disks by METIS / IFU

Miwa Goto
(University Observatory Munich)

Message

(1) IFU is no extravagance for spoiled astronomers

- not only for spatially resolved spectroscopy
- but also for spatially unresolved spectroscopy

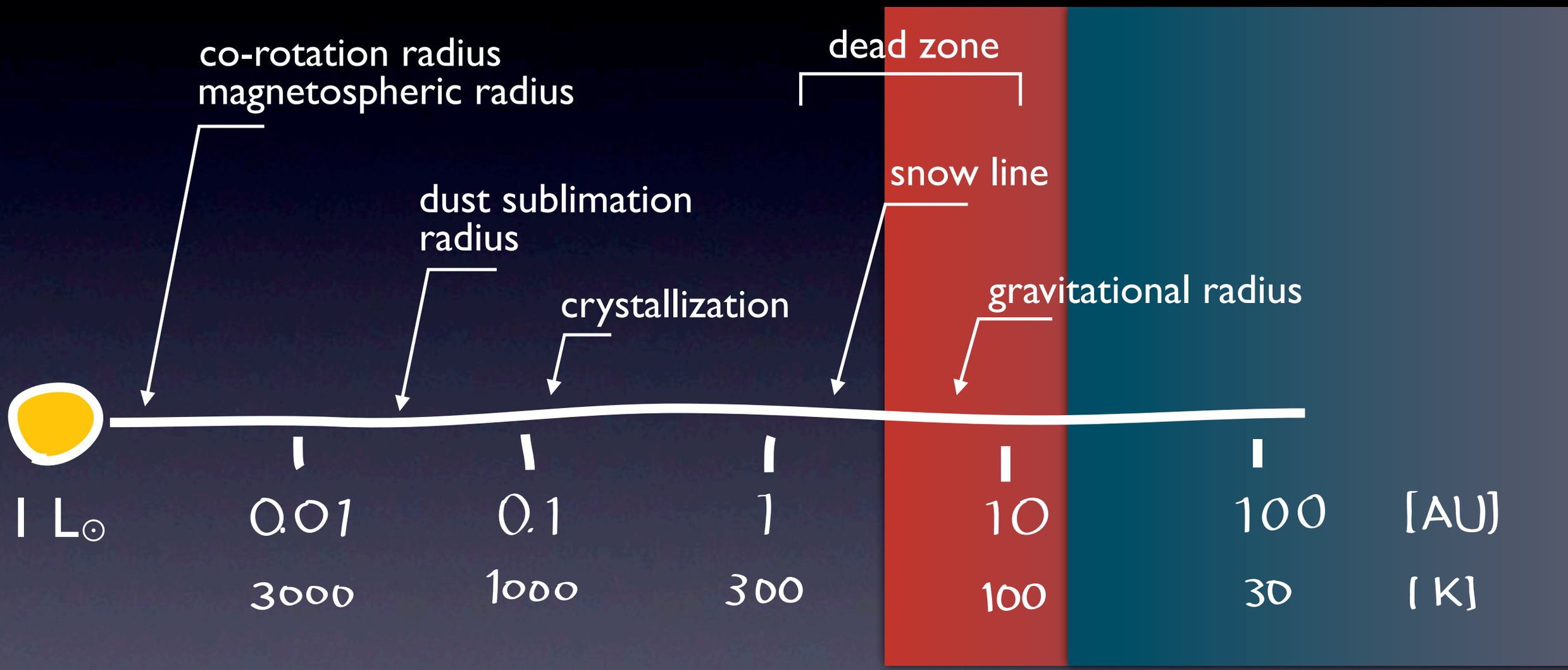
(2) spectro-astrometry

- wavelength calibration key for high precision astrometry

(3) METIS cross dispersing mode?

- why high resolution long slit is not a good idea

Disk



ELT/METIS

VLT/CRIRES at 100 pc

Gravitational radius

$$r_g = \frac{GM_*}{c_s^2}$$

sound speed of ionized gas = escape velocity

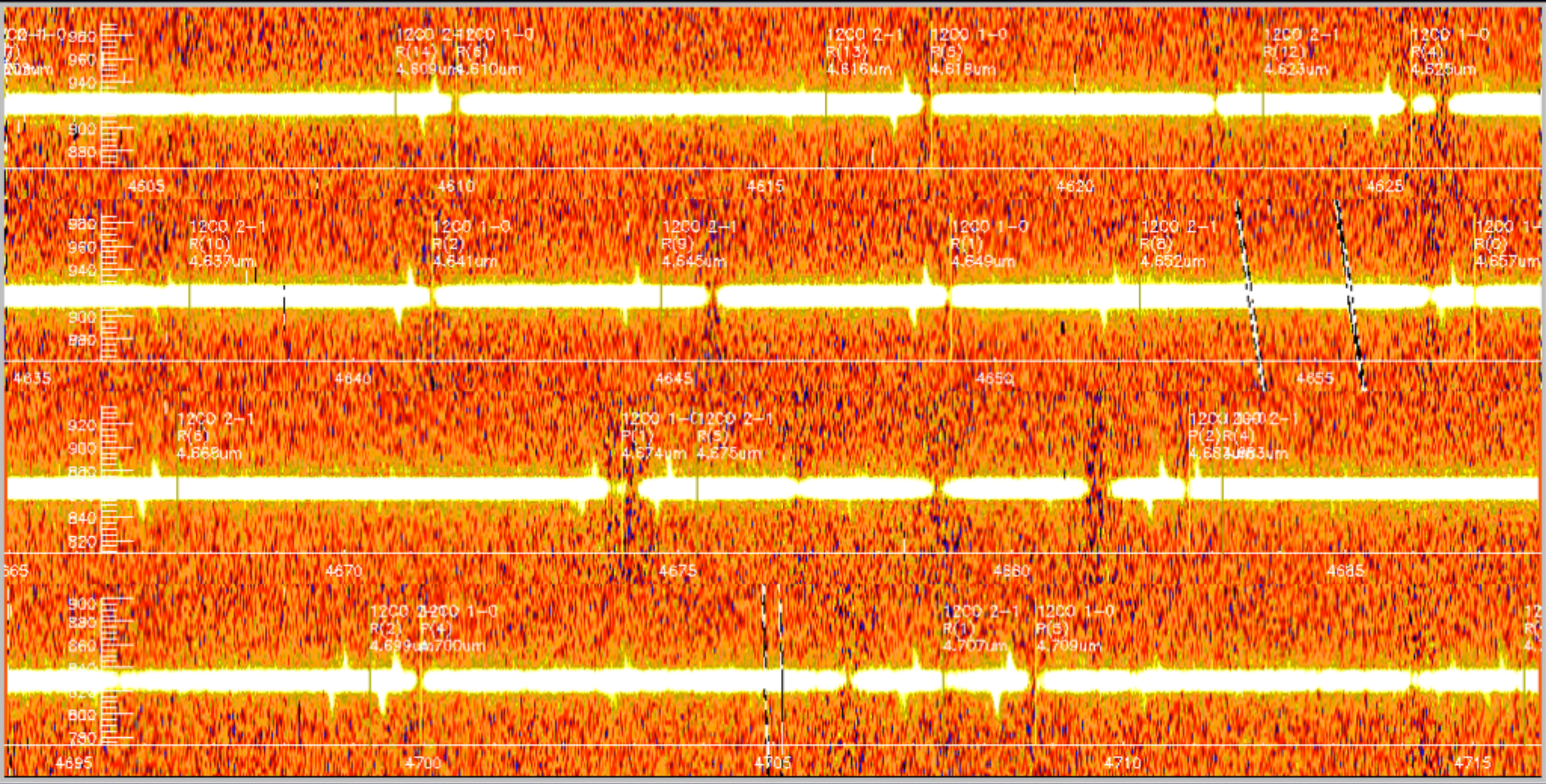
photoevaporation / disk dissipation in scope

Herbig Ae/Be 18 AU 100 pc 0”.2

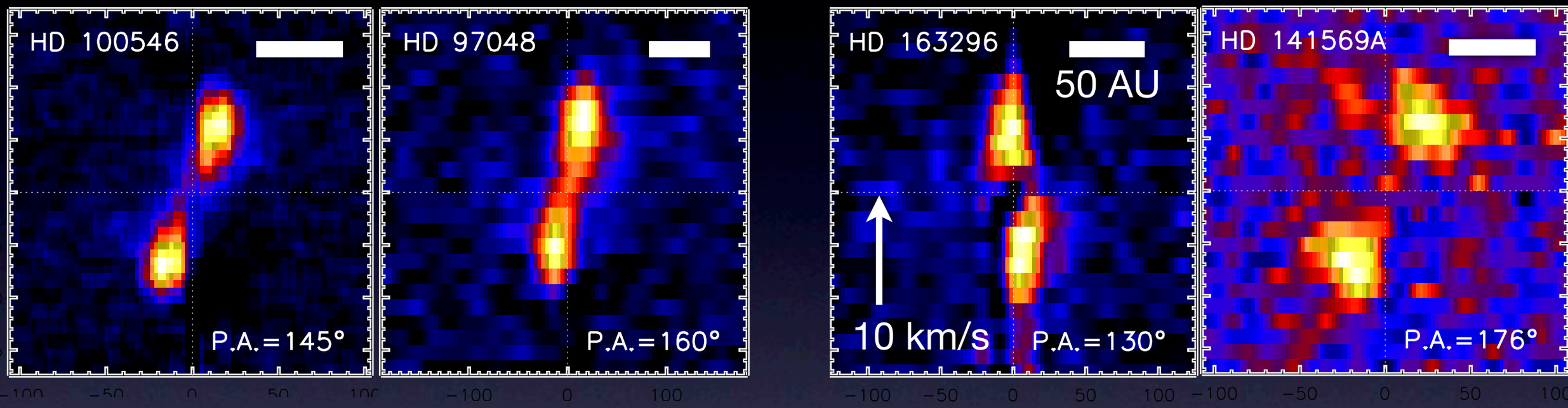
is not it possible to resolve it by CRIRES

Can CRIRE do that?

yes



Can CRIRE do that?



The problem: This is almost exhaustive list

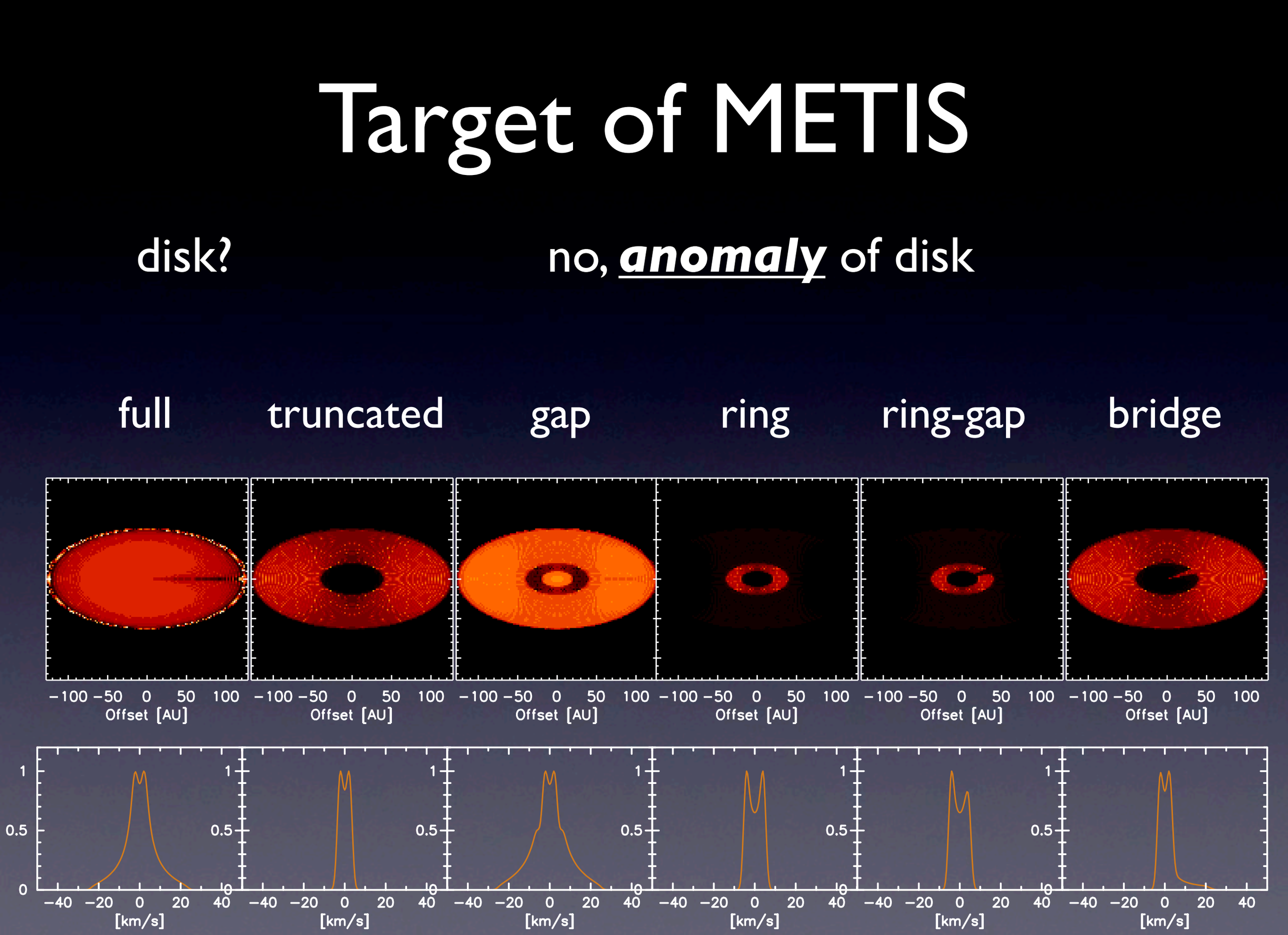
$$r_g = \frac{GM_*}{c_s^2}$$

Herbig Ae/Be	18 AU	100 pc	0”.2
T Tauri	9 AU	140 pc	0”.06

Target of METIS

disk? no, ***anomaly*** of disk

full truncated gap ring ring-gap bridge

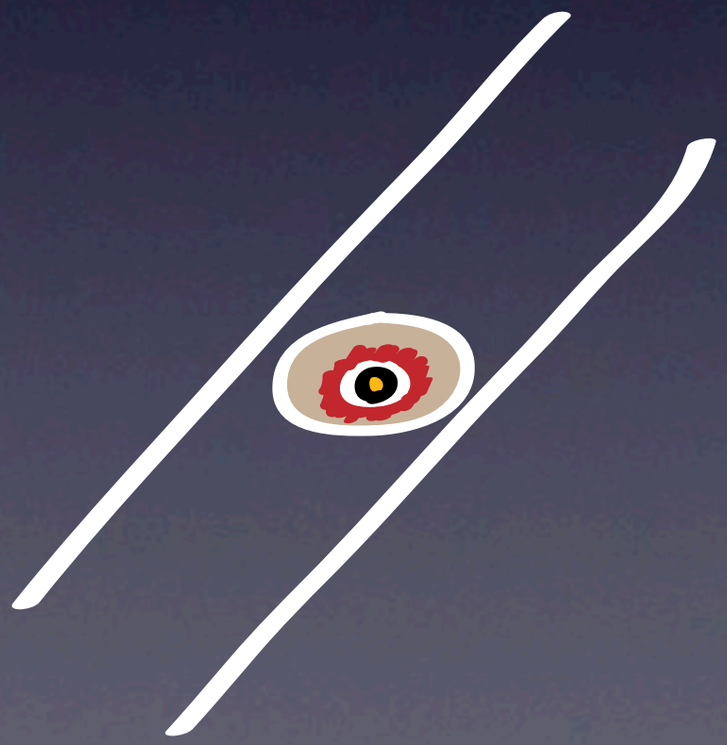


Slit vignetting

$$r_g = \frac{GM_*}{c_s^2}$$

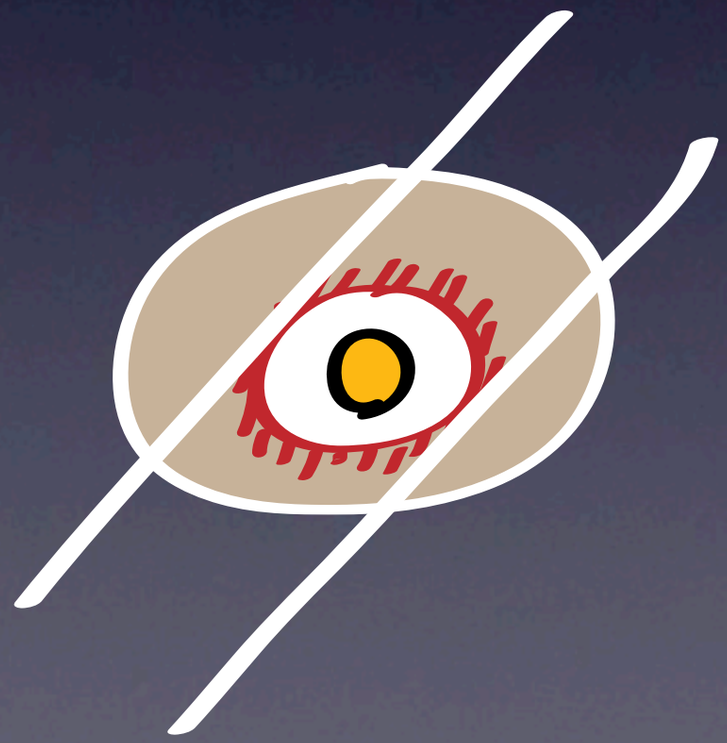
CRIRES

$r_g <$ slit



METIS

$r_g \sim$ slit

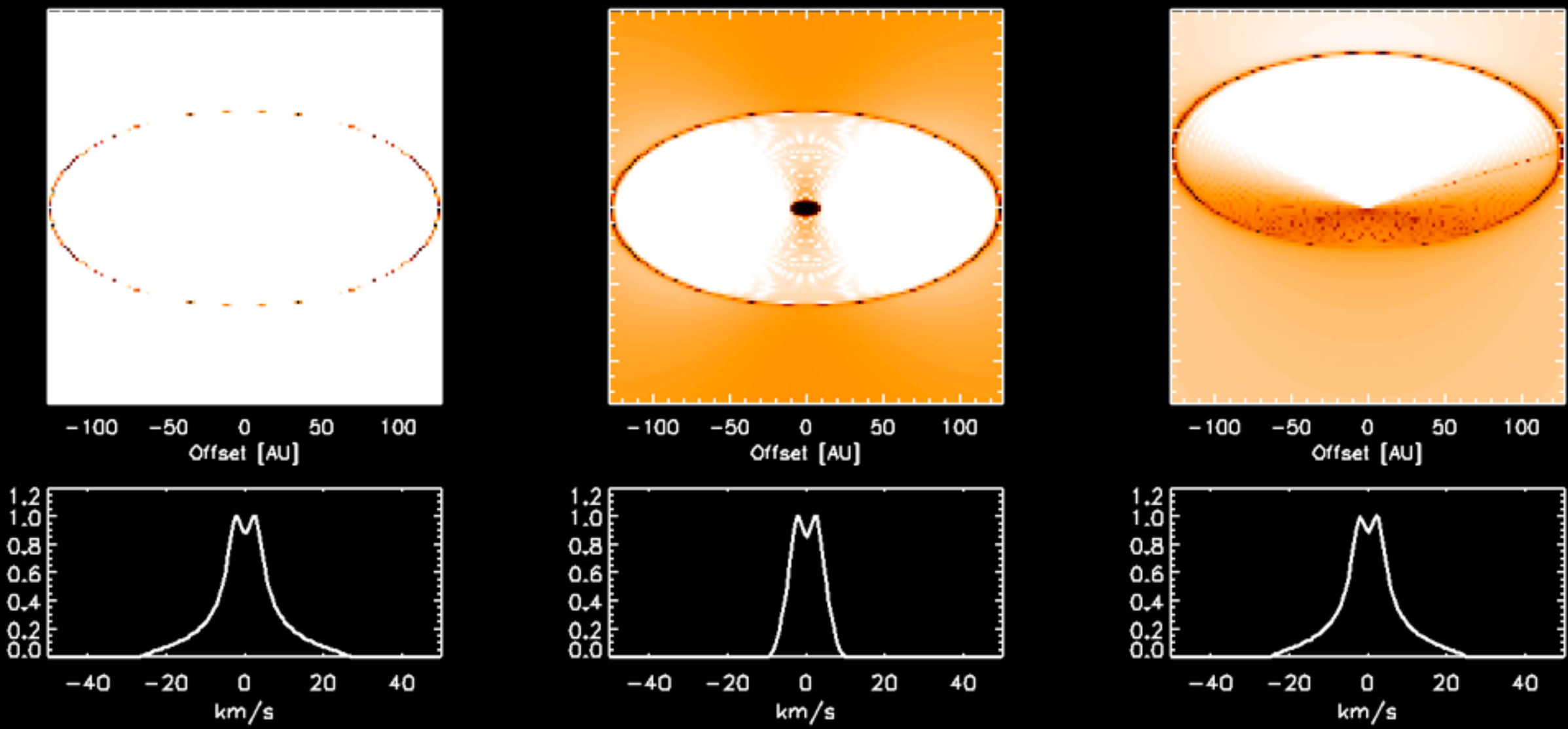


Slit vignetting

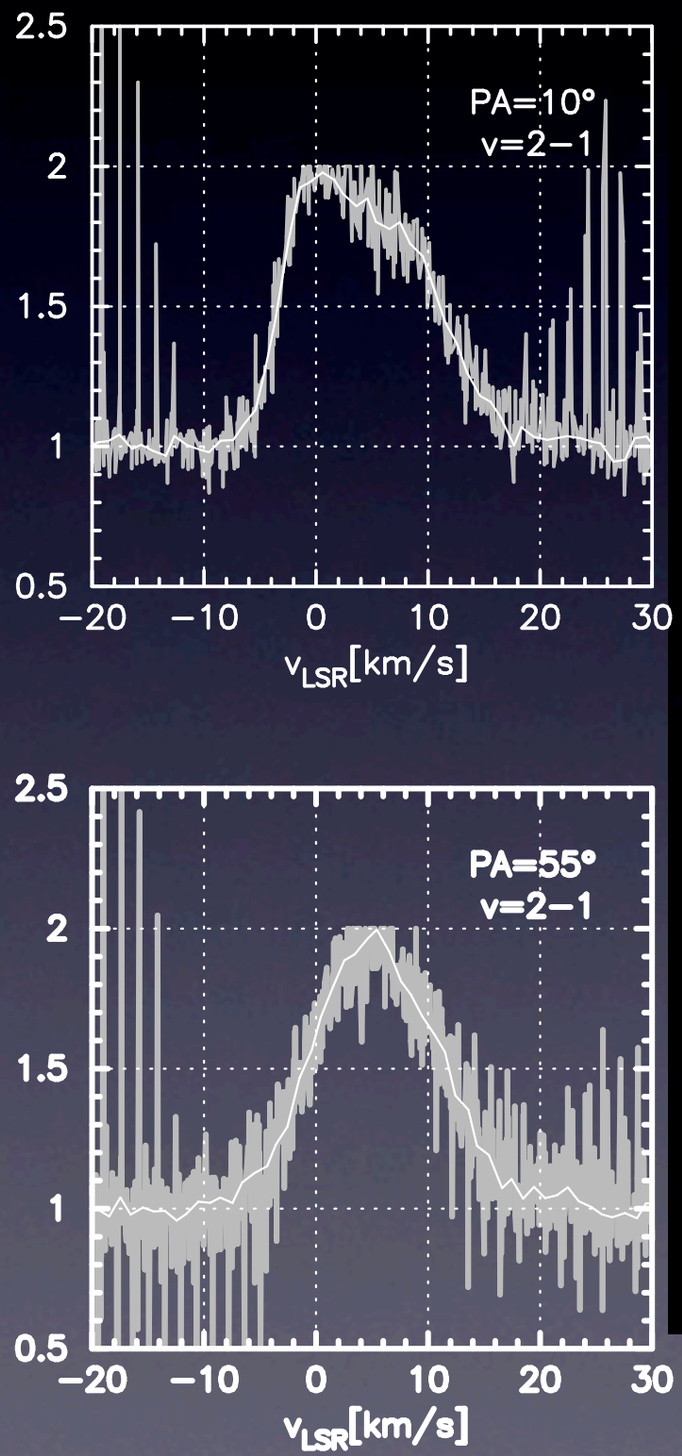
full disk

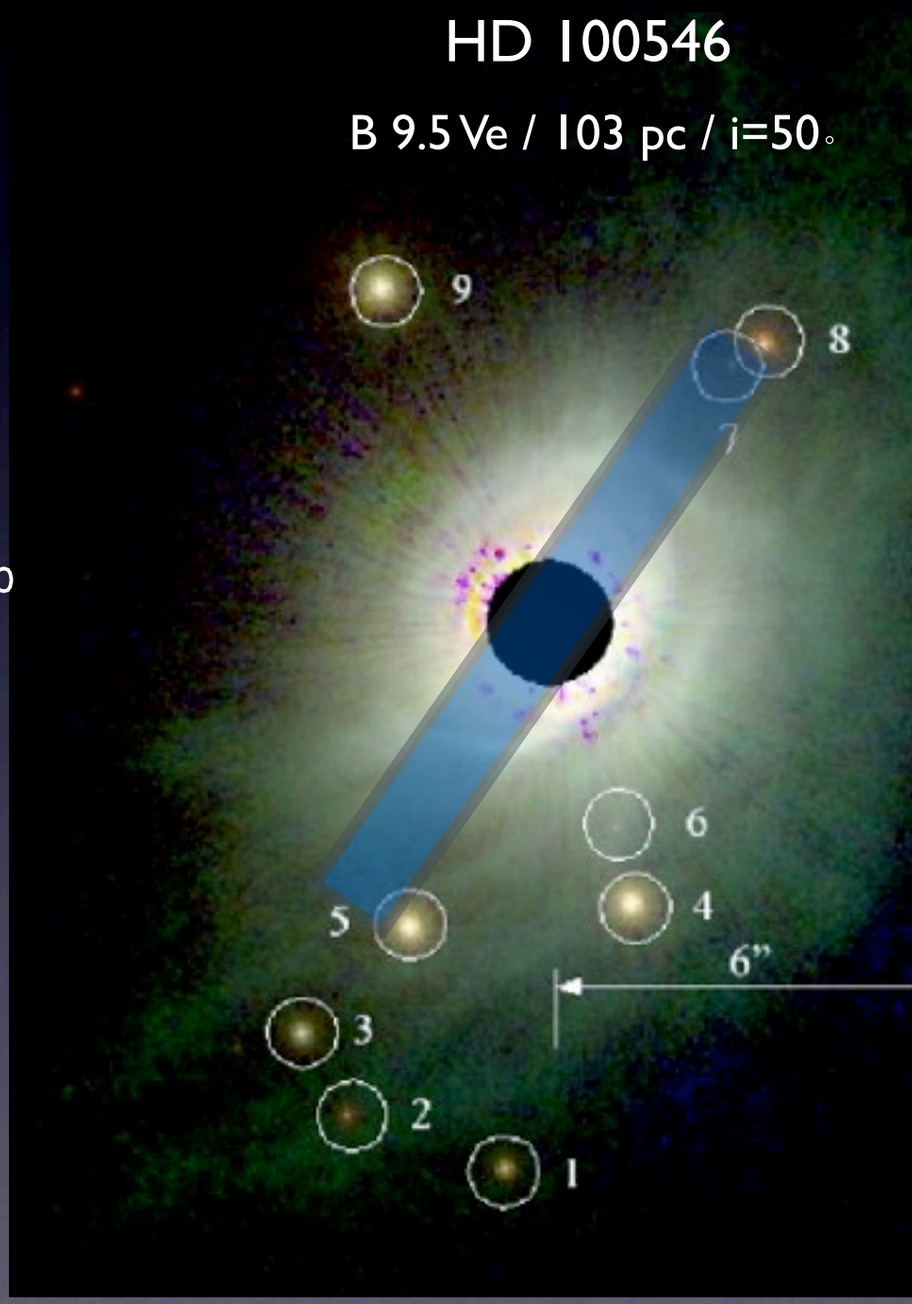
truncated disk

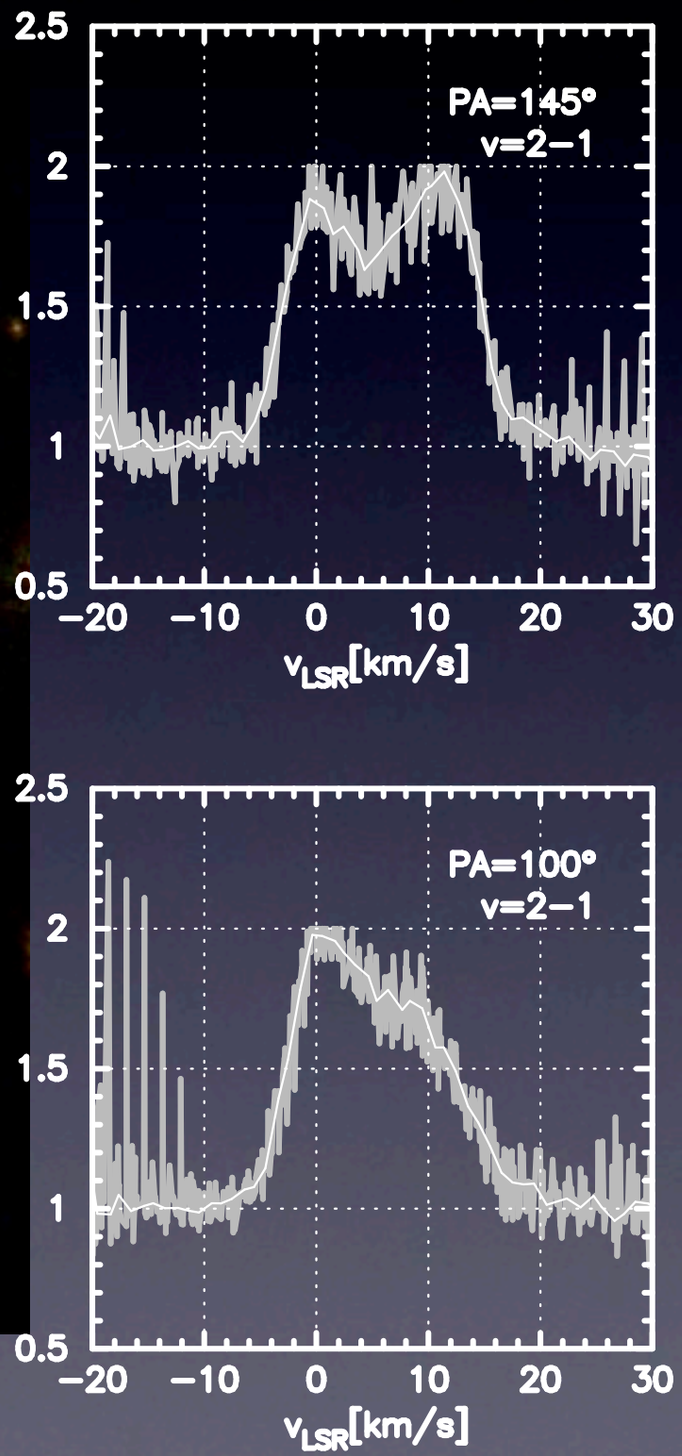
flared disk



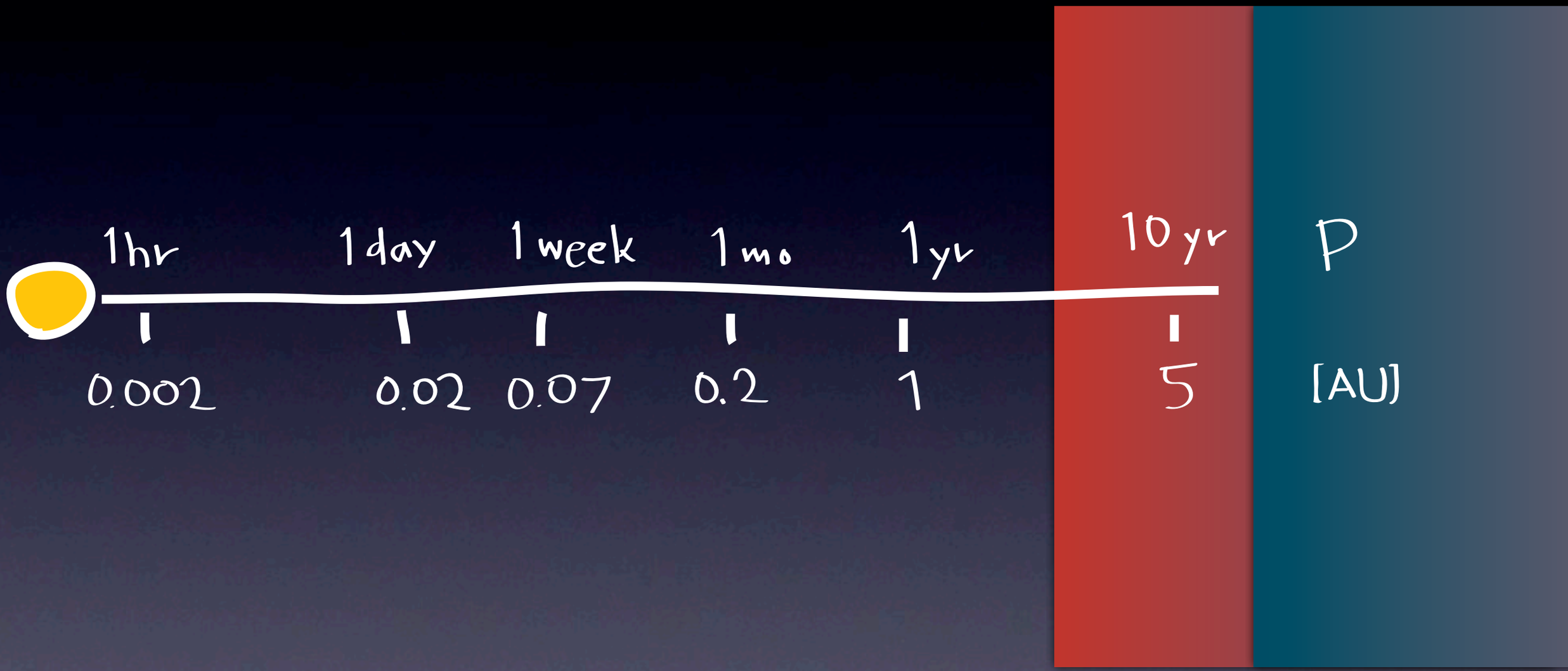
CRIRES observation





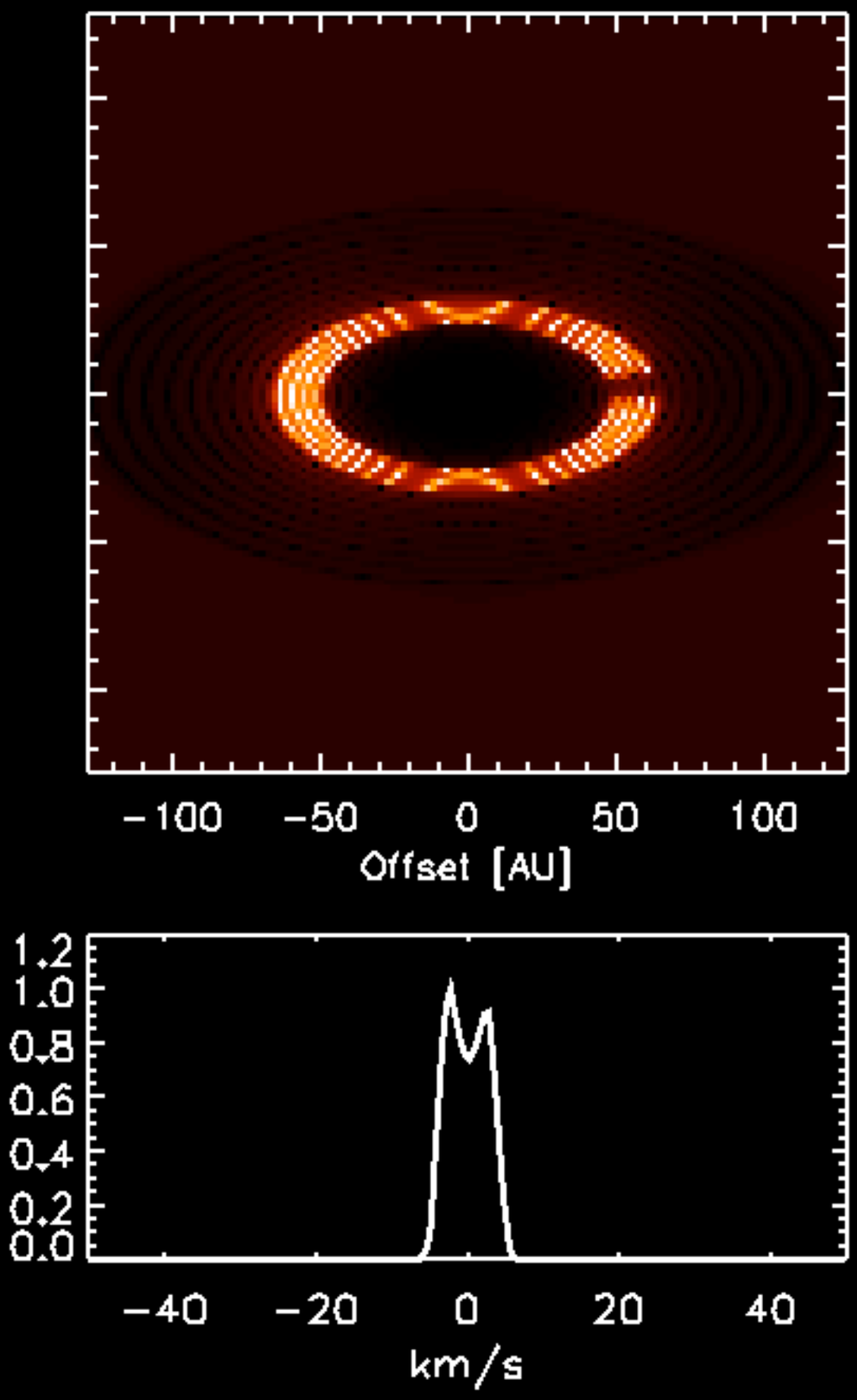


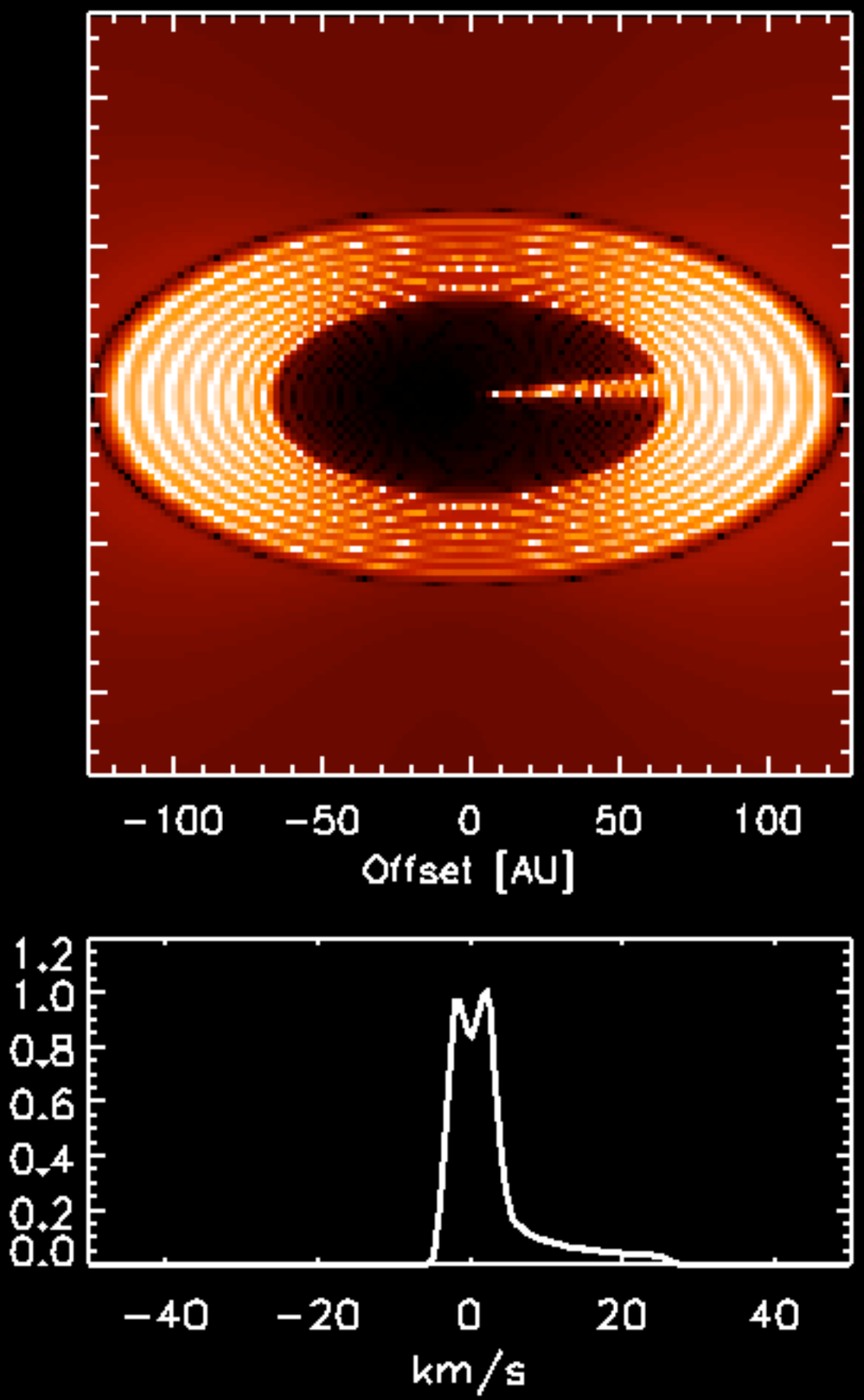
Orbital time scale



Monitoring

Ring-gapped disk





Monitoring

Bridged disk

this only makes sense
when we can guarantee
slit vignetting is not an issue
IFU is a must

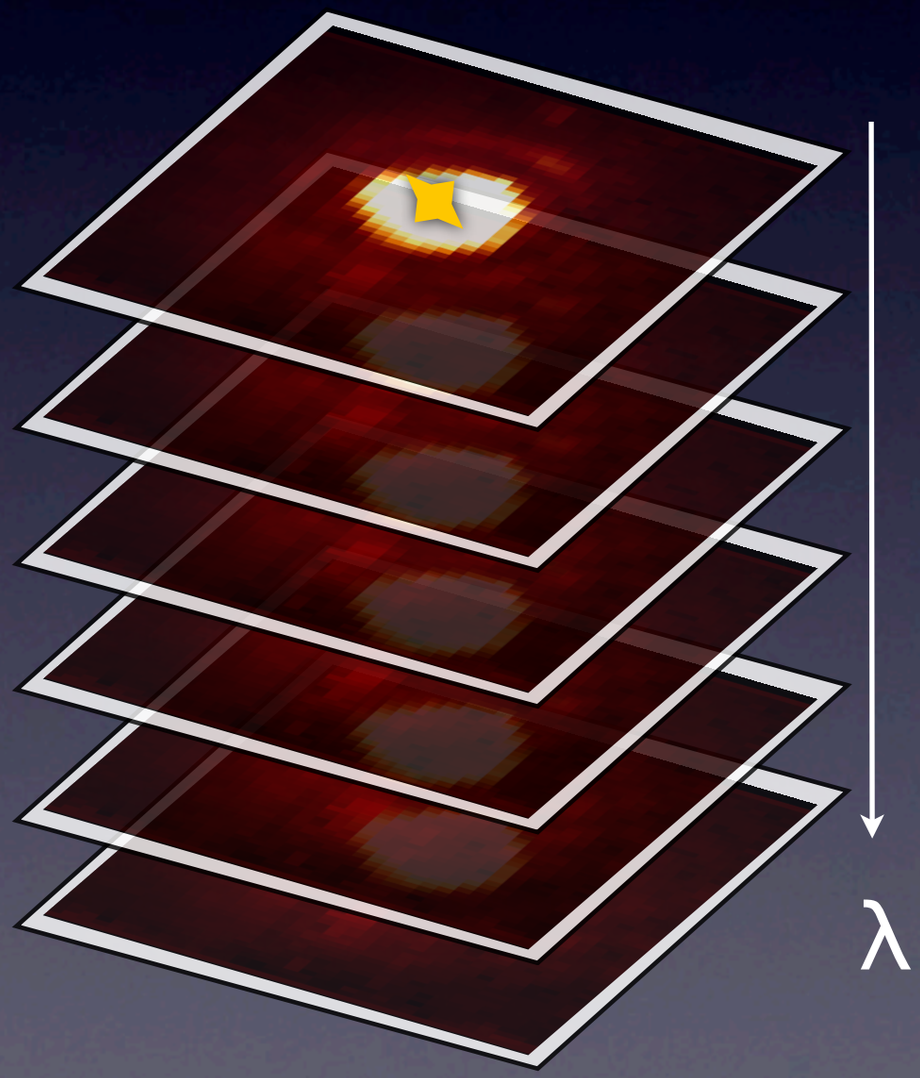
unless slit repeatability
accurate << 1 mas

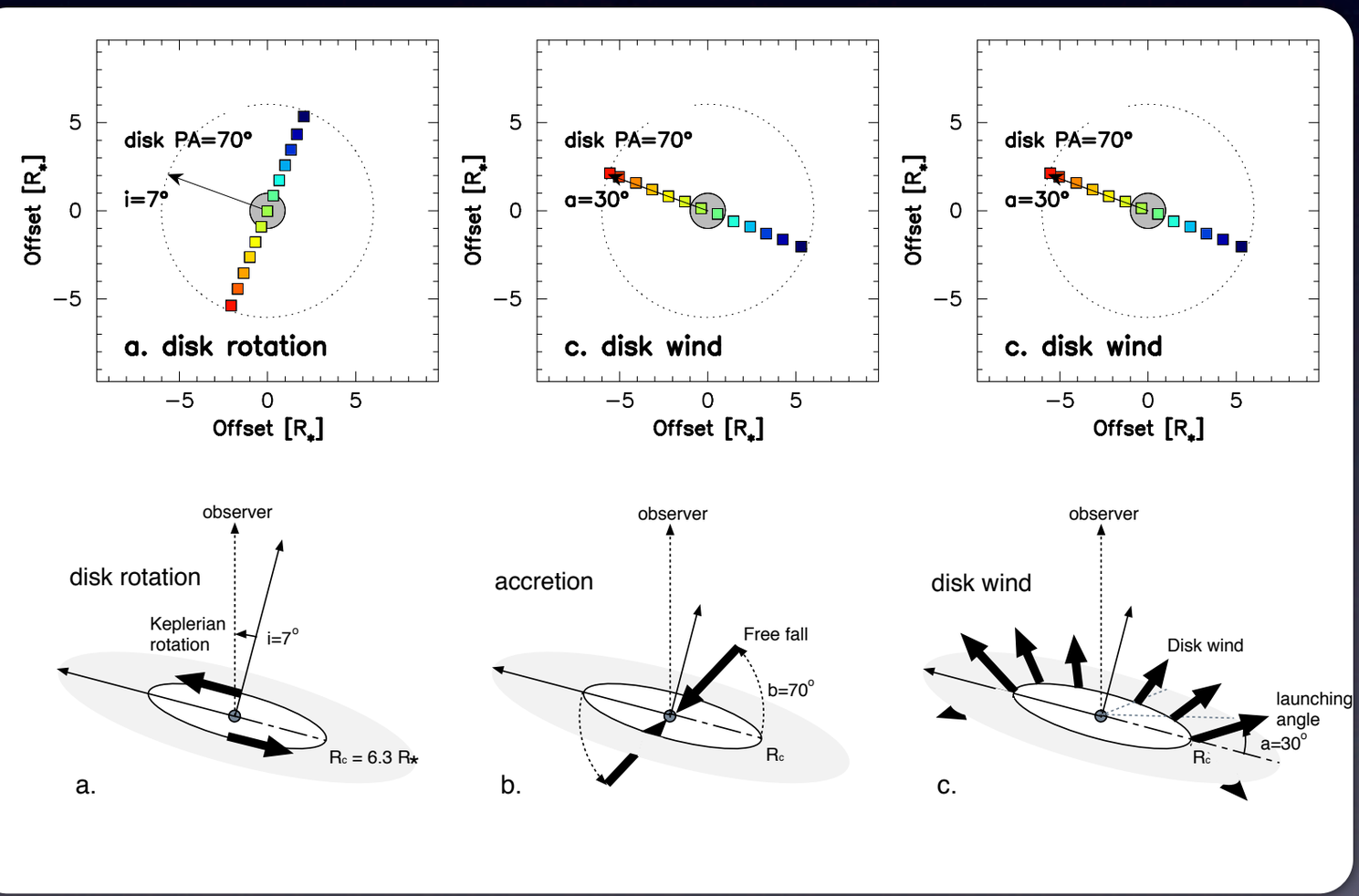
📌 otherwise hundreds of
fake planets to be discovered

Spectroastrometry

Lesson learned from SINFONI

- 2D astrometry



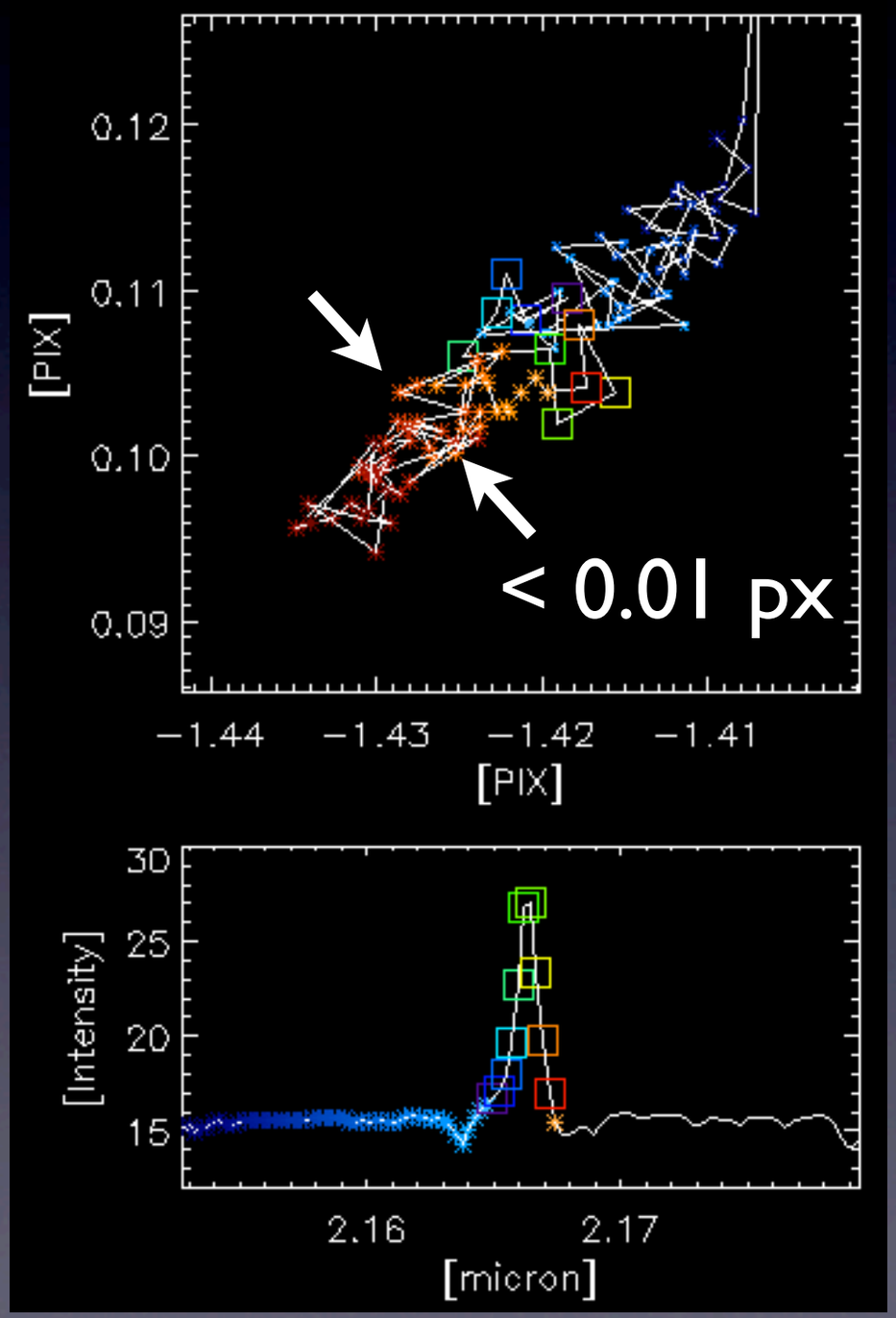


2D Spectro-astrometry

advantage

- signal high
- ~100% slit through put
- precision high ~ $\sqrt{N}$
- less influence of slit defect
- less influence of PSF variation

Precision achieved

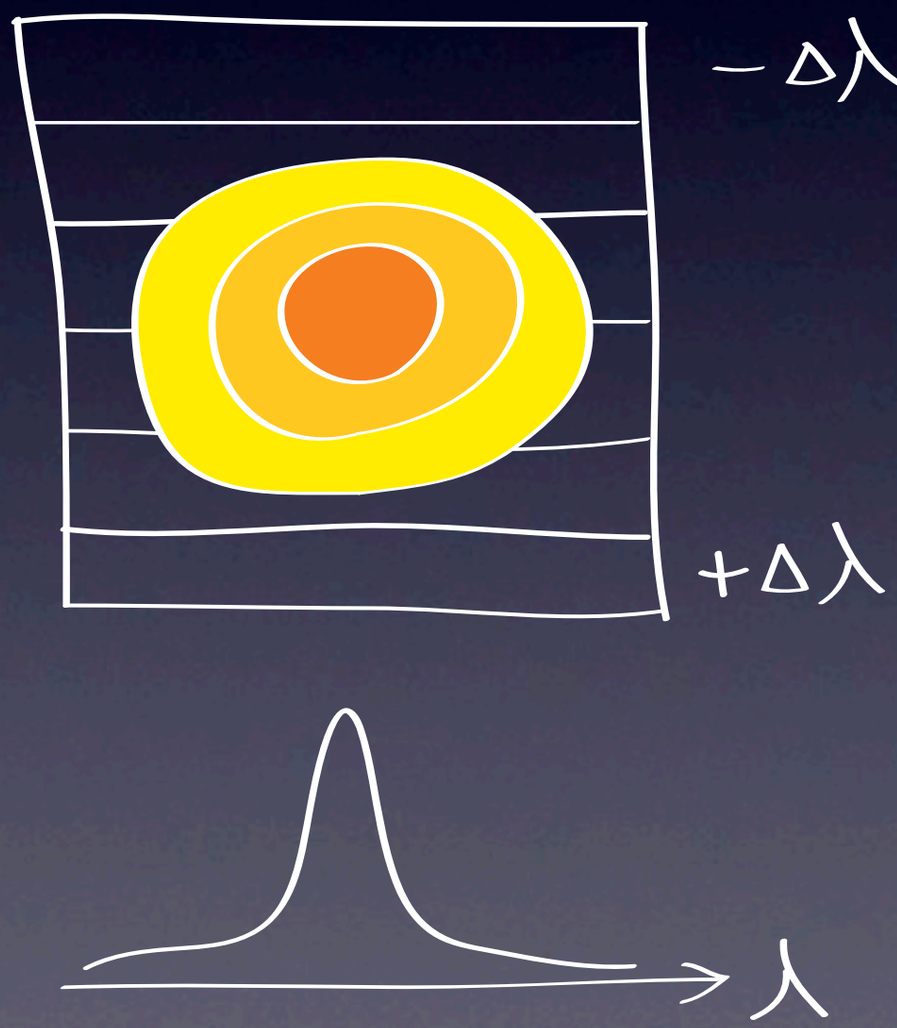


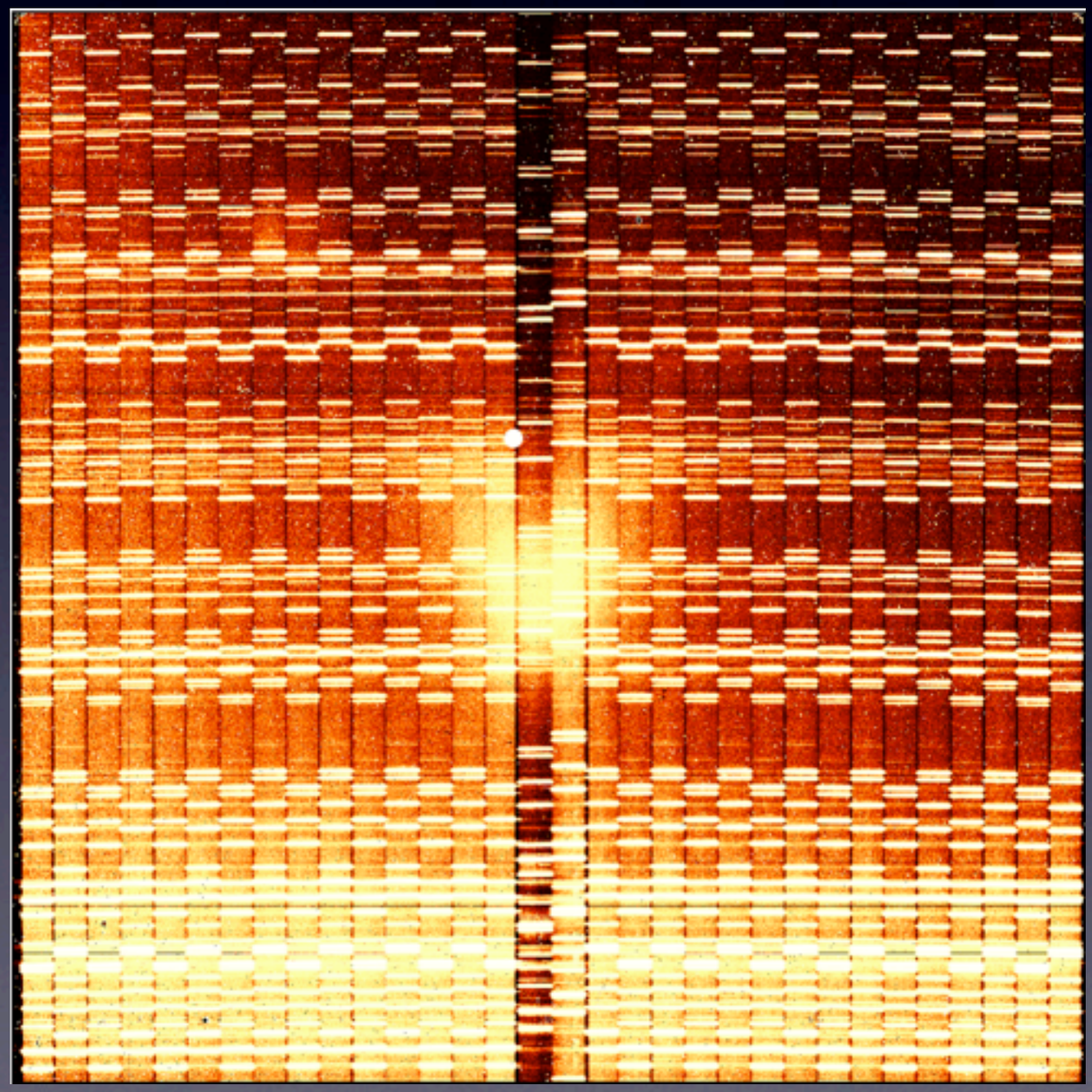
< 0.01 pix precision routine (100 uas)

= 12.5 mas x 0.01 x 150 pc
= 0.02 AU
= 4 Ro

Astrometric precision

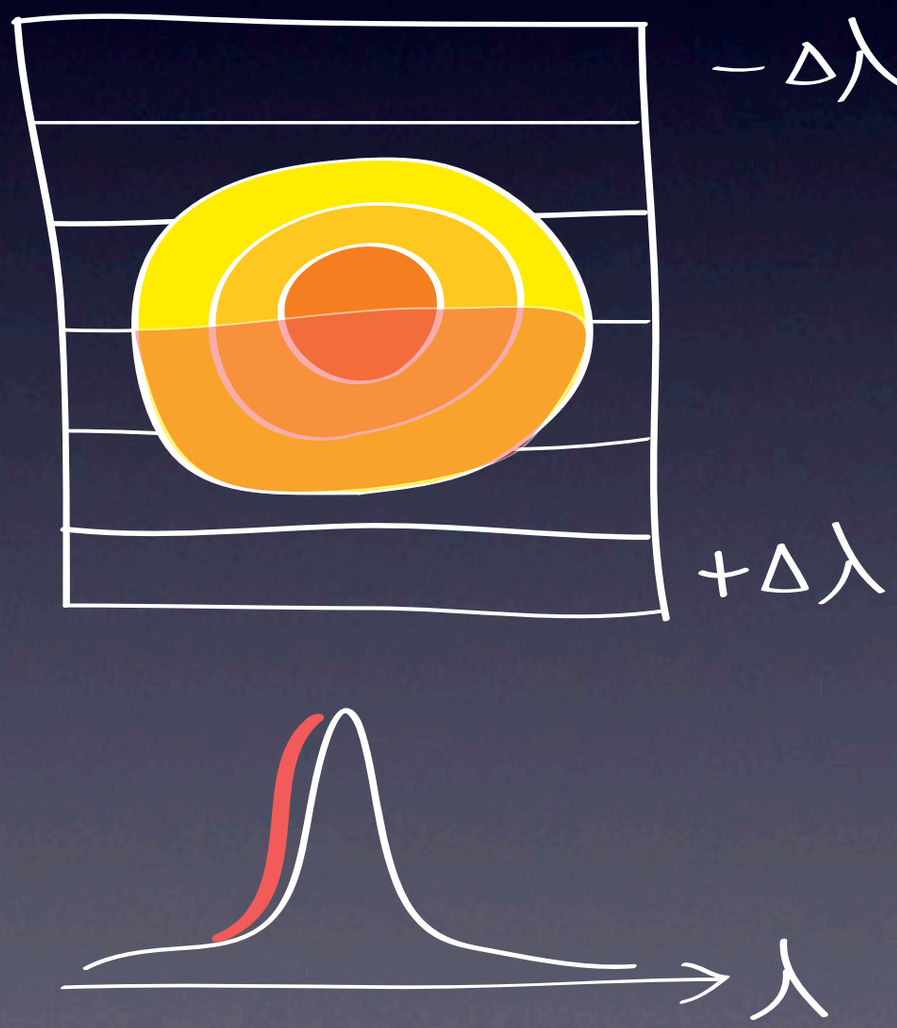
is wavelength calibration precision

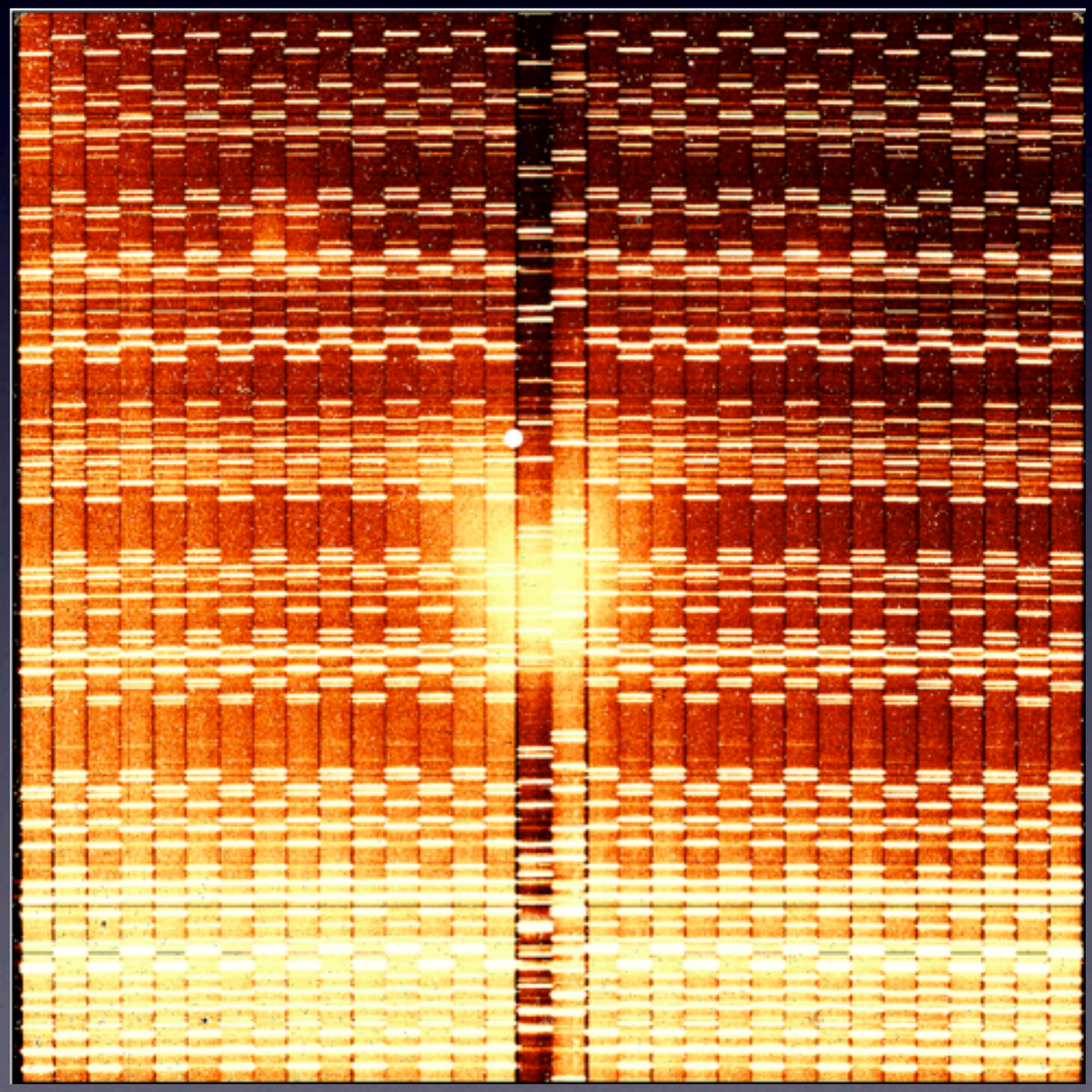




Astrometric precision

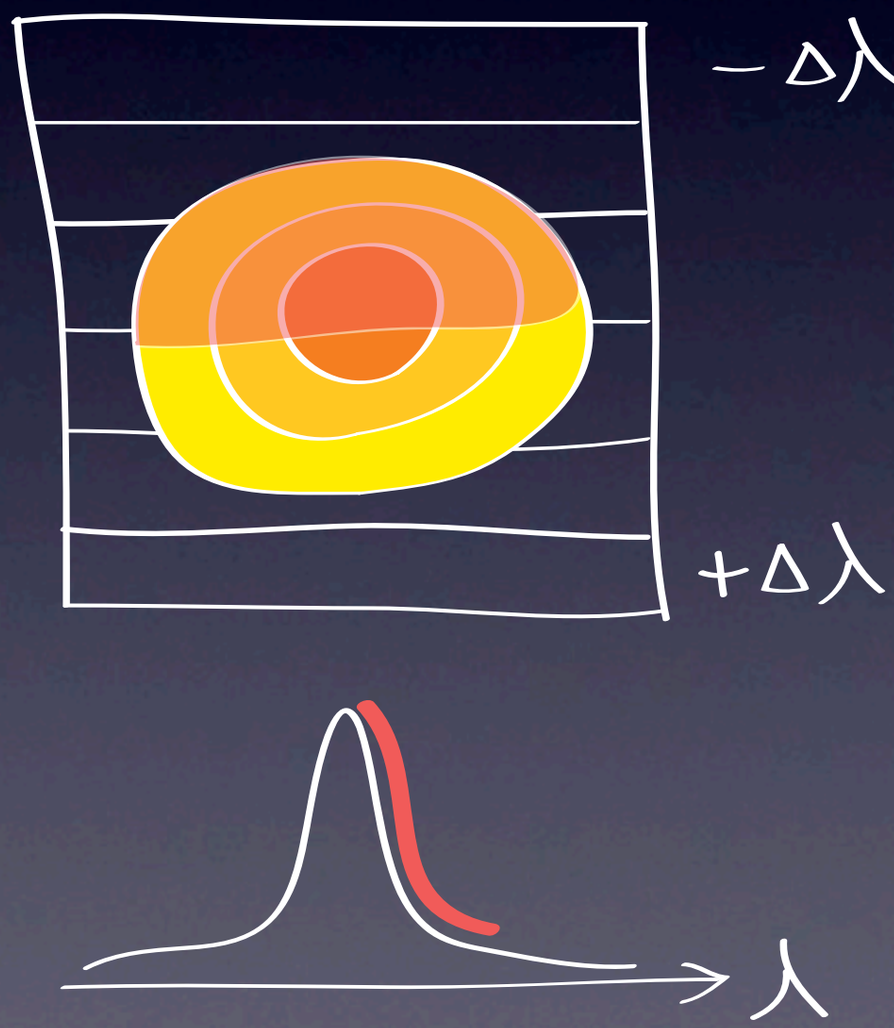
is wavelength calibration precision

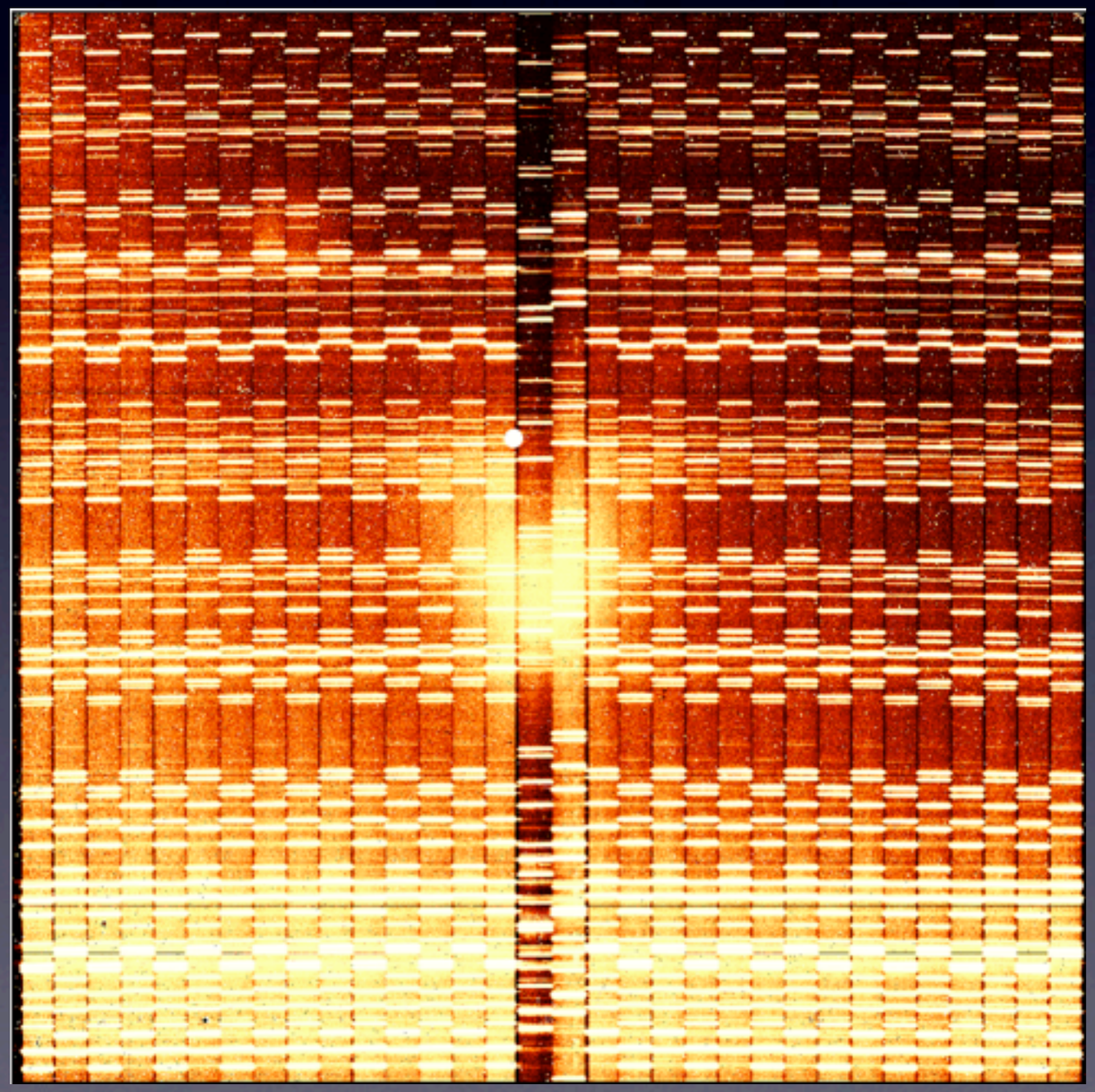




Astrometric precision

is wavelength calibration precision

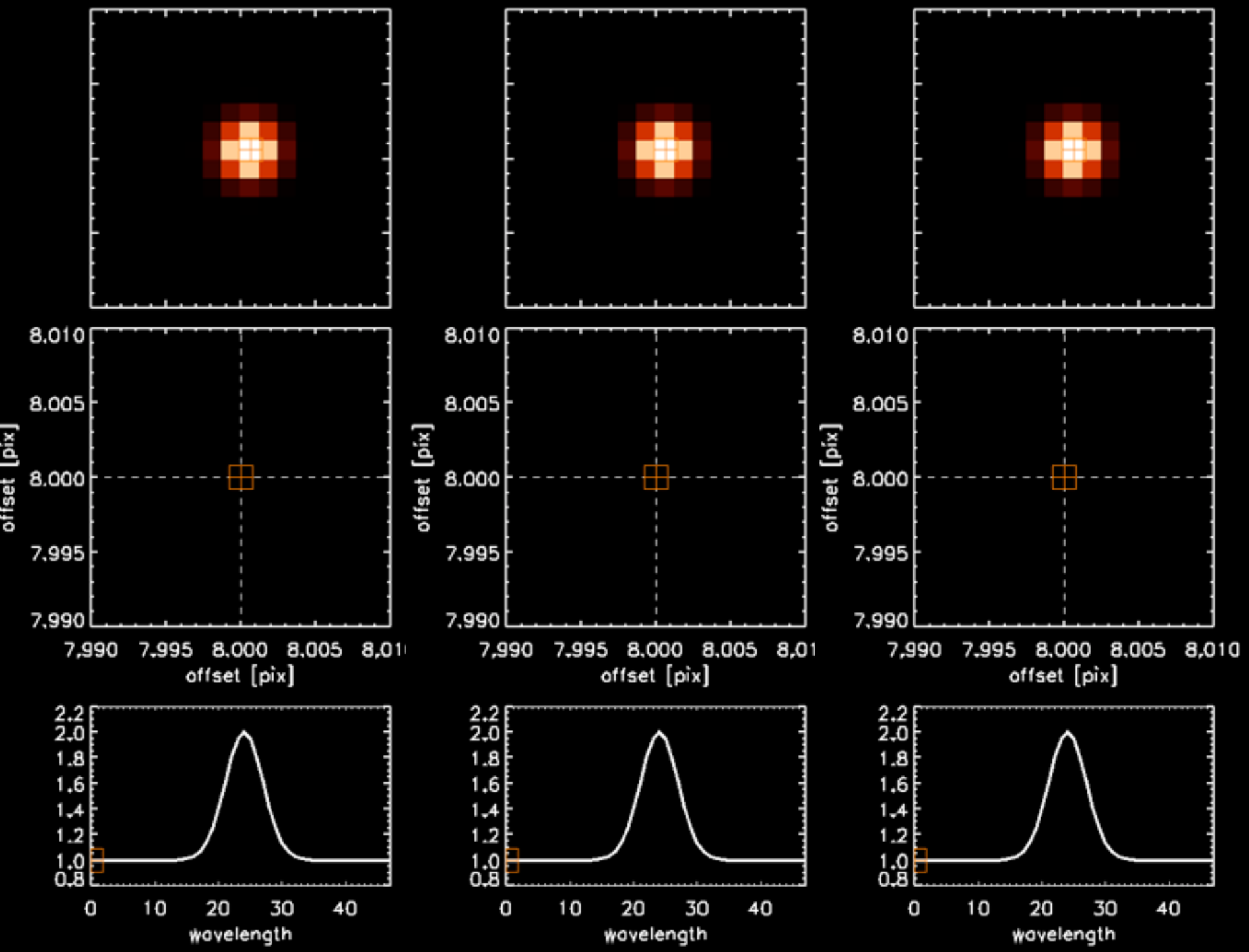




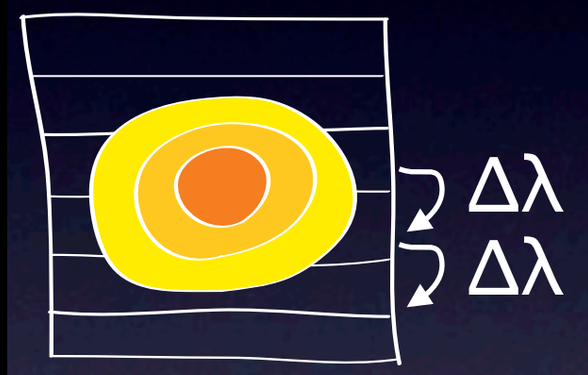
Δλ=0.00 pix

Δλ=0.01 pix

Δλ=0.05 pix



astrometric precision ~ 0.12 x Δλ

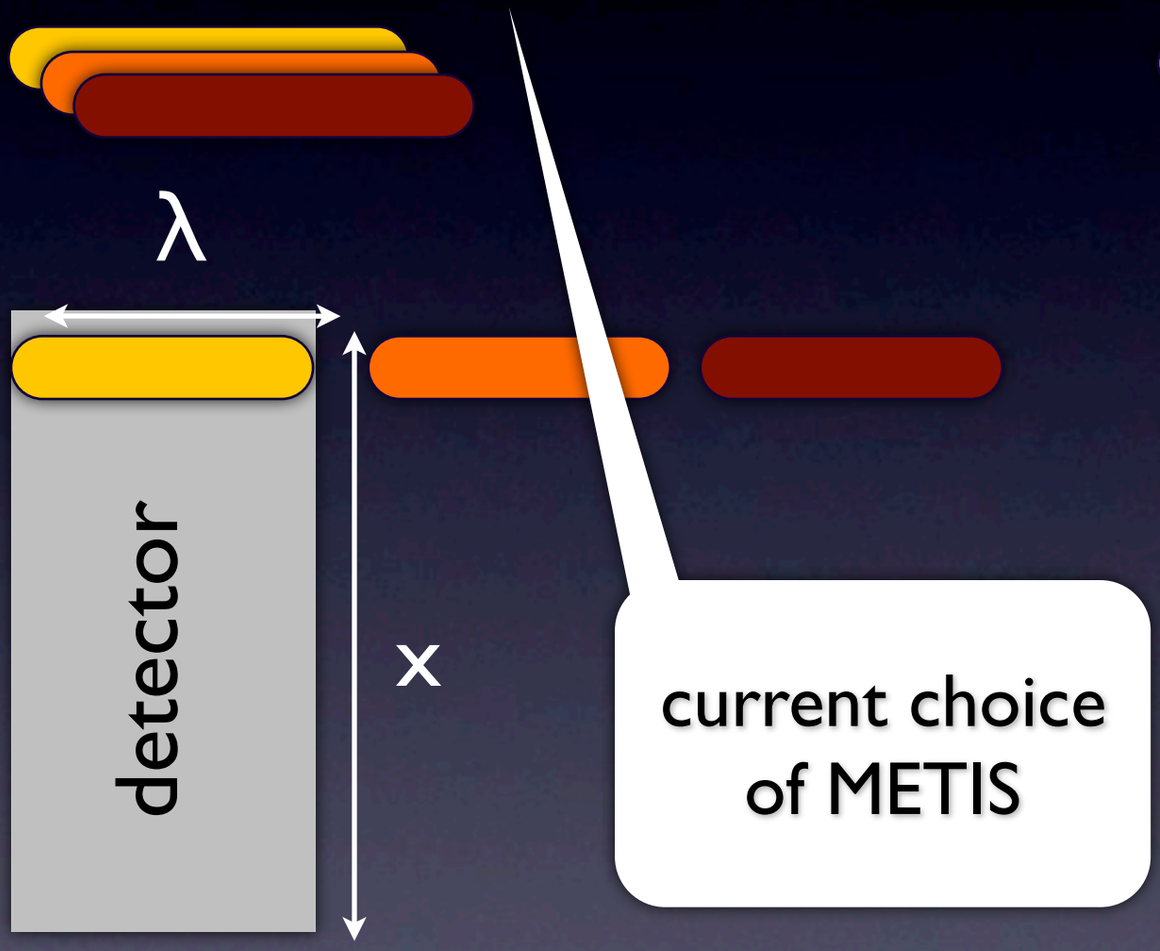


0.01 pix precision astrometry

0.1 pix precision wavelength calibration

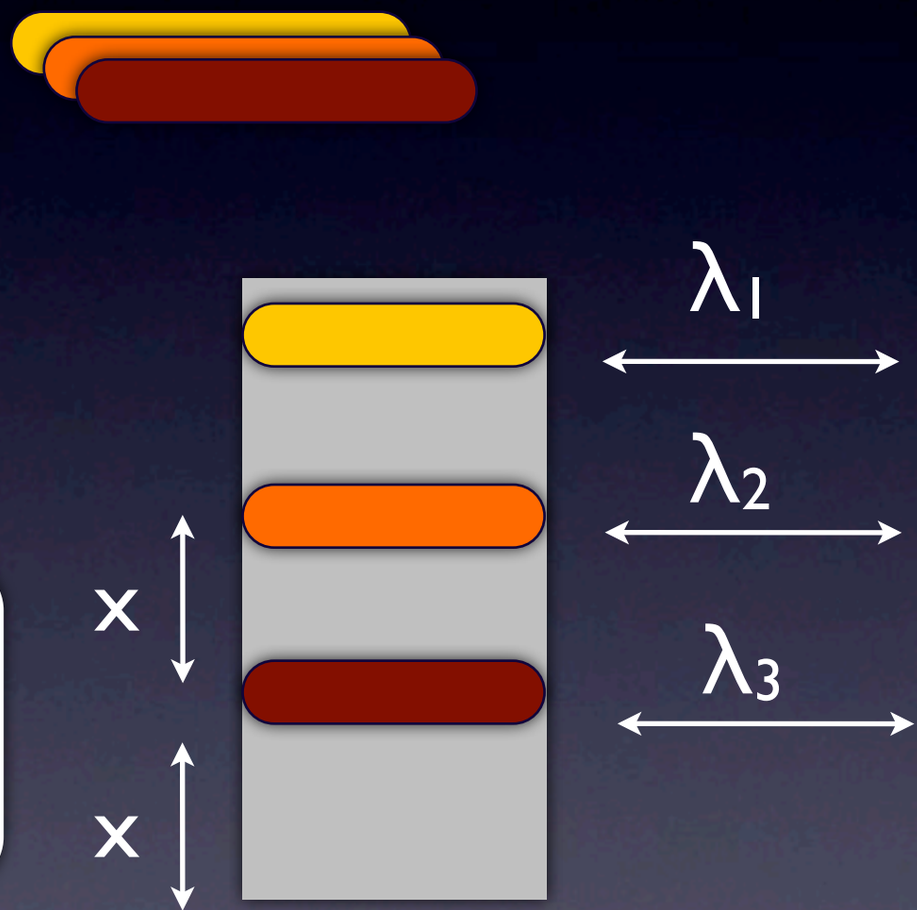
METIS pre-disperser

parallel dispersion



λ coverage: small
x coverage: large

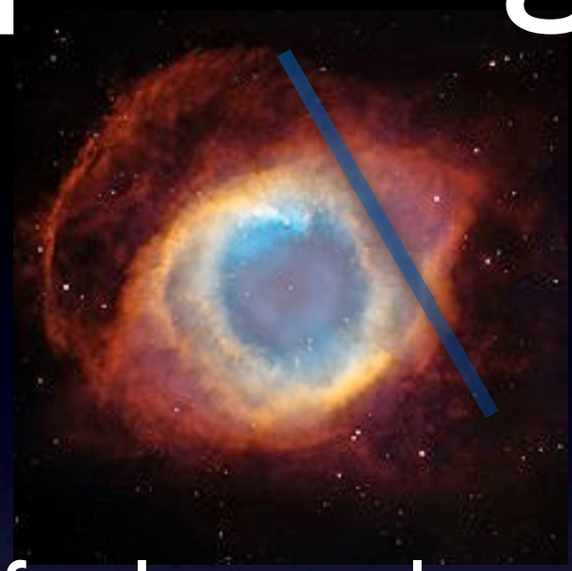
cross-dispersion



λ coverage: large
x coverage: small

METIS cross-dispersing mode

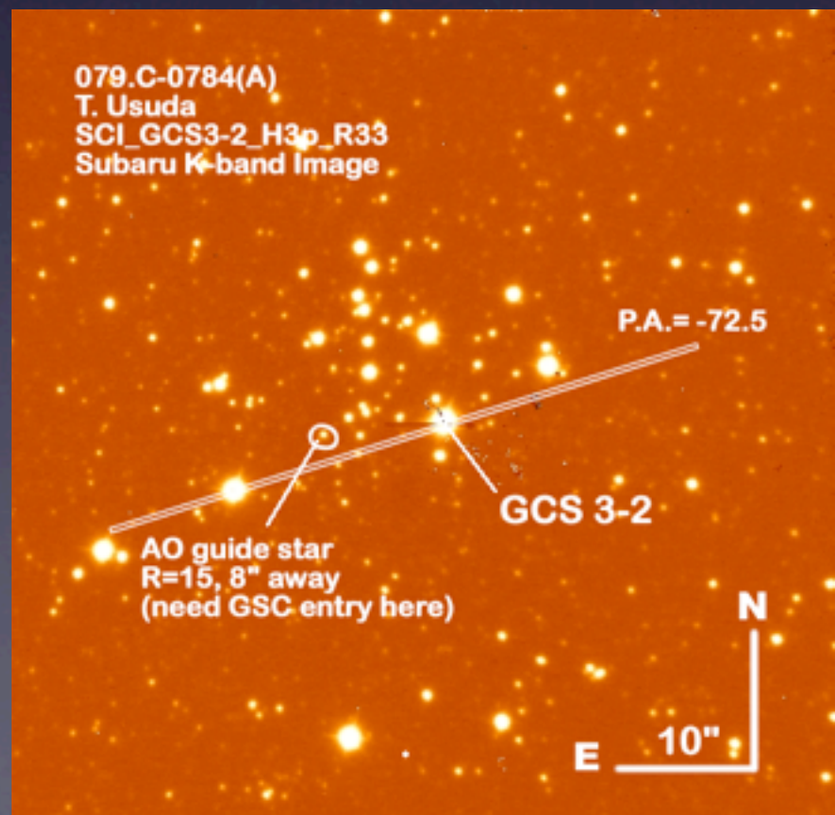
spatial coverage >> wavelength coverage
really?



- extended object
  - photon bucket ~D^2
  - $B\lambda$/pix ~ D^{-2}

no good target for large telescope
in terms of sensitivity

- multiple objects
  - high precision PA in advance
  - high precision proper motion
  - adjusting PA = re-acquisition = 10 min
  - 1/4 (personal success rate)



Wavelength coverage

- R=100,000

  - we are dealing with gas

  - molecules. (⟷ hydrogen and other atoms)

  - vibrational **band**

    - C-H (CH_4, C_2H_2, etc)
    - O-H (OH, H_2O, etc)
    - C=O (CO, CH_3OH, etc)

Every inch of wavelength coverage counts

10 years ago

2003 Nov, High resolution spectroscopy meeting at ESO

"Why CRIRES not cross-dispersing spectrograph?"

Alan Moorwood replied:

"CRIRES design took time with a long break in between. If we designed it now, we would do it differently."

now CRIRES being upgraded for cross-dispersing mode

did we learn anything?

Message again

- IFU is no extravagance
  - a must
  - because of vignetting by slit
  - slit ~ rg (gravitational radius)

- spectro-astrometry
  - tricky systematics from wavelength calibration error

- cross dispersing mode
  - not immediate implimentation
  - just make pre-disperser cross disperser for future