



The Voyager Journey to the Edge of Interstellar Space

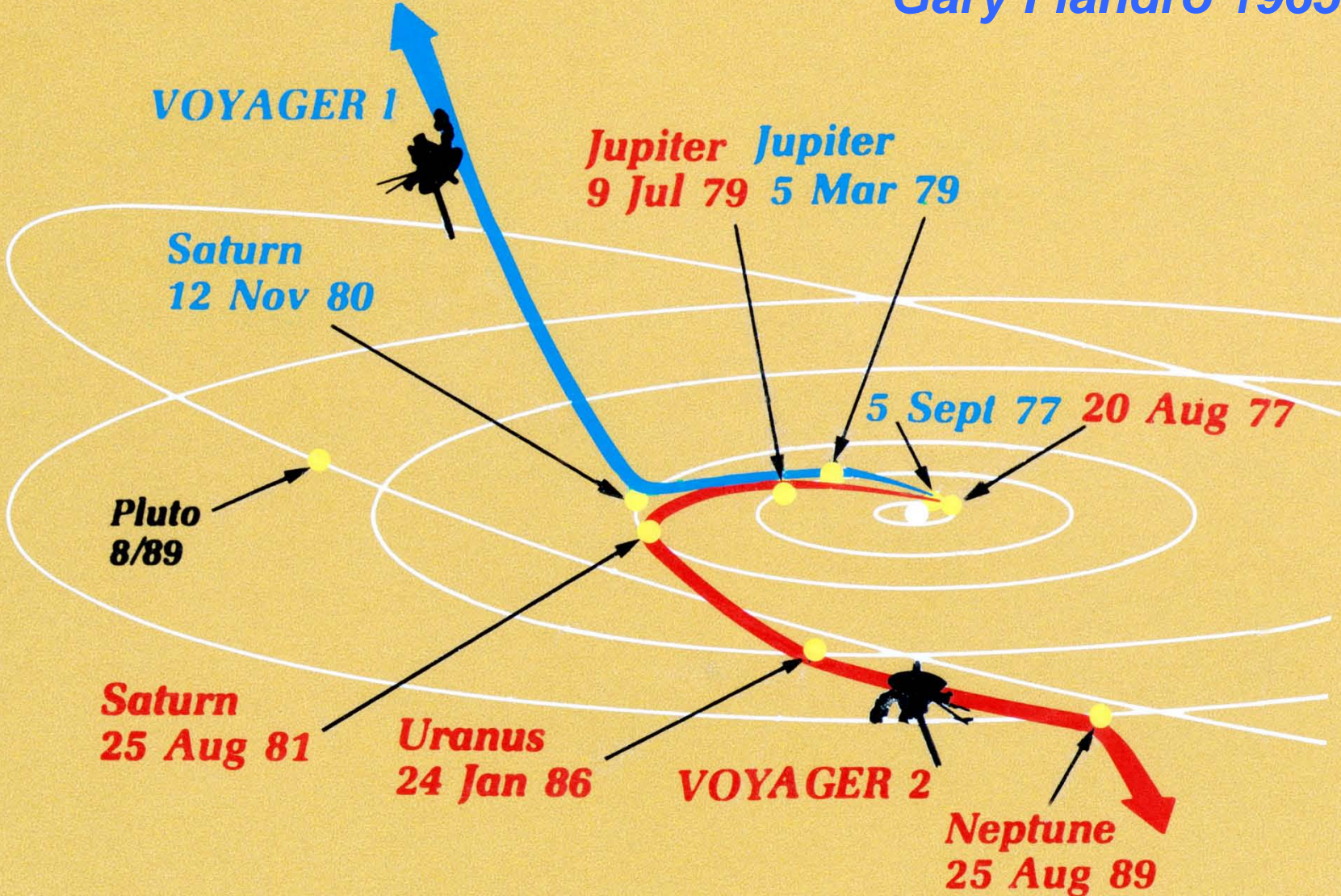
Spacepart12

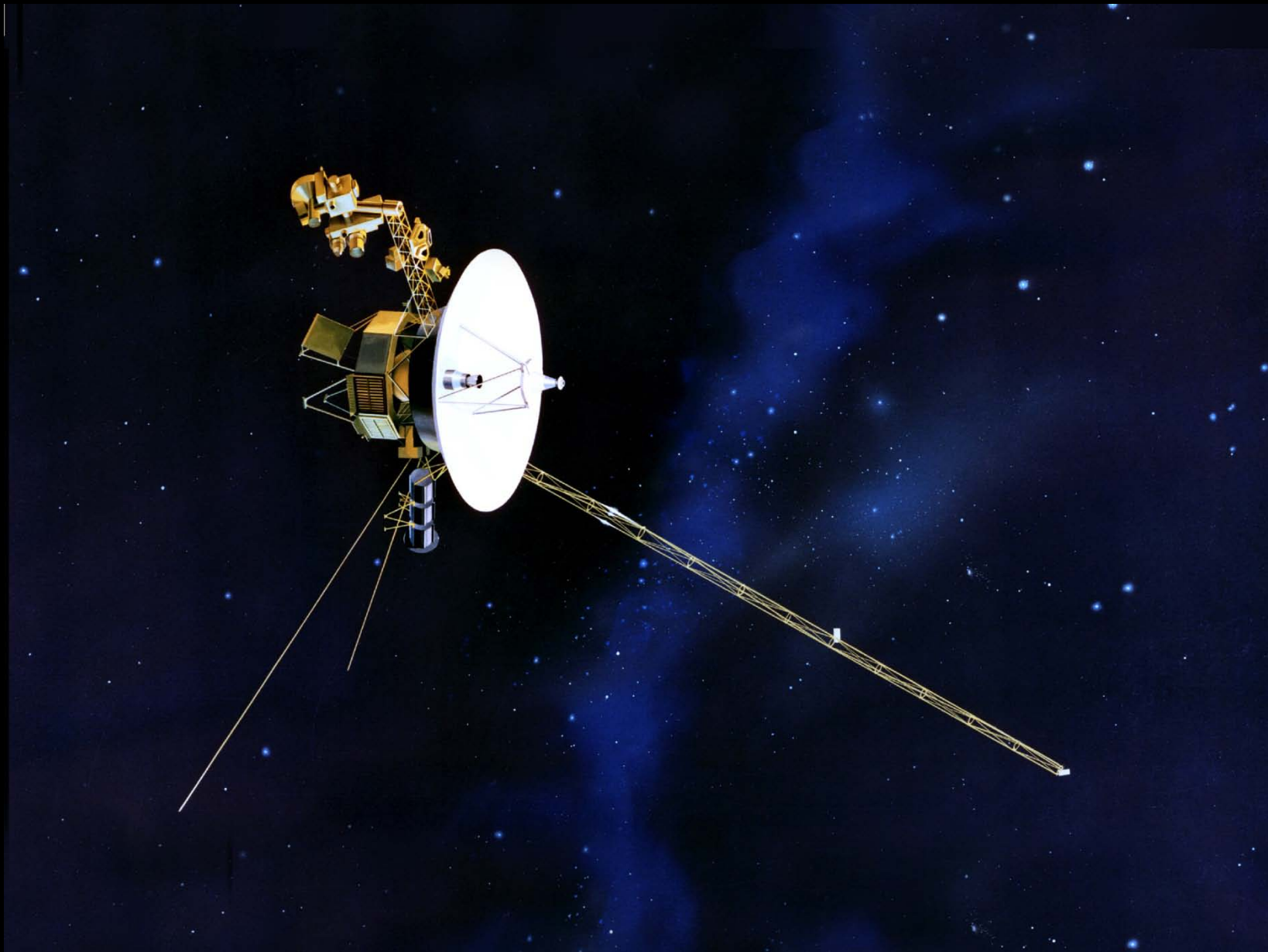
CERN

Edward Stone

November 5, 2012

Gary Flandro 1965



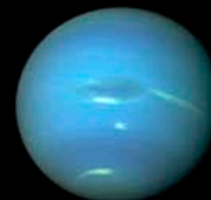
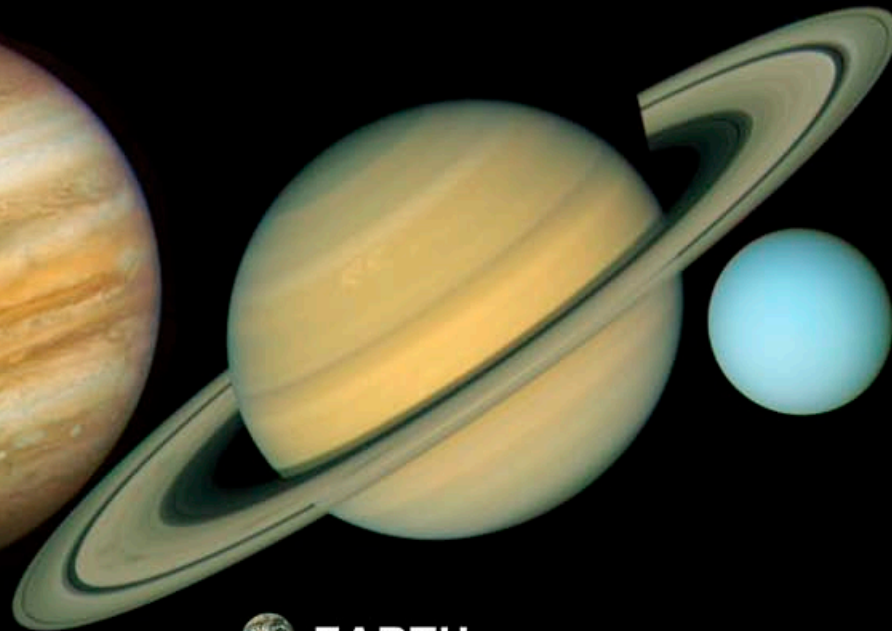


JUPITER
5 AU

SATURN
10 AU

URANUS
19 AU

NEPTUNE
30 AU



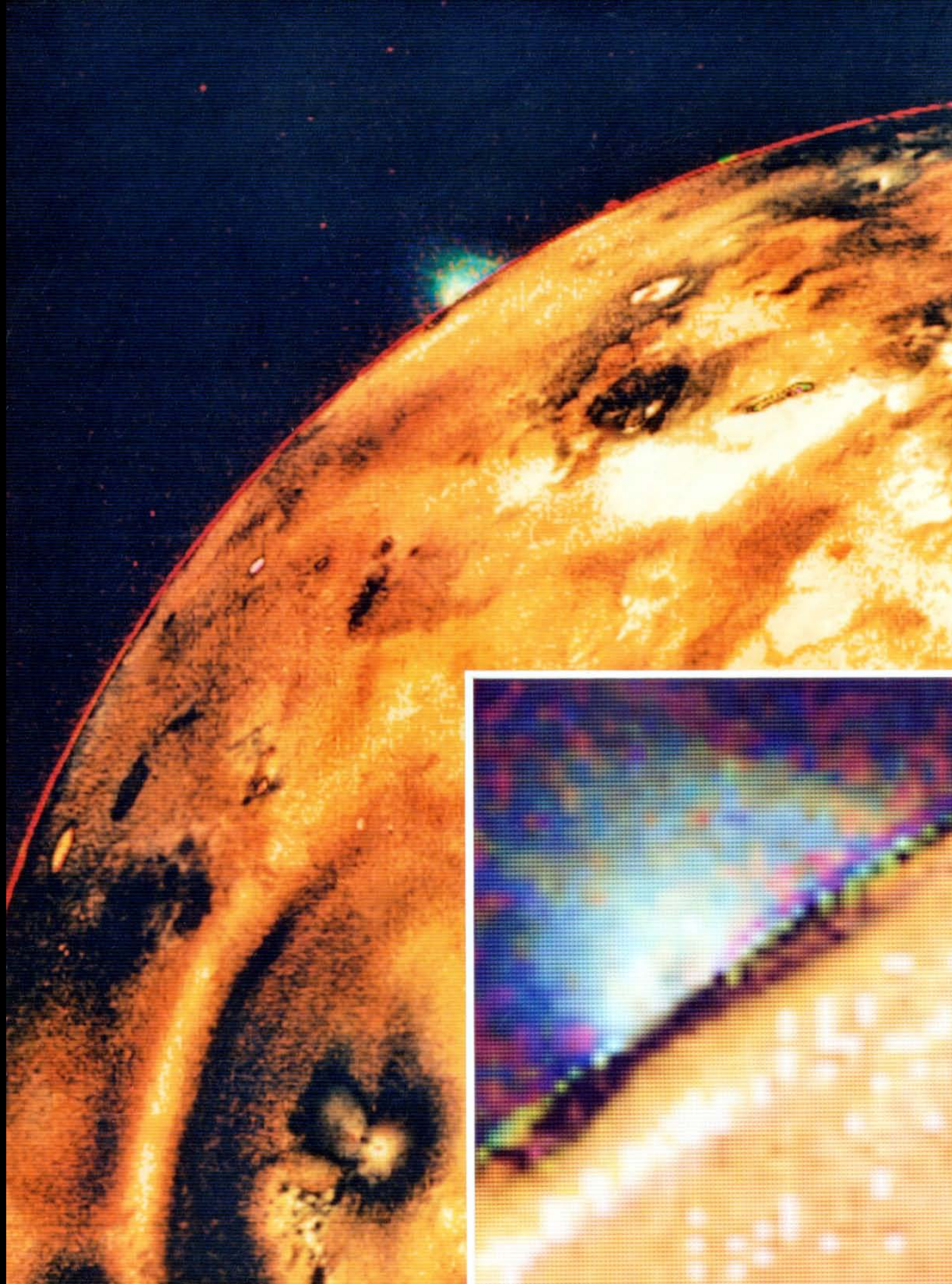
EARTH
1 AU



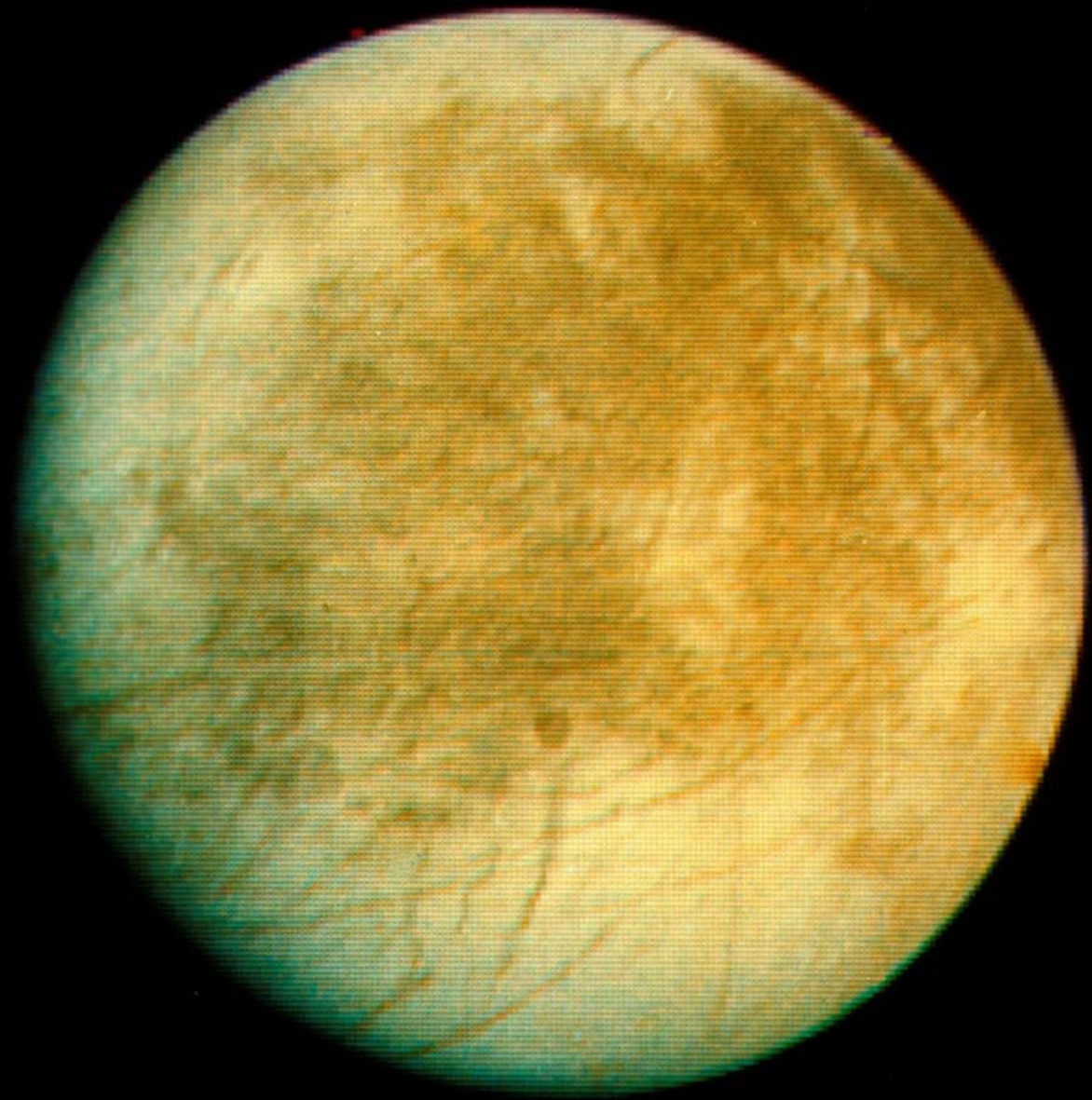
Jupiter 5 AU



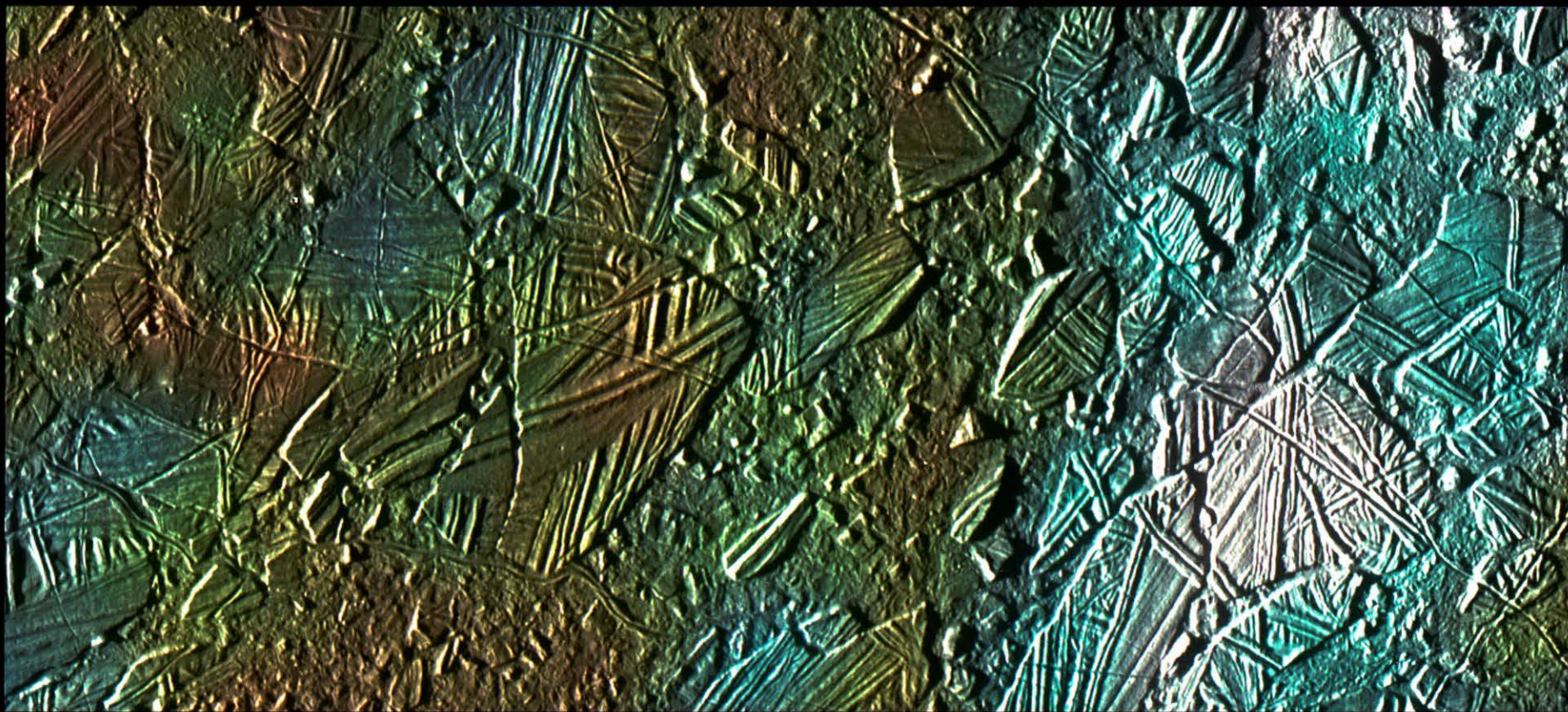
Io



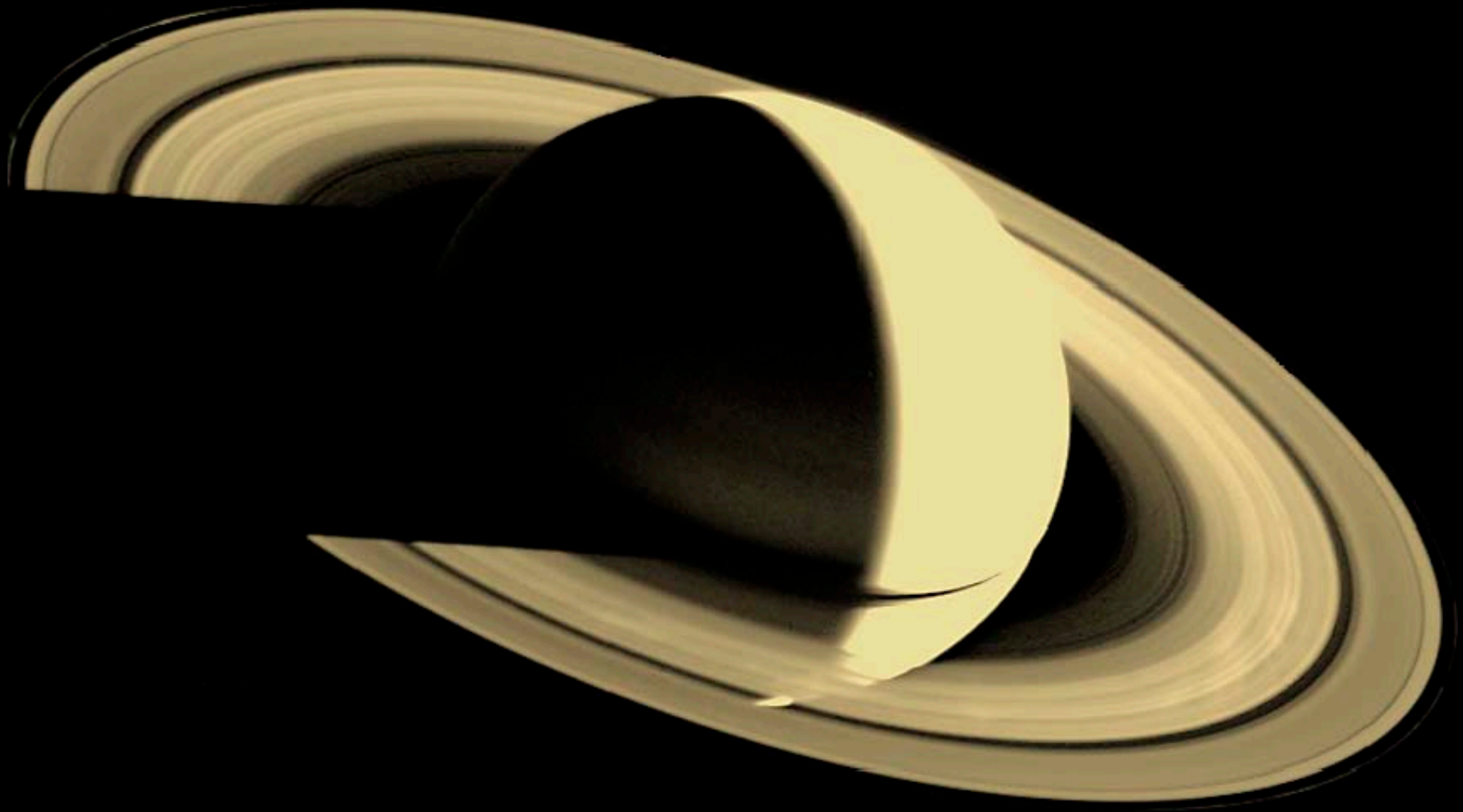
Io



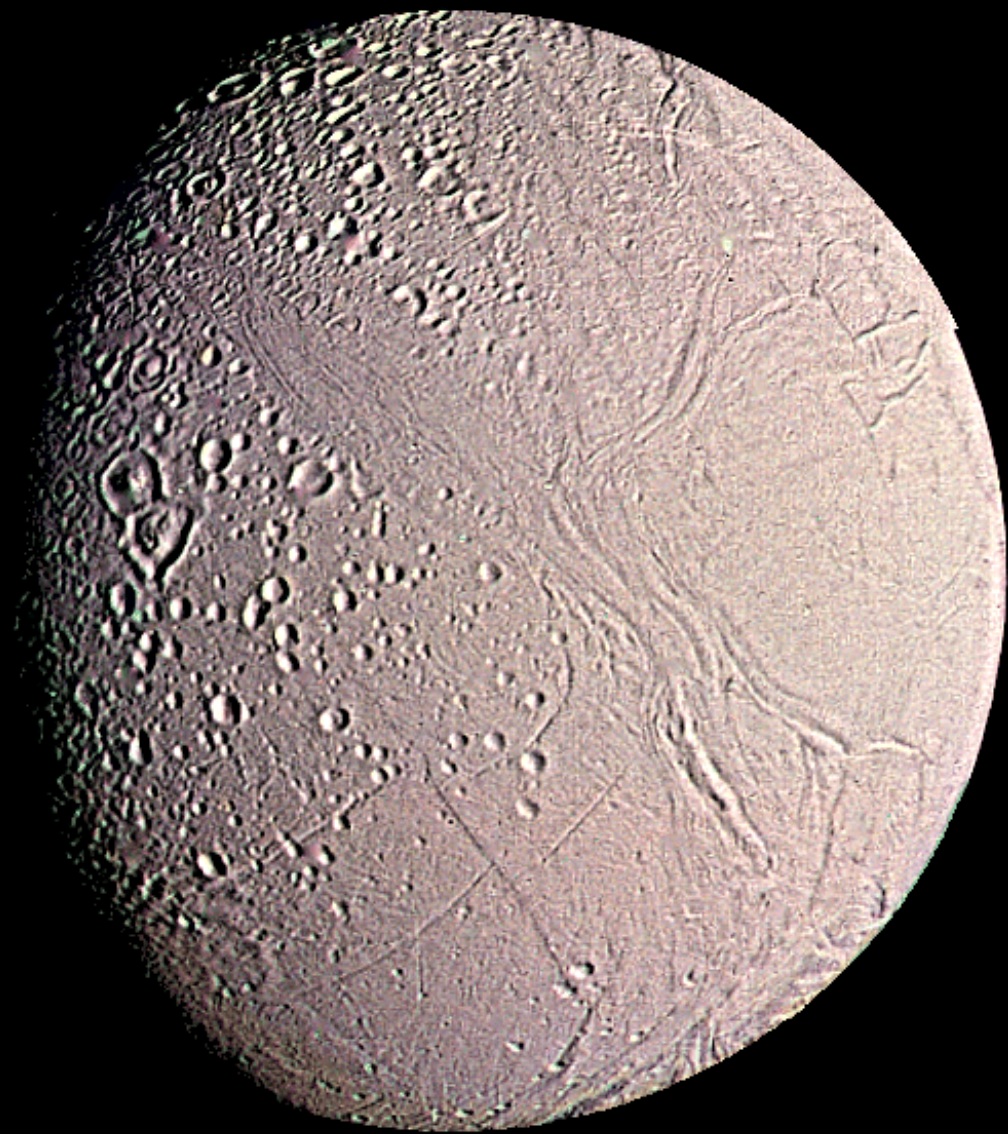
Europa



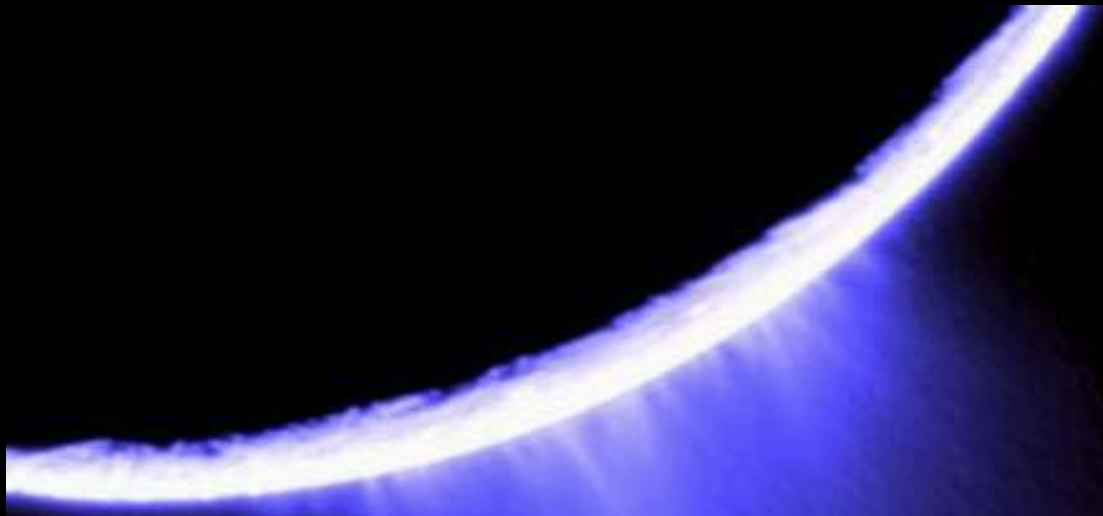
Europa (Galileo)



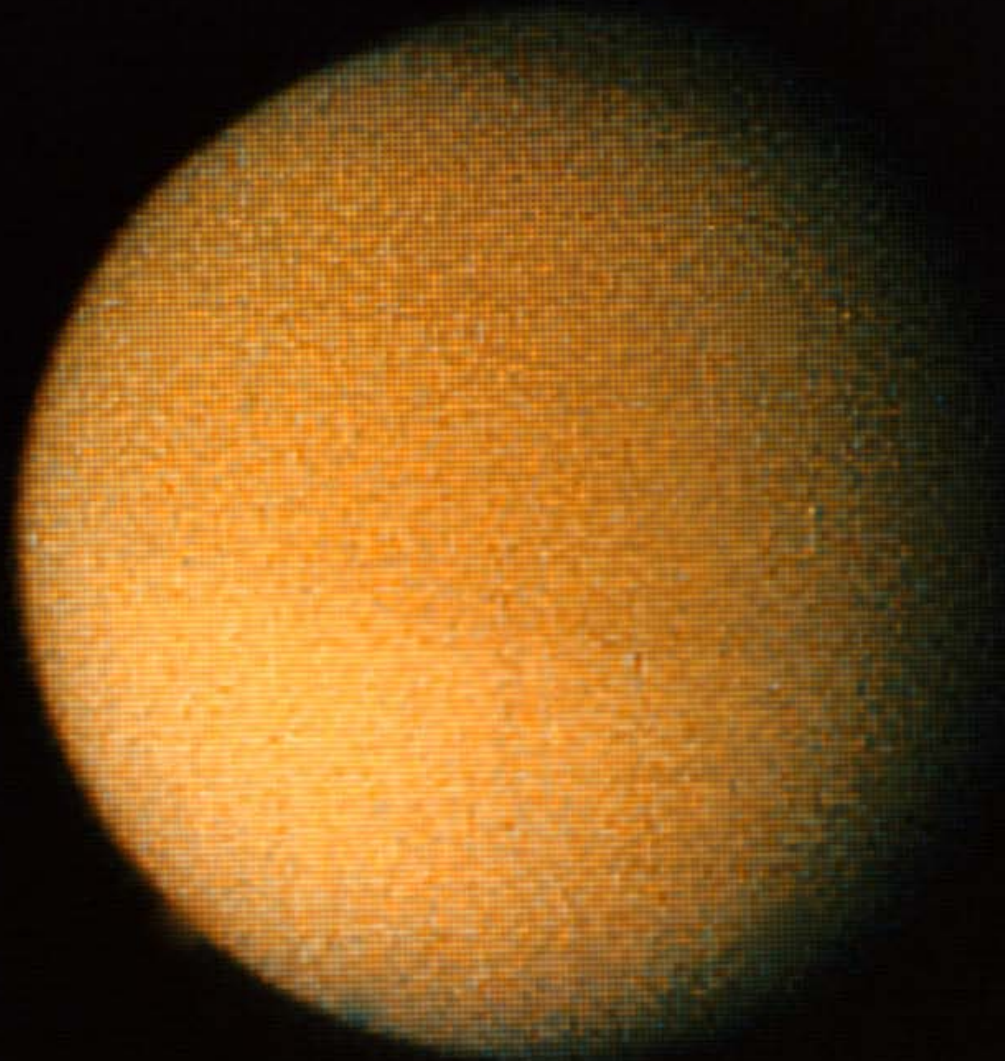
Saturn 10 AU



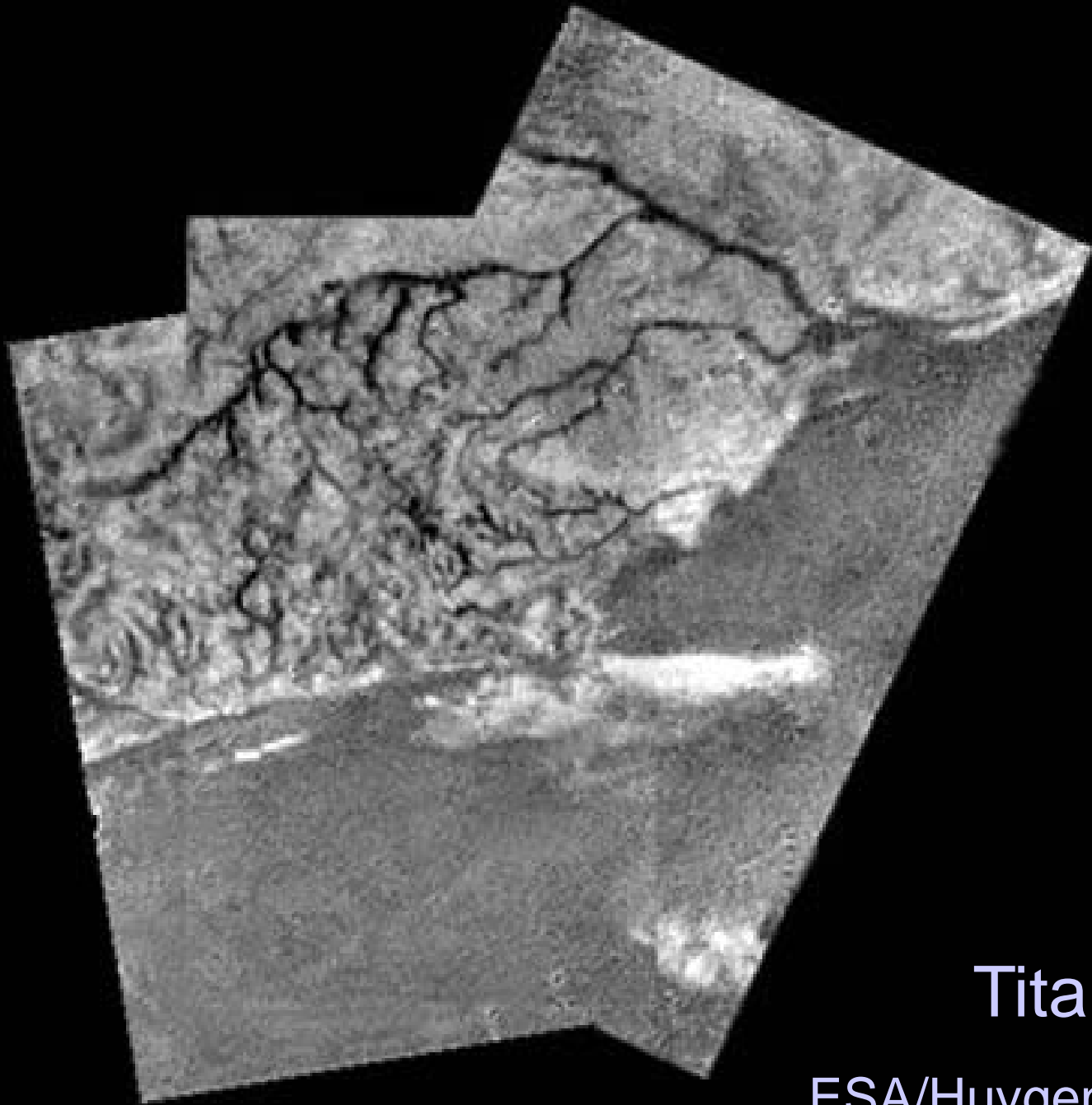
Enceladus



Enceladus (Cassini)

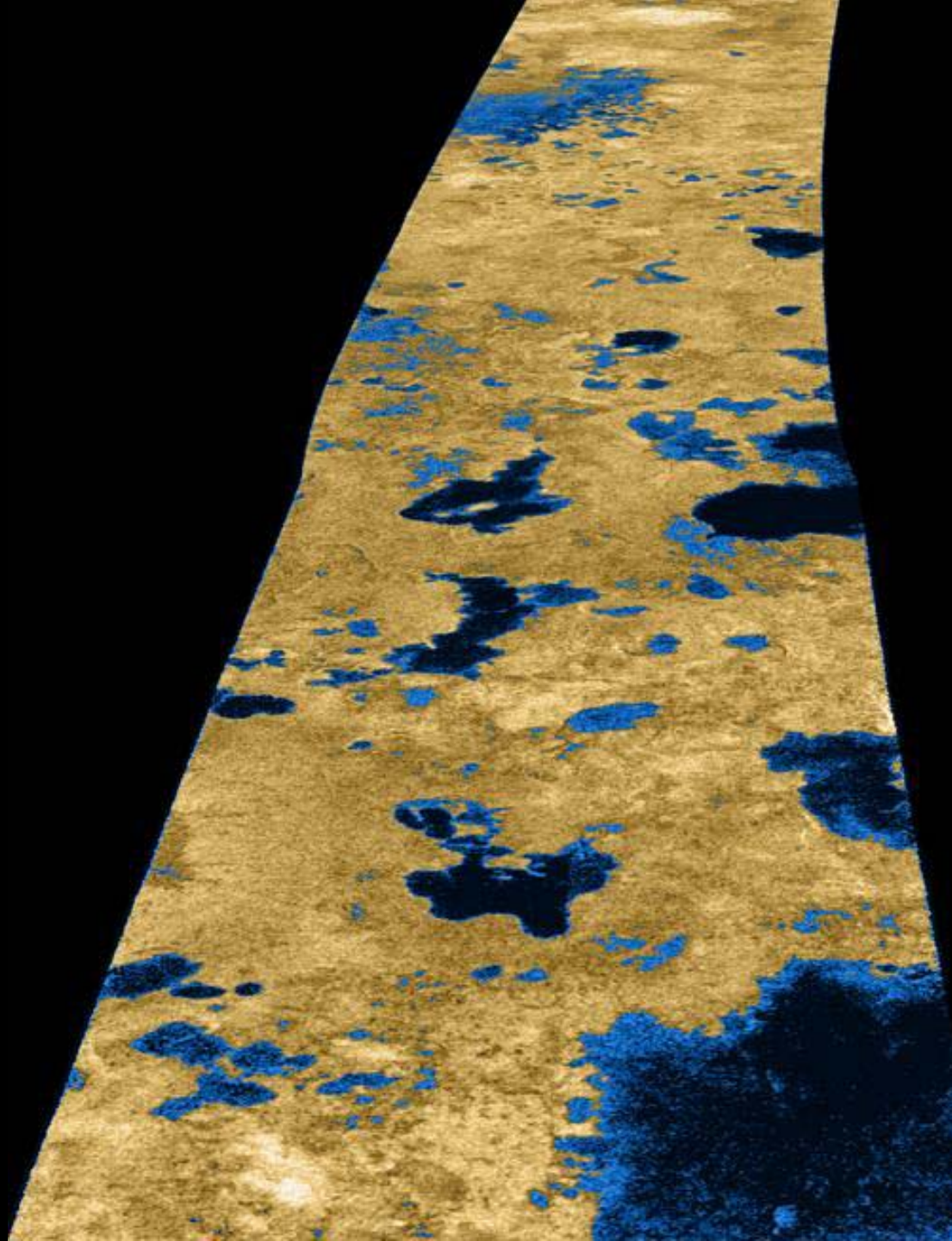


Titan



Titan

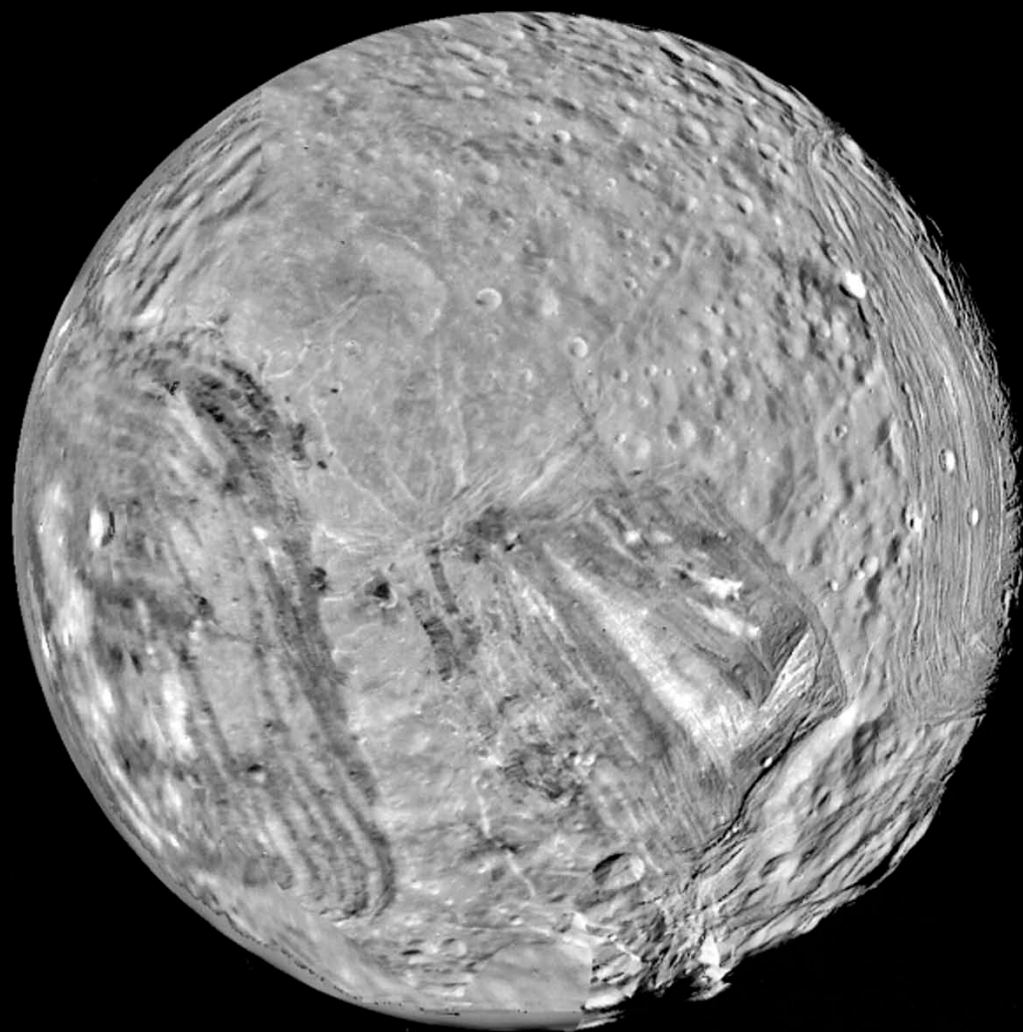
ESA/Huygens Probe



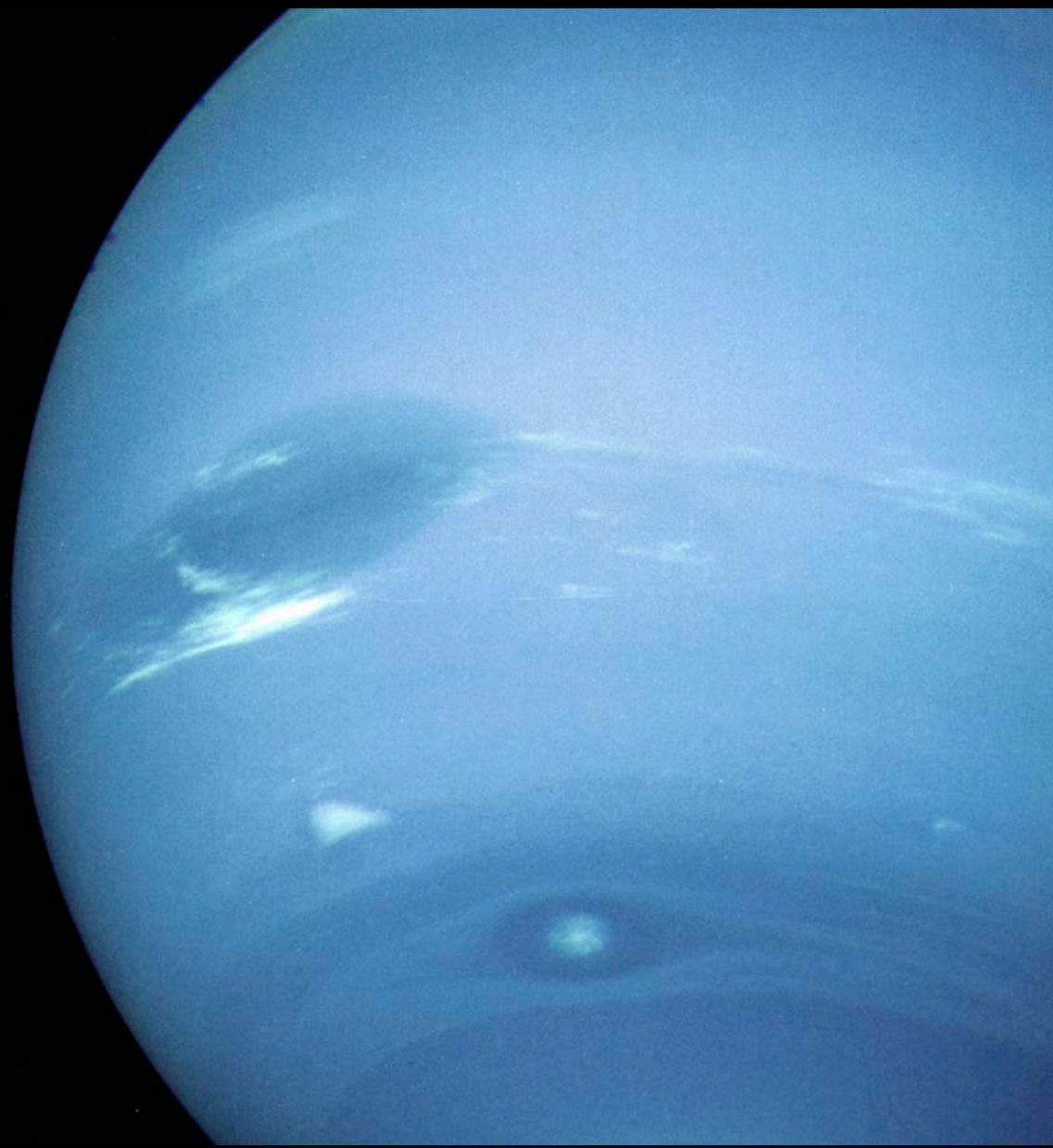
Titan
(Cassini)



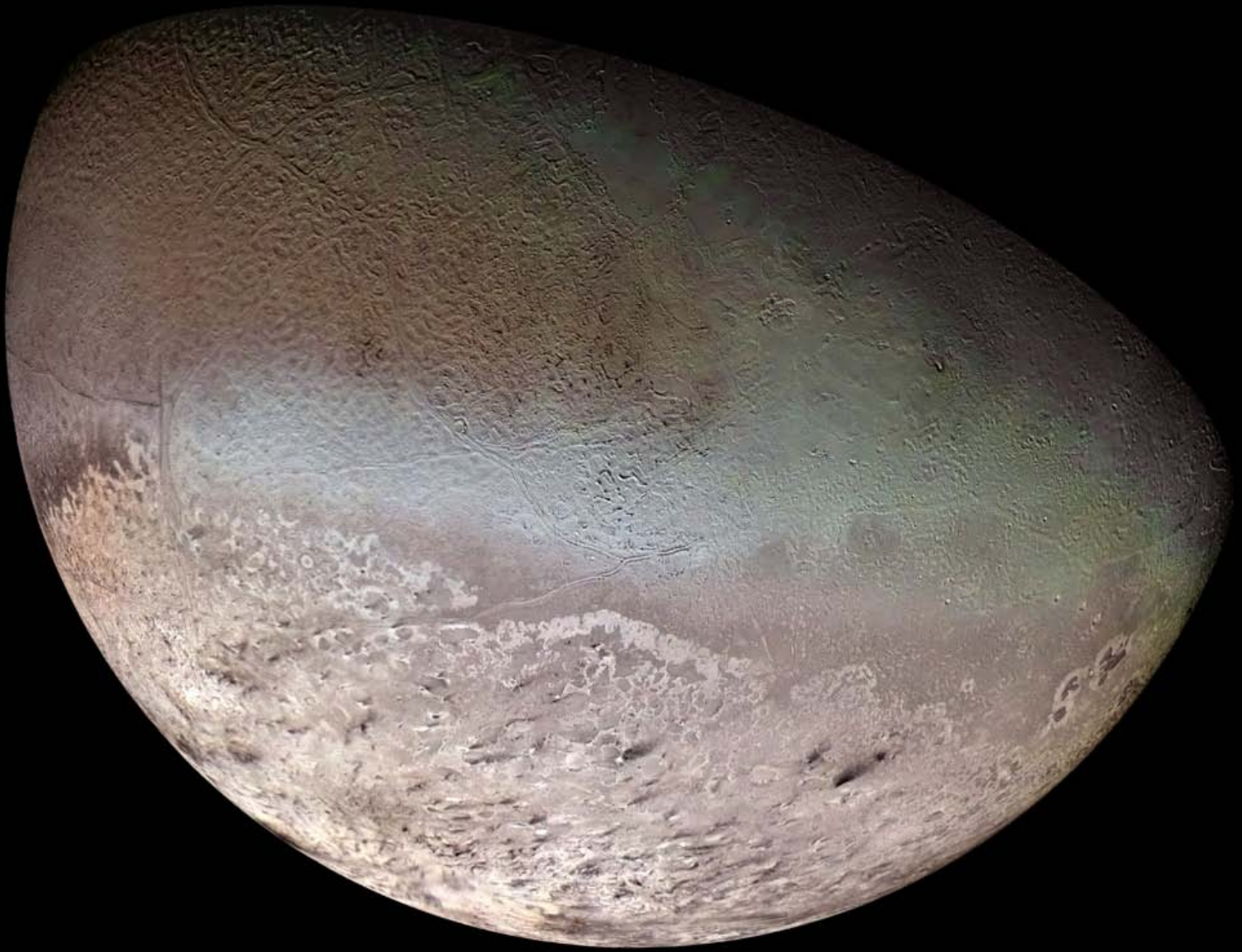
Uranus 19 AU



Miranda

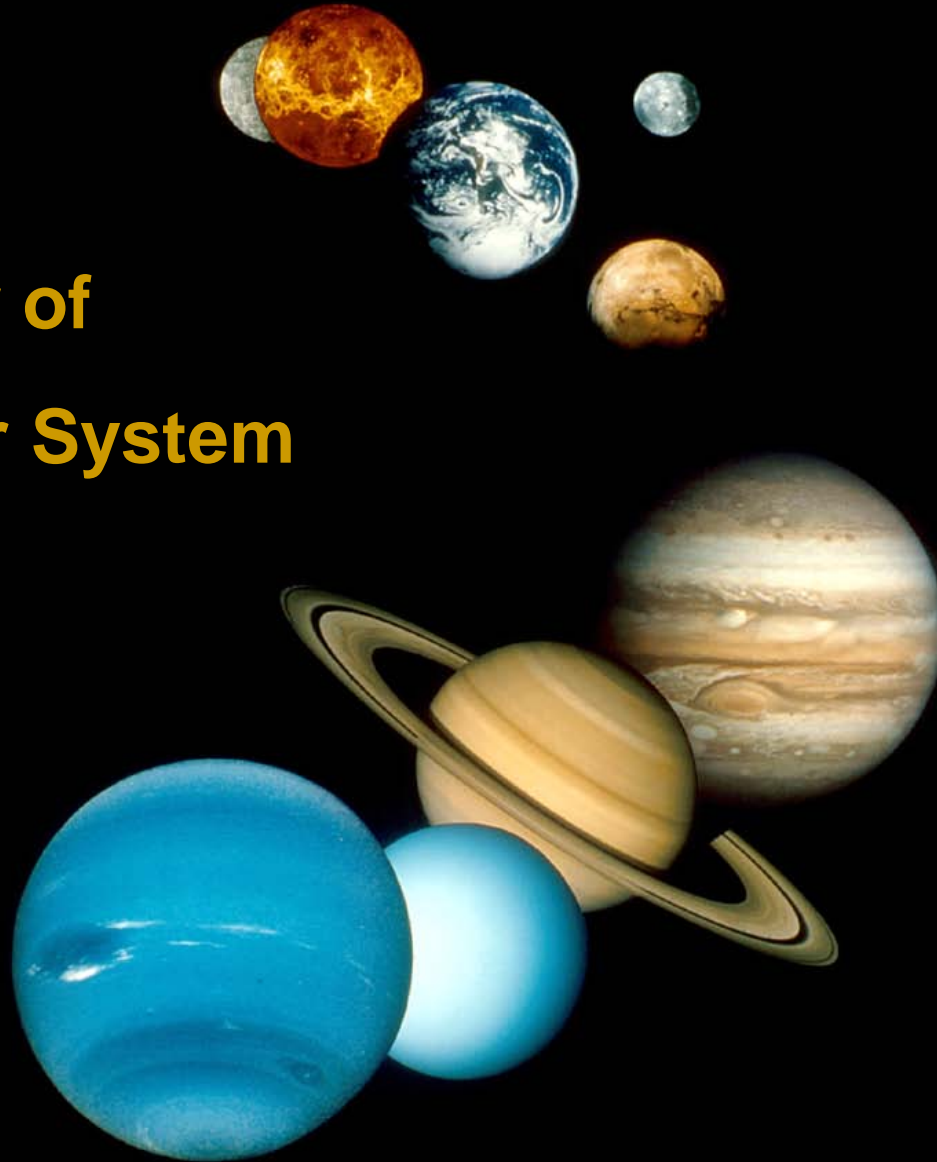


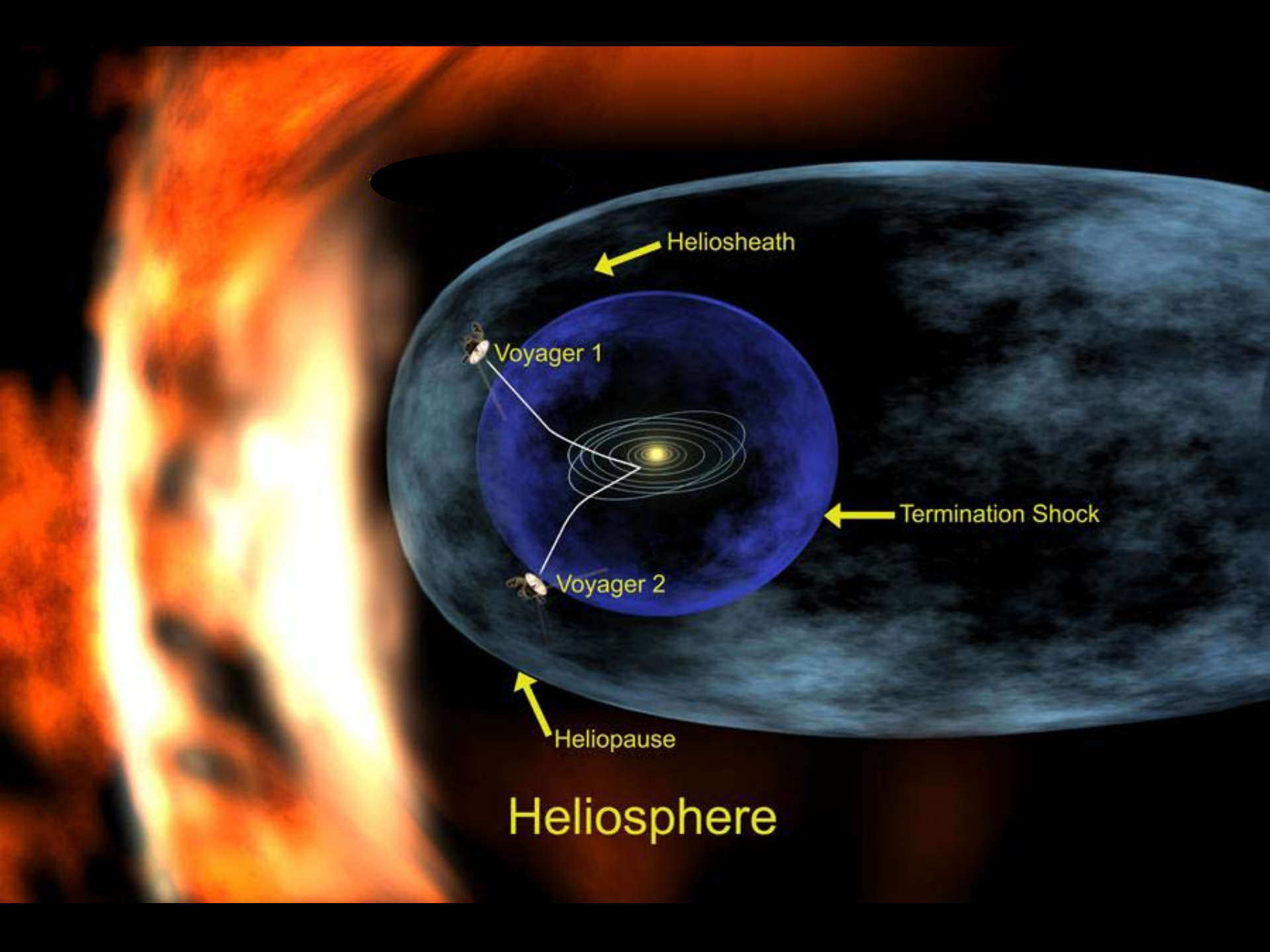
Neptune 30 AU



Triton

**A New View of
the Solar System**





Heliosheath

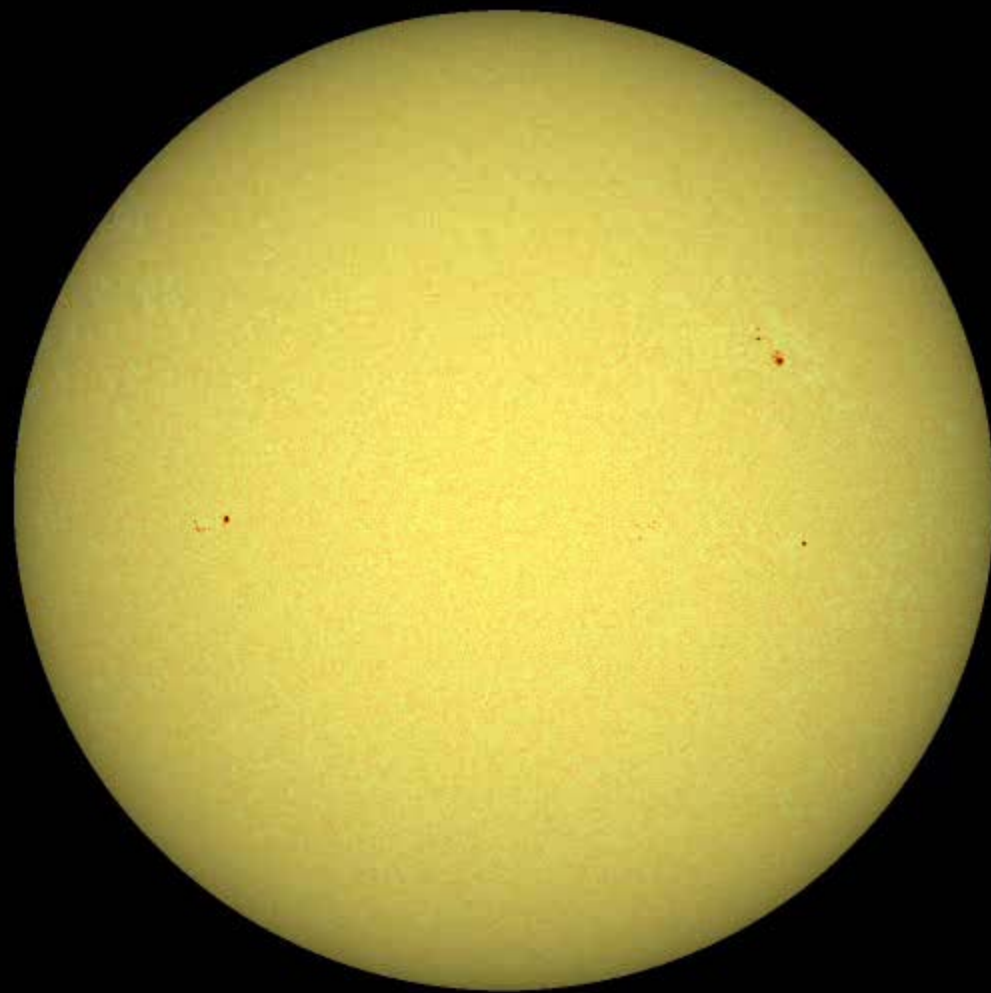
Voyager 1

Termination Shock

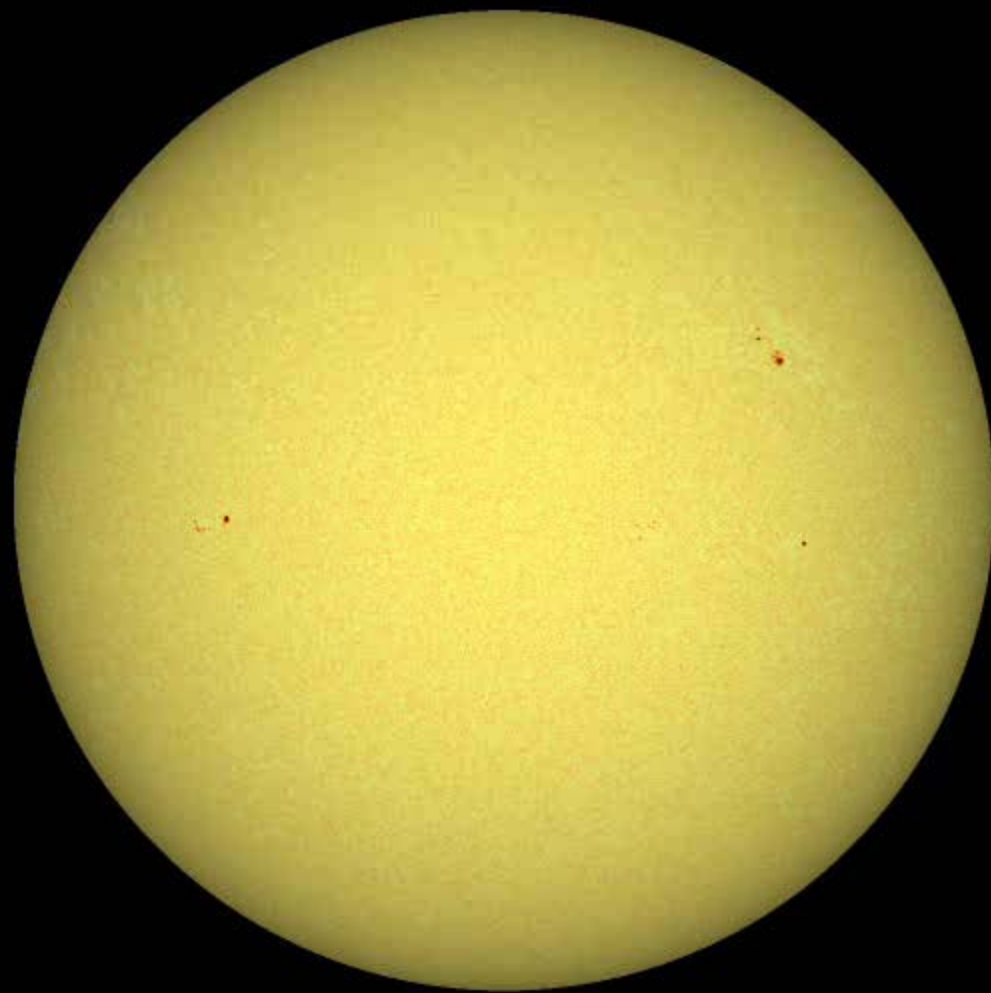
Voyager 2

Heliopause

Heliosphere

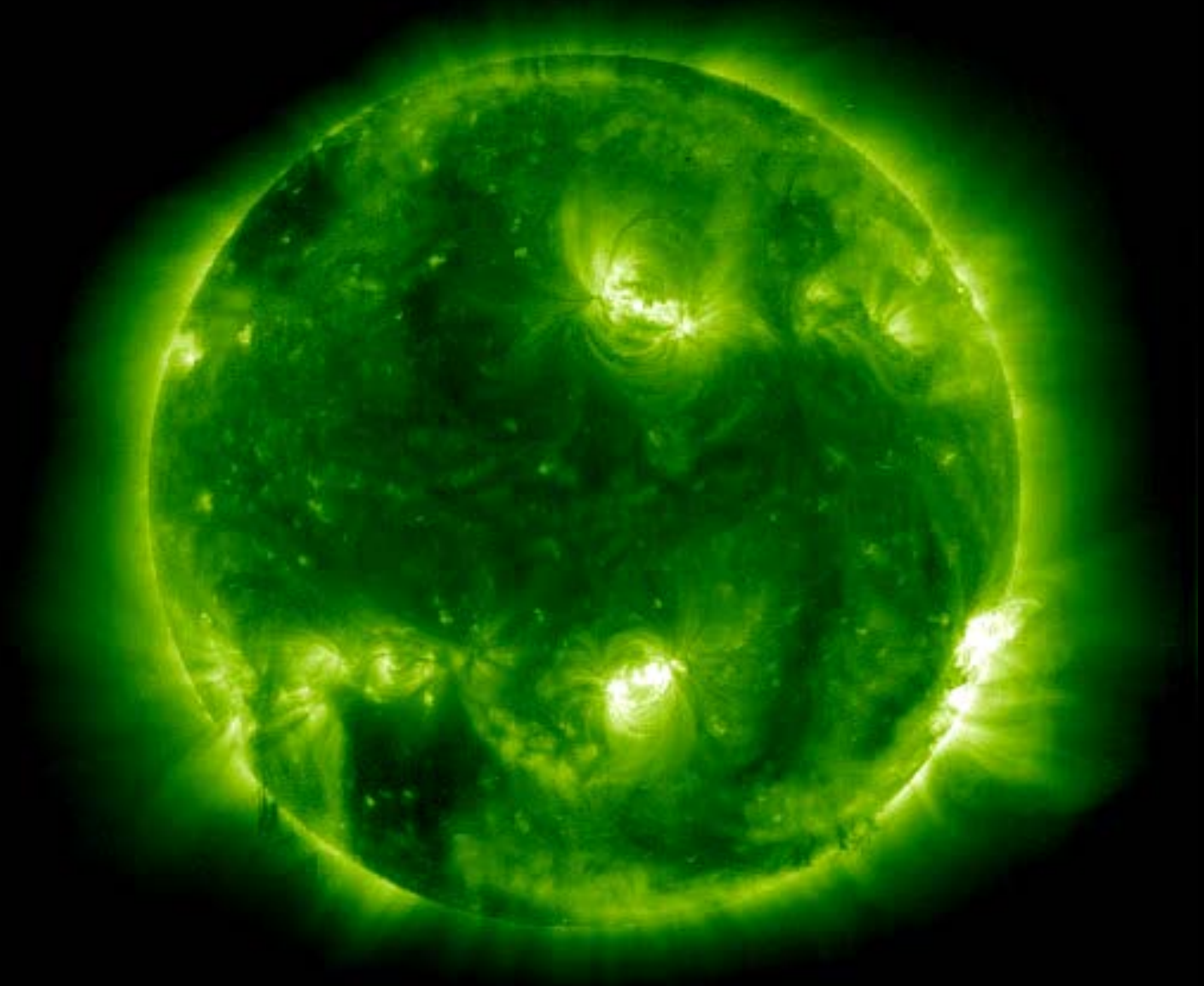


SOHO

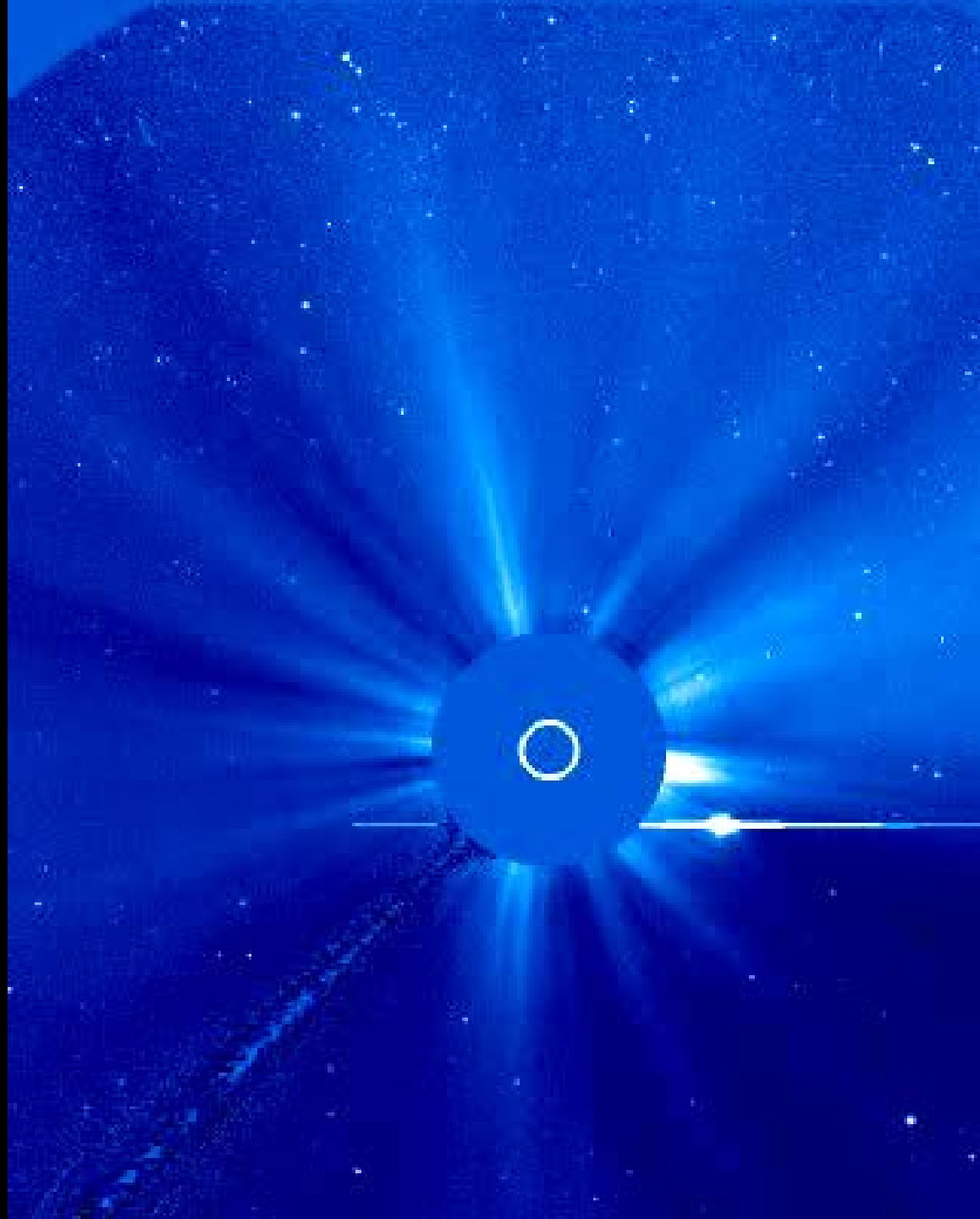


SOHO

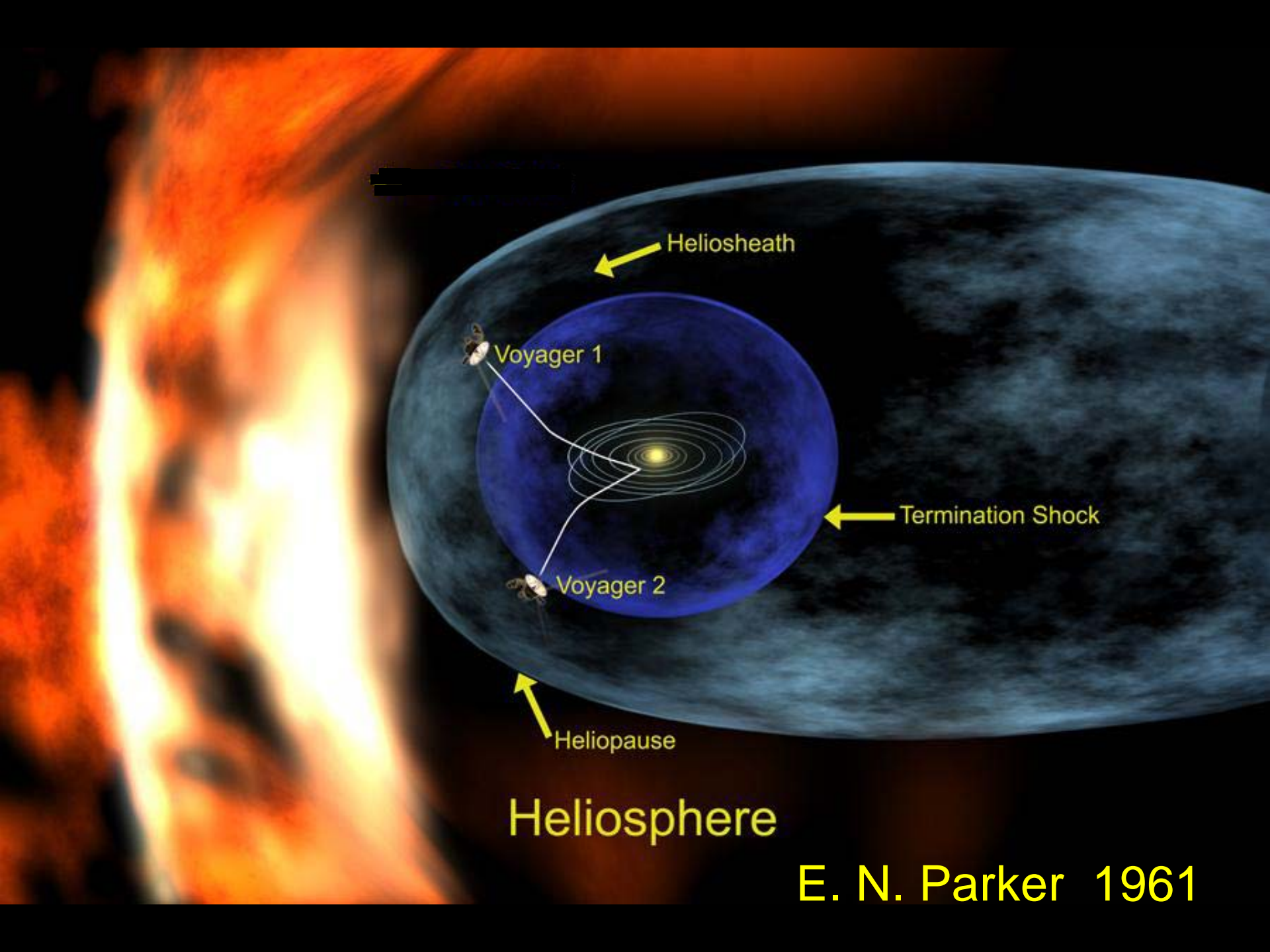
Solar Maximum



SOHO



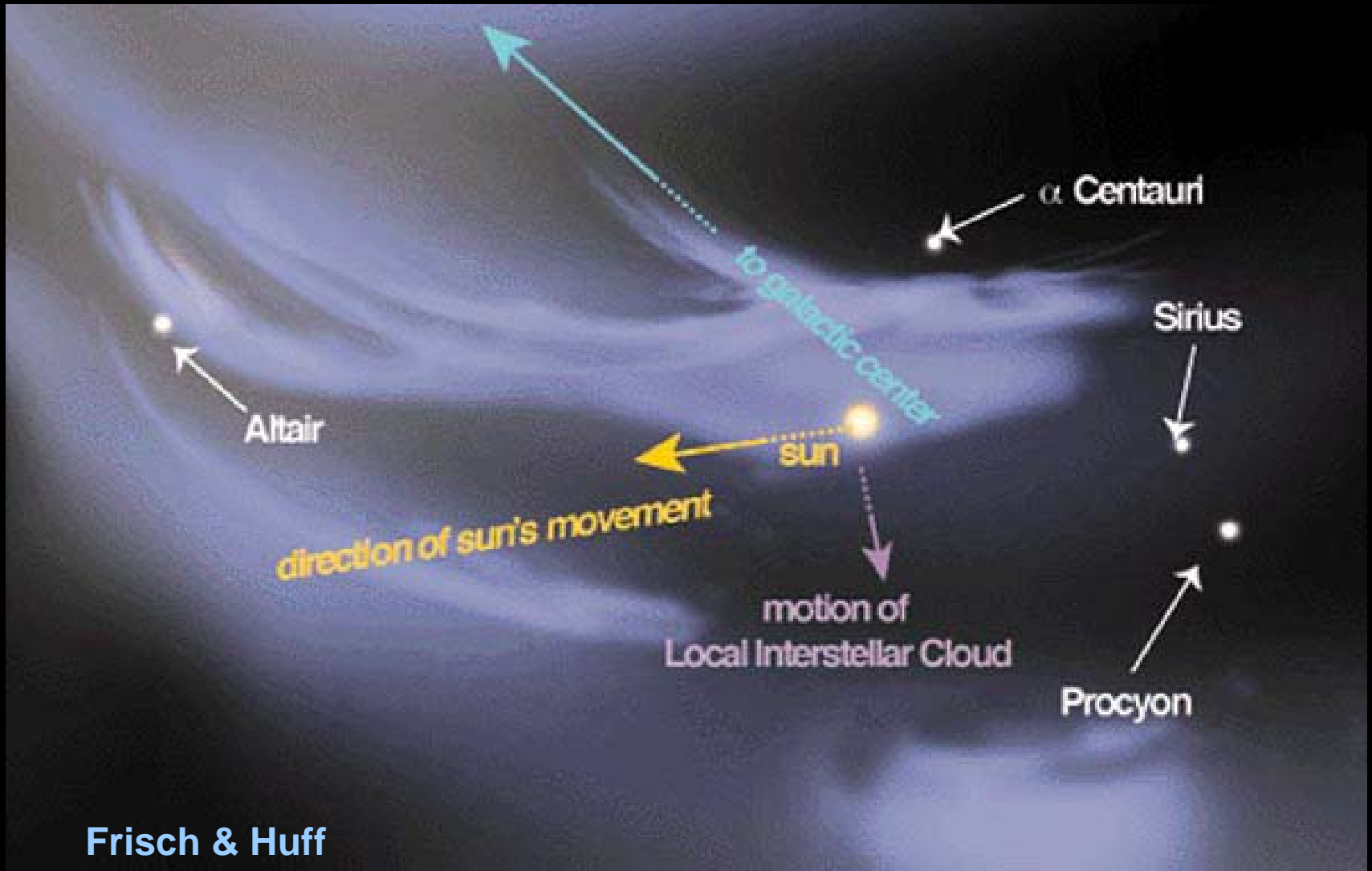
SOHO



Heliosphere

E. N. Parker 1961





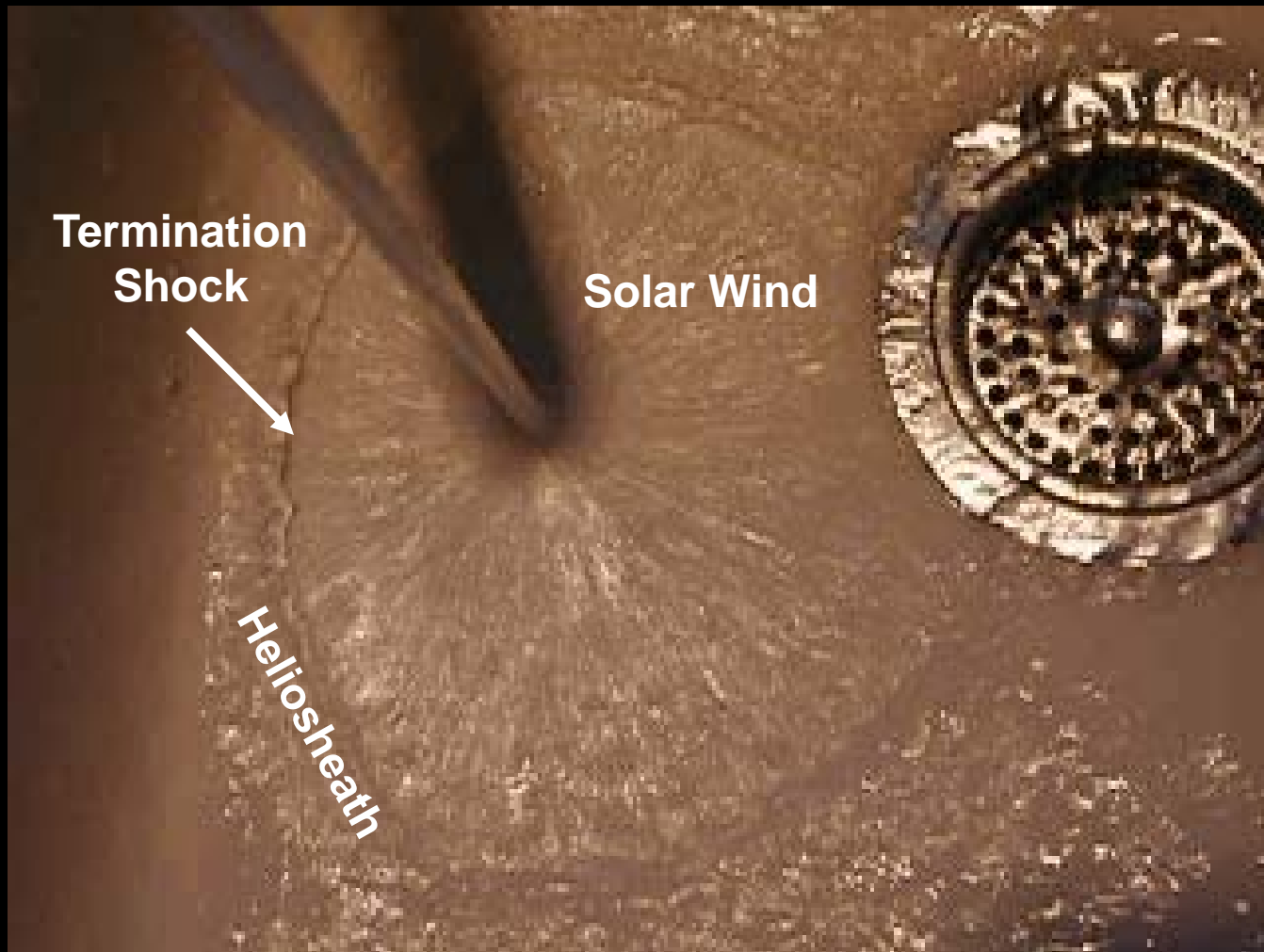
Frisch & Huff

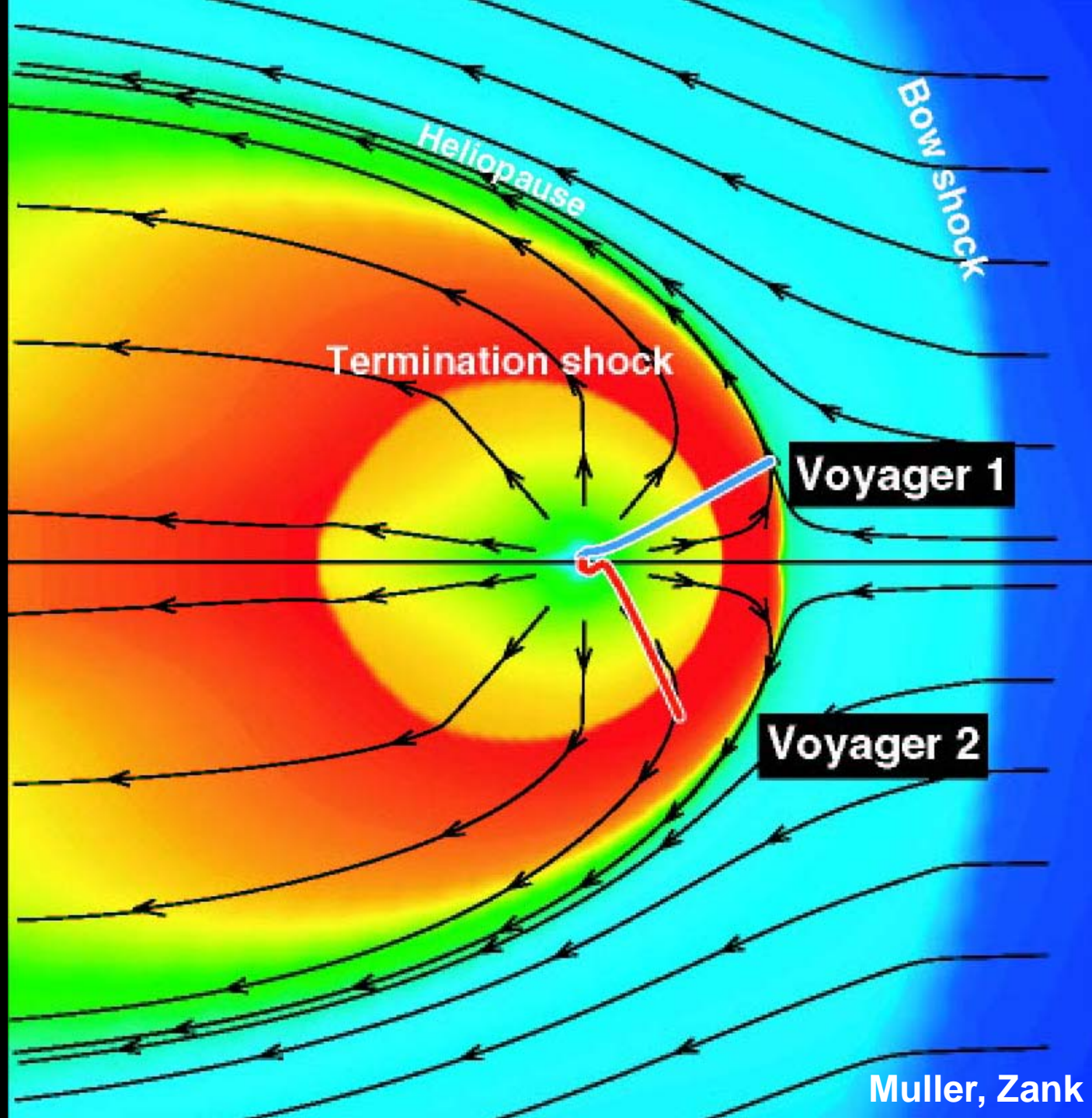


HST- Orion Nebula



The Heliosphere in a Kitchen Sink





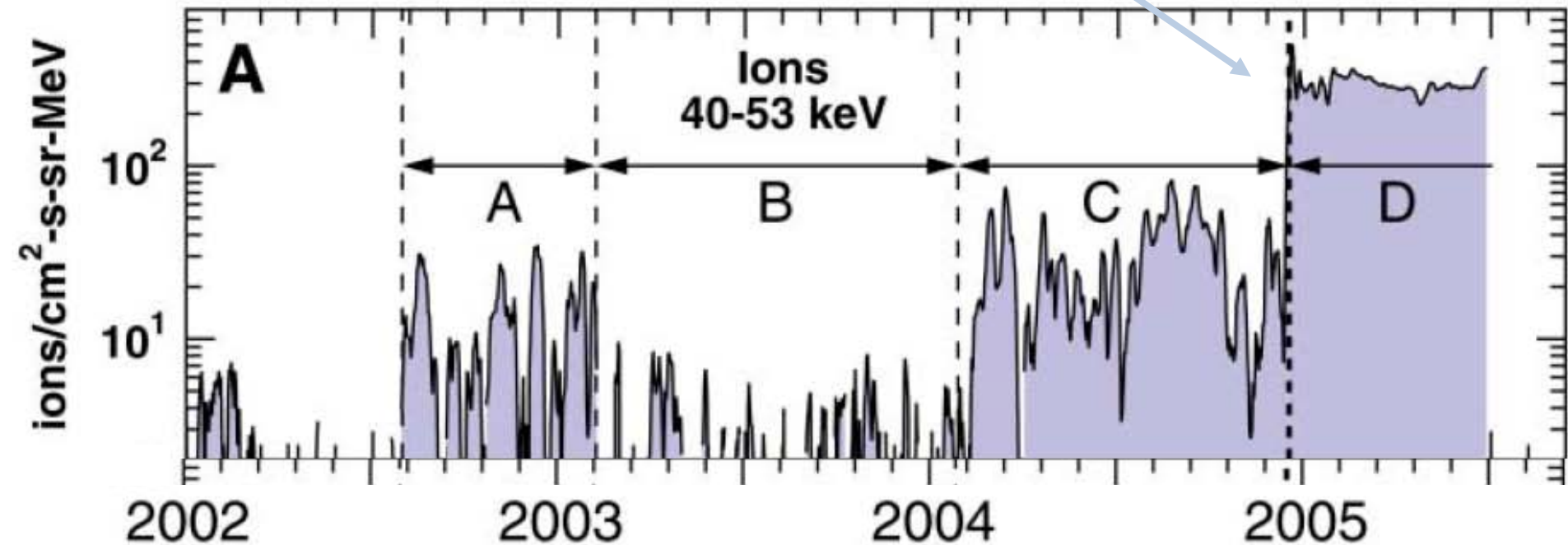
Shock at 94 AU

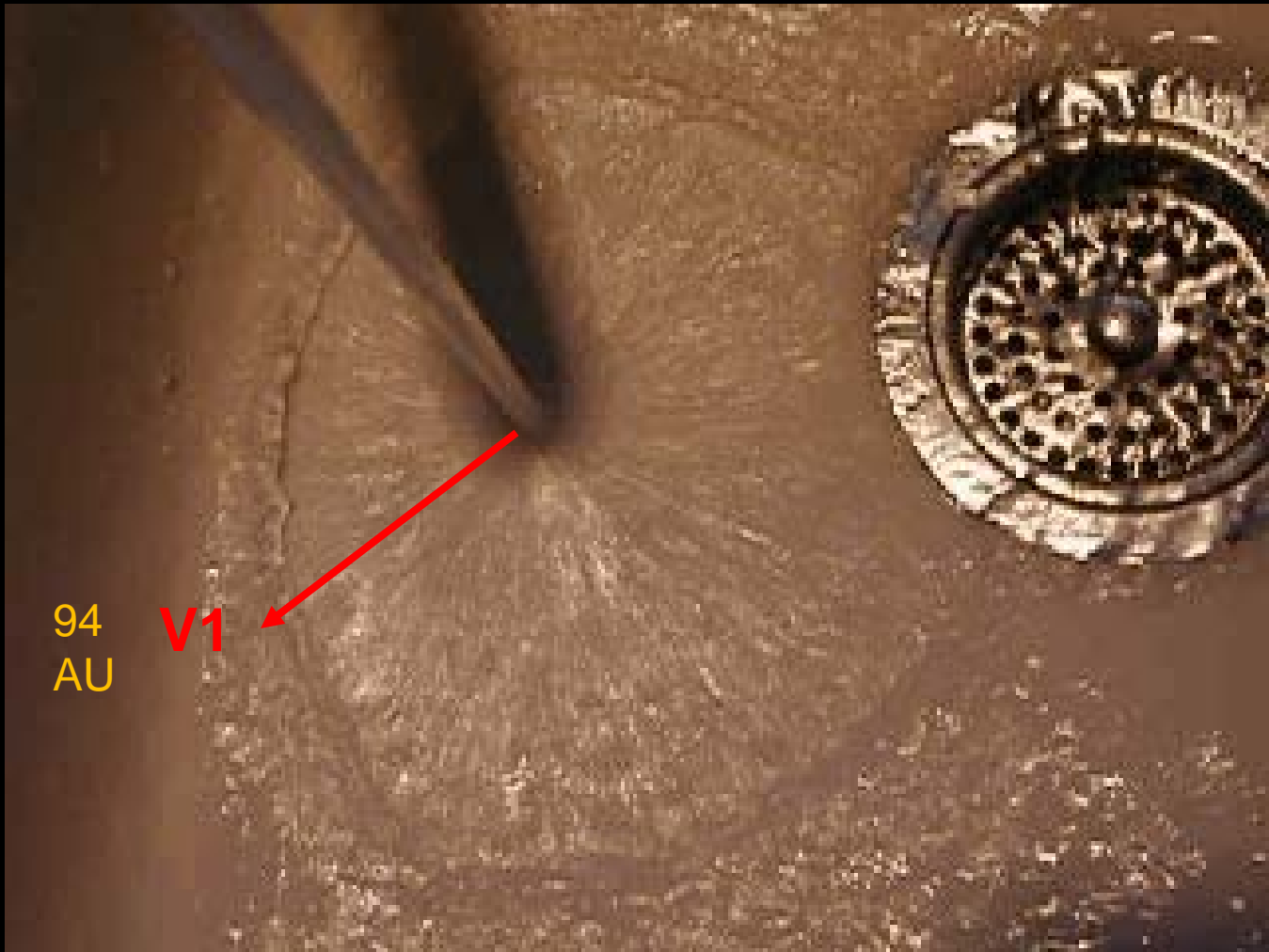
8.7 billion miles

December 16, 2004

Shock is source of
low energy ions

1% speed of light





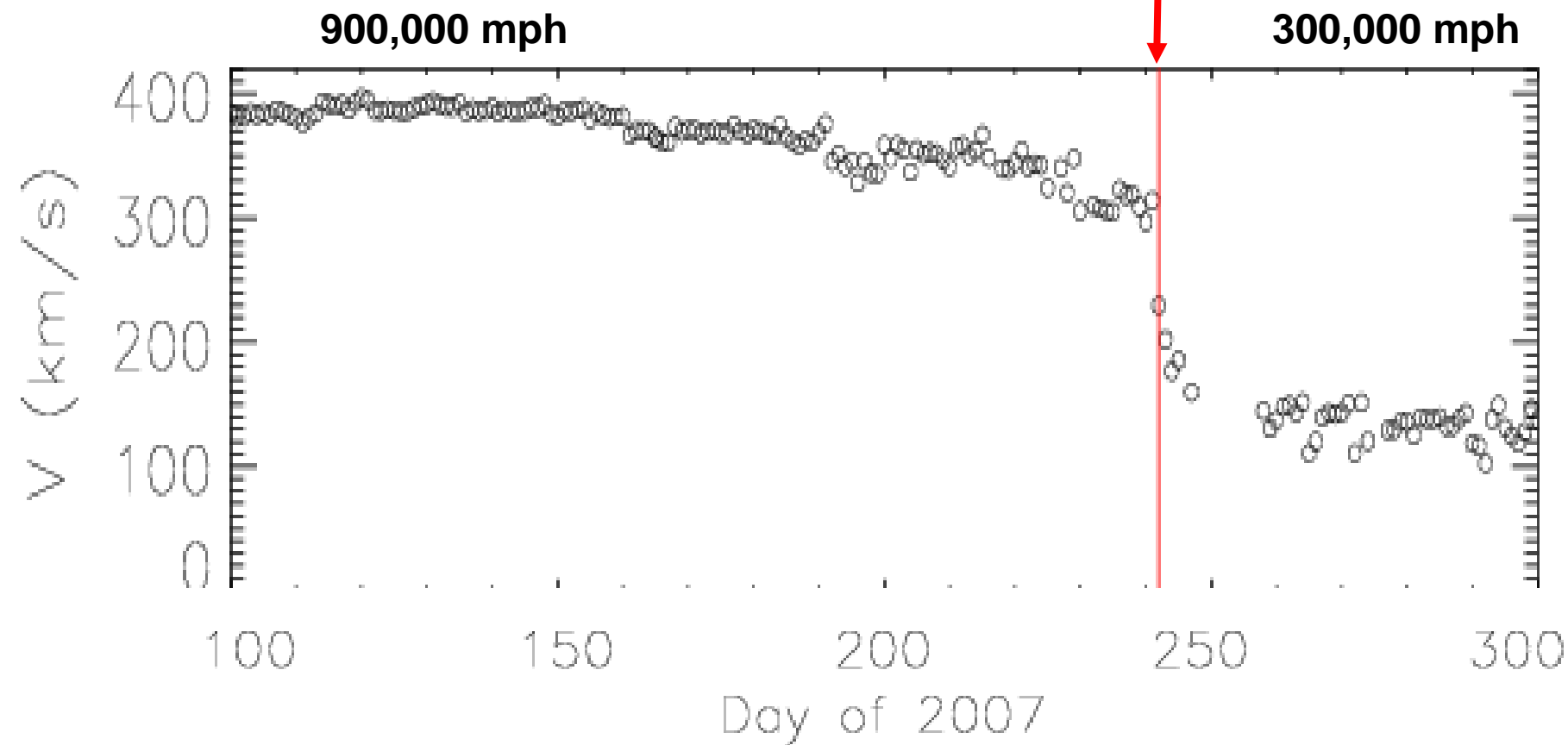
94
AU

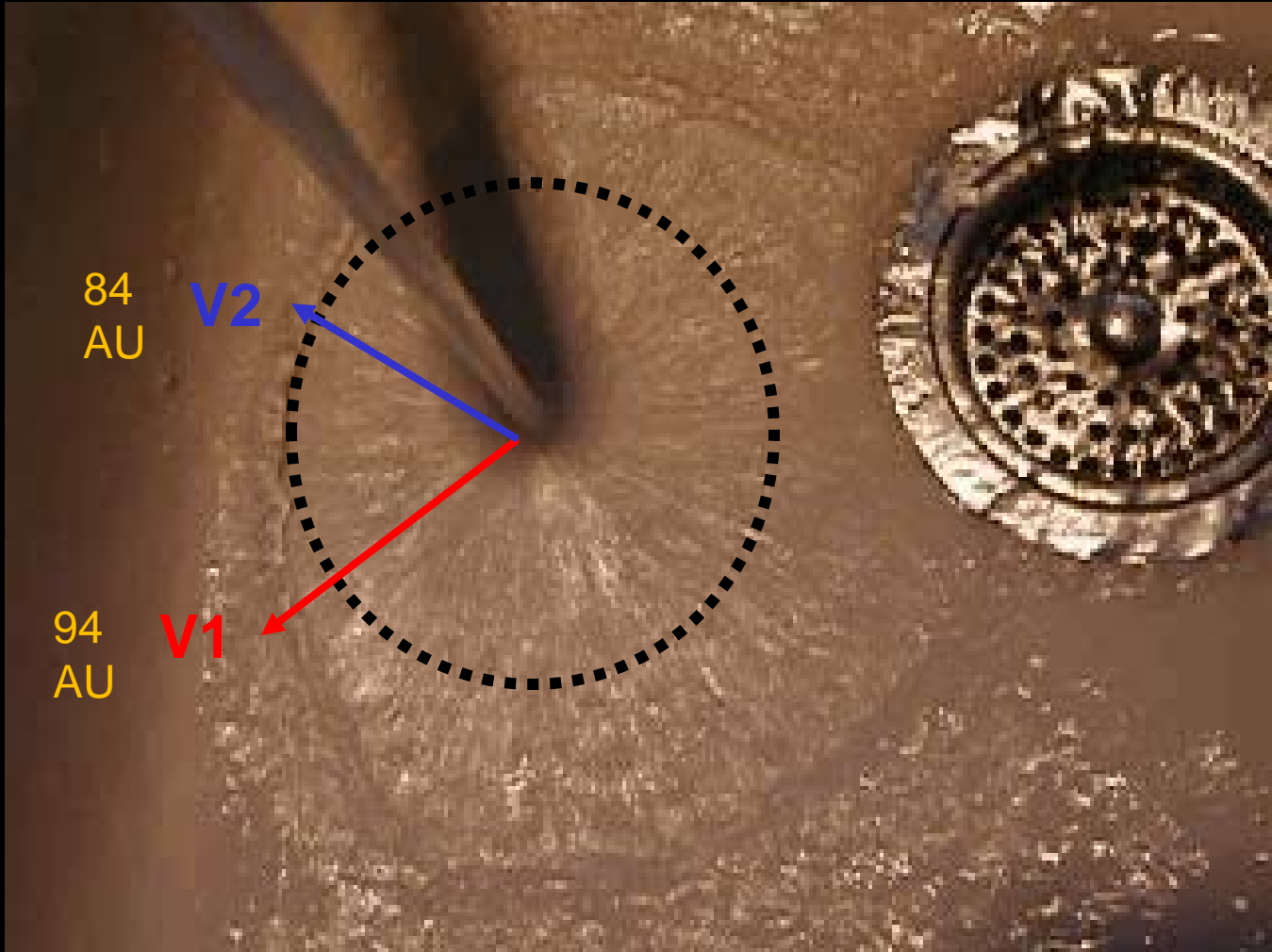
V1

V2 crossed termination shock at 83.7 AU

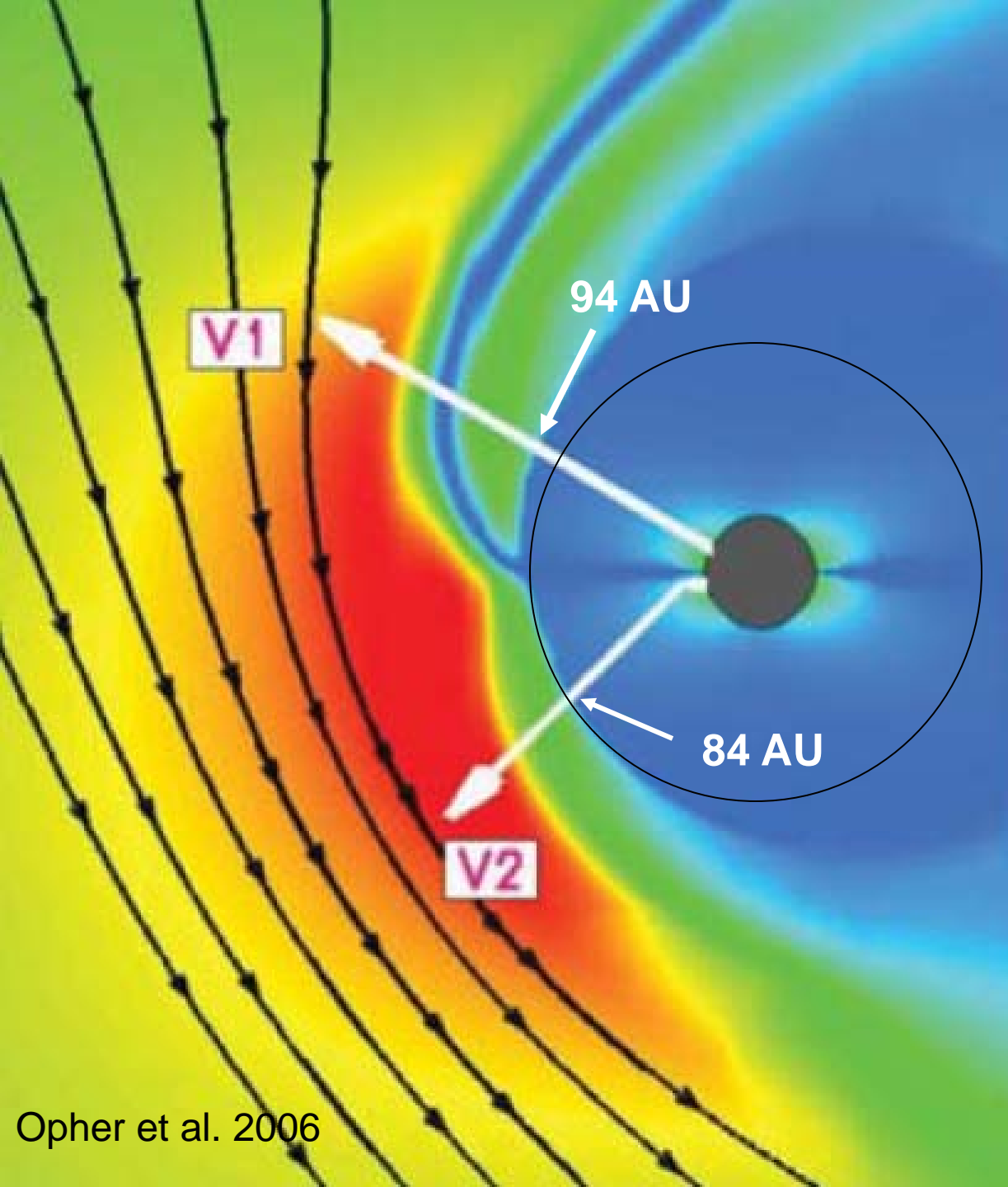
7.8 billion miles

August 30, 2007





Interstellar magnetic field presses inward in southern hemisphere

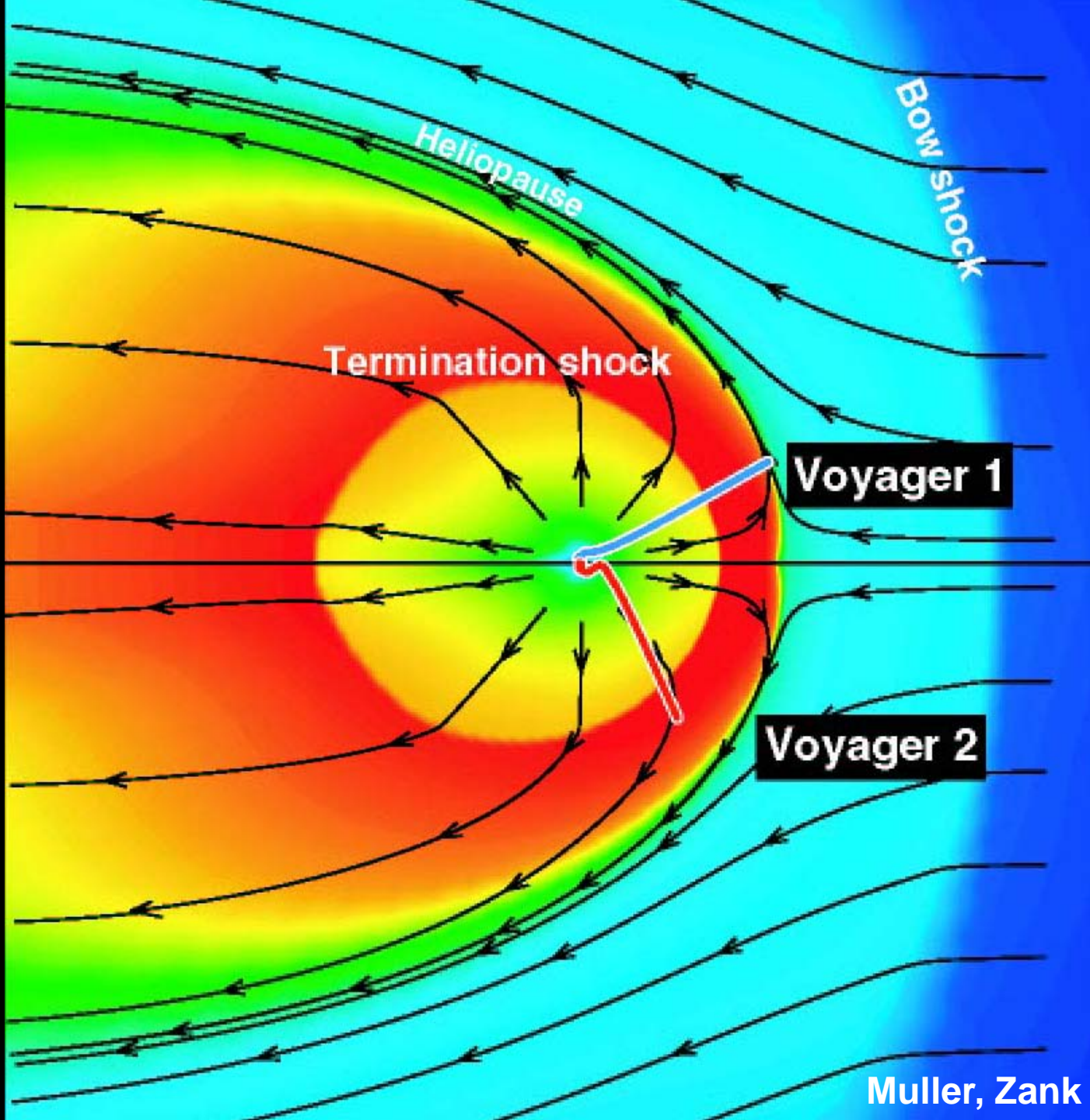


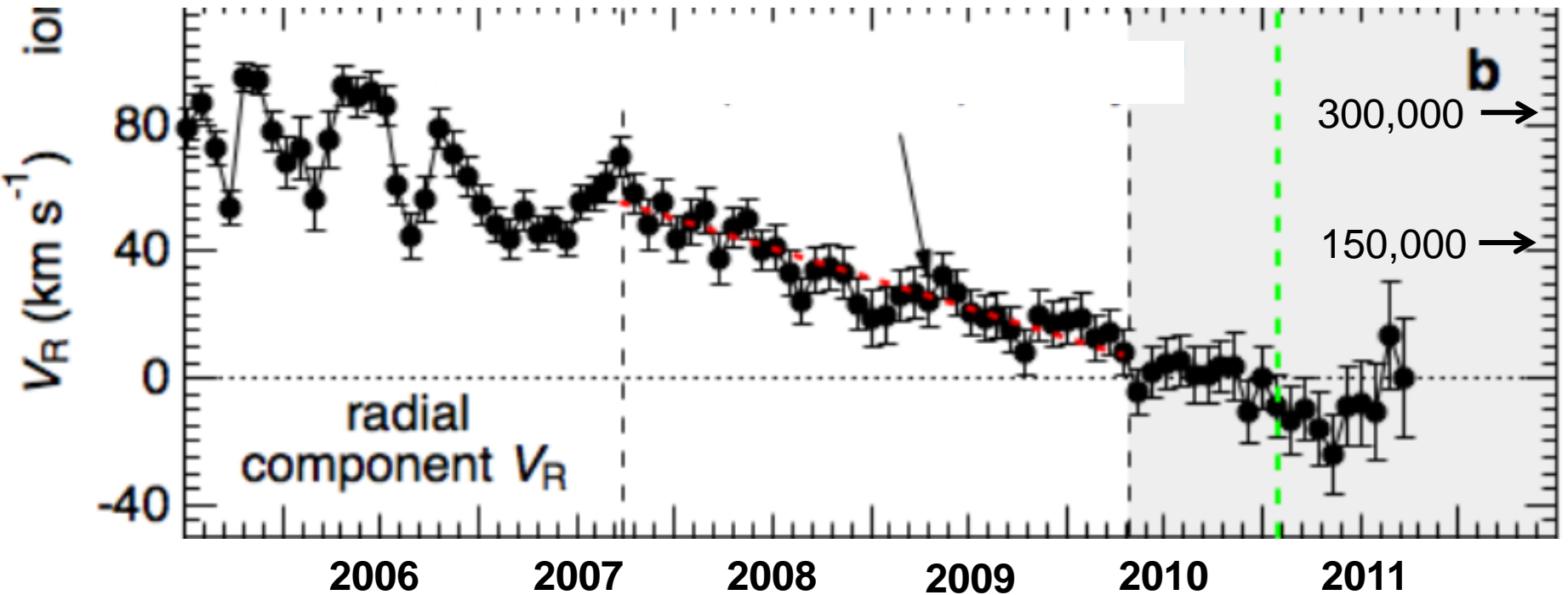
V1

94 AU

84 AU

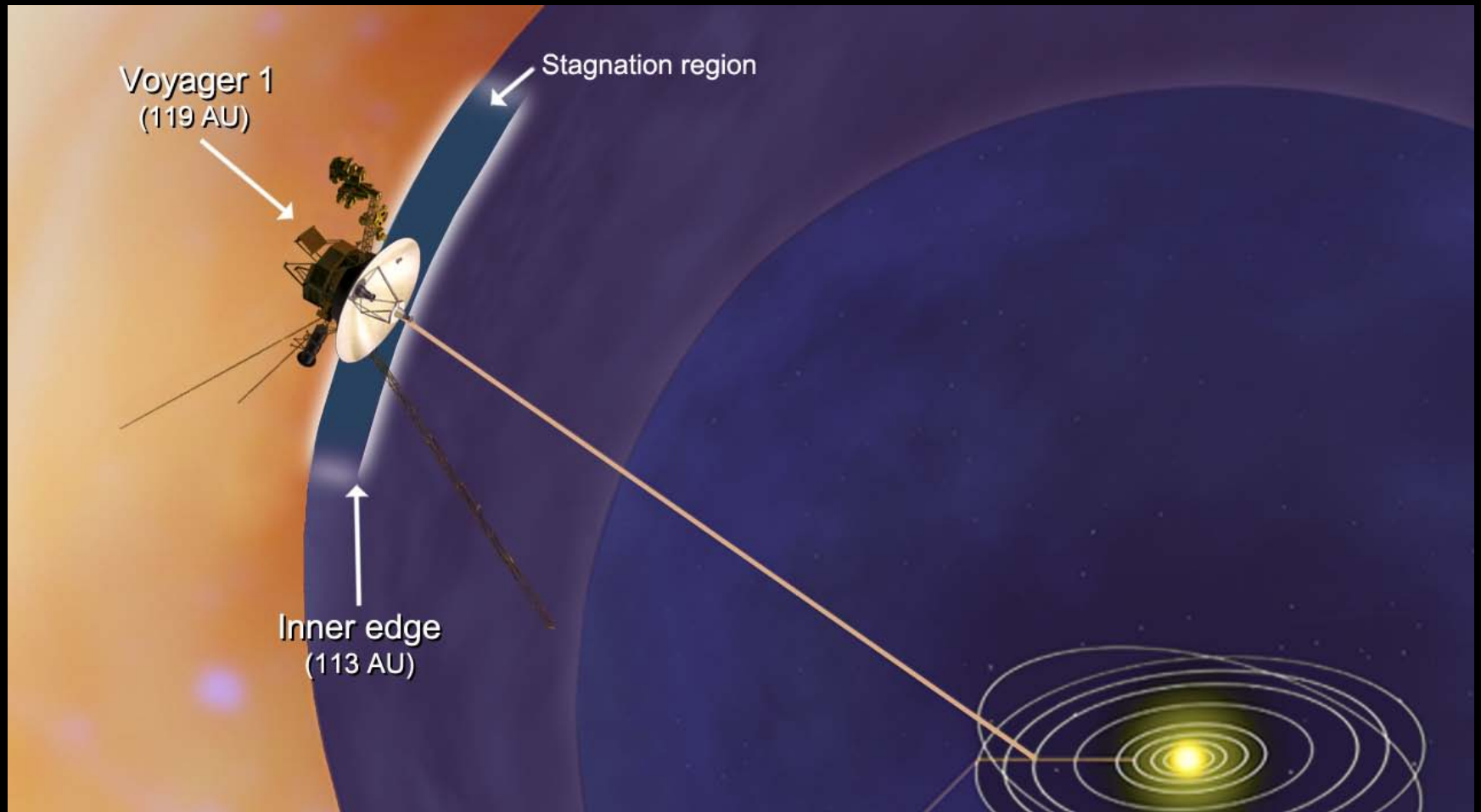
V2



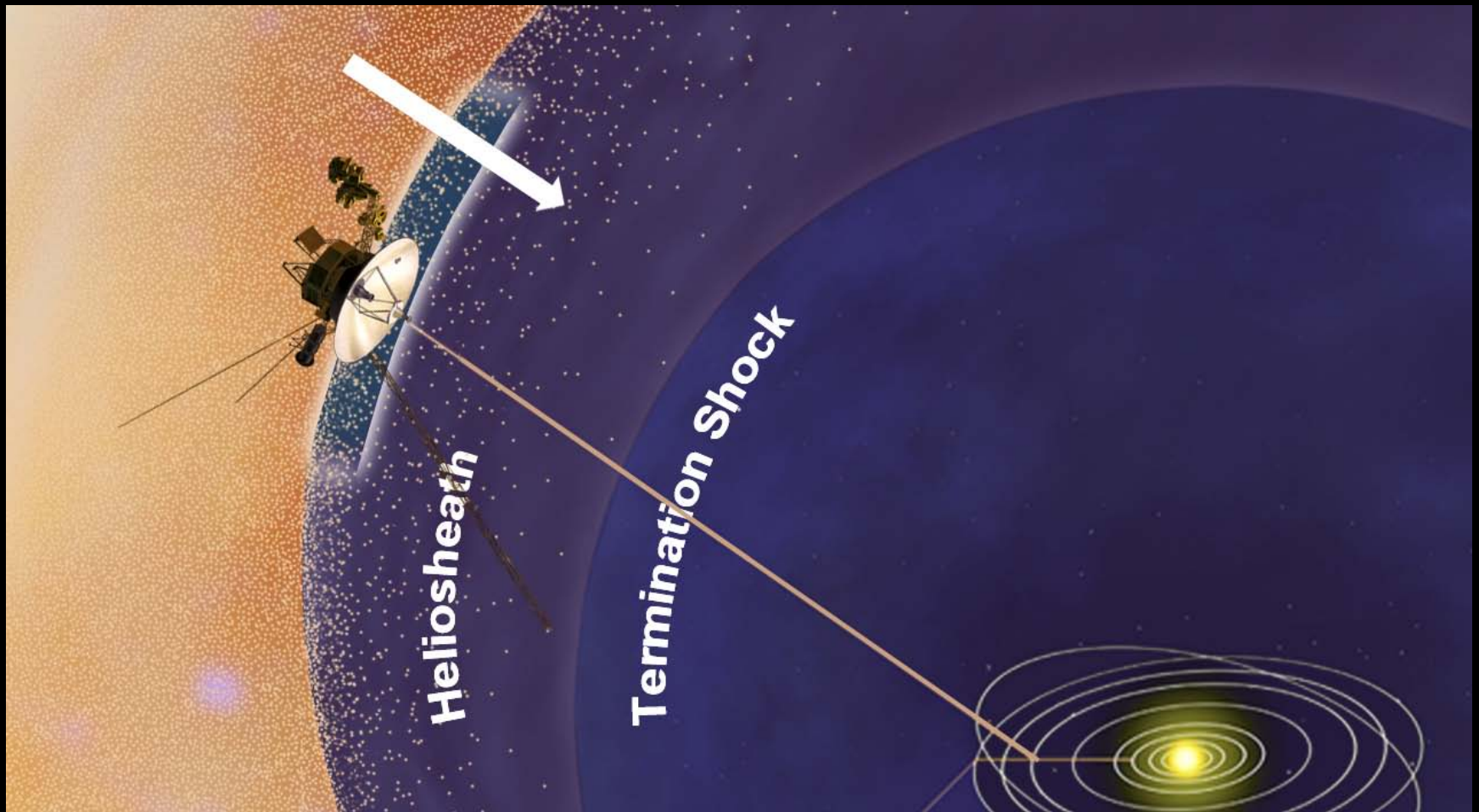


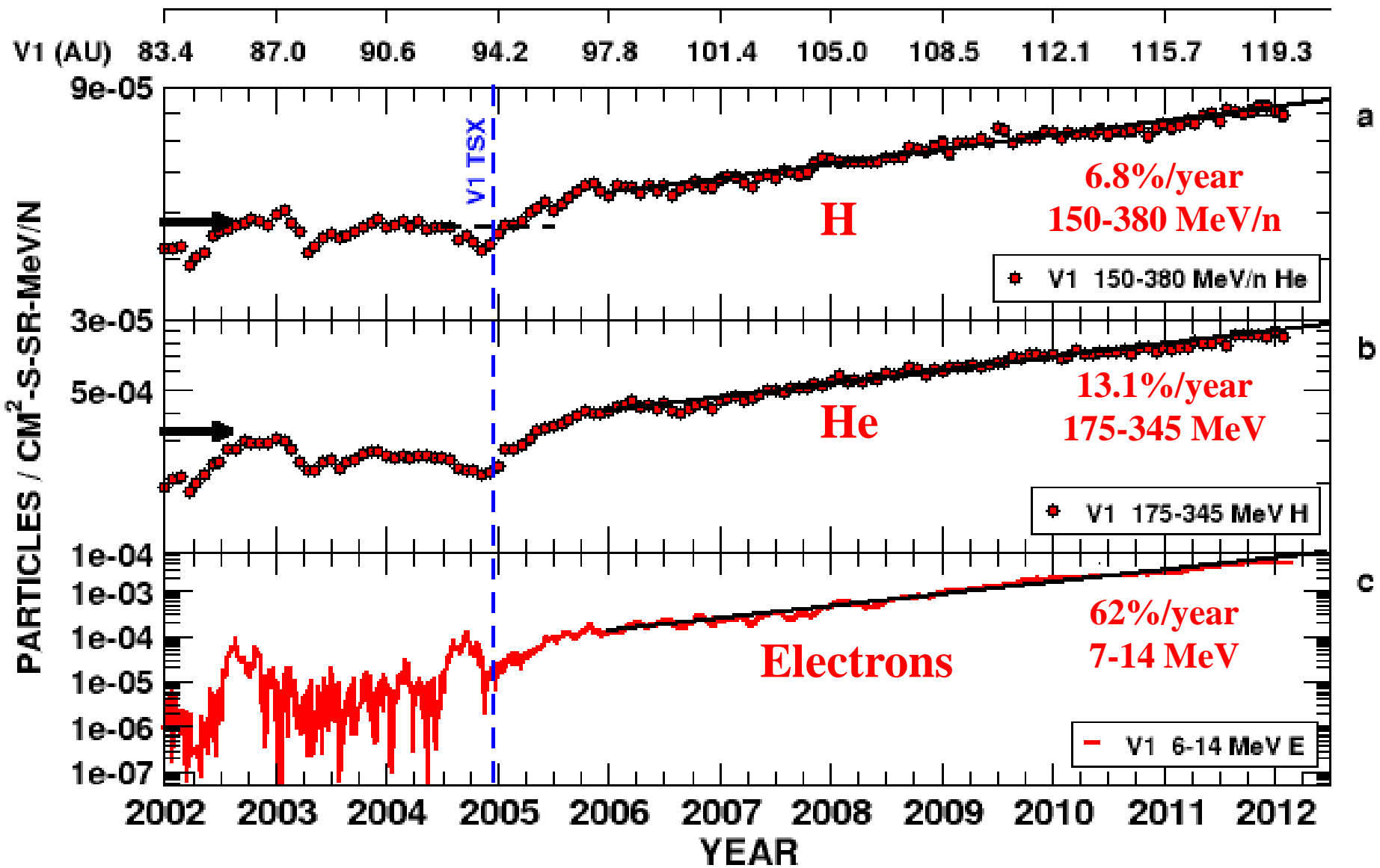
In 2010, the solar wind was no longer moving outward- a quasi-stagnation region

Stagnation Region



Cosmic Rays from Nearby Supernovas Diffusing In (nuclei with $>40\%$ speed of light)

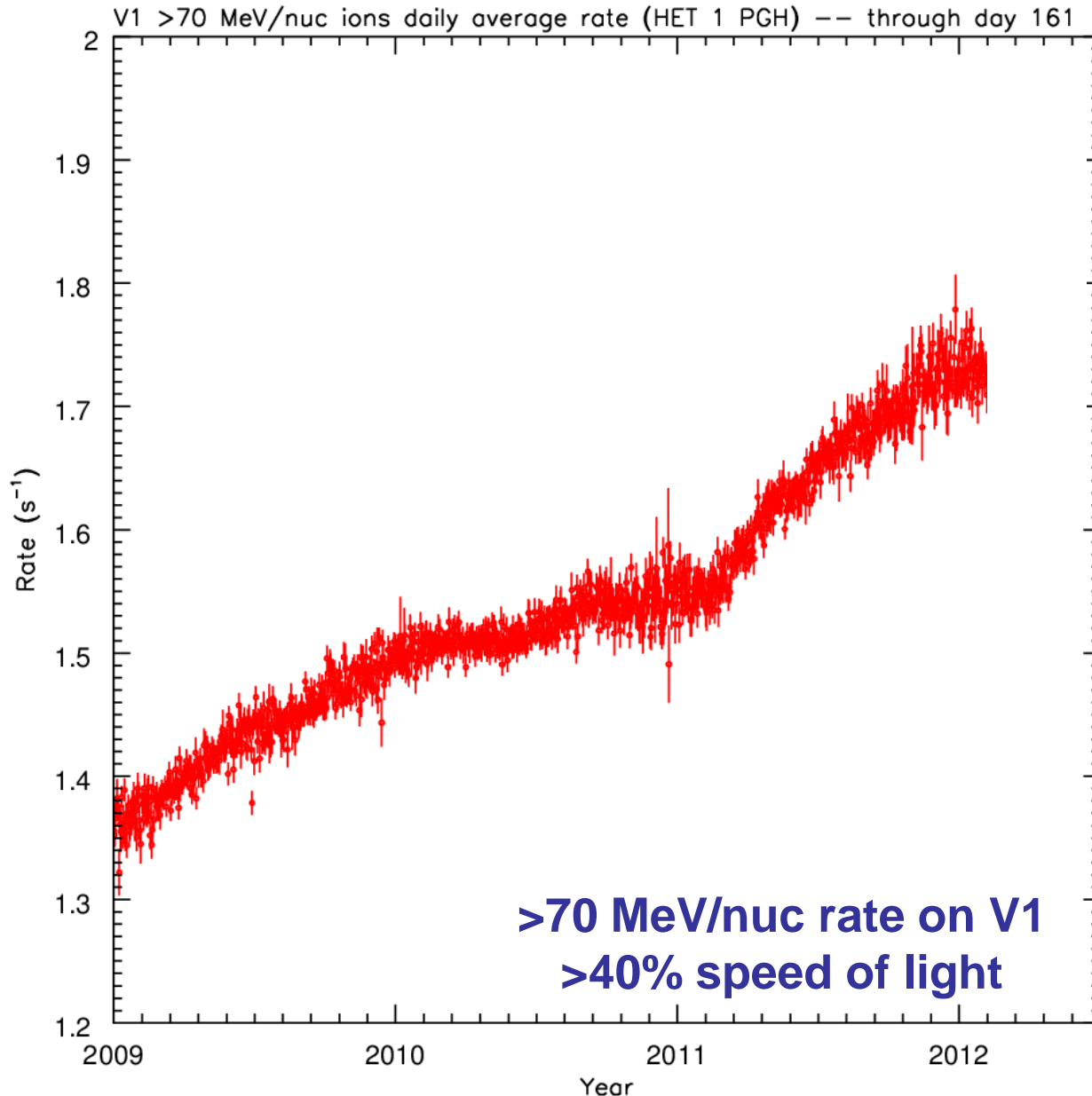




Electron Data Background Corrected
 Arrows indicate V1 intensity levels over the cycle 22 solar minimum (1997.0 - 1999.0)

Rate of Cosmic Rays Diffusing in from Galaxy

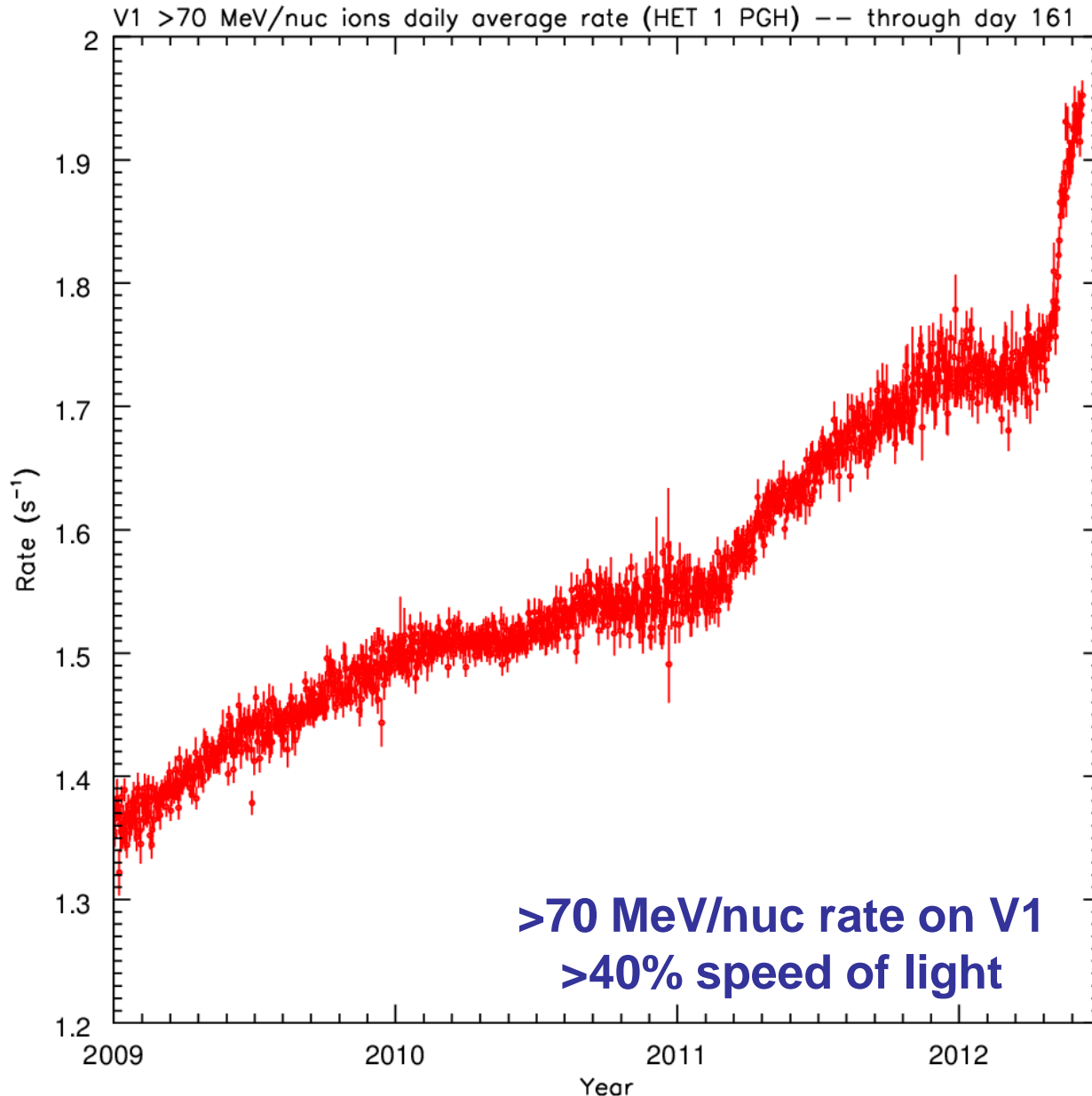
Jun 13 12:55 2012 File : ~oce/sm/voyager/May_2012_increase/v1.IPGH_time.ps



Rate increased
9% per year
over last 3 years

Rate of Cosmic Rays Diffusing in from Galaxy

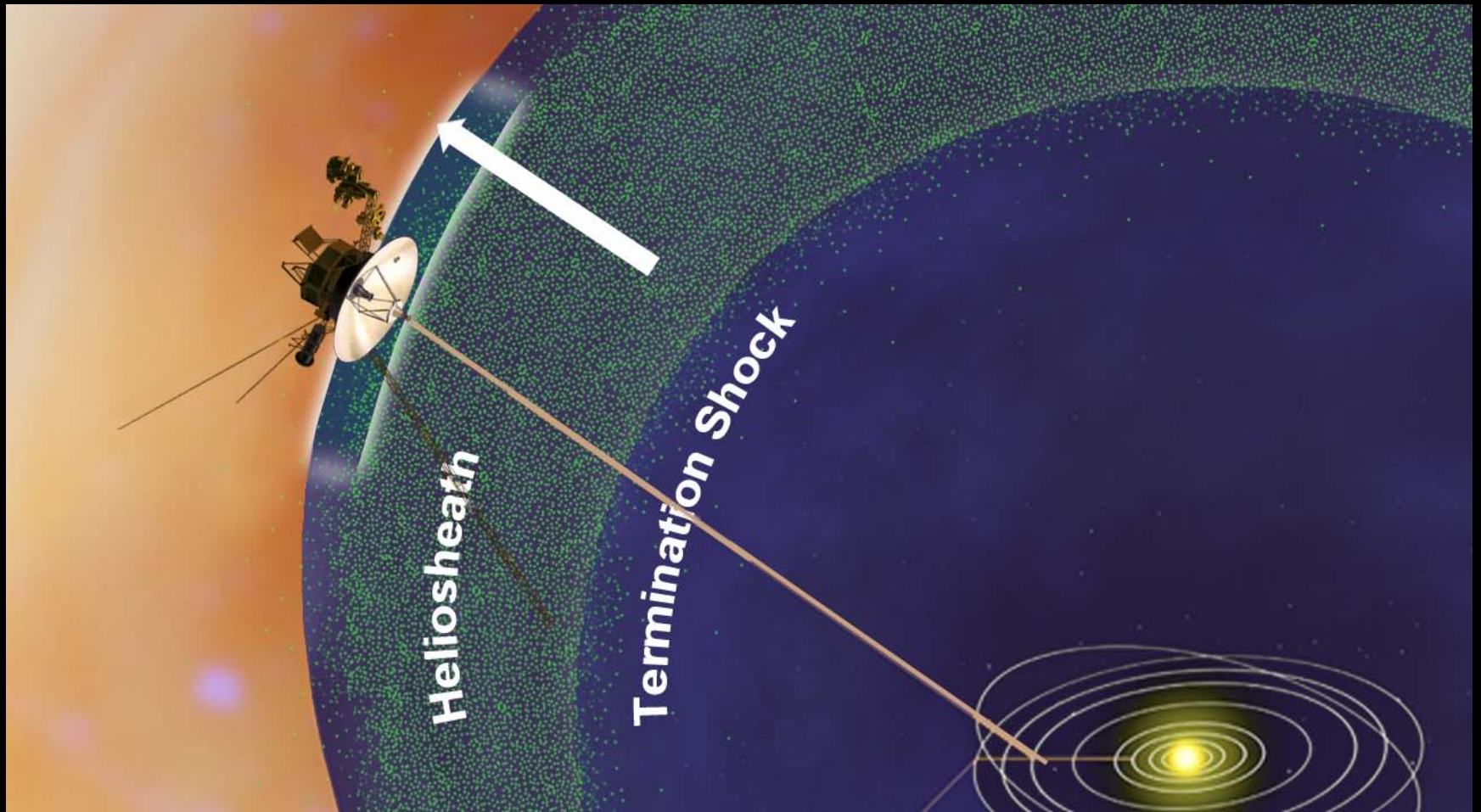
Jun 13 12:55 2012 File : ~oce/sm/voyager/May_2012_increase/v1.IPGH_time.ps



Rate increased
9% per year
over last 3 years

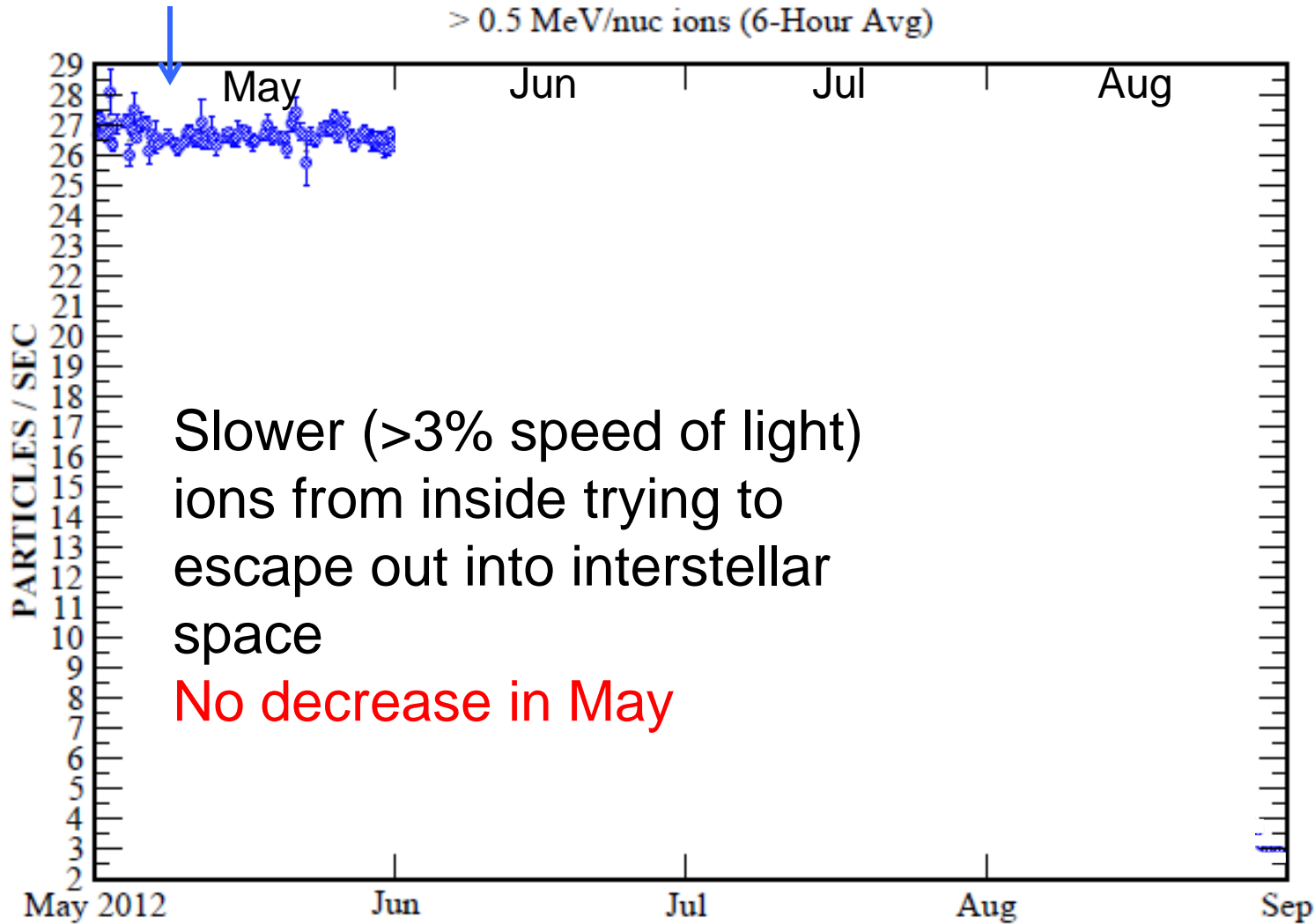
In May the rate
increased 5% in
one week and
9% in a month

Energetic Ions from Termination Shock Leaking Out (nuclei with $\sim 5\%$ speed of light)



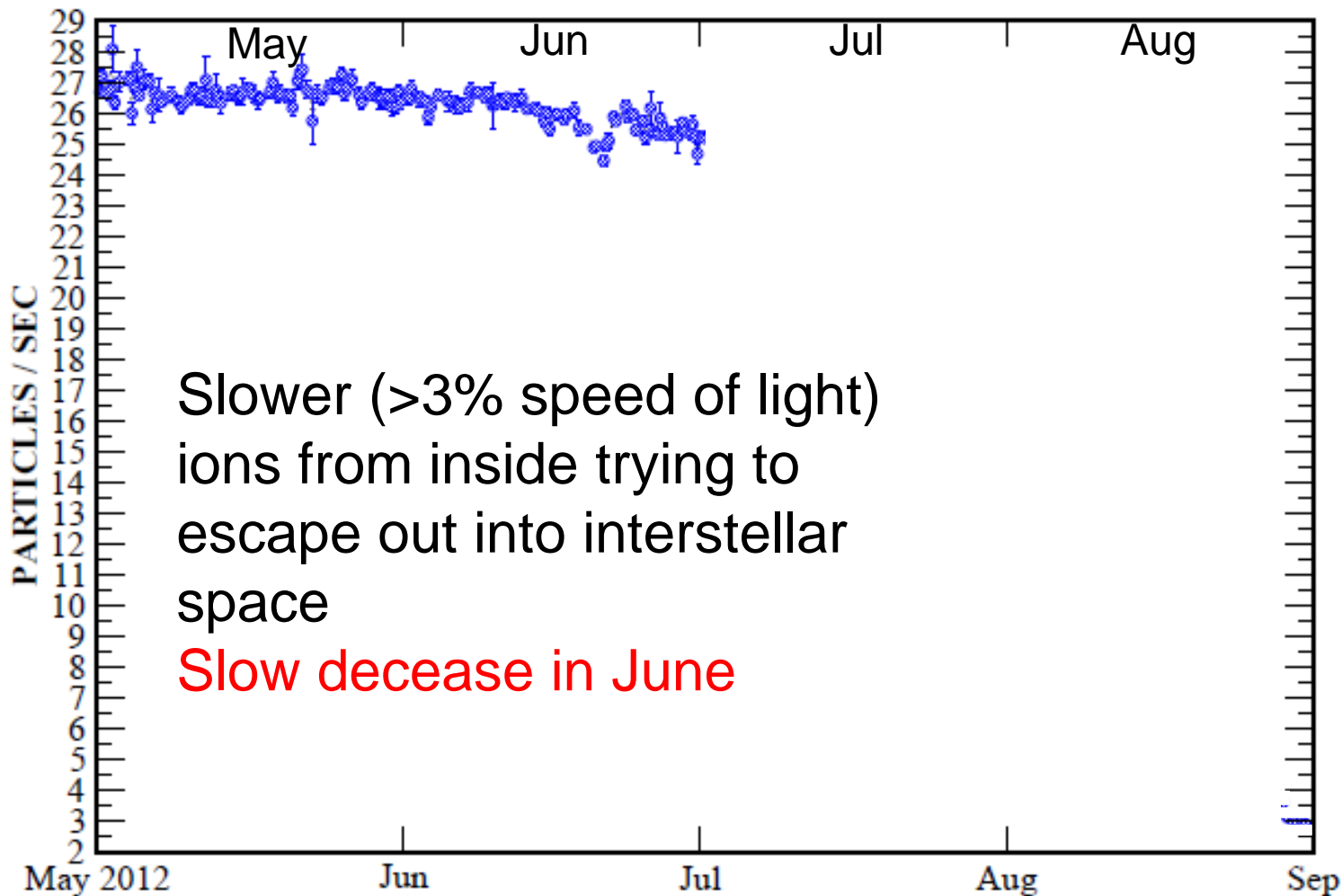
VOYAGER-1

> 0.5 MeV/nuc ions (6-Hour Avg)



VOYAGER-1

> 0.5 MeV/nuc ions (6-Hour Avg)

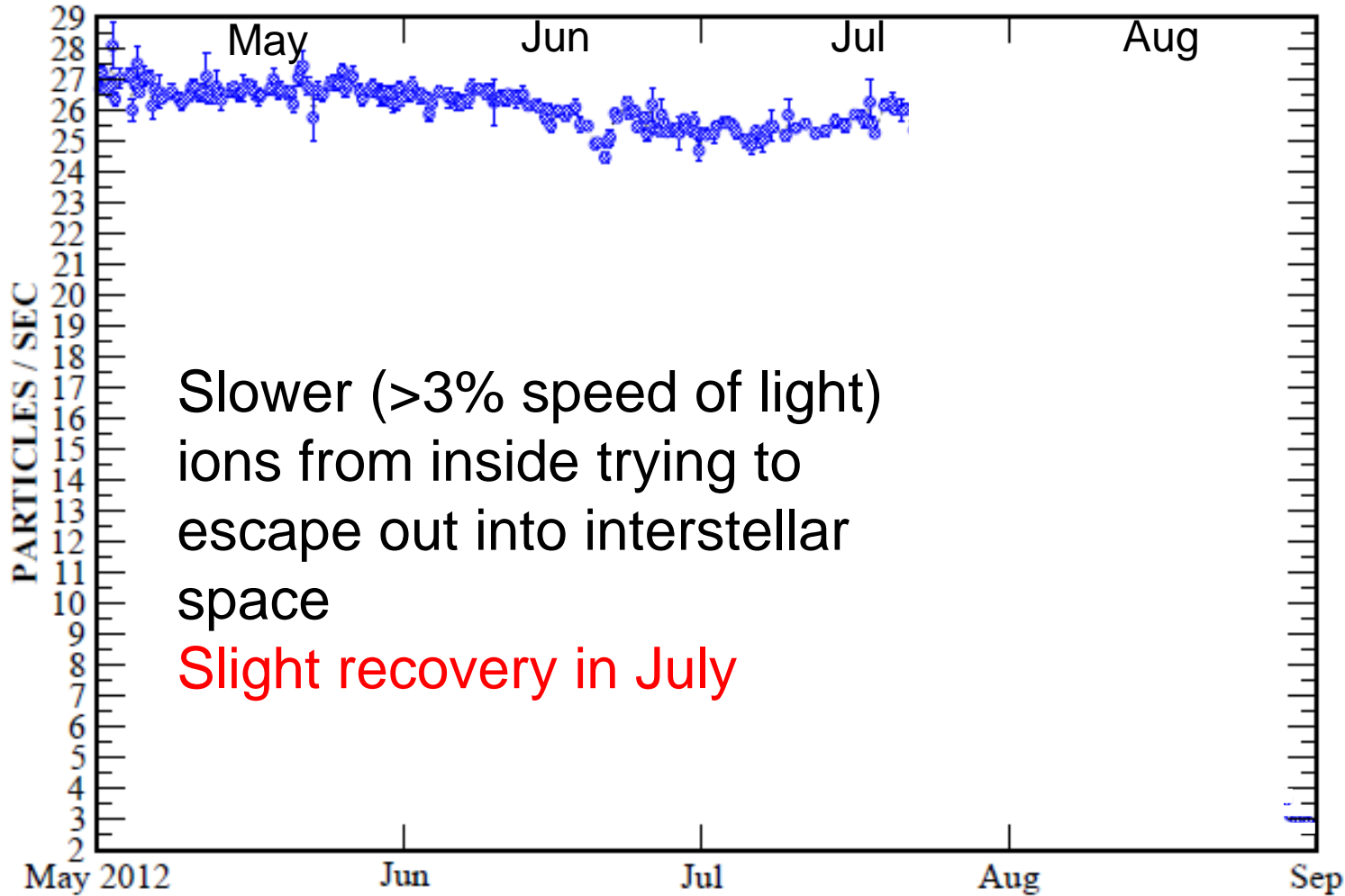


Slower (>3% speed of light)
ions from inside trying to
escape out into interstellar
space

Slow decrease in June

VOYAGER-1

> 0.5 MeV/nuc ions (6-Hour Avg)

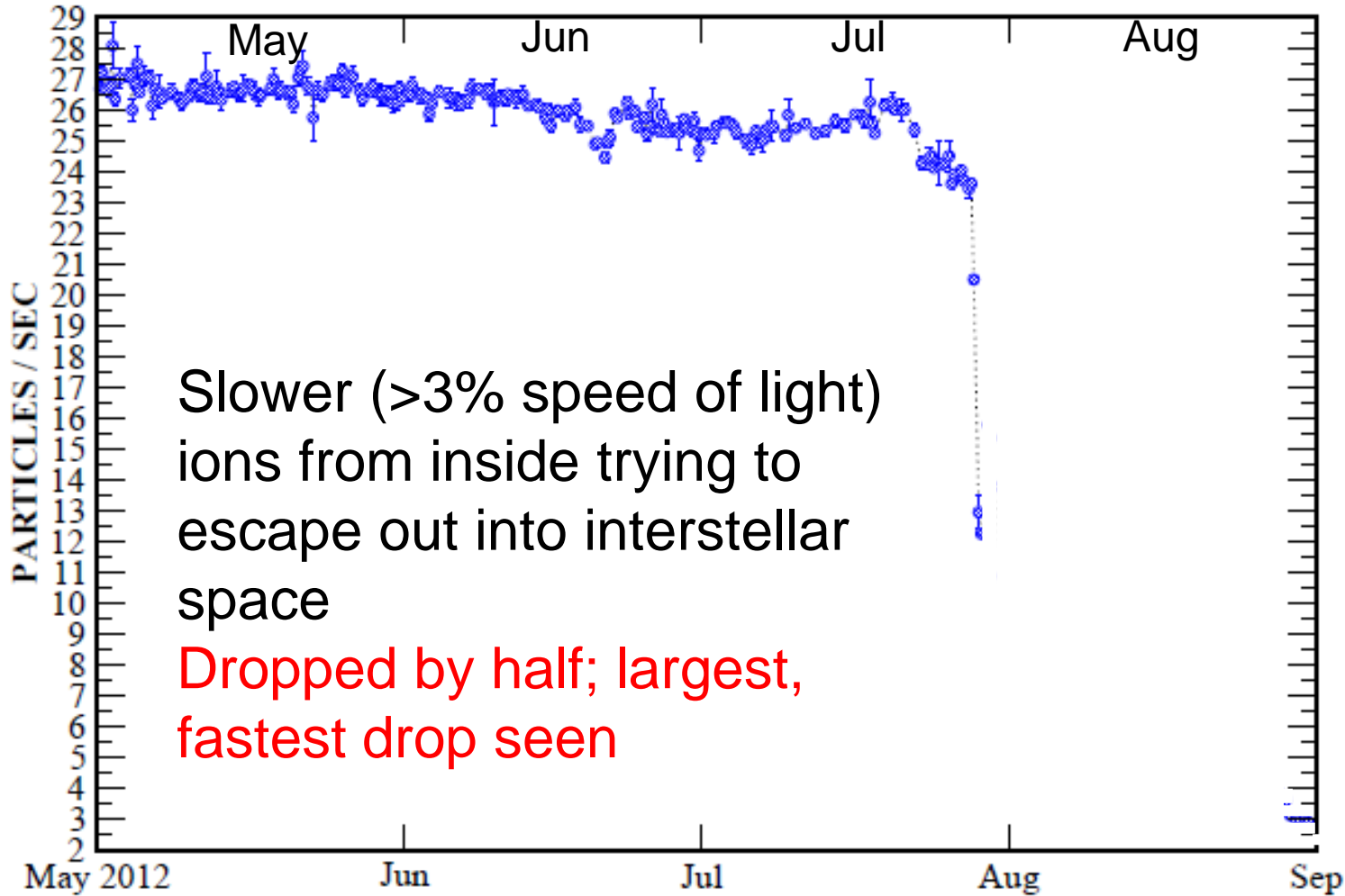


Slower (>3% speed of light)
ions from inside trying to
escape out into interstellar
space

Slight recovery in July

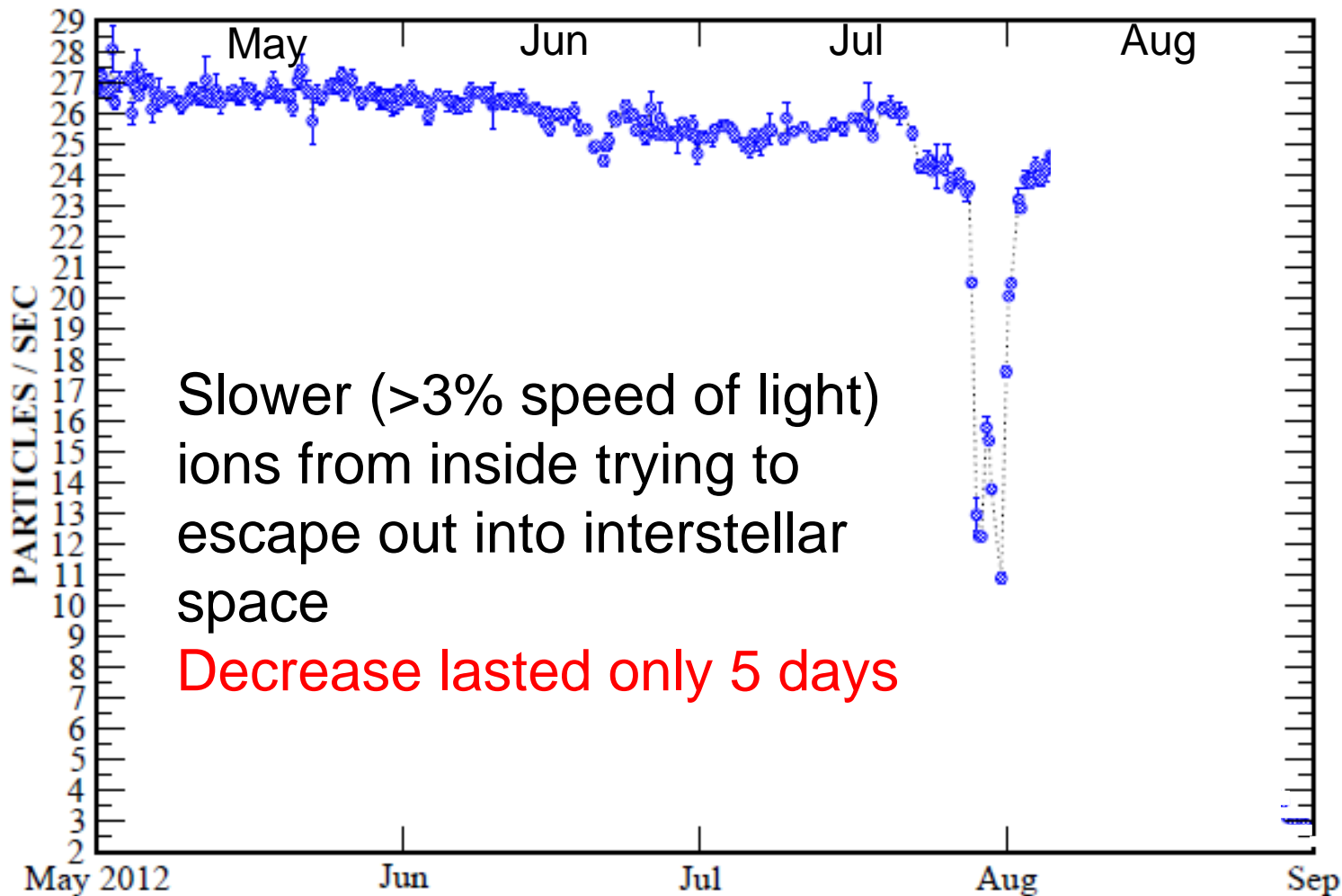
VOYAGER-1

> 0.5 MeV/nuc ions (6-Hour Avg)



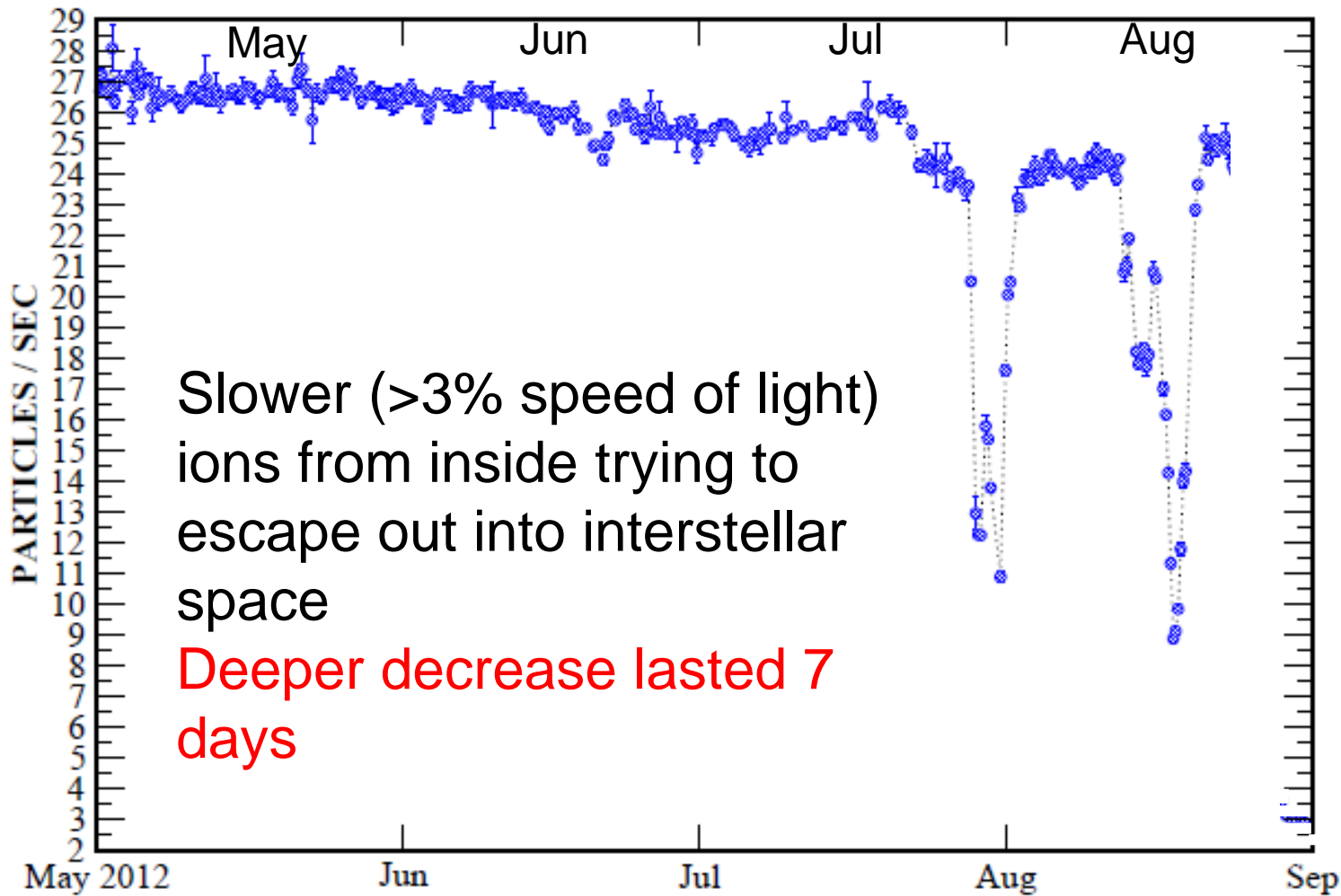
VOYAGER-1

> 0.5 MeV/nuc ions (6-Hour Avg)



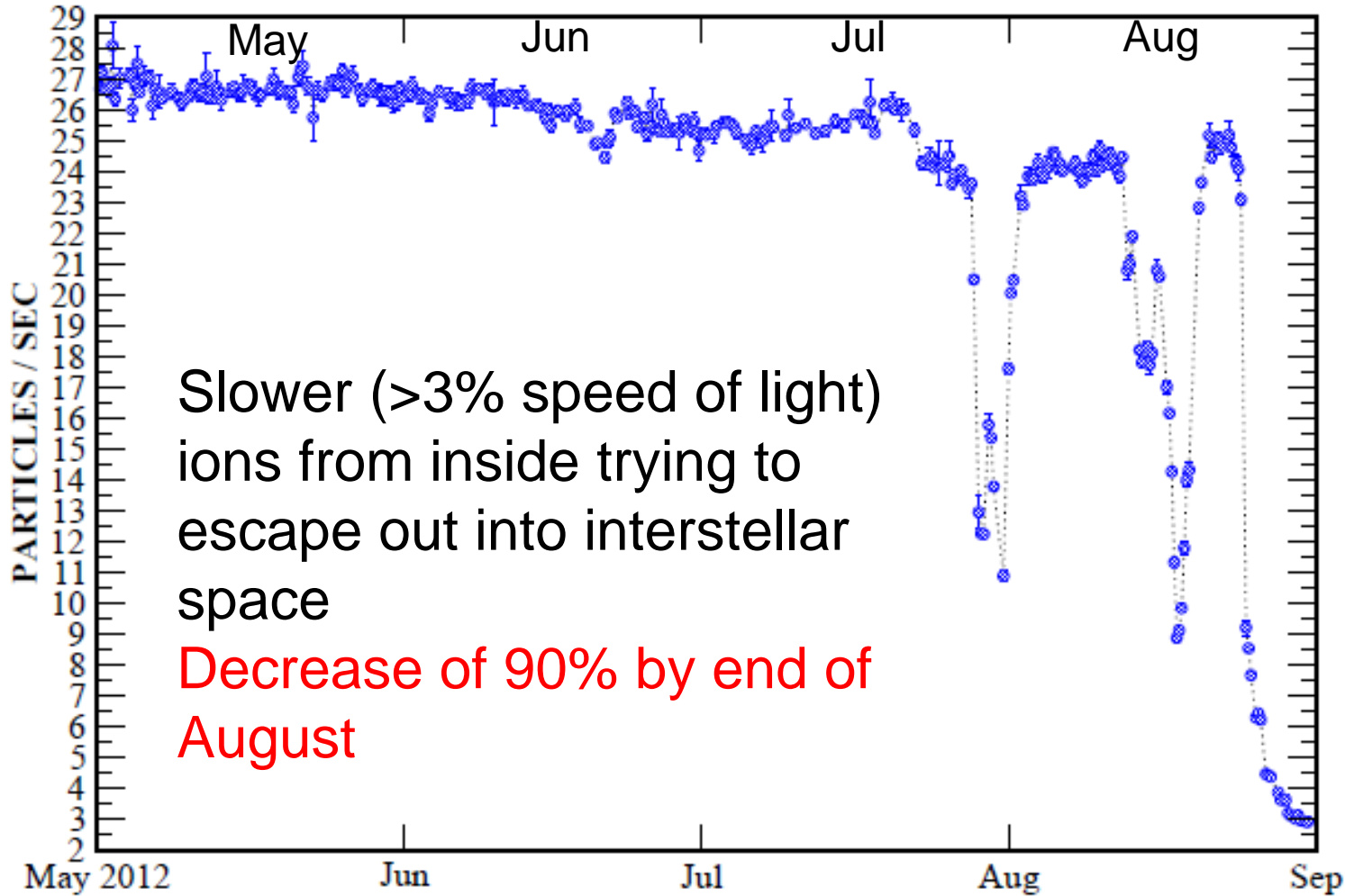
VOYAGER-1

> 0.5 MeV/nuc ions (6-Hour Avg)



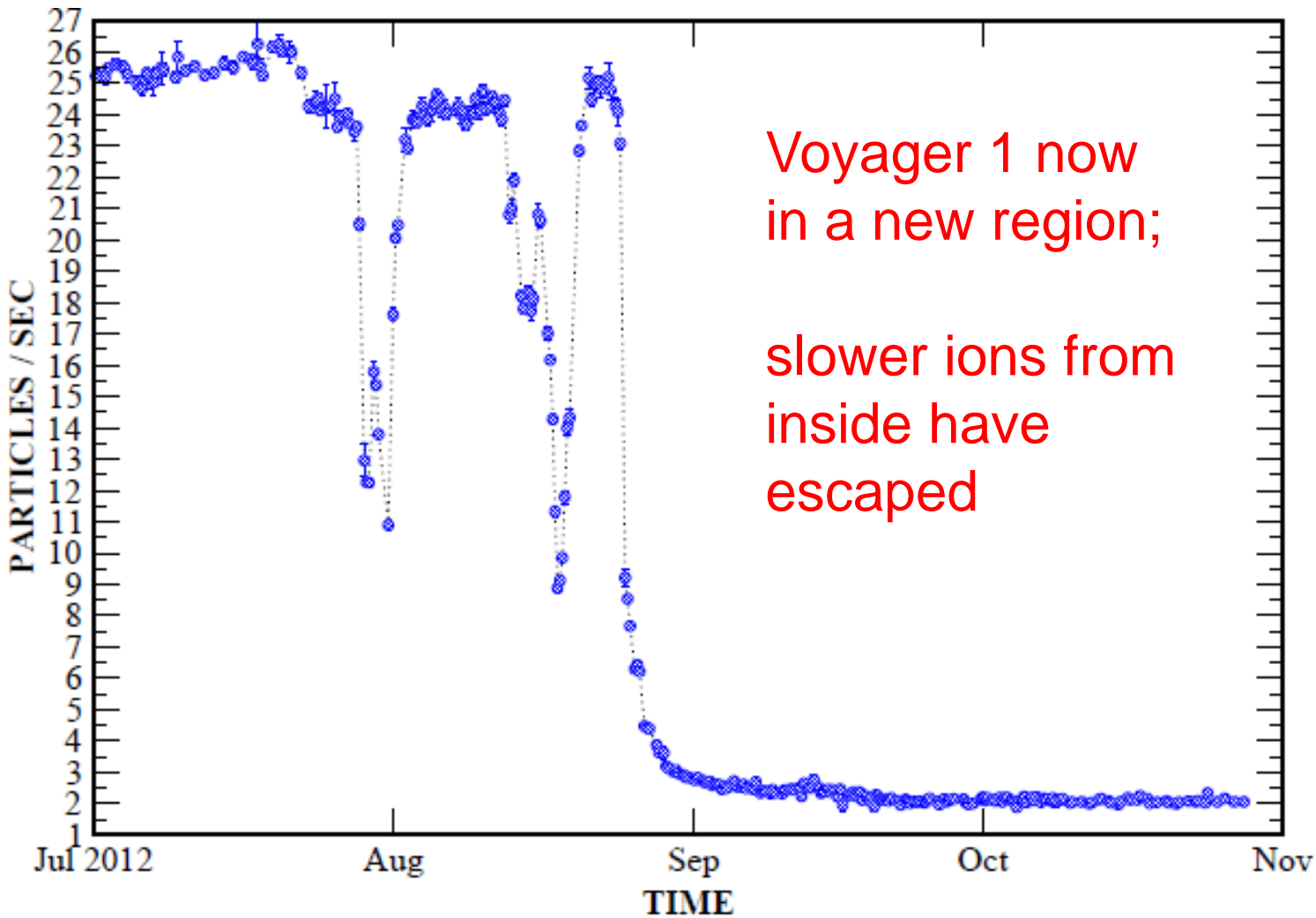
VOYAGER-1

> 0.5 MeV/nuc ions (6-Hour Avg)



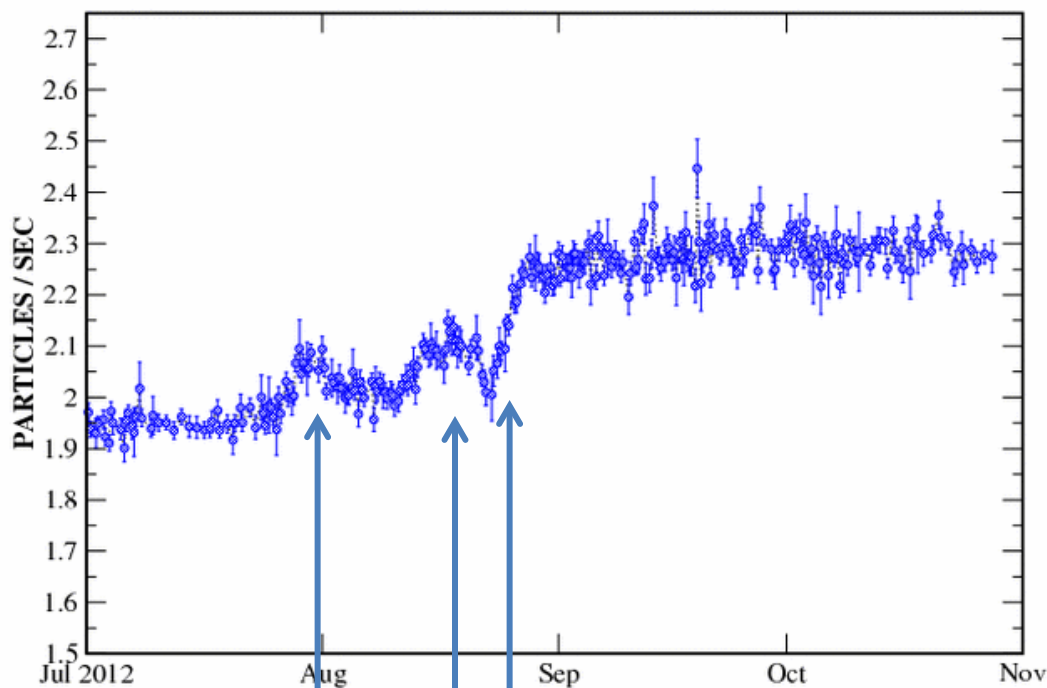
VOYAGER-1

> 0.5 MeV/nuc ions (6-Hour Avg)



Voyager 1 now
in a new region;

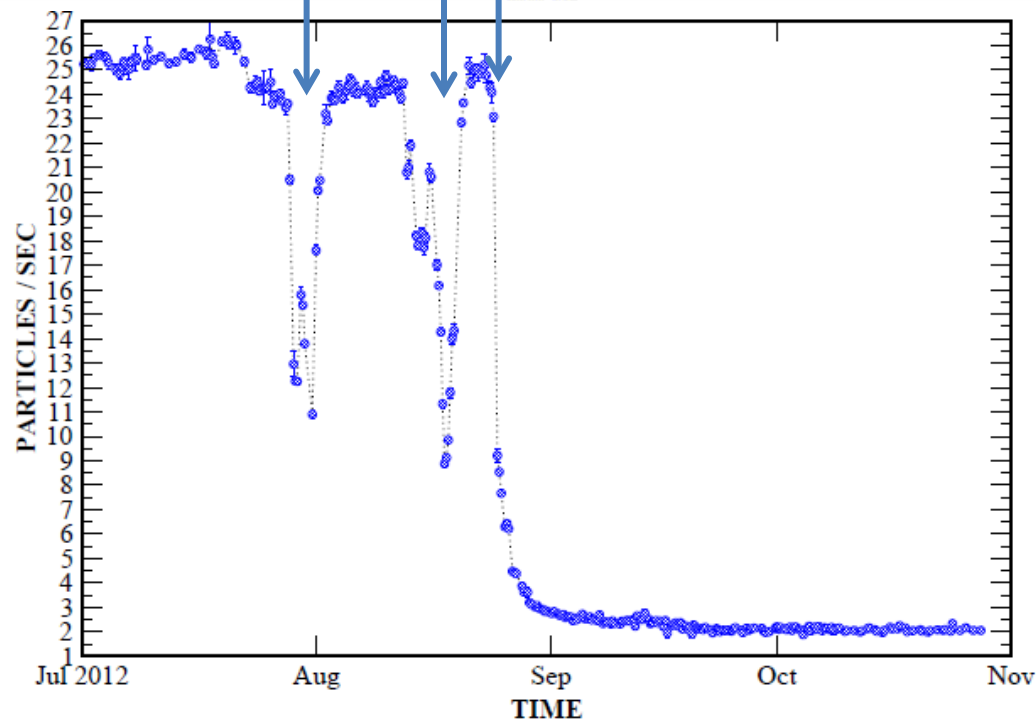
slower ions from
inside have
escaped

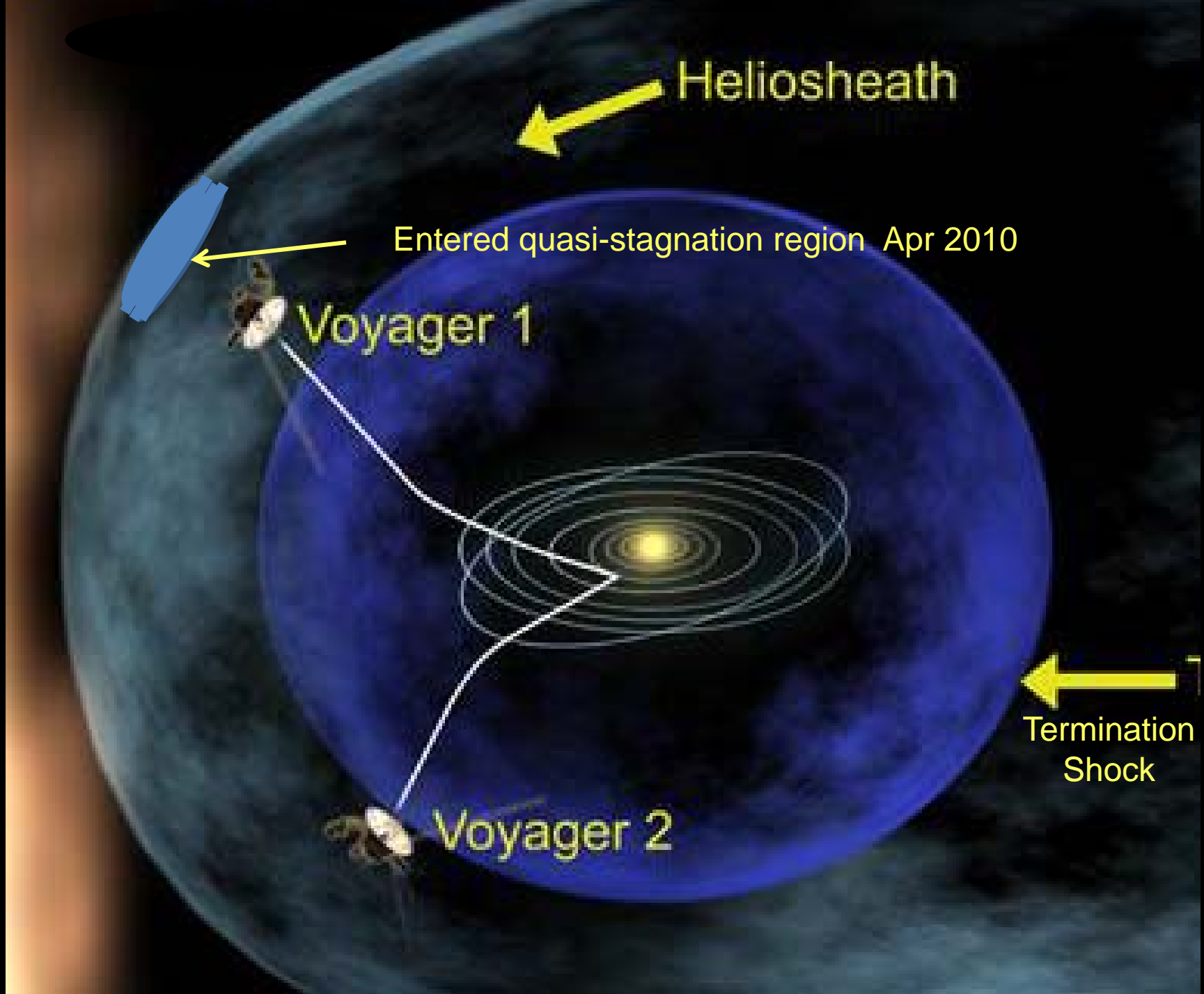


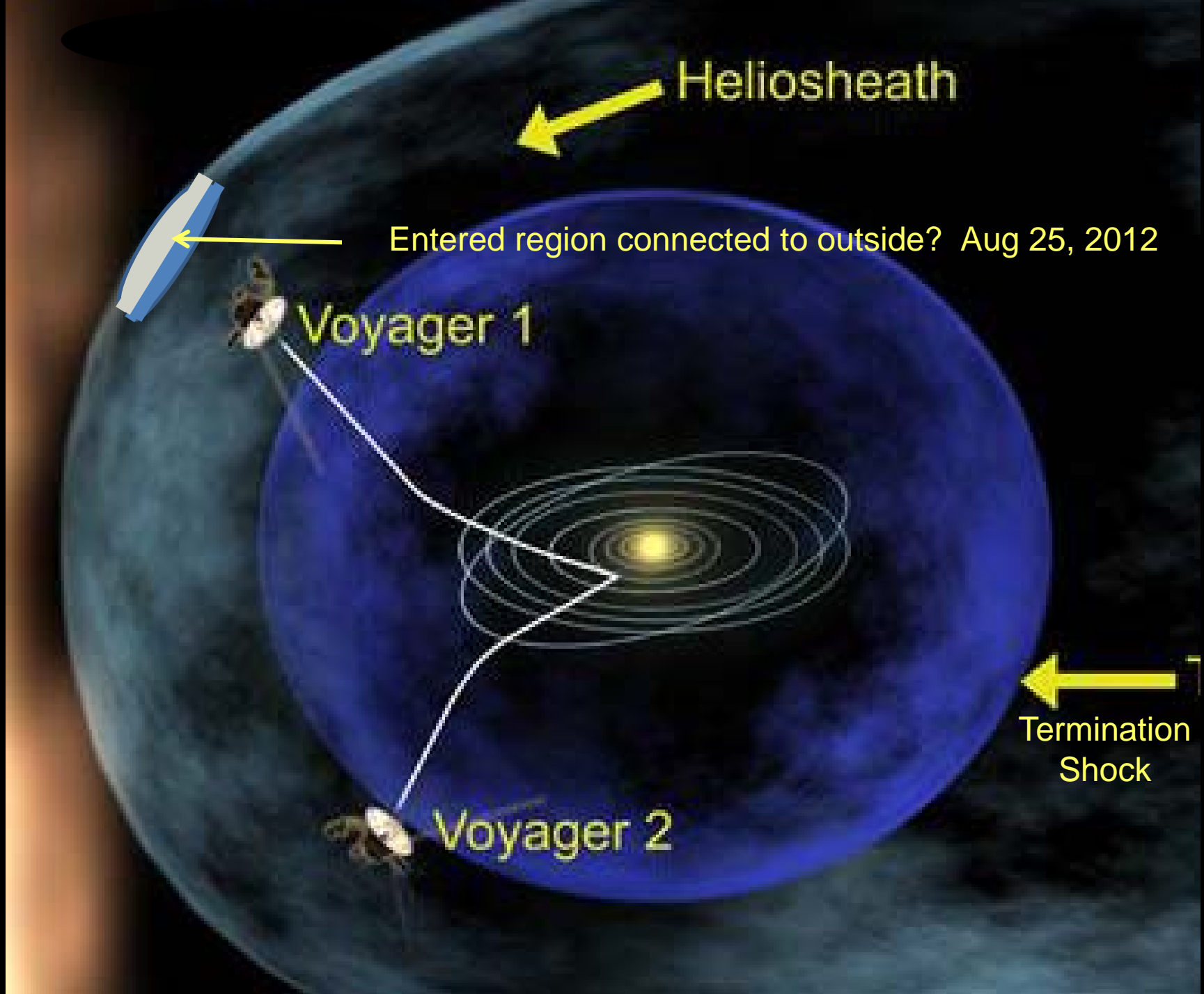
Cosmic rays from outside increased at same time as ions from inside escaped

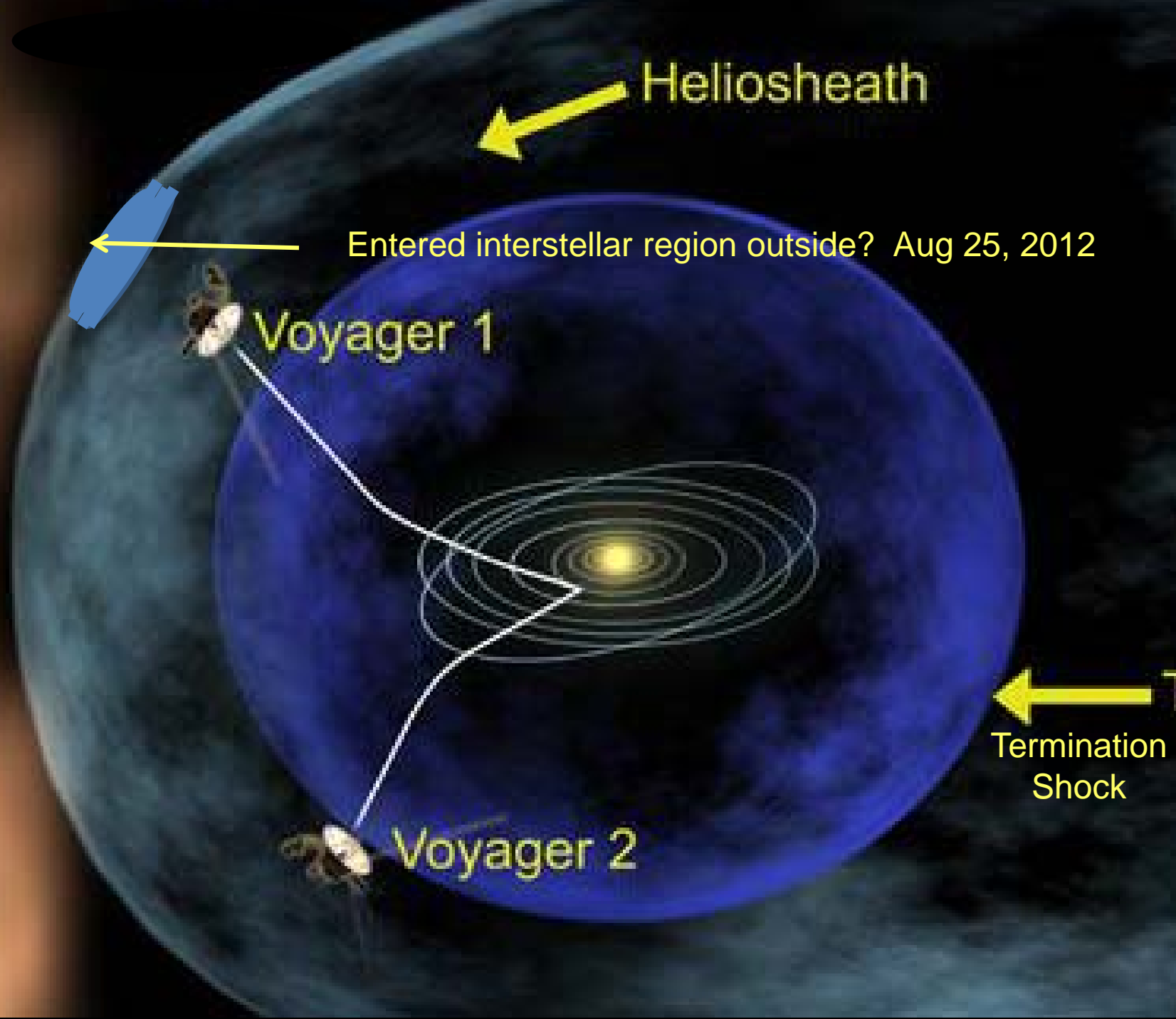
Is Voyager 1 in interstellar space, or is there a new region inside that is connected to interstellar space outside?

voyager.gsfc.nasa.gov









Heliosheath

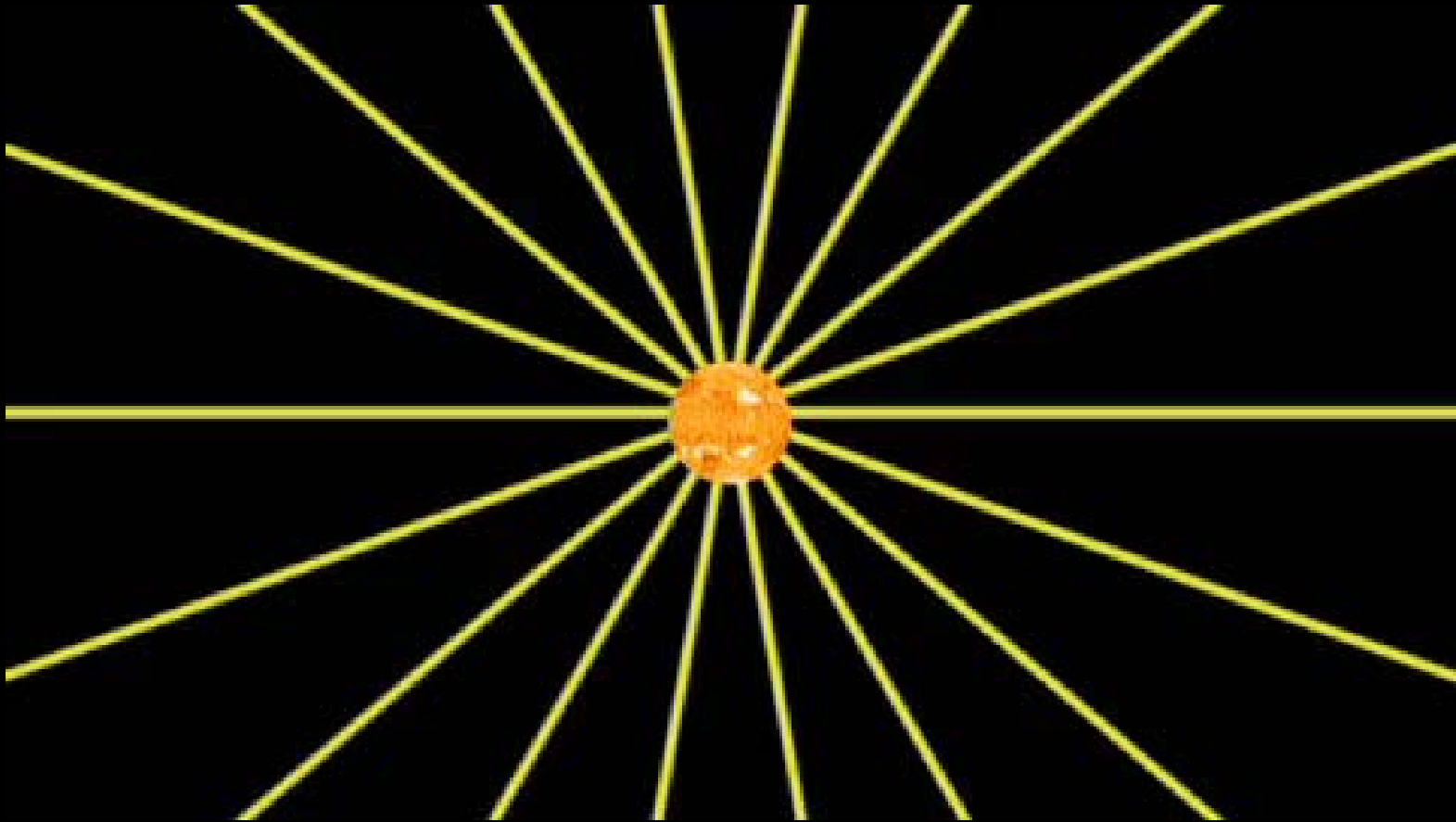
Entered interstellar region outside? Aug 25, 2012

Voyager 1

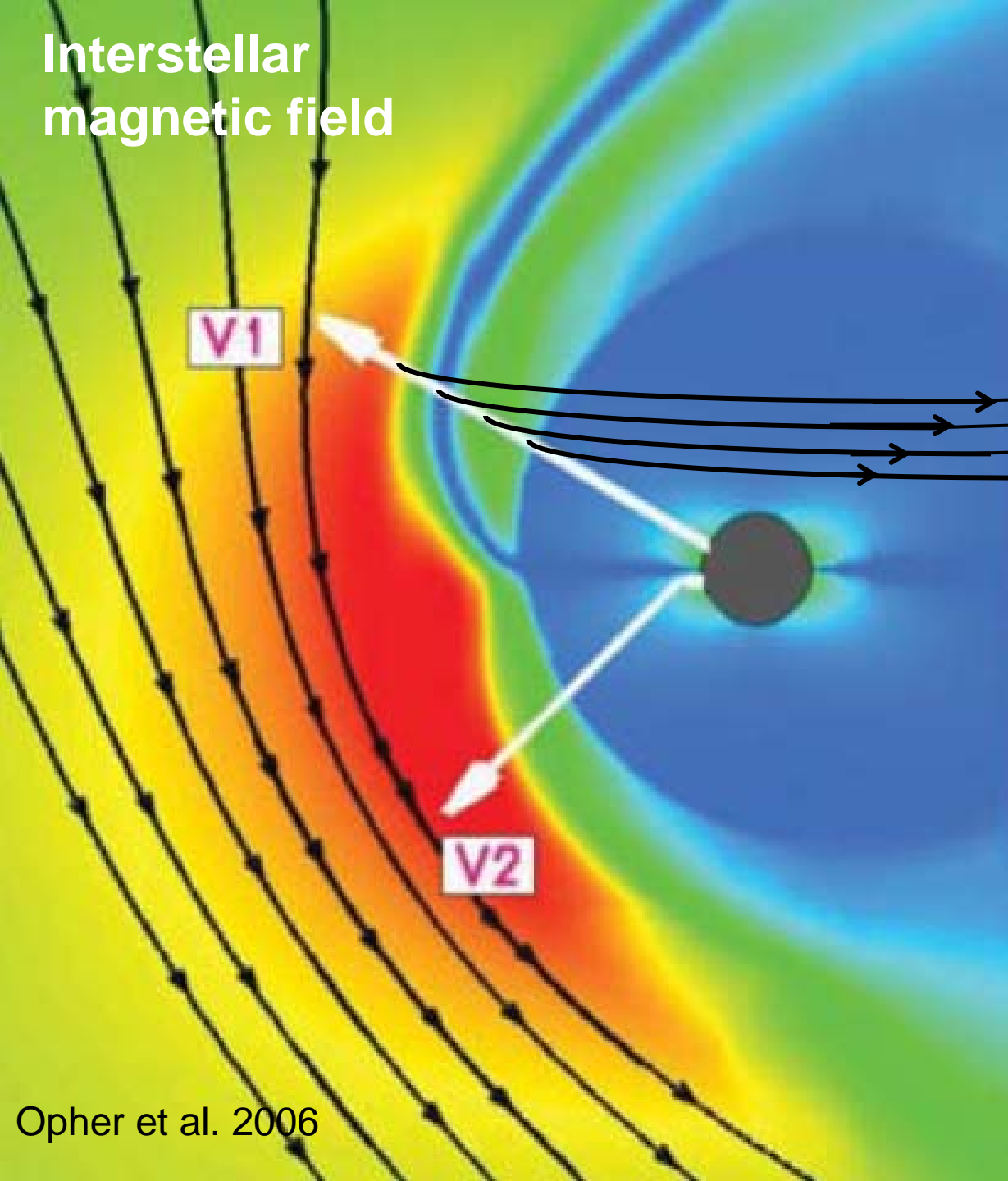
Voyager 2

Termination Shock

Spiral Magnetic Field



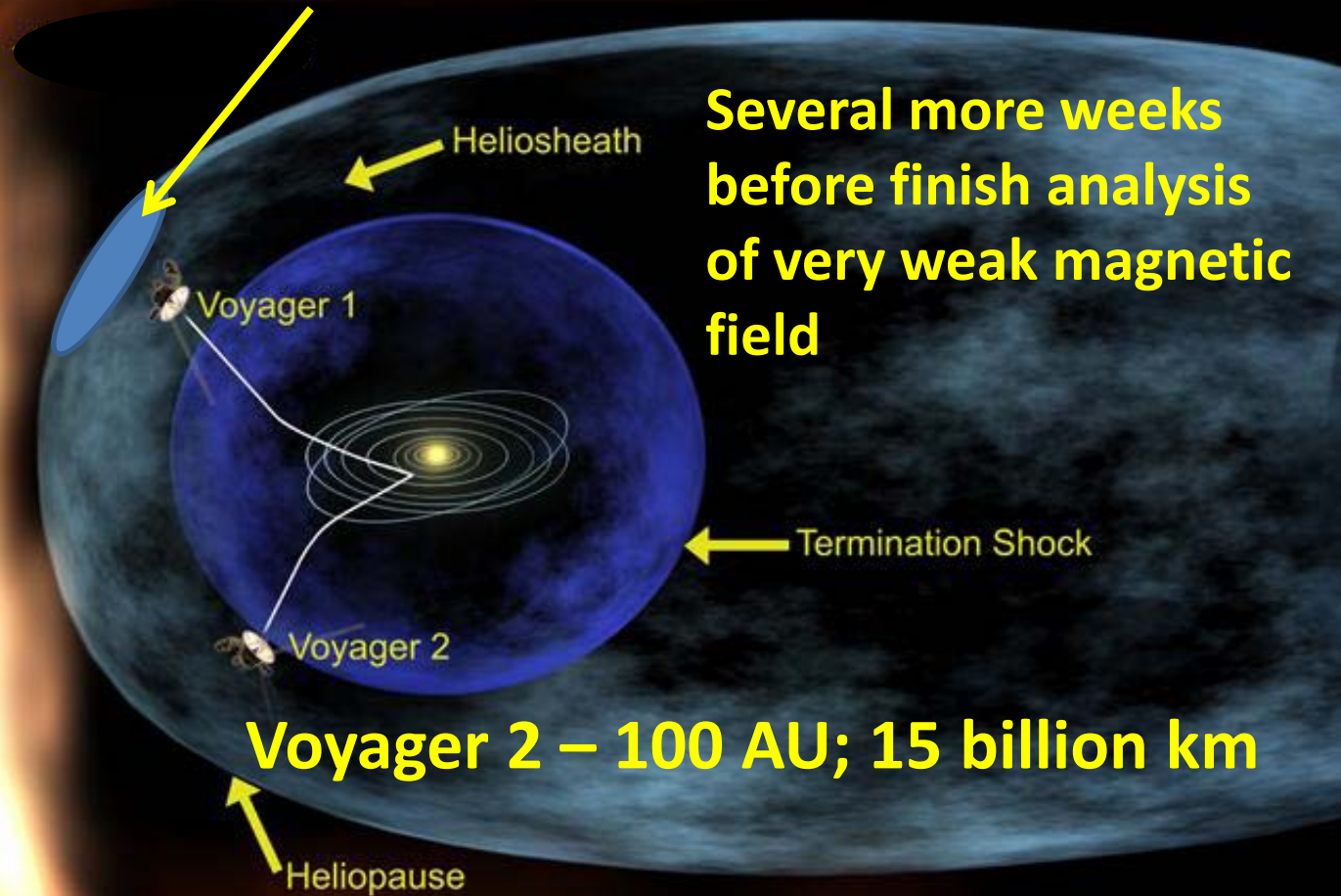
**Interstellar
magnetic field**



**Spiral magnetic field
from solar rotation is
east-west**

**Interstellar magnetic
field is inclined about
60° to the east-west
direction**

Voyager 1 – 122 AU; 18 billion km



**Several more weeks
before finish analysis
of very weak magnetic
field**

Voyager 2 – 100 AU; 15 billion km

Heliosphere

Heliopause

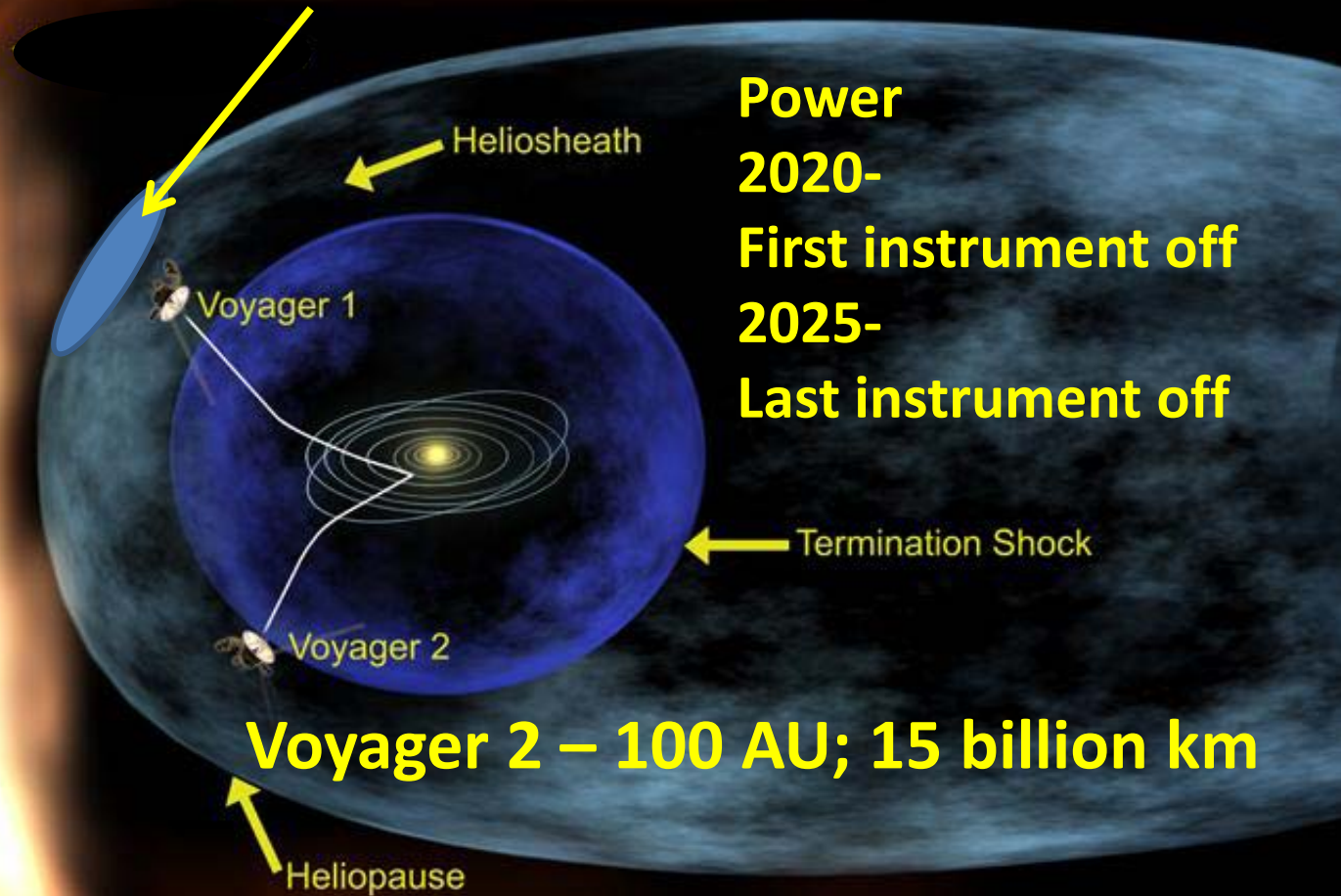
Termination Shock

Heliosheath

Voyager 1

Voyager 2

Voyager 1 – 122 AU; 18 billion km



Power

2020-

**First instrument off
2025-**

Last instrument off

Voyager 2 – 100 AU; 15 billion km

Heliosphere

The Journey Continues...

