Measuring Sky Brightness with a Digital Camera

Paris 2004

Stuttgart 2003

Prof. Kirschbaum presented methods to measure the brightness of the night sky

- Lux meter
- Solar cell
- CCD camera

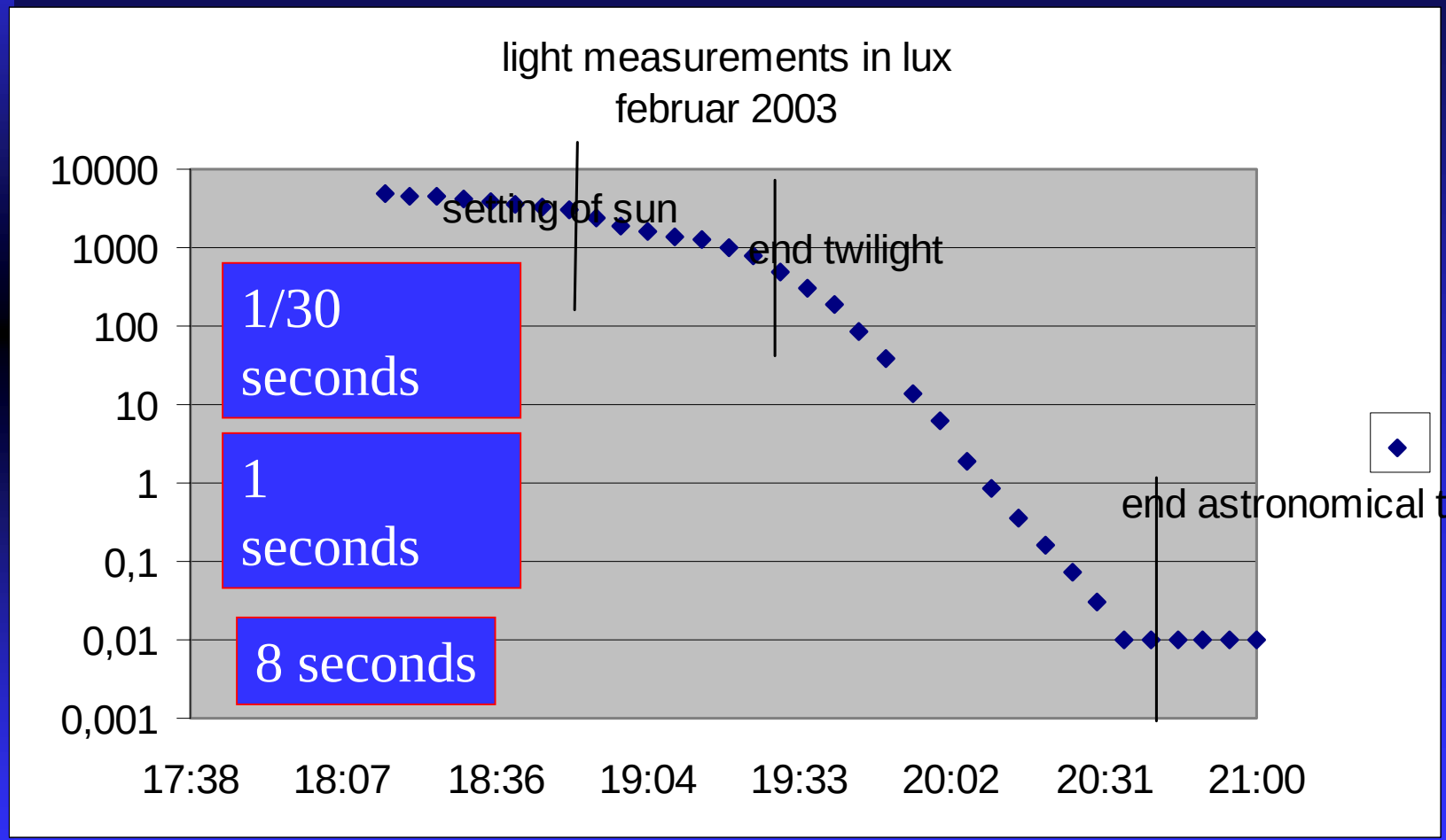
Idea

- Why not a normal digital photo camera?
- These cameras are widespread, cheap and easy to handle
- Can these camera’s be used for reliable measurements of the night sky brightness?

Sony Camera

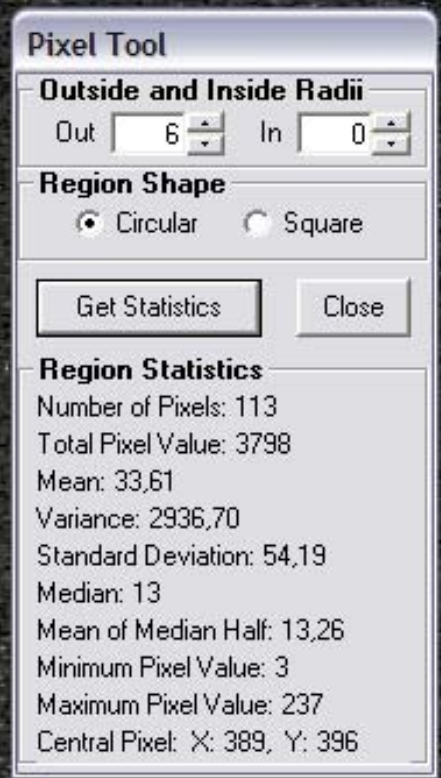
- Costs about 150 euro
- 3 megapixel
- Manual setting
- Maximum exposure time of 8 seconds
- Raw exposures
- F2.8 aperture

Tests


light measurements in lux
februar 2003
10000
1000
100
10
1
0,1
0,01
0,001
setting of sun
end twilight
end astronomical t
1/30 seconds
1 seconds
8 seconds
17:38
18:07
18:36
19:04
19:33
20:02
20:31
21:00

Test On Stars, Aquila

- Minimal magnitude of stars of about 7
- Magnitude 1 stars saturated
- Pixel counts of sky about 20



Results and Limitations

- Possible to make images and measurements of sky in different locations
- Problem 1: always use the same camera and results are not comparable
- Problem 2: Colour sensitivity of camera and eye are different

Plan

- To make the measurements objective and comparable
  - Use the brightness of the stars to scale the method
  - Use a specific filter to make responses of the camera in visual, specific wavelengths

Method

- Falchi and Cinzano, CCD measurements of night sky brightness:
  - Make images of various parts of the sky with known stars with different altitudes
  - Determine the Extinction coefficient k
  - Determine the Photometric scale factor C
  - Determine the sky brightness at the location

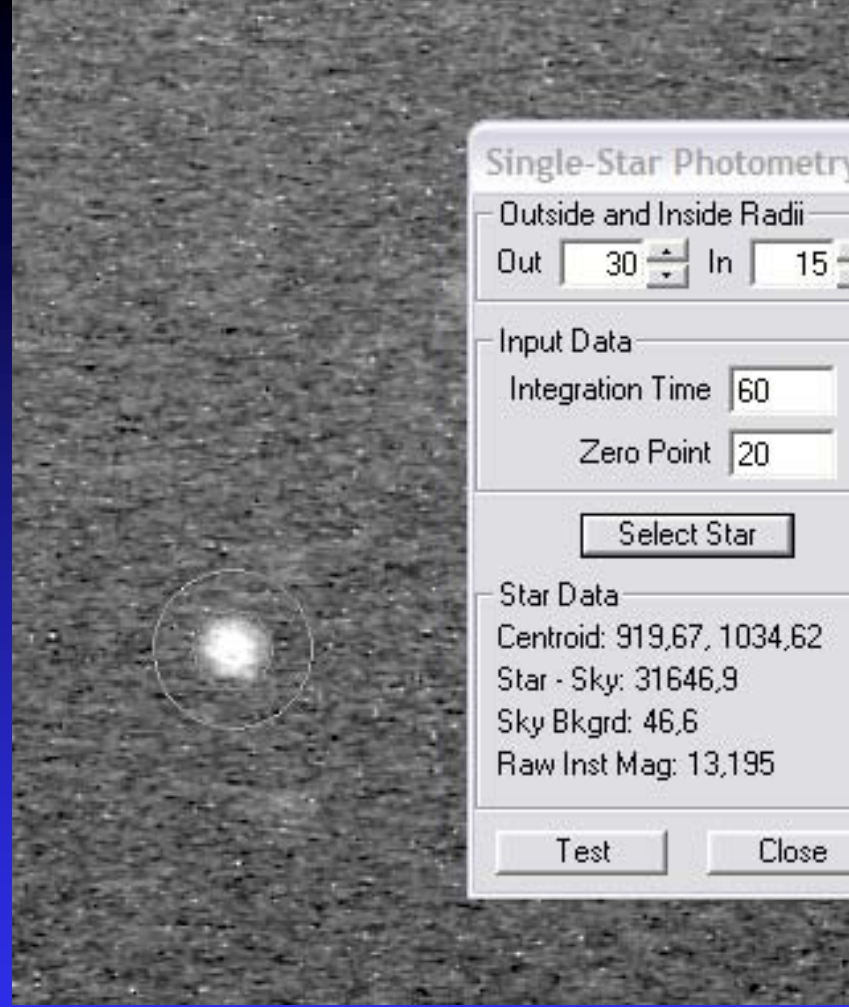
Practical

- Bought
  - Johnson V filter (100 euro)
  - A lot of memory (tiff files are 6 Mb)

Images

- No moon
- 8 seconds
- Tele (about 10 cm lens)
- Aperture F2.8
- Focus 5 meter to obtain not saturated stars
- Dark and flat frames

Analysing

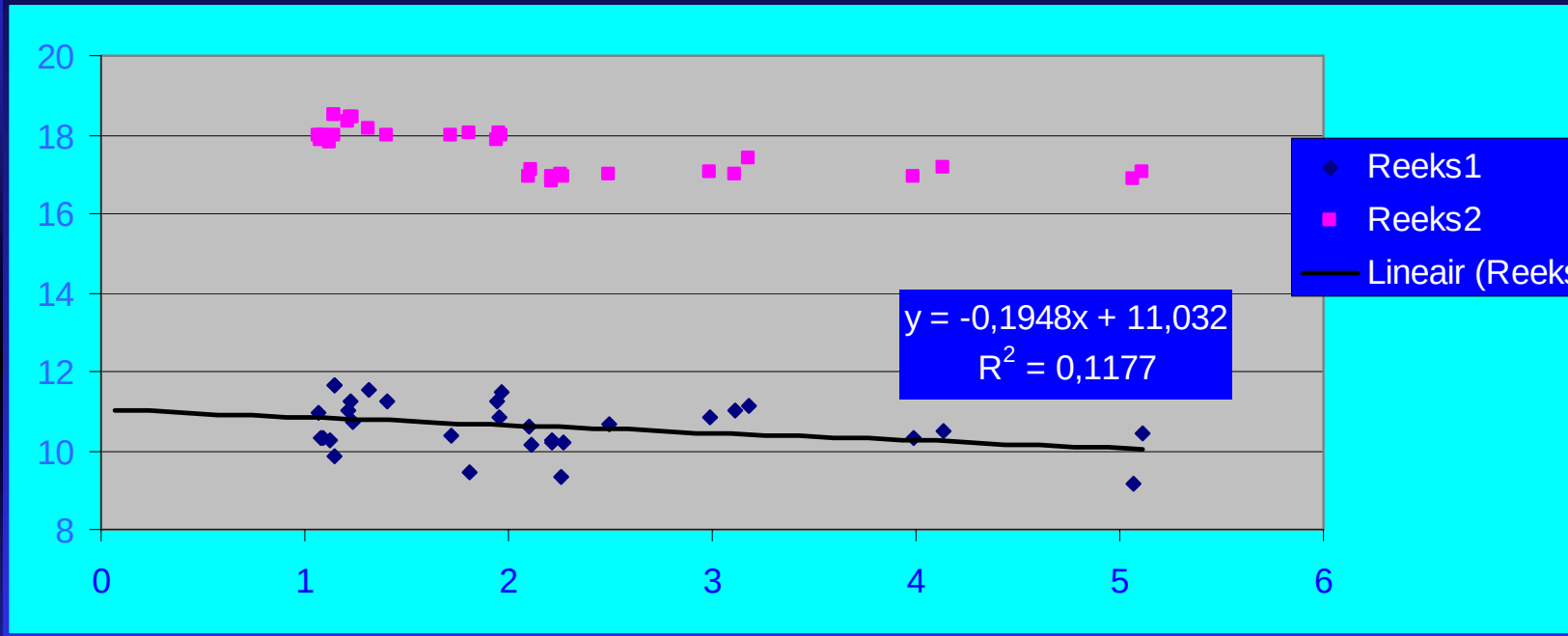


- AIP 4 (IRIS)
  - Determining star- sky
  - Determining sky background

Results

star	altitude	altitude in rad	star-sky per second	sky per second	magnitude Hipparchus	X=1/sin alt	Y= Ma cat +2.5 log (Star-Sky)
Beta Gem	36,2	0,63	3408,71	3,87	1,22	1,69	10,05
Alpha Gem	37,3	0,65	3141,08	3,57	2,02	1,65	10,76
Iota Gem	33	0,58	545,36	4,27	3,79	1,84	10,63
Gamma Le	50,5	0,88	2504,41	2,33	2,23	1,30	10,73
Eta Leo	46,3	0,81	864,75	2,41	3,52	1,38	10,86
Alpha Leo	42,2	0,74	2828,13	2,75	1,41	1,49	10,04
Theta Leo	51,2	0,89	998,25	2,29	3,33	1,28	10,83
Alpha Cmi	17	0,30	2260,63	8,70	0,40	3,42	8,79
Beta Cmi	17,6	0,31	499,36	8,37	2,89	3,31	9,64
Delta Uma	85	1,48	975,33	1,42	3,30	1,00	10,77
Alpha Uma	76,6	1,34	1989,88	1,45	1,82	1,03	10,07

Results



- Extinction coefficient k= between 0,2 and 0,6 per airmass
- Photometric scale factor C= 11,1 ±0,2 magnitude

Results

- The photometric scale factor C gives the correction factor to make the camera a real measuring device
- The formula to make a pixel count P into a magnitude:

$$M=C-2,5*\log(P/1168)$$

(1 pixel= 1168 square second)

Results and Limitations

Location	Km from Utrecht	Sky brightness Zenit magn	Sky brightness cd/m2	Artificial sky brightness	artificial/natural brightness
Utrecht	4		0,0048964	0,004696435	23,482175
Rijnouwen	5,4		032398	0,003039813	15,199065
Odijk			9442	0,000744235	3,721175
Werkhoven			7415	0,000541515	2,707575
Cothen			3039	0,000103893	0,519465

Results and Limitations

star	altitude	altitude in rad	time	sky	sky per second
Eta Aur	31,6	0,551524	8	5,54	0,6925
Iota Aur	24,6	0,429351	8	8,64	1,08
Beta Tau	25,5	0,445059	8	8,78	1,0975
Alpha Uma	80,2	1,3997541	8	0,76	0,095
Beta Uma	85,6	1,4940018	8	0,9	0,1125
Gamma Uma	81,8	1,4276793	8	0,86	0,1075
Delta Uma	78,1	1,3631021	8	0,64	0,08
Epsilon Uma	73	1,2740904	8	0,4	0,05
Alpha Vir	20,4	0,3560472	8	6,11	0,76375

- Results not reliable with dark(er) skies

Future

- Try to find collaborators
  - Present results in Paris
  - Write an article about the results in Dutch
- Try to get a camera with longer exposure time
- Take this winter measurements in different towns in Holland
- Take measurements in one sport uring a night
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