Távcső mechanikák

Két fő alapvető típus:

- altazimutális
- ekvatoriális

Célunk: point + track (beállítás és követés)

Az ég elfordulása kb. 15 fok/óra!

Equatorial Mounts

The traditional mounting system is called the equatorial mount.
Note that we are pointing the telescope to different places on the sky - that is, we are working in two dimensions. Therefore, we need to have two axes that are perpendicular to each other - like x and y. In an equatorial system, one axis is made exactly parallel to Earth's rotation axis, and this is called the polar axis. The second axis is at right angles to this polar axis, and it is called the declination axis. The telescope moves N-S about the declination axis and E-W about the polar axis.

Some things to note:

*** To point at a target requires moving the telescope about both axes.

*** To track on the target during the exposure requires moving about the polar axis only. Because the polar axis is exactly parallel to Earth's rotation axis, we need only spin the telescope about this axis at just the same rate that Earth spins.

This is the chief advantage of the equatorial mounting system.
The N-S position does not change, and a simple clock mechanism can regulate the E-W tracking of the target.

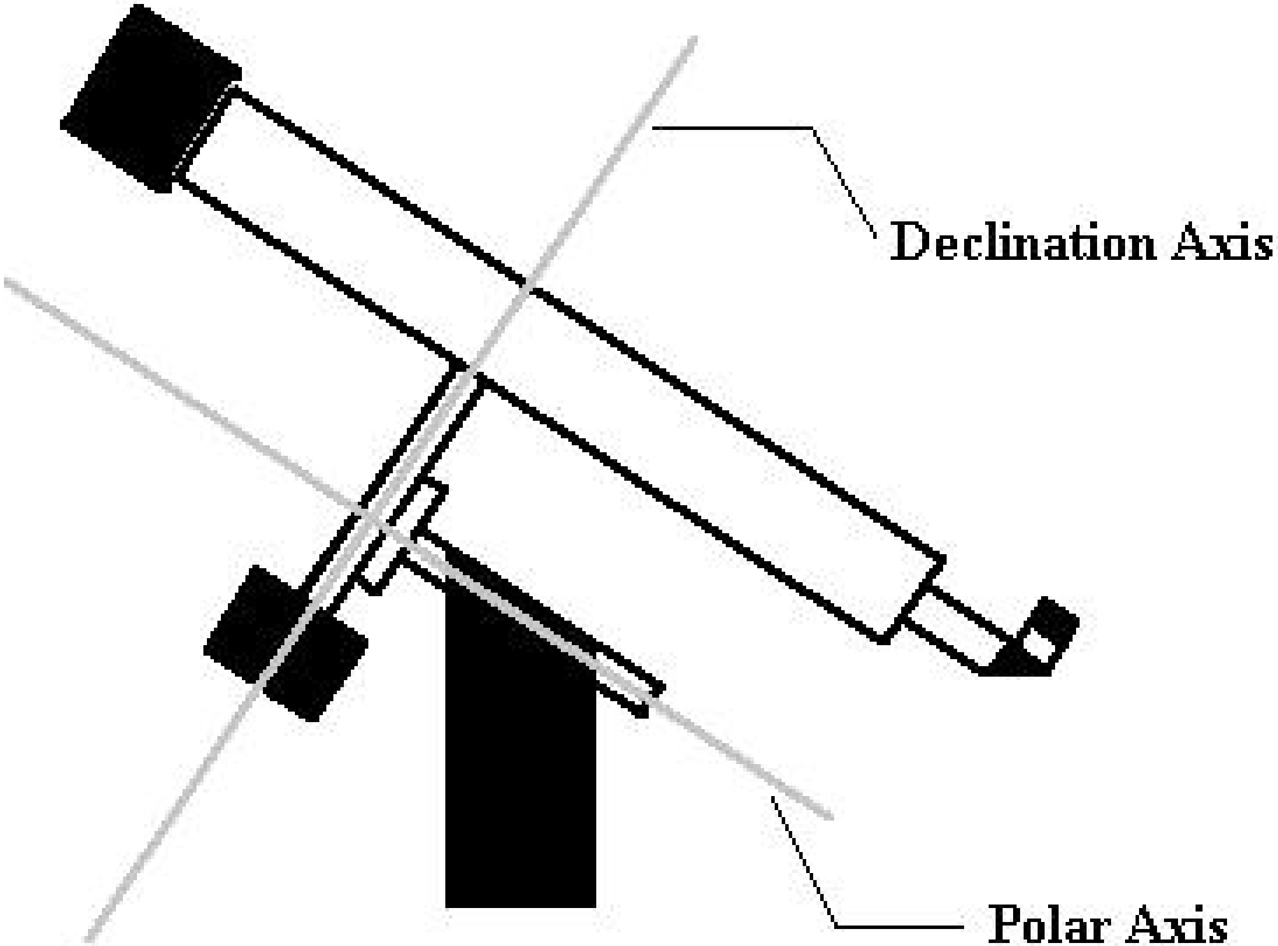
*** The main drawback of the equatorial mount is that the axis parallel to Earth's rotation axis is a difficult orientation with respect to the ground, and it is different for every observatory.
For example, in Toronto the polar axis must make an angle of about 45° with respect to the ground. In another location, such as Hawaii, the polar axis must be positioned to have an angle of about 19° to the ground. Positioning these large mechanical structures at these odd angles creates difficulties that increase rapidly as the size and mass of the telescope increase.

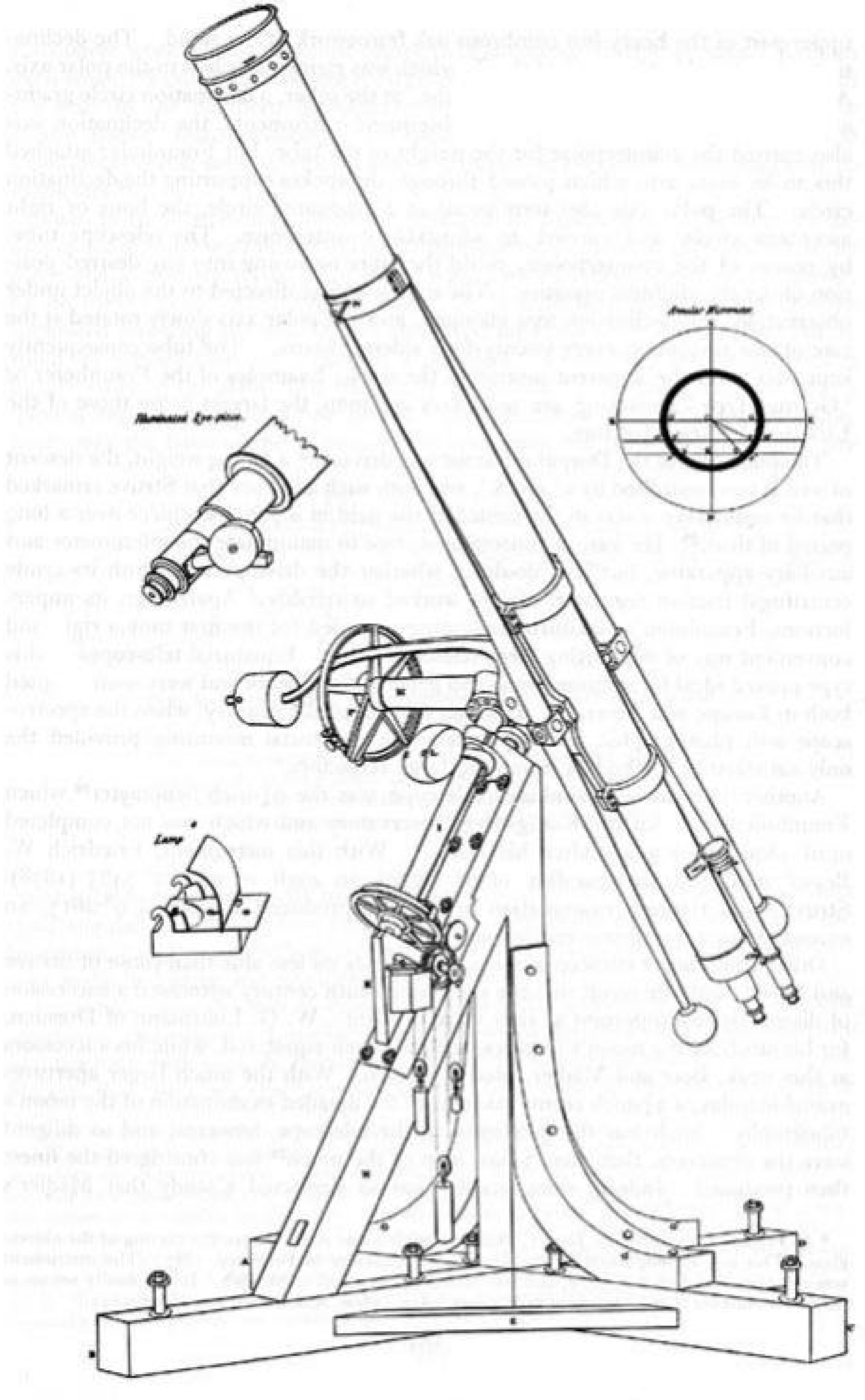
The basic idea of an equatorial mount has been achieved in several different ways. Each has a polar axis and a declination axis, but each arrangement is different.

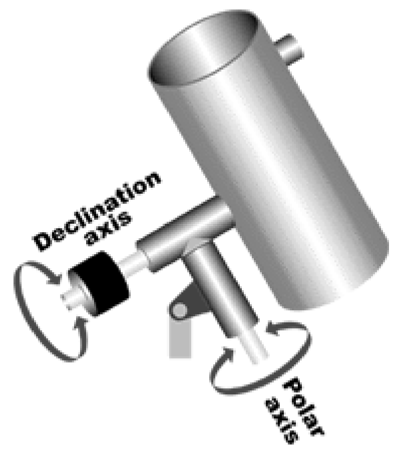
1. German Mount

In this approach, the declination axis is at the end of the polar axis, which is on top of a pier to raise the telescope to a convenient height. This arrangement can point to any part of the sky, but it experiences great mechanical stress because the weight of the telescope must be held at the end of the axis. There is a counter weight to balance the telescope on the declination axis, but that just doubles the weight that the polar axis must support. This stress limits the German mount to relatively small, light telescopes.

Side View




Annular Micrometer
Illuminated Eye-Piece
Lamp


Declination axis
Polar axis

Gemini G-41 Field

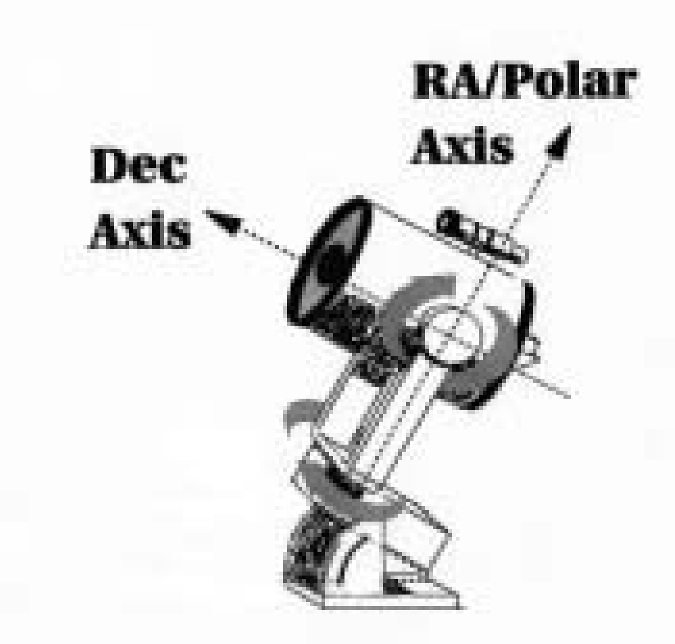
ASTRO-PHYSICS

ASTRO-PHYSICS
1200 SERVO DRIVE

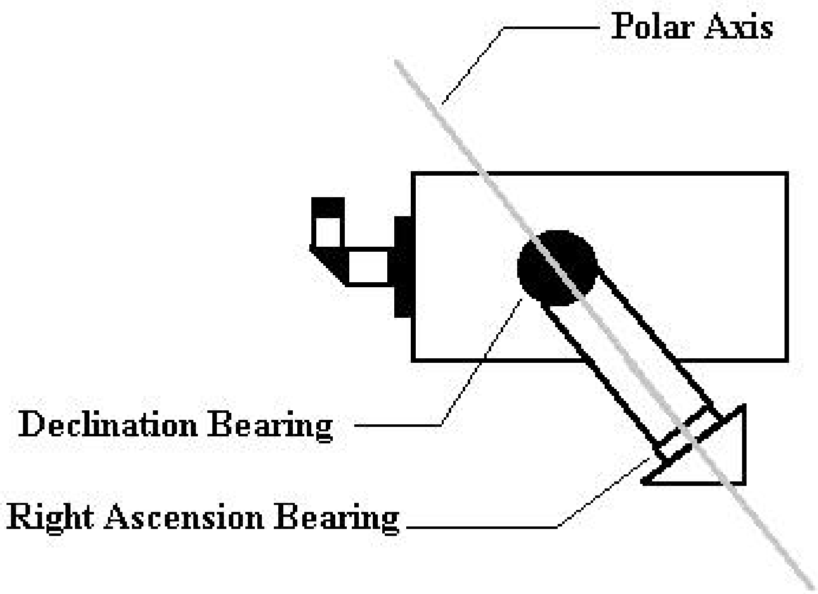
2. Fork Mount

In this scheme, the polar axis branches into a fork. The declination axis holding the telescope is anchored on both ends by the two sides of the fork. This provides much stronger declination support for the telescope, but there is still no support for the weight at the end of the polar axis. Another limitation is that the room for the telescope at the bottom of the fork is limited. Either the telescope can have only small instruments if it wants to view all parts of the sky, or it cannot view along the polar axis if it is used with larger instruments.

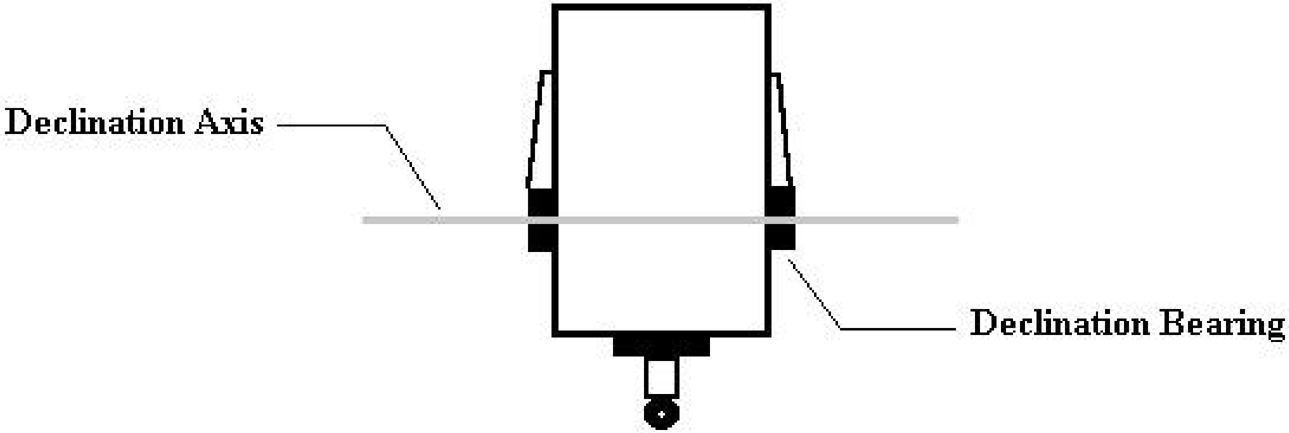
This mounting method was used for telescopes up to mirror diameters of 2.5 m

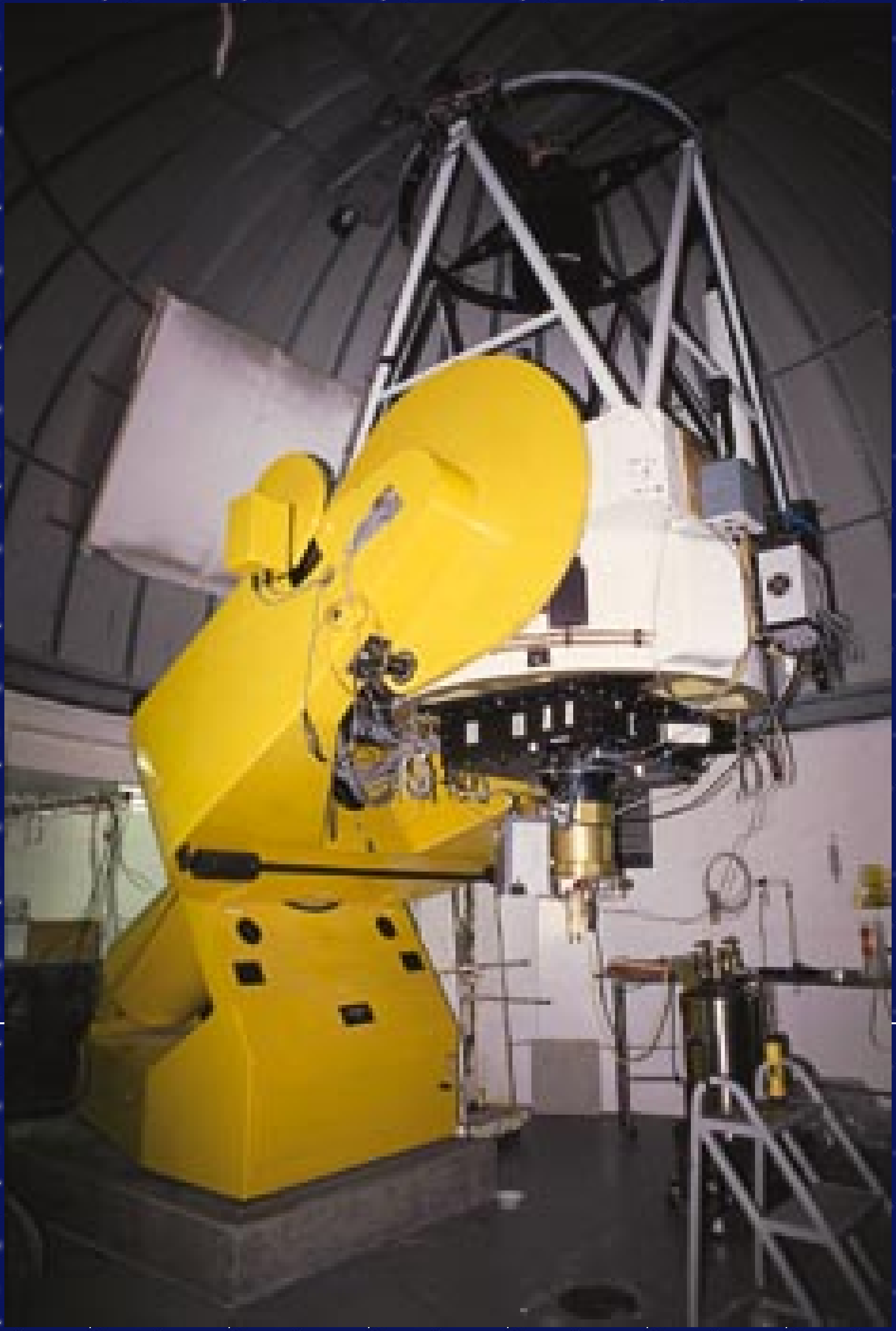


Side View



Top View

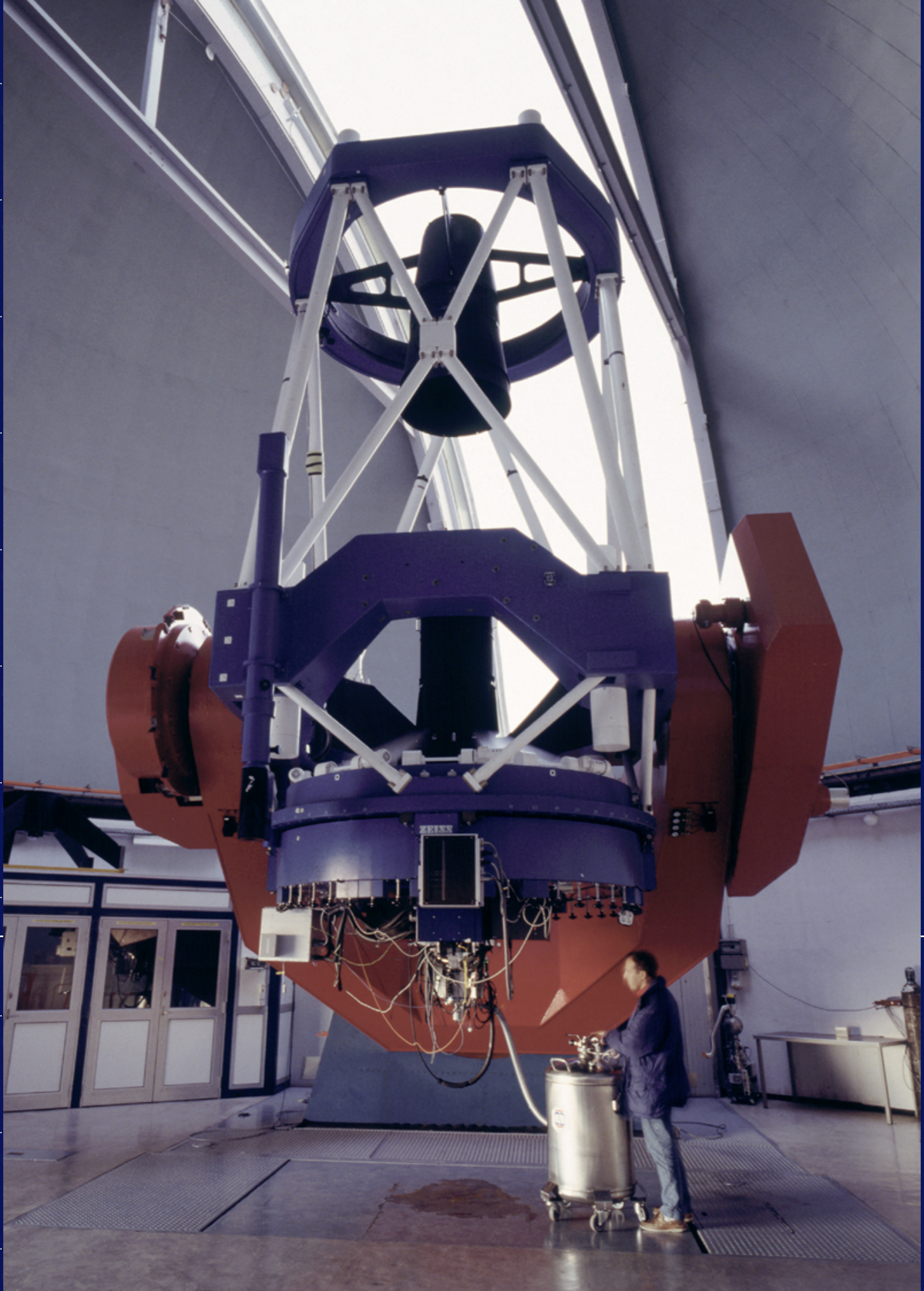




ESO

La Silla

2.2 méter

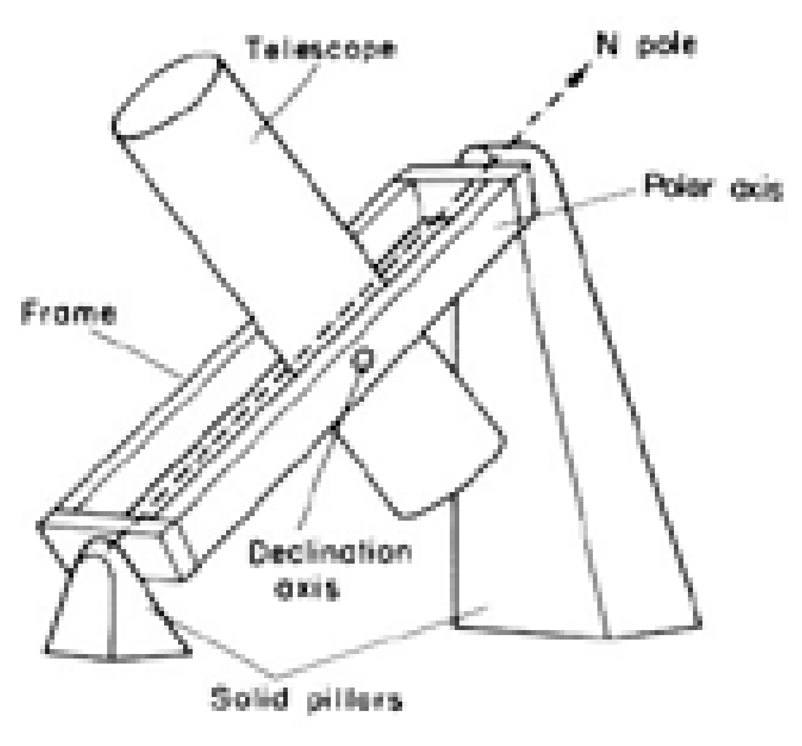


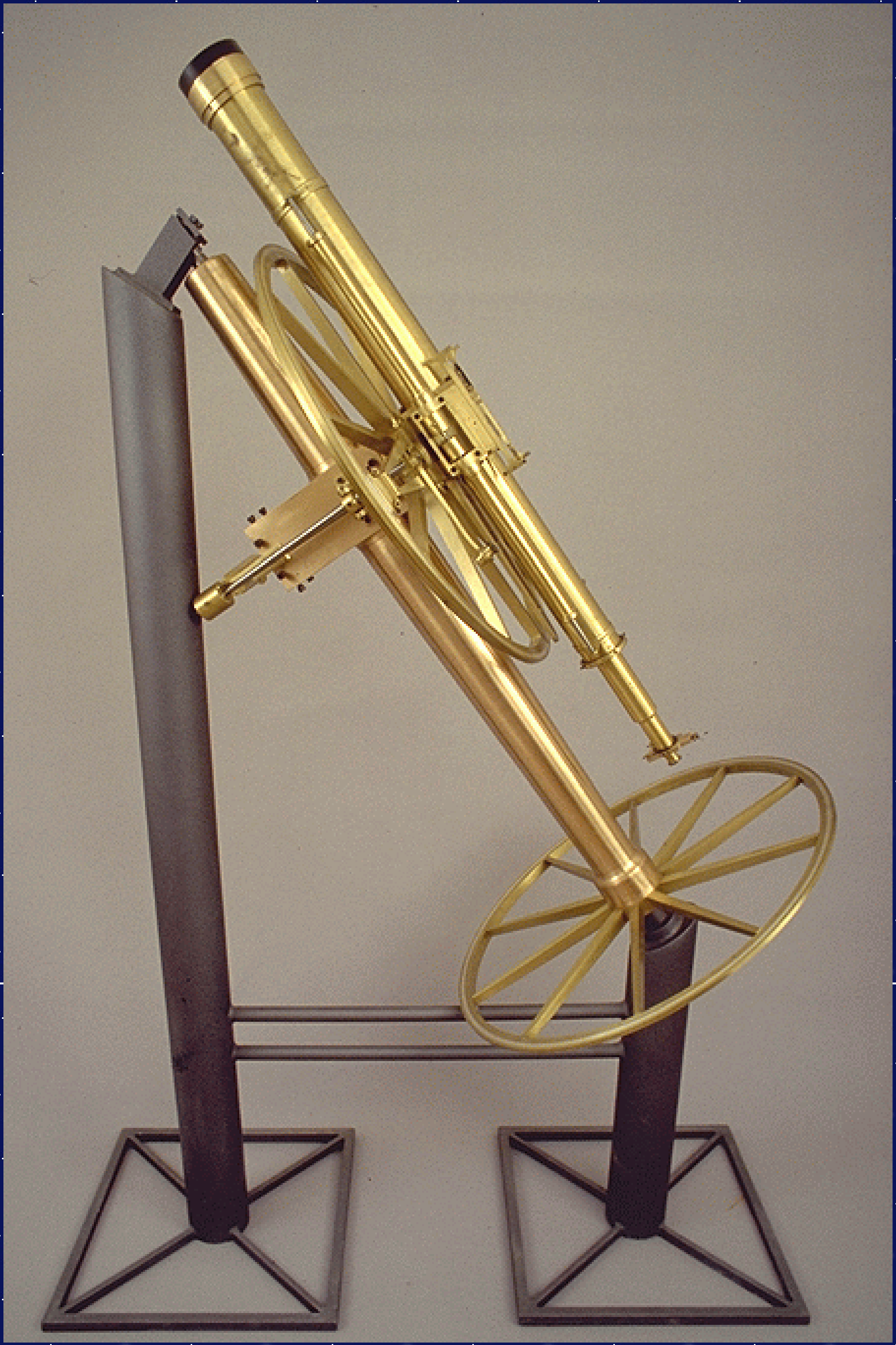
3. English Mount

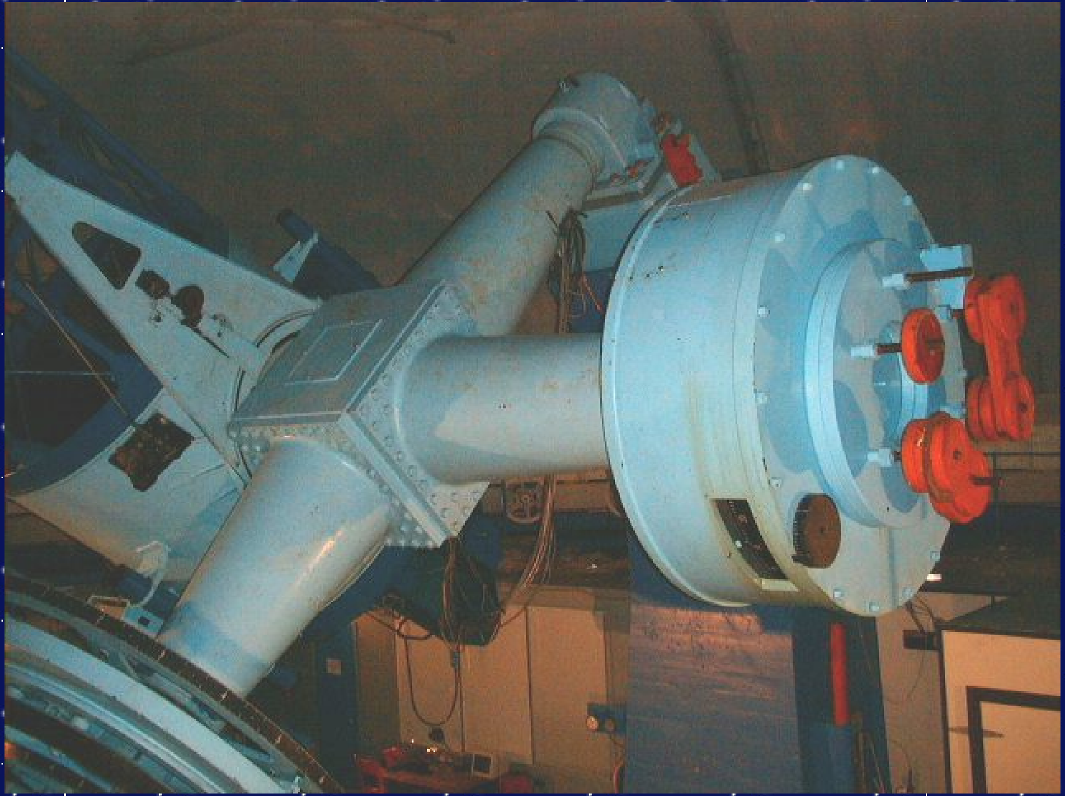
A third variation of the equatorial mount is the English mount. In this arrangement, the polar axis is supported at the top and the bottom on vertical piers. This relieves the mechanical stress on the polar axis. However, the telescope is attached on one side of the polar axis, so the declination axis is now the one that feels the mechanical stress.

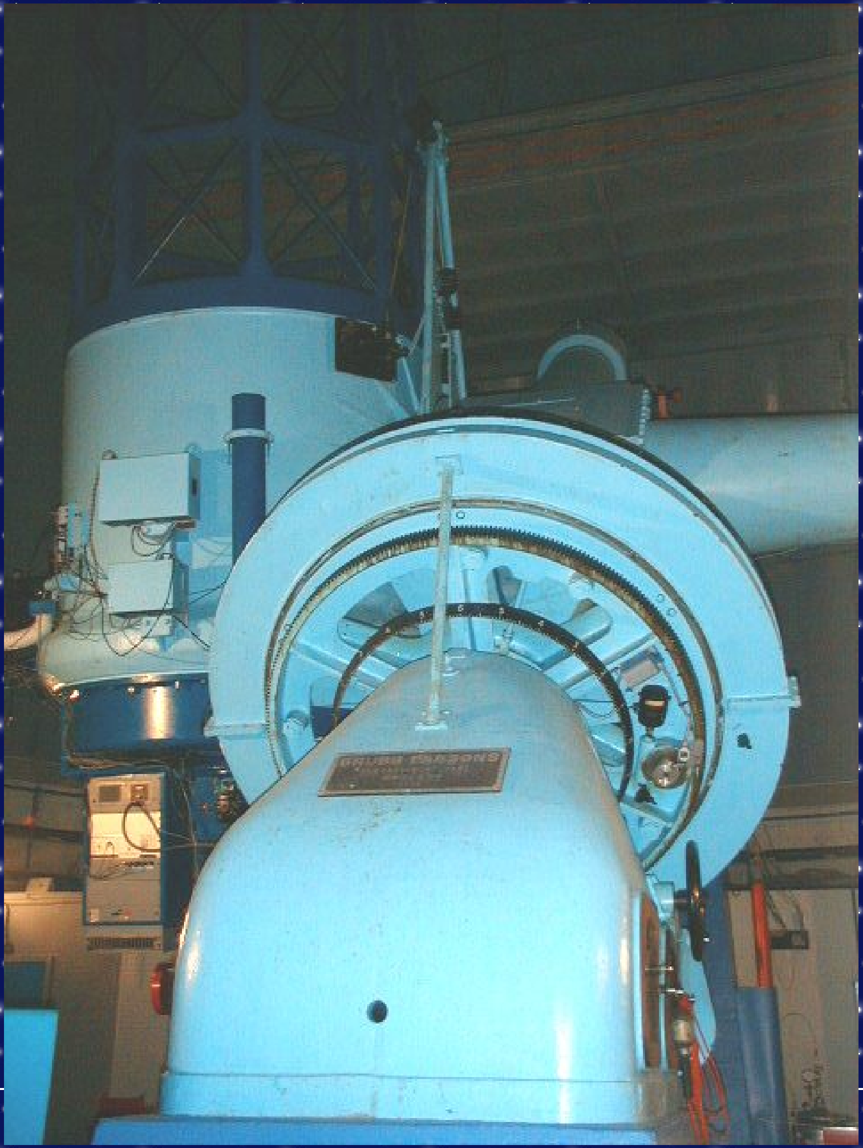
The English mount is not restricted to just part of the sky, as was the case for the fork mount, but it is convenient for only half of the sky at one time. For one half of the sky the telescope is slung beneath the polar axis, making it easy to reach the focus for observing. For the other side of the sky, however, the telescope is on top of the polar axis, making it difficult to reach the focus, except by standing on a very tall ladder. This difficulty can be solved by ``reversing" the side of the polar axis on which the telescope is attached, but this only swaps the sides of the sky that the telescope can view easily.

The large telescope of the University of Toronto's David Dunlap Observatory, which has a mirror diameter of 1.88 m, has an English mount. Therefore, this mounting system is comparable to the fork design in the size of the telescope it can accommodate.








GRUBB PARSONS

4. Horseshoe Mount

When astronomers wanted to build telescopes larger than 2.5 m, it was necessary to devise a new mounting arrangement that would be able to carry larger telescopes. The solution was the horseshoe mount that was invented for the 5-m telescope that was completed in the late 1940's and used for all the 3 to 5-m telescopes built for 1950 to 1970. The Canada-France-Hawaii Telescope, finished in the early 1970's, was one of the last telescopes built with this mounting scheme.

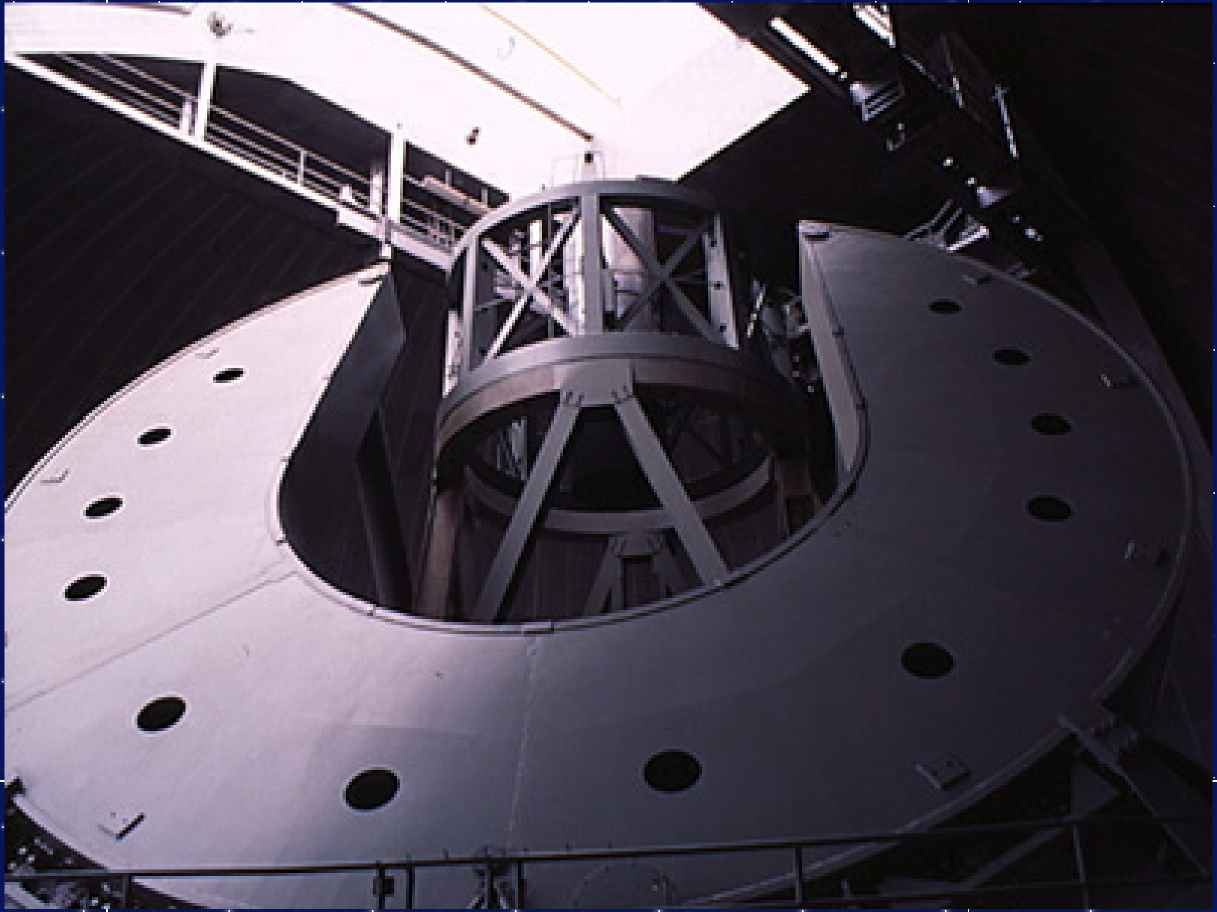
The goals of the horseshoe design are:

1. support both ends of both axes
2. have unrestricted access to the whole sky

To achieve these goals, there is a fork-like polar axis that is mounted on the top end to a horseshoe-shaped support. The fork provides support for both ends of the declination axis, and the horseshoe mount provides support at the top end of the polar axis. Because the horseshoe is open, the telescope can be tilted down all the way to see objects that are located directly along the polar axis in the sky.

For every mount, the pier(s) on which the polar axis rests are separate from the floor and the remainder of the observatory building. The piers extend down through the building, into the ground down to the level of solid rock. In this way, the telescope is isolated from any vibrations in the observatory building.

HAT



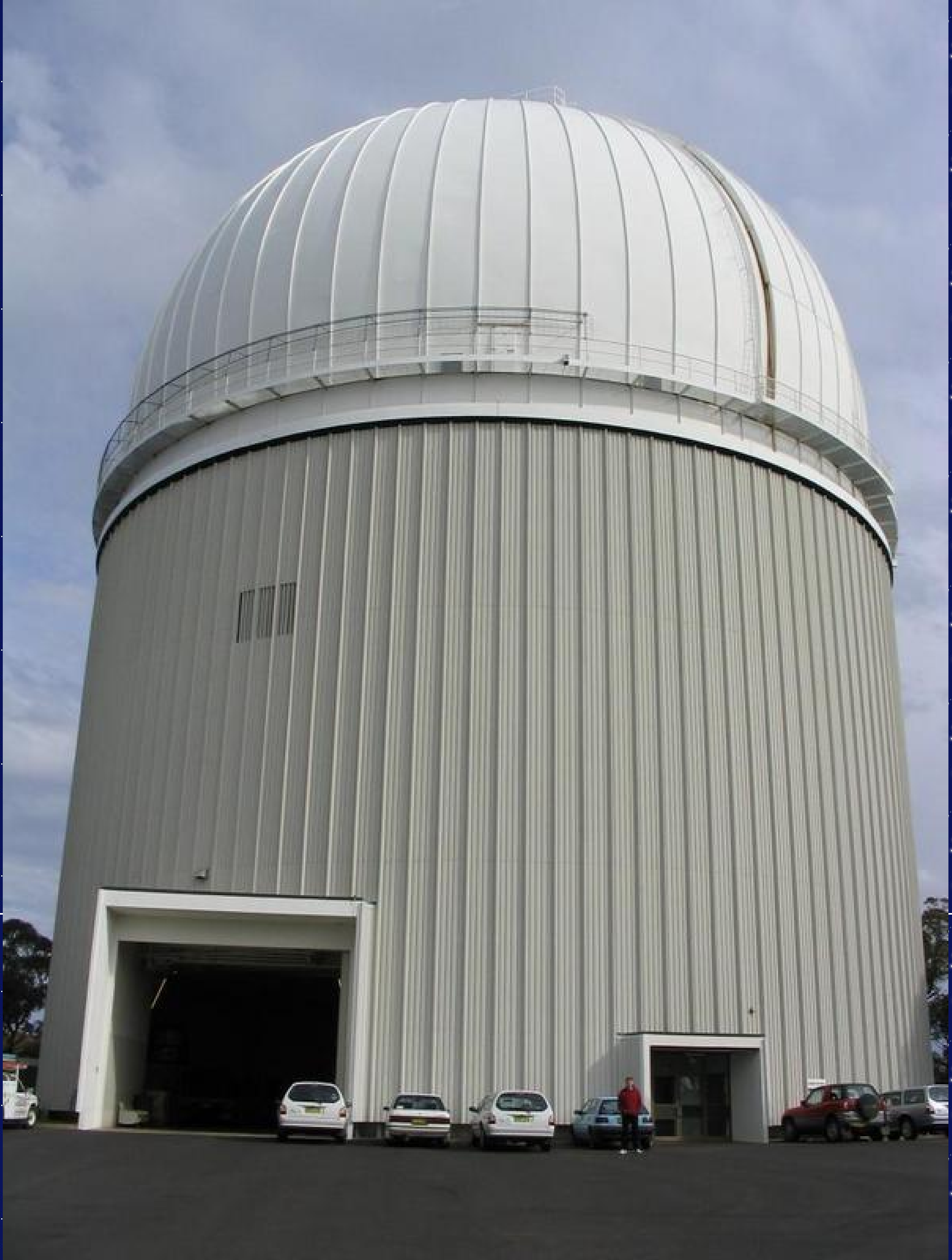
Palomar, 200 inch/ 5 méter

AAT

3.9 méter

SSO

Túlméretezett kupolák...



Altitude-Azimuth Mounts

The equatorial mounting system has the advantage of simplicity of operation; after pointing the telescope toward a target, we can track that object for the duration of the observation by moving the telescope about one axis at a constant rate. However, the price for achieving this simplicity is high. The polar axis must be precisely aligned parallel to Earth's rotation axis, which is always an odd angle with respect to the ground. This forces the mechanical structure to be very massive to achieve the necessary strength. A second cost is that the dome must be large but empty to provide clearance for the full range of movement of the telescope. As a consequence of these factors, the cost of building a telescope increases rapidly as the telescope mirror grows in size. The empirical rule of thumb is that the cost is proportional to the 2.7^{th} power of the diameter of the telescope.

For example, going from the 5-m Palomar telescope to the 10-m Keck telescope, the diameter has doubled, but the cost would have increased by 2 to 2.7th power = 6.5. The amount of light collect would have increased by only 2 to 2th = 4, so the cost per photon is more with the larger telescope. This rapid increase in the cost of telescopes effectively limited the maximum size of a telescope after the completion of the 5-m Palomar telescope in the late 1940's.

To break this economic limit, astronomers switched to the altitude-azimuth mounting scheme. This same approach is used for radar antennae and cannon mounts. The two axes are now oriented vertically and horizontally. The vertical axis is a fork that holds the two ends of the horizontal axis, and the horizontal base can be spun around a vertical axis at its centre. Because there are no peculiar angles, it takes a less massive, less expensive mount to sustain a given size of telescope. This leads to a significant cost saving.

The telescope moves up and down in altitude (also called elevation) with a total range of 0° to 90 deg. The base of the support is turnable from 0° to 360° or to ± 180 deg. This restricted range of motion, while still covering the whole sky, leads to another substantial saving in the size of the dome that is needed for the telescope.

There are, of course, several penalties for these savings:

1. The telescope must be moved in both coordinates while tracking a target.

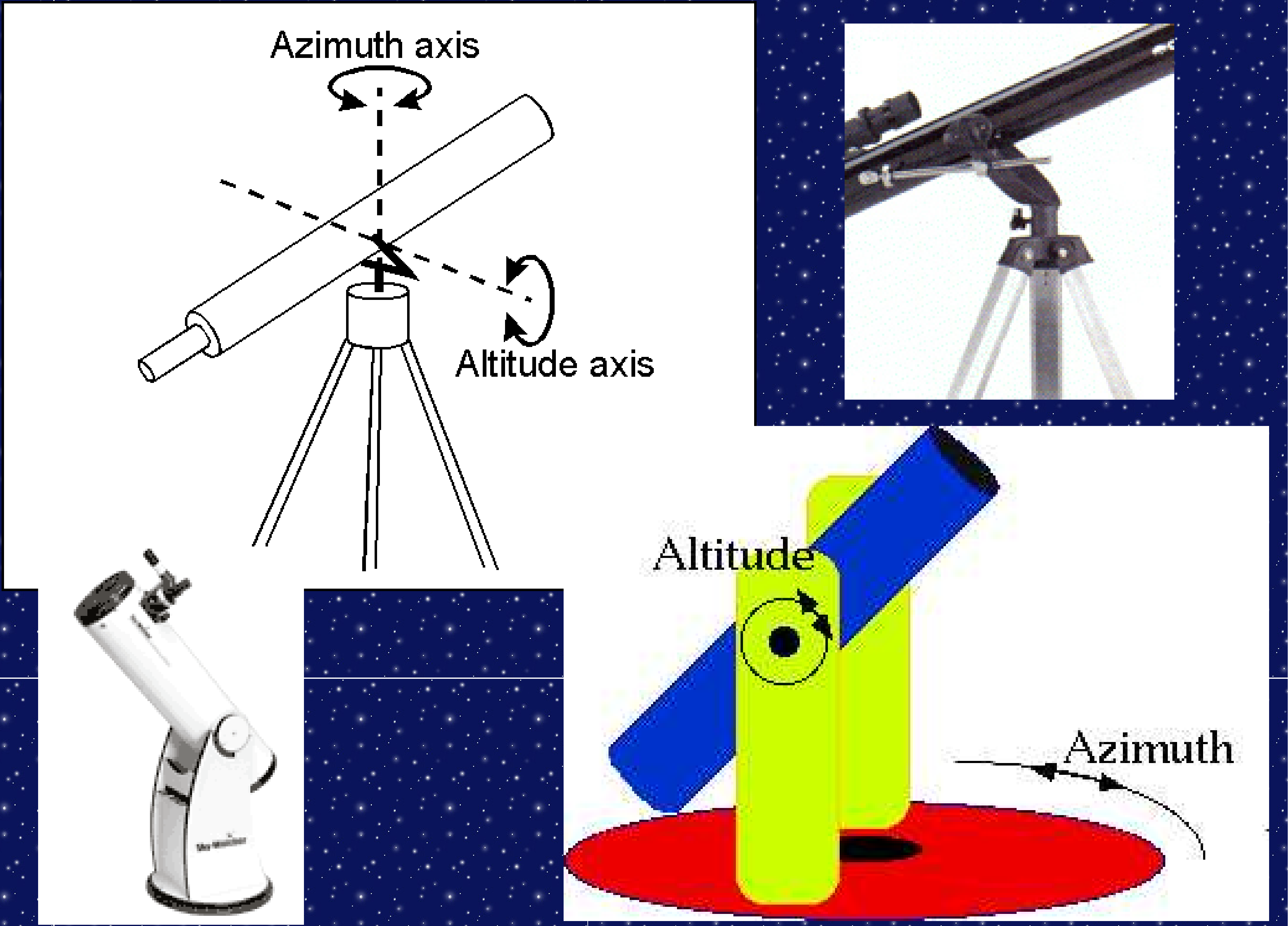
2. The tracking rate varies with position in the sky. The most extreme case of this is when an object passed through the zenith. In this case, the base must be spun around 180° in azimuth in order to continue following the object.

3. The field of view rotates. This is not a problem for point sources, such as stars, but it must be addressed for any extended source by either rotating the instrument or by derotating the image.

Each of these problems can be solve, particularly with the aid of computers, and the cost of solving them is small compared to the gain provided by the altitude-azimuth design.

A little history is useful here. The construction of larger telescopes using the altitude-azimuth mount was not begun until the 1970's and it took a while after that to develop. Before that, another solution was to improve the efficiency of the detectors. Photographs were the primary detectors in astronomy for many decades. They have the advantage that they are large, relatively cheap, and can serve as both the detector and the data storage device. However, a photograph is grossly inefficient.

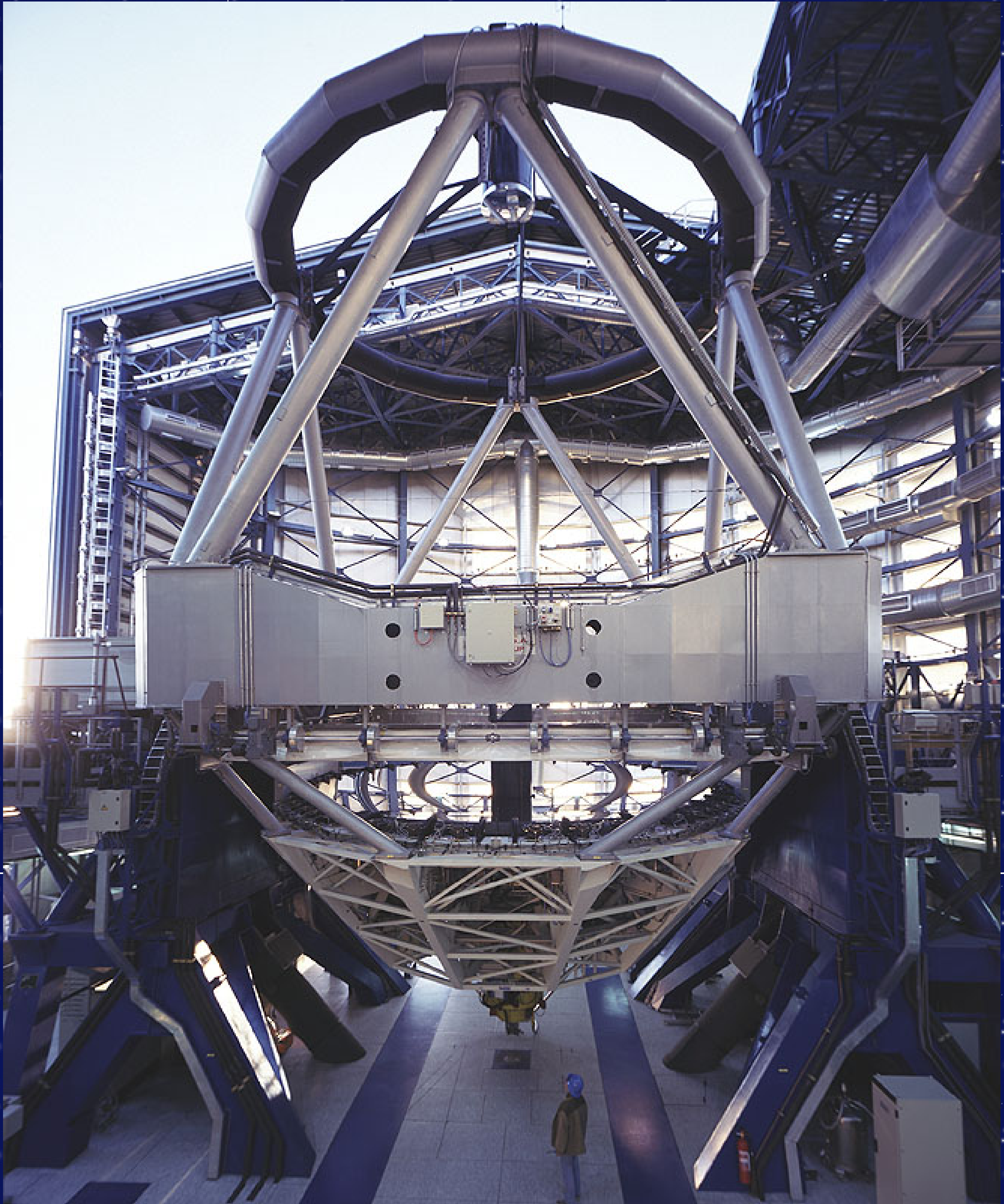
The image created uses 1% of the light at most, and there are many ways that the efficiency can be lower than this. That means that the photograph wastes 99+% of the light.


Azimuth axis
Altitude axis
Altitude
Azimuth

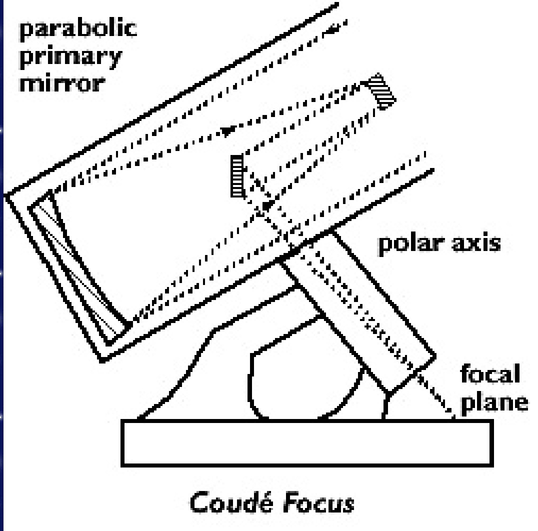
VLT

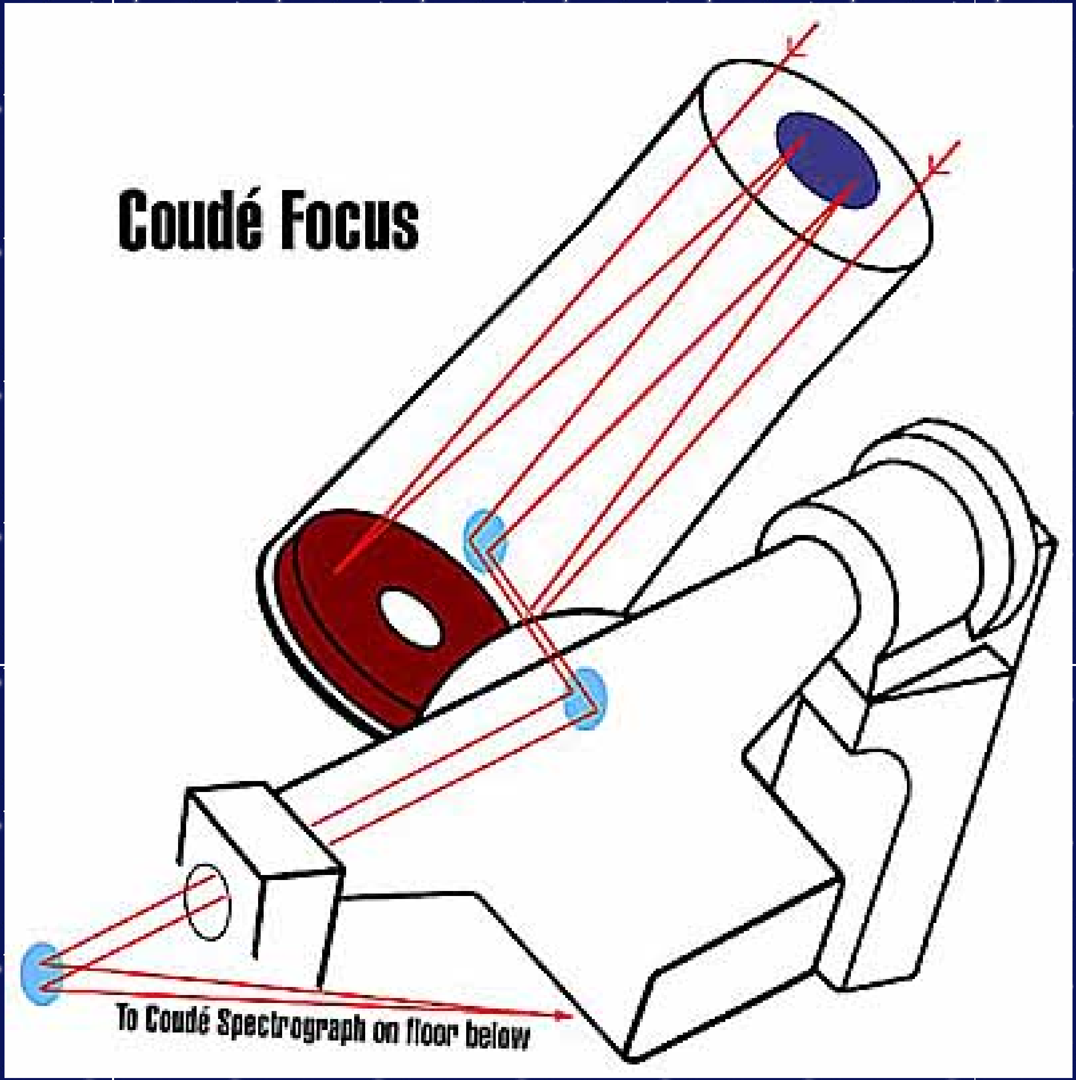
Kueyen

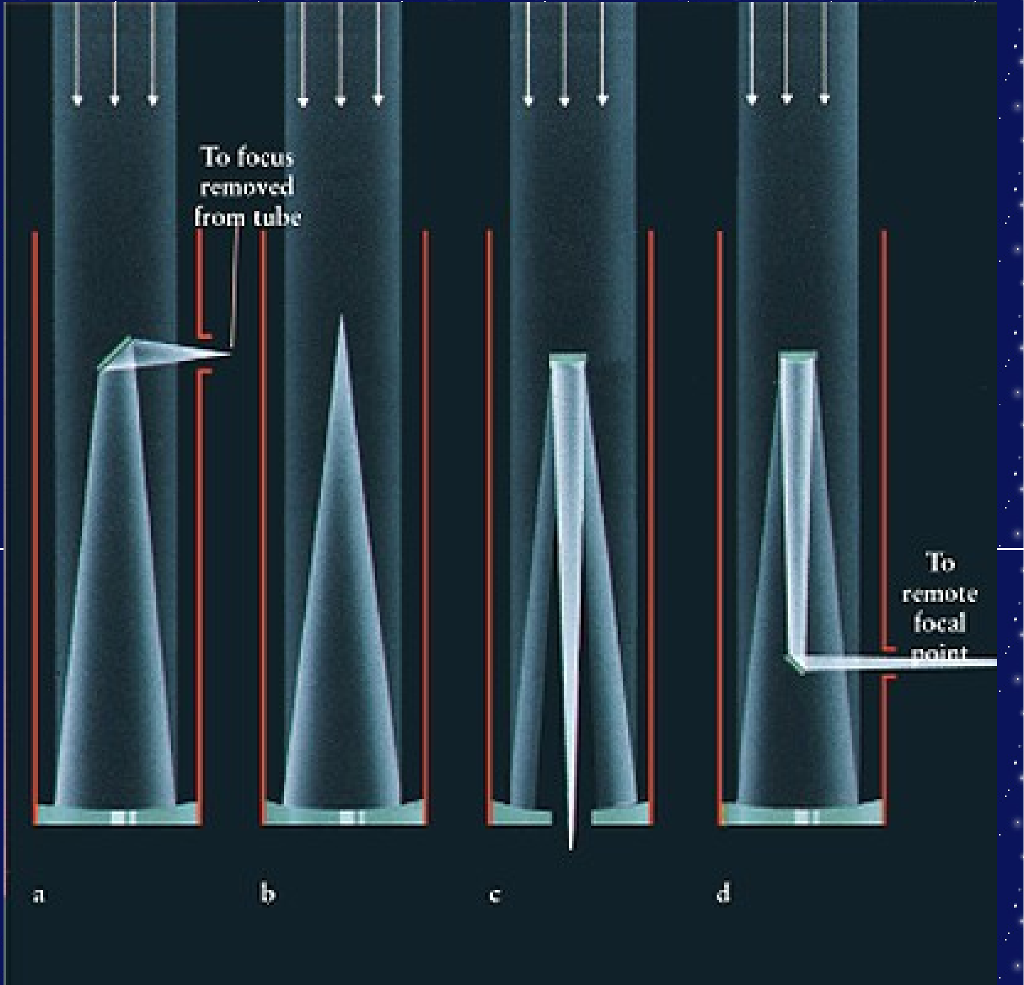
8.2 méter



Fix fókuszhelyzet: Coudé-fókusz





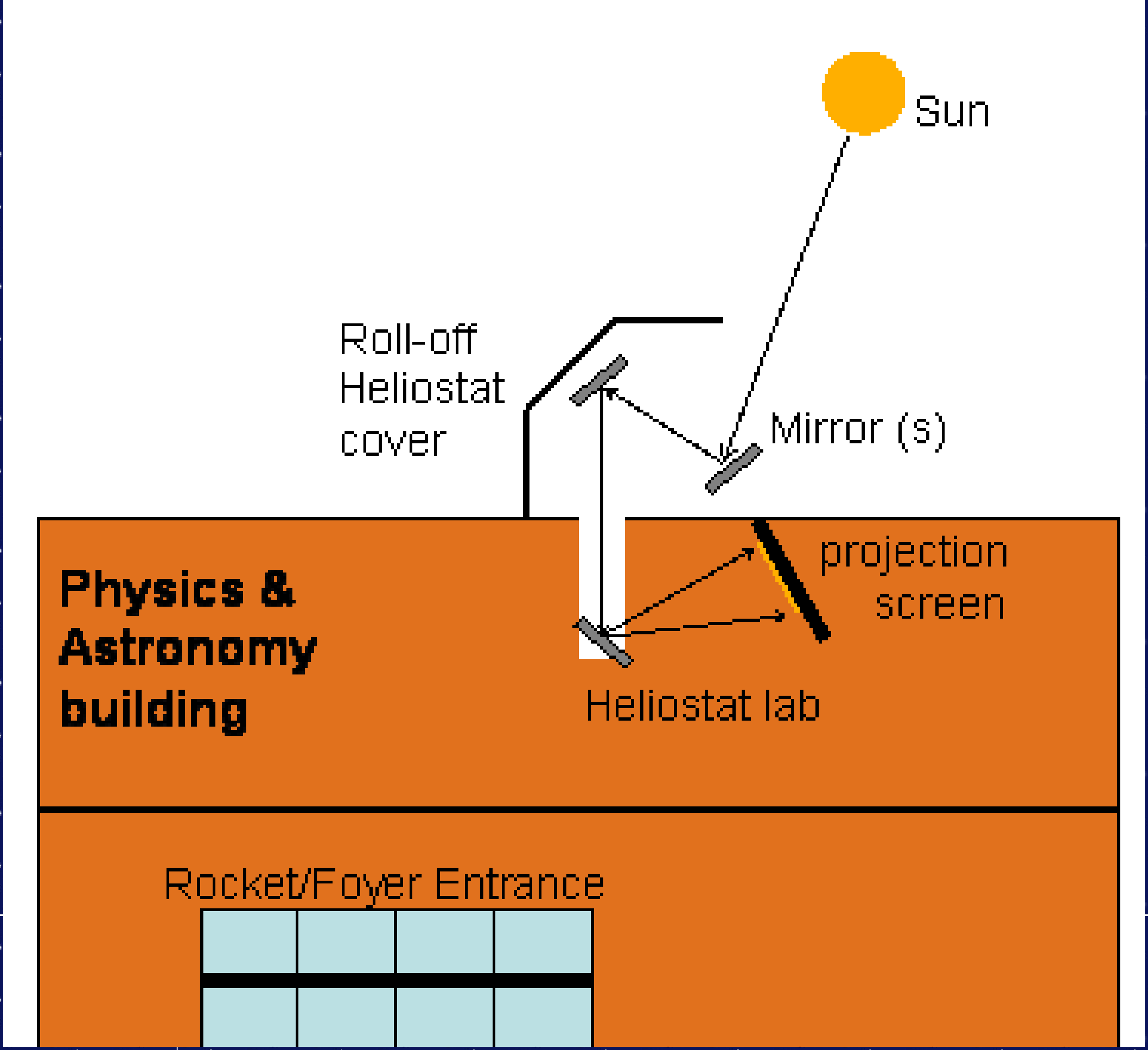


Nap észleléséhez:

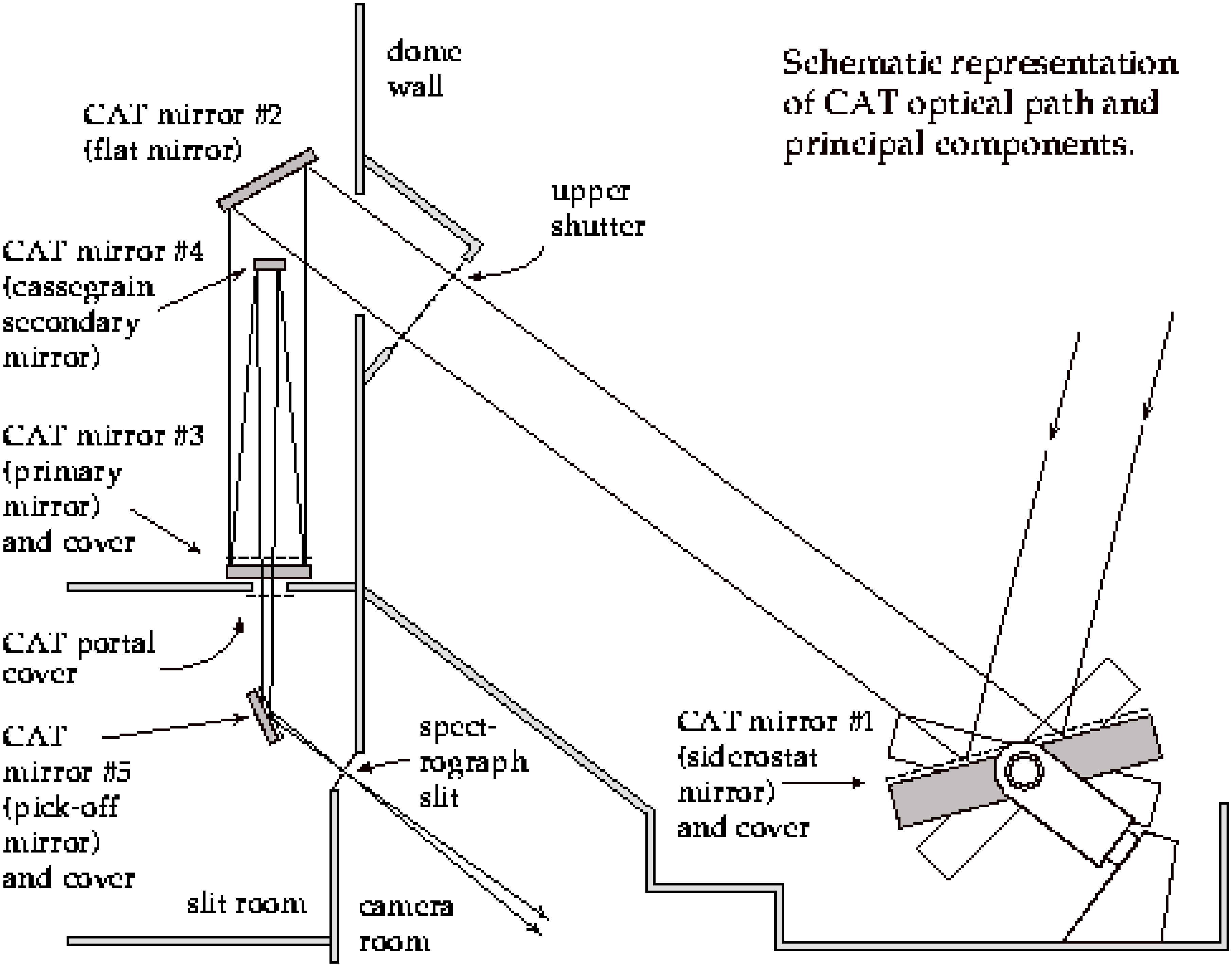
- sziderosztát
földön fekszik

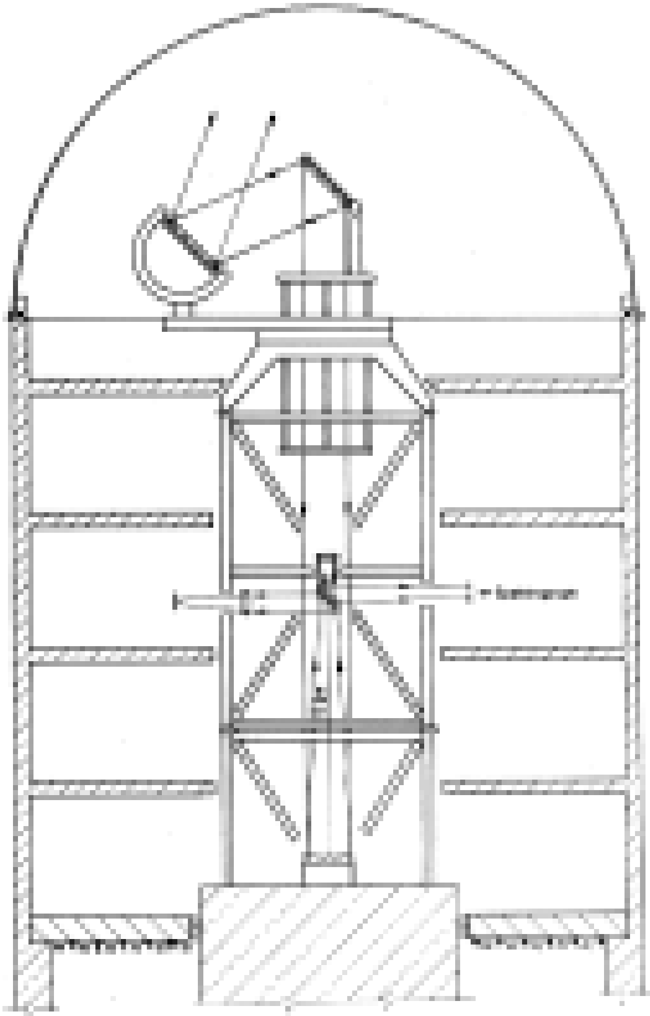
- heliosztát
égi pólus, tükör

- cölösztát
vertikális, 2 tükör
nincs képforgás



Schematic representation of CAT optical path and principal components.





cölosztát