NOTCam – recent developments

STC-meeting, La Palma, 15/11-2010
Anlaug Amanda Djupvik

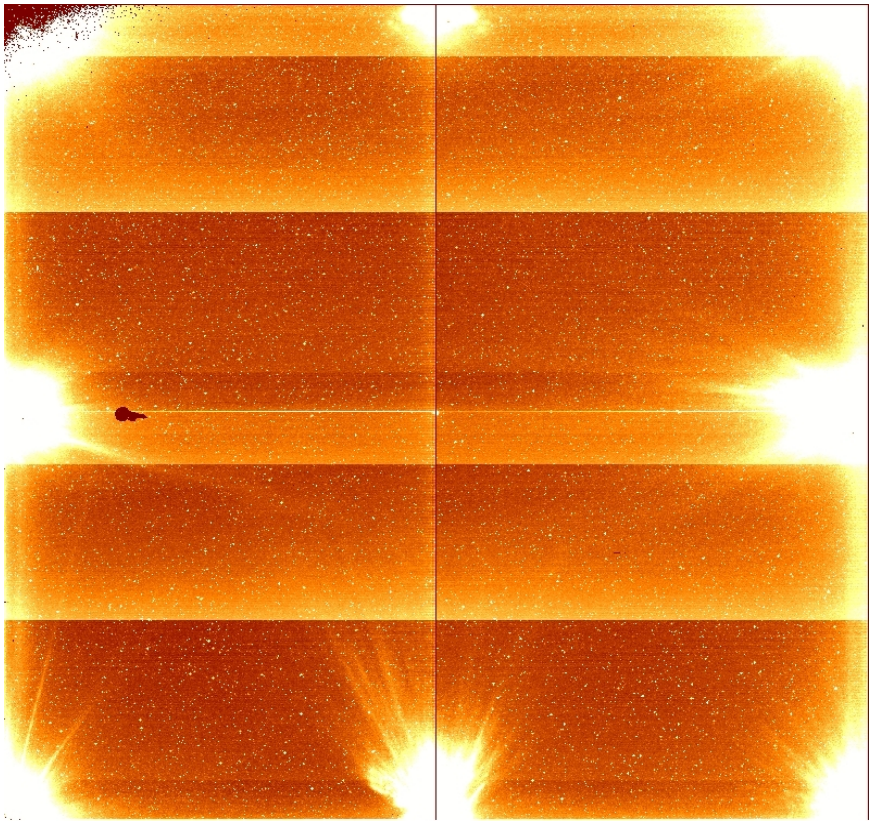
Outline of talk

- Upgrade of clockboards in January 2010
- Correcting the non-linearity
- Correcting the optical distortion of WF-camera
- Obtaining Z and Y broad band filters

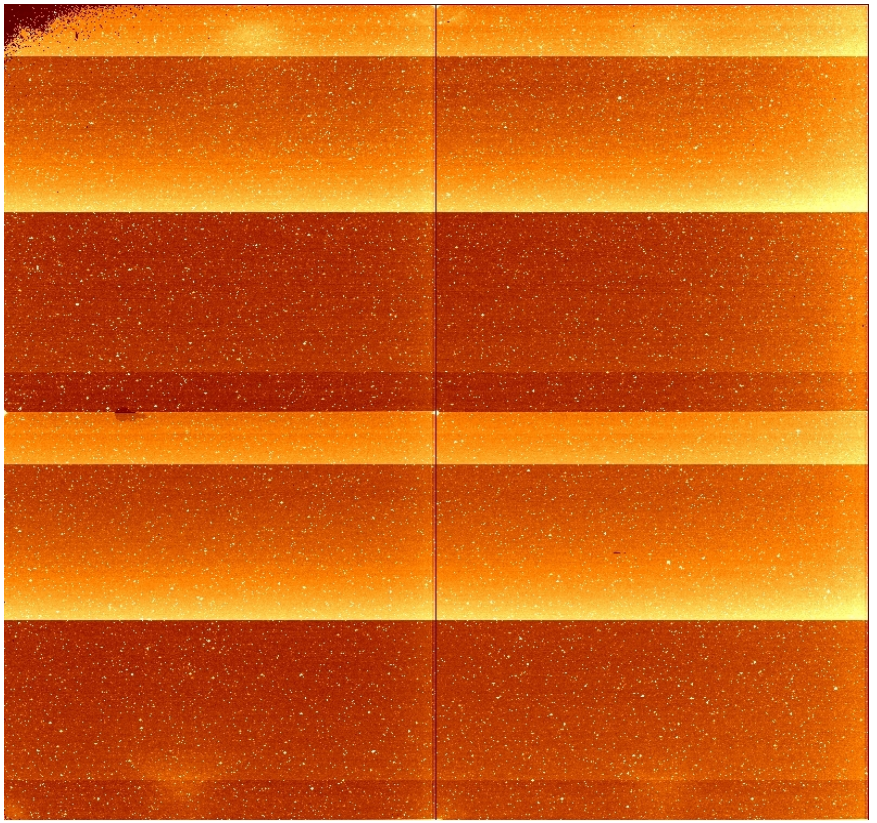
New controller clock-boards

- New boards, designed and made by Graham, installed Jan-2010
- Clock voltage levels modified from 3.5V to 5V (Rockwell specification)
- Results: 1) Shift register glow practically removed

BEFORE



AFTER



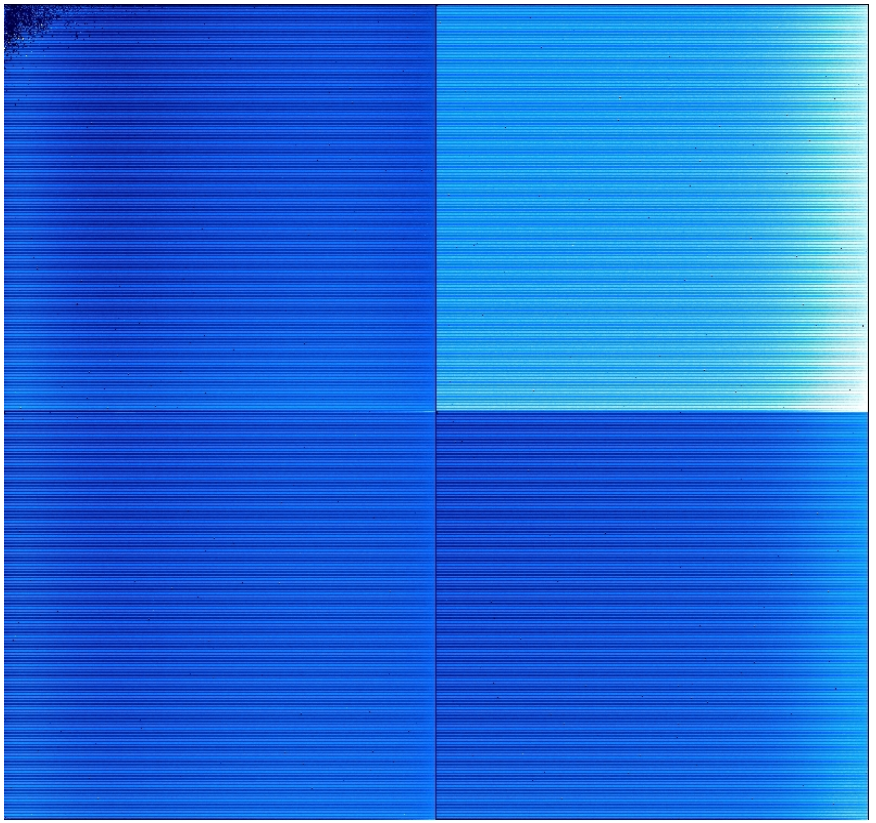
La Palma, 15/11/2010

320 second darks using “dframe 40 8”

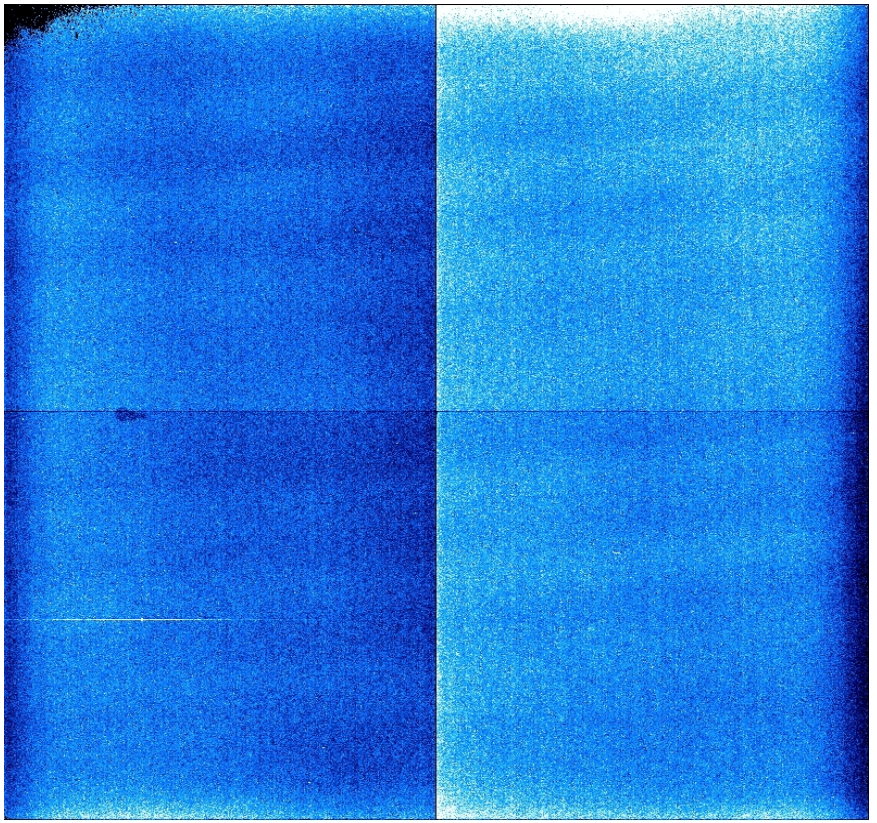
New controller clock-boards

- New boards, designed and made by Graham, installed Jan-2010
- Clock voltage levels modified from 3.5V to 5V (Rockwell specification)
- Results: 2) Stripes seen in reset images removed

BEFORE-AFTER



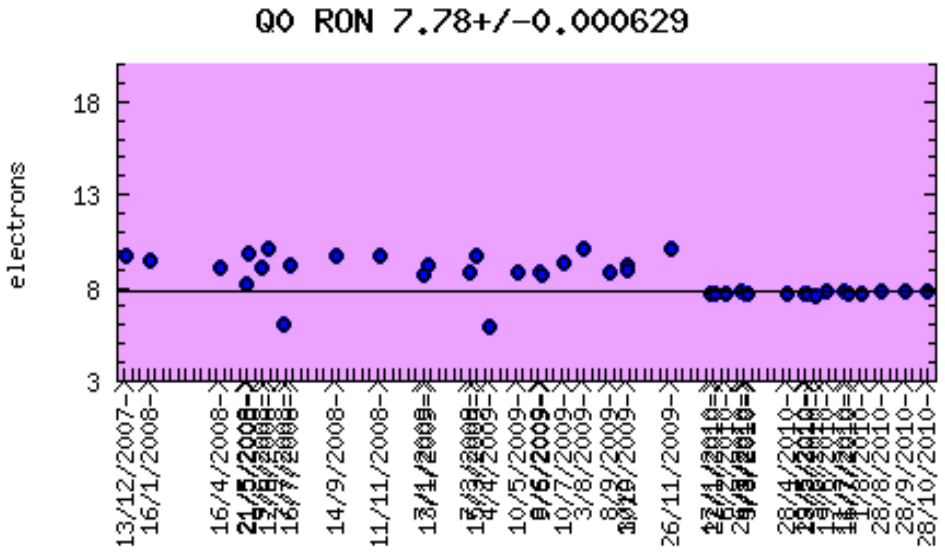
AFTER



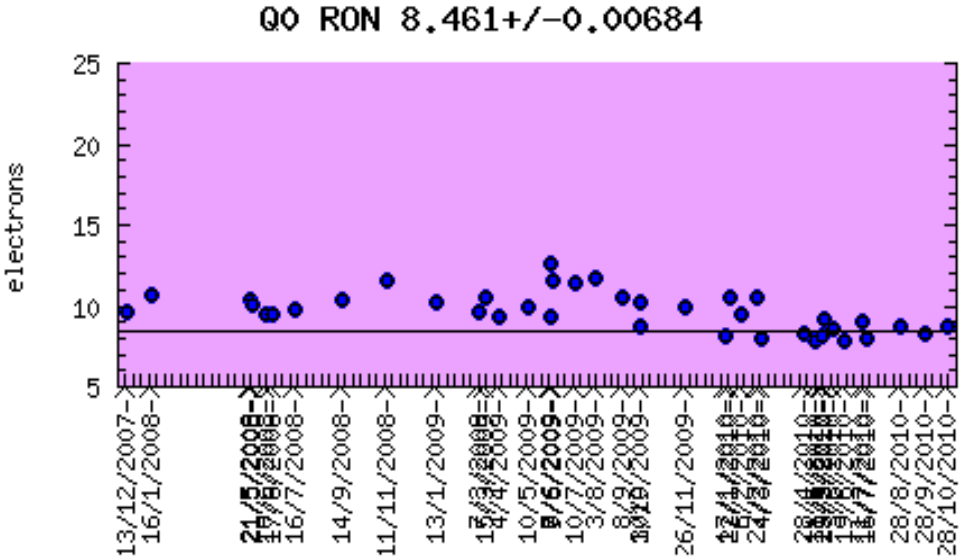
Reset readout (i.e. pre-exposure read)

New controller clock-boards

- New boards, designed and made by Graham, installed Jan-2010
- Clock voltage levels modified from 3.5V to 5V (Rockwell specification)
- Results: 3) Lower readout noise (from 10 to 8 electrons)



Reset-read-read (exp,mexp)



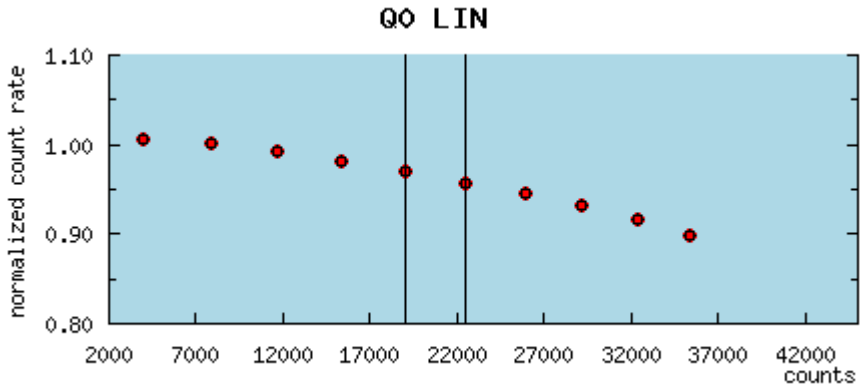
Ramp-sampling (frame)

http://www.not.iac.es/instruments/notcam/staff/clockboards/newclockboards.html

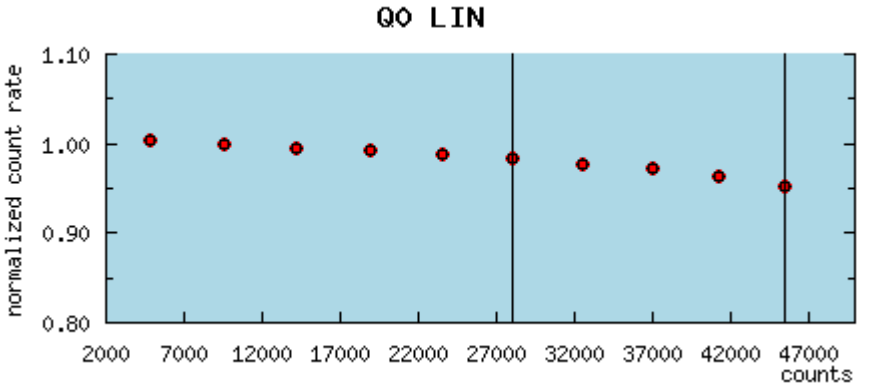
See above URL for an Internal NOT Report on clockboards.

Non-linearity of NOTCam arrays

- While CCDs are linear to 0.1% over a large dynamical range, NIR arrays are inherently non-linear due to using “reversed-biased” photodiodes: Q = CV, but usually not beyond 10%.



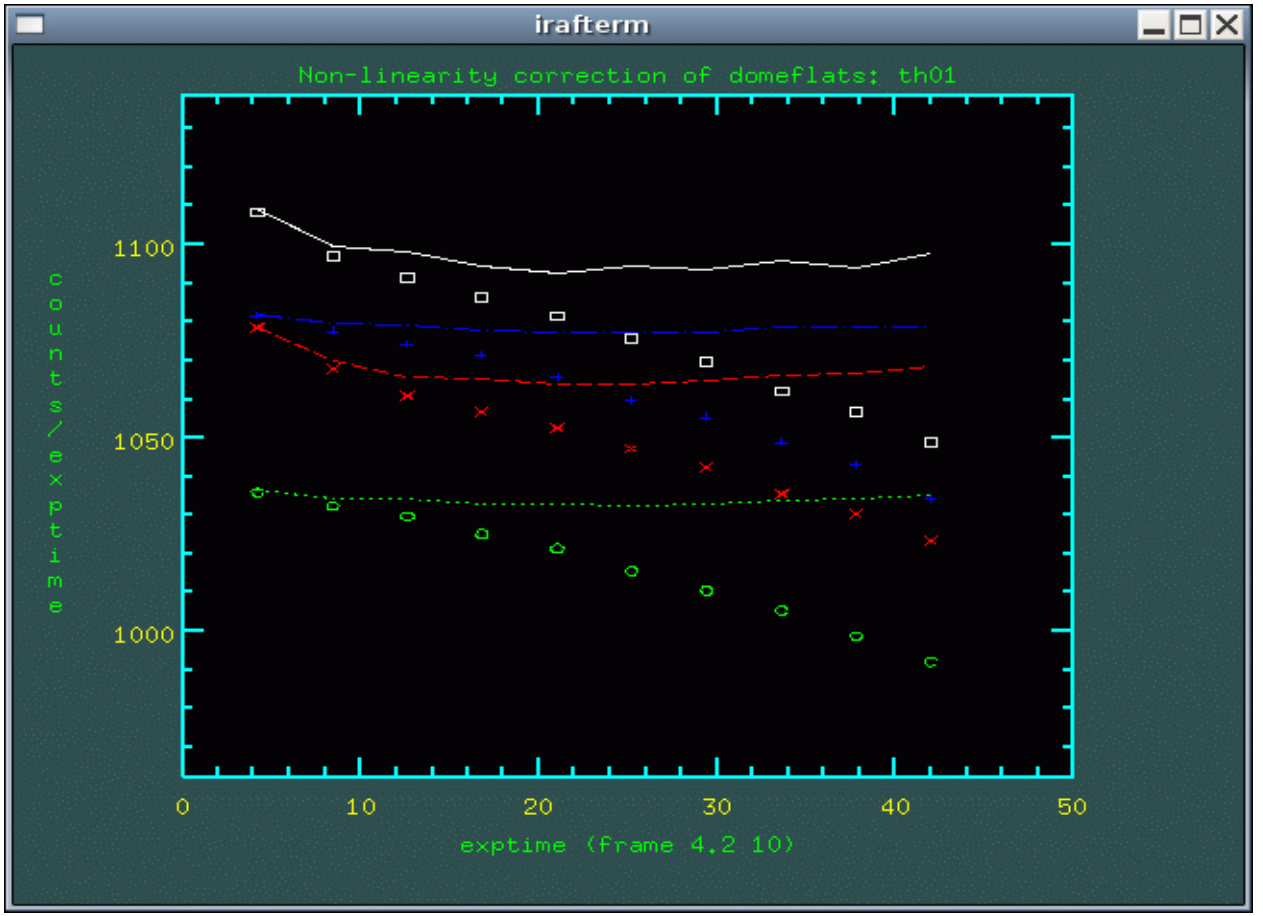
SWIR1



SWIR3

Non-linearity correction

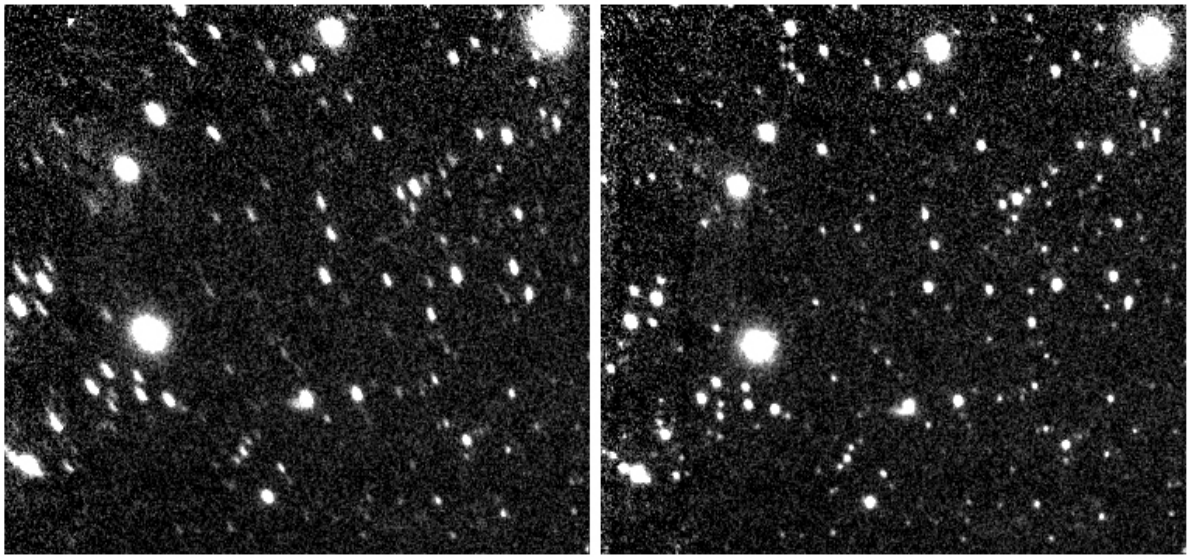
- Non-linearity determined by fitting a 3rd order polynomial per pixel
- Pixel-by-pixel correction coefficients in download archive (two images)
- New script mklincor.cl in future version of notcam.cl IRAF package
- Tested on dome flats
- Tested on stars



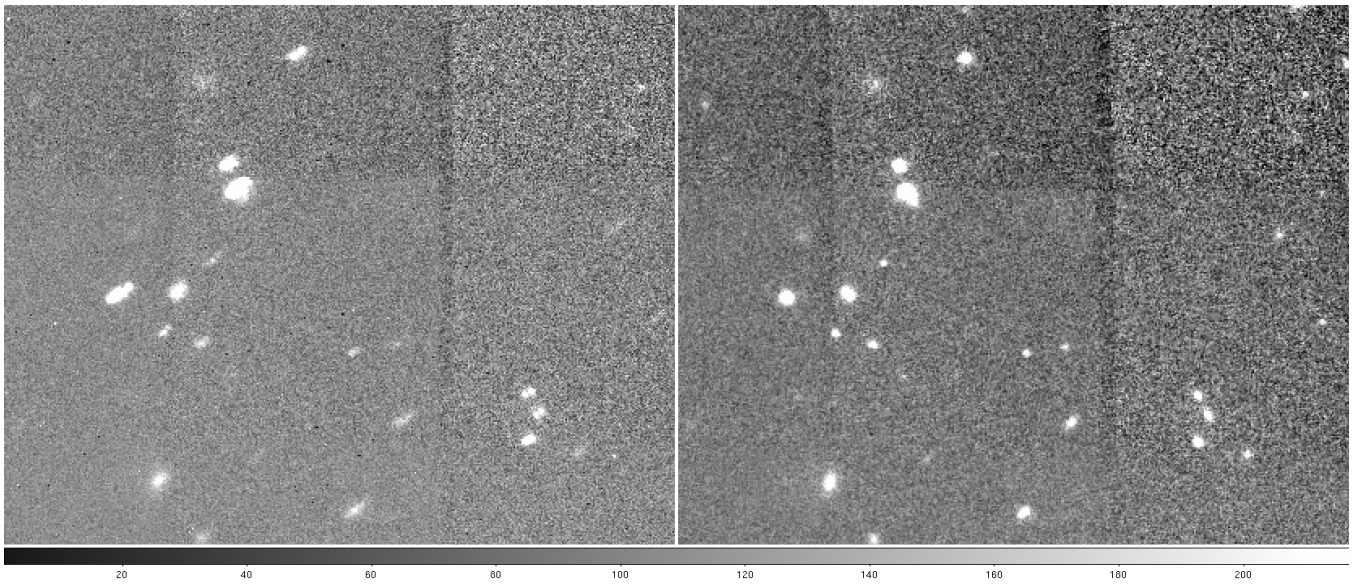
More at http://www.not.iac.es/instruments/notcam/calibration.html

Distortion of the WF camera

Magnus Gålfalk, 2004
2MASS reference, 108 stars
IDL script
Upper left corner
Ks -band



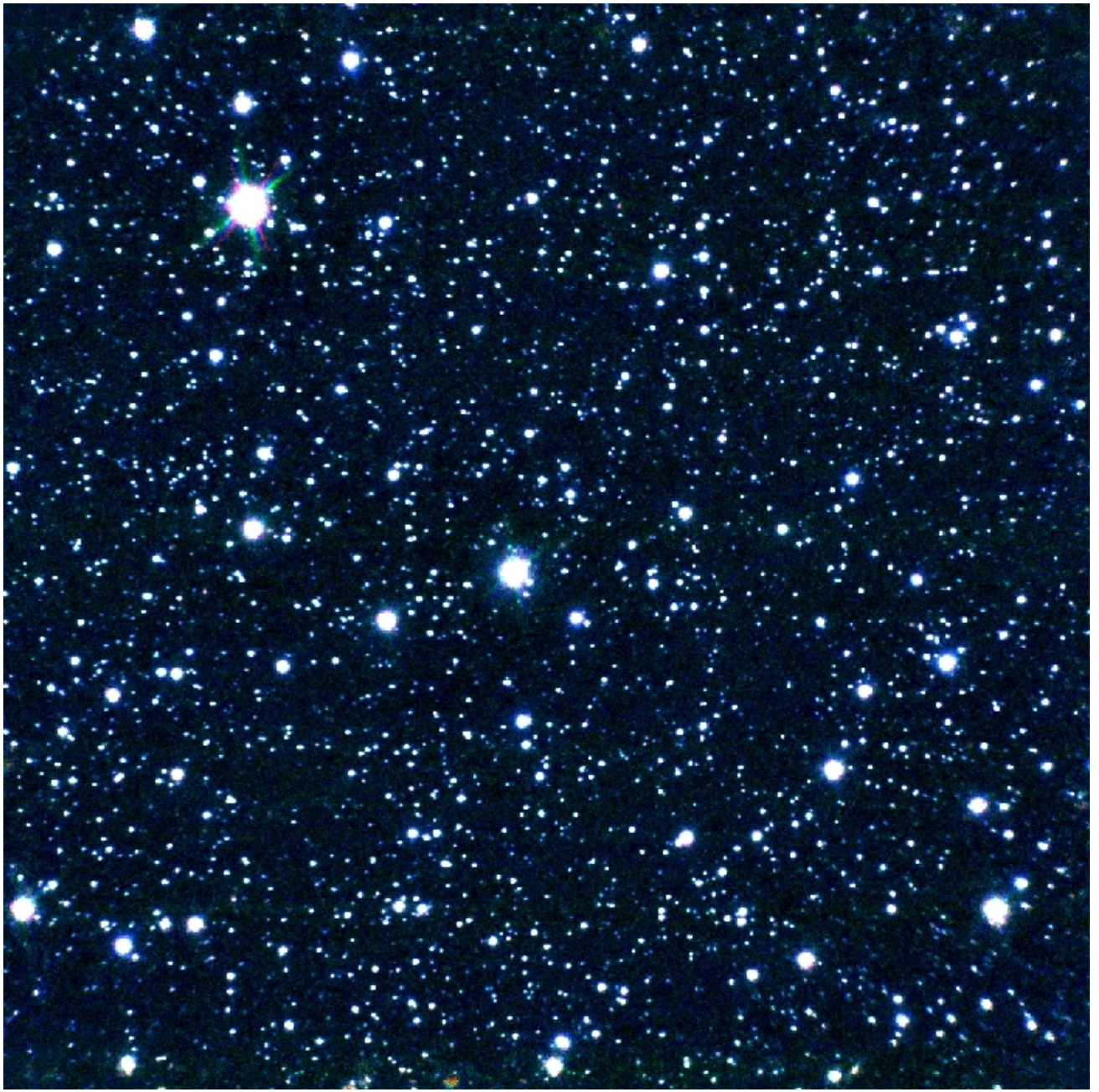
Vallery Stanishev, 2009
SDSS image reference
IDL script
Upper right corner
H-band



Distortion correction for *notcam.cl*

To make a model we need:

- A rich stellar field
- Accurate positions: 2MASS accurate to 0.08” over the range 9 < Ks < 14.
- Good image quality



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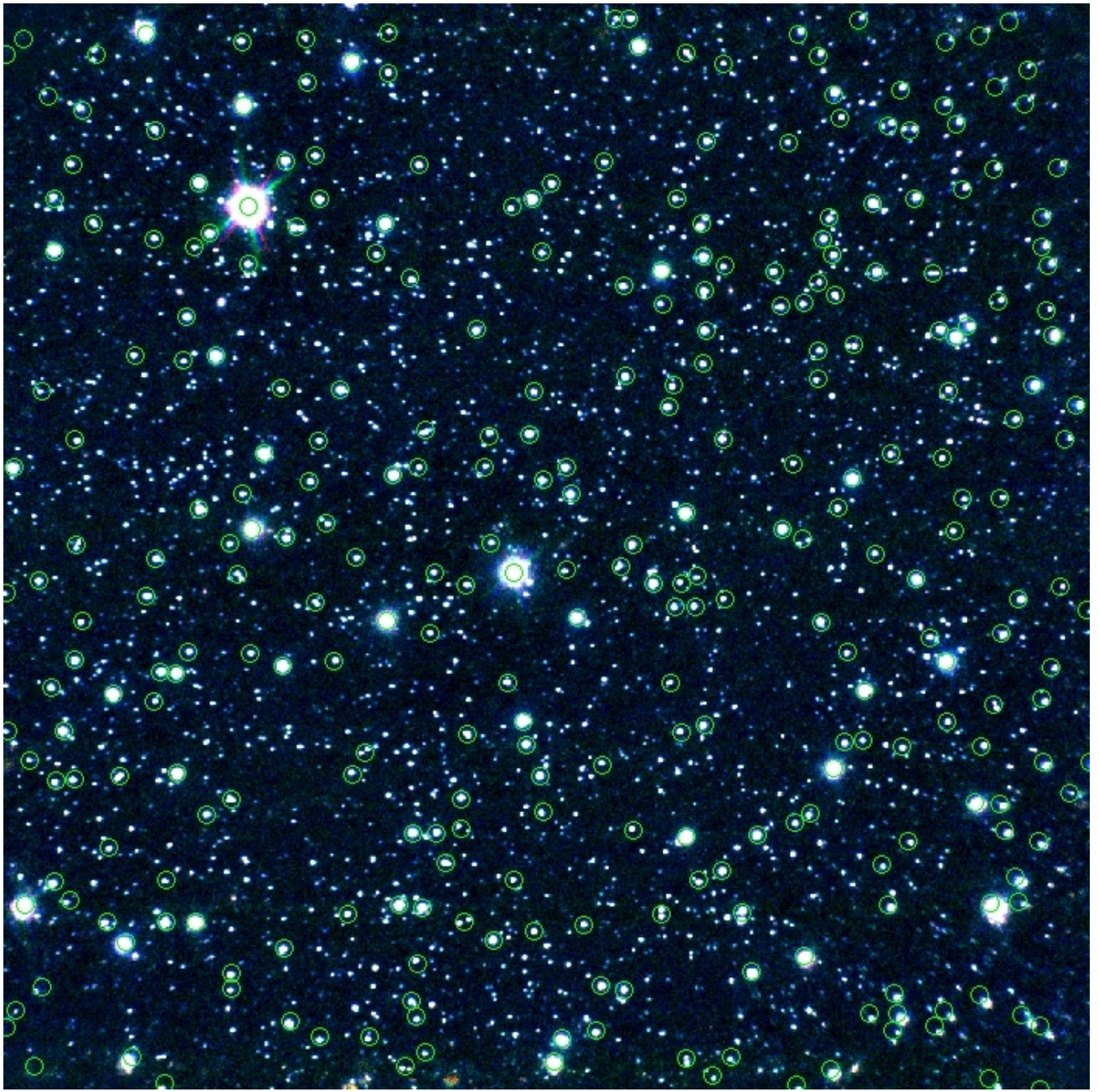
We got:

- 306 stars 2MASS PSC
- 9-point dithers in J,H,Ks
  “frame 5 6”
- FWHM ~ 0.5”



La Palma, 15/11/2010

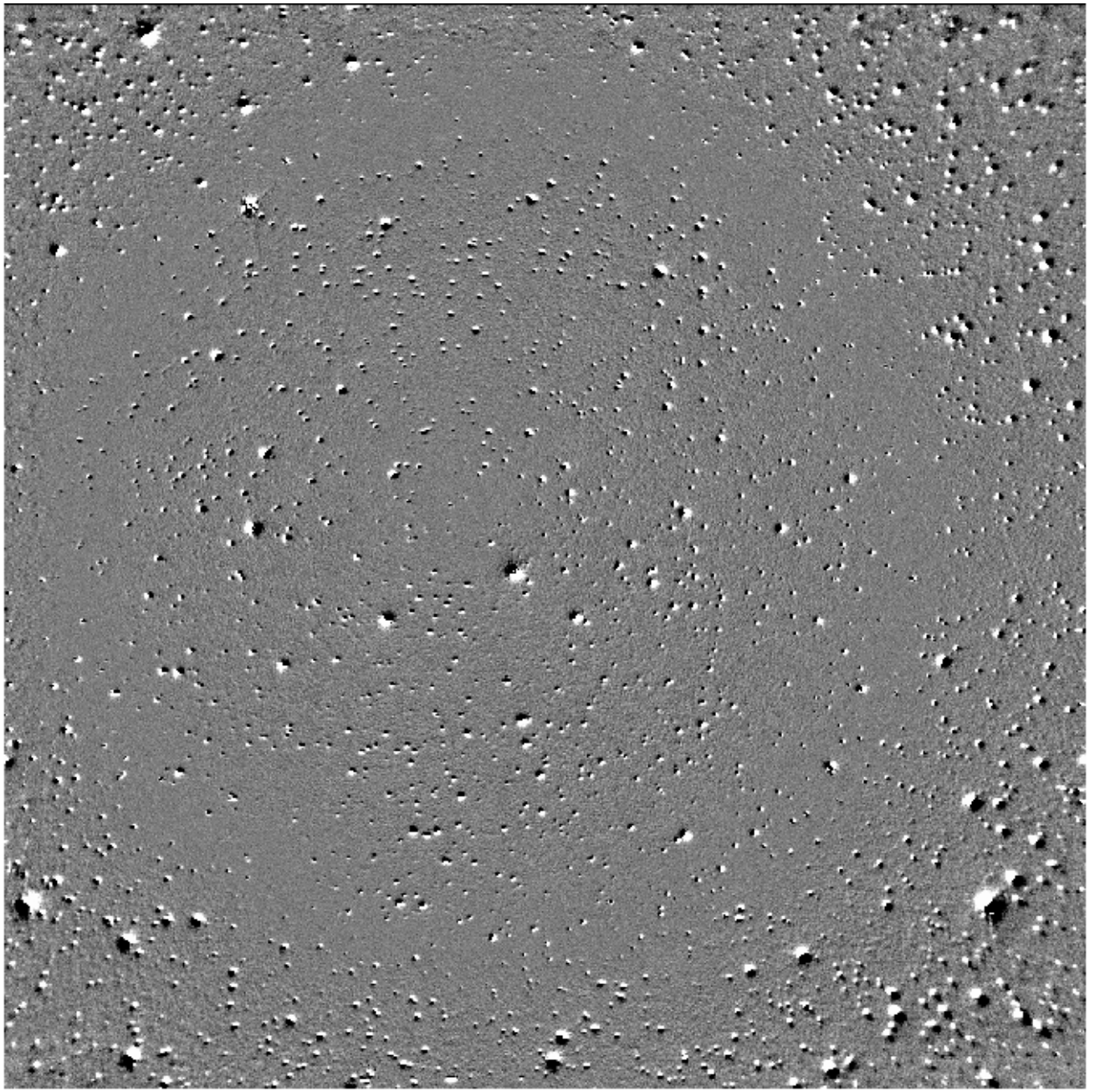
Distortion correction for *notcam.cl*

Make a model:

- IRAF task geomap
- Fit 9 x 260 positions using 4th order Legendre polynomial
- RMS of fit < 0.7 pix ~ 0.16”
- Include correction as an option in scripts:

  reduce.cl
  reduce_bs.cl

after flat-field correction and sky-subtraction.



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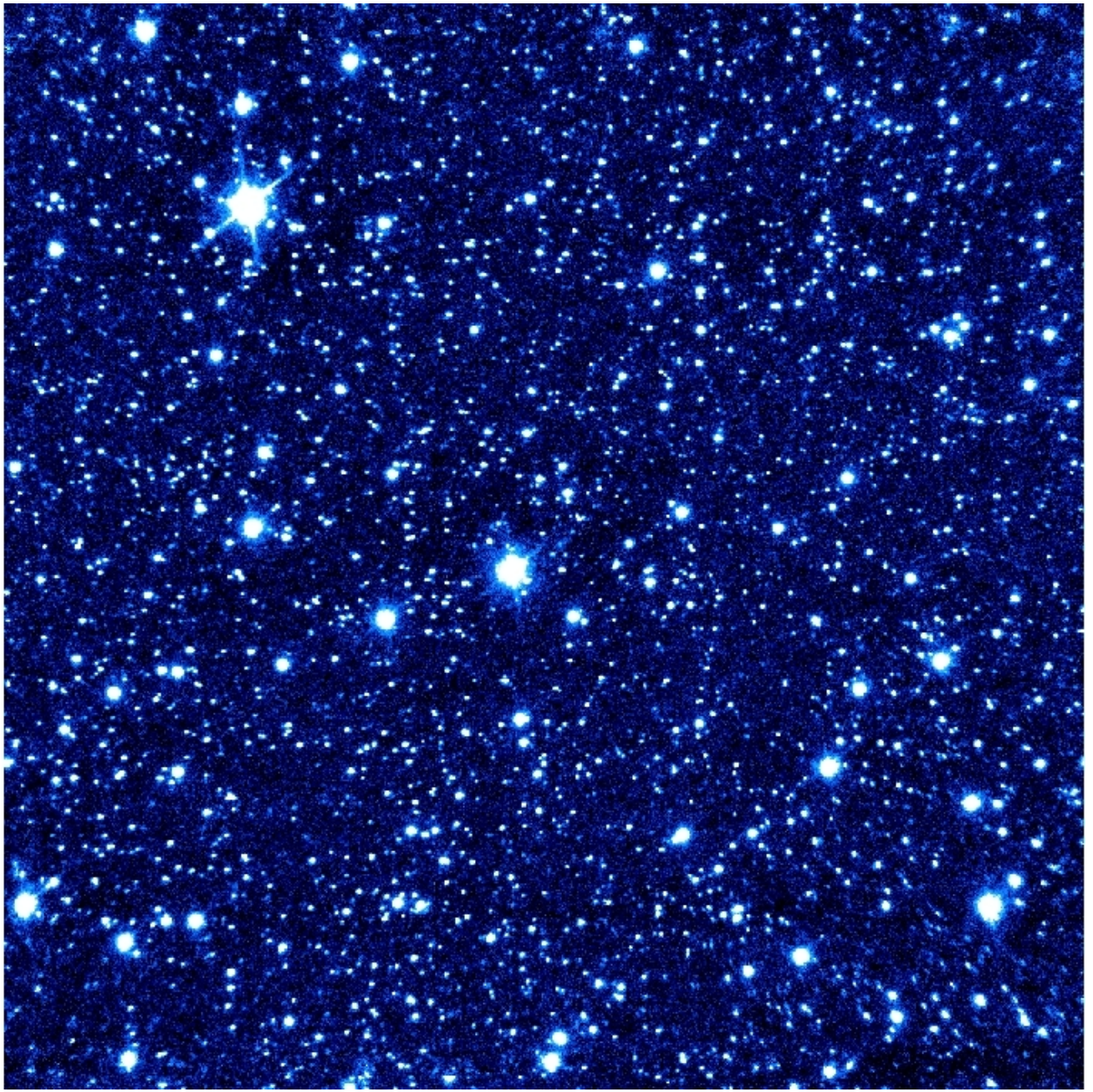

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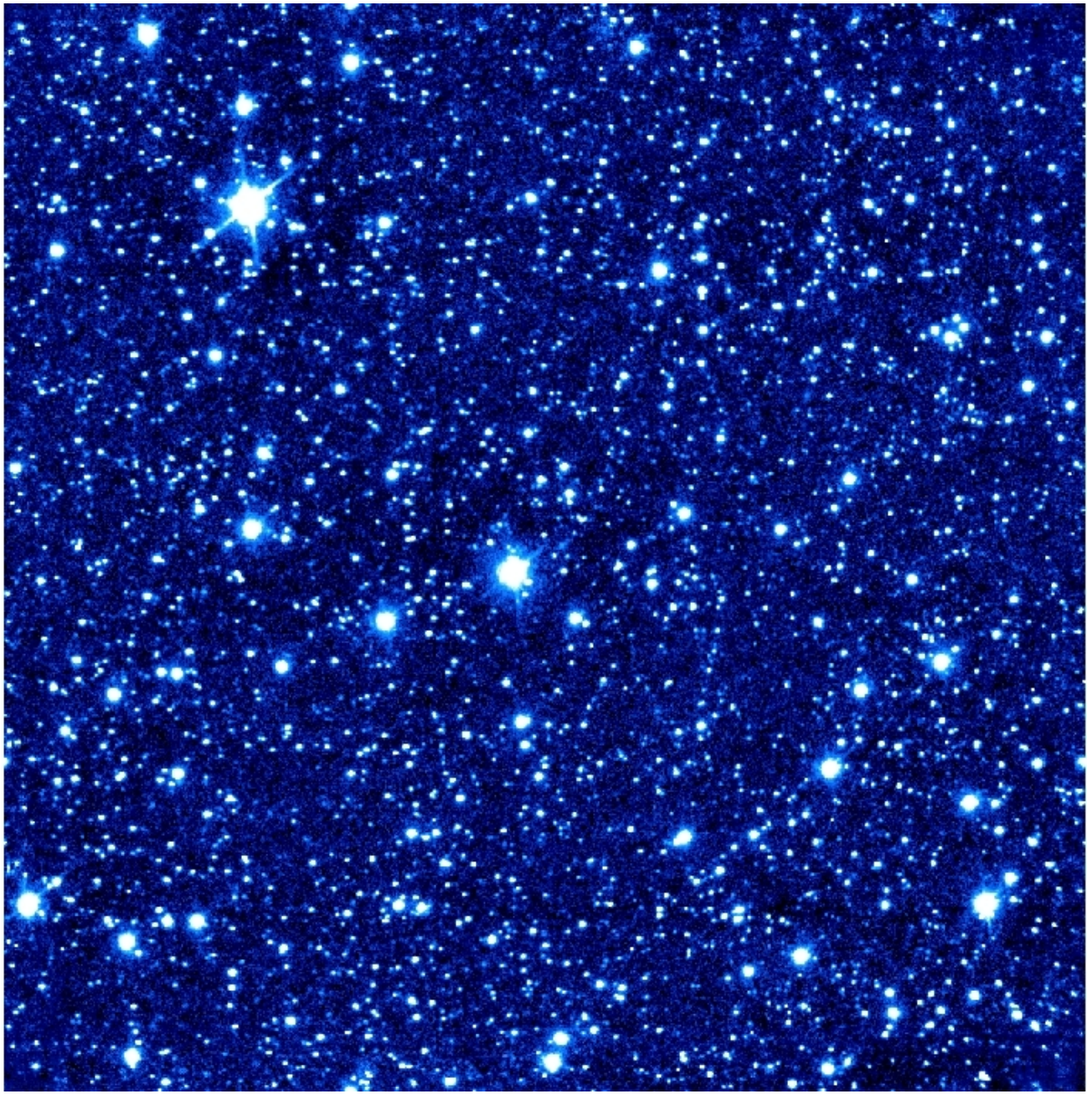
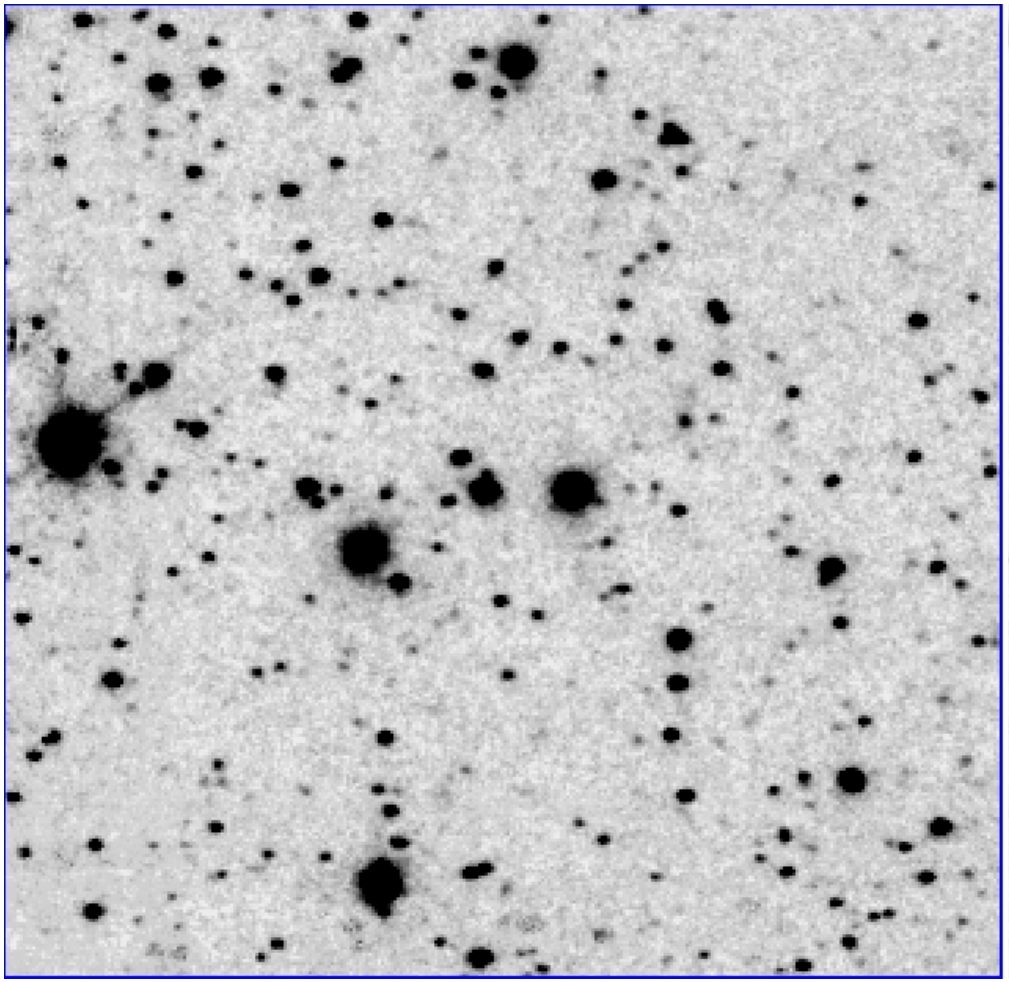
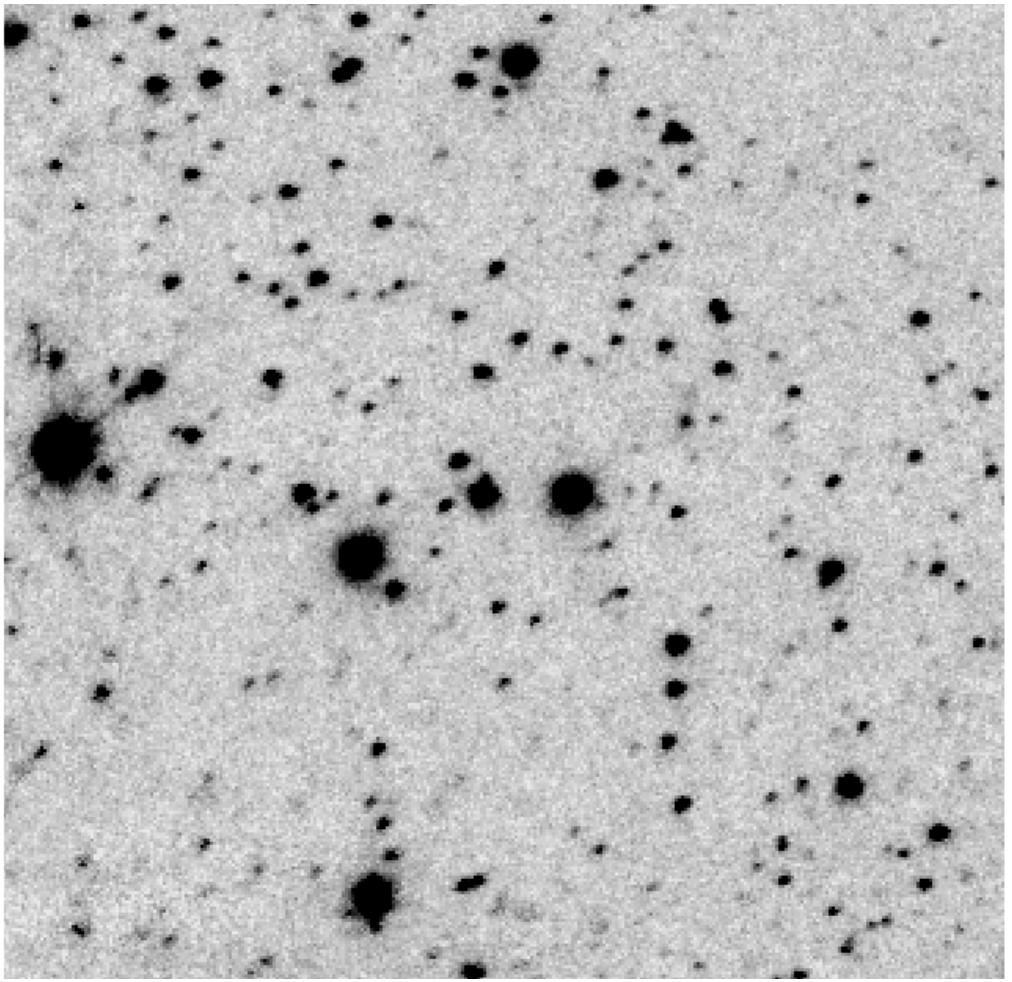


Comparison of corners - lower left

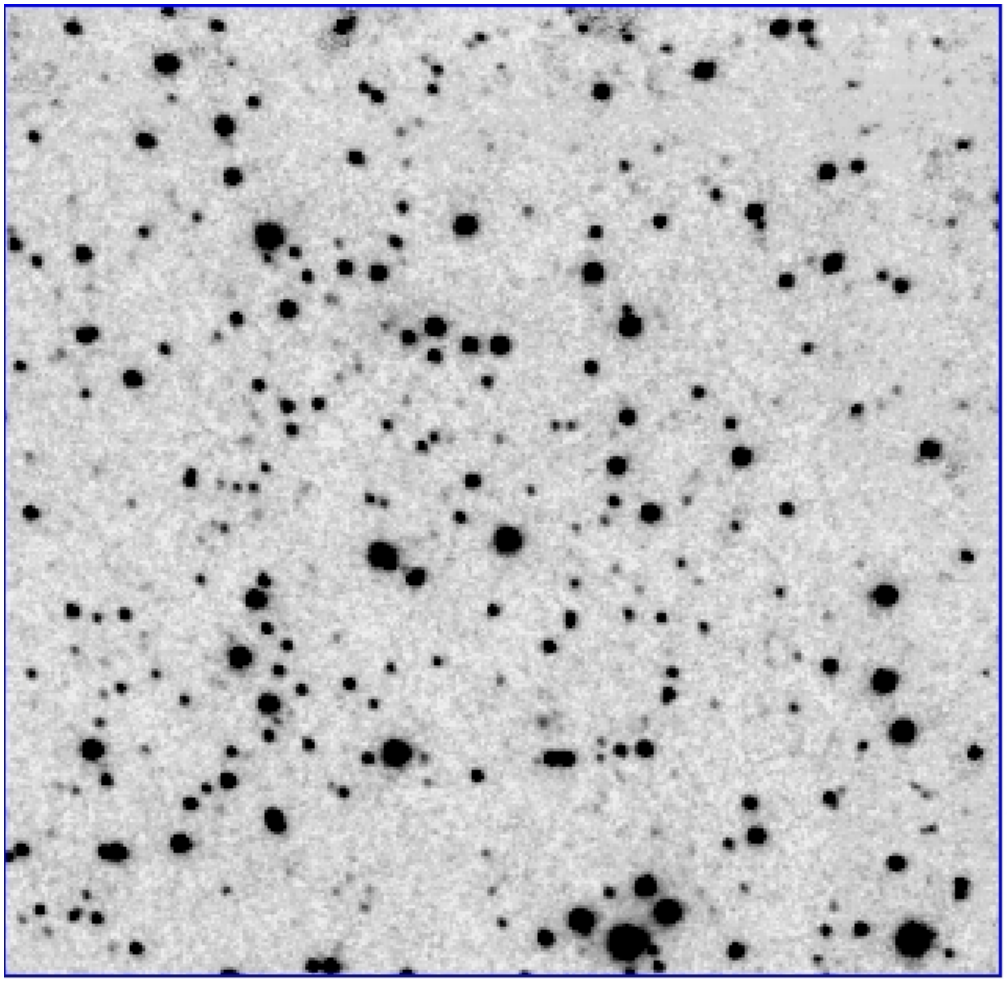


AFTER

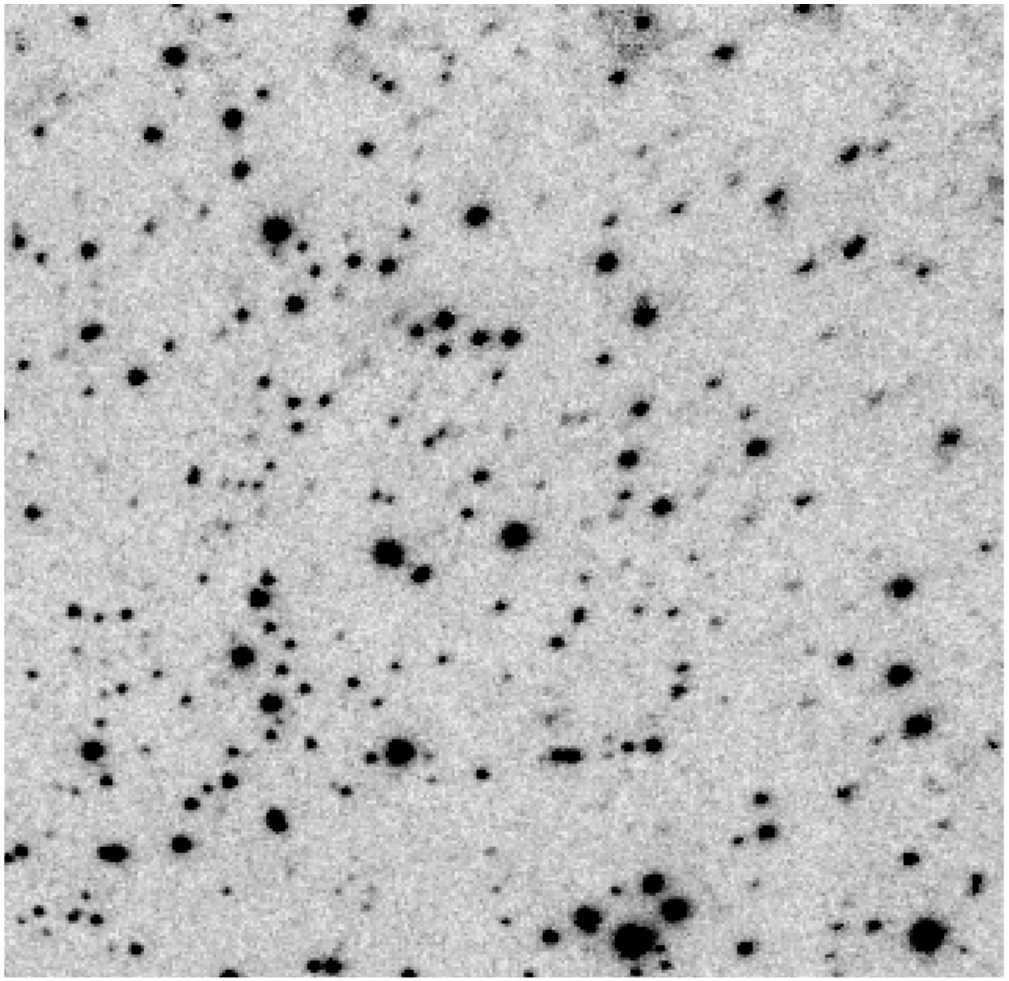


BEFORE

Comparison of corners – upper right

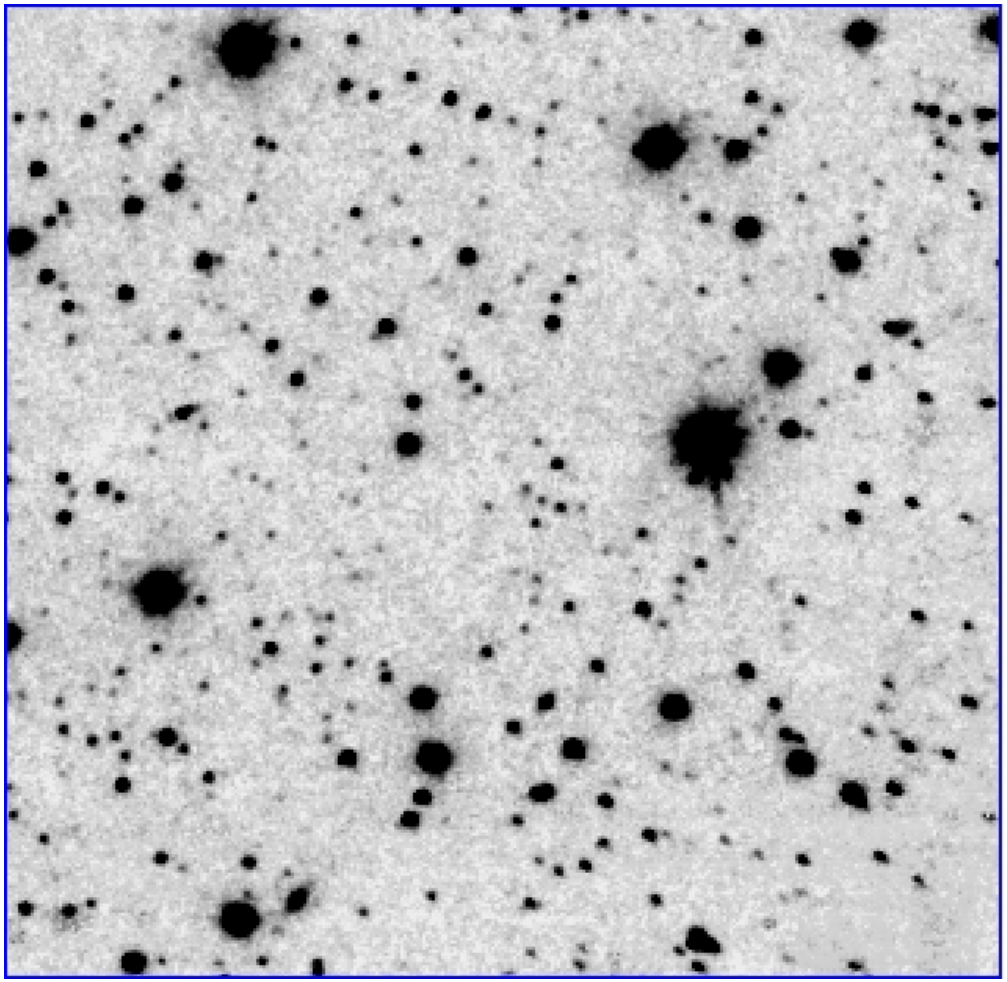


AFTER

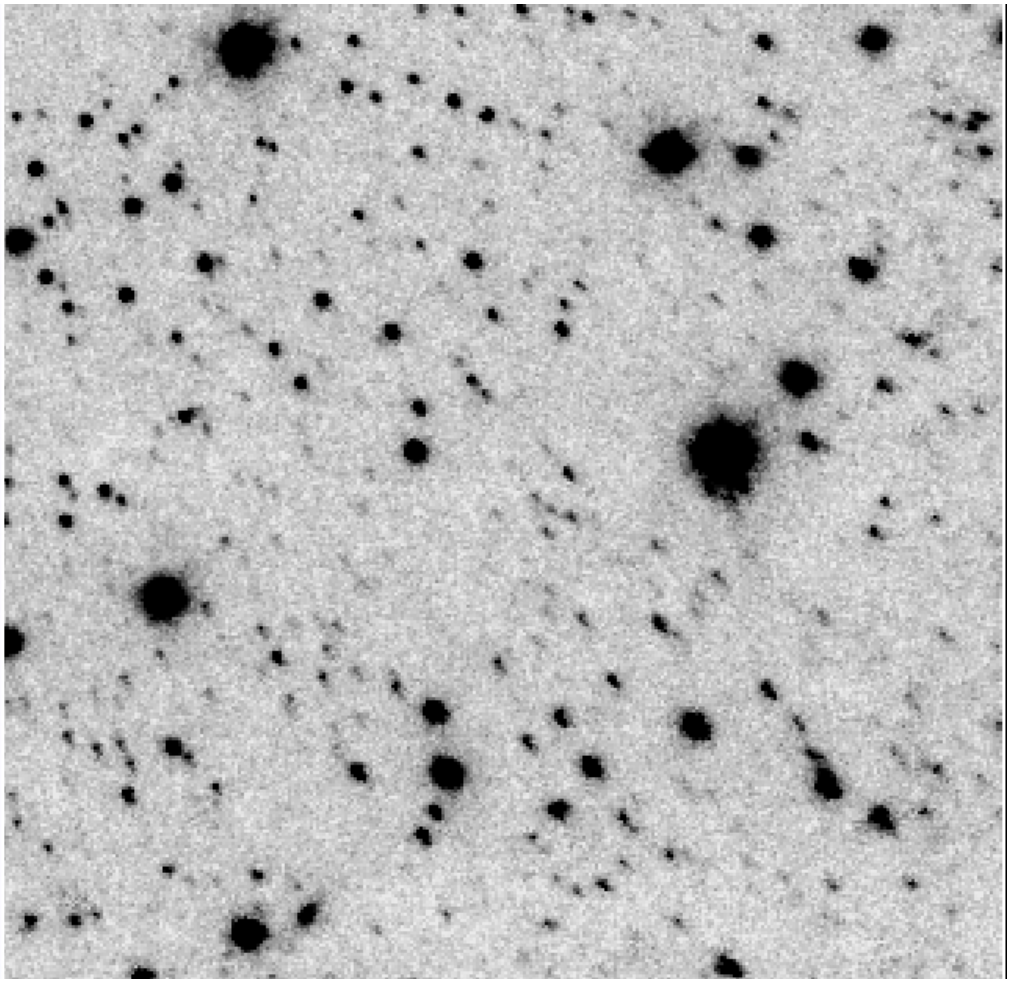


BEFORE

The worst corner – lower right



AFTER

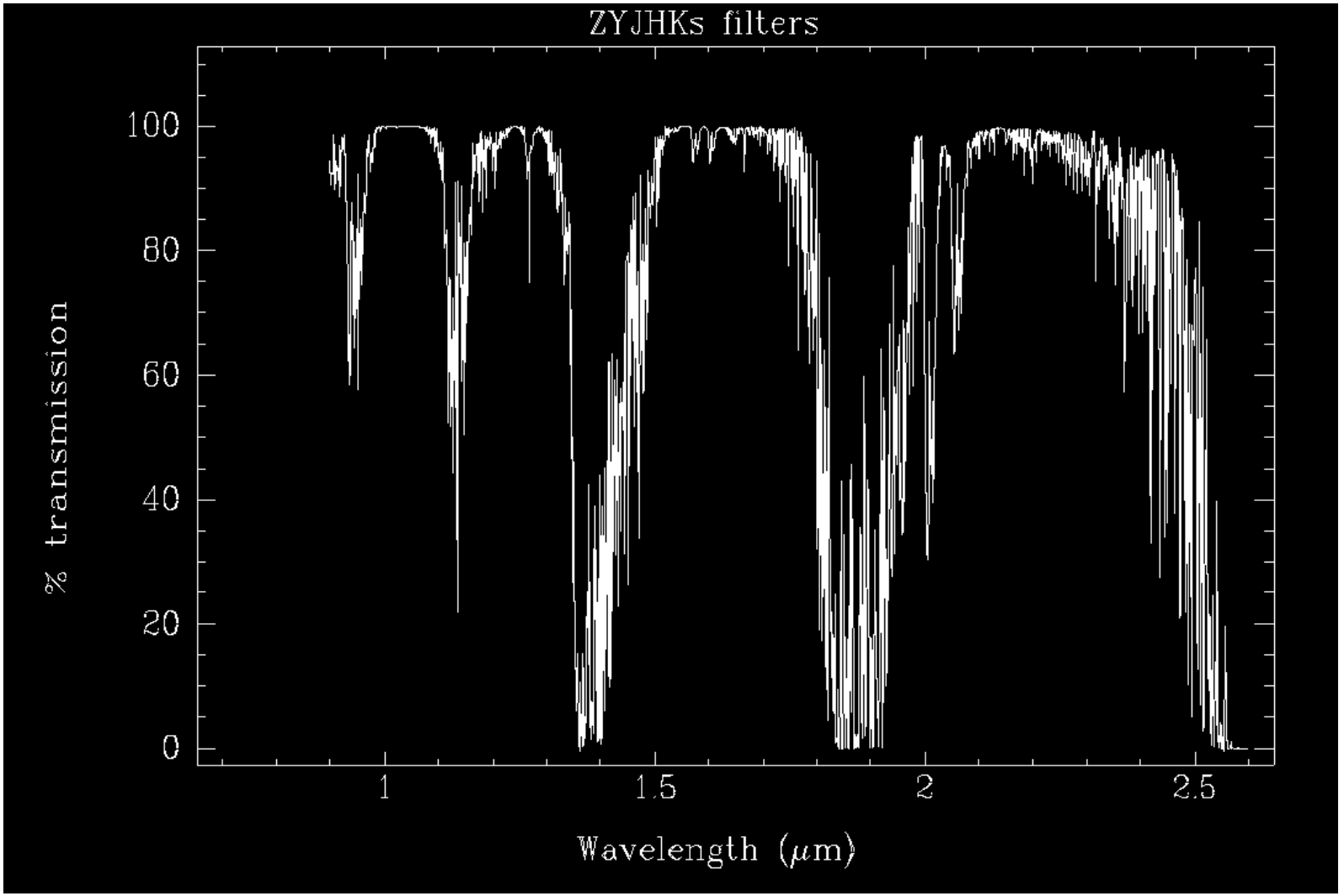


BEFORE

Distortion correction – TBD

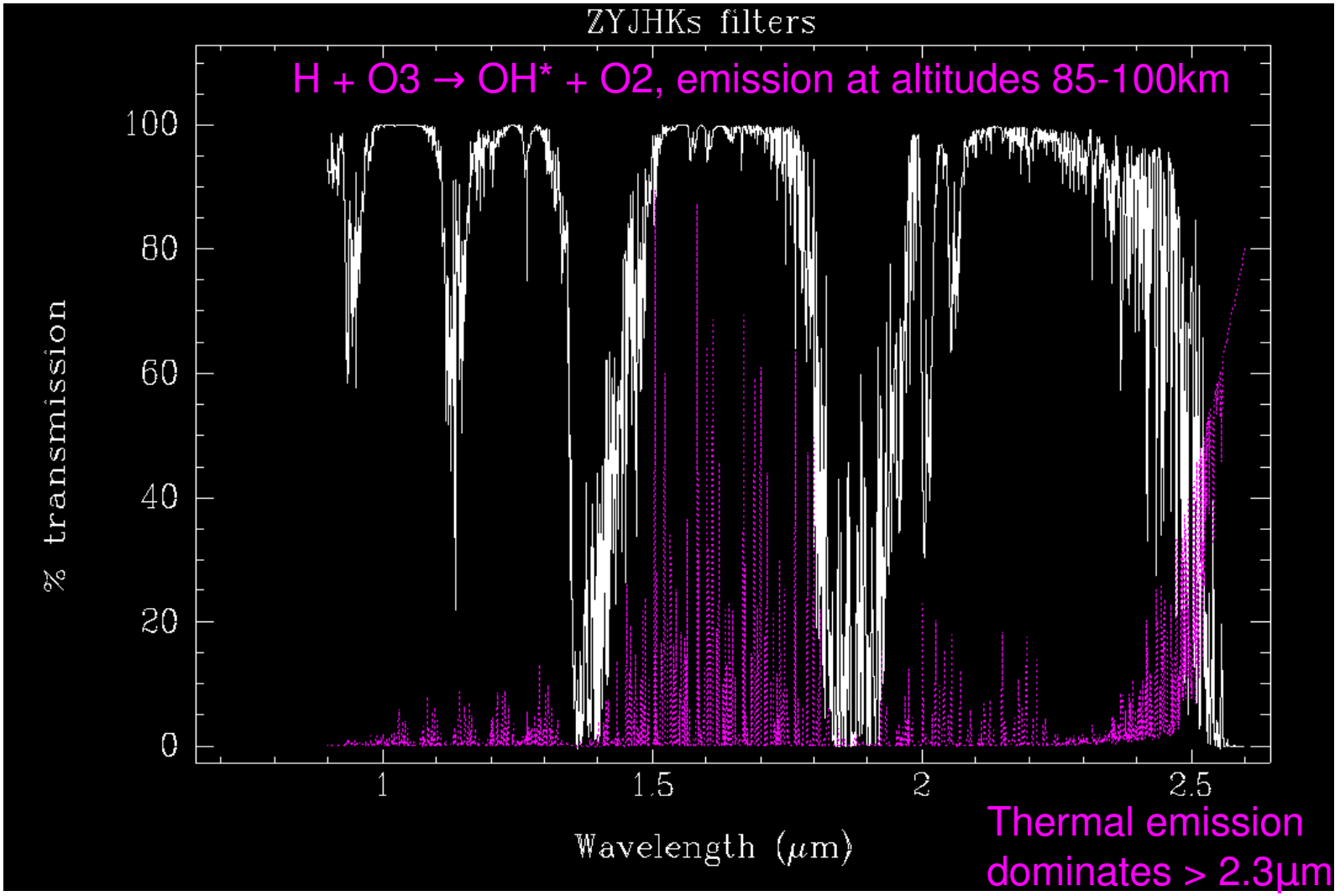
- Find distortion correction for J and Ks bands (not equal!)
  - previous images shown for H-band
- Photometry checks on flux conservation:
  1) individual-image stellar fluxes equal within < 1%
  2) median-combined-image stellar flux losses practically gone
- Check the astrometric solution:
  - if accuracy is too low, we need to consider empirical models of the distortion, using look-up tables
- Make the correction files available in down-load archive
- Update **notcam.cl** to include distortion correction as an option in the scripts **reduce.cl** and **reduce_bs.cl** (after flat-fielding, zero-pixel correction, and sky subtraction)

New broad band Z and Y filters



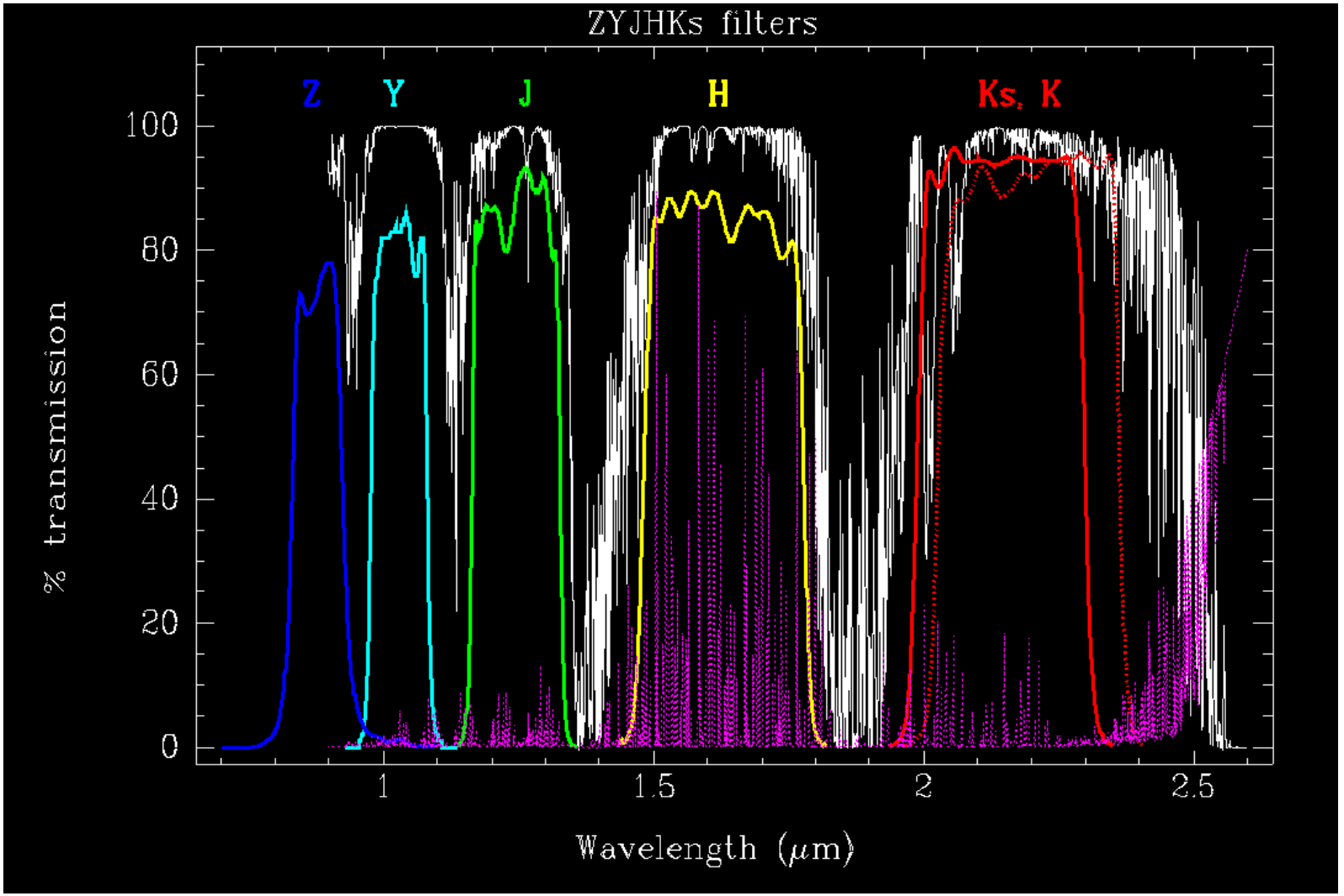
Sky transmission and emission based on ATRAN models (Lord, 1992) calculated for Cerro Pachon (airm=1,PWV=4.3mm) by Gemini. Mean PWV at ORM is 4.8 (over the year) and 3.3 (Jan-Jun).PWV = precipitable water vapor, the column density, varies from 1-15 mm.

New broad band Z and Y filters



Sky transmission and emission based on ATRAN models (Lord, 1992) calculated for Cerro Pachon (airm=1,PWV=4.3mm) by Gemini. Airglow and thermal emission.

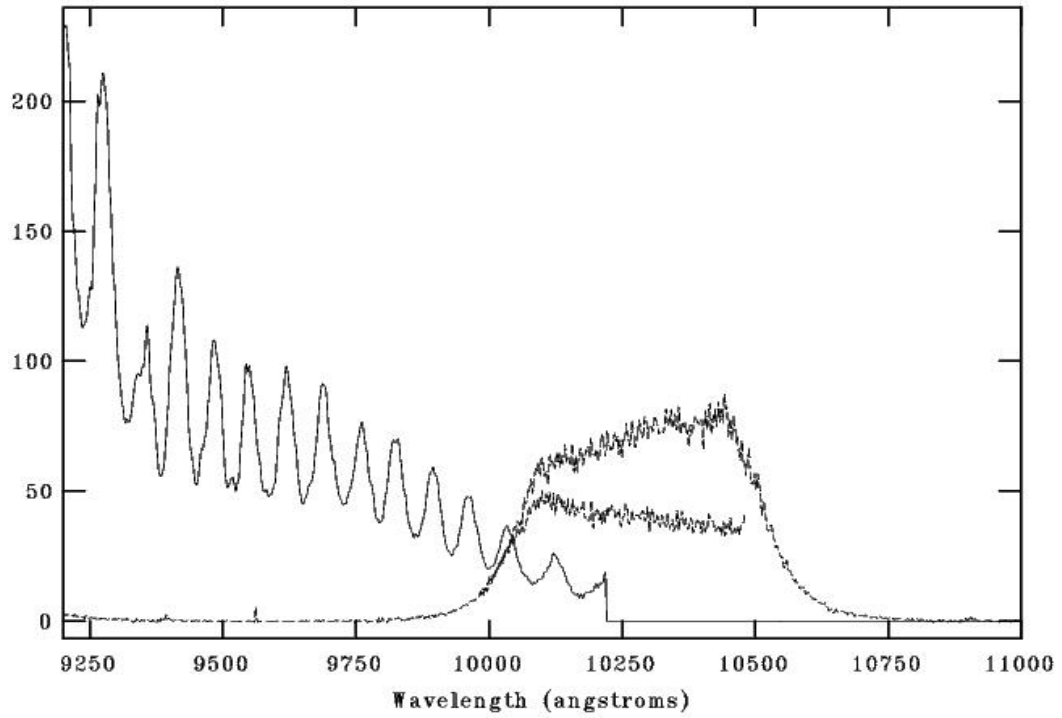
New broad band Z and Y filters



Sky transmission and emission based on ATRAN models (Lord, 1992) calculated for Cerro Pachon (airm=1,PWV=4.3mm) by Gemini.
The UKIRT ZYJHK photometric system. Actual NOT ZYJHK filter transmission curves.

Why Z and Y ?

- The UKIRT Infrared Deep Sky Survey ZYJHK Photometric System (UKIDSS) the successor of 2MASS (3 magnitudes deeper)
- Important window for science: 1) cool, near brown dwarfs, 2) high-redshift starburst galaxies, 3) galaxy clusters at 1 < z < 2, and 4) highest-redshift quasars)
- NOTCam has a good QE at its “blue” end where CCDs perform badly

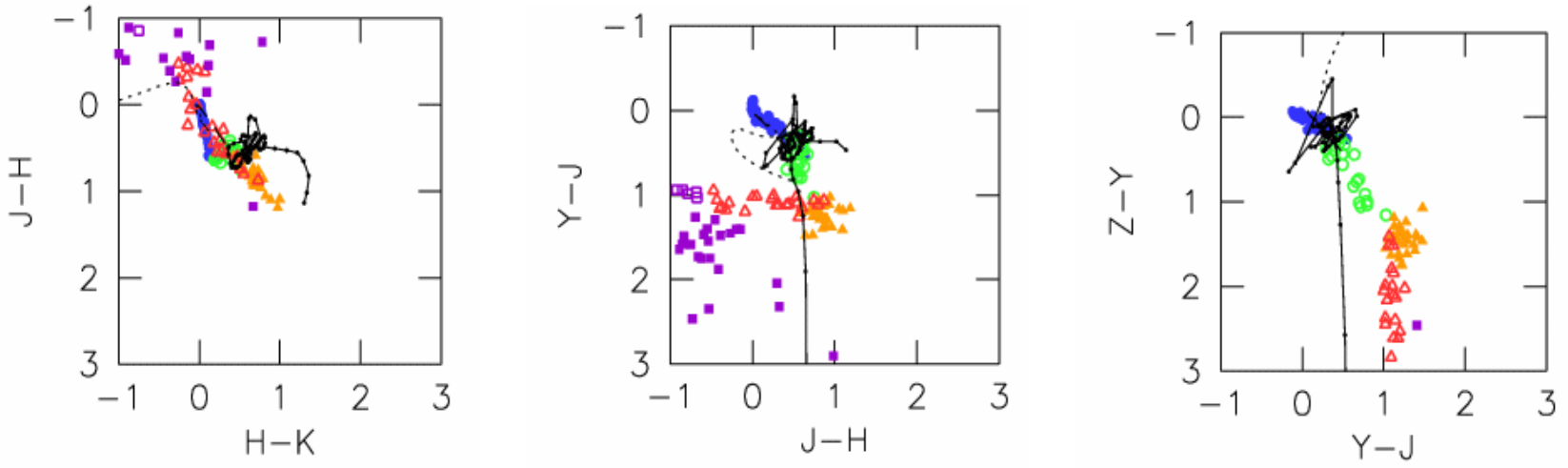


ALFOSC/NOTCAM comparison (Telting, 2005)

ALFOSC+CCD#8, grism#5
NOTCam+SWIR1, grism#1, Yn

Expect even better:
- SWIR3/SWIR1 sensitivity = 1.7 (at J-band region)
- Y-filter has 80% transmission compared to 60% for Yn

Colour-colour diagrams

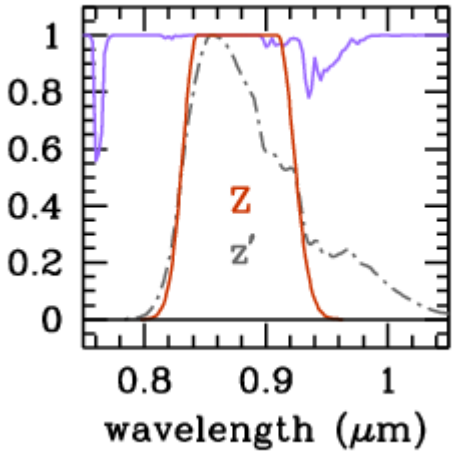


O-K dwarfs
M dwarfs
L dwarfs
T dwarfs
Cool Brown Dwarfs model
__Quasars 0 < z < 8.5
....white dwarfs

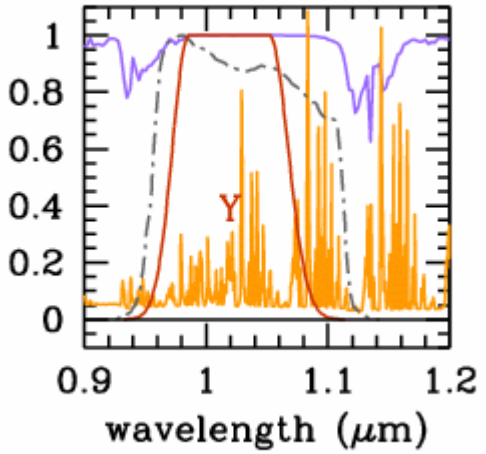
Hewett et al. 2006, MNRAS 367,454

Filter specifications

- Using the UKIRT definition for the Z and Y bands when specifying filters:
  0.83 - 0.925 µm, 0.97 – 1.07 µm (FWHM / 50% points)
- Size: max 5mm thick, diameter=25mm
- To be used tilted by 6 degrees, at a temperature of 74 K
- Single substrates, non-radioactive materials
- Peak transmission > 80%, Out-of -band blockage to 0.01% (0.3 – 2.6 µm)



UKIDSS Z compared to the optical SDSS z', a long-pass filter defined by the falling QE of the CCD.



UKIDSS Y compared to the Hillenbrand Y-filter.

NIR filter manufacturers

Quotes in euros:

	Asahi Spectra	Omega Optical	NDC IR Eng.	Research El-Opt	Barr
Z	2230	3700-5900	2964	no answer	12000-15000
Y	2230	3700-5900	528	no answer	6230-10000

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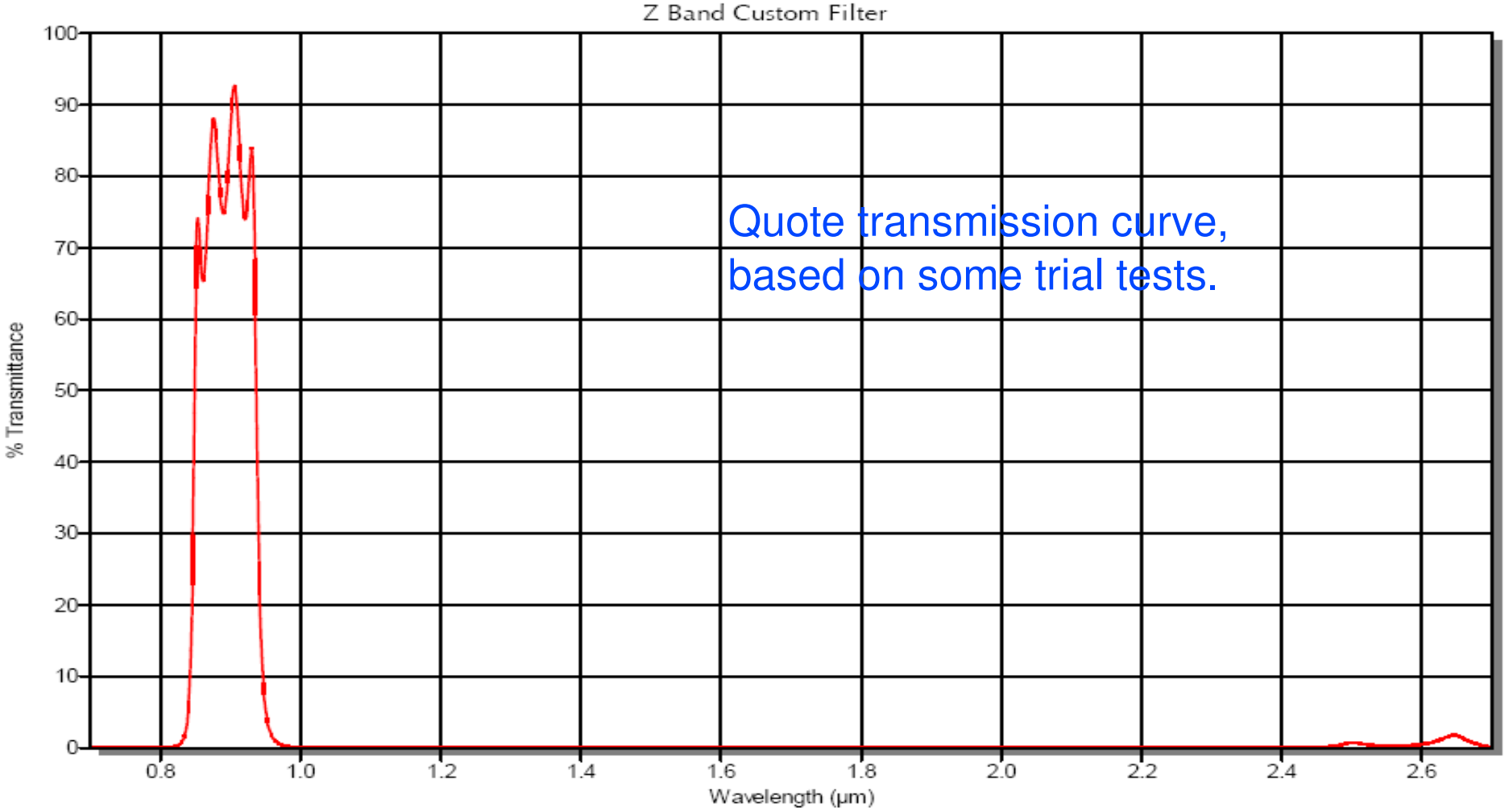
<u>NDC IR Engineering (UK)</u>

Manufactured most of our other NOTCam filters
Manufactured the UKIRT/WFCAM Y,J,H,K filters (but not the Z!)
Had the Y-filter in stock
Provided a detailed quote with specifications included

Making the Z filter

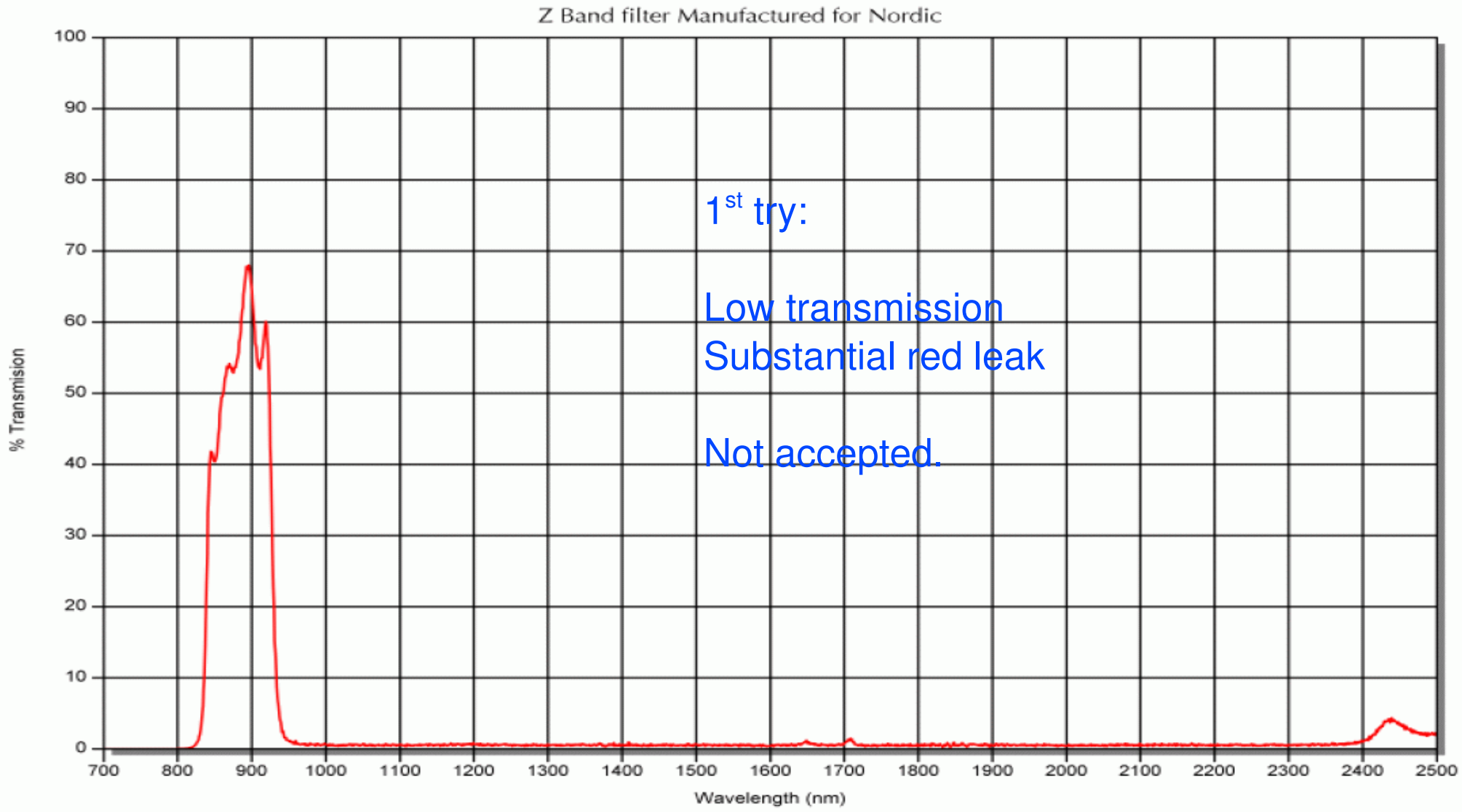
- Y-filter OK. Peak transmission = 85%. Standard. Same as UKIRT's Y.
- Z-filter much more difficult to produce.

3.3.1 Z-Band Filter.



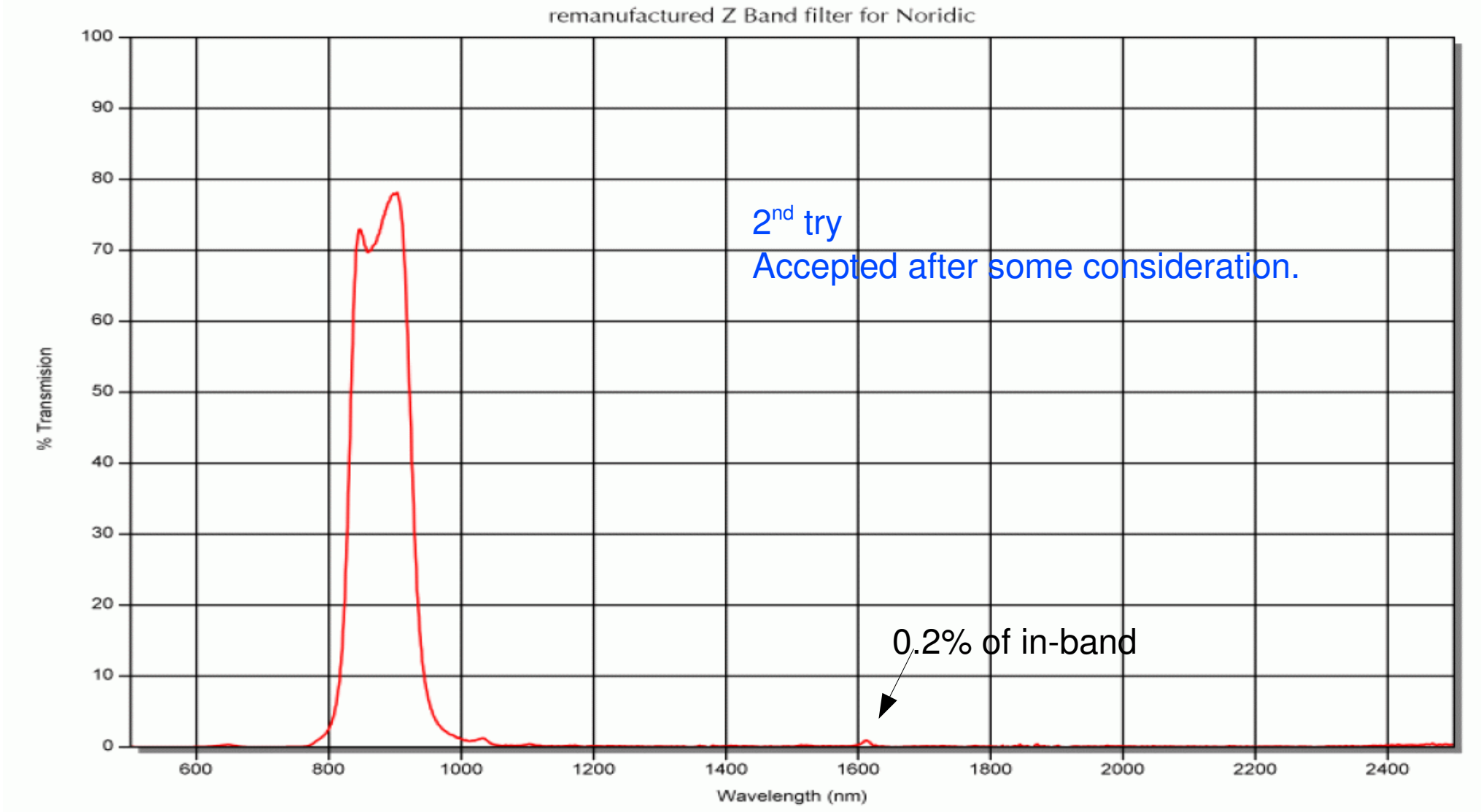
Making the Z filter

- The problem is that the materials used for the blocking, required over a large dynamical range, absorbs at the blue end causing 0% transmission at 800nm and sloping up from about 950 to 1150 where it flattens out.



Making the Z-filter ... again...

- Completely different design, using more expensive chemicals. According to NDC, this is the best they can do.



Next things to do:

- Upgrade notcam.cl to v2.4 (include non-linearity correction and distortion correction), early 2011
- Install (Jan-11) and commission the new Z and Y filters

- Continue the battle against the observing overheads
- If possible, further reduce the pick-up noise
- Upgrade of detector quality control (on-going)
- Improve