

SOLARIS



A Focused Solar Polar Mission from Outside the Ecliptic Plane

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SOUTHWEST RESEARCH INSTITUTE

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REVEALING THE MYSTERIES OF THE SUN'S POLES

Why Solaris?



Solaris is a **FOCUSED single spacecraft Solar Polar Mission** addressing crucial unanswered questions that can **only** be answered from a polar vantage.

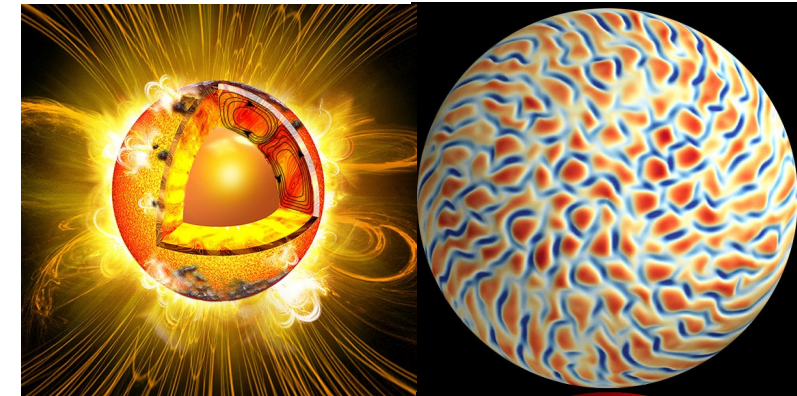
The Sun is a star that we can study with unprecedented resolution... and yet there are big, fundamental questions that are still unanswered...

- *How does the Solar Cycle Work?*
- *How does the Solar Dynamo, that drives the Solar Cycle, work?*

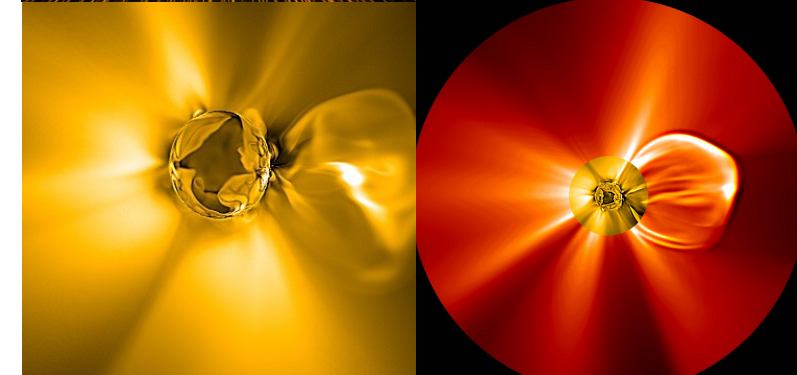
These questions can **ONLY** be answered by observing the Sun from a **sustained** vantage **over the Sun's poles**.

Breakthrough Science to be Addressed:

Solar Dynamo:
Polar flows distinguish dynamo mechanisms



Space Weather:
Longitudinal structure & dynamics of CMEs



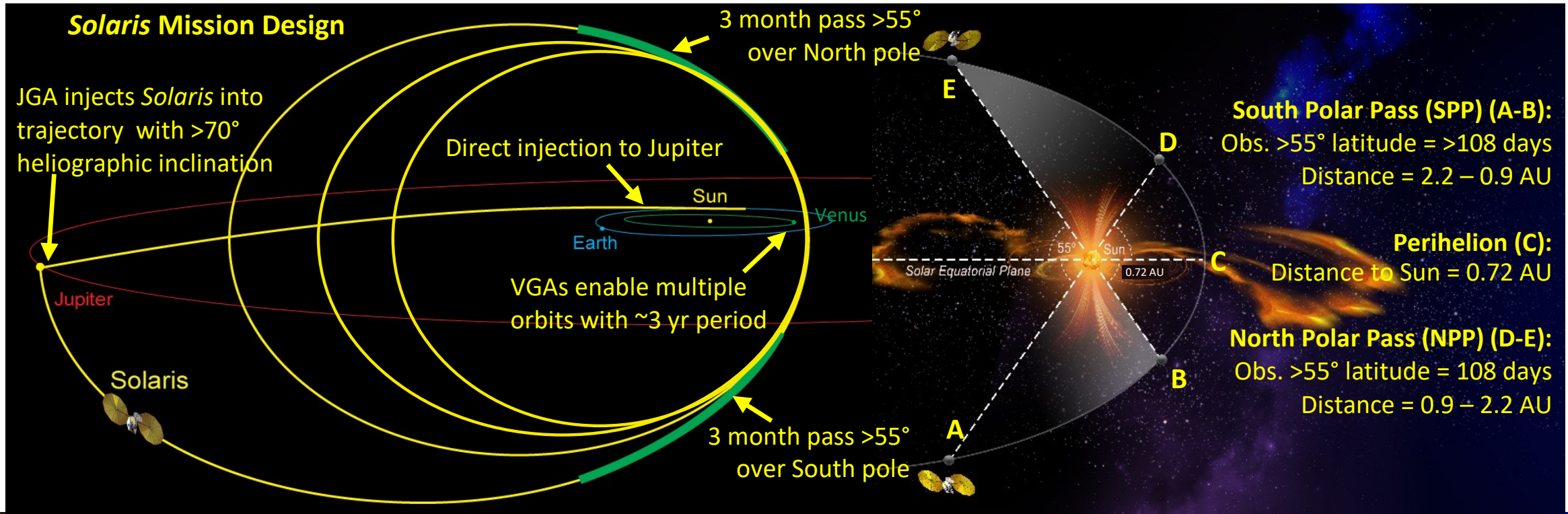
A Solar Polar mission is an opportunity the community has been wanting for 50 years!

Why Solaris?



- **FOCUSED Single spacecraft solar polar mission** to address crucial, unanswered questions of solar dynamo & space weather science that can only be answered via **sustained** imaging of Sun's poles.
- Robust mission design from previous MDEX Phase A study, with a Jupiter-gravity-assisted ballistic trajectory over the Sun's poles.

- Launch Nov. 2031
- Jupiter fly-by Mar. 2033
- South Polar Pass Aug. 2035
- North Polar Pass Feb. 2036



Compelling science, crucial measurements, elegant mission design

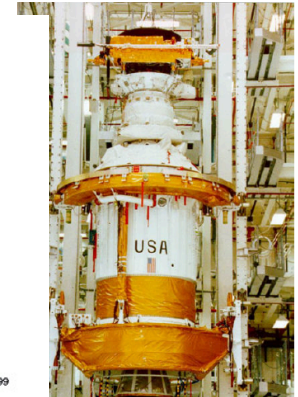
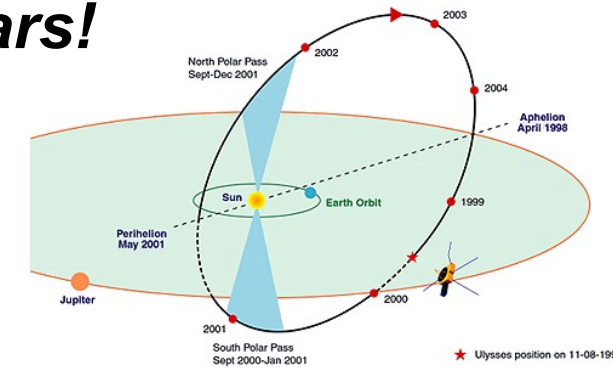
A Solar Polar Imaging Mission has been a long time coming...



The Heliophysics community has wanted, and studied, a solar polar imaging mission for >50 years!

- International Solar Polar Mission (ISPM)
- Original Solar Probe Concept was a polar mission
- Solar Polar Imager (SPI)
- Japanese Solar-C/Plan A Mission

Ulysses (ISPM)



However, **until now**, it has been **assumed** that it would take a **flagship mission**, like Parker Solar Probe, to do a solar polar imaging mission...

Now, taking advantage of **enabling technologies & innovative mission design**, we can do a **solar polar mission** as a MDEX or STP/Discovery-class mission!

Solaris completes the ISPM...matured and improved!

Solaris' Goal #1 – Understanding the Dynamo



Solaris' Goal #1 is about the **dynamo**...and the dynamo is a **universal physical process**, fundamental **not just for Heliophysics**, but **planetary science**, **earth science** and **stellar astrophysics**.

To understand how **polar magnetic fields & flows** reveal the Sun's global dynamics and the **mechanisms** that underlie the **solar dynamo**, which ultimately shape the **solar activity cycle**.

- *Solaris'* measurements are the **missing link**...
- ...and can **only** be obtained by a sustained, high latitude (polar) vantage point.

Decadal Survey - (2013) - "The deep, ponderous flows that carry patterns of magnetic flux to the poles regulate the seeding of the deep-seated dynamo that generates subsequent solar cycles... The missing information will come, in part, from measurements of the hard-to-view solar poles".



Solaris science is big...it is not incremental!

Solaris Goal #2: Understanding the role of transient dynamics in structuring the corona and nascent solar wind



How do CMEs interact with the corona and evolve in longitude?

View from solar equator

- We can't see the full extent of **global interactions**
- We can't see longitudinal structure/motion
- **Enabling** observations for **space weather research!**

View from *Solaris*

Solaris observes longitudinal structure and dynamics of coronal mass ejections

Solaris provides enabling Observations for Space Weather Research



Solaris' Goal #2 will also provide...

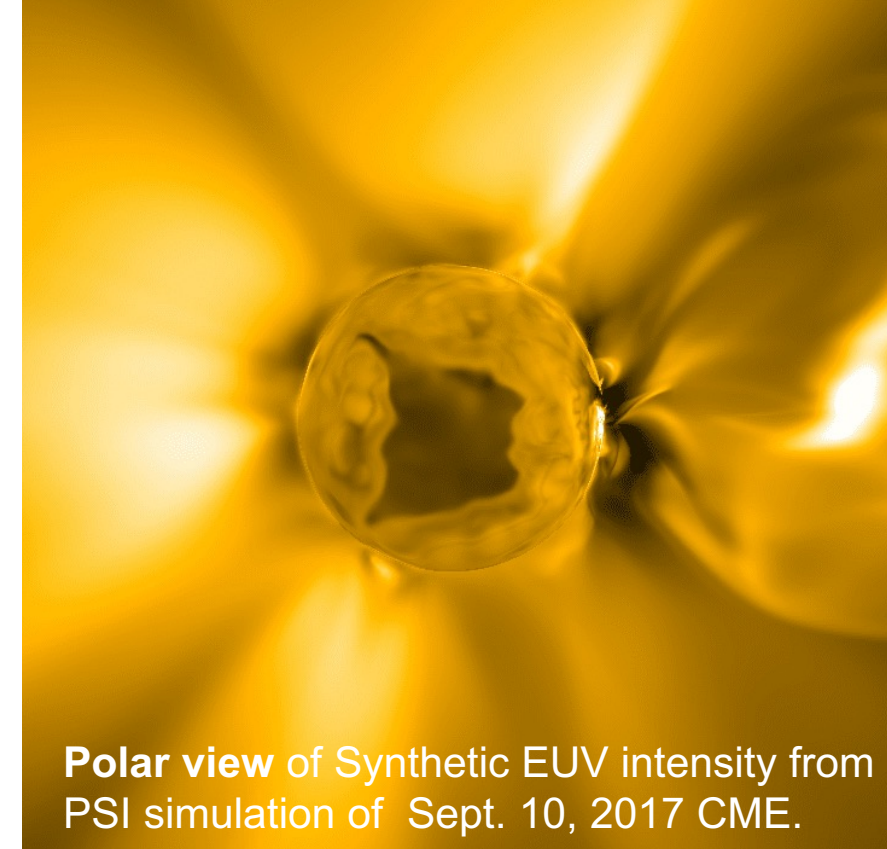
...the first simultaneous, 360° longitudinal views of coronal structure and CME eruption, ***providing new insight into our understanding of space weather.***

We don't really understand the longitudinal extent or impact of solar storms and CMEs... WHY some are narrowly focused and others are truly global.

- e.g., October 28, 2021 CME & SPE was detected both at Earth and Mars...separated by 180° in longitude!

Out-of-the-ecliptic observations are ***complementary*** to those made using similar instruments at L1, L4/L5 and in Earth orbit.

Simultaneous 360° Polar View of all longitudinal coronal structure



Polar view of Synthetic EUV intensity from PSI simulation of Sept. 10, 2017 CME.

Solaris captures the global coronal response to solar activity

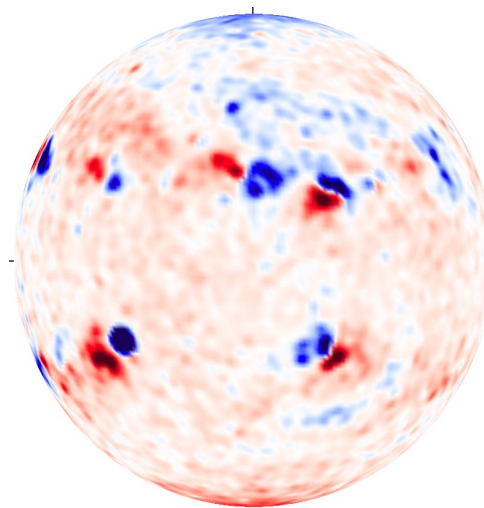
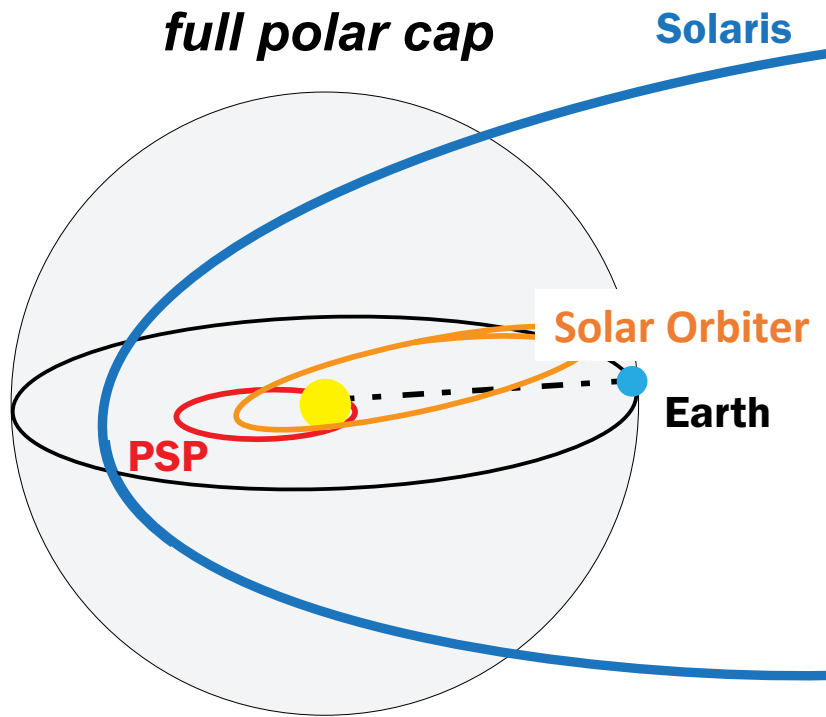
Solaris' sustained polar view is key!



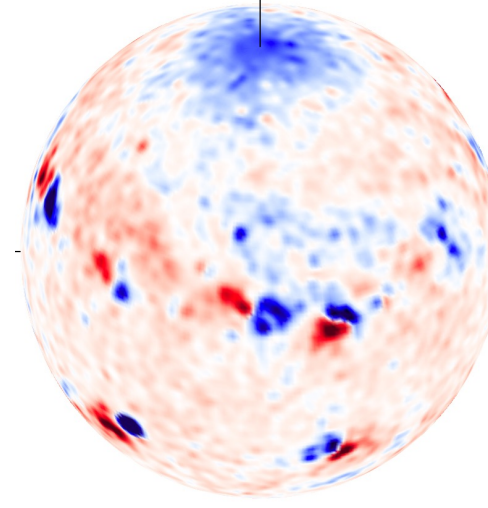
Solaris will achieve what no other existing or planned mission has or will...

Solaris provides complementary science to all past/existing missions *through unobscured views of polar coronal holes and evolution of the full polar crown for multiple rotations.* (>100 days, >60 deg latitude)

Solaris observes the full polar cap

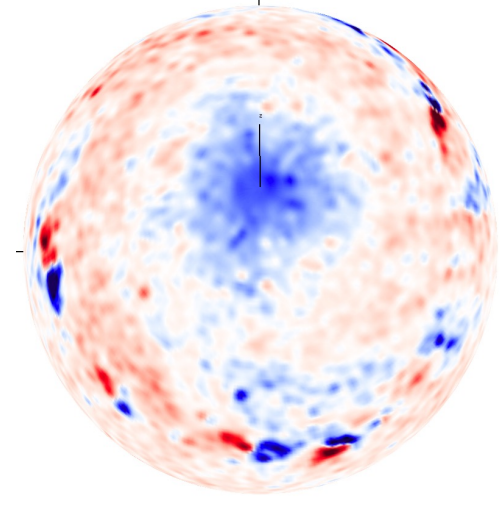


Ecliptic



Solar Orbiter @ 32 deg.

(~10 days >30 deg.)



Solaris @ 75 deg.

(>100 days >55 deg.)

Images courtesy Jon Linker & Cooper Downs

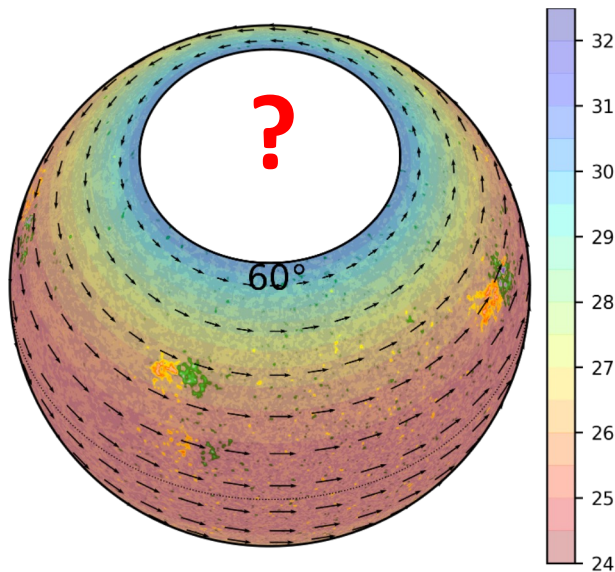
Solaris observes all longitudes within 60° of observed disk center for > 100 days per pole/orbit

Why do we need to go to the poles?



Observations of the magnetic field, and three intrinsically coupled flows at the Sun's poles are the missing link to our understanding of the solar dynamo

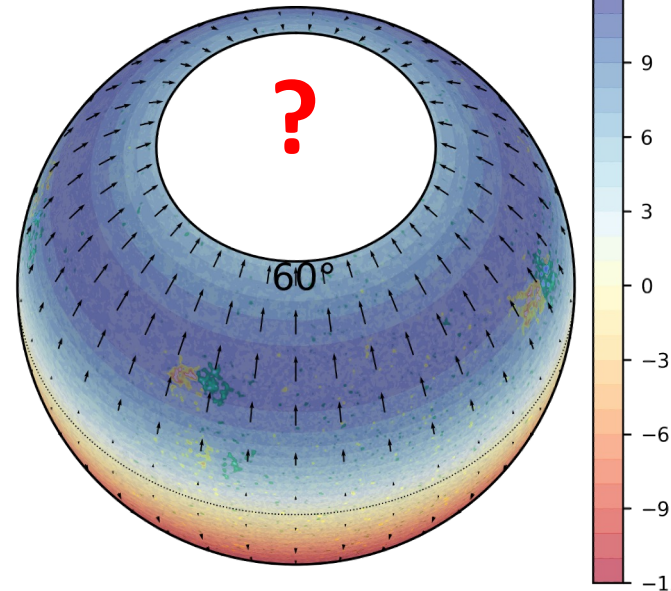
Differential rotation: Is there a **polar vortex**?



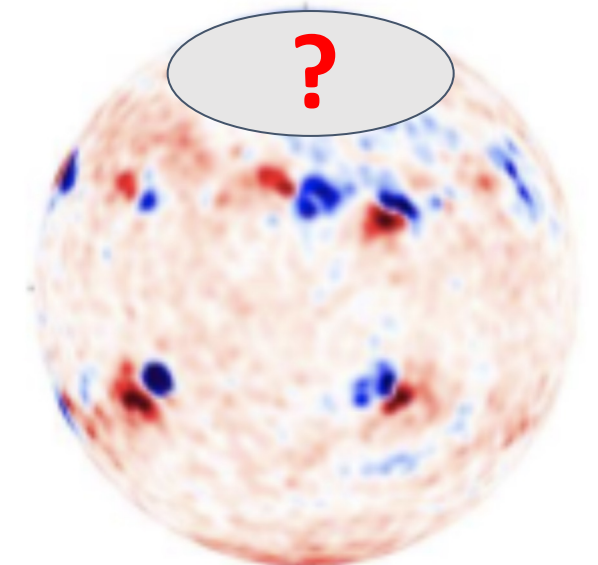
Global convection: Are there **spinning gyres** at the poles?



Meridional circulation: Are there high-latitude **counter-cells**?



Magnetic field: Are there polar magnetic **sources or sinks**?



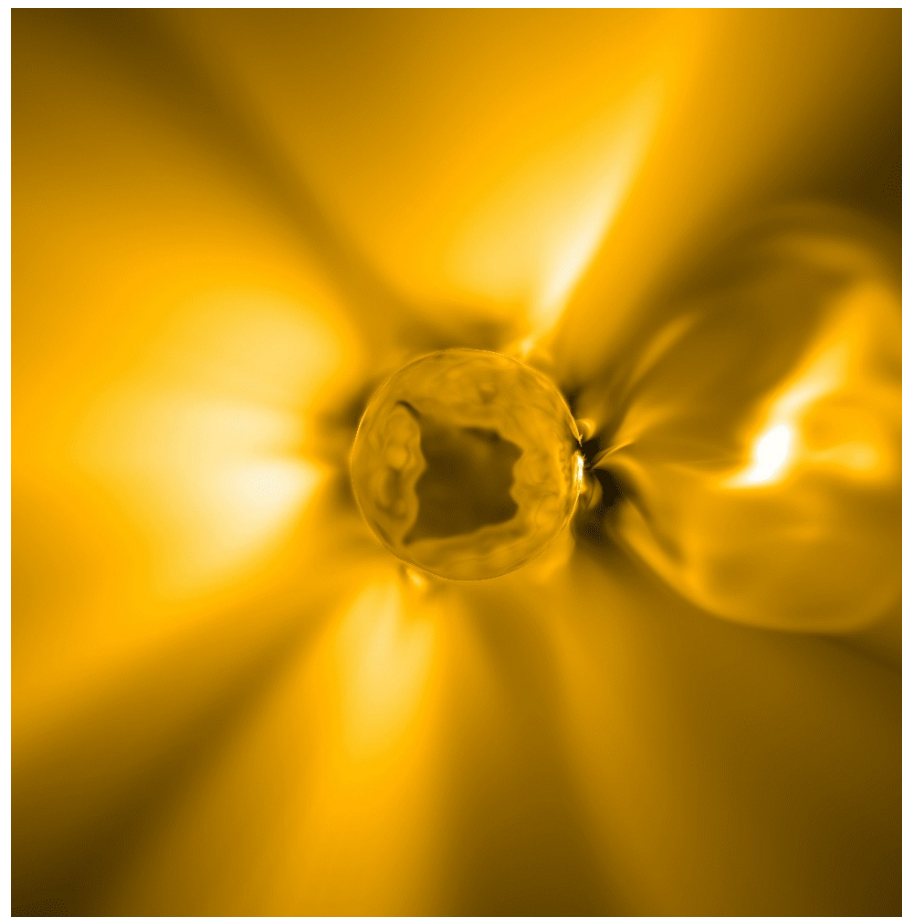
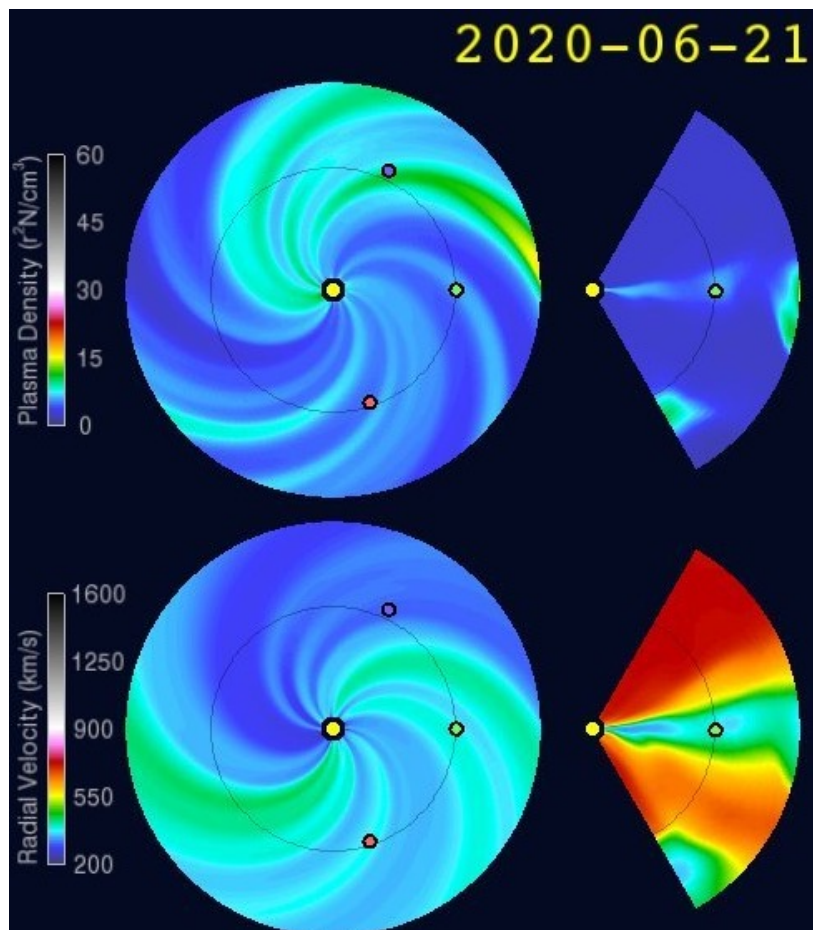
Observations of polar magnetic field and flows are key to understanding how the solar dynamo works

“Fried Egg – Sunny-side Up” View of the Heliospheric Current Sheet



Polar Vantage Shows Ecliptic Plane Evolution of Heliospheric Structure

Solaris will provide first observations to directly compare with ENLIL Model



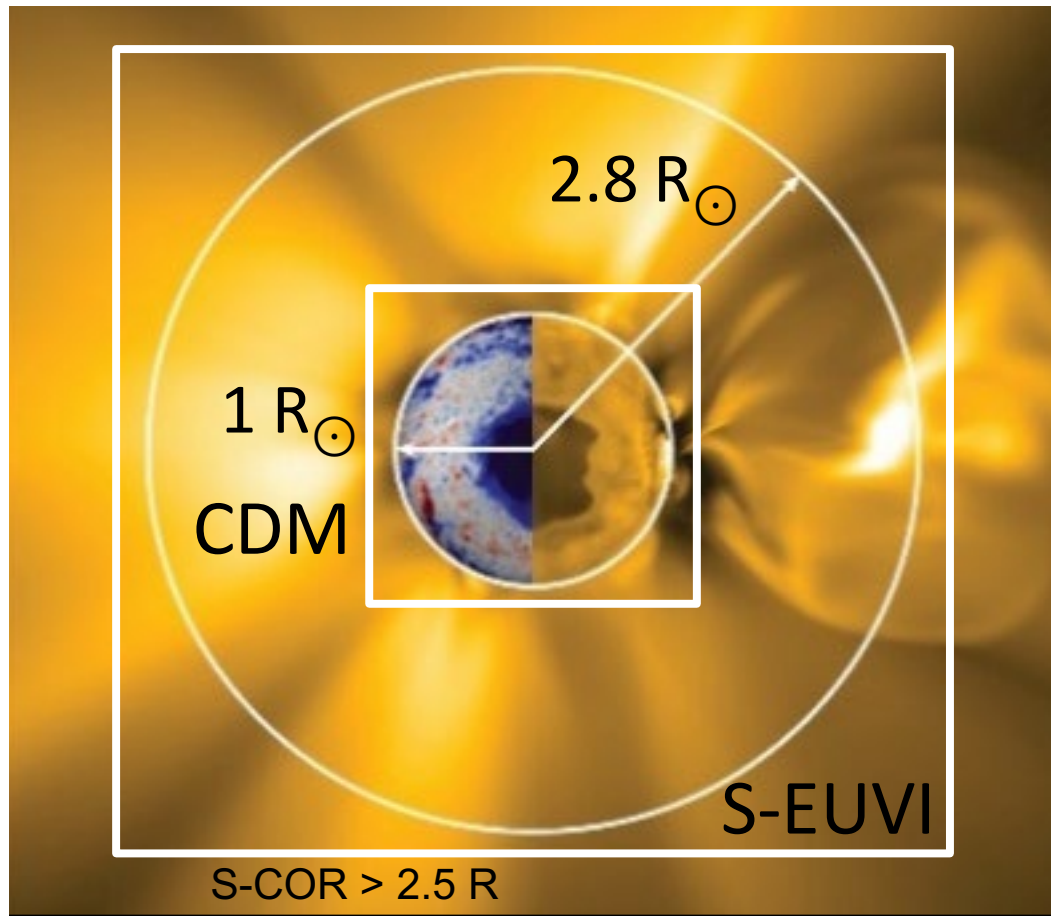
Polar view of Synthetic EUV intensity from PSI simulation of Sept. 10, 2017 CME.

Complimentary out-of-ecliptic observations with Vigil, Solar Orbiter, PSP, SWFO (L-1)

What do we need to do *Solaris* science?



***Sustained polar FOV with capable, COMPACT remote sensing instruments...
The new science comes from the NEW VANTAGE!***



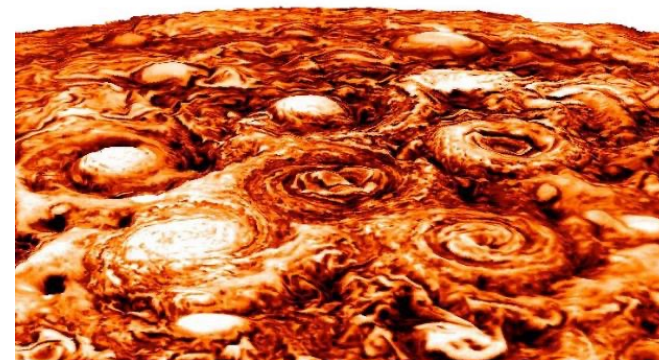
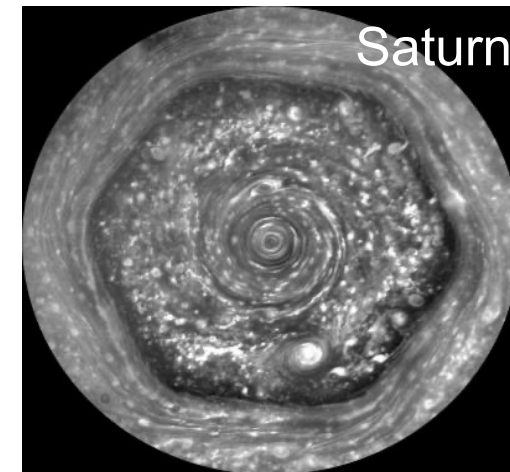
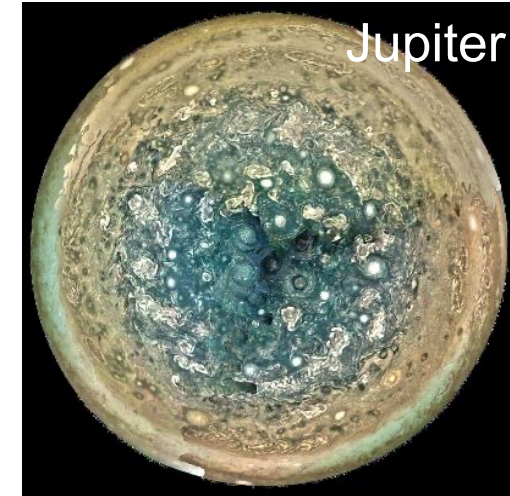
Instrument	Solaris Measurements
Remote Sensing:	
Compact Doppler Magnetograph (CDM) (1 min. cadence, 4 Mm /2 pixels, >72 days)	Dopplergrams to helioseismically measure polar flows to constrain dynamo models Magnetograms to quantify polar magnetic flux & constrain dynamo models
Wide Angle EUV Imager (EUVI)	EUV images of coronal structure on disk & out to >3.0 solar radii, (10 min cadence, 4 Mm /2 pixels, >72 days)
White Light Coronagraph (COR) (2.5 to 15 Rs @ 1 AU) (5 to 30 Rs @ 2 AU)	360° out-of-the-ecliptic WL coronal observations to overlap with EUV images & provide continuous coverage of longitudinal expansion from the low, through the middle to high corona & solar wind
In-situ:	
Magnetometer (MAG)	In-situ vector magnetic field to measure heliospheric magnetic structure to constrain models & compare with estimates of polar flux

Solaris achieves the critical measurements at sustained high latitudes required to close on science objectives

Exploring one of the last unknown regions of the Solar System



- **We expect *Solaris*** to reveal clues to our understanding of the solar dynamo which drives the solar cycle...
- We also expect “***unexpected***” ***discoveries*** which inevitably happen when exploring a new part of the solar system for the first time!
- Just as our understanding of Jupiter and Saturn are being **transformed by polar observations** from Juno & Cassini...
- ...we expect our understanding of the **solar dynamo** and **solar activity** to be **transformed by the polar observations** from ***Solaris***.

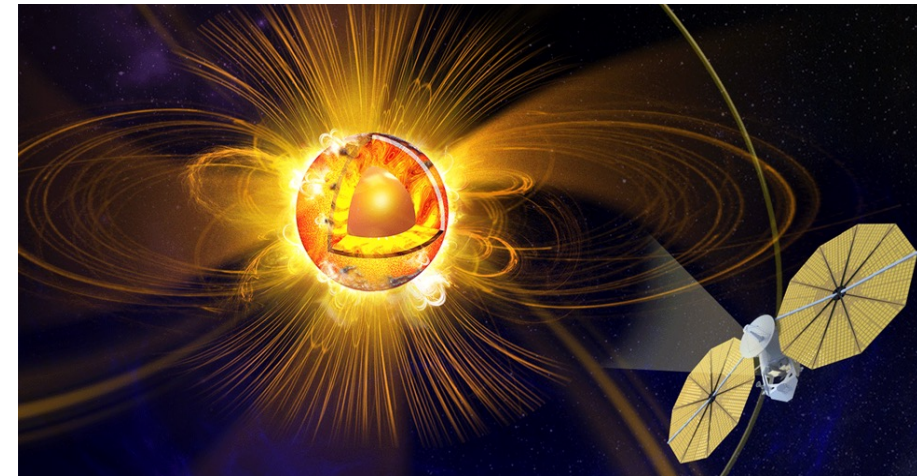


New perspectives yield new insights!

Summary



- *Solaris* mission concept is a **FOCUSED single spacecraft Solar Polar Mission, ready to go NOW**, addressing crucial unanswered questions that can only be answered from a polar vantage!
- **Serves as a Pathfinder for both Science & Mission Design in advance of a bigger Flagship (4 π) Solar Polar Constellation Mission (e.g., TRACE >SDO, IBEX >IMAP)**
- It is an opportunity the community has been wanting for 50 years!
- ***Solaris*** is achievable NOW to complement current/future missions (Solar Orbiter, Vigil, Parker Solar Probe).
- The *Solaris* Solar Polar mission concept is scale-able...
 - **MIDEX mission**
 - **STP/Discovery-class mission**
 - 1st spacecraft of a 4 π constellation (Polar view, L1, L5)



Solaris is ready NOW to be NASA's next Heliophysics MIDEX or STP/Discovery-class mission