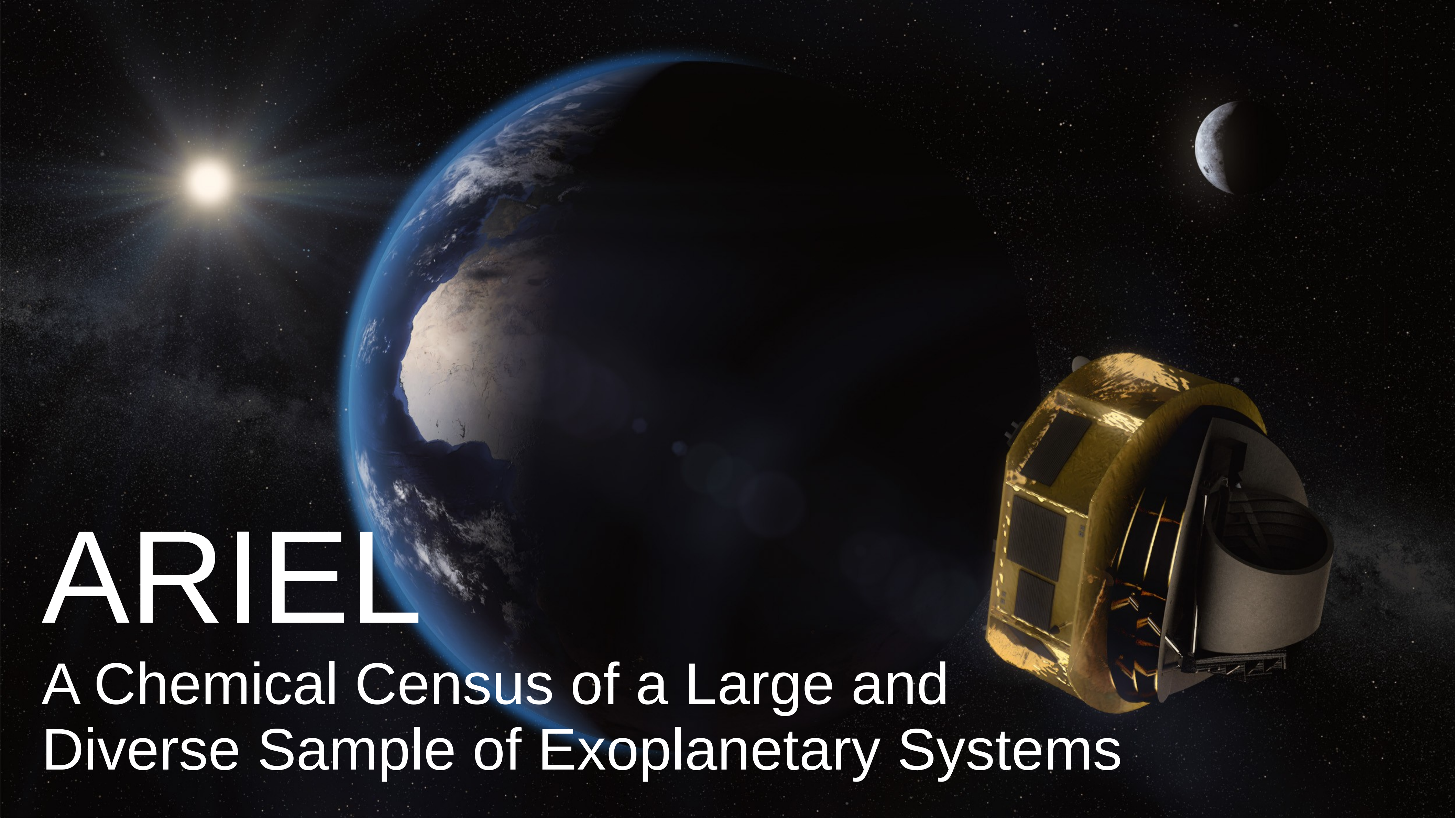


ARIEL

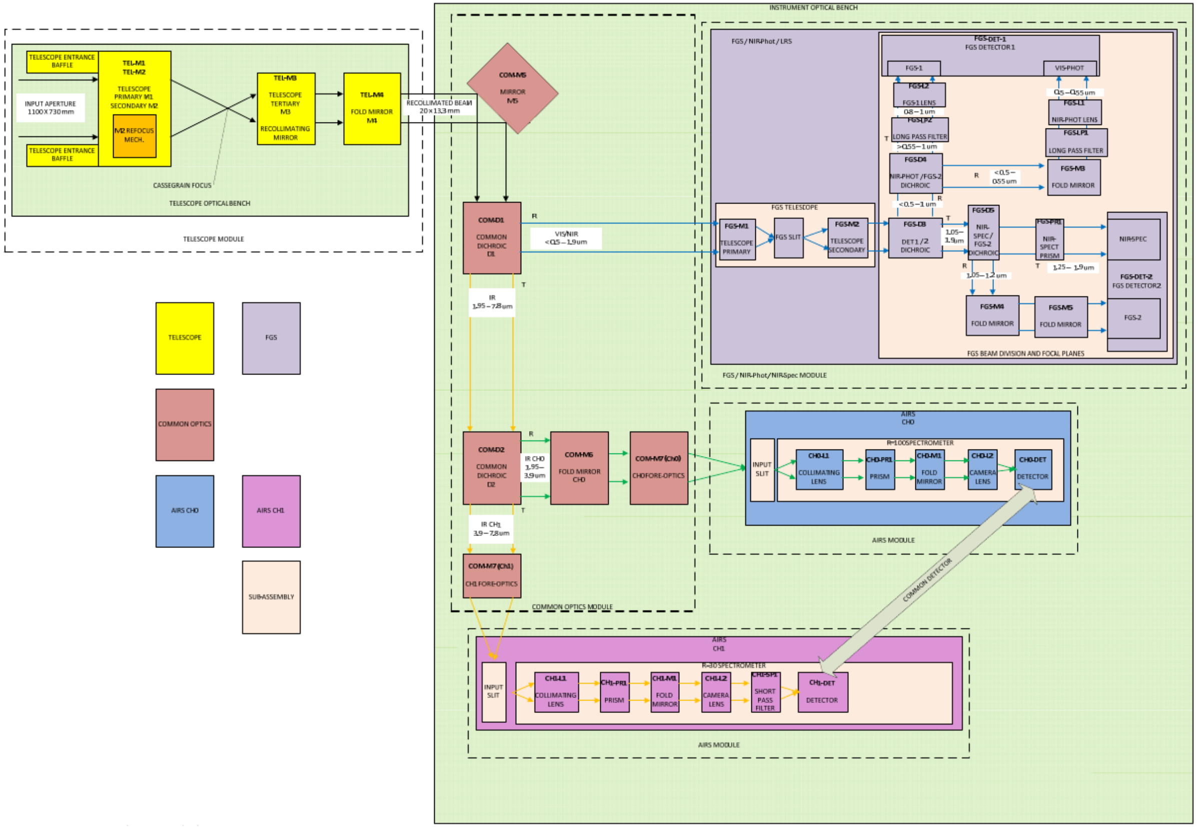
A Chemical Census of a Large and Diverse Sample of Exoplanetary Systems

ARIEL fact-sheet

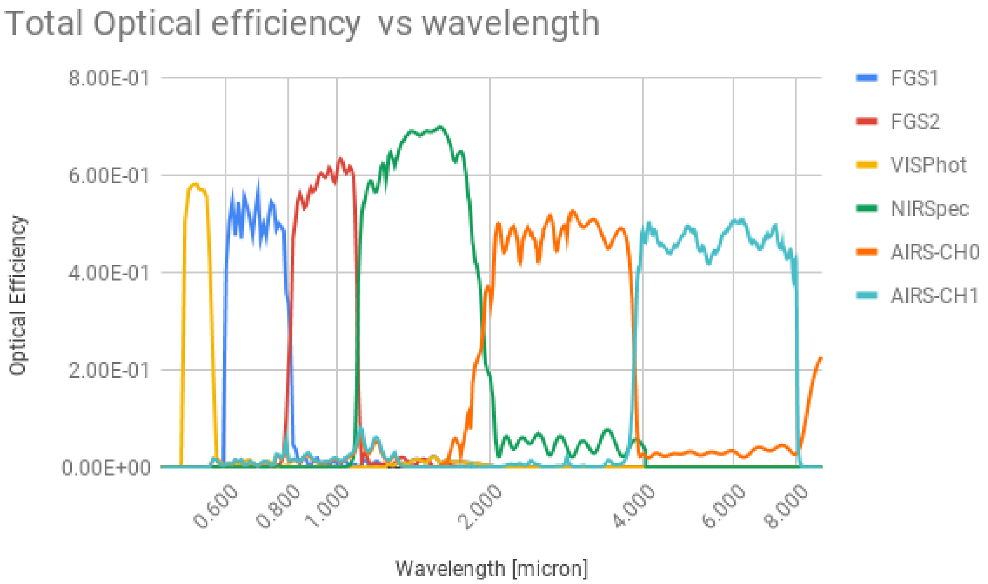
Name	λ (μm)	Spectral Resolution Reqt / Design
VisPhot	0.5 – 0.55	Photometer
FGS-1	0.8 – 1.0	Photometer
FGS-2	1.05 – 1.2	Photometer
NIRSpec	1.25 – 1.95	R≥10 / 20 – 25
AIRS-Ch0	1.95 – 3.9	R≥100 / 102 – 180
AIRS-Ch1	3.9 – 7.8	R≥30 / 30 – 64

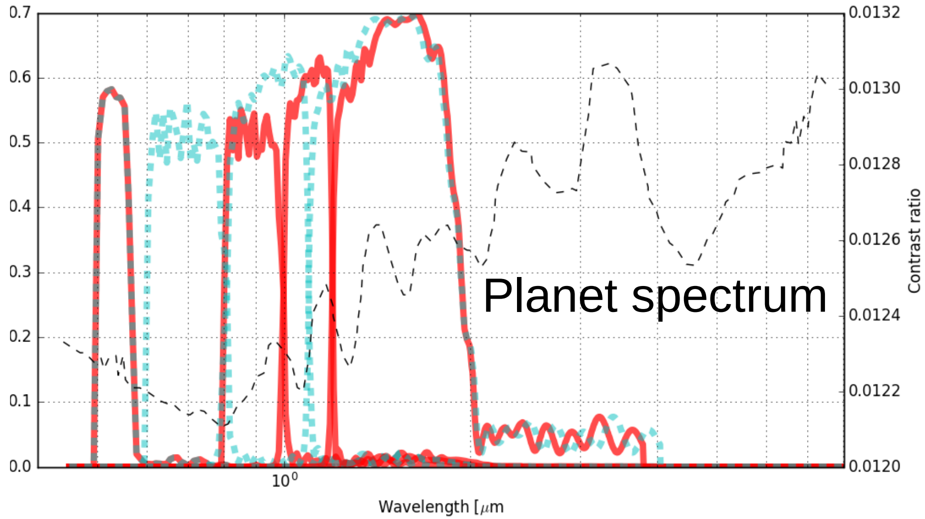
- 1-m class Cassegrain telescope
- L2 orbit
- Photon noise dominated performance
- Ultra-stable spectrophotometry, better than 10–20 ppm
- Fast slew over large portion of skys: ~70deg/15min + 5min overhead

Payload optical diagram



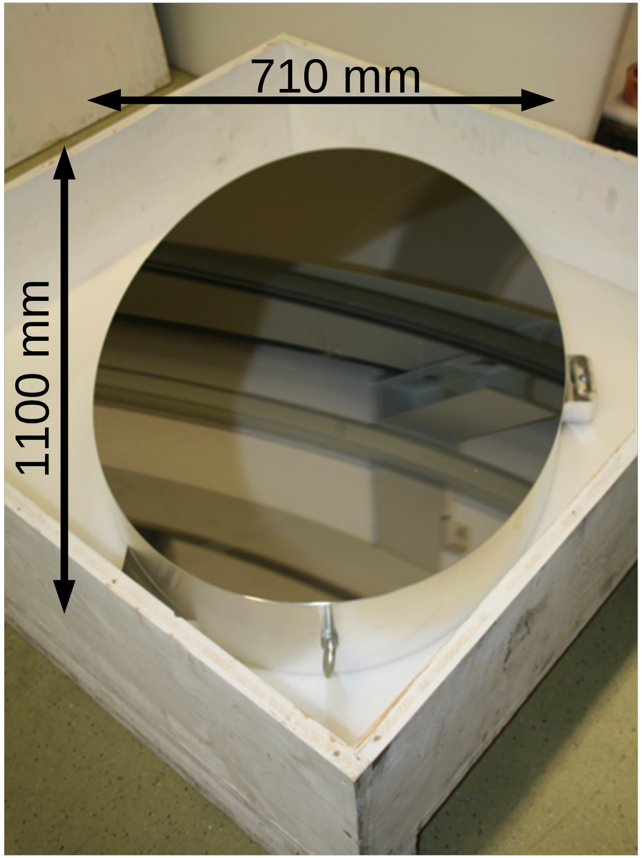
Photometric and spectroscopic bands



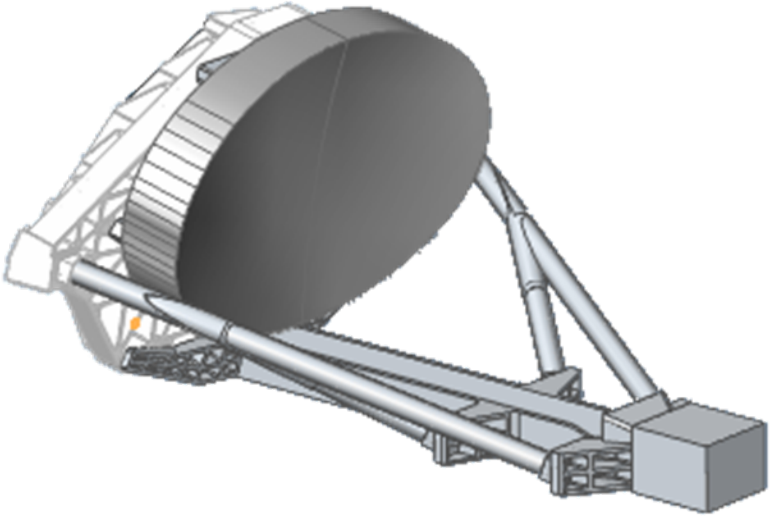


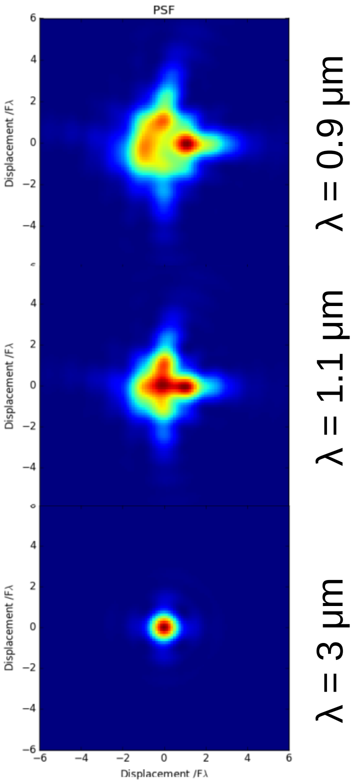
Not included: detector quantum efficiency

Narrow FOV, light bucket instrument

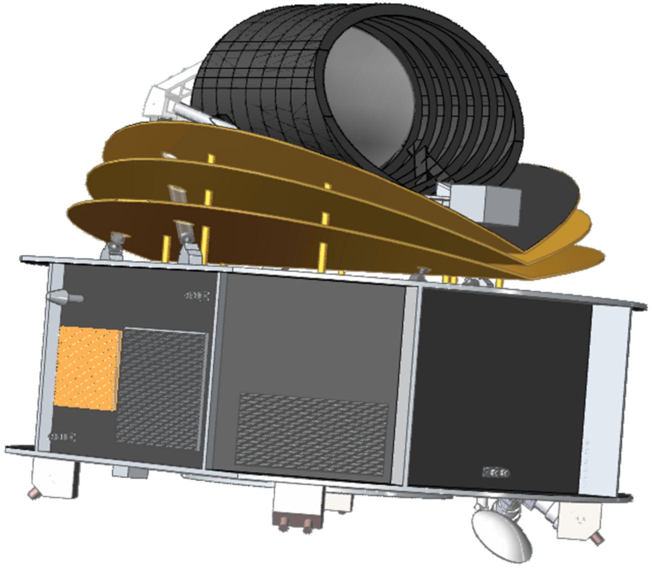


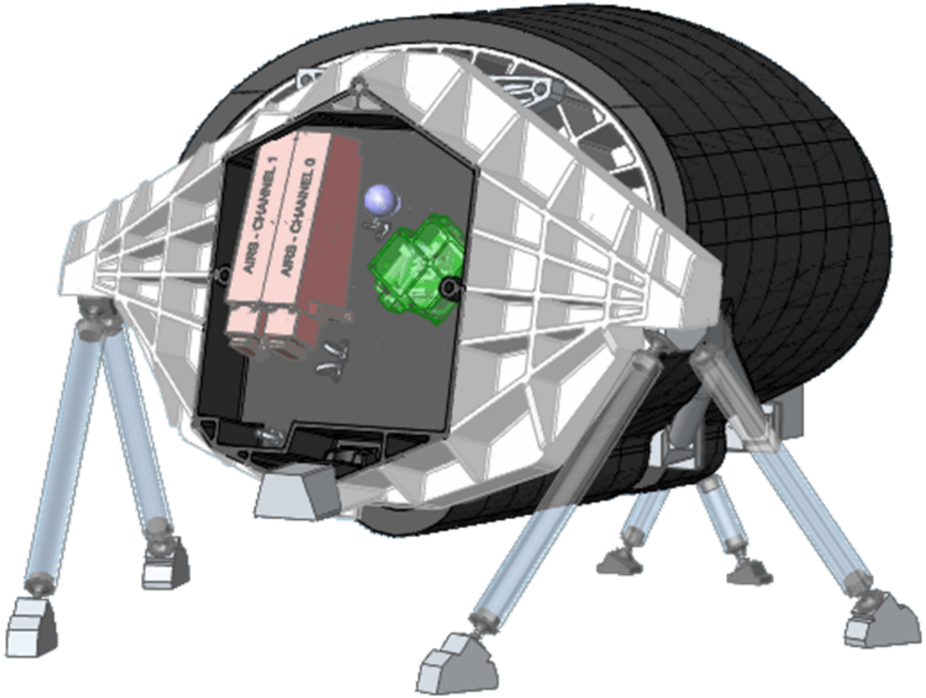
- Aluminium primary mirror
- Silver coated
- Diffraction limited at $\lambda \geq 3$ μm



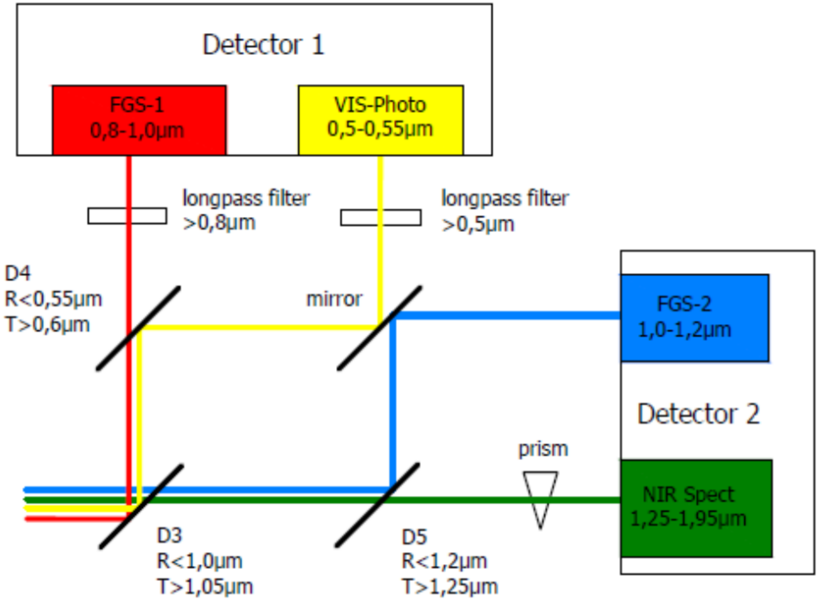


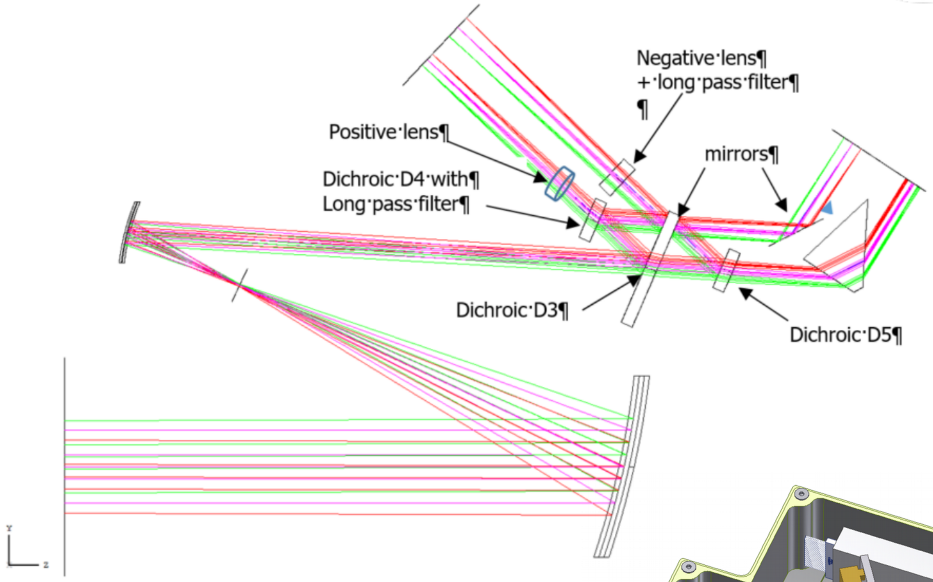
Payload and service module

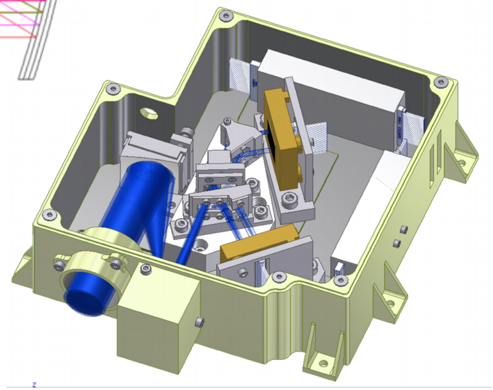




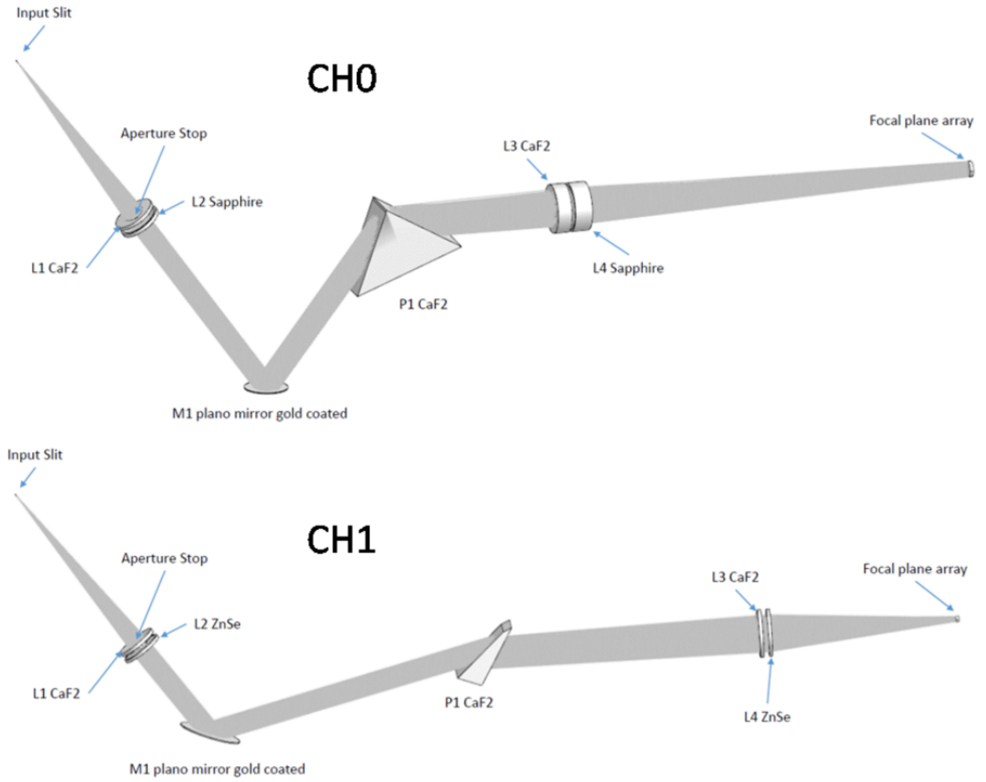
VISPhot – FGS1 – FGS2 – NIRSpec

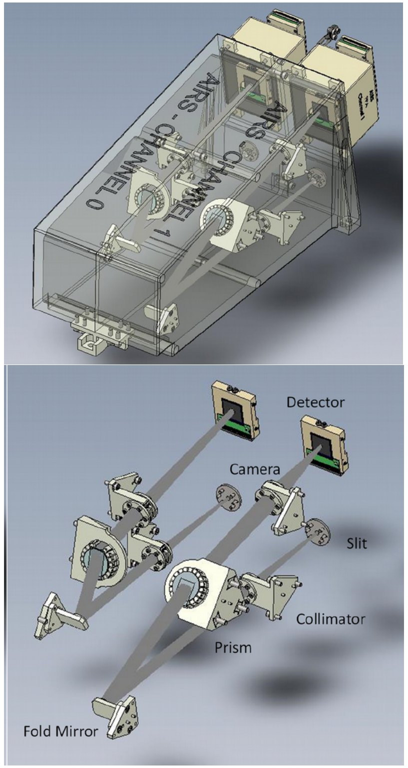






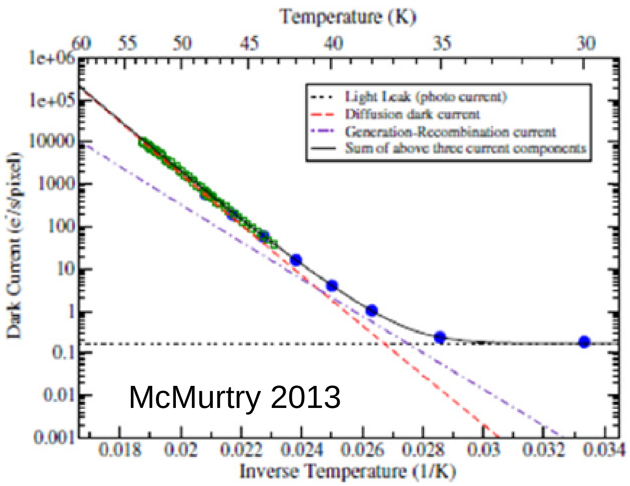
AIRS CH0 – CH1

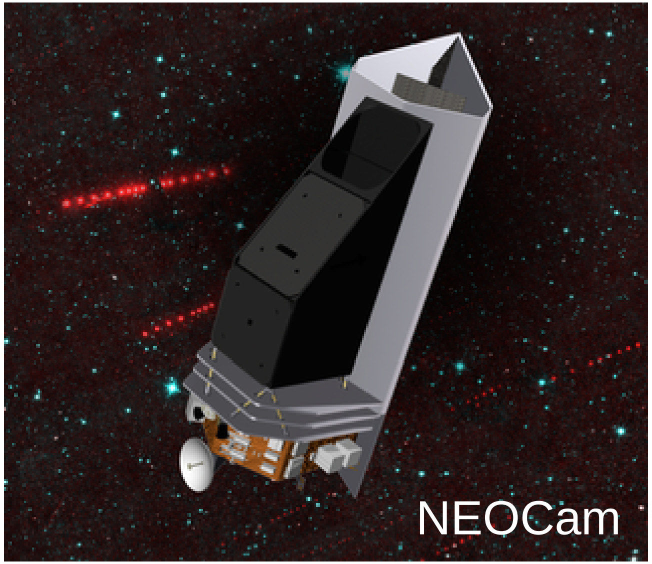

Input Slit
CH0
Aperture Stop
L2 Sapphire
L1 CaF2
L3 CaF2
Focal plane array
L4 Sapphire
P1 CaF2
M1 plano mirror gold coated
Input Slit
CH1
Aperture Stop
L2 ZnSe
L1 CaF2
L3 CaF2
Focal plane array
P1 CaF2
L4 ZnSe
M1 plano mirror gold coated

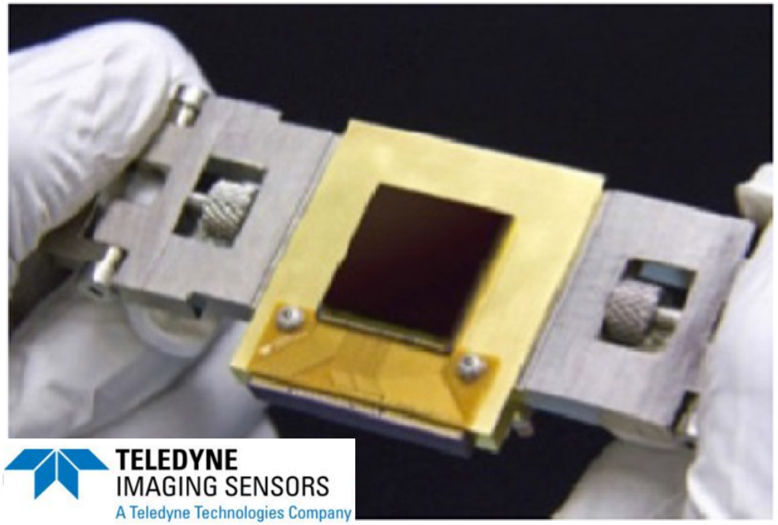

AIRS - CHANNEL 0
AIRS - CHANNEL 1
Detector
Camera
Slit
Collimator
Prism
Fold Mirror

HgCdTe (MCT) detectors

Teledyne–IS







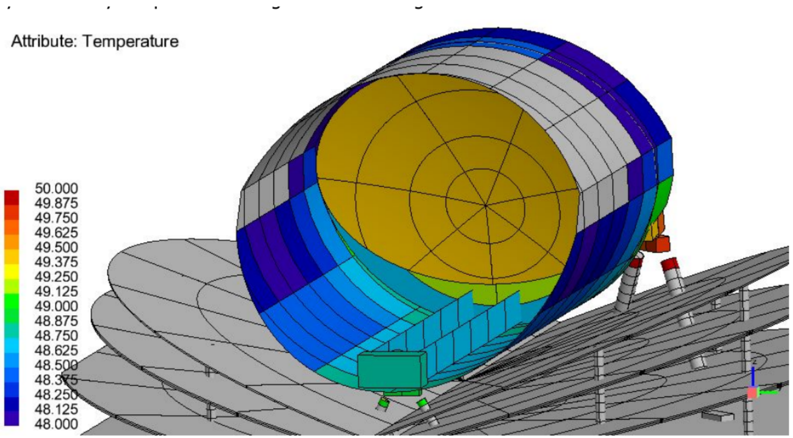
Euclid electronics and detector heritage

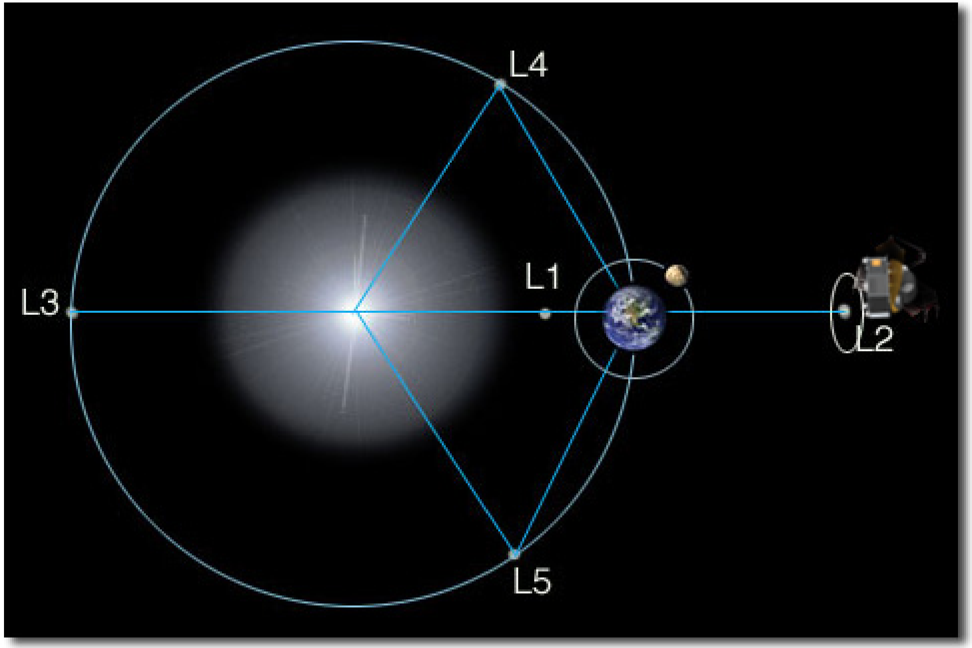
AIRS-CH1 leverages US-NEOCam development, but ARIEL–customised

Negligible systematics by design

Type of uncertainty	Source	Mitigation Strategy
Detector noise	Dark current noise	Choice of low-noise detectors
	Readout noise	
	Gain stability	Calibration, post- processing data analysis, choice of stable detectors.
	Persistence	Post-processing decorrelation. Continuously staring at a target for the whole duration of the observation.
Thermal noise	Emission from telescope, common optics and all optical elements	Negligible due to surface emissivity properties and in-flight temperatures of the payload.
	Temperature fluctuations in time	Negligible impact by design
Astrophysical noise	Photon noise arising from the target	Fundamental noise limit, choice of aperture size (M1 diameter).
	Photon noise arising from local zodiacal light	Negligible over ARIEL band
	Stellar variability with time	Multi-wavelength stellar monitoring, post-processing decorrelation
Pointing jitter	RPE and PDE effects on the position, Spectral Energy Sistribution, and detector intra/inter pixel response	Small RPE and PDE, Nyquist sampling, post-processing decorrelation
	Slit losses	Spectrometer input slit sufficiently large

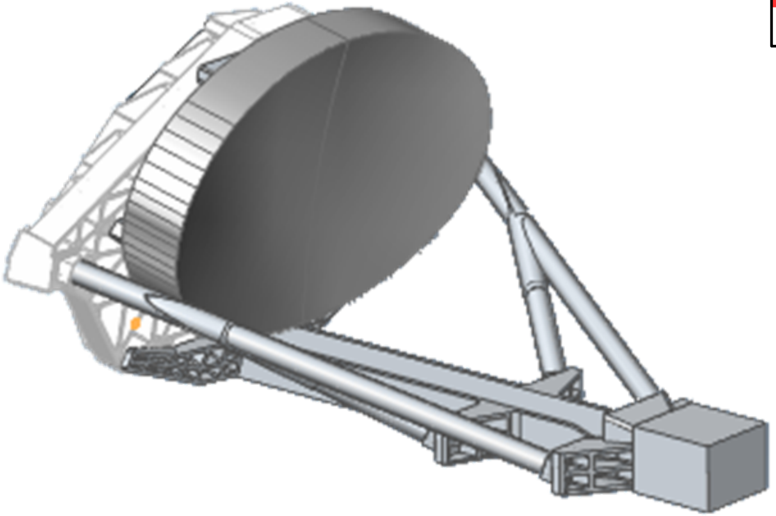
Ultra-stable operational environment

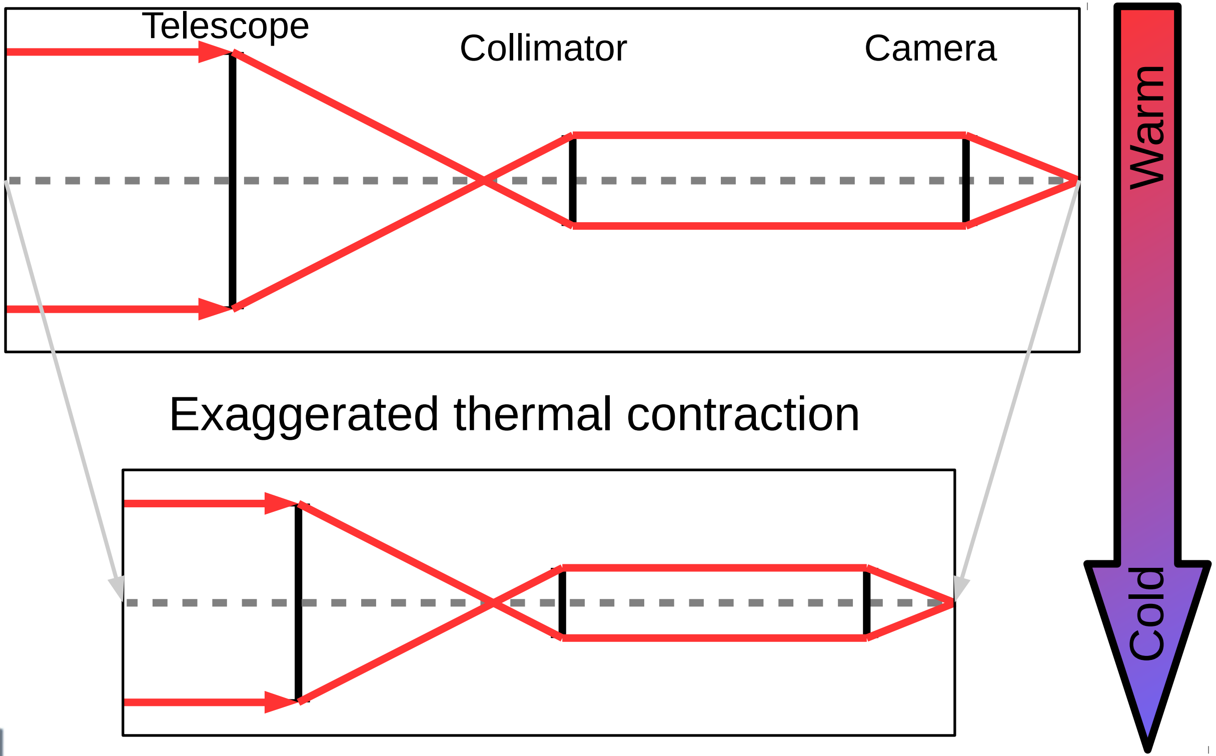




Built to be photometrically stable

Achieved by using same material (**aluminium**) for telescope mirrors, supports, optical benches and channel instruments.





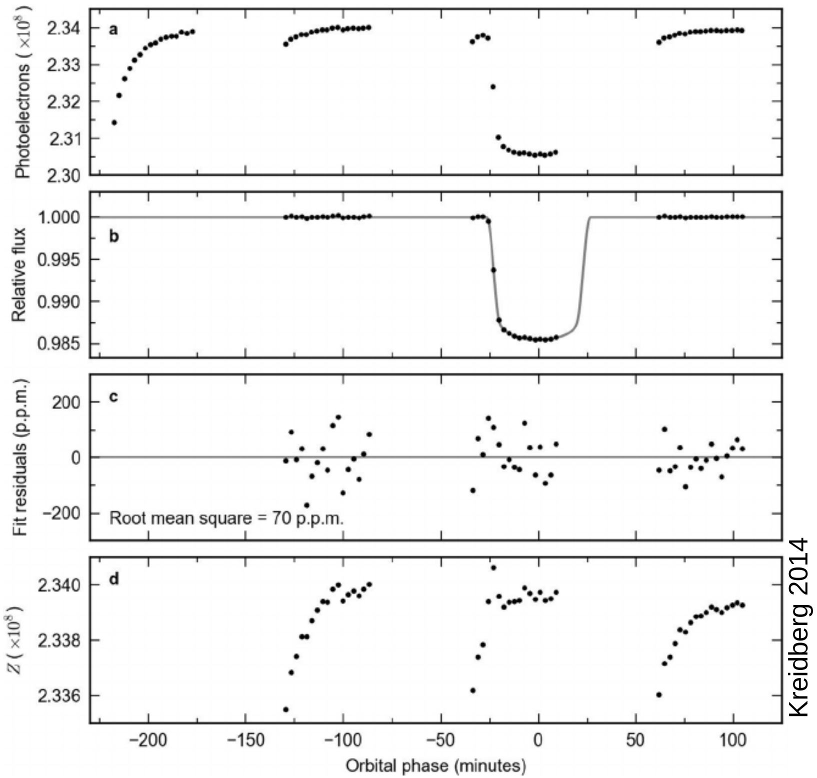
Negligible PSF variations during observations.
ΔFWHM/FWHM << 0.1%

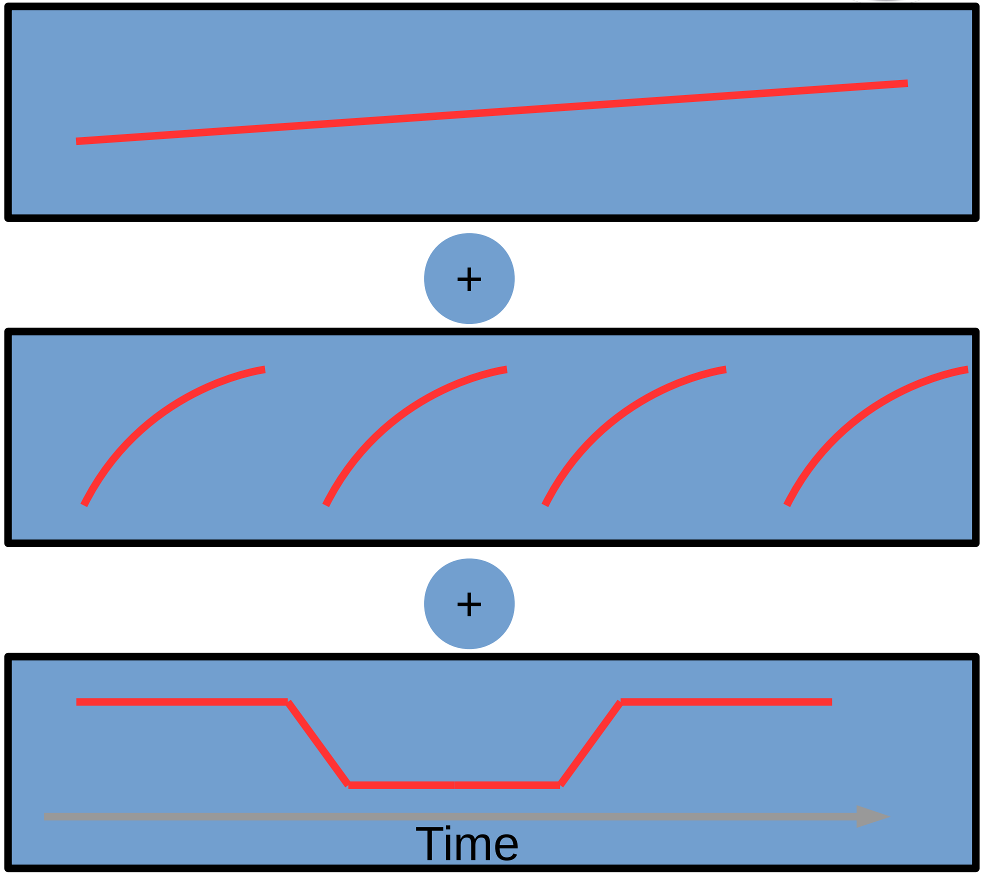
Pointing stability

- Can be problematic in presence of intra– and inter–pixel detector response variations
- Can however be made negligible applying good practice in instrument design
  - All focal planes shall be Nyquist sampled spatially
  - Flat field coefficient shall be know with sufficient precision (< 0.5%)
- Both are true in ARIEL

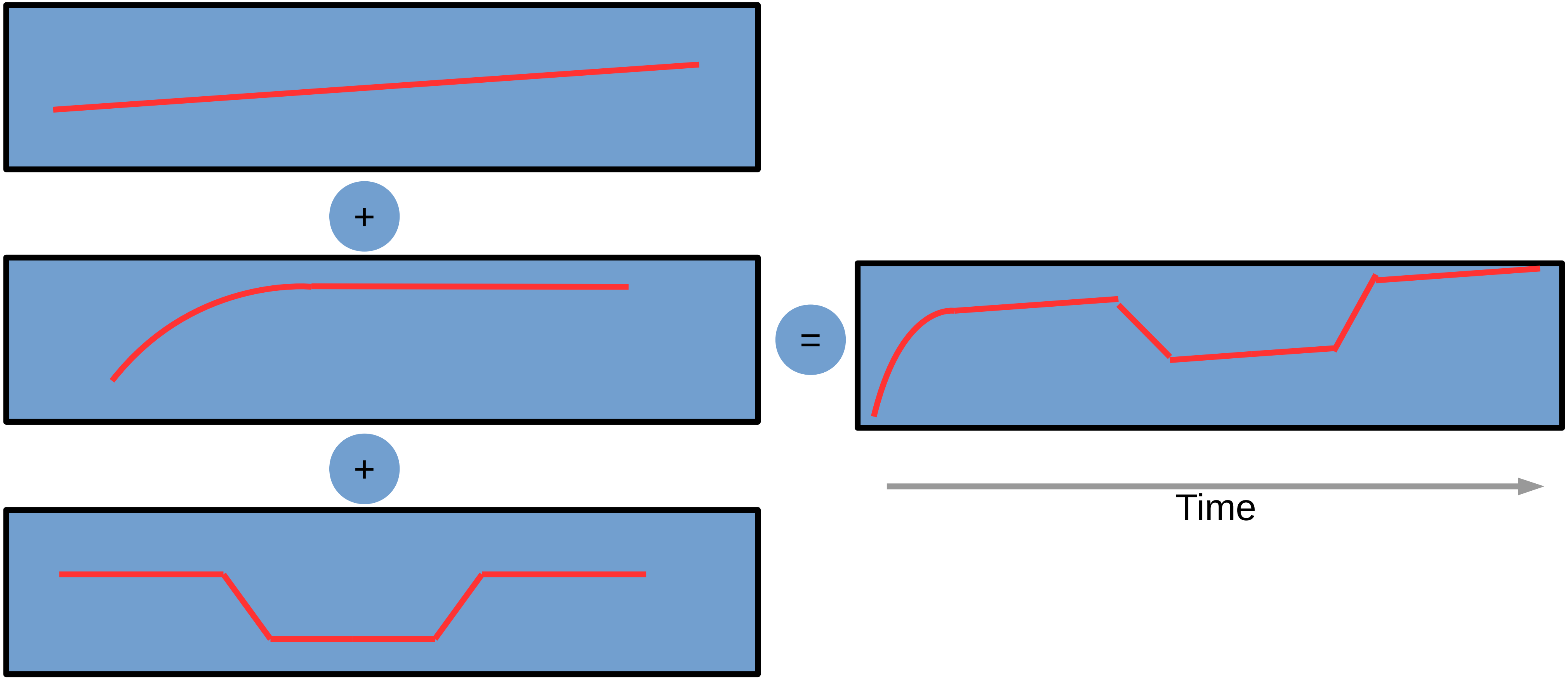
Detector effects seen in HST–WFC3

Don’t apply to ARIEL

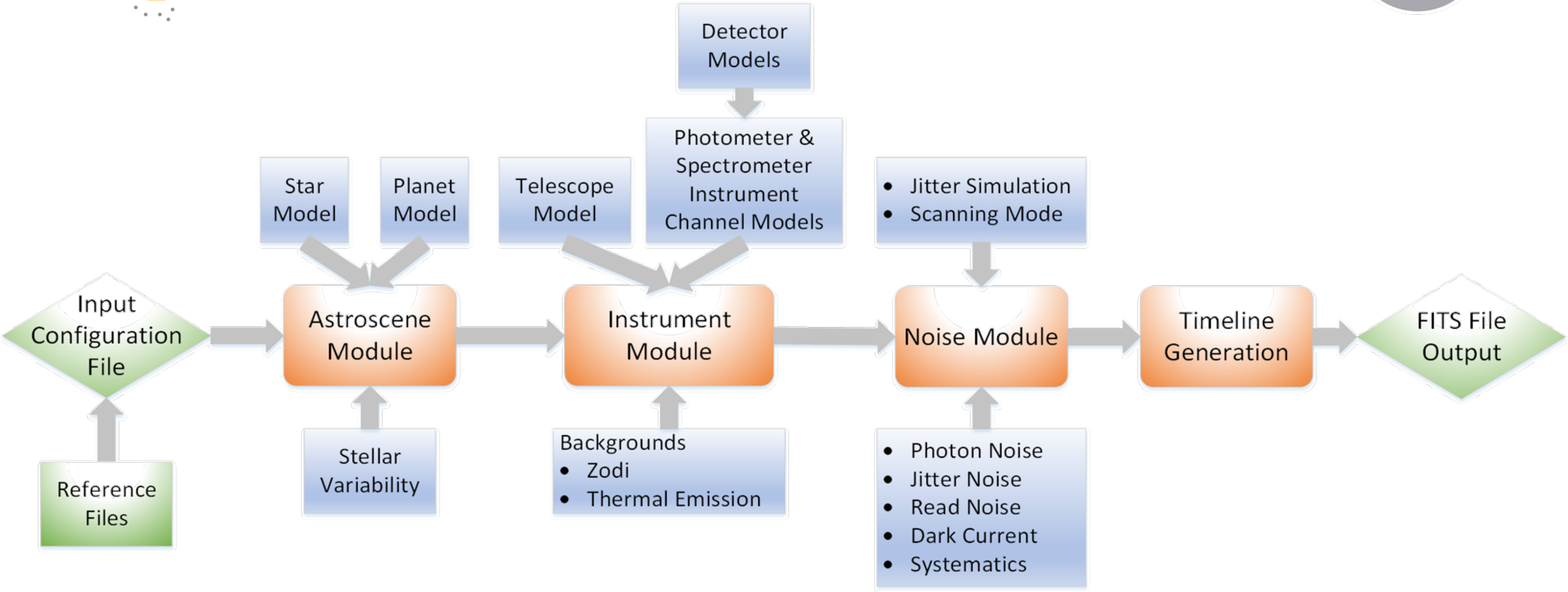




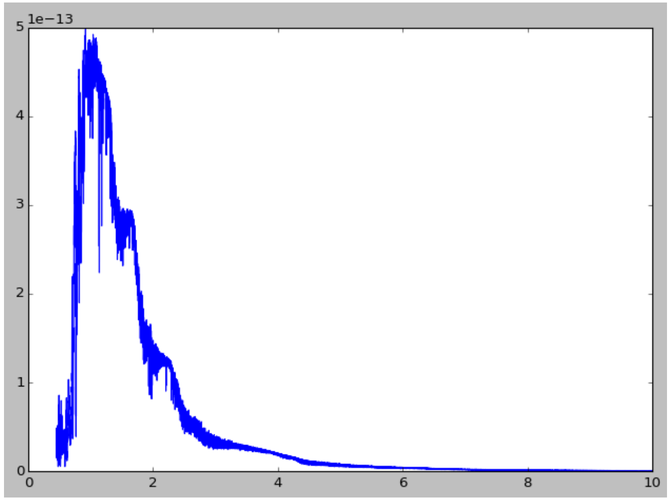
Long staring: detector is stable



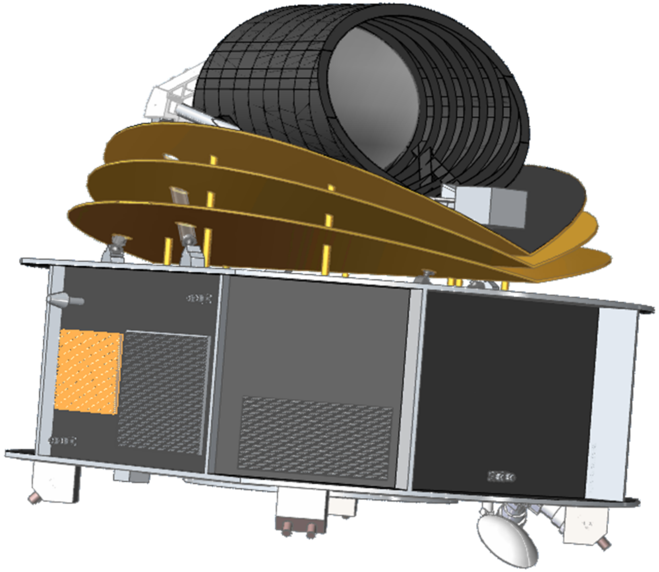
The ARIEL end-to-end simulator



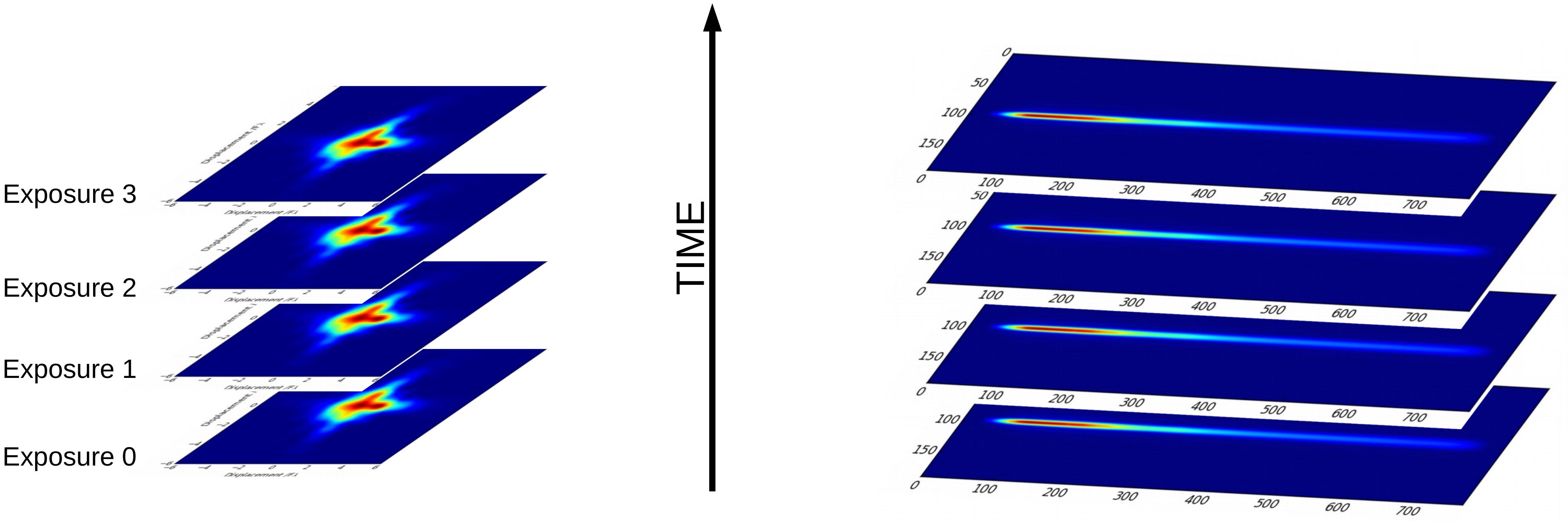
Input



+

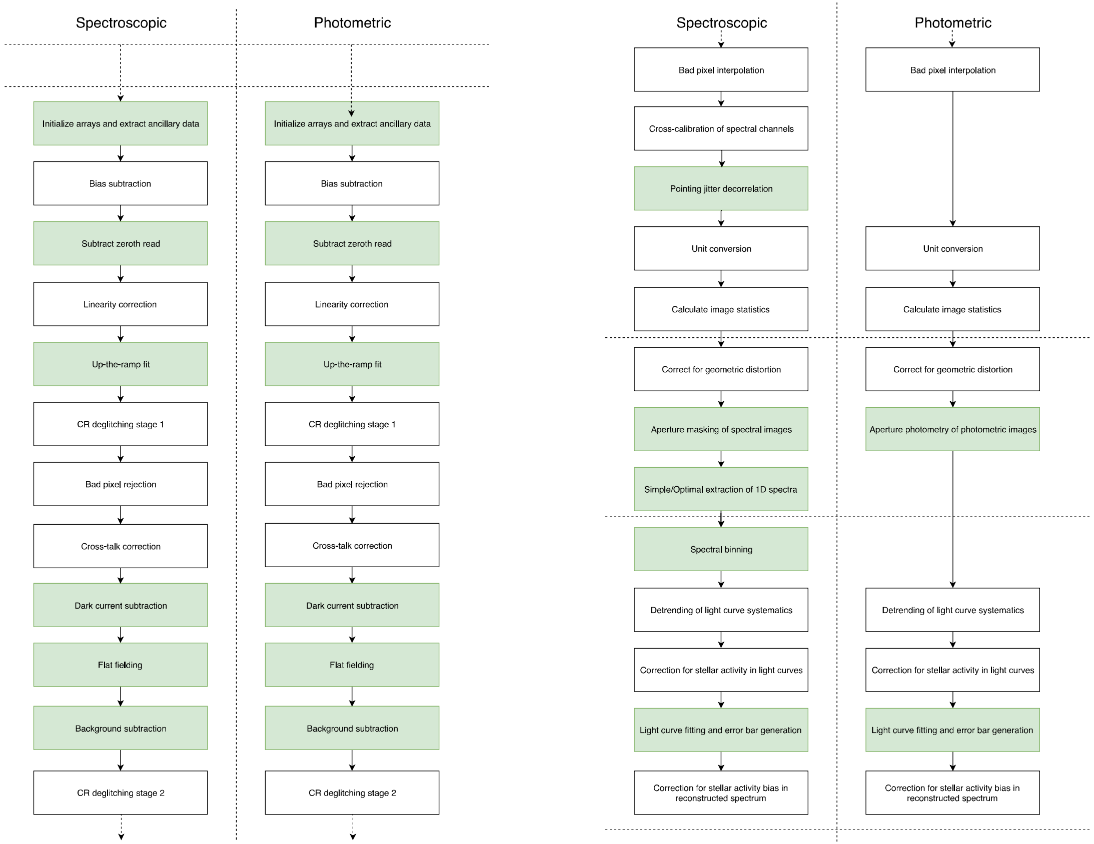


Output



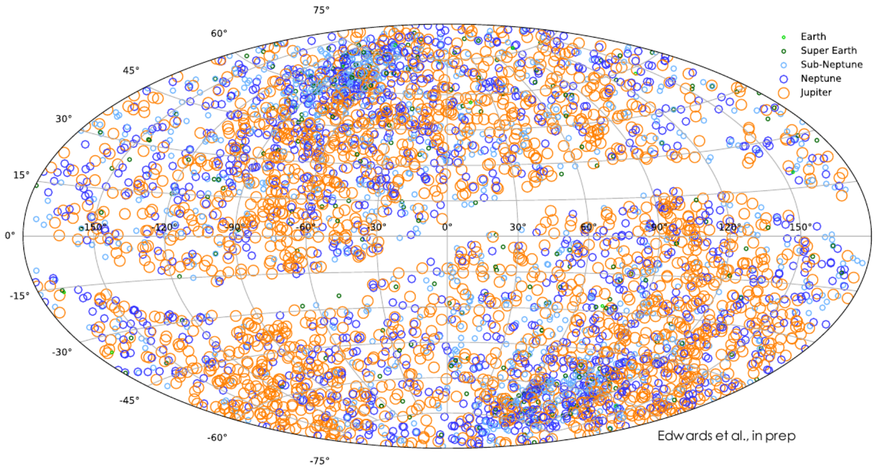
ADaRP

ARIEl Data Reduction Pipeline



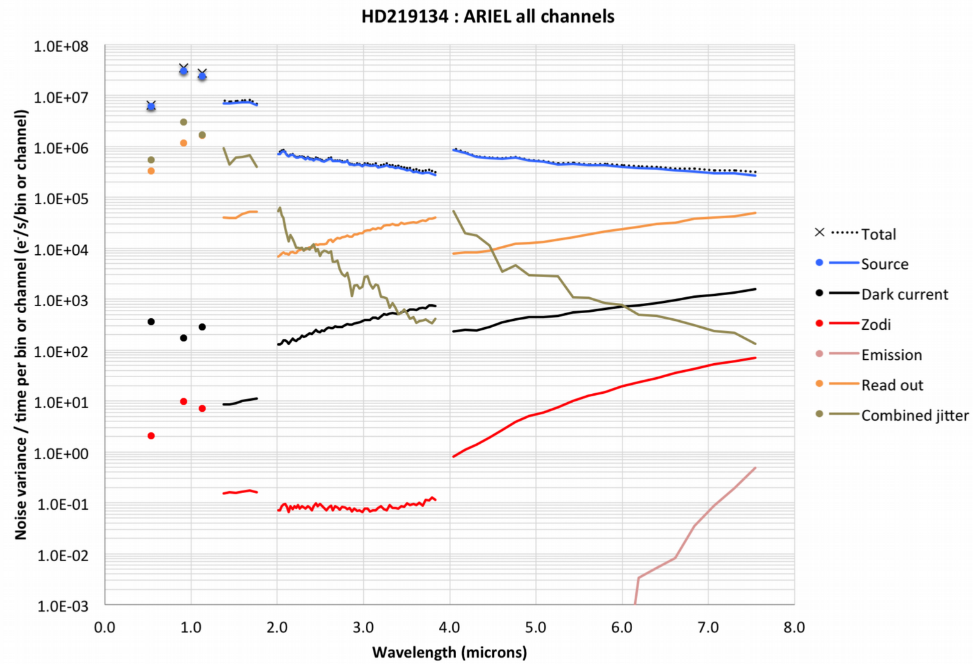
- Under definition in phase B1
- A working prototype exists
- Used to reduce ExoSim data

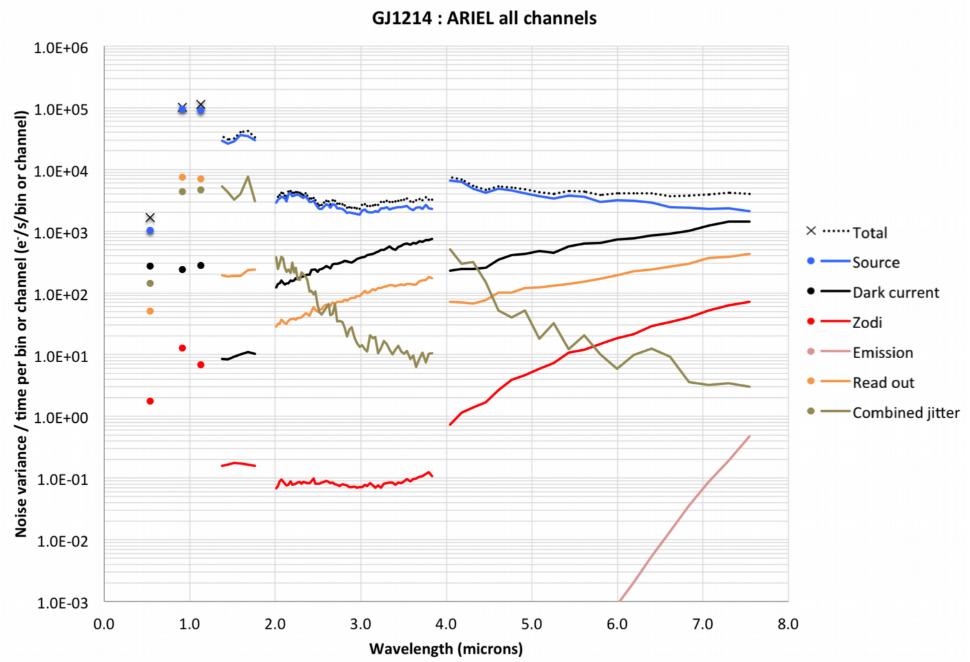
Mission Reference Sample and archetypes



- Thousand of targets to chose from
- Select a large, about 1,000, diverse exoplanets
- Mission is sized using archetypal targets for bright and faint sources
  - GJ1214 : a cold (T3000K) faint (m_k = 8.8) M dwarf
  - HD219134: a bright (m_k = 3.5) k-star

ARIEL end-to-end performance

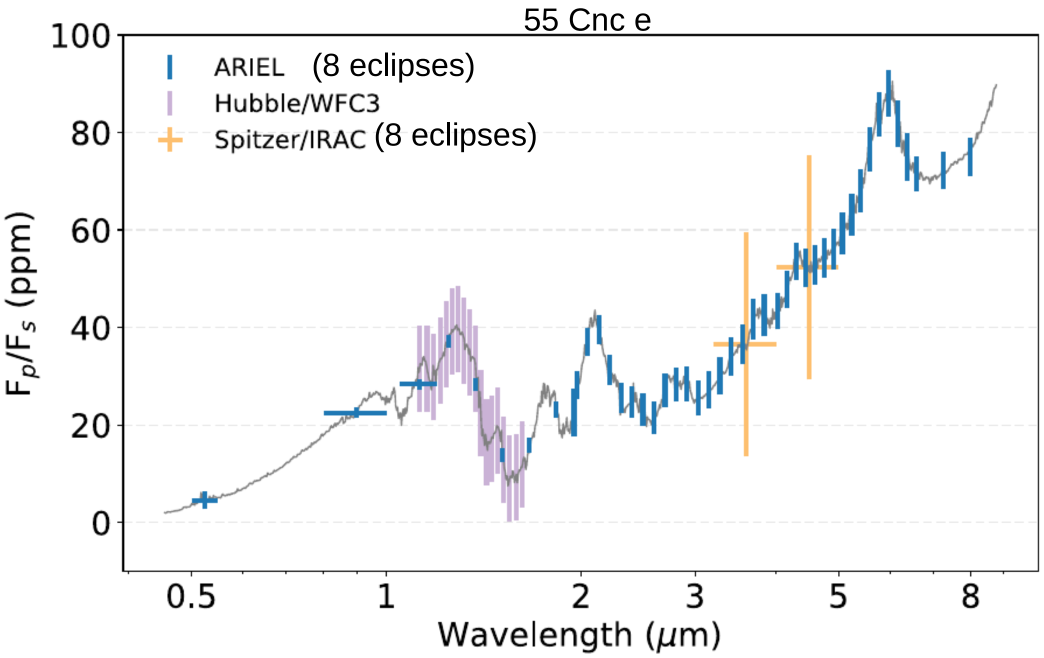


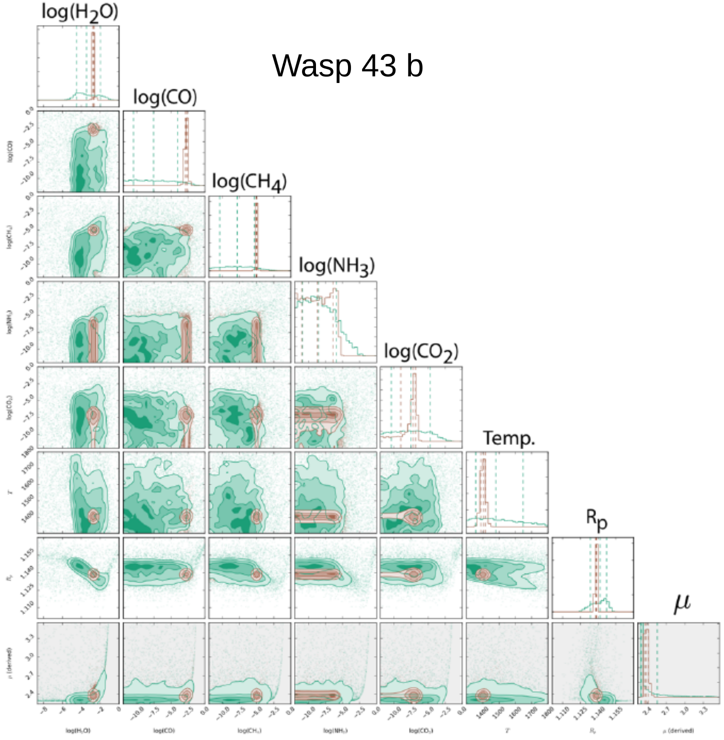


Comparison with other instruments

Not only a question of error bar sizes

Continuous coverage → formidable spectroscopic mapper

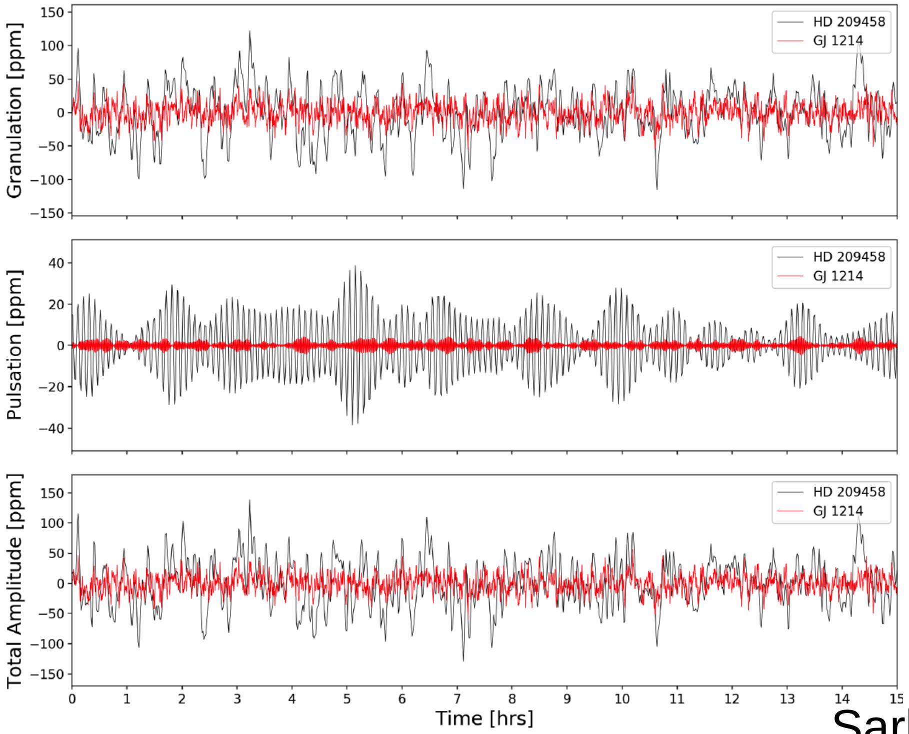


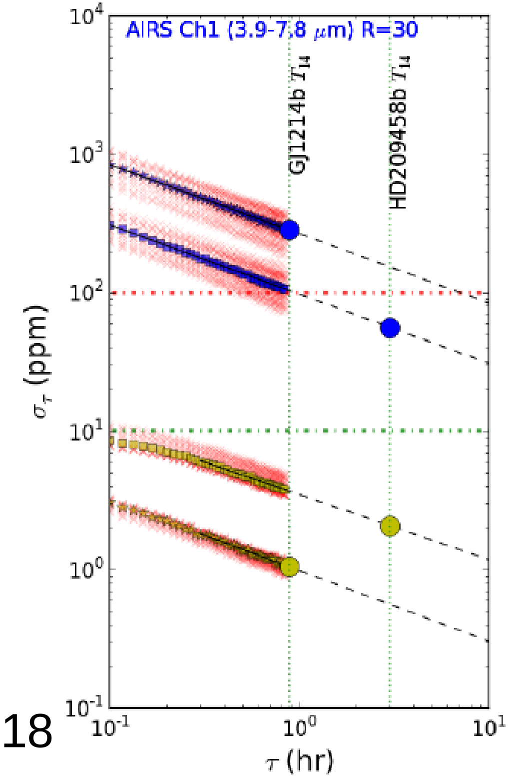


Green: WFC3 – Red: ARIEL

Star activity: pulsation and granulation

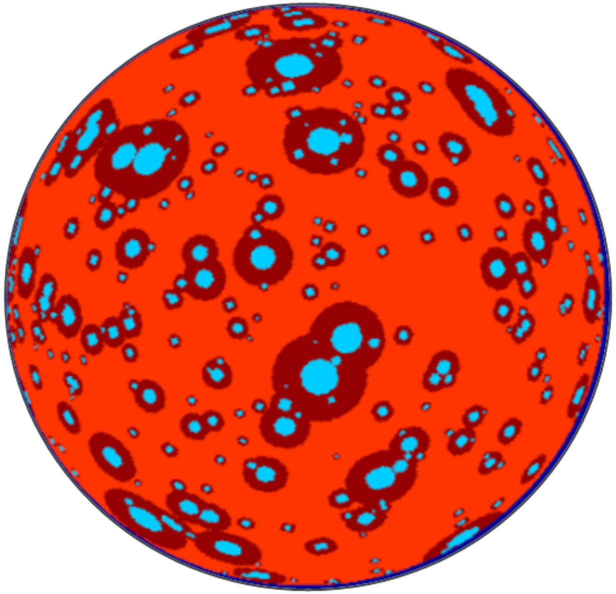
Negligible for ARIEL



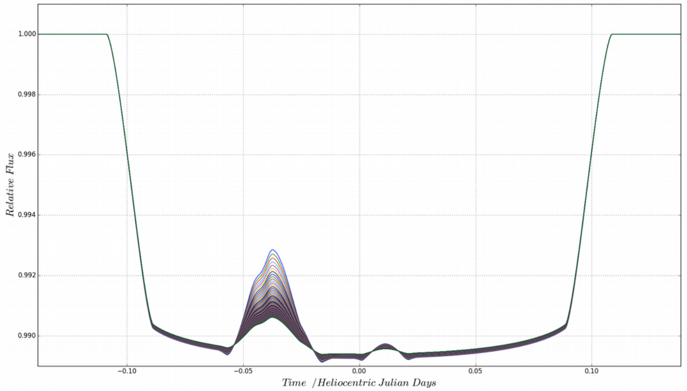


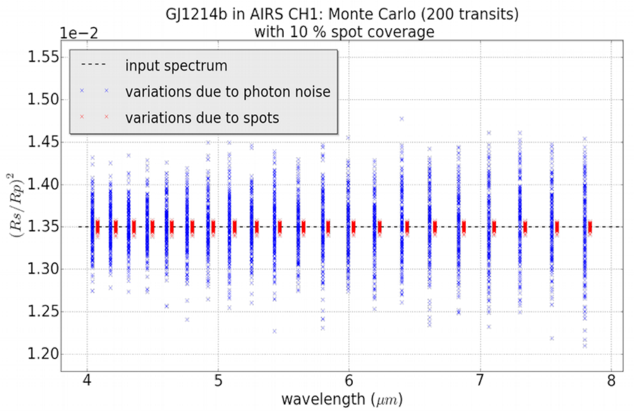
Sarkar 2018

Star activity: spots & faculae

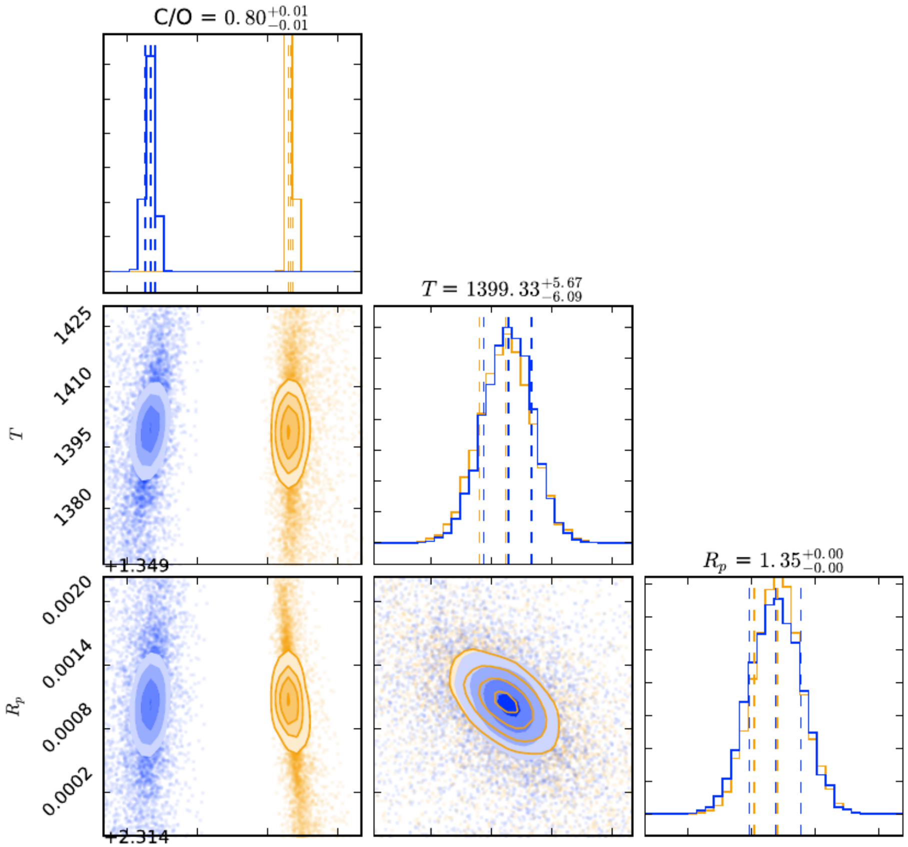


- Cold spots shown in light blue.
- Hot faculae shown in brown.





Abundances



$C/O = 0.80^{+0.01}_{-0.01}$
$T = 1399.33^{+5.67}_{-6.09}$
$R_p = 1.35^{+0.00}_{-0.00}$
T
1425
1410
1395
1380
+1.349
R_p
0.0020
0.0014
0.0008
0.0002
+2.314

Closing thoughts

- ARIEL is designed to be the most efficient chemical mapper of a large and diverse population of known transiting exoplanets
- ARIEL performance is dominated by the astrophysical noise of the targets in the Mission Reference Sample
- Nothing prevents observing fainter targets in instrument noise dominated regime
- Performance modelling to support payload/ground segment development
- Performance modelling to support science development