HUMANITY'S JOURNEY TO INTERSTELLAR SPACE

INTERSTELLAR PROBE

APL JOHNS HOPKINS APPLIED PHYSICS LABORATORY

Interstellar Probe: A New Mission for a New Century

Ralph L. McNutt, Jr.

The John Hopkins University Applied Physics Laboratory, USA

Moscone South
Hall D, Inspire Stage
Centennial Central

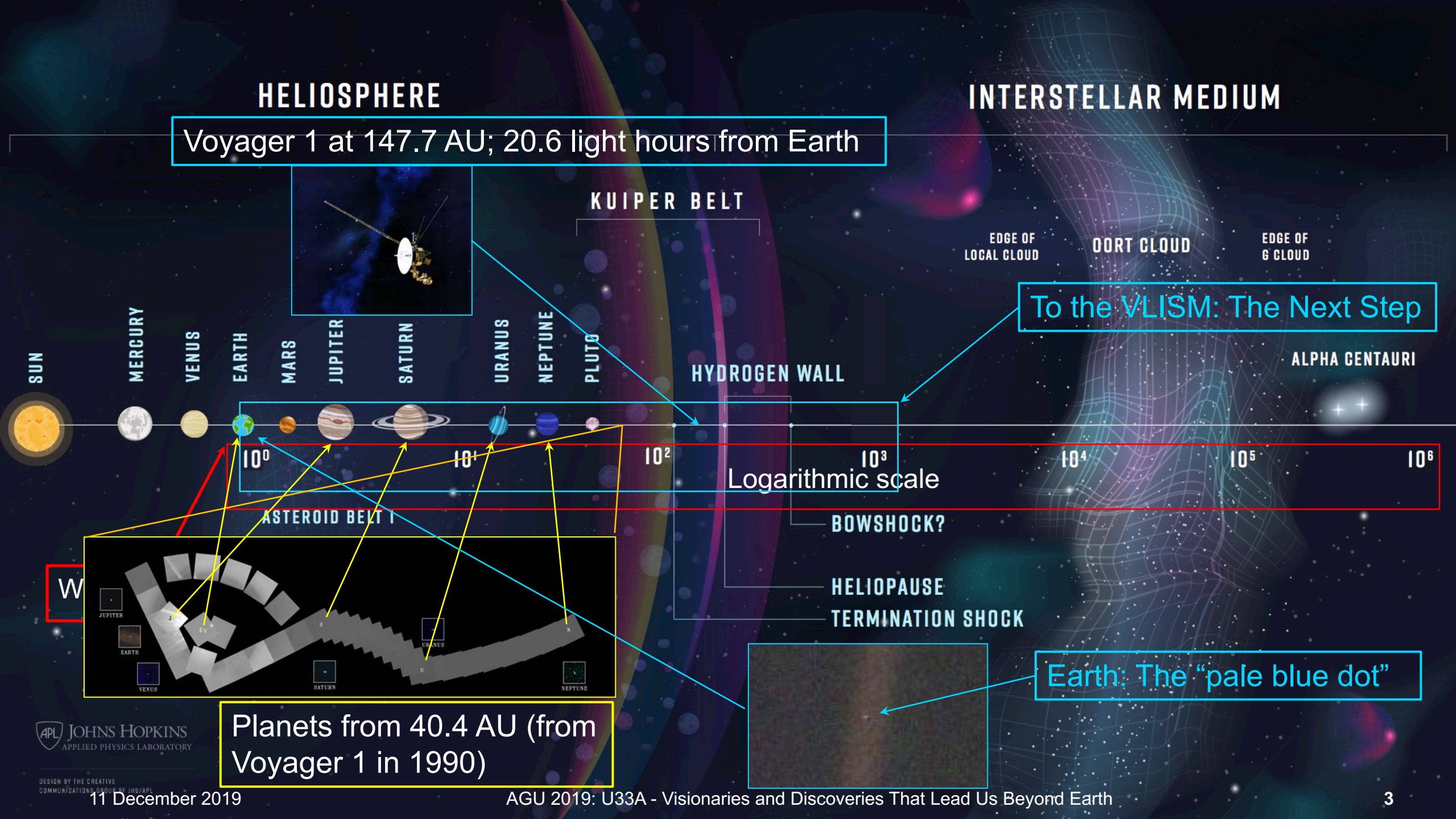
AGU 100 FALL MEETING
San Francisco, CA | 9–13 December 2019

15:10 – 15:25
Wednesday
11 December 2019

"Interstellar Probe"

INTERSTELLAR PROBE

- … is a mission through the outer heliosphere and to the nearby "Very Local" interstellar medium (VLISM)
- … uses today's technology to take the first explicit step on the path of interstellar exploration (faster than the Voyagers – on an SLS or commercial equivalent)
- … can pave the way, scientifically, technically, and programmatically for more ambitious future journeys (and more ambitious science goals)


HELIOSPHERE
INTERSTELLAR MEDIUM
Voyager 1 at 147.7 AU; 20.6 light hours from Earth
KUIPER BELT
EDGE OF LOCAL CLOUD
OORT CLOUD
EDGE OF G CLOUD
To the VLISM: The Next Step
SUN
MERCURY
VENUS
EARTH
MARS
JUPITER
SATURN
URANUS
NEPTUNE
PLUTO
HYDROGEN WALL
ALPHA CENTAURI
10^0
10^1
10^2
10^3
10^4
10^5
10^6
Logarithmic scale
ASTEROID BELT
BOWSHOCK?
HELIOPAUSE
TERMINATION SHOCK
JUPITER
EARTH
VENUS
SATURN
URANUS
NEPTUNE
Earth: The “pale blue dot”
Planets from 40.4 AU (from Voyager 1 in 1990)
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Three "Special Probes"… One Beginning … and One To Go

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National Academy of Sciences
National Research Council
2101 Constitution Avenue
Washington 25, D. C.

INTERIM REPORT NO. 3

March 1960

to

Space Science Board

of

Committee on
Physics of Fields and Particles in Space

I. Introduction

In Interim Reports to the Space Science Board of October 24, 1958 and February 10, 1959, the Committee proposed a wide range of experimental work to be conducted in its field of cognizance. These documents were approved by the Space Science Board and forwarded to the interested Government agencies - especially the newly formed National Aeronautics and Space Administration. At the same time and as a further assistance to the formulation of the NASA program, the Committee also reviewed all of the proposals submitted to it, recognizing, however, that such reviews would not in general constitute a continuing task of the Committee or the Board.

In this report the Committee turns to the matter of future programs in response to the SSB Memorandum 139 of 5 February 1960. Attention is devoted principally to the period of 1960-65; in addition, some observations are submitted concerning work which would be appropriate to the 1965-1975 period. This report was prepared as a result of a meeting held at the Enrico Fermi Institute for Nuclear Studies, University of Chicago on March 4-5, 1960. A list of those participating is given at the end of this report.

March 1960:
The "Simpson Committee"

Parker Solar Probe

Interstellar Probe

Ulysses

Special Probes

" " 3c solar magnetic field
Stabilization is required

b. Outer solar system probe: to be aimed away from the Sun in the plane of the ecliptic. (It is hoped that motion away from the Sun to the extent of 5 or 6 astronomical units per year could be accomplished by 1965)

Experiments:
Payload Group 6c scale size of the 11 year cosmic ray modulation
" " 6e transport of particles and fields from the Sun

Parker Solar Probe:
12 August 2018
3:31 a.m. EDT

Ulysses:
6 October 1990
11:47:16 UTC
(STS-41 launch)

A Scientific Beginning 100 Years Ago

Discovery of Galactic Cosmic Rays by Balloon

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PHYSICAL MAGAZINE

Editorial deadline for no. 23 on November 2, 1912.

No. 21/22. 13th year November 1, 1912.

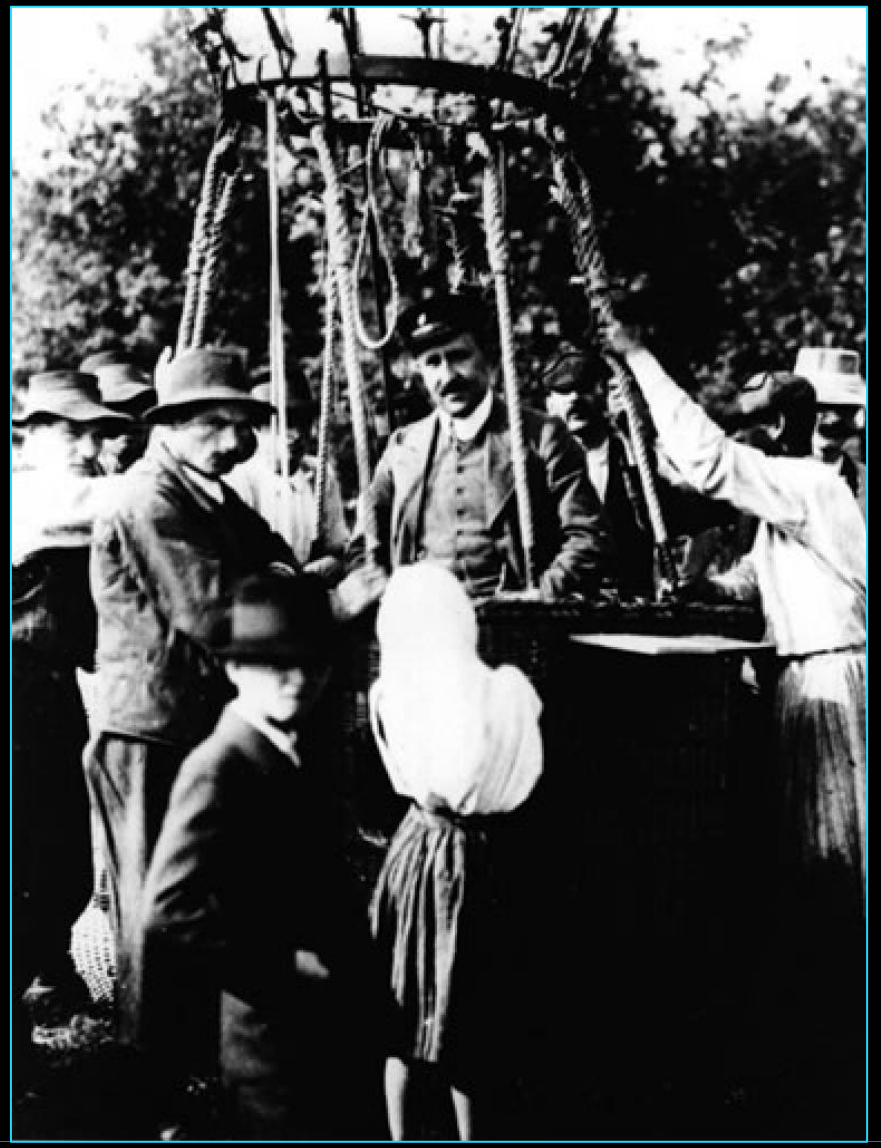
84th meeting of German naturalists and doctors in Münster i.W. from the 15th to the 21st of September 1912.

From the Department of Geophysics, Meteorology and Geomagnetism:

Viktor F. Hess (Vienna), On observations of penetrating radiation during seven free balloon rides.

In the previous year I have already had the opportunity to undertake two ballooning trips to investigate the penetrating radiation;

The investigations so far have shown that the penetrating radiation observed in closed vessels is of very complex origin. Part of the radiation comes from the radioactive substances on the earth's surface and in the uppermost soil, stratified and will change relatively little. A second proportion influenced by meteorological factors will come from the radioactive substances of the atmosphere - essentially from RaC. **My balloon observations seem to indicate that there is still a third component of total radiation that increases in height and also exhibits strange intensity fluctuations on the ground.** Further research will have to pay the most attention to them.



Neither the Question…nor the Answers… are new

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JPL study of 1976 – 1977:

Science Aspects of a Mission Beyond the Planets

LEONARD D. JAFFE AND CHARLES V. IVIE

Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, California 91103

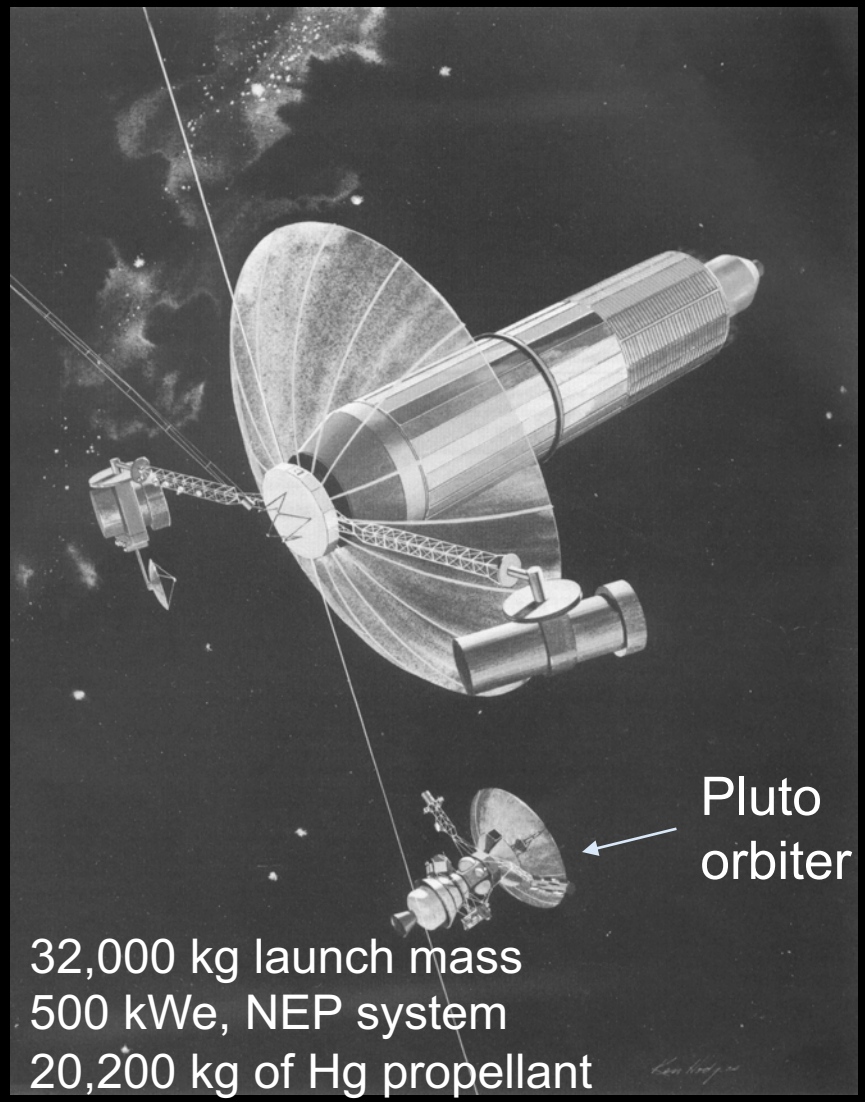
Received July 26, 1978; revised April 10, 1979

Primary Objectives

(1) Characterize the heliopause
(2) Determine characteristics of the interstellar medium
(3) Improve the stellar and galactic distance scale
(4) Determine characteristics of cosmic rays
(5) Determine characteristics of the solar system as a whole

Secondary Objectives

(1) Determine characteristics of Pluto and its satellites and rings, if any.
(2) Determine characteristics of distant galactic and extragalactic objects
(3) Evaluate problems of scientific observations of another solar system from a spacecraft



The Heliosphere and LISM

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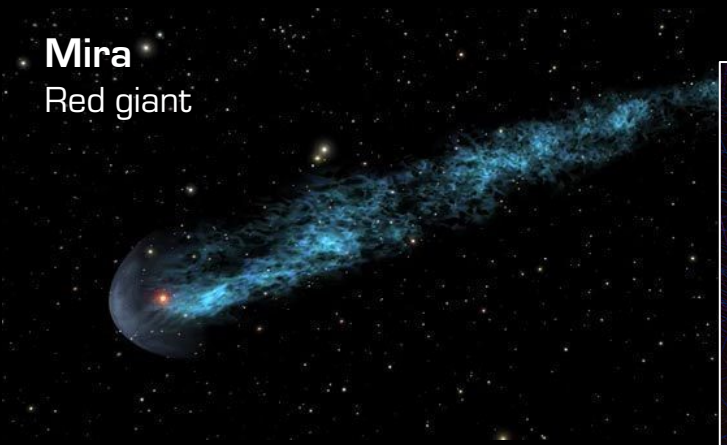
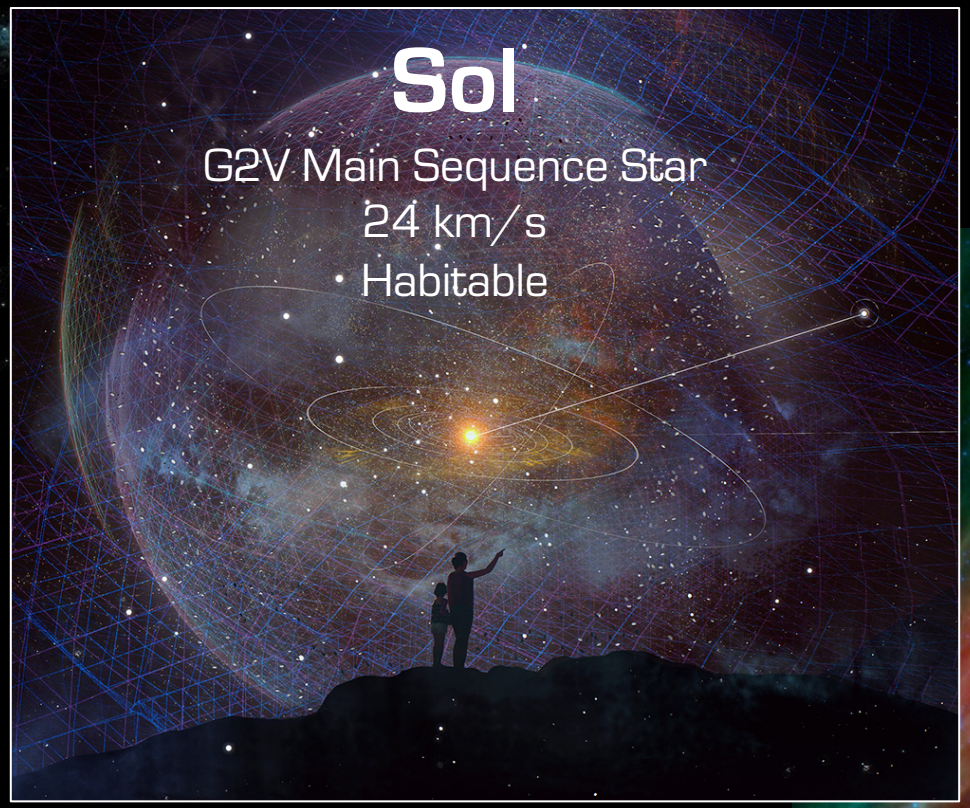
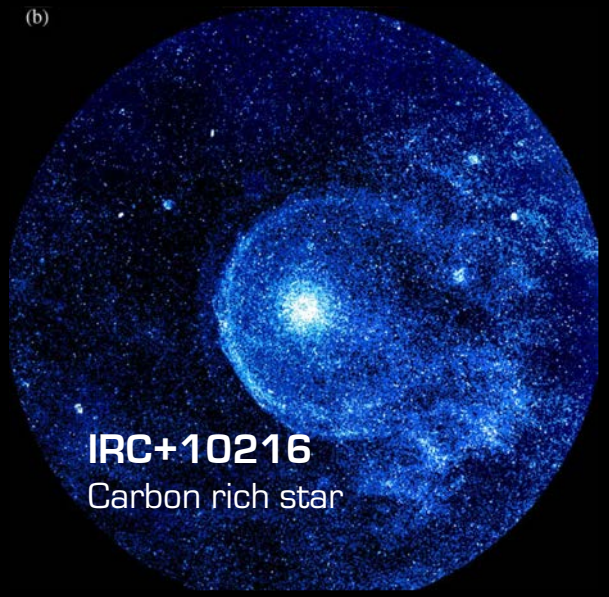
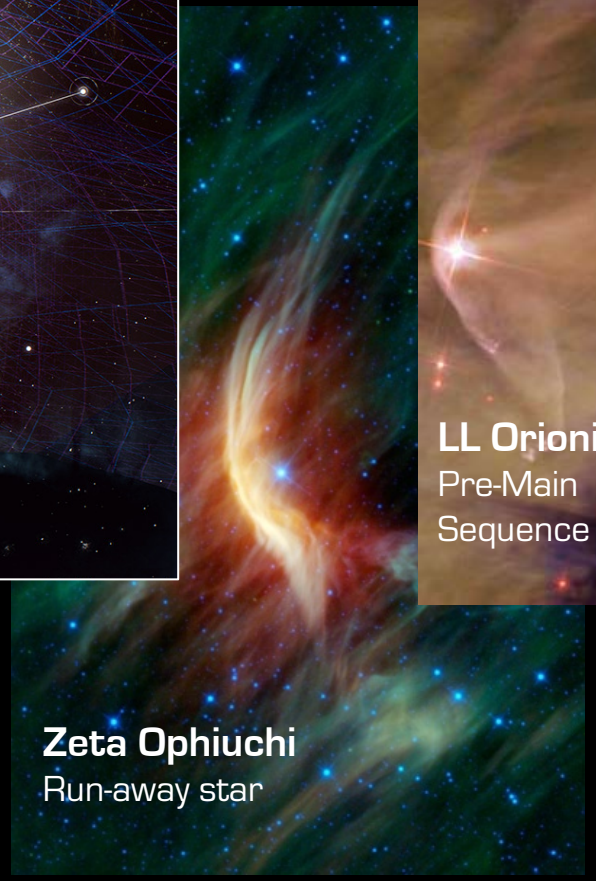


Mira
Red giant





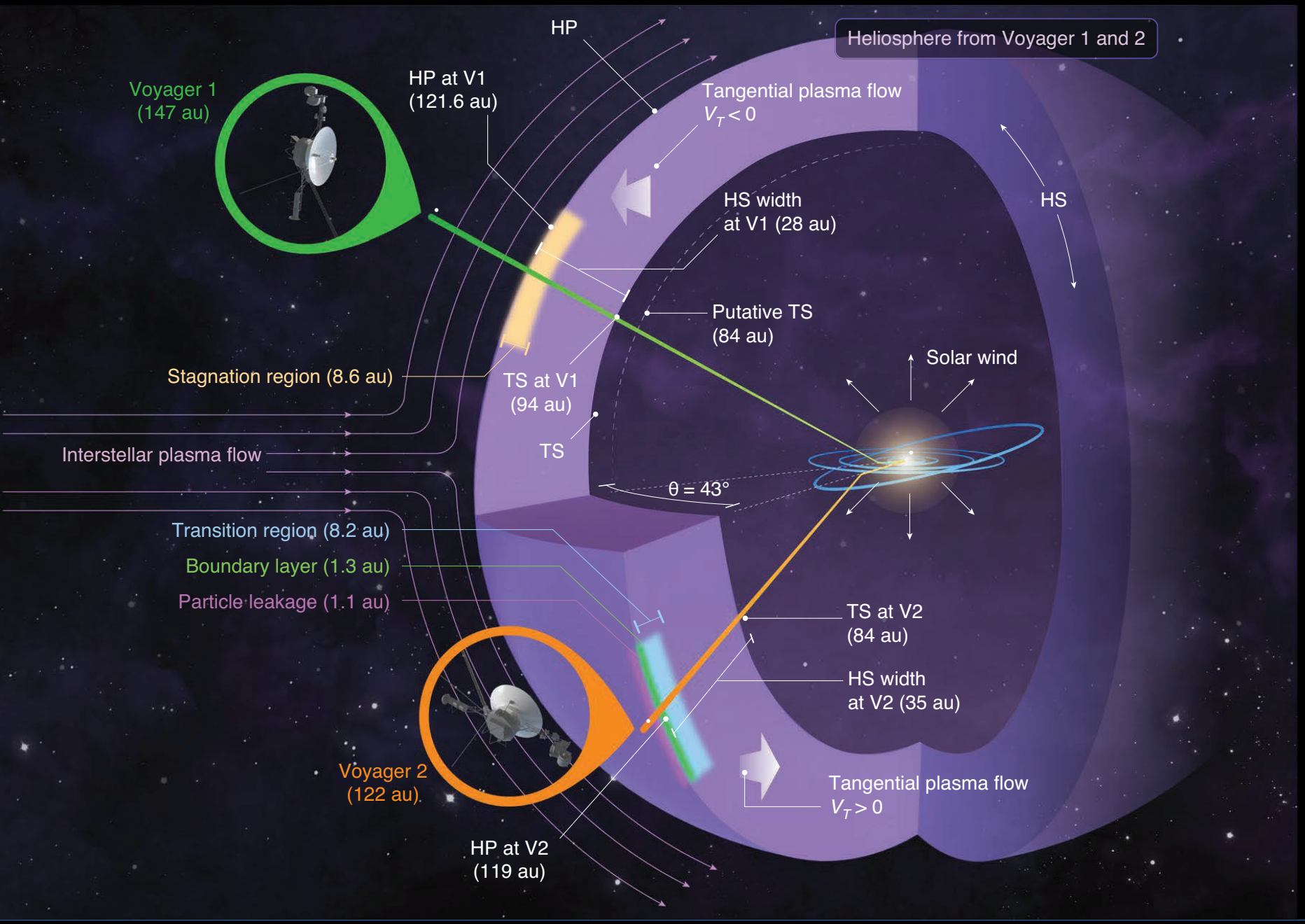
IRC+10216
Carbon rich star



Zeta Ophiuchi
Run-away star

LL Orionis
Pre-Main Sequence Star

BZ Camelopardalis
Binary white dwarf and main sequence



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From Inside Out
Global Nature of the Heliosphere

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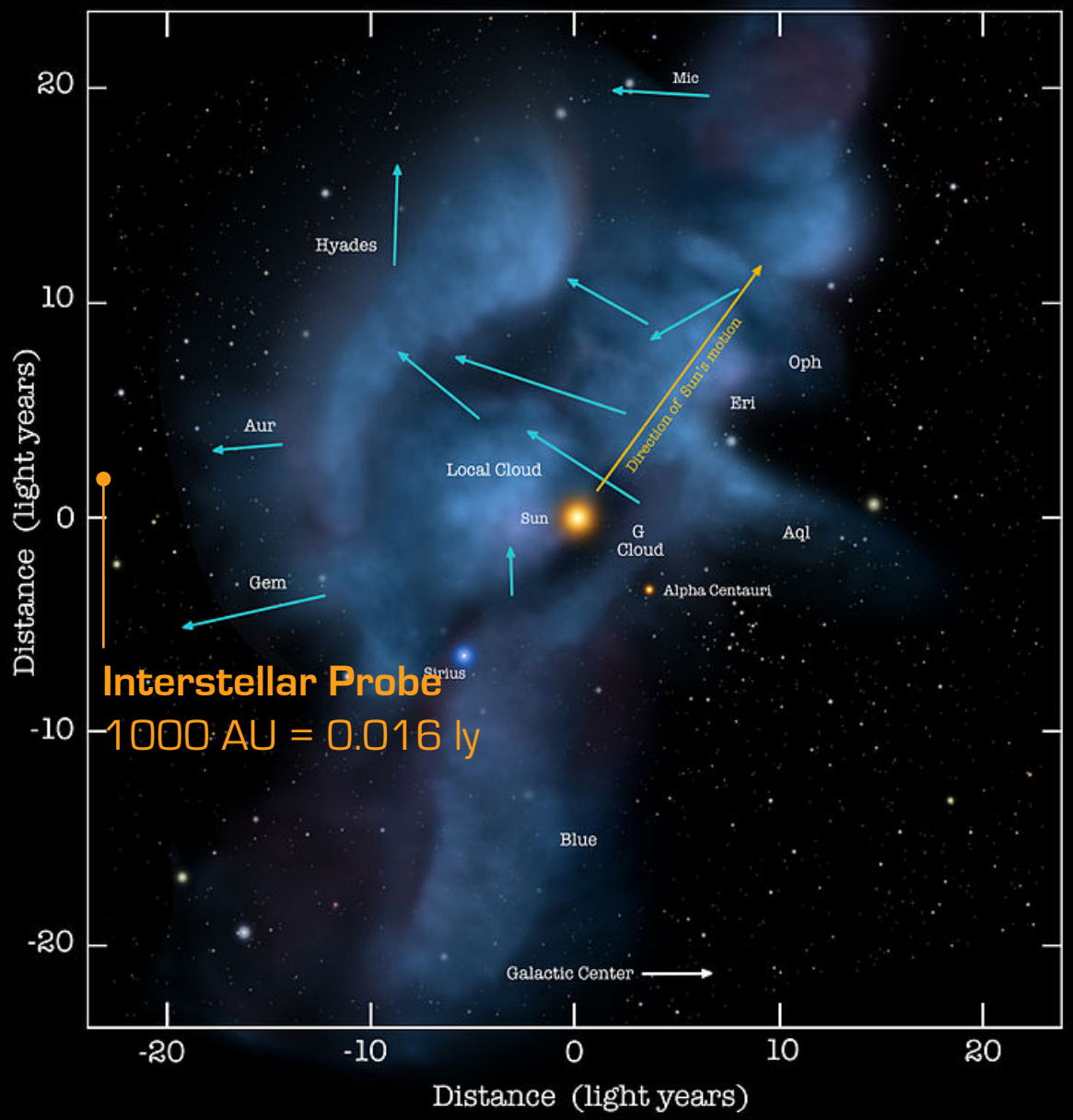

From Outside In

Sampling the Galactic Environment for the First Time

Along the Way…

Potential Cross-Divisional Contributions with High Return

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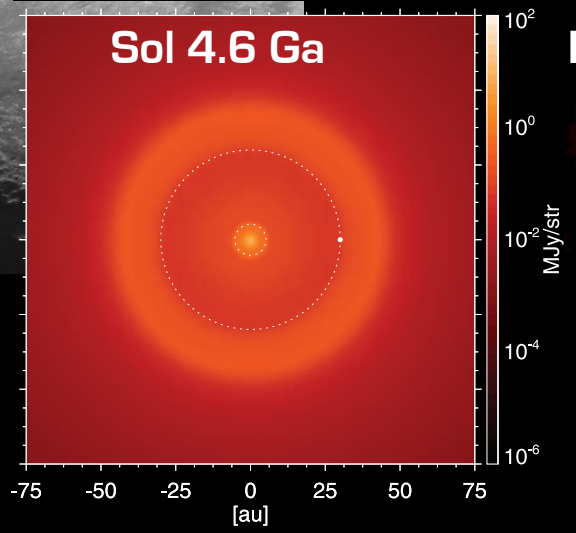
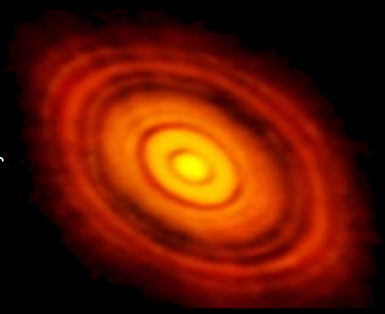
Dwarf Planets and KBOs

Solar system formation

Circum-Solar Dust Disk

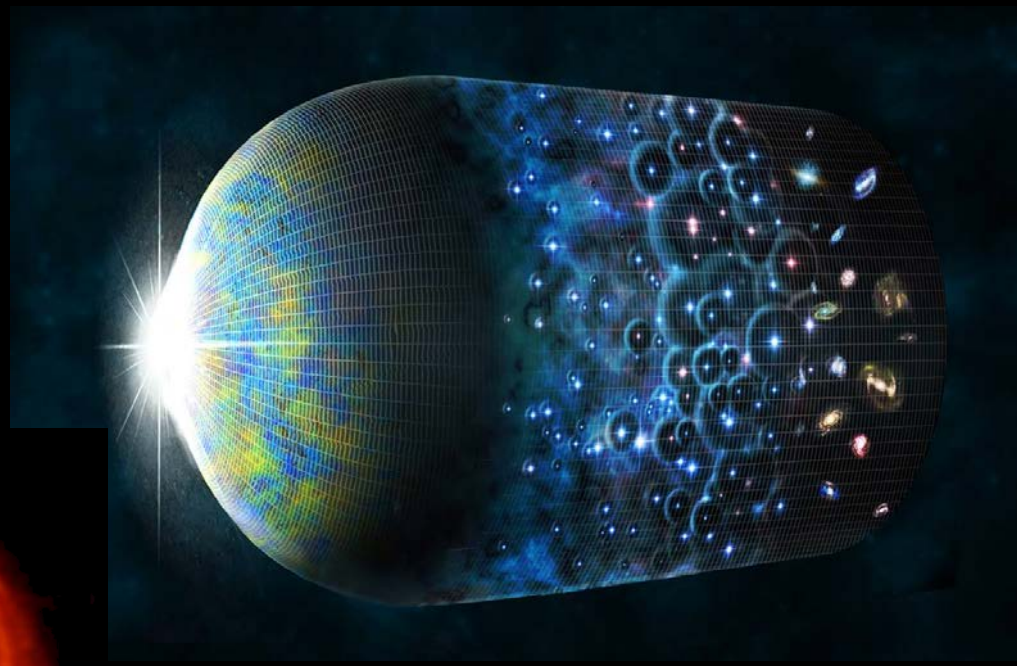
Imprint of solar system evolution





Extra-Galactic Background Light

Early galaxy and star formation



A “Menu” Approach

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- Look widely across the science and technical communities
- Assemble a “Menu” of what has been done and what can be done
- By its nature this is a “superset” of what might be implemented
- “Ordering” from the menu will we a charge to a future Science Definition Team – at NASA’s discretion
- But one always would like the assurance about what orders can be placed – and delivered – and what they would cost
- This approach has been adopted successfully in the past in providing input to the Decadal Surveys

Where We Could Go: Target Map

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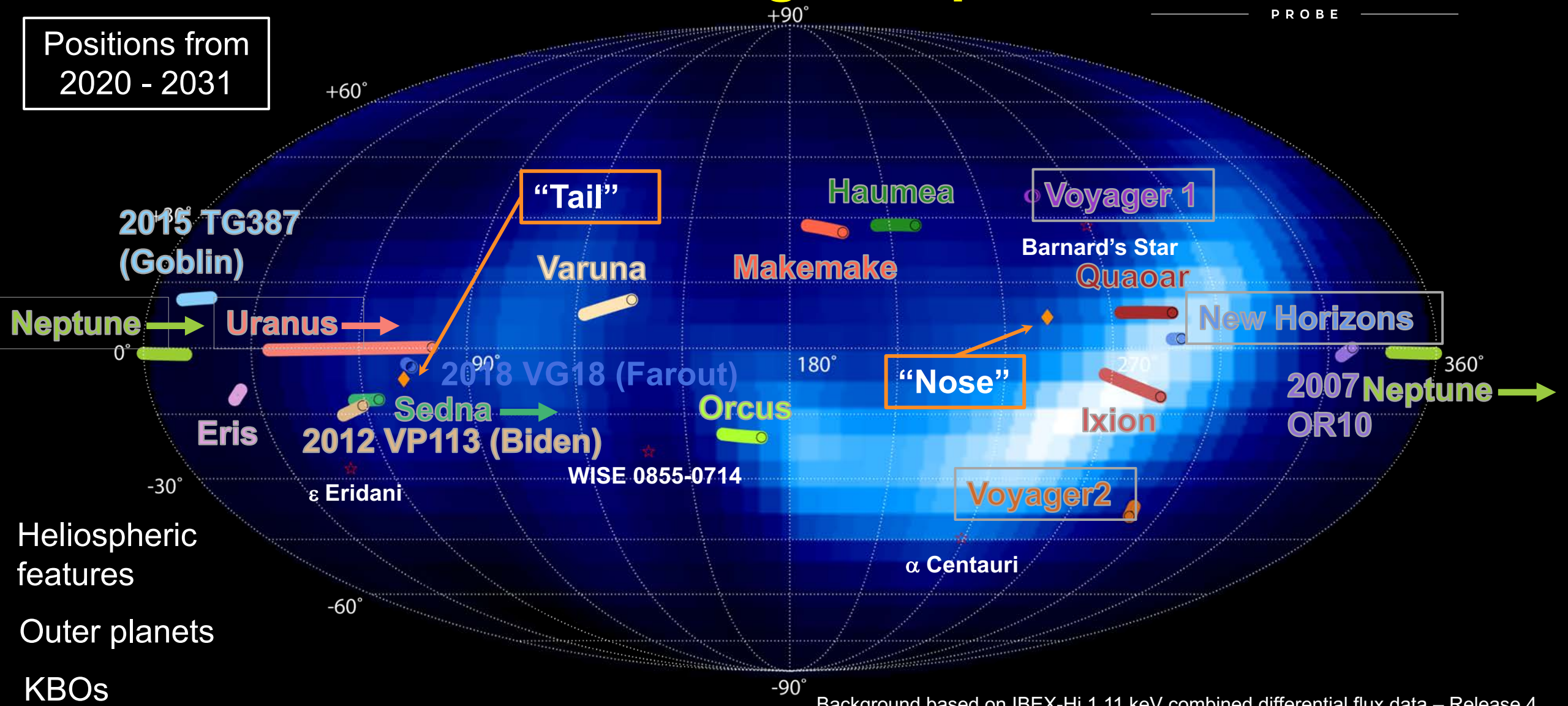
Positions from 2020 - 2031



Heliospheric features

Outer planets

KBOs

Background based on IBEX-Hi 1.11 keV combined differential flux data – Release 4

Engineering Requirements

- Engineering requirements are needed to frame the engineering study
  - "Bound the box" – but allow for trades
  - Still evolving

(1) Enable a mission that can be launched no later than 1 January 2030.

(2) Have the capability to operate from a maximum range of not less than (NLT) 1000 astronomical units (AU) from the Sun.

(3) Require no more than 400 Watts of electrical power (We) at the beginning of mission (BOM) and be able to operate at no less than half of the BOM amount at the end of mission (EOM).

(4) Achieve a mission lifetime of not less than (NLT) 50 years with a probability of success of NLT 85%.

Critical Trade-Offs Are Not New

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- **Mass: Driven by flyout speed and payload capability**
- **Communication:** Solid, near-term, tested engineering

Nor Are Enabling Technologies

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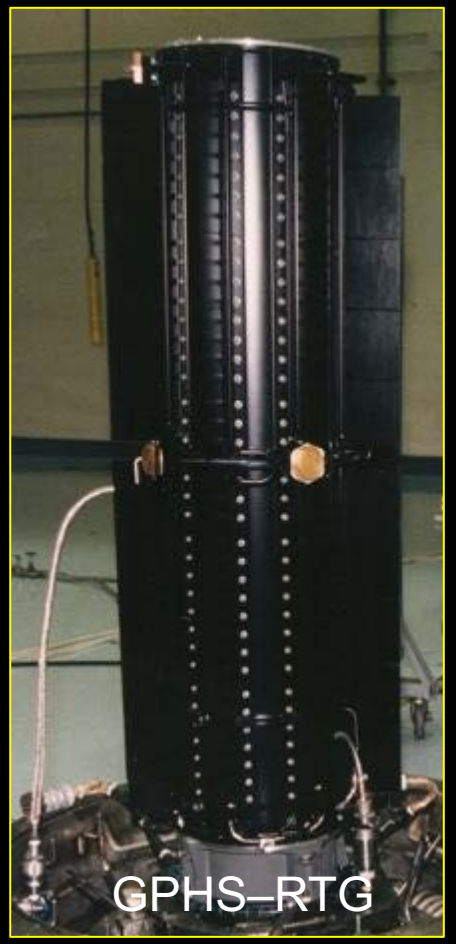
- **Power:** GPHS/MHW derivative RTG – efficiency and lifetime for use *in vacuo*


GPHS–RTG


MHW–RTG

- **Propulsion/Launch Vehicle:** Keys for implementation

…	Oct 19	Nov 19	Dec 19	Jan 20	Feb 20	Mar 20	Apr 20	May 20	Jun 20	July 20	Aug 20	Sep 20	Oct 20	…	Sep 21
	Wksp 2019								Prelim Results	ACE Run		Interim Report	Wksp 2020		Final Report

Longevity
- SC lifetimes/failures, long-lasting systems, failure modes

- Develop process of failure modes and accelerated testing

- Symposium to discuss results;

- Report and papers

Science

ConOps

Instruments
- Candidate payload components with parameters + operating requirements

- Define baseline payloads

Trajectory / Launch Vehicle

Comm and GNC trades

Heat Shield
- Attitude control at burn
- High temp coating

- If yes, define ConOps parameters

Mechanical
- Design spacecraft layout

Power
- Compare NG-RTG, GPHS-RTG and MHW-RTG using GPHS components

ACE Run

Interim Report

Work -shop Input

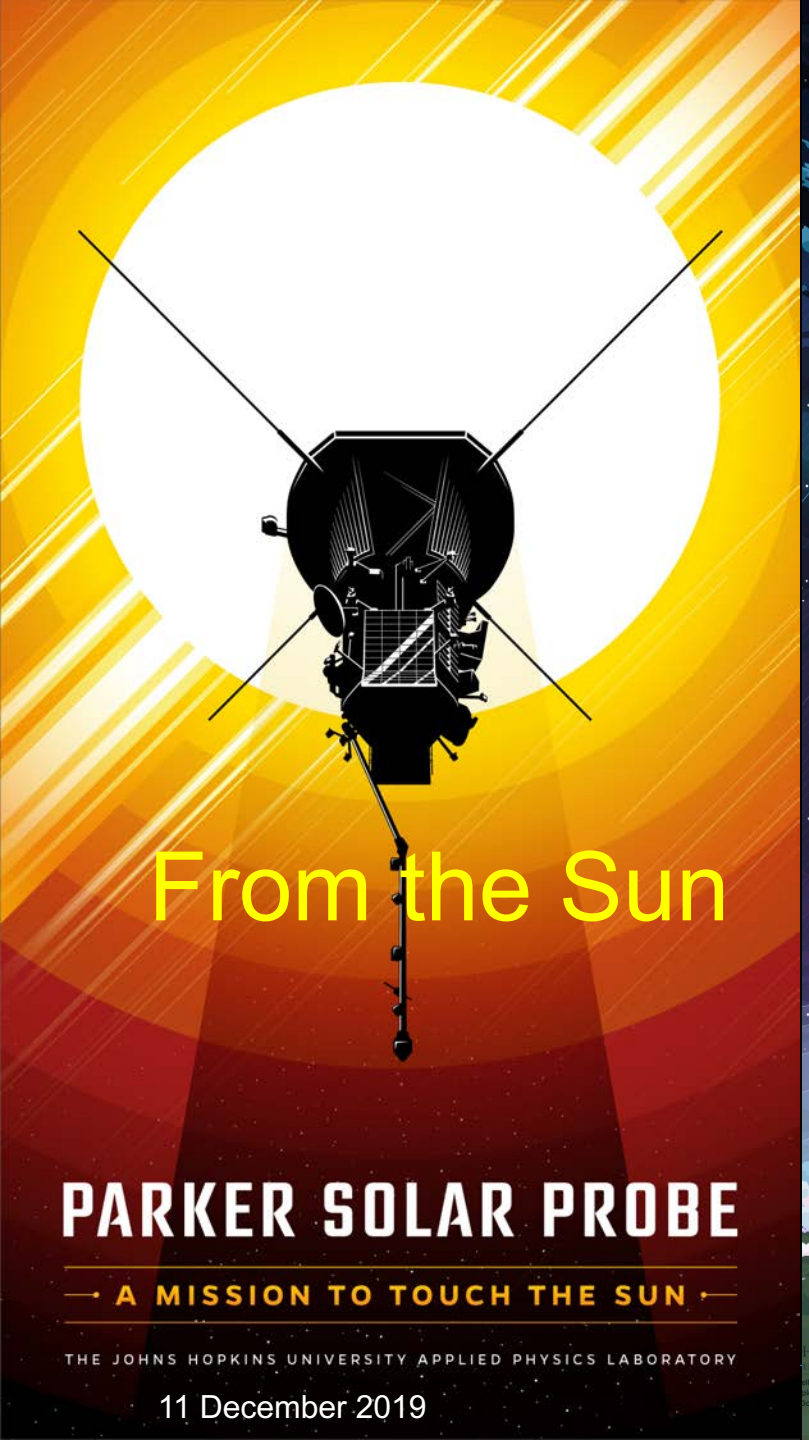
Revise Report

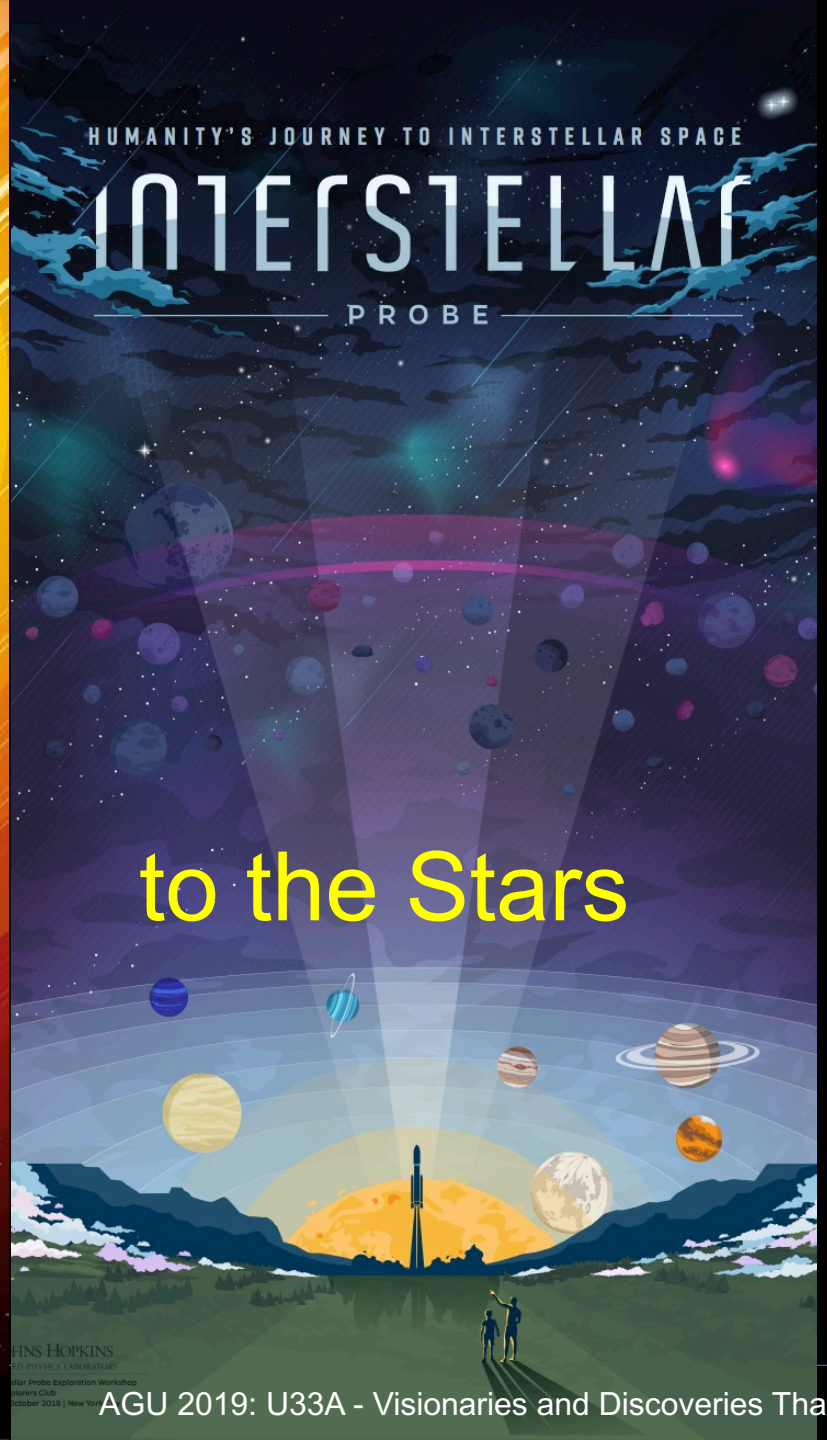
Final Rprt

ACE = **A**PL **C**oncurrent **E**ngineering Laboratory
Engineering requirements:
- 400 W
- Launch-able 1/1/30
- >50 years
- >1000 AU

24 February 2030…

… Faster and Onward !





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The real journey has only just begun…