

Testing the Solar Probe Cup, An Instrument Designed to Touch the Sun

Phyllis Whittlesey¹, Anthony Case², Justin Kasper³, Kenneth Wright¹, Benjamin Cramer³, Jonathan Cirtain⁴, Jay Bookbinder², Kelly Korreck², Michael Stevens², Todd Schneider², and Jason Vaughn⁴.

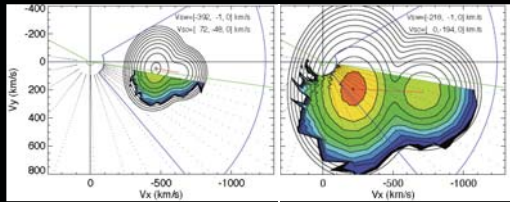
¹: University of Alabama in Huntsville ²: Smithsonian Astrophysical Observatory ³: University of Michigan ⁴: NASA Marshall Space Flight Center

Abstract: Solar Probe Plus will be the first, fastest, and closest mission to the Sun, providing the first direct sampling of the solar wind and the first direct sampling of the traditional Faraday Cup design and materials for immersion in this high temperature environment. Sending an instrument of this type into a never-seen particle environment requires extensive characterization prior to launch to establish sufficient measurement accuracy and instrument response. To reach this end, a number of tests are created for allowing SPC to see ranges of appropriate ion energies and electrons, as well as a facility that reproduces solar photon spectra and fluxes for this mission. Having already characterized the noise floor, we recently completed a round of particle testing to see if the deviations in Faraday Cup design fundamentally change the operation of the instrument. Results and implications from these tests will be presented, as well as performance comparisons to cousin instruments such as those on the WIND space

of the Alfvénic corona. The Solar Probe Cup (SPC) is a unique re-imagining of this type into a never-seen particle environment requires extensive characterization prior to launch to establish sufficient measurement accuracy and instrument response. To reach this end, a number of tests are created for allowing SPC to see ranges of appropriate ion energies and electrons, as well as a facility that reproduces solar photon spectra and fluxes for this mission. Having already characterized the noise floor, we recently completed a round of particle testing to see if the deviations in Faraday Cup design fundamentally change the operation of the instrument. Results and implications from these tests will be presented, as well as performance comparisons to cousin instruments such as those on the WIND space

What is SPC?

The Solar Probe Cup (SPC) and the Solar Probe Analyzers (SPAN) form the plasma instruments in the Solar Wind Electrons Alphas and Protons suite on Solar Probe Plus (SPP). The spatial resolution of these instruments operating together is illustrated in the model below:

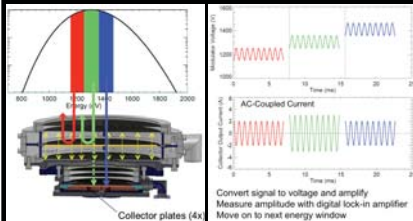


At $R = 38.4R_{\odot}$ Green – SPAN FOV Blue – SPC FOV

SPC is a Faraday Cup

□ A Faraday cup operates by:

- Using a voltage biased, variable-value modulating grid which selectively prevents or permits portions of the plasma population with E/q greater than the modulating bias voltage.
- Collecting the charged particles on rear collector plates, obtaining a current, often in picoamperes.

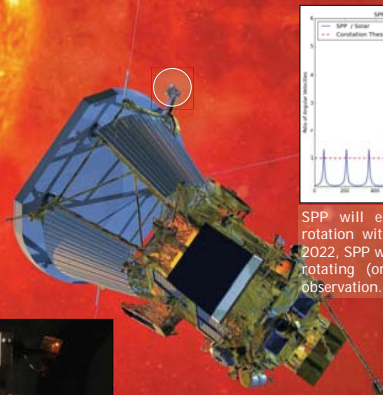


Left: The modulation procedure in use on SPC. Each color represents a different energy 'window'. The size, or amplitude of the waveform, increases as SPC scans for higher energy values in the environment.

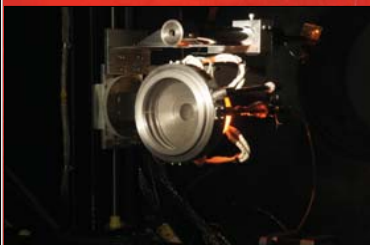
Convert signal to voltage and amplify. Measure amplitude with digital lock-in amplifier. Move on to next energy window.

To the Edge of the Corona

SPC is mounted on a strut peering around SPP's heat shield, where direct exposure to the Sun raises temperatures to an excess of 1500C.



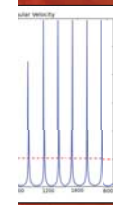
SPP will enter orbit with 2022. SPP will be rotating (or co-rotating) with the Sun.



The SPC in the SWF: SPC's collector plates are brought to temperature with contact heaters.



The Solar Wind Facility (SWF) exposes SPC to a range of ion and electron distribution energies.



periods of co-rotation with the Sun. By the end of 2022, SPP will be rotating (or co-rotating) with the Sun.



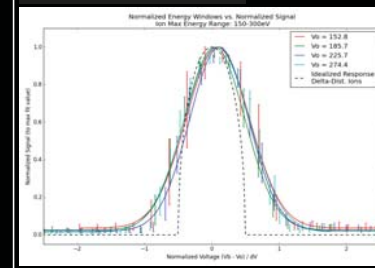
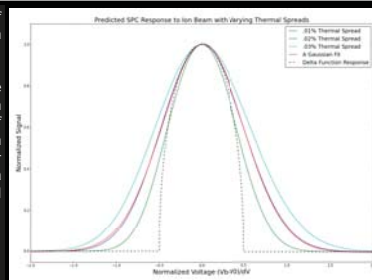
The Solar Simulator (SES) at NASA's Marshall Space Flight Center simulates the solar photon and thermal environment.

Where Are We Now?

Results from an analytic model of SPC's response to incident ion populations.

A Gaussian fit to SPC's response for a 0.02% thermal spread in ion energy and expected response of SPC to a mono-energetic ion population are shown for comparison. The 'wings' are a measure of population thermal spread.

V_b = Ion Energy
 V_0 = Window Center Voltage
 dV = Window Width



SPC measures a cold ion population over a range of energies. (July 2014) Abbreviations are as above.

Error bars are centered about points of measurement, with solid lines as Gaussian fits.

Using $x = (V_b - V_0) / dV$ scales signal in all energy windows to a normalized value, allowing for direct comparison between energy windows of different amplitude as well as between model & experimental results.

Comparison to Past Faraday Cups

	VOYAGER	WIND	SPP
Ion (p^+ , α) energy range	10eV – 5.950keV	150eV – 8keV	150eV - 8keV
Electron energy range	10eV – 5.950keV	N/A	100eV - 2keV
Operating frequency	400Hz	200Hz	1171.875Hz
Modulating Waveform	square	square	sine

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