

**The ANIME mission concept:  
exploring three near-Earth asteroids with a CubeSat**

# ANIME



## Asteroid Nodal Intersection Multiple Encounters

**Davide Perna**

on behalf of the ANIME team



**Politecnico  
di Torino**



Agenzia Spaziale Italiana

## In a nutshell



### ✓ ASI ALCOR small satellites program

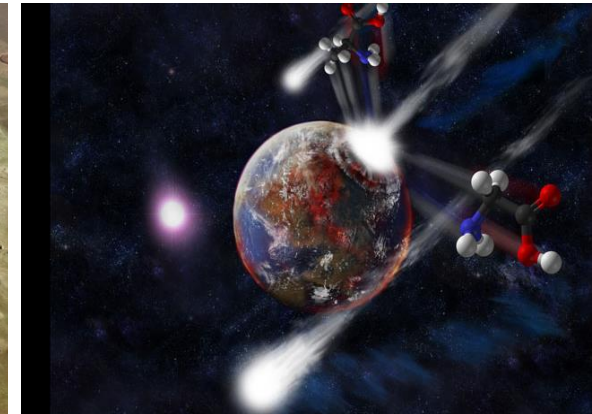
- 8-month Phase A completed in 2024
- Presumed launch date:  $\geq 2029$

### ✓ Interplanetary 12-U CubeSat

- Encounters with multiple near-Earth asteroids (NEAs)
  - 2 flybys with “potentially hazardous asteroids” (PHAs)
  - Rendezvous with a “small” ( $< 100$  m) NEA
- Payload: 2 COTS cameras (+ transponder)

### ✓ Robust, flexible, low-cost, high-return concept

- For planetary science and planetary defense



# Target asteroids & scientific return

## ✓ Baseline rendez-vous target: 2000 SG344

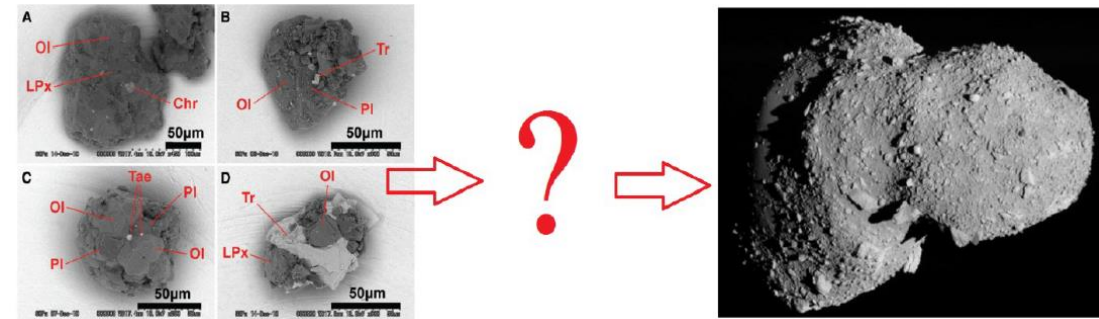
- Diameter  $\sim$  40 m (H=24.7)
- Top ranks in Risk & Accessibility lists
- 2-month nominal campaign
- Cm-scale images
- Radio science
- Constraints to orbit/Yarkovsky/YORP

## ✓ Fly-by targets: PHAs

- Alternative scenarios based on launch date
- $V_{rel} \approx 10$  km/s @  $\approx 50$  km distance
- Decimetre-scale images

Pebble / planetesimal accretion  
vs. collisional evolution

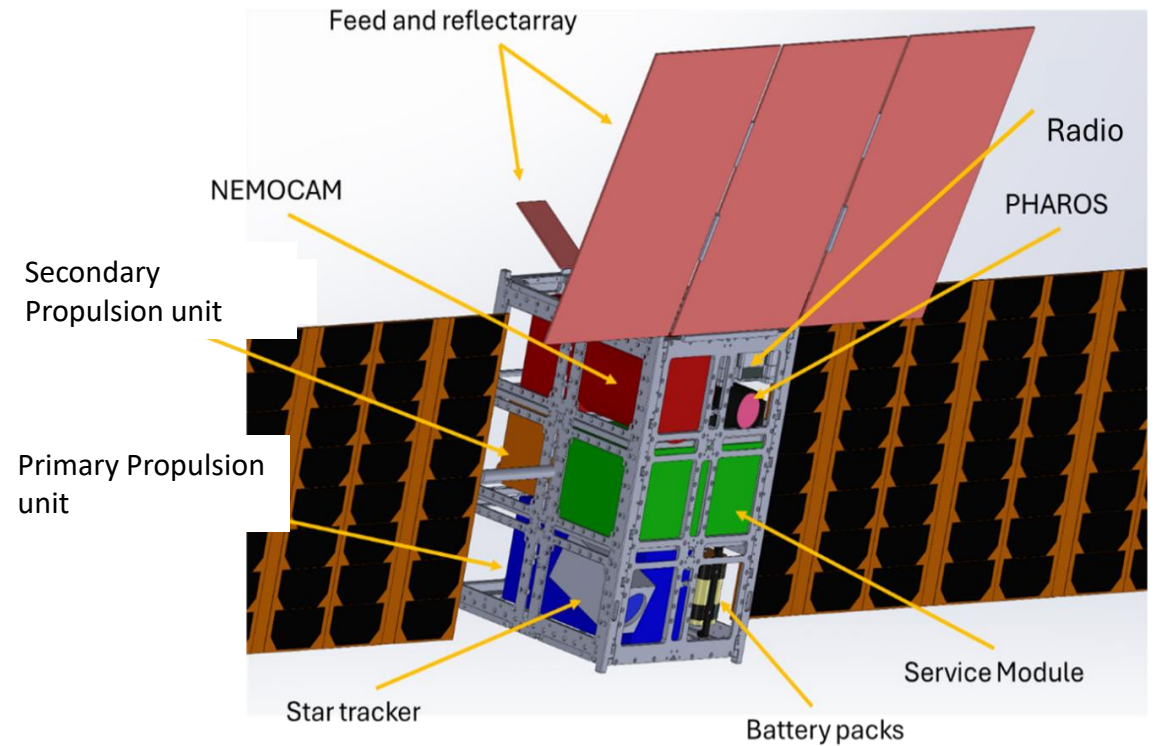
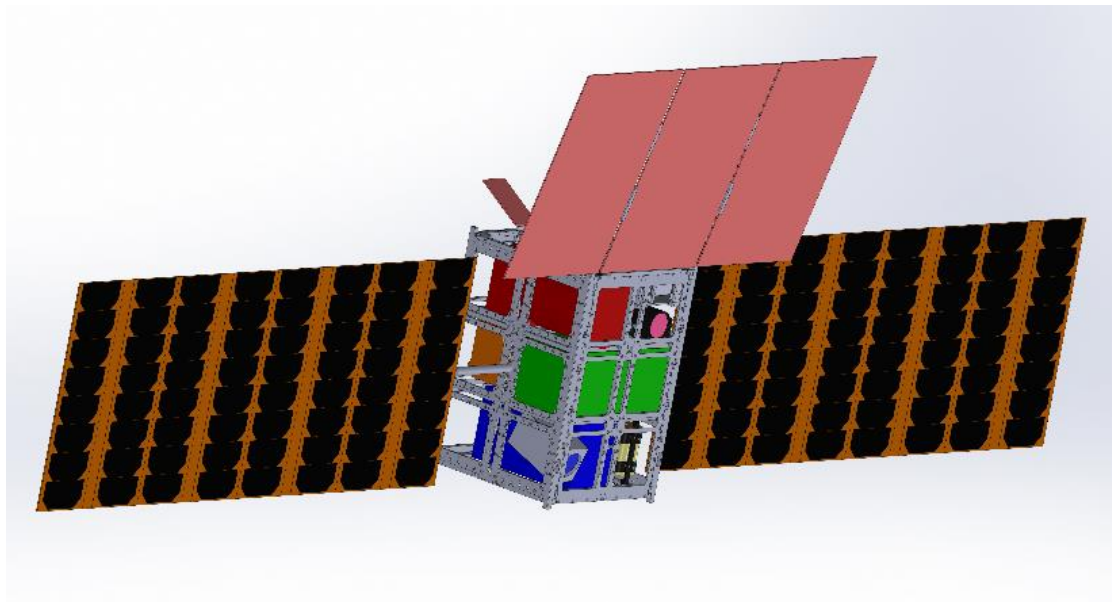
Need to visit <100-m asteroids to address questions about the monolithic vs. cohesive vs. rubble pile aggregation structure of small asteroids



	FoV (across track)	Spatial Resolution (@ 100 km)	Focus
<b>NEMOCAM</b> (panchromatic)	2.22°	0.95 m	> 10 km
<b>PHAROS</b> (RGB)	5.0°	7.8 m	> 400 m

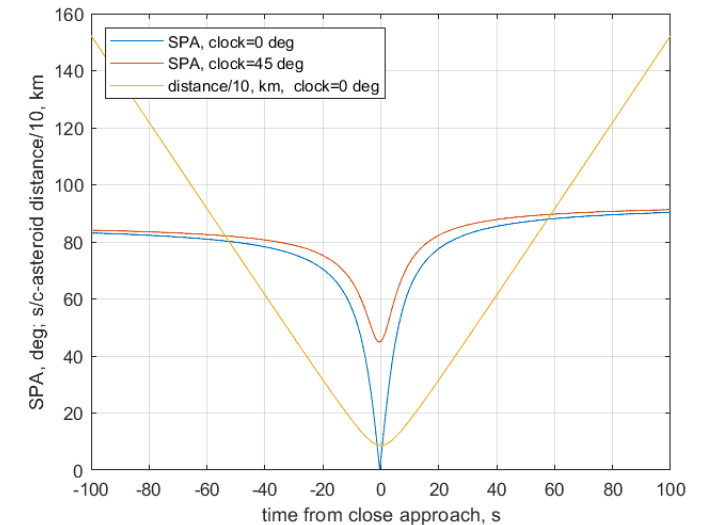
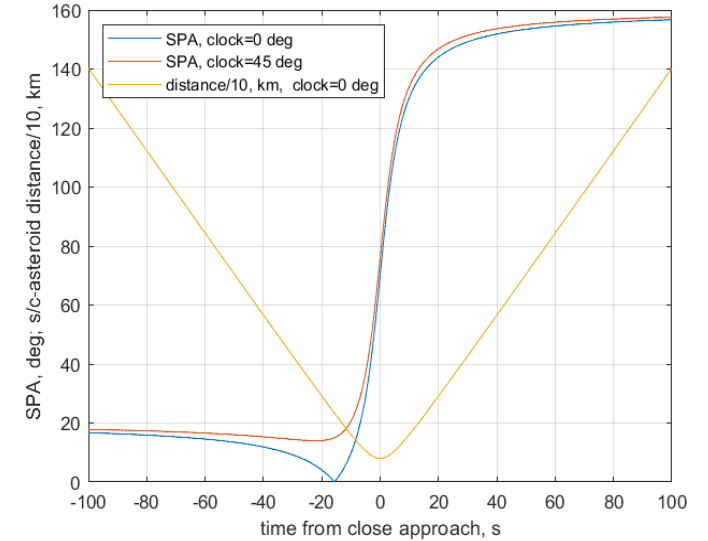
# Platform Configuration

- Standard 12U structure with minor customization
- Protrusions: folded solar wings, secondary propulsion nozzles

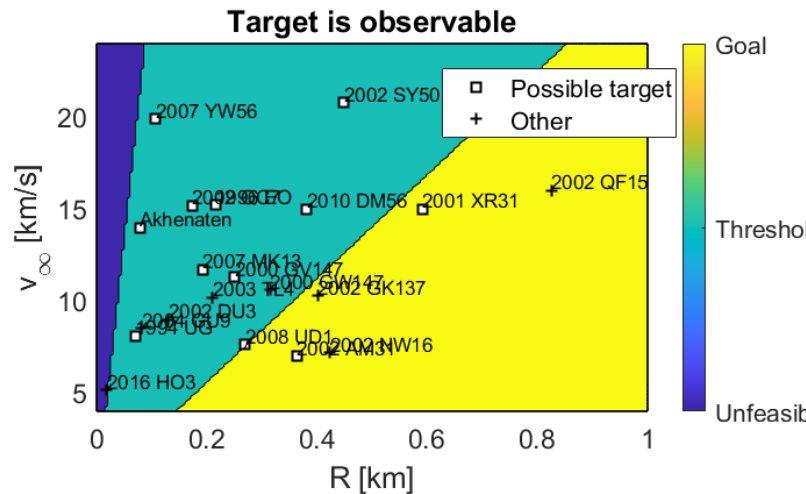
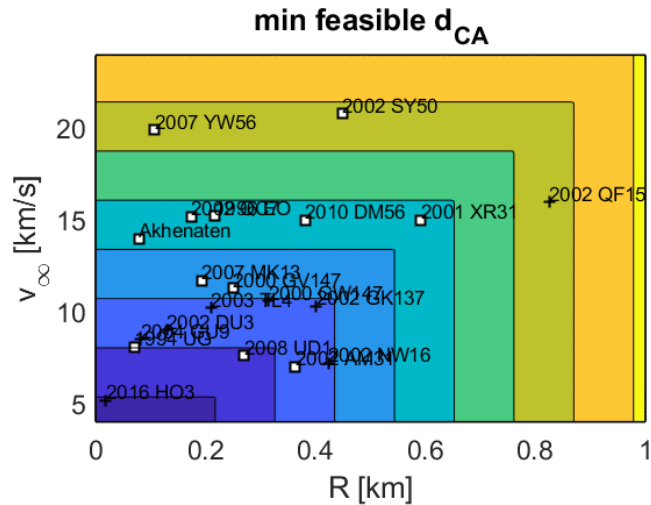
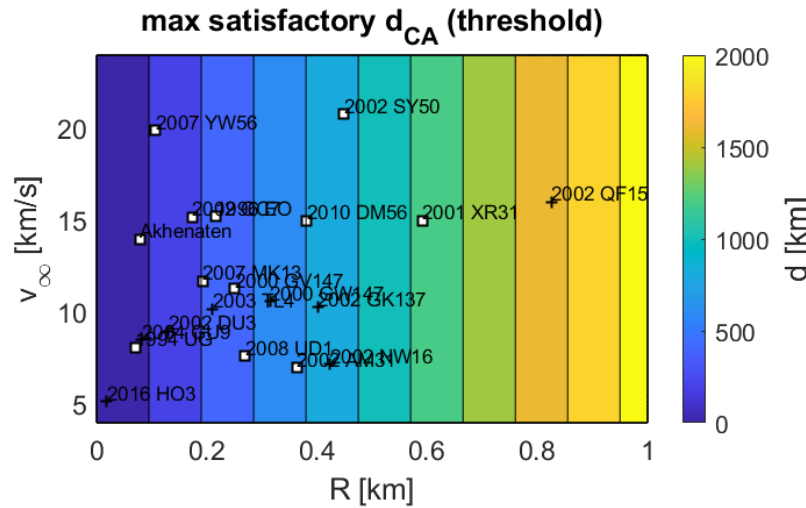
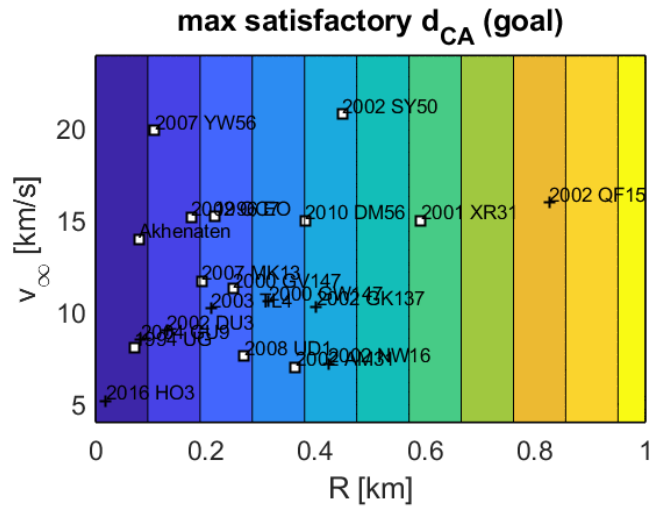


# Interplanetary trajectory

- Selection of flyby targets in light of observation requirements
- Launch windows in 2029 – 2033
- Range of escape conditions considered
- Fly-by approach analysis
  - Reaction wheels performance → minimum altitude at CA
  - Clock angle influences phase angle at close approach



## Interplanetary trajectory – Fly By Targets Observability



1. A max **satisfactory distance** is identified from Sci. Requirements
  - *Threshold: 1/100 D*
  - *Goal: 1/1000 D*
2. A min **feasible distance** is retrieved assuming:
  - Max spin rate:  $10^\circ/s$
  - Max spin acc.:  $0.67^\circ/s^2$
  - Entire target in FoV
3. If feasible distance < satisfactory distance, the target is deemed **feasible for correct observation**

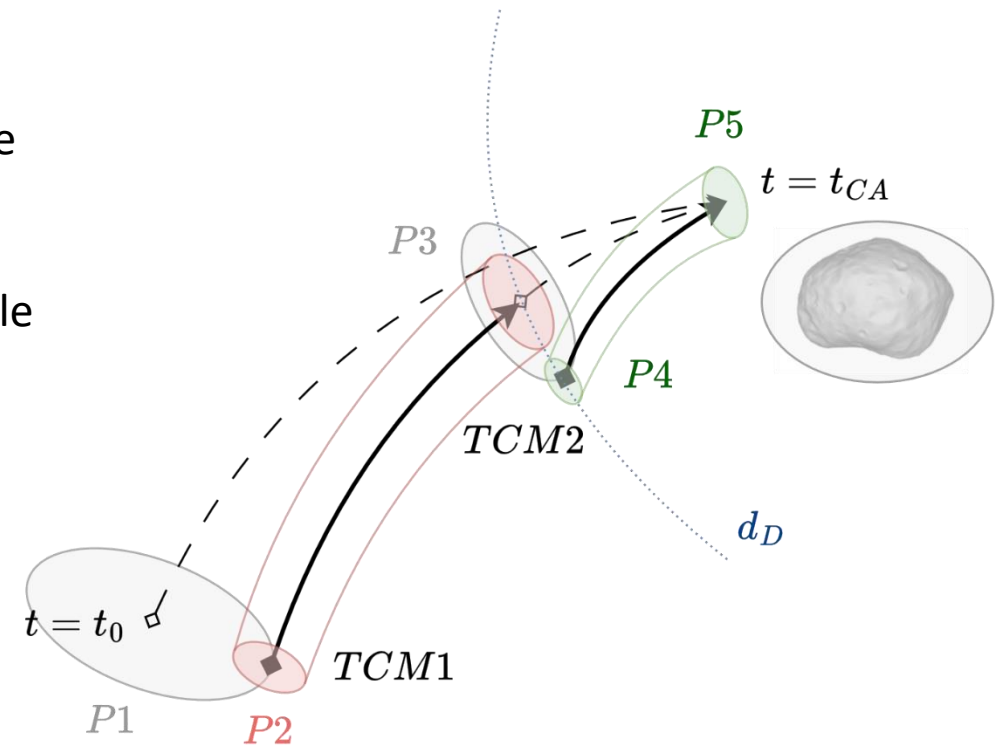
# Interplanetary trajectory – Fly By B-Plane Targeting

✓ Approach

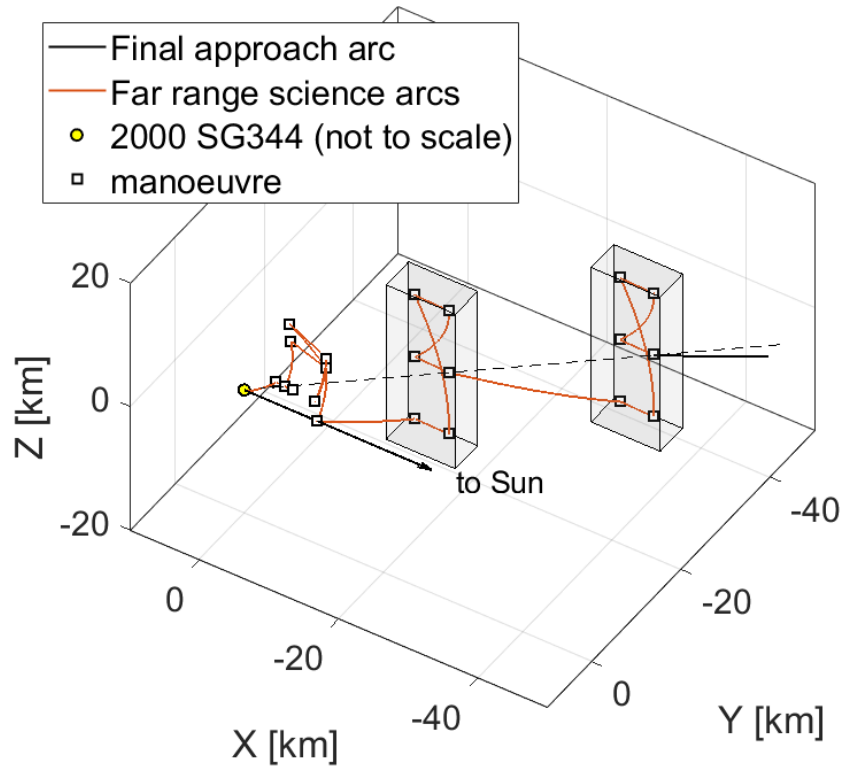
- After asteroid detection, a guidance strategy must be computed, to correct B-plane entry errors
- A chemical propulsion unit is needed to grant the necessary control authority in the small time available

✓ Solution

- Algorithm selected: Two-TCM strategy



# Rendezvous Trajectory Analysis – Far Range



*Far Range Trajectory, Hill's Frame.*

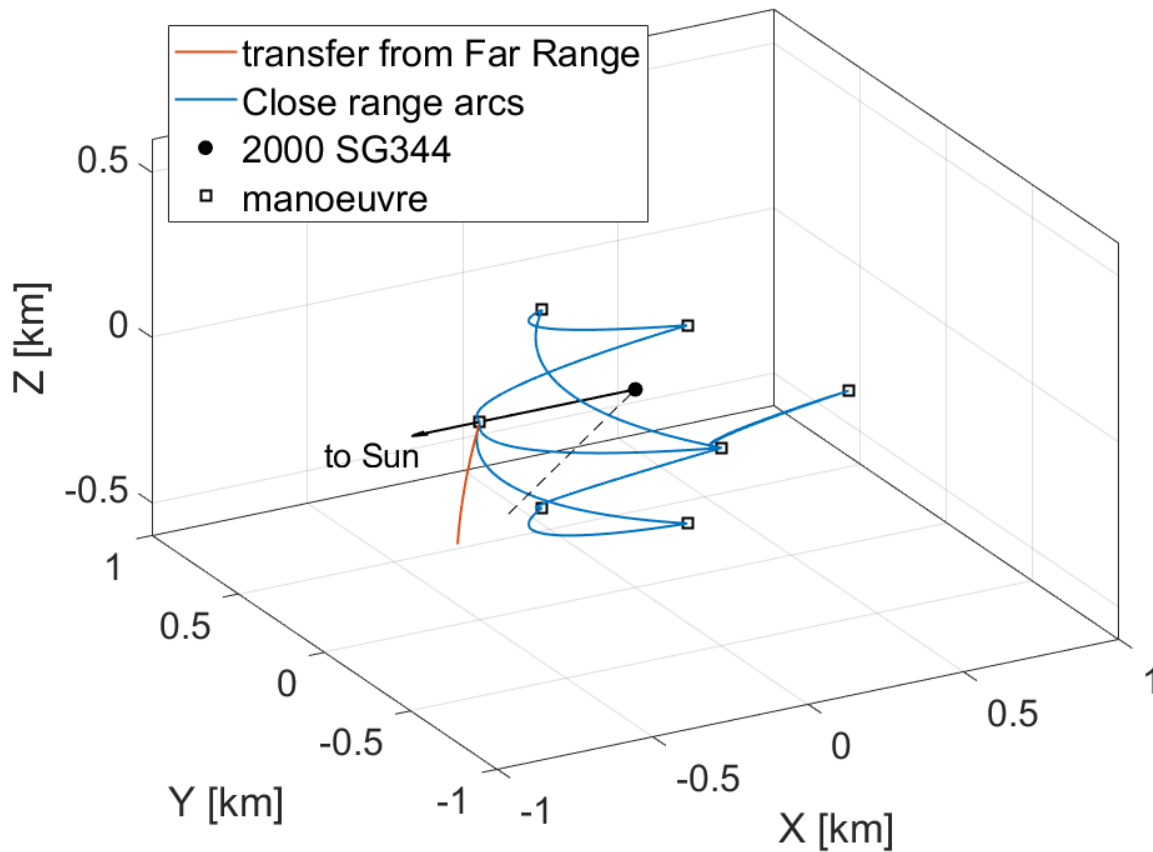
## ✓ Requirements and Constraints

- Imaging at different resolution in pan and RGB
- Imaging at different intervals of SPA
- Out of plane imaging
- Camera performance, NEMOCAM focal distance

## ✓ Strategy

- Bi-impulse arcs and unpowered SRP exploiting arcs at 50 km and 25km distance
- Hyperbolic arcs at 10.5 km, to reach also higher SPA
- Holding distance at 5km, to have a more robust transfer towards the close range

# Rendezvous Trajectory Analysis – Close Range



*Close Range Trajectory, Hill's Frame*

## ✓ Requirements and Constraints

- Imaging at high resolution
- Imaging at different intervals of SPA
- Out of plane imaging
- Unpowered arcs at distance <1km (radioscience)
- Unpowered arcs at  $v < 2v_{esc}$
- NEMOCAM Out of Focus
- Camera performance, Pharos focal distance (400m)

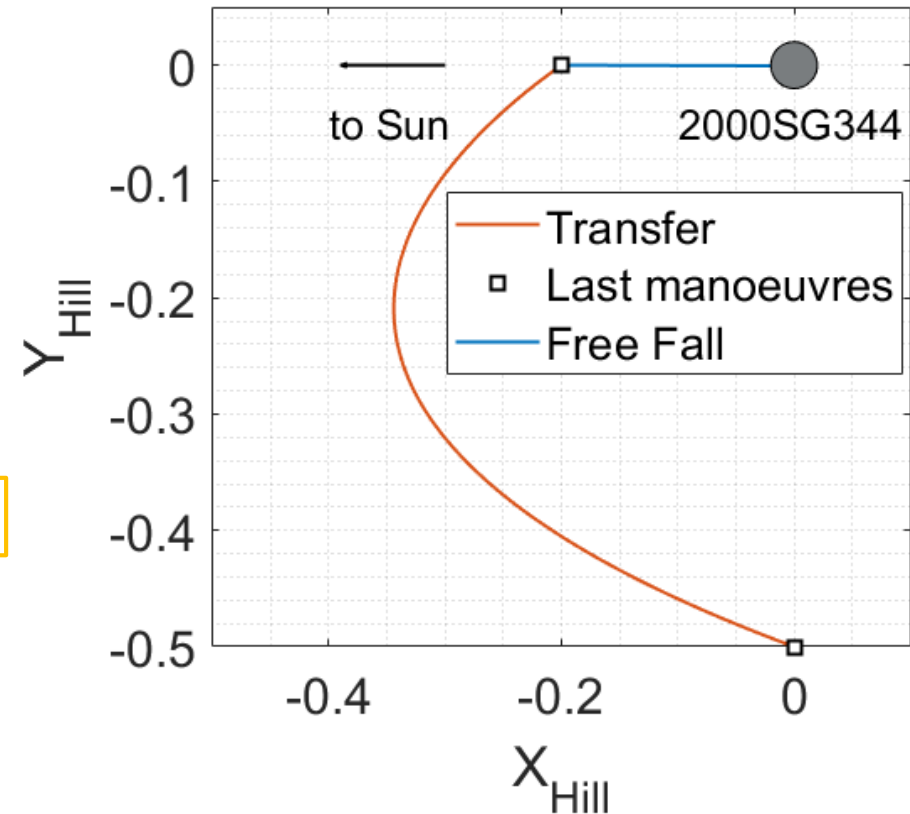
## ✓ Strategy

- Hyperbolic arcs at 500m distance

# Rendezvous Trajectory Analysis – Disposal

- After CR operations, transfer arc towards 200m distance,  $0^\circ$  SPA, in plane
- Free fall driven by SRP and asteroid's gravity
- Transfer of 1 day
- Free fall of 7.76 h (nominal)

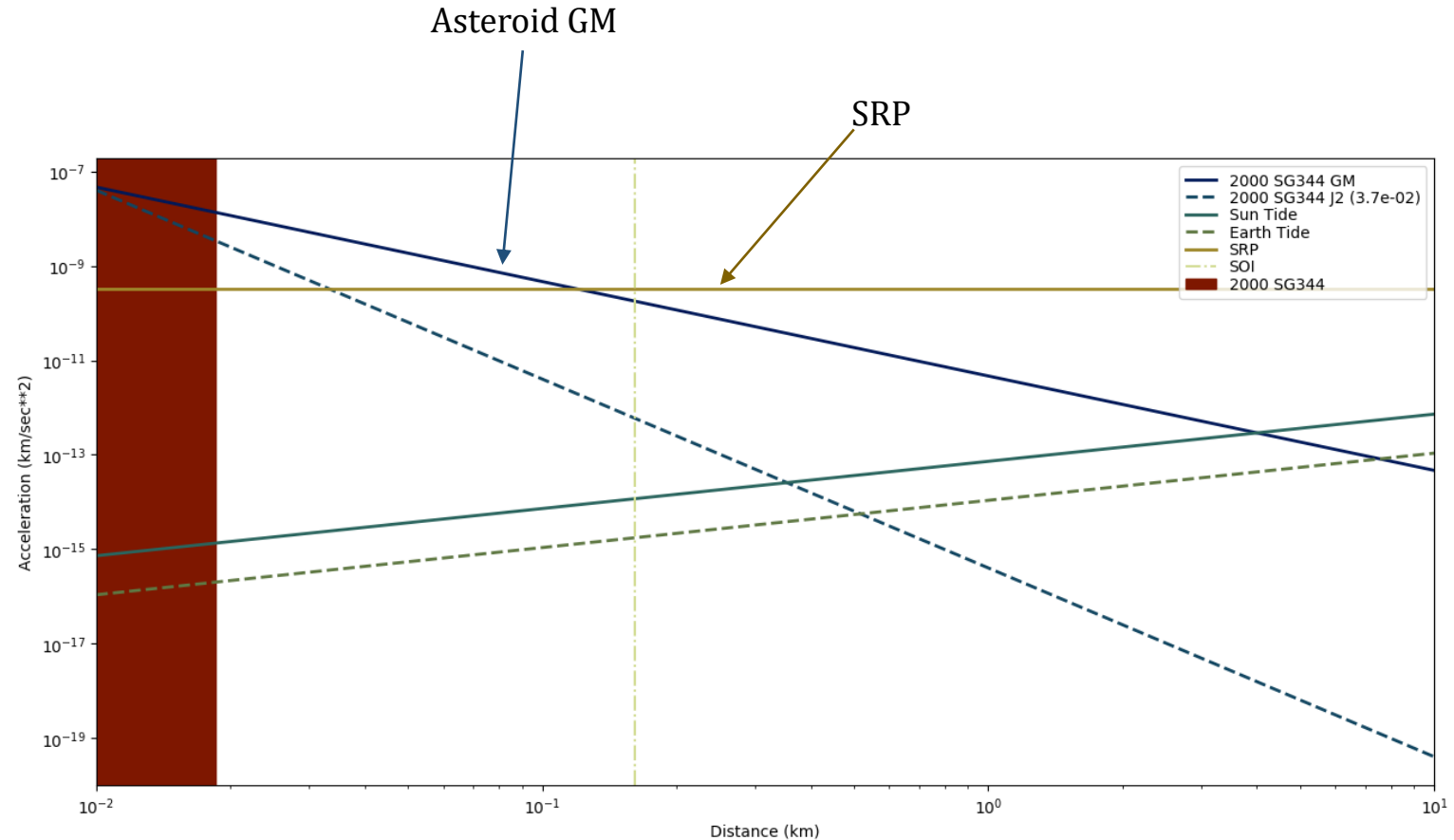
The free fall could represent a possible opportunity for radioscience



*Proposed disposal trajectory, Hill's Frame.*

# Radio science experiment

- To measure the asteroid's gravity to constraint its interior structure (total mass and mass distribution)
- To characterize the heliocentric orbit and non-gravitational accelerations (Yarkovsky)
- SRP particularly influent at small bodies environments → for 2000 SG344 it is the dominant acceleration above ~ 150 m altitude



**THANK YOU!**



**davide.perna@inaf.it**