Planning an observing run

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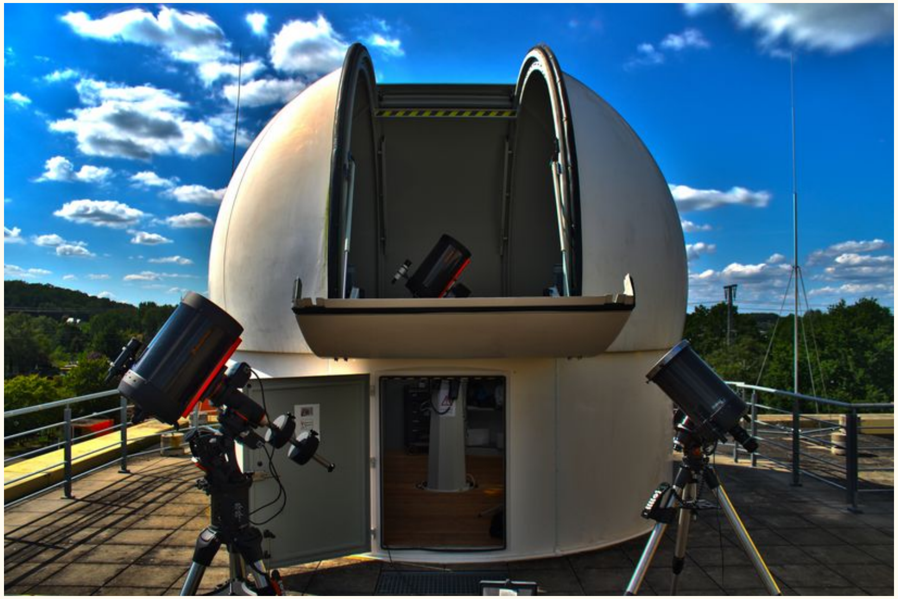
Research workshop on evolved stars
02.09.2019

Overview

1. Obtaining telescope time
2. Creating your target list (will be covered in another lecture!)
3. Preparing your run
    a. Target visibility
    b. Finding charts
    c. Instrument setup
    d. Weather constraints
    e. Exposure times



Obtaining telescope time

- Telescope time can be obtained by writing **observing proposals.**
- Depending on your home institution, you have access to different facilities.
- The more friends you have in different places, the more telescopes you can access!

We have access mainly to the European Southern Observatory (**ESO**) telescopes.

Credit: ESO/Y. Beletsky

ESO

- Two sites: La Silla and Paranal (both in Chile – **why?**)
- 2 to 8-meter class telescopes
- A wide range of instruments available: **photometry**, **spectroscopy**, interferometry, polarimetry.

The structure of an observing proposal

- **Title** – concise, yet informative

Spectra for Hot Subdwarf Stars ❌

The **First Volume-limited Complete** Catalogue of Hot Subdwarf Stars ✅

- **Abstract** – what is the question, why is it important, how are the observations going to help answering it.
- **Scientific justification** – scientific background leading to your question, further details of its importance.
- **Immediate objective** – which kind of data will you obtain and **how** you will use the observations to reach your goal.
- **Technical justification** – telescope and instrument setup.
- **Weather requirements** – worst conditions in which your observations can be done.

The structure of an observing proposal

- **Target list** – not necessarily definitive
- **Previous use of facilities**
- **Publications**
- **Public Survey Duplications**

I got time! Now what?

- **Observing modes:**
  - Visitor
  - Queue
  - Remote (not possible for ESO)
- **Visitor & Remote:** you know when the run is happening and execute it yourself.
- **Queue:** you further detail how you want the observations to be executed (**Phase 2**), and the resident astronomer will execute them when the conditions are suitable – weather, visibility, priority.

Target visibility

- What is the very first constraint to be taken into account?

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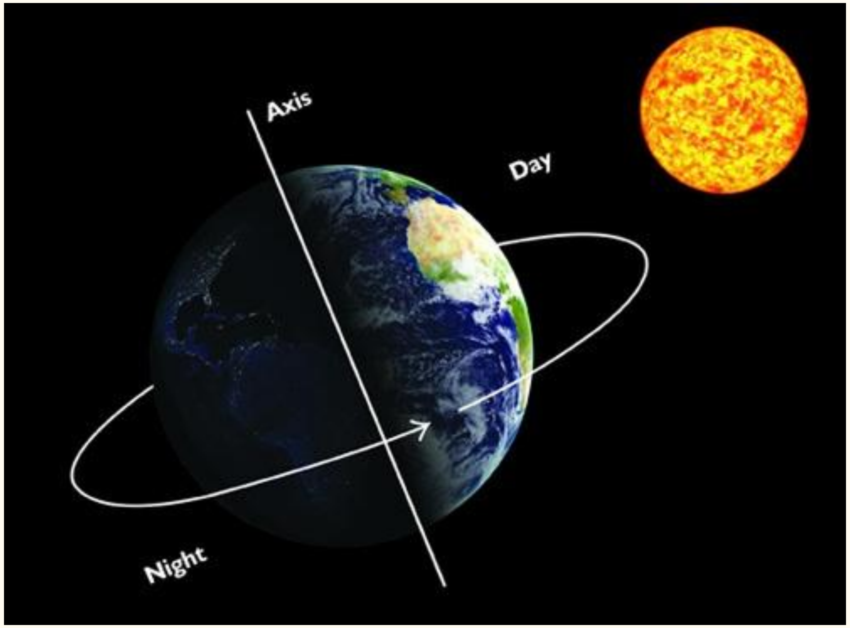
- This implies it has to be at the opposite direction of the Sun.



Celestial coordinate systems

- Analogous to the geographic coordinate system (i.e. latitude and longitude); allow us to specify positions of celestial objects.
- Defined by a fundamental plane (0° latitude) and a primary direction (0° longitude).
- E.g. for the geographic coordinate system:
  - Fundamental plane:
  - Primary direction:

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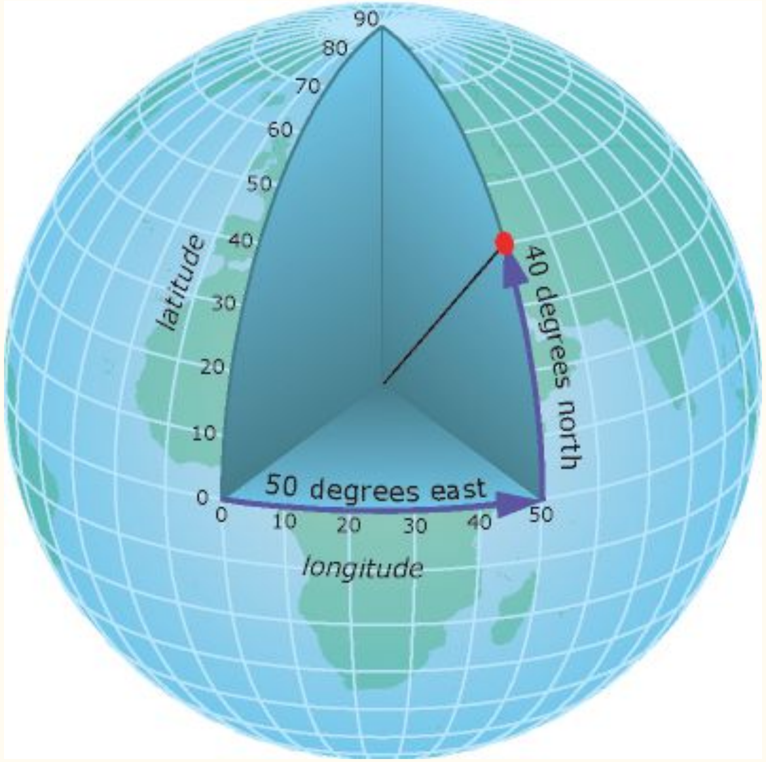
- E.g. for the geographic coordinate system:
  - Fundamental plane: Equator
  - Primary direction: Greenwich



Our campus: 52°24'36.2"N 12°58'30.1"E

Ondrejov 60cm: 49°54'53.3"N 14°46'46.6"E

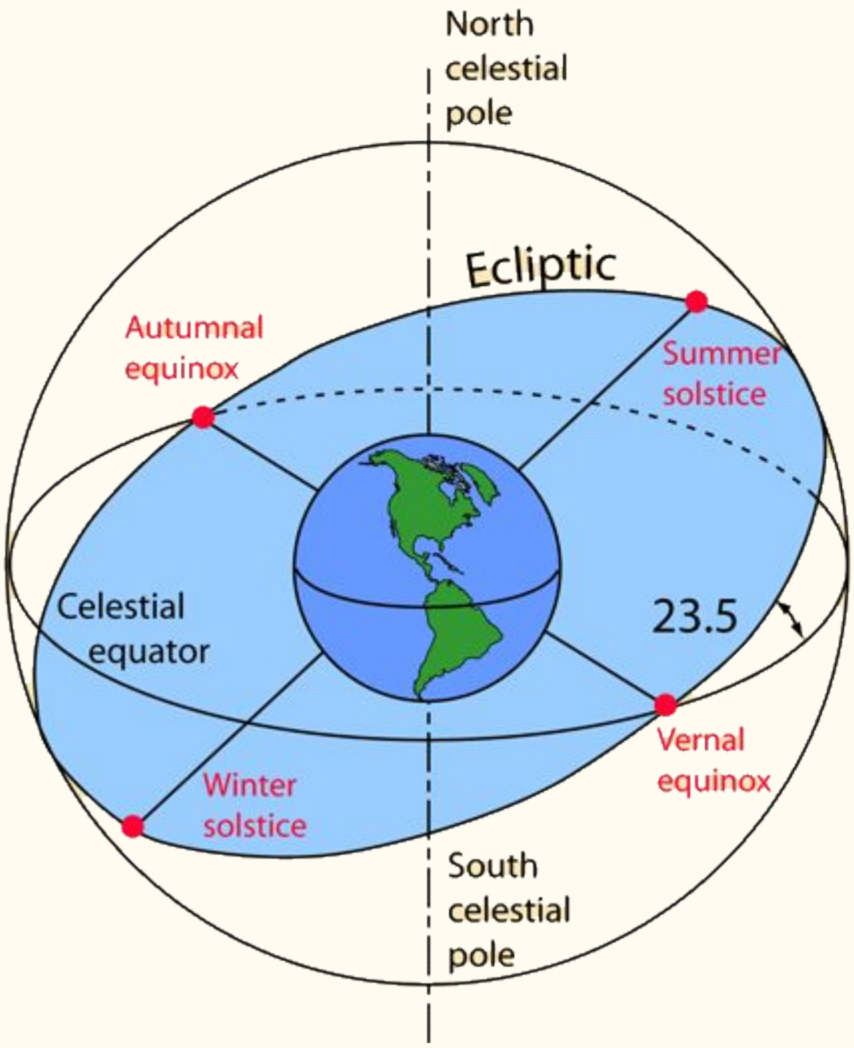
* 1°= 60' = 3600"

Celestial coordinate systems

System	Centre	Fundamental plane	Primary direction
Horizontal	Observer	Horizon	North
Equatorial	Earth	Celestial equator	Vernal equinox
Ecliptic	Earth	Ecliptic	Vernal equinox
Galactic	Sun	Galactic plane	Galactic Center

Equatorial coordinate system

- Celestial equator: simply the projection of the Earth's Equator on the Sky.
- Vernal equinox: intersection between the celestial equator and the ecliptic (= Sun's apparent path during the year) when the Sun leaves the Southern hemisphere.



Equatorial coordinate system

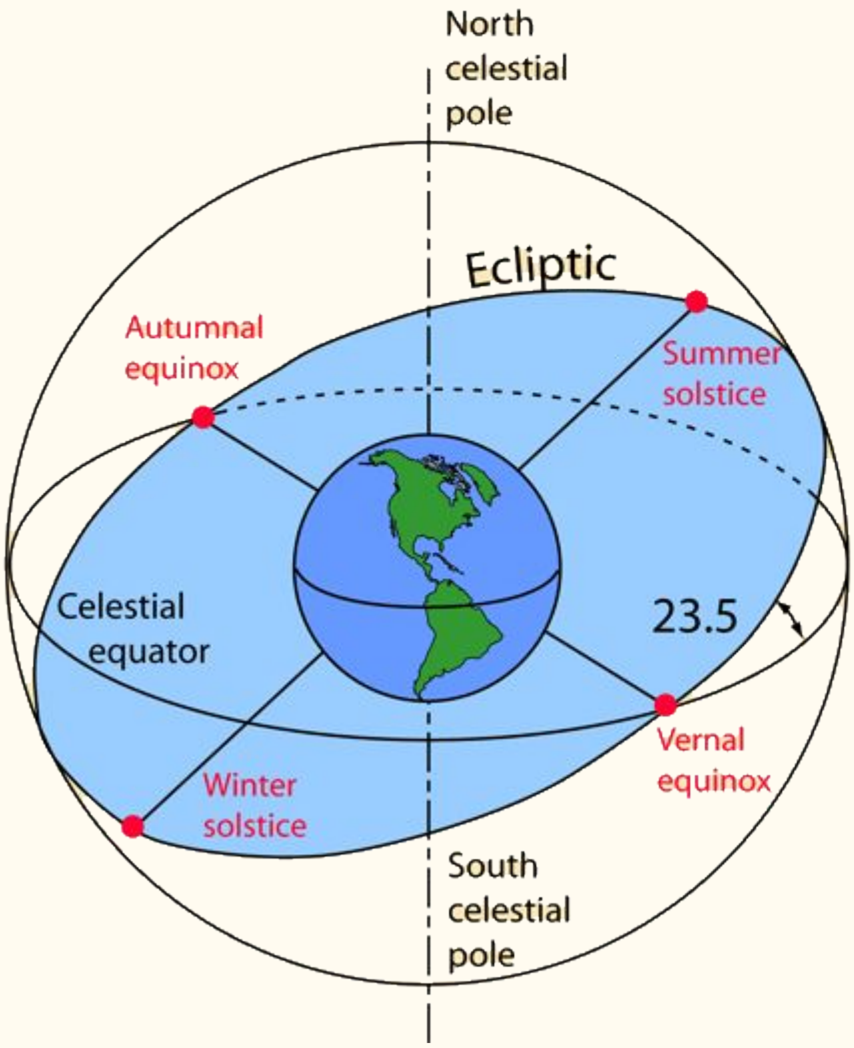
WARNING!

Because of the Earth's precession, the system is not exactly fixed!

Important to define the **epoch** of coordinates.

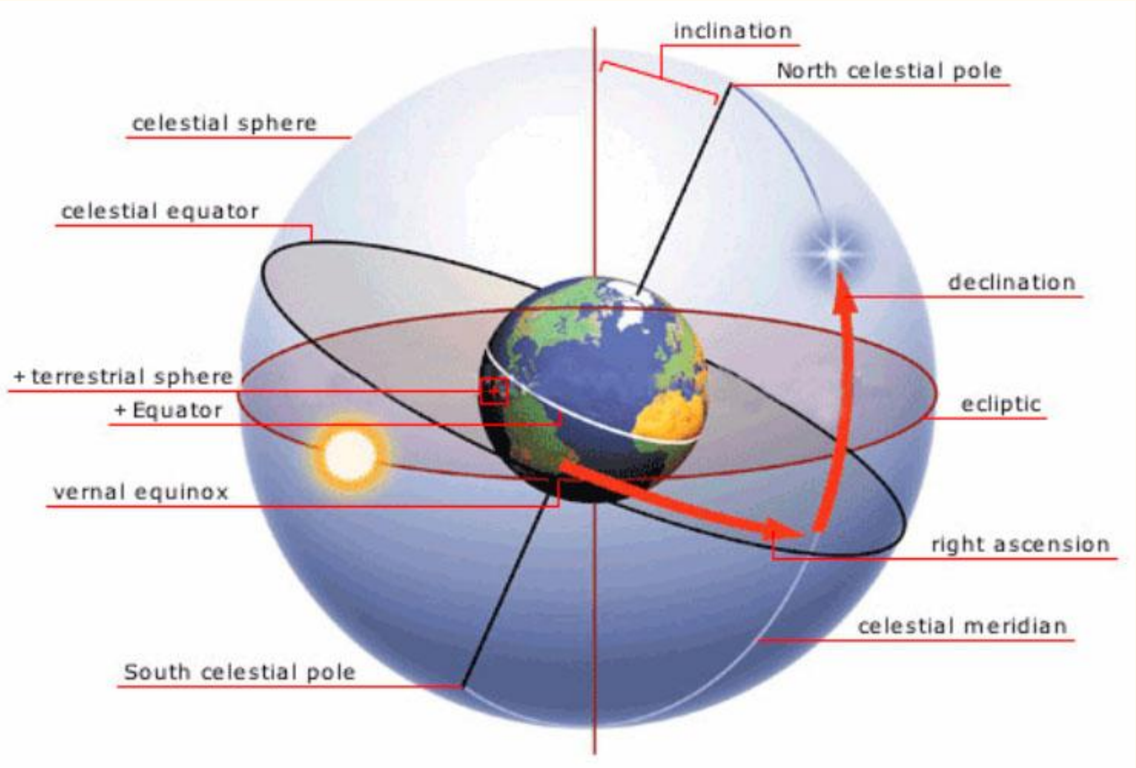
Usual: J2000.0

Gaia: J2015.5



Equatorial coordinate system

- Right-handed convention: coordinates increase northward from and eastward around the fundamental plane.



Coordinates are **right ascension** and **declination**

Equatorial coordinate system

- Right ascension and declination can be measured in degrees:

$$0° < \alpha < 360°,\ -90° < \delta < 90°$$

For example, HD49798: $\alpha = 102.02°$; $\delta = -44.32°$

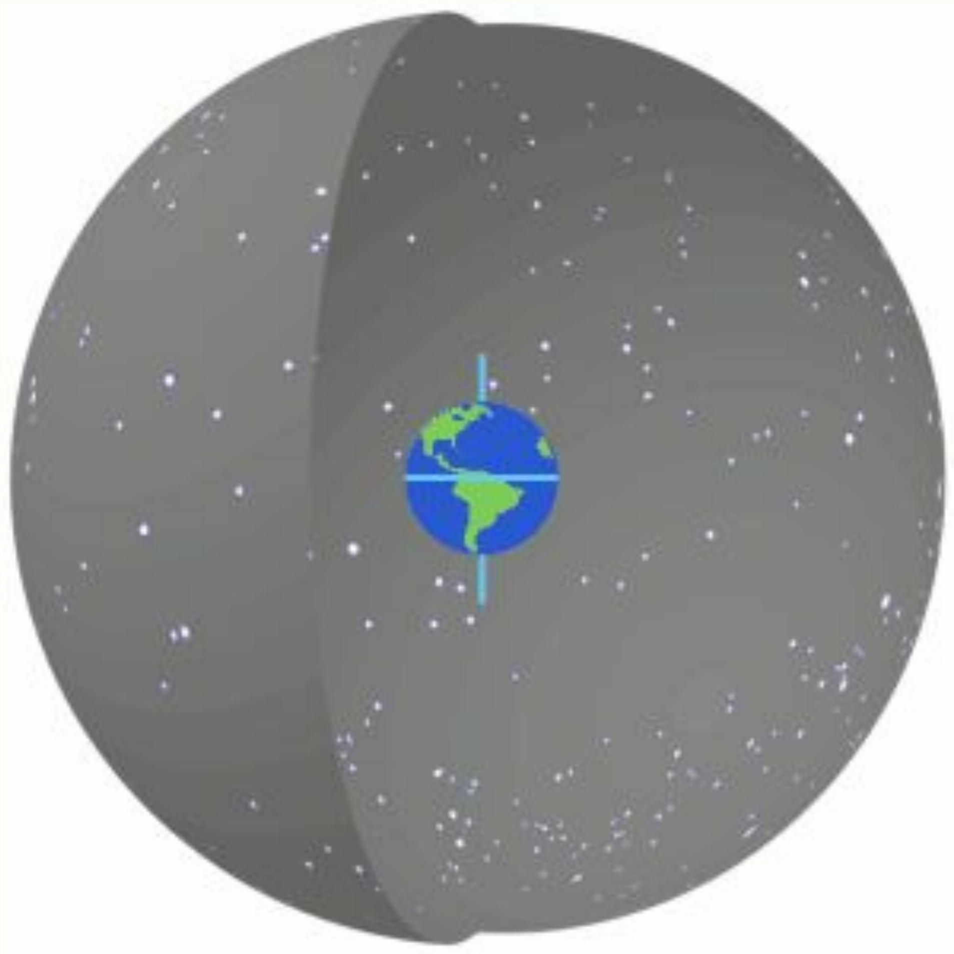
- More commonly, however, they are measured in HMS and DMS
  - HMS = hours-minutes-seconds; DMS = degrees-minutes-seconds

$$0 < \alpha < 24h,\ -90° < \delta < 90°$$

HD49798: $\alpha = 06{:}48{:}04.70$; $\delta = -44{:}18{:}58.4$

* 1° = 60' = 3600"

Equatorial coordinate system

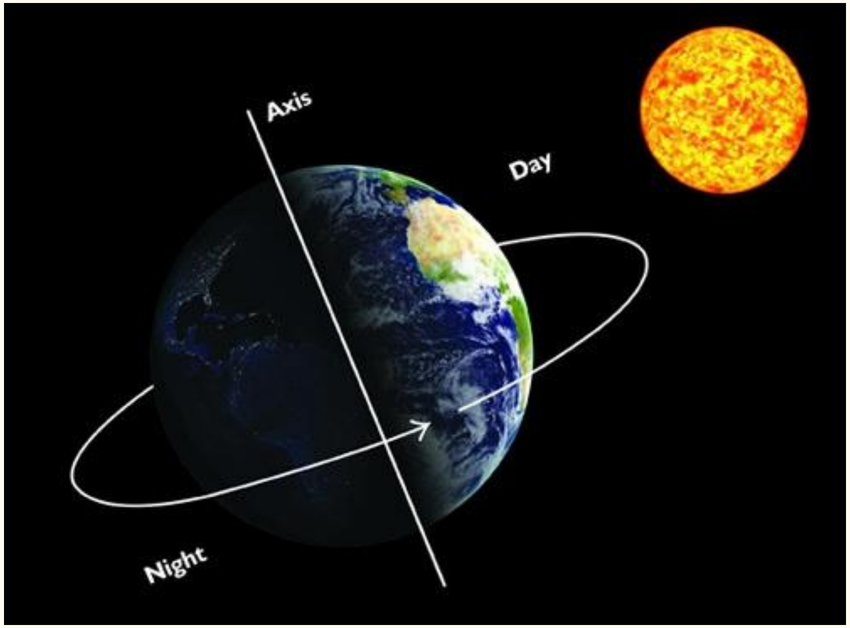


Target visibility

- What is the very first constraint to be taken into account?

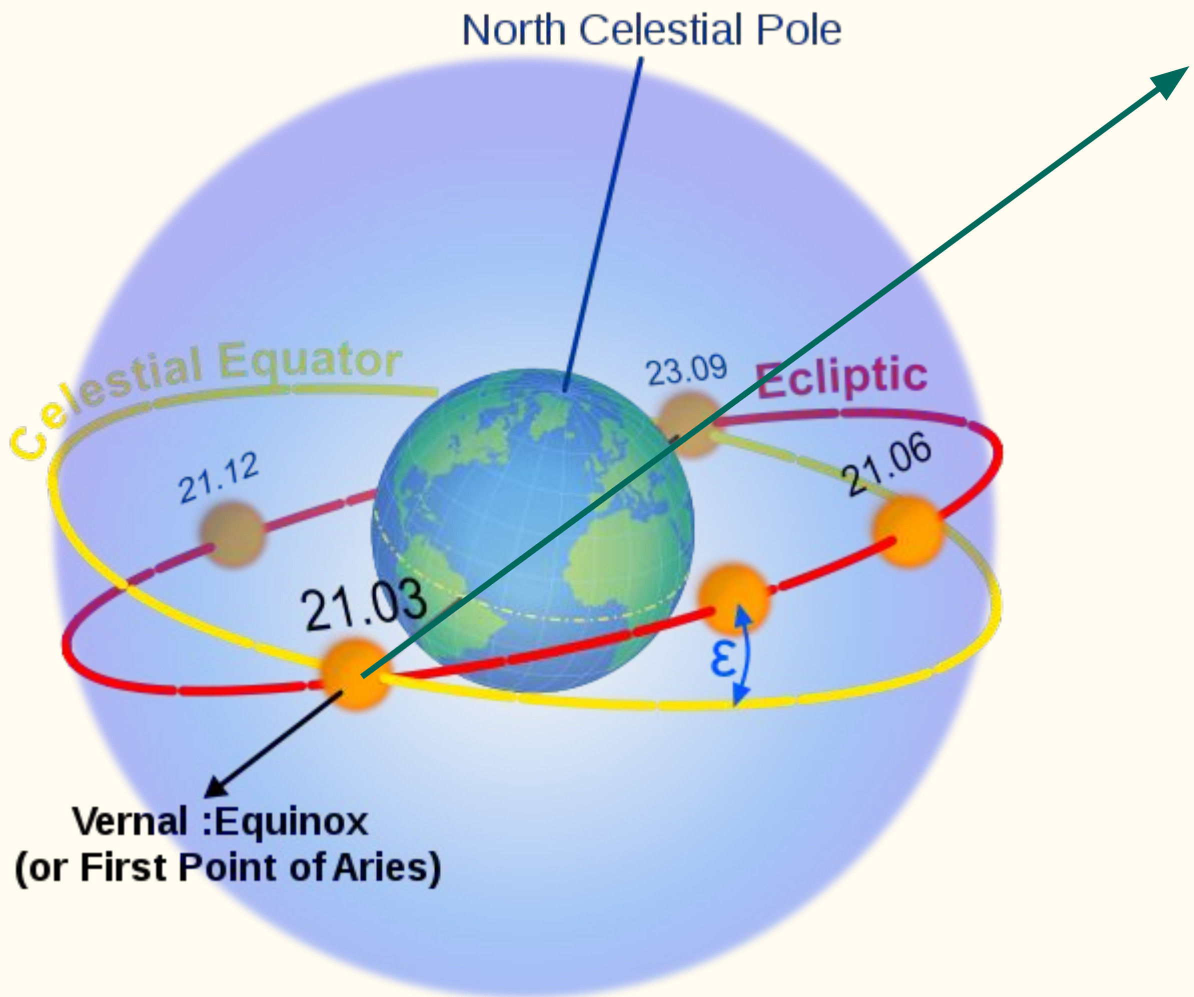
  The star has to be visible at night! ;)

- This implies it has to be **on the opposite direction of the Sun**



How do we check that?

Target visibility

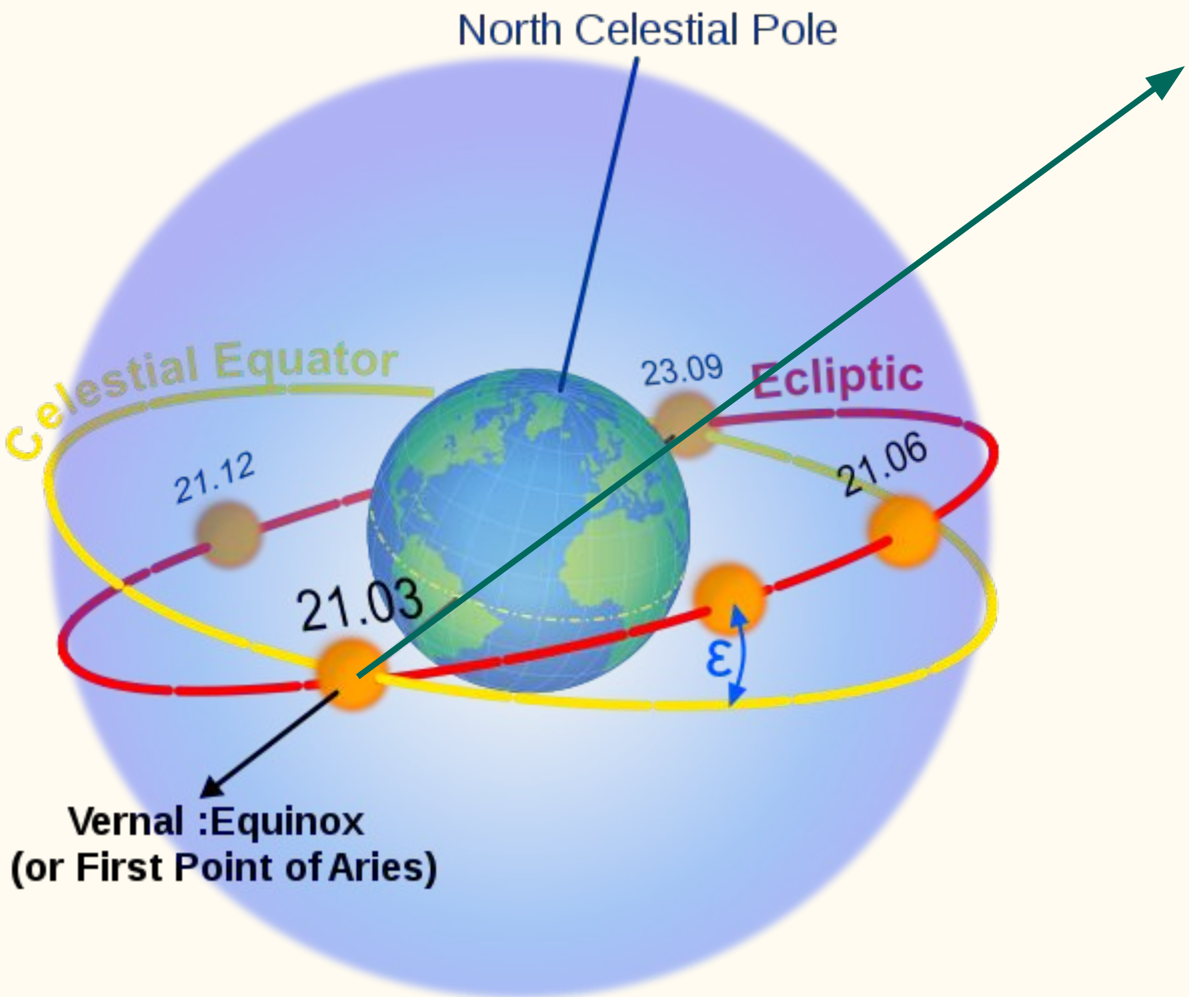


On ~March 21st, the Sun's right ascension is 0h

That implies that the night side is centred at

??

Target visibility



On ~March 21st, the Sun's right ascension is 0h

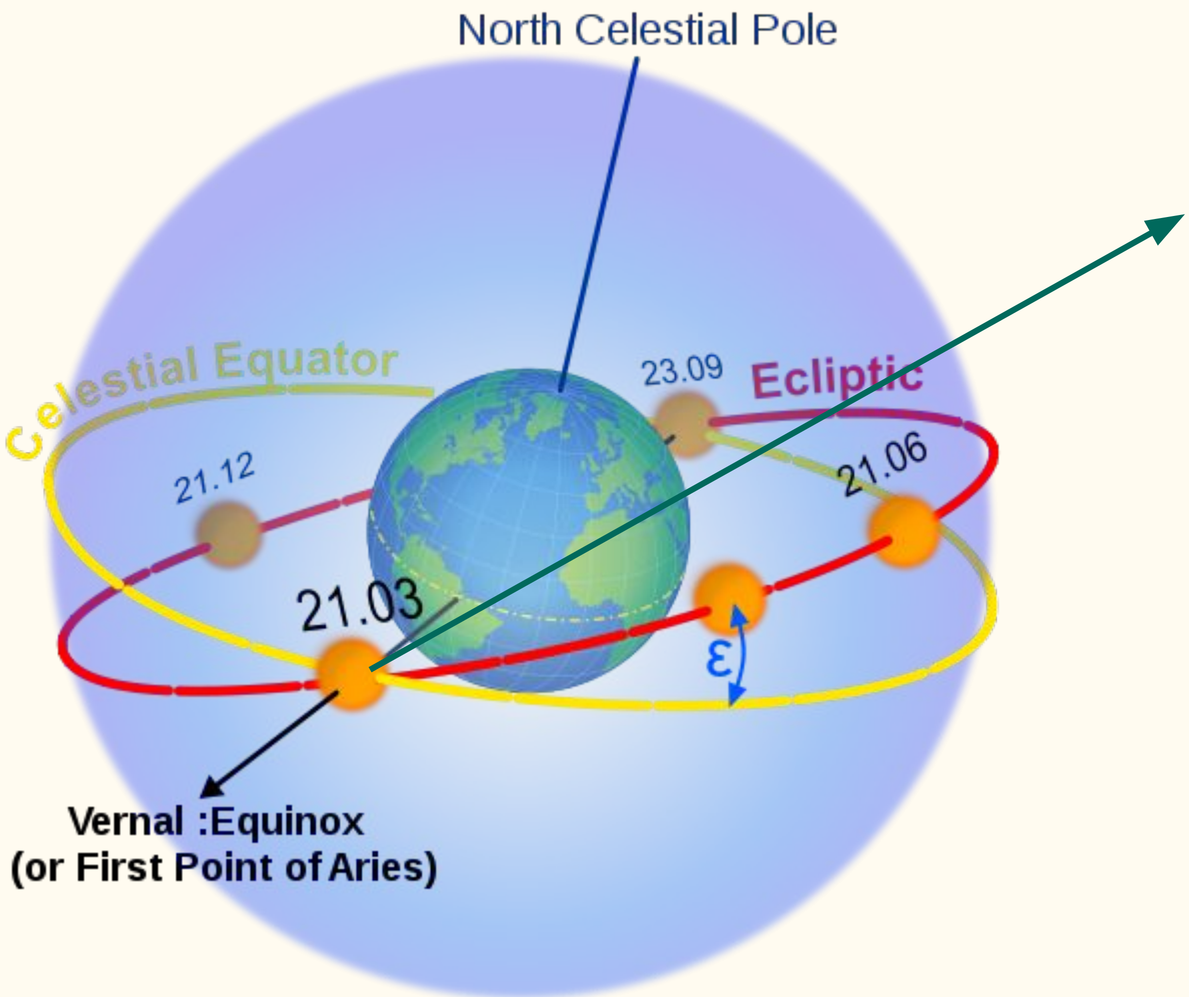
That implies that the night side is centred at

$$\alpha = 12h$$

Given the night's duration, we can observe targets with

$$6h < \alpha < 18h$$

Target visibility



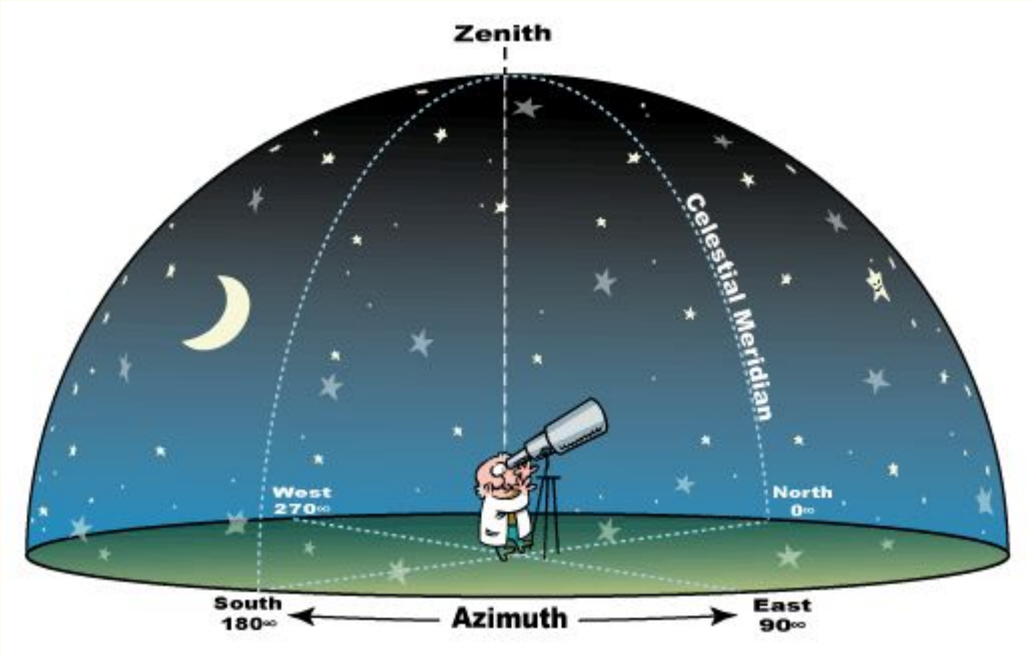
On ~March 21st, we can observe targets with

$$6h < \alpha < 18h$$

What about one month later?

Target visibility

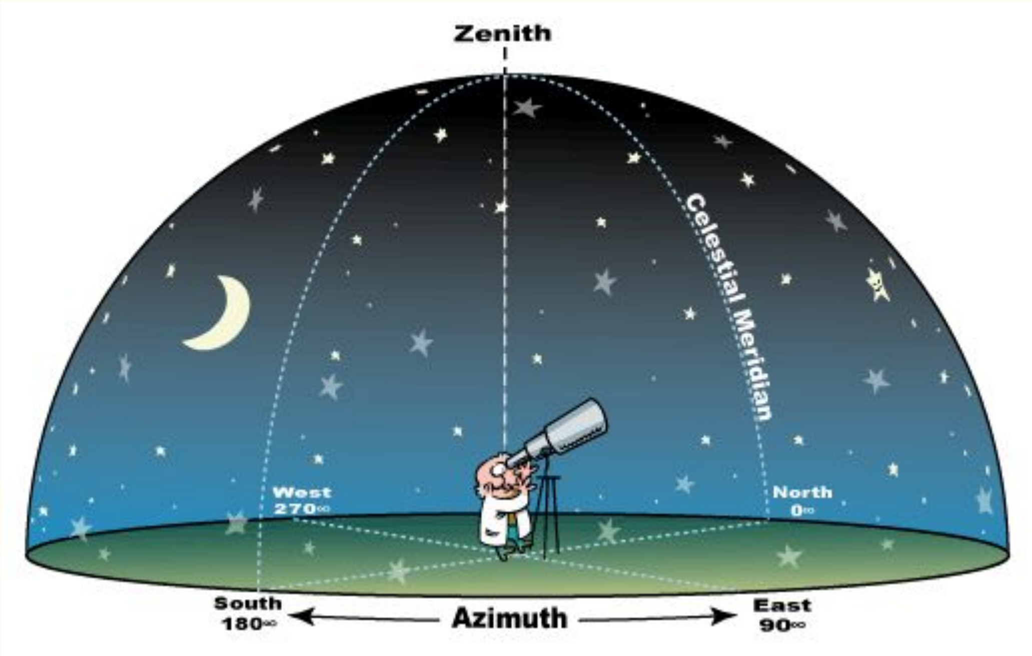
- The next constraint is our geographic location: we only see half of the celestial sphere.



Target visibility

- The next constraint is our geographic location: we only see half of the celestial sphere.

52°



?

Target visibility

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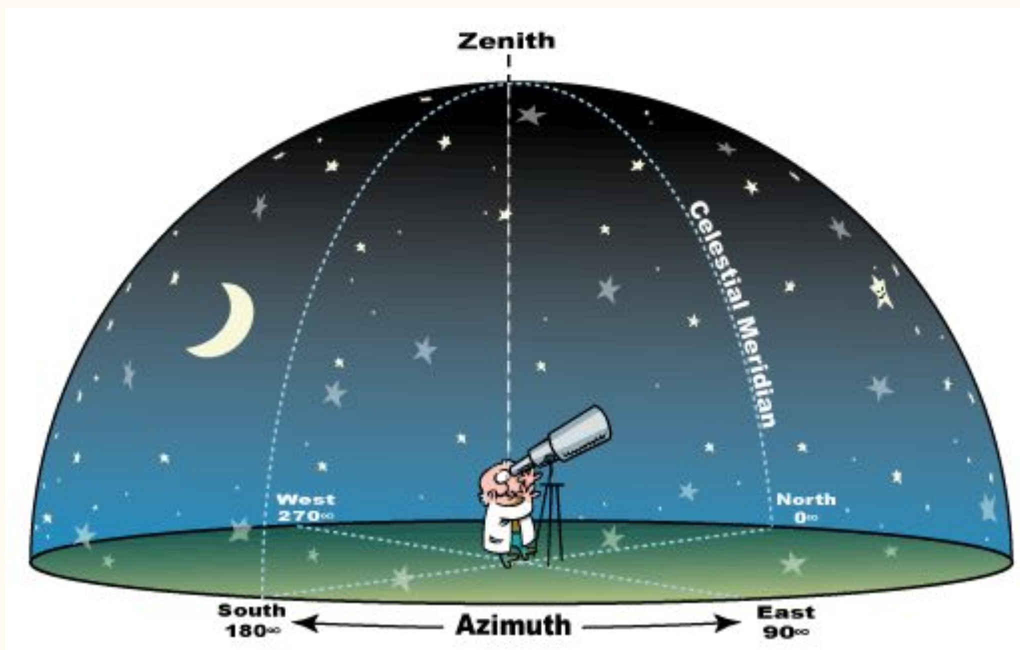
52°



-38° -38°

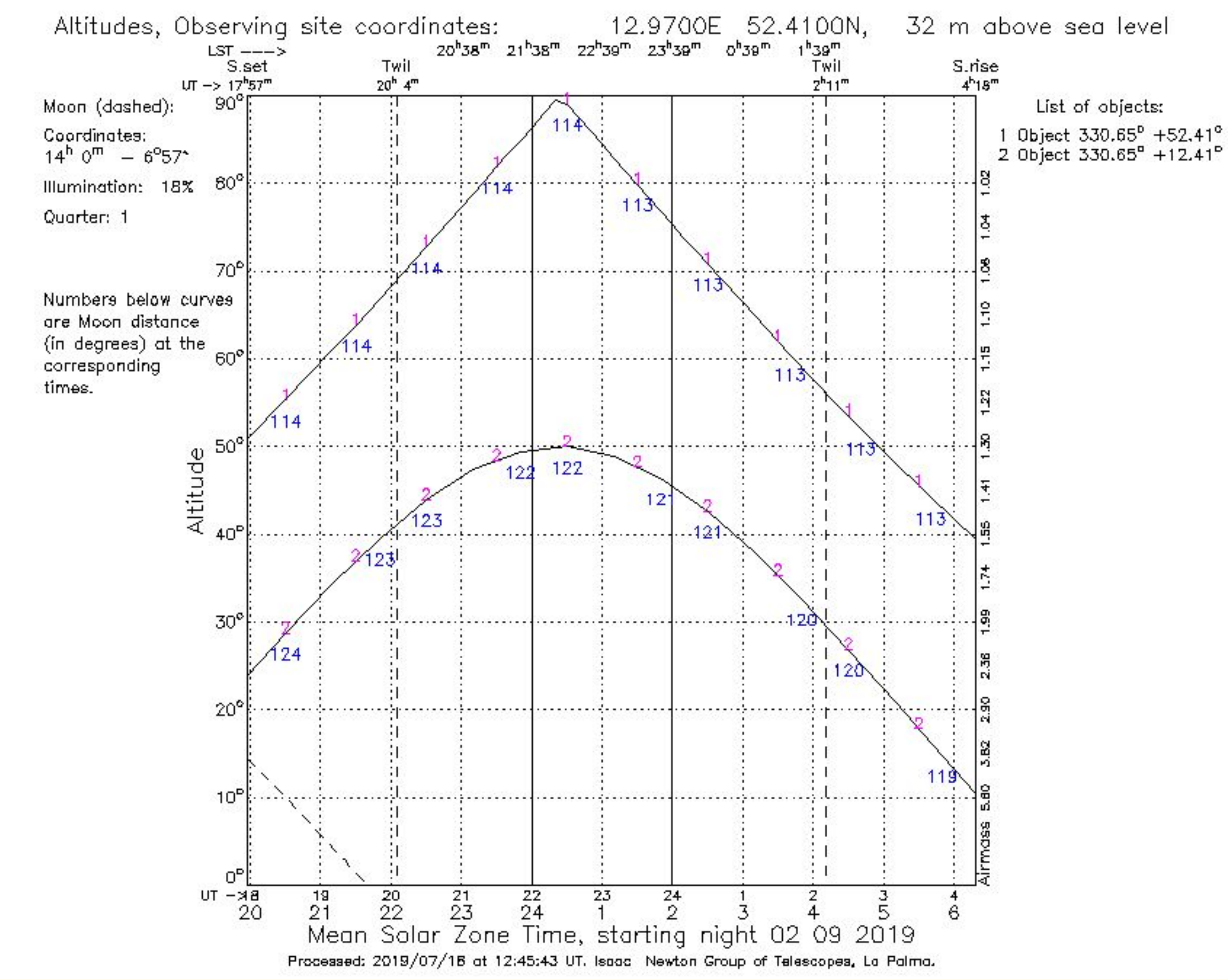
Target visibility – summary

- **Right ascensions we can observe**: determined by the **time of the year**
- **Declinations we can observe**: determined by our **location**

Target visibility

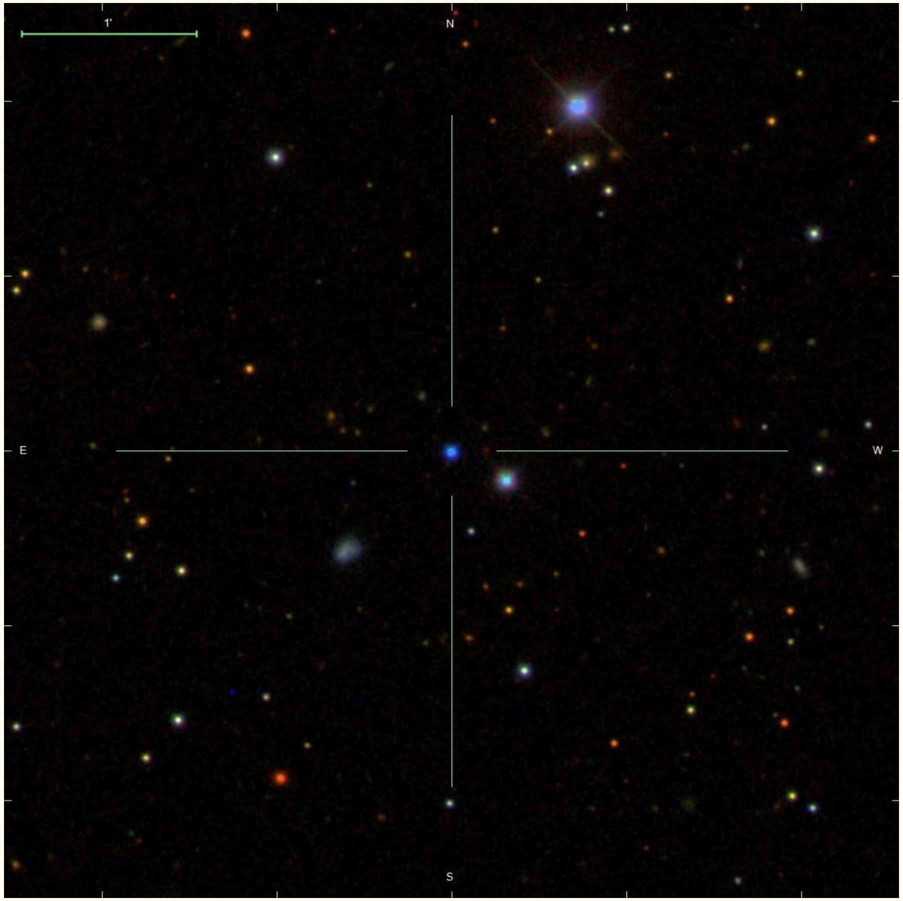
No, you don't have to calculate by hand every time!

http://catserver.ing.iac.es/staralt/



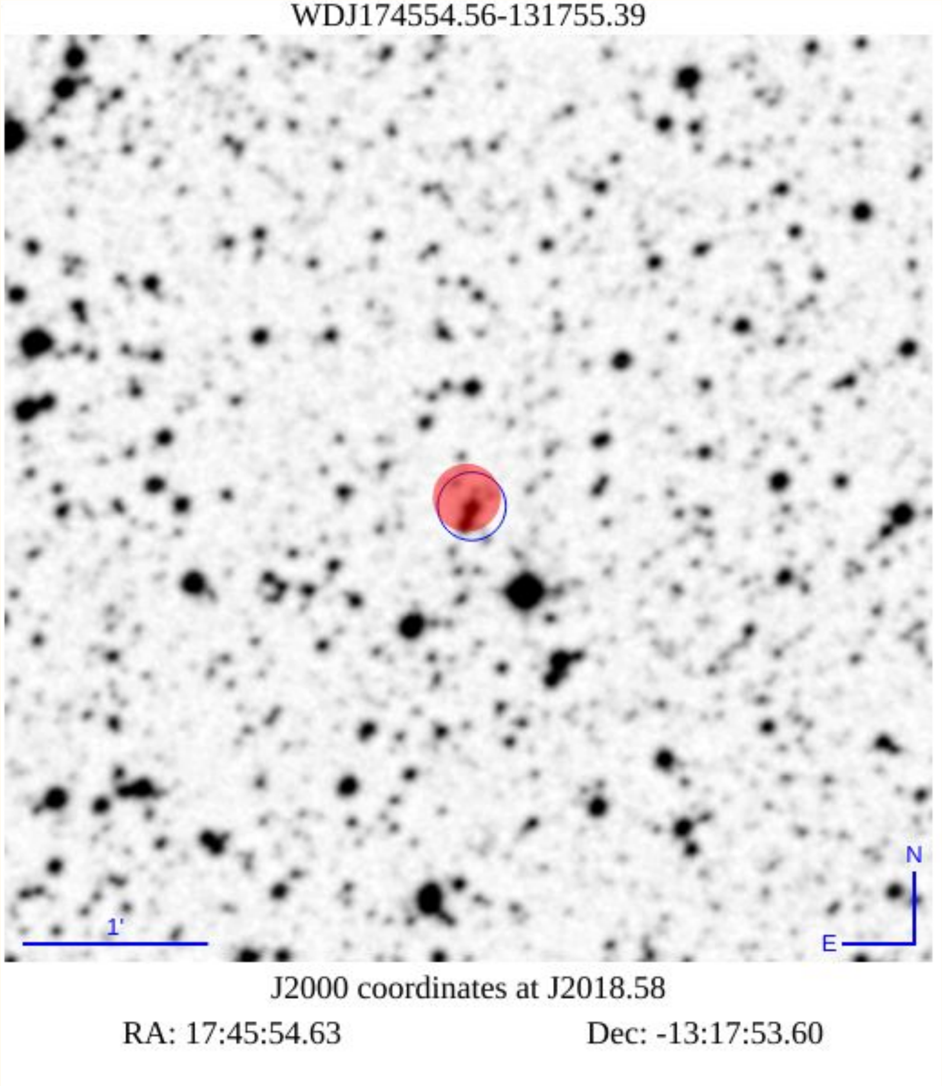
Finding charts

- Sometimes, it is straightforward to identify your target on an image.



Finding charts

- Sometimes, not ***at all.***
  - Dense regions
    (Galactic bulge, Galactic disk)
  - Close neighbours



Finding charts

- It is important to check **before your run** if your target is easily identifiable.
- In any case, you should have finding charts at hand.
- Useful tools:
  - Aladin: https://aladin.u-strasbg.fr/AladinLite/
  - SDSS finding chart tool: https://skyserver.sdss.org/dr14/en/tools/chart/chartinfo.aspx
  - IRSA finding chart tool:

    https://irsa.ipac.caltech.edu/applications/finderchart/
  - Python package astroplan:

    https://astroplan.readthedocs.io/

Instrument setup

- **Which configuration** do you need to execute your observations?
  - Photometry:
    - Filter
    - Binning
  - Spectroscopy:
    - Grating (resolution)
    - Central wavelength (spectral coverage)
    - Slit size
    - Binning

Instrument setup

- **Which configuration** do you need to execute your observations?
  - Photometry:
    - **Filter**
    - Binning
  - Spectroscopy:
    - **Grating (resolution)**
    - **Central wavelength (spectral coverage)**
    - Slit size
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Depend on the science that you are interested in doing.

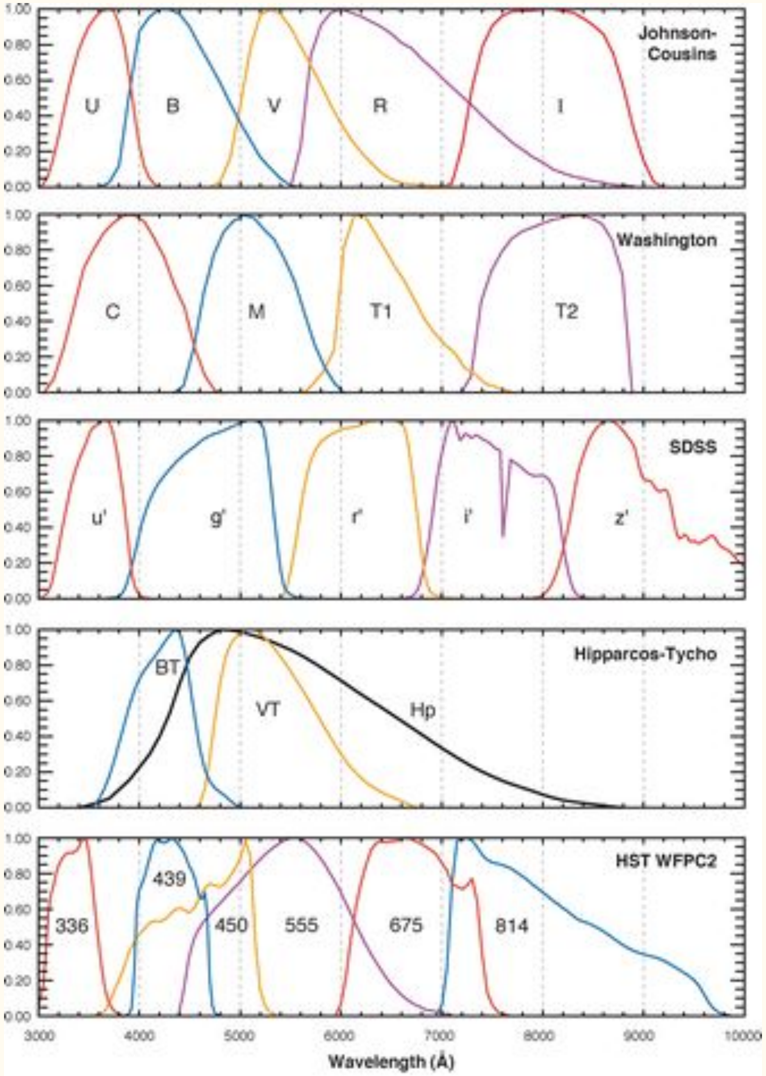
Instrument setup

- **Which configuration** do you need to execute your observations?
  - Photometry:
    - Filter
    - **Binning**
  - Spectroscopy:
    - Grating (resolution)
    - Central wavelength (spectral coverage)
    - **Slit size**
    - **Binning**

Depend on the science, but **also on the weather conditions!**

Instrument setup: photometry

- **Filter:** you want to maximize the contribution of your star, and minimize contamination.
- Examples:
    - if your star emits predominantly in the blue, use a red-blocking filter to minimize sky contamination.
    - if you want to study variability in a specific line, use a narrow filter centred on this line.



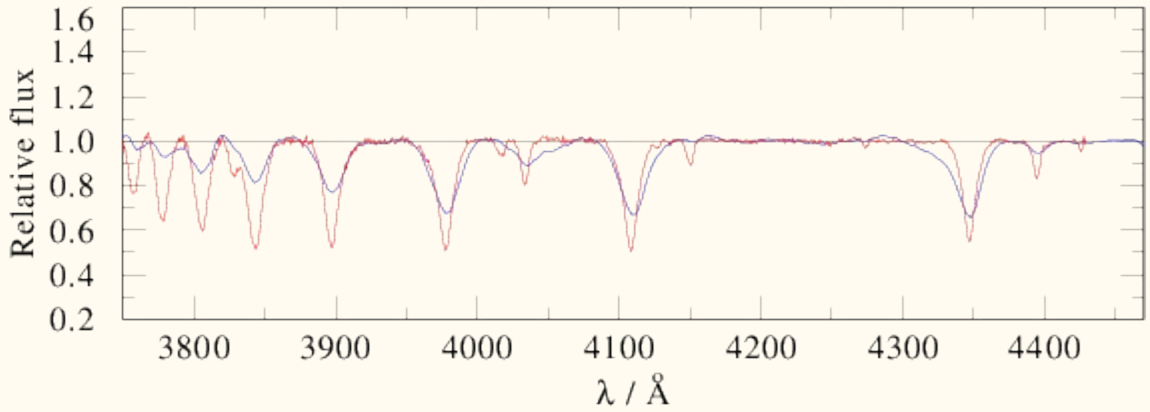
Bessell, MS. 2005
Annu. Rev. Astron. Astrophys. 43: 293–336

Instrument setup: spectroscopy

- **Central wavelength (spectral coverage):** similar function to the filter – you want to maximize the contribution of the region you want to study.
- **Grating (resolution):** the higher the resolution, the more the incoming light is spread on the CCD – more points per wavelength region.

  As a result, there is less light in each region – your signal decreases. Especially for faint targets, you should think about the lowest resolution required for your science.

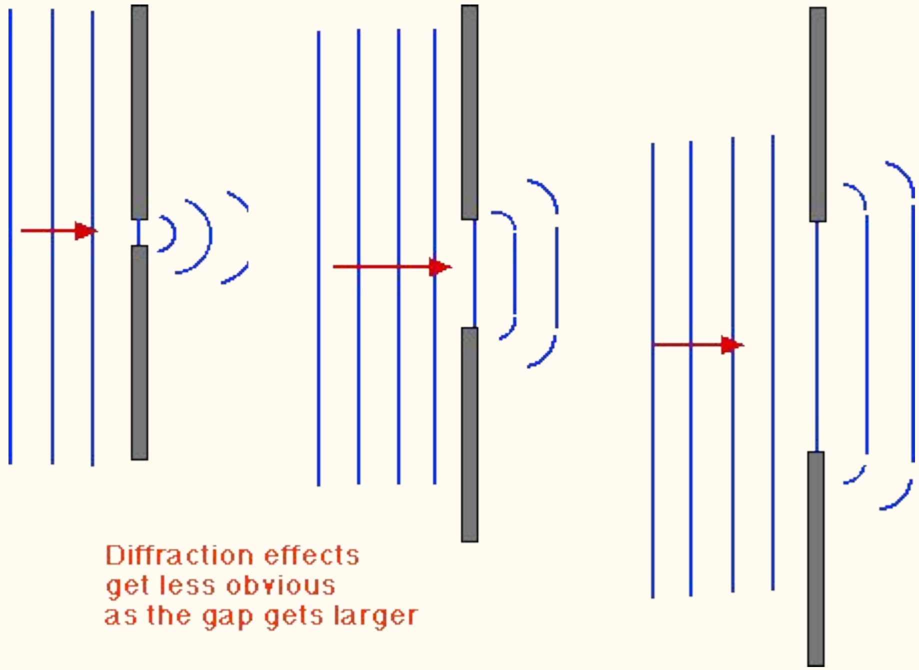
Resolving power: $R = \lambda/\Delta\lambda$



blue and red spectra were taken with the 200 lines/mm and 900 lines/mm gratings, respectively.

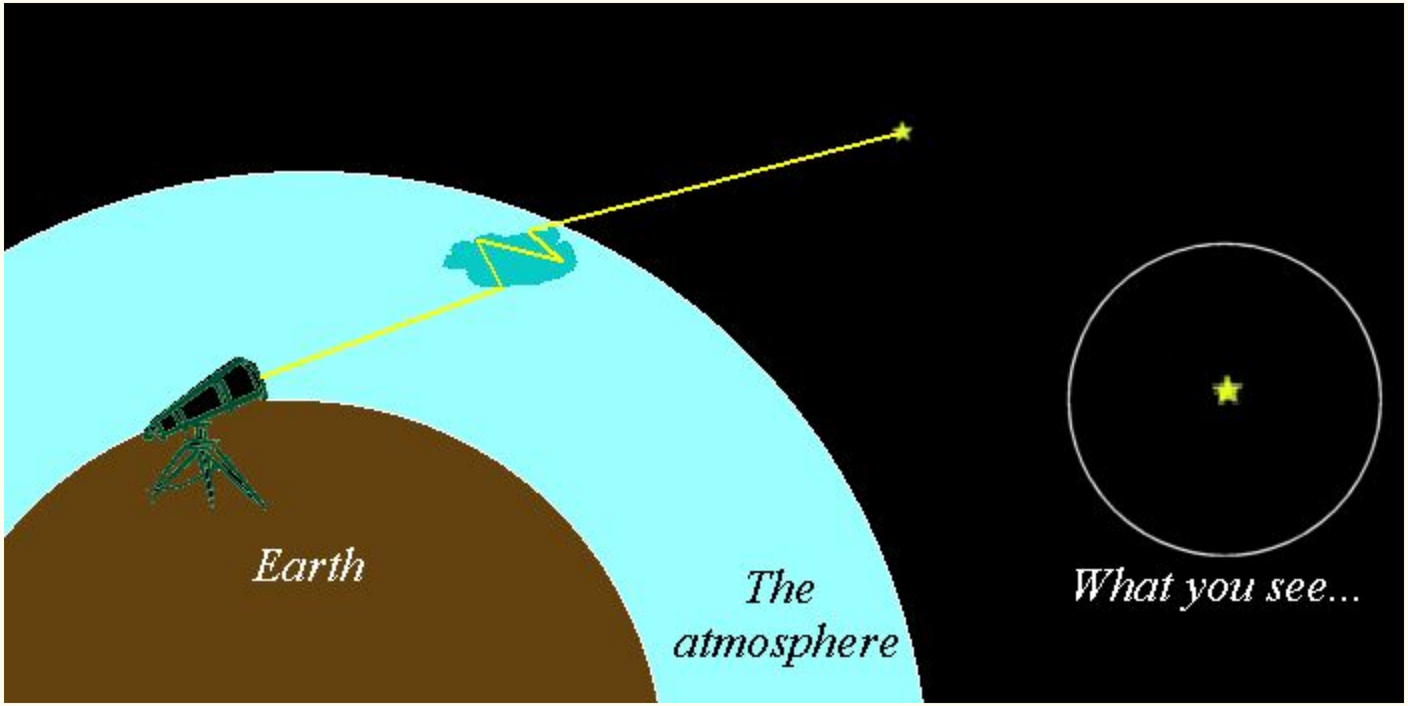
Instrument setup: spectroscopy

- **Slit size** also impacts on the resolution. The smaller the slit, the higher the resolution – but the less light from your target you are receiving. Again, a balance between the signal and the resolution you require must be achieved.

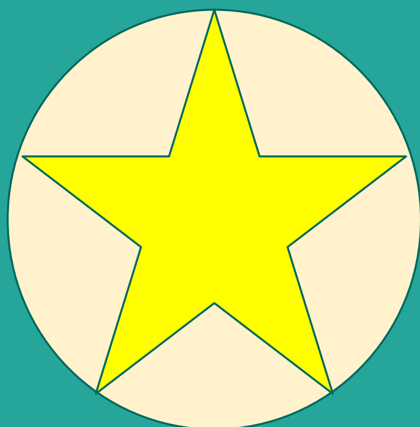


Instrument setup: spectroscopy

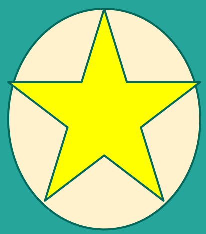
- **Slit size** also impacts on the resolution. The smaller the slit, the higher the resolution – but the less light from your target you are receiving. Again, a balance between the signal and the resolution you require must be achieved.
- The **seeing** also has to be kept in mind for deciding the slit size.

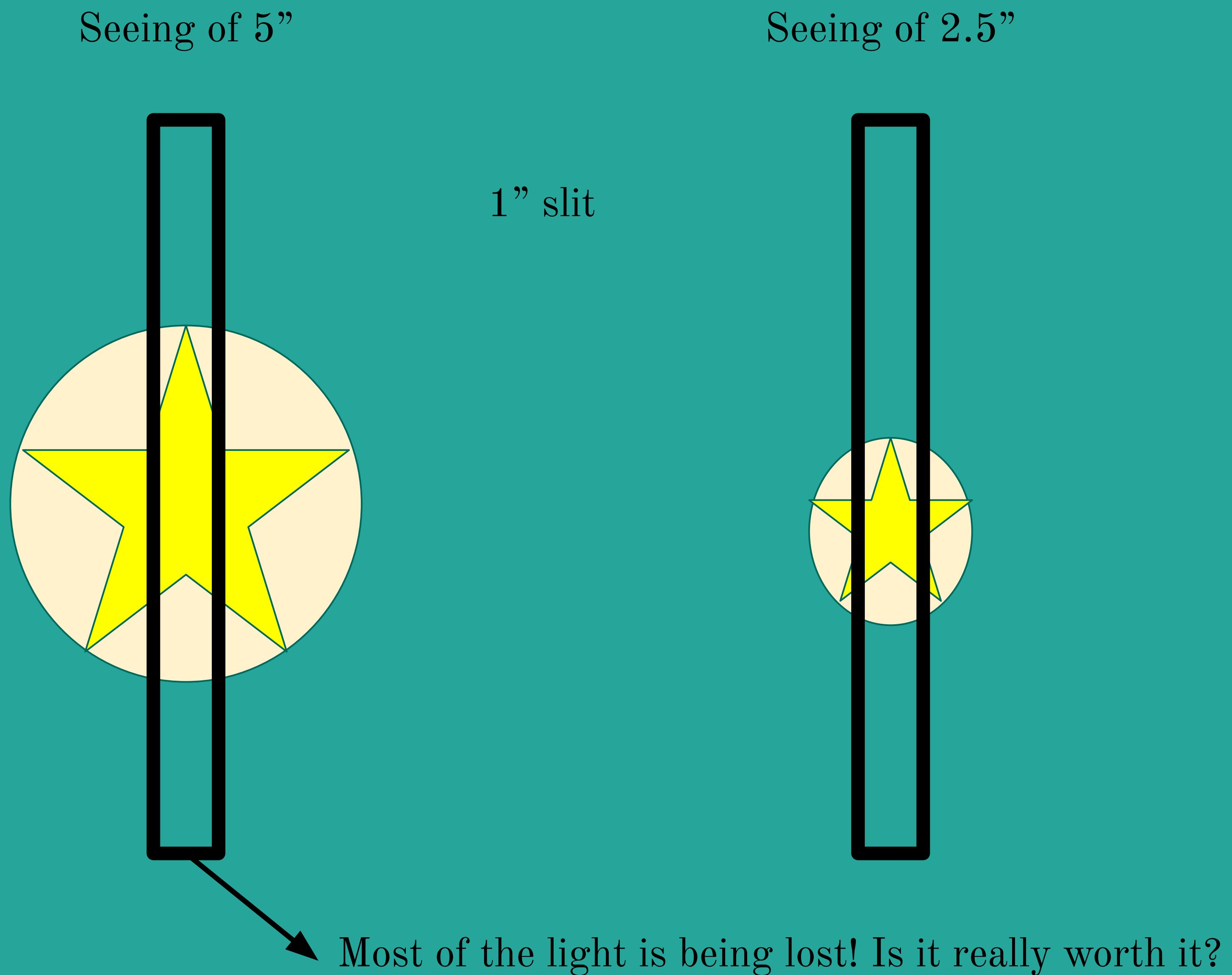


Seeing of 5”



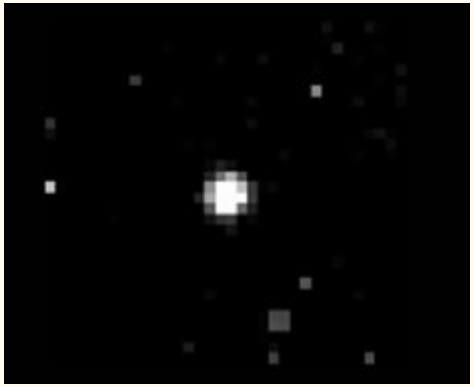
Seeing of 2.5”



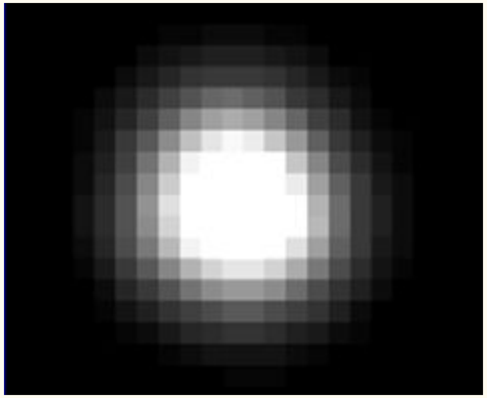

Seeing of 5”
Seeing of 2.5”
1” slit
Most of the light is being lost! Is it really worth it?

Seeing and binning

- The CCD at the telescope has a certain pixels scale, e.g. 0.5”/pixel.



- Seeing = 0.5” ⇒ star is in one pixel.
  UNDERSAMPLED.

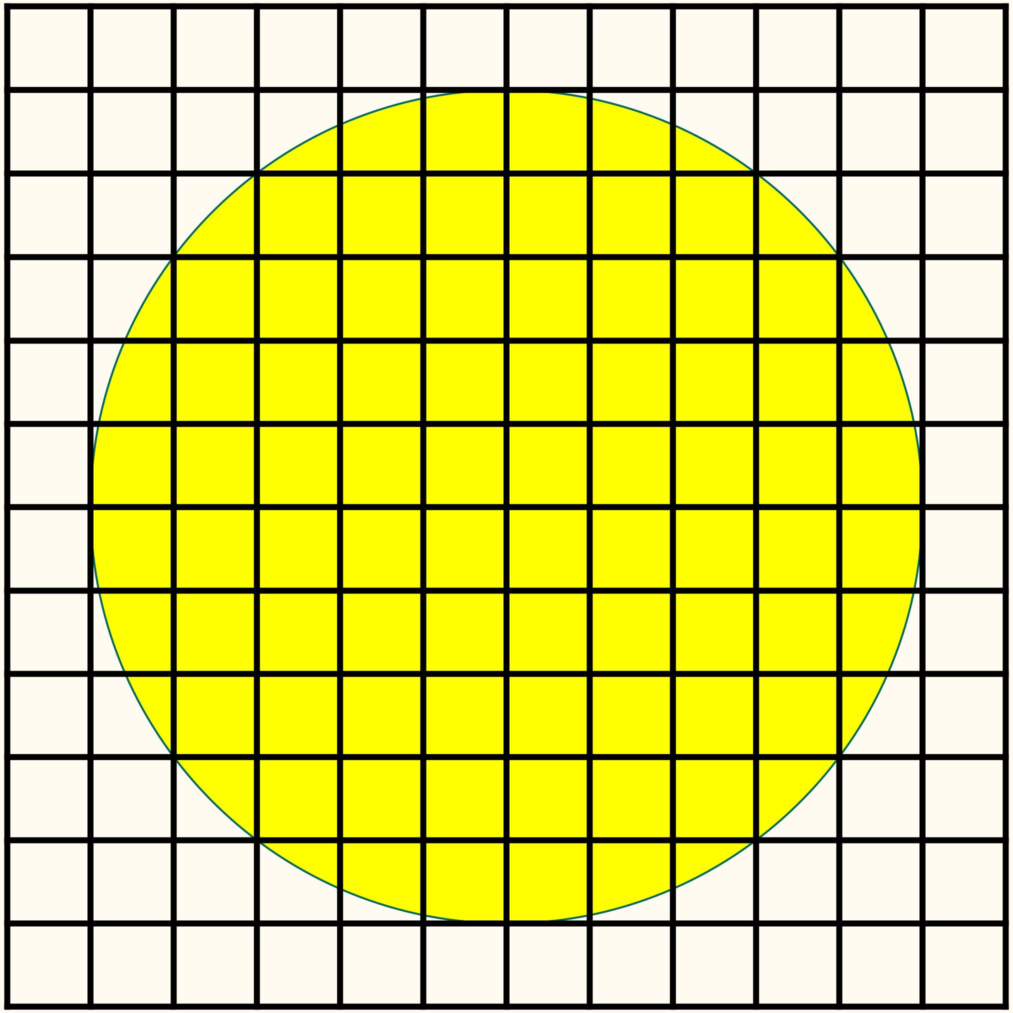


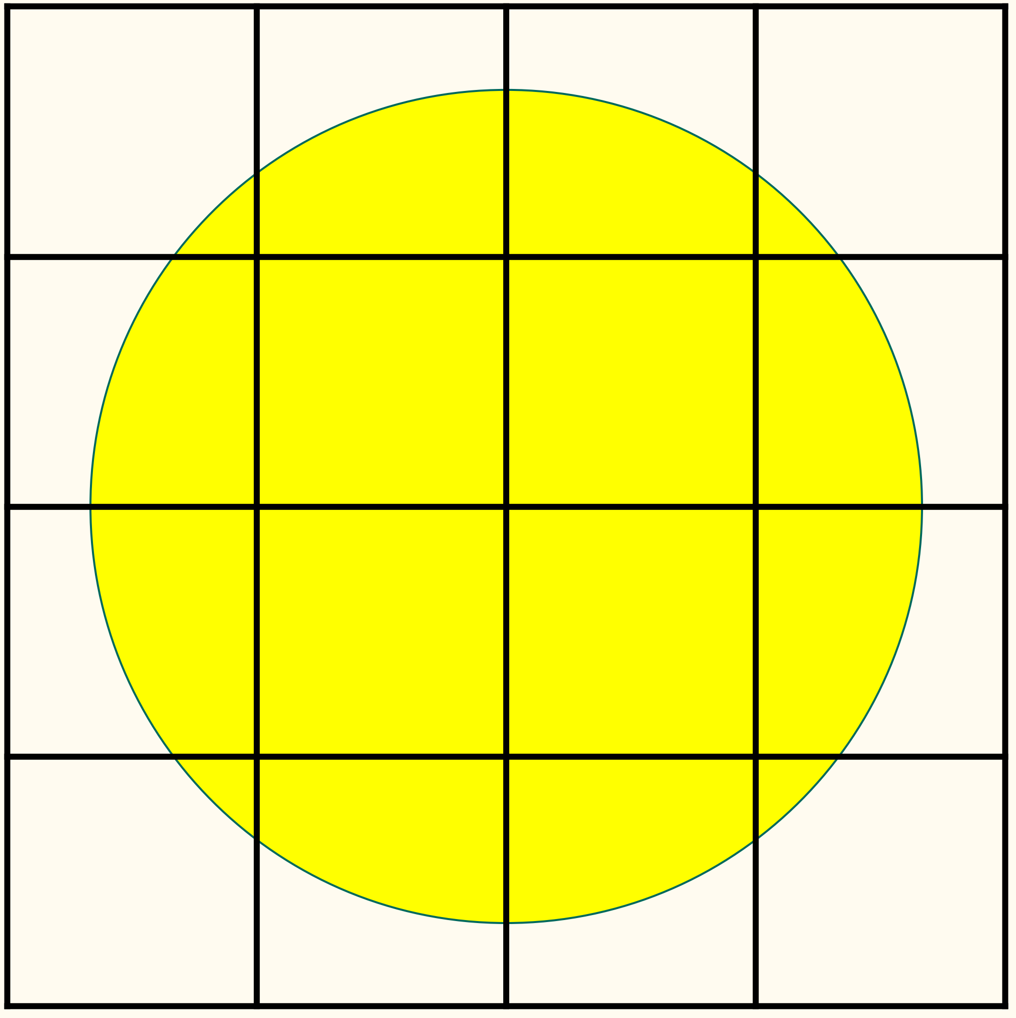
- Seeing of 5”⇒ star is in 10 pixels.
  OVERSAMPLED.

Seeing and binning

- Ideal sampling is ⅓ of the seeing (Nyquist theory).

- Seeing of 5” ⇒ ideal pixel size is 1.66”.
- If my detector has a scale of 0.5”/pixel, I should apply a 3x3 binning.



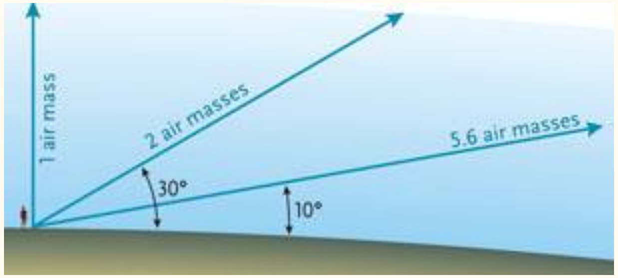


Weather constraints

- Seeing
  - If you need high resolution spectroscopy, you should limit the seeing so you can use a small slit.
  - If your field is crowded, you need small seeing to resolve your star.
- Lunar phase and distance
  - Your star needs to above the background.
- Cloud coverage
  - Clouds are the optical astronomer's worst enemy. Still, some observations can be executed with thin cloud coverage.
- Airmass
  - A measurement of how high in the sky is your target.

$$\text{Airmass} = \sec z, \text{ where } z \text{ is the zenital distance.}$$

  - The smaller the airmass, the less atmospheric effect.



Exposure times

- The best way to verify in which conditions your observations can be executed is using exposure time calculators.

  For ESO:

  https://www.eso.org/observing/etc/

- These are not always available:
  - Use exposure time calculators for similar telescope/instrument.
  - Infer from previous experience.
  - Experiment!

Summary – preparing your observing run

- Long-term preparations
  - Have your target list ready.
  - Check which objects are going to be observable during your nights.
  - Make finding charts for these targets – give special attention to crowded fields.
- Short-term preparations
  - Check the weather conditions.
  - Given these conditions, what is the ideal instrument setup?
  - Given these conditions and instrument setup, what is the exposure time for each target?