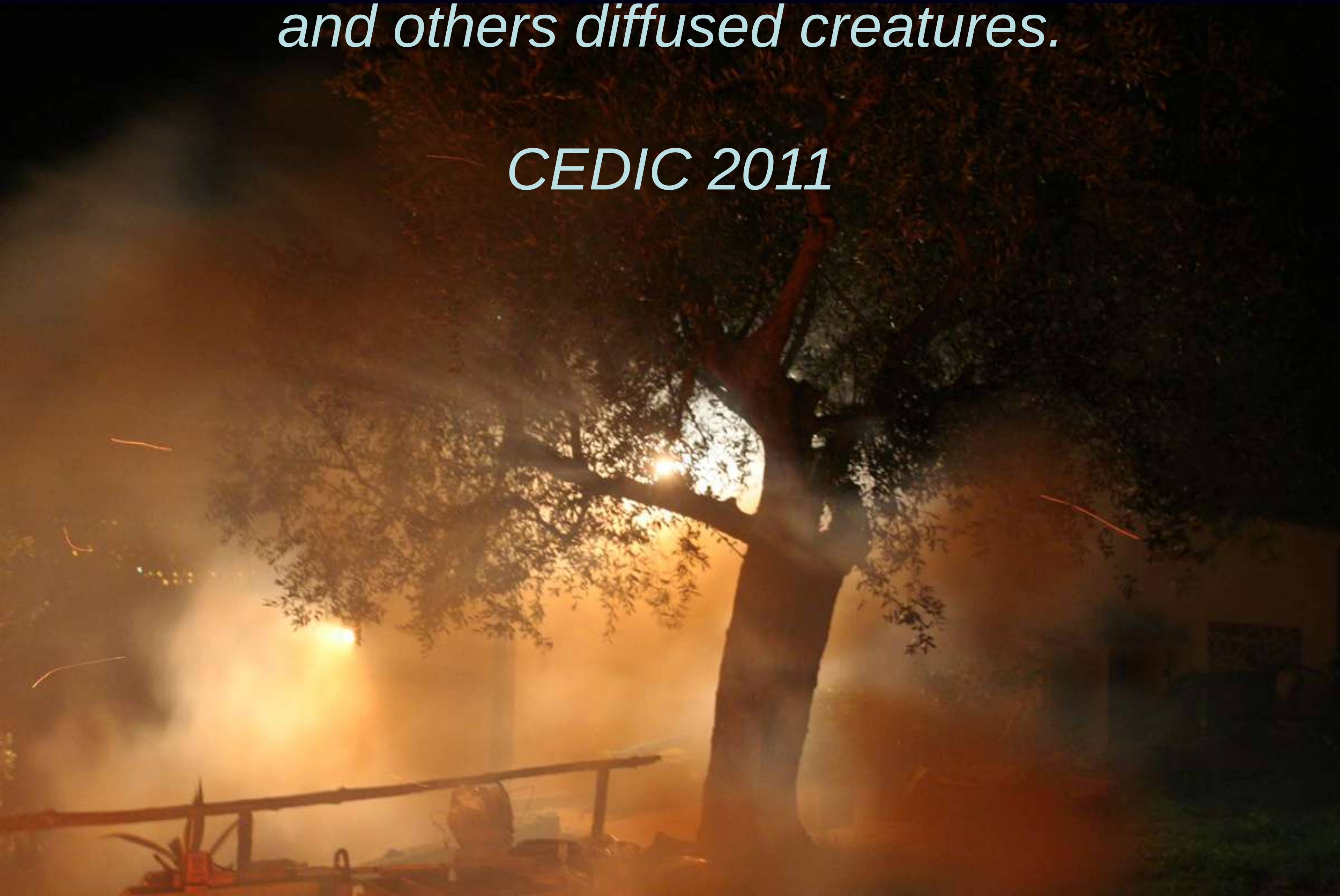
Reflections on reflection nebulae and others diffused creatures.

CEDIC 2011



The fantastic zoology of reflection nebulae

Zoology of nebulae: the variety of shapes and color is determined by the laws of interactions between light and matter

1) Interactions between light and matter

2) Searching for dust: strategies for a fruitful chase

3) Tips and tricks: imaging the invisible (or, at least, the scarcely visible!)

My partners of this chase

ASA astrograph 10” f 3.6
WO fluorite triplet 80 mm f 6.0
Gemini 42

Canon L 135 mm, f 2.0
Losmandy G11

SBIG STL 11000 M
Baader filters HαLRGB

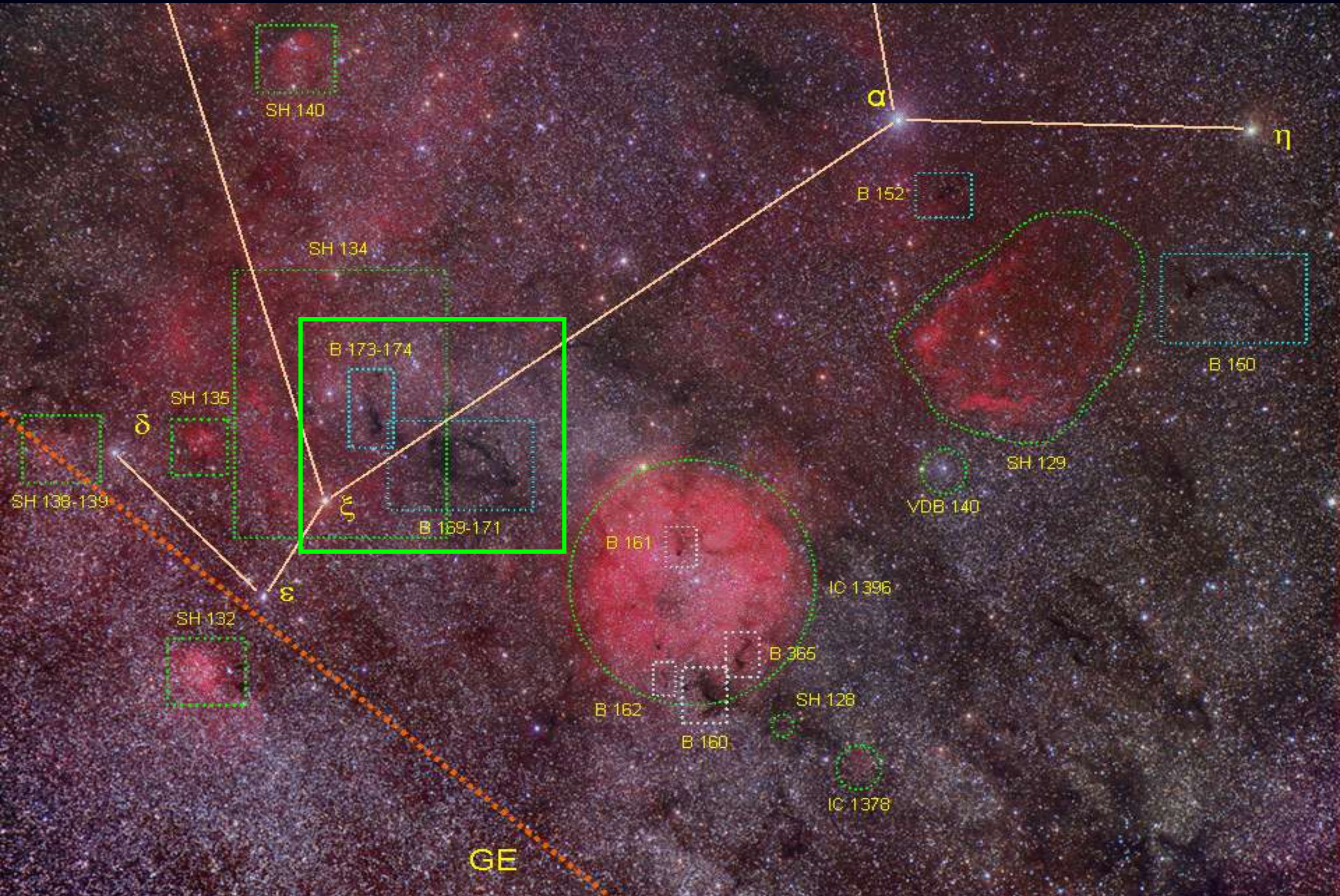
Acquisition:
CCDsoft, the Sky VI, Focus Max
CCDcommander.

Processing:
CCDstack, PixInsight LE, Image J, CS

LRGB, HαRGB composites.
10 to 40 hrs of integration for each image

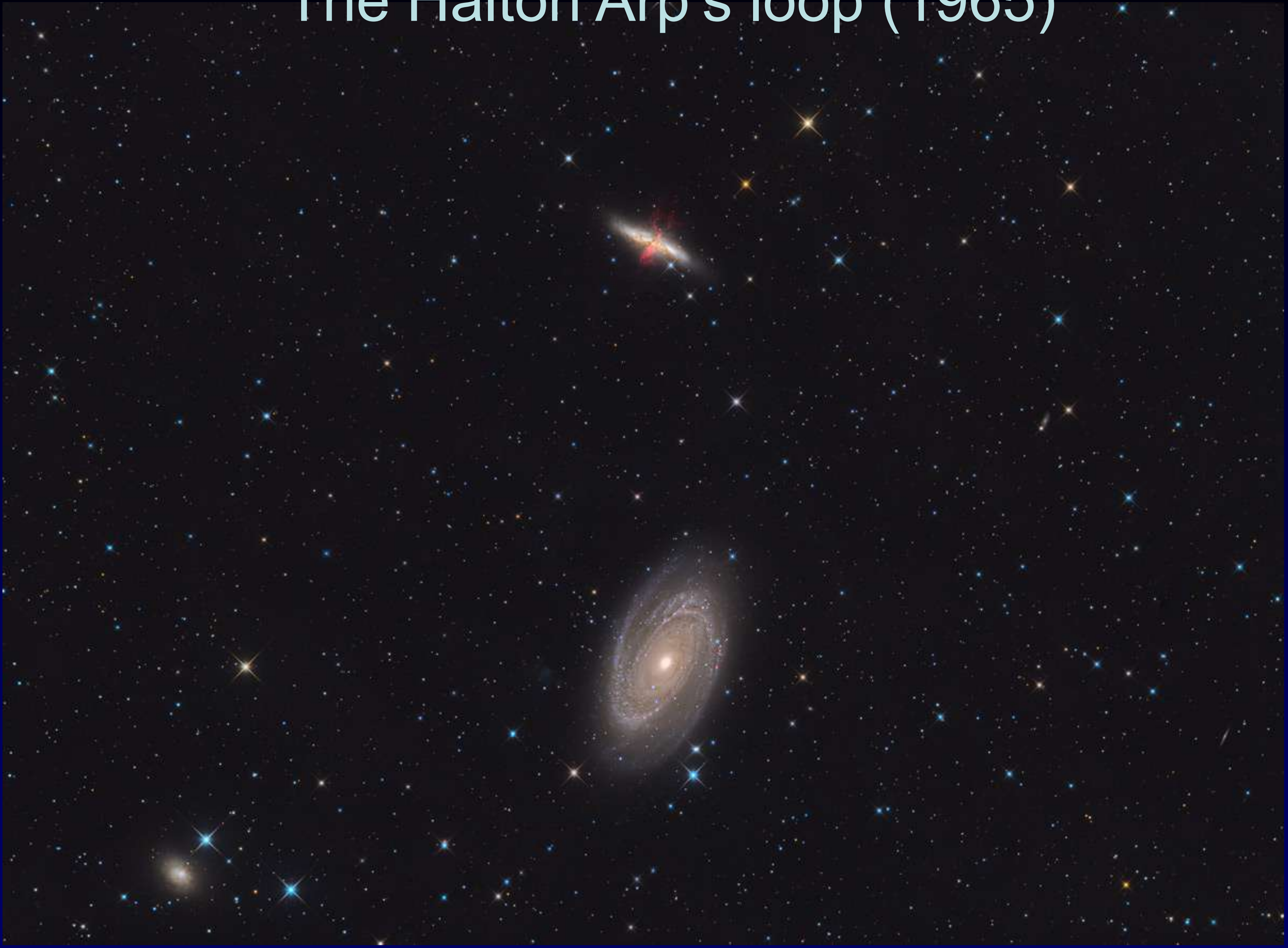
I can see you because of what you hide...

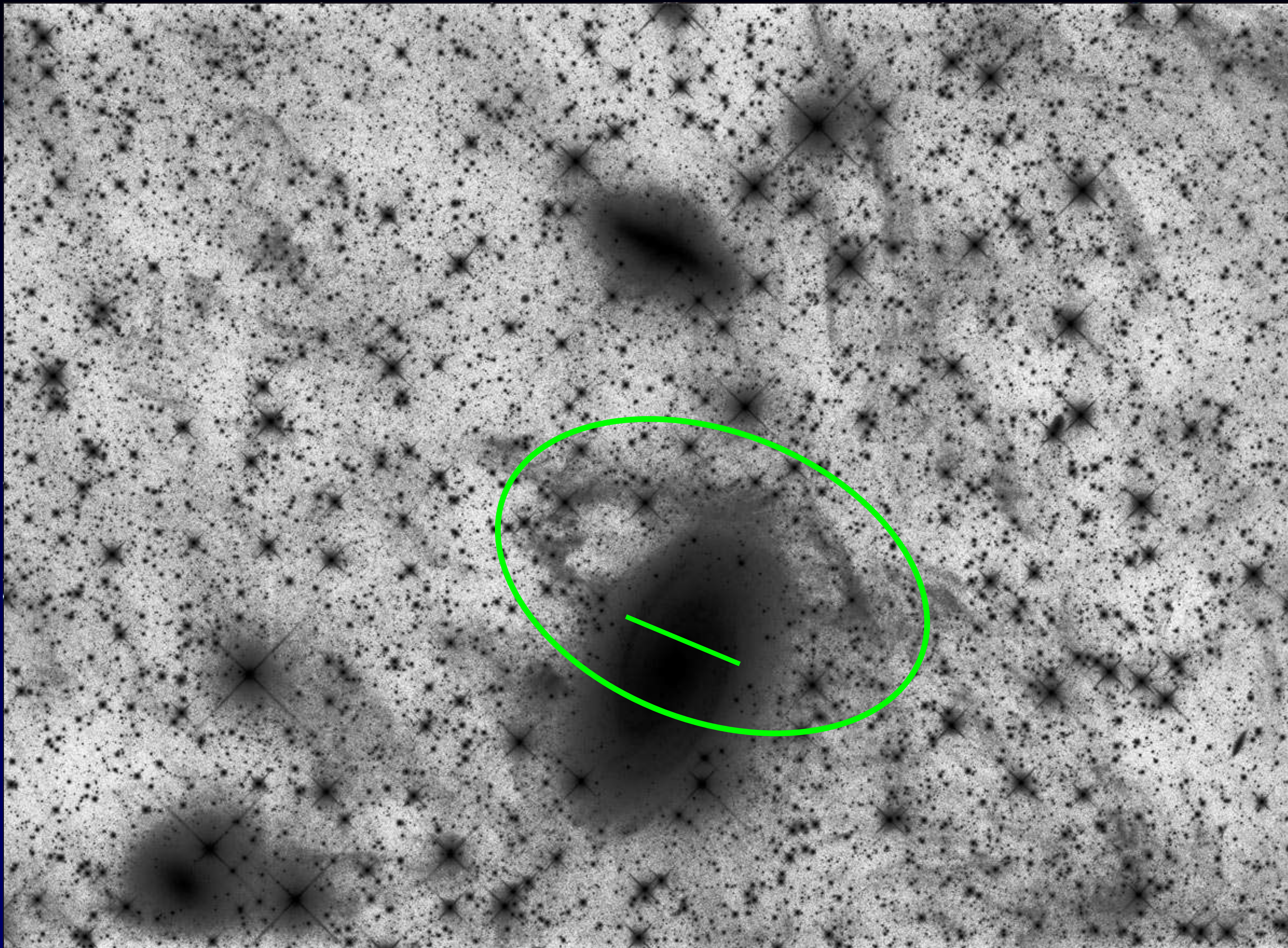
- The clouds of Barnard (1927)
- The Cepheus flare (1934)
- - The Arp’s loop (1965)


SH 140
α
η
B 152
SH 134
B 173-174
SH 135
δ
SH 138-139
ξ
B 169-171
B 160
SH 129
VDB 140
B 161
IC 1396
ε
SH 132
B 365
SH 128
B 162
B 160
IC 1378
GE

Five Barnard's clouds

The Halton Arp's loop (1965)

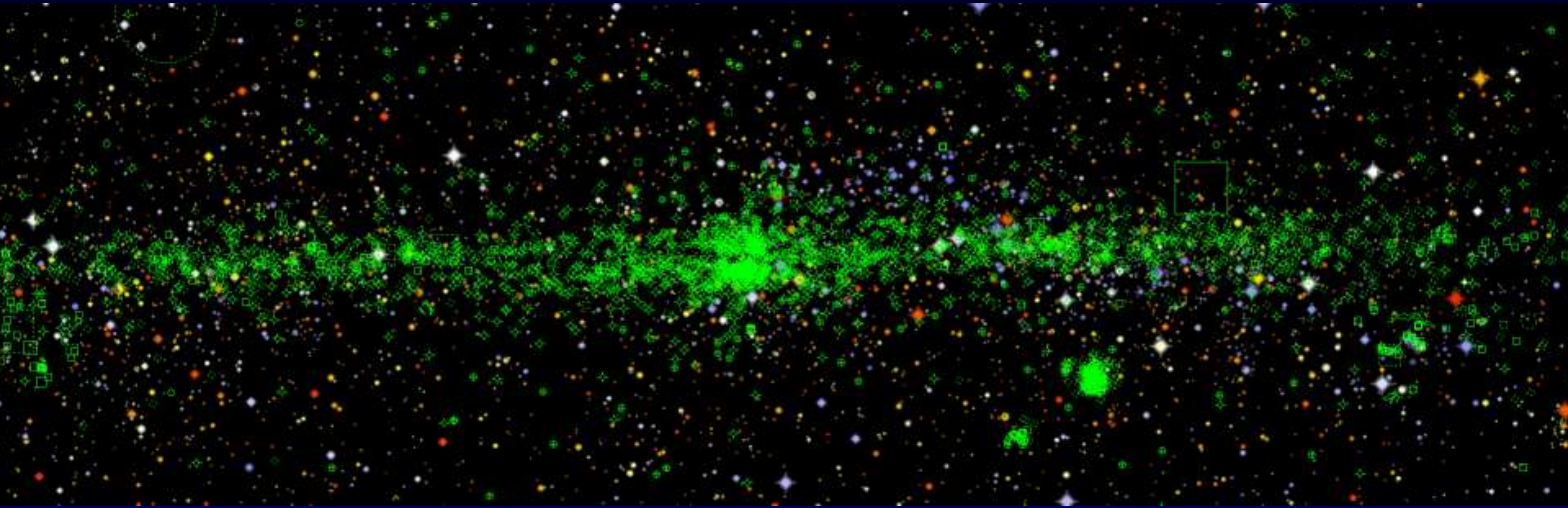


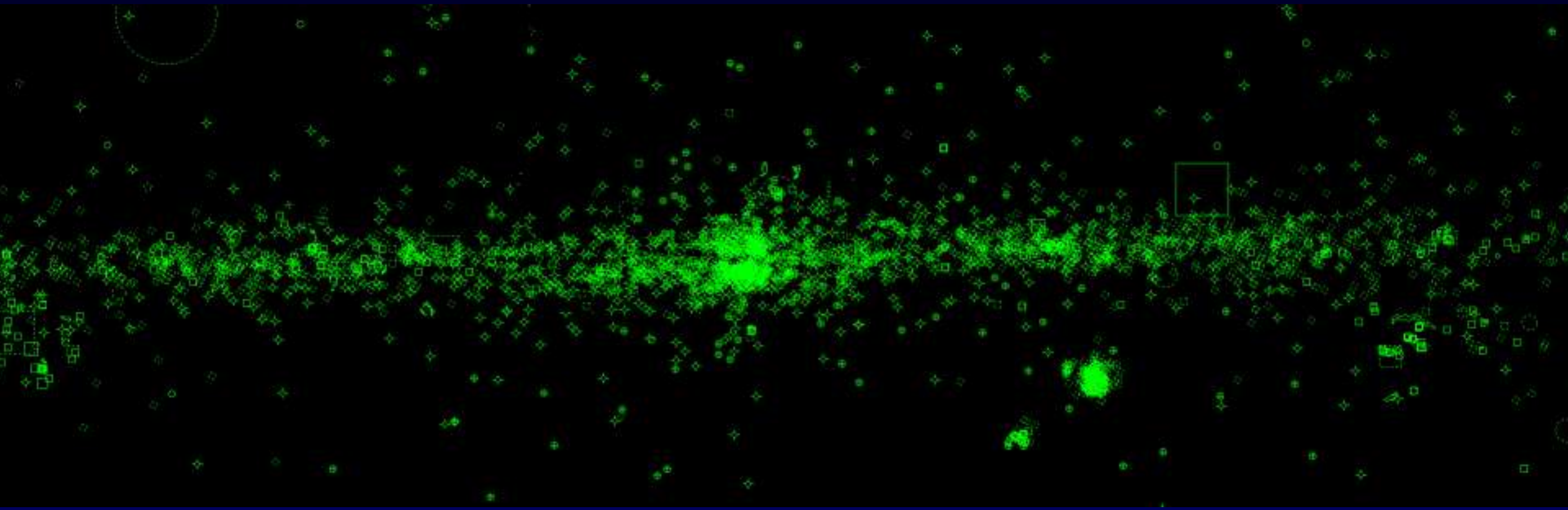


One surprising thing about the Arp’s loop:

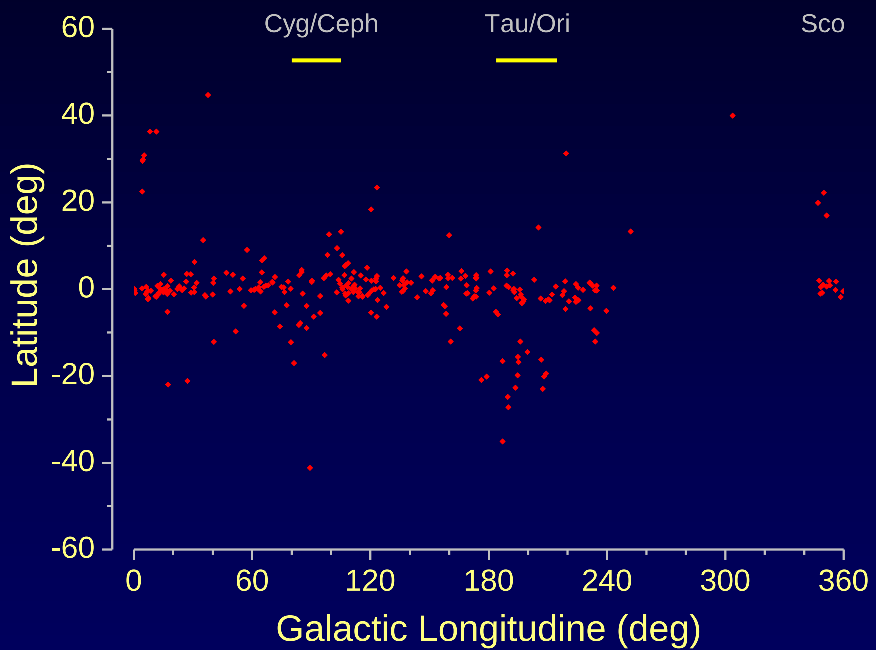
these structure are at a very high galatic latitude

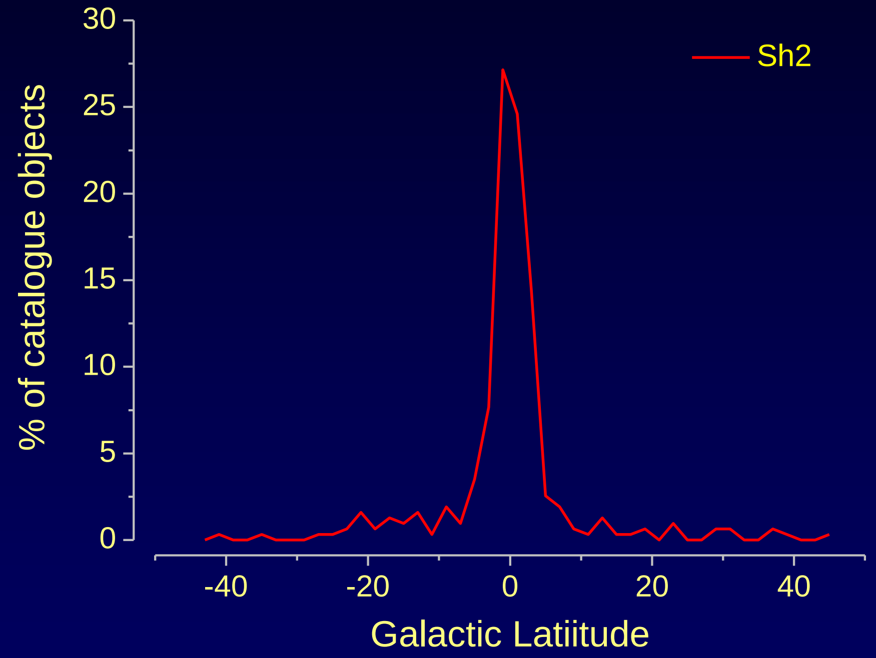
Our galaxy from far away: HII regions





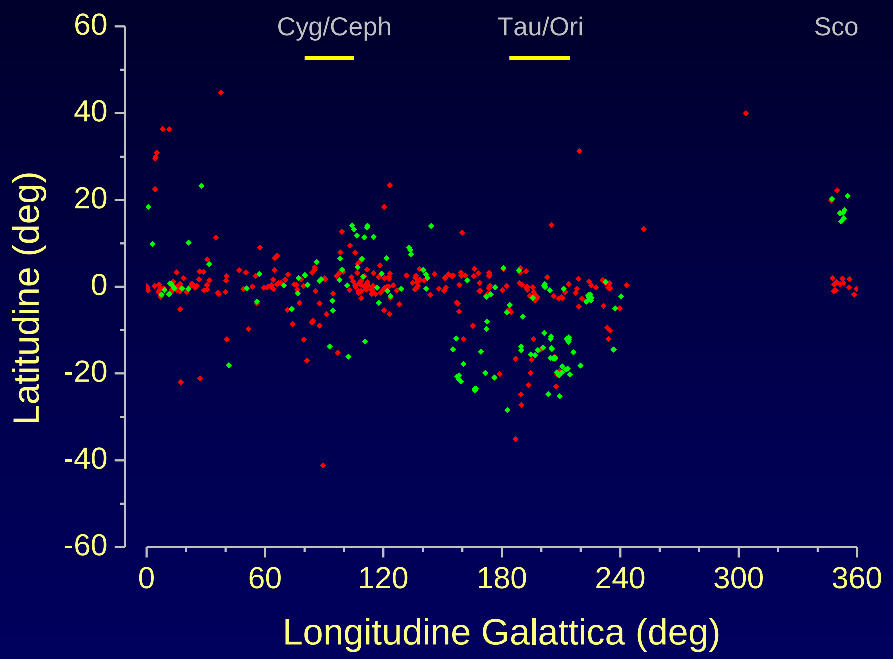
Stewart Sharpless' catalogue of HII regions (1959)

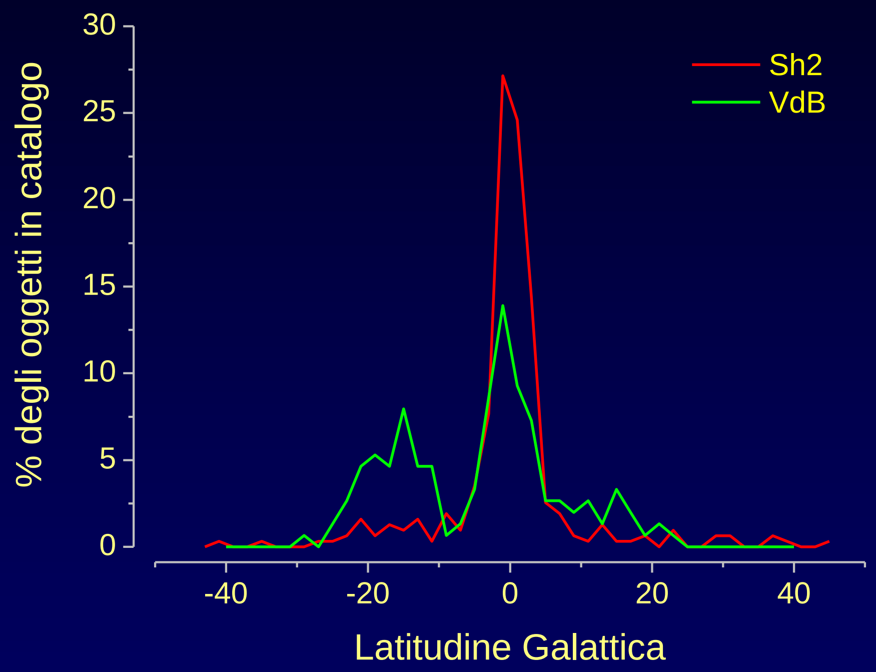


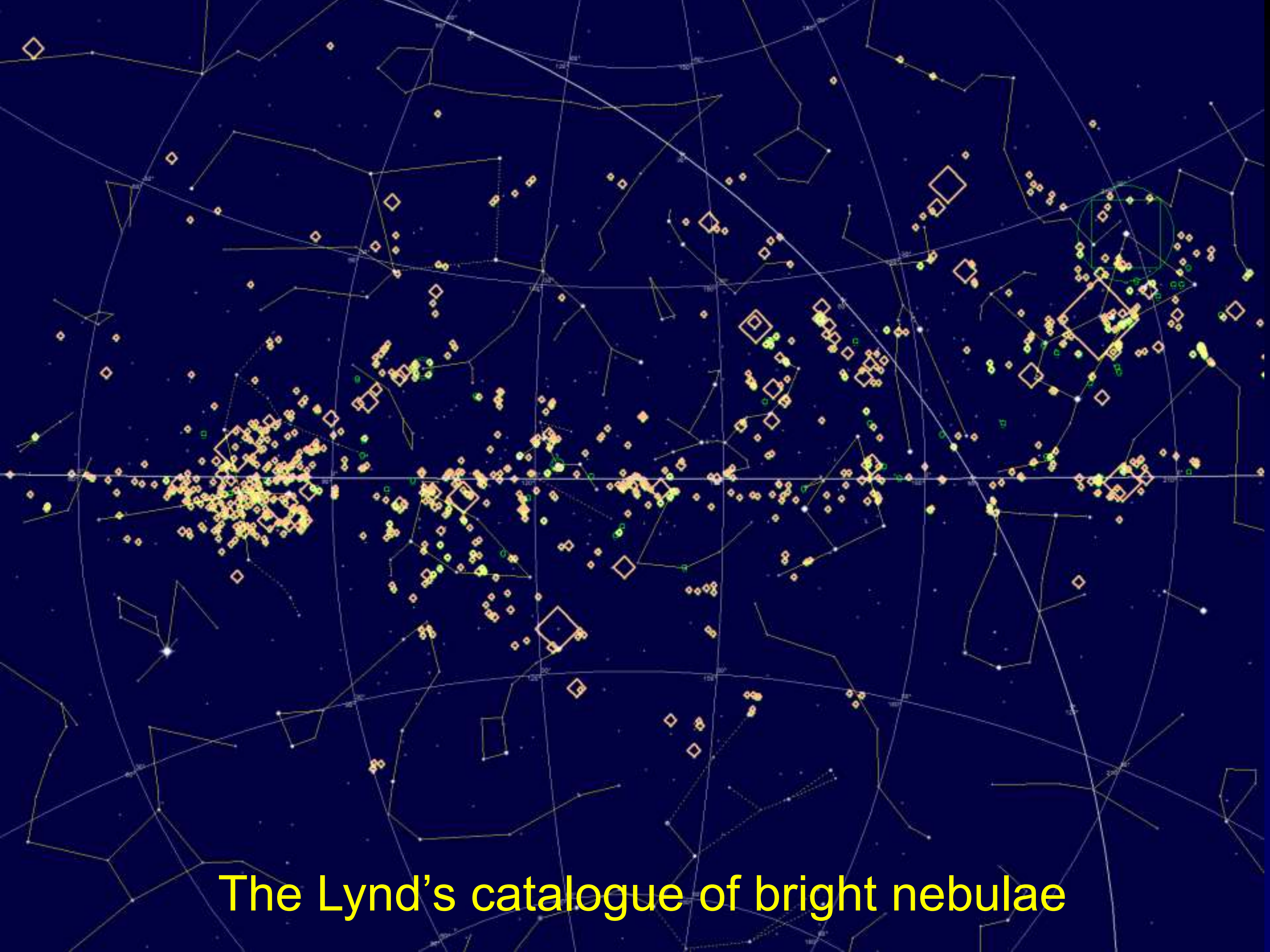


85% of HII objects from the SH2 catalogue are within 10° from the Galactic equator

Sydney vd Bergh's catalogue of reflection nebulae (1966)

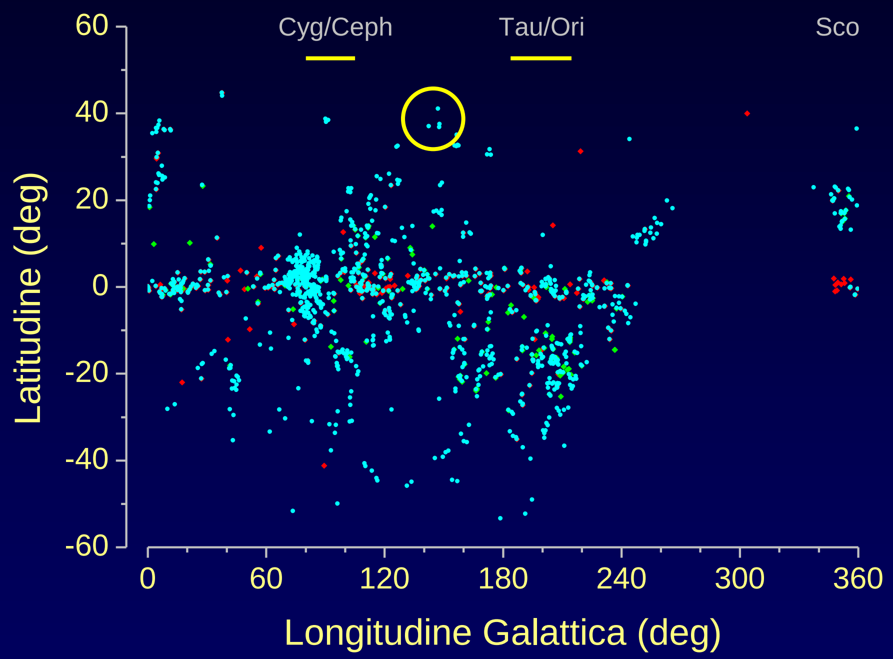


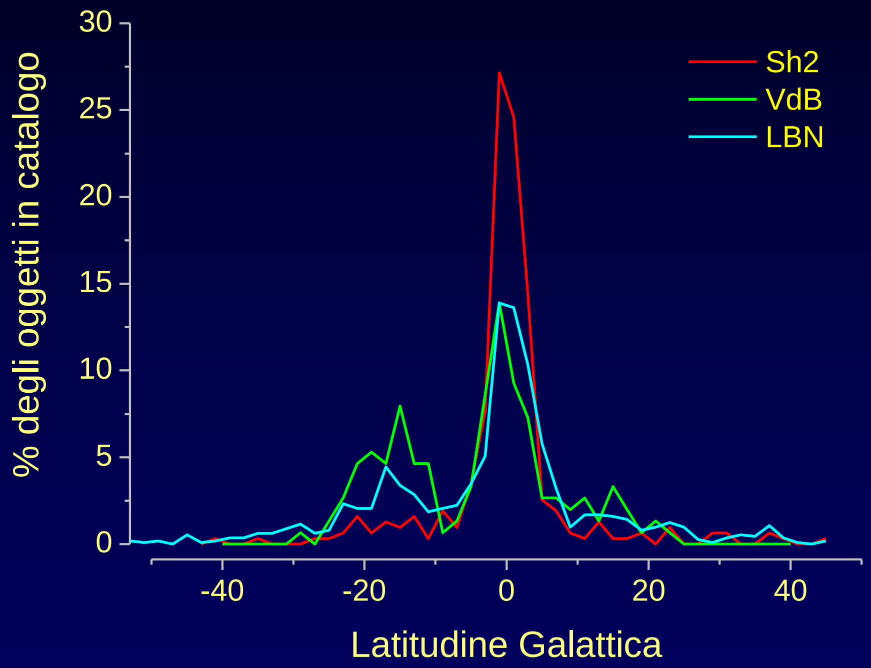




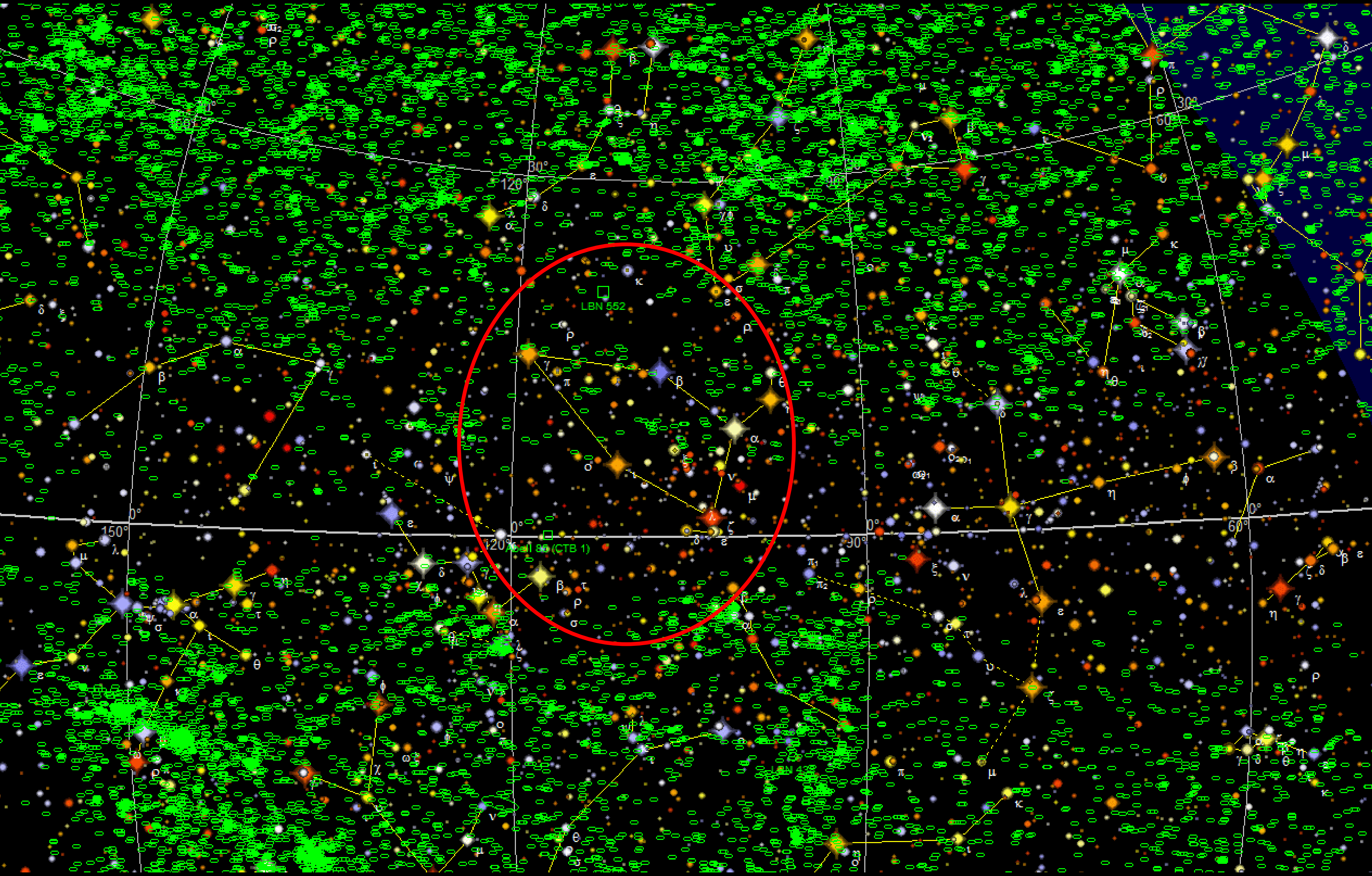
The Lynd’s catalogue of bright nebulae

Beverly Lynd’s catalogue of bright nebulae (1965)

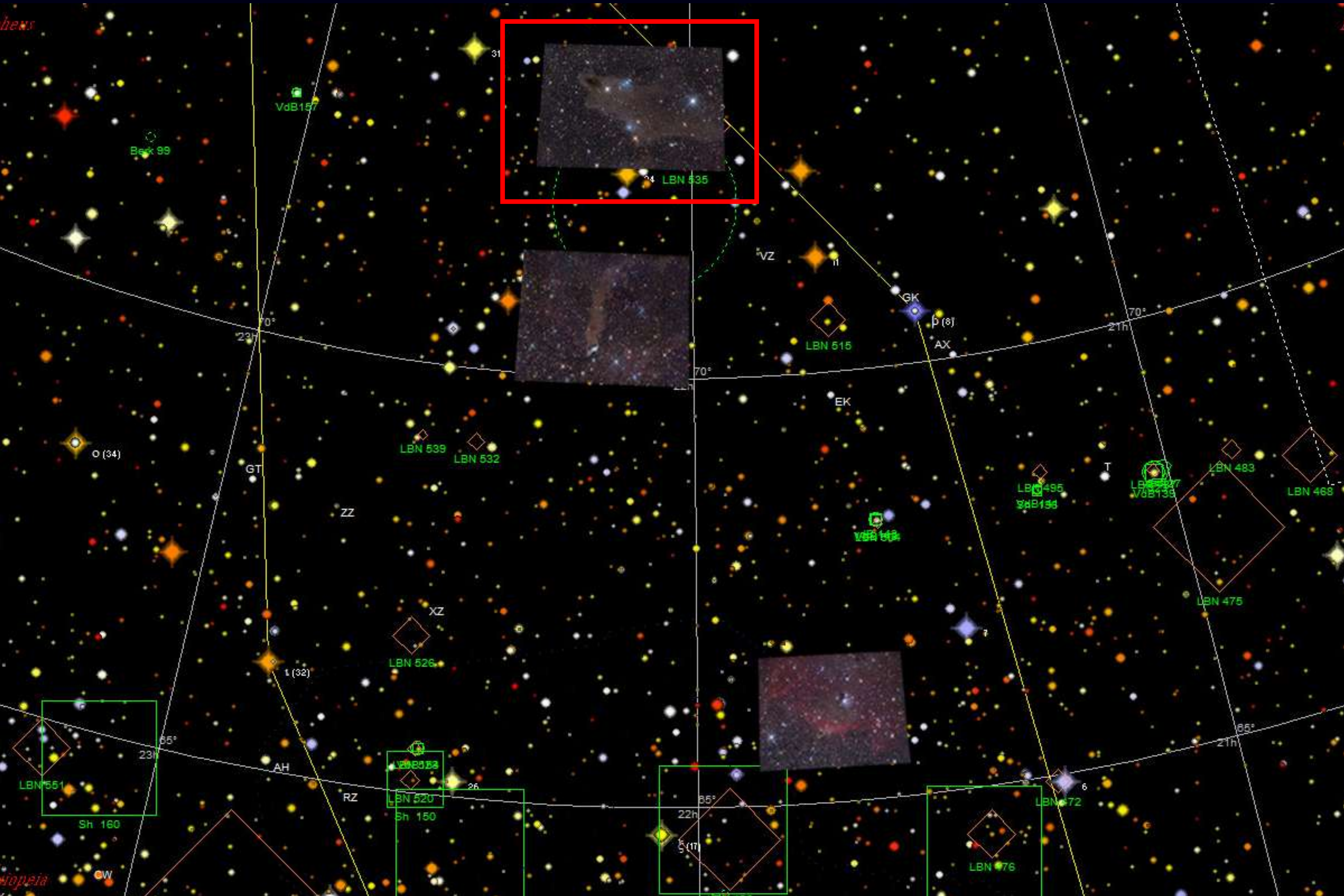




Hubble, 1934: the Cepheus flare.



VdB 149 – VdB 150 - LBN 535

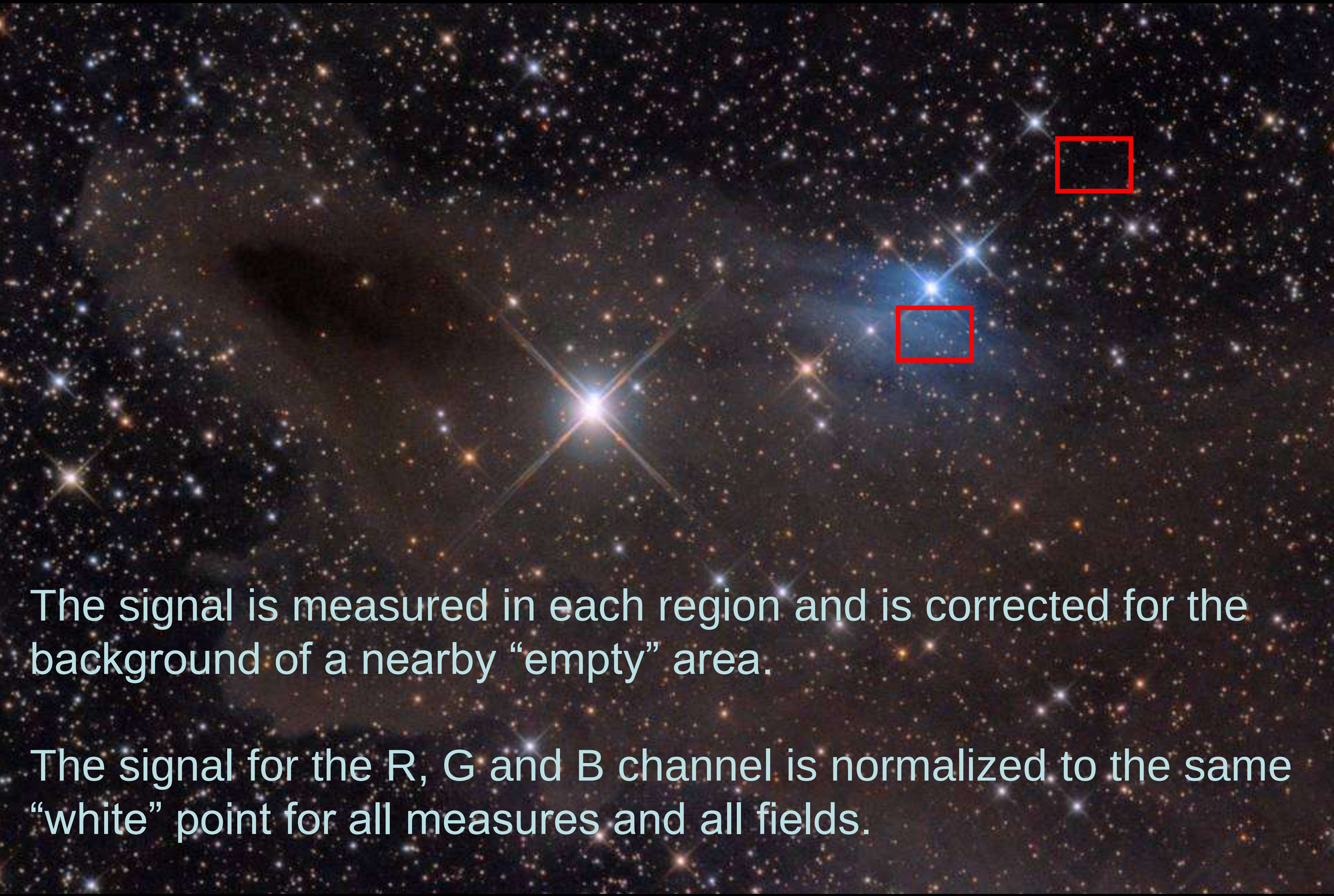


VdB 149, 150 and LBN 435

UGC 11851 Sd
m 15.3 2.6’ x 1.5’
B extinction: 1.22 m

NGC 7351 SBbc
m 10.5 4.2’ x 3.4’
B extinction: 0.24 m

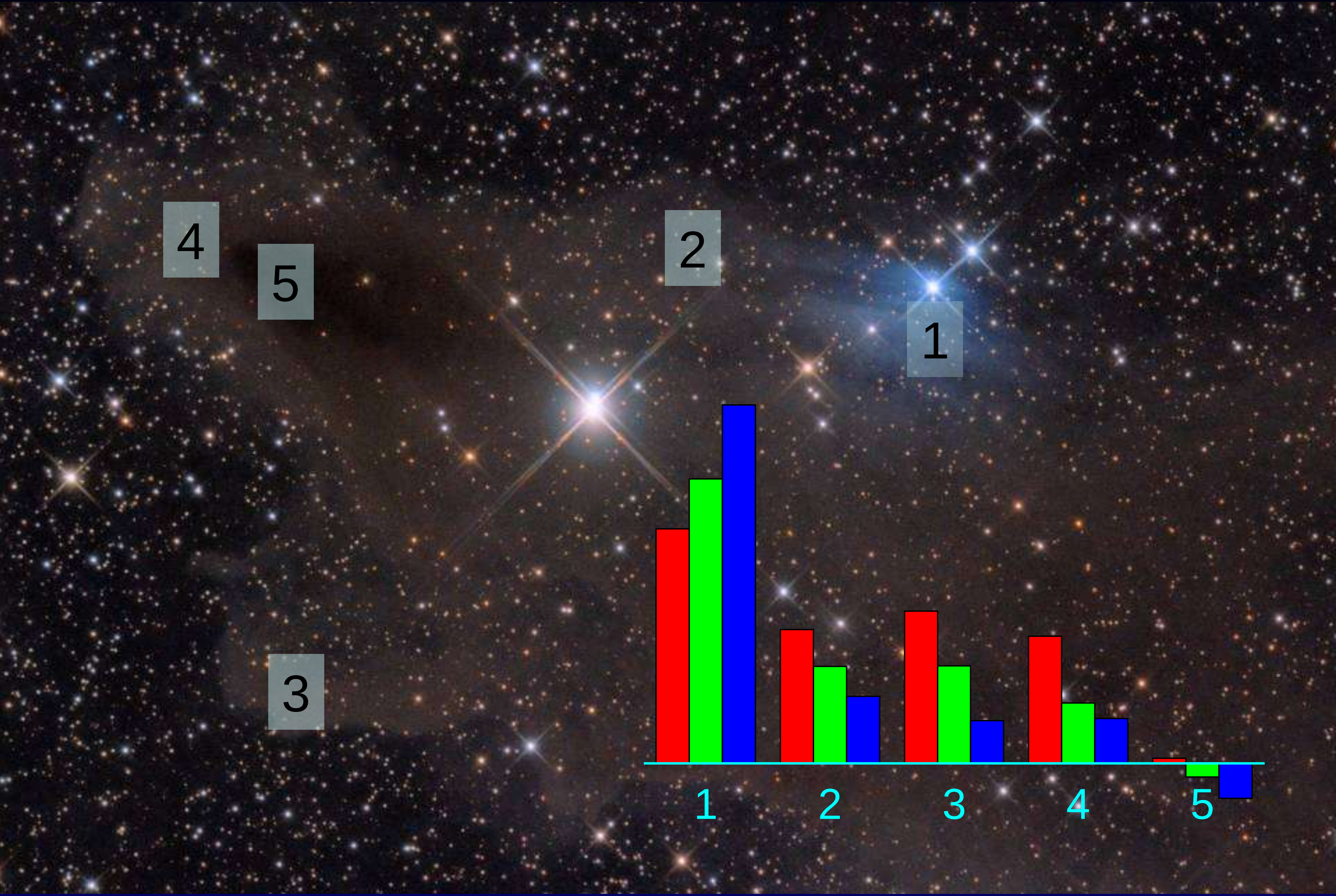
What is the color of this stuff?



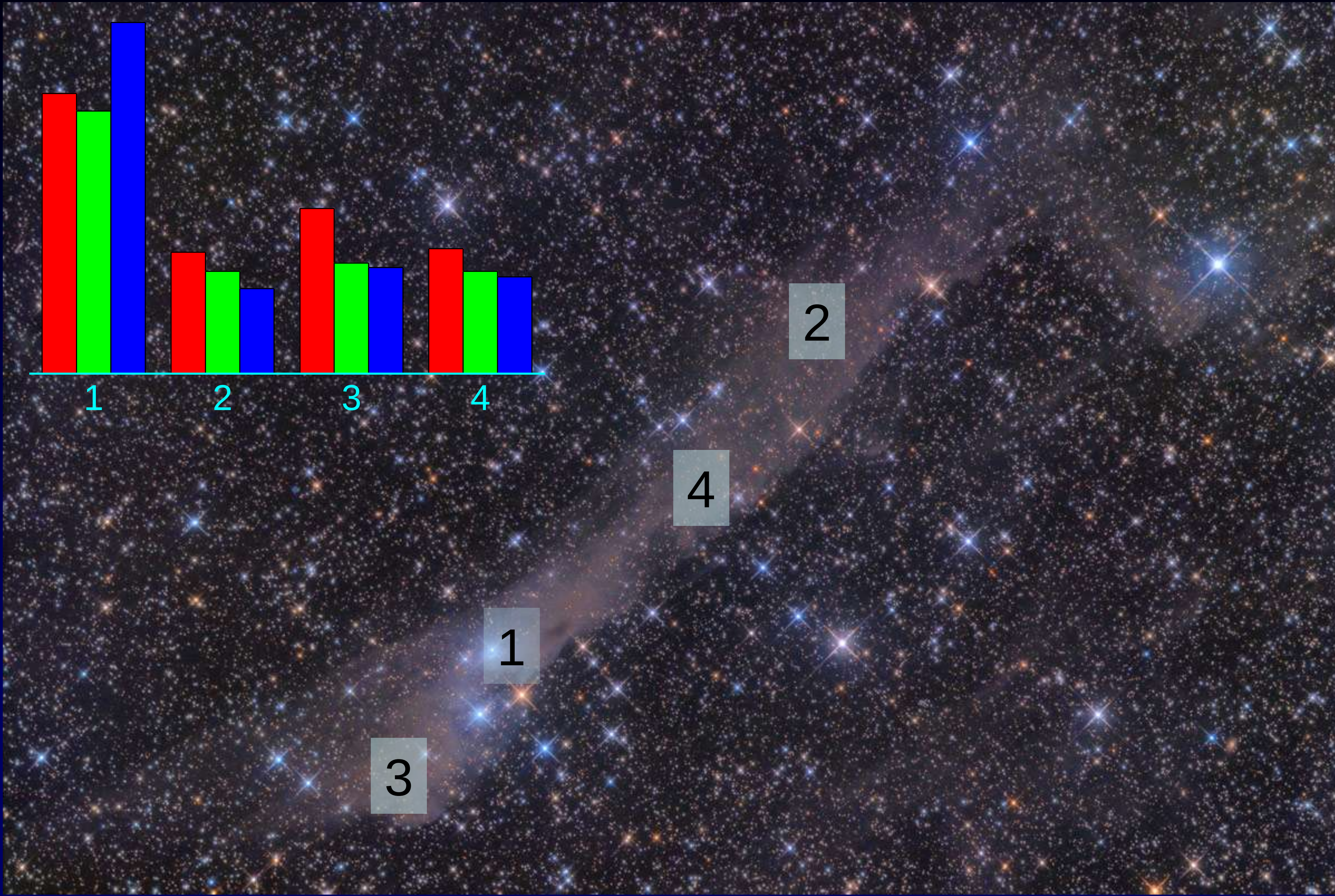
The signal is measured in each region and is corrected for the background of a nearby “empty” area.

The signal for the R, G and B channel is normalized to the same “white” point for all measures and all fields.

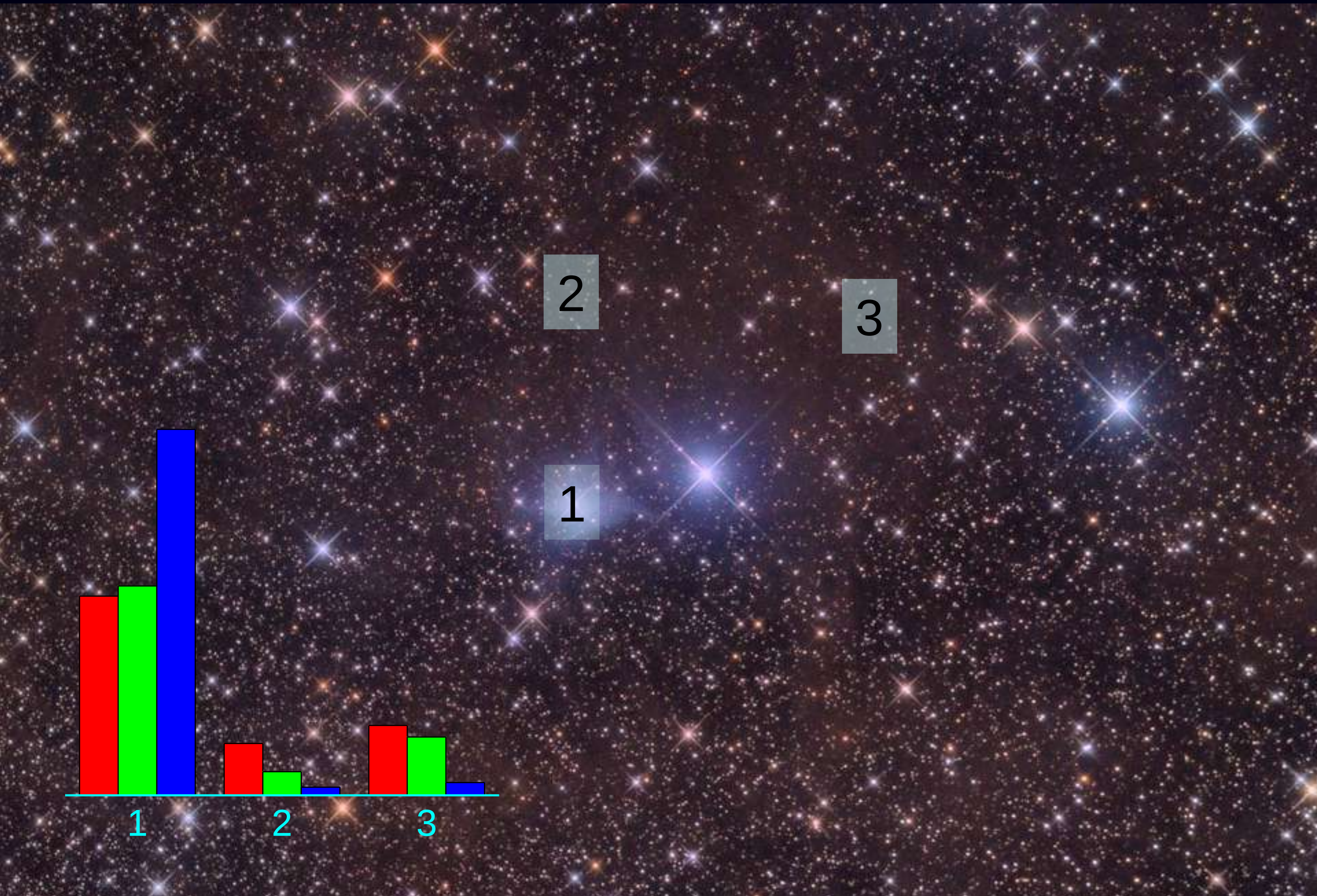
What is the color of this stuff?



VdB 158 - LBN 534 - DG 191 *Cassiopeia - Andromeda*

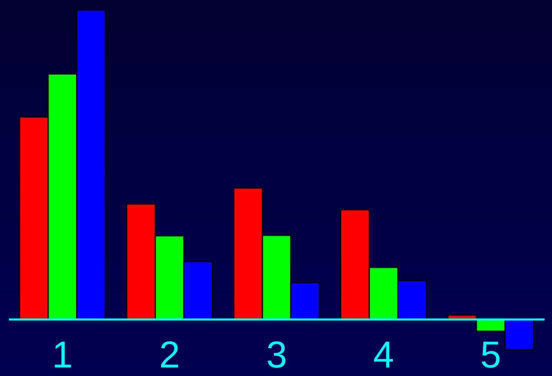


VdB 143 *Cepheus*



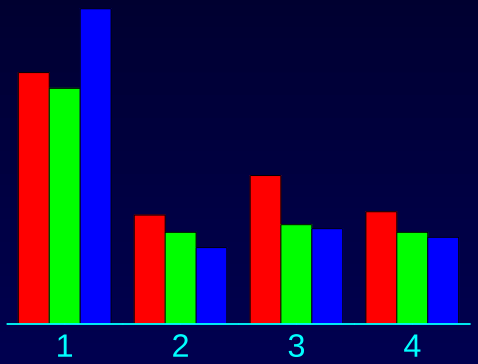
Colors vary subtly within the same nebula and in different nebulae

VdB 150



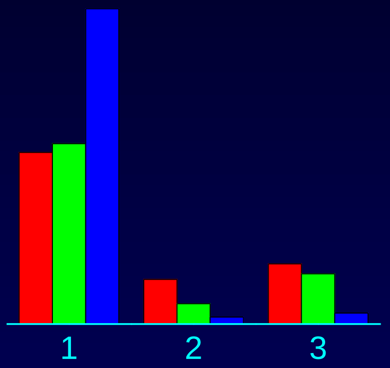
B8.4
12000°k

VdB 158



B8
12000°k

VdB 143



B3V
18.000 °k

The spectral type of the illuminating star contributes to the colors of the lanscape

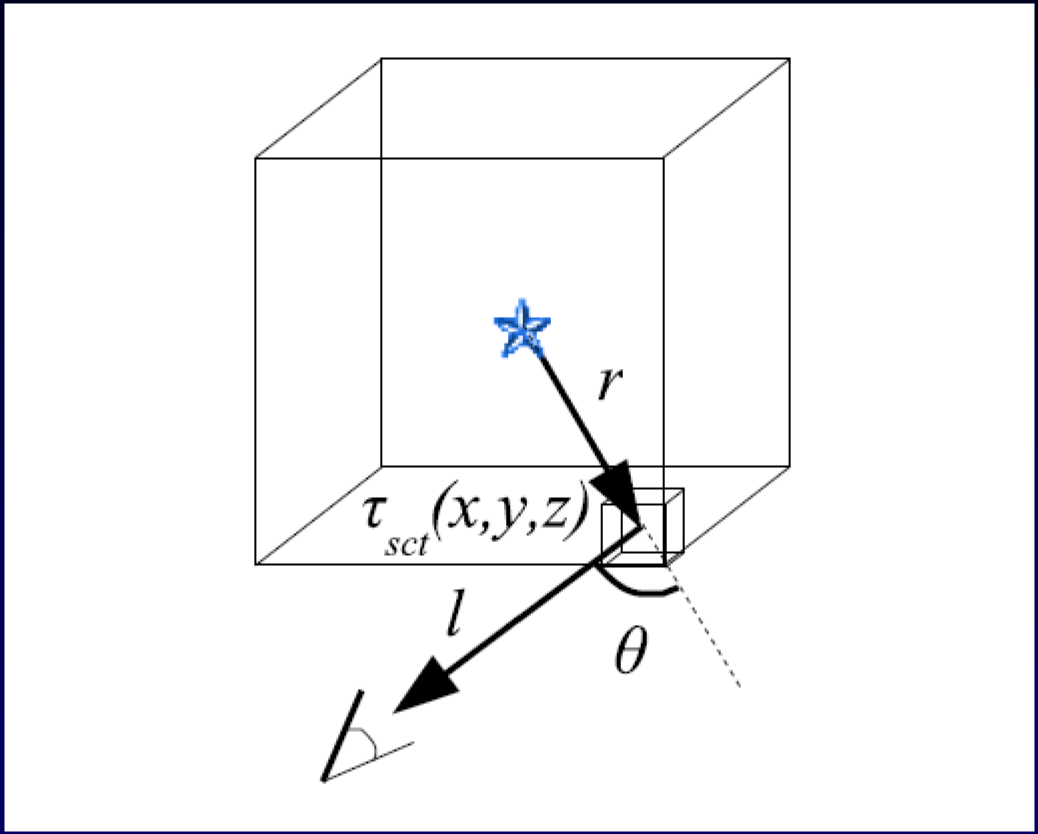
VdB 12, VdB 13, VdB 17 (NGC 1333) *Perseus*

VdB 102, VdB 101 *Scorpio*

Physical mechanisms ruling the emission of light from gas and dust

- Emission due to ionization and following recombination
- Emission because of scattering and reflection
- Emission due to fluorescence: ERE (Extended Red Emission)
- Absorption in the UV-visible spectra and thermal re-emission in the infrared

Scattering:
an indirect path from the illuminating star to the observer



Scattering and reflection nebulae

In a reflection nebula light is reflected and absorbed by dust grain. There is no direct light emission, with the only exception of fluorescence.

The color of the scattered light depends strongly on two factors:

1) color of the light source

2) dimension and composition of the grains interacting with light.

Scattering depends on the size of the diffusing particles: dependecy of σ_{sct} da λ

1) Particles are shorter that the wavelength (d<<200 nm)

Rayleigh Scattering:

$$I(\lambda) \propto 1/\lambda^4$$

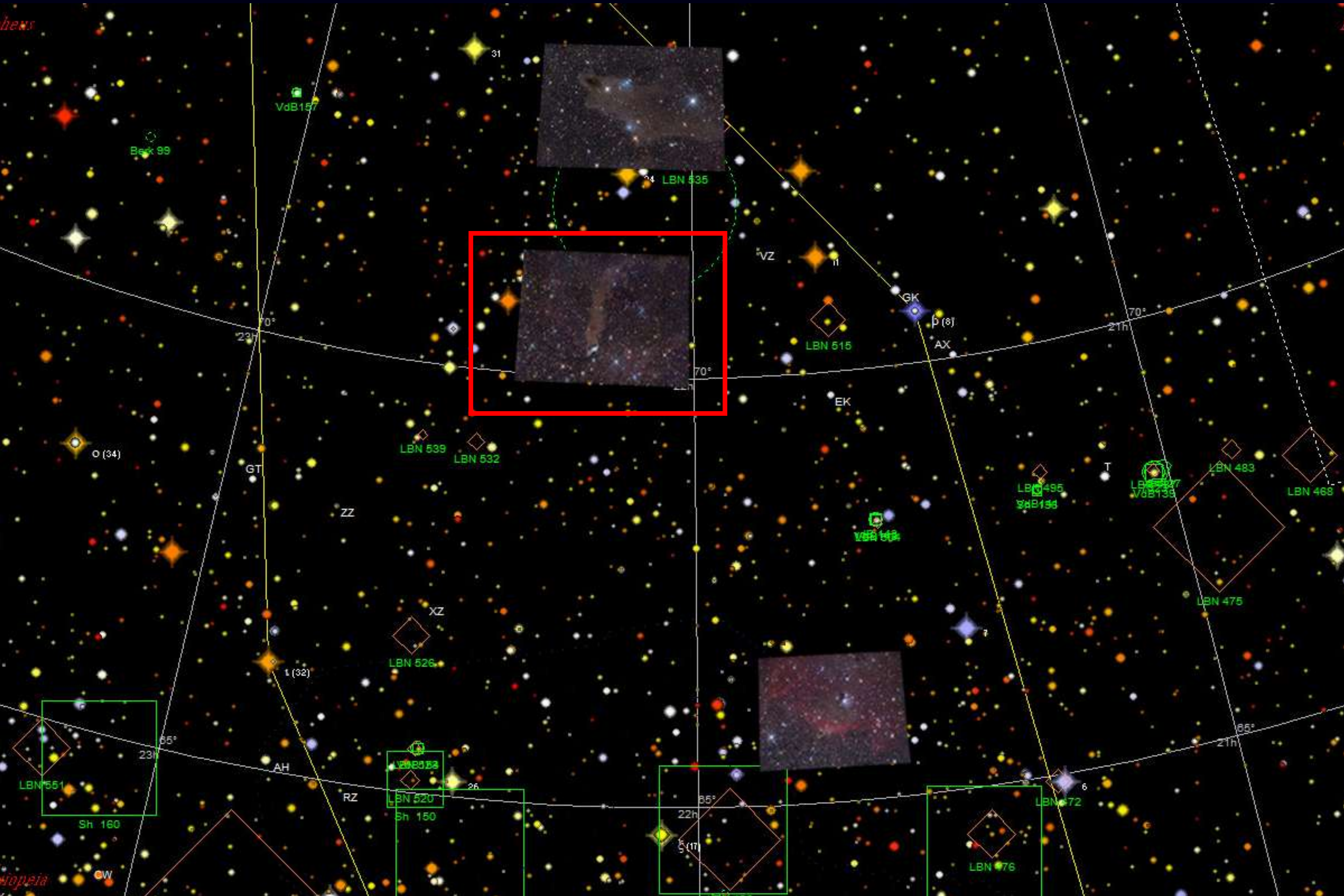
2) Particles are comparable to the light wavelength (200 nm < d < 1000 nm)

Mie scattering:

$$I(\lambda) \propto 1/\lambda$$

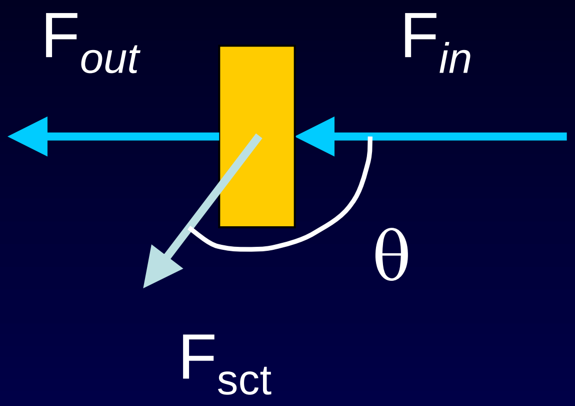
3) When particles gets larger that the wavelength I does not depend on λ

VdB 152



VdB157
Berk 99
LBN 535
VZ
GK
LBN 515
AX
EK
LBN 539
LBN 532
O (34)
GT
ZZ
LBN 495
LBN 483
LBN 468
LBN 475
XZ
LBN 526
ι (32)
LBN 551
Sh 160
AH
RZ
LBN 520
Sh 150
LBN 472
LBN 476
CW

What is left after scattering: extintion

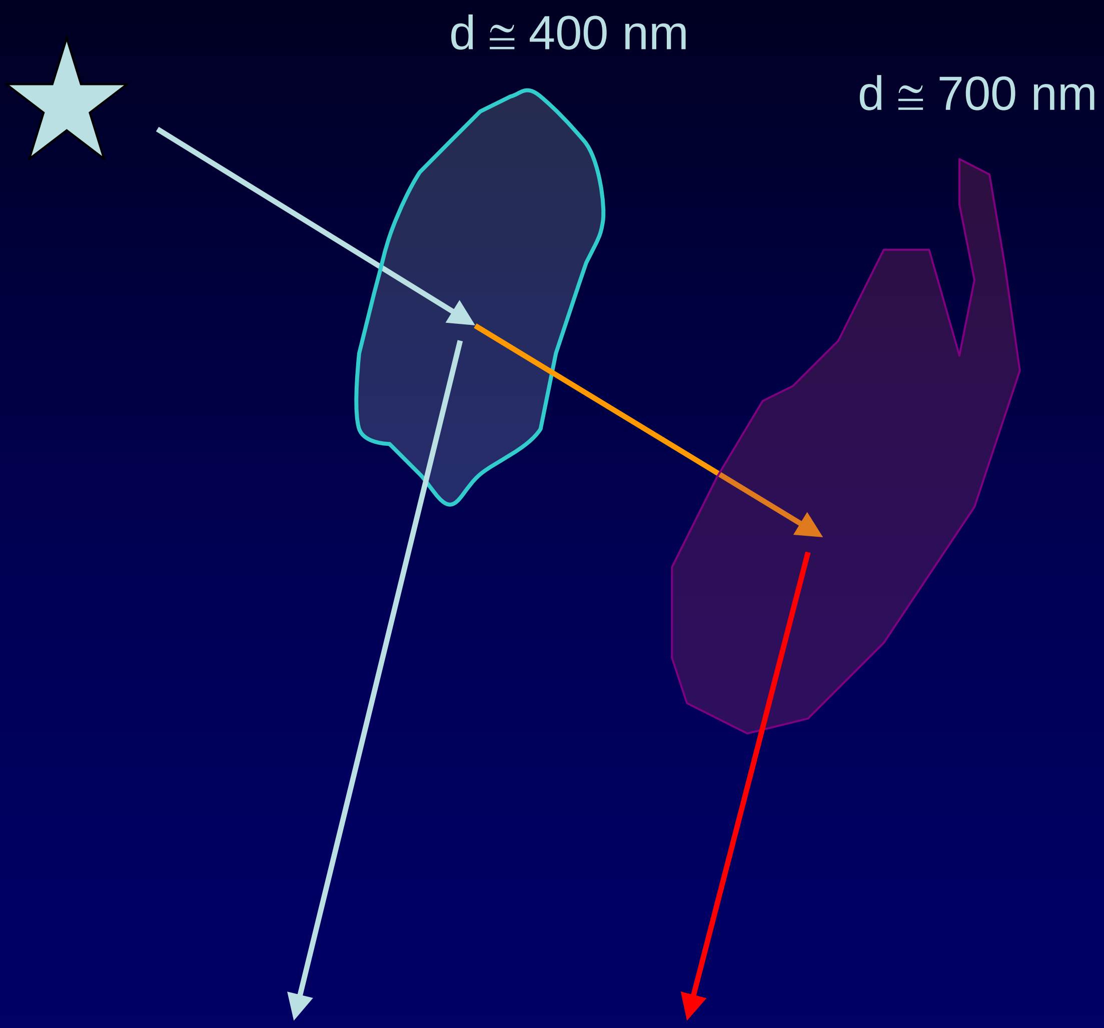


$$F_{out} = F_{in} - F_{sct} - F_{abs}$$

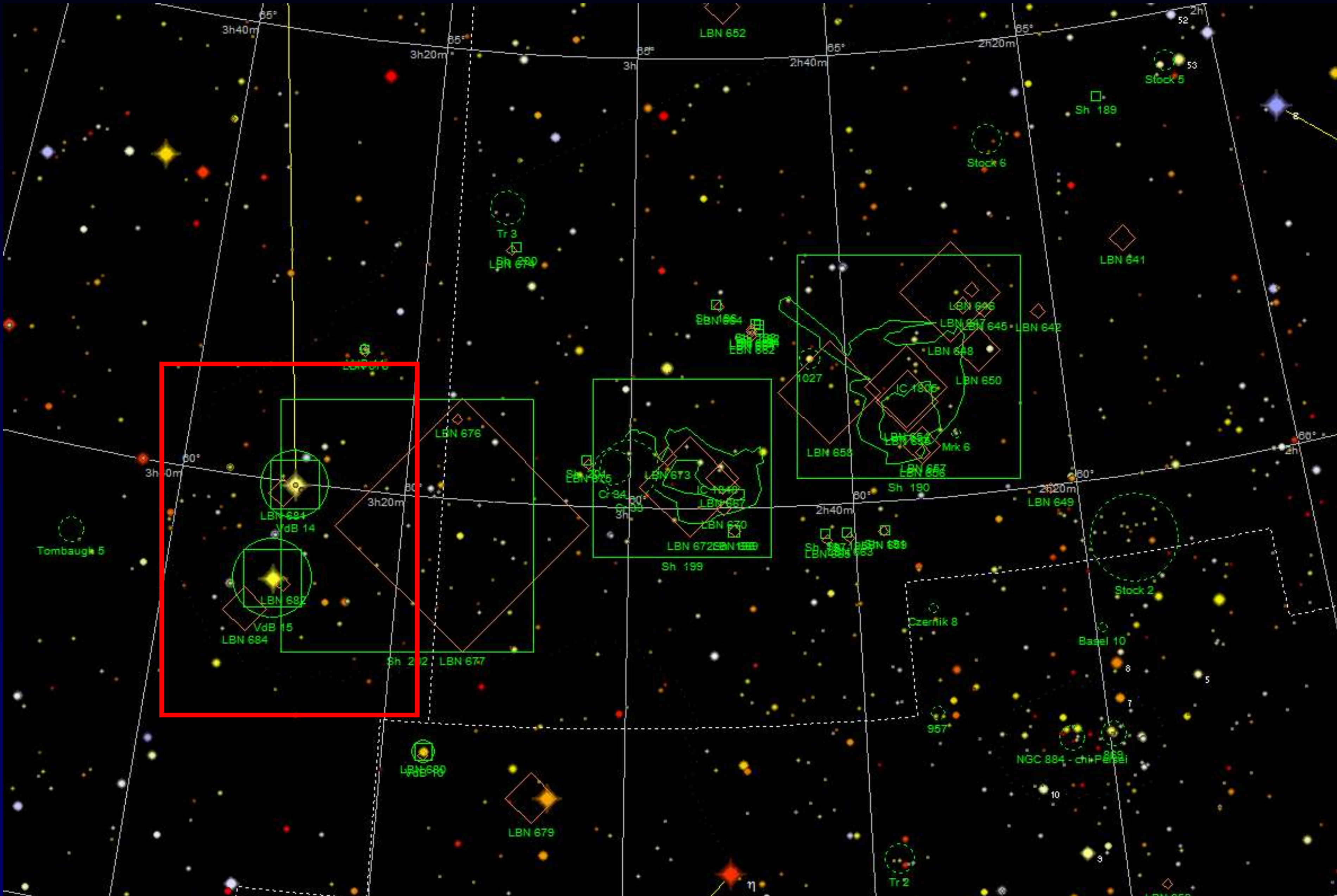
Since the fraction of light lost to scattering is larger for bluer photons, the light that crosses the absorbing layer is redder than the incident one.

Scattering is responsible for dust reddening

The color of reflection nebulae depends on the particle size, on the geometri of the dust layers and on extintion



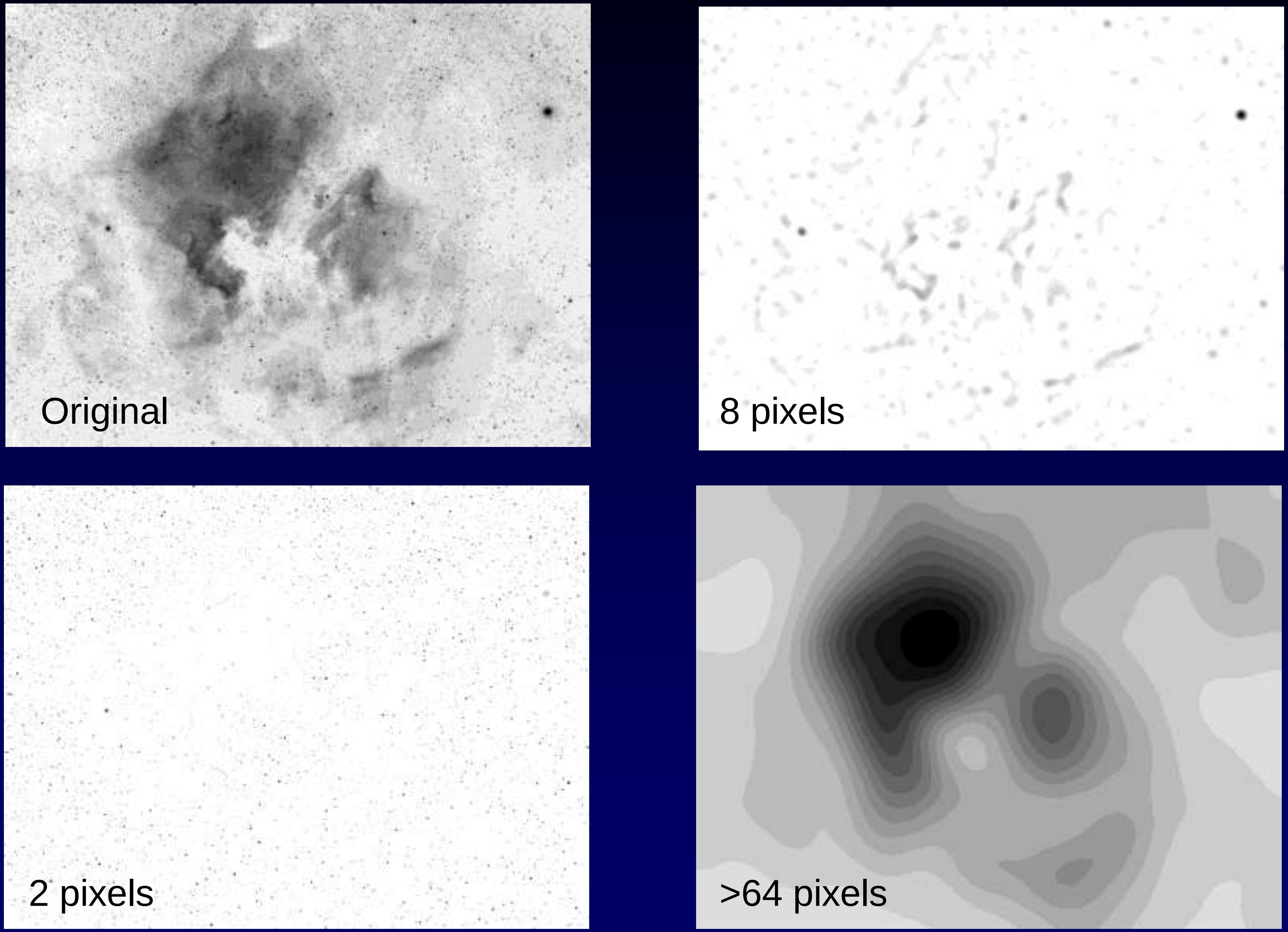
VdB15 – LBN 684 – LBN 682



VdB 15 – VdB 14 - LBN 684 – LBN 682

VdB 18, LBN 718 - 721, NGC 1342

Decomposing the image at different scales



The decomposition can be used to create luminance masks selective for the stars

Masks are build to isolate specific components of the image given its spatial characteristics.

The level regulations are then applied through the star masks that selectively address the regulation on the stars or protect them.

$$R(x,y) = M(x,y)\cdot f(O(x,y)) + (1 - M(x,y))\cdot O(x,y)$$

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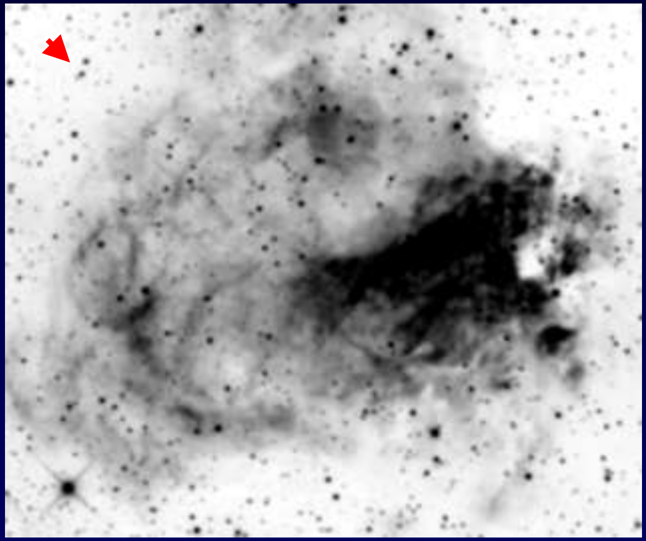
Two essential tools of the trade:

1) star mask

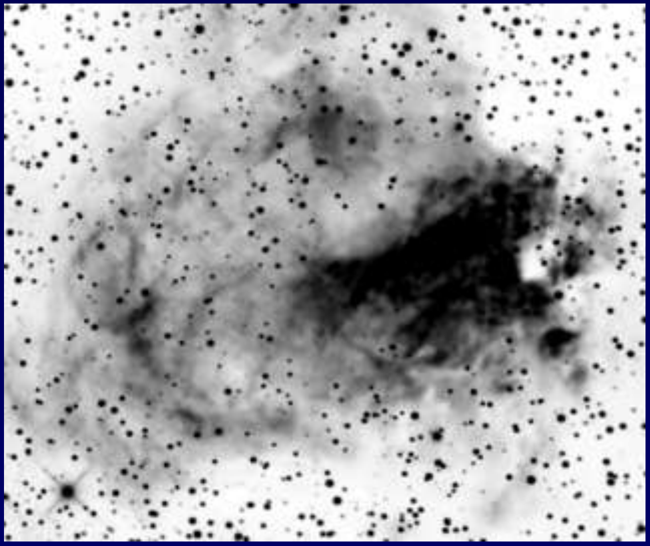
2) ibrid star-luminance mask



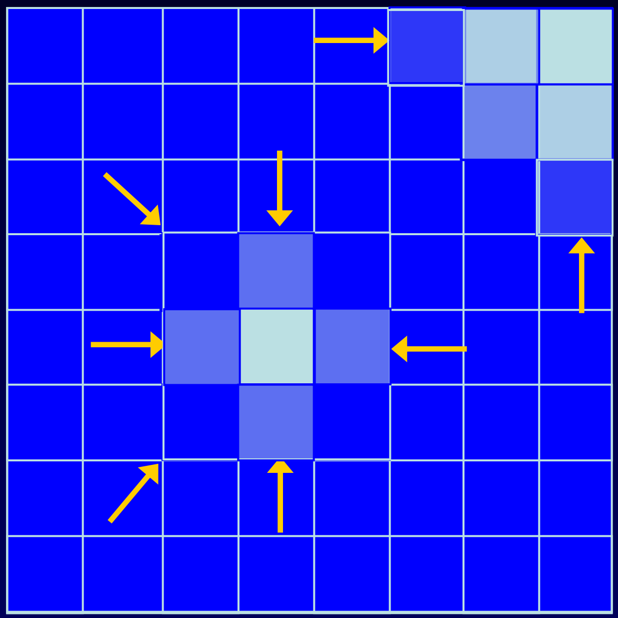
Luminance and low pass filter

WL 3-11

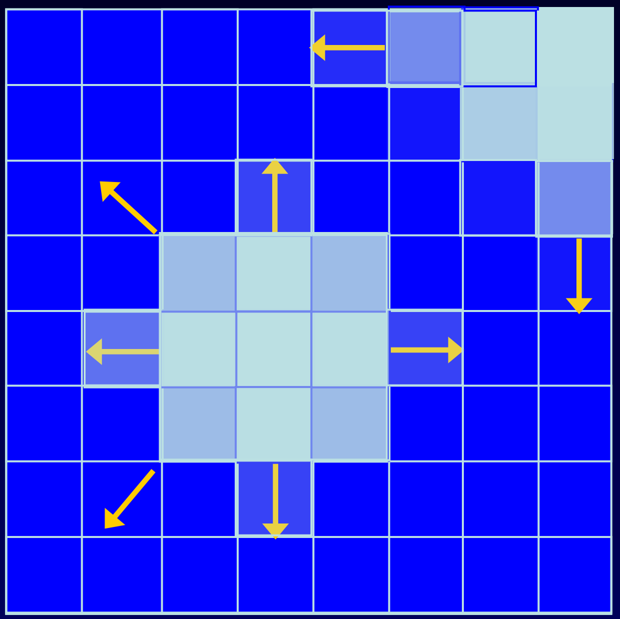
Lumi
min
WL 3-11



Morphological operators: erosion and dilation.

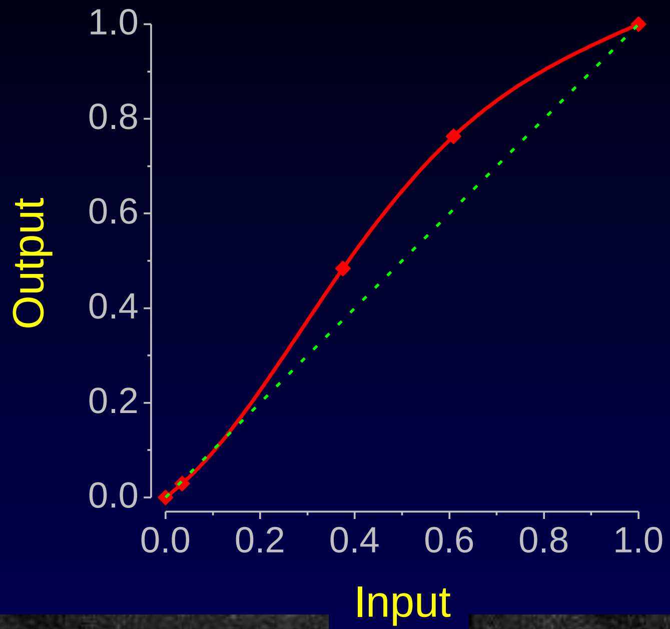


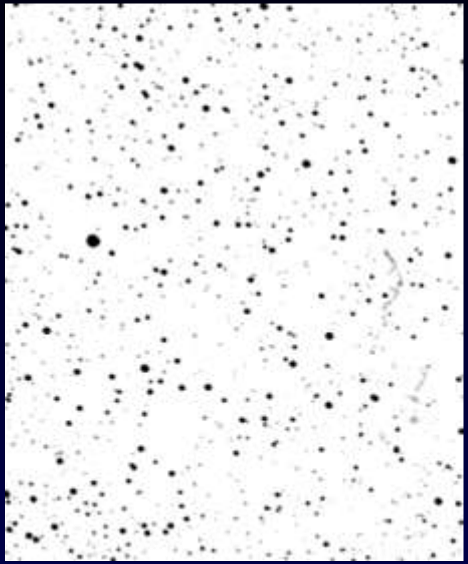
Erosion reduces the size of the feature forcing its edges to the inside



Dilation increases the size of the feature

Masking a transformation





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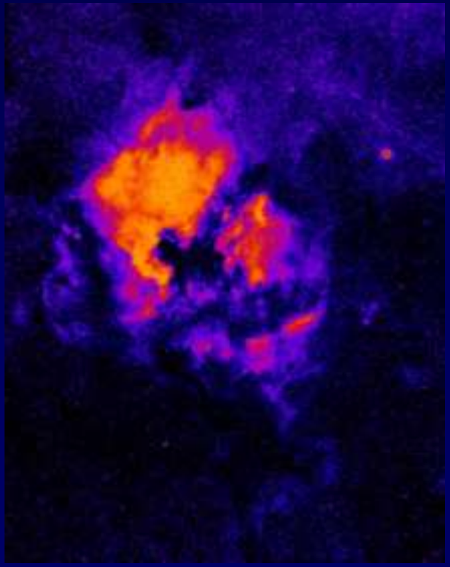


original

after the curve operator

difference

Original

midpoint increase

Star protection

Difference

Using the morphological operators to control the star field

1) Masks are obtained from the luminance layer applying a wavelet band pass filter

2) stars can be dilated to extend the range of their protection

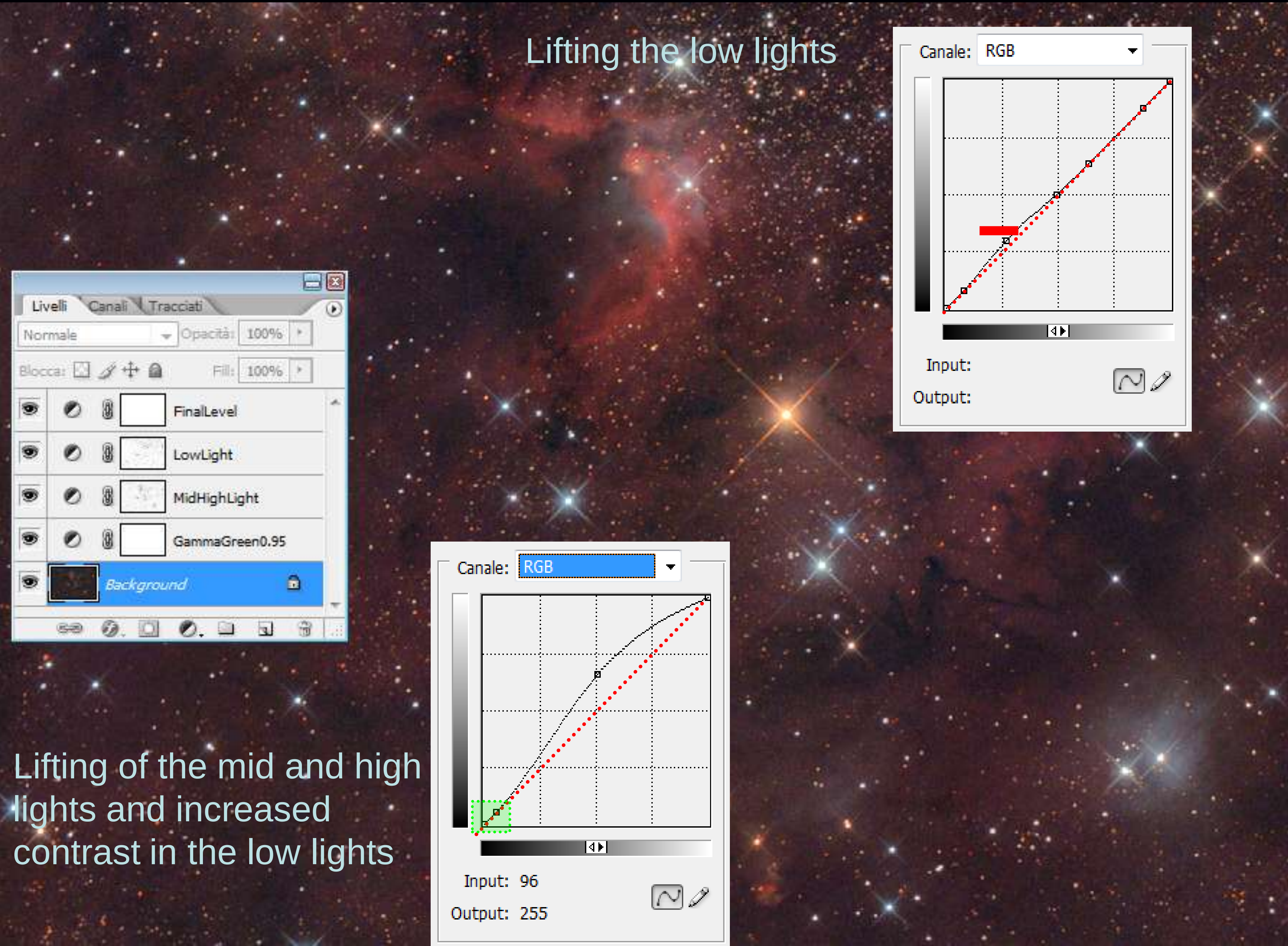
3) stars diameter and their luminance can be (to some extent only!) reduced by CAREFULLY applying the erosion operator through the star mask

Using star masks at the regulation level

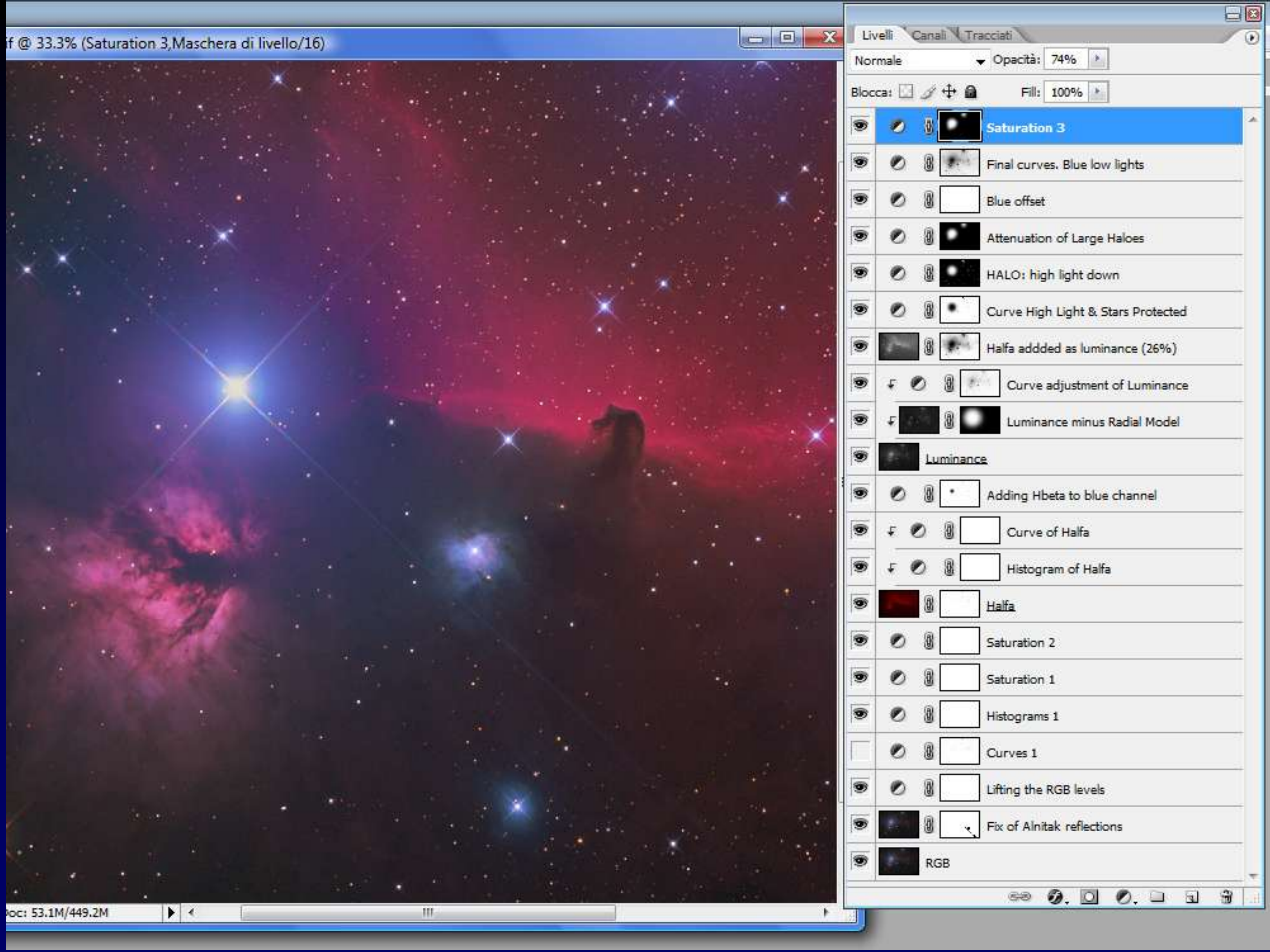
1) Star masks can be used to reduce the effects of the regulations levels to the pixels occupied by stars (black mask). Simmetrically, the regulation level can be targetted ospecifically to the stars (white masks)

2) In Photoshop this result is obtained by applying each regulation level through an appropriate mask

3) Different regulation levels can be applied to control specific aspects of the image.


Lifting the low lights
Canale: RGB
Input:
Output:
Livelli
Canali
Tracciati
Normale
Opacità: 100%
Blocca:
Fill: 100%
FinalLevel
LowLight
MidHighLight
GammaGreen0.95
Background
Canale: RGB
Input: 96
Output: 255
Lifting of the mid and high lights and increased contrast in the low lights

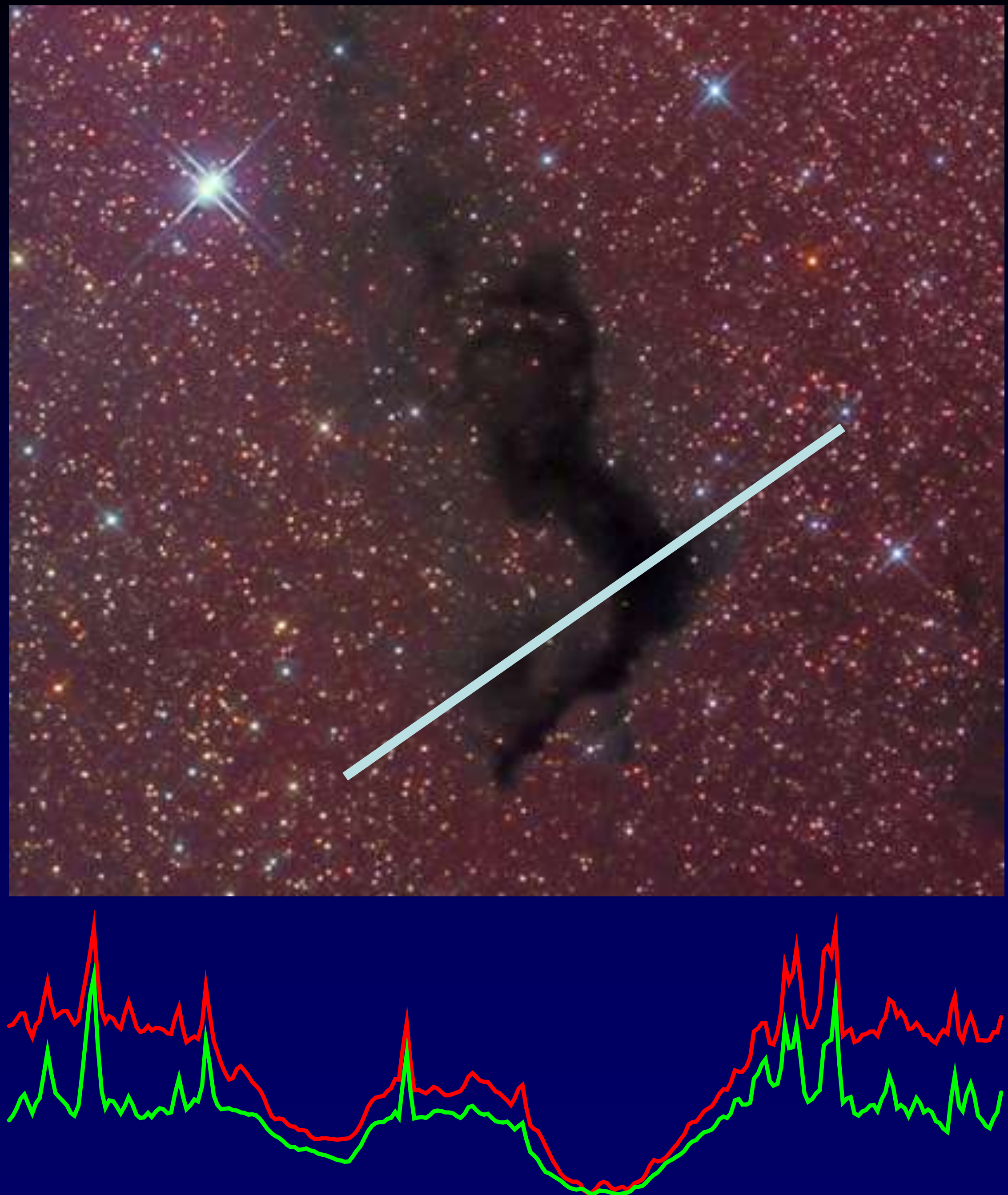
Extreme stars require extreme measures



f @ 33.3% (Saturation 3,Maschera di livello/16)
Livelli
Canali
Tracciati
Normale
Opacità: 74%
Blocca:
Fill: 100%
Saturation 3
Final curves. Blue low lights
Blue offset
Attenuation of Large Haloes
HALO: high light down
Curve High Light & Stars Protected
Halfa addded as luminance (26%)
Curve adjustment of Luminance
Luminance minus Radial Model
Luminance
Adding Hbeta to blue channel
Curve of Halfa
Histogram of Halfa
Halfa
Saturation 2
Saturation 1
Histograms 1
Curves 1
Lifting the RGB levels
Fix of Alnitak reflections
RGB
oc: 53.1M/449.2M

More opportunities: blending with Hα

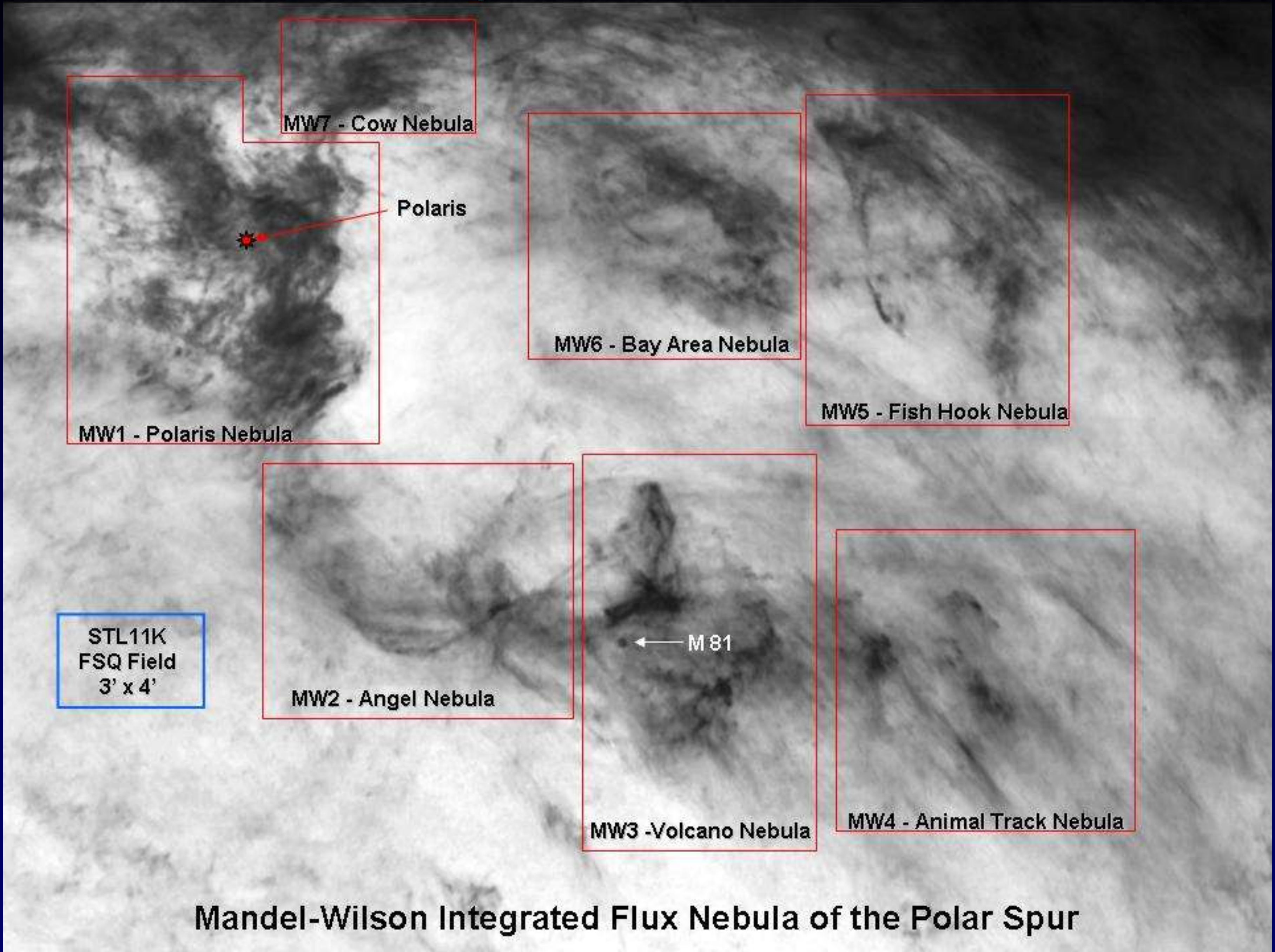
More opportunities: blending with Hα



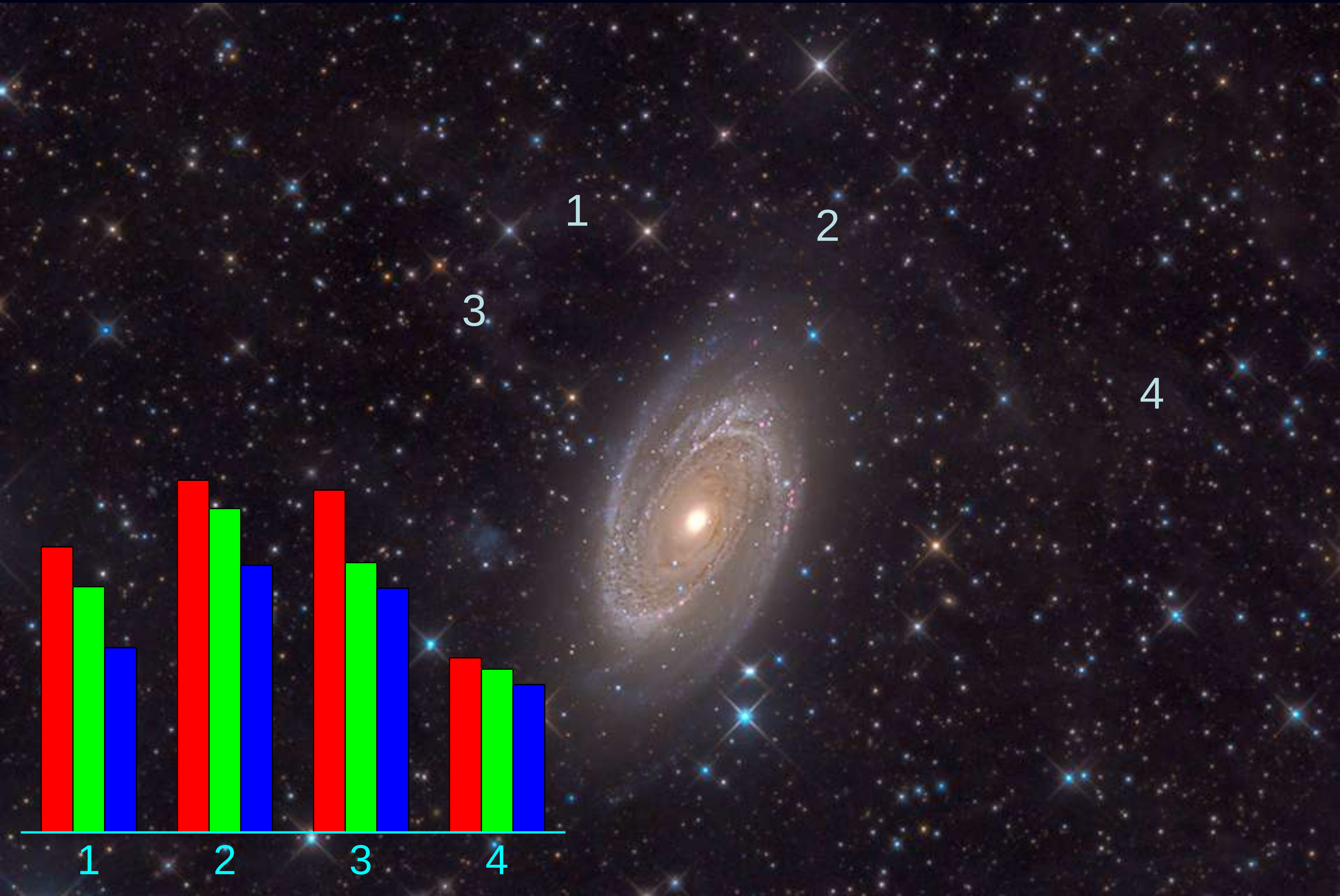
More tricks with color in the sky

Heading north: the integrated flux nebulae

High latitude nebulae



The color of the IF nebula?



The dark side of flats

- Imaging of faint extended objects with wide field instruments and large sensors requires:
- 1) very, very very properly executed flat fields
- 2) the field must be as free as possible from illumination artifacts

Proper flat fielding

1) perfect matching of the imaging train between the imaging run and the flat field run

2) correct subtraction of the flat fields dark/bias

3) flats exposed within the linear range of the sensor

4) the flat field source must be lambertian and uniform

5) flats must not add discernible noise to the images

5) Flats must not add discernible noise to the images

Computing the noise present in a flat field

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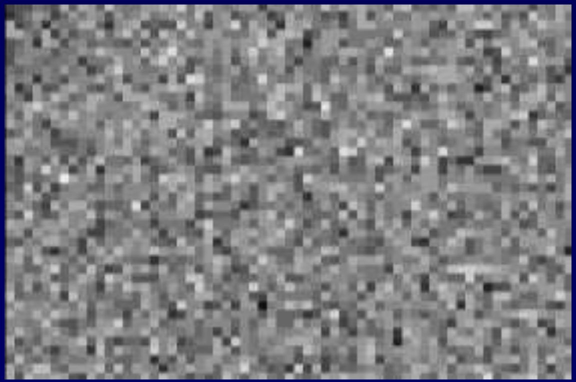

SD of single flat

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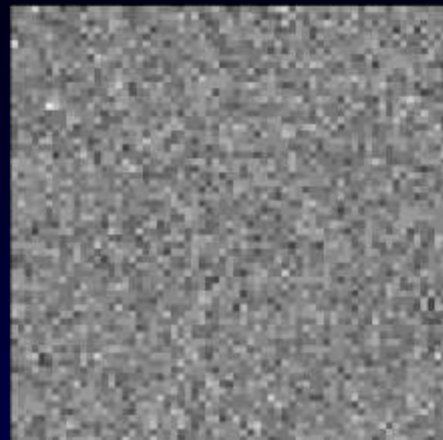
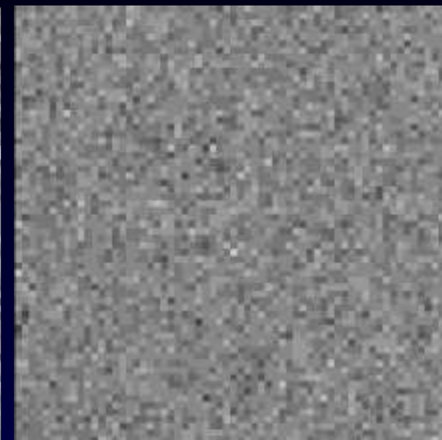
SD/sqrt(2)

Beating the noise of the Flat Field

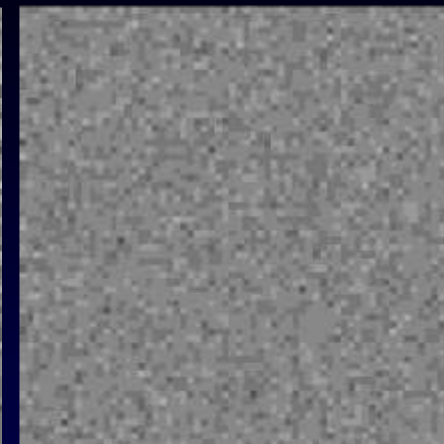
n=1



n=2

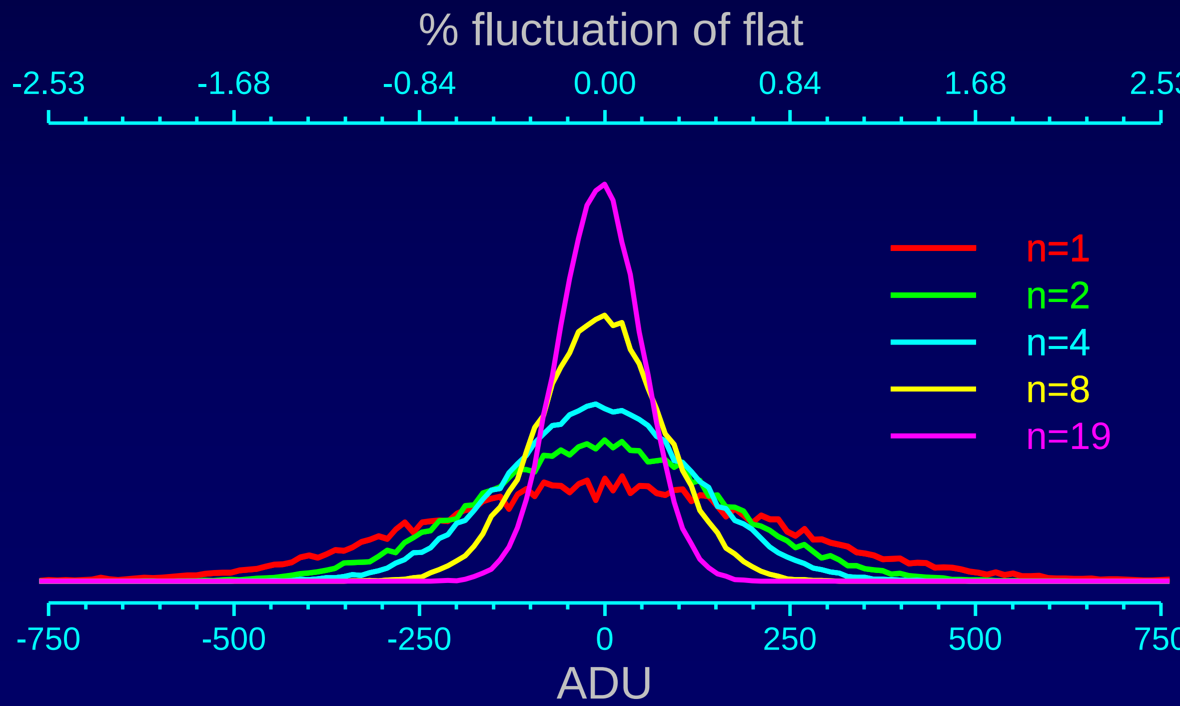


n=4

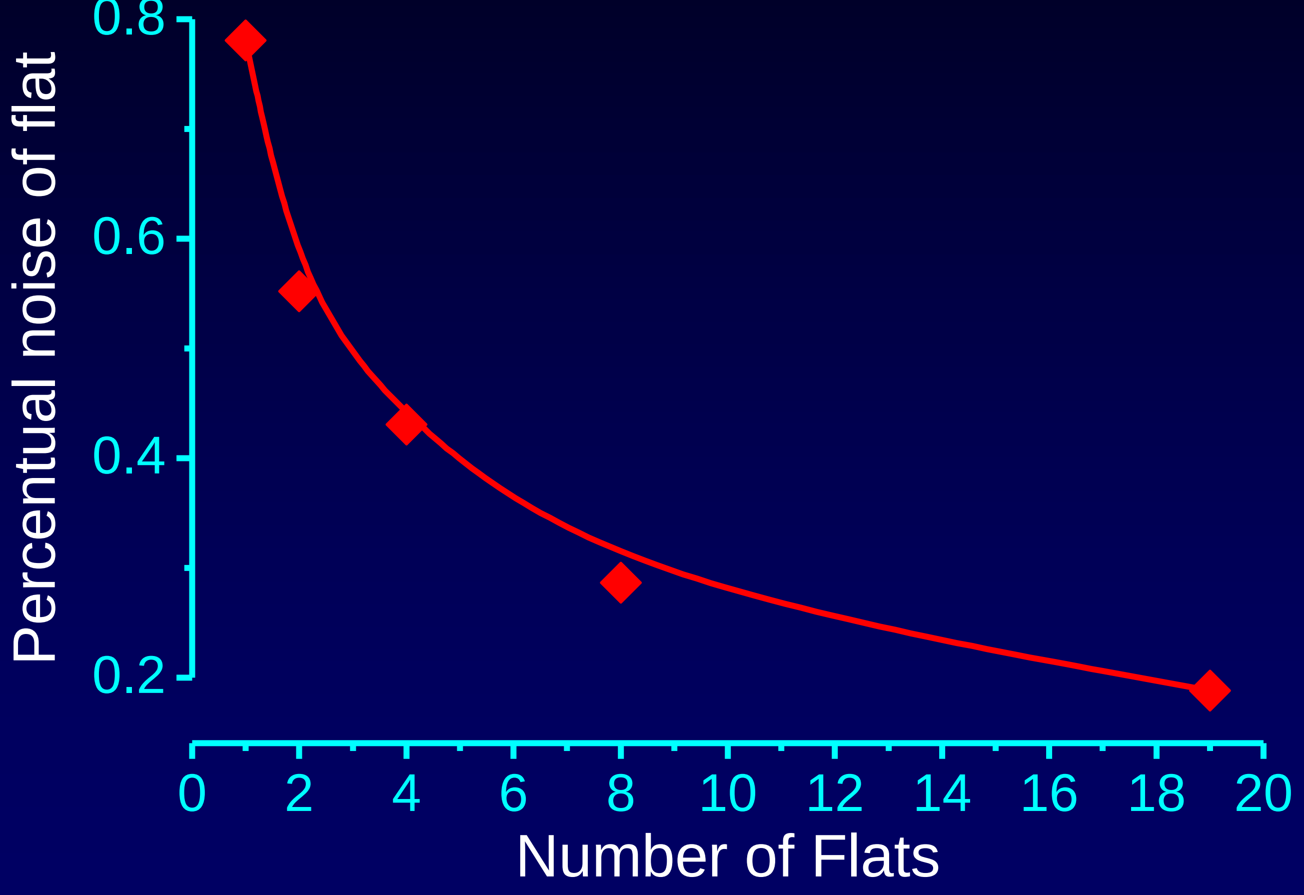


n=8

n=19



Look into your heart and pick a number



Let's make an empirical test using NGC 4395

Let's make an empirical test using NGC 4395

Perfect matching of the imaging train between the imaging run and the flat field run

Fighting the illumination artifacts

If all the previous conditions are met and your light images looks like this:

It is not a flat problem but rather an illumination artifact, caused by stray light.

LBN 105 - LBN 106 *(Hercules)*

Thanks to all