

3-5 September, Loughborough University, UK

# 2018 Radiance International Workshop



## Validation of HDR derived illuminance measurement in a conservation setting

John Mardaljevic

Professor of Building Daylight Modelling  
School of Architecture, Building and Civil Engineering  
Loughborough University, UK

Natural illumination in buildings  
is characterised by huge  
**spatial** and **temporal**  
variation



Simulation of daylight exposure

**Point in time**

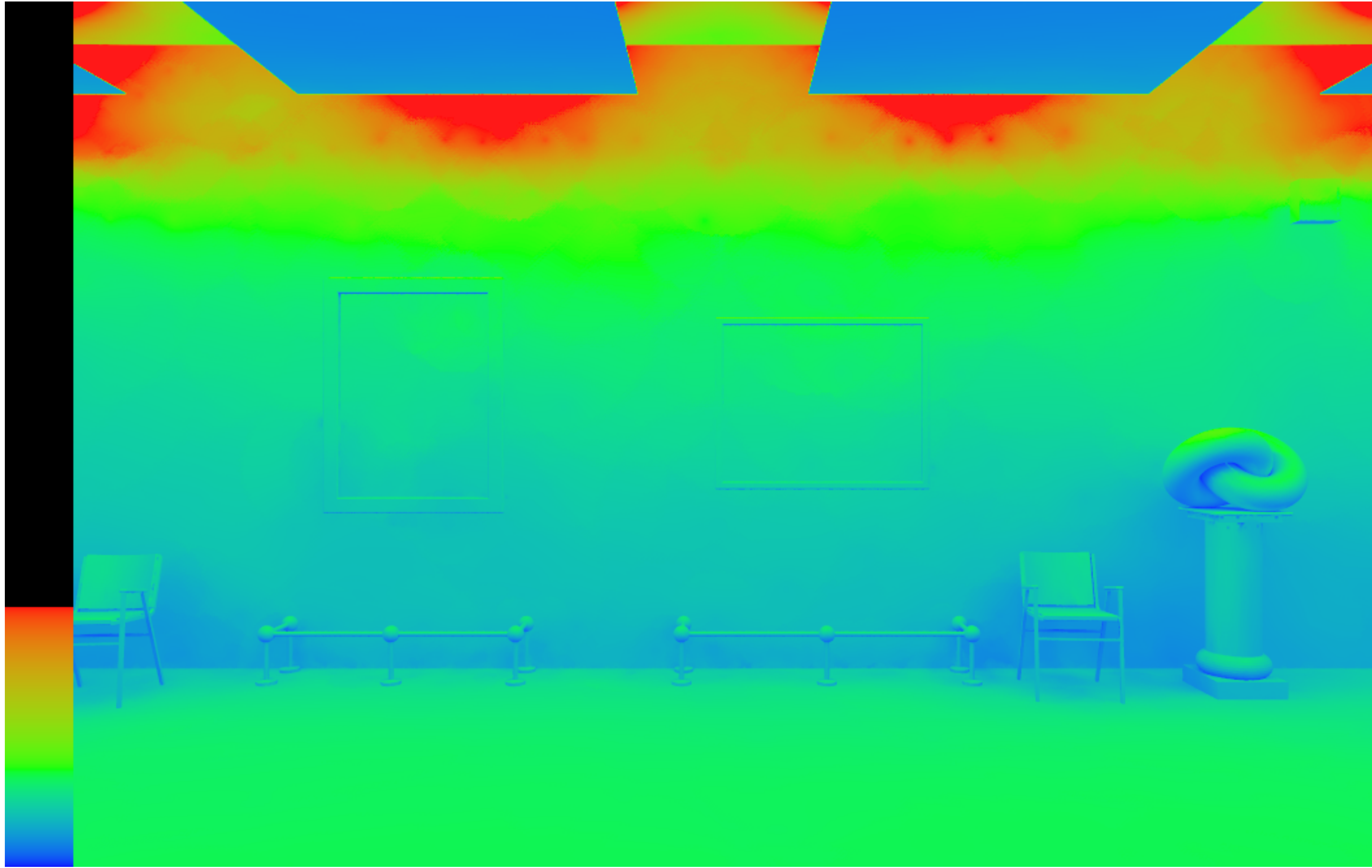
1992



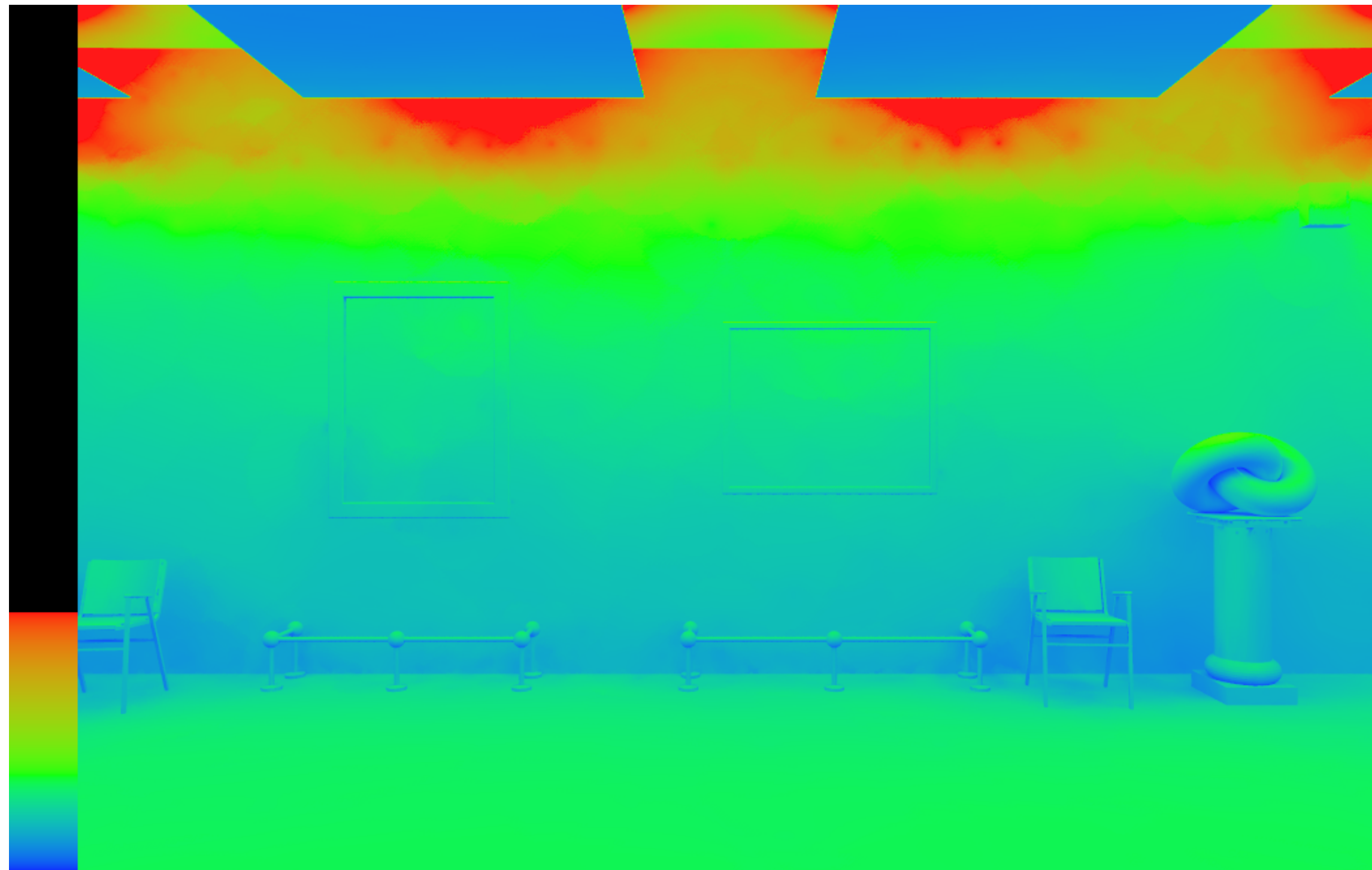
ection  
<<<



Lux  
450  
350  
250  
150  
50



Illuminance [lux]



Luminance [cd/m<sup>2</sup>]



First need to compute the light falling **onto** surfaces before we can compute the brightness of those surfaces



Simulating the long-term exposure of  
an art work to daylight

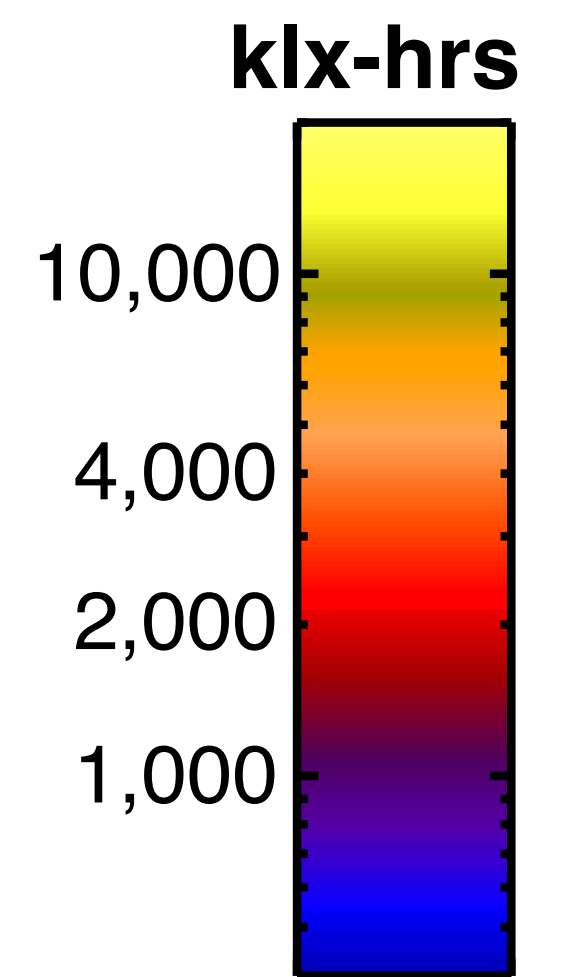
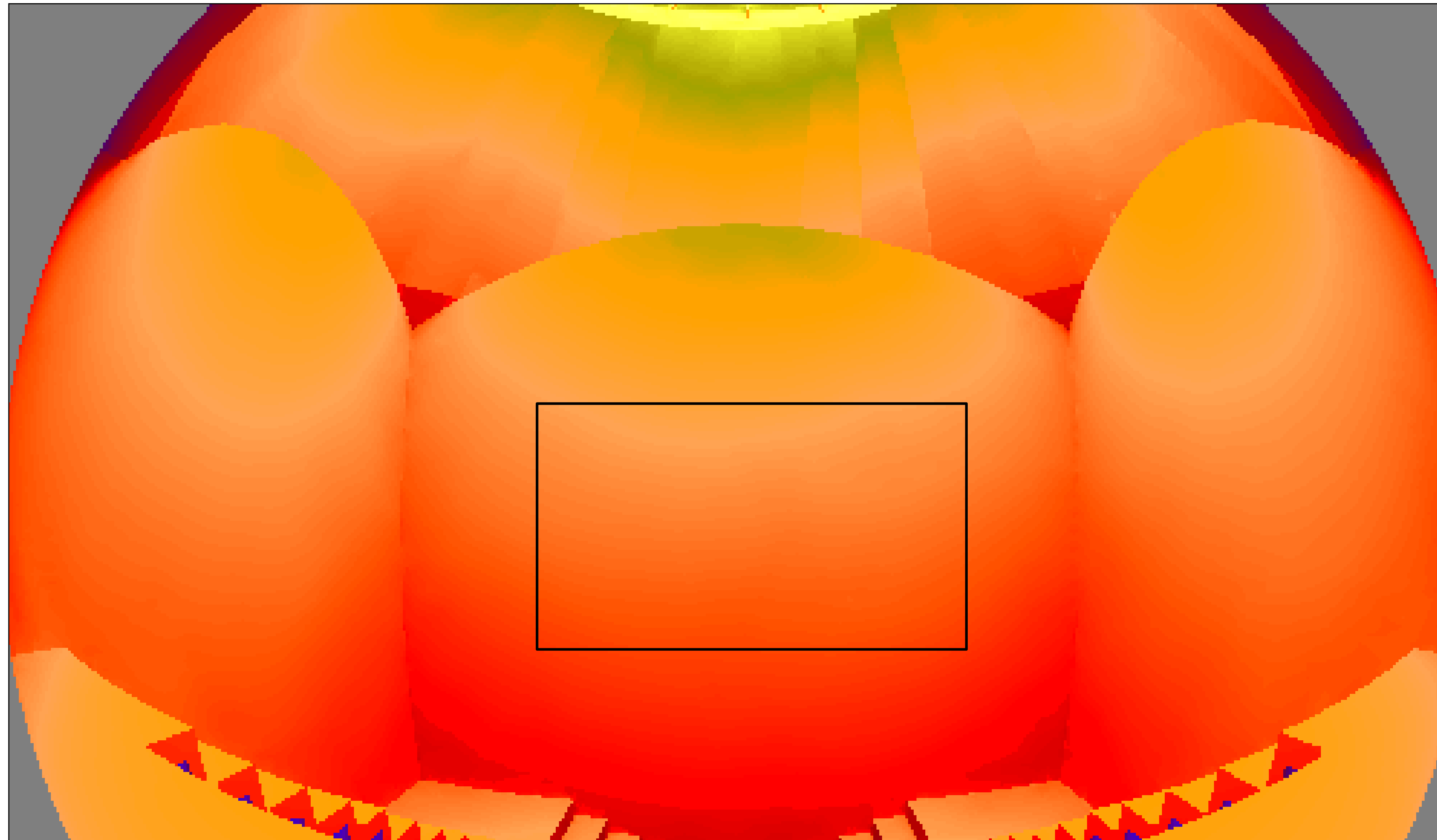
**Climate-Based Daylight Modelling  
(CBDM)**

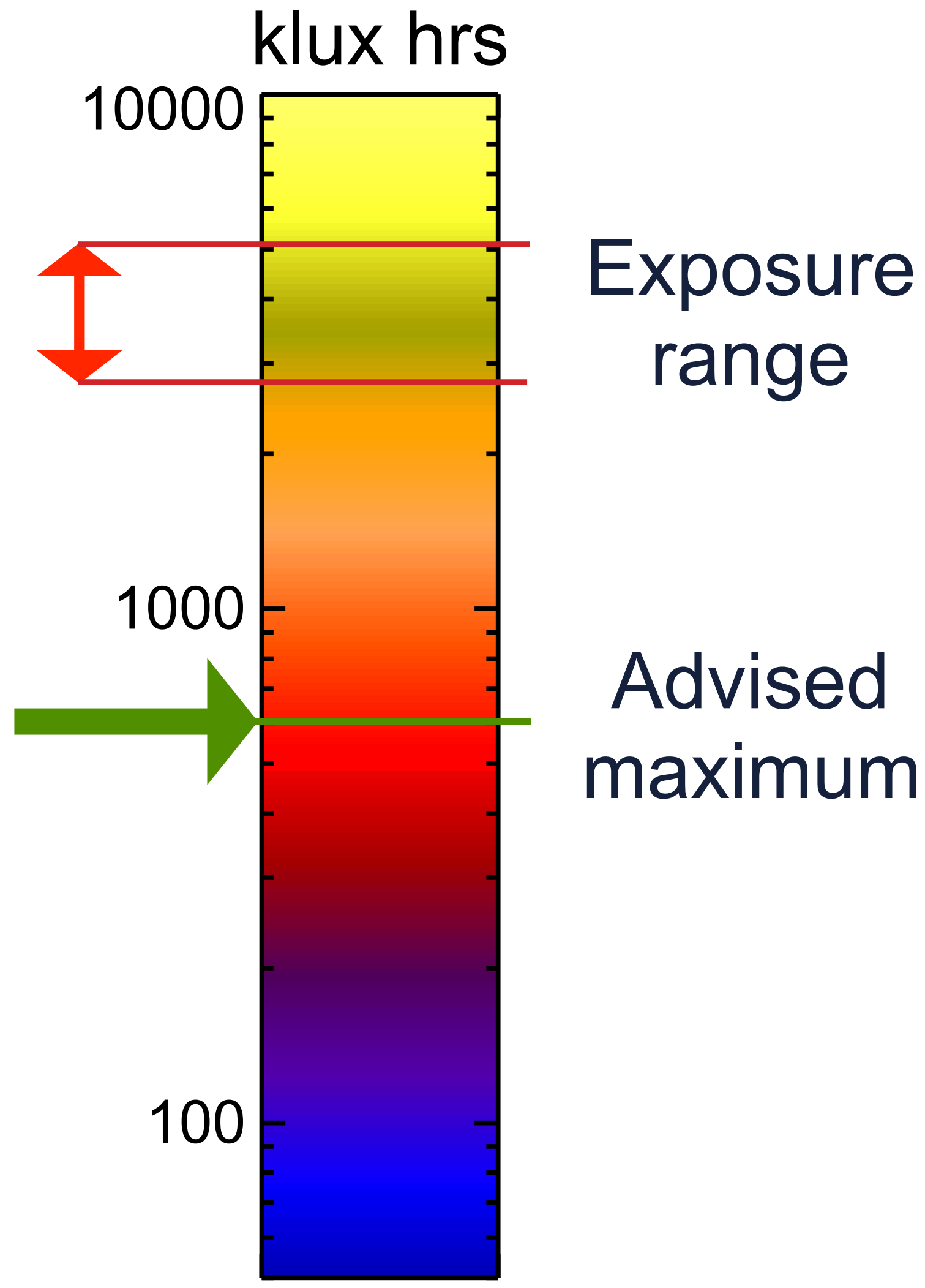
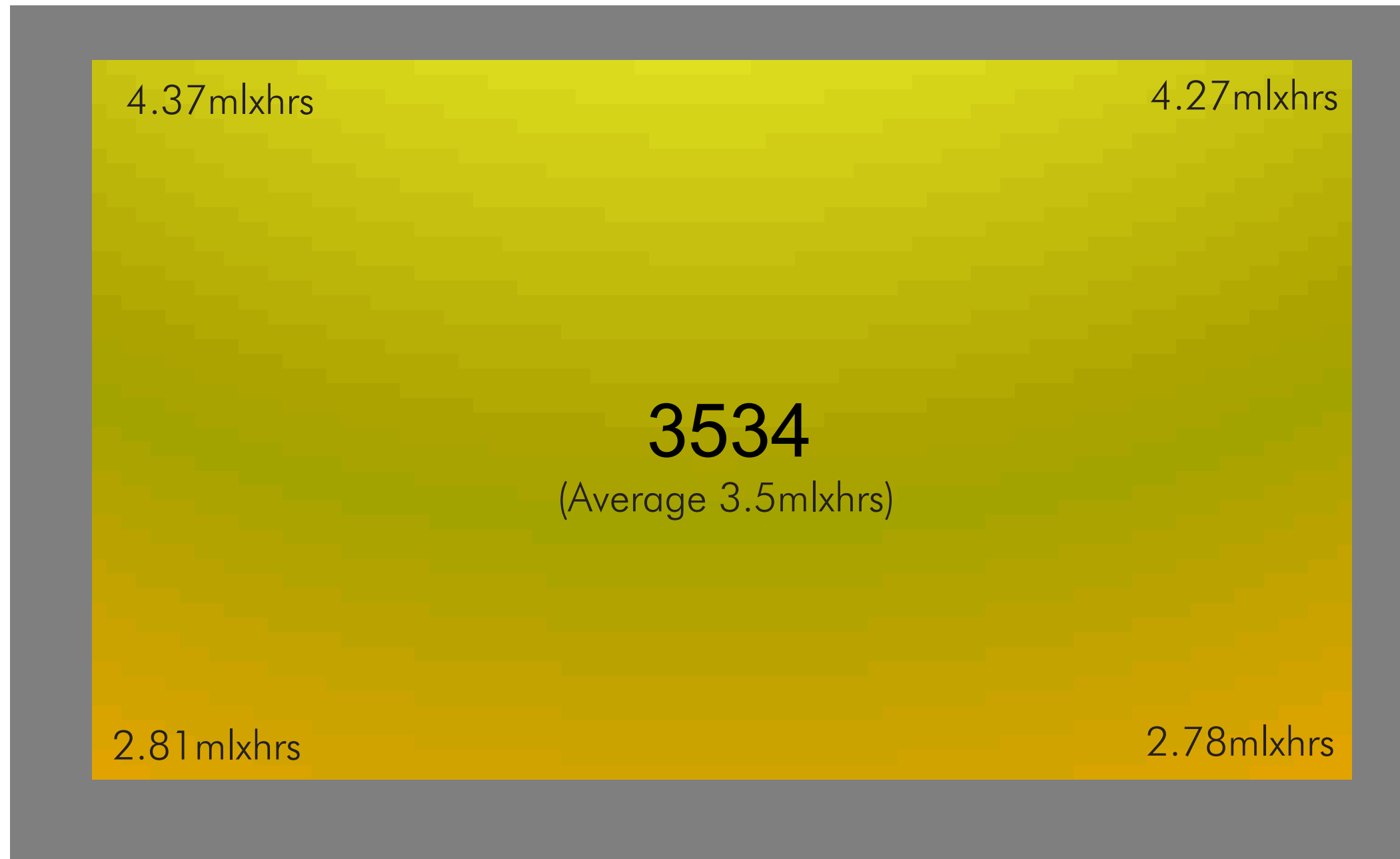
# Mount Stewart, Belfast





# Cumulative annual illumination







# Ickworth House

Bury St. Edmunds





Illuminance can be derived from  
the luminance (i.e. HDR) image

**Illuminance Proxy HDR imaging**



# The Smoking Room

## Ickworth House



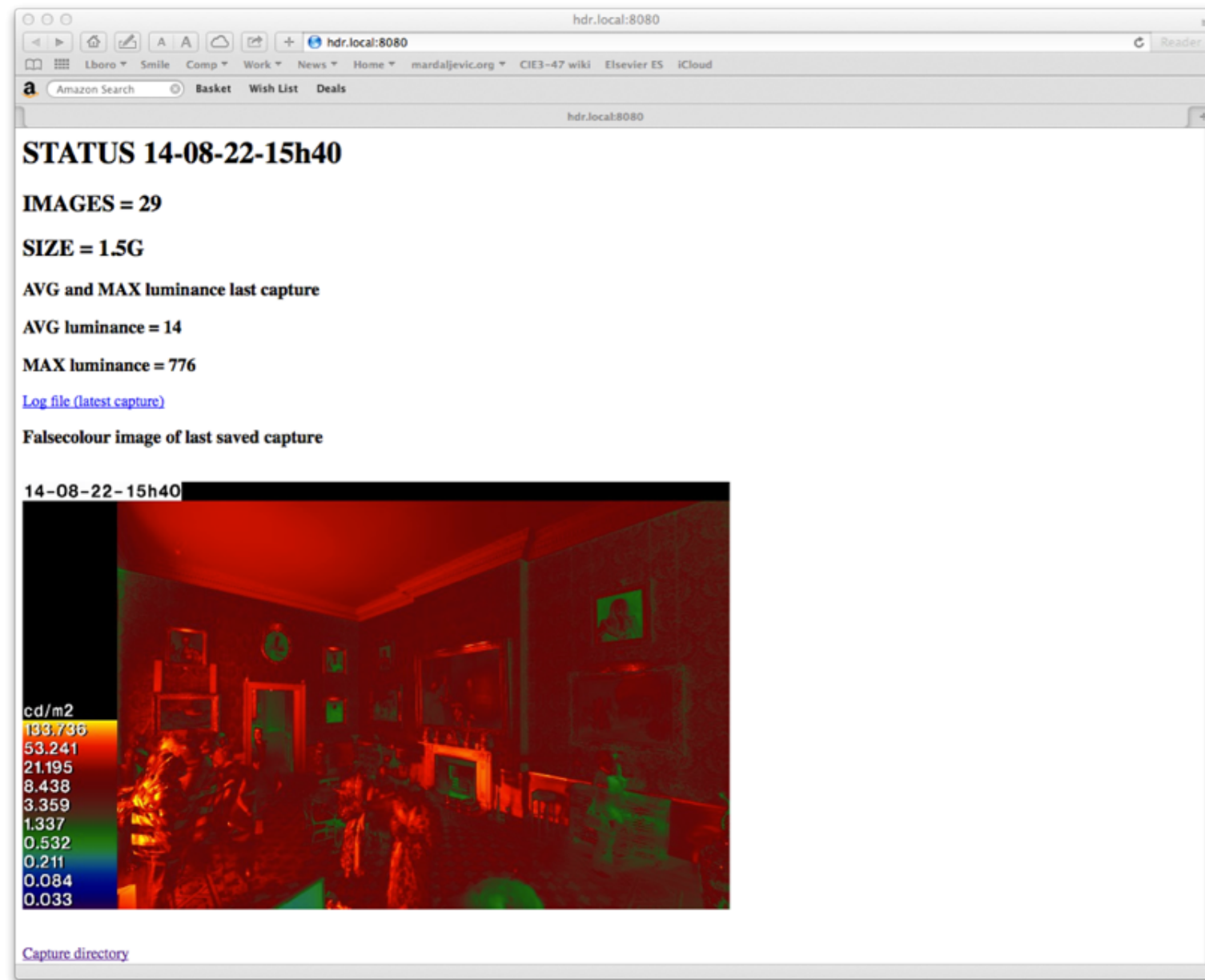


The practicalities



# Long-term, autonomous HDR capture

- HDR capture every 10 minutes
- Unattended duration ~6 to 9 months
- On-the-fly deletion of 'dark' images
- Status webpage broadcast on ad-hoc wifi network



Consumer  
DSLR



'Headless' Mac Mini





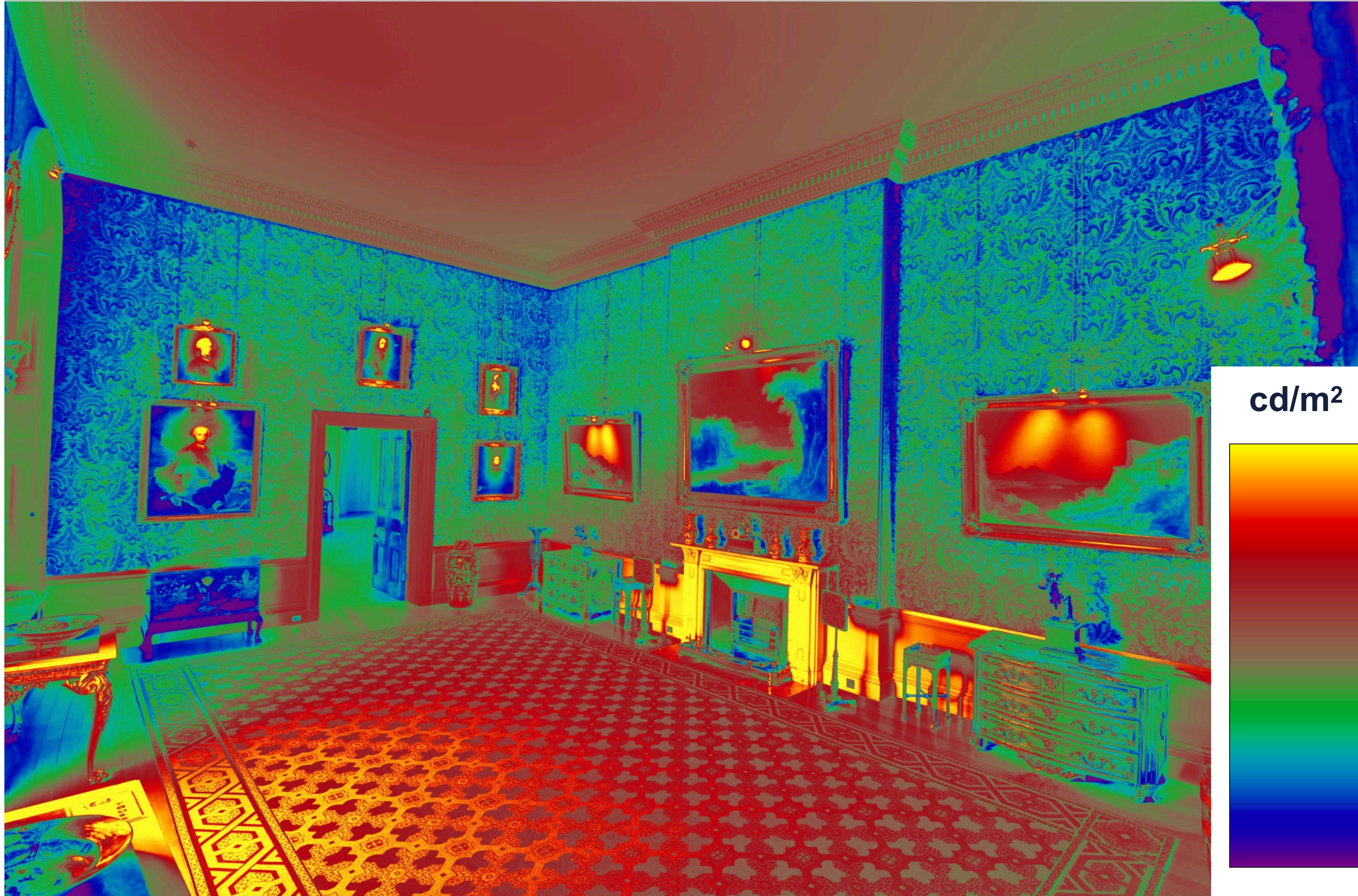




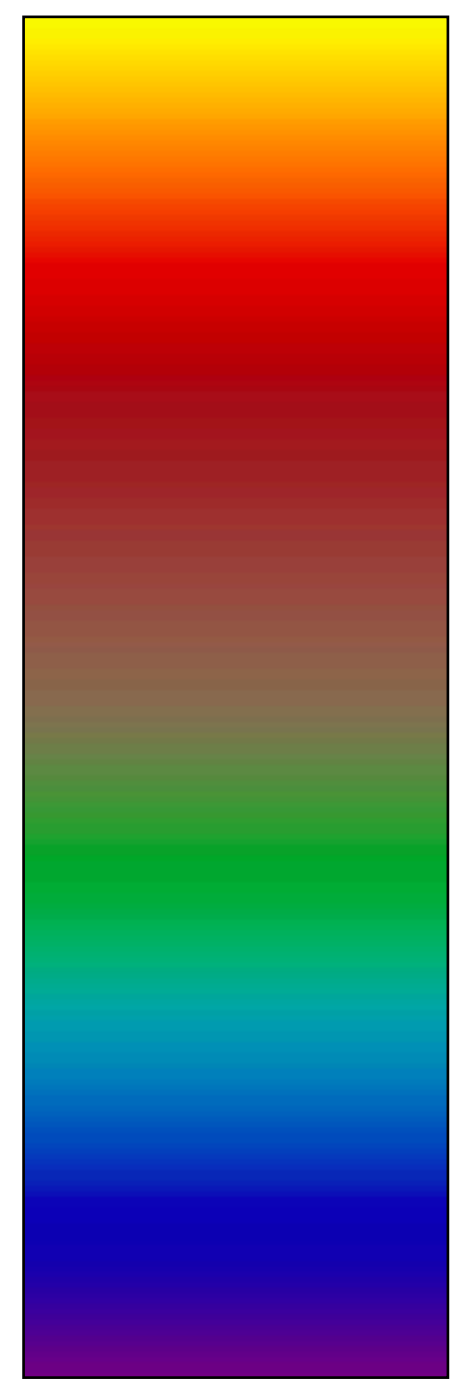








cd/m<sup>2</sup>

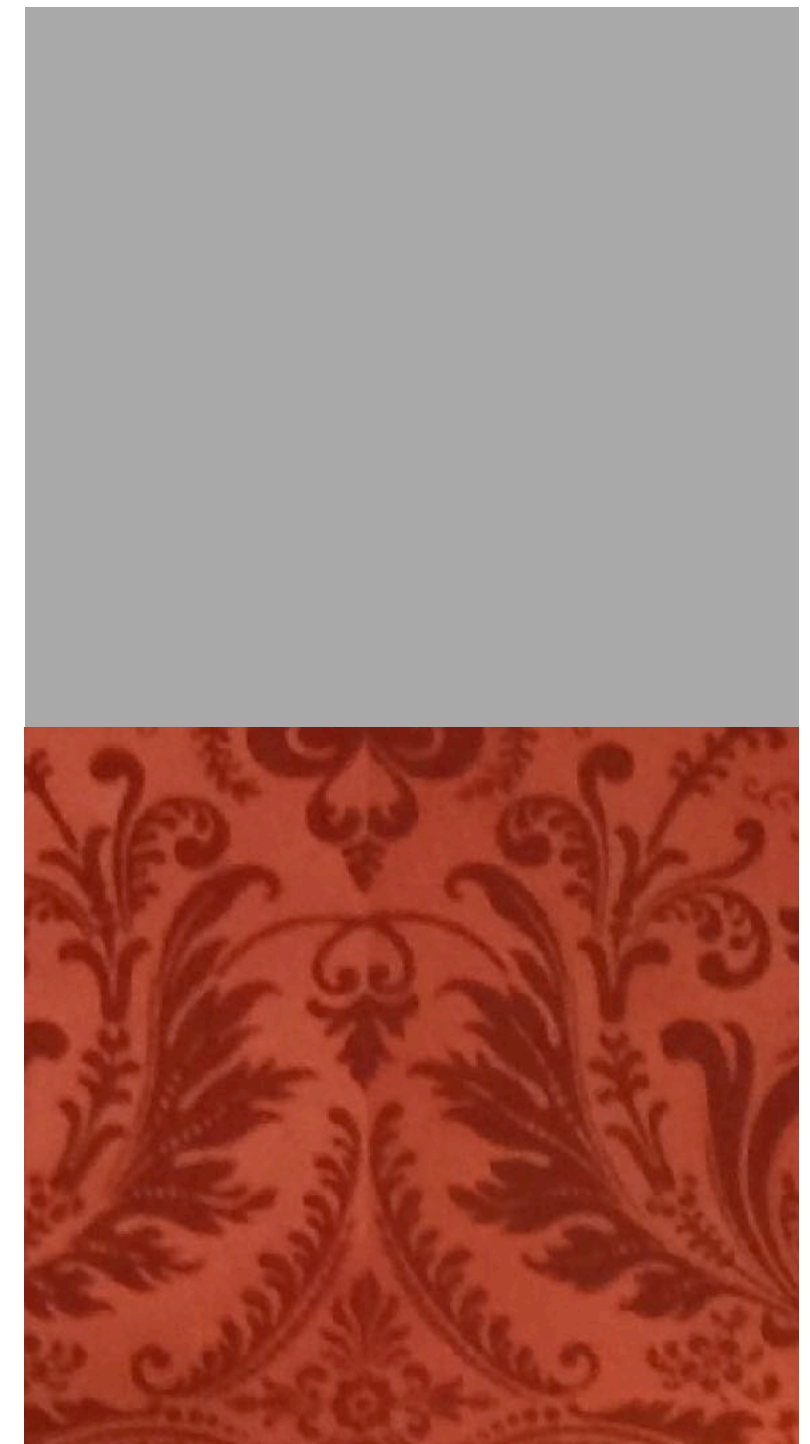


70  
35  
17  
8.4  
4.2  
2.1  
1  
0.5



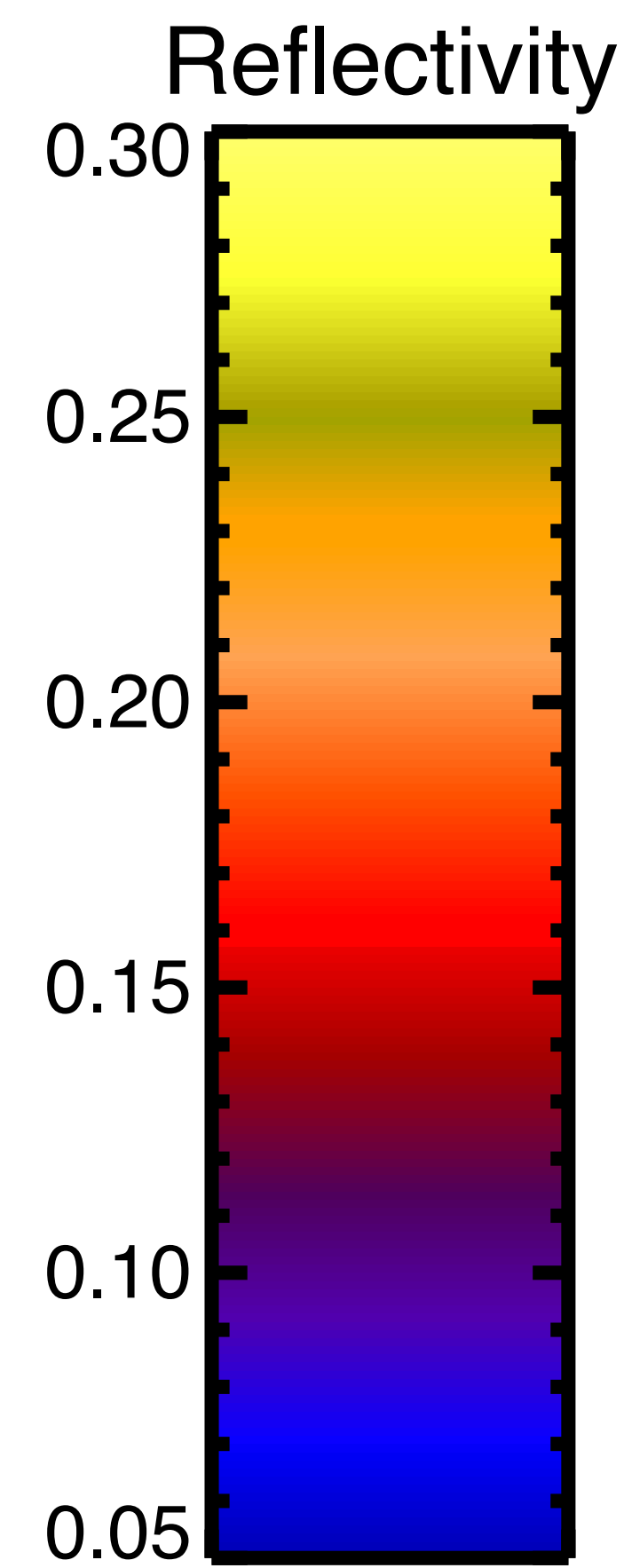
Derive illuminance from  
HDR luminance

$$E_r = \frac{\pi L_r}{\rho_r}$$



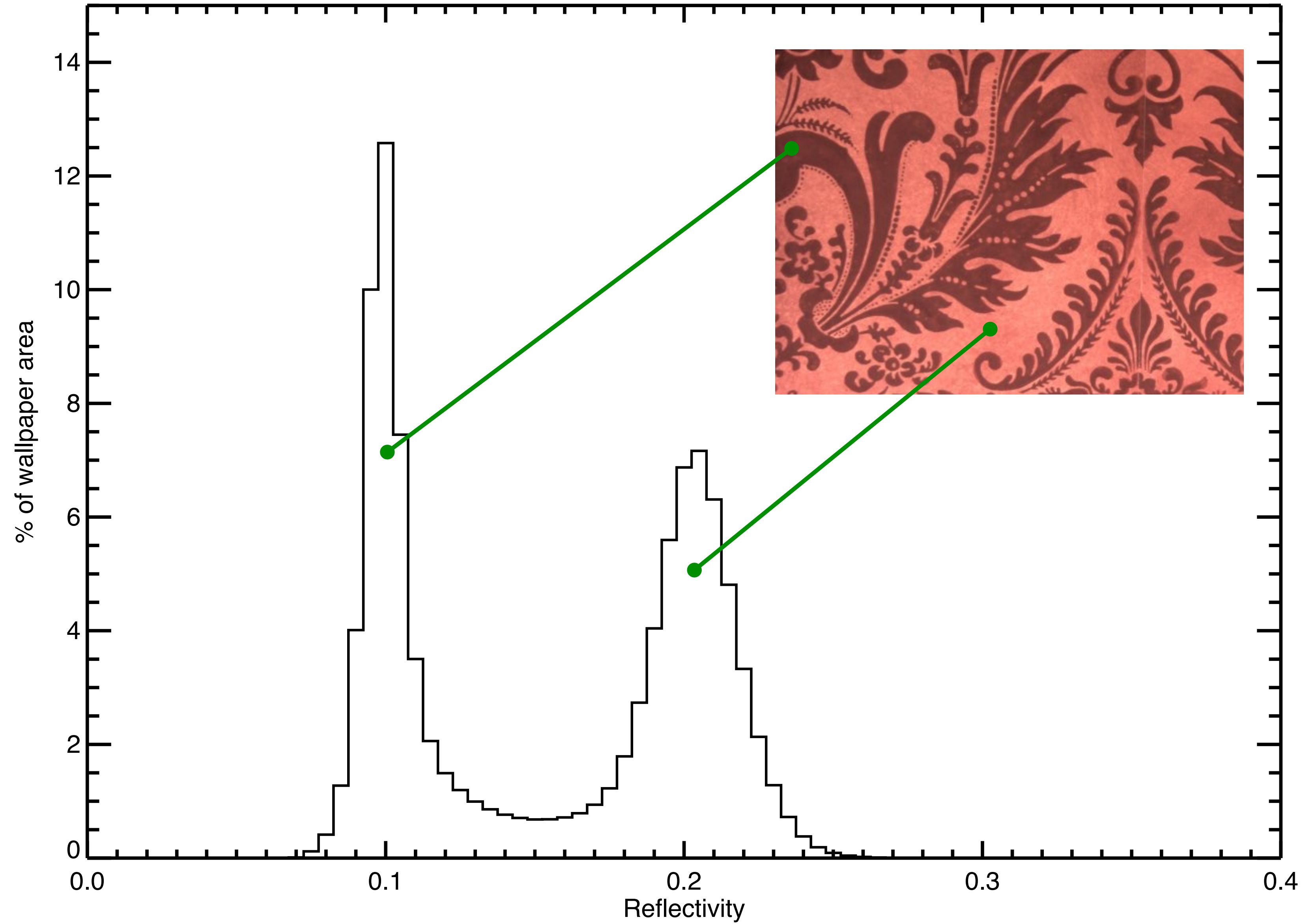


# Reflectance map





Reflectivity histogram



Average for image = 0.16



Random 350 pixels

Reflectance - box average



Mean for image = 0.157

Mean [stdev] of box samples = 0.155 [0.017]



Random 700 pixels

Reflectance - box average



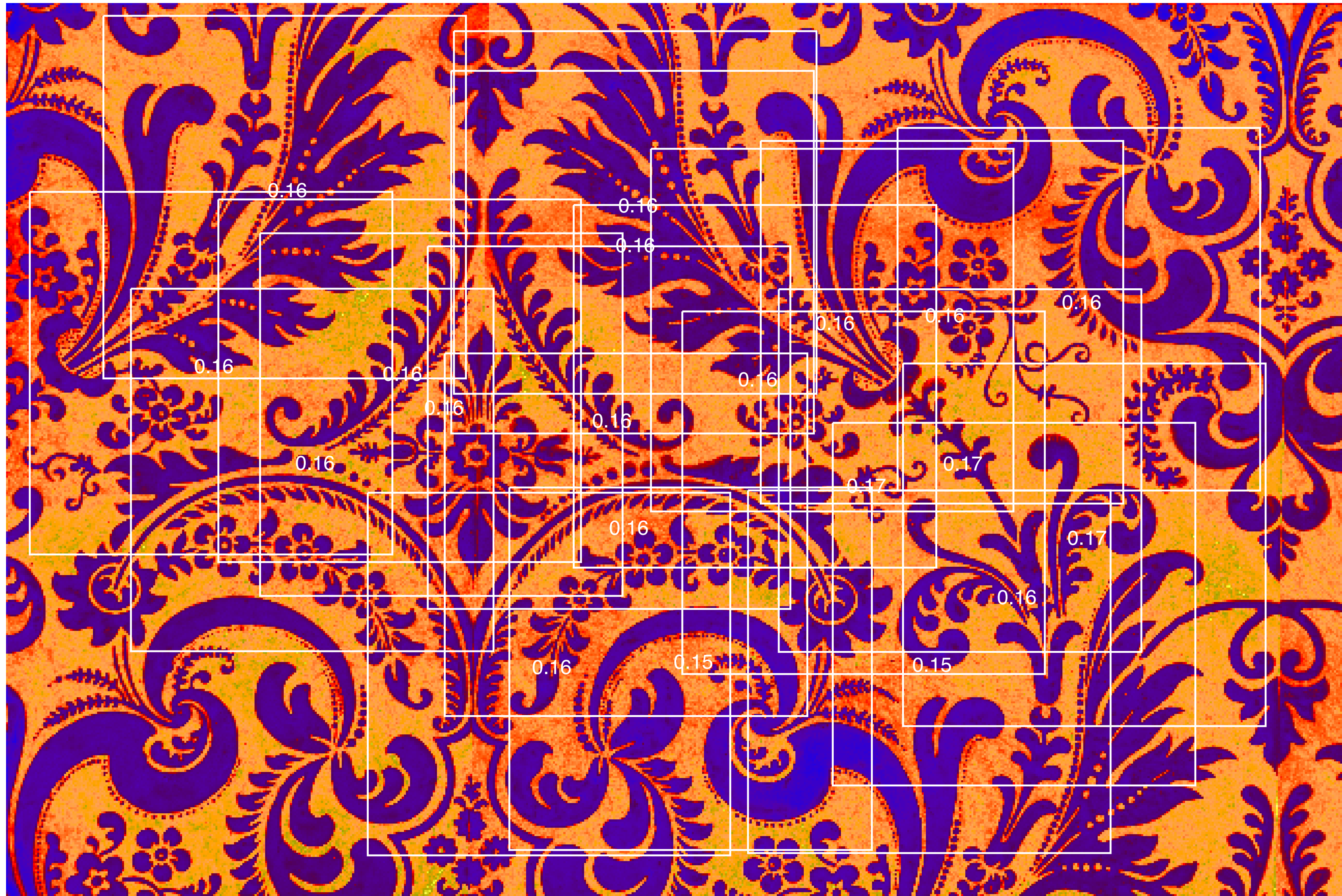
Mean for image = 0.157

Mean [stdev] of box samples = 0.156 [0.007]



Random 1400 pixels

Reflectance - box average



Mean for image = 0.157

Mean [stdev] of box samples = 0.160 [0.004]





**2x the minimum  
'safe' size**



Apply vignetting correction,  
subtract electric light contribution



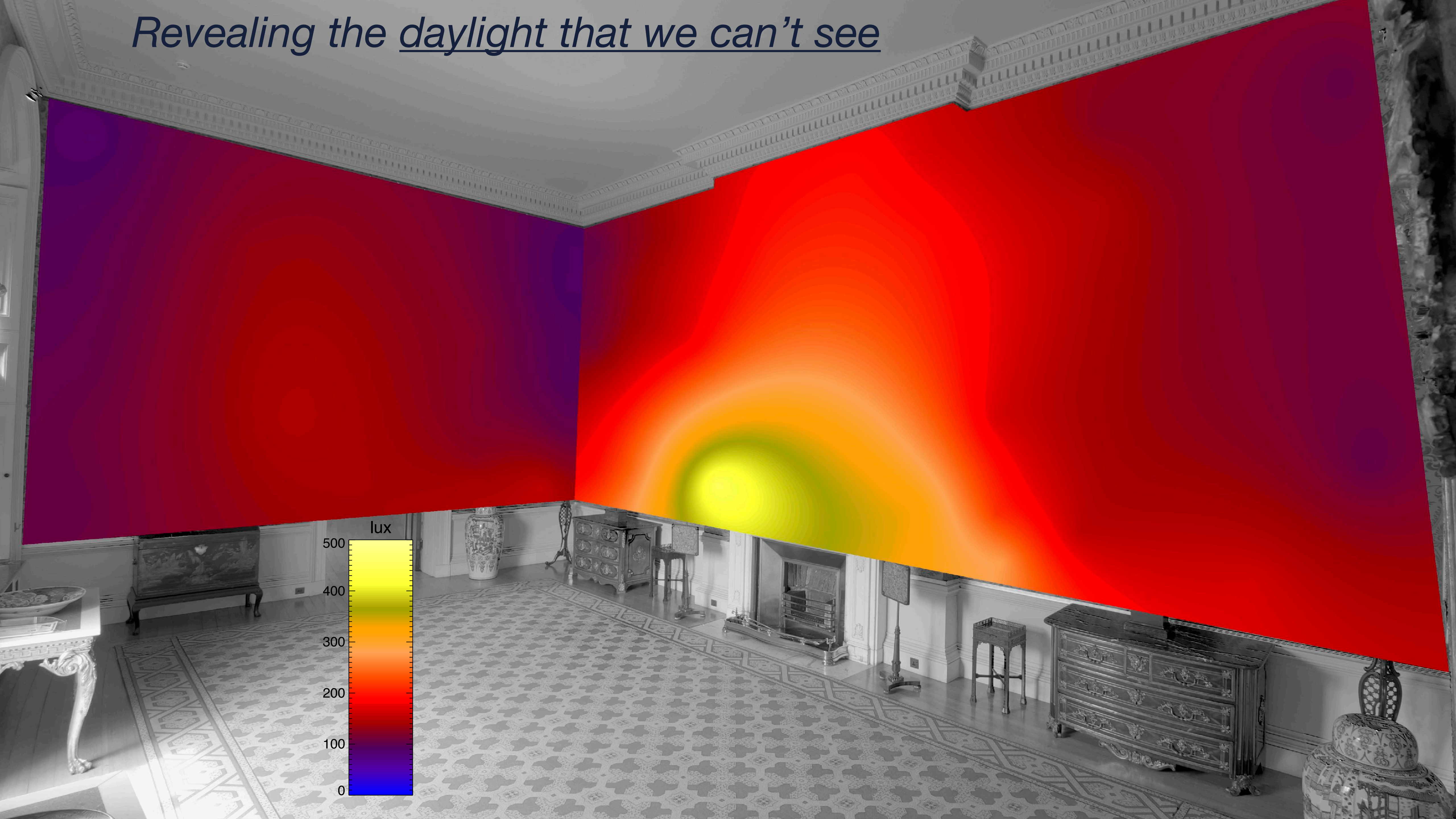


# Interpolate illumination field across target patches





# Revealing the daylight that we can't see





# Ghostly encounters

Share spine-chilling thrills at some of the most haunted historic houses and castles across England, Wales and Northern Ireland. With ghostly tales from centuries past, there are plenty of ways to get into the spirit of things on a day out with us. Take an eerie walk with your family in a haunted house if you dare. Here's our pick of the most hair-raising haunted locations, and their spooky stories. Are you brave enough to pay them a visit?



**i** Are you ready to hunt for ghosts at Blickling Hall?



**Blickling Estate**  
Norfolk



## Blickling Hall, Norfolk

Thought to be the birthplace of Anne Boleyn, her headless ghost is said to return on the anniversary of her execution.

Other ghostly residents allegedly include Sir John Falstofe and Sir Henry Hobart, whose dying groans can be heard emanating from the West Turret Bedroom on the anniversary of his death.

Spot ghosts at Blickling Hall

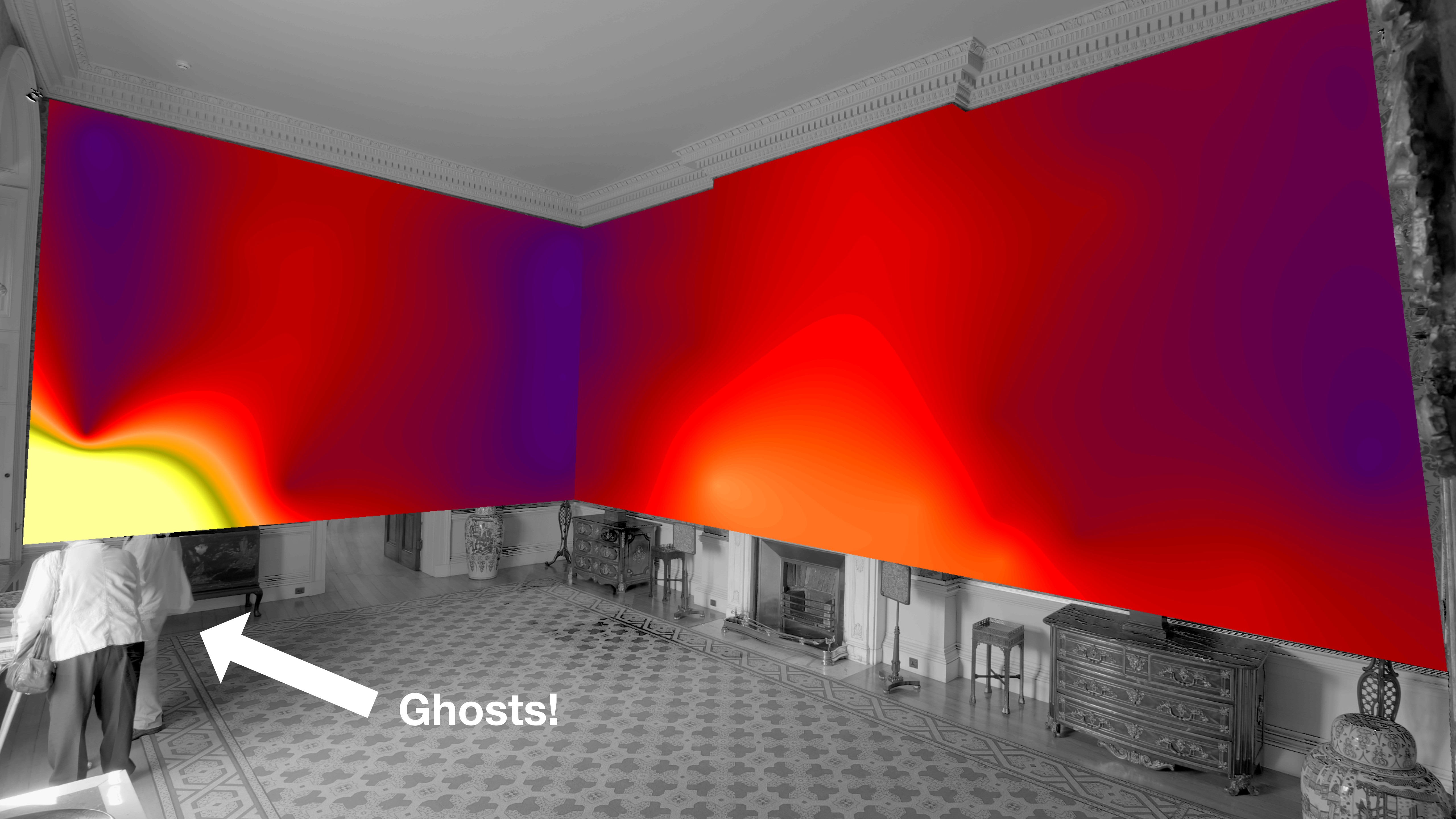












Ghosts!



16-06-07-12h30





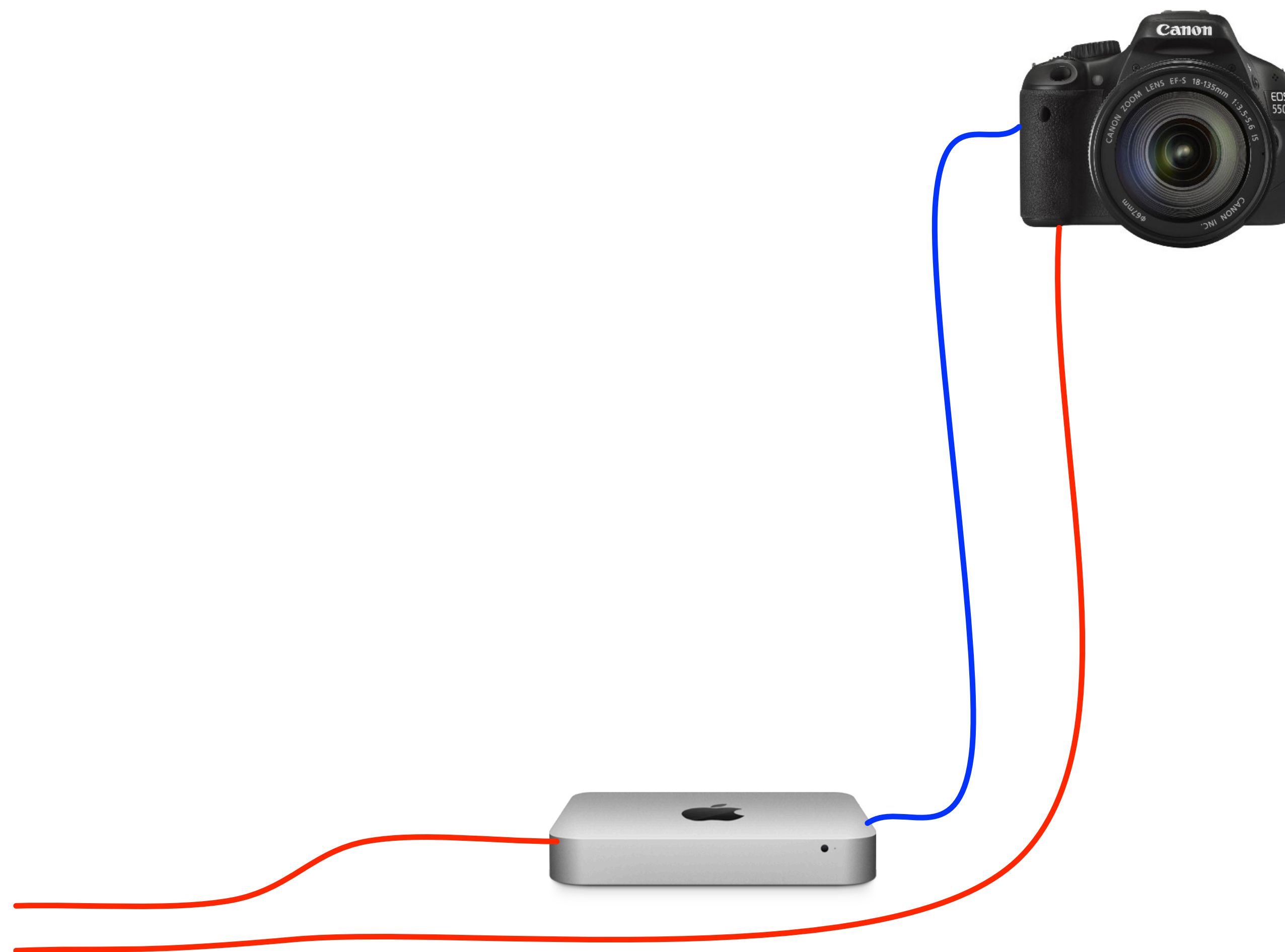
Validation of HDR-derived  
Illuminance + comparison of daily  
dose values @5sec and @10min



Every 5 seconds



Every 10 minutes





HDR capture every 10 mins  
Illuminance measurement every 5 secs



Centre

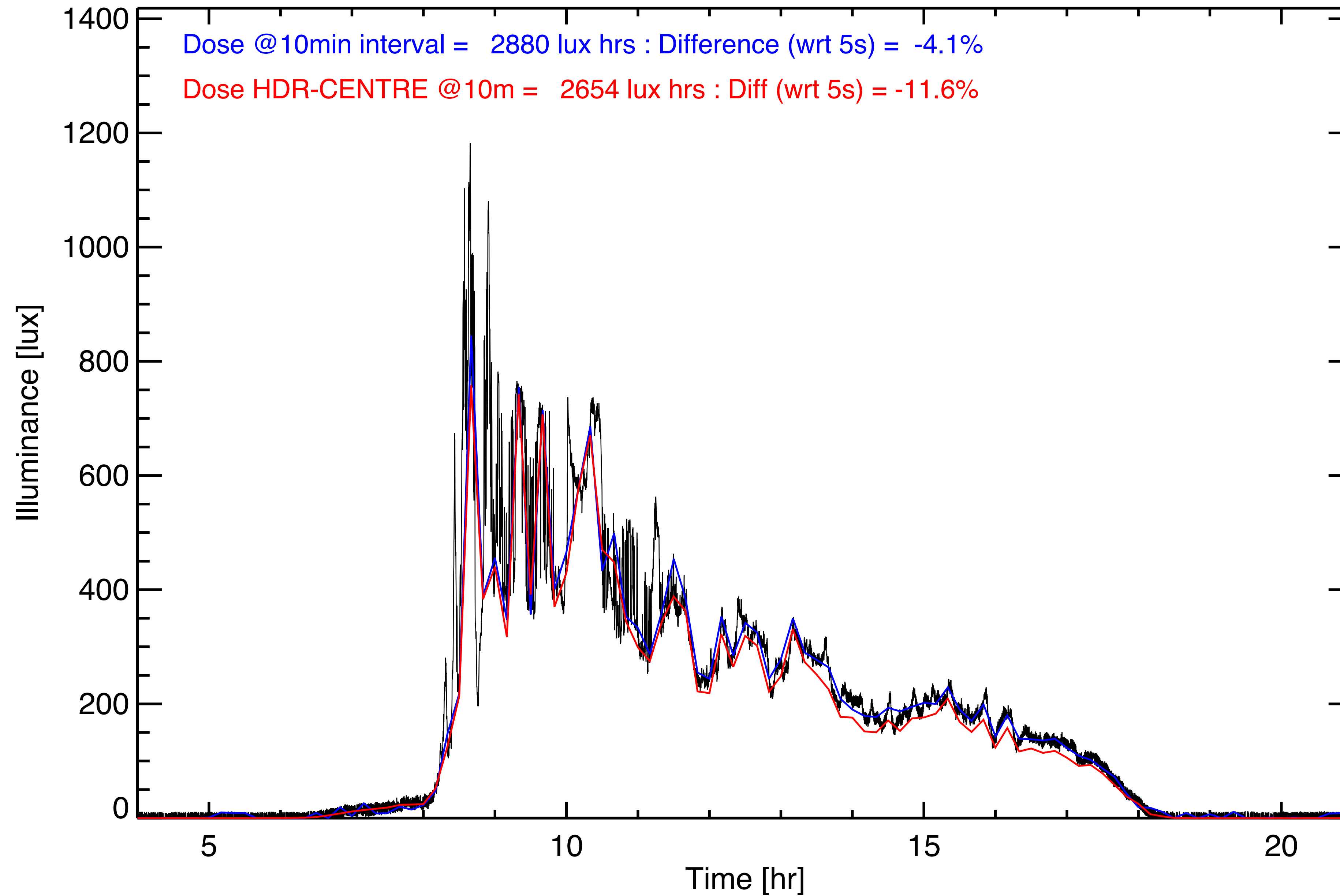


Edge

74 days

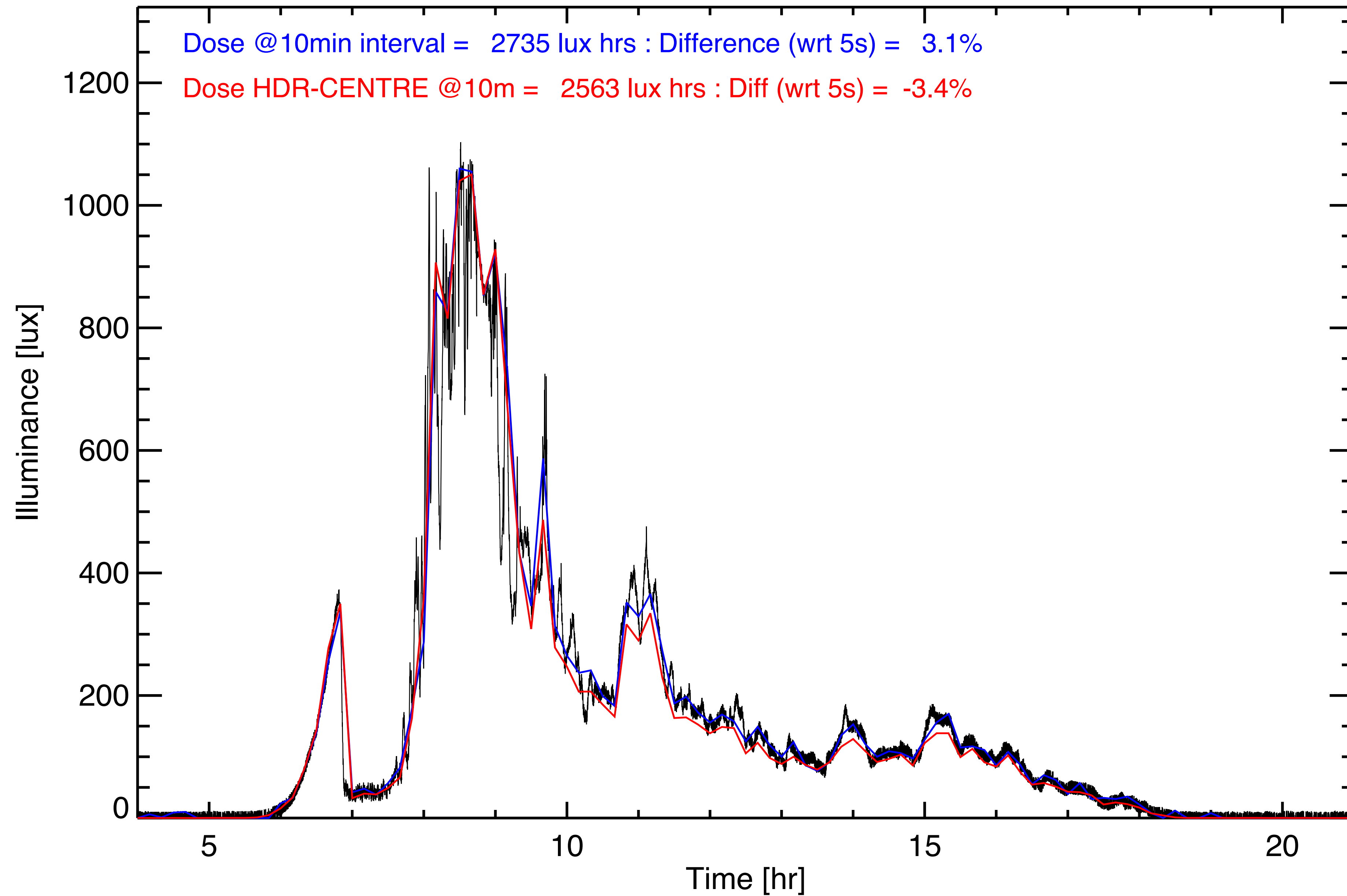


16-03-16 Dose @5sec interval = 3004 lux hrs



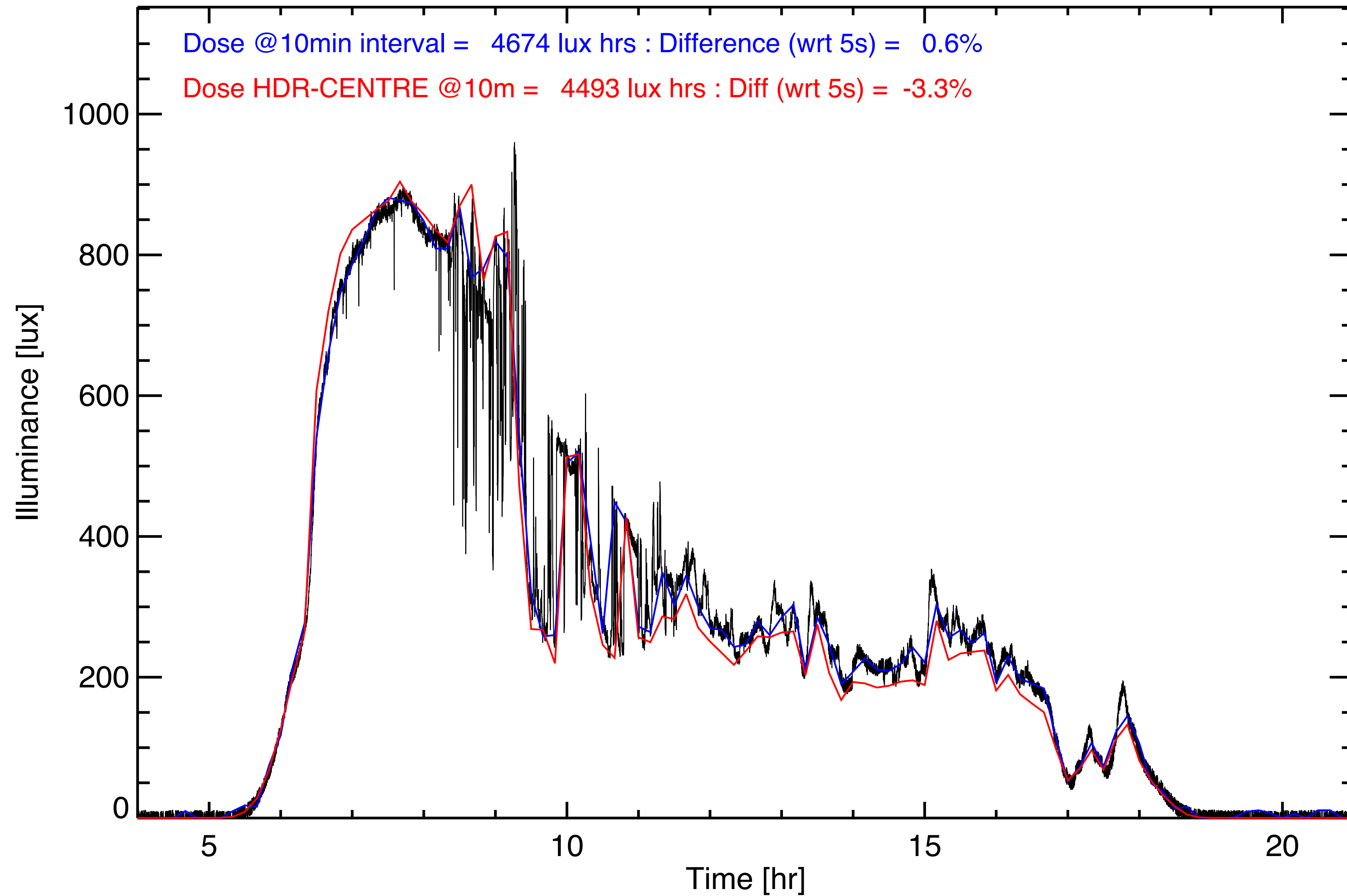


16-03-21 Dose @5sec interval = 2652 lux hrs



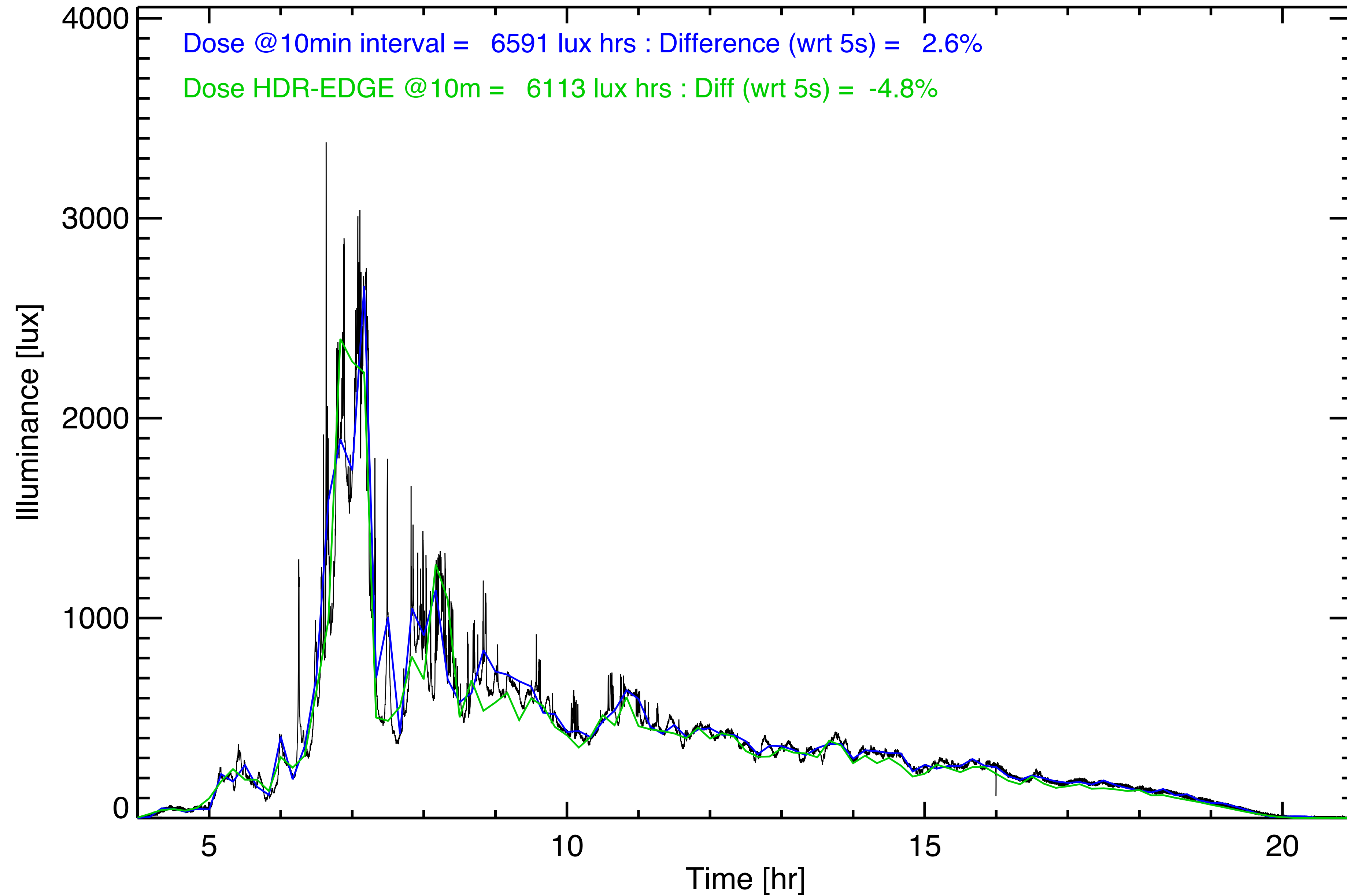


16-03-30 Dose @5sec interval = 4645 lux hrs



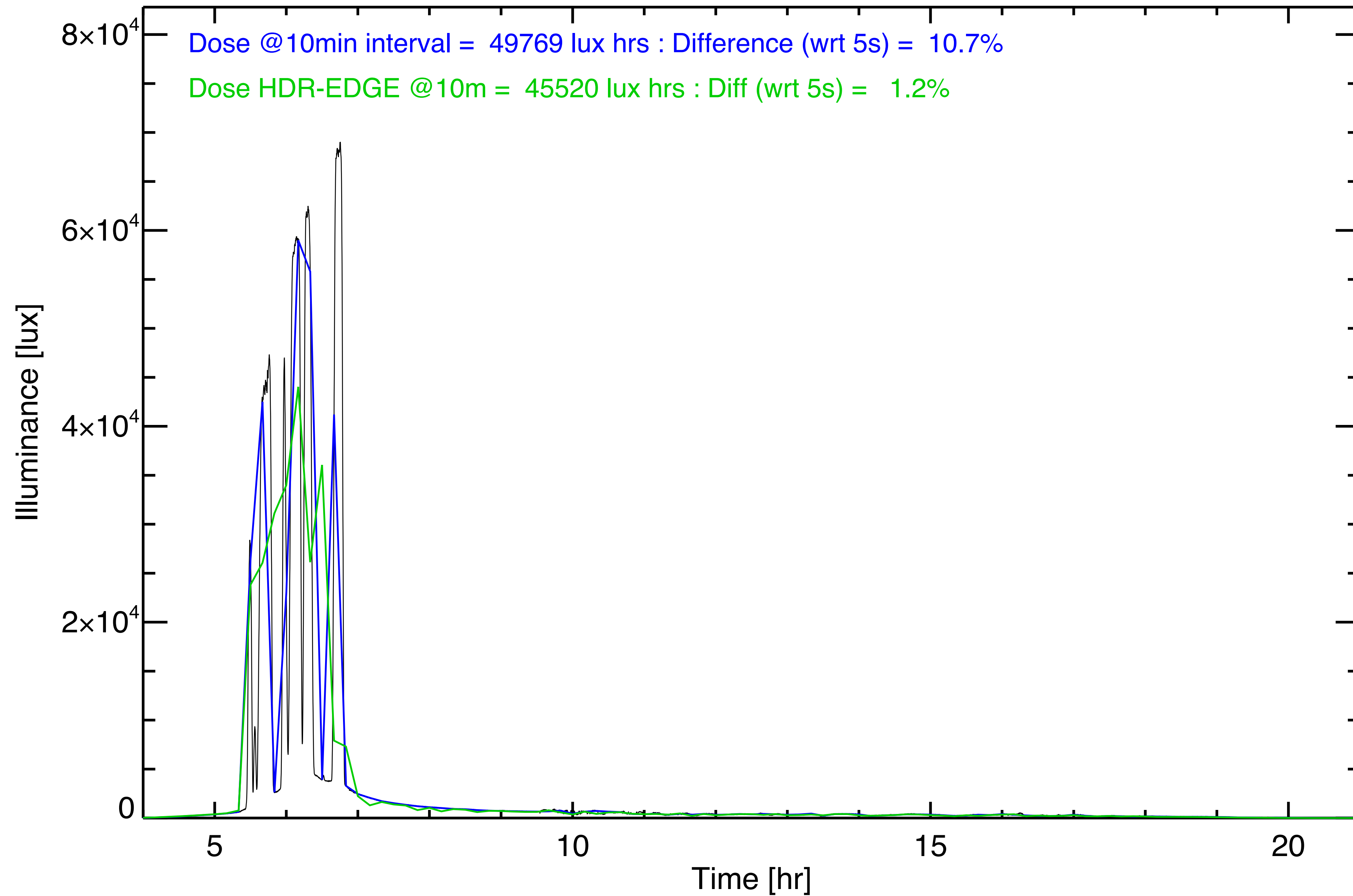


16-05-14 Dose @5sec interval = 6421 lux hrs



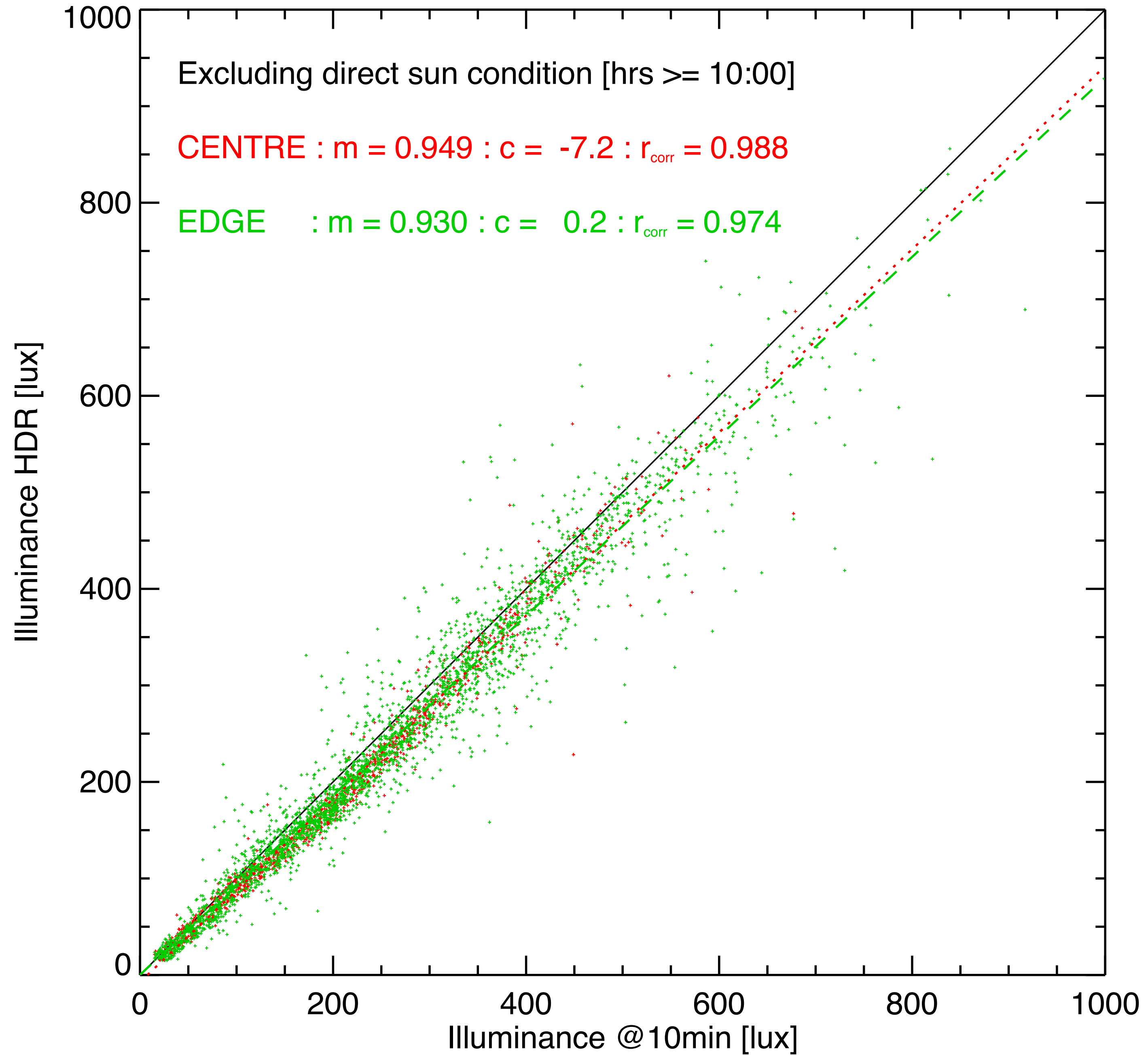


16-05-24 Dose @5sec interval = 44968 lux hrs



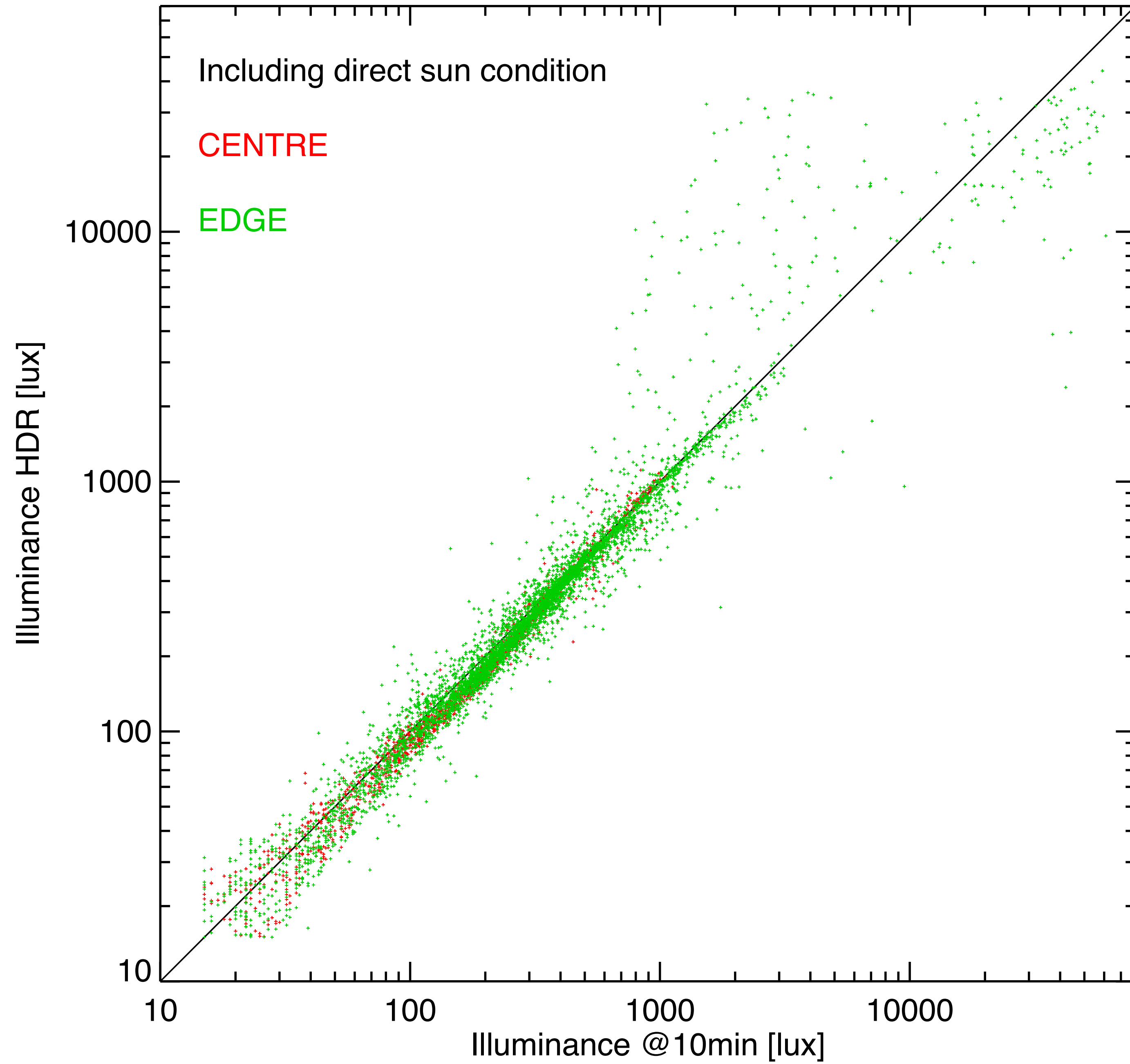


# Illuminance @10min vs. HDR



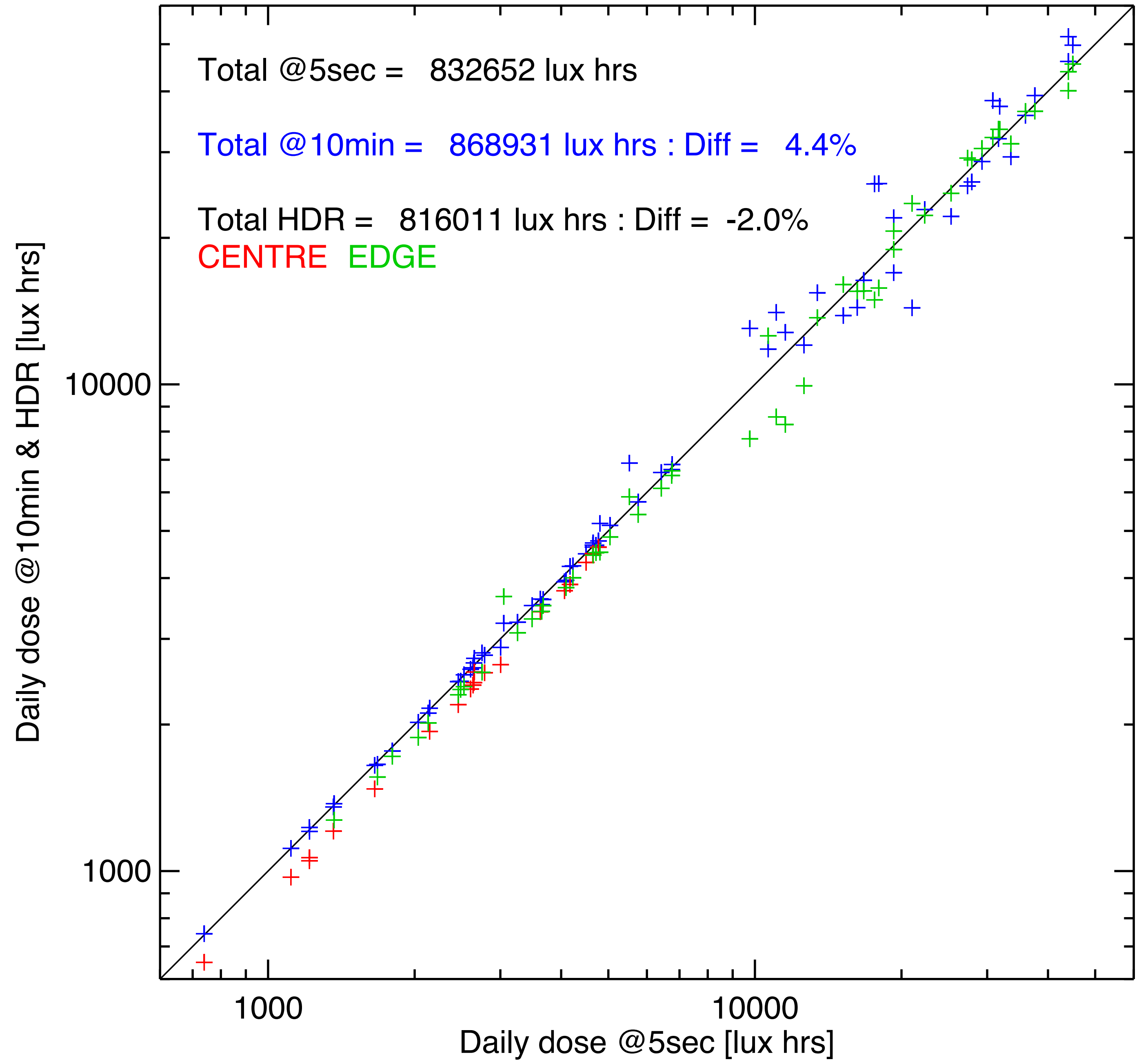


# Illuminance @10min vs. HDR





# Daily dose @5sec vs. @10min & HDR





# Comparison of HDR derived illuminances with the Hanwell Logger



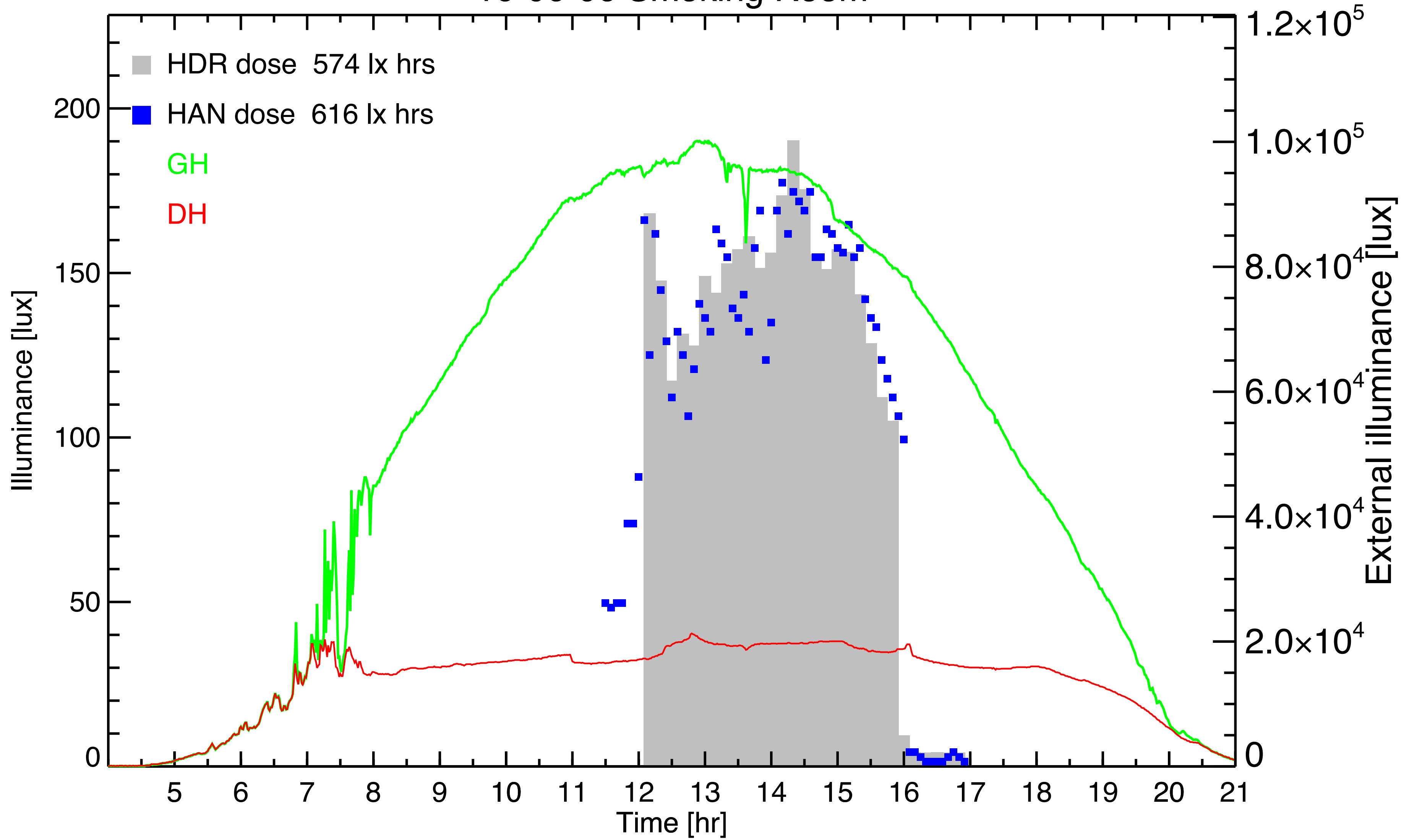






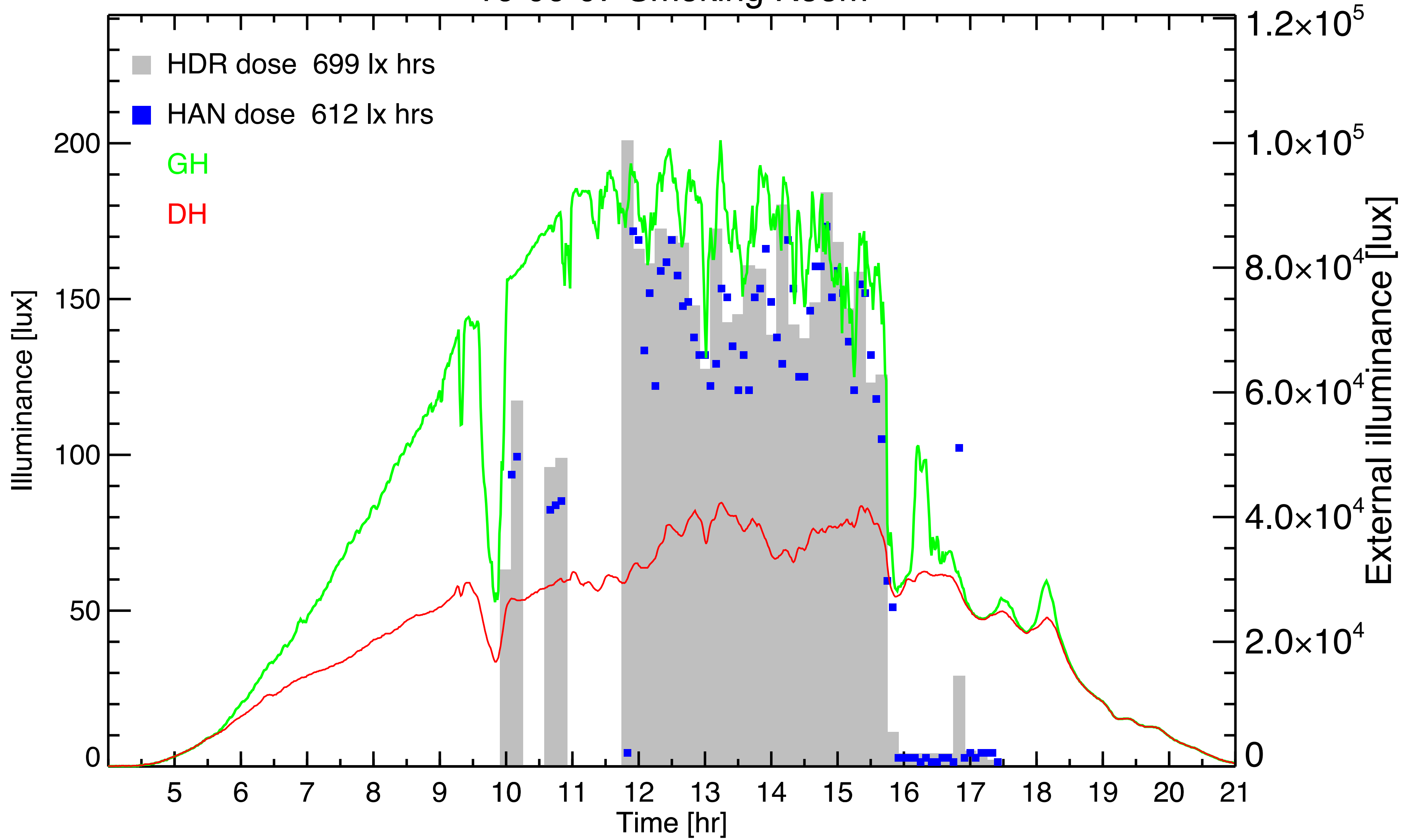


# 16-06-06 Smoking Room



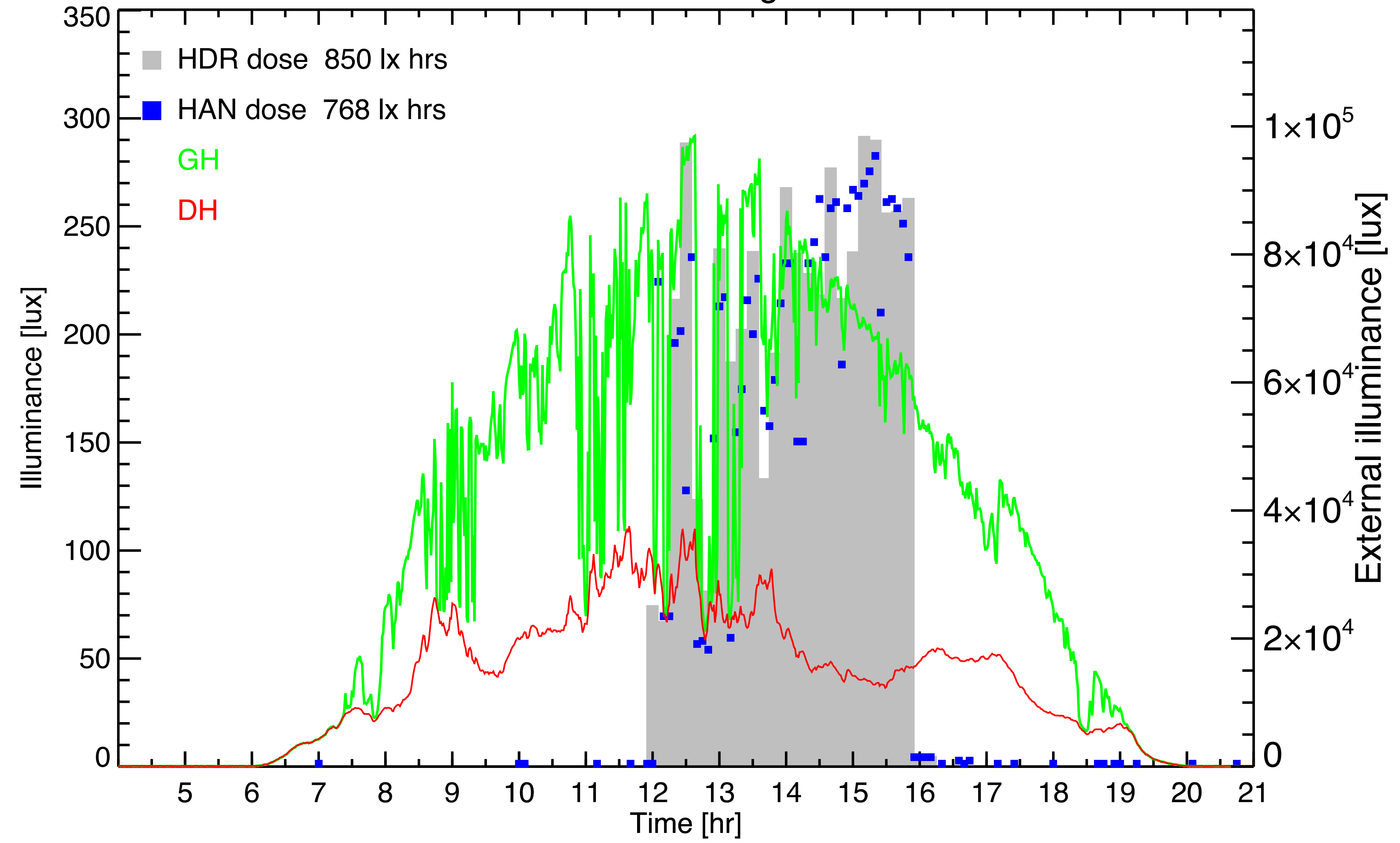


# 16-06-07 Smoking Room



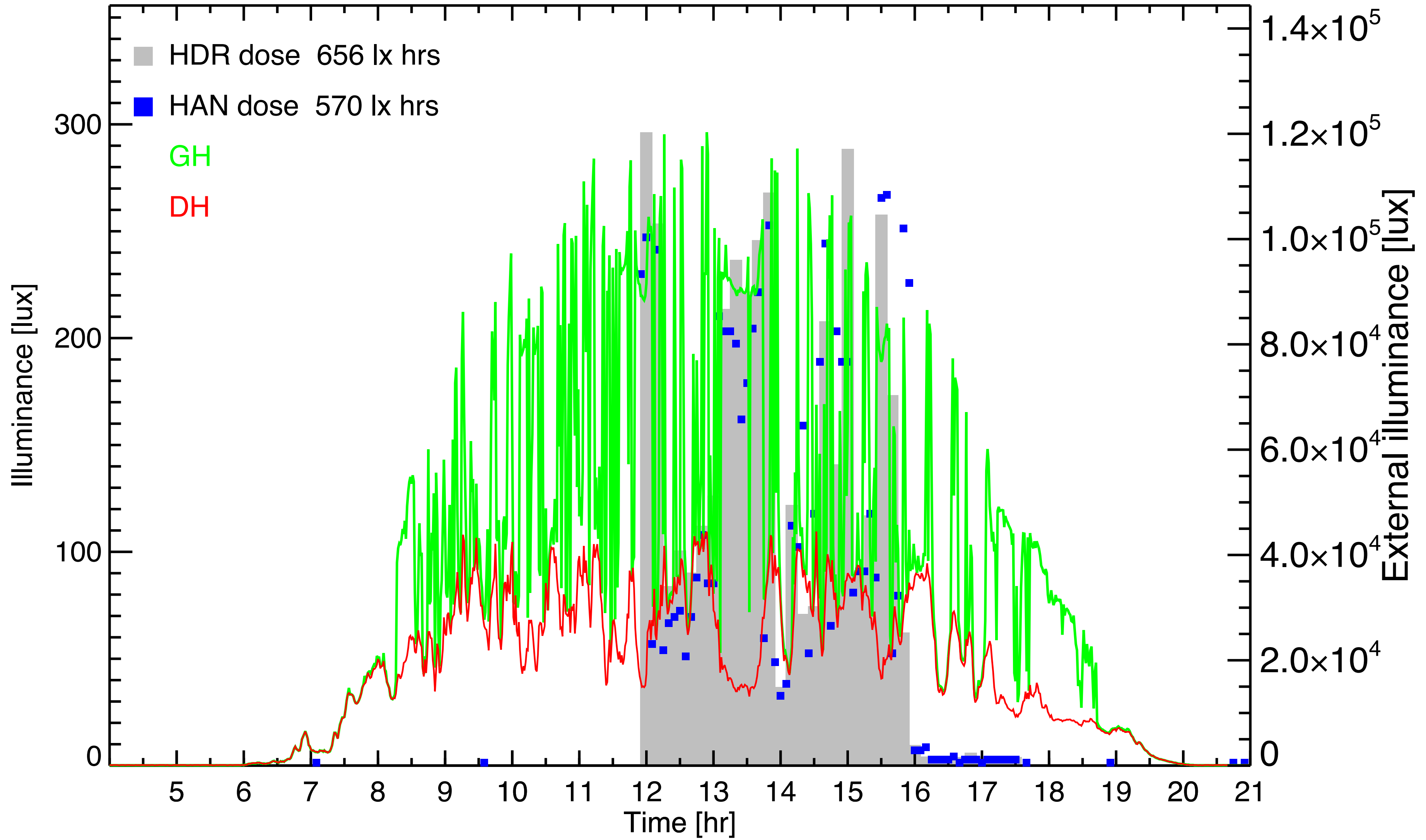


# 16-09-01 Smoking Room



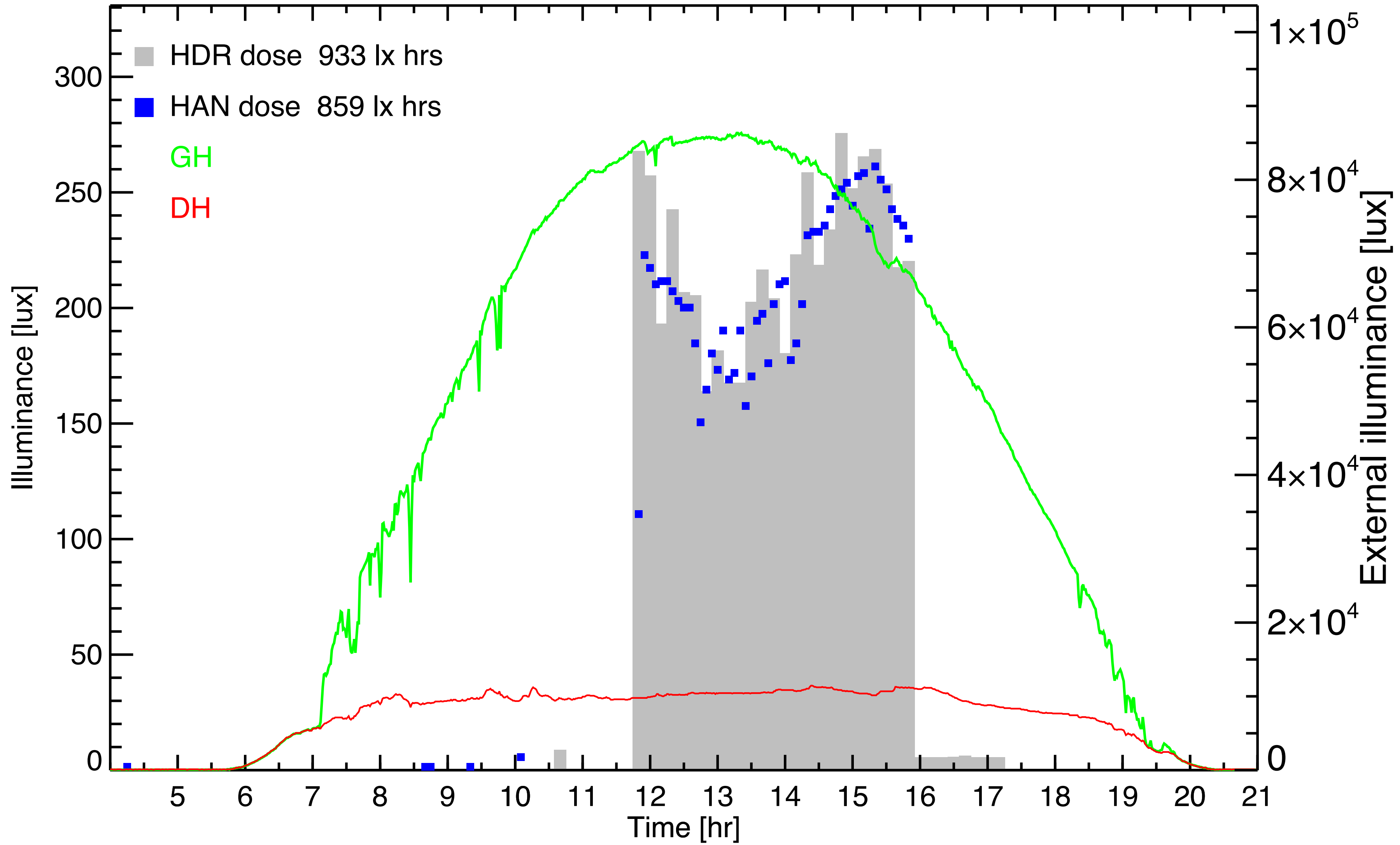


# 16-08-21 Smoking Room



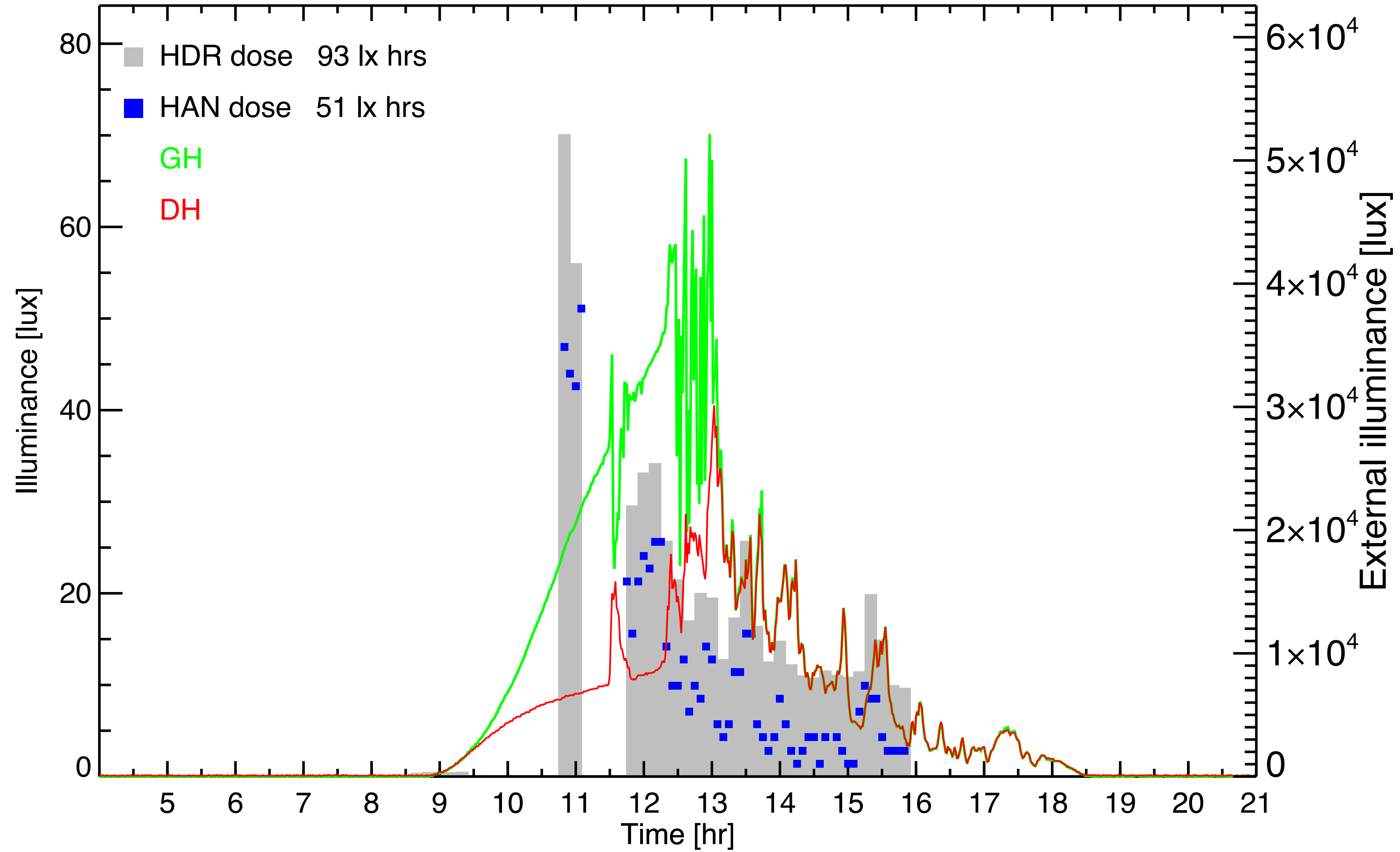


# 16-08-23 Smoking Room



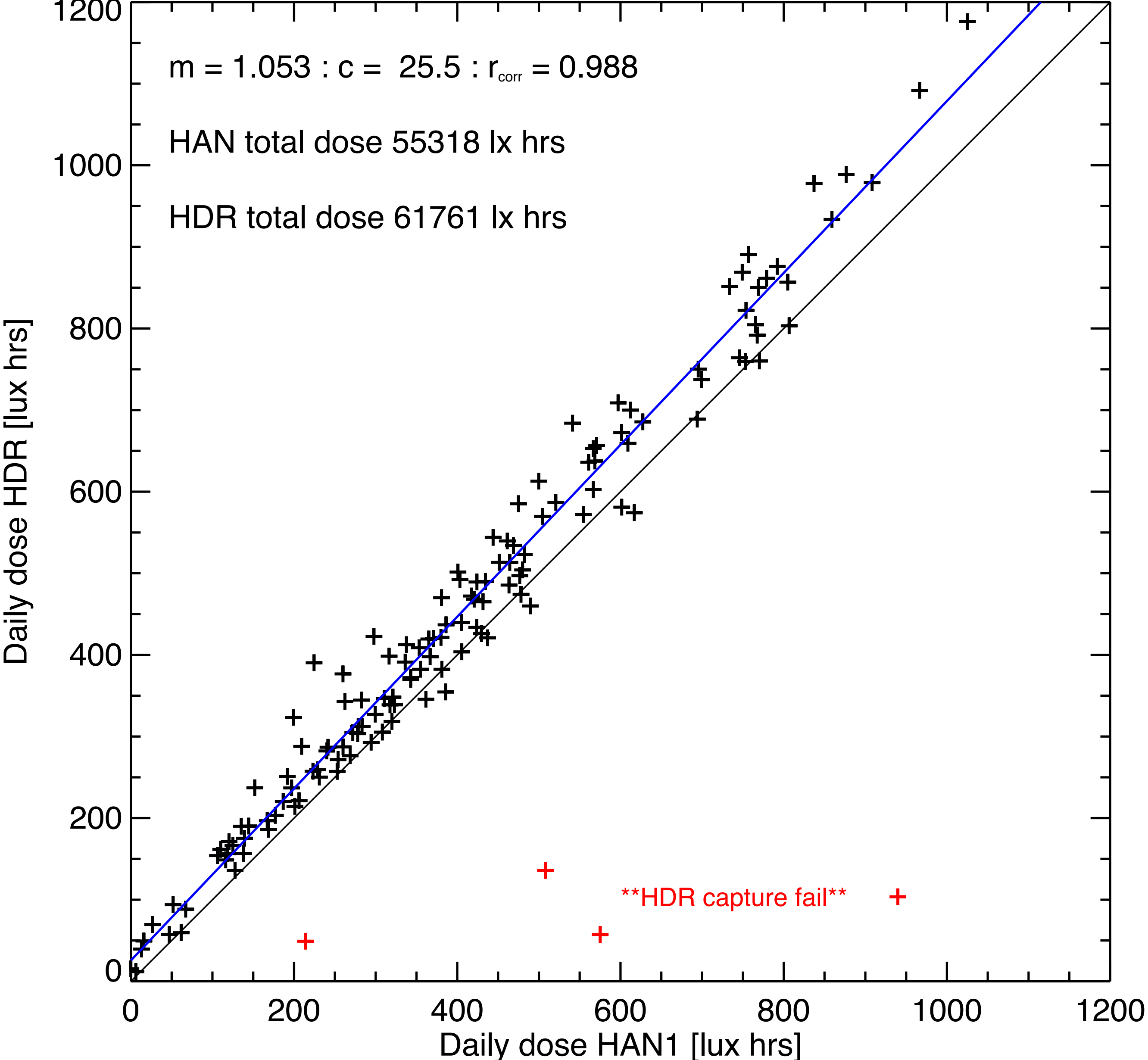


# 16-11-06 Smoking Room





# Daily dose HAN1 vs. HDR

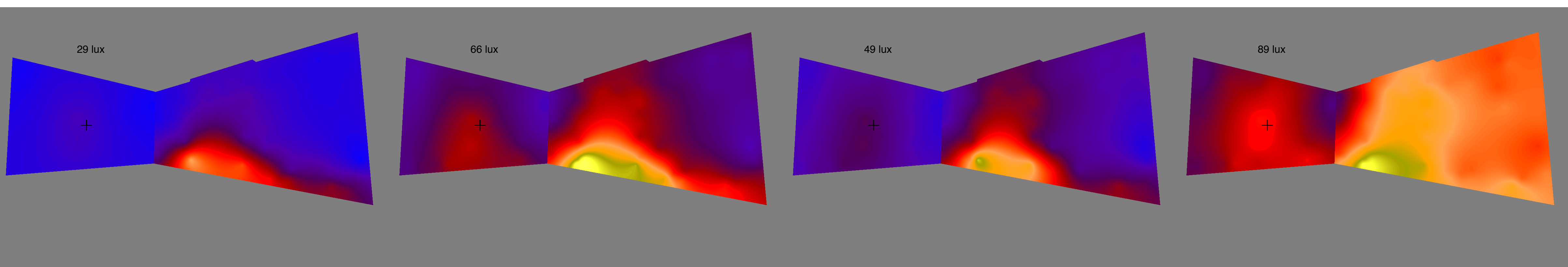
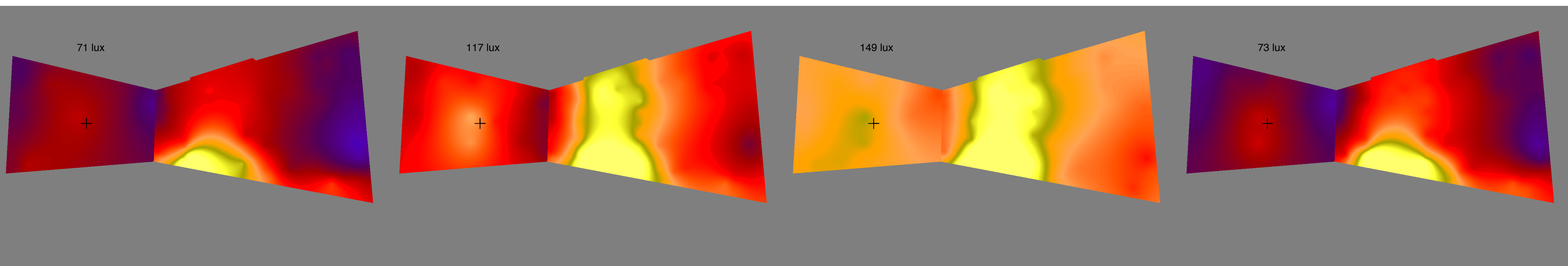
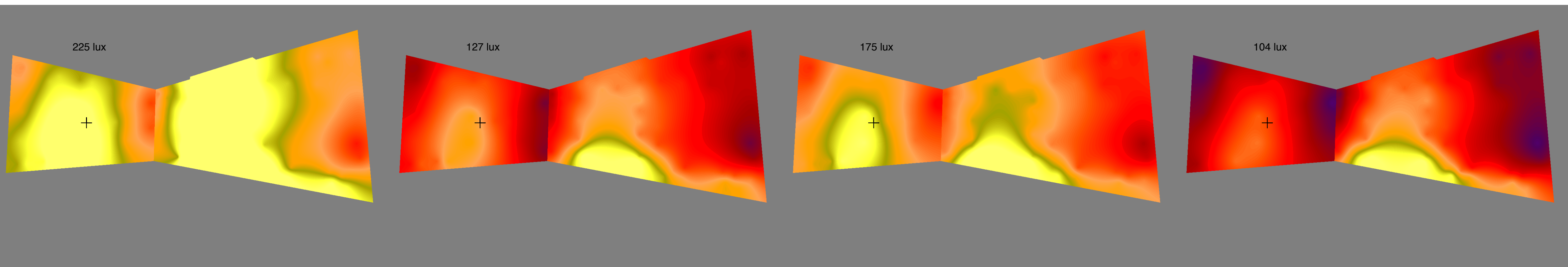


Hanwell exposure  
10.4% less than  
HDR-derived



Which gives us the confidence to  
proceed with the interpolated  
illuminance maps

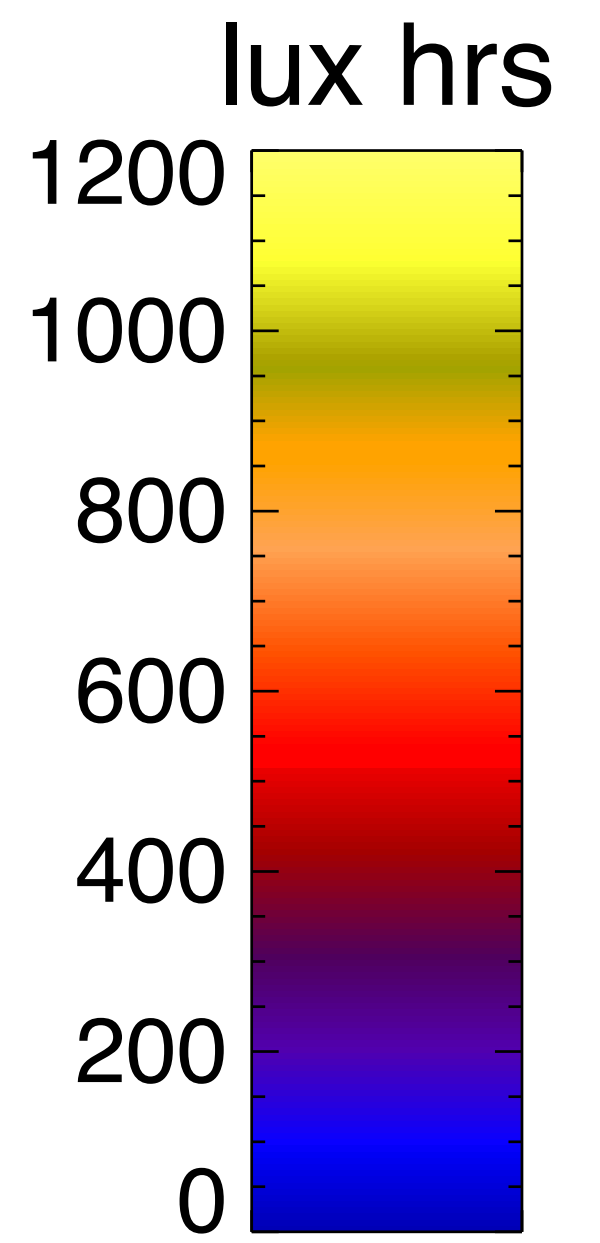
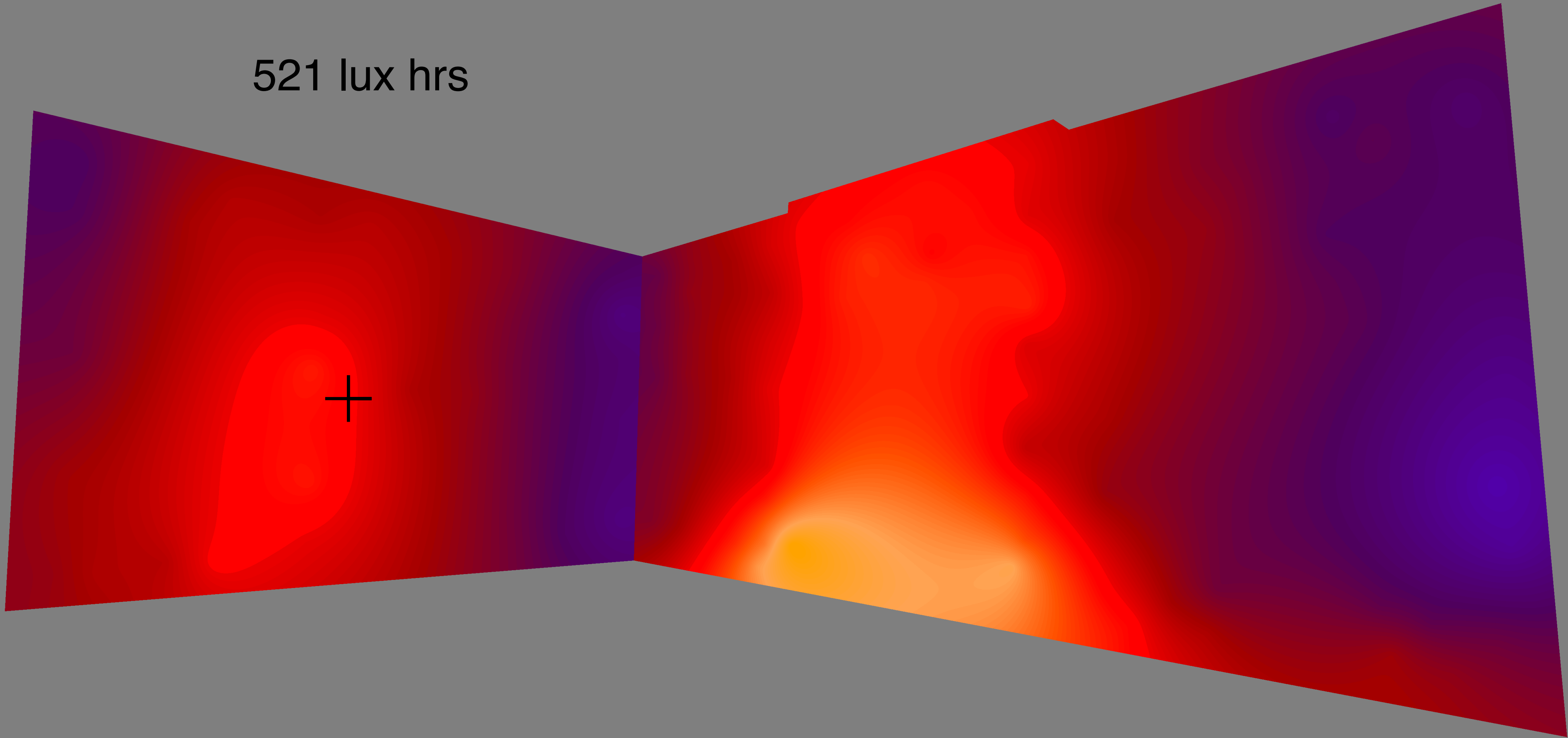






16-06-06

521 lux hrs



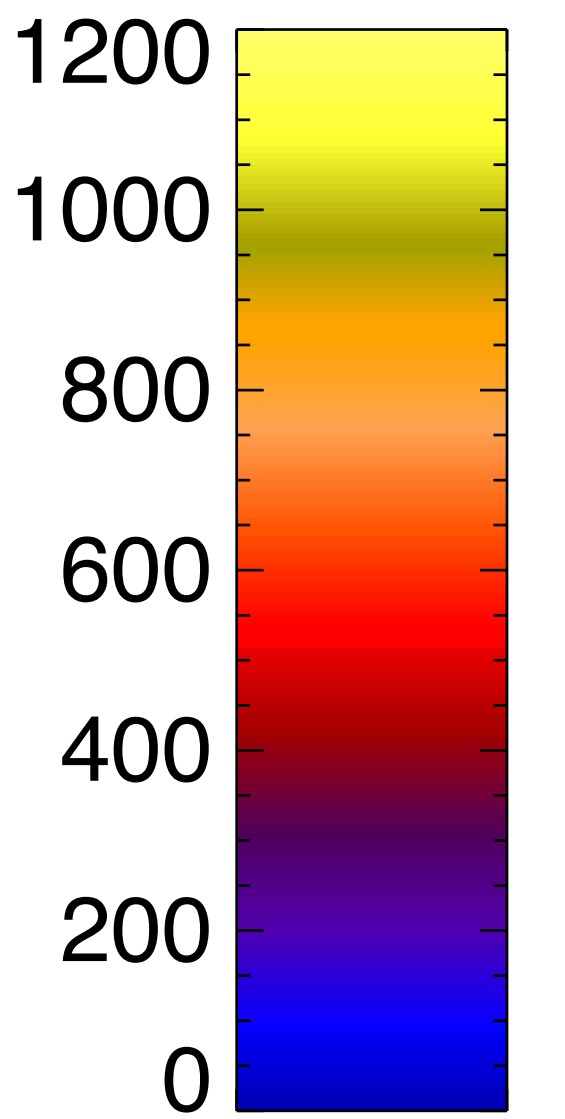


16-06-07

636 lux hrs



lux hrs





# Acknowledgements

**Katy Lithgow:** National Trust, UK

**Nigel Blades:** National Trust, UK

**Stephen Cannon-Brookes:** UCL/Cannon-Brookes Lighting & Design, UK

<http://climate-based-daylighting.com/>

[Link to staff webpage](#)

