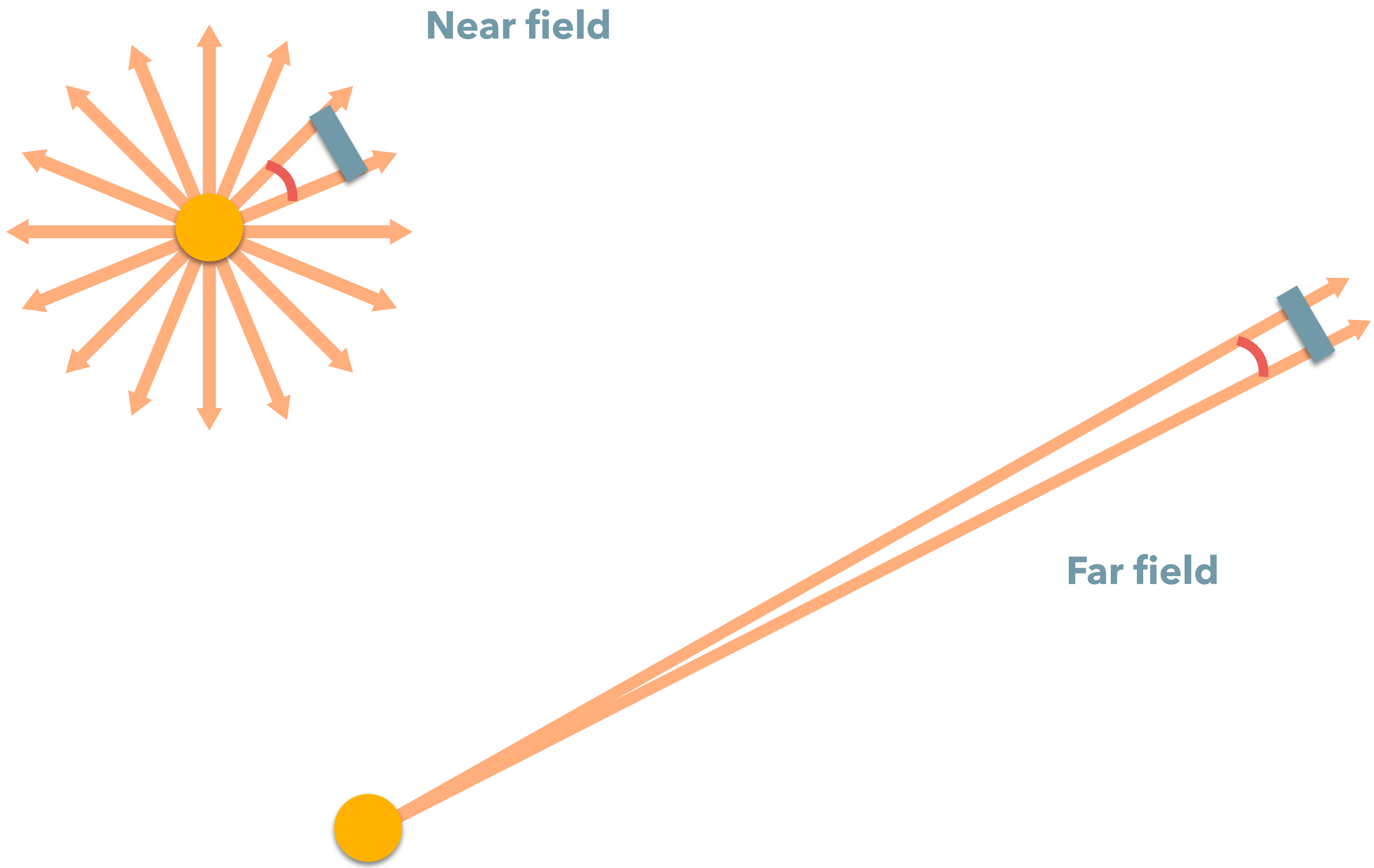
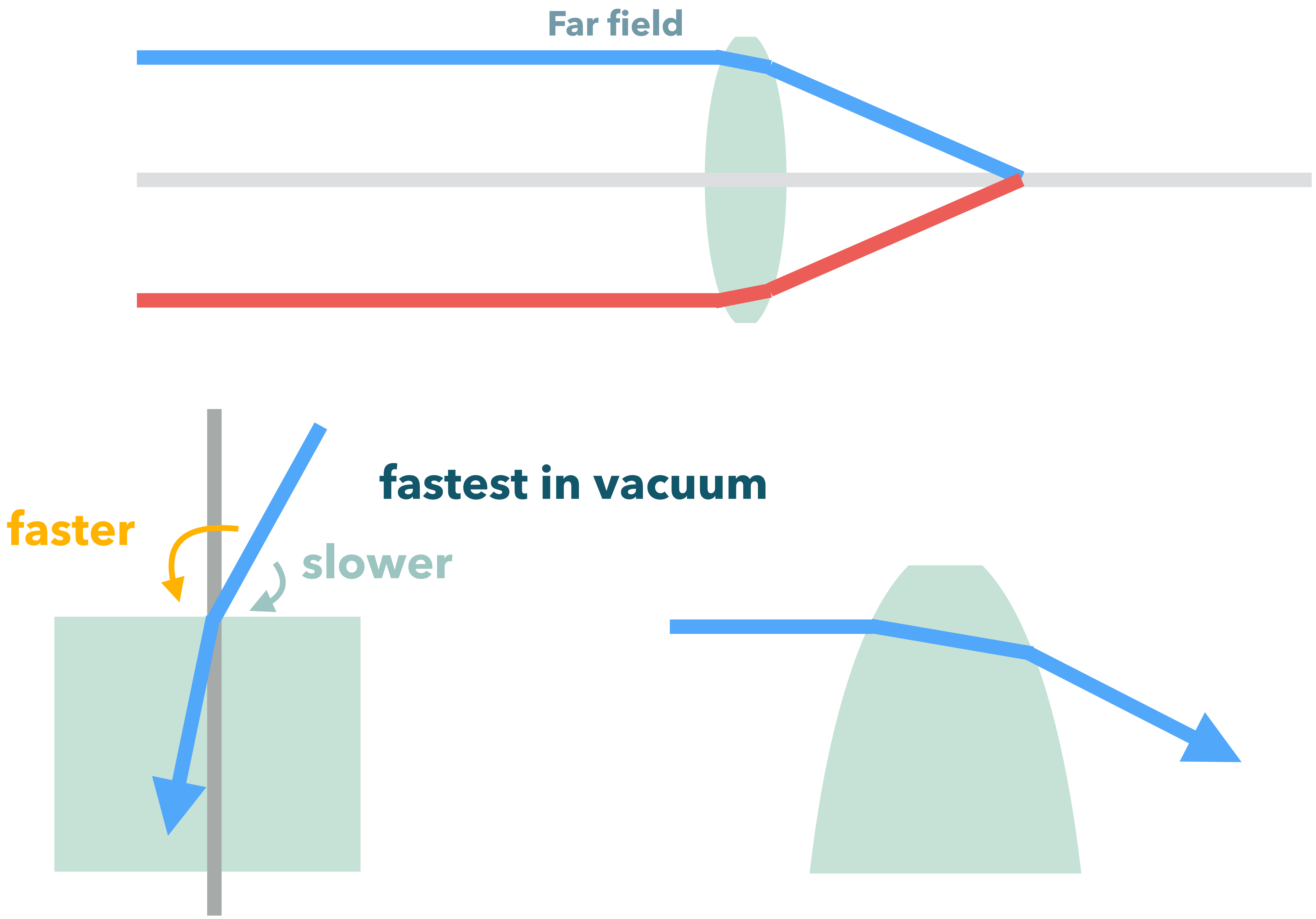
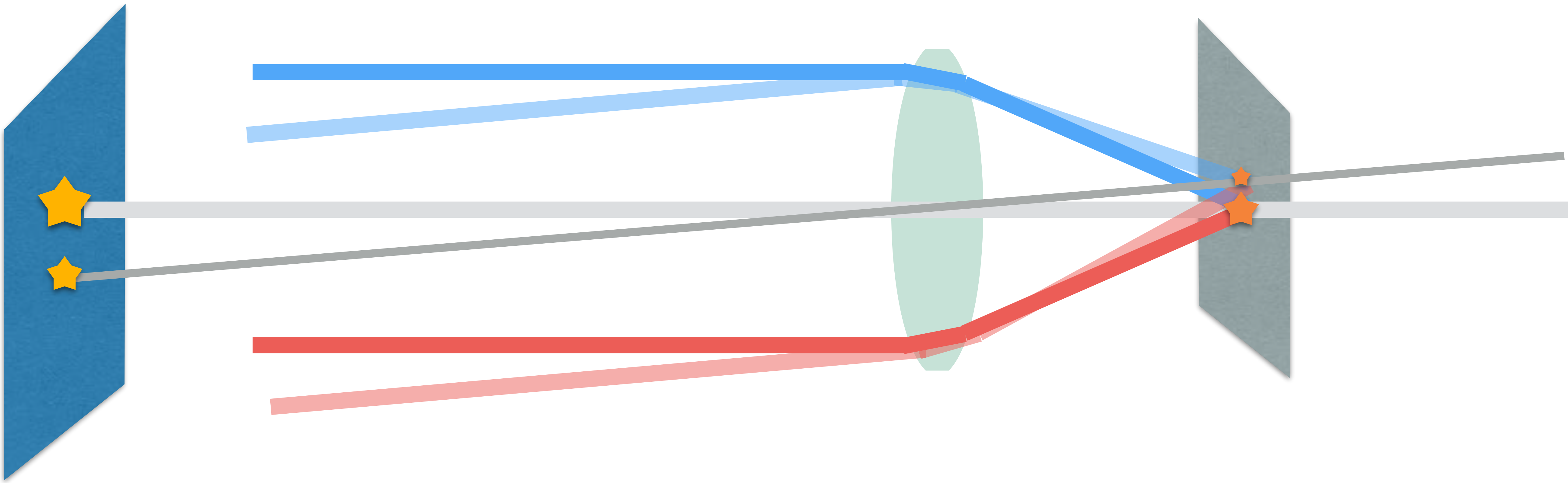
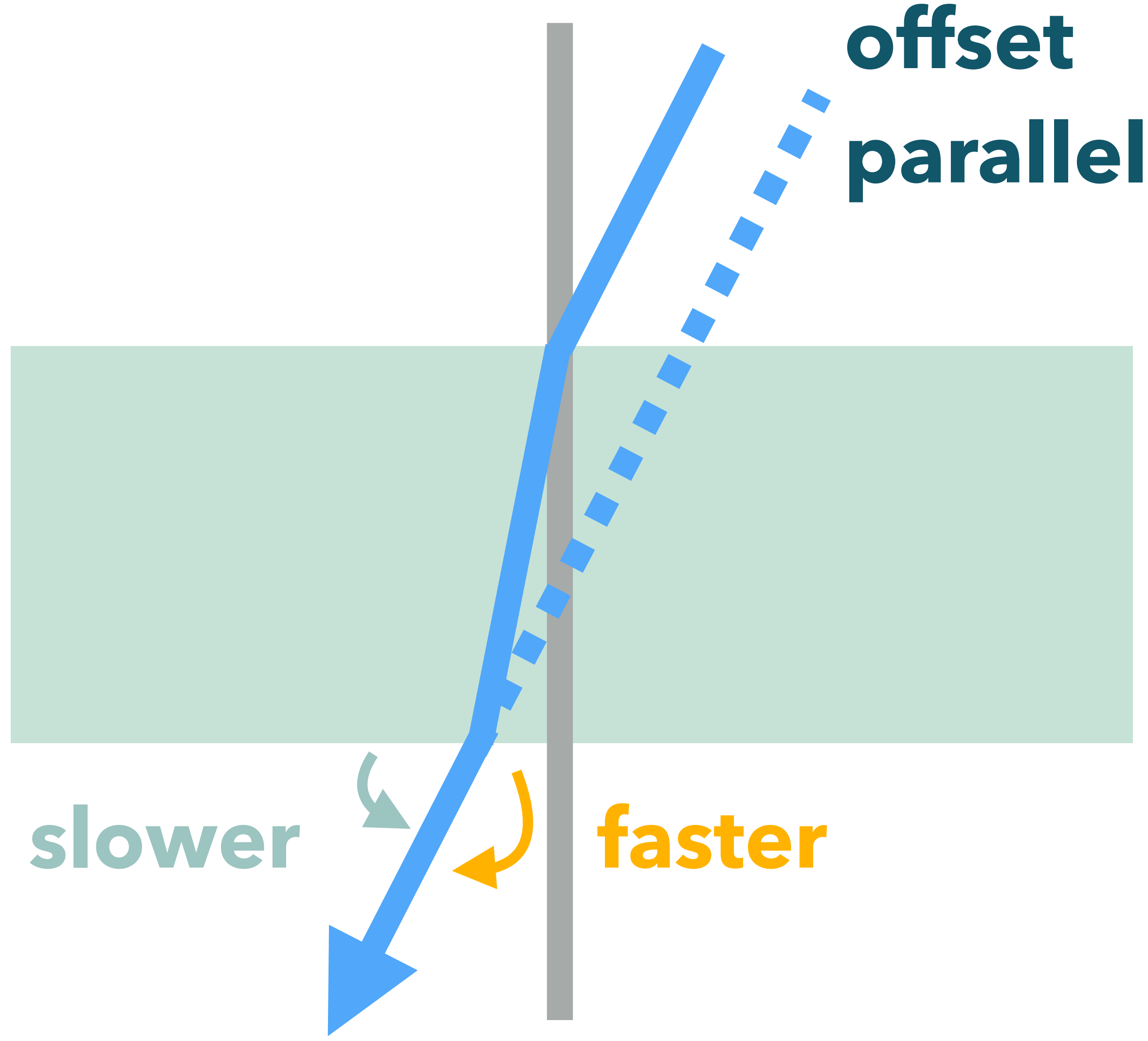
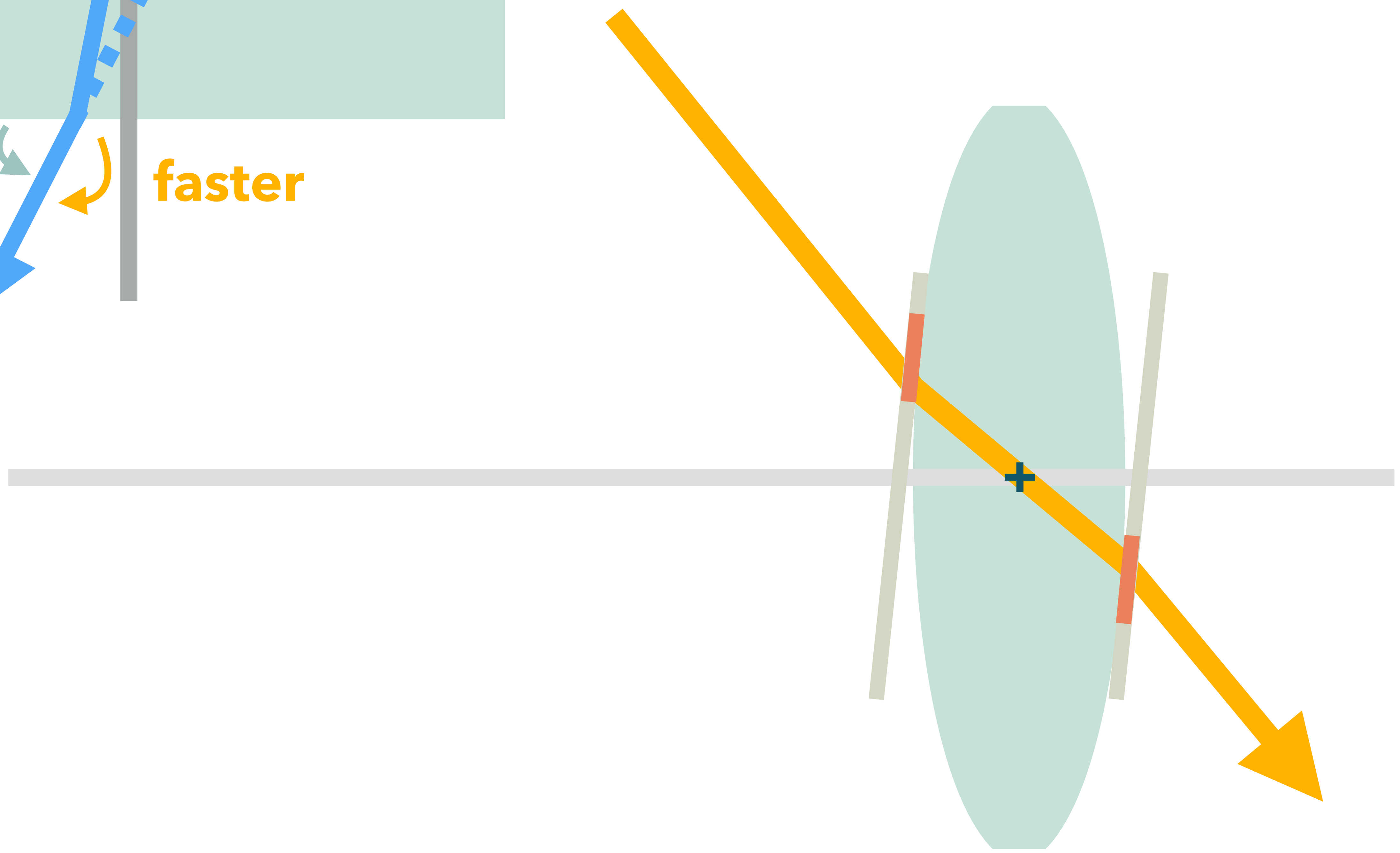

Near field
Far field

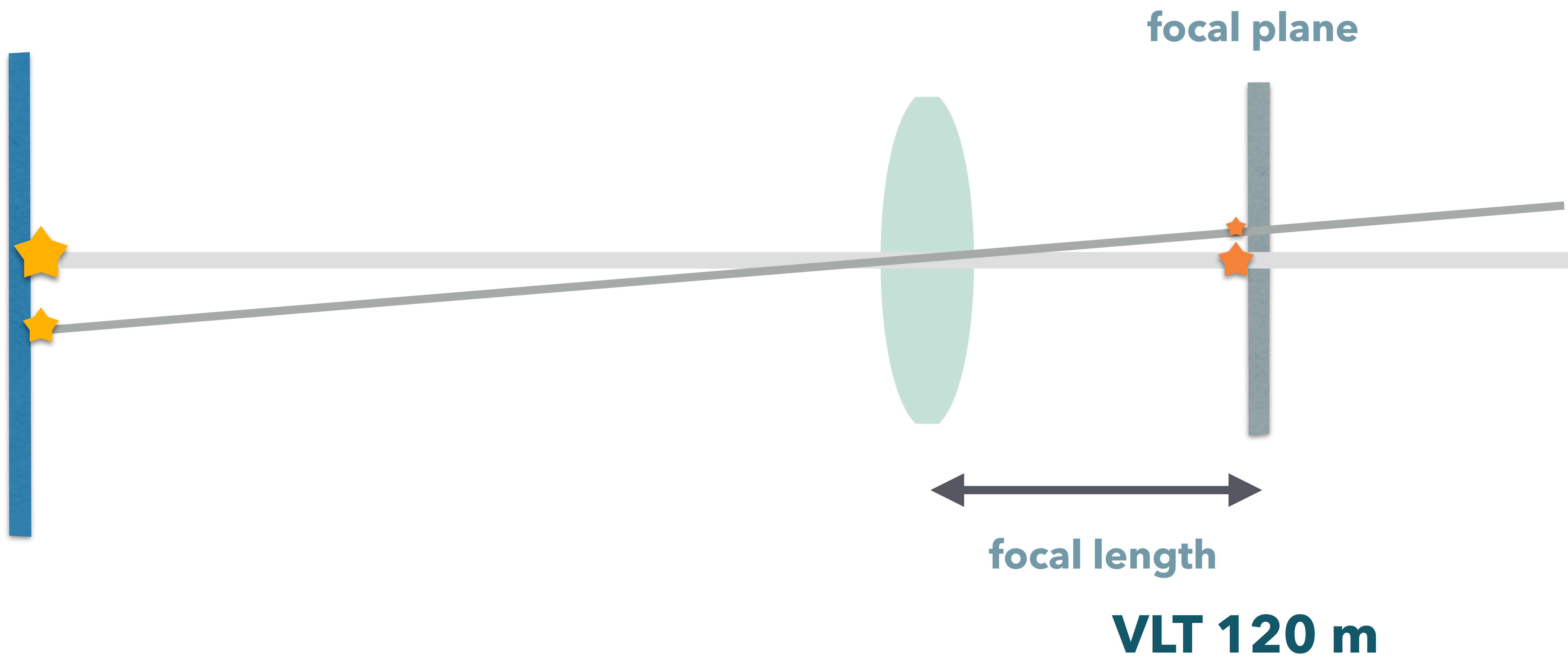
Lens



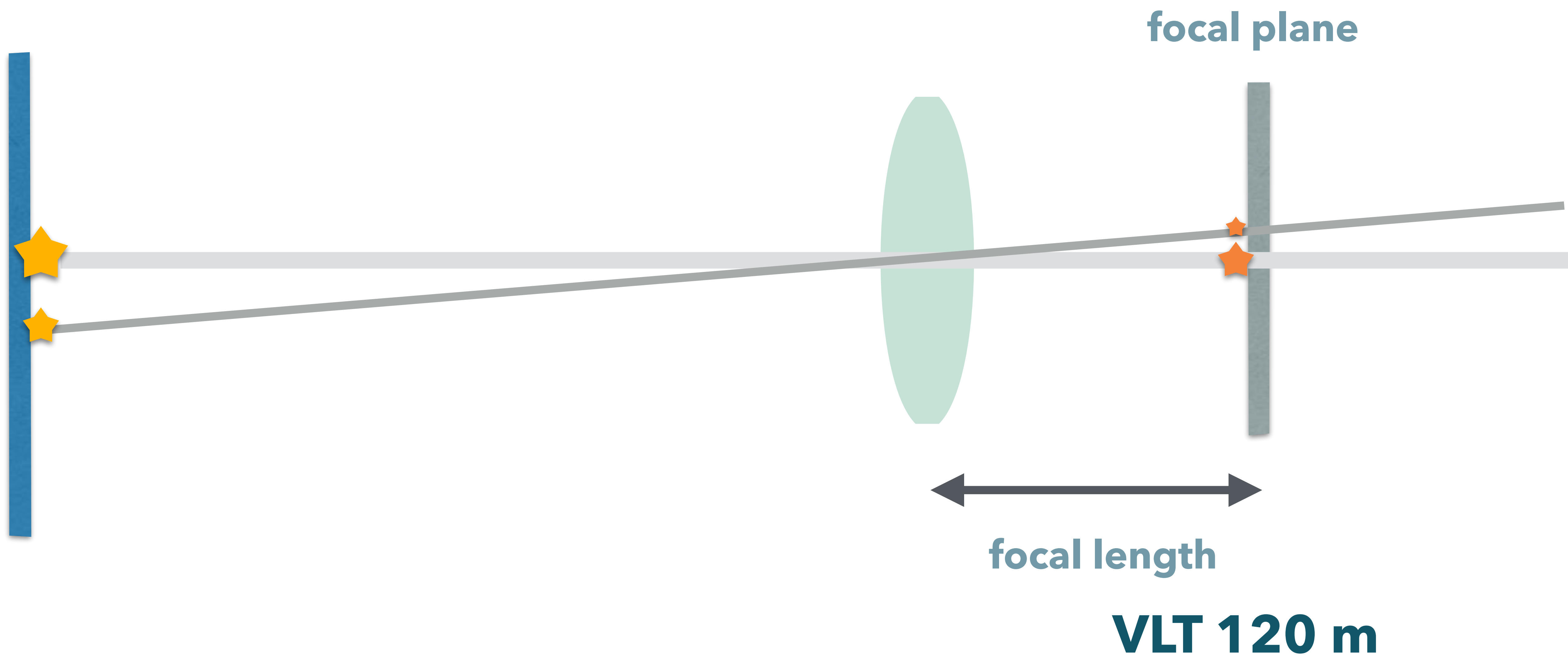



offset
parallel
slower
faster

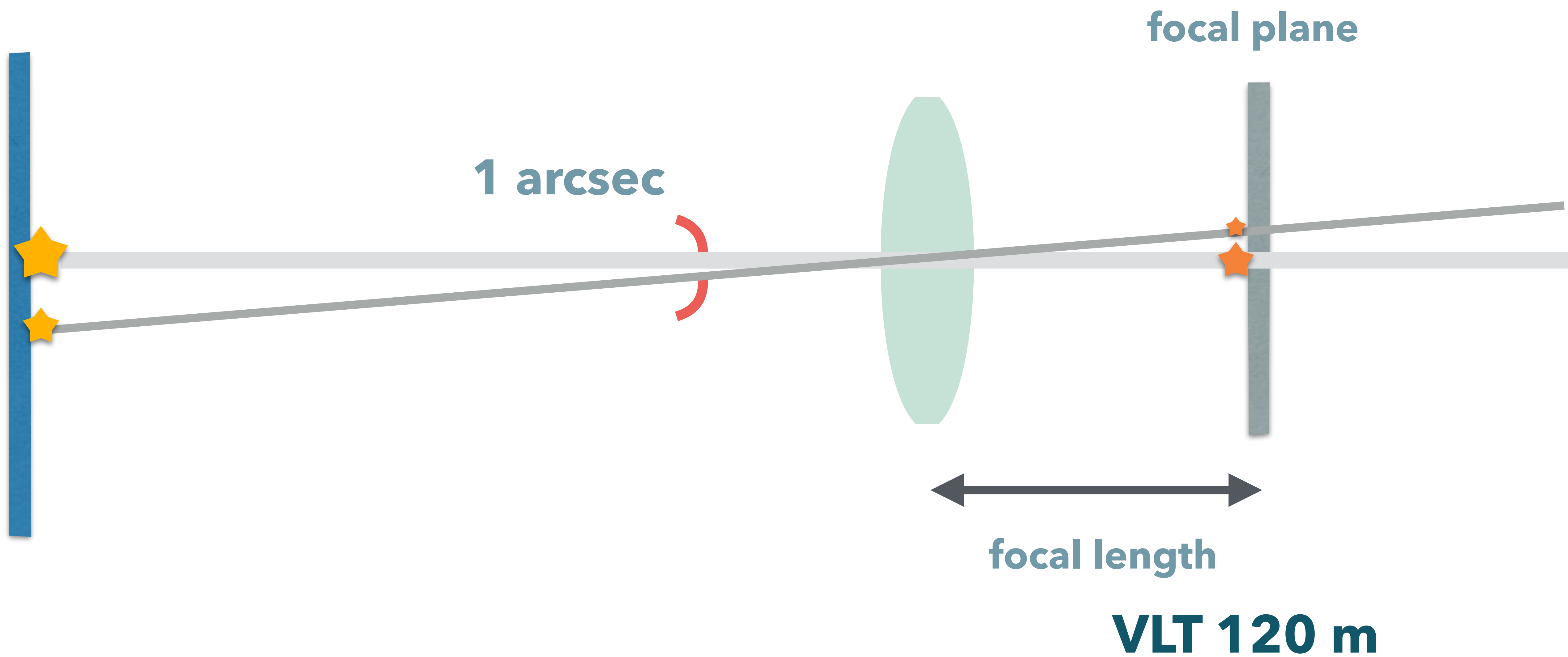




focal plane
focal length
VLT 120 m



1 How much is the plate scale at the focal plane?



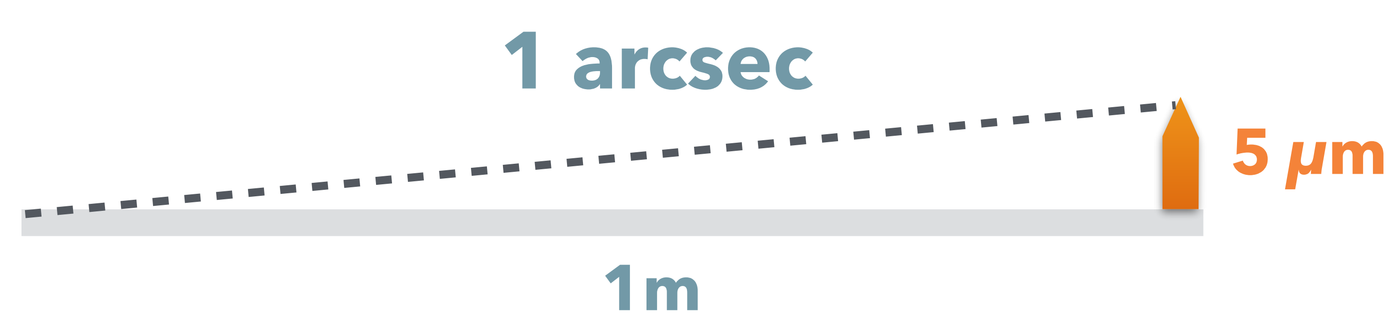
1 How much is the plate scale at the focal plane?

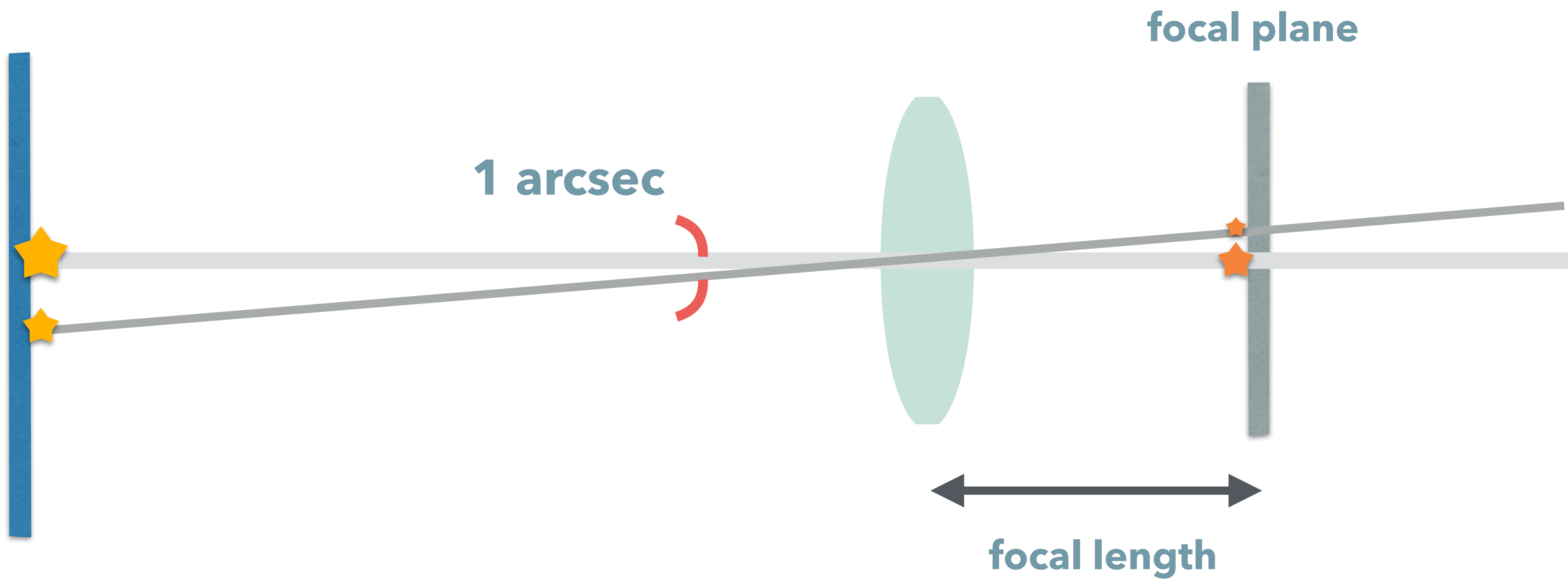
360° = 3600 * 360 arcsec

360° = 2π radian

1 arcsec = 2π / (3600 * 360)

= 4.84e-6 radian





VLT 120 m

1 How much is the plate scale at the focal plane?

$$360° = 3600 * 360 \text{ arcsec}$$

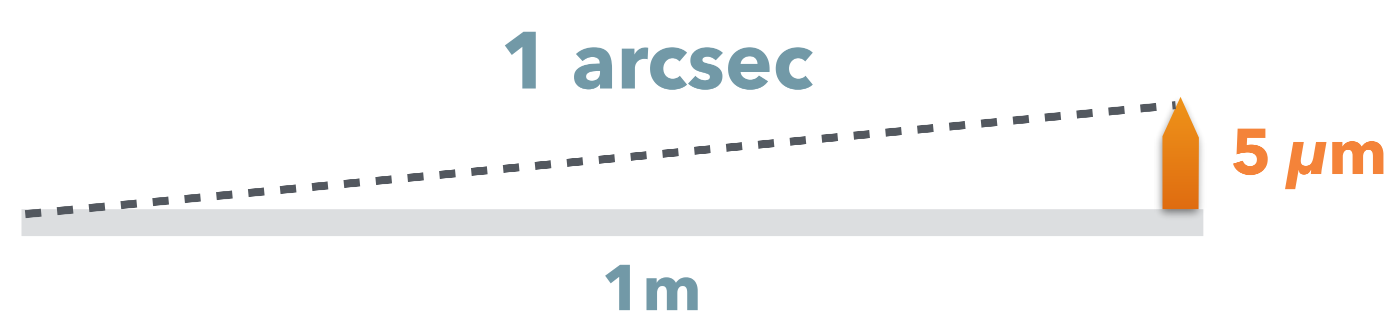
$$360° = 2\pi \text{ radian}$$

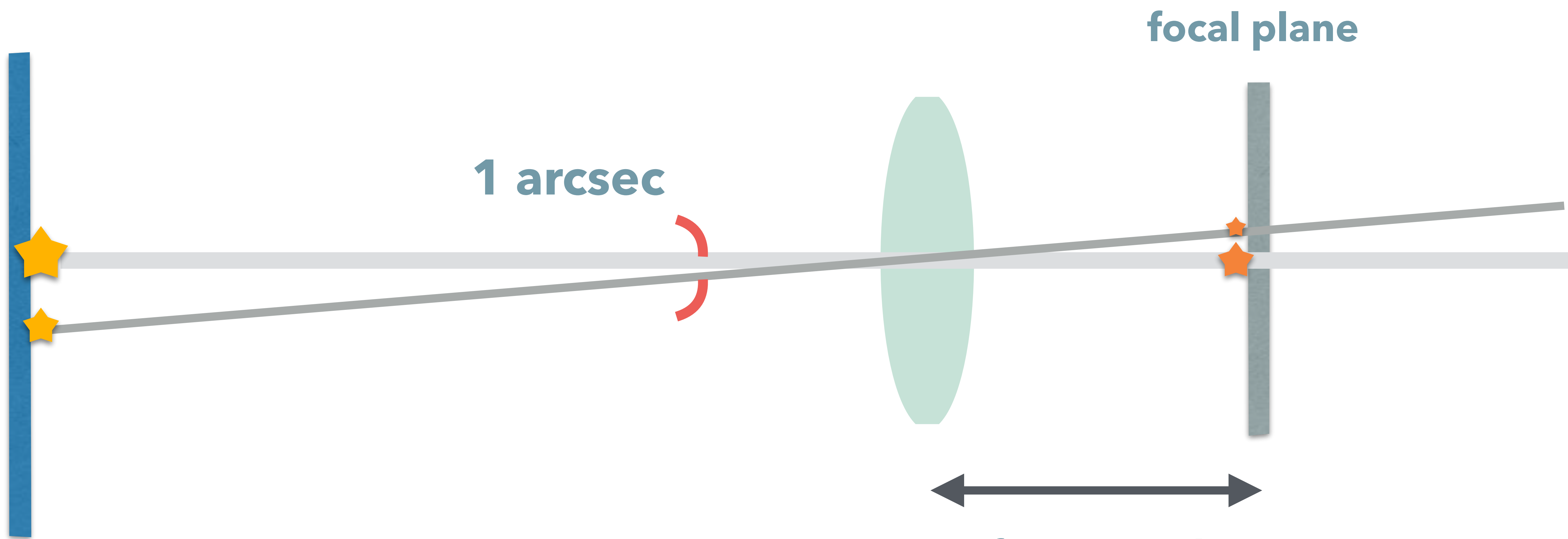
$$1 \text{ arcsec} = 2\pi / (3600 * 360)$$

$$= 4.84\text{e-}6 \text{ radian}$$

120 * 4.84e-6
= 0.5 mm

1 mm → 2 arcsec





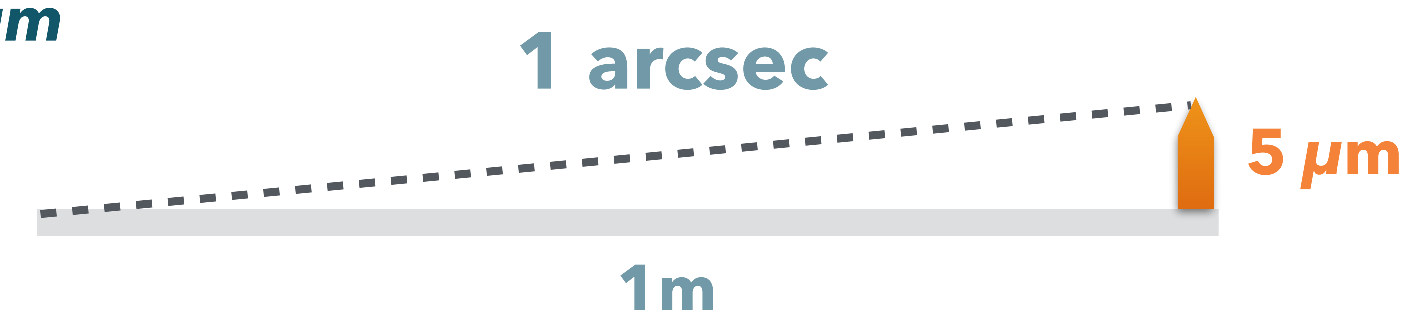
VLT 120 m

2 Check

50 mas	pixel /scale
27 μm	physical size of one pixel
1 arcsec	**27 * 1e3 / 50 =540 μm**

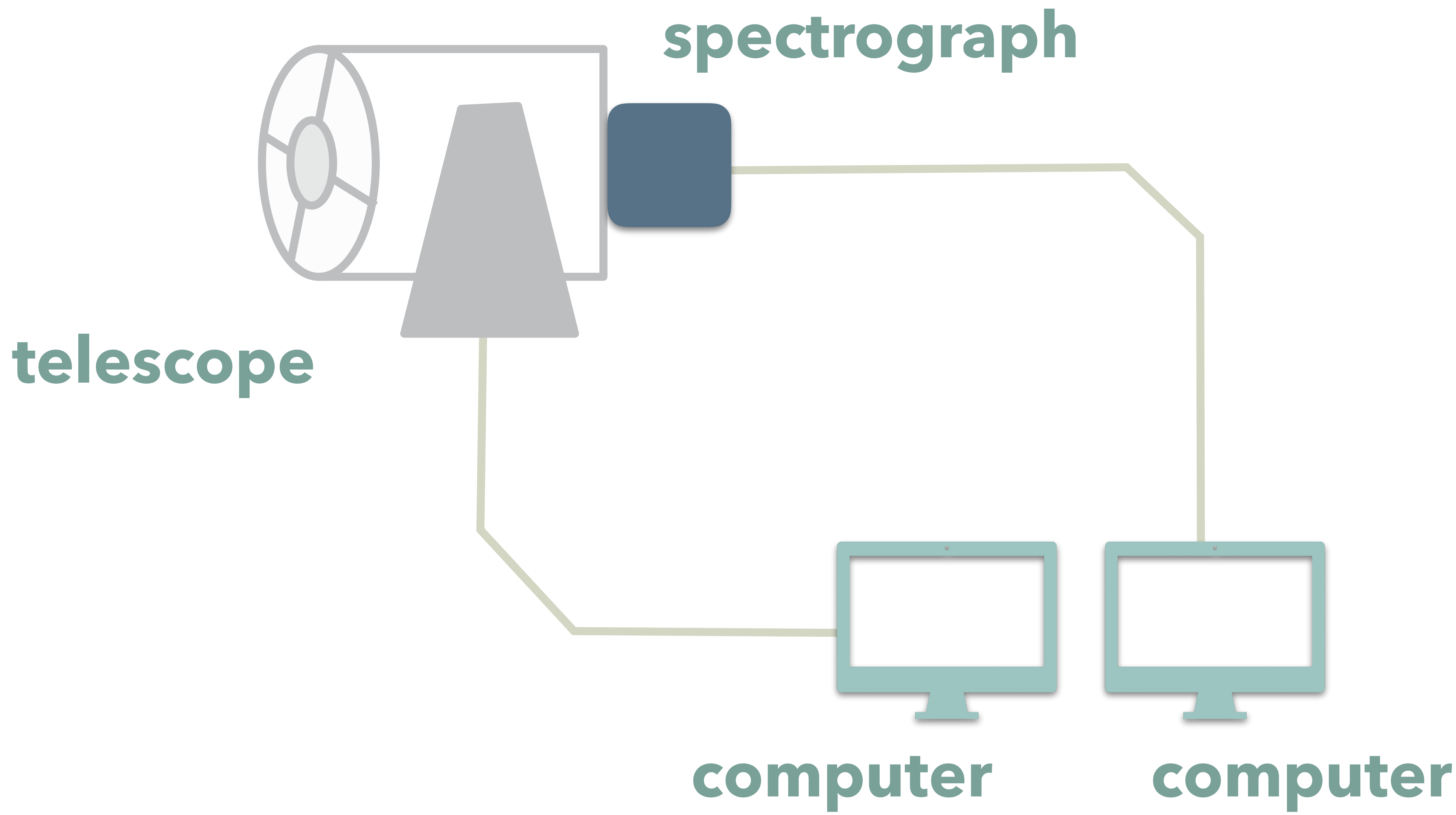
120 * 4.84e-6
= 0.5 mm

1 mm → 2 arcsec



How a spectrograph works

a system of spectrograph

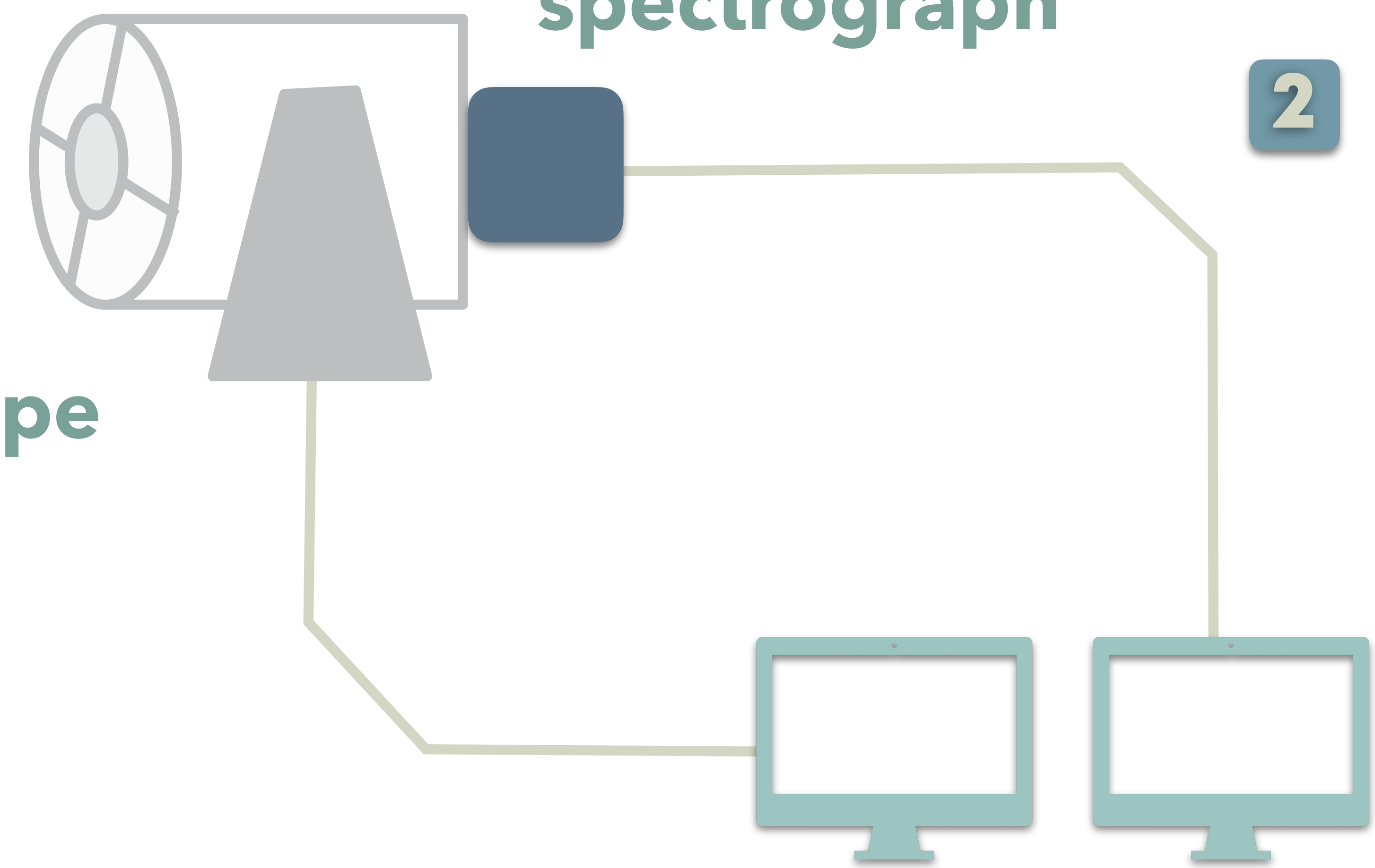


How a spectrograph works

a system of spectrograph

1 cryosystem

chamber
cooler



2 mechanism

motors for

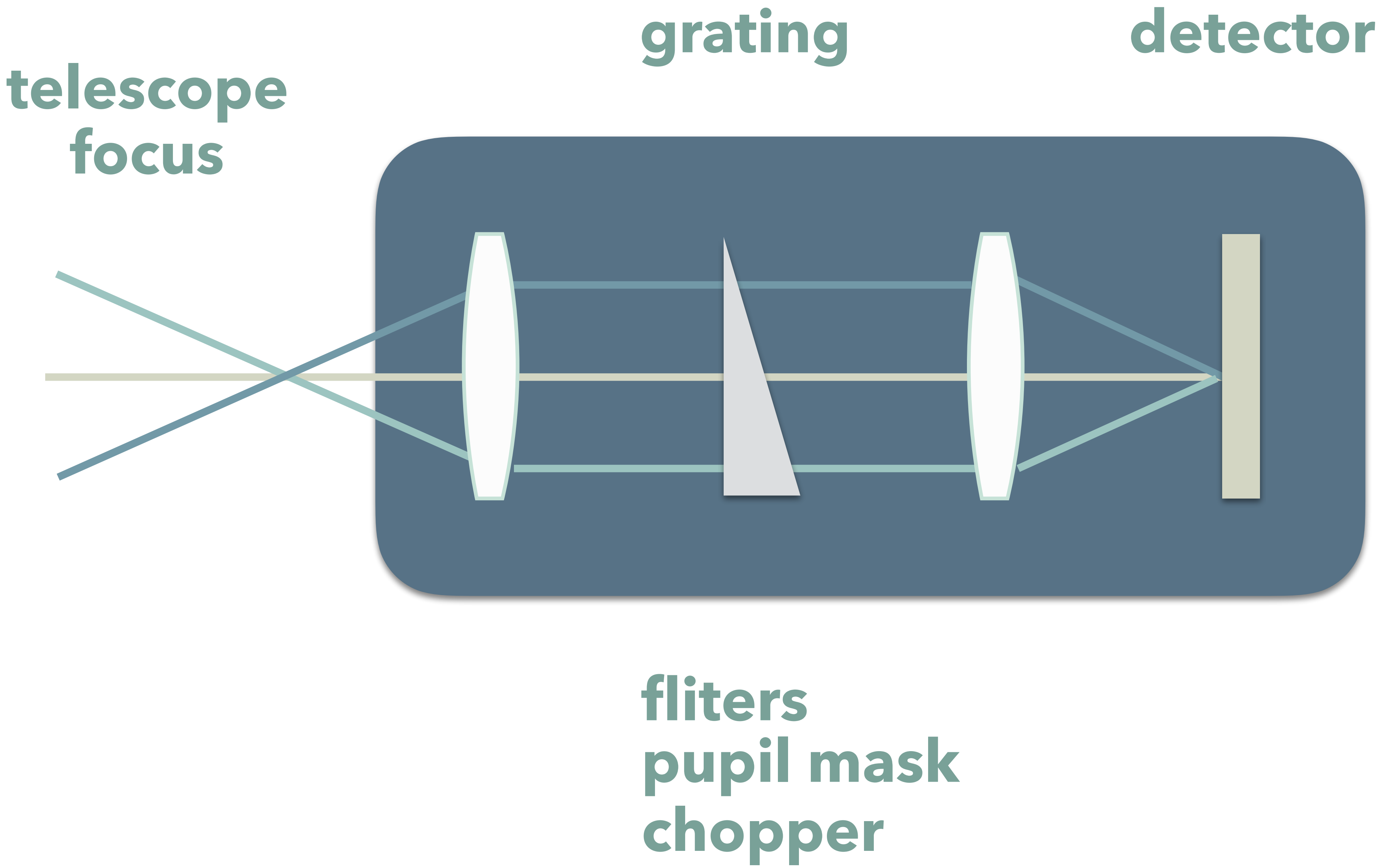
filter wheel
focus
pick off

3 optics

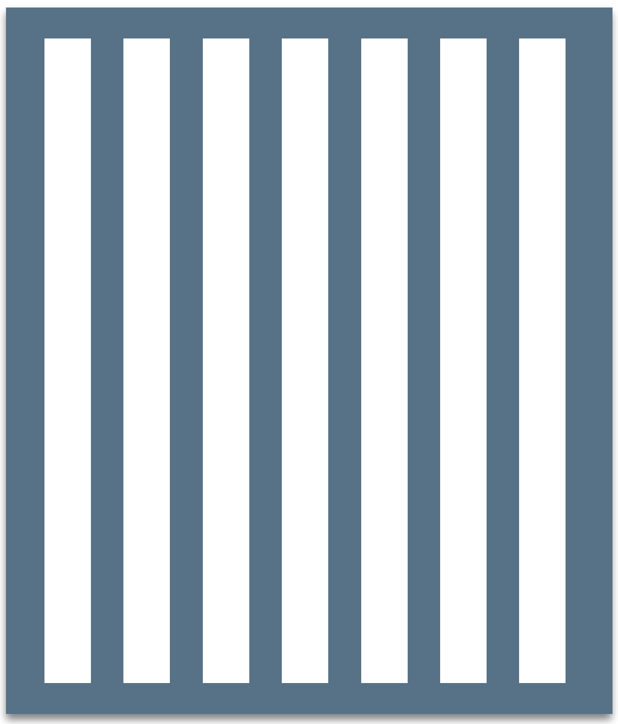
lens
mirror
filters
grating

4 electronics detector clock driver readout

Spectrograph



Diffraction grating



transmissive grating with slits

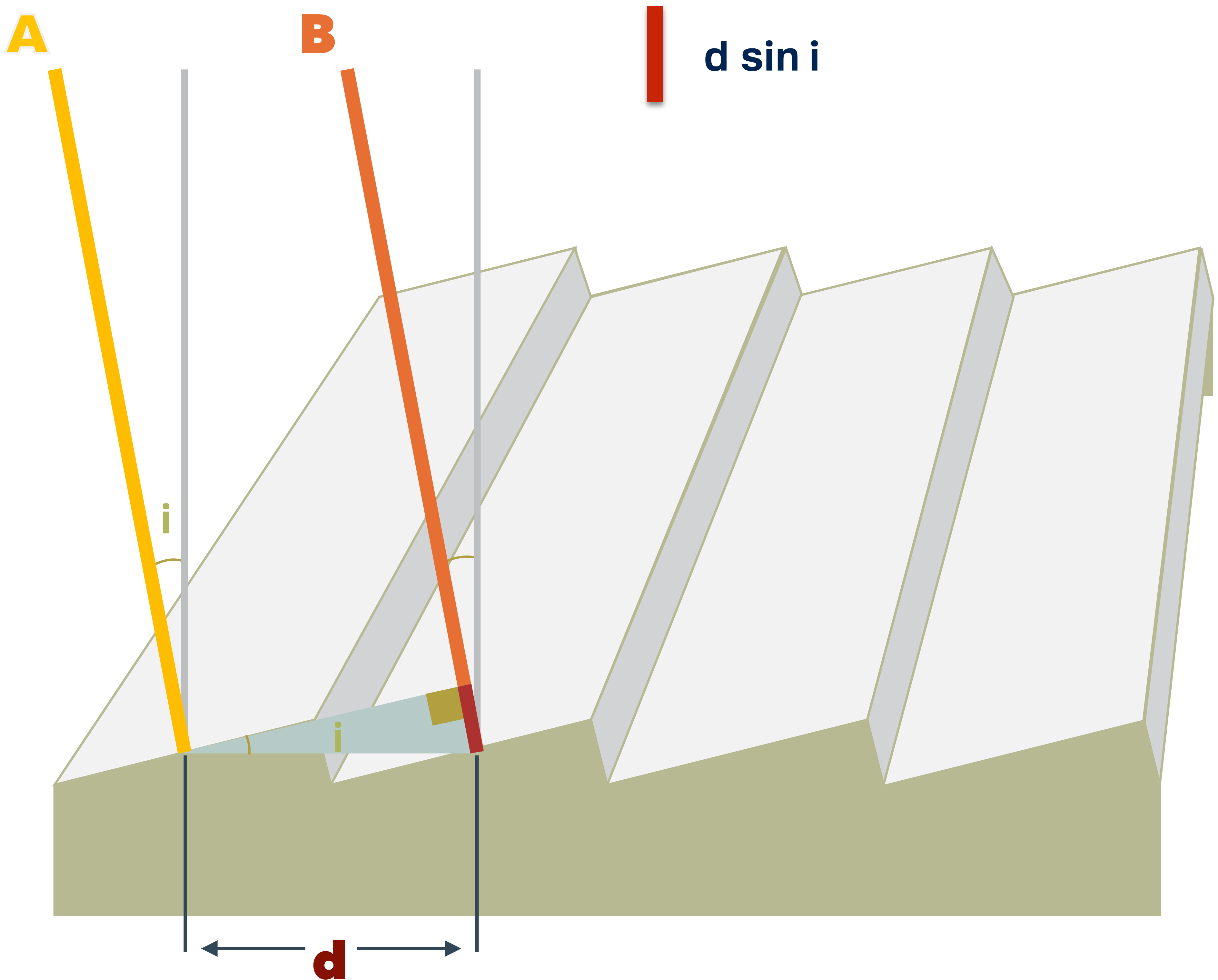
regular openings

blazed grating

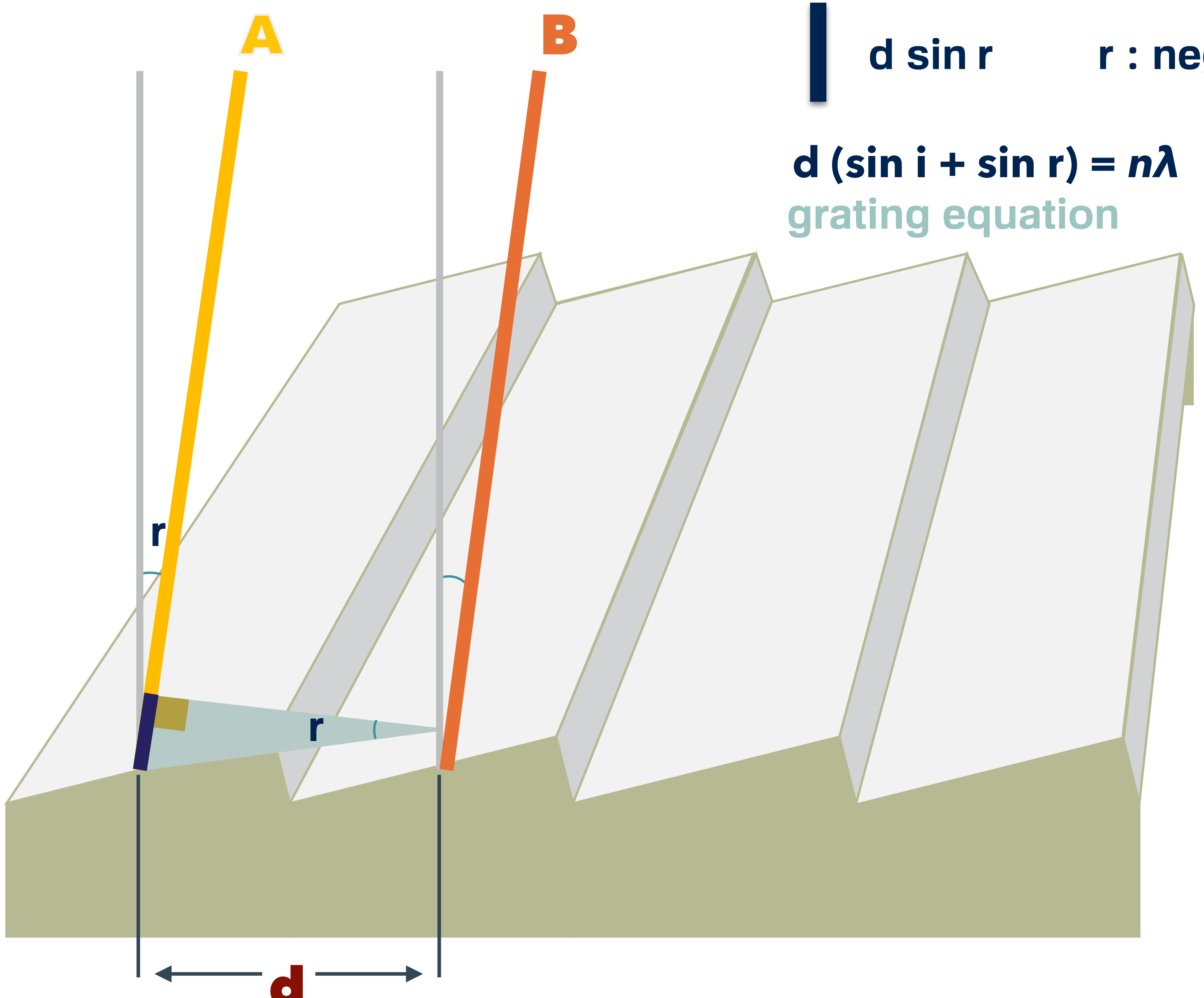
multiple advantages

1. diffraction by a single slit
2. diffraction by a multiple slit

blazed grating



note : measure always wavefront



d sin r   r : negative

$d(\sin i + \sin r) = n\lambda$

grating equation

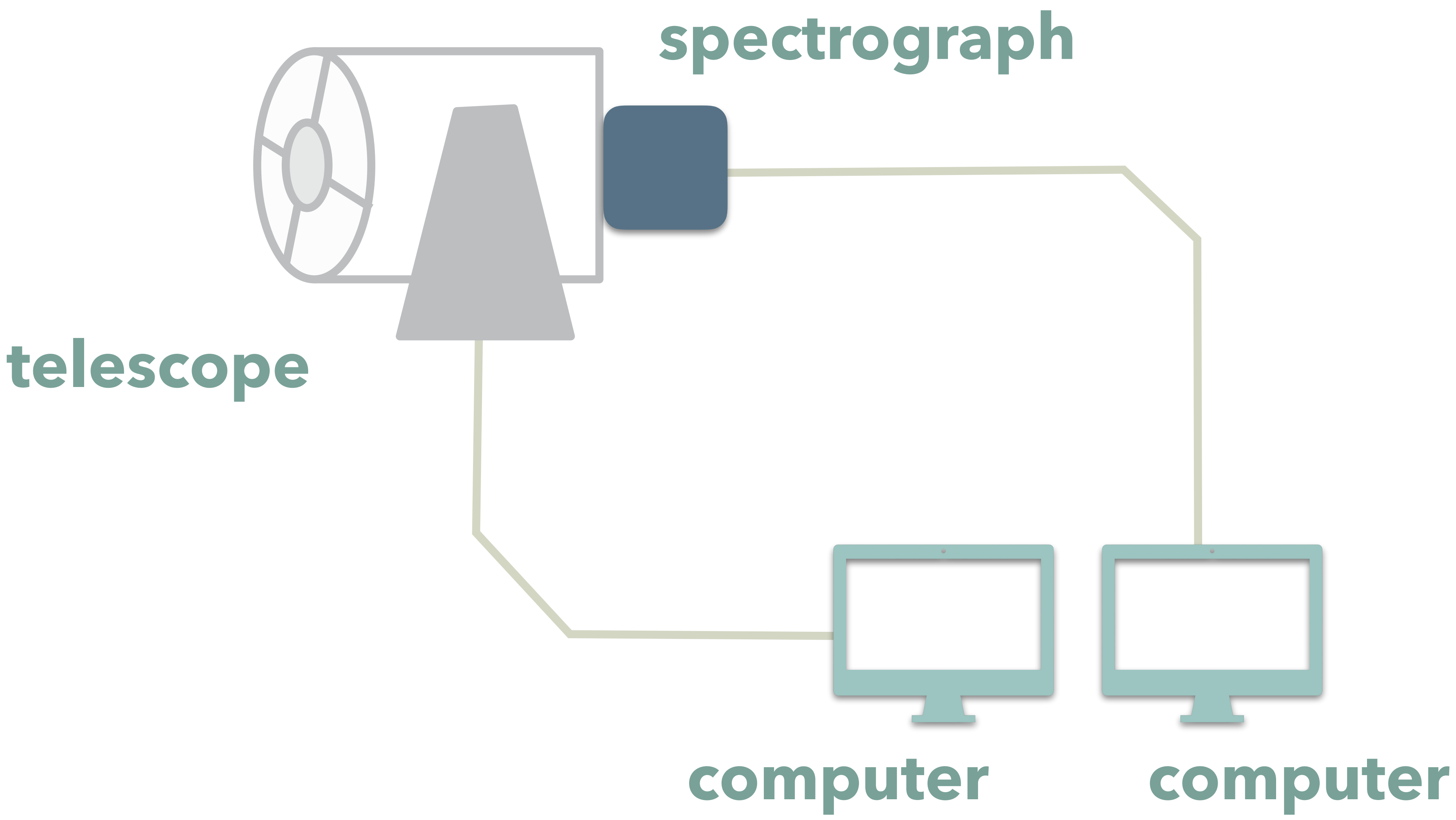
$i = -r$

blaze angle

blaze wavelength

$i \neq -r$ happens because of diffraction

a system of spectrograph



Spectrograph

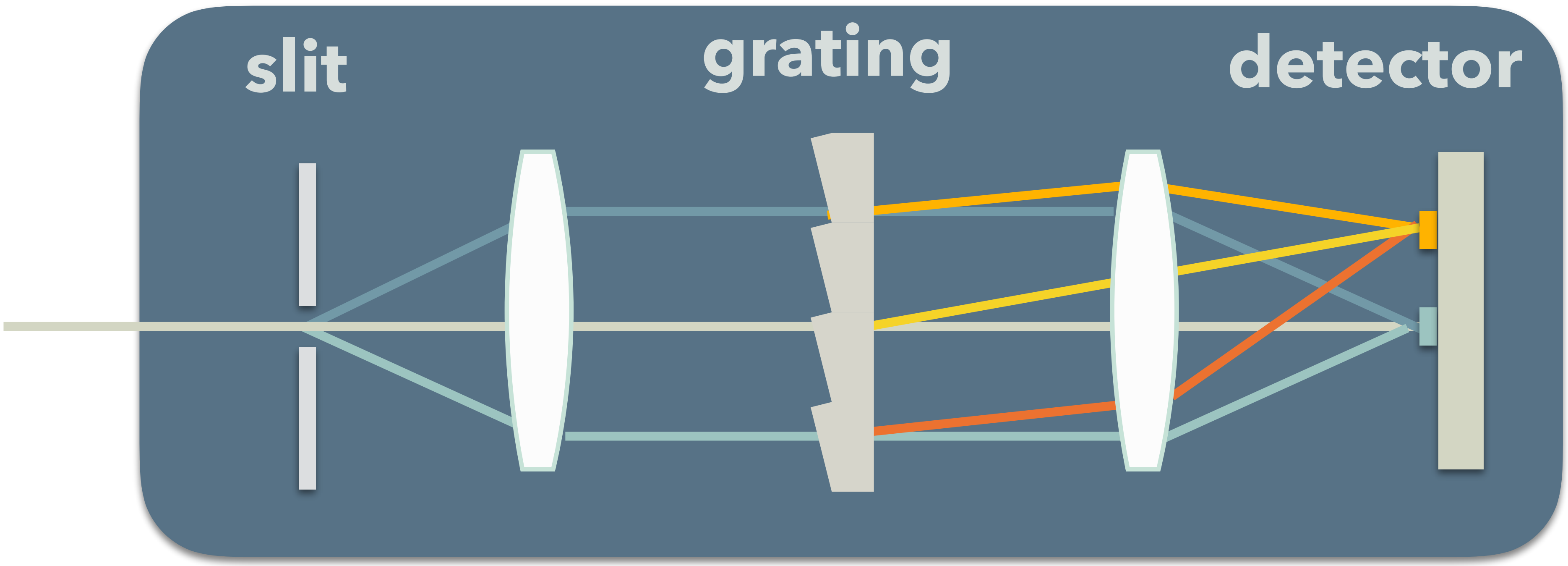


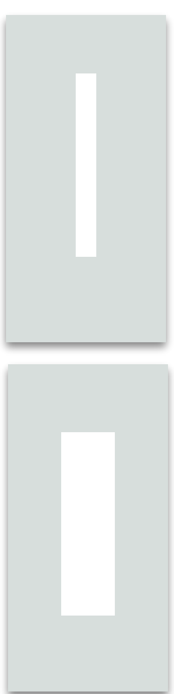
image of slit

project a slit image

change the deflection angle of a slit image according to color

on the different location of a detector

slit



spectral resolution

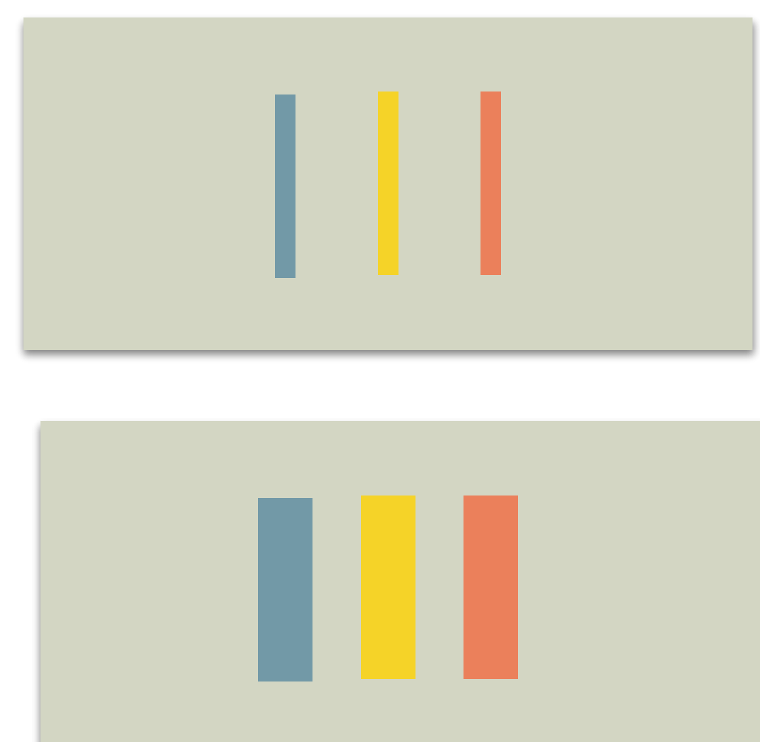
proportional to slit width

NIRSPEC at Keck II

High resolution: R=25,000, 3-pixel slit (0.43")

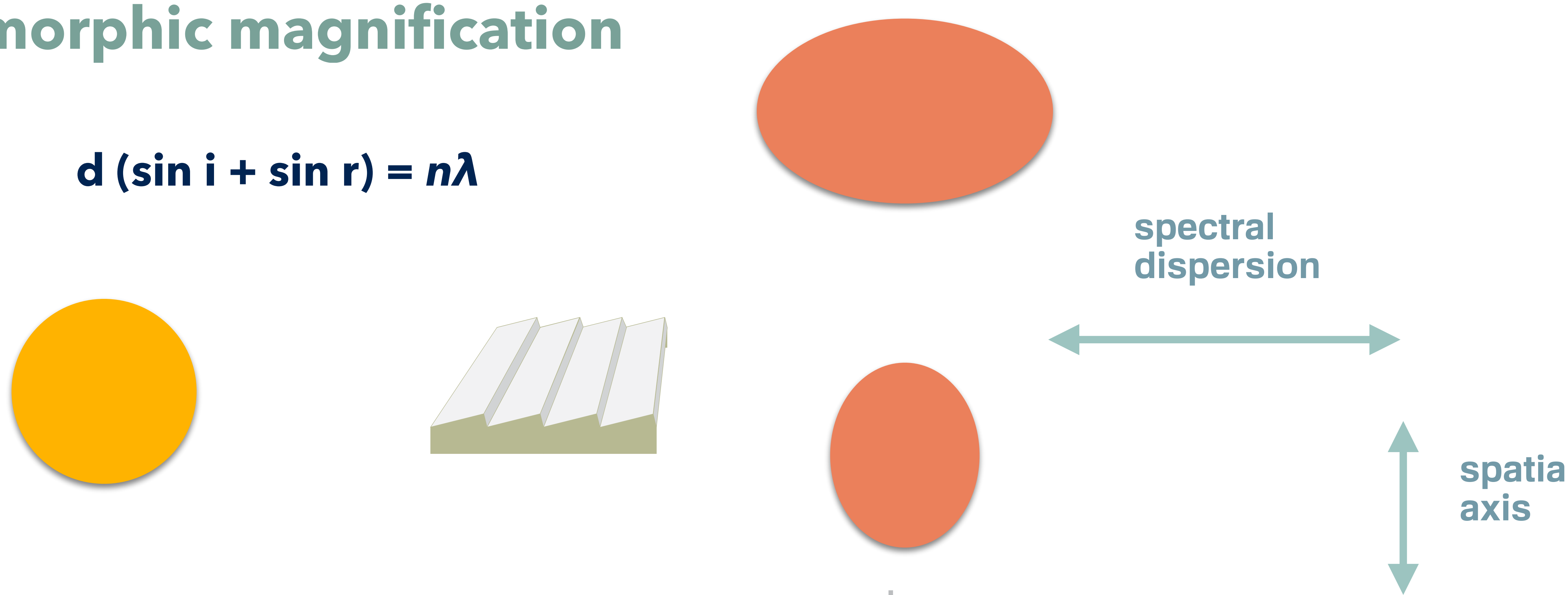
	R ?
0.288"x24 (2-pix)	
0.432"x24 (3-pix)	25,000
0.720"x24 (5-pix)	

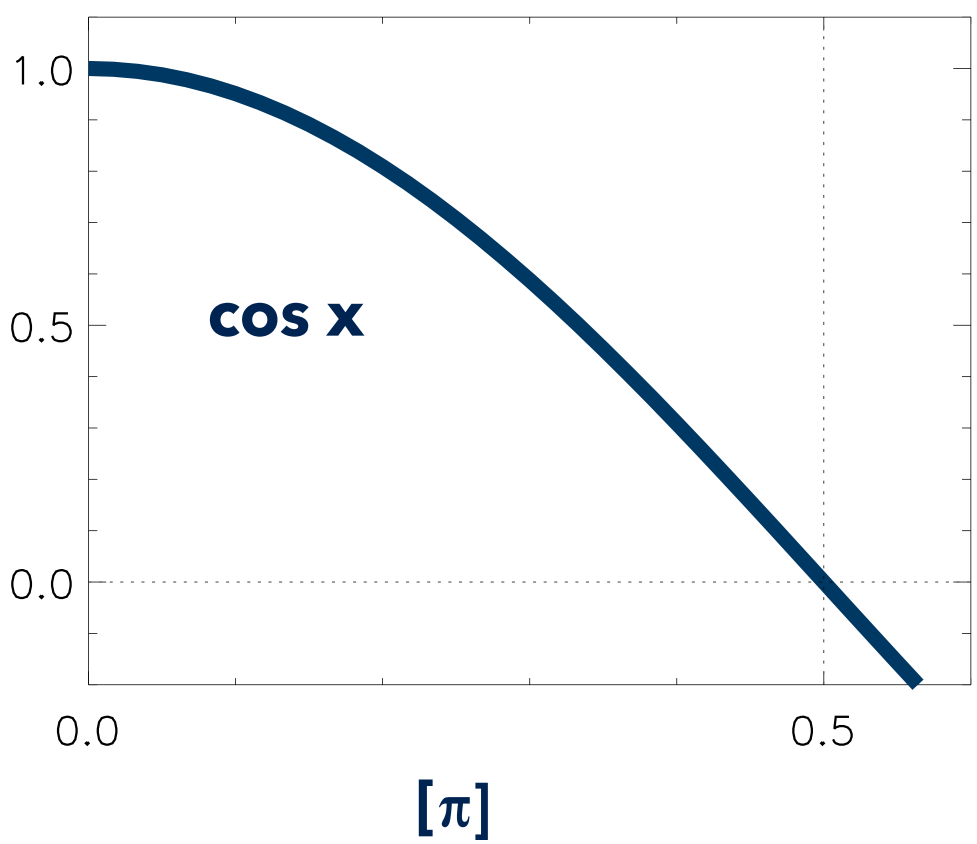
detector

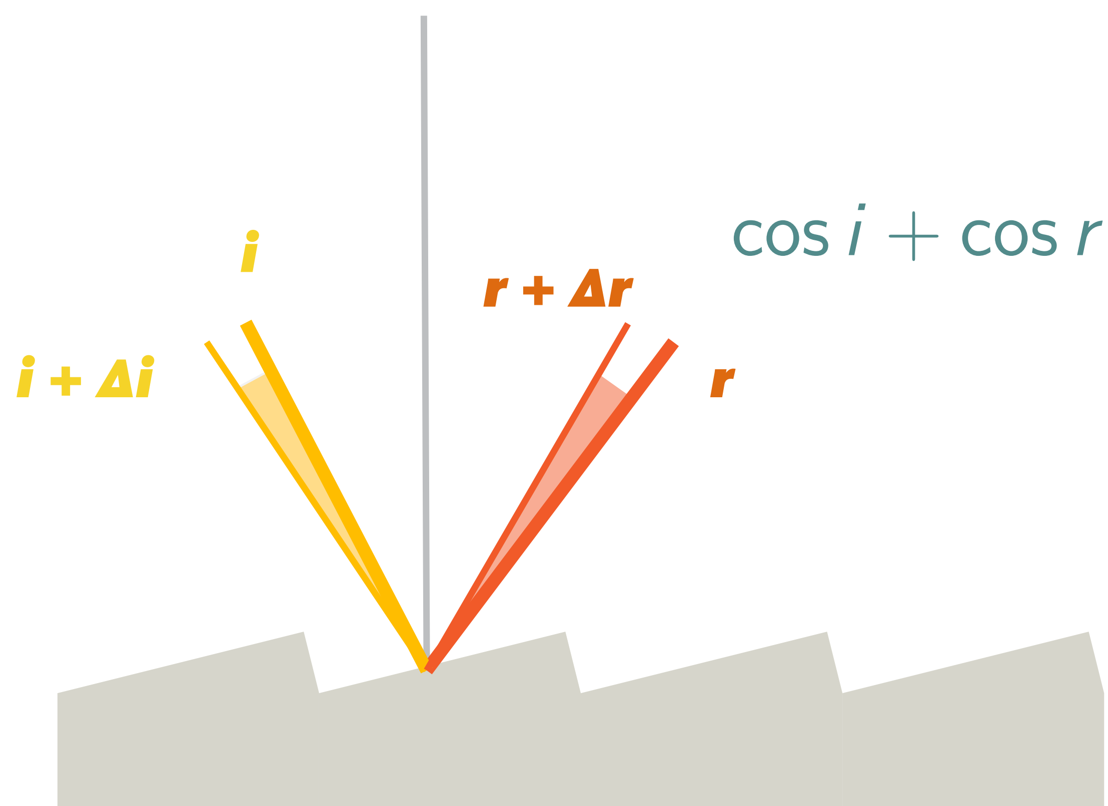


Anamorphic magnification

d (sin i + sin r) = $n\lambda$







$$\cos i + \cos r \frac{dr}{di} = 0$$

$$\frac{dr}{di} = \frac{\cos i}{\cos r}$$

$i > -r$ magnification

$i < -r$ reduction

$\frac{dr}{di} = 1$ same size

$$d(\sin i + \sin r) = n\lambda$$

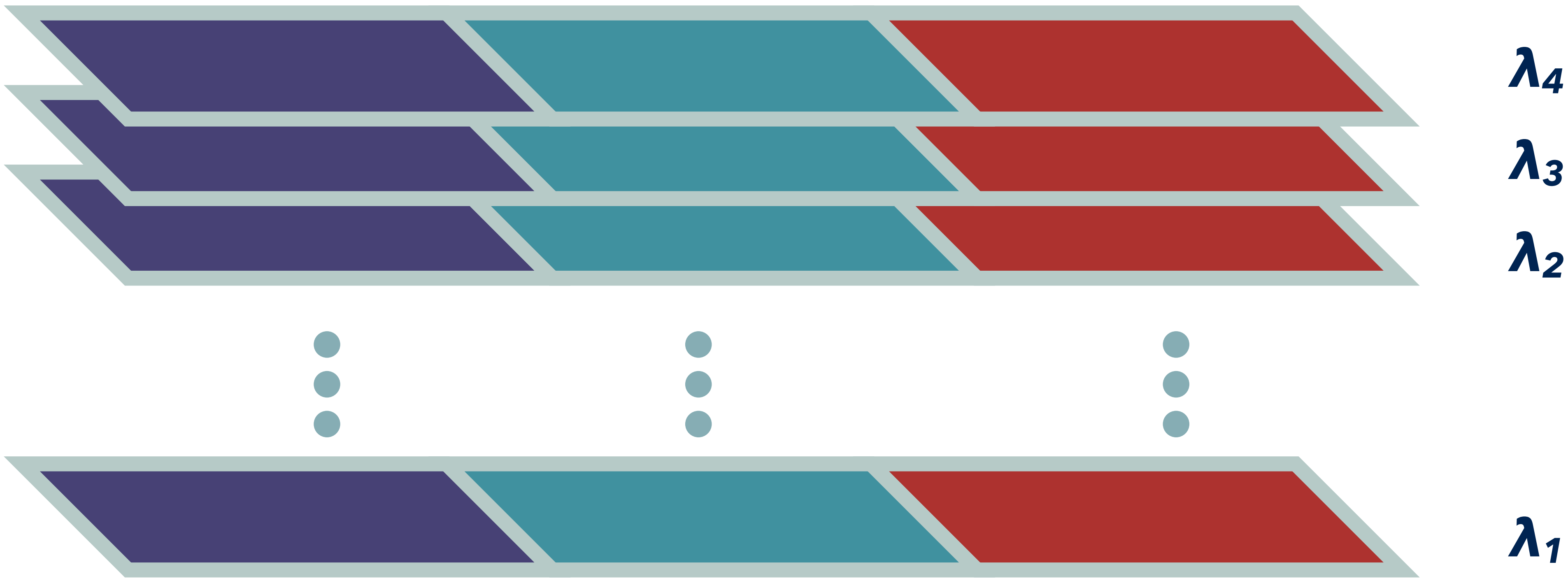
free spectral range

$$n\lambda_1 = (n+1)\lambda_2$$

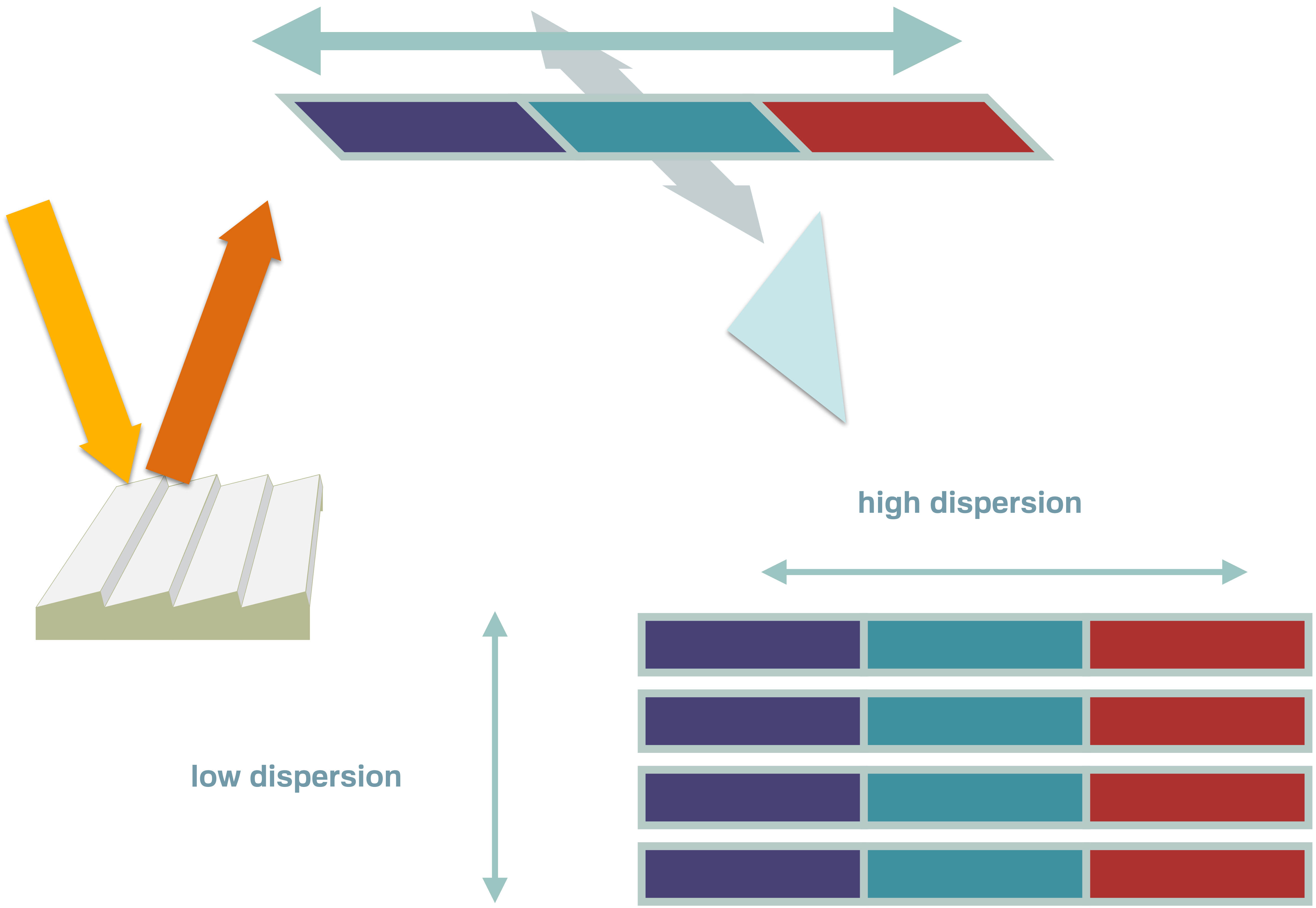
λ_1 and λ_2 reflected same direction

intensified in the same way

what to do with overlap?

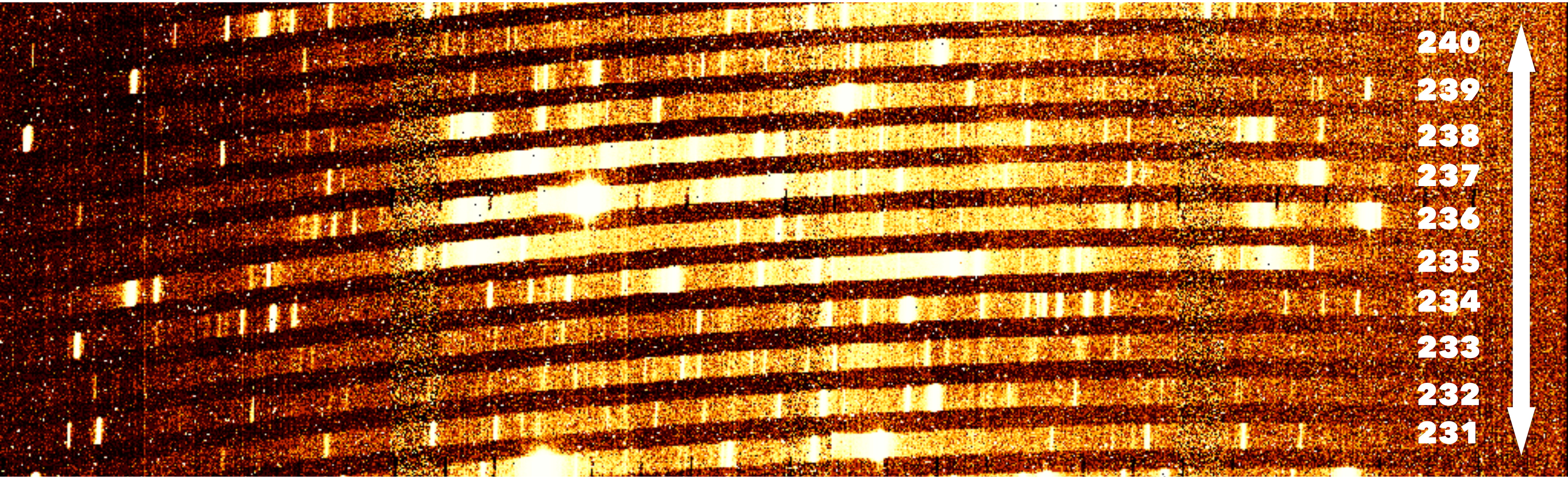


$n\lambda_1 = (n+1)\,\lambda_2$

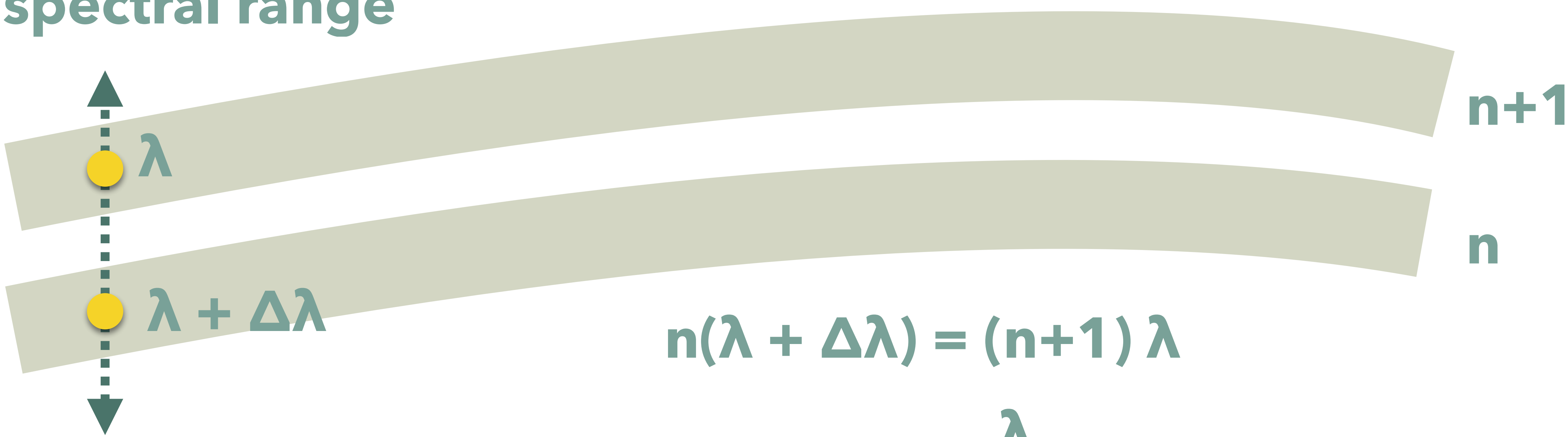


fit in square format detector

which side is longer wavelength?



free spectral range

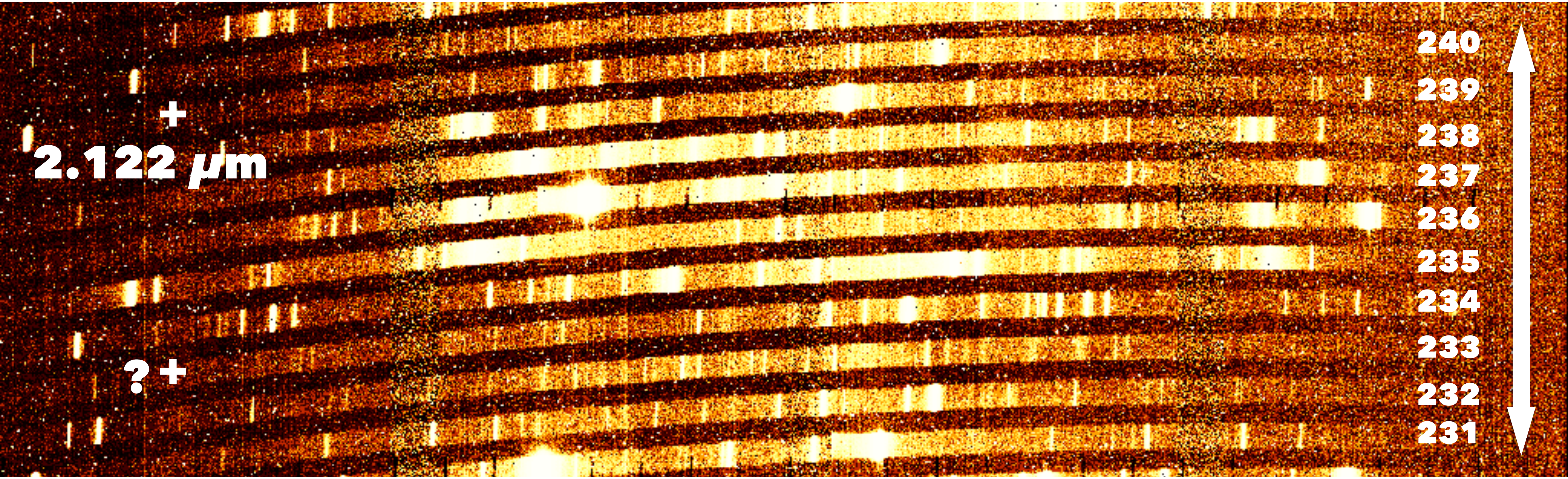


$$n(\lambda + \Delta\lambda) = (n+1)\,\lambda$$

$$\Delta\lambda = \frac{\lambda}{n}$$

low dispersion

prism dispersion



1. calculate the wavelength