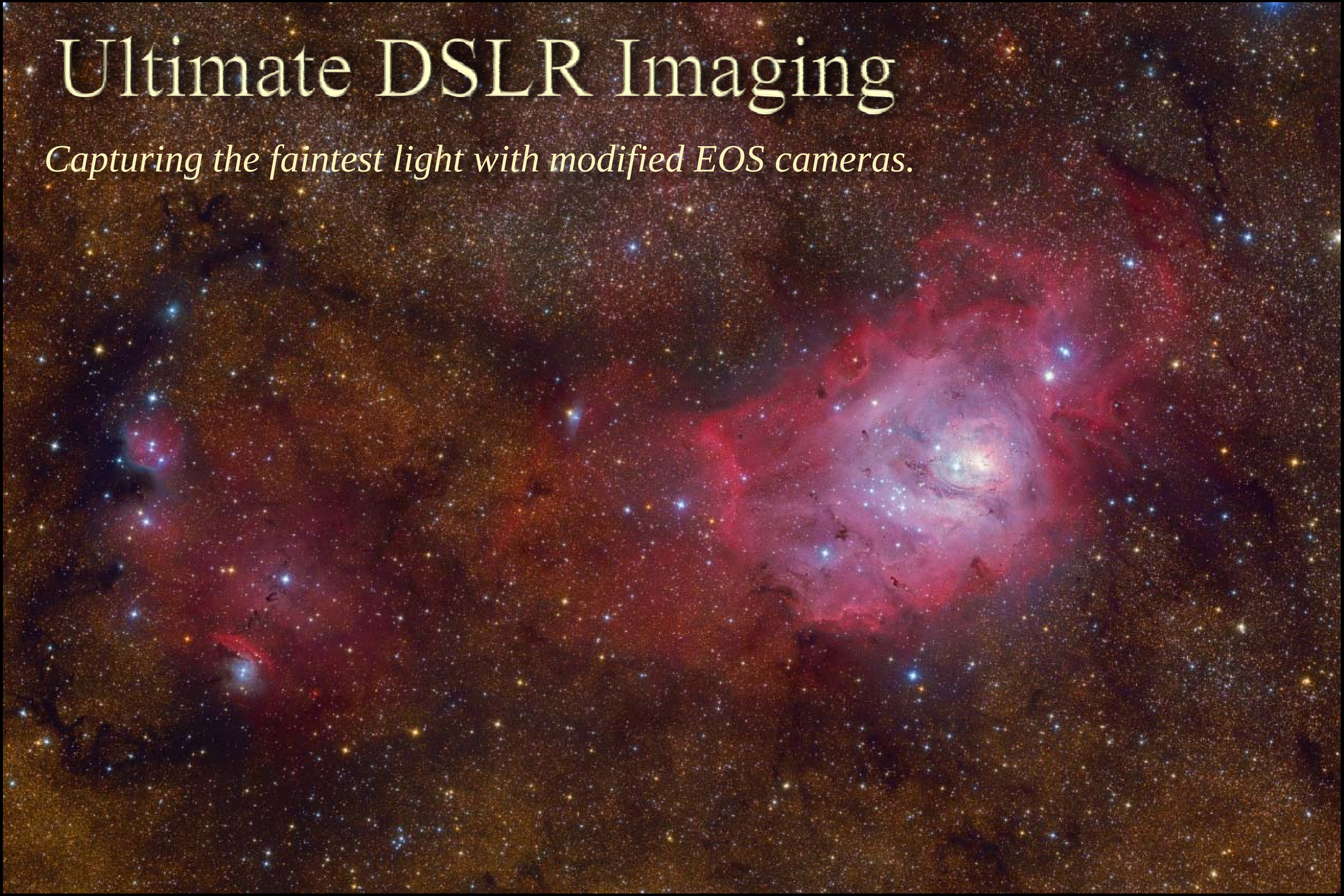
Ultimate DSLR Imaging

Capturing the faintest light with modified EOS cameras.



C E D I C - 2 0 1 1

Ivan Eder, Hungary

1. About DSLRs in general
   - *DSLR vs. CCD*
   - *QE graphs*
   - *Canon vs. Nikon*
   - *Canon vs. Canon*
2. Imponrtant acquisition rules, tips
   - *telescope, exposure time, ISO setting, shooting mode, temperature monitoring, dithering, sky quality, calibration frames*
3. Important processing tips
   - *raw interpolation method, calibration method,*
4. Recommended setup for ultra faint light imaging

Why DSLR camera?

- easy and fast to setup
- compact size, lightweight, etc.
- low power consuption, no computer required

→ ideal for the field, we can move easily to very dark skies with it!

- very easy to use, → great starter camera
- attractive price
- wide range of use (astro, daylight, video, etc.)

Are DSLRs really as bad as we may think compared to CCD cameras?

DSLR:

- mostly beginners use them →
  - → less imaging and processing skill result usually poor quality images
- avid astrophotographers move to CCD

CCD:

- most of the high quality CCD images are:
  - taken and processed by experienced imagers,
  - acquired from very dark places
  - used very long exposure times (10+ hours)

DSLR vs CCD

- DSLR pros:

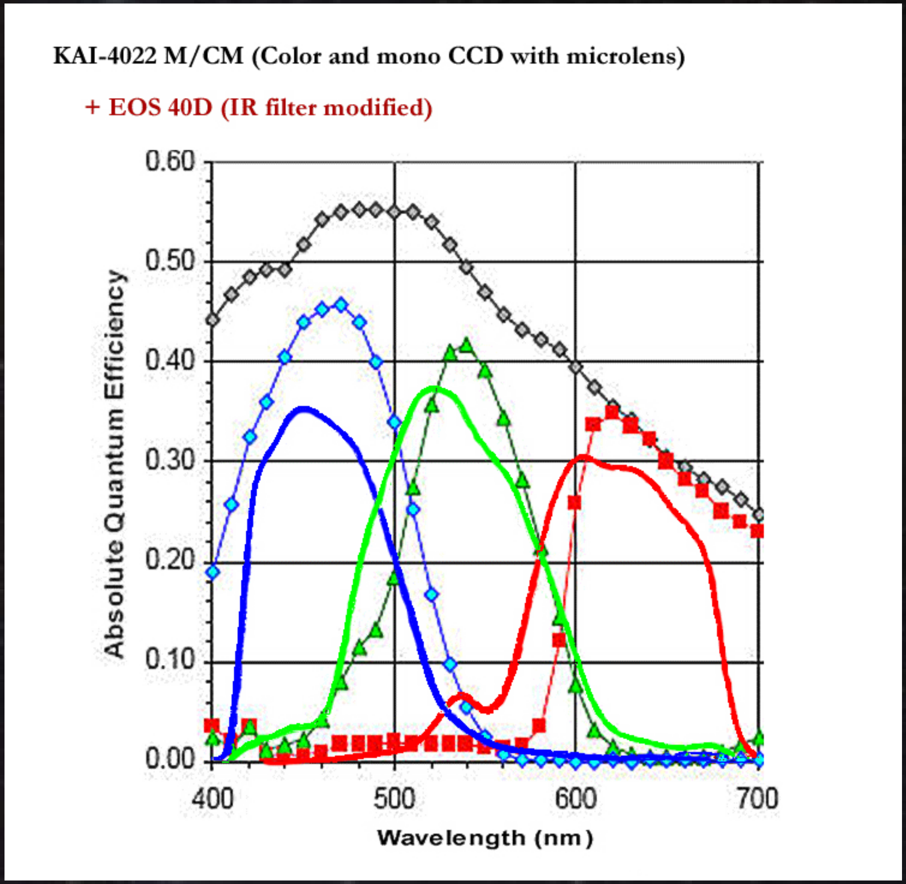
- low dark noise ➔ imaging is possible without cooling
- low readout noise
- low power comsumption, no computer needed, easy to setup in dark places

- DSLR cons:

- less dynamic range (only affects very bright objects, such as M42, 47 Tuc)
- somewhat lower sensitivity (see QE graphs)
- CFA filters (RGB) ➔ limited use of narrowband filters
- no cooling ➔ exposure time limit (depending on temperature)
- dark river problem (?) ➔ can be removed with dark frames

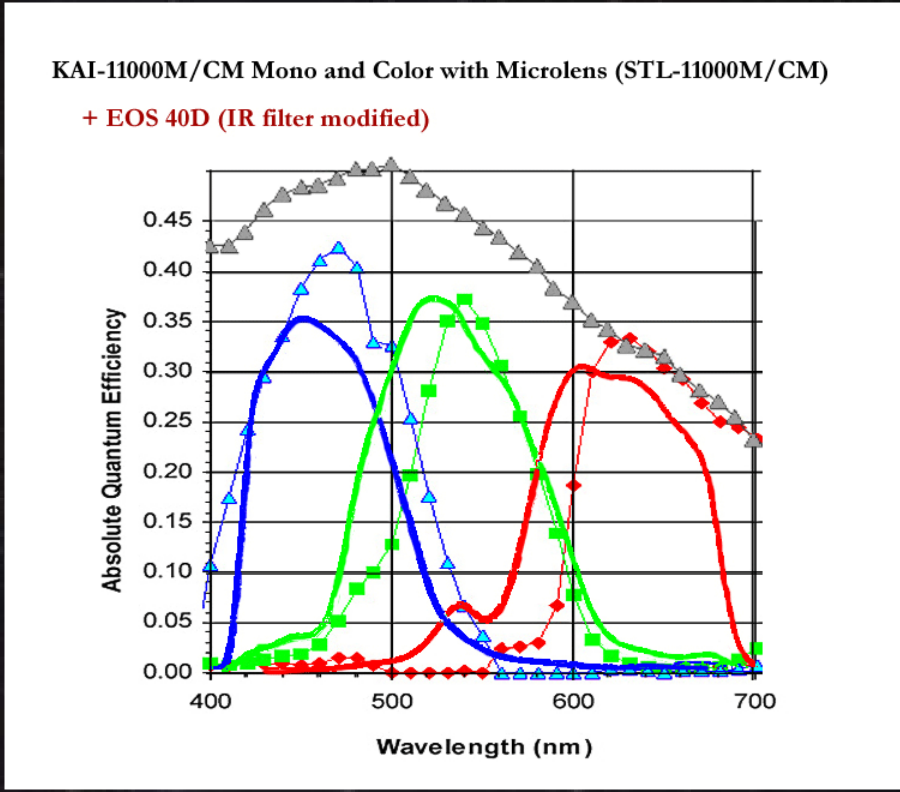
QE graphs

KAI 4022 (eg. STL-4020, SXV-H16) vs. EOS 40D modified :



QE graphs

KAI 11000 (eg. STL-11000) vs. EOS 40D modified :

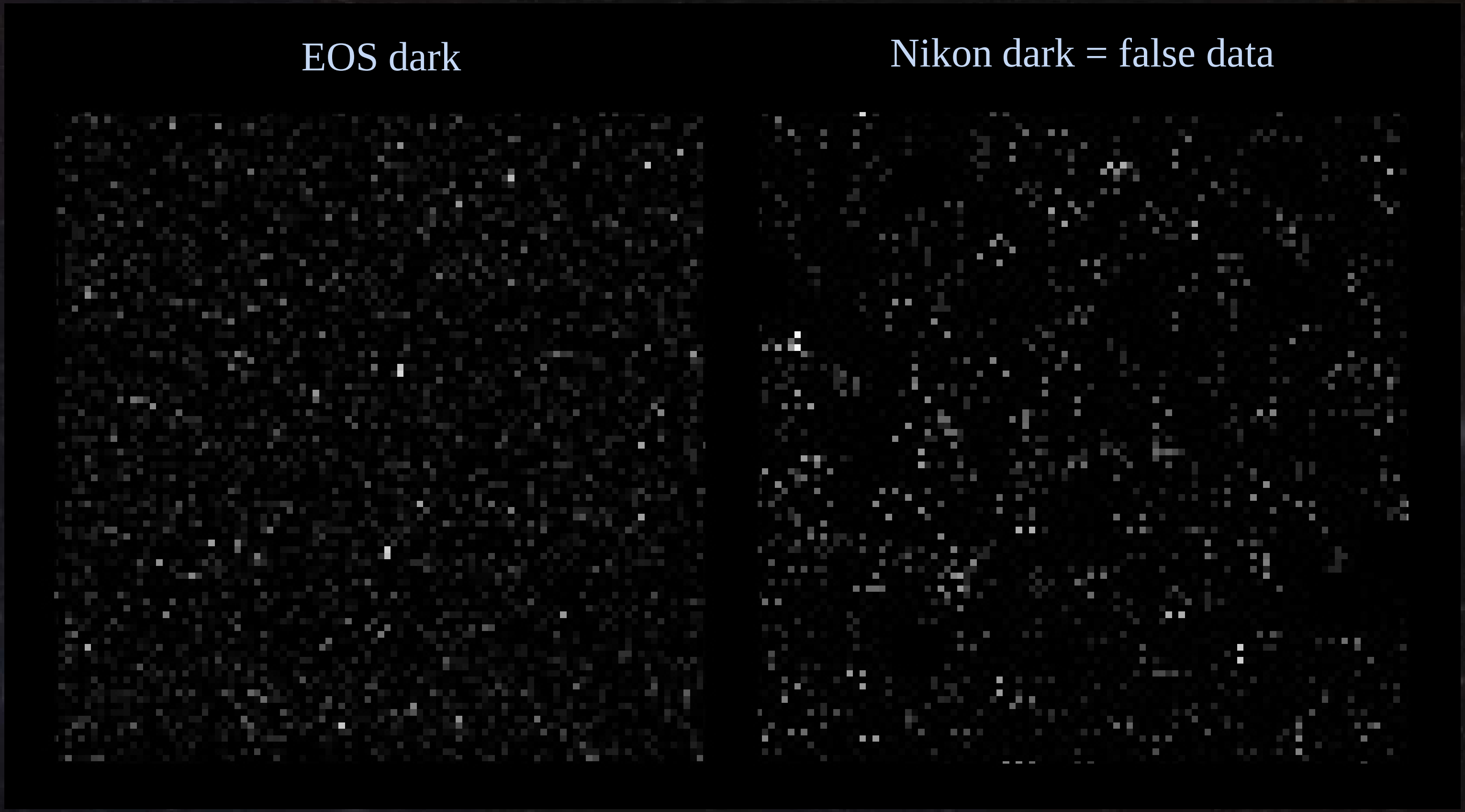


Canon vs. Nikon?

Raw images coming from Nikon cameras have already been modified, filtered. ➔ Nikons still have no true Raw image!

➔accurate calibration is not possible!

(The only way to get true raw is to apply „mode 3”, what means we have to force to switch off the camera after each exposures, when it is still busy with noise reduction...)



EOS vs. EOS

Old ➔ new:

Newer models have:

- more pixels, higher QE, less noise ➔ somewhat better overall image quality.
- no amplifier glow
- live view, that is very effective for focusing (with bahtinov mask)

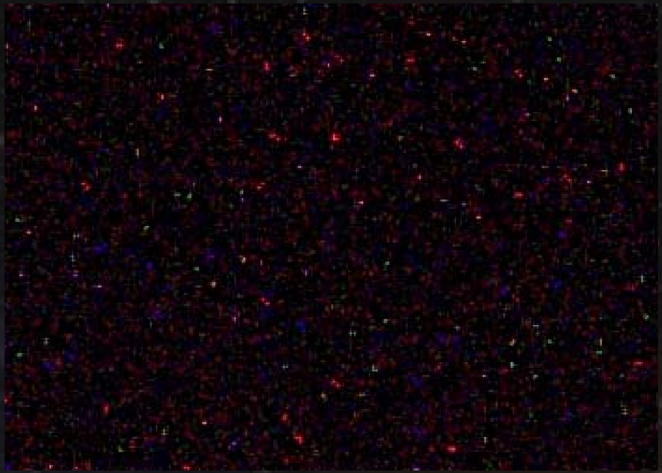
-Eos vs. Eos:

- there are no two identical cameras (just like in the case of telescopes) ➔ different noise characteristics, see next page:

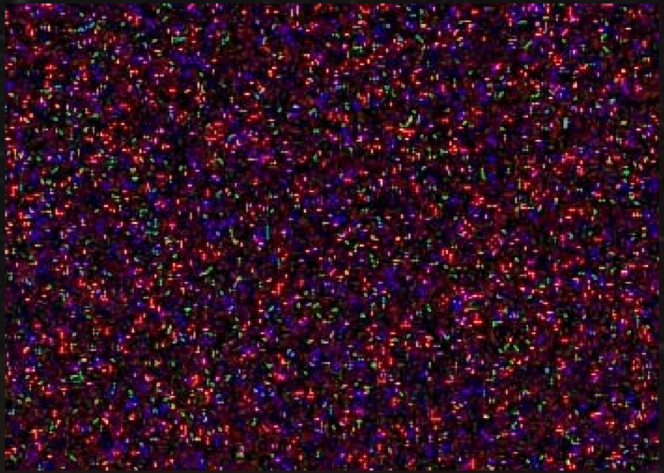
Thermal noise differences

Long exposure and strongly streched dark frames.

Identical conditions

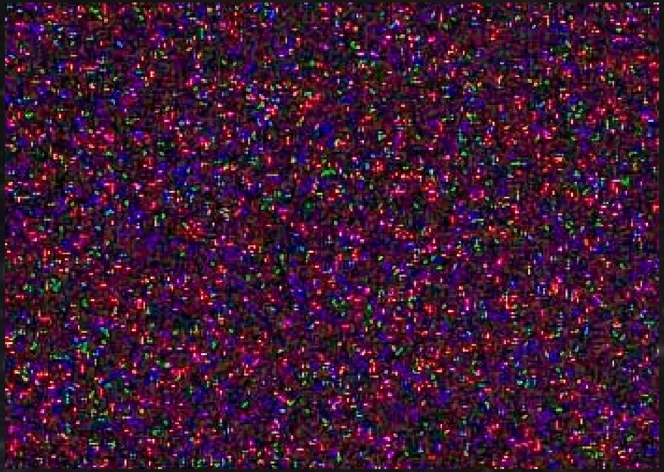


EOS 350D -no1



EOS 350D -no2

EOS 30D -no1



EOS 30D -no2

EOS 350D vs. EOS 5DmkII

Image comparison of NGC 1333

Frame 1:
130/780 (F/6),
350D, 10 min

Frame 2:
200/710 (light gath. p. = F/4),
5DmkII, 5 min

light gathering power = factor ~ 2
exposure time = factor 2
camera s/n ratio ➔ factor ~ 2
(not a measured value)

„Dark river”

Dark river (or horizontal banding)
can easily be corrected with dark frames.

- Make sure to use a program, that makes calibration steps on raw images!
(eg: IRIS, or the latest versions of ImagesPlus, etc.)
DeepSkyStacker? Not recommended…

Wrongly corrected, banding still exsist

Corrected with darks in IRIS

IMAGING RULES

Acquisition:

- Telescope light gathering power (F number)
- Exposure times, ISO setting
- continous shooting with equal pauses
- temperature monitoring/recording to match dark frames
- dithering
- sky quality
- importance of calibration frames

Processing:

- calibration on raw images (IRIS, IP bayer basic raw)
- raw interpolation method (gradient vs. Linear)
- stack with some kind of median algorythm *(sigma clipping, kappa sigma, median, median-mean, minmax excluded average, etc...)*

Use fast telescopes !

Fast telescopes collect more light at the same time, at given FL!

(eg.: 100/800 vs. 200/800)

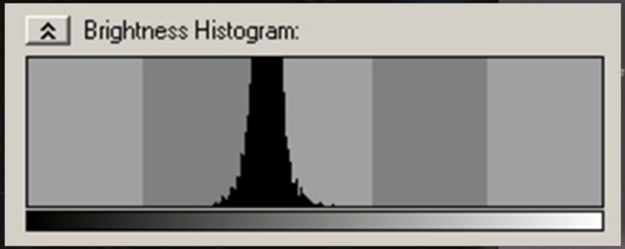
- ➔ shorter exposure time needed (F/4 is 4 times faster, than f/8!)
- ➔ more data in a period of time
- ➔ less thermal noise
- ➔ better s/n ratio

- shorter exp time means less guiding problems as well (flexure, etc...)

Use long sub exposure times!

- Background should be brighter than we'd like to see, than image quality will be less affected by readout noise, ➔ better quality of subs

- Background intensity level should be appr. 25% (or more) on the histogram!



Lot of frame give better result.

Shooting a lot of frame to one object, to improve s/n ratio

Requiring amount of frames depends on object brightness (as well as other things).

LBN 777
(streched)

Single frame

(5 min)

Lot of frame give better result.

Shooting a lot of frame to one object, to improve s/n ratio

Requiring amount of frames depends on object brightness (as well as other things).

LBN 777
(streched)

10 frames
(50 min)

Lot of frame give better result.

Shooting a lot of frame to one object, to improve s/n ratio

Requiring amount of frames depends on object brightness (as well as other things).

LBN 777
(streched)

120 frames

(600 min)

What ISO setting?

- Optimal ISO setting depends on a lot of things, *(such as camera, temperature, telescope, sky quality, object, etc...)*

- High ISO settings (400, 800, 1600) usually give better result than lower settings, within a given total exposure time.
  - *Avoid extreme values (ISO 50, 100, and 3200, 6400, or more)*
  - *Stacking of more high ISO images give better result, than less low ISO image, if we* ➔

- Keep background intensity over 25% on histogram- whatever ISO we are using. Very important!
  - *If our exposure is good with eg. 5 min. at ISO 1600, use longer exposures at lower ISO settings to get equivalent saturation. (shoot 10mins for 800, 20 mins for 400, 40mins for 200 respectively.*

Continuous shooting

- Using equally long pauses means that chip temperature will be tempered after a few exposures ➔

➔ darks will match the light frames.

Monitor temperature to match dark frames!

- If we record temperatures, we can store darks for later use!

➔ helpful, if

- we can not shoot enough darks during/after a session.
- we have more and more darks in time, what gives better result.

Dithering

- Dithering (random displace) helps to eliminate both sensor artefacts, hot pixels and incorrect dark subtraction.

LBN 777 (unstreched)

(Dithered with
Lacerta M-Gen autoguider)

Dithering

- Dithering (random displace) helps to eliminate both sensor artefacts, hot pixels and incorrect dark subtraction.

NGC 6726 (CrA)
uncalibrated

(Dithered with
Lacerta M-Gen autoguider)

Sky quality

Imaging from dark sky:

We can get the same result:

- -in a fraction of time (less subs needed),
- -with better s/n ratio,
- -less final noise,
- -less problems of the system,
  (camera, vignetting, sky gradient)
- - less problem with processing, etc.

-Is it important?

-Yes! It is worths it
to move out!

Accurate calibration frames

Dark:

- Continuous shooting!
- Temperature monitoring, use separate darks for every 2-3 C degree temp diff!
- Shoot darks in a dark place, (camera body can not block strong light)
- camera body have to be uncovered (not the optical train!), allowing it to cool.
- the more numbers of darks the better the correction

Flat:

- Sensor cleaning: switch off!
- Sensor nonlinearity ➔ the longer the exposures the better the correction ➔

➔ Shoot flats under low light conditions!

- Best histogram state (exposure time) is program dependent
- Be careful with illumination, it has to be very even! *(I use skyflats)*

IMAGING RULES

Processing:

- calibration steps on raw images (IRIS, IP bayer basic raw, NO DeepSkyStacker!)
  Program has to make calibration steps BEFORE rgb conversion!
- raw interpolation method (gradient vs. Linear)
- stack with some kind of median algorythm *(sigma clipping, kappa sigma, median, median-mean, minmax excluded average, etc...)*

Raw interpolation method - gradient vs. linear)

There are a lot of interpolation method, what makes color images from raw CFA (color filter array) images.

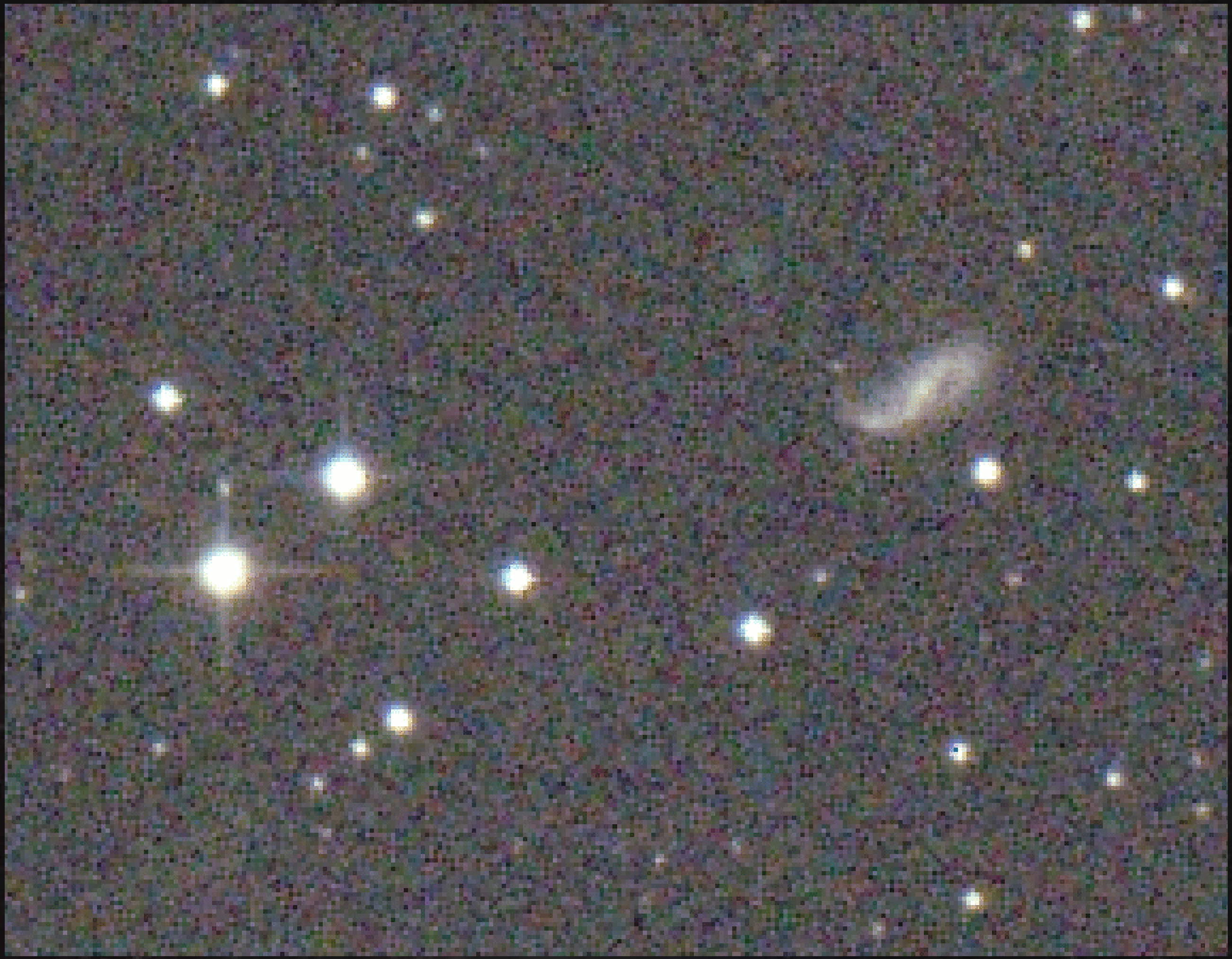
Here we can see the difference between „*gradient*” and „*linear*” method, coming out from IRIS.

On the gradient image there are somewhat more details, but the noise is stronger.

It is recommended, when we have large pixels or/and the spot size is very small (good and fast optics, very good seeing, short FL).

Linear method gives a bit smoother result, with a bit less sharpness.

It should be better for normal conditions, giving smoother details of extended objects.



The 6 most important thing

- Dark sky
- Ultra fast optics *with large corrected field*
- Long exposure times
- accurate calibration frames
- modified EOS *(preferably 5DmkII)*
- stand alone autoguider *(Lacerta-MGen)*

Imaging setup

My portable imaging setup:

- 200/710 Newtonian

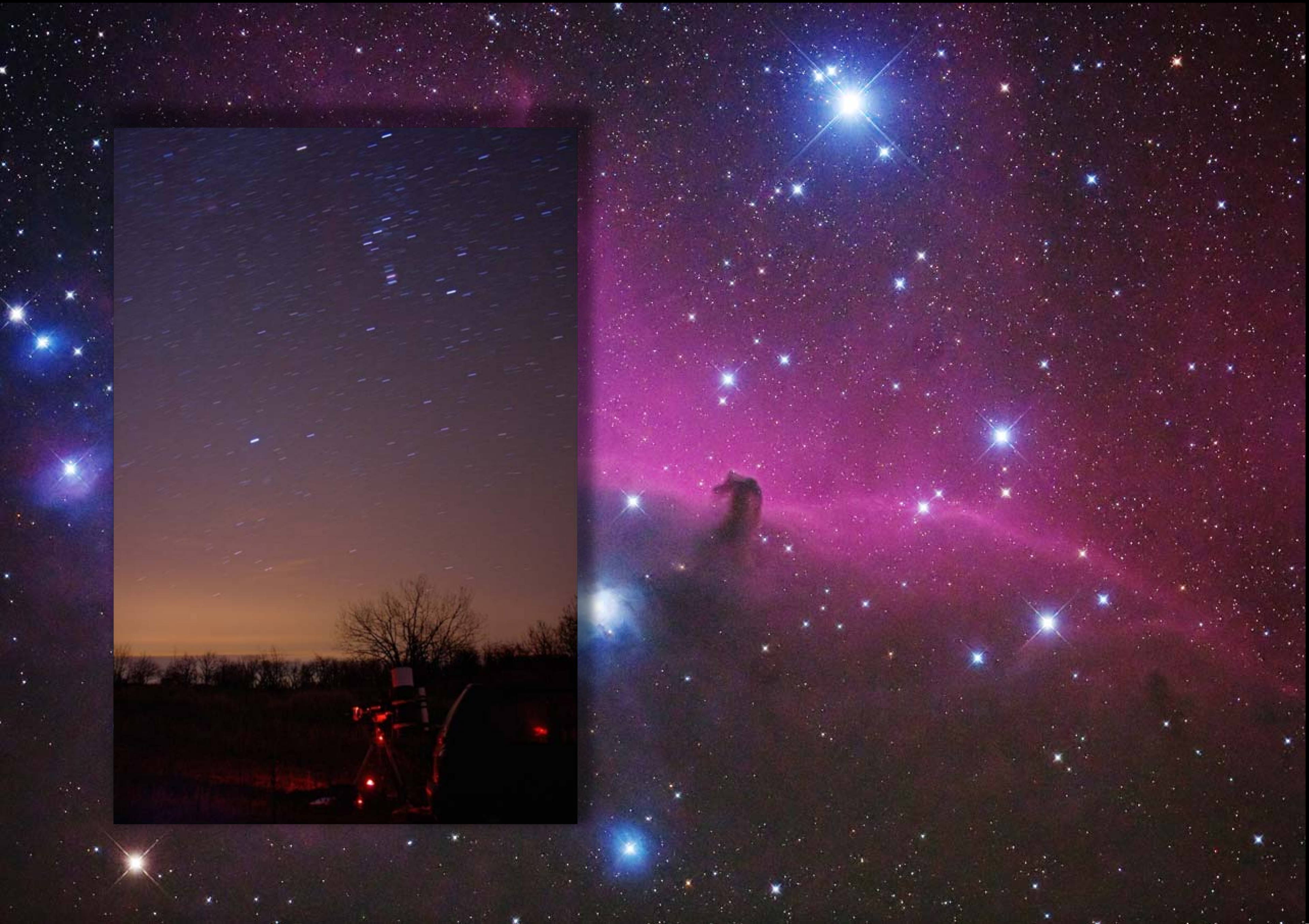
  F/3.55 (F/4)

- modified EOS
- Lacerta-M-Gen guider

  full automatic operation, incl.
  exposure control,
  dithering

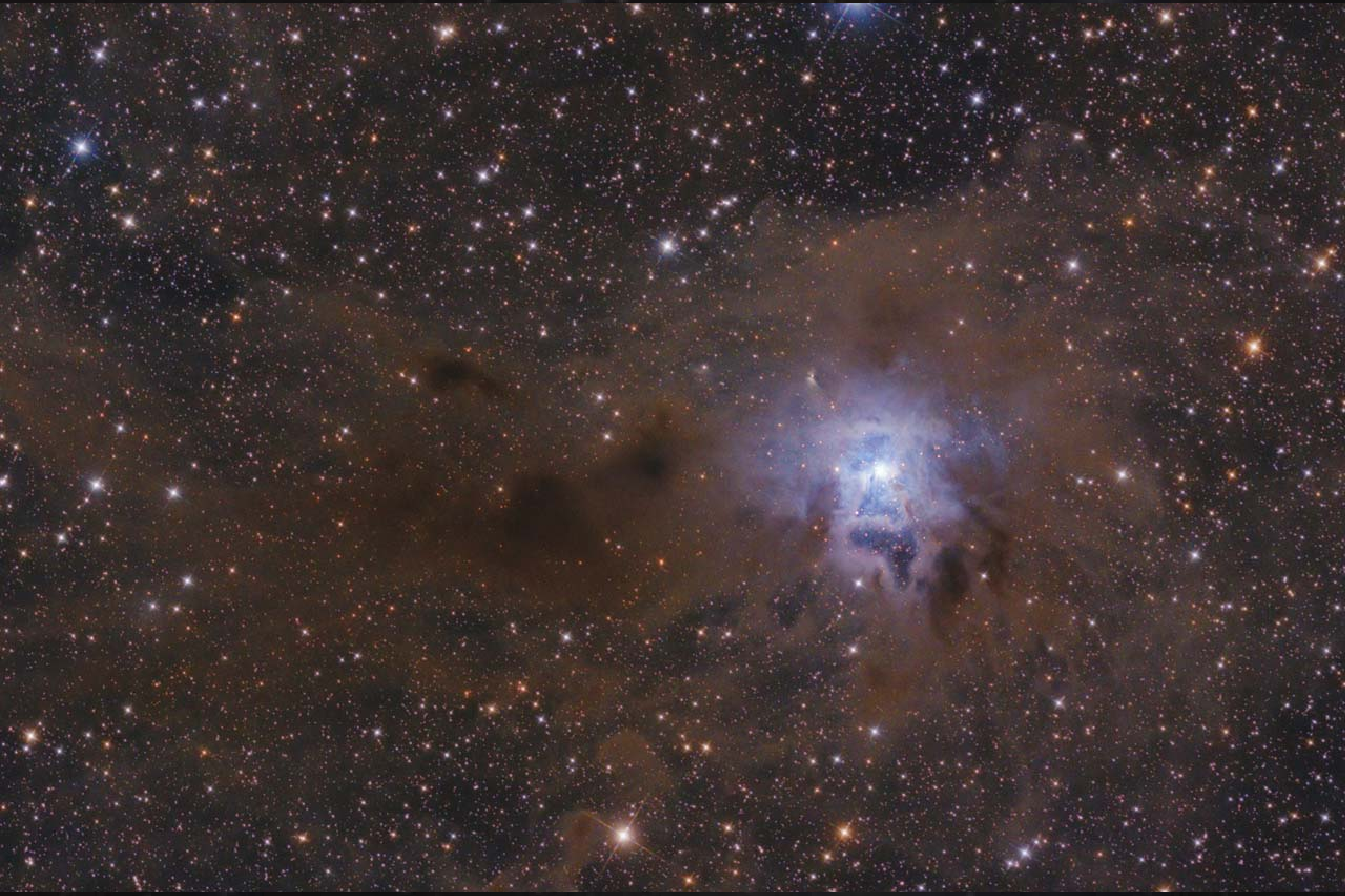
Single 5 minutes at ISO 1600 from mag 21 sky (measured at zenith)

Single 5 minutes at ISO 1600 from mag 21 sky (at zenith)



130/780 + EOS 350D, 180 minutes total, from dark sky,

200/710 + EOS 5DmkII, 220 minutes total, from dark sky, cropped



FOV difference

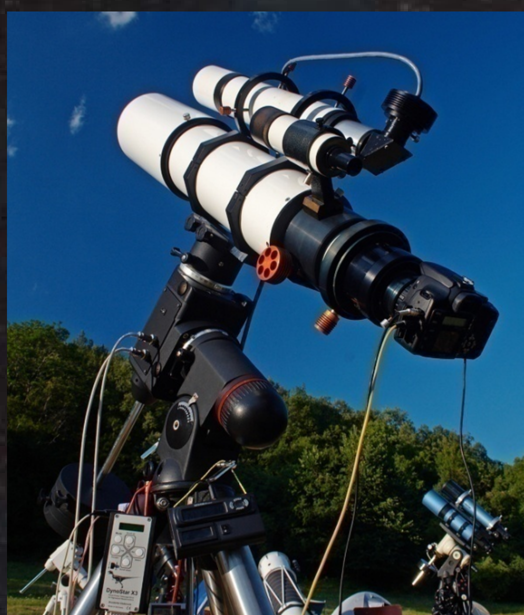
Comparison…

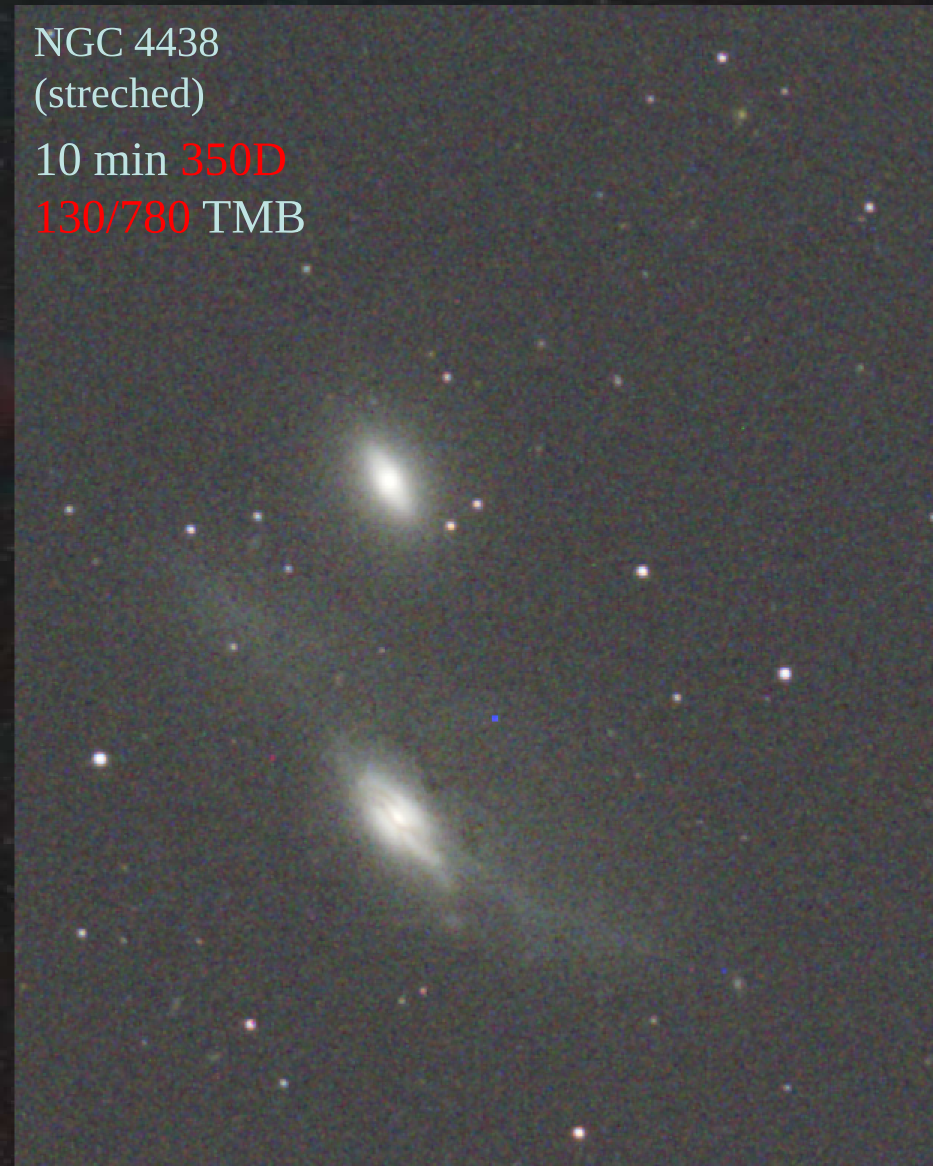
…of two identical FOV setup:

- -1: 130mm with 350D (APS-C)
- -2: 300mm with 5D mkII (Full frame)

Signal difference is a factor of more than 4 times, (aperture)

Additional difference is coming from the s/n differences between the cameras
(about a factor of 2).





Aperture rules!

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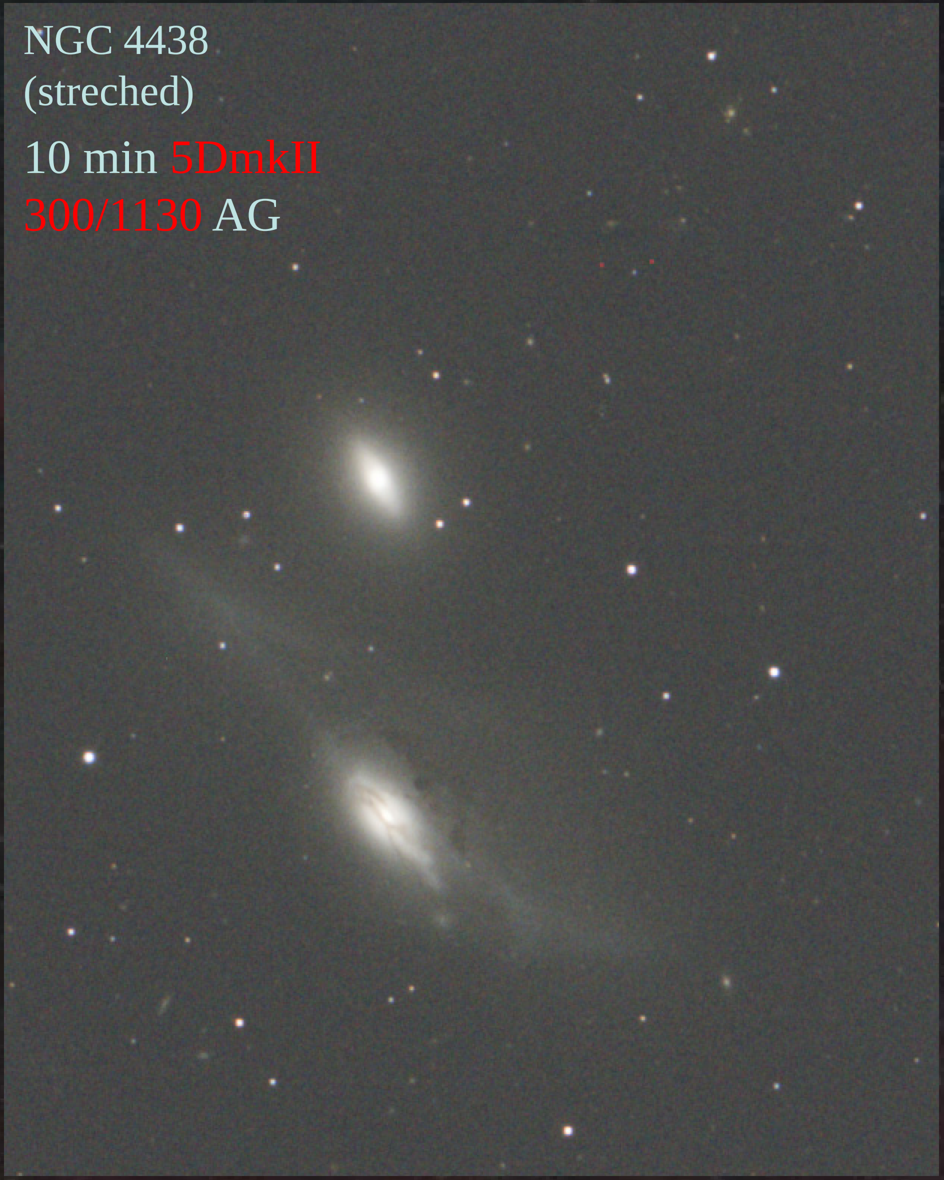

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Additional difference is coming from the s/n differences between the cameras
(about a factor of 2).

Total difference is: ***factor of ~8!!!*** ➔

We get the same result in 1/8th of a time!

M81-82   180 min, 130/780 + 350D

M81-82   220 min, 300/1130 + 5D mkII


Thank you for your attention!