ELT Planetary Camera and Spectrograph (PCS)

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PCS Science: High-Contrast Imaging of exoplanets & disks

Small FoV [~1”], high contrast [~1e-8], high spatial resolution (~4 mas), eXtreme AO

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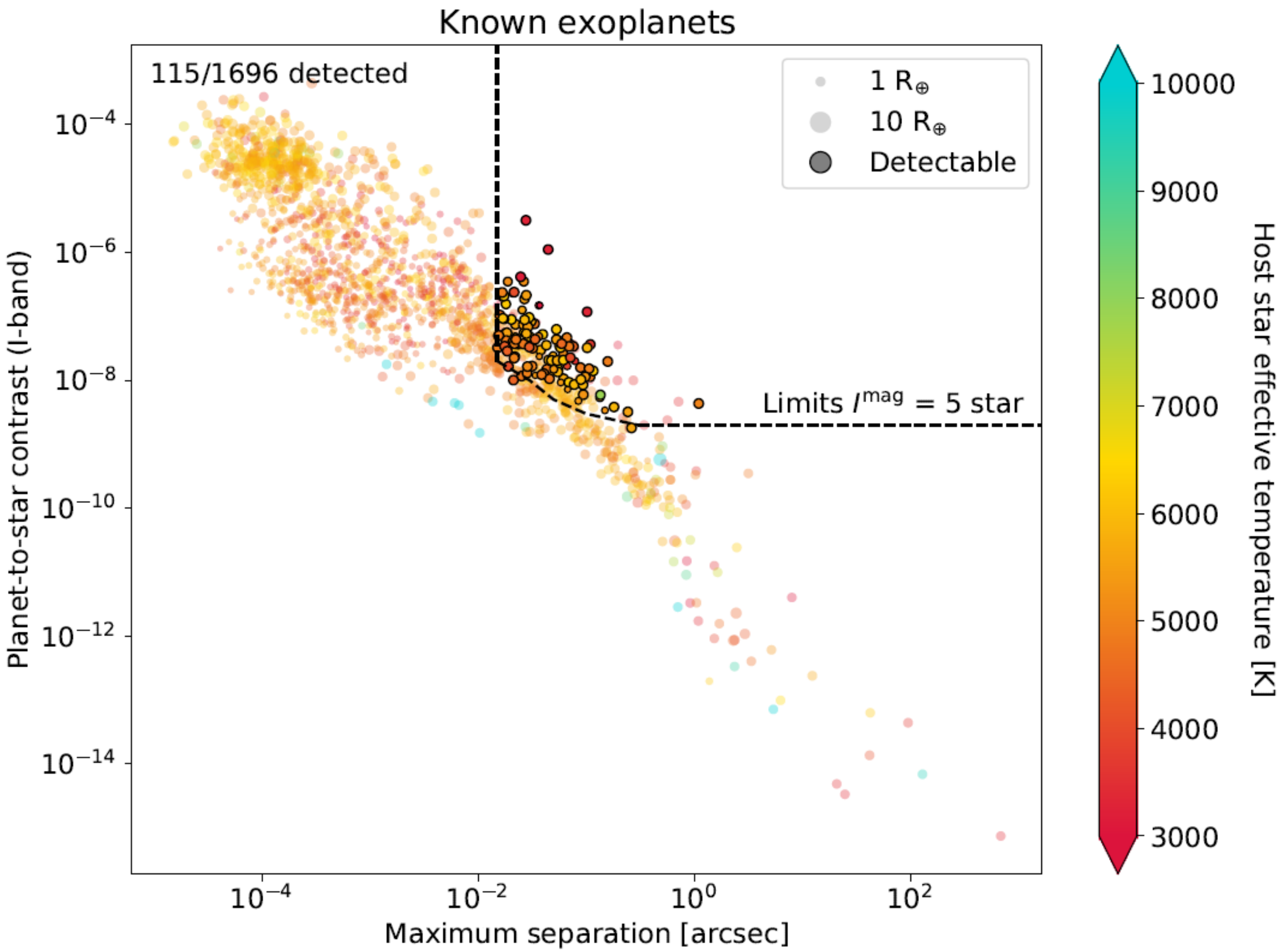
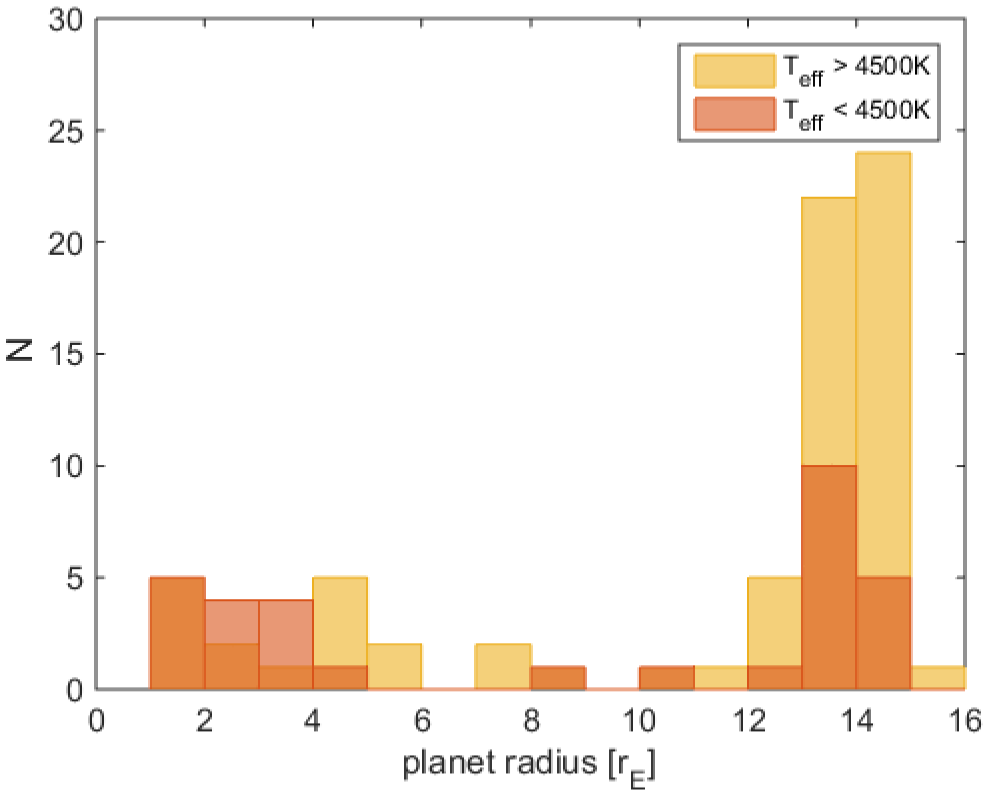
Artist's impression of the planet orbiting Proxima Centauri, eso1629a

PCS observable exoplanets



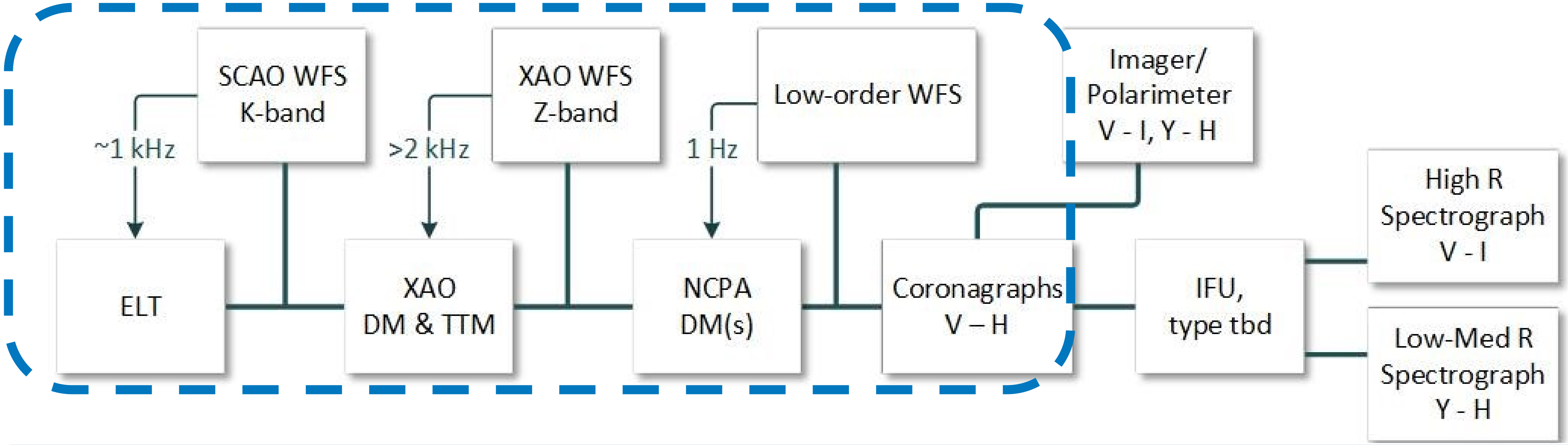


Kammerer/Kasper:

Realistic PCS sensitivity model already known Exoplanets (mostly from RV), 20 hrs observation:

>100 Exoplanets observable, down to Earth mass

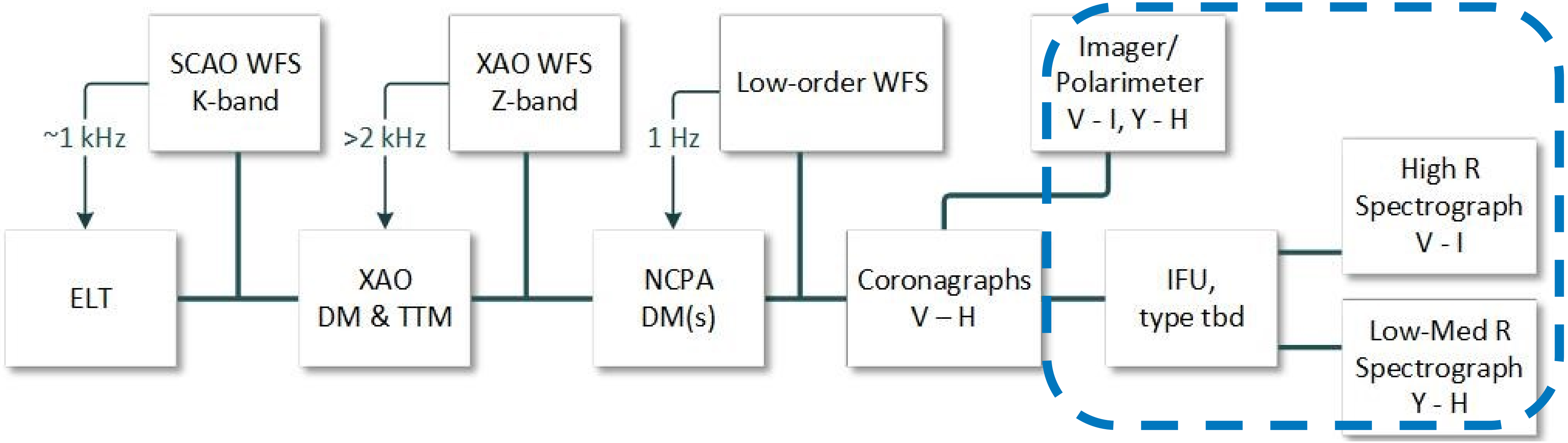
PCS concept v0



AO	
WFS 1	Modulated Pyramid WFS, NIR
DM 1	ELT M4
WFS 2	FF WFS (tbd, Zernike, Pyramid, Bi-O-Edge…)
DM 2	New development with Bertin-Alpao, 128 actuators across aperture
RTC	Low latency, framerate >~3 kHz, RL predictive control capability

Low-order WFS / coro	
WFS type	Tbd
Coro type(s)	Tbd, Perfect coro 2nd or 4th order for initial analysis
Dark hole	One-sided, IWA < 10 mas
DM LO	COTS NCPA DM, 64 actuators across pupil

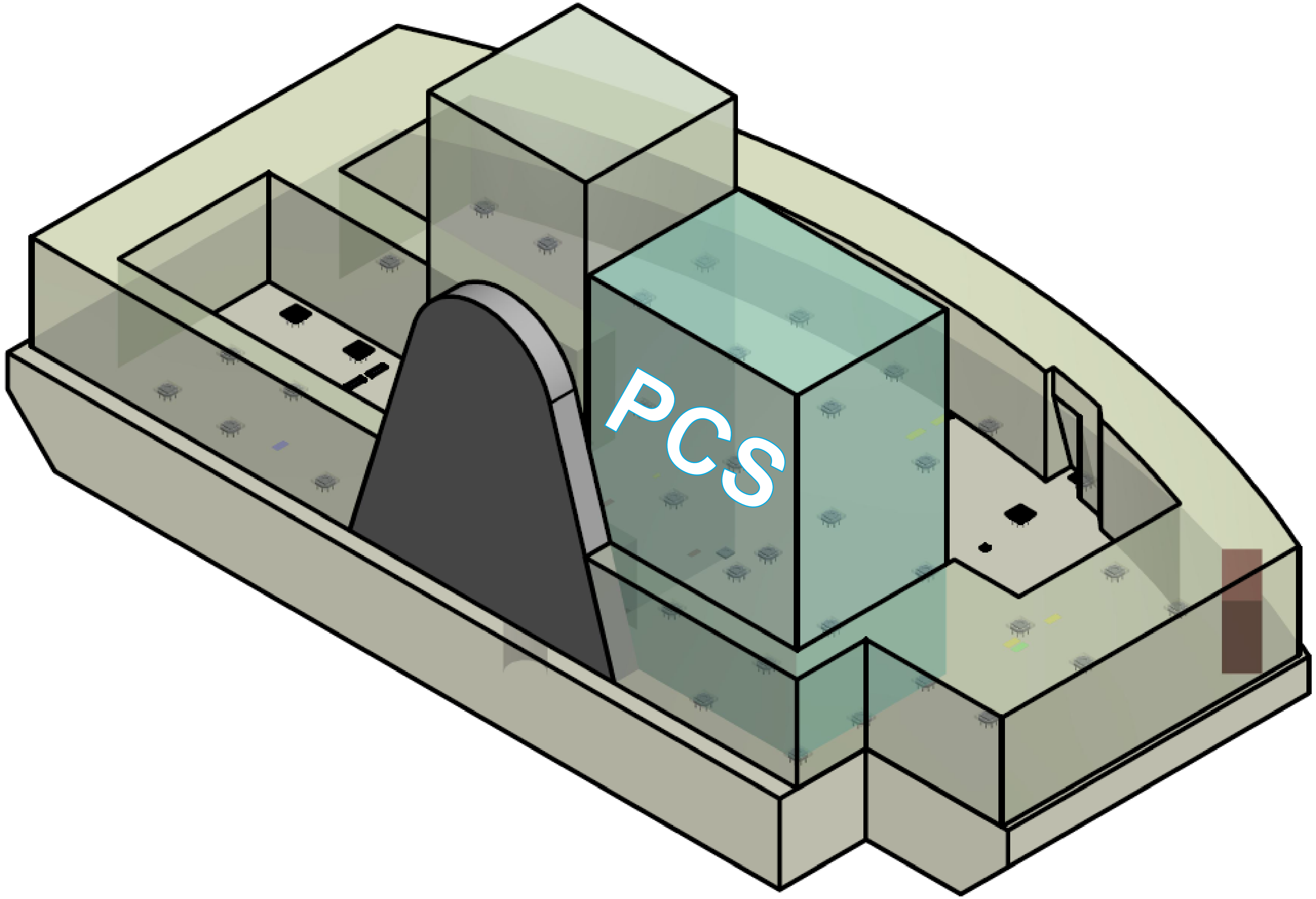
PCS concept v0



Imager	
Vis and IR channel (is there a detector that covers both?)	Vis: 600-1000nm (scientific CCD / CMOS), IR: 1000-1800 nm (Hawaii or SAPHIRA)
Spatial sampling	Super Nyquist at shortest wavelength
FoV	> 1.5” x1. 5”
Polarimetric mode	Yes

Spectrograph	
Type	IFU
R	Vis: ~100k (600-1000nm, bandpass up to 100nm) IR: ~1-10k (?, 1000-1800 nm, bandpass up to 300 nm)
#Spaxels	> 250 (semi-circle out to ~12l/D with l/D sampling)
Spaxel sampling	~l/D (necessary to go to Nyquist?)

Volume, mass…



10m x 6.6m x 4.75m

Mass budget unclear for now (depends on instrument configuration on PCS platform), ideally stay well below 14 tons

PCS is not yet started, currently in pre-phase-A (aka the roadmap)

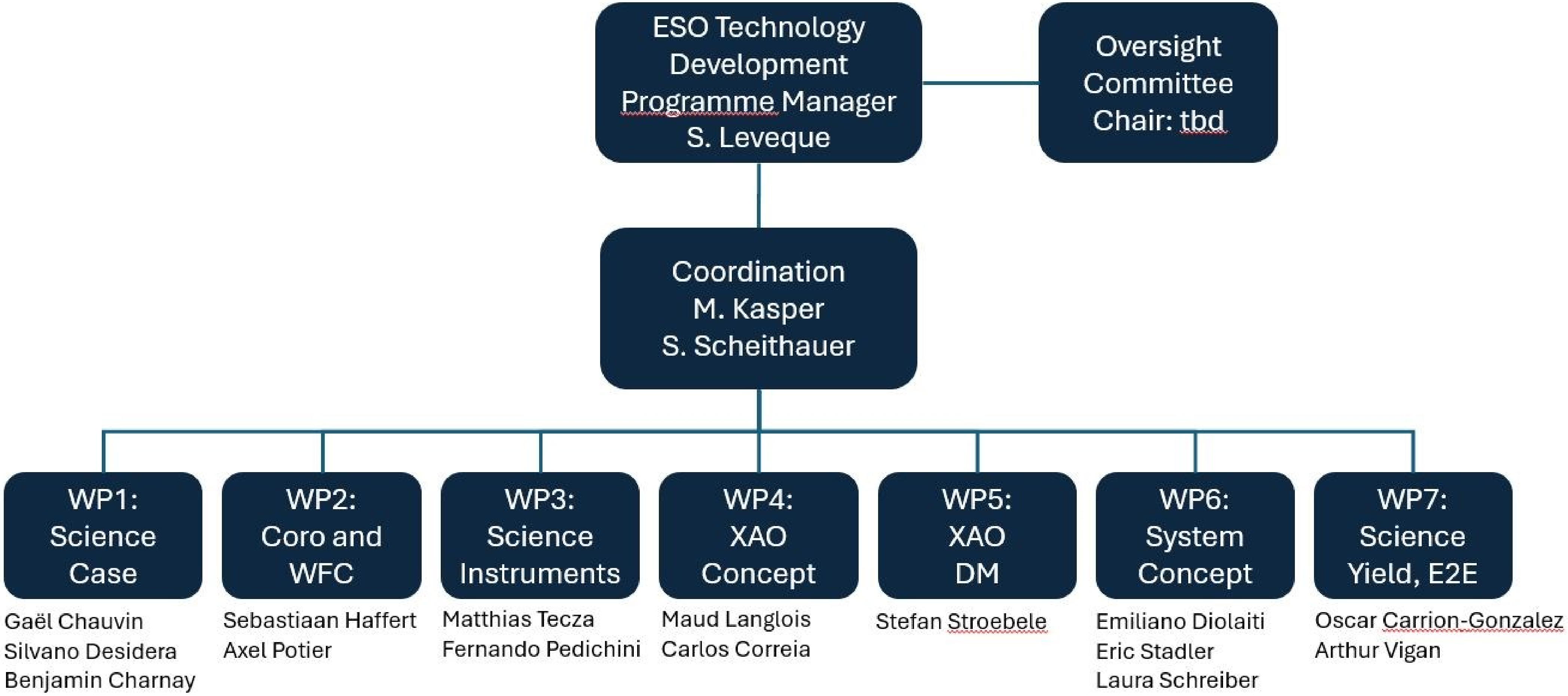
Instrument	Main specifications			Schedule				
	Field of view/slit length/ pixel scale	Spectral resolution	Wavelength coverage (μm)	Phase A	Project start	PDR	FDR	First light
MICADO	Imager (with coronagraph) 50.5″ × 50.5″ at 4 mas/pix 19″ × 19″ at 1.5 mas/pix	*I, Z, Y, J, H, K* + narrowbands	0.8–2.45	2010	2015	2019		
	Single slit	*R* ~ 20 000						
MORFEO	AO Module SCAO – MCAO		0.8–2.45	2010	2015			
HARMONI + LTAO	IFU 4 spaxel scales from: 0.8″ × 0.6″ at 4 mas/pix to 6.1″ × 9.1″ at 30 × 60 mas/pix (with coronagraph)	*R* ~ 3 200 *R* ~ 7 100 *R* ~ 17 000	0.47–2.45	2010	2015	2018		
METIS	Imager (with coronagraph) 10.5″ × 10.5″ at 5 mas/pix in *L*, *M* 13.5″ × 13.5″ at 7 mas/pix in *N*	*L*, *M*, *N* + narrowbands	3–13	2010	2015	2019		
	Single slit	*R* ~ 1400 in *L* *R* ~ 1900 in *M* *R* ~ 400 in *N*						
	IFU 0.6″ × 0.9″ at 8 mas/pix (with coronagraph)	*L*, *M* bands *R* ~ 100 000						
ANDES	Single object	*R* ~ 100 000	0.4–1.8 simultaneously	2018				
	IFU (SCAO)							
	Multi object (TBC)	*R* ~ 10 000						
MOSAIC	~ 7-arcminute FoV ~ 200 objects (TBC)	*R* ~ 5 000–20 000	0.45–1.8 (TBC)	2018				
	~ 8 IFUs (TBC)	*R* ~ 5 000–20 000	0.8–1.8 (TBC)					
PCS	Extreme AO camera and spectrograph	TBC	TBC					

1 milliarcsecond (mas) = 0.001″

https://elt.eso.org/instrument/

PCS Phase-A > 2029

PCS roadmap (2025-2027), ~120 contributors from more than a dozen institutes (Europe and US)



Goals of PCS roadmap collaboration

Clear understanding of the PCS instrument’s scientific objectives

Draft instrument concept addressing these scientific objectives

Rough estimates of important instrument budgets (volume, weight, transmission, power, cost)

Analysis of scientific capabilities of the proposed concept

Summary in a white paper by end of 2027

Establish training opportunities for graduate students and fellows in the field of high-contrast imaging

Procurements

T0:2029, PDR: 2032, FDR: 2034, MAIT ~1st mid of the 2030s

- Scientific detectors
  - Instruments: Optical (low noise scientific CCD, 8k x 8k - tbc) and NIR (low noise, 8k x 8k - tbc)
  - WFS: low RON, red optical – NIR, 200x200 px (WFS 1), 400x400 px (WFS 2)
- Optics
  - very small FoV (1”) -> relatively small optics (<~20-30 cm beam footprint)
  - superb optical quality and stability
  - High transmission coatings
- Coronagraph components (phase and amplitude masks, high precision, few 10s mm in diameter)
- Spectrograph: Slicer or integrated fiber optics for coupling focal plane to spectrograph, disperser
- DMs (128 and 64 actuators across aperture)

Thank you!

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