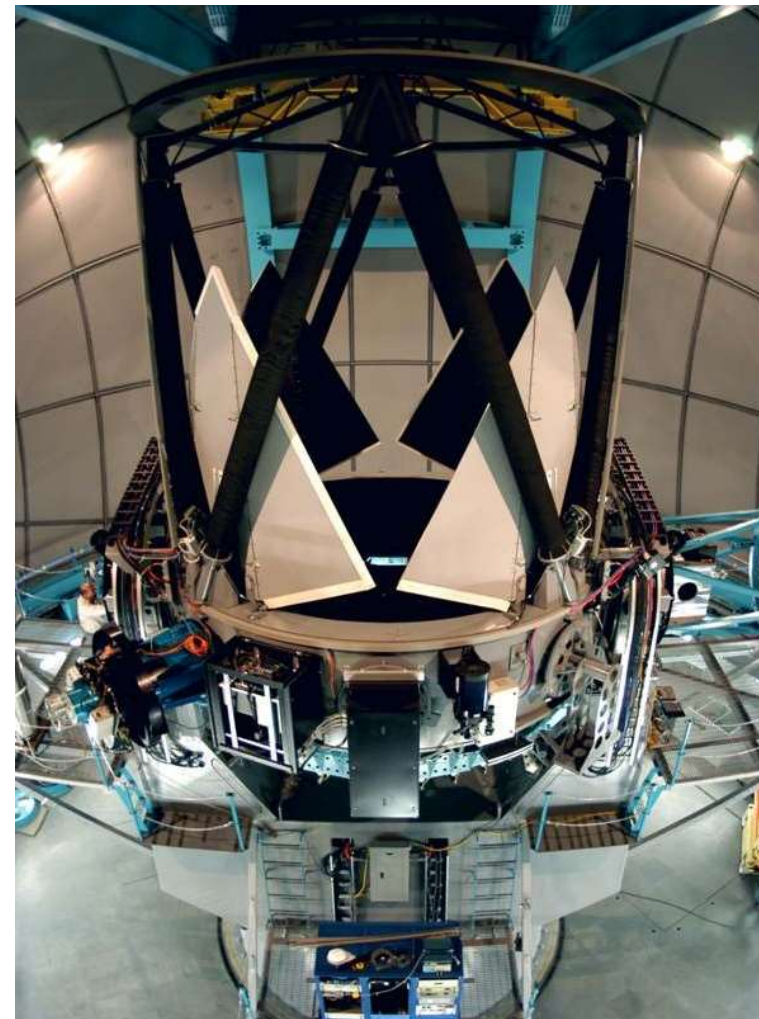


Telescópios Óticos

Coletores de radiação



Introdução

- Hans Lippershey (1608): primeiro telescópio?
- Patente: "*for seeing things far away as if they were nearby*"



HANS LIPPERHEY.
Secundus Conspiciliarum inventor.

Galileu (1609)



Galileo (15 Feb 1564 – 8 Jan 1642)



The Telescope Revolution



- In 1609 Galileo started the telescope era (up to 30x magnif.)

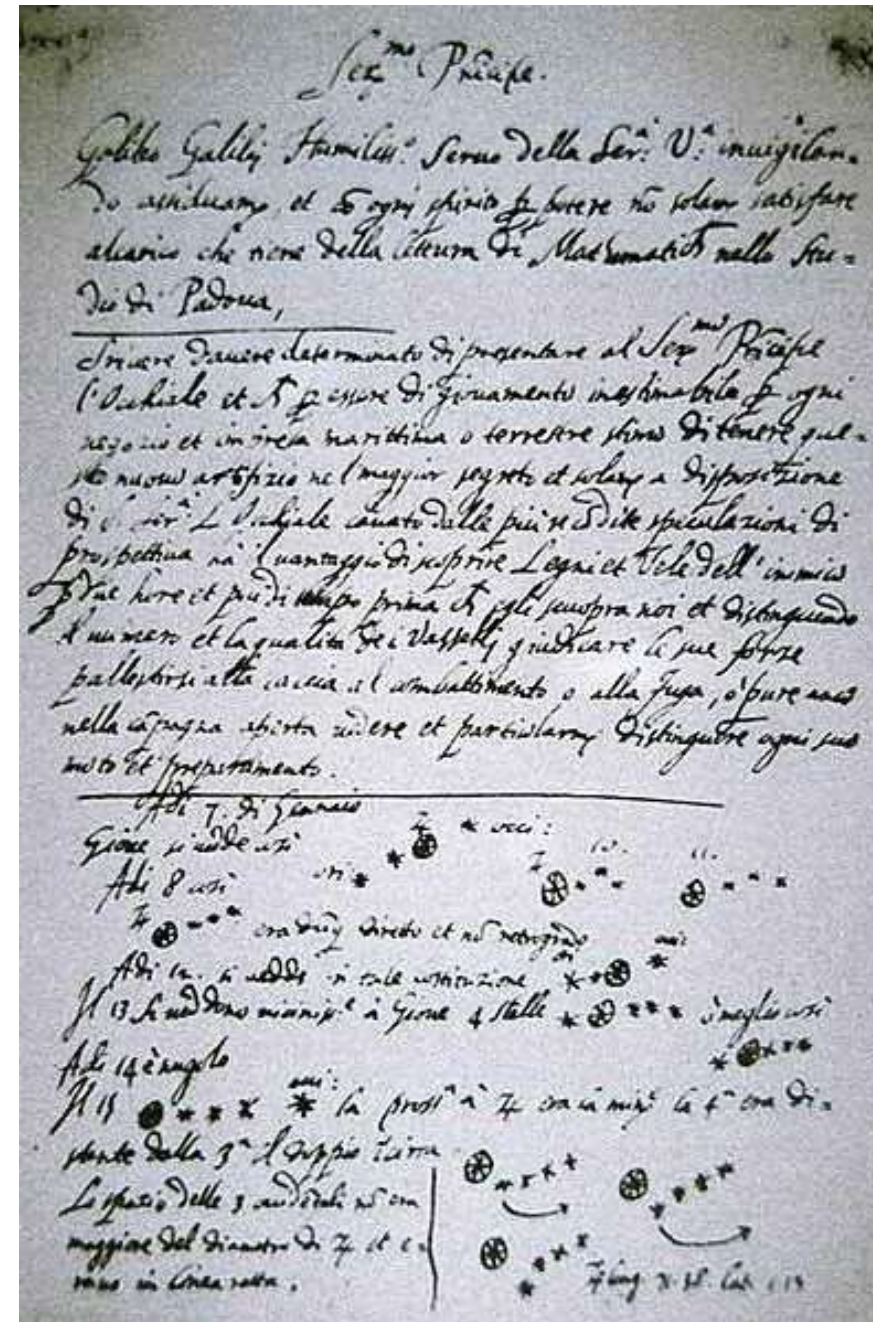
Galileo (15 Feb 1564 – 8 Jan 1642)

Jupiter's moons

- First observations on 7 Jan 1610

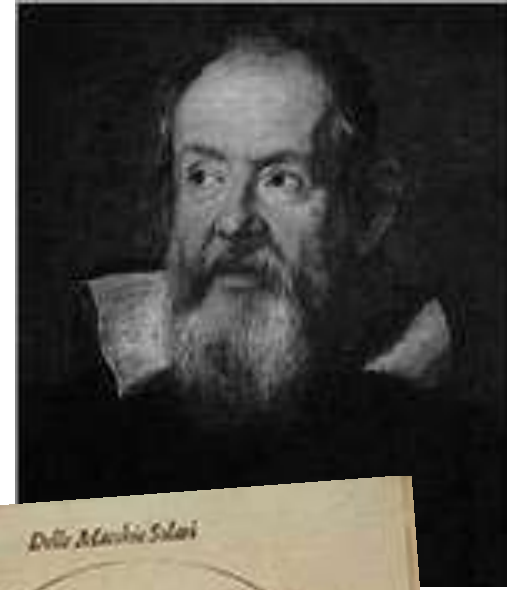
Observationes Jovianae
1610

2. ult. Febr. Mart. H. 12	○ ● ●
3. ult. Mart.	● ● ○ *
2. Febr.	○ ● ● *
3. Mart.	○ * ●
3. Mart. 5.	* ○ *
7. Mart.	* ○ ● ●
6. Mart.	● ● ○ *
8. Mart. H. 17.	* * * ○
10. Mart.	* * * ○ *
11.	* * * ○ *
12. H. 7. Febr.	* ○ *
17. Mart.	* * ● *
14. Febr.	* * ● *



Galileo observed sunspots ~ at the end of 1610: rotação solar (also observed by Thomas Harriot)

Manchas na superfície do Sol
observadas por Galileo 1612-1613



● Funções principais:

⇒ coleta de energia (\propto área coletora)

⇒ formação da imagem: resolução angular

● Aumento da área coletora

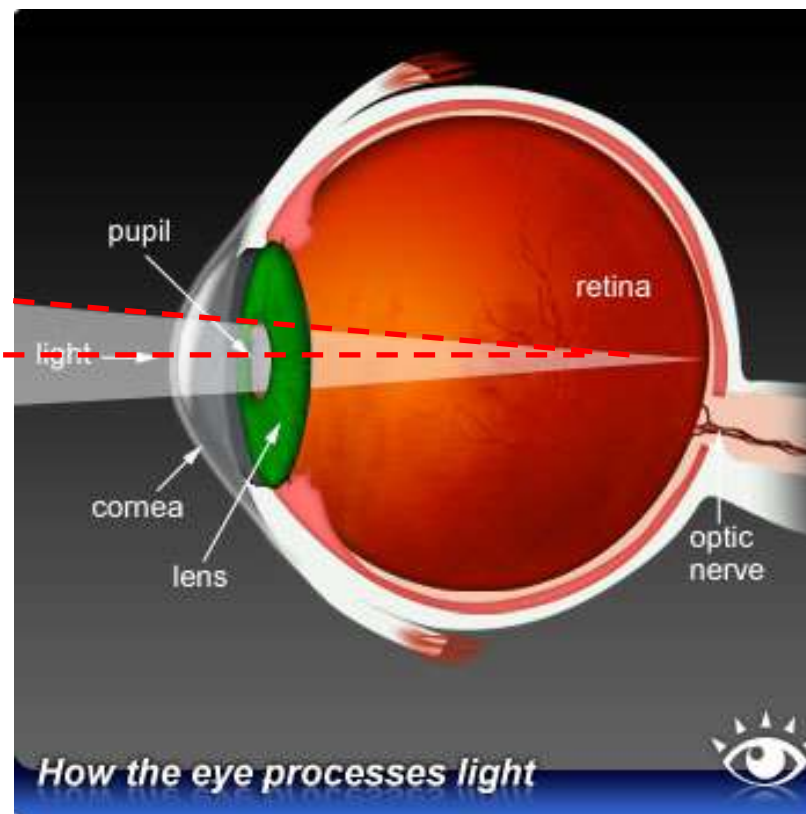
⇒ detecção de objetos fracos

⇒ maior resolução angular



Resolução angular

E	1	20/200
F P	2	20/100
T O Z	3	20/70
L P E D	4	20/50
P E C F D	5	20/40
E D F C Z P	6	20/30
F E L O P Z D	7	20/25
D E F P O T E C	8	20/20
L E F O D P C T	9	
F D P L T C E O	10	
F E Z O L C F T D	11	

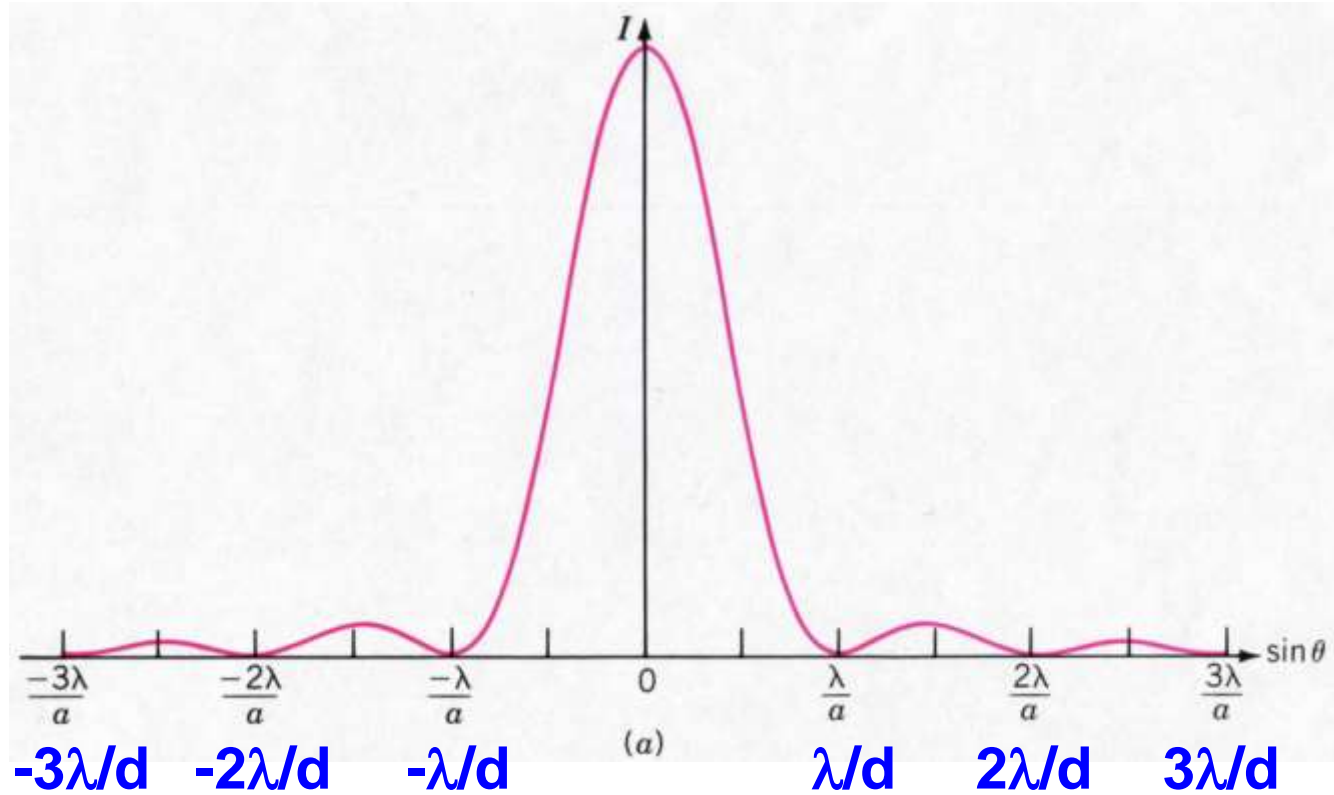
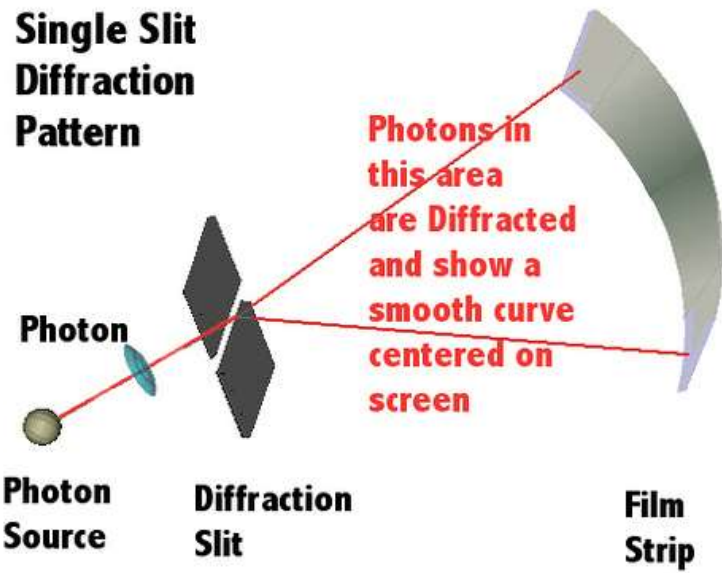


É o menor ângulo que pode ser discernido

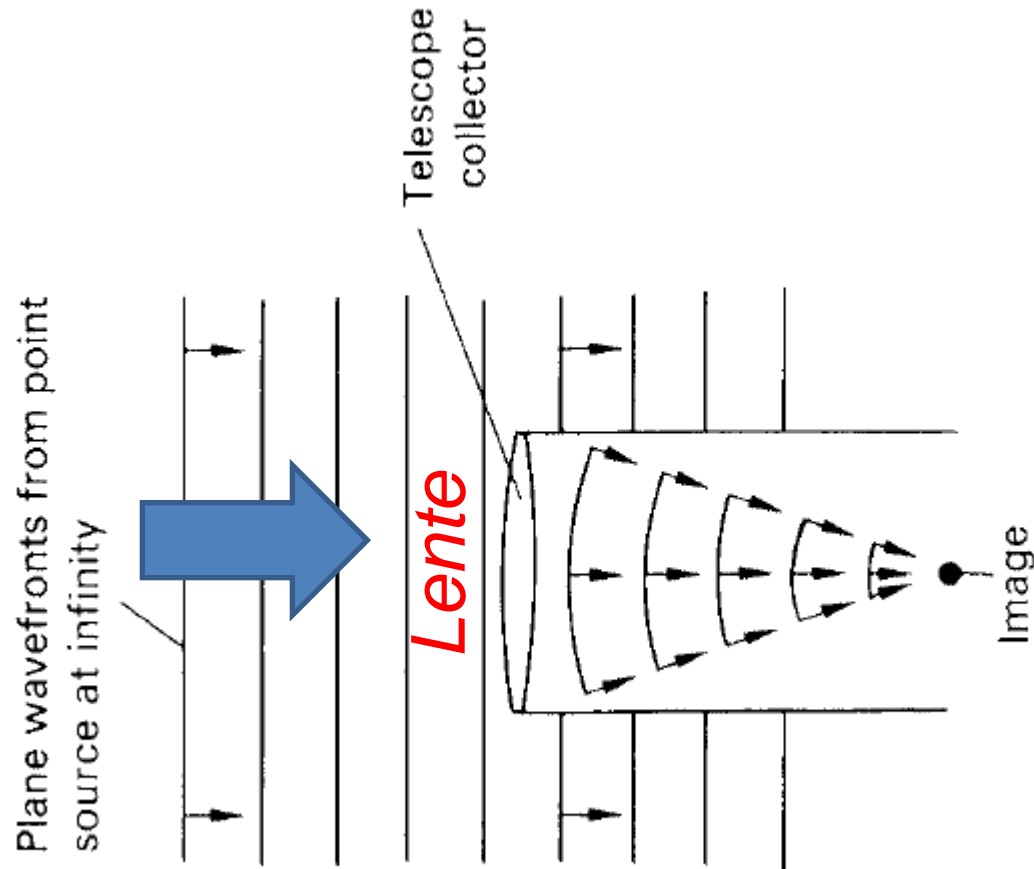
Resolução angular: difração de uma fenda

$$I_{\theta} = I_0 \frac{\sin^2(\pi d \sin \theta / \lambda)}{(\pi d \sin \theta / \lambda)^2}$$

Single Slit Diffraction Pattern



Resolução angular: difração de uma abertura circular



Roy & Clarke

padrão de difração

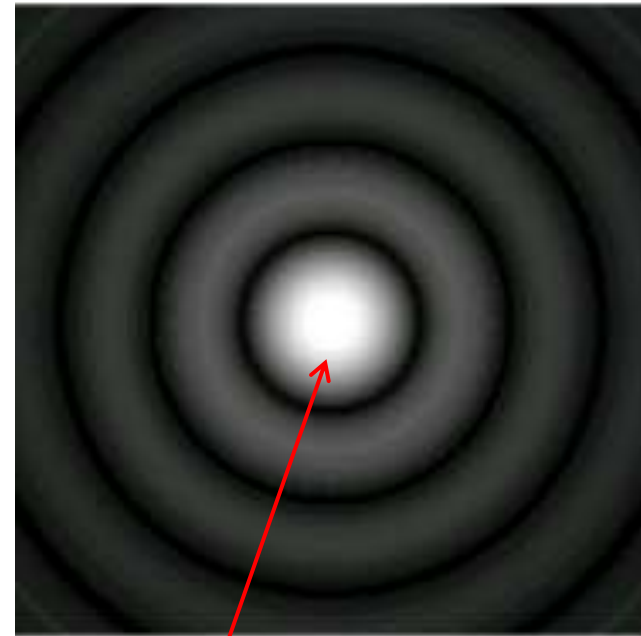


Figure 16.5. Wavefronts arriving at the telescope aperture

Disco de Airy: disco central definido pelo primeiro mínimo

Resolução angular: Critério de Rayleigh

O limite de resolução é quando o máximo de um disco de Airy é sobreposto no primeiro mínimo da outra imagem

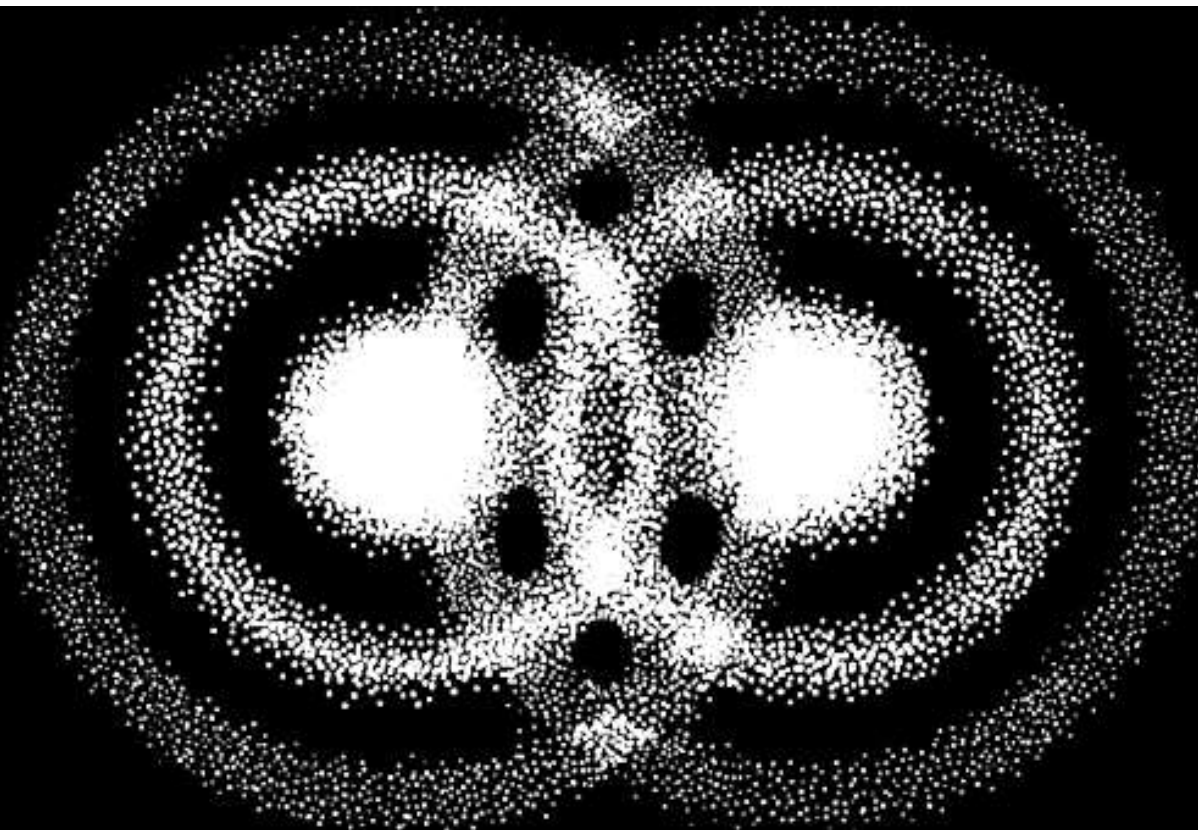


Figure 1.1.29. Image of two distant point sources through a circular aperture

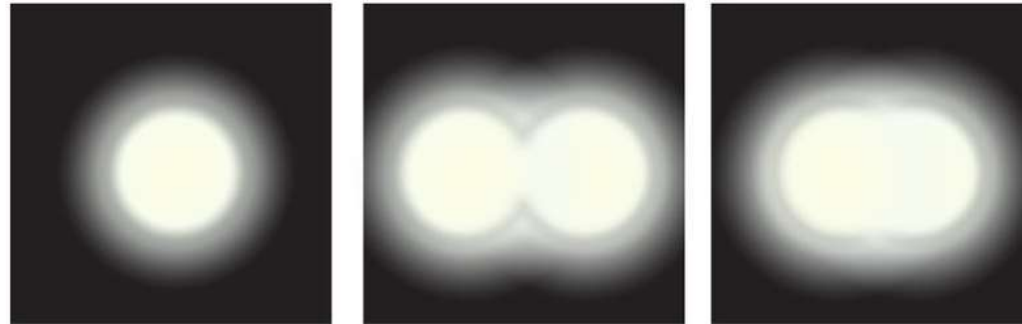
O primeiro mínimo ocorre a um raio α [rad]:

$$\alpha = 1.22 \lambda / d$$



HST (2.4m)
~ 0,05"

Resolução angular: Critério de Rayleigh



$$\alpha \text{ [rad]} = 1,22 \lambda / d$$

For $\lambda = 540\text{nm}$:

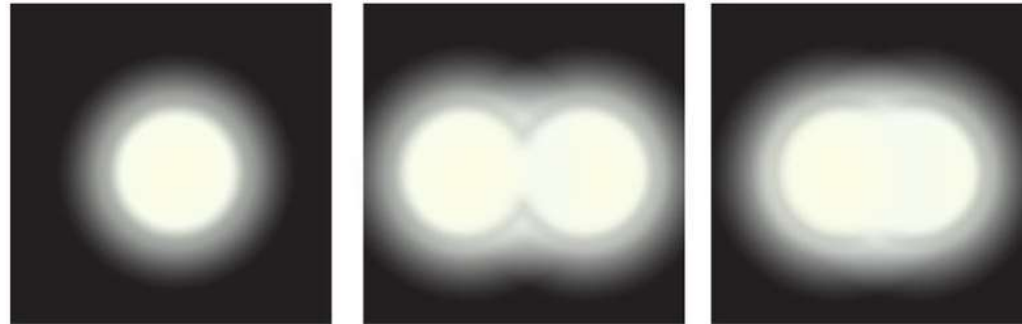
$$\alpha["] = 0,136 / d[\text{m}]$$

Por exemplo, para $\lambda = 540\text{nm}$ e $d = 1\text{m}$, a

resolução angular $\alpha = 0,136''$

mas o limite imposto pelo *seeing* é maior ($\sim 1''$)

Resolução angular: Critério de Rayleigh



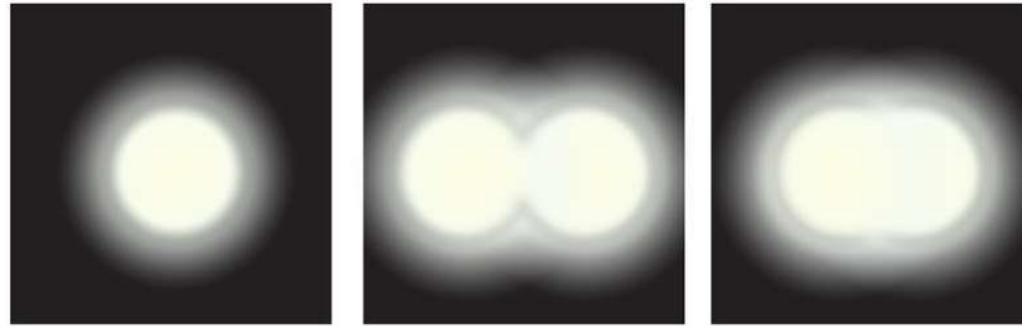
$$\alpha \text{ [rad]} = 1,22 \lambda / d$$

For $\lambda = 540\text{nm}$:

$$\alpha[\text{''}] = 0,136 / d[\text{m}]$$

Um telescópio com $d = 13,6 \text{ cm}$ alcança no ótico uma **resolução angular de 1''**, da mesma ordem que o limite imposto pelo *seeing* ($\sim 1''$)

Resolução angular: Critério de Rayleigh



$$\alpha \text{ [rad]} = 1,22 \lambda / d$$

For $V = 540\text{nm}$:

$$\alpha[\text{''}] = 0,136 / d[\text{m}]$$

For $K = 2,2\mu\text{m}$:

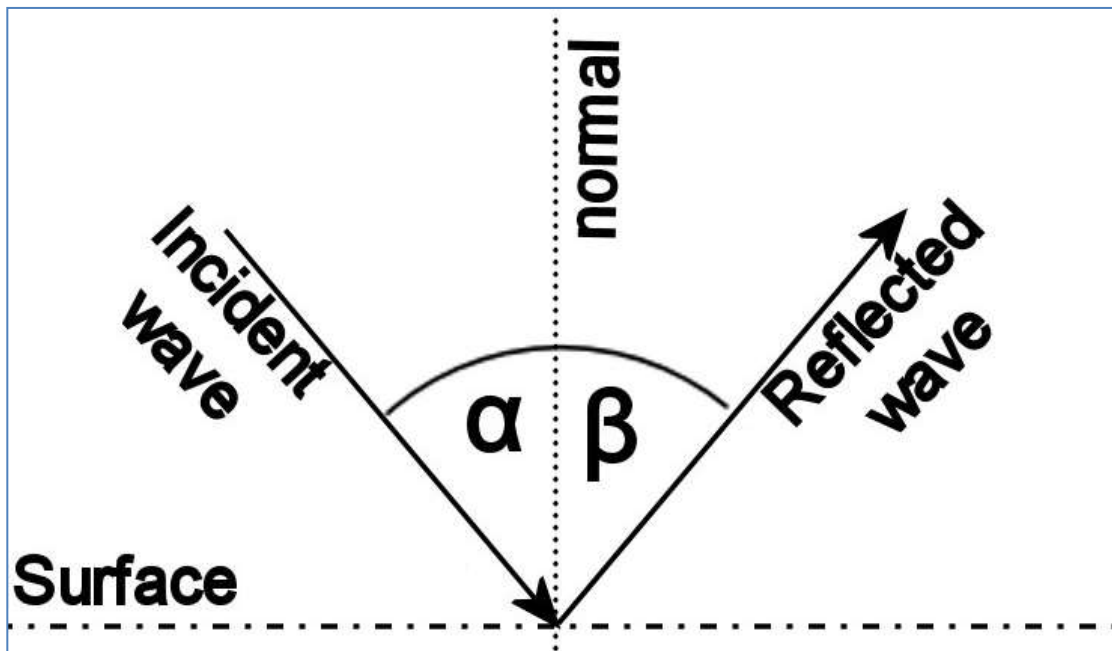
$$\alpha[\text{''}] = 0,55 / d[\text{m}]$$

Na banda K do infravermelho, um telescópio com $d = 1 \text{ m}$ alcança uma resolução angular de $0,55\text{''}$

Princípios de ótica

Lei de reflexão

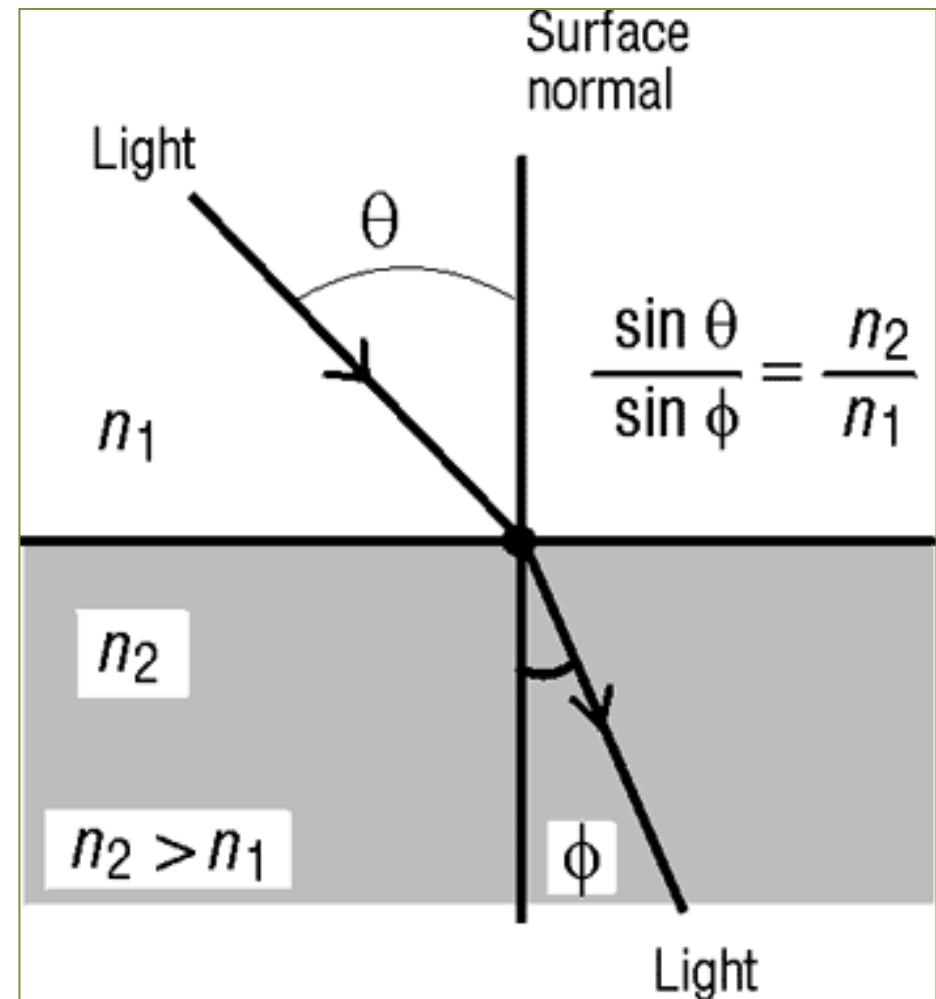
$$\alpha = \beta$$

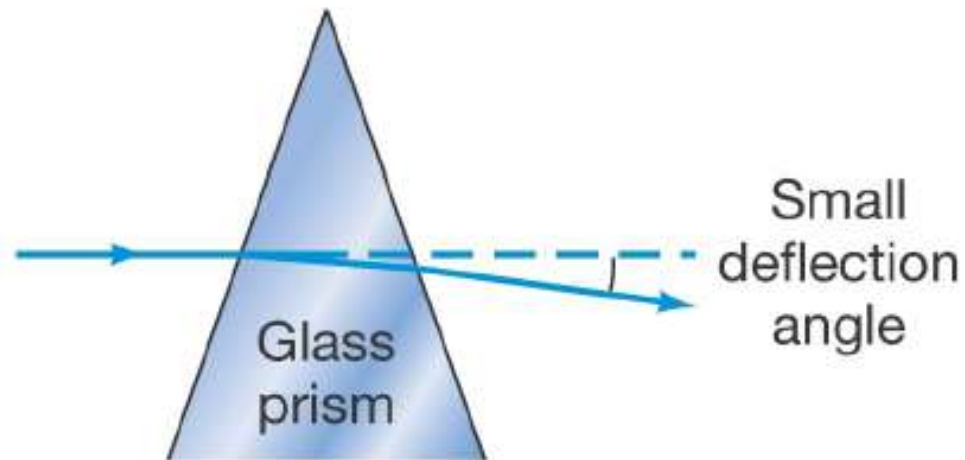
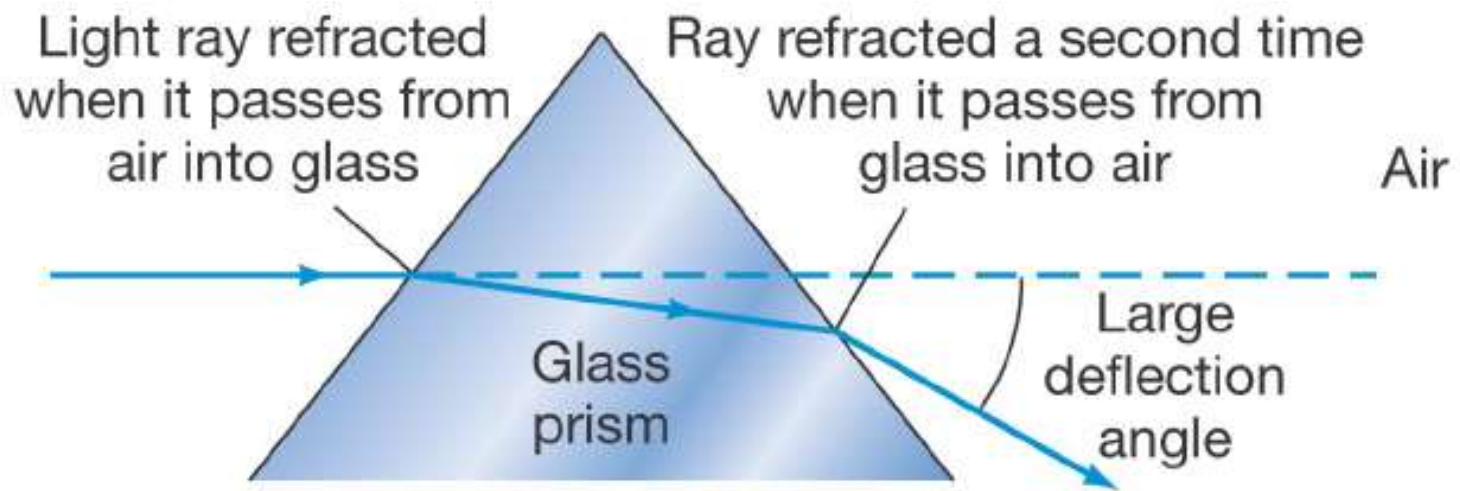


Lei de

refração (Snell)

$$\sin \theta / \sin \phi = n_2 / n_1$$



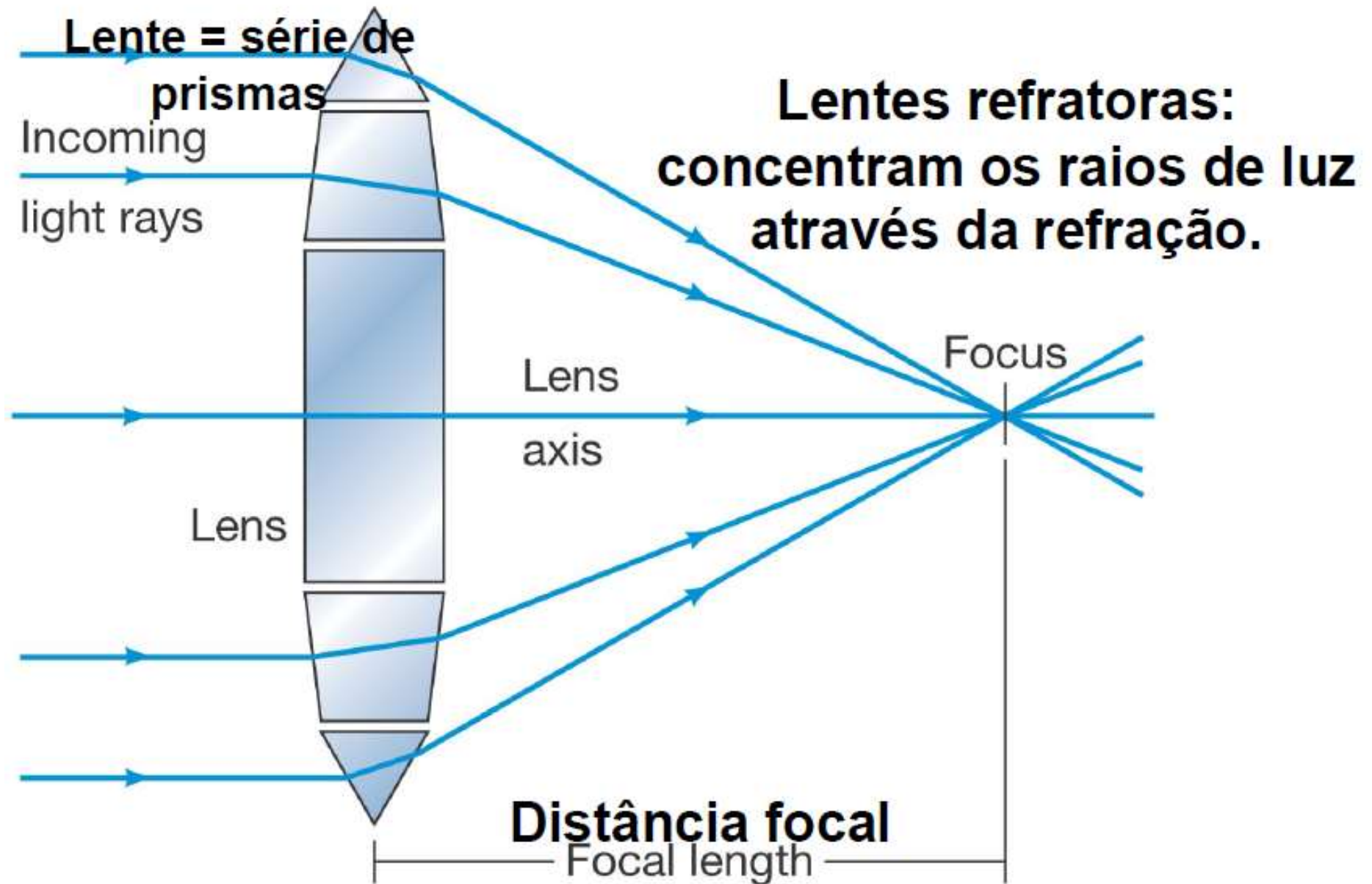


(a)

Copyright © 2008 Pearson Education, Inc., publishing as Pearson Addison-Wesley.

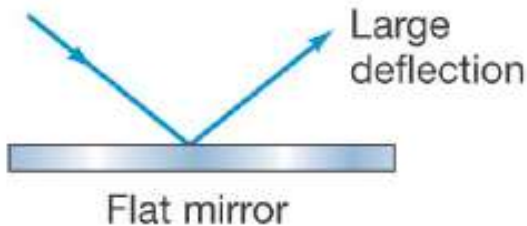
Em um prisma o ângulo de refração depende do ângulo entre suas faces.

Telescópios Refratores

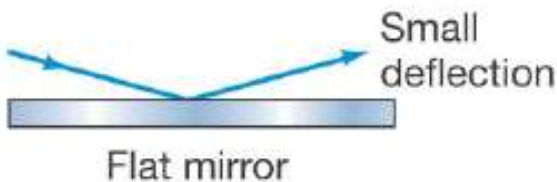


Telescópios Refletores

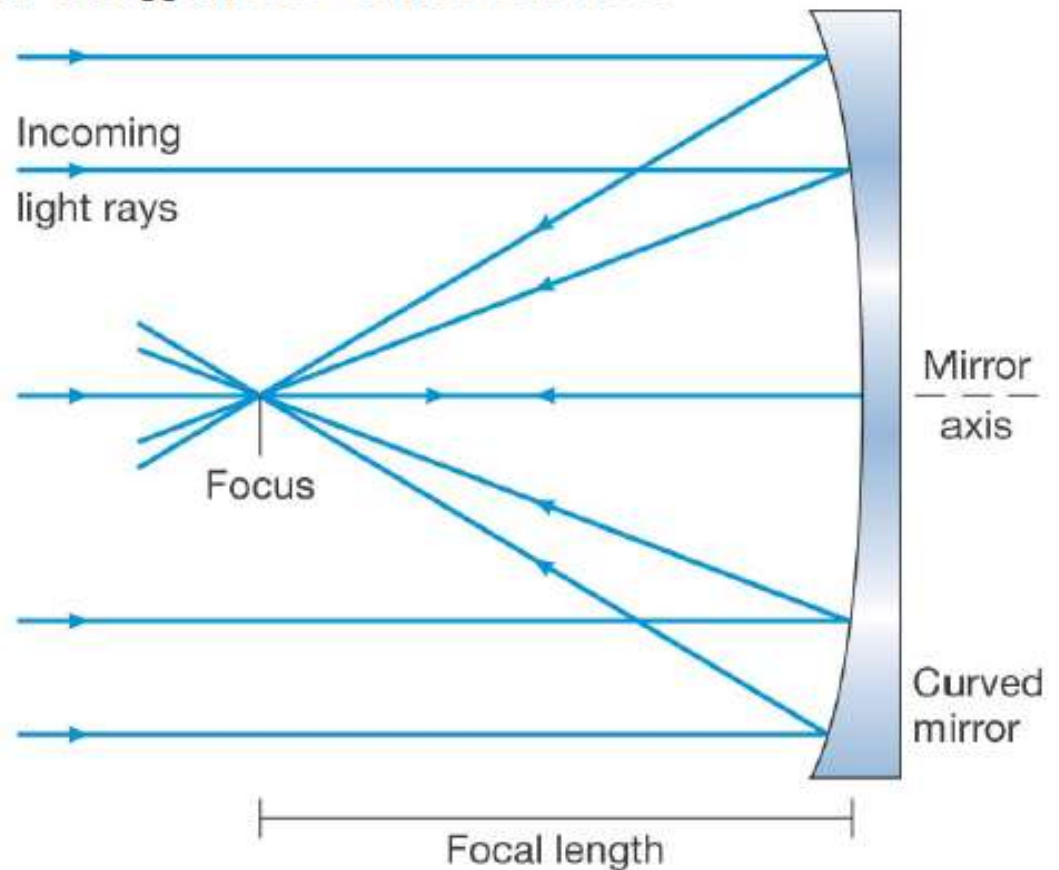
Espelho curvo: concentra os raios de luz através da reflexão em ângulos diferentes



Reflexão depende do ângulo de incidência



(a)

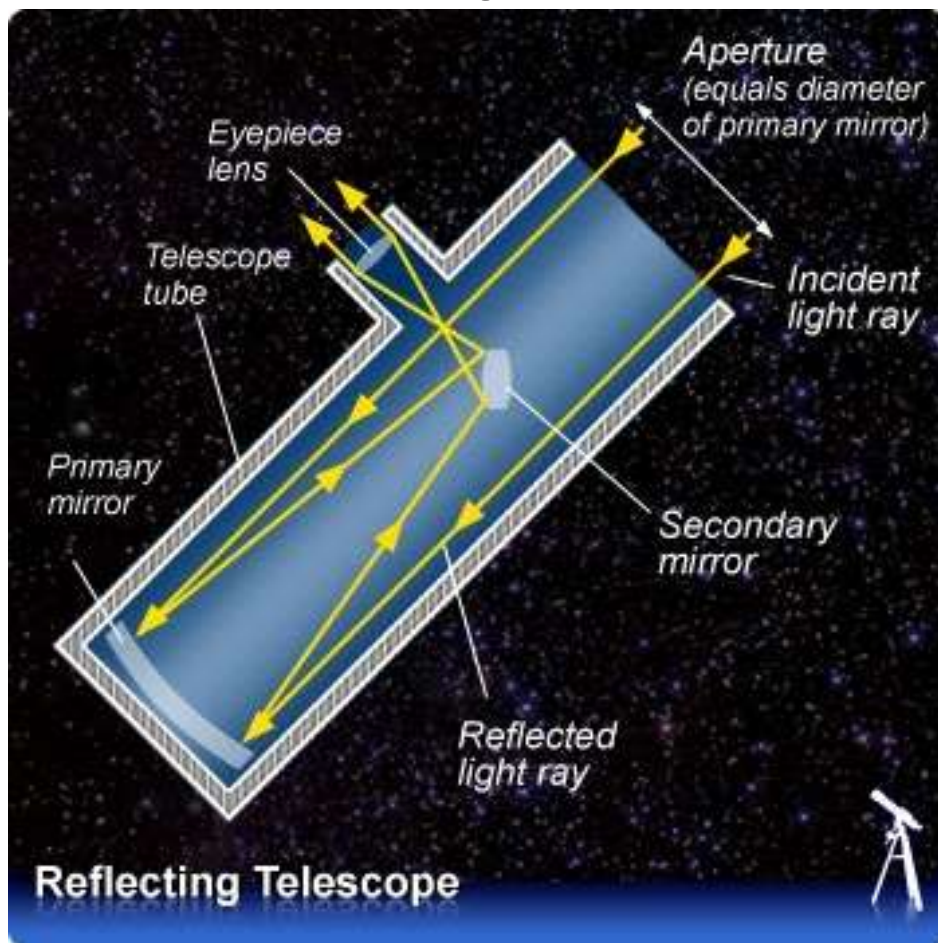


(b)

Tipos de coletor (objetiva)

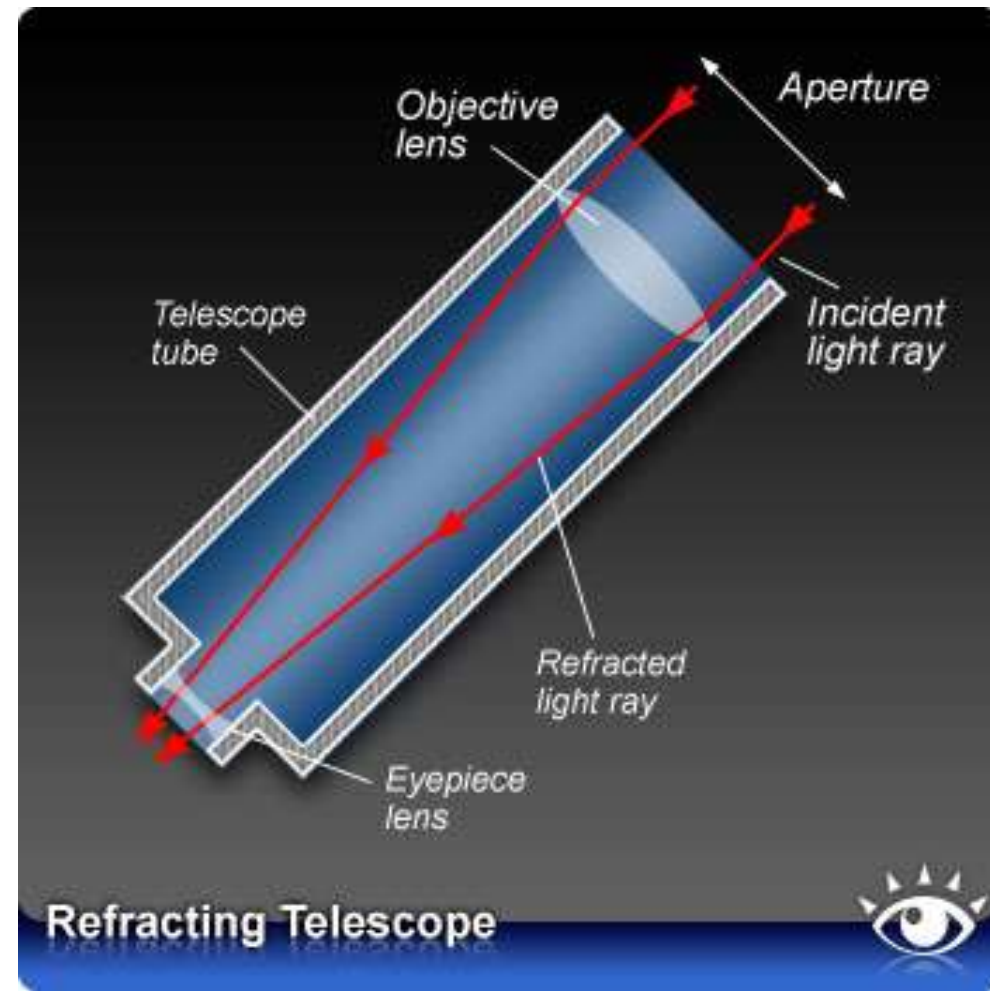
Lente: telescópio refrator

- Importância histórica (1608-9)
- Ainda usados para astronomia amadora



Espelho: telesc. refletor

- Newton (1668) inventou o primeiro refletor factível
- Grandes telescópios são todos refletores



O primeiro refletor?

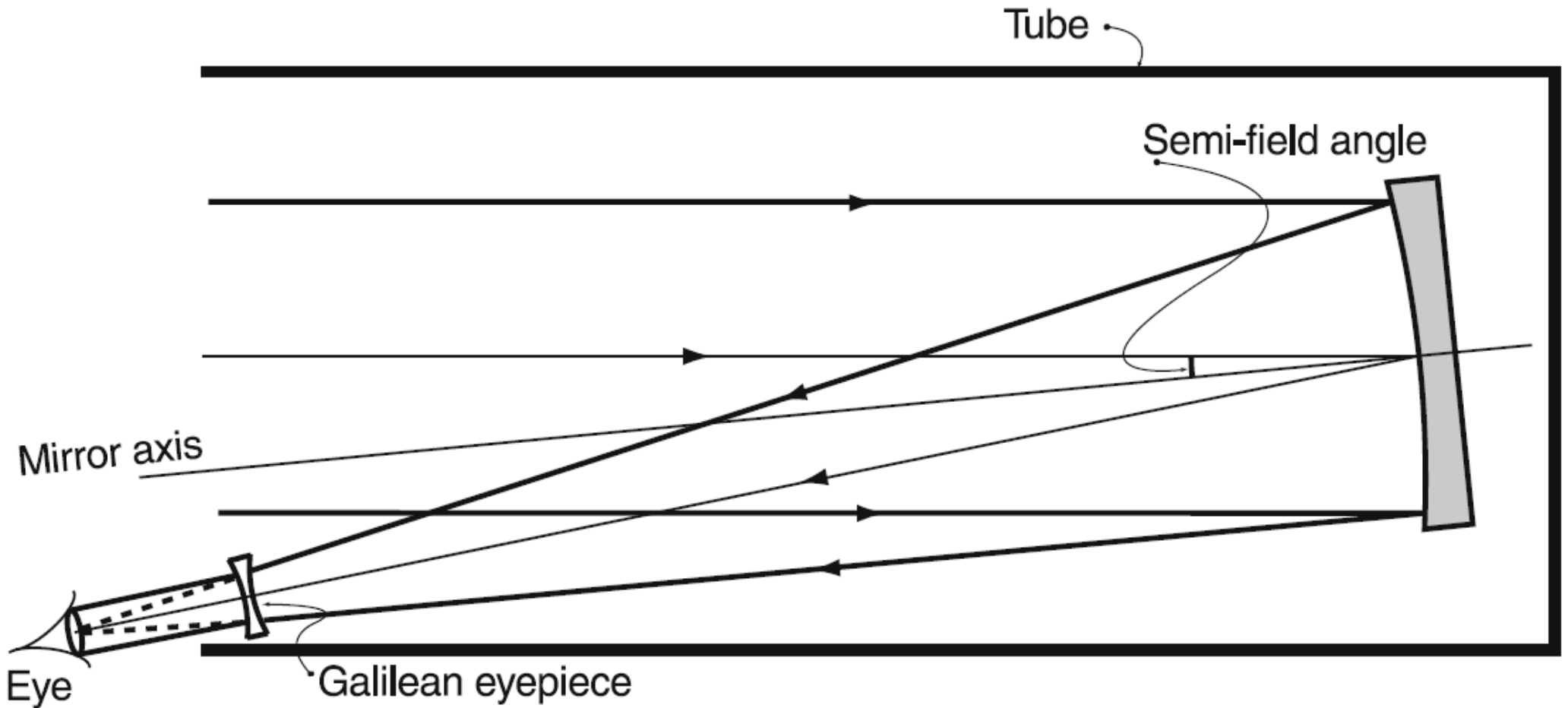
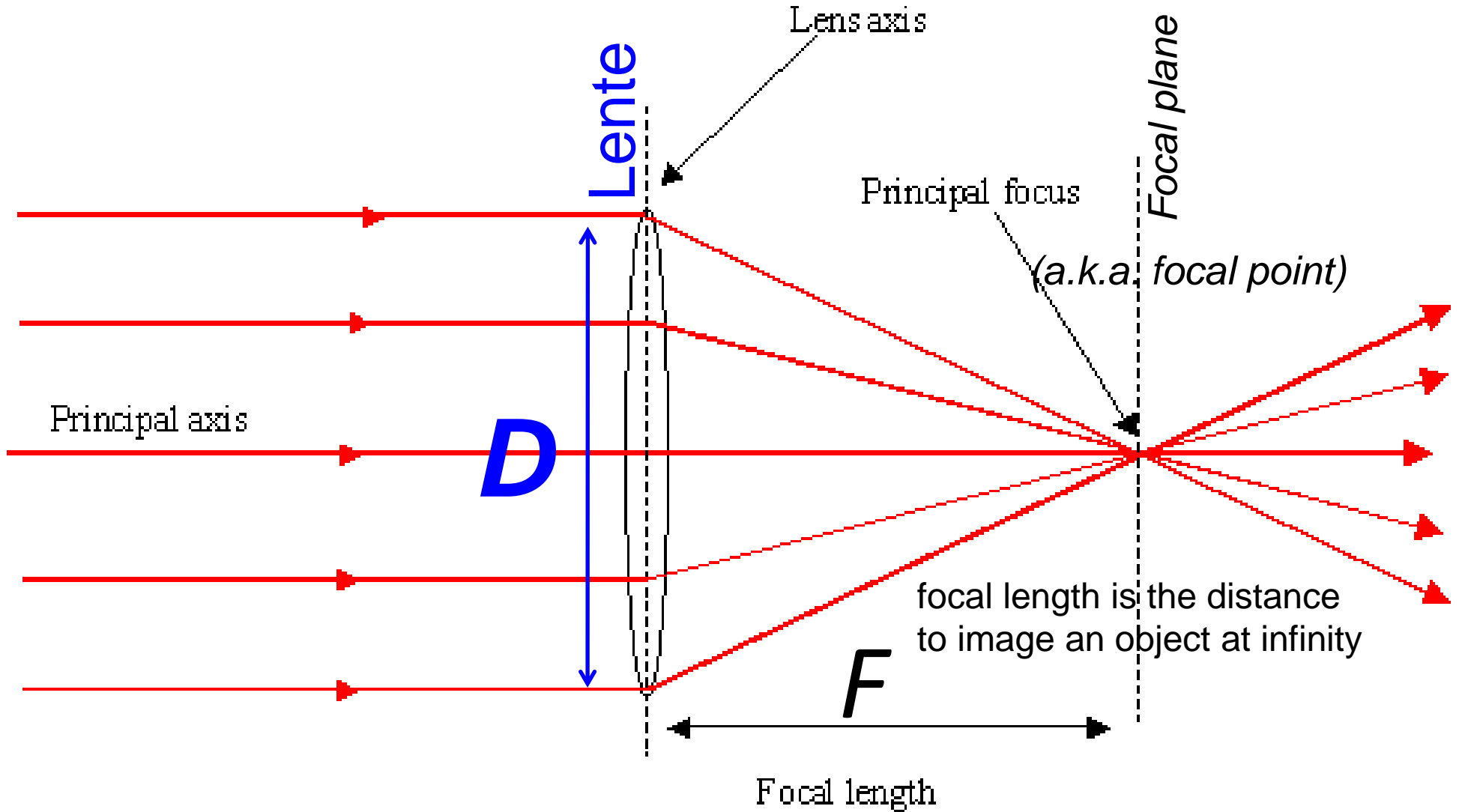


Fig. 1.1. Zucchi's attempt at a Herschel-type front-view reflecting telescope, 1616

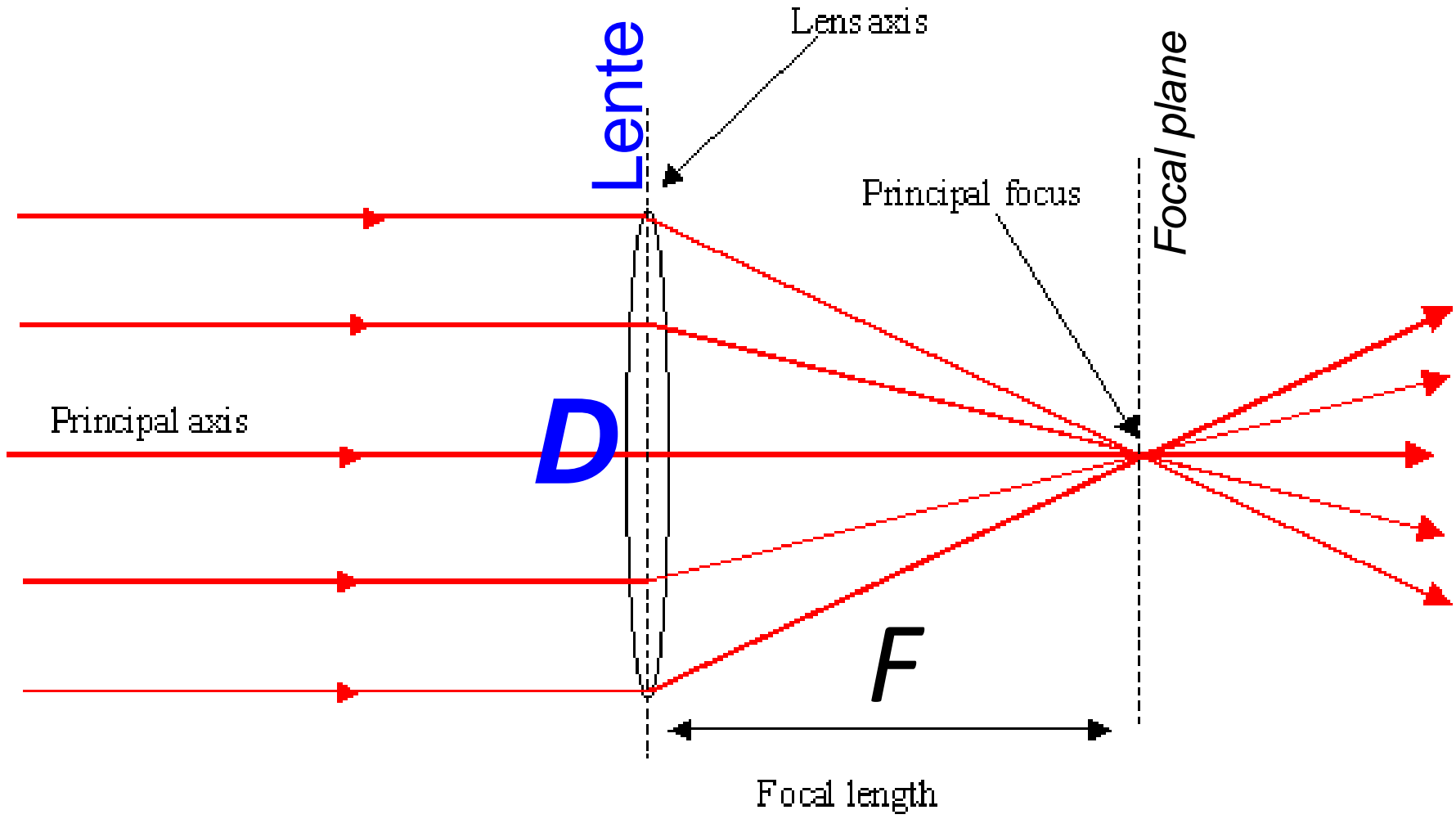
Foco, plano focal, distância focal

distância focal F , abertura da objetiva D



Razão focal $f/\#$

distância focal F , abertura da objetiva D , razão focal $f/\#$



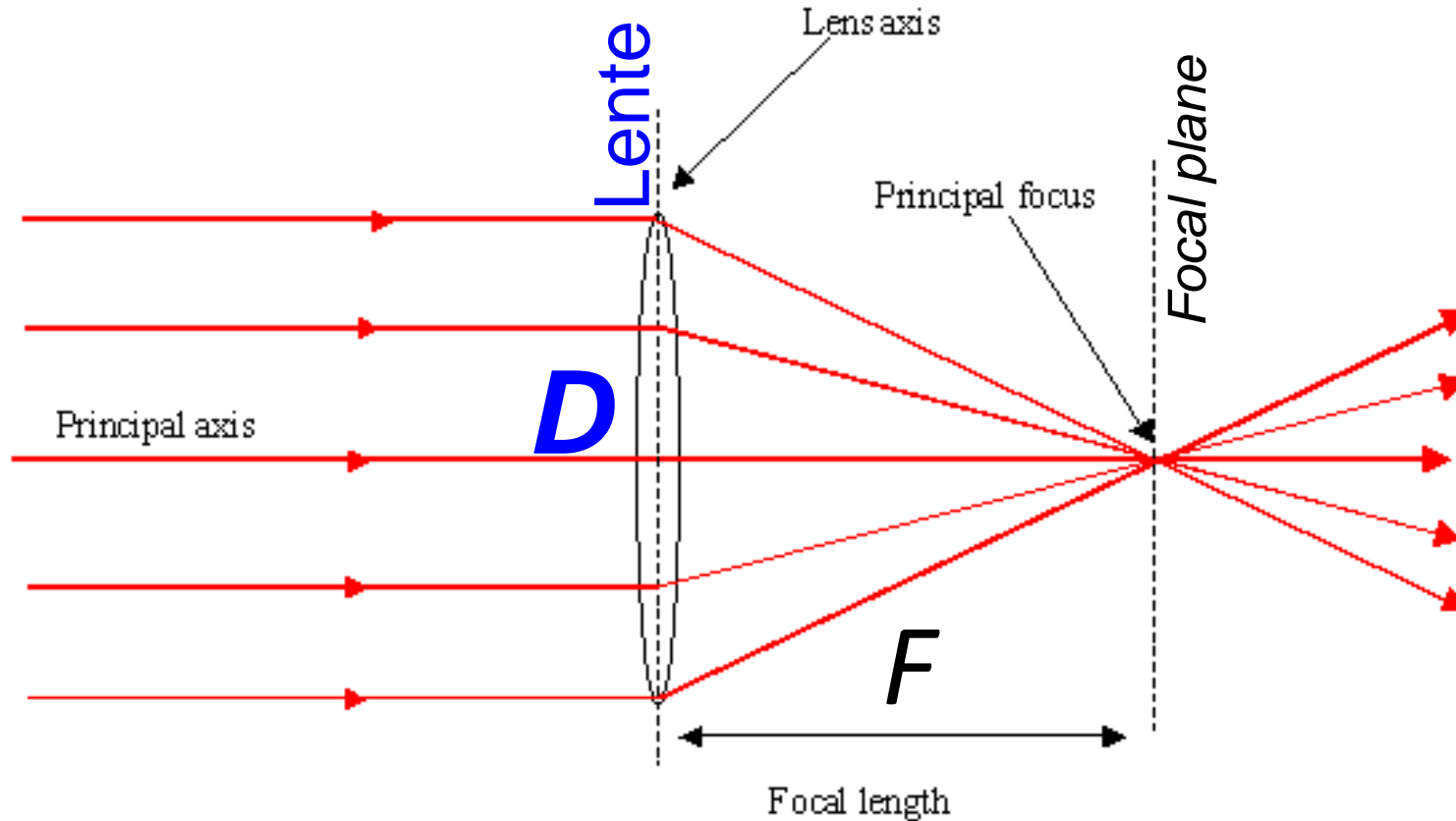
www.antonine-education.co.uk/Physics_A2

Razão focal $\equiv f\text{-ratio} \equiv f\text{-number} \equiv f/\# = F/D$

Short (low) $f/$ (e.g. $f/3$): faster: brighter: wider field of view

Razão focal $f/\# = F/D$

distância focal F , abertura da objetiva D , razão focal $f/\#$



Exemplo: telescópio de 1,6m do OPD tem $f/10$ no foco Cassegrain, qual a distância focal F ?

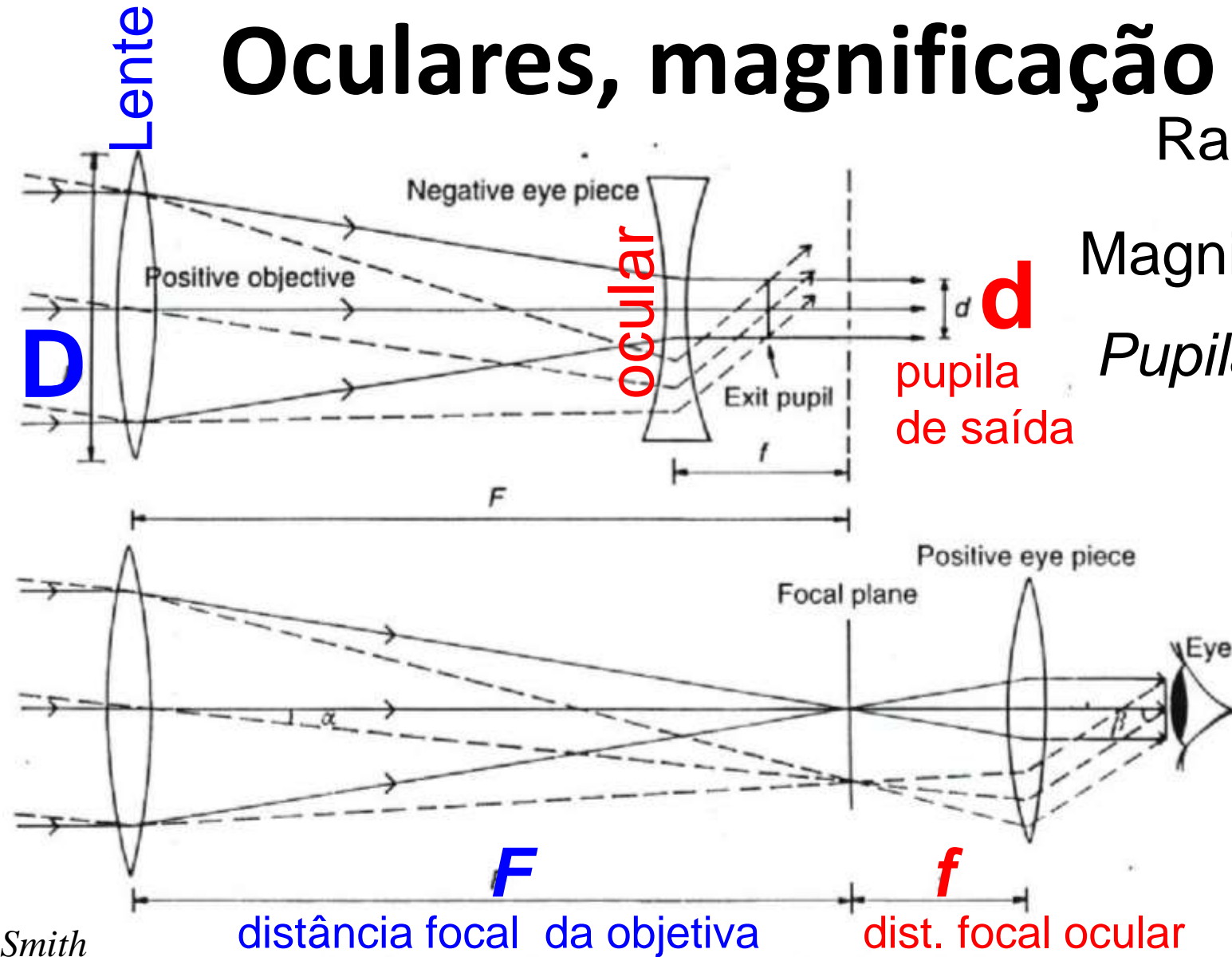
Rpta: $F/D = 10$, como $D=1,6\text{m}$, então $F = 16\text{m}$

Oculares, magnificação

Razão focal = F / D

Magnificação $m = F / f$

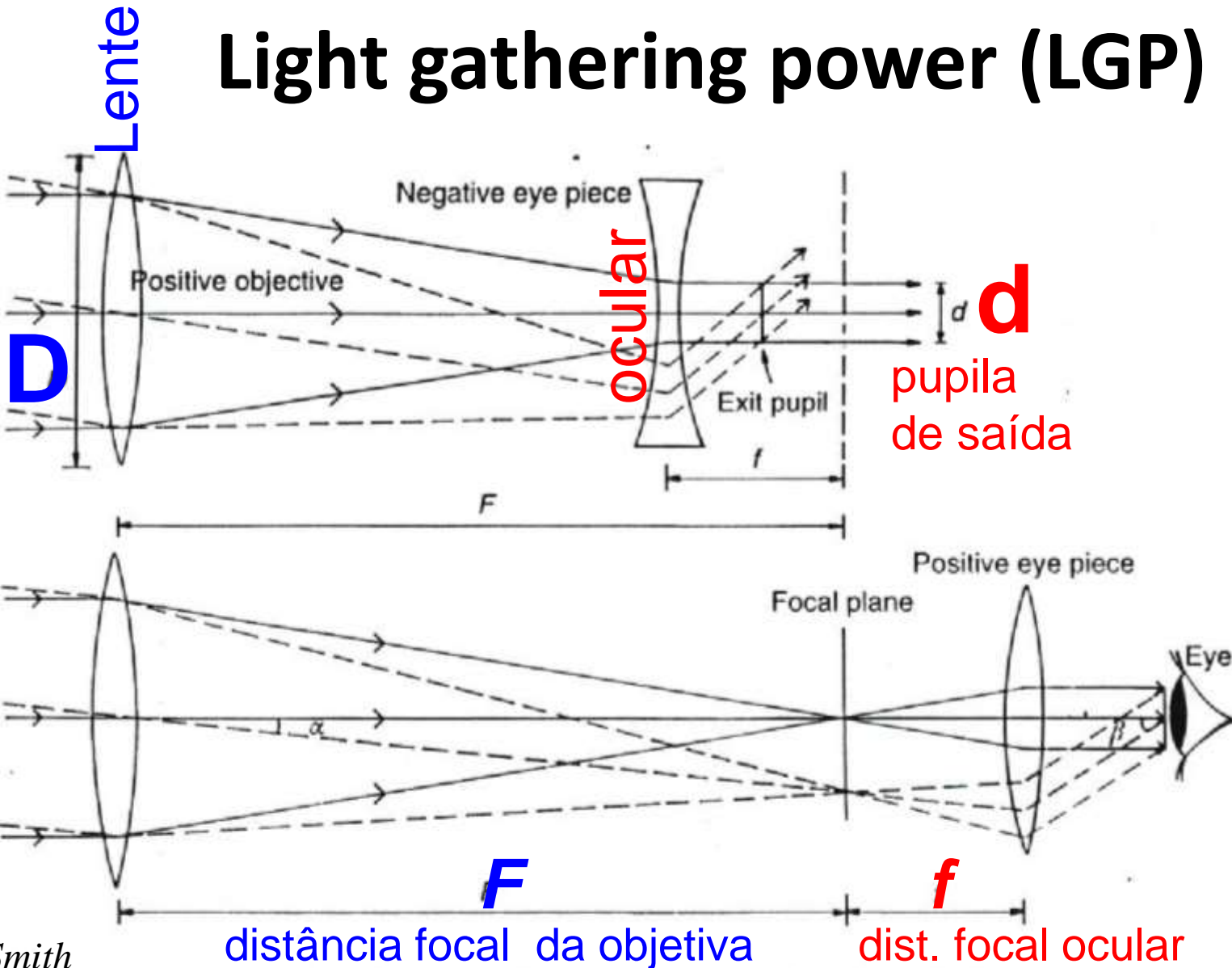
Pupila saída $d = D/m$



Smith

Fig. 2.2. Principles of refracting telescopes. *Upper*: Galilean design. *Lower*: Keplerian design. The objective lens, of diameter D , focuses the parallel light from a distant star in the focal plane, at distance F (the focal length) from the objective; the eyepiece magnifies the image and produces a parallel beam at the eye. The image of the objective formed by the eyepiece is known as the exit pupil and is marked in both diagrams by a vertical bar. The magnification is $m = \beta/\alpha = F/f$. If d is the diameter of the exit pupil, then $d = D/m$. The Galilean design produces an upright image while the more common Keplerian one produces an inverted image. A typical

Light gathering power (LGP)



Poder coletor (light gathering power, LGP) é área da objetiva

$$LGP = \pi (D/2)^2$$

Pessoa jovem na escuridade $d_e \sim 7\text{mm}$

Ex. telescópios com respeito ao olho:

10cm: 200 maior

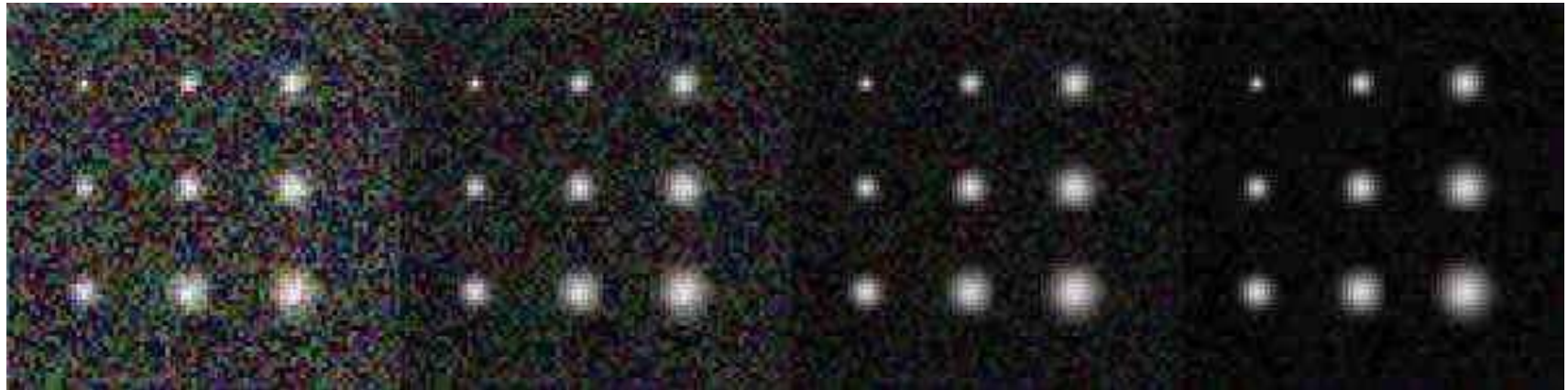
8m: 1.3×10^6 maior!

Smith
 Fig. 2.2. Principles of refracting telescopes. Upper: Galilean design. Lower: Keplerian design. The objective lens, of diameter D , focuses the parallel light from a distant star in the focal plane, at distance F (the focal length) from the objective; the eyepiece magnifies the image and produces a parallel beam at the eye. The image of the objective formed by the eyepiece is known as the exit pupil and is marked in both diagrams by a vertical bar. The magnification is $m = \beta/\alpha = F/f$. If d is the diameter of the exit pupil, then $d = D/m$. The Galilean design produces an upright image while the more common Keplerian one produces an inverted image. A typical

Razão sinal-ruído

Signal-to-noise ratio (S/N)

$$S/N = \text{sinal/ruído}$$



S/N = 2

S/N = 4

S/N = 8

S/N = 16

simulation of stars observed with a signal-to-noise ratio ranging from 2:1 to 16:1

Tempo de integração

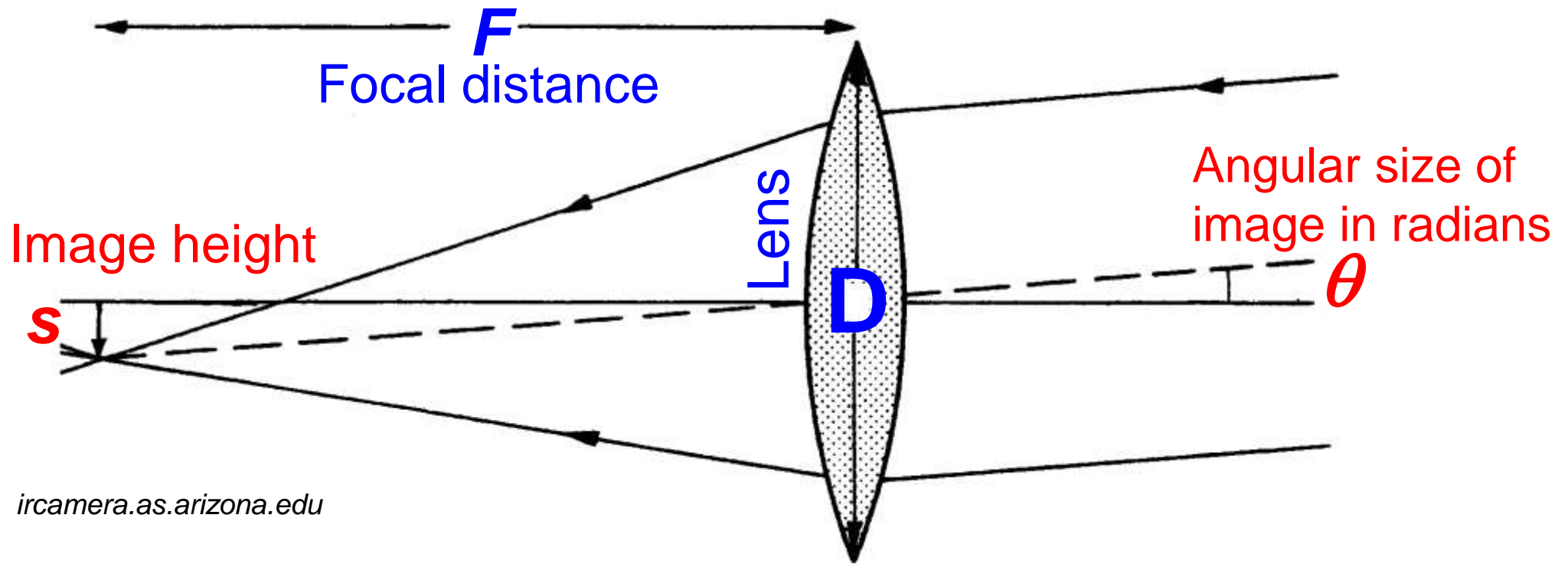
Juntando os 4 telescópios VLT/ESO (8m cada) podemos ter um “super-VLT” com um diâmetro equivalente a 16m. Se com esse super-VLT podemos observar uma galáxia em 1h, quanto tempo levaria essa observação (com o mesmo S/N) se fosse feita no telescópio de 1,6m do OPD?

Rpta: 100 horas. Considerando 2h de observação no OPD (próximo ao meridiano) por noite, a observação levaria no total 50 noites ...

$$t_1 = (D_2/D_1)^2 t_2$$

t_1 , t_2 : tempo com telescópio de diâmetro D_1 , D_2

Tamanho físico da imagem



ircamera.as.arizona.edu

Tamanho físico s da imagem θ no detetor:

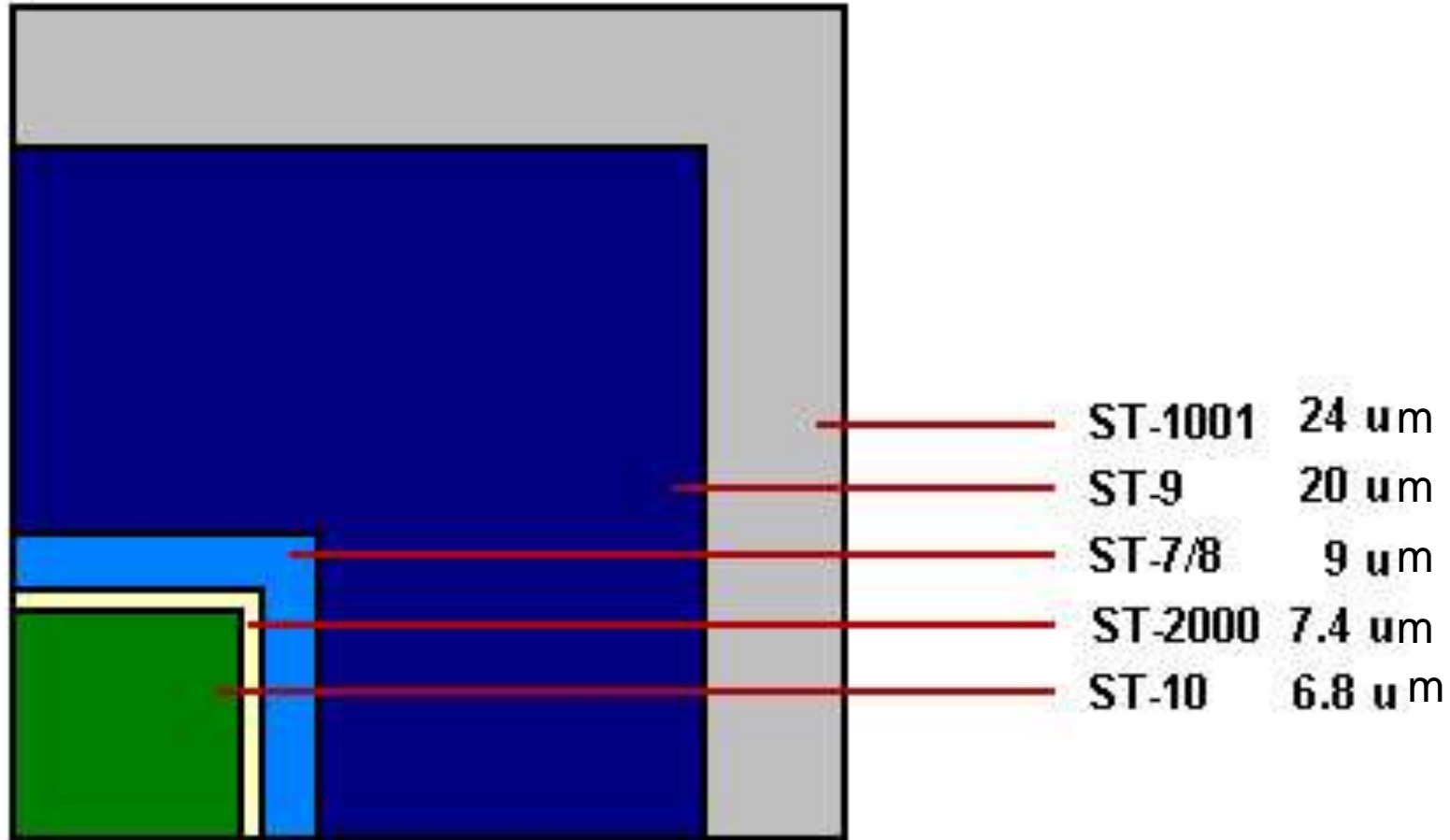
$$s = F \tan \theta \sim F \theta$$

Exemplo: se $F = 8m$, calcular s para $\theta = 1''$

$1 \text{ rad} = 206265''$, então $s = 8m * 1/206265 = 3,9 \times 10^{-5} m = 39 \mu m$

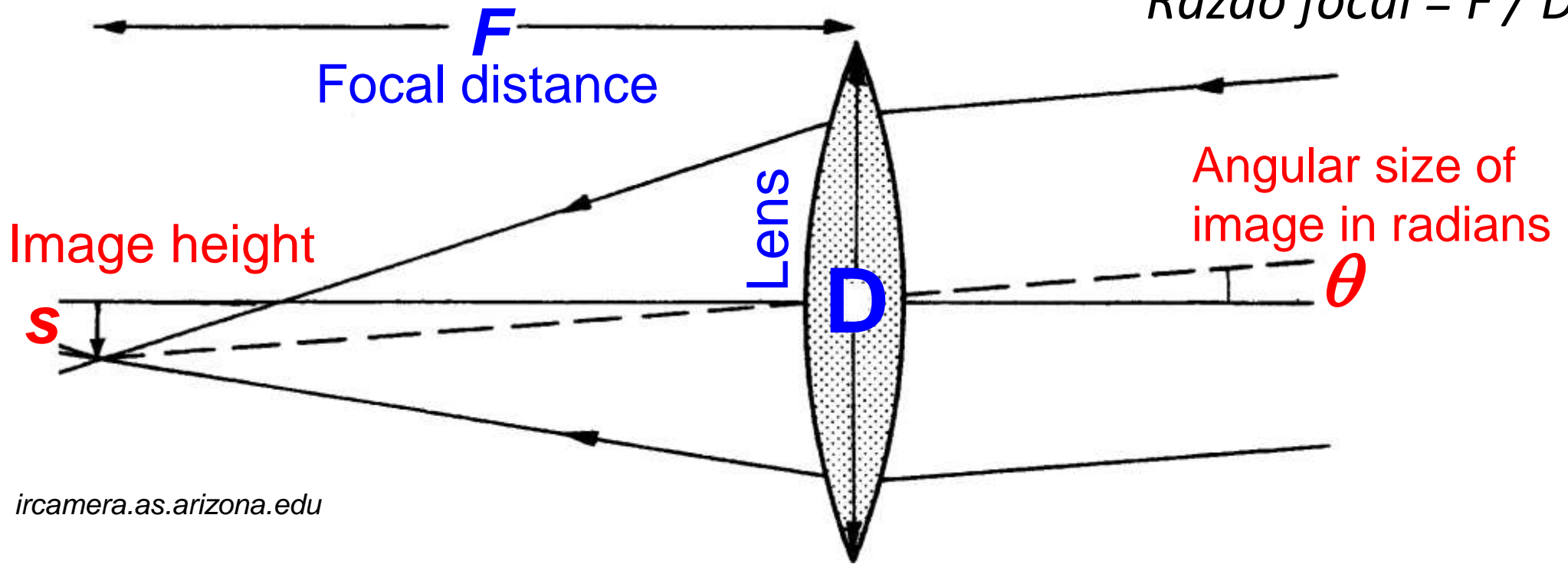
How large is a CCD?

Relative Pixel Sizes



Tamanho físico da imagem, escala de placa

Razão focal = F / D



ircamera.as.arizona.edu

Tamanho físico s da imagem θ : $s = F \tan \theta \sim F \theta$

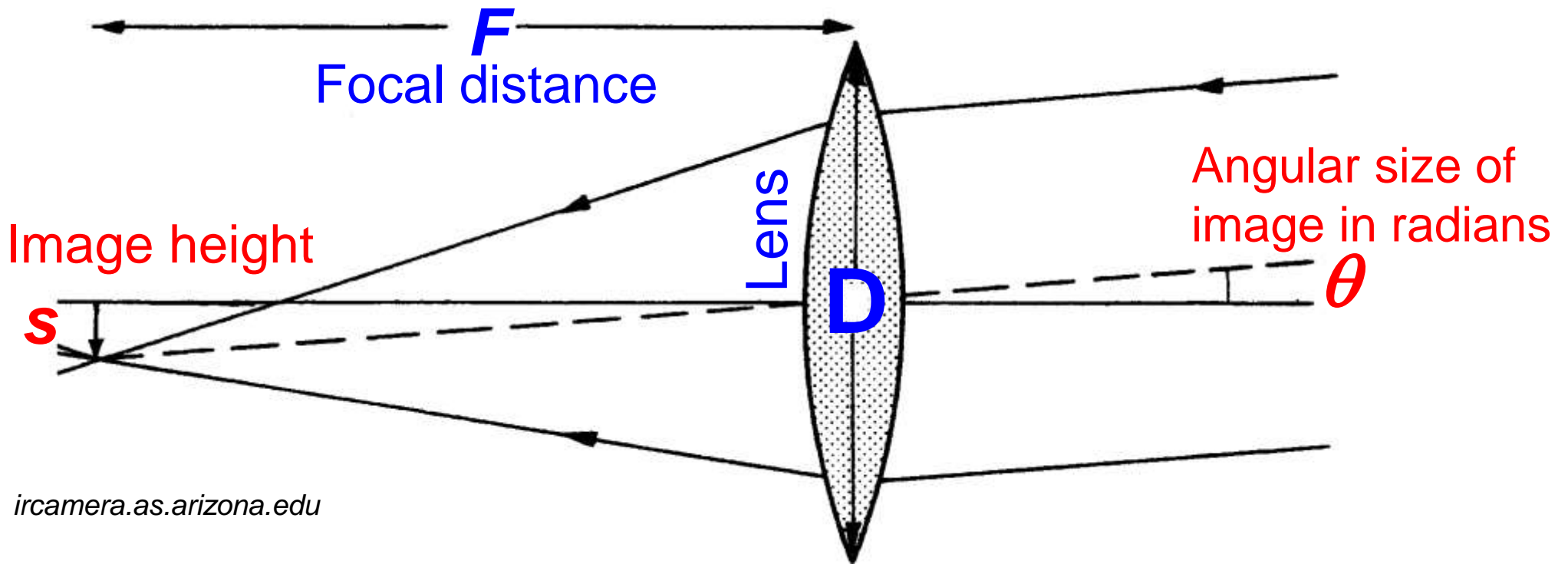
Escala de placa $p = d\theta/ds = 1/F = 206265''/F$

IAG: $f/13.5$; $D=61\text{cm}$. Qual a escala de placa?

$$F = 13.5 \times 61\text{cm} = 8235 \text{ mm}$$

$$p = 206265''/8235\text{mm} = 25''/\text{mm} = 0.5''/20\mu\text{m} \quad (1\text{mm}=10^3 \mu\text{m})$$

Field of view



ircamera.as.arizona.edu

Escola de placa $p = d\theta/ds = 1/F = 206265'' / F$



A



B

Using the same CCD chip on two telescopes with different focal lengths affects the field of view and image scale, but not the display size.

CCD: 9-micron pixels, 765x510 array

Telescope A: 500mm focal length

Telescope B: 1000mm focal length

Telescopios refractores: Field of view

Escala de placa $p = d\theta/ds = 1/F = 206265'' / F$



A



B

Using the **same telescope with different CCDs** affects the field of view and display size, but not the image scale.

Telescope: 500mm focal length

CCD A: 9-micron pixels, 765x510 array

CCD B: 9-micron pixels, 1530x1020 array



A



B

Using **different CCDs and different telescopes** can lead to any number of results, like for example **equivalent fields of view**. In this case, a large CCD with a long-focal-length scope gives the same field as a small CCD on a short-focal-length scope, but the image scale is greater on the larger instrument. The display size is also considerably larger in the second image.

Telescope A: 400mm focal length

CCD A: 7.4-micron pixels, 640x480 array

Telescope B: 1250mm focal length

CCD B: 6.8-micron pixels, 2174x1482 array

Telescópios refratores: desvantagens



Longest refractor (1m) at Yerkes observatory

- mecânica

- ↳ lente deve ser suportada pelas laterais, e, pela falta de suporte central, a lente tende a distorcer

- Tamanho do tubo

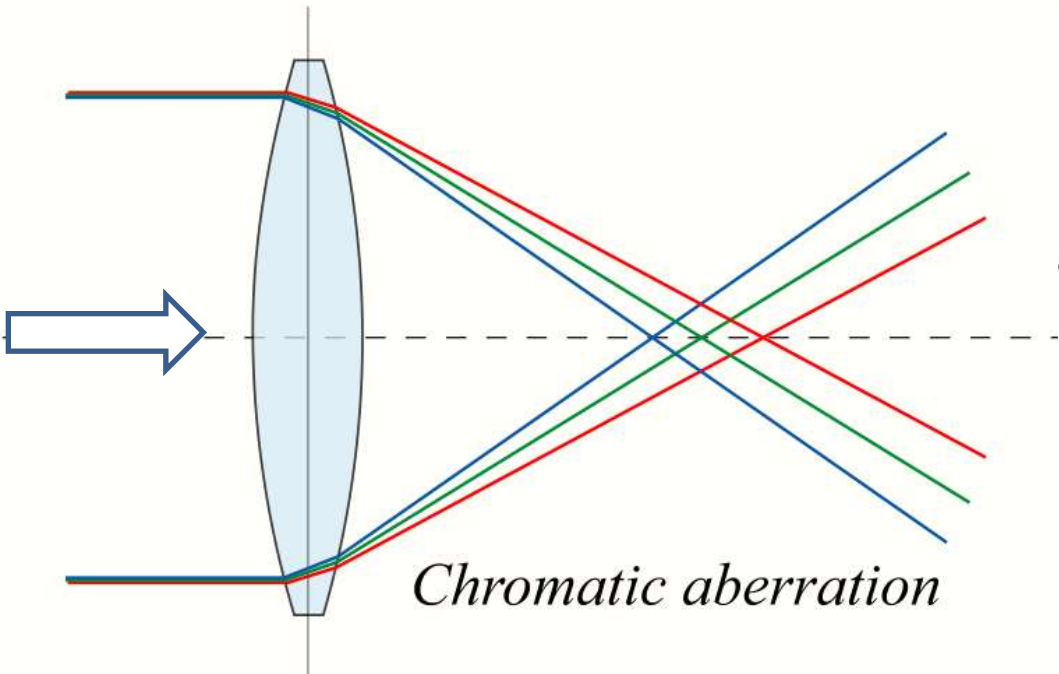
- ↳ Para diminuir as distorções (aber. cromática/esférica) ou o peso da lente, a dist. focal é grande, elevando \$\$\$\$. Ex: cúpulas enormes

- absorção da lente

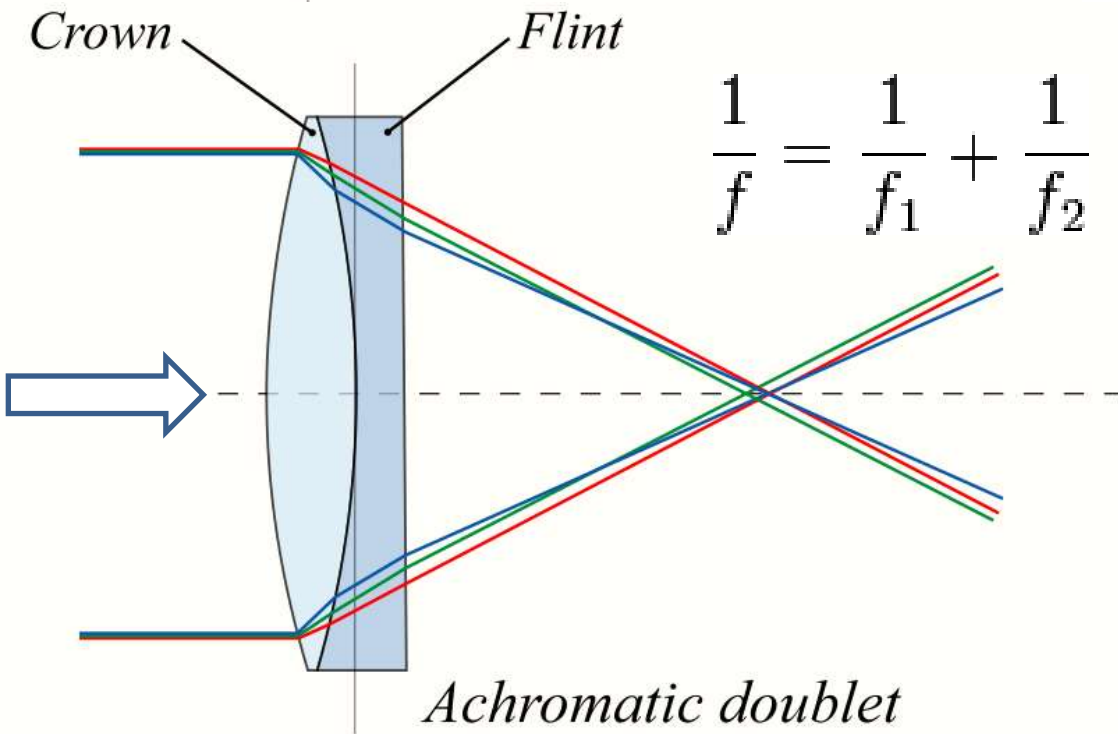
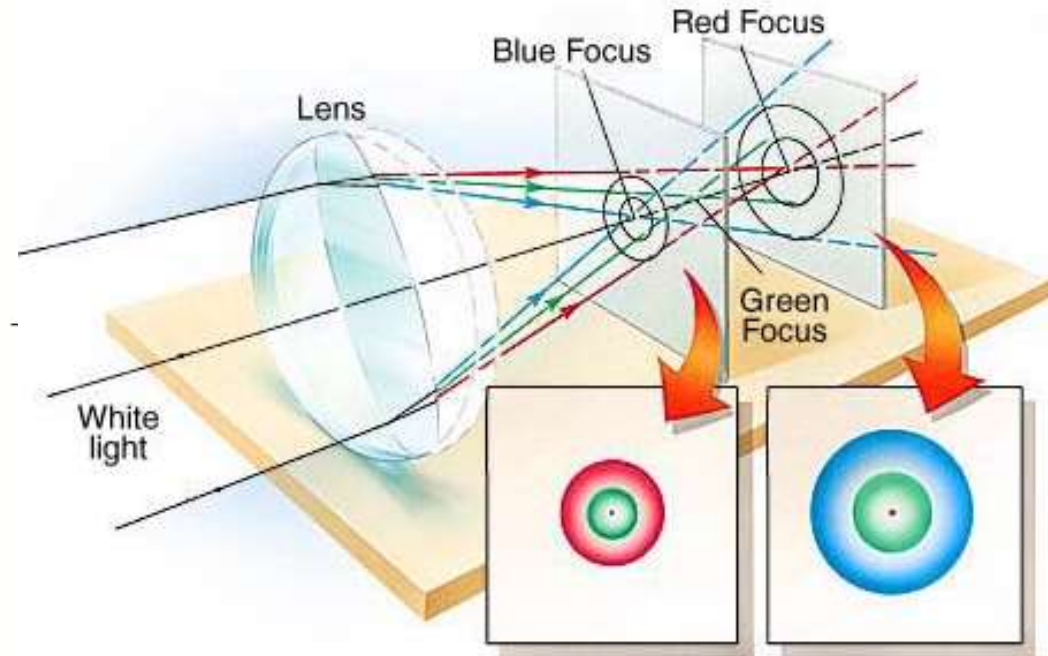
- ↳ luz UV não passa

- Imperfeições na lente ou bolhas de ar

Telescópios refratores: desvantagens



Chromatic aberration



Achromatic doublet

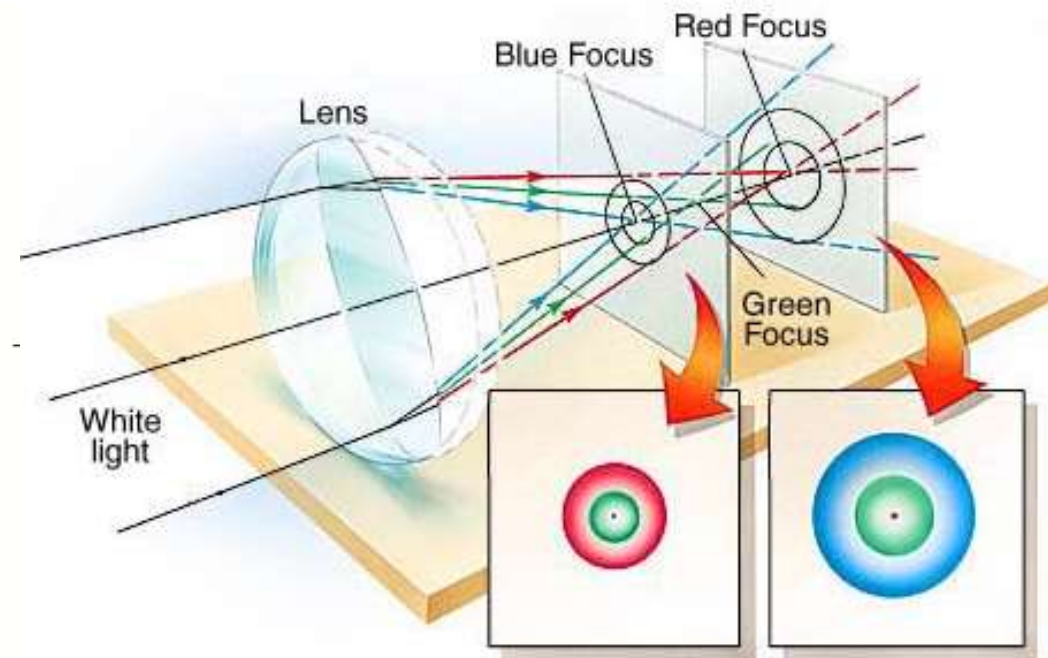
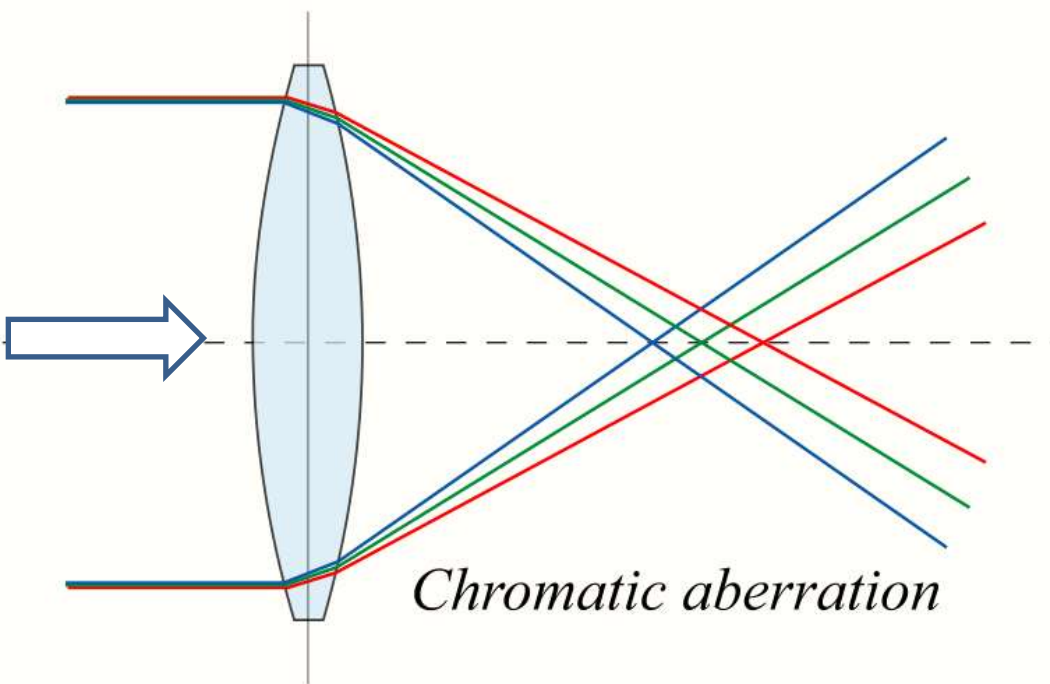
$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

Aberração cromática

⇒ índice de refração $n(\lambda)$, assim a distância focal $f(\lambda)$

⇒ correção com objetivas “acromáticas” por fusão de lentes (dubletos, tripletos, etc): porém, não é total

Telescópios refratores: aberração cromática



índice de refração $n(\lambda)$, assim a distância focal $f(\lambda)$

Table 1.1.5.

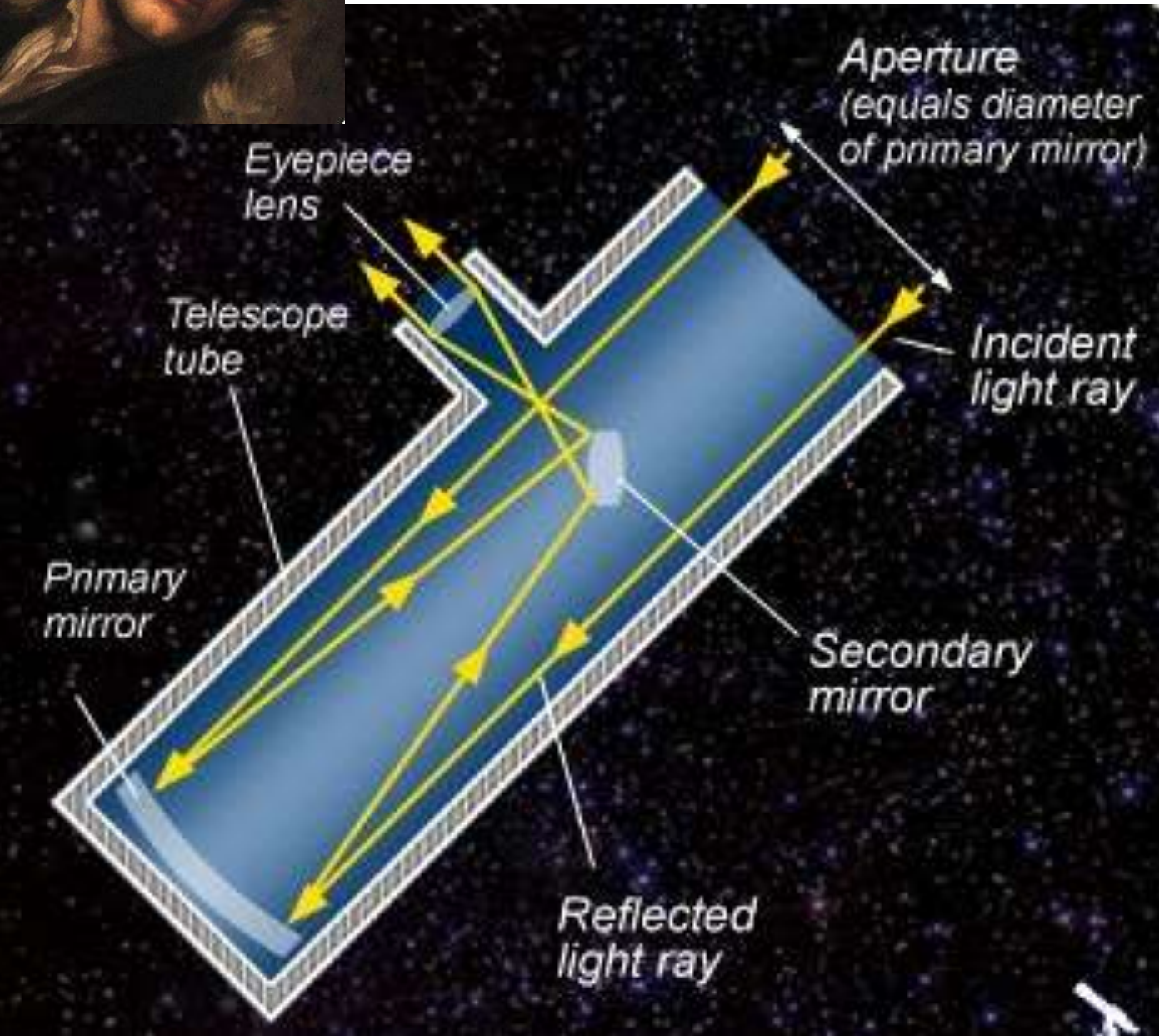
Glass type	Refractive index at the specified wavelengths (nm)				
	361	486	589	656	768
Crown	1.539	1.523	1.517	1.514	1.511
High dispersion crown	1.546	1.527	1.520	1.517	1.514
Light flint	1.614	1.585	1.575	1.571	1.567
Dense flint	1.705	1.664	1.650	1.644	1.638



Telescópios refletores

“Inventado” por Newton (1668)

At least the first working reflector



● **Objetiva: espelho**

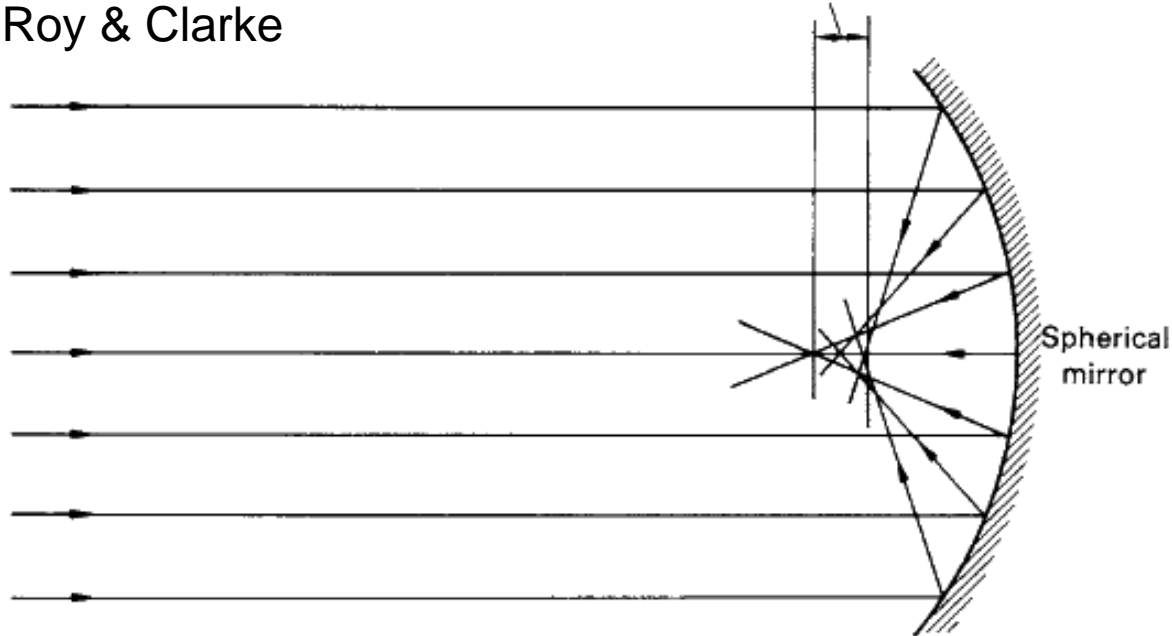
⇒ Não sofre de aberração cromática

⇒ O espelho de Newton foi esférico, mas a forma mais comum é de uma parábola, que faz foco em um único ponto

Roy & Clarke

Longitudinal spread of image

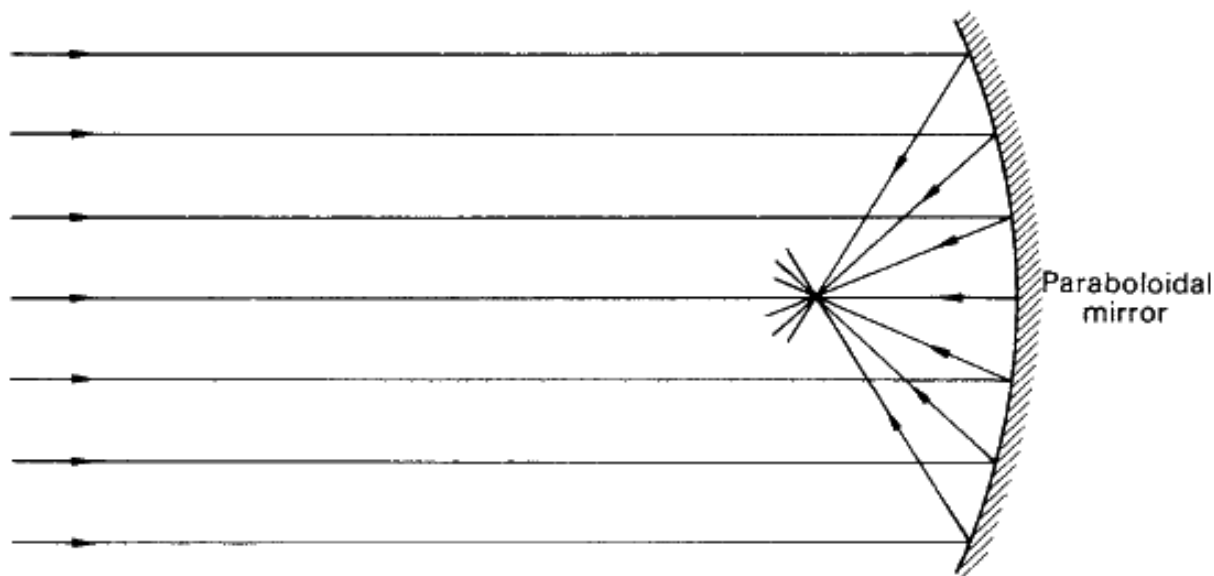
Aberração esférica



Spherical mirror

Espelho esférico (aberração esférica)

(a)



Paraboloidal mirror

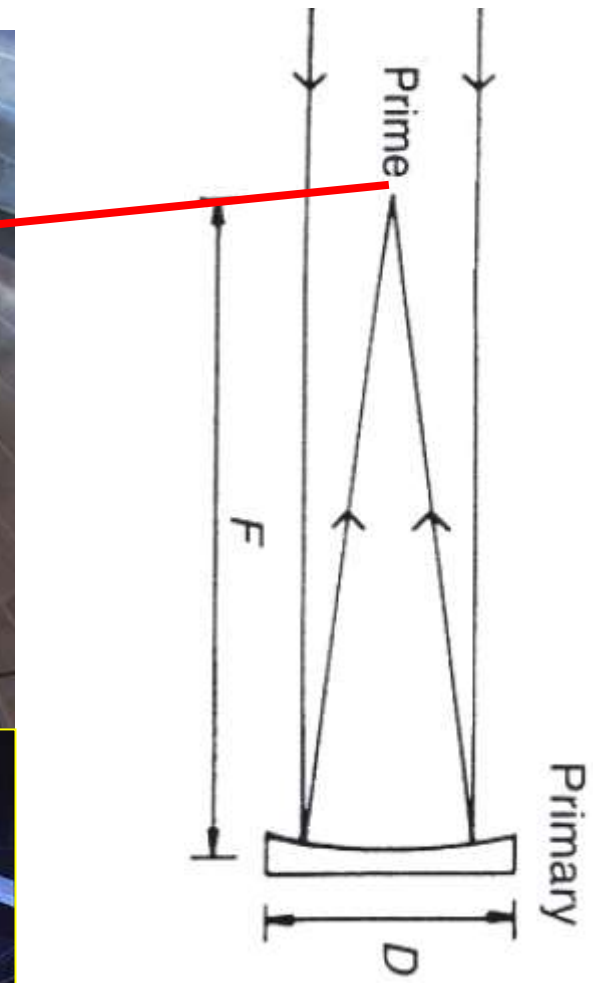
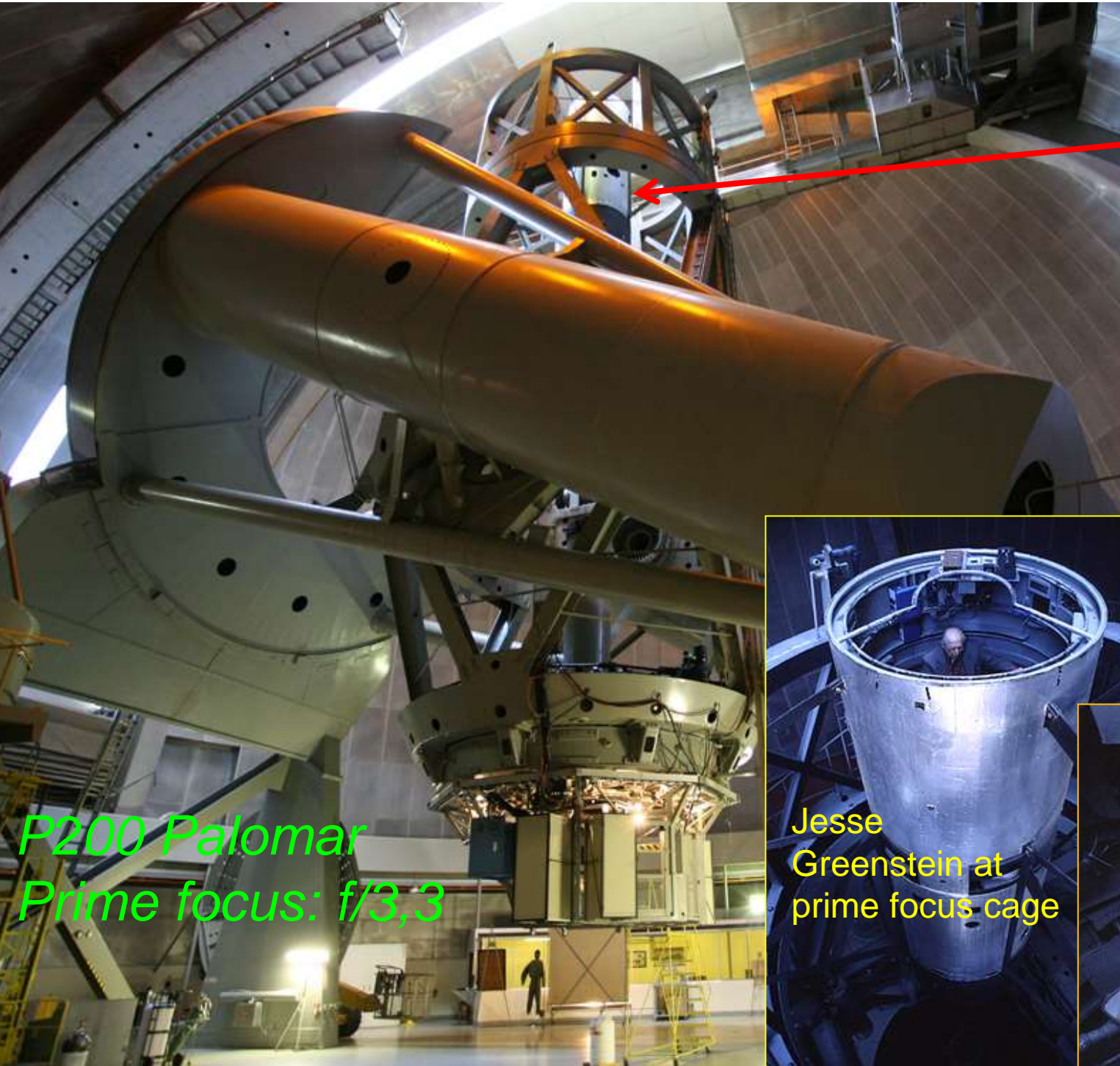
Espelho parabólico

(b)

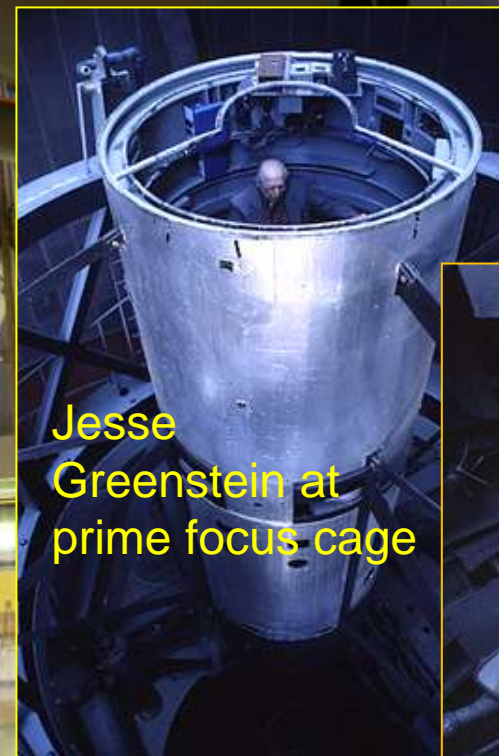
Figure 16.23. (a) Spherical mirror exhibiting the effect of spherical aberration. (b) Paraboloidal mirror removes spherical aberration; incident rays parallel to the optic axis are brought to the same focus, independent of their distance from the axis.

Tipos de foco: *prime focus*

Smith



P200 Palomar
Prime focus: $f/3,3$

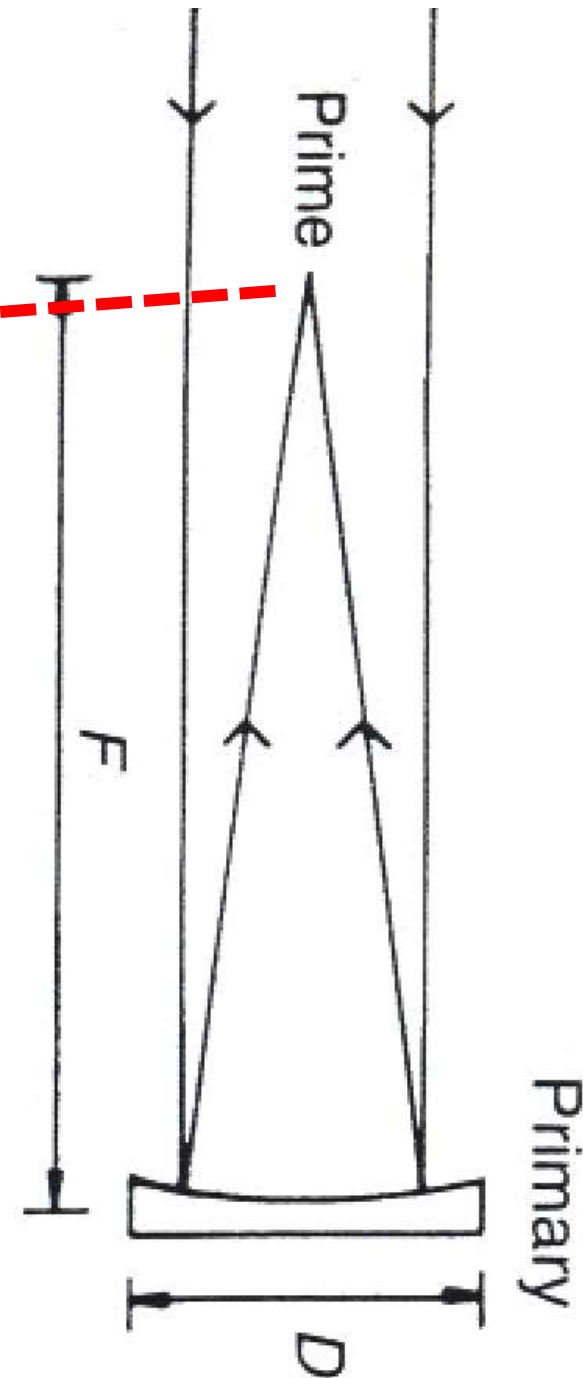
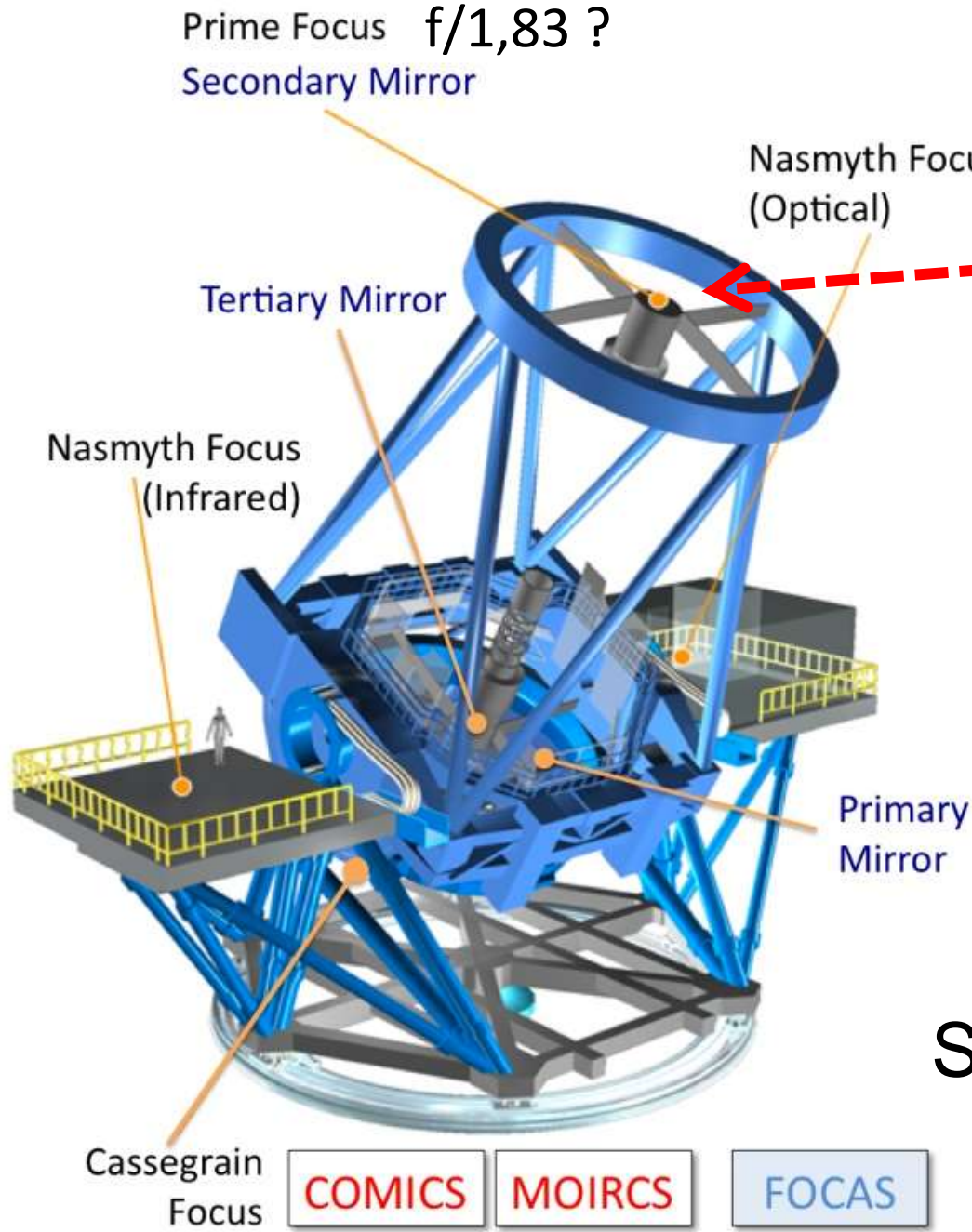


Jesse
Greenstein at
prime focus cage



Prime focus do Subaru (8m)

Smith



***Prime focus do Blanco
telescope (4m at CTIO)***

Turma de Astrofísica Observacional 2012



Instalação
da DECAM

DECAM instalada (Setembro 2013)



DECAM

(Dark Energy Camera)

2,2° FOV (62 CCDs)

+ 12 CCDs (guiagem e foco)

570 Mpixel
Camera

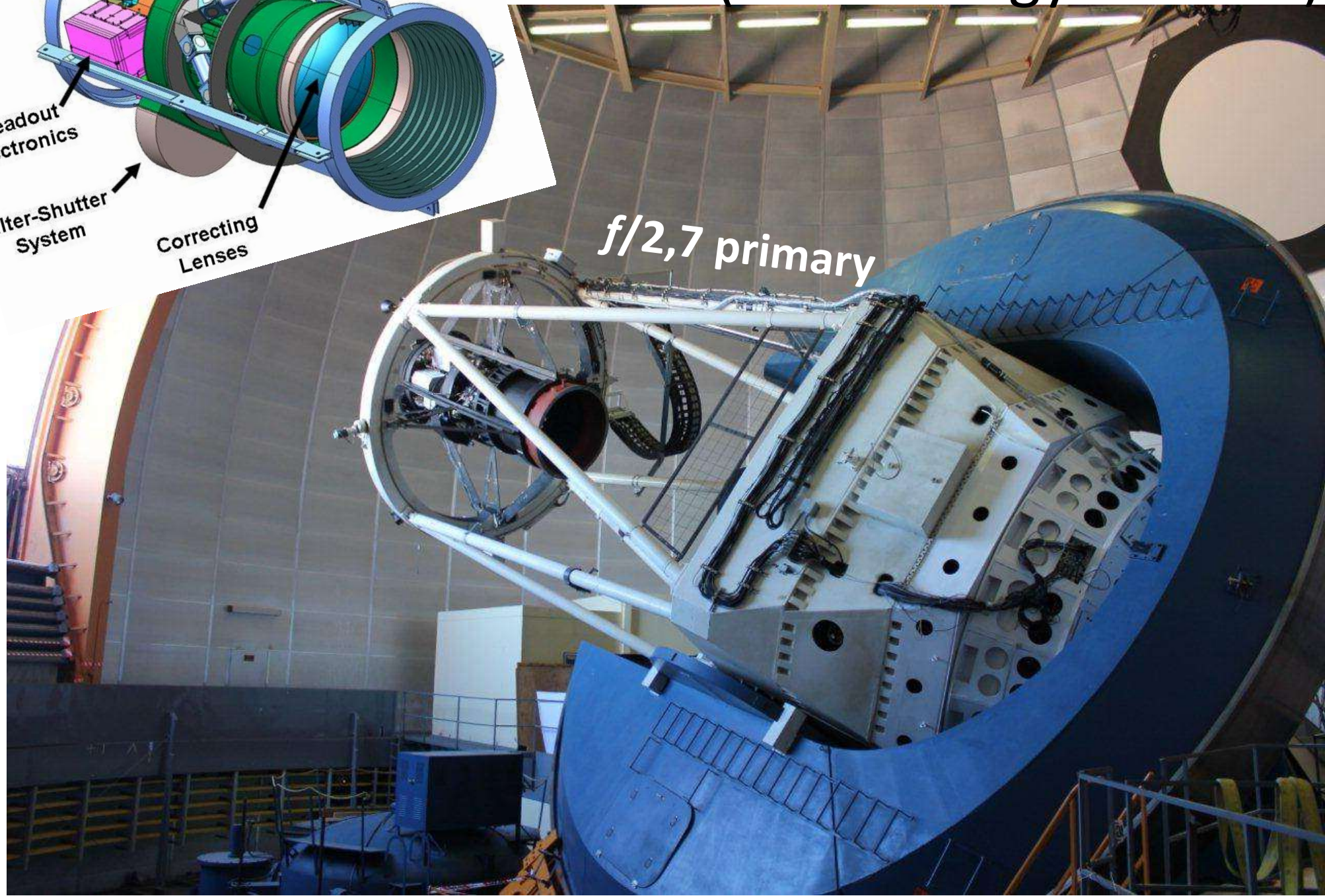
Hexapod
Adjustor

Readout
electronics

Filter-Shutter
System

Correcting
Lenses

$f/2,7$ primary



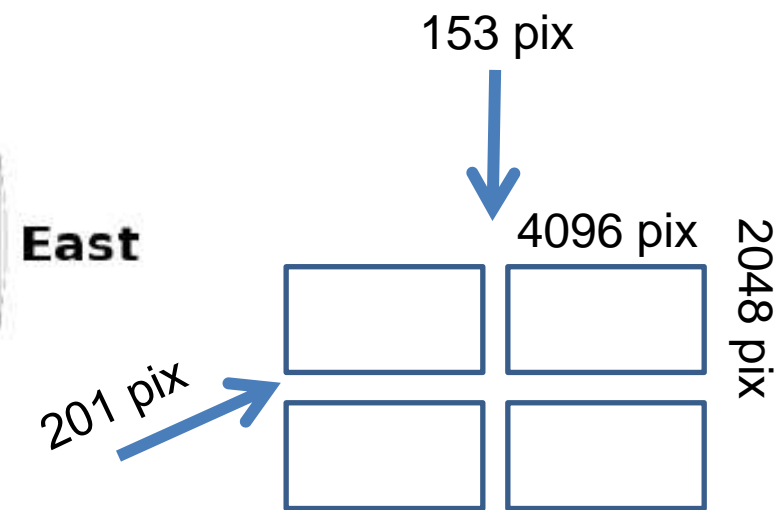
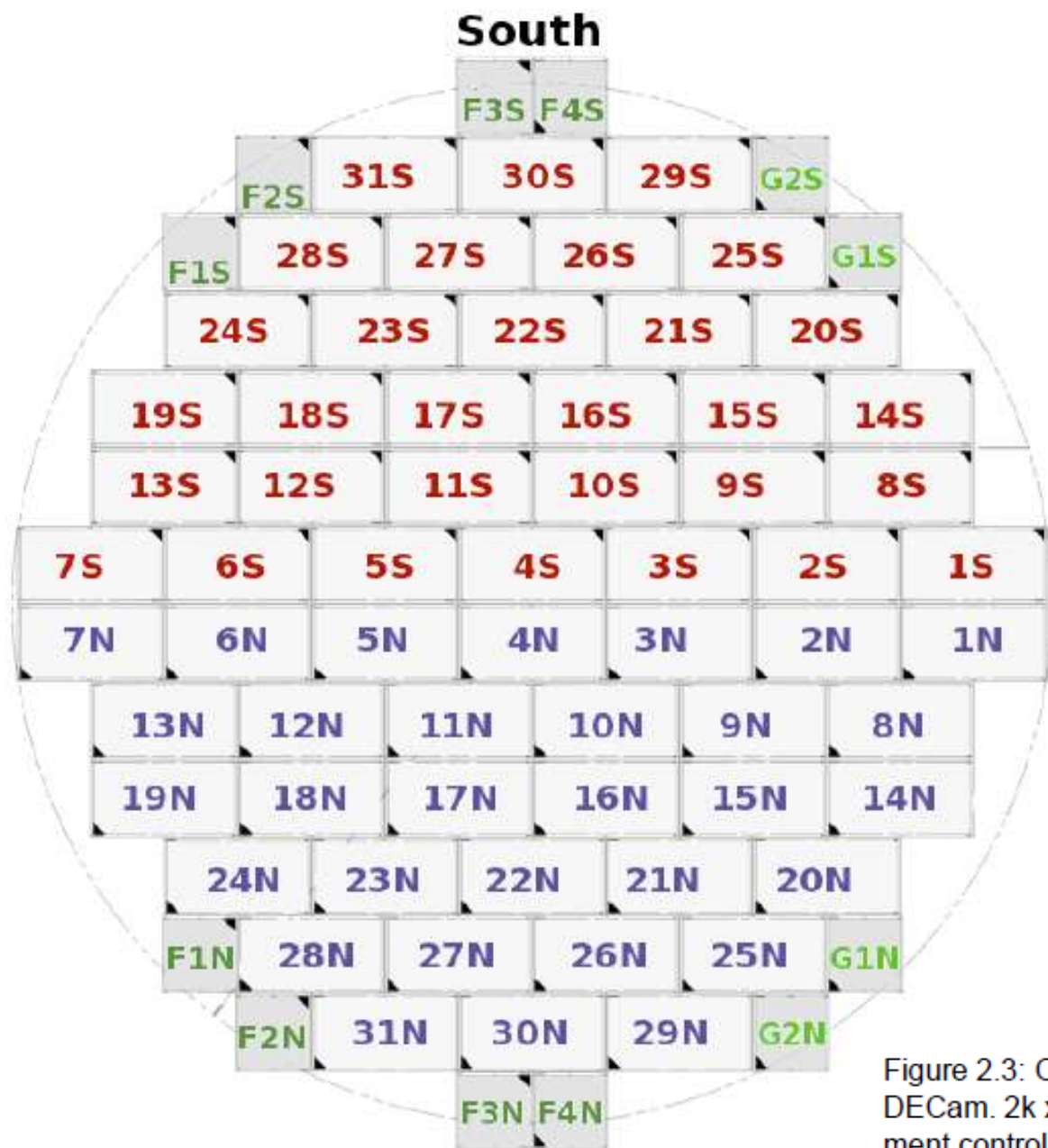
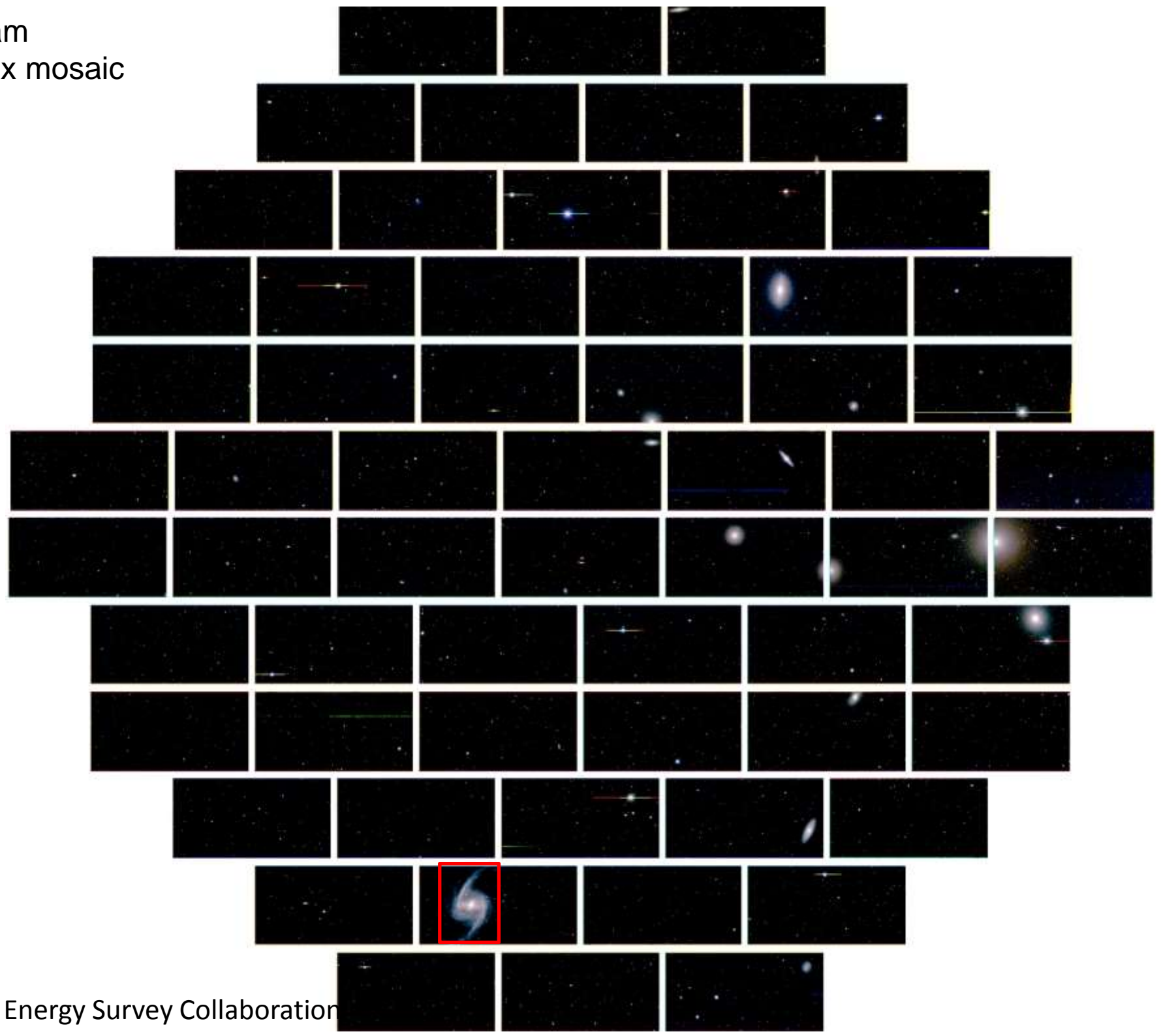


Figure 2.3: Orientations on the sky and spatial footprint of the FPA for DECam. 2k x 2k CCDs labeled as "F" will be used for focus and alignment control; those labeled as "G" will be used for guiding. Two amplifiers on each chip may be used for parallel read-out. The pixel coordinate origin is in the lower-left corner of each detector array.

DECam
Fornax mosaic



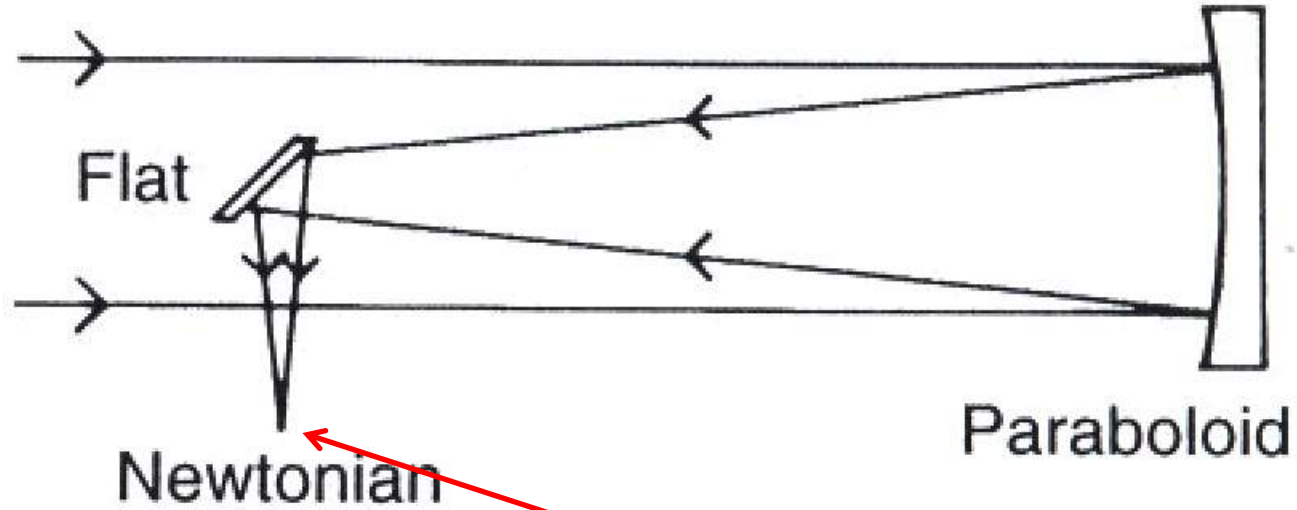
NGC 1365 is a barred spiral galaxy around 60 million light years from Earth, located in the Fornax galactic cluster.

© Dark Energy Survey Collaboration



Refletores: *Newtonian focus*

Smith

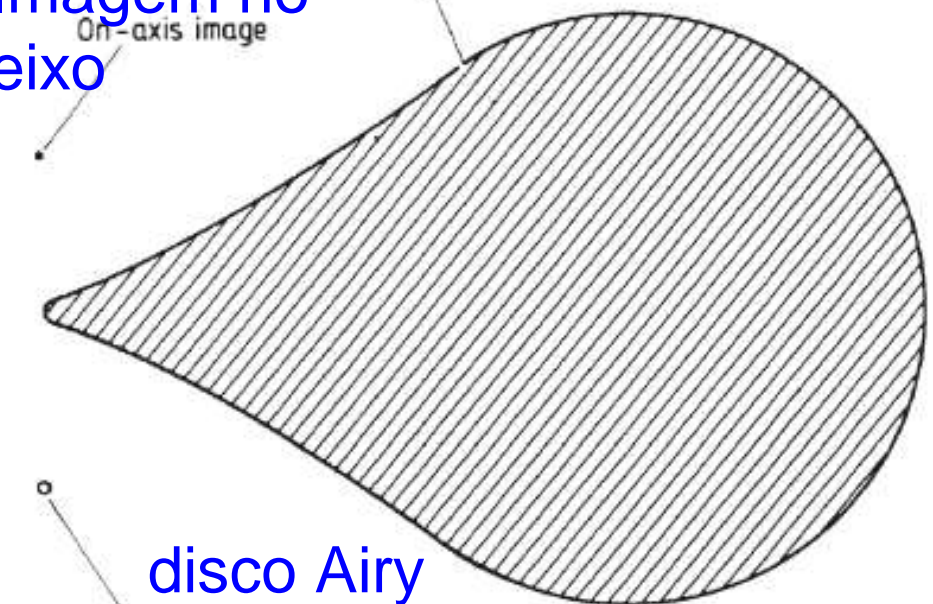


Newtonian focus

Refletores: qualidade da imagem do *prime/Newtonian*

Kitchin $\frac{1}{2}$ grau fora do eixo da imagem

Imagem no eixo



disco Airy

Airy disc

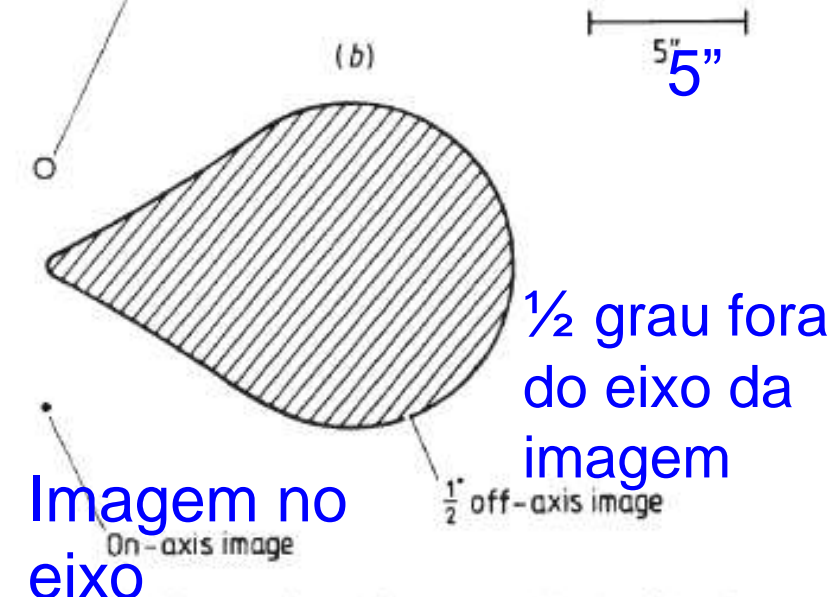
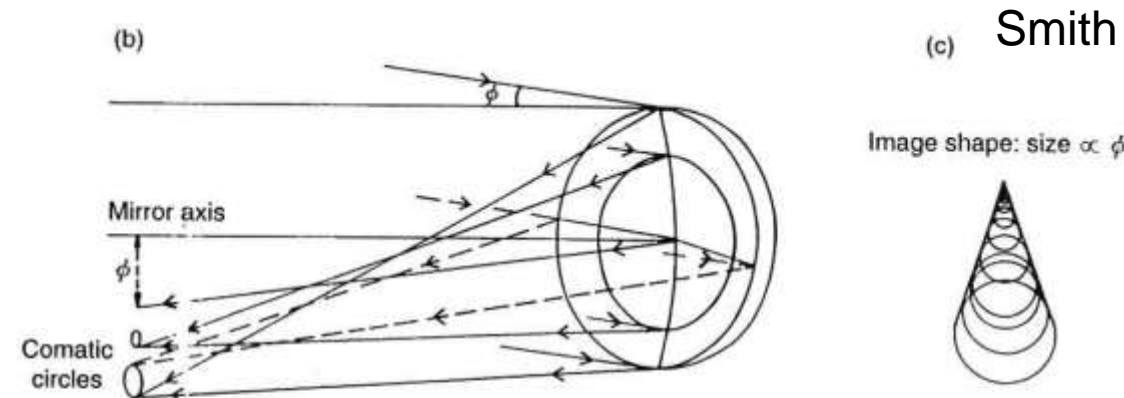
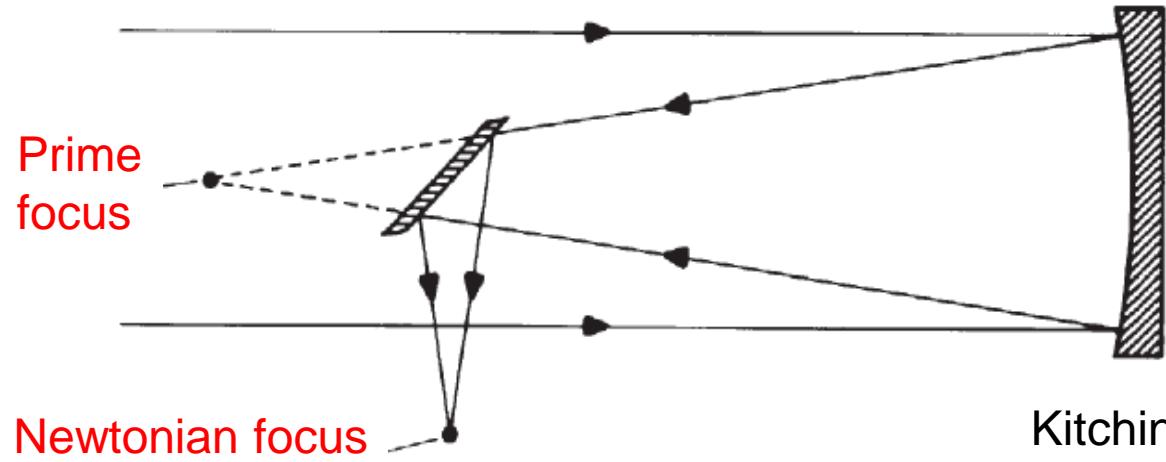


Imagem no eixo



(b) Coma for a paraboloidal mirror; each annular zone of the mirror forms a circular image whose size decreases with the size of the zone; for the positive coma illustrated, the smaller images are nearer the axis; within each image, each point is formed by rays from diametrically opposite sides of the mirror. (c) The overall image shape formed by comatic aberration; the overlapping circles form a 'tear-drop' shape whose size is proportional to the off-axis angle (*contd over*).



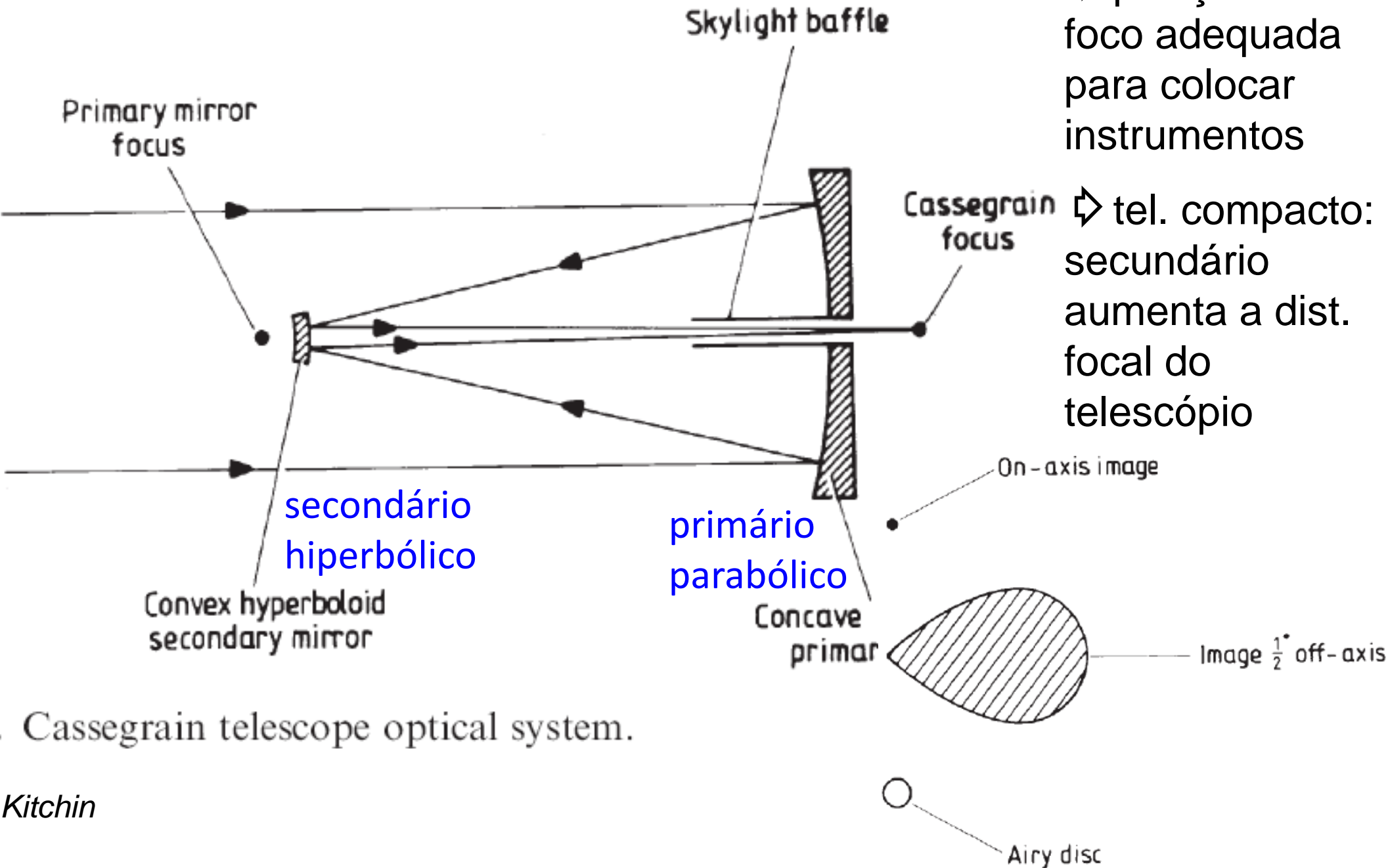
Prime focus

Newtonian focus

Kitchin

Images in Newtonian telescopes. (a) 1 m f4 telescope; (b) 0.5 m f8 telescope.

Refletores: foco Cassegrain



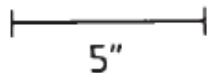
⇒ posição do foco adequada para colocar instrumentos

⇒ tel. compacto: secundário aumenta a dist. focal do telescópio

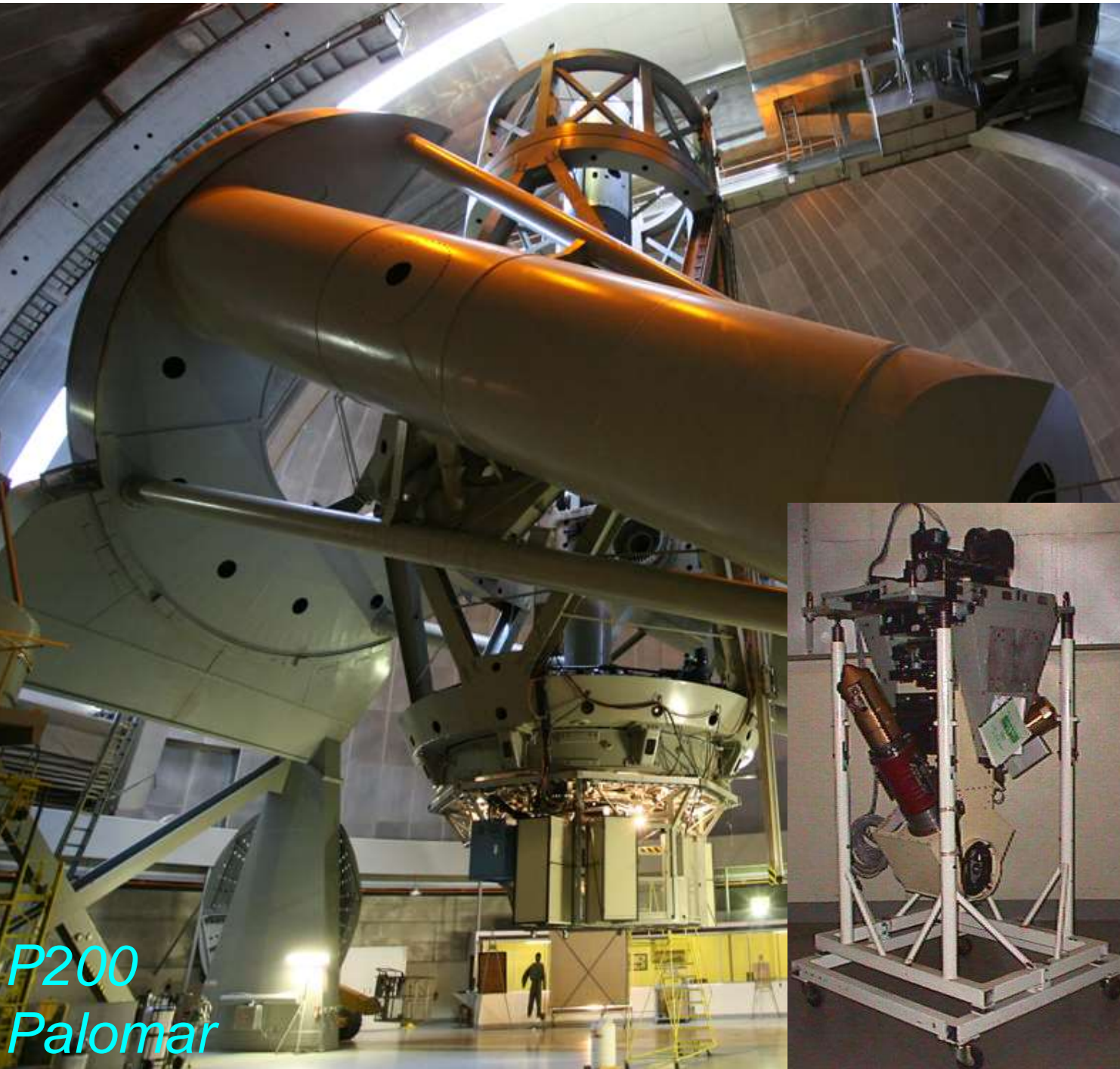
Cassegrain telescope optical system.

Kitchin

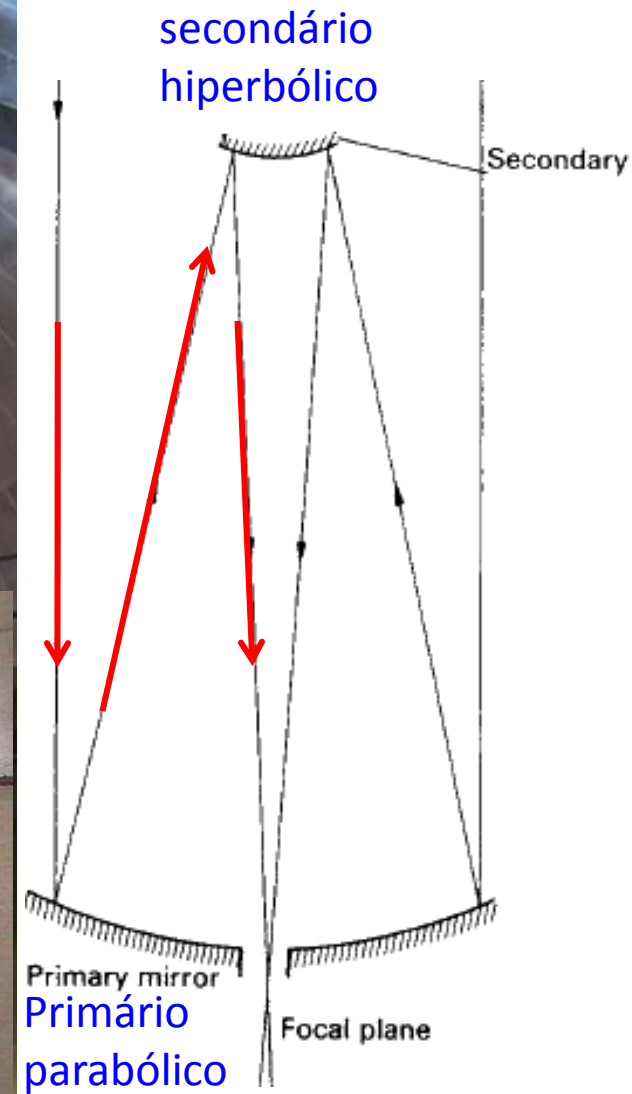
Images in a 0.25 m f4/f16 Cassegrain telescope



Refletores: foco Cassegrain



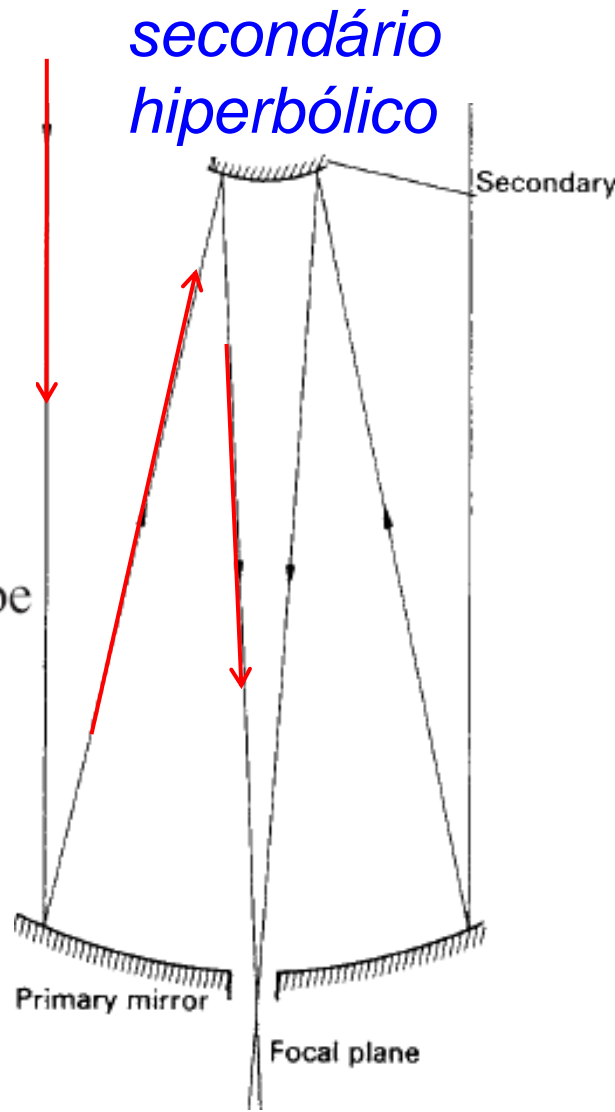
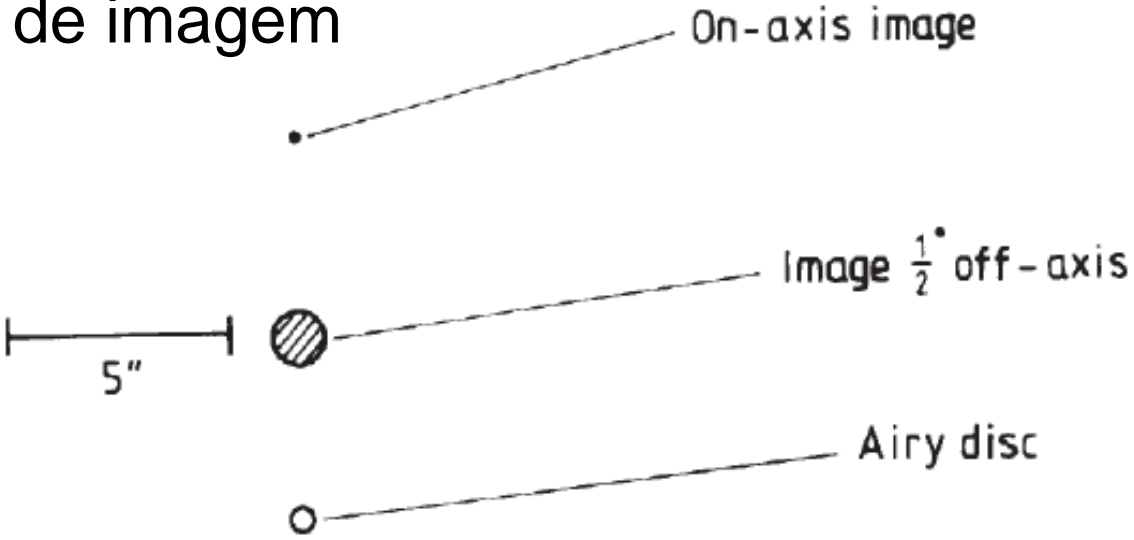
P200
Palomar



Palomar 5m: Último grande telescopio de tipo Cassegrain

Refletores: Ritchey-Chrétien telescope

Variação do Cassegrain com primário hiperbólico: melhor qualidade de imagem



Ray tracing images in a 0.5 m f3/f8 Ritchey-Chrétien telescope

Kitchin



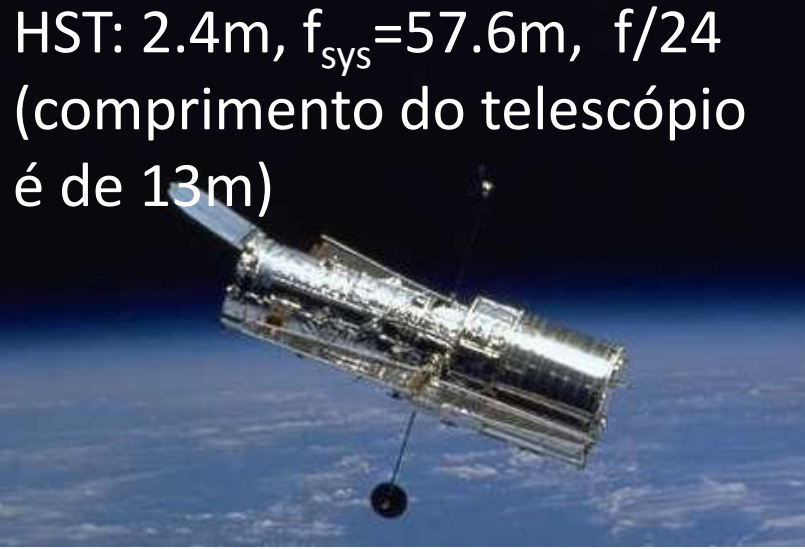
George Ritchey's 24-inch (60cm) reflecting telescope, first RCT constructed in 1927

primário hiperbólico

Refletores: Ritchey-Chrétien telescope



SOAR: 4.1m, f/16

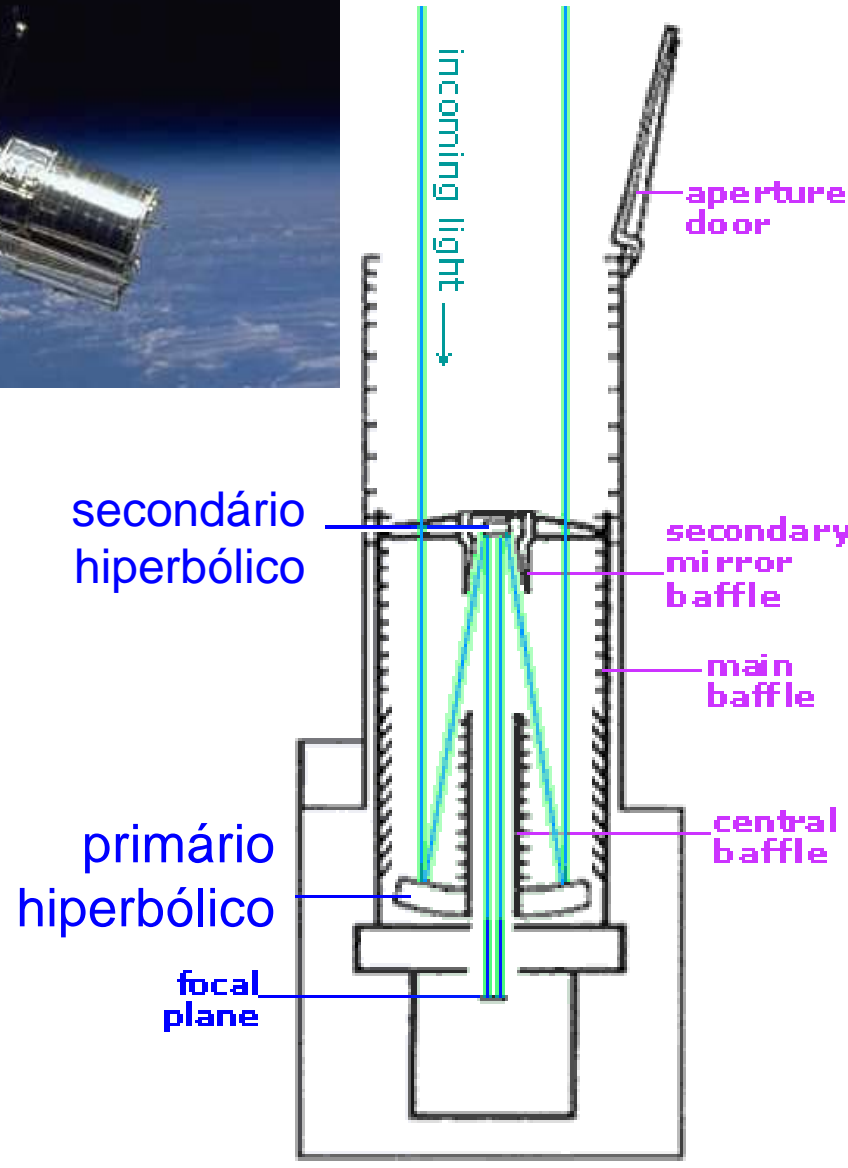


HST: 2.4m, $f_{sys} = 57.6m$, f/24
(comprimento do telescópio é de 13m)



LNA: 1.6m, f/10

Cut through HST

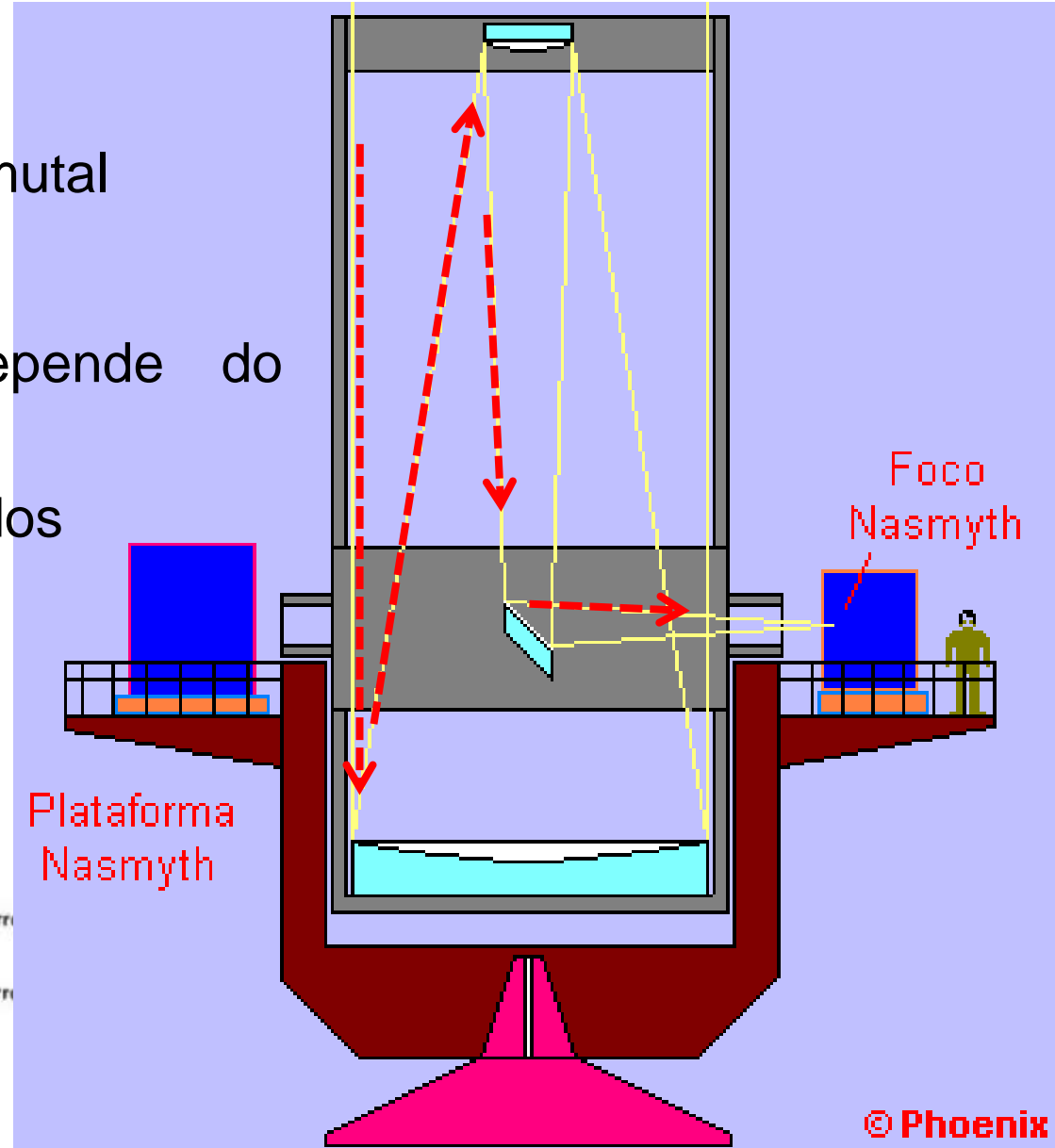
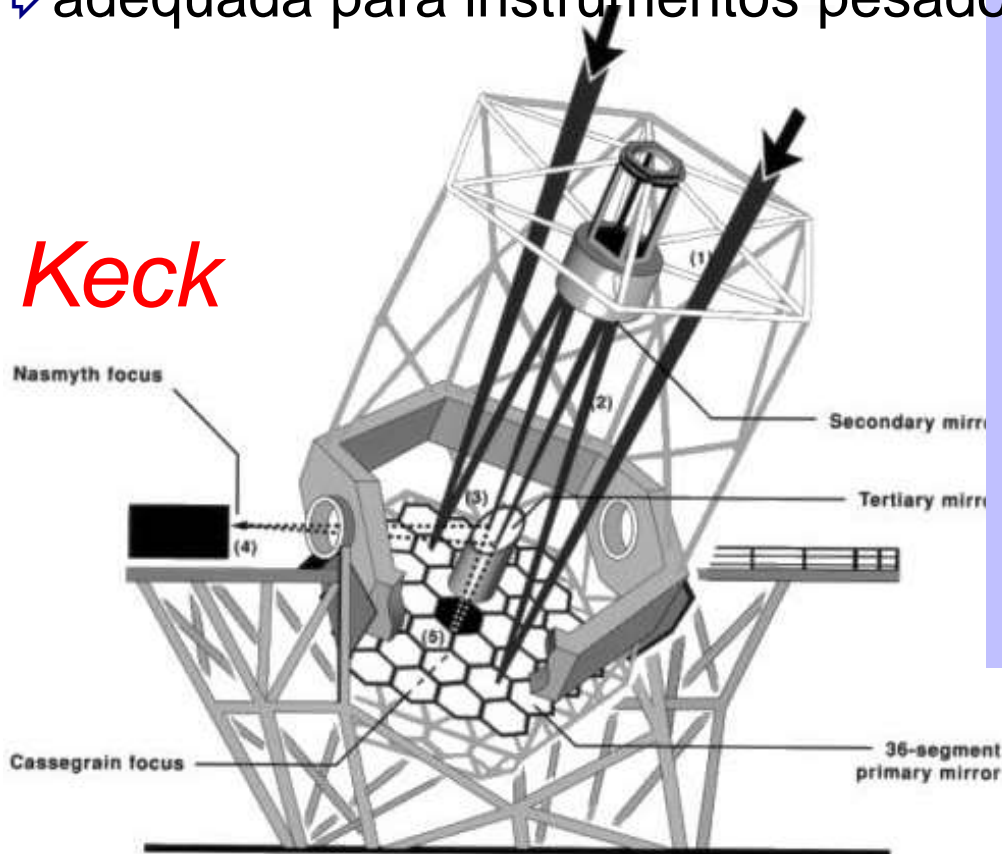


Refletores: focos Nasmyth e Coudé

Nasmyth

- ↳ telescópio com montagem alta-azimutal
- ↳ espelho plano no eixo de altura
- ↳ posição do foco é fixa: independe do movimento do telescópio
- ↳ adequada para instrumentos pesados

Keck



Grandes telescópios têm foco Nasmyth para grandes instrumentos, exceto o Gemini ...

Refletores: foco Coudé

Coudé: similar ao Nasmyth mas p/ montagem equatorial

↳ espectrógrafo f. Coudé no OPD

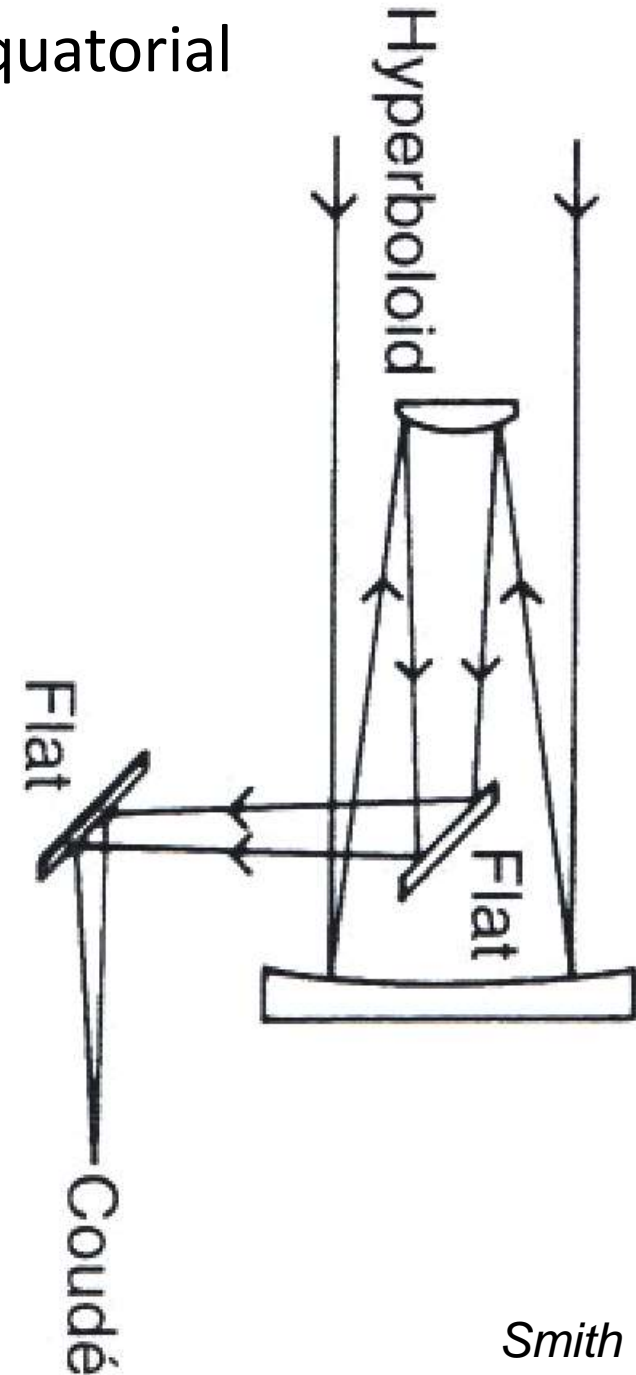
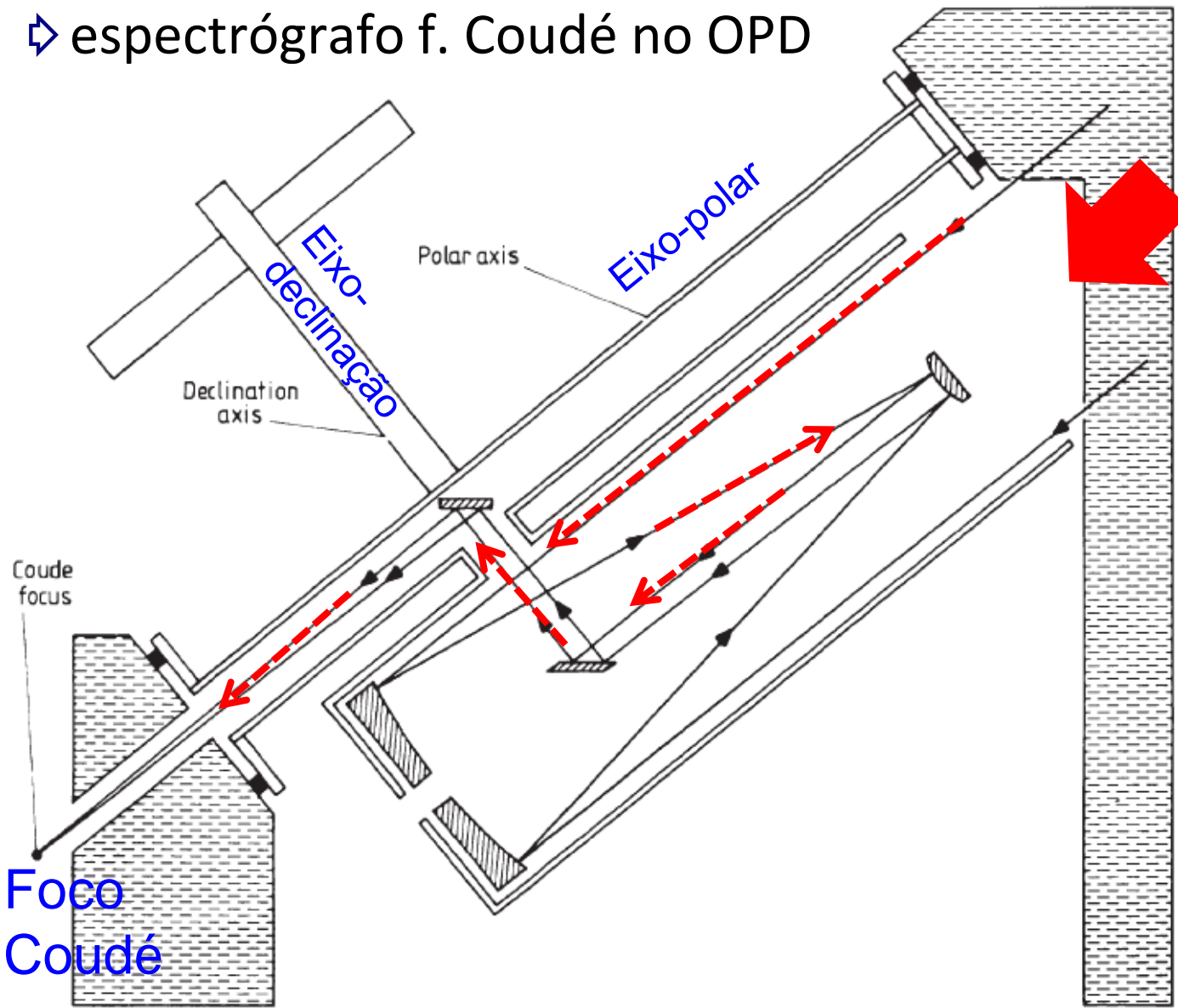


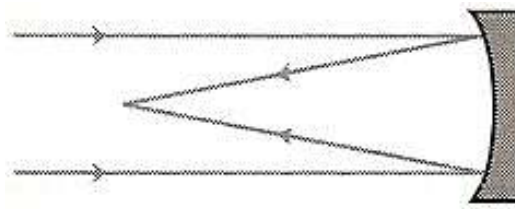
Figure 1.1.44. Coudé system for a modified English mounting.

Kitchin

Smith

Refletores: outros focos

The 48-inch (1.2m), Schmidt Telescope (f/2.5; covers 7°) at Palomar. Map of the whole Northern Hem. (basis for GSC)



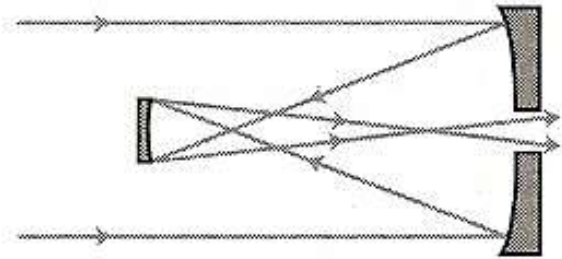
Prime focus



Newtonian



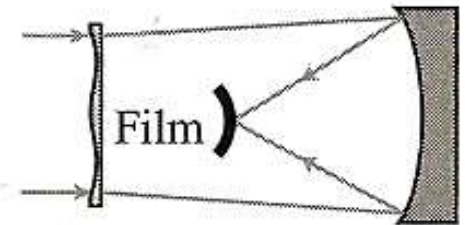
Cassegrain



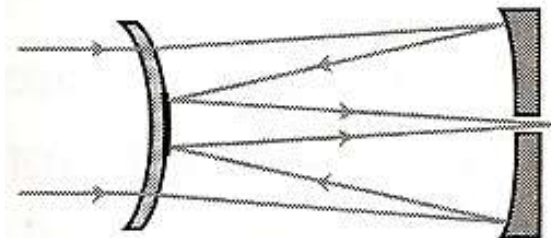
Gregorian



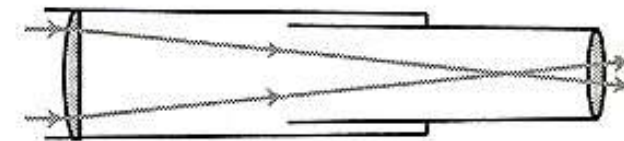
Schmidt-Cassegrain



Schmidt Camera

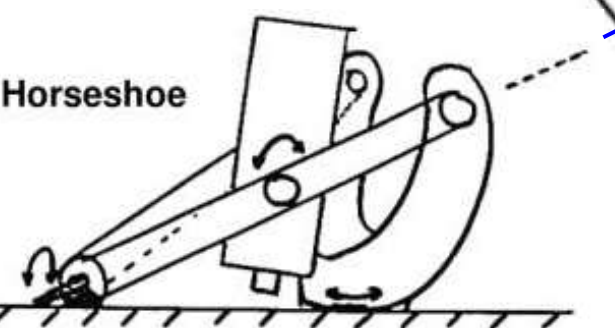
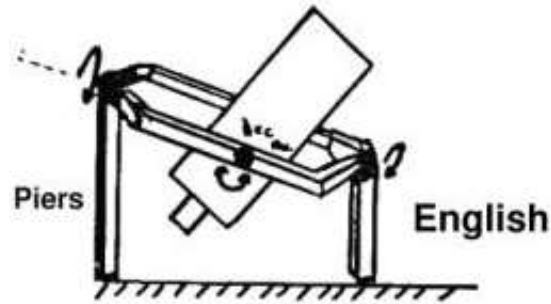
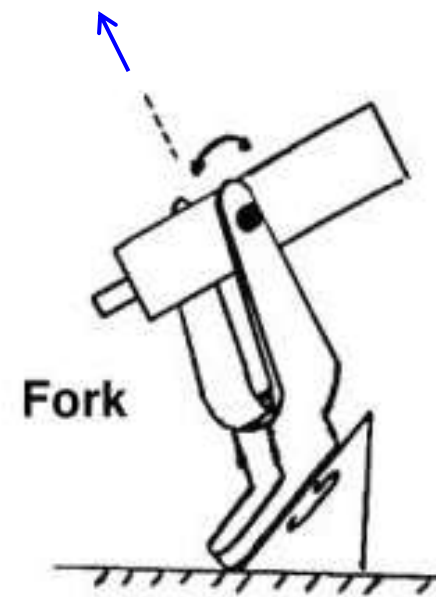
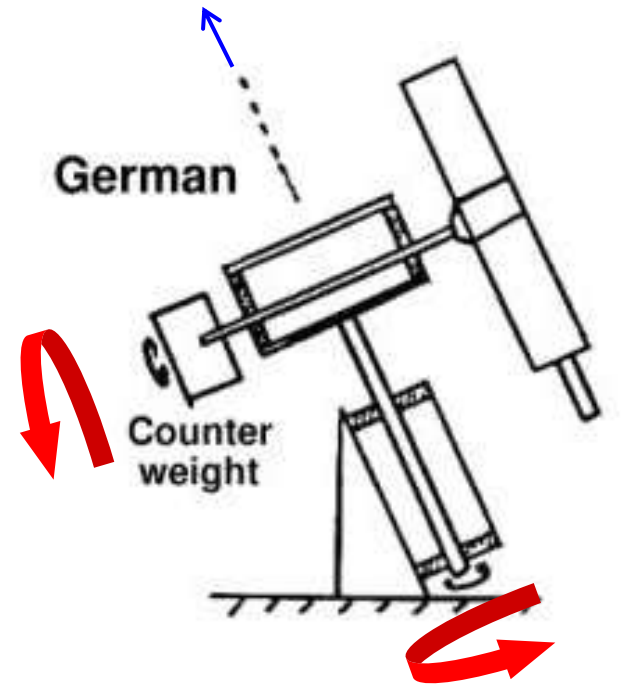
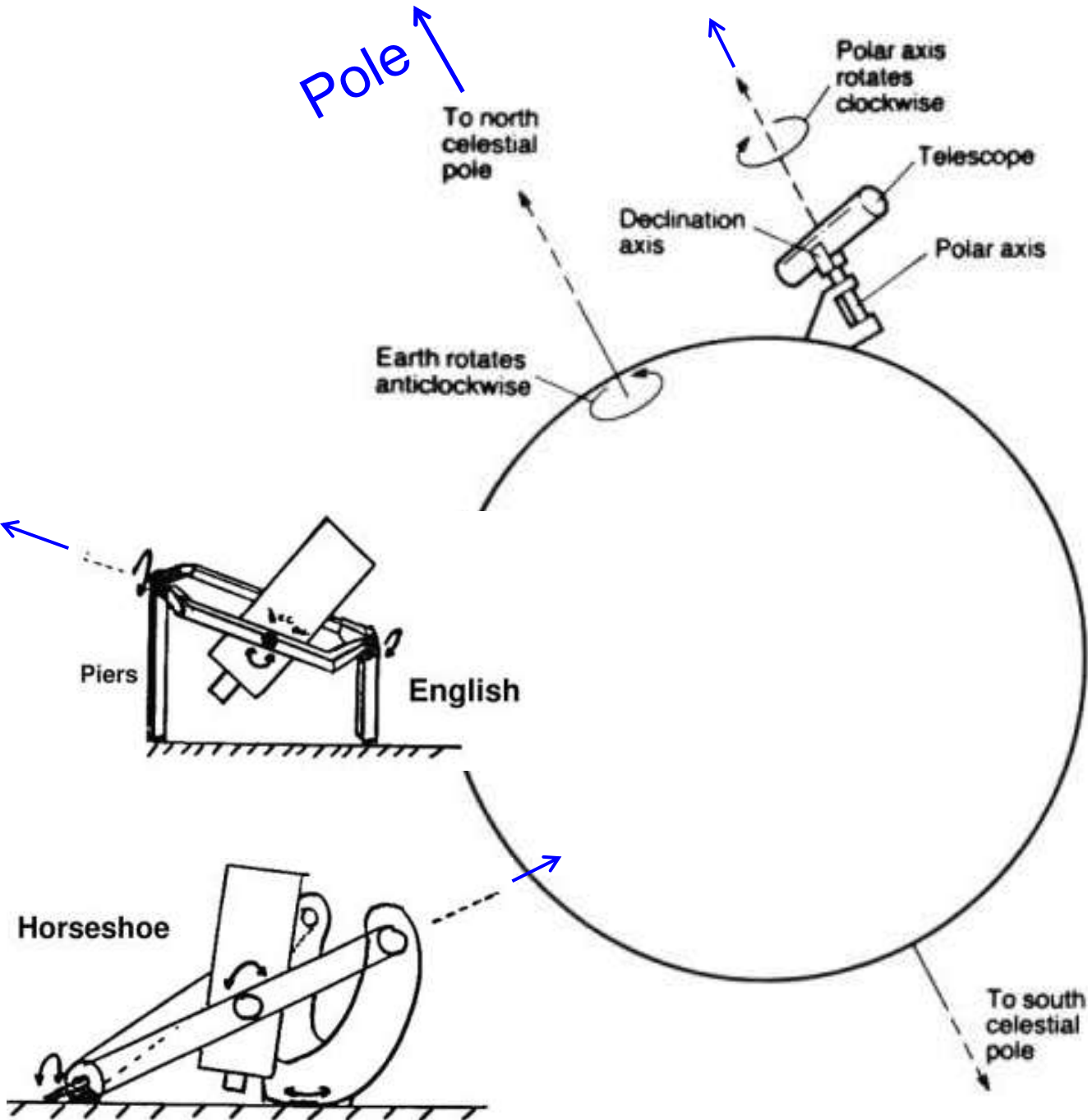


Maksutov



Refractor

Montagens: Equatorial



Montagens: Equatorial / German

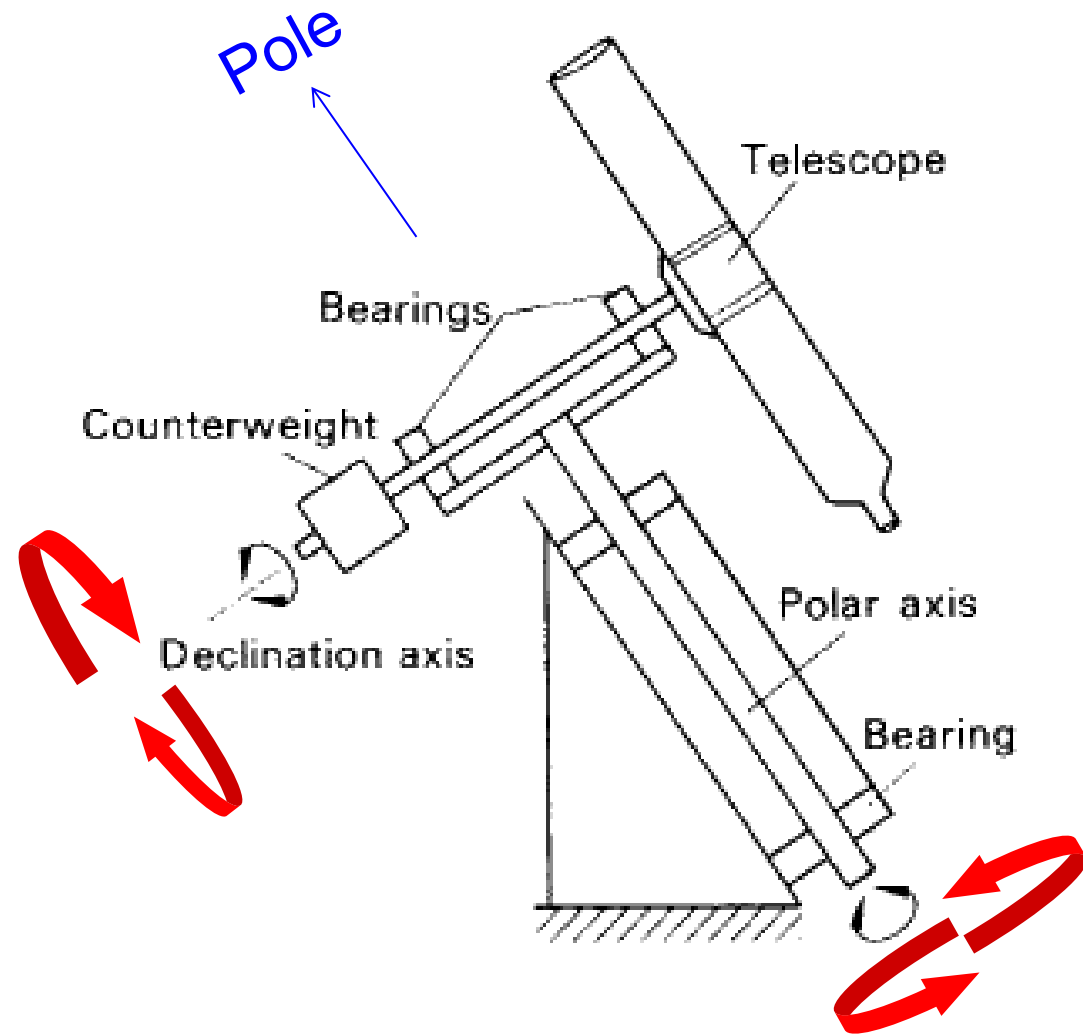
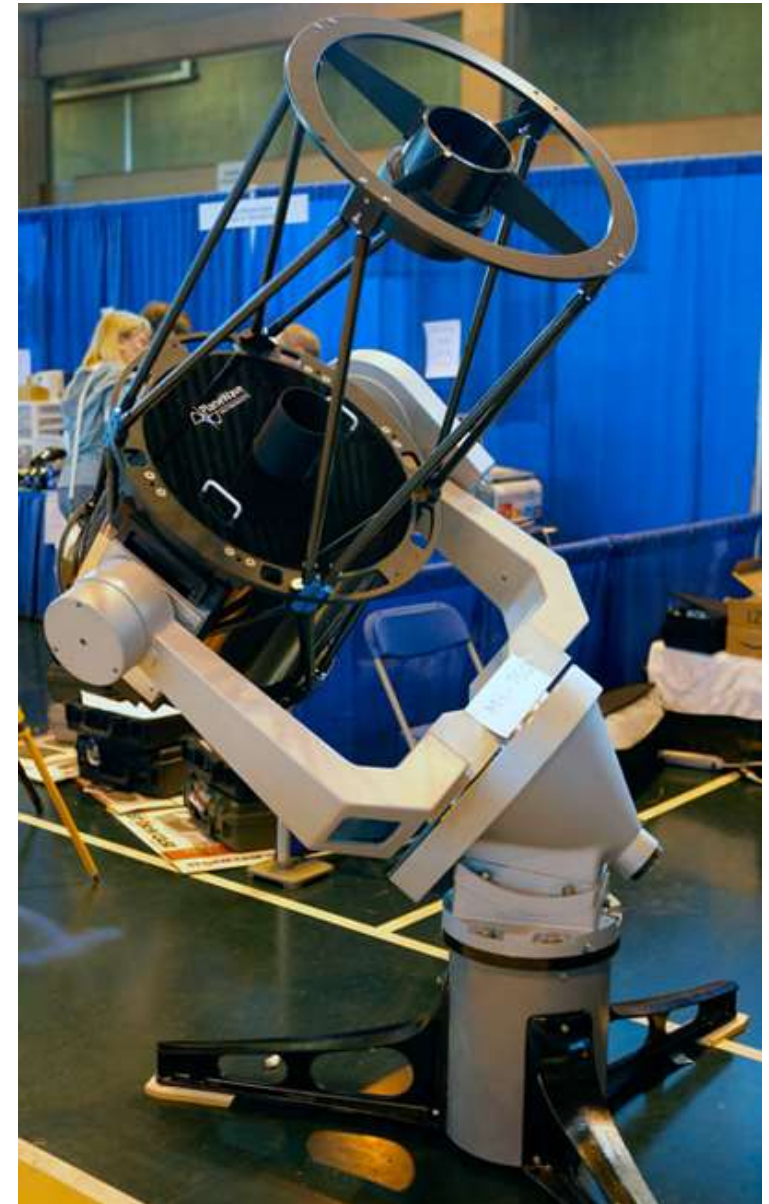
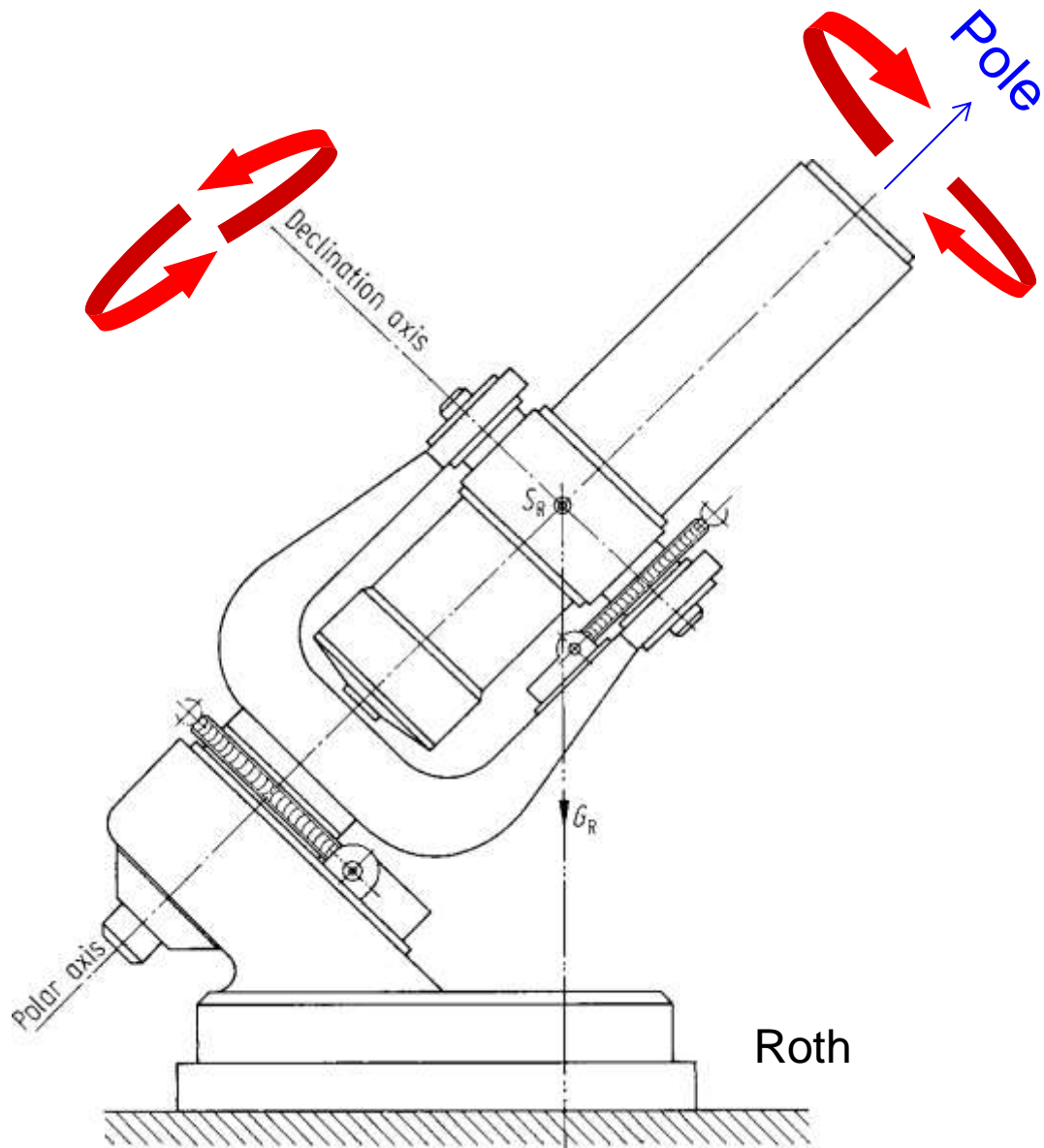


Figure 22.4. The principle of the German mounting.

Roy & Clarke

Montagens: Equatorial / Fork (Garfo)



Fork equatorial



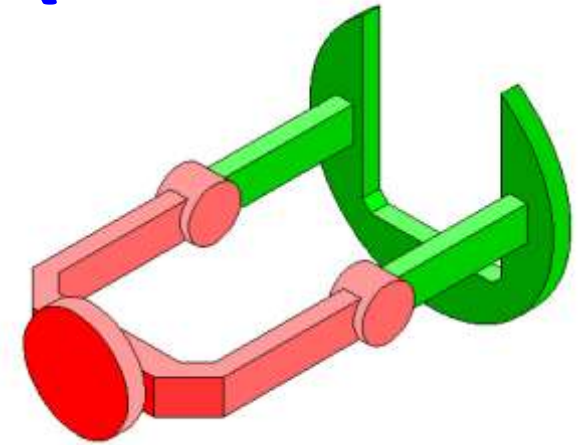
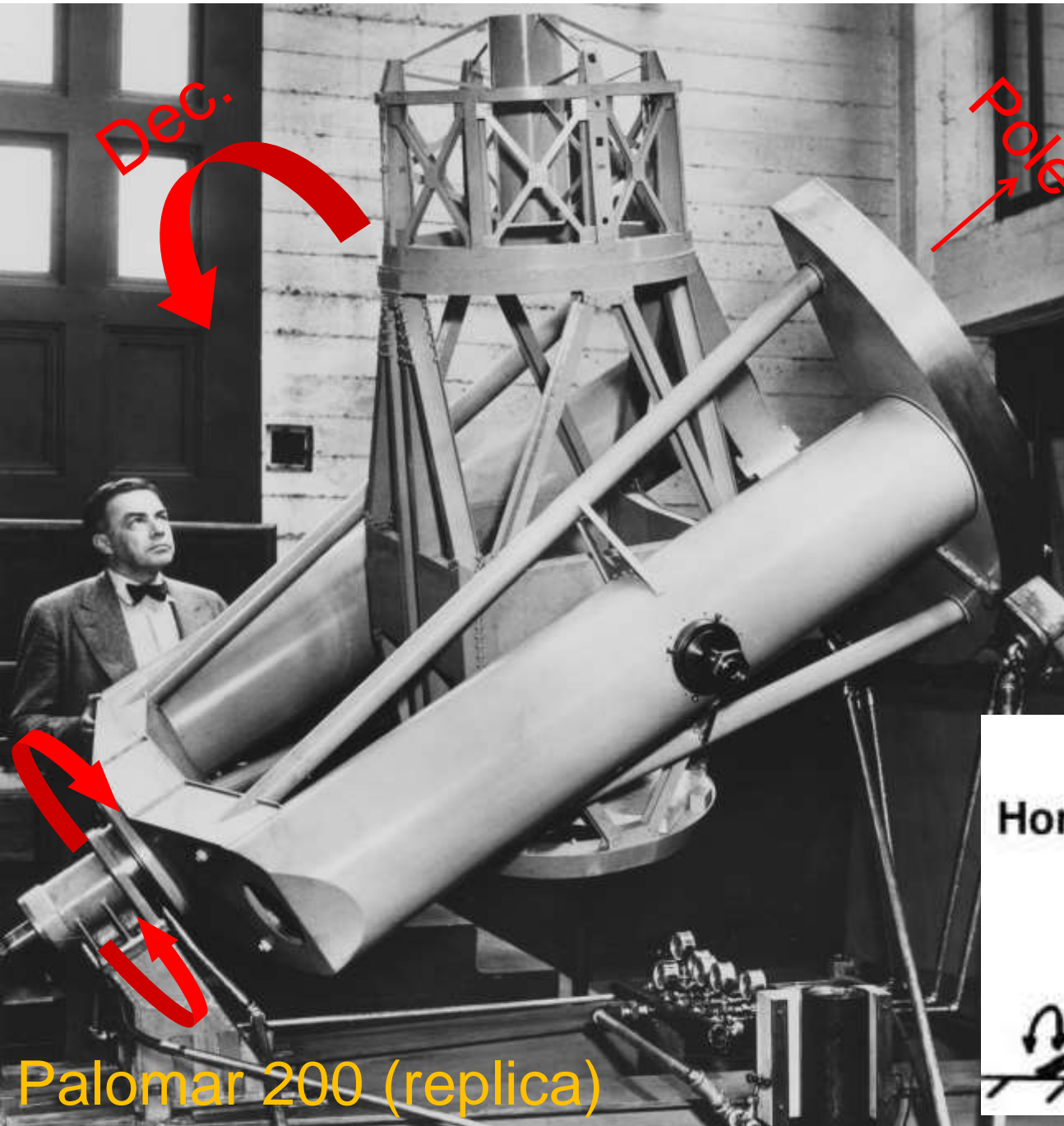
2,2 m telescope at La Silla Fork mount

Turma 2012, Astrofísica Observacional

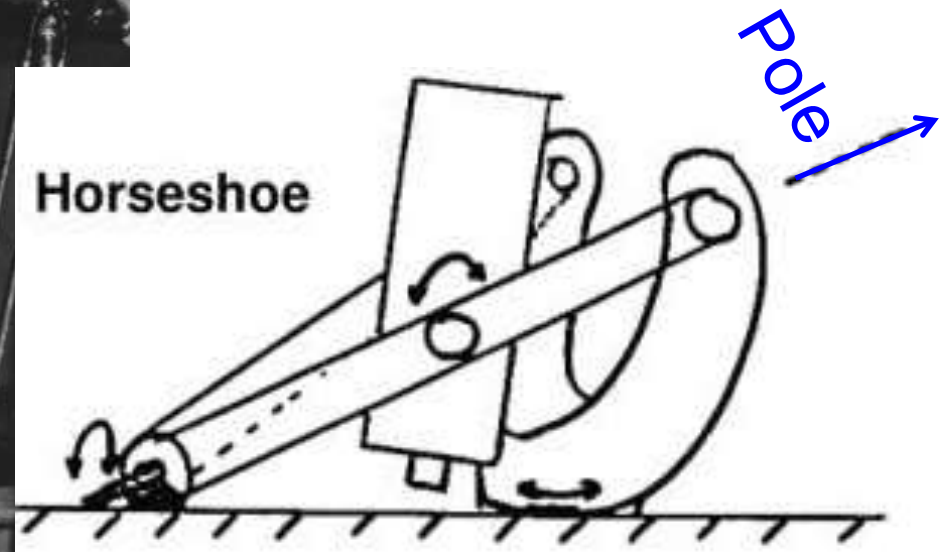
2,2 m telescope at
La Silla
Fork mount



Montagens: Equatorial / *Horseshoe* (Ferradura)

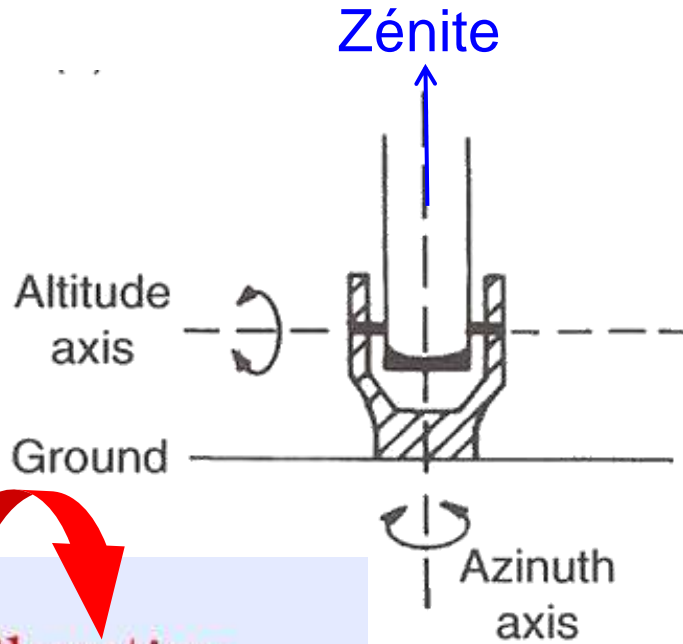


Grandes telescópios ($\leq 5\text{m}$) antigos tem montura *horseshoe*

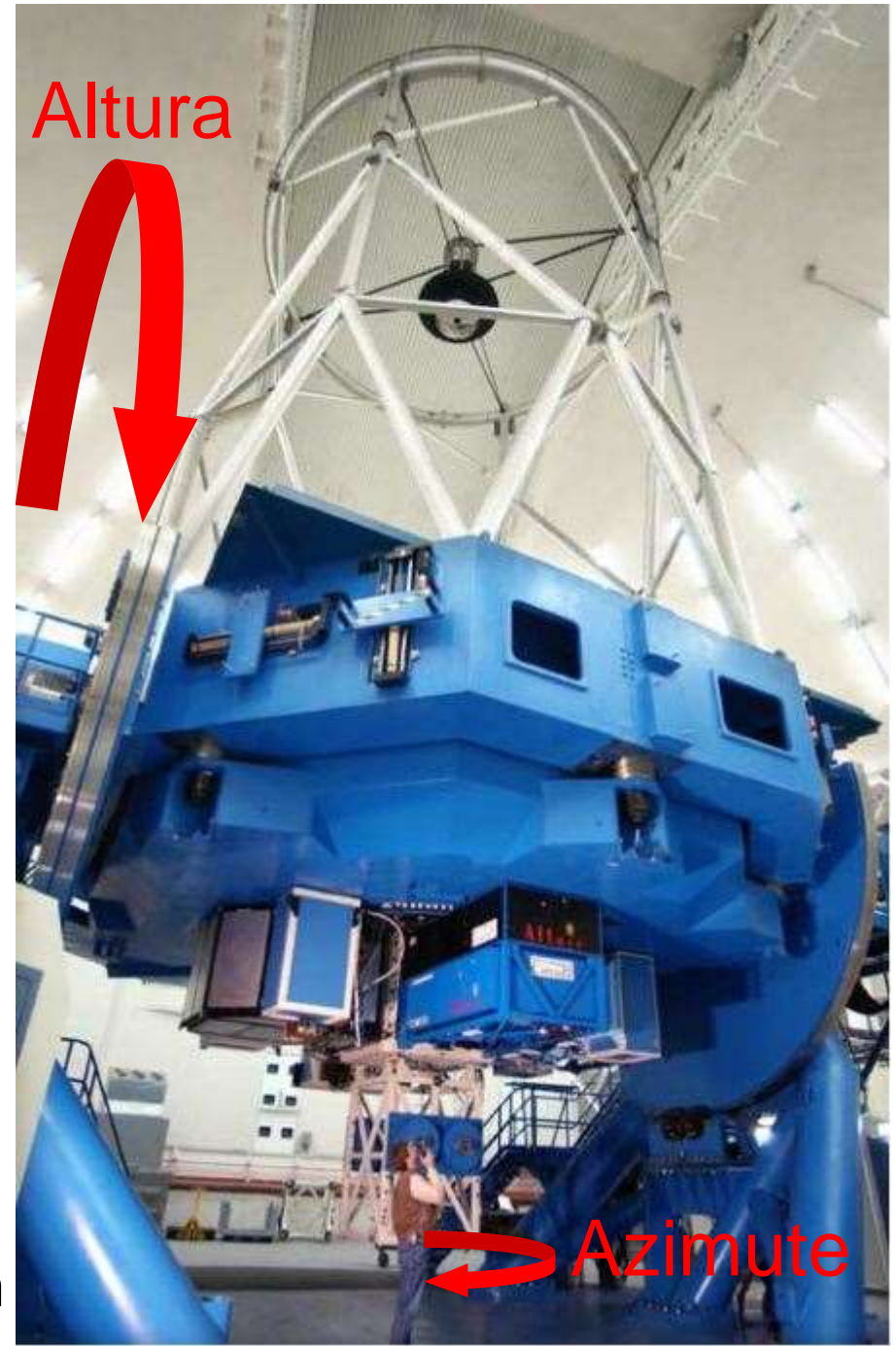


Montagens: Alta-azimutal

↳ comum nos grandes telescópios recentes



Gemini North



•Montagem de trânsito

↳ Círculo meridiano (astrometria)

→ IAG/USP – Valinhos



36

Optical telescopes

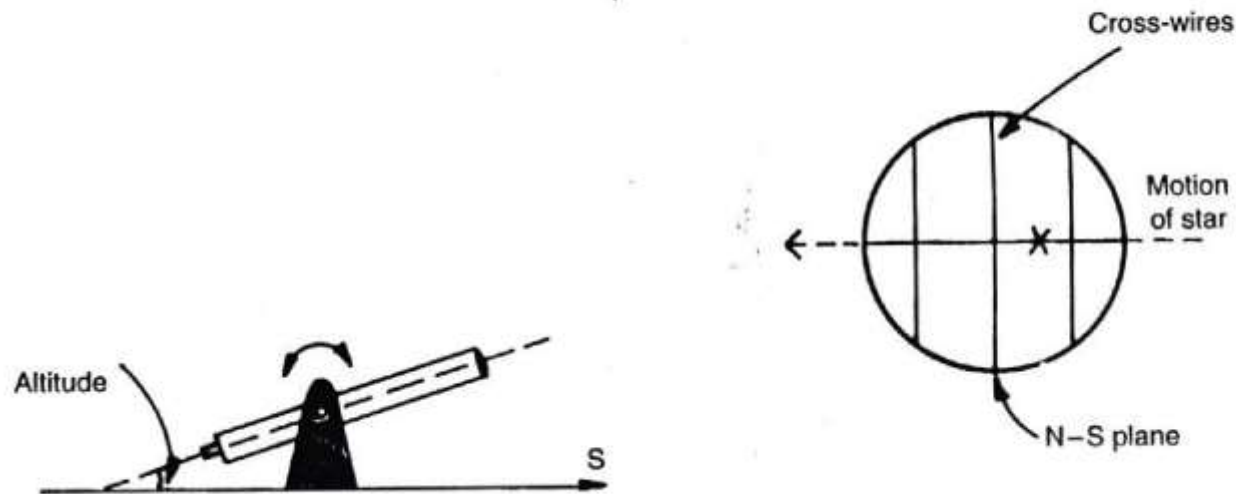


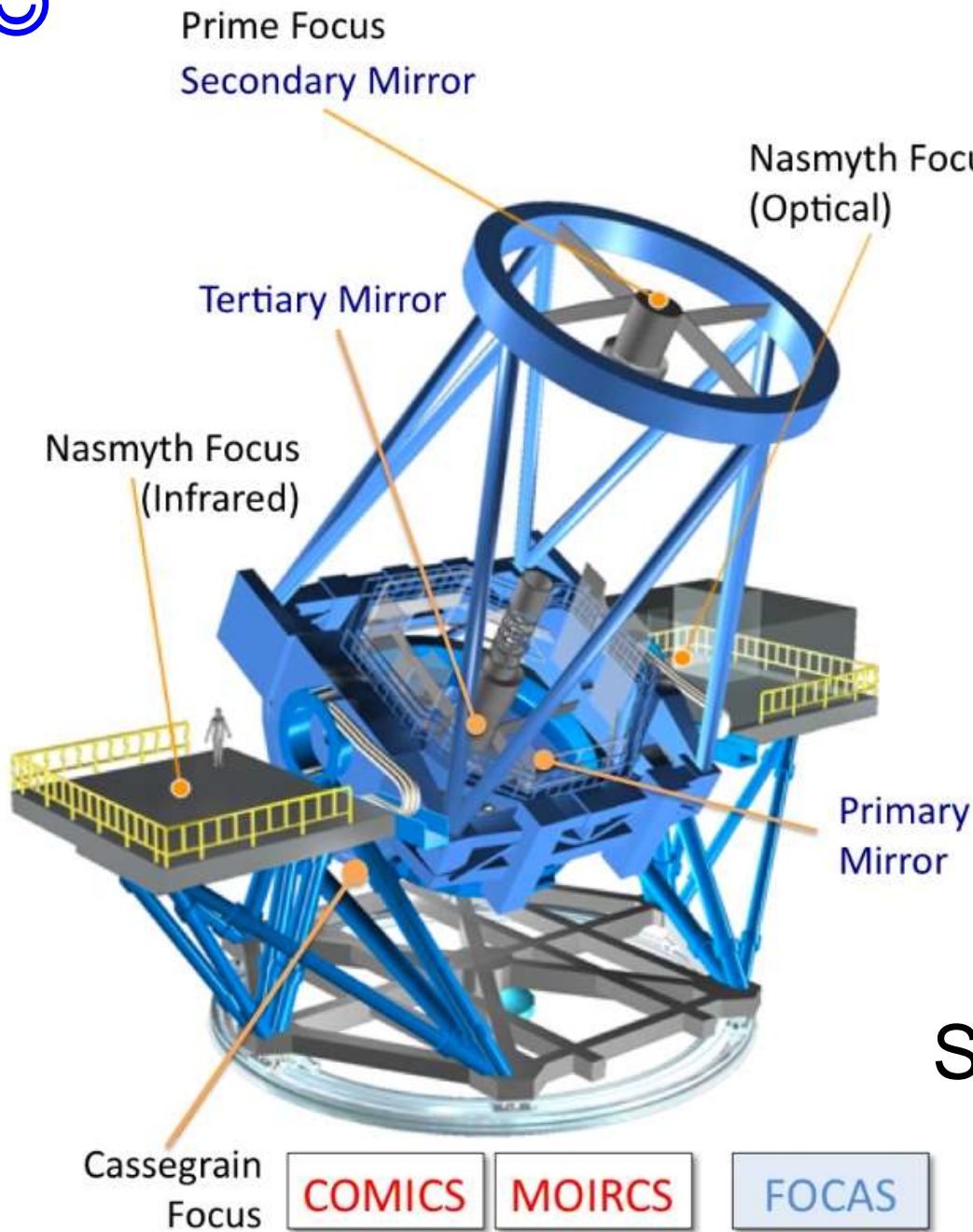
Fig. 2.13. View along the east–west horizontal axis of a transit telescope in the northern hemisphere. The telescope can move only in a vertical plane which is aligned north–south. The inset shows the view through the telescope. The star of interest is placed on the horizontal cross-wire by adjusting the altitude of the telescope and then it is timed as the Earth’s rotation causes it to drift from east to west across the vertical cross-wires. The average of the three timings for the case shown gives the time of transit across the optical axis of the telescope. The apparent motion is from right to left (in the northern hemisphere) because of the inversion of the image in an astronomical telescope (see Fig. 2.2).



Smith

Subaru has Prime + Nasmyth + Cassegrain focus

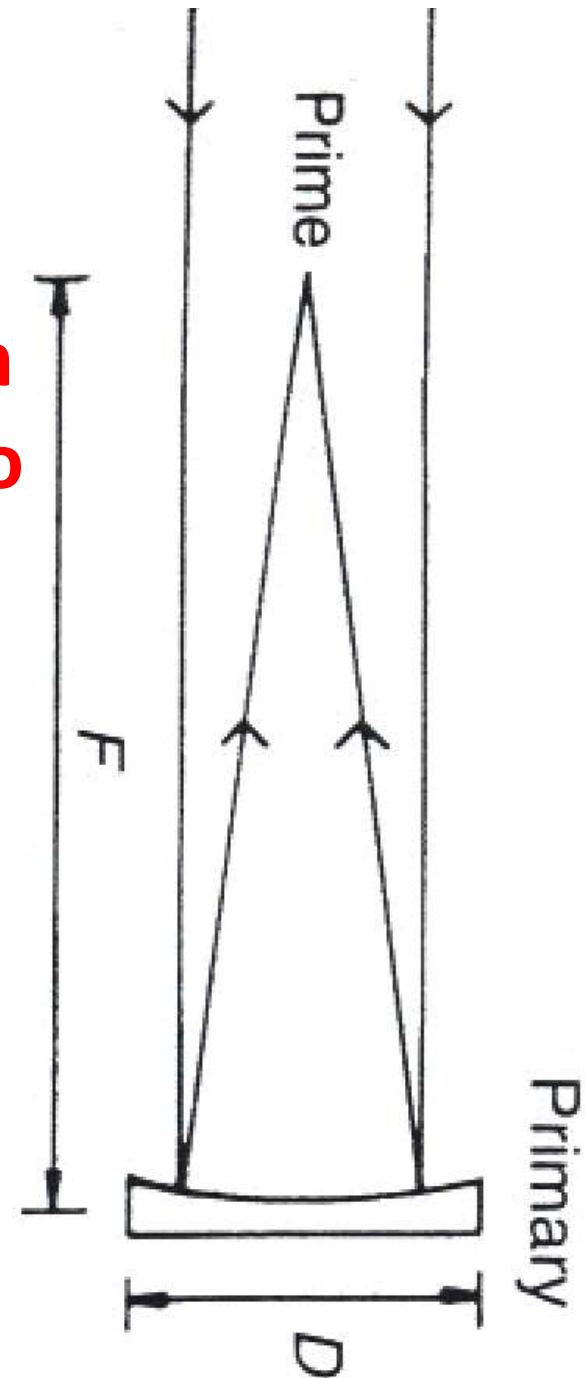
Smith



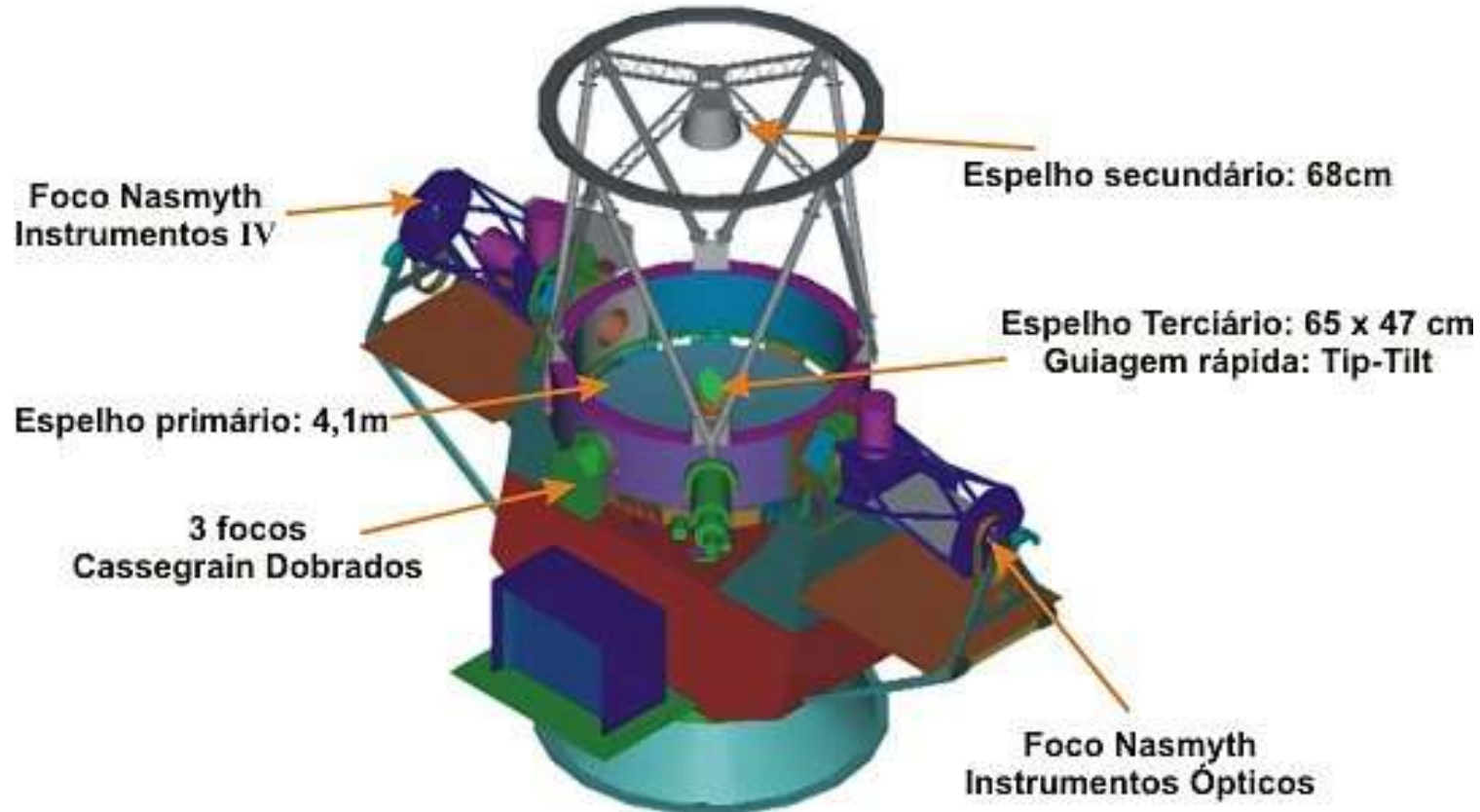
Gemini tem apenas foco Cassegrain



Subaru



SOAR: focos Nasmyth, mas não tem Cassegrain “puro”.
São usados focos Cassegrains “dobrados” por um espelho plano
(não pode fazer polarimetria devido ao espelho terciário)



O apontamento e a guiagem não são perfeitos em nenhuma montagem

⇒ flexão mecânica da estrutura

⇒ erros nas engrenagens

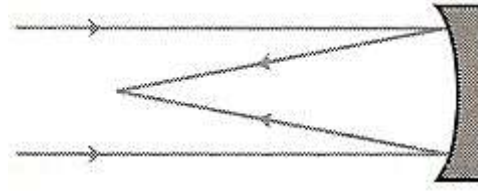
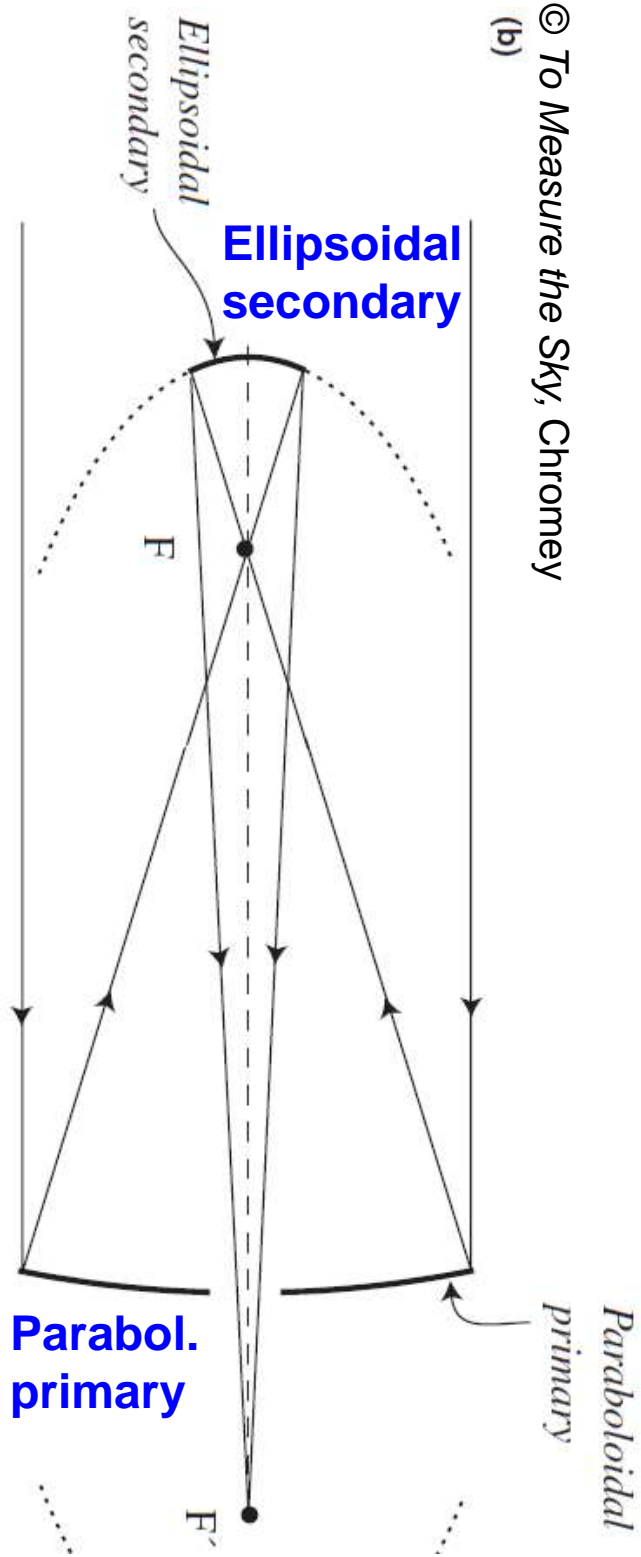
⇒ refração atmosférica

⇒ correção da guiagem é feita por *guiders* e *auto-guiders*

→ indispensável para integrações longas

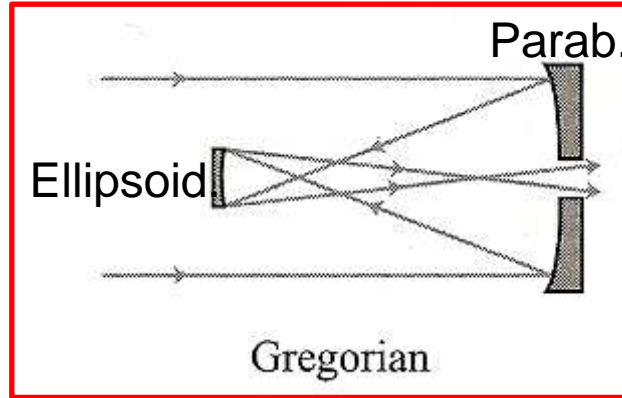
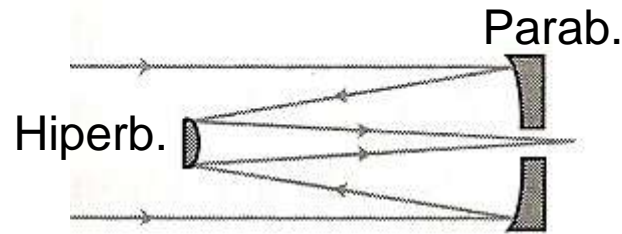
Outros focos: Gregorian

© To Measure the Sky, Chromey
(b)



Prime focus

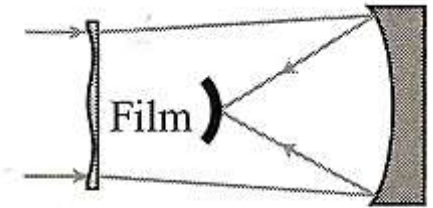
Newtonian



Cassegrain

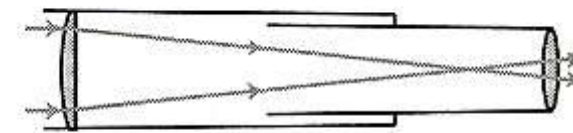
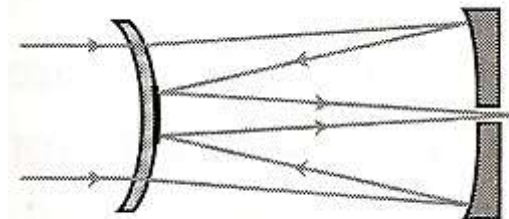
Gregorian

RC: primary and secondary hyperbolic



Schmidt-Cassegrain

Schmidt Camera

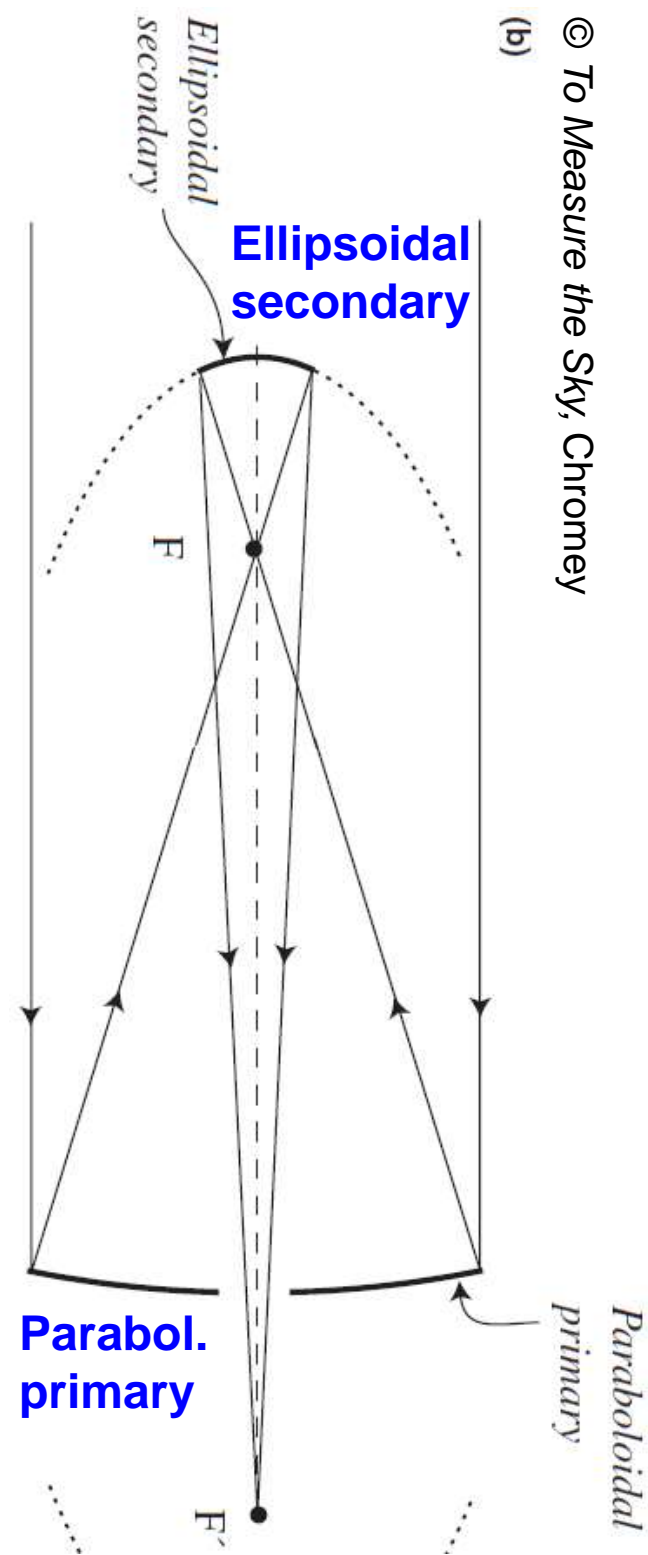


Maksutov

Refractor

Outros focos: Gregorian

Magellan 6.5m telescopes



Schmidt Camera (catadioptric telescope)



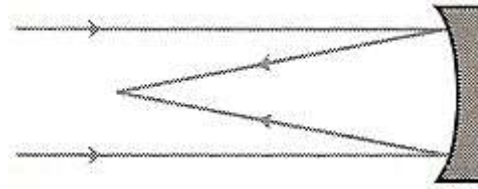
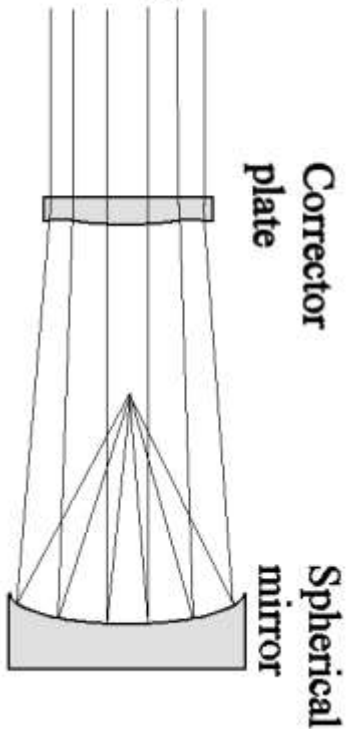
Proposed by Bernhard Schmidt
(1879 – 1935) in 1929

telescópio híbrido:
lens+mirror

- espelho primário esférico (sem coma do parabólico)

- lente antes do primário corrige aberração esférica

- única aberração: curvatura de campo



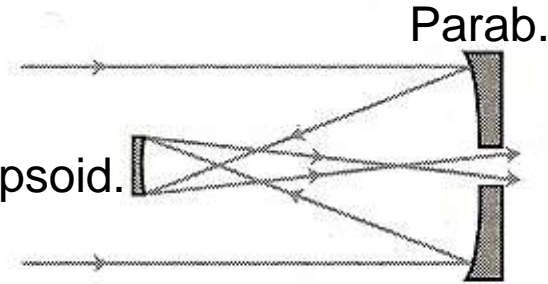
Prime focus



Newtonian



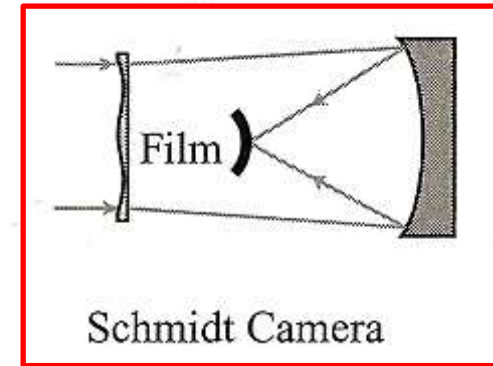
Cassegrain



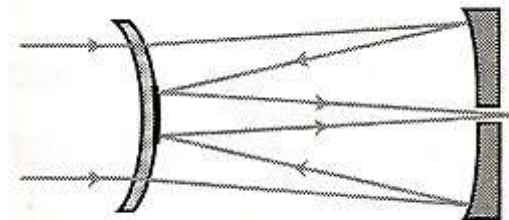
Gregorian



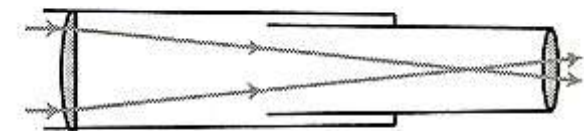
Schmidt-Cassegrain



Schmidt Camera



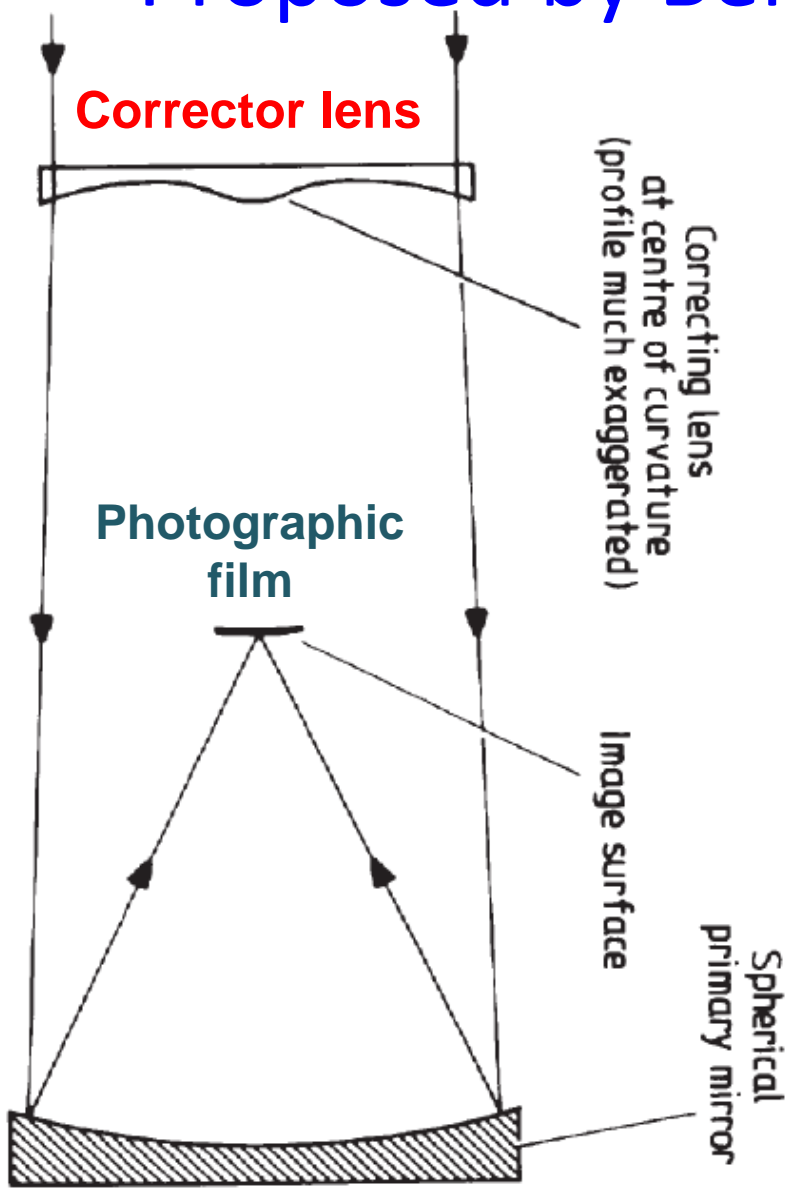
Maksutov



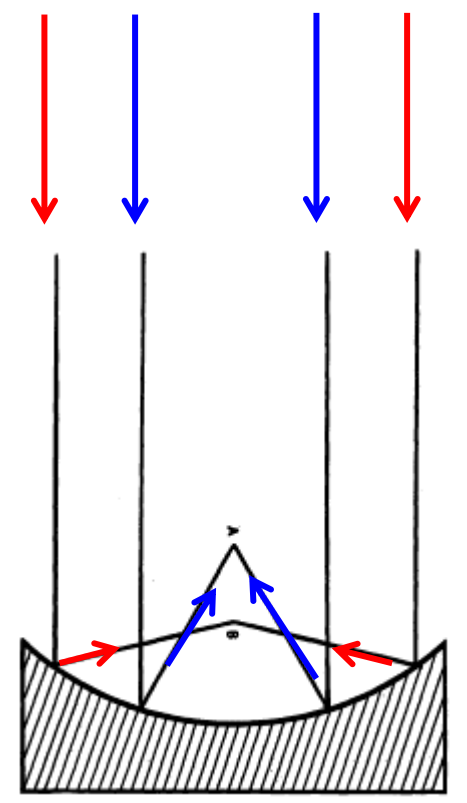
Refractor

Schmidt Camera (catadioptric telescope)

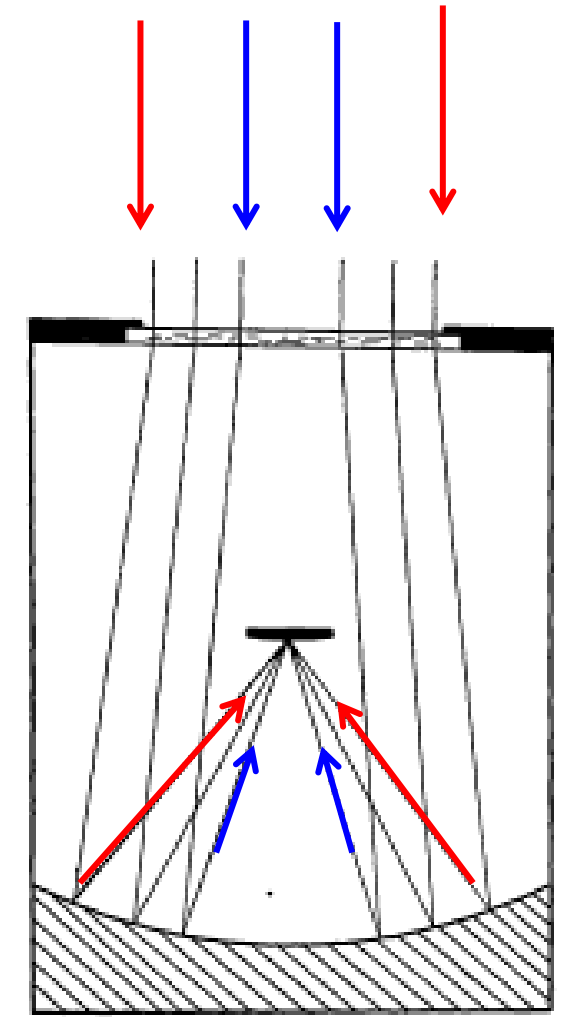
Proposed by Bernhard Schmidt in 1929



Spherical primary



Spherical primary (spherical aberration)

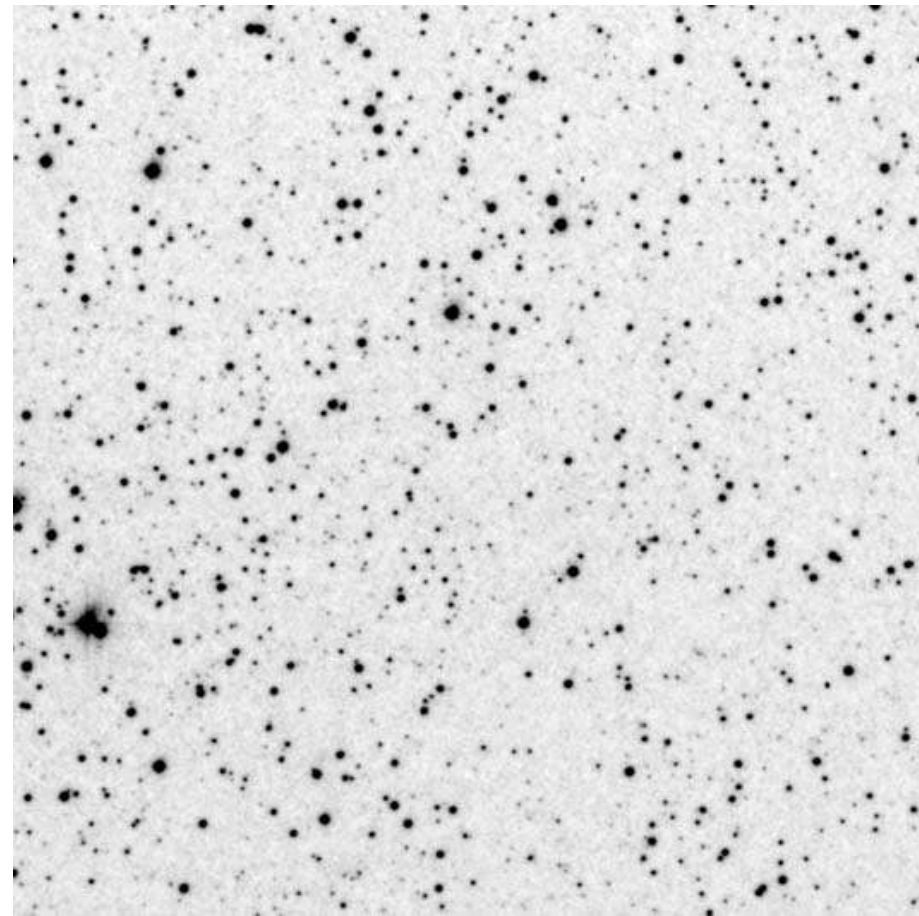


Spherical primary + lens eliminates aberration

Figures from Smiley et al. 1936, PA 44, 415



*The 48 inch (1,22m) Oschin **Schmidt Telescope** at the [Palomar Observatory](#)*



Palomar Observatory Sky Survey - POSS

The Survey utilized 14-inch square photographic plates, covering about 6° of sky per side (approximately 36 square degrees per plate). November 11, 1949 to December 10, 1958.

**Going
Going**

**Wider,
Deeper**

Moon:



**Fields of
view of:**

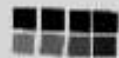
P200:



Keck:



HST:



A single POSS-II plate (DPOSS scan)

The STScI Digitized Sky Survey

http://stdatu.stsci.edu/cgi-bin/dss_form



Object name GET COORDINATES Clear

Get coordinates from [SIMBAD](#) [NED](#)

[Retrieve an Image](#)

Target: M31 Resolved by: SIMBAD

[Retrieve from](#)

- POSS2/UKSTU Red
- POSS2/UKSTU Blue
- POSS2/UKSTU IR
- POSS1 Red
- POSS1 Blue
- Quick-V
- HST Phase 2 (GSC2)

[\(detailed information about the Surveys\)](#)

[RA](#) [Dec](#) J2000 ▾

[Height](#) (max: 60.0) [Width](#) (max: 60.0) arcminutes

[File format](#) [Compression \(FITS only\)](#)

Save file to disk (instead of displaying)

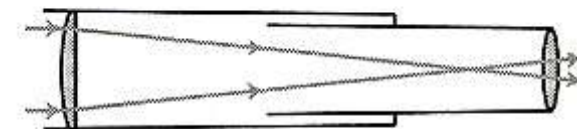
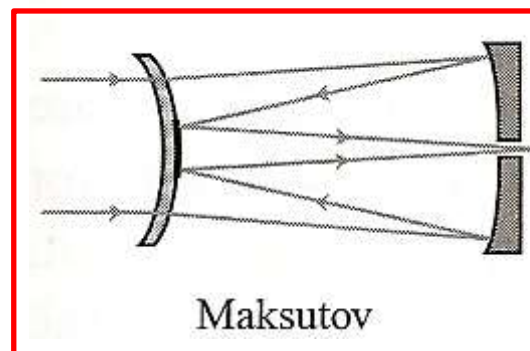
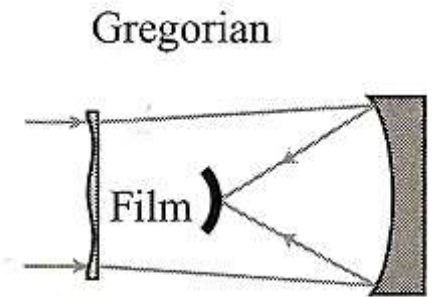
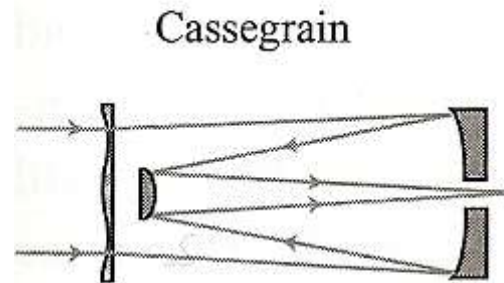
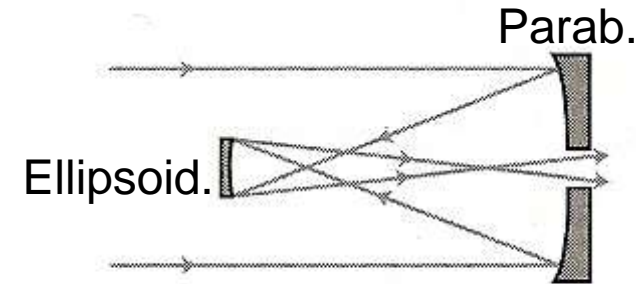
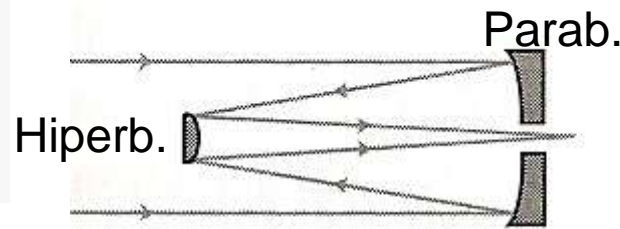
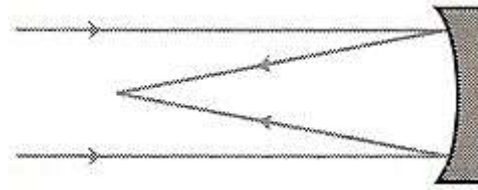
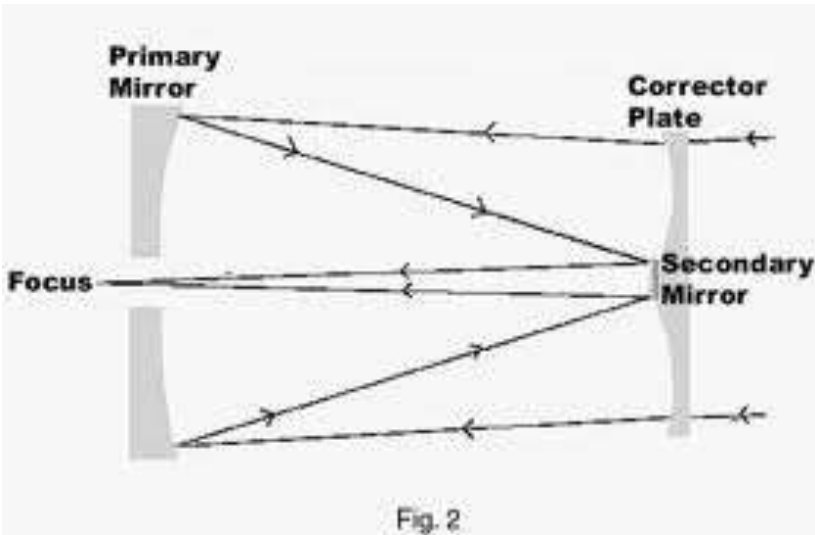
[HST Field of View Overlay \(1st generation GIF only\):](#)

[Roll angle \(V3\):](#)

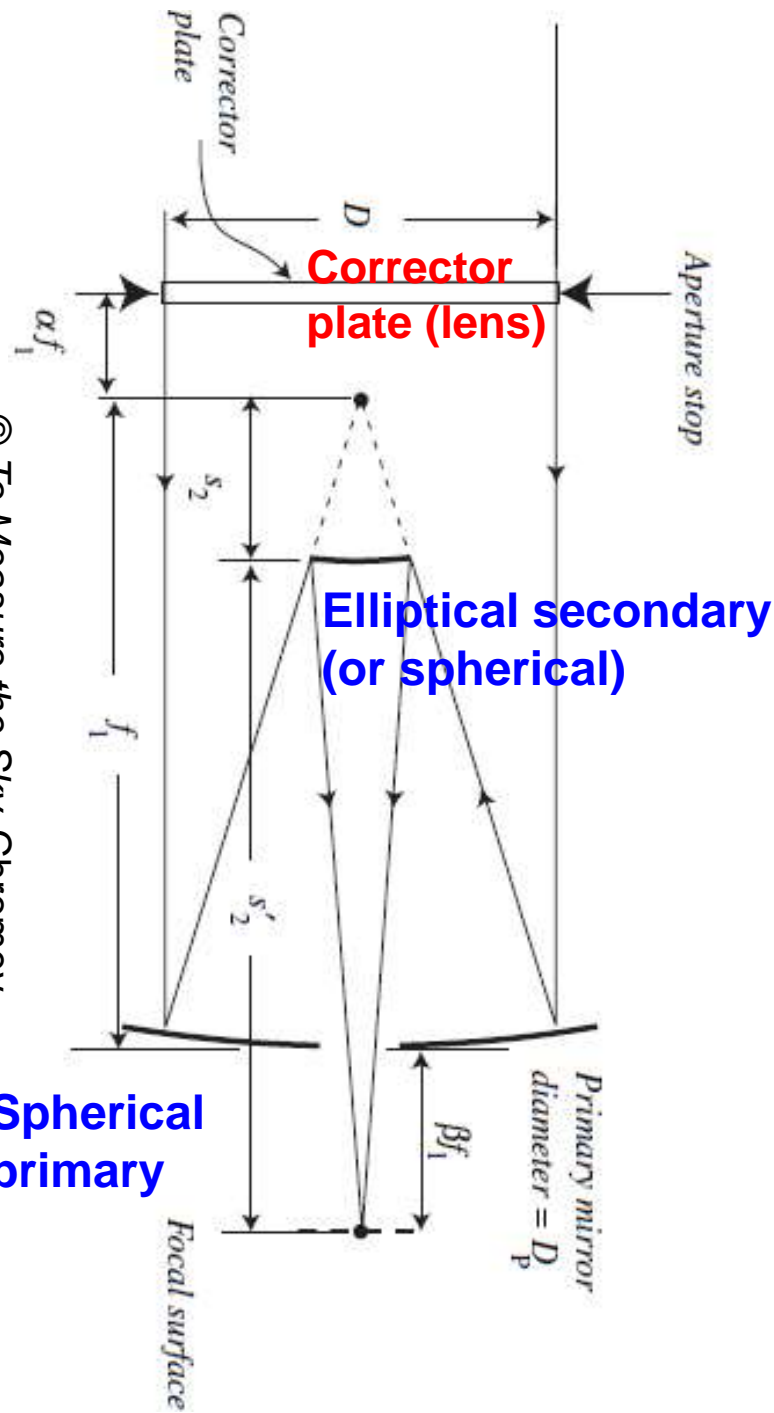
M31 from the
Digitized Sky Survey,
60 x 60 arcmin



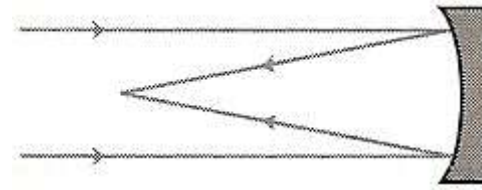
Maksutov (catadioptric telescope)



Schmidt-Cassegrain (catadioptric telescope)



© To Measure the Sky, Chromey



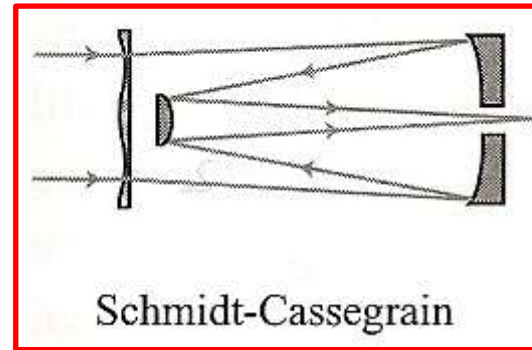
Prime focus



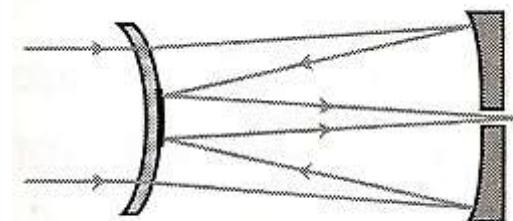
Newtonian



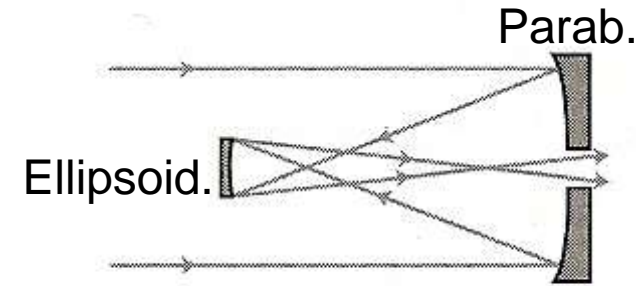
Cassegrain



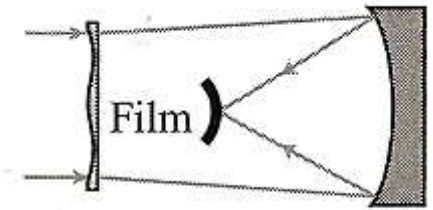
Schmidt-Cassegrain



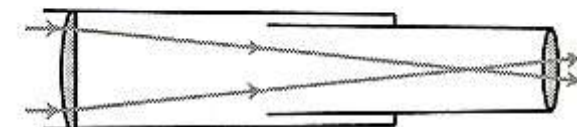
Maksutov



Gregorian

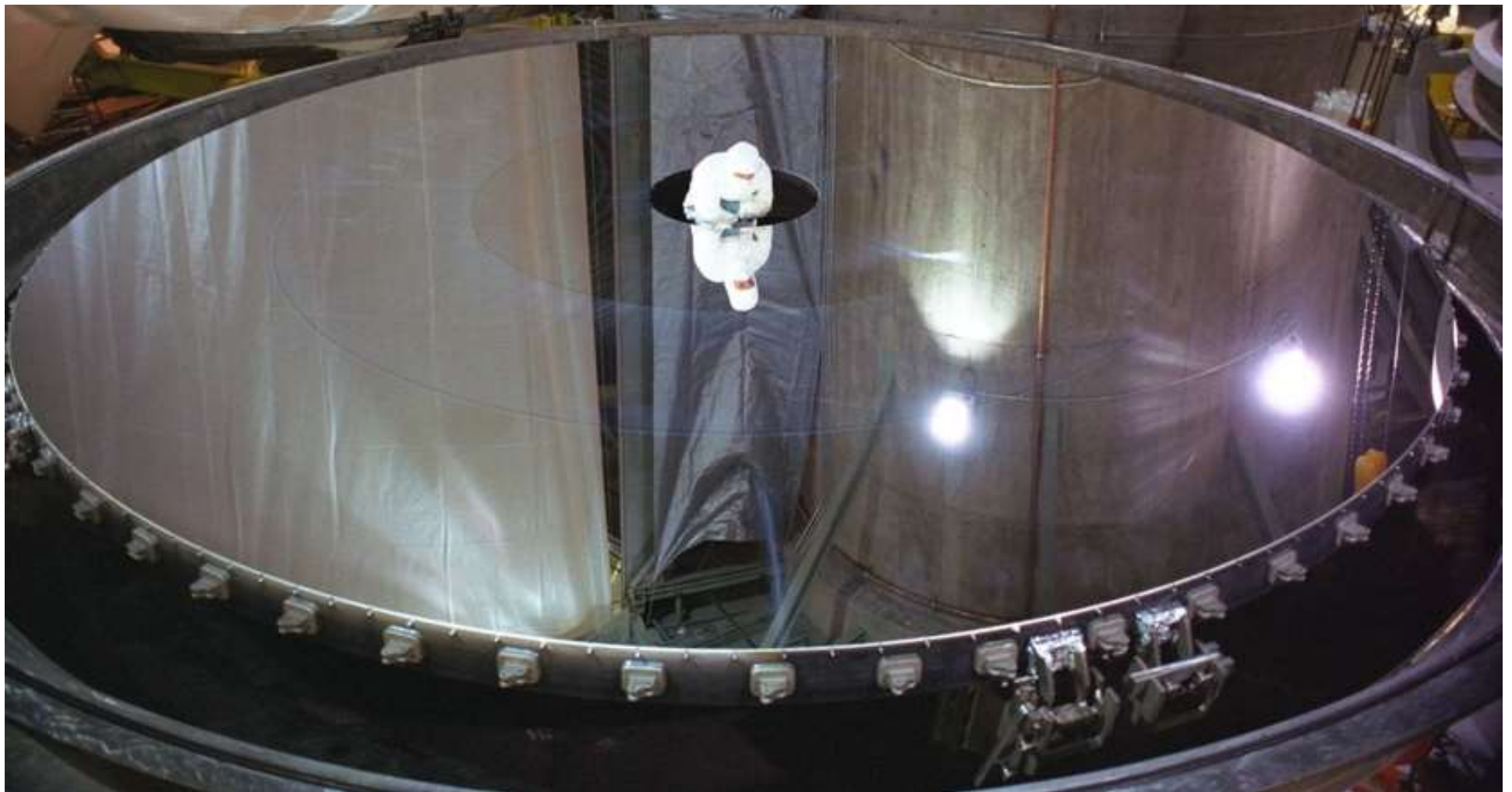


Schmidt Camera



Refractor

Refletores : revestimento dos espelhos (*mirror coating*)



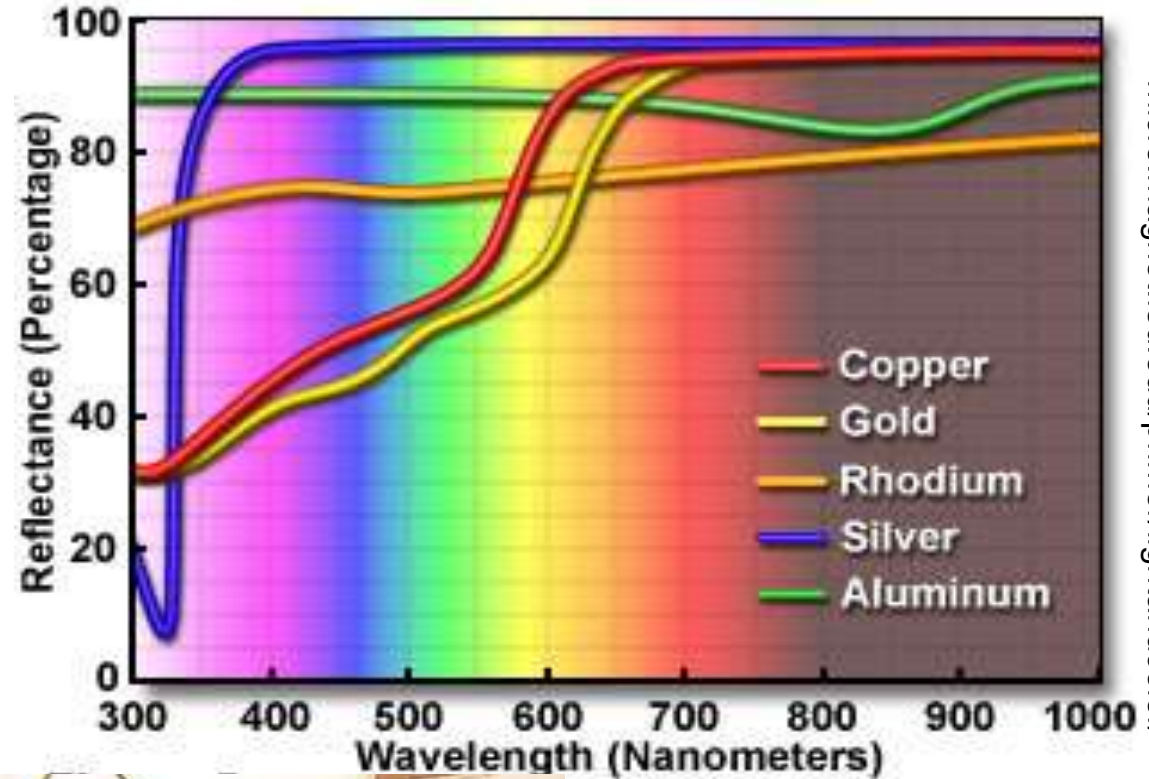
Refletores: revestimento do espelho

- Revestimento (coating)
Ótico-UV (alumínio) , IR: prata



Aluminizado tel. 0.6m da Serra da Piedade no LNA

Reflectance of Metallic Mirror Coatings



micro.magnet.fsu.edu/primer/lightandcolor/



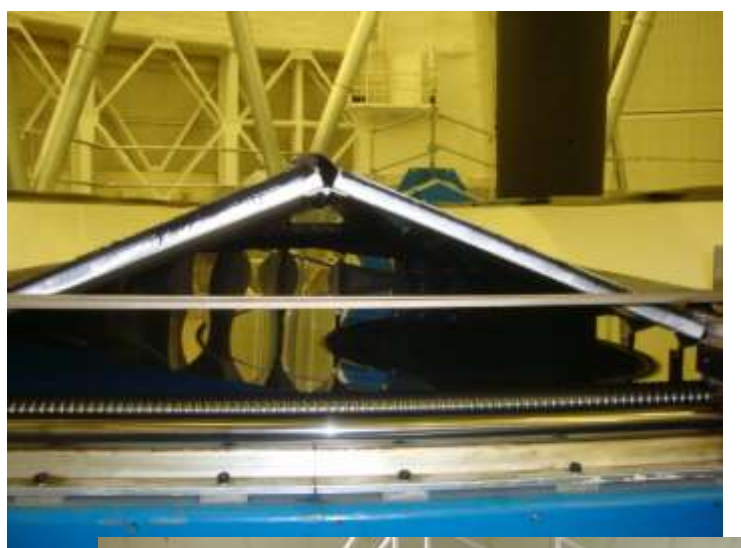
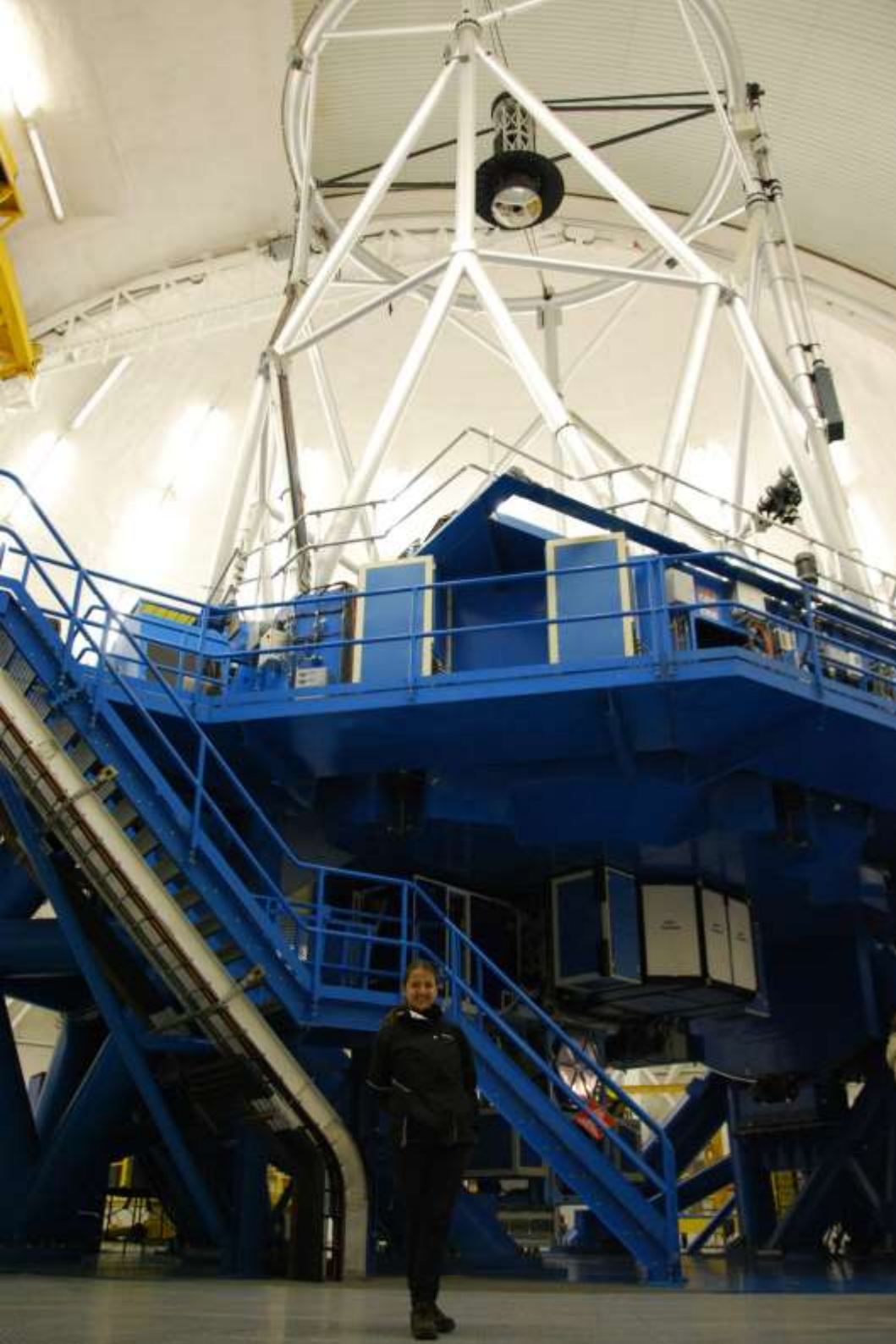
➤ Até há pouco a prata não era muito usada em grandes telescópios pois o revestimento desgasta-se rapidamente (meses). Desde 2004 o Gemini utiliza prata protegida

Aluminizado do espelho primário do telescópio P200 (5m)

<http://www.youtube.com/watch?v=gxp6aMhoT9U>

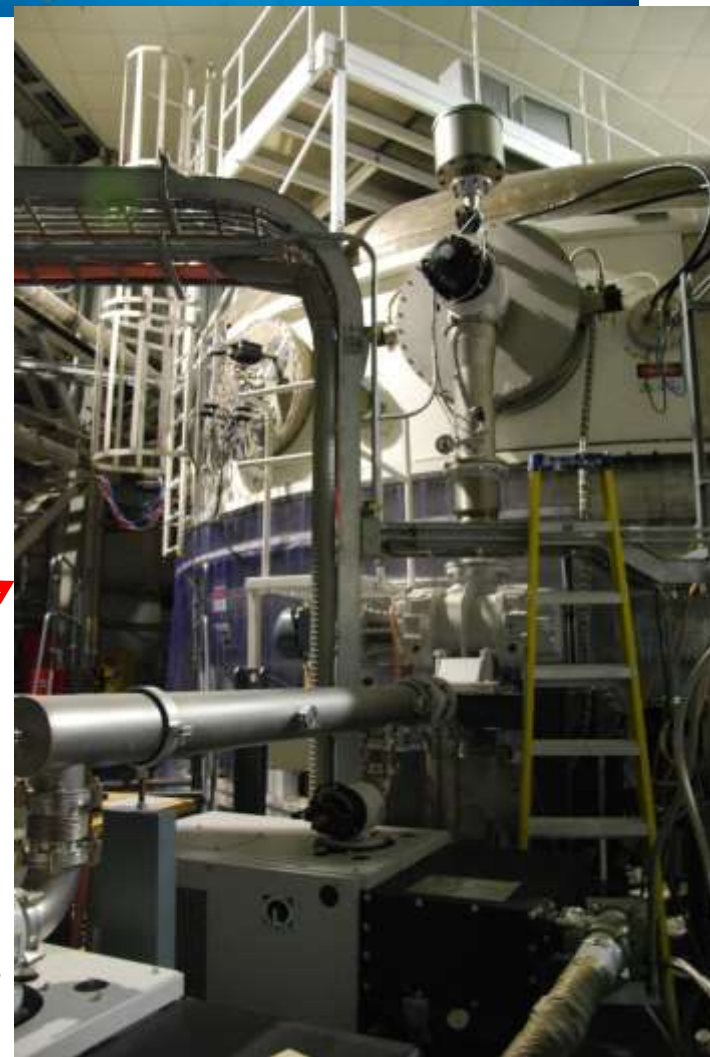


**Gemini South : First large telescope
with protected silver coating**



**Gemini S.
primary**

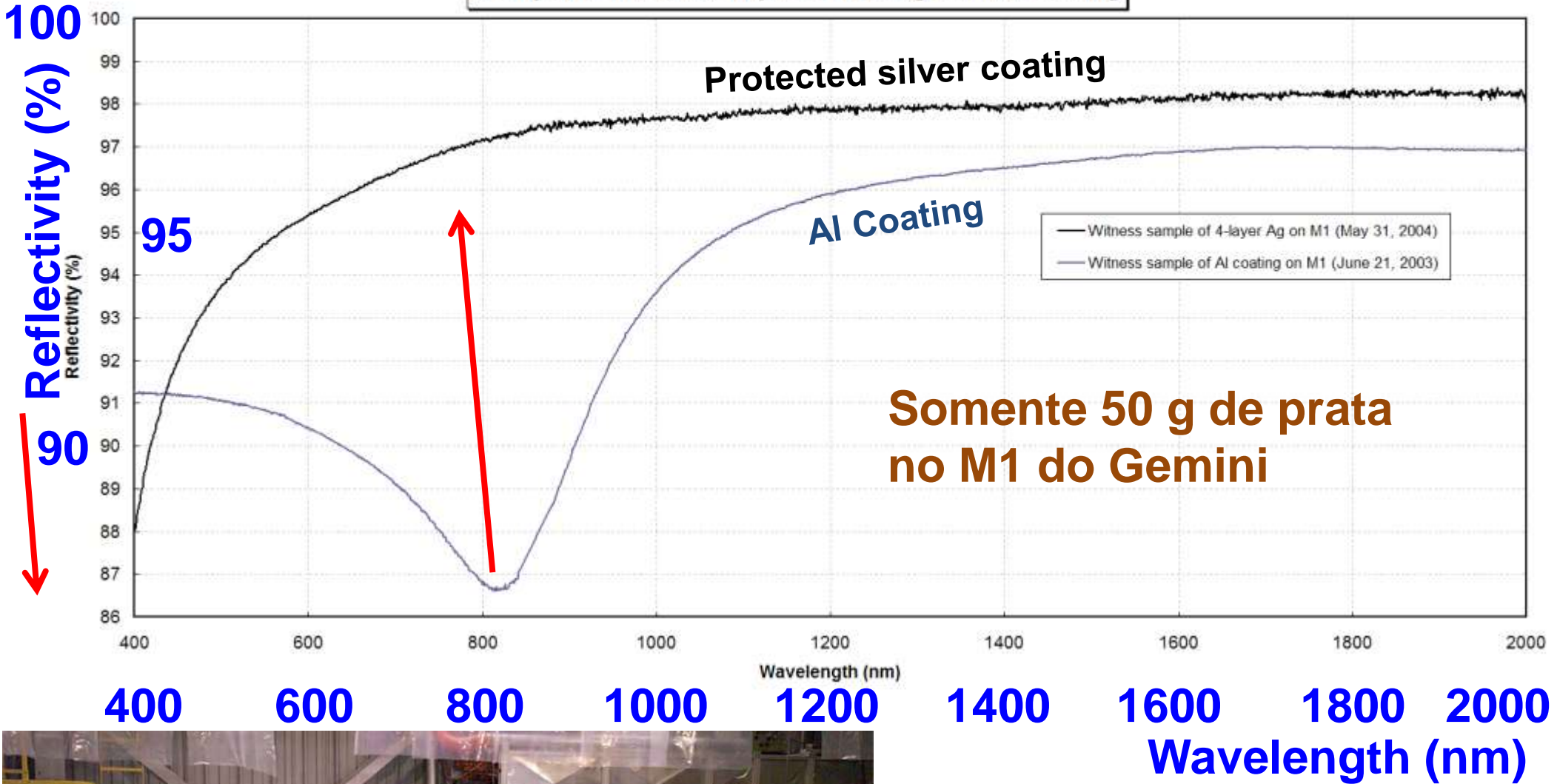
Instruments



**Coating
chamber**

**Ana (AGA5802
student) in front of
Gemini South**

Comparison between protected-Ag and Al coating

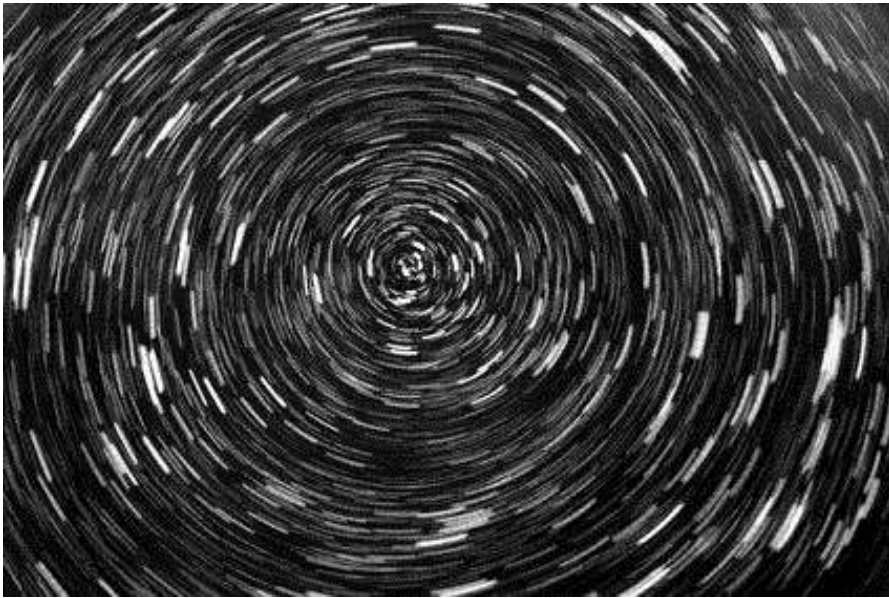


Somente 50 g de prata no M1 do Gemini



Ag: better reflectivity and less emissivity in the IR

Field rotation in AltAzimutal telescopes



Left to right: Jorge + AGA5802 students
(Patricia, Fernando, Ana, Nathalia,
Viviane, Miguel, Marcelo, Andressa) @
NTT 3,6m telescope (La Silla, ESO),
April 2012

One of the NTT field de-rotators at a Nasmyth focus

© Jorge M., La Silla, April 2012

