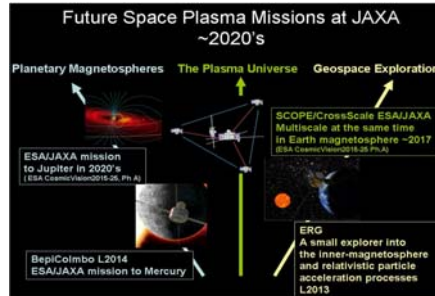


「我々の将来地球惑星磁気圏ミッション」における電場・波動・電波計測：特にERG計画

Electromagnetic field measurements for our future missions: Especially for ERG

~ from Mercury, through Earth, toward Jupiter ~



P2-030

Y. Kasaba¹, H. Kojima², S. Yagitani³, Y. Kasahara³, T. Imachi³, K. Ishisaka⁴,
A. Kumamoto¹, T. Ono¹, Y. Katoh¹, H. Misawa¹, F. Tsuchiya¹

(1. Tohoku Univ. 2. Kyoto Univ. 3. Kanazawa Univ. 4. Toyama Pref. Univ.)

[Objectives] Detection of Electric Field / Plasma Wave / Radio waves

- All plasma frequency range
- All X/Y/Z components

*Earth-Orbit : Sensitive measurement in DC ~ few 10MHz
*Earth-Orbit / Lunar surface : Low-frequency Interferometer in several 10s MHz

*Jovian orbit : Radiation & Activities from the ionosphere, magnetosphere, and satellite in DC ~ several 10s MHz

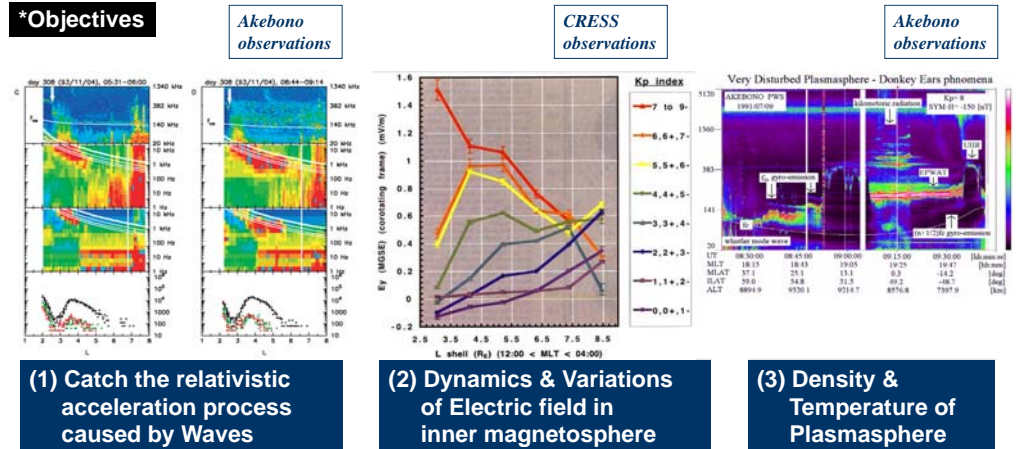
ERG/PWE: Plasma Wave Experiment

~ from Mercury (BepiColombo/MMO-PWI) to **Earth's Radiation Belt** ~

Electric Field Sensors (32m tip-to-tip dipoles)		
WPT (Wire-Probe anTenna)	DC-10MHz	[Tohoku U et al.]
MEFISTO (Mercury Electric Field In-Situ TOol)	DC - 3MHz	[Sweden]
Magnetic Field Sensors (search-coils)		
SC (3-axis Search-Coils)	few Hz ~ 20kHz	[Kanazawa U et al.]
DC/Low frequency Electric field (E: 0Hz ~32Hz)		
EWO-EFD (Electric Field Detector)		[Toyama Pref. U et al.]
Low/medium frequency E/B field (E: 10Hz ~ 20kHz, B: 0Hz ~20kHz)		
EWO-WFC/OFA (WaveForm Capture/Onboard Frequency Analyzer)		[Kyoto U et al.]
High frequency E/B field (E: <10kHz~10MHz)		
HF (High-Frequency)	DC-10MHz	[Tohoku U et al.]



*Objectives



(1) Catch the relativistic acceleration process caused by Waves

(2) Dynamics & Variations of Electric field in inner magnetosphere

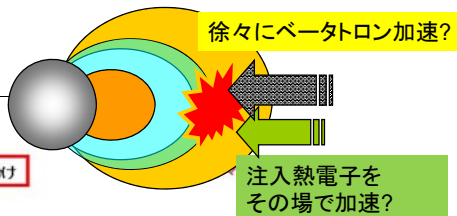
(3) Density & Temperature of Plasmasphere

<Team Members>

[PI]		Yasumasa Kasaba	(Tohoku Univ.)
[Sensors]	WPT	Yasumasa Kasaba	(Tohoku Univ.)
	MEFISTO	Lars Blomberg	(KTH)
	SC	Satoshi Yagitani	(Kanazawa Univ.)
[Receivers]	EWO [WFC]	Hirotsugu Kojima	(Kyoto Univ.)
	[EFD]	Keigo Ishisaka	(Toyama Pref. U.)
	HF	Atsushi Kumamoto	(Tohoku Univ.)
[Software]		Yoshiya Kasahara	(Kanazawa Univ.)

PWE: 目標

要求事項(1)

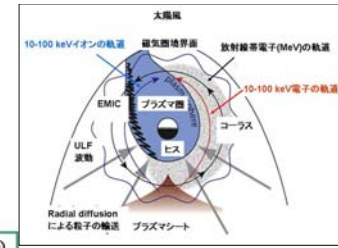


成功基準 I

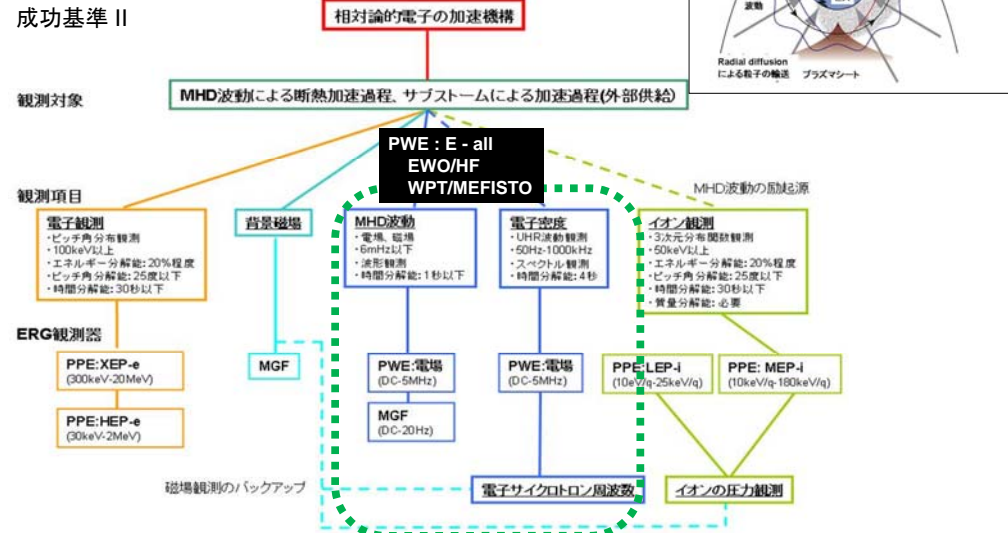


PWE: 目標

要求事項(2)

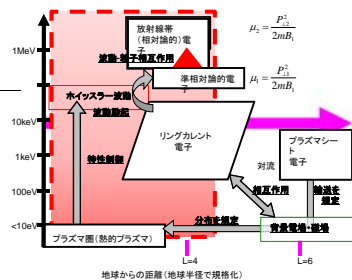


成功基準 II

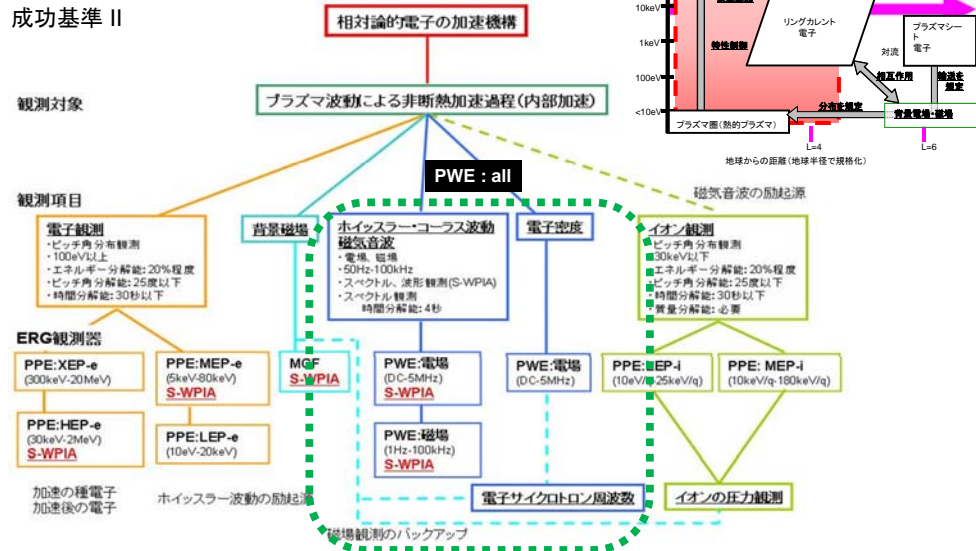


PWE: 目標

要求事項(3)



成功基準 II

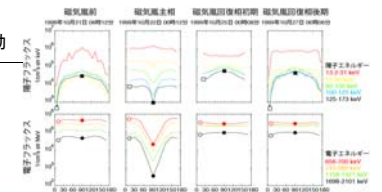


PWE: 目標

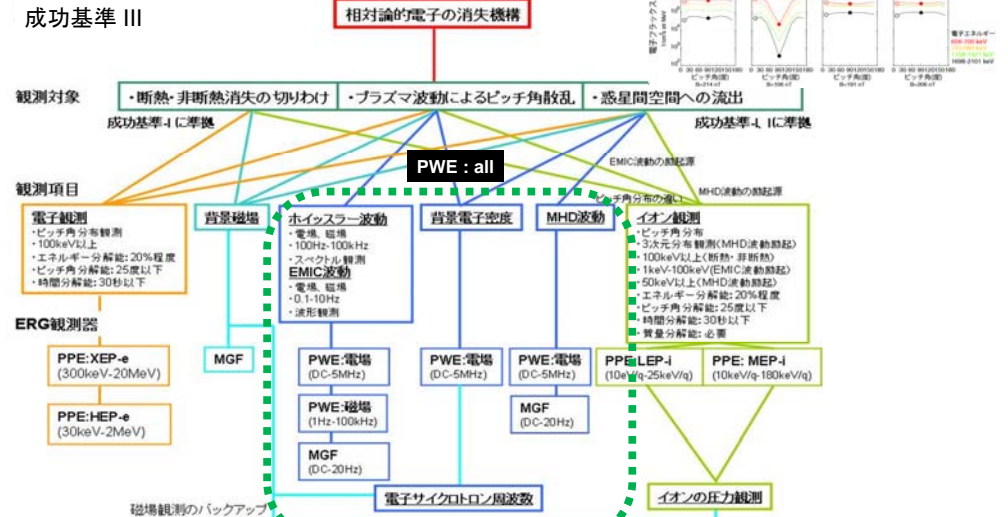
要求事項(4)

電子ピッチ角分布・イオンピッチ角分布(背景磁場)の観測

断熱消失: 電子とイオンの挙動は同じ。異なれば、電子に特有な消失過程が発動



成功基準 III

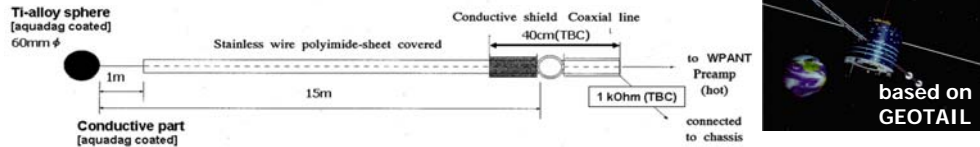


3. PWE: Sensors - E

Electric field: Dipole wire antennas

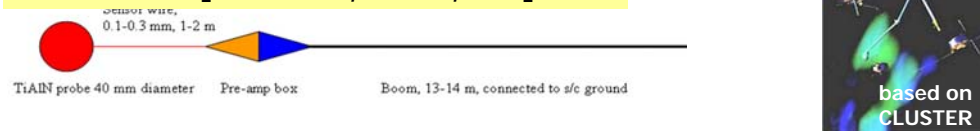
~ First long wire antenna (32m tip-to-tip length) aboard a Planetary Orbiter ~

WPT-S [from Tohoku Univ. etc.]



Optimized for plasma waves & radio waves

MEFISTO-S [from KTH, IRF-U, etc.]



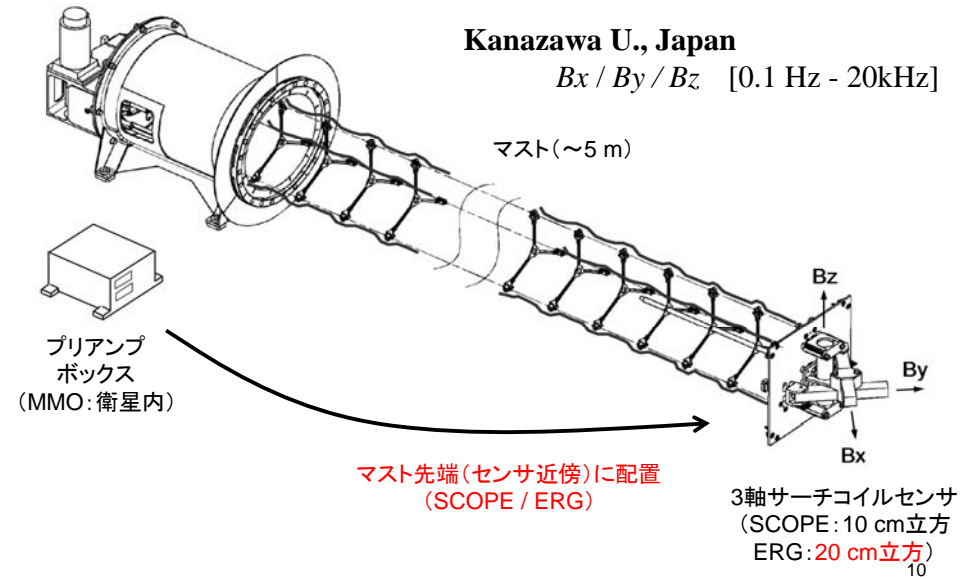
Optimized for dc & low frequency electric field

3. PWE: Sensors - B

Magnetic Field: Search Coil Magnetometers (SC)

Kanazawa U., Japan

$B_x / B_y / B_z$ [0.1 Hz - 20kHz]



4. PWE: Sensors - Receiver

Design Overviews

[Receivers]

- * **EWO-EFD**: DC - 32Hz
 - connected to the WPT and MEFISTO electric field sensors
 - Double Probe Dynamic range 110 dB for Electric field
 - Single Probe Spacecraft potential for Electron density
- * **EWO-WFC/OFA**: 10Hz - 20kHz for E, few Hz - 20kHz for B
 - connected to WPT / MEFISTO (E) & SC (B)
 - Waveform receiver with spectrum data (derived in MDP)
- * **HF receiver** <10kHz - 10MHz
 - connected to the WPT / MEFISTO (E)
- * **MDP/DPU (digital Processing Unit)** (x 1-5)
 - connected to EWO-E/B, SORBET, MEFISTO-E, (MAST-WPT-E)
 - CMD/HK I/F
 - TLM calculations: FFT, Compression, Triggering, Packet

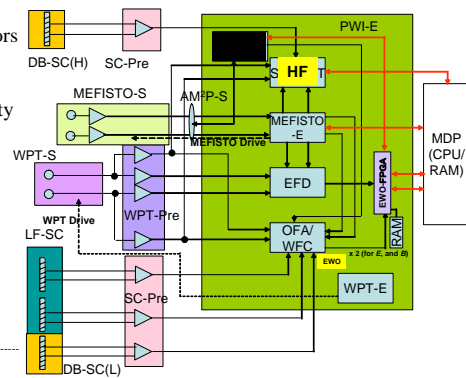


Figure 2.2: PWE block diagram.

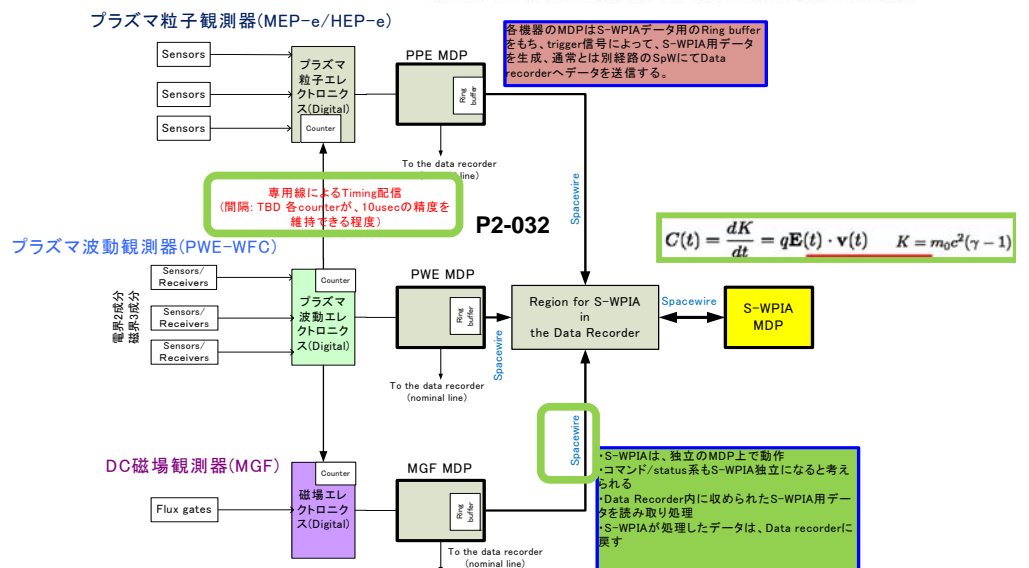
PWE: Sensors - Receiver

(see Kojima et al. [P2-032])

Software Wave-Particle Interaction Analyzer

「波動と粒子のCorrelationをとってから時間積分」という試み

波動-粒子の位相関係を保存した形での時間積分の実現



SCOPE/PWI (Plasma Wave Instruments)

~now in the Phase-A development phase (Launch: 2019 [tbc]) ~

Electric Field Sensors – 3-axial

WPT	(Wire-Probe anTenna)	50-100m	DC - 10(30)MHz
SPT	(Spin-Axis anTenna)	5-10m	few – several MHz

Magnetic Field Sensors (search-coils)

SC	(3-axis Search-Coils)	10 Hz – 100kHz
----	-----------------------	----------------

DC/Low frequency Electric field (E: 0Hz ~32Hz)

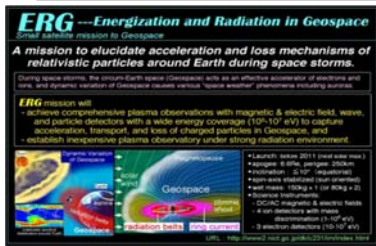
EWO-EFD (Electric Field Detector)

Low/medium frequency E/B field (E: 10Hz ~ 100kHz, B: 0Hz ~20kHz)

EWO-WFC/OFA (WaveForm Capture/Onboard Frequency Analyzer)

High frequency E/B field (E: 1kHz~10MHz)

HFA (High Frequency Analyzer)



Requirements

- ✓ Wide-band Simultaneous Observations from DC ~ 30MHz
- ✓ 3-Axial DC Electric Field measurements by Mother-NearDaughter pair
- ✓ All = 6 components Electric & Magnetic Field vector by Mother-NearDaughter ... Electron scale by Mother FarDaughter ... Electron-Ion Coupling scale
- ✓ Sun & Magnetospheric Activity Monitor by Mother-Daughter pairs
- ✓ Detection of Boundary Crossing with high-time resolutions by Mother-Daughter pairs

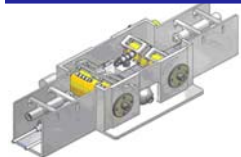
<Team Members>

[PI]		Hirotsugu Kojima	(Kyoto Univ.)
[Sensors]	WPT	Yasumasa Kasaba	(Tohoku Univ.)
	SPT [by System]	Ken Higuchi	(JAXA)
	SC	Satoshi Yagitani	(Kanazawa Univ.)
[Receivers]	EWO	Hirotsugu Kojima	(Kyoto Univ.)
		Keigo Ishisaka	(Toyama Pref. U.)
	HFA	Atsushi Kumamoto	(Tohoku Univ.)
[Software]		Y. Kasahara	(Kanazawa Univ.)

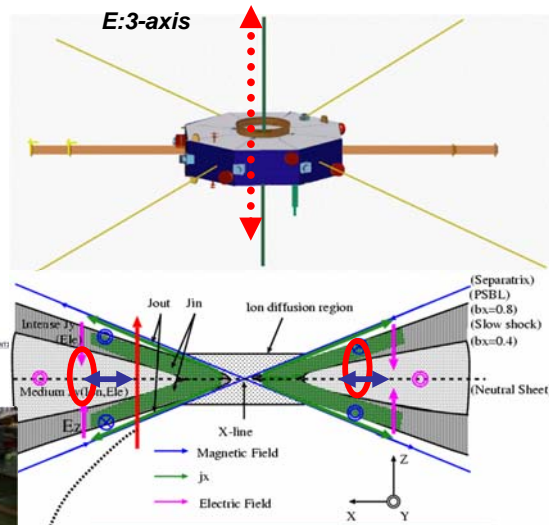
Electric Monopole/Dipole Antenna

~ SCOPE-PWI: Spin-axis Probe Antenna (SPT) ~

Rigid antenna for the spin-axis extension



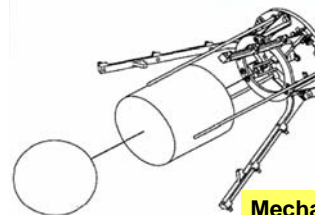
EVMR-ANT-1/3 [S-520-23 Sounding Rocket]



Cover the whole-components in key regions

SCOPE-PWI: Wire Probe Antenna (WPT)

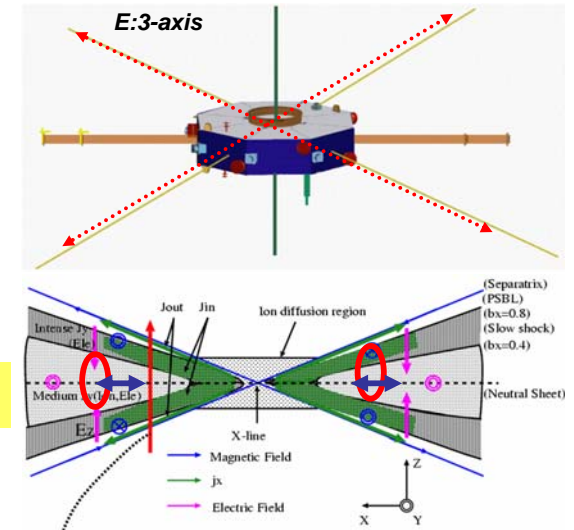
Surface element test (2007)



Mechanical Model (2008)



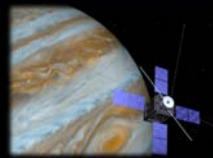
Proc. 2009 IEEE



Cover the whole-components in key regions

Jovian Magnetospheric Orbiter (JMO)

Optimized to Magnetospheric Sciences
for Multi-Scale studies for Jovian System



- * First multi-spacecraft: Jovian 'Geotail' with the EJSM fleet,
- * First solar wind Info: comprehensive comparison, and
- * First magnetospheric imaging coupled with in-situ views.

Complete Survey by Coordinated Techniques

Coupling of latest IN-SITU & IMAGING techniques
Coupling with JEO & JGO = Multipoint studies

Launched by H-IIA

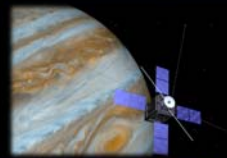


Complete Survey of Wide Time-Regime

Complete Survey of All Region

Jovian Magnetospheric Orbiter (JMO)

Optimized to Magnetospheric Sciences
for Multi-Scale studies for Jovian System



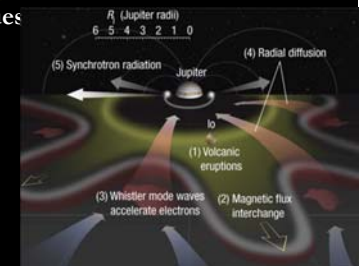
- * First multi-spacecraft: Jovian 'Geotail' with the EJSM fleet,
- * First solar wind Info: comprehensive comparison, and
- * First magnetospheric imaging coupled with in-situ views.

Complete Survey by Coordinated Techniques

Coupling of latest IN-SITU & IMAGING techniques
Coupling with JEO & JGO = Multipoint studies

Complete Survey of Wide Time-Regime

Complete Survey of All Region



Significance of remote radio obs.

- wave form, spectral, polarization, and 3D-direction finding measurements

anisotropic velocity distribution of energetic ele.
(loss-cone, beam, ...)

radio wave
direction
spectra
polarization
wave form

source location
beaming
wave mode
time variation

①Rotationally driven activities

- injections
- M-I couple

②Particle acceleration

- QP phenomena
- main oval
- satellite footprint

③Jupiter-satellite binary

- Io plasma torus
- Ganymede m'sphere

- incomplete wave experiment in JUNO mission

Summary of radio observations

