A Jovial opportunity for CIAO - Part II

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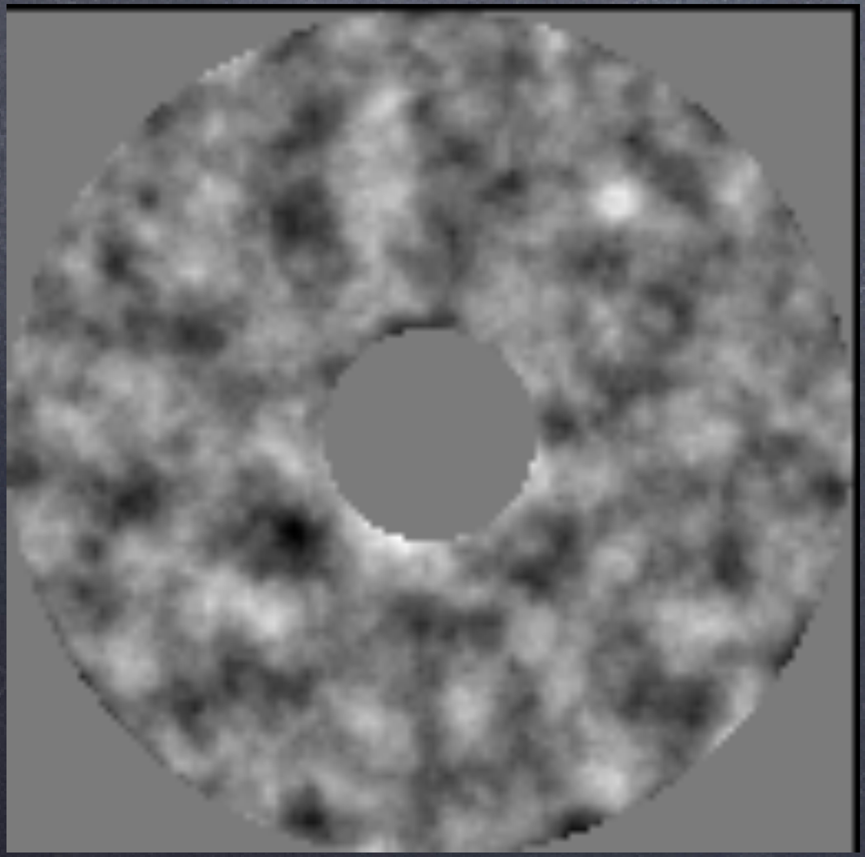
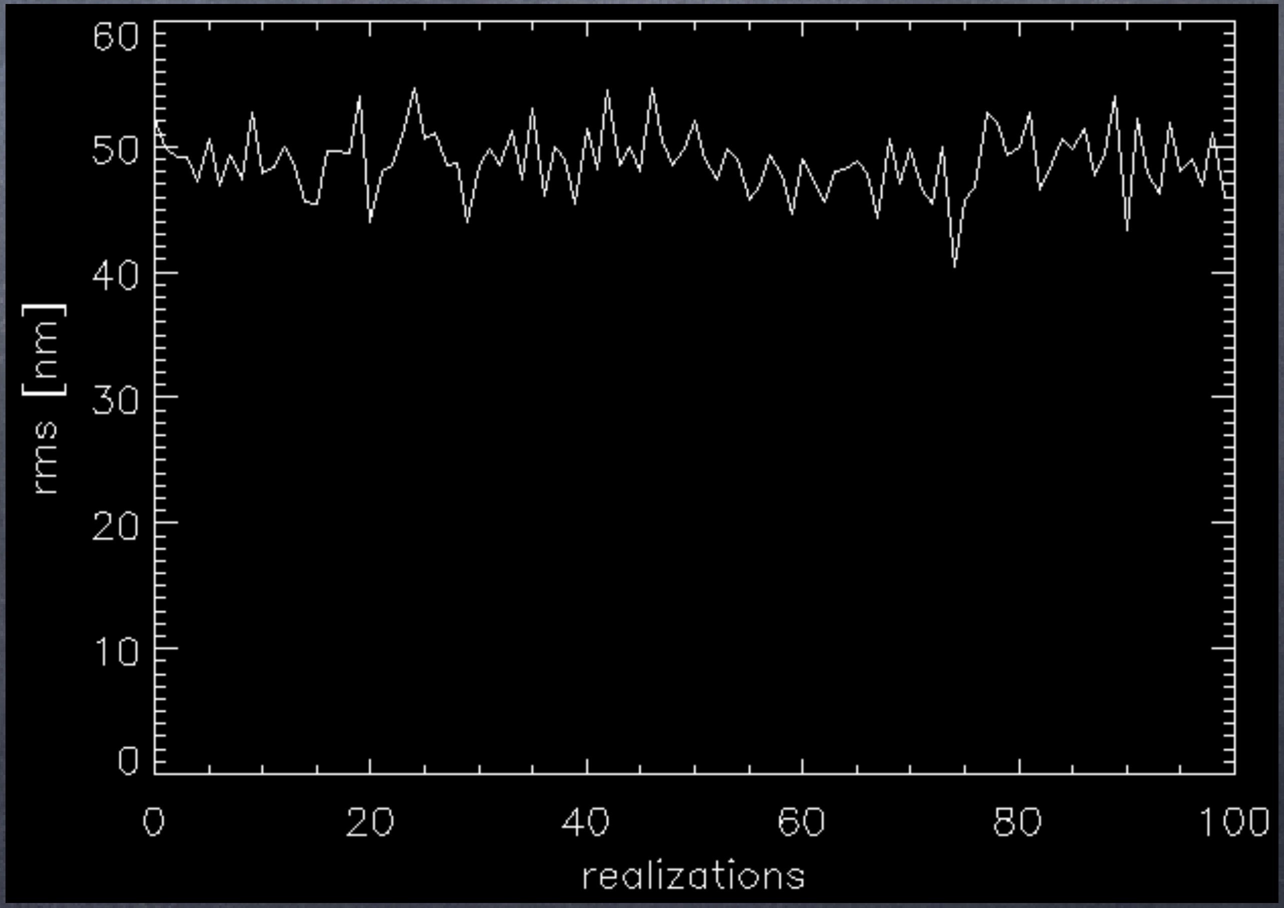
CIAO performance on-axis - 1

$$\sigma_{AO}^2 \simeq \sigma_{\text{fitting}}^2 + \sigma_{\text{temp.}}^2 + \sigma_{\text{aliasing}}^2 + \sigma_{\text{meas.}}^2 + \sigma_{\text{aniso.}}^2 \ [\text{rad}^2]$$

$$\sigma_{\text{fitting}} \simeq \frac{\lambda}{2\pi}\, k_{\text{fit.}} \left(\frac{D}{r_0(\lambda)}\right)^{\frac{5}{6}} \simeq 50\, nm$$





CIAO performance on-axis - 2

$$\sigma^2_{\mathrm{AO}} \simeq \sigma^2_{\mathrm{fitting}} + \sigma^2_{\mathrm{temp.}} + \sigma^2_{\mathrm{aliasing}} + \sigma^2_{\mathrm{meas.}} + \sigma^2_{\mathrm{aniso.}} \; [\mathrm{rad}^2]$$

$$\sigma_{\mathrm{temp.}} \simeq \frac{\lambda}{2\pi} \left(\frac{\Delta t = 3\, ms}{\tau_0(\lambda)} \right)^{\frac{5}{6}} \simeq 80\, nm$$

$$\sigma_{\mathrm{aliasing}} \propto \frac{\lambda}{2\pi} \left(\frac{D}{r_0(\lambda)} \right)^{\frac{5}{6}} \simeq 23\, nm$$

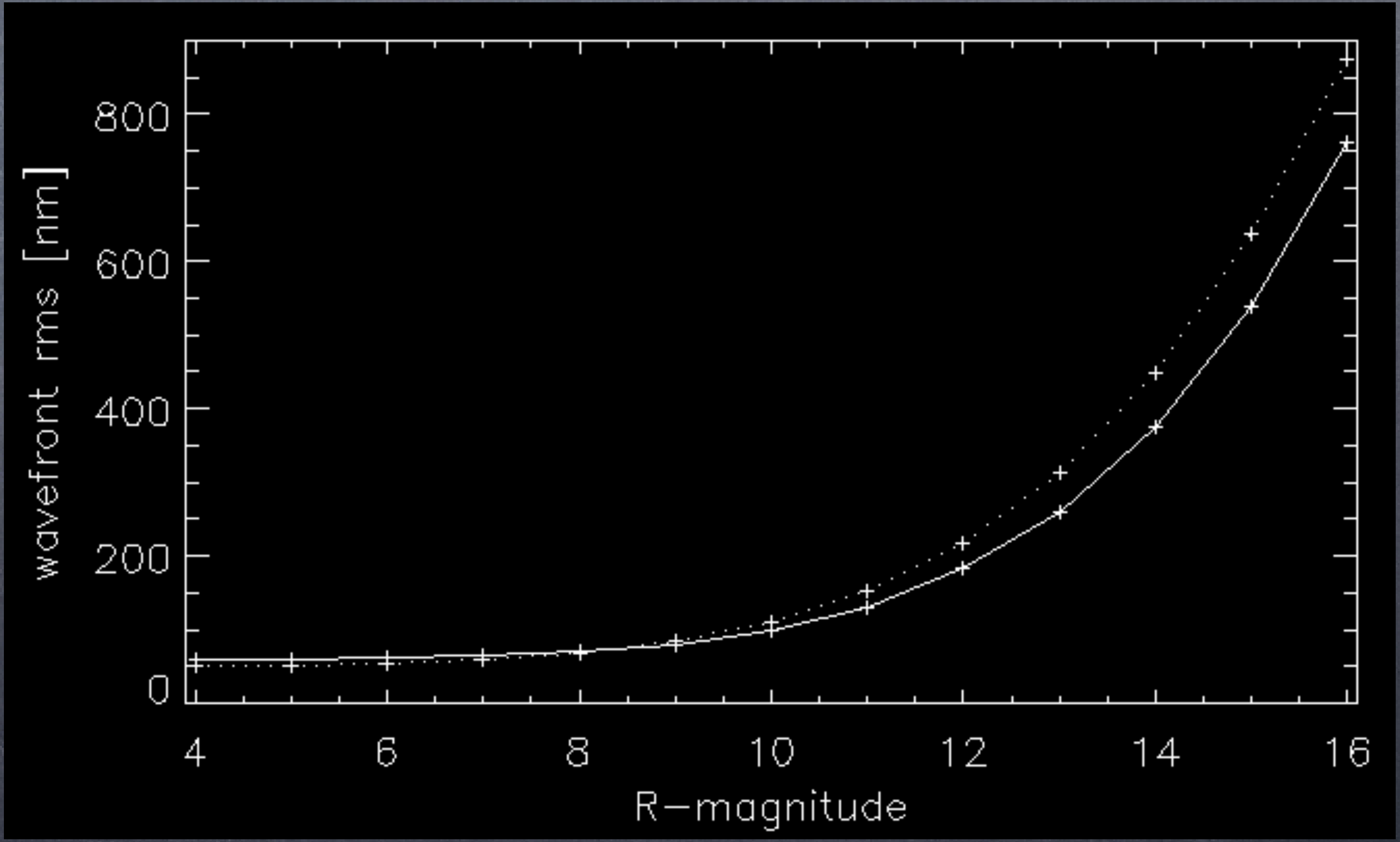
(from PAOLA simulations)

CIAO performance on-axis - 3

$$\sigma^2_{\text{AO}} \simeq \sigma^2_{\text{fitting}} + \sigma^2_{\text{temp.}} + \sigma^2_{\text{aliasing}} + \sigma^2_{\text{meas.}} + \sigma^2_{\text{aniso.}} \ [\text{rad}^2]$$

Altitude [km]	C_N^2 [%]
0	69
0.5	10
3	4
6	9
10	4
13	2
16.5	2
r_0 [cm]	10.0
τ_0 [ms]	3.00
$\mathcal{L}_0$ [m]	27.0

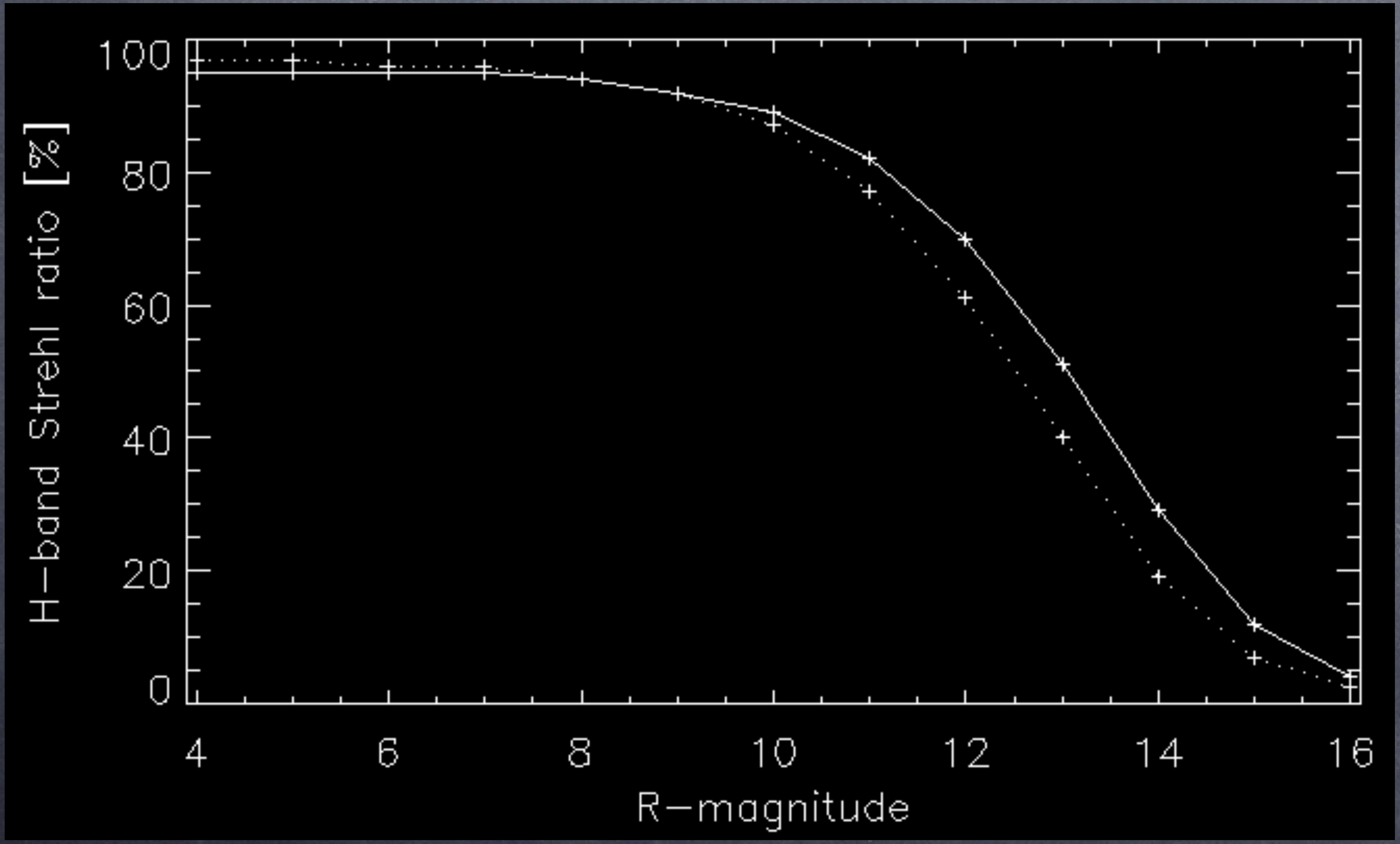
vent au sol [m/s]	5
vent en altitude [m/s]	10
$d_{\text{DM}} = d_{\text{ASO}}$ [cm]	10.4
λ_{ASO} [nm]	709
$\Delta\lambda_{\text{ASO}}$ [nm]	158
transmission jusqu'à l'ASO	0.3
retard de la boucle [ms]	0.5
σ_e (RON) [e^-/px]	1



(PAOLA simulations)

CIAO performance on-axis - 4

$$\sigma^2_{\mathrm{AO}} \simeq \sigma^2_{\mathrm{fitting}} + \sigma^2_{\mathrm{temp.}} + \sigma^2_{\mathrm{aliasing}} + \sigma^2_{\mathrm{meas.}} + \sigma^2_{\mathrm{aniso.}} \; [\mathrm{rad}^2]$$



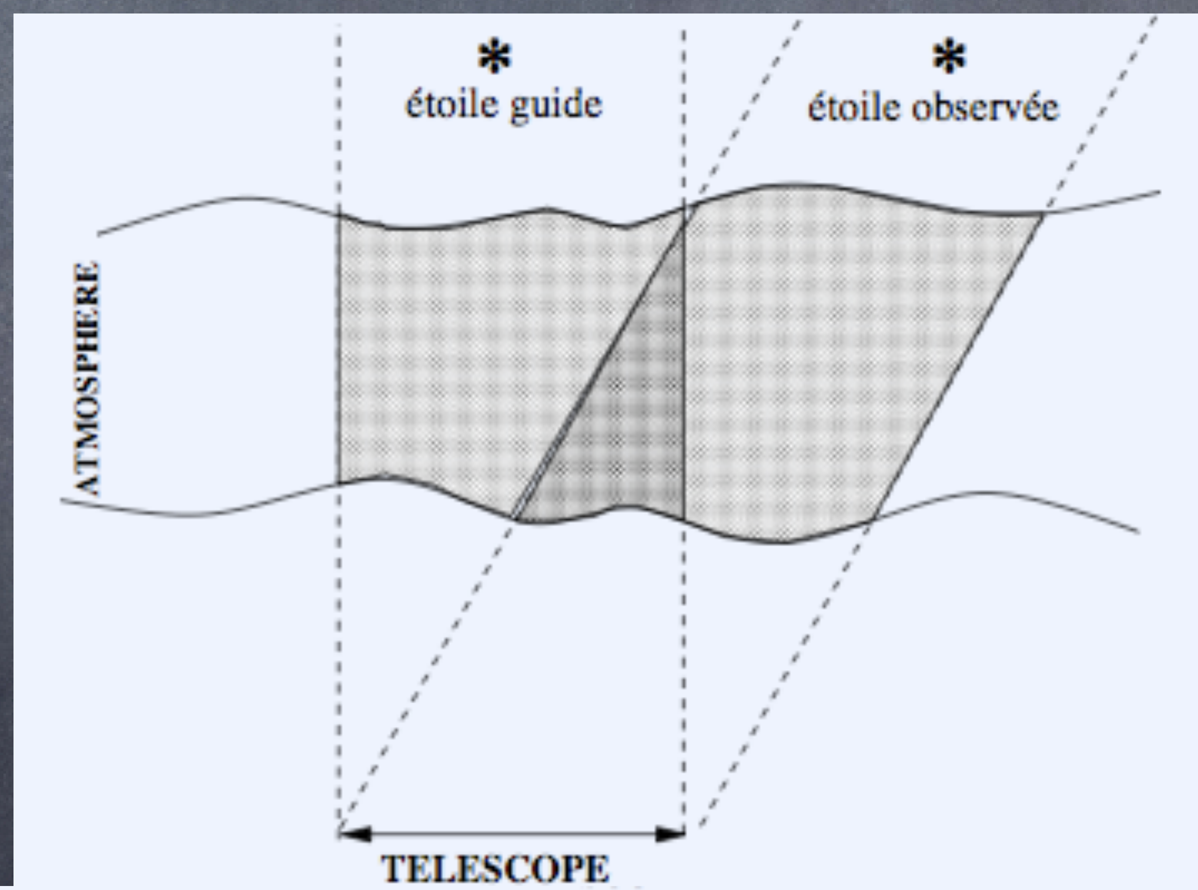
Strehl_H=0.95
=> Strehl_V=0.63

(PAOLA simulations)

... and off-axis ? - 1

$$\sigma_{\text{aniso.}} \simeq \frac{\lambda}{2\pi}\left(\frac{\theta}{\theta_0}\right)^{\frac{5}{6}}$$

with the isoplanatic angle theta_0 = a few arcsec only in the visible...



... and off-axis ? - 2

But, for tip-tilt alone, the "isokinetic angle" is a few tens of arcsec rather than a few arcsec

In fact, low-order modes de-correlates more slowly with theta

=> Possibility to limit the correction to lower modes only (the ones with correlation>0.5, hopefully more than just tip-tilt)...

Anyway: need for wide-field measurement & correction !

``Simple'' solution (1 DM!) for wide-field correction: GLAO (Ground-Layer AO), which basically corrects from the GL contribution only, measuring the integrated turbulence from many directions and averaging the measures, hence better measuring the GL contribution - in fact: common layer to the many directions = the GL.

(GL)AO on Jupiter - 1

In the case of Jupiter, 30-50" wide, we plan to adopt a solar-AO-like type of wide-field measurements for wavefront sensing, implying cross-correlations of the images rather than photocenter calculus.

=> Correlating Shack-Hartmann wavefont sensor

$$CC(\vec{\Delta}_i) = \sum \sum I_M(\vec{x}) \times I_R(\vec{x} + \vec{\Delta}_i)$$

where: CC=cross-correlation, I_M=subaperture image, I_R=reference image, Delta_i=pixel shift.

(GL)AO on Jupiter - 2

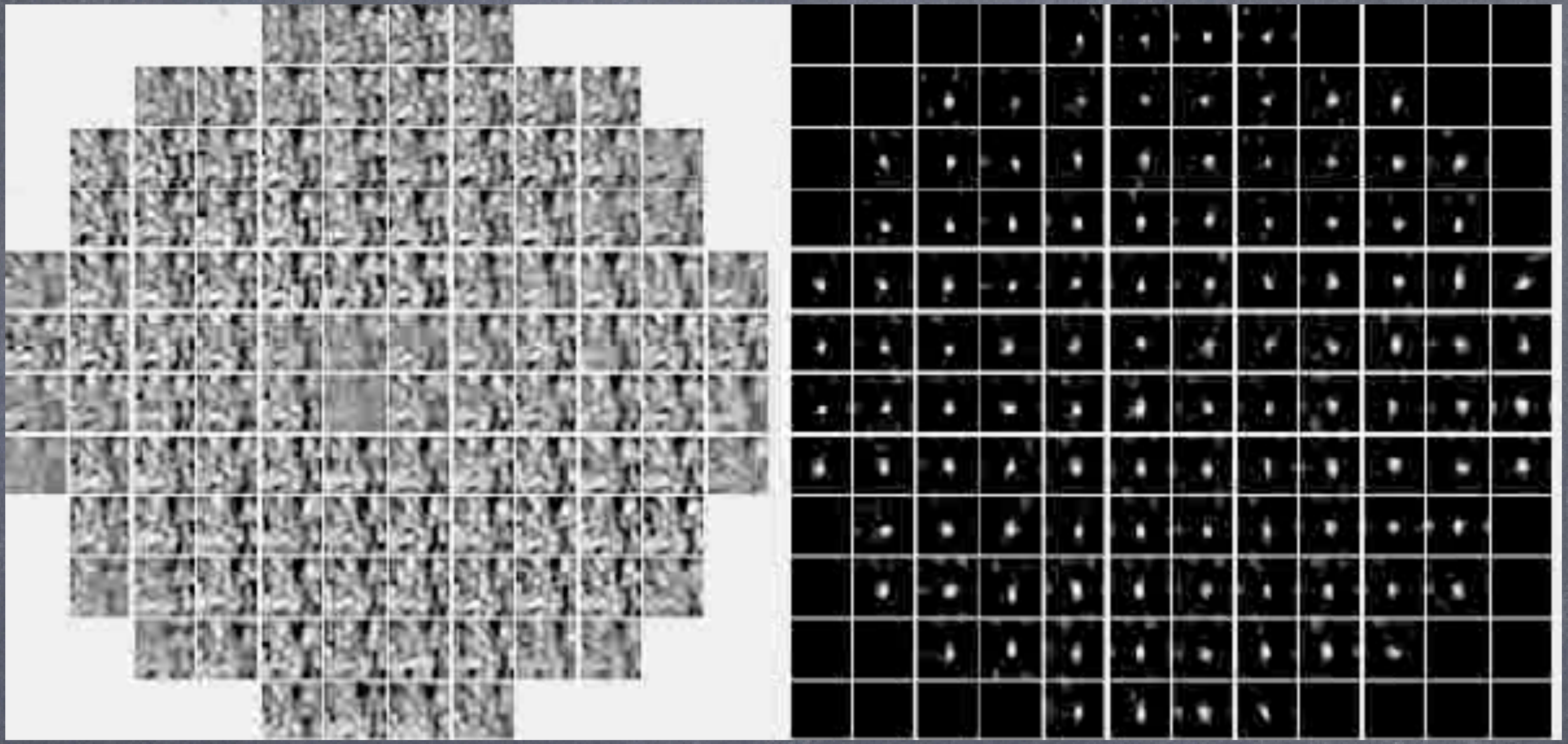
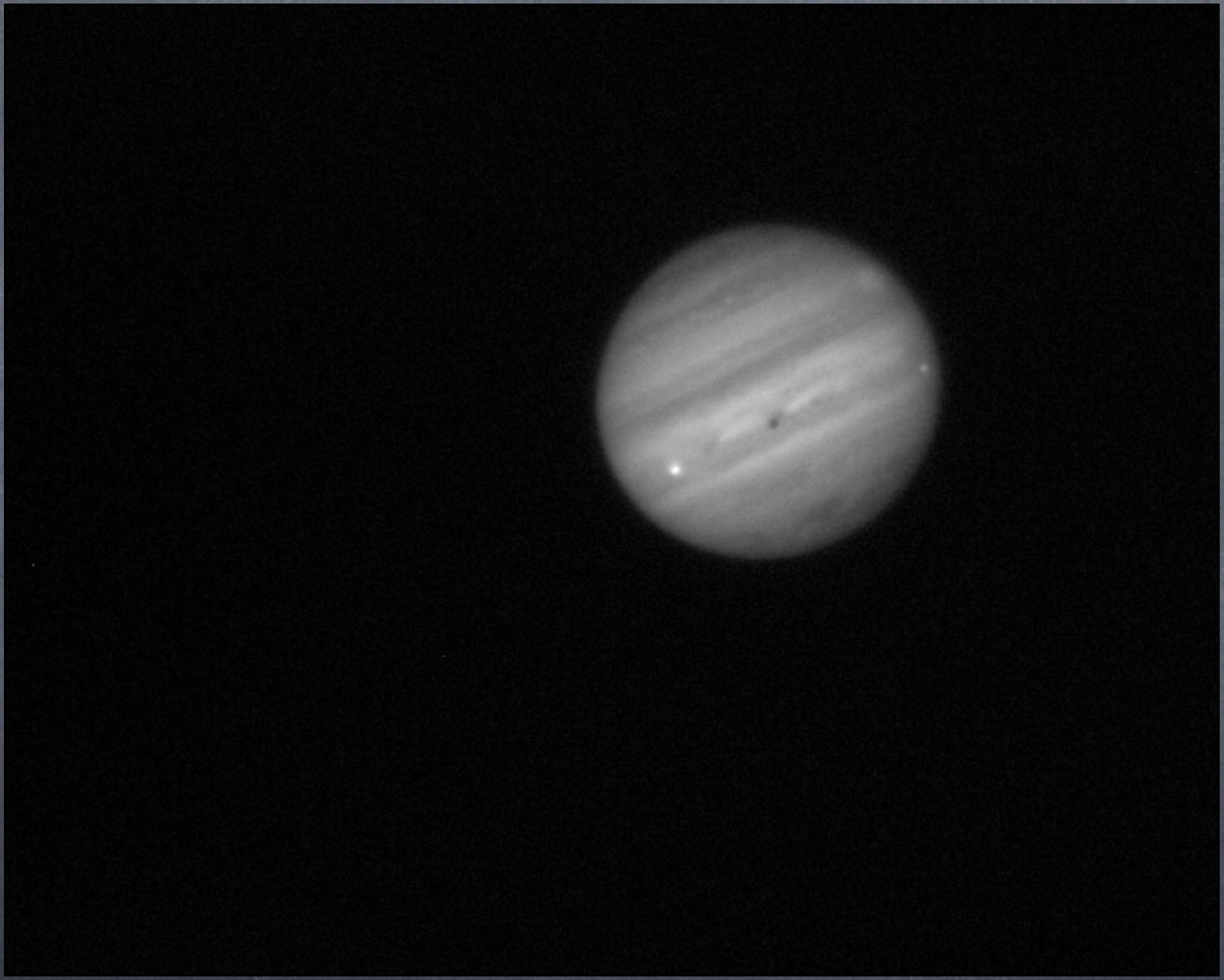


Figure 14: Still from a movie showing Principle of correlating Shack–Hartmann wavefront sensor. Cross-correlation techniques are used to track the low contrast granulation images or any other extended object of sufficient contrast (Rimmele and Radick, 1998). The movie shows a time sequence of wavefront sensor camera images with 12 subapertures across the pupil of the DST. The cross-correlation functions of the subaperture images of granulation are shown on the right. (To watch the movie, please go to the online version of this review article at http://www.livingreviews.org/lrsp-2011-2.)

(From Rimmele & Marino, Living Rev. Solar Phys. 8, 2011)

(Jupiter obs'd w/HiPIC@C2PU)



(Lyu Abe et al., last monday night, band H)