Telescopes and Ground Based Observations

Linda Schmidtobreick
European Southern Observatory, Chile

La Silla Observing School, 2nd February, 2026

Who am I - a superfast introduction


DA KOMM ICH WECH
RUHRPOTT

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My science topics: evolution of compact binaries, nova shells

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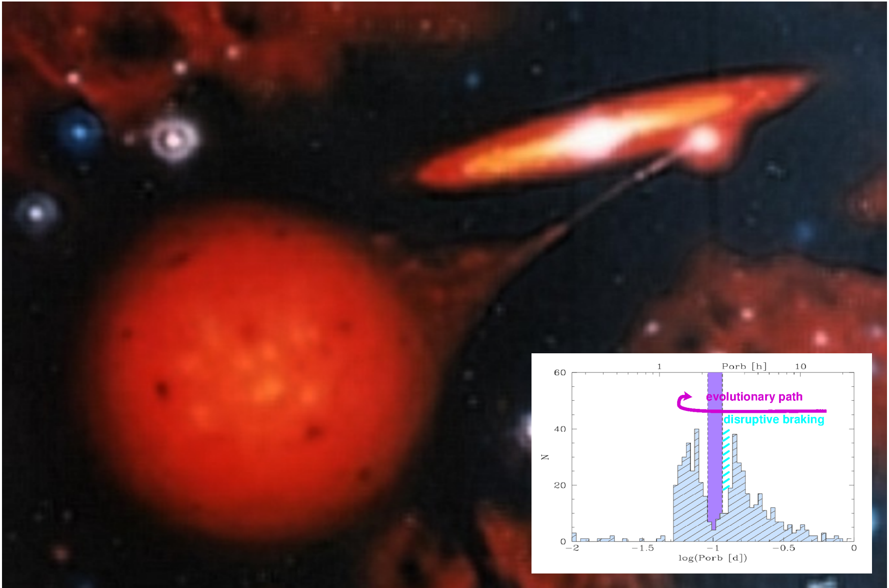
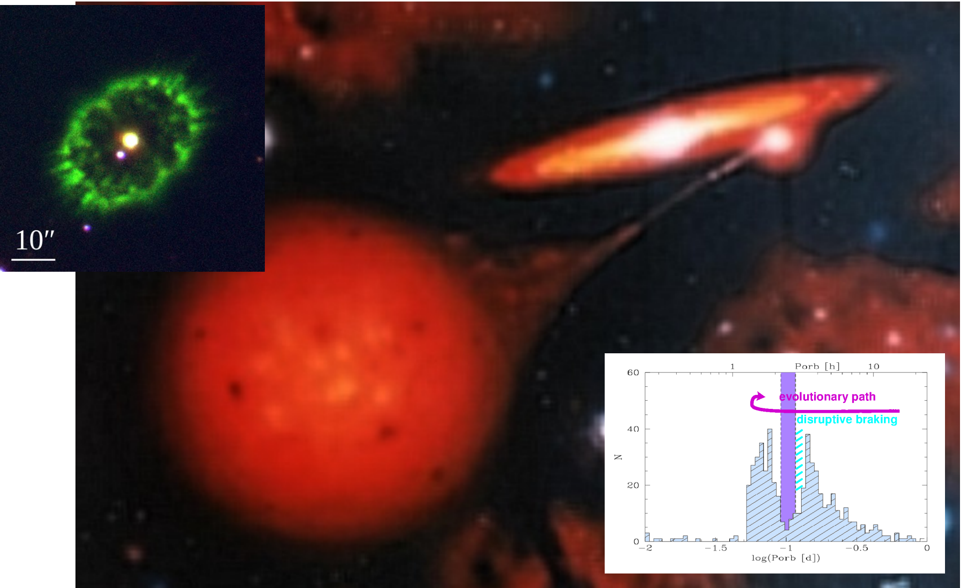


My science topics: evolution of compact binaries, nova shells



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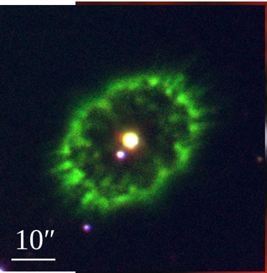

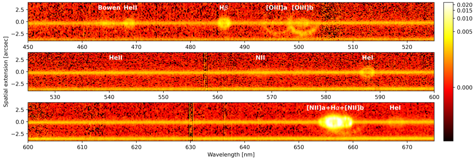

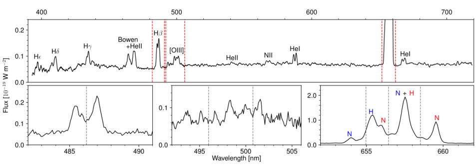

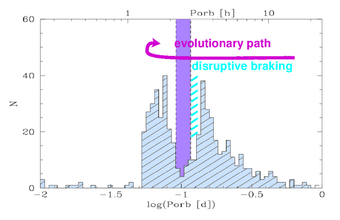

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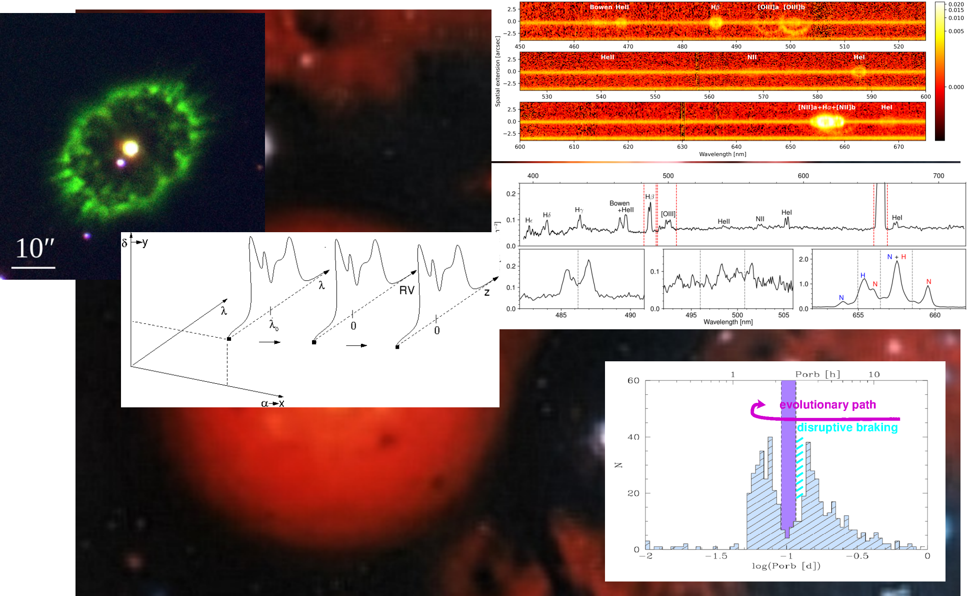

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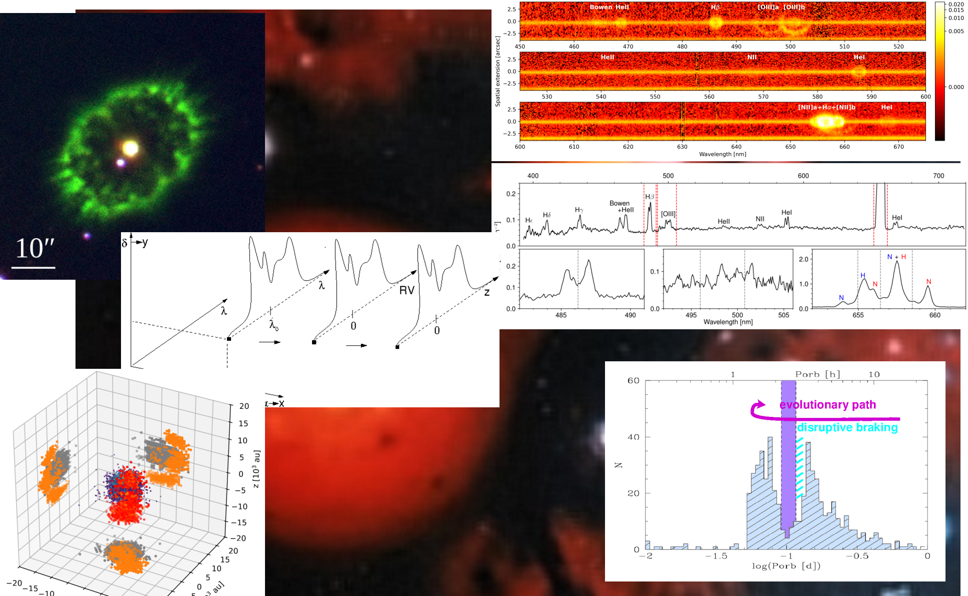

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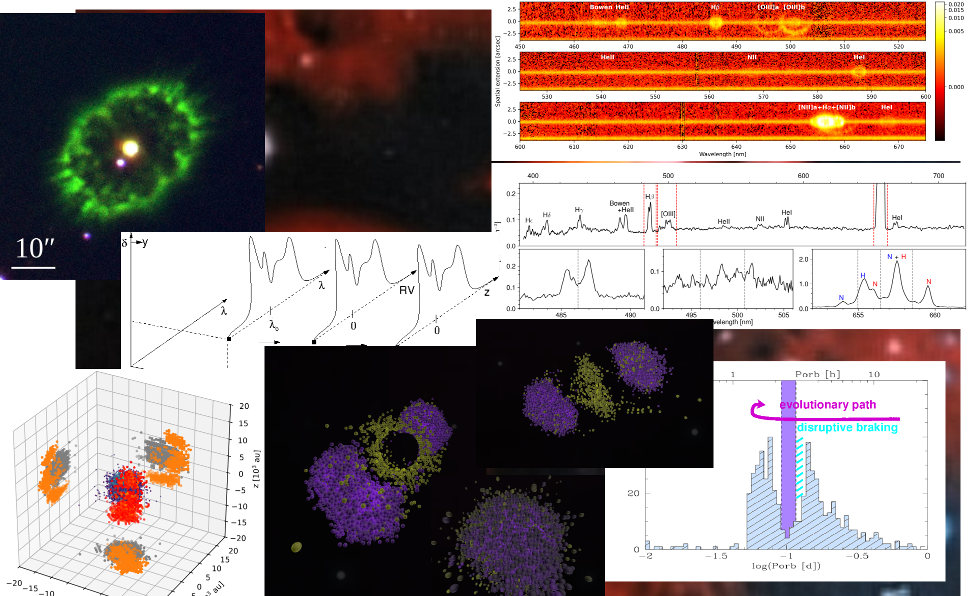


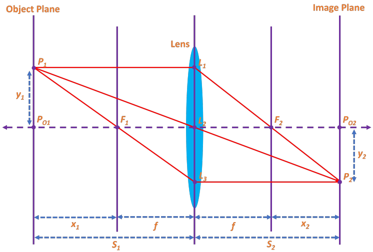
My role at ESO:

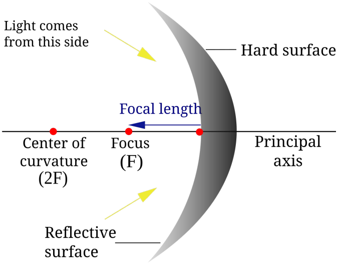
operational astronomer

in the past:
on La Silla: Instrument scientist for WFI, EFOSC, SOFI
on Paranal: Instrument scientist for
ISAAC, FORS2, KMOS, NACO, GRAVITY, MOONS
Deputy for the office for Science

at the moment:
IOT coordinator
(interplay between Instrument Scientists and Engineering)
on my way into retirement

Basic telescope optics: Lenses and curved mirrors





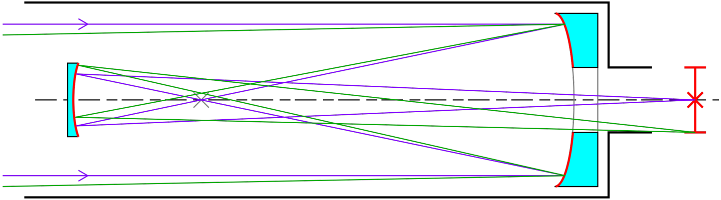
For thin lenses: $\frac{1}{f} = \frac{1}{S_1} + \frac{1}{S_2}$

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

object at distance d_o; image at distance d_i

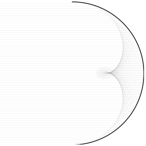
In both cases, moving the object to infinity, results in the image being in the focal plane

An astronomical telescope is a combination of lenses or mirrors that allows to capture the image of a body in infinity in the focal plane.



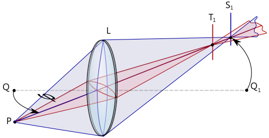
focal length f controls the size of the field of view
pupil diameter D controls the amount of light gathered
focal ratio $N = \frac{f}{D}$

Basic telescope optics: some optical errors

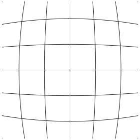


spherical aberration

coma



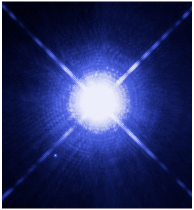
astigmatism



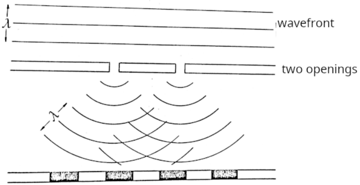
distortion

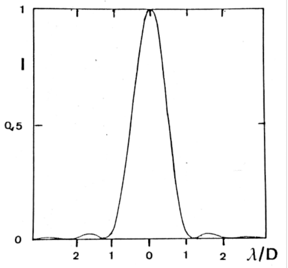
Ritchey-Chrétien: hyperbolic shaped mirrors to avoid the coma
Both, NTT and the 3.6-m telescopes at La Silla are of this type.
One still has to deal with possible astigmatism (improve the alignment) and distortion (astrometric corrections of higher order)

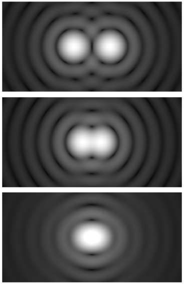
Feature from having a secondary mirror:



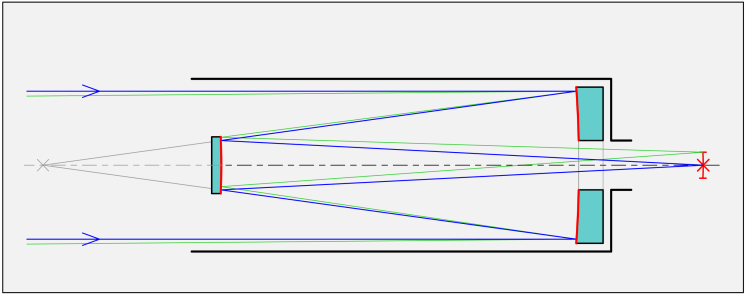
Two adjacent points in the object give rise to two diffraction patterns:



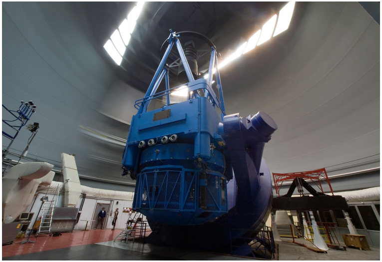


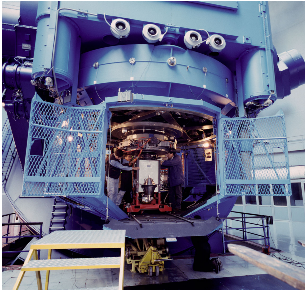


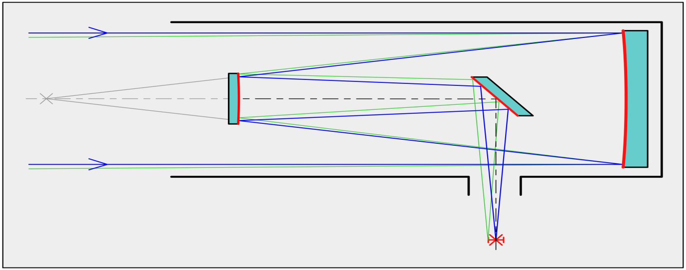
Raleigh criterion: $\Theta = 1.22\frac{\lambda}{D}$
telescope resolution is then approximated by: $R = \frac{\lambda}{D}$



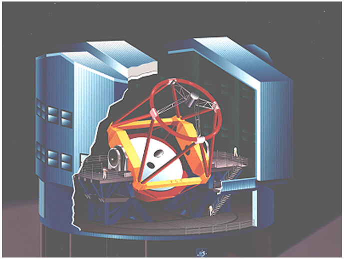
Example:

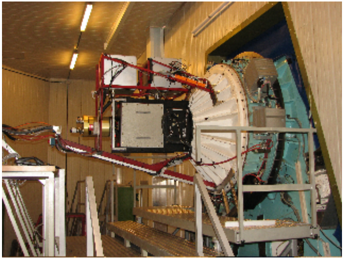






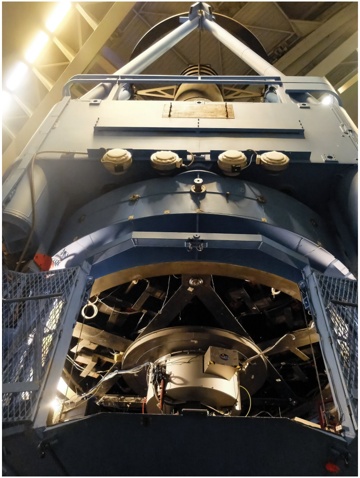
Examples:



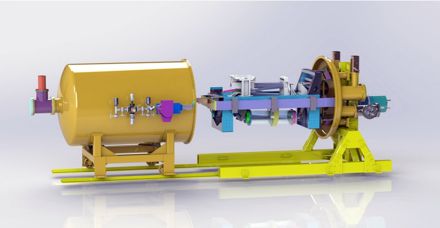


Light is fed into a fibre (either in Nasmyth or Cassegrain) and led into an instrument in the Coudé room (below the telescope).

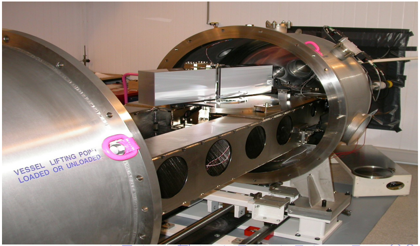
Example: HARPS and NIRPS at ESO's 3.6-m telescope:



Cassegrain focus



NIRPS



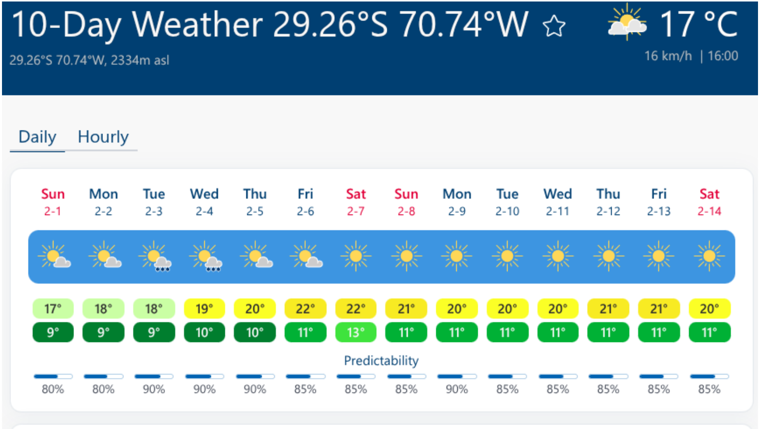
HARPS

GROUND BASED OBSERVING

Ground-based Telescopes

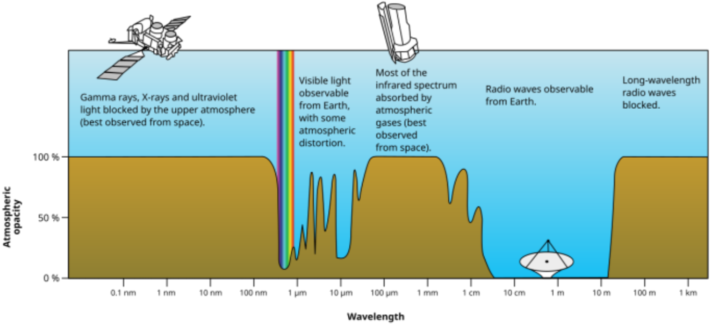
- easier and cheaper than in space
- easier to fix if things go wrong
- but looking through the Earth's atmosphere
  $\longrightarrow$
  - weather
  - atmospheric opacity
  - Earth rotation and airmass
  - differential refraction
  - turbulence
  - gravity and telescope mounting

Weather

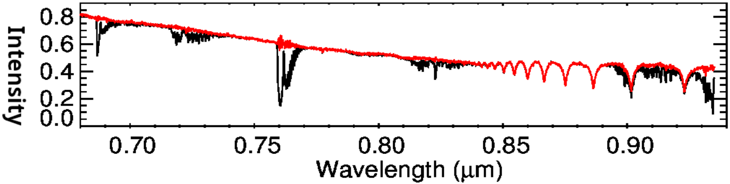


but also wind and humidity play a role

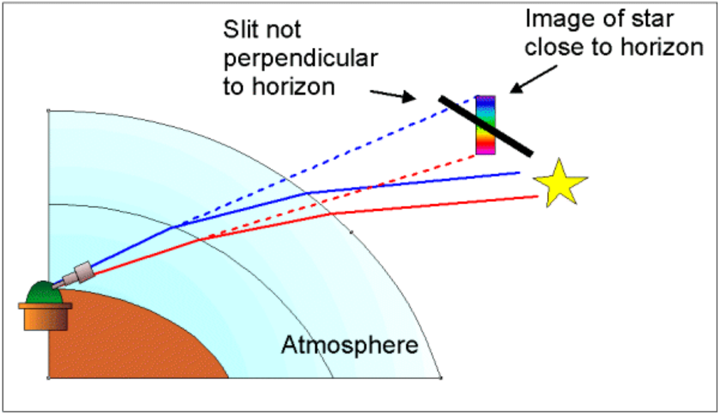
Overall atmospheric opacity → observing windows



Telluric lines:



Differential Refraction

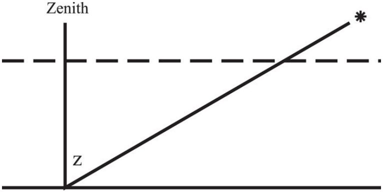


For imaging: elliptical images $\rightarrow$ usage of filters!
For spectroscopy: align slit perpendicular to horizon

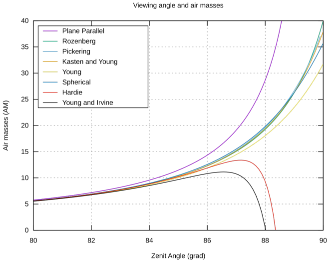
Airmass X: measure of the amount of air along the line of sight

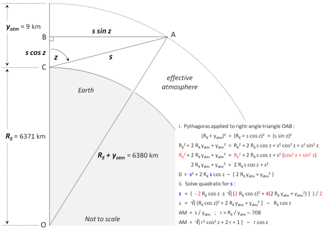
$$\sigma = \int \rho ds,\ \sigma_z = \int \rho dz$$
$$X = \sigma / \sigma_z$$
$$X = s / s_z$$

assuming a plane-parallel atmosphere:



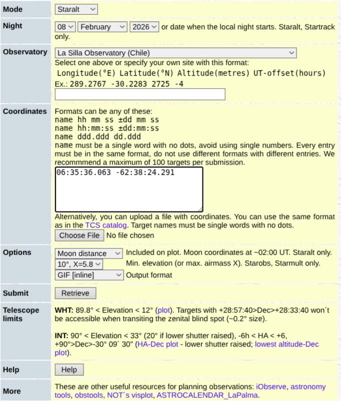
$$X = \sec z$$



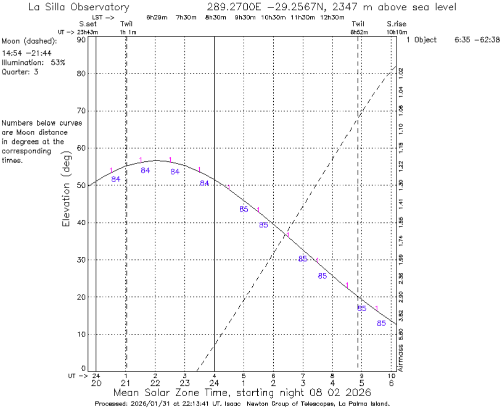


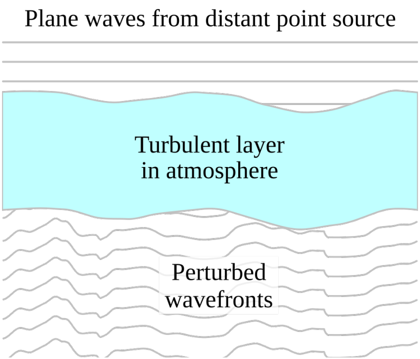
Earth rotation and airmass: planning of observations

Observing tools: https://www.eso.org/sci/observing/tools.html
STARALT: https://astro.ing.iac.es/staralt/

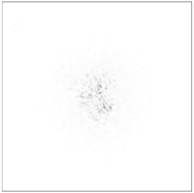


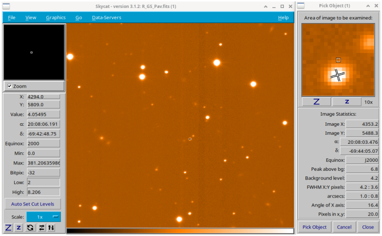
Mode	Staralt
Night	08 February 2026 or date when the local night starts. Staralt, Startrack only.
Observatory	La Silla Observatory (Chile) Select one above or specify your own site with this format: Longitude(°E) Latitude(°N) Altitude(metres) UT-offset(hours) Ex.: 289.2767 -30.2283 2725 -4
Coordinates	Formats can be any of these: name hh mm ss ±dd mm ss name hh:mm:ss ±dd:mm:ss name ddd.ddd dd.ddd name must be a single word with no dots, avoid using single numbers. Every entry must be in the same format, do not use different formats with different entries. We recommmend a maximum of 100 targets per submission. 06:35:36.063 -62:38:24.291 Alternatively, you can upload a file with coordinates. You can use the same format as in the TCS catalog. Target names must be single words with no dots. Choose File No file chosen
Options	Moon distance — Included on plot. Moon coordinates at ~02:00 UT. Staralt only. 10°, X=5.8 — Min. elevation (or max. airmass X). Starobs, Starmult only. GIF [inline] — Output format
Submit	Retrieve
Telescope limits	WHT: 89.8° < Elevation < 12° (plot). Targets with +28:57:40>Dec>+28:33:40 won´t be accessible when transiting the zenital blind spot (~0.2° size). INT: 90° < Elevation < 33° (20° if lower shutter raised), -6h < HA < +6, +90°>Dec>-30° 09´ 30" (HA-Dec plot - lower shutter raised; lowest altitude-Dec plot).
Help	Help
More	These are other useful resources for planning observations: iObserve, astronomy tools, obstools, NOT´s visplot, ASTROCALENDAR_LaPalma.





seeing is an atmospheric condition





The resulting image quality is measured as the full width at half maximum of the optical intensity of a long exposure point source. It depends on the seeing, the airmass and the wavelentgh.

Gravity: balance and flexure

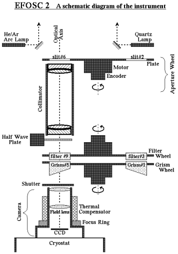
Gravity pulls at telescope and instruments and can cause deformation

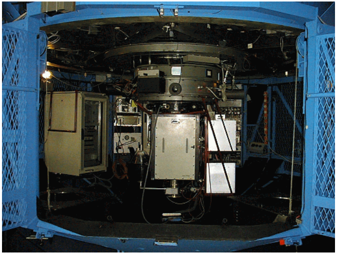
$\longrightarrow$

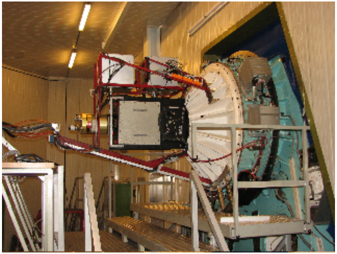
telescopes need to be balanced

instruments need to be designed for the focus they are in

Bad example: EFOSC



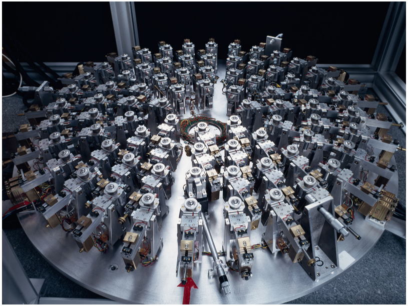


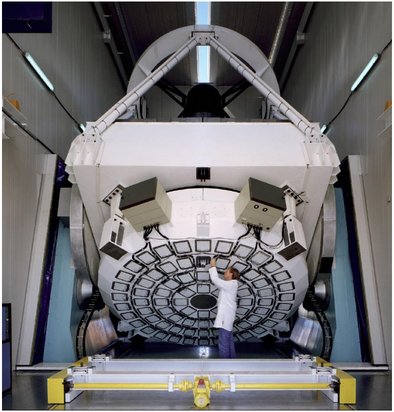


EFOSC img acq NarrowSlit

#1 acquisition 1000344585

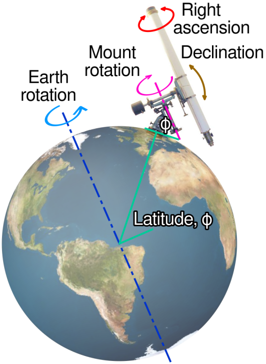
Mirrors are lighter than lenses but a single-block large mirror becomes very heavy as it needs a certain thickness to keep its shape.

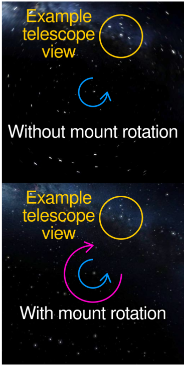


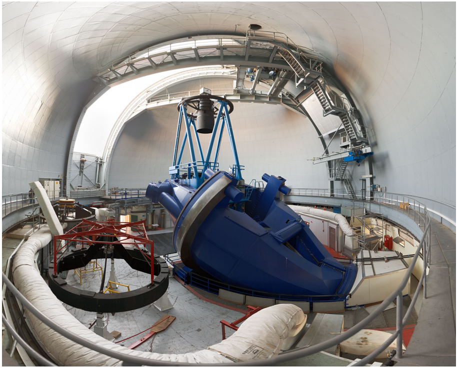


Use a thin mirror and support it with actuators → Active Optics
Was tested first on NTT, all new telescopes use this technique now

Equatorial mount



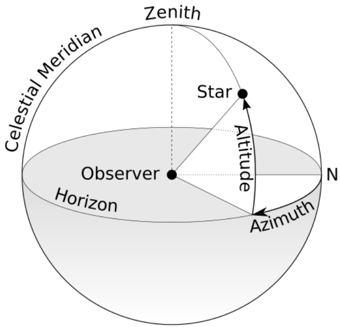




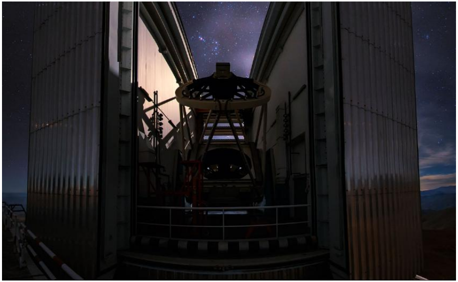
easy to track but gets difficult for large or heavy telescopes - balance

Altazimuth mount

Simple mount with two perpendicular axes - one vertical one horizontal



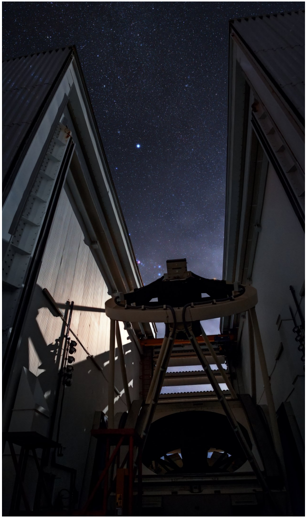
Altazimuth mounts at ESO




ESO 3.6-metre telescope
Swiss 1.2-metre Leonhard Euler Telescope
New Technology Telescope
ESO 1-metre Schmidt telescope
MPG/ESO 2.2-metre telescope
Danish 1.54-metre telescope
MarLy 1-metre telescope
ESO 1-metre telescope
ESO 1.52-metre telescope
ESO 0.5-metre telescope
Dutch 0.9-metre telescope
Danish 0.5-metre telescope
Bochum 0.61-metre telescope

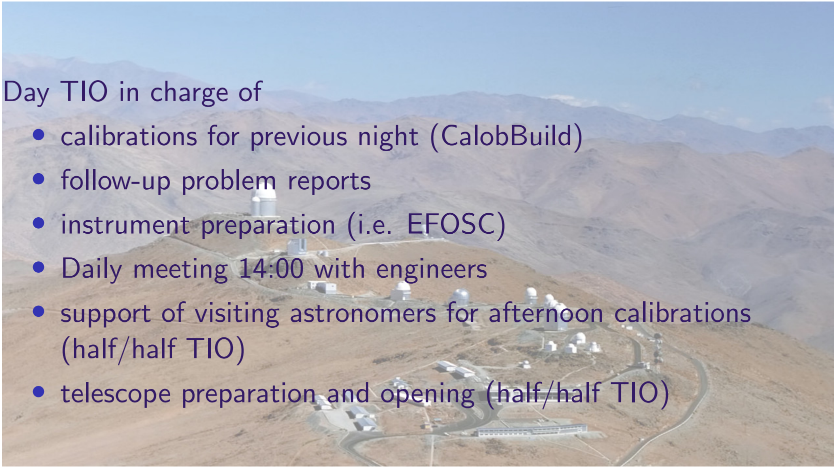
The La Silla Site

NTT and 3.6



The La Silla Site

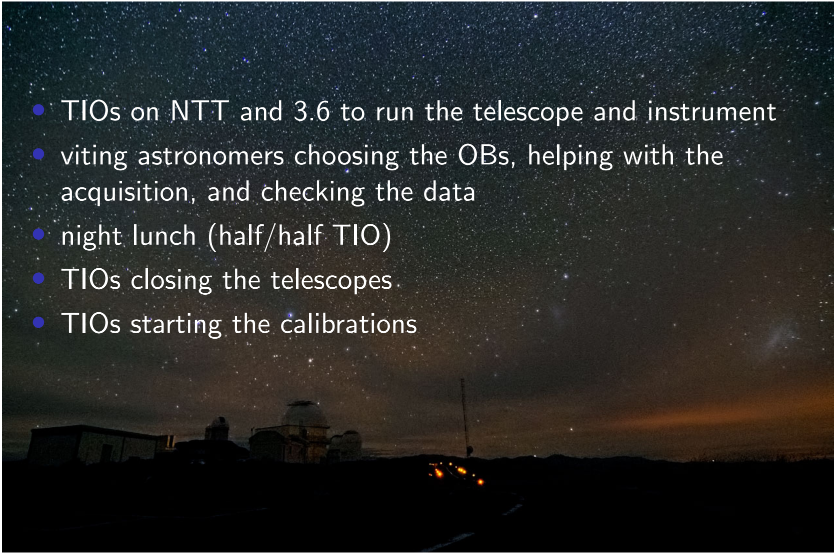
A typical day...



Day TIO in charge of

- calibrations for previous night (CalobBuild)
- follow-up problem reports
- instrument preparation (i.e. EFOSC)
- Daily meeting 14:00 with engineers
- support of visiting astronomers for afternoon calibrations (half/half TIO)
- telescope preparation and opening (half/half TIO)

A typical night...



- TIOs on NTT and 3.6 to run the telescope and instrument
- viting astronomers choosing the OBs, helping with the acquisition, and checking the data
- night lunch (half/half TIO)
- TIOs closing the telescopes
- TIOs starting the calibrations

The End