Observing in the IR with the NOT

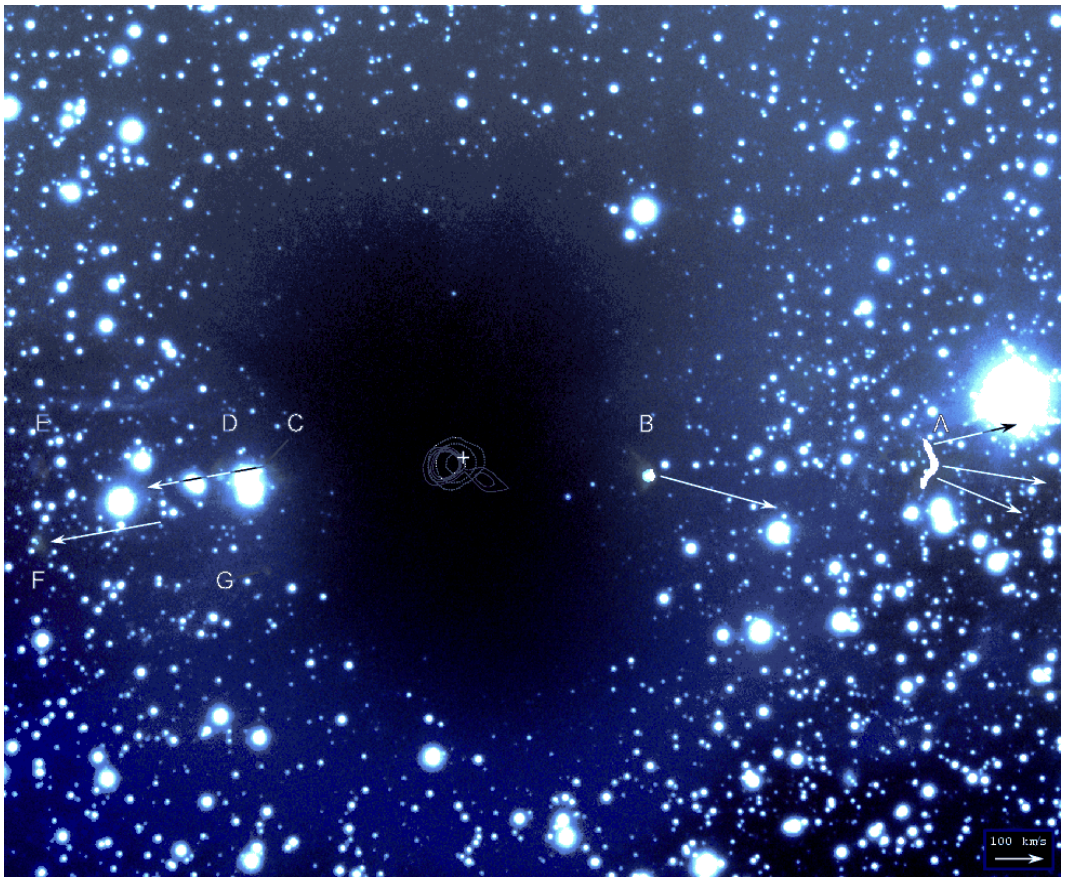
STC-meeting, La Palma, 11/5-2009

Anlaug Amanda Djupvik

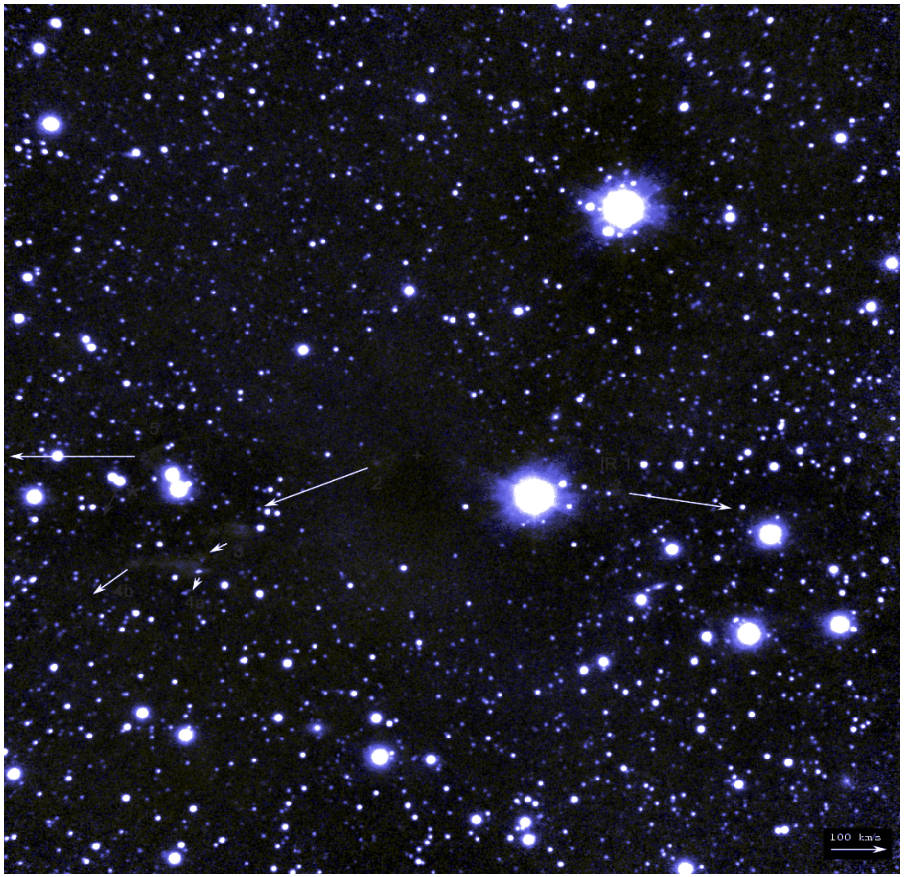
Outline of talk

- Why is the IR interesting?
- The IR sky, windows, backgrounds
- The NOT's Near-IR instrument NOTCam - capabilities
- Current status and available tools for the users
- Some images and science results obtained with NOTCam
- Future plans

Why observe in the IR?

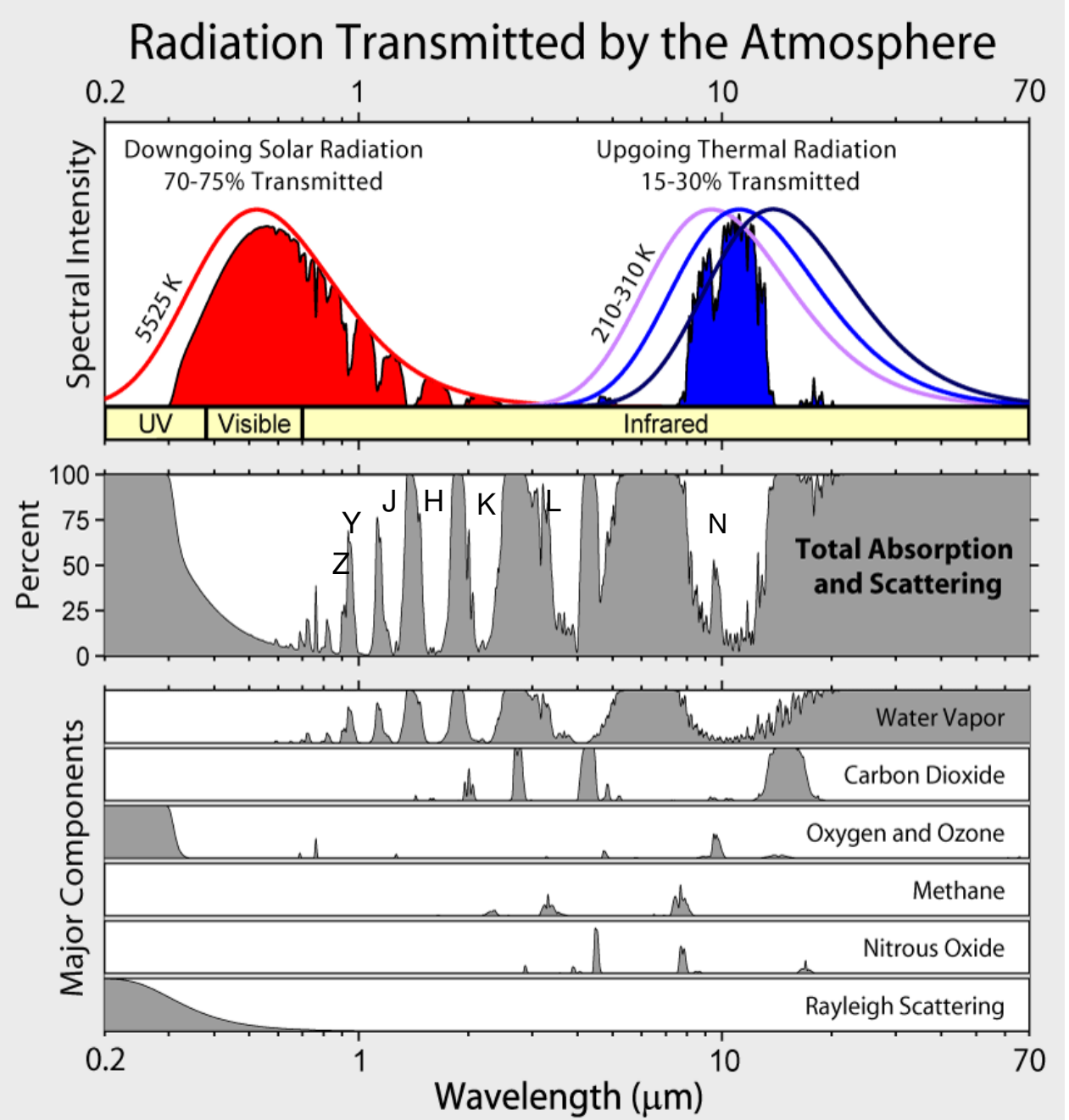


ALFOSC Hα, [SII], R-band



NOTCam H2 line, K-band

Gålfalk & Olofsson, 2007, A&A 475, 281



- IR windows --> ZYJHKLMNQ
- Water vapor content varies with altitude
- Importance of the atmospheric window 8-14 µm for GW

Background radiation at night:

$\lambda > 2.3$ µm:

- thermal emission dominates

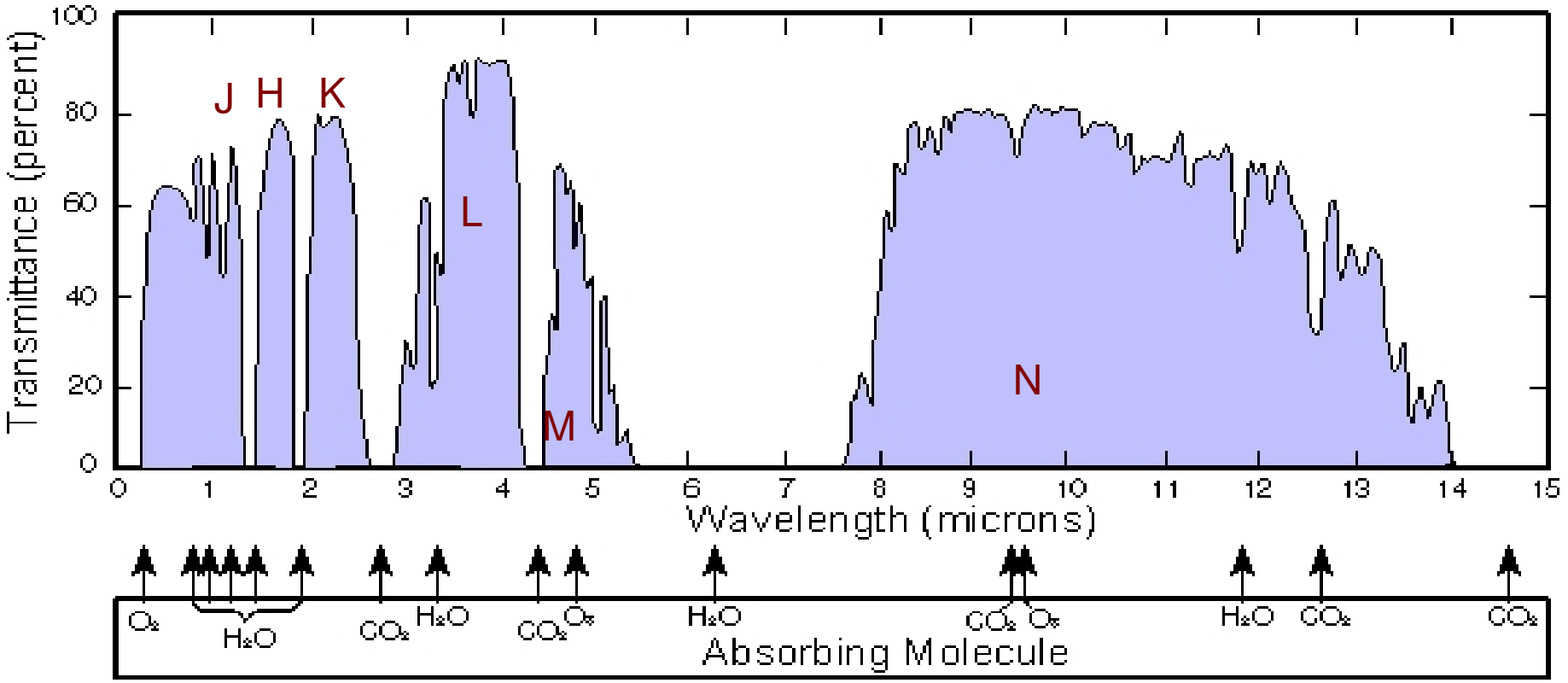
$\lambda < 2$ µm:

- Rayleigh scattered light
- Airglow (H + O3 --> OH* +O2)

mostly H-band and variable

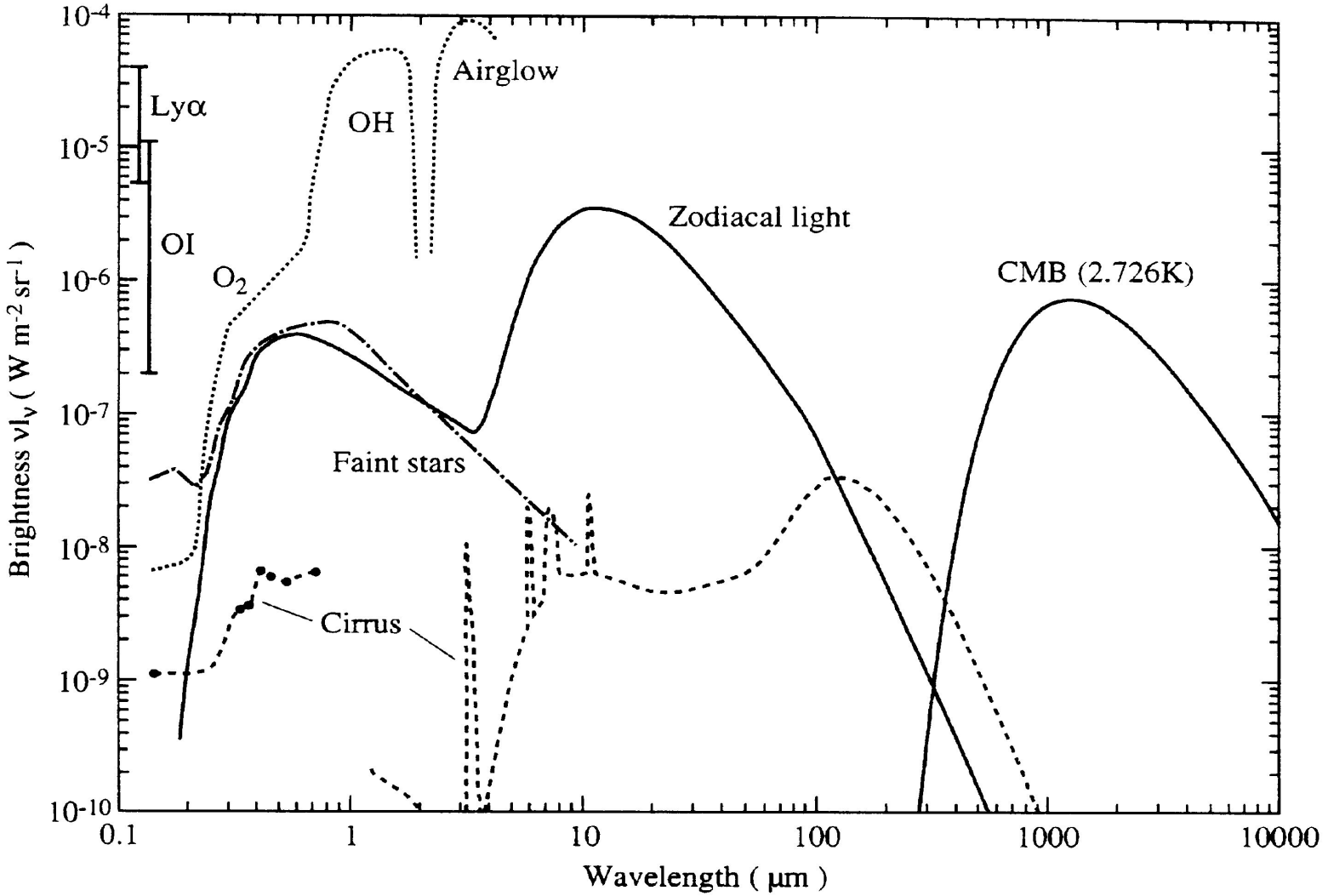
10% over 5-15 minutes

The atmospheric throughput



- Thermal emission from telescope and
-

The IR sky


Airglow
OH
Lyα
OI
O2
Zodiacal light
CMB (2.726K)
Faint stars
Cirrus
Brightness νI_ν (W m^-2 sr^-1)
Wavelength (μm)
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9
10^-10
0.1
1
10
100
1000
10000

NOTCam

HgCdTe 1k Hawaii array (0.8 – 2.5 µm)
WF-cam (0.234”/pix, 4'x4')
HR-cam (0.078”/pix, 80”x80”)
Yn, J, H, Ks, K filters + 16 narrow-band filters
Spectroscopy (R=2500 and R=8000)
4 polaroids
Small cold stops

- First light at NOT Jun-01
- First visitor run Apr-02
- Spectroscopic mode Aug-03
- First Science Array Oct-05
- 2nd Science Array Dec-07
- First remote observing Jun-09

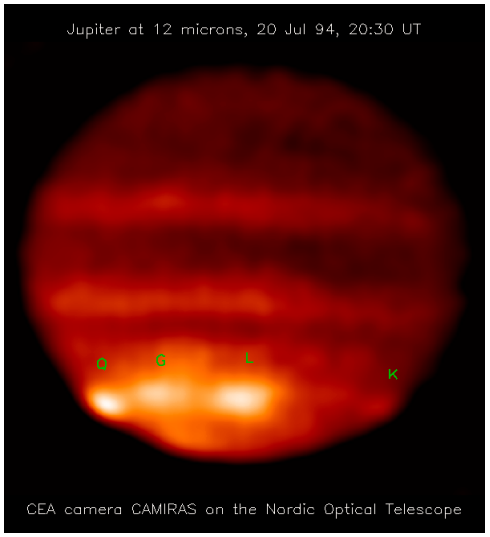
Strength: - no beam folding
- has a shutter
Weaknesses: - long readout time
- a “dead” column in centre
- optical distortion of WF camera

The NOT and the Infrared

Measured SKY brightness (mag/square “) in bright nights

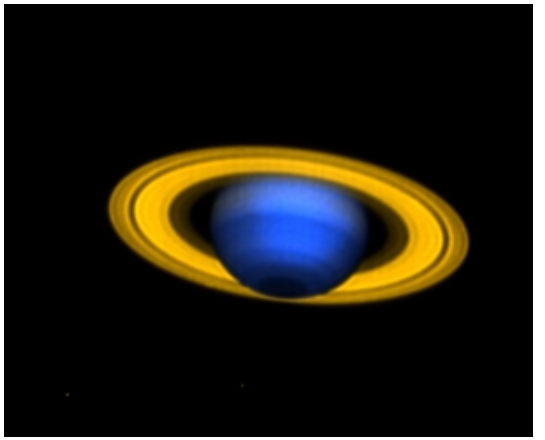
	NOT	TNG	WHT	VLT	UKIRT
J	15.6	15-16	15.4	16.5	15.6-16.4
H	13.9	13.4-14.7	14.2	14.4	13.7-14.3
Ks	13.2		13.0	13.0	
K	13.1	12.5-13.0			13.2-13.8

CAMIRAS 1994 (N)



ARNICA 1996 (JHK)

SIRCA 2003 (K,H2O)



NOTCam - status of today

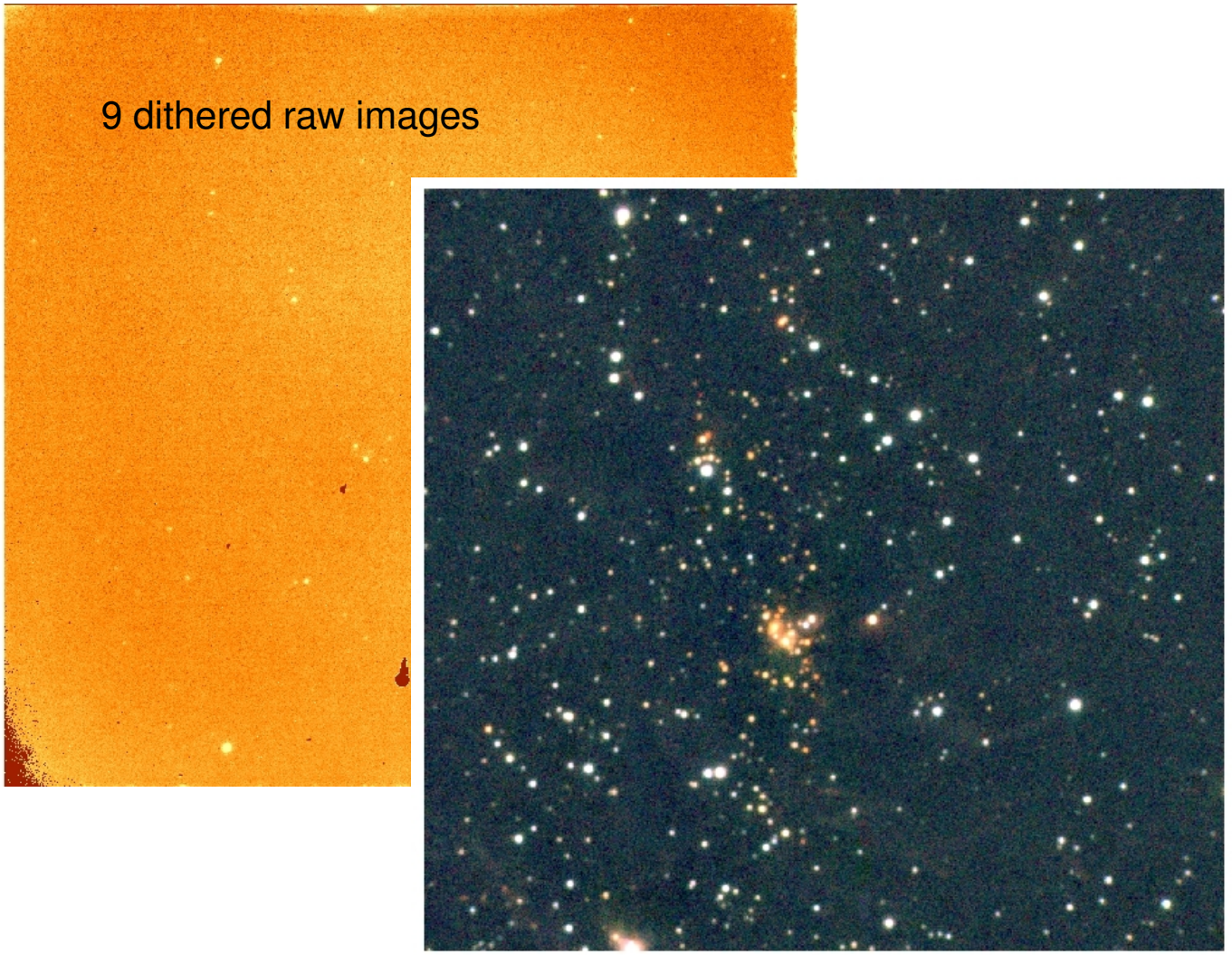
- Well behaving cryostat – one year cold
  fill tube o-rings need consideration
- Science Array (since Dec-07) well behaving
  minor improvements to the clock-boards
- Data acquisition improved (Sequencer, guide areas, tel offset)
- Overheads (a problem, must be improved)
- Tools: observing scripts, flat field archive, reduction package

Near-IR observing

- Need to remove the high and variable sky background --> always dithering
  --> beam-switching

- Avoid saturation --> persistency effects
  --> cross talk
  Needs fine-tuning of exp times

Quick-look reduction tools



JHK composite image

NOTCam archive:

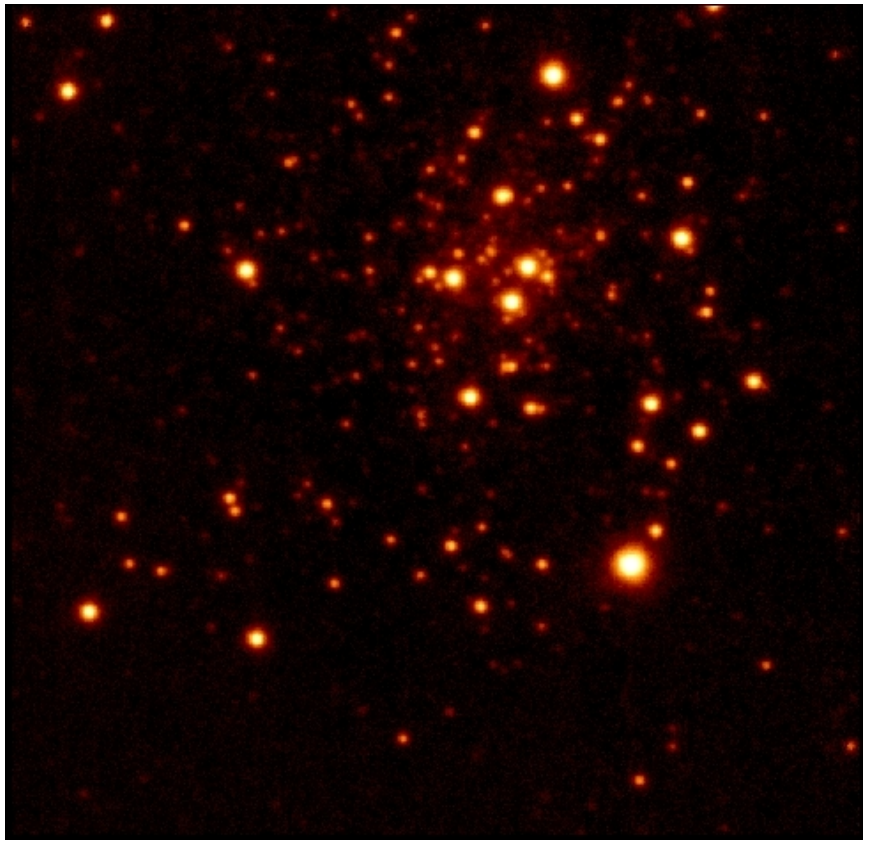
- bad pixel file
- flat fields

NOTCam IRAF pkg

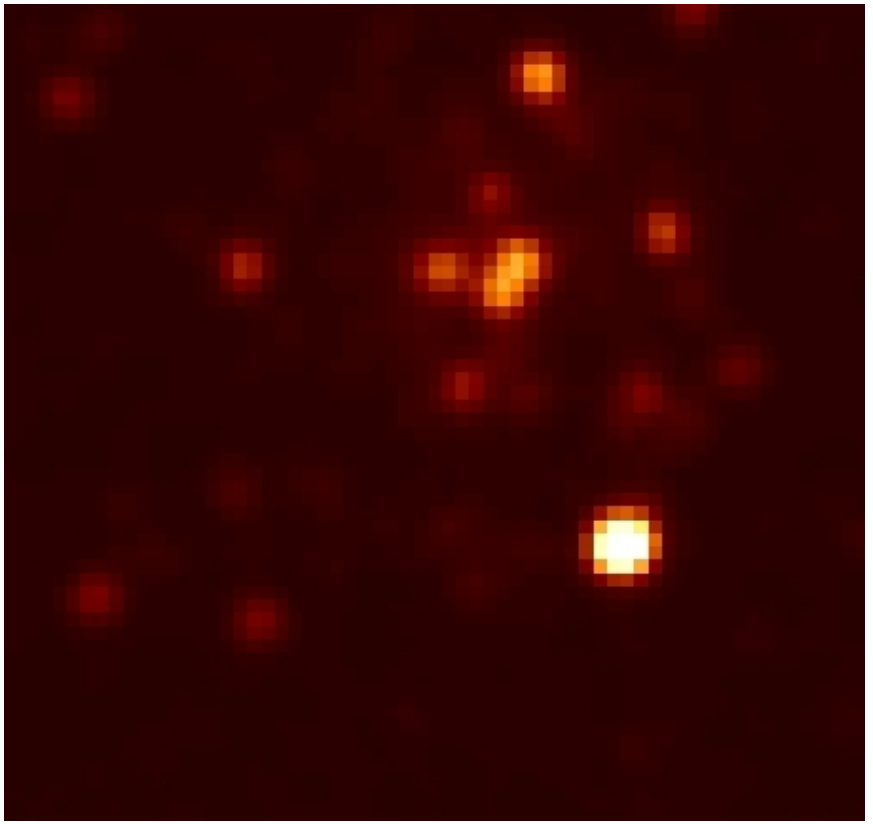
Task reduce.cl

- make sky template
- subtract the sky
- divide by flat field
- image registration
- image combination

Spatial resolution – HR camera



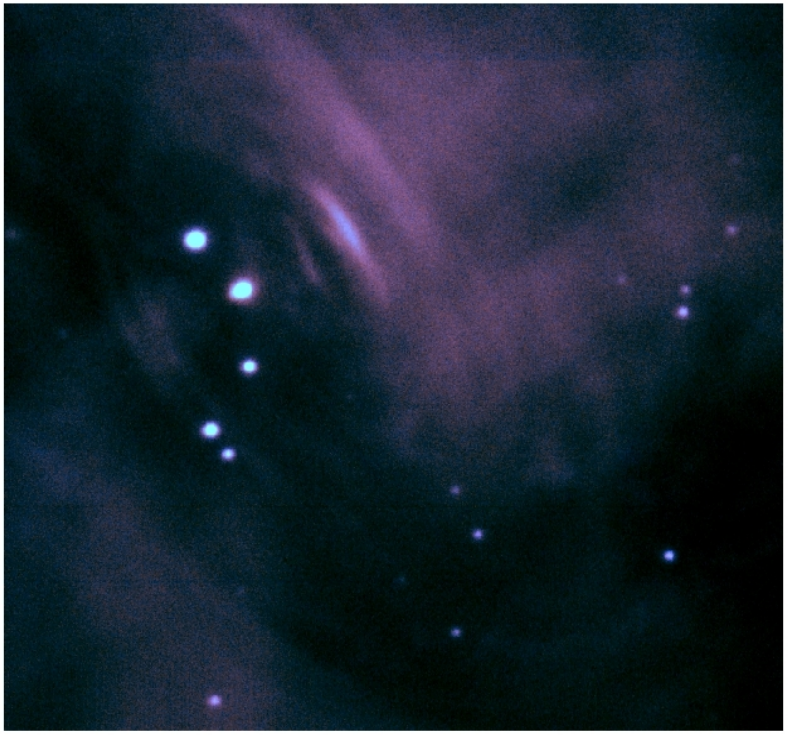
NOTCam, H-band. 0.078”/pix, 0.4” seeing



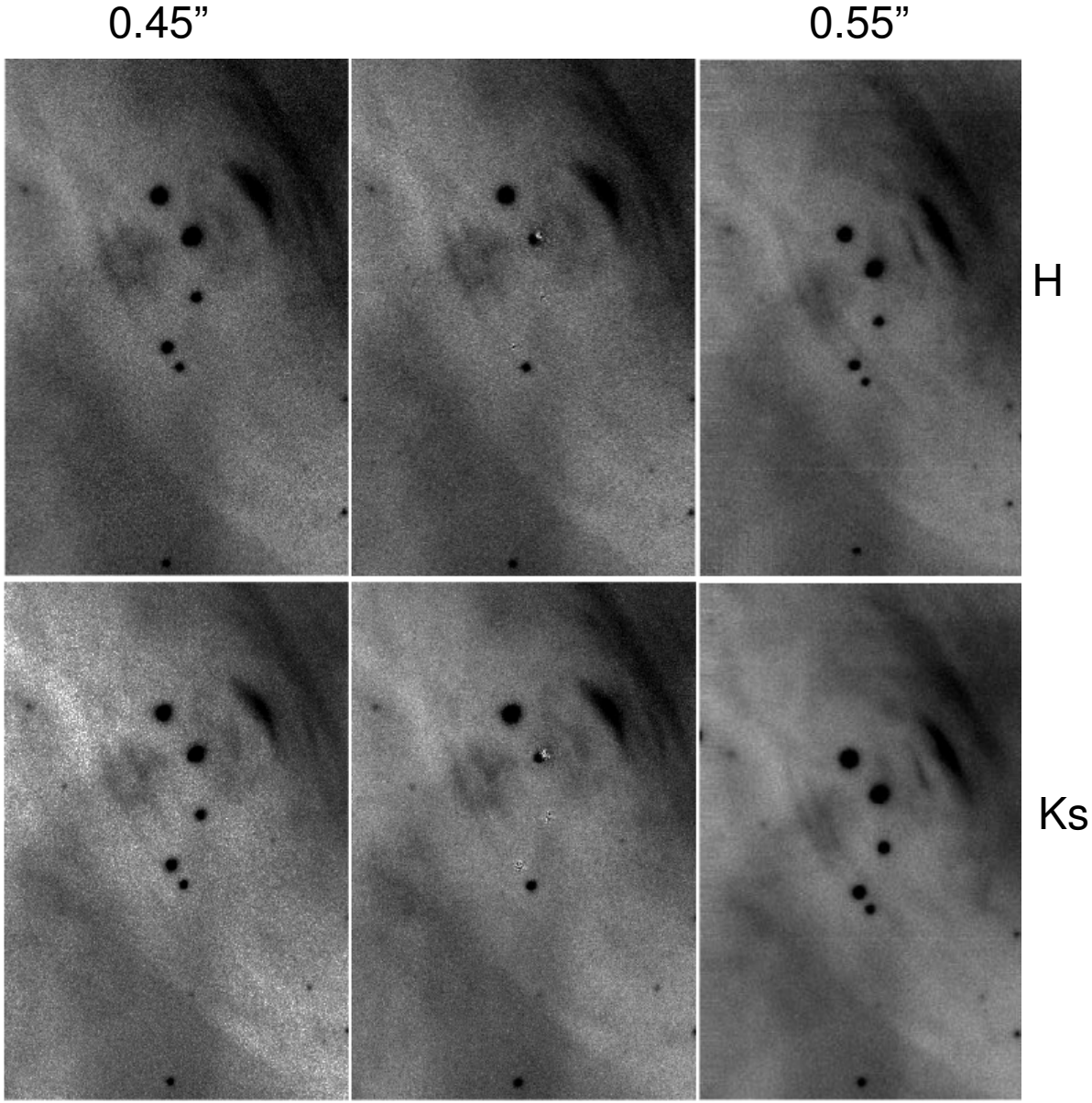
2MASS, H-band, 1”/pix

The HR camera has an excellent optical quality

The Crab pulsar HR-cam H+Ks



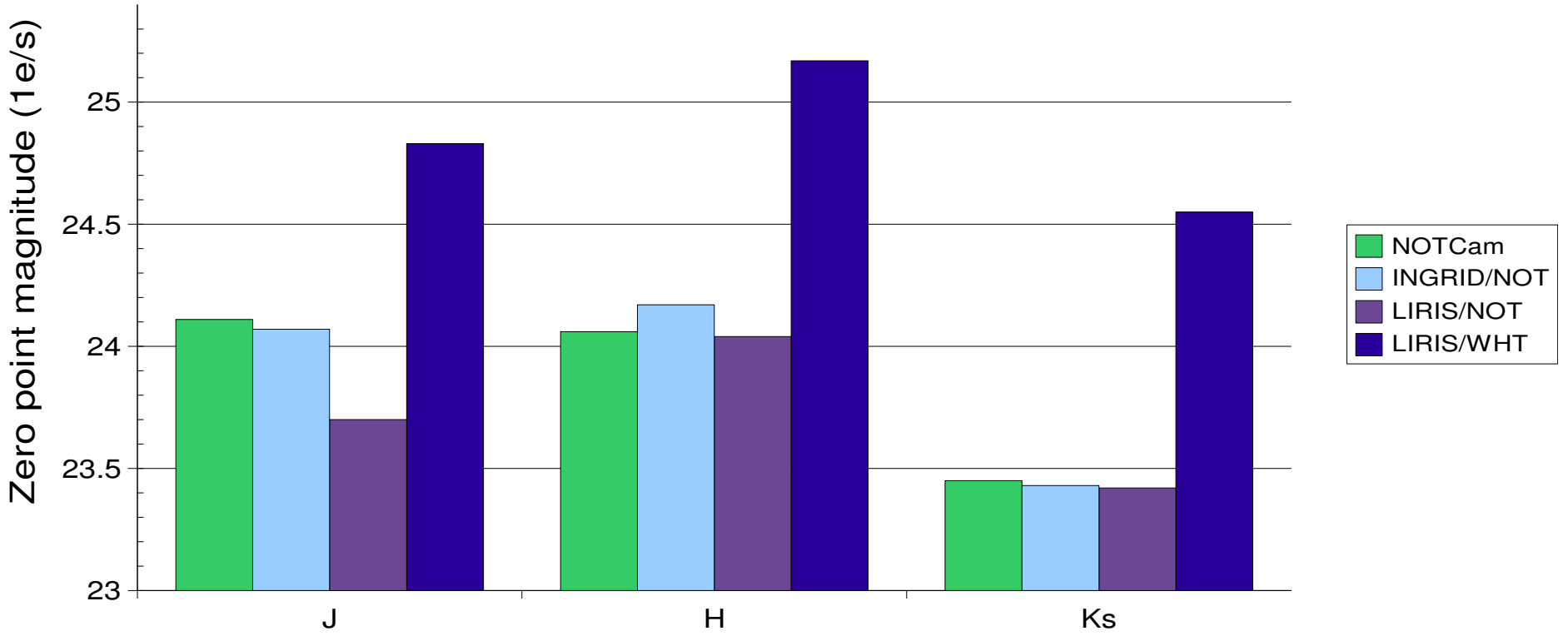
Pulsar – knot distance = 0.65”



La Palma, 11/05/2009

Tziamtzis et al. 2009, submitted A&A

How does NOTCam compare?



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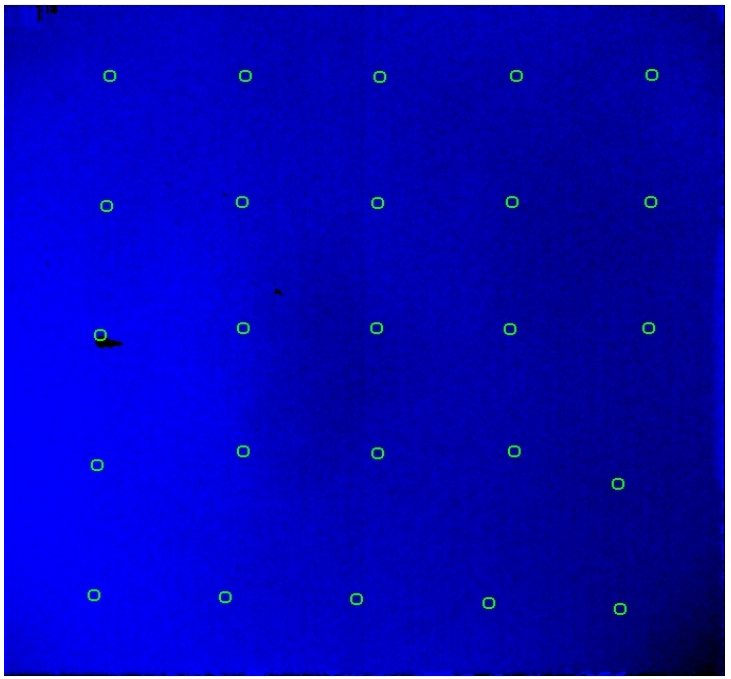
Photometric precision

WF-cam 0.234”/pix



Single image

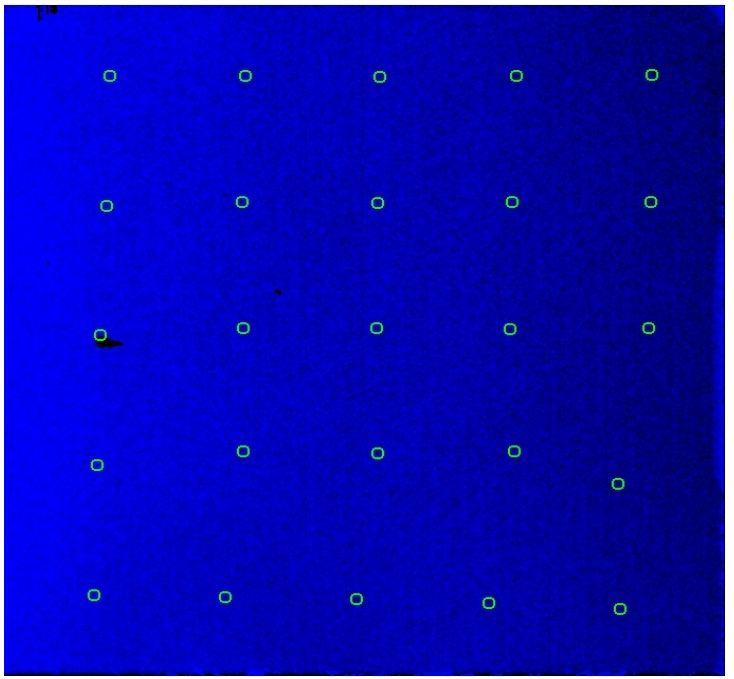
Ks: 0.037 mag --> 0.015 mag (5 images)

H: 0.039 mag

J: 0.035 mag --> 0.023 mag (2nd flat)

Includes: bad pixels, optical distortion, sky variations, flat field errors etc.

HR-cam 0.078”/pix



Single image

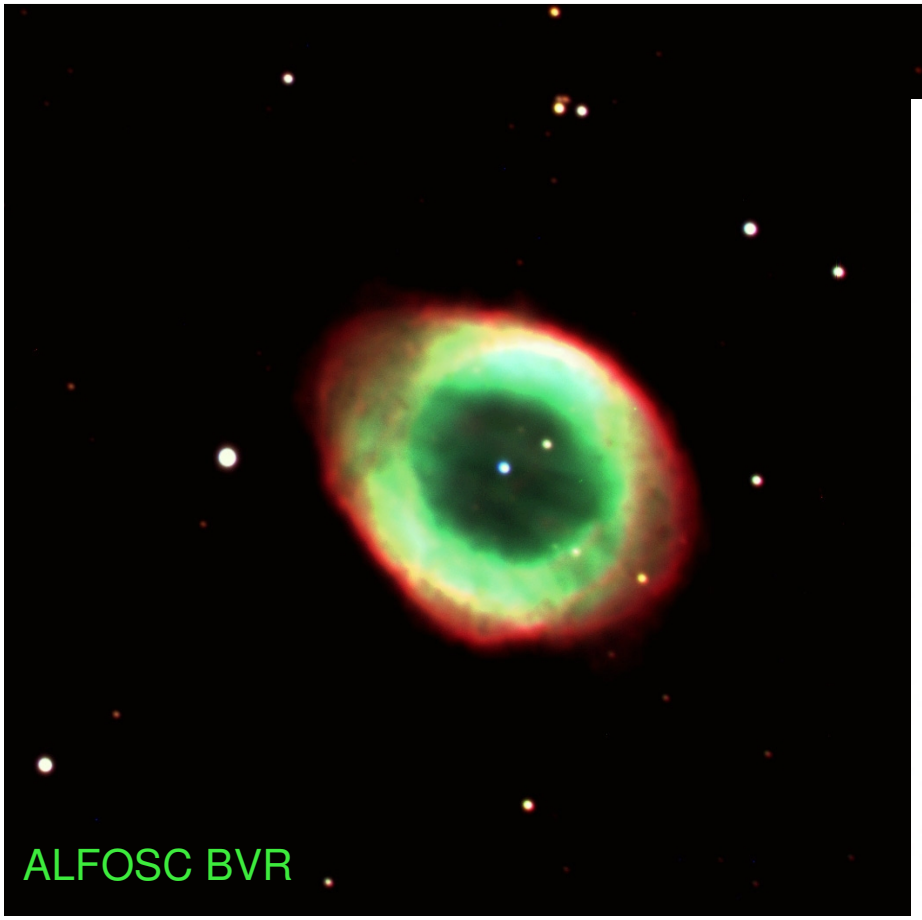
Ks: 0.015 mag

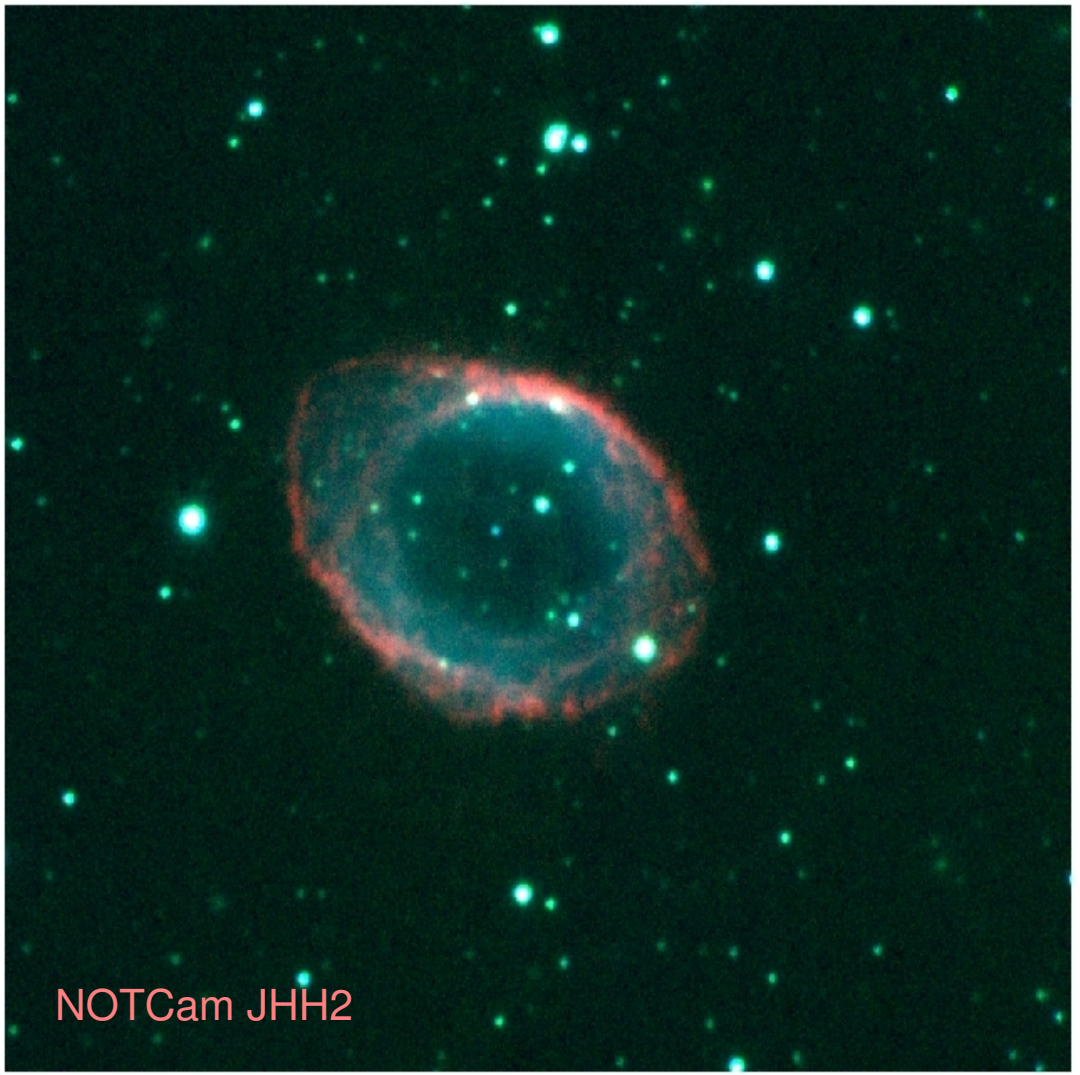
H: 0.011 mag

J: 0.019 mag

No optical distortion, better sampling of PSF

The Ring Nebula - again





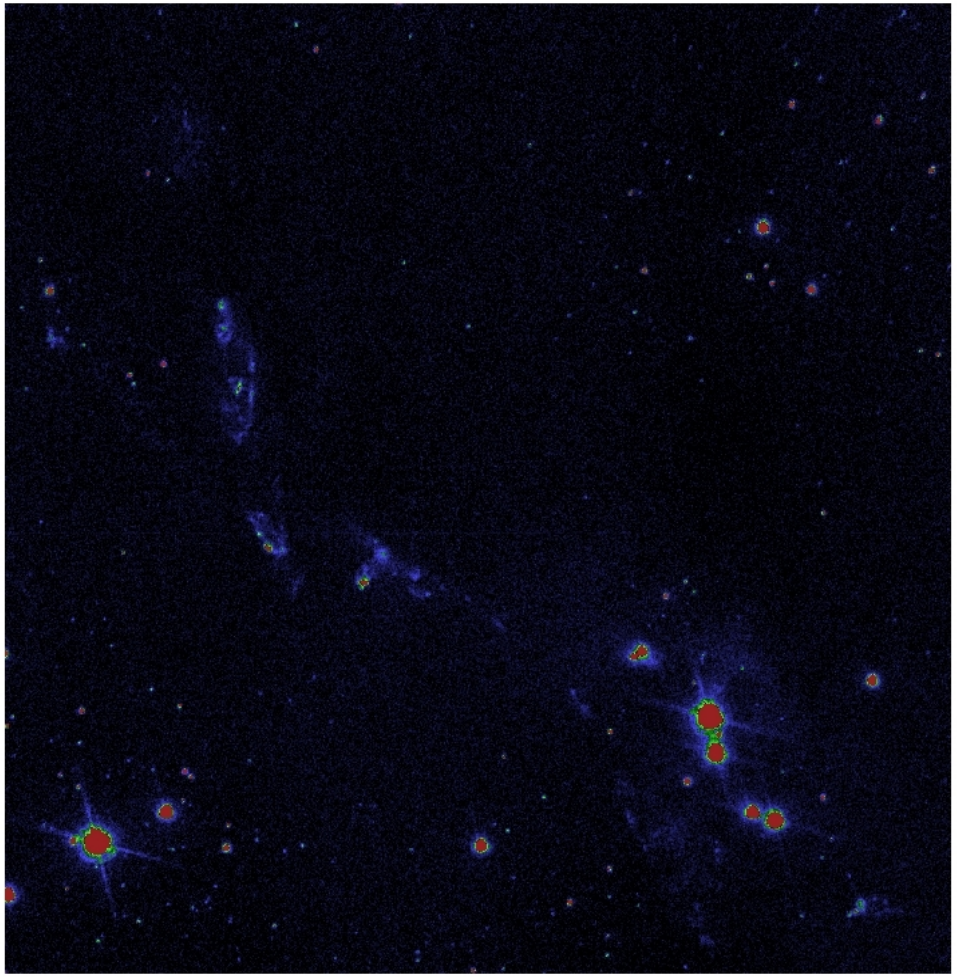
The Ring Nebula - again

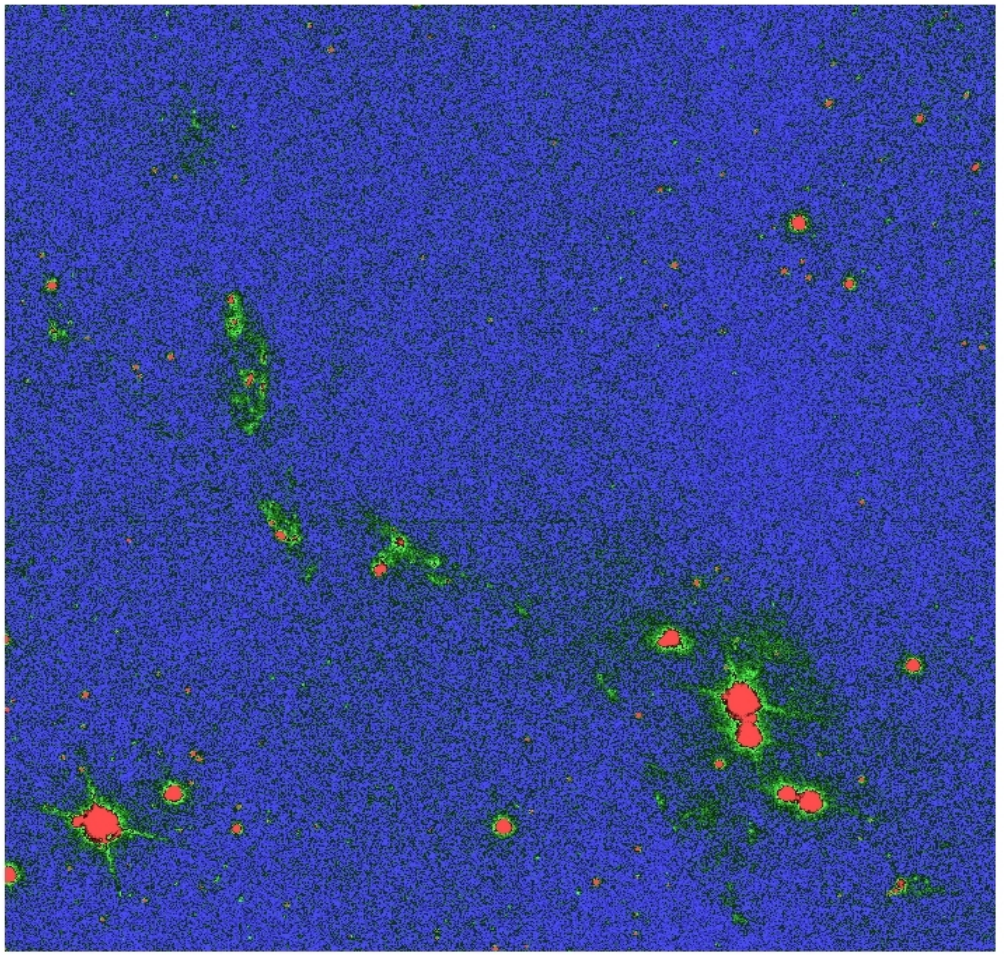
NOTCam: J, H, H2 line

NOTCam + ALFOSC: Hα, J, H2 line

La Palma, 11/05/2009

An image taken last night





Back-up data for one of the Turku summer school projects

Future Goals with NOTCam

- Map and correct the optical distortion of WF-camera
- Minimize the observing overheads
- Upgrade to Wollastons for polarimetry
  NOTCam would do well - cassegrain focus, no folded beam
- Improving “blue” coverage with Z and Y filters
  NOTCam would do well – high “blue” throughput
- If possible, further reduce pick-up noise
- Combat the so-called “dark current problem”
- Upgrading of quality control (on-going)