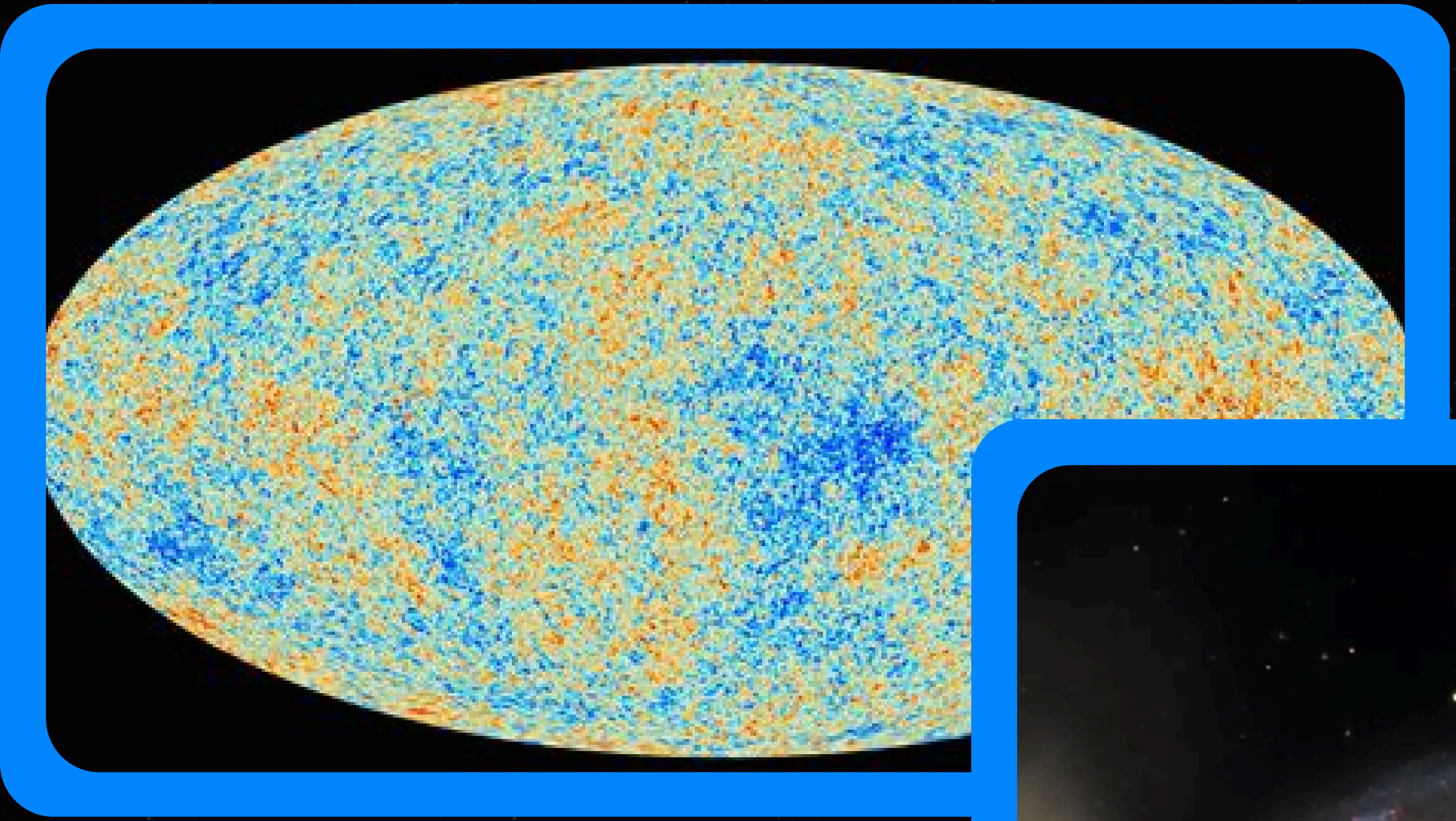
SISTEMA DE POSICIONANIENTO CÓSMICO

LA TENSIÓN DE HUBBLE



Método 1: Fondo de Microondas

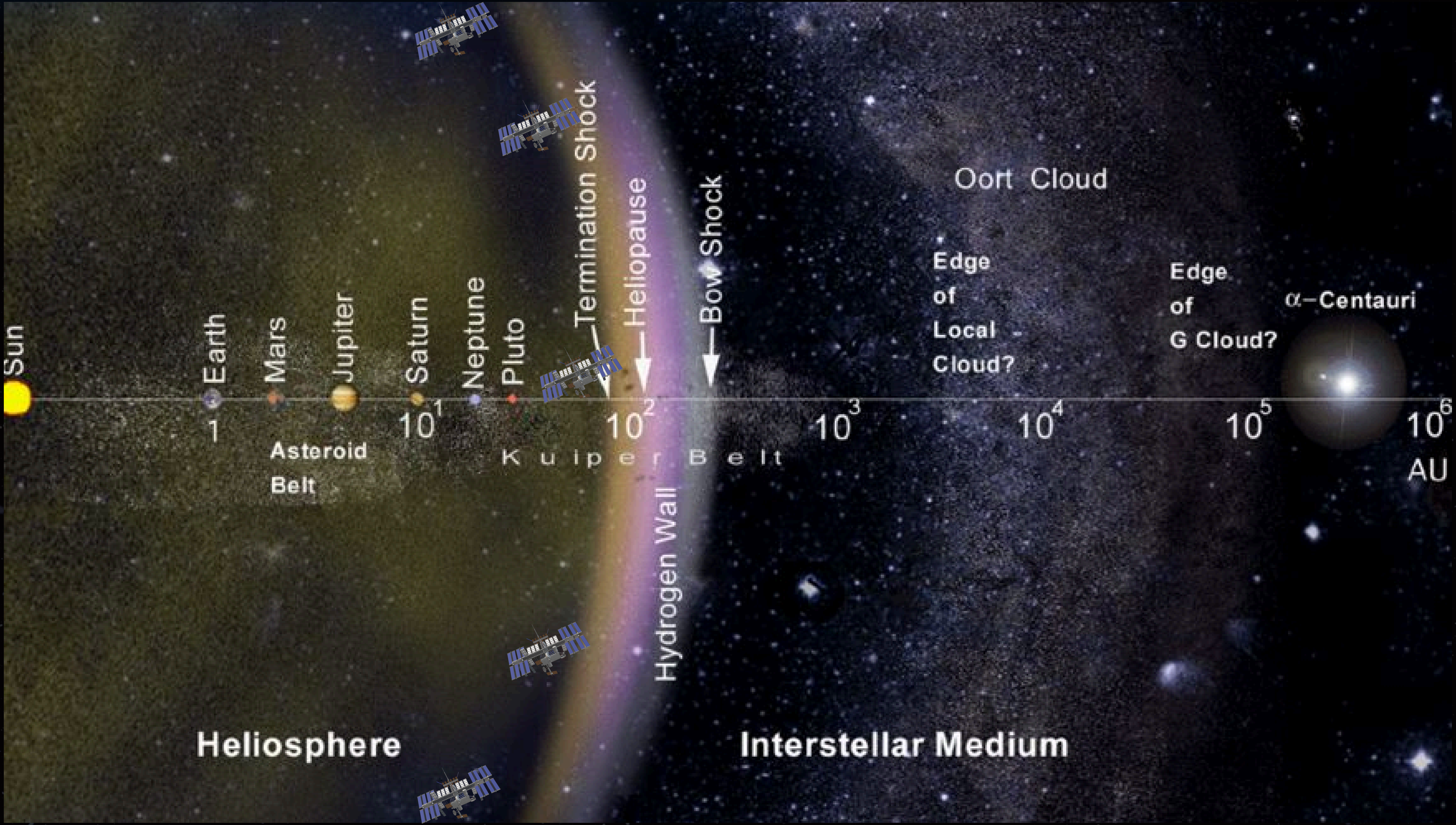
67.4 km/s/Mpc

Método 2: Estrellas Cefeidas

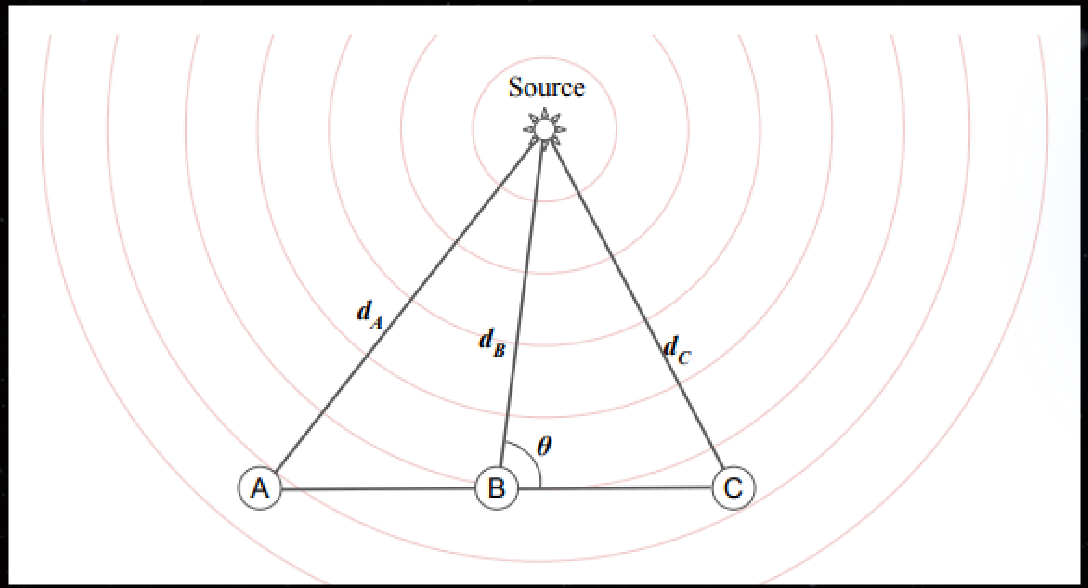
73 km/s/Mpc

1. Cambia la edad estimada del universo.
2. Afecta distancia a objetos lejanos.
3. Podría significar física nueva y desconocida.
4. JWST y DESI no han resuelto el misterio.

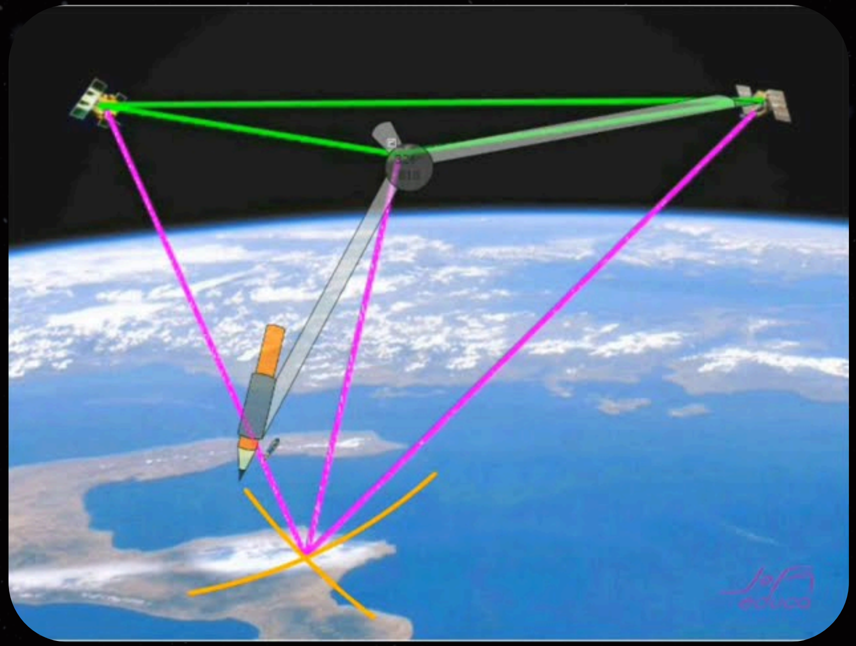
¿QUÉ ES EL CPS?



Sun
Earth
Mars
Jupiter
Saturn
Neptune
Pluto
Termination Shock
Heliopause
Bow Shock
Hydrogen Wall
Oort Cloud
Edge of Local Cloud?
Edge of G Cloud?
α−Centauri
1
10^1
10^2
10^3
10^4
10^5
10^6
AU
Asteroid Belt
Kuiper Belt
Heliosphere
Interstellar Medium

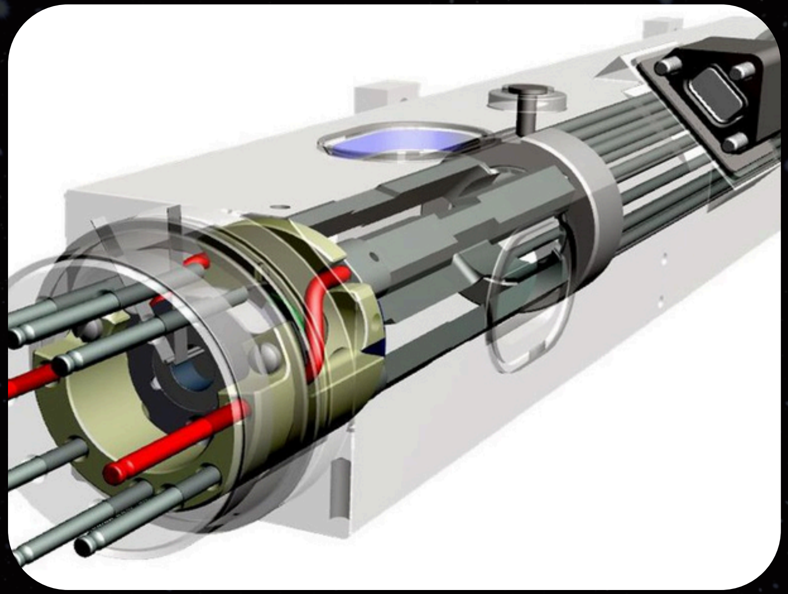


CÓMO FUNCIONA



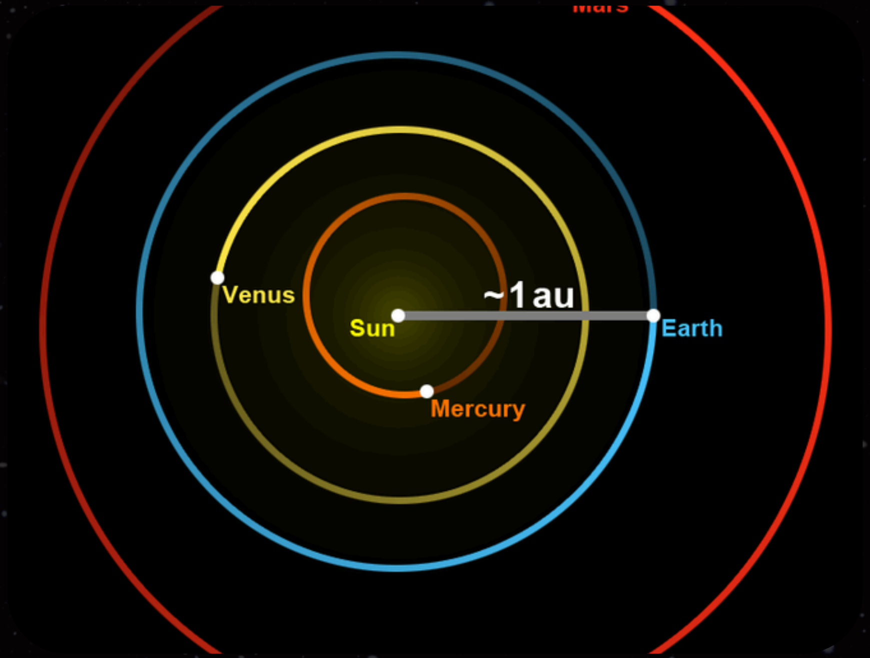
TRIANGULACIÓN

Los 5 satélites miden el tiempo que tarda una señal (fotón) en viajar entre ellos.



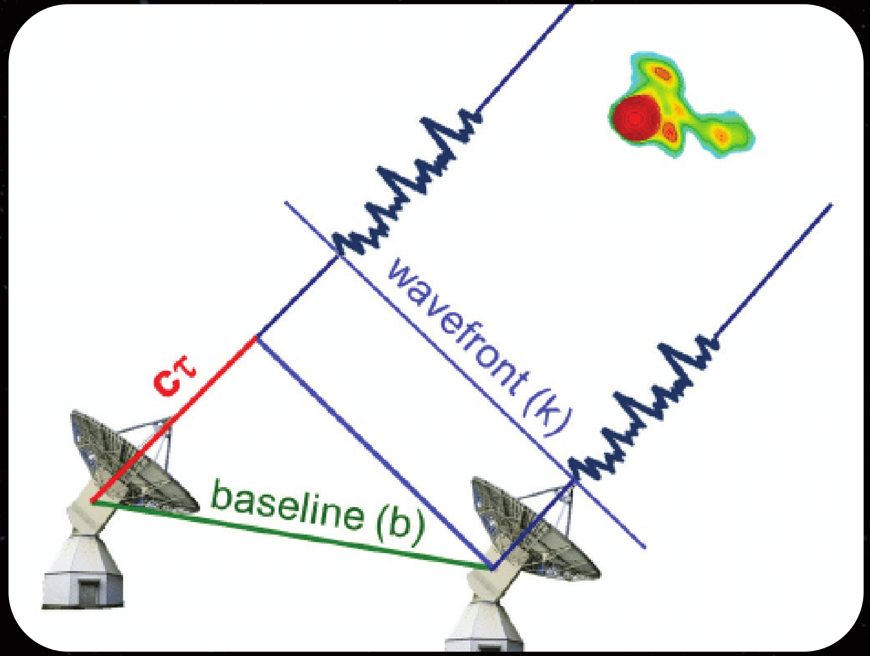
RELOJ ATÓMICO

Basado en el Deep Space Atomic Clock de la NASA.



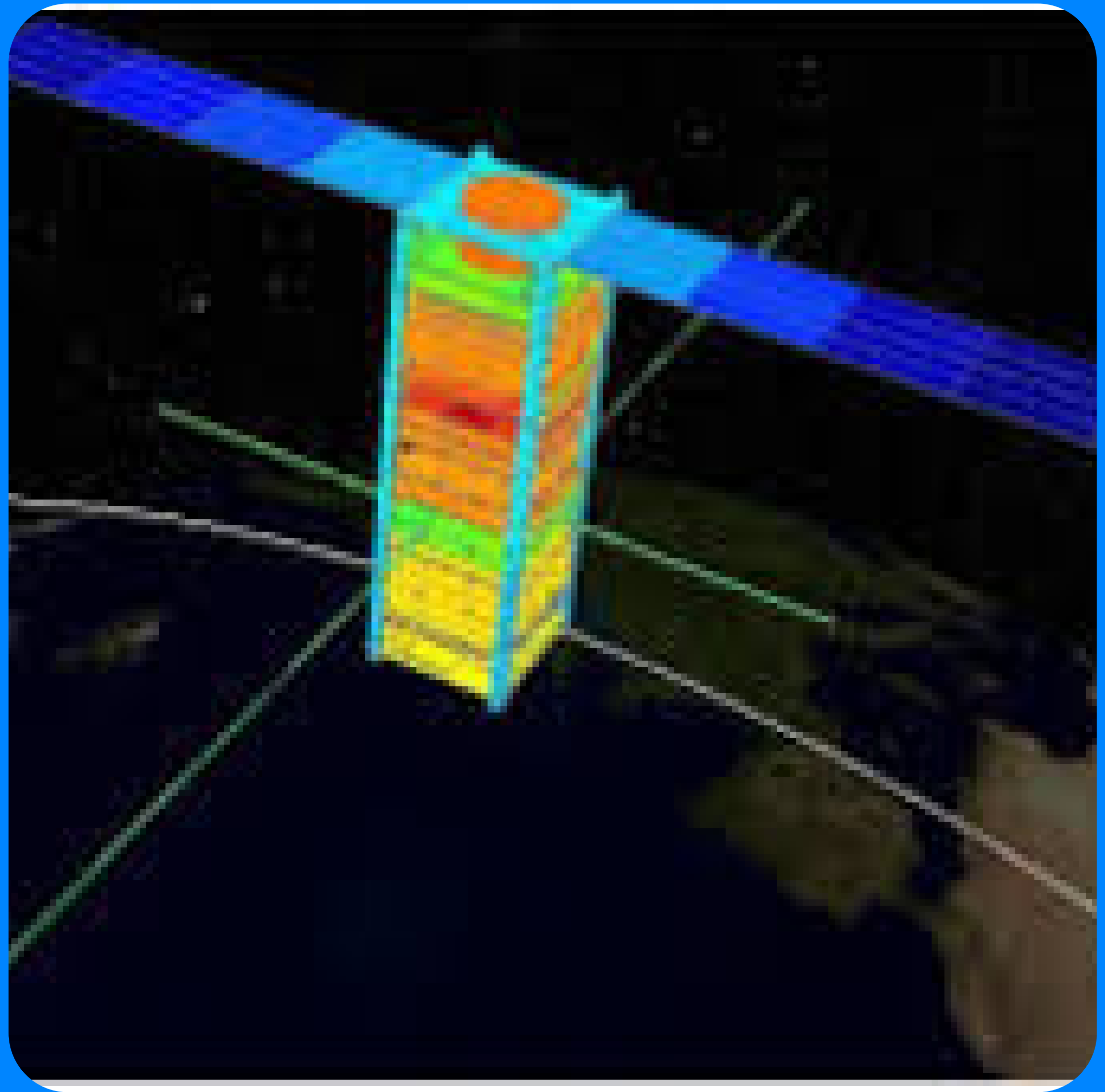
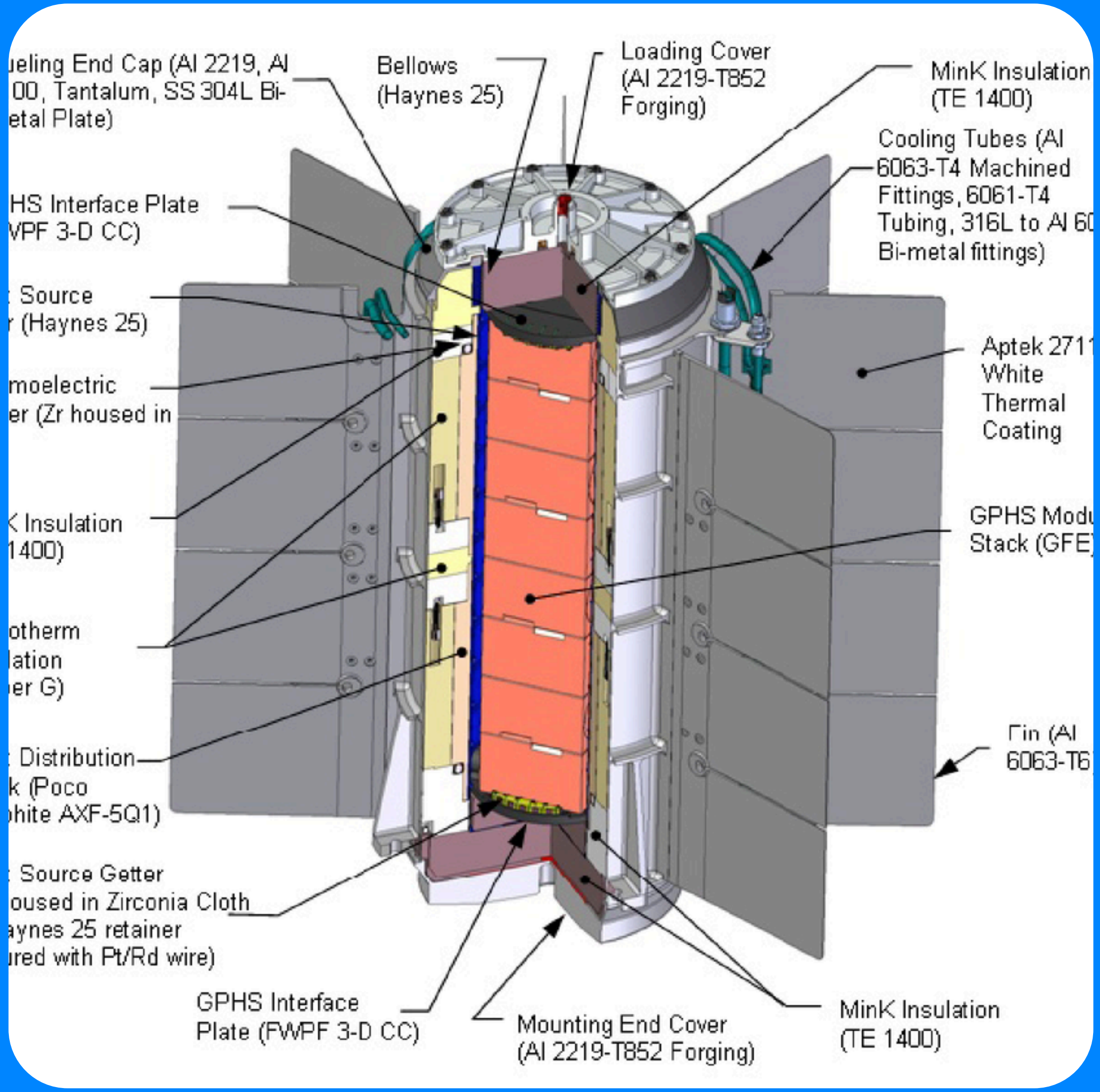
BASELINE ENORME

20-100 veces la distancia Tierra-Sol.

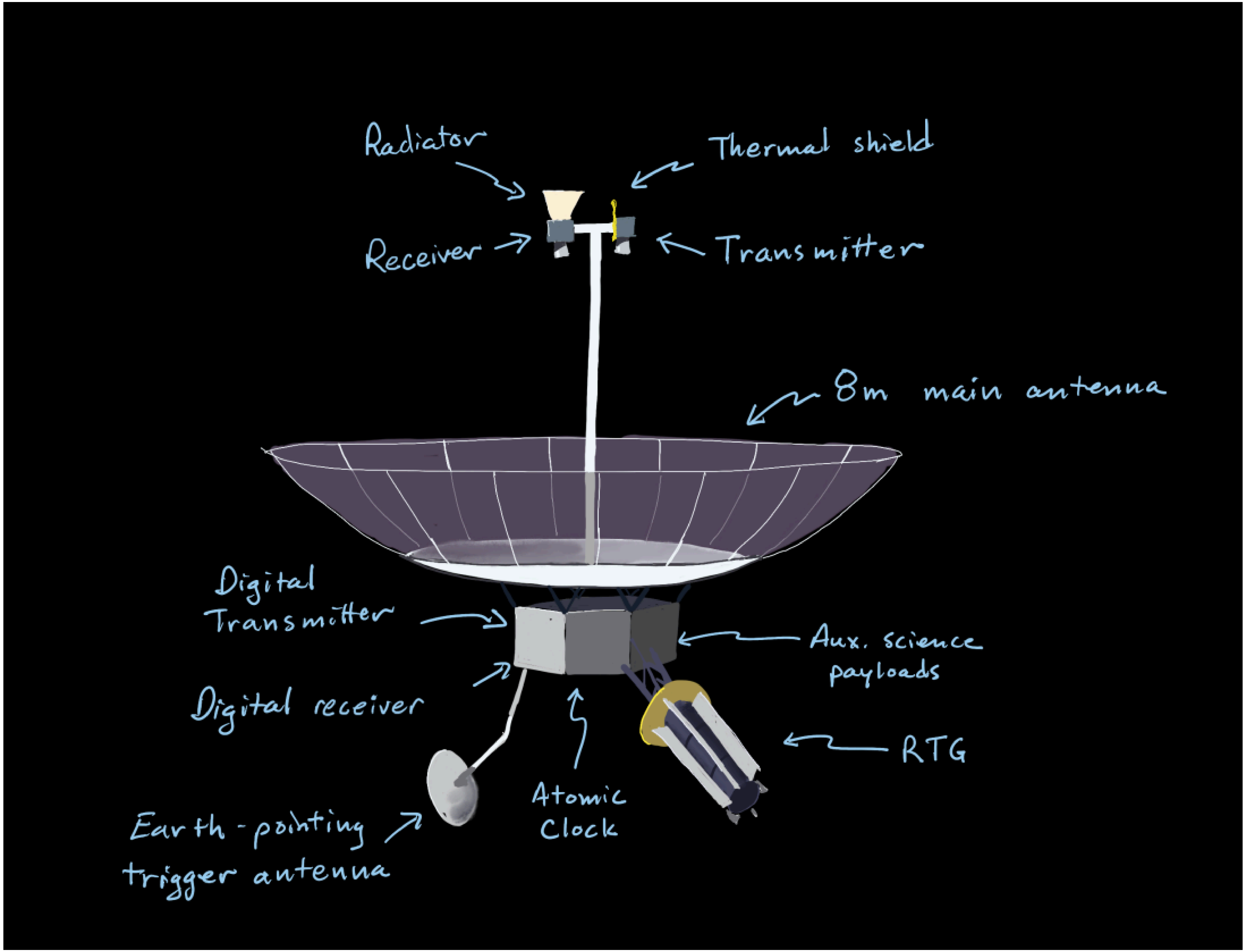


VLBI CÓSMICO

Interferometría de Linea de Base Muy Larga a escala solar.

RETOS DE INGENIERÍA


Radiator
Thermal shield
Receiver
Transmitter
8m main antenna
Digital Transmitter
Aux. science payloads
Digital receiver
RTG
Atomic Clock
Earth-pointing trigger antenna

QUÉ PODRÍA DESCUBRIR EL CPS

Materia Oscura

Medir su “grumosidad” rastreando el bamboleo de Destellos de Radio Rápidos (FRBs) procedentes del cosmo lejano.

Ondas Gravitacionales

Detectar ondas de micro-hertz generadas por agujerons negros supermasivos binarios, todavía no detectadas.

DÓNDE ESTAMOS HOY?

2019 - 2021

Prueba exitosa del Deep Space Atomic Clock en mision STP-2

Febrero 2026

Informe NIAC Fase I publicado: el CPS es operacionalmente factible

Proximo paso

Posible Fase II NIAC con estudios de viabilidad tecnica ampliados

Futuro

Construccion y lanzamiento (requiere financiacion adicional aun no asegurada)

Que es NIAC?

NASA Innovative Advanced Concepts

Programa de la NASA que financia conceptos de vanguardia. La mayoria no llega a mision real, pero este estudio demuestra que el CPS es tecnicamente viable.

GRACIAS

NIAC project report: Solar system-scale VLBI to dramatically improve cosmological distance measurements

Matthew McQuinn[*1,2], Miguel Morales[2], Casey McGrath[3,4,5], Alyssa Alvarez[1], Katelyn Glasby[6], T. Joseph W. Lazio[7], Kiyoshi Masui[8], Lyujia Pan[2], Jonathan Pober[9], and Huangyu Xiao[10,11]

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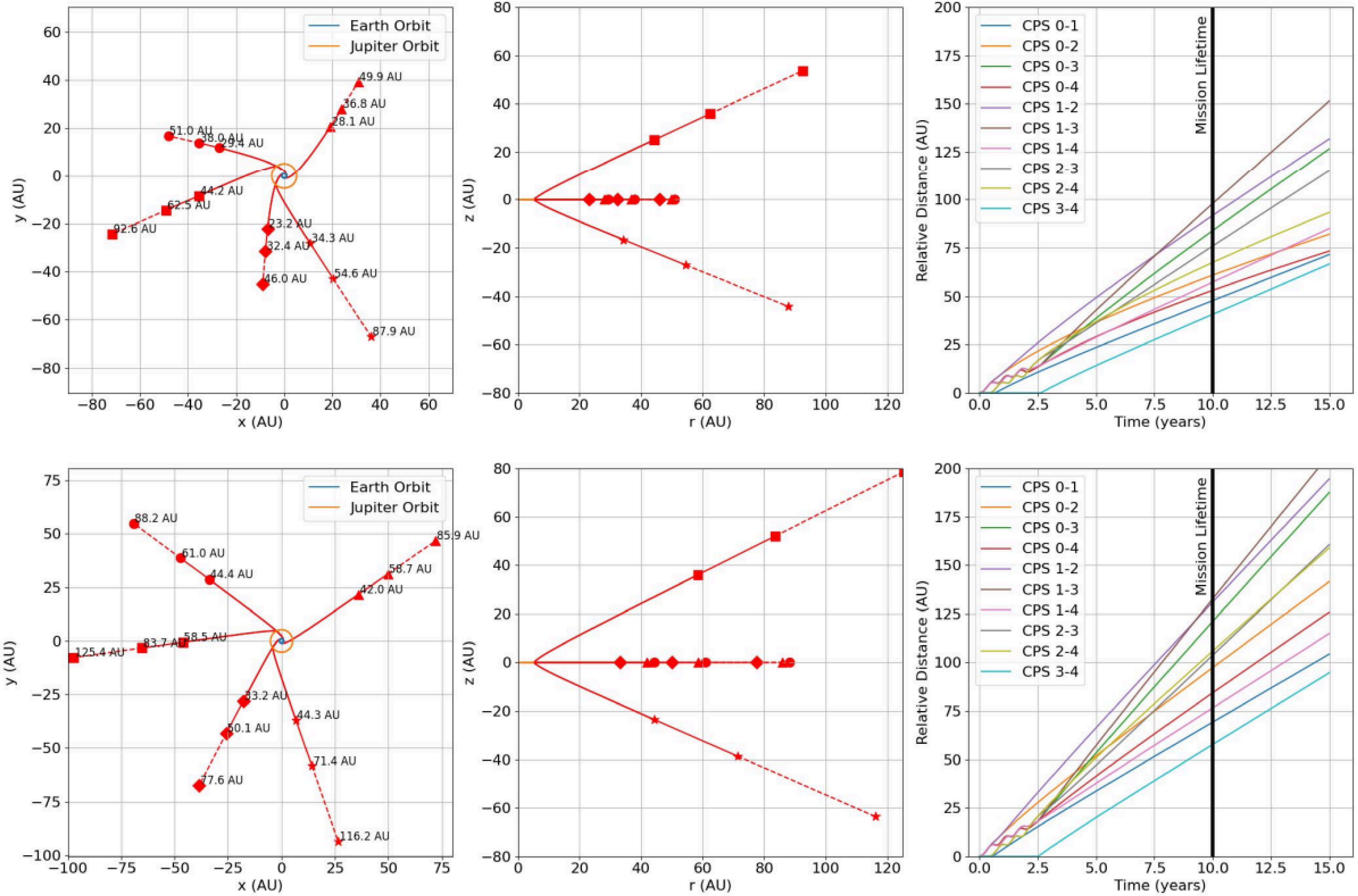
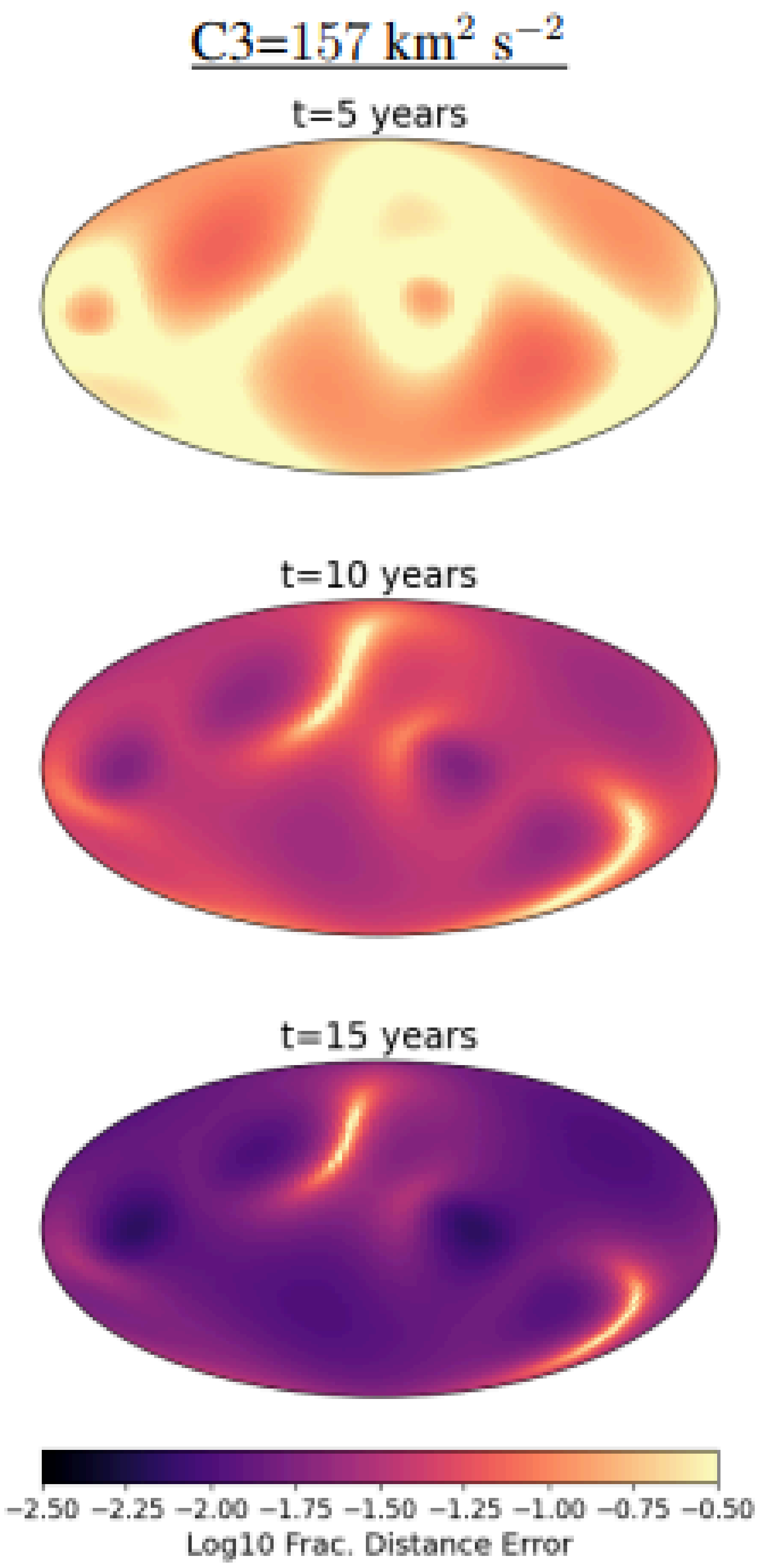


Earth Orbit
Jupiter Orbit
x (AU)
y (AU)
51.0 AU
38.0 AU
29.4 AU
49.9 AU
36.8 AU
28.1 AU
44.2 AU
62.5 AU
92.6 AU
23.2 AU
32.4 AU
46.0 AU
34.3 AU
54.6 AU
87.9 AU
r (AU)
z (AU)
Relative Distance (AU)
Time (years)
Mission Lifetime
CPS 0-1
CPS 0-2
CPS 0-3
CPS 0-4
CPS 1-2
CPS 1-3
CPS 1-4
CPS 2-3
CPS 2-4
CPS 3-4
88.2 AU
61.0 AU
44.4 AU
85.9 AU
58.7 AU
42.0 AU
125.4 AU
83.7 AU
58.5 AU
33.2 AU
50.1 AU
77.6 AU
44.3 AU
71.4 AU
116.2 AU



Understand FRB rates and fluences at > 3 GHz: Establishing a sample of at least ten well-characterized repeating FRB sources (with detectable fluxes at $\gtrsim 4$ GHz, sufficiently small scattering times, and some having optimal distances for expansion science) is essential for validating the CPS concept. This requires systematic follow-up of known repeaters and possibly dedicated higher-frequency surveys.

Study time delays from interstellar medium refraction: Further investigation of scattering and refraction in the Milky Way interstellar medium would inform the minimum operational frequency. Low-scattering sightlines might enable sufficiently precise timing at frequencies lower than the CPS target of $\nu = 4 - 6$ GHz. This would benefit CPS as FRBs tend to be brighter at lower frequencies.

Develop low-power space clocks: The atomic clock represents the largest power requirement in our nominal design, using specifications from the Deep Space Atomic Clock. These power demands likely exceed what can be supported by radioisotope sources with wattage comparable to that on the New Horizons spacecraft. The development of more efficient atomic clocks with similar Allan deviations is likely essential for mission feasibility.

Develop solid-state storage for deep space: Our analysis indicates that at least 30 TB of onboard storage per spacecraft is needed to store the voltage timeseries when coordinating with terrestrial observatories. This would require, for example, four Phison 8 TB SSDs (Table 2; TRL6). This would allow CPS to coordinate with terrestrial observatories for an estimated cumulative time of two years before drive failure. Additional storage capacity or longer-lifetime solid-state drives would benefit the mission.

Understand achievable C3 and orbit optimization: The cosmic expansion and dark matter science benefits from higher launch velocities (C3). Development of more powerful third- and fourth-stage boosters would enable higher C3 values, as would minimizing spacecraft mass. CPS's distance sensitivity to cosmological sources is limited by the shortest baselines. While our nominal mission envisions paired spacecraft launches, separate launches for each spacecraft to maximize separations would provide more sensitive distance measurements.

Optimize receiver system temperature: Our nominal 20 K system temperature may be achievable even at a 300 K internal temperature for the spacecraft given recent advances in LNA technology (Weinreb & Shi, 2021), and this could be aided by putting the LNA on a cold plate or possibly even employing LED cooling. Minimizing system temperature should be a priority as this allows proportionally smaller antennas on each spacecraft.

Develop radioisotope power systems: CPS likely requires radioisotope power sources comparable to the 10 kg of plutonium-238 (Pu-238) power source on New Horizons, which had 6% electric conversion efficiency. NASA currently produces 1.5 kg/year of Pu-238 at Oak Ridge National Laboratory – a rate requiring more than a decade to produce the plutonium for the five CPS spacecraft.