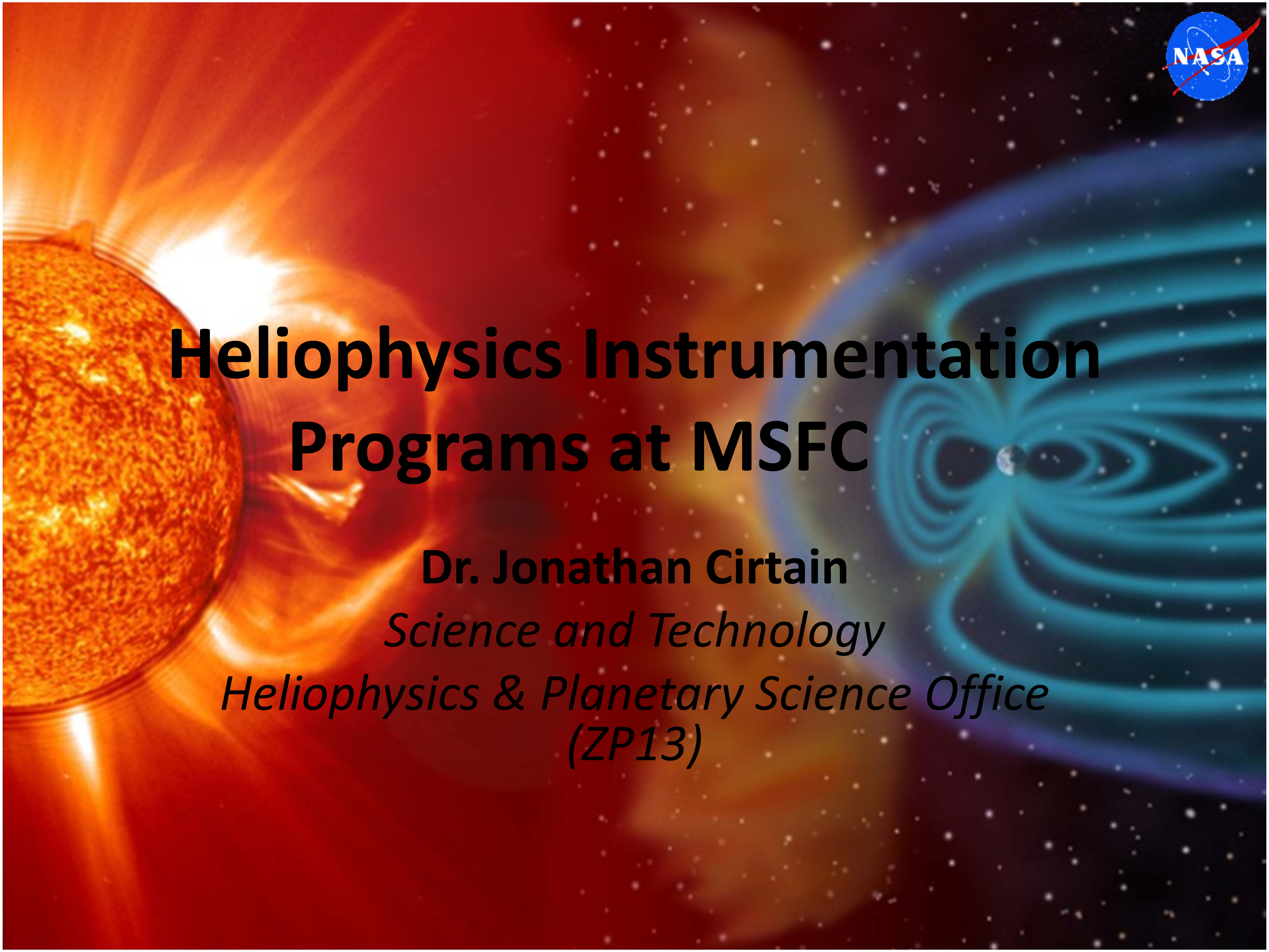


Heliophysics Instrumentation Programs at MSFC

Dr. Jonathan Cirtain

Science and Technology

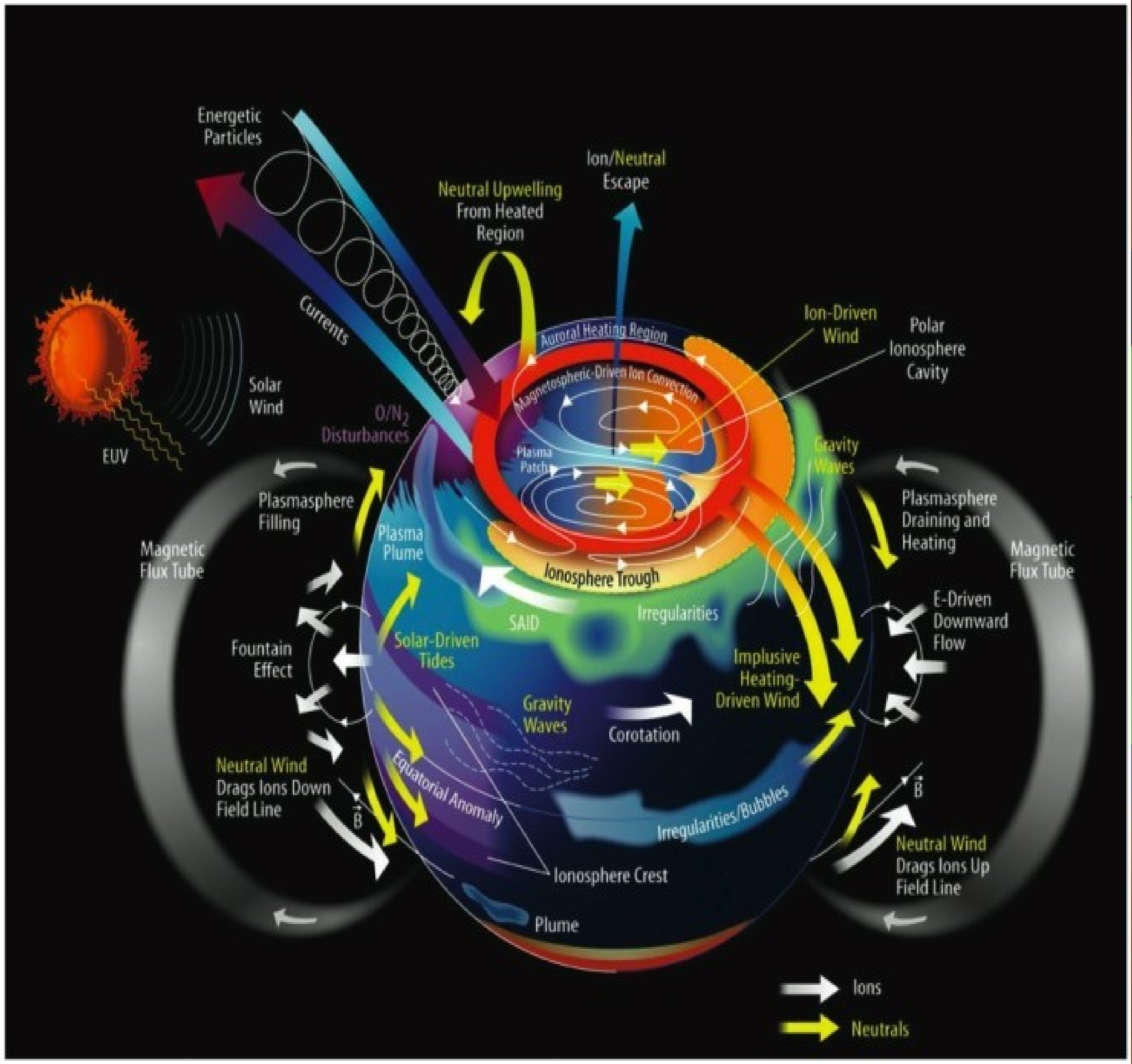
Heliophysics & Planetary Science Office (ZP13)

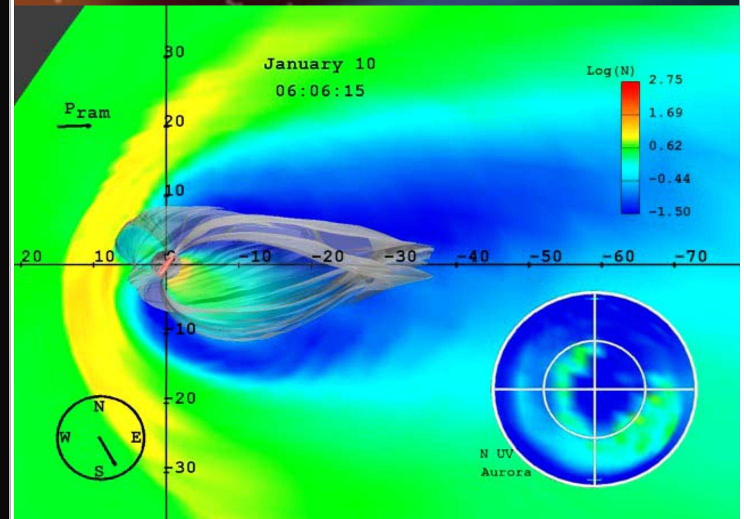
Overview

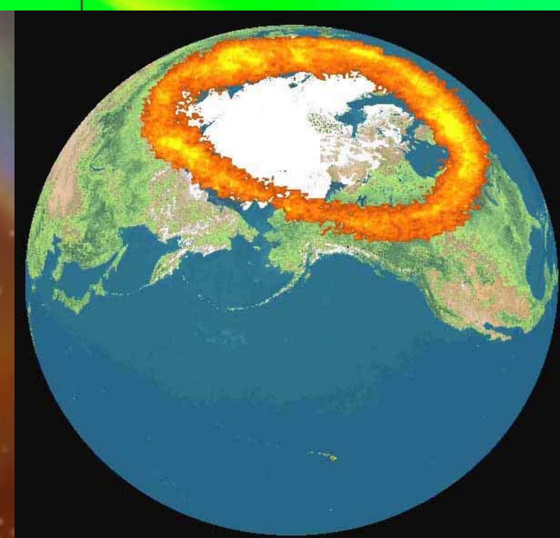
- Introduction to the Heliophysics
- The Heliophysics System Observatory
- Solar Probe Plus – SWEAP
- The Solar Ultraviolet Magnetograph Instrument
- The High-resolution Coronal Imager

The Solar Influence on the Heliosphere

Space Weather's Terrestrial Influence
(an example)



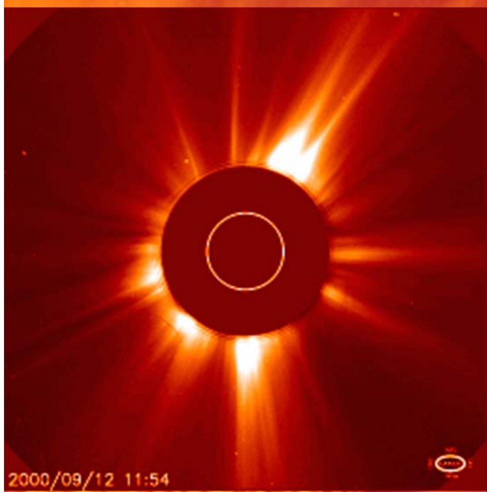


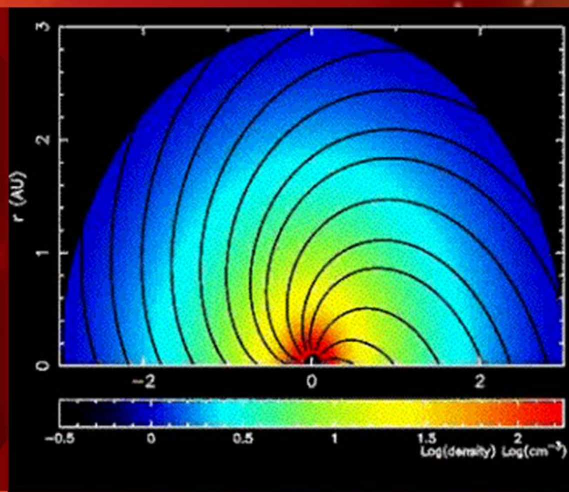


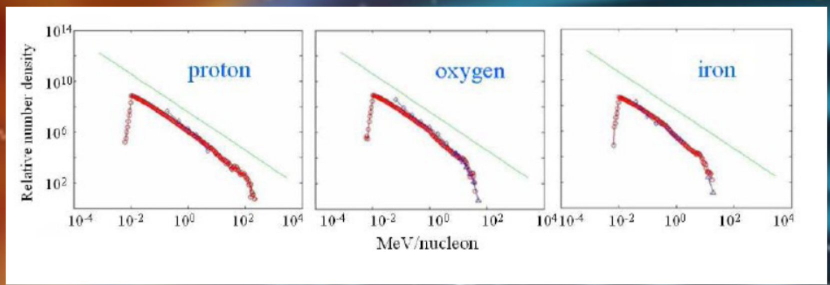
Space weather interacts with Earth's B-Field and can dramatically affect the Earth

Forecasting Space weather

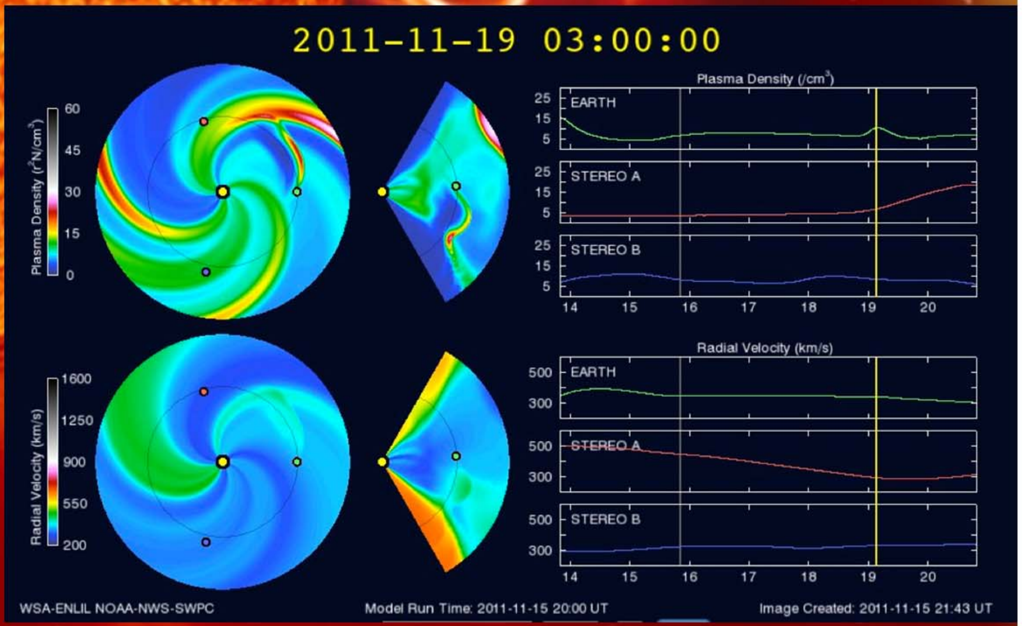
- •semi-empirical near-Sun module that approximates the outflow at the base of the solar wind
- •sophisticated 3-D magnetohydrodynamic numerical model that simulates the resulting flow evolution out to Earth.

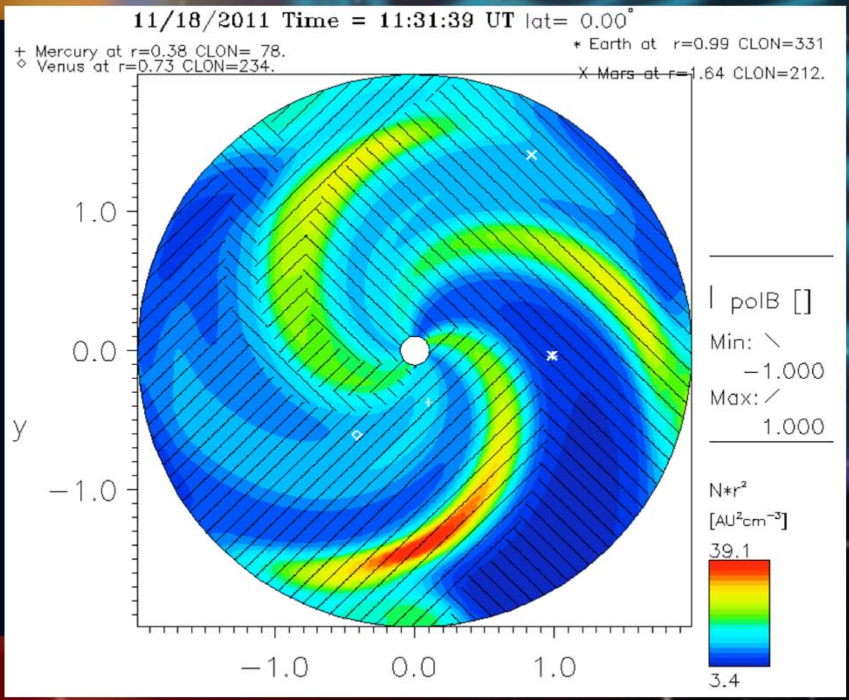






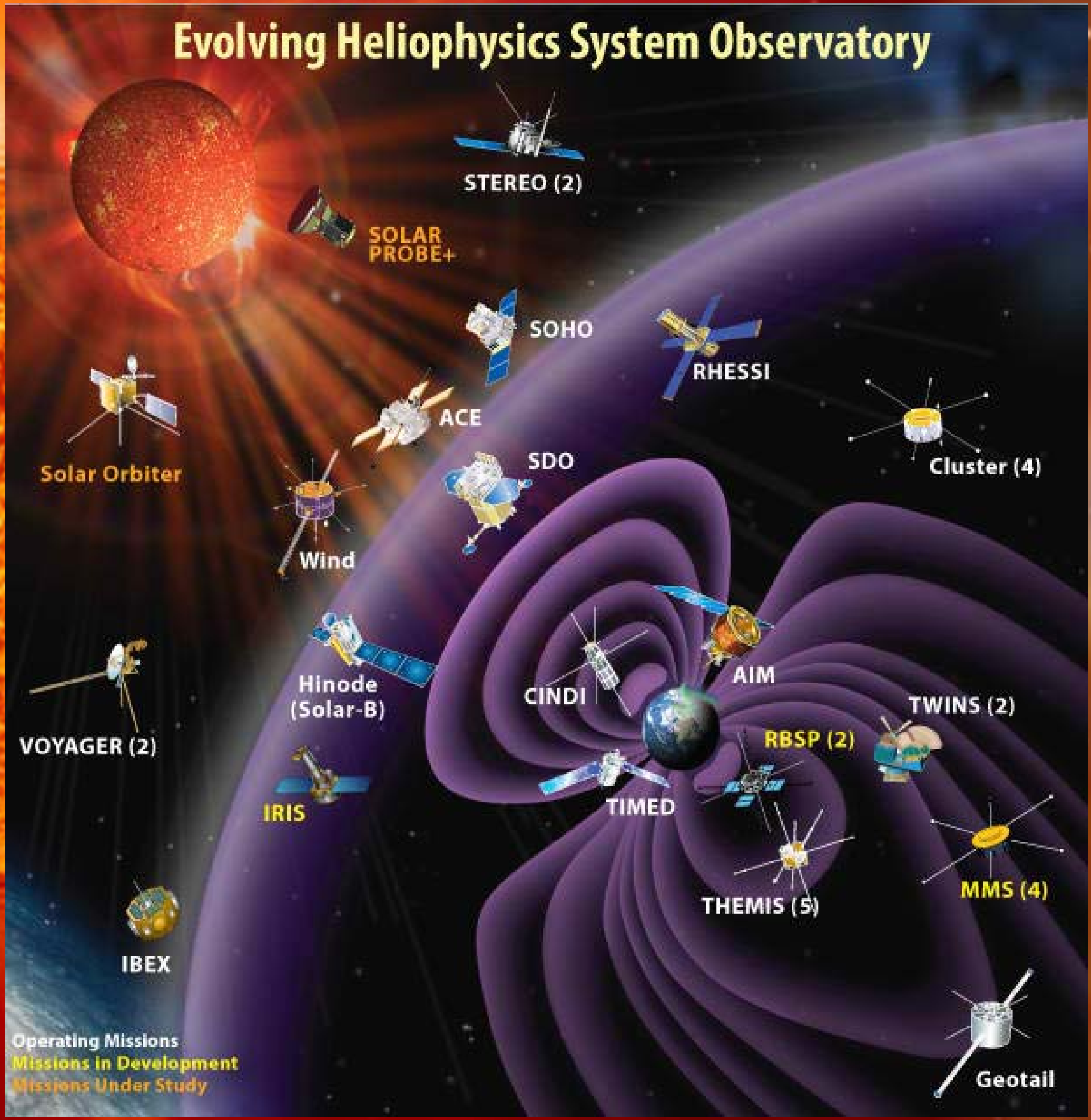
Courtesy: Dr. G. Zank UAH-CSPAR





Courtesy NOAA: http://www.swpc.noaa.gov/

The Heliophysics System Observatory



- 17 missions in operation
- 5 in Phase B-D
- 2 in Phase A
- Study the solar interior, photosphere and corona, space weather, the Geosphere and out to the boundary of the Heliosphere

Note: These numbers do not reflect the contributions/assests of Sounding rockets, balloons, NOAA, DoD and ground based observatories

Solar Probe Plus

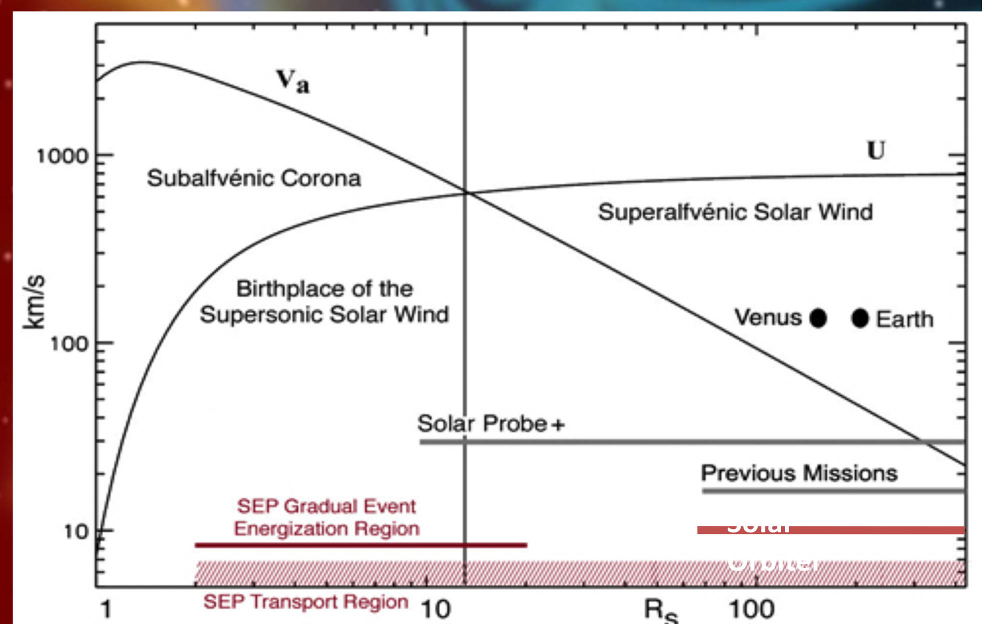
Overview

Using in-situ measurements made closer to the Sun than by any previous spacecraft, SPP will determine the mechanisms that produce the fast and slow solar winds, coronal heating, and the transport of energetic particles.

Solar Probe Plus will fly within 9.5 solar radii (Rs) of the Sun, having "walked in" from 35 Rs over 24 orbits.

Sponsor: NASA SMD/Heliophysics Div

- Program Office – GSFC/LWS
- Project Scientist - APL
- Project Management - APL
- S/C Development & Operations – APL
- Science payload selected by AO
  - Smithsonian Astrophysical Observatory
  - UC Berkeley
  - NRL
  - SwRI



Solar Probe Plus

Launch

- Dates: Jul 30 – Aug 19, 2018 (21 days)
- Max. Launch C3: 159 km^2/s^2

Trajectory Design

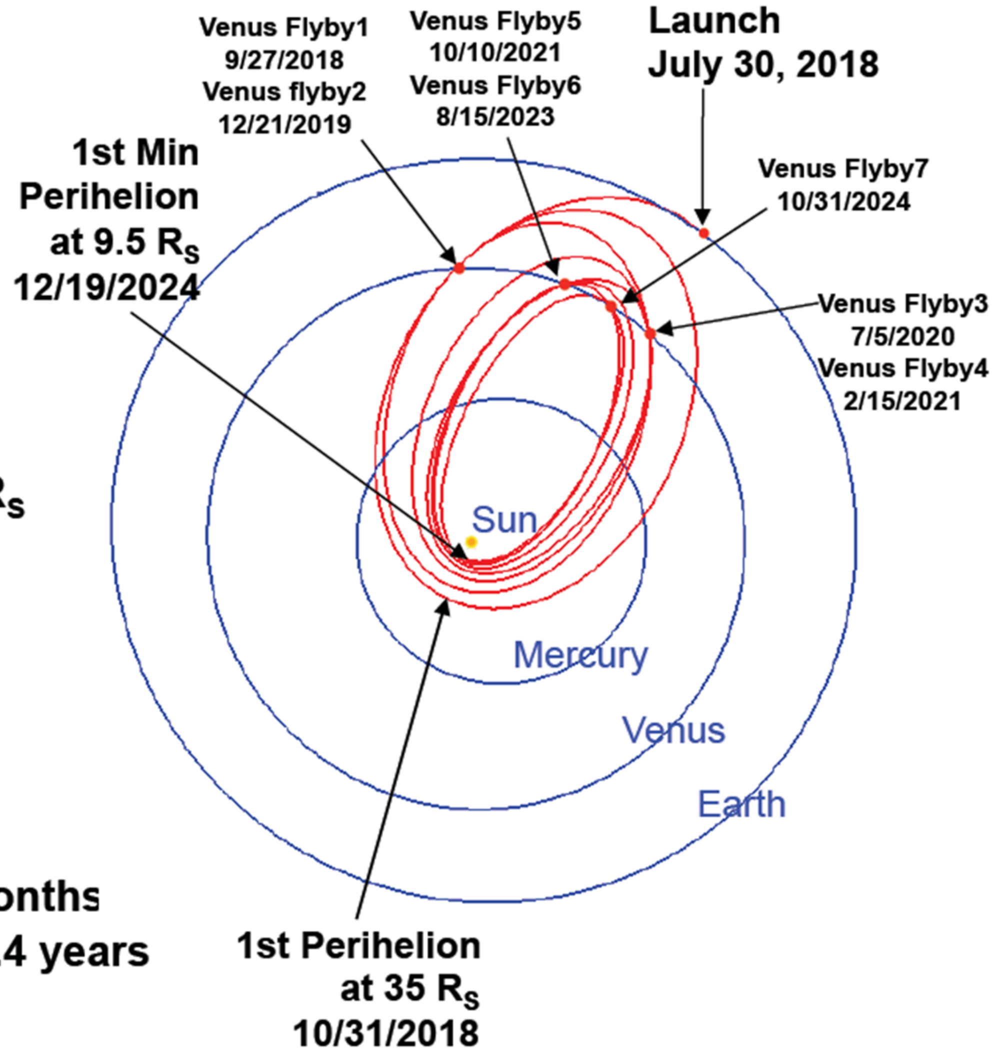
- 7 Venus gravity assist (V^7GA) flybys
- No deep space maneuver
- 24 perihelion passes
- Aphelion < 1.018 AU
- Perihelion gradually decreases to 9.5 R_S

Final Solar Orbit

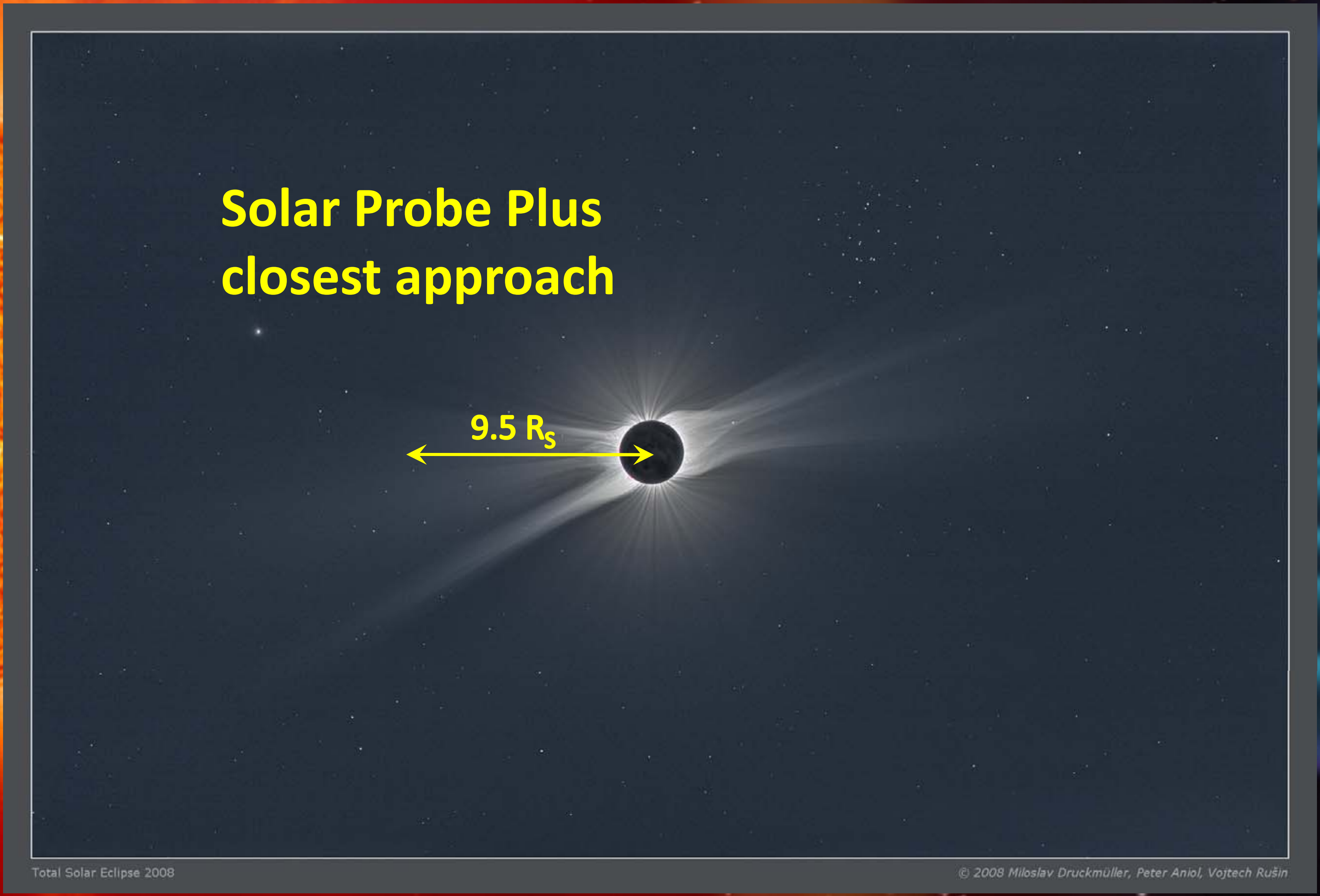
- Perihelion: 9.5 R_S
- Aphelion: 0.73 AU
- Inclination: 3.4 deg from ecliptic
- Orbit period: 88 days

Timeline

- Launch to 1st perihelion (0.16 AU): 3 months
- Launch to 1st min perihelion (9.5 R_S): 6.4 years
- Mission duration: 6.9 years

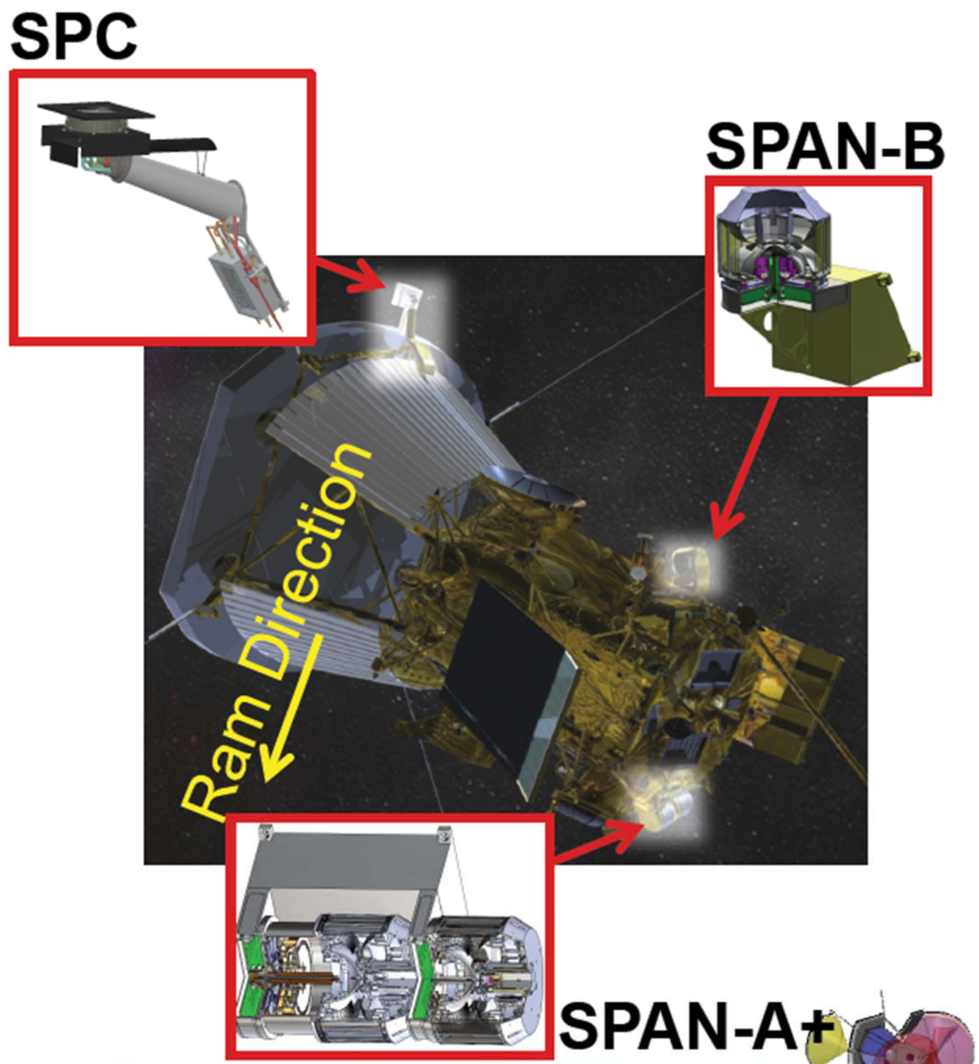


Solar Probe Plus



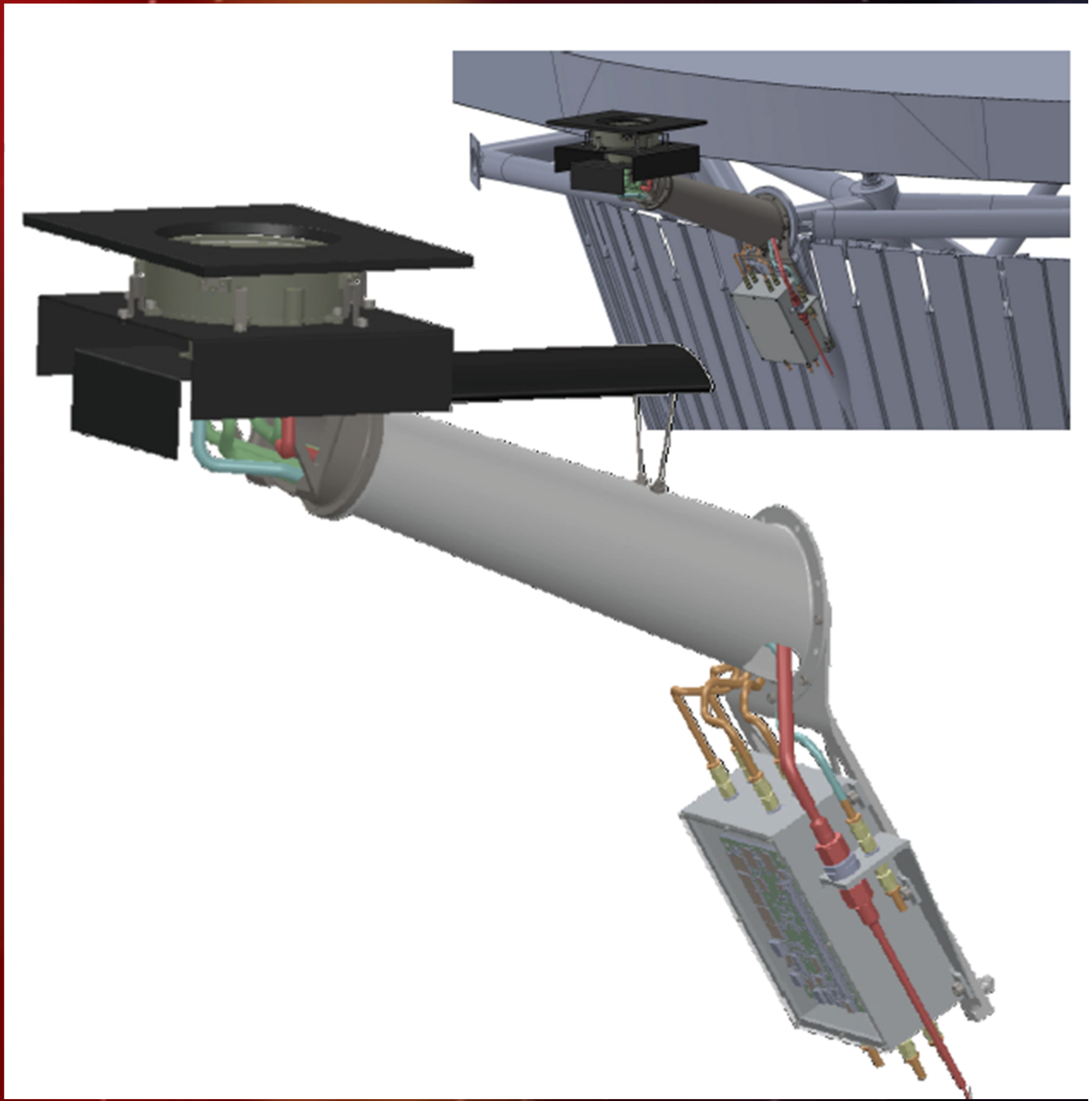
The Solar Wind Electrons Alphas and Protons Suite on SPP

- SWEAP Consists of Two Instruments (SPC & SPAN) and an Electronics Module (SWEM)
- SPC – Solar Probe Cup
  - Sun-viewing Faraday Cup
- SPAN – Solar Probe Analyzers
  - SPAN-A+, ion and electron electrostatic analyzers (ESAs) on ram-side of spacecraft bus
  - SPAN-B, electron ESA on anti-ram size of spacecraft bus
- SWEM – SWEAP Electronics Module (not shown)
  - Single electrical interface to SPP, distributes power, commands instruments, formats and buffers data products, interfaces with FIELDS



Solar Probe Cup (SPC) Design Description

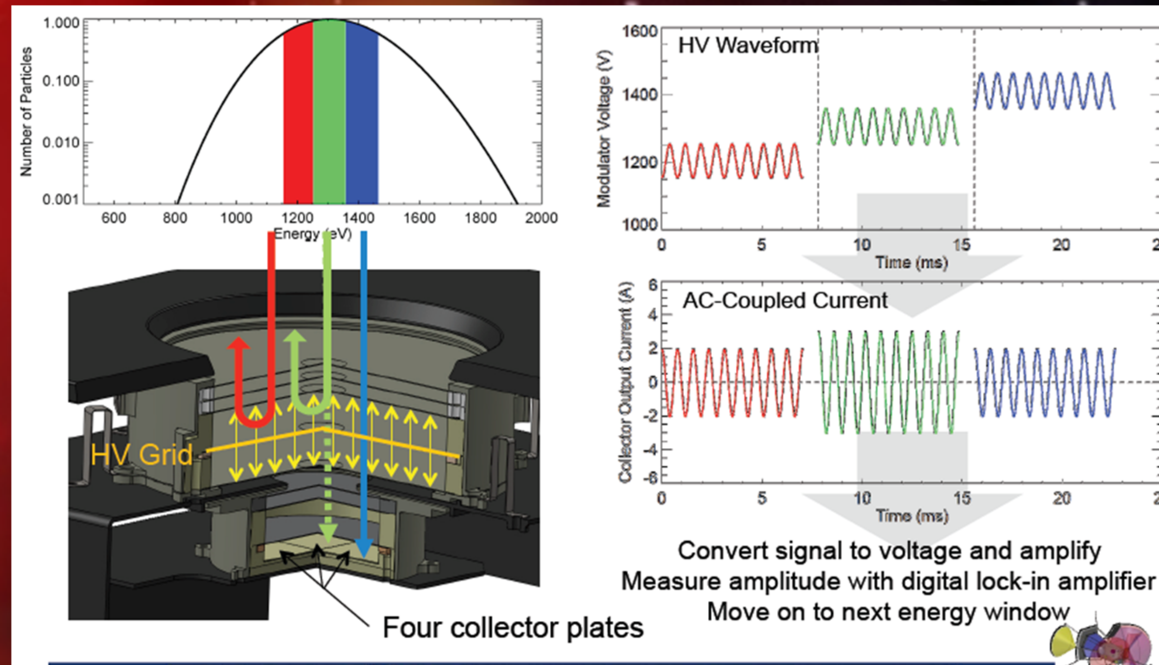
- SPC is a Faraday Cup that looks directly at Sun, measuring flows within 30 of radial
- SWEAP-provided strut interfaces SPC to SPP
- SPC has an independent thermal shield and radiator system
- SPC is effectively a vacuum tube without the glass
    - Metal grids (tungston or rhenium) at high voltages select particles
    - Collector plates record currents from ions and electrons
- Pre-amp amplifies currents and sends signal to SWEAP Electronics Module

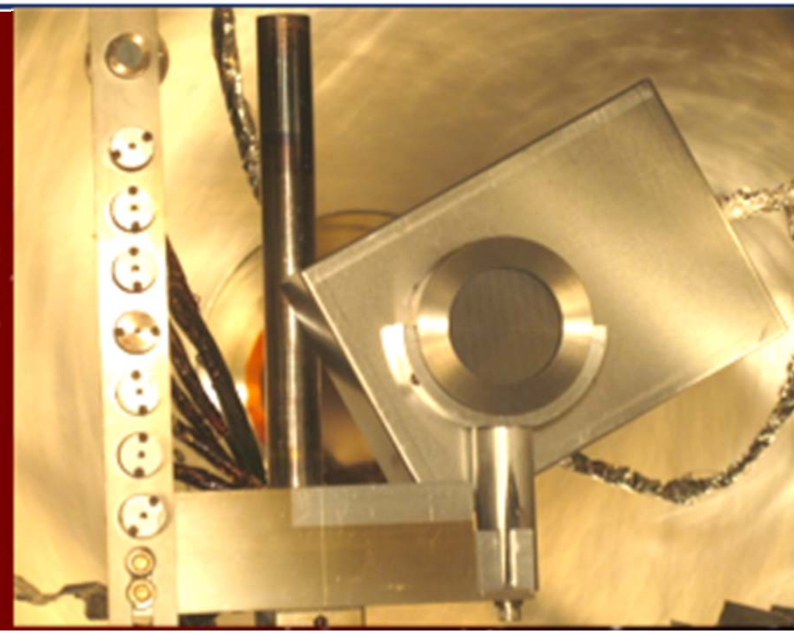


SPC Operations Concept

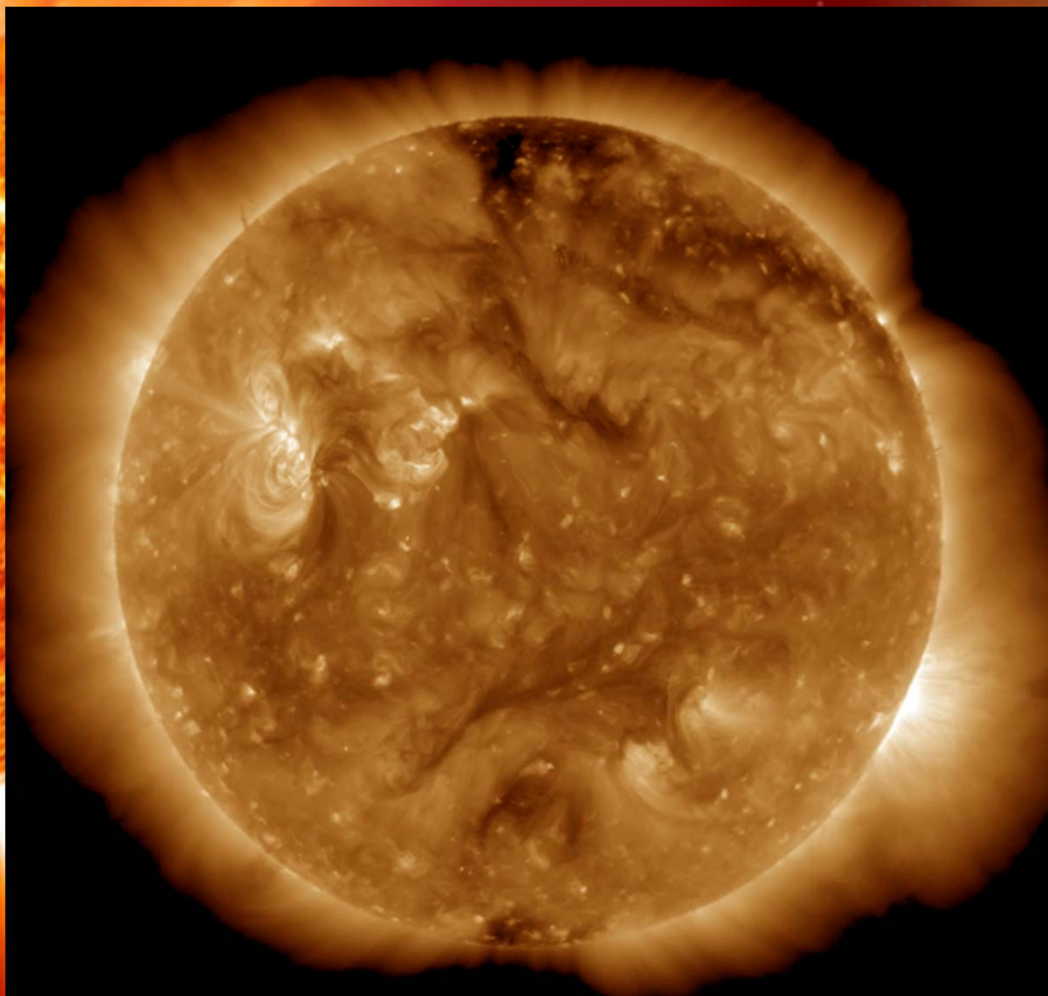
MSFC contributions:

- Testing and calibration of the Solar Probe Cup
- Technology development for the high temperature materials used for both the grids and the radiation/thermal shield
- Radiation analysis
- Post-launch data analysis
- Solar Wind and Heliosphere theory and modelling





The need for high resolution

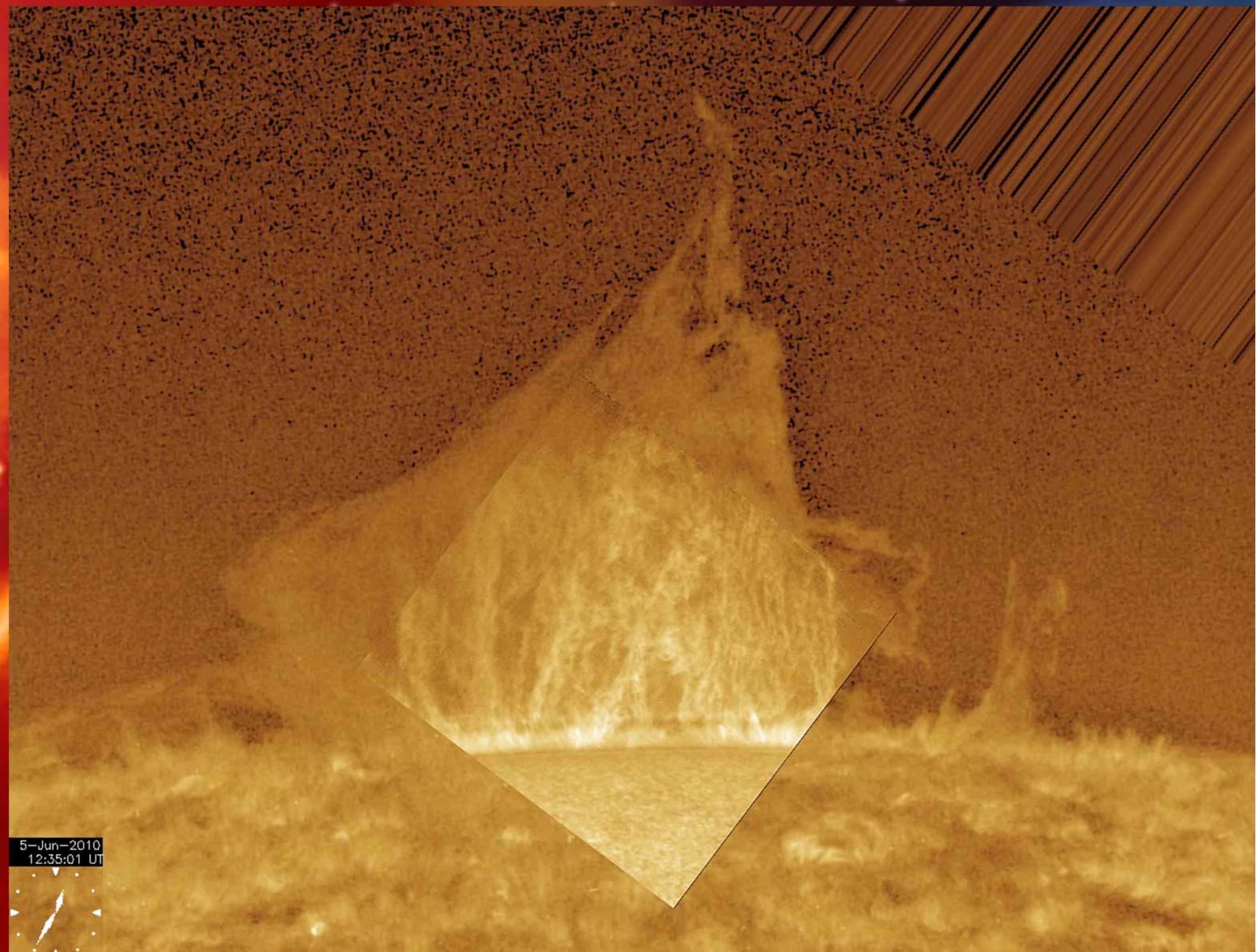


SDO Atmospheric Imaging Array (AIA) data captures the full sun in 8 channels

- 1 image in each channel every 20 seconds.
- Data collected 24/7
- Spatial resolution of ~1000km

The power of spatial resolution and context images

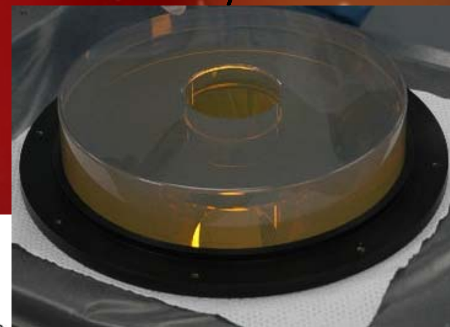
- The background images are from AIA (30.4 nm) and the foreground images are from *Hinode*/SOT (Ca II)
- AIA images are ~1000km resolution
- SOT images are ~150 km resolution
- Cadence is basically the same between the two instruments

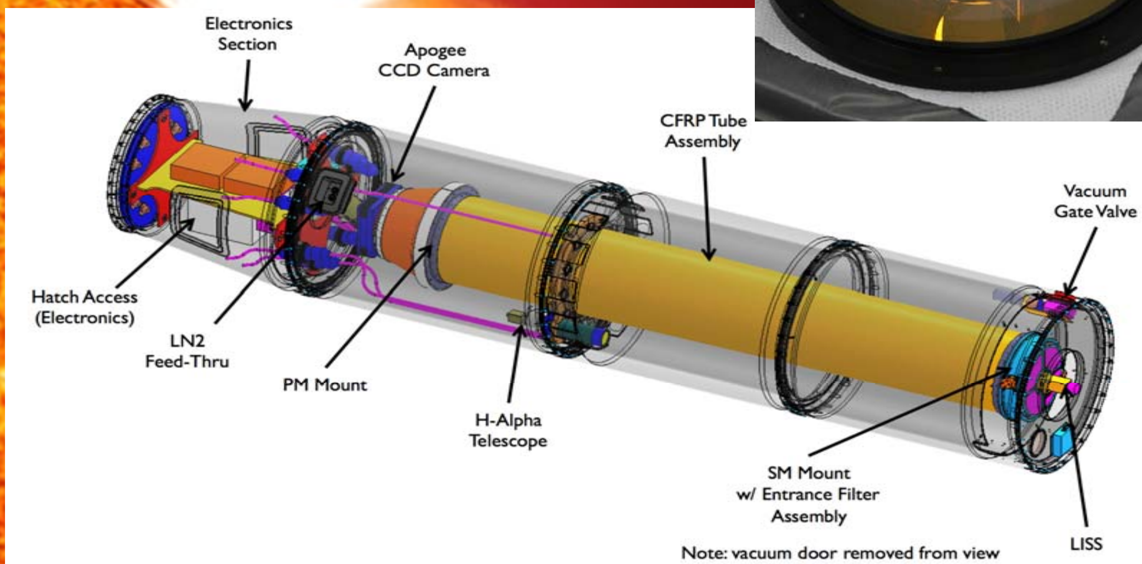


High resolution Coronal imager: Hi-C

- MSFC and Harvard-Smithsonian CfA partnership mission
- Mirrors fabricated by MSFC & UA-Huntsville
- At 150km spatial resolution, Hi-C is a 10x increase in resolution in X-ray imaging

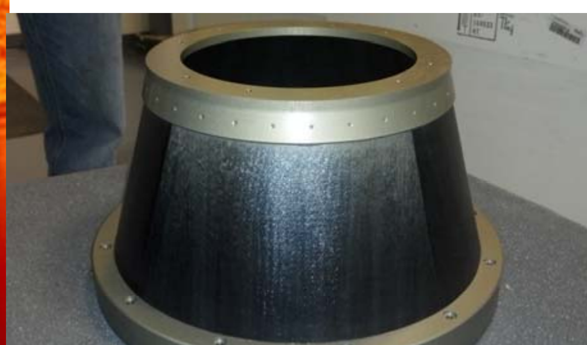
Primary Mirror





CCD (4Kx4K)

Camera system



H-alpha telescope

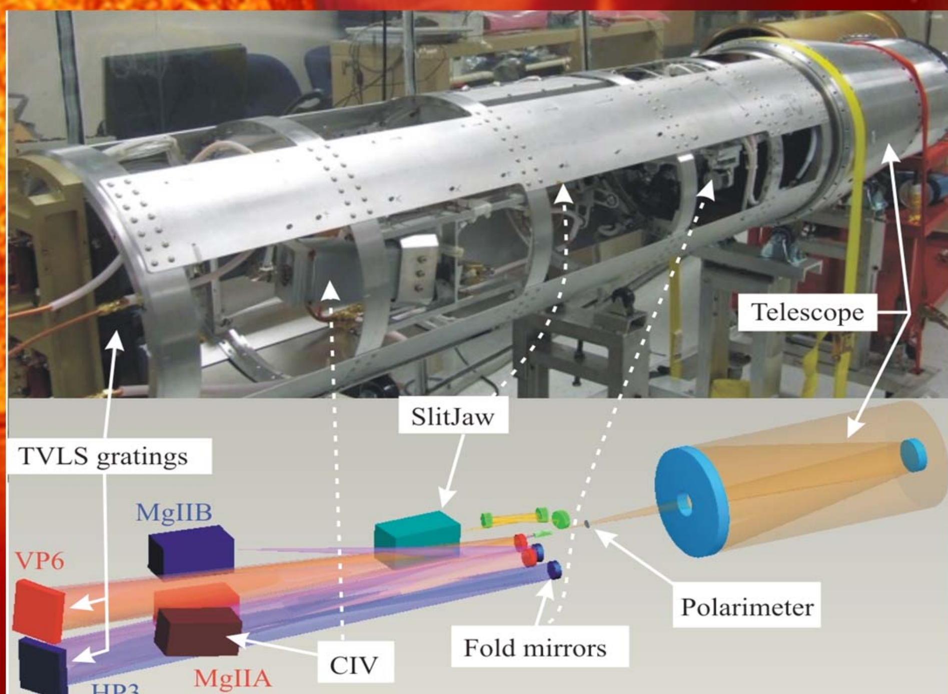
International Partners: University of Central Lancashire (U.K.); Lebedev Polytechnic Institute (Russian Federation)

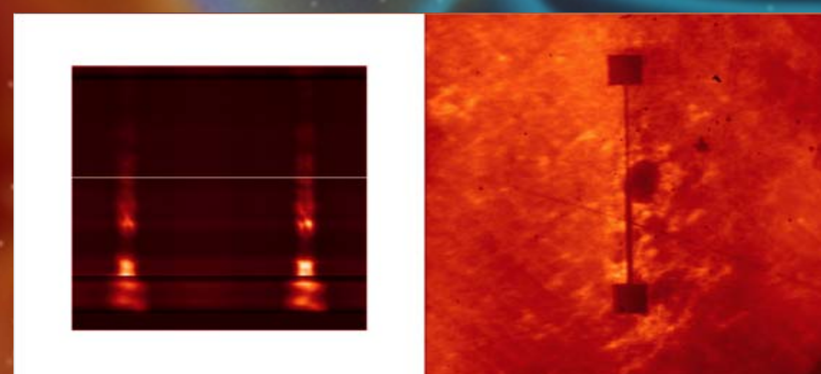
Solar Ultra-violet Magnetograph Investigation: SUMI

- Initial Launch 30 July 2010

<u>Technology Goals Addressed</u>

- ***UV dual-beam*** Spectro-polarimetry
- Torodial Variable Line-spaced gratings
- Dielectric High Reflectivity coatings to maximize UV through put
- "Cold mirror" thermal design to reject near-UV and visible radiation





Domestic Partners: NSO, GSFC/NASA, LMSAL, NCAR

International Partners: University of Oslo: Norway

The Future

Heliophysics at MSFC

- Sounding rocket Instrument test bed
  - Develop instrumentation to measure the solar vector magnetic field in the chromosphere (CLASP)
  - Develop instrumentation to study the energy release mechanisms in solar flares (MaGIXS)
- Support new missions: SPP, MMS, RBSP, Solar Orbiter, Solar-C and Explorers
- Develop physics-based ***data-driven*** models of the Heliosphere from the Solar surface to within the Earth's magnetosphere and ionosphere
- Heliospheric Space Weather Prediction/Forecasting for human space flight missions