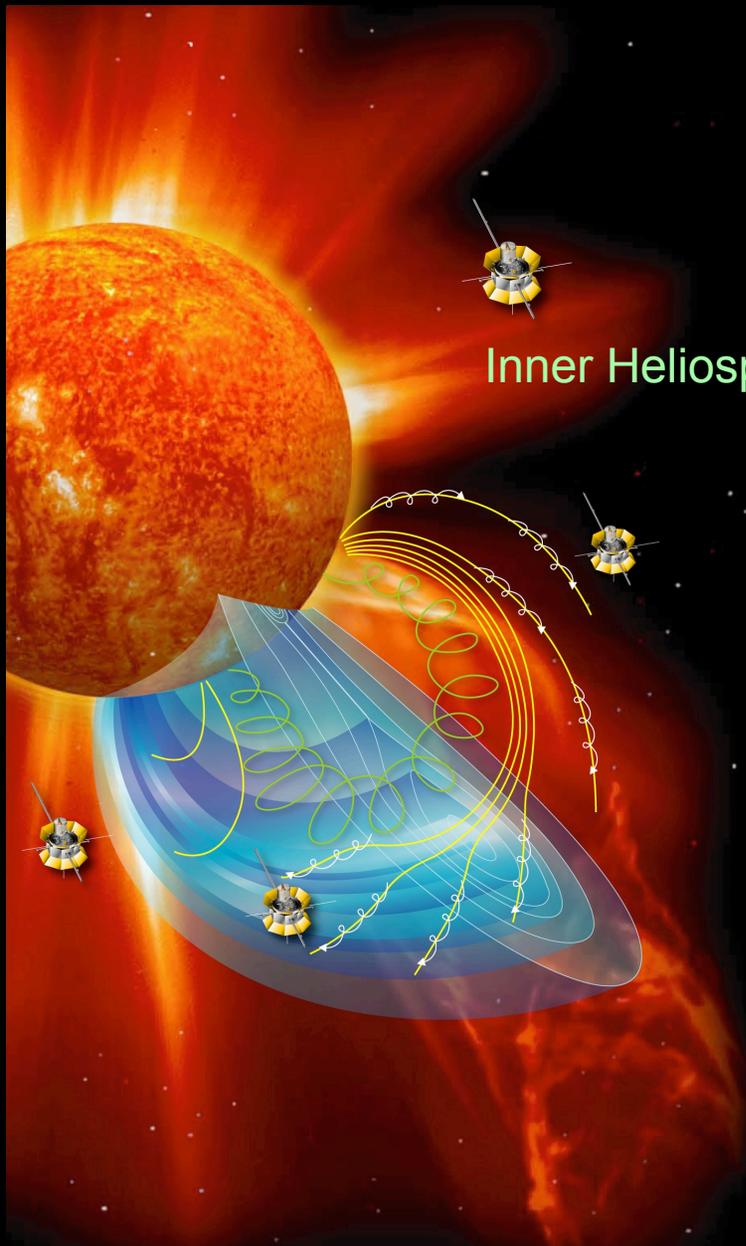
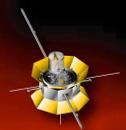


**The Joint NASA Sentinels and
ESA Solar Orbiter Missions
HELEX**

Adam Szabo (Sentinels Study Scientist)
NASA Goddard Space Flight Center



Farside Sentinel



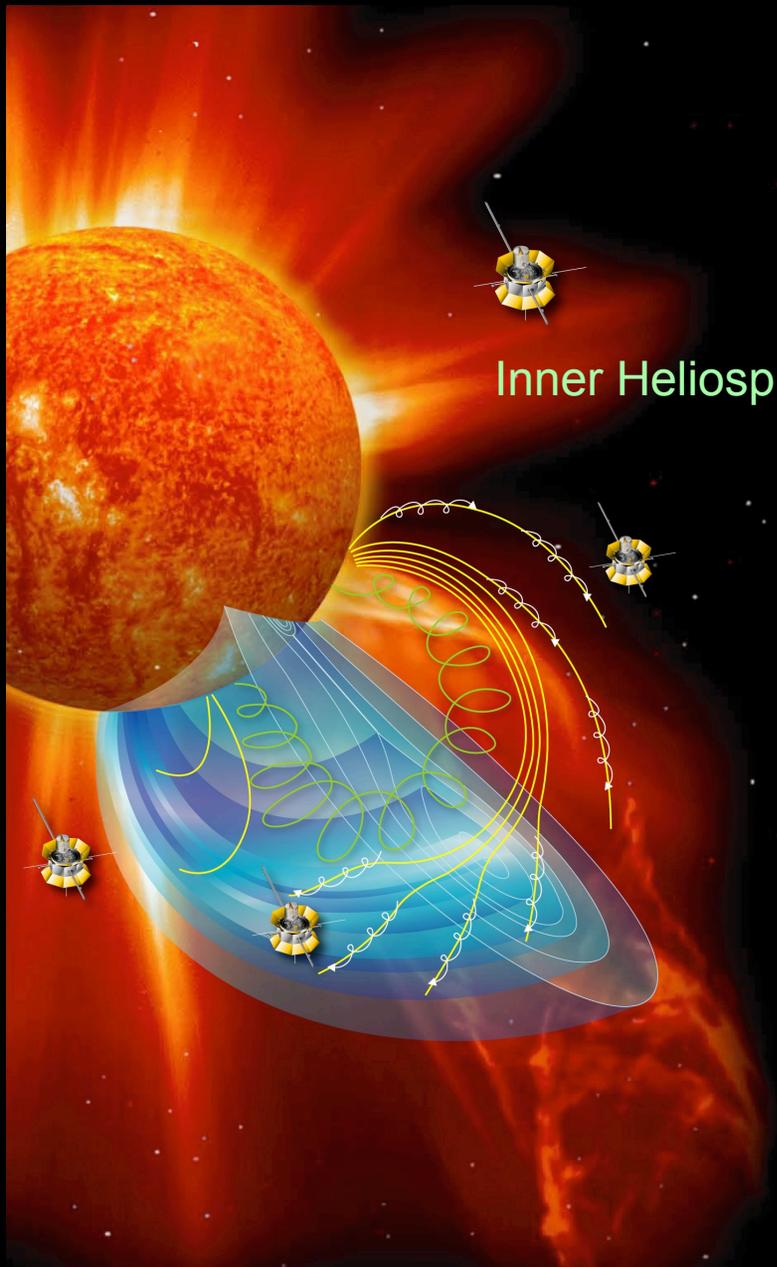
Inner Heliospheric Sentinels



Near-Earth Sentinel



Sentinels STDT Configuration



Solar Orbiter

Inner Heliospheric Sentinels

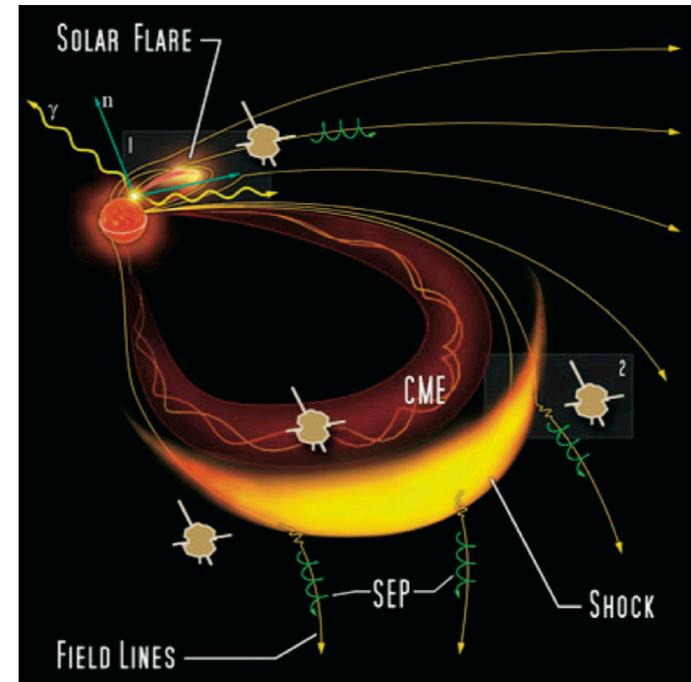
Sentinels/Solar Orbiter JSTDT Configuration

Near-Earth Assets

Joint HELEX Science Objectives

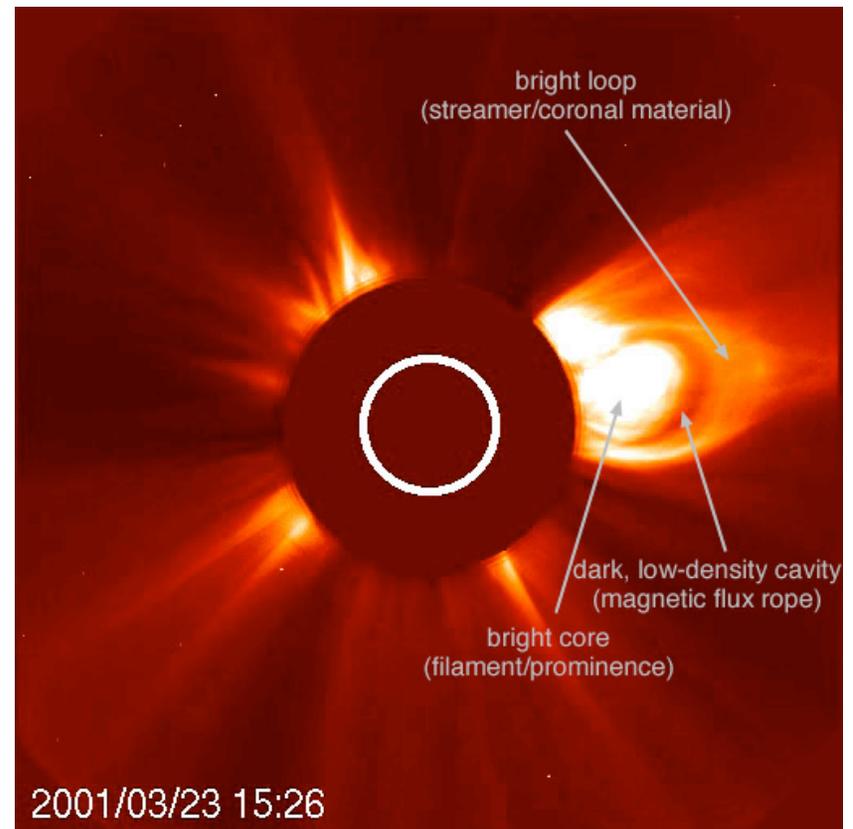
- What are the sources, acceleration mechanisms, and transport process of solar energetic particles?
- How do coronal mass ejections evolve in the inner heliosphere?
- What are the origins of the solar wind streams and the heliospheric magnetic field?

Overall objectives veru similar to both the Sentinels STDT and original Solar Orbiter science objectives – a natural fit.



HELEX Measurement Requirements

- Simultaneous in-situ measurements at multiple locations in the inner heliosphere to capture the spatial structure and temporal evolution of the phenomena.
- Connect in-situ measurements to remote sensing observations of the solar corona – overlapping in-situ and remote observations.
- Detailed plasma diagnostics of the solar corona to connect to in-situ measurements in order to identify source regions and mechanisms.



Detailed Measurement Requirements

Table 3-2. HELEX measurement prioritization

Obj.	Question	Inner Heliospheric Measurements (Sonic point < X < 0.5 AU)																Coronal Measurements (0 to 60 Rs)																				
		Energetic Particles		Energetic Particle Composition		Energetic Particle Charge State		Suprathermal/EI electrons		Solar Wind Ions		Solar Wind Electrons		Solar Wind Composition		DC Vector Magnetic Fields		AC Magnetic Fields		Local Plasma Waves		Remote Radio Waves		Photospheric Magnetic Fields		EUV Spectroscopy		EUV Imaging		Near-Sun Coronagraphy		Wide FOV Coronagraphy or HI		X-Ray Imaging		Gamma-Ray Detection		Neutrons
		Orb	Sent	Orb	Sent	Orb	Sent	Orb	Sent	Orb	Sent	Orb	Sent	Orb	Sent	Orb	Sent	Orb	Sent	Orb	Sent	Orb	Sent	Orb	Sent	Orb	Sent	Orb	Sent	Orb	Sent	Orb	Sent	Orb	Sent	Orb	Sent	
2.1 What are the origins of the solar wind streams and the heliospheric magnetic field?	2.1.1 Where does the slow and fast solar wind come from?	S	S	S	S			S	S	R	R	S	R	R	R	R	R			R	S	S	S	R		R		R		S		R	S					
	2.1.2 What are the solar sources of the HMF?	S	S	S	S	S	S	R	R	R	R					R	R							R						R	S							
	2.1.3 What is the solar origin of turbulence and structures at all scales in the solar wind?	S	S	S	S						R	R	S	S	S	S	R	R	R	R	R	R	S	S	R		R		R									
2.2 What are the sources of energetic particles?	2.2.1 What are the sources of energetic particles and how are they accelerated to high energy?	R	R	R	R	S	R	R	R	R	R	R	R	R	R	R	R	S	S	S	S	R	1st: R 2nd: S	S		S		R		R		R	R	1st: R 2nd: S		1st: R 2nd: S		
	2.2.2 How are solar energetic particles released from their sources and distributed in space and time?	R	R	R	R	S	R	R	R	R	R	S	S			R	R	R	R	R	R	S	S	S			S		R		R		S	S				
2.3 How do coronal mass ejections evolve in the inner solar system?	2.3.1 How is the structure of ICMEs related to their origin?							R	R	R	R	S	R	R	R	R	R					S	R	R		S		R		R		R		1st: R 2nd: S				
	2.3.2 How do transients add magnetic flux to and remove it from the heliosphere?	S	S	S	S	S	S	R	R	R	R	S	S	R	R	R	R					S	R	R		S		R		R		R		1st: R 2nd: S				
	2.3.3 How and when do shocks form near the Sun?	R	R	R	R	S	S	S	S	R	R	R	R	S	S	R	R	S	S	S	S	S	R	S		S		R		R		S						

R: Required; S: Supportive Measurement; blank: not needed
 Note: With respect to Question 2.2.1, the working group was divided as to whether EUV imaging should be considered required or supportive.

Summery of Instrument Type Requirements

Table 3.1 Measurements required to achieve the HELEX science objectives			
2.1 Origin of the Solar Wind and HMF			
Energetic Particles	Solar Wind	Fields	Remote Sensing
	Suprathermal electrons Solar wind ions Solar wind electrons (S) Solar wind composition	DC B fields AC B fields Plasma waves (O)	Photospheric fields EUV spectroscopy EUV imaging Near-Sun coronagraphy Wide-angle coronagraphy X-ray imaging
2.2 Sources of Energetic Particles			
Energetic Particles	Solar Wind	Fields	Remote Sensing
Energetic particles EP composition EP charge states	Suprathermal electrons Solar wind ions Solar wind electrons Solar wind composition*	DC B fields AC B fields Remote radio waves (O + 1 S) Plasma waves (O)	EUV imaging Near-Sun coronagraphy Wide-angle coronagraphy X-ray imaging Gamma-ray** Neutron**
2.3 Transients			
Energetic Particles	Solar Wind	Fields	Remote Sensing
Energetic particles EP composition	Suprathermal electrons Solar wind ions Solar wind electrons Solar wind composition	DC B fields Remote radio waves	Photospheric fields EUV imaging Near-Sun coronagraphy Wide-angle coronagraphy X-ray imaging**

HELEX Program Implementation

- JSTD T Report released October 2007
- ESA and separate NASA SoLO instrument AO Fall 2007

- Solar Orbiter Launch May 2015
- Sentinels Launch Mar 2017

- Primary joint operations Oct 2018 – Mar 2020

- SoLO at 34° solar latitude Mar 2025