


# Astro Pixel Processor

## overview of current and future functionality

drs. E.M.W.P. Haverkamp (Mabula)

# overview

- introduction
- what is APP?
- current and future functionality

## overview

- Widefield Mosaic animation
- APP images !
- beta team
- end

overview

Check introductory presentation !

https://www.astropixelprocessor.com/presentations/

## introduction

- Mabula?
- education
- publication
- professional career

## introduction - Mabula?

Mabula Haverkamp
10 april 1977, Ndala (Tanzania)

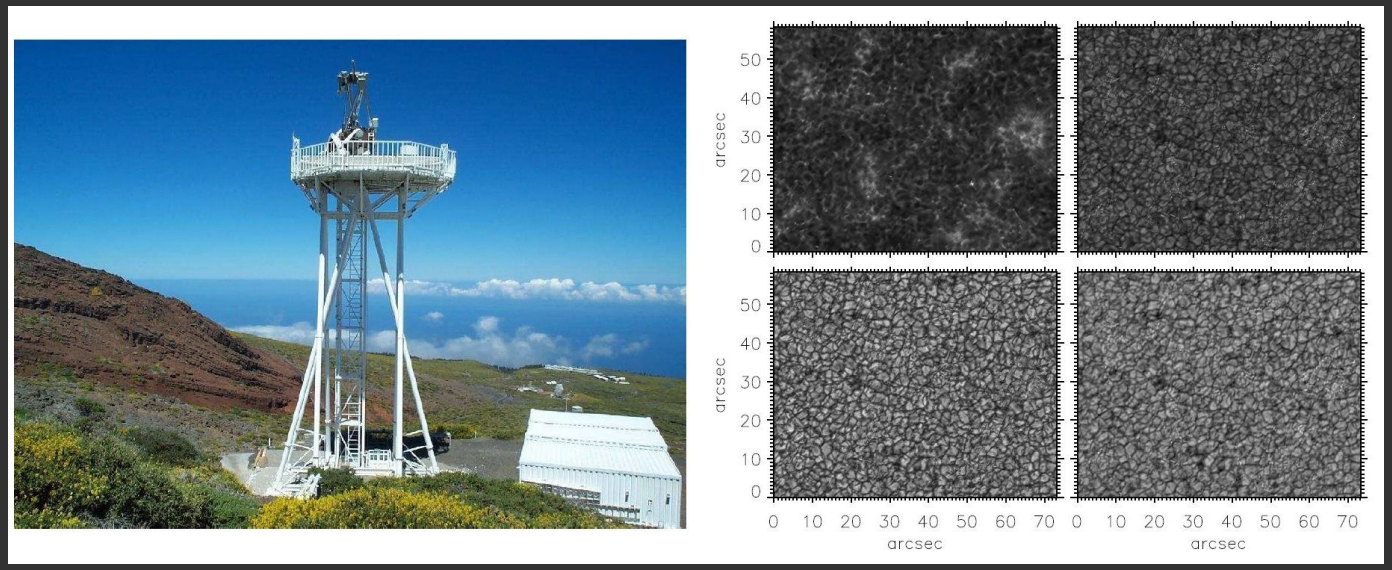




introduction - education

drs. M.Sc. Astrophysics, University of Utrecht 2004

Solar magnetic fluxtubes diagnosed from isolated internetwork bright points - An analysis of Dutch Open Telescope observations



introduction - publication

Astronomy & Astrophysics, AA 441, 1183-1190 (2005)

A&A 441, 1183-1190 (2005)
DOI: 10.1051/0004-6361:20053373

## DOT tomography of the solar atmosphere

### IV. Magnetic patches in internetwork areas

**A. G. de Wijn[1], R. J. Rutten[1,2], E. M. W. P. Haverkamp[1] and P. Sütterlin[1]**

[1] Sterrekundig Instituut, Utrecht University, Postbus 80 000, 3508 TA Utrecht, The Netherlands
e-mail: [A.G.deWijn;R.J.Rutten]@astro.uu.nl
[2] Institute of Theoretical Astrophysics, Oslo University, PO Box 1029 Blindern, 0315 Oslo, Norway

(Received 5 May 2005 / Accepted 23 June 2005 )

**Abstract**

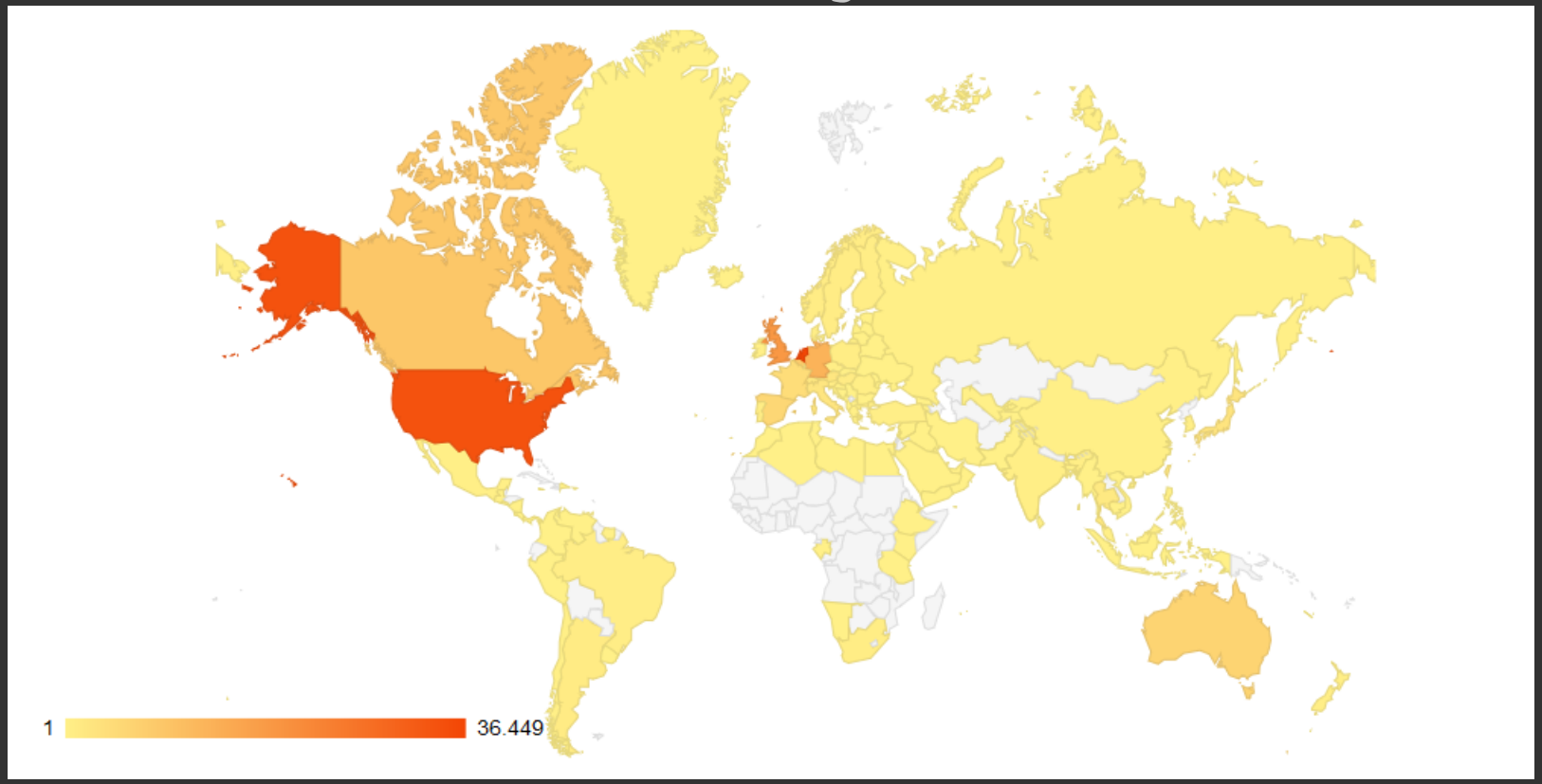
We use G-band and Ca II H image sequences from the Dutch Open Telescope (DOT) to study magnetic elements that appear as bright points in internetwork parts of the quiet solar photosphere and chromosphere. We find that many of these bright points appear recurrently with varying intensity and horizontal motion within longer-lived magnetic patches. We develop an algorithm for detection of the patches and find that all patches identified last much longer than the granulation. The patches outline cell patterns on mesogranular scales, indicating that magnetic flux tubes are advected by granular flows to mesogranular boundaries. Statistical analysis of the emergence and disappearance of the patches points to an average patch lifetime as long as $530 \pm 50$ min (about nine hours), which suggests that the magnetic elements constituting strong internetwork fields are not generated by a local turbulent dynamo.

introduction - professional career

- Market Maker for Curvalue, 2005-2009
- Middleware/ICT consultant for Axxius BV, 2010-2011
- diagnosis: chronic sarcoidosis 2011 - now
- In recovery! Start development of APP 2015 - now
- Launch of Aries Productions and APP, 2 june 2017

introduction - Aries Productions

APP went global!



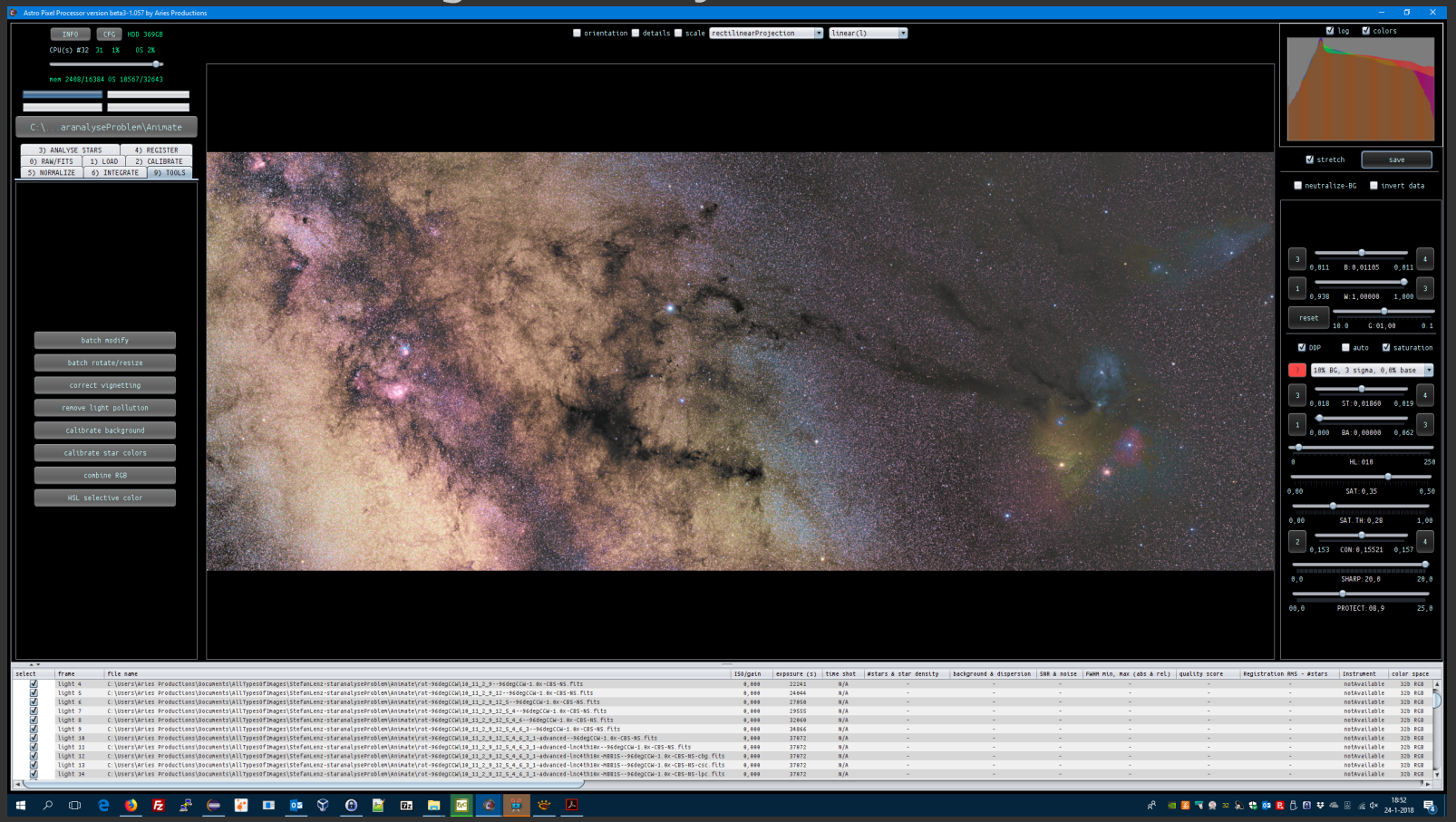
BBC Sky at Night Magazine

First Light Review by Sara Wager in January 2018 issue



# what is APP?

image courtesy of Stefan Lenz



## what is APP?

complete application for pre & post processing of Deep Sky exposures

- data calibration
- star analysis, shape & size
- registration, regular & mosaics

## what is APP?

complete application for pre & post processing of Deep Sky exposures

- normalisation of light & flat frames
- data integration
- post-processing tools

## current and future functionality

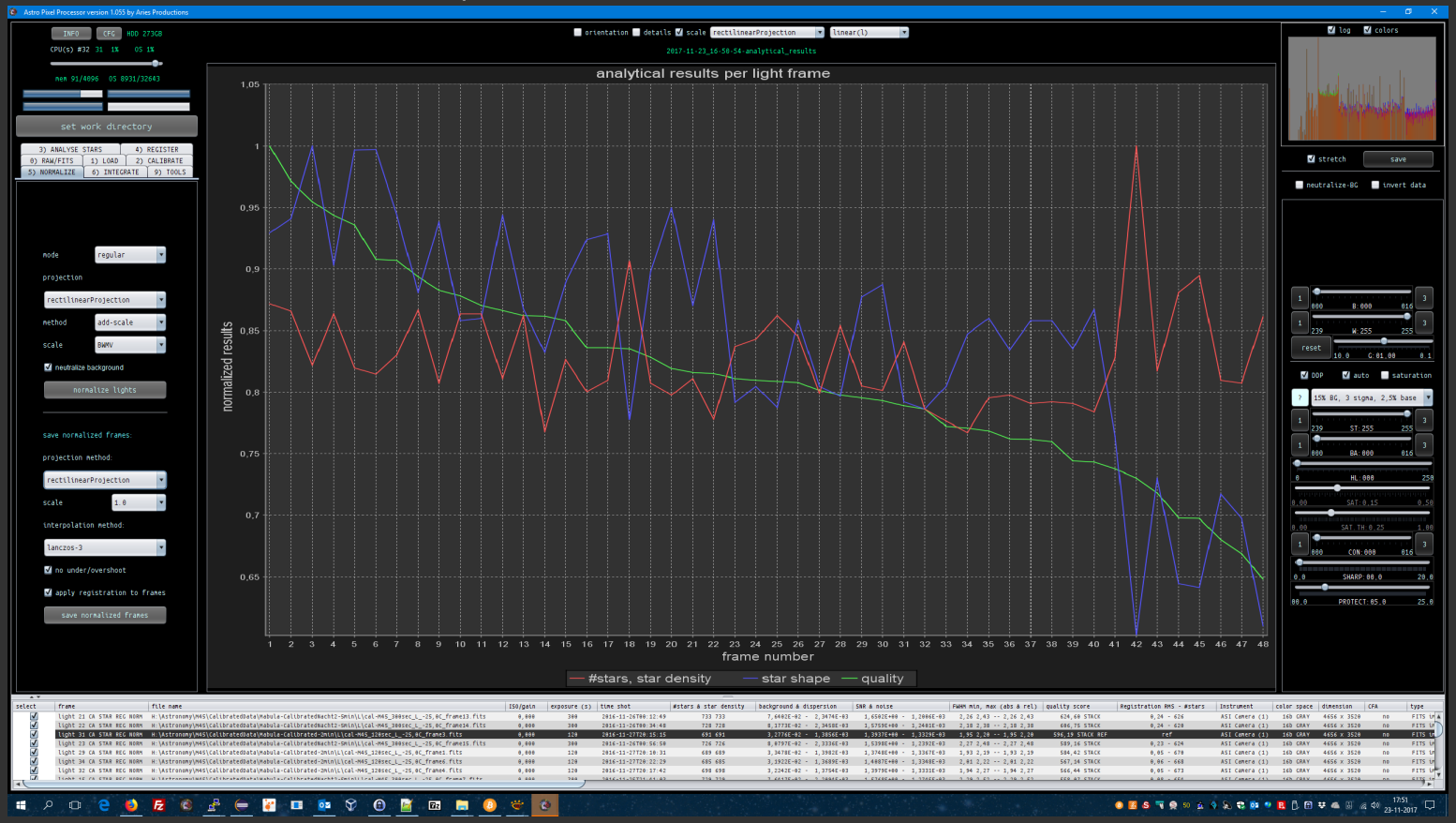
- GUI Graphical User interface
- 0) RAW/FITS
- 1) LOAD
- 2) CALIBRATE
- 3) ANALYSE STARS

current and future functionality

- 4) REGISTER
- 5) NORMALIZE
- 6) INTEGRATE
- 9) TOOLS

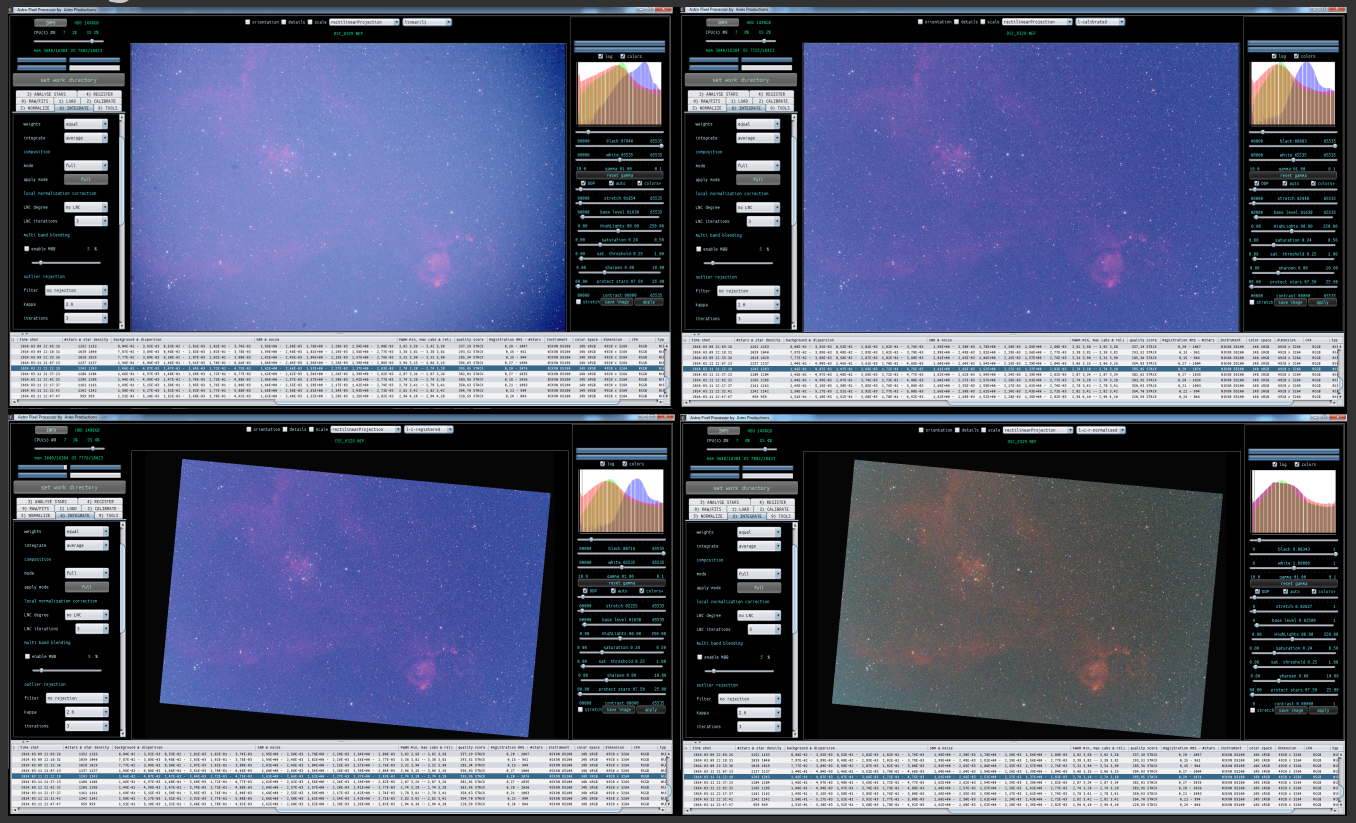
# GUI - analytical results

## Frame list panel with metadata and results

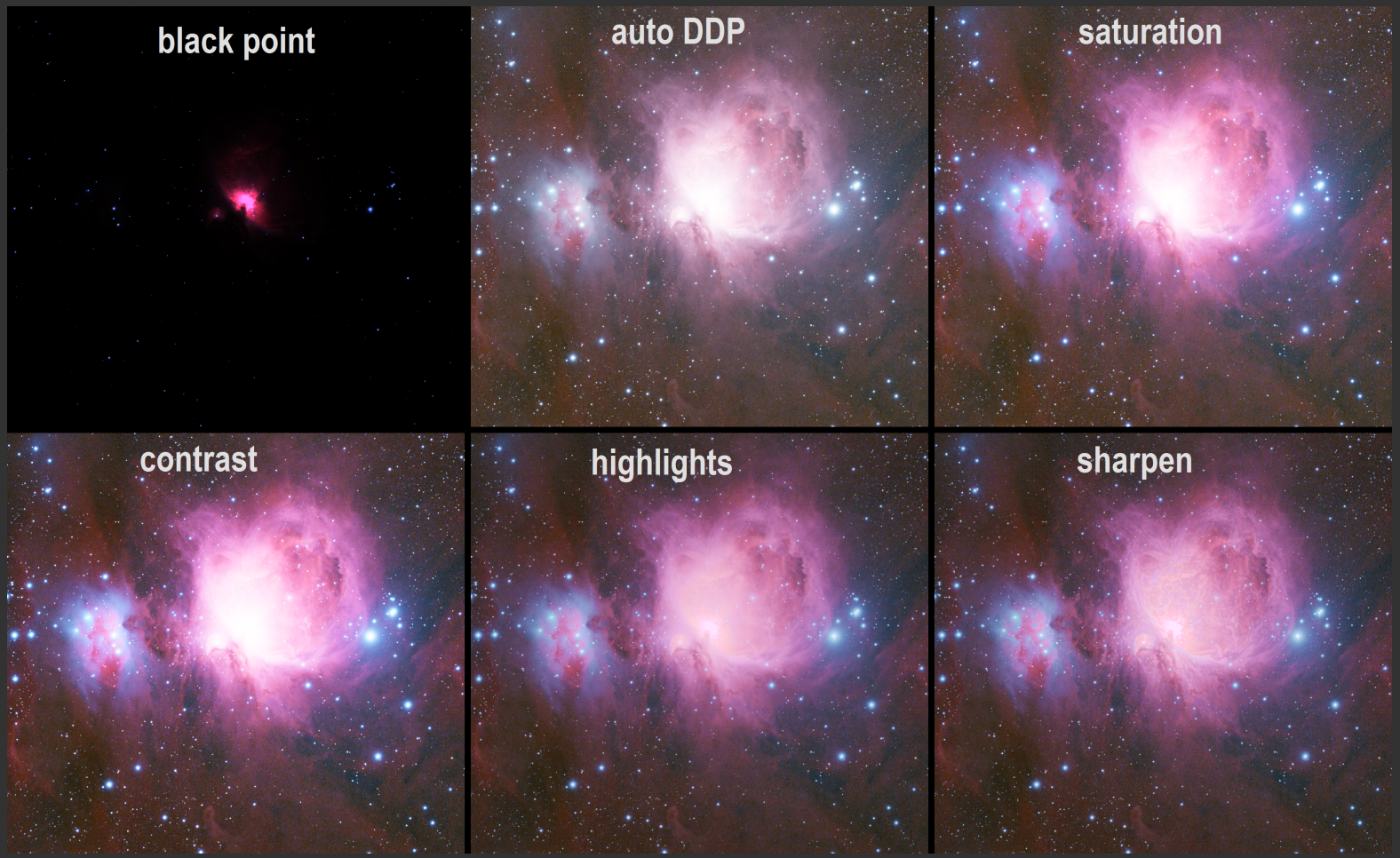


# GUI - check results!

## image viewer window - linear to normalized mode

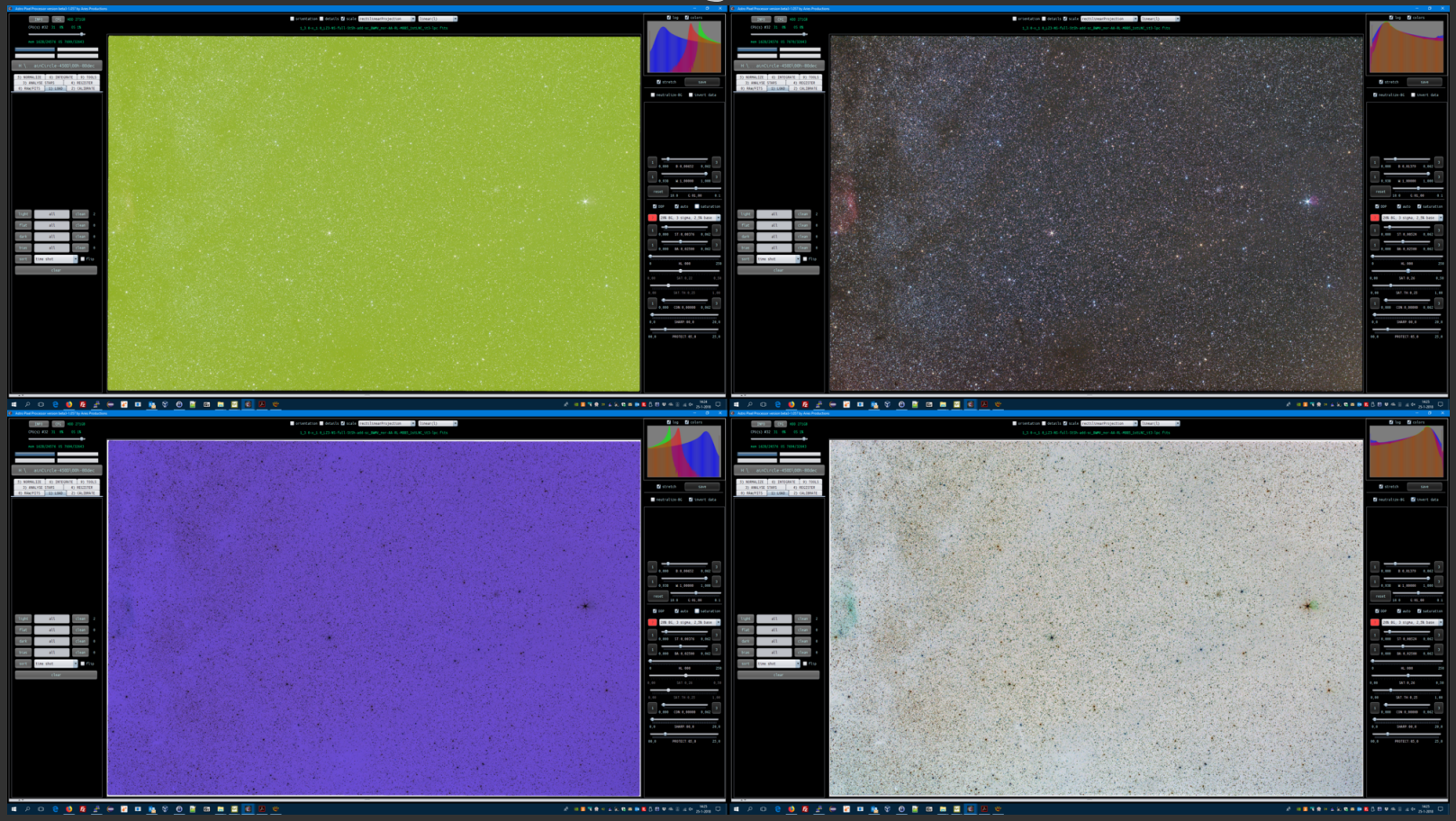


# GUI - histogram & preview filter



# GUI - histogram & preview filter

## Neutralize Background and Invert



GUI - future:

- GPU for preview filter and image drawing
- upgrade to color-preserving preview
- image viewer mode: Multi-Resolution Support Noise levels
- detach image viewer with histogram (multi-screen setup)

GUI - future:

- statistics of image in viewer
- save & load configuration(s)
- automatic multi-channel & -session processing

## 0) RAW/FITS: raw data settings

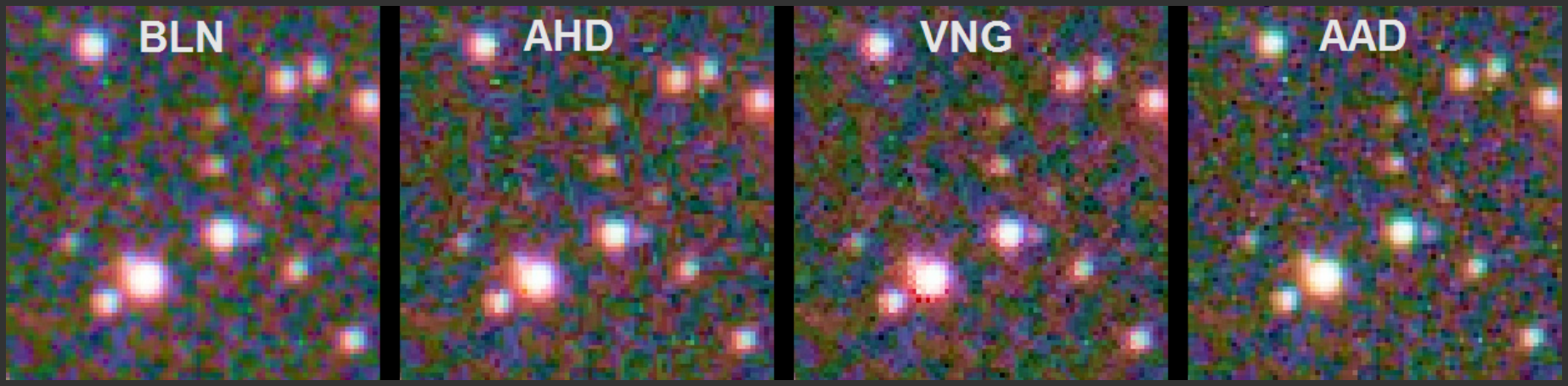
- Bayer CFA patterns (RGGB)
- Bayer CFA algorithms (AAD)
- camera white balance
- RGB multipliers (for adjusting white balance)
- force CFA interpretation (CFA data from capture software like SGP)

## CFA debayer algorithms

- no interpolation (mono sensor data)
- bilinear
- adaptive edge
- adaptive airy disc (default)
- super pixel

Adaptive Airy Disc - AAD

innovative debayer algorithm,
developed by Mabula, especially
for our astronomical images

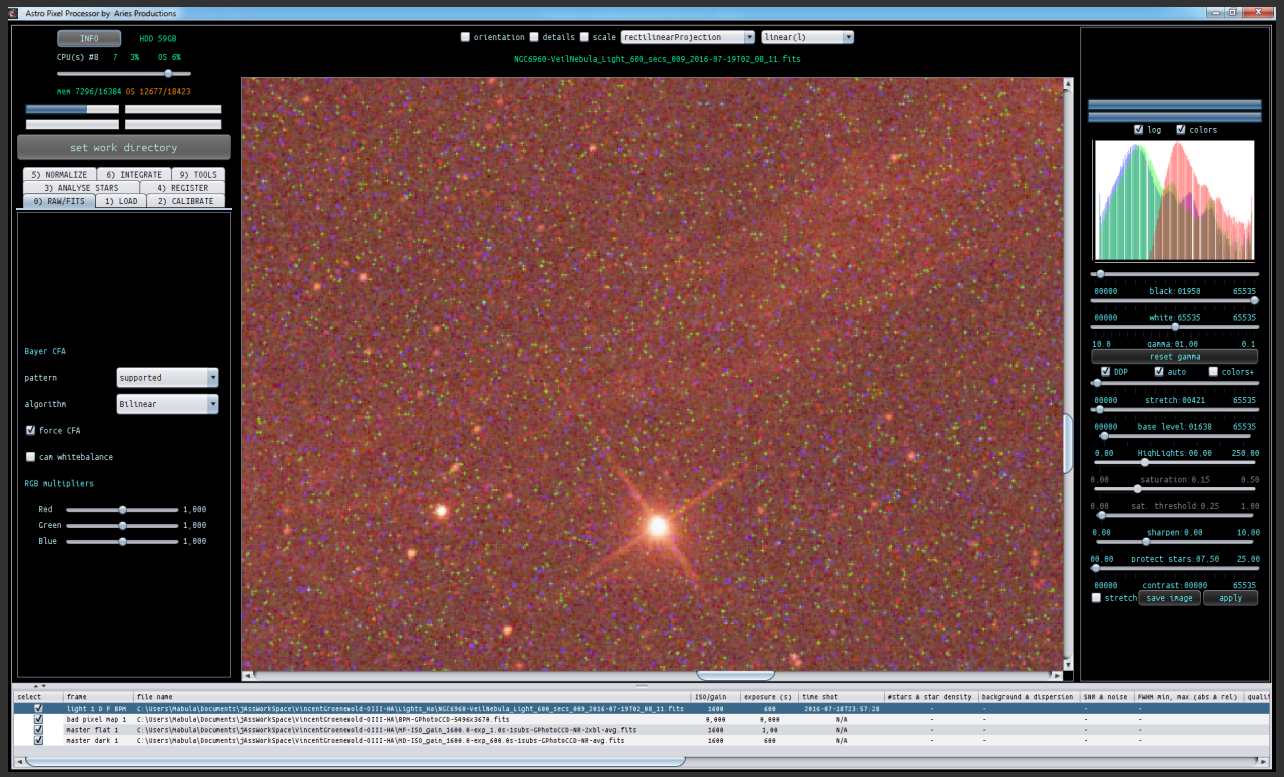


## CFA debayer algorithms - narrowband

- hydrogen alpha
- hydrogen beta
- Sulfur II
- Oxygen III
- Nitrogen II

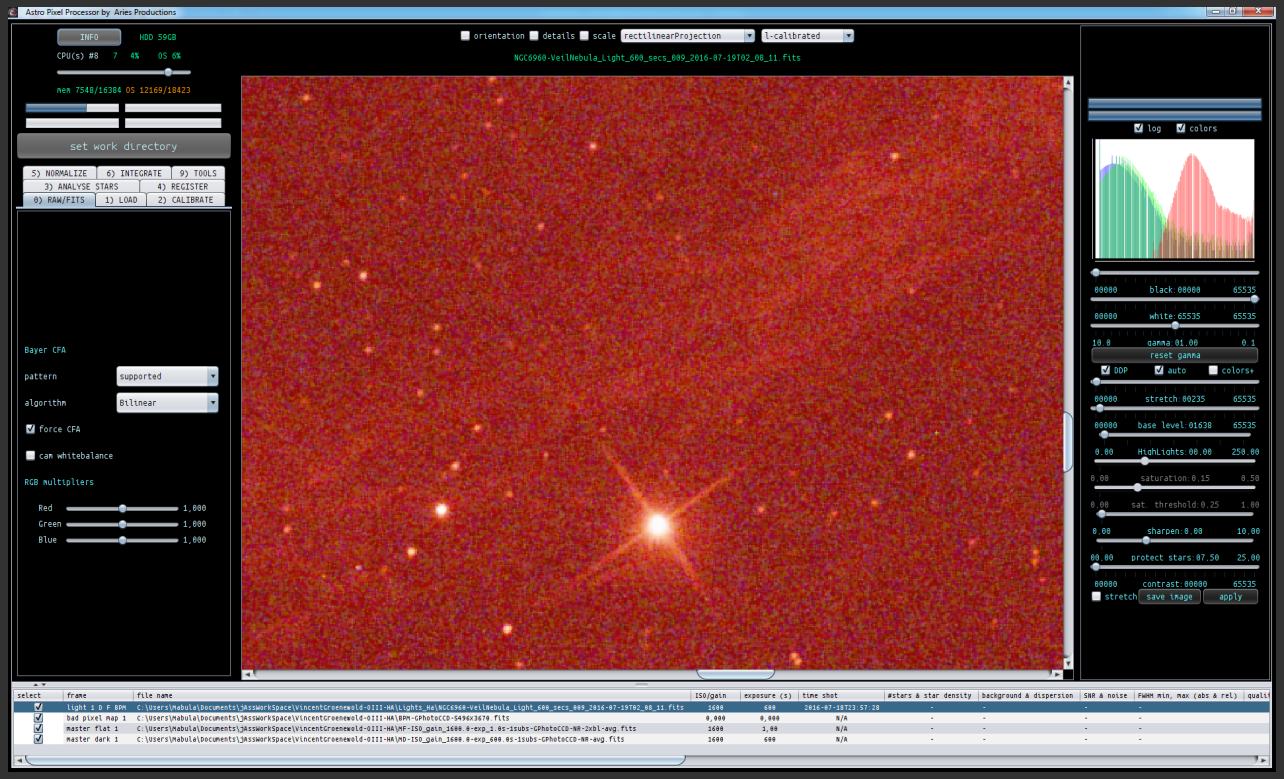
Hydrogen alpha debayer?

example - Veil Nebula, Vincent Groenewold, Canon EOS 6D
uncalibrated light frame



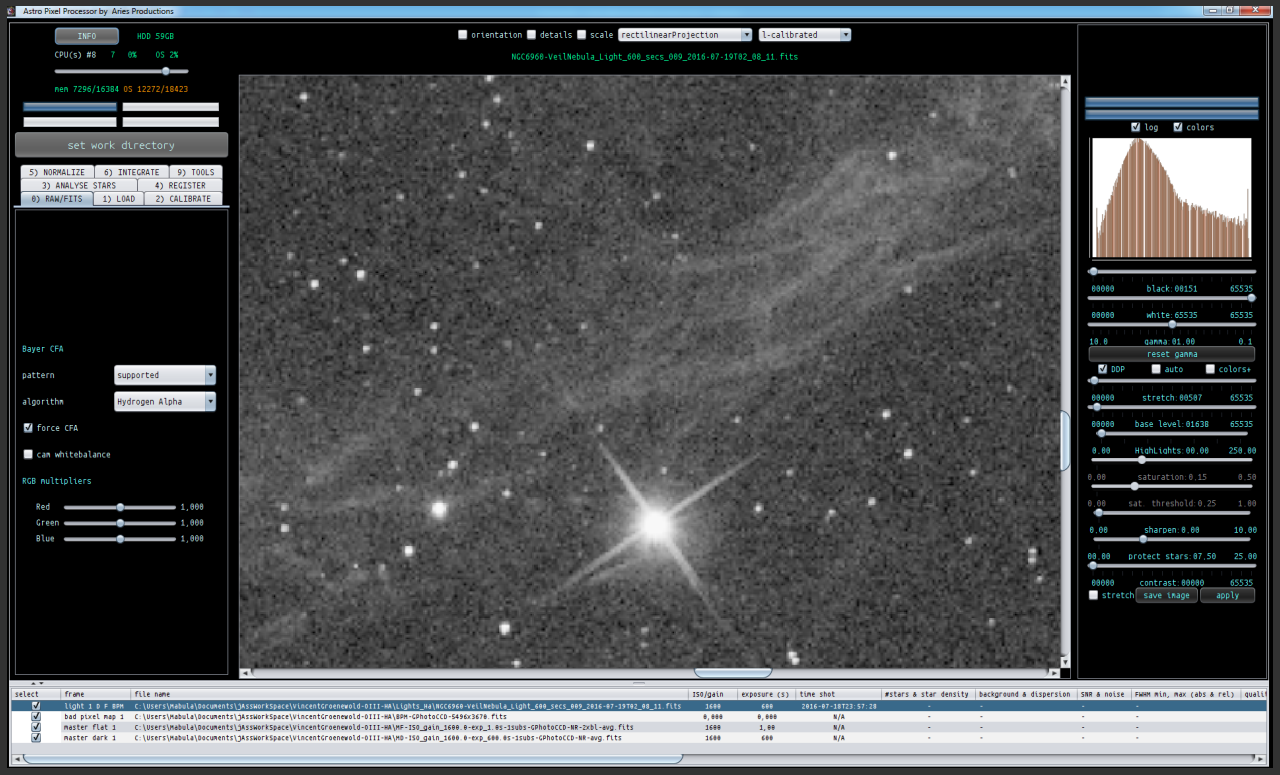
Hydrogen alpha debayer?

example - Veil Nebula, Vincent Groenewold, Canon EOS 6D
calibrated using bias, flats and bad pixel map



Hydrogen alpha debayer?

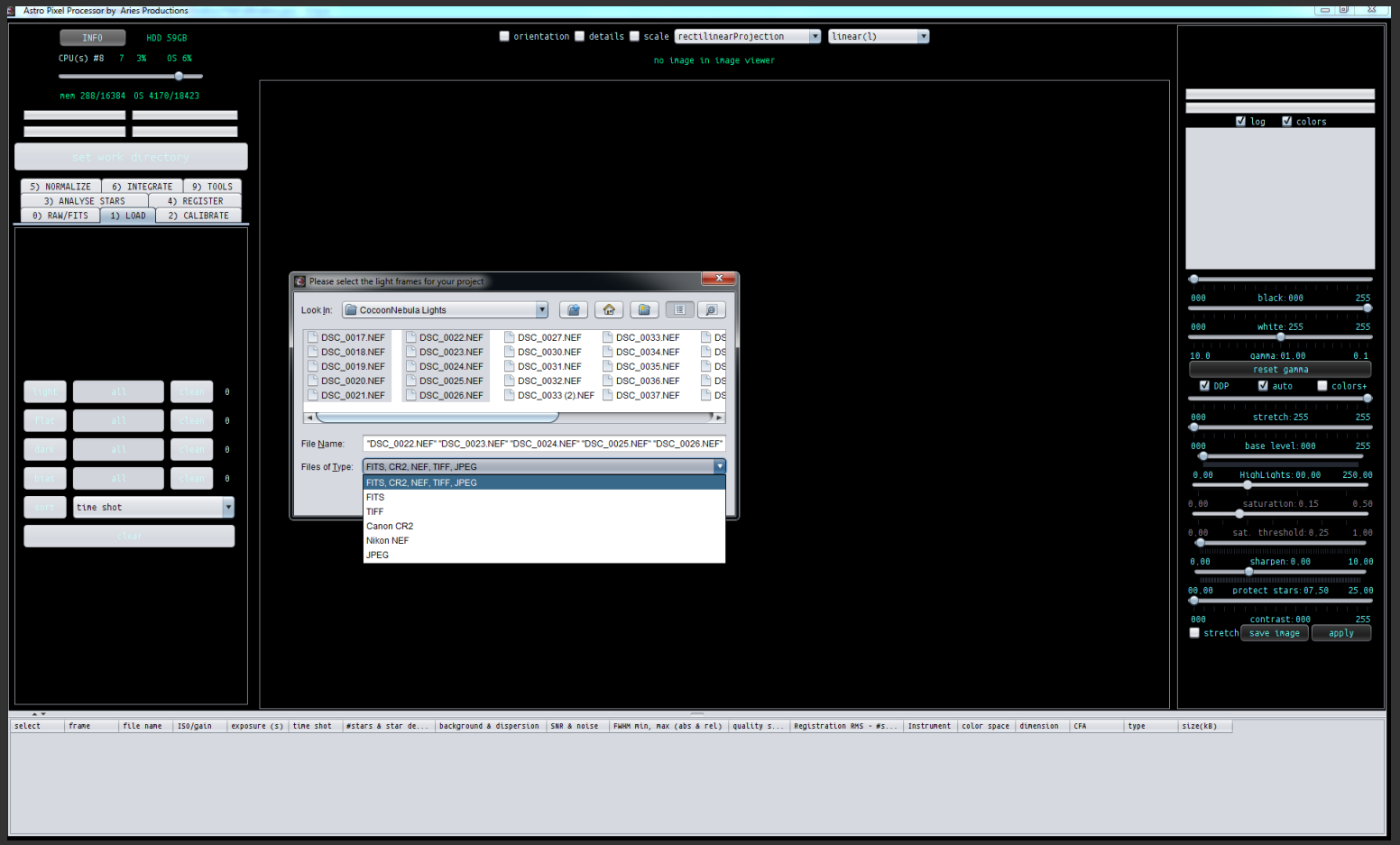
example - Veil Nebula, Vincent Groenewold, Canon EOS 6D
calibrated and H-alpha debayer applied



## 0) RAW/FITS future:

- support for Sony, Pentax, Fuji, Adobe DNG etc.. RAW frames !
- non Bayer CFA sensor support like Fuji X-Trans
- PNG load/save
- camera model $\rightarrow$ XYZ $\rightarrow$ sRGB/Adobe1998 (linear!)

# 1) LOAD

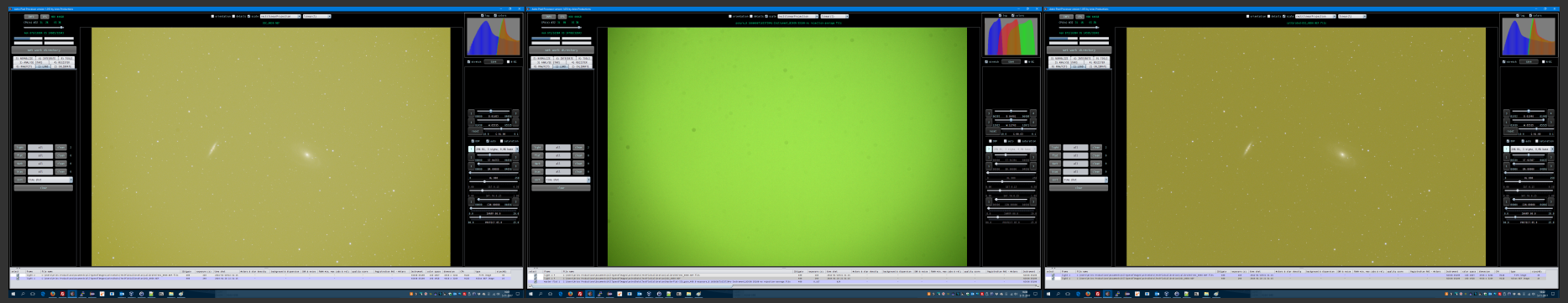

Astro Pixel Processor by Aries Productions
INFO
HDD 59GB
CPU(s) #8 7 3% OS 6%
mem 288/16384 OS 4170/18423
set work directory
5) NORMALIZE
6) INTEGRATE
9) TOOLS
3) ANALYSE STARS
4) REGISTER
0) RAW/FITS
1) LOAD
2) CALIBRATE
orientation
details
scale
rectilinearProjection
linear(l)
no image in image viewer
Please select the light frames for your project
Look In:
CocoonNebula Lights
DSC_0017.NEF
DSC_0018.NEF
DSC_0019.NEF
DSC_0020.NEF
DSC_0021.NEF
DSC_0022.NEF
DSC_0023.NEF
DSC_0024.NEF
DSC_0025.NEF
DSC_0026.NEF
DSC_0027.NEF
DSC_0030.NEF
DSC_0031.NEF
DSC_0032.NEF
DSC_0033 (2).NEF
DSC_0033.NEF
DSC_0034.NEF
DSC_0035.NEF
DSC_0036.NEF
DSC_0037.NEF
File Name:
"DSC_0022.NEF" "DSC_0023.NEF" "DSC_0024.NEF" "DSC_0025.NEF" "DSC_0026.NEF"
Files of Type:
FITS, CR2, NEF, TIFF, JPEG
FITS, CR2, NEF, TIFF, JPEG
FITS
TIFF
Canon CR2
Nikon NEF
JPEG
log
colors
black: 000
white: 255
gamma: 01.00
reset gamma
DDP
auto
colors+
stretch: 255
base level: 000
HighLights: 00.00
saturation: 0.15
sat. threshold: 0.25
sharpen: 0.00
protect stars: 07.50
contrast: 000
stretch
save image
apply
light
all
clear
dark
bias
flat
time shot
select
frame
file name
ISO/gain
exposure (s)
time shot
#stars & star de...
background & dispersion
SNR & noise
FWHM min, max (abs & rel)
quality s...
registration RMS - #s...
instrument
color space
dimension
CFA
type
size(kB)

## 2) CALIBRATE

data normalization in flat-field correction

maintains color $\equiv$ data integrity

ADU $\propto$ photons!



## 2) CALIBRATE

currently:
strict rules for ISO/gain and exposure
using bias, darks, flats & bad pixel mapping

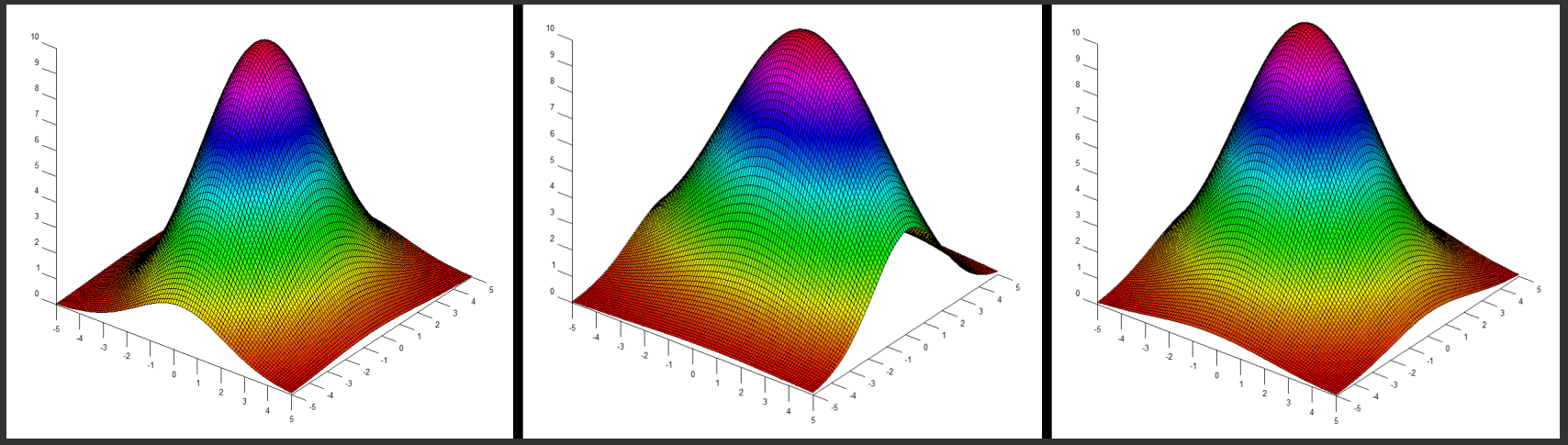
future:
fully automatic
with dark frame scaling and warning system

## 3) ANALYSE STARS

currently: general 2D elliptical Gaussian model

$$I(x,y) = I_0 \exp(-(A(x-x_0)^2 - 2B(x-x_0)(y-y_0) + C(y-y_0)^2)) \quad (1)$$

future: fully automatic star detection



## 4) REGISTER

- transparant flip in X/Y for data mirrored in 1 axis
- Dynamic optical Distortion Correction
  (pincushion, barrel, moustache)
- different optical setups
- automatic N-view mosaic solutions

## 4) REGISTER

- camera + optics calibration (focal length, principal point)
- save camera + optics profile
- rectilinear & equirectangular projections

## 4) REGISTER - Dynamic Distortion Correction DDC

Ralph Wagter - 180 degrees mosaic
Canon EOS 6D & Samyang 14mm f/2.8



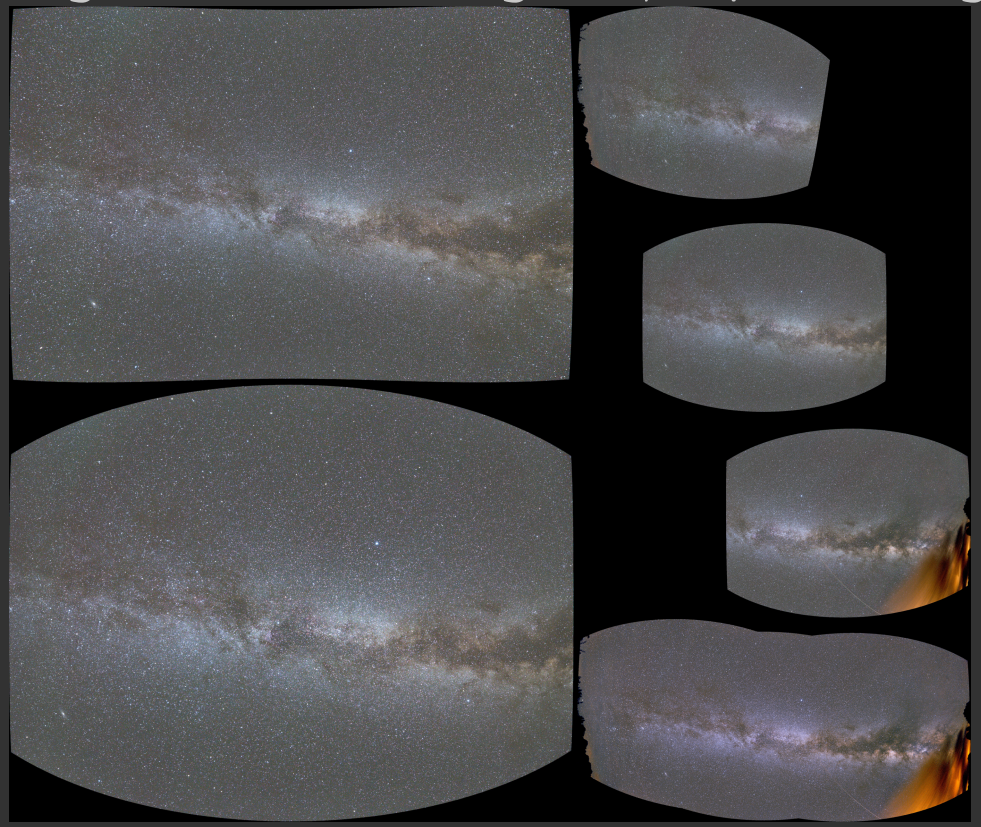
## 4) REGISTER - Dynamic Distortion Correction DDC

Ralph Wagter - 180 degrees mosaic
Canon EOS 6D & Samyang 14mm f/2.8



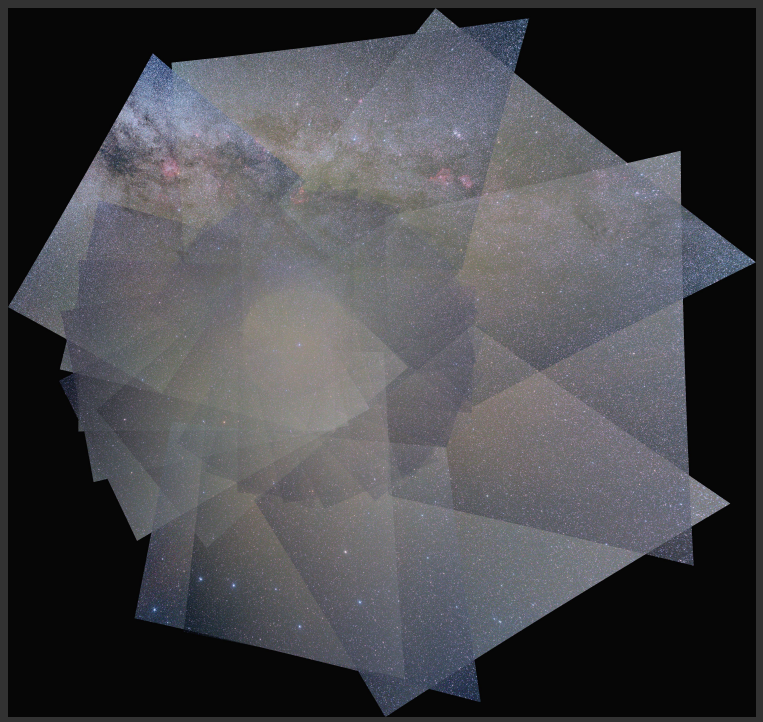
## 4) REGISTER - camera + optics calibration

Field Of View larger than 120 degrees, equirectangular projection



## 4) REGISTER - N-view mosaic solutions

Scott Rosen 30 panel mosaic
Canon 450D & 6D, 50mm f/1.8 Olympus Zuiko



4) REGISTER future:

- comet registration
- optimizations in mosaic algorithms
- more map projections like cylindrical
- automate with focus on reducing parameters

5) NORMALIZE

data normalization ?

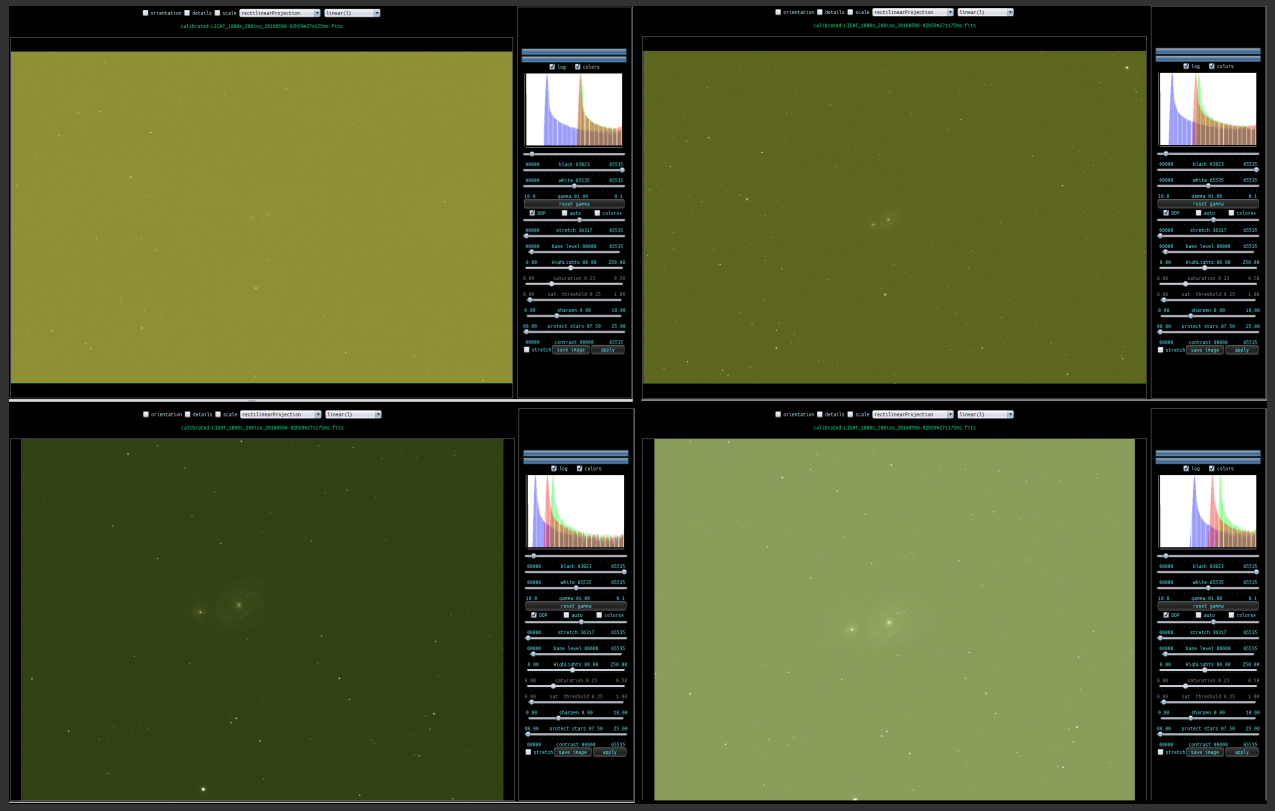
M51, the Whirlpool Galaxy
iso: 320
exposure: 900s, 1800s
focal length = 575mm, 816mm
Nikon D5100 BCF, Takahashi TSA102

## 5) NORMALIZE - M51, the Whirlpool Galaxy

| background & dispersion | | | | | |
|---|---|---|---|---|---|
| 3,52E-01 | - 4,08E-03 | 3,59E-01 | - 4,18E-03 | 1,43E-01 | - 2,54E-03 |
| 2,21E-01 | - 3,23E-03 | 2,40E-01 | - 3,40E-03 | 1,04E-01 | - 2,16E-03 |
| 1,36E-01 | - 2,48E-03 | 1,63E-01 | - 2,70E-03 | 8,62E-02 | - 2,00E-03 |
| 3,37E-01 | - 3,95E-03 | 4,06E-01 | - 4,39E-03 | 2,13E-01 | - 3,16E-03 |

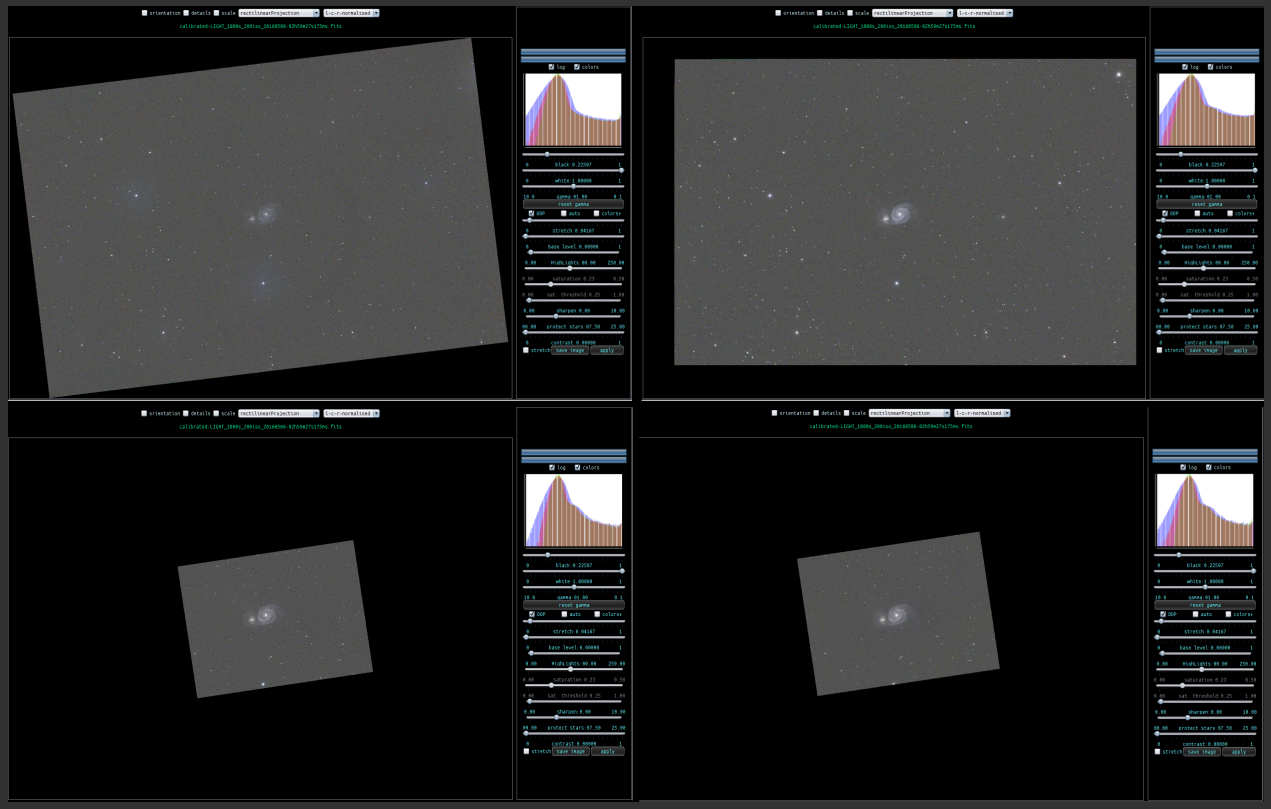
# 5) NORMALIZE - M51, the Whirlpool Galaxy

## BEFORE



# 5) NORMALIZE - M51, the Whirlpool Galaxy

## AFTER



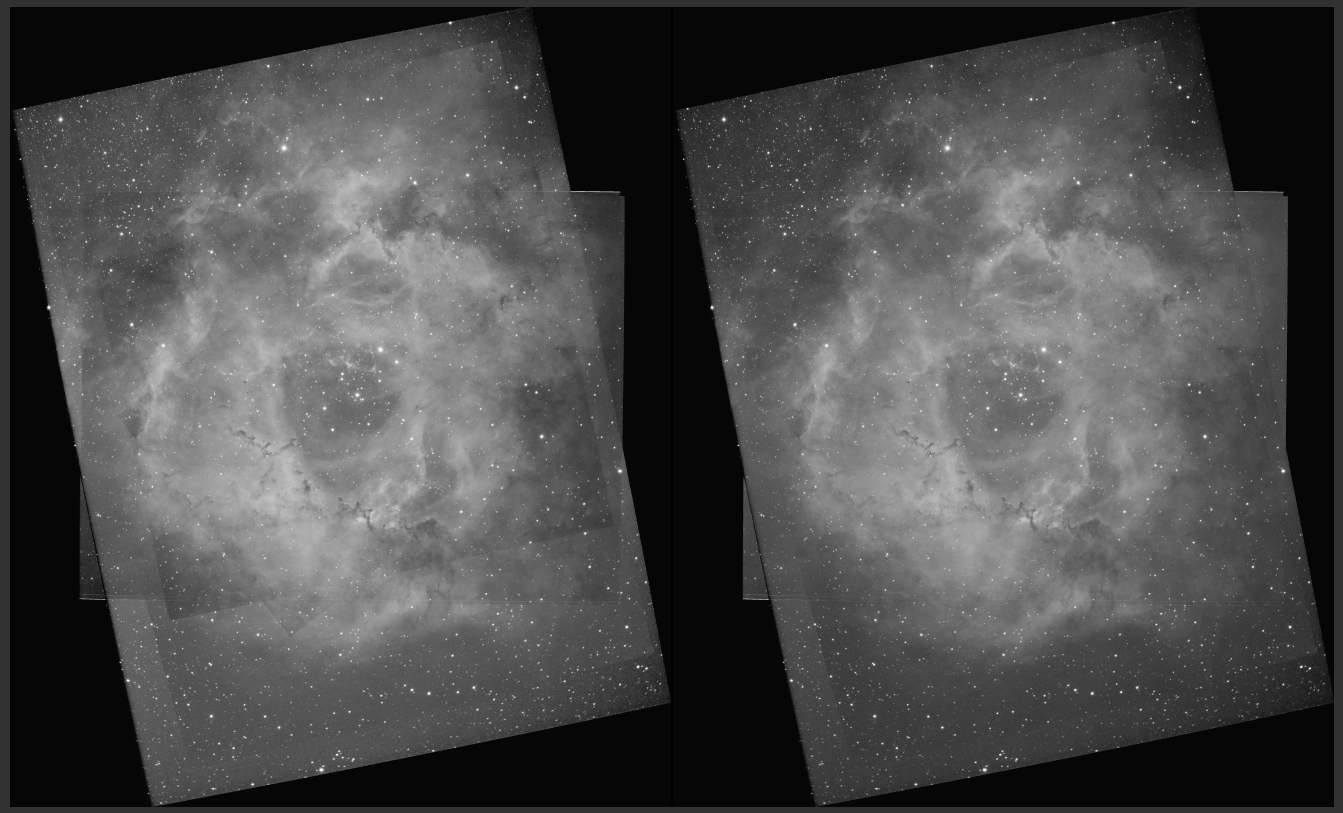
## 5) NORMALIZE

data normalization before integration

- exposures become statistically comparable
- improvement outlier rejection
- improvement average/median in integration
- noise reduces, SNR improves
- vital in case of multiple OTA's / cameras / imaging sessions

# 5) NORMALIZE

advanced mode



5) NORMALIZE future:

fully integrated in 6) INTEGRATE

- speed up processing time 20-30%
- possibility to normalize non-linear data
- Local Normalization Correction 2.0

# 6) INTEGRATE

data integration

- weights
- composition
- Local Normalization Correction (LNC)
- Multi-Band Blending (MBB)

## 6) INTEGRATE

data integration

- outlier rejection filters
- output maps
- pixel interpolation

## 6) INTEGRATE

data integration

- scale
- drizzle & bayer drizzle
- projection

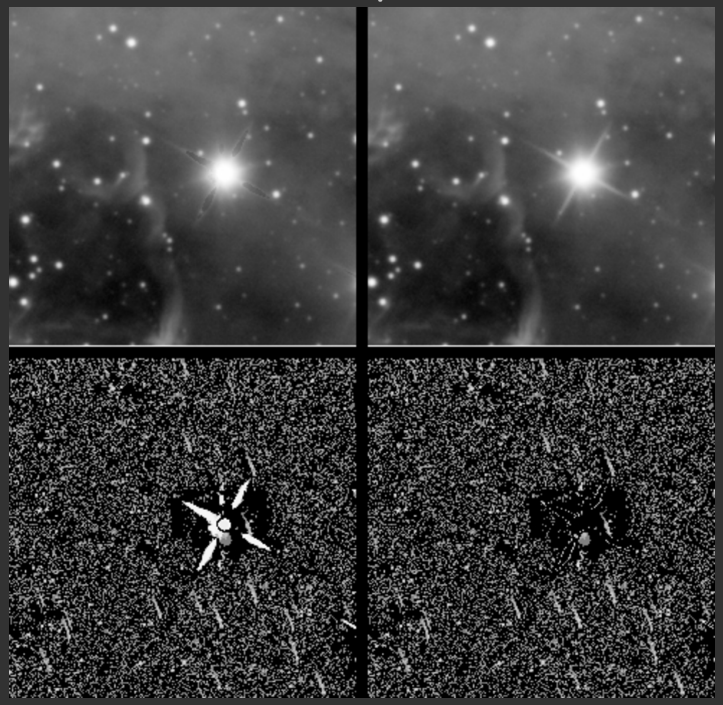
## 6) INTEGRATE - outlier rejection filters

APP 1.057, improved outlier rejection

- MAD sigma / winsor sigma clipping
- Local Normalization outlier rejection
- diffraction protection

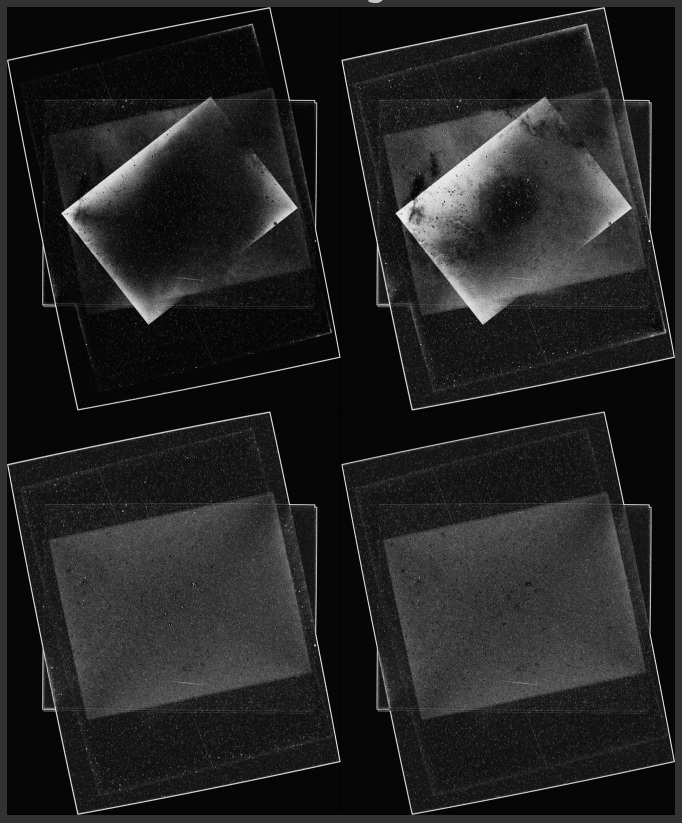
## 6) INTEGRATE - outlier rejection filters

diffraction protection

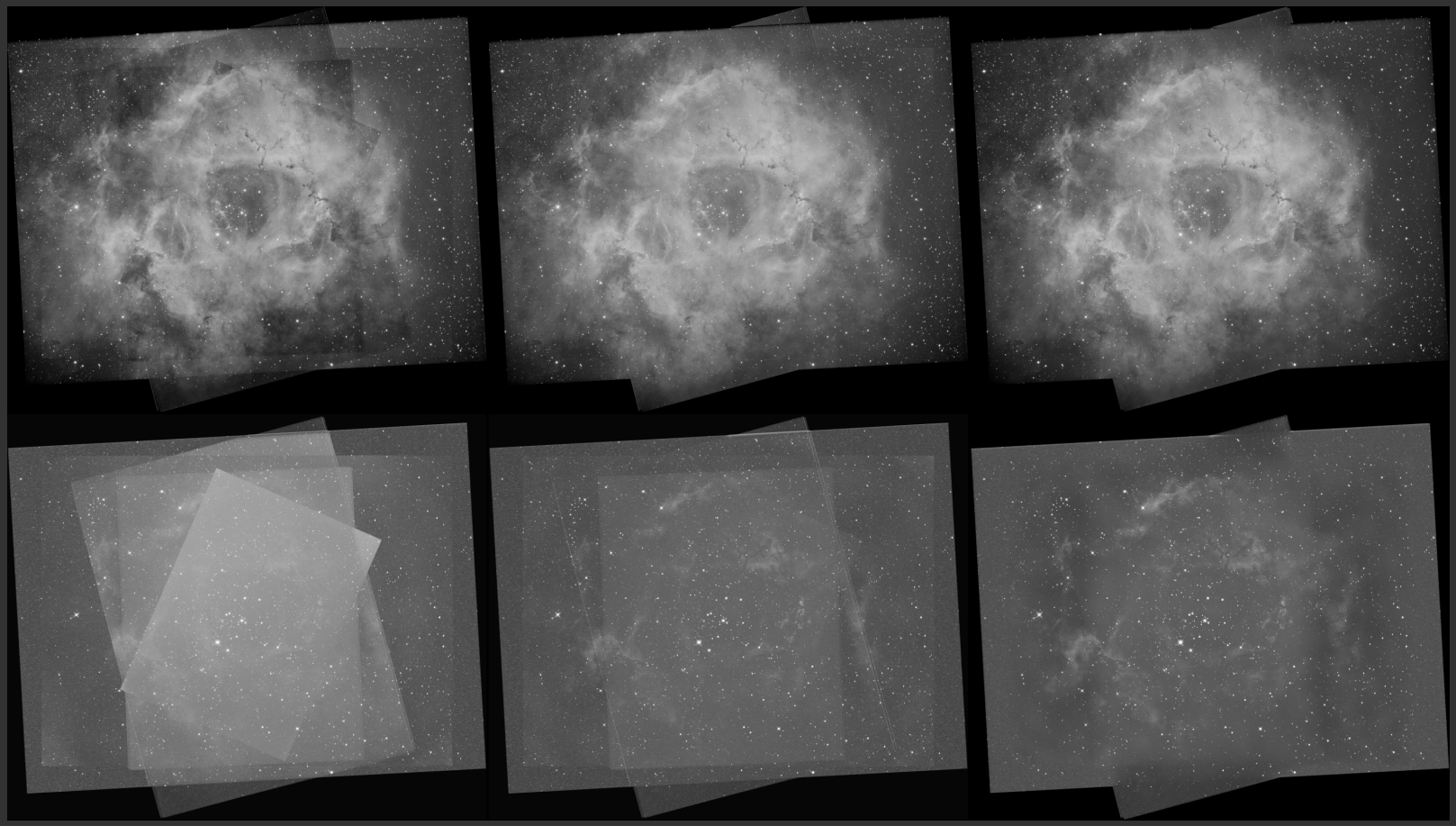


## 6) INTEGRATE - outlier rejection filters

Local Normalization MAD outlier rejection with diffraction protection



# 6) INTEGRATE - LNC + MBB



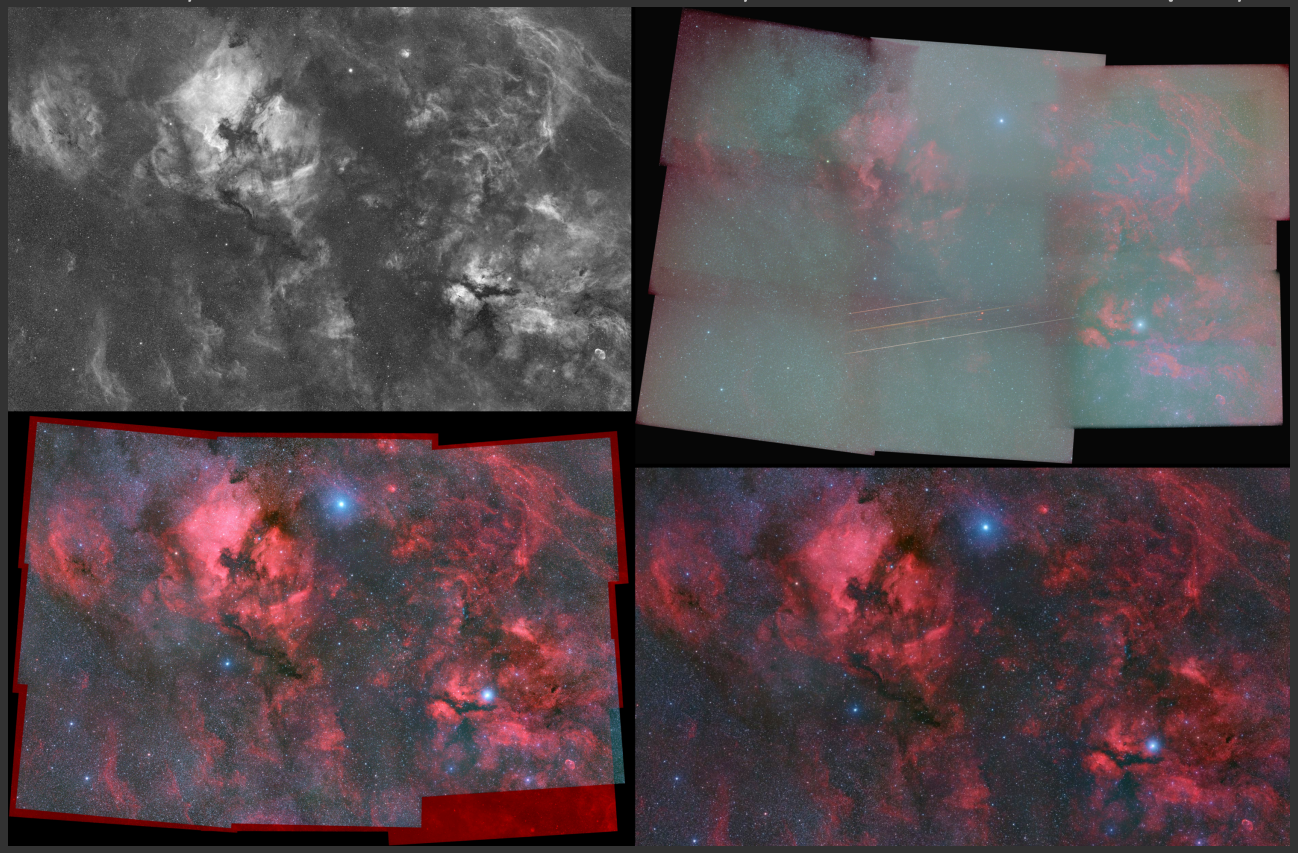
## 6) INTEGRATE - LNC + MBB

Yves van den Broek - Barnard's Loop
Nikon D810a, WO Star 71 apo



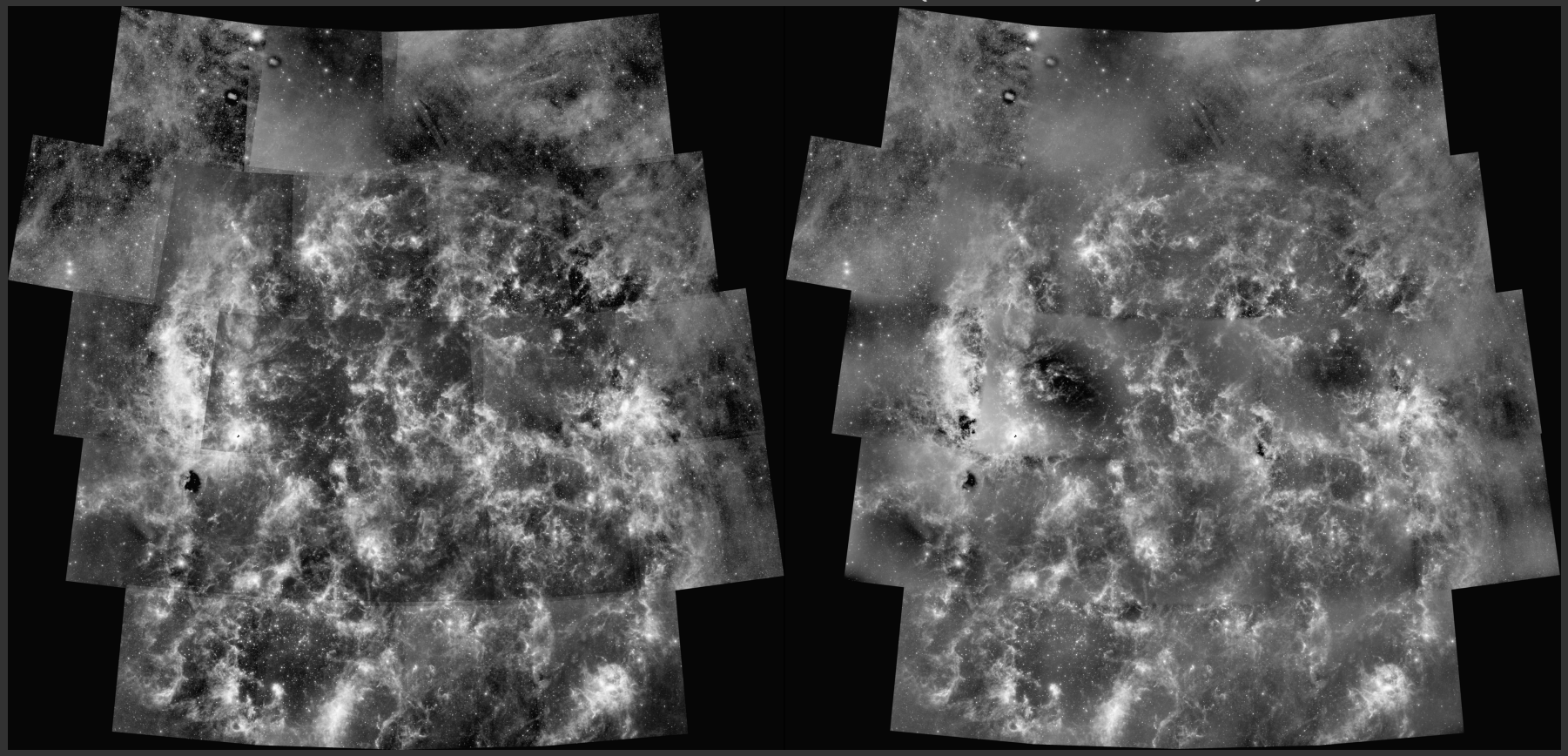
# 6) INTEGRATE - LNC + MBB + DDC

Yves van den Broek - North America to Crescent HaRGB
Nikon D810a, D600 mono cooled, WO Star 71 apo, 9 panel



## 6) INTEGRATE - future: LNC 2.0 needed!

WISE - Wide-field Infrared Survey Explorer (NASA)
data of Tarantula Nebula (Judy Schmidt)



## 6) INTEGRATE - future:

- all settings in metadata
- adjust integration name
- new data interpolation algorithms?

## 9) TOOLS

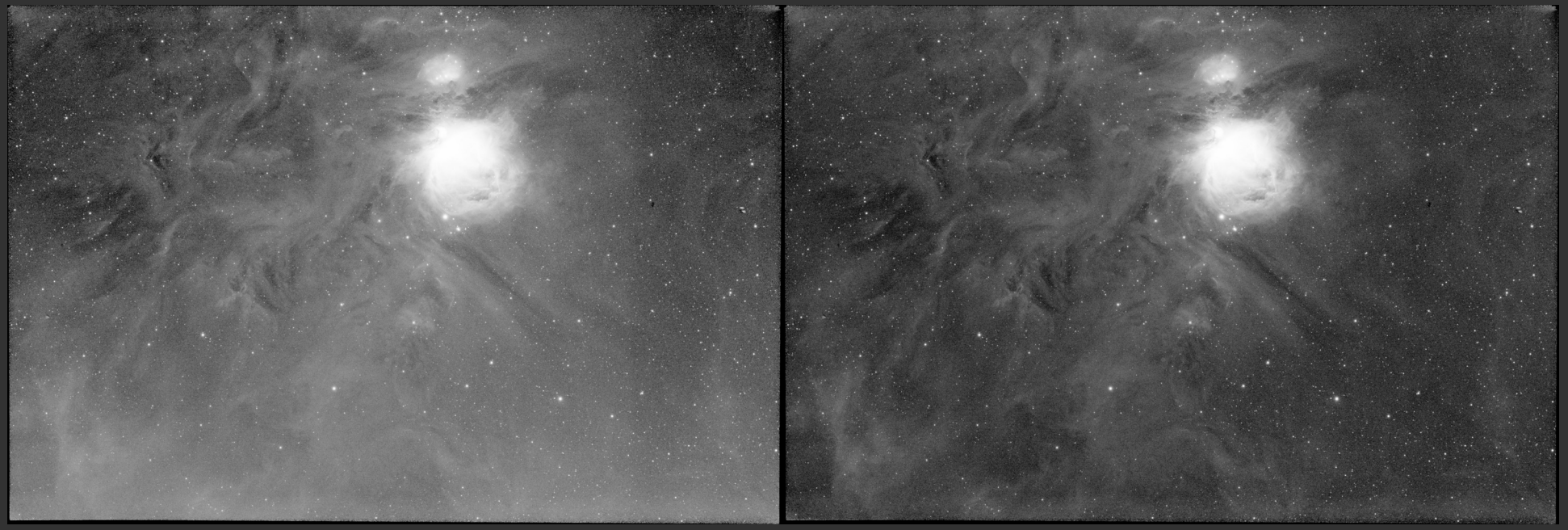
- Batch Modify (crop/uncrop, metadata, add, multiply)
- Batch rotate/resize (flip in X/Y axis)
- correct vignetting tool (Kang-Weiss models)
- remove light pollution

# 9) TOOLS

- calibrate background
- calibrate star colors (Black Body physics)
- Combine RGB (LRGB, HARGB etc..)
- HSL selective color

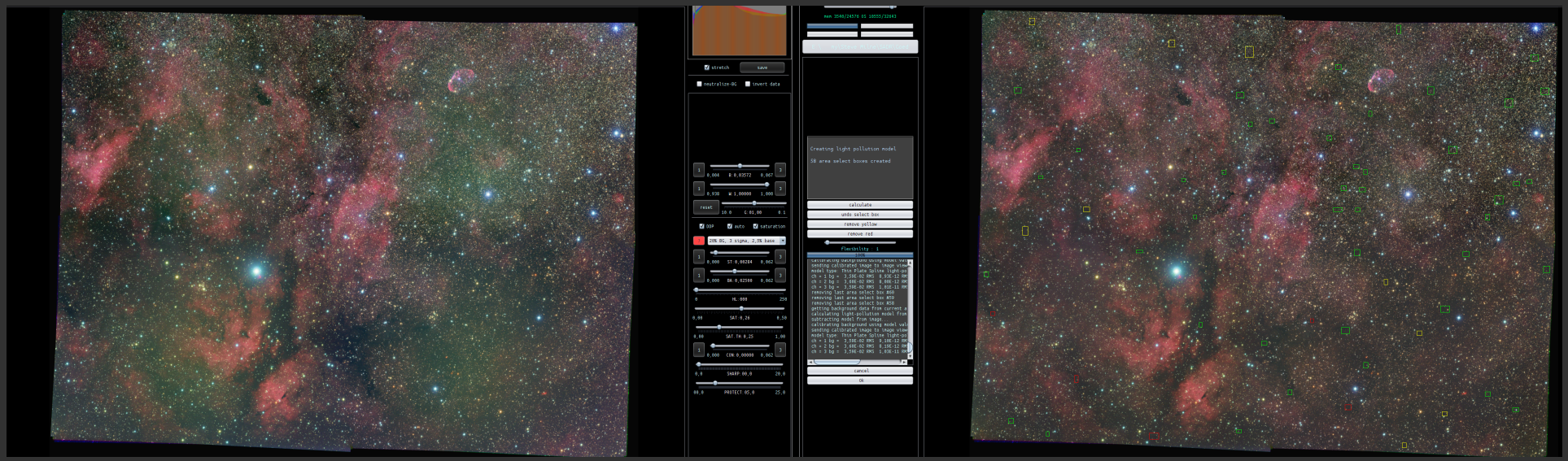
## 9) TOOLS - remove light pollution

Yves van den Broek - Orion - H-alpha - Nikon D600 mono



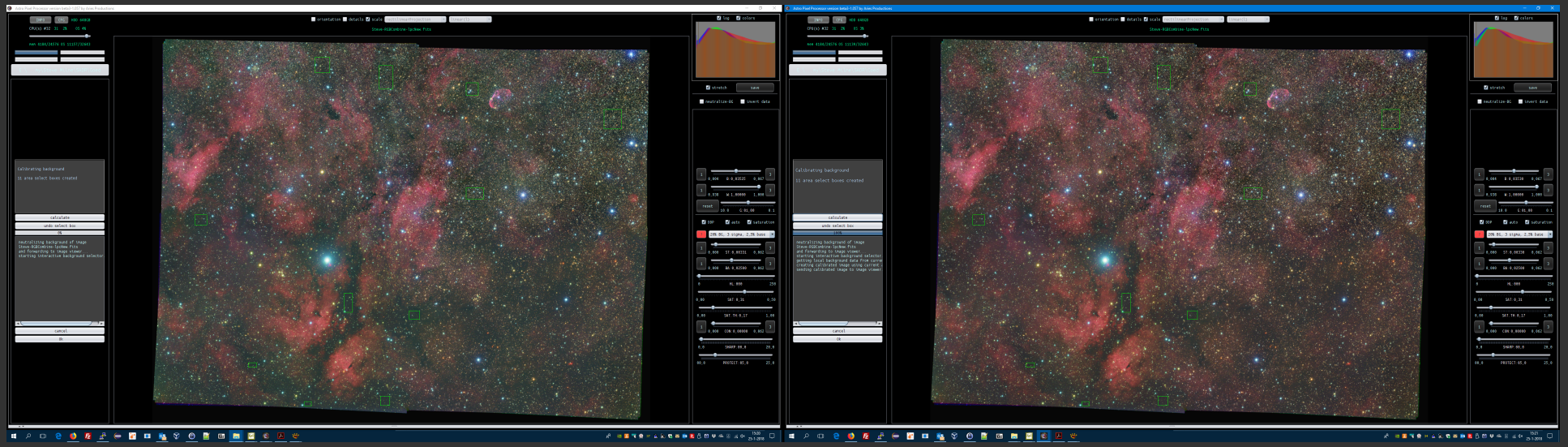
# 9) TOOLS - remove light pollution

Steven Milne - SADR - multi-channel mosaic



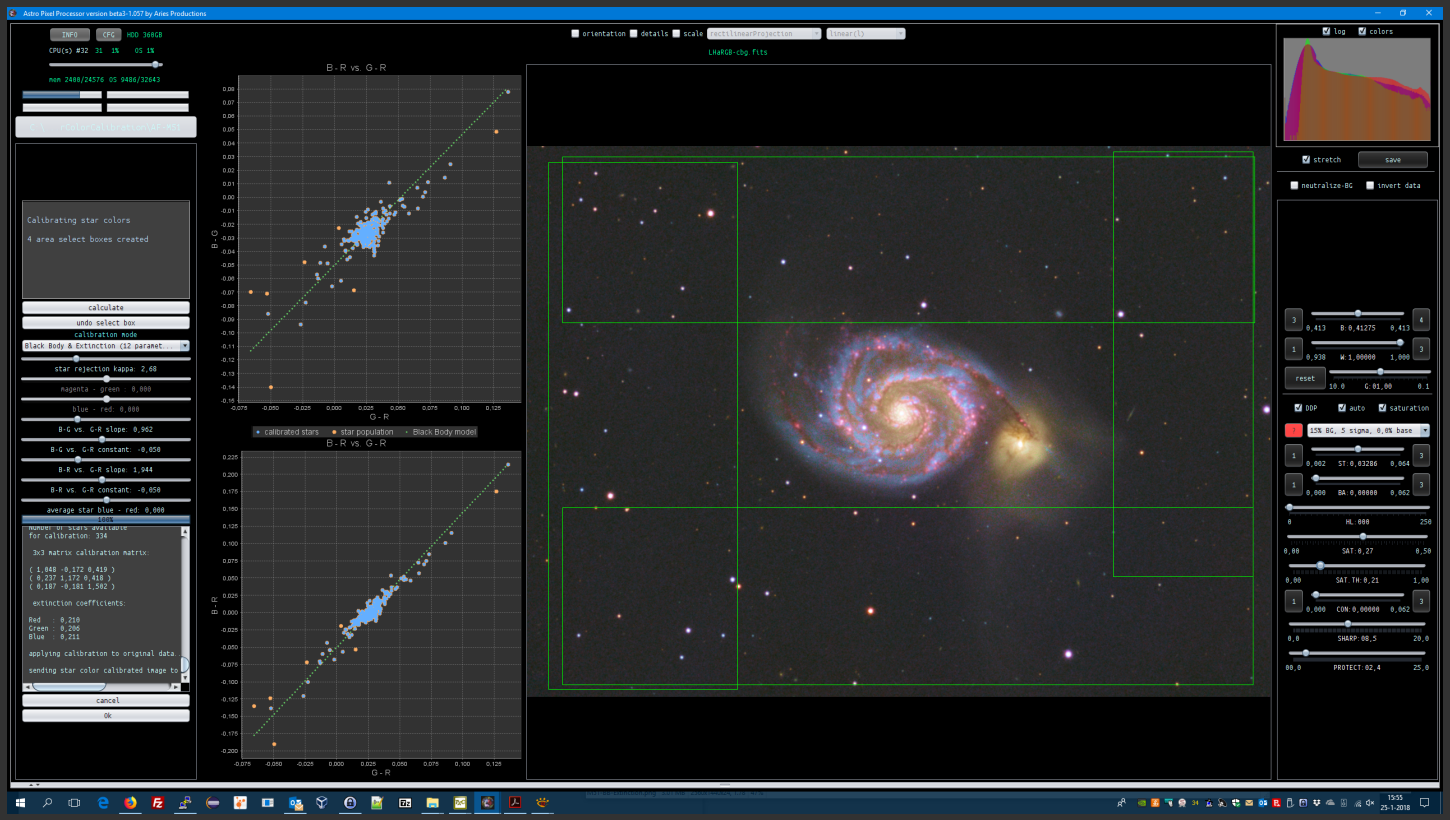
## 9) TOOLS - calibrate background

Don’t surpress faint nebulosity!



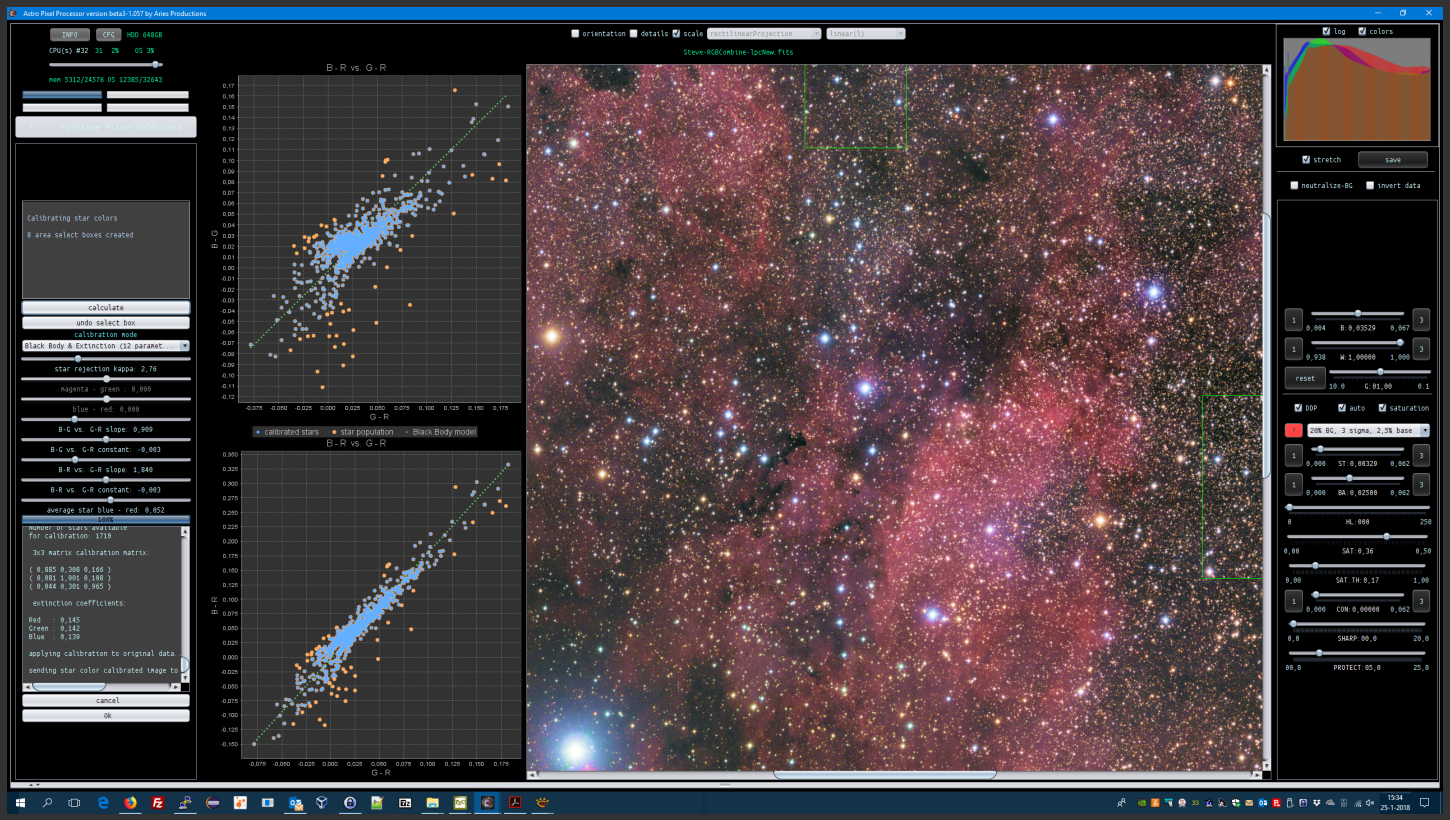
# 9) TOOLS - calibrate star colors (Black Body physics)

## Fit star population to Black Body model



# 9) TOOLS - calibrate star colors (Black Body physics)

## Fit star population to Black Body model



## 9) TOOLS: future

- deconvolution
- multi-resolution support noise reduction
- multi-resolution support sharpening
- plate solving
- view correction models: light pollution removal & correct vignetting

## 9) TOOLS: future

- image comparison (different images in image viewer)
- HDR added to RGB combine tool
- mask tool and integrated into relevant tools
- star reduction/removal

APP future

What did I forget ?

support@astropixelprocessor.com

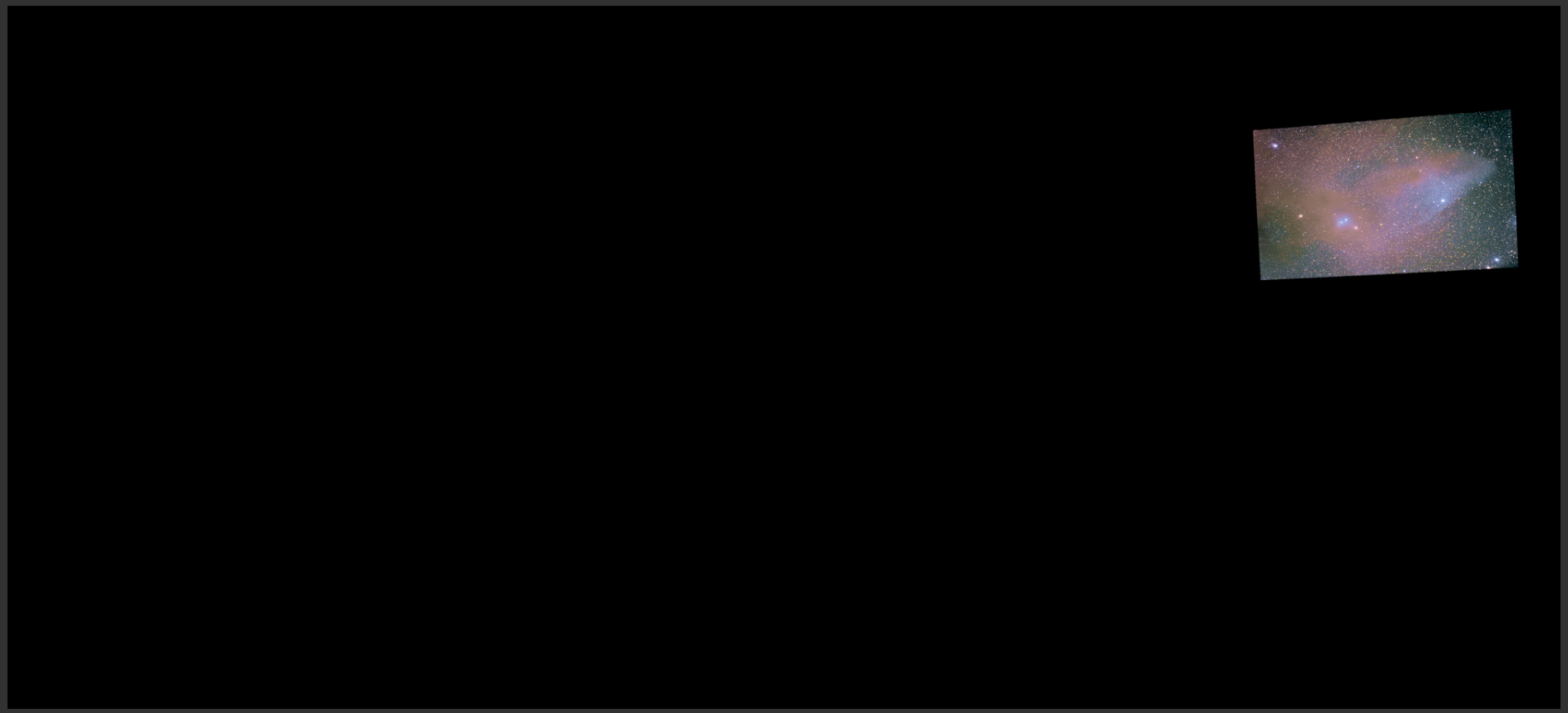
https://.../community/development-priorities/

Example: Widefield Mosaic

Milkyway & Rho Ophiuchi Mosaic
by Stefan Lenz, shot at Kiripotib, Namibia

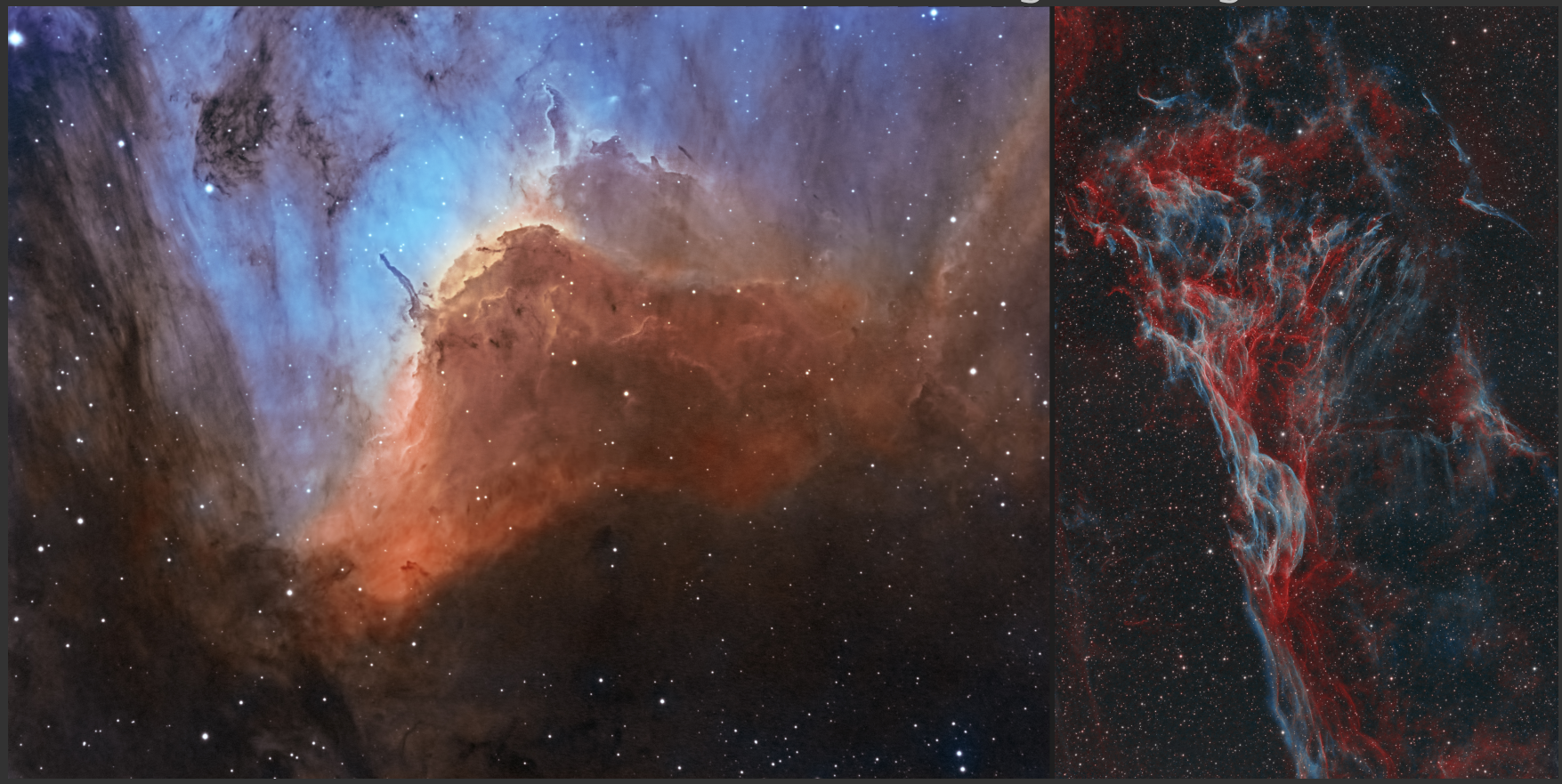
Nikon D810a, Nikon VR 400mm f/2.8G, 135mm f/1.8G
completely processed with Astro Pixel Processor 1.057

Milkyway & Rho Ophiuchi Mosaic by Stefan Lenz



## APP images - Sara Wager APODs

Bi-Colour Pelican Nebula and Pickerings Triangle mosaic



# APP images - Diego Colonnello collection



APP images - Yves van den Broek



## APP images - André van der Hoeven

## Kees Scherer, Dominique Dierick, Sara Wager combined !





Beta team

very grateful to:

Yves van den Broek, Rob Musquetier, Dominique Dierick, Marc Theunissen, Vincent Groenewold, Kees Scherer, André van der Hoeven, Wei-Hao Wang, Scott Rosen, Hans van Overzee, Maurice Toet, Olly Penrice, Tom O'Donoghue, Cory & Tanja Schmitz, Christian van den Berge, Marco Verstraaten, Jos Wennmacker

**www.starry-night.nl**

Questions?

support@astropixelprocessor.com

https://www.astropixelprocessor.com/community/

