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Particle Environment Package (PEP)

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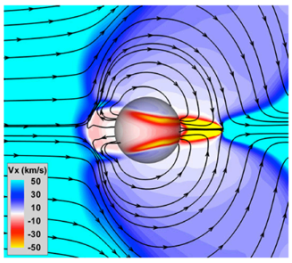
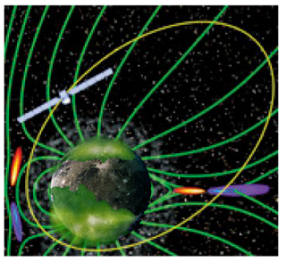
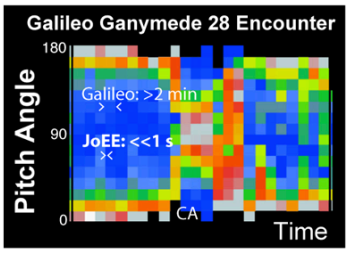
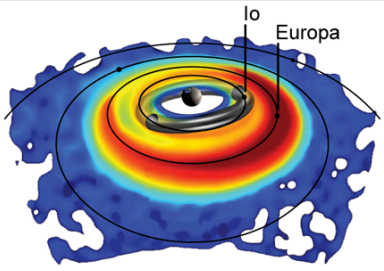
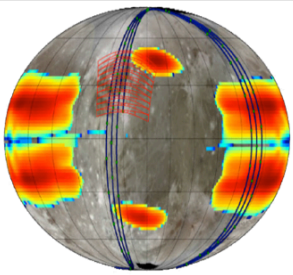
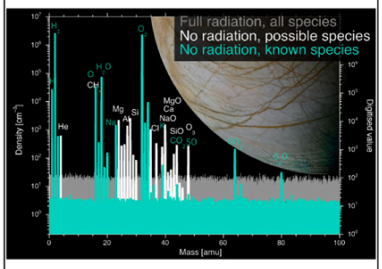
Abstract

Particle Environment Package (PEP) is a suite of particle sensors proposed for the ESA JUICE mission. PEP includes sensors for the comprehensive measurements of electrons, ions, energetic neutrals, and neutral gas. PEP covers over nine decades of energy <0.001 eV to >1 MeV with full angular coverage. Combining remote global imaging via energetic neutral atoms (ENAs) with in-situ measurements, PEP addresses all scientific objectives of the JUICE mission relevant to particle measurements. PEP will seek answers for four overarching science questions: How does the corotating magnetosphere of Jupiter interact with complex and diverse environment of Ganymede? How does the rapidly rotating magnetosphere of Jupiter interact with seemingly inert Callisto? What are the governing mechanisms and their global impact of release of material into the Jupiter magnetosphere from Europa and Io? How do internal and solar wind drivers cause such energetic, time variable and multi-scale phenomena in the steadily rotating giant magnetosphere of Jupiter? We discuss the suite's sensor basic design, performance, radiation mitigation principles and demonstrate how the suite fully addresses its scientific objectives.

JDC: Jovian Dynamics & Composition	**JEI: Jovian Electrons & Ions**	**JoEE: Jovian Energetic Electrons**
Instantaneous 3D flow of ion plasma and composition to understand the magnetoshpere and magnetosphere-moon interactions	Instantaneous 3D electron plasma at unprecedented high energy resolution to probe the mysteries of the moons' aurorae and ionization of iogenic gas	Sub-second pitch-angle distributions of energetic electrons to probe acceleration mechanisms, magnetic field topology and boundaries
		
JENI: Jovian Energetic Neutrals & Ions	**JNA: Jovian Neutrals Analyzer**	**NIM: Neutral Ion Mass Spectrometer**
Global imaging of Europa/Io tori and magnetosphere combined with high-resolution energetic ion measurements	Mapping weathering of the icy moons and imaging the Io torus	First-ever direct sampling of the exospheres of Europa, Ganymede, and Callisto
		

PEP Instrument Overview and Performance

Zenith Unit (ZU): JDC, JEI, JoEE, redundant DPU, power system with redundant converters, single interface to S/C
Nadir Unit (NU): JDC, JEI, JoEE, JNA, NIM, redundant DPU, power system with redundant converters, single interface to S/C
JENI (Nadir deck): Electrical interface to NU

PEP sensor description	Basic Performance	Radiation Mitigation
JDC - Jovian Dynamics and Composition: Compact ion sensor using reflectron and reflecting surface achieving high mass resolution and high sensitivity. Instantaneous 3D distributions of positive, negative ions, constraining charge-states, electron measurement capability	**Masses**: 1-70 amu, M/ΔM=30 **Energies**: 1 eV – 41 keV, ΔE/E=12% **FOV**: 2x90˚x360˚ **Geom. Factor**: $9x10^{-3}$ cm² sr eV/eV (total)	Radiation tolerant ceramic channel electron multipliers (CCEM), triple coincidence and focusing on minimized detector
JEI - Jovian Electrons and Ions: Instantaneous 3D distributions of plasma electrons, ion measurement capabilities	**Energies**: 1 eV – 50 keV, ΔE/E=5% **FOV**: 2x90˚x360˚ **Geom. Factor**: $2x10^{-2}$ cm² sr eV/eV (total)	Radiation tolerant CCEMs and anti-coincidence solid state detector (SSD)
JoEE - Jovian Energetic Electrons: Ultra-lightweight energetic electron sensor built on the Galileo energetic particle detector technique. Instantaneous pitch-angle distributions and spectra.	**Energies**: 25 keV – 1 MeV, ΔE/E≤20% **FOV, resolution**: 2x12˚x180˚, 12˚x22˚ **Geom. Factor:** 0.18-$3.6x10^{-3}$ cm² sr (total)	Anti-coincidence SSDs and position coincidence
JENI - Jovian Energetic Neutrals and Ions: Combined energetic ion and ENA camera based on Cassini, IMAGE and Juno. Global imaging of magnetosphere and neutral gas tori.	**Masses**: H, He, CNO, S (ions and ENAs) **Energies:** 500 eV – 5 MeV, ΔE/E<14% **FOV, resolution:** 90˚x120˚, 2˚x2˚ (≥10 keV H) **Geom. Factor:** 0.013-1.80 cm² sr (total, incl. eff.)	Triple coincidence, pulse-height rejection and variable aperture
JNA - Jovian Neutrals Analyzer: ENA camera based on successful instrument on the Lunar Chandrayaan-1 mission. Imaging of Io plasma torus, backscattered and sputtered surface products.	**Masses**: light and heavy ENAs **Energies**: 10 eV – 3.3 keV (H) **FOV, resolution:** 15˚x150˚, 7˚x25˚ **Geom. Factor:** 0.34 cm² sr eV/eV **Efficiency:** 10^{-4}-10^{-3} depending on mass and energy	Triple coincidence
NIM - Neutral Ion Mass Spectrometer: Compact design based on TOF and reflectron. First-ever exospheric neutral gas and thermal plasma mass spectroscopy at Jupiter's moons.	**Masses**: 1-1000 amu, M/ΔM=1100 **FOV**: 10˚x360˚ **Sensitivity**: 2 cm^{-3} (5s integration), 10^{-3} cm^{-3} (ions)	Tight timing coincidence and focusing onto minimized detector behind graded shielding