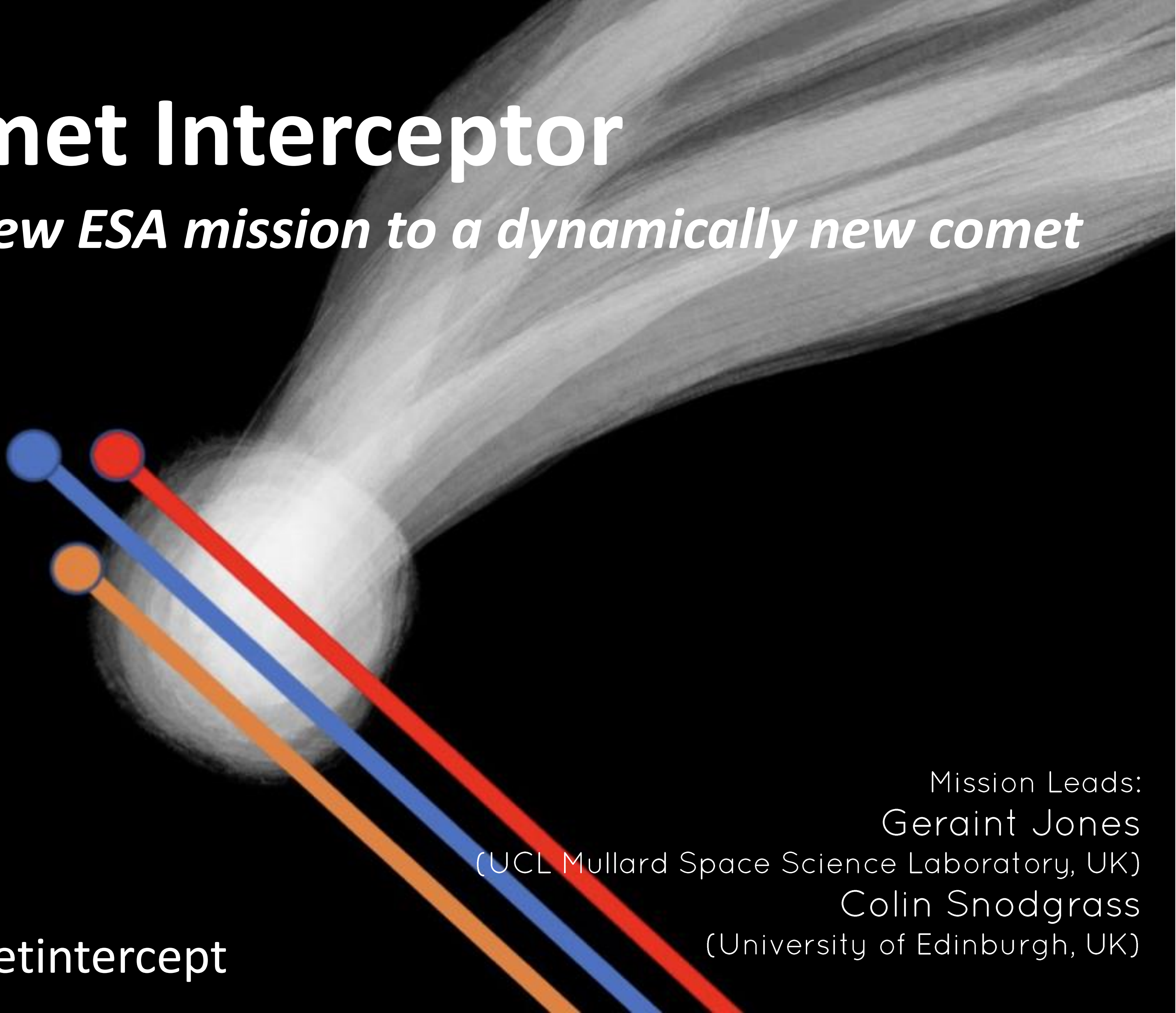
Comet Interceptor

The new ESA mission to a dynamically new comet



Mission Leads:
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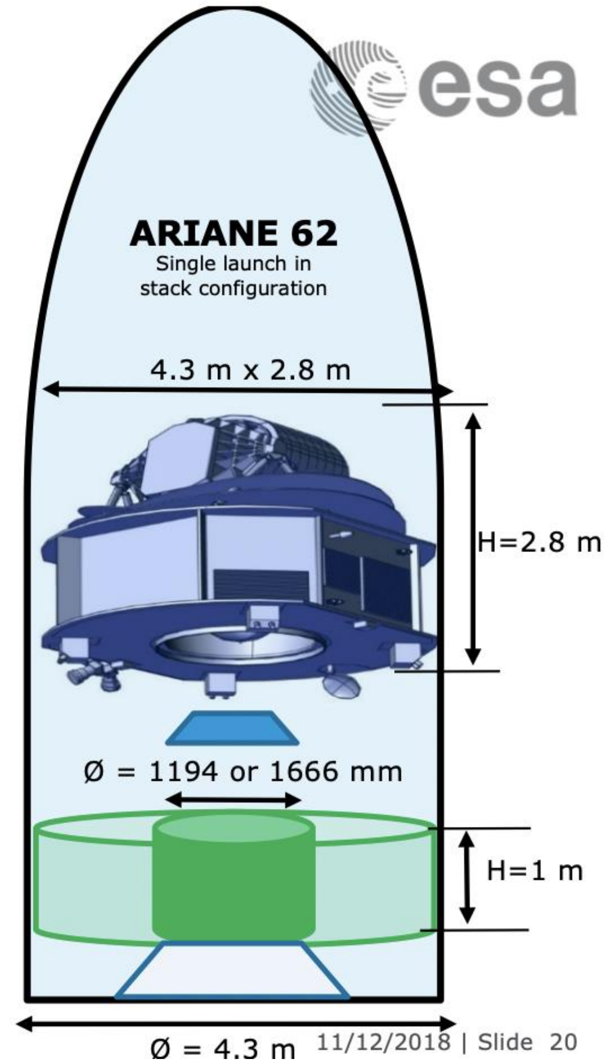
@cometintercept

Overview

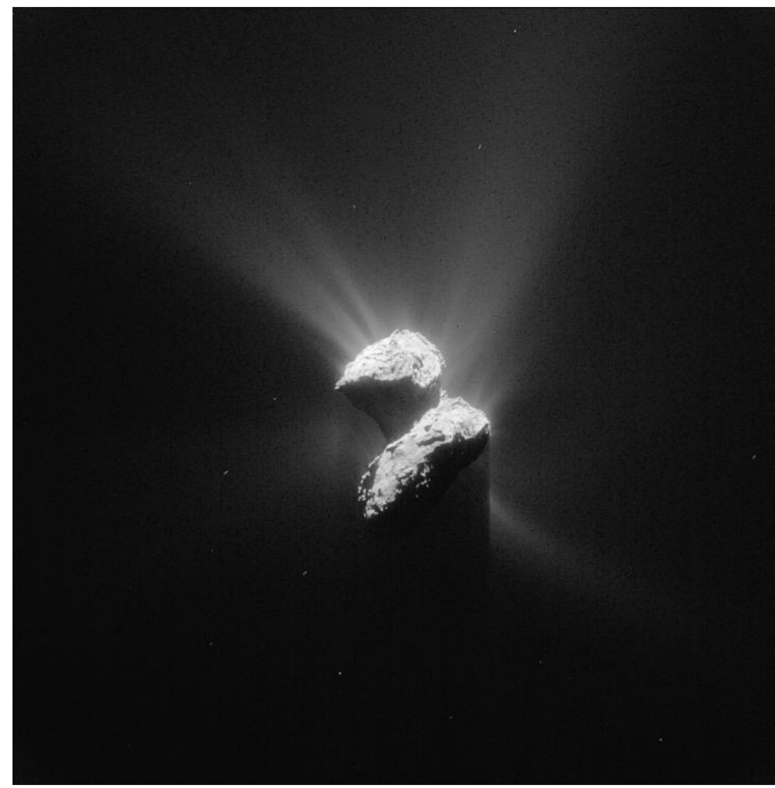
- On June 20 2019, **Comet Interceptor** was selected by ESA as its first F-class mission.
- Maximum cost to ESA at completion, excluding launch: €150M.
- ESA member states and other collaborating agencies generally fund instruments and the science teams.
- Shared launch with Ariel exoplanet telescope, to Sun-Earth L2 point, in 2028
  - Limits on mass (originally 1000 kg, now 800 kg)
  - Must fit underneath Ariel, and be designed to support it during launch

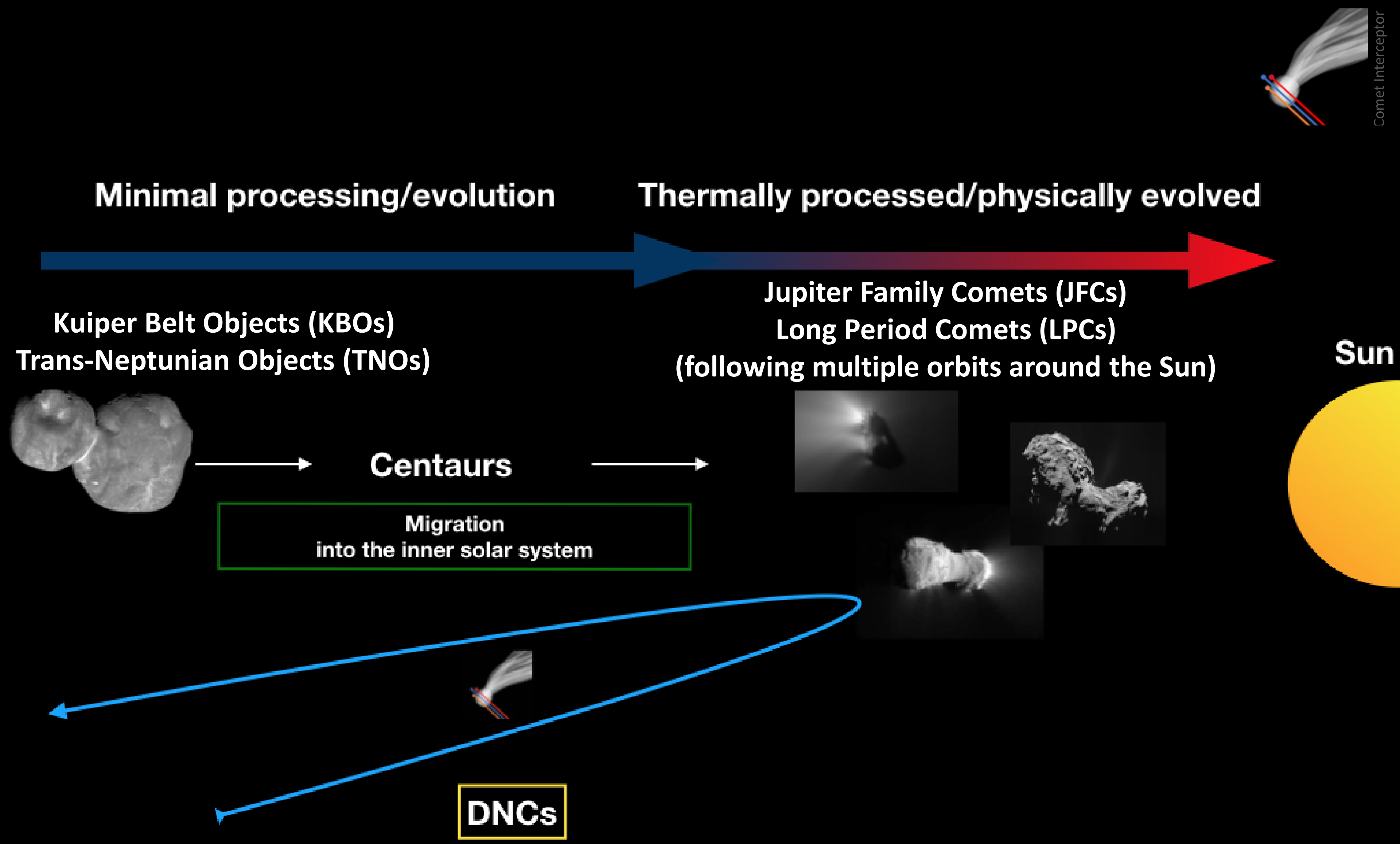


Comet Interceptor is a mission targeting a dynamically-new comet, or an interstellar object.

Why?

- All previous comet missions have been to objects that have passed the Sun many times
- Targets were relatively evolved, with thick dust mantles
- A dynamically-new comet (DNC) is one that is probably nearing the Sun for the first time
- A mission to a DNC would encounter a pristine comet, with surface ices as first laid down at the Solar System’s formation

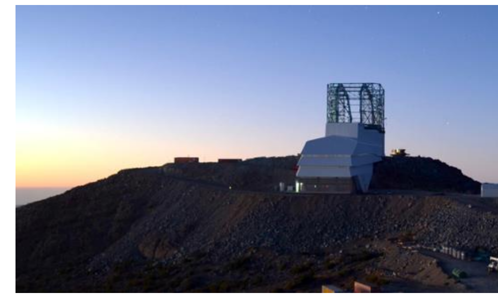



Comet Interceptor
Minimal processing/evolution
Thermally processed/physically evolved
Kuiper Belt Objects (KBOs)
Trans-Neptunian Objects (TNOs)
Jupiter Family Comets (JFCs)
Long Period Comets (LPCs)
(following multiple orbits around the Sun)
Sun
Centaurs
Migration
into the inner solar system
DNCs

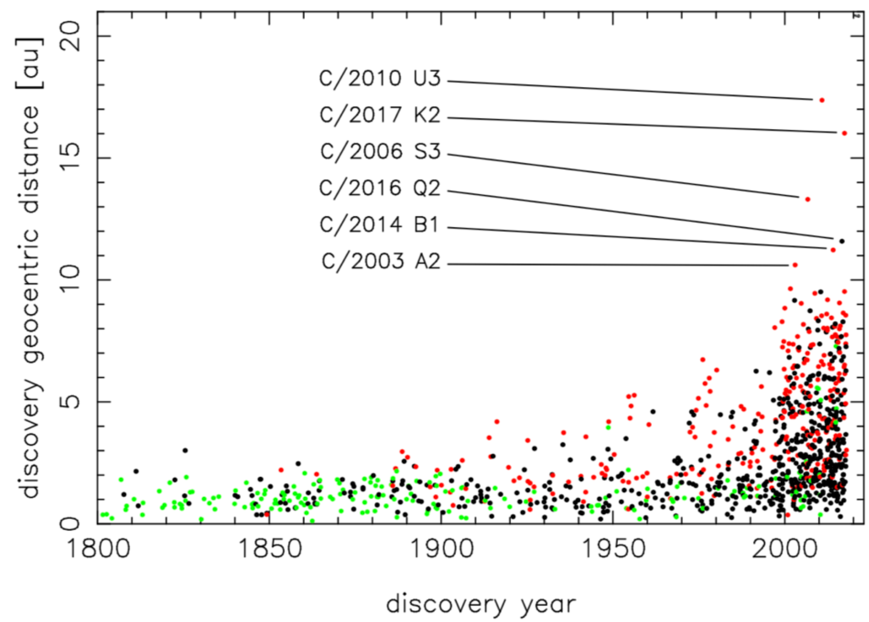
Comet Interceptor is a mission targeting a dynamically-new comet, or an interstellar object.

How?

- The only way to encounter a DNC 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 LSST – the *Large Synoptic Survey Telescope*
    - LSST probably won't increase the number of DNCs found every year, but will increase the distance at which they're discovered inbound
- Comet Interceptor spacecraft can wait in dynamically-stable location L2 until the target is found

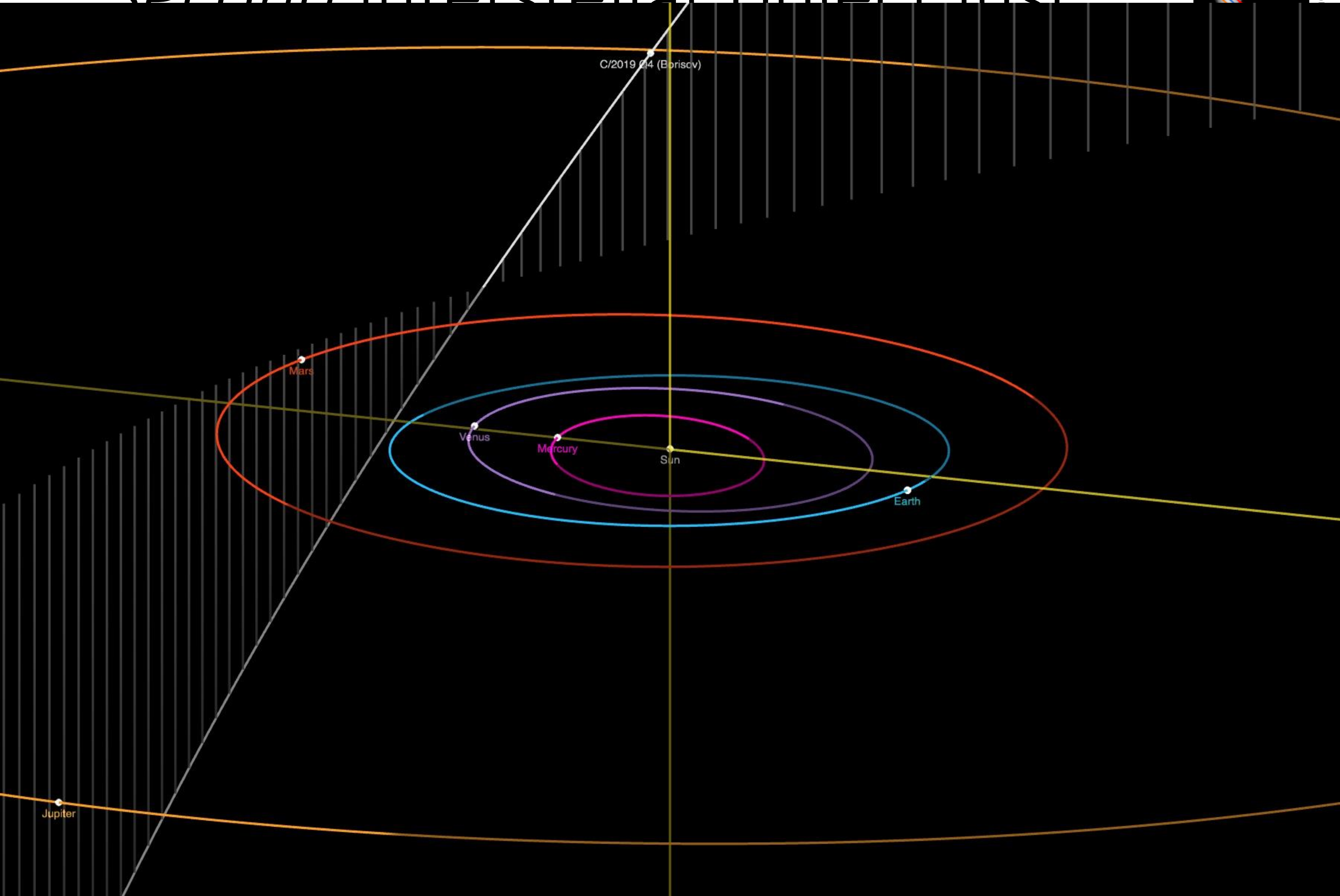


LSST Project/NSF/AURA



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

Second interstellar object just



et Interceptor

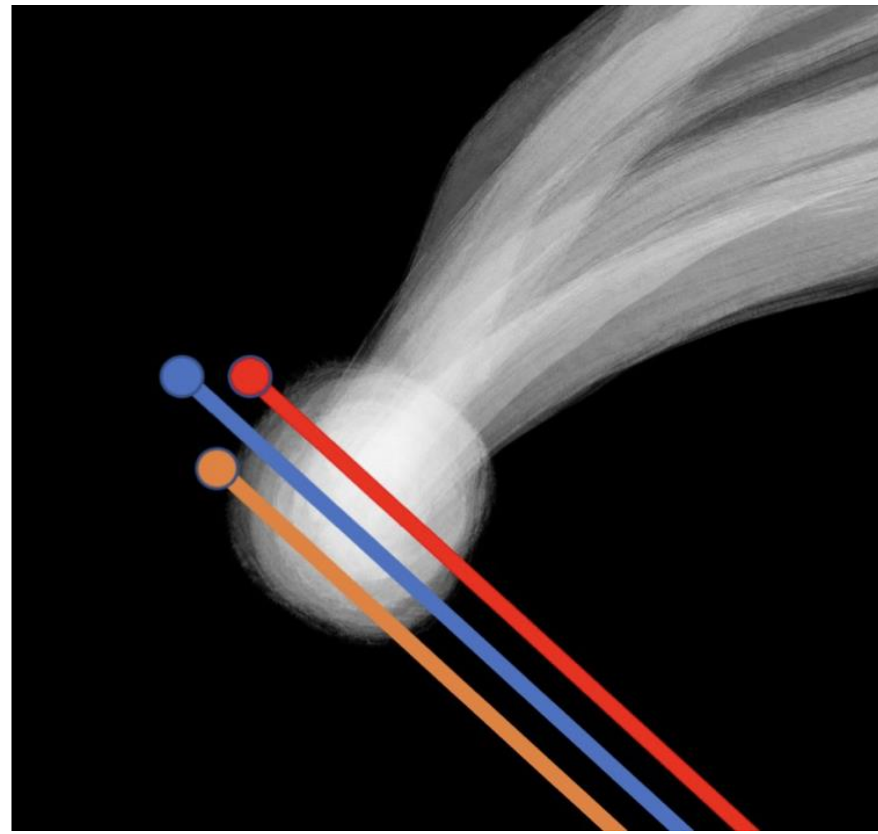
Multiple spacecraft architecture

Comet Interceptor

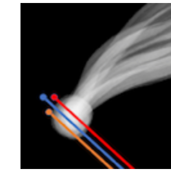
- F-class call encouraged multi-point measurements

- Very useful at a comet:
    - To separate time and space variation in coma
    - To enable simultaneous coma + nucleus + magnetic fields studies at different distances

- Also useful in flyby case, separating safe / distant measurements and high risk / high gain close approaches



New Science



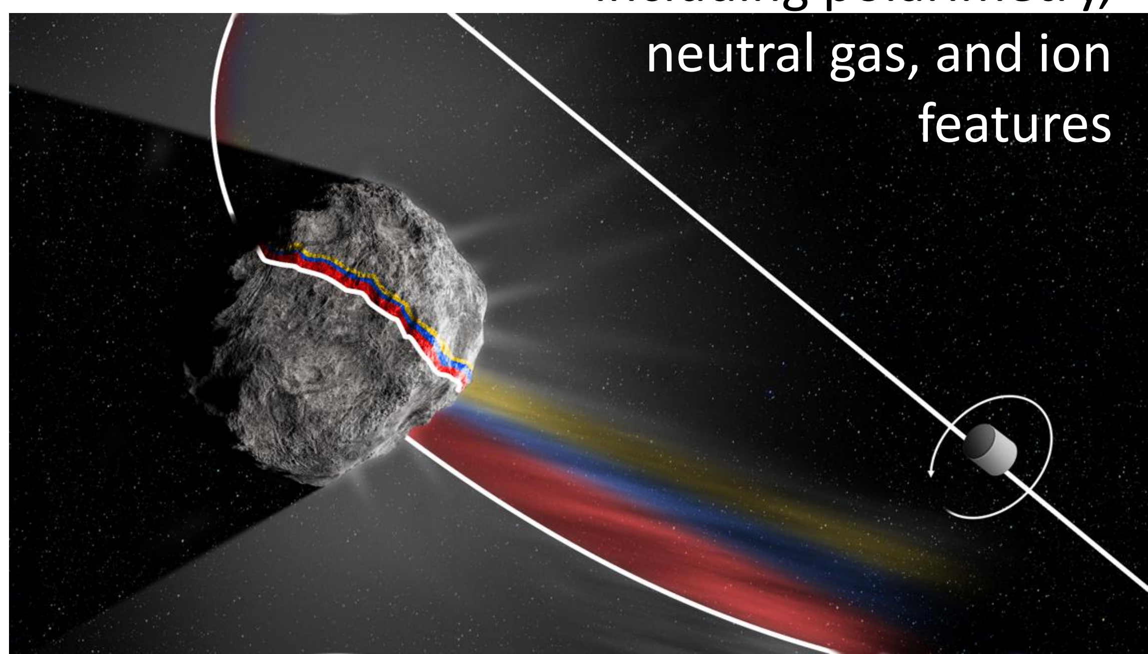
Comet Interceptor

- **Multi-point measurements** of cometary environment, including plasma: separation of spatial and temporal effects.

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

- **Entire Visible Sky** (EnVisS): Multispectral and polarimetric mapper All-sky view of dust, including polarimetry, neutral gas, and ion features

- **Energetic Neutral Atoms**: first observations of solar wind-neutral charge exchange processes at a comet

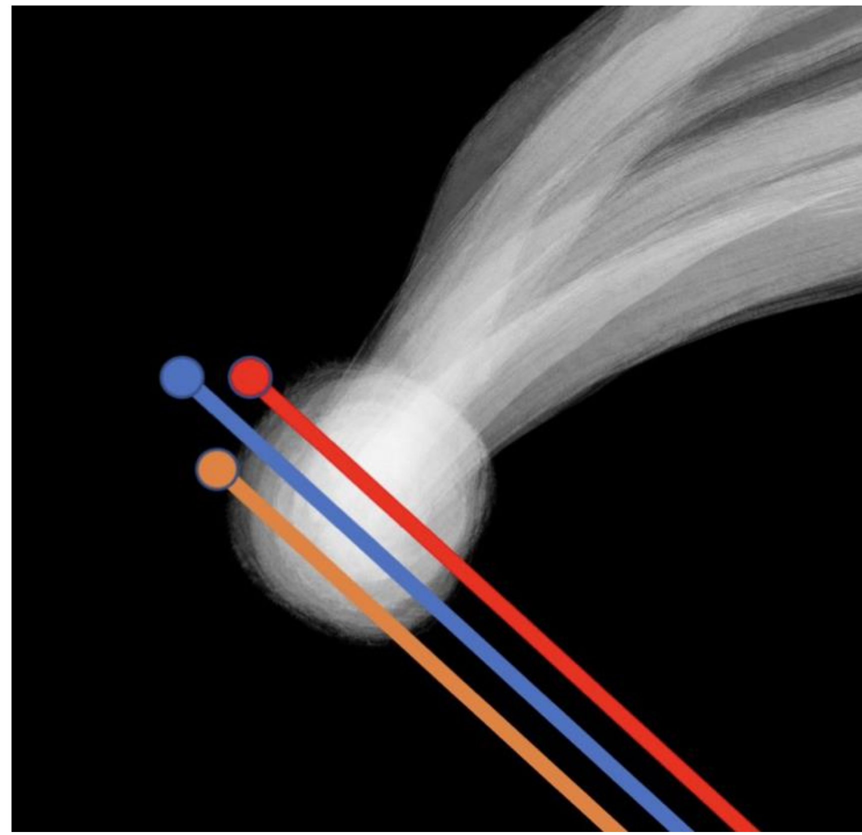


Multiple spacecraft architecture

- A: main spacecraft (ESA)
  - 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 (JAXA)
  - Targeted to pass through inner coma
  - Will probably survive encounter
  - In-situ sampling, coma imaging
  - 3 axis stabilised, ~24U sized

- B2: nucleus + coma (ESA)
  - Targeted at nucleus (but unlikely to actually hit it)
  - May survive, but designed to be expendable
  - In-situ sampling, nucleus + coma imaging
  - Spin stabilised, no AOCS

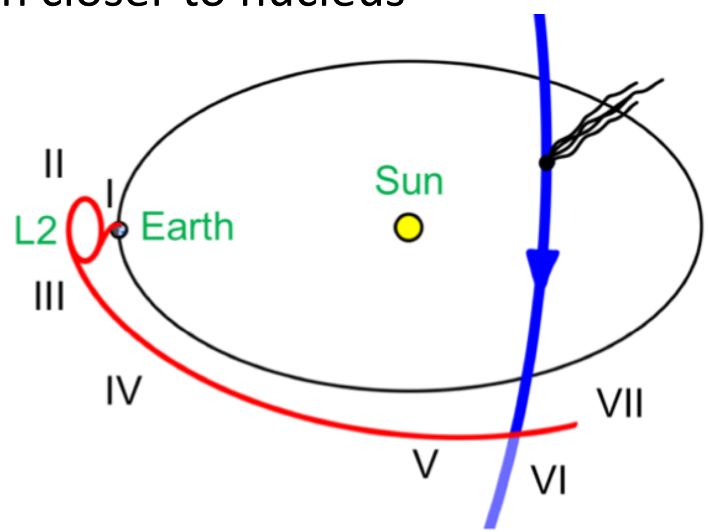


Mission Profile

- Mission ‘parked’ at L2 after launch with Ariel, waits for new target discovery by LSST or other ground-based survey (2-3 years)
- Short cruise and fast flyby near 1 AU
  - Encounter location within a restricted heliocentric distance range, for thermal and power reasons
- Encounter has to take place close to the ecliptic – each comet crosses the ecliptic at two locations
- Mothership with remote sensing payload, distant ‘safe’ flyby (few 1000 km)
- Released sub-spacecraft take instruments on different trajectories through coma, including much closer to nucleus

Mission Phases

I	Launch & delivery to L2
II	Station-keeping at L2
III	Departure from L2
IV	Cruise and instrument commissioning
V	Separation of spacecraft elements
VI	Target Encounter
VII	Data playback and solar wind studies, if possible



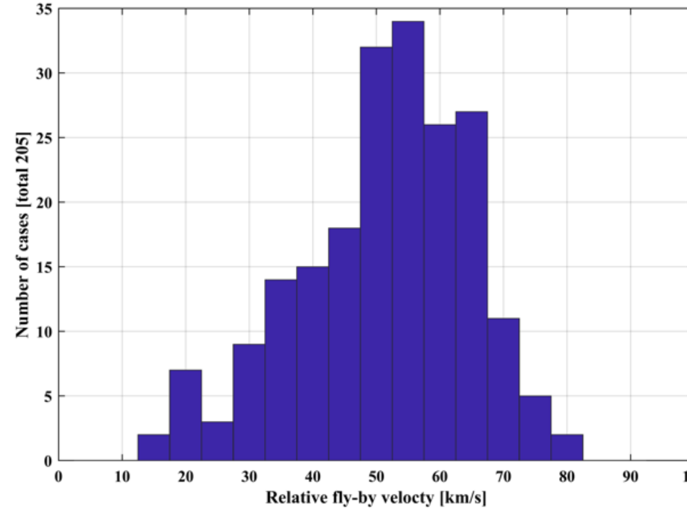
Not to scale

Comet Interceptor

Challenges and Solutions

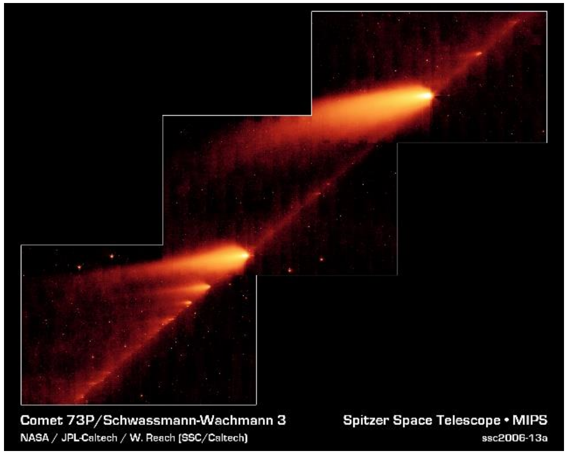
CHALLENGES

- 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 (increases risk of dust impact damage)– have to design for this scenario
- Cost means that entire mission should be < 5 years



SOLUTIONS

- Spacecraft design can cope with range of different encounter geometries – no HGA 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.
  Mission to short period comet will carry out new science: not repeat of previous missions.

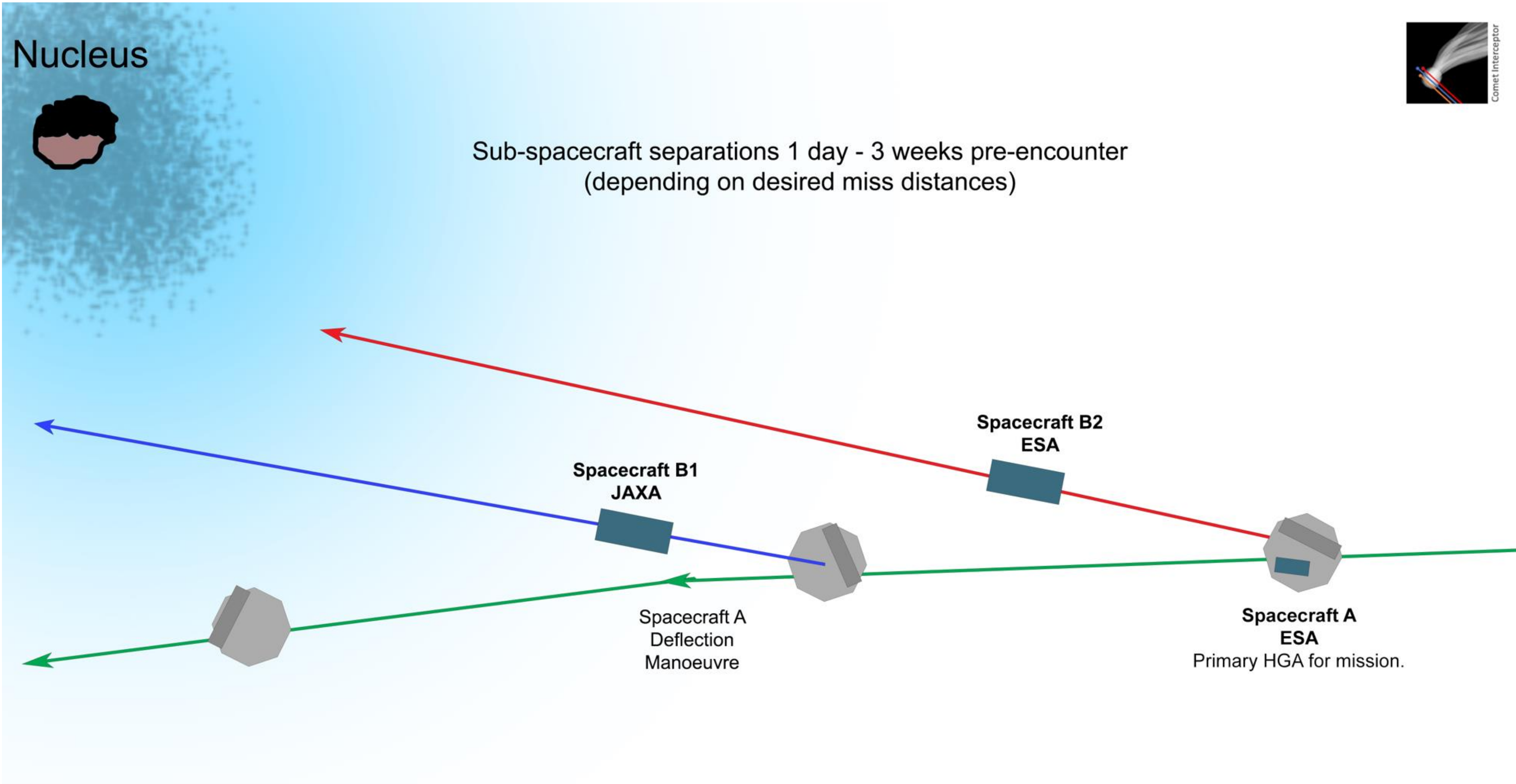


Interstellar Targets?

- 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
  - but they assume a much higher delta-v than is realistic for comet interceptor (dedicated Falcon-Heavy launch)
- Possibly different science if low activity like ‘Oumuamua, but would be hard to turn down such an opportunity
- Payload optimized for DNC, but would still be useful at ‘Oumuamua

ESO/M.Kornmesser

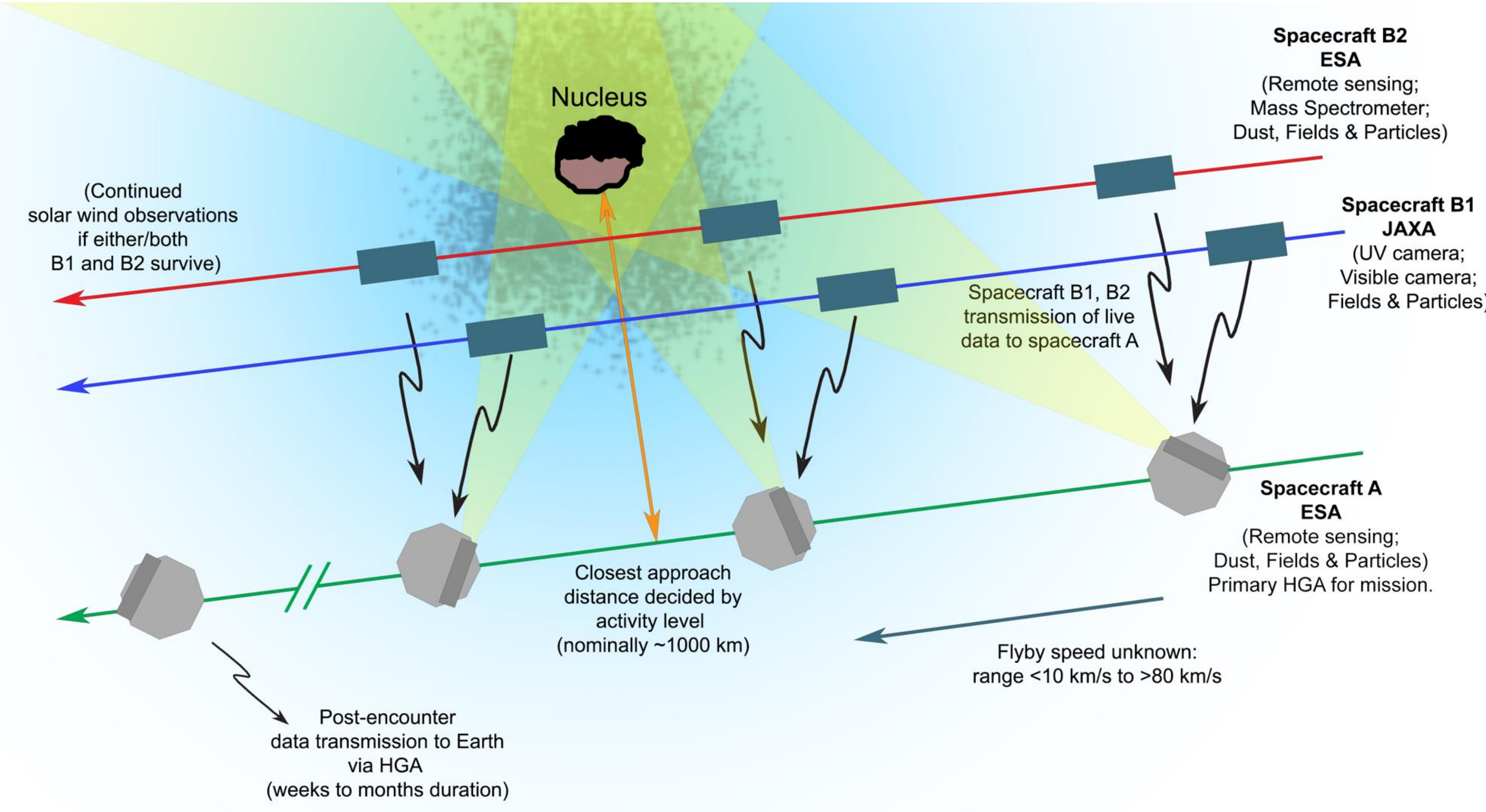
Proposed Spacecraft Separation Scenario



For simplicity and to minimize cost, sub-spacecraft B2 will be spin-stabilized, no attitude and orbital control systems.

Close Encounter Scenario

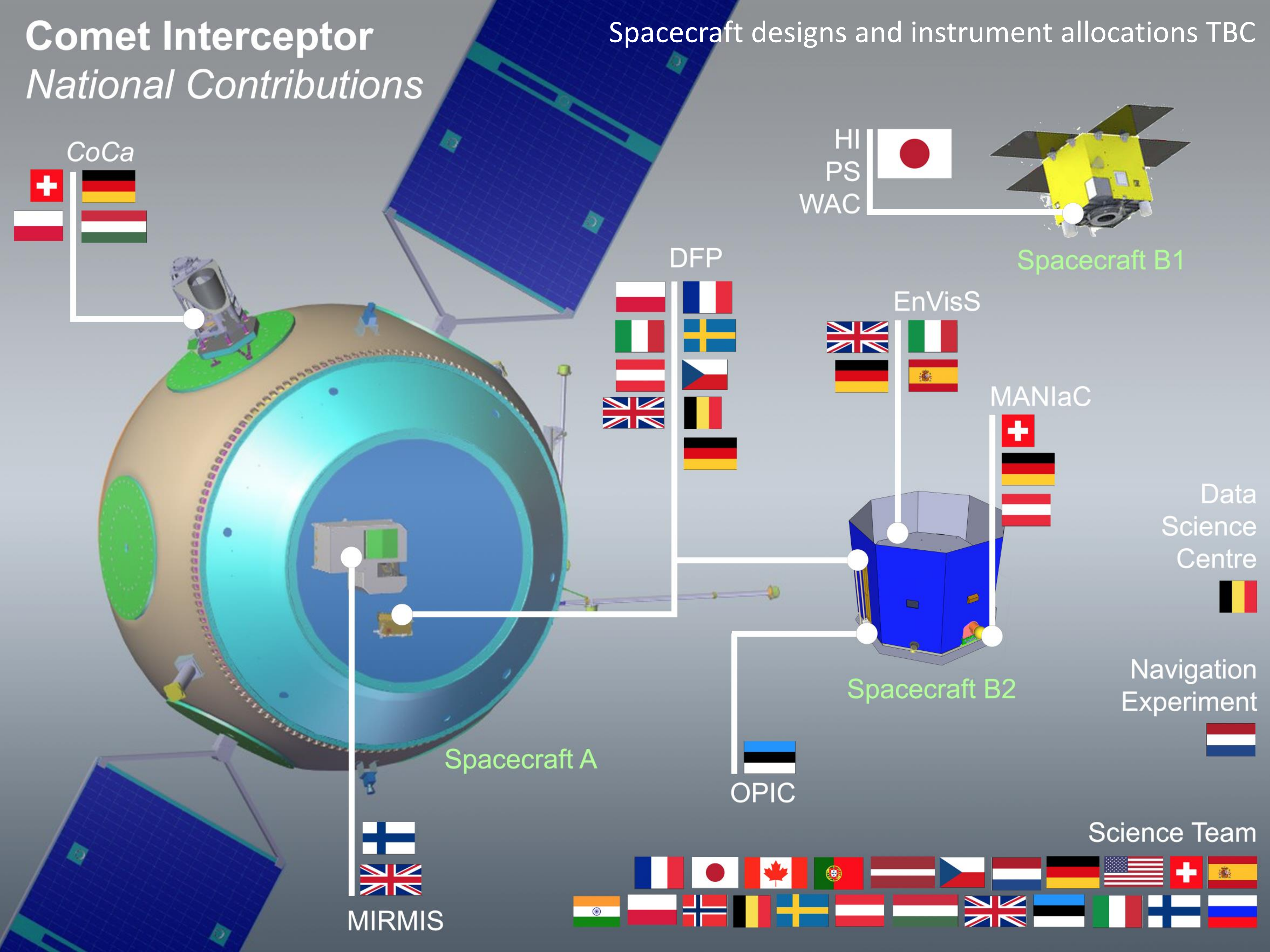
Comet Interceptor



Proposed payload

Spacecraft	Instrument	Description
A ESA	CoCa	Visible/NIR imager
	MIRMIS	NIR/Thermal IR spectral imager
A / B2 ESA	DFP	Dust, Fields & Plasma (similar on A and B2)
B2 ESA	MANIaC	Mass spectrometer
	EnVisS	All-sky multispectral visible imager
	OPIC	Visible/NIR imager
B1 JAXA	HI	Lyman-alpha Hydrogen imager
	PS	Plasma Suite
	WAC	Wide Angle Camera

- F-class call constraints required high TRL instrumentation: a minimum TRL of 5/6 attainable by the end of 2019
- Proposed payload has strong heritage from past missions and instruments already developed/built for future missions



Comet Interceptor
National Contributions
Spacecraft designs and instrument allocations TBC
CoCa
HI
PS
WAC
Spacecraft B1
DFP
EnVisS
MANIaC
Data Science Centre
Navigation Experiment
Spacecraft B2
OPIC
Spacecraft A
MIRMIS
Science Team

Comet Interceptor Team

Mission Proposal Lead: Prof. Geraint Jones, UCL Mullard Space Science Laboratory, UK
Mission Proposal Deputy Lead: Dr. Colin Snodgrass, University of Edinburgh, UK

The Comet Interceptor team comprises an international group of 130 scientists and engineers from 68 institutions and 24 countries (in Europe, USA and Japan)

What Next?

- Following selection, a Concurrent Design Facility (CDF) study initiated
- Instrument designs being refined and discussed with ESA
- Second CDF study later in 2019
- Industrial call for proposals in 2020


Hardware Team Meeting
September 6, Edinburgh

Interested?

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