Paper Number: SH21B-0410

The Plasma and SupraThermal Ion Composition (PLASTIC) Instrument: Final Diagnostic Development Phase for the STEREO Mission

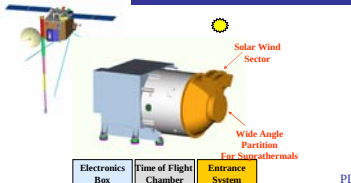
L. M. Blush[1], P. Bochsler[1], H. Daoudi[1], A. Galvin[2], R. Karrer[1], L. Kistler[2], B. Klecker[3], E. Möbius[2], A. Opitz[1], M. Popecki[2], B. Thompson[5], R. F. Wimmer-Schweingruber[4], P. Wurz[1]

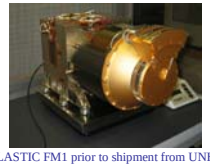
[1] *Physikalisches Institut, University of Bern, Switzerland*
[2] *University of New Hampshire, Durham, NH, USA*
[3] *Max-Planck Institut für Extraterrestrische Physik, Garching, Germany*
[4] *Institut für Experimentelle und Angewandte Physik, University of Kiel, Germany*
[5] *Goddard Space Flight Center, Greenbelt, MD, USA*

Abstract

The PLAsma and SupraThermal Ion Composition (PLASTIC) instrument project is entering the final phases of instrument development prior to integration with the Solar Terrestrial Relations Observatory (STEREO) spacecraft in early 2005. The STEREO mission will provide a unique opportunity to investigate the 3-dimensional structure of the heliosphere, with particular focus on the origin, evolution, and propagation of Coronal Mass Ejections (CMEs). The mission also seeks to determine the sites and mechanisms of energetic particle acceleration as well as develop a 3-D time-dependent understanding of the ambient solar wind properties. As one of four STEREO instrument packages coordinating remote sensing and *in situ* measurements, the PLASTIC instruments will diagnose properties of the solar wind and suprathermal protons, alphas, and heavy ions. PLASTIC will determine bulk solar wind plasma parameters (density, velocity, temperature, temperature anisotropy, and alpha/proton ratio) and the distribution functions of major heavy solar wind ions in the energy per charge range 0.25-100keV/e. A full characterization of the solar wind and suprathermal ions will be achieved with a system that measures ion energy per charge (E/q), ion velocity distribution (v), and ion energy (E). Two identical PLASTIC instruments located on the separate spacecraft will provide *in situ* plasma measurements in order to study physical processes low in the corona and in the inner heliosphere. Elemental and charge state abundances provide tracers of the ambient coronal plasma, fractionated populations from coronal and heliospheric events, and local source populations of energetic particle acceleration. In this presentation, the PLASTIC operation principles and aims will be presented along with a review of development status and current instrument calibration results.

The STEREO/PLASTIC Instrument



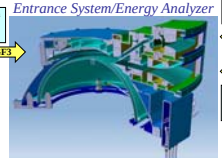


PLASTIC FM1 prior to shipment from UNH to University of Bern for detailed ion beam calibrations

PLASTIC Measurement Principle

Wide Angle Partition (Suprathermal Ions) **WAP**

Entrance System/Energy Analyzer

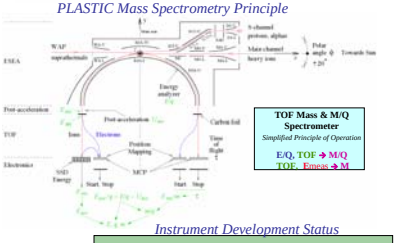


Solar Wind Sector (H, He) **SWS S-Channel**

GF1 OR GF2

Solar Wind Sector (Z>2 Composition) **SWS Main Channel**

PLASTIC Mass Spectrometry Principle



TOF Mass & M/Q Spectrometer
Simplified Principle of Operation
E/Q, TOF → M/Q
TOF, Emeas → M

Instrument Development Status

- Sub system development and testing completed
- Flight Model 1 (FM1) vibration tests completed
- FM1 ion beam calibrations ongoing
- FM2 under construction, testing proceeds January 2005
- Delivery of Flight Models for spacecraft integration February 2005
- STEREO launch February 2006

PLASTIC Instrument Sub Systems Overview

Entrance System FM2

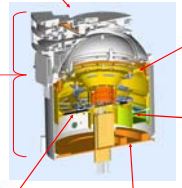
The development and detailed testing of instrument sub-systems is necessary to meet the delivery schedule and enhances the understanding of full instrument operation

Carbon foils

Sub-System Measurements

Entrance System	polar angle E/q
C-foil, MCPs	TOF
SSDs	in-ecliptic angle E

Entrance System/ Energy Analyzer

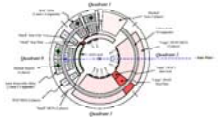


Time of Flight Section

Solid-State Detector Frame

Micro-Channel Plate Frame

Position Anodes



E-Box containing operation and command electronic and power supplies

Entrance System Ion Optic Calibration

Entrance System Functionality

- Select geometric factor (G)
- Select polar angle (ϕ)
- Select energy/charge (E/q)
- Suppress UV, solar wind electrons, scattered ions

calibration provides the relation between:

applied electrode voltage (V)

$G, \phi, \Delta\phi, E/q, \Delta E/q$

Entrance System Ion Beam Calibrations in the UBern CASYMS Facility

Analyzer & Deflection Constants

A relation between applied electrode voltages and selected energy as well as selected angle is need to set flight operation value and interpret measurements

Deflection & Analyzer Constants

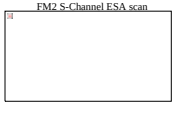
$k_{ESA} = \frac{V_{ESA}}{E/q}\phi \qquad k_{electrode} = \frac{E/q}{V_{electrode}}$

Ion Acceptance Geometric Factor

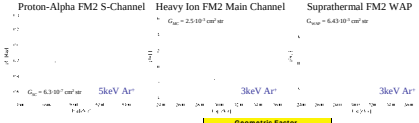
During flight, the ion flux will be calculated utilizing the geometric factor and the measured count rate

Geometric Factor $G = \iint T \cos\theta \cdot dA_0 \, dE/E \, d\Omega$ units of cm² str keV/keV

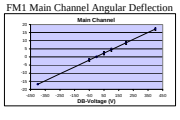
FM2 S-Channel ESA scan



Proton-Alpha FM2 S-Channel | Heavy Ion FM2 Main Channel | Suprathermal FM2 WAP



FM1 Main Channel Angular Deflection



Channel	theta	Geometric Factor FM1	FM2	Simulations
WAP	-30	5.6E-03	6.4E-03	3.5E-03
	-120	6.8E-03		
	21.5	3.1E-03		
Main Channel	60	3.0E-03	2.5E-03	2.4E-03
S-Channel	60	6.2E-07	6.3E-07	5.0E-06

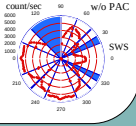
Channel	Electrode	FM1 $k_{electrode}$	FM1 FWHM	FM2 $k_{electrode}$	FM2 FWHM
S-Channel	SCO-L	3.2	10.4%	3.2	10.6%
	SCI-U	3.7	13.2%	3.6	10.8%
	ESA	8.5	6.3%	8.5	6.3%
Main Channel	ESA	8.3	6.1%	8.3	6.5%
WAP	ESA	8.3	6.8%	8.3	7.3%

Channel	FM1 k_{ESA}	FM1 FWHM*	FM2 k_{ESA}	FM2 FWHM*
S-Channel	0.12	0.4	0.11	0.3
Main Channel	0.13	1.9	0.13	1.8
WAP	n/a	3.2	n/a	3.1

Azimuthal Response Uniformity

Azimuthal response uniformity will improve with post-acceleration (PAC) focusing

Entrance System Exit Slit



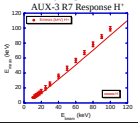
Solid State Detector Ion Energy Measurements

Energy defect is needed to interpret solar wind (and suprathermal) ion response of the SSD (Canberra PIPS 25mm Si entrance window)

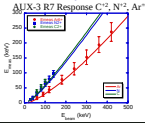
SSD AUX Frame on Test Preamp

Measurement of Ion Energy Response

Hydrogen Ions



Heavy Ions



Measurements in MEFISTO Beam Facility compared with a LSS analytic model of energy response

Time of Flight- Integrated Instrument Calibrations

Time of Flight Section Functionality

- Measure ion time of flight (TOF)
- Measure energy (E)
- Determine azimuthal location (θ)
- Ion intensities

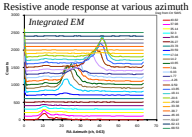
Processes measurements yield:

- Velocity distributions ($\vec{v}$)
- Elemental and charge state distributions (m/q, m, q)
- Ion densities (n)
- Temperature and anisotropy ($T_{\parallel}$, $T_{\perp}$)
- At a time resolution of ~1 minute or more

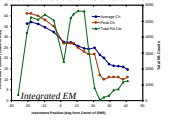
PLASTIC FM1 Instrument in CASYMS Facility

Anode Localization of Start Pulse

Resistive anode response at various azimuth



Resistive anode channels vs. azimuth



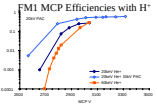
Energy & Time of Flight Measurements

Integrated FM1 Energy & TOF 47 keV air beam - SWS

Integrated FM1 Resistive Anode 47 keV air beam - SWS *90°/64 ch*

Integrated FM1 start pulse position for different V_{MCP}

TOF for 60 keV He+ ESA Scan



Deflection & E/q Sweep Operation

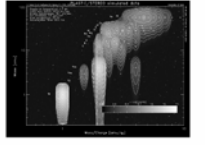
Instrument Response Simulation

The PLASTIC instrument response can be simulated by utilizing instrument parameters and sub-system calibrations

Future work will entail refinements to the instrument response, with better instrument parameters and further testing of sub-system operation.

- SSD response to full range of ion species
- C-foil SEE, ion scattering

PLASTIC M-M/Q Matrix



Special acknowledgement to J. Fischer, J. Jost, M. Sigrist, A. Etter, and the extended University of Bern team as well as M. Granoff and many others of the University of New Hampshire PLASTIC team.
This work is supported by the Swiss National Fund and PRODEX Grant C90119.