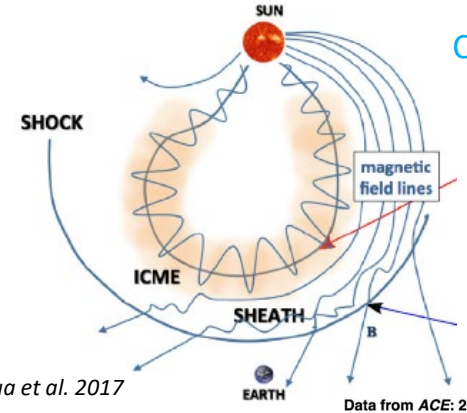
The Solar Wind Plasma Sensor (SWiPS) on the SWFO-L1 Mission

Presented by: Robert W. Ebert on behalf of the SWiPS Team

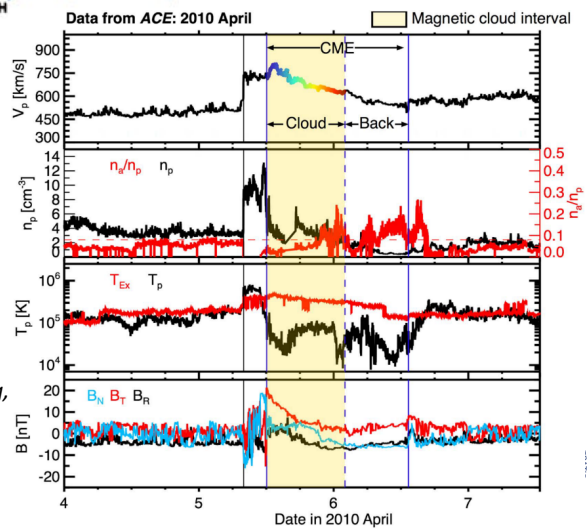
SWiPS Science Objectives

- The SWiPS measures solar wind ions, the super-sonic flow of hot plasma from the Sun, at 1 AU.
- The measurements are used to characterize Space Weather causing events such as:
  - Coronal mass ejections (CMEs).
  - Interplanetary (IP) shocks.
  - Corotating interaction regions (CIRs).
  - High-speed flows associated with coronal holes.
- SWiPS provides early warning of changes which affect the geomagnetic environment.
- Solar wind ion velocity, density, temperature, & dynamic pressure are provided every minute.

CMEs and IP Shocks



Kilpua et al. 2017



Deforest, de Koning, & Elliott, 2017

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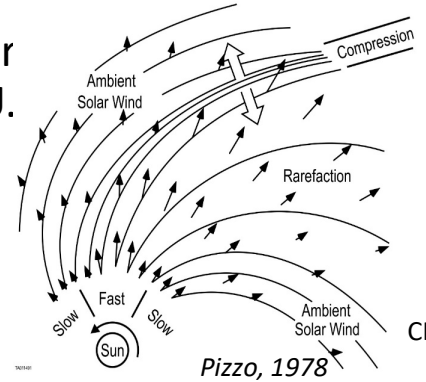
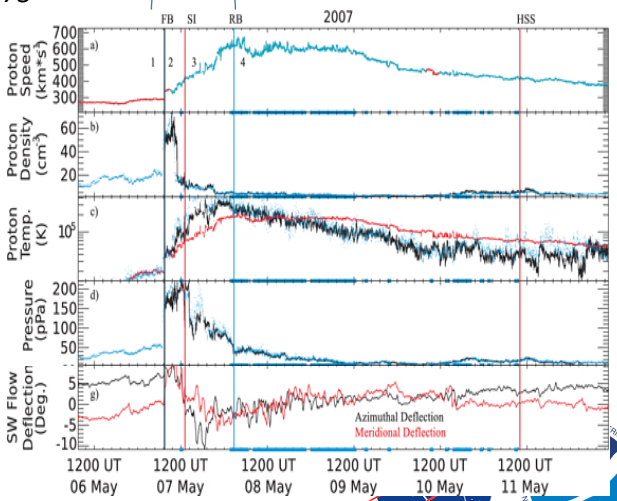
Corotating Interaction Region



Pizzo, 1978

CIR Compression



Broiles et al. 2013

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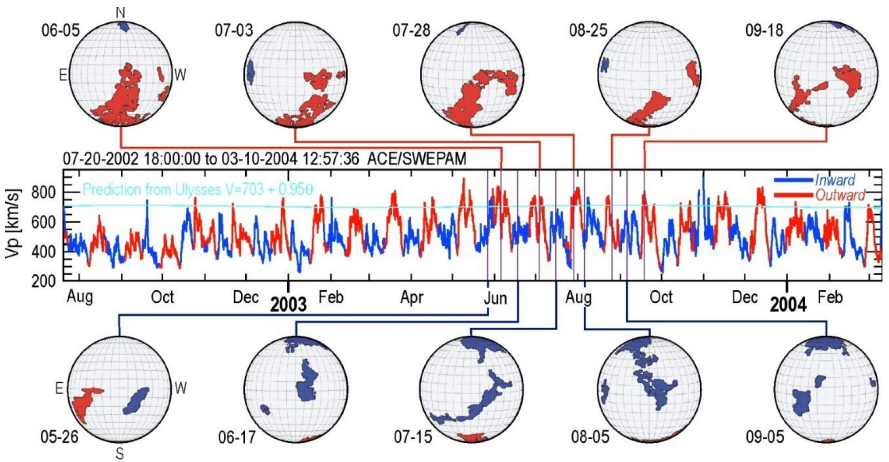
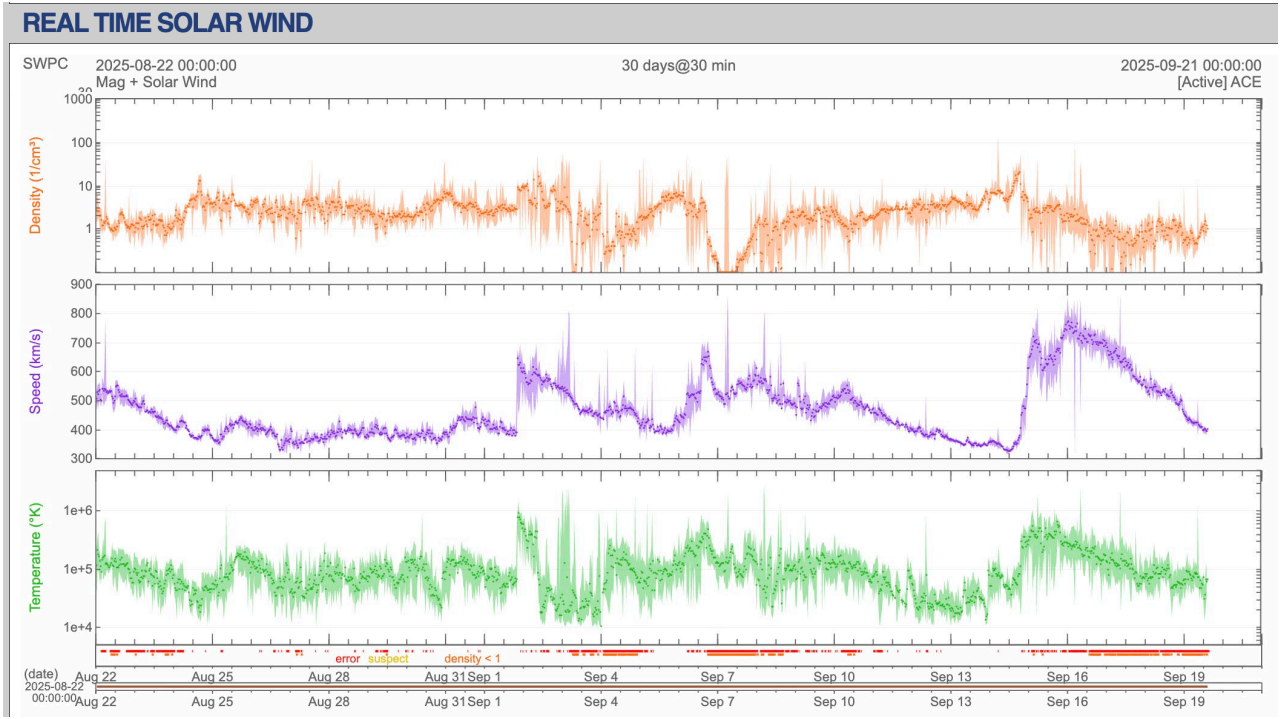
High-speed Flows from Coronal Holes



Elliott et al. 2012

SWiPS Space Weather Applications

- SWiPS measurements will provide
  - real-time identification of Space Weather events that can adversely impact the Earth.
  - real-time inputs for Space Weather prediction models.



Density

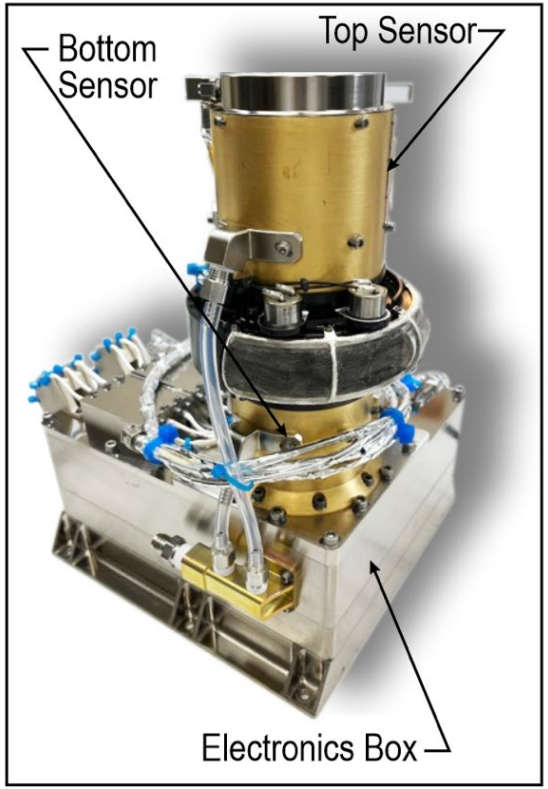
Speed

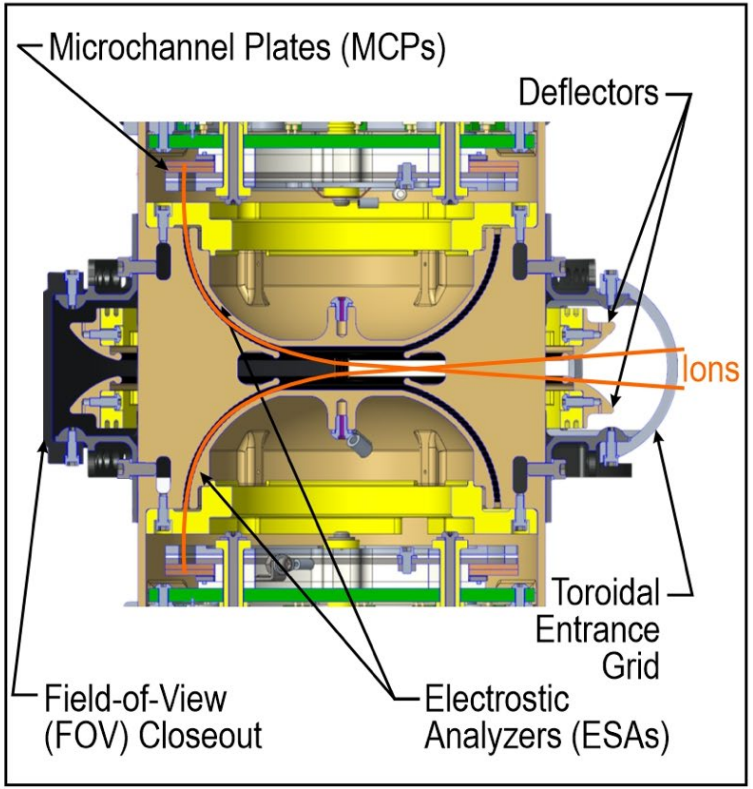
Temperature

30 days of real-time solar wind data from NOAA/SWPC

SWiPS will provide similar data for NOAA/SWPC starting in 2026

SWiPS Instrument Design



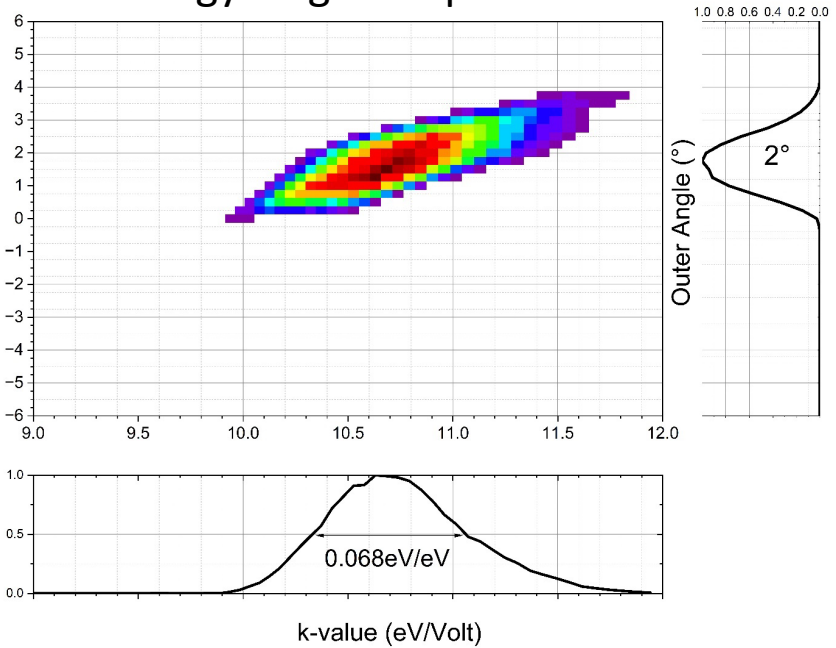


- Top and Bottom sensors can both measure ions
  - Only one sensor measures solar wind ions during nominal ops
- ESA based sensors with broad energy/charge range
- Out-of-ecliptic FOV via electrostatic deflection
- Selected redundancy: ESAs, detectors, and front-end electronics
- Cross-cal between sensors is possible

SWiPS Instrument Key Parameters

Instrument Key Parameters	Measured Value
Energy range	0.17 - 33 keV/q (ions) (128 discrete steps)
Energy resolution, ΔE/E (FWHM)	0.07 eV/eV
Time Resolution	60 s
Field-of-view	90° (azimuth) 45° (elevation)
Azimuth Angular Resolution	4 – 5° (< ±25°) 9 – 10° (> ±25°)
Elevation Angular Resolution	2 - 3° (FWHM)
Analyzer Constant (k)	10.7 eV/V
Geometric Factor (per anode)	3 – 7 x 10^{-6} cm^2 sr eV/eV

Energy-Angle Response



Instrument parameters obtained via ground calibration

SWiPS Performance Requirements

Measurement	Requirement	SWiPS Compliance
Data Acquisition	60 seconds	Complies
Ion Velocity Range	200 – 2500 km s^{-1}	Complies
Ion Velocity Accuracy	+/- 10%	Complies w/ waiver
Ion Density Range	0.1 – 150 cm^{-3}	Complies
Ion Density Accuracy	+/- 10%	Complies w/ waiver
Ion Temperature Range	40,000 – 2,000,000 K	Complies
Ion Temperature Accuracy	+/- 10%	Complies w/ waiver
SW Ion Dynamic Pressure	1 - 100 nPa	Complies

Forward modeling of instrument response used to predict instrument performance

SWiPS Data Products

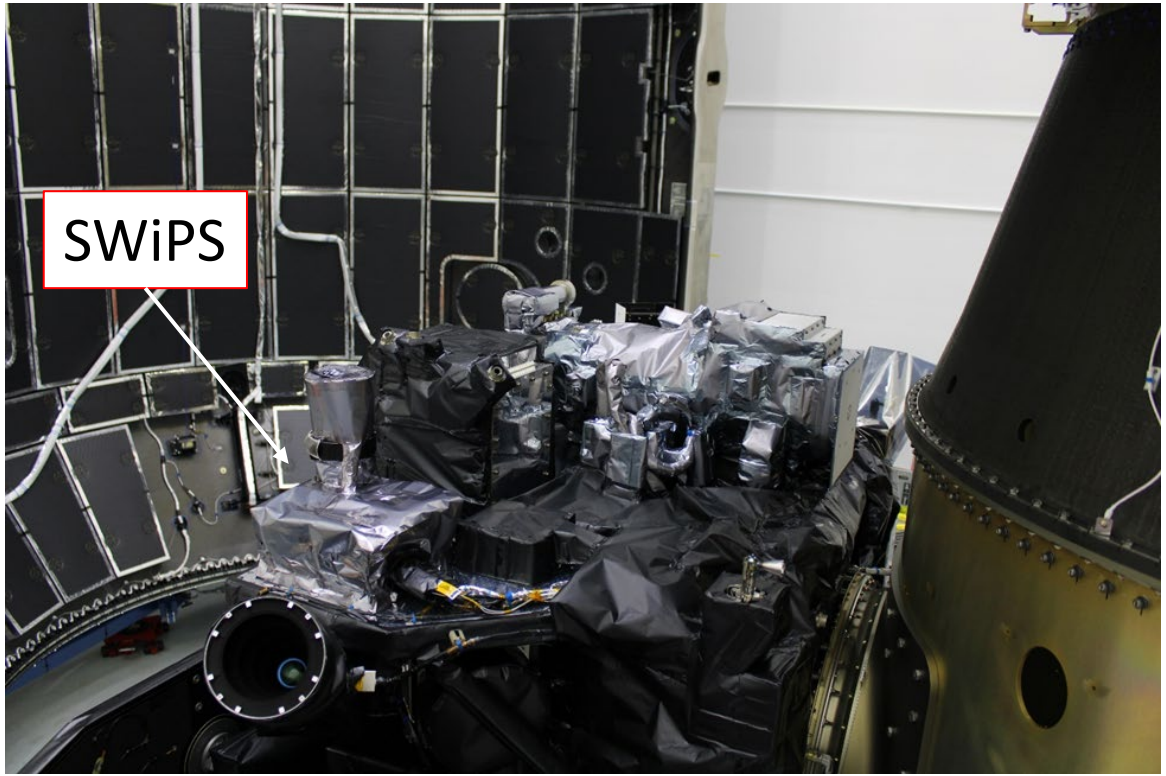
Level	Description	Target Use
0b	CCSDS packets unpacked into complete energy angle sweeps	• Real-time latency NOAA internal • Common starting point for SWPC and NCEI pipelines
1a	Full resolution science data count rates at full energy, azimuth, and elevation	• Real-time latency, NOAA internal • Retrospective, external; NCEI processing
1b	3-D Phase Space Distribution as a function of energy, elevation, and azimuth	• Real-time latency, SWPC internal • Retrospective, external, base product for science users wanting to apply their own calibration
2	Full temporal resolution moments of protons (p) and alphas (a); n_p, T_p, $\mathbf{V}_p$, n_a, $\mathbf{V}_a$, and Total Dynamic pressure ($n_p m_p V_p^2 + n_a m_a V_a^2$)	• Real-time SWPC data

SWiPS team has delivered code to NOAA for all data product levels

SWiPS Commissioning Timeline

Task Name	Duration	Start Date
Low Voltage Checkout	1 d	Mon 9/29/25
High Voltage Checkout	1 d	Wed 10/29/25
Full Science Checkout	1 d	Sat 11/1/25
In-Flight Calibration	1 d	Tue 11/4/25
Thruster Interaction Test - 1	1 d	Sun 11/9/25
Thruster Interaction Test - 2	1 d	Sat 11/15/25
Thruster Interaction Test - 3	1 d	Fri 11/21/25
Thruster Interaction Test - 4	1 d	Thu 11/27/25
Thruster Interaction Test - 5	1 d	Wed 12/3/25

Summary



The SWiPS instrument and team are ready for launch!