The NASA Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission: An emerging era of global, hyperspectral Earth system remote sensing

SPIE Remote Sensing
Palais de la Musique et des Congrès
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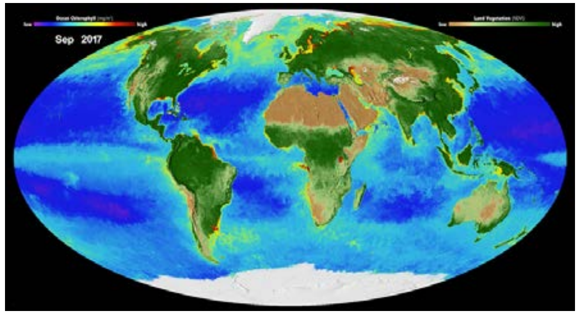
Plankton, Aerosol, Cloud, ocean Ecosystem (PACE)



PACE Science

New opportunities to monitor fisheries and respond to toxic algae blooms, and key ocean and atmosphere data for forecasting air quality and weather that will improve our understanding of Earth's climate.

Mission Elements (Organization)

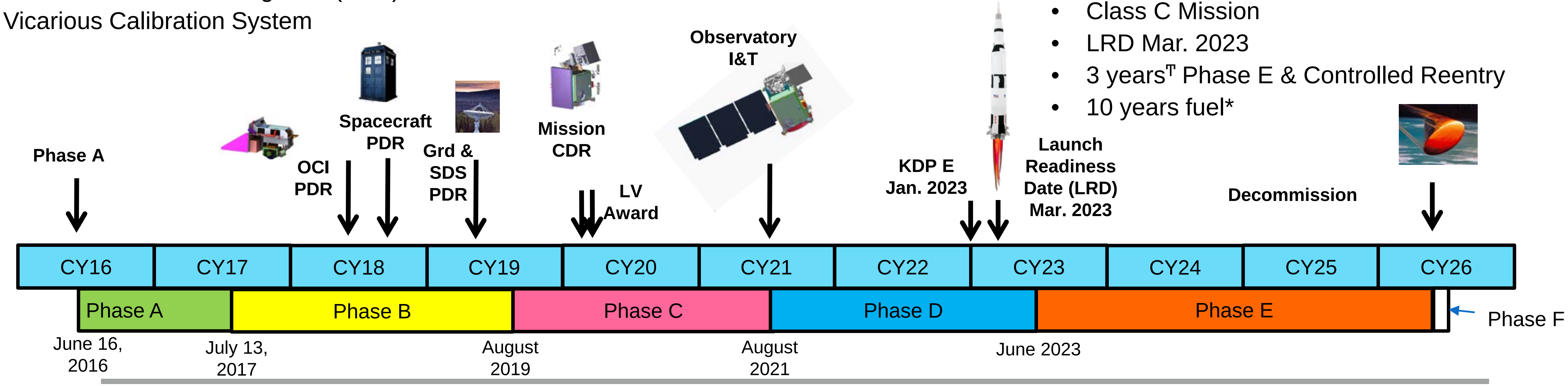
- Competed Science Team (NASA ESD)
- Vicarious Calibration (NASA ESD)
- Ocean Color Instrument (GSFC)
- Science Data Analysis (GSFC)
- Spacecraft – (GSFC)
- Polarimeters – (SRON, UMBC)
- Launch services (LSP)

Mission Complement:

- HyperSpectral Scanner
- Two Polarimeter Instruments
- Spacecraft Earth Pointing Platform
- OBPG Science Data Segment (SDS)
- Vicarious Calibration System

Key Mission Parameters

- 98° inclination; ~676.5 km altitude
  - Sun-Sync (1pm MLT AN),
  - 2 day global coverage
- Class C Mission
- LRD Mar. 2023
- 3 years[T] Phase E & Controlled Reentry
- 10 years fuel*



[T] Baseline Requirement

* Fuel only, design life is 3 years, the extra 7 yrs is ~9% of the required mission fuel budget

PACE Partners (US)

PACE Partners (International)

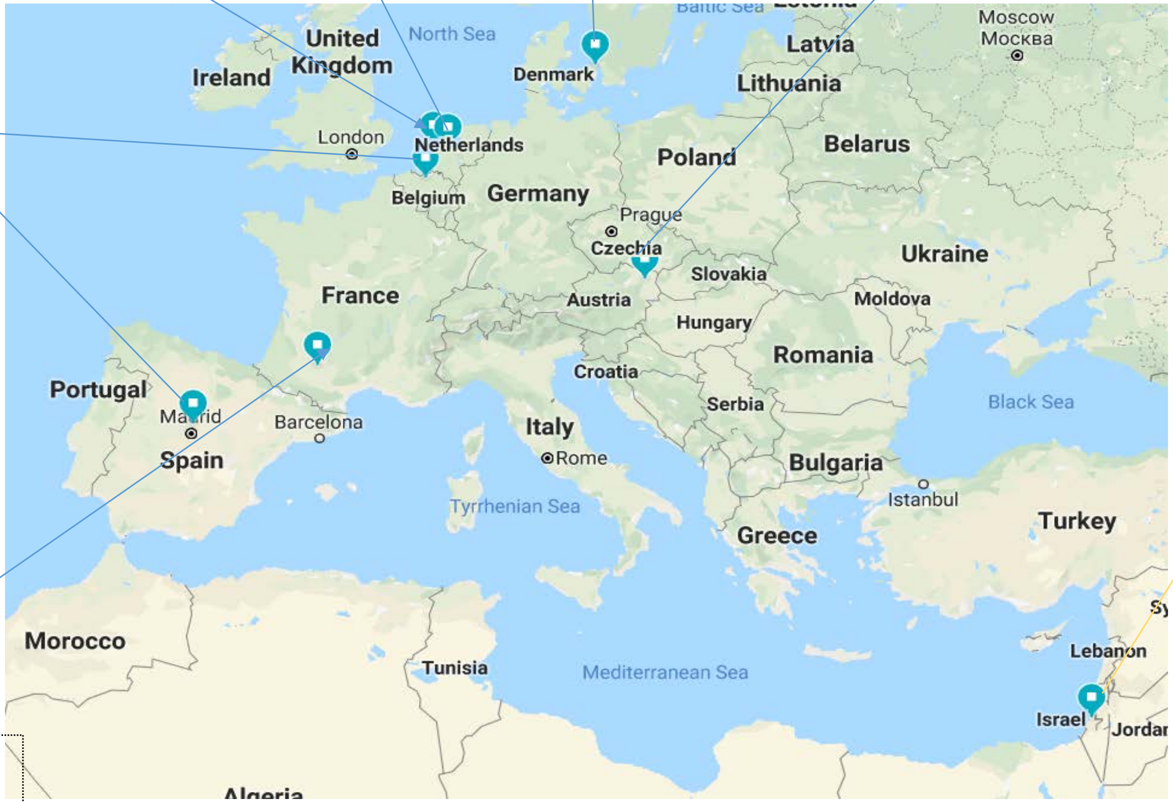
SRON

TNO innovation for life

DTU

RUAG
Aerospace Defence Technology

THALES

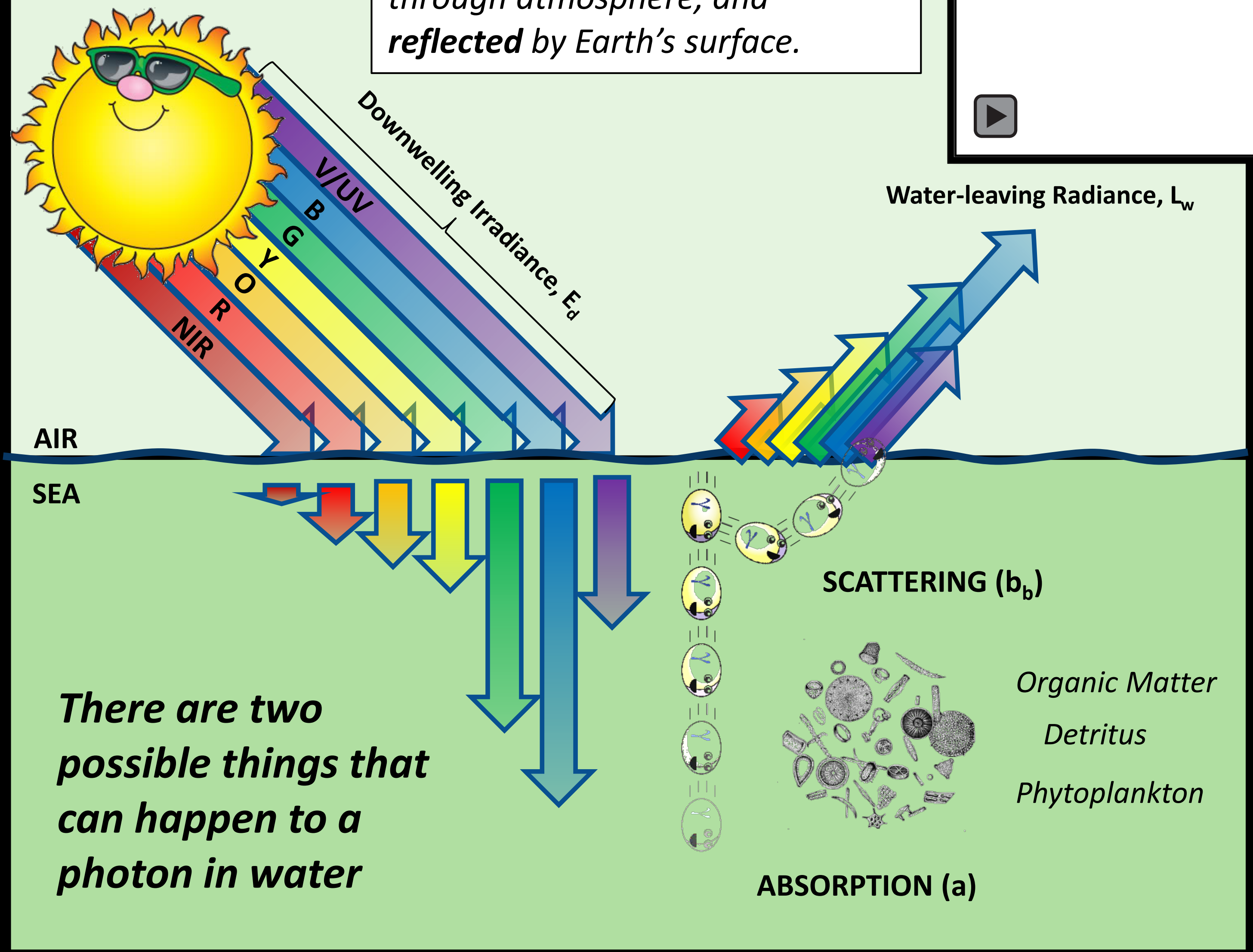


Acktar
Advanced Coatings

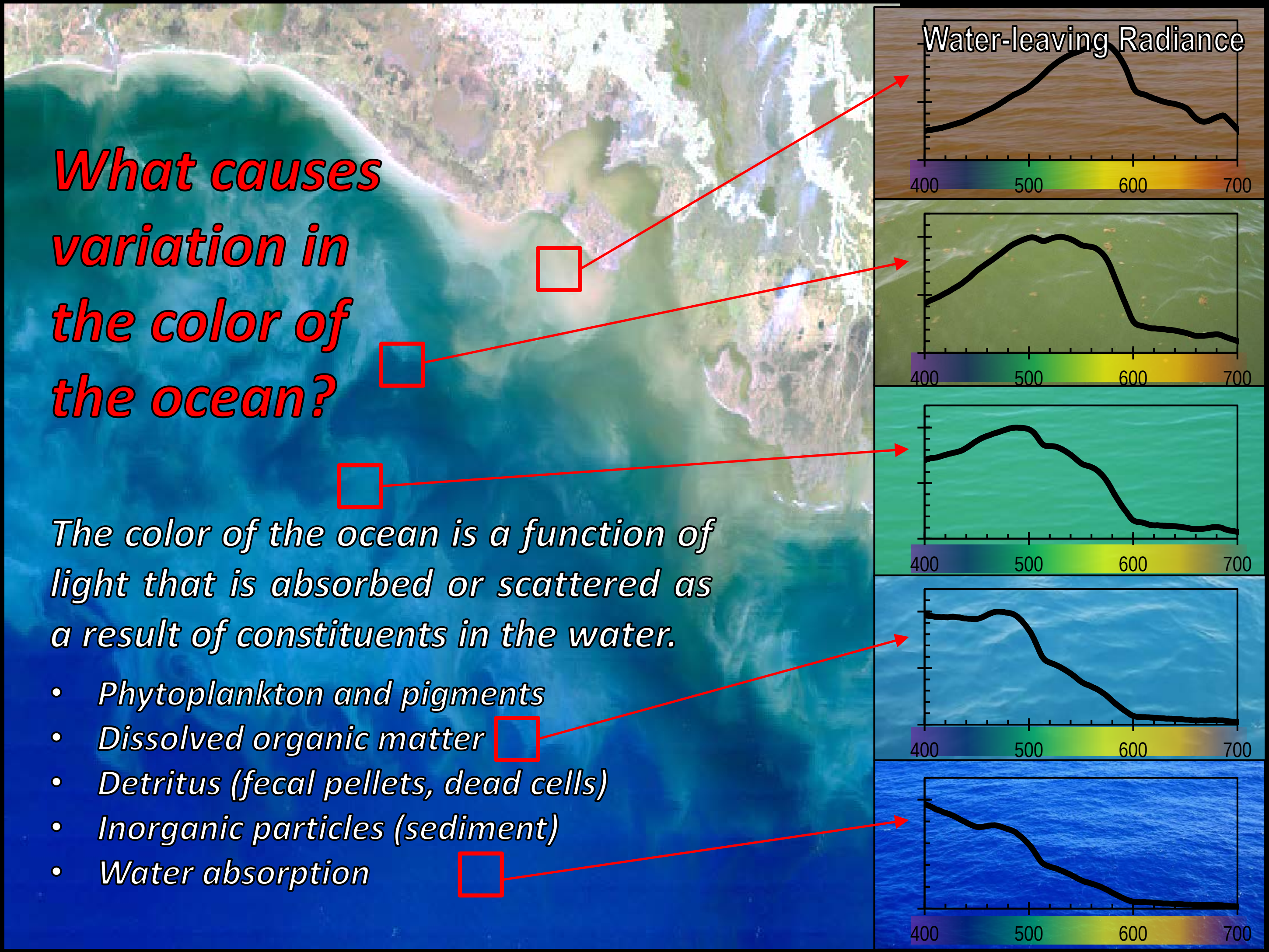
AIRBUS

Legend:
Procurement Vendor
Services Vendor
Assembly House

*Measurements of ocean color are based on electromagnetic energy emitted by sunlight, transmitted through atmosphere, and **reflected** by Earth's surface.*

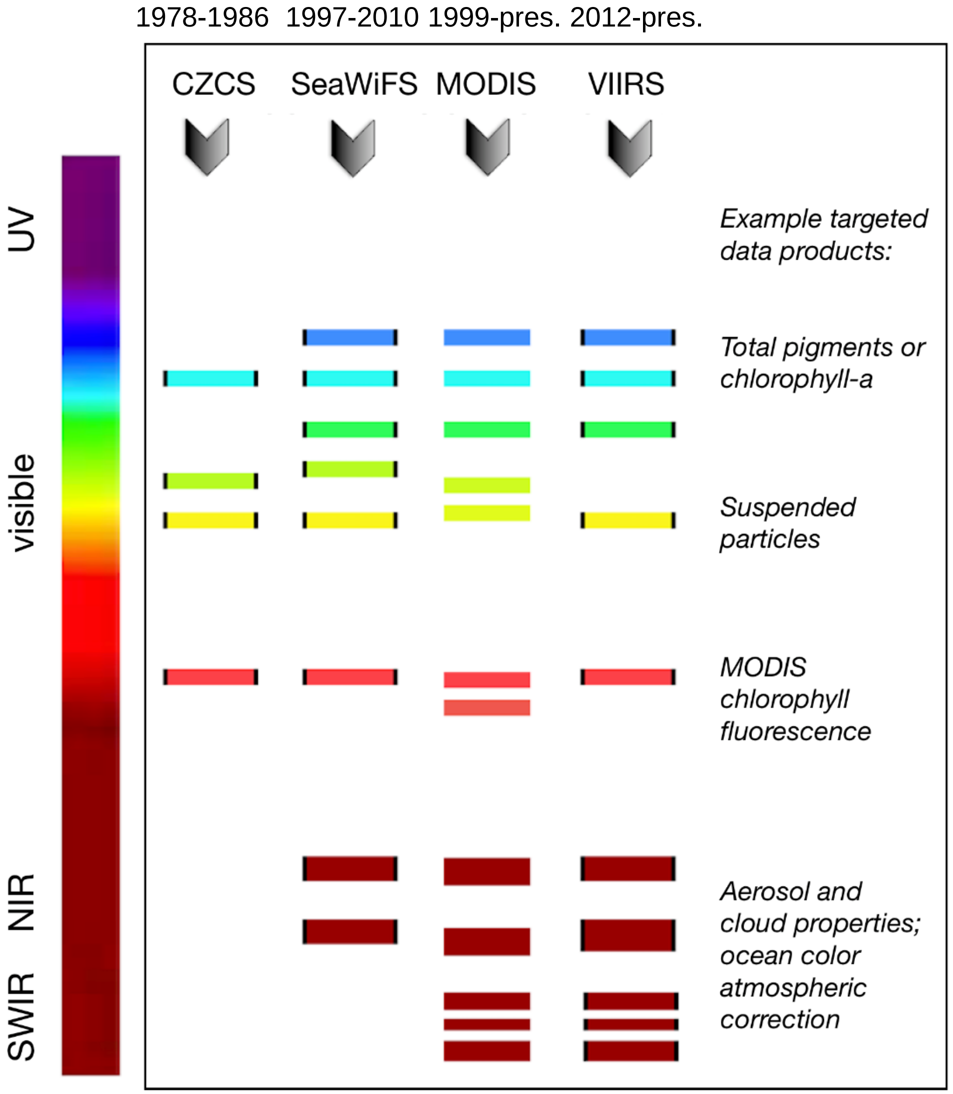


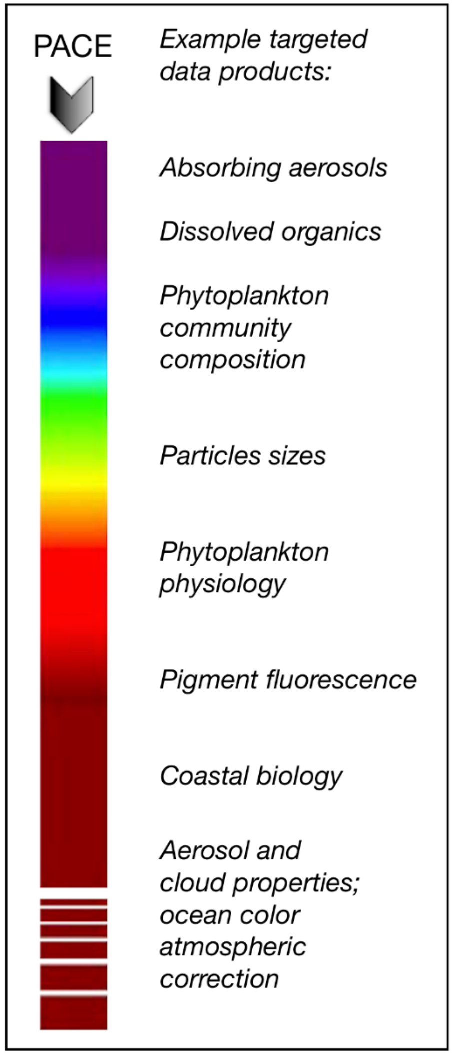
There are two possible things that can happen to a photon in water



What causes variation in the color of the ocean?
The color of the ocean is a function of light that is absorbed or scattered as a result of constituents in the water.
• Phytoplankton and pigments
• Dissolved organic matter
• Detritus (fecal pellets, dead cells)
• Inorganic particles (sediment)
• Water absorption
Water-leaving Radiance
400
500
600
700

Moving from multi-spectral radiometry to spectroscopy

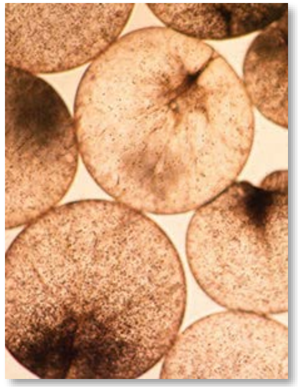




Example diatom

Linda Armbrecht, abc.com.au

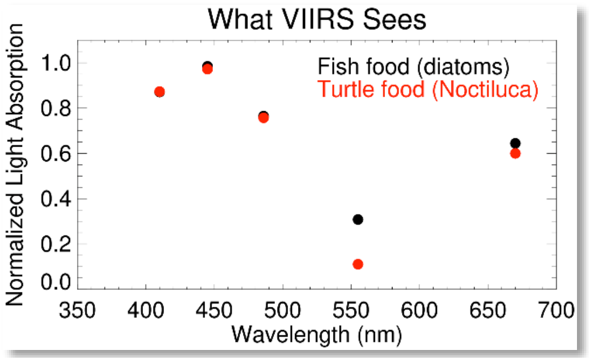
Example Noctiluca

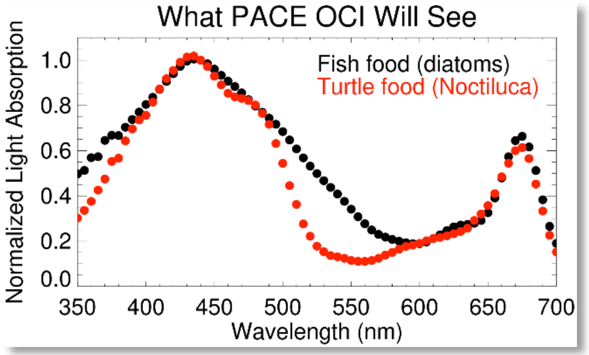


1 mm

Joaquim Goes, LDEO

signals from the ocean are small & differentiating between constituents requires additional information relative to what we have today

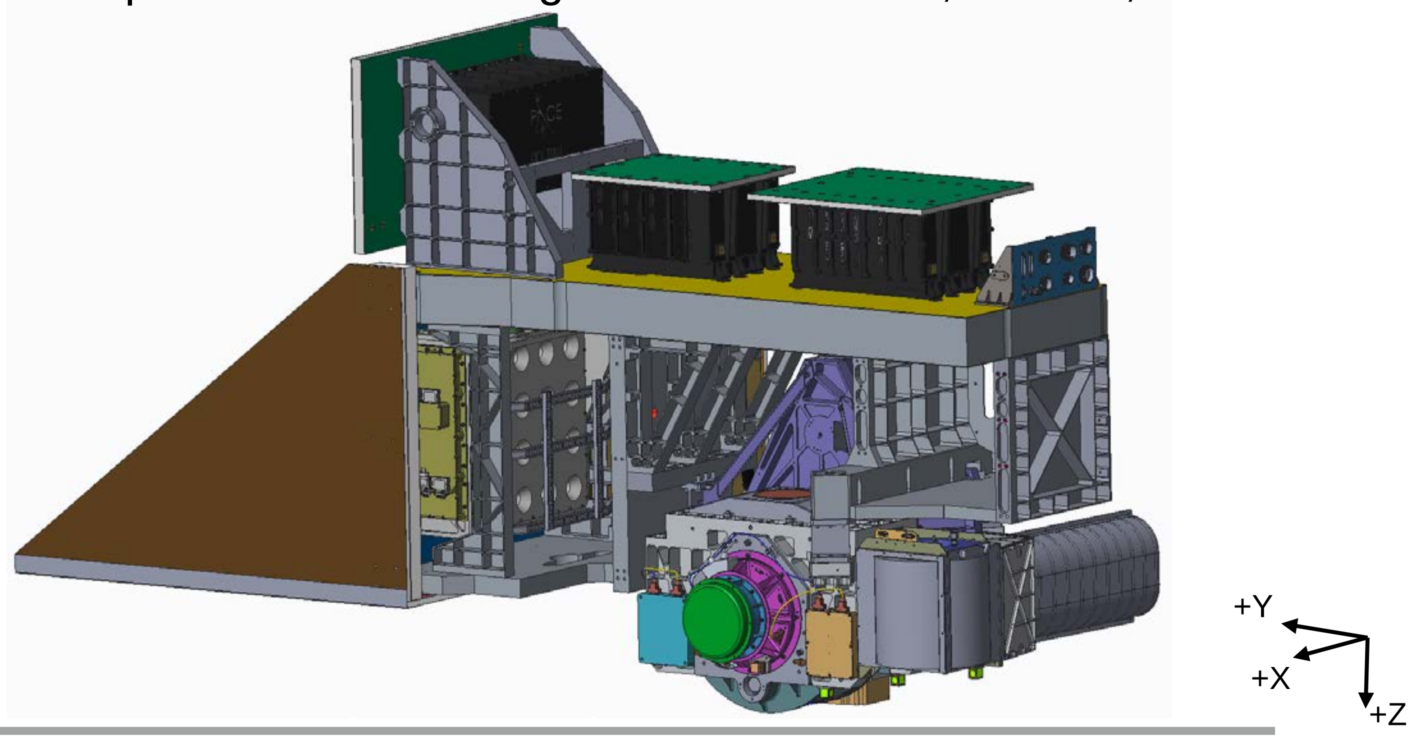




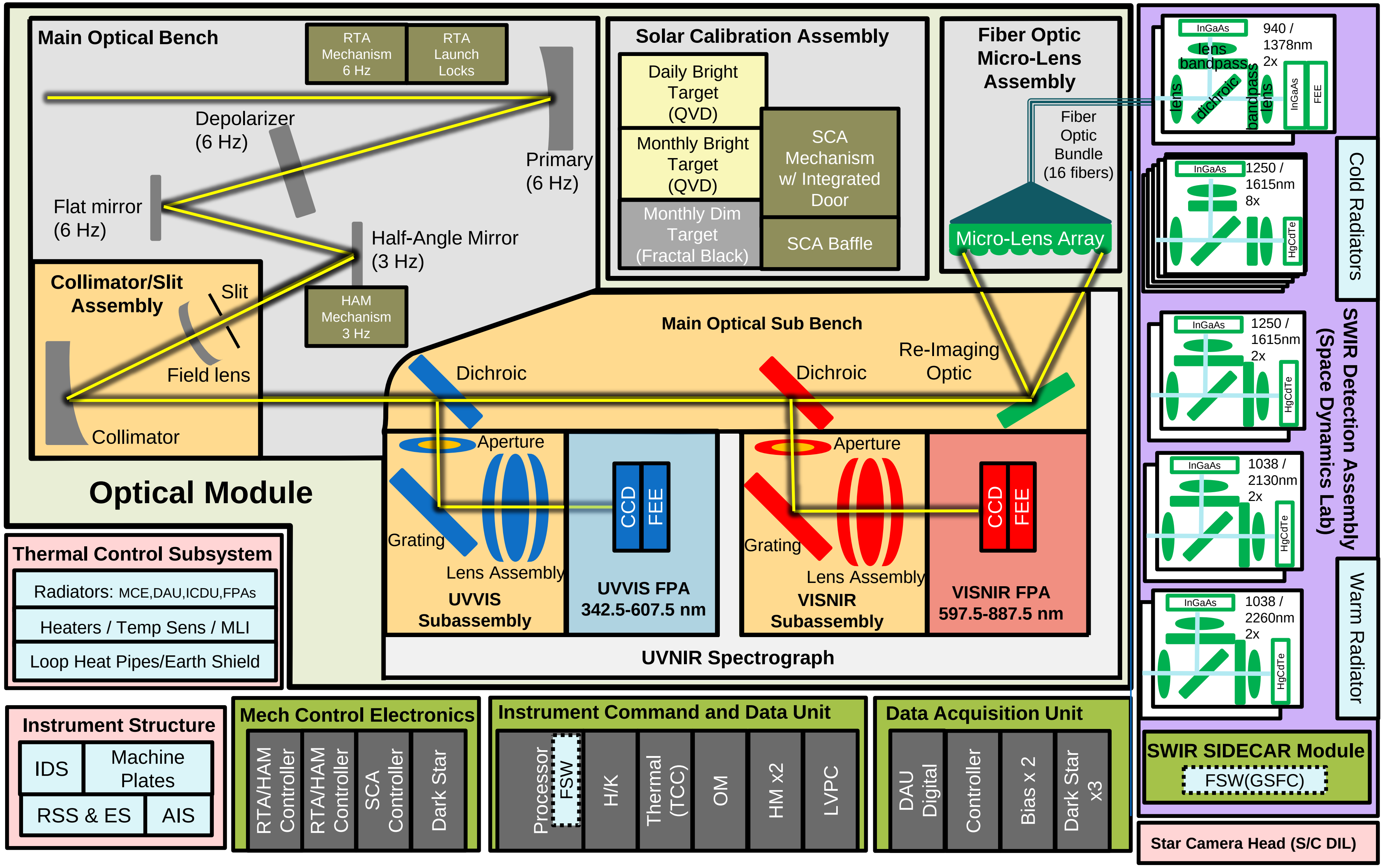
OCI Instrument Overview

Instrument Mass	260 kg CBE , 305 kg NTE
Instrument Power	280 W CBE , Orbital Average
Thermal System	Passive Cooling with Loop Heat Pipes
Mechanisms	Rotating Telescope Mechanism (~6Hz) Half Angle Mirror Mechanism (~3Hz) Solar Calibration Mechanism (<500 Cycle)
Deployments	Rotating Telescope Launch Lock
Ground Sample Distance	1050m at Nadir
Aperture	90mm
iFOV	0.08^o Along Track x 1.42^o Cross Track
UVNIR System EFL	0.134m
UVNIR System f/no	1.49
Total Field of Regard	+/- 56.5^o
Dynamic Range	SNR at L_{typ} , No Saturation at L_{max}
UVNIR Bands (nm)	342.5nm – 887.5nm , 5nm Resolution
NIRSWIR Bands (nm)	940, 1038, 1250, 1378, 1615, 2130, 2260
UVVIS & VISNIR FPAs	2 CCDs, 128 x 512, 26 micron Integrated 14 Bit ADC
NIRSWIR FPAs	16MCT/16InGaAs Photodiodes, < 250 micron analog output to SIDECAR ASIC
Relative Radiometric Accuracy	< 0.5% Pre-Launch 1-sigma
SNR @ L_{typ}	> 1000:1: 340 – 700nm > 600:1: 700 – 865nm > 50:1 940 – 2260nm
On-Board Solar Calibration Assembly	Daily & Monthly Solar Calibration Targets
Orbital Average Data Rate	13 Mbps up to 40 Mbps

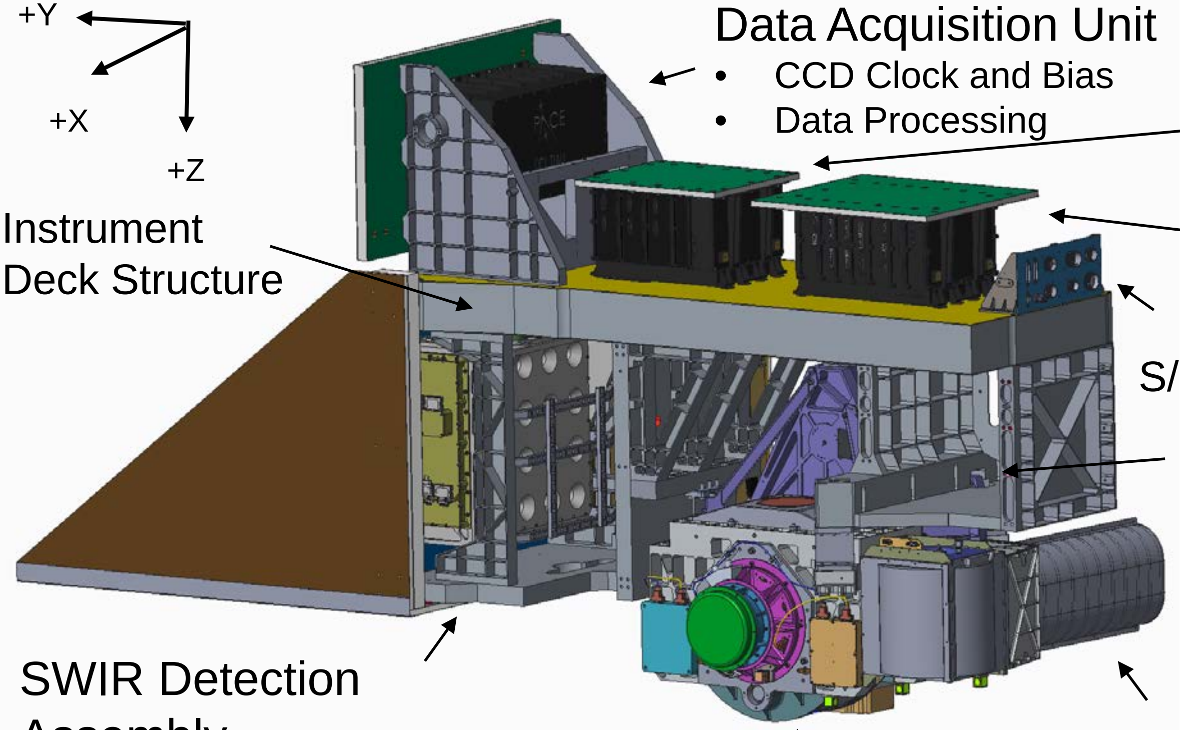
- Cross-Track Rotating Telescope
- UVVIS & VISNIR Slit Grating Hyperspectral Spectrographs
  - 2 CCD FPAs with On-Chip TDI Synchronized with Rotating Telescope and Half Angle Mirror
- NIR-SWIR Fiber Coupled Multiband Filter Spectrograph
  - 32 InGaAs/MCT Single Photo Diode FPAs with Digital TDI
- Concept follows the heritage of the SeaWiFS, MODIS, and VIIRS



OCI Instrument System Optical Block Diagram



OCI Subassemblies & Functions



Data Acquisition Unit

- CCD Clock and Bias
- Data Processing

Motor Control Electronics

- RT, HAM, SCA Actuator Control

Instrument Command & Data Unit

- Processor, House Keeping, Thermal Control, Power Distribution

Instrument Deck Structure

S/C Electrical Interface

S/C Mechanical Interface

SWIR Detection Assembly

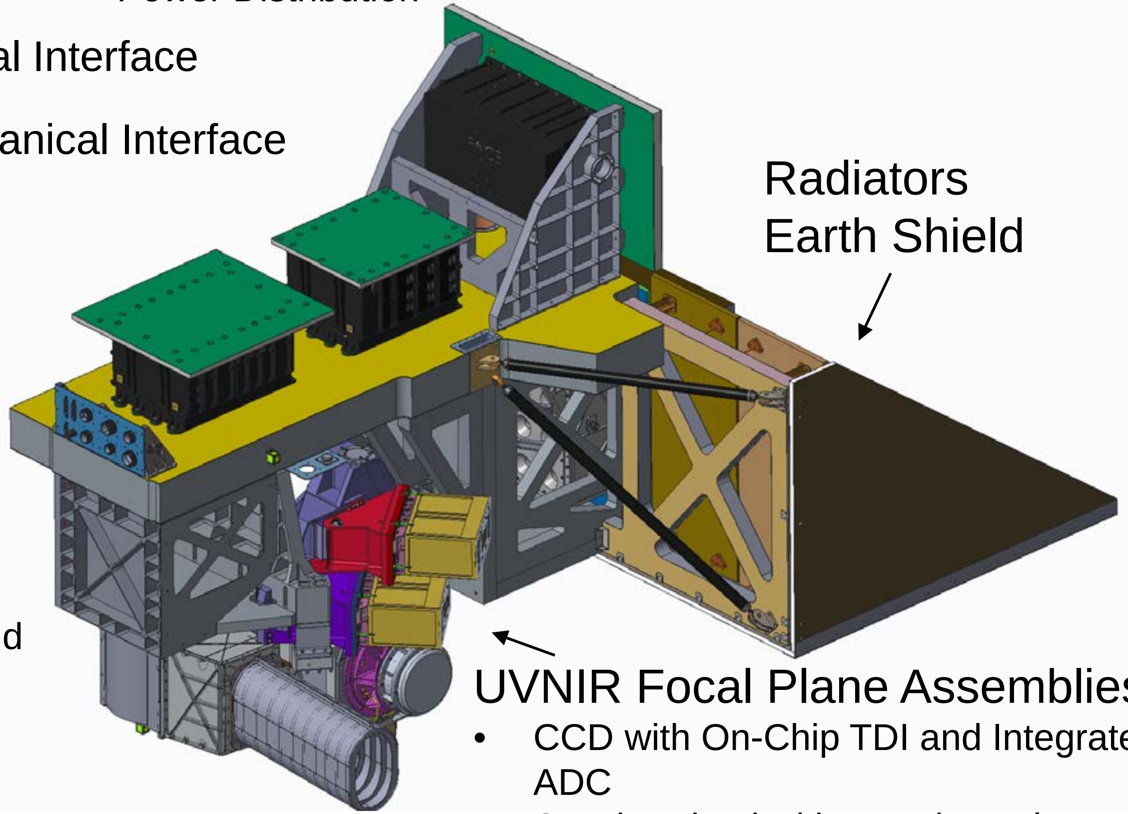
- NIR-SWIR Fiber Coupled Multiband Filter Spectrograph
- 32 InGaAs/MCT Single Photo Diode FPAs with Digital TDI

Optical Module

- Main Optical Bench
  - Rotating Telescope
  - Half Angle Mirror
- Main Optical Sub-Bench
  - Slit Grating UVNIR Hyperspectral Spectrograph
  - Slit - Fiber Coupled NIR SWIR “Light Bucket”

Solar Calibration Assembly

- Integrated carousel mechanism with 3 calibration targets and reusable door



Radiators Earth Shield

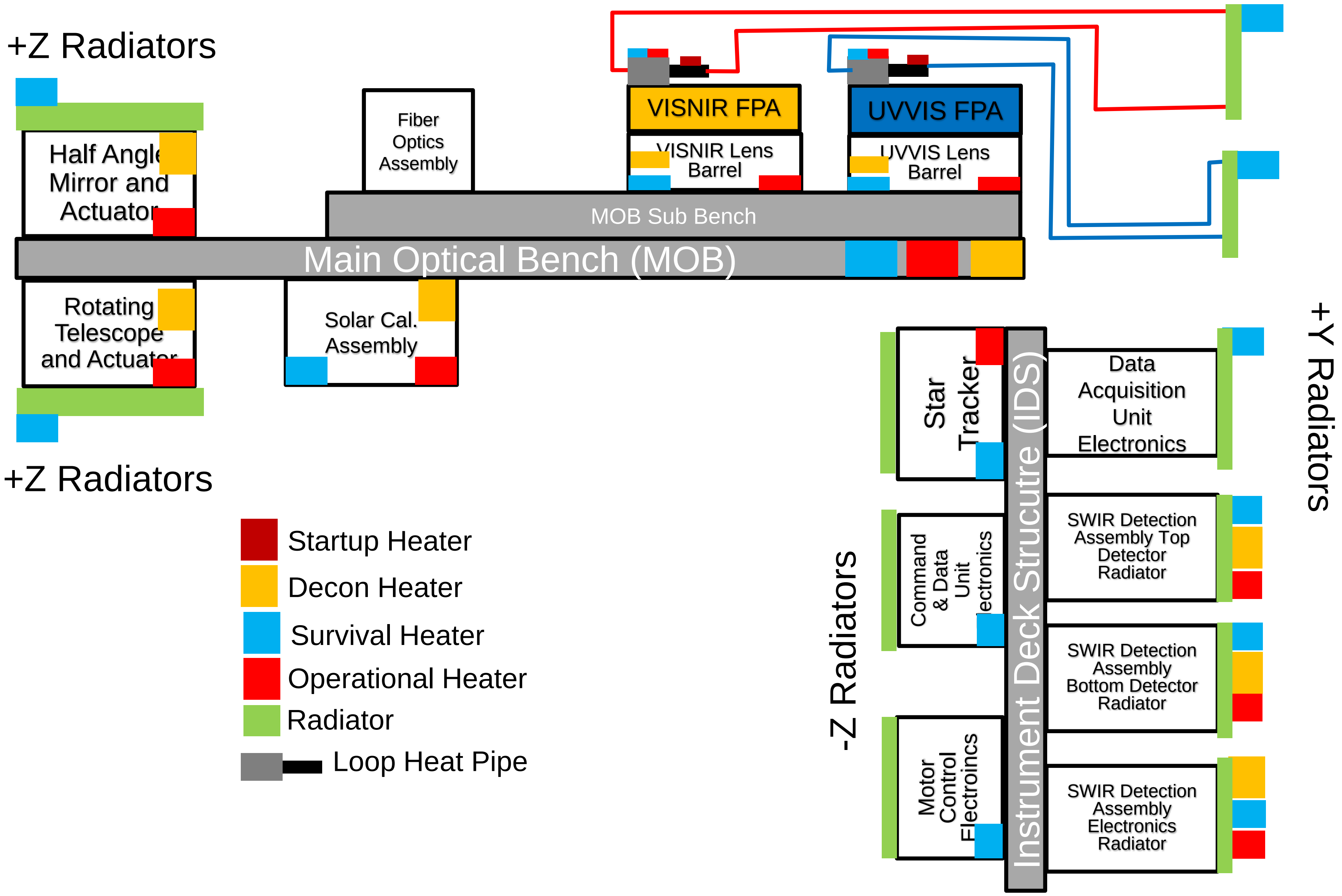
UVNIR Focal Plane Assemblies

- CCD with On-Chip TDI and Integrated ADC
- Synchronized with Rotating Telescope and Half Angle Mirror

Thermal Control System Summary

Description

- Thermal Control System is primarily a passive heat flow design composed of radiators and straps.
- FPA interface Thermal Control System is the only active thermal design with the Loop Heat Pipe.
- Operational, Survival and Decontamination heaters provide temperature control throughout the different phases of the mission.
- Thermal design has been updated based on test data through ETU testing of RT, HAM and the mechanisms
- The UVNIR radiators, SDA temperatures are maintained through use of Earth Shade limiting the radiator view factor to earth by 80%.



PACE: phytoplankton – all things great & small

- OCI is 2-day global coverage hyperspectral in the UV-NIR with 7 SWIR bands
- Headed towards instrument and mission CDR this winter
- Working to a launch in 2023 (Preserving 2022 Launch Opportunity)