



HDR Images (High Dynamic Range)

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Dynamic Range of Images



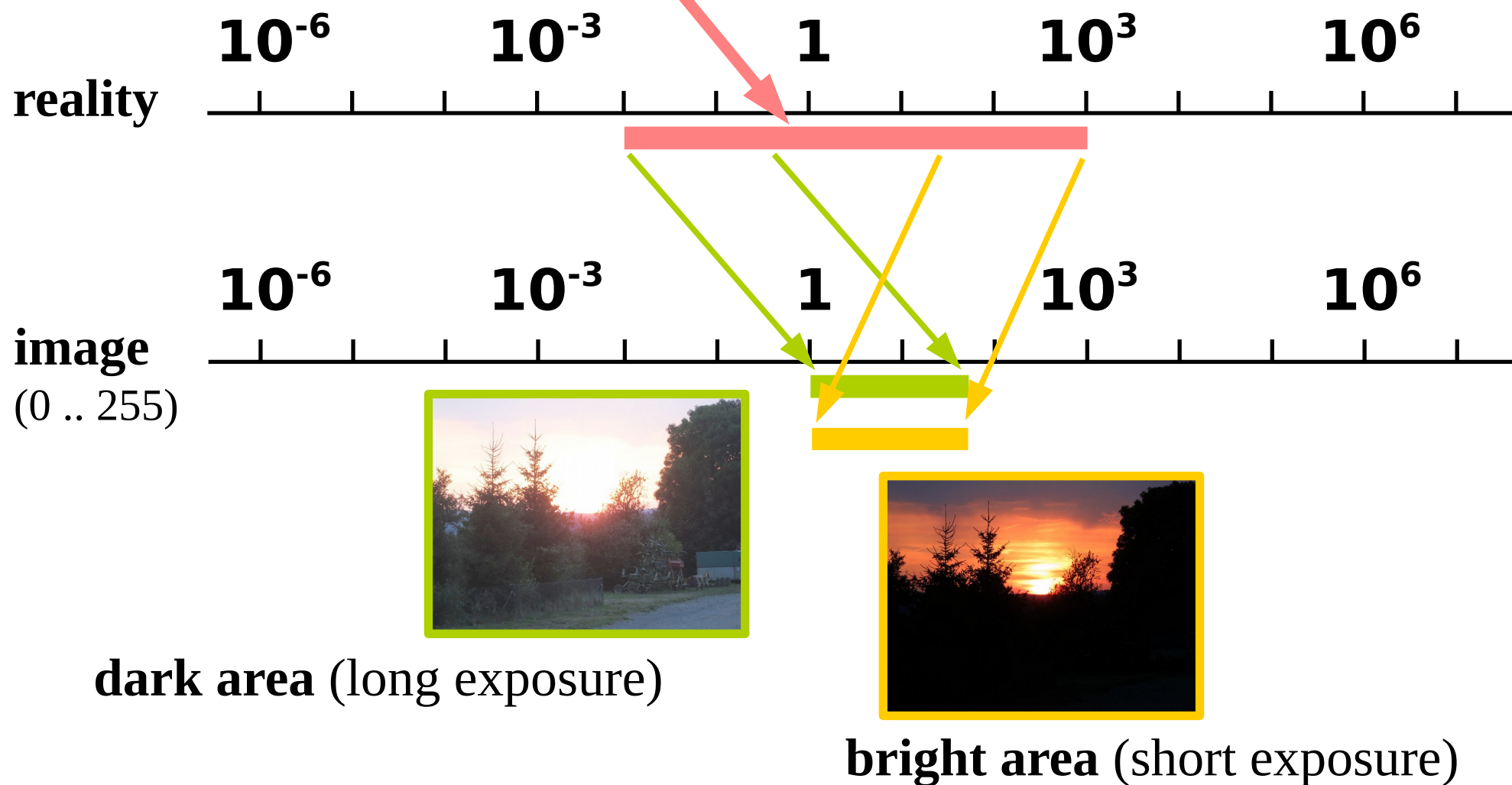
bright part
(short exposure)



dark part
(long exposure)



Dynamic Range of Images





HDR Graphics

◆ High Dynamic Range

- As opposed to Low Dynamic Range – standard images
- Pixels – floating point numbers
- e.g. **float[3]** for RGB (96bpp)

◆ Capture of HDR data

- Synthetic / via computation (rendering)
- Photographic (multi-exposure, specialised cameras)

◆ Display on LDR output devices

- Transfer to reduced range („tone-mapping“)

RGBE Pixel Format (Radiance)

- ✦ Format of **.hdr** files (Radiance)
 - Reduced size (only 4 bytes per pixel)
 - Individual **mantissa** [RGB], shared **exponent** [E]
- ✦ **Mantissa [RGB]**
 - Type **float**, normalised to between $\frac{1}{2}$ a 1
- ✦ **Exponent [E]**
 - Binary exponent in two's complement (8 bit number)
- ✦ Example: [**0.3, 0.02, 0.1**]
= [0.6, 0.04, 0.2] $\cdot 2^{-1} \rightarrow$ [**153, 10, 51, 127**]



Other HDR Formats

◆ **OpenEXR (.exr)**

- Industrial Light & Magic (G. Lucas 1975, Star Wars etc.)
- Completely open, libraries are open source
- Several compression algorithms (ZIP, wavelets), type **half**
- User-extensible pixel format

◆ **Portable Float Map (PFM)**

- Analogous to PPM / PGM / PBM
- Three **float** per pixel
- No compression



HDR Photography

✦ **Multiple exposure**

- Static scene
- Constant aperture, varying exposure time
- Sequence e.g. from **1/1000s** to **2s**
- Built-in „bracketing“ (–2 EV, 0, +2 EV)
- „Super-bracketing“ (e.g. 7 photos in rapid succession)

✦ **Processing a sequence of images to HDR**

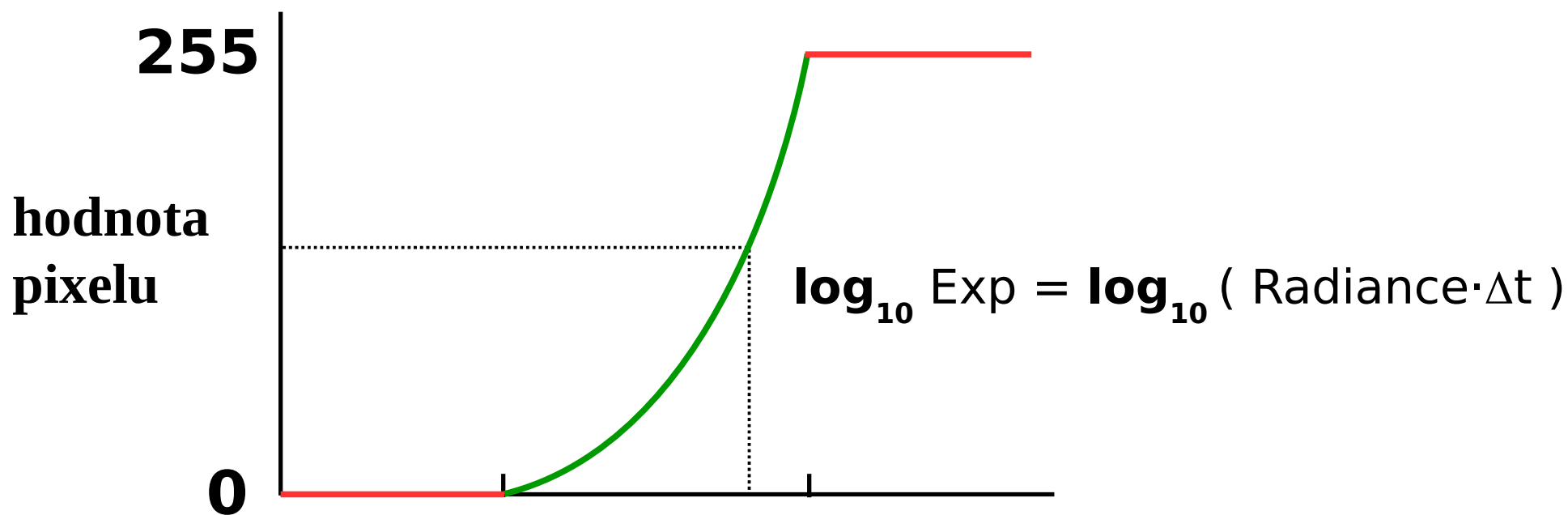
- Conventional photo applications (PhotoShop, GiMP..)
- HDR Shop (<http://www.hdrshop.com/>)
- Functions: auto-calibration, registration



Křivka citlivosti senzoru (CCD)

♦ kvalitativně známá funkce

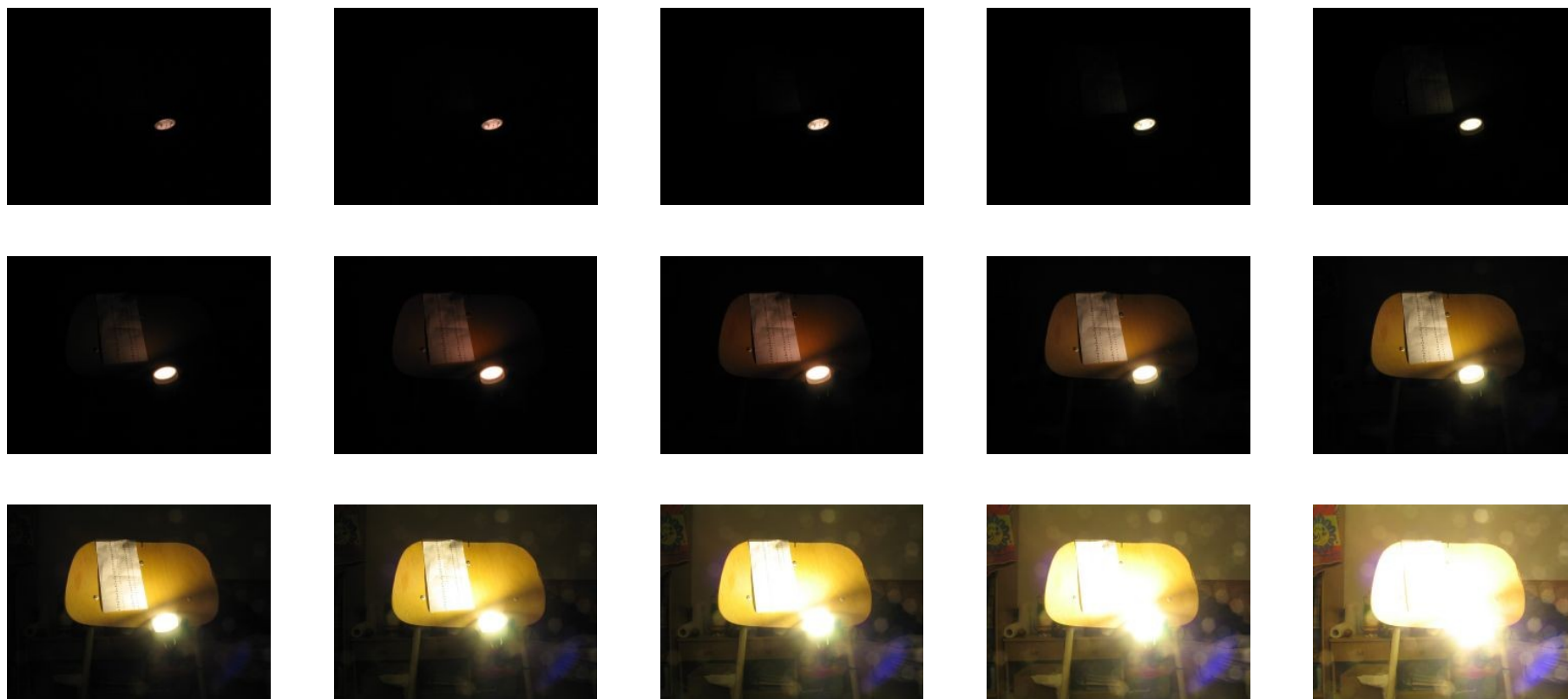
- konkrétní konstanty je třeba nastavit (kalibrace)
- „auto-kalibrace“ při skládání (předpoklad stejné předlohy)





HDR Acquisition Example

- **15 exposures** between 1/2000s and 8s (1 EV steps)
- Assembly: HDR shop





Reproducing HDR Images

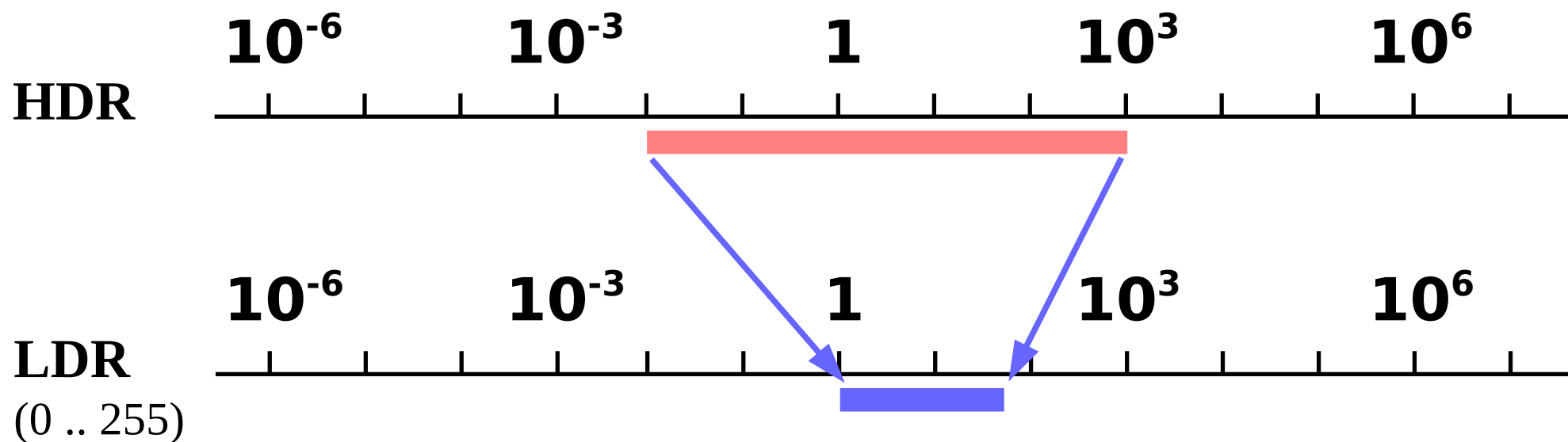
- ◆ Simple trimming of image range
 - Overflow → flare (white or „glare“ effects)
- ◆ „tone mapping“
 - Standard: transformation of entire HDR range to LDR
 - Global vs. local techniques
 - Local contrast preservation etc.





„Tone Mapping“

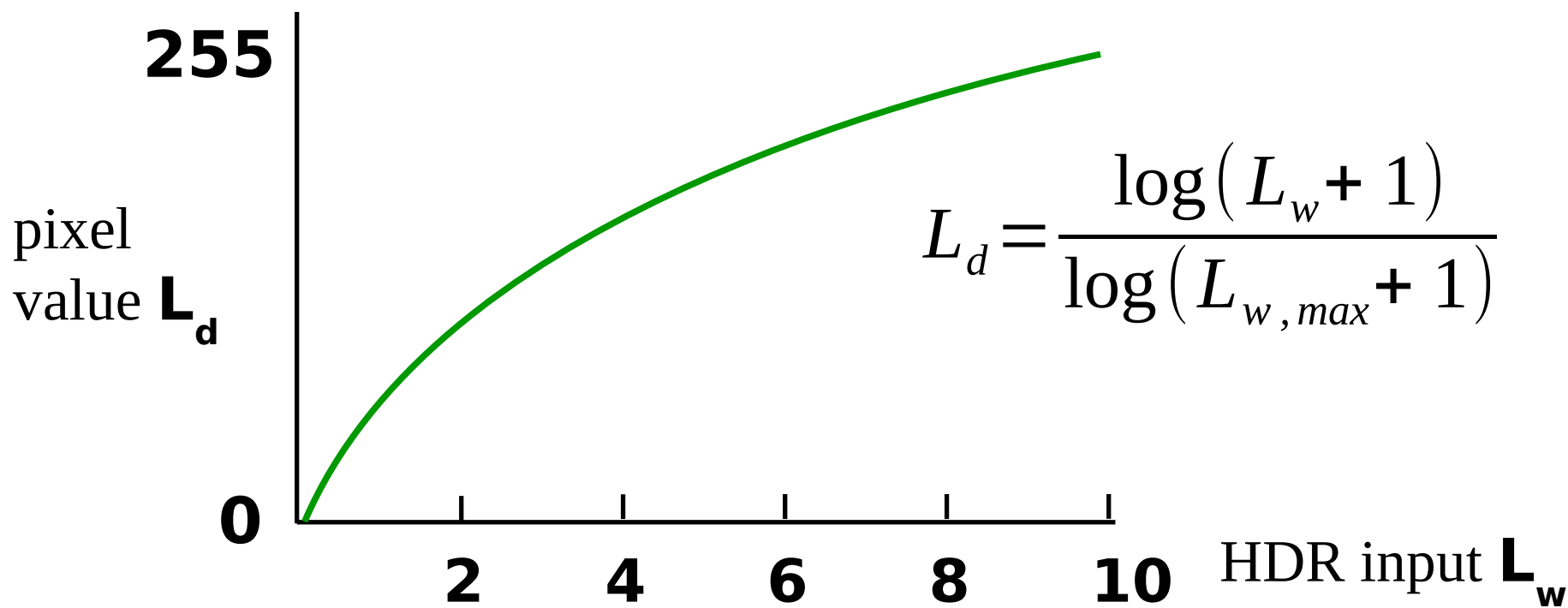
- ◆ Transformation of HDR to LDR
 - Goal: maintaining of contrast & details in dark & light areas
- ◆ **global** vs. **local** conversion





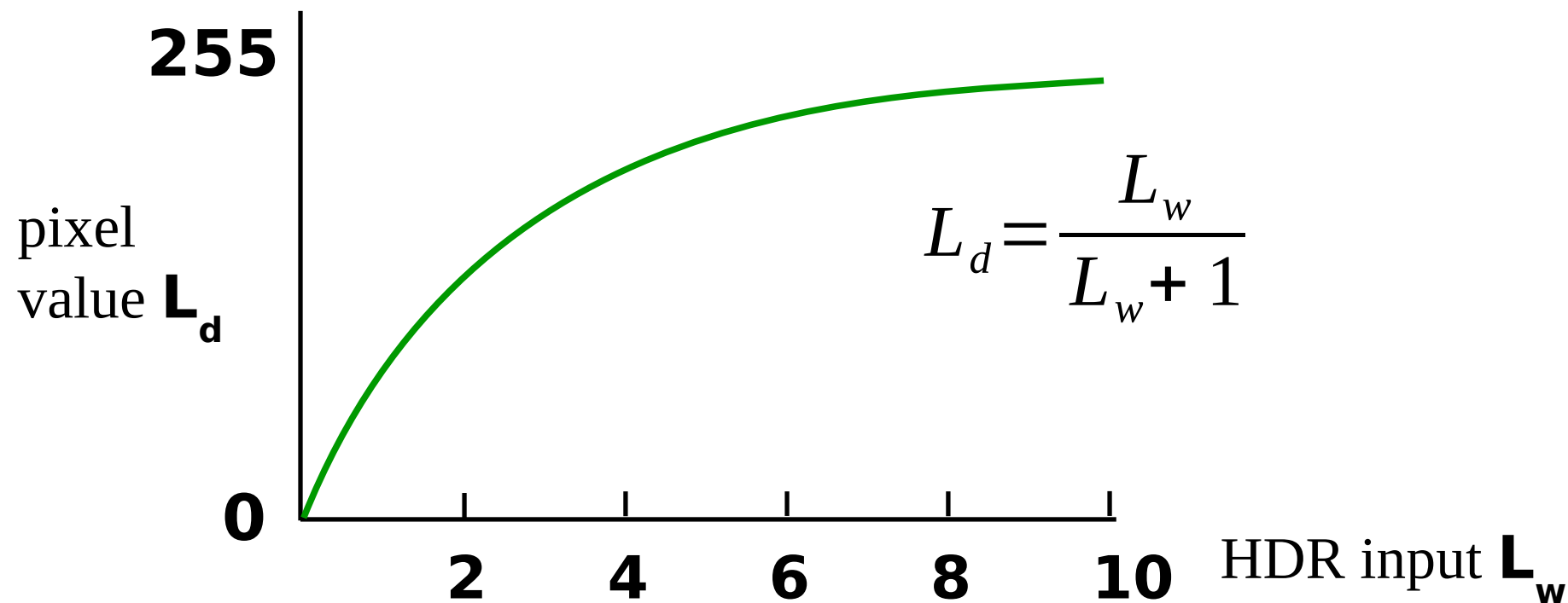
Global Operators

- ◆ **Logarithmic curves, sigmoids, ..**
 - Implemented as LUT and/or GPU shader





Sigmoid





Gamma Compression

◆ Existing mechanism

- Disadvantage: discoloration

$$L_d = L_w^\gamma$$

◆ Gamma compression of intensity

- Colour information is retained
- Intensity is compressed as above



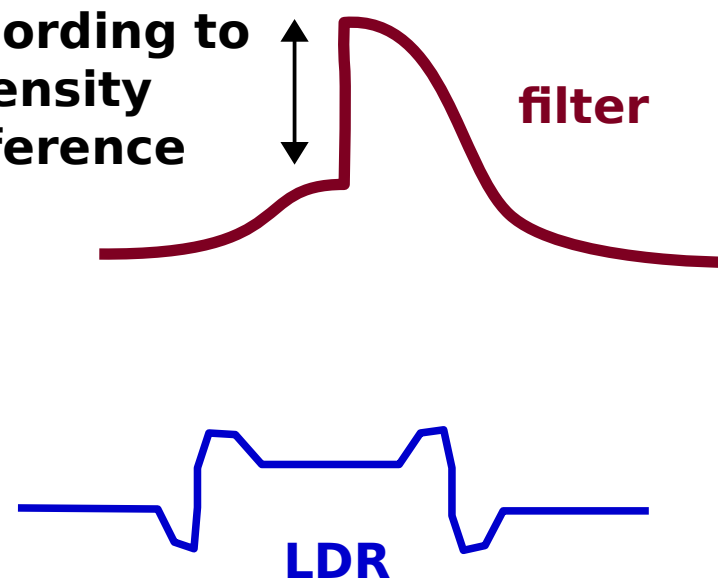
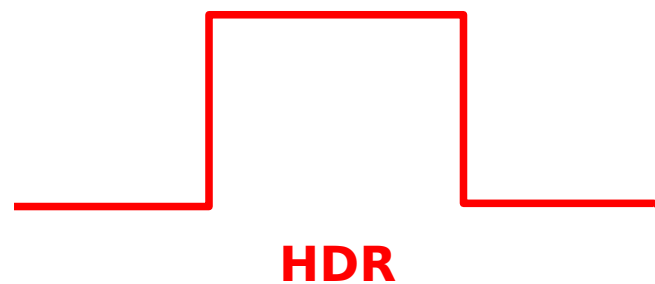
Local Operators

♦ Goal: locally retain contrast

- Edge detection
- Local analysis of brightness

♦ Bilateral filtering (1998+)

- Non-linear filtering





Applications for HDR

◆ Photography

- Improved reproduction of natural scenes
- Powerful „tone mapping“, natural looking results
- HDR panoramas (sun in the frame, sky vs. landscape)

◆ CGI (computer generated images)

- Standard use for „**environment mapping**“ (light maps of the surround)
- All internal results and calculations are „HDR“
- Realistic looking glossy reflections, motion blur, etc.

Examples – „tone mapping“



LDR



Tone-mapped HDR

Examples – „tone mapping“



Examples – „tone mapping“



Examples - „tone mapping“



Example



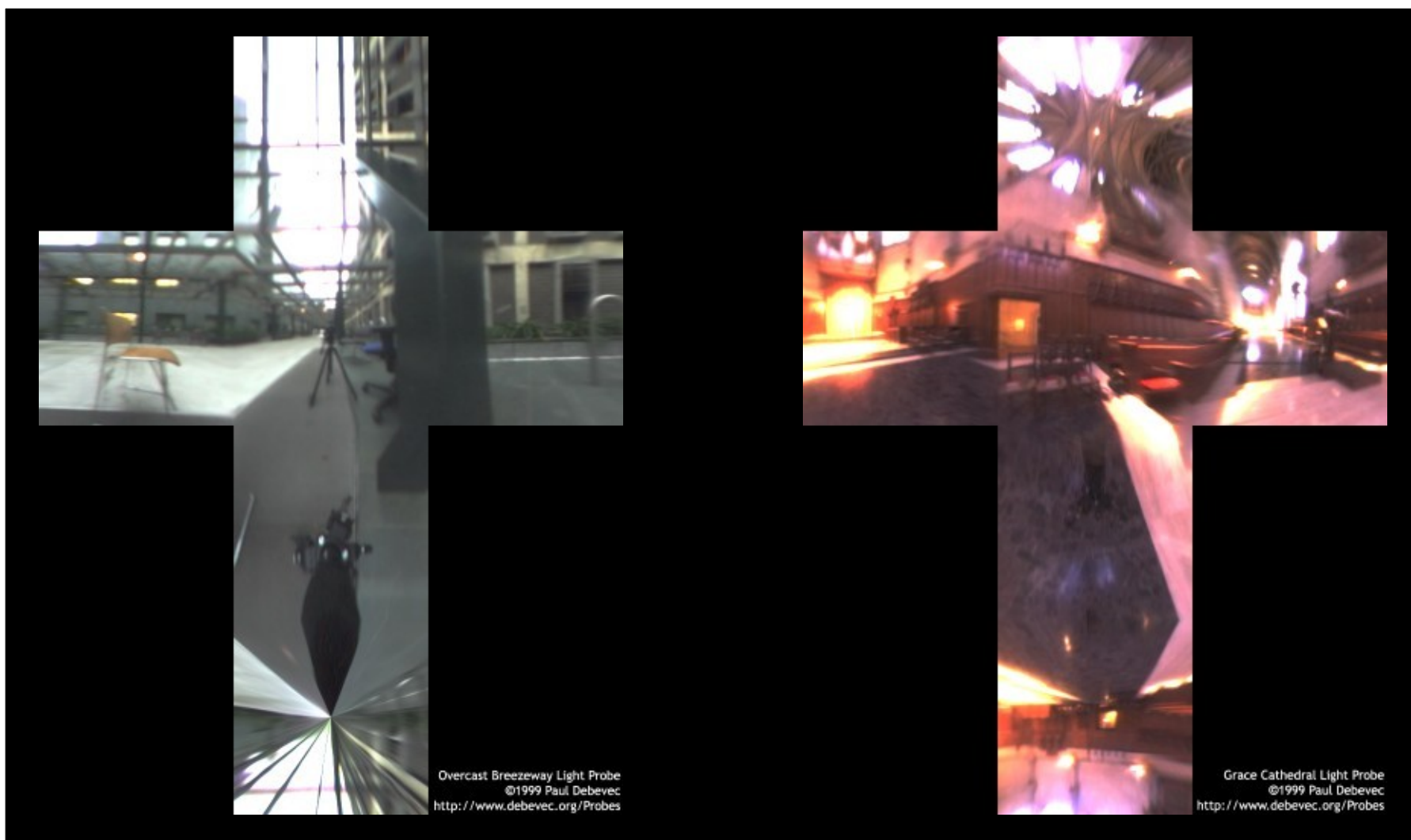
Environment-map (latitude/longitude mapping)

Light Reflection Example





Environment („cube-map“)



End



Further information:

- <http://www.debevec.org/>
- <http://cgg.mff.cuni.cz/~pepca/hdr/>
- <http://www.hdrshop.com/>
- <http://www.mpi-inf.mpg.de/resources/hdr/>