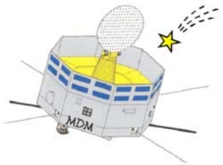


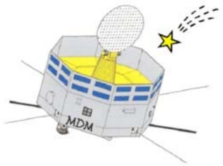
BepiColombo MMO Payload

Mercury Dust Monitor (MDM)

1st Meteor and Dust meeting

at National Astronomical Observatory of Japan

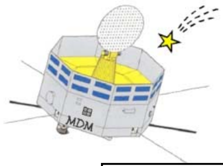
3 July 2007

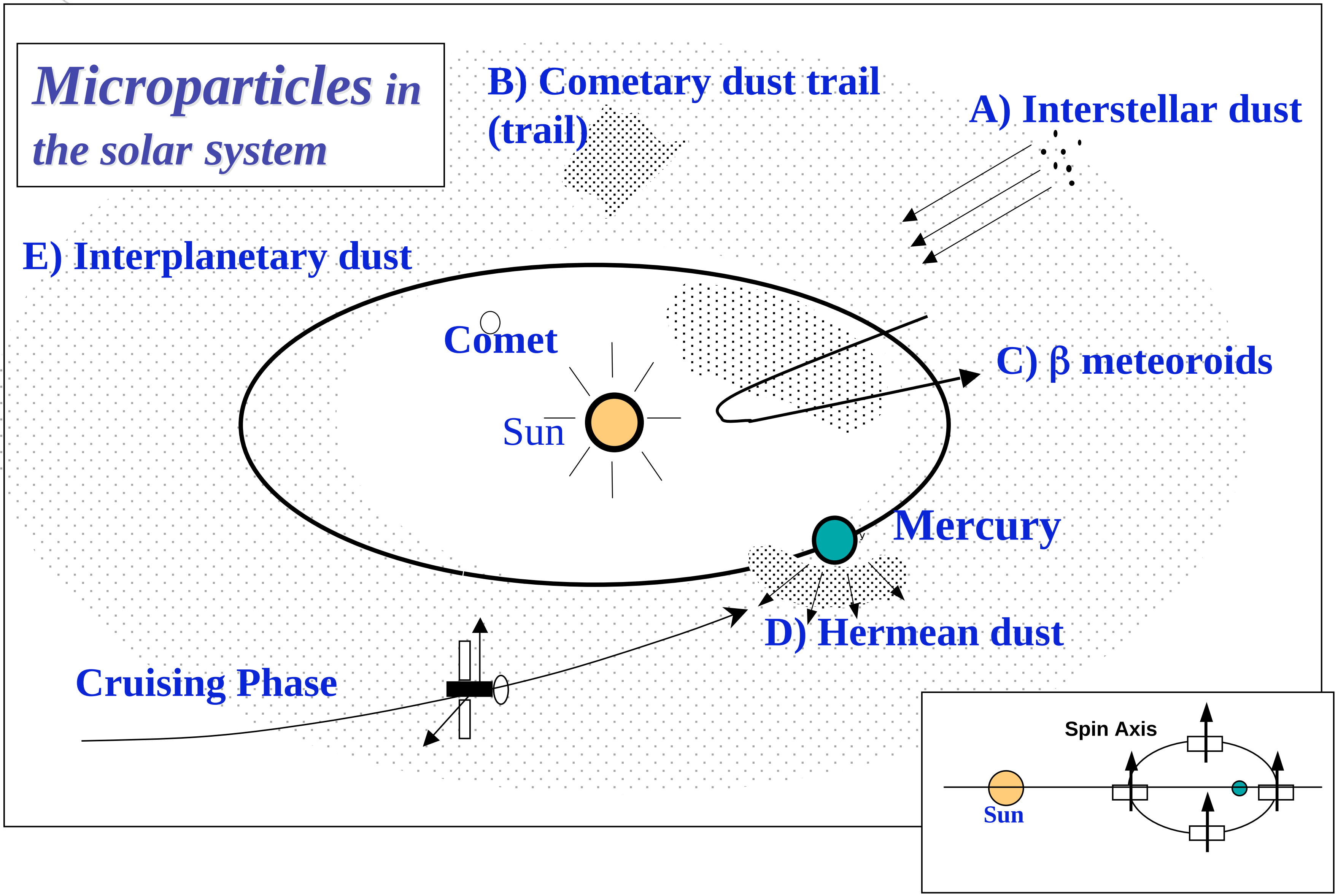


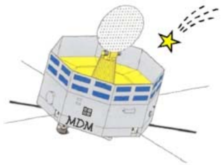
BepiColombo MMO Payload

Mercury Dust Monitor (MDM)

K.Nogami ---Dokkyo Medical University
M.Fujii --- FAM Science Co., Ltd.,
H.Ohashi ---Tokyo University of Marine Science and Technology
T.Miyachi --- Waseda University
S.Sasaki --- National Astronomical Observatory of Japan
H.Yano --- ISAS / JAXA
A.Fujiwara --- ISAS / JAXA
H.Shibata --- Kyoto University
S.Minami --- Osaka City University
S.Takechi --- Osaka City University
T.Iwai --- University of Tokyo
G.Kuraza --- Waseda University
T.Ohnishi --- Osaka City University
E.Grün --- Max Planck Institute for Nuclear Physics, Germany
R.Srama --- Max Planck Institute for Nuclear Physics, Germany



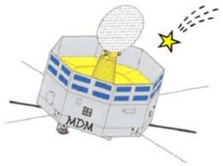

Microparticles in
the solar system
B) Cometary dust trail
(trail)
A) Interstellar dust
E) Interplanetary dust
Comet
Sun
C) β meteoroids
Mercury
D) Hermean dust
Cruising Phase
Spin Axis
Sun



Historical dust mission of inner solar system

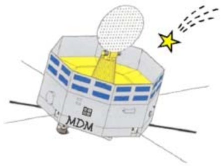
Spacecraft	distance range (AU)	spin axis direction	sensor orien- tation (deg.)	mass thresh- old (g)	sensitive area (m^2)	solid angle (sr)	dy- namic range
Helios 1/2	0.3–1	N	65, 134	$9 \cdot 10^{-15}$	0.012	1.23	10^4
Galileo	0.7–5.4	S, E	120	$4 \cdot 10^{-15}$	0.1	1.4	10^6
Pioneer 9	0.75–0.99	N	90	$2 \cdot 10^{-13}$	0.0074	2.9	200
Pioneer 8	0.97–1.09	N	90	$2 \cdot 10^{-13}$	0.0094	2.9	200
HEOS 2	1	var.	0	$2 \cdot 10^{-16}$	0.01	1.03	10^4
Hiten	1	N	90	$2 \cdot 10^{-15}$	0.01	1.5	$3 \cdot 10^4$
Ulysses	1–5.4	E	85	$4 \cdot 10^{-15}$	0.1	1.4	10^6
Pioneer 10	1–18	E	180	$8 \cdot 10^{-10}$	0.26(1)	2.8	1
Pioneer 11	1–10	E	180	$6 \cdot 10^{-9}$	0.56(1)	2.8	1

(1) initial area, actual area decreased as cells were punctured



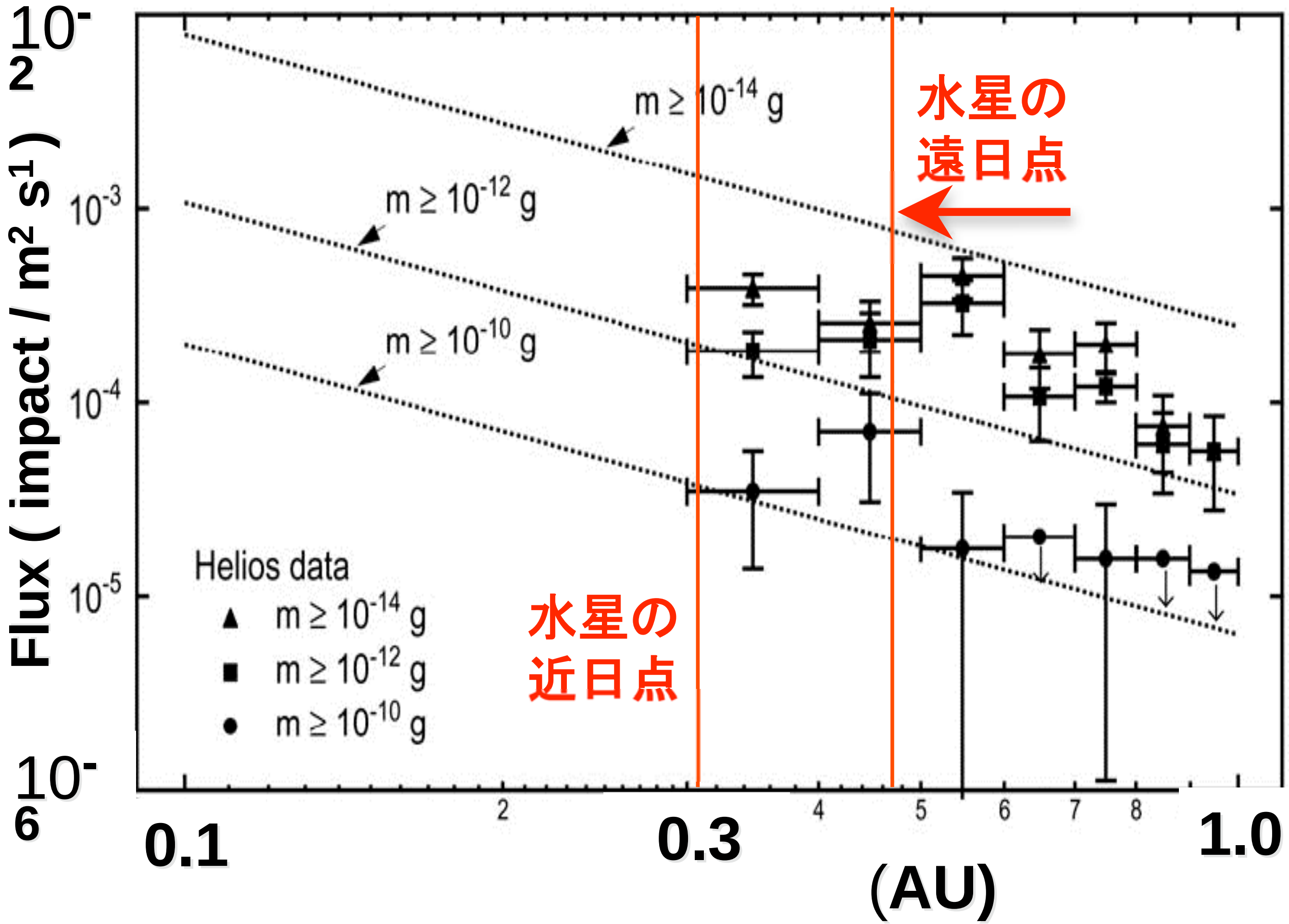
Scientific Objectives

Dust Types	*Scientific Interests*
Dust flux within the Inner Solar System	Confirm the flux and size distribution as a function of the heliocentric distance. In-situ measurement to constrain zodiacal dust cloud distribution model.
Cometary Dust	Possible encounters with the cometary dust trails and highly eccentric trajectories.
Beta Meteoroids	Direct flux measurement in the vicinity of Mercury (0.31-0.47 AU) help to understand mechanism and location.
Interstellar Dust	Possible detection of large interstellar dust (>>1 micron) intruding so close to the
Dust to Mercury (V orbit = 47.5 km/s)	Investigation of temporal and directional variations of dust influx throughout Mercurian orbit to identify the key meteoroid sources. Estimate external mass accretion rate to the Mercurian surface Constraint to space weathering effect on the Mercurian surface. Assessment of meteoroid impact contribution to the formation of the tenuous Na-K atmosphere.
Dust from Mercury (V esc.= 4.25 km/s)	Search for Mercurian dust ejection (e.g., temporal dust cloud?) by meteoroid impacts, similar to the Jovian satellites. Possible interaction with the magnetic field, similar to the Jovian satellite dust stream.



Dust flux near Mercury

from Mann et al. 2003



BepiColombo/MMO
DM / SWG #6 [May 2007]

Mission Scenario (no change)

Launch: 2013 August

Earth/Lunar swing-by
Venus swing-by x 2
Mercury swing-by x 2

Interplanetary Cruising

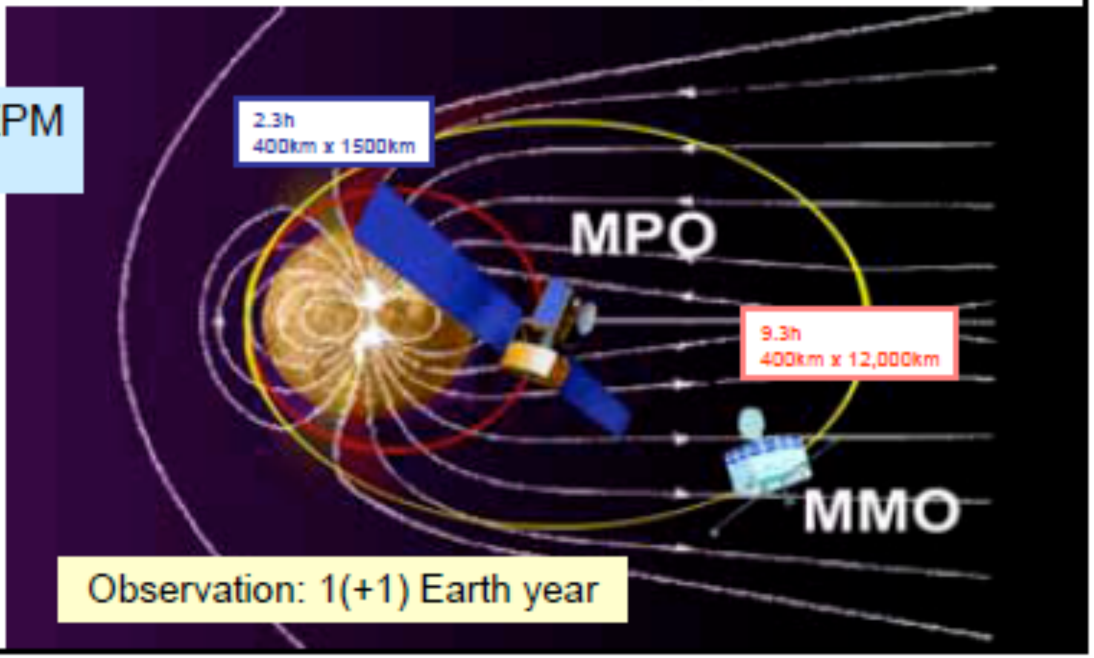
Electric Propulsion [SEPM]

Arrival: 2019 August

Mercury Orbit Insertion
Chemical Propulsion [CPM]

MCS = MMO+MPO+CPM+SEPM
(Mercury Cruise Composite System)

launched by
Soyuz Fregat 2B
from Kourou

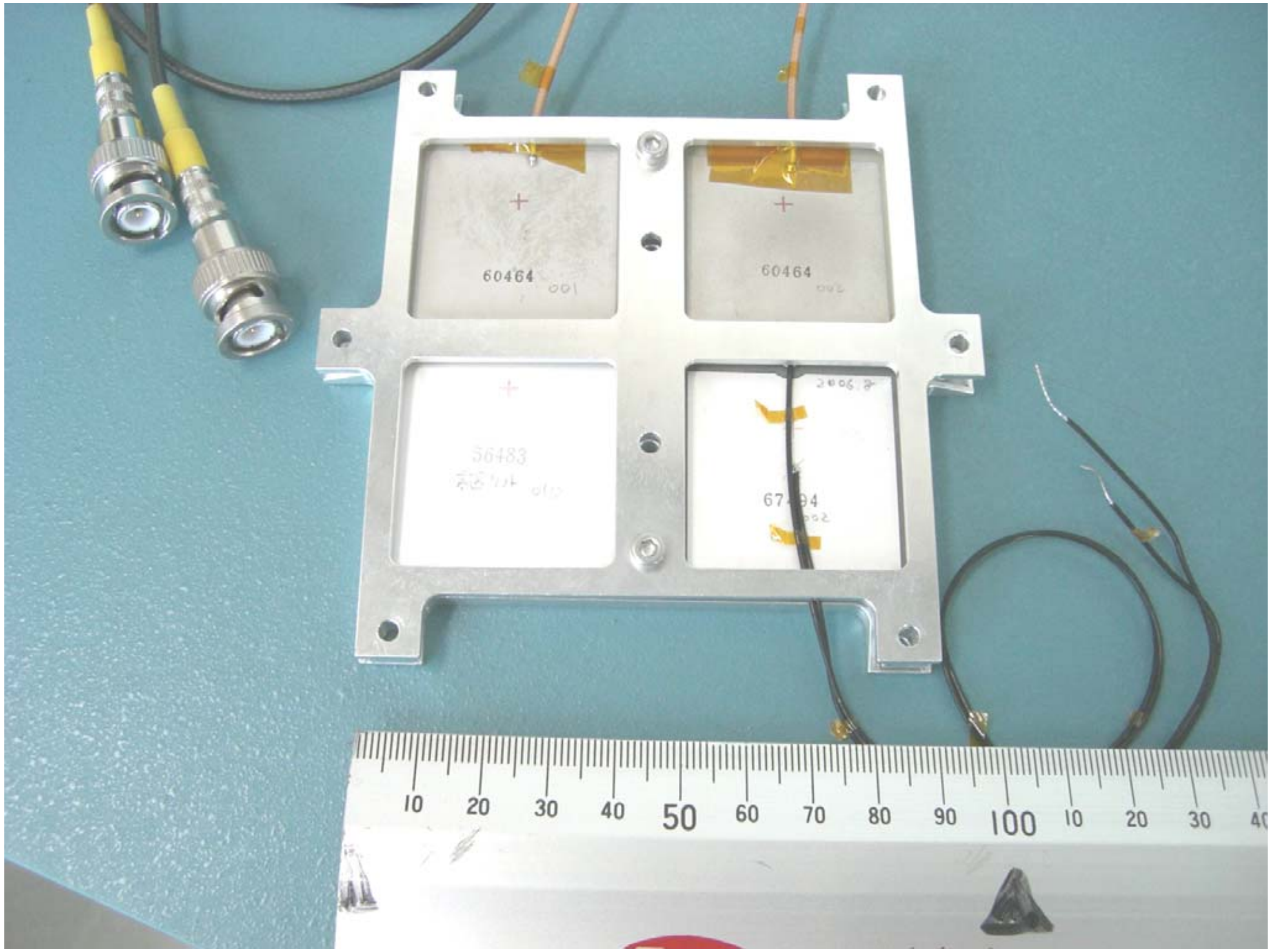


Observation: 1(+1) Earth year

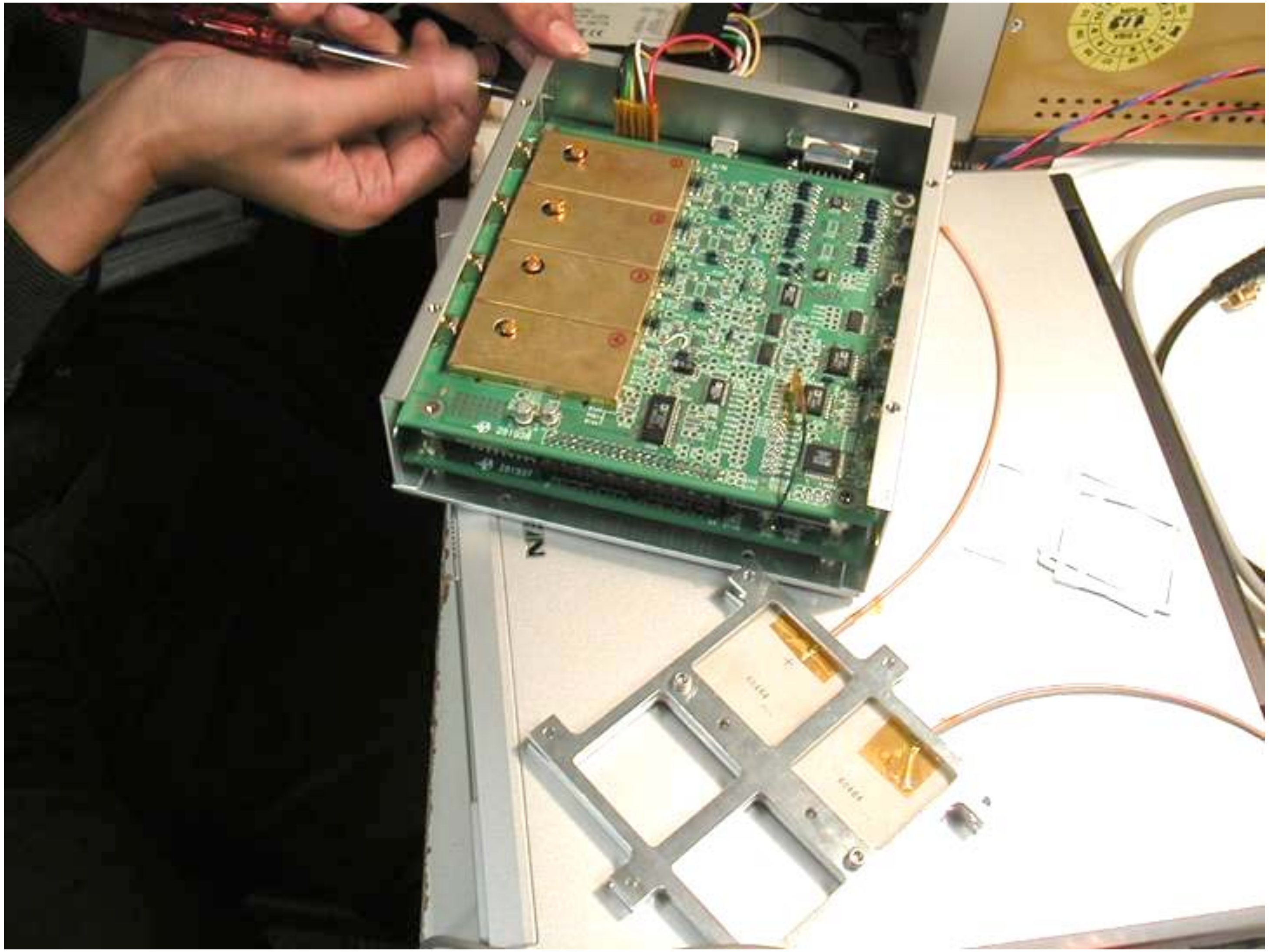
Red: JAXA
Blue: esa

MDM-S 4 PZT sensors set in the frame

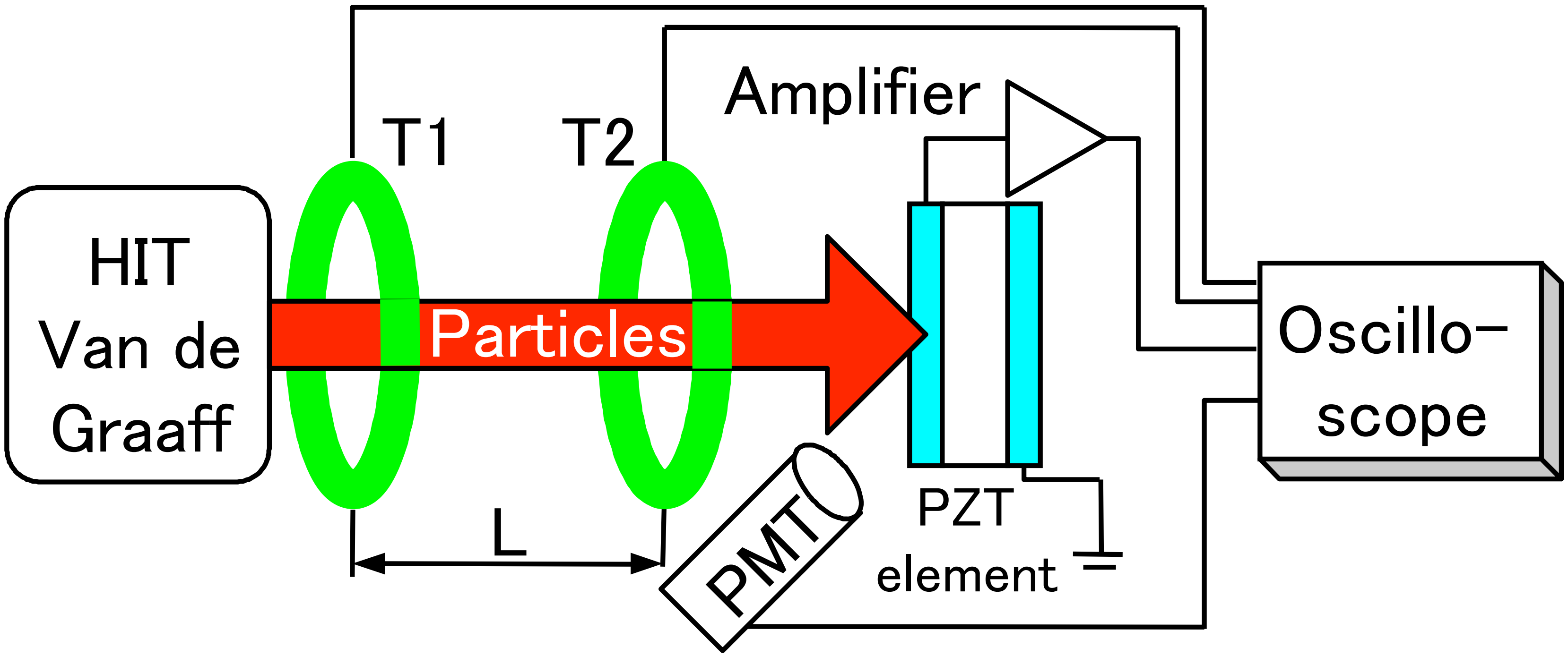
PZT: 4cm×4cm×2mm



Circuit board & sensor frame



Van de Graaff dust accelerator



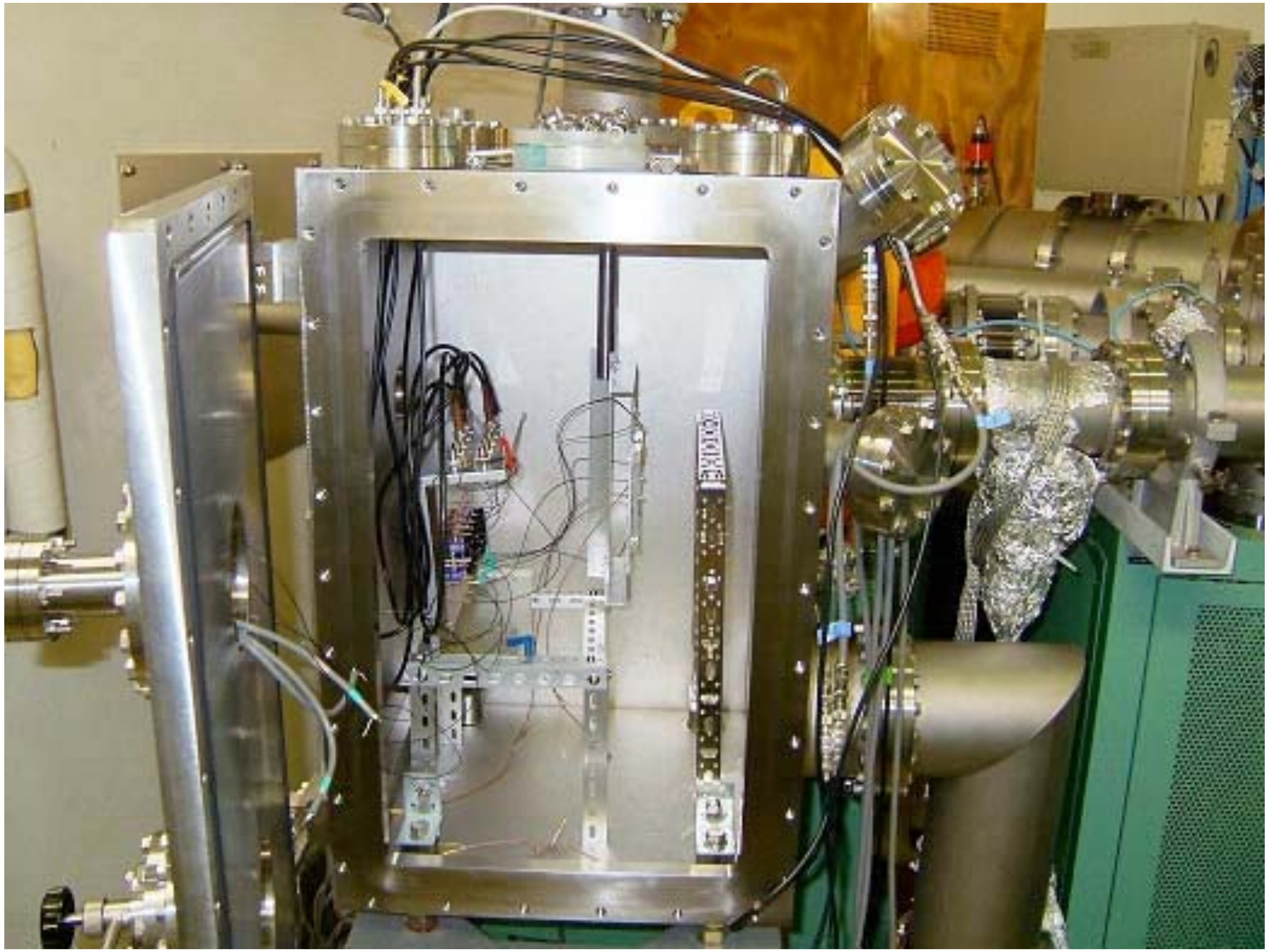
flight time: *t* velocity: $v = L/t$

charge: $q = cV$, induced voltage *V* and capacitance 1pF.

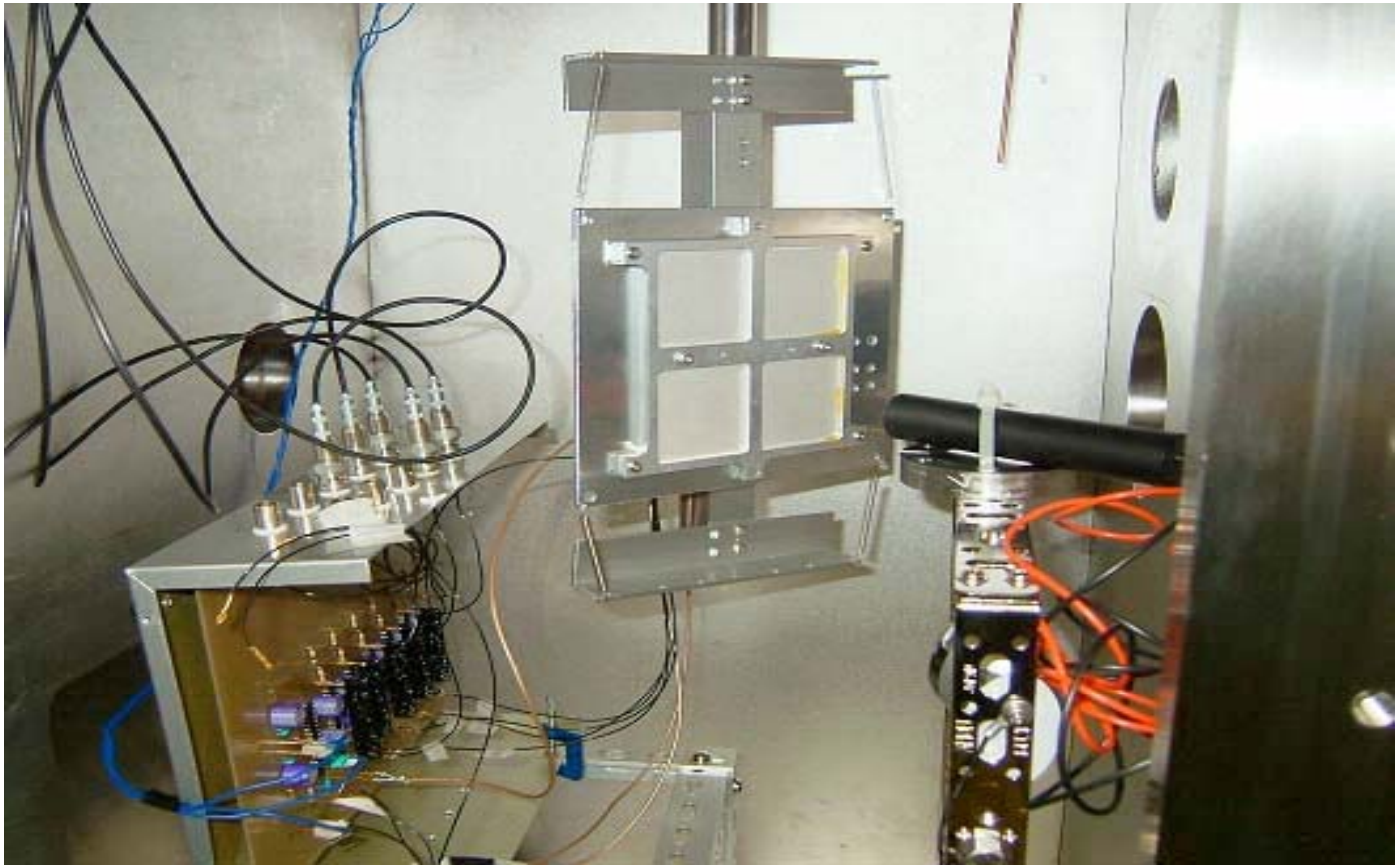
energy: $mv^2/2 = qU$, acceleration voltage *U*

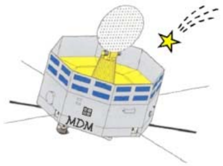
mass: $m = 2qU/v^2$

Experiment chamber of the dust accelerator at HIT



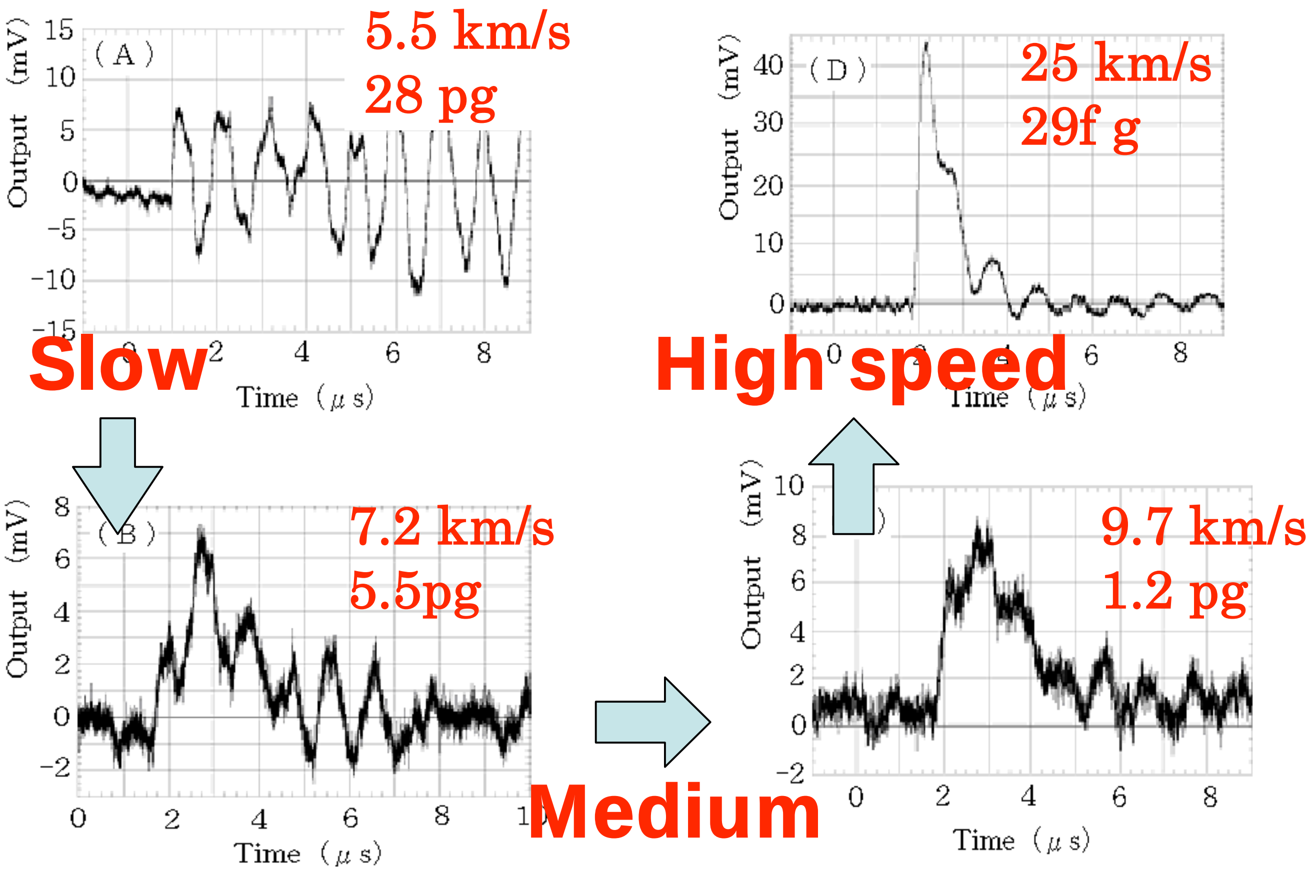
PZT sensor in the dust accelerator chamber



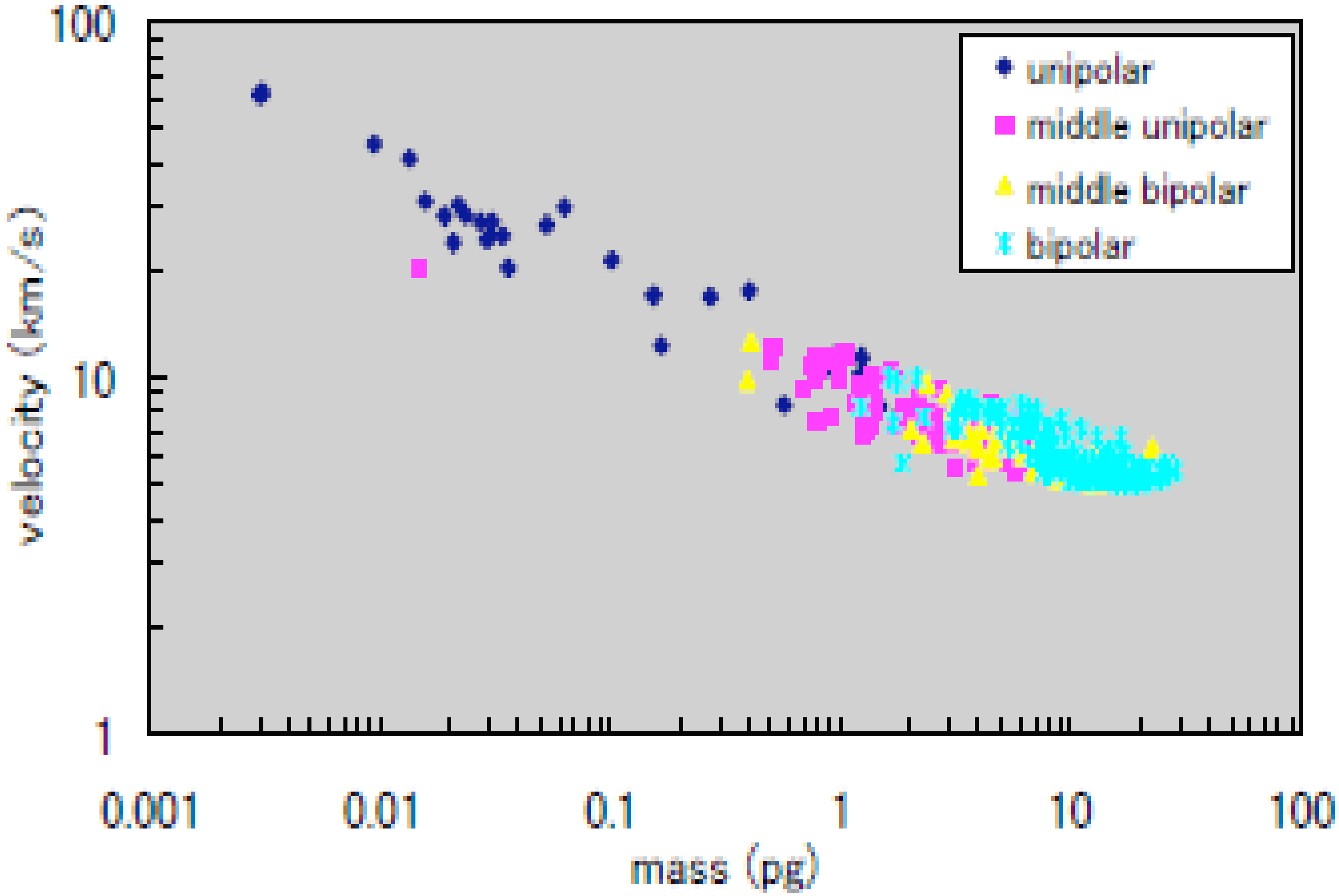


Typical waveform (MPI-K)

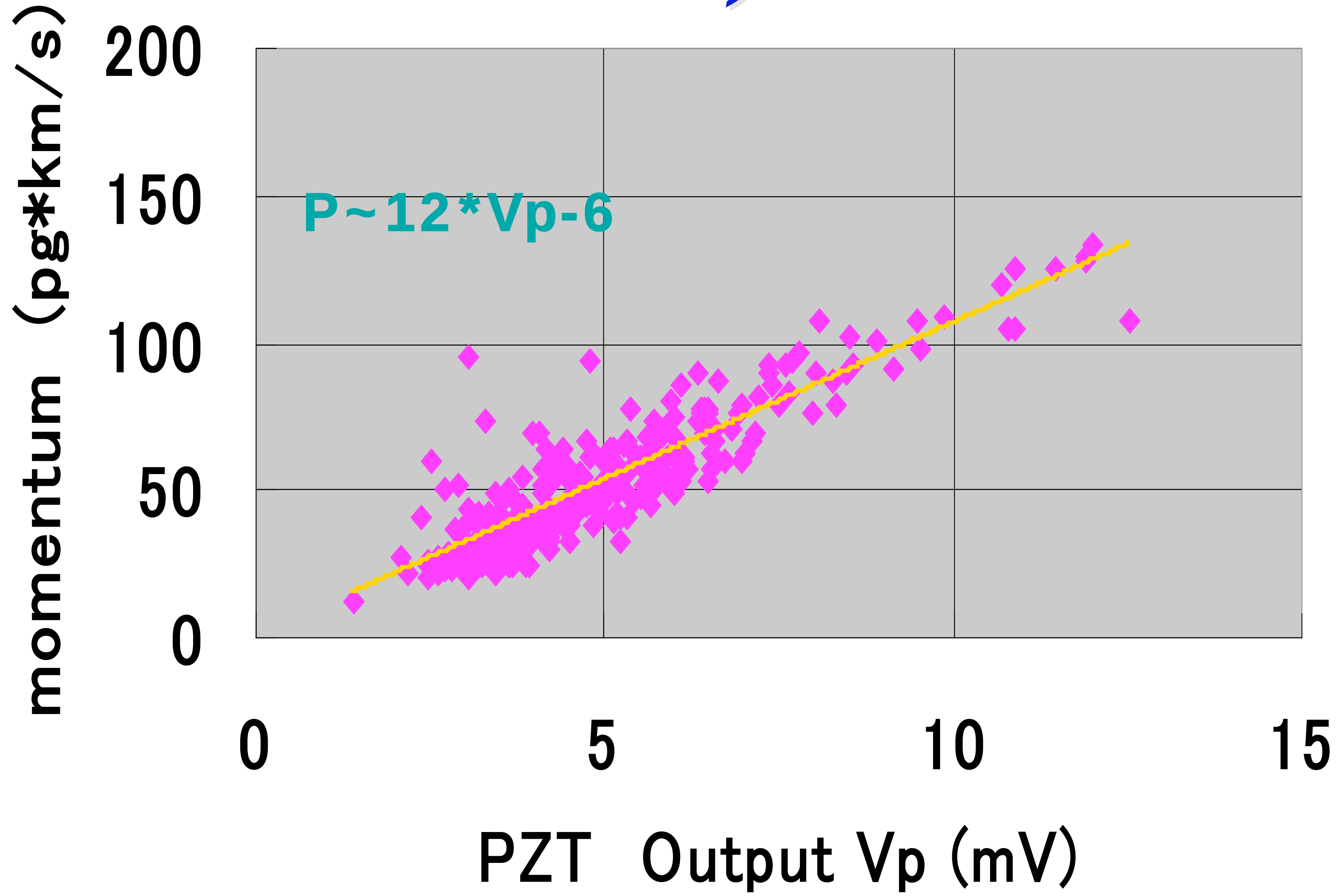
Change with velocity (Iron particles)



Particle mass vs. velocity by the van de Graaf dust accelerator

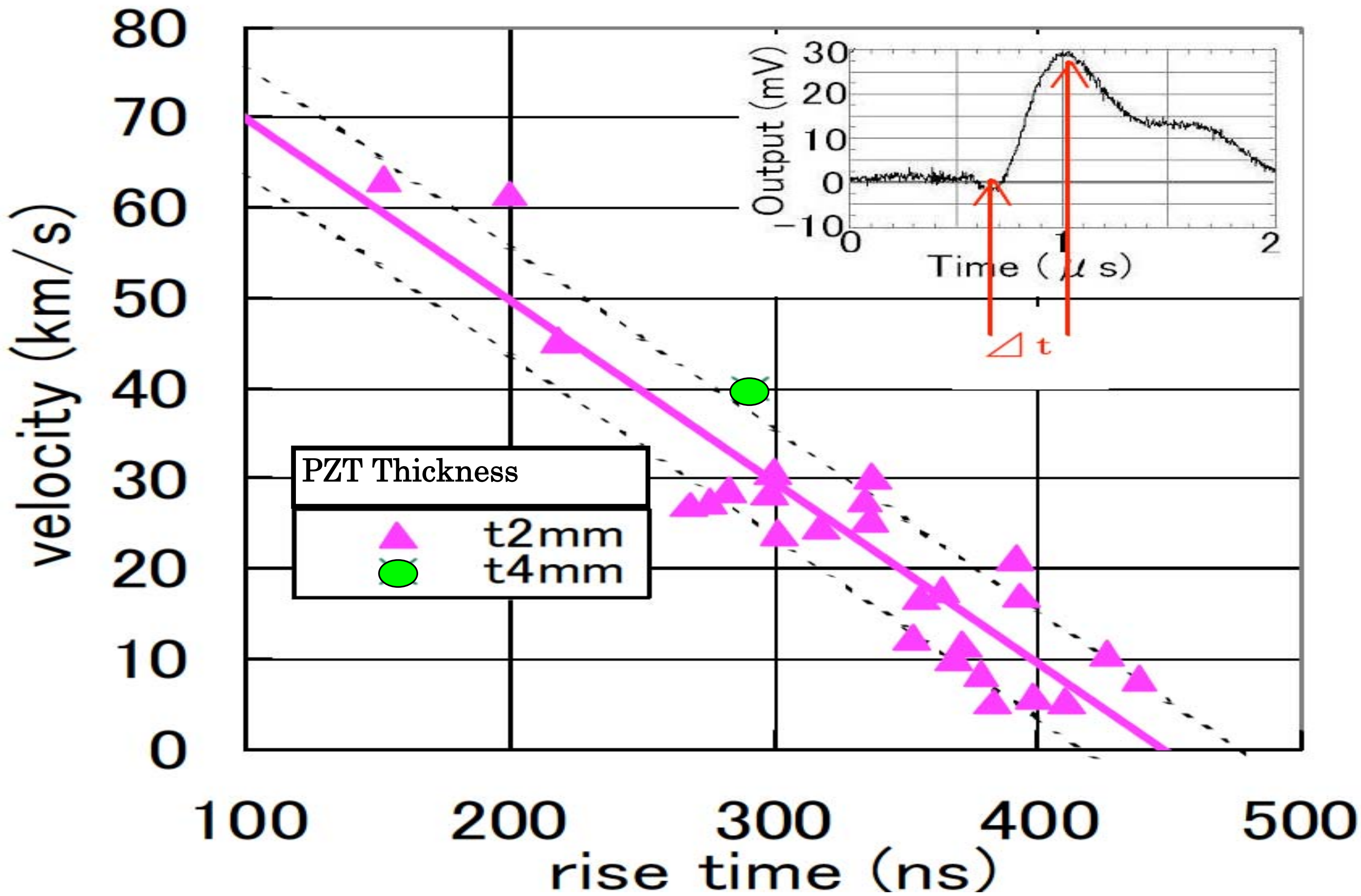


Vp vs momentum (Sample Ⅱ)



Rise time vs. velocity of single peaked pulse

High speed impact (> 8 km/s)



水星の近日点での衛星

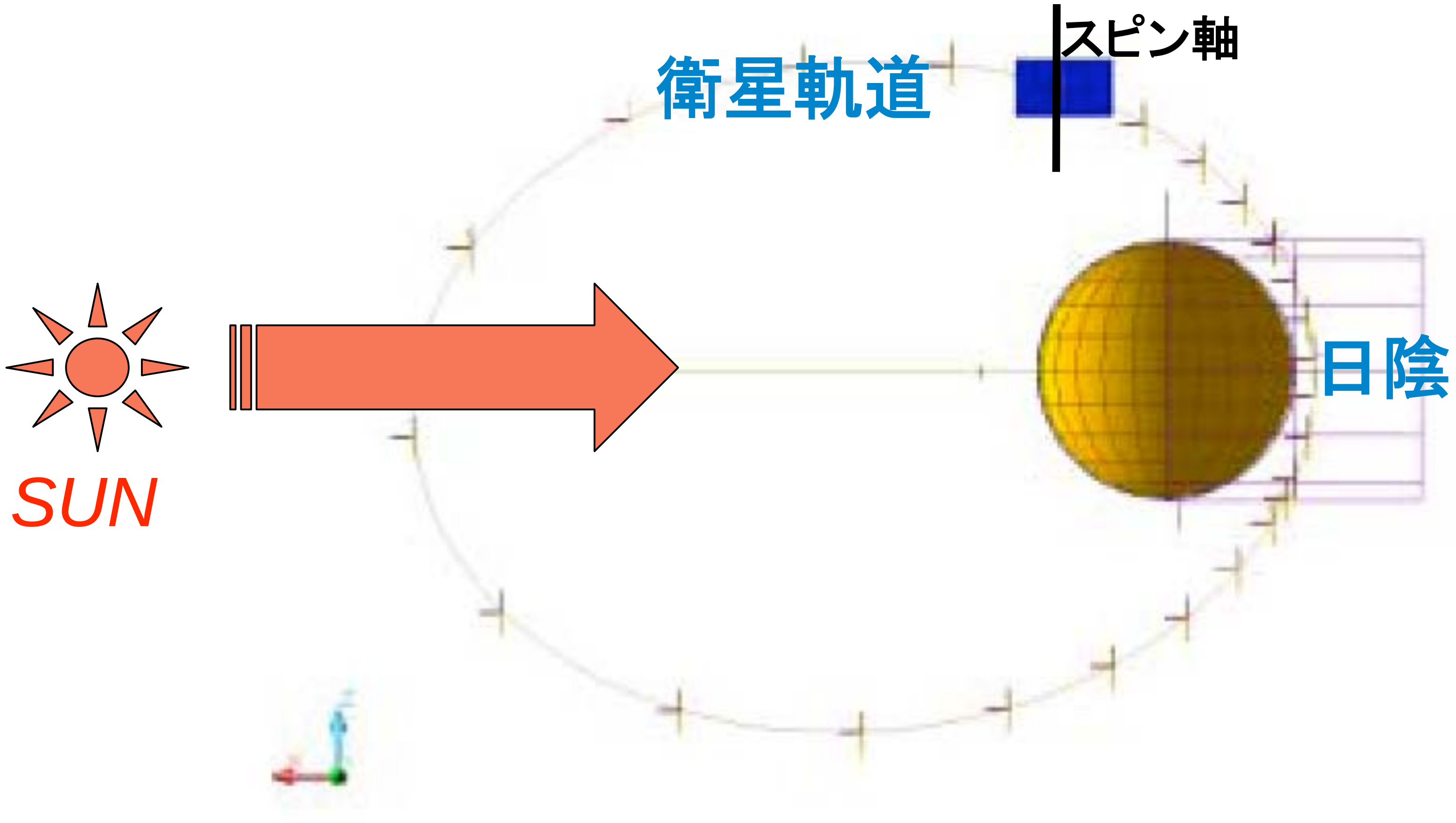
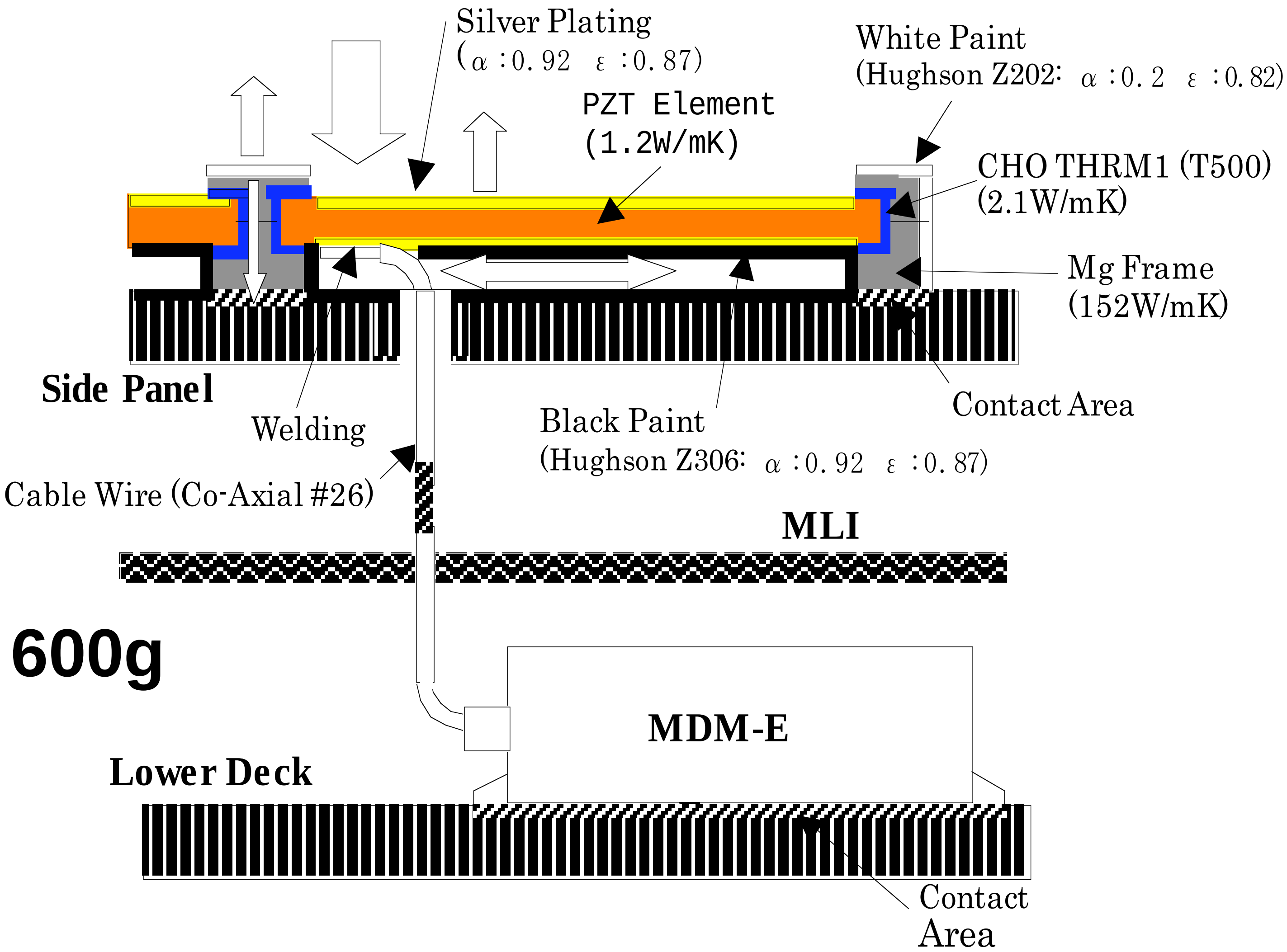


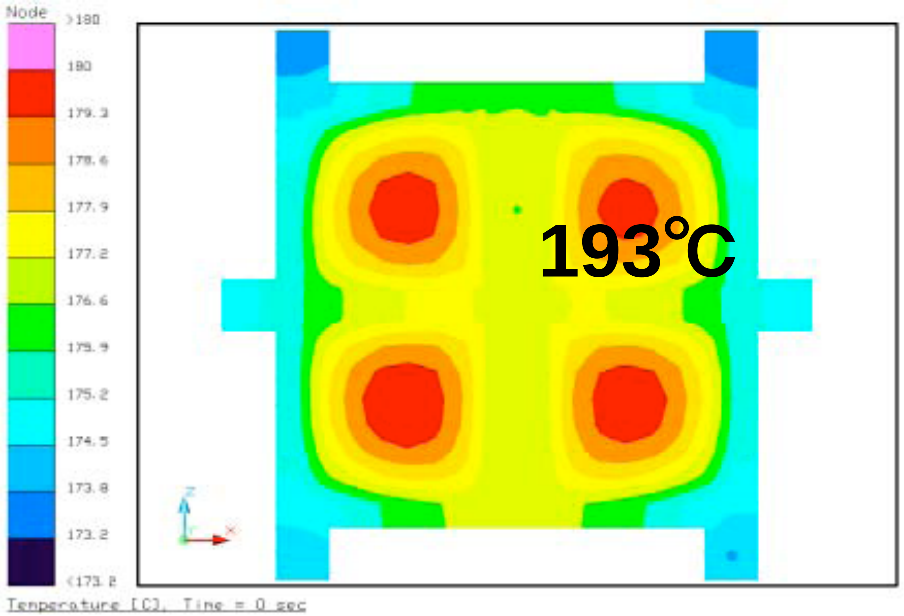
図 3　軌道図（V1-HOT-A_OBSCOM）

Installation of MDM and heat flow



Total ≒ 600g

Thermal mathematical calculation of the PZT sensor



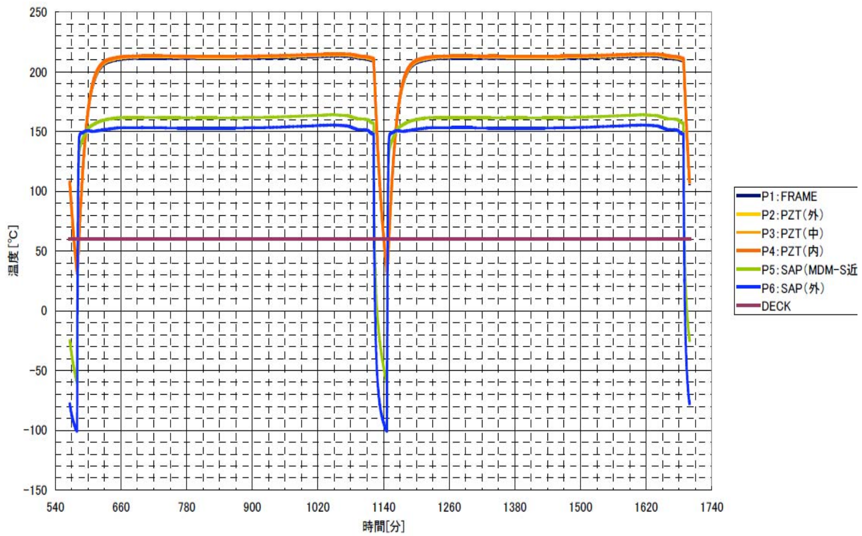
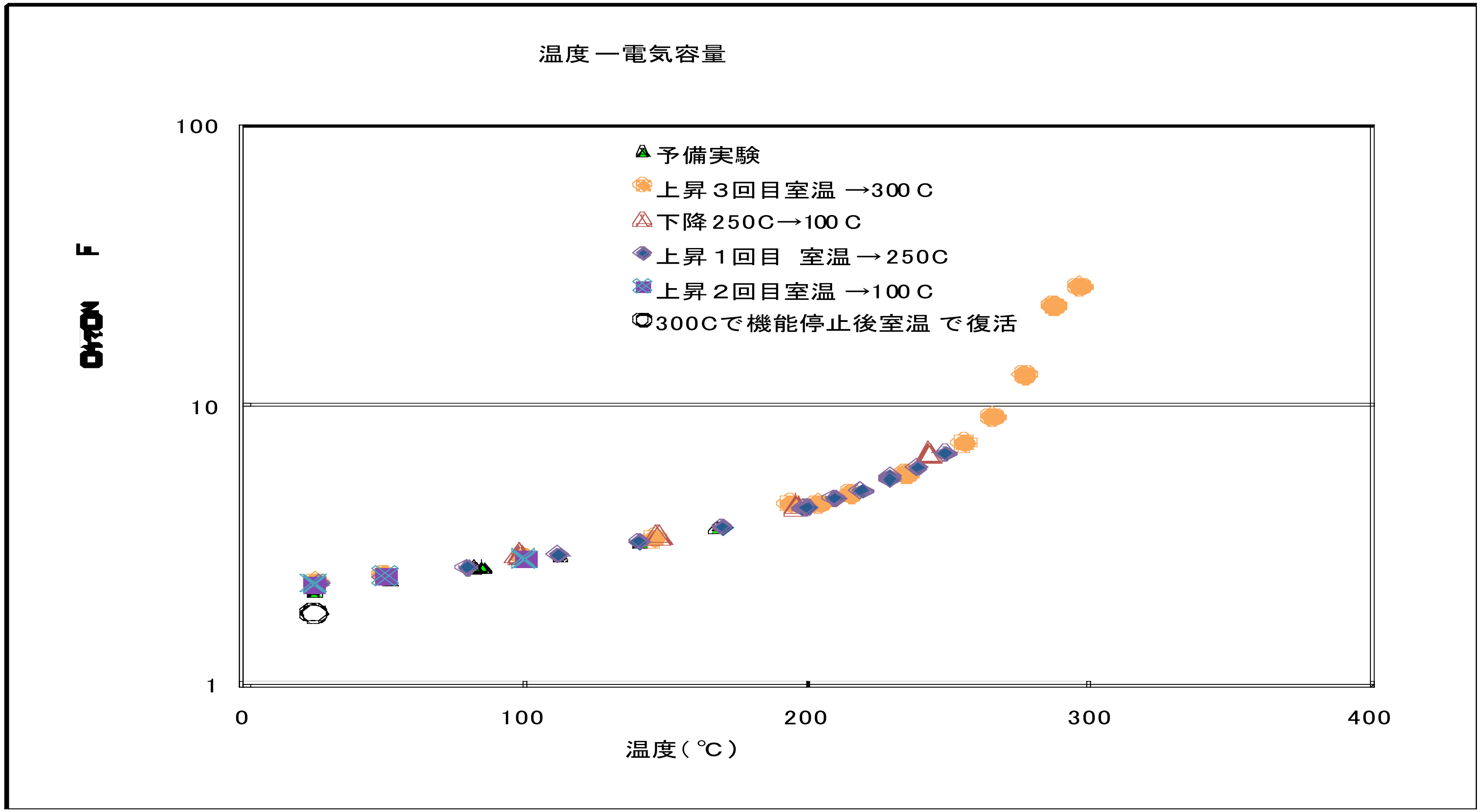


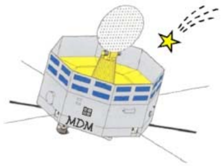
図 19 時刻歴応答(V1-HOT-A_OBSCOM,表 10μm,裏 100μm,各 0.01W/K)

近水点での温度分布
ピエゾの中心で193℃
電極表面： 銀 α＝0.50、ε＝0.18

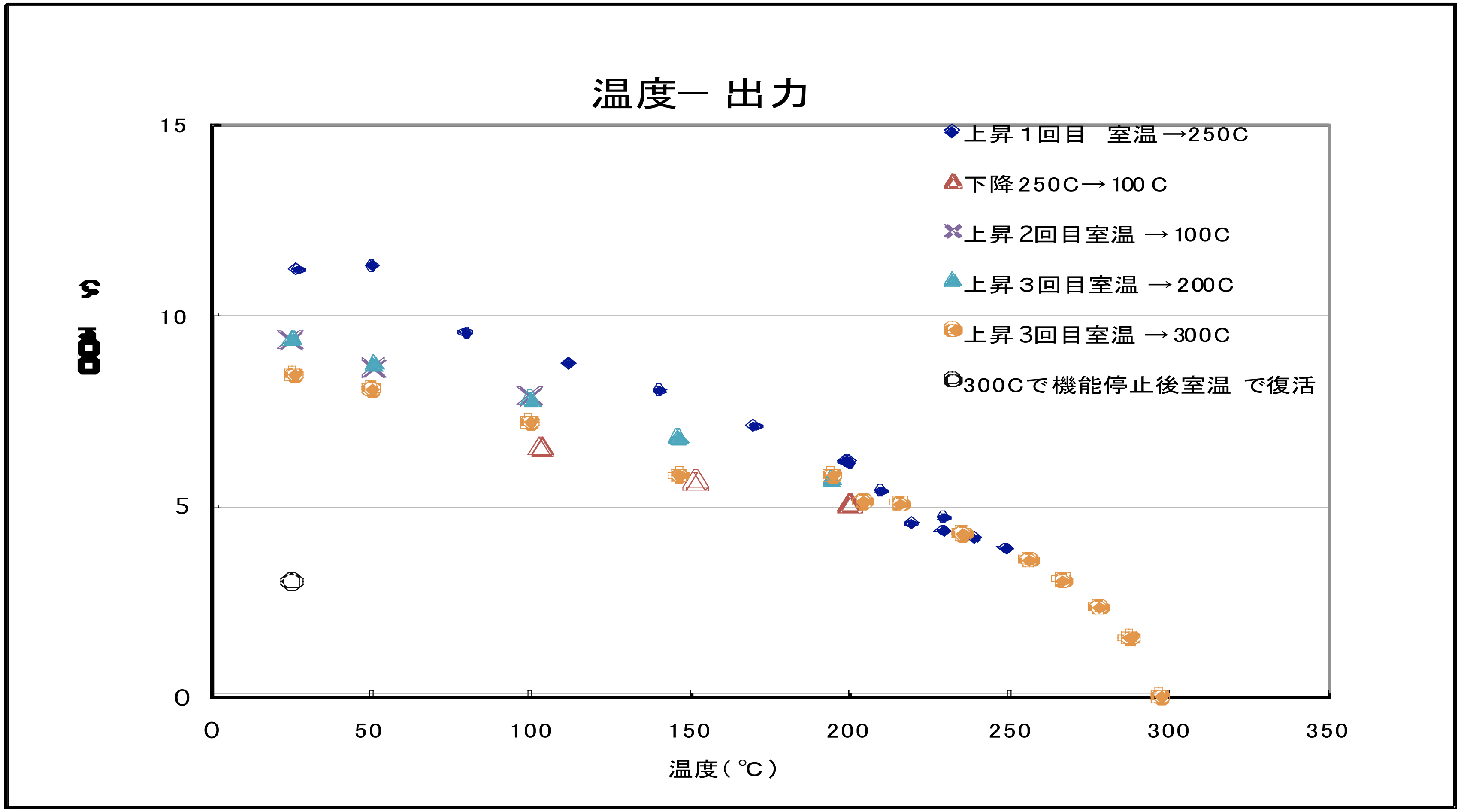
最悪条件での温度変化
（2周期 ≒ 20時間）
ピエゾの中心で210℃
ボルトからの衛星への熱伝導小

ピエゾの温度と電気容量





ピエゾの温度と出力


温度ー 出力
15
10
5
0
0
50
100
150
200
250
300
350
温度（℃）
上昇１回目　室温→250C
下降250C→100 C
上昇 2回目室温 →100C
上昇３回目室温 →200C
上昇 3回目室温 →300C
300Cで機能停止後室温 で復活

おわり (***End***)