

RGB Radiometry and Photometry with Common Instruments

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Night photometry: low light fluxes,
below the resolution of old conventional luxmeters

SQM – Sky Quality Meter helps a lot.

It can be adapted to get a smaller angular aperture.

And to become a computer periphery.

Even a PV panel may do –

with a multimeter, esp. connected to a computer.

Continuous monitoring at several sites, Brno online:

`amper.ped.muni.cz/weather`

Another electric solutions offer microlux sensitivities.

Most informative way: imaging radiometry

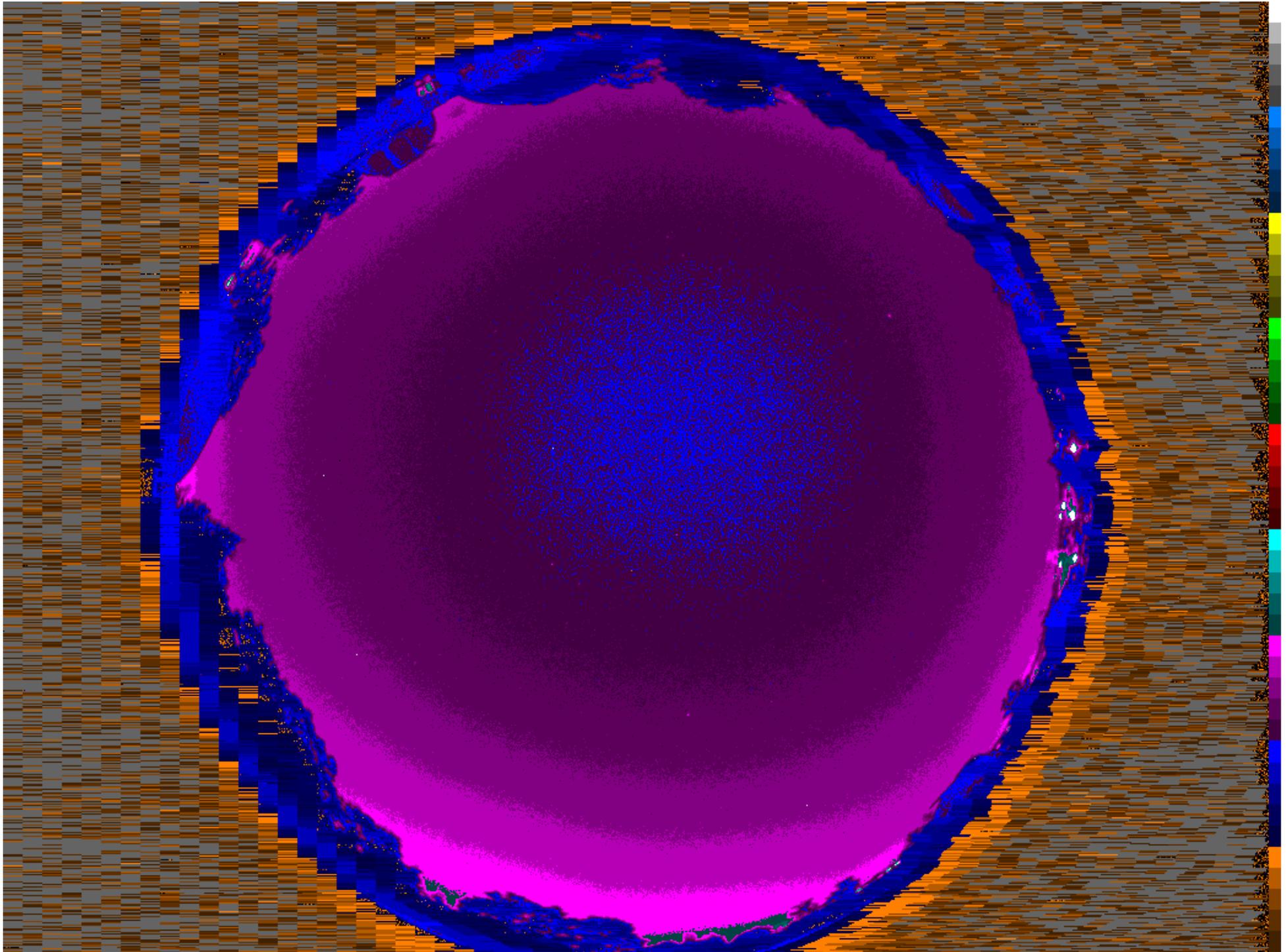
Scientific CCD cameras with filter wheels (ISTIL, NPS)

Modern “citizen” digital cameras

– offering raw data, manual control and many second exposures

Full fish-eye view – an ideal. Two examples:





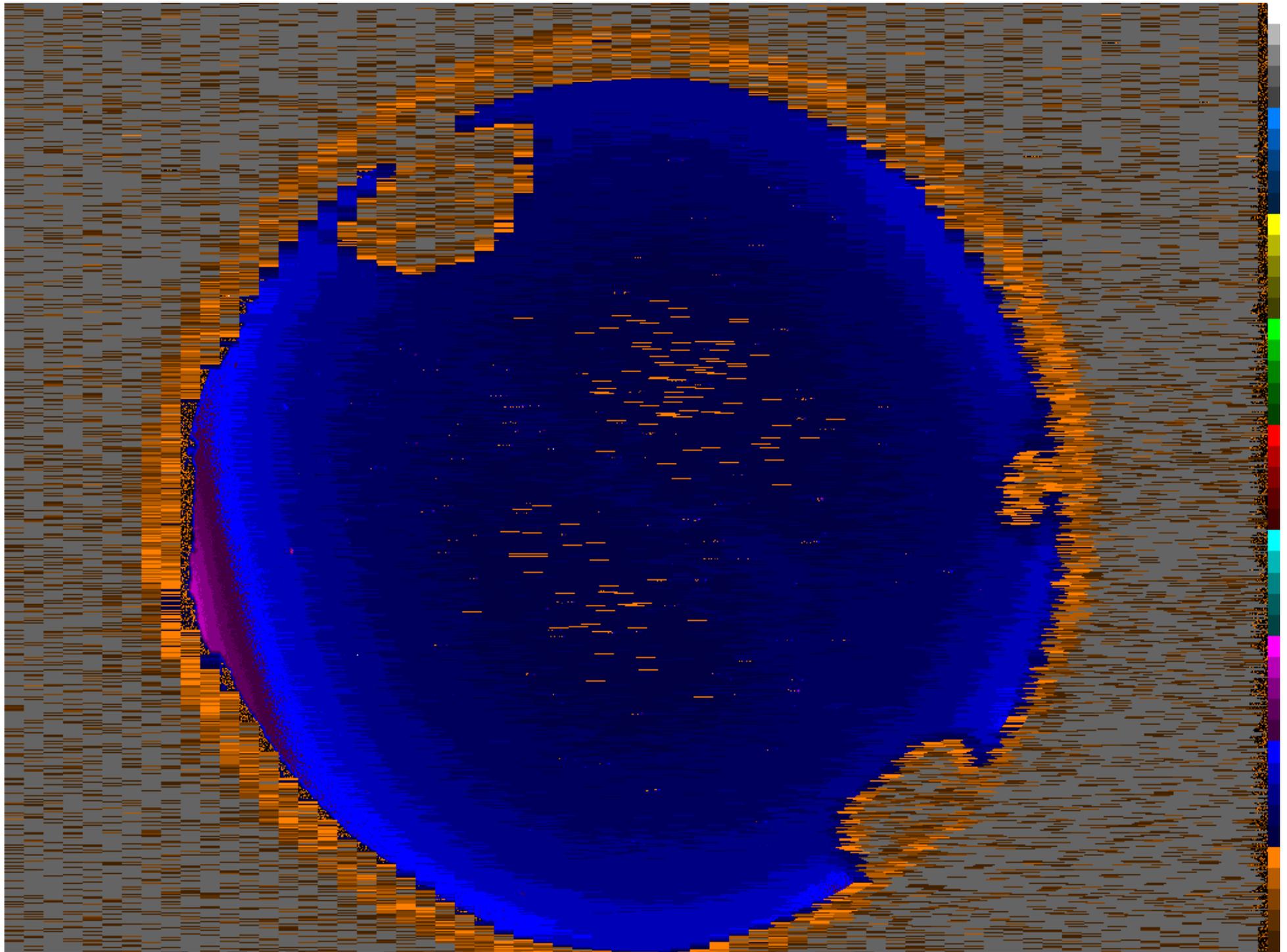
– sky above Brno Observatory, 2005-8-12 22:32:33
(Perseid maximum, beginning of astronomical night)
Nikon 990 with FC-E8 fish-eye converter, 60 s exposure

Horizontal illuminance 0.018 lx

Computed SQM 0.0041 cd/m², 18.54 mag

Fine steps: 0.2 mag, middle red: 1 cd/m², middle magenta: 0.01 cd/m²





– 22 km to the WNW, three hours later

Horizontal illuminance 0.0020 lx

Computed SQM 4.79E-4 cd/m², 20.88 mag

Middle blue: 0.001 cd/m²

2004: software published (GPL),

2005 and 2006: Giant Mountains Natural Park exploration

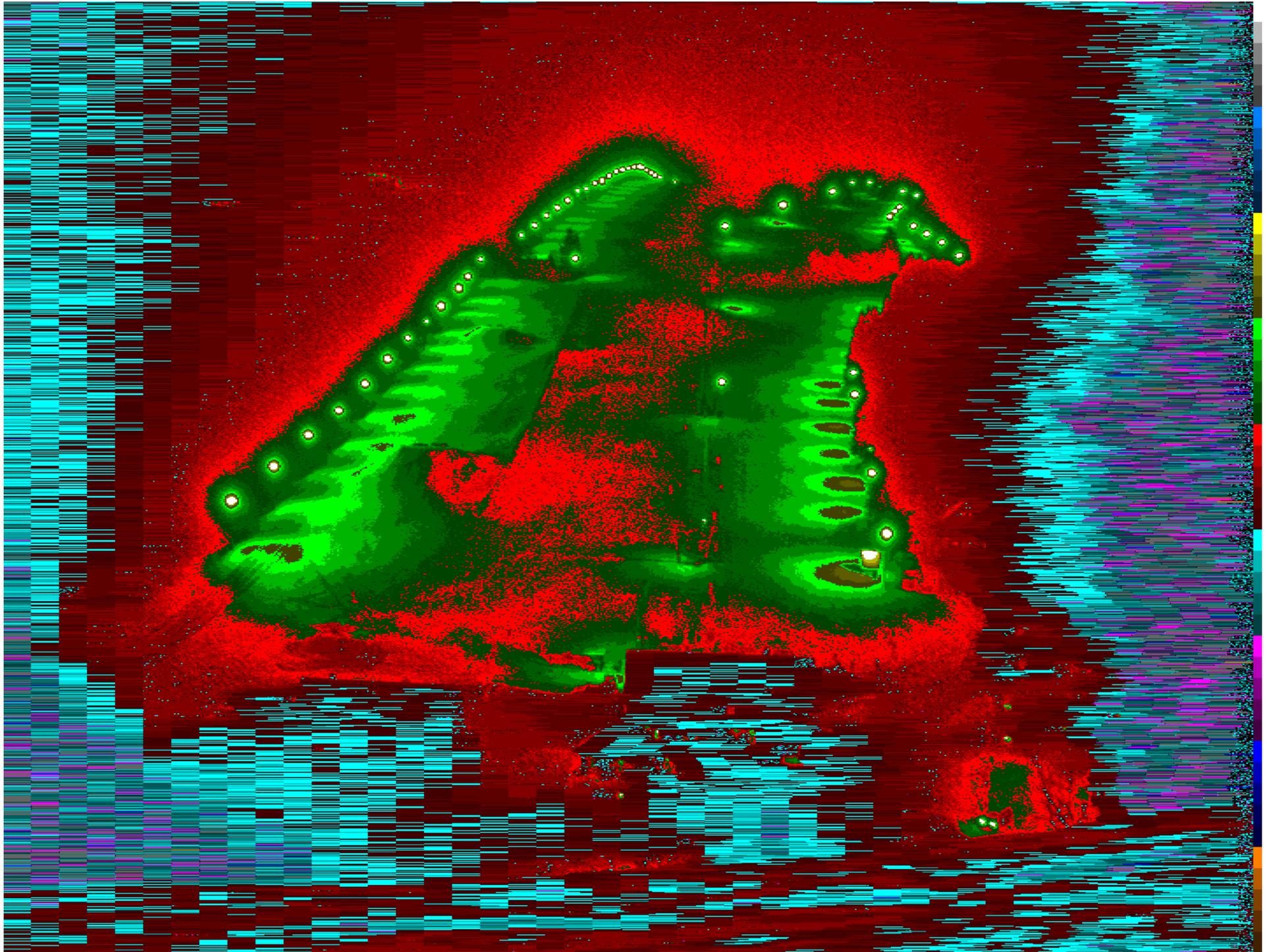
The Park's winter night environment:

2× to 10000× more light than in nature

natural dominants disappear, lamps reign the landscape

two strongly lit ski slopes add more light than the rest of the world





1 0 8 0.315	1 1 22 0.420	1 2 34 0.524	1 3 50 0.719	1 4 76 1.04	1 5 96 1.24	1 6 87 1.15	1 7 64 0.888	1 8 33 0.565	1 9 2 0.277
2 0 14 0.339	2 1 27 0.444	2 2 44 0.602	2 3 68 0.927	2 4 124 1.61	2 5 158 1.98	2 6 131 1.64	2 7 90 1.18	2 8 40 0.602	2 9 0 0.215
3 0 15 0.363	3 1 30 0.505	3 2 52 0.794	3 3 98 1.36	3 4 276 6.39	3 5 314 6.50	3 6 241 4.33	3 7 141 2.60	3 8 42 0.624	3 9 0 0.120
4 0 15 0.344	4 1 33 0.521	4 2 65 0.937	4 3 160 2.70	4 4 649 9.52	4 5 360 5.48	4 6 385 6.02	4 7 284 7.57	4 8 38 0.614	4 9 0 0.0906
5 0 17 0.329	5 1 36 0.547	5 2 89 1.23	5 3 663 10.7	5 4 513 7.24	5 5 313 4.71	5 6 428 6.16	5 7 78 1.38	5 8 27 0.441	5 9 0 0.0961
6 0 16 0.325	6 1 49 0.704	6 2 168 3.58	6 3 1088 14.3	6 4 340 4.95	6 5 329 4.92	6 6 764 11.8	6 7 58 0.850	6 8 14 0.342	6 9 0 0.0688
7 0 18 0.345	7 1 77 1.23	7 2 587 11.1	7 3 820 12.3	7 4 290 3.78	7 5 452 5.96	7 6 1082 18.3	7 7 64 1.06	7 8 9 0.280	7 9 0 0.0716
8 0 21 0.362	8 1 131 4.24	8 2 1283 15.3	8 3 393 5.50	8 4 253 3.05	8 5 380 4.98	8 6 1152 17.5	8 7 101 3.16	8 8 13 0.317	8 9 0 0.0680
9 0 23 0.423	9 1 166 4.14	9 2 1102 15.2	9 3 357 4.76	9 4 294 3.51	9 5 446 6.09	9 6 944 18.8	9 7 155 5.02	9 8 16 0.339	9 9 0 0.0693
10 0 29 0.533	10 1 120 1.67	10 2 191 2.91	10 3 232 2.77	10 4 342 4.87	10 5 230 2.56	10 6 251 3.08	10 7 172 2.30	10 8 31 0.575	10 9 0 0.0434
11 0 4 0.196	11 1 58 0.868	11 2 34 0.698	11 3 51 0.963	11 4 75 2.69	11 5 30 0.706	11 6 43 0.841	11 7 80 1.09	11 8 41 1.13	11 9 0 0.0777
12 0 0 0.0838	12 1 11 0.255	12 2 20 0.348	12 3 31 0.508	12 4 71 1.25	12 5 26 0.518	12 6 26 0.564	12 7 88 1.49	12 8 106 1.85	12 9 0 0.0692
13 0 0 0.0727	13 1 0 0.108	13 2 12 0.278	13 3 26 0.419	13 4 38 0.691	13 5 29 0.552	13 6 22 0.418	13 7 56 1.69	13 8 50 1.16	13 9 24 0.463
14 0 16 0.405	14 1 27 0.474	14 2 28 0.507	14 3 30 0.530	14 4 28 0.519	14 5 36 0.616	14 6 40 0.638	14 7 32 0.564	14 8 24 0.445	14 9 18 0.414

– maxima over 200 lx

half of the light to the camera comes directly from luminaires

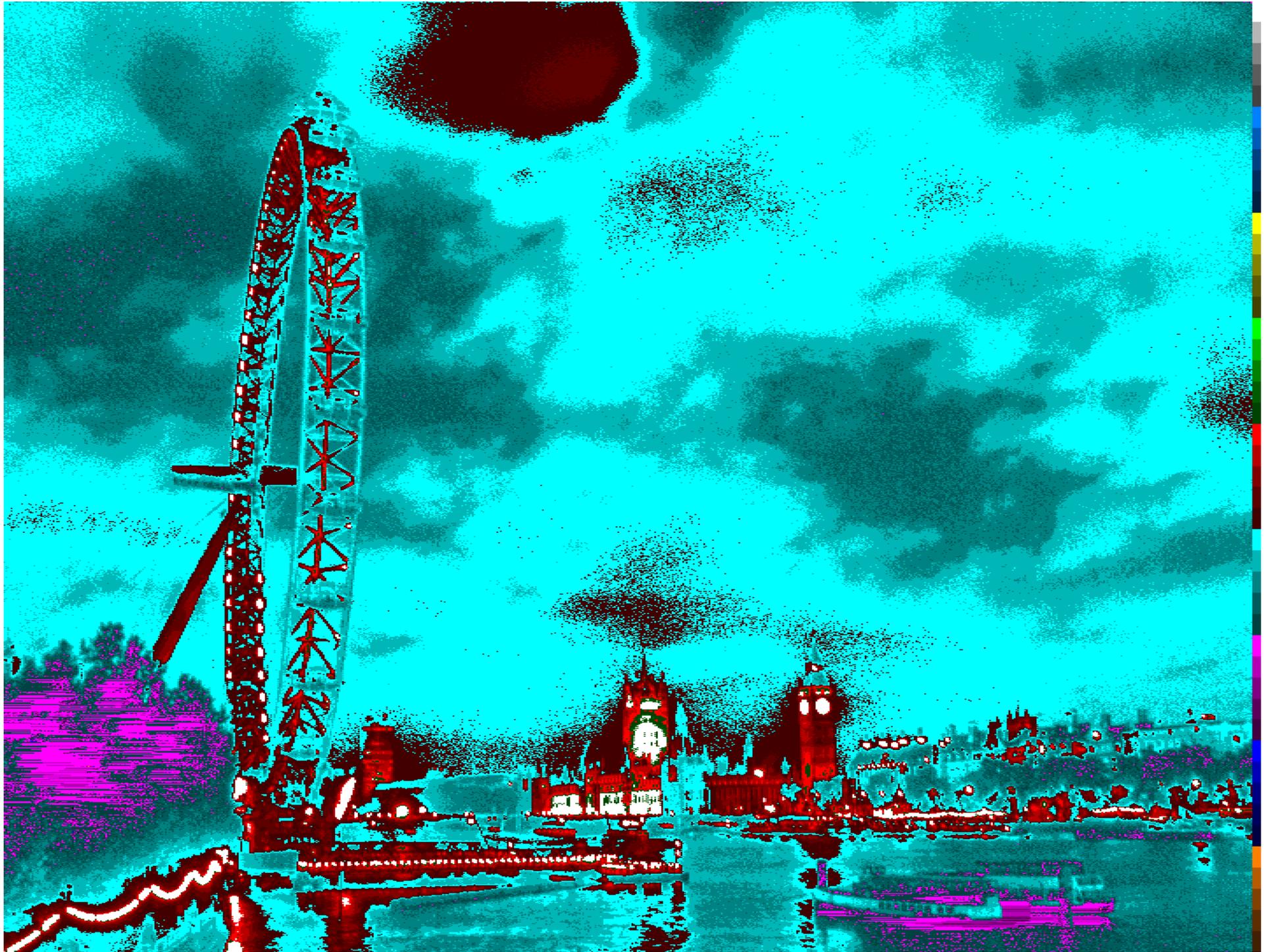
(luminances are given at the bottom of the grid tiles,
median pixel readings in the centre)

London views:

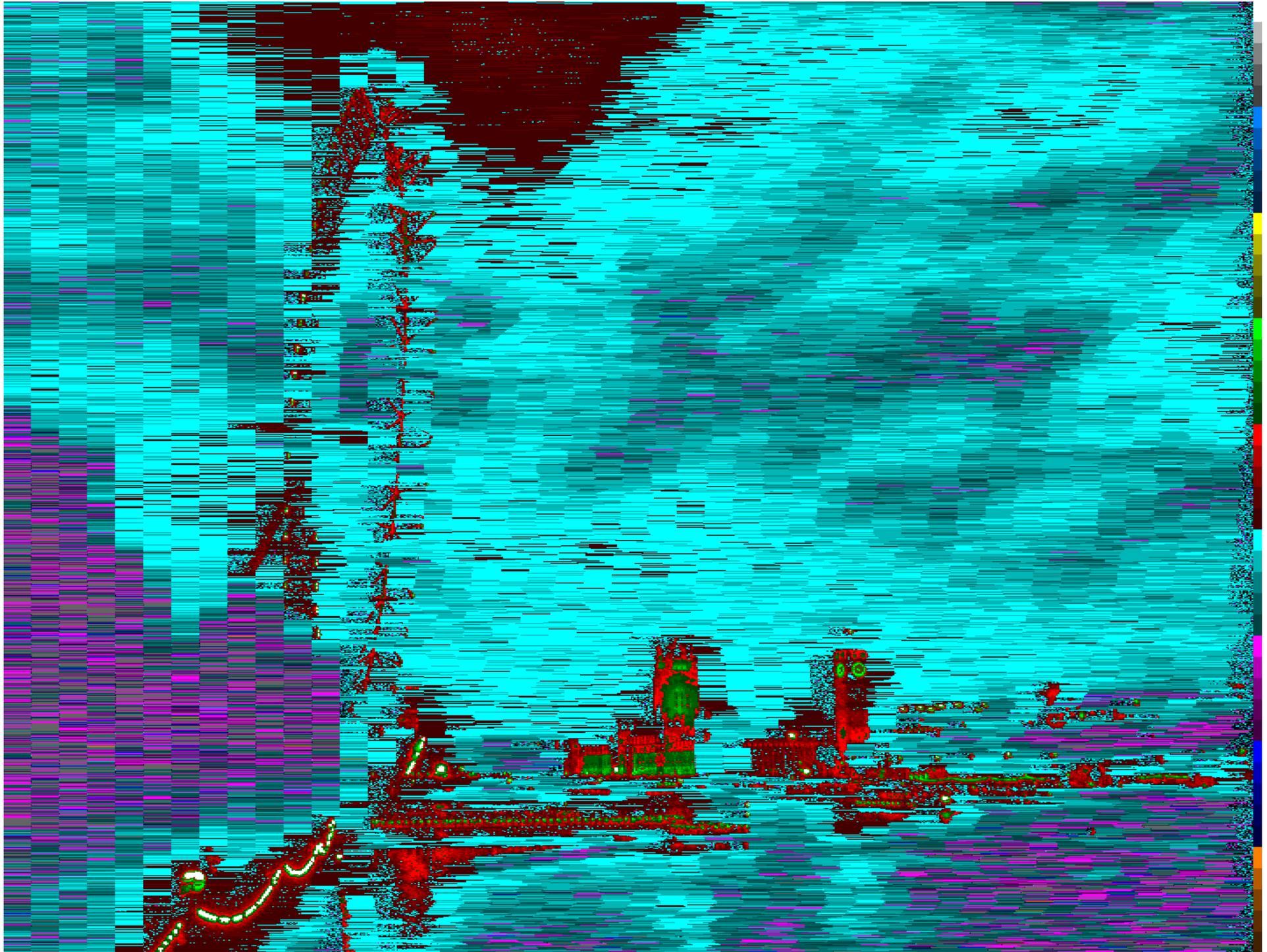


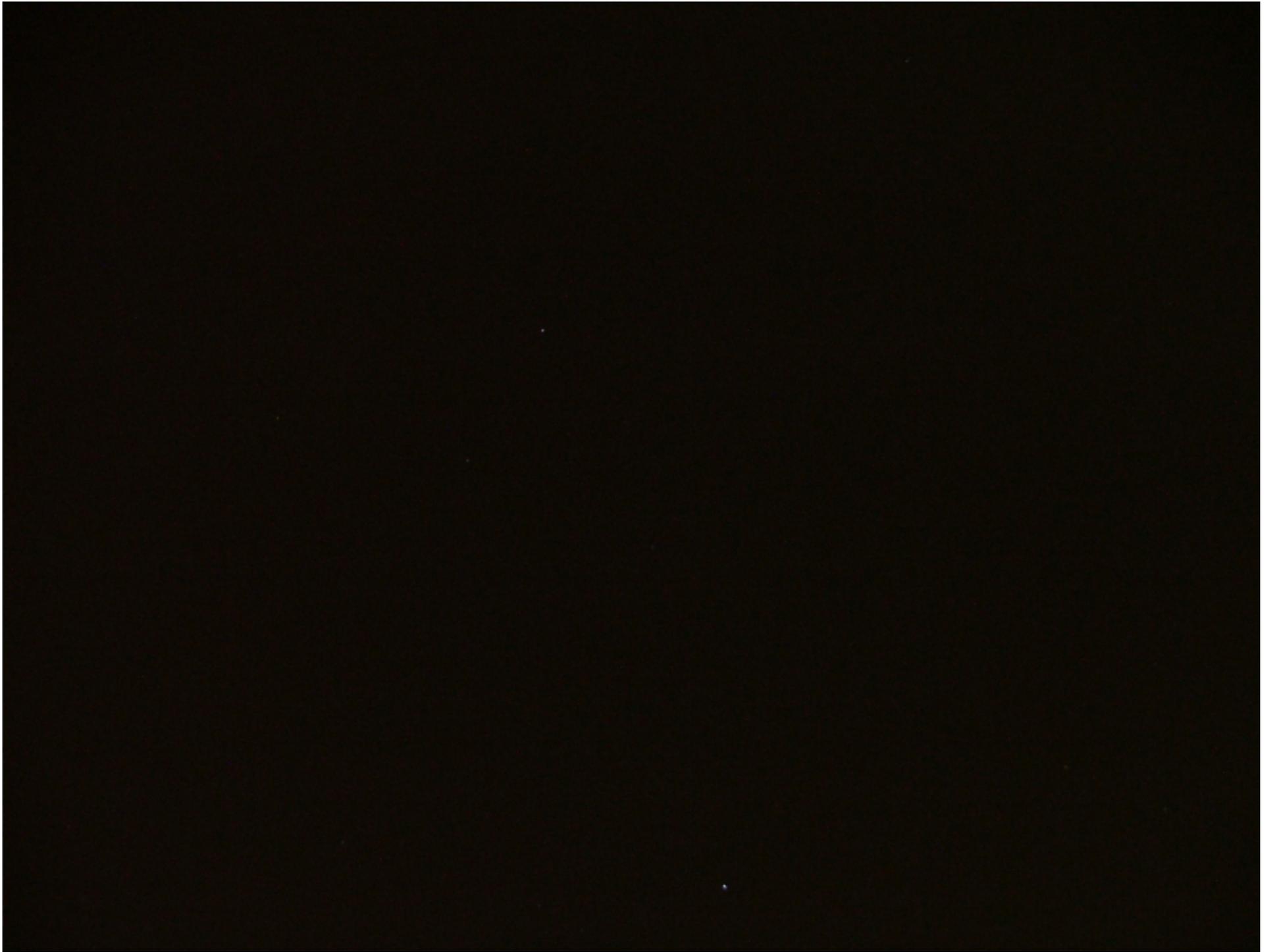


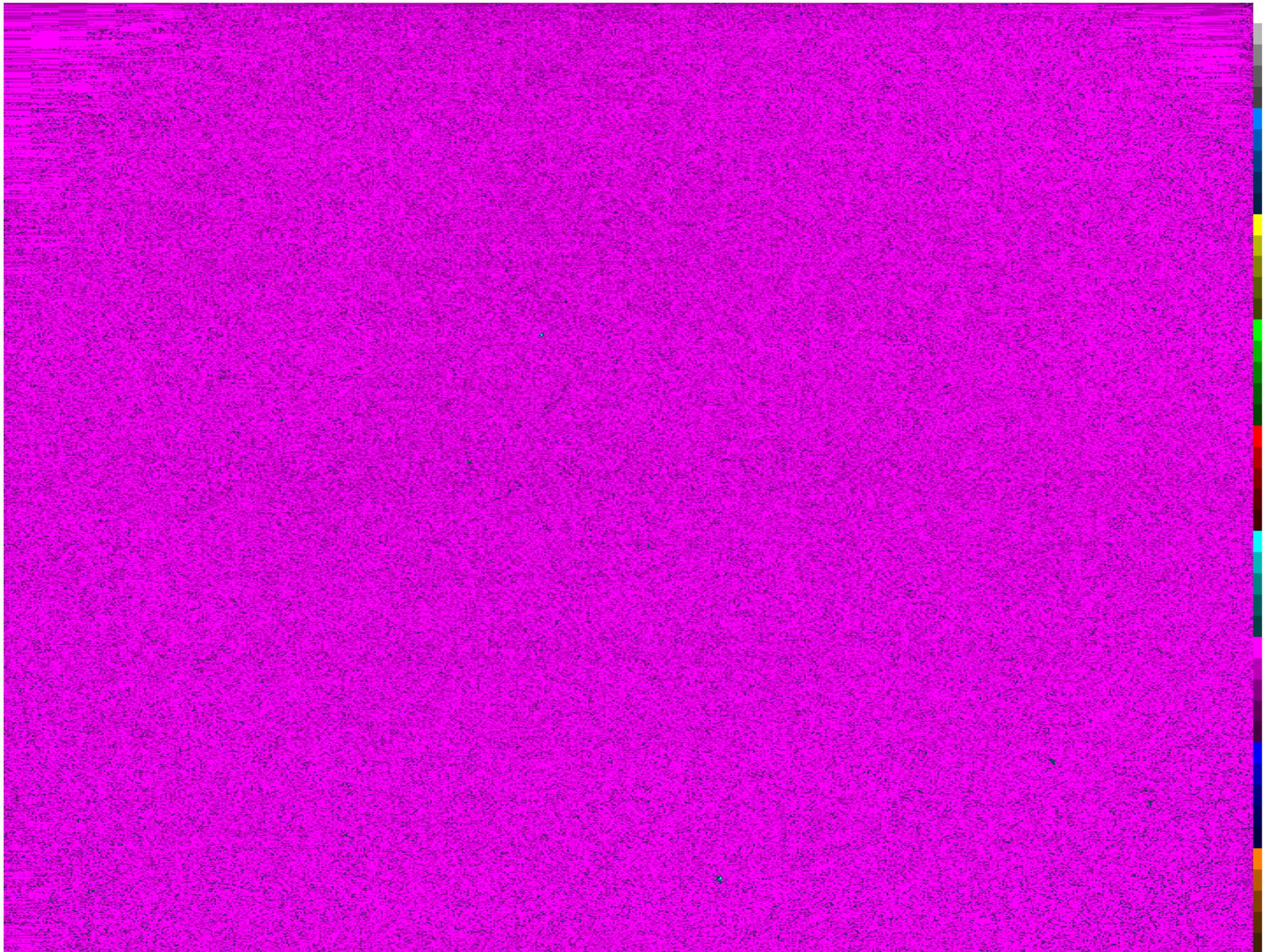












1 0 68 0.0223	1 1 94 0.0229	1 2 102 0.0224	1 3 104 0.0221	1 4 103 0.0220	1 5 108 0.0224	1 6 111 0.0232	1 7 114 0.0236	1 8 107 0.0238	1 9 83 0.0228
2 0 84 0.0237	2 1 104 0.0235	2 2 107 0.0231	2 3 108 0.0232	2 4 107 0.0228	2 5 111 0.0232	2 6 114 0.0239	2 7 116 0.0243	2 8 117 0.0251	2 9 102 0.0248
3 0 95 0.0239	3 1 108 0.0234	3 2 108 0.0234	3 3 109 0.0233	3 4 108 0.0228	3 5 110 0.0232	3 6 113 0.0236	3 7 115 0.0242	3 8 118 0.0246	3 9 114 0.0255
4 0 99 0.0232	4 1 108 0.0230	4 2 109 0.0235	4 3 107 0.0227	4 4 107 0.0225	4 5 109 0.0227	4 6 111 0.0232	4 7 113 0.0234	4 8 116 0.0240	4 9 116 0.0249
5 0 103 0.0235	5 1 110 0.0233	5 2 111 0.0236	5 3 108 0.0229	5 4 108 0.0229	5 5 109 0.0230	5 6 112 0.0234	5 7 112 0.0236	5 8 115 0.0240	5 9 118 0.0250
6 0 108 0.0238	6 1 112 0.0238	6 2 111 0.0237	6 3 111 0.0231	6 4 112 0.0232	6 5 114 0.0234	6 6 114 0.0237	6 7 114 0.0237	6 8 116 0.0242	6 9 119 0.0248
7 0 106 0.0233	7 1 112 0.0236	7 2 111 0.0232	7 3 110 0.0229	7 4 111 0.0232	7 5 112 0.0233	7 6 113 0.0233	7 7 114 0.0235	7 8 114 0.0236	7 9 117 0.0242
8 0 108 0.0235	8 1 111 0.0236	8 2 108 0.0229	8 3 110 0.0229	8 4 112 0.0231	8 5 115 0.0233	8 6 114 0.0234	8 7 113 0.0236	8 8 115 0.0237	8 9 114 0.0240
9 0 110 0.0238	9 1 113 0.0241	9 2 112 0.0235	9 3 113 0.0233	9 4 114 0.0235	9 5 116 0.0238	9 6 115 0.0239	9 7 115 0.0240	9 8 114 0.0239	9 9 117 0.0245
10 0 110 0.0240	10 1 115 0.0244	10 2 113 0.0238	10 3 114 0.0235	10 4 114 0.0235	10 5 116 0.0238	10 6 117 0.0239	10 7 116 0.0242	10 8 116 0.0243	10 9 118 0.0248
11 0 109 0.0242	11 1 115 0.0245	11 2 114 0.0241	11 3 114 0.0238	11 4 116 0.0239	11 5 118 0.0240	11 6 120 0.0244	11 7 119 0.0245	11 8 119 0.0249	11 9 122 0.0254
12 0 109 0.0246	12 1 117 0.0246	12 2 117 0.0248	12 3 119 0.0245	12 4 119 0.0246	12 5 120 0.0249	12 6 122 0.0251	12 7 123 0.0253	12 8 123 0.0256	12 9 125 0.0261
13 0 105 0.0247	13 1 117 0.0248	13 2 117 0.0249	13 3 118 0.0246	13 4 119 0.0249	13 5 121 0.0251	13 6 122 0.0253	13 7 124 0.0255	13 8 125 0.0259	13 9 122 0.0261
14 0 100 0.0253	14 1 118 0.0254	14 2 118 0.0254	14 3 119 0.0253	14 4 121 0.0252	14 5 121 0.0260	14 6 125 0.0259	14 7 126 0.0261	14 8 127 0.0265	14 9 118 0.0267

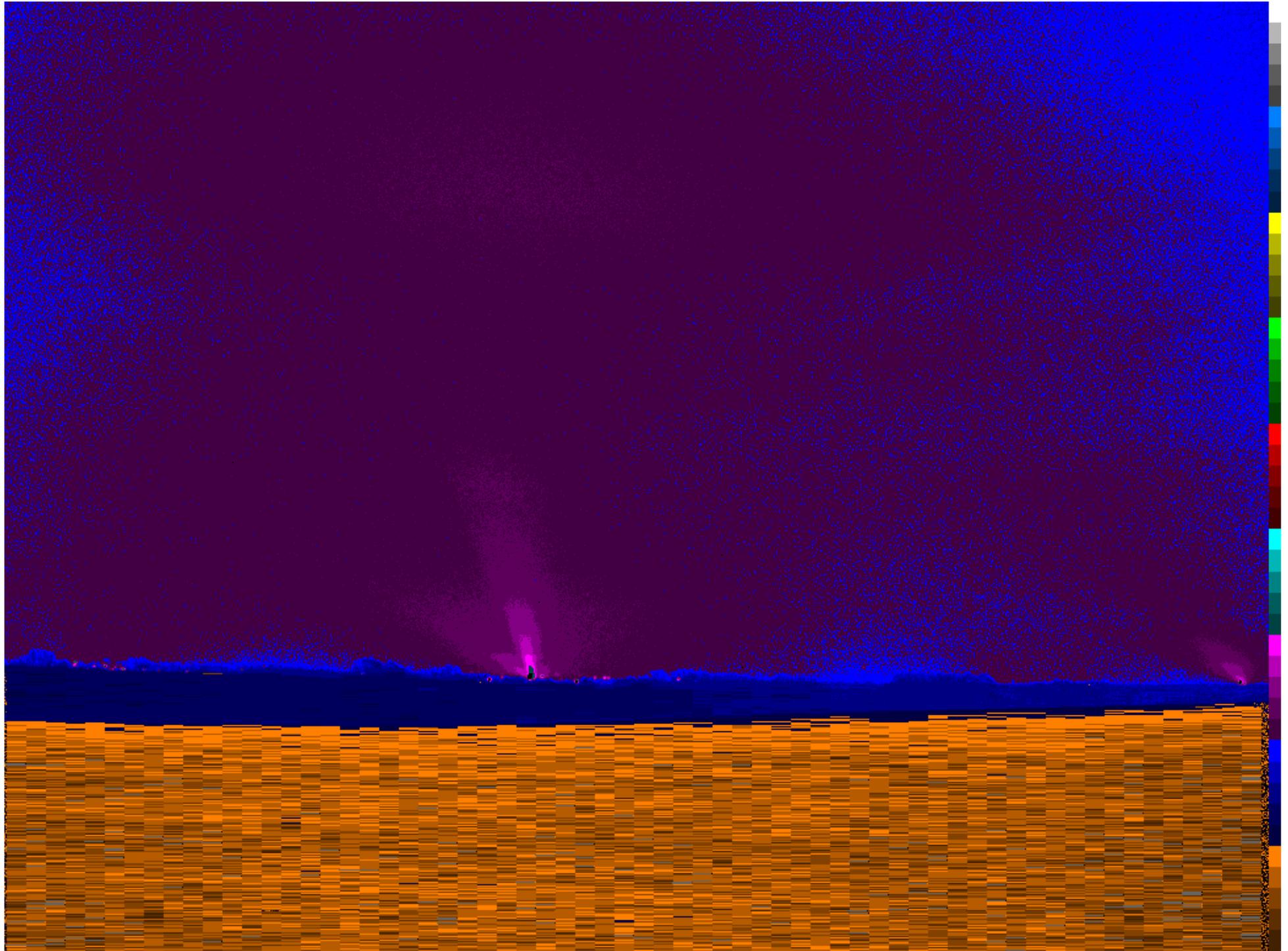
– clear sky with (top of) Northern Cross and Vega

0.024 cd/m² – almost hundred times the natural value

(2s exposure, 2004-09-09 22:53)

Anonymous Czech (celestial) churches:

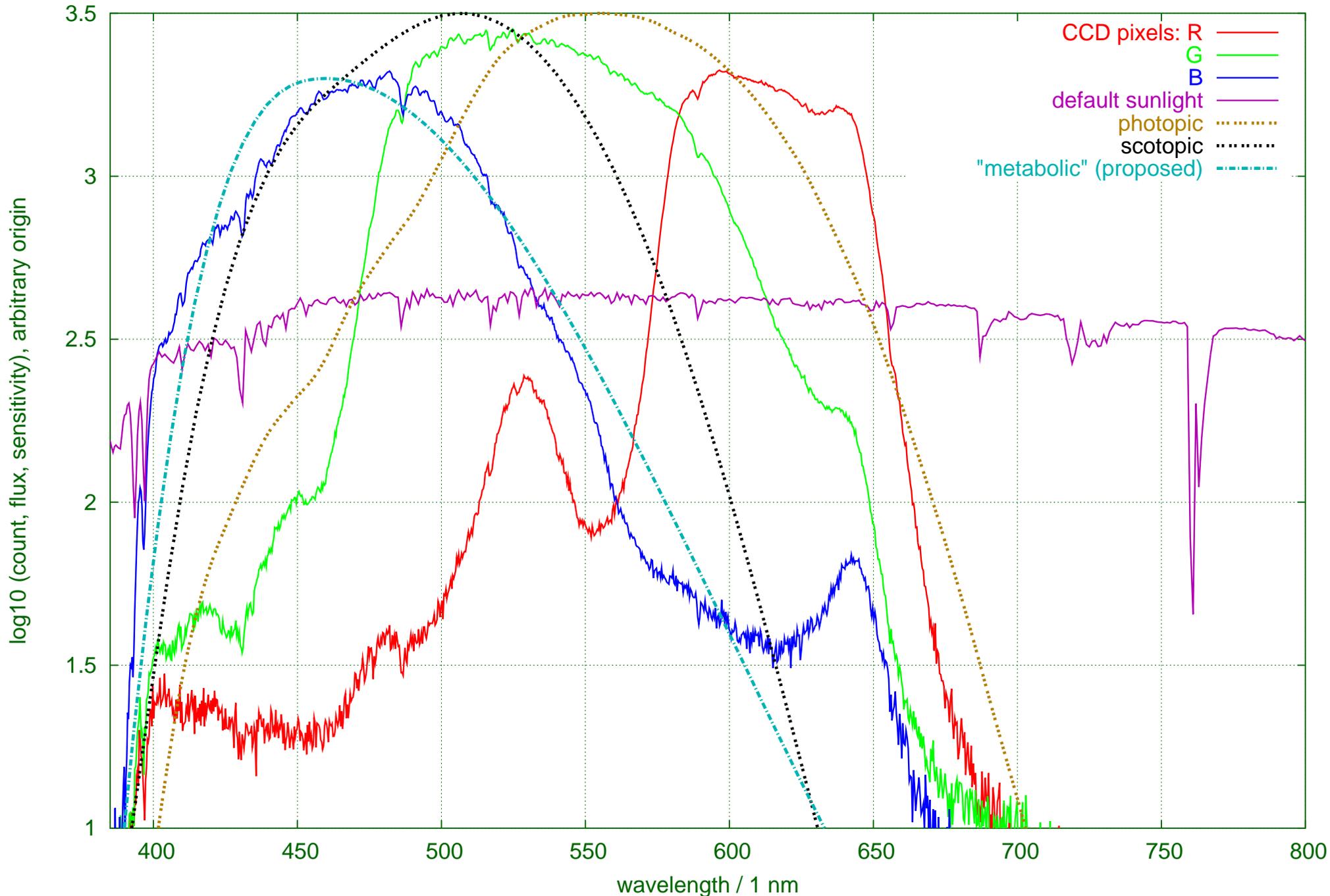




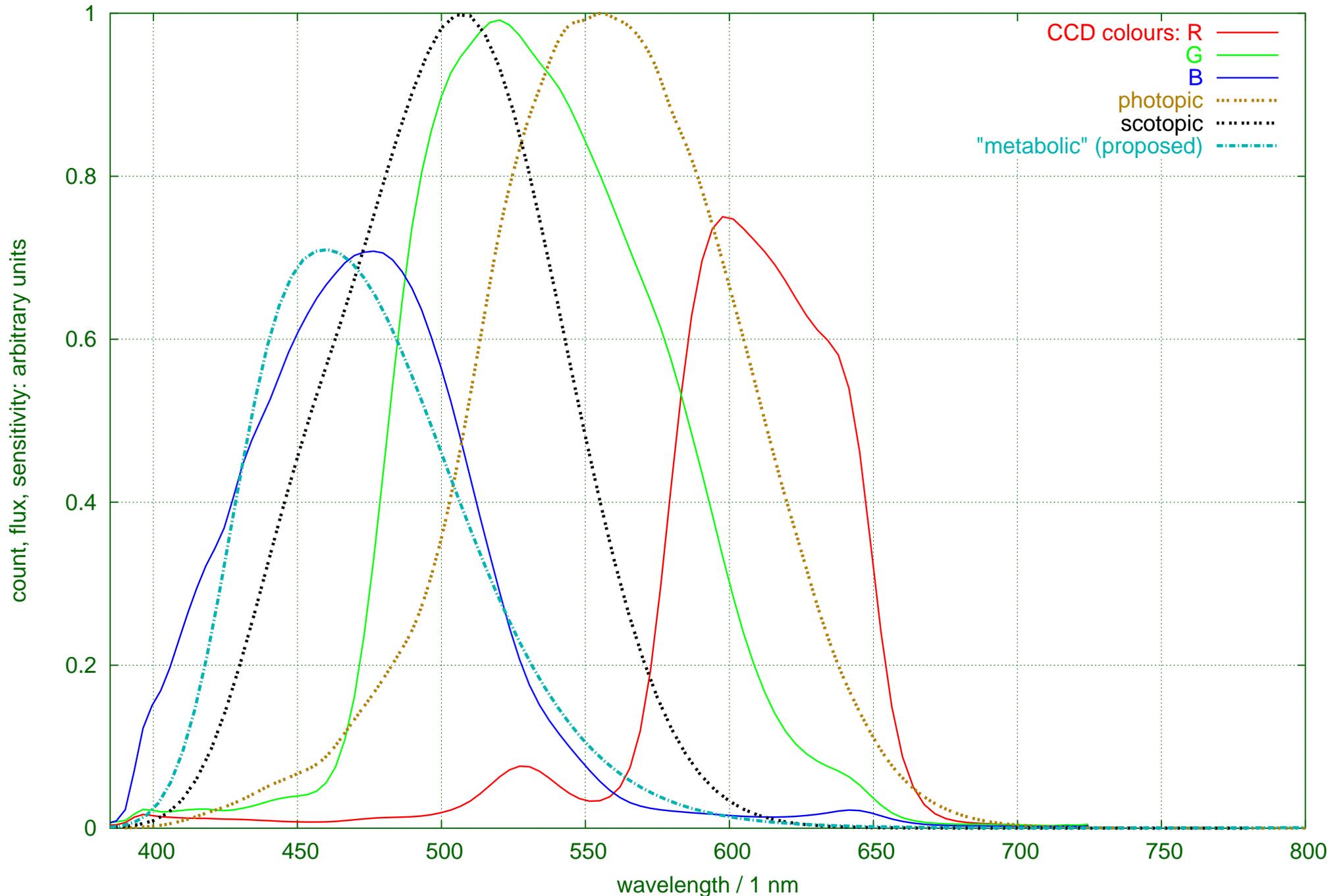
Calibration

- “some” luminance: sunlit/moonlit paper (or white standard)
- spectral sensitivity
- vignetting
- image geometry
- ... good luminances, or even illuminance

Fuji S5000 raw solar spectrum at 'airmass=1.5'



Fuji S5000 spectral sensitivity



Vignetting (light fall-off from the image center)
from images of the same strip, taken at various angles:





Vignetted luminance of yellowish S wall, Brno Observatory

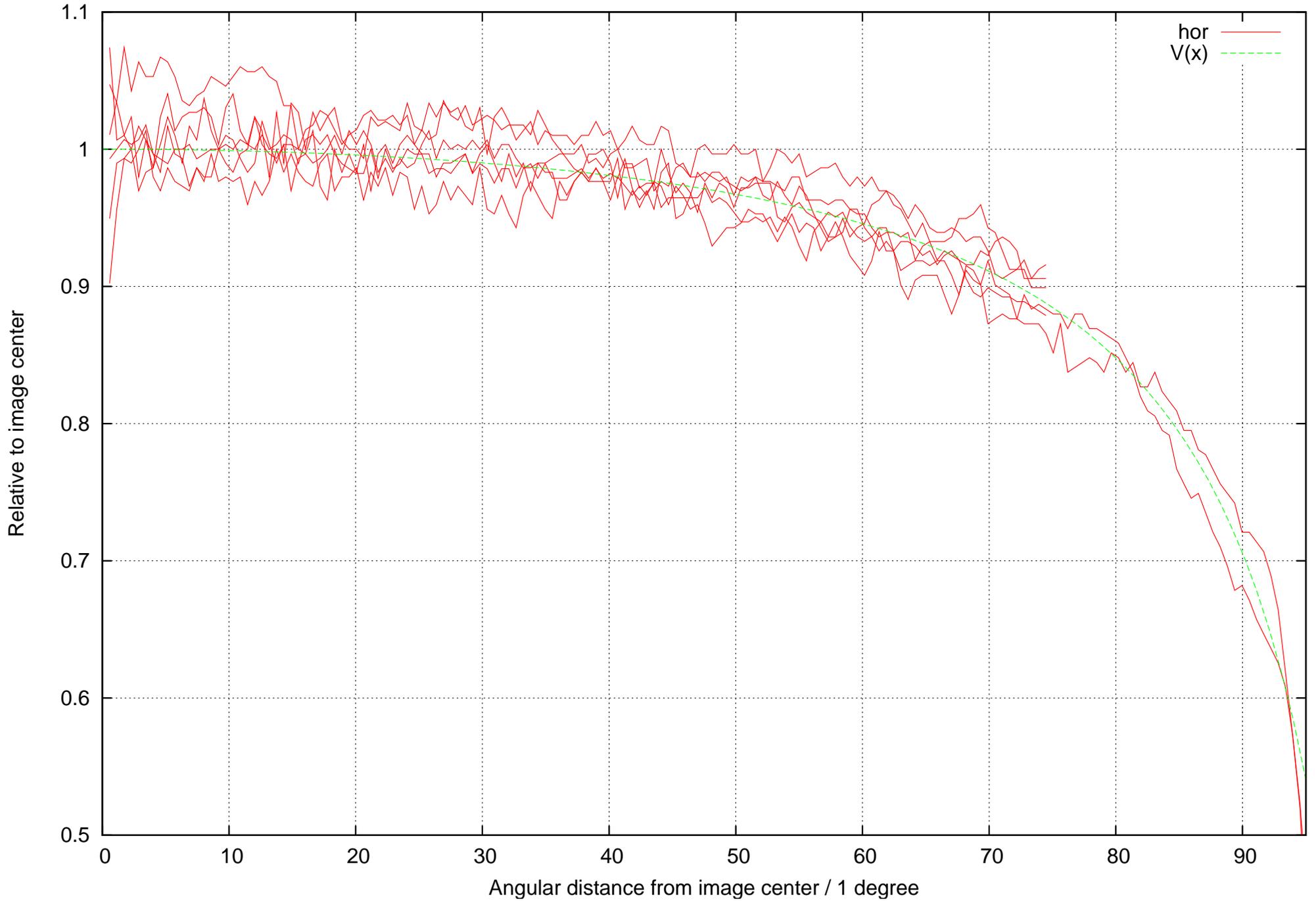
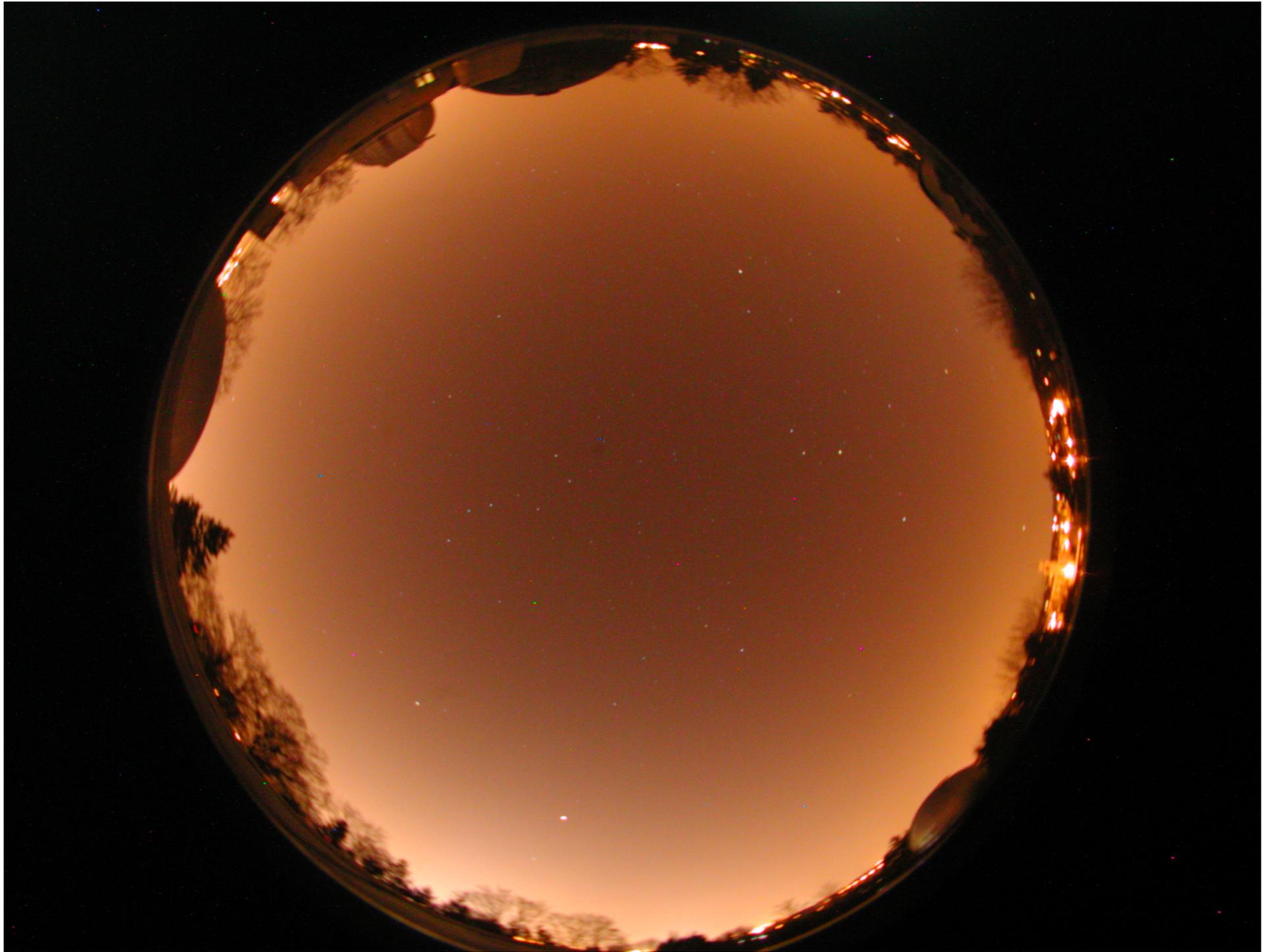
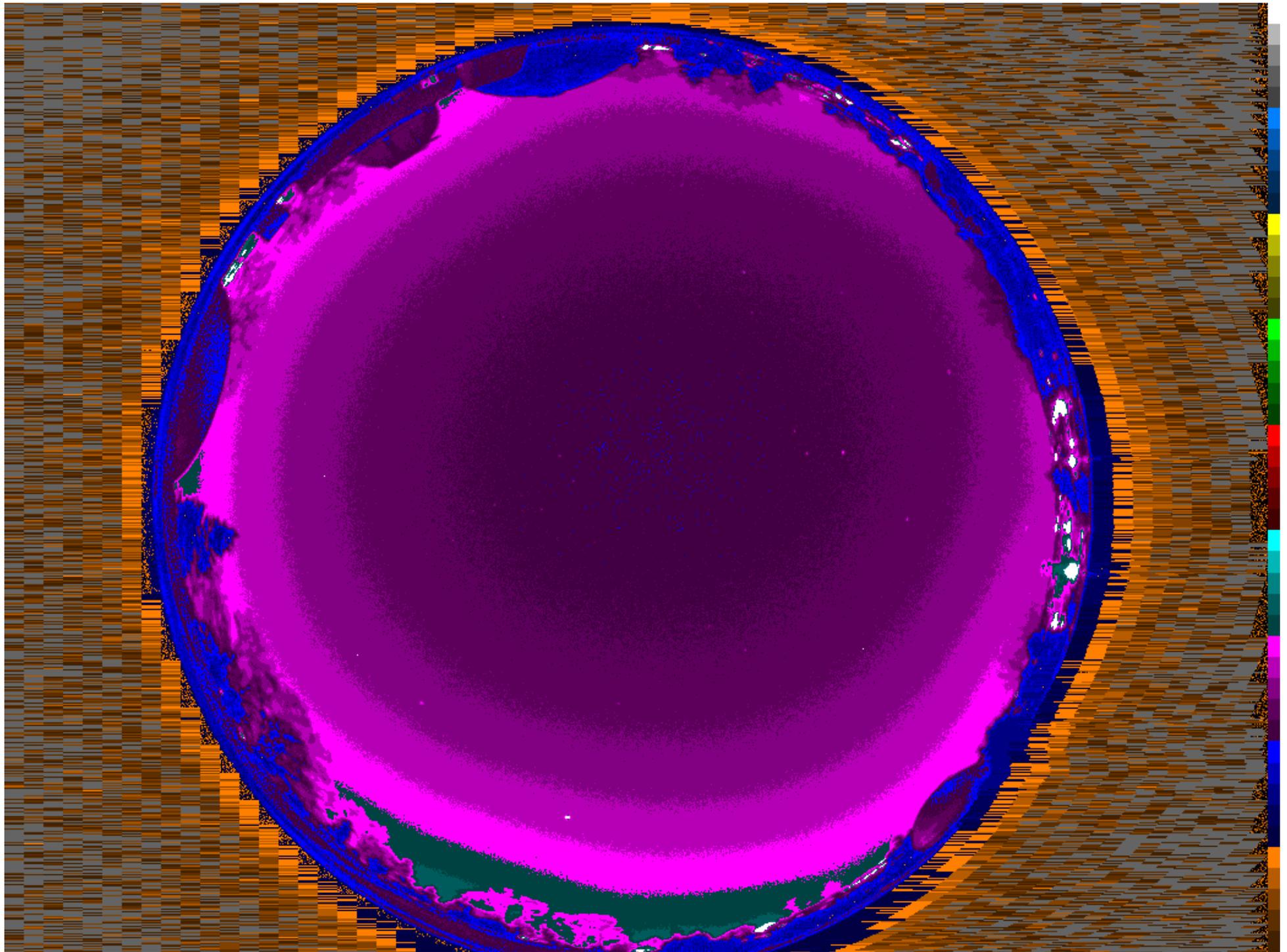
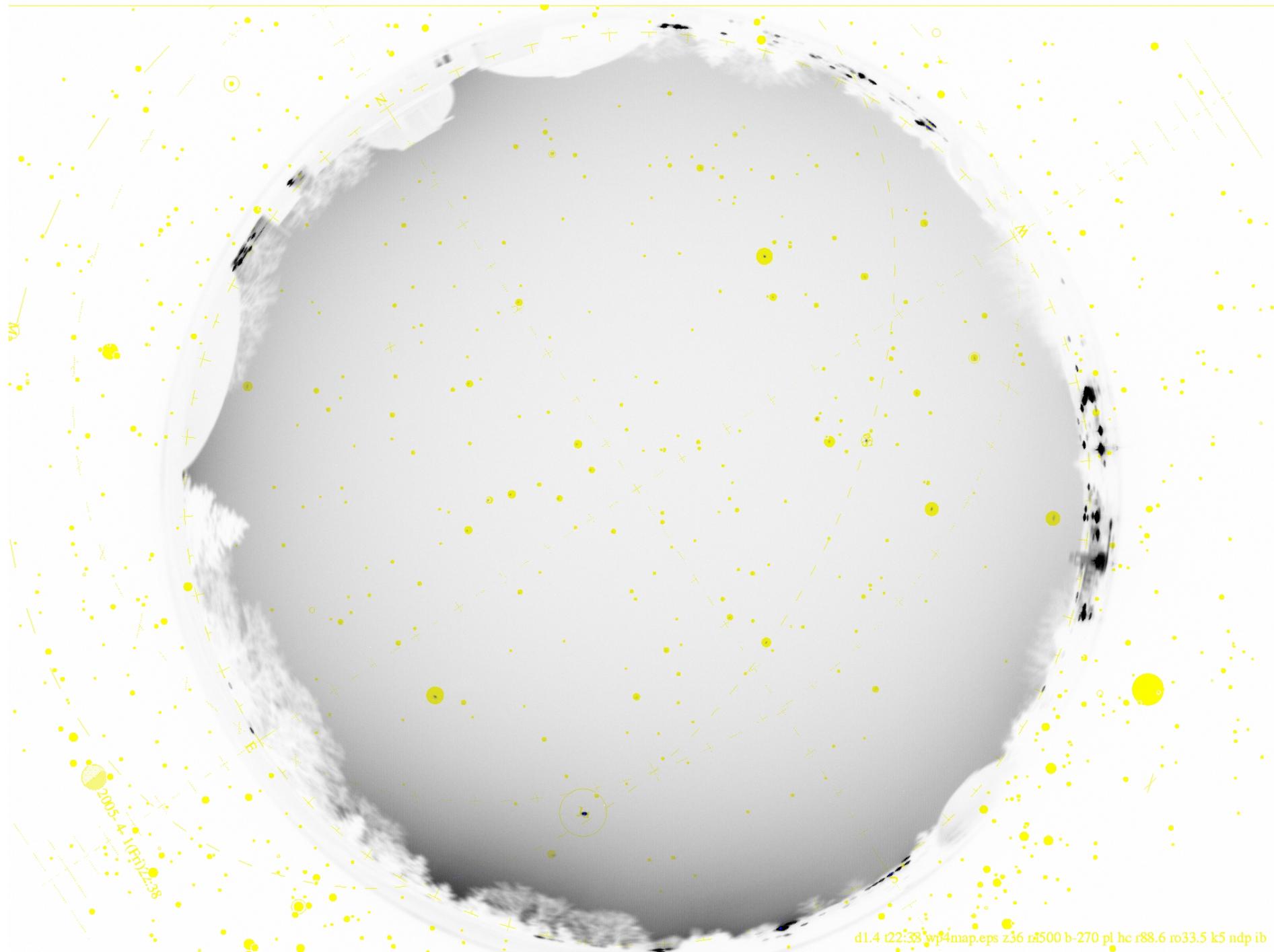


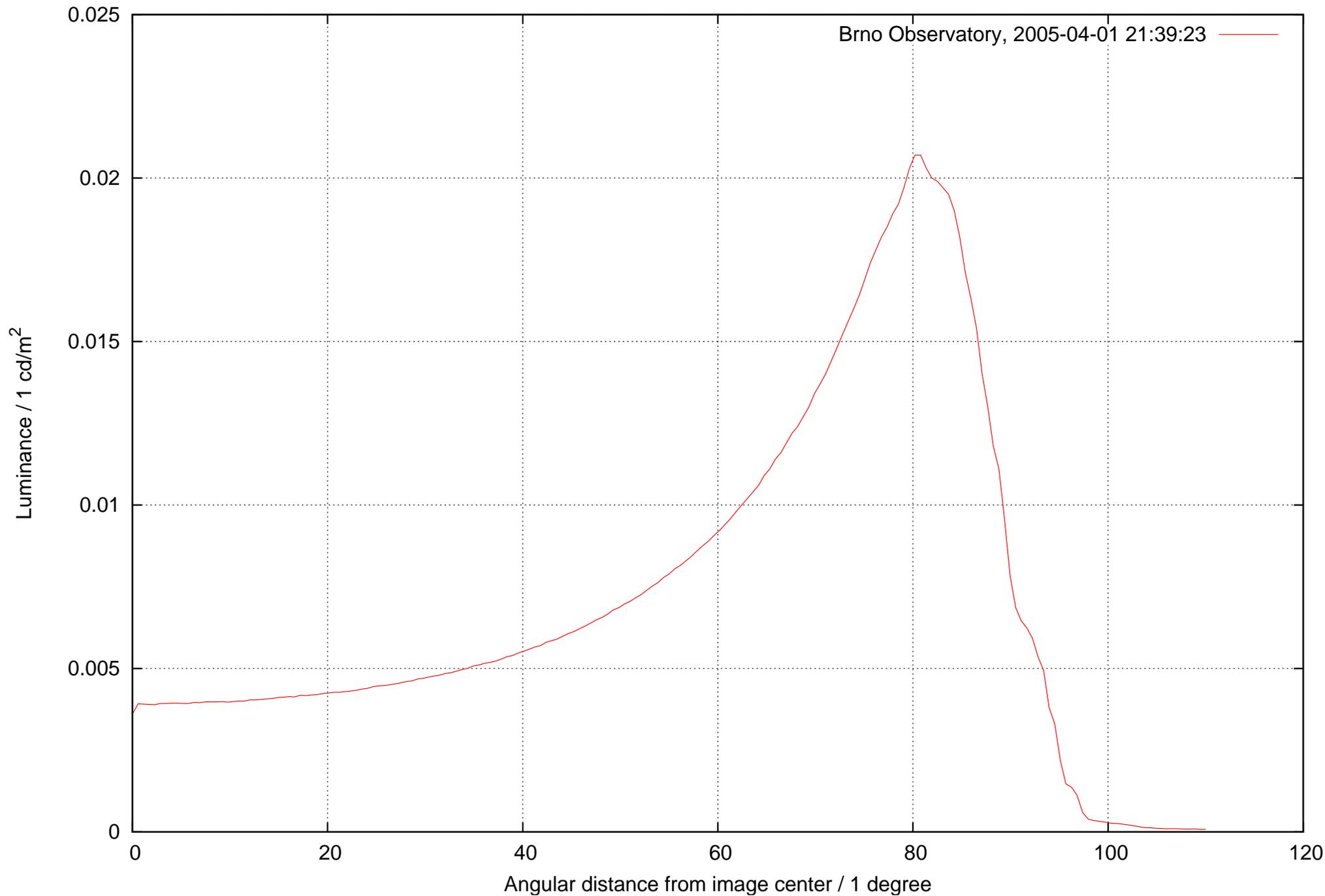
Image geometry from fitting a star map with a suitable projection:
(Brno Observatory, 2005-04-01 21:39:23, 60 s exposure)





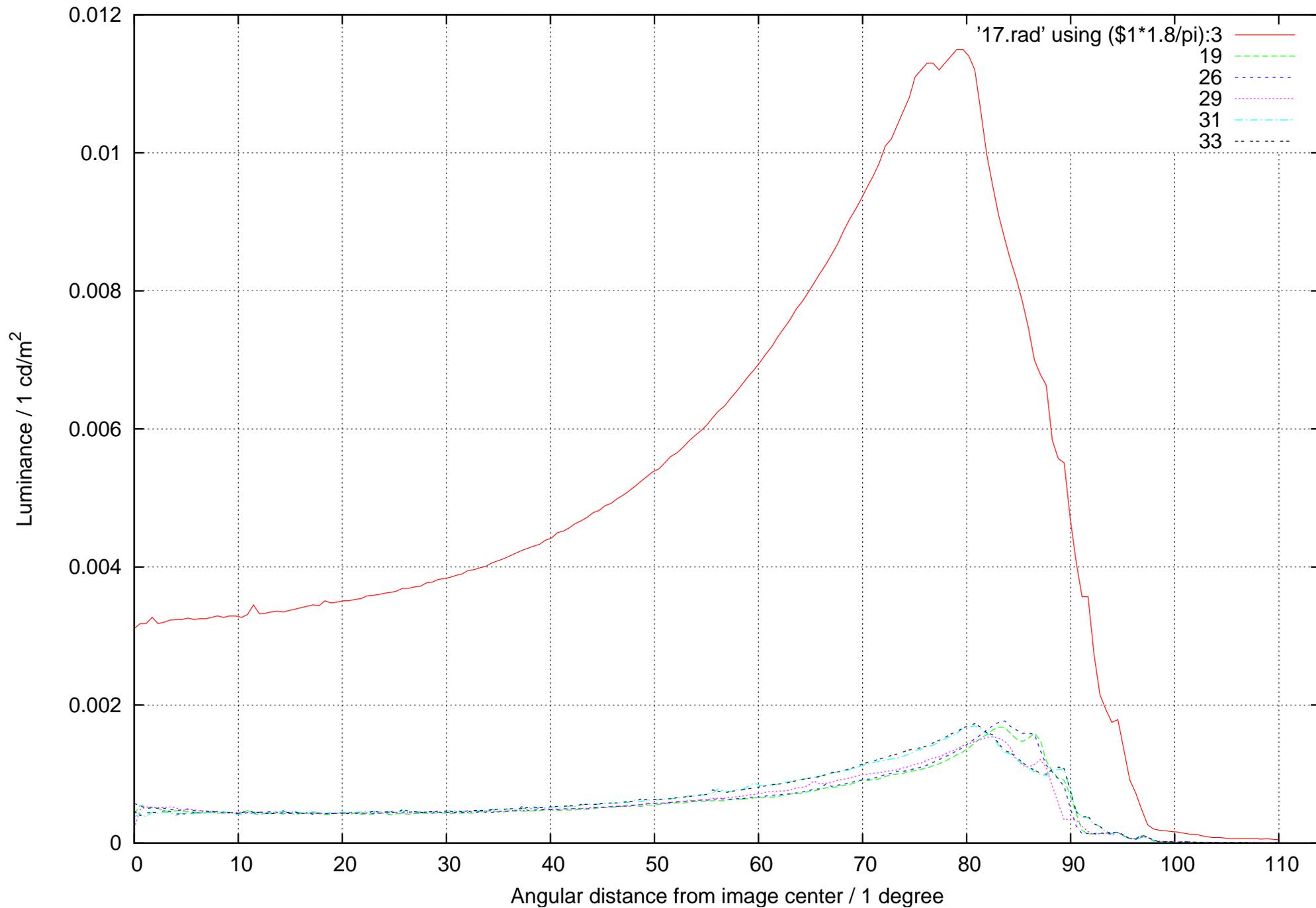


Luminance at various zenith distances

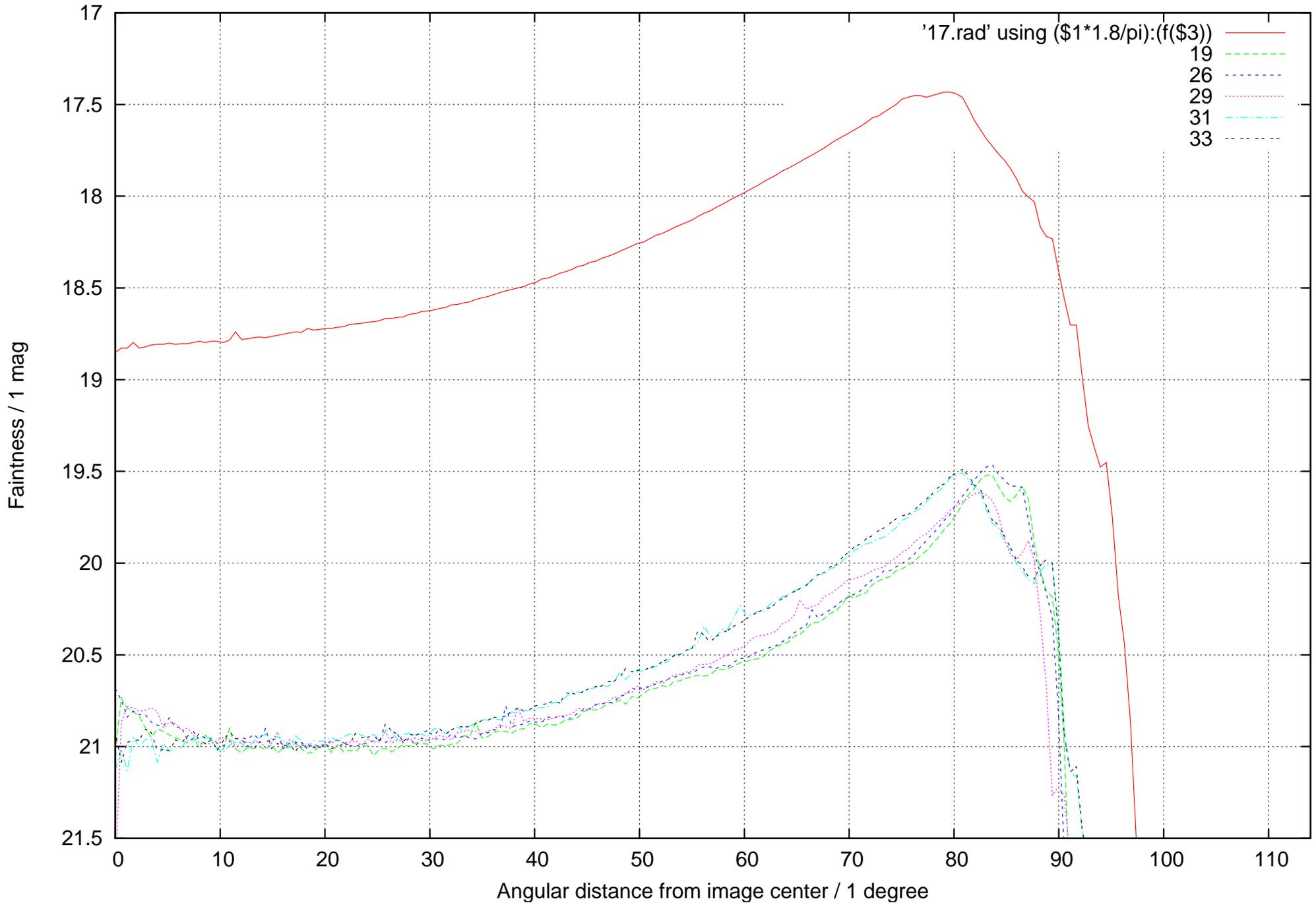


Knowing vignetting and geometry, sky luminance profiles can be made
(again the 2005 Perseid maximum night):

Luminance at various zenith distances (Brno and 22 km from it, Aug 12/13 2005)



Faintness of 1 square second (Brno and 22 km from it, Aug 12/13 2005)



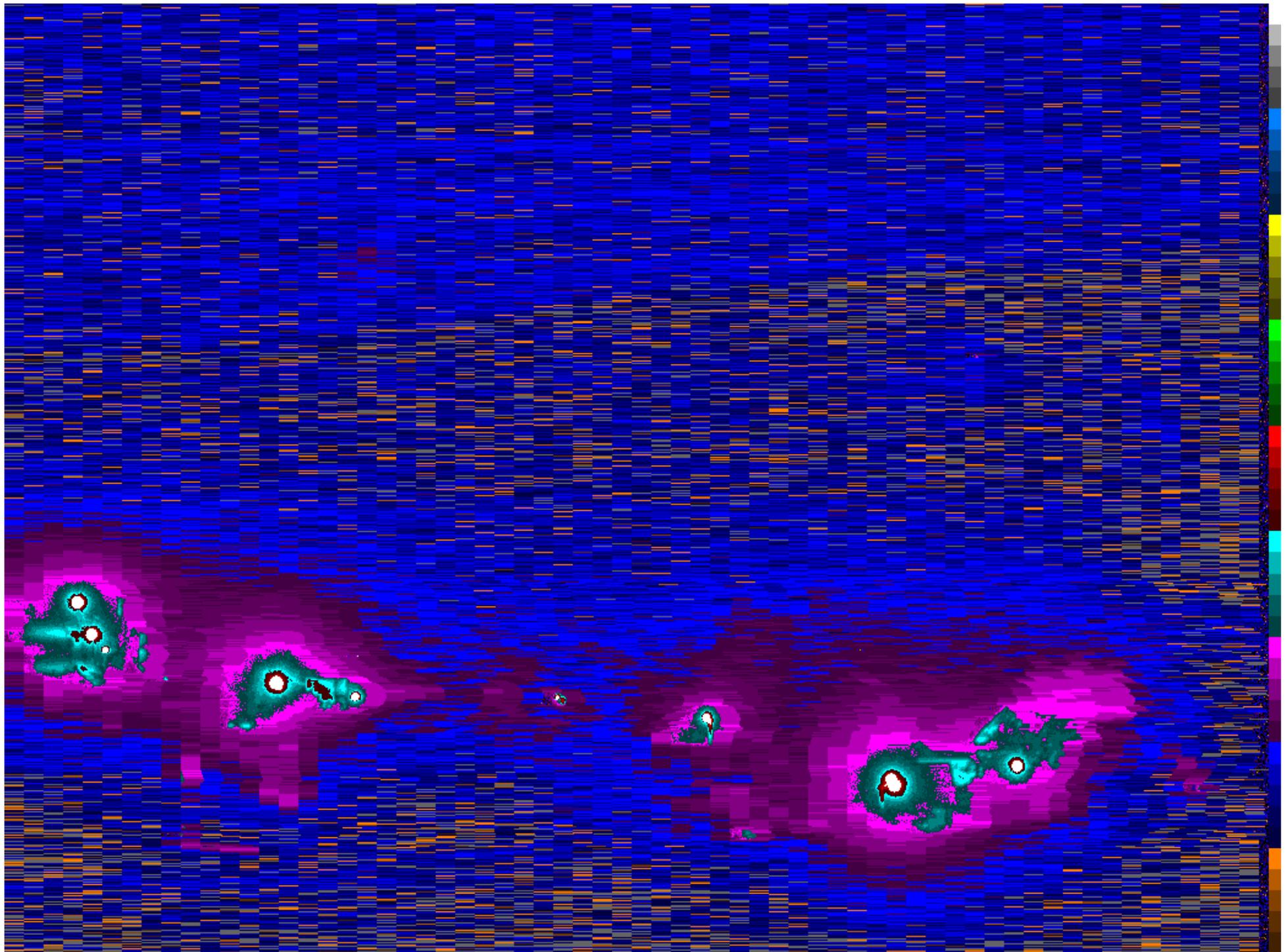
Direct comparison with a luxmeter reading is possible:



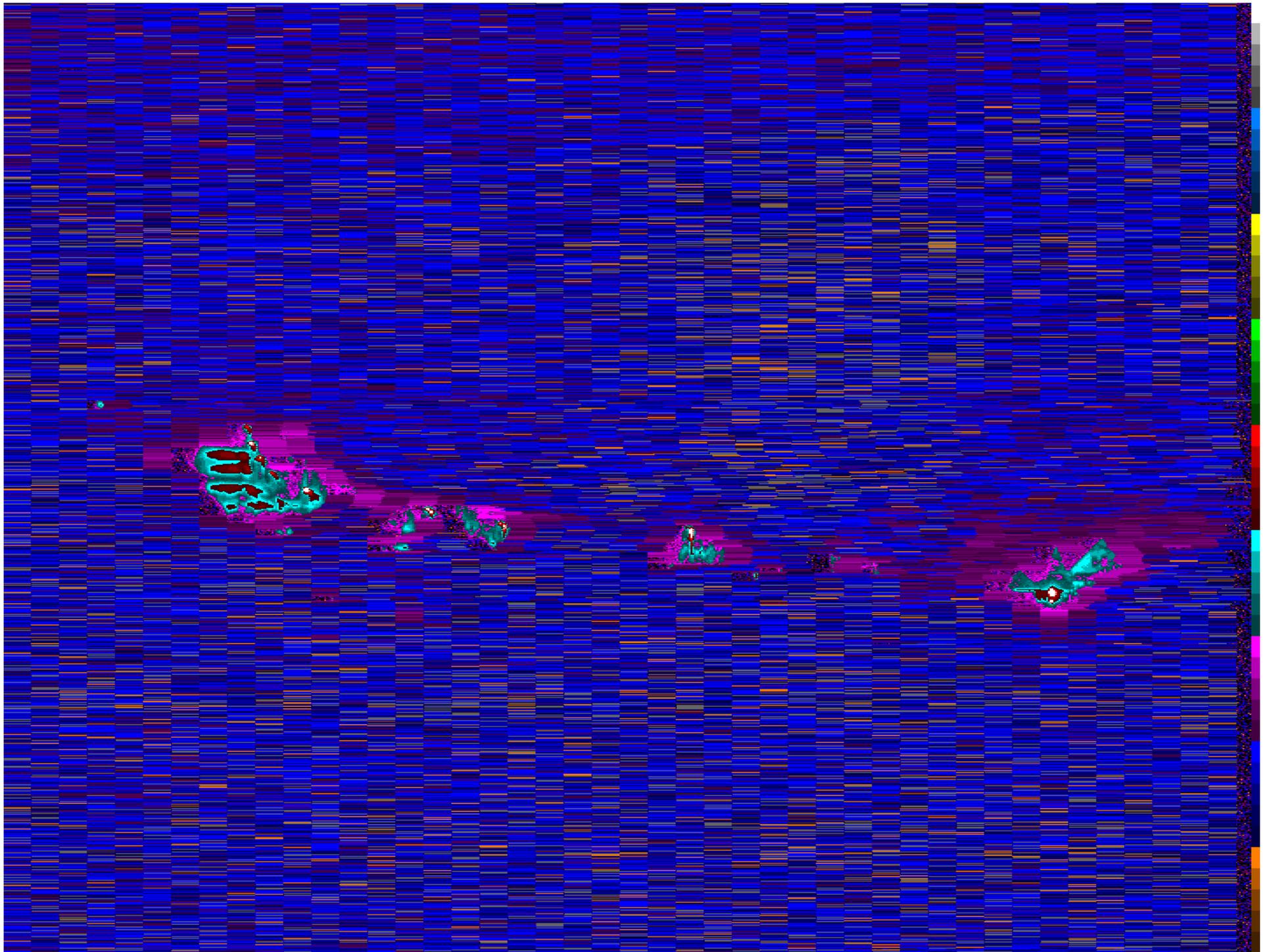
Good retrofit in Hostetin

(Images before by Nikon 990, after by Fuji S5000)









– vast improvement:

10× lower imissions,

25× less “direct” light (coming mostly just from illuminated masts now)

even with 3× more light onto the road...

The tools:

series of exposures (2 s, 1/8 s, 1/125 s, 1/2000 s)

an adapted David Coffin's dcrow

raw2lum

Which camera is the best one?

Any which outputs almost all darkframe pixels as non-zero.

(If many pixels are 0, low-light photometry is less accurate.)

Future tasks:

Automated stellar photometry (to arrive at air transparency),
two-component vignetting model (for any aperture and focal length),
use of archived jpeg images (with their black-box magic) to document
changes over years.

www.astro.cz/darksky