

# High Resolution Deep Sky Astrophotography

From the data acquisition to the final image

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t OudeTheater Oss/NL, May 01, 2010  
(ROBTICS Astronomical Instruments)

# Contents

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Examples for optimum setup

CCDs for stationary setup

Target selection

Image acquisition

Calibration and registration

Color combining

Narrowband techniques

Processing in Photoshop CS

Typical workflow



# Setup Canon 200mm f/2.8 L lens

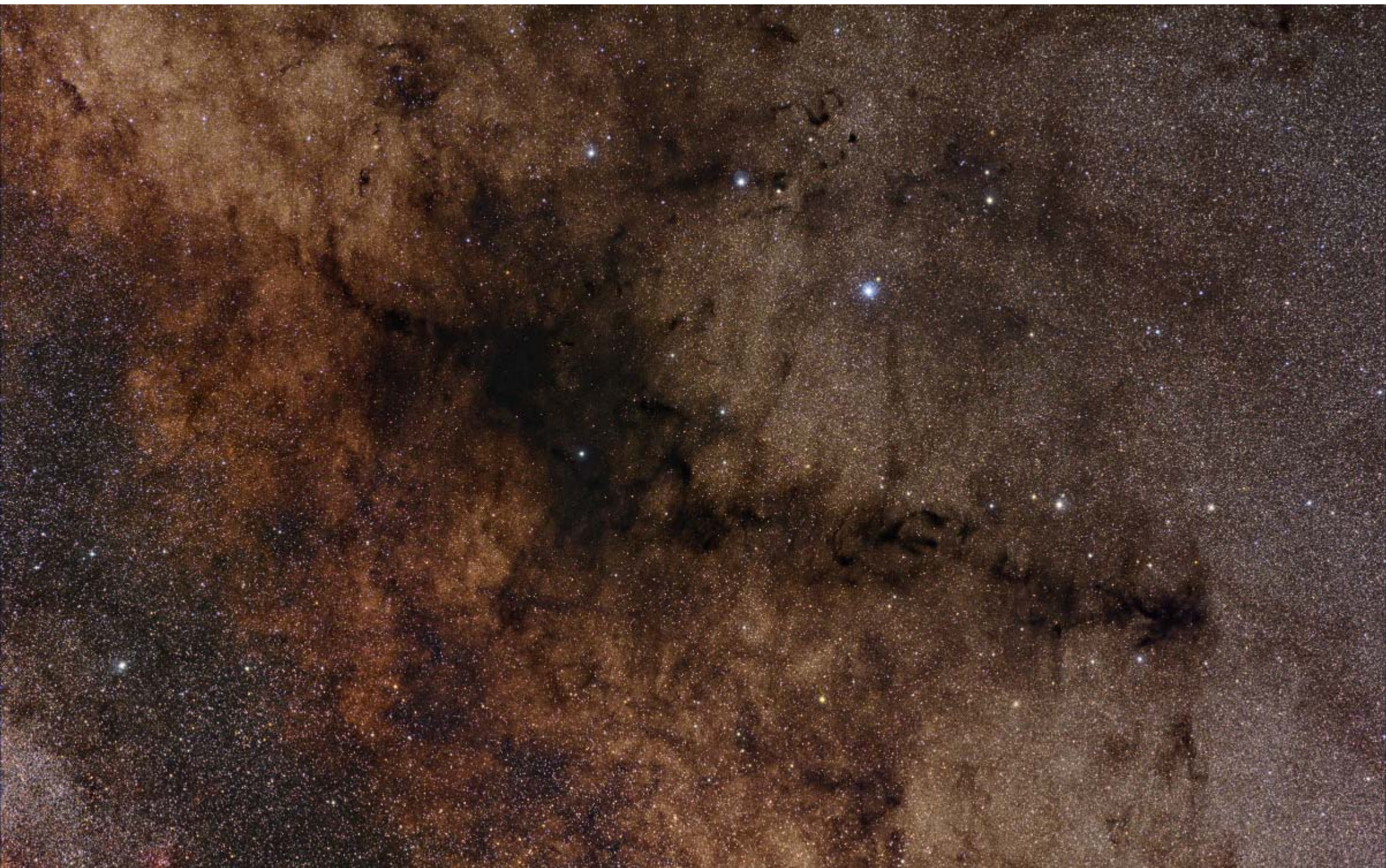
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Field  $7^\circ \times 10^\circ$  with STL-11000  
Res. 9,2"/Pixel

- No guiding at  $< 100\text{mm}$  FL
- Simple portable setup
- Short exposures
- Not seeing dependant



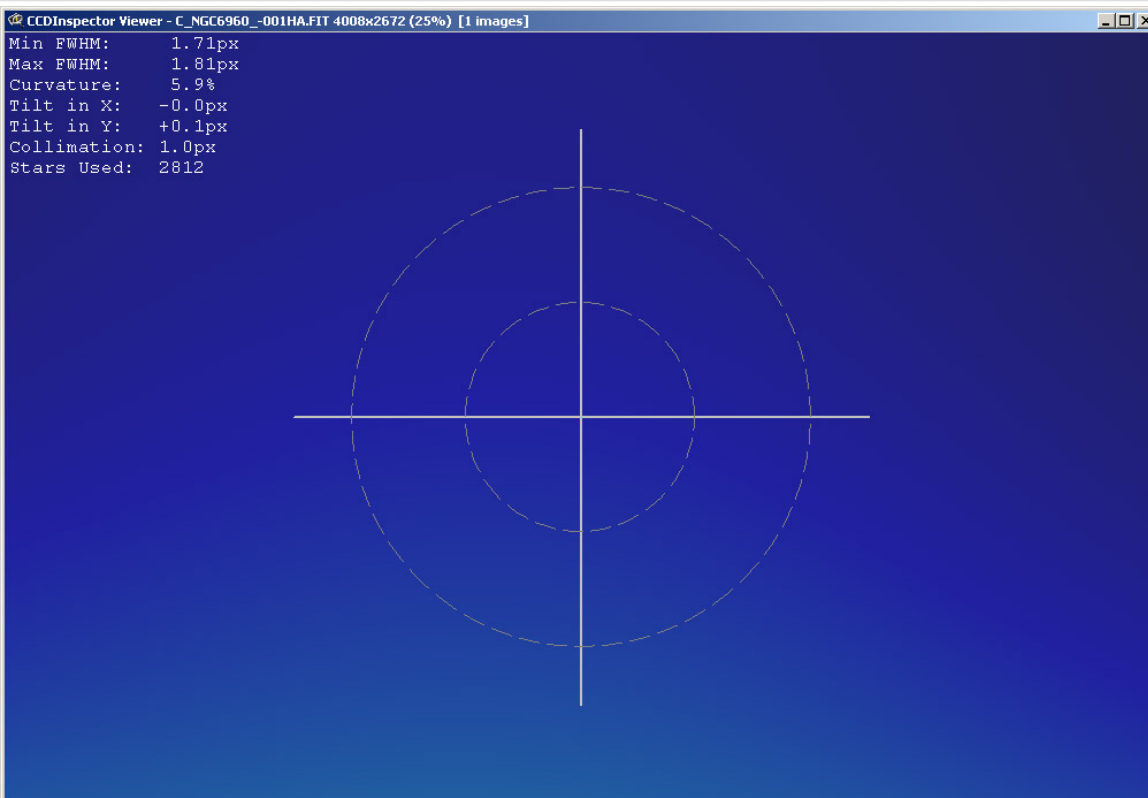






# Setup Tec-140 (Incl. TEC medium format flattener)

D 140 mm  
FL 980 mm  
Field 125' x 83' with STL-11000  
Res. 1,87"/Pixel





# Examples Tec-140 (with STL-11000)

- Flat field
- Seeing not critical
- Optimum for nebulae
- Portable (upper limit!)

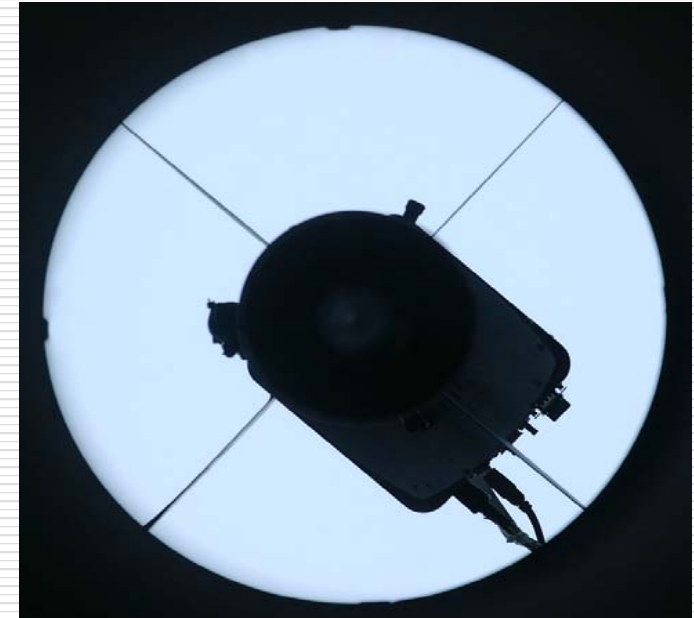
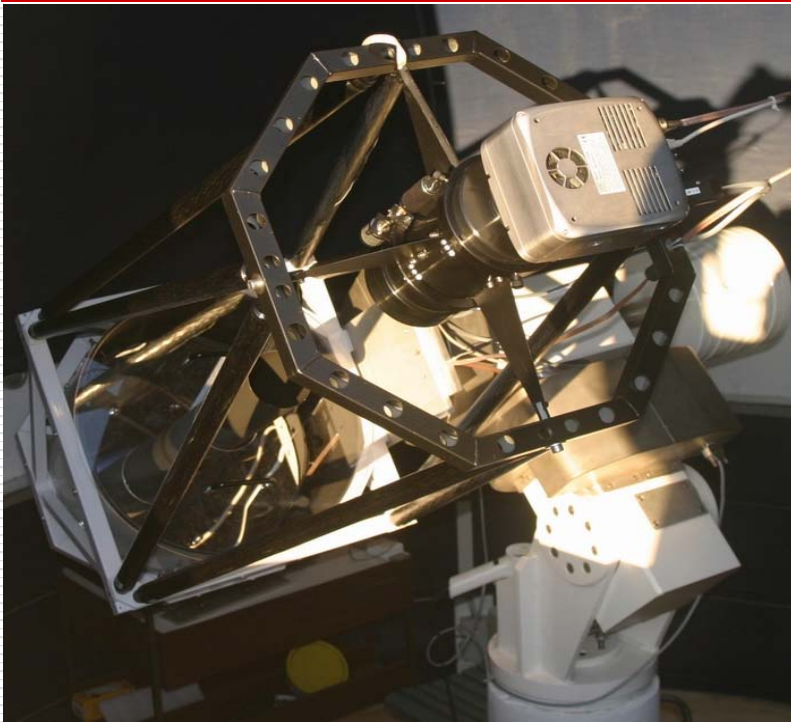




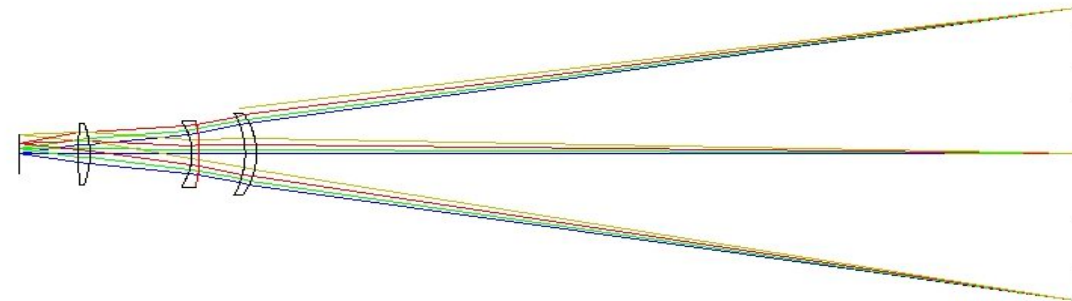




# Setup Cassegrain f/3 (stationary)



D 402 mm  
FL 1200 mm  
Field 102' x 68' with STL11000  
Res. 1,5"/Pixel



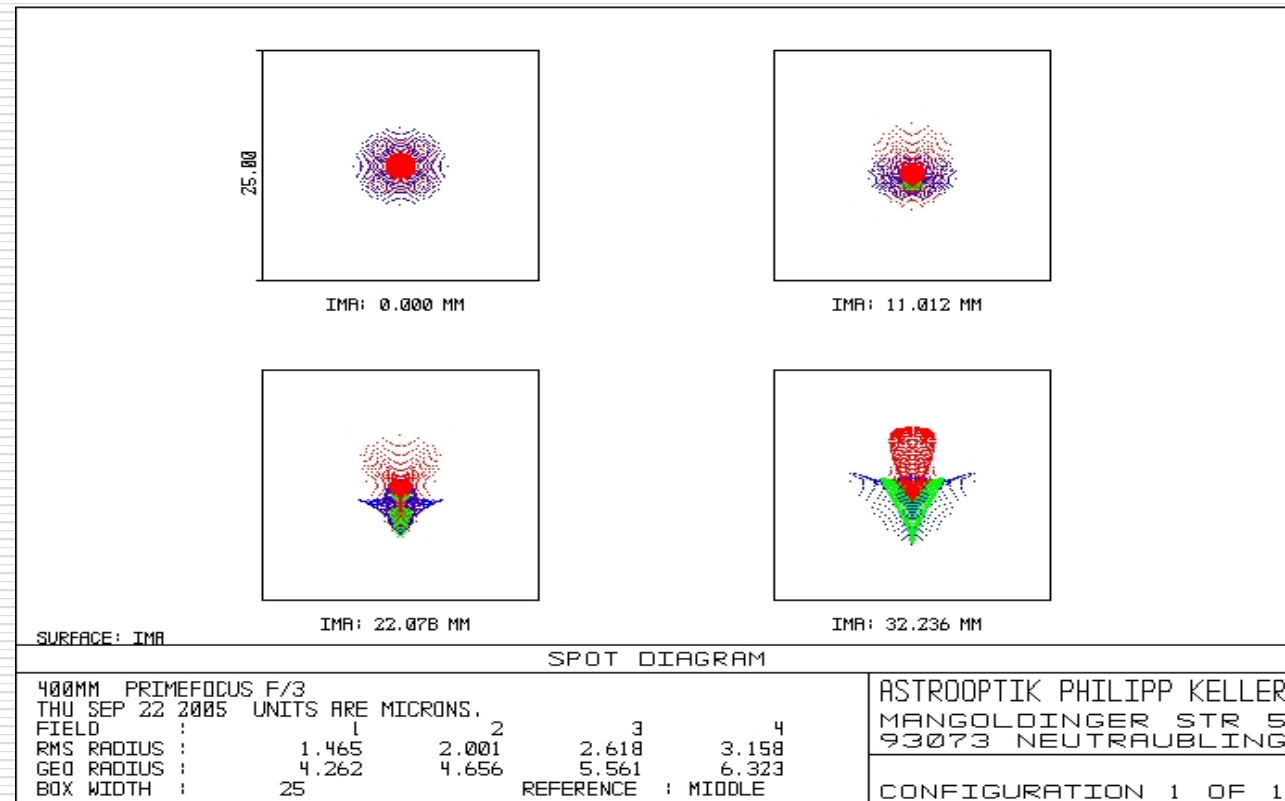
LAYOUT  
400MM CCD PRIMEFOCUS CORRECTOR D=110MM  
THU JAN 23 2003  
TOTAL LENGTH: 1210.48369 MM

ASTROOPTIK PHILIPP KEL  
KORNWEG 9A  
93080 PENTLING



# Setup Cassegrain f/3

- Superb design
- OTA 50 kg
- No temperature drift
- Optical alignment critical
- Depth of focus 0.02 mm
- Obstruction acceptable
- Align camera to spiders
- Sort cables





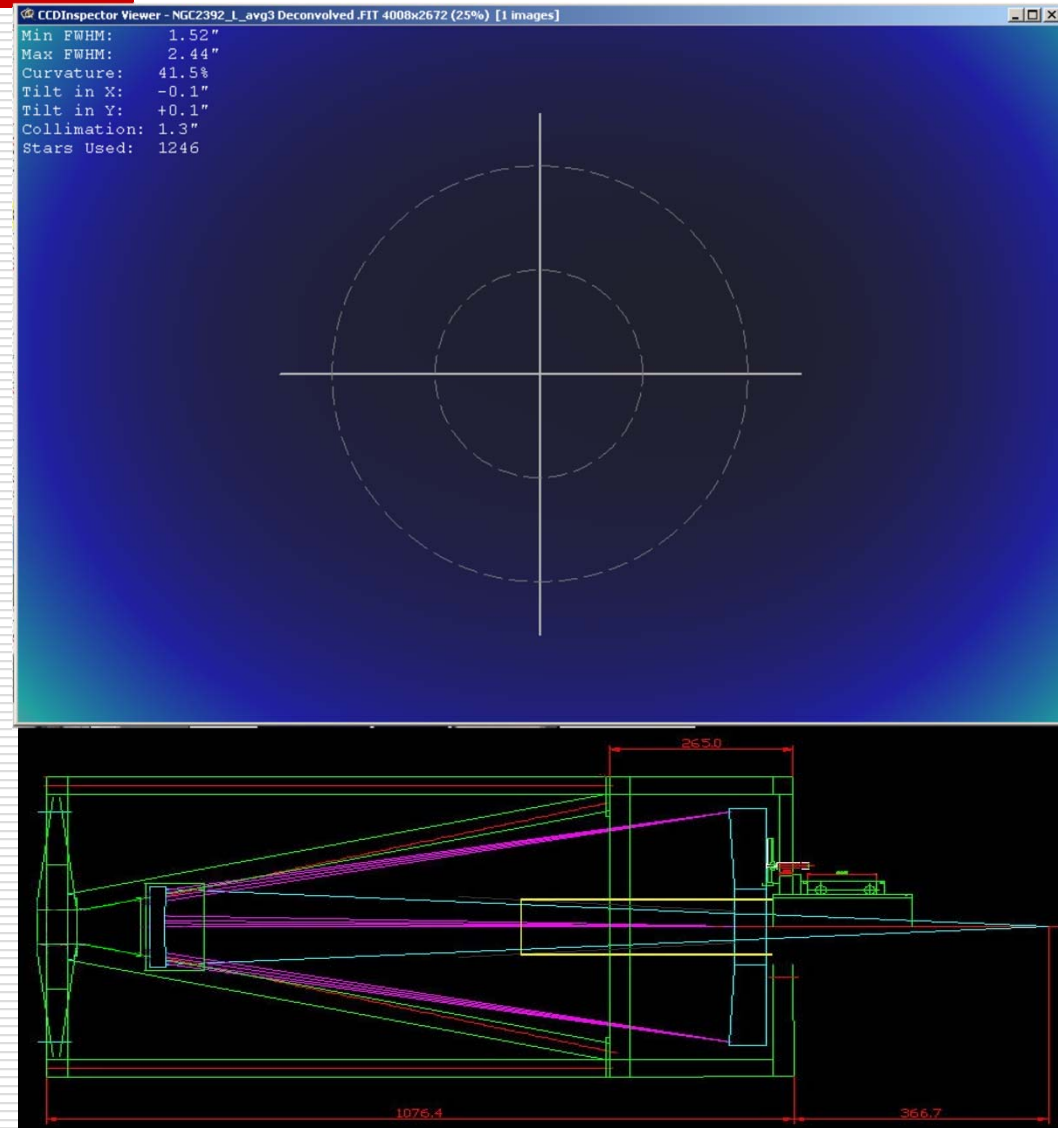
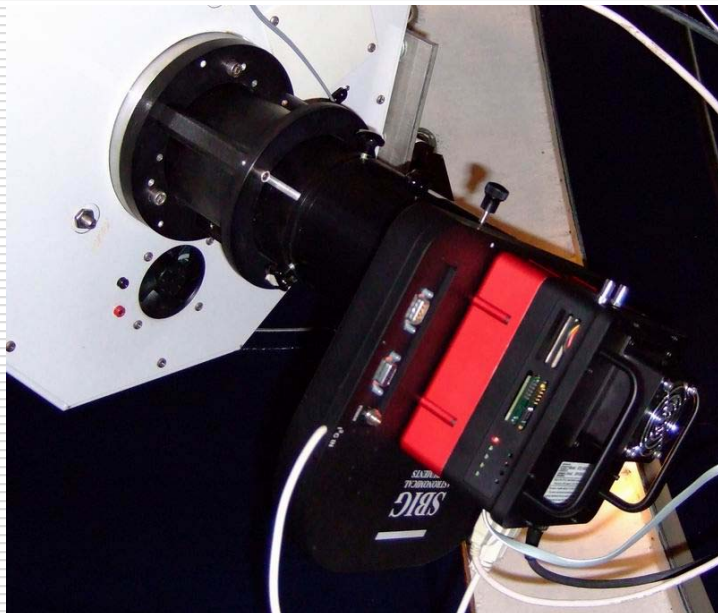




# Setup Cassegrain f/10 (stationary)

D 402 mm  
FL 4000 mm  
Field 30' x 30' with STX 16803  
Res. 0,46"/Pixel

Center 1.5" FWHM  
Edge 2.5" FWHM







# Stationary setup CCD

- No. pixels: 16,8 Million (9x9  $\mu\text{m}$ )
- Chip size: 37 x 37 mm
- QE: 60% at 550 nm
- Dark current (-30C): 0,018 e-/s
- Readout noise: 9 e-
- Cooling: 50° C below ambient
- Antiblooming: yes
- Backfocus: 65 mm
- Weight: 4.6 kg incl. wheel



**SBIG**

**STX 16803**



# Setups with big chip CCDs

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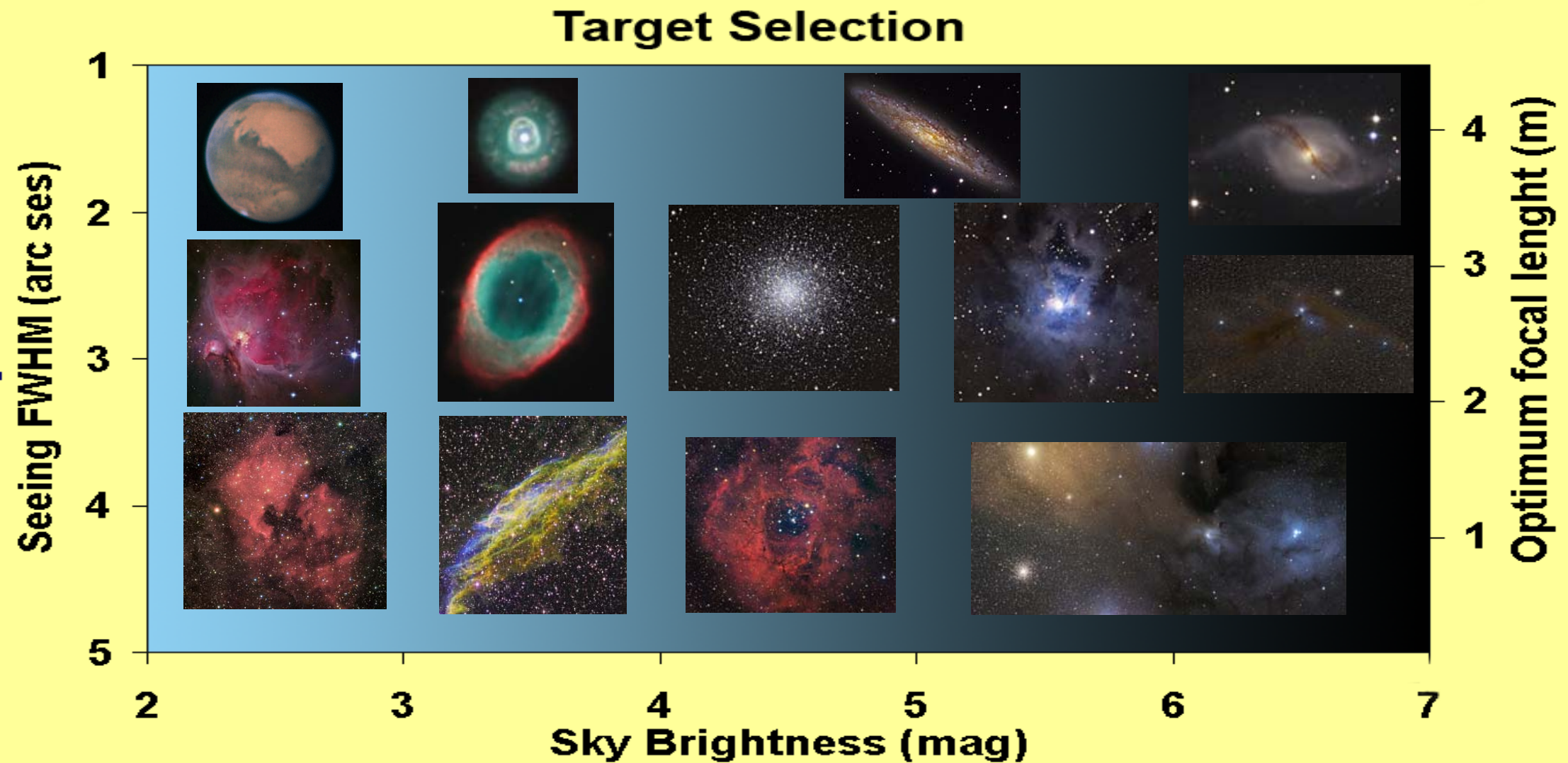
- Quality (flat field, large even illumination)
- Aperture (big = deep small = mobile)
- f-Factor (field of view  $\leftrightarrow$  resolution)
- Mount (good tracking)
- Location (distance - darkness)
- Versatile (different F/L)

Myth:

Big aperture and fast f-ratio not suited for light polluted location

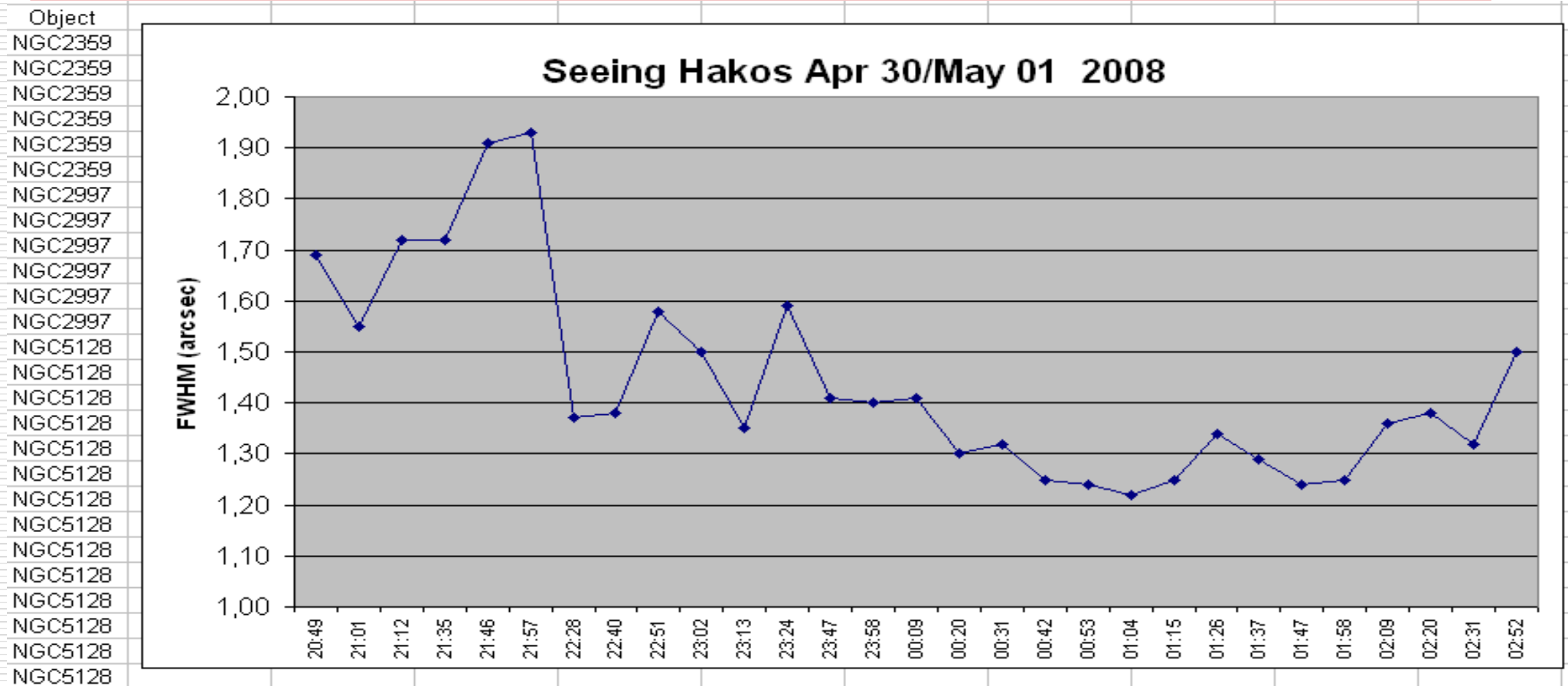
**NO!**

# Adapt to the Sky Conditions!



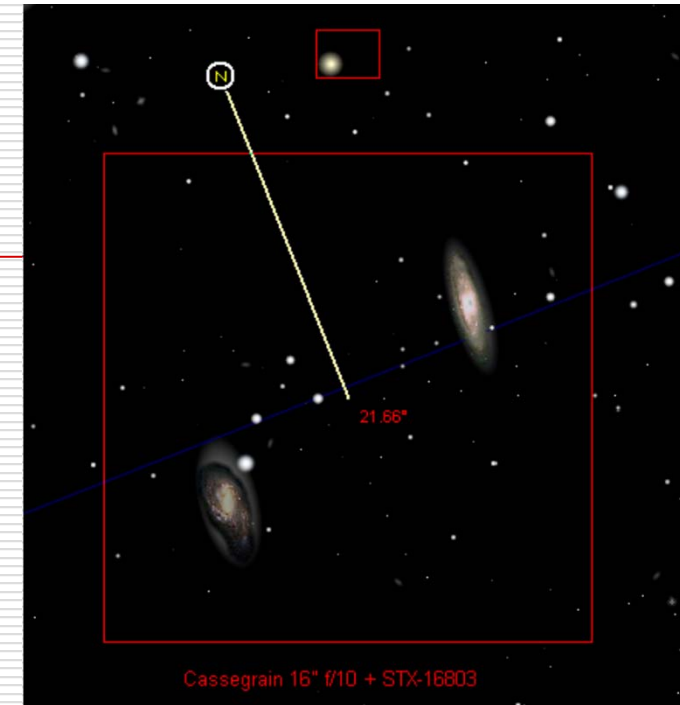


# Seeing conditions at Hakos/Namibia



# Exposure Session

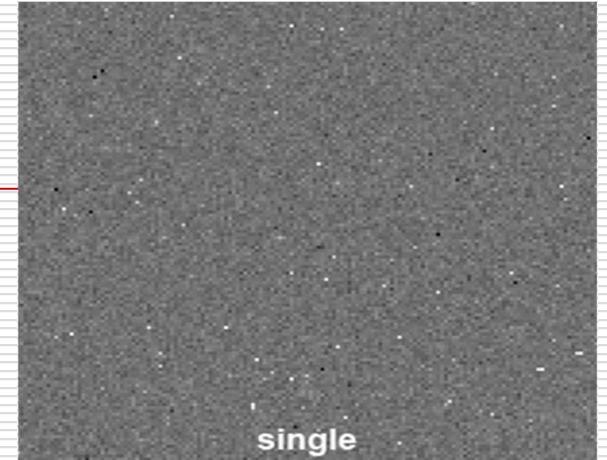
- Target selection (according meridian pass)
- Target framing (The-Sky support)
- Select guide star (1-3 sec) - dithering
- Focusing (encoder helpful)
- Test exposure 10 sec 2x2bin, check collimation with CCDInspector
- Binning: 1x1 bin preferred for all frames  
(target: sky limited exposures)
- Frame exposure: LRGB at F/3: 10 min  
at F/10: 20 min  
Ha, O3, S2: 30-60 min
- Collect as many frames as possible, minimum 3 per channel!





# Calibration

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- **Flat frames** (correction for chip illumination)
- **Dark frames** (correction dark current and CCD defects)
- **Bias frames** (for skaling of dark frames)

Master-calibration frame library !

Target: at least same number of dark/bias as light frames (10+)

Low sky background: high quality master dark

High sky background: high quality master flat (for each filter)

Noise decreases with the root of the frame number



# Registration + Combining

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- Defect correction (Column defects removal in batch processing)
- Open and inspect for planes, satellites, guiding errors
- Processing in Maxim DL in groups of 5-8 (save processing time!)
- Aligning: star matching preferred
- Combining: average (< 5 frames)
  - Sigma average (> 5 frames – time consuming!)
  - Min-max excluded average (> 6 frames)
- Save in 32 bit floating format

# Color Creation

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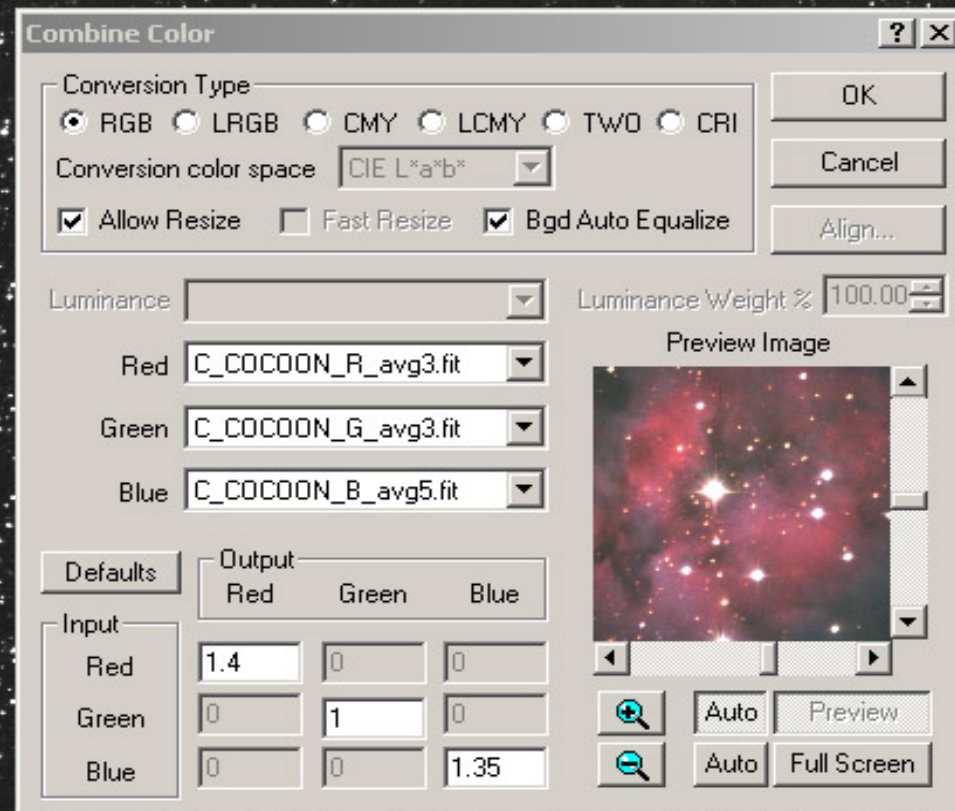
- Open the unstretched calibrated combined files in Maxim DL
- Typical color weighting factors for Baader CCD filters:
  - R 0.8
  - G 1
  - B 1.2
- Exact values depend on altitude and sky conditions
- G2V calibration ensures exact weighting  
see article Al Kelly: <http://www.ghg.net/akelly/artdraf7.htm>
- Save as 16 bit tif image
- Luminance should be processed separately and added later



# Color Creation

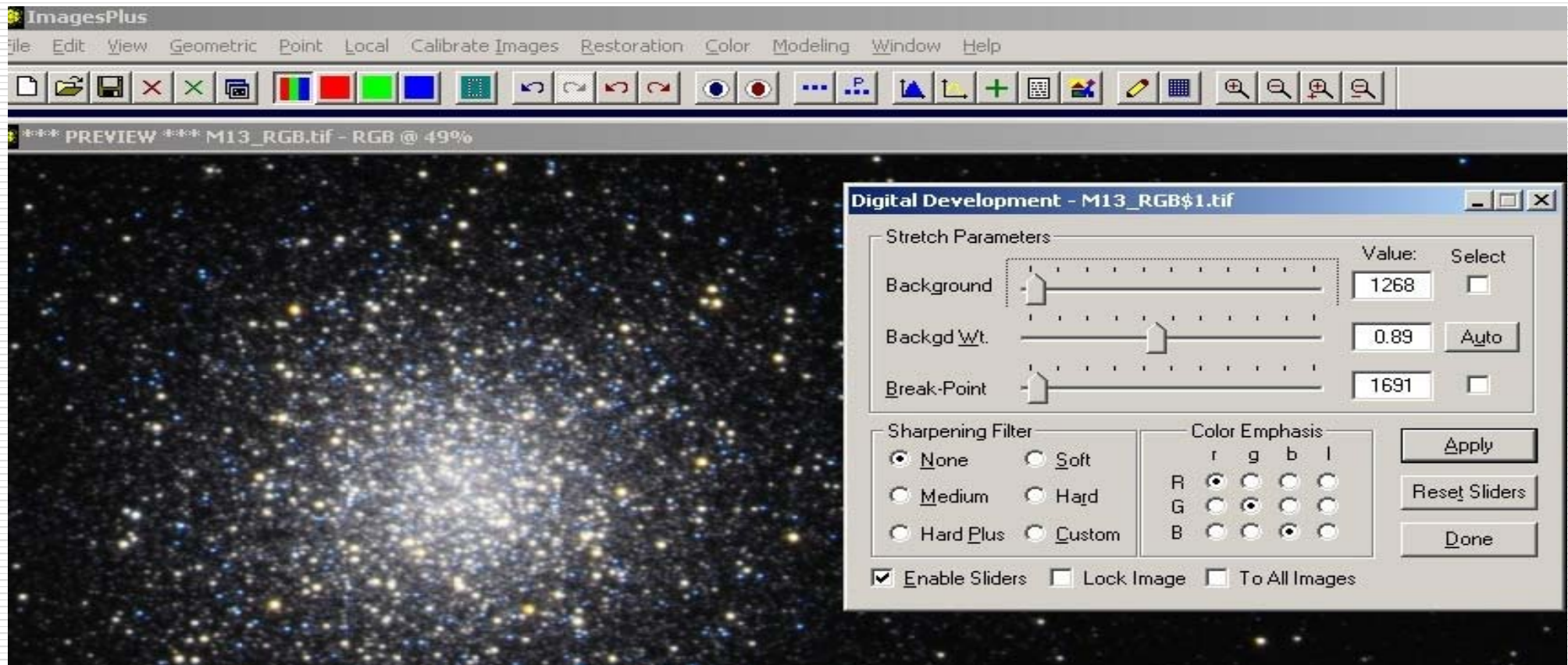
C\_COCCOON\_R\_avg3.fit | C\_COCCOON\_B\_avg5.fit | C\_COCCOON\_G\_avg3.fit |

C\_COCCOON\_R\_avg3.fit



# Stretching - DDP

- DDP preferred for galaxy images, globulars
- ImagesPlus supplies good star colors, increase saturation by 10% before applying DDP, no sharpening in this stage!





# Gradient Handling

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## Symmetrical gradients

Vignetting Remover filter (RGB mode, limited to 50% size!)

## Asymmetrical gradients (light pollution, Moon)

Gradient Remover filter

Both as Photoshop Plug-ins from Rob Miller:

[http://www.atm-international.com/Astrophotos/photoshop\\_plugins.htm](http://www.atm-international.com/Astrophotos/photoshop_plugins.htm)

or: Russ Croman's GradientXTerminator:

<http://www.rc-astro.com/resources/GradientXTerminator/>

# Narrowband Filtering

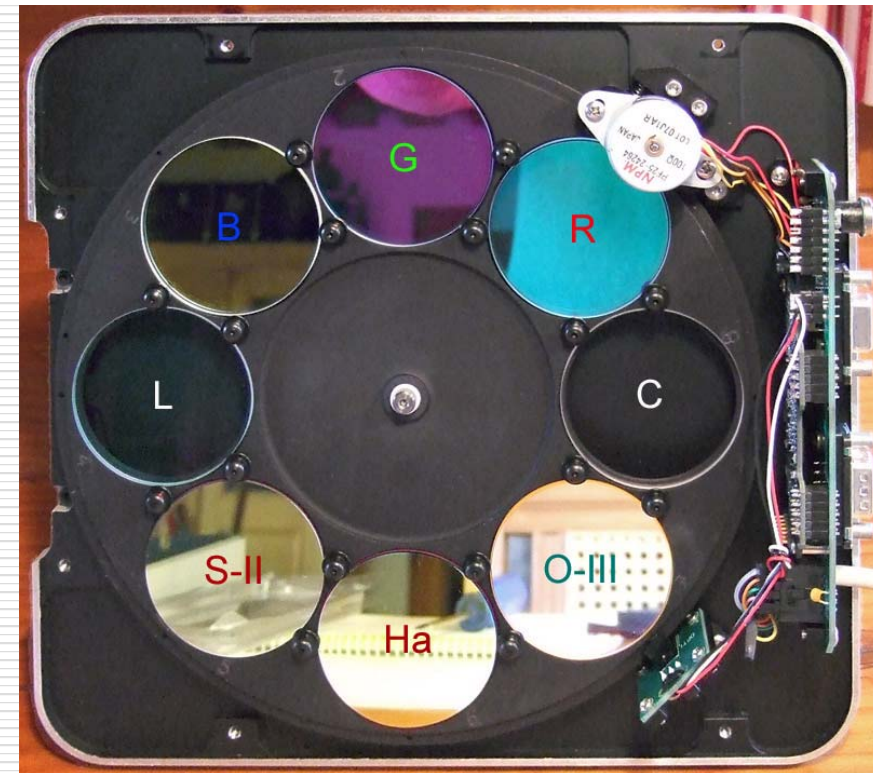
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## Advantages:

- Suppression of sky background
- Increased contrast for Nebulas (longer exposure!)
- Additional information with false colors

## Available:

- **H-alpha (656 nm)**
- **O-III (501 nm)**
- **S-II (672 nm)**
- H-beta (486 nm)
- Methane (889 nm)





# Large Binocular Telescope (LBT Arizona /USA)

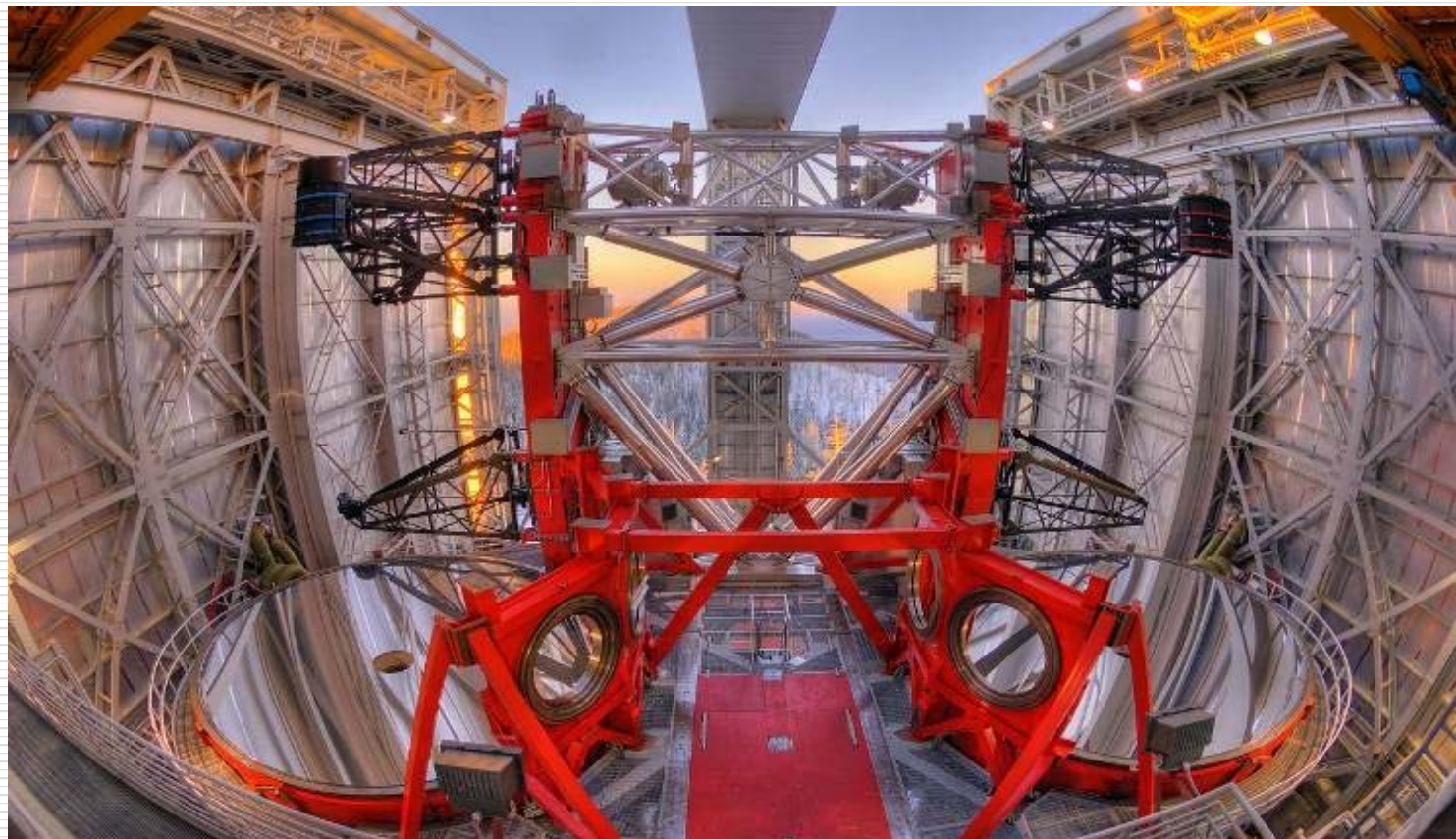
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Link: [http://medusa.as.arizona.edu/lbto/astronomical\\_images.htm](http://medusa.as.arizona.edu/lbto/astronomical_images.htm)

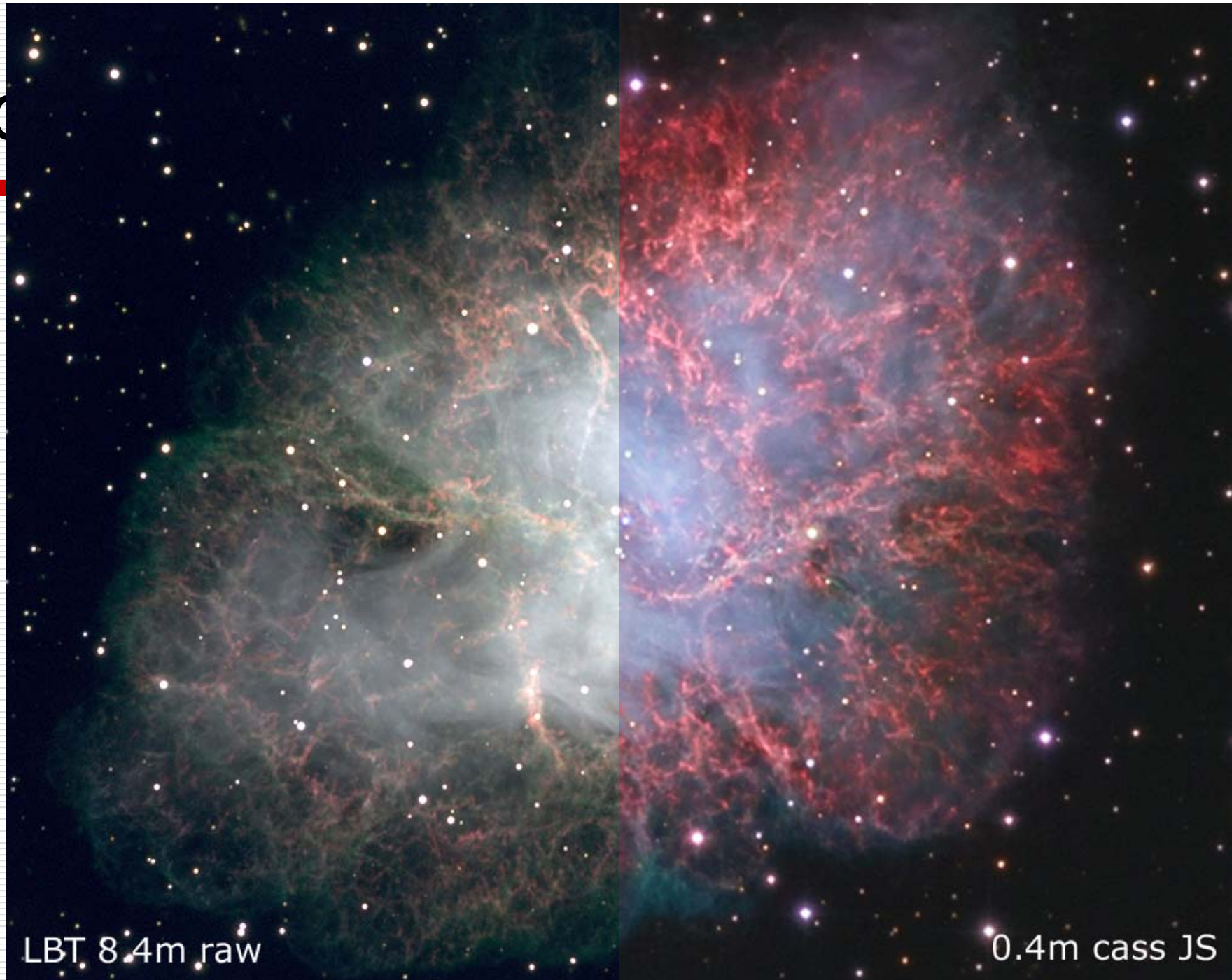
LBT Commissioning:

M 1 image on following  
page was referred to  
my own image by LBT  
research stuff in Arizona:

„Your image is better“



Co



LBT 8.4m raw

0.4m cass JS



# ESO 1999 – JS 2006 animation on M 1

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# How to compete with the pro's?

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Invest in exposure time to get good raws....  
(very expensive for professionals!)

Aperture / Exposure time	Mag at S/N=3	Resolution (arcsec eff.)
ESO 8,5 m 10 sec	24,6	0,5
IAS 0,5 m 10 sec	18,4	1,5
IAS 0,5 m 10 min	22,5	1,5
IAS 0,5 m 100 min	23,8	1,5
IAS 0,5 m 1000 min	25,0	1,5



# Eagle Nebula (M 16) 0,5 m at IAS



# Pillars of Creation in M 16

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S-II/H-alpha/O-III 0,5 m JS

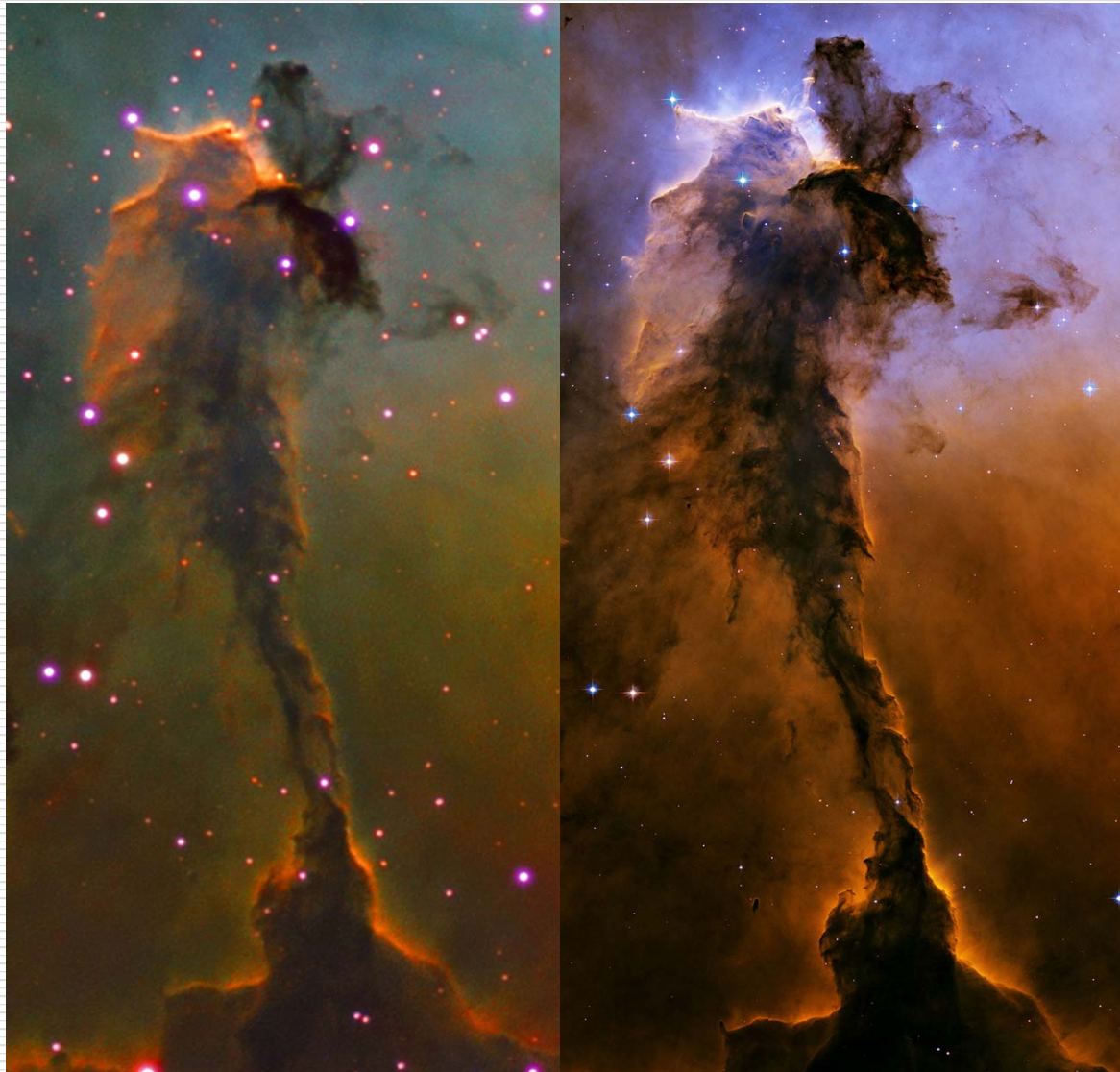


S-II/H-alpha/O-III 2,5 m HST



# Rose in M 16

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S-II/H-alpha/  
O-III 0,5m JS

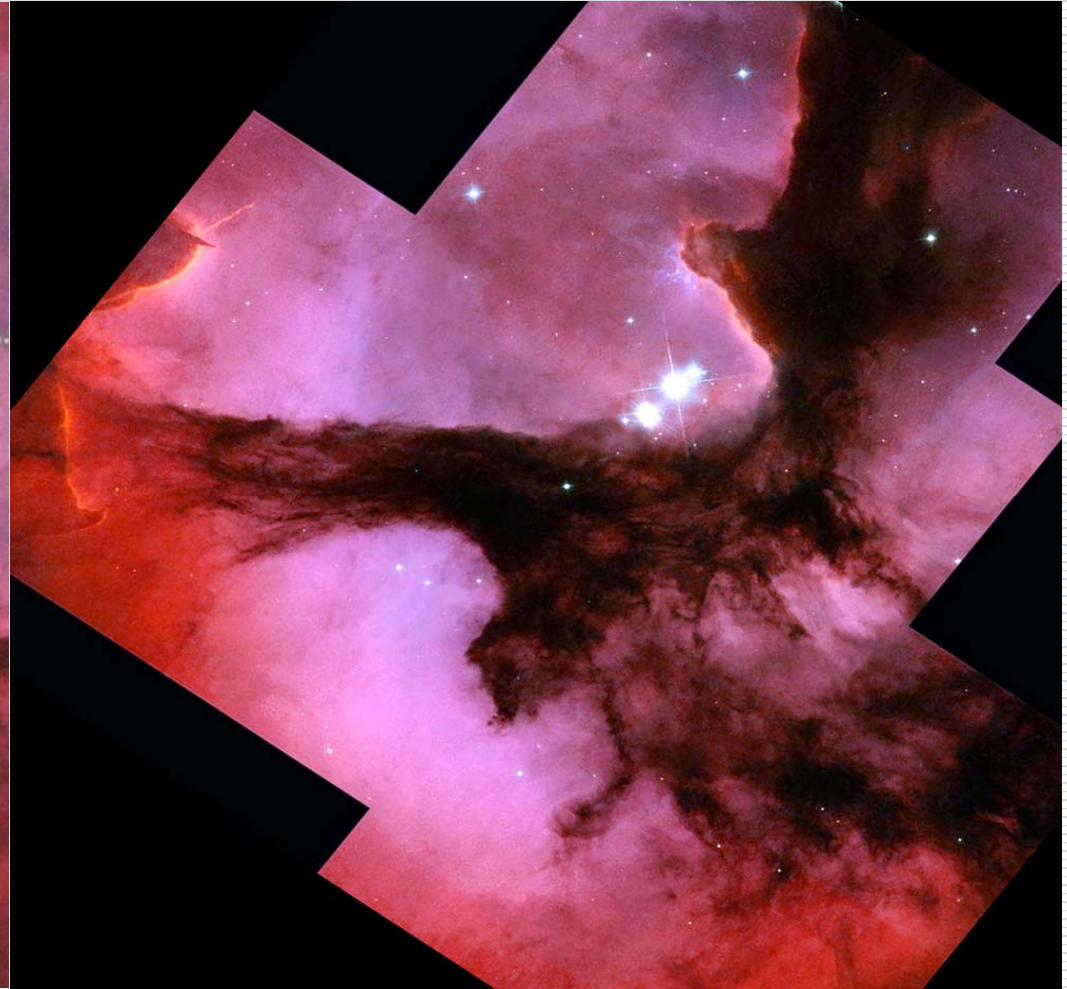
S-II/H-alpha/O-III  
2,5m HST

# Center of Trifid Nebula (M 20)

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0,5 m JS



2,5 m HST



# How to improve?

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- Search for dark rural skies, laminar winds
- Invest in a stable setup
- Optimize and recheck focus position
- Make mosaics
- Use narrowband filters
- Use good calibration files (master bias, dark, flat)
- Exercise in postprocessing

# Eta-Carina Nebula (NGC 3372)





# Keyhole in Eta-Carina (NGC 3372)

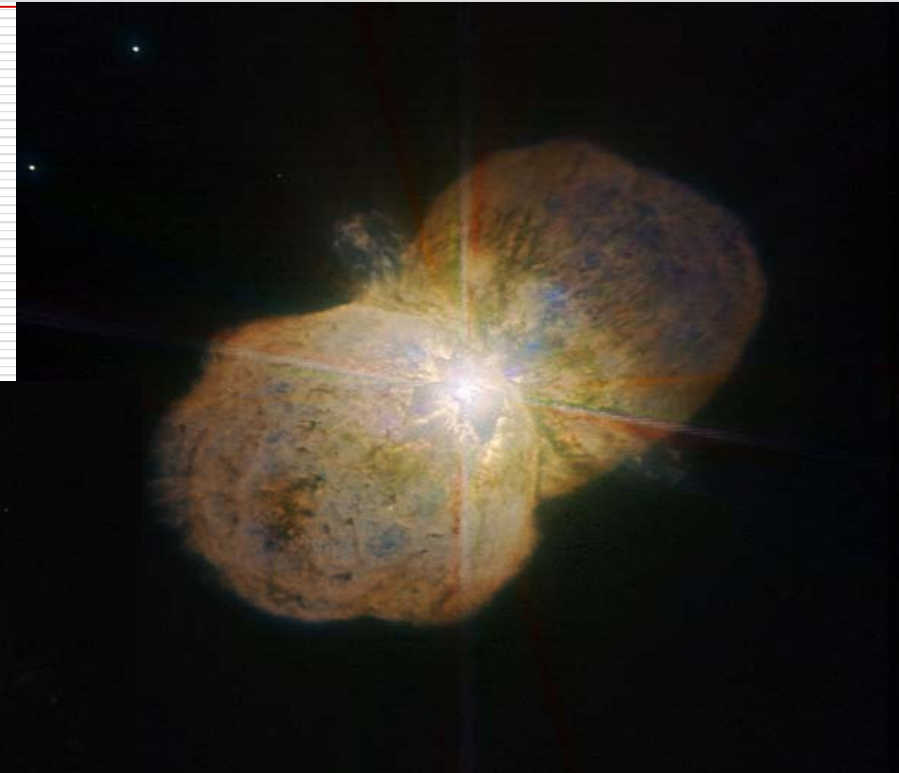
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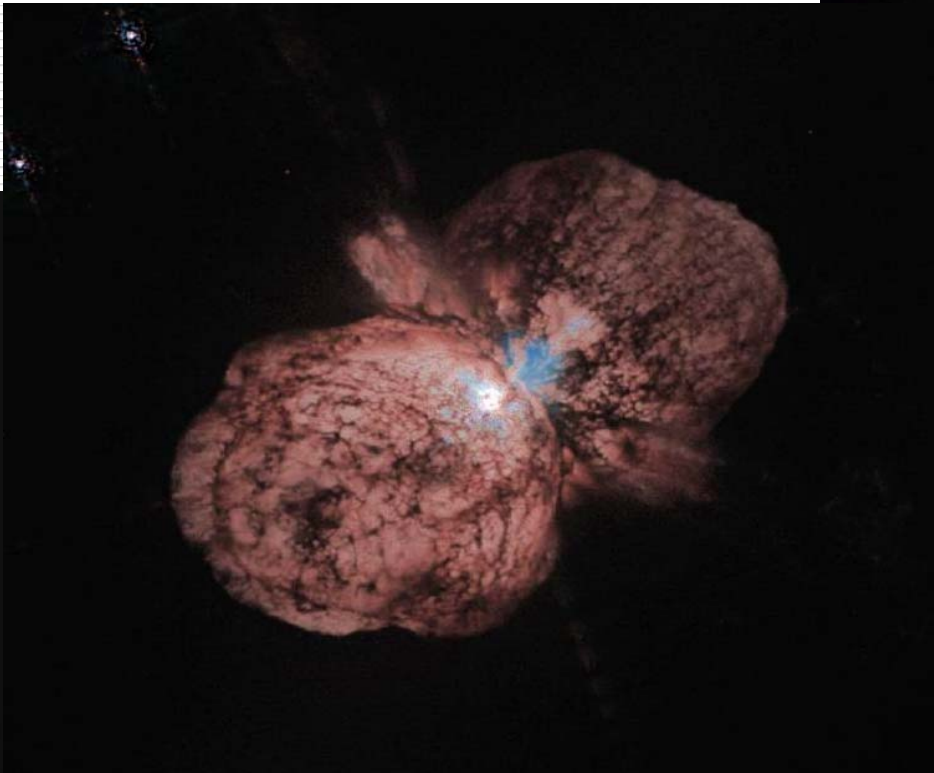
# Eta Carina - Homunculus (20" diameter)

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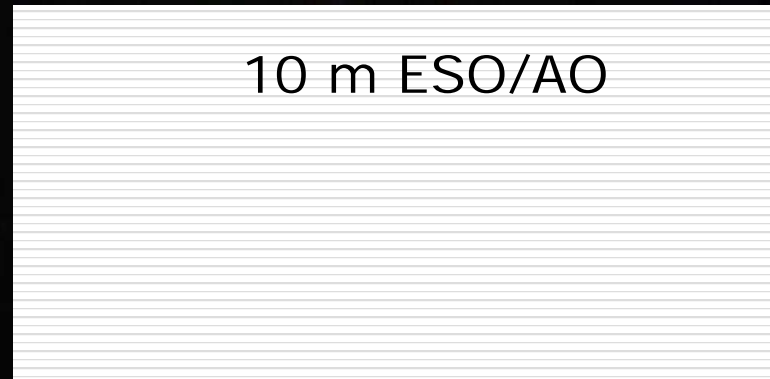
2,5 m HST



0,5 m JS



10 m ESO/AO





# Postprocessing PS I

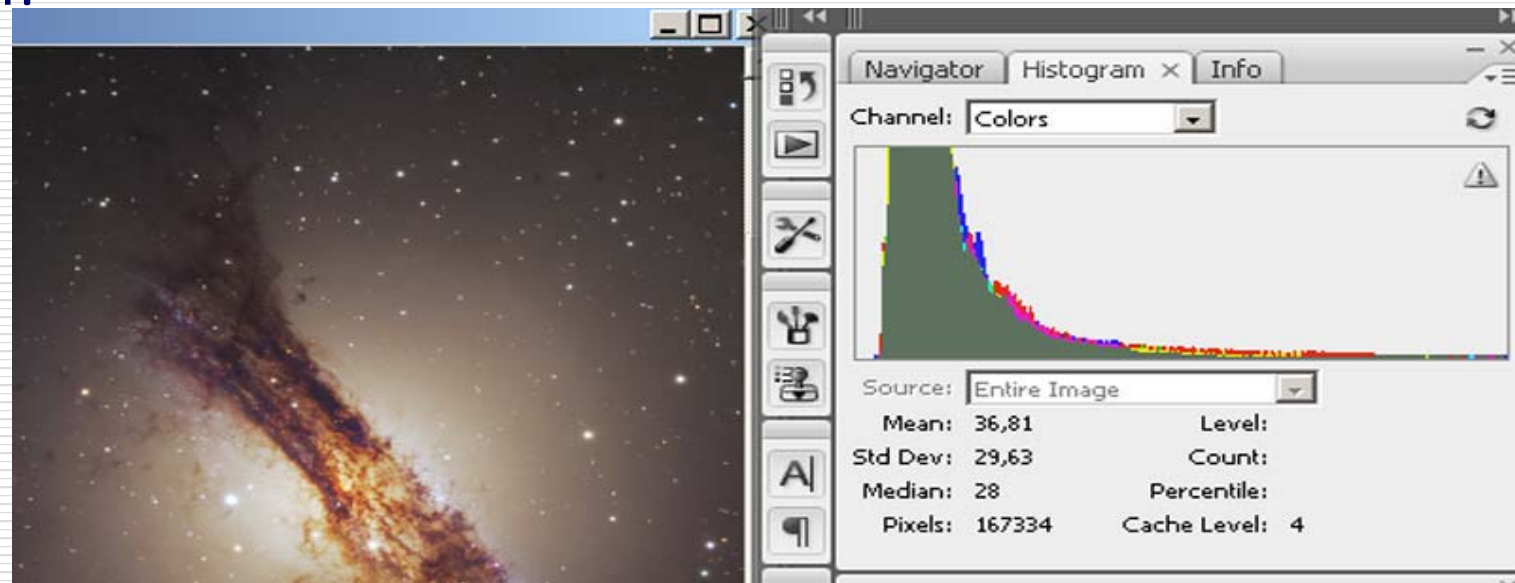
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## Import:

Fits Format imported by Fitsliberator (Freeware) into Photoshop converting to 16 bit tiff

## Histogramm:

Clipped (black and white) areas are generating an irreversible loss of information!



# Postprocessing PS II

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## Colors:

- Take colors in 1x1 binning
- Use 1:1:1 color weighted steep LRGB filters
- Use flats (gradients!)
- Do RGB acquisition in RGB-RGB-RGB sequence
- Increase saturation in early stage
- Create synthetic luminance in no L available



# Postprocessing PS III

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## **Sharpening:**

Less is superior!

Excessive sharpening produces artefacts and may destroy the image

Sharpening only should be applied to bright areas!

## **Noise Reduction:**

Noise reduction means low pass filtering, loss of details is the consequence

NR only should be used for darker areas

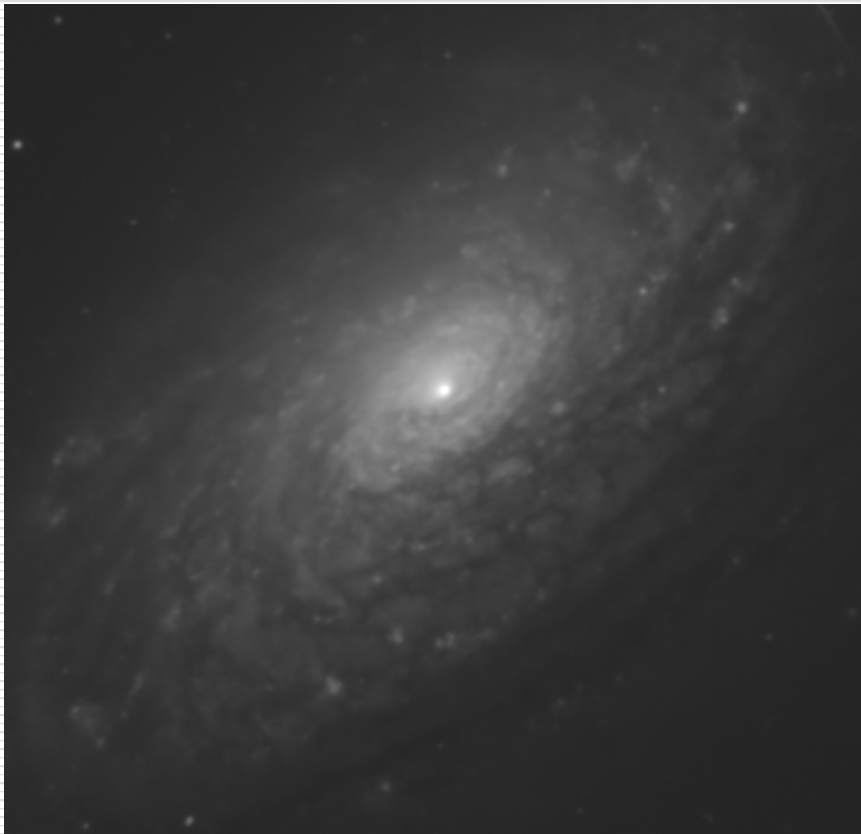
Bright areas are showing a high S/N ratio and contain details that are sacrificed by applying noise reduction

# Postprocessing PS IV: revealing details

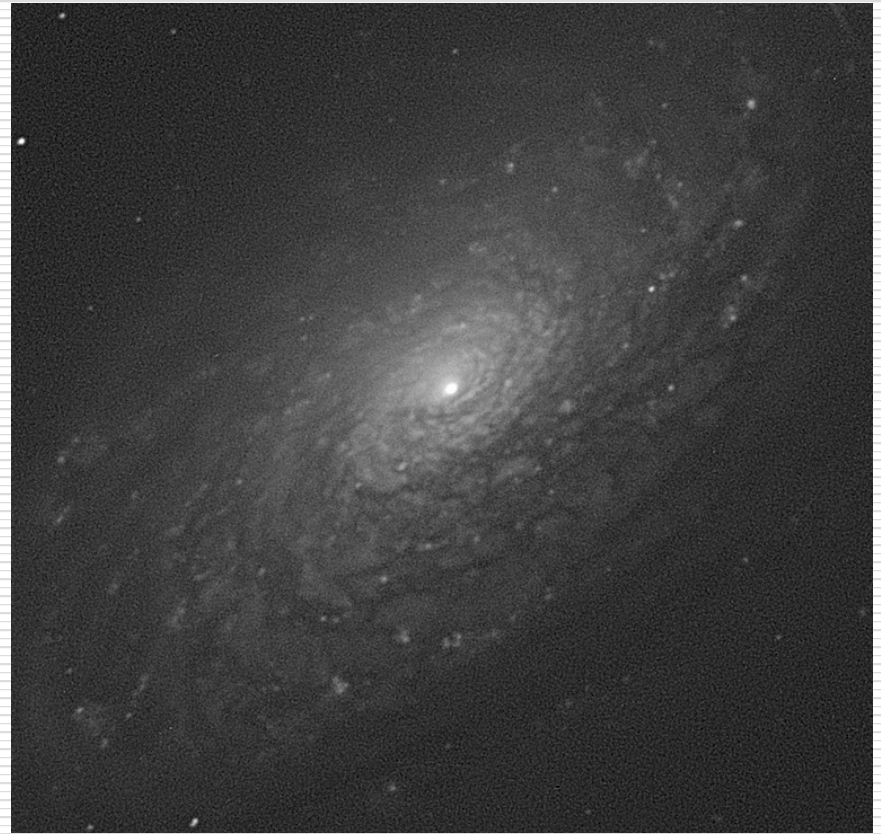
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Exposure **30 min**

M 63 straight luminance



M 63 luminance with wavelets filter



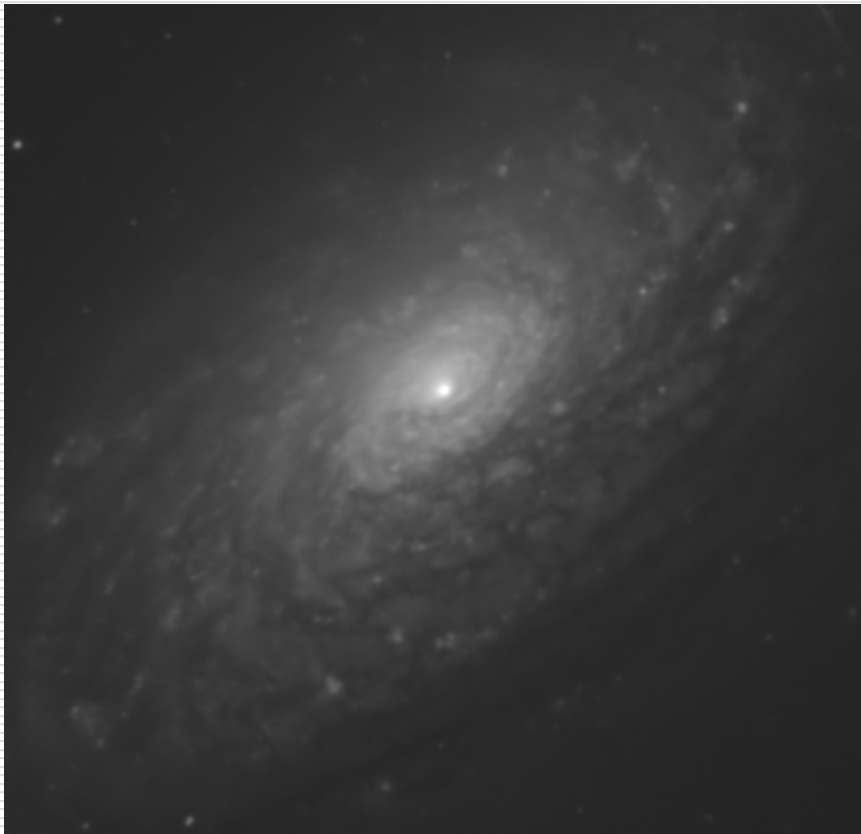


# Postprocessing IV: revealing details

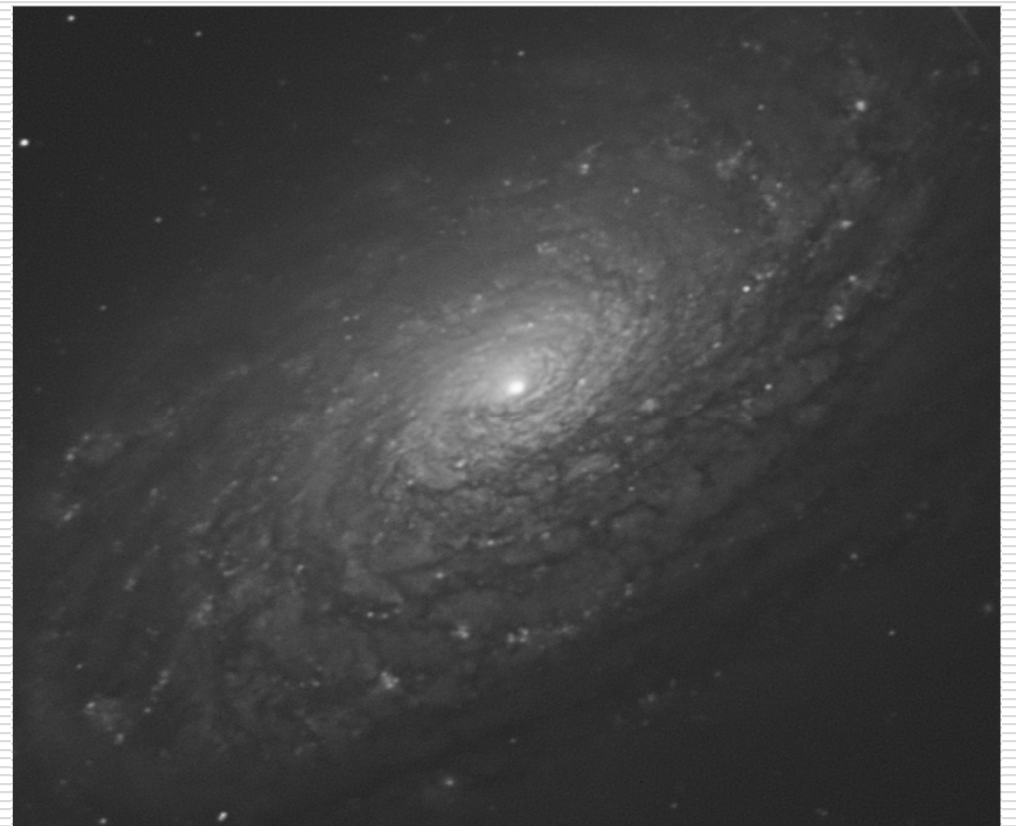
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Exposure **8 h**

M 63 straight luminance

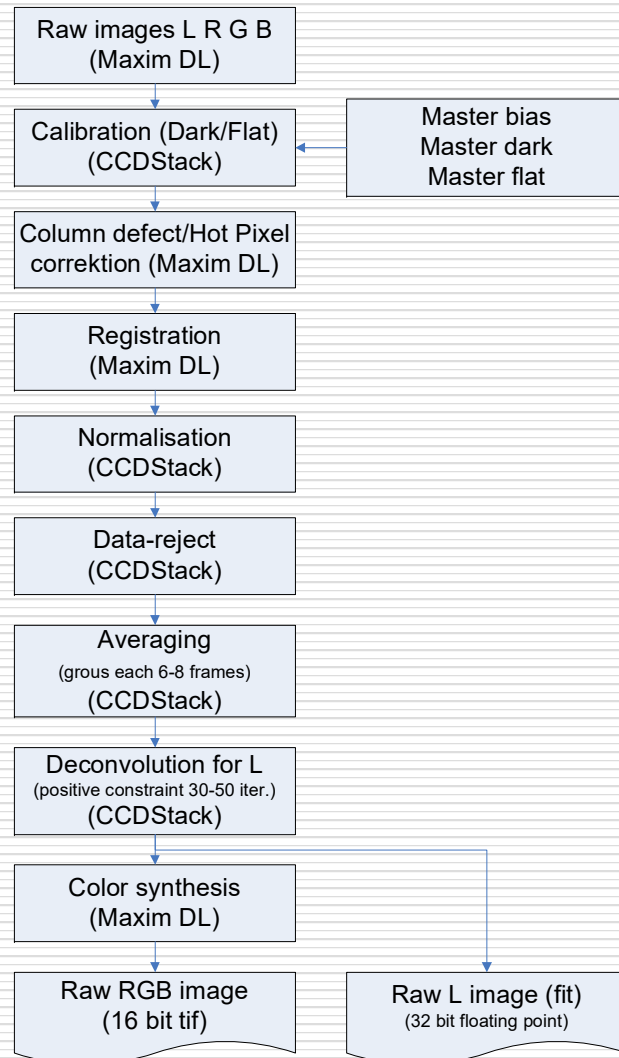


M 63 luminance with wavelets filter



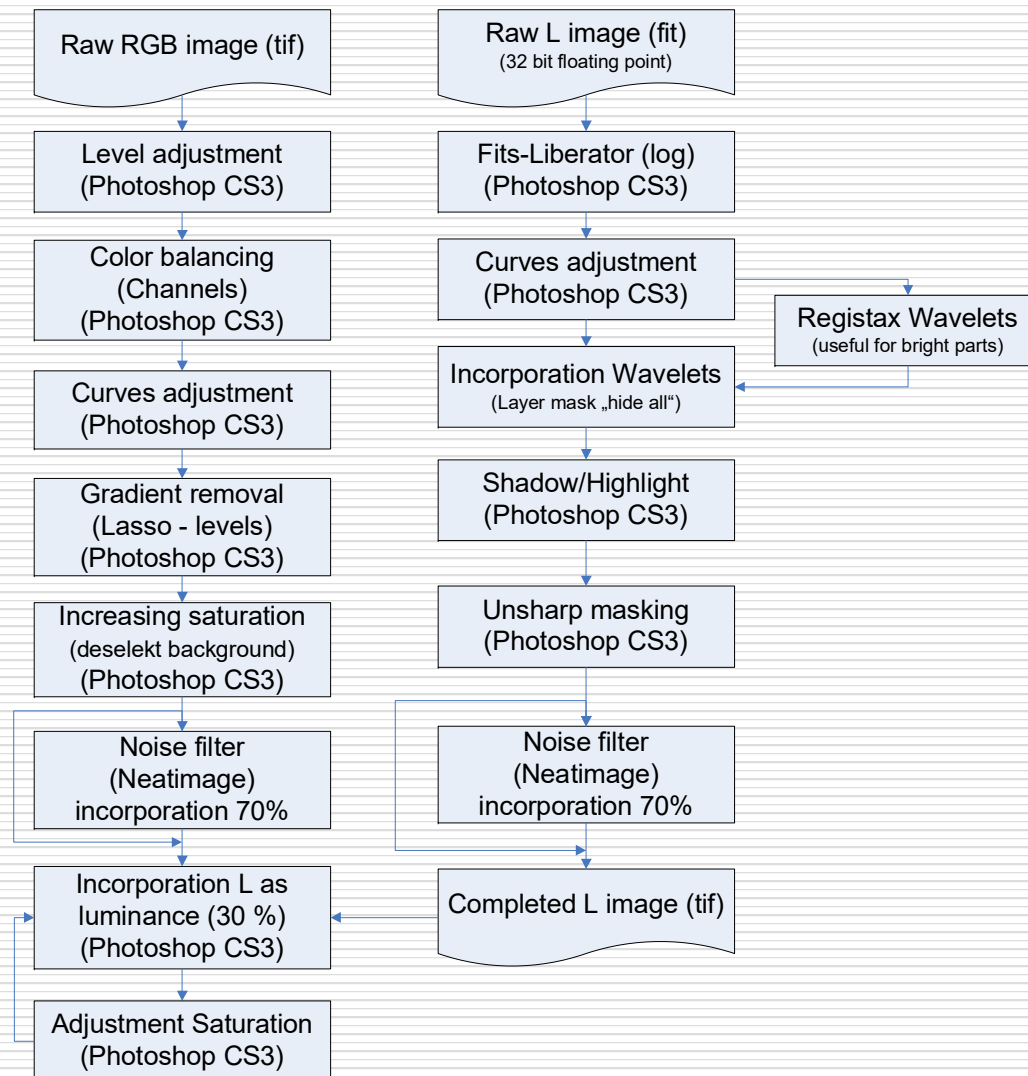
# Workflow 1

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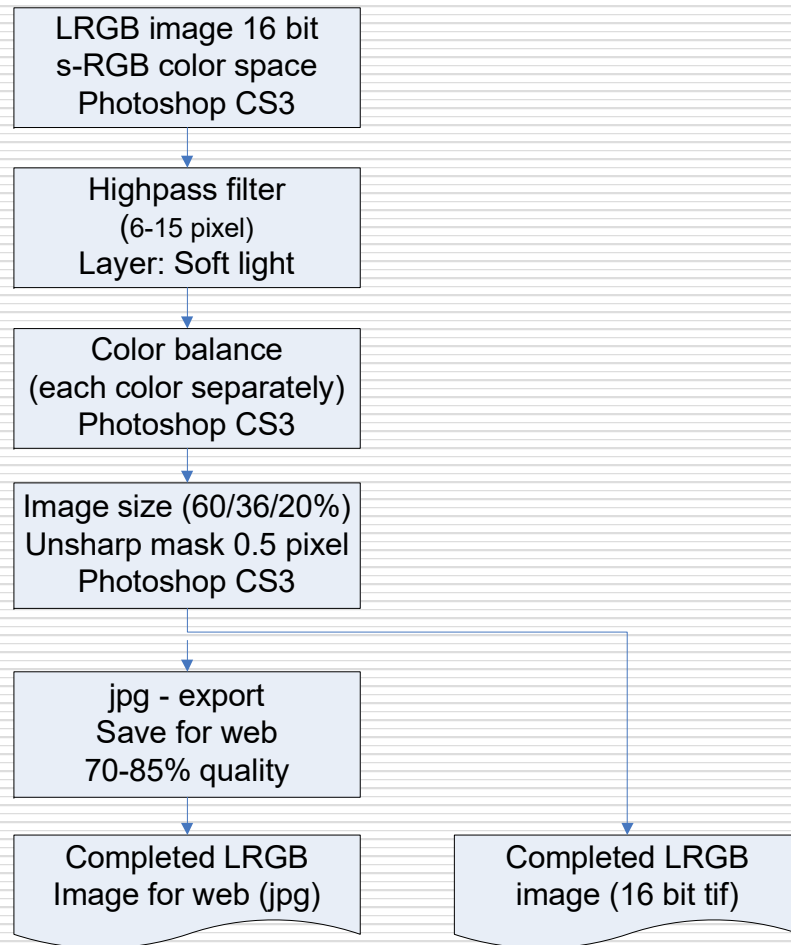


# Workflow 2



# Workflow 3

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# Future

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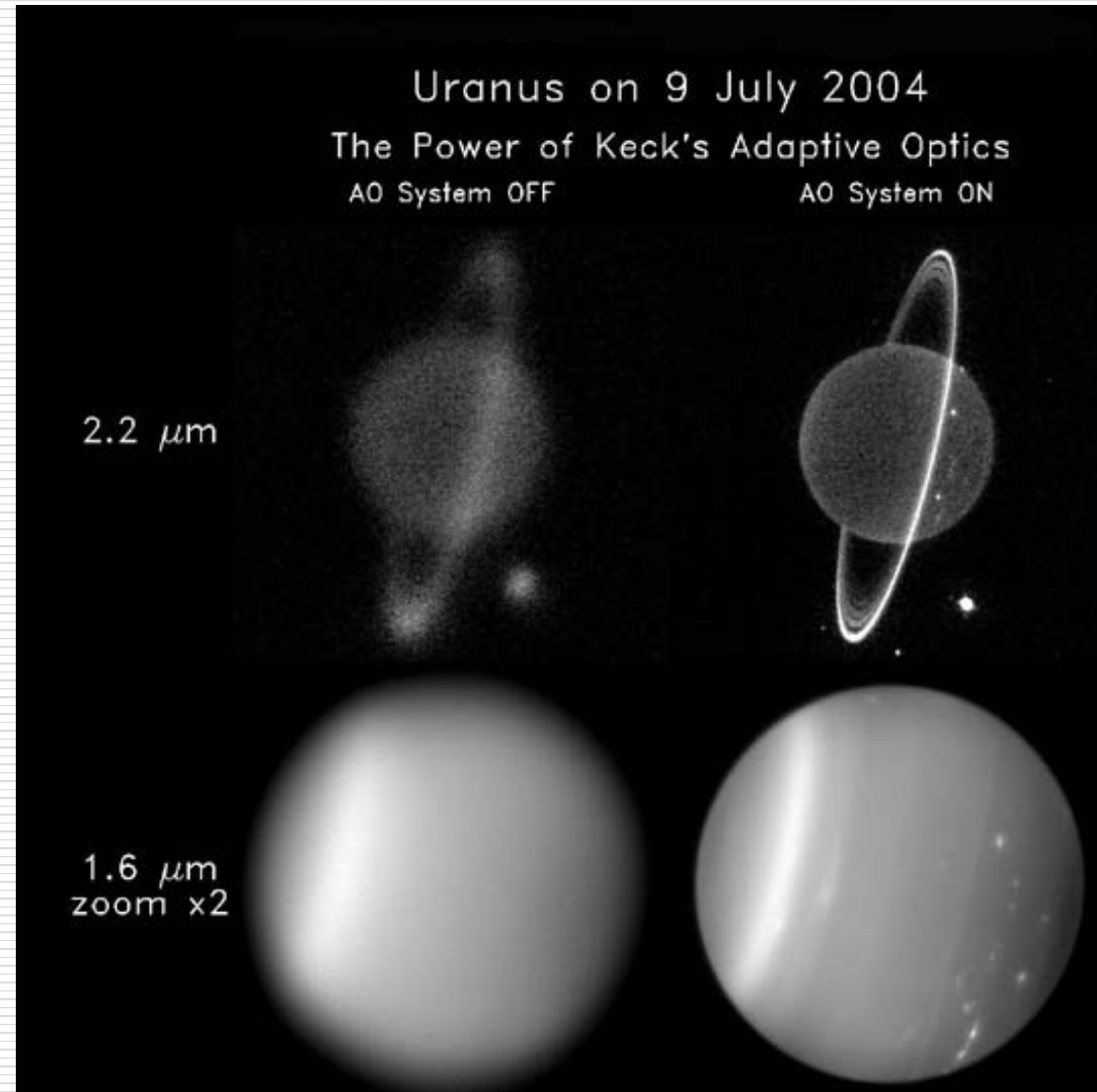
Bigger high efficient CCD chips

Remote imaging from dark sites

Single photon CCDs

Adaptive Optics for amateurs -

or: Lucky imaging!





# Links

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Panther-Observatory:

<http://panther-observatory.com/>

Philipp Keller Telescopes:

<http://www.astrooptik.com/>

SBIG CCD Cameras:

<http://www.sbig.com/>

Baader Filters:

<http://www.baader-planetarium.de/>

Robtics Astropoducts:

<http://robtics.nl>

