Observation Planning

What goes in to planning an observation?

- Determine the science goal and the measurements needed for that goal
- Select the targets and the telescope
- Determine when the target can be observed
- Plan out the observations

Planning your measurements

- To plan a measurement, you need a question in mind
- pick a telescope and an instrument capable of answering that question
    - determine whether the instrument is sensitive enough to do the measurement (we’ll address this more later in the semester)
- plan out a night so you know how much time to request

Can a target be observed?

- In order of importance:

1. Is the target up? (above the horizon, not behind a tree)

2. Is the moon in the way, or nearby? (the moon increases the sky brightness & background and scatters light into the telescope)

3. Is the weather good? (you can only assess this on the day of, but you can often find weather statistics for a given site and time of year to know how likely it is that the weather will cooperate)

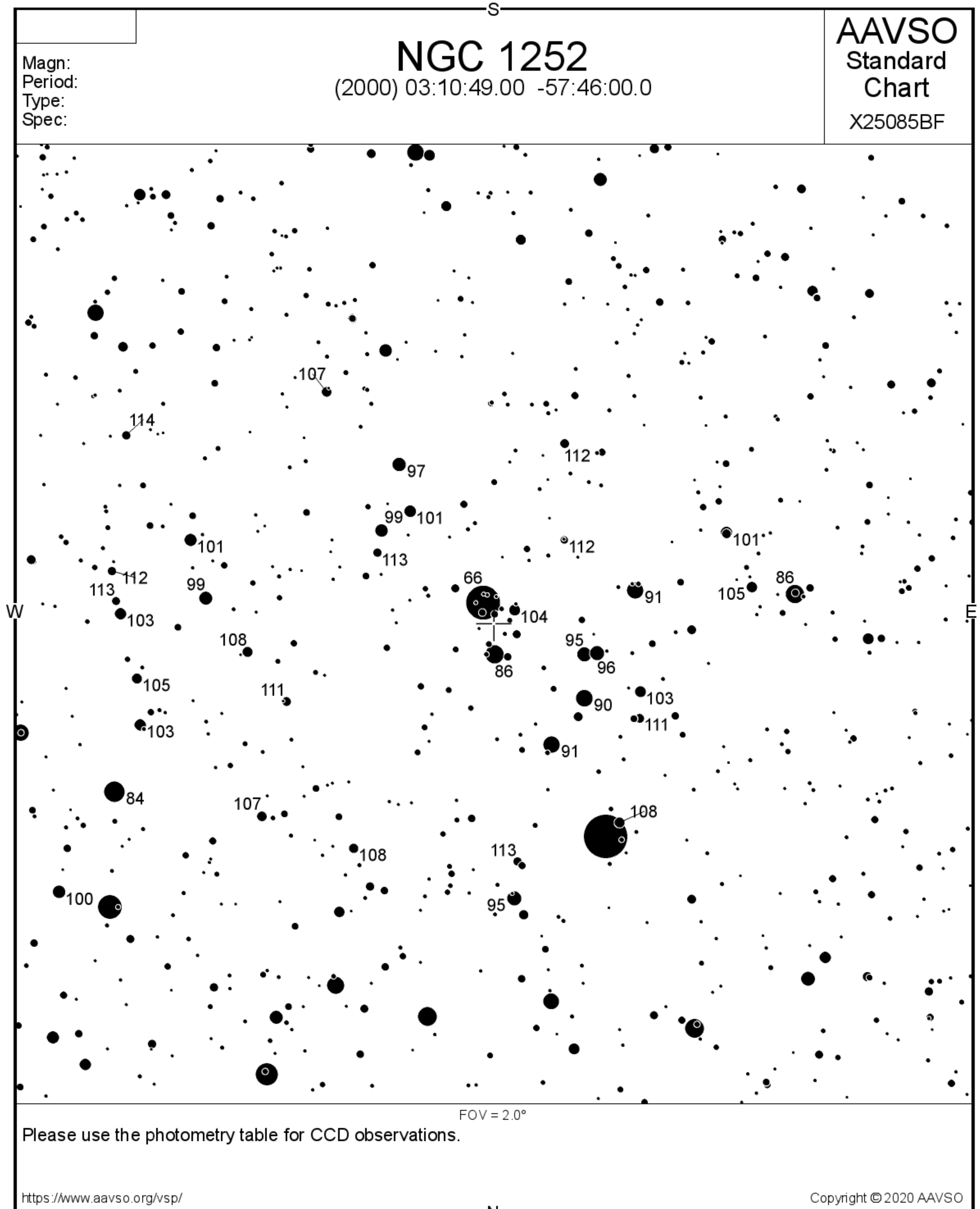
Plan out the night

- Pick your targets
- Figure out which ones to observe when: you want to observe every source as close to transit as possible (with an equatorial mount telescope)
- Plan out the amount of time for each step:
  - Telescope setup
  - Flats, Biases, & Darks (coming soon)
  - Target acquisition
  - Integration

Target Acquisition: Finder Charts

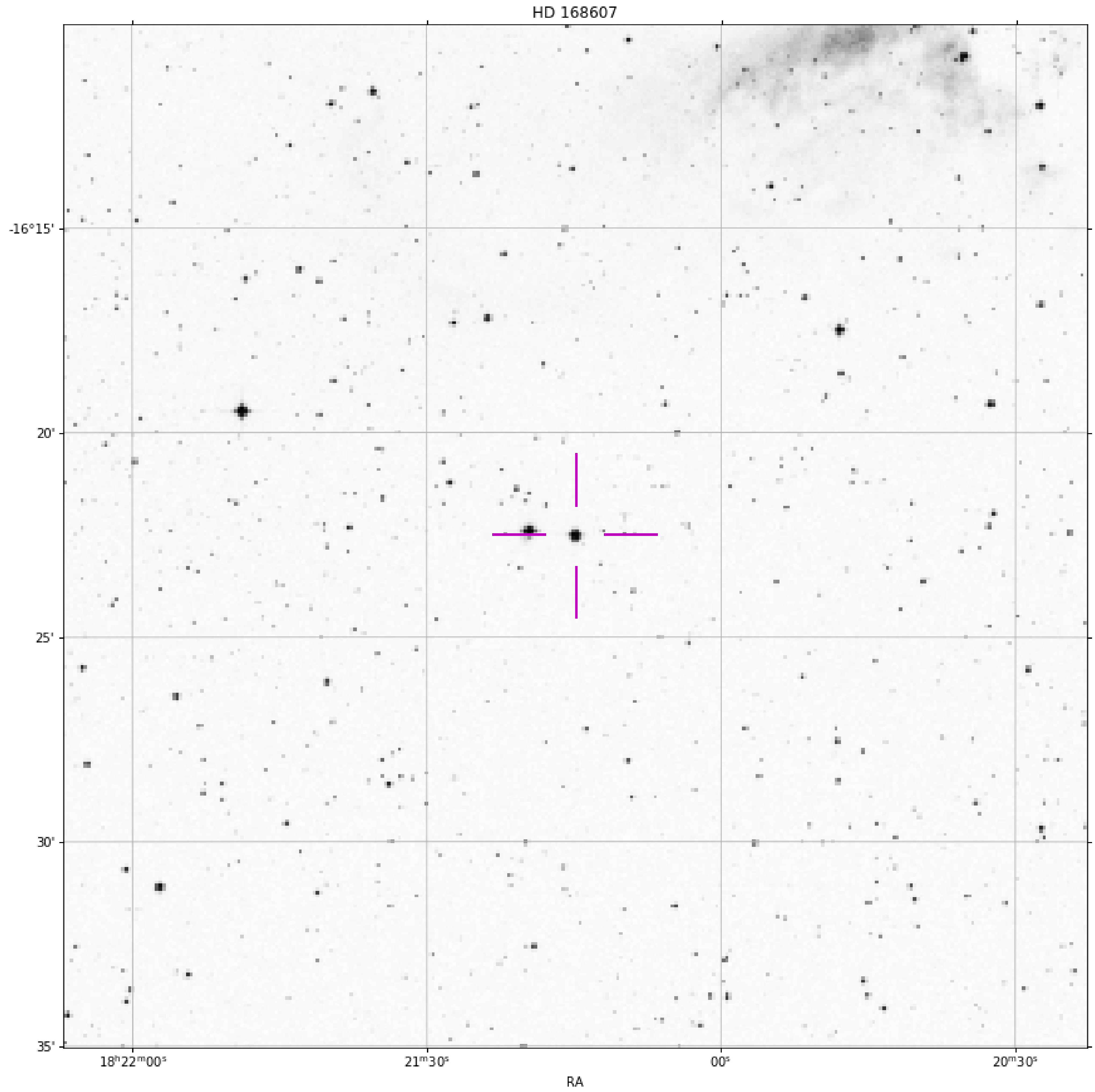
- Finding your targets by eye means identifying known sources that are bright enough, usually using a star chart
- With a CCD, we can see much fainter stars, so we need a much more complete star chart
- Finder Charts are archival images of a given part of the sky. Since stars stay approximately put, we can use images taken any time in the last 50-100 years to give us a sense of what a given area will look like

Finder charts can either be plots of catalogs, where the dot size is proportional to the star brightness…

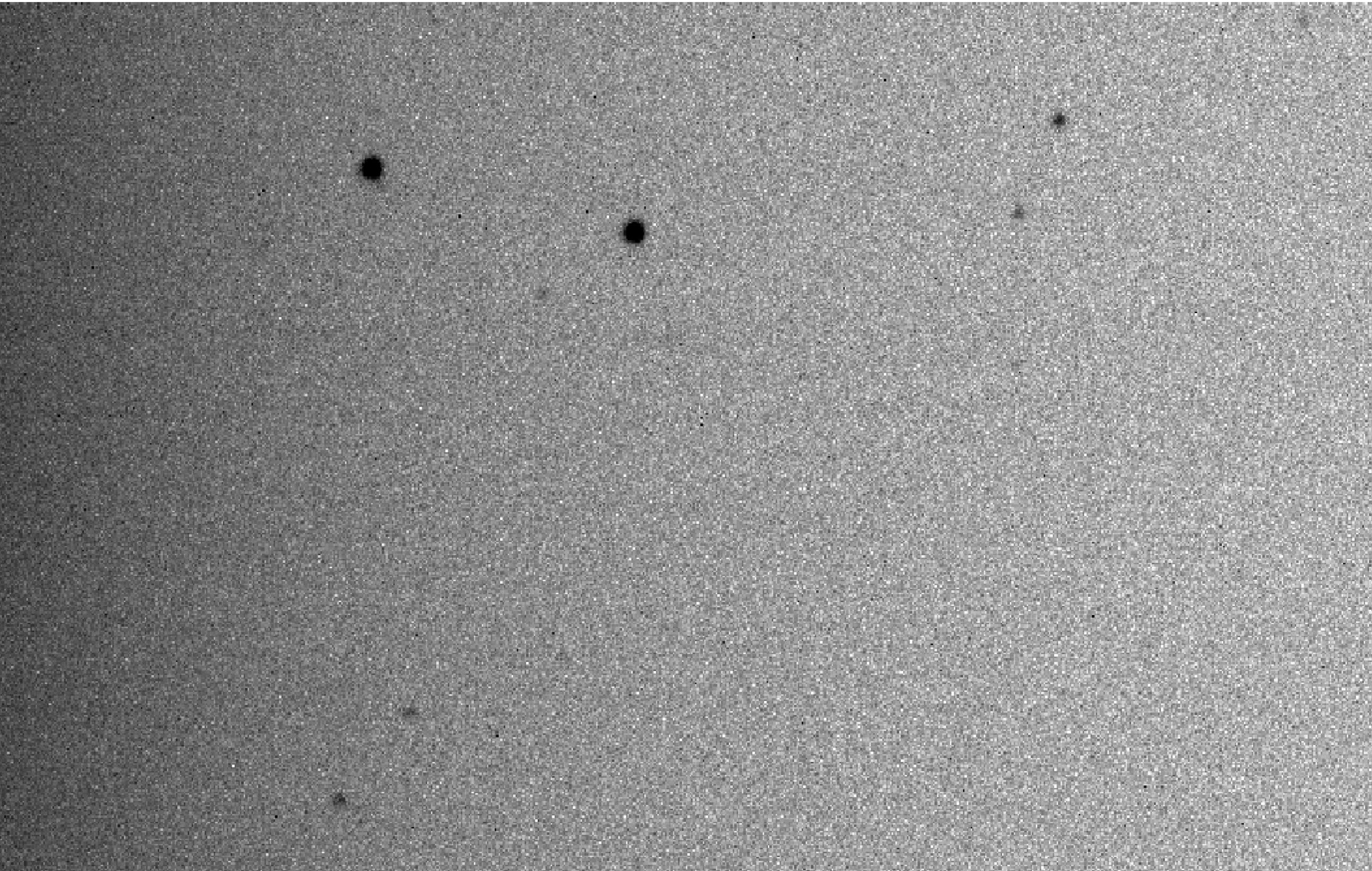


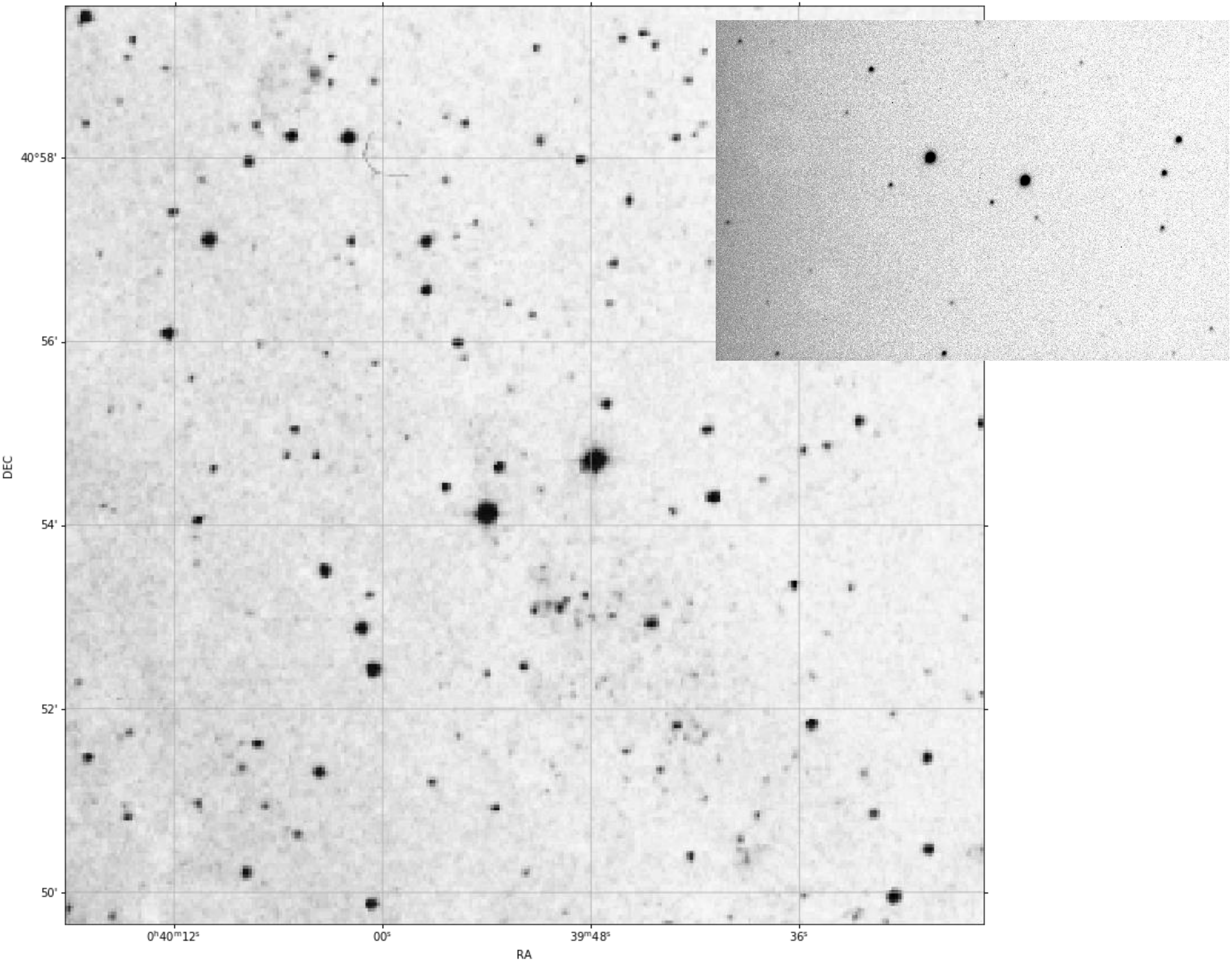
…or they can be an image of the sky in the optical, showing what a real image looks like

To use these, you match patterns on the sky. Sometimes this can be very tricky, as your field-of-view may be different from the finder chart, and your orientation can be the wrong direction.

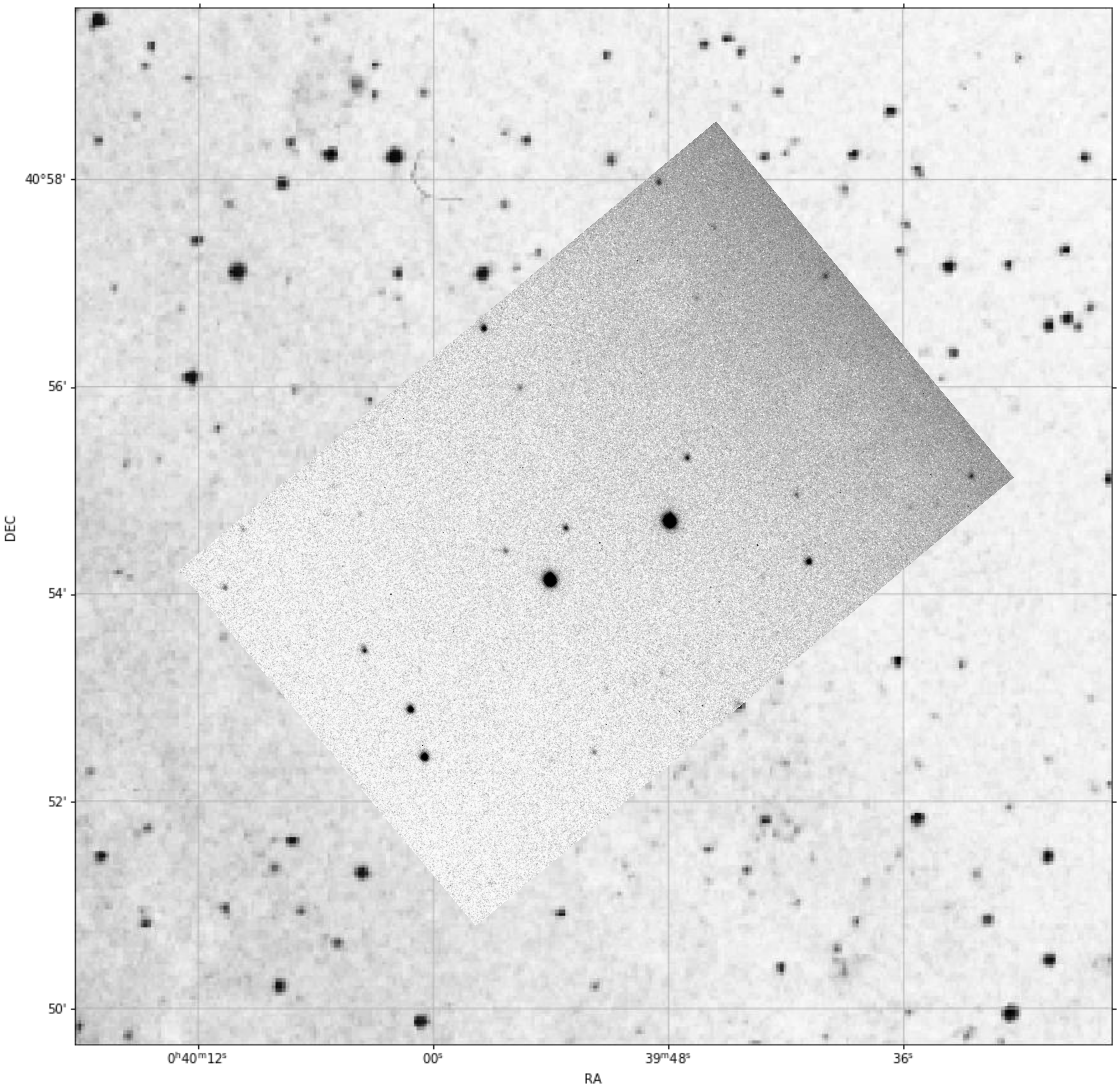


Real images are not as clean as finder chart images





40°58'
56'
54'
52'
50'
DEC
0h40m12s
00s
39m48s
36s
RA



40°58'
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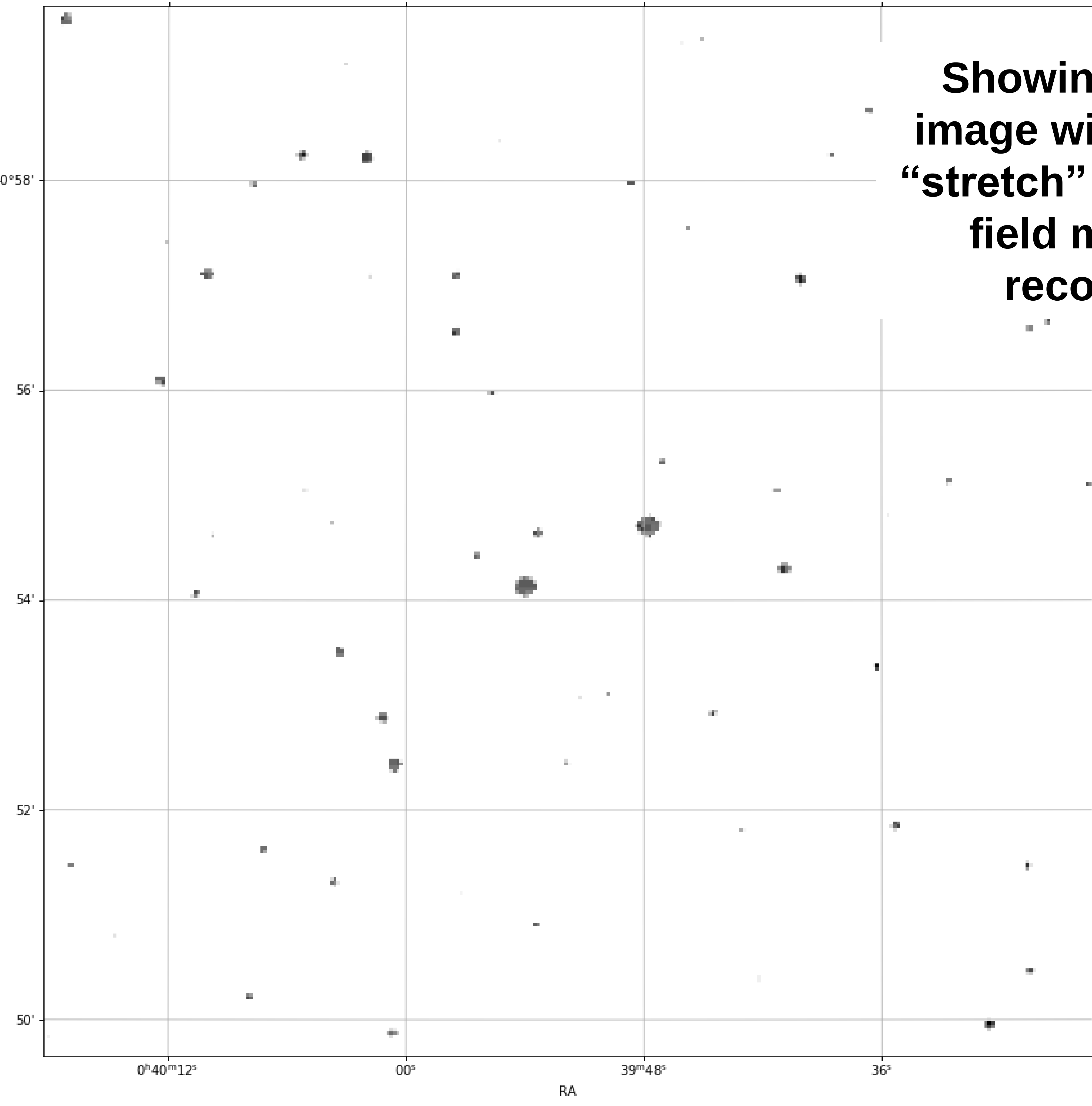
50'
DEC
0h40m12s
00s
39m48s
36s
RA

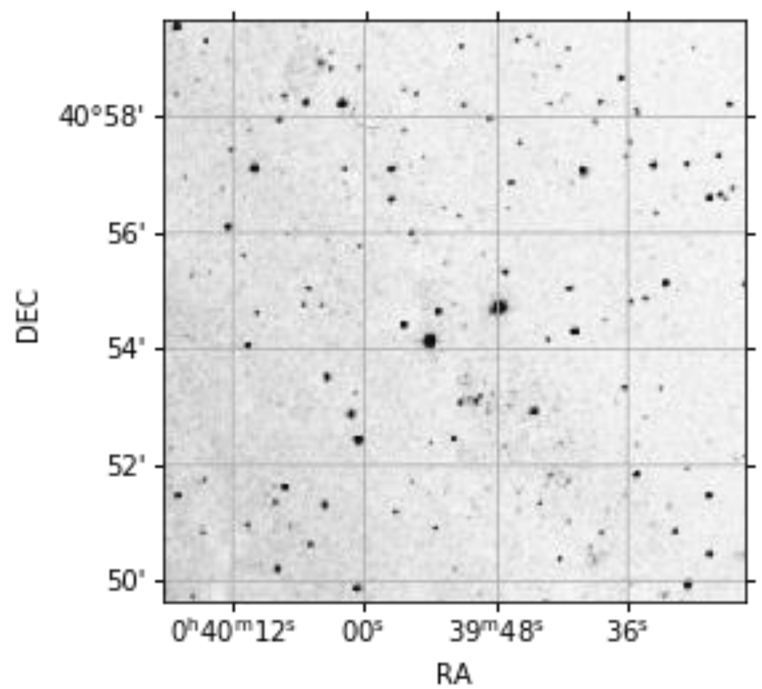
Tips for target acquisition

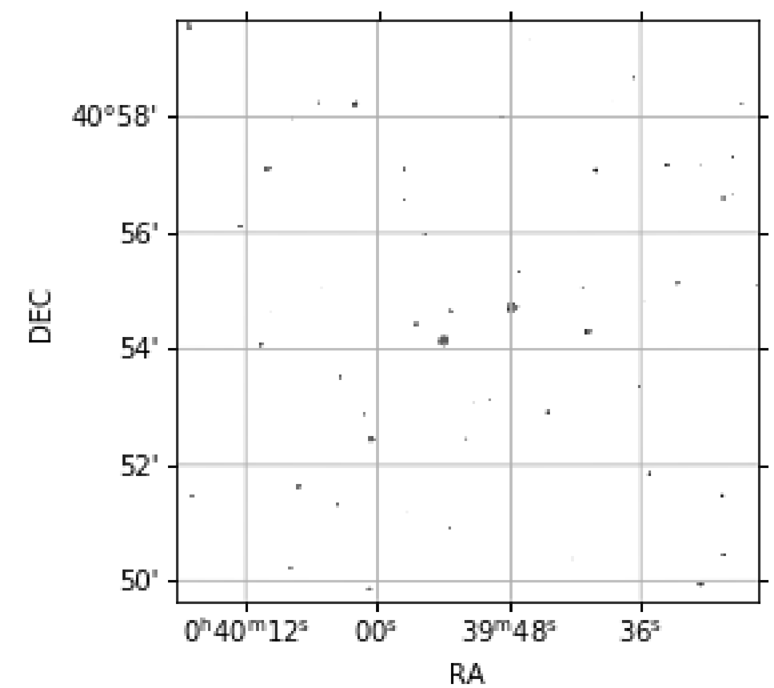
- Use the clear filter
- Verify your focus on a bright star (out of focus images might look like there's nothing there)
- Verify the angle of your field on a known source
- Re-scale your finder image to show only stars you're likely to detect (this can be tricky)
- Know the size of your field-of-view on the finder chart

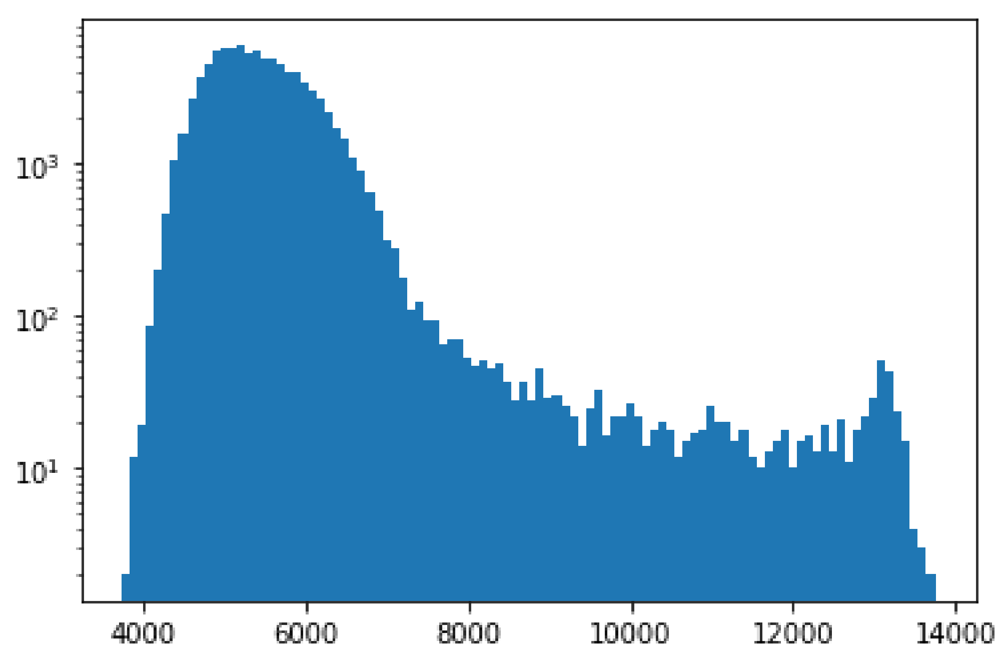


Showing the finder image with a different “stretch” can make the field much more recognizable

See “RescalingAFinderChart.ipynb” for instructions on how to do this.



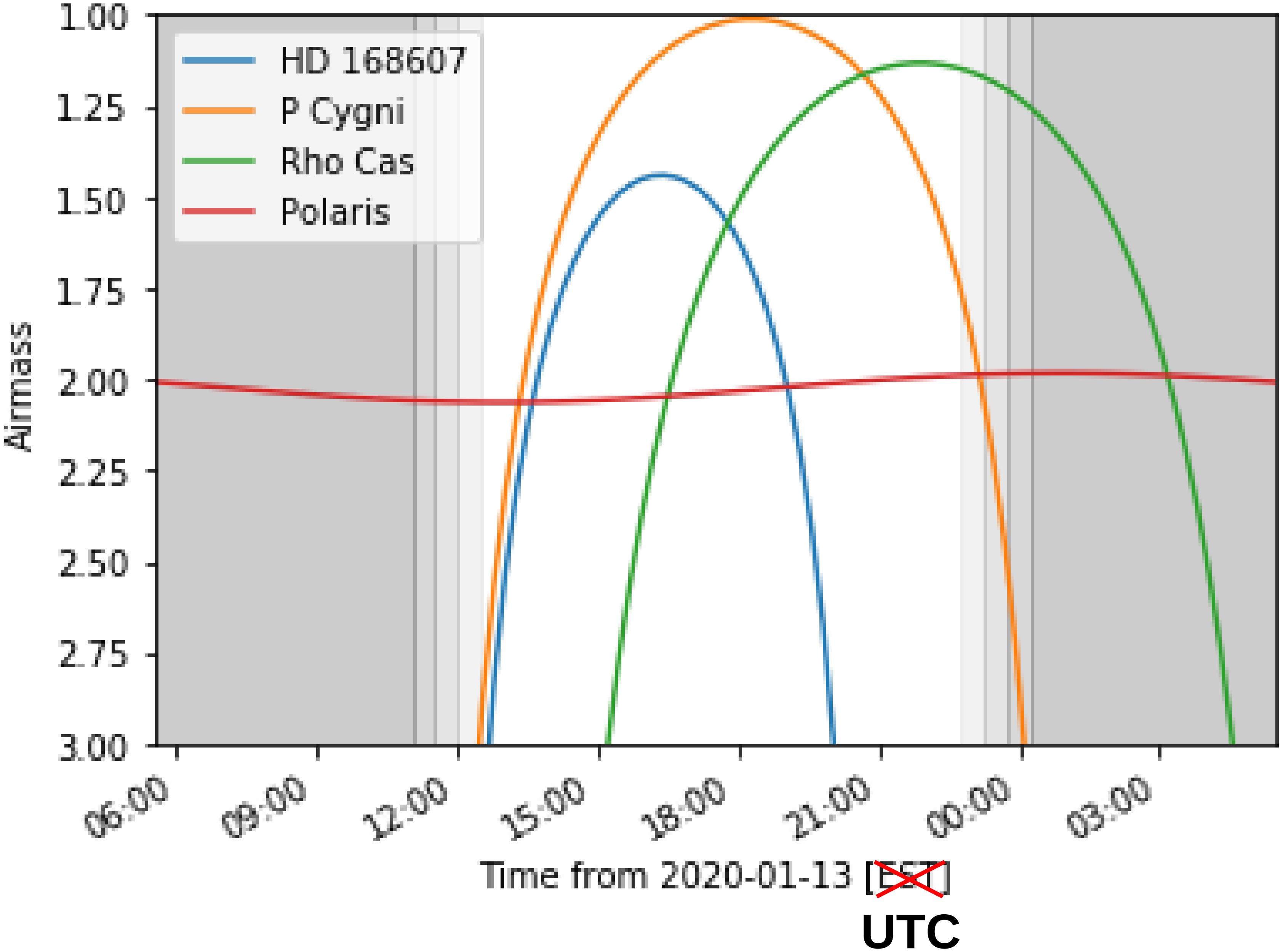




Airmass (Altitude) Plots

- Airmass plots show you which targets are observable when

- You want to observe objects as close to zenith as possible, with the lowest airmass (highest elevation)

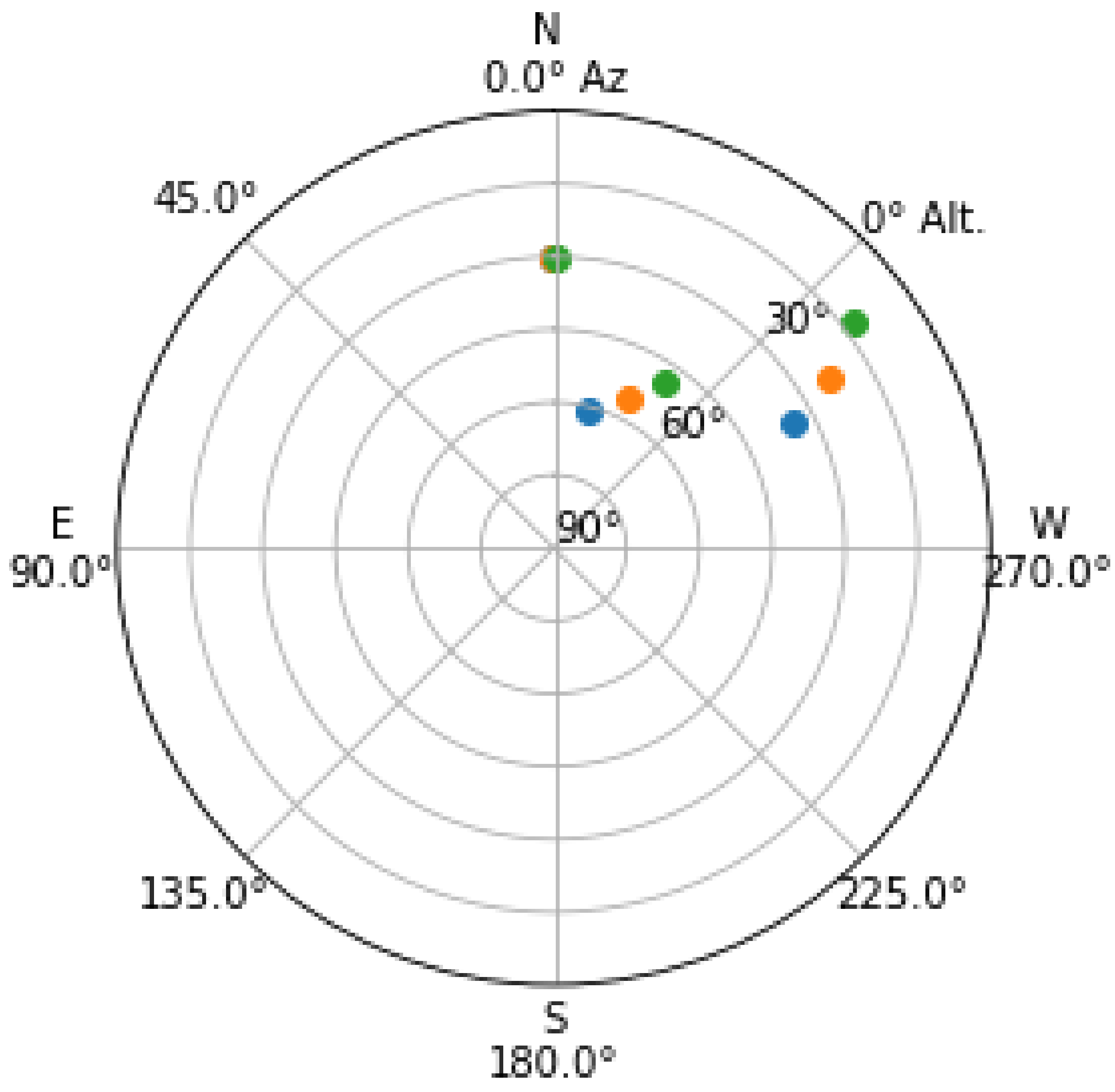


Airmass <-> Altitude

- Airmass tells you approximately how much atmosphere there is along the line of sight *relative to* straight up
- Zenith Angle ZA = 1-elevation
- Airmass = 1 / cosine(za)
- Object straight up: zenith angle ZA = 0°, elevation=90°, airmass=1
- Object at 60° za (30° elevation) has airmass=2

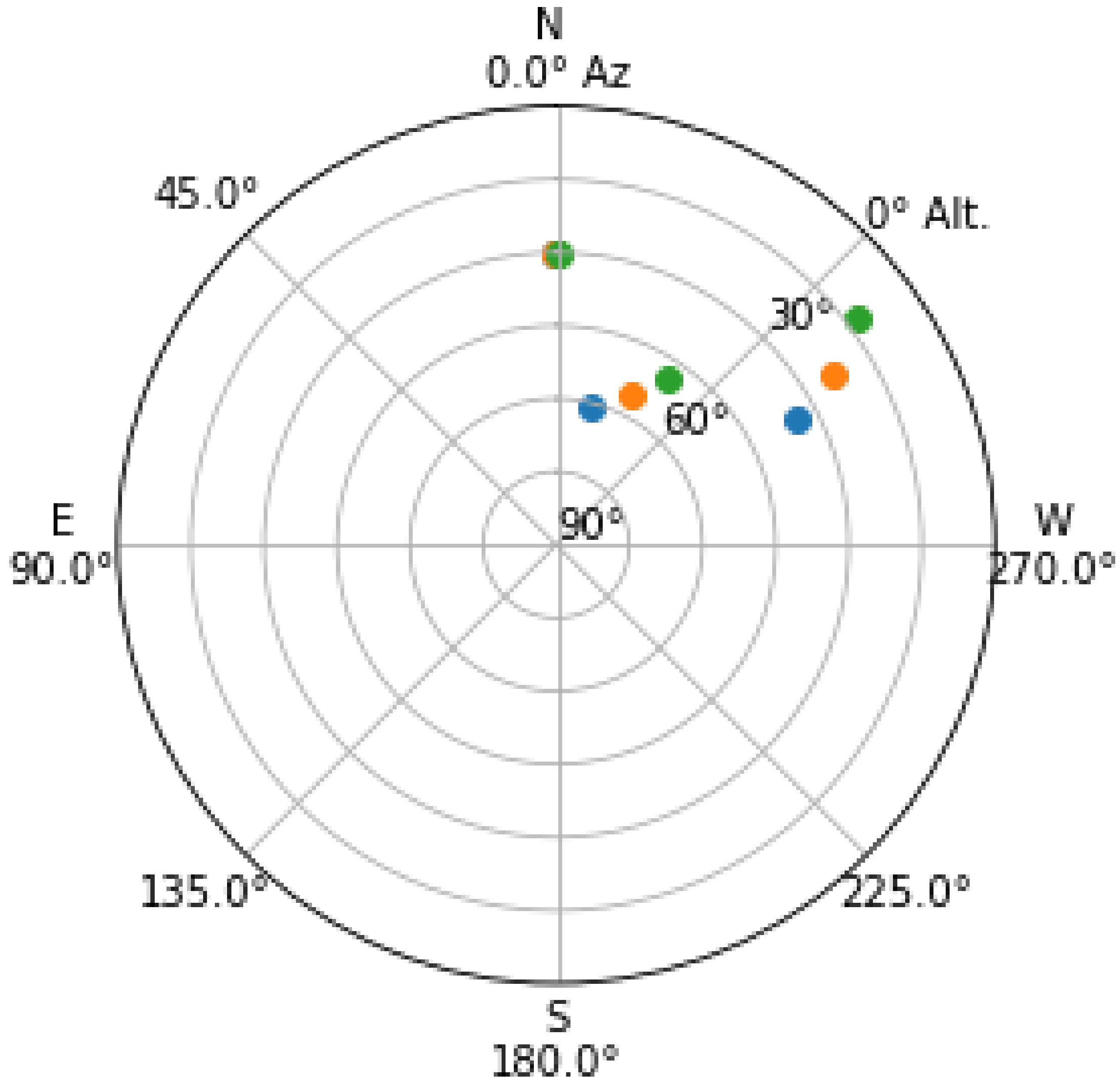
Sky Charts

- You can also make “sky charts” like this polar plot, which shows the sky from your perspective - where are your targets relative to you? You can use charts like this to compare to cloud maps to make sure you’re pointing in a reasonable direction
- The points in this plot are shown at three different times. Why is one of them stationary?



Sky Charts

- What parts of the sky are unobservable? Are there some that are always unobservable?



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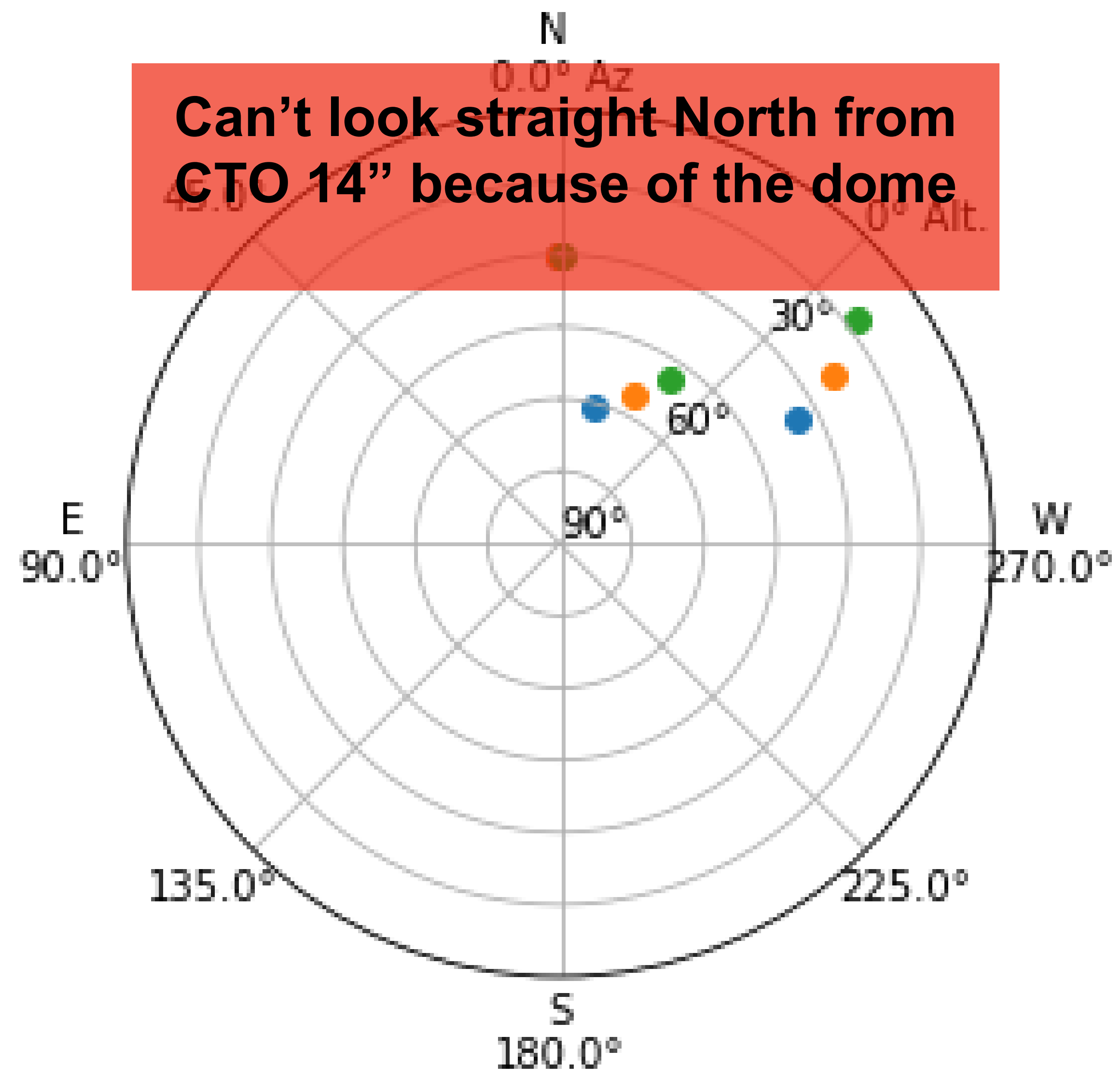

Can’t look straight North from CTO 14” because of the dome

Finding out more about your tools

- Most of the planning tools are found in the astroplan library:
  https://astroplan.readthedocs.io/en/latest/

- You will use these three often:
  `plot_finder_image`
  `plot_sky`
  `plot_airmass`

Planning out the night

Night Plan

18:00 1. – Set up 12 inch telescope on one of the south spots.

18:45 2. – Calibrate telescope to Capella and then pick Rigel as a star to test tracking.

19:20 3. – Target and track HD23432 and then take 5, 3 second images in 3 filters.

19:55 4. - Target and track HD47240 and then take 5, 4 second images in 3 filters.

20:30 5. - Target and track M1 (mv=8.4) and then take 5, 30 second images in 3 filters.

21:15 6. - Target and track M37 and then take 5, 3 second images in 3 filters.

21:50 7. - Target and track M44 and then take 5, 2 second images in 3 filters.

22:20 8. - Target and track M81 and then take 5, 20 second images in 3 filters.

22:50 9. – Take images of dark sky in N,W,E and take darks and flats.

23:30 10. – Put telescope away and check data.

Copy data onto flash drive, or e-mail it to self

Telescope Setup

- DetailedTelescopeOperations.pdf describes how to set up the scopes
- For the 12” and 14” Meade telescopes (used by Group 1 & 2 last night), the operations are the same
- Alignment and focus are critical
- What happens if you don’t get a good alignment solution at the start of the night?

Target Acquisition

- From the detailed instructions:
  “**Important note:**
  In order to find and center an object, do it with the eyepiece first. Once you have it in the center of the eyepiece, you can remove the eyepiece and insert the CCD camera and center and focus the object in the field of the camera. The field of view of the camera is small and you can waste a lot of time (and go to a lot of frustration) trying to find the object with the camera. Very likely, after you hit the GOTO button to slew to the object, it will not show up in the field of the camera. DO NOT try to find the object by inserting the camera and start taking images first. Do this using the eyepiece.“

- Take this advice as far as you want; sometimes it’s better to be lucky than good….

Prepping for Lab 2: Photometry

- Our present goal is to plan, set up, and complete an observation for Lab 2: Photometry

- Photometry is how we measure light from stars and other point sources. We count photons of some color.

What can you do with photometry?

- Measure stellar (or galaxy) flux
- Measure object color
- Create color-color and color-magnitude diagrams
- Measure *variations* in object luminosity & color
- From the above comes the vast majority of modern astrophysics

Color-Magnitude Diagram

What sorts of targets are good for the photometry project?

- Stars
- Multiple star systems (binaries, triples, etc)
- Stellar clusters (but generally not globular clusters)
- Variable stars

What are important considerations for target selection?

- Are the targets up this season?
- Are they bright enough to observe?
  - We will have to figure out what our *limiting magnitude* is at CTO
- Are they *faint* enough to observe?
  - The brightest stars in the sky may saturate the detectors!

Where can I find interesting targets (for CTO)?

- Messier catalogue: 110 bright objects. For photometry, exclude the resolved ones
- The AAVSO (American Association of Variable Star Observers) website: https://www.aavso.org/, especially the “target tool”

Lab 2 has (mostly) pre-selected targets

- M 33: Galaxy, well-resolved. Not a great photometry target, but it looks cool.
- NGC 869: an open cluster, good for making a color-magnitude diagram
- Gamma Andromedae: a very bright multiple star system
  - This system may be too bright to observe! However, it's great to point at if there are clouds.
- We need to include standard star fields. Select any field from this list: https://www.aavso.org/apps/vsd/stdfields
- Add your own targets if you like. Betelgeuse would be interesting.

AAVSO standard star fields

Id ▲▼	Name ▲▼	RA ▲▼	Dec ▲	Fov ▲▼	Count ▲▼
4014	GD 421	2	70	15	5
4061	PG1343+578	14	60	15	2
4051	GD 314	12	60	15	6
1006	NGC 7790	24	60	20	218
4075	PG1648+536	17	55	15	5
4052	PG1210+533	12	55	15	3
4033	GD 299	10	55	10	1
4031	PG0846+558	9	55	15	3
4013	GD 278	2	55	15	3
4060	GD 325	14	50	15	4
4042	GD 300	10	50	15	3
4041	PG0943+521	10	50	15	2
4011	GD 277	1	50	15	3
4010	GD 275	1	50	15	2
4087	GD 405	23	45	15	2
4086	SA41 SF2	22	45	15	5
4085	SA41 SF1	22	45	15	8
4084	SA41	22	45	30	13
4082	SA38 SF4	19	45	15	7
4081	SA38 SF3	19	45	15	4

Photometry: Calibration

- Calibration is critical for photometric measurement
- Many things affect how much light from our targets makes it onto the CCD, including: atmosphere, telescope, filters, CCD properties, etc.
- Most of these can be partially or entirely accounted for by doing differential photometry, i.e., comparing your measurement to the measurement of a target with known properties

How is observation preparation different for different telescopes?

- At professional observatories, visiting astronomers do not have to set up the telescopes themselves; instead, telescope operators do it

- Observation plans must be extremely precise, often down to the second: in *queue mode* observing, the telescope operator supervises an automated script that performs sequential observations

- Calibrations may be done as a standard batch at the beginning or end of the night