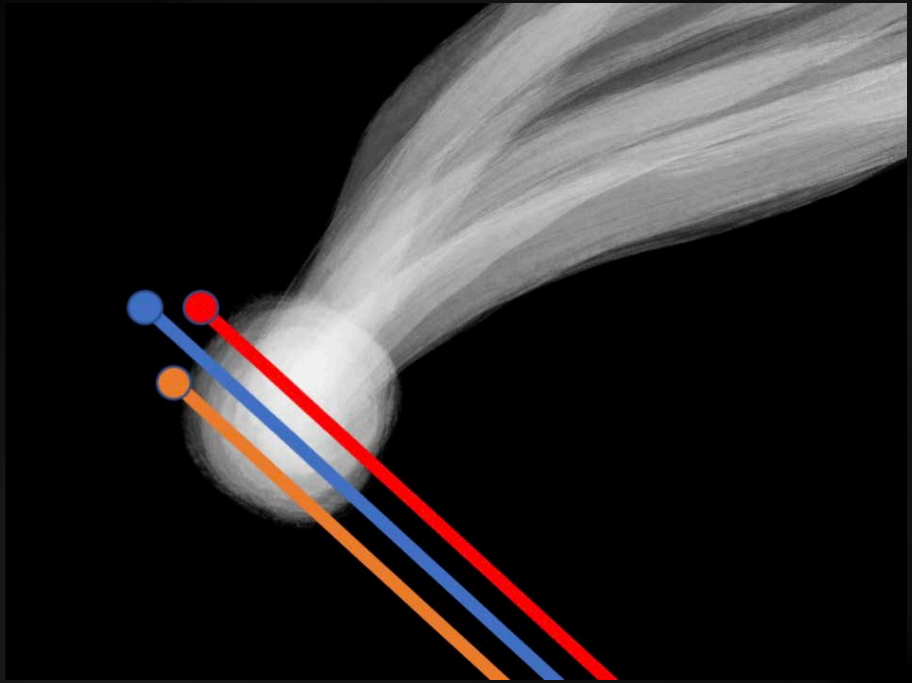
Comet Interceptor

An ESA mission to an ancient world

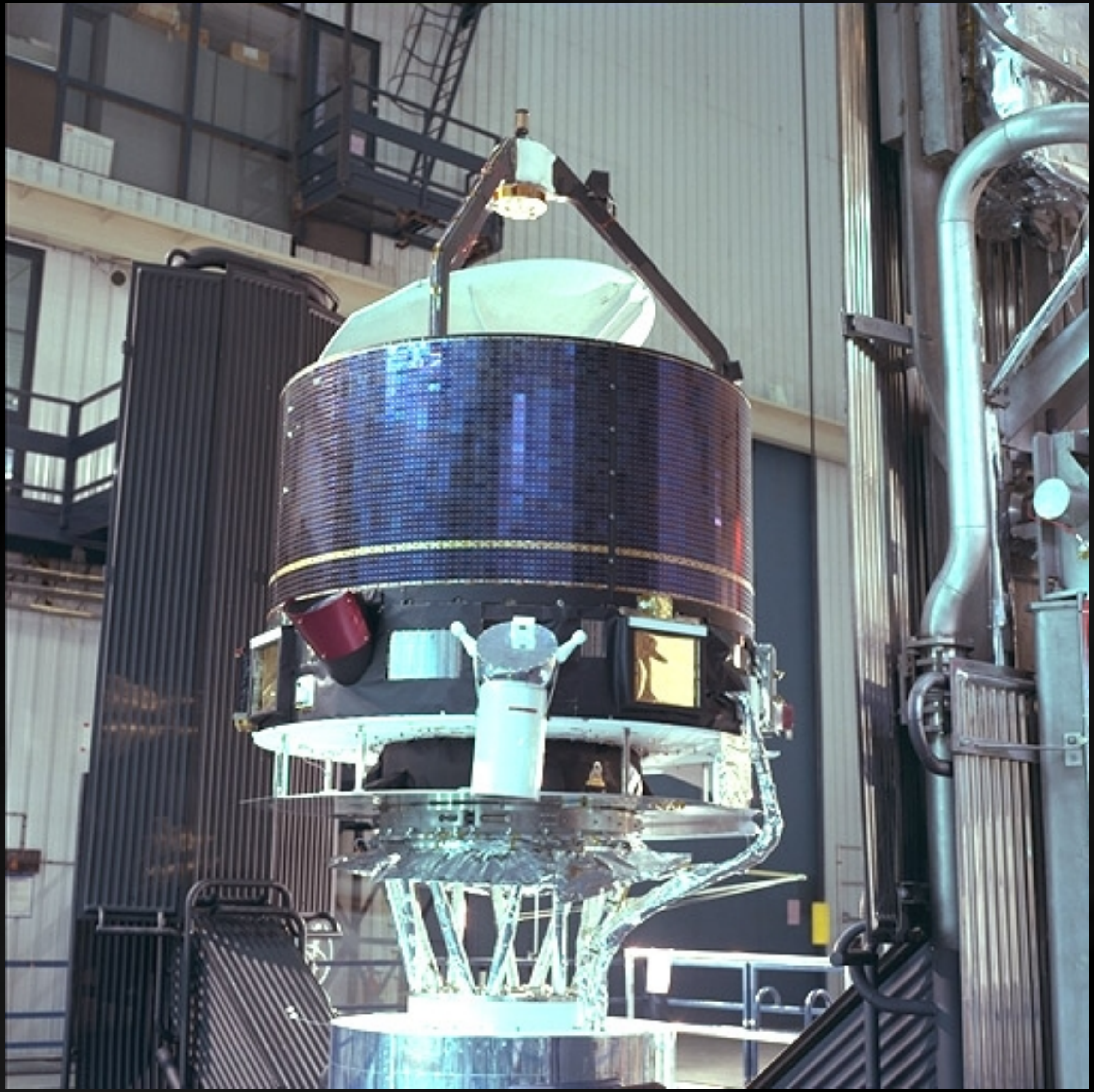


Geraint Jones
UCL Mullard Space Science Laboratory, UK
Centre for Planetary Science at UCL/Birkbeck, UK

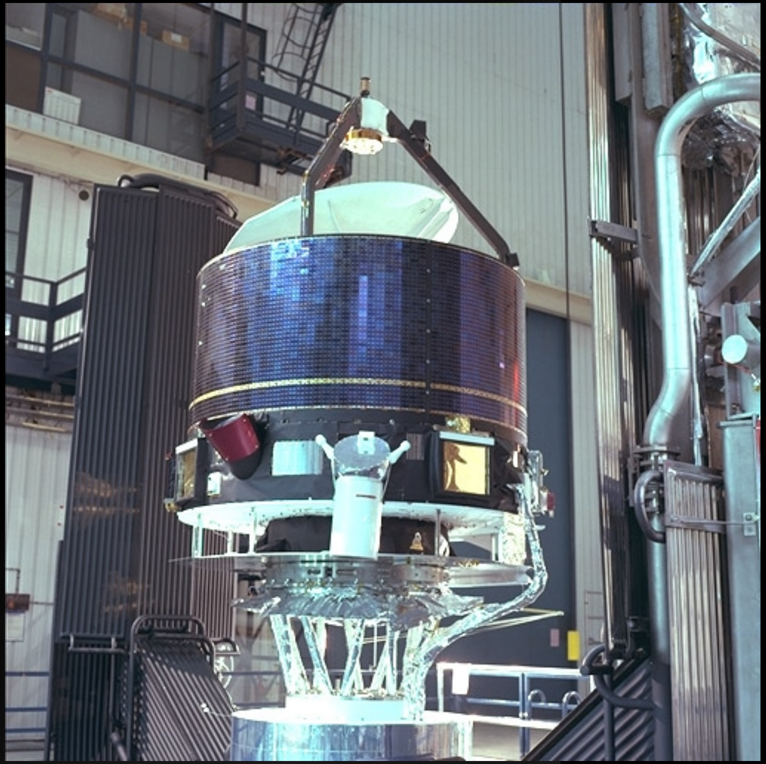
Colin Snodgrass
University of Edinburgh, UK

and the Comet Interceptor Team

Giotto



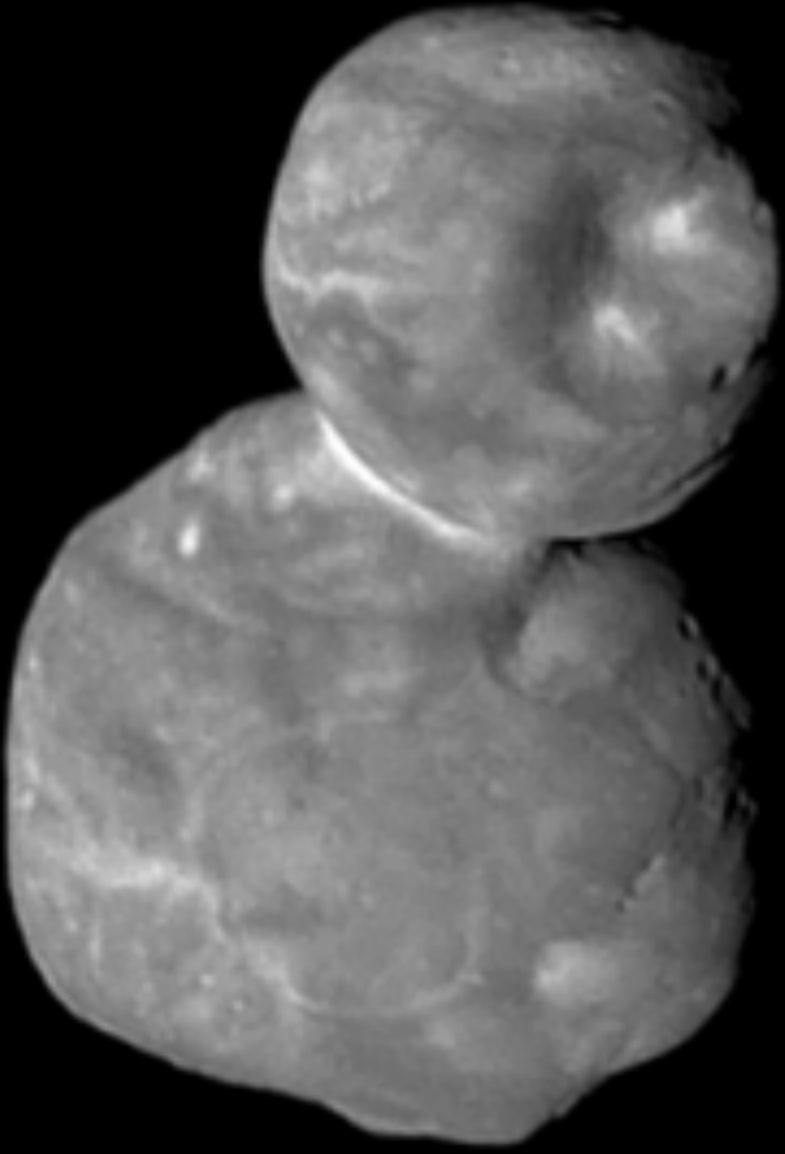
Halley’s nucleus from Giotto



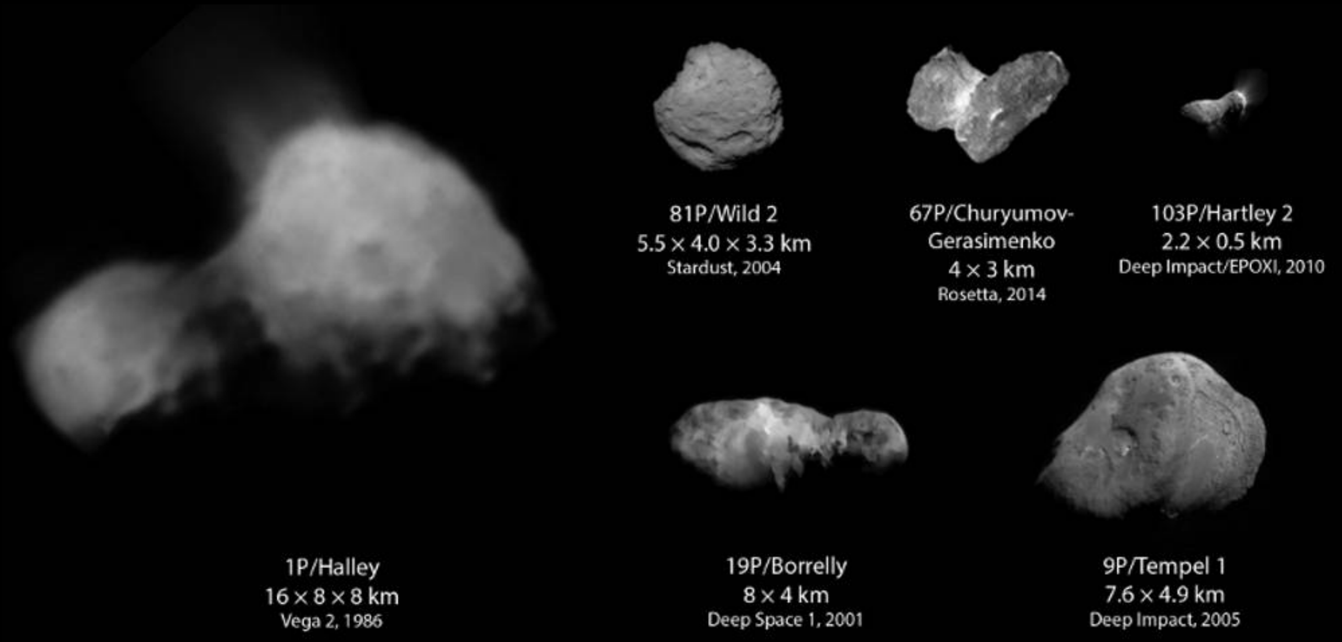
Rosetta

ESA/Christian Stangl

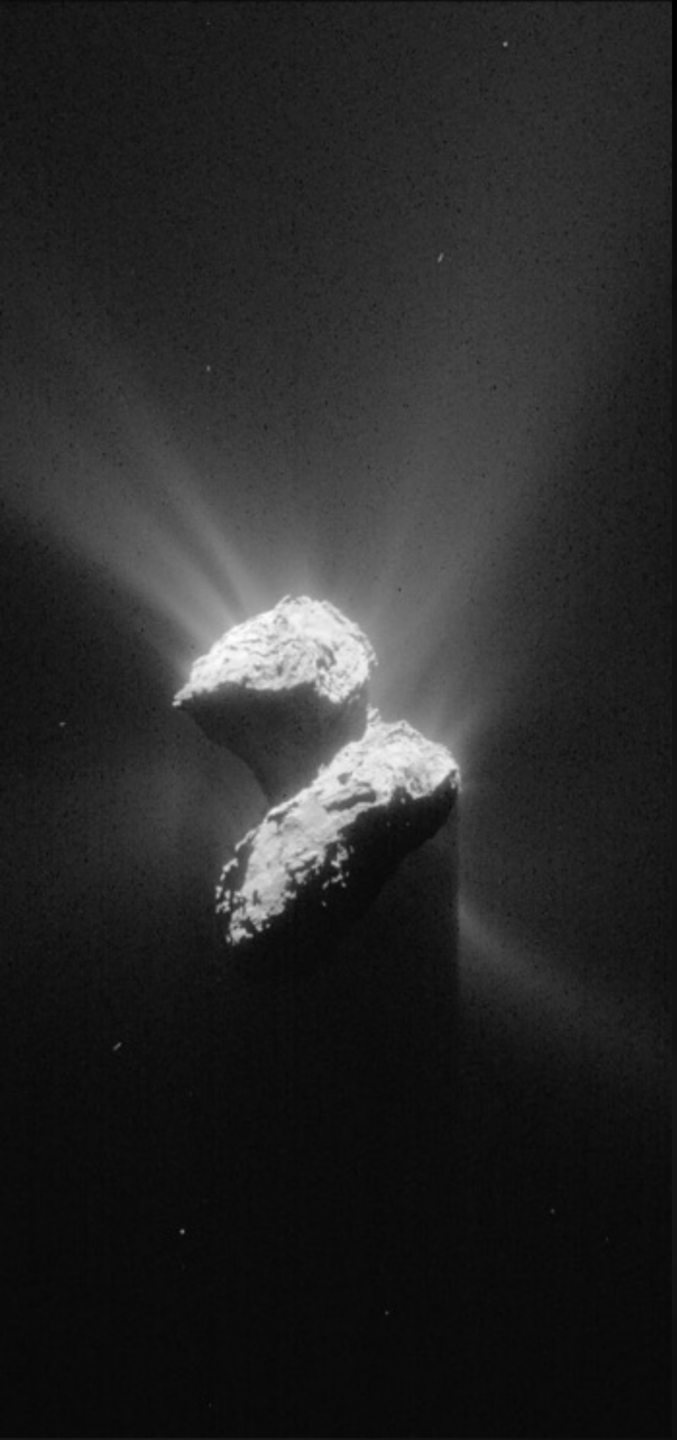
Comet Interceptor



NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute



Halley: Russian Academy of Sciences / Ted Stryk. Tempel 1 and Hartley 2: NASA / JPL / UMD. Borrelly: NASA / JPL / Ted Stryk. Wild 2: NASA / JPL. Montage by Emily Lakdawalla.

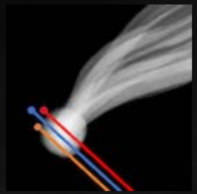


Comet Interceptor is a mission targeting a long-period comet, preferably dynamically-new, or an interstellar object.

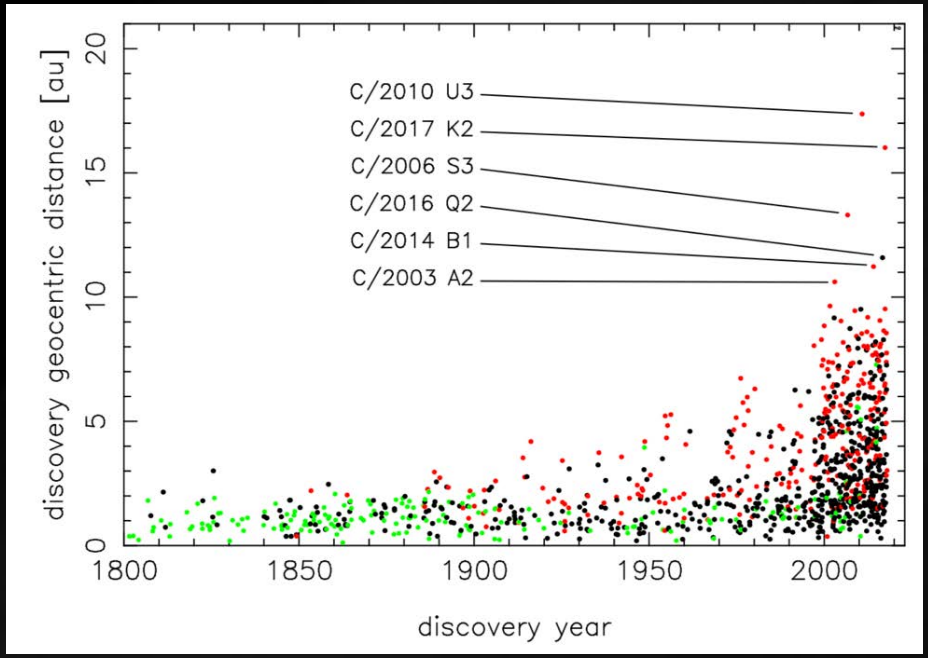
Why?

- All previous comet missions have been to objects that have passed the Sun many times
- Targets were relatively evolved, with thick coatings of dust on their surfaces
- A dynamically-new comet is one that is probably nearing the Sun for the first time
- A mission to such an object would encounter a **pristine** comet, with surface ices as first laid down at the Solar System's formation

How?



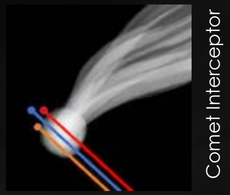
- The only way to encounter a long period comet is to discover it inbound with enough warning to direct a spacecraft to it
- The likelihood of this happening will soon be greatly increased by the Vera Rubin Observatory/LSST – the *Legacy Survey of Space and Time*
- VRO/LSST might not increase the number of long period comets found every year, but will increase the **distance** at which they're discovered inbound
- Still not enough time to plan and build a spacecraft



M. Królikowska & P. A. Dybczynski 2019, arXiv 1901.01722

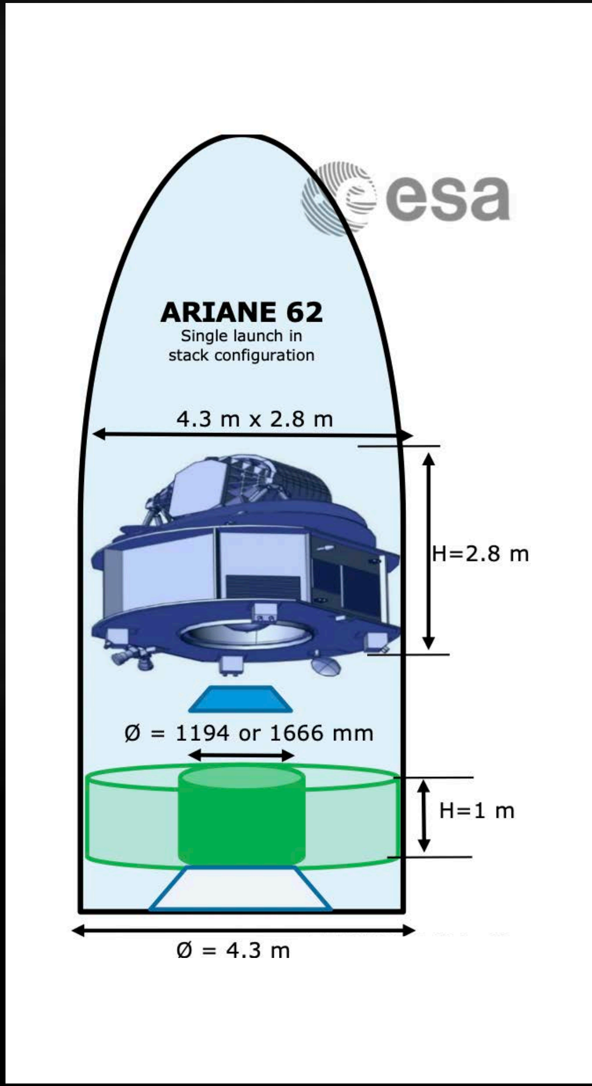
Solution: A Wait in Space

- The way to encounter a new comet is to design and build a spacecraft that can cope with a variety of comet encounter geometries
- Launch to a stable 'parking' location in space
- Relatively rapid reaction to new discoveries (departure from parking location 6-12 months after target discovery)



ESA F-class call

- On July 2018, F-class mission call announced.
- Maximum cost to ESA at completion, excluding launch: €150M.
- ESA member states and other collaborating agencies generally fund instruments and the science teams.
- Shared launch with Ariel exoplanet telescope, to Sun-Earth L2 point, in 2028
  - Limits on mass (originally 1000 kg, now lower)
  - Was to fit underneath Ariel, and be designed to support it during launch



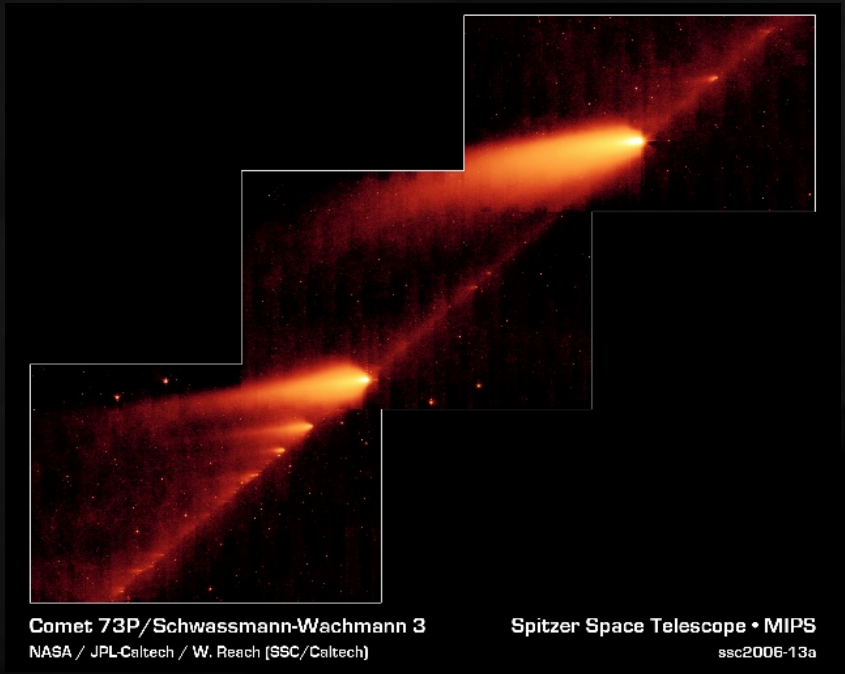
Challenges

- Mission has to be designed to encounter comets on a wide range of possible trajectories and encounter speeds
- Retrograde orbits could mean flyby speeds > 70 km/s in worst case
- Cost means that entire mission should be < 5 years

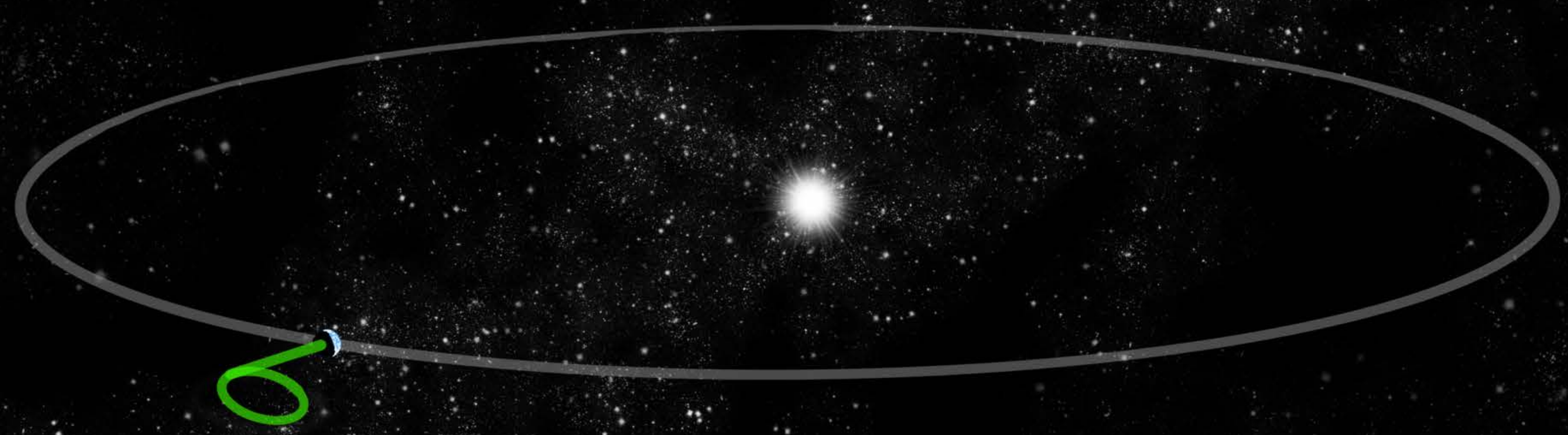
Solutions

- Spacecraft design can cope with range of different encounter geometries – no high gain antenna to Earth at encounter. Dust shielding equivalent to that used on Giotto
- Wait at L2 limited to ~3 years
- If no suitable target found, backup short period comets identified, including 73P.

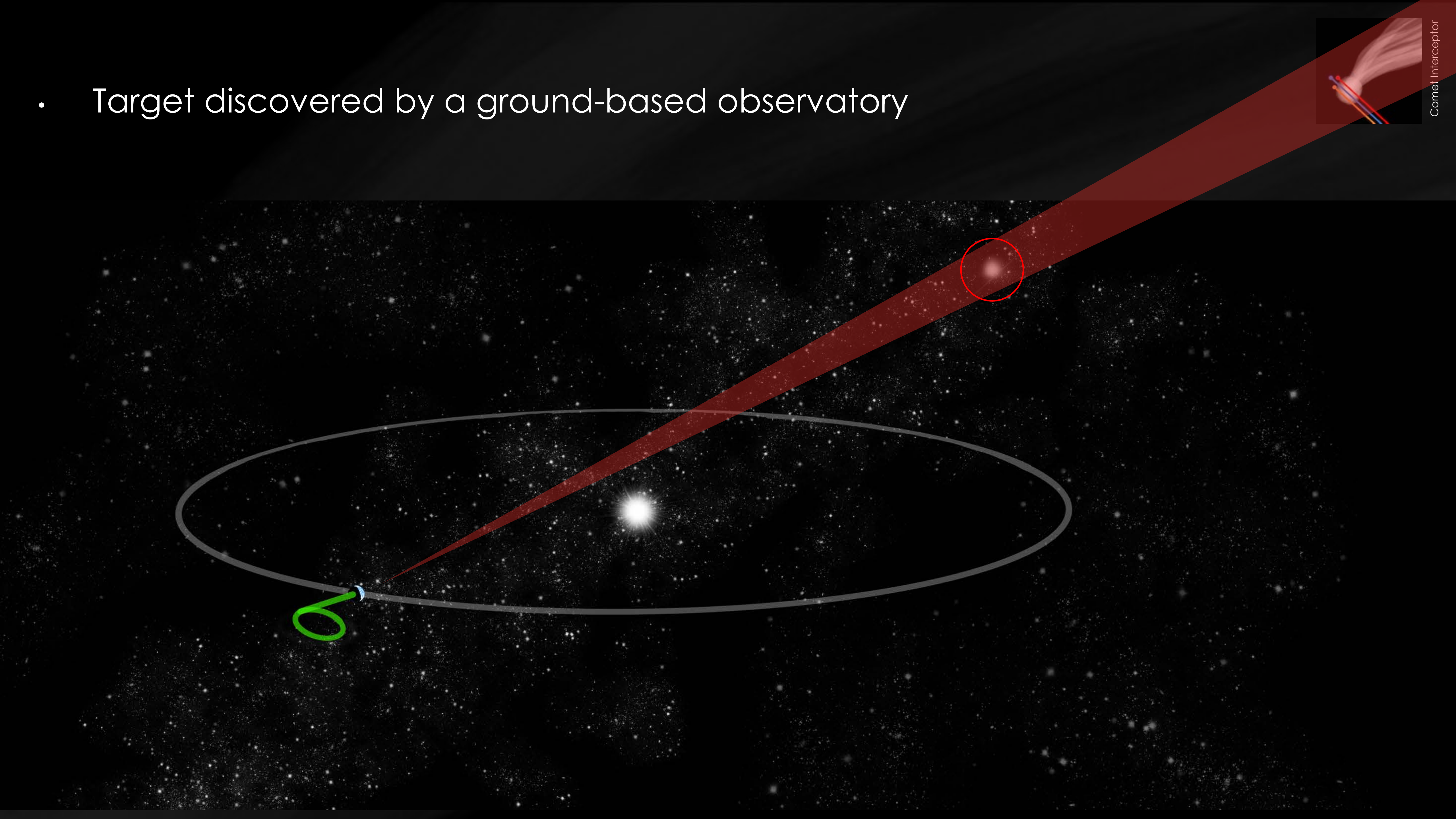
A mission to short period comet will carry out new science: not repeat of previous missions.



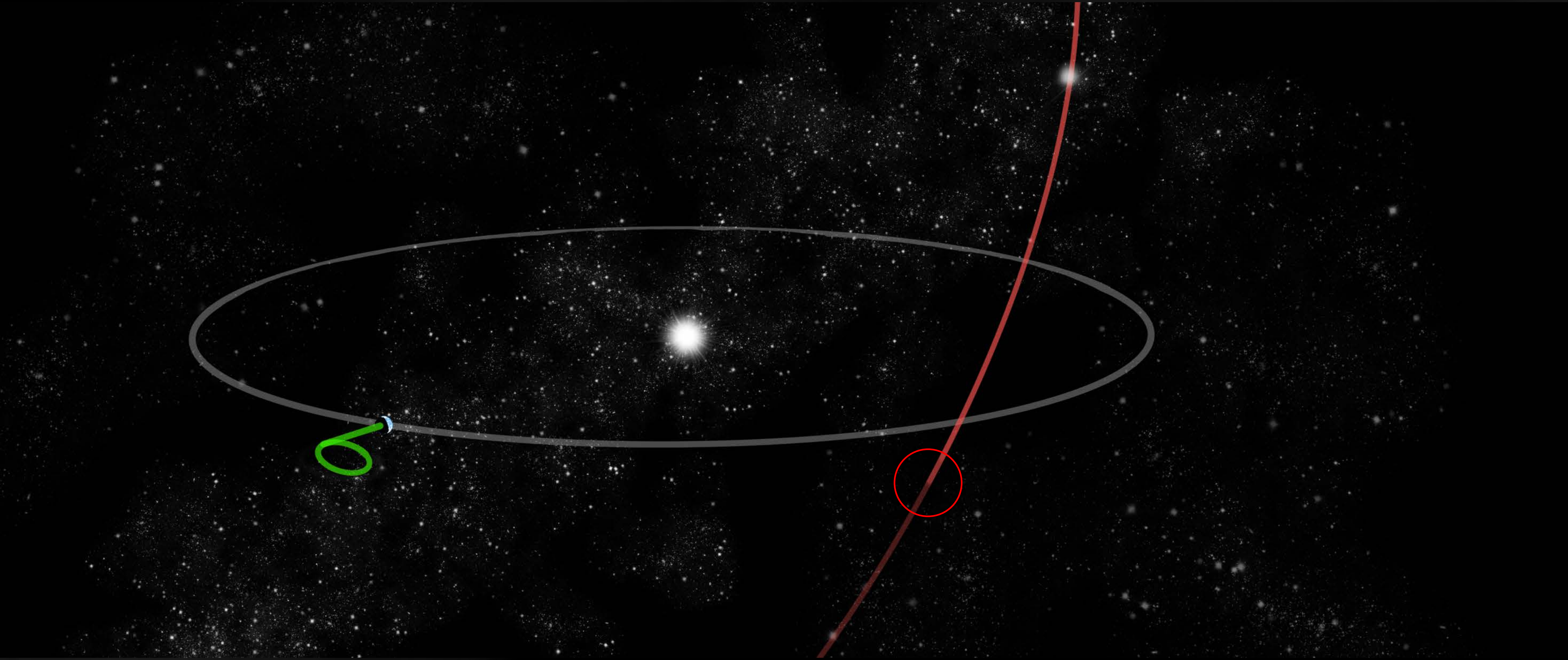
- Mission ‘parked’ at stable Lagrange point L2 after launch with Ariel
- Waits for up to 2-3 years for new target discovery



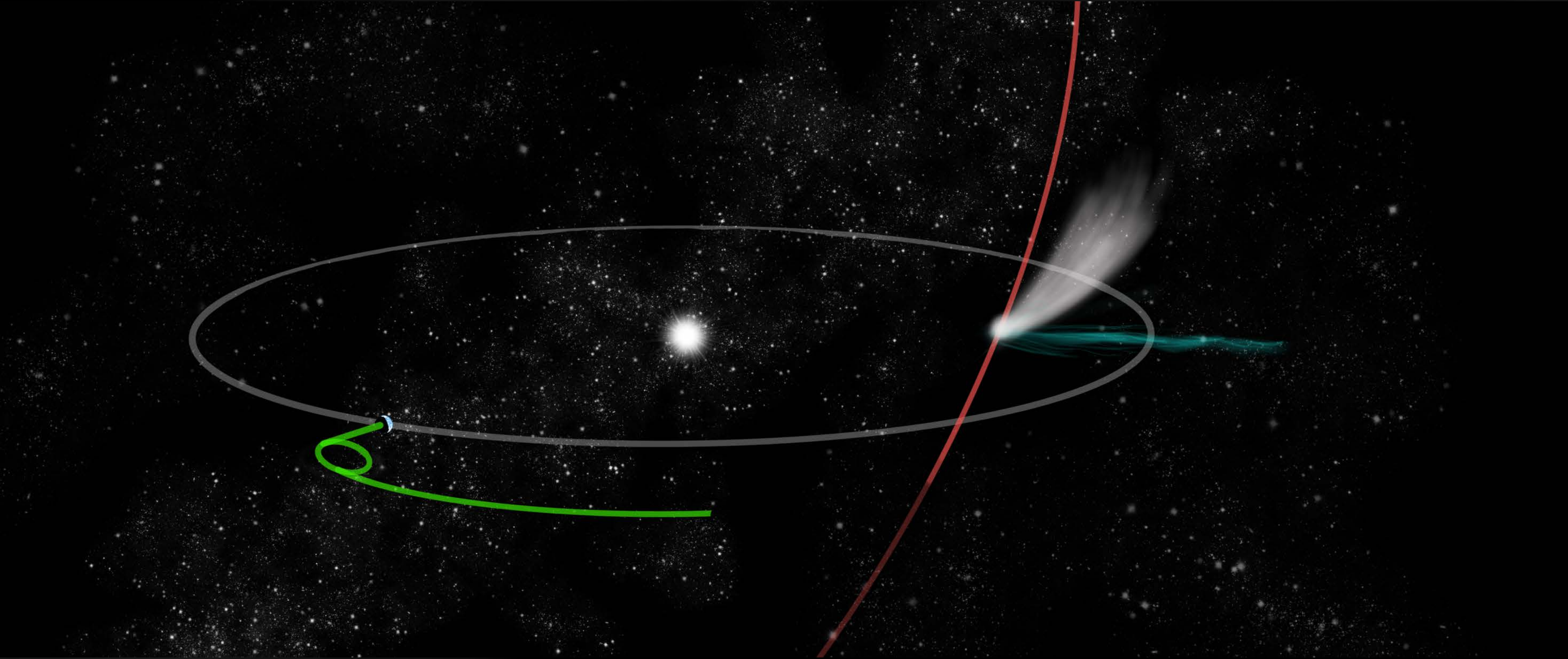
- Target discovered by a ground-based observatory



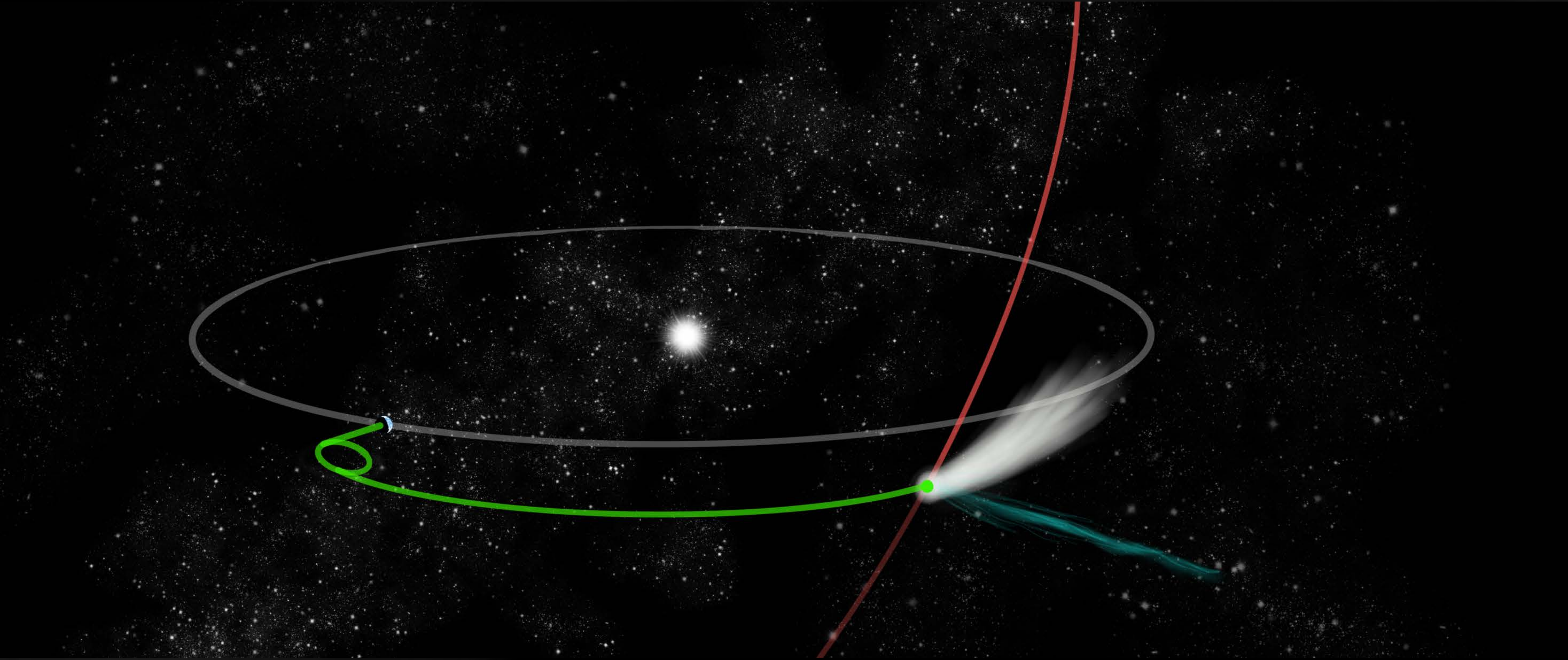
- Orbit computed and ecliptic crossing point predicted

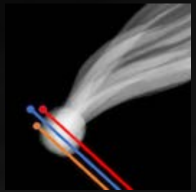


- Comet Interceptor leaves L2 to intercept comet's path



- Encounter with comet close to the ecliptic plane





Comet Interceptor

Example – C/2001 Q4 (NEAT)

- Based on previous bright dynamically-new comet
- Real comet found ~3 years out
- VRO-LSST would have found it ~8 years out
- Target known before launch
- ~1.5 year wait
- ~3 year cruise


© 2004 by Carlos Vázquez Darias (Tenerife, Canary Islands)

Interstellar targets?

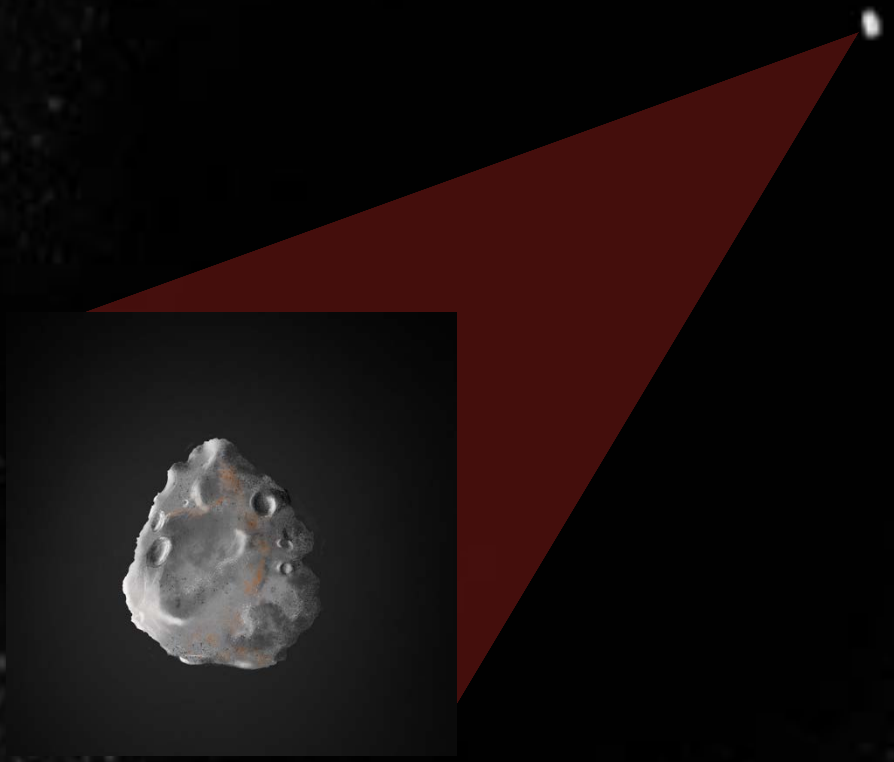
- Unlikely to occur, but possibility exists that an interstellar target (highly hyperbolic orbit) could be discovered and reached
- ‘Oumuamua study (Seligman & Laughlin 2018) showed that LSST finds one accessible target in ~10 years. Non-negligible chance of a suitable target within 2-3 years
- Comet 2I/Borisov – a sign of promising discovery statistics?

NASA

ESO/M.Kornmesser

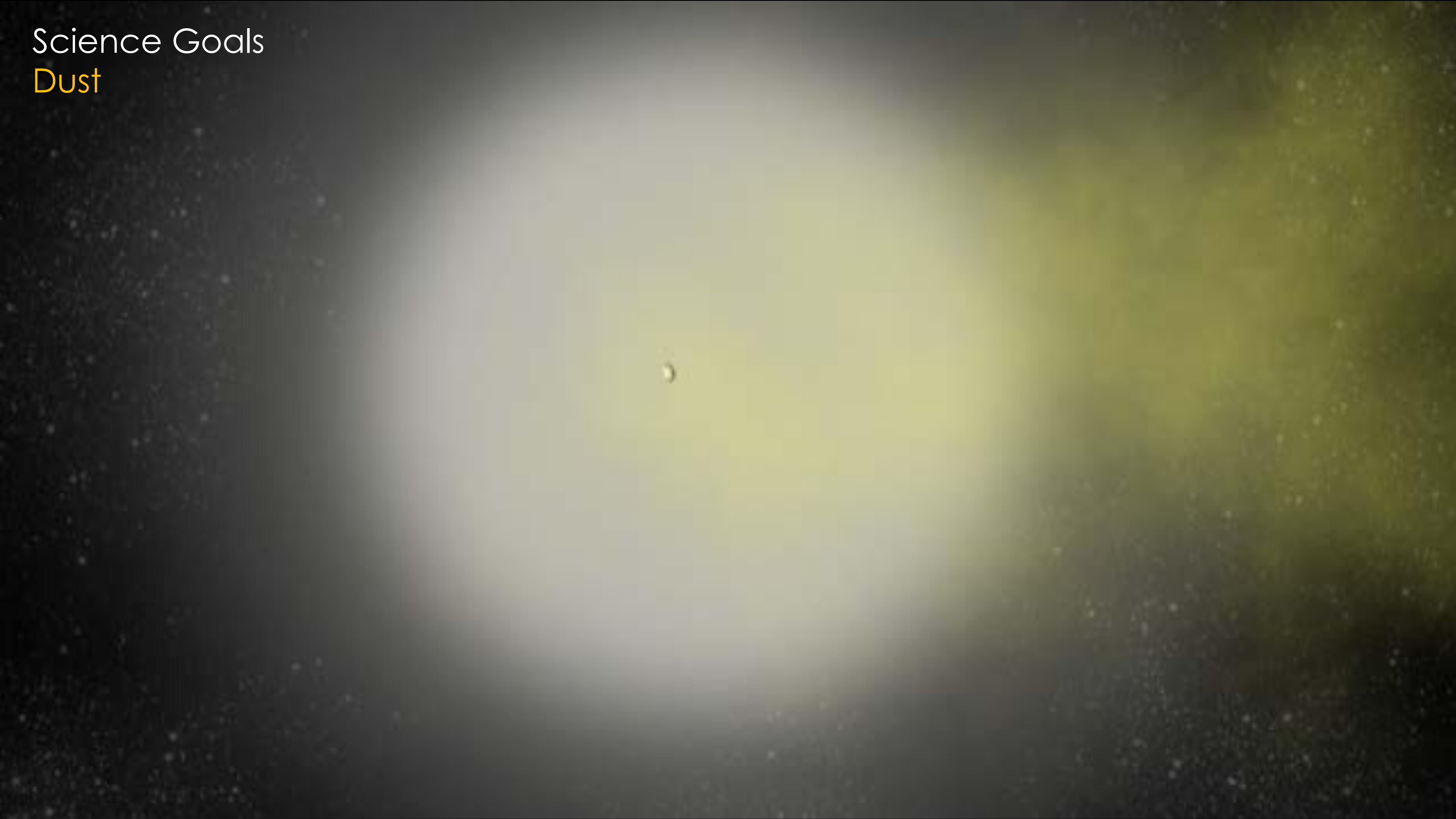
Science Goals

Nucleus



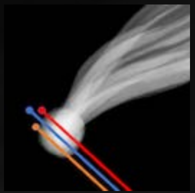
Science Goals
Neutral Coma

Science Goals
Dust



Science Goals
Plasma

Multiple Spacecraft Architecture



Comet Interceptor

- To separate time and space variations in coma
- Simultaneous coma + nucleus + particles & fields studies at different distances
- Separating safe / distant measurements and high risk / high gain close approaches

- A: main spacecraft
  - Passes sunward of comet at ~1000 km ('safe' distance)
  - Data relay for other spacecraft
  - Propulsion + communication
  - Minimum payload to ensure results even if other spacecraft fail

- B1: inner coma
  - Targeted to pass through inner coma
  - In-situ sampling of ions, nucleus + coma imaging
  - 3 axis stabilised

- B2: nucleus + coma
  - Targeted at nucleus (but unlikely to actually hit it)
  - Plasma environment, nucleus + coma imaging
  - Spin stabilised

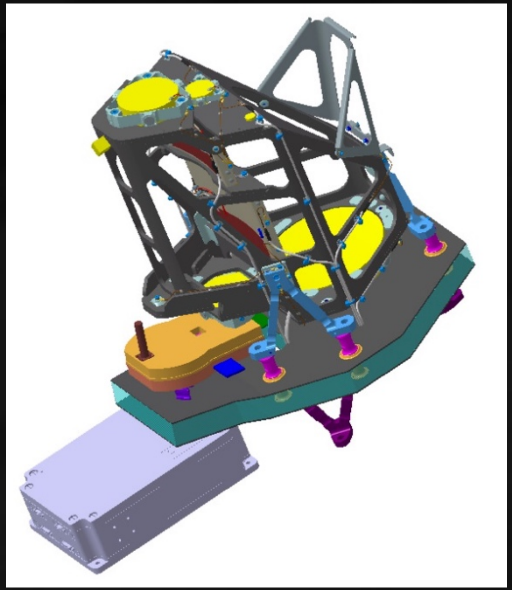
Payload - A

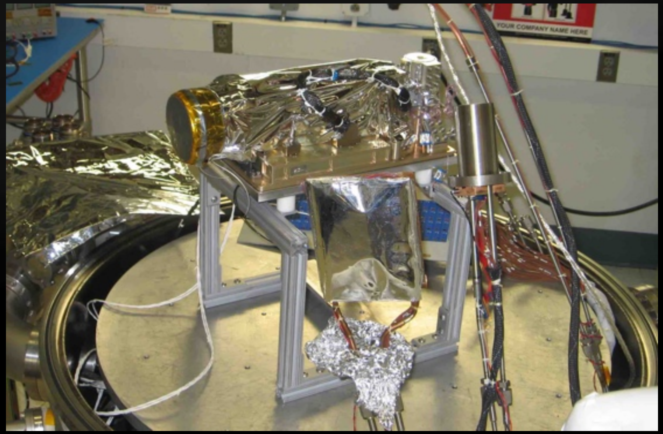
- CoCa – visible camera, based on TGO CaSSIS
  - Flight spare of CaSSIS, with filter wheel added

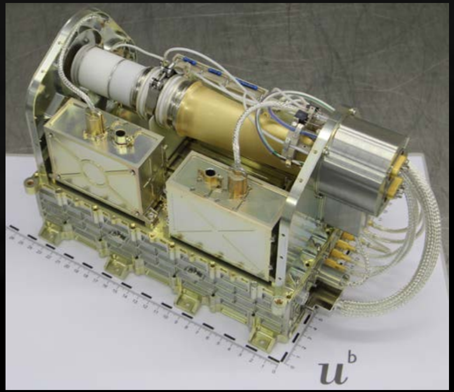
- MANIaC – mass spectrometer
  - Rosina heritage

- MIRMIS – IR camera
  - 1-1.5μm imaging channel
  - 2.5-5μm coma gasses point spectrometer channel
  - 6-20μm thermal IR imager

- Dust, Field, and Plasma (DFP) package
  - DISC – dust impact sensor
  - COMPLIMENT – plasma + E-field
  - FGM – magnetometers
  - LEES – electrons
  - SCIENA – ions & energetic neutrals

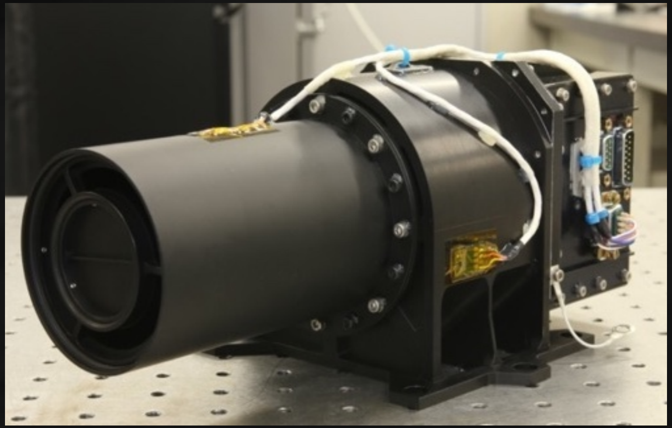


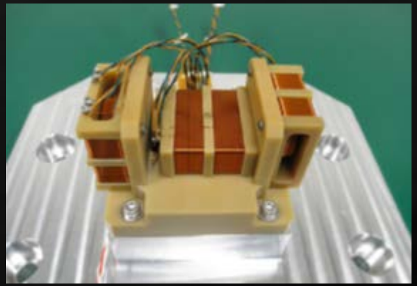


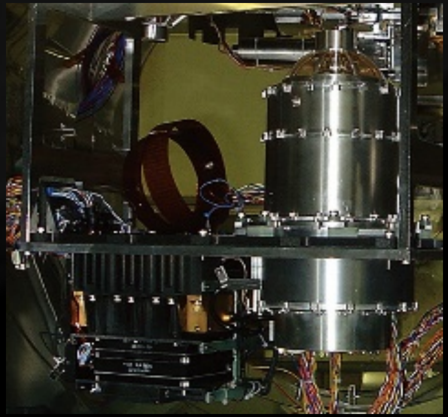


Payload – B1 (JAXA)

- Hydrogen Imager – FUV camera
  - Hydrogen maps via Ly-α, water production rate. Re-flight of PROCYON/LAICA
- Plasma suite (BepiColombo heritage)
  - MAG – magnetometer
  - ICA – ion mass spec (time of flight)
- Wide Angle Camera
  - 30-60deg, monochrome camera
- Narrow Angle Camera
  - Few metre resolution at closest approach, for 0.25s

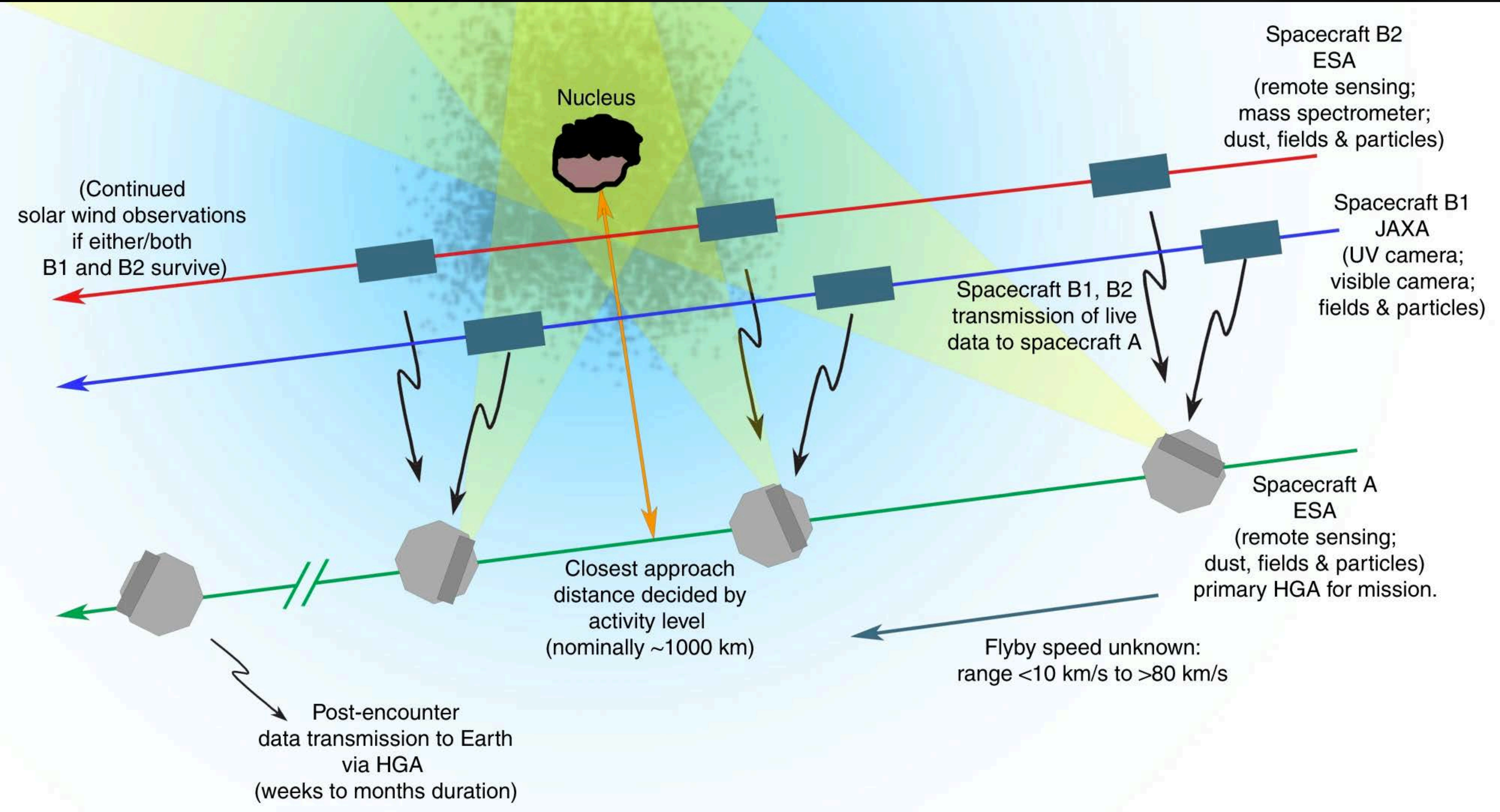




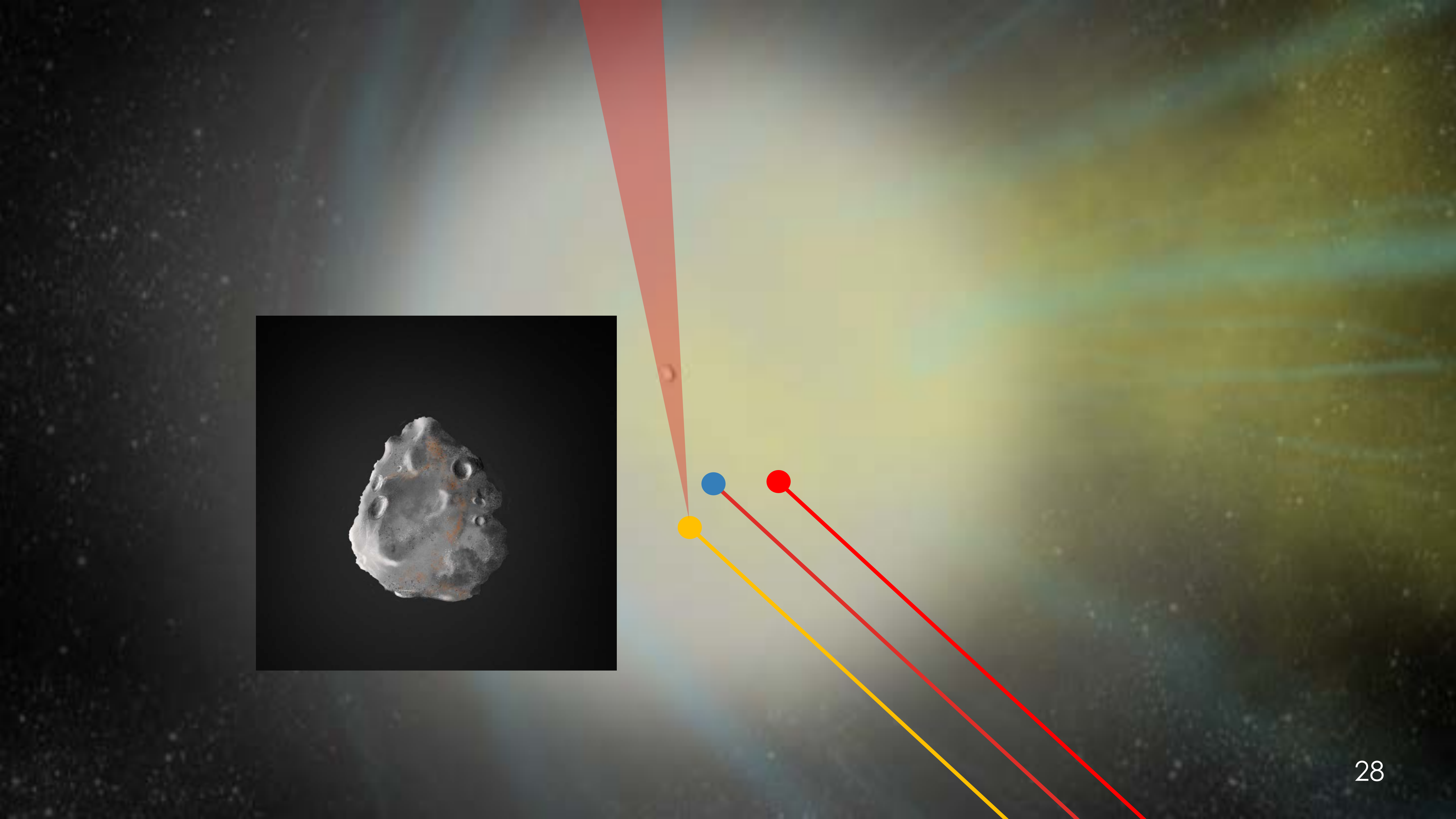


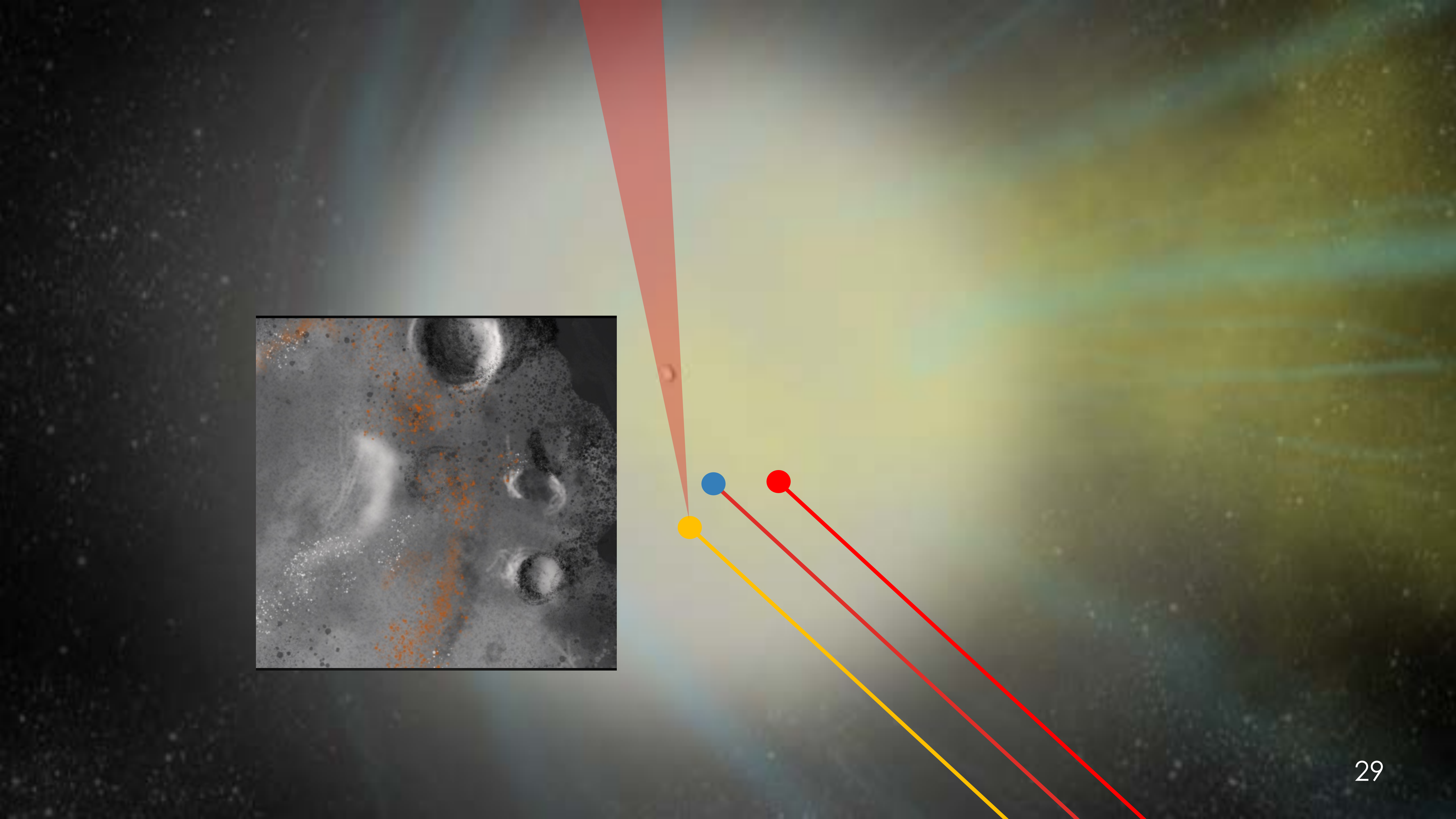
Payload – B2

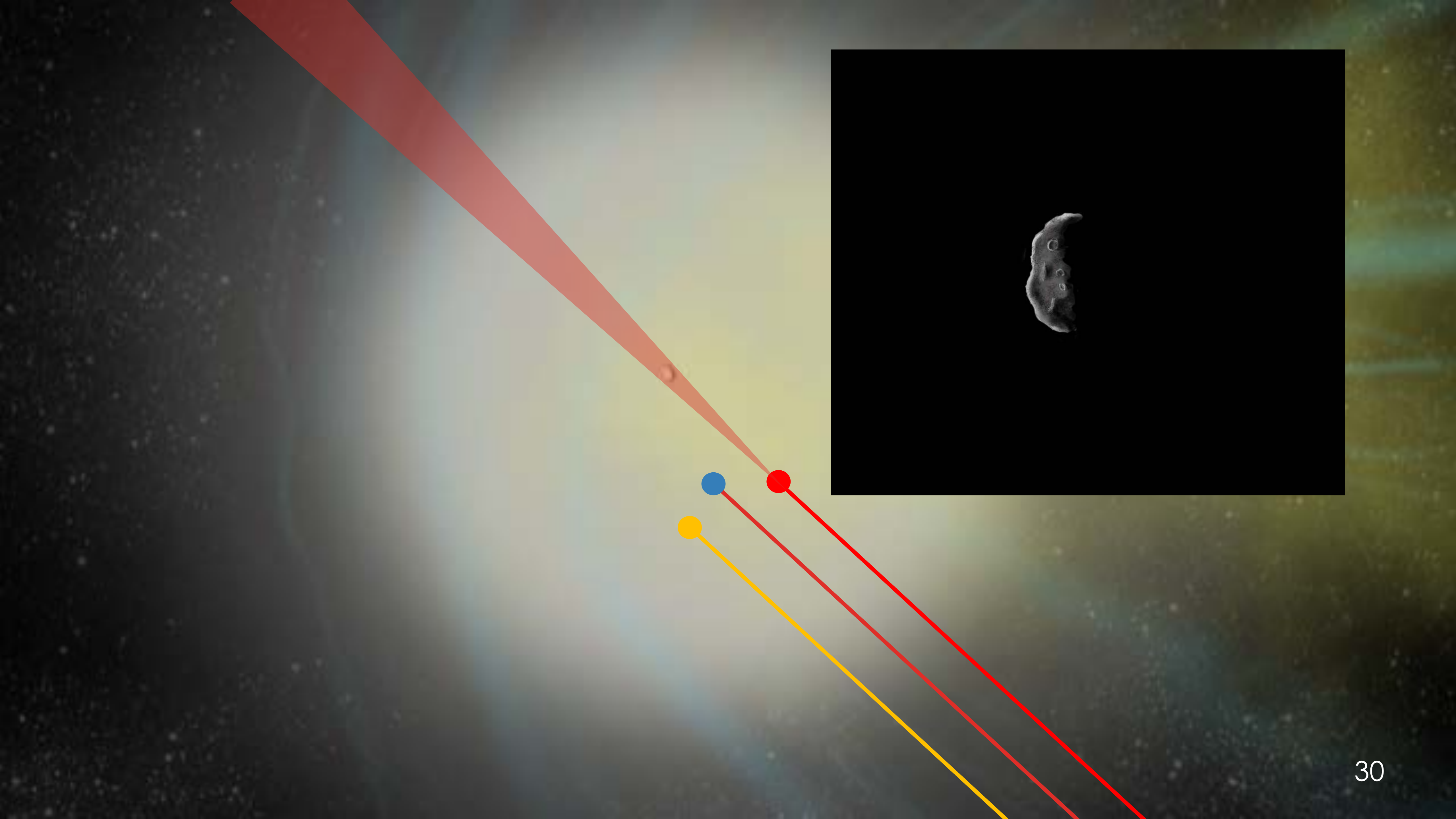
- EnVisS – coma mapping camera
  - Narrowband and polarimetric imaging filters, ~180deg stripe, scans whole sky
- OPIC – forward looking camera
  - Monochromatic visible camera
- DFP – B
  - DISC – dust impact sensor
  - FGM – magnetometers
  - COMPLIMENT – plasma + E-field (TBC)



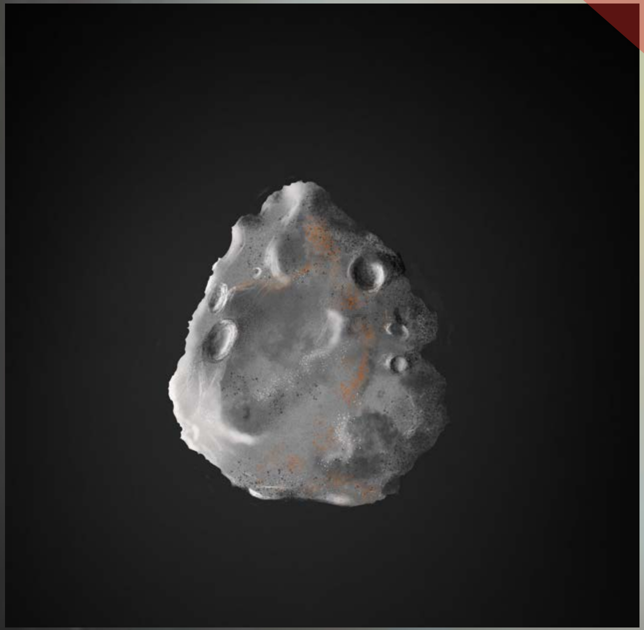
Spacecraft B2
ESA
(remote sensing;
mass spectrometer;
dust, fields & particles)
Nucleus
(Continued
solar wind observations
if either/both
B1 and B2 survive)
Spacecraft B1
JAXA
(UV camera;
visible camera;
fields & particles)
Spacecraft B1, B2
transmission of live
data to spacecraft A
Spacecraft A
ESA
(remote sensing;
dust, fields & particles)
primary HGA for mission.
Closest approach
distance decided by
activity level
(nominally ~1000 km)
Flyby speed unknown:
range <10 km/s to >80 km/s
Post-encounter
data transmission to Earth
via HGA
(weeks to months duration)







Multiple views of cometary nucleus: views from three spacecraft reveal 3D structure of nucleus and coma from a single flyby

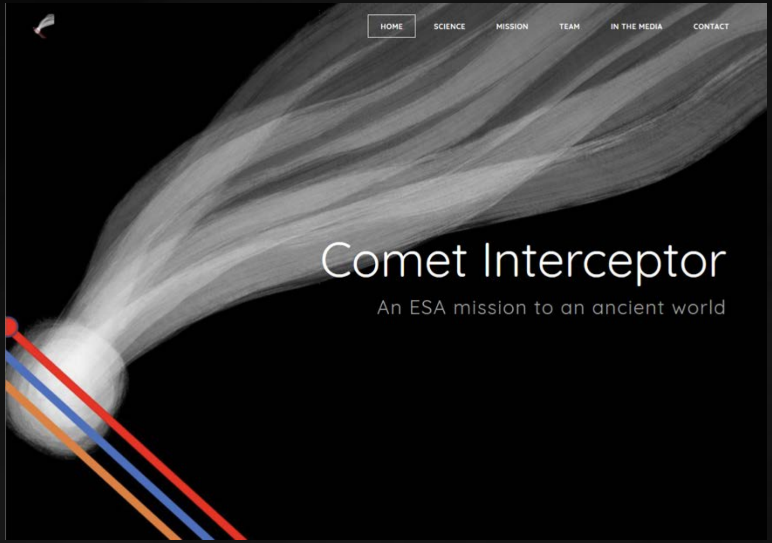


What has happened so far

- June-July 2019: initial Concurrent Design Facility study, ESTEC
- November 2019: Second CDF study
- ESA CDF studies have established a spacecraft and mission design that is feasible
- This will be used as the basis of the invitation to tender from ESA to industry

Comet Interceptor


NASA, ESA, and G. Bacon (STScI)



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