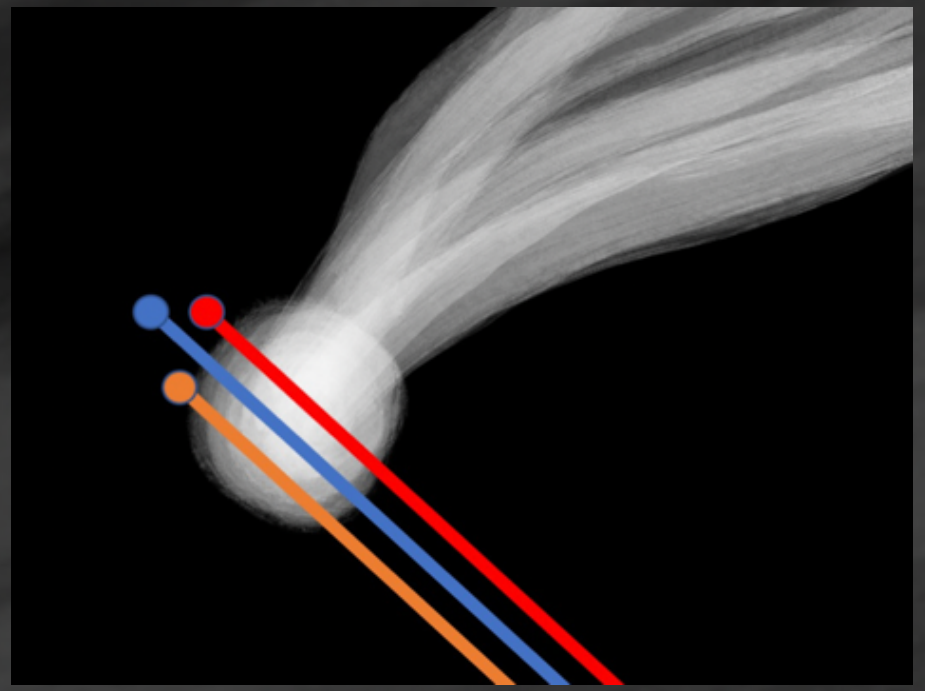
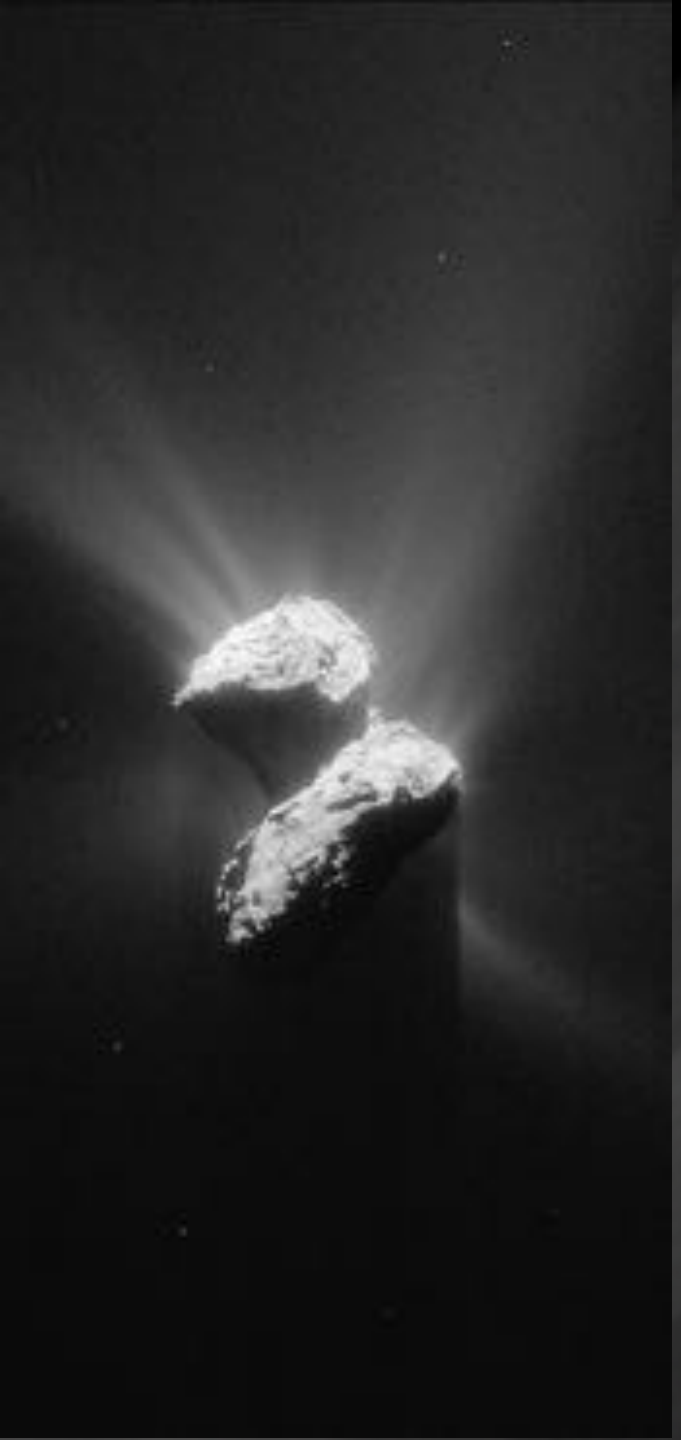
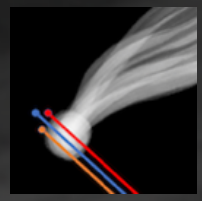
The importance of LSST to ESA's Comet Interceptor mission



@cometintercept

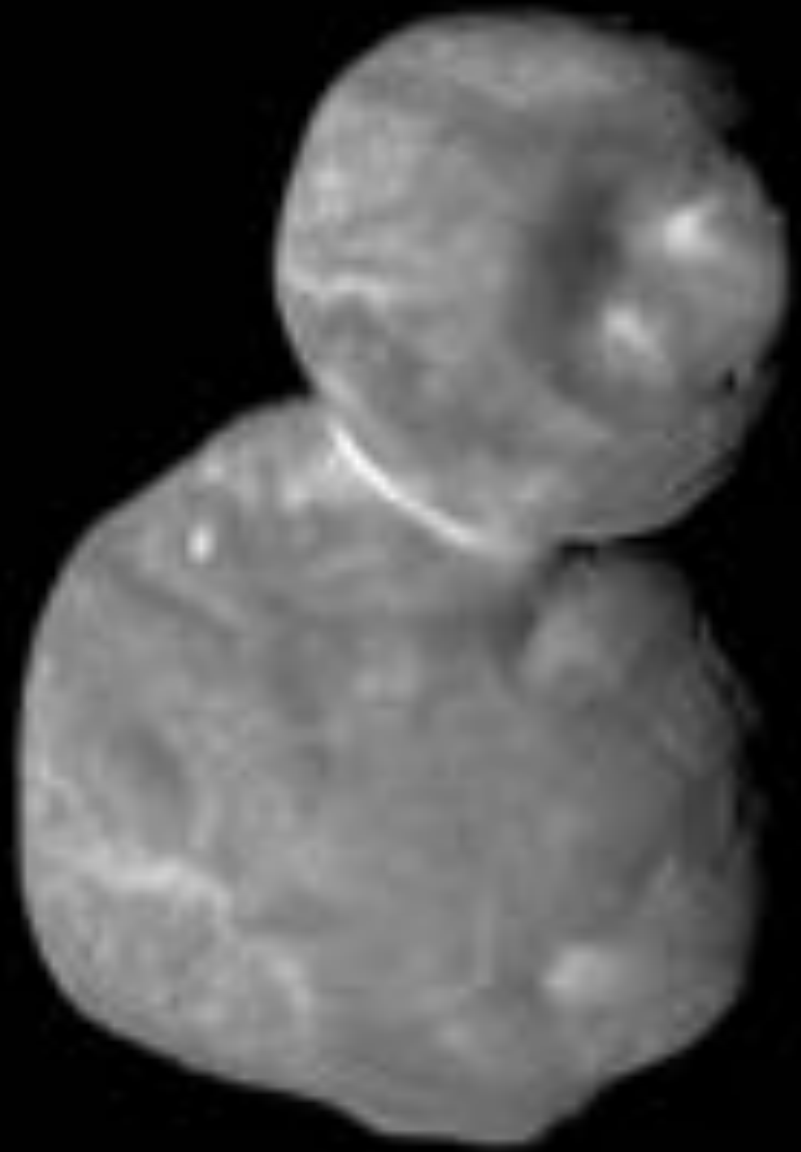


Comet Interceptor is a mission targeting a long-period comet, preferably dynamically-new, or an interstellar object.



Why?

- All previous comet missions have been to objects that have passed the Sun many times
- Those comets have changed over time, and are covered in a thick layer of dust
- A dynamically-new comet is one that is probably nearing the Sun for the first time
- These are **pristine**



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

ESA / Rosetta / MPS for OSIRIS Team; MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA

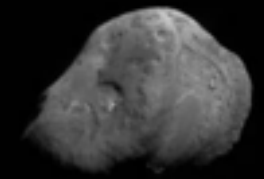
1P/Halley
16 × 8 × 8 km
Vega 2, 1986

81P/Wild 2
5.5 × 4.0 × 3.3 km
Stardust, 2004

67P/Churyumov-Gerasimenko
4 × 3 km
Rosetta, 2014

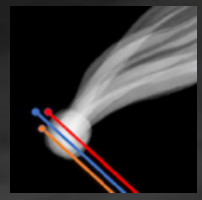
103P/Hartley 2
2.2 × 0.5 km
Deep Impact/EPOXI, 2010

19P/Borrelly
8 × 4 km
Deep Space 1, 2001



9P/Tempel 1
7.6 × 4.9 km
Deep Impact, 2005

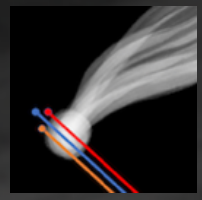
Halley: Russian Academy of Sciences / Ted Stryk. Tempel 1 and Hartley 2: NASA / JPL / UMD. Borrelly: NASA / JPL / Ted Stryk. Wild 2: NASA / JPL. Montage by Emily Lakdawalla.



Comet Interceptor

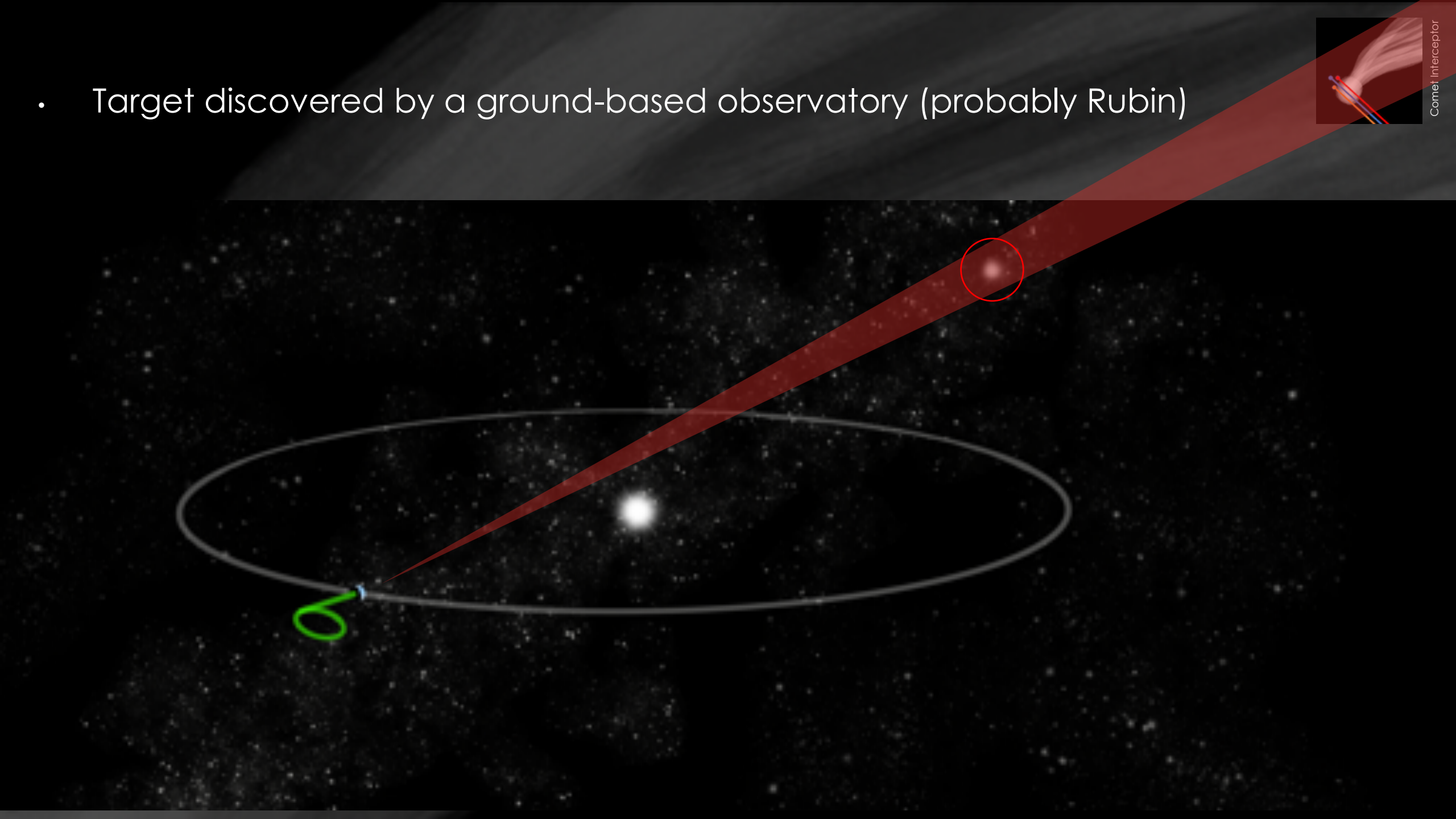
- New comets are unknown targets, can't plan and build mission years in advance
- Need to build a flexible mission and pick the target later
- ~few years warning, best way is to launch and wait in space
- ESA's first F-class mission gives an opportunity to do this:
  - Shared launch with Ariel to Sun-Earth L2 point
  - Wait
  - Set off on intercept course when comet discovered
  - Fast fly-by reconnaissance – first view of a new comet

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

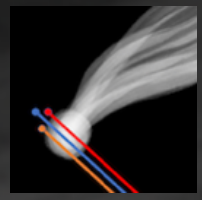


Comet Interceptor

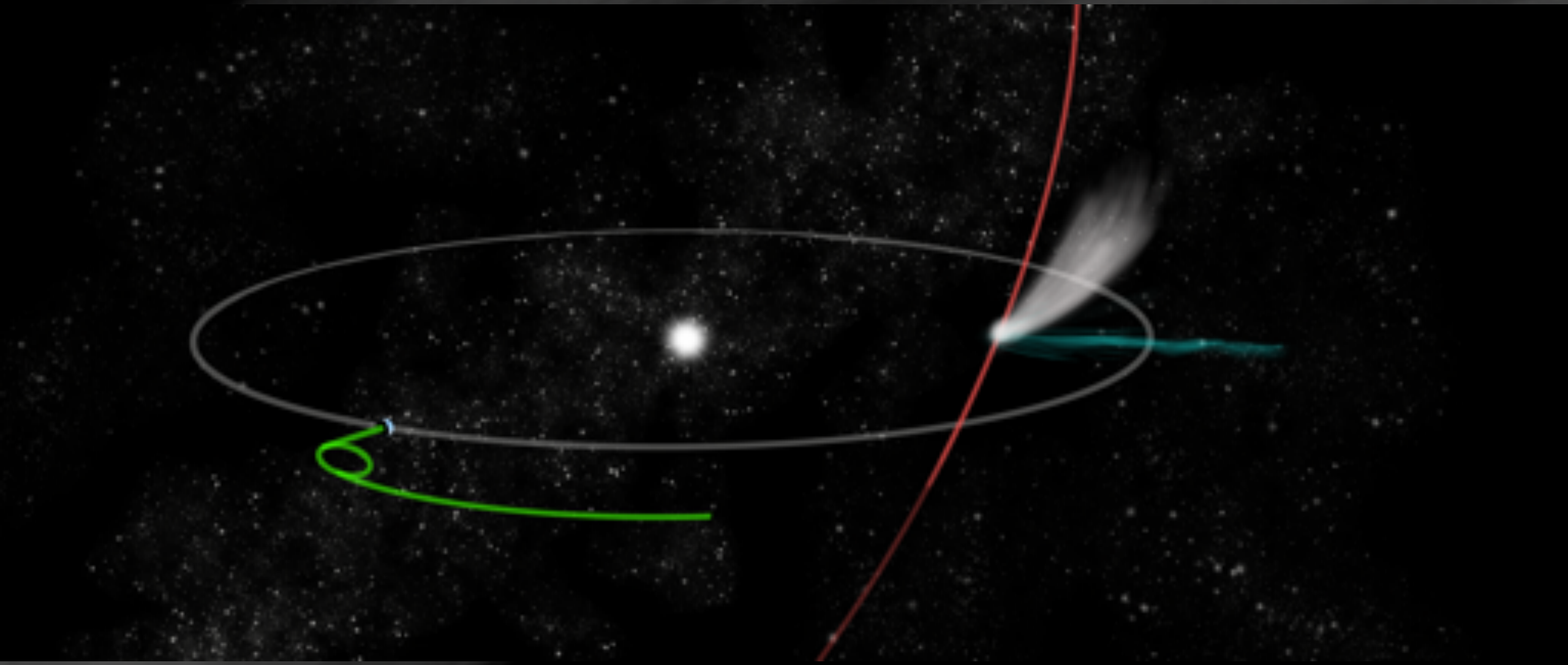
- Target discovered by a ground-based observatory (probably Rubin)

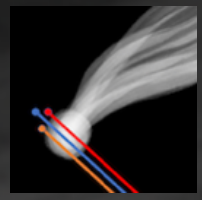


- Orbit computed and ecliptic crossing point predicted



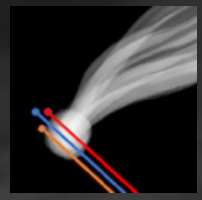
- Comet Interceptor leaves L2 to intercept comet's path



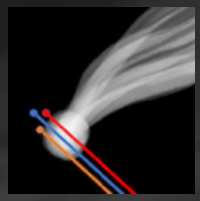


Comet Interceptor

- Encounter with comet close to the ecliptic plane

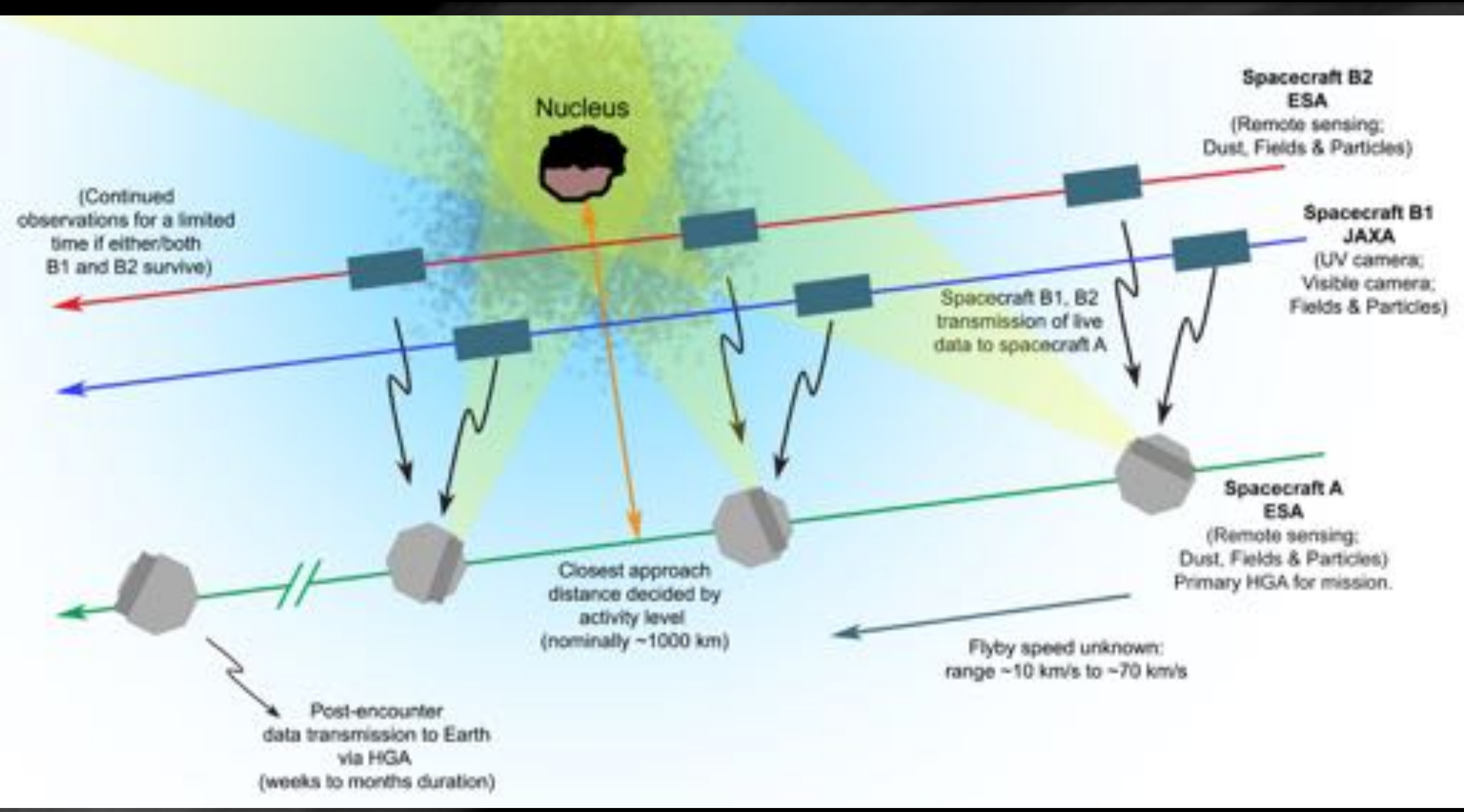


A Multi-Spacecraft Mission

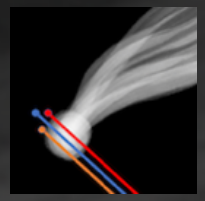

Comet Interceptor

- A: main spacecraft — safe / distant measurements
- B1: inner coma
- B2: nucleus + coma

→ higher risk / high gain
closer approaches
to nucleus


Nucleus
Spacecraft B2
ESA
(Remote sensing;
Dust, Fields & Particles)
(Continued
observations for a limited
time 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 ~70 km/s
Post-encounter
data transmission to Earth
via HGA
(weeks to months duration)

Example – C/2001 Q4 (NEAT)

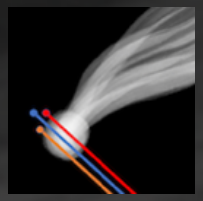


- Based on previous bright dynamically-new comet
- Real comet found ~3 years out
- VRO-LSST would have found it ~8 years out
- Target would have been known before launch
- ~1.5 year wait
- ~3 year cruise

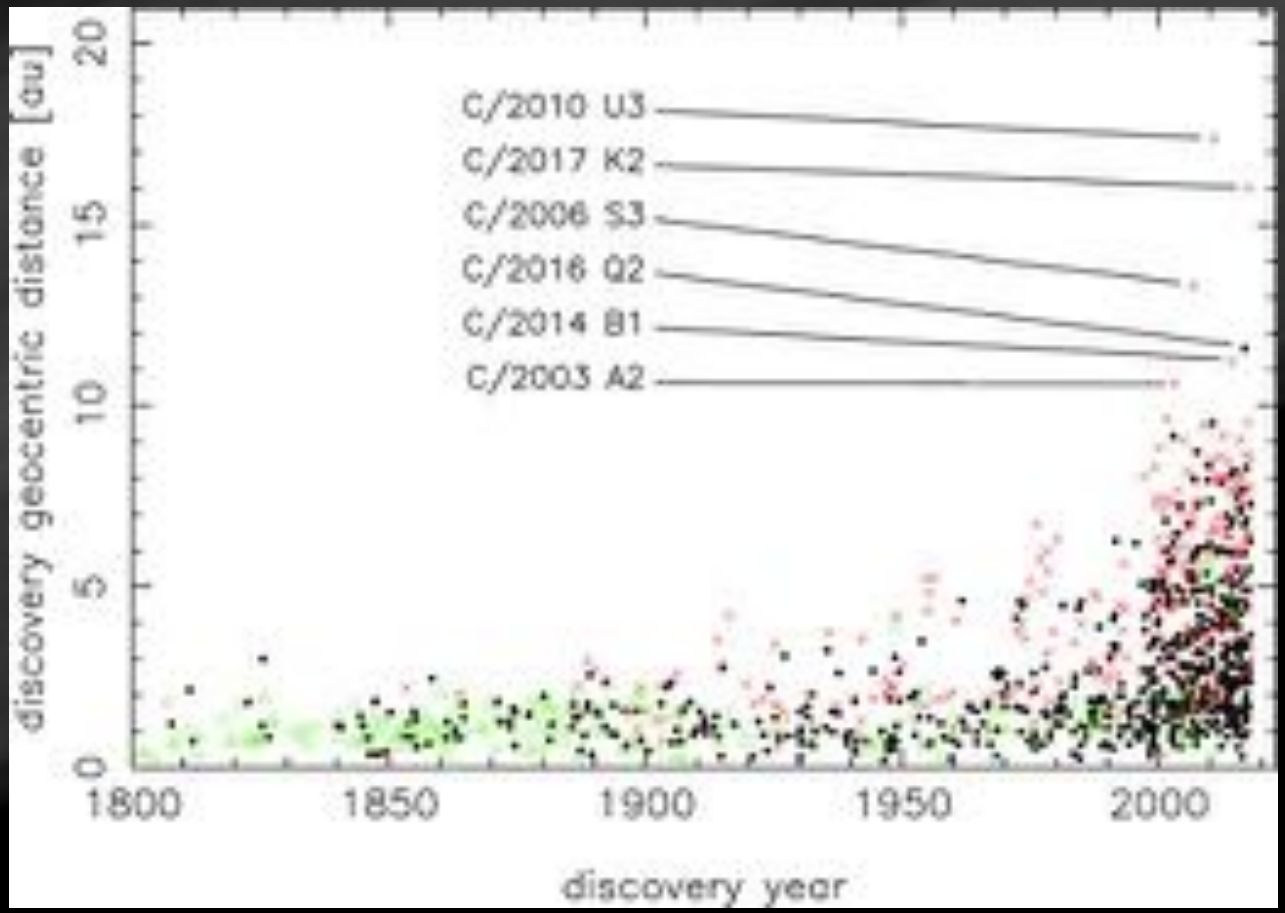
Table 7.2.1. Dates of key events in example mission to C/2001 Q4 (NEAT).

Event	Date
LSST discovery	~July 1996
Launch	10-Dec-1999
Departure from L2	29-Jul-2001
Real discovery	*24-Aug-2001*
OP Nav images begin	Jan 2004
Flyby	14-May-2004
End of mission	Nov 2004

Discovery of distant comets

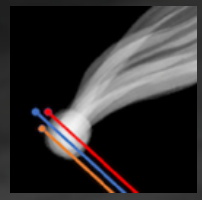


- Distance at which comets are discovered is increasing
- Comets have shown activity at 20-40 au in deep images.
- With LSST, expectation is that discovery at large distances will be routine
- Gives warning times of years
- Enables trajectory optimization to give mission with OK wait times and fuel mass



Królikowska & Dybczyński 2019, MNRAS 484, 3463

Comet Interceptor trajectories



- Longer warning time means a greater range of comets can be reached
- Increases the chances of a successful mission to a new comet

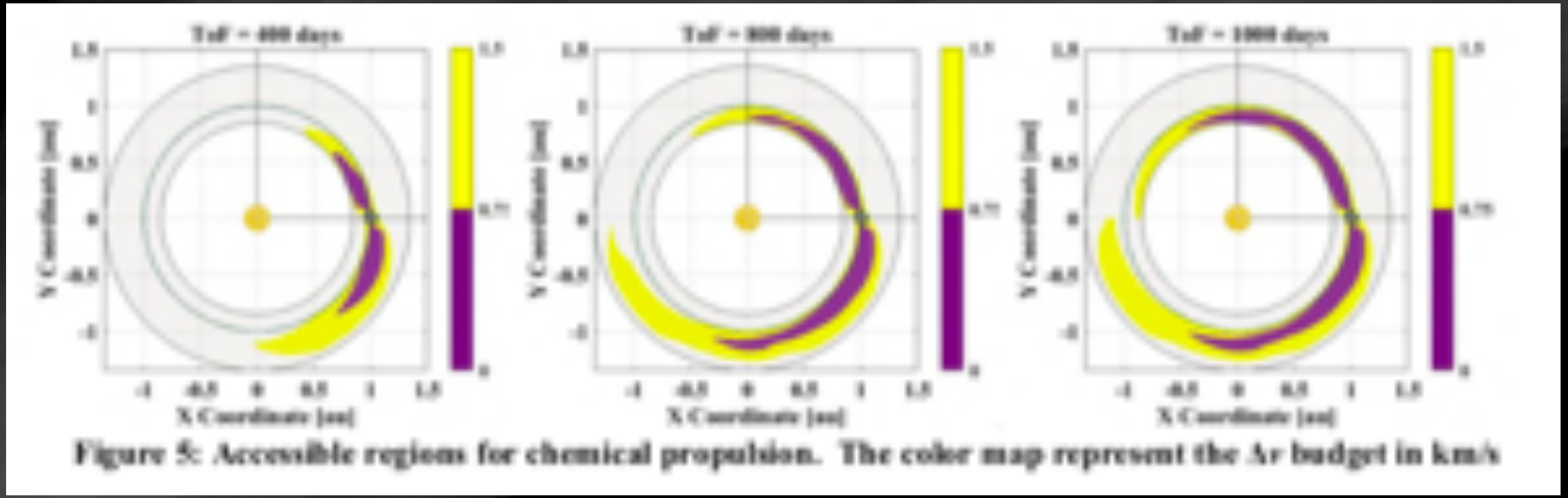
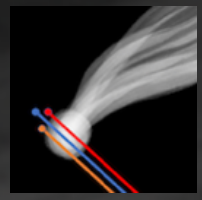


Figure 5: Accessible regions for chemical propulsion. The color map represent the Δv budget in km/s

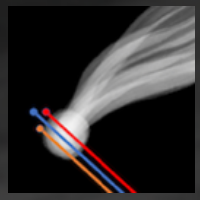
Sánchez et al 2021, submitted

LSST simulations


Comet Interceptor

- Critical for detailed assessment of CI success is the question of how far from the Sun LSST will find comets, and at what rate
- New survey simulator tool being developed (see flash talk by Grigori Fedorets) that will be used to predict comet discovery rate
- Inputs:
  - Distribution of expected comet orbits
  - Comet brightness model
  - Input distribution of nucleus sizes, peak activity/brightness and slope parameter

LSST simulations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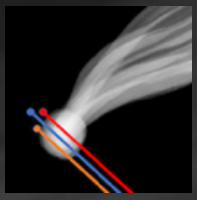
Set of 1700 synthetic comets from Boe et al 2019, Based on model by Wiegert & Tremaine 1999

LSST simulations



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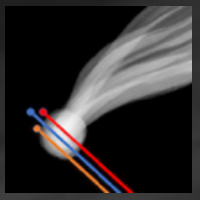
Simple brightness model:
$Af\rho = Af\rho_1 \times r^k$
k = -4 (SPC), -2 (LPC) ?

LSST simulations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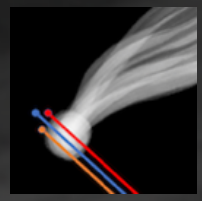
Based on historic comet observations

LSST simulations



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  re
- Inputs:
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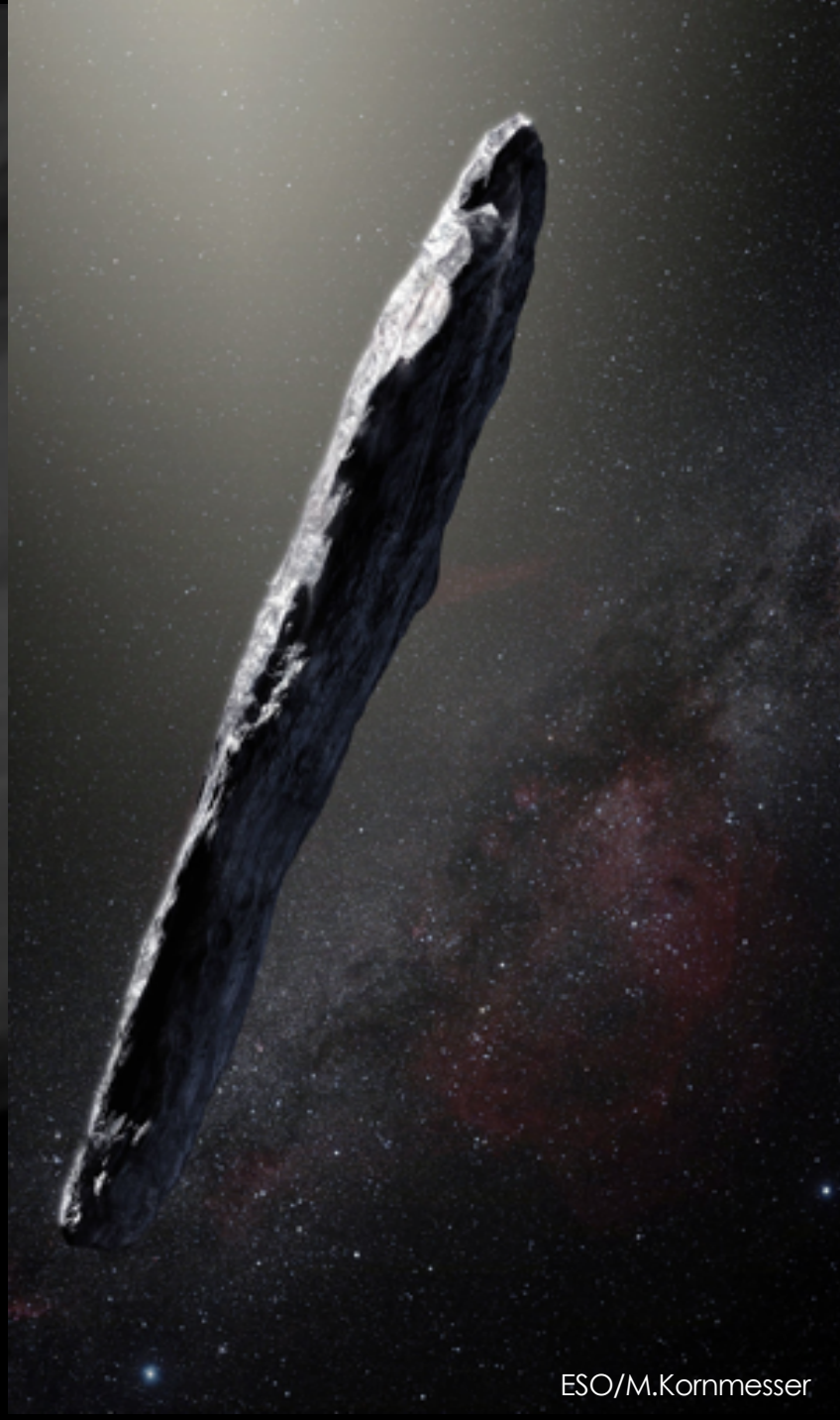
COMING SOON! Simulator nearly complete, aim to have simulations done this summer to feed into CI system SRR in October

Critical to demonstrate that LSST will do what we need it to for CI mission adoption in 2022

Interstellar targets?

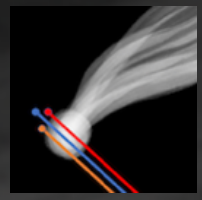
- ‘Oumuamua study* showed that Rubin Observatory could find one accessible target in ~10 years.
- A small but non-zero chance of a suitable target within 2-3 years
- Comet 2I/Borisov – a sign of promising discovery statistics?

NASA



ESO/M.Kornmesser

* Seligman & Laughlin 2018



http://www.cometinterceptor.space/

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