Opto-mechanical design of a High Contrast Module (HCM) for HARMONI

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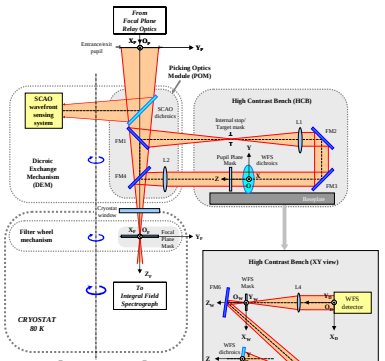
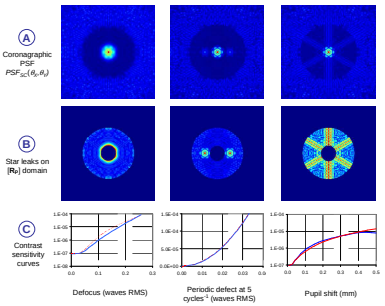


Schematic view



Summary

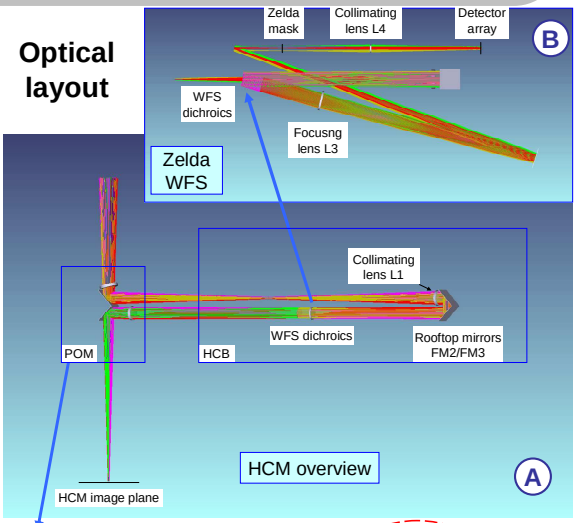
HARMONI is a first-light visible and near-IR integral field spectrograph of ESO's Extremely Large Telescope. A Single Conjugate Adaptive Optics sub-system will provide diffraction-limited spectral images in a Nyquist-sampled 0.61 x 0.86 arcsec field of view with a R=3000-20000 spectral resolution. The High Contrast Module (HCM) will add an essential high-contrast imaging capability for HARMONI to spectrally characterize young giant exoplanets and disks with flux ratio of 1E-6 at 0.1-0.2" from their star. It uses an apodized pupil coronagraph to lower the intensity of the diffracted starlight and limit the dynamic range on the detector, and an internal wavefront sensor to calibrate non-common path aberrations.

From science to technical requirements

SCIENCE REQUIREMENTS	VALUES
Spectral range	Science: From 1.25 to 2.45 µm Wavefront sensing: From 1.20 to 1.25 µm
Contrast (see definition below)	≤ 1.5 10^{-5} at 200milli-arcsec (mas)
Throughput (including PPM apodization, see definition below)	> 50 % in full science spectral range
FoV and FoV sampling	860 x 610 mas sampled at 4 mas
Outer Working Angle (OWA)	> 300 mas
Inner Working Angle (IWA)	< 75 mas
WFE measurement accuracy (performed by built-in WFS)	λ/100 RMS in full science spectral range

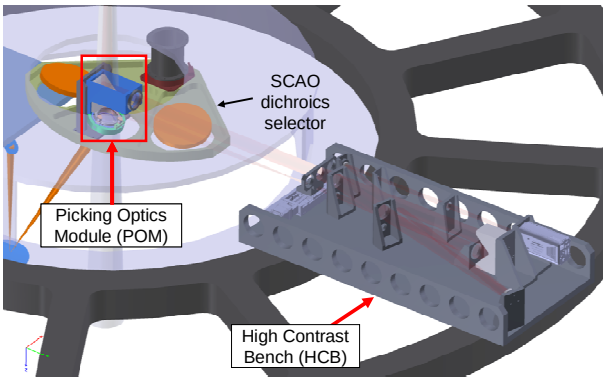
TECHNICAL REQUIREMENTS		VALUES
Optics transmission (excluding PPM)		> 85 % in full science spectral range
Image position and stability (at FPRO focal plane)		20 and 2 µm respectively along X_F and Y_F axes 200 and 20 µm respectively along Z_F-axis
Image quality	Global (tilt and focus removed)	< 32 nm RMS (goal 17 nm)
	Low spatial frequency errors (< 5 cycles)	< 17 nm RMS (goal 9 nm)
	Mid spatial frequency errors (5-20 cycles)	< 20 nm RMS (goal 10 nm)
	High spatial frequency errors (> 20 cycles)	< 18 nm RMS (goal 10 nm)
Exit pupil position and stability		< 0.25 and 0.1 % of the pupil diameter respectively

Optical layout

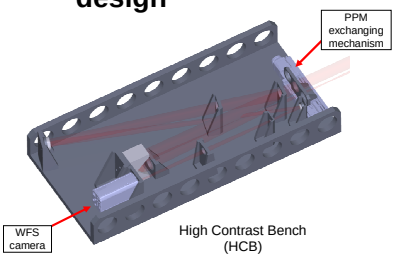


System budget

Type of perturbation	Amplitude	Sensitivity coefficient *a*	Power *p*	Weight *w*	Contrast *C*
Image quality	δ (waves RMS)				
Nominal	0.06	-	-	-	8.7E-08
Tilt Alignment	0.05	5.7E-04	4	1	3.6E-09
Atmospheric dispersion	0.39	5.7E-04	4	1	1.3E-05
Focus	0.02	1.6E-02	4	1	2.5E-09
Astigmatism	0.05	4.5E-02	5	1	1.4E-08
Oscillatory Low frequency (< 5 cycles)	0.01	1.2E-02	2	0.5	6.2E-07
Mid frequency (5-20 cycles)	0.01	9.0E-02	2	0.5	4.5E-06
High frequency (> 20 cycles)	0.02	2.0E-02	2	0.5	4.0E-06
Sub-total RMS	**0.10**				**1.5E-05**
Pupil shift	*s* (mm)				
Lateral alignment	0.2	5.6E-05	2	1	2.3E-06
				Total RMS	**1.5E-05**
				Science requirement	**1.5E-05**



Mechanical design



Preliminary system budgets confirm that contrast requirement is achieved

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