

Why you should consider exporting your renders as HDRI

NOTE: The video has the brightness range compressed and some pictures are displayed too bright on the dark parts.

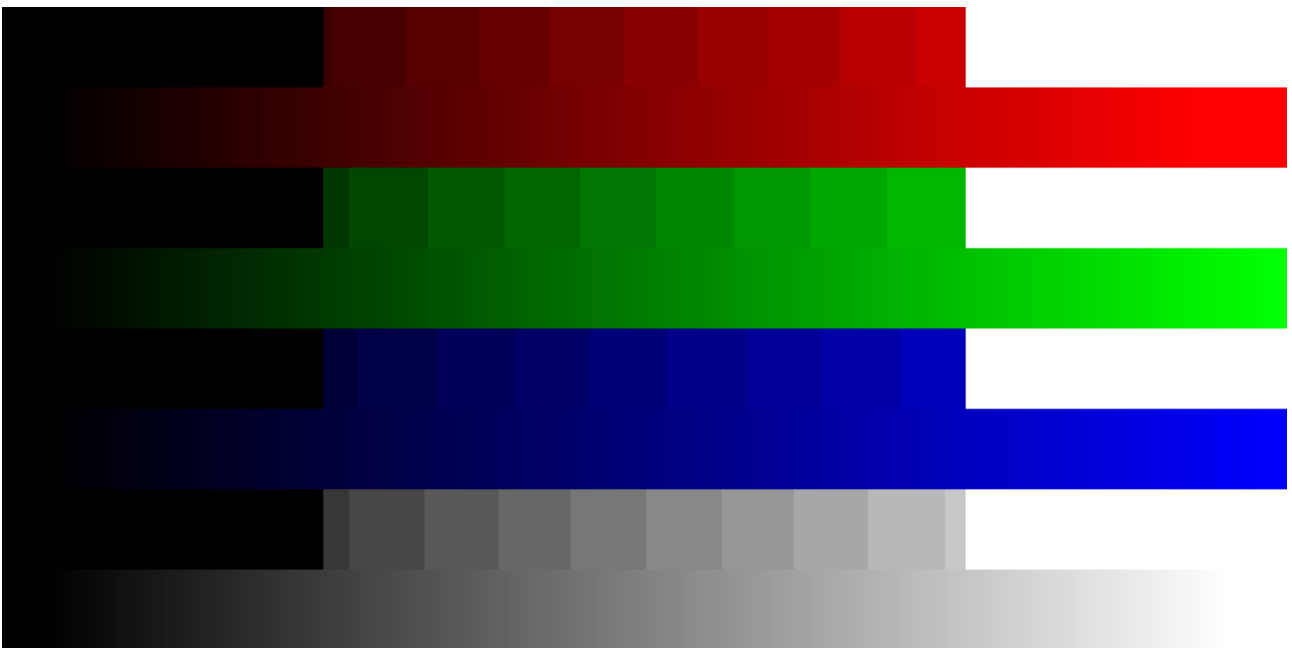
This has to be said right at the beginning: a render has to look good on the monitor. If it doesn't, you did a sloppy job with the lighting. If you save a render and open the image in a graphics application and the histogram shows empty spaces left and right, you should consider working on the lighting and rendering again.

An HDRI is, of course, a high dynamic range image. Bryce can use them for image based lighting and can also export a render as HDRI.

But what does high dynamic range actually mean? There are two aspects to it. One is what everyone thinks, the range of the brightness of lights. Obviously, the sun is brighter than a lamp and still brighter than an unlit room with the blinds down. An hdr image file can accommodate such a high difference of light, but the eye cannot; nor can the monitors or a photographic print. That's where tone mapping comes in to remedy that.

The other aspect is in how many discrete steps the darkest and the brightest parts of an image can be represented. The graphics card of a computer monitor allows for 256 discrete steps between any primary colour red, green and blue or, combined, shades of grey. Of course, that makes 16 million colours, but only 256 brightness shades.

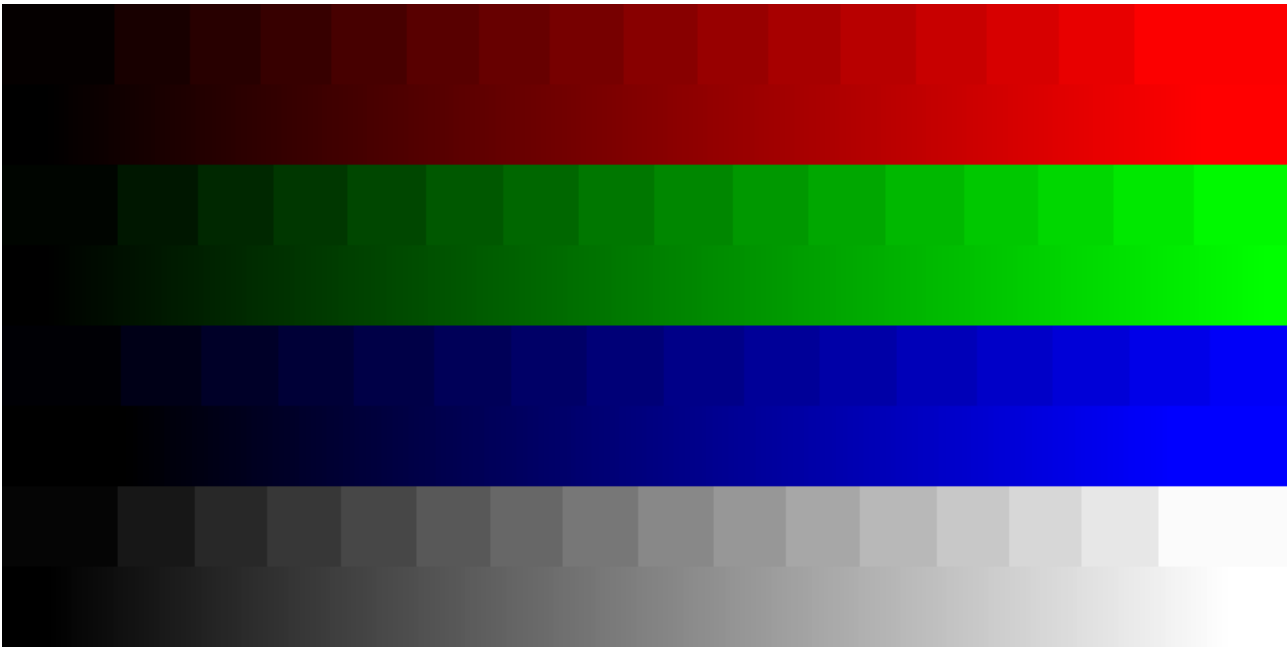
An hdr image file can potentially hold 4 thousand Million discrete steps between black and white. A Bryce render has potentially 65 thousand discrete steps, of which only 256 are displayed.



The picture above represents the limited capability to display dark and bright parts. An HDRI for IBL has the wider range.

The picture below (next page) represents a Bryce render exported as an HDRI. There is not more distance between dark and bright but the discrete steps are much finer than when just saving the render as 24 bit (8 bit per colour) BMP or TIFF file.

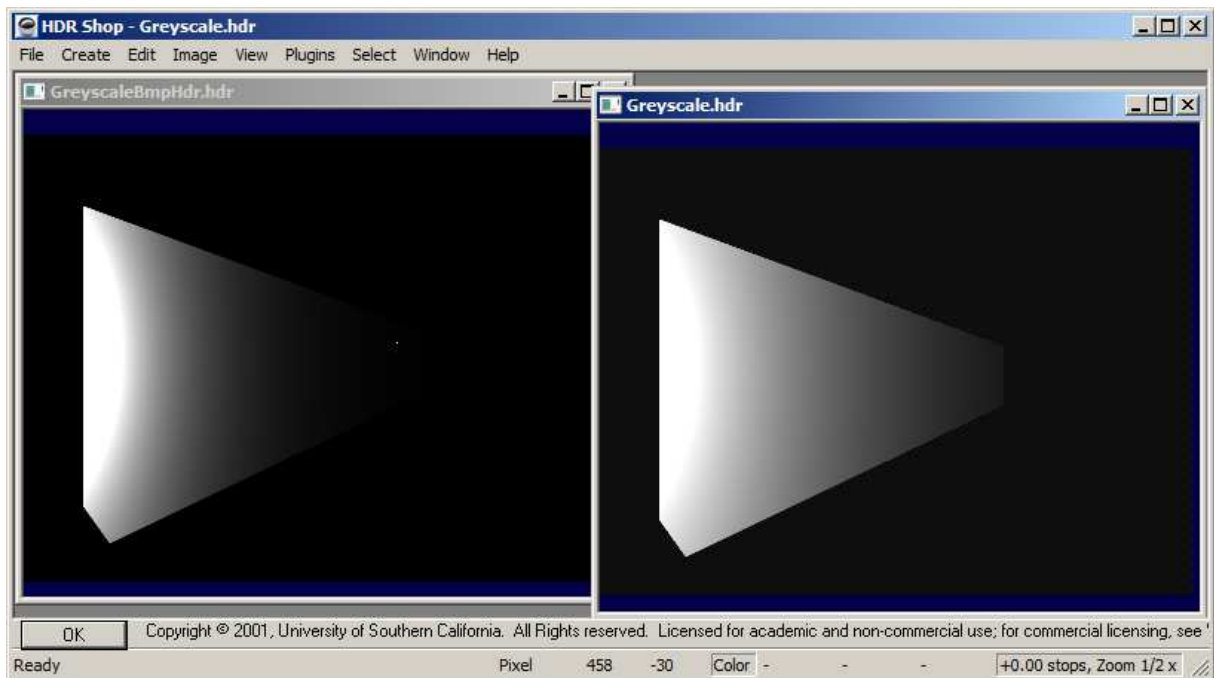
Bryce renders the picture internally with 16 bit per colour, the pixel values are represented as floating point values between 0.000 (black) and 1.000 (white). If the render is saved, this is done with 8 bits per colour, the pixel values are represented as integer values between 0 (black) and 255 (white). However, a render can be exported in the quality it was rendered. This has to be done right after the render finishes.



I know, it's all a bit boring and theoretical and no artwork to enjoy. The simple scene below has a fully black sky, a 2D face with the default material and a square spot with linear falloff lighting it. Note that 48-bit dithering is engaged. I render this and export the image as HDR; I also save the scene normally as BMP.

HDRShop helps us to measure the pixel values. HDRShop, as most HDR capable graphics applications do, applies a linear tone-mapper to the image, which means that the full dynamic range is squashed between the 0 to 255 range of the graphics card.

I load the normally saved BMP and measure the pixel values. At left, the 2D Face is burned out with light, halfway to the right, there is no light left, the value goes to 0. I save this BMP as HDR and load it as HDR. There is no difference in the pixel values.

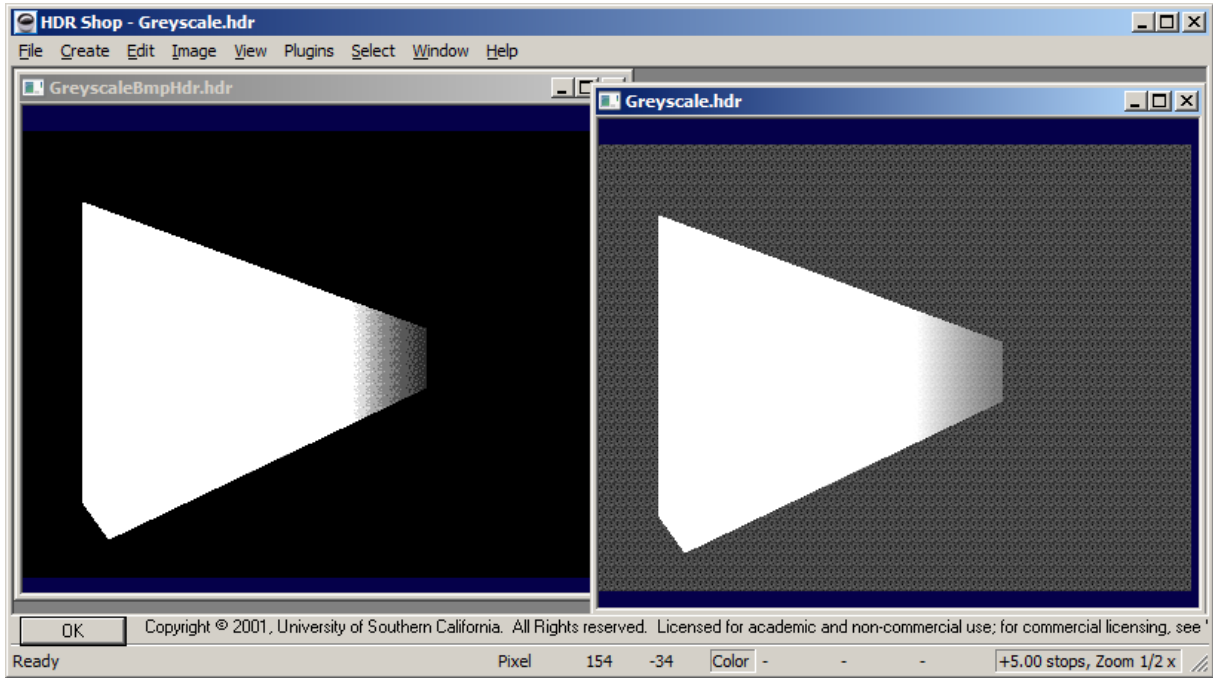


I load the HDR image I exported from Bryce right after the render. The linear tone-mapper already shows the image differently. The burned-out part at left is still burned out, the pixel values at 0.996. Now moving right, we see that the pixel values decrease but do not get to 0. Only the background pixels go to 0.000 but sometimes to 0.003. There is definitely much more information in the HDR

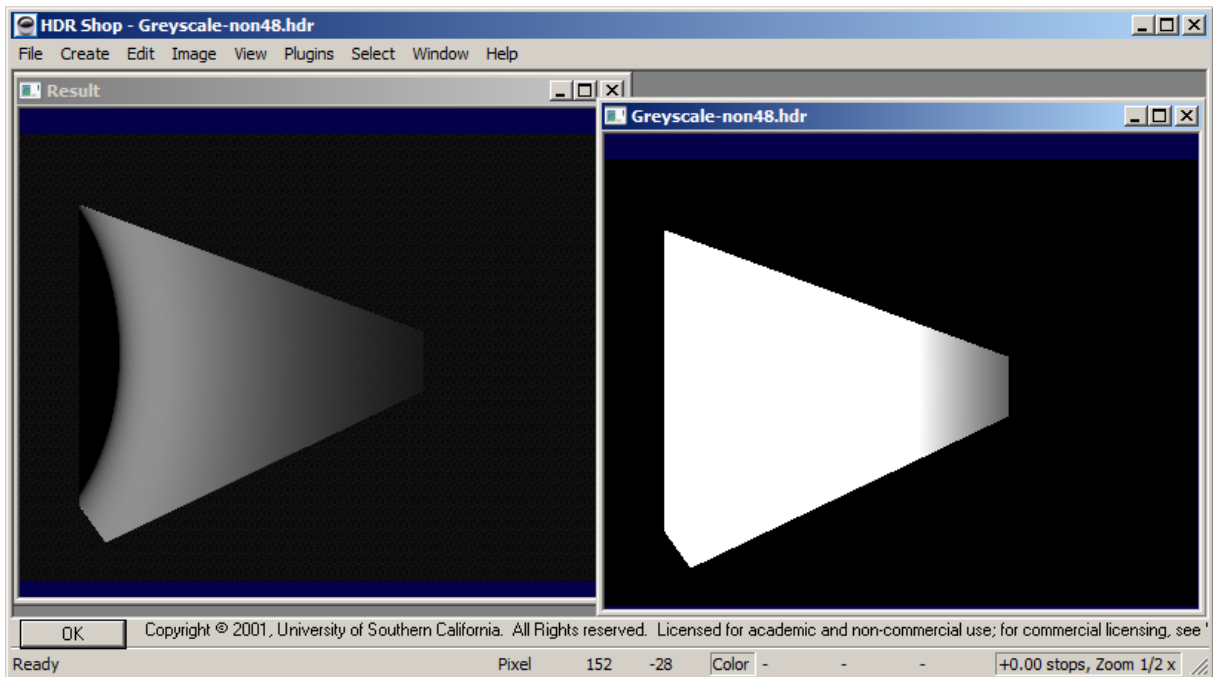
exported render than in the conventionally saved one. We do not gain at the high lights — burned-out stays burned-out, just like an overexposed photograph either taken by a digital camera or an analogue one with film. But we do gain a lot towards the darker parts.

HDRShop permits to change the f-stop (+ and - keys). A full f-stop in photography means either double or half-light. Stepping up the f-stops, we note that the black backdrop is not fully black. The pattern we see at the very dark end of the picture is the result of 48-bit Dithering.

Doing the same with the BMP also shows suddenly noise. Again the result of 48 bit dithering but much less prominent, because the BMP just cannot hold so many dark shades.



At left, +12 f-stops on the BMP converted to HDRI; at right +5 f-stops on the exported HDRI.

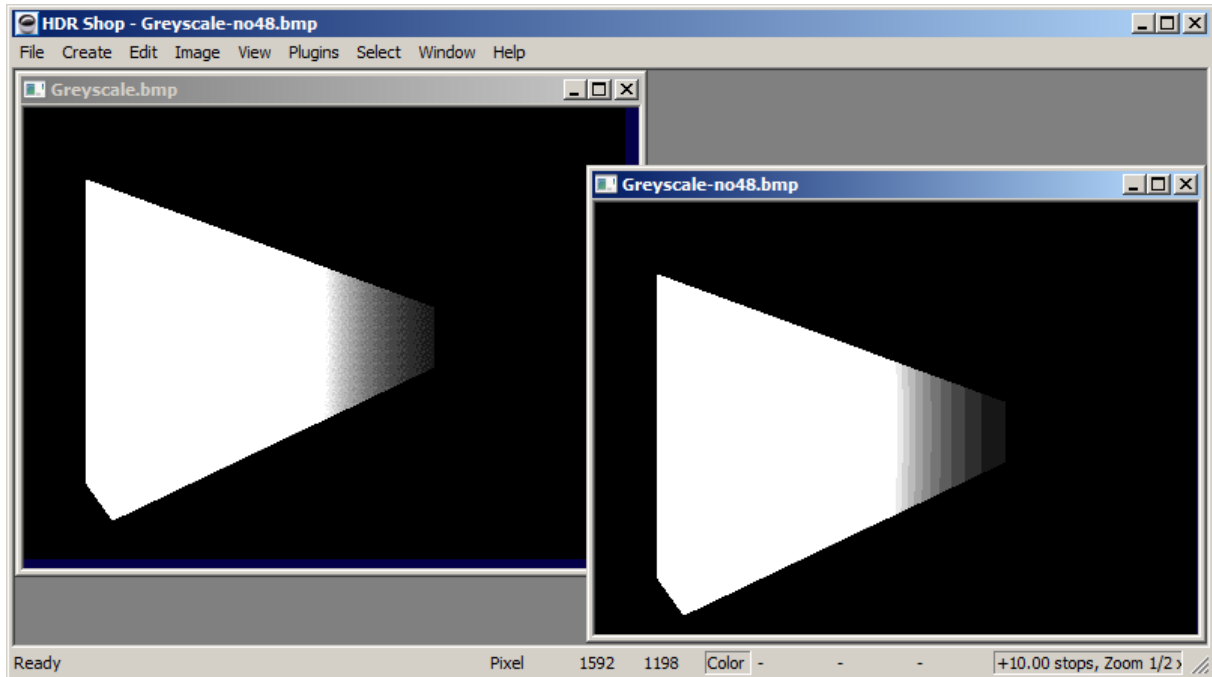


At left the exported HDRI minus the BMP converted to HDRI; at right, rendered without 48 bit dithering, exported as HDRI and shown with +5 f-stops like above at right.

Let's look at a render made without 48 bit Dithering engaged and exported as HDRI. No matter how much the f-stop is increased, the background stays black (above right). Dithering softens the

transition between the intensity steps, if the 48 bit render is saved as 48 bit TIFF or 96 bit HDR1, there is no need for dithering. In fact, dithering is counterproductive and worsens the result.

As far as conventionally saving is concerned, using 48 bit Dithering will give a better result.



The BMP at left has 48 bit Dithering enabled, the one at right has not.

Tone-mapping

Maybe the above arguments have convinced you that exporting a render as HDR1 is worthwhile. But then, it is certainly nice to have a lot of information embedded in an image but what's the use if it cannot be displayed?

Tone-mapping makes the desired information visible. There are local and global tone-mappers. Global ones operate on the whole image. Local ones also take isolated parts into account. Global tone-mapping is easier to handle. There are around 50 tone-mapping operators and none is the best. However, the one Bryce has built in is a very versatile one that gives pleasing results in most cases. You can load a square or a 2:1 aspect ratio image into Bryce IBL, tone-map it and export it as a low dynamic range image LDRI, all from the Sky Lab.

There are free programs that offer HDR1 support. At this time, Picturenaut 3.2 (<http://www.hdrilabs.com/picturenaut/>) is only available for Windows 32 and 64 bit, but work for a Mac version is in progress (halfway done, as the website says).

Luminance HDR 2.3.0 is free (<http://qtpfsgui.sourceforge.net/>) and available for Windows 32 and 64 bit as well as for the 64 bit Mac.

FDR Tools Basic (http://www.fdrtools.com/front_e.php) is free in the Basic version, 32 bit Windows and Mac. The Advanced version is also available as 64 bit for Mac and Windows and comes at 39 Euros.

Another program is Fhotoroom HDR (<http://www.fhotoroom.com/>) previous name Artizen HDR. It is also free (though there are watermarks); the professional edition comes at \$49.95 (probably Canadian dollars). It is only available for Windows.

And of course, Adobe Photoshop can handle HDR1 and has a limited tone-mapper since CS2.

HDRShop has no tone-mapping operators but it accepts the free Banty's Toolkit (<http://www.banterle.com/francesco/toolkit.php>), as Picturenaut does, and it is free.



Let's first have a look at a photographic HDRI with a large range between dark and bright. This HDRI is free and available on my website. Go to Raytracing > Resources > HR-HDRI > Page 1 > Lac Souterrain. I transformed it to the spherical projection and in HDRShop, I can measure the pixel intensities.

On the bottom right the pixel values are displayed. We get over 3000 for red on the bulb of the centre lamp and about 0.005 deep in the cave at right. In fact, this HDRI has a dynamic range far in excess of two Million to one. Above it is linearly tone-mapped. Renders exported from Bryce have the brightest spot at 0.996, say at 1.0. Therefore, this example doesn't interest us much.

Without going into detail at this moment, here is something interesting. At left, the rendered image as BMP converted to HDRI, at right the same render exported as HDRI.



Both pictures were tone-mapped exactly the same, using the Pattanaik operator (after Sumanta Pattanaik), which is based on sensitivities of the rods and cones in the human eye. The one from the BMP at left has more contrast but severe errors on the dark parts, which are rendered white. On the right, it looks correct, though rather desaturated. This example shows again that converting a BMP into a HDRI format is not the same as exporting a render as HDRI.

Since Bryce renders exported as HDRI do not have an excessive brightness range; in fact, not more than an LDRI. What they do have are finer brightness steps within the brightness range. Outright tone-mapping is actually not very helpful because the range can be displayed directly.

What you get by exporting the render as 96 bit HDRI (or 48 bit TIFF) is more information between dark and bright for post-production and image optimising. You can bring out details or emphasize details which would be difficult and fiddly doing in Bryce.



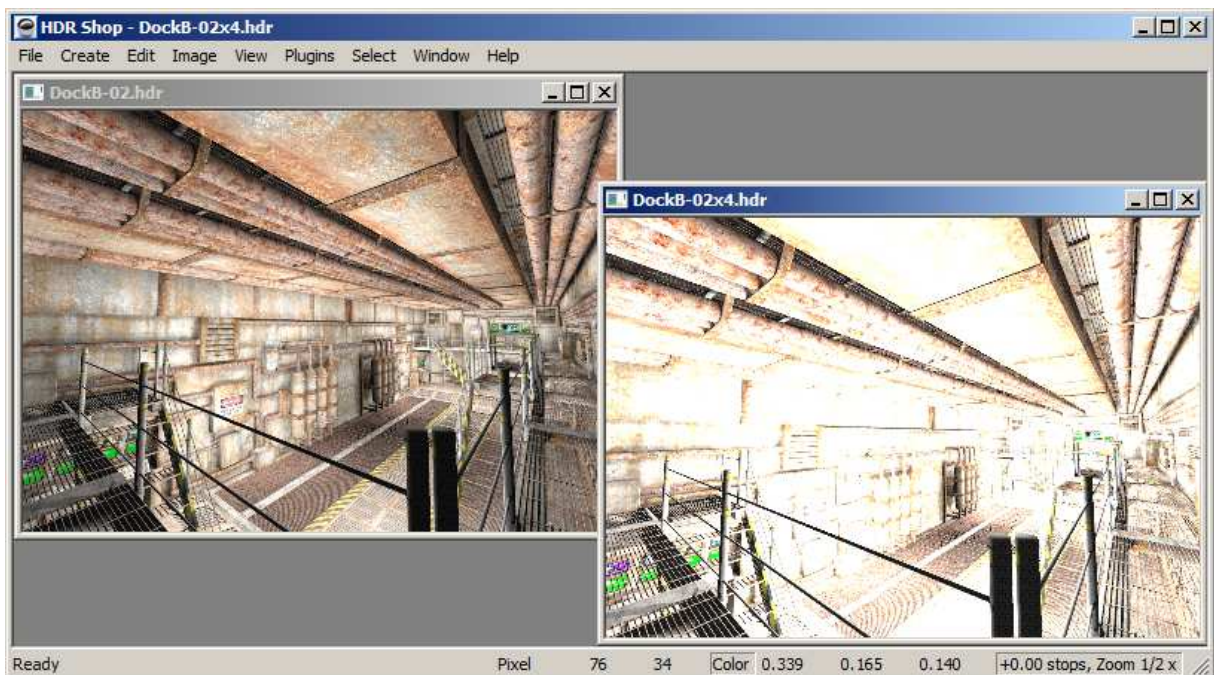
The render above, exported as an HDR, has its lowest value at 0.046 and its highest at 0.980. At left, the BMP; right tone-mapped in Pictuernaut with the Exposure operator with Exposure at -0.2, Offset 0 and Gamma 1.0.

Below left tone-mapped in Luminance HDR with the old Fattal operator; Alpha 0.2, Beta 0.5, Saturation 0.9 and Noise Reduction 0.2, right Dramatic in Artizen HDR 2.9.



These are three examples with the same render to demonstrate some of the possibilities.

If we have an HDR image, we can multiply the pixel values. This will make the result brighter, but it does not change the dynamic range. It is the same as opening the aperture of a camera to let more light hitting the film or sensor. If tone-mapped, both images look the same.



At left, the HDRI as loaded; at right, all pixel values multiplied by 4. If the f-stop is decreased twice, the pictures look the same. If both are tone-mapped and one is subtracted from the other, only black remains.



Above is another tone-mapping experiment. At left, the rendered BMP, at right tone-mapped in Picturenaut using the Adaptive Logarithmic operator with Exposition 0, Bias 0.5, Shadow Luminance -1, Contrast 0.1 and gamma 1.4. The goal here was to make the shadows less deep.



The last example of tone-mapping uses Photoshop CS5. To do this, the HDRI must be converted to LDRI using Mode 32 bit to 8 bit. This opens the dialog. Above at left the rendered BMP, at right the exported HDRI tone-mapped. The example does not look realistic, but the glow effect may be desired.

A tone-mapping operator analyses the complete picture in order to decide how the pixel values have to be manipulated. The pictures below were tone-mapped with exactly the same operator and parameters. The HDRI used for both was LacDesDix. Why is the left one over bright and the right one looks good?



Tone-mapping the light probe in the angular map projection has about a third of the image black. Therefore, the brightness of the rest of the image is boosted. The left picture is the result of tone-mapping the light probe. The angular map was transformed to the spherical projection before the

tone-mapping operator was applied. The result is shown at right. It is important to make sure there are no frames around an HDRI image that is to be tone-mapped.

To wrap up what we have discussed in this video:

- An HDRI used as a light probe for IBL usually has a very wide range between black and white, the range is so wide, that it cannot be displayed;
- Exporting a render as HDRI has a brightness range that can be displayed just like an LDRI, but there are much more brightness steps between black and white and therefore a lot more information than can be directly displayed;
- Rendered images exported as HDRI can be better optimised because they contain much more information; they can also be tone-mapped to make the result dramatically different, if desired;
- Some of the HDRI capable programs that offer some tone-mapping operators are available for the Mac and Windows and are free – though there are others that come at a price;
- Tone-mapping operators analyse the complete picture and determine how the values of the pixels has to be manipulated to give a pleasing result.
- If you intend to save your render as a conventional 8 bit per channel BMP or TIFF, engage 48 bit dithering.
- If you intend to export your render as 16 or 32 bit per channel TIFF, HDR or EXR, disable 48 bit dithering.

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