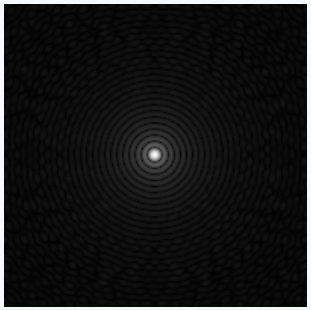
Optical gain compensation for the HARMONI-SCAO Pyramid WFS

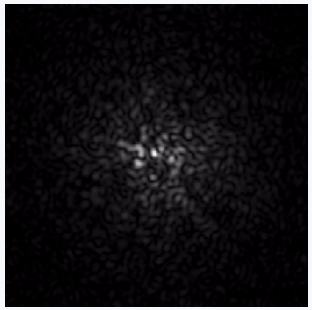
WFS in the VLT/ELT era V – 14th October 2020

Charlotte Z. Bond, Vincent Chambouleyron, Jean-François Sauvage, Noah Schwartz, Carlos Correia and Thierry Fusco.

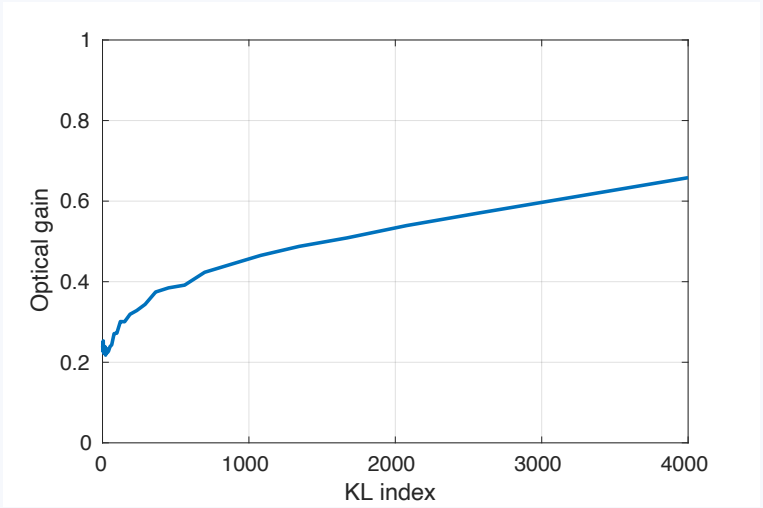
PyWFS optical gain



Calibration state*



Operating state*



Knowledge of the optical gains can be used to compensate the CM

Reduced sensitivity

Smaller optical gains

Mismatch between calibration and on-sky response

$$G_{opt} = \begin{pmatrix} G_1 & & \\ & \ddots & \\ & & G_n \end{pmatrix}$$

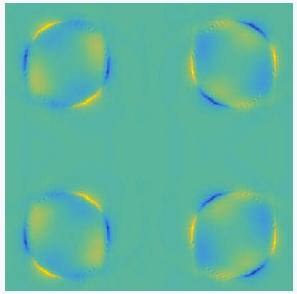
$$\mathrm{CM}_{sky} = \left(\frac{1}{G_{opt}}\right)\mathrm{CM}_{calib}$$

* Courtesy Vincent Chambouleyron

The convolutive model

V. Chambouleyron et al., 'Pyramid wavefront sensor optical gains compensation using a convolutional model', A&A, 2020.

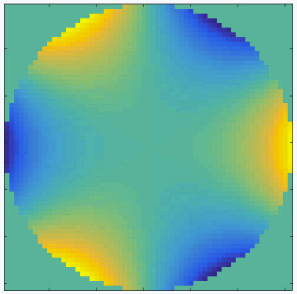
→ A PyWFS working with small residual phases is equivalent to a change in modulation.



$mI(\phi_i)$

Meta intensity

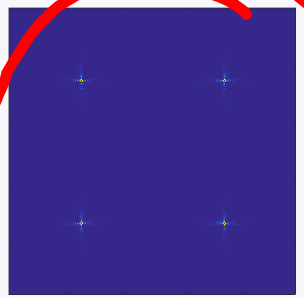
=



ϕ_i

Phase

$\ast$

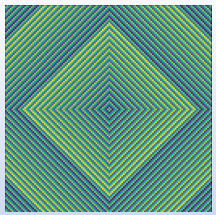


$IR(m,\omega)$

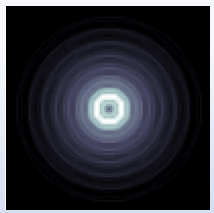
Impulse response (model of the WFS)

$$IR(m,\omega) = 2\Im\{\hat{m}(m * \omega)\}$$

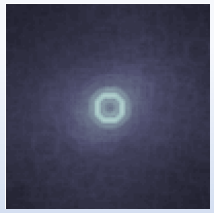
m, PyWFS Fourier mask



ω, focal plane weighting (PSF + modulation)

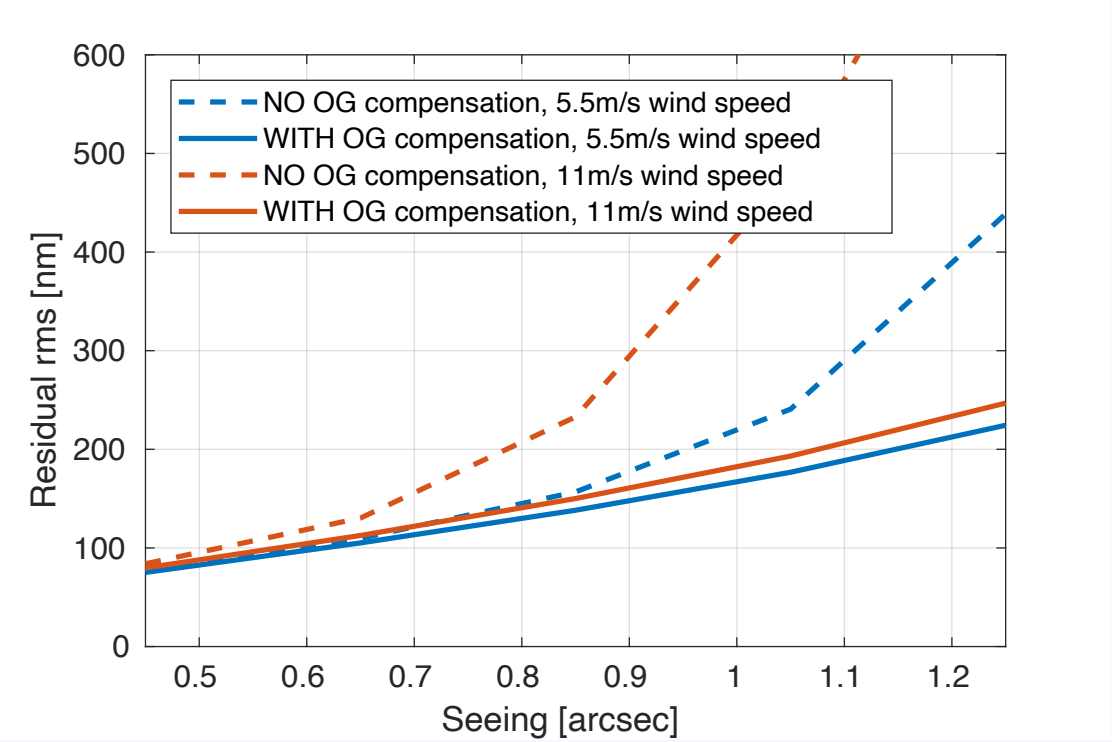


Calibration

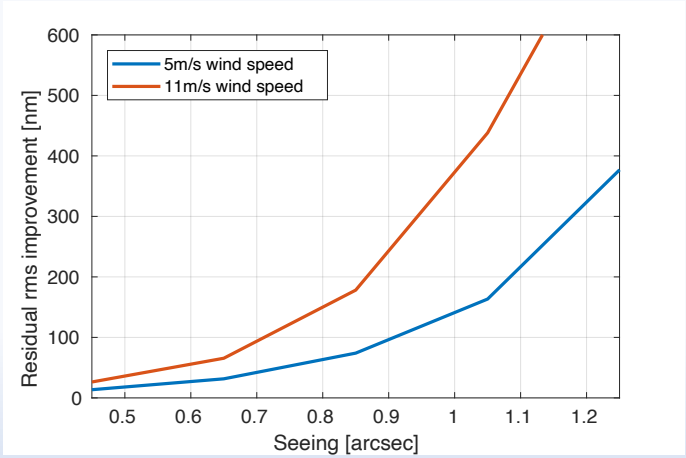


Operation

The impact of OGs on H-SCAO



- H-SCAO simulated in OOMAO.
- The **OG is estimated and compensated** using the convolutive model and full knowledge of the residual phase.

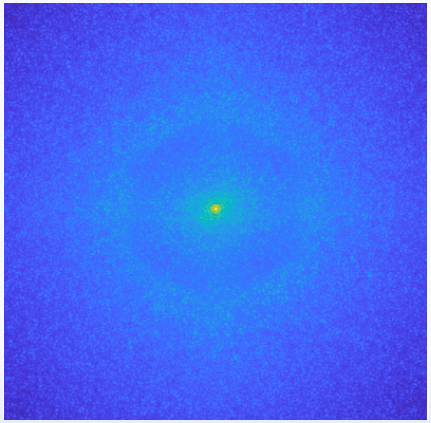


HARMONI SCAO

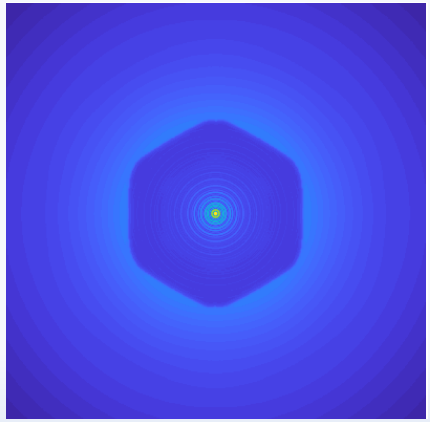
- Visible PyWFS (0.7 – 1 µm)
- ~4000 KL modes
- Modulation = 3λ/D

Estimating OGs in practice

- In practice we do not have full knowledge of the residual phase.
- Ideally a camera placed in a nearby focal plane could provide the PyWFS PSF (not an option for HARMONI).
- Alternative approach: use a reconstructed PSF.
  - Is using only the fitting error sufficient?



Simulated PSF: single closed loop phase



Reconstructed PSF: fitting error only

OG compensation using a reconstructed PSF: fitting error only

Preliminary results

- PSF modelled using different values of r_0.
- Simulation case: seeing = 1.05”, wind speed = 5.5m/s.
- Good OG compensation achieved with r_0 within -10% to +30% of true value.