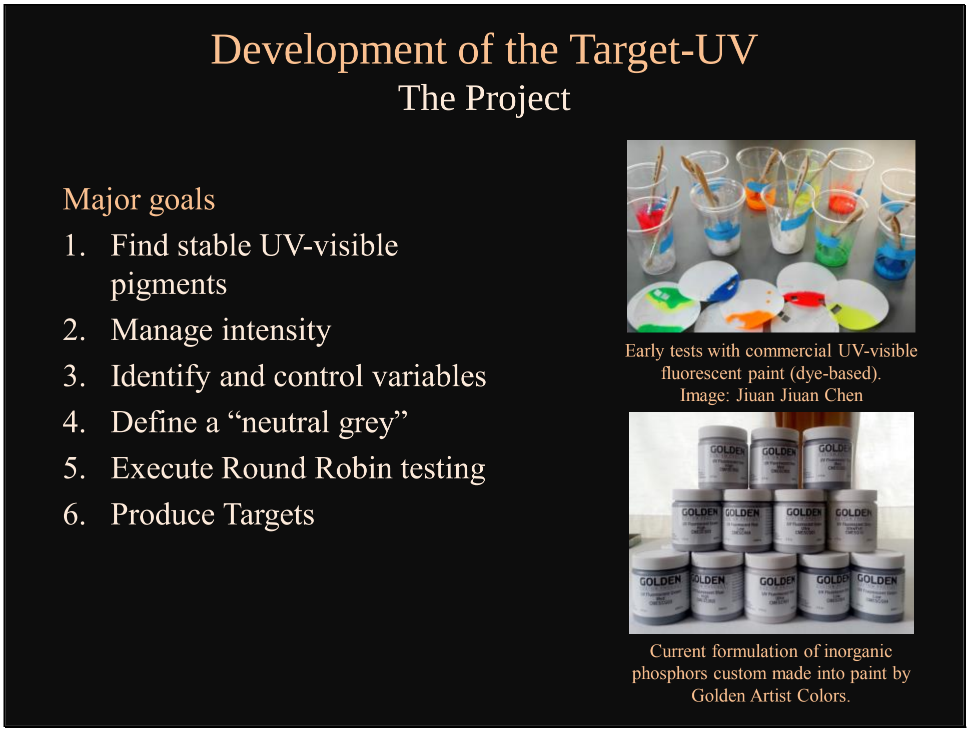
We need standards for all types of conservation documentation, including UV-visible fluorescence. The AIC Guide to Digital Photography and Conservation Documentation reads: “Targets act as the technical metadata by providing known RGB values within the image. Targets also provide a visual reference for the viewer.”

Here are some examples of visible light targets, which are commonly used in our field to establish exposure and color balance. The UV-visible target we developed is similar in its goal and purpose.

Slide 6

UV-visible documentation is highly subjective. For example, can you tell me which image here *accurately* reflects the fluorescence of this hand-painted photograph? The answer depends on the keenness of your eyesight, but also the nature of the UV source you are using, and many other factors. We will discuss the variables in more detail later, but note that these images vary considerably in both color and intensity.

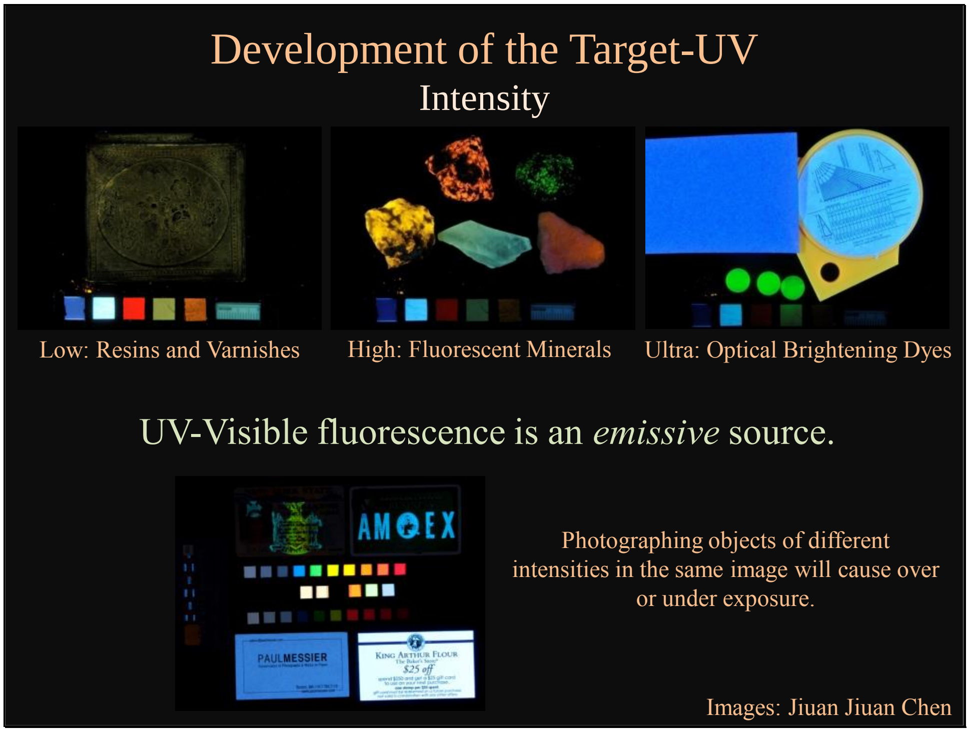
Slide 7



The development of the Target: Here you can see a list of the major goals of the project. Our first challenge was to find stable UV-visible pigments, which would act as the foundation of the Target. On the top right, you can see some of JJ's first experiments with commercially available paints. Unfortunately, these are mostly dye-based, so stability was a limiting factor.

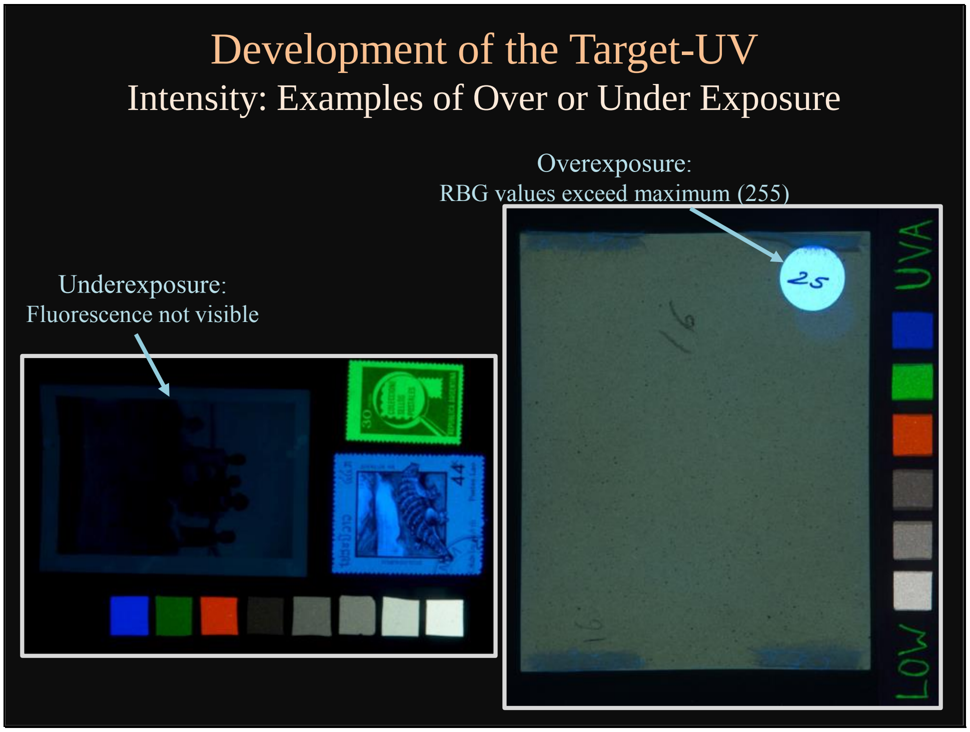
Eventually, we settled on our current formulation, pictured on the bottom right. These paints are made from more stable inorganic phosphors that have been custom-made into paint for us by Golden Artist Colors. Once we had our paint, we could move onto other challenges, like: managing intensity, identifying and controlling variables, defining a neutral grey, testing the target, and finally, producing the Targets.

Slide 8



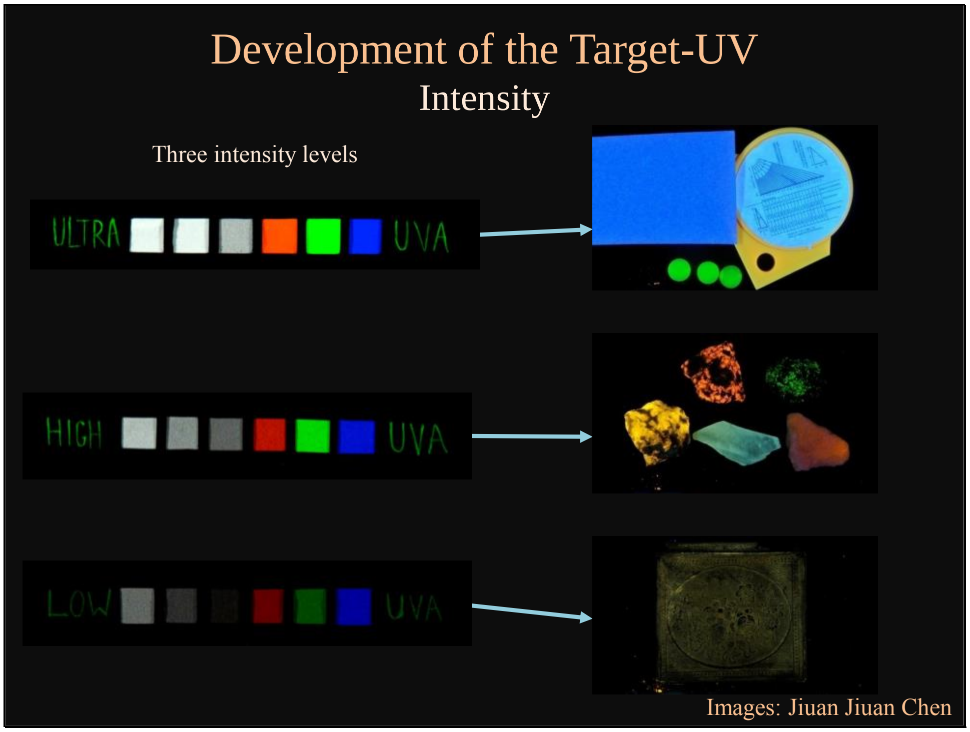
Intensity presents a challenge that is somewhat unique to UV-visible documentation, since we are documenting an emissive source. For this reason, exposure will be dependent on the fluorescent intensity of the object you are documenting. Photographing objects of different intensities in the same image will cause over or under exposure.

Slide 9



Here are some examples of this issue. On the left you can see that this object has been underexposed, while the fluorescent stamps next to it look great. On the right, this optically brightened label has been overexposed because the exposure has been set for the low fluorescence of this paper.

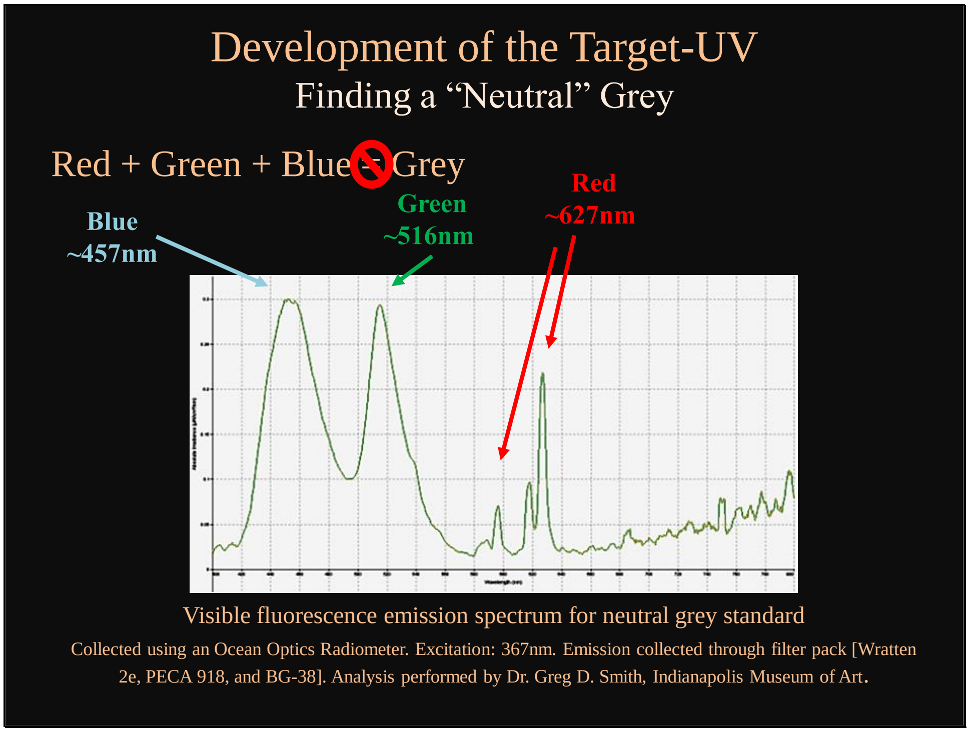
Slide 10



Early on, we decided that the best solution for this issue was to divide the Target into three different intensity levels.

- Ultra would be for items that were manufactured to fluoresce, such as paper with optical brightening agents and fluorescent dyes.
- High would match the intensity of bright, naturally fluorescent materials, like minerals and uranium glass.
- Low would be for many applications in conservation documentation, such as thin applications of resins, varnishes and pigments.

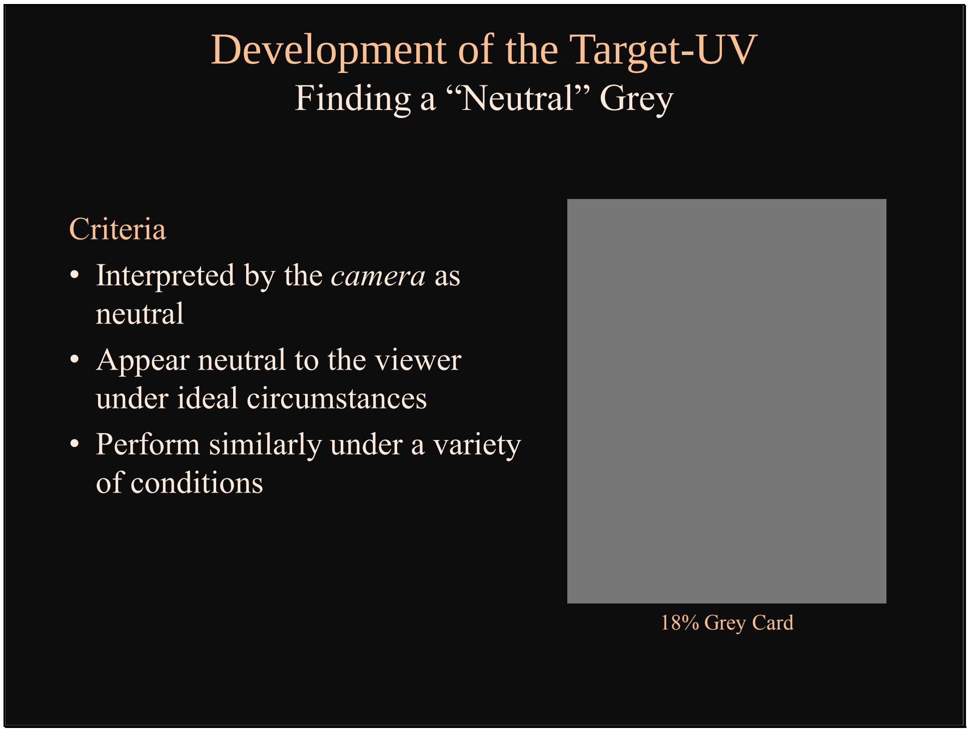
Slide 11



The next step was to formulate a neutral grey. The intent was to mix red, green and blue pigments to create a neutral grey to serve as the backbone of the project as discussed in the next slide. Let's just say that this was not a straightforward process, and required significant experimentation to arrive at our current grey.

Greg Smith, conservation scientist at the Indianapolis Museum of Art, provided us with this spectrum which shows the emission of the grey as measured through common camera filtration. Peaks from blue, green, and red combine to produce the appearance of a neutral grey.

Slide 12

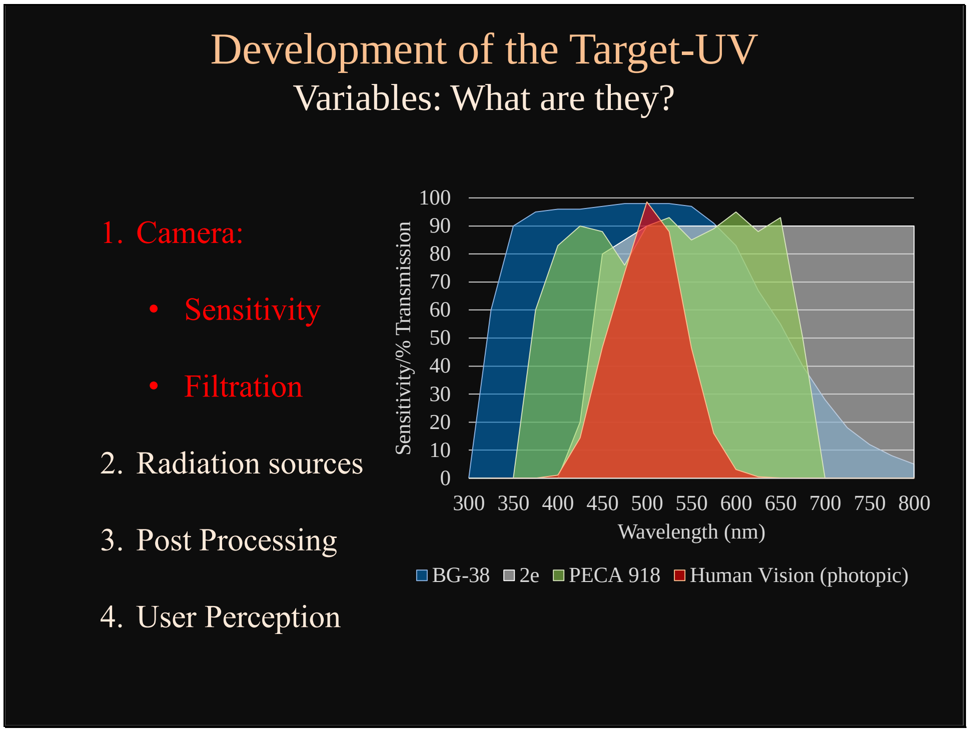


Defining the neutral grey may have been the most time consuming and challenging aspect of this project. The main goals for this grey were:

- To be interpreted by the *camera* as neutral. We’ll talk more about this in a minute, but this proved to be an important point.
- The grey should appear neutral to the viewer, but this also proved to be a more complex issue than originally hoped --more on that later too.
- The grey should perform similarly under a variety of conditions. Which, after all, is the point of any standard.

I’d like to point out some similarities with a traditional 18% grey card, which is designed to provide consistent parameters for normal light photography even under changing lighting conditions.

Slide 13

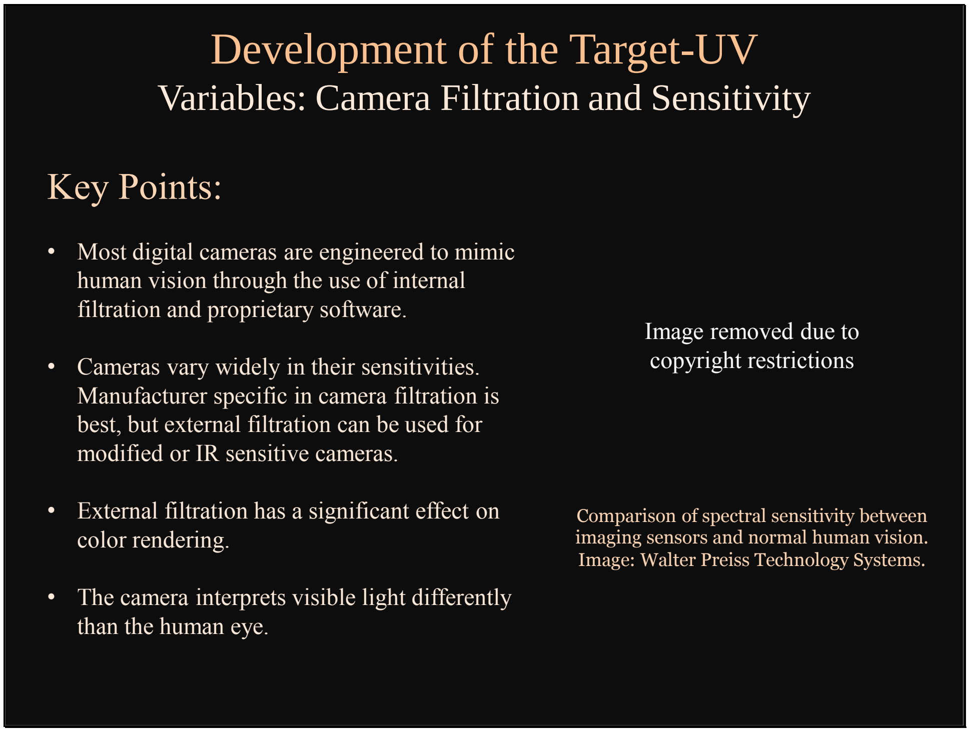


We had some variables to consider:

- The camera provides some pretty significant variables. Digital cameras vary considerably in their sensitivity based on manufacturer and sensor type.
- Filtration is also an issue. In this graph I have overlaid some common filters used for UV-visible documentation. In the blue, is a “BG-38”, which is a typical *in-camera* filter designed to limit infrared, since digital camera sensors have more sensitivity in this range than we do. The grey and green graphs are overlapping, but these represent some common *on camera filtration,* the Wratten 2e filter and the PECA 918 UV-IR cut filter. As you can see in the center of this graph, where all the filters overlap, the nature of the information coming into the camera sensor is significantly altered by this filtration. As a comparison, a final overlay is a typical photopic curve for human vision. Note how the filters bring us a little bit closer to that human vision curve.

Source of data for spectra: Kodak, Peca products and Edmund optics

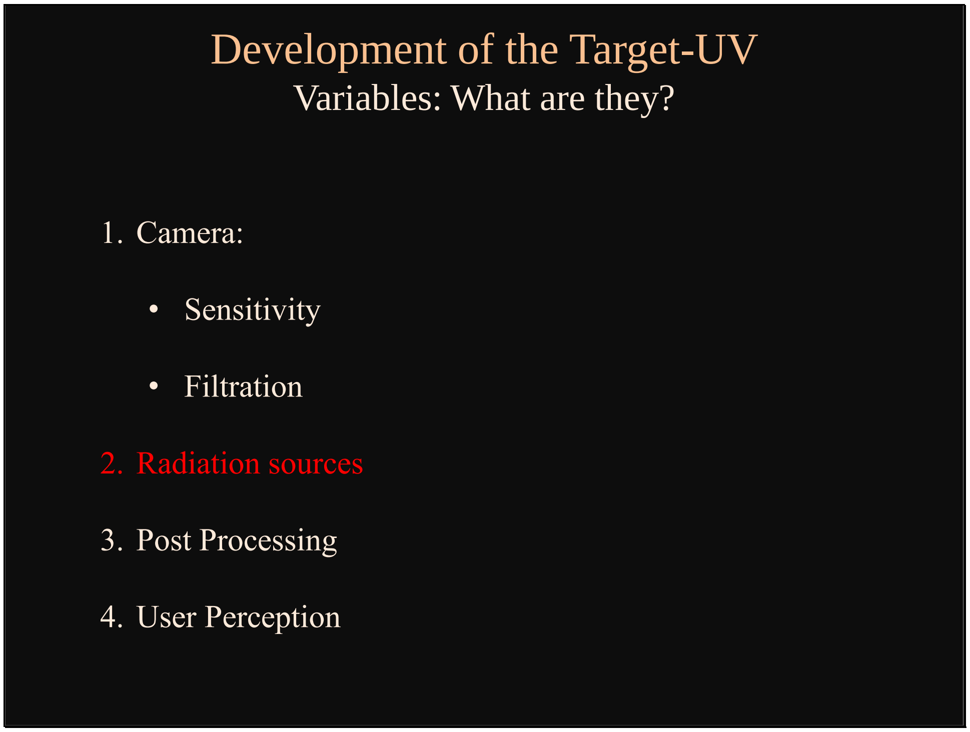
Slide 14



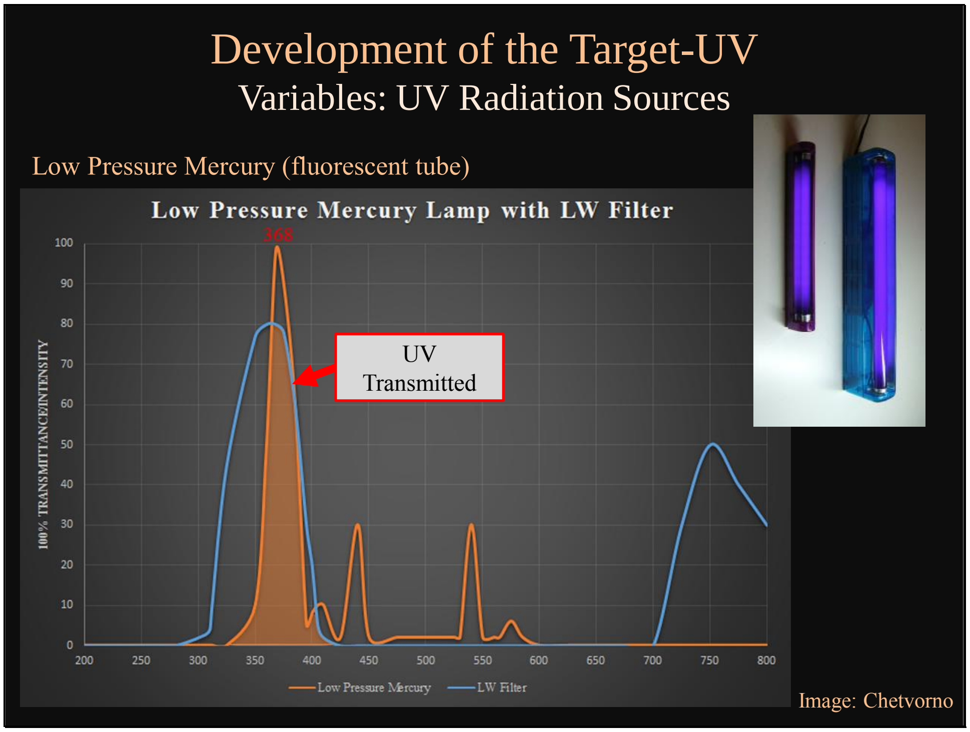
Camera filtration and sensitivity present a significant set of variable that need to be understood, especially when setting a standard neutral gray:

- First, digital cameras are *designed* to mimic human vision. This is done with internal filtration and proprietary software that interprets what the camera sees.
- Cameras *also* vary considerably in their sensitivities. The image (removed due to copyright restrictions, can be found at www.fen-net.de/walter.preiss/e/slomoinf.html) on the right shows some of the differences between the two most common sensor types, CMOS and CCD. Due to these differences, manufacturers use filtration and software that best works with their components.
- External filtration is also an important factor.
- And finally, we see visible light differently than the camera does. This point seems obvious, but is often overlooked in normal light photography.

Slide 15



Continuing with variables –incident radiation. We will review some common UVA sources.

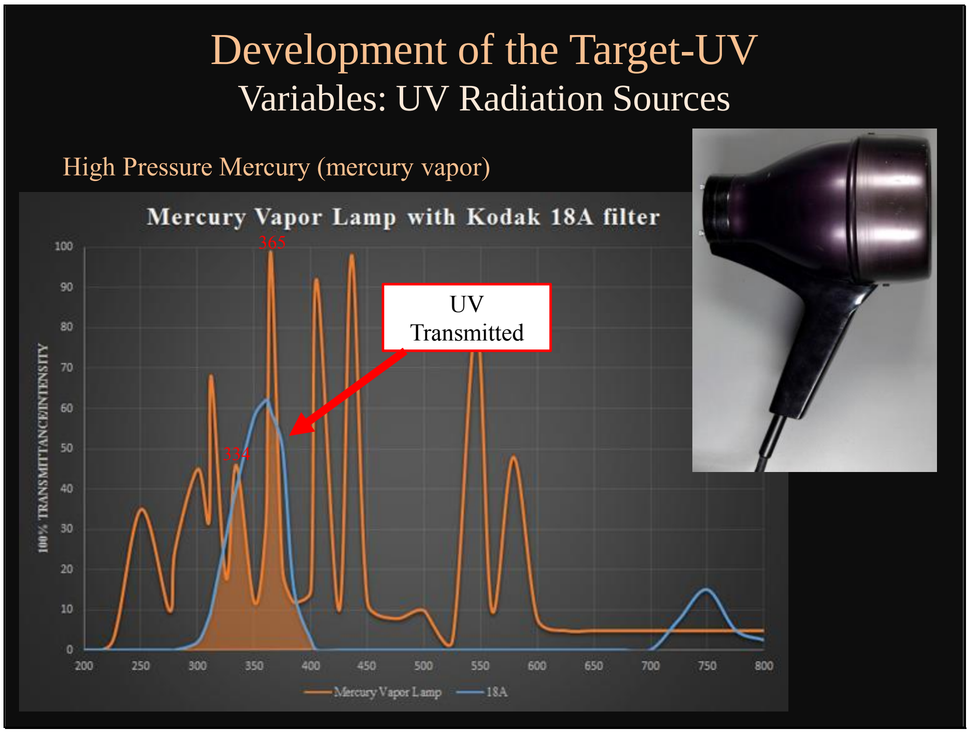


The most common UV source is probably low pressure mercury, in the form of a fluorescent tube. These are also called black lights. Their emission is typically very reliable, with major peaks around 368nm. This graph shows the emission of a super-bright two made by UV systems, a lamp which has filtration over the lamp - shown by the red line - that limits the visible light output.

Source of data for spectra: UV Systems

Image credit: "Two black light lamps" by Chetvorno - Own work. Licensed under Creative Commons Zero, Public Domain Dedication via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Two_black_light_lamps.jpg#mediaviewer/File:Two_black_light_lamps.jpg

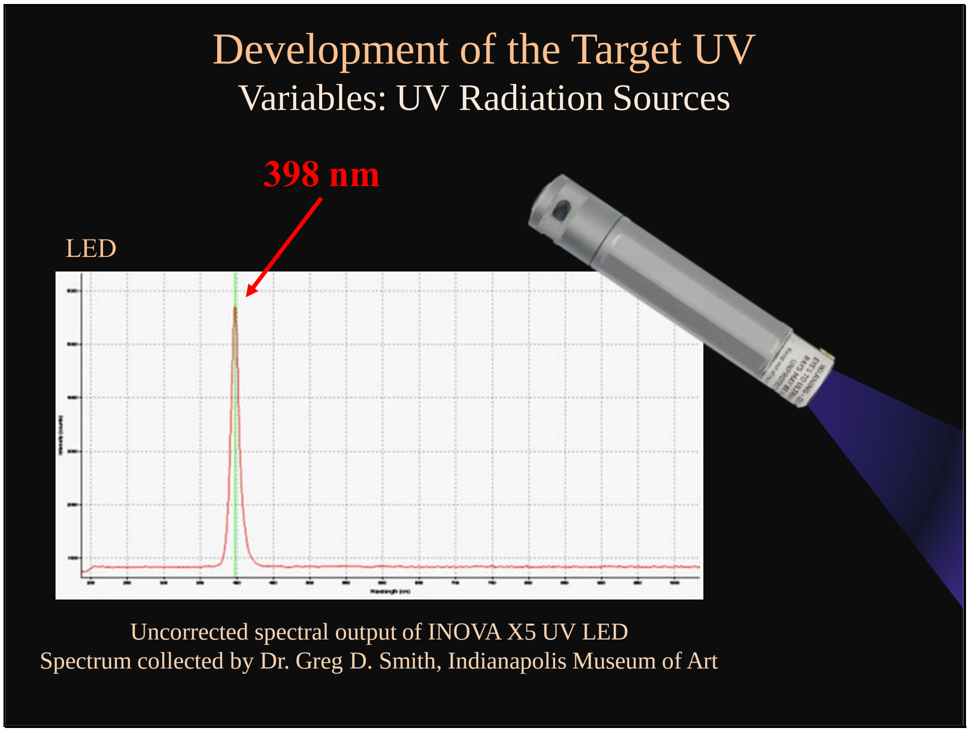
Slide 17



Another common type of radiation source is high pressure mercury lamps, which use mercury vapor. These require long warm up times but create a lot of UV radiation. As you can see in this graph, the emission of this lamp varies a bit from the low pressure mercury lamp. Significant filtration is needed to limit the considerable emission in the visible. Its main UVA peak is at 365nm, but it also has a secondary peak at 334nm.

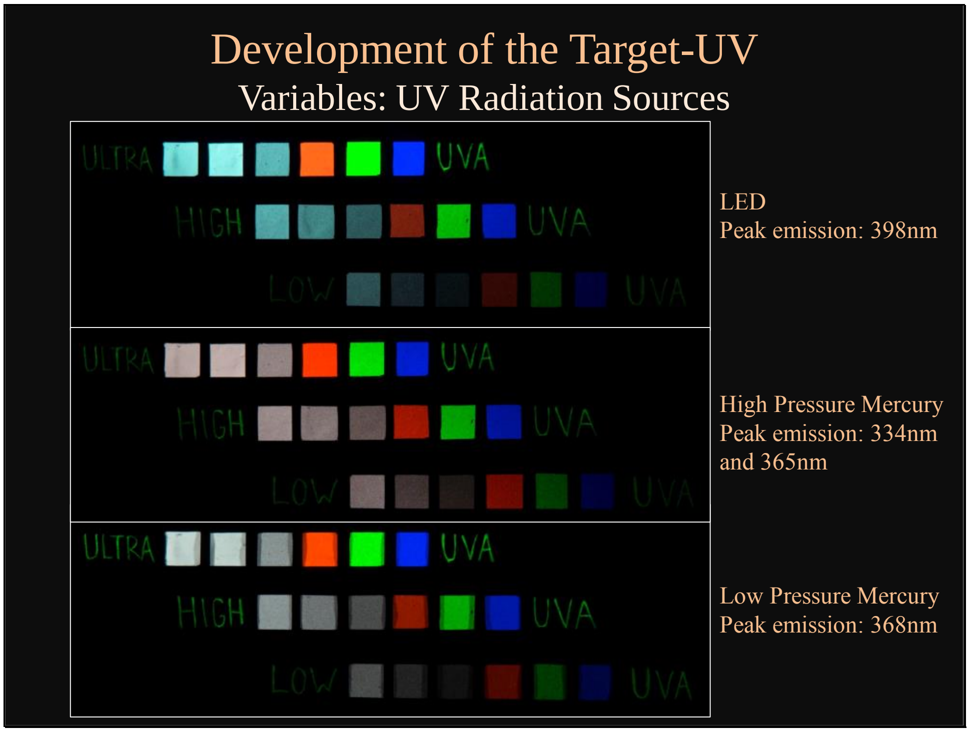
Source of data for spectra: Zeiss and Kodak

Slide 18



Another UV source that is gaining popularity - LED. This is a UV flashlight that you may be familiar with made by Inova. Its LEDs emit at 398nm, which barely qualifies as UV. This graph from Greg Smith at the IMA, shows the emission spike at 398nm. This intense, narrow spike is characteristic of LEDs, but can be targeted to any range. Unfortunately, UV LEDs closer to 367nm are still a little hard to find and more expensive.

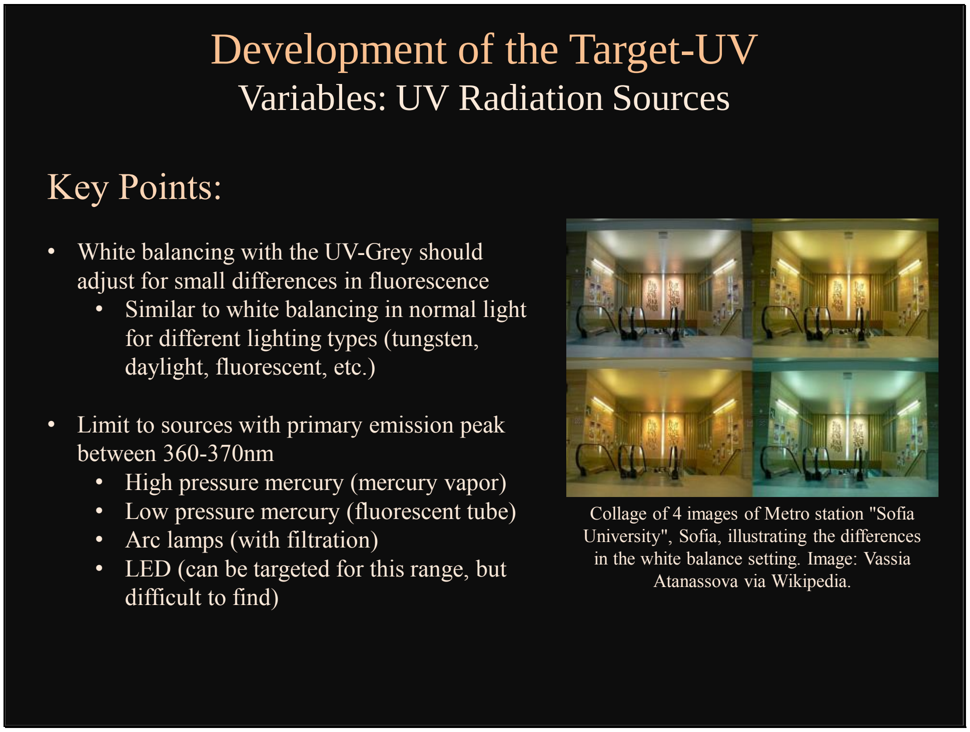
Slide 19



This slide shows the differences in fluorescence that caused by the differing emission peaks cause of the various UV sources. Here is a prototype of the Target photographed with settings calibrated for a low pressure mercury source. This set, pictured on the bottom, appears neutral because it was used to set the white balance.

However, the other sets (seen in the middle and top images) photographed with the same settings as the bottom image, appear very *un-neutral*. The LED source causes significant shift to the blue, while the high pressure mercury source shows a red shift. As suggested by the images, this color change is visually apparent when switching between these sources. While the visual difference is most striking, it is also important to note that these sources vary considerably in the intensity of radiation as well, which will effect exposure times.

Slide 20

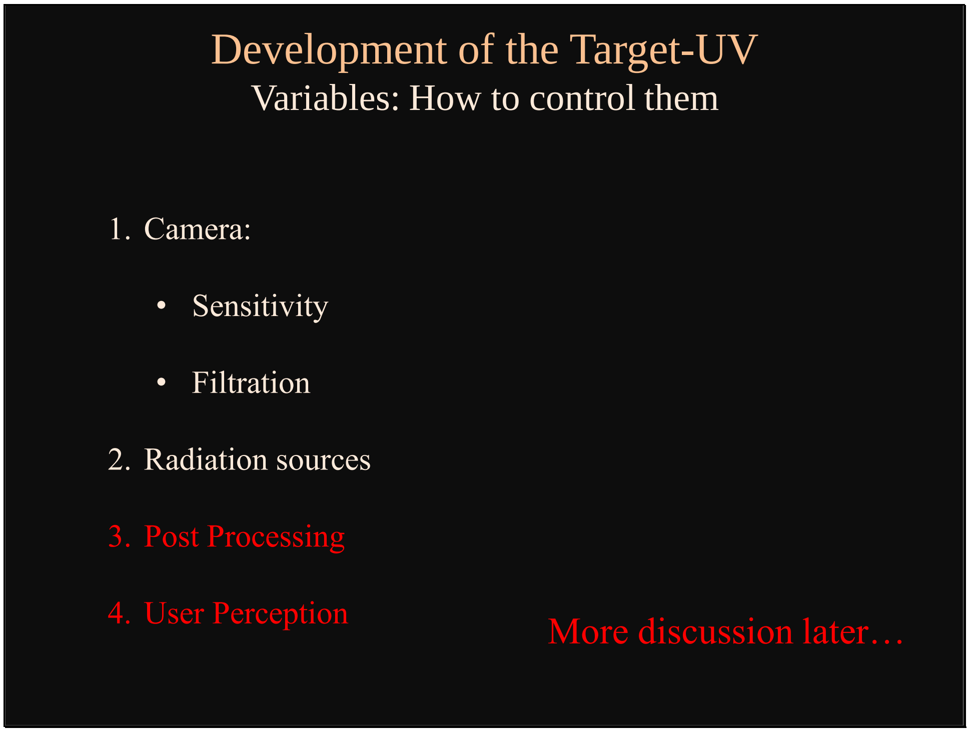


This is where the Target comes in. White balancing with the UV-Grey should adjust for small differences in radiation sources. Such adjustments are analogous to setting the white balance in normal light photography when switching from a daylight source to a fluorescent or tungsten source.

Of course, our product cannot accommodate large shifts in UV radiation, so some limitations should be noted. For the purpose of standardization, UV sources should be limited to the most common types, which have main emission peaks between 360 and 370nm.

Image credit: "Metrostation-Sofia-University-white-balance-collage" by Vassia Atanassova - Spiritia - Own work. Licensed under Creative Commons Attribution-Share Alike 3.0-2.5-2.0-1.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Metrostation-Sofia-University-white-balance-collage.jpg#mediaviewer/File:Metrostation-Sofia-University-white-balance-collage.jpg

Slide 21

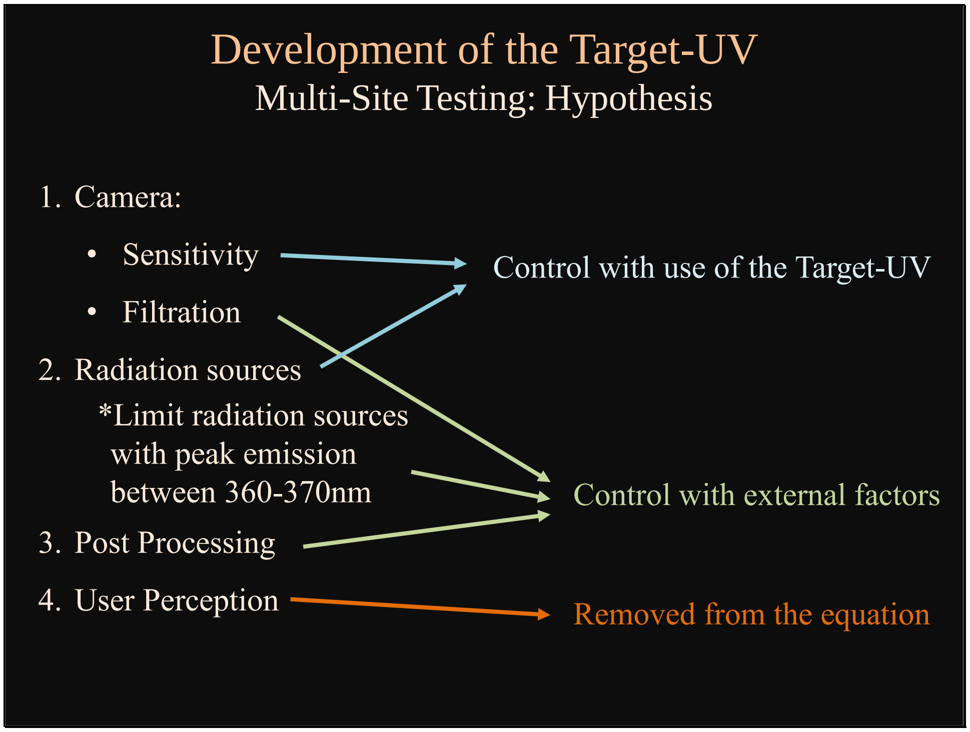


The final two variables are:

- Post processing, typically done with Photoshop or another raw editing program.
- User perception.

These are huge factors with this type of documentation. We will talk about this briefly in terms of the testing, but these variables deserve more discussion than I can give them today.

Slide 22

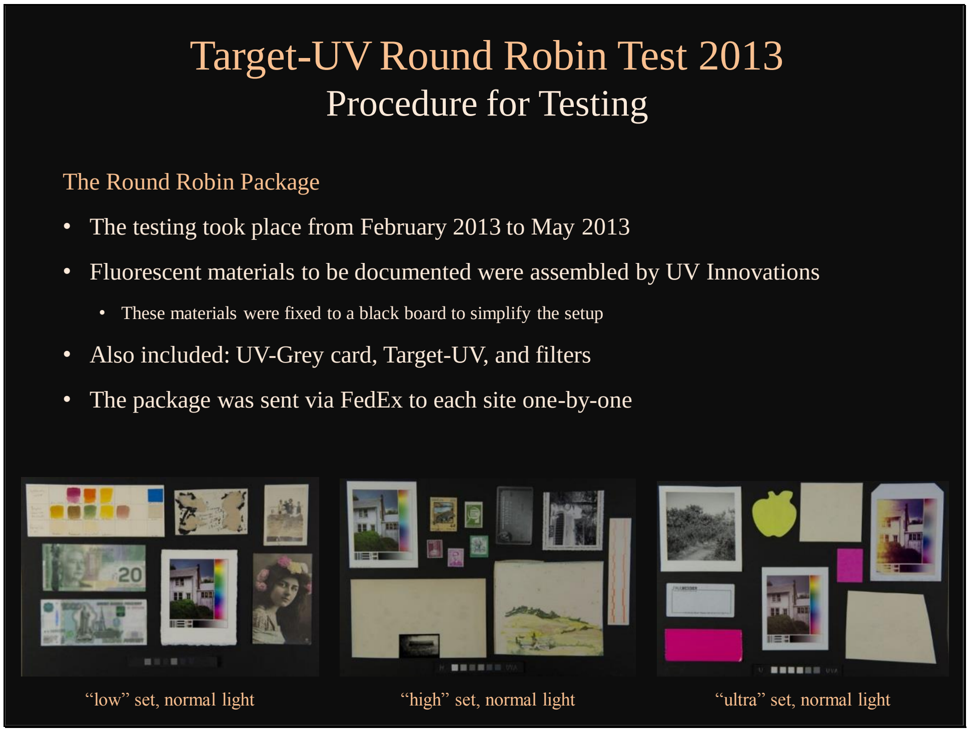


The next phase of the project was testing. We wanted to see how well the Target could accommodate all of these variables.

Two main variables are being controlled by the Target-UV and UV-Grey. These are the sensitivity of the camera, and the specific radiation source being used. This means that the Target-UV should be produce consistent results regardless of camera manufacturer or type, and using any radiation source that has a main peak between 360 and 370 nm. This includes most sources, but does cut out our handy LED flashlight.

Many of the other variables are controlled by external factors. This means standardizing filtration, limiting those UV sources, and instituting a workflow that regulates post processing. These are all significant variables that can be eliminated *only* by consistency in use. This final variable, user perception, is a tricky one. But, by setting our exposure values and color rendering to known values on the Target-UV, we are effectively eliminating this as a variable. This is easier said than accepted, but as you will see in the coming slides, things aren't always as they appear.

Slide 23



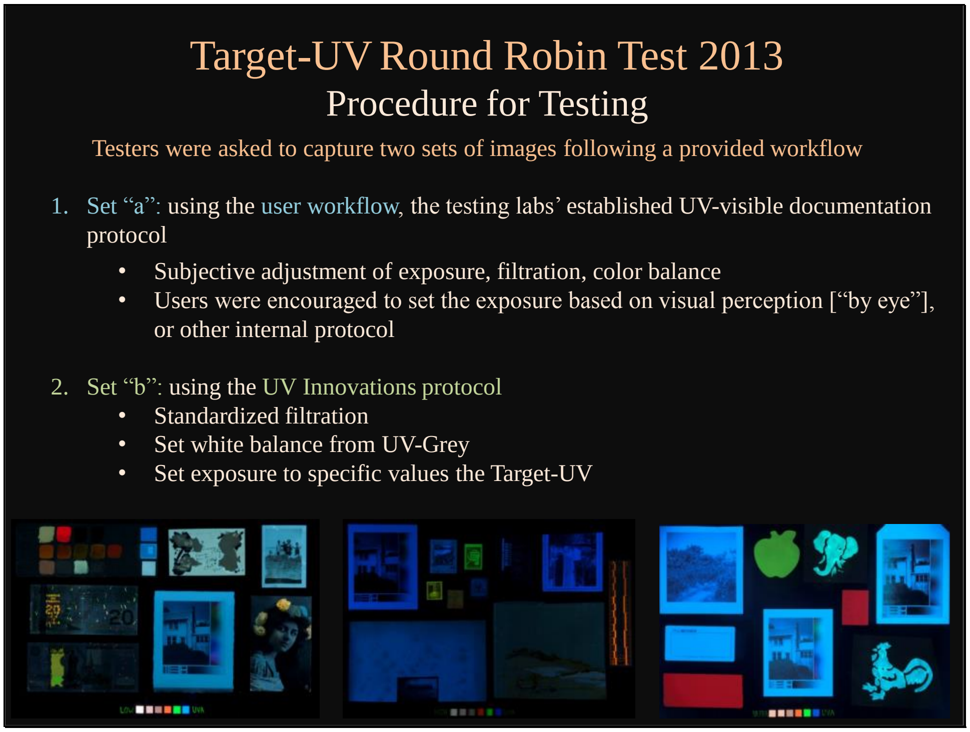
The testing took place from February to May 2013. We assembled a group of easily transportable fluorescent objects that might commonly be documented in conservation. We attached these items to black Fome-cor, so they were easy to document. On the bottom here you can see some normal light images of these objects. They were grouped by intensity level. These went into a FedEx box with the UV-Grey card, a set of Target-UV, and a set of filters. The box went around the world from site to site.

Slide 24

We chose the sites based on their availability, interest and equipment. Specifically, we wanted to choose sites that (1) had a UV workflow already in place, and (2) represented some of the variables we were trying to test.

We are grateful to all these institutions for their time and participation in the testing. The final list is seen above.

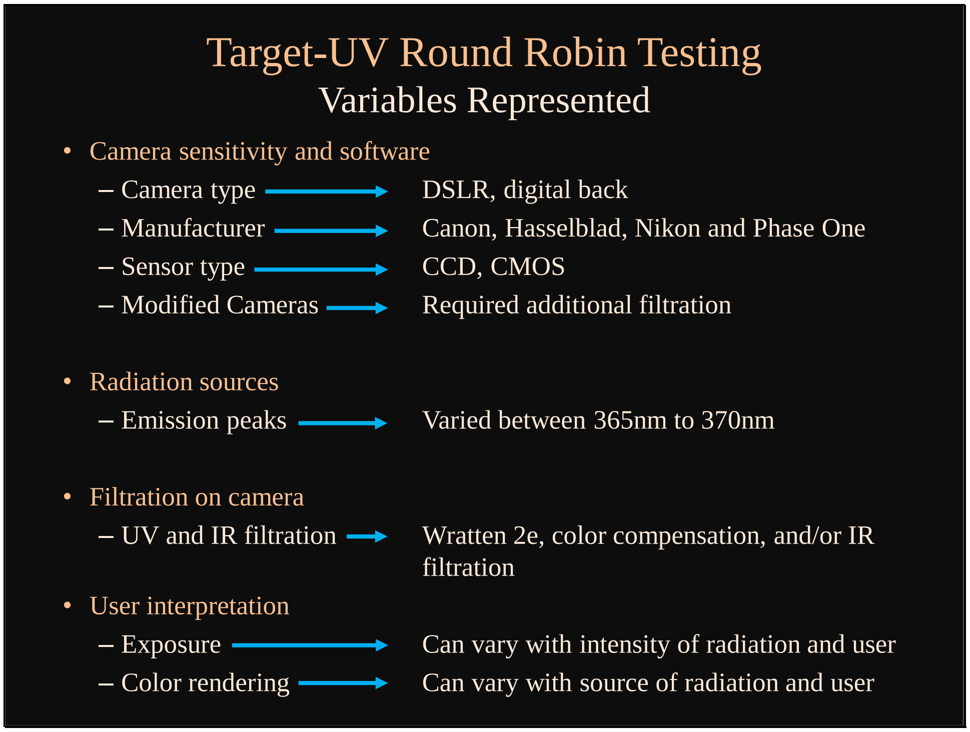
Slide 25



Each site was asked to capture two sets of images. Set “A” would represent the testing sites’ existing internal workflow, which usually included a subjective adjustment of exposure and color balance. Filtration was also variable. Some used the guidelines set out in the AIC Guide to Digital Photography and Conservation Documentation, but most used color and exposure values based on visual perception during the documentation session.

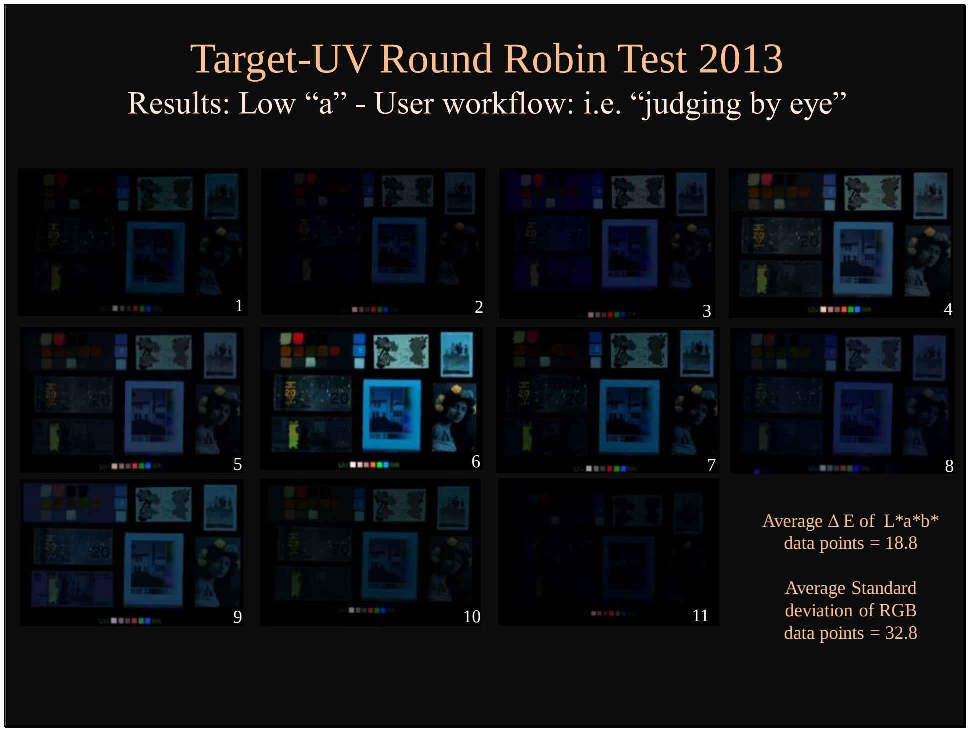
The “A” set was meant to be a contrast to the next set of images – the “B” set. This was done using our workflow which standardized filtration, set the white balance from the UV-grey, and set exposure to values on the Target-UV. Our expectation was that we would see inconsistency among the testing sites in the A set, and hopefully consistency in the “B” set.

Slide 26



Ultimately, we had an excellent representation of variables. Common camera types and manufacturers were represented, as well as several sensor types. Cameras that had been modified to be sensitive to UV and infrared were also included. Radiation sources varied, with high pressure mercury, low pressure mercury, and arc lamps used. In addition, set “A” showed variability in filtration as well as user interpretation.

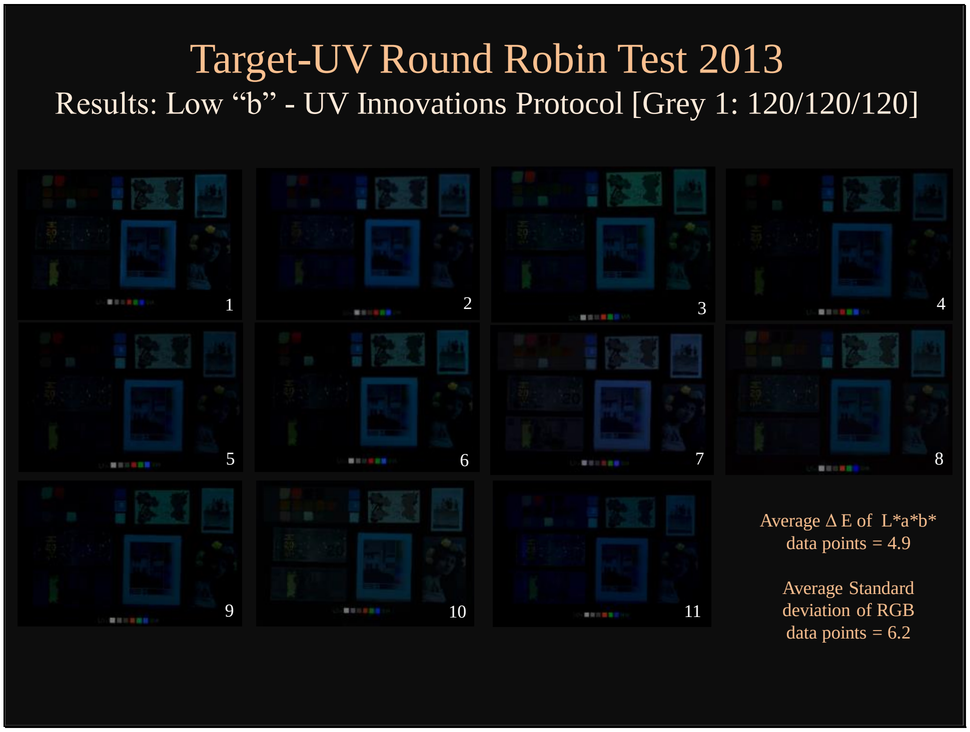
Slide 27



Here are the results for objects with “low” fluorescence. This slide represent all the “A” images. Each number represents a testing site. As you can see there is quite a bit of variability here. On the whole, the images are pretty dark, which would be expected for this intensity level. There are definitely some outliers.

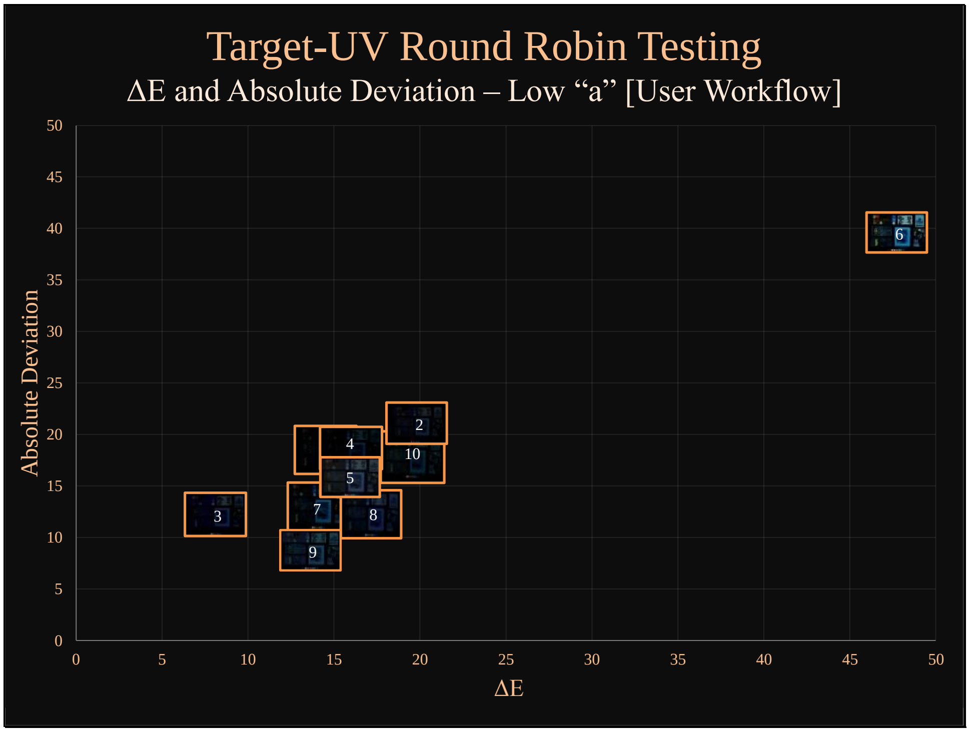
Each users perception of the fluorescence is slightly, or significantly different. RGB values were collected from the images using Photoshop and used to calculate the delta E and standard deviation you see in the bottom right corner. For this group, those numbers are pretty high. Delta E is over 18 and standard deviation is 32.8 - a significant lack of consistency.

Slide 28



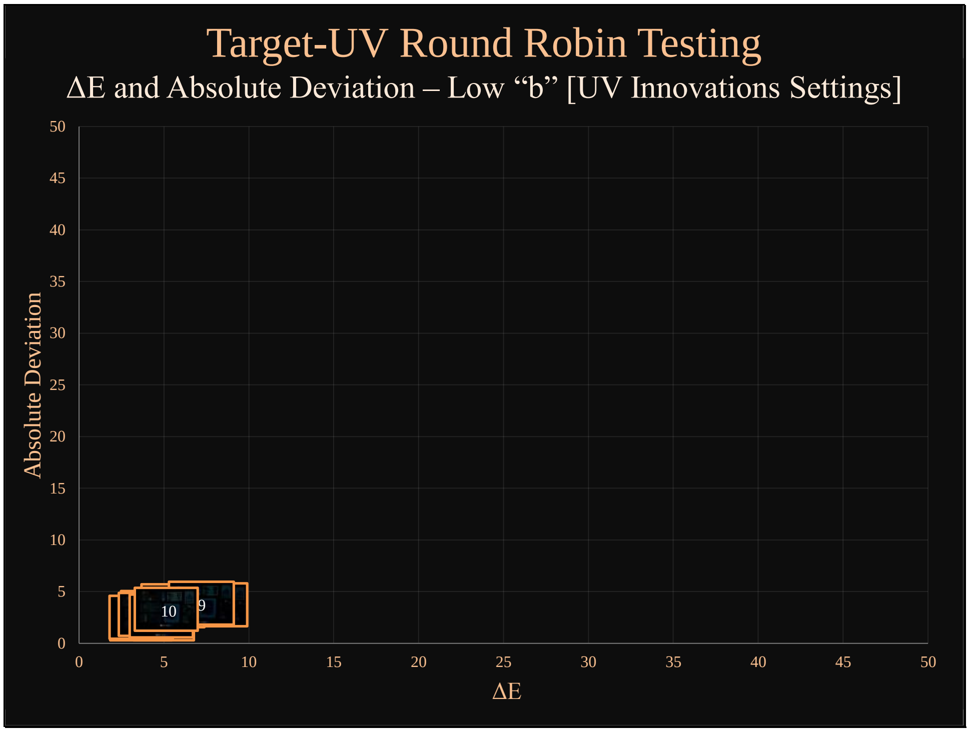
These are the low-fluorescent results using the UV innovations settings or the "B" set. As mentioned before, filtration and workflow were standardized and the exposure was set to values on the Target. The visual difference is clear. The Delta E was reduced to 4.9, about one quarter of the previous value, and the standard deviation to 6.2.

Slide 29



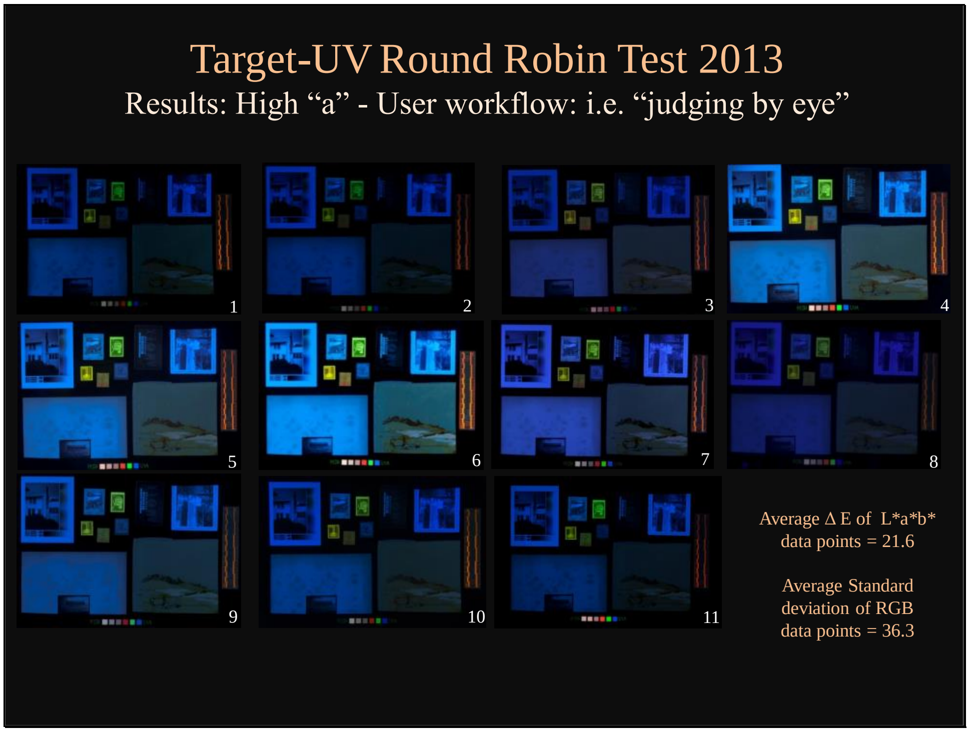
To visualize this a bit better, these graphs plot the delta E against the absolute deviation from the average RGB values for each image. This gives you an idea of the level of variability in the “A” images. The further out from zero, the more variable the image is from the average. There is a cluster in the bottom left here, of variability that hovers around 15 to 20 delta E with a similar absolute deviation. Again, notice some outliers in the top right as the delta E and absolute deviation increase.

Slide 30



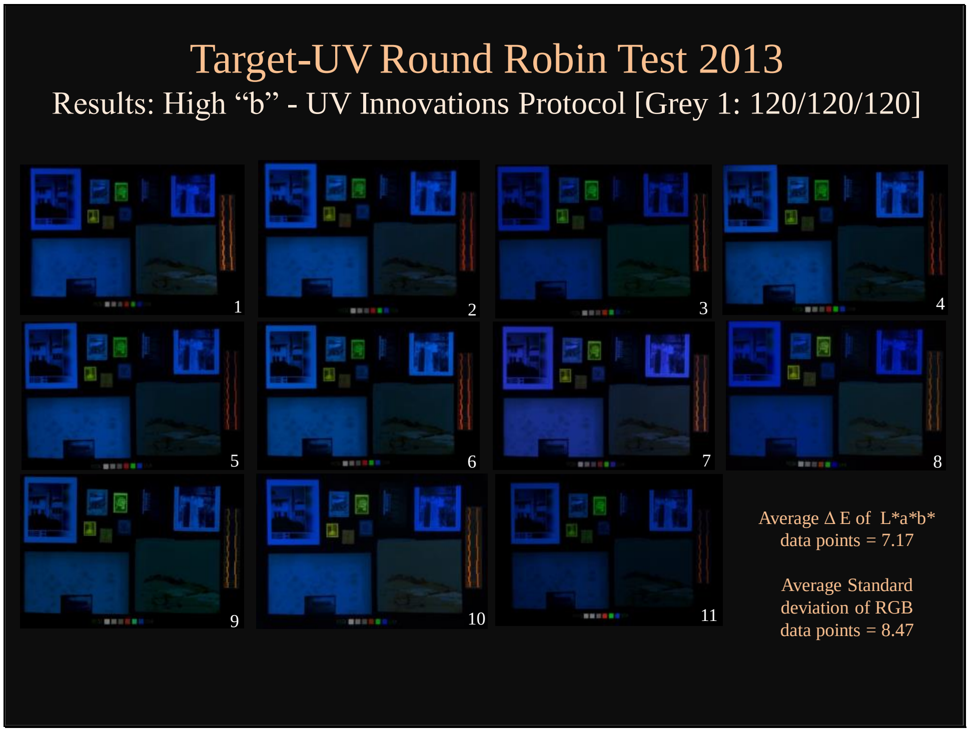
This next graph shows a significant decrease in variability in the “B” images captured with the UV innovations settings. There is only one group here in the bottom left of similar images. No outliers.

Slide 31



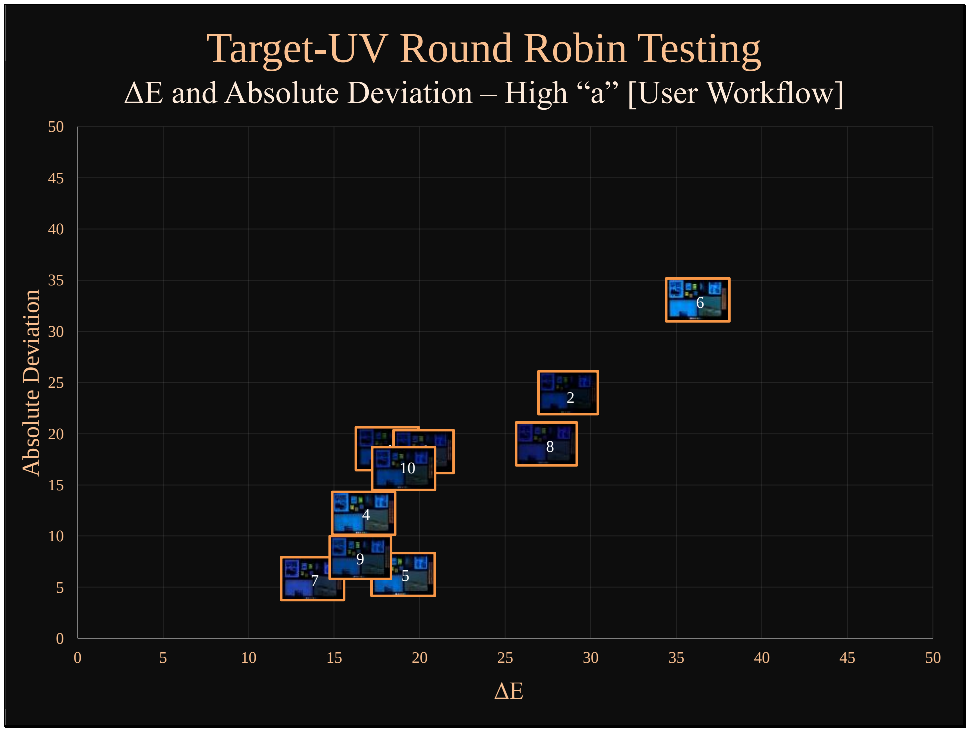
Here is the set of “high” fluorescent items. This group of “A” images shows a similar level of variability with the user workflow that we saw in the “low” images. Delta E and standard deviation values are pretty similar to the “low” fluorescent images. It is a little easier to see the differences in color rendering and exposure here. Notice the differences that occur when user interpretation is a factor.

Slide 32



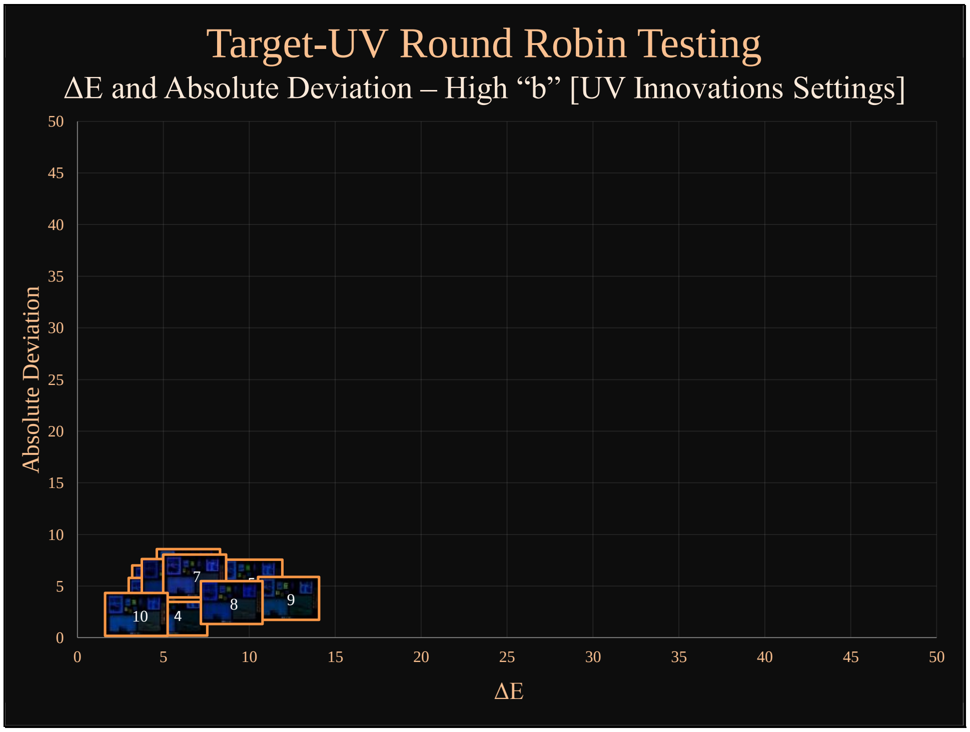
The "B" set again shows a significant reduction in the visual differences. These images are pretty similar. This is reflected in a reduction of the delta e values and the standard deviation.

Slide 33



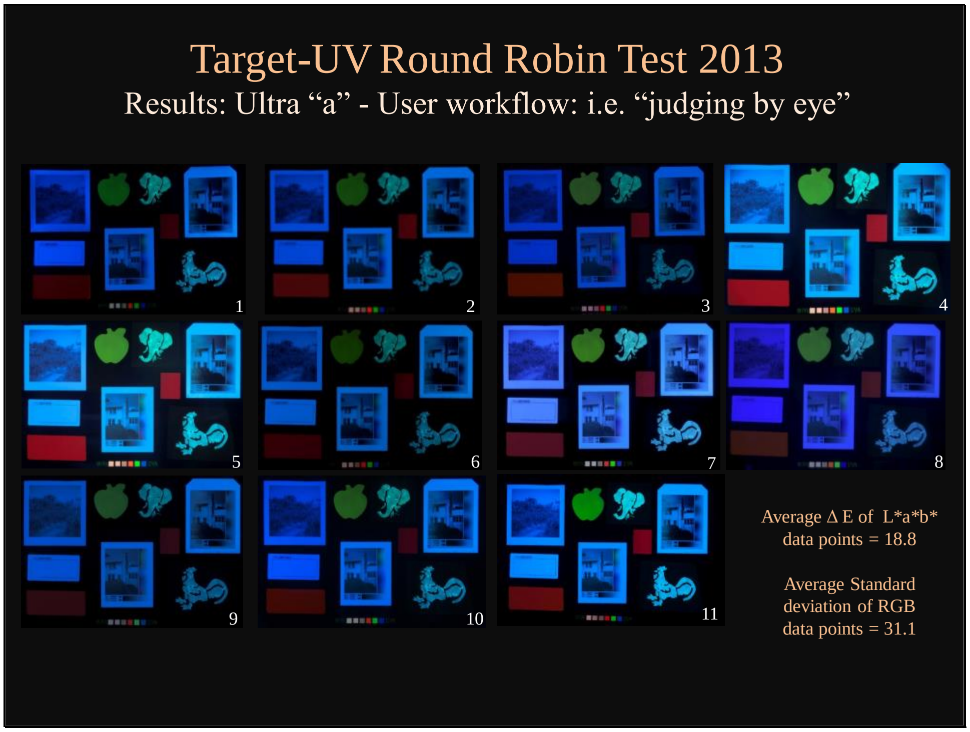
Here is a graph of the "A" images. There is a pretty wide spread of delta e and absolute deviation that we saw with low fluorescence.

Slide 34



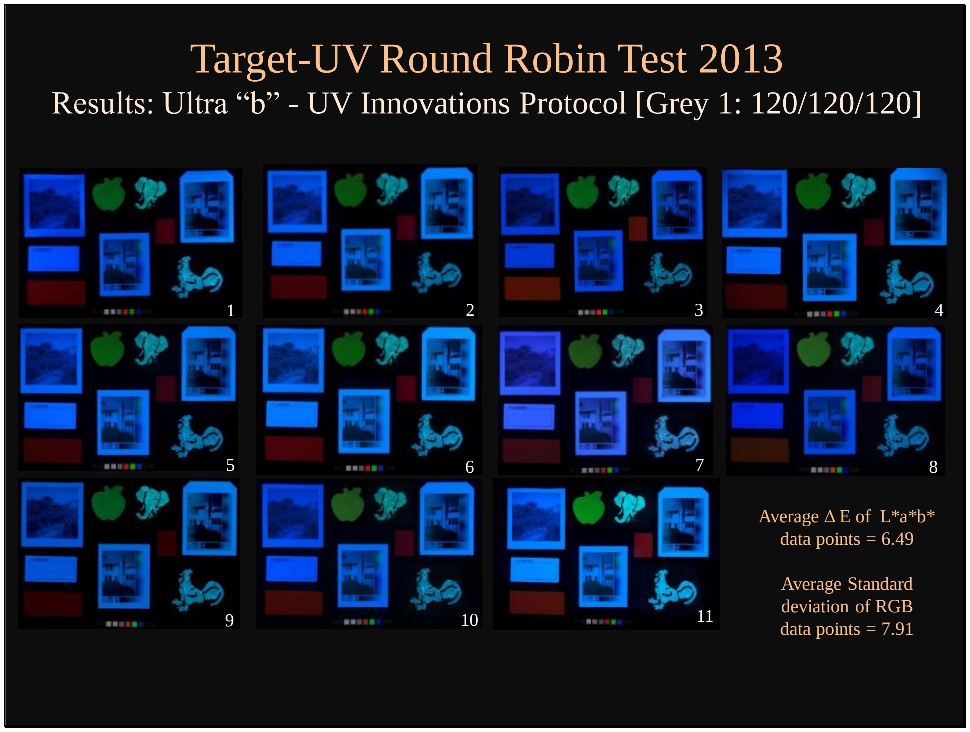
There is a similar reduction in delta e and absolute deviation in the "B" group that followed the UV innovations settings.

Slide 35

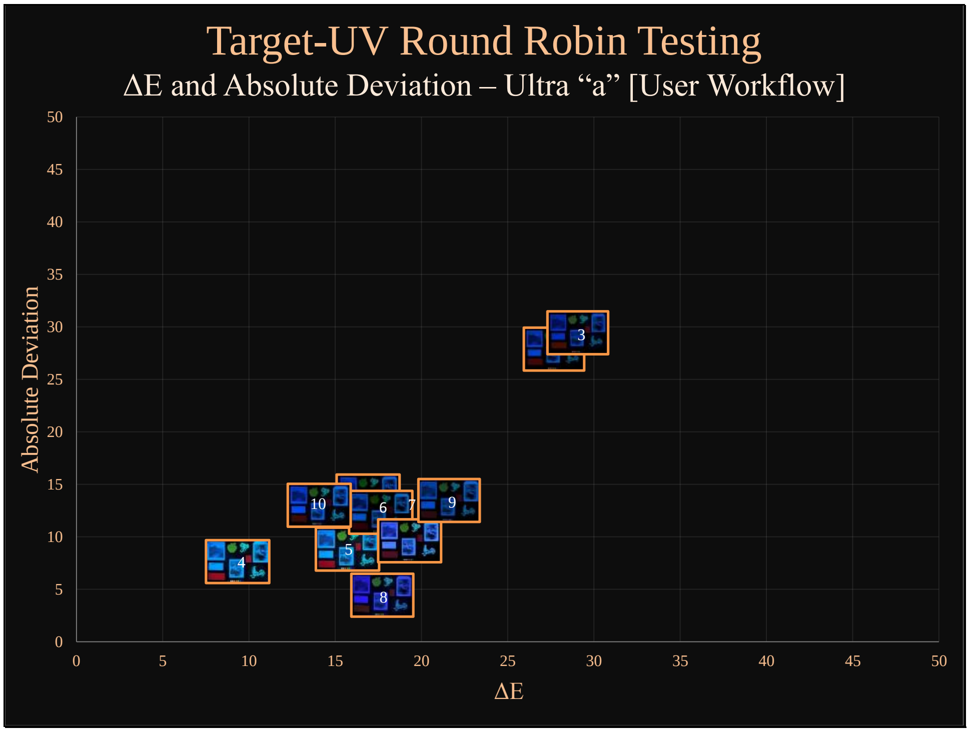


Here is the last set -the "ultra" images. These "A" images show some differences in perception by the viewers. Some of these images reached maximum RGB values of 255, meaning they were overexposed beyond the capacity of the sensor. Again, delta E and standard deviation are similar to the low and high-fluorescent sets. I hope you are beginning to see the amount of variability in user perceptions and workflows.

Slide 36

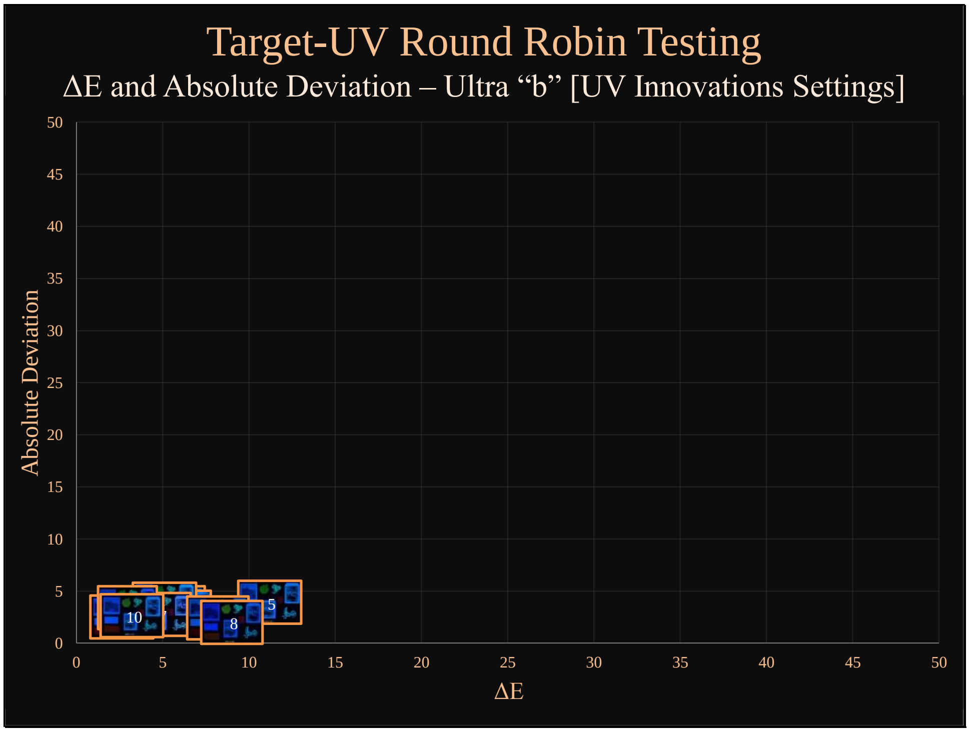


The “B” group, using the Target and UV innovations settings shows more consistency, which is again reflected in the reduction of the delta E and standard deviation values. Can you see the power of standardization and consistent workflows?



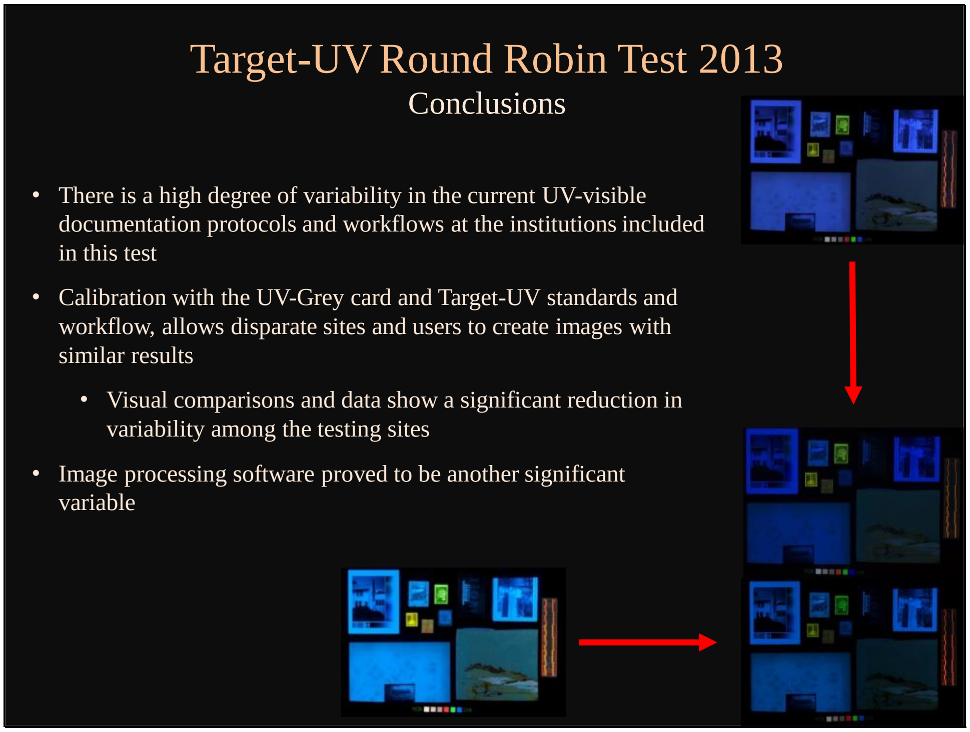
A graph of the "A" set shows the variability in interpretation present in the user workflows.

Slide 38



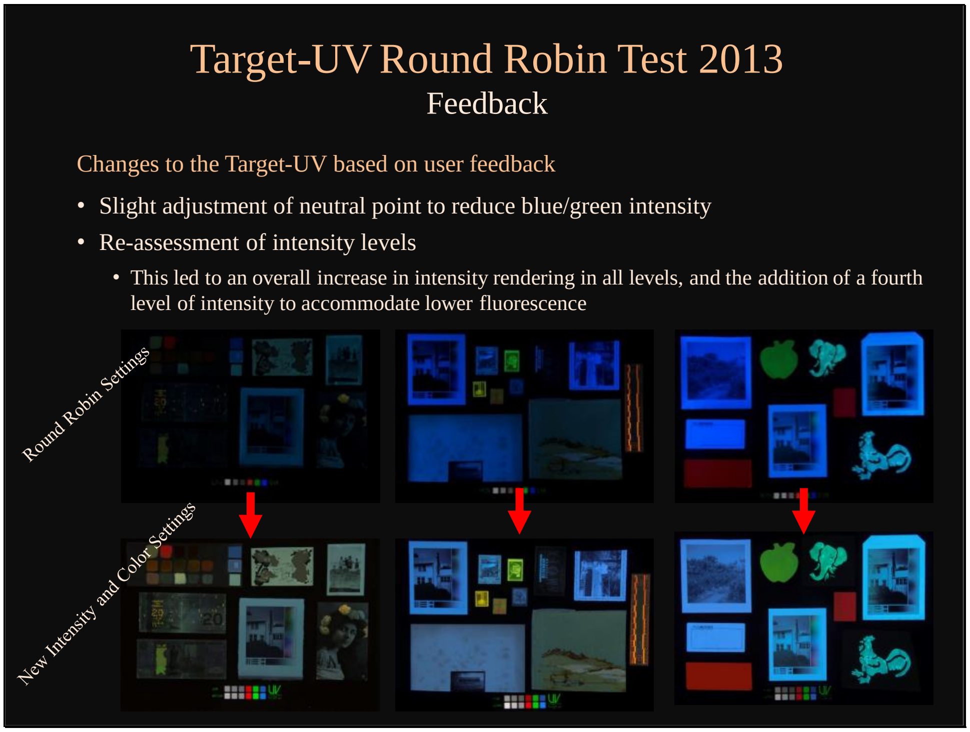
As with the “low” and “high” fluorescence groups, the “B” set of “ultra” images shows standardization reduces the delta e and absolute deviation.

Slide 39



Some conclusions:

- There is a high degree of variability in current UV-visible documentation protocols. Our small group of testers illustrated this in their "A" images.
- Calibration with the UV-Grey card and Target-UV allows disparate sites to create similar images. The visual comparisons are clear. This means that the Target-UV successfully controlled the variables we laid out earlier.
- One point I'd like to make, but can't spend too much time on, is that image processing software proved to be another significant variable that we are still working out. This was most noticeable with the cameras that required post processing using proprietary software, like the Hasselblad and Phase One systems. All the DSLRs could be processed with Adobe Photoshop Raw.



We got a lot of valuable feedback on this testing. Most users noted a slight blue/green cast in the images, so the neutral point of the grey was adjusted to reduce this.

The most common comment we got related to intensity. Many users felt that the low images in particular were too dark, and hard to see. Though they may reflect an accurate rendering of intensity, most said that the image just weren't *useable*. To deal with this issue, we increased the intensity rendering, as you can see here. The color change is also visible. This adjustment allows us to capture a lot more detail and reduces the tendency of the blue values of the image to max out. Not pictured, we also added a fourth intensity level to allow a bit more flexibility.

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These products should be ready soon. We have partnered with Image Science Associates who will manufacture and sell the Target-UV and UV-Grey. They made the wonderful prototype pictured on the bottom here. We have a few more things to do, but we hope to have these available later this year. Up next is some much needed ageing tests to put a reliable replacement date on the pigments, but we expect them to perform well. We are also still working out some of the workflow issues.

Some future goals include a larger format Target and a UVC Target. For more information, you can visit our website at www.uvinnovations.com

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