The Blackbody's Black Body

A Comparative Experiment Using Photographic Analysis

In the last section we introduced the ideal blackbody: a hypothetical device from physics that absorbs all wavelengths of electromagnetic (EM) radiation. Reflecting absolutely no light, an ideal blackbody is blacker than black—really it represents the absence of light altogether. The LessLoss **Blackbody** is of course a real-world approximation of this ideal. We want to show you how close we've come by showing you the extreme amounts of EM radiation our **Blackbody** can absorb. (The more effective an absorber, the better the device is to clean up stray EM radiation). To show you this, we must first over overcome a few obstacles.

Light intensity: too much dynamic range

Light intensity varies in gigantic proportions. From a single photon to the overwhelming power of radiant sunlight, the magnitude of dynamic range is almost unimaginable. People can adapt to intense changes in light, but only over time. At high noon, we can still discern subtle shades of high mountain snow; at night, we still manage to find our way around by moonlight. Capturing both of these contrasting scenes in a single snapshot is impossible: the dynamic range far exceeds the maximum resolvable dynamic range of any image capturing device. Even if we could capture such data, displaying it on a computer monitor, in print, or on film would be impossible.

Our eyes can identify a dynamic range of about 10 to 14 EV (exposure value) in a single scene, or, around 24 EV considering the eye's ability to adapt. A color photograph may have 6 EV of dynamic range. A cheap 6 bit laptop can only display 64 shades of grey. The vast dynamic range of natural light intensities doesn't fit into such a limited scale. As mentioned above, even in nature, we need time to adjust to new brightness scales, otherwise we're effectively blinded for a time. This is what we're up against. We can't show the **Blackbody's** blackness directly, but we can illustrate it. We must move hidden bits to a comfortable zone, keeping relative proportions intact.

The setup Equipment used

LENS

Carl Zeiss Makro-Planar ZF 100mm/f2. At f22 aperture, at 0.68m focusing distance.

CAMERA

Nikon D3 professional. Shutter speed 1/250 s, "Neutral" picture control setting (smooth, unexaggerated, low contrast tone curve). Custom white balance set at ~5350K, 200 ISO sensitivity, AdobeRGB colour space.

PROCESSING

Adobe Camera Raw 4.4 camera profile. ProPhotoRGB colour space, 16 bit depth data, White balance 5350K temperature, –6 tint.

LIGHT SOURCE

Multiblitz Profilux 400 monolight studio flash head, ~50 Joules/Watt seconds of light energy, with honeycomb grid to reduce spill-light reflections from nearby objects. Color temperature — 5500K (+/– 150K). Flash duration — 1/700 s, ~1m distance from object.

Get ready Calibration

Keep in mind, your monitor provides only very few discreet steps of what in reality represent innumerable shades of light intensity gradations. We have to make it all fit into our monitor's 8 bit range of light intensity per color channel. (8 bits in binary = a maximum of 256 [from 00000000 to 11111111, which is 0 to 255]).

To make sure you see the following data correctly, please make the proper adjustments to your monitor's brightness and contrast settings so you see eight shades of shadows on the left, and eight shades of highlights on the right in the graphic below. Once you've done so, you should be able to see everything we're showing in the upcoming test.

The magnitude of dynamic range from 0 (pitch-black) to 255 (completely white) is shown below. On some monitors it is impossible to display all shades, so the range isn't as smooth as it should be. Banding results. If the following two images appear similar, your monitor is struggling.

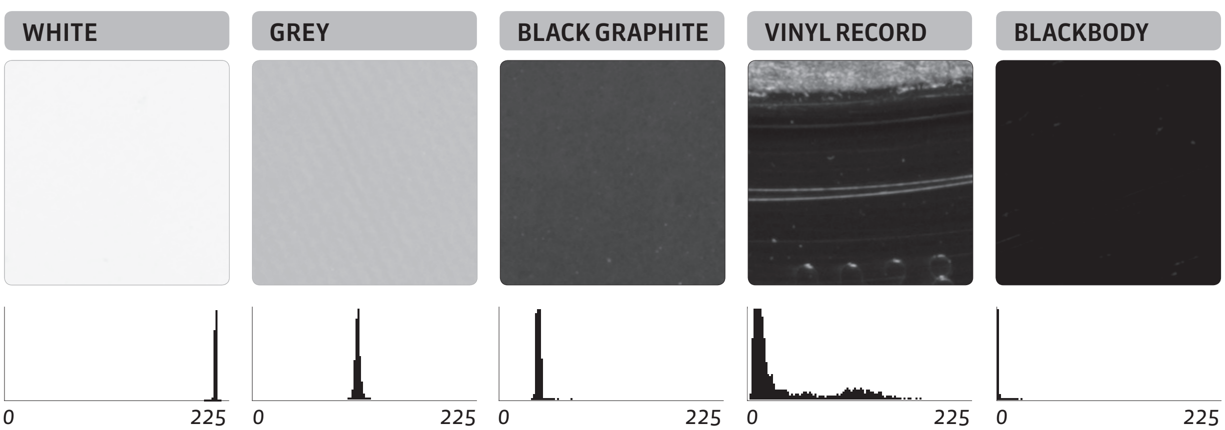
Remember, this scale represents the viewing equipment's limitations to depict the data. In reality, there's much more data in the raw data files. The viewing scale would need to be substantially larger to directly show the depth of blackness reflected by the **Blackbody** in accurate proportion.

Gathering raw data Controlled conditions

With the given equipment setup, we took carefully controlled photographs of all five test objects. It is common knowledge that one can change the perceived darkness of an object, simply by changing the angle of incidence. At certain angles, a record can appear light grey or even white. So, we chose a particular angle to maximize these objects' darkness. Also, the **Blackbody** was positioned well within its 35 degree angle of influence.

As for chosen materials, Black Graphite was the darkest paper available from a specialty art store. To go even darker, we chose the darkest portion of a vinyl record: the 'lead-out' groove between the final track and the label. The label itself is black.

The illustration below shows how intense the flash was when we took these control pictures. Beneath each picture is the corresponding intensity plot for each brightness gradation from 0 to 255. This represents the entire dynamic range we can show on screen. The plots show how much of each gradation each picture represents (i.e., how many pixels of each brightness level are present).



Callibrated White Target ("Lastolite EzyBalance" — used for colour correction, exposure control, accurate colour rendition).

Callibrated Grey Target ("Lastolite EzyBalance" — used for colour correction, exposure control, accurate colour rendition).

"Black Graphite" paper sheet, satin finish. Darkest paper available in art supply store.

Black vinyl record, lead-out groove, black paper label, some studio master numbers visible.

"LessLoss Blackbody" radiator.

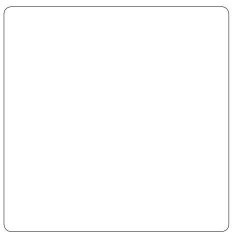
Next, we processed the data by running a digital exposure magnification algorithm set at +4 EV for each photographed object. We did this to simulate having set up 15 additional identical flash sources around the objects, all at the same distance. With this amount of light, some of the photographs would have become overexposed. Notice only the white and grey targets are completely white in appearance, while the blackest of all available papers still has some small traces of data left. The record label's black paper was also hopelessly overexposed, going over the limits of our dynamic range; but, the **Blackbody** is still very dark, with only a few visible signs due to imperfections and dust particles.

Interpreting & analysis 16x brighter

DIGITAL EXPOSURE COMPENSATION SET AT **+4 EV**

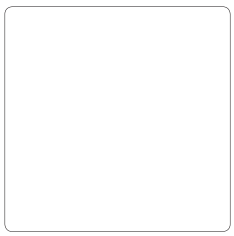
By increasing the exposure we begin to expose data otherwise invisible to the human eye, which lies buried within the 16 bit RAW files. Other bits of data which no longer fit within the dynamic range settings are now thrown off the scale.

WHITE



Completely white, all information is lost.

GREY

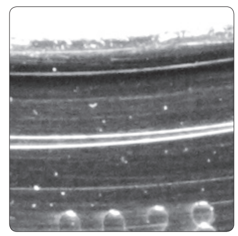


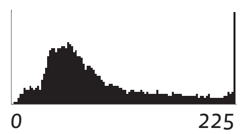
Completely white, all information is lost.

BLACK GRAPHITE

Some traces of information left, approaching total whiteness.

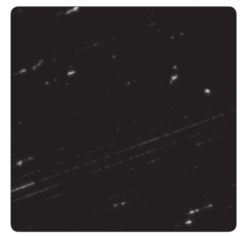
VINYL RECORD

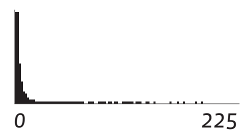




The dark black vinyl is becoming lighter. Some color casting is now visible. Black paper label is completely overexposed and off scale.

BLACKBODY





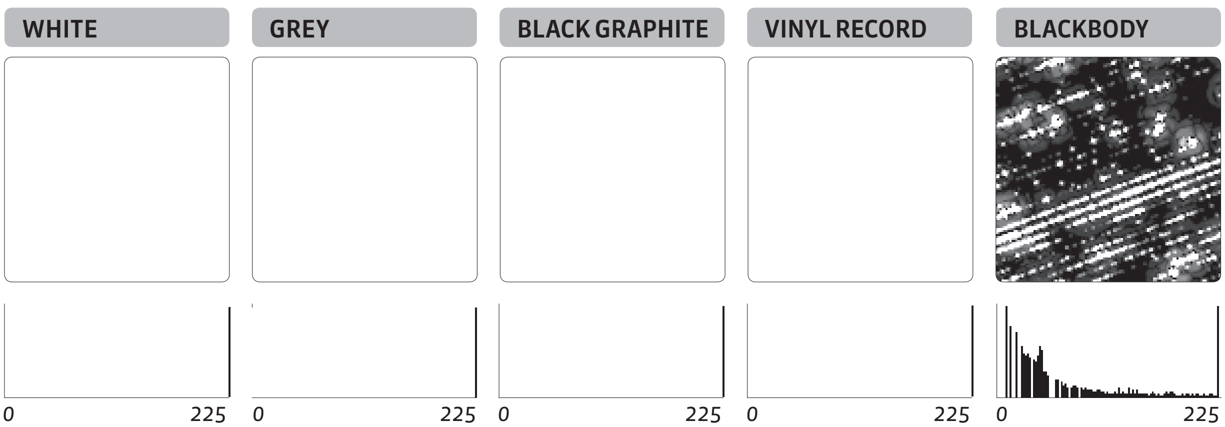
The Blackbody is still black. Only small traces of reflective surface dust are visible.

Next, we returned to the original data to raise the virtual light source all the way to 65,536 times brighter. This emulates something like a football stadium of light sources in our studio, all 0.6 meters from the object! If your viewing equipment had no limitations, the paper would be blindingly bright. Notice even the record surface was brighter than our dynamic range allows, and yet, even so, the **Blackbody** was still essentially black, with only some imperfections scattering light in unpredictable ways. Where, you might ask, was all of this intense light going? It was being absorbed and largely turned into blackbody radiation.

Interpreting & analysis 65,536x brighter

DIGITAL EXPOSURE COMPENSATION SET AT **+16 EV**

Taking the exposure now to an extreme brightness, we expose and make visible the very last bit of information lying within the 16 bit RAW files.



Completely white, all information is lost.

Completely white, all information is lost.

Completely white, all information is lost.

Completely white, all information is lost.

The Blackbody is still essentially black. Overexposed surface dust particles emit some light pollution.

Photonic sponge "Soaking up" noise

This experiment shows how effectively the **Blackbody** captures photonic energy, transforming it into blackbody radiation. Although it is not a perfect blackbody, it is close such that the principle of EM absorption is in strong effect. As a proximate object to your gear, the LessLoss **Blackbody** conditions the "EM ecosystem" in a novel way. Whereas traditional shielding must also influence the shielded electronics via emission of the shield's own spectral fingerprint, the LessLoss **Blackbody** functions as a strong absorber of EM radiation and a reflector of blackbody radiation. Because blackbody radiation has virtually no spectral signature at room temperature, it doesn't cause any sound coloration.