

Light as a Disruptor to be Measured

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Pollution: what's that?

- centuries ago: religious notion only
-
- 60's: toxic additives to the environment
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- now, a *technical term*, take it calmly:
 - Alteration of the Natural State
 - due to Human Activity
-
- – if harmful to us or other beings,
- that might be difficult to find

chemical example

- Low level exposure to arsenic in drinking water **may pose cancer risk**
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- Long-term, low level exposure to arsenic in drinking water may increase a person's risk of skin cancer, according to a new study conducted in Hungary, Romania and Slovakia. The study suggests that **levels of inorganic arsenic previously thought to be harmless** may have a carcinogenic effect over a longer period of time.

example of Noise / Sound

- Sound pollution?
-
- (sound: OK, good, healthy, reasonable...)
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- Therefore: Noise pollution.
- Or: Acoustic pollution

Which sound is **no pollutant**?

That of **natural origin**

- If the natural background is very silent, even a small amount of acoustic energy added by people is regarded as very polluting.
-
- If the man-made sound adds just 0.5 dB to the natural background, with no discernible spectral difference, we cease to notice such minor pollution (0.5 dB is 12 %). It is **tolerable**...

Want to Sleep Well?

- Darkness and silence are a must

Light as a pollutant

- Light pollution – no heavy issue?

Reasons for lighting

- people out of nature don't like darkness, even adults
- darkness is full of ghosts
- today, no ghosts, but: murderers, robbers...
- seeing your way makes walking or riding easier
- but **no crime reduction**, on the contrary...

Life in nature

- most animals active at night
- darkness is the basic protection
- alteration of light environment is fatal for them
 -
 - The points or areas of super-high luminance are the worst,
 - but
- even the mere absence of natural darkness is a problem

Light is a serious pollutant

- **Photopollution:**
 - degradation of photic habitat
 - by artificial light
 - (Verheijen, 1985)
- **Darkness is a biological imperative**
- **Scotobiology**

Similar to fossil carbon emissions

Both pollutants considered harmless 40 years ago,

both are very harmful.

Solution:

don't waste so much, be careful
the less, the better

Light regarded as Dirt – a blasphemy?

- Isn't light the very symbol of goodness?
-
- Of course... but a false one
- **Natural variation of day and night is the real blessing**
-
- Compromising a true night by artificial lighting is pollution, albeit inevitable in some cases in some amount; **all outdoor lighting is polluting**

We should accept this fact... and adhere to any of compatible definitions of Light Pollution

- (as listed with references [in Wikipedia](#)):
- Degradation of photic habitat by artificial light.
- Alteration of natural light levels in the outdoor environment owing to artificial light sources.
- **Alteration of light levels in the outdoor environment (from those present naturally) due to man-made sources of light.** Indoor light pollution is such alteration of light levels in the indoor environment due to sources of light, which compromises human health.
- **The introduction by humans, directly or indirectly, of artificial light into the environment.**

Let's inspire by

- World experts **shed light** on the extent of dangers of night-time artificial lighting:
- 'The most important thing for us is to raise awareness of the dangers of artificial light at night...' (prof. Abraham Haim, September 2012)
- (see also University of Haifa **press release**)

Our goal: minimizing light amounts at night, incl. wiping out light serving no purpose

- Amounts? The oldest “unit”: **candle** – so much light sends candle flame in each direction around itself
- Its modern implementation: **candela** – one of the 7 basic units of **SI**
- Unit of? **Luminous intensity**
- Do we see it? No.

We perceive **ratios** of Luminance

- luminance is expressed in units of candela per square metre, **cd/m²**
- **non-English** languages may name it shortly and conveniently: **nit**, symbol 'nt'
- **luminance can be documented by any camera giving raw counts** from its CCD or CMOS pixels; knowing the exposure settings, the only parameter to be found is a proportionality constant, valid forever



Do we have an instrument, measuring the luminance directly?

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- Yes we have – the SQM
- However, it displays a logarithmic quantity
- - faintness of a “angular square second” expressed in magnitudes (faintness: the more the fainter)
- roughly, 5 mag : 1000 nt, 10 mag : 10 nt, 15 mag: 0.10 nt, 20 mag: 1 mnt, 21.6 mag: 0.25 mnt... (what corresponds to 7.5 mag?)
- (precisely, 1080, 10.8, etc. - neglect 8 %)

A more common instrument is a luxmetre

-
- - we can get some luminances by it too:
- point it toward a large surface of a uniform luminance, keeping it no farther than $1/5$ of its size from it
- and divide its reading by π , or simply by 3
- Any camera can be calibrated this way!

Pointing the sensor away from the surface gives its illuminance, the ratio of the previous reading to this one is the *albedo*. Try this for asphalt or concrete roads!

Day and night alteration of the 'horizontal illuminance' the basic rhythm of our world

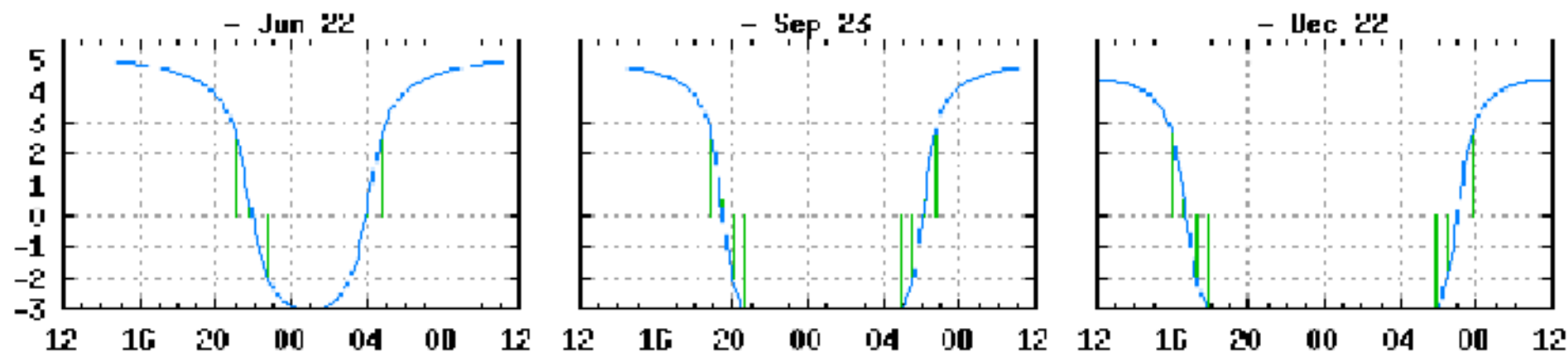
- sunny day 30 thousand to 100 thousand lux
- 1/1000 lx at night
- overcast: 3x to 30x less
- day/night ratio: 3 millions to 1000 millions
- full moon night – 1/10 lx
(the ratio day/night diminishes 100x)



What about indoors?

- Orders of magnitude less light than outdoors – originally
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- Now, tens or hundreds of lux at night
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- Often stronger than in daytime...
-
- But traditionally? Vertical illuminance 1 m from a candle is 1 lx.

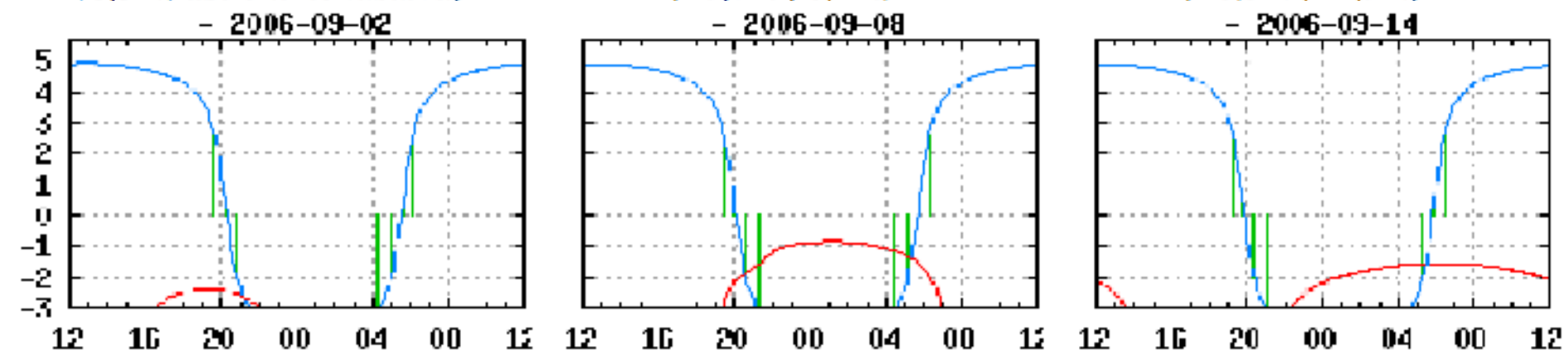
log (horizontal illuminance / 1 lx) clear sky, with/out Moon



letní slunovrat
(6,3 h, astron. nenastává)

rovnodennost
(10,7 h, 8,2 h)

zimní slunovrat
(14,5 h, 11,9 h)



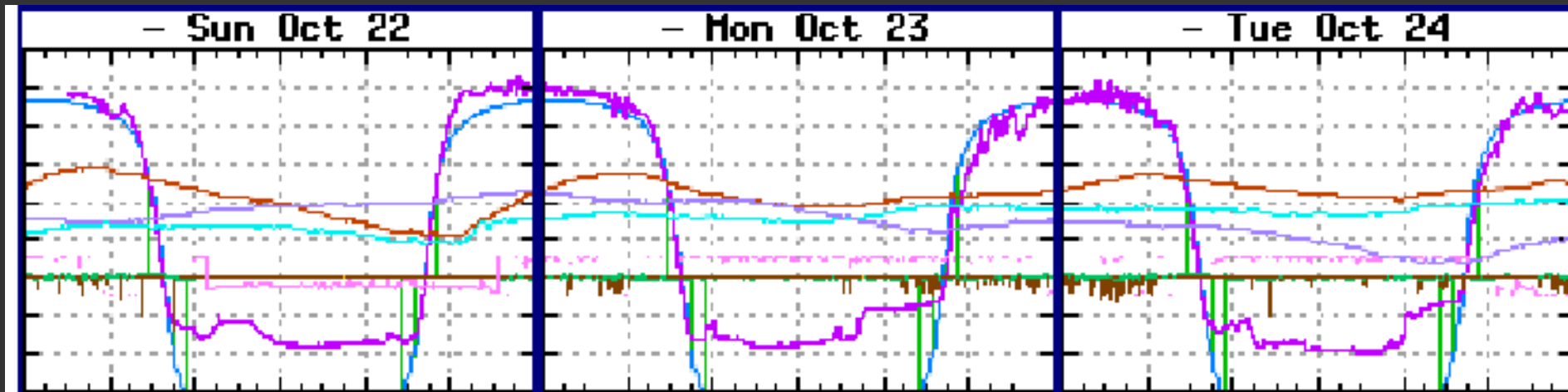
půl dne po první čtvrti
(max. 0,004 lx, ve dne...)

úplněk
(téměř 0,2 lx)

0,5 d před poslední čtvrtí
(až 0,03 lx)

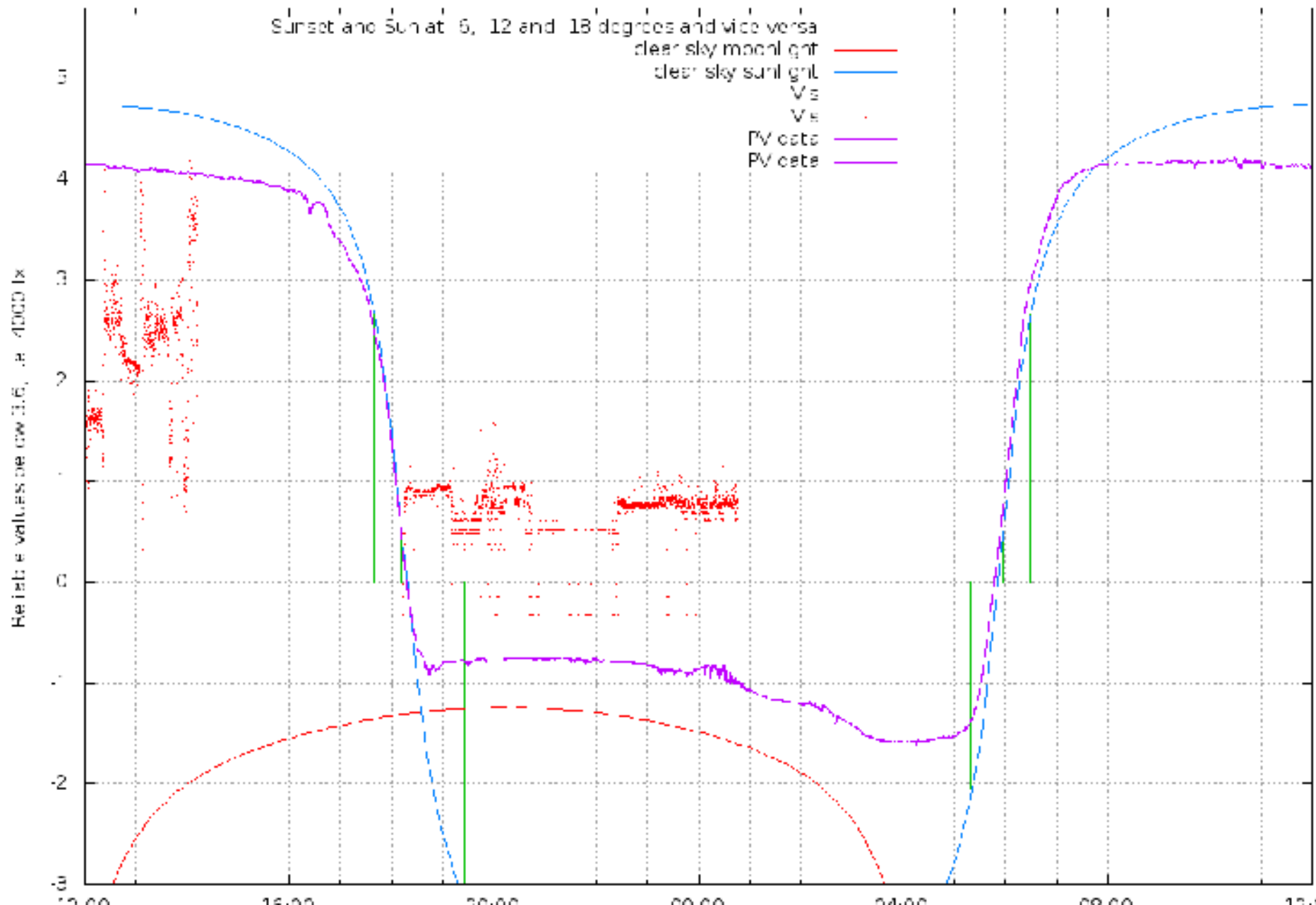
Brno, Kuhberg

- Clear sky: 1 to 2 centilux instead of 1 millilux
- Overcast: decilux levels

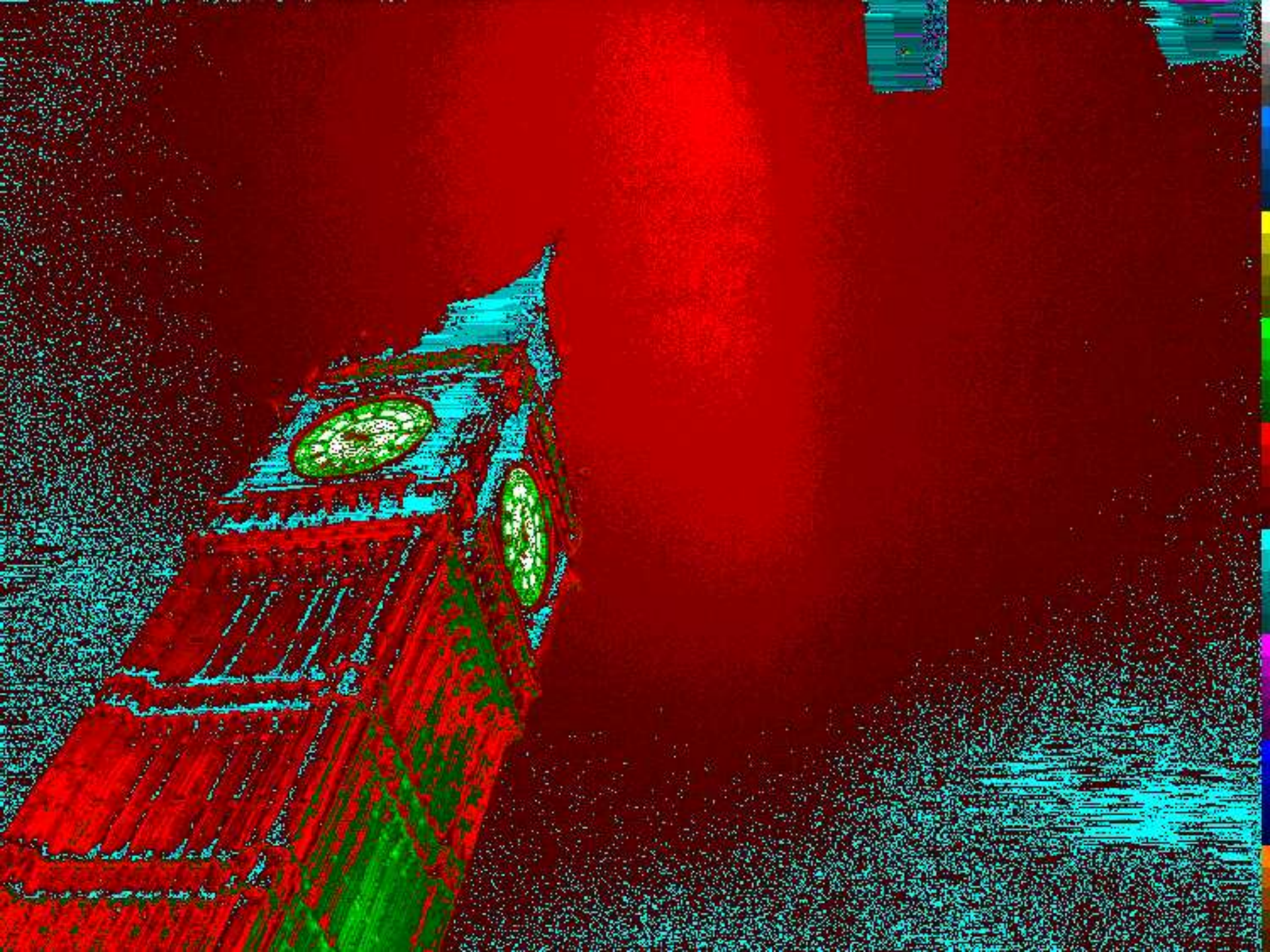


ISL29020 data

log10 (illuminance / lx), ending at 2012-03-04 noon







raw2lum example



What do we need to (be able to) measure:

- http://amper.ped.muni.cz/light/lp_what_is.pdf

Overcast sky at night outdoors, ground and window illuminances, billboard luminances, brightnesses of distant lamps (i.e., luminous flux densities arriving from them)...

Luxmeter, SQM and raw-data cameras enable us to do that all, we should just learn it...