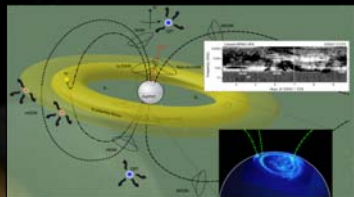


# Radio and Plasma Wave Investigations (RPWI) in Japan --- NOW: HF & RWIpre Unit I-CDR

**Radio:** first Direction/Polarization, **Subsurface** (80kHz - 45MHz)  
**Wave:** first **Wave-Particle interaction** (few - 1MHz/20kHz)  
**E-field:** first DC E-field measurement (Langmuir probe)  
**Plasma:** first Low-T plasma measurement (Langmuir probe)



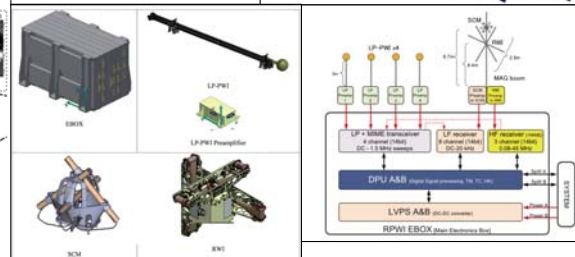
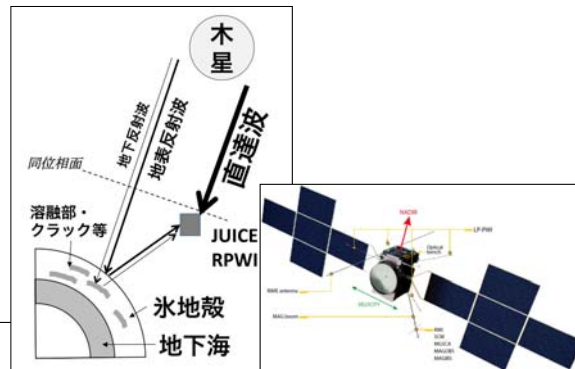
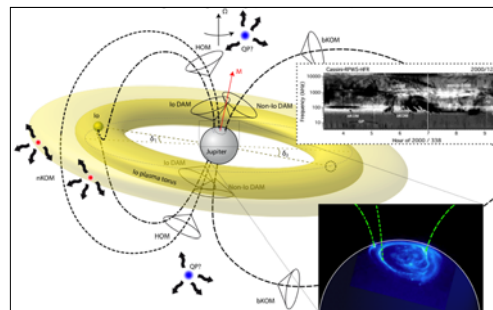
Y. Kasaba (Tohoku Univ.) + RPWI-Japan

- (1) Jovian system: Structure & Variation ~Fast rotating Giant magnetosphere~
- (2) Jovian system: Energy release ~System filled with energetic particles~
- (3) Satellite - Jupiter system ~Electrical coupling of Satellite - Jupiter~
- (4) Satellite environment ~Atmosphere, Magnetosphere, and Interiors~

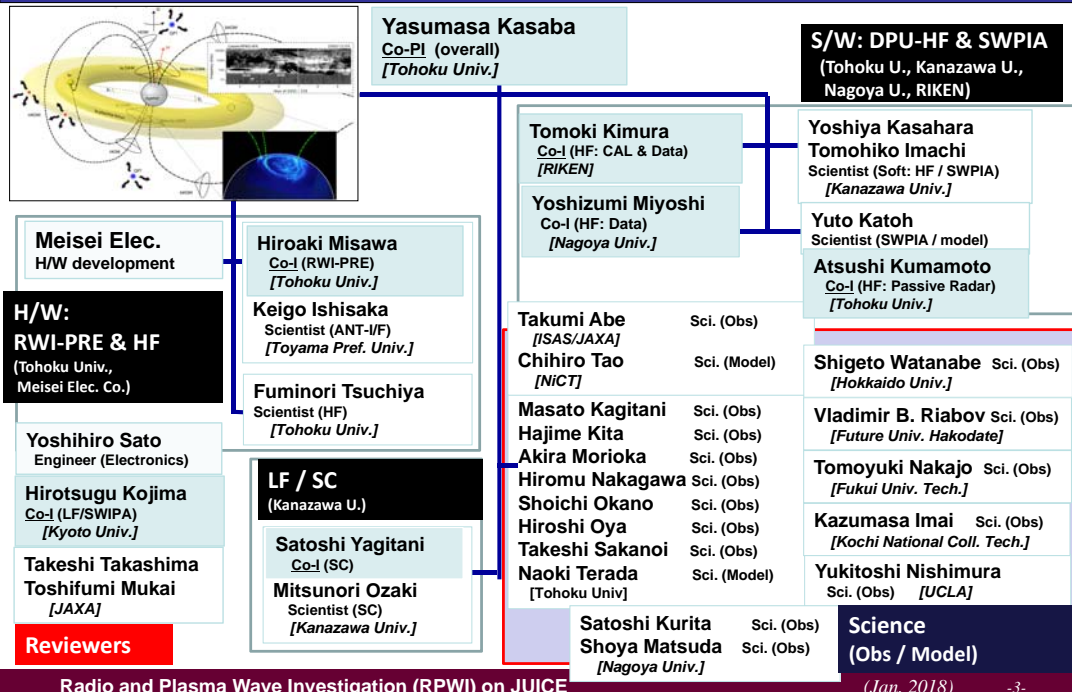
## みんなでふたたび木星へ、そして氷衛星へ その4 ~電波・プラズマ波動観測器RPWIの飛翔へ~

笠羽 康正<sup>1</sup>, 三澤 浩昭<sup>2</sup>, 土屋 史紀<sup>2</sup>, 笠原 禎也<sup>3</sup>, 井町 智彦<sup>4</sup>, 木村 智樹<sup>5</sup>, 加藤 雄人<sup>6</sup>, 熊本 篤志<sup>7</sup>, 小嶋 浩嗣<sup>8</sup>, 八木谷 聡<sup>9</sup>, 尾崎 光紀<sup>9</sup>, 石坂 圭吾<sup>9</sup>, 埜 千尋<sup>9</sup>, 三好 由純<sup>9</sup>, 阿部 琢美<sup>10</sup>, Baptiste Cecconi<sup>11</sup>, 諸岡 倫子<sup>12</sup>, Jan-Erik Wahlund<sup>12</sup>, JUICE-RPWI日本チーム

(要旨) 欧州宇宙機関(ESA)木星探査機JUICEに搭載される電波・プラズマ波動観測器RPWI(Radio Plasma Wave Instruments)は、欧州チームにとり木星探査機カッシーニ搭載のRPWS、日本チームにとり月探査機かぐや・ジオスペース探査衛星ERG・日欧木星探査機BeppiColombo搭載の電波・プラズマ波動・レーダー観測群からの発展展開となる。木星・衛星周回軌道への初投入となる低周波電子・イオンおよびDC電場観測機能、電磁場三成分のプラズマ波動観測機能、電波の方向検知・偏波観測機能、および高度オンボード処理によるパッシブ表面・地下探査レーダー機能や波動-粒子相互作用検出機能により、木星磁気圏の構造・ダイナミクスおよびガリレオ衛星群との相互作用、氷衛星の大気・電離圏および氷地殻・地下海へのアクセスを狙う。2016年7月に仙台で行われた「RPWIチーム会合」での最新状況を踏まえ、1970年代に遡る本チームの経緯・目標・展望を述べる。



## RPWI: Contribution from Japan ---- TEAM structure



## Radio and Plasma Wave Investigations (RPWI)

**(2) Jovian system: Energy**  
 ~System filled with Relativistic particles~

Particle accelerations along the field lines?  
 MEV acceleration by Wave?  
 Injection of plasmas into the inner region?

**first Direction/Polarization/Reflection!** HF

<Radio: Remote with UV/IR & Radar>  
 Global high-Energy activities!  
 Remote sounding of Satellites!

<Wave: In-situ>  
 Direct detection of Electromagnetic energy exchanges!

**first Wave-Particle interaction**

**(3) Satellite - Jupiter system**  
 ~Electrical coupling of Satellite - Jupiter~

Current connections between them?  
 Enhancement by plasma from satellites?

**(1) Jovian system: Structure**  
 Fast rotating Giant magnetosphere ~

MIT Couplings?  
 Retraction of rot. Energy to outside?  
 Effects from outside? SW / EUV

**first detection!**

<DC E-field: In-situ>  
 Grasp the plasma motion & acceleration E-field!

<Low-T plasmas: In-situ>  
 Grasp the plasmas around/from satellites!

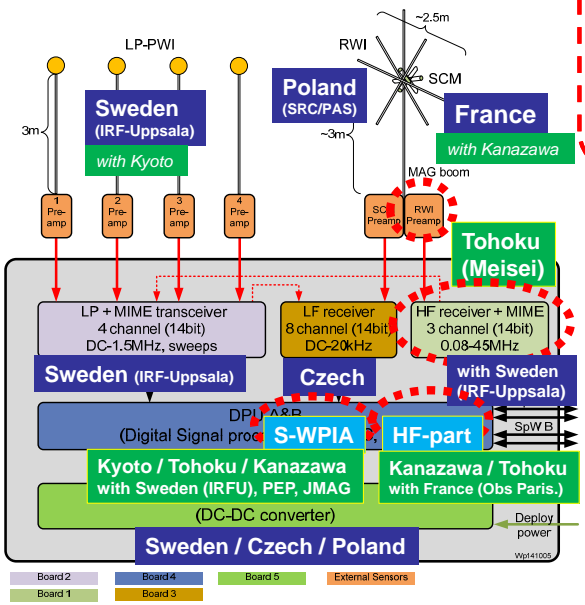
**first detection!**

**(4) Satellite: Environment & Crust**  
 ~Electrical sounding of Atmosphere / Interior~

Plasma production: Volcano, Water, ...?  
 Conductivity of Surface & Subsurface?

# RPWI: Contribution from Japan

[Co-PI] Y. Kasaba (Tohoku Univ.)



**<Remote sensing: Radio>**

**[HF-System]**

- \* RWI Preamp (Tohoku / Meisei)
- \* HF - Receiver (Tohoku / Meisei + IRF-Uppsala)
- \* DPU: HF - Software (Tohoku / Kanazawa)

**HF Passive Radar**

**<In-situ: Wave, DC-field, Low-T plasma>**

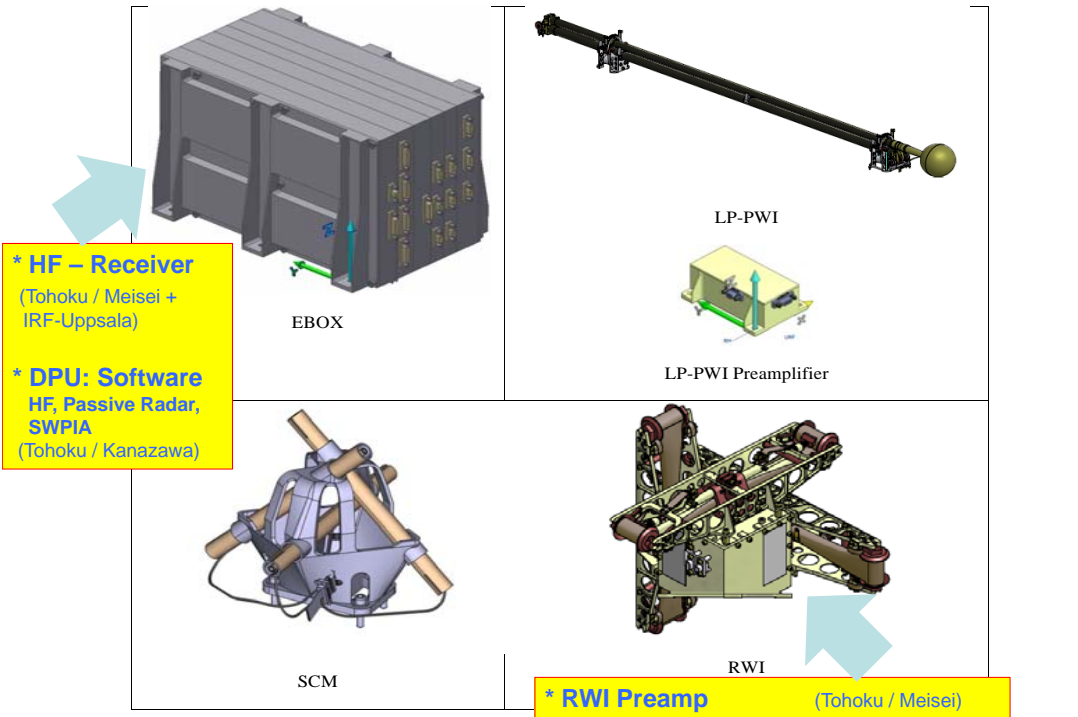
**[LF & LP-System]**

- \* Software-type WPIA (Tohoku/Kyoto/Kanazawa)
- \* Contribution to design: E/B sensor, Langmuir Probe (Kyoto/Kanazawa/Tohoku)

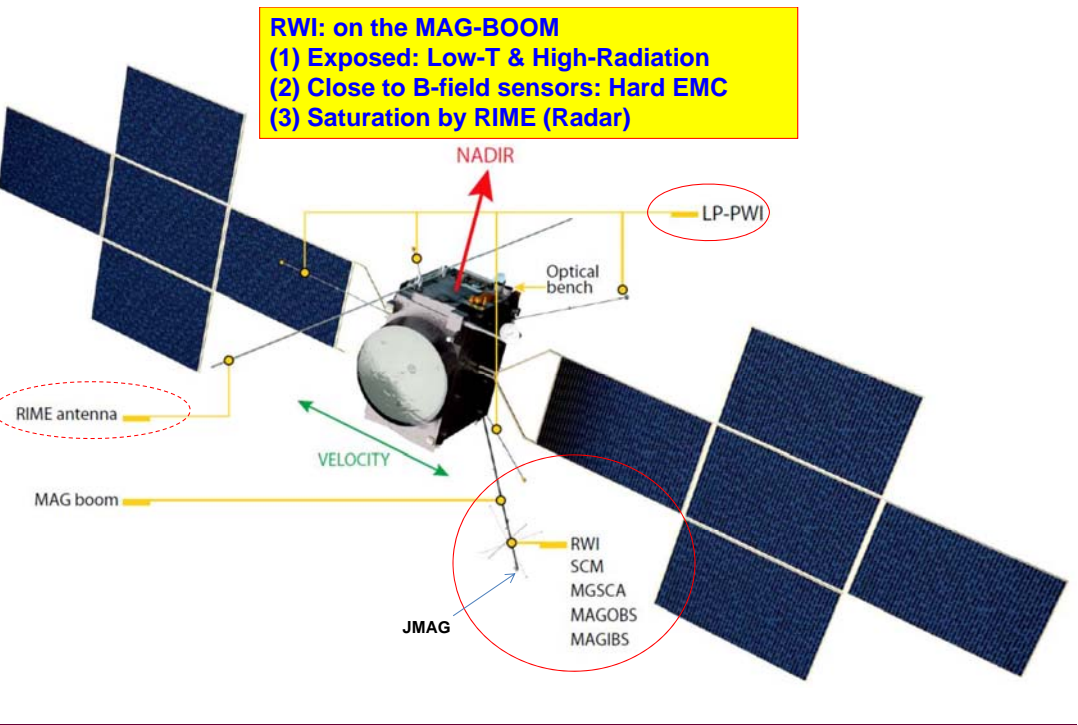
**S-WPIA**

**[Science]**  
Hokkaido, Hakodate FU, Tohoku, Nagoya, Toyama PU, Kanazawa, Fukui IT, Kyoto, Kouchi NCT, RIKEN

Radio and Plasma Wave Investigation (RPWI) on JUICE (Jan. 2018) -6-



Radio and Plasma Wave Investigation (RPWI) on JUICE (Jan. 2018) -7-



Radio and Plasma Wave Investigation (RPWI) on JUICE (Jan. 2018) -8-

# RPWI: HW Contribution from Japan ---- RWI-preamp + HF

## Shipment of HF/RWI EM2-1 from Meisei: 29 May 2017



Radio and Plasma Wave Investigation (RPWI) on JUICE (Jan. 2018) -9-



# RPWI: H/W Contribution from Japan ---- RWI-preamp

## High Radiation

"Al 3.0mm + Ta 1.3mm" → <100krad  
(established)

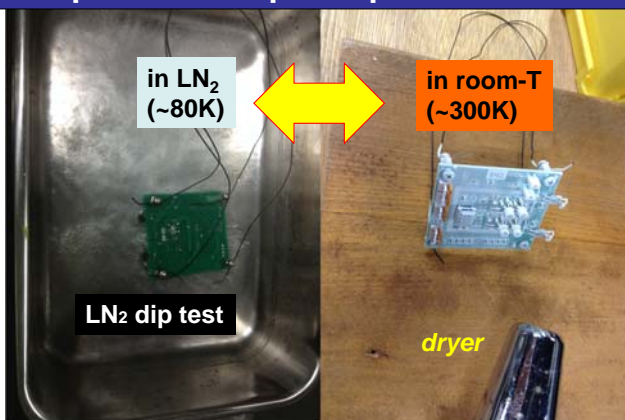
## Long Harness (~20m for 50MHz)

- Tested & revised to 'Co-axial 20m', well covered by Rad-shield  
→ Performance was confirmed by EM2.  
(established)

## Low/High Temperature

**Thermal Vacuum Test:**  
+110 ~ -180 degC [off-status]  
by BBM#4 (2015)  
EM1-1/2 (2016)  
EM2-1 (2017)

[EM2-1]  
\* When RWI-pre PCB > -150 degC, satisfied performance.  
\* When RWI-Chassis = -170 degC, RWI-pre PCB could be -140 degC.  
(established)

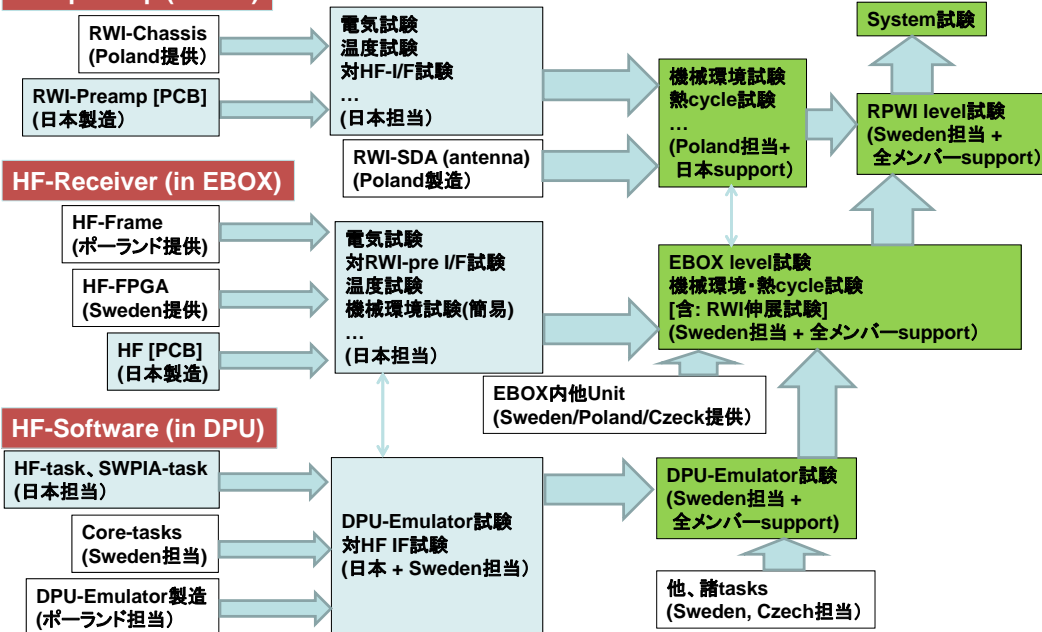


**LN2 low temperature shock-cycle test**  
'300K <-> 80K' x 20  
by BBM#4 (2015)  
EM1-0 (2016)  
EM2-0 (2017)  
→ No damage was found.  
(established)



# RPWIの日本側担当部に関する検証方法: EM2以降

## RWI-preamp (in RWI)



# RPWI: Contribution from Japan ---- Schedule

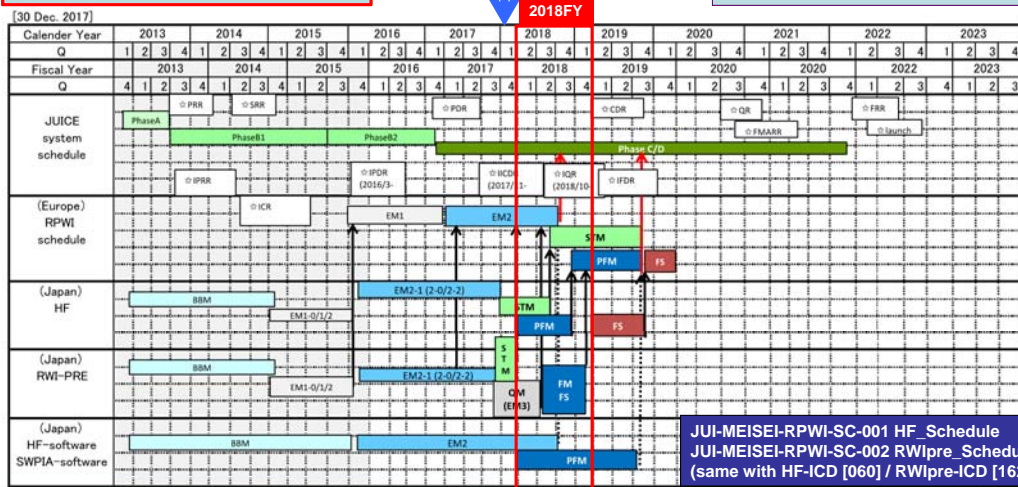
## [RWI preamp - shipment]

EM2-1 (usable as STM) E Mar 2018  
[Renovation: from Jan 2018]  
QM(=EM3) E June 2018  
[Manufacturing: from March 2018]  
FM/FS E Feb 2019  
[Manufacturing: from Nov 2018]

## [HF - shipment]

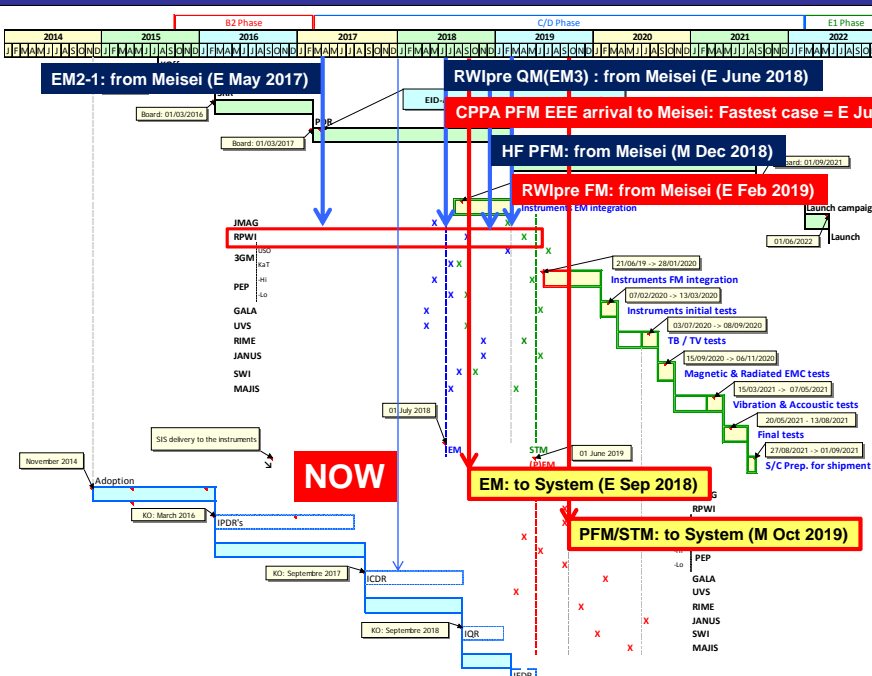
STM E July 2018  
[Manufacturing: from Apr 2018]  
PFM M Dec 2018  
[Manufacturing: from Aug 2018]  
FS M Nov 2019  
[Manufacturing: from July 2019]

**NOW**



JUI-MEISEI-RPWI-SC-001 HF\_Schedule  
JUI-MEISEI-RPWI-SC-002 RWIpre\_Schedule  
(same with HF-ICD [060] / RWIpre-ICD [162])

# <ref> System Schedule ("PI day #10 - Presentation #07 - Instrument schedule V3") [Oct 2017]



# RPWI: H/W Contribution from Japan ---- RWI-preamp + HF

[hard points] radiation, low/high-temperature, long harness (~20m)

## RWI-ANT

Poland (Astronika)

2.5m tip to tip x 3 pairs  
(8m from S/C, ~20m harness)

(80k-45MHz) x 3h (u/v/w)

DEPLOYED (SCALE 1:6)

## RWI-Pre EM2-1 (EM2)

(shipped to IRFU: May 2017)  
(to be shipped to System: June 2018)

→To be refurbished for 'STM-usage'  
(shipped to AST: End March 2018)

## RWI EM2-2 (BBM)

[test: Jan 2018-]  
(to be kept in Japan, till 2033)  
for the Elec. design evaluation of QM

## RWI-pre QM

(shipped to AST: E June 2018)

RWI-Pre  
Tohoku Univ  
Meisei

[Heritage]  
MMO/WPT-Pre  
Kaguya/PWS-Pre

Radio and Plasma Wave Investigation (RPWI) on JUICE

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# RPWI: H/W Contribution from Japan ---- RWI-preamp + HF

[hard points] radiation, low/high-temperature, long harness (~20m)

## RWI-ANT

Poland (Astronika)

2.5m tip to tip x 3 pairs  
(8m from S/C, ~20m harness)

(80k-45MHz) x 3h (u/v/w)

DEPLOYED (SCALE 1:6)

## HF

Tohoku Univ  
Meisei

with HF-FPGA  
from IRF-Uppsala

## [Heritage]

Kaguya/LRS  
ERG/HFA

## HF EM2-1 (EM2)

(shipped to IRFU: E May 2017)  
(to be shipped to System: June 2018)

## HF EM2-2 (BBM)

[test: Jan 2018-]  
(to be kept in Japan, till 2033)  
for the Elec. design evaluation of PFM

## HF STM

(shipped to IRFU: E July 2018)

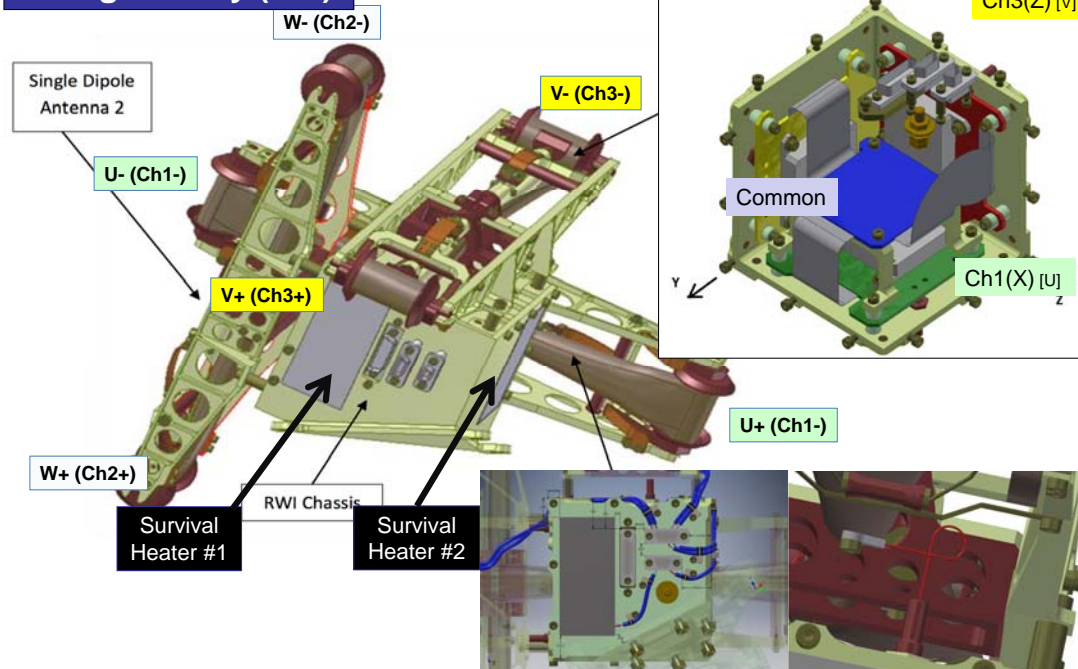
## HF PFM

(shipped to IRFU: M Dec 2018)

Radio and Plasma Wave Investigation (RPWI) on JUICE

(Jan. 2018) -15-

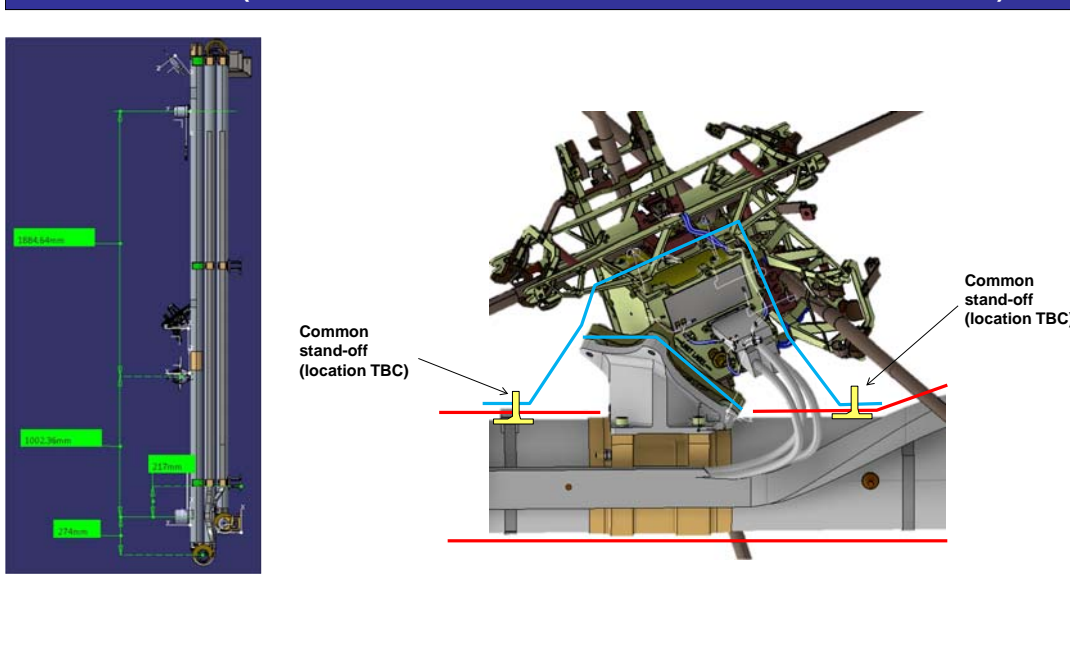
# RPWI: geometry (QM)



Radio and Plasma Wave Investigation (RPWI) on JUICE

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# RPWI on Boom (QM: from JUI-ADST-SYS-TN-000265\_01-1 MLI-definitions)



Radio and Plasma Wave Investigation (RPWI) on JUICE

This document is provided by JAXA (Jan. 2018)



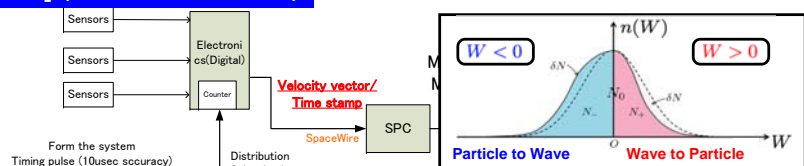
# [DPU: Software-type Wave Particle Interaction Analyzer (SWPIA)]

Implementation: by IRFU (supported by LF + HF)

[Specification to IRFU: from Tohoku / Kyoto / Kanazawa]  
 'JUI-IRFU-RPWI-TN-091' (SWPIA design)

## [PEP/ISA] (ion distribution function)

[Heritage]  
 ERG/S-WPIA



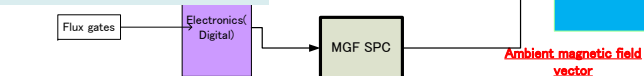
## [RPWI/LF] (E- and B-waveform)

## [RPWI/DPU] (correlations between them)

[Arase] "special MDP" + PWE, ...  
 Electron interaction  
 (~ kHz)

[JUICE] SpW I/F: from PEP to RPWI  
 Ion interaction

## [JMAG] (background DC-B field)



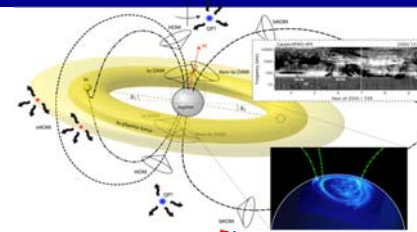
Radio and Plasma Wave Investigation (RPWI) on JUICE

(Jan. 2018) -21-

# [DPU: Passive SubSurface Radar (PSSR)]

[Specification to IRFU: from Tohoku + IRFU]  
 JUI-IRFU-RPWI-TN-087 (PSSR design)

[Heritage]  
 Kaguya/LRS

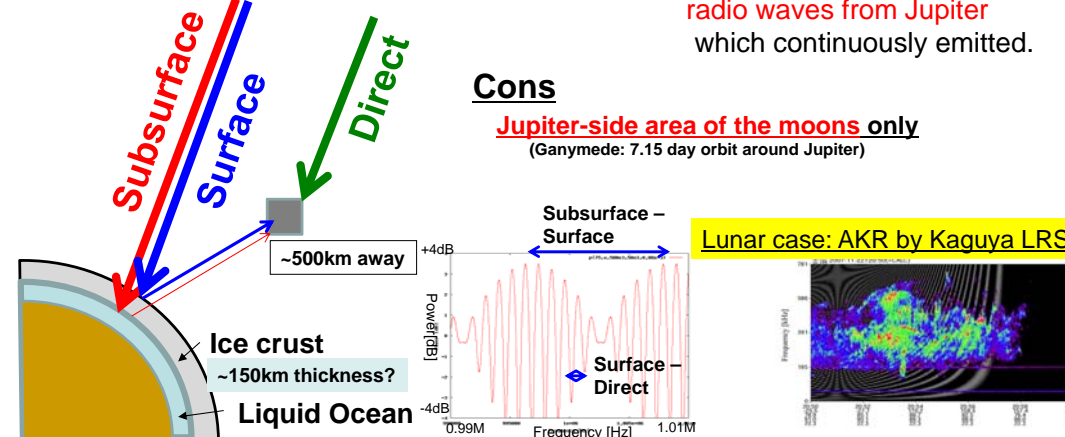


## Pros

Radio Source: Low-Frequency (& Wide-band) radio waves from Jupiter which continuously emitted.

## Cons

Jupiter-side area of the moons only  
 (Ganymede: 7.15 day orbit around Jupiter)



Radio and Plasma Wave Investigation (RPWI) on JUICE

(Jan. 2018) -22-