Astronomical imaging

(image formation, atmospheric turbulence, intro to adaptive optics)

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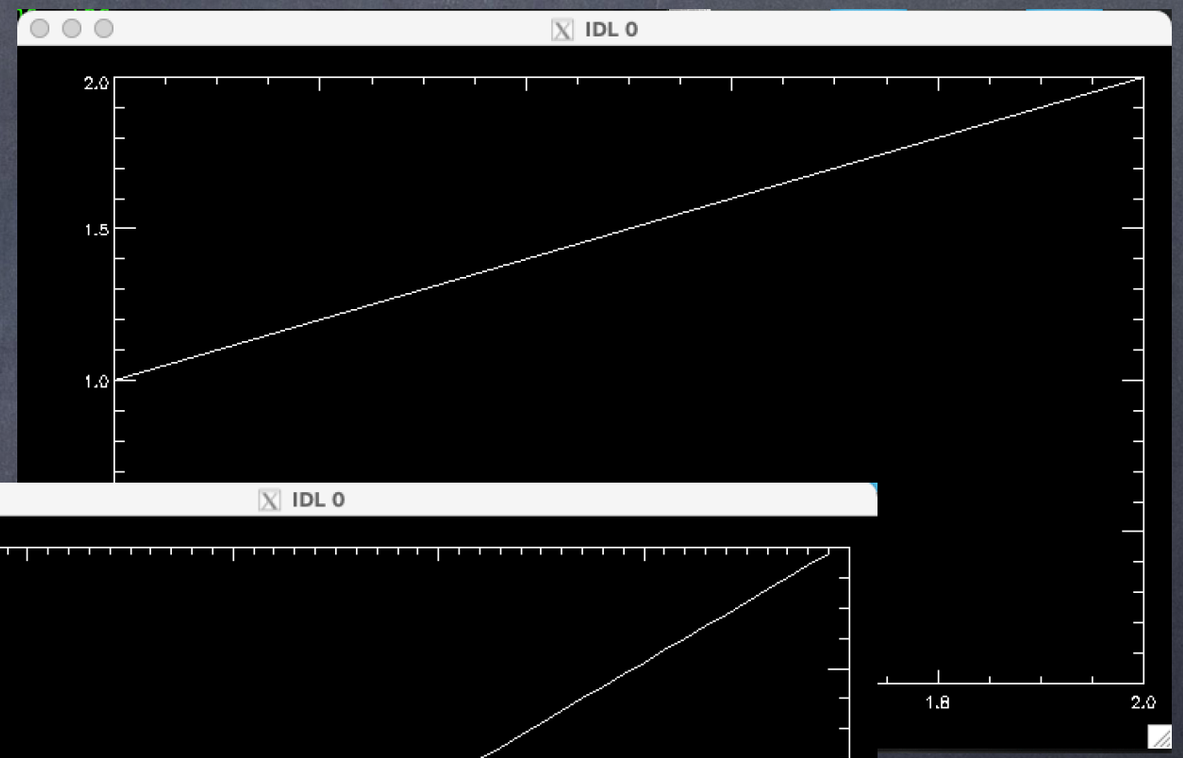
Menu

- High-angular resolution imaging in astronomy
- Atmospheric turbulence
- Numerical modelling of perturbed wavefronts
- Formation of resulting images (+detection noises)
- *(Introduction to speckle interferometry)*
- Introduction to adaptive optics (AO)
- AO error budget
- Post-AO point-spread function morphology
- Anisoplanatic error study (ideal AO system)

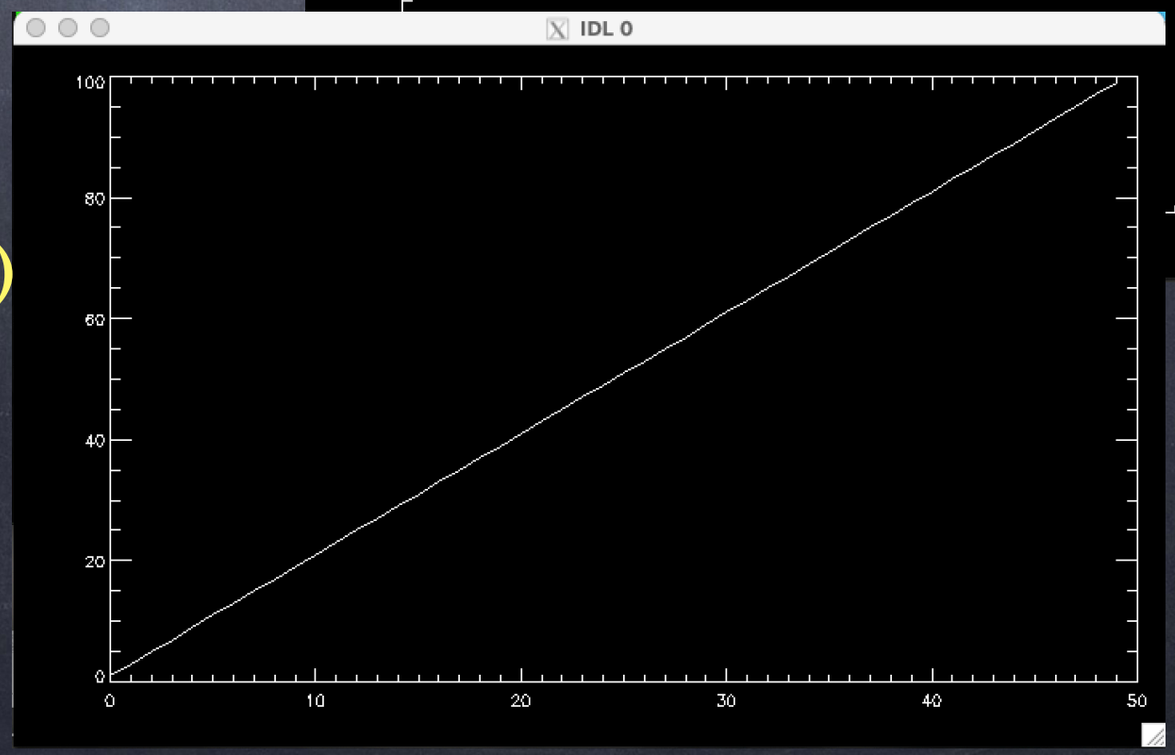
(IDL stuff – 1)

- launch IDL (or IDLDE=IDL+interface), on zztop (+VPN launched before), with ssh -Y

- test it:
  IDL> print, ‘hello’
  IDL> plot, [1,2], [1,2]



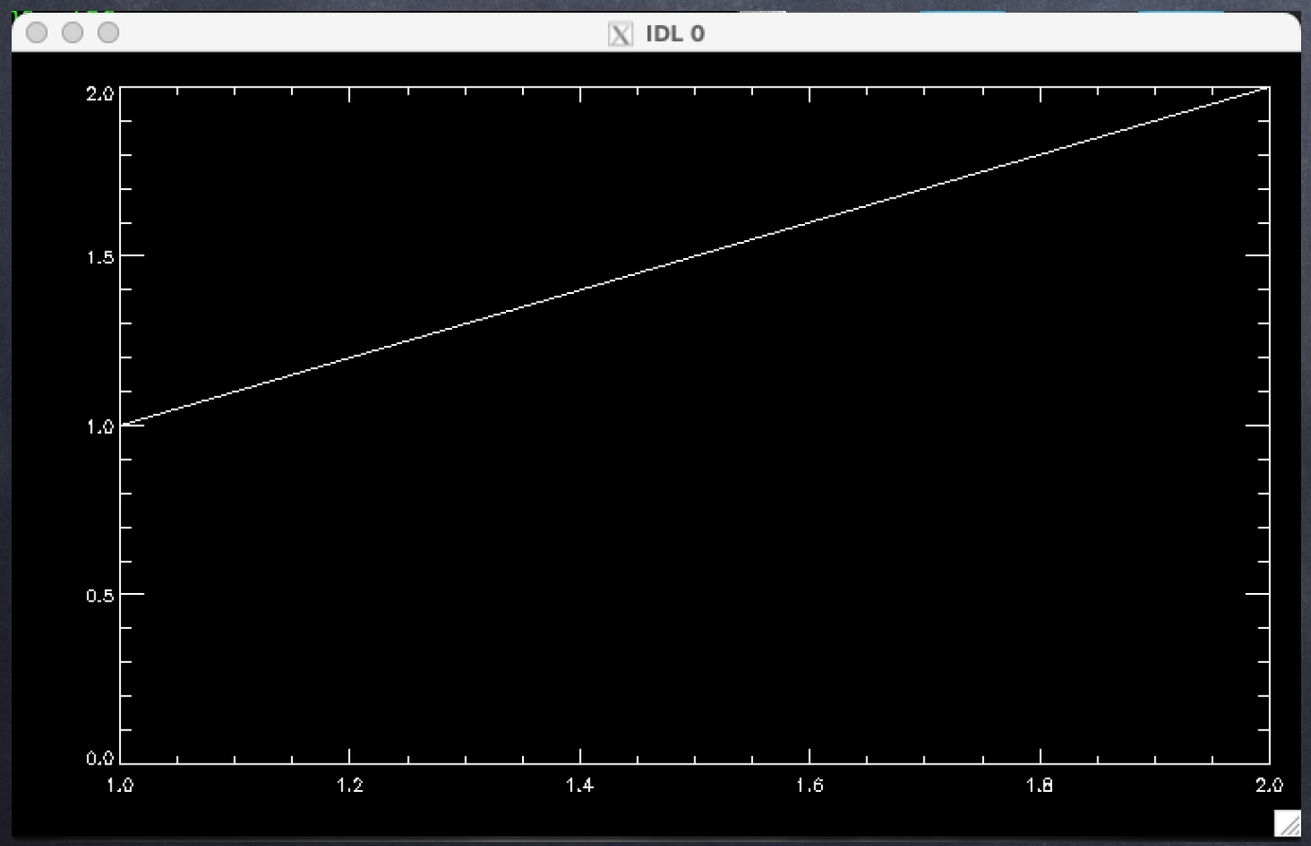
- test it more:
  IDL> xx=findgen(50)
  IDL> yy=2*xx+1
  IDL> plot, xx, yy

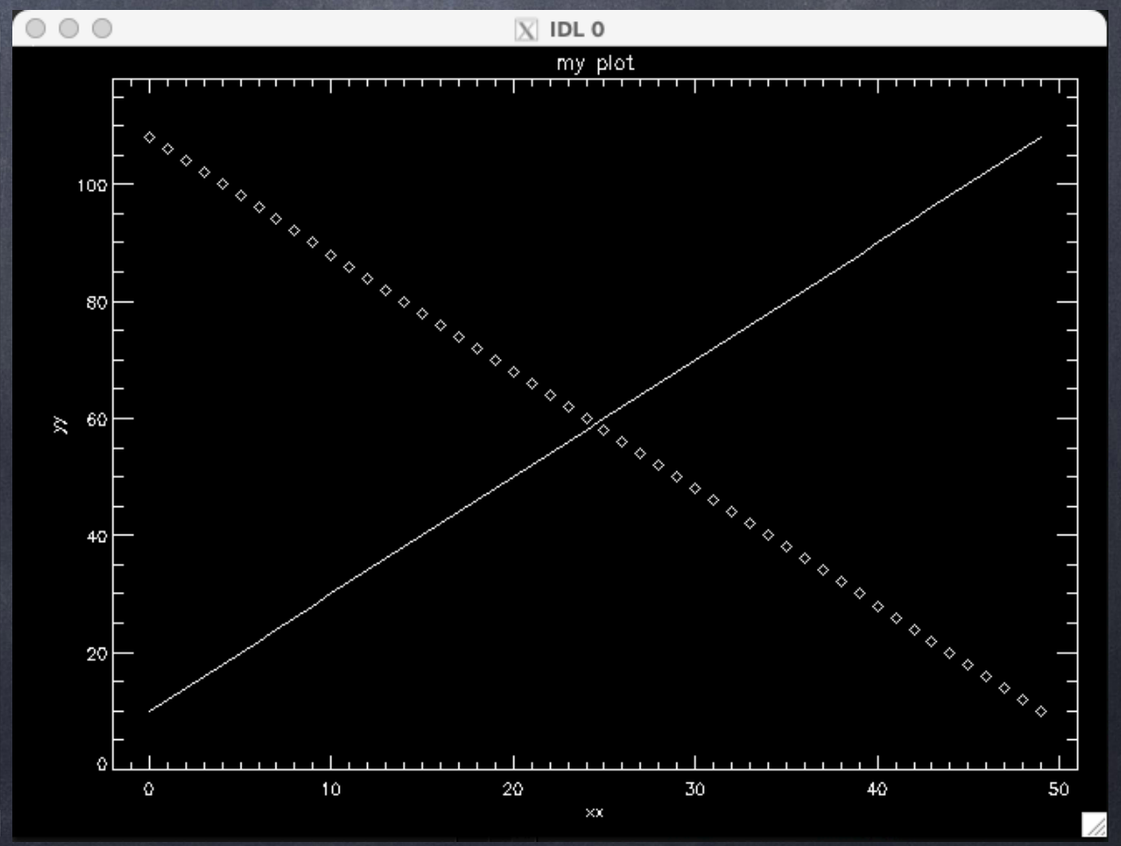


(IDL stuff – 2)

- test it more:

```
IDL> xx=findgen(50)
IDL> yy=2*xx+10
IDL> plot, xx, yy, TIT='my plot', XTIT='xx', YTIT='yy', $
                XR=[-2,51], /XS, YR=[0,118], /YS
IDL> oplot, xx, min(yy)+max(yy)-yy, PS=4
```

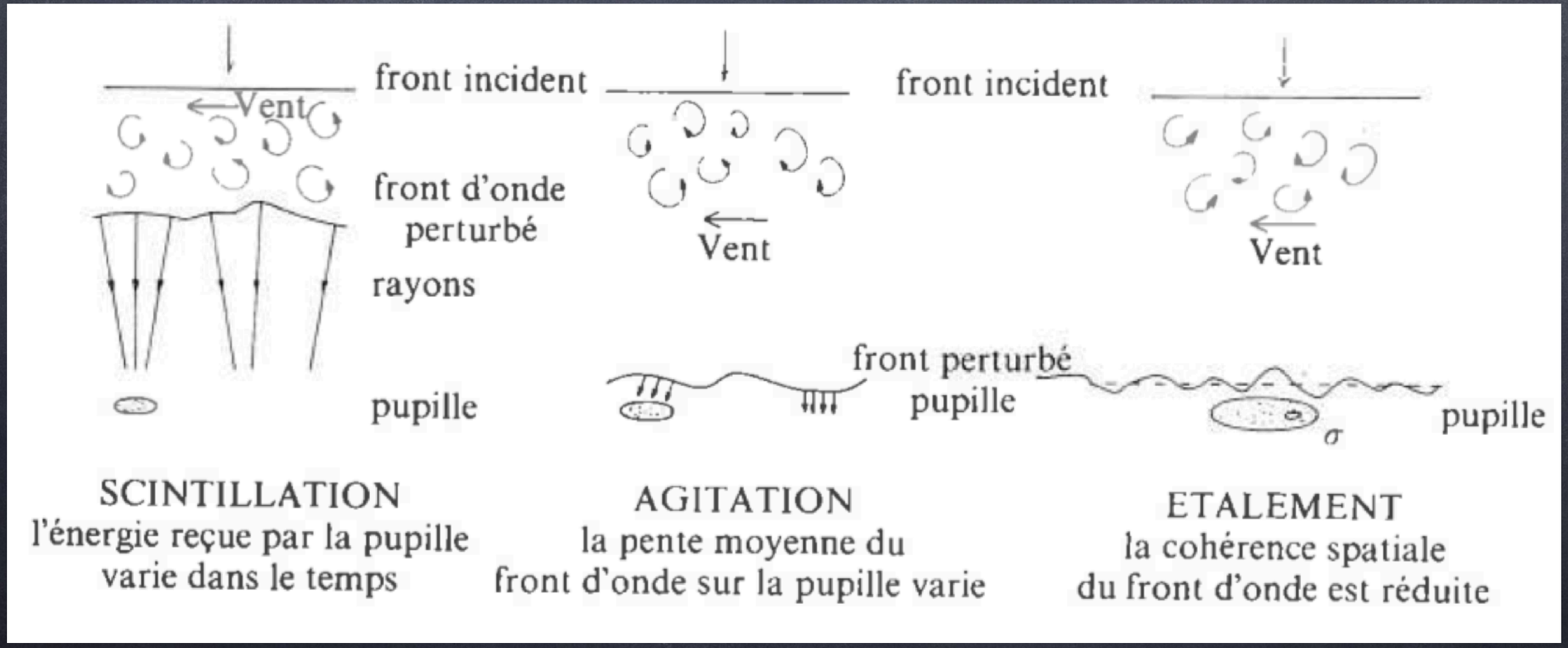




Images & turbulence — 01

The image formed through turbulent atmosphere (optically speaking) is degraded:

- Scintillation (due to intensity fluctuation in the pupil).
- Agitation (due to angle-of-arrival variation).
- Spreading (due to a loss of spatial coherence).



(Illustration from Pierre Léna, Astrophysique — Méthodes physiques de l'observation, CNRS Éd. (2me éd.), p.177)

Images & turbulence — 02

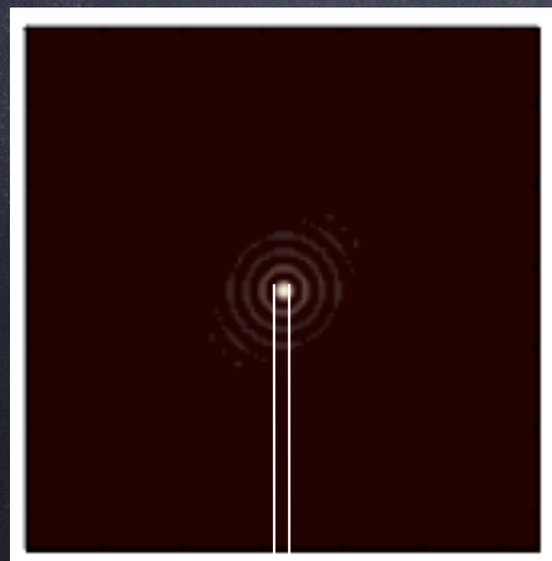
The object-image relation between the intensity $I(\alpha)$ in the image plane (i.e. the focal plane of the telescope) and the brightness $O(\alpha)$ of the object (in the sky) is a relation of convolution implying the point-spread function (PSF) $S(\alpha)$ of the whole ensemble telescope+atmosphere, with α the angular coordinates in the focal plane:

$$I(\vec{\alpha}) = O(\vec{\alpha}) * S(\vec{\alpha})$$

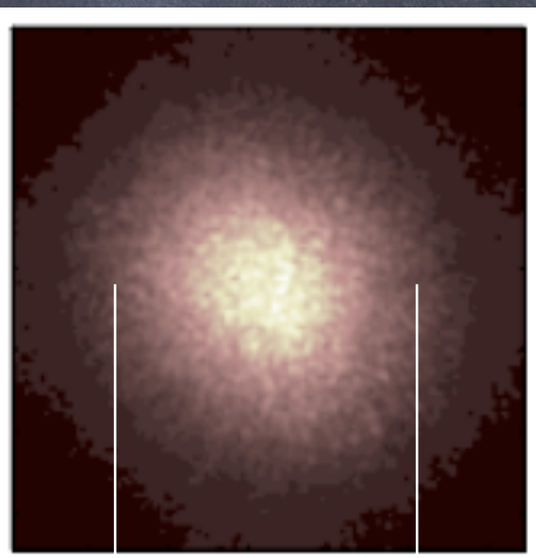
Images & turbulence — 03

$$I(\vec{\alpha}) = O(\vec{\alpha}) * S(\vec{\alpha})$$

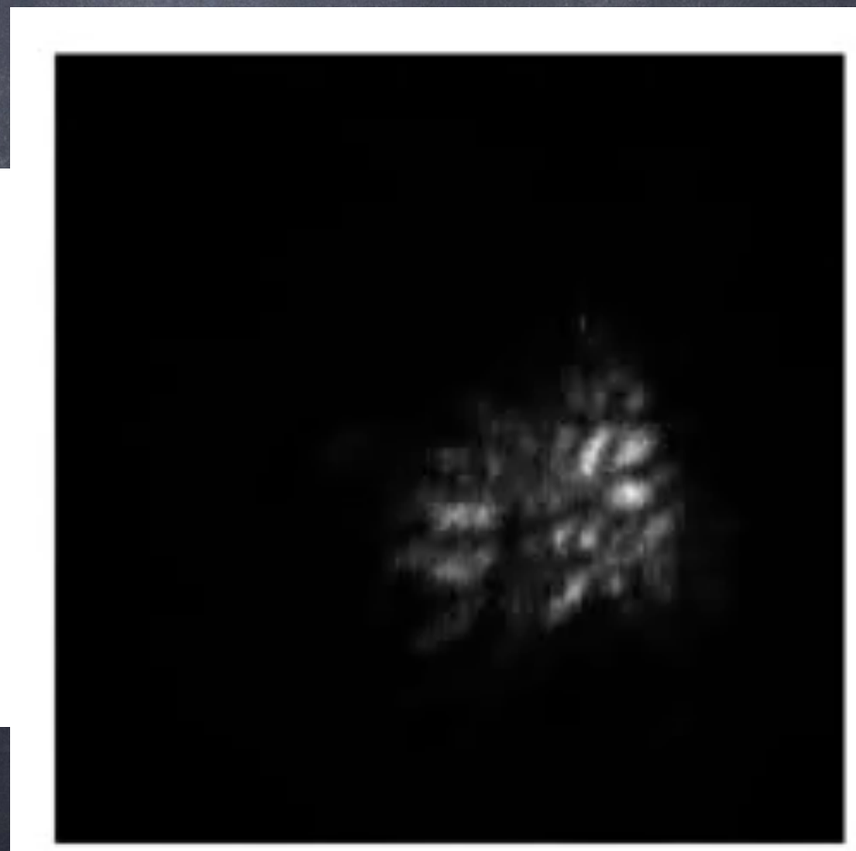
This relation is valid notably at the condition that the system is invariant by translation (everything happens within the isoplanatic domain)...



λ/D



λ/r_0

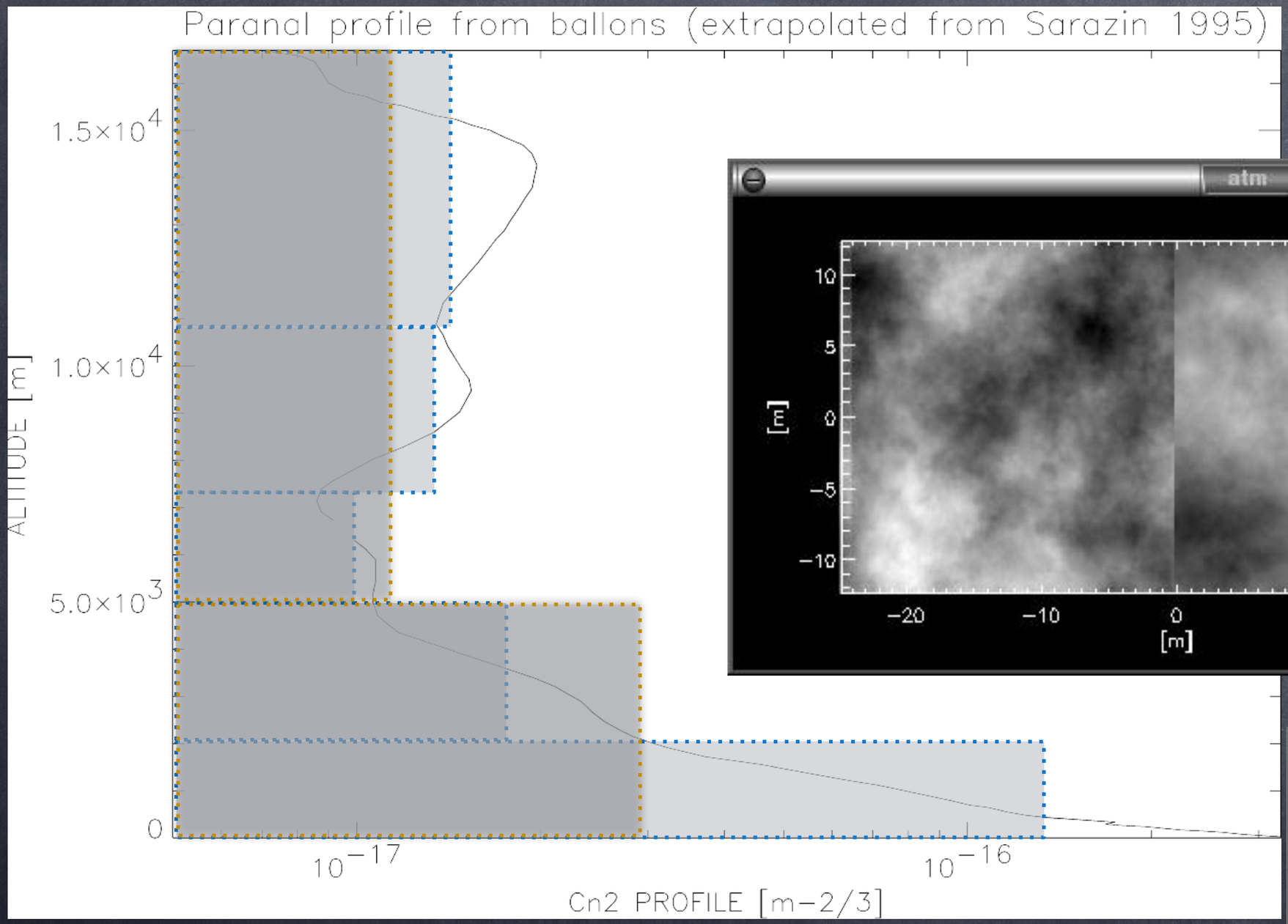


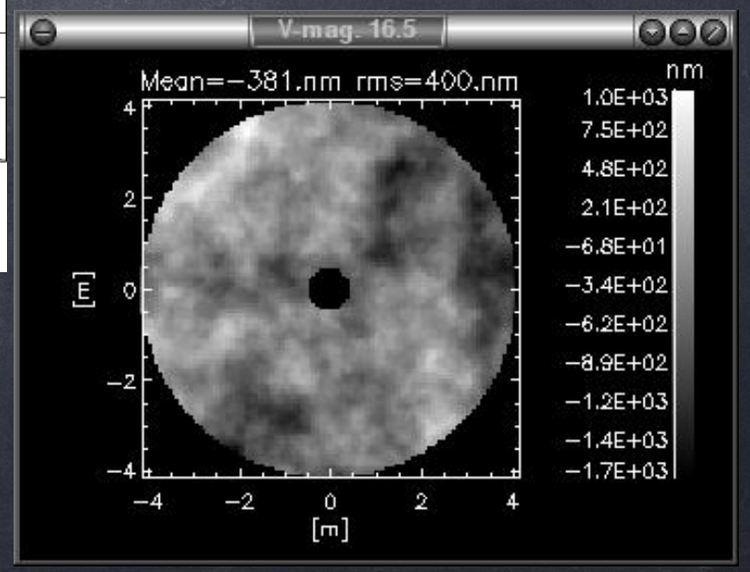
Images & turbulence — 04

Some orders of magnitude concerning the turbulent atmosphere:

	λ = 500 nm	λ = 2.2 μm
Fried parameter (r_0)	→ 10 cm	60 cm
velocity of the turbulent layers (v)	→ 10 m/s	id.
=> image FWHM ($\epsilon \approx \lambda/r_0$)	→ 1"	~1"
=> evolution time ($\tau_0 \propto r_0/v$)	→ 3 ms	18 ms

Images & turbulence — 05





Images & turbulence — 06