

Determining Lens Vignetting with HDR Techniques

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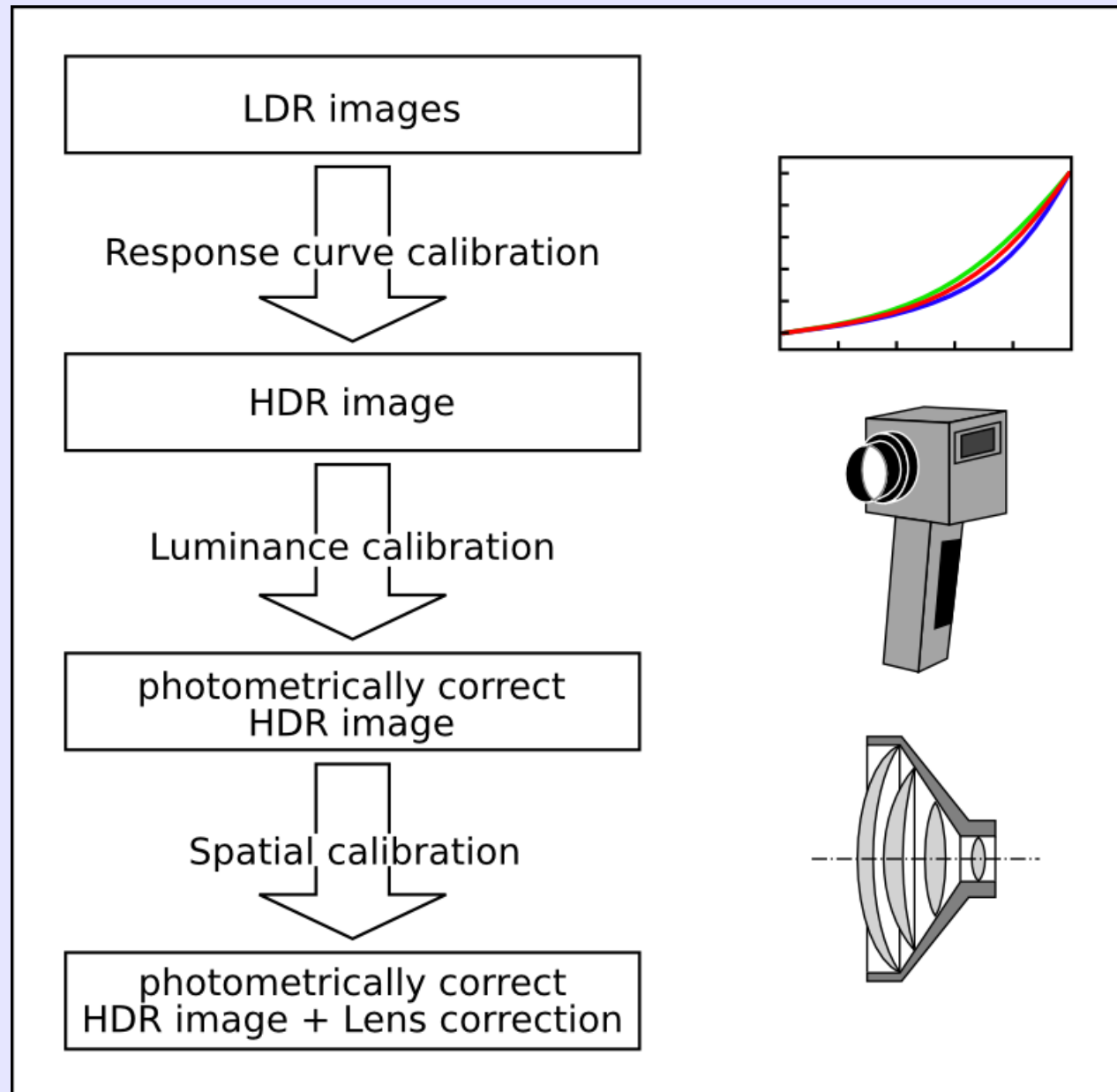
Bulgarian National Lighting Conference
Varna, 10–12 June 2007

Lighting'2007

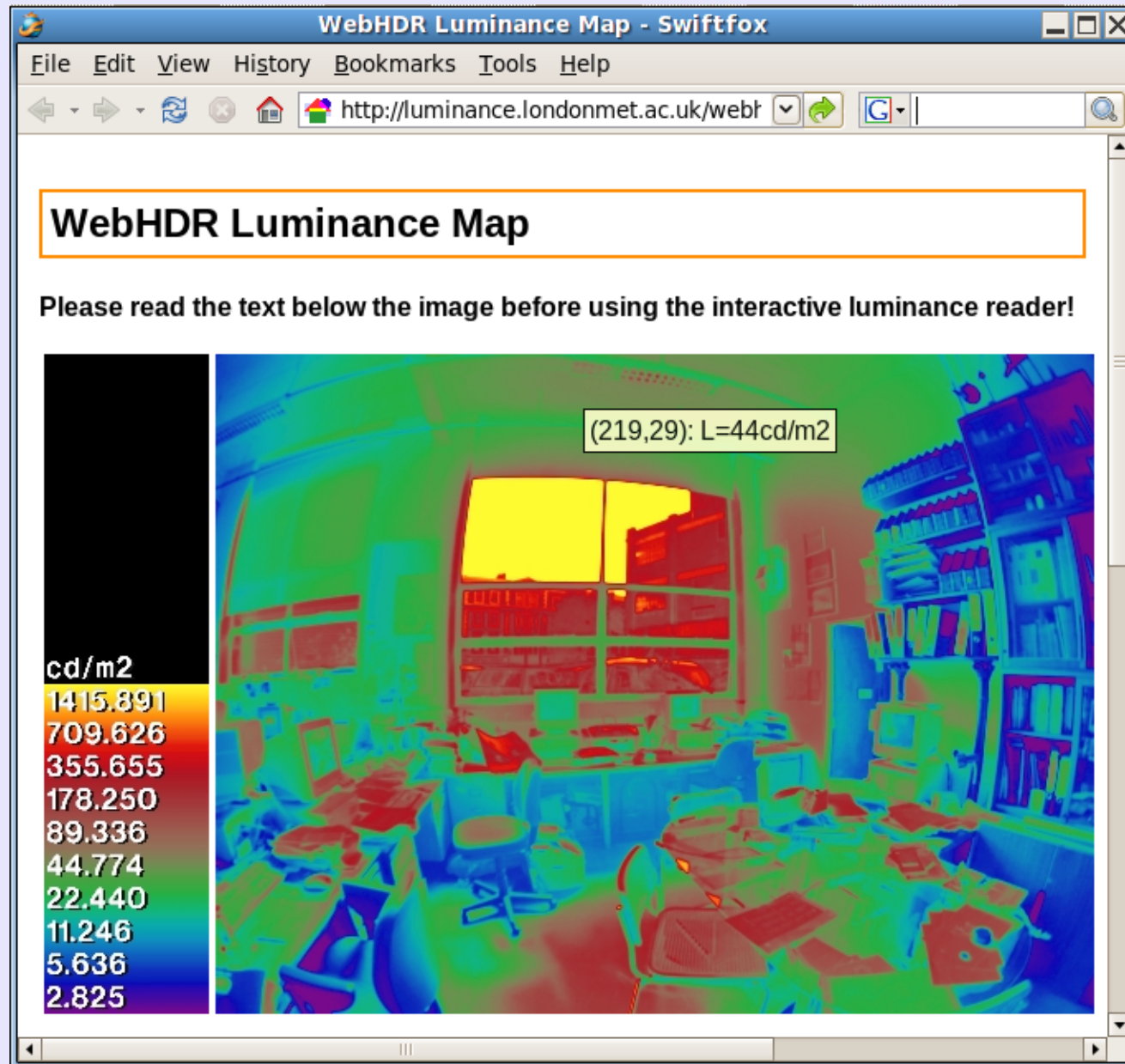
High Dynamic Range Images

- Data is stored in photometric units, i.e. cd/m^2
- Depending on image format, very large dynamic range, e.g. RADIANCE RGBE format: 10^{76} with 1% accuracy
- Inexpensive consumer digital camera can be used to measure luminance distribution
- Image calibration required. More calibration for higher accuracy...

Calibration



HDR Images



Vignetting



Source: wikipedia.org

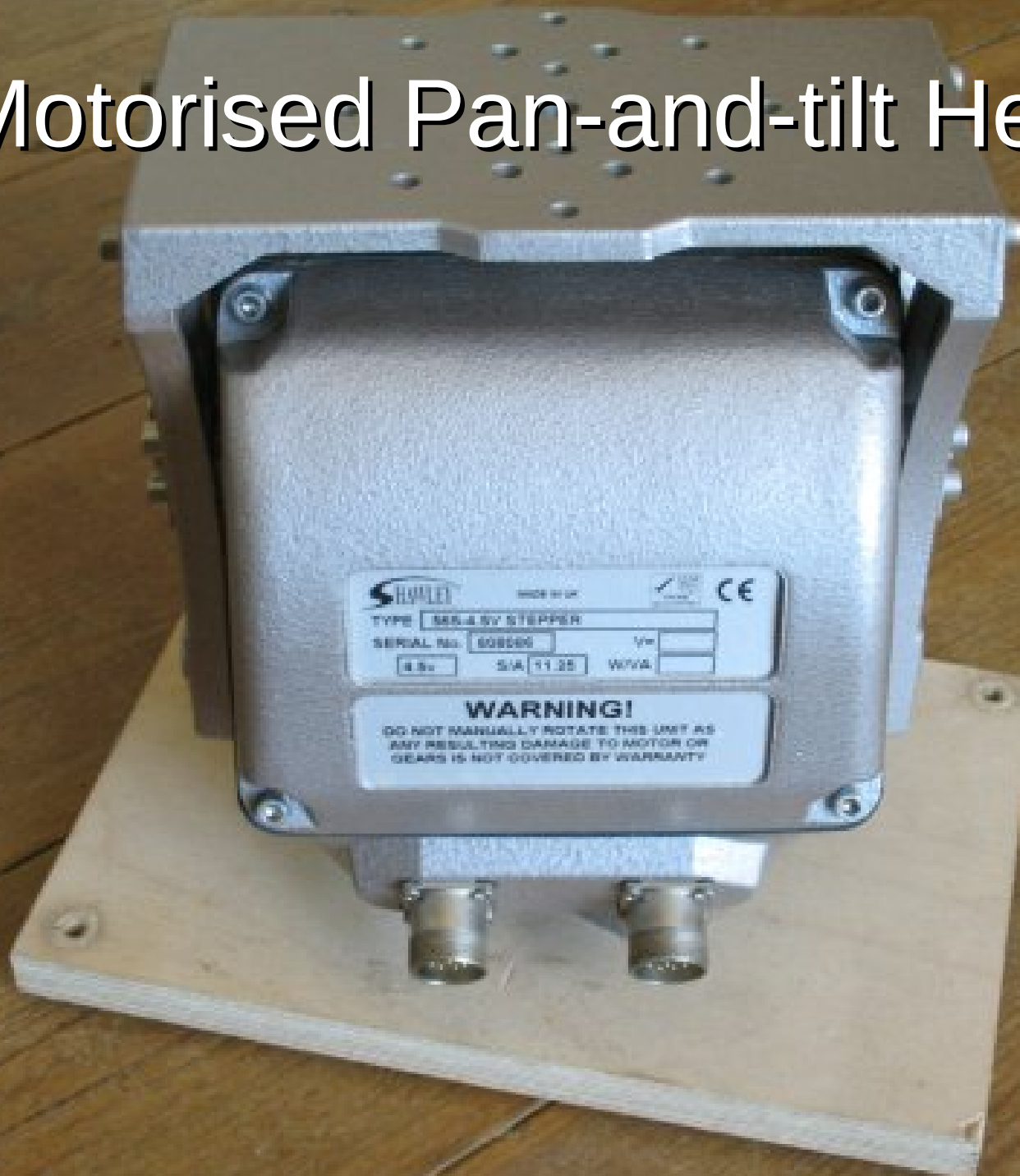
Determining Vignetting

- Difficult to determine
- Option 1: Compute from a series of overlapping photographs
 - inaccurate
- Option 2: Compute from one photograph of an evenly lit wall
 - not suitable for fish-eye lenses, integrating spheres not widely available
- New approach: HDR and Pan-and-tilt head

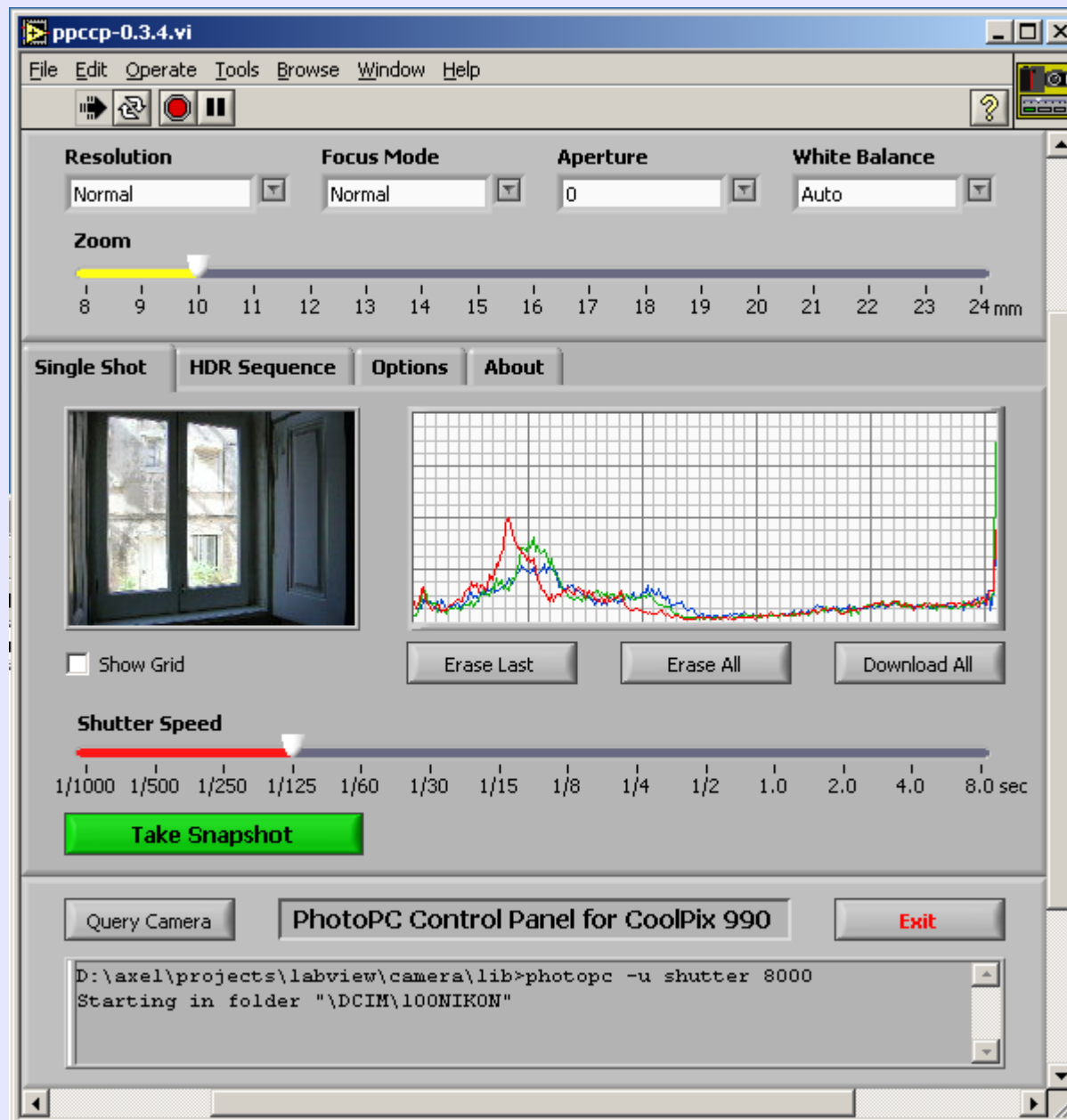
CoolPix 990 with Fish-eye Lens



Motorised Pan-and-tilt Head



Software Control Panel



High-tech Light Source

cd/m²

157.739

62.797

25

9.952

3.962

1.577

0.627

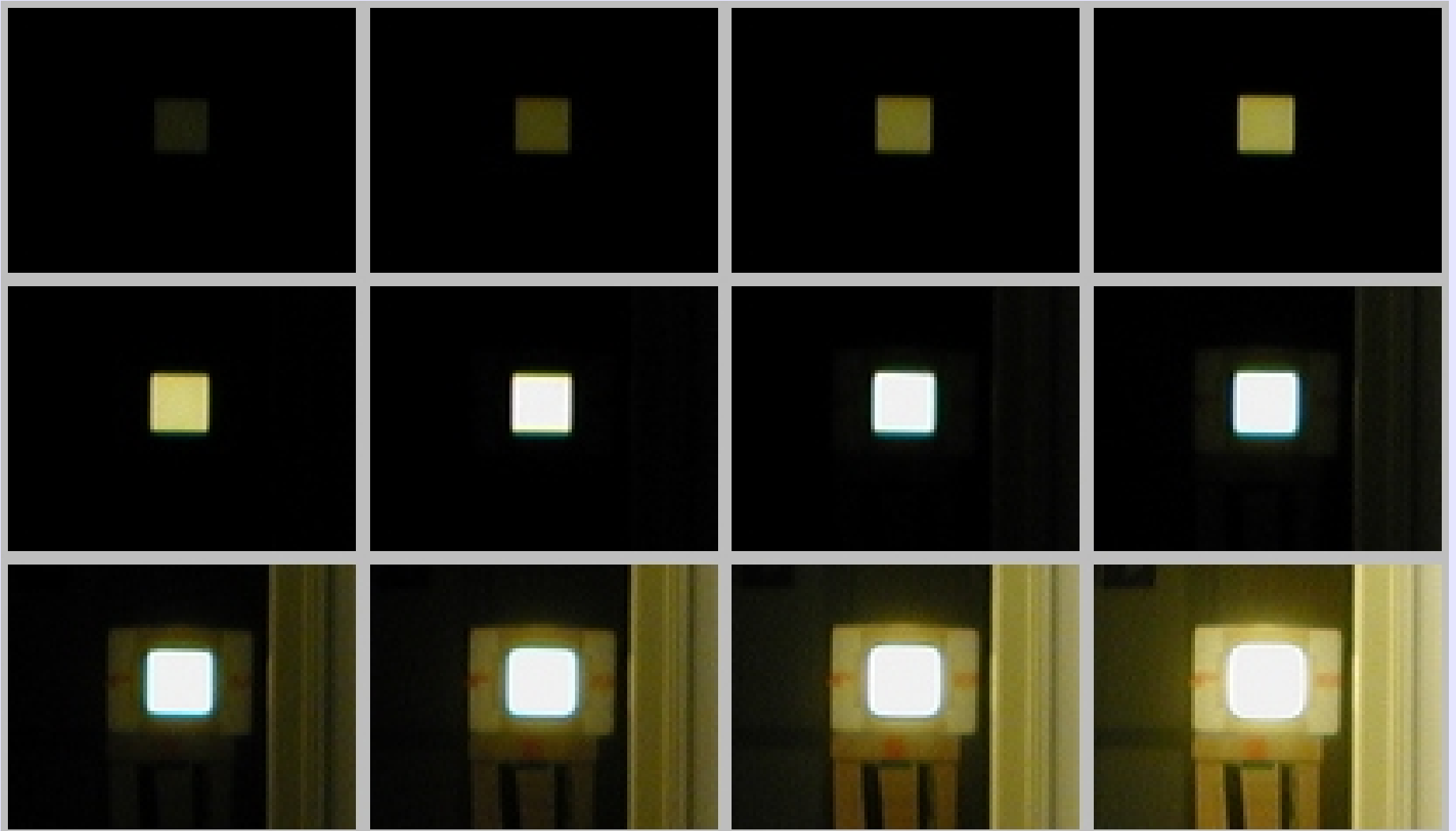
0.25

0.099

0.039



Exposure-bracketed Sequence



Automated Image Capture

- 61 steps corner-to-corner
- Shutter speed from 1/1000 to 2 s (12 exposures)
- Resolution 2048 x 1532 pixels
- Full-frame fish-eye, no black border
- $61 \times 12 = 732$ images
- 750 MB in total
- HDR generation with *hdrgen* and *pfstools* for comparison



Light Source

Photograph



Hot Pixels

HDR Image

False-colour HDR Image

cd/m²

7.079

3.548

1.778

0.891

0.446

0.223

0.112

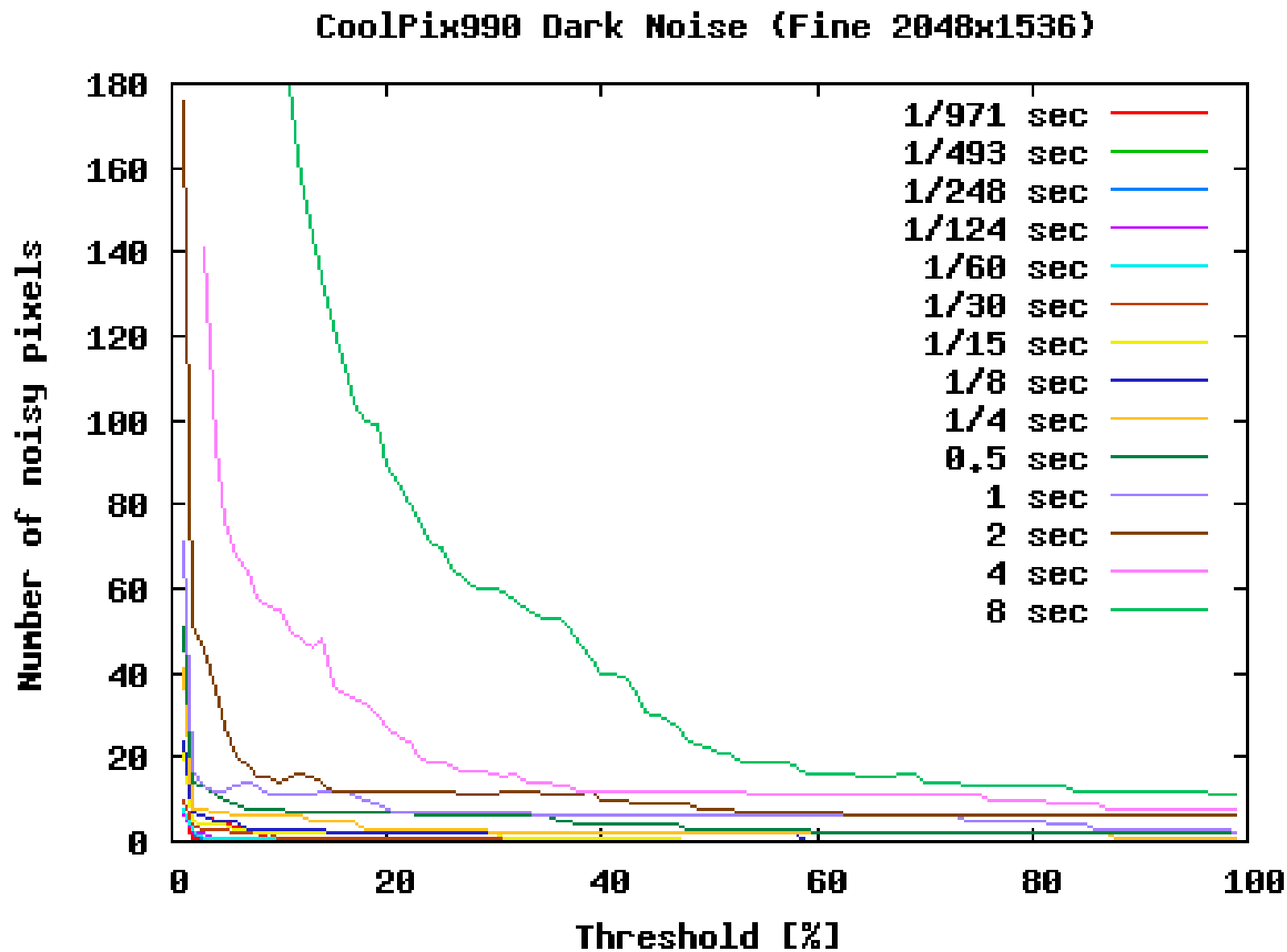
0.056

0.028

0.014



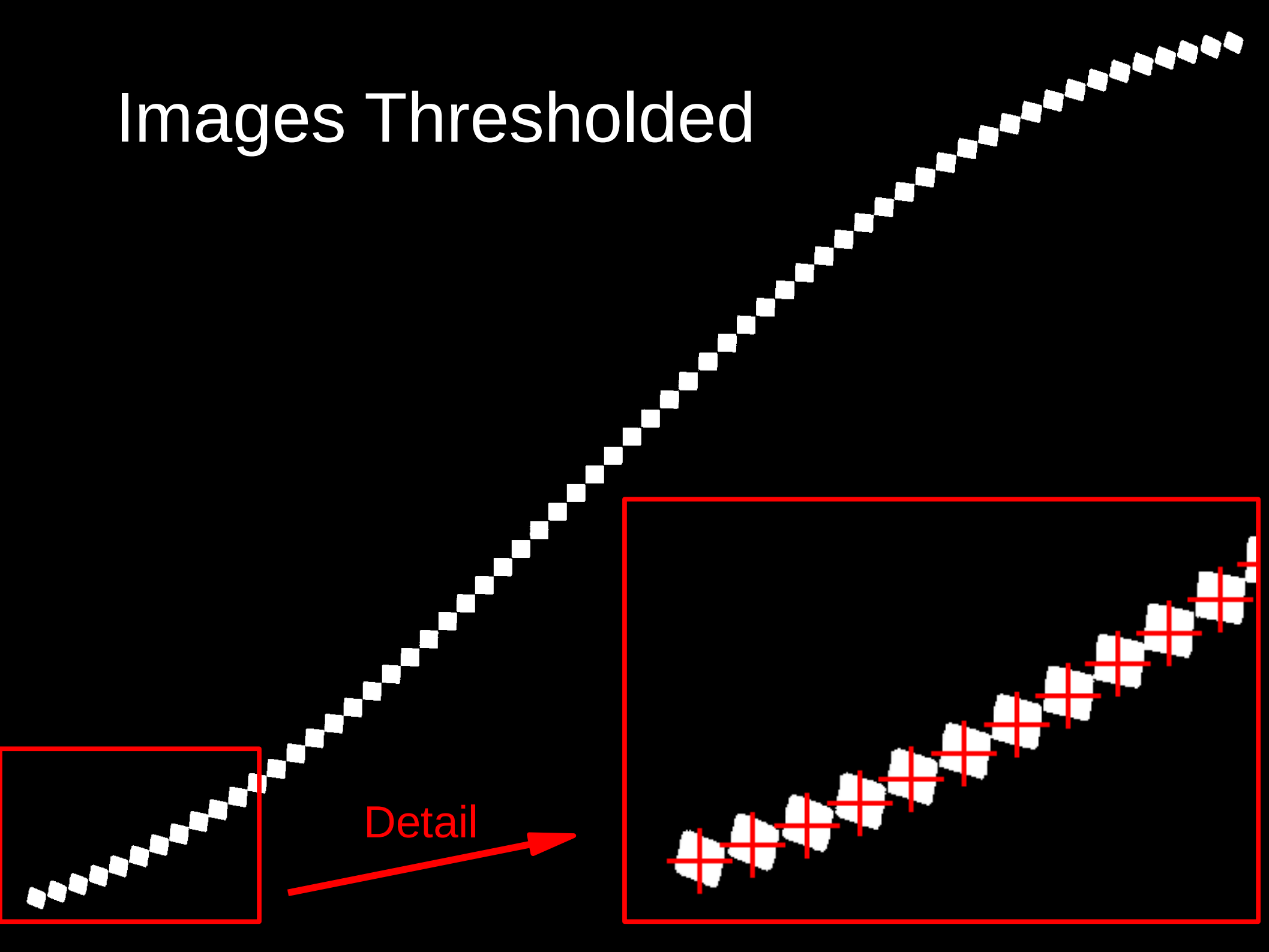
Remove Hot Pixels



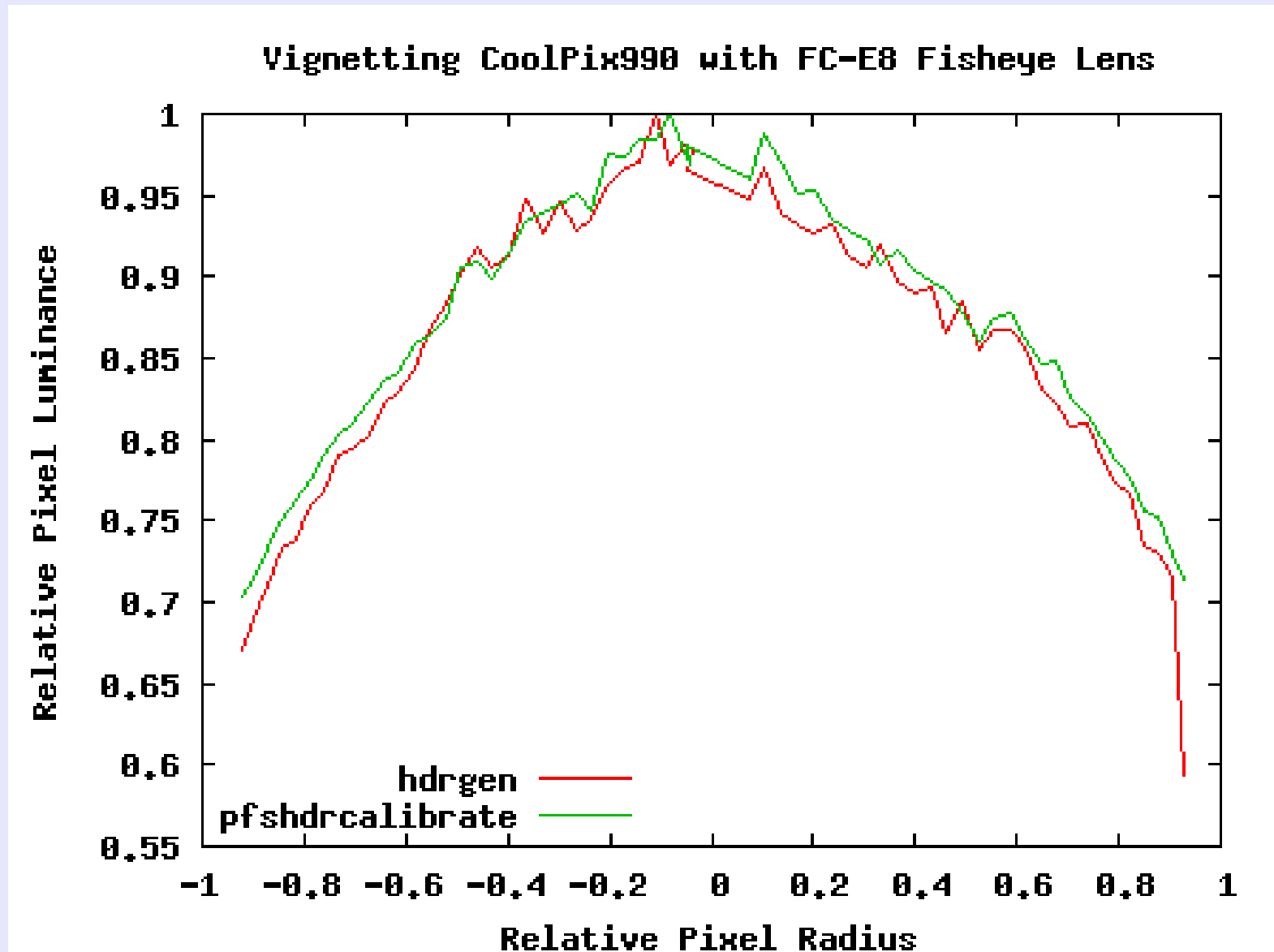
Patch Luminance

- Patches are darker near the corner, brighter at the image centre
- Pixels below a certain threshold set to black so that only light source is left
- Pixels forming the light source are averaged
- Radius assumed zero at image centre, one at corner
- Plot source luminance against radius...

Images Thresholded



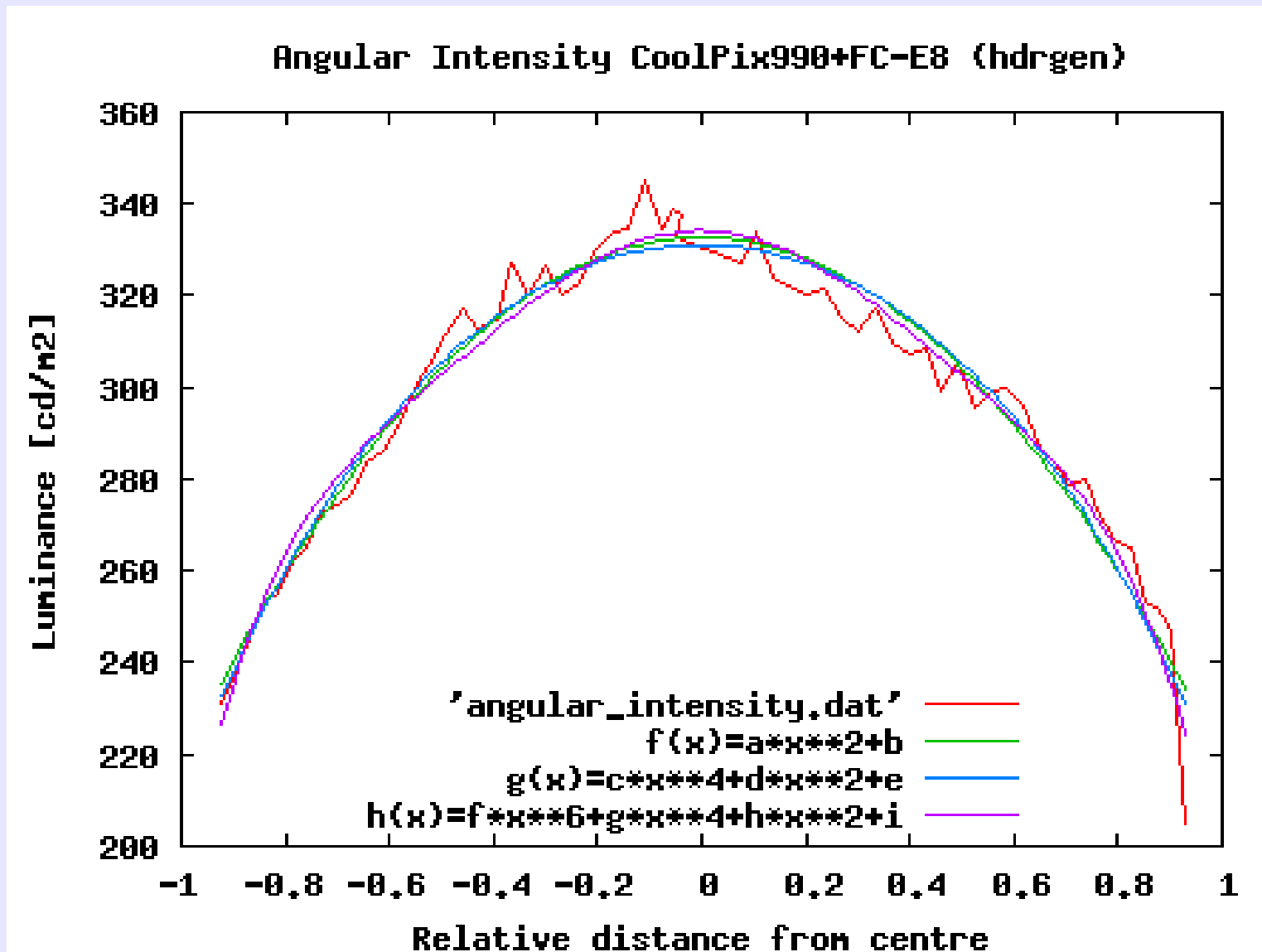
hdrgen vs pfshdrcalibrate



Vignetting

- Vignetting described with polynomial (even order only)
- $f(r) = a + b*r^2 + c*r^4 + d*r^6$
- Results from *hdrgen* and *pfsHDRcalibrate* match
- Additional absolute calibration of image luminance required
- Correction done with RADIANCE's *pcomb* program

Luminance vs Radius



Software

- WebHDR
<http://luminance.londonmet.ac.uk>
- *jpegpixi*
<http://www.zero-based.org/software/jpegpixi/>
- *pfsHDRcalibrate*
<http://www.mpi-inf.mpg.de/resources/hdr/calibration/pfs.html>
- *hdrgen*
<http://www.anywhere.com>
- RADIANCE
<http://radsite.lbl.gov/radiance/>

Thank You