THE IMAGING TRAIN

ASTROPHOTOGRAPHY

ASTROPHOTOGRAPHY BASICS

- Understanding FOCAL RATIO and ‘speed’
- found by dividing the focal length by the aperture
  - Focal length: The length that the light travels inside the telescope, in mm
  - Aperture: The size of the opening, in mm
- Ex: Typical 80mm Refractor: 480mm focal length
  - 480/80 = 6; f/6
- Lower numbers equal ‘faster’ telescopes
  - This refers to the ‘density’ of light striking the sensor. The smaller the focal ratio, the more compressed the light is, and the brighter the image will be
  - So, an **f/5** system can gather light at the image plane **4-times as fast** an **f/10** system, but the image will be only one-half as large (assuming the same aperture).
  - Faster = shorter images (subs) = more forgiveness
  - *However, dimmer stars can only be seen with larger apertures. Focal ratio doesn’t matter.

WHAT DO YOU NEED?

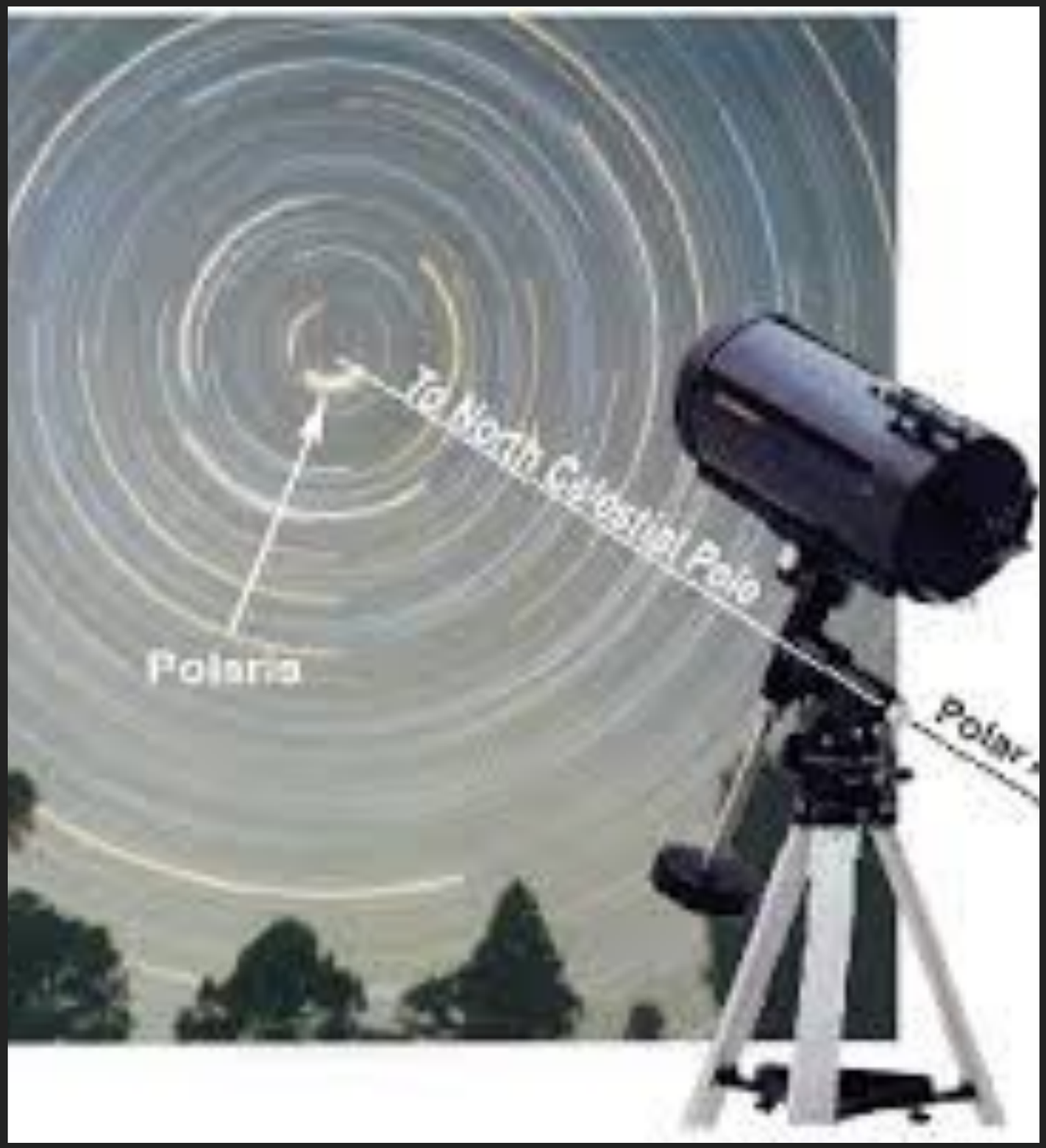
- Mount - something to track the sky.
  - Should be the majority of your budget
- Lens - Telescope? Camera Lens?
- Image plane correction
- Focusing Ability
- Filters?
- Camera
- Guider?

THE IMAGING TRAIN

MOUNTS

ALT/AZ MOUNTS

- Alt/Az vs EQ (GEM)
  - Alt/Az: Ease of use, but limited to very short exposures (30s)
    - Rotator?
    - Wedge?
    - Typically larger PE (periodic error)



GEM MOUNTS

- Requires more precision with set up - polar alignment
- Capable of unlimited exposure times
- Wide range of price (**tends to equal precision**)
- Worm gear/belt drive
- Absolute encoders?
- Divide capacity by half for imaging - for non top-tier gear

STAR TRACKERS

- iOption Startacker Pro
- $299
- Best with DSLR + Wide lens
- 2-4min exposures max
- Good reviews
- Requires star finding knowledge
- 6lb Capacity

EQ MOUNTS

- SKY-WATCHER EQ6-R PRO EQUATORIAL GO-TO MOUNT
- $1,595.00
- Trainable periodic error correction
- Belt Drive (as opposed to gears)
- 44lb Capacity
- Built in DSLR trigger

EQ MOUNTS

- Celestron CGX
  - $2300
  - 55lbs
  - Easy to Use
  - Can be hit or miss
- Also, Takahashi (used)
- Losmandy
- Other iOptron - w/Encoders

EQ MOUNTS – PREMIUM MOUNTS

- Paramount MyT
- Astro-Physics Mach1
- Avalon M-Uno
- About $6-7000
- Different level of fit and finish
- Only needed for long exposures
- Better Software

NEXT GEN MOUNTS

- Rainbow Astro
- ‘Strain Wave Gear’ driven
- Size of star tracker, but full fledged mount
- Very good tracking, no backlash
- Packable in a backpack
- $4000-6500

MOUNT – FINAL THOUGHTS

- Look for used equipment
  - AstroMart - best classifieds
- Most say at least half your budget
- Remember - also need a good tripod
- Try stay at 75% max weight or below
- Think about the future

THE IMAGING TRAIN

TELESCOPES

LENS

- Easy to find used lenses
- Do research on sharpest lens for your needs
- Least expensive option
- Start with 200-400mm focal length, or wider
- You probably already have something reasonable

REFLECTORS

- Pros
  - Best Bang for the Buck (largest aperture per cost)
  - Can be very sharp
  - Can be very fast (f/3-range)
  - Good contrast
- Cons
  - Can be hard to collimate
  - Short focal range (back focus)
  - Bulky/heavy
  - Diffraction spikes, which some love
  - Large coma effect - requires correction

NEWTONIANS

- teleskop-express.de
- Or, Astro-tech, Orion, or Meade
- Imaging Newts starting at $250

- All Newts require a Coma Corrector
- Most are f/5 at lower prices

CASSEGARAINS – SCHMIDT CASSEGRAIN

- Pros
  - Long focal length = ‘zoom’
  - Very large apertures
  - Wide range of focal ratios - f/10-f/2
  - Huge focal range (back focus)
  - Great for galaxies and PNs
- Cons
  - Collimation can be difficult
  - Loss of contrast
  - ‘Mirror flop’
  - Needs correction/reduction
  - Heavy
  - Dew Magnet

SCT

- MEADE 8" LX200-ACF ($1200)
- Celestron 8” EDGEHD ($1350)
  - Locking Primary mirror
  - Coma free optics
  - Slow at f/10
  - Affordable apertures to 14”
- ** Do not attempt to image with a standard SCT.

REFRACTORS

PROS
- SUPER-SHARP – HIGHEST OPTICAL QUALITY AVAILABLE IN SMALL TELESCOPES
- COMPACT
- WIDE F.O.V.
- ‘NEVER’ NEEDS COLLIMATION
- SEALED SYSTEM
- VERY HIGH CONTRAST

CONS
- EXPENSIVE
- CAN PRODUCE FALSE COLORS
- SMALL APERTURES – LARGEST IS 6”
- ALMOST ALWAYS NEED TO REPLACE FOCUSER


STELLARVUE

80MM REFRACTORS

- Explore Scientific ED80
  - Or, Orion ED80 (cheaper, but…)
- Highly recommended as first imaging scope
- Very forgiving in terms of tracking and focus
- Nice, wide (rich) fields
- Reasonably to very fast
- Need at least 3 lenses (triplet)
- Reality - need 4 lenses

THE IMAGING TRAIN

FOCUSERS

FOCUSERS – WHICH IS FOR WHAT?

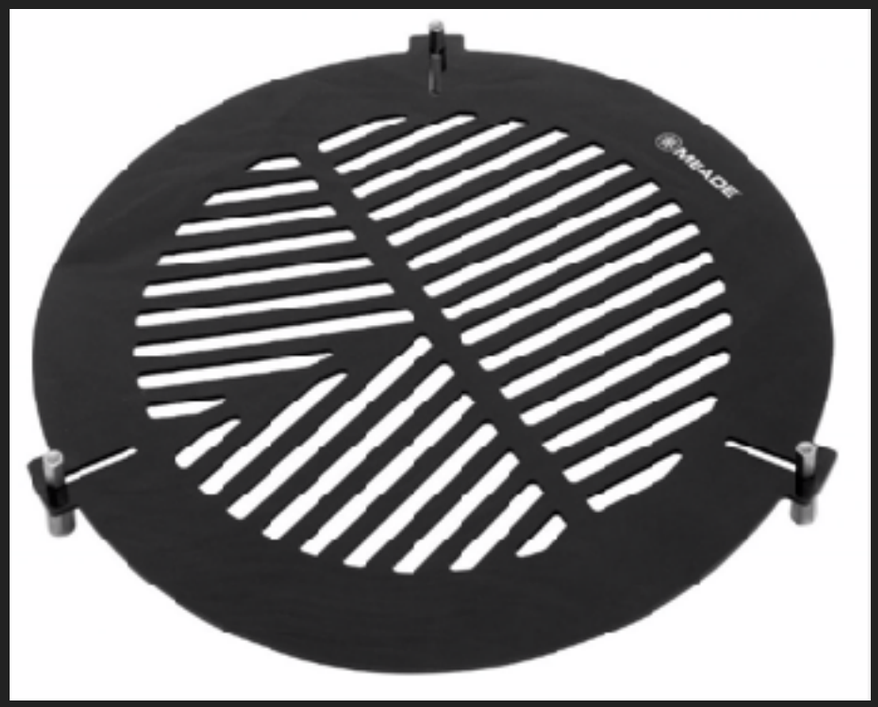
- Type - Crayford or Rack & Pinion?
  - Crayford: Cheaper, smooth - might slip with heavy loads
  - R&P: Costly, strong - can be jerky if not made well
- Tube Length
  - Newts: Require very short tubes (focal range) - 1.5”
  - Refractors: Can require very long tubes - up to 4.5”
  - SCT: Short tubes (.75-1.5”) needed because rough focus done with built in focuser
- All imagers use aftermarket focusers.

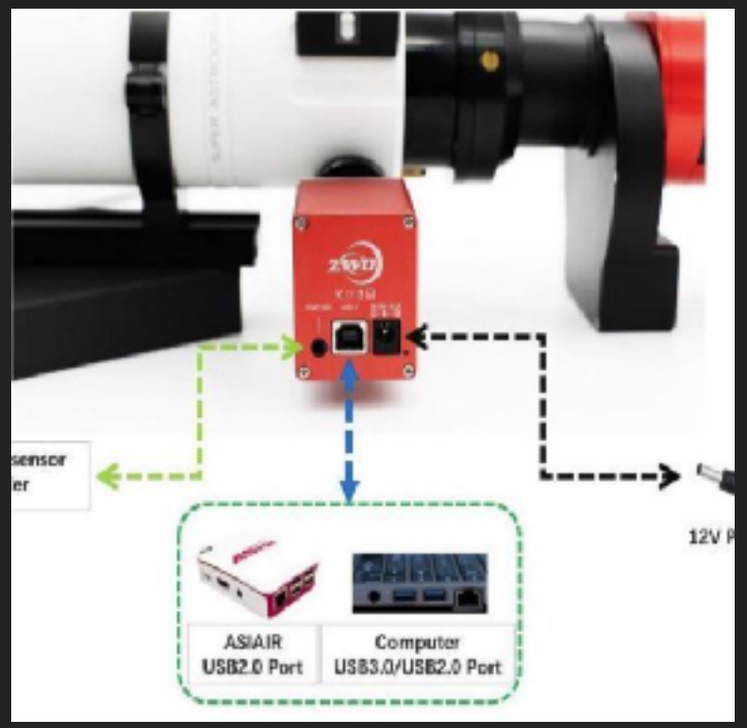
FOCUSER THOUGHTS

- You can not focus by eye
  - The CRZ (critical focus zone) is super small:
    - F/R squared * 2.2
      - f/5.6 = 68 microns = .0027”
      - f.10 = 220 microns = .0087”
      - Human hair - approx 80 microns
      - My focuser moves in 1 micron steps
- Motorized is best, even if hand driven
- Need correct flange - make sure one is made for your scope!

FOCUSING OPTIONS

- Attachment motors for focusers
  - $200-400
- DIY: Arduino Focuser 2
- Bhatinov mask
- Software assisted:
- MetaGuide
- SharpCap





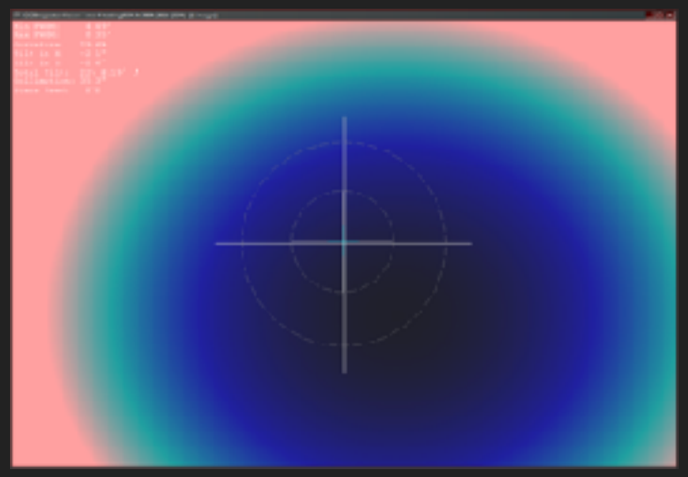
THE IMAGING TRAIN

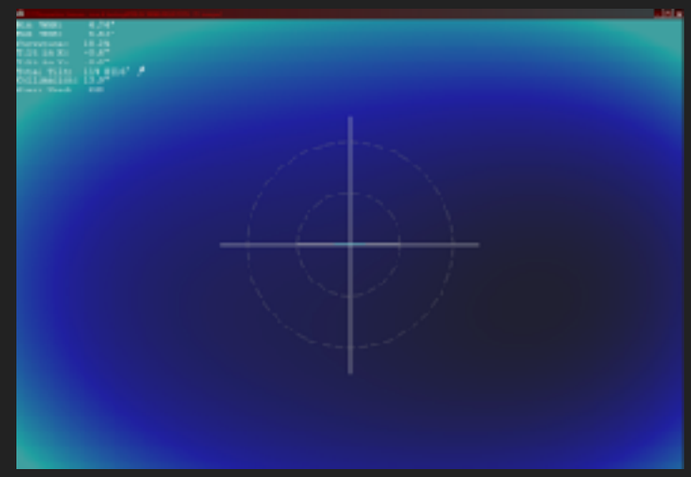
REDUCERS/CORRECTORS/ FLATTENERS

REDUCERS/CORRECTORS

- What do we need?
  - Refractors: Reducer, Flattener or R/F - often scope-specific, usually .8x
  - Reflectors: Coma Corrector, Reducer?
  - SCT, RC: R/C, .67x, .63x, .5x, .33x
- Corrected SCT: Reducer, .7x

REDUCERS/CORRECTORS





- Most Importantly:
  - What is the **back focus** of the device?
    - How far MUST the sensor be from the back of the device?
      - Often 55mm (the distance of a t-ring+DSLR)
      - This will define what equipment can be considered
  - How large is the **image circle** produced by the device?
    - Need to insure fully-illuminated and corrected image circle is larger then your sensor to avoid vignetting/coma/distortion.

THE IMAGE TRAIN

CAMERAS

CAMERAS

- Lots of choices - $800-$10,000
- Mono vs OSC vs DSLR
- CMOS vs CCD
  - CCD: Older tech, Noisier, Easier
  - CMOS: Less noise, Amp Glow
- Cooling? - 2 stage is best
- Sealed chamber?
- Software/Hardware compatible?
- Size of chip defines F.o.V. - use online tools to simulate

CAMERA CHOICES

- DSLR: Nikon D5300 - most recommended for Astrowork
  - Used for $250
  - Astro-modded $450 (Full Spectrum)
  - Huge Plus - Gigantic sensor
  - Big minus - no cooling; noisier, needs lots of dark frames
- BackYard Nikon/EOS $50

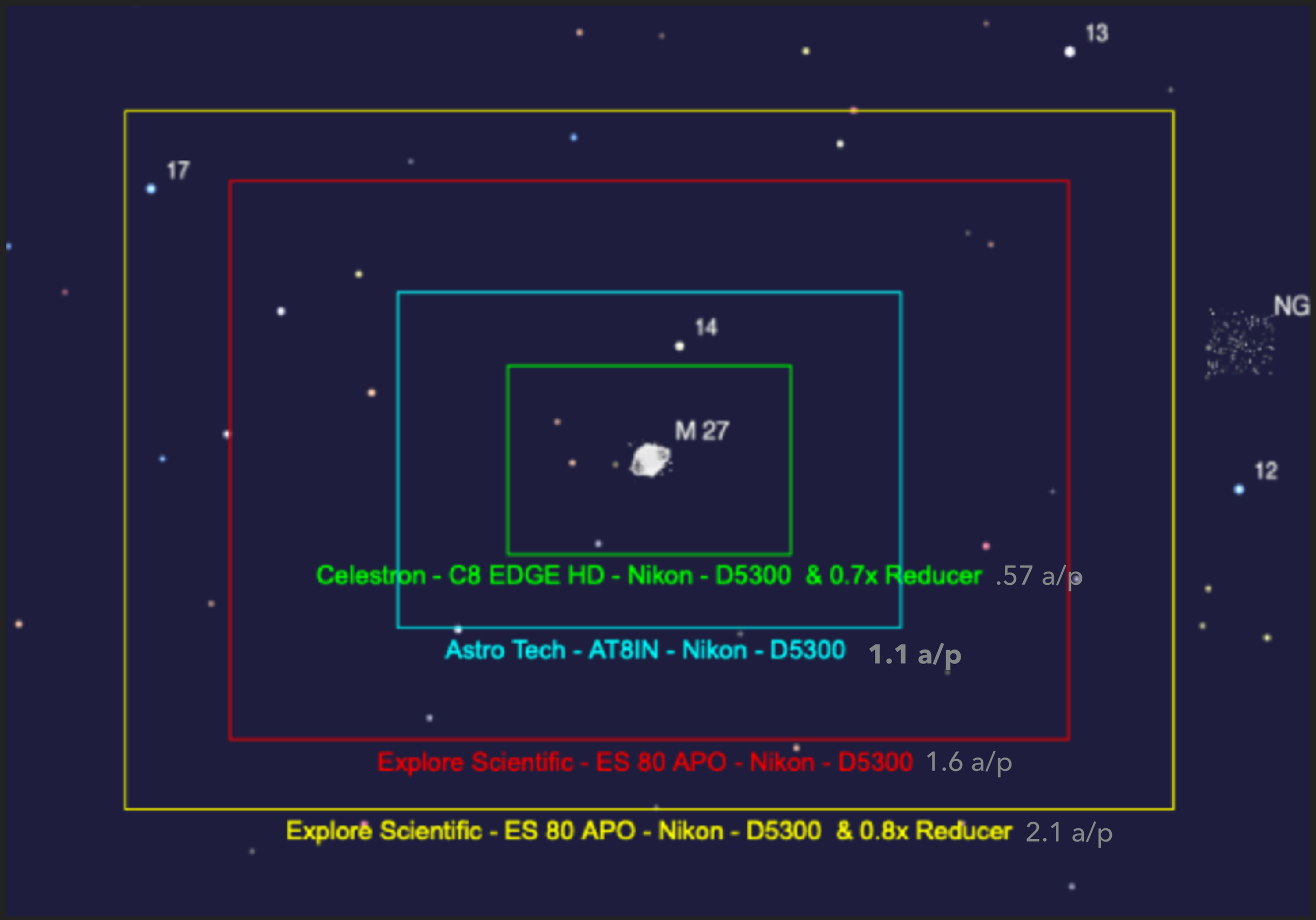
- ZWO 183MC PRO - Color CMOS
  - Cooled
  - $800
  - Less and half as large of a sensor
  - SharpCap Pro $10/year

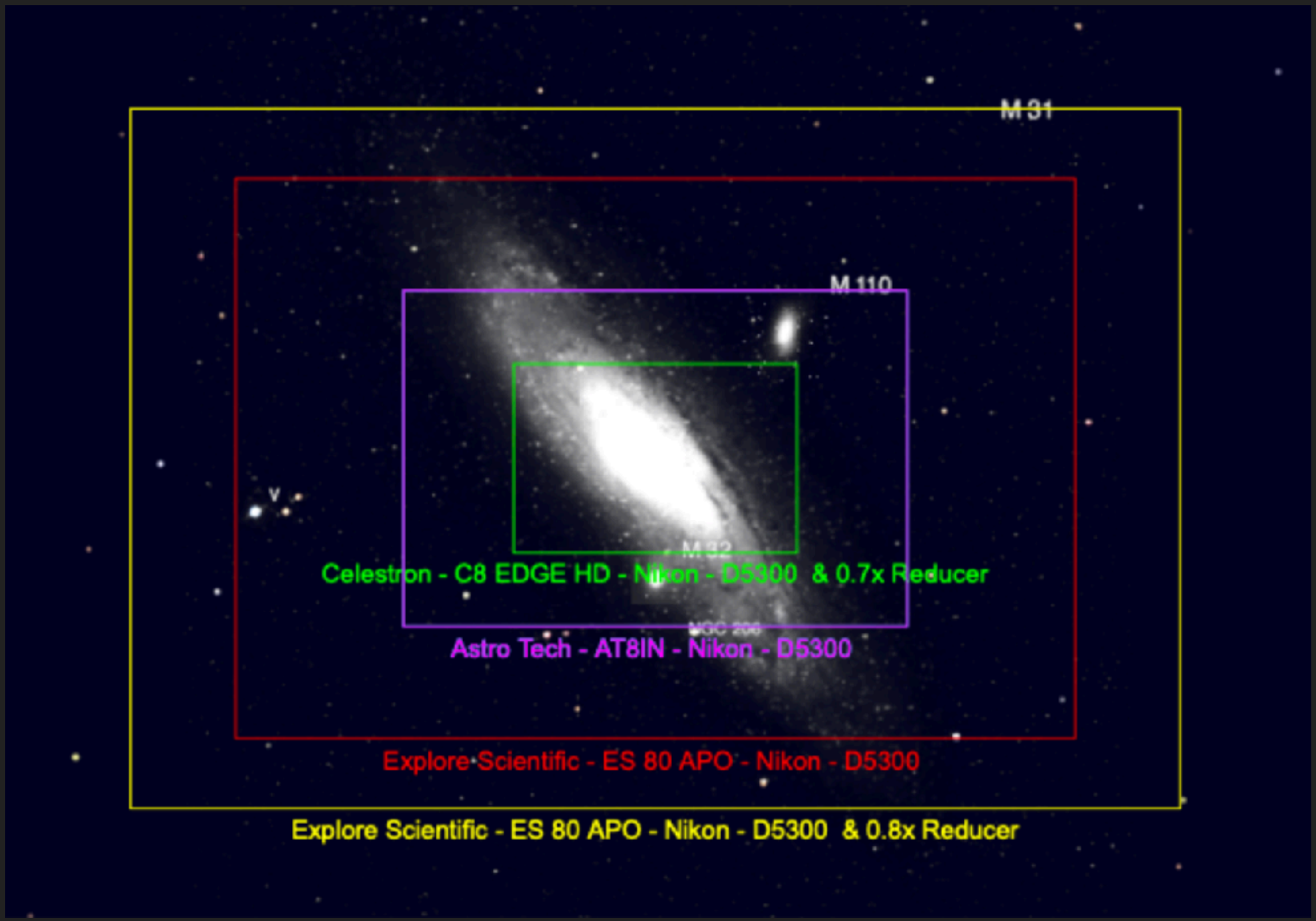
CAMERA CHOICES

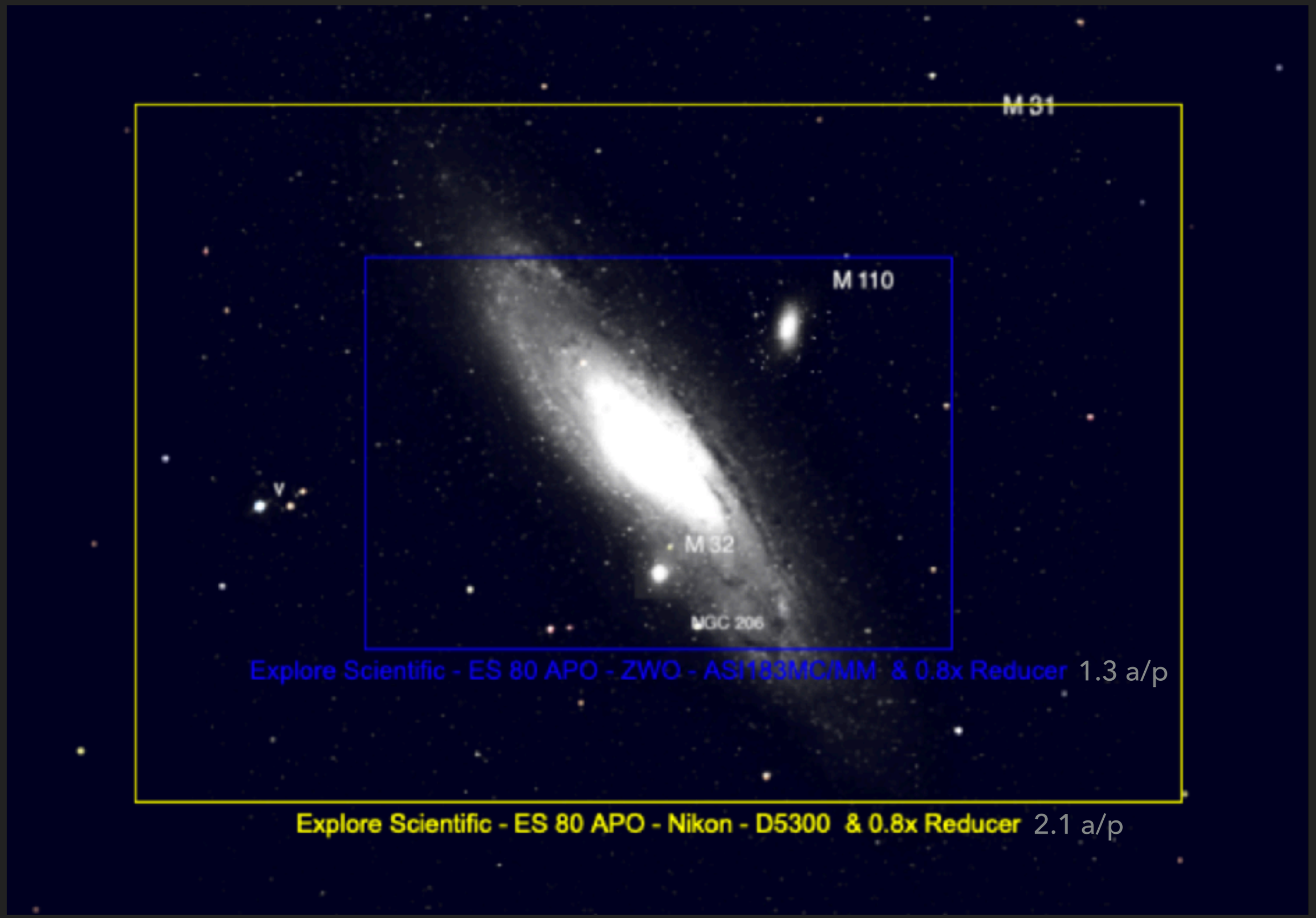
- Used 8300-based CCD
  - QHY9
  - SBIG ST-8300
- $800ish
- BUT - need to remember
  - Need filters
  - Filter wheel
  - Guider

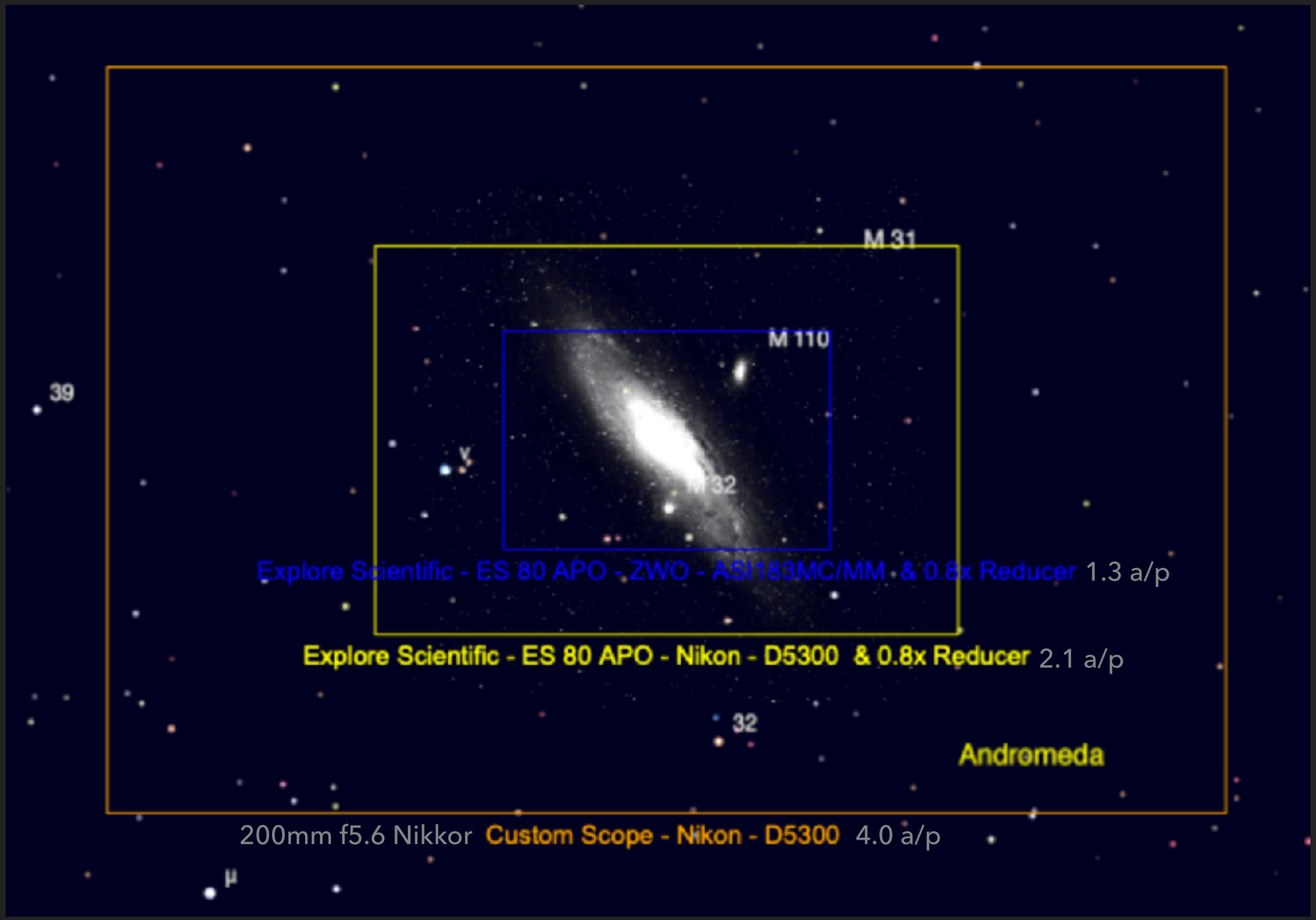
UNDERSTANDING IMAGE SCALE

- Defined as the number of arc seconds of sky recorded per pixel.
  - pixel size (microns) x 206.3 /focal length in mm = image scale in arcsec/pixel
- Proper sampling: Each star should be recorded over 3-4 pixels.
- Seeing (sky clarity) defines size of star (point spread)
- Our skies are usually 2-4, so each star, at best, is 2-4 arc-seconds in size.
- For proper sampling, we need a maximum of a .66 image scale, or each pixel recording .66 arc-sec of sky
- Proper scale is hard to achieve - software can help (drizzle algorithm)


13
17
NG
14
M 27
12
Celestron - C8 EDGE HD - Nikon - D5300 & 0.7x Reducer .57 a/p
Astro Tech - AT8IN - Nikon - D5300 1.1 a/p
Explore Scientific - ES 80 APO - Nikon - D5300 1.6 a/p
Explore Scientific - ES 80 APO - Nikon - D5300 & 0.8x Reducer 2.1 a/p


M 31
M 110
M 32
NGC 205
Celestron - C8 EDGE HD - Nikon - D5300 & 0.7x Reducer
Astro Tech - AT8IN - Nikon - D5300
Explore Scientific - ES 80 APO - Nikon - D5300
Explore Scientific - ES 80 APO - Nikon - D5300 & 0.8x Reducer


M 31
M 110
M 32
NGC 206
Explore Scientific - ES 80 APO - ZWO - ASI183MC/MM & 0.8x Reducer 1.3 a/p
Explore Scientific - ES 80 APO - Nikon - D5300 & 0.8x Reducer 2.1 a/p



Explore Scientific - ES 80 APO - ZWO - ASI183MC/MM & 0.8x Reducer 1.3 a/p

Explore Scientific - ES 80 APO - Nikon - D5300 & 0.8x Reducer 2.1 a/p

200mm f5.6 Nikkor Custom Scope - Nikon - D5300 4.0 a/p

THE IMAGING TRAIN

OFF AXIS GUIDERS

OAG

- Most important measure is width
- Otherwise, they are fairly similar
- Should be in front of filter wheel
- Eliminated flexure issues
- Saves weight/bulk

- **Guiders** - the more sensitive the better
  - Lodestar X2
  - Star Shoot Auto-Guider
  - STi
  - QHY5-III

THE IMAGING TRAIN

FILTER WHEELS

FILTER WHEELS

- Again, width will define options
- 5,7,9,11
- What size filters do you need? What size is the sensor?
- Compatible with your Software?
- Insure proper connections with camera and OAG
- L,R,G,B,Ha,Oiii,Sii,Nii,Hb,IDAS, Black?, Moon?,


QSI
PATENT PENDING

ADAPTERS/SPACERS

- Millimeters matter
- Know your needs - 42mm? 48? T? C?
- Try to plan to have mm's left over - and fill in with spacers
- Worst comes to worst: Precise Parts
- Stellarvue - great source of spacers
- Threaded connections are best

- Required back focus = x-adapter+OAG+FW+back-spacing of sensor

USED EQUIPMENT

- Typically 20-40%off new - often for perfect condition
- Prices stable (unless new model/technology), so can sell for purchase price - more or less.
- Most active sites:
  - Cloudy Nights - I’ve bought many things - never a bad experience; huge volume
  - Astromart - small yearly fee, tend to see higher quality gear
  - astrobuysell.com - Canada-based site.
  - Sky and Telescope Marketplace - pretty dead

SOFTWARE

- Most are platform dependent
- Free, or almost, Capture Software
  - Kstars/Ekos - all platforms - free, open source
  - https://nighttime-imaging.eu - N.I.N.A. - free, os
  - Sharpcap - PC ($10/yr)
  - BackYard EOS/Nikon ($50)
  - Nebulosity 4 ($95) plus PHD2 (free guiding software)
  - Not free: Voyager, Sequence Generator Pro, The Sky X
- Free, or almost, Processing Software
  - Deep Sky Stacker (free) and GIMP (free photoshop)
  - Star Tools ($50)
  - Astro Pixel Processor ($150)
- PixInsight: $250

MAKING CHOICES

- First: What do you want to accomplish?
  - Planetary/Moon
  - Bright Objects
  - Deep Sky
- What equipment do you already have?
- Scope/lens: Start with something **less than 600mm** focal length and **F/4-f/6**.
- Make sure to look at image scale, esp. if you are not heavily into post processing (Try to stay **under 1arc-sec/pixel**)
- Choose bright objects and short exposures to start
  - Test your system to see when star trails start to appear
- Do research and ask questions - some equipment is notoriously frustrating.

THE IMAGING TRAIN

ASTROPHOTOGRAPHY