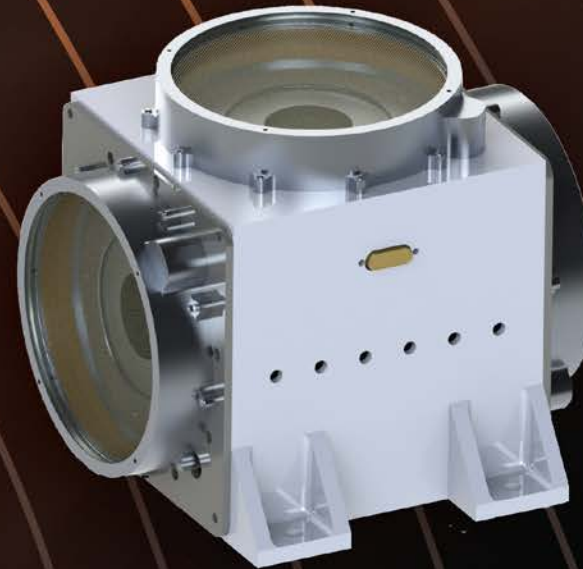




Plasma
Instrument
for Magnetic
Sounding



Joseph Westlake and the PIMS Team
OPAG: 24 August 2015



Instrument Elements:

Faraday Cup



Central Electronics Unit

Instrument Team:PI: **Joseph Westlake**,Johns Hopkins University/Applied Physics
Laboratory (APL)Deputy PI: **Ralph McNutt**, APLInstrument Project Manager: **Cindy Kim**, APLInstrument Lead Engineer: **Matthew Grey**, APLFaraday Cup Lead: **Justin Kasper**, UMDeputy Faraday Cup Lead: **Anthony Case**, SAOInvestigation:

PIMS measures the plasma surrounding Europa to characterize the magnetic fields generated by plasma currents.

Goals:

- Determine Europa's magnetic induction response, corrected for plasma contributions, to estimate ocean salinity and thickness.
- Understand the mechanisms responsible for weathering and releasing material from Europa's surface into the atmosphere and ionosphere.
- Understand how Europa influences its local space environment and Jupiter's magnetosphere.

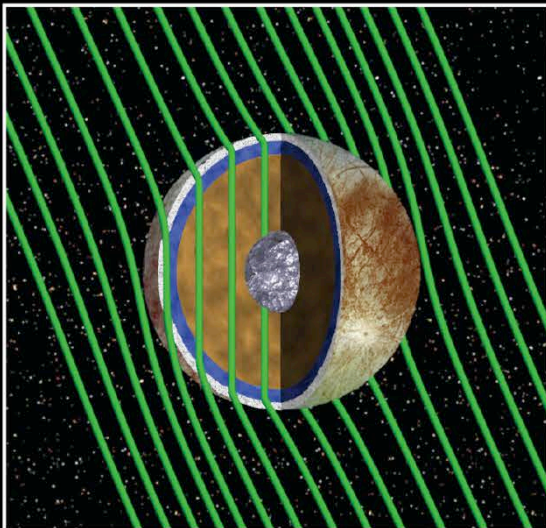
Instrument Capabilities:

- In Magnetospheric Mode:
 - Electron Energy: 10 eV – 2 keV
 - Ion Energy: 20 eV – 7 keV
- In Ionospheric Mode:
 - Electron Energy: 1 – 50 eV
 - Ion Energy: 1 – 50 eV
- Energy Resolution: 10% $\Delta E/E$
- Sensitivity: $0.5 \text{ pA/cm}^2 - 1 \times 10^5 \text{ pA.cm}^2$
- FOV: 3x90 deg. Cone
- Temporal Resolution: 1s for a full ion and electron sweep

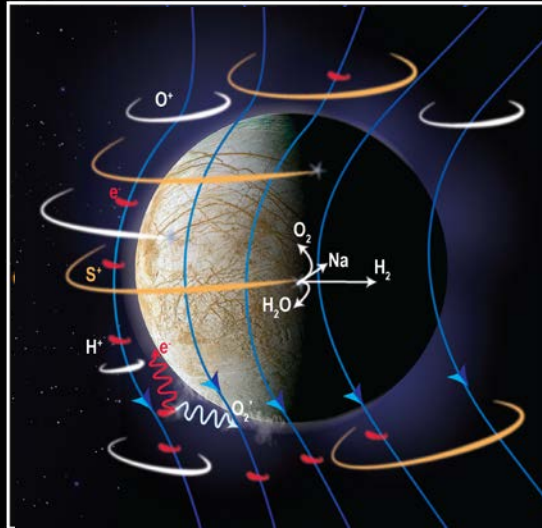
	Team Member	Responsibilities (bold = lead): Instrument Development and Sci. Investigation Development [Relevant Mission Experience]
PI	Joseph Westlake, APL	Lead science investigation and technical implementation: PIMS [Cassini INMS, CAPS, MIMI; MMS-EPD; JUICE PEP]
Deputy-PI	Ralph McNutt, APL	FC Instrumentation, electronics, & signal processing; Jovian plasma sheet [Voyager PLS, LECP; MESSENGER; New Horizons PEPPSI; Cassini INMS; SPP]
NASA Funded Co-Investigators	Anthony Case, SAO	Deputy FC Lead & SAO Institutional PI , FC design, FC testing, cal, analysis; FC performance verification [SPP-SWEAP, DSCOVR-PLASMAG, LRO-CRaTER]
	Xianzhe Jia, UM	Jupiter plasma data requirements development; Modeling Lead ; Europa Interaction MHD Model [Cassini, Galileo, JUICE PEP, J-MAG, RPWI]
	Justin Kasper, UM, SAO	FC Lead, Michigan Institutional PI ; Plasma diagnostics , FC optimization [Wind, SPP-SWEAP, SPP-FIELDS, DSCOVR-PLASMAG, LRO-CRaTER]
	Krishan Khurana, UCLA	Map magnetic sounding requirements to plasma requirements; Magnetic sounding [Galileo MAG; Cassini MAG; JUICE PEP, Themis/Artemis]
	Margaret Kivelson, UCLA	Magnetic sounding at Europa from Galileo; Magnetic sounding measurements in the presence of strong plasma perturbations [Galileo MAG, Cassini MAG, Cluster MAG, Themis/Artemis]
	Carol Paty, GT	Europa ionosphere requirements development; Europa Interaction MHD Model [Cassini CAPS, MAG; JUICE PEP]
	Abigail Rymer, APL	EMI/EMC lead , Electron measurements, spacecraft potential; Mag. plasma diagnostics [Cassini CAPS, MIMI]
	James Slavin, UM	Plasma effects on magnetic sounding; Magnetic sounding & magnetospheric plasma [ISEE-3, MGS, MESSENGER, MMS MAG, BepiColombo STROFIO & MAG, JUICE J-MAG]
	H. Todd Smith, APL	Magnetospheric ion measurements ; Neutral & plasma torus model ; [Cassini CAPS, MIMI, BepiColombo Strofio]
	Michael Stevens, SAO	FC response, FC optimization, FC analysis software; Data Products ; Plasma diagnostics [SPP-SWEAP, Wind-SWE, DSCOVR,-PLASMAG, Voyager PLS]
Ext. Funded Collab.	Joachim Saur, U Cologne	Coupled modeling of Europa gas and plasma interaction, energetic particles near Europa [HST, JUNO, JUICE RPWI & J-MAG]
	Norbert Krupp, MPS	Jovian magnetosphere expert [Galileo EPD, Cassini MIMI, Mars Express ASPERA3, Venus Express ASPERA4, BepiColombo SERENA, MPPE]
	Elias Roussos, MPS	Jovian particles and particle irradiation expert [Cassini MIMI, Mars Express ASPERA3, JUICE PEP, J-MAG]

The PiMS Investigation Addresses High-Priority Europa Science Goals

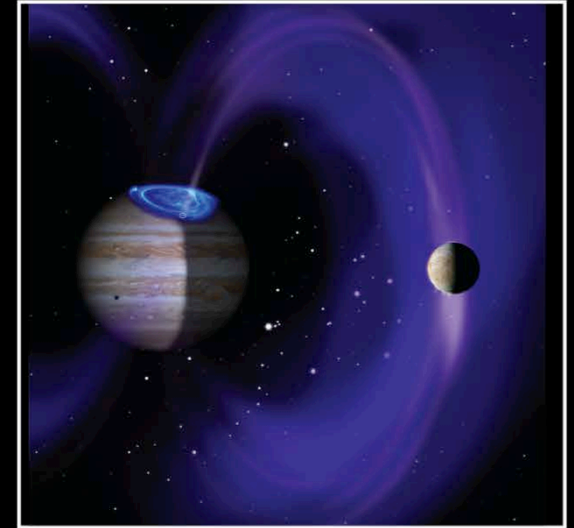
PiMS Investigation 1: Determine Europa's magnetic induction response, corrected for plasma contributions, to estimate ocean salinity and thickness. (NRC Decadal Objectives 1, 2, & 5).

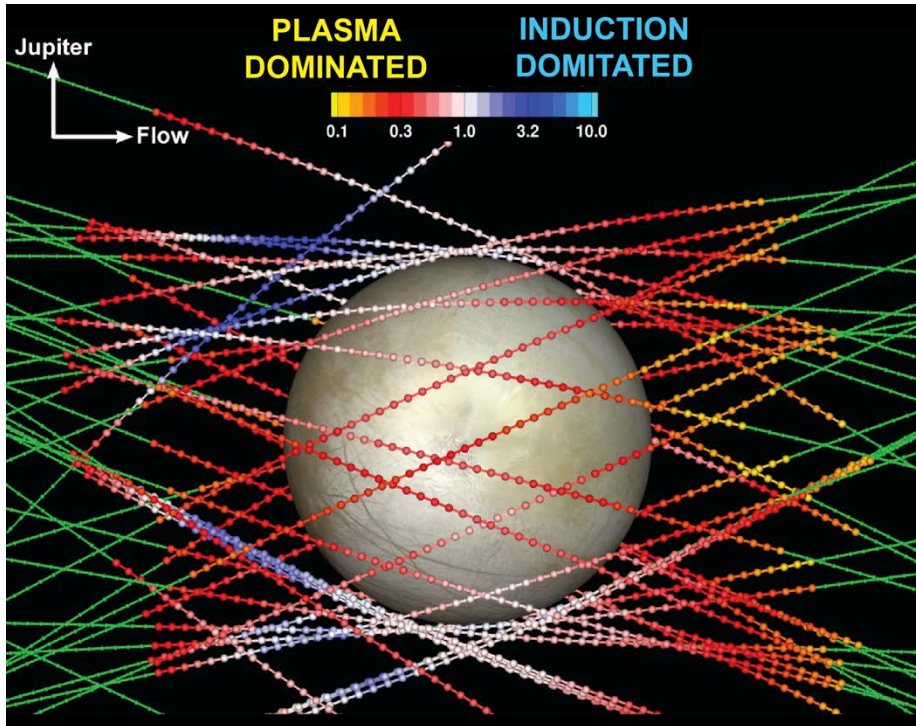


PiMS Investigation 2: Understand the mechanisms responsible for weathering and releasing material from Europa's surface into the atmosphere and ionosphere (NRC Decadal Objective 3).

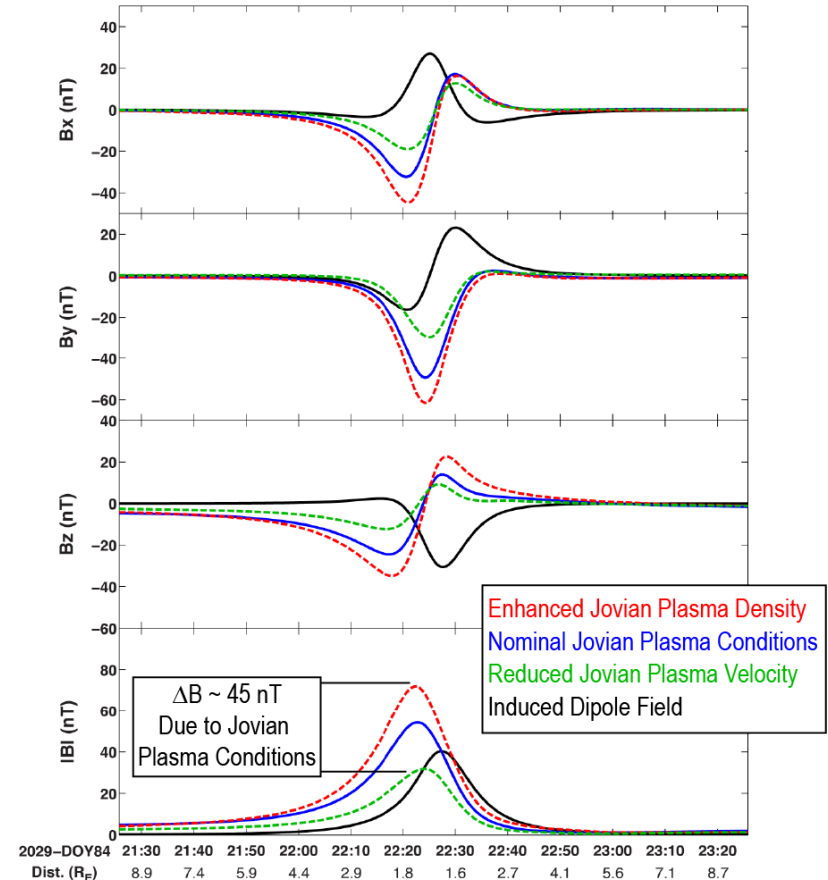


PiMS Investigation 3: Understand how Europa influences its local space environment and Jupiter's magnetosphere (NRC Decadal Objective 5).





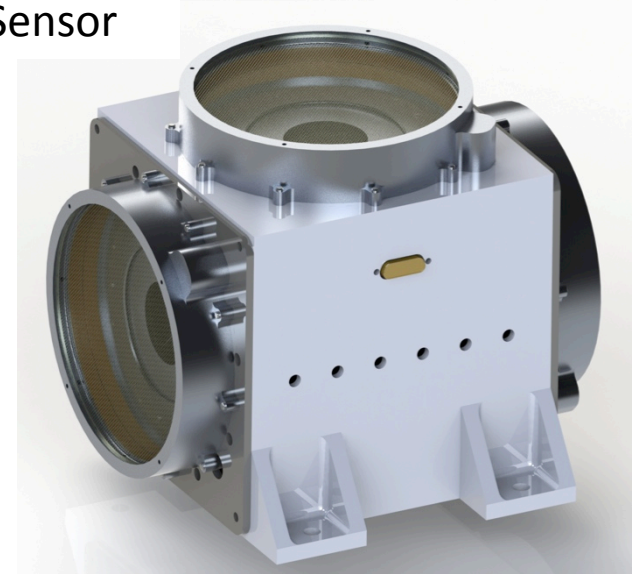
- PIMS will measure and correct for the strong plasma induced fields surrounding Europa allowing for precise magnetic sounding.
- The figure shows the ratio of the plasma induced magnetic fields to the induction dominated magnetic fields plotted over the Europa flyby trajectories



- The amplitude and phase of Europa's magnetic signature is strongly influenced by plasma conditions.

- PIMS is composed of three **Faraday Cups**, each with a 90° FOV.
- FCs measure the **current** produced on metal collector plates by charged particles with sufficient energy per charge (E/q) to pass through a modulated retarding grid placed at variable (AC) high voltage (HV).
- In the **Jovian magnetospheric plasma** PIMS measures:
 - The density and flow velocity of ions with energies below 7 keV
 - The density and energy spectrum of electrons with energies below 2 keV
- In **Europa's ionosphere**, and transitional plasmas PIMS measures:
 - The density and temperature of ions and electrons

PIMS Sensor

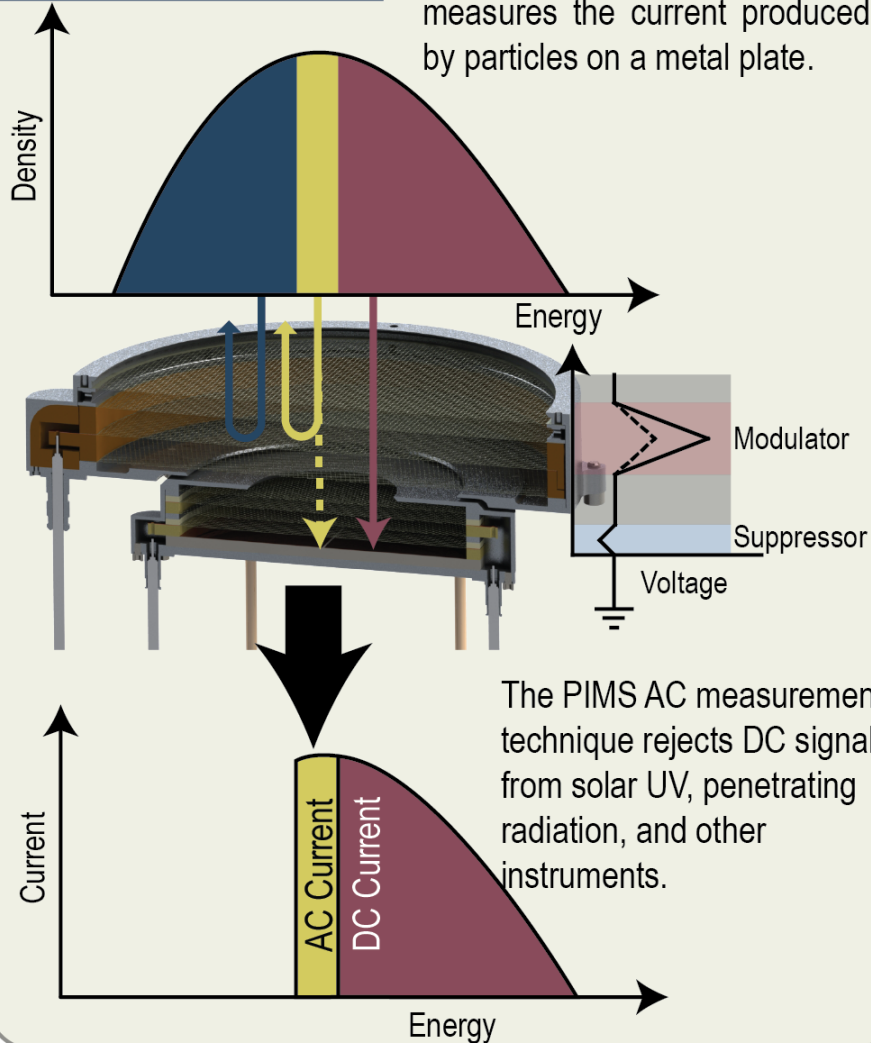


PIMS Central Electronics Unit



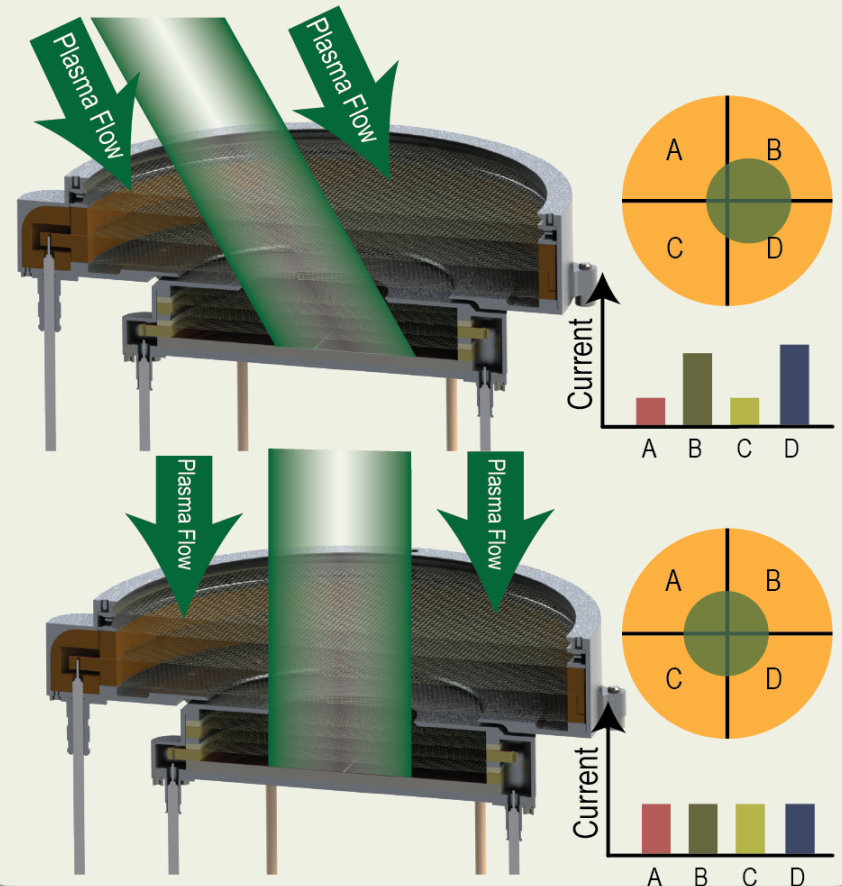
1. PIMS Density

PIMS is a simple sensor that measures the current produced by particles on a metal plate.

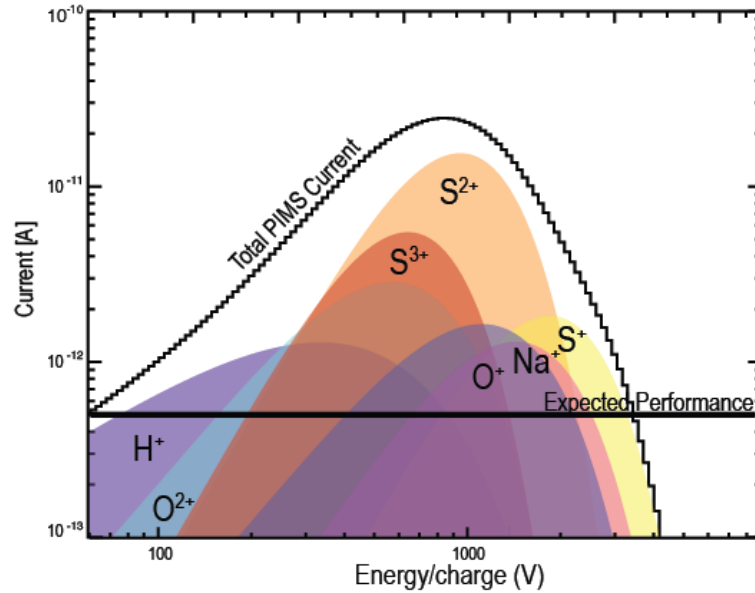


2. PIMS Flow Direction

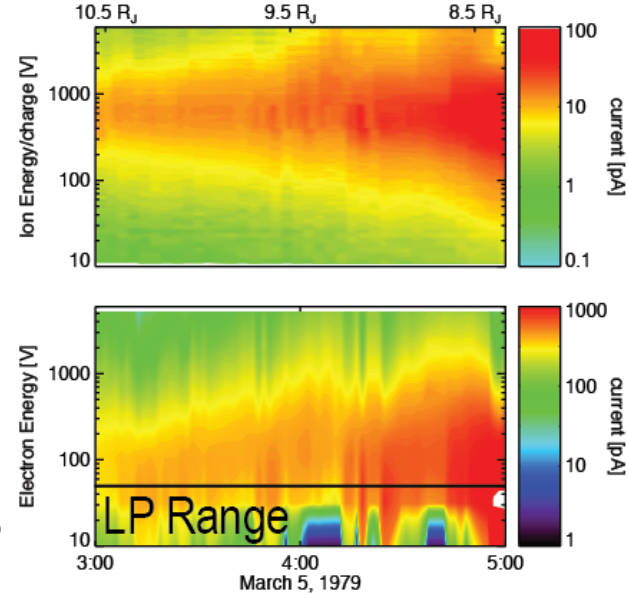
PIMS Measures the plasma flow direction by comparing the current collected on a segmented metal plate. When the plasma is moving supersonically with respect to the instrument the limiting aperture produces a collimated ion beam in the sensor.



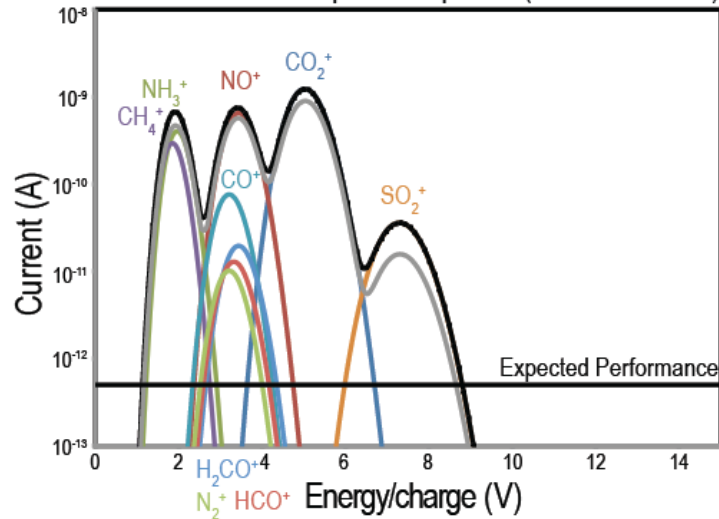
PIMS Jovian Magnetosphere



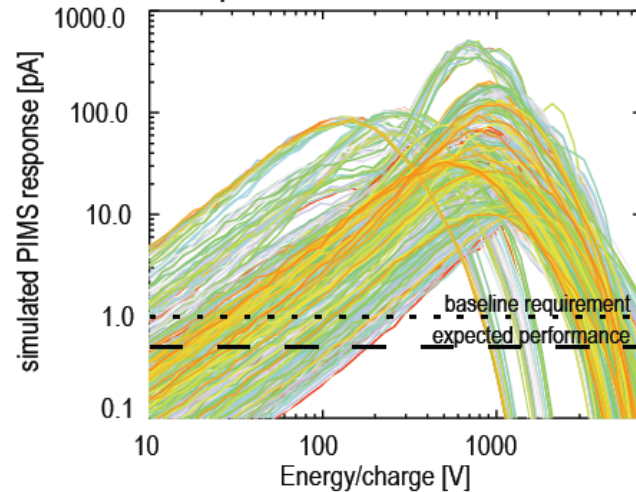
Voyager 1 inbound, crossing the Europa orbit: PLS measurements



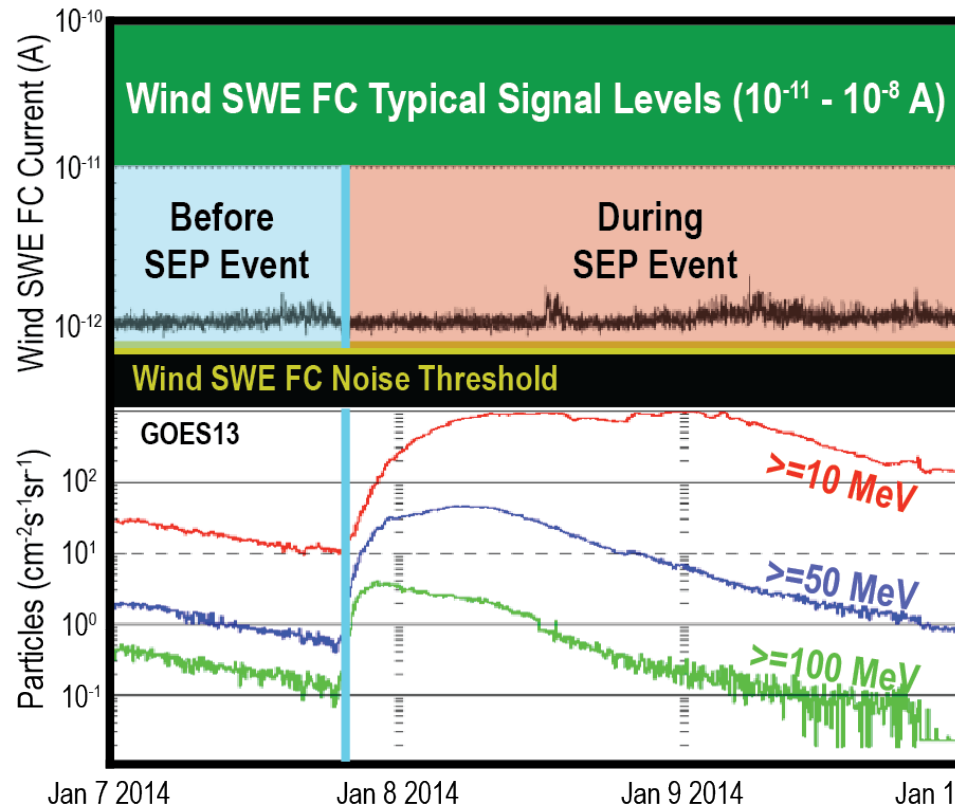
PIMS Europa Ionosphere (25 km/100 km)



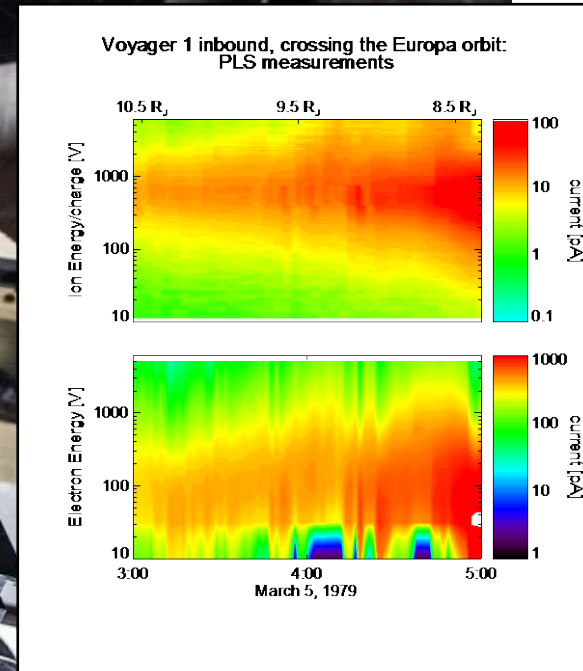
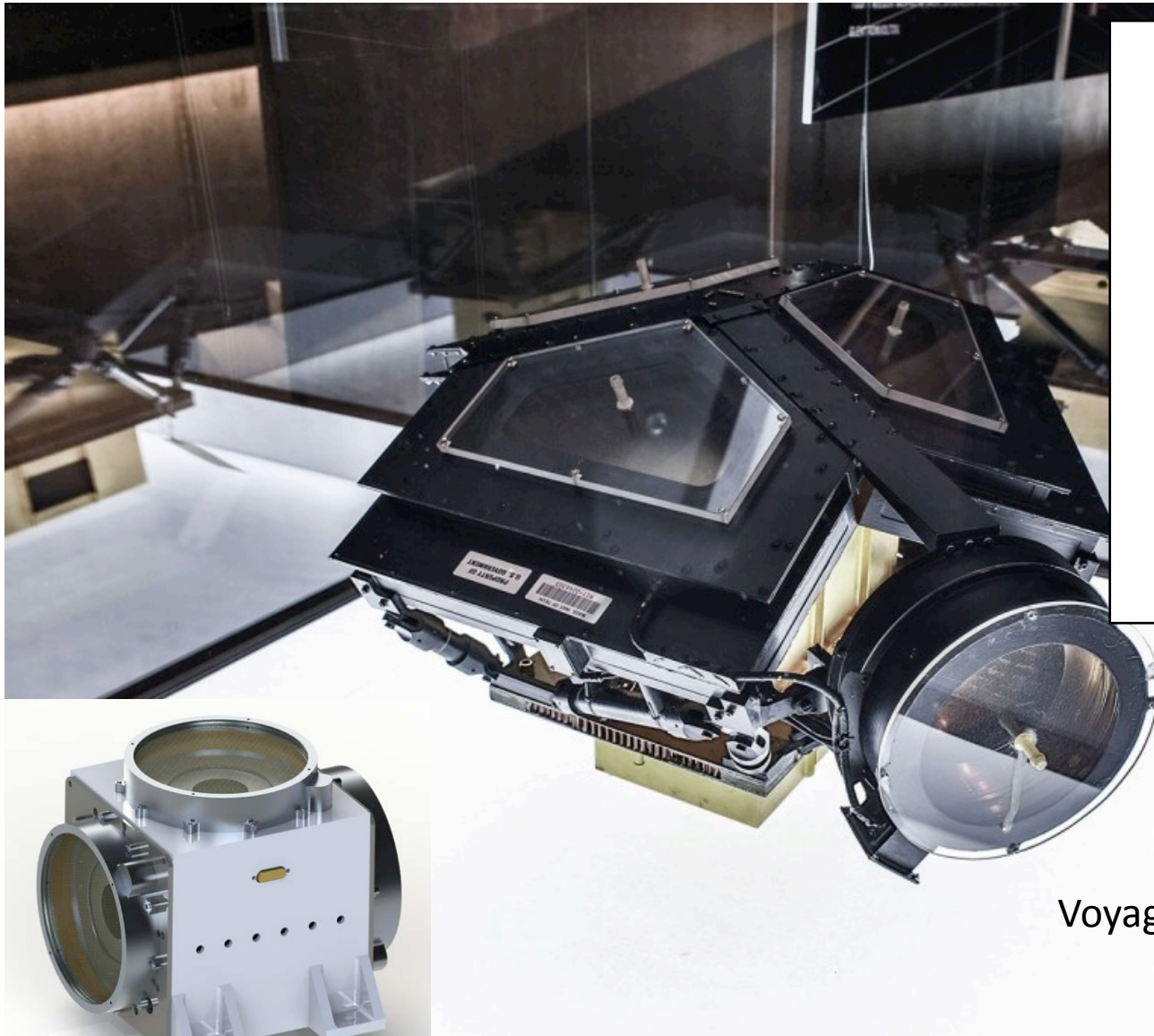
PIMS Response for Galileo PLS conditions



Faraday Cup Radiation Tolerance



No additional FC noise has been observed during Solar Energetic Particle (SEP) events on Wind. **This is in-flight confirmation that the synchronous detection technique is unaffected by penetrating radiation.**

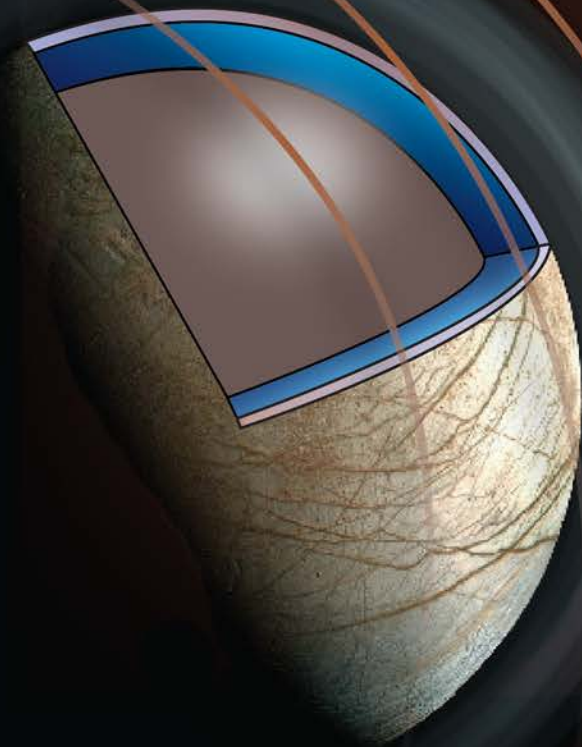
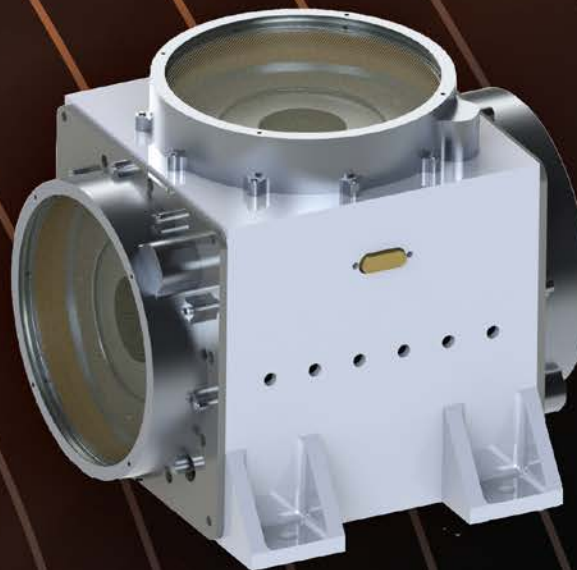


Europa PIMS

Voyager PLS



Plasma
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Thank you!



JOHNS HOPKINS
APPLIED PHYSICS LABORATORY



UNIVERSITY OF
MICHIGAN



Smithsonian

EXTRA SLIDES

Science Goal	Science Objectives	Science Investigation	Scientific Measurement Requirements	
			Observables	Physical Parameters
Explore Europa to Investigate Its Habitability	Characterize extent of the ocean and its relation to the deeper interior (Decadal Objective 1)	PIMS Investigation 1: Determine Europa's magnetic induction response, corrected for plasma contributions, to estimate ice shell thickness, ocean thickness, and salinity (<i>Clipper Investigation IO.2</i>)	PIMS Observable 1.1: Measure the characteristics of the rapidly co-rotating Jupiter plasma that governs the intensity and structure of magnetic perturbations from plasma near Europa	Jovian Plasma Ion Density, Flow Velocity, Temperature, Derived Ion Composition Electron Density, Temperature
	Characterize ice shell and any subsurface water, including their heterogeneity, and the nature of surface-ice-ocean exchange (Decadal Objective 2, <i>Clipper Objective IO</i>)		PIMS Observable 1.2: Measure the magnetic perturbations from plasmas originating from Europa by measuring the conductivity of Europa's ionosphere and identifying plumes and measuring their mass-loading.	Europa Ionosphere & Plume Ionosphere Ion Density, Flow Velocity, Temperature, Derived Ion Composition Electron Density, Temperature
	Understand Europa's space environment and interaction with Jupiter's magnetosphere (Decadal Objective 5)		PIMS Observable 1.3: Measure the thermal to suprathermal pickup ions generated from Europa, their related currents, and Europa's Alfvén wing structure to determine their influence on the magnetic field observed near Europa	Europa Pick-Up Ions Ion Density, Flow Velocity, Temperature, Derived Ion Composition Electron Density, Temperature
	Determine global surface compositions and chemistry, especially as related to habitability (Decadal Objective 3)	PIMS Investigation 2: Understand the mechanisms responsible for weathering and releasing material from Europa's surface into the atmosphere and ionosphere (<i>Related to Clipper Investigation C.1, C.2</i>)	PIMS Observable 2.1: Measure Jupiter's O and S ions responsible for producing Europa's sputtered atmosphere.	Jovian Plasma Ion Density, Flow Velocity, Temperature, Derived Ion Composition Electron Density, Temperature
	Understand Europa's space environment and interaction with Jupiter's magnetosphere (Decadal Objective 5)		PIMS Observable 2.2: Measure the composition of the cold, ionized components of the atmosphere	Europa Ionosphere & Plume Ionosphere Ion Density, Flow Velocity, Temperature, Derived Ion Composition Electron Density, Temperature
	Understand habitability of Europa's ocean through composition and chemistry. (<i>Clipper Objective C</i>)	PIMS Investigation 3: Understand how Europa influences its local space environment and Jupiter's magnetosphere, the structure of Europa-associated partial torus and the possible existence of Europa plumes.	PIMS Observable 3.1: Measure the Jovian plasma torus structure to determine the influence of the Europa particle source	Jovian Plasma Ion Density, Flow Velocity, Temperature, Derived Ion Composition Electron Density, Temperature
	Understand Europa's space environment and interaction with Jupiter's magnetosphere (Decadal Objective 5)		PIMS Observable 3.2: Measure the electrons and electron beams that connect Europa with Jupiter's ionosphere to determine the magnitude of the field-aligned current systems.	Electrons Electron Density and Temperature