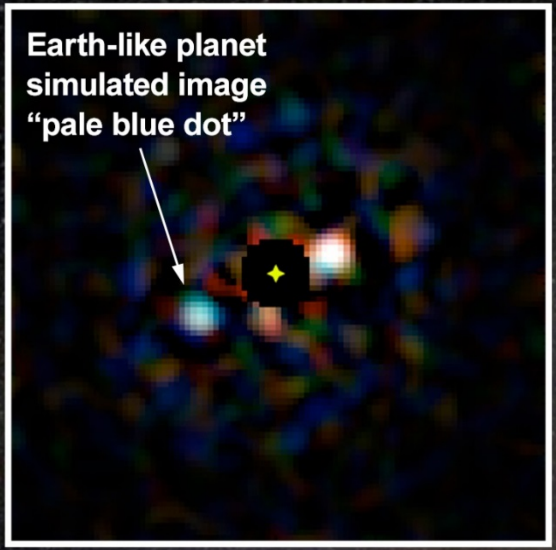

Space mission and instrument design to image the Habitable Zone of Alpha Centauri

αCenA

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, Ruslan Belikov[1] (PI), Sandrine Thomas[1], Julien Lozi[2], Sasha Weston and the ACESat team (Northrop Grumman Xinetics / Space systems Loral)

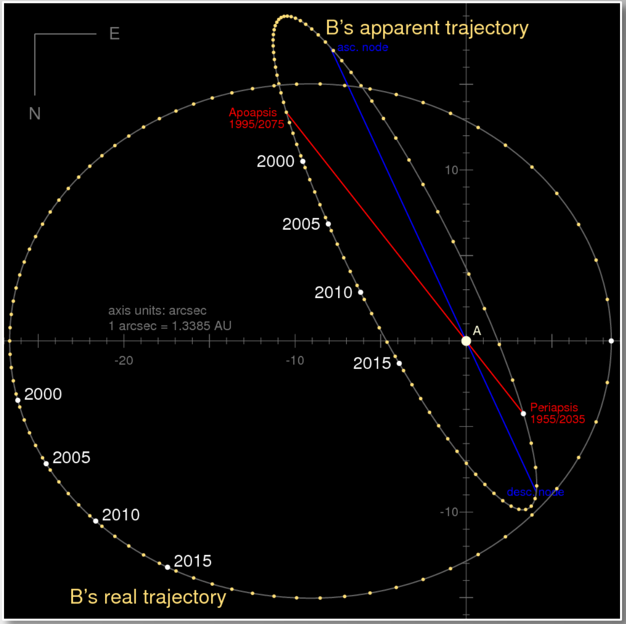
αCenB

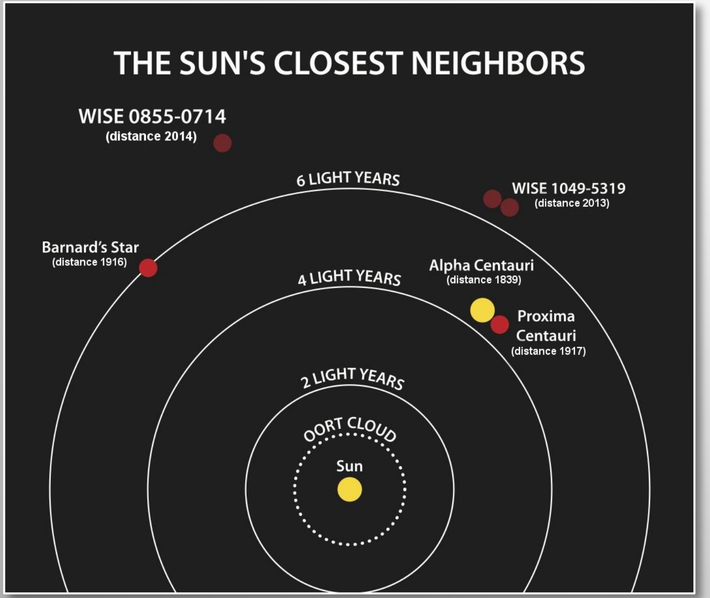
1 NASA Ames Research Center, 2 Subaru Observatory

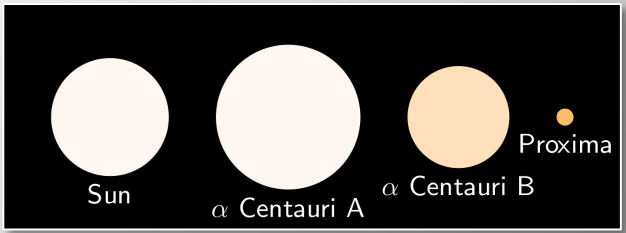
αCen AB: a Unique Opportunity for small optical space telescopes

Why Alpha Centauri?

- Alpha Centauri is a our closest star and the only one accessible where the Habitable Zone is accessible to a 30cm class telescope
- The system is binary and therefore it double the probability of finding a earth like planet reaching close to 50% chances according to latest Kepler statistics.
- An earth –size planet has been found in 2012, aCen Bb, but is too close to the star. This increases the likelihood of a earth-like planet in the HZ of the star.





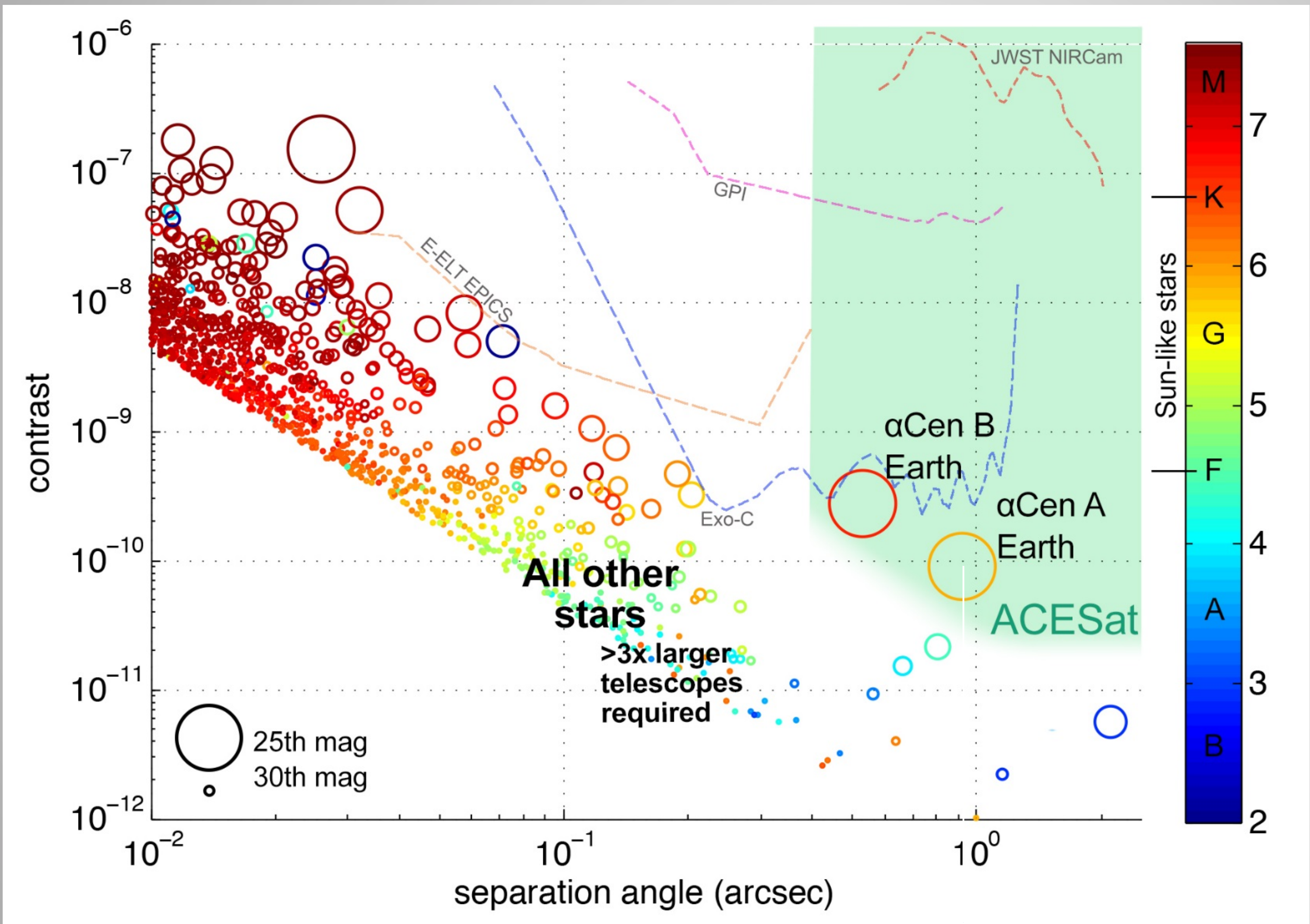


Other science cases

- ACESAT will be also able to measure the exozodiacal light at Alpha Centauri and some other nearby stars. This is critical for other NASA mission design.

αCen AB: a Unique Opportunity for small optical space telescopes

Simulation of a (hypothetical) Earth twin at quadrature around every nearby star

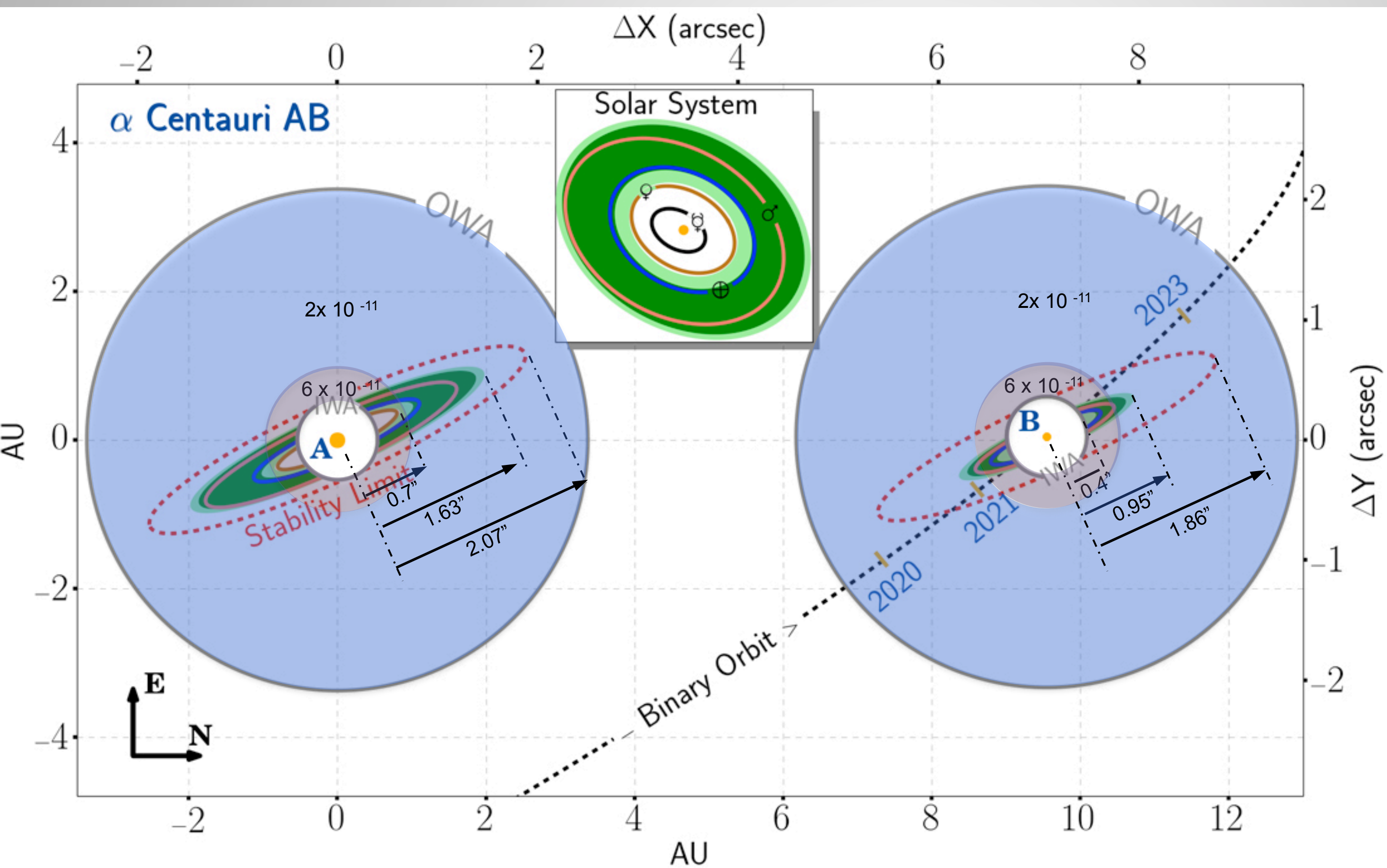


2.7 λ/D for 30cm telescope

- Example: αCenA Earth twin with a 30cm telescope at 500nm:
  - separation: 0.92" = 2.7 λ/D
  - flux: ~1 photon per minute for ~10% end-to-end QE (roughly same as for flagship telescope looking at Earths 10pc away)
- αCen is in a class of its own: any other star requires a >3x larger (> 10x more expensive) telescope

Scientific requirements

Goal: Image 0.5 to 2.0 R_e planets' equivalent brightness, in the HZ of aCen A&B during a 2 year mission



Contrs.	IWA	OWA
aCen B		
$6x10^{-11}$	***0.4"***	0.95"
$6x10^{-11}$	1.6λ/D	3.8λ/D
aCen A		
$2x10^{-11}$	***0.7"***	1.63"
$2x10^{-11}$	2.7λ/D	6.5λ/D
Stability limit (aCen A)		
$2x10^{-11}$		2.07"
$2x10^{-11}$		8.3λ/D
Sensitivity		
SNR=5	1.6 Days	
ODI Calibration	30 Days	

Credit: Billy Quarles, NASA Ames

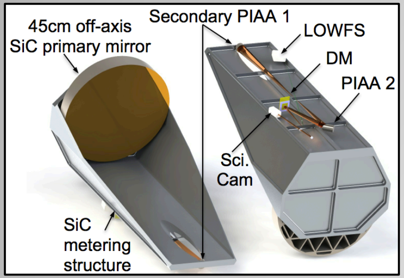
Alpha Centauri Exoplanet Satellite (ACESat) Mission Overview

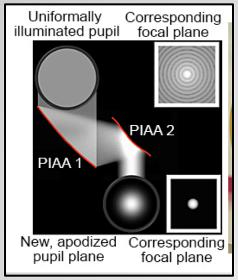
ACESat will directly image and characterize the planets and circumstellar debris disks of Alpha Centauri A & B, with the specific objective of identifying potentially habitable Earth-like planets.

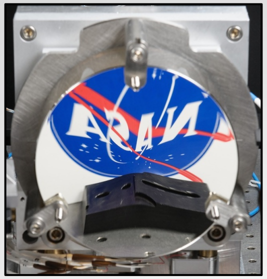
Mission Time Life and Orbit	SMEX-Class, 2-Years (>90% completeness), Earth trailing
Spacecraft Bus	LADEE Type, Secondary Payload to GTO
Instrument/Telescope	Unobstructed 45cm, Full Silicon Carbide
Coronagraph architecture	Baseline: PIAA Embedded on Secondary and tertiary telescope mirror. PIAACMC backup
Coronagraph performance	1×10^{-8} raw 6×10^{-11} @ 0.4” (With ODI) 2×10^{-11} @ 0.7”
Field of View (OWA)	2.5” x 2.5”
Imaging detector	1k x 1k EMCCD 0.08”/px Sampling
Wavelength	400 to 700 nm, Dichroics 5 bands @ 10% each.

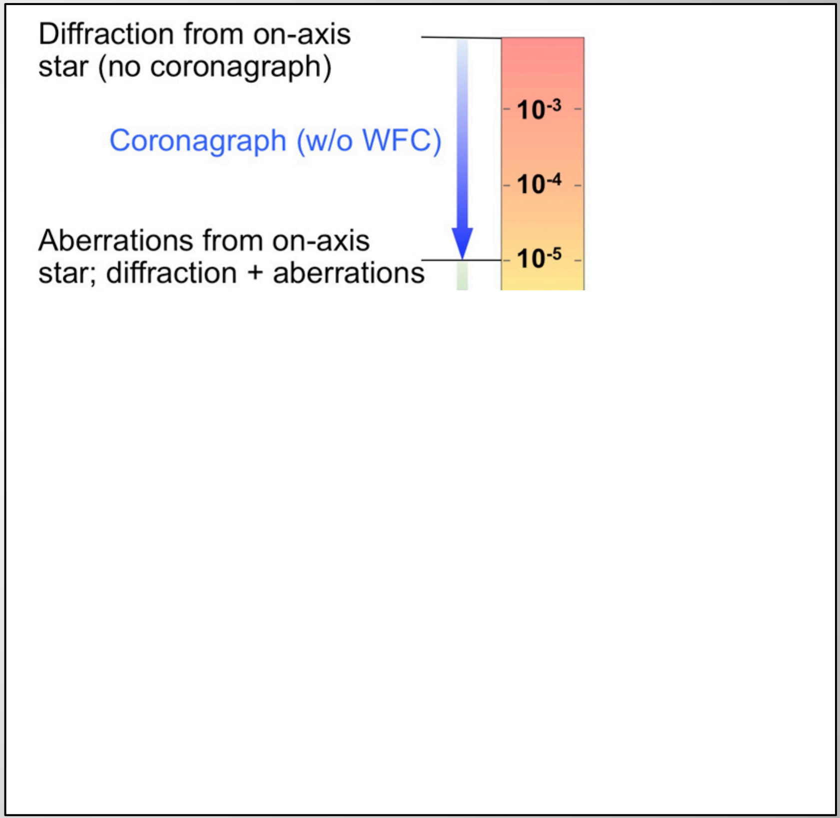
Instrument Building blocks

45 cm off-axis telescope with an **embedded** PIAA -> 10^{-5} (1.6 – 10λ/D)



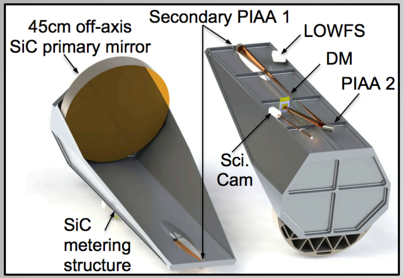


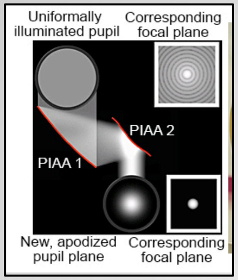


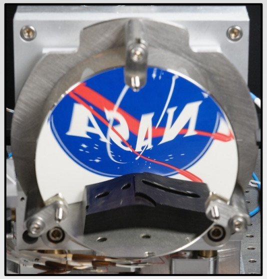


Instrument Building blocks

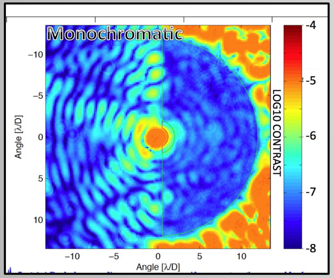
45 cm off-axis telescope with an **embedded** PIAA -> 10^{-5} (1.6 – 10λ/D)

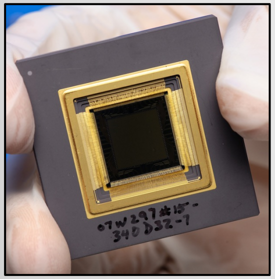


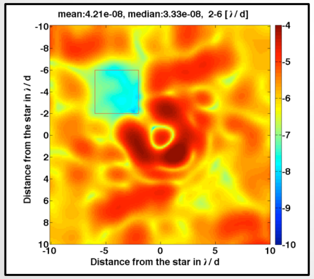


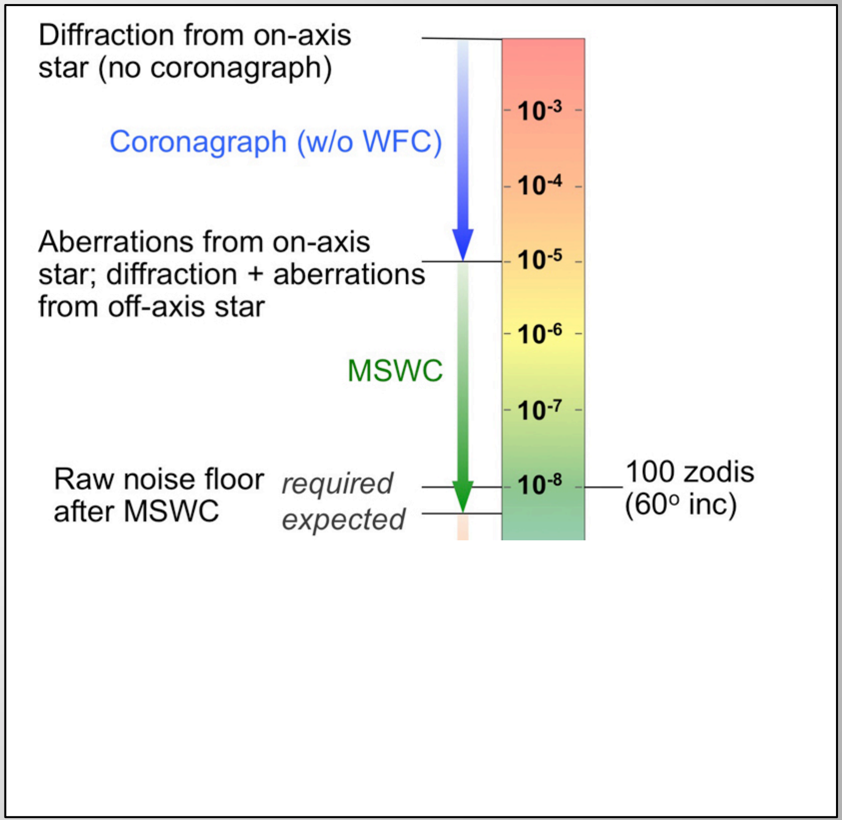


WFC (Multi-Star Wave Front Control) -> 10^{-8}



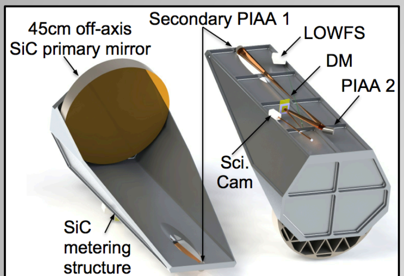


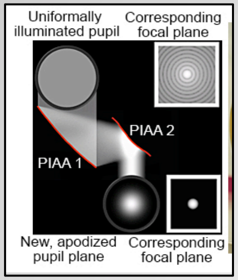


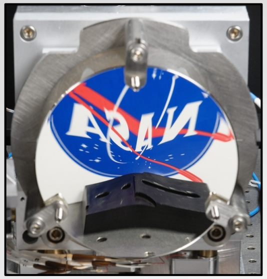


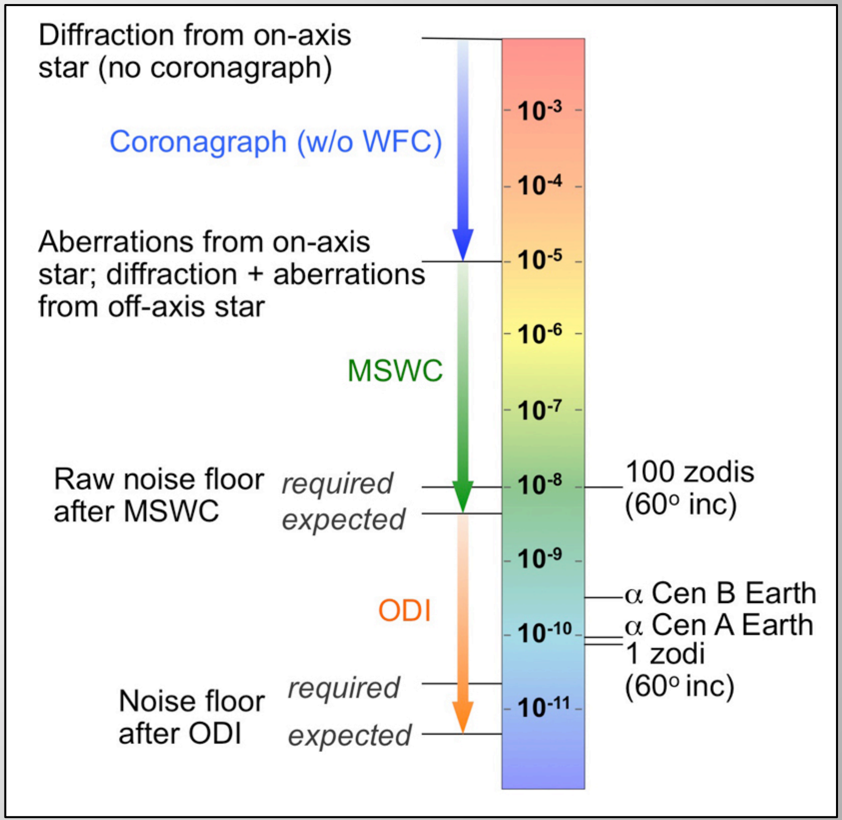
Instrument Building blocks

45 cm off-axis telescope with an **embedded** PIAA -> 10^{-5} (1.6 – 10λ/D)









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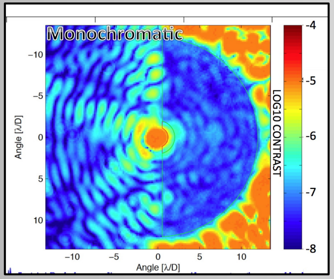
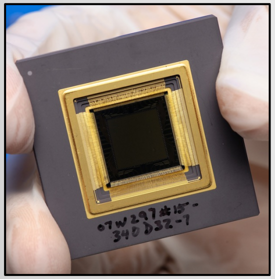
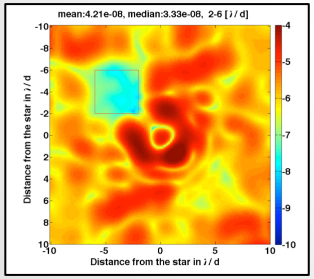
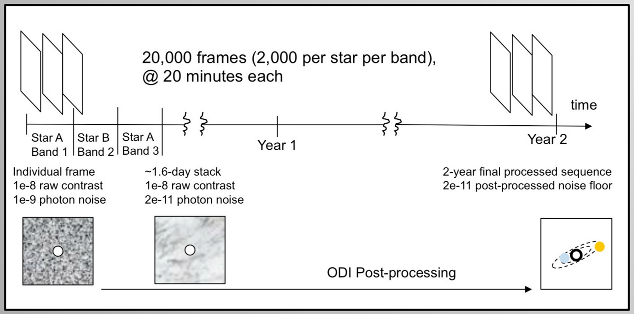
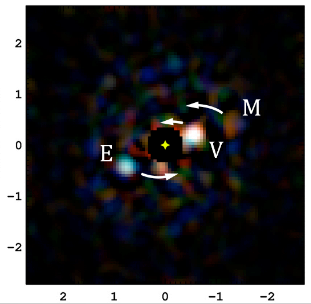




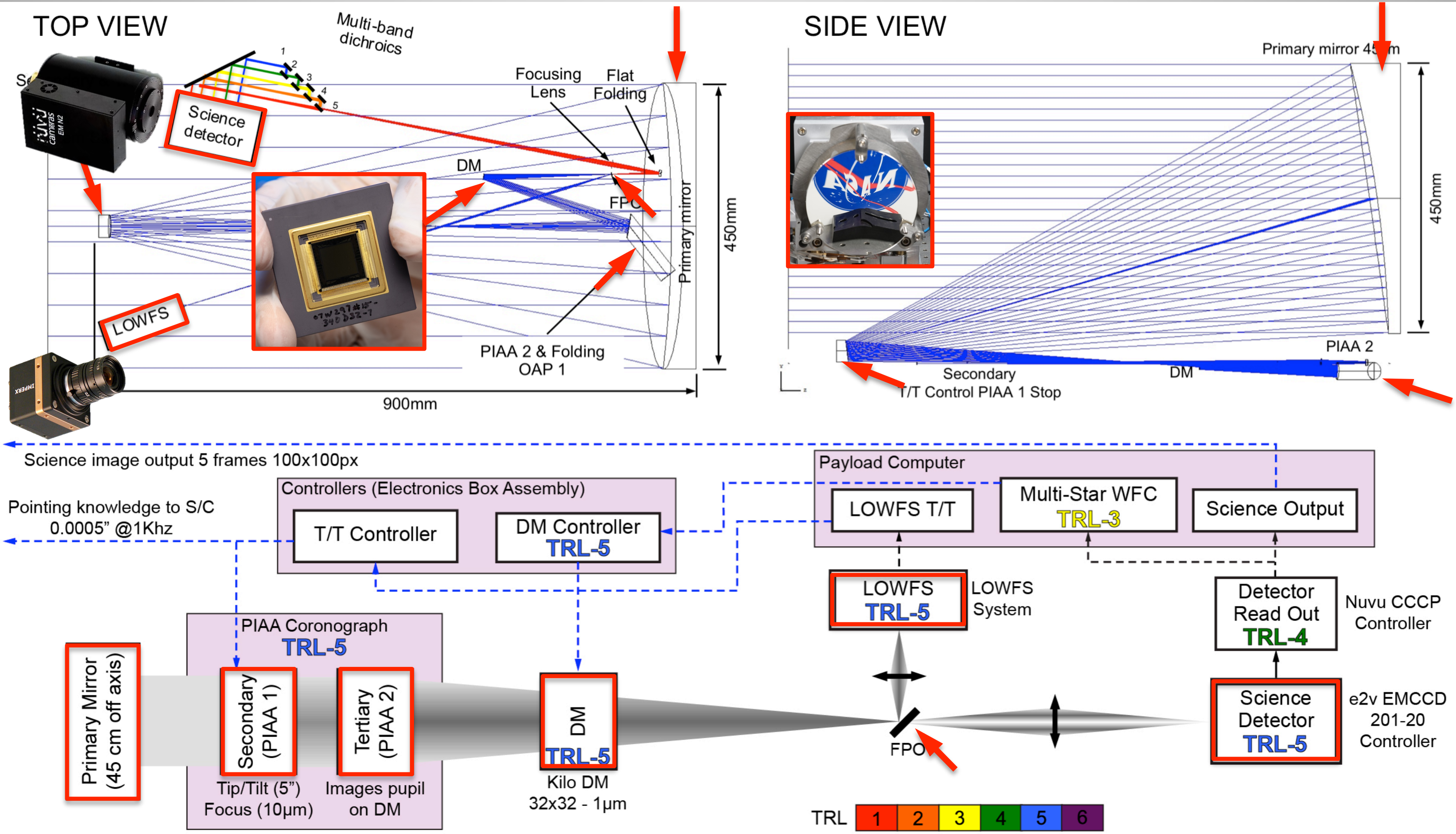


Continuous observation ODI -> 10^{-11}

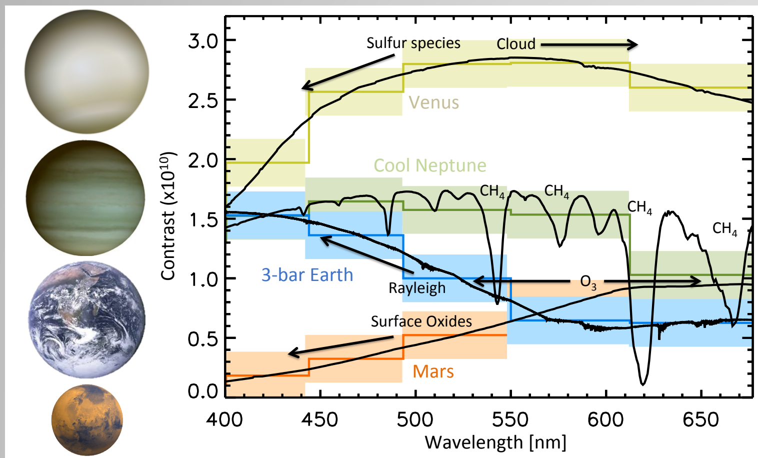




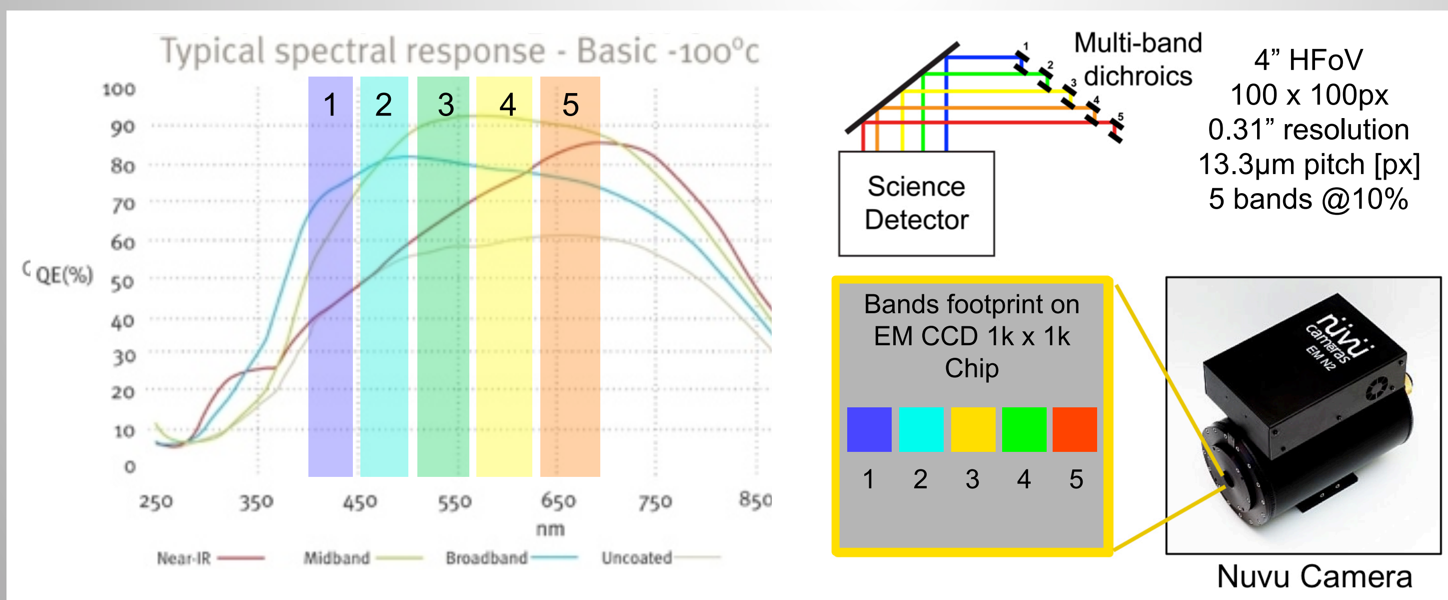
Optical and system design



Multi-Spectral Imager



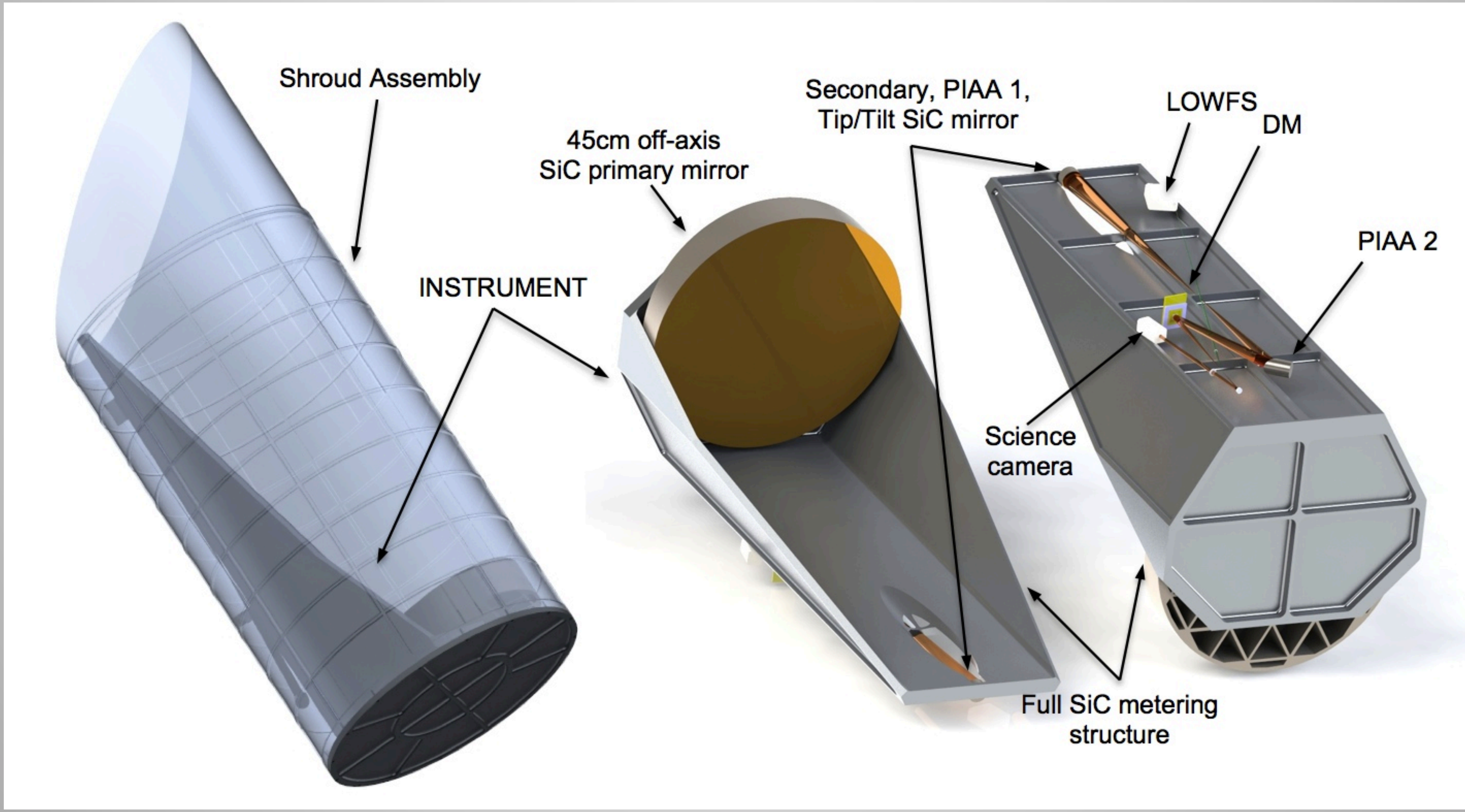
- Wavelength: **400 nm to 700 nm** (Contains 40% aCen A flux)
- **Five channels** of 10% bandwidth each.
- **SW (400nm):** Blue rayleigh scattering indicates **earth-like atmosphere**. (Const. coatings and QE)
- **LW (700): CH_4 absorption bands**. Limited by QE and WFC bandwidth.



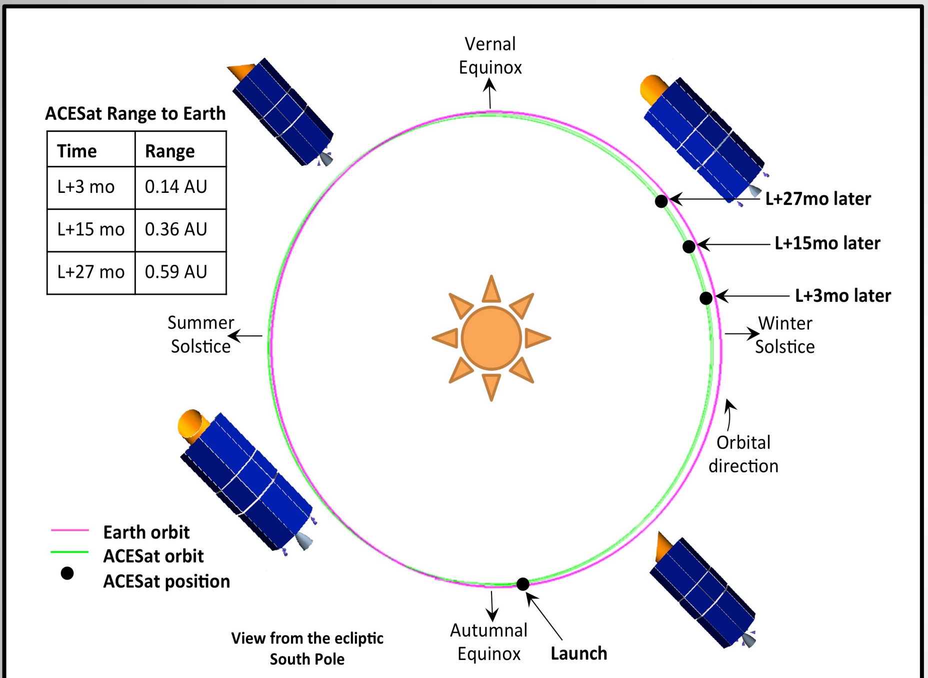
- E2v EMCCD 201-20 **almost zero RON**
- Short 10s exposure time to avoid cosmic rays

Telescope Hardware

- Full SiC 45cm, Off-axis telescope, L/25 max end-to-end WFE (Total 45Kg mass)
- Active thermal control to maintain 10˚C operation with 0.1˚C PV stability
- 0.5mas RMS stability LOWFS (Demonstrated for CAT III EXCEDE Lockheed Martin)



Mission operations



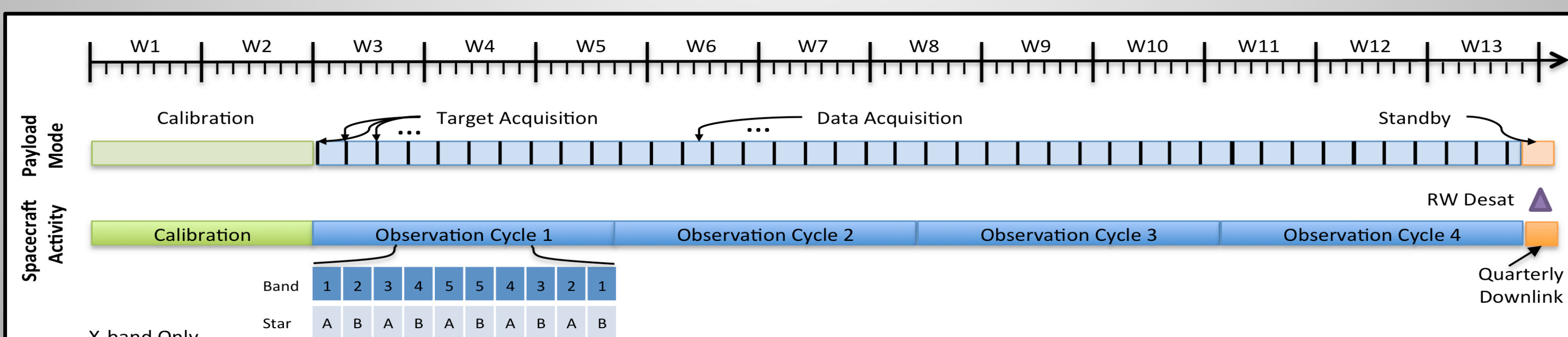
Time	Range
L+3 mo	0.14 AU
L+15 mo	0.36 AU
L+27 mo	0.59 AU

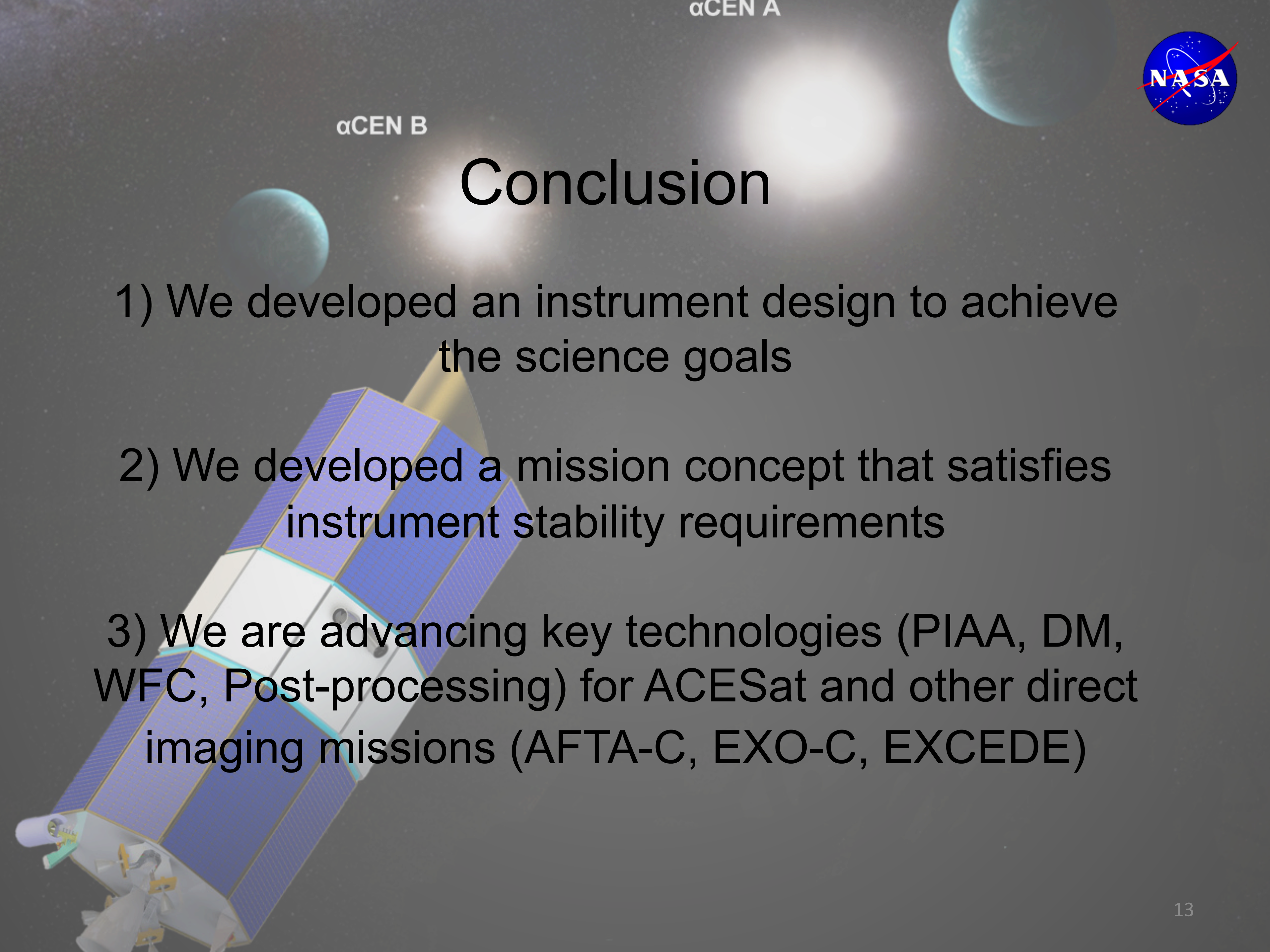
High stability pointing spacecraft

Unperturbed observation per quarter, 1.6 days/band/star

Quarterly operations:

- **DSN Downlink** and reaction wheels desaturation and quarter end.
- **90˚ Roll** to keep sunshield in position
- **Calibration** per quarter (Speckle MSWC, LOWFS).





Conclusion

1) We developed an instrument design to achieve the science goals

2) We developed a mission concept that satisfies instrument stability requirements

3) We are advancing key technologies (PIAA, DM, WFC, Post-processing) for ACESat and other direct imaging missions (AFTA-C, EXO-C, EXCEDE)

Questions?

Image credit: Juan Nabzo, Jan 5th 2015, Chilean Patagonia