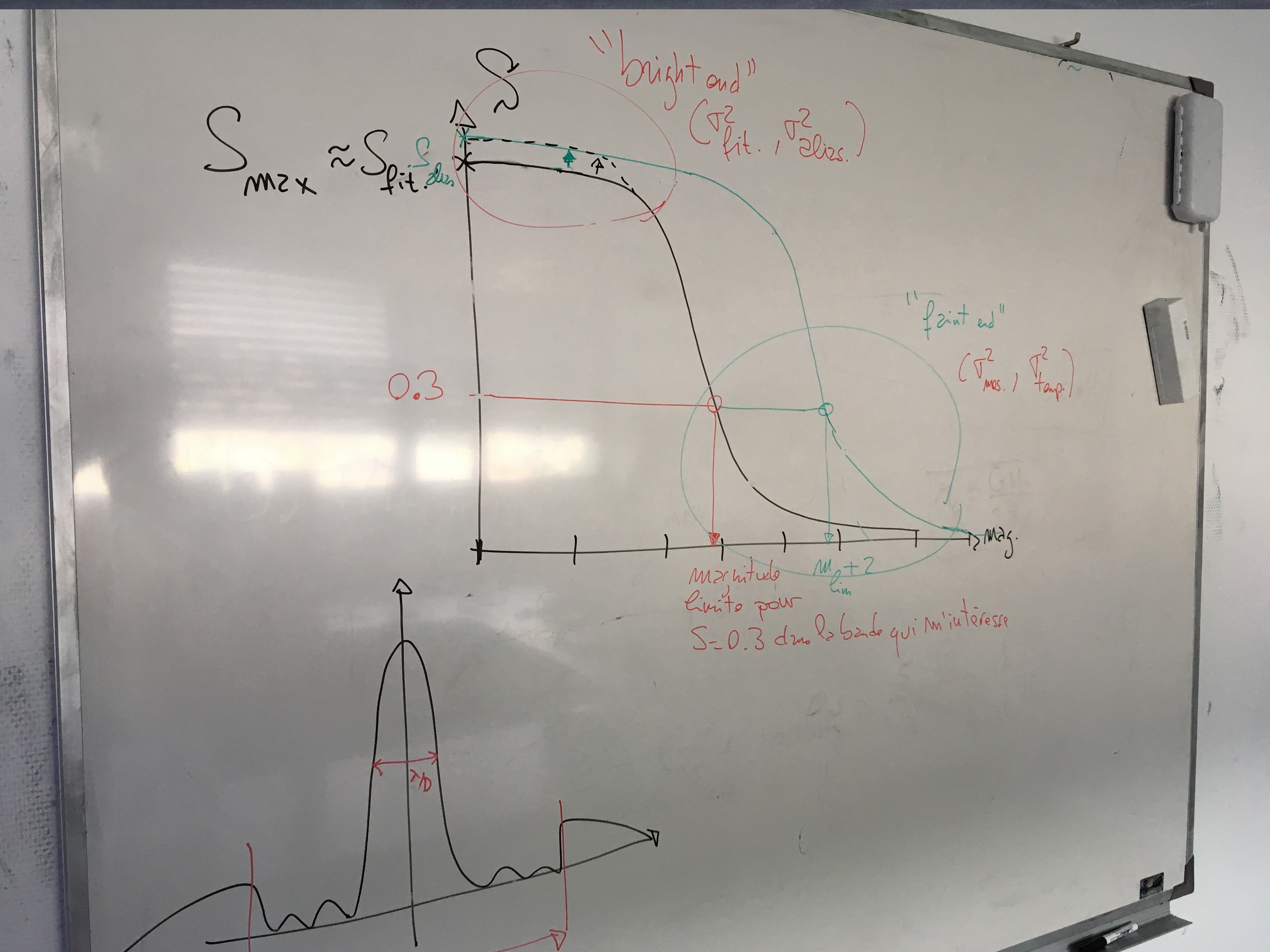
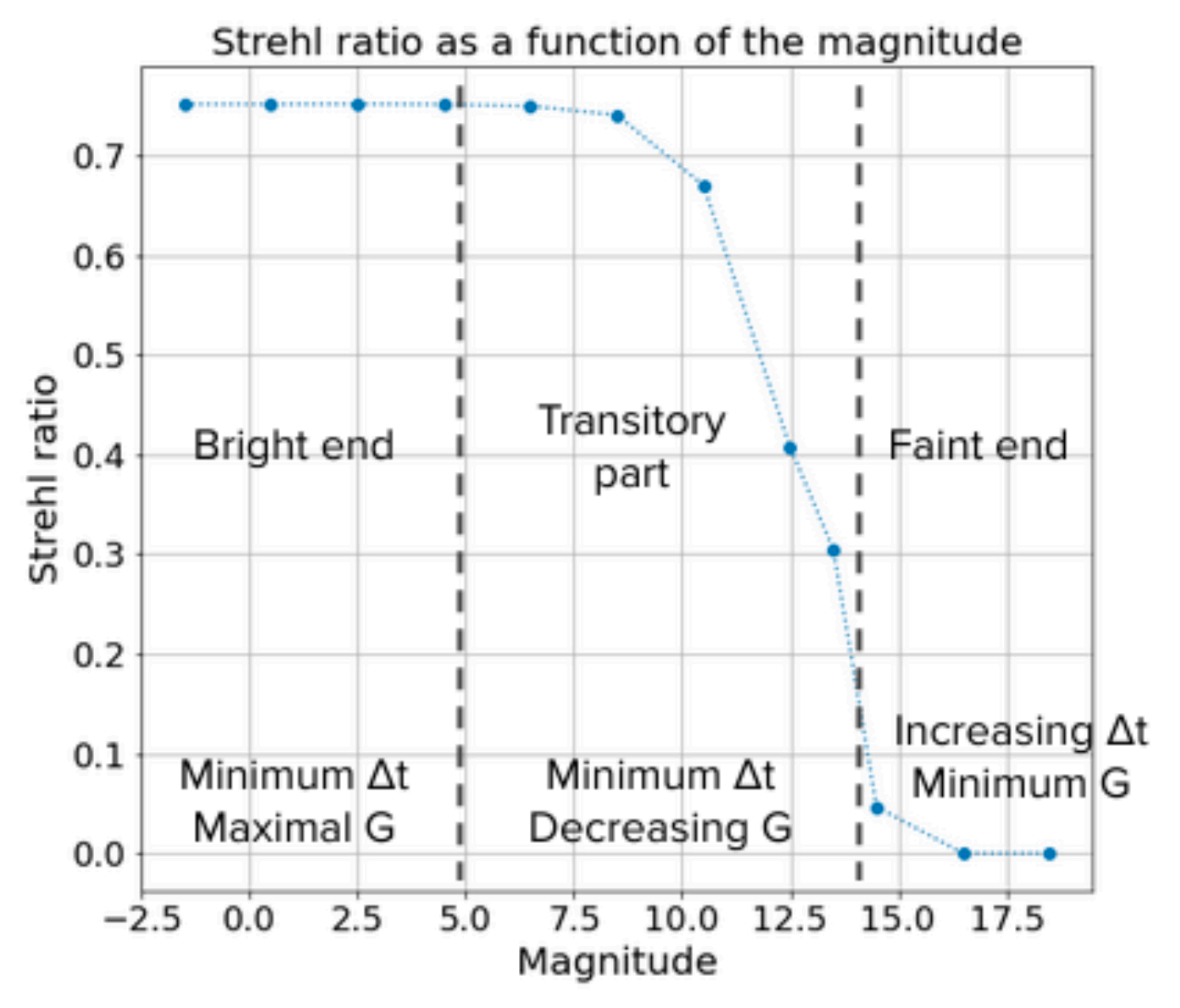


S
Smax ≈ Sfit.Salias
"bright end"
(σ2fit. , σ2alias.)
0.3
"faint end"
(σ2mes. , σ2temp.)
mag.
magnitude limite pour S=0.3 dans la bande qui m'intéresse
mlim+2
λ/D



Strehl ratio as a function of the magnitude
Strehl ratio
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Bright end
Transitory part
Faint end
Minimum Δt
Maximal G
Minimum Δt
Decreasing G
Increasing Δt
Minimum G
−2.5
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
Magnitude

AO partial correction…

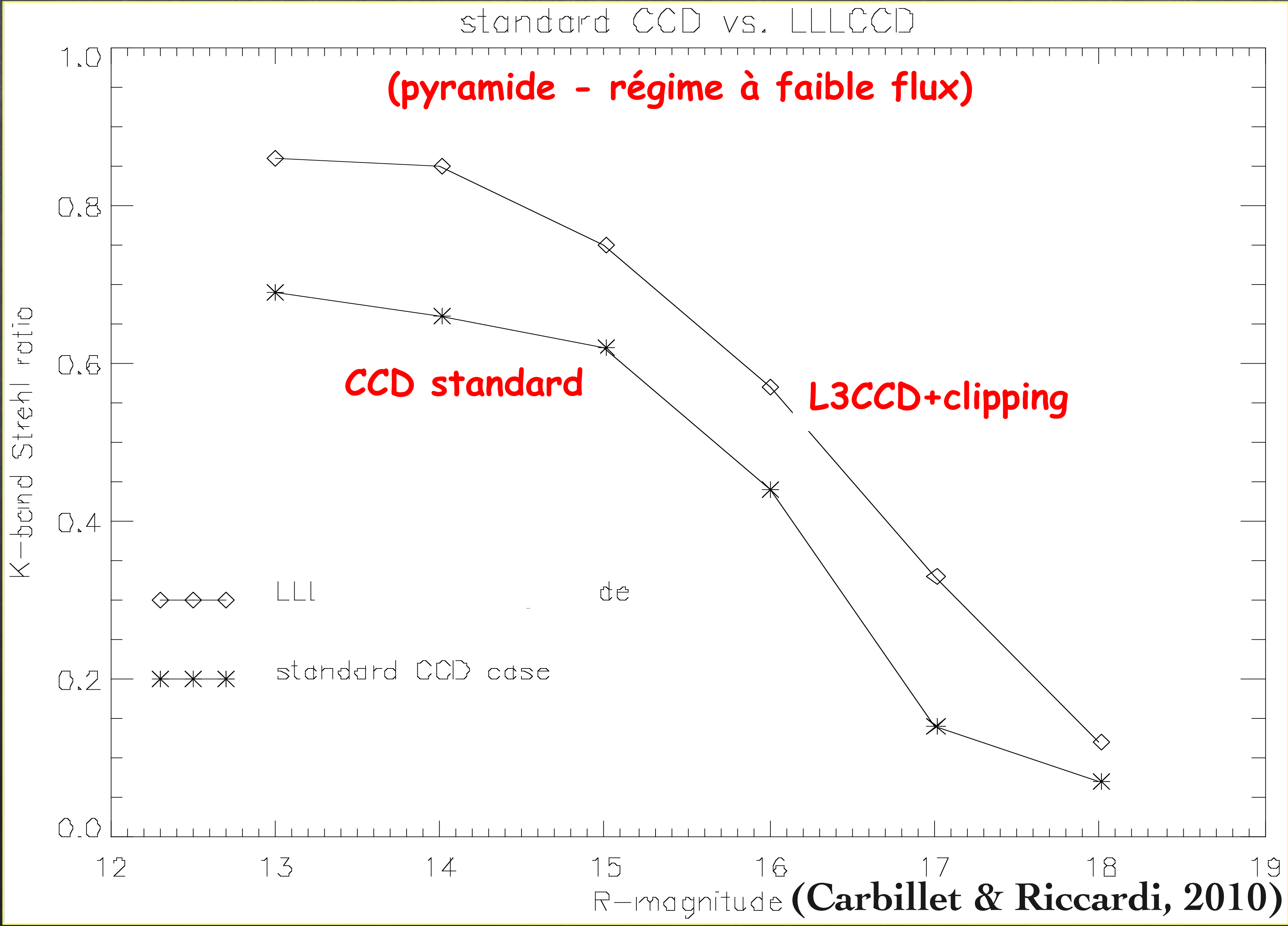
TT bad correction
=> agitation
=> image blurring

HO bad correction
=> coherence loss
=> coherent core reduced, more intense halo

Hence, for a given Strehl ratio, one should have:
- NGS AO => better resolution,
- LGS AO => better encircled energy…

Are other improvements possible ? - Example #1

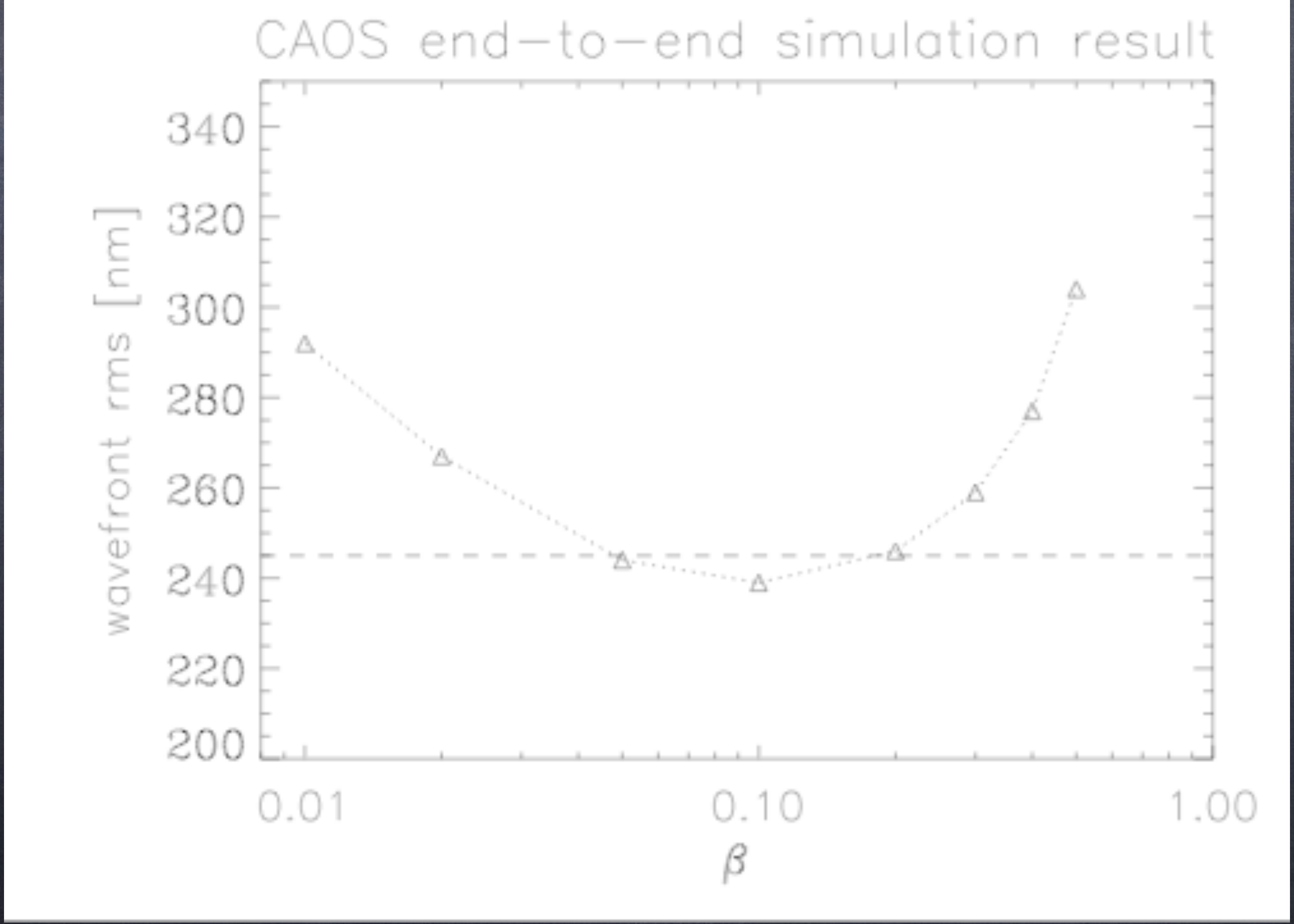
WFS: replace CCDs with EMCCDs ?...



(Carbillet & Riccardi, 2010)

Are other improvements possible ? - Example #2

WFS: add a TT sensor ?…



Are other improvements possible ? - Example #3

Image reconstruction: take into account the quality of correction within deconvolution process ?… (=> Strehl constraint)

G. Desiderà and M. Carbillet: Strehl-constrained IBD for post-AO data 3

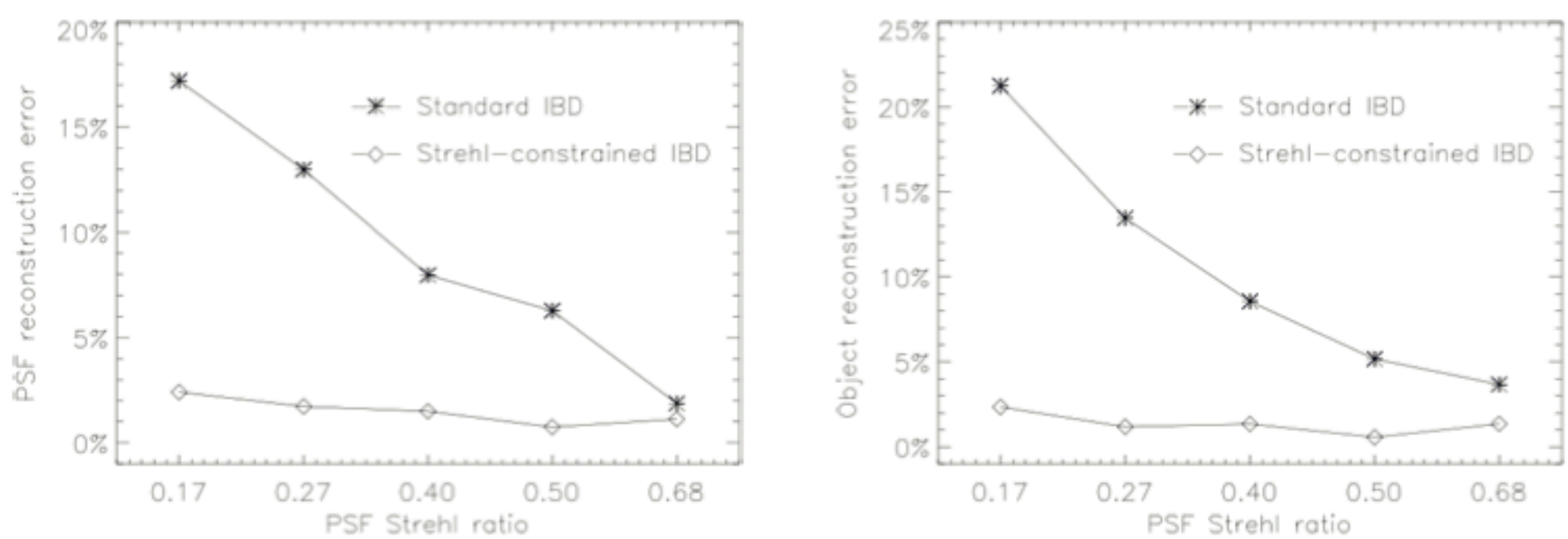
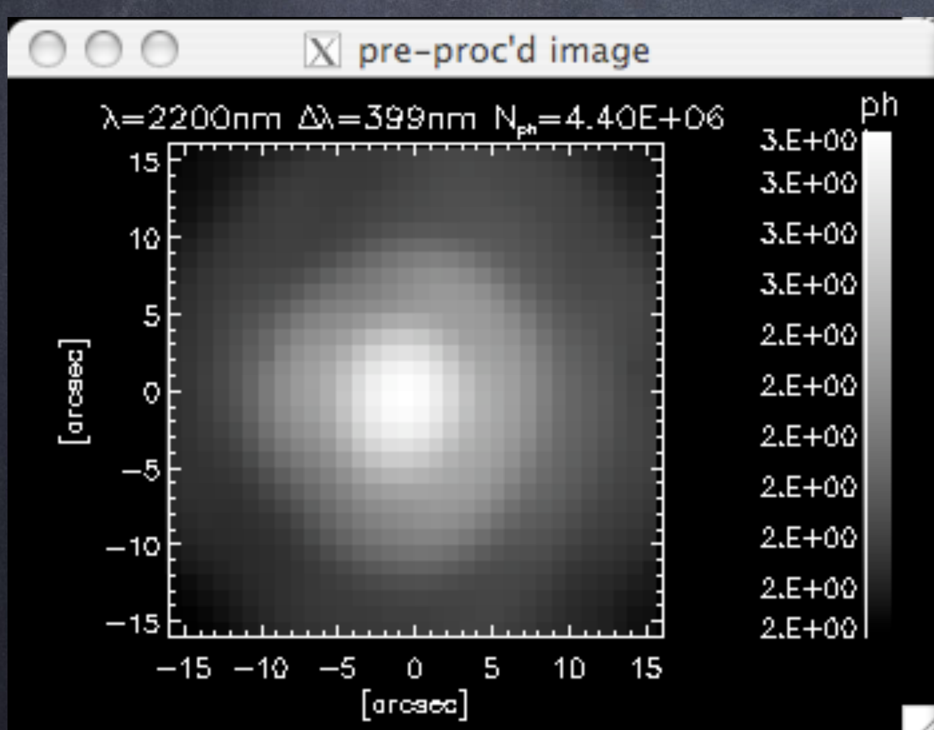
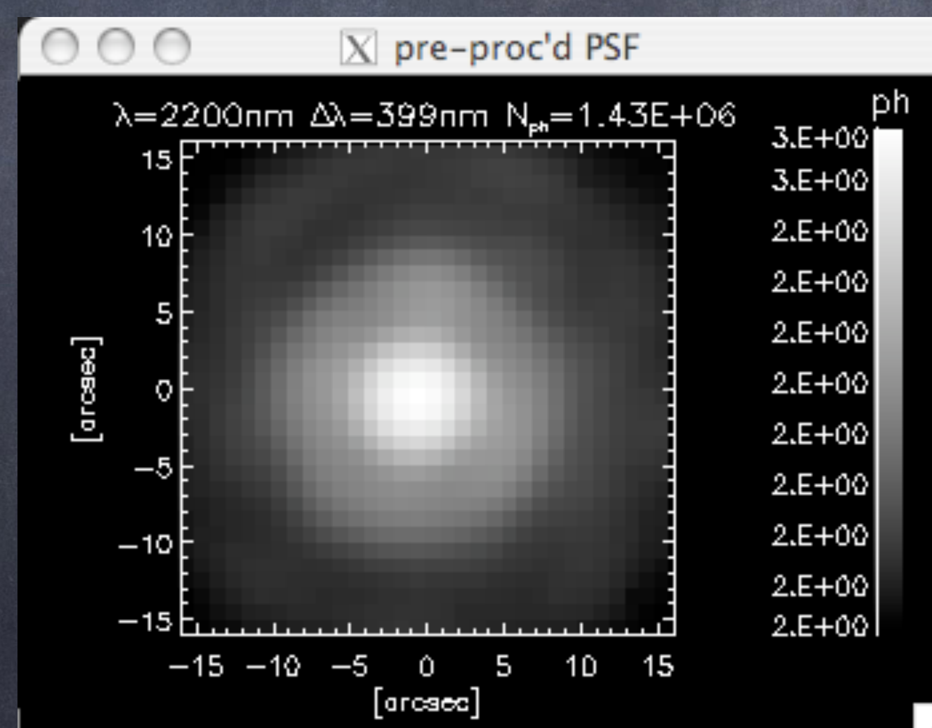


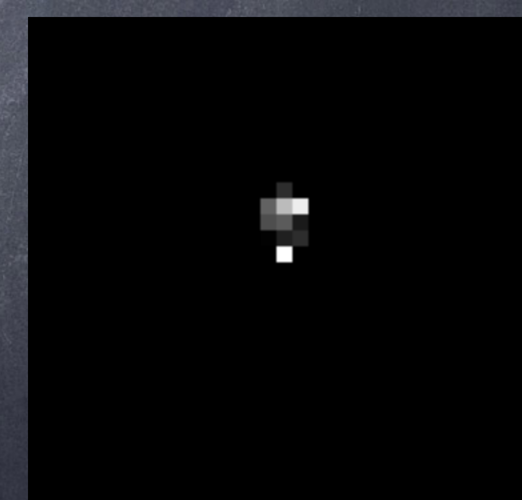
Fig. 2. *Left*: final error on the reconstruction of the PSF. *Right*: final error on the reconstruction of the object. Both plots are made as a function of the SR of the image data and comparing the simple IBD (rhombuses) to the Strehl-constrained IBD (asterisks). A gain of up to a factor ~10 is achieved for the poorer SR.

Are other improvements possible ? - Examples - 4

Image reconstruction : improve again resolution ?…
(=> Computational Super-Resolution)

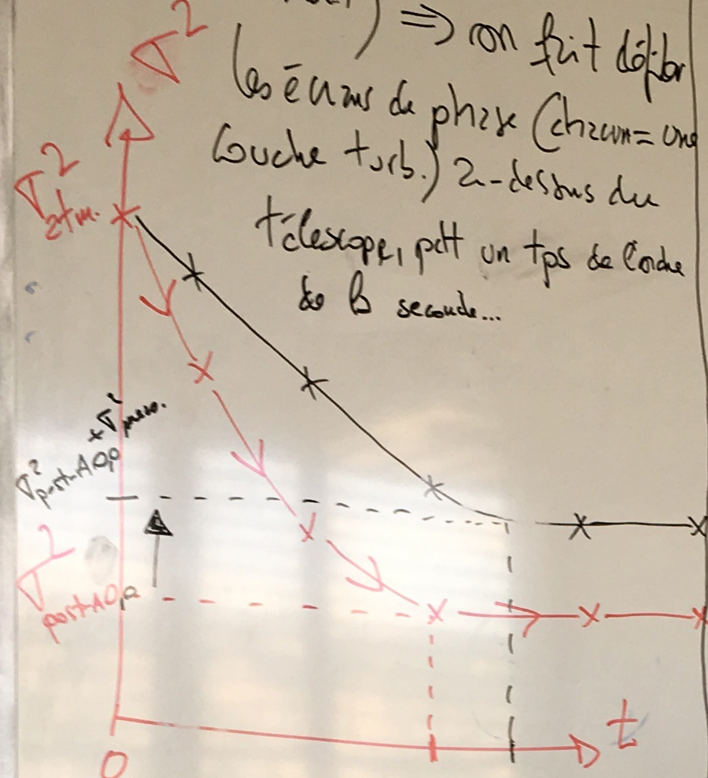






(HD 87643 observed with NACO/VLT, super-resolution algorithm of Anconelli et al. (A&A 2005))

Hypothèse de Taylor (pas le bouillonnement) ⇒ on fait défiler les écrans de phase (chacun = une couche turb.) au-dessus du télescope, pdt un tps de l'ordre de 10 seconde...

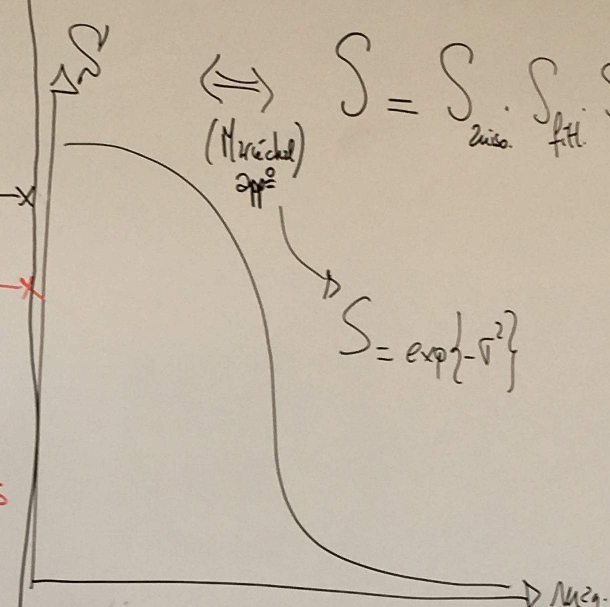


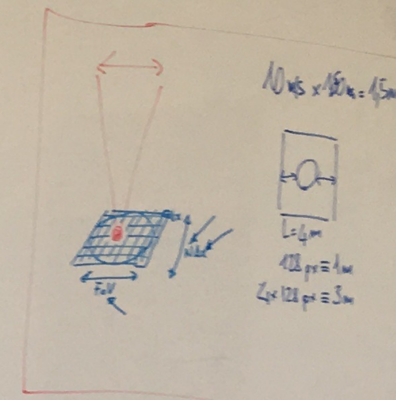
$$\sigma^2_{post\text{-}AO} = \sigma^2_{aniso.} + \sigma^2_{fitt.} + \sigma^2_{meas.} + \sigma^2_{alias.} + \sigma^2_{temp.} + \sigma^2_{NCPA} + \dots$$

$\Longleftrightarrow$ (Maréchal approx.)

$$S = S_{aniso.} \cdot S_{fitt.} \cdot S_{meas.} \cdot S_{alias.} \cdot S_{temp.} \cdot S_{NCPA}$$

$$S = \exp\{-\sigma^2\}$$





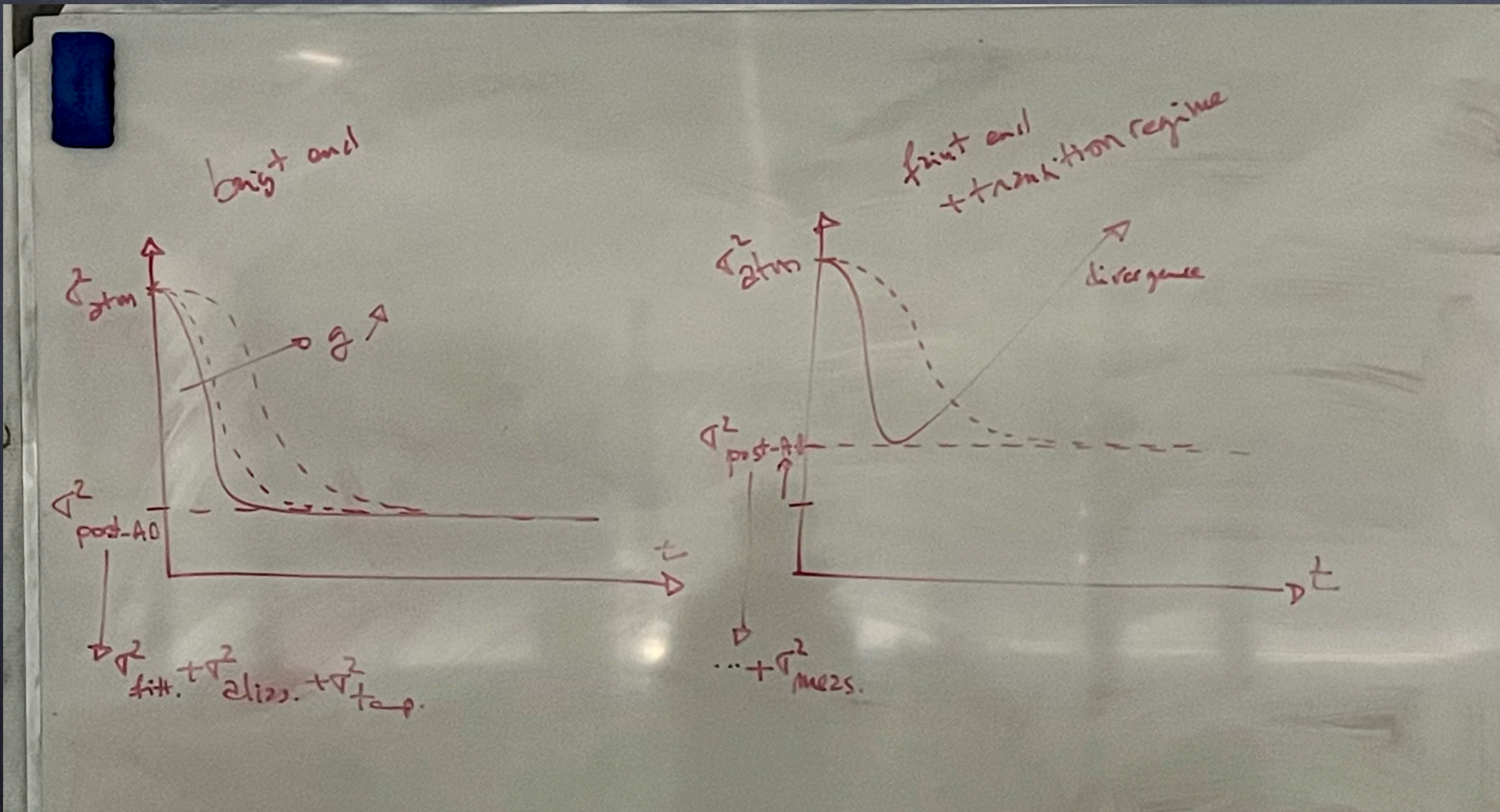
$$\text{mag} \nearrow \Rightarrow \left\{ \begin{array}{l} \frac{1}{N} \nearrow \\ \frac{\sigma_r^2}{N^2} \nearrow \end{array} \right\} \Rightarrow \sigma^2_{meas.} \nearrow \Rightarrow S_{meas.} \searrow$$

Ici :
- objet = étoile guide ⇒ $\sigma^2_{aniso} = 0$ (⇒ $S_{aniso.} = 1$)
- pas d'aberrations non-vues ⇒ $\sigma^2_{NCPA} = 0$ (⇒ $S_{NCPA} = 1$)
- $\sigma^2_{fitt.}$, $\sigma^2_{alias.}$ restent constants (r_0 et $d_{WFS} = d_{DM}$ fixes)
- $\Delta t_{intégration}$ fixé ⇒ $\sigma^2_{temp.}$ constant
- Seul $\sigma^2_{meas.}$ varie, en fonction de N. Et, dans un 1er temps, on ne considère que le bruit de photons.

$$\sigma^2_{meas.} = \sigma^2_{phot} \propto \frac{1}{N}$$

- ... $+ \sigma^2_{temp.} + \sigma^2_{meas.}$

about the gain of the pure integrator command law…



End-to-end AO modeling with the Software Package CAOS -1

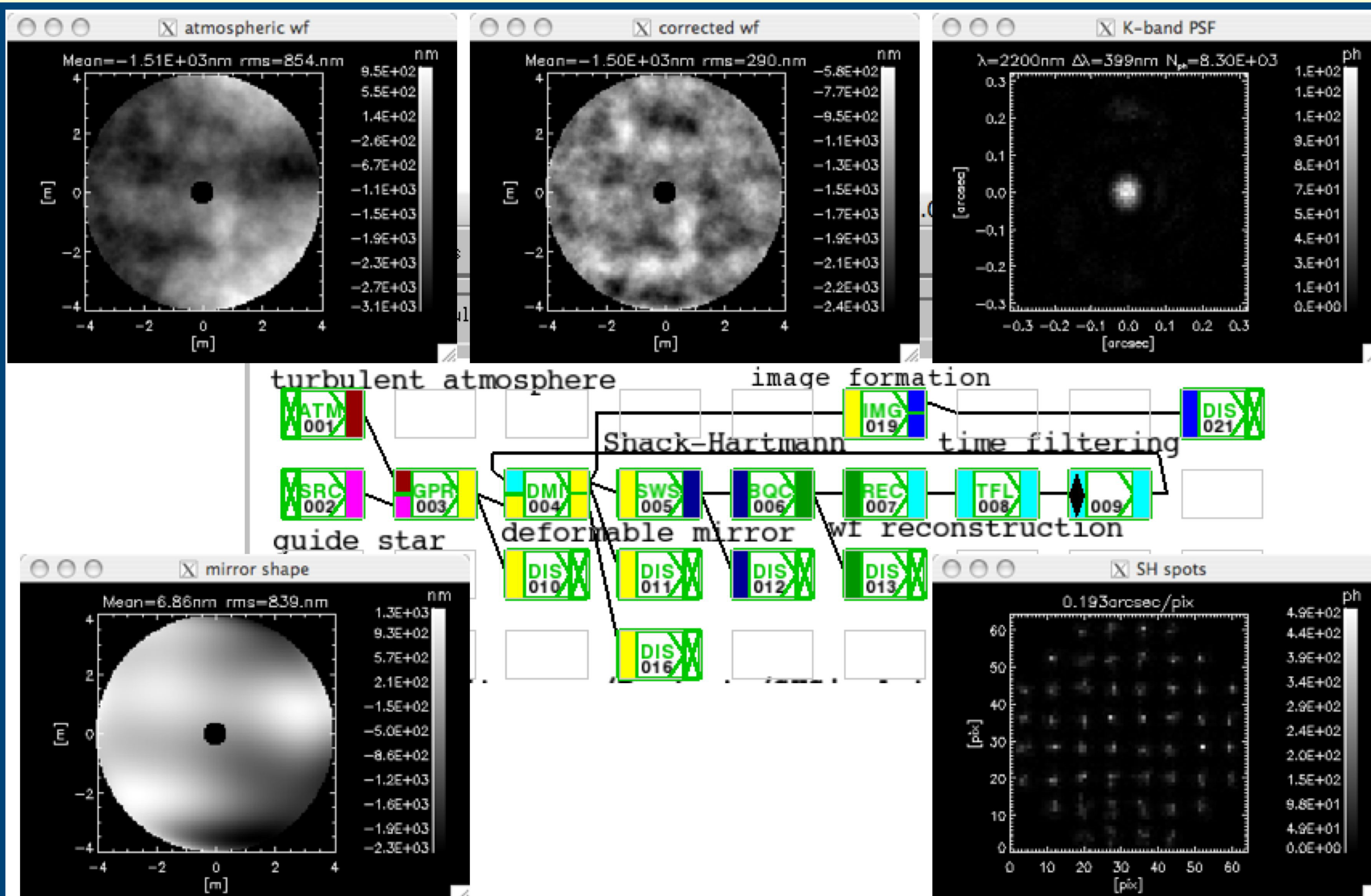
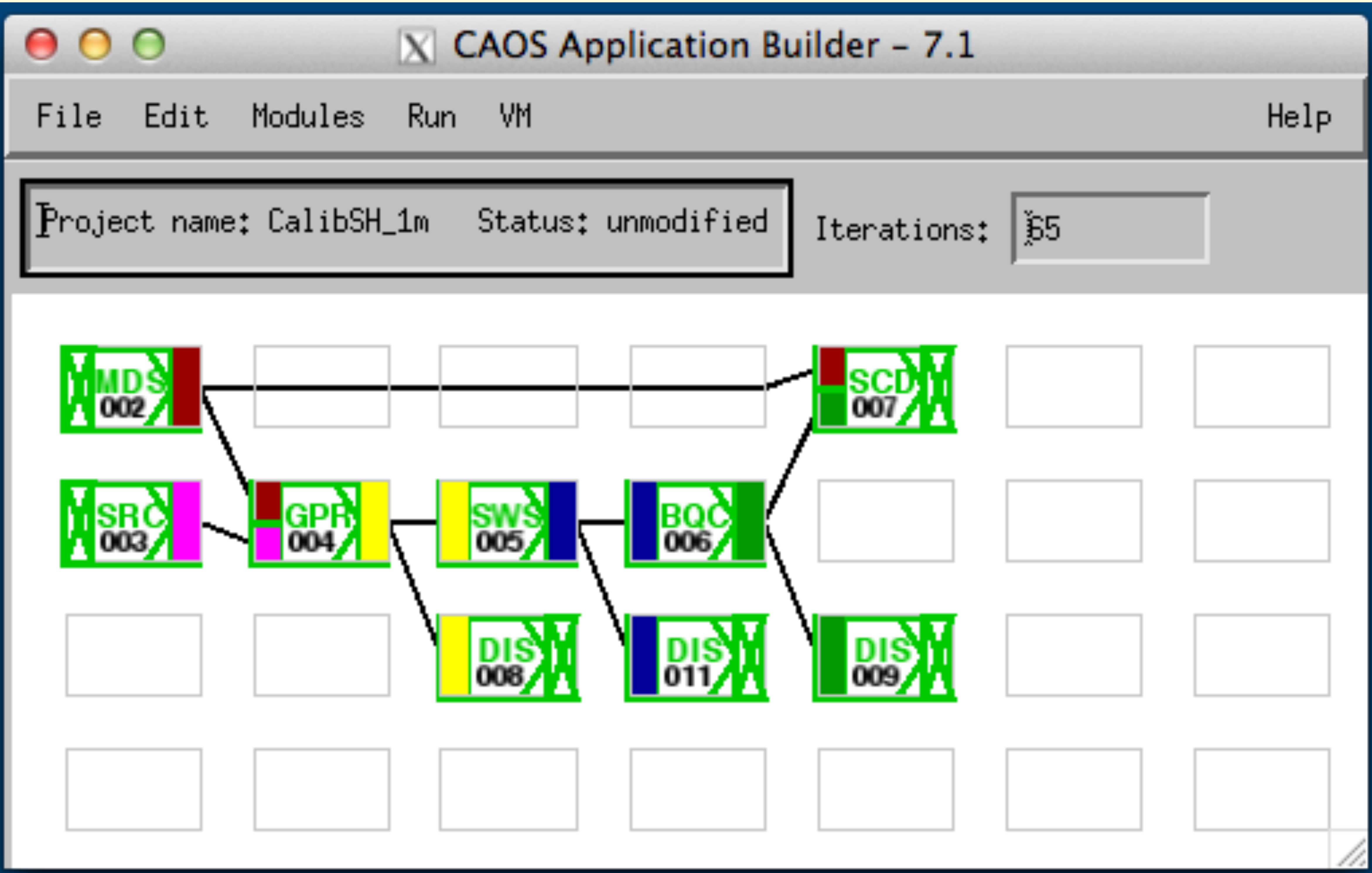


Table 1. The 31 modules of the **Software Package CAOS**, version 7.0.

Module	Purpose
Optical turbulence & image formation	
ATM - ATMosphere building	-builds the turbulent atmosphere (FFT+subharmonics, Zernike) (see also utility PSG - Phase Screen Generation)
SRC - SouRCe definition	-characterizes the guide star/observed object
GPR - Geometrical PRopagator	-propagates light from source to telescope through atmosphere
IMG - IMaGing device	-forms an image of the observed object (+detector noises)
Wavefront sensing	
PYR - PYRamid wavefront sensor	-simulates the pyramid wavefront sensor
SLO - SLOpe computation	-computes the slopes from the pyramid signals
SWS - Shack-Hartman Wavefront Sensor	-simulates the Shack-Hartmann (SH) wavefront sensor
BQC - Barycentre/Quad-cell Centroiding	-compute the signals from the SH spots centroiding calculus
IWS - Ideal Wavefront Sensing	-applies "ideal" wavefront sensing (see text)
TCE - Tip-tilt CEntroiding	-computes and reconstructs tip-tilt
Wavefront reconstruction, control & correction	
REC - wavefront REConstruction	-reconstructs the wavefront
TFL - Time-FiLtering	-applies time-filtering after wavefront reconstruction
SSC - State-Space Control	-applies state-space control
DMI - Deformable MIrror	-simulates the behavior of a deformable mirror (DM)
TTM - Tip-Tilt Mirror	-simulates the behavior of a tip-tilt mirror
Calibration	
CFB - Calibration FiBer characterization	-defines a fiber to be used for calibration purpose
MDS - Mirror Deformation Sequencer	-generates a sequence of DM modes or influence functions
SCD - Save Calibration Data	-saves the calibration data (interaction matrix+set of deformates)
Wide-field AO	
AVE - signals AVEraging	-averages measurements from various wavefront sensors
COM - COMbine measurements	-combines measurements from various wavefront sensors
DMC - Deformable Mirror Conjugated	-corrects at different conjugated altitudes
Other modelling modules	
LAS - LASer characterization	-defines laser projector characteristics
NLS - Na-Layer Spot definition	-characterizes the Sodium-layer behavior
IBC - Interferometric Beam Combiner	-combines the light from two apertures
COR - COROnagraphic module	-simulates various coronagraphs (Lyot, Roddier&Roddier, FQPM)
AIC - Achromatic Interfero-Coronagraph	-simulates the Achromatic Interfero-Coronagraph
BSP - Beam SPlitter	-splits the light beam
Other utility modules	
WFA - WaveFront Adding	-adds or combines together wavefronts
ATA - ATmosphere Adding	-adds or combines together atmospheres
IMA - IMage Adding	-adds or combines together images
STF - STructure Function	-calculates the structure function and compares to theory

End-to-end simulation of a complete AO system: calibration



End-to-end simulation of a complete AO system: running...