ICARUS

Investigating the Chronology of stellar Activity and Radiation using UV Spectra

Yellow Team, Alpbach *2026*, High-Energy processes

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Content

Science

Instrument

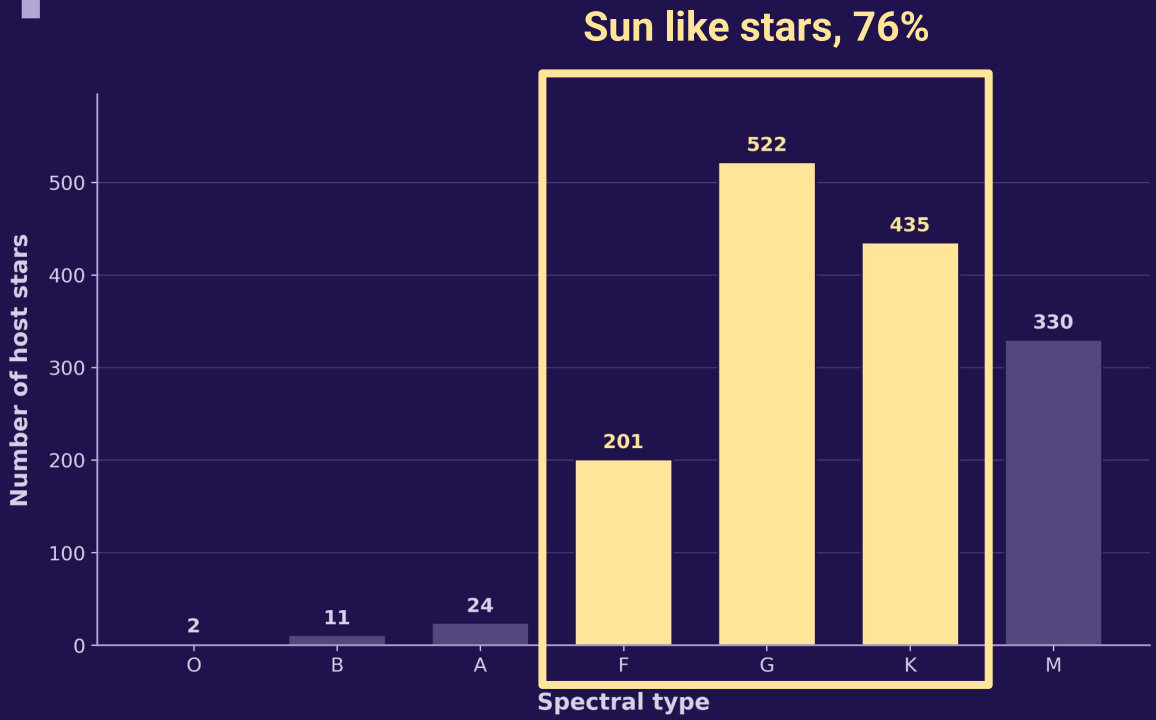
Mission

Programs

Science

Motivation

There are over ***1100* confirmed exoplanet-hosting stars (July 2026)** in the *Milky Way* that are of the Solar type.

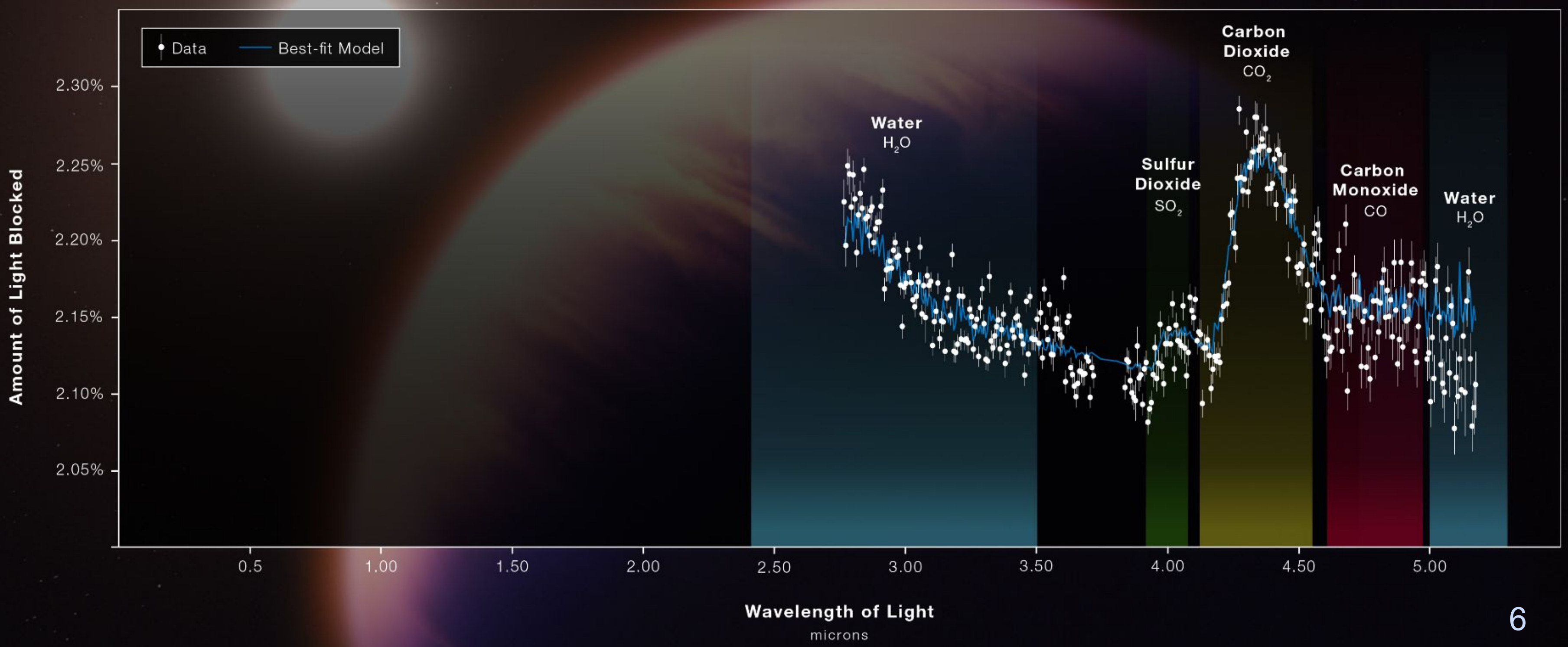


Histogram of exoplanet host stars by Spectral Type *image source: NASA, ESA, CSA, J. Olmsted (STScI)*

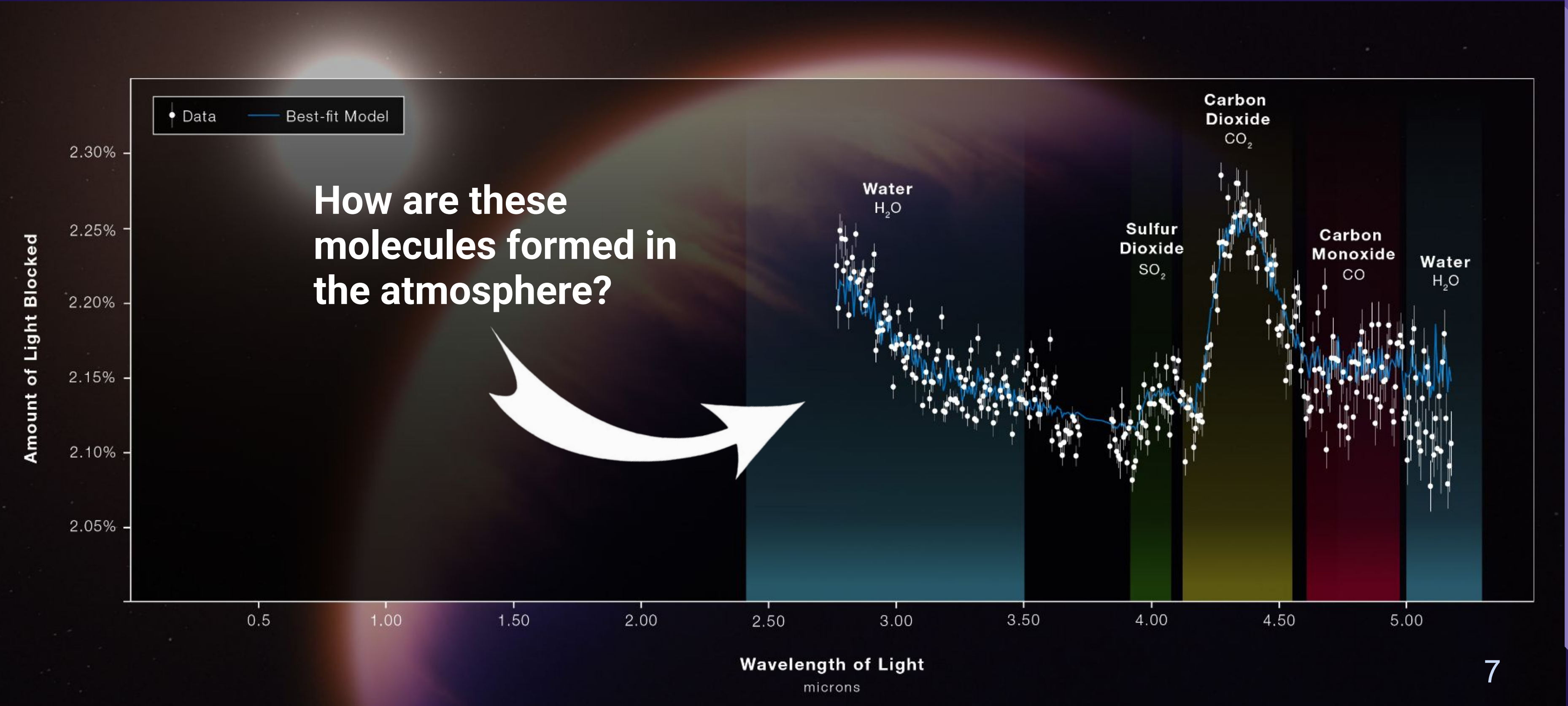
How we study atmospheres

image source: NASA, ESA, CSA, J. Olmsted (STScI)

How we study atmospheres



How we study atmospheres



How are these molecules formed in the atmosphere?

The Star

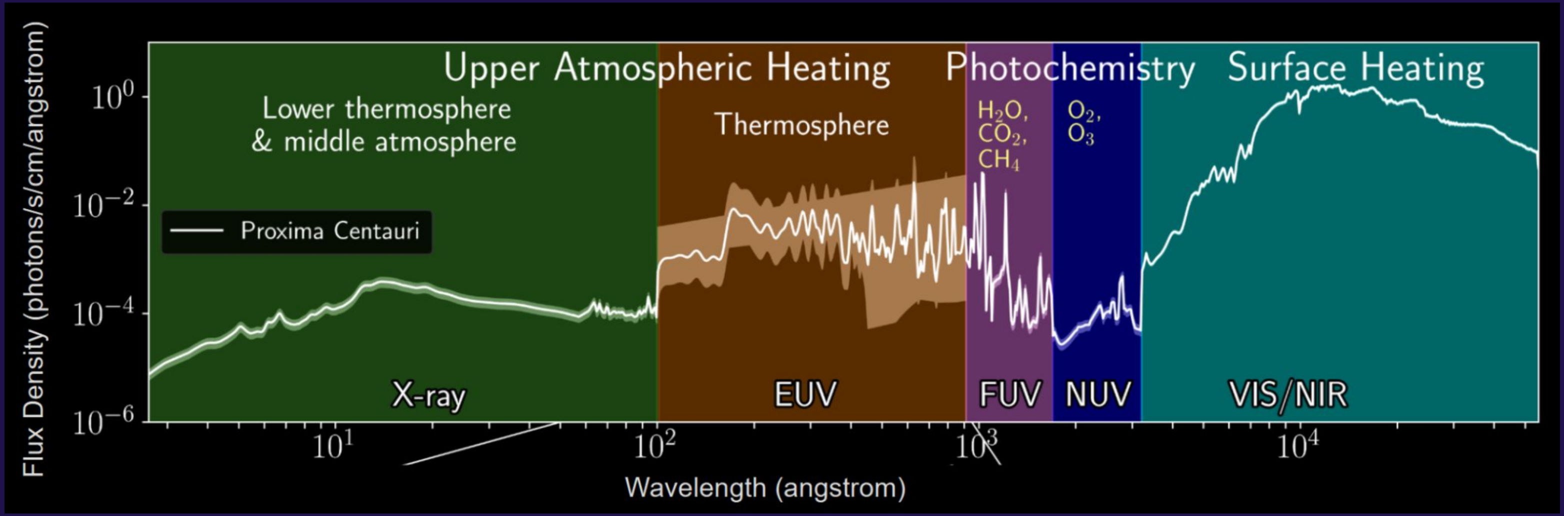
The Composition & Escape

Knowing the **stellar UV environments** of planets around these stars is crucial to understand their atmospheric composition and escape.

The Range

UV photons super power:

Dissociating atmospheric molecules → **Changes Planet Atmospheric Composition**
Providing information to reconstruct unobservable EUV flux → **Atmospheric Escape**



Through Time

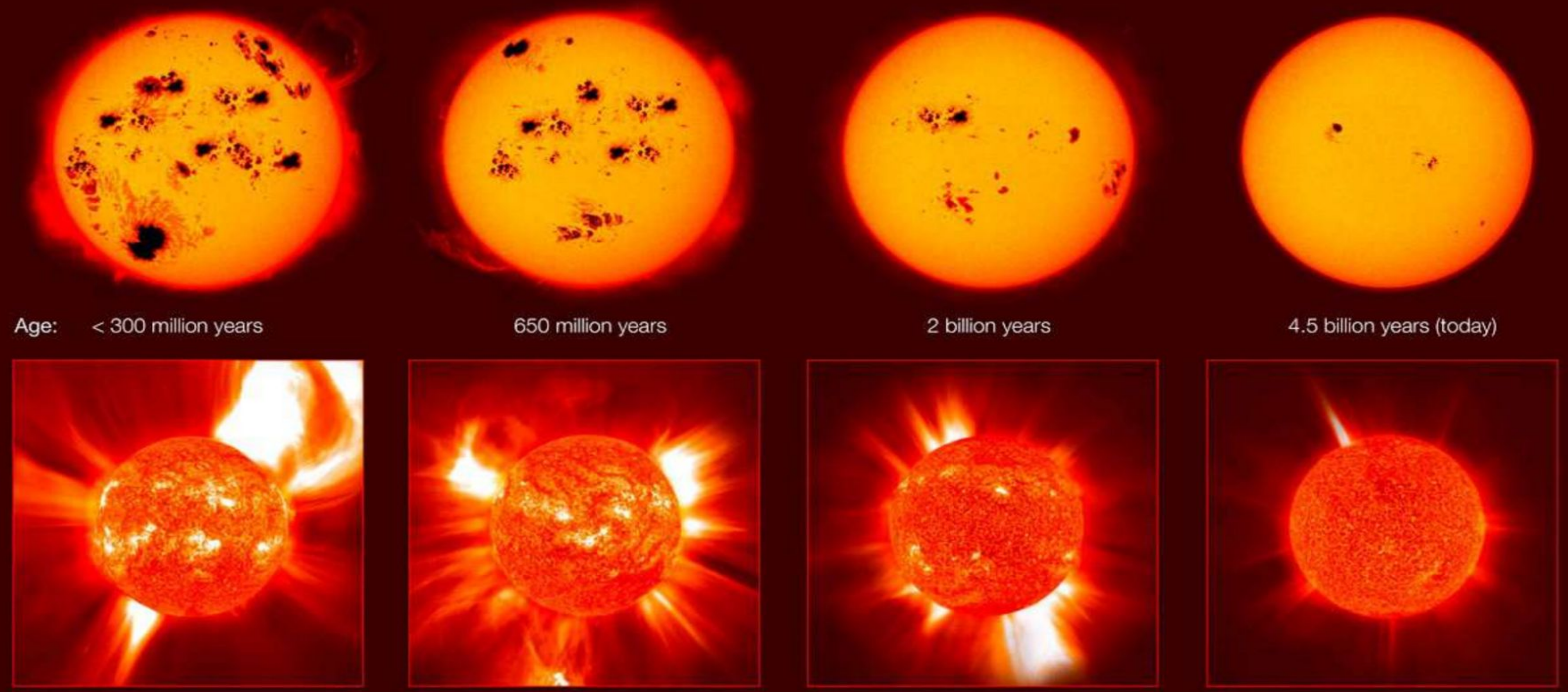
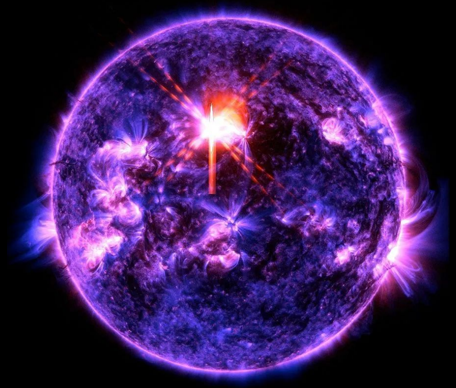


Image source: NASA/SDO

Stellar Variability



Stellar variability categories: *(Ribas et al., 2017)*

- Flare events (hours)
- Rotation (months)
- Magnetic activity cycles (years)

Predicting the occurrence of short term stellar variability events requires complex modelling:

- PHOENIX *(Allard, 2017)*
- PEGASUS *(Malia et al., 2023)*

Ly-α: Driver of Photochemistry

Lyman-α **~37–75%** of the total UV flux (*115–310 nm*) from FGK-type stars, depending on stellar activity
(Ribas et al., 2005)

Lyman-α emission **varies with stellar age and flaring**, reshaping the radiation environment planets experience over time
(France et al., 2013)

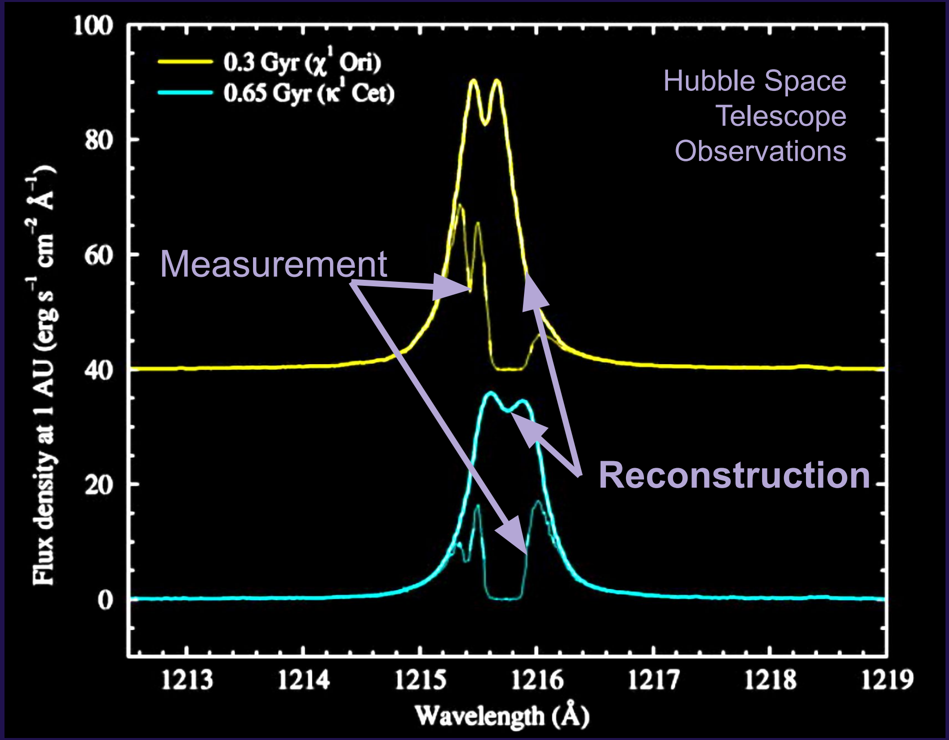


Figure source: Ribas et al., 2005

Mg-II: EUV Stellar Emission

Mg II core-to-wing ratio, is a **proxy for** chromosphere activity that correlates with solar **extreme ultraviolet (EUV) irradiance**

(Viereck et al., 2001)

Mg II h & k emission **varies with stellar type**

(Buccino & Mauas, 2008)

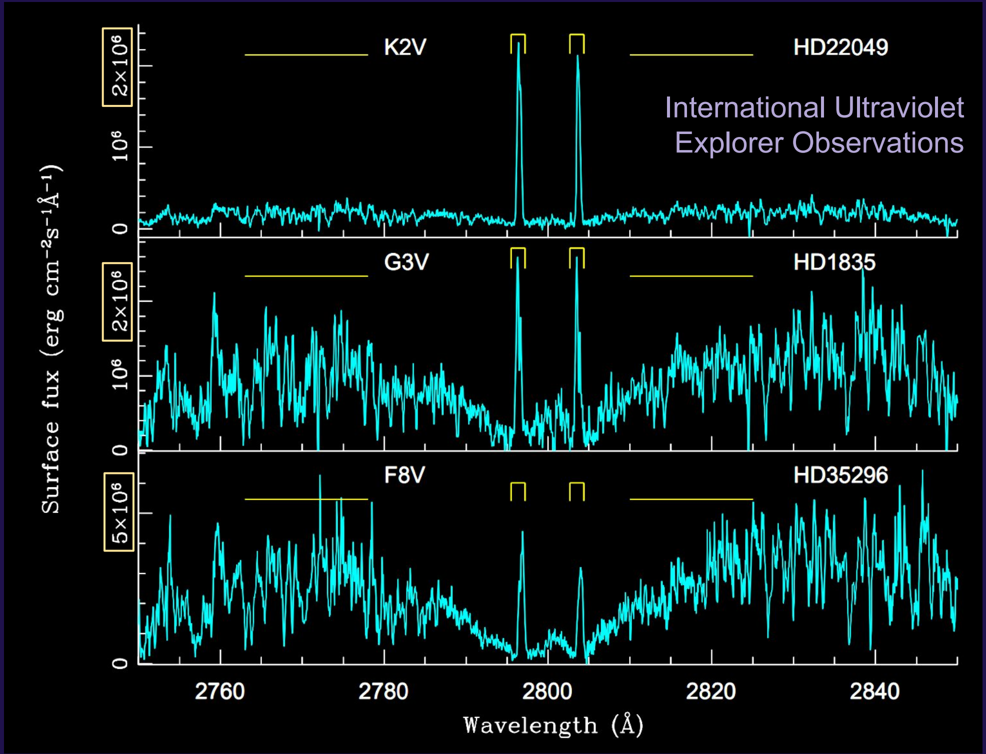


figure source: Buccino & Mauas, 2008

Image source: https://www.esa.int/ESA/Our_Missions

State of the Art

Previous/Ongoing Missions:

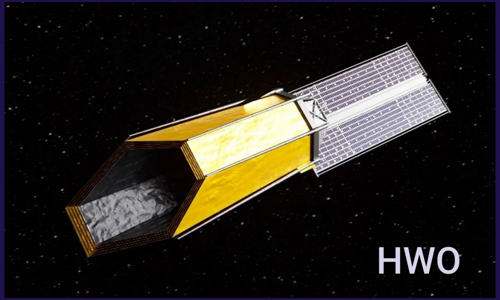
HST and MUSCLES

IUE

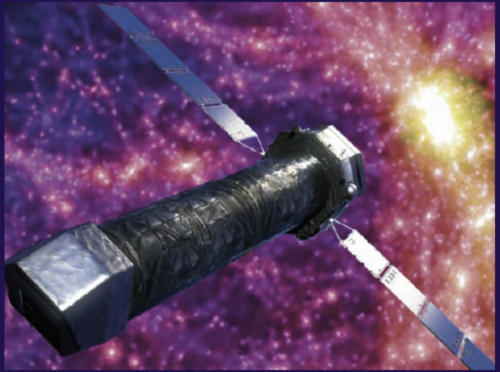
SWIFT

PLATO

Future Missions:



HWO



NewAthena

Mission statement

This mission shall trace the **radiation history of Sun-like stars** to aid the search for life outside the Solar System

Science objectives

How does the ***Ly-α emission*** *in FGK-type stars change with stellar age?*

How does the ***Mg II emission*** *in FGK-type stars change with stellar age?*

How does the ***NUV stellar continuum*** *in FGK-type stars change with stellar age?*

What is the ***temporal emission variability*** *in FGK-type stars?*

Spectral Resolution Estimates

Spectral resolution requirements are driven by ISM contamination of the Lyα and Mg II h&k profiles, following the reconstruction methodology by France et al. (2013) using HST observations: **R = c/Δv**

Ly-α

- 299,792.458 (km/s) / 30 (km/s) ~ 10,000 → Faint Stars
- 299,792.458 (km/s) / 7.5 (km/s) ~ 40,000 → Bright Stars

Mg II

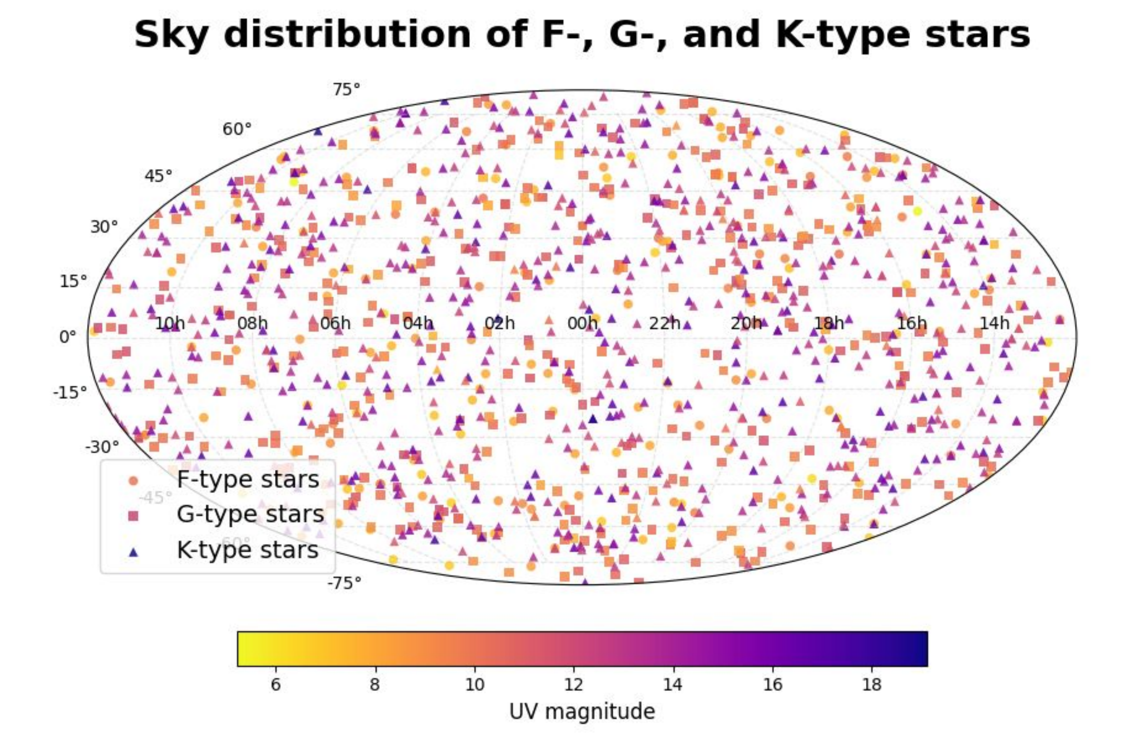
- 299,792.458 (km/s) / 2.6 (km/s) ~ 115,000

Data source: https://www.cosmos.esa.int/web/gaia/edr3-gcns

Target Selection

1222 stars

Queried initial sample **F, G, and K spectral-type stars** within a radius of **d < 30 pc** from the Gaia archive.



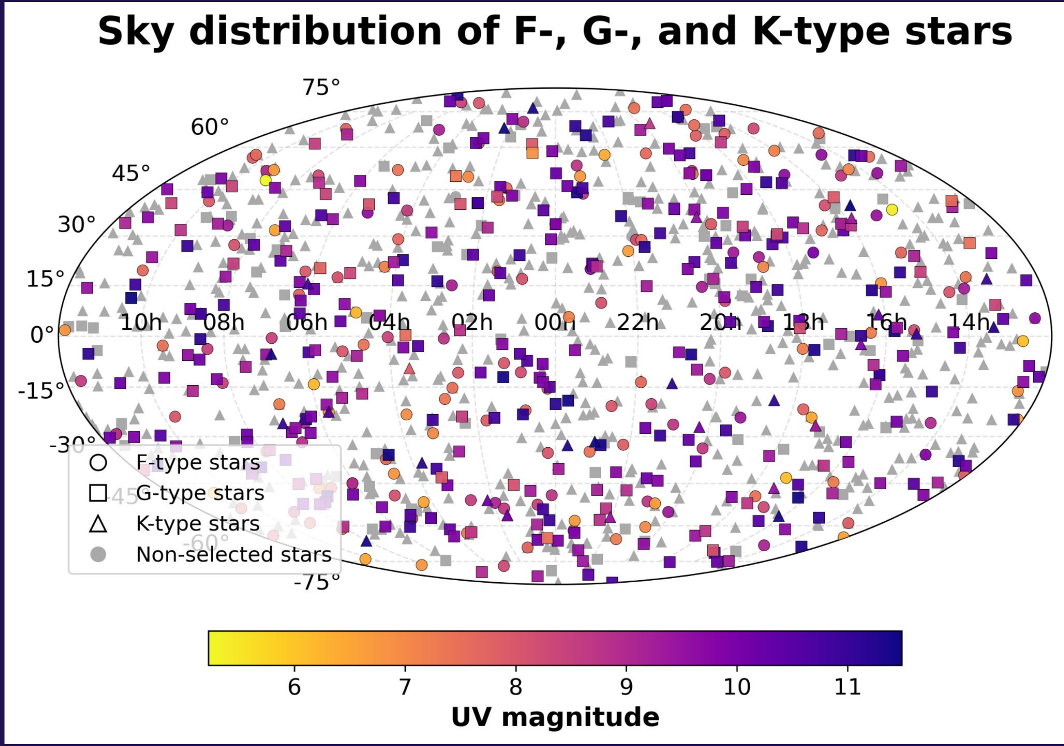
Science
Instrument
Mission
Program

Target Selection

507 after UV cut-off

Applied apparent magnitude limit threshold at **UV mag < 11.5,** filtering out faint targets with **insufficient flux**.

Stars with missing age data were omitted from further analysis.



Data source: https://www.cosmos.esa.int/web/gaia/edr3-gcns

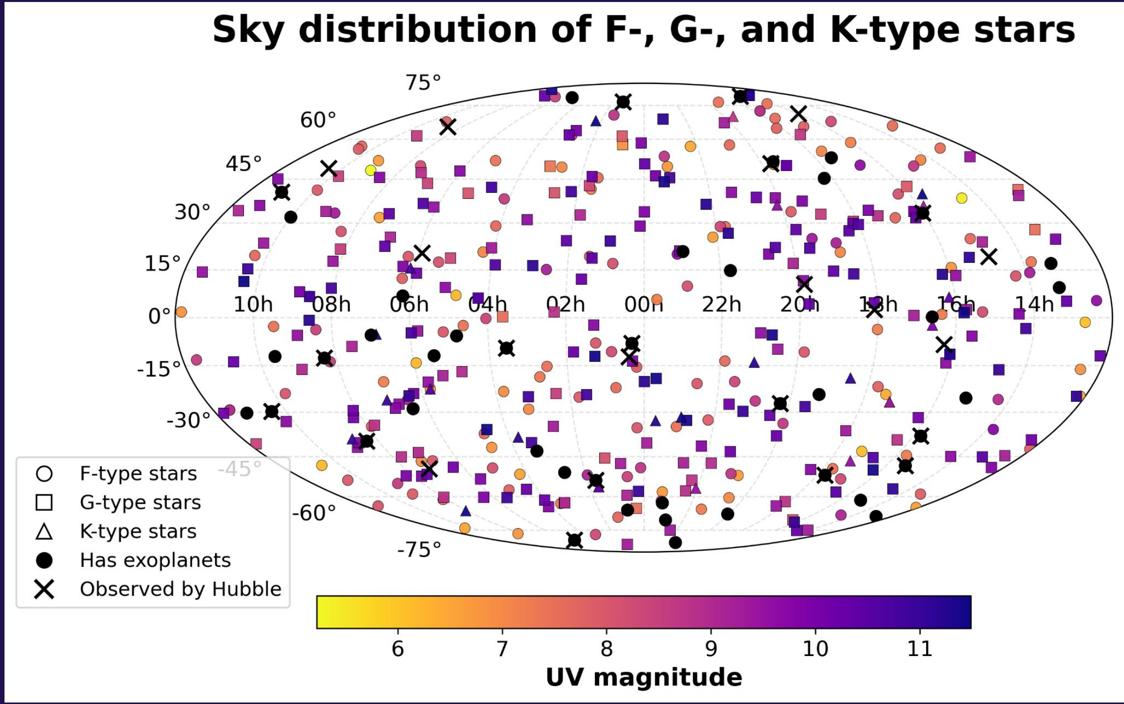
Target Selection

435 final sample

Stellar age distribution across the full evolutionary range and exclusion of faintest stars per age group.

43 stars have been observed exoplanets and

27 stars were observed by Hubble.



Science

Instrument

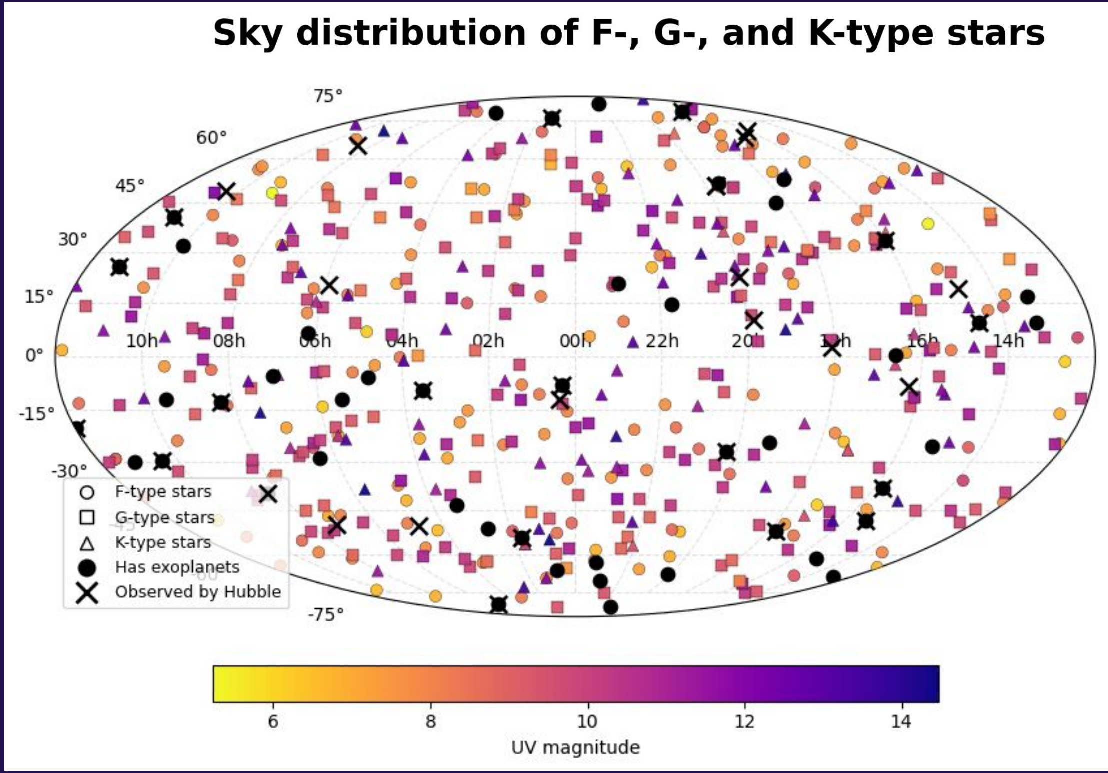
Mission

Program

Targets and Lifetime

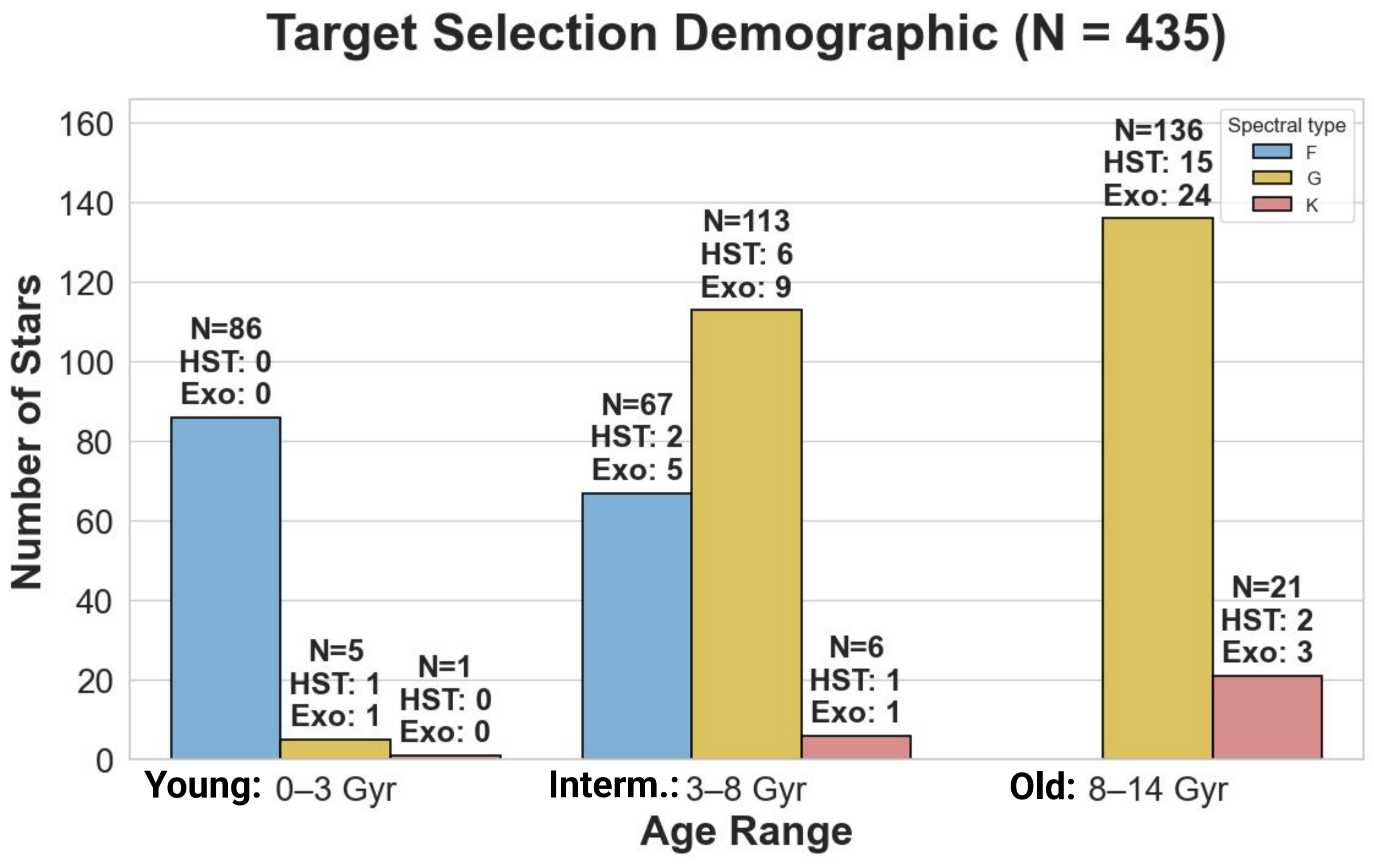
435 final sample

for the faintest target we will need an integration time of 518.4 ks



Target Selection

(Wojno, 2018)



Science
Instrument
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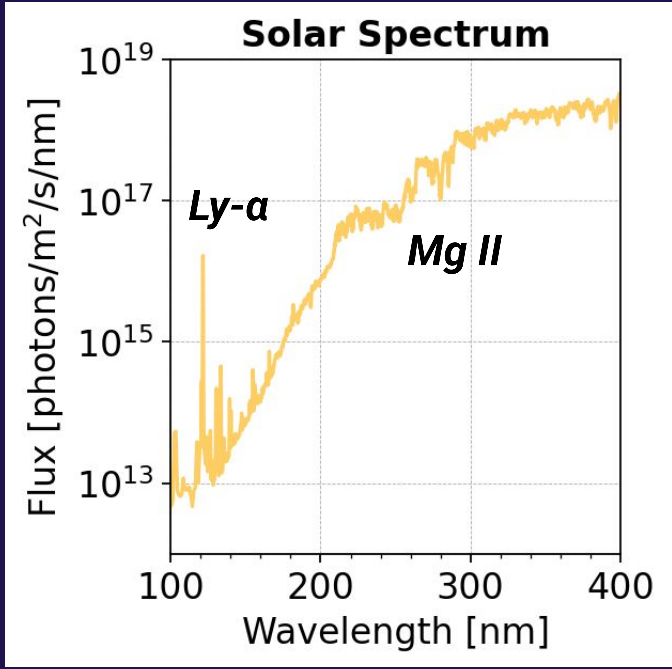
Program

Stellar limiting magnitude

How faint are the stars of interest in the UV spectrum?



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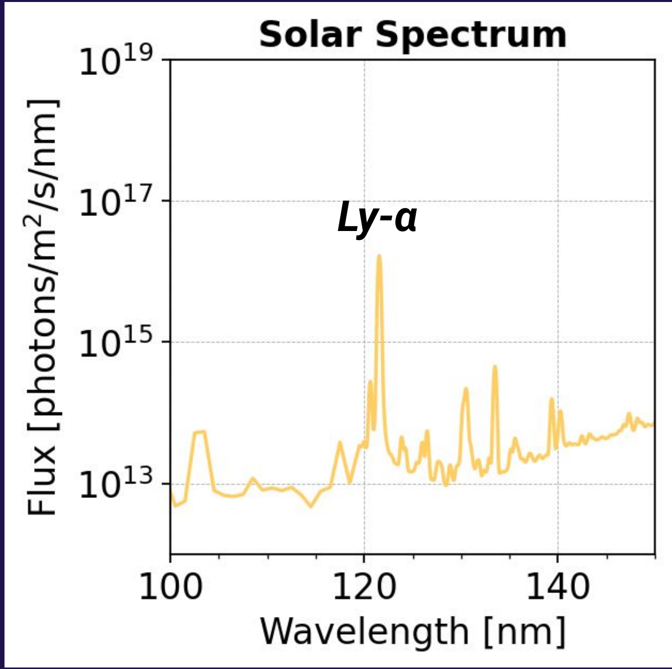

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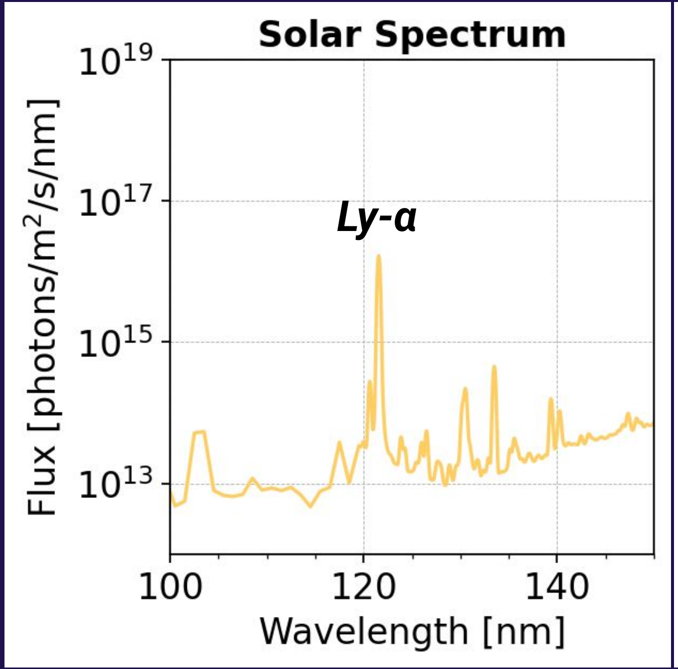

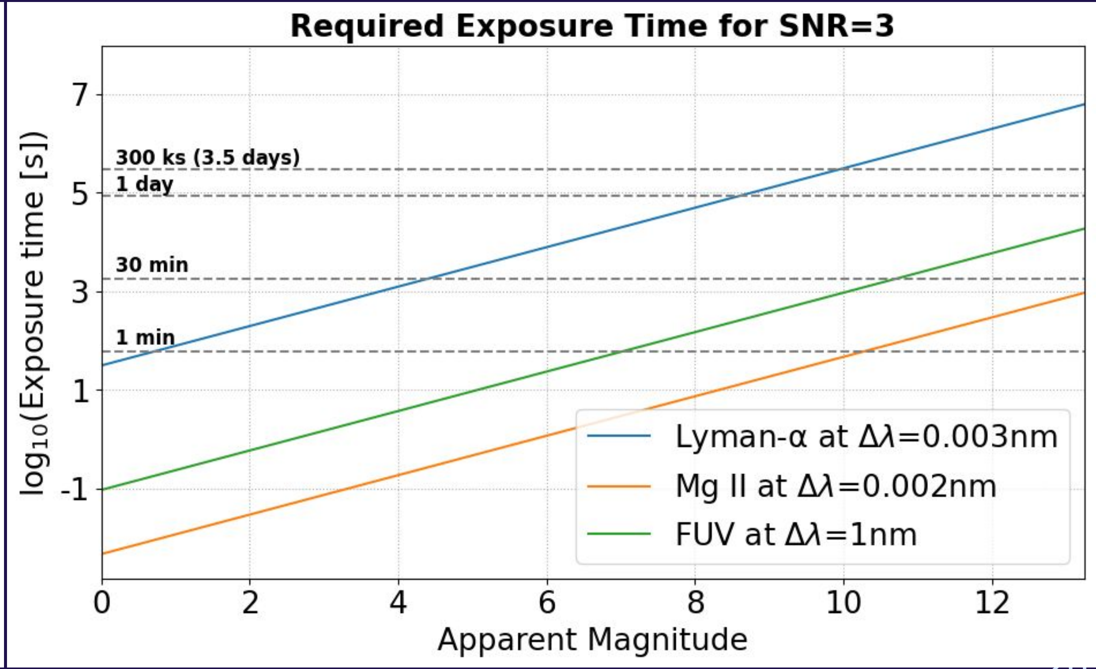

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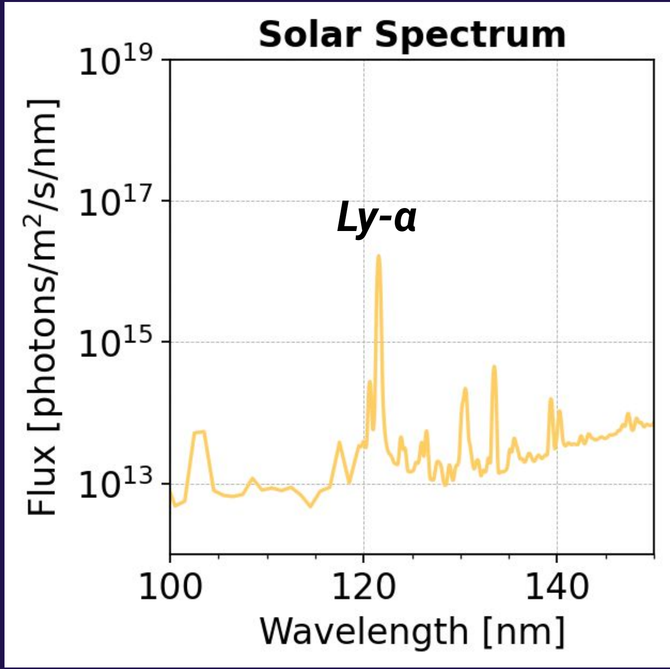

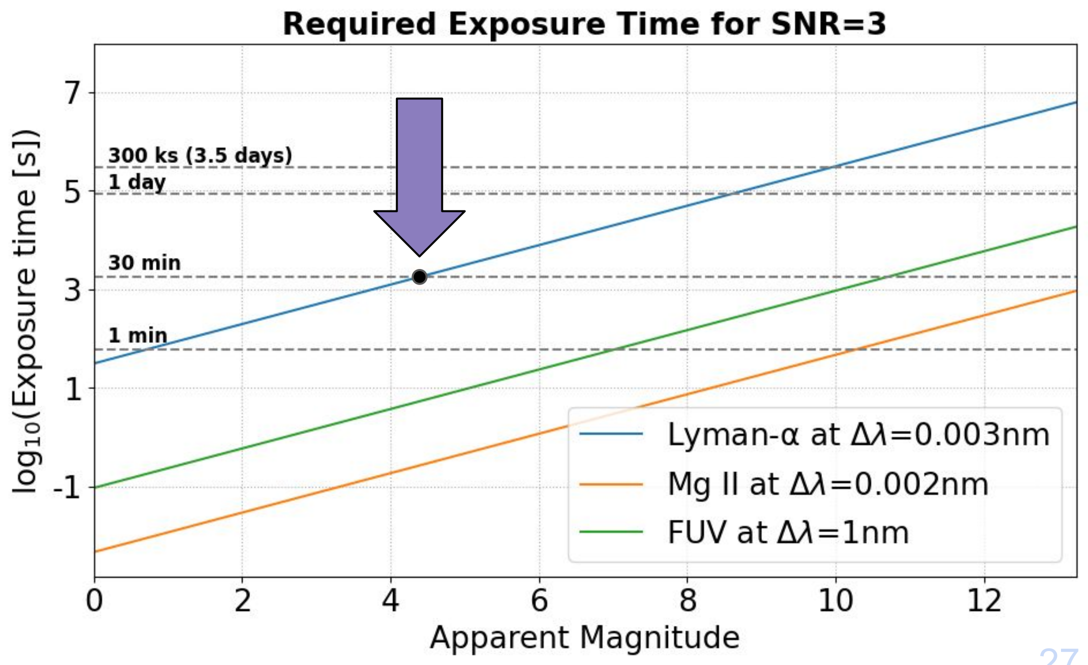

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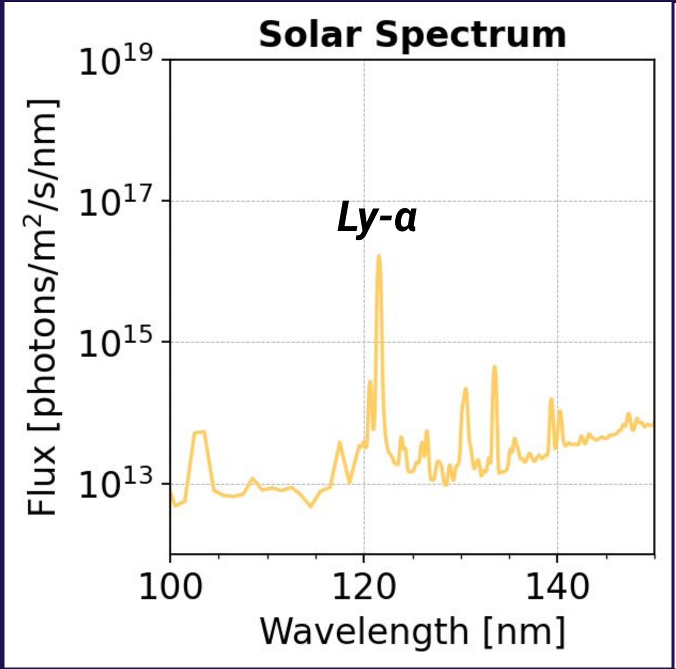
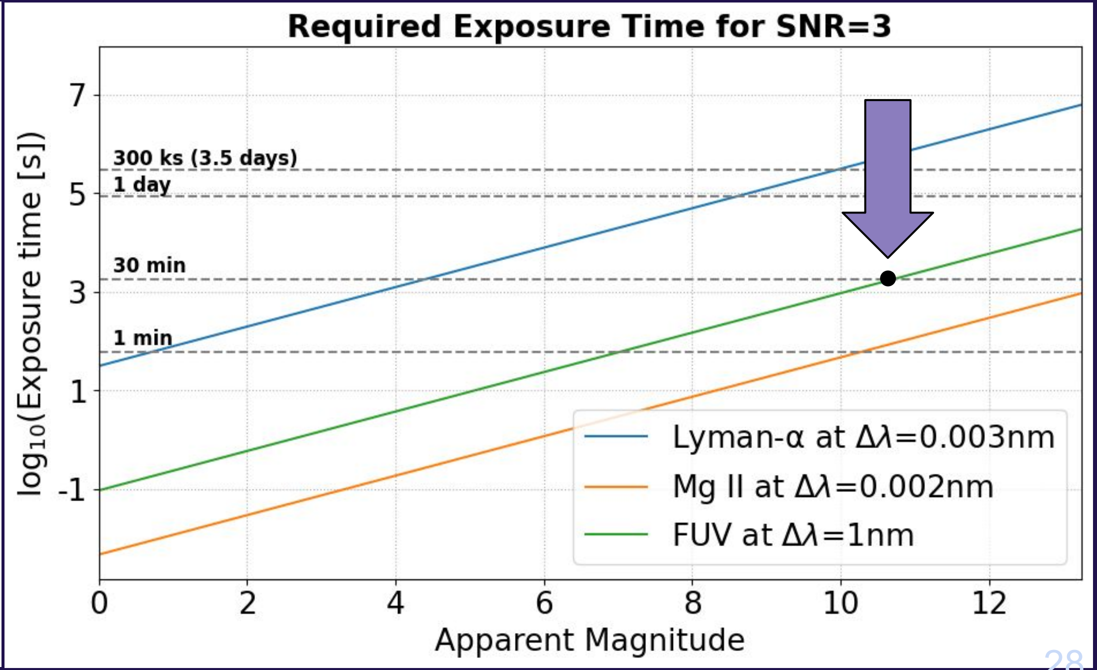




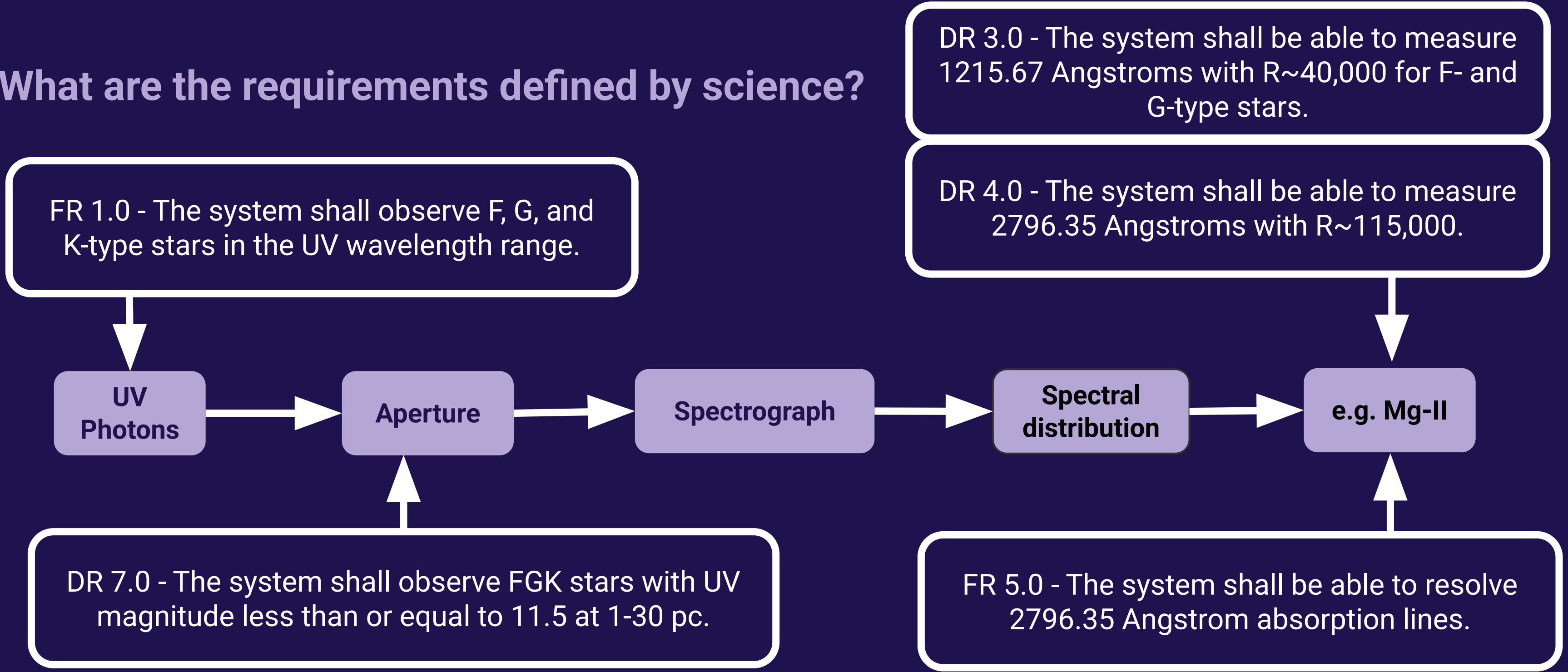
Observation Strategy

1. Single campaign observation
2. Focus on UV continuum emission and Ly-α & Mg II lines
3. Observation shall achieve SNR of 3 in max. 518.4 ks (6 days) for faintest star

Instrument

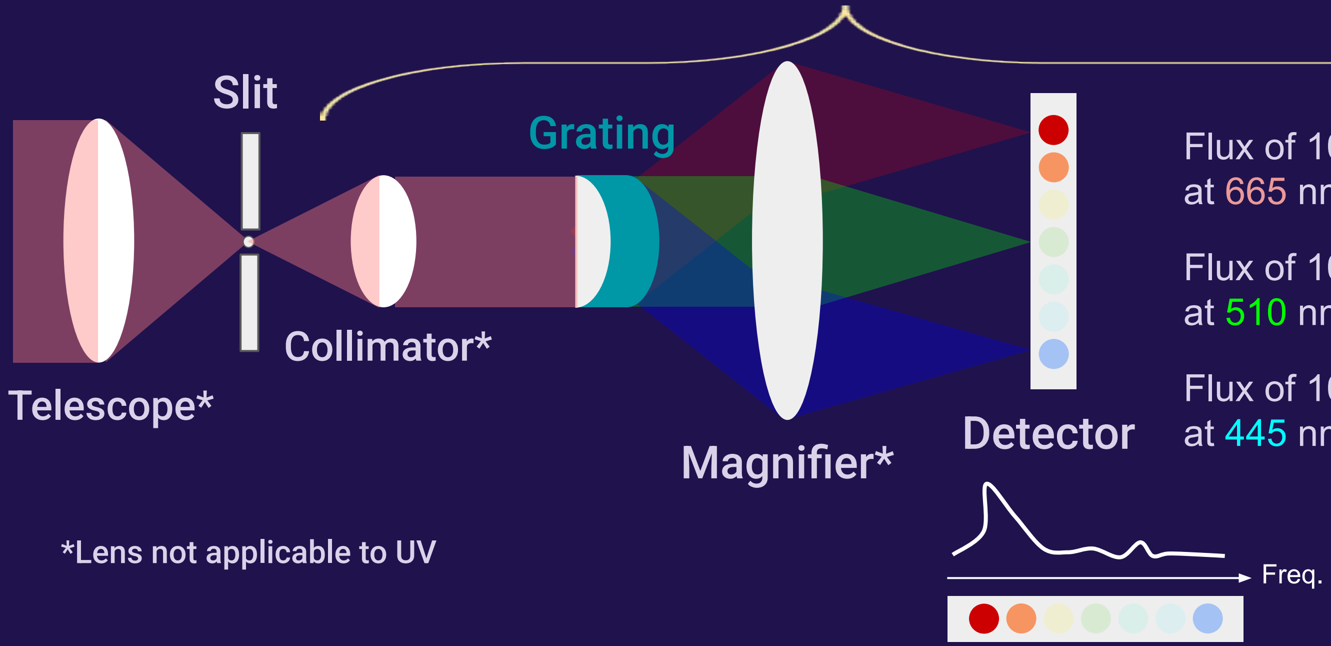
From science to measurement

What are the requirements defined by science?



Instrument Concept

UV Photons → Aperture → Spectrograph → Spectral distribution → Separated spectral points



Flux of 10^{13} photon•m^{-2}•s^{-1}•nm^{-1} at 665 nm

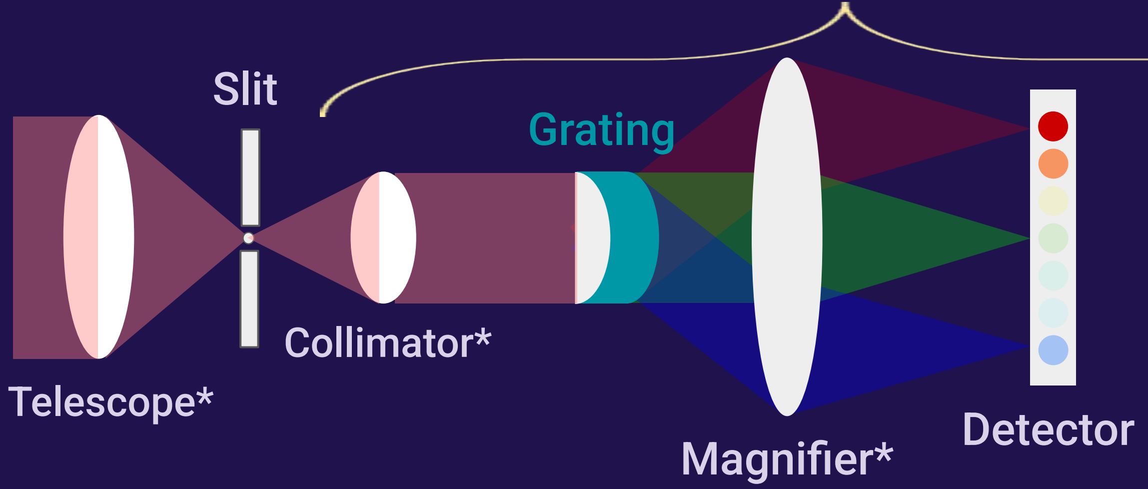
Flux of 10^{17} photon•m^{-2}•s^{-1}•nm^{-1} at 510 nm

Flux of 10^{15} photon•m^{-2}•s^{-1}•nm^{-1} at 445 nm

*Lens not applicable to UV

Instrument Concept

UV Photons → Aperture → Spectrograph → Spectral distribution → Separated spectral points



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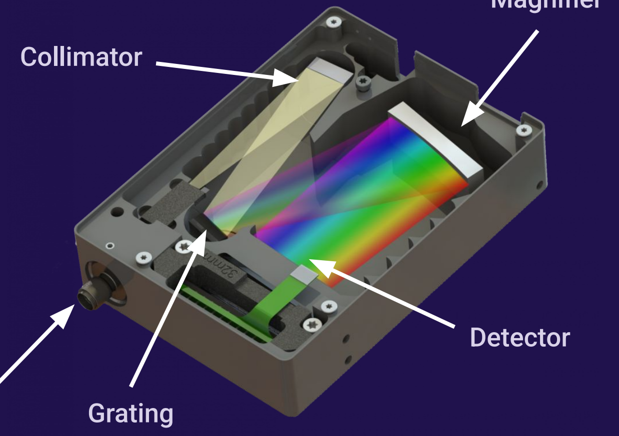
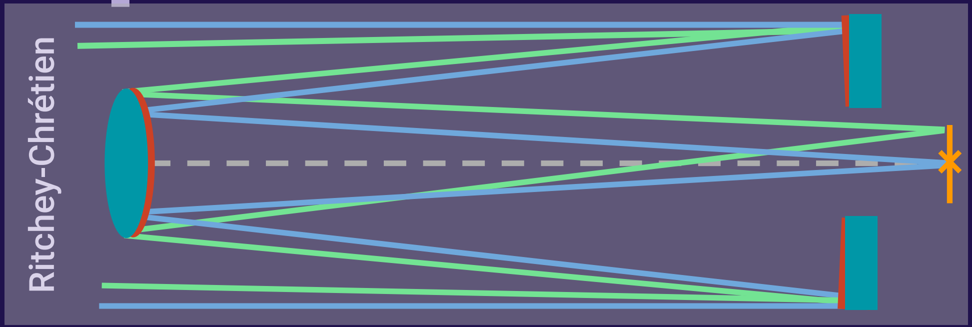


Inside of optical bench from Avantes

Telescope



Focus

Secondary mirror
w/ UV coating

Primary mirror
w/ UV coating

How do we ensure reflectivity performance given the strong absorption of UV?

Choosing $Al+MgF_2$ coating:

- Reflectance >80% from ~115–200 nm (including Ly-a emission line).
- Reflectance >90% above 200 nm.
- Sharp cutoff below ~115 nm (drops to <20%).
- Flight-proven: same coating used on Hubble, STIS, COSTAR.

Ritchey-Chrétien telescope from CFF Telescopes

Aperture requirement

How big does our telescope need to be to be able to see our targets?

Signal is governed by **throughput** (transmission, detector QE), aperture, and exposure time.

Requirements define a SNR = 3

- For maximum **11.5 stellar** magnitudes (faintest as defined in DR7.0) and
- an exposure time of **518.4 ks (6 d)** at the Ly-α line.

50 cm aperture

*Swift UVOT operates with a 30 cm aperture, and much lower resolution.

Focal length

How long is the optical path through our telescope?

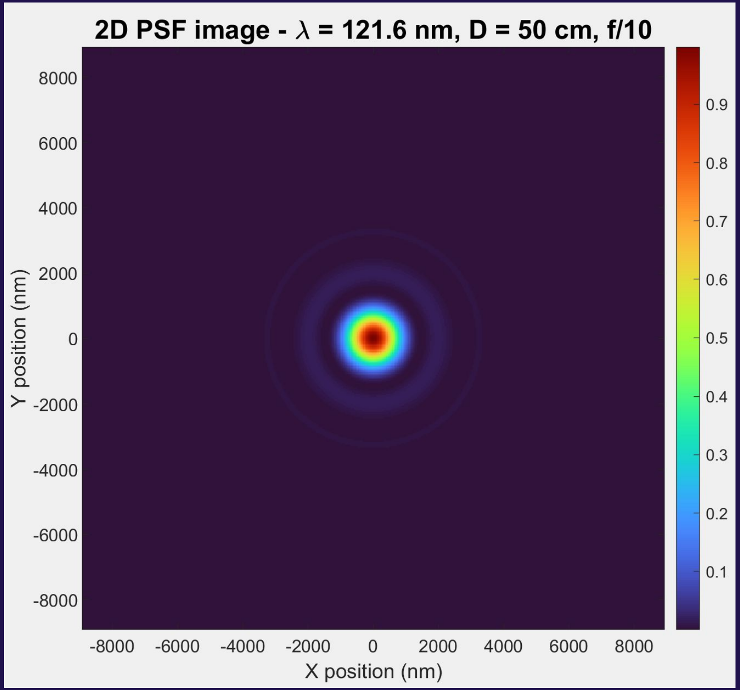
- Heritage UV telescope Swift uses f/12–13.
- SWaP design pushes ICARUS' focal ratio to f/10 for a more compact instrument.
- At 0.5 m aperture, f/10 results in a 5 m optical path,

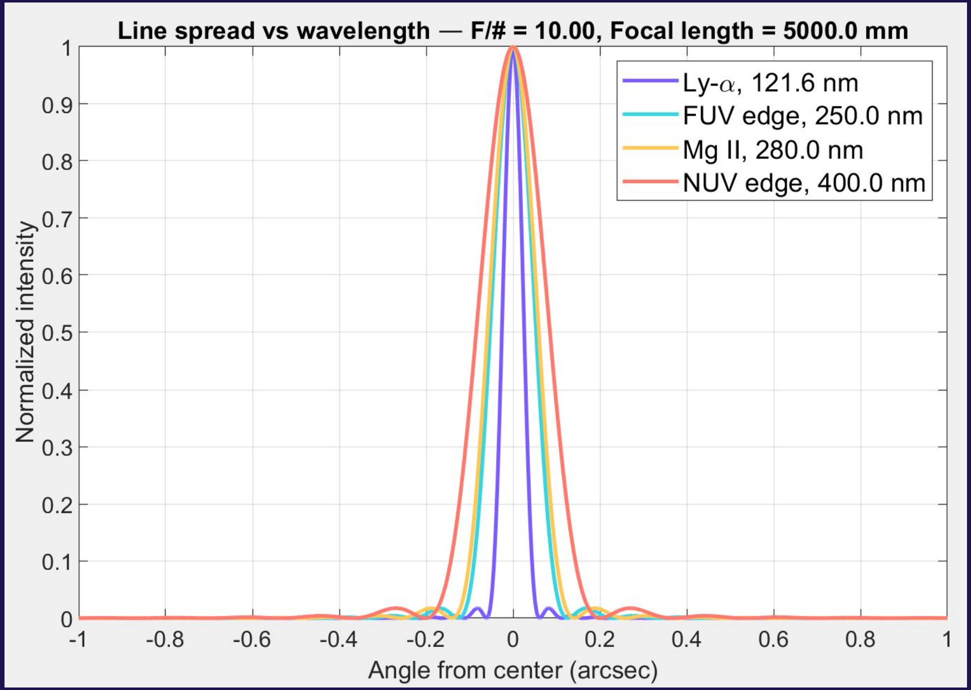
Ritchey-Chrétien compresses 5-meter optical path into a physical structure of ~1 m physical length.

Parameter	ICARUS-UV	UVOT (SWIFT)
focal ratio	Primary: f/2.5; Secondary: f/4	Primary: f/2; Secondary: f/6.36
Physical tube length	~1 m	1 m
Design	Ritchey-Chrétien	Ritchey-Chrétien

Point spread function (PSF)

The PSF is the blurred pattern a perfect point of light produces after passing through an optical system.



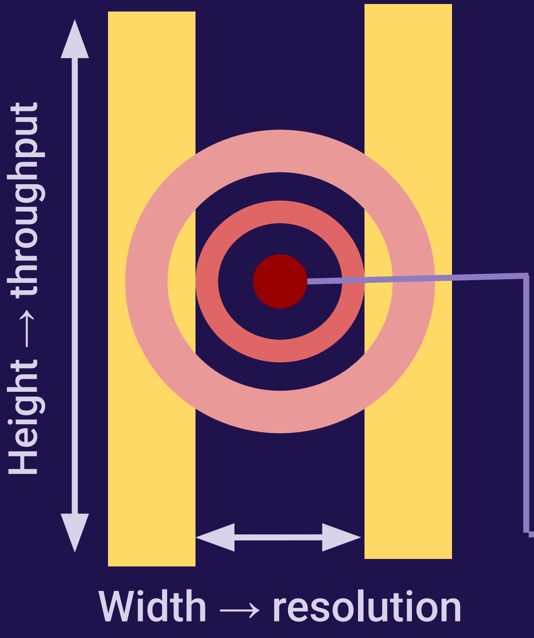


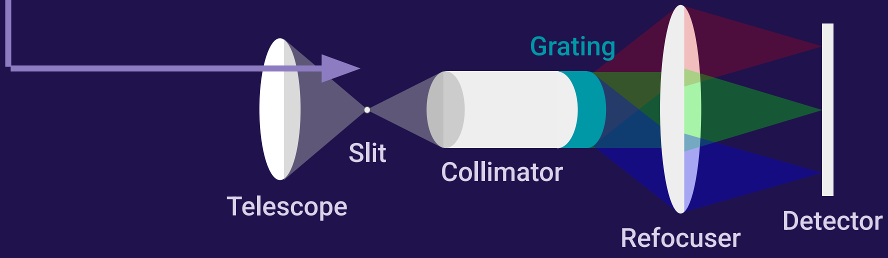
The slit

* margin of 3 px each side

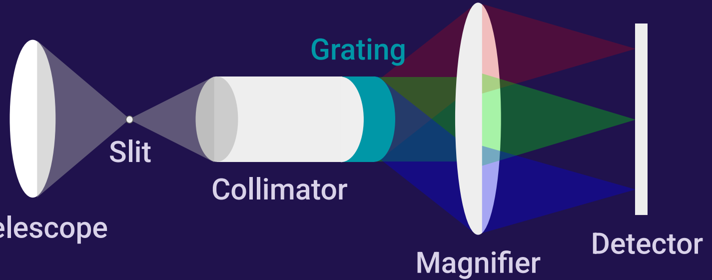
Channel	Slit Width	Slit Height (pxl = 9 μm)	M
Ly-α (121.6 nm)	5.43 μm	10 pxl (90 μm)	1.66x
FUV (100-250 nm)	4.47 μm	15 pxl (135 μm)	2.01x
Mg-II (280 nm)	12.50 μm	16 pxl (144 μm)	-
NUV (250-400 nm)	11.17 μm	20 pxl (180 μm)	-

RSS of jitter error TBD -> will give derived number





Detector

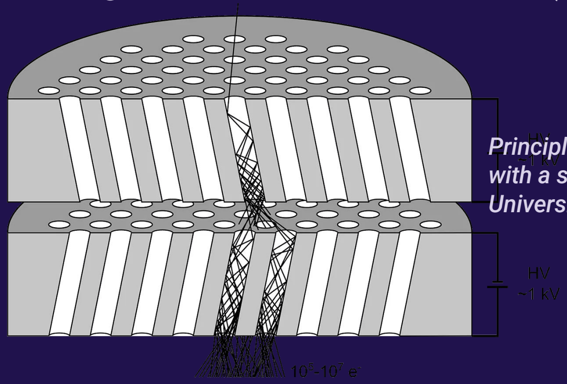


Driving constraints:

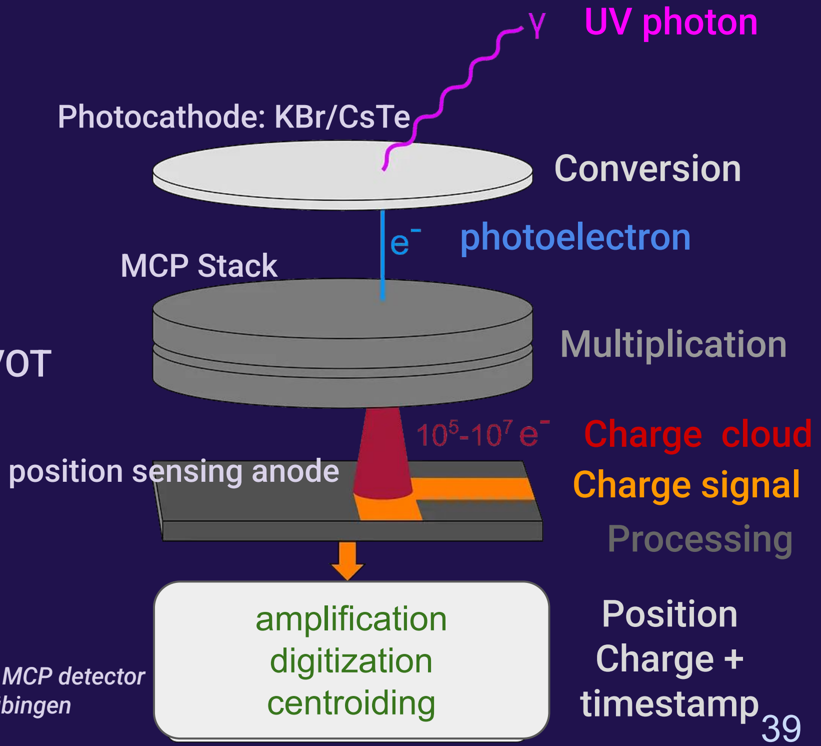
+ High photon efficiency (no loss through filters)
+ Low readout noise
+ Thermal requirement
+ Rated for mission lifetime

<u>Choice: Microchannel plate (MCP) detector</u>

Heritage: UV detector on Hubble (STIS, COS), Swift/UVOT

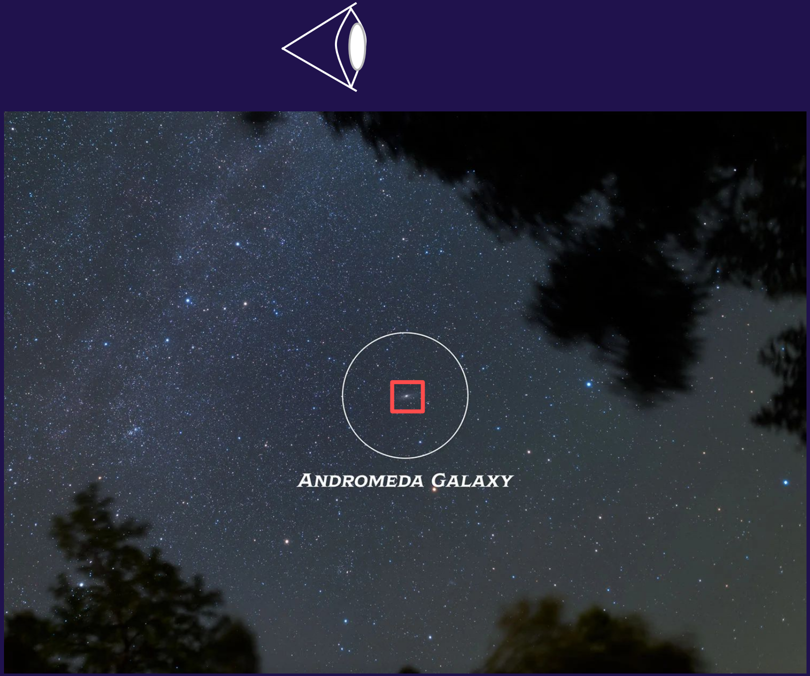


Principle of the photon detection with a stack of 2 MCPs from Universität Tübingen

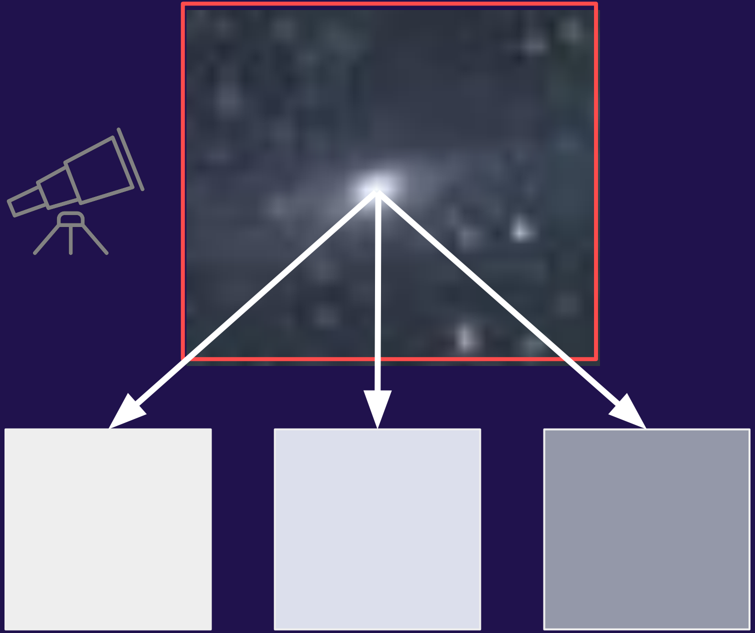


Principle of the UV MCP detector from Universität Tübingen

Let's see it in action!



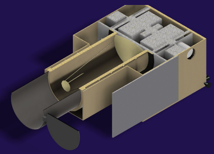
Let's zoom in



Human spectrometer results

Let’s see it in action!

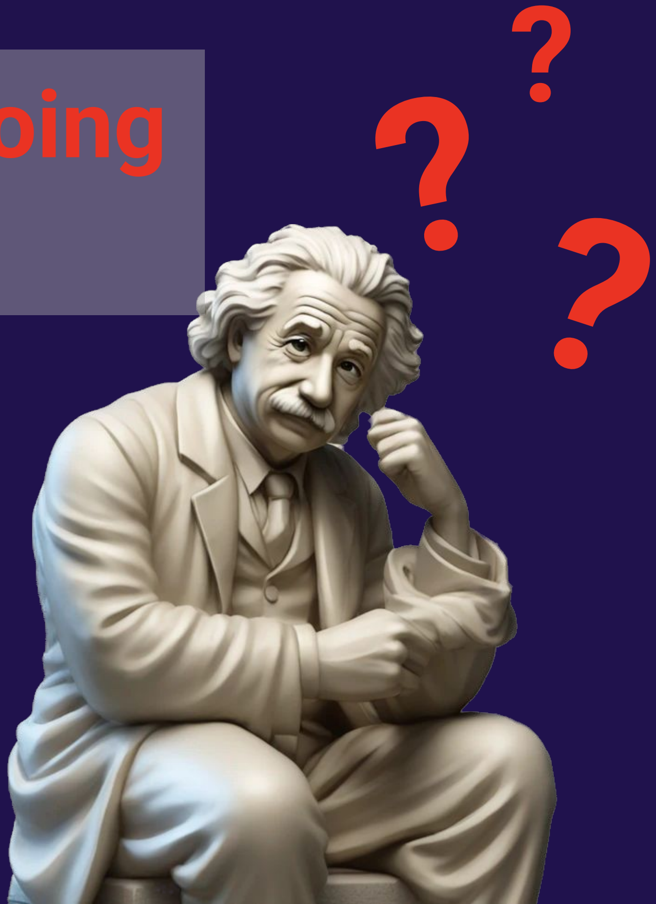
Spectrograph identified 16 results



R~100 spectrometer results

Let's see it in action!

What is going on here?!

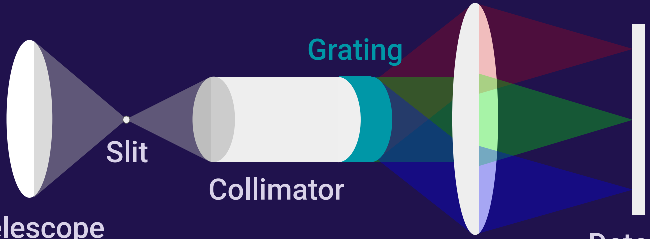


Let’s analyse the problem

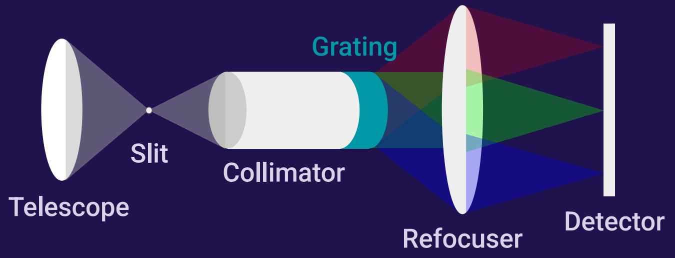
- ✅ - Telescope shall provide a suitable aperture
- ✅ - Telescope shall focus down the rays to a focus point
- ✅ - Slit shall let through only the point source
- ✅ - The collimator shall be chosen so to project parallel rays on the grating
- ✅ - The grating shall be of suitable size to separate the parts of spectra
- ✅ - Magnifier shall refocus the wavelengths to detector


Polishing a telescope mirror.
Credits: Christel Sasso / CAPA Pictures / Safran

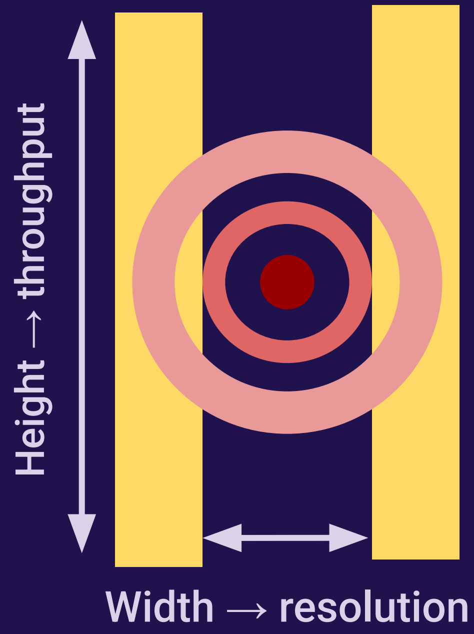
Could it be the slit and projection on the slit?



The slit



What we wanted

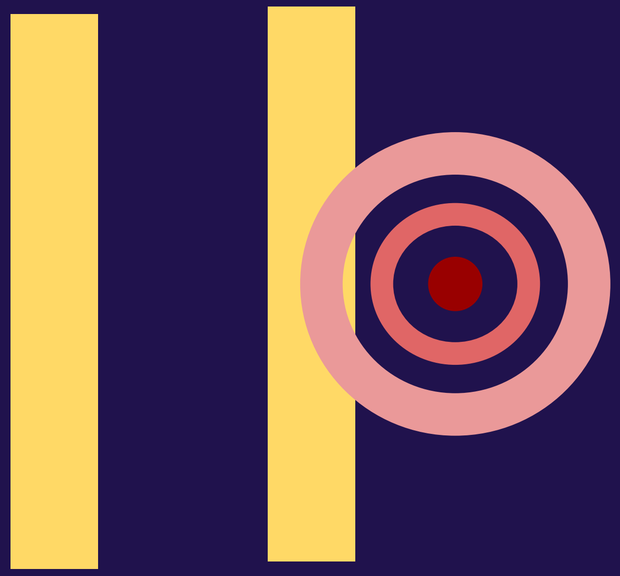


How was our pointing?

Platform pointing error: ~10 arcsec

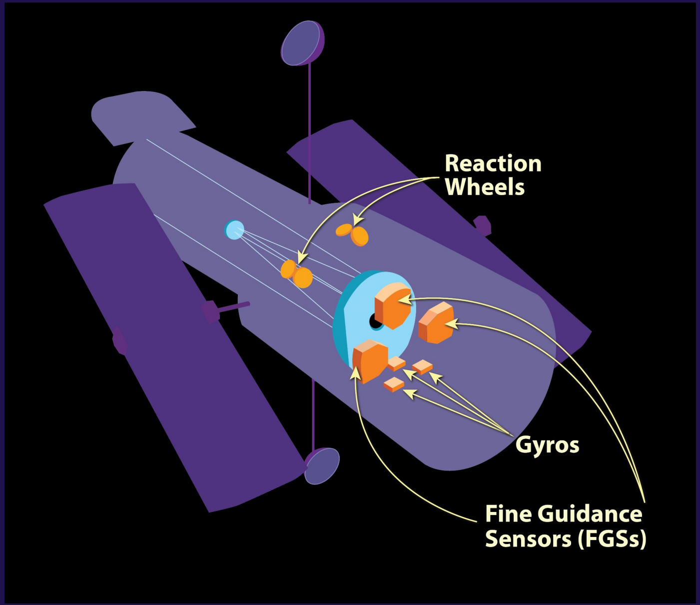
Let's re-check requirement for pointing error: ~0.024 arcsec

What we had likely



Fine Guiding System (FGS)

What FOV shall the FGS have to capture the star despite residual pointing uncertainty?



FGS on Hubble Space Telescope from NASA/STScI

Star tracker + Reaction wheels + Gyroscopes:

Requirement: Coarse pointing accuracy ~10 arcsec

Field of View (FOV):

Account for residual pointing uncertainty (Factor 2x): ~20 arcsec

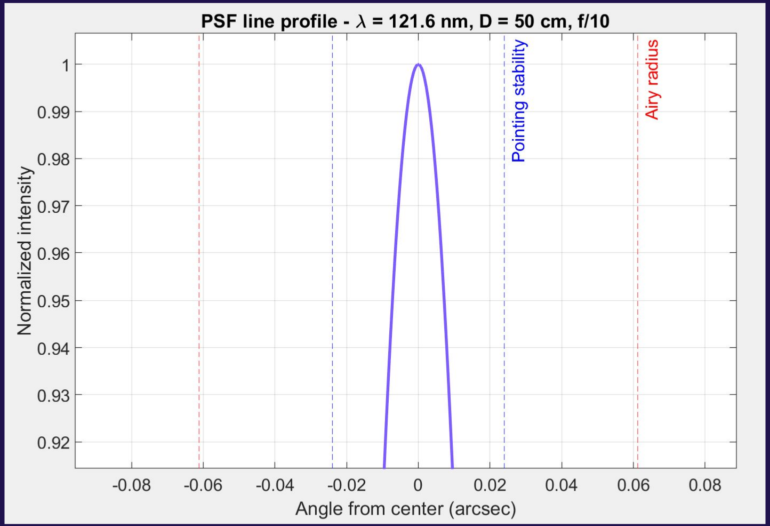
→ *Imaging*

Fine Guiding System (FGS)

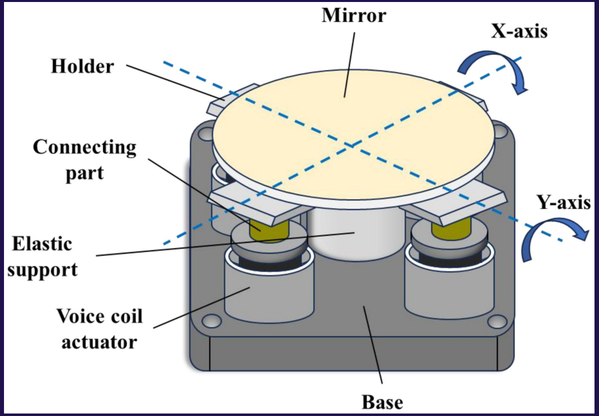
Imaging Spectrograph: Pixels are deliberately oversampled relative to the PSF -> sub-pixel centroid precision for accurate fine-pointing

CMOS image sensor from Teledyne

SR7.1: Fine Pointing accuracy of 0.024 arcsec



Tip-tilt mirror for fine pointing

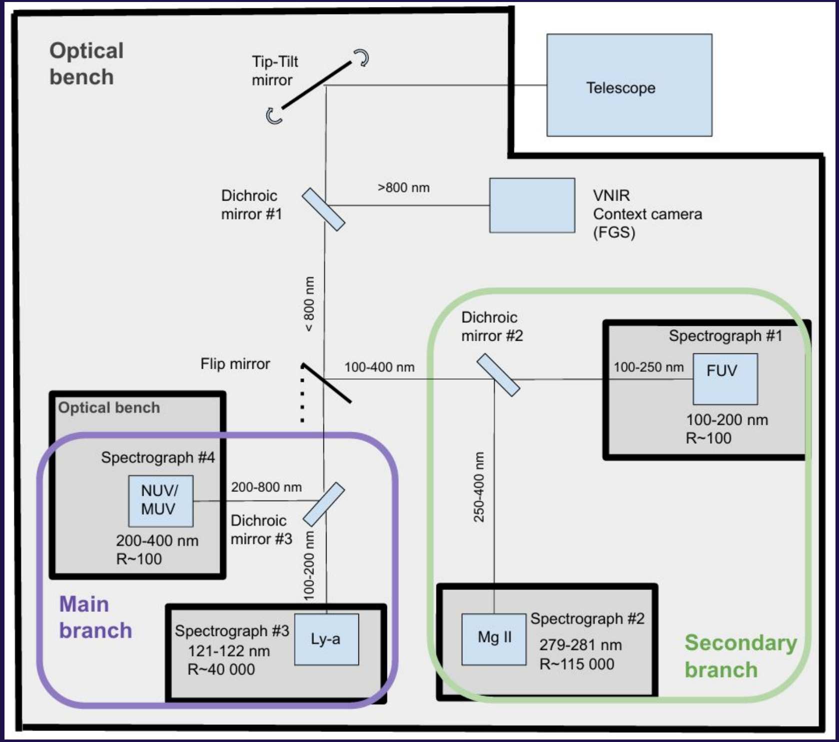


Structure of a two-axis tip–tilt mirror from MDPI

System Architecture

- 1 Telescope
- 4 Spectrographs
- 3 Dichroics
- 1 Tilt mirror
- 1 Context camera
- 1 Tip-tilt mirror
- Temp. sensors
- Heaters
- Thermal strips

All on optical bench (except for telescope). Spectrographs on separate optical benches.



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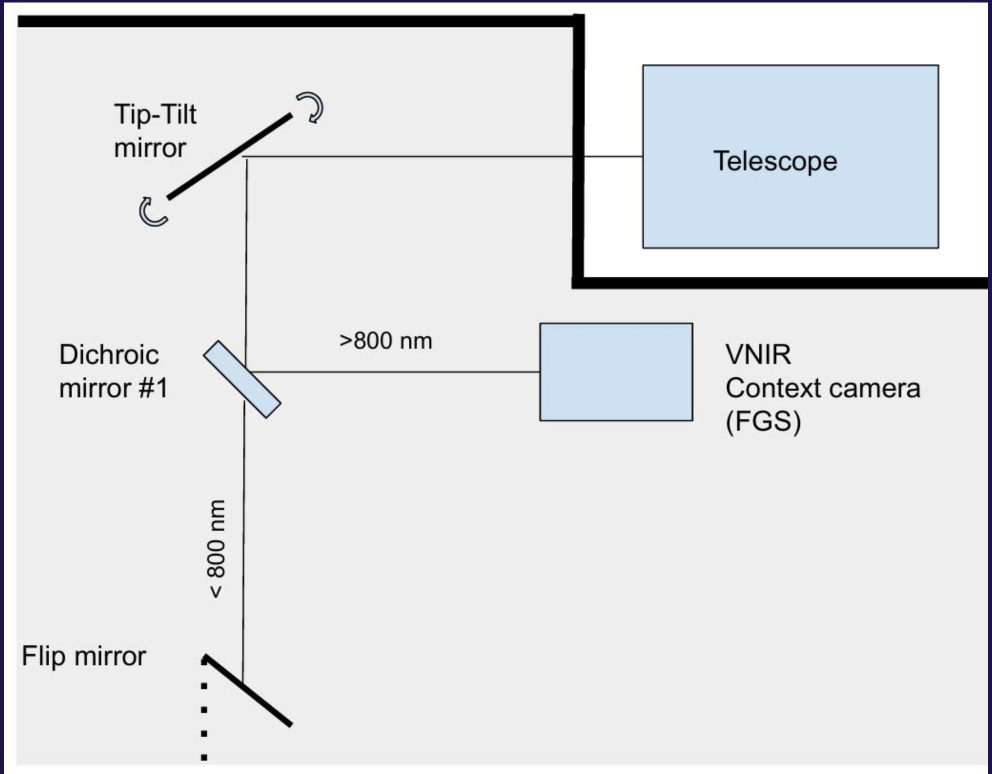

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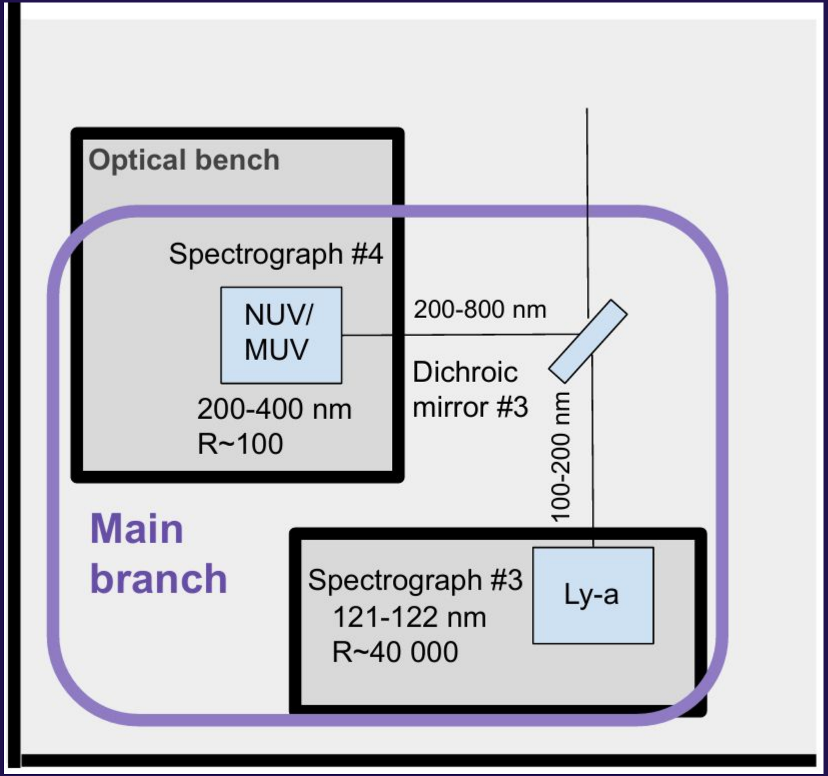

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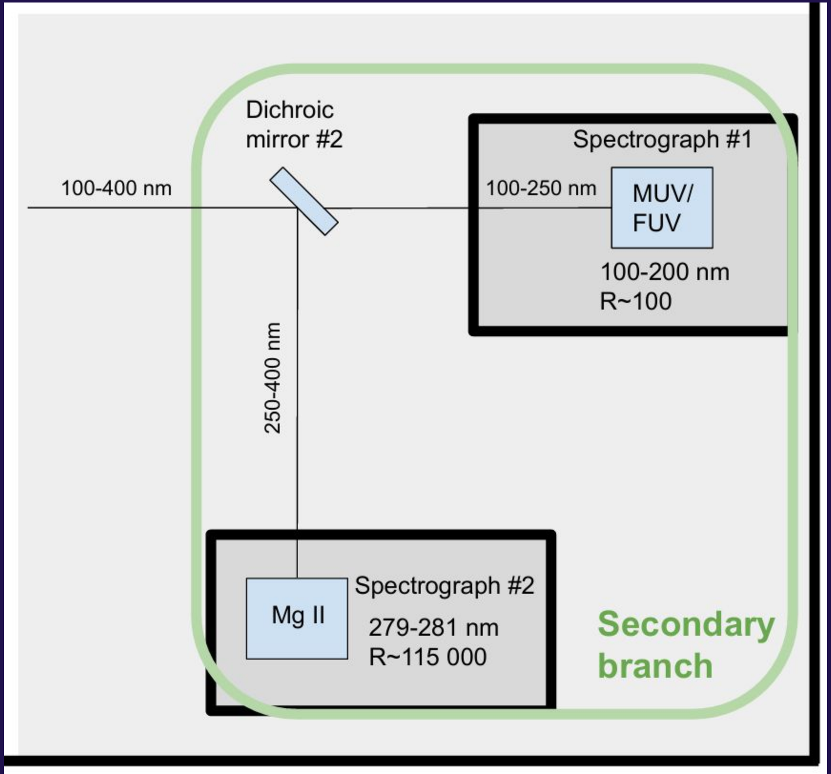
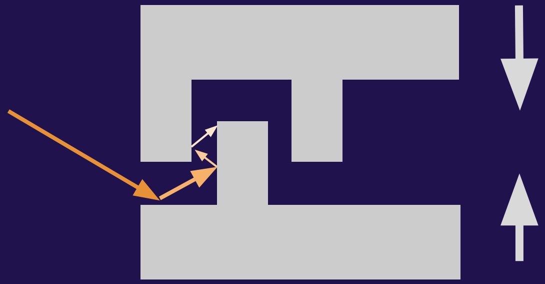
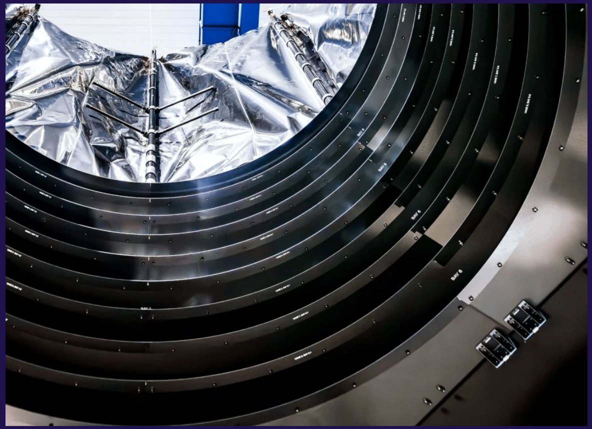


Stray light mitigation

- Baffle
  - Avoid sun reflection → outlined in orbit selection
- Field stops
- Aperture stops
- Black coating on all surfaces
- Light tight interconnections



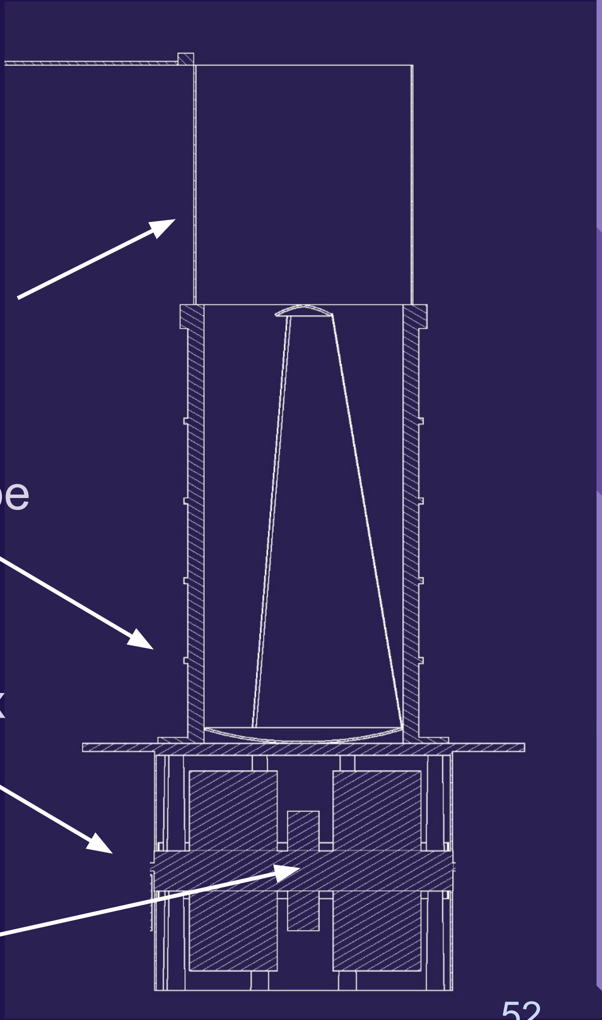
Light tight intersections on the optical box.



NASA's Nancy Grace Roman Space Telescope stray light baffle with aperture stops.
Credit NASA/Chris Gunn (cropped).

Payload packaging

- Telescope looking perpendicular to the solar panels
- Measurement components enclosed in a optical box
- Optical components on optical bench
- 11 temperature sensor and heaters
- Heat transport strips



Data packaging

Spectrograph

Electrical signal ↓ Photon count and position

Detector asm.

Digital reading ↓ Digitalised signal

Payload computer

e.g. SpaceWire or MIL-STD-1553 ↓ File from cache (CCSDS standards)

Radio

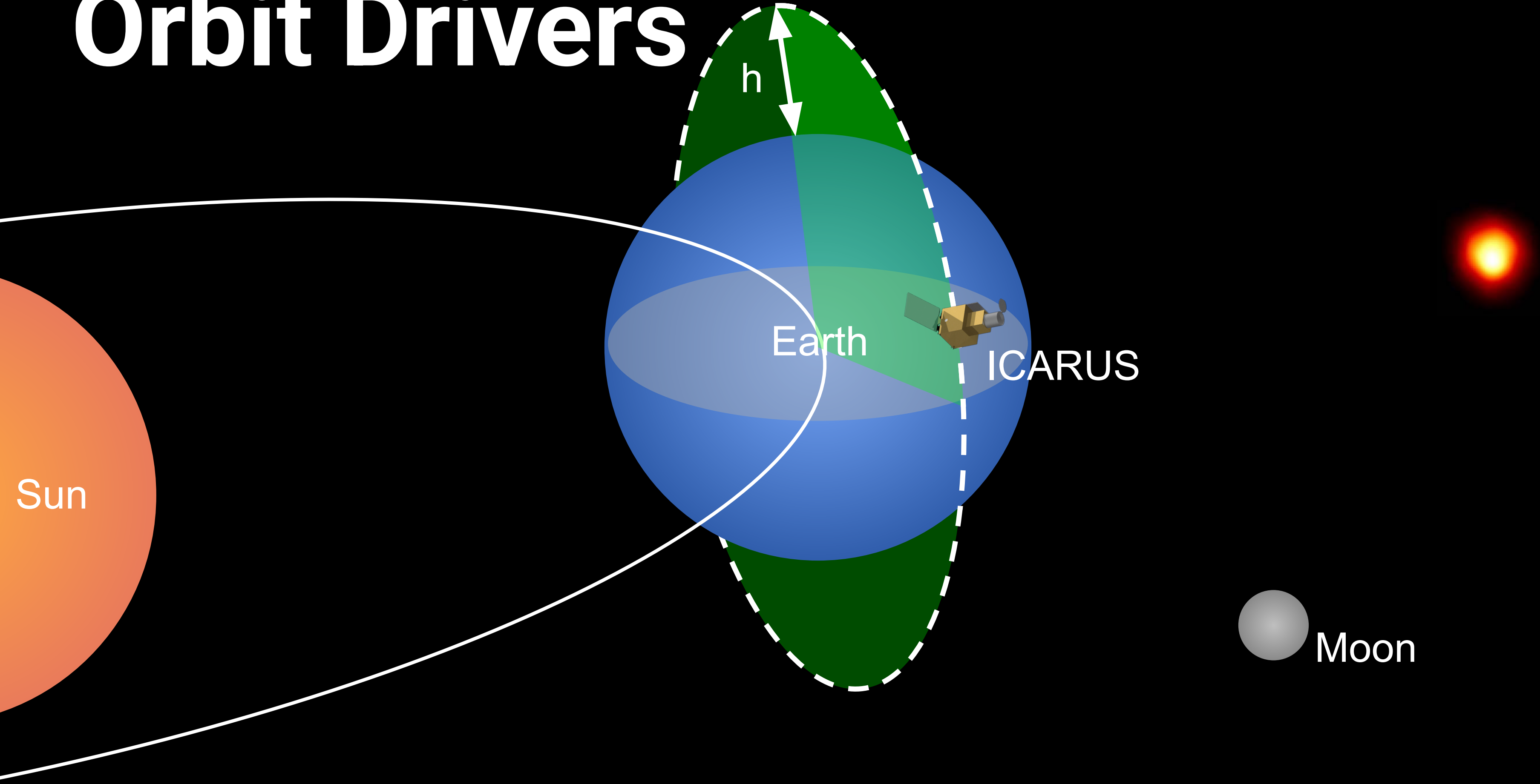
Magic radio waves ↓ File stored for downlink

< 9 MB per file

Mission

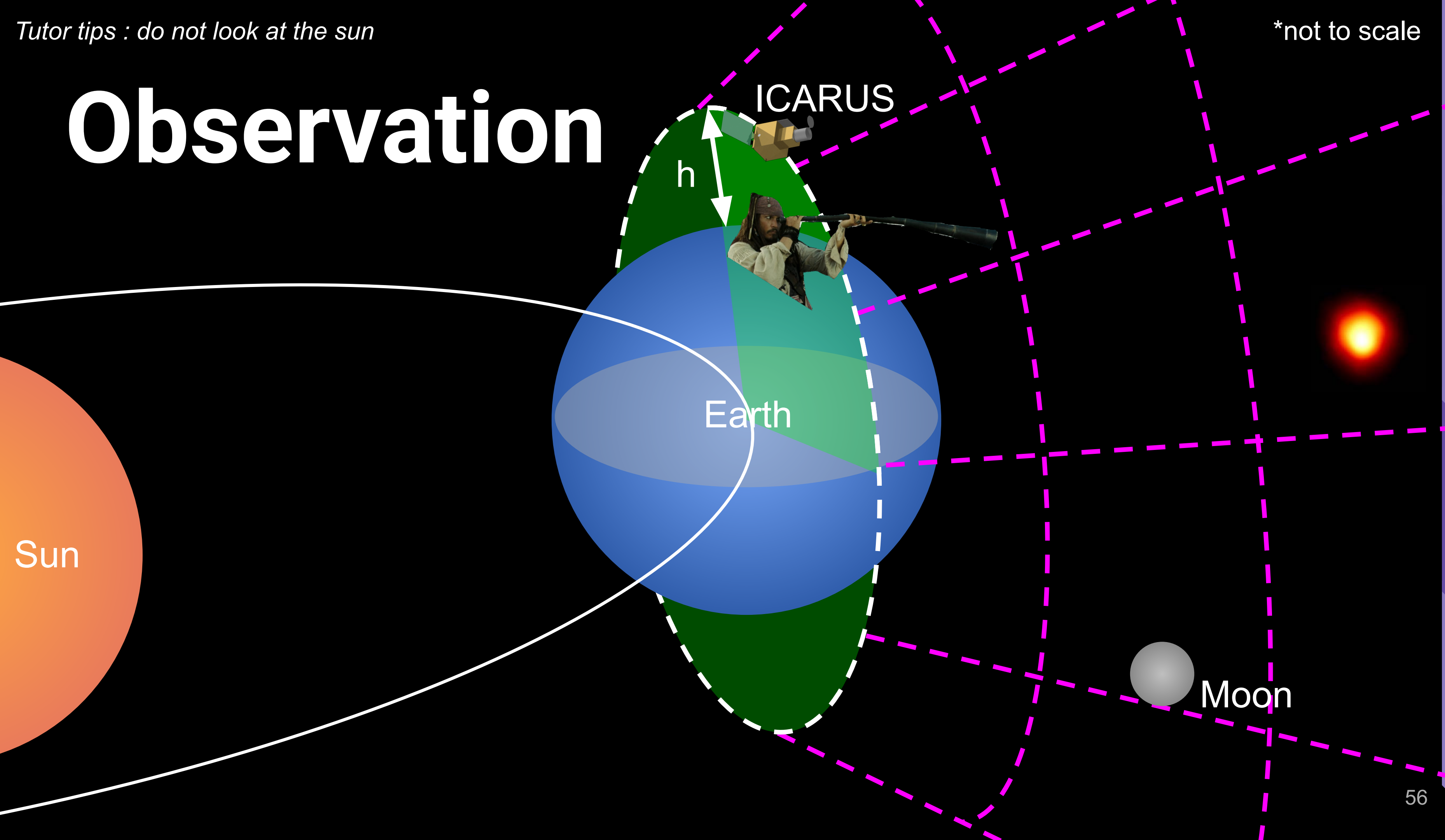
Orbit Drivers

*not to scale

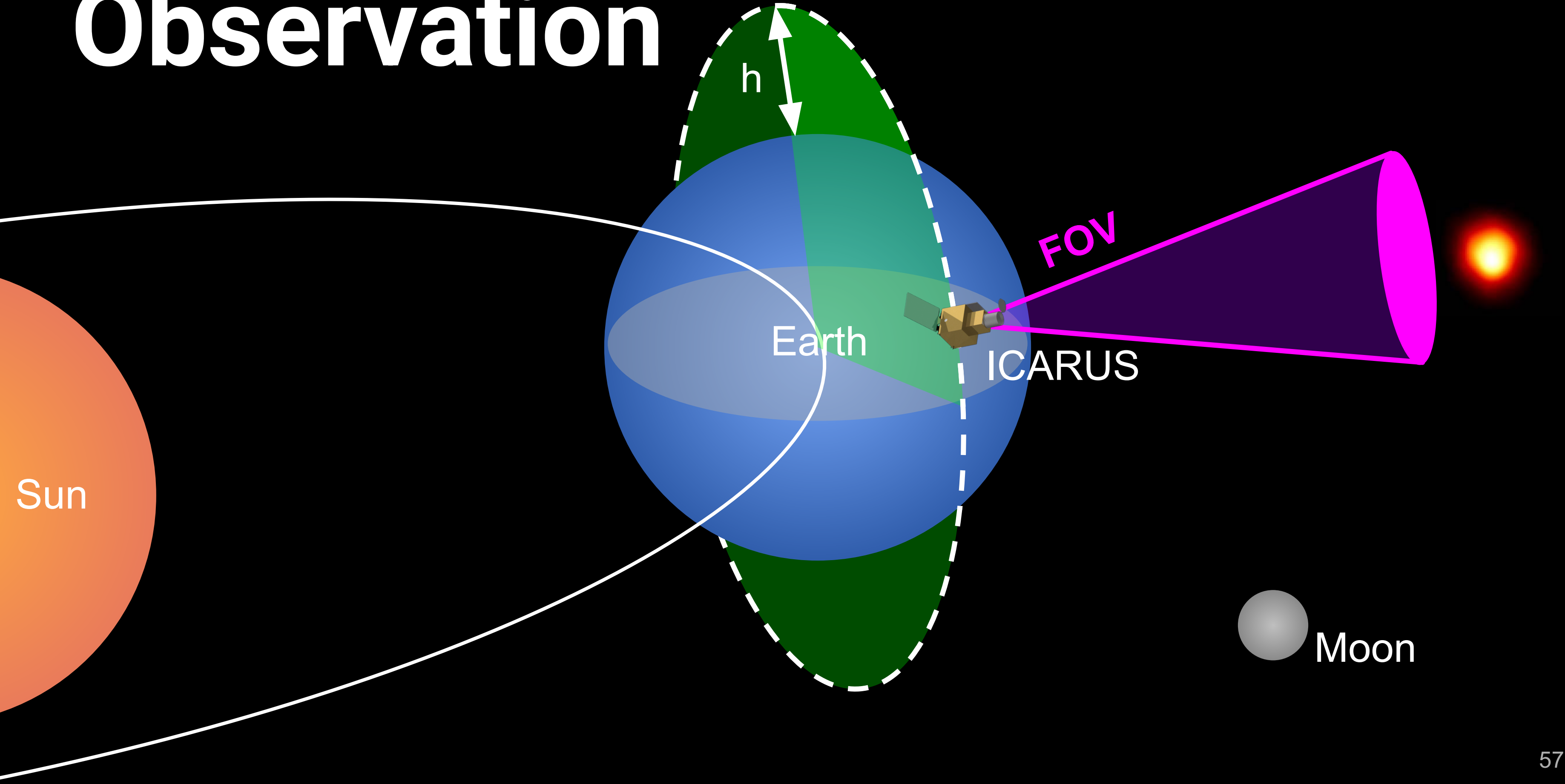


*not to scale

Observation



Observation



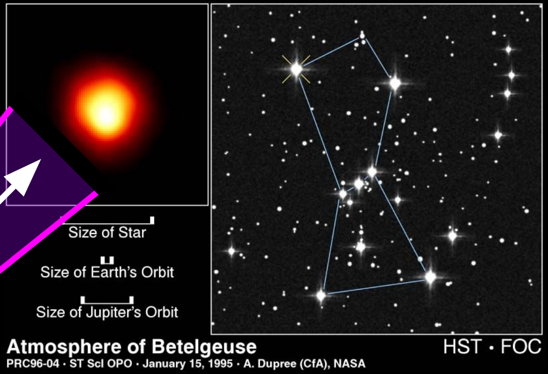
Based on num. calculations

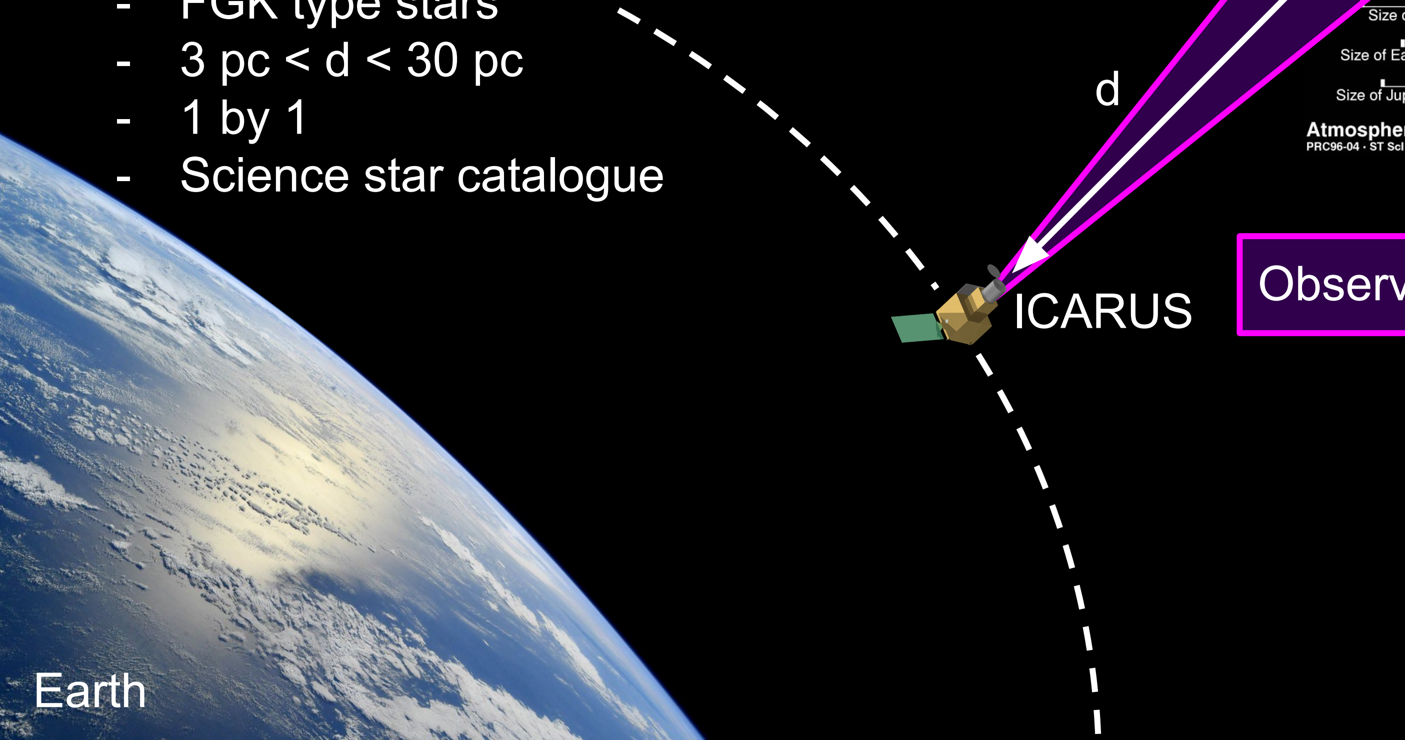
*not to scale

Observation

Objectifs:

- FGK type stars
- 3 pc < d < 30 pc
- 1 by 1
- Science star catalogue





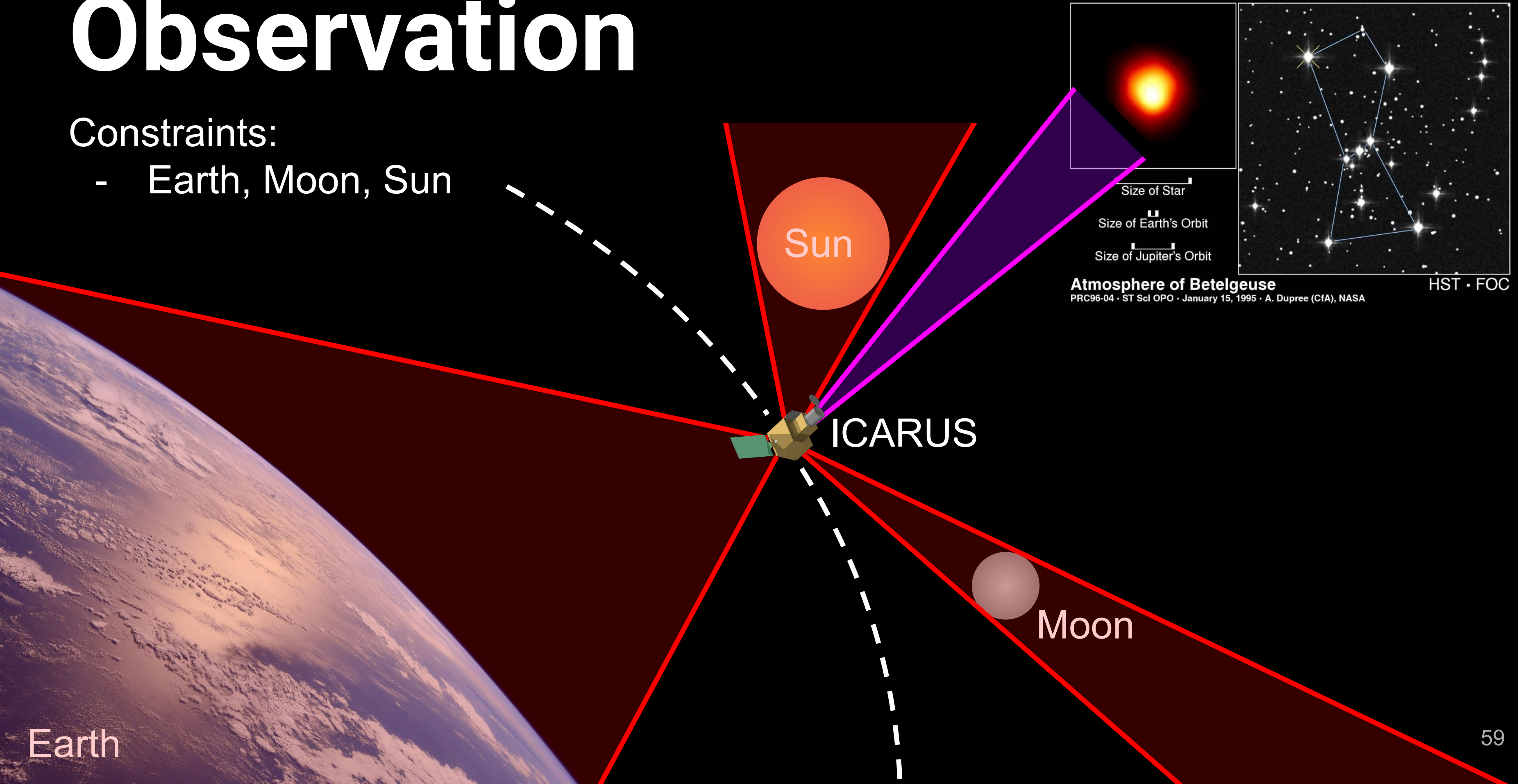
Observation up to 6d

Based on num. calculations

*not to scale

Observation

Constraints:
- Earth, Moon, Sun



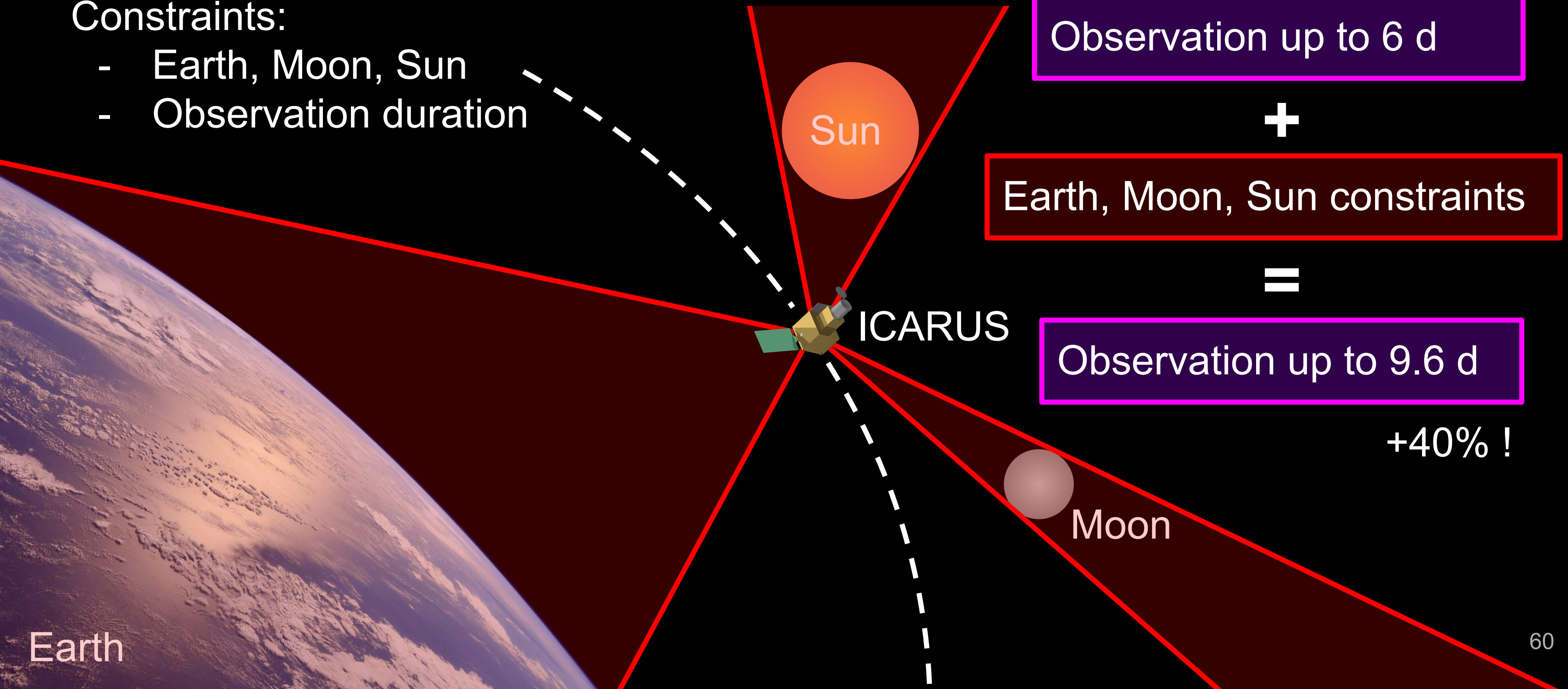
Based on num. calculations

*not to scale

Observation

Constraints:

- Earth, Moon, Sun
- Observation duration



Observation up to 6 d

+

Earth, Moon, Sun constraints

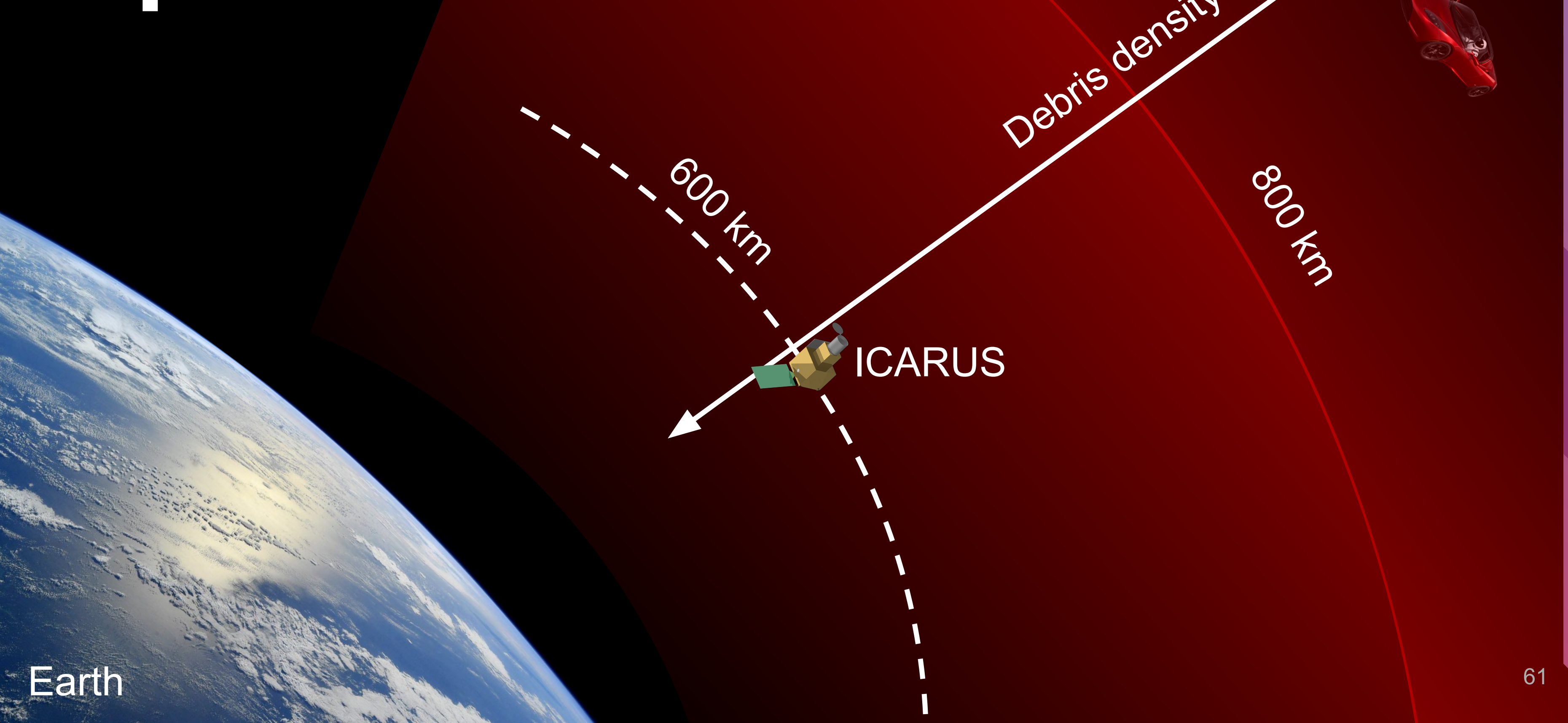
=

Observation up to 9.6 d

+40% !

NASA, History of On-orbit Satellite Fragmentations, 16th Edition

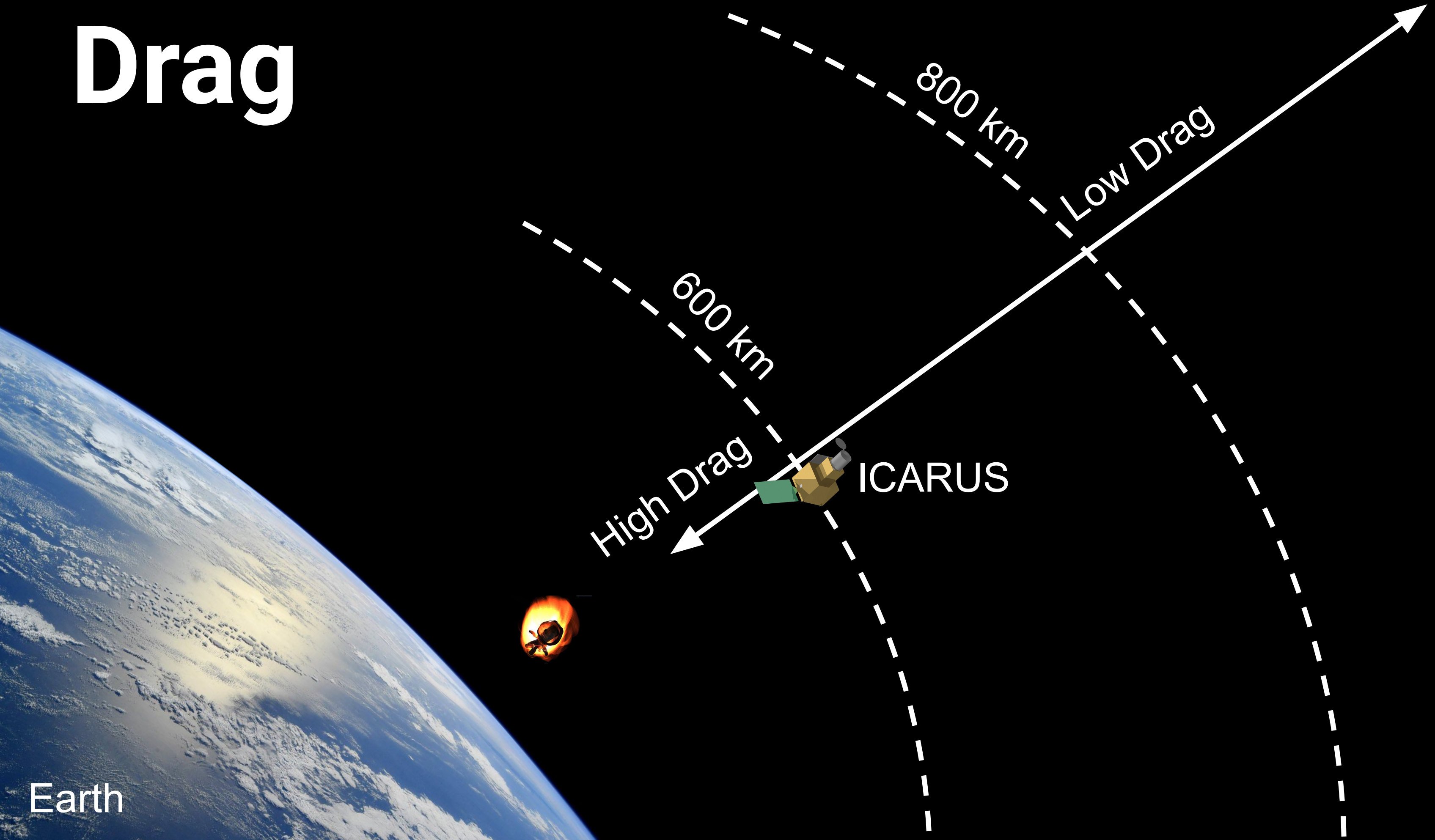
Space debris



NASA, History of On-orbit Satellite Fragmentations, 16th Edition

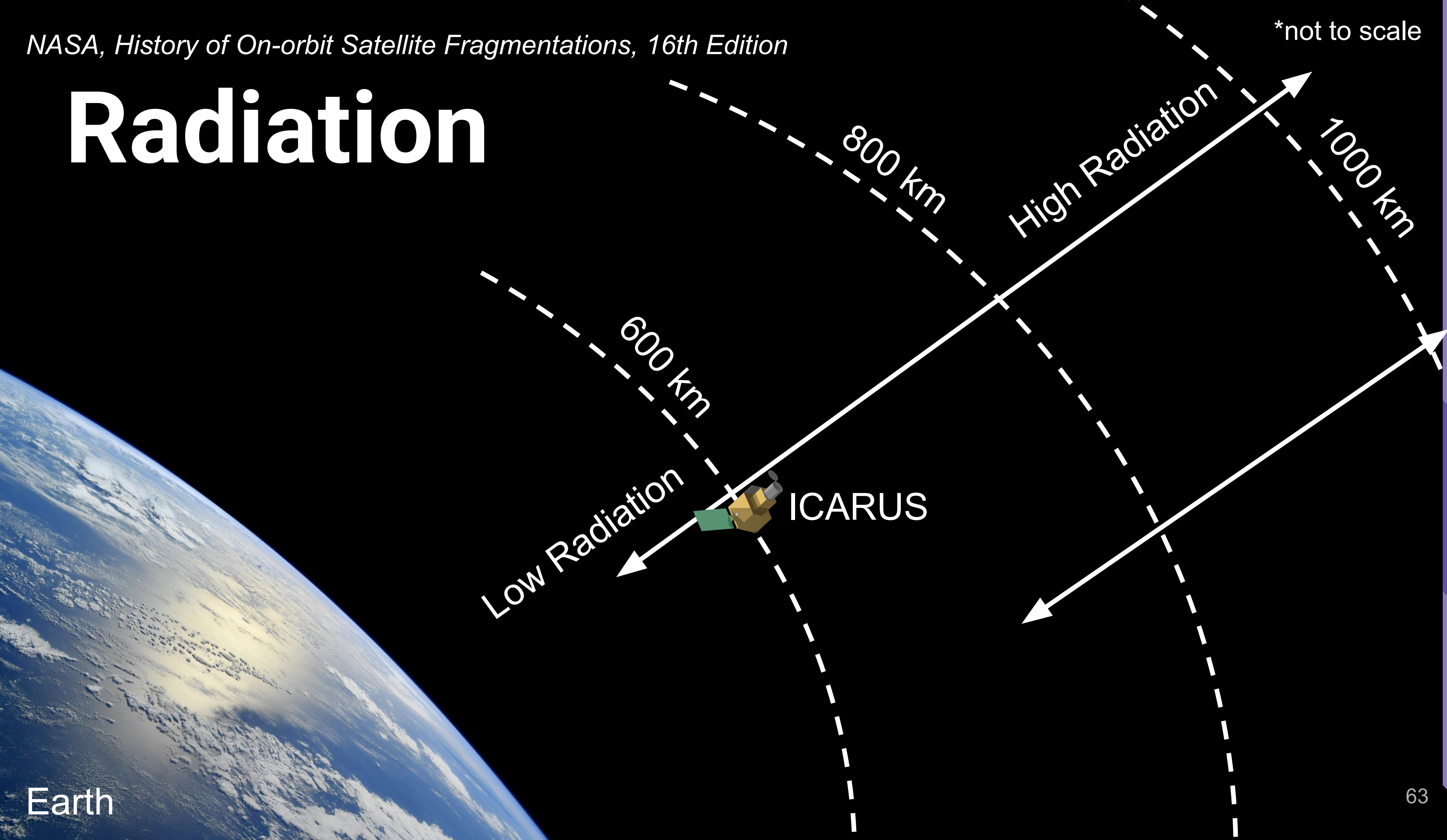
*not to scale

Drag



NASA, History of On-orbit Satellite Fragmentations, 16th Edition

Radiation



Wertz J. R. et al., 3rd edition, Space mission analysis and design

*not to scale

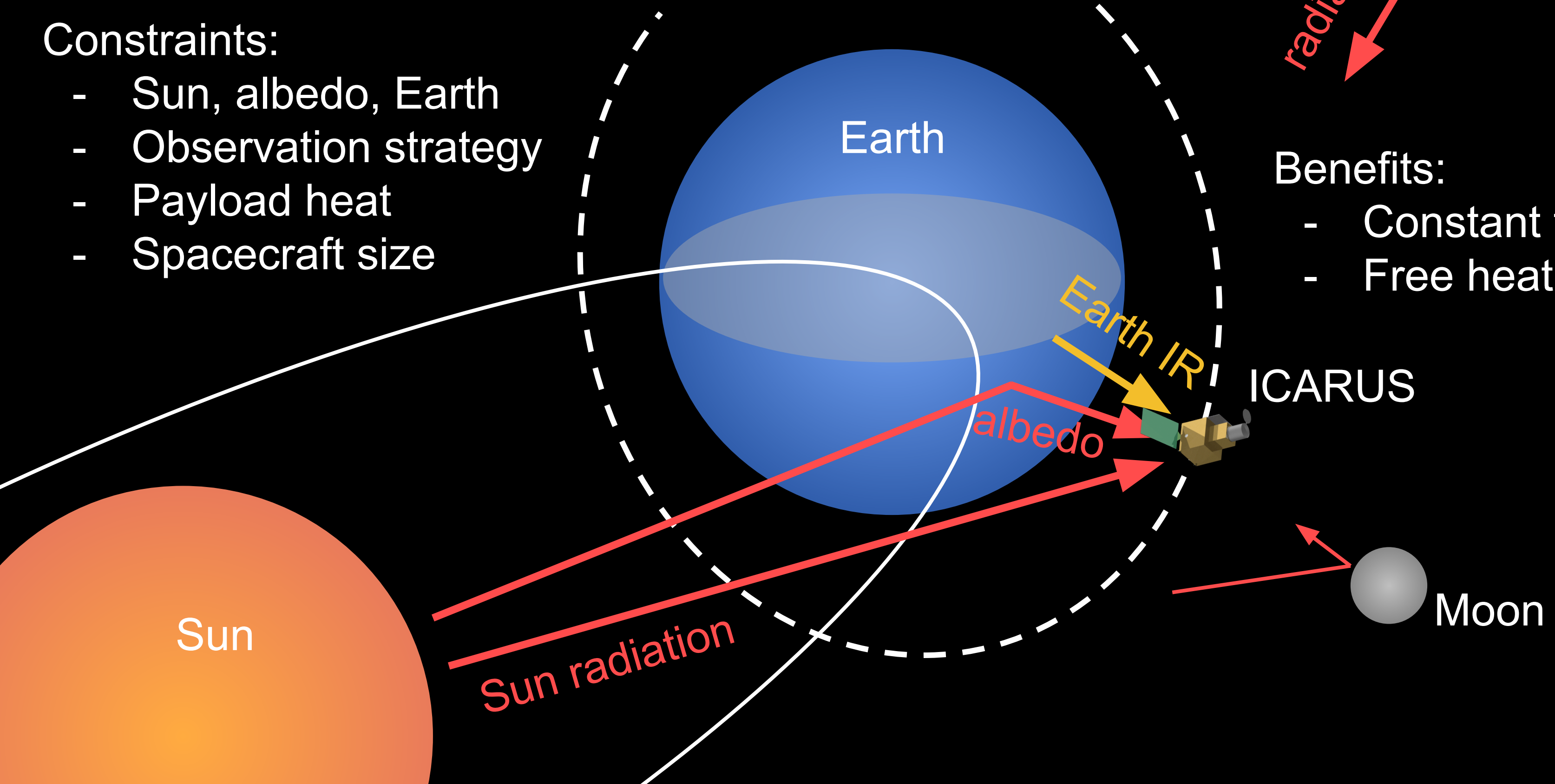
Thermal exchanges

Constraints:

- Sun, albedo, Earth
- Observation strategy
- Payload heat
- Spacecraft size

Benefits:

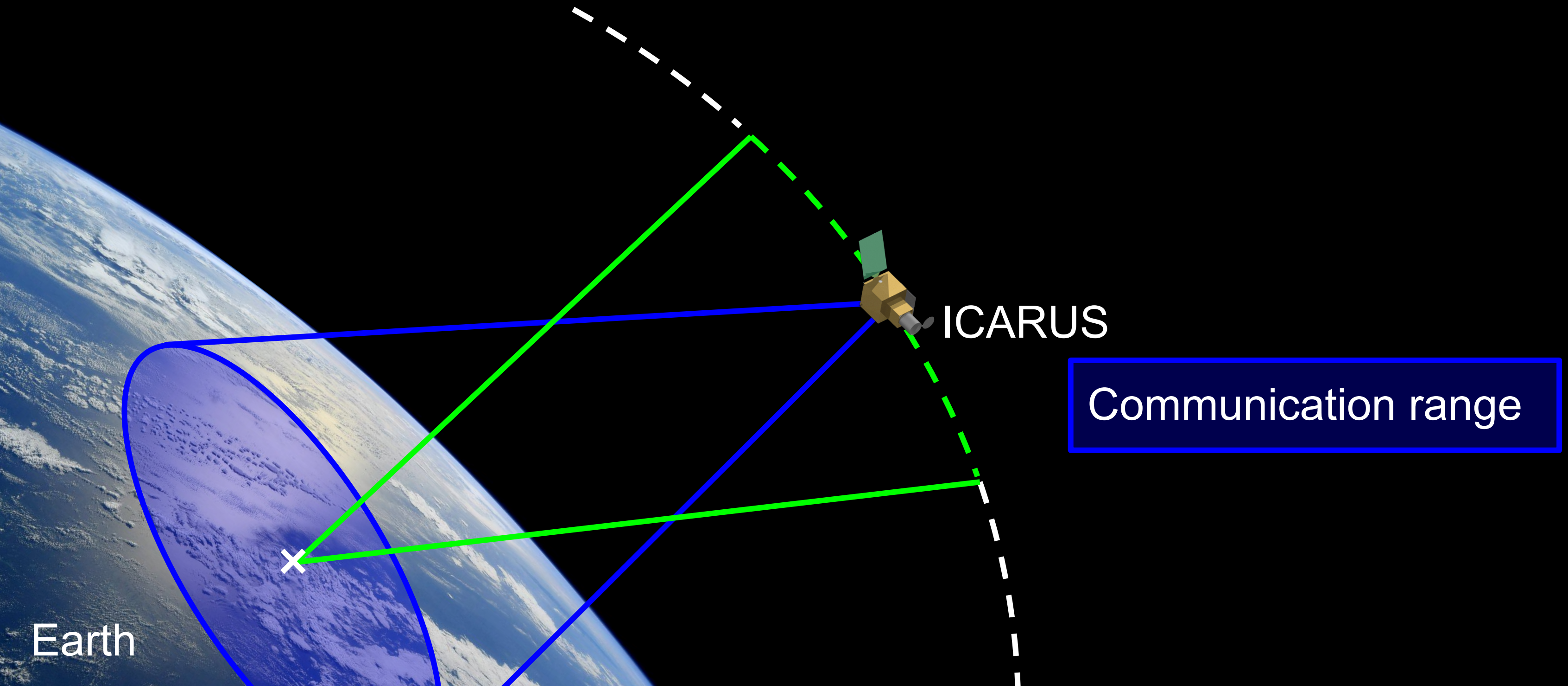
- Constant thermal
- Free heat



Wertz J. R. et al., 3rd edition, Space mission analysis and design

*not to scale

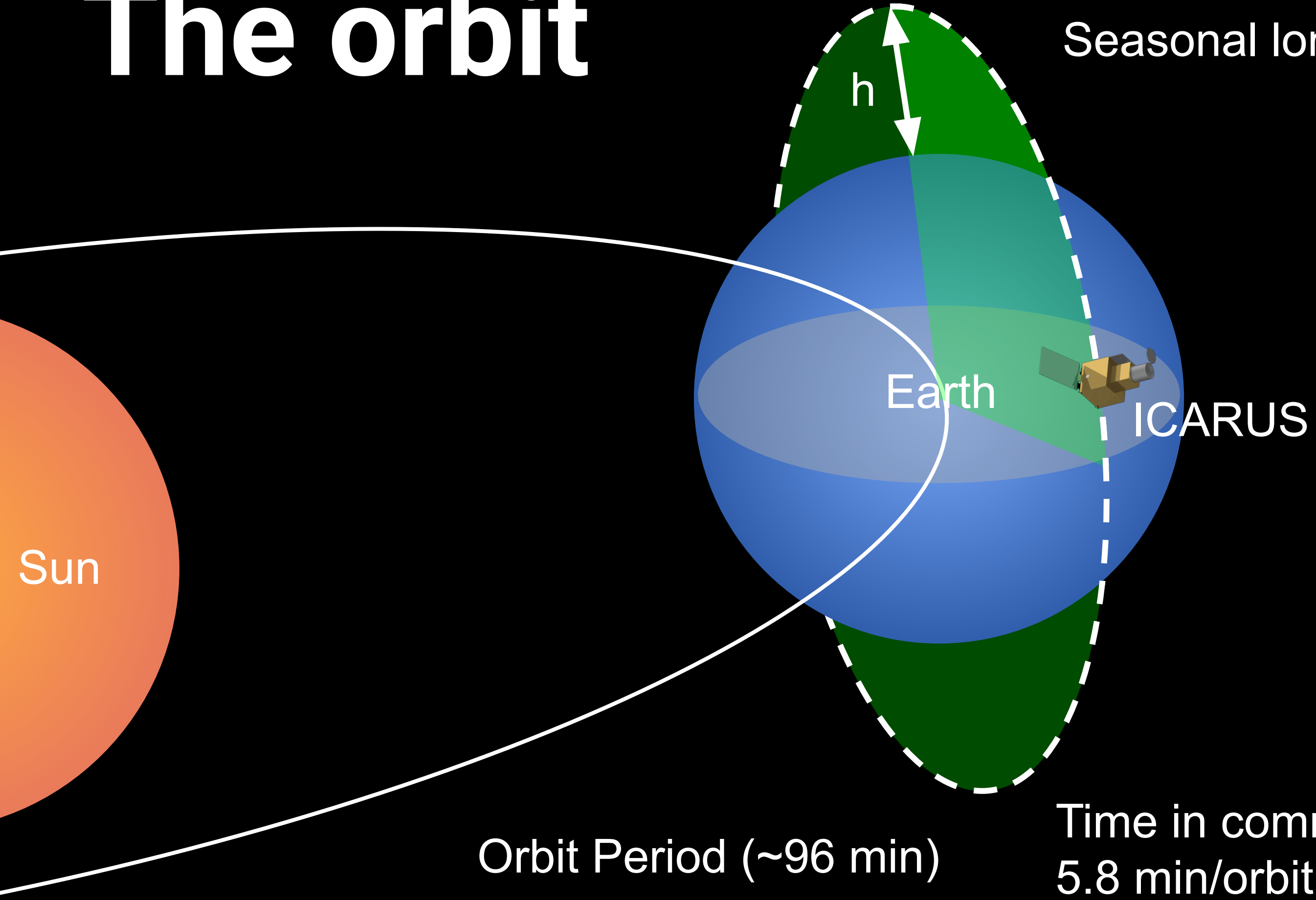
Communications



Wertz J. R. et al., 3rd edition, Space mission analysis and design

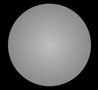
*not to scale

The orbit



Seasonal lon. shift ~1°/day

- SSO dusk/dawn
- 15 orbit/day
- i = 97.7°
- h = 597 km



Orbit Period (~96 min)

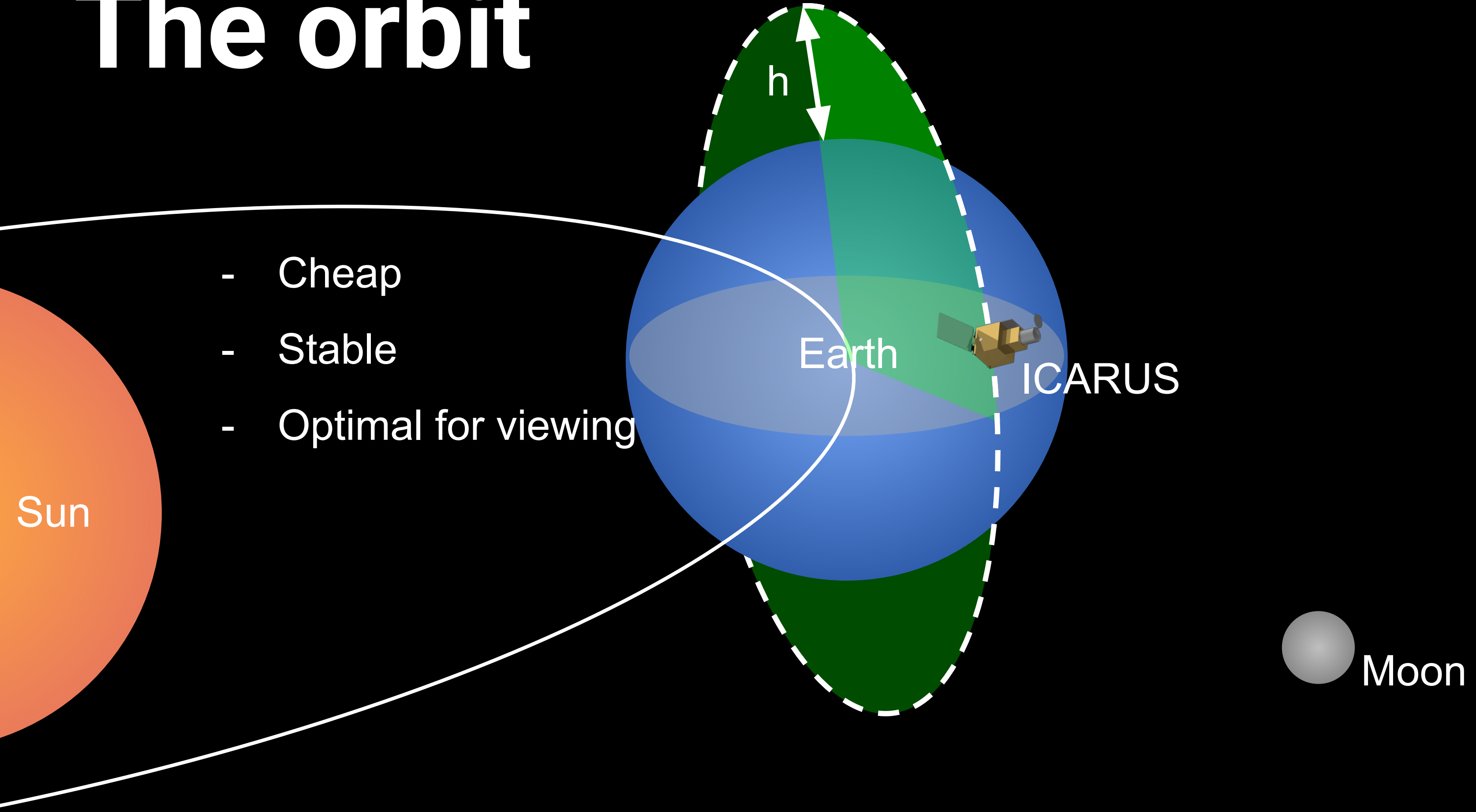
Time in communication range
5.8 min/orbit

Wertz J. R. et al., 3rd edition, Space mission analysis and design

*not to scale

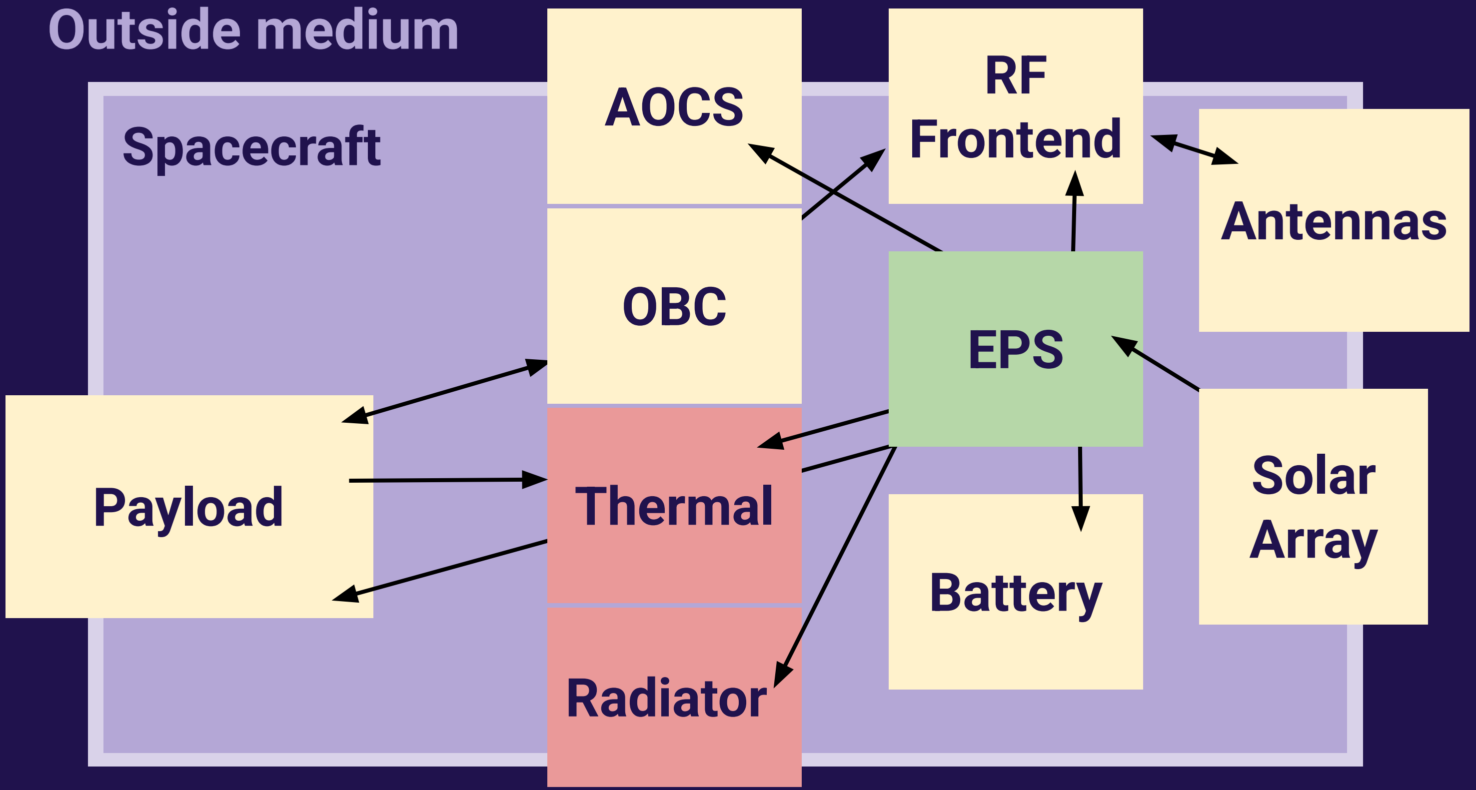
The orbit

- Cheap
- Stable
- Optimal for viewing

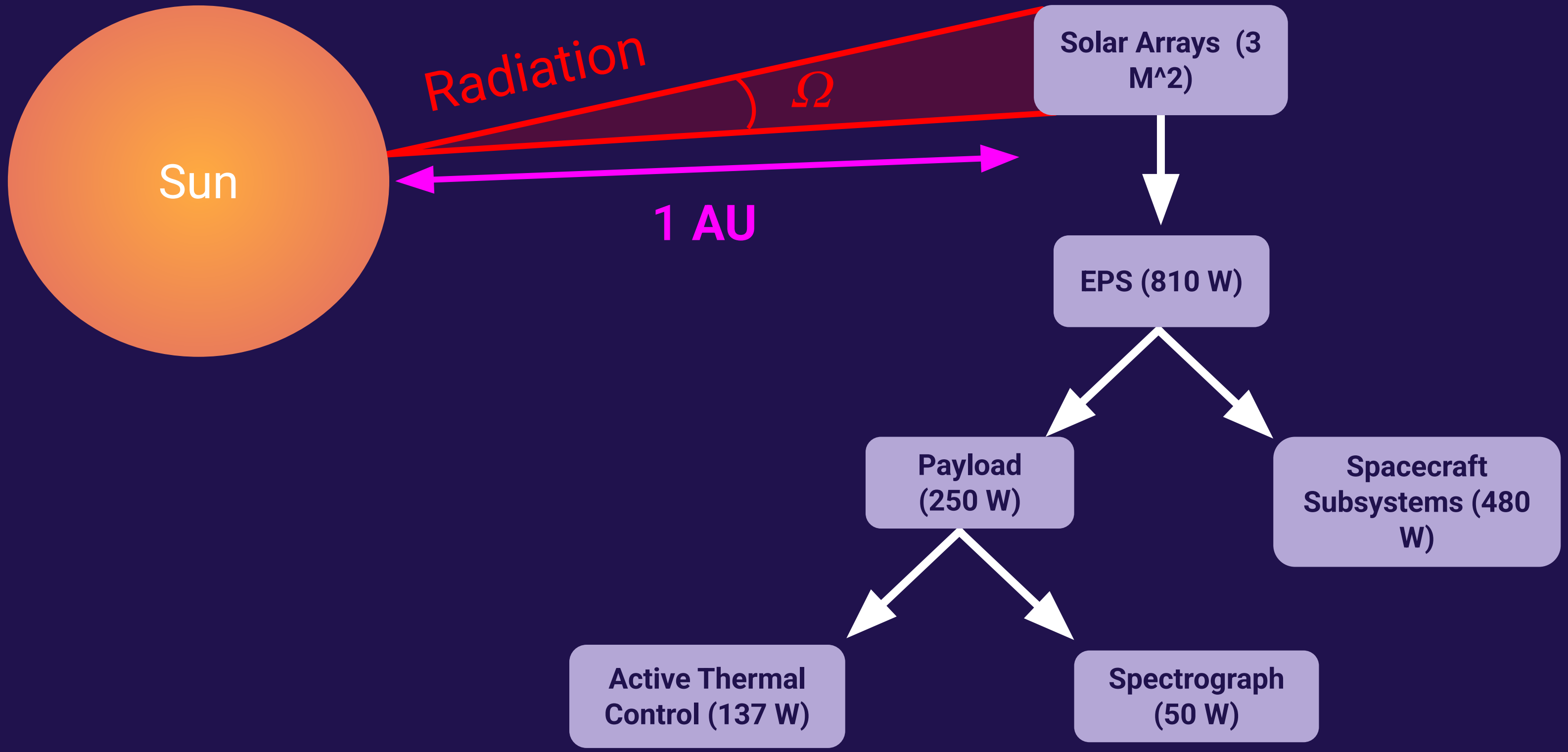


Spacecraft

Spacecraft subsystem FBD



Power budget drivers



source: https://www.azurspace.com/en/products/space-products/

EPS, Batteries and Solar panel

810W
extreme case from maneuver

1.05 kW
Worst power target

~ 3 m^2
Deployed array area (2 wings)

SOLAR ARRAY:

- **AZUR SPACE** 3G30-class triple-junction cells. (~ 30% cell efficiency)
- Packing Factor of 90%.
- **EOL** after 5 year degradation, pointing/cosine losses. (~903 W)

BATTERIES & DISTRIBUTION:

- **Li-ion battery** (space standard, 17.6 kg).
- **Regulated PCDU** with max-power-point tracking distributes and protects power.
- Peak load and downlink / slew, safe-mode holds a maximum power floor.

EPS mass (arrays + batteries + PCDU): 100 kg base / 110 kg with margin source: https://www.azurspace.com/en/products/space-products/

EPS, Batteries and Solar panel

810 W
extreme case from science

1.05 kW
BOL

~ 3 m²
Deployed array area (2 wings)

Parameter	Value
Array Size	1.5 X 1.05 m
Array Efficiency	30 %
Mass	103.6 kg
Volume	0m^3 (panels deployable so initial volume 0)

Thermal Stability and contamination

±0.1 K
Thermometer stability (ESA heritage)

0.8 m²
Radiator area

33 kg
Bus thermal control-mass

- **Hardware**: heat pipes, straps, MLI foil, closed-loop controllers, radiator …
- worst **HOT** case analyse defining requirements on the **radiator**.
- Low-outgassing materials, consistent with contamination control.
    - Shall induce further study to fulfill the impact on the mission.

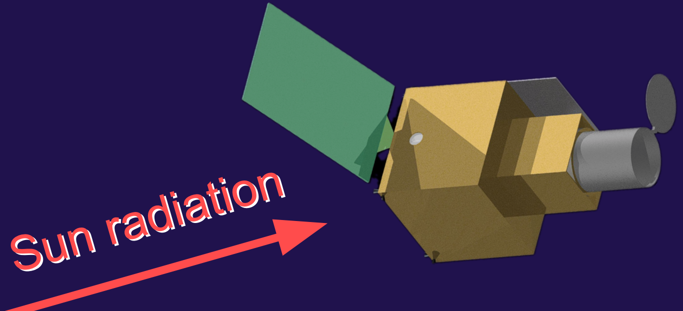
Thermal plans

Proposition (1)

- With only MLI foil

Edge case thermal design

Payload mass reduced



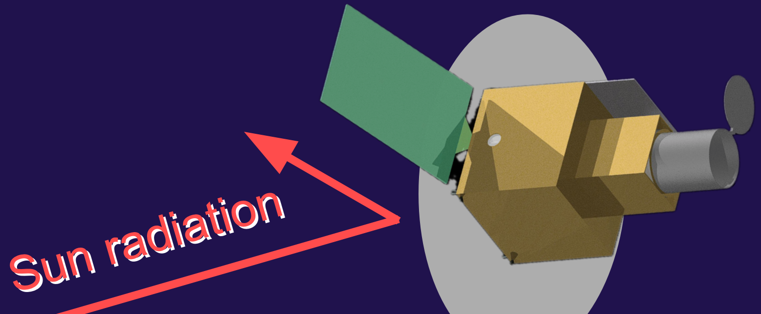
Proposition (2)

- With a sunshield

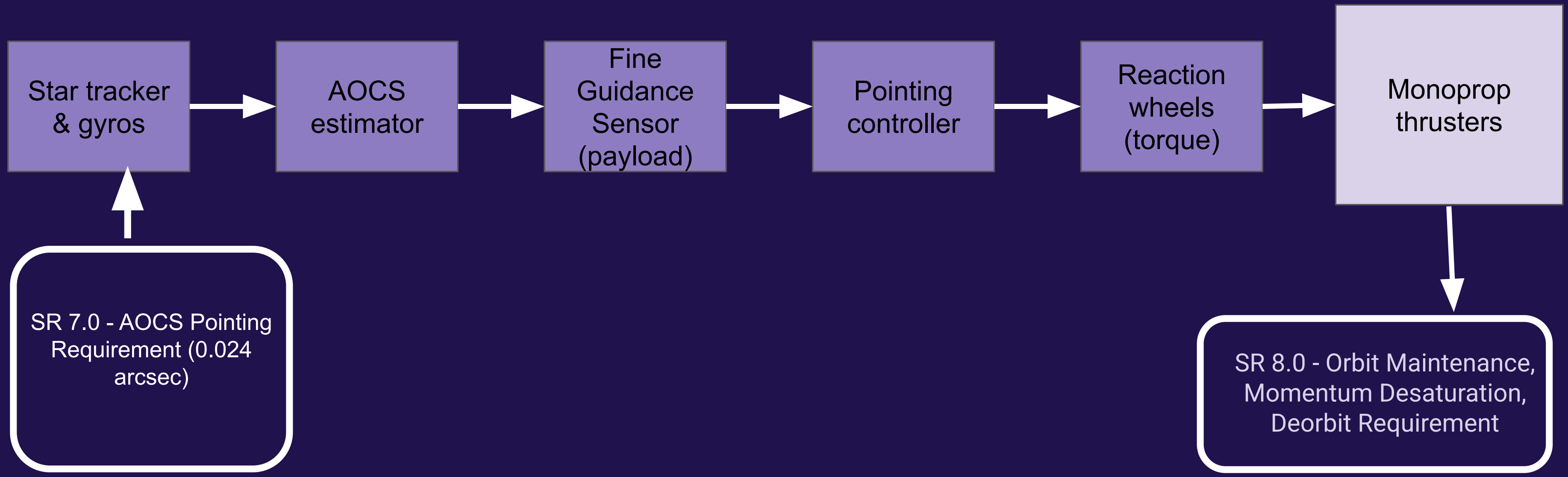
Observation strategy harder !

Complex payload mass balance

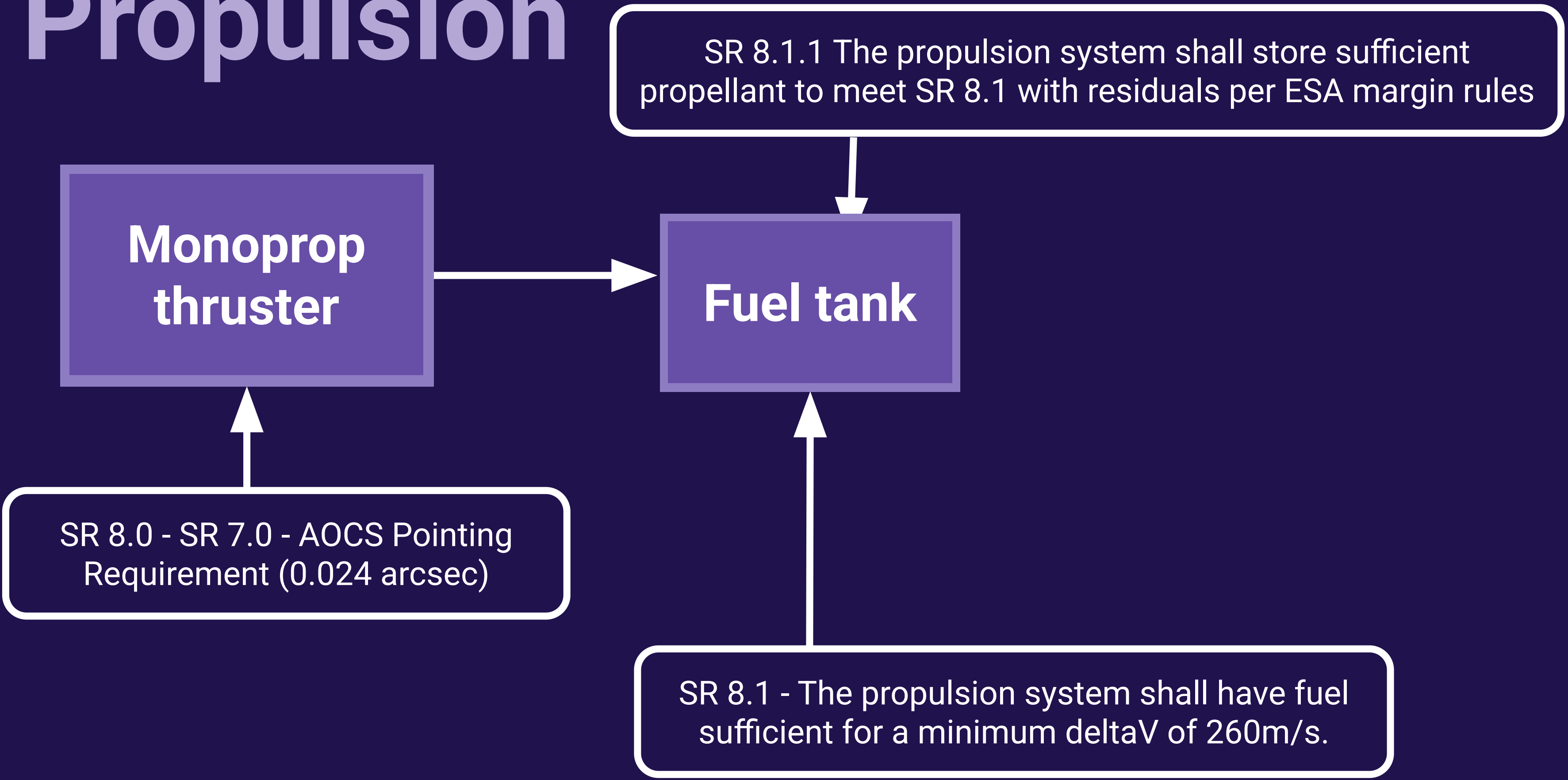
Easier thermal controlling



AOCS and Fine-Guidance Chain



Propulsion


SR 8.1.1 The propulsion system shall store sufficient propellant to meet SR 8.1 with residuals per ESA margin rules
Monoprop thruster
Fuel tank
SR 8.0 - SR 7.0 - AOCS Pointing Requirement (0.024 arcsec)
SR 8.1 - The propulsion system shall have fuel sufficient for a minimum deltaV of 260m/s.

AOCS + Propulsion Components

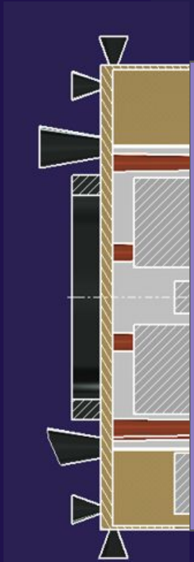
Reaction Wheels
CubeSpace CW40k

Parameter	Value
Pointing Stability	11 arcsec
Power Draw	35W (4x)
Mass (w/ 5% margin)	4kg (4x)
Volume	∅180mm x 60mm

Thrusters
4x MONARC 22-6
8x MONARC 1

Parameter	Value
ISP	220
Dry Mass (thrusters)	6kg
Fuel Mass	~72kg
Volume	95.6 L total

5 yr (+5 yr extended) ΔV Allocation:



SYSTEM & HERITAGE:

- 12 hydrazine monoprop thrusters: 4 × 22 N (Moog MONARC-22-6) de-orbit cluster + 8 × 1 N (MONARC-1)
- Thrusters oriented away from the UV aperture (plume avoidance)
- Flight heritage: MONARC family
- Isp ≈ 220 s; ΔV = 259 m/s

OBC

PAYLOAD
DATA - 50 MB/obs

→

NanoMind HP MK3
ARM + FPGA

→

Comms (X-band)
downlinks to Kiruna GS

Dual ARM Cortex-A9
up to 800 MHz + Xilinx Zynq FPGA

1 GB DDR3 RAM
512 MB with ECC enabled

up to 233 GB
eMMC storage — vastly exceeds our 200 MB need

weight: 240 g
95 × 95 × 31.5 mm

20 kRad TID
radiation tolerance

3× SpaceWire + USB
+ LVDS/FPGA I/O, CAN/SPI/RS422/485

Flight-proven (TRL8)

Data & Link Budget

- 96,5 min orbit period
- 14,9 orbits/day

0,23 GB/day — Generated

0,92 GB/day — Downlink capacity

margin +20%

Instrument
50 MB / obs

→

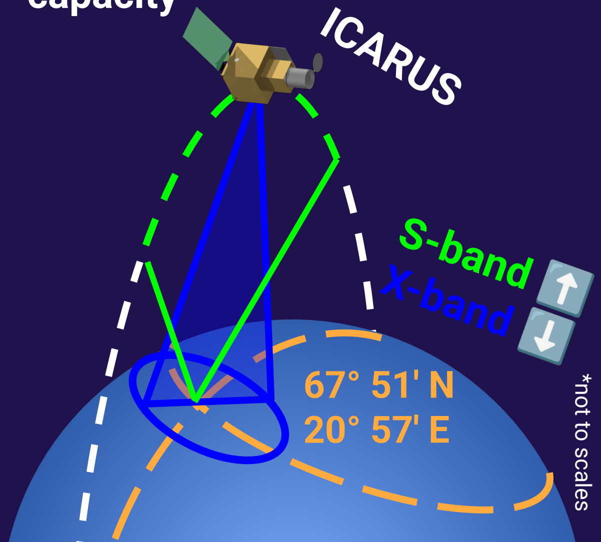
OBDH/Storage
150 of 200 MB buffer

↓

X-band
2 Mbit/s (X-Neo)

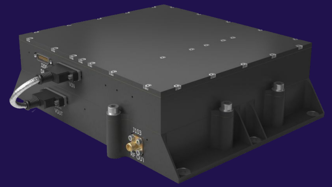
→

KIRUNA GS
72.5 min/day contact

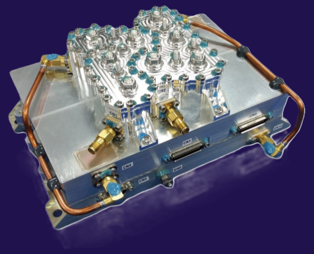


Communications

Parameter	Device 1 - Safran X-NEO (X-band downlink)	Device 2 - Honeywell STC-MS03 (S-band uplink / TT&C)
Role / function	Primary X-band science data downlink	Primary S-band command/telemetry (TT&C) uplink
Data rate	600 Mbit/s Tx capability far exceeds baseline need	32 kbps Rx up to 6.25 Mbit/s Tx
Modulation / architecture	8PSK 4D TCM high spectral efficiency	SDR, GaN amplifier in-flight configurable
Frequency band	8025 - 8400 MHz (X-band, EESS allocation)	2025–2110 / 2200–2290 MHz down (S-band, EESS)
Quality / class	NASA Level I highest assurance class	Flight-qualified SDR class (confirm exact rating)
Heritage	OPS-SAT; 800+ orbit-years across product line	ESA CHEOPS + commercial; multiple flight models



Safran Data Systems X-NEO



Honeywell STC-MS03

Both units:
- 10 yr LEO design life,
-flight-proven, TRL 8
- low programmatic risk in our mission

Payload mass

Low TRL -> High Uncertainty

Subsystem	Mass
Optics	77.6 kg
Mechanical	52.13 kg
Thermal Control	4.45 kg
Detector	18 kg
OBC	0.25 kg
Misc	7.5 kg
Total	~ 160 kg

Spacecraft mass

High TRL -> Low Uncertainty

Subsystem	Mass
Spacecraft Structure	150 kg
Mechanical	55 kg
OBC	60 kg
Comms	6 kg
Thermal Control	30 kg
EPS	103.6 kg
Misc	50 kg
Total	~ 455 kg

Overall Mass Budget

Payload **Mass: ~ 160 kg**	+	**Spacecraft** **Mass: ~ 455 kg**	+	**Margins + Propellant:** **Maturity & System**	=	**Total Wet Mass: ~ 941 kg**

Low TRL -> High Uncertainty

High TRL -> Low Uncertainty

Volumes are order-of-magnitude packaging estimates (component / tank sizing, not vendor CAD - to be refined once all hardware is selected.

Structure and Payload

STRUCTURE REQs.:

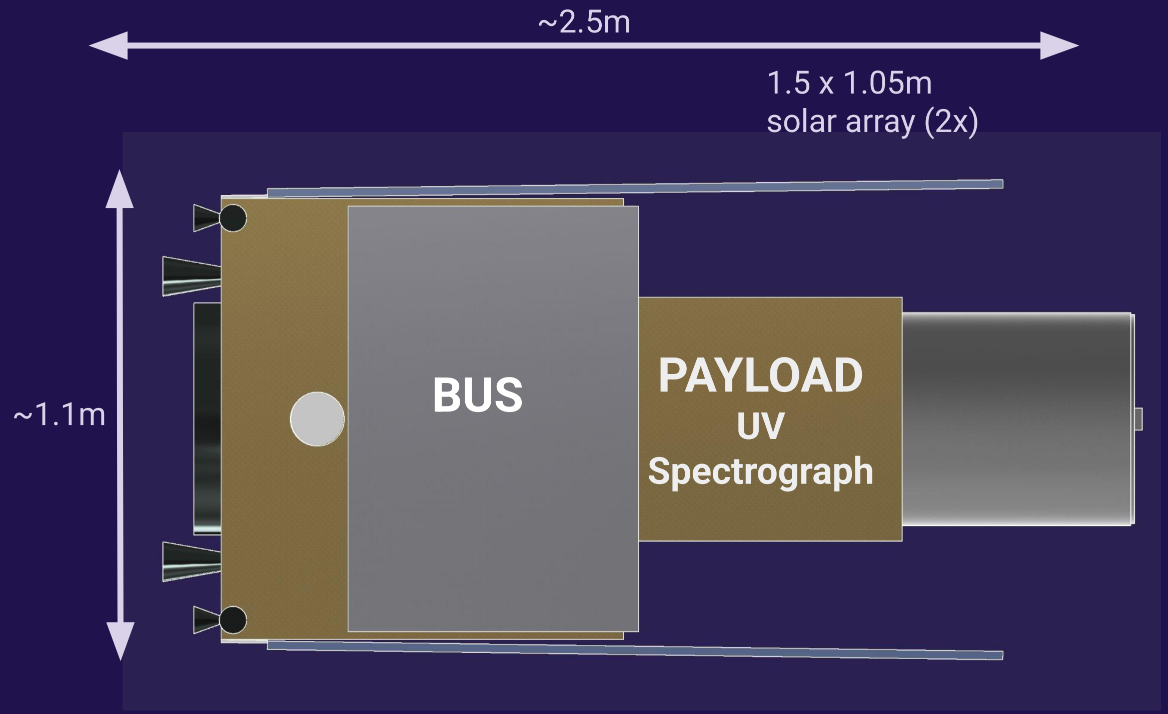
1. **Survive** Vega-C launch loads without resonance.
2. Retain **payload alignment** after launch.
3. Isolate **reaction-wheel vibration** from the bench.
4. Keep centre of mass on the thrust axis.

PAYLOAD ACCOMMODATION:

1. **Isostatic** mounting **decouples** payload from bus.
2. Thermal straps / radiator **isolate** optics from bus heat.
3. Fine-guidance interface closes the AOCS pointing loop.
4. Aperture door, purging, bake-out protect cleanliness.

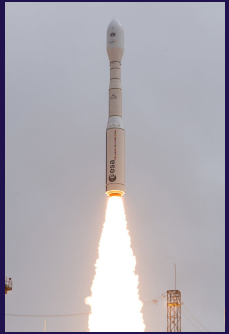
UV through is highly sensitive to molecular and particle contamination.
It drives materials, propulsion placement, and integration and launch operations.

Configuration and dimensions

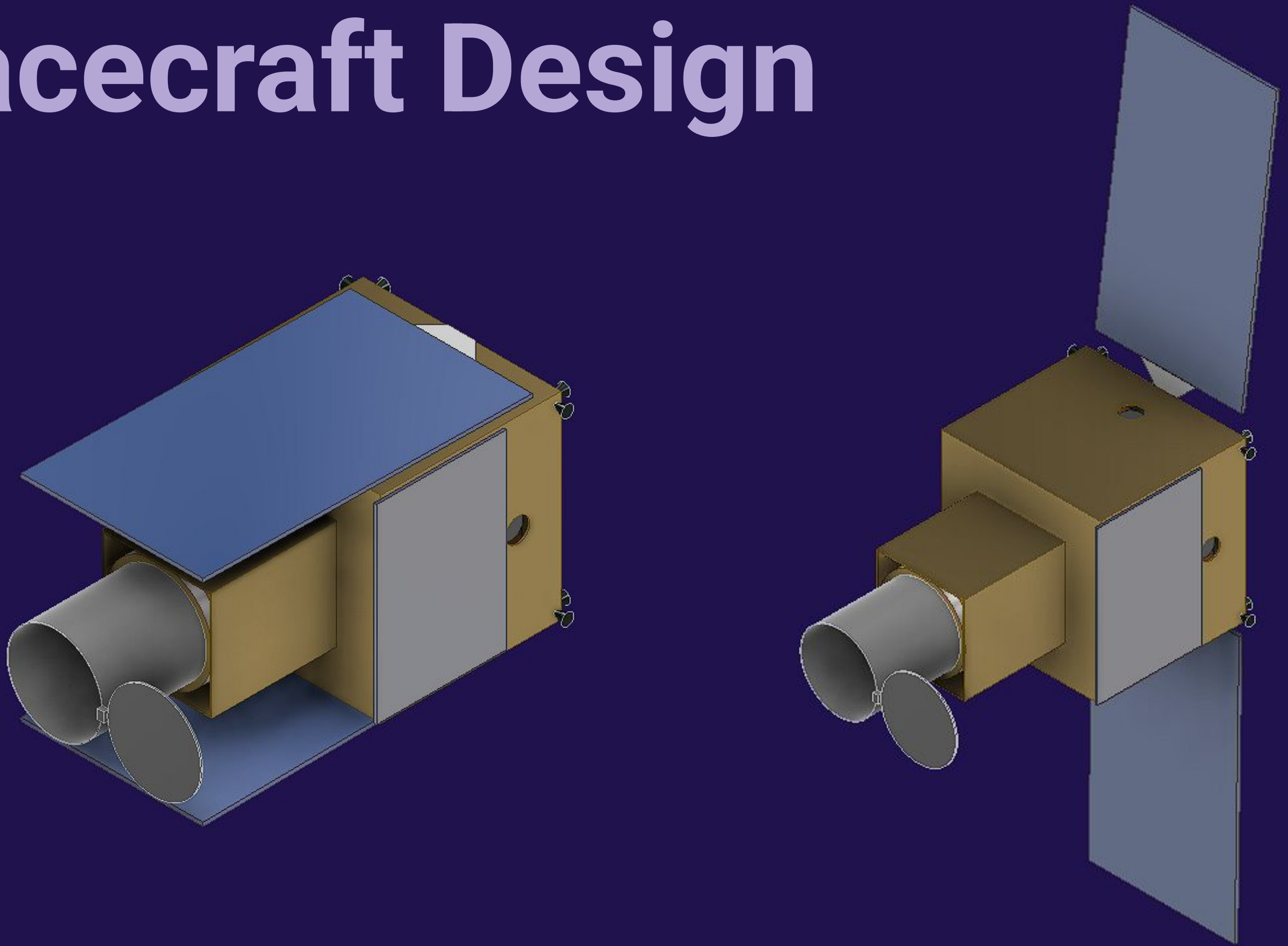


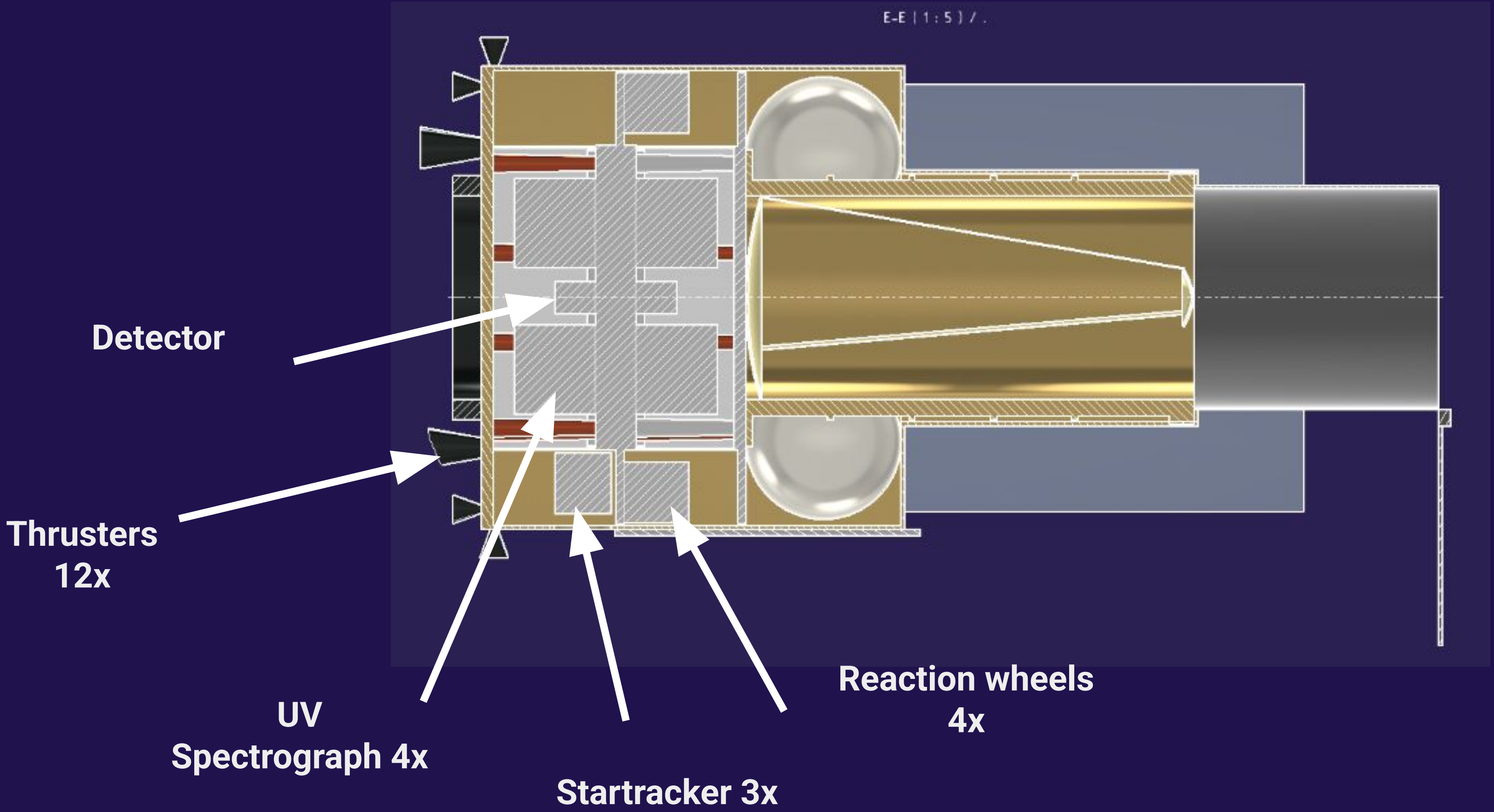
Dedicated radiator

1. **Payload Envelope:**
   ~ 2.25 x 0.75 x 0.75 m
2. **Stowed spacecraft envelope:**
   ~ 2.5 x 1.1 x 1.1 m
3. **Solar-array span:**
   (2x 1.5 x 1.05 m)
4. **Launch Vehicle:**
   Vega C - 3.3 m, dia x > 9 m tall



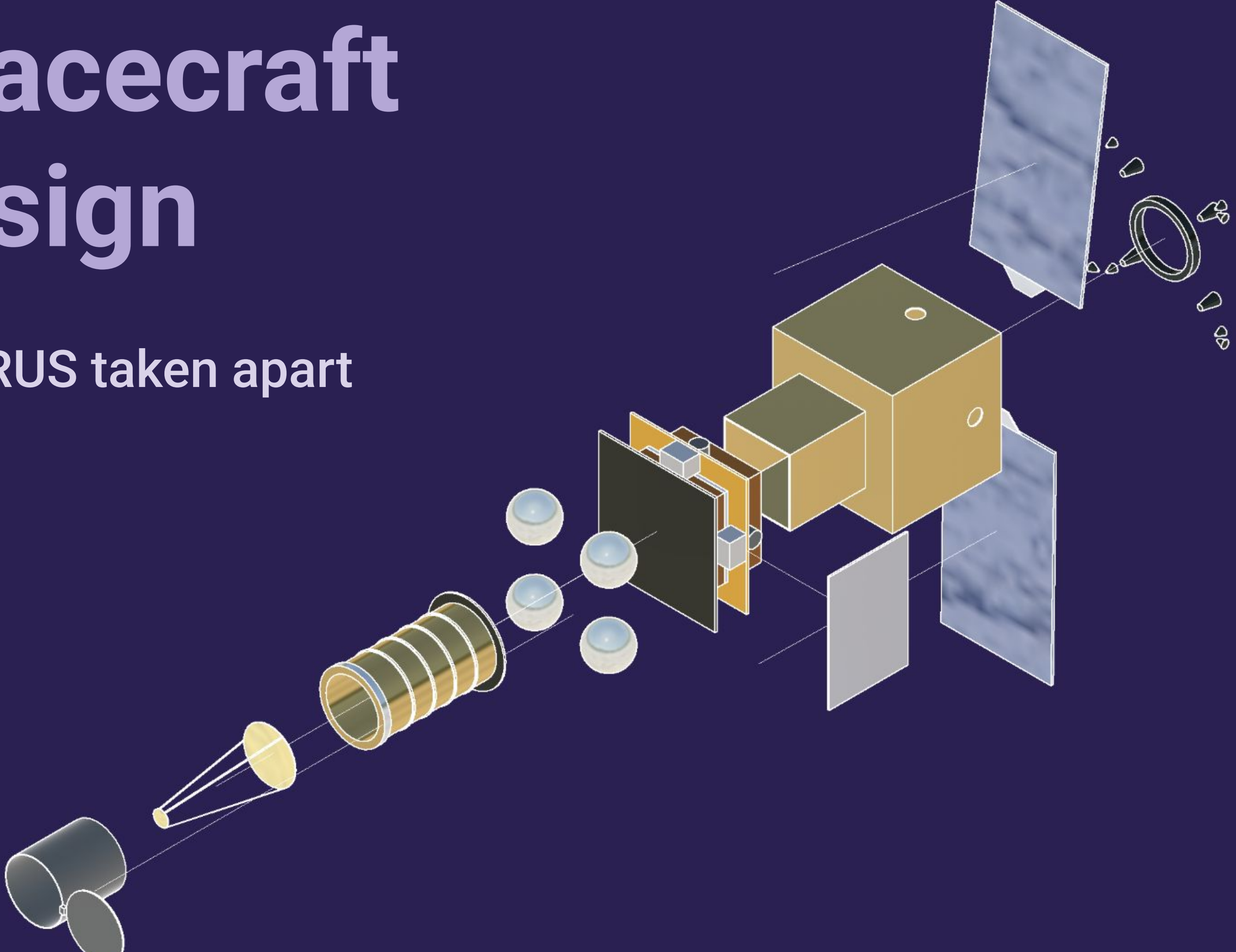
Spacecraft Design



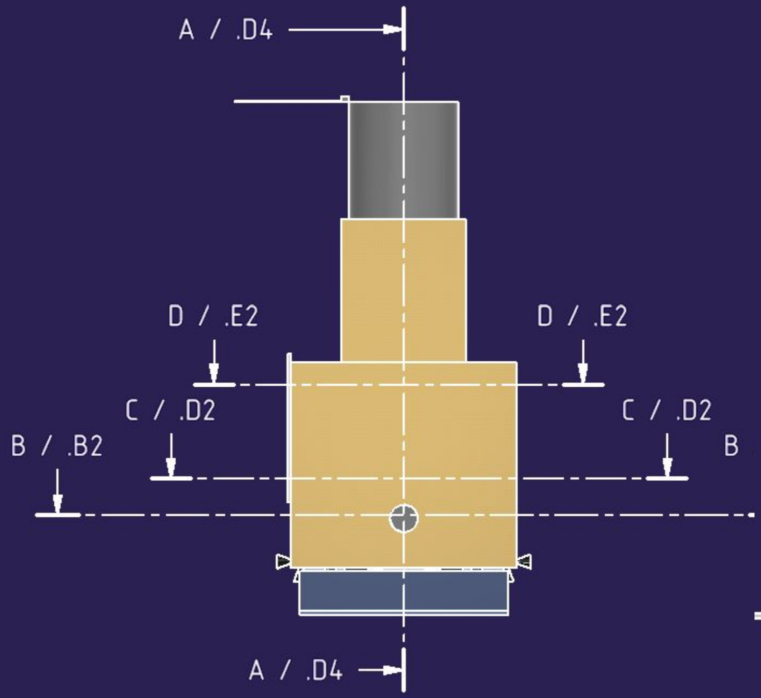

Detector
Thrusters 12x
UV Spectrograph 4x
Startracker 3x
Reaction wheels 4x

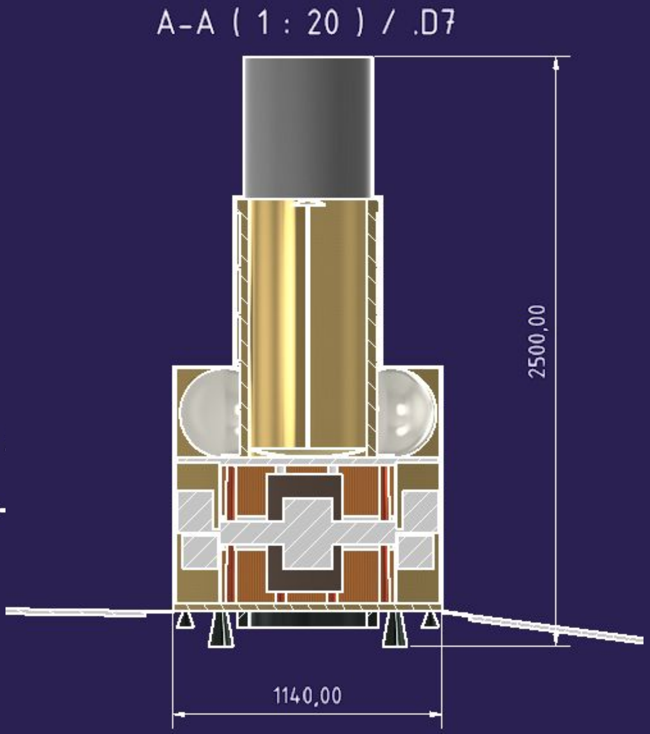
Spacecraft Design

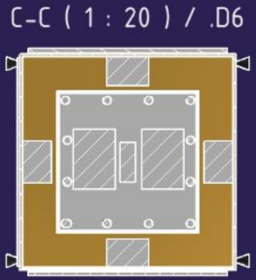
ICARUS taken apart

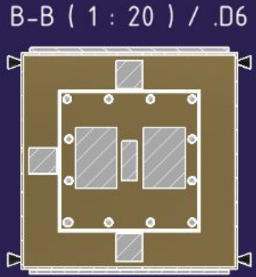


Spacecraft Design





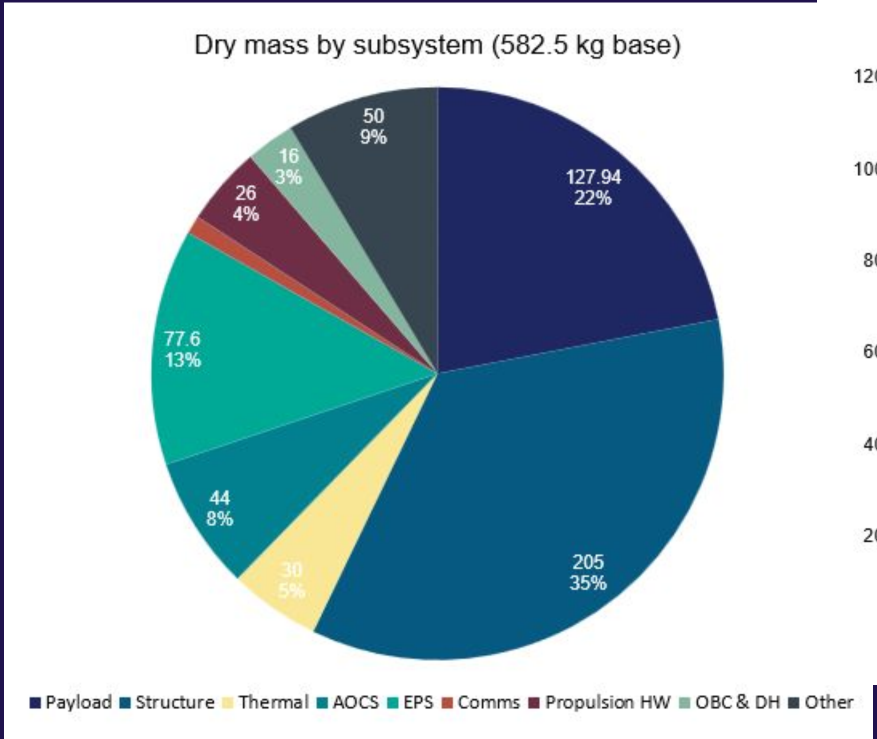


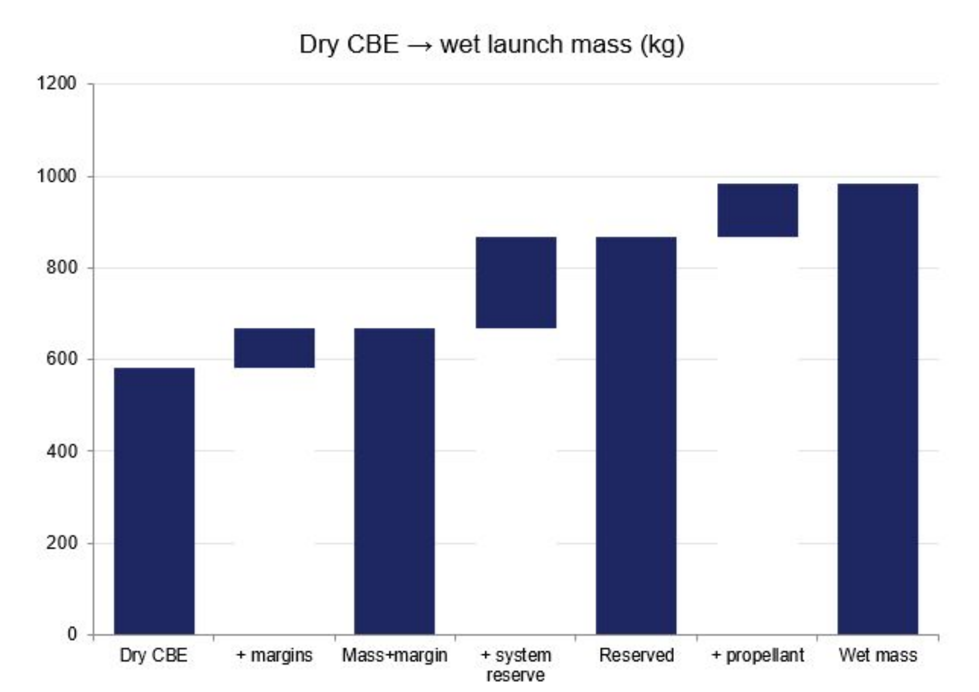


Power Budget

Operation %	0%	4%	1%	4%	90%	1%
Subsystem	Safe Mode	Comms (idle)	Nominal/Science			Maneuver
			Observation	Main Branch	Secondary Branch	i.e deorbit
Spacecraft bus + subsystems	173 W	373 W	173 W	295 W	295 W	480 W
Payload	143.6 W	143.6 W	143.6 W	249 W	249 W	144 W
Total (30% margin)	411 W	672 W	411 W	707 W	707 W	810 W

Mass and Power Summary:





Wet launch mass CBE: ~ 941kg, Maneuver-mode power: ~ 810W worst case vc ~ 902 W EOL array supply

TRL Evaluation

Which components have the lowest TRL and highest risk for our science closure?

LOW TRL → HIGH RISK *(science-closure gate)*

High-res spectrographs *4 spectrographs of different resolution - bespoke, first-of-kind combination*	TRL 3
Coating for UV instruments *Highly selective wavelength reflective coatings*	TRL 5
Custom optical bench assembly *Assembly can create unforeseen problems*	TRL 5
Custom fine pointing system *High-precision FGS and tip-tilt system*	TRL 4-5

HIGH TRL → HERITAGE *(low risk)*

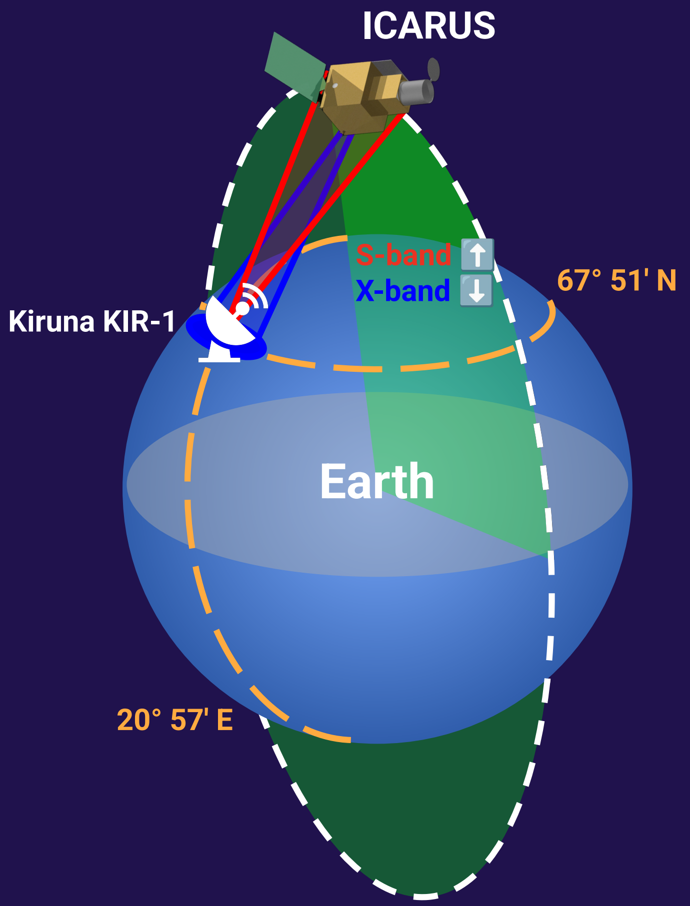
AOCS *Sodern star tracker, Bradford reaction wheels*	TRL 7
Active Heating Systems *+/- 0.1 K stability is achievable in stable temperature LEO conditions*	TRL 7
Communications & OBC	TRL 9

System-level mission TRL ≈ 3; determined by Payload Resolution Requirements

Ops & Coms

Ground Station

Feature	Specification	Mission Benefit
RF Bnds	S-Band: Uplink and Telemetry X-Band: Payload Downlink	Enables high-speed 2.0 Mbit/s data dumps
Hardware	13m and 15m Parabolic Dishes	High sensitivity ensures a robust link margin
Coverage	~10-15 passes/day	Fully closes the preliminary data budget
Operations	ESOC Control (CCSDS Standards	Low - risk standardized flight operations

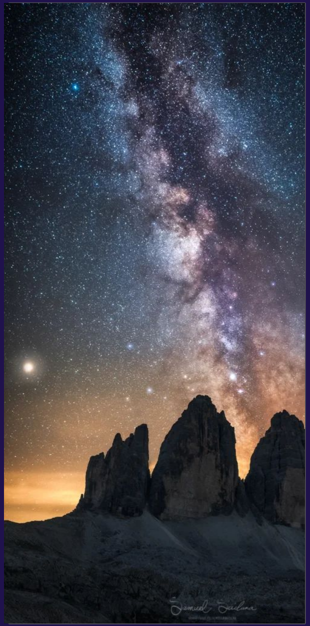


*not to scales

ConOps: Mission Phases

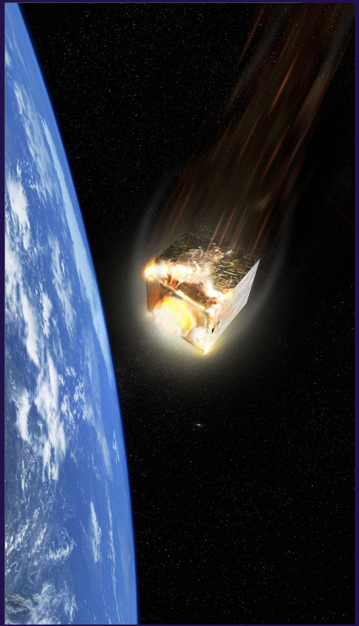
Development and testing

Launch and Early Orbit Phase(LEOP) and Commissioning



Nominal Science

Extended Science



Decommissioning and Disposal

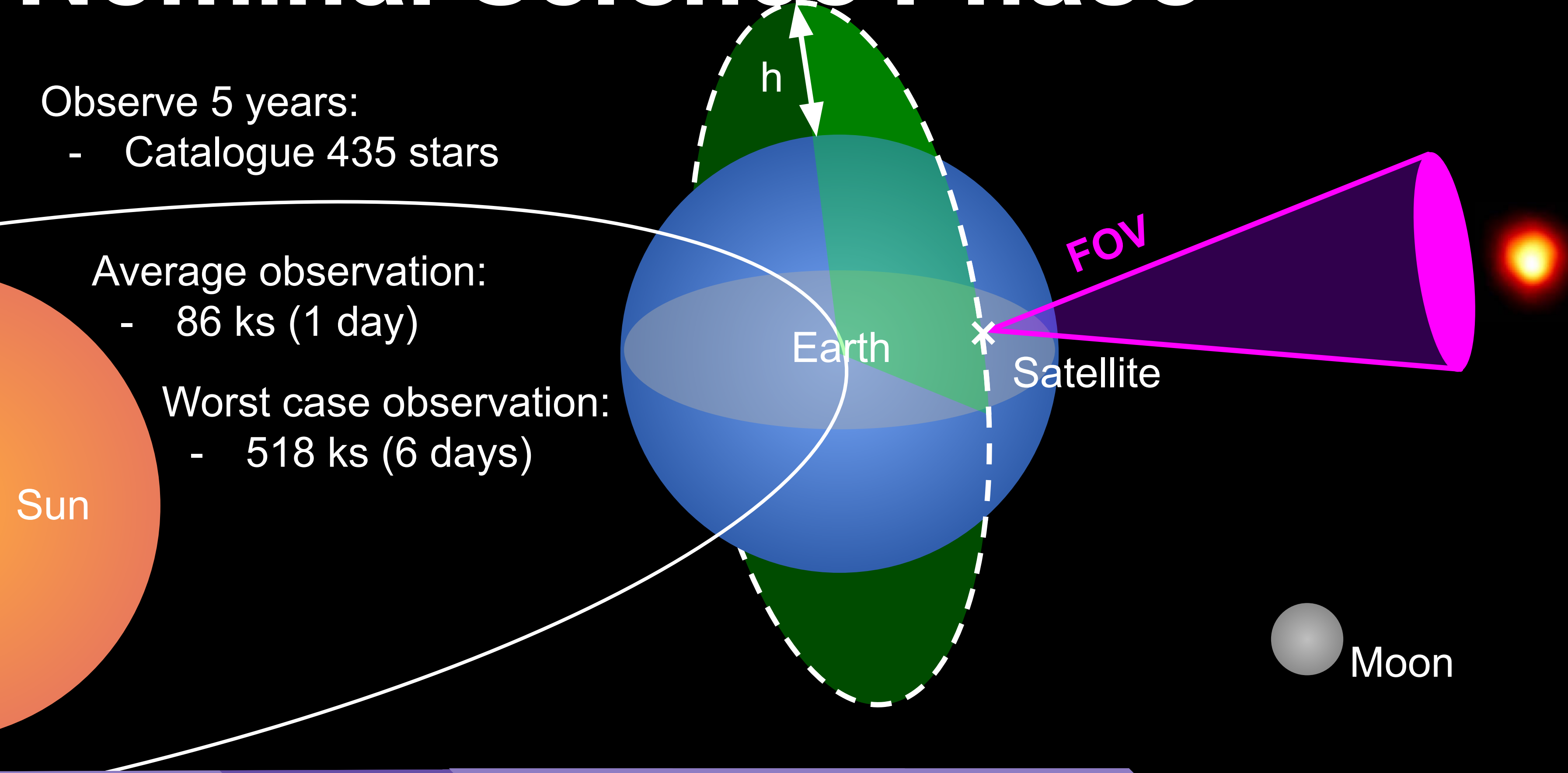
Nominal Science Phase

*not to scale

Observe 5 years:
- Catalogue 435 stars

Average observation:
- 86 ks (1 day)

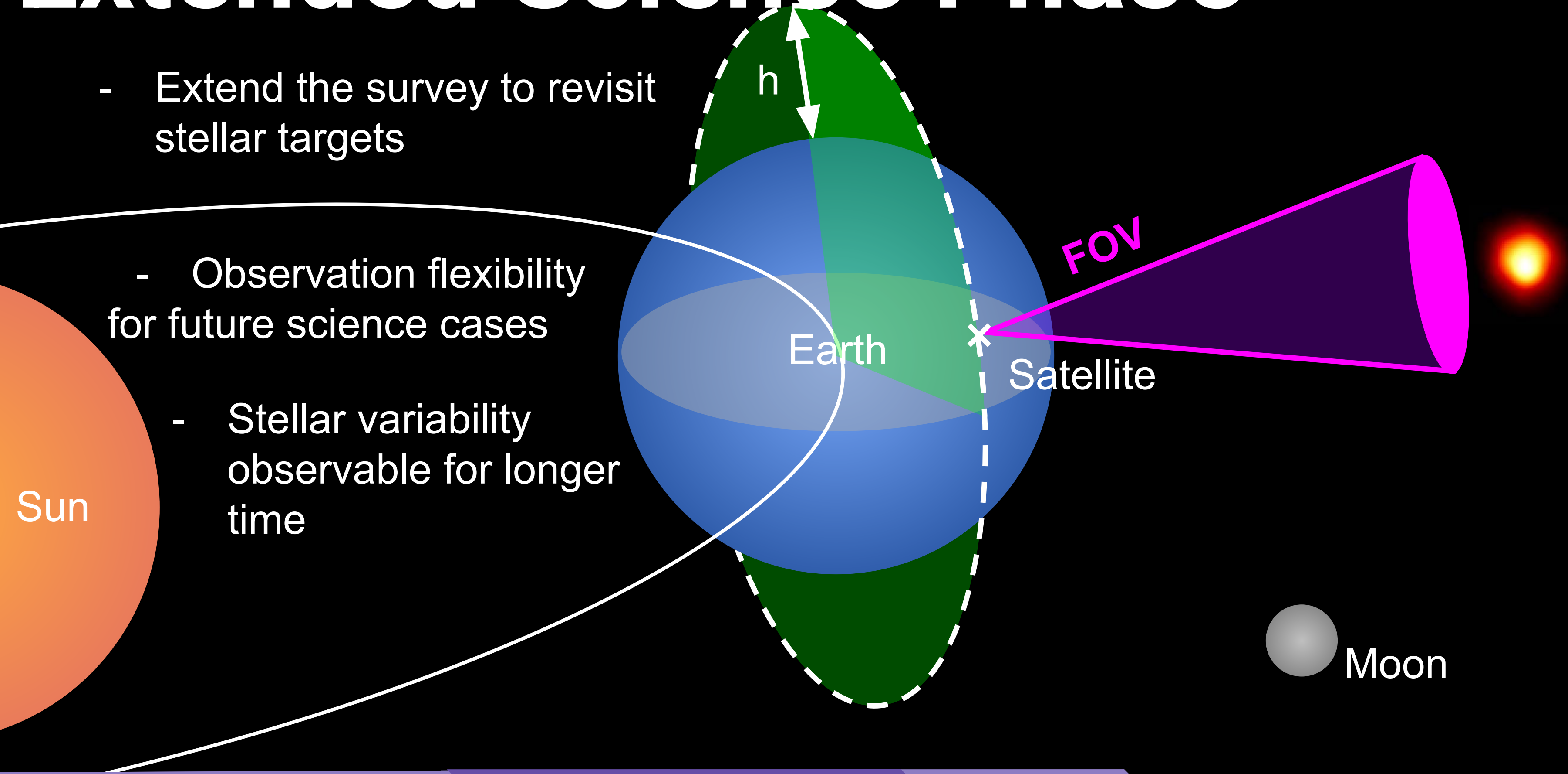
Worst case observation:
- 518 ks (6 days)



*not to scale

Extended Science Phase

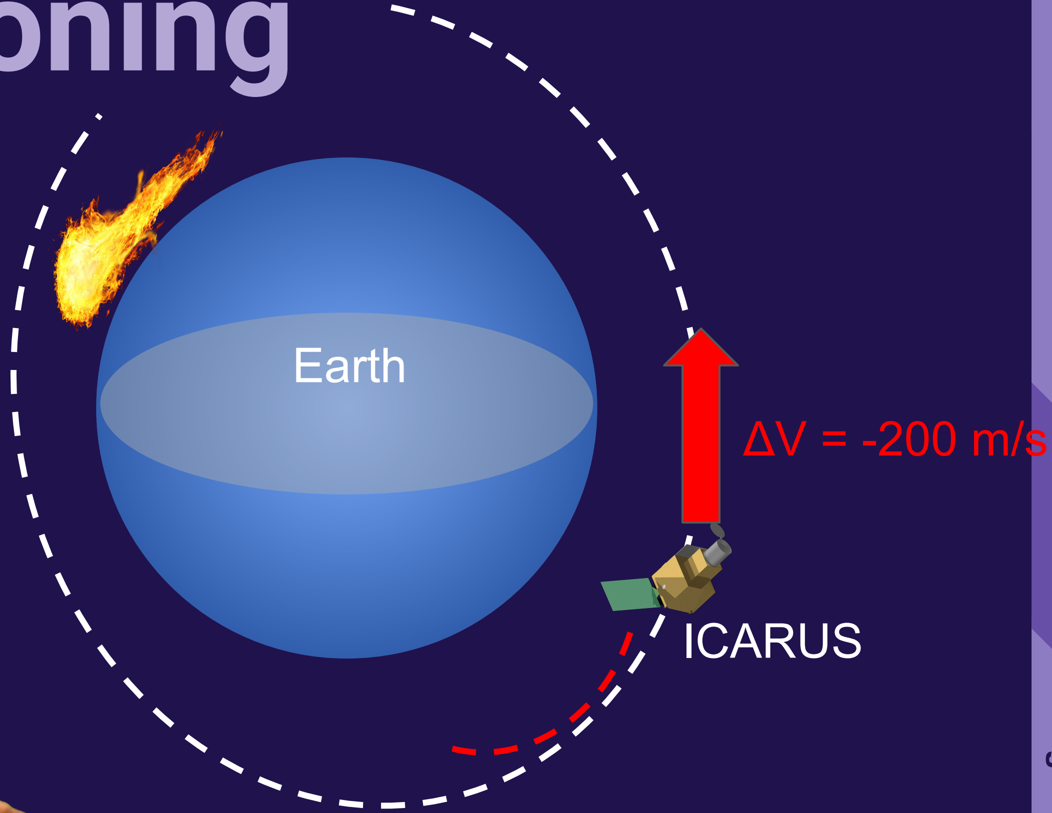
- Extend the survey to revisit stellar targets
- Observation flexibility for future science cases
- Stellar variability observable for longer time



Decommissioning

- Deorbiting according to ESA Rules kept < 5 years.

→ESA Space Debris Mitigation Requirements ESSB-ST-U-007-Issue1



Programmatics

Risk Matrix

Severity – 1: No/min. Consequences - 5: Launch opportunity Lost
Likelihood – A: Minimum >1/Project - E: Maximum 1/10.000 Projects

Severity					
5					
4		PR2	PR3		
3			SR1		
2					
1					
	A	B	C	D	E

Likelihood

Risk elements

- **SR1** – The requirement to observe 494+ stars twice with very long integration times (3.47 days per measurement) leaves little margin for schedule slips.
- **PR2** – Internal mechanical vibrations (e.g., from reaction wheels) could disrupt the extreme 0.024 arcsecond science pointing stability, blurring the spectral data.
- **PR3** – Inability to maintain the highly precise +-0.1K thermal control loop could cause structural warping of the optics or drift in detector dark current.

Risk Matrix

Risk Mitigation

- **SR1** – Reduce the Number of targets to reduce measuring time. To consequently reduce the schedule shifts.
- **PR2** – Conduct test to study possible vibrations and jerk, produced by actuators and implement mechanical dampening.
- **PR3** – Conduct thermal load tests and optimize thermal system

Severity – 1: No/min. Consequences - 5: Launch opportunity Lost
Likelihood – A: Minimum >1/Project - E: Maximum 1/10.000 Projects

5					
4		PR2	PR3		
3			SR1		
2					
1					
	A	B	C	D	E

Severity

Likelihood

Cost breakdown

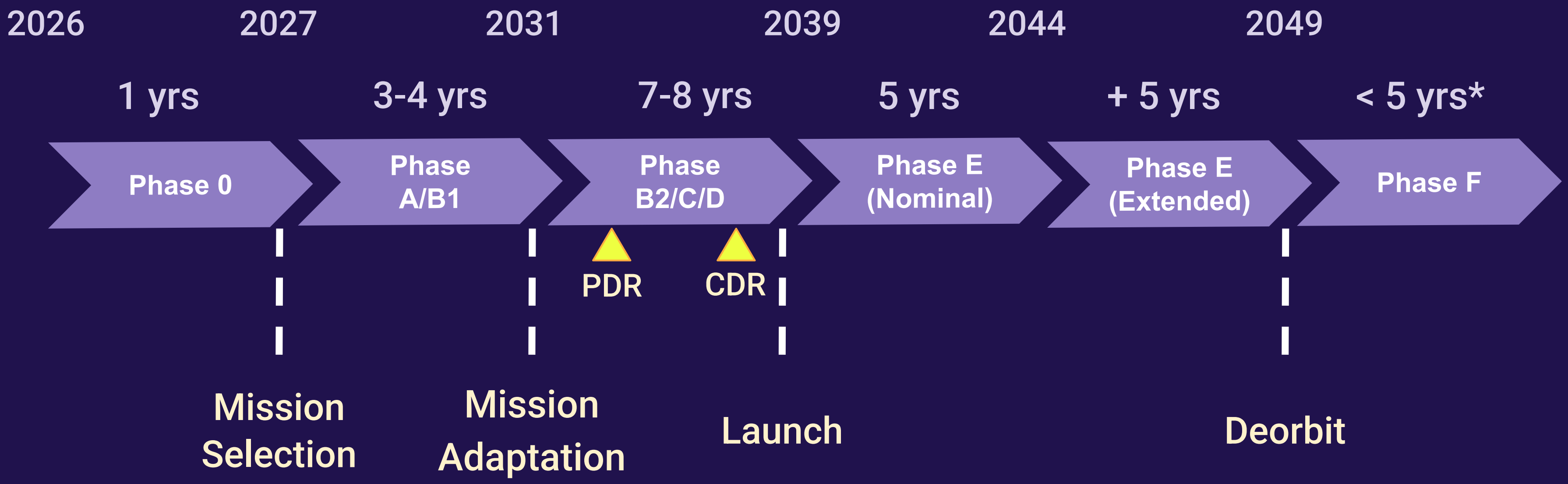
Duration	Launcher	Spacecraft	Target	Dry Mass	Special
5 yrs (Nominal)	Vega-C	standard	SSO Terminator	869 kg	Purging (Lens)

Spacecraft	280
Payload + Telescope (ESA part)	10
Mission Operation Costs	54
Science Operation costs	44
Launcher (Vega-C + ICARUS Logo)	58
Industry Margin	92
Subto margin (25%)	70

- Payload provided and funded by ESA Member States. * Roughly ~ 30% of ESA Costs.
- M-Class cost cap for estimated ESA Cost at Completion (CaC) is 670M€ at 2025 e.c.

∑ ~ 608 M€

Development



*ESSB-ST-U-007

Descoping

Decision Drivers:

- Effect on science return and science closure
- Effect on mission operations
- Conservation of costs, mass and time budgets.

Descope Options:

- Reduce number of sensors (omit Mg-II absorption line resolution)
- Reduce number of observation targets
- Reduce mission operation time

Outreach

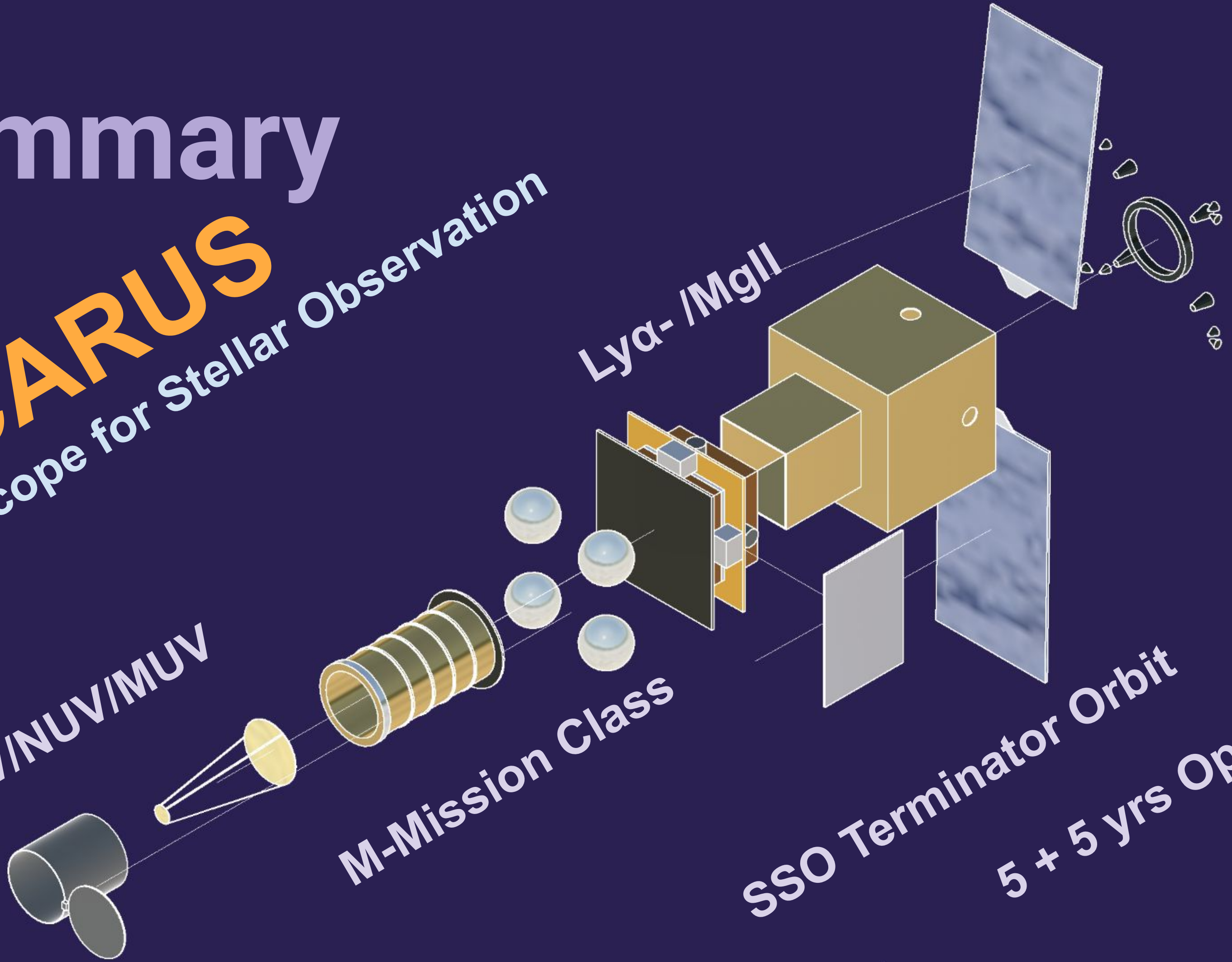
- Articles in popular-science magazines across europe
  - Astronomy Now (UK), NTvN (NL), Sterne und Weltraum (DE), Ciel et Espace (FR), Coelum Astronomia (IT), Urania (PL), Populär Astronomi (SE), etc.
- Social Media post about the mission
  - Instagram, Facebook, LinkedIn, article on ESA website
- Primary/secondary education:
  - Educate "why your sunscreen and our telescope care about the same wavelengths" and hand out sunscreen

@Willem, want to sponsor us?

Summary

ICARUS

UV Telescope for Stellar Observation



Lyα- /MgII

FUV/NUV/MUV

M-Mission Class

SSO Terminator Orbit

5 + 5 yrs Operation

Thank you!

Yellow Team, Alpbach *2026*, High-Energy processes

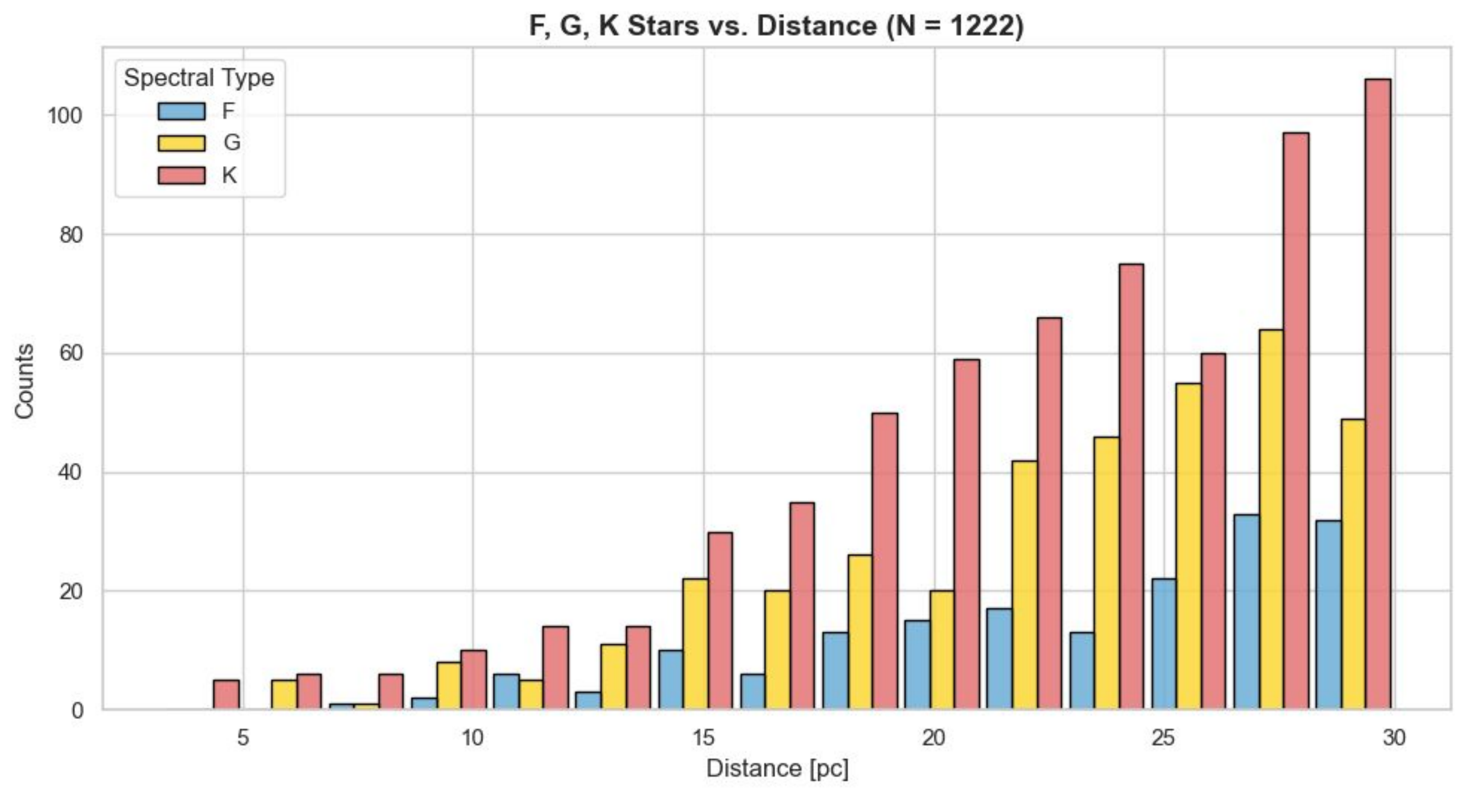
Students: *Laura Barone, Eric Bär, Alexandre Branco, Franz de la Torre Westphal, Hülya Falkena, Zoi Filiou, Rudolf Hansen, Niklas Herzig, Valerija Koseleva, Hugo Lancery, Angelina Lonsky, Markus Maalt, Sarina Mahler, Wilhelm Öhlin, Kathryn Kennedy, Szymon Szczeciński*

Tutors: *Christian Gritzner & Aljona Blöcker*

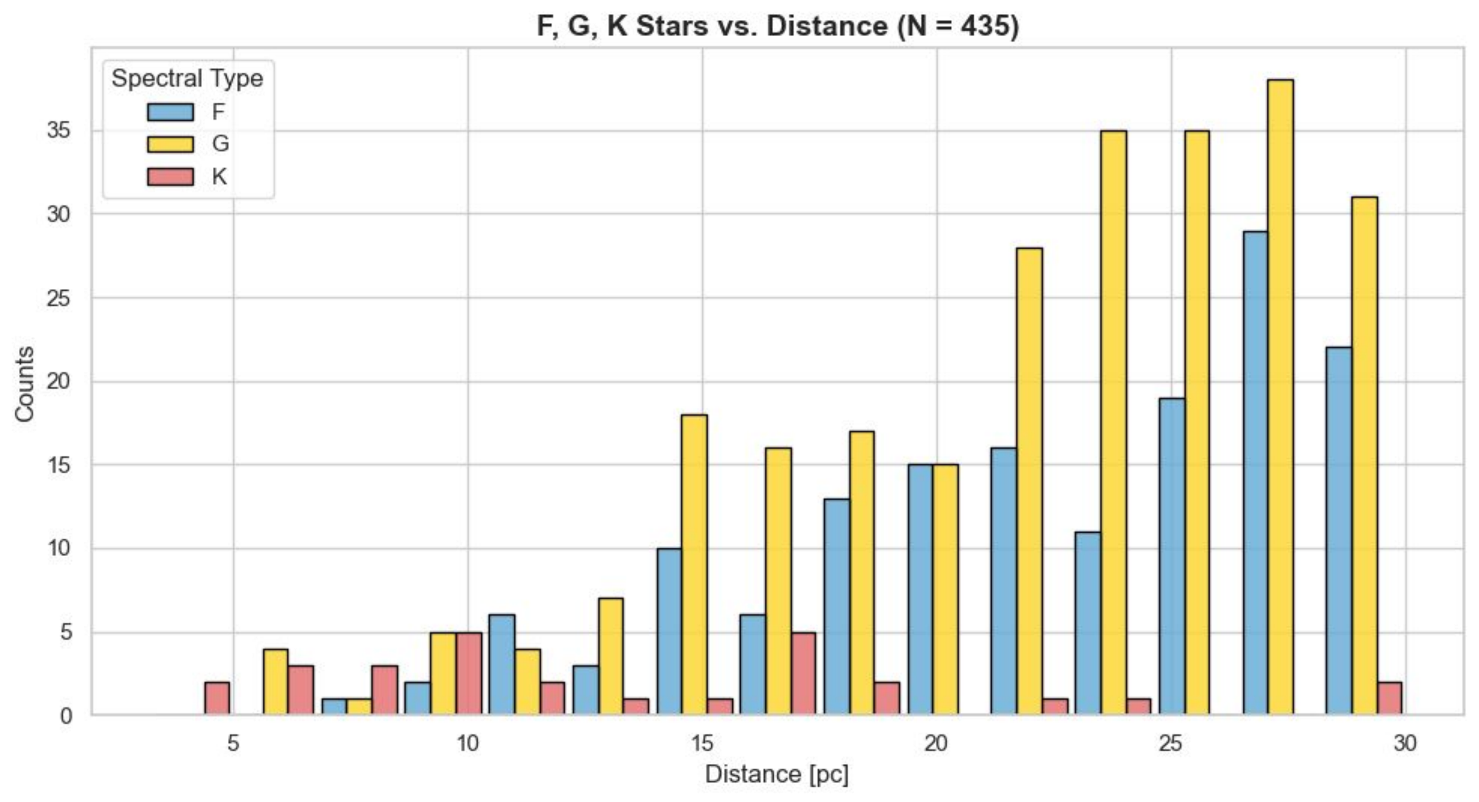
BACKUP SLIDES


Hugo seeing someone copy pasting an
entire excel sheet in the presentation

Distribution of Gaia Stars

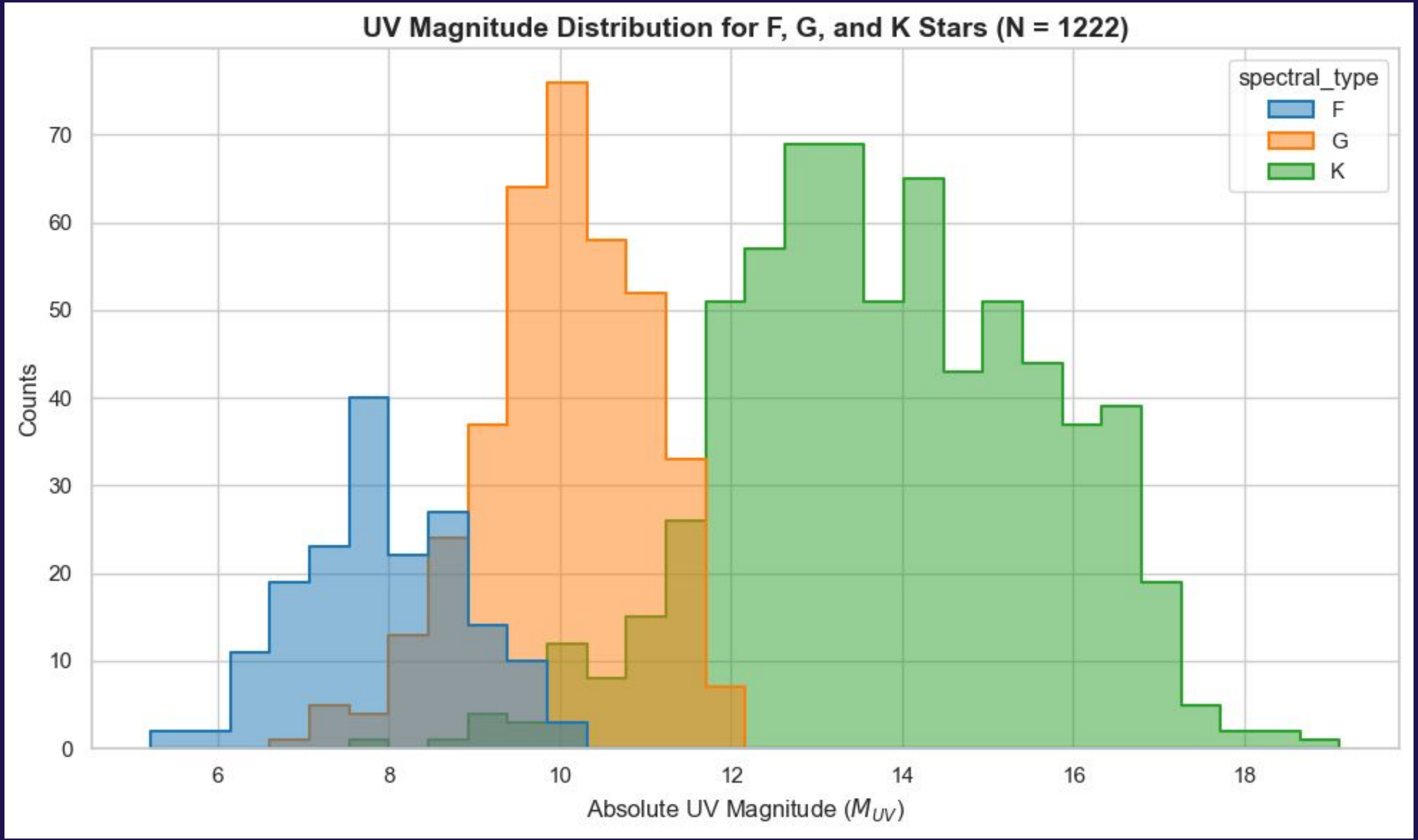


Distribution of Target Stars

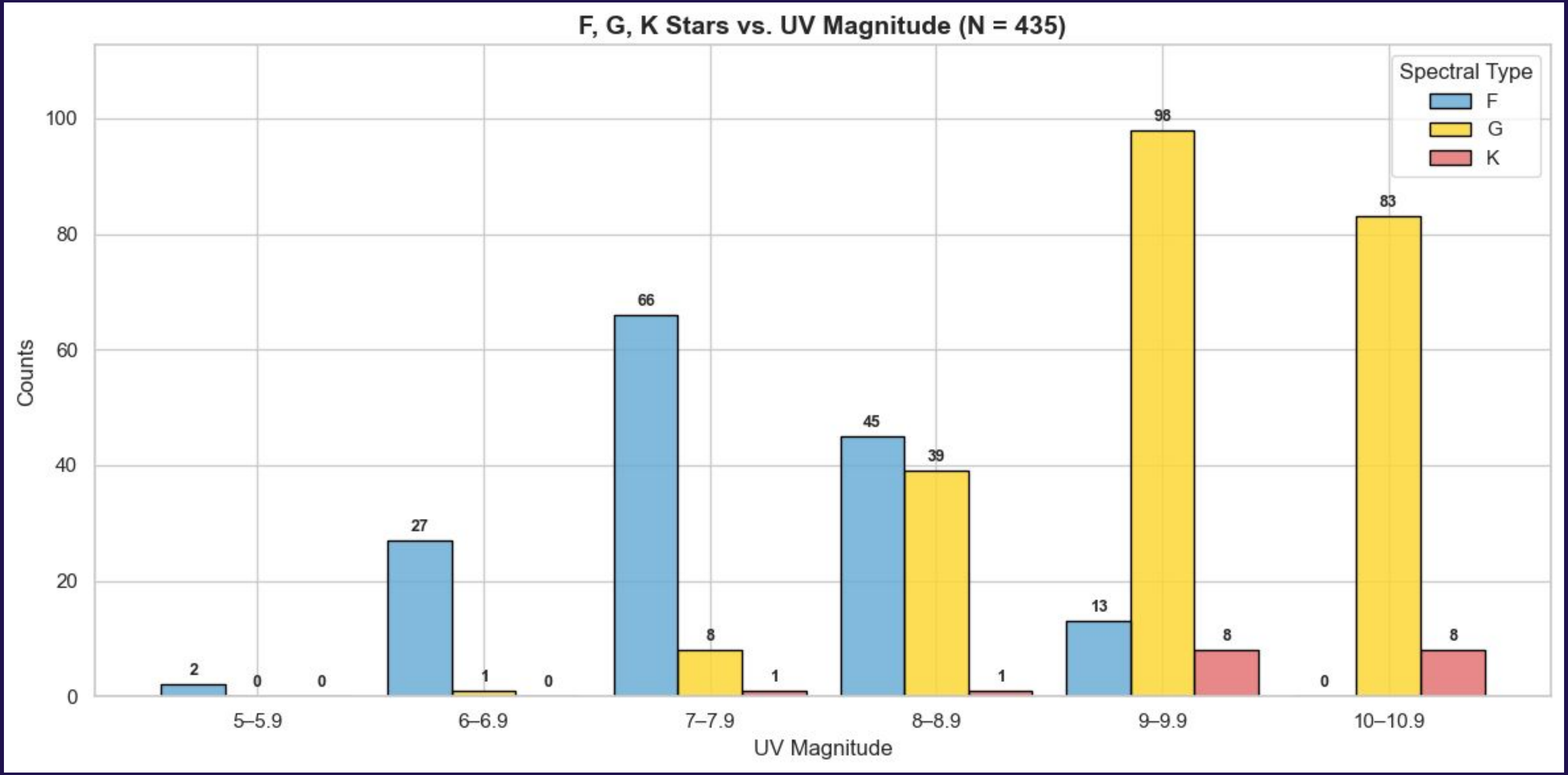


Science
Instrument
Mission
Program

General Magnitude Distribution

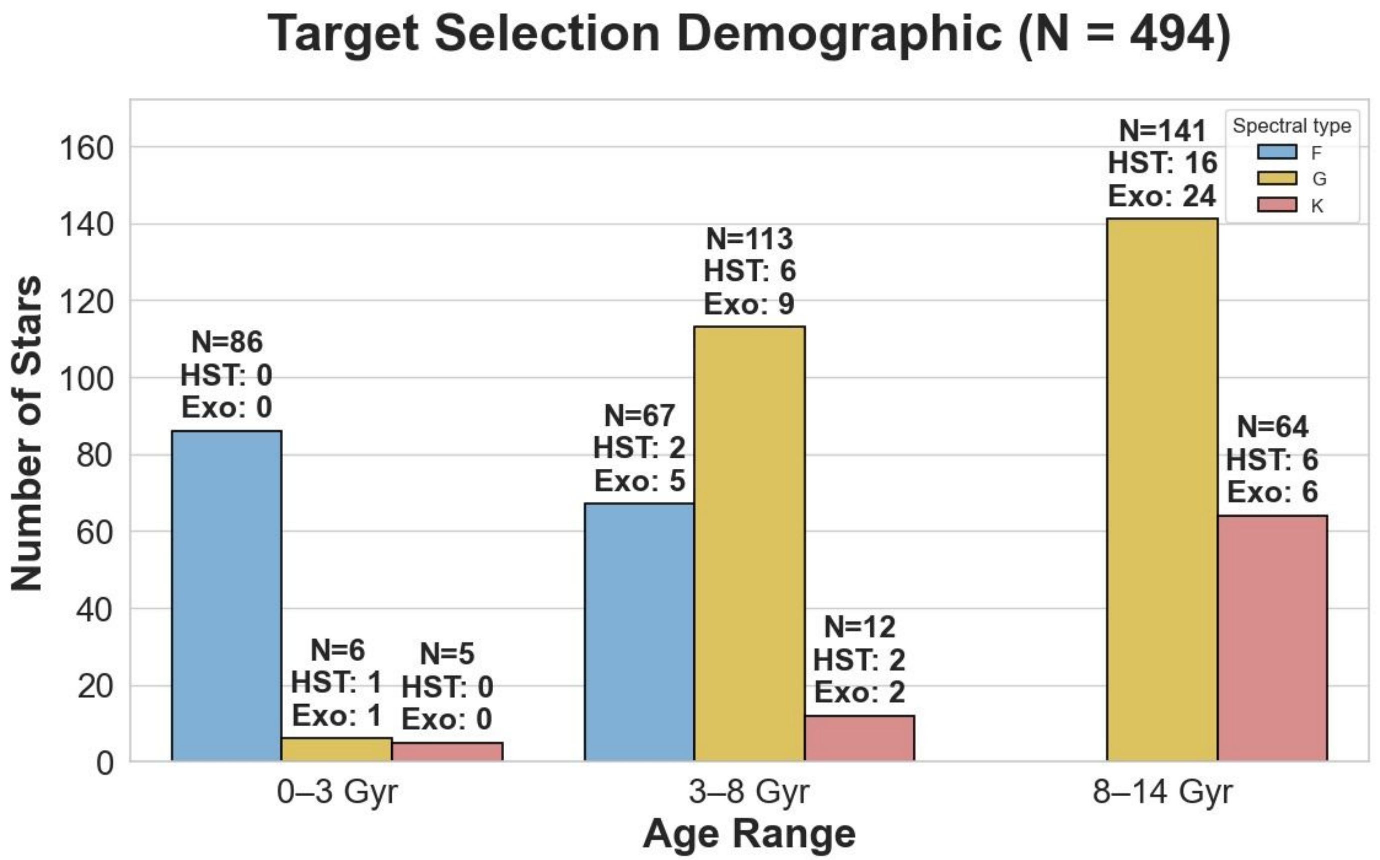


General Magnitude Distribution



Science
Instrument
Mission
Program

General Magnitude Distribution



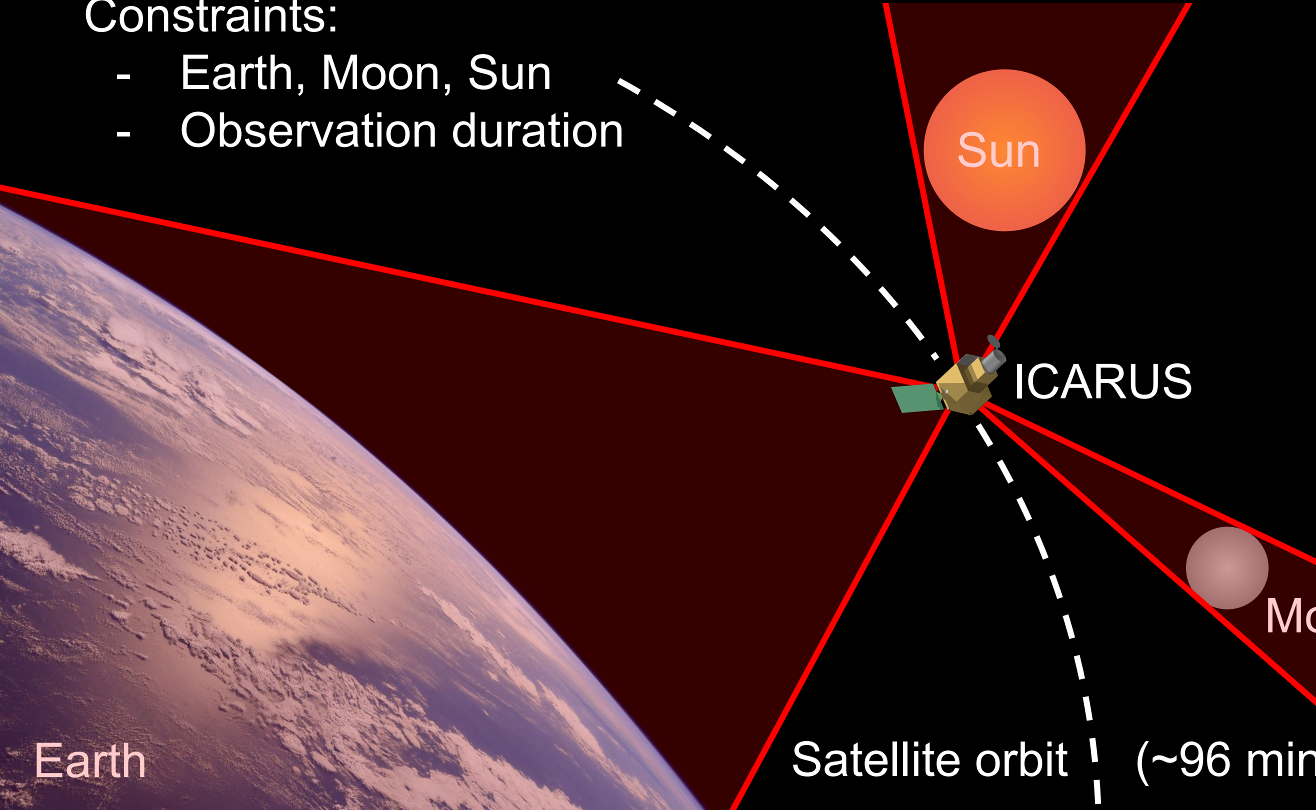
Based on num. calculations

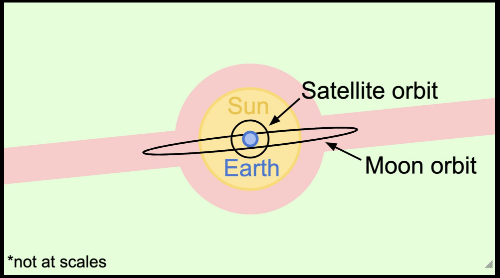
*not to scale

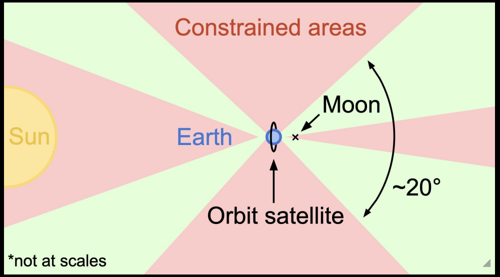
Observation strategy

Constraints:

- Earth, Moon, Sun
- Observation duration







Cost breakdown

Duration	Launcher	Spacecraft	Target	Dry Mass	Special
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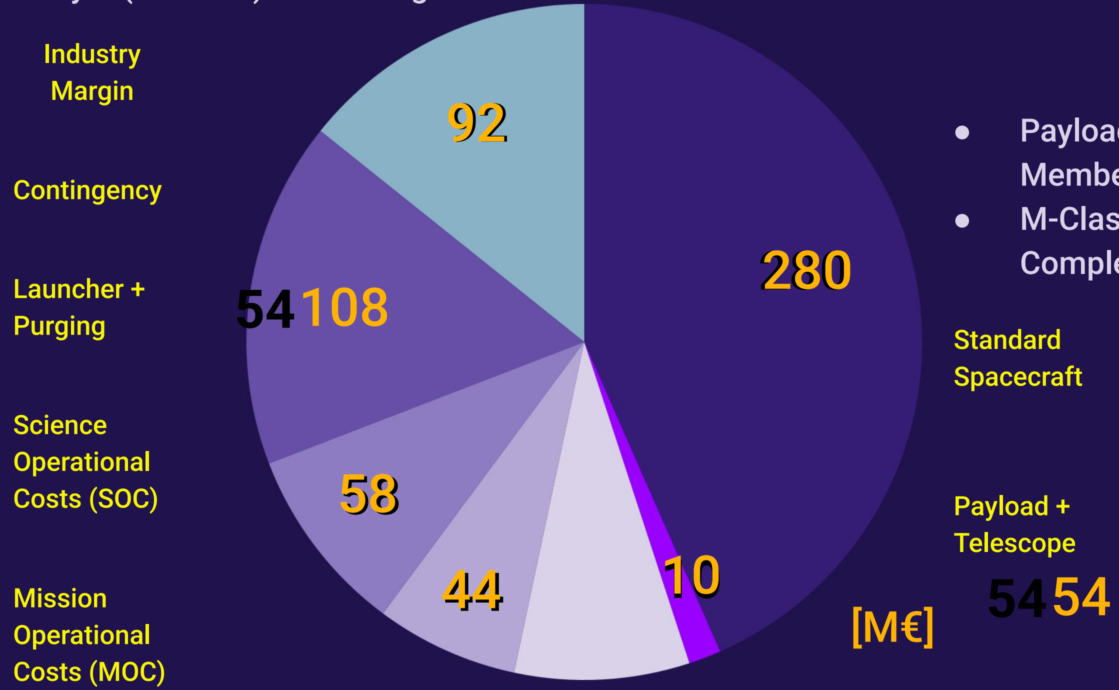

- Payload provided and funded by ESA Member States.
- M-Class cost cap for estimated ESA Cost at Completion (CaC) is 670M€ at 2025 e.c.

~ 610 M€

Modes

ideally 0%		4%	2%	4%	90%
Safe Mode		Comms (idle)	Nominal/Science		
Eclipse	Launch and early Orbit Phase		Observation	Main Branch	Secondary Branch
OBC, Comms, AOCS, Thermal Mgt.	OBC, Comms, AOCS (sun acquisition), Thermal Mgt.	OBC, Comms, AOCS, Thermal Mgt.	FGS + Gymball, OBC, Comms, Thermal Mgt.	SGs (Ly-alpha, MUV-FUV) + 2 detectors, OBC, Comms, AOCS, Thermal Mgt.	SGs (Mg II, MUV/NUV) + 2 detectors, OBC, Comms, AOCS, Thermal Mgt.

Descoping

Decision Drivers:

- Effect on science return and science closure
- Effect on mission operations

Descope Options:

- Omit Mg-II absorption line resolution
- Reduce number of targets

Summary

Science Goal	Science Objectives	Observation Strategy	Instrument
...	...	...	...
...	...	...	...
...	...	...	...

Spacecraft	Mission	Ops & Comms	Programmatics
mass < 1000kg	...	...	...
...	...	...	...
...	...	...	...