

# High Dynamic Range Imagery



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## **WHAT IS HIGH DYNAMIC RANGE IMAGERY?**

In short... A high dynamic range image is simply a picture that has a lot of detail in brightness range from deep shadows to bright highlights. Typically these images contain more range than can be captured with traditional photographic techniques.

Typical HDR image files contain from 48 to 96 bits of range per pixel.

(RGB)  $3 \times 16$  bits = 48 bits per pixel. Up to  $3 \times 32$  bits = 96 bits per pixel.

HDR files also contain a much wider color range as well. (Just like real life.)

All HDR file formats have linear response curves and no color profiles.

According to Wikipedia:

“High dynamic range imaging (HDRI for short) is a set of techniques that allow a far greater dynamic range of exposures than normal digital imaging techniques. The intention is to accurately represent the wide range of intensity levels found in real scenes, ranging from direct sunlight to the deepest shadows.”

## **WHAT IS HDRI USED FOR?**

1. Computer Graphics Rendering & Special Effects. Image based Lighting.
2. Tonal Range Control (Tone Mapping) to produce standard pictures.
3. Display on special HDR monitors.

It is important to understand how your client will use the final image in order to deliver the correct end product. Do they intend to use the images for rendering computer generated scenes? Do they just need a tone mapped 24 bit image?

## HOW ARE HDR IMAGES CAPTURED?

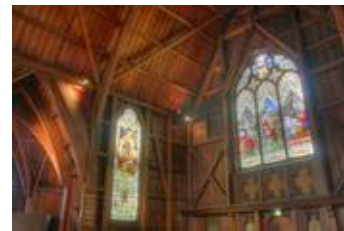
Some cameras such as the Better Light scan backs can already capture fairly wide dynamic range in a single exposure. (Up to about 12 stops.) Many outdoor scenes do not contain more than 10-12 stops of range .

But some scenes such as dark interiors with bright windows showing an outdoor scene do require more than 12 stops of range to capture all of the detail in the shadow areas and highlights. The typical approach to shooting HDR images involves shooting several overlapping exposure brackets and then using special software to combine the exposures into an HDR file.

With traditional SLR type digital cameras typically exposures are shot 2 stops apart. A sequence of 4 to 10 exposures are typically needed. The finished exposures are then combined into an HDR image using special software.



Image Sequence



Tone Mapped Result

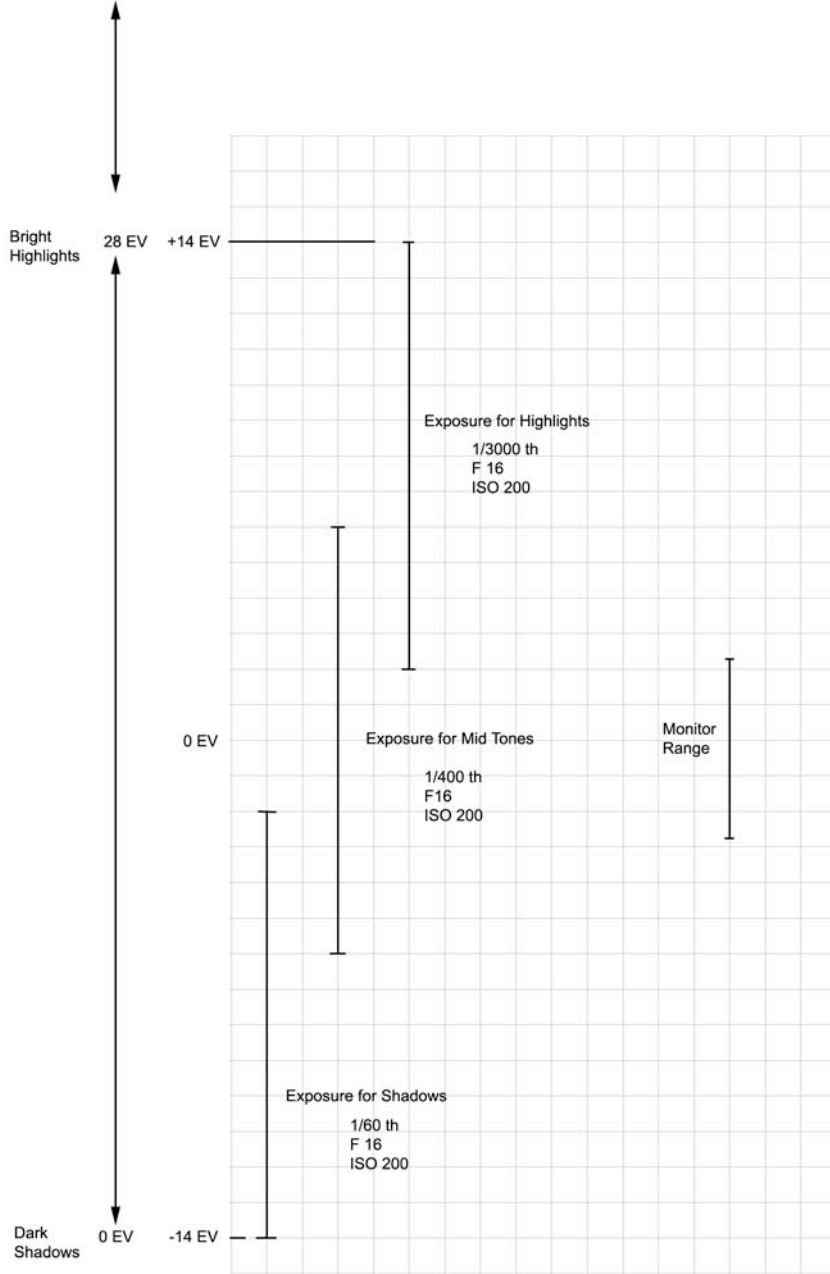
With cameras like the Better Light scan backs and the Panoscan camera images can be shot at wider exposure intervals due to the extended 14 bit range of the camera. Typically the images may be shot 4 stops apart.

NOTE: It is best to have the camera locked down on a tripod for shooting the exposure sequence. Although most HDR compositing software can automatically shift the images into alignment when combining the exposures... This adds time to the process and sometimes leads to errors. Always try to avoid camera movement when shooting the image sequences.



The Sun!  
+ 17 EV

# High Dynamic Range Capture



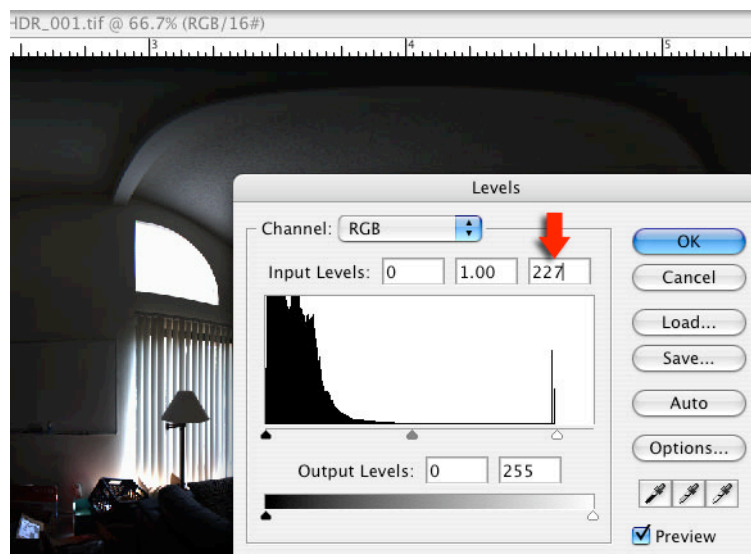
## SPECIAL CONSIDERATIONS FOR BETTER LIGHT CAMERAS

When preparing images for HDR processing there are a few issues that come up. The camera's response curve and bit depth will be important factors to achieve success. Always shoot and retrieve files in 16 bits for HDR work.

Since most digital SLR cameras apply some sort of tonal range curve to the images they produce... Most HDR processing software assumes that the images you shot have a similar curve. Some programs also allow a selection of linear response for the processing as well. (Linear is best for HDR work.) Photoshop CS2's HDR script assumes all images have a non-linear response curve. This means you **MUST** apply a tonal range curve to your exposures prior to stacking HDR exposures with Photoshop CS2. With all other programs you should retrieve your files as linear with no curves applied. Then select linear response when building your HDR files.

One unique factor in combining linear images from a Better Light camera is dealing with the clipping range of the files. All HDR processing programs assume that your linear images will clip at the full 16 bit (65,536). But this is not the case with the 16 bit files from the Better Light camera. The files will clip at significantly lower levels. About 90% of full. **This means that the 16 bit linear files from the Better Light cameras will NOT overlap and range correctly with most HDR processing software unless the files are adjusted first.** Fortunately this is easily corrected with the levels control in Photoshop.

So... Before processing the files with your HDR software you need to open the files up in Photoshop CS2 (Older versions will not work with 16 bit files) to do a level adjust.



Adjust top level to 227

Failure to properly adjust the levels in your files prior to combining them into an HDR file will result in several unsatisfactory artifacts in the finished HDR file. Highlights will not be driven to full white and there will be ugly artifacts in the areas where the exposure ranges overlap. (Basically holes in the histogram.)

Once the files have been ranged to the full 16 bits they can be properly processed by most HDR building applications.

## WHAT SOFTWARE TO USE?

There are several applications that can build HDR files from your images. Some also perform tone mapping as well. Here are a few recommended programs:



Photomatix Pro <http://www.hdrsoft.com>

Photomatix pro is the only application that has been specifically designed to read the meta-data on Better Light TIFF files and automatically range the images correctly. This program is highly recommended. It is available for Macintosh and Windows platforms. Photomatix also has a Tone Mapping function and an HDR Viewer as well. Photomatix supports & creates most popular HDR file formats. The Pro version costs \$99. And there is also a free trial version.



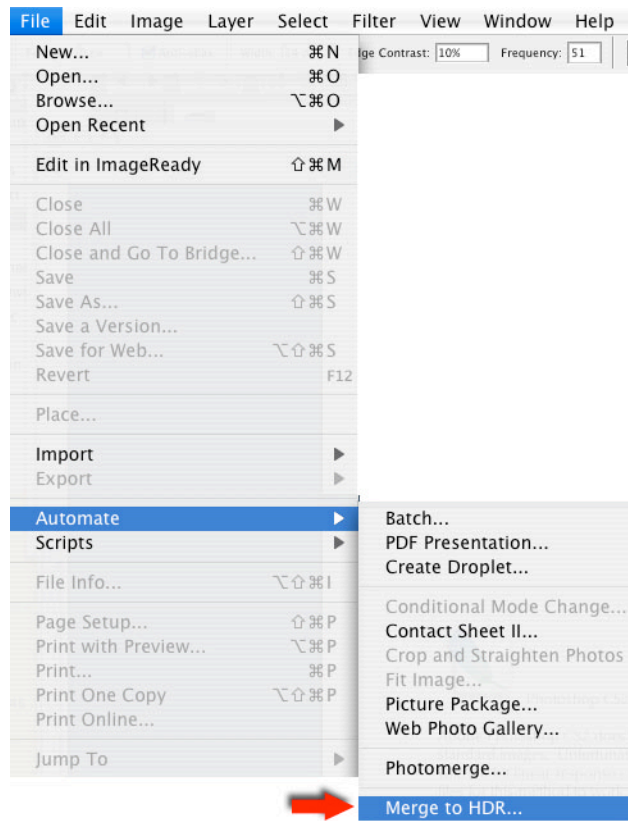
HDR Shop <http://gl.ict.usc.edu/HDRShop>

HDR Shop is probably the most famous program available for building HDR files. HDR shop is also the most capable and comprehensive tool. HDR shop does require that you specify the bracket separation when importing your images. (Example: -4 EV, 0 EV, +4 EV...) HDR Shop is for Windows only. HDR shop can read and save in most HDR formats. HDR shop is available in a Version 1 and Version 2 license. The Version 2 license is \$600. For 24 months. The Version 1 can be used for free on a trial basis.



## Photoshop CS2

Adobe Photoshop CS2 does have an automatic script for creating HDR files from standard images. Unfortunately it does not have a selection for importing images with 16 bit linear response curves so you must apply a gamma curve to your 16 bit files for this method to work.



Once the exposures have been merged into an HDR you can use the exposure slider to adjust the image for retouching and viewing. Photoshop CS2 costs \$649. CS2 is available for Macintosh or Windows. CS2 is invaluable for HDR editing & viewing. CS2 can save in many popular HDR formats.

## POPULAR HDR FILE FORMATS

HDR images require a higher number of bits per color channel than traditional images, both because of the linear encoding and because they need to represent values from  $10^{-4}$  to  $10^8$  (the range of visible luminance values) or more. 16-bit ("half precision") or 32-bit floating point numbers are often used to represent HDR pixels. However, when the appropriate transfer function is used, HDR pixels for some applications can be represented with as few as 10-12 bits for luminance and 8 bits for chrominance without introducing any visible quantization artifacts.

Since the introduction of HDR by Greg Ward several file formats have emerged. Some are uncompressed and can be quite large. Others offer compression schemes that reduce file size but may introduce errors. Here are the most Popular ones:

1. Logluv TIFF is an encoding used for storing high dynamic range imaging data inside a TIFF image. Logluv TIFF's design solves two specific problems: storing high dynamic image data and doing so within a reasonable amount of space. Traditional image format generally stores pixel data in 24 bits, with 8 bits for each color component. This limited the possible colors to subsection of all visible colors. Using a triplet of floats to represent RGB was a viable a solution, but it trippled the size of the file. To solve both of these problems - and a few others, Logluv TIFF uses 15 bits per component to store the pixel, making it 48 bits per pixel. Instead of using RGB, Logluv uses a color space derived from CIE Luv. One of the other drawbacks of 24 bit RGB was the linerization of the colors. This made it difficult to adjust the tonal quality of the color without adjust the color itself. Logluv uses a logarithmic scale to store its components. This made it extremely well suited for handling HDR data.

2. Radiance RGBE was proposed by Greg Ward as a viable format for storing HDR images in 2002. Radiance calculates light values as floating point triplets, one each for red, green and blue. But storing the full data for each pixel (24 bytes) is a burden even for modern systems. Two stages are used to compress the image data. The first scales the three floating point values to share a common 8-bit exponent, taken from the brightest of the three. Each value is then truncated to an 8-bit mantissa (fractional part). The result is four bytes, 32 bits, for each pixel. This results in a 6:1 compression, at the expense of reduced colour fidelity. The second stage performs run length encoding on the 32-bit pixel values. This has a limited impact on the size of most rendered images, but it is fast and simple.



3. OpenEXR is a high dynamic range imaging image file format, released as an open standard along with a set of software tools created by Industrial Light and Magic, released under a Free software license similar to the BSD license. It is notable for supporting 16-bits-per-channel floating point values (half precision), with a sign bit, five bits of exponent, and a ten-bit mantissa. This allows a dynamic range of over thirty stops of exposure, and is directly supported by the Cg programming language. Lossless compression of high dynamic range data is also supported.

4. Photoshop format also supports an HDR format that is uncompressed and retains full dynamic range and color.

#### VIEWING & RETOUCHING HDRI

Once an HDRI file has been created you will need software to open and view the files. It should be mentioned that there are some new display devices coming onto the market that allow images to be displayed with full range. One such device is manufactured by a company called Brightside.

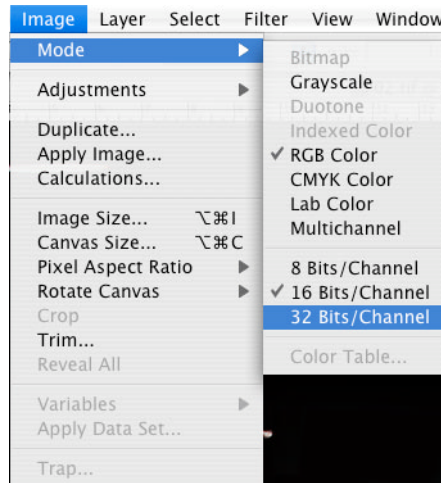


The \$49,000. Brightside Display.

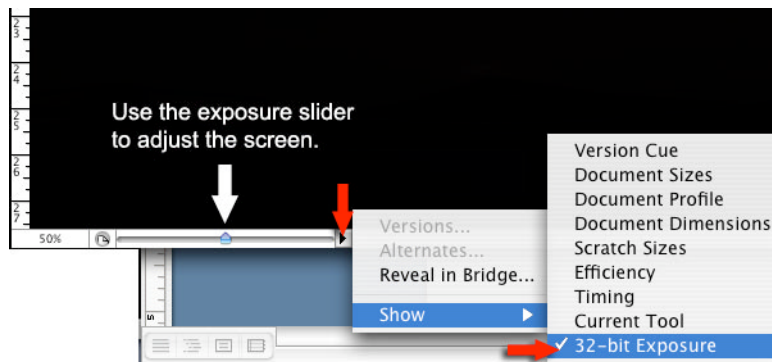
The Brightside display boasts a full 16 bit per color (96 bits) per pixel range with a contrast ratio of 200,000:1. It can produce pixels that range from 0 to 3,000 candela/m<sup>2</sup>. It actually hurts your eyes to look at a picture of the sun displayed on this monitor.

Since not everyone wants or needs a \$49,000. Display to look at HDR images there are ways to use a normal monitor with special software to adjust the monitor to see all of the range in a picture. The free trial version of Photomatix has a very good HDR viewer. However Photoshop CS2 actually lets you EDIT and RETOUCH in HDR with a special exposure slider. Older versions of Photoshop do not handle HDR. Only CS2 has these exposure controls...

To activate the exposure slider in Photoshop CS2 you must convert the image to 32 bits per pixel. (96 bit mode.)



Once the image has been changed to 32 bits per color you may enable the 32 bit exposure slider. This menu slider is located in the lower left corner of the image window as shown.



You may now use the exposure slider to brighten or dim the display window to view the highlights and shadows. Note this control does not alter the image in any way. It only changes the display brightness range. This allows you to see into shadows for editing. Many tools such as the cloning tool does work in this 32 bit per color mode. Some tools & layers may not work in 32 bit mode. Future versions of Photoshop should enable all editing features including layers in this 32 bit per color mode.

## WHO STARTED THIS HDR THING?

According to Wikipedia:

“Gregory Ward is widely considered to be the founder of the file format for high dynamic range imaging. The use of high dynamic range imaging in computer graphics has been pioneered by Paul Debevec. He is considered to be the first person to create computer graphic images using HDRI maps to realistically light and animate CG objects.”

Gregory Ward <http://www.anywhere.com/gward/>

Paul Debevec <http://www.debevec.org>

## LINKS TO MORE INFO

The web is the best way to find out more info... Look up “High Dynamic Range Imaging.” Here are some links I consider important.

<http://www.debevec.org/>

<http://www.debevec.org/Research/HDR/>

<http://www.debevec.org/Research/IBL/>

<http://www.debevec.org/Research/IGI/>

<http://www.debevec.org/Research/LS/>

<http://radsite.lbl.gov/radiance/HOME.html>

[http://www.anywhere.com/gward/papers/REINHARD\\_Flyer.pdf](http://www.anywhere.com/gward/papers/REINHARD_Flyer.pdf)

<http://www.openexr.com/>

[http://www.anywhere.com/gward/hdrenc/hdr\\_encodings.html](http://www.anywhere.com/gward/hdrenc/hdr_encodings.html)

<http://www.cinepaint.org/>

[http://www.kanzelsberger.com/pixel/?page\\_id=12](http://www.kanzelsberger.com/pixel/?page_id=12)