Astrophysical Techniques

I: Observing Strategies and Constraints

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&

Peter Wheatley

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Overview

Key Topics:

- Observing strategies and constraints
- Observing in the optical-IR
- X-ray and gamma-ray astronomy
- Radio/sub-mm observing
- Data archive mining

Online materials:
www.astro.warwick.ac.uk/people/steeghs/mpags-as2

Assignments to D.T.H.Steeghs@warwick.ac.uk *and* P.J.Wheatley@warwick.ac.uk , please include AS2 in subject.

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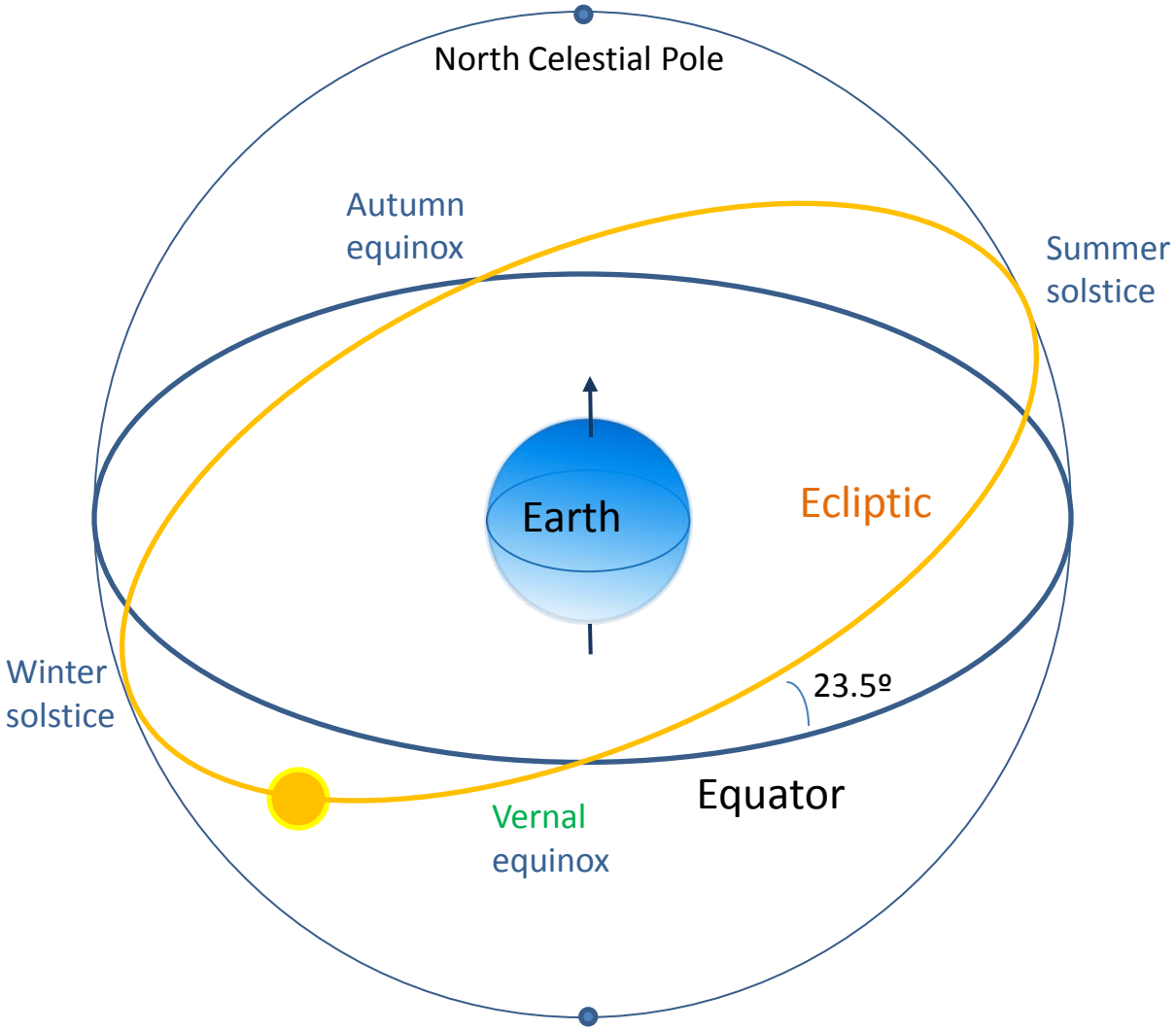
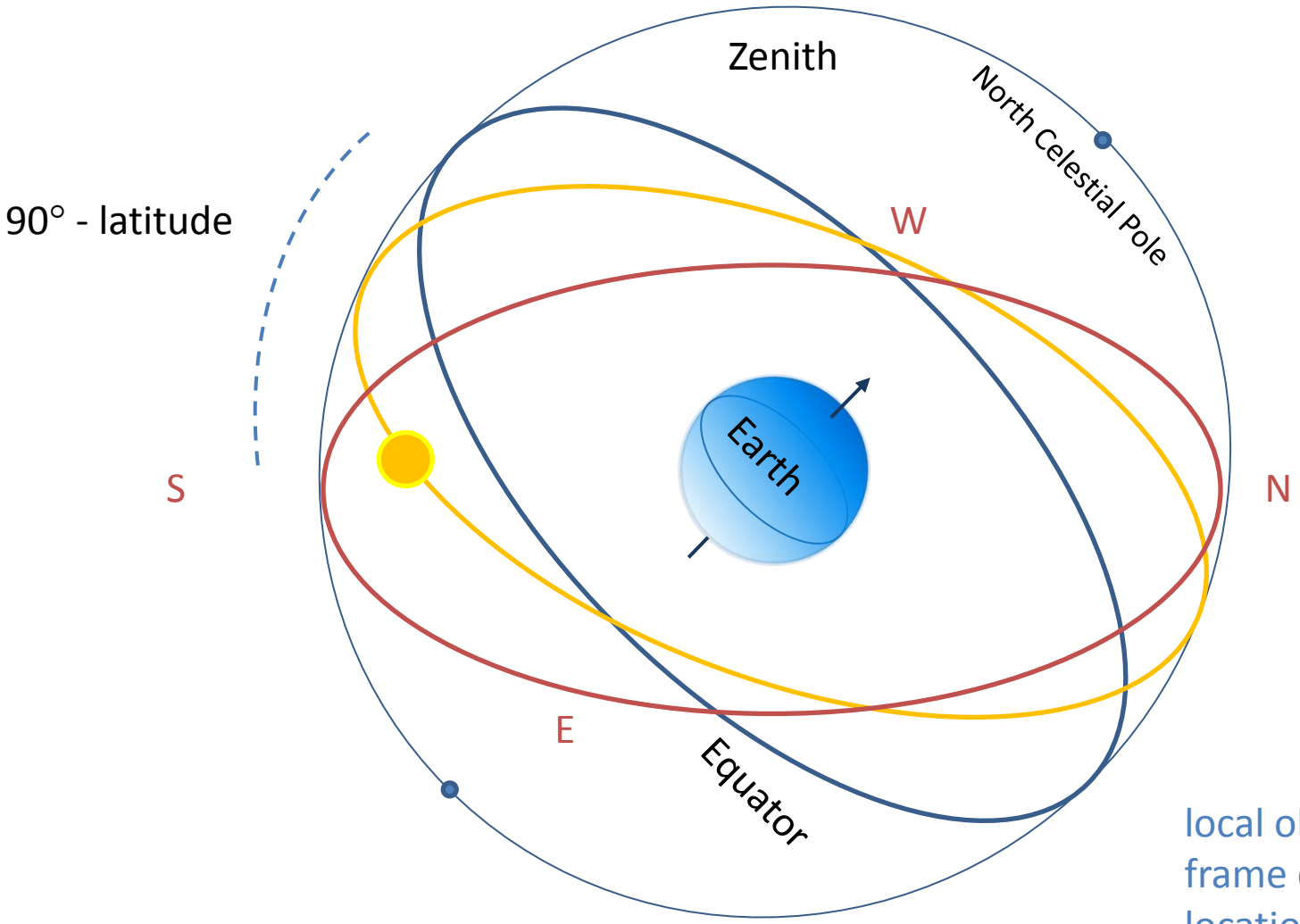
The celestial sphere

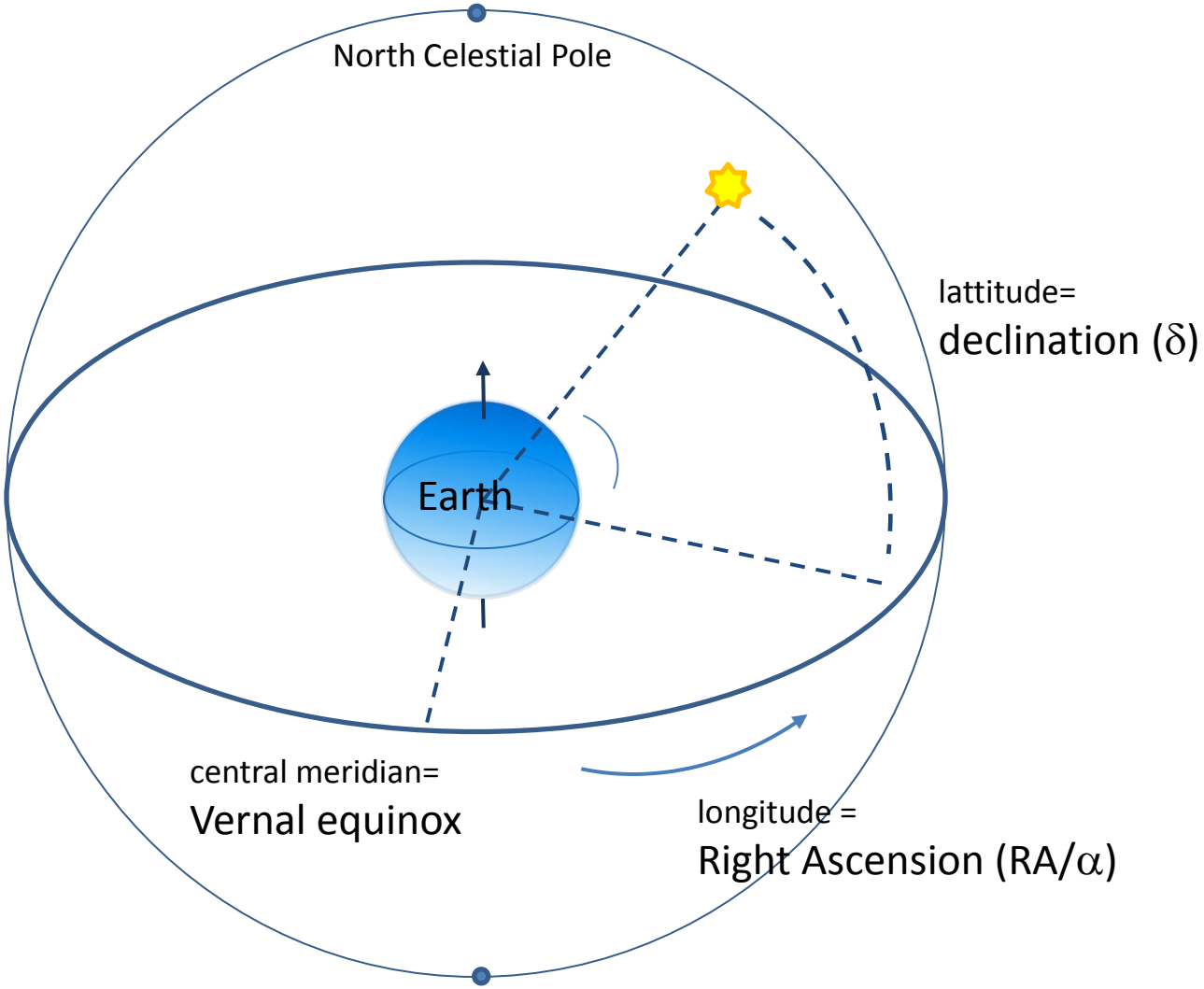


The celestial sphere ; local horizon



local observer frame depends on location and time

The celestial sphere ; coordinates



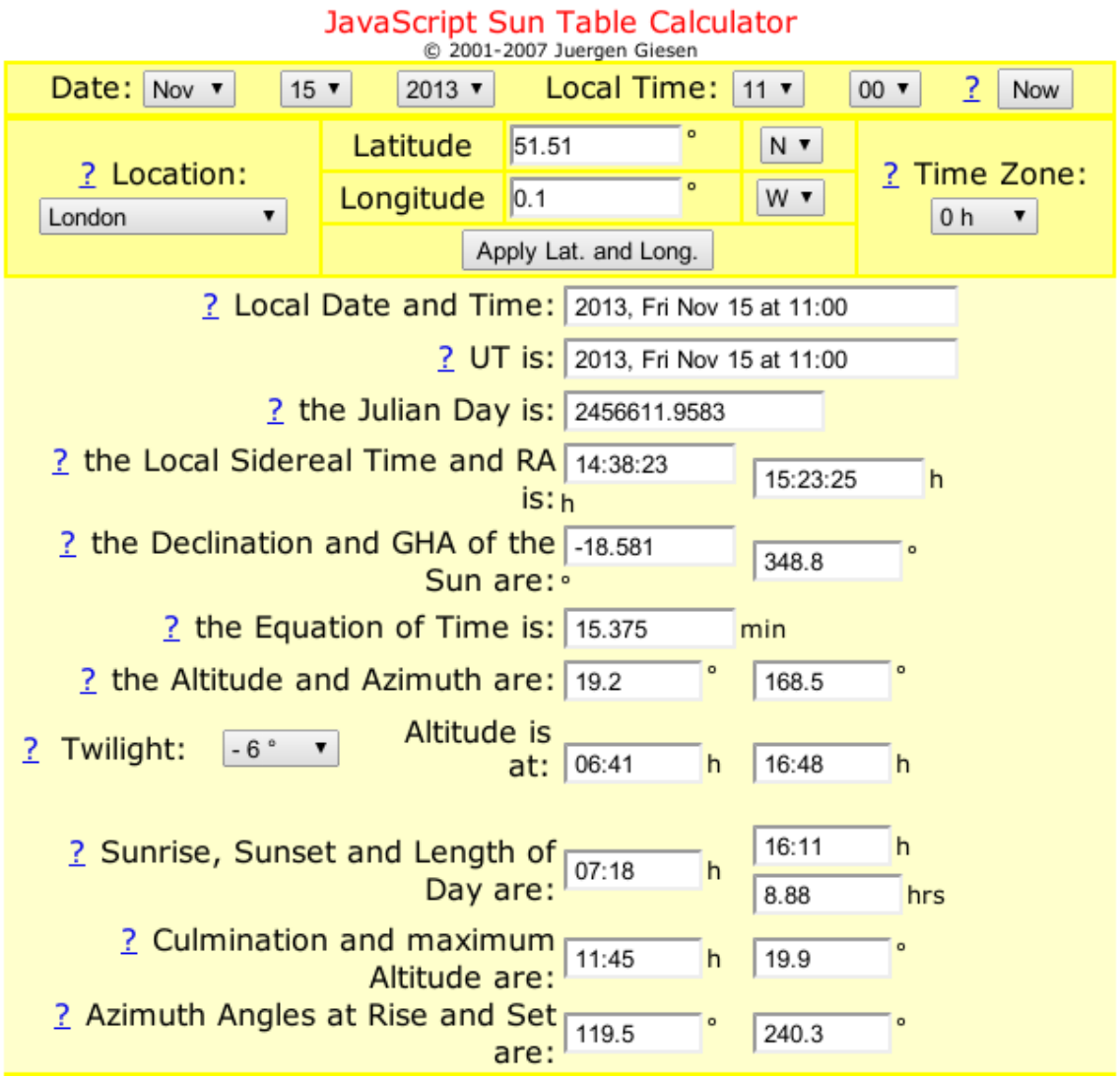
Equatorial Coordinates (RA/Dec)

- Right Ascension (R.A. or α) as longitude, often expressed in hours, minutes and seconds (or decimal hours or degrees)
- Declination (δ) as latitude in degrees (either decimal or sexagesimal)
- Constant declination arcs are not great circles (cos δ projection), thus 1 second is only 15” at equator
- Current RA and Dec of the Sun?
- Precession and nutation of the Earth causes movement of the equinoxes ; need to specify *equinox and epoch of coordinates*

  precession period of 25,800 yrs, +/- 24 degrees (~50”/yr)
  nutation period of 18.6 years, 23” amplitude

  e.g. equinox of reference coordinate system: B1950 or J2000
  epoch of observation : 2013.0

JavaScript Sun Calculator for the lazy



http://www.jgiesen.de/astro/astroJS/sunriseJS/index.htm

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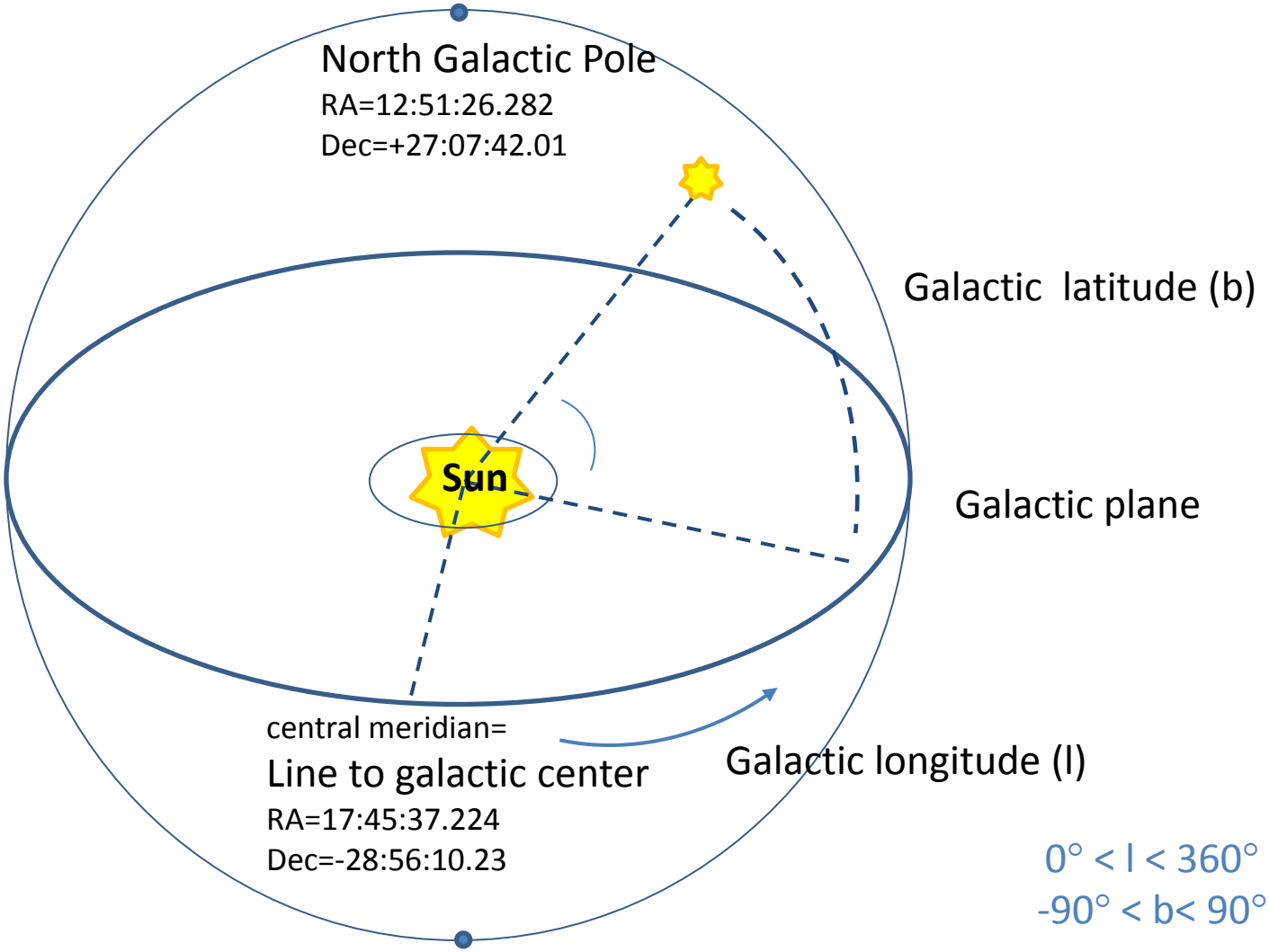
Galactic coordinates (l,b)



$0° < l < 360°$

$-90° < b < 90°$

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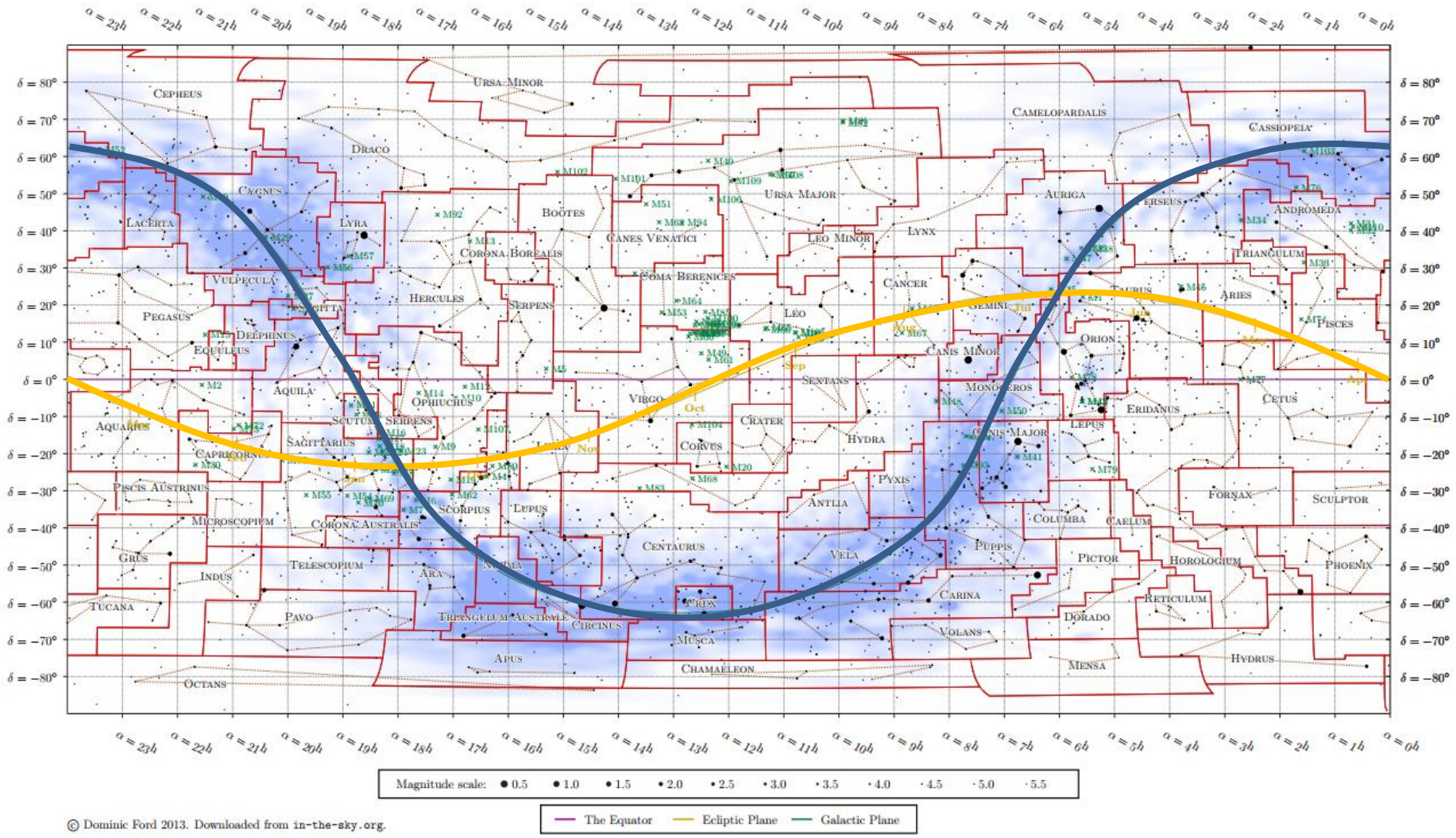
Equatorial Projections



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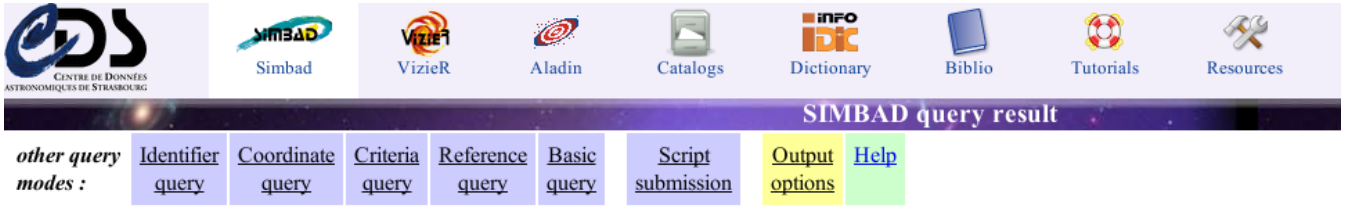
Tools example: Simbad



Identifier Query:
http://simbad.u-strasbg.fr/simbad/sim-fid

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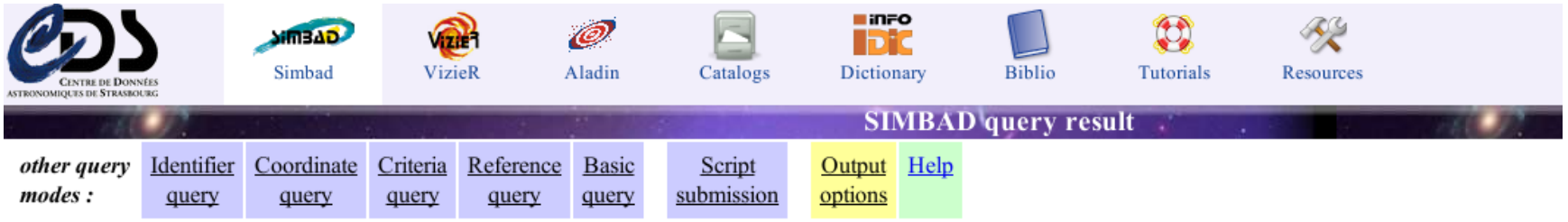
Tools example: Simbad



Object query : coord 17 08 19.08 -25 48 31.7 (FK5, 2000, 2000), radius: 2 arcmin

Number of rows : 4 plot this list of objects ◉ Equat. ○ Gal ○ SGal ○ Ecl

N	Identifier	dist(asec)	Otype	ICRS (J2000) RA	ICRS (J2000) DEC	Sp type	#ref 1850 - 2012	#notes
1	V* V2051 Oph	0.00	DN*	17 08 19.08	-25 48 31.7	~	173	0
2	1RXS J170818.5-254844	14.56	X	17 08 18.502	-25 48 43.99	~	0	0
3	CD-25 11972	73.62	*	17 08.4	-25 48	~	2	0
4	USNO-A1.0 0600-13191139	96.45	*	17 08 15.842	-25 49 57.67	~	1	0

plot this list of objects ◉ Equat. ○ Gal ○ SGal ○ Ecl

Store this result in the CDS portal

To bookmark this query, right click on this link: simbad:coo=17 08 19.08 -25 48 31.7,rad=2 arcmin and select 'bookmark this link' or equivalent in the popup menu

Coordinate Query:
http://simbad.u-strasbg.fr/simbad/sim-fcoo

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Tools example: NASA-SAO ADS

SAO/NASA ADS Astronomy Query Form for Thu Nov 10 10:28:07 2011

Sitemap What's New Feedback Basic Search Preferences FAQ HELP

Find ADS on Facebook!

Send Query | Return Query Form | Store Default Form | Clear

Databases to query: Astronomy Physics arXiv e-prints

Authors: (Last, First M, one per line) SIMBAD NED ADS Objects

Exact name matching | Object name/position search

Require author for selection | Require object for selection

(OR AND simple logic) (Combine with: OR AND)

Publication Date between (MM) (YYYY) and (MM) (YYYY)

Enter Title Words | Require title for selection

(Combine with: OR AND simple logic boolean logic)

Enter Abstract Words/Keywords | Require text for selection

(Combine with: OR AND simple logic boolean logic)

Return 200 items starting with number 1

ADSLabs Full Text Search: Search within articles

myADS: Personalized notification service

http://adsabs.harvard.edu/abstract_service.html

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Sidereal time and hour-angle

- Sidereal versus synodic periods ; sidereal day is 23h56m
- *Local Sidereal Time* (LST) = R.A. of local meridian
  LST =0 when vernal equinox is at meridian
- *Hour angle* reflects distance from meridian ; at LST=1h, the vernal equinox is one hour angle (15 degrees) west of meridian (equiv. LST = HA of vernal equinox)
- Local hour angle of star ; HA = LST – RA
  [target visibility ; want to minimise HA]
- Greenwich Sidereal Time (GST) is LST for reference observer at Greenwich ; LST = GST – longitude West
- Observatories often have both UTC (solar day) and LST clocks

Finer details

Accurate pointing of a telescope to a target requires a number of additional corrections/factors to be considered:

- Aberration due to Earth orbit
- Refraction due to Earth atmosphere
- Proper motion of your target
- Annual parallax
- Epoch of observation versus Epoch and Equinox of coordinates
- …

These are usually taken care of for you, so your main concern is establishing object visibility and feasibility of observations

Additional constraints

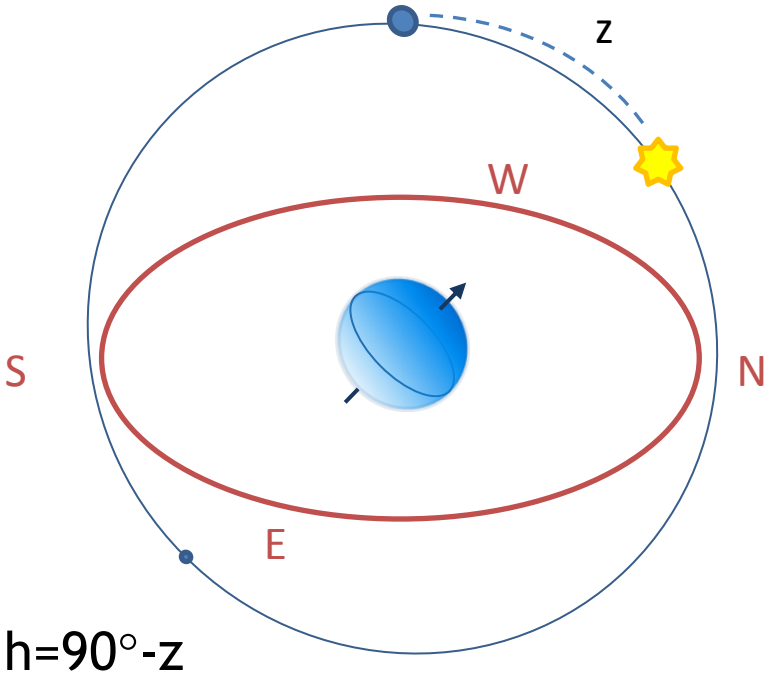
- Target accessibility for observing also affected by atmospheric effects and sky background

- Atmosphere:
  - wavelength dependent extinction
  - wavelength dependent refraction
  - image quality aka seeing

- *Airmass* reflects amount of atmosphere column along line of sight, above effects scale with airmass

- Background:
  - source detection over background; optical background heavily modulated by phase and location of Moon

Airmass



- Airmass

  Zenith angle *z*

  local altitude *h* with h=90°-z

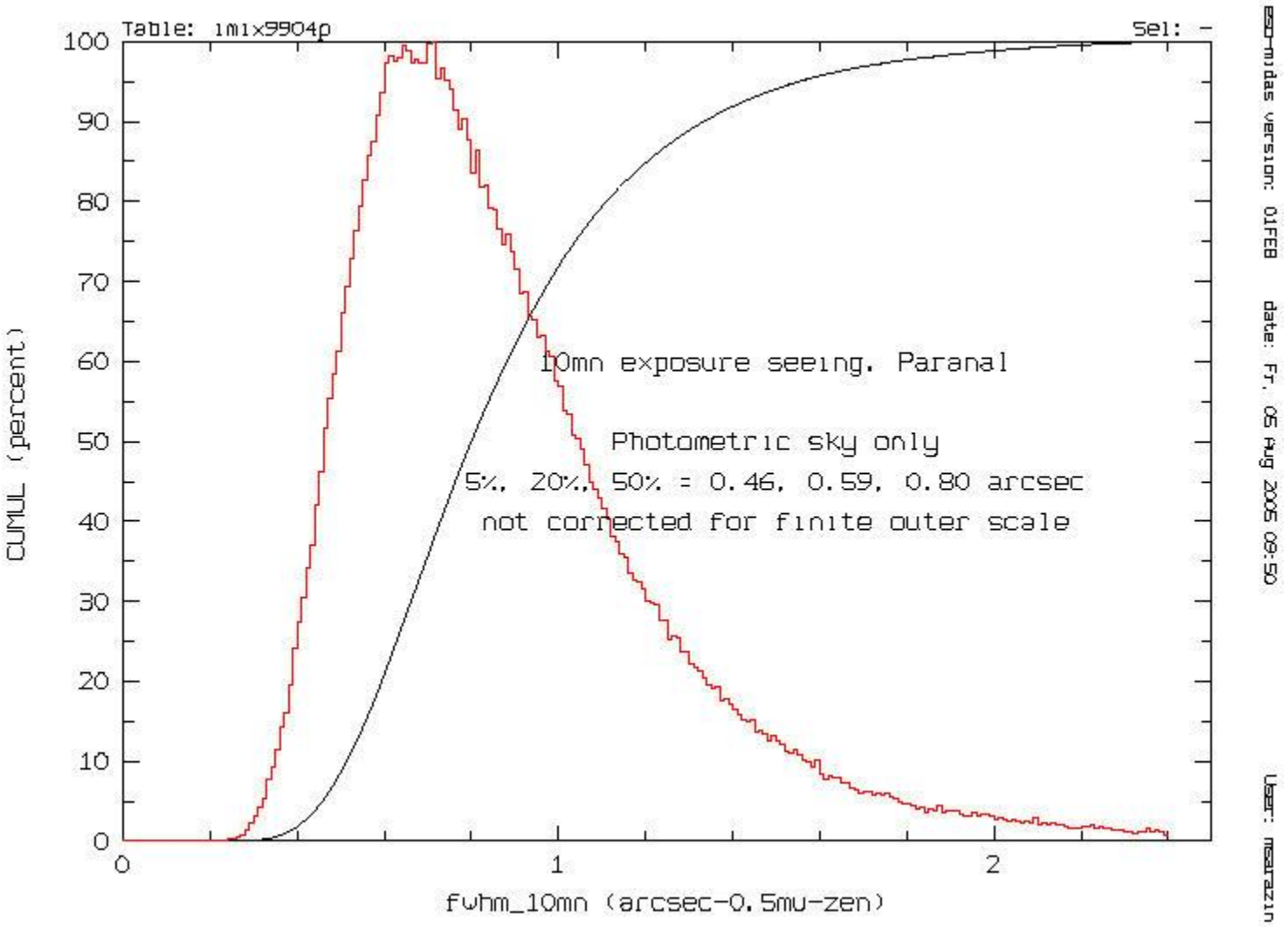
  airmass: *X~sec(z)*

  e.g. airmass ~ 2 at elevation 30°

  accurate at high z:

$$X = \sec z - 0.0018167(\sec z - 1) - 0.002875(\sec z - 1)^2 - 0.0008083(\sec z - 1)^3$$

Seeing



Seeing histogram at Cerro Paranal (ESO-VLT)

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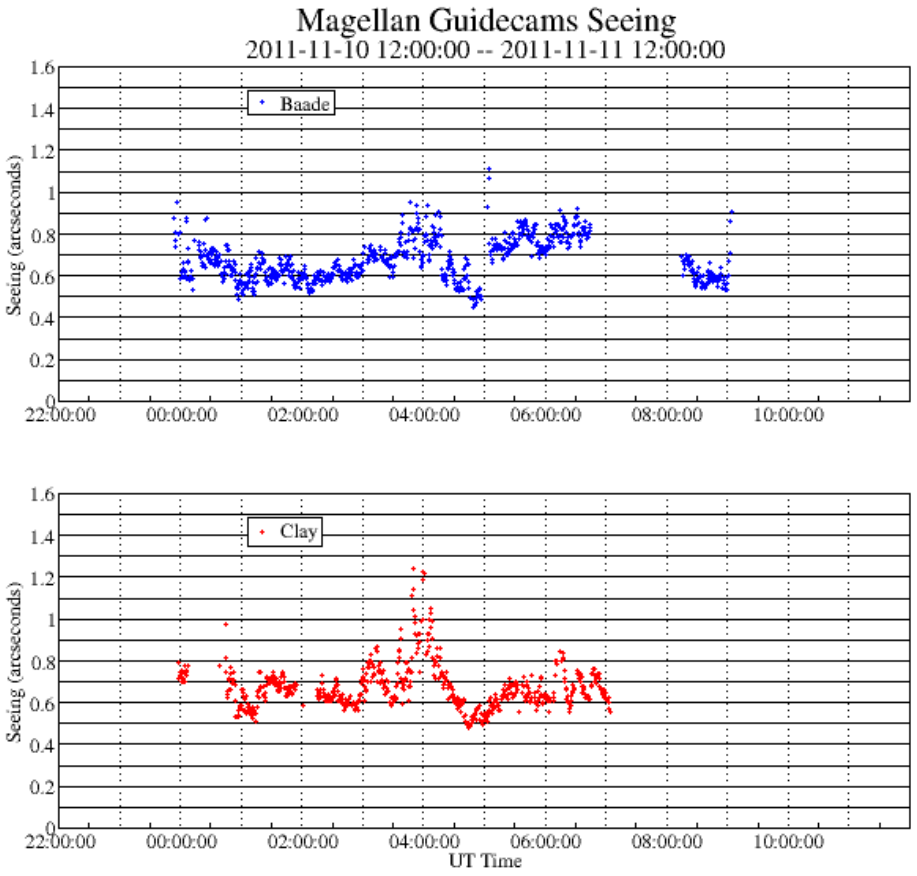
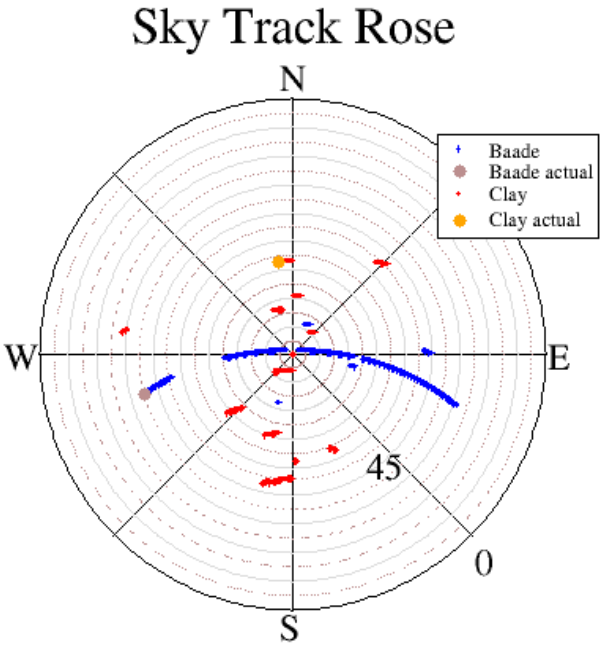
Seeing





Night at Las Campanas Observatory (Magellan telescopes)

[seeing degrades roughly proportional to $z^{0.6}$, so 50% worse at X=2]

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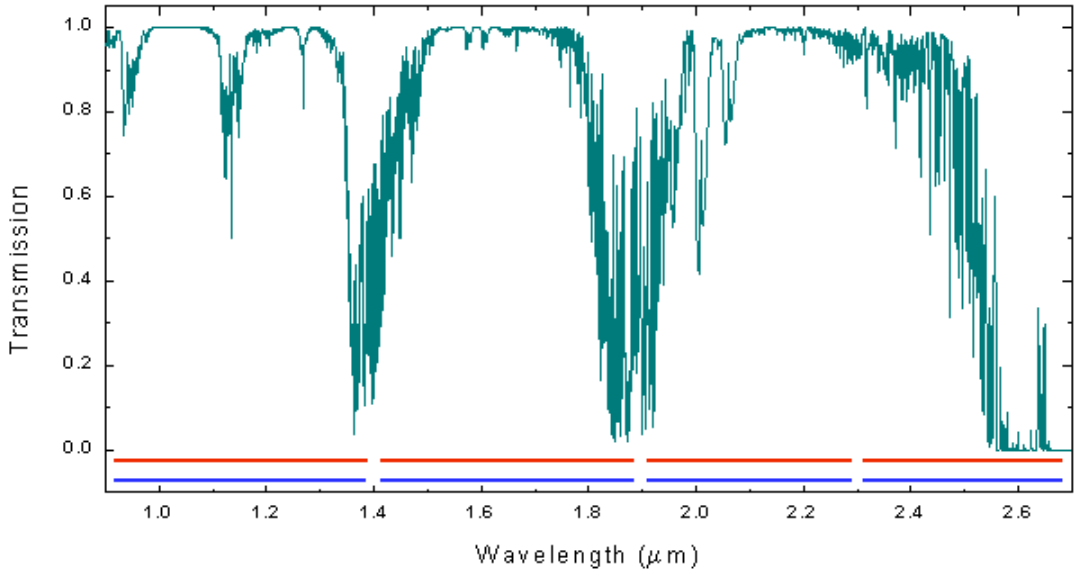
Extinction (more later)

Wavelength (nm)	Extinction (mag / air mass)
310	1.37
320	0.82
340	0.51
360	0.37
380	0.30
400	0.25
450	0.17
500	0.13
550	0.12
600	0.11
650	0.11
700	0.10
800	0.07
900	0.05

Wavelength (μm)	Extinction mag / air mass)
1.25 (J)	0.015
1.65 (H)	0.015
2.20 (K)	0.033



Wavelength dependent extinction at Mauna Kea

[directly proportional to airmass]

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Lunar Contribution to Background

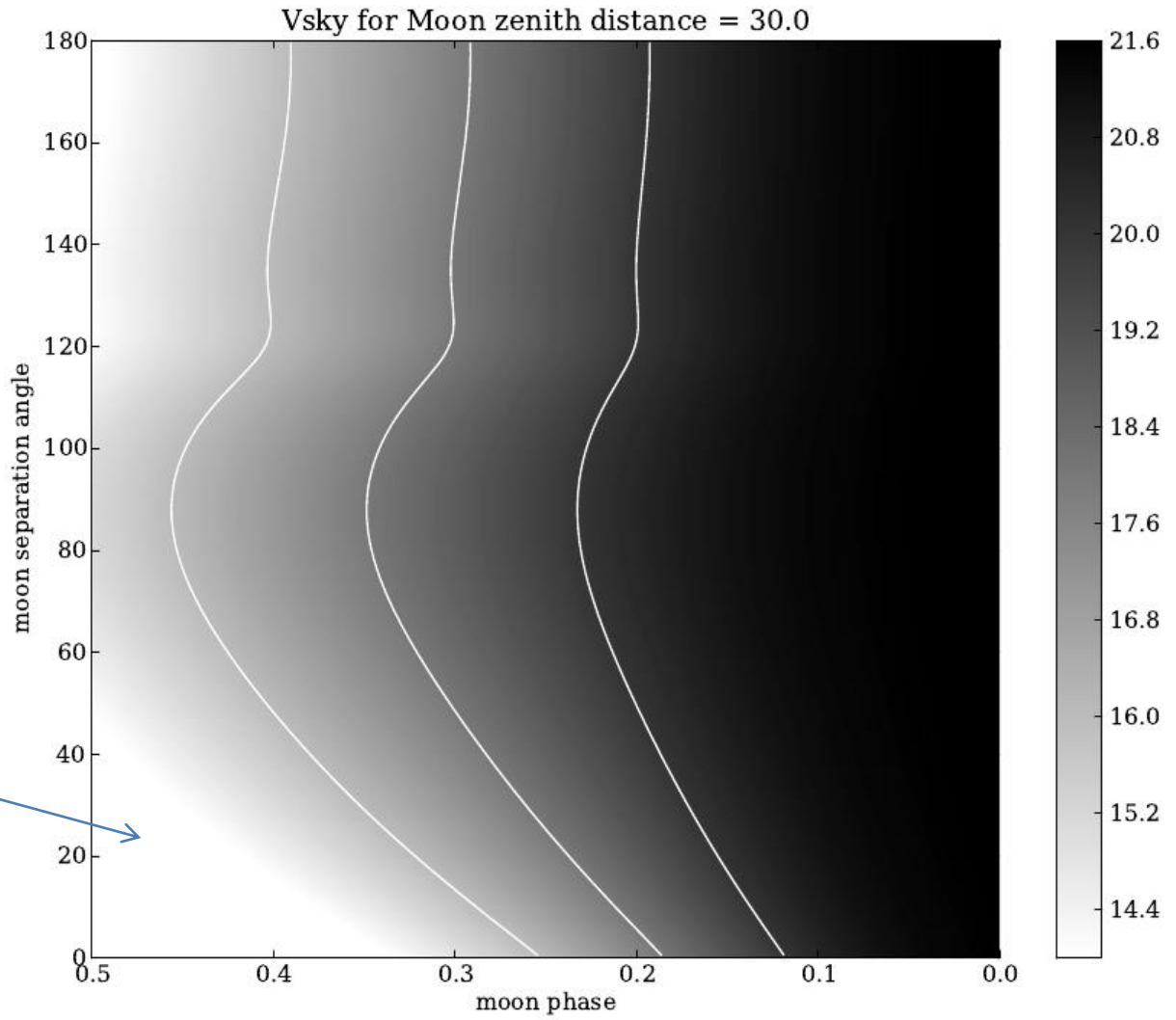
- Lunar Phase : Bright time versus Dark time

  sky background up to 5 mags brighter near full moon and at small lunar separations, down to 3 mags at 80%

- Airglow and zodiacal contributions can dominate near new Moon

- Less of an issue when you go to redder wavelengths, when airglow and thermal sky components dominate

Moon Sky background in V



Avoid <30°

Note large dynamic range

Using Krisciunas & Schaefer (1991) moon background model

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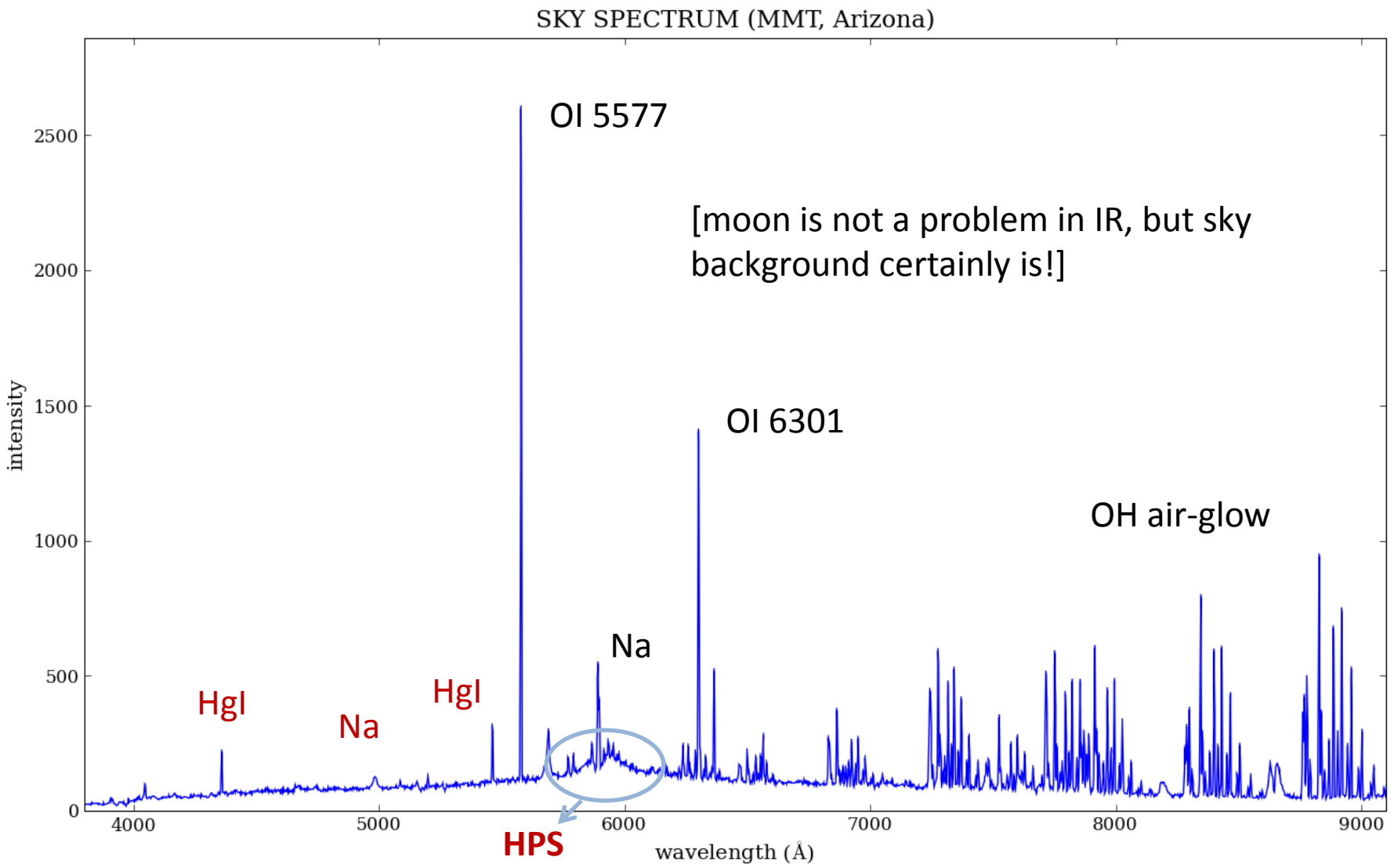
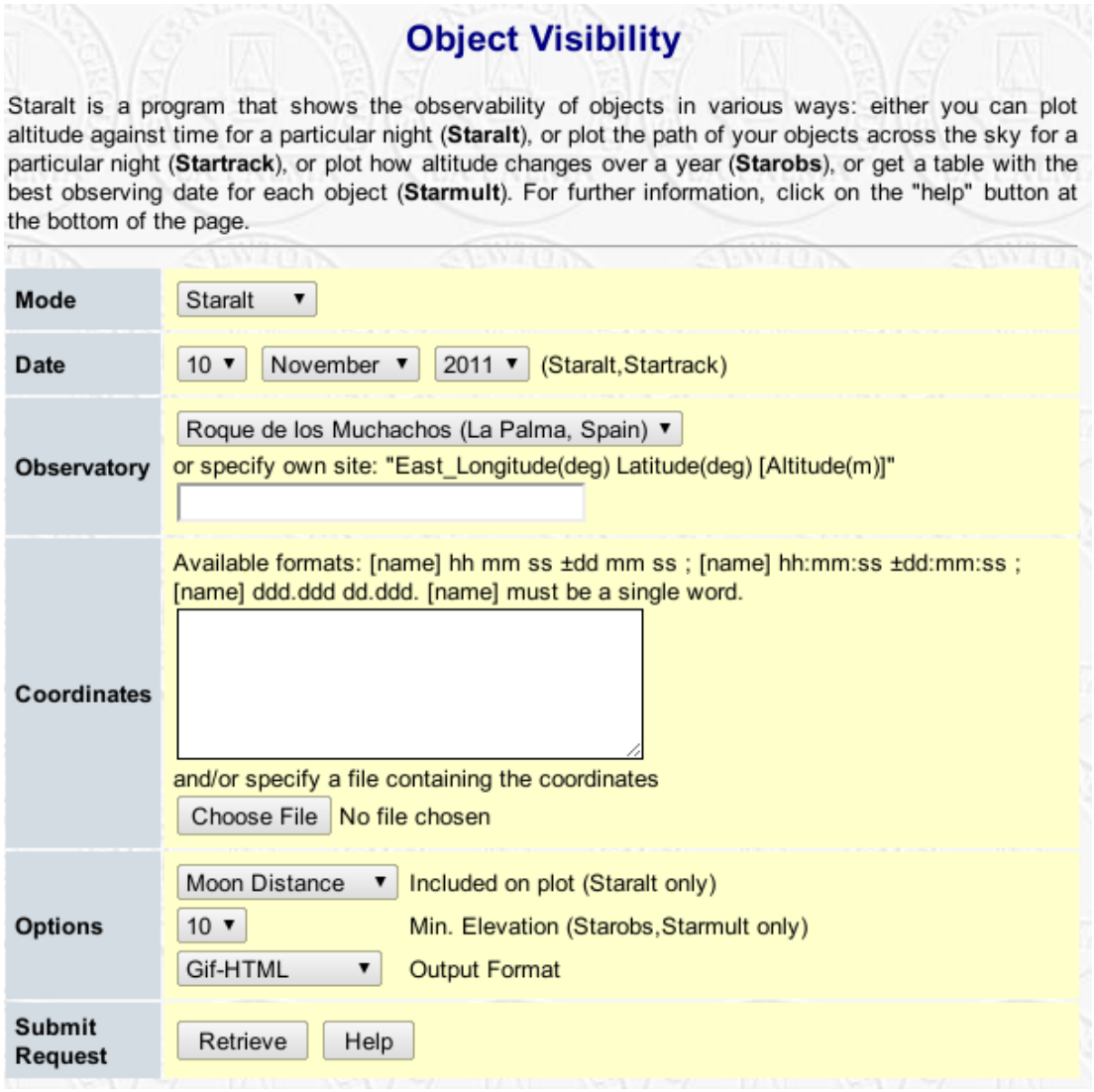
Sky background



Tools example: StarAlt @ ING



Object Visibility

Staralt is a program that shows the observability of objects in various ways: either you can plot altitude against time for a particular night (**Staralt**), or plot the path of your objects across the sky for a particular night (**Startrack**), or plot how altitude changes over a year (**Starobs**), or get a table with the best observing date for each object (**Starmult**). For further information, click on the "help" button at the bottom of the page.

Mode	Staralt ▾
Date	10 ▾ November ▾ 2011 ▾ (Staralt,Startrack)
Observatory	Roque de los Muchachos (La Palma, Spain) ▾ or specify own site: "East_Longitude(deg) Latitude(deg) [Altitude(m)]"
Coordinates	Available formats: [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. and/or specify a file containing the coordinates Choose File No file chosen
Options	Moon Distance ▾ Included on plot (Staralt only) 10 ▾ Min. Elevation (Starobs,Starmult only) Gif-HTML ▾ Output Format
Submit Request	Retrieve Help

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

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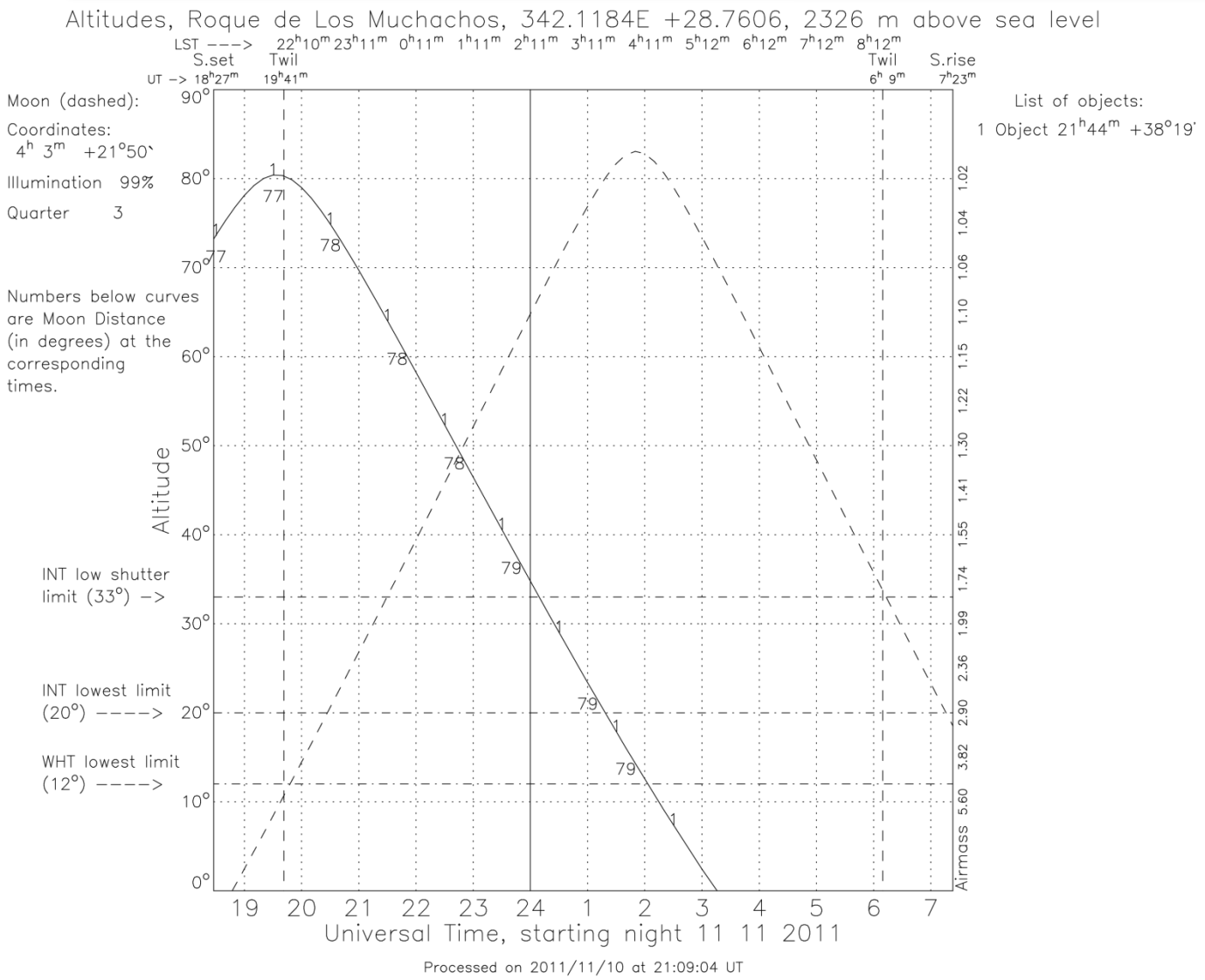
Tools example: StarAlt @ ING



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

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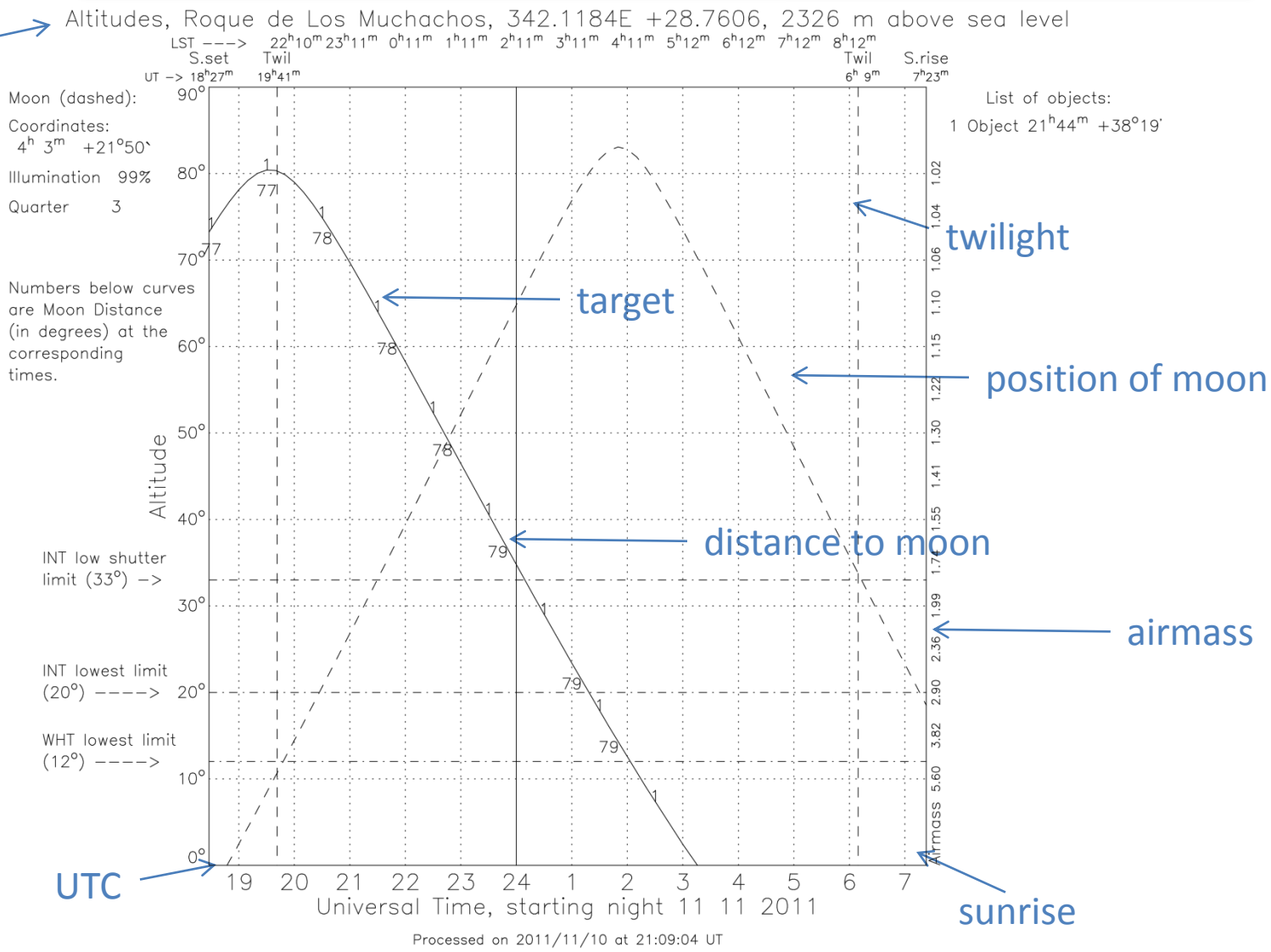
Tools example: StarAlt @ ING

geodetic Location of observatory

moon stats



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