Plasma Measurement II

Ion Probes

Plasma Probe on Sounding Rocket VII

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May 17, 2017

Outline

- Learning from SR-V
- Early design of ion probe for SR-VII
- Final design
- Tests
- Final procedure

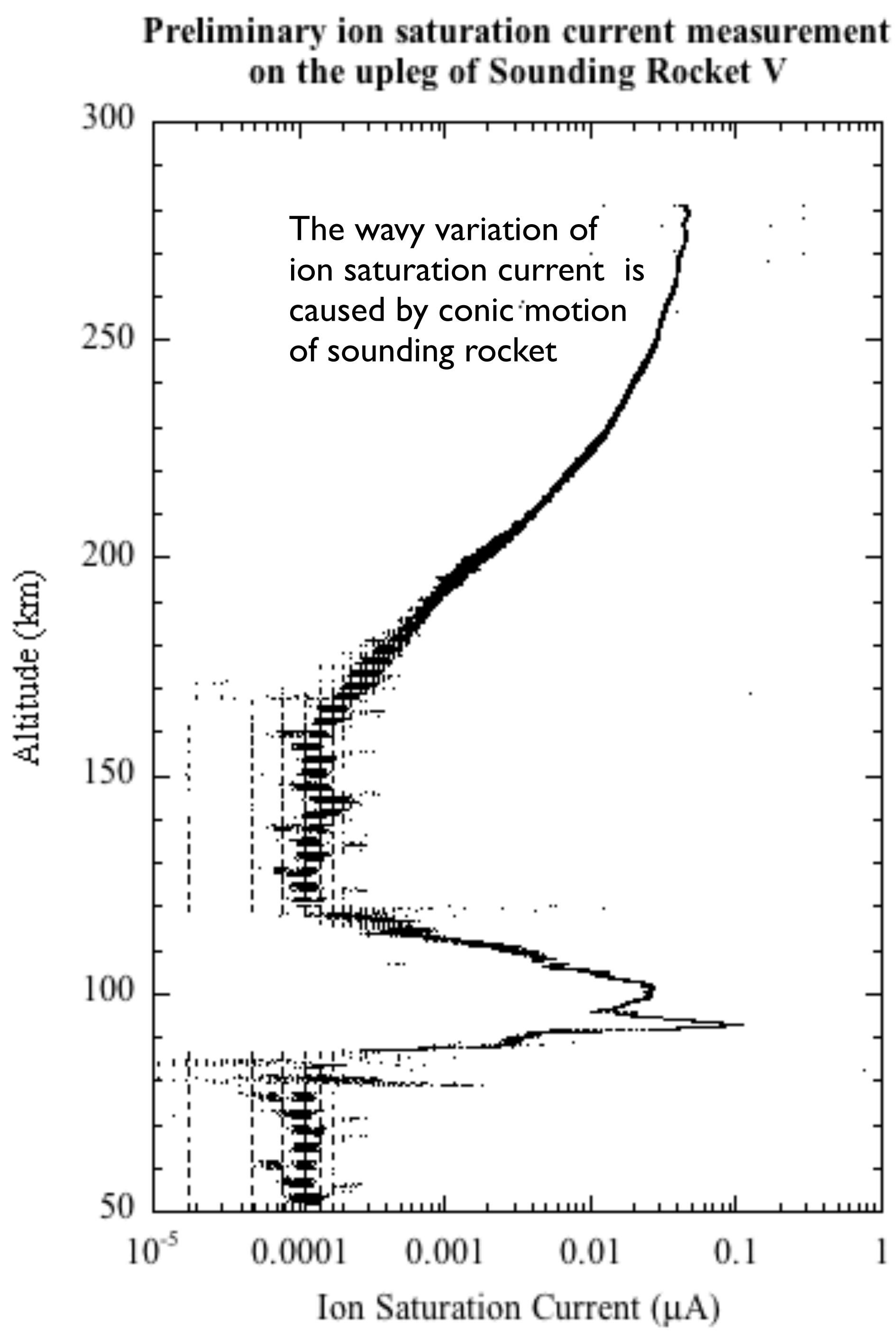
Learning from SR V

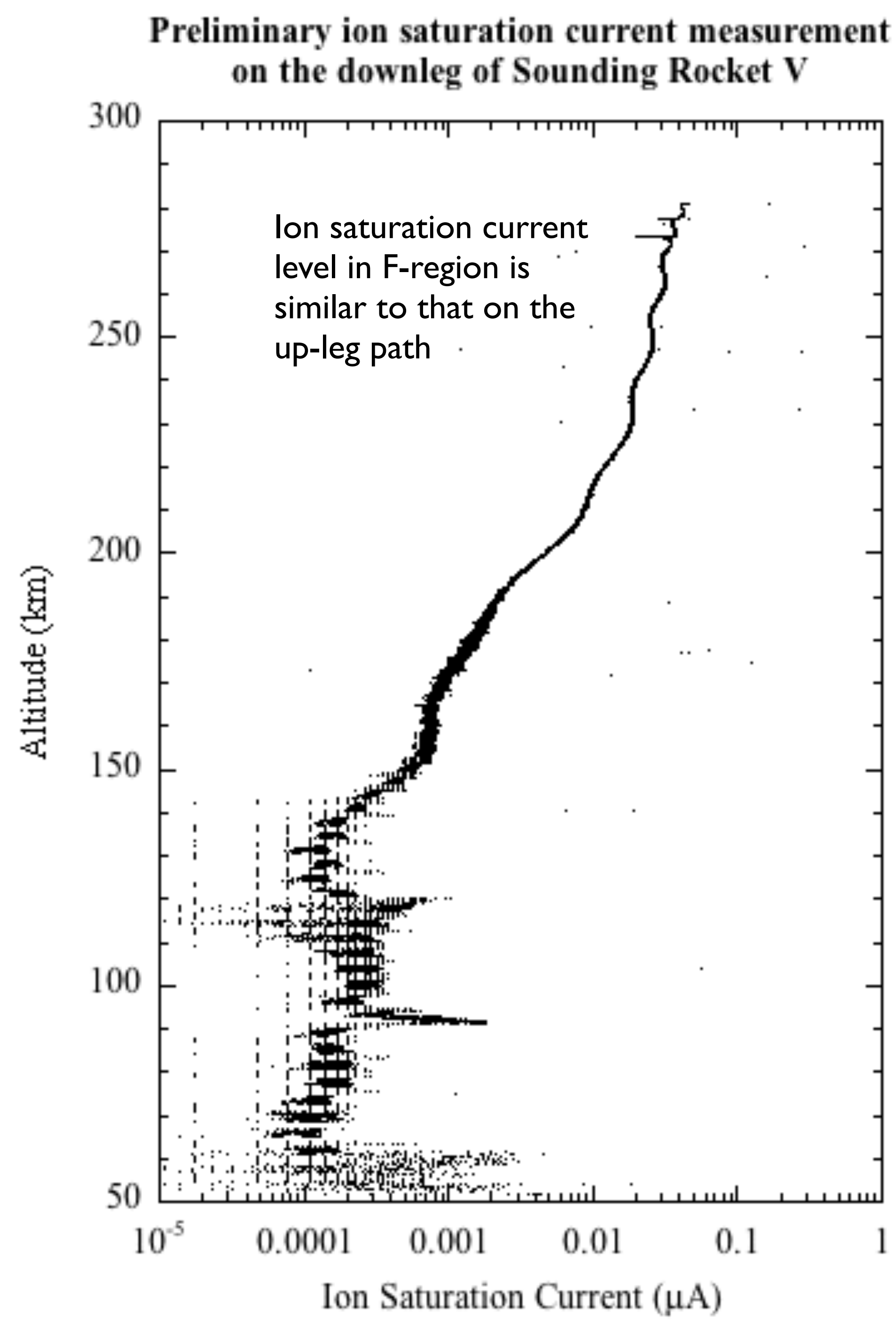
- Attitude determination of rocket
- VG1 anomaly
- VG2 (ΔV) pattern distortion
- No VG2 shown in E-region
- Possible improvements in future missions

Attitude determination

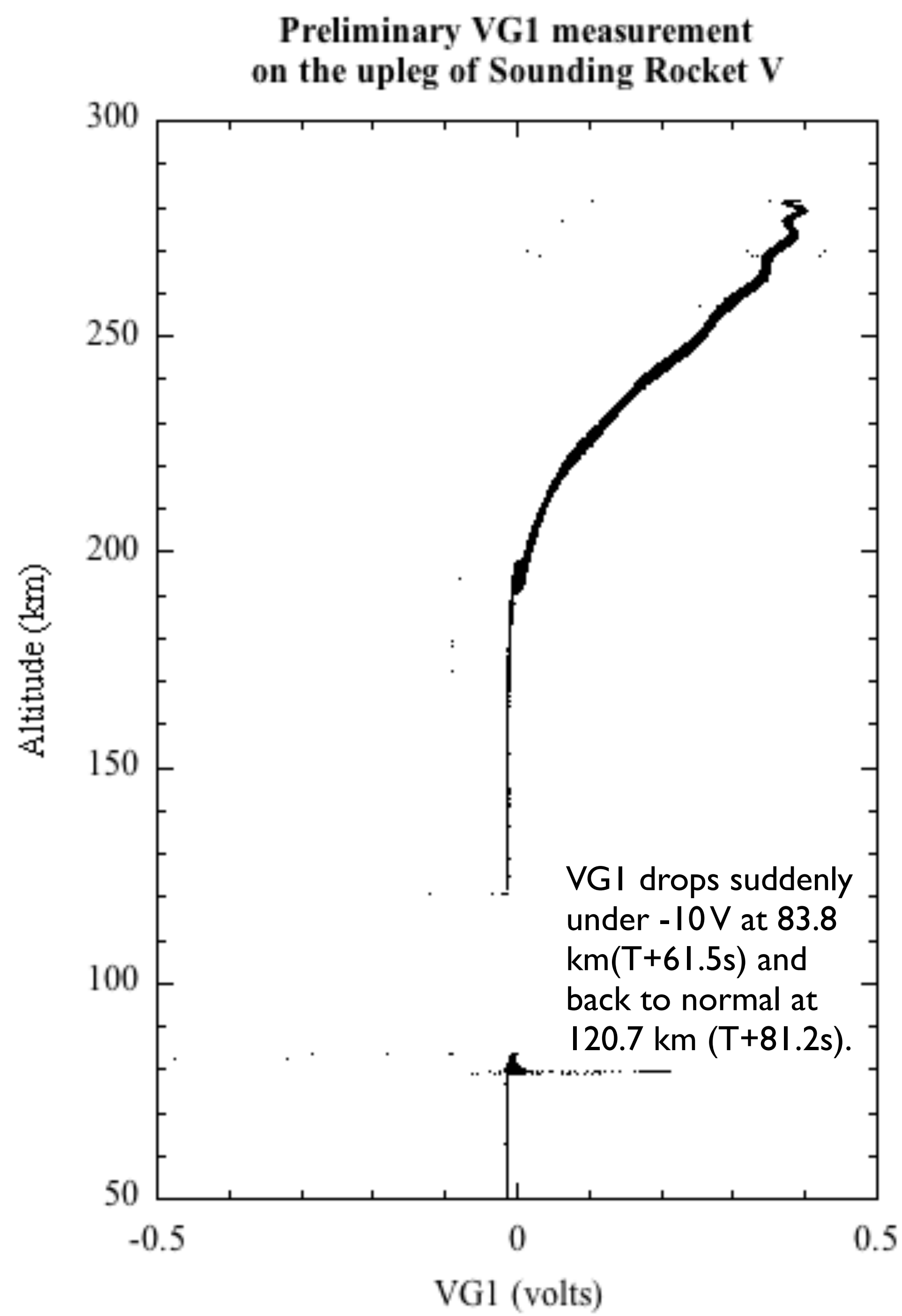
- A design fault in determining the attitude of Sounding Rocket V
- Additional vector measurement is required (sun sensor, star sensor, or an extra tilt ion probe)

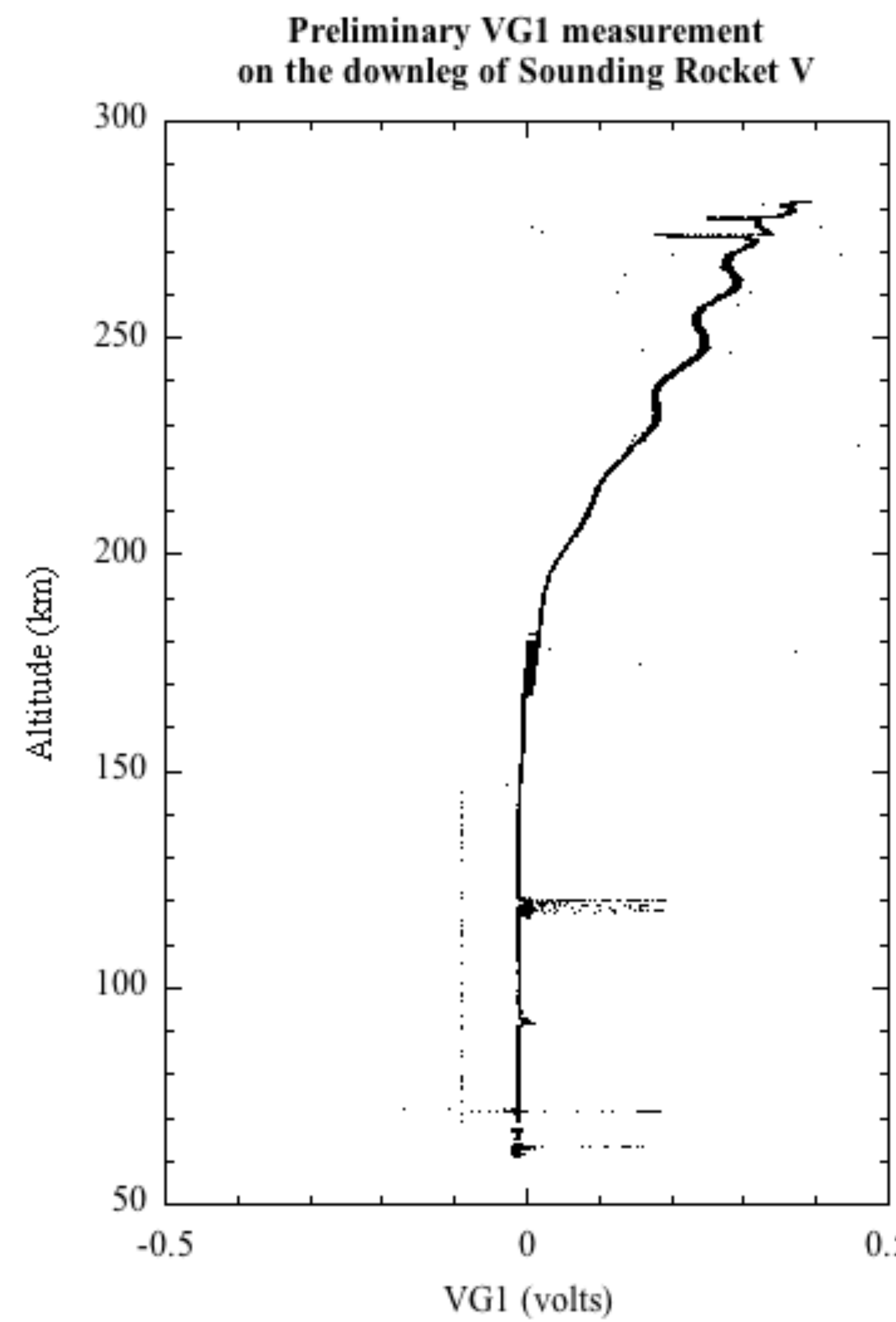
Ion saturation current



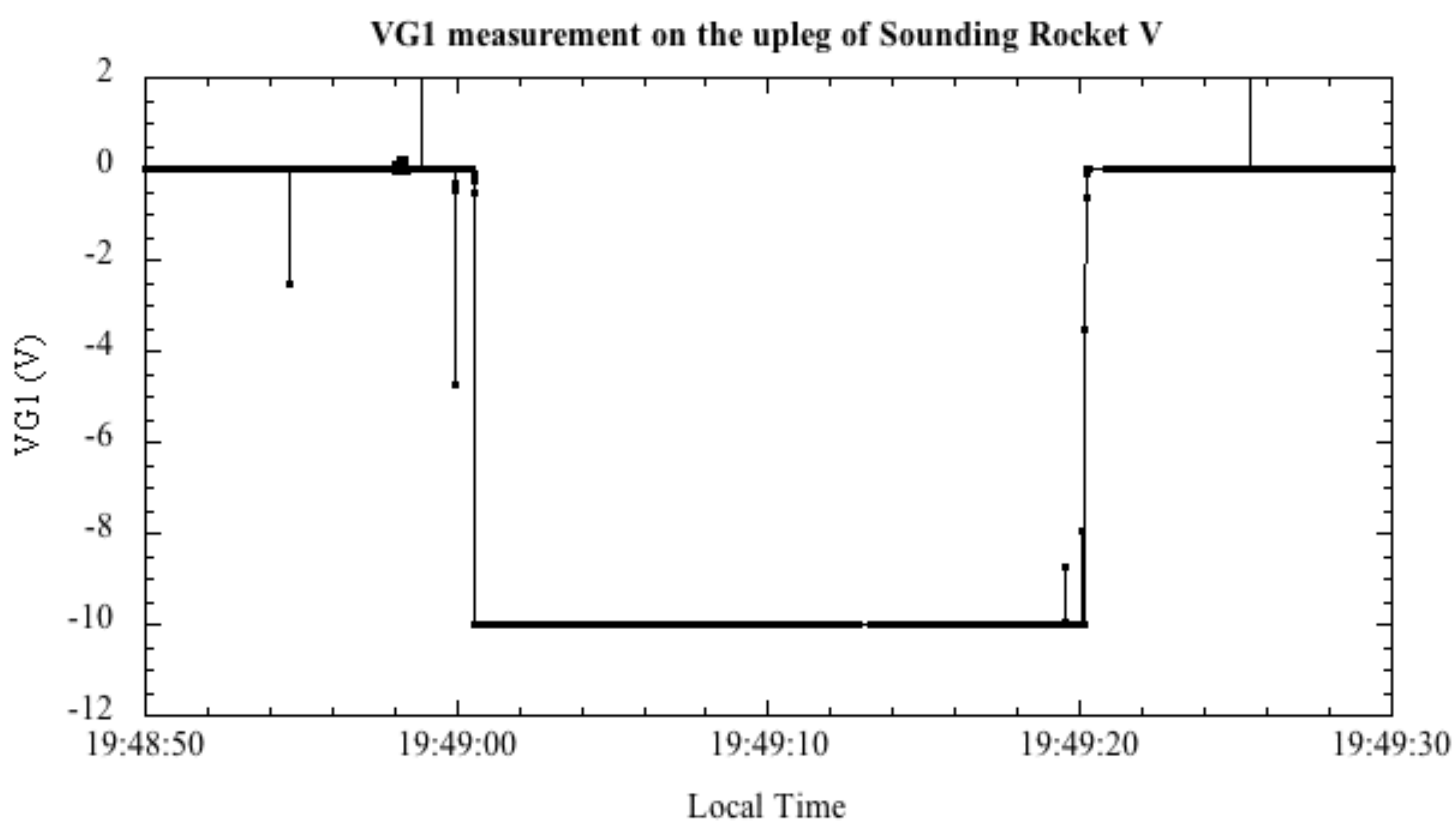


VG1 anomaly


Preliminary VG1 measurement
on the upleg of Sounding Rocket V
Altitude (km)
VG1 (volts)
300
250
200
150
100
50
-0.5
0
0.5
VG1 drops suddenly under -10V at 83.8 km(T+61.5s) and back to normal at 120.7 km (T+81.2s).

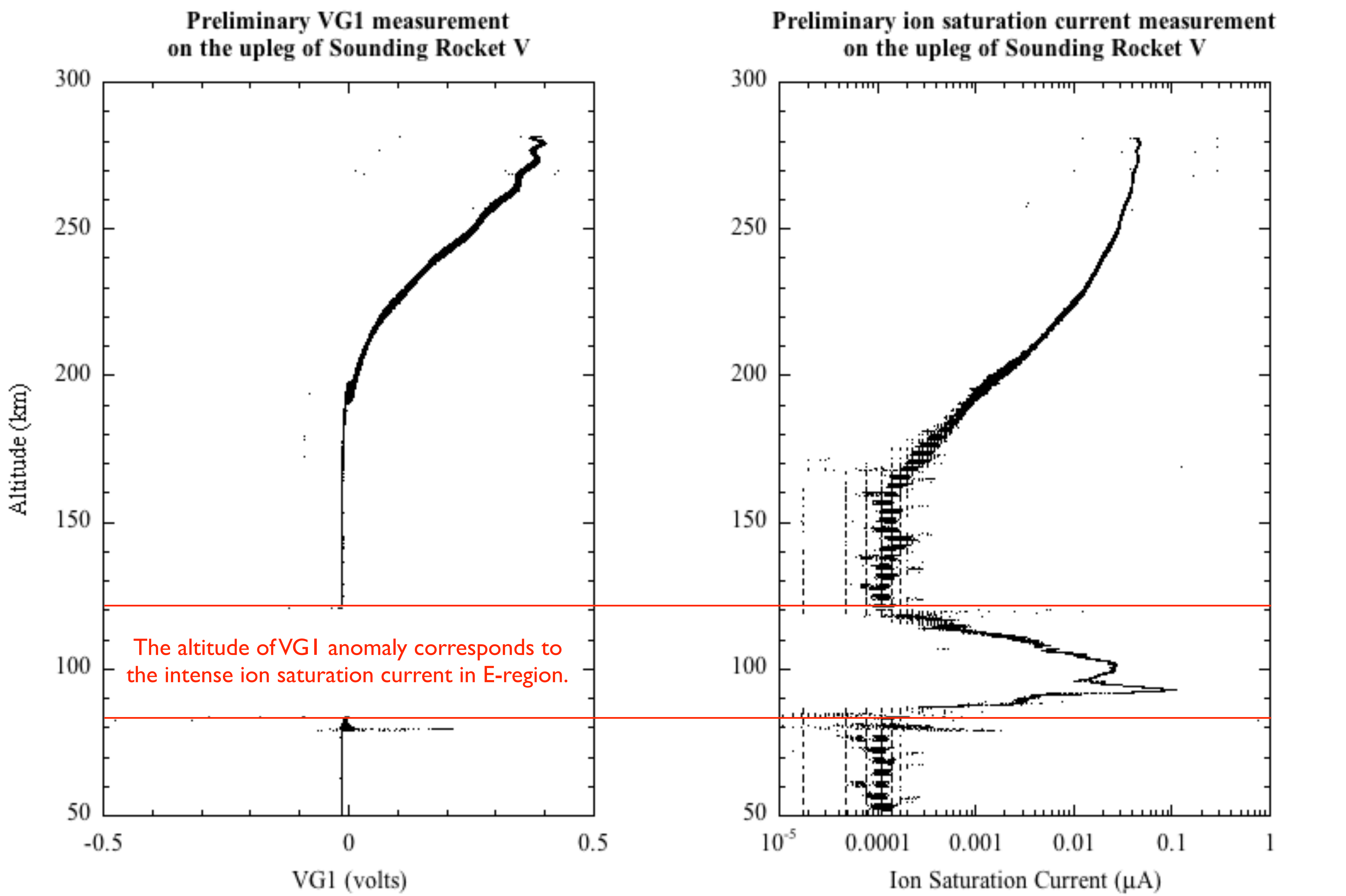

Preliminary VG1 measurement
on the downleg of Sounding Rocket V
Altitude (km)
VG1 (volts)
300
250
200
150
100
50
-0.5
0
0.5

VG1 anomaly

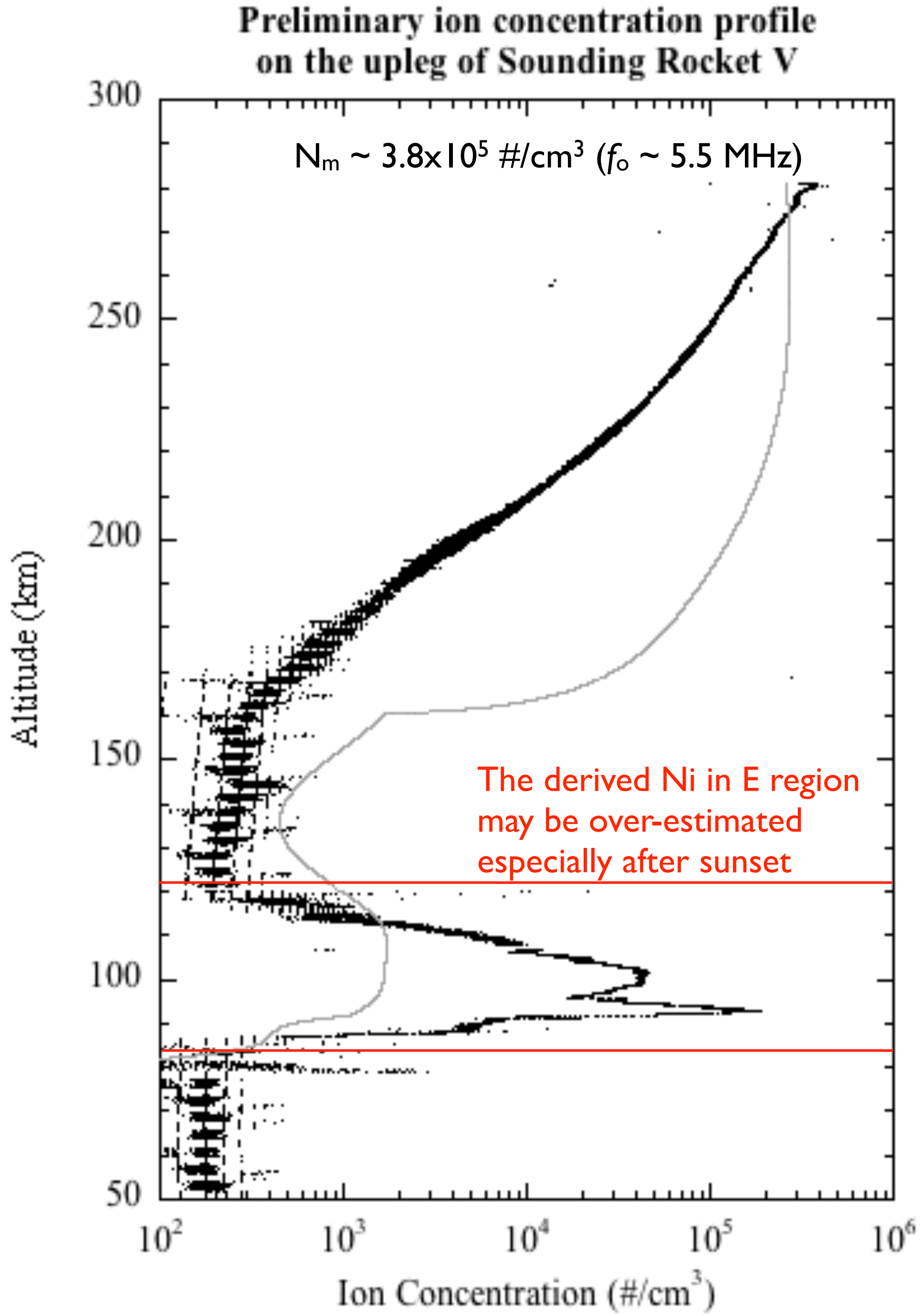


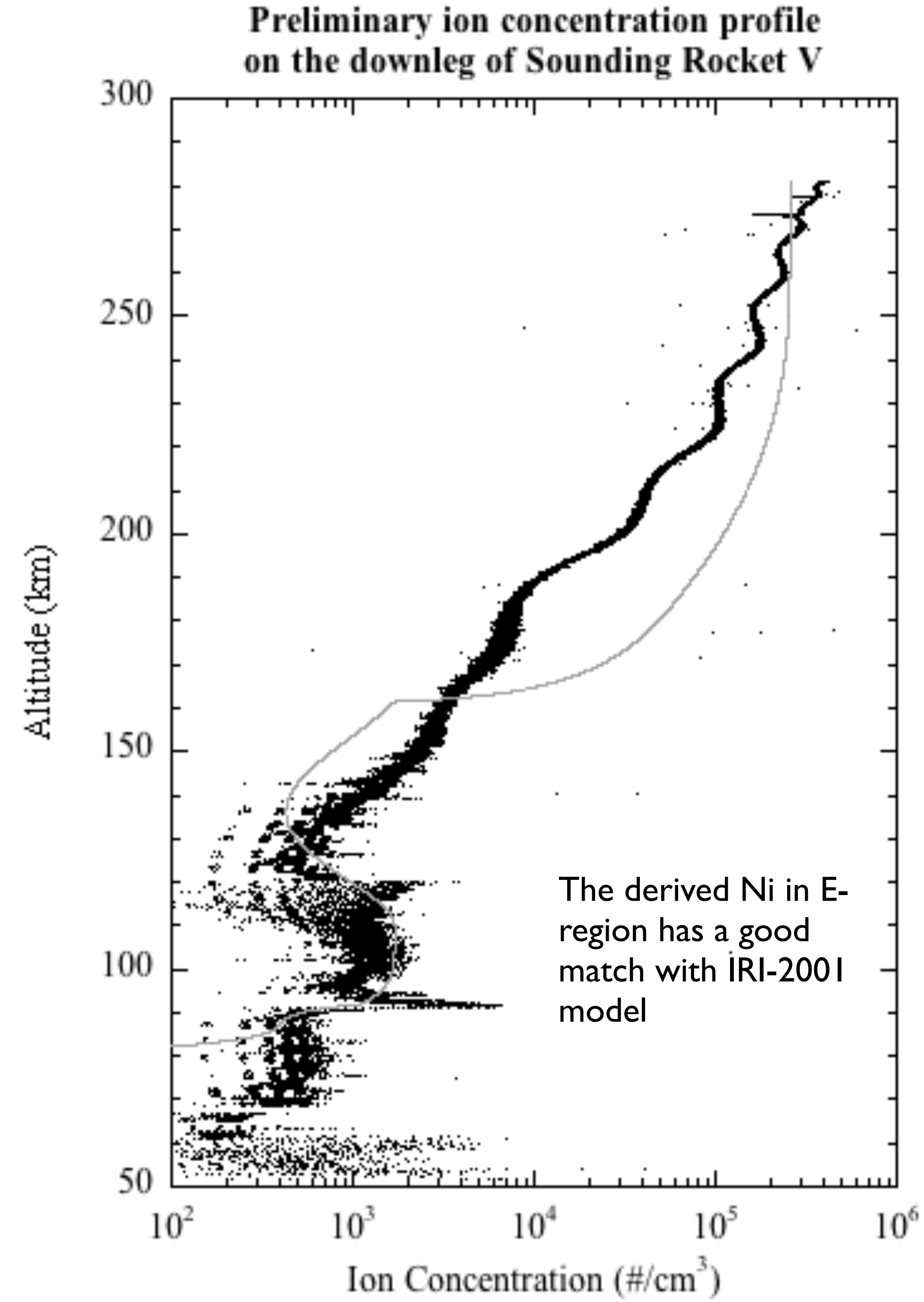
The dropped VG1 should be between -10 and -15 volts.
The -10-volt is the lowest limit of A/D conversion and -15-volt is the lowest limit of payload's power supply.

VG1 and Ii comparison (up-leg)



Ion concentration





VG1 anomaly

- VG1 and Ii are measured from ion trap
- The VG1 anomaly could be caused by a metal fiber connection between G1 (aperture) and G3 (suppressor) during T+61.5s and T+81.2s
- The anomaly will suck more ions into the ion trap and increase ion saturation current
- A calibration for VG1 anomaly could be performed via simulation or experiment

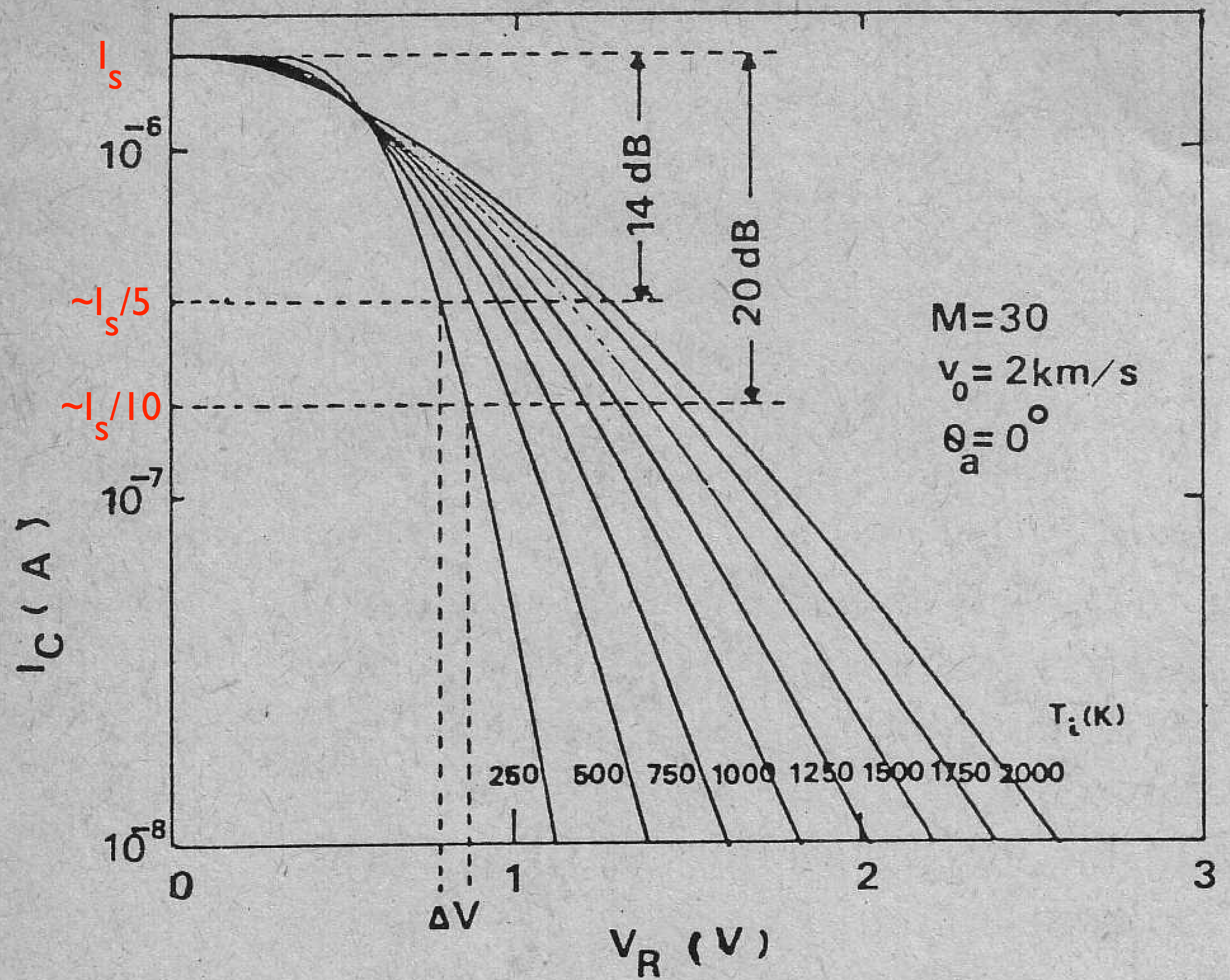
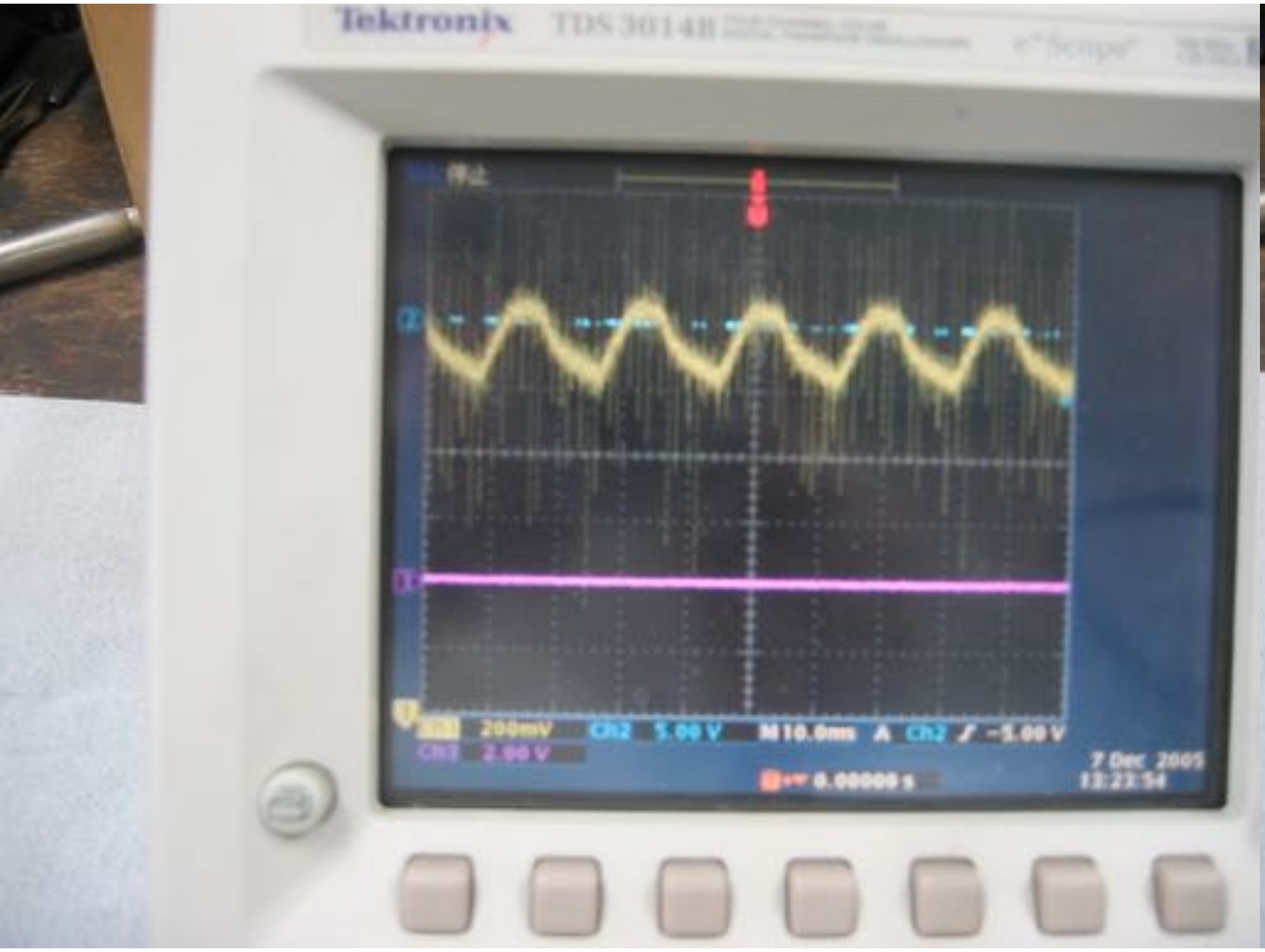
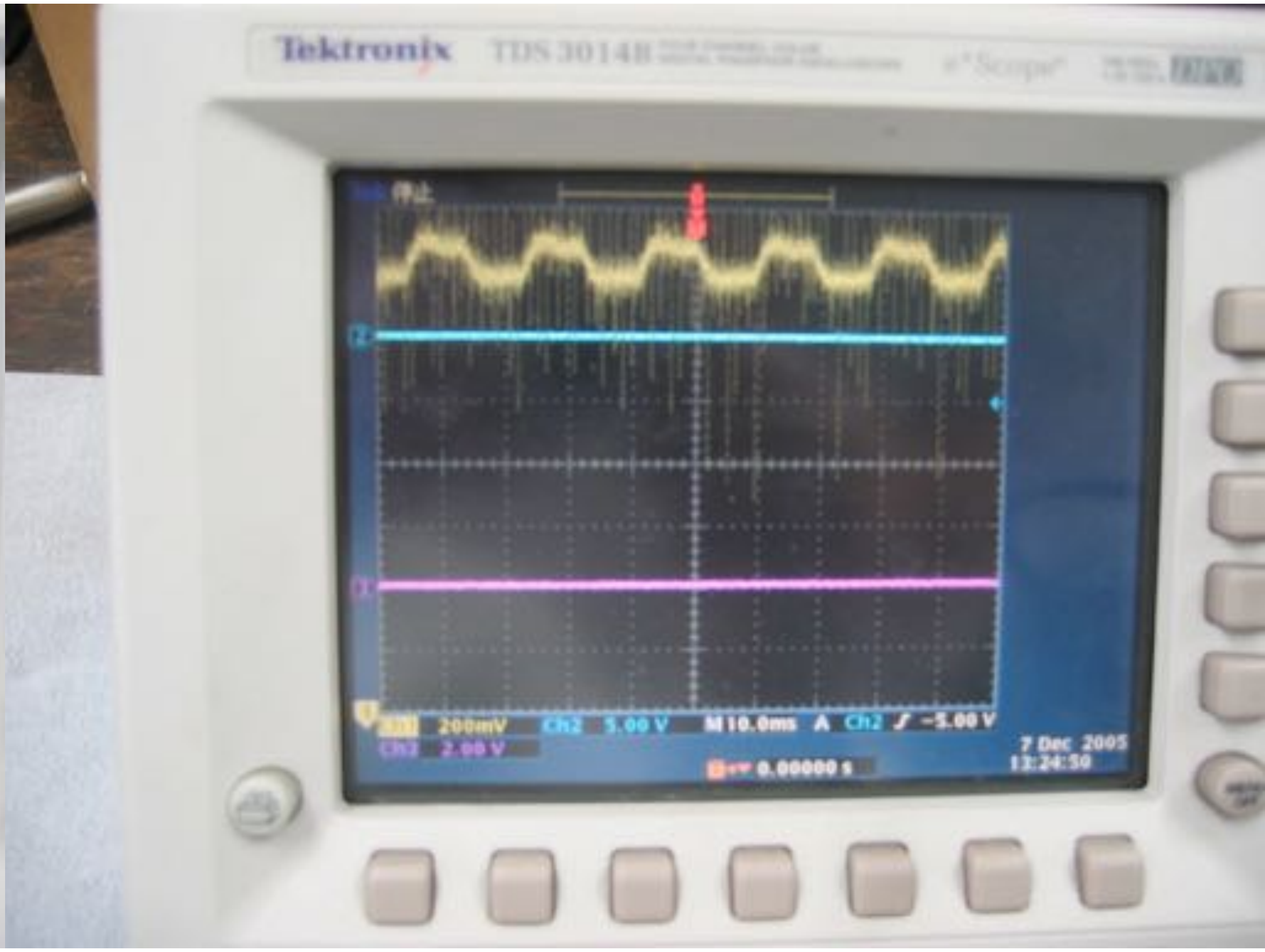


FIG. 2. An example of theoretical plane-type RPA characteristics. The principle of this method is also shown.

VG2 patterns measured in lab

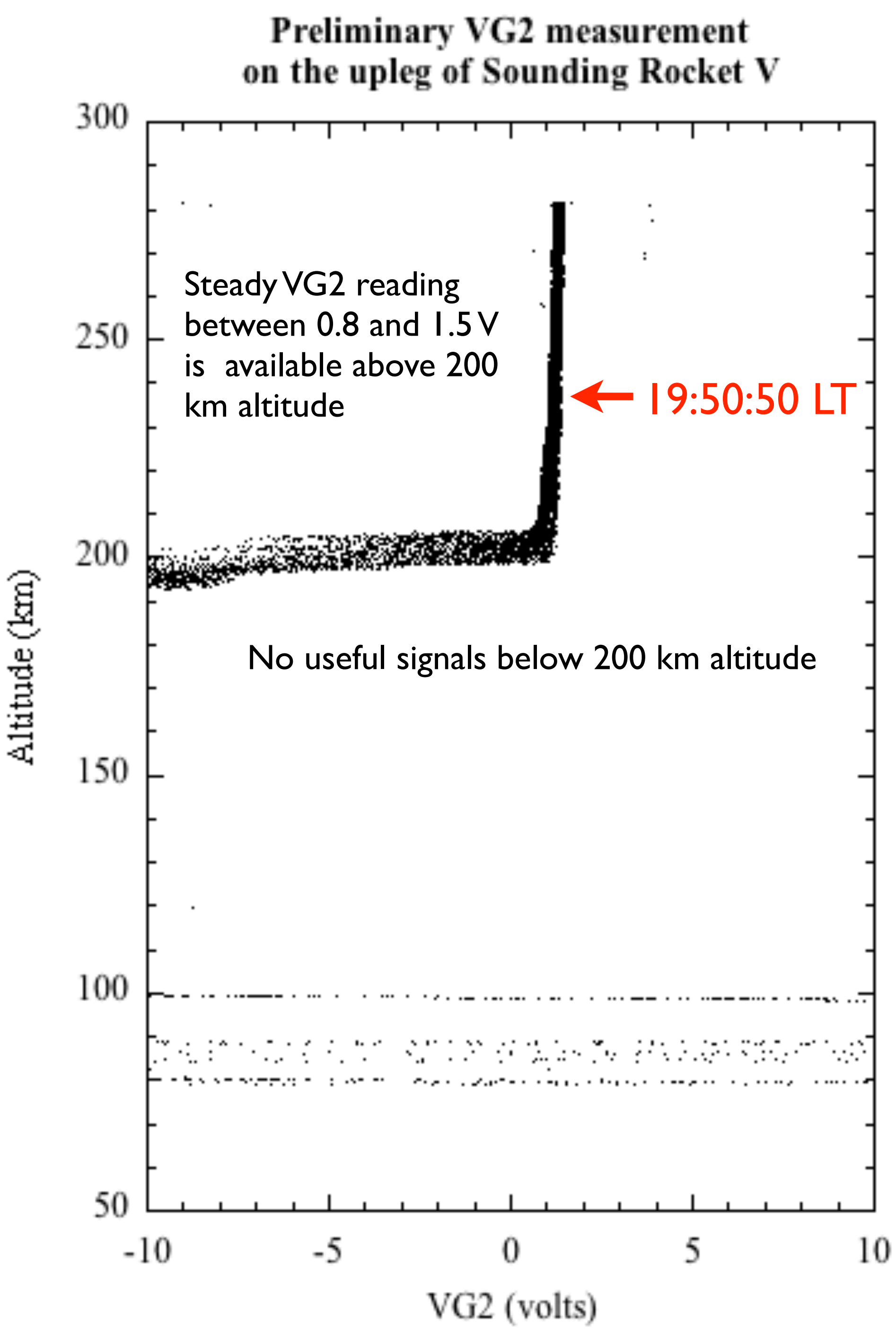


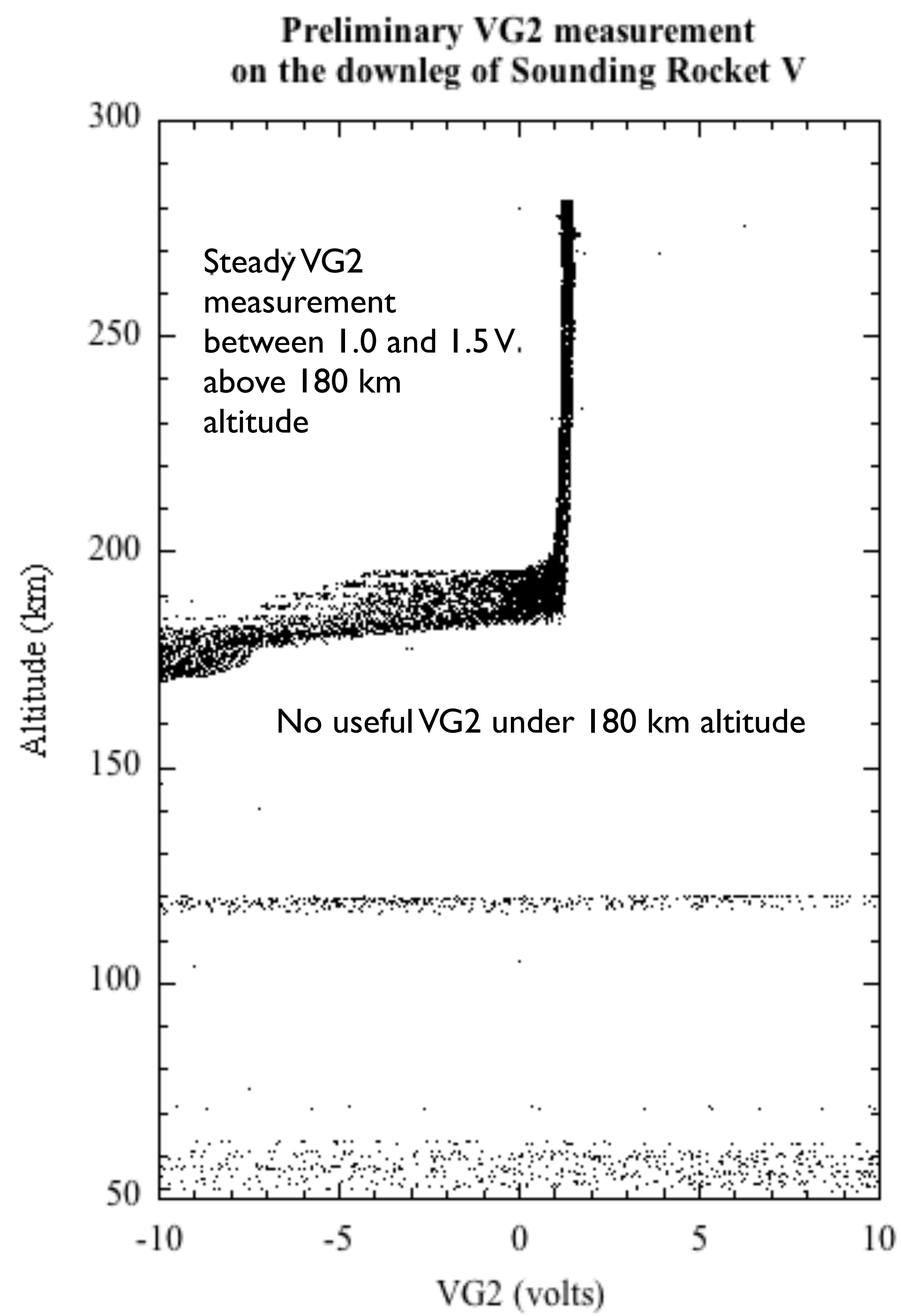


Low ion flux

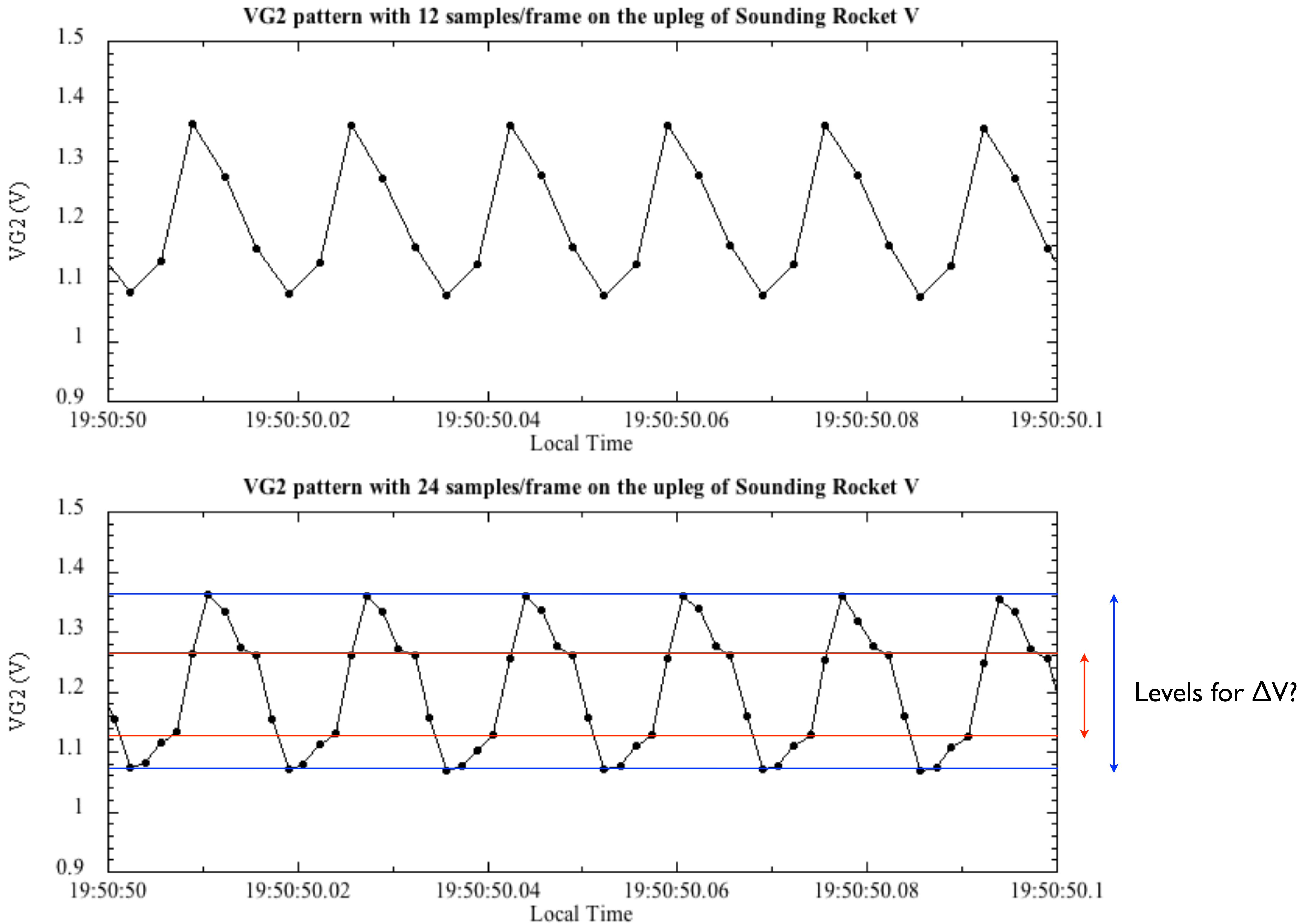
High ion flux

VG2 measurement

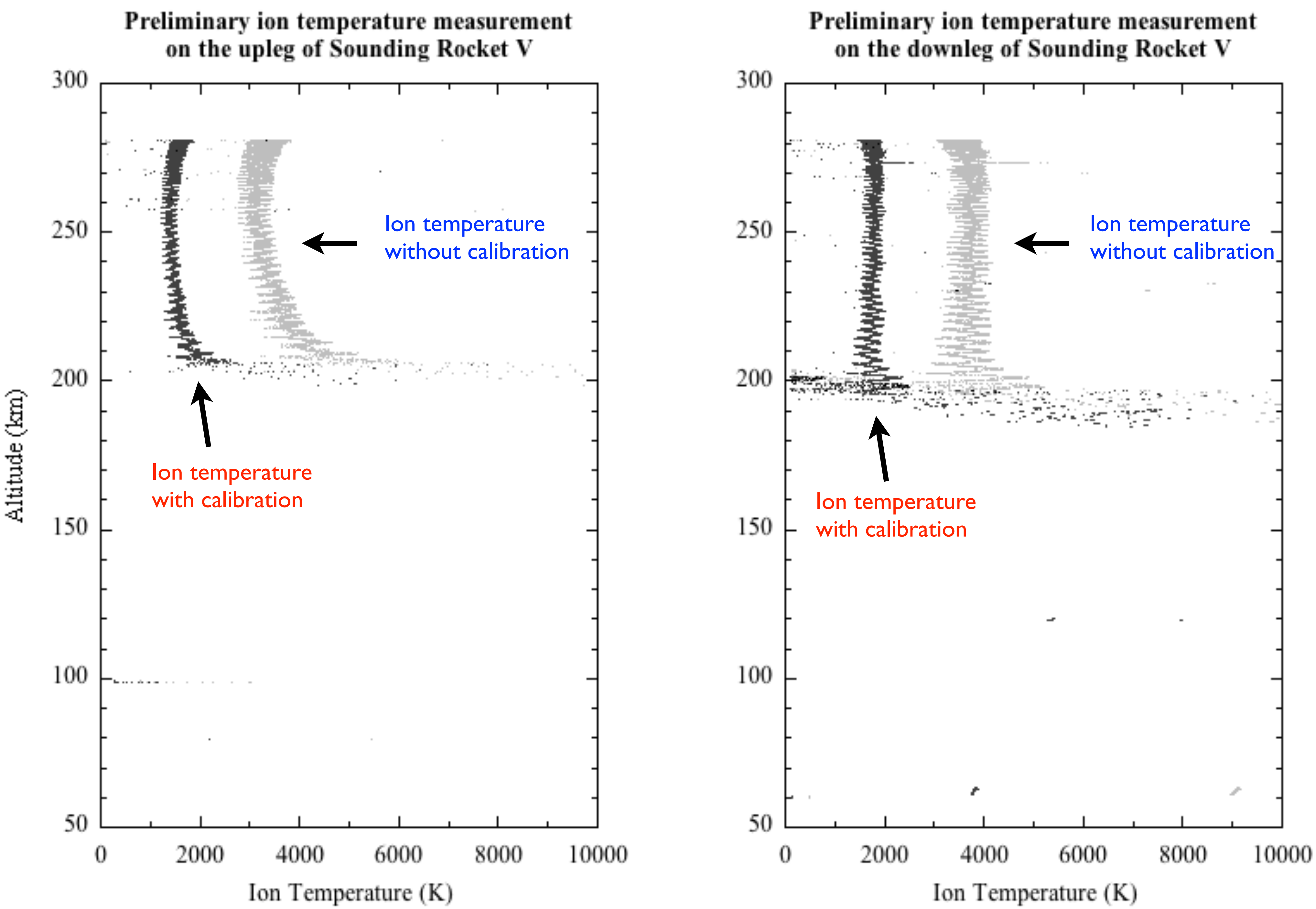




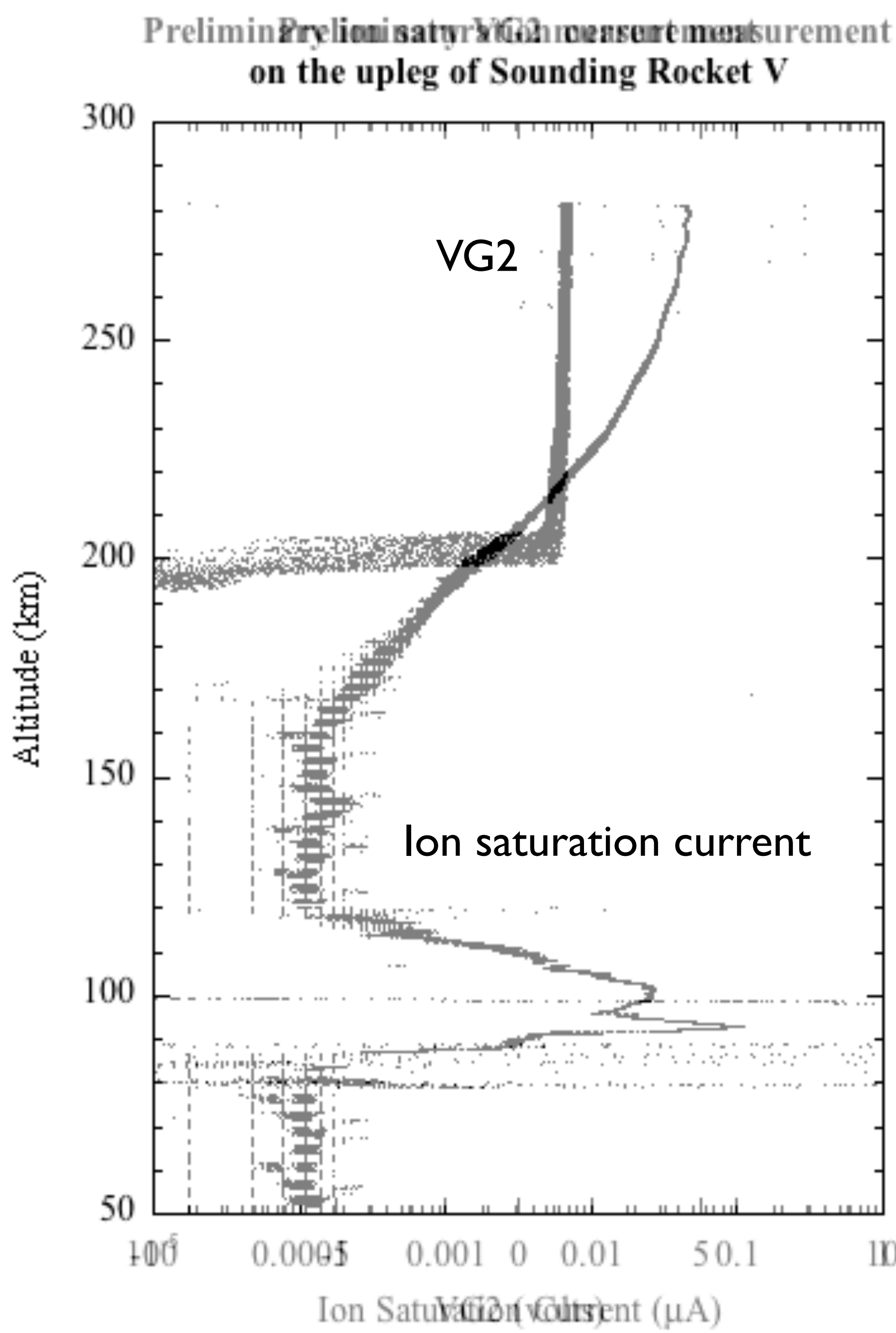
VG2 patterns in F-region

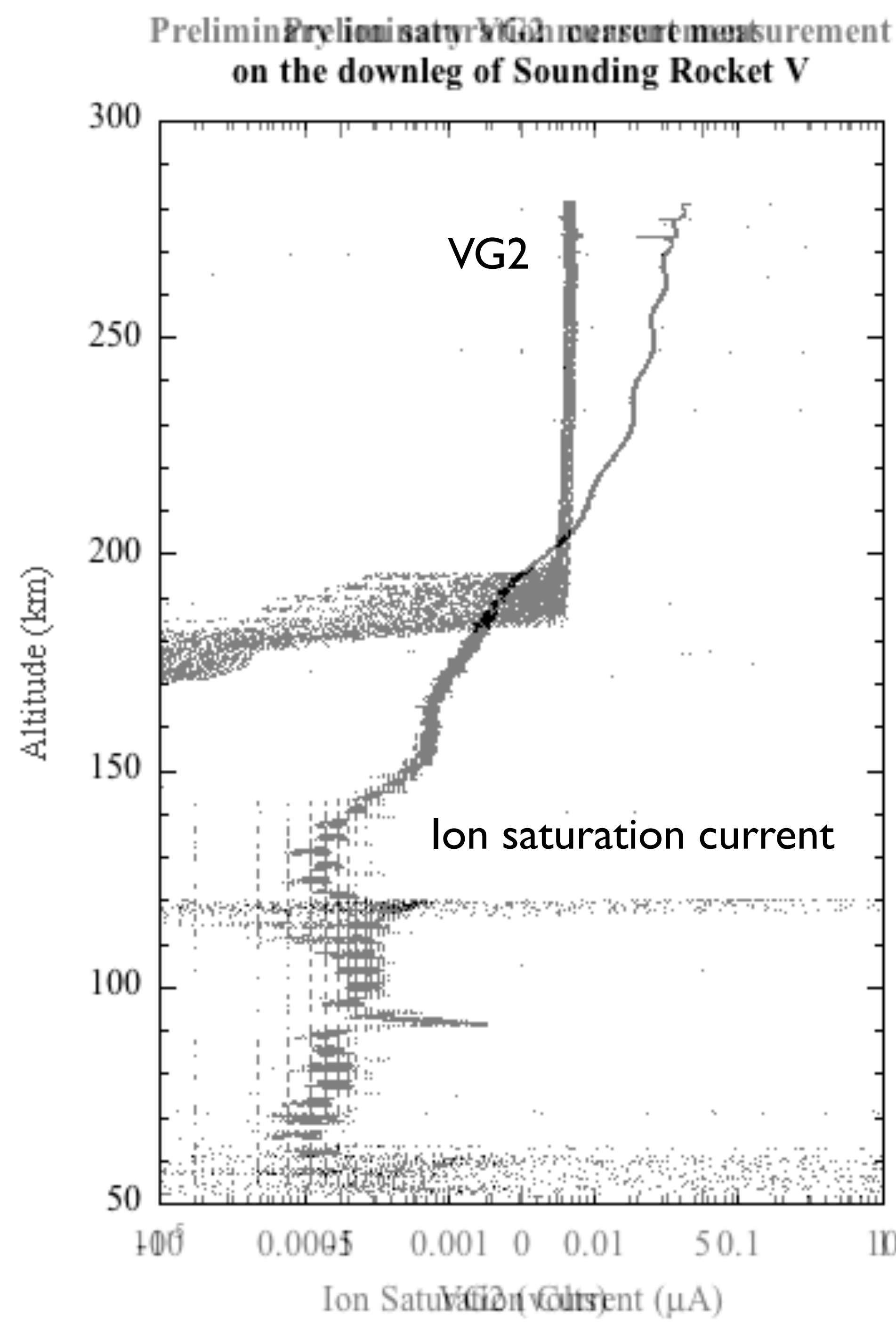


Ion temperature



No VG2 in E-region





A possible cause

- VG1 is only measured from ion trap (IT), not from retarding potential analyzer (RPA)
- VG2 measurement would be insensitive for very low ion flux condition (< 0.002 μA)
- If both VG1s in IT and RPA have the same voltage, the appropriate VG2 should be available in E-region during the up-leg path from our measurement
- If the VG1 in IT is abnormal low, Ii in IT will increase very high and RPA cannot find the corresponding 14dB and 20dB level of the Ii by modulating VG2

Possible improvements in future missions

- New configuration → attitude determination
  - Two ion traps (one is directed to normal and the other is tilt)
  - One retarding potential analyzer with normal direction
  - One three-axial flux-gate magnetometer
  - One Langmuir probe (optional) for electron information
- It is requested to clean up the inside of nose cone before launch
- High sensitive and good responsive amplifiers for retarding potential analyzer → deriving ion temperature at very low ion flux condition and from good pattern

What's new for ion payload onboard Sounding Rocket VII

- Altitude determination of sounding rocket
- Refining RPA's circuit
- Performing plasma injection test in our space payload laboratory
- **Sensor cleaning with ion bombardment and heat conduction**
- Add one Langmuir probe

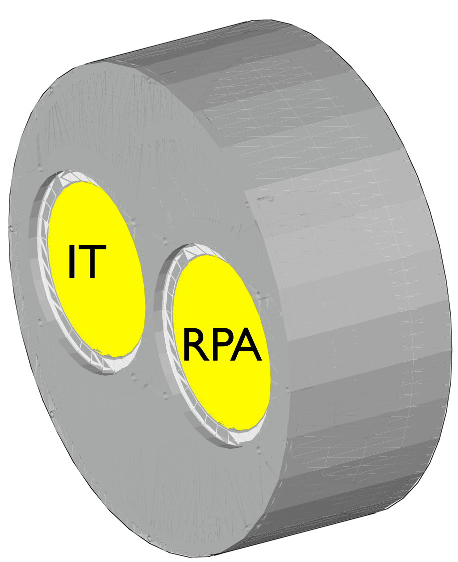
Sensors (early design)

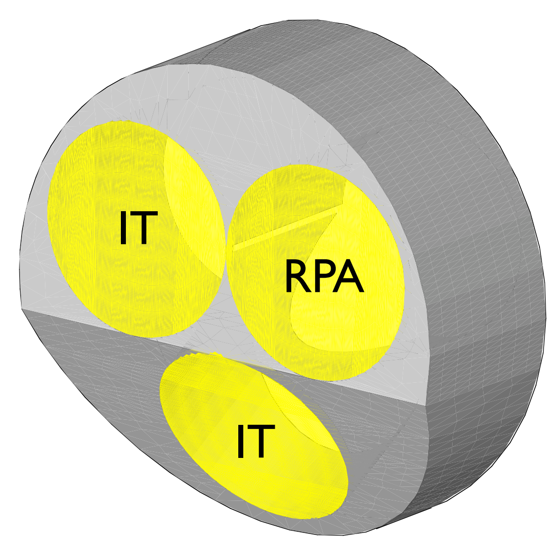
SR-V

- One normal-directed ion trap
- One normal-directed retarding potential analyzer
- One 3-axis aspectmeter

SR-VII

- One normal-directed ion trap
- One normal-directed retarding potential analyzer
- One 3-axis aspectmeter
- **One tilt-directed ion trap**
- **Langmuir probe**





248 inner, 300 outer

Mechanical specification (early design)

SR-V

- Dimension
  - Sensor head: **248** mm D x **95** mm H
  - Electronics box: 200 mm D x **200** mm H
- Mass
  - Sensor head: **6.920** kg
  - Electronics box: **6.760** kg
  - Total: **13.680** kg

SR-VII

- Dimension **248 inner, 300 outer**
  - Sensor head: (**248 or more**) mm D x **195** mm H
  - Electronics box: 200 mm D x **100** mm H **300 mm D x 200 mm H**
- Mass
  - Sensor head: **~15** kg
  - Electronics box: **~4** kg
  - Total mass: **~19** kg

Electrical specification (early design)

SR-V

- Power: +28 V, **420** mA, **11.76** W
- Measurement range:
  - Current: $10^{-11} \sim 10^{-6}$ A
  - Magnetometer: ±70000 nT with ± 2°
- A/D conversion: ±10 V, 16 bits
- Output: single **38.4** kbps RS-422 serial port at and **6 analog outputs for backup channels**

SR-VII **150 mA, < 4.2W**

- Power: +28 V, **570** mA, **<16** W
- Measurement range: ERV: 3×10^{-10} - 1×10^{-5} Other: 1×10^{-11} - 3.3×10^{-7}
  - Current: $10^{-11} \sim 10^{-6}$ A
  - Magnetometer: ±70000 nT with ± 2°
- A/D conversion: ±10 V, 16 bits
- Output port: single **76.8** kbps RS-422 serial port

Design

- Goals
- Requirements
- Sensors
- Electronics
- Geophysical parameters
- Data packets
- Pre-launch criterions

Goals

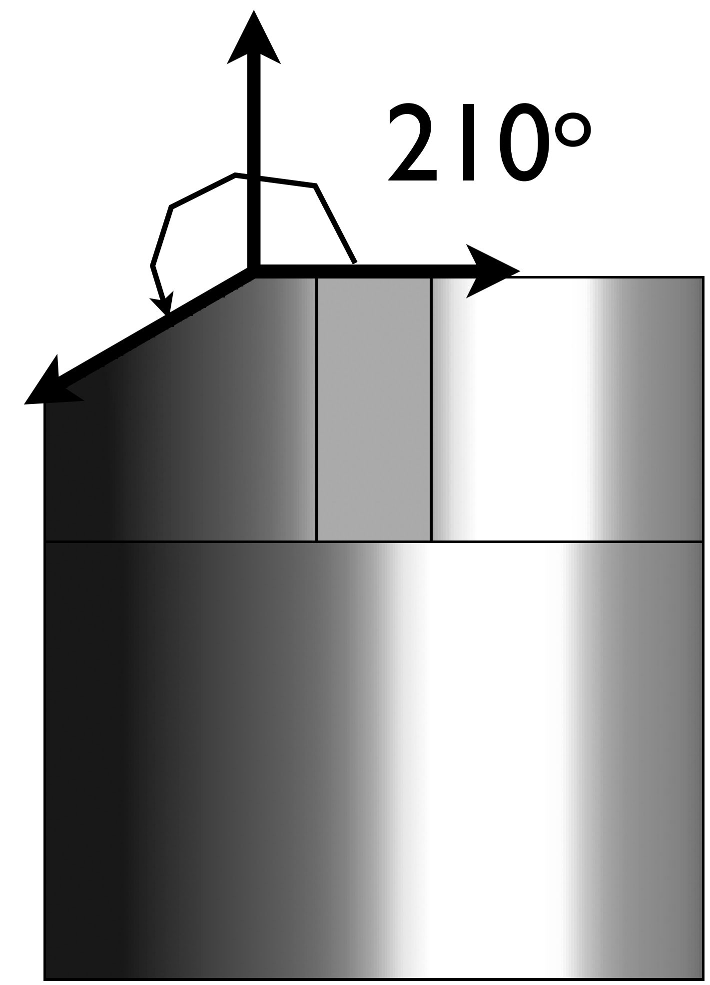
- Scientific goals
  - In-situ measure the ionospheric plasma temperature and density profiles over Taiwan
  - Co-incident E-region plasma irregularity observations (30 MHz radar, **52 MHz radar**, digisonde chain, GPS scintillation measurement, and **FORMOSAT-3/COSMIC**)
- Capacity build-up
  - Rocket-based plasma probe technology transfer
  - Attitude determination of sounding rocket

Requirements

- Field of view
- Magnetic field
- Electrical potential
- Heating process

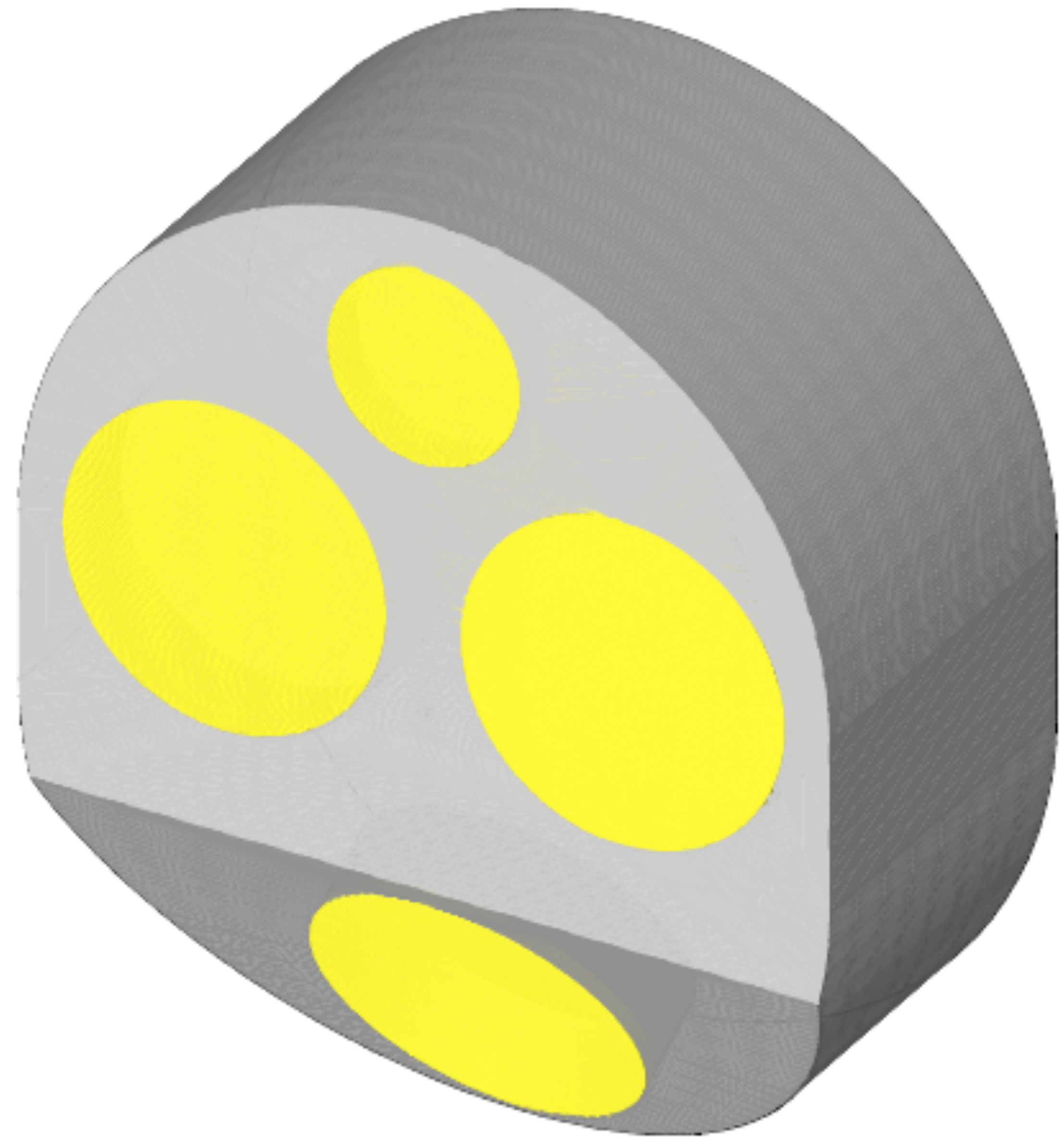
FOV

- Any obstacles in front of sensors will block or alter plasma flow into the sensors
- 210 degree forward-facing field of view
- No obstacle in front of ion sensors when the in-situ measurement is on



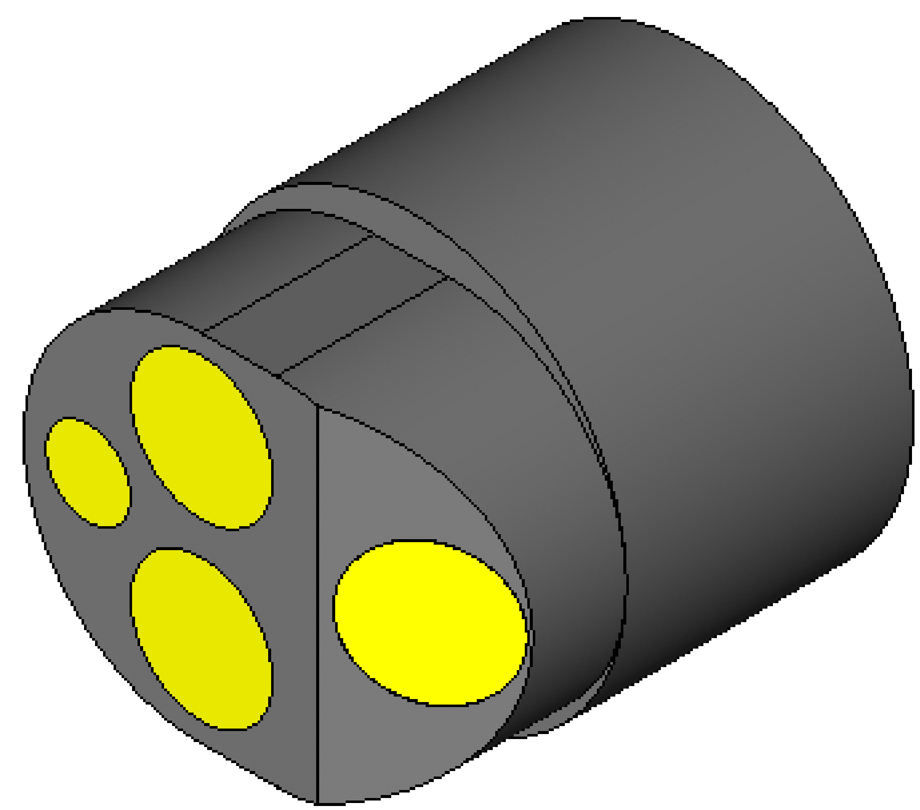
Magnetic field (close to sensors)

- Magnetic field will distort the path of incoming plasma
- No permanent magnet and magnetized material nearby the sensors
- Interference on magnetic field should be less than 0.05 Gauss at the sensors



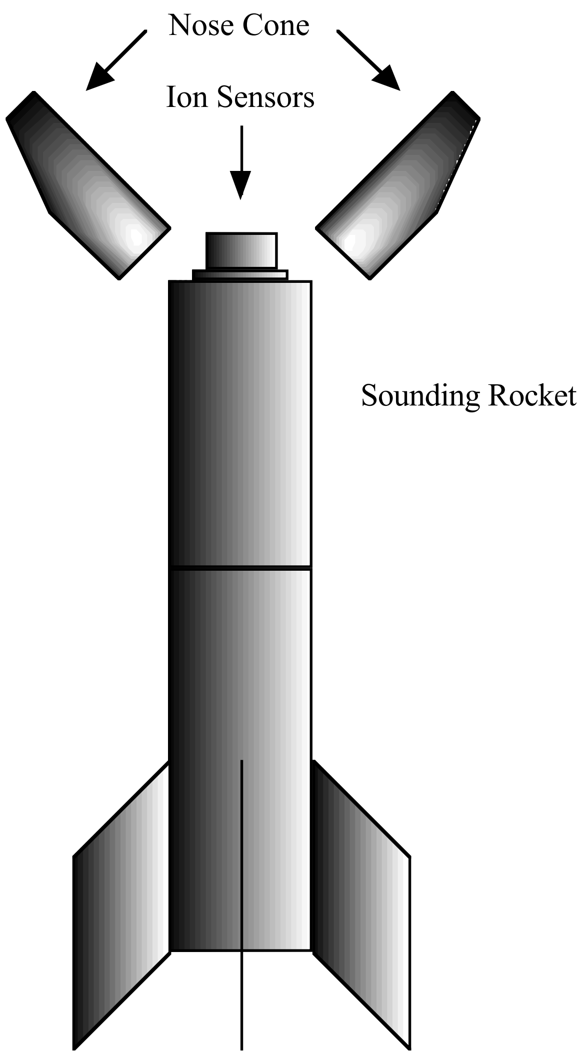
Magnetic field (close to aspectmeter)

- Magnetic field will affect the accuracy of aspectmeter
- Interference on magnetic field should be less than 0.05 Gauss in amplitude and far away from 4 Hz in frequency



Electric potential

- In general, electric potential of sounding rocket will be negatively biased with respect to ambient plasma. However, during the sunlit condition, solar EUV may knock off electrons from conductive skin of sounding rocket, the sounding rocket will be positively biased with respect to ambient plasma. Electric potential should be smaller than 1 volt with respect to ambient plasma (negatively biased is fine for this measurement)
- **Conductive paint on the surface of Sounding Rocket is necessary**



SOP for heating process

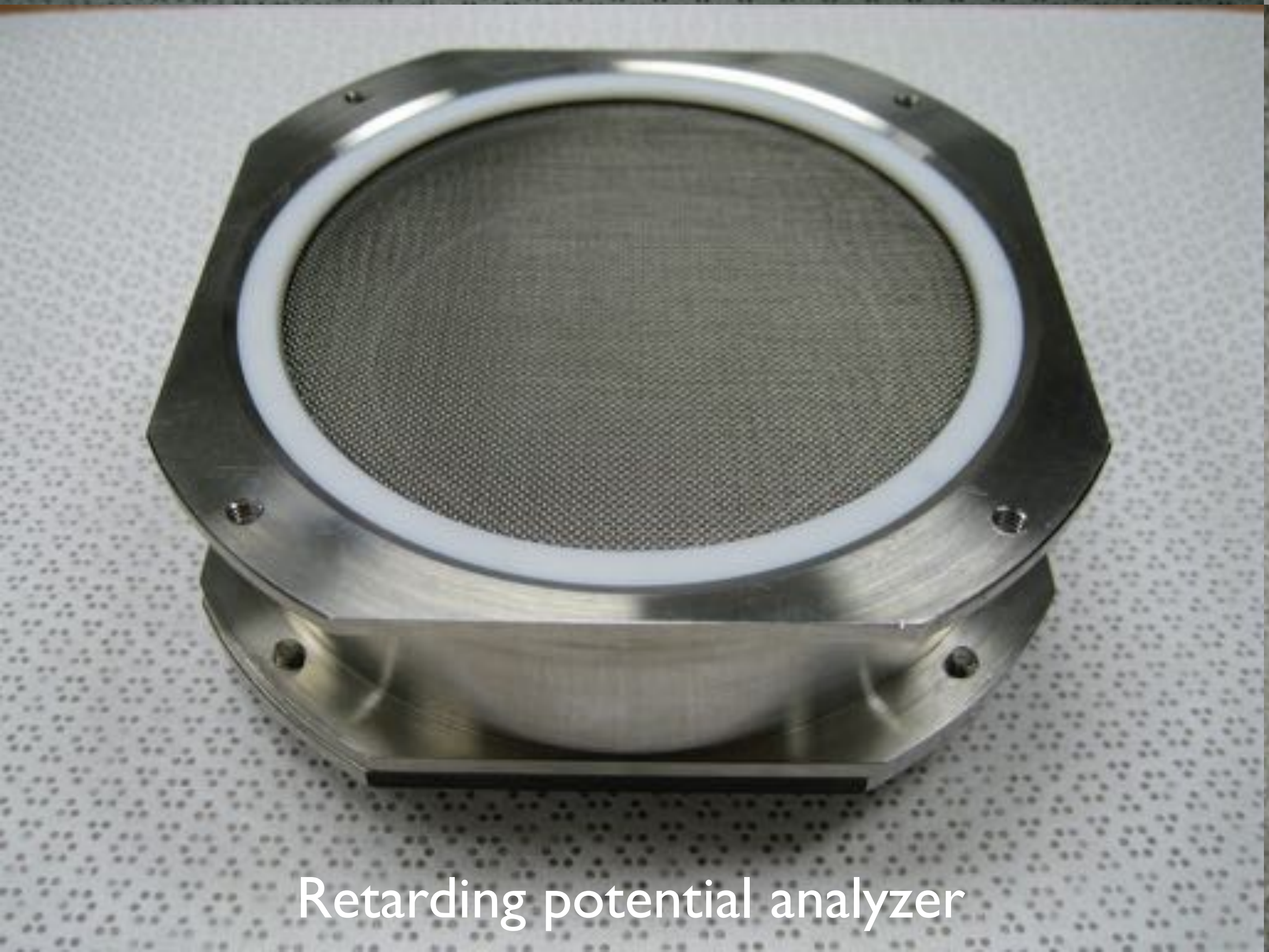
1. Installing filament and thermocouple around the ion sensors.
2. Connecting cables between the feedthroughs on the rocket body and filament/thermocouple.
3. Sealing the nose cone.
4. Filling in fresh N_2 gases.
5. Turning on heater controller and adjusting the voltage regulator to limit the temperature up to **110 °C** for **60 to 90 minutes**.
6. Turning off the voltage regulator and heater controller.
7. **Keeping the fresh N_2 gases flow continuously**.

Sensors

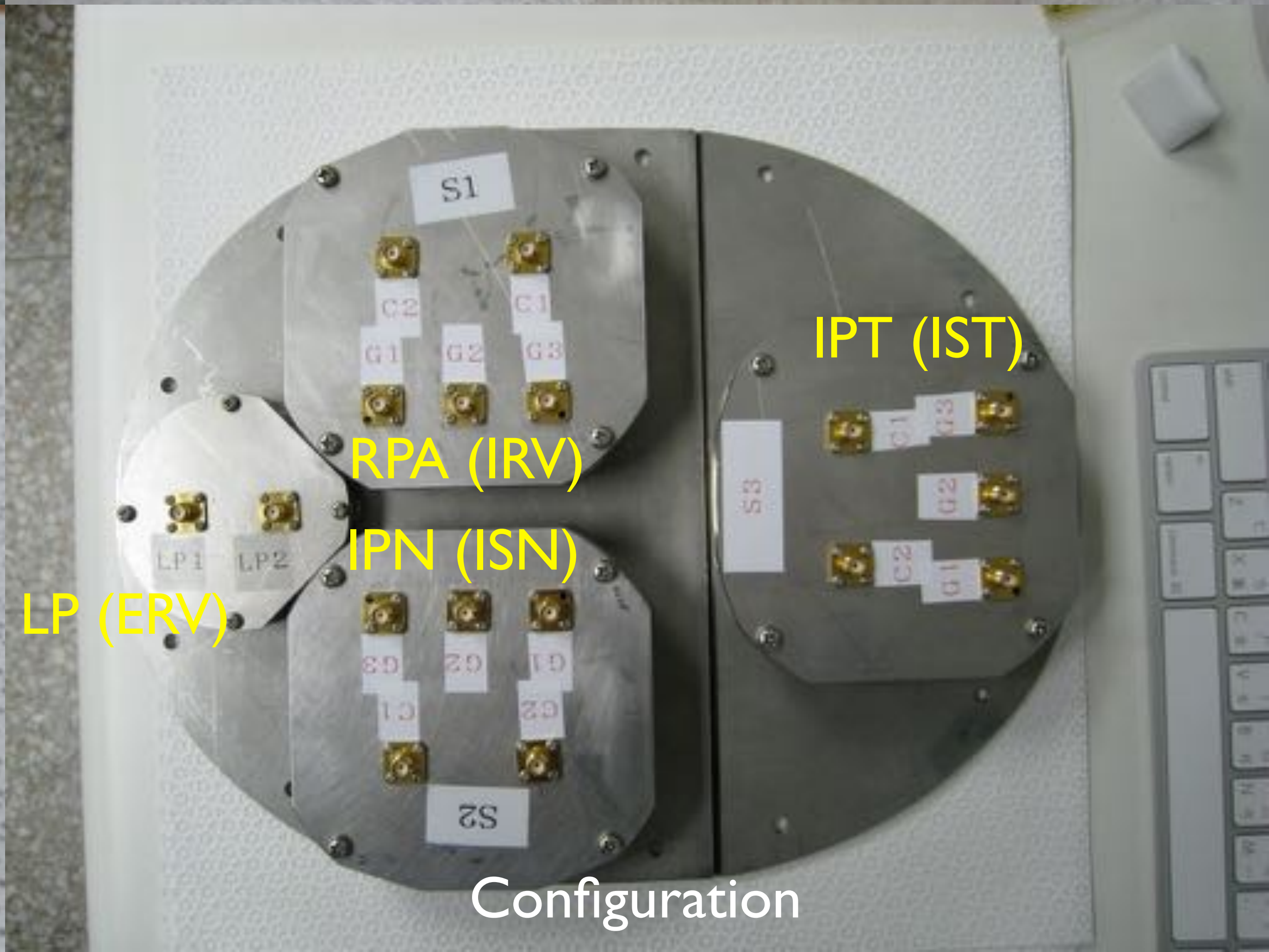
- Two ion traps (normal-directed and tilt-directed)
- One retarding potential analyzer
- One Langmuir probe
- One three-axis flux-gate magnetometer (installed inside the electronics box)

Ion traps

Langmuir probe



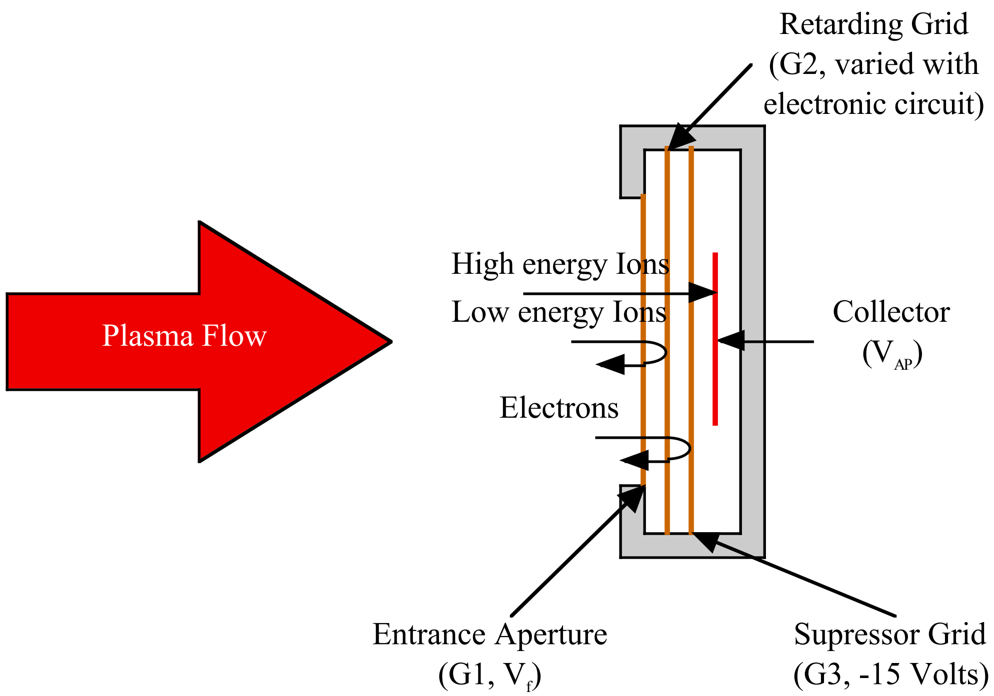
Retarding potential analyzer



Configuration

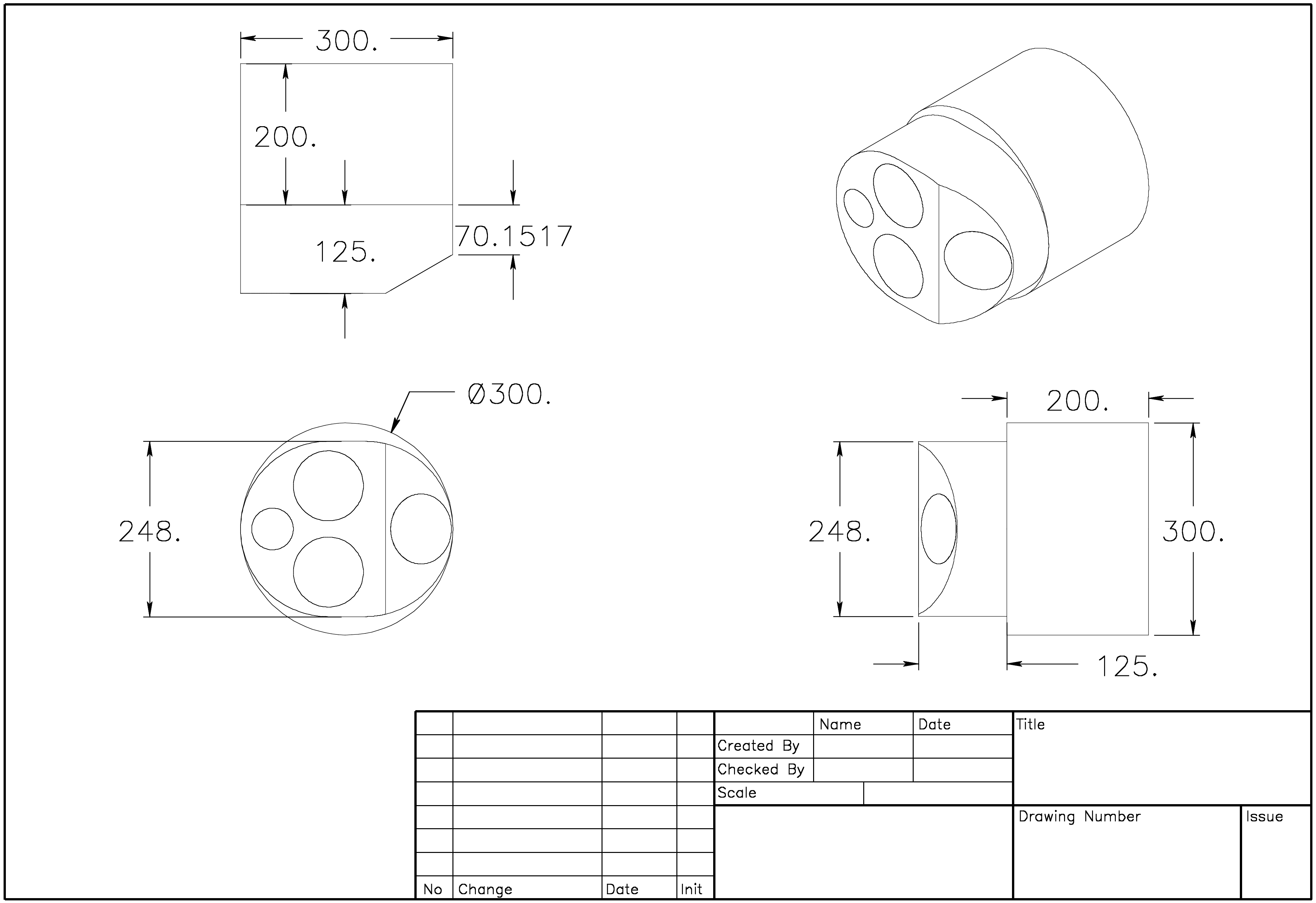
Principles of measurement

- Measuring electric current generated from ionospheric ions hitting on collector plate
- For IT, the retarding voltage is floating potential
- For RPA, the retarding voltage will be varied with electronic circuit



$$\Phi = C\sum_s n_{so}U_s\left\{\frac{1}{2}\left[1+erf(\beta_s F_s)+\frac{\exp(-\beta_s^2 F_s^2)}{\sqrt{\pi}\beta_s U_s}\right]\right\} \qquad \beta_s = \sqrt{\frac{m_s}{2\kappa T_s}},\ \beta_s F_s = U_s / \sqrt{\frac{2\kappa T_s}{m_s}} - \sqrt{\frac{q_s \phi_M}{\kappa T_s}}.$$


LP (ERV)
RPA (IRV)
IPN (ISN)
IPT (IST)

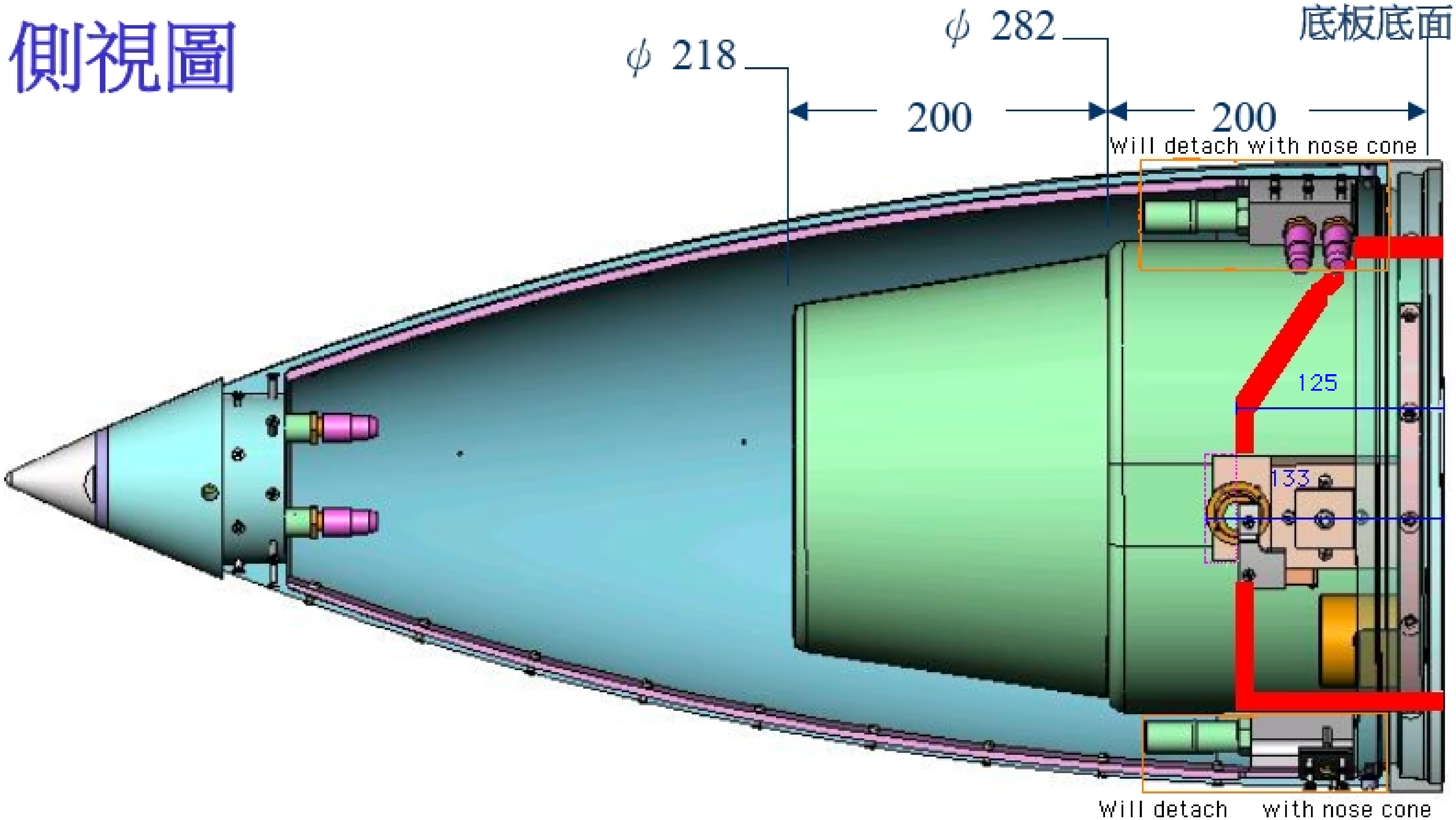

300.
200.
125.
70.1517
Ø300.
248.
200.
248.
300.
125.
Name
Date
Title
Created By
Checked By
Scale
Drawing Number
Issue
No
Change
Date
Init

~ 20 kg

Mechanical parameters

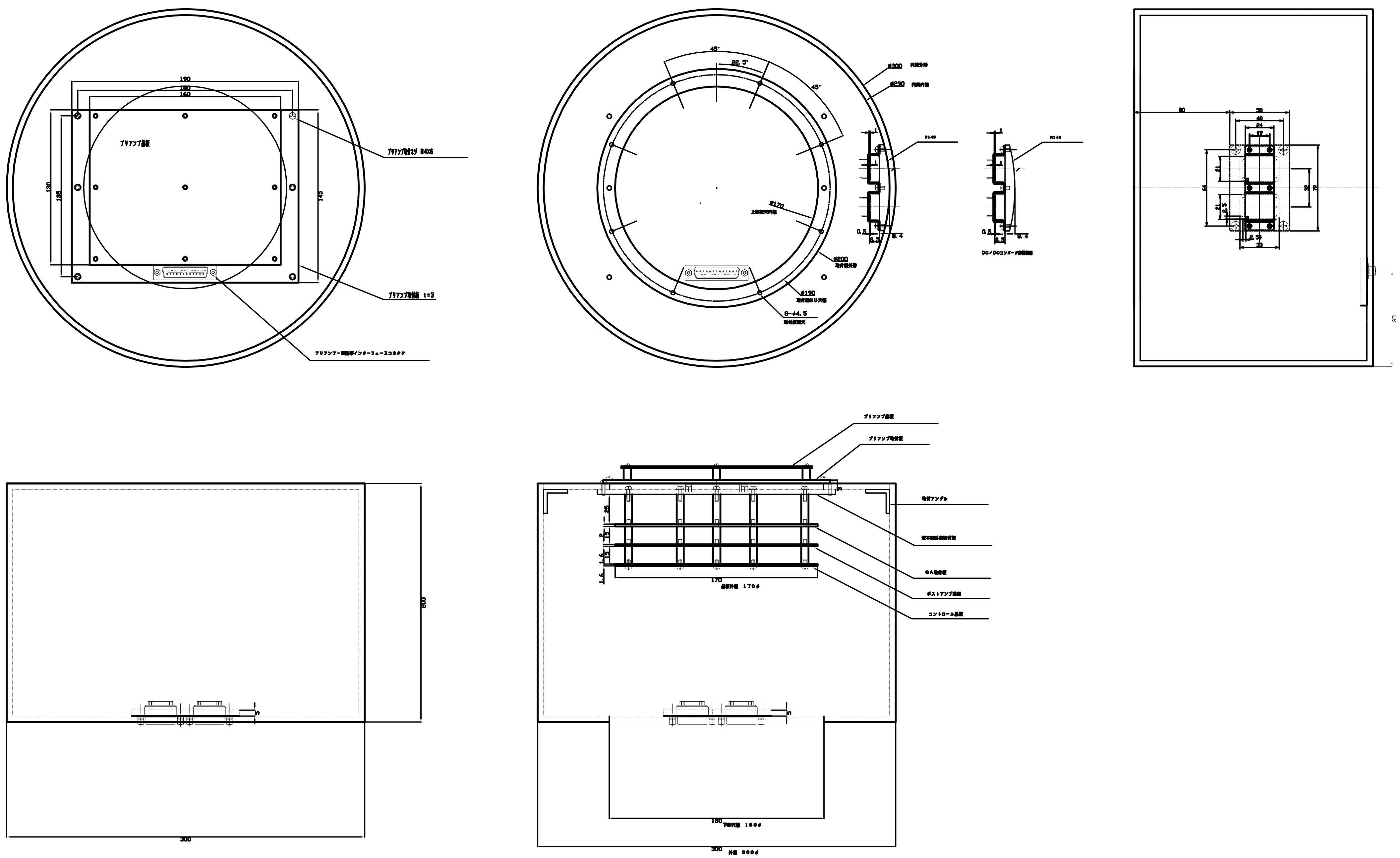
- Mass estimates
  - Total: 20 kg
- Temperature limits
  - Sensor head: 0 - 100 °C (operating), -10 - 110 °C (Non-operating)
  - Electronics box: 0 - 50 °C (operating), -10 - 70 °C (Non-operating)

側視圖



φ 218
φ 282
底板底面
200
200
Will detach with nose cone
125
133
Will detach with nose cone

Electronics box

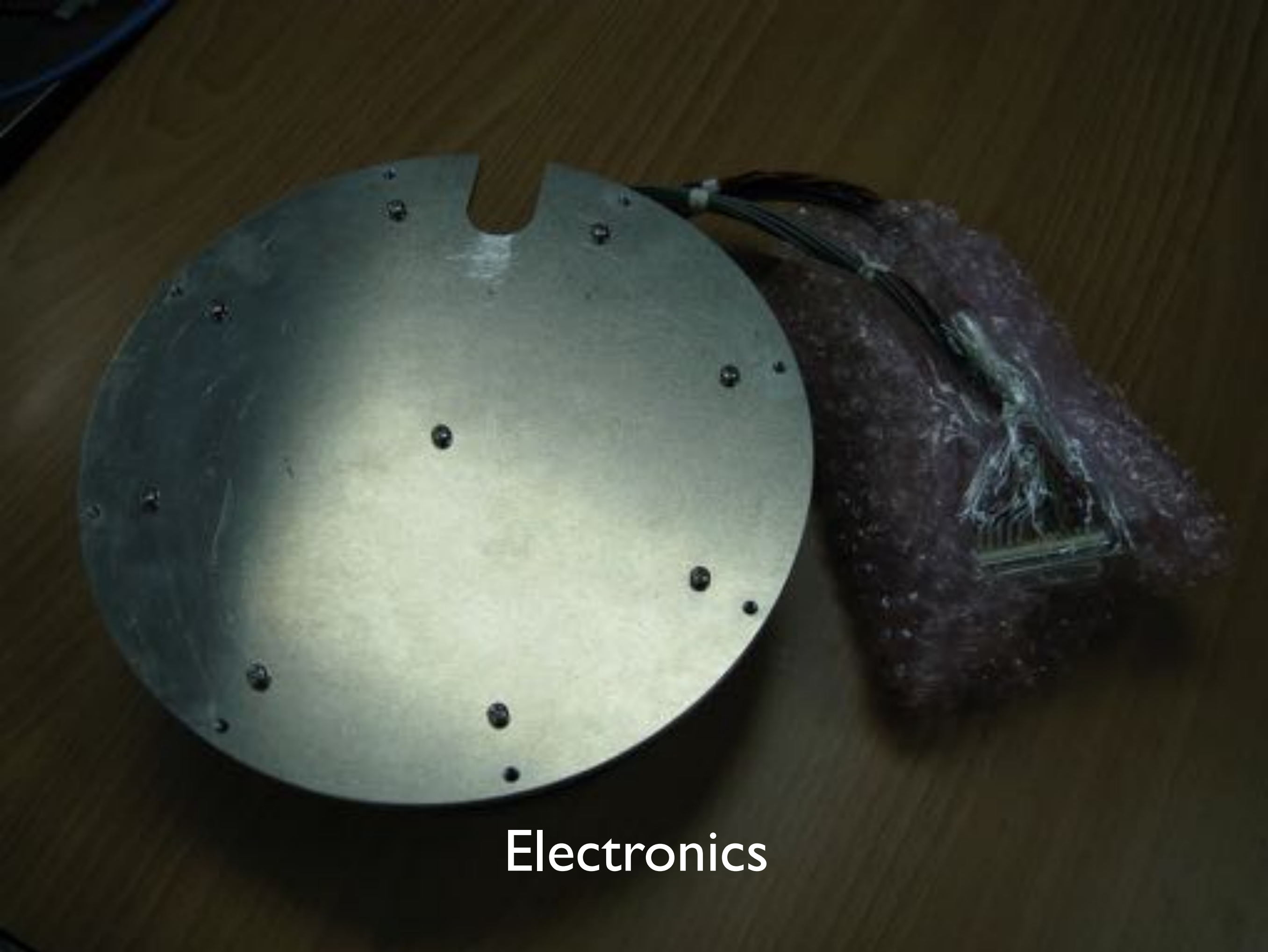


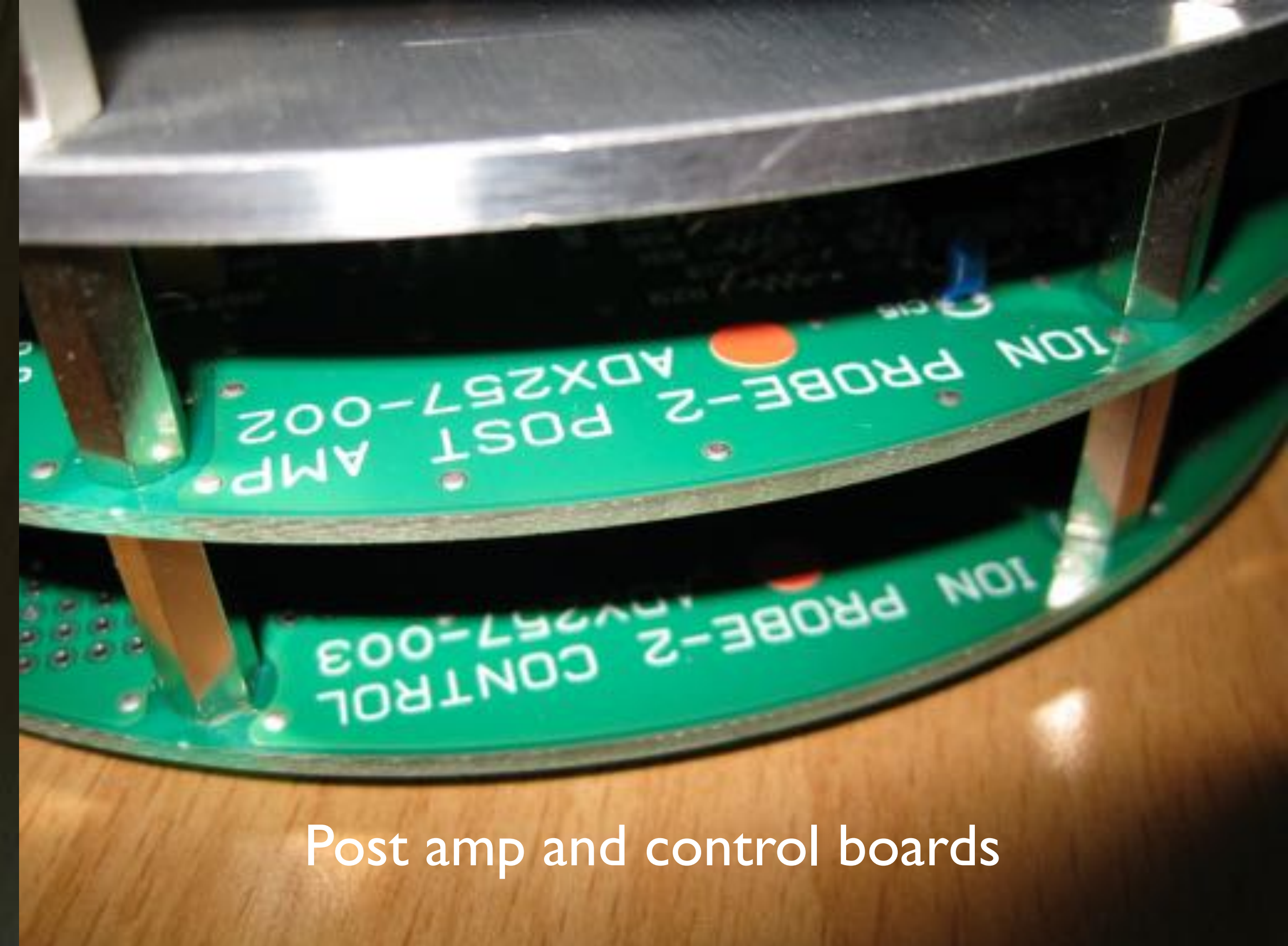
Grid specification

Sensor	Grid	Function	Voltage	Mesh density (lines/inch)	Wire size (inch)	Transparency
ISN and IST	G1	Shield	floating potential	40	3.937×10^{-3}	0.7098
	G2	Shield	floating potential	165	1.969×10^{-3}	0.4559
	G3	Suppressor	-15 V	40	3.937×10^{-3}	0.7098
	Collector	Collector	-6 V	N/A	N/A	N/A
IRV	G1	Shield	floating potential	40	3.937×10^{-3}	0.7098
	G2	Retarding grid	-1.48 to 3.0 V -5.4 to 6.0 V	165	1.969×10^{-3}	0.4559
	G3	Suppressor	-15 V	40	3.937×10^{-3}	0.7098
	Collector	Collector	-6 V	N/A	N/A	N/A

Electronics

- One pre-amp board
- One post-amp board
- One control board
- One three-axis flux-gate magnetometer


Electronics



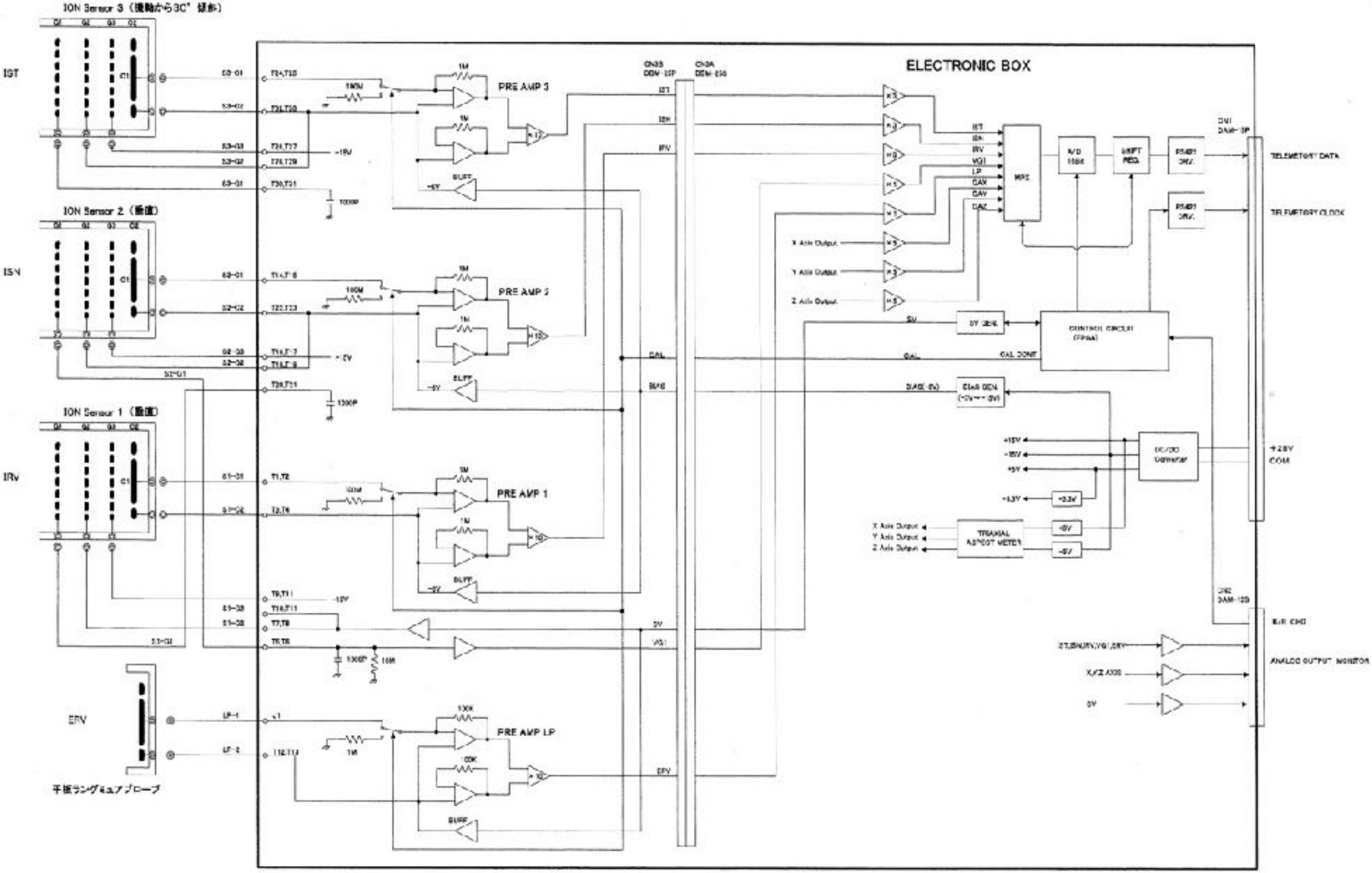
Post amp and control boards


3-axis fluxgate magnetometer


Pre amp board

Aspectmeter

Installation	Inside the electronics box
Type	3-axis fluxgate magnetometer
Dimension	75 mm L x 75 mm W x 19 mm H
Weights	0.05 kg
Power requirement	+5 V, 30 mA, -5V, 10 mA
Operating temperature	0 °C~ 50 °C
Shock	100 G
Frequency response	DC to 400 Hz
Measurement range	-70000 to +70000 nT
Output analog signal	-4 to +4 V
Output impedance	100 Ω
Accuracy	± 2 degrees



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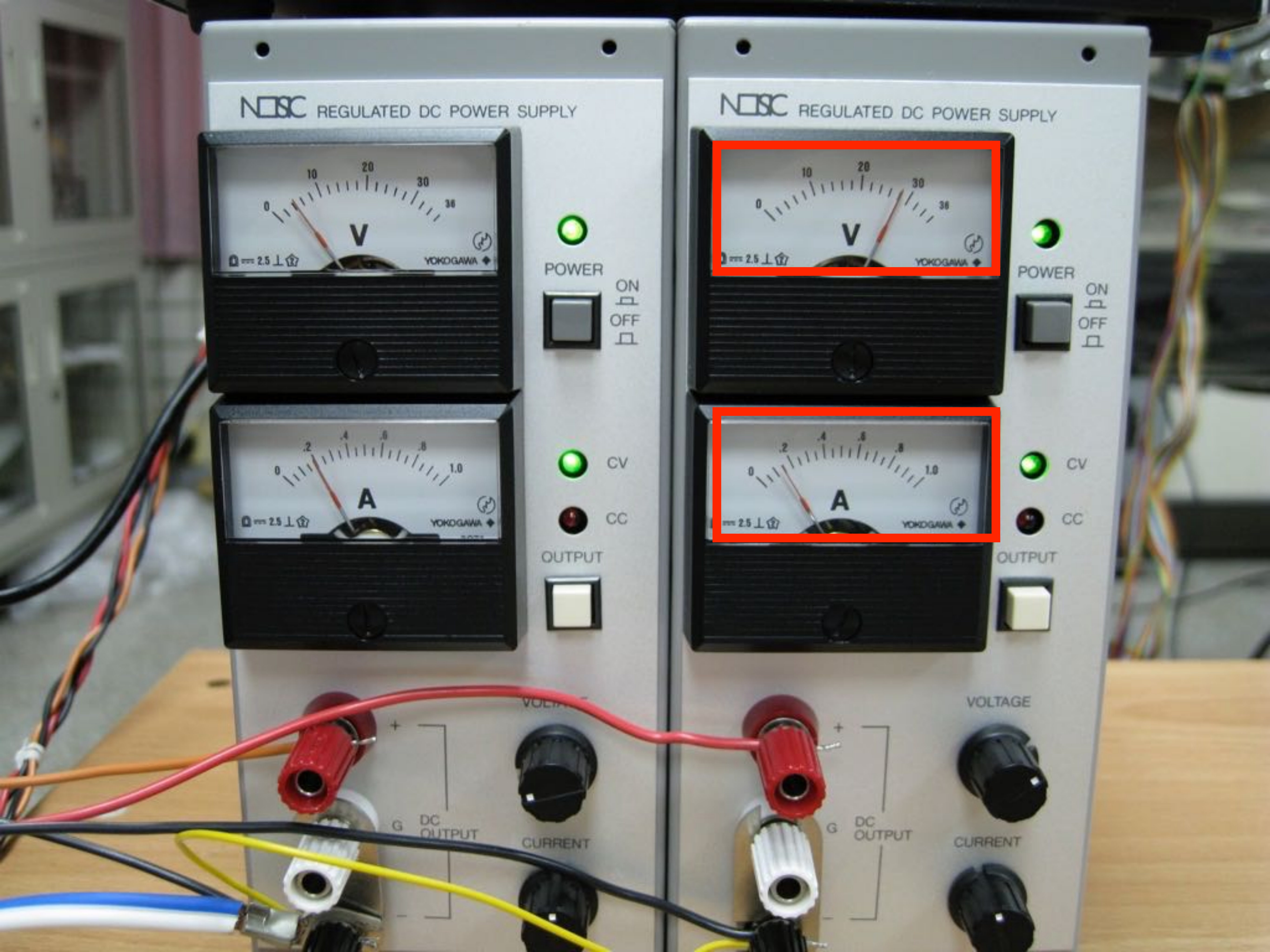
型式	イオンプローブII
図名	ブロック図
図番	ADC257−011

Power requirements

- Input voltage: 28±6 VDC
- Current: 150 mA
- Power consumption: 4.2 W



REGULATED DC POWER SUPPLY
REGULATED DC POWER SUPPLY
POWER
ON
OFF
CV
CC
OUTPUT
POWER
ON
OFF
CV
CC
OUTPUT
VOLTAGE
CURRENT
DC OUTPUT
CURRENT
DC OUTPUT
YOKOGAWA

Communication interface

- Analog/digital data communication
- Analog output: ±10 volt
- Digital output: RS-422
- Adjustable baud rate: 38.4/76.8 kbps, default is 76.8 kbps.
- Dual D-sub 15-pin connectors: one D-sub connector with pins (CN1) to IOP and battery, and the other connector with sockets (CN2) to telemetry

端　子　表

機器名称　ION PROBE2

コネクタ記号	CN−1

— (1／1)

コネクタ品名	
機器側	DAM−15P
計装側	DAM−15S

Connector in payload

番号	配線先	信号名	線種	電流容量	端末処理	備考
1	BATT	+28V	N			
2	BATT	COM	N			
3	N. C					
4	TM	DATA (+)	N			
5	TM	DATA (−)	N			
6	TM	CLOCK (+)	N			
7	TM	CLOCK (−)	N			
8	TM	COM	N			
9	N. C					
10	N. C					
11	N. C					
12	N. C					
13	N. C					
14	N. C					
15	N. C					
16						
17						

端　子　表

機器名称　ION　PROBE2

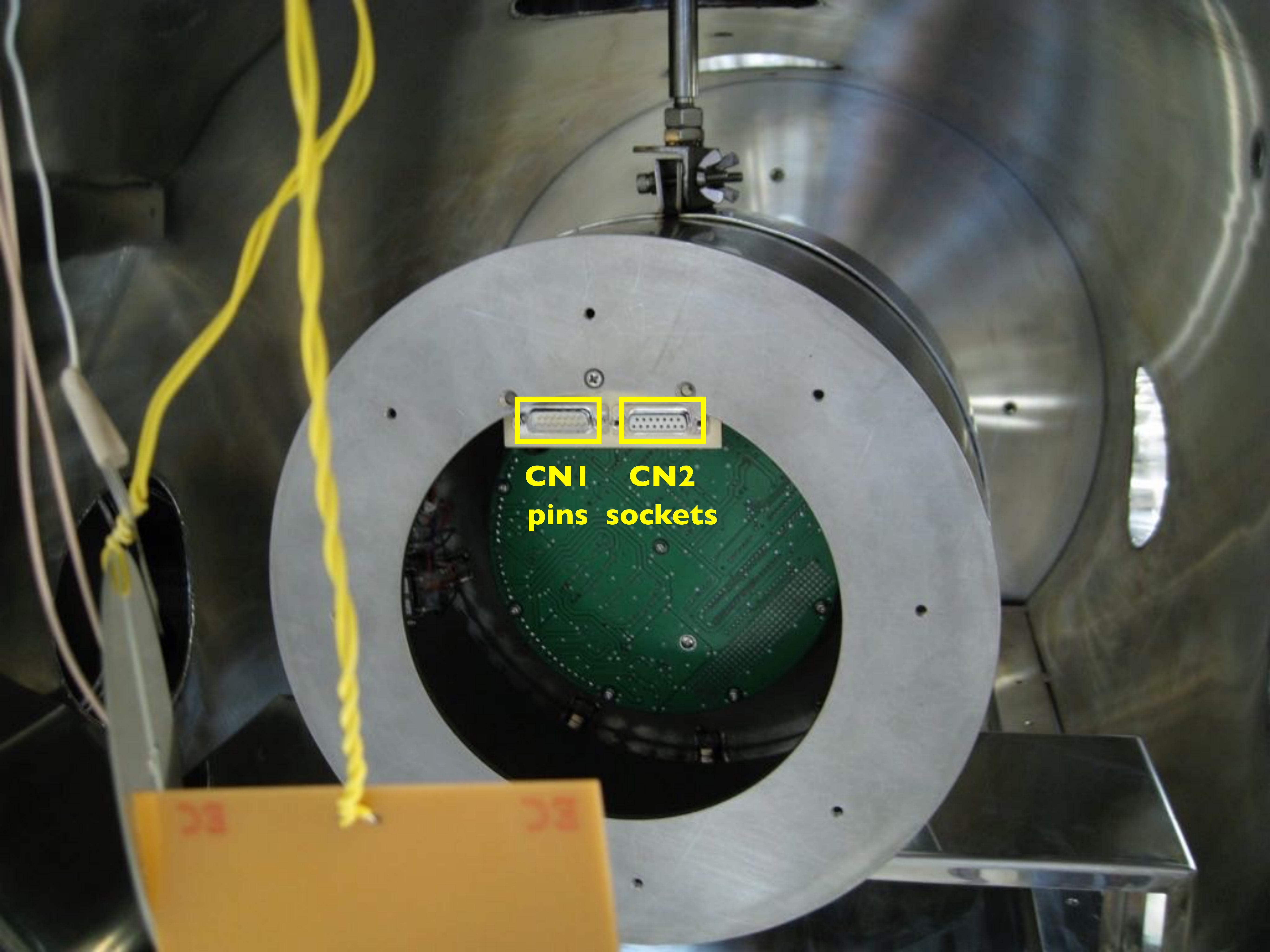
コネクタ記号	CN−2

—　(1／1)

コネクタ品名	
機器側	DAM−15S
計装側	DAM−15P

Connector in payload

番号	配線先	信号名	線種	電流容量	端末処理	備考
1		IRV　MONI　(S1)	S			
2		ERV　MONI　(LP)	S			
3		ISN　MONI　(S2)	S			
4		IST　MONI　(S3)	S			
5		COM	S			
6		VG2　MONI	S			ｼｰﾙﾄﾞ:14PIN
7		CLOCK　SEL	N			7-8 ｵｰﾌﾟﾝ:76.8KHz
8		COM	N			7-8 ｼｮｰﾄ :38.4KHz
9		VG1　MONI　(S2)	S			
10		GAX　MONI	S			
11		GAY　MONI	S			
12		GAZ　MONI	S			
13		COM	S			
14		COM	S			6ピンのシールド
15						
16						
17						


CN1
pins
CN2
sockets

Geophysical parameters

- Electron temperature (Langmuir probe)
- Ion temperature (retarding potential analyzer)
- Ram speed (retarding potential analyzer)
- Composition (retarding potential analyzer)
- Angle of attack (aspectmeter and two ion traps)
- Ion density (normal-directed ion trap, retarding potential analyzer, aspectmeter, and two ion traps)

Measurement range

Parameters	Range (A)	Voltage (V)
ERV	3×10^{-10} - 1×10^{-5}	0.0003 ($10/2^{16-1}$) - 10
IRV	1×10^{-11} - 3.3×10^{-7}	0.0003 - 10
ISN	1×10^{-11} - 3.3×10^{-7}	0.0003 - 10
IST	1×10^{-11} - 3.3×10^{-7}	0.0003 - 10

GAX			GAY			GAZ		
周波数(KHz)	偏差(dB)	出力(Vp-p)	周波数(KHz)	偏差(dB)	出力(Vp-p)	周波数(KHz)	偏差(dB)	出力(Vp-p)
1	0.000	10.000	1	0.000	10.000	1	0.000	10.000
10	0.000	10.000	10	0.000	10.000	10	0.000	10.000
20	-0.282	9.680	20	-0.247	9.720	20	-0.175	9.800
50	-1.556	8.360	50	-1.391	8.520	50	-1.432	8.480
100	-4.702	5.820	100	-4.466	5.980	100	-4.672	5.840
200	-10.995	2.820	200	-10.663	2.930	200	-10.873	2.860
500	-22.710	0.732	500	-22.430	0.756	500	-22.615	0.740
1000	-31.119	0.278	1000	-30.995	0.282	1000	-30.995	0.282

ＩＯＮ　ＰＲＯＢＥ　＃１　入出力特性

'07/11/20

IRV		ERV		ISN		IST	
IN (A)	OUT (V)	IN (A)	OUT (V)	IN (A)	OUT (V)	IN (A)	OUT (V)
1.90E-10	0.0066	1.80E-09	0.0018	1.90E-10	0.0065	1.90E-10	0.0065
2.90E-10	0.0095	2.80E-09	0.0028	2.90E-10	0.0095	2.90E-10	0.0094
5.80E-10	0.0185	5.80E-09	0.0058	5.80E-10	0.0185	5.80E-10	0.0181
1.08E-09	0.0333	1.08E-08	0.0108	1.08E-09	0.0335	1.08E-09	0.0330
3.08E-09	0.0931	1.00E-07	0.1001	3.08E-09	0.0938	3.08E-09	0.0929
5.08E-09	0.1525	1.00E-06	0.9924	5.08E-09	0.1540	5.08E-09	0.1528
1.01E-08	0.3016	1.00E-05	9.917	1.01E-08	0.3047	1.01E-08	0.3028
2.01E-08	0.5996			2.01E-08	0.6056	2.01E-08	0.6027
4.01E-08	1.1960			4.01E-08	1.2070	4.01E-08	1.2020
1.00E-07	2.9830			1.00E-07	3.0140	1.00E-07	3.0020
2.00E-07	5.9640			2.00E-07	6.0250	2.00E-07	6.0040
3.00E-07	8.9440			3.00E-07	9.0360	3.00E-07	9.0050
3.40E-07	10.136			3.40E-07	10.241	3.40E-07	10.2060

Data packets

- Data packet: 96 words/frame
- Word unit: 16 bits/word (MSB first)
- Frame period/rate:
  - **20** ms/**50** frame $\cdot$ s^{-1} if **76.8** kbps RS-422 is selected
  - **40** ms/**25** frame $\cdot$ s^{-1} if **38.4** kbps RS-422 is selected

Packet contents of ion probe onboard Sounding Rocket VII

SYNC: 0xEB90

FC: sequence count

W00	**W01**	**W02**	**W03**	**W04**	**W05**	**W06**	**W07**	**W08**	**W09**	**W10**	**W11**
SYNC	FC	ERV	ISN	IRV	ERV	GAX	IRV	ERV	IST	IRV	ERV
W12	**W13**	**W14**	**W15**	**W16**	**W17**	**W18**	**W19**	**W20**	**W21**	**W22**	**W23**
GAY	IRV	ERV	ISN	IRV	ERV	GAZ	IRV	ERV	IST	IRV	ERV
W24	**W25**	**W26**	**W27**	**W28**	**W29**	**W30**	**W31**	**W32**	**W33**	**W34**	**W35**
VG1	IRV	ERV	ISN	IRV	ERV	GAX	IRV	ERV	IST	IRV	ERV
W36	**W37**	**W38**	**W39**	**W40**	**W41**	**W42**	**W43**	**W44**	**W45**	**W46**	**W47**
GAY	IRV	ERV	ISN	IRV	ERV	GAZ	IRV	ERV	IST	IRV	ERV
W48	**W49**	**W50**	**W51**	**W52**	**W53**	**W54**	**W55**	**W56**	**W57**	**W58**	**W59**
VG1	IRV	ERV	ISN	IRV	ERV	GAX	IRV	ERV	IST	IRV	ERV
W60	**W61**	**W62**	**W63**	**W64**	**W65**	**W66**	**W67**	**W68**	**W69**	**W70**	**W71**
GAY	IRV	ERV	ISN	IRV	ERV	GAZ	IRV	ERV	IST	IRV	ERV
W72	**W73**	**W74**	**W75**	**W76**	**W77**	**W78**	**W79**	**W80**	**W81**	**W82**	**W83**
VG1	IRV	ERV	ISN	IRV	ERV	GAX	IRV	ERV	IST	IRV	ERV
W84	**W85**	**W86**	**W87**	**W88**	**W89**	**W90**	**W91**	**W92**	**W93**	**W94**	**W95**
GAY	IRV	ERV	ISN	IRV	ERV	GAZ	IRV	ERV	IST	IRV	ERV

Data packet (cont.)

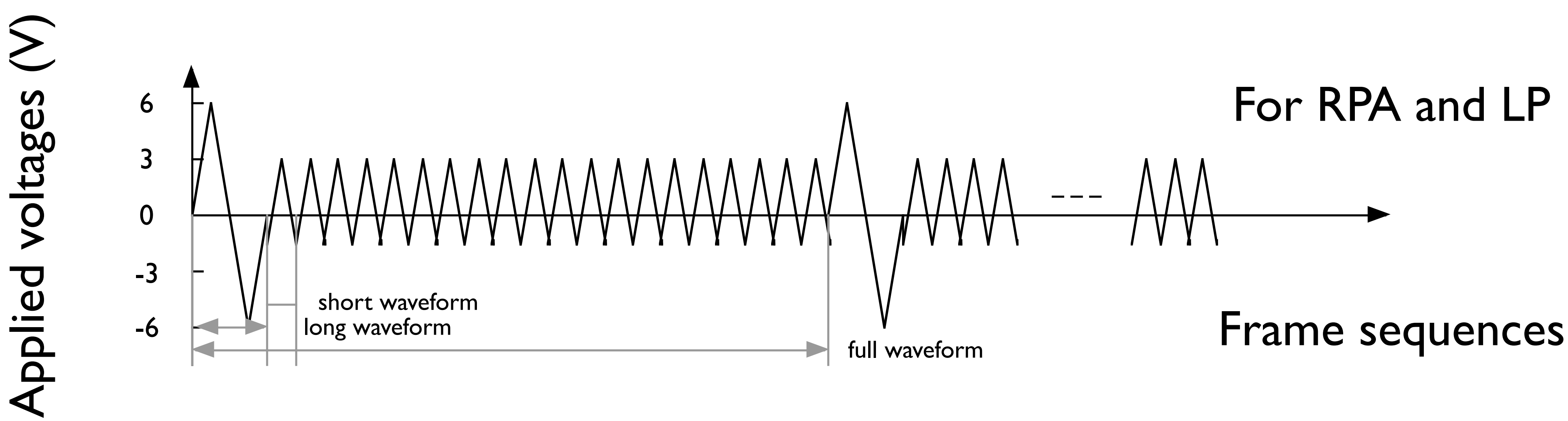
- Packet content:
  - Ion saturation current (ISN) from normal-directed IT
  - Ion saturation current (IST) from tilt-directed IT
  - Ion current (IRV) from normal-directed RPA (with retarding voltage sweeping between -1.48 and 3.0 or -5.84 and 6.0 volts with voltage step ΔV=0.02V)
  - Electron current (ERV) from Langmuir probe (with probe voltage sweeping between -1.48 and +3.0 or -5.84 and +6.0 volts with voltage step ΔV=0.02V)
  - Floating potential (VGI) from normal-directed IT
  - X-, Y-, and Z-axis components (GAX, GAY, and GAZ) of geomagnetic field from 3-axis flux-gate magnetometer (aspectmeter)

Data packet (cont.)

- For **76.8** kbps:
  - **200** Hz for VG1, GAX, GAY and GAZ samples (λ ~ **20** m for 2 km/s uplift speed)
  - **400** Hz for ISN and IST samples (λ ~ **10** m for 2 km/s uplift speed)
  - **1600** Hz for IRV and ERV samples (448/1184 samples or 14/37 frames for IRV/ERV sweeping from low to high with ΔV=0.02V)
  - ~**3.57/1.35** Hz for Ti and Te or λ ~ **0.56/1.48** km for 2 km/s uplift speed

- For **38.4** kbps:
  - **100** Hz for VG1, GAX, GAY and GAZ samples (λ ~ **40** m for 2 km/s uplift speed)
  - **200** Hz for ISN and IST samples (λ ~ **20** m for 2 km/s up speed)
  - **800** Hz for IRV and ERV samples (448/1184 samples or 14/37 frames for 1 IRV and ERV sweeping from low to high ΔV=0.02V)
  - ~**1.79/0.68** Hz for Ti and Te or λ ~ **1.12/2.96** km for 2 km/s uplift speed

Sweeping voltage pattern



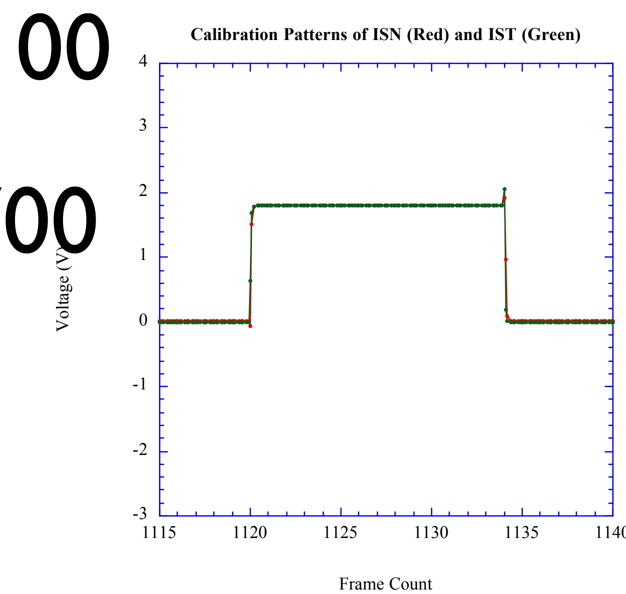
1 x full waveform (317 frames, 6.34s) = 1 x long waveform (37 frames, 0.74s) + 20 x short waveforms (14 frames, 0.28s).
Calibration waveform (14 frames) will happen in front of the long waveform every 9 full waveform (2,853 frames, 57.06s).

Criterions for pre-launch check

- ISN (W03) and IST (W09)
- IRV (W04)
- ERV (W05)
- VG1 (W24)
- GAX, GAY, and GAZ (should not be used for pre-launch check)
- Calibration is triggered every 57.06 seconds.

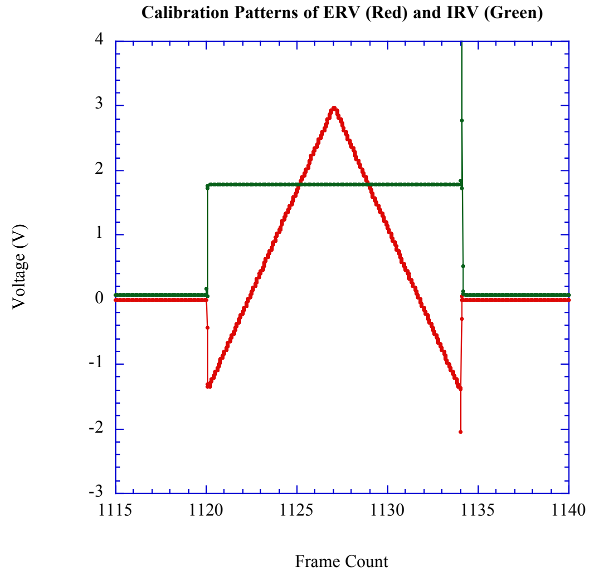
ISN and IST

- ISN: **W03**, W15, W27, ..., W87.
- IST: **W09**, W21, W33, ..., W93.
- If neither plasma nor electric current ejection (calibration) to collector, the output of the ISN and IST should be close to 0 volt.
- Calibration off: 0x7F00 < (ISN/T) < 0x8100
- Calibration on: 0x9500 < (ISN/T) < 0x9700



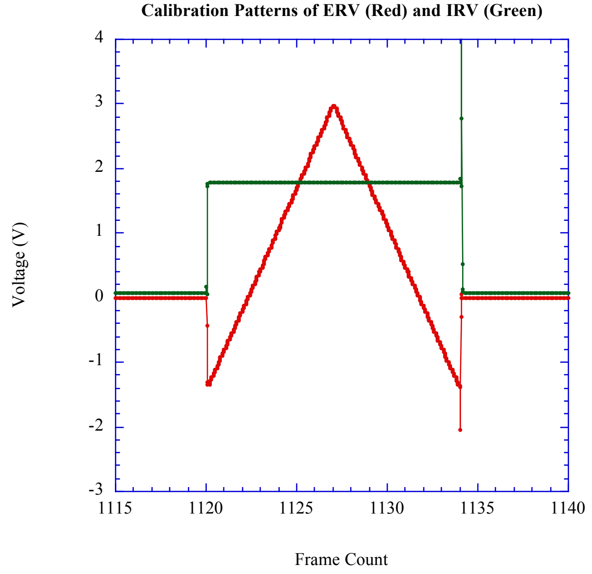
IRV

- IRV: **W04**, W07, W10, ..., W94.
- If neither plasma nor electric current ejection (calibration) to collector, the output of the IRV should be close to 0 volt.
- Calibration off: 0x7E00 < IRV < 0x8200
- Calibration on: 0x9500 < IRV < 0x9700



ERV

- ERV: W02, **W05**, W08, ..., W94.
- If neither plasma nor electric current ejection (calibration) to collector, the output of the ERV should be close to 0 volt.
- Calibration off: 0x7F00 < ERV < 0x8100
- Calibration on: 0x6E00 < ERV < 0xA700



ERV

- To use W05 as pre-launch check of ERV.
- The first ERV (W02) in each frame is smaller than the other nearby ERV reading. It is not a good candidate for check.

EB	90	0E	C6	7F	B1	8D	49	9C	F2	7F	BD	D3	80	9C	F4
7F	BD	AC	71	9C	F0	7F	BB	6C	E5	9C	ED	7F	BD	8D	47
9C	EC	7F	BD	89	6A	9C	ED	7F	BD	AC	70	9C	EA	7F	C0
81	36	9C	EC	7F	C1	8D	48	9C	E9	7F	C0	D3	A4	9C	F2
7F	BD	AC	74	9C	EF	7F	C1	6D	01	9C	EA	7F	BF	8D	47
9C	EC	7F	BF	89	40	9C	ED	7F	C1	AC	73	9C	EE	7F	BD
81	38	9C	EF	7F	C1	8D	4A	9C	EF	7F	C2	D3	92	9C	EF
7F	C0	AC	72	9C	EF	7F	C1	6C	F5	9C	EC	7F	C1	8D	4C
9C	E8	7F	C2	89	75	9C	E9	7F	C5	AC	6D	9C	E8	7F	C1
81	38	9C	E7	7F	C2	8D	4A	9C	E6	7F	C3	D3	7B	9C	E5
7F	C2	AC	75	9C	E2	7F	C4	6C	E9	9C	E0	7F	C2	8D	49
9C	DD	7F	C4	89	77	9C	DE	7F	C2	AC	72	9C	D6	7F	C2
EB	**90**	0E	C7	7F	B5	8D	49	9C	DB	7F	C1	D3	9E	9C	DD
7F	C2	AC	74	9C	D9	7F	C2	6C	F1	9C	DA	7F	C4	8D	46
9C	DB	7F	C3	89	4F	9C	D9	7F	C2	AC	78	9C	DA	7F	C3
81	35	9C	D5	7F	C4	8D	47	9C	D6	7F	C4	D3	99	9C	DC
7F	C4	AC	79	9C	D8	7F	C3	6D	08	9C	D9	7F	C4	8D	47
9C	D7	7F	C4	89	62	9C	D3	7F	C4	AC	77	9C	D3	7F	BF
81	37	9C	D2	7F	C4	8D	46	9C	D2	7F	C4	D3	80	9C	D3
7F	C4	AC	77	9C	D3	7F	C5	6C	E7	9C	CF	7F	C4	8D	45
9C	CE	7F	C4	89	87	9C	D1	7F	C5	AC	7A	9C	CD	7F	C5
81	35	9C	CD	7F	C5	8D	47	9C	CB	7F	C6	D3	8D	9C	CD
7F	C5	AC	74	9C	C8	7F	C6	6C	F4	9C	CD	7F	C5	8D	48
AC	76	9C	CD	7F	C6	EB	90	0E	C8	7F	B8	8D	48	9C	CC

VG1

- VG1: **W24**, W48, and W72.
- Before launch, the value should be close to 0 volt.
- No calibration will be applied on VG1.
- 0x6000 < VG1 < 0xA000

GAX, GAY, and GAZ

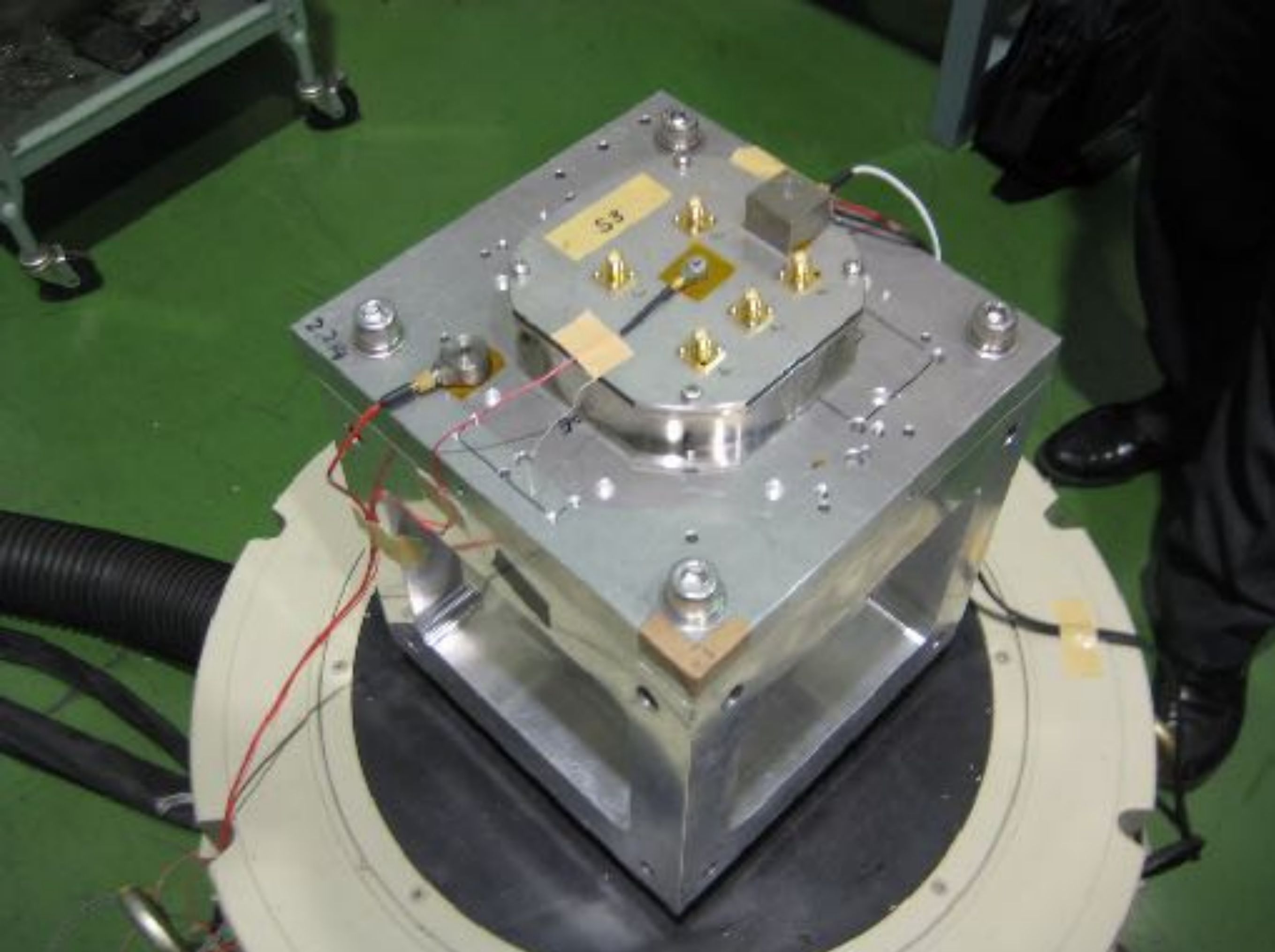
- GAX: W06, W30, W54, and W78.
- GAY: W12, W36, W60, and W84.
- GAZ: W18, W42, W66, and W90.
- Varied with payload attitude and local geomagnetic field and no calibration will be applied on them
- Should not be used for pre-launch check

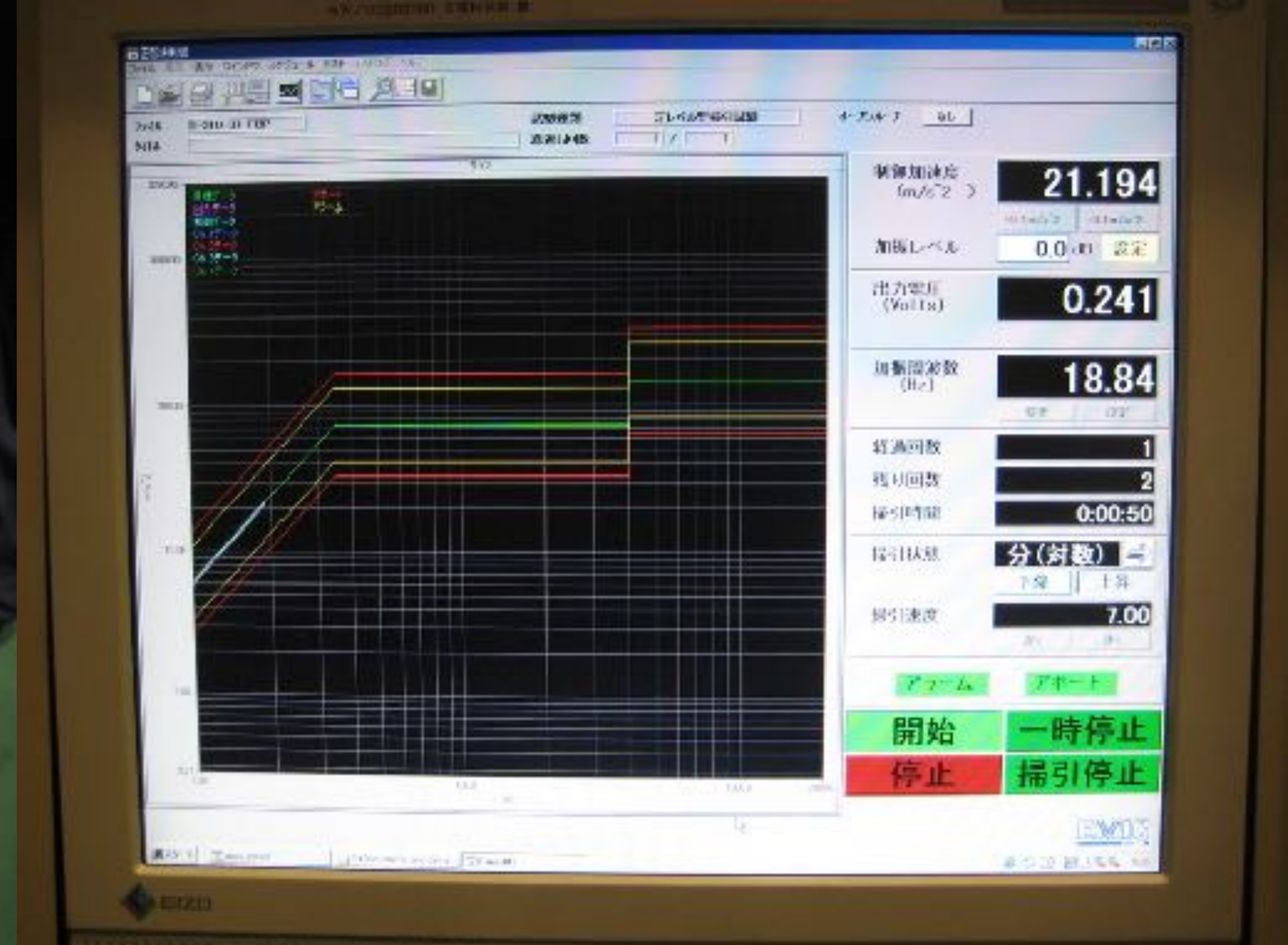
Tests

- 11/13-14/2007: vibration test at ISAS
- 11/25-29/2007: performance/heating test at OCU
- 01/10/2008: performance test at NCU
- 05/19/2008: analog signals to telemetry
- 06/26/2008: performance test of Langmuir probe
- 07/11/2008: digital signals to IOP at CSIST
- 08/15/2008: heating test on ion probes

Tests (cont.)

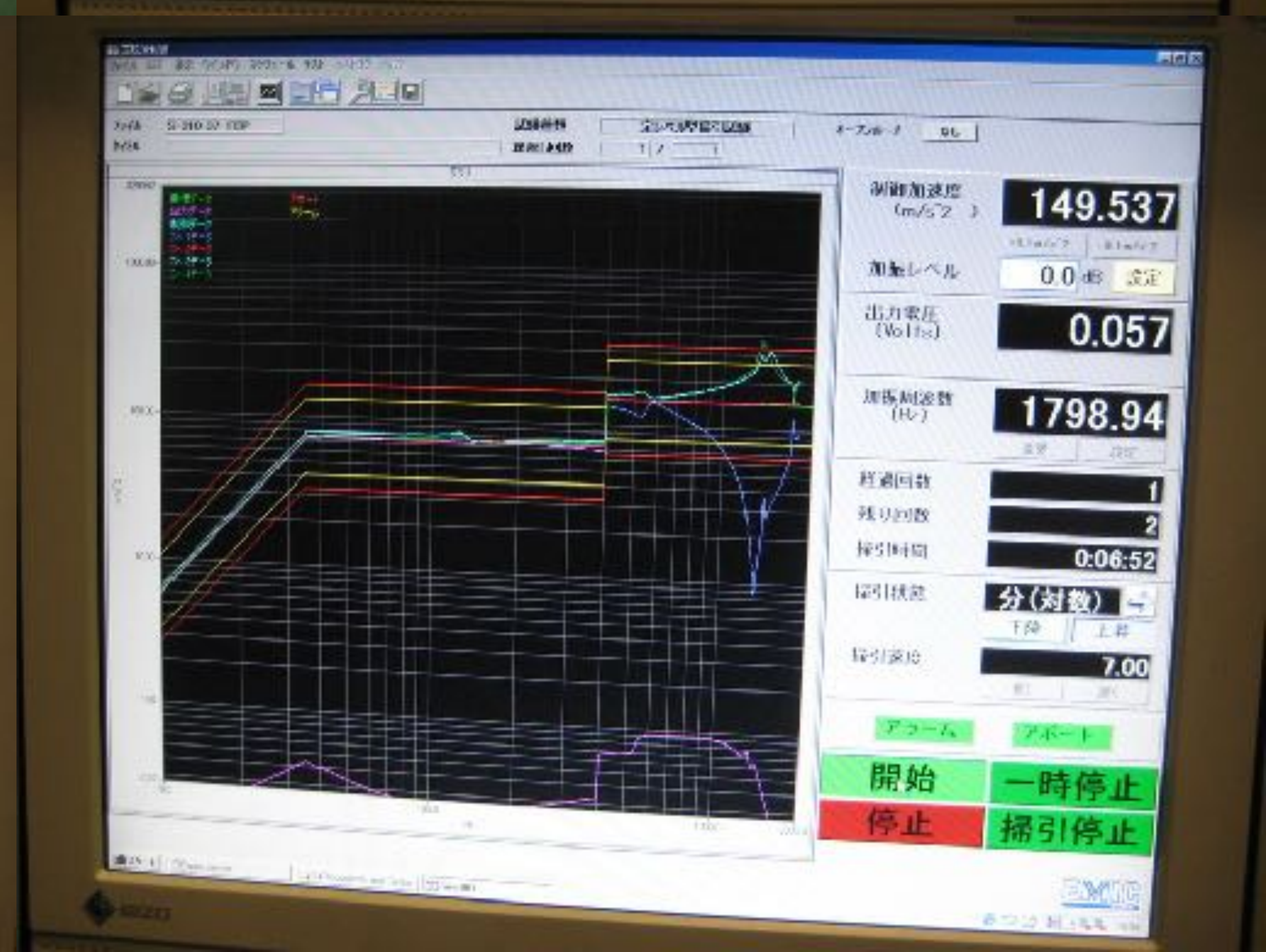
- 03/23-30/2009: nose cone separation tests
- 05/27-06/03/2009: rotation tests with IOP
- 06/22-25/2009: environmental tests - thermal cycling
- 07/01/2009: vibration test
- 07/20/2009: vibration test - payload only



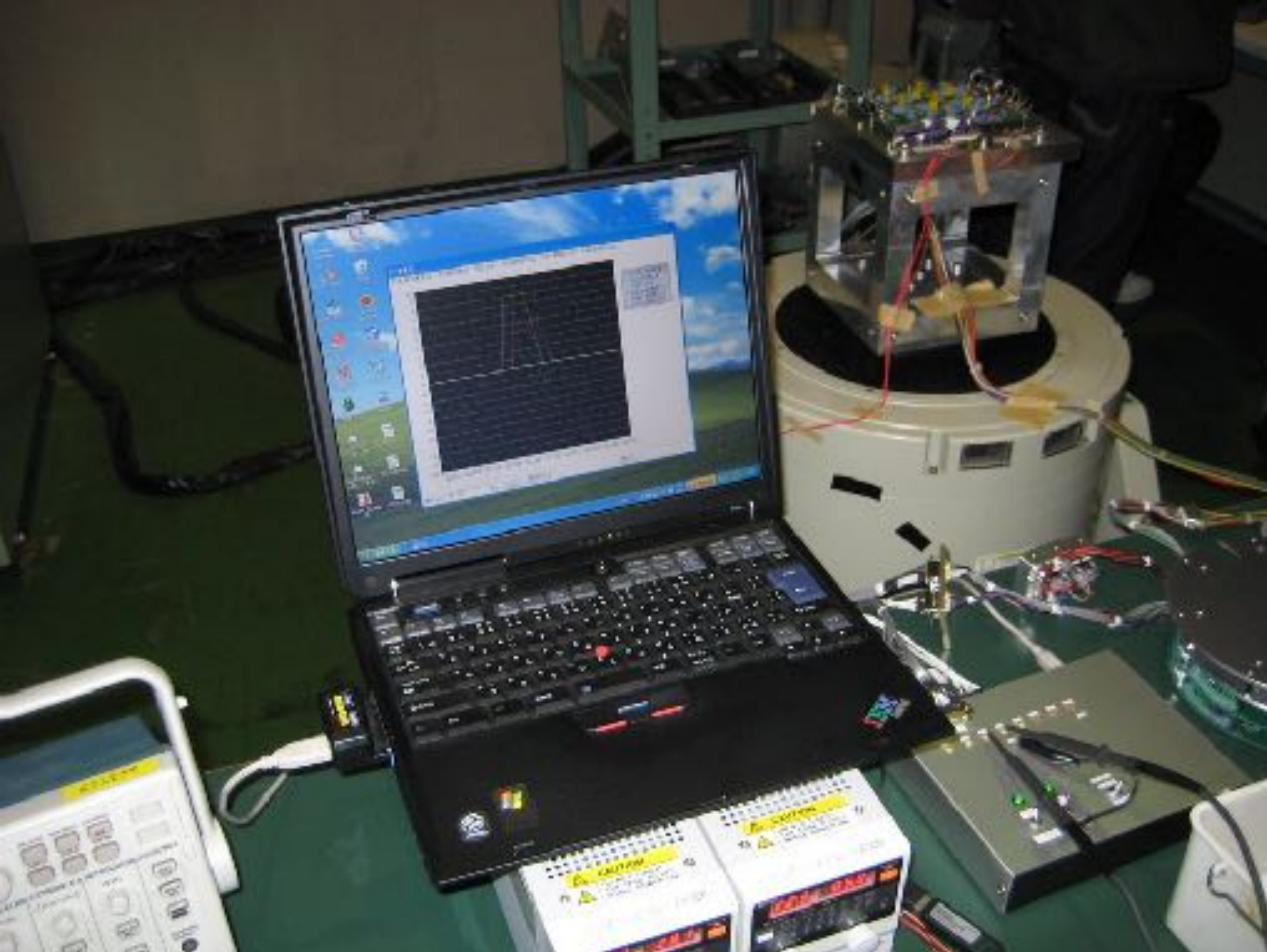


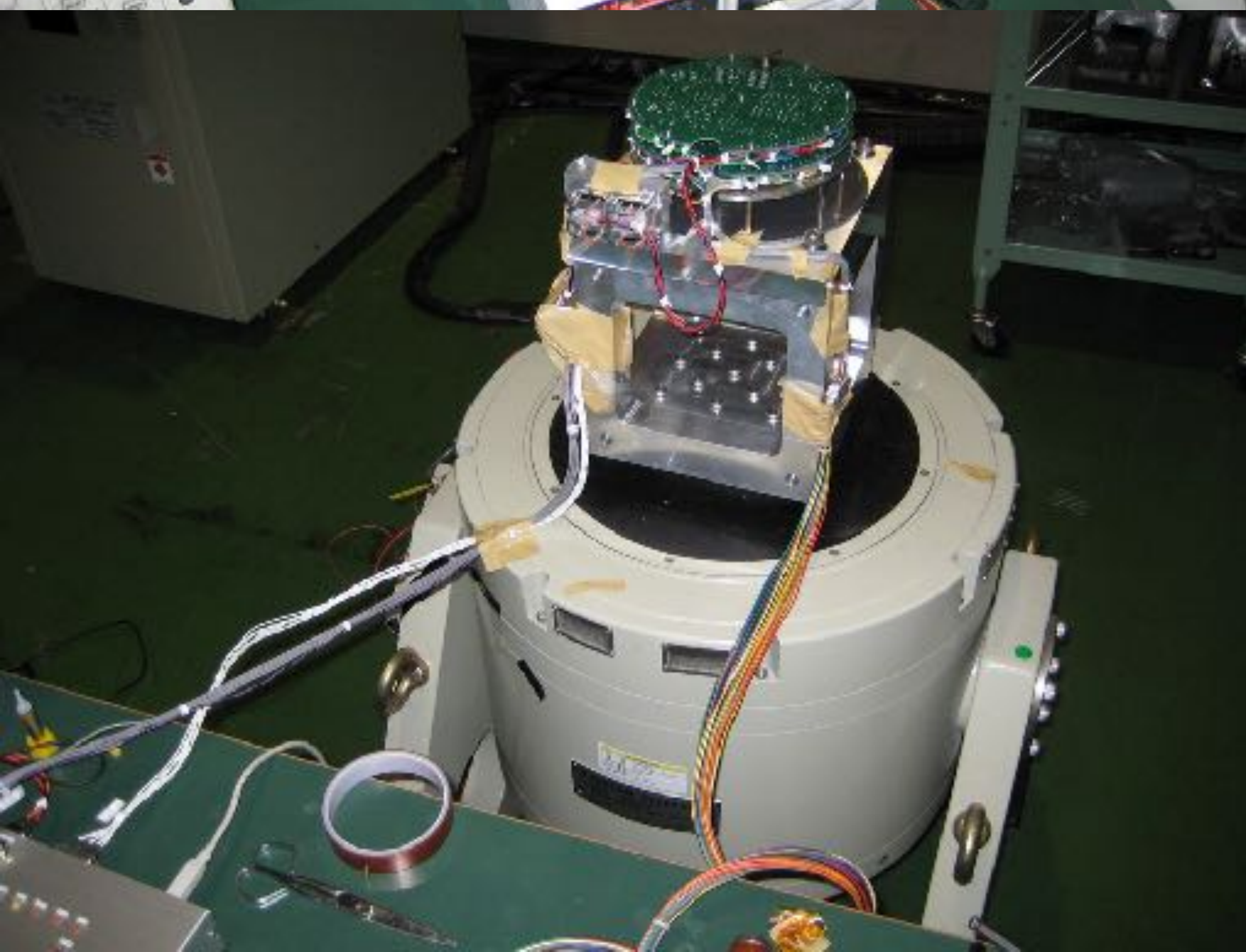
21.194
0.241
18.84
0:00:50
分(対数)
7.00
開始
一時停止
停止
掃引停止

100G
10G
100Hz
1kHz
146.984
0.570
469.70
0:01:55
分(対数)
7.00
開始
一時停止
停止
掃引停止

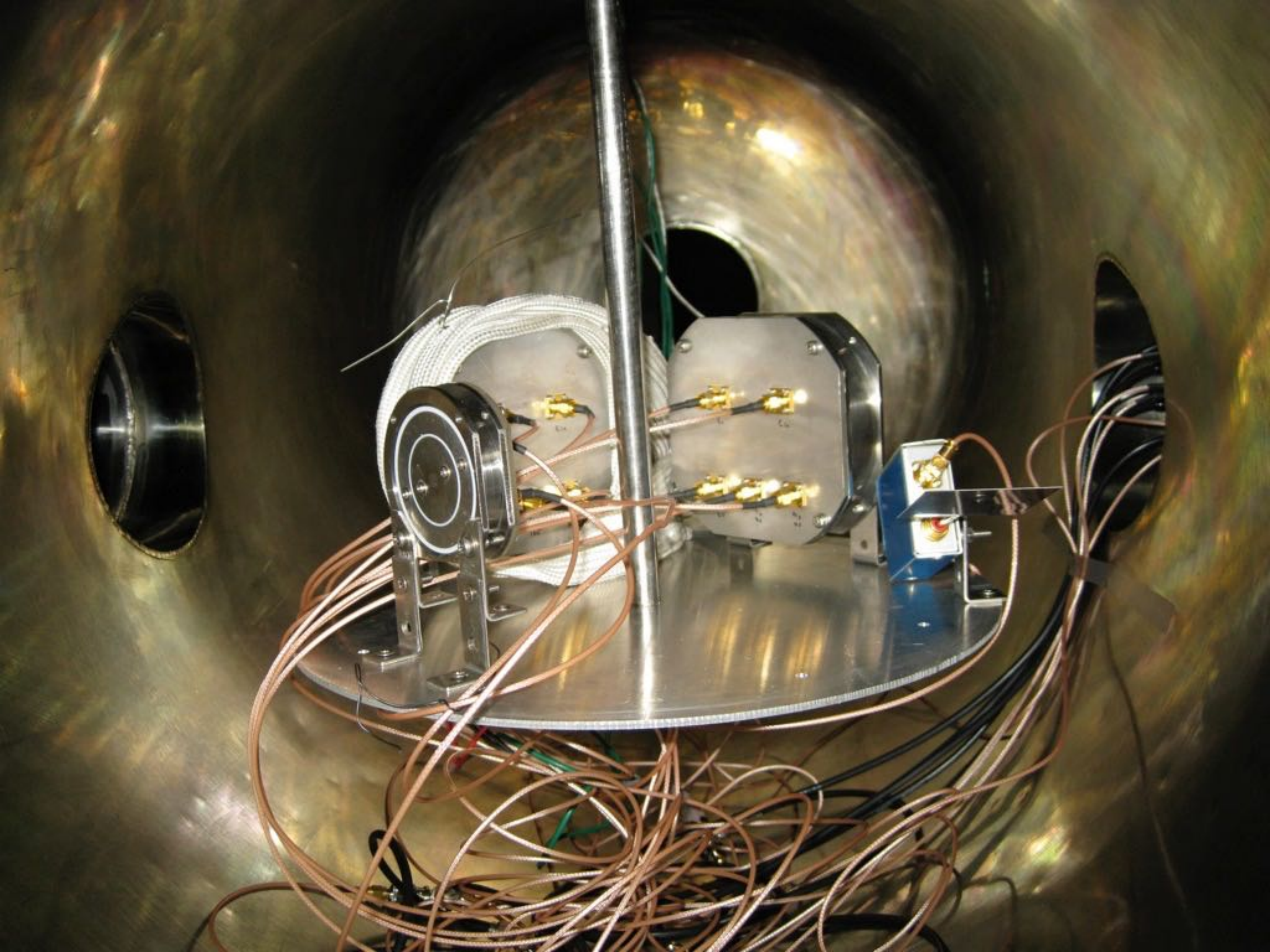


149.537
0.057
1798.94
0:06:52
分(対数)
7.00
開始
一時停止
停止
掃引停止

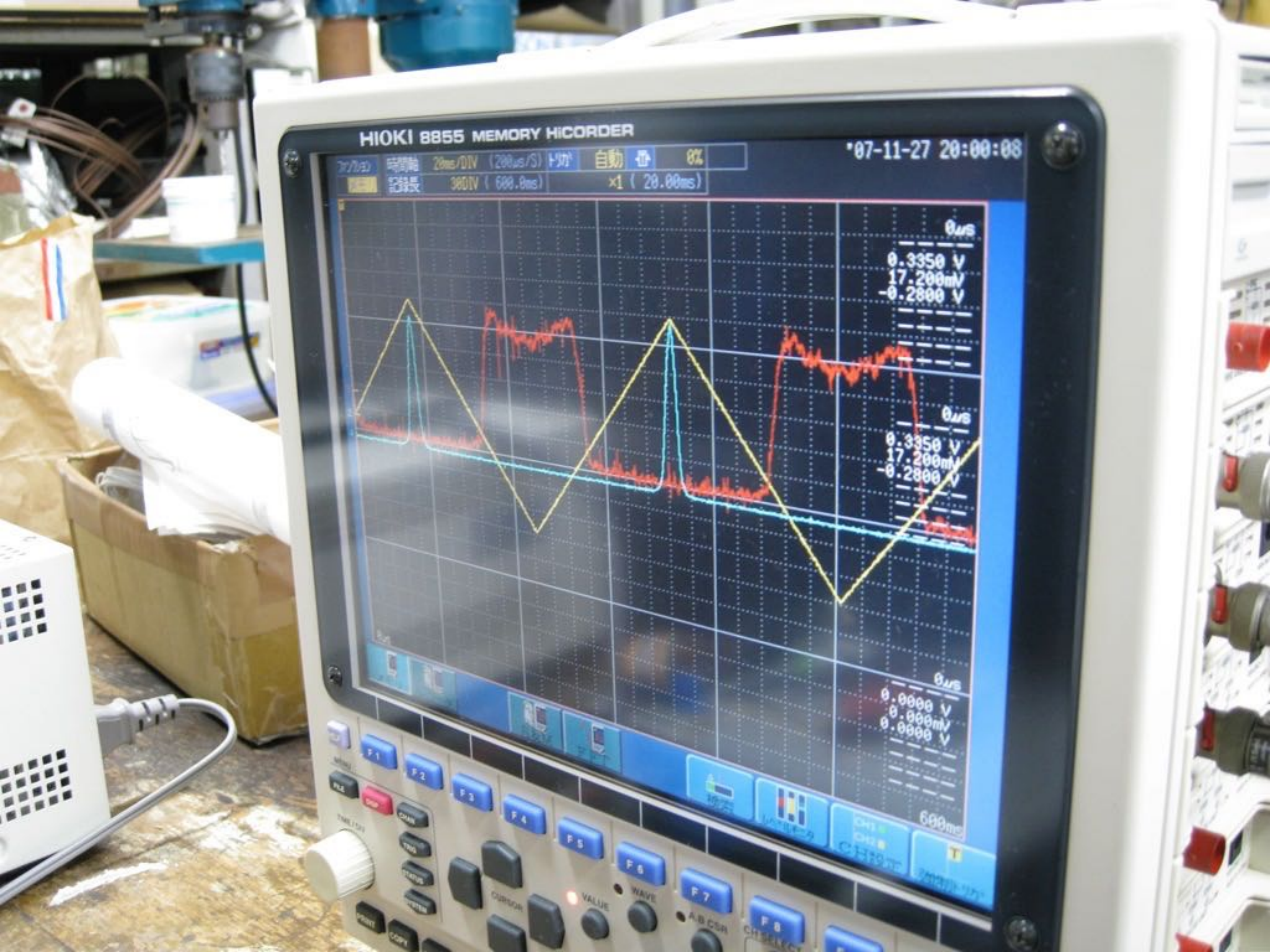


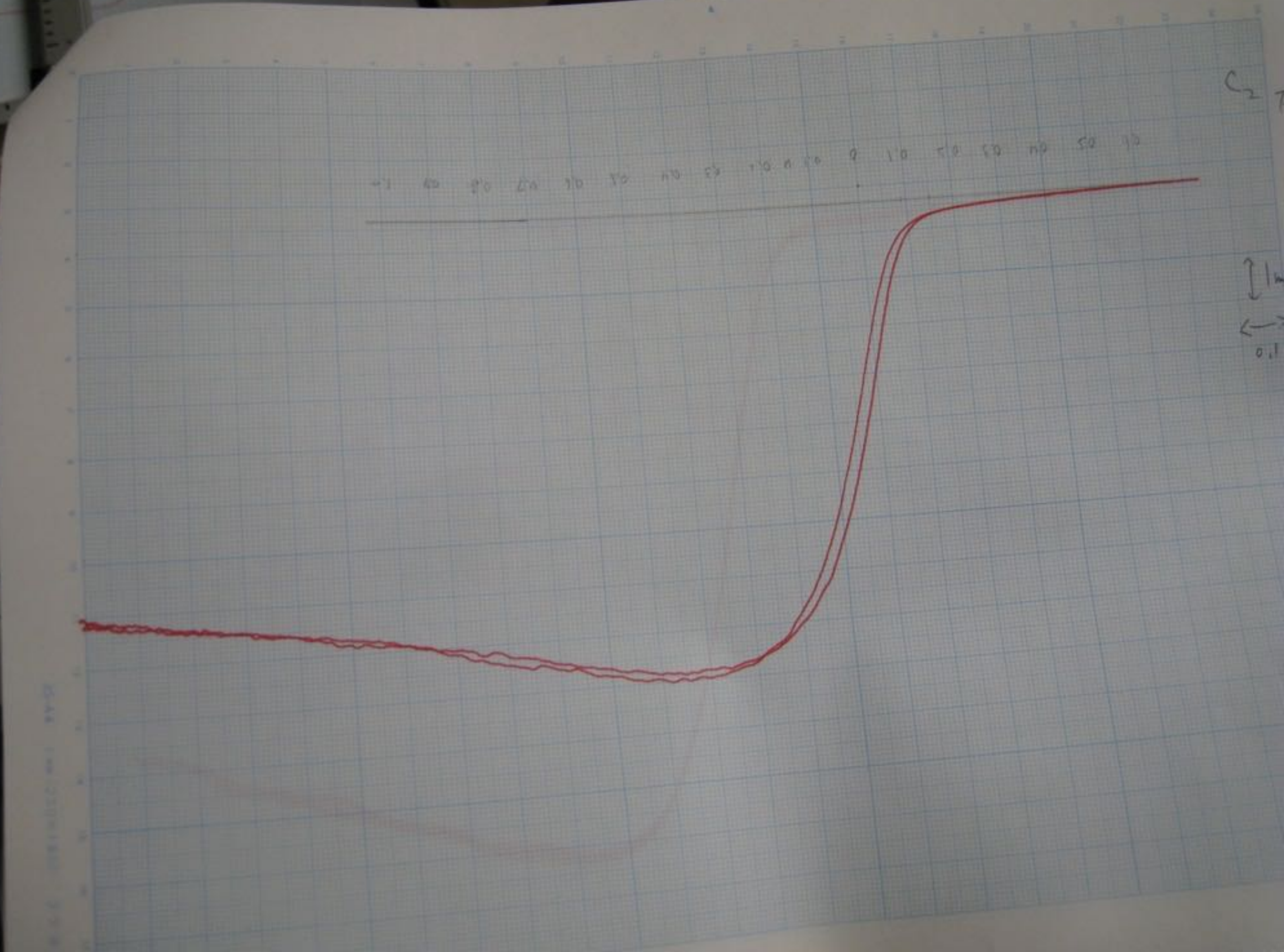


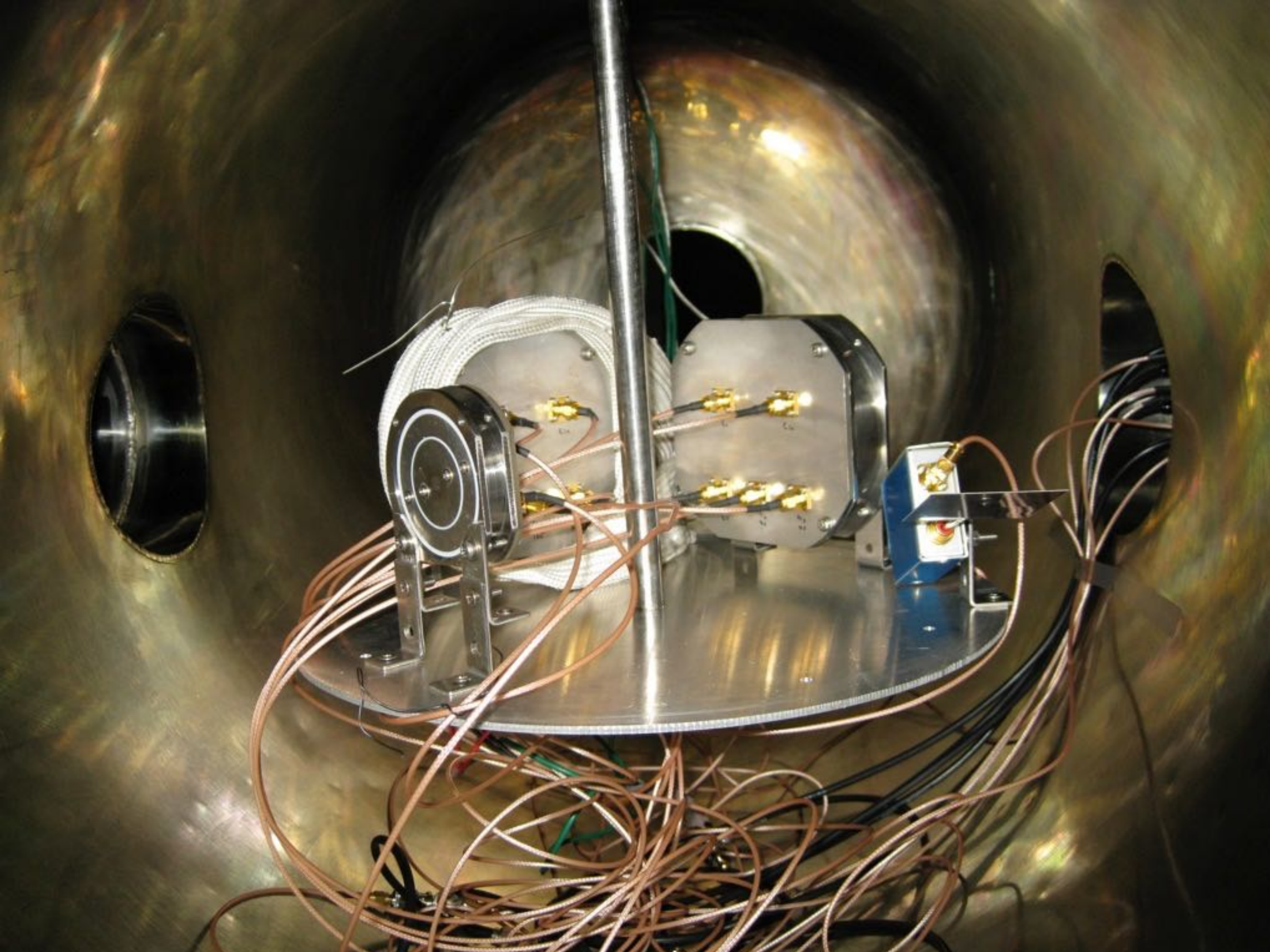

146.938
0.635
803.57
2
1
0:01:13
分(対数)
7.00
開始
一時停止
停止
掃引停止




SCAN TIME / DIV.
BAND WIDTH
DISPERSION / DIV.
INTENSITY
FOCUS
SCALE ILLUM.
POWER
ON
OFF
LOG. (dB)
WARNING
SCANNING
IF LEVEL ADJ.
MANUAL SWEEP
REFERENCE LEVEL (dBV)
(0dBV=1V)
RF ATT (dB)
INPUT
1MΩ 18PF
SCAN MODE
SINGLE
MANUAL
SCAN TRIGGER
VIDEO
EXT.
LINE
AUTO
VIDEO FILTER
10Hz
100Hz
OFF
FULL
PER DIV.
ZERO
LIN.
2dB
10dB
TUNING
FINE
USE WHEN
10kHz~50Hz/DIV.
TG OUT
75Ω
TRACKING GENERATOR
OUTPUT LEVEL
(dBm)
MODE
NORMAL
TUNED AMP
AGC
ON >30kHz
OFF
FREQ. ADJ.
MARKER POSITION
TAKEDA RIKEN
TR4120
TRACKING SCOPE
30 MHz
CENTER FREQUENCY
COARSE


HIOKI 8855 MEMORY HiCORDER
'07-11-27 20:00:08
時間軸
20ms/DIV
(200µs/S)
トリガ
自動
0%
記録長
30DIV (600.0ms)
×1 (20.00ms)
0µs
0.3350 V
17.200mV
-0.2800 V
0µs
0.3350 V
17.200mV
-0.2800 V
0µs
0.0000 V
0.000mV
0.0000 V
600ms
F1
F2
F3
F4
F5
F6
F7
F8
VALUE
WAVE
CURSOR





S1
C2
C1
G1
G2
G3
LP1
LP2
S2
S3

PWR PL
TMP
115
115c
TM
POWER
HEATER
ALM PL
CT
COUNTS

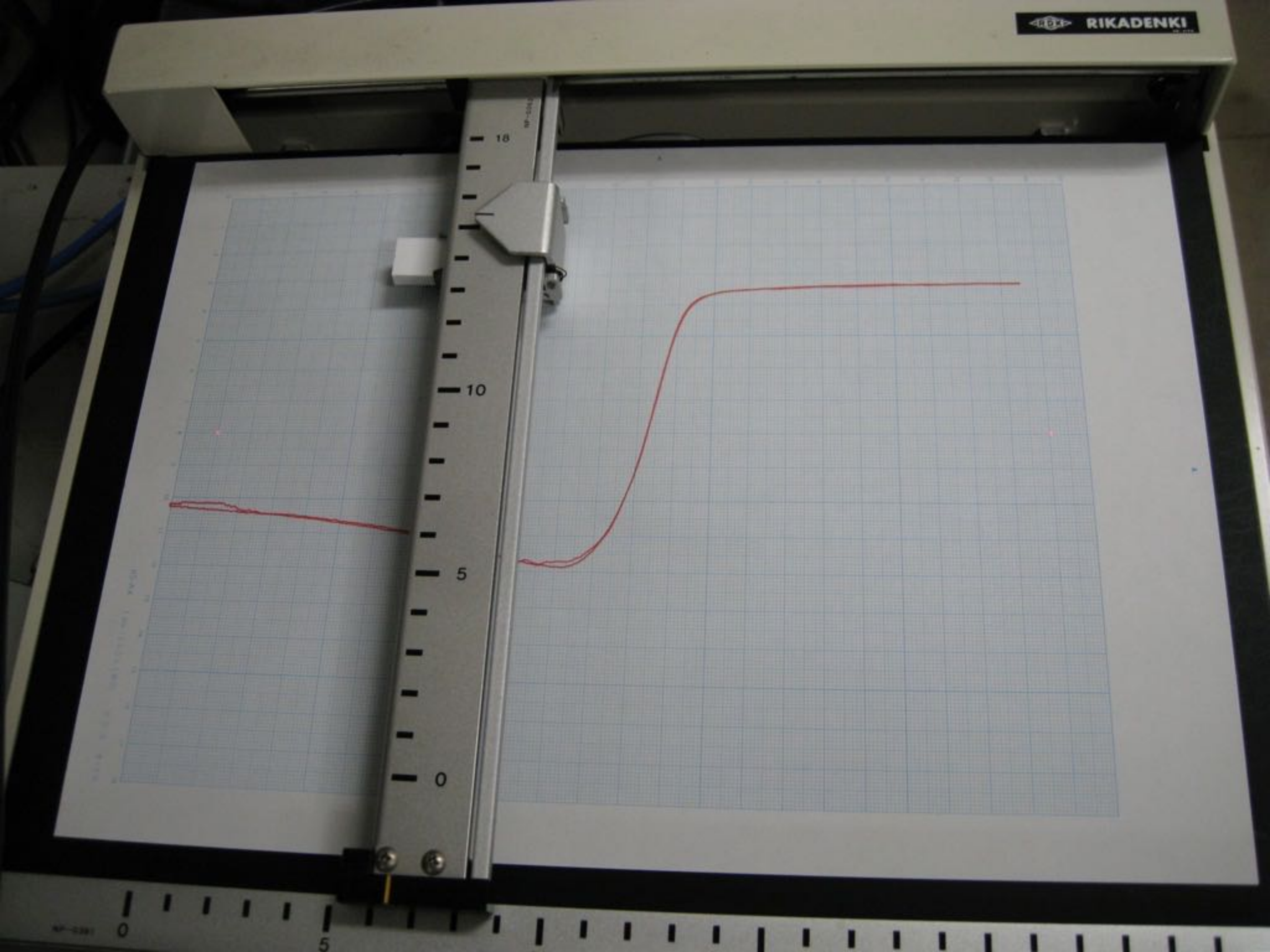
5A


DAILY

ULVAC
Pa
TORR
ZERO
1MA
0.2MA
ADJ.
ADJ.
IONIZATION VACUUM GAUGE CONTROL GI-TL2-8-5

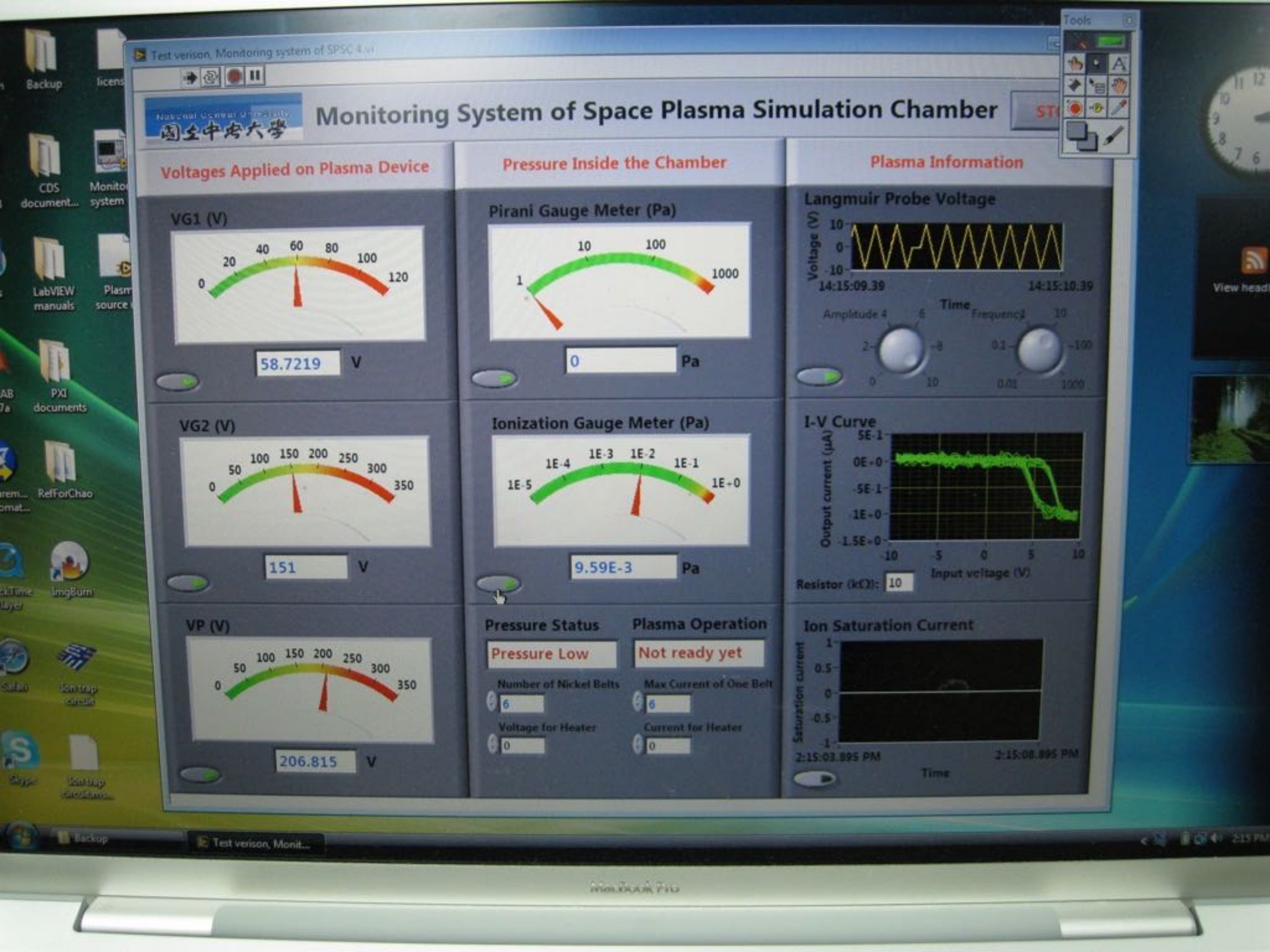
DAILY

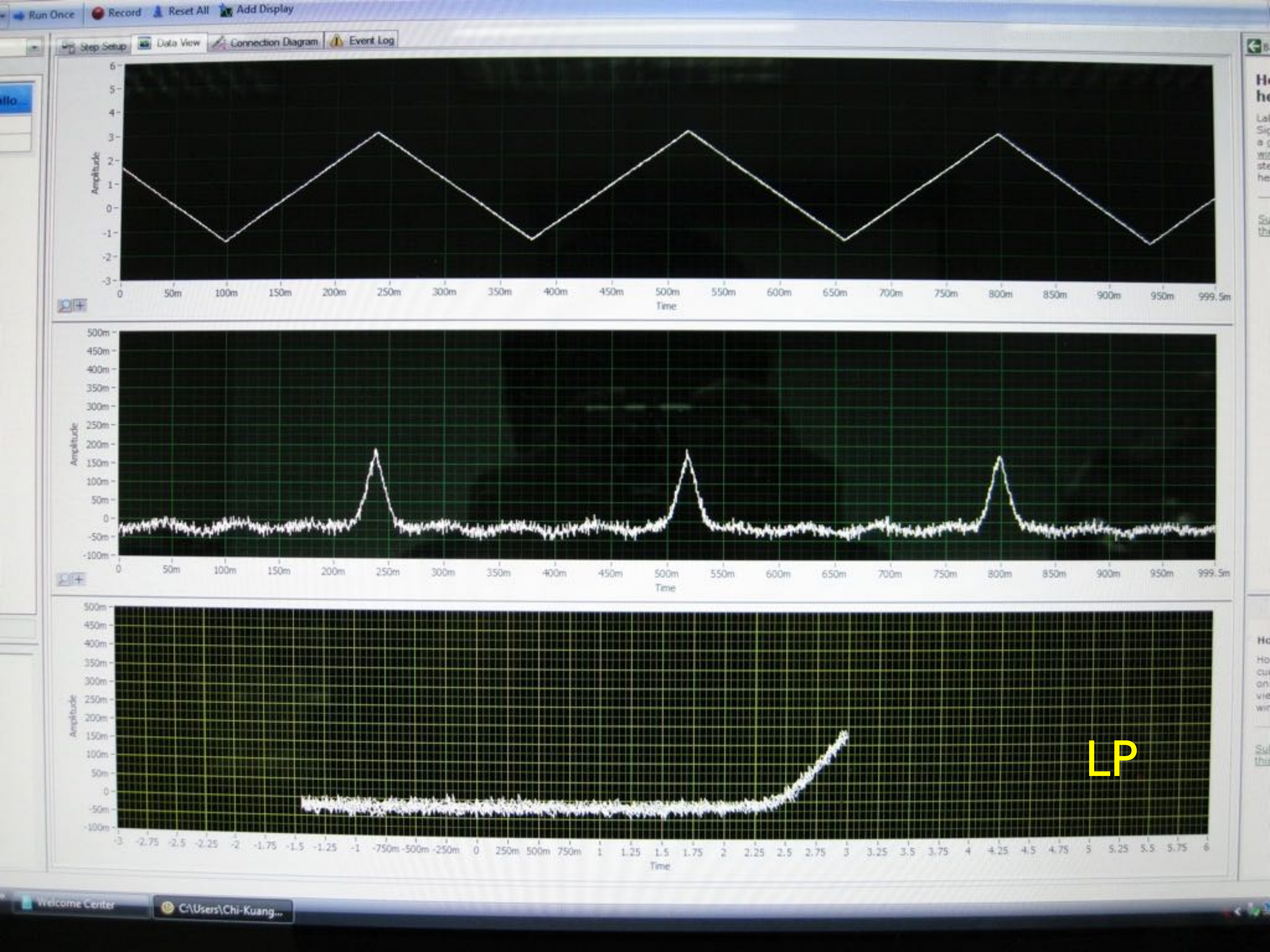
ULVAC
Pa
TORR
ZERO
1MA
0.2MA
ADJ.
ADJ.
FILAMENT POWER
IONIZATION VACUUM GAUGE CONTROL GI-TL2-8-5


RIKADENKI
18
10
5
0
0
5

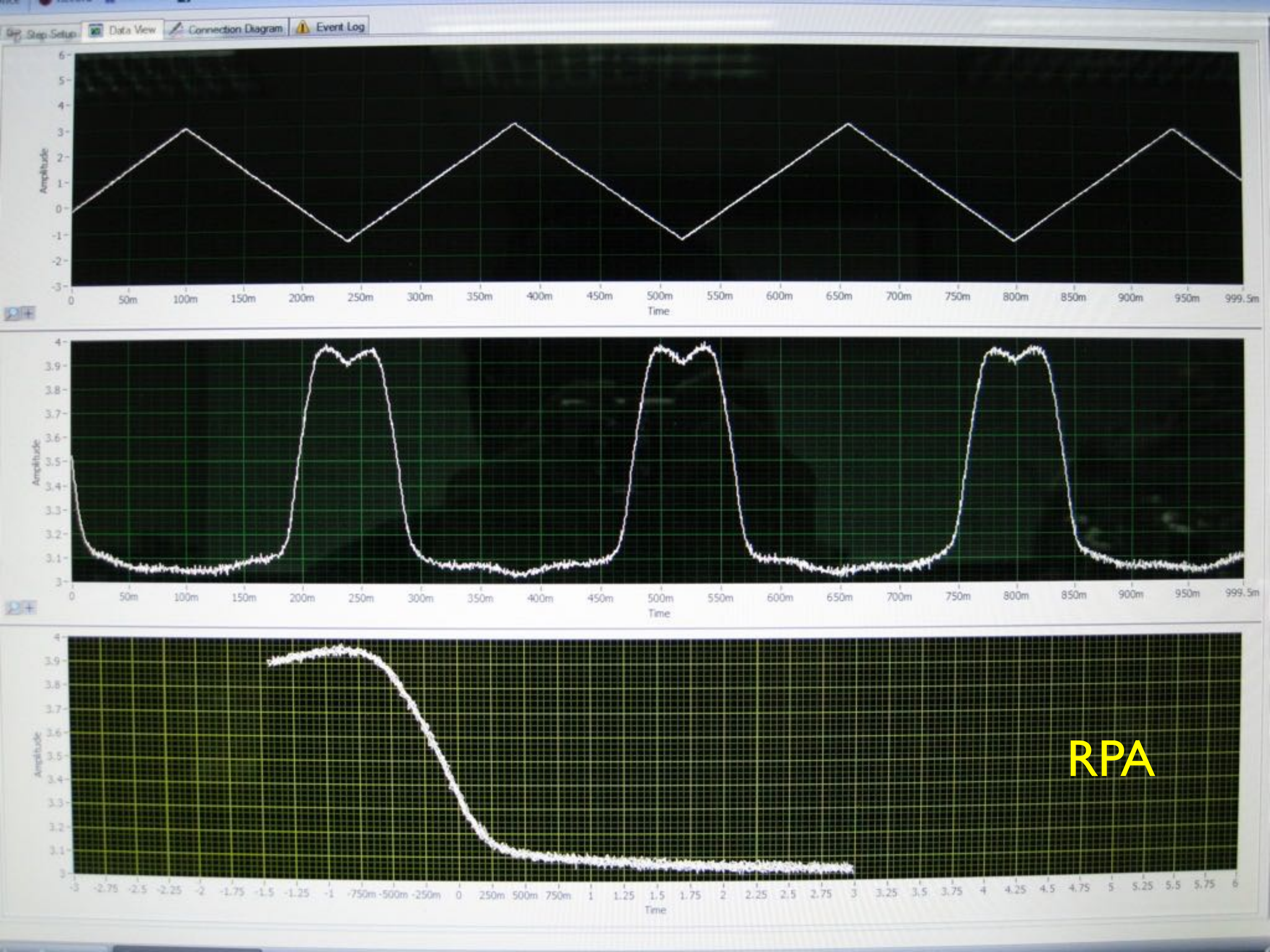

メモリ
20ms/DIV (200us/S)
30DIV (600.0ms)
自動
0%
'07-11-26
IRV
ERV


NATIONAL
INSTRUMENTS


Test verison, Monitoring system of SPSC 4.vi
Monitoring System of Space Plasma Simulation Chamber
Voltages Applied on Plasma Device
Pressure Inside the Chamber
Plasma Information
VG1 (V)
58.7219
V
Pirani Gauge Meter (Pa)
0
Pa
Langmuir Probe Voltage
Voltage (V)
14:15:09.39
14:15:10.39
Time
Amplitude
Frequency
VG2 (V)
151
V
Ionization Gauge Meter (Pa)
9.59E-3
Pa
I-V Curve
Output current (μA)
Input voltage (V)
Resistor (kΩ): 10
VP (V)
206.815
V
Pressure Status
Pressure Low
Plasma Operation
Not ready yet
Number of Nickel Belts
Max Current of One Belt
Voltage for Heater
Current for Heater
Ion Saturation Current
Saturation current
2:15:03.895 PM
2:15:08.895 PM
Time
Backup
CDS document...
LabVIEW manuals
PXI documents
RefForChao
ImgBurn
Test verison, Monit...
View head
MacBook Pro



Run Once
Record
Reset All
Add Display
Step Setup
Data View
Connection Diagram
Event Log
Amplitude
Time
LP
Welcome Center
C:\Users\Chi-Kuang...

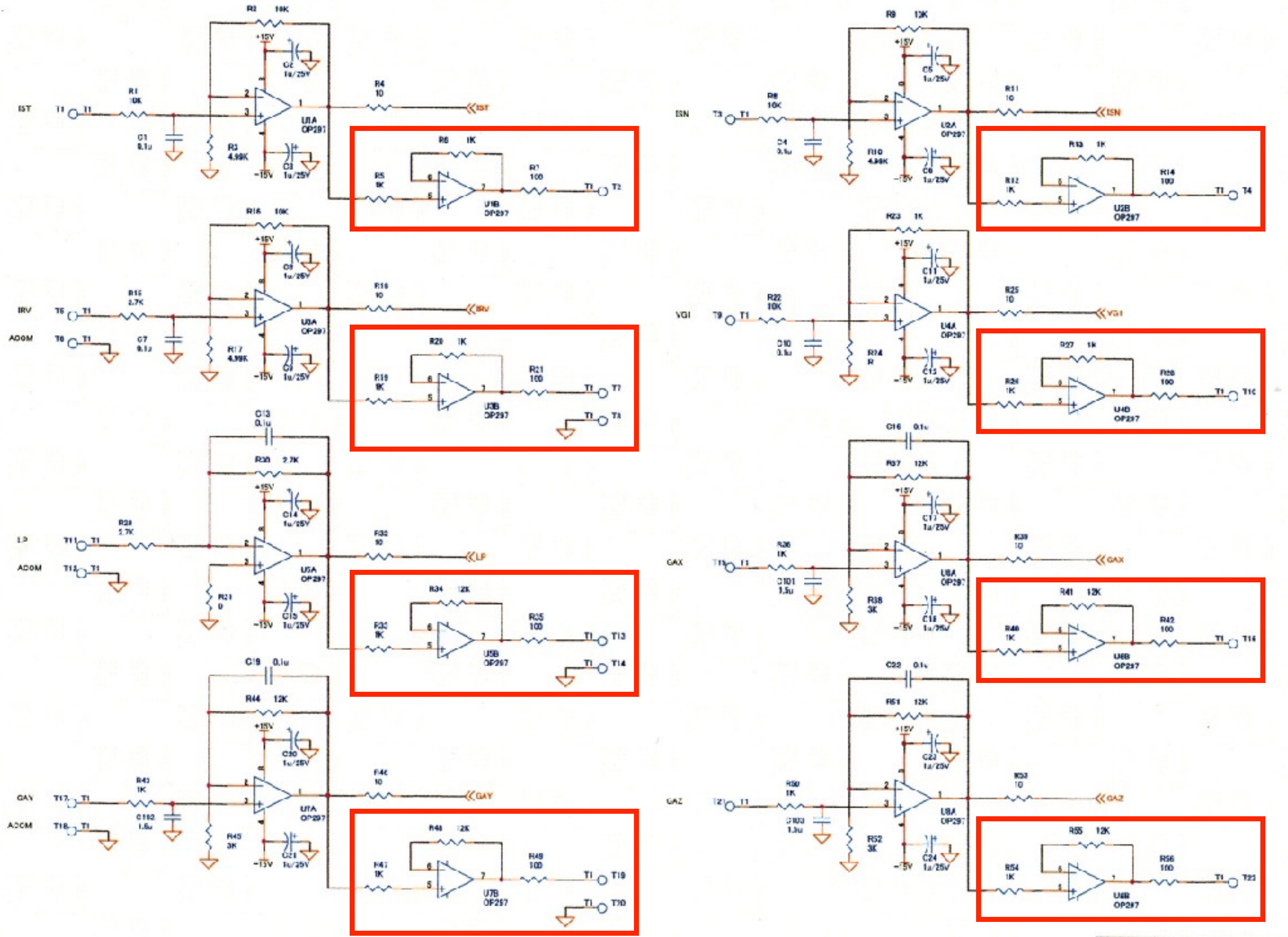


Step Setup
Data View
Connection Diagram
Event Log
Amplitude
Time
RPA


LabVIEW Quick Reference Guide

Analog output interface

- Numbers of channel: 9
- Analog output level: ±10 volt
- A D-sub 15-pin connector to telemetry
- Redundant channels for science data



IST
ISN
IRV
VGI
LP
GAX
GAY
GAZ
ACOM
+15V
-15V
OP297

OP297

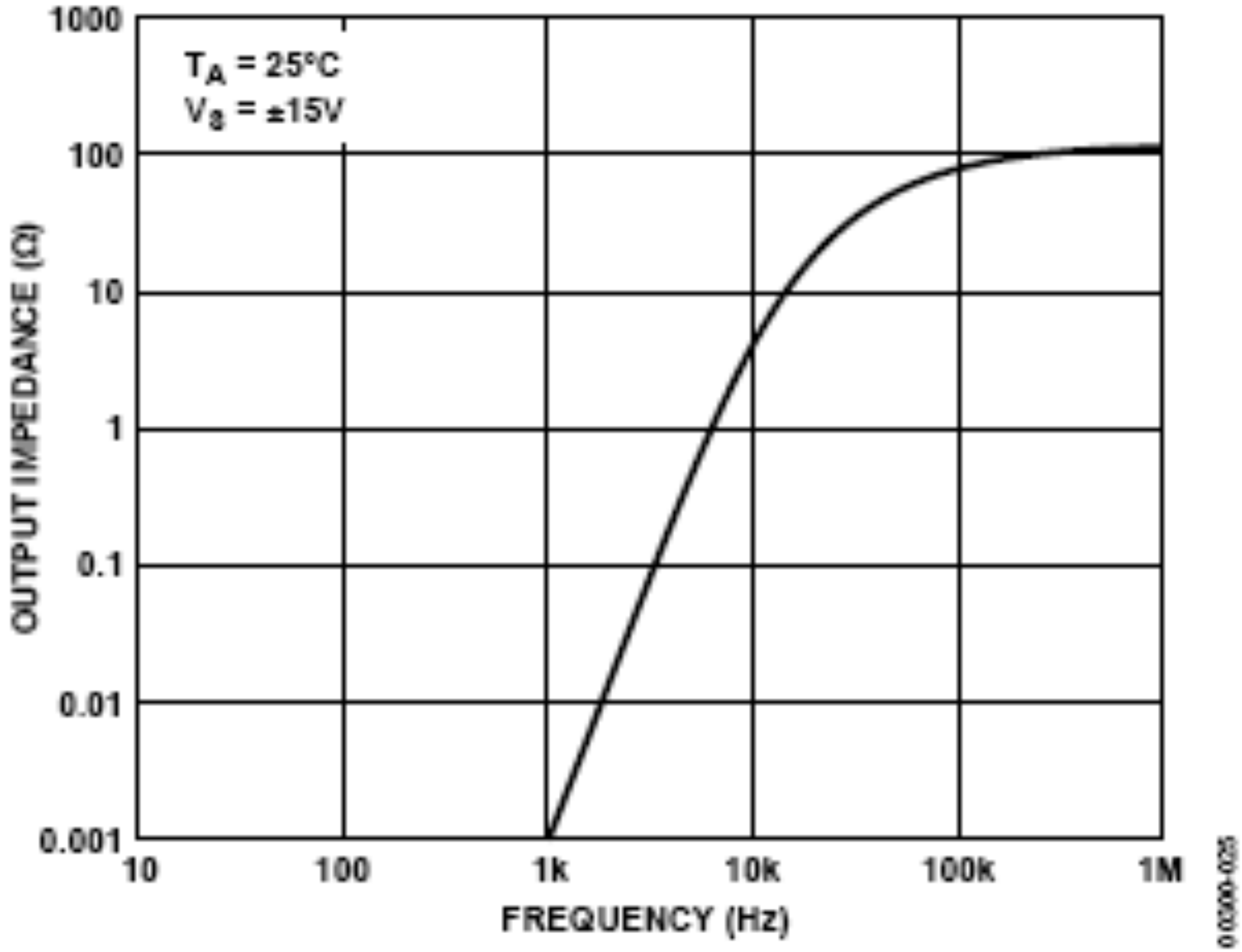


Figure 25. Open-Loop Output Impedance vs. Frequency

Output impedance < 10 Ω

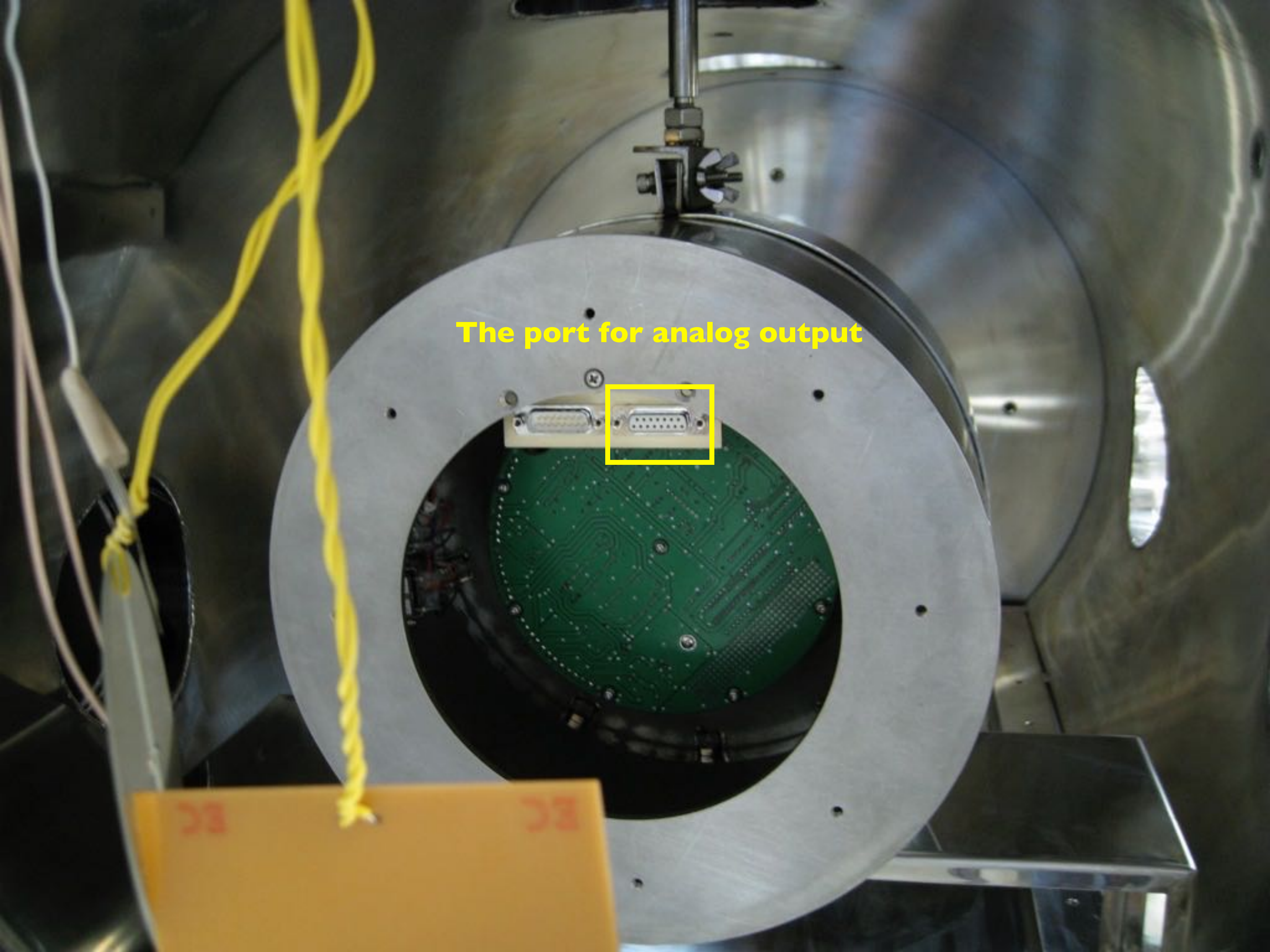
端　子　表　　　機 器 名 称　ＩＯＮ　ＰＲＯＢＥ２

コネクタ記号	ＣＮ－２

— （１／１）

コ ネ ク タ 品 名	
機 器 側	ＤＡＭ－１５Ｓ
計 装 側	ＤＡＭ－１５Ｐ

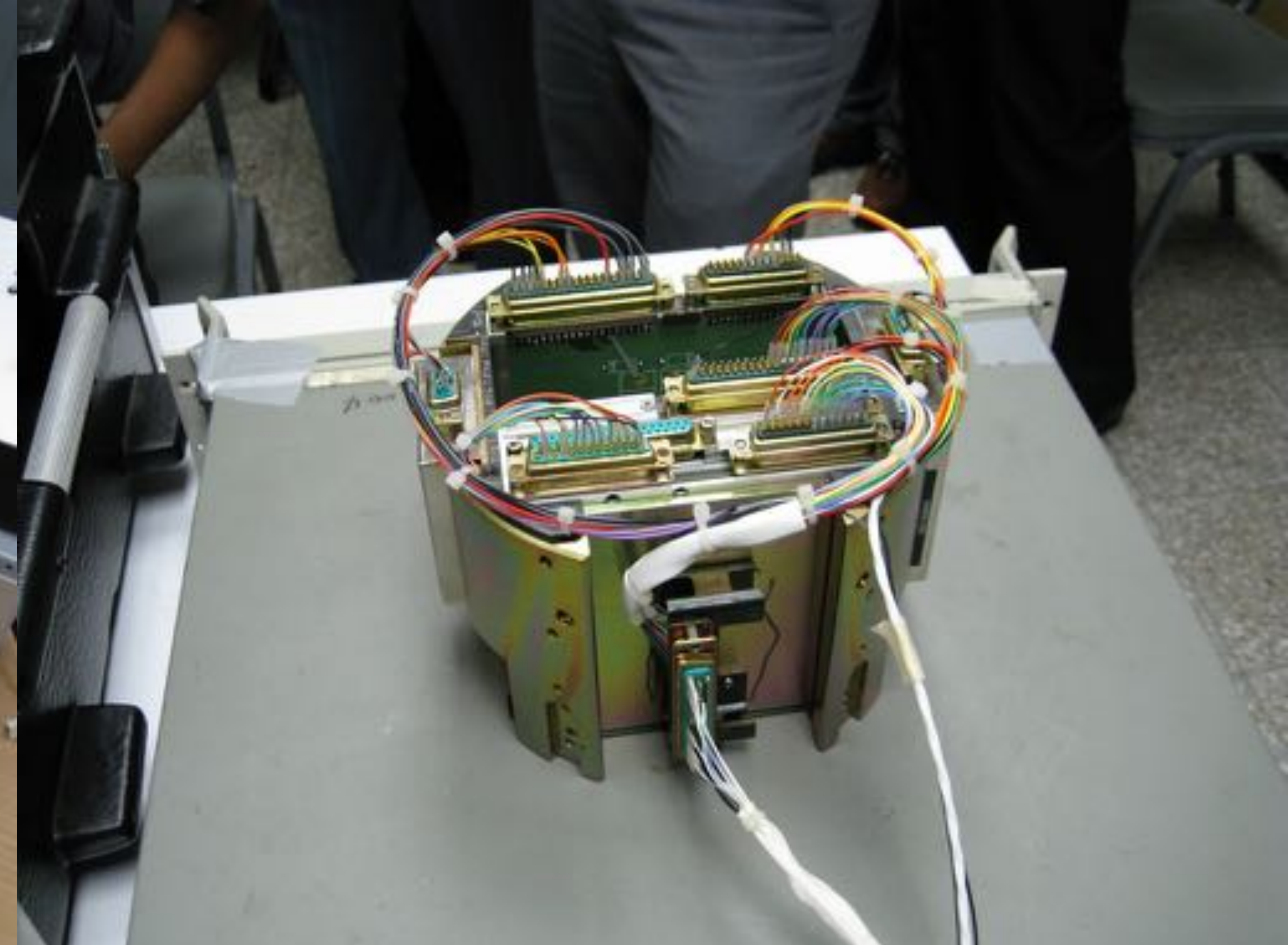
番号	配 線 先	信 号 名	線種	電流容量	端末処理	備 考
１		ＩＲＶ ＭＯＮＩ（Ｓ１）	Ｓ			
２		ＥＲＶ ＭＯＮＩ（ＬＰ）	Ｓ			
３		ＩＳＮ ＭＯＮＩ（Ｓ２）	Ｓ			
４		ＩＳＴ ＭＯＮＩ（Ｓ３）	Ｓ			
５		ＣＯＭ	Ｓ			
６		ＶＧ２ ＭＯＮＩ	Ｓ			ｼｰﾙﾄﾞ：14PIN
７		ＣＬＯＣＫ ＳＥＬ	Ｎ			7-8 ｵｰﾌﾟﾝ:76.8KHz
８		ＣＯＭ	Ｎ			7-8 ｼｮｰﾄ :38.4KHz
９		ＶＧ１ ＭＯＮＩ（Ｓ２）	Ｓ			
１０		ＧＡＸ ＭＯＮＩ	Ｓ			
１１		ＧＡＹ ＭＯＮＩ	Ｓ			
１２		ＧＡＺ ＭＯＮＩ	Ｓ			
１３		ＣＯＭ	Ｓ			
１４		ＣＯＭ	Ｓ			６ピンのシールド
１５						
１６						
１７						


The port for analog output

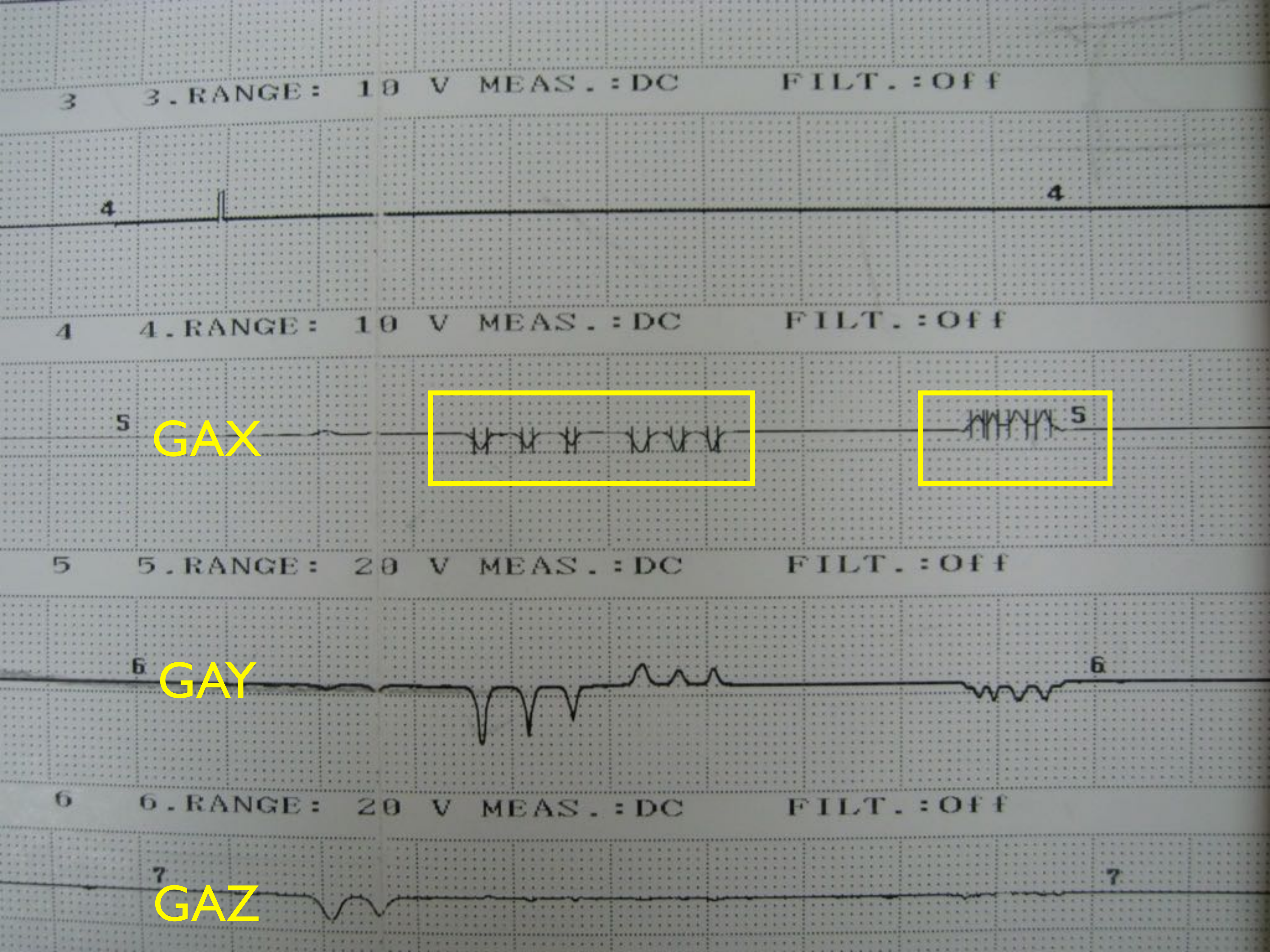
A/D module of CSIST

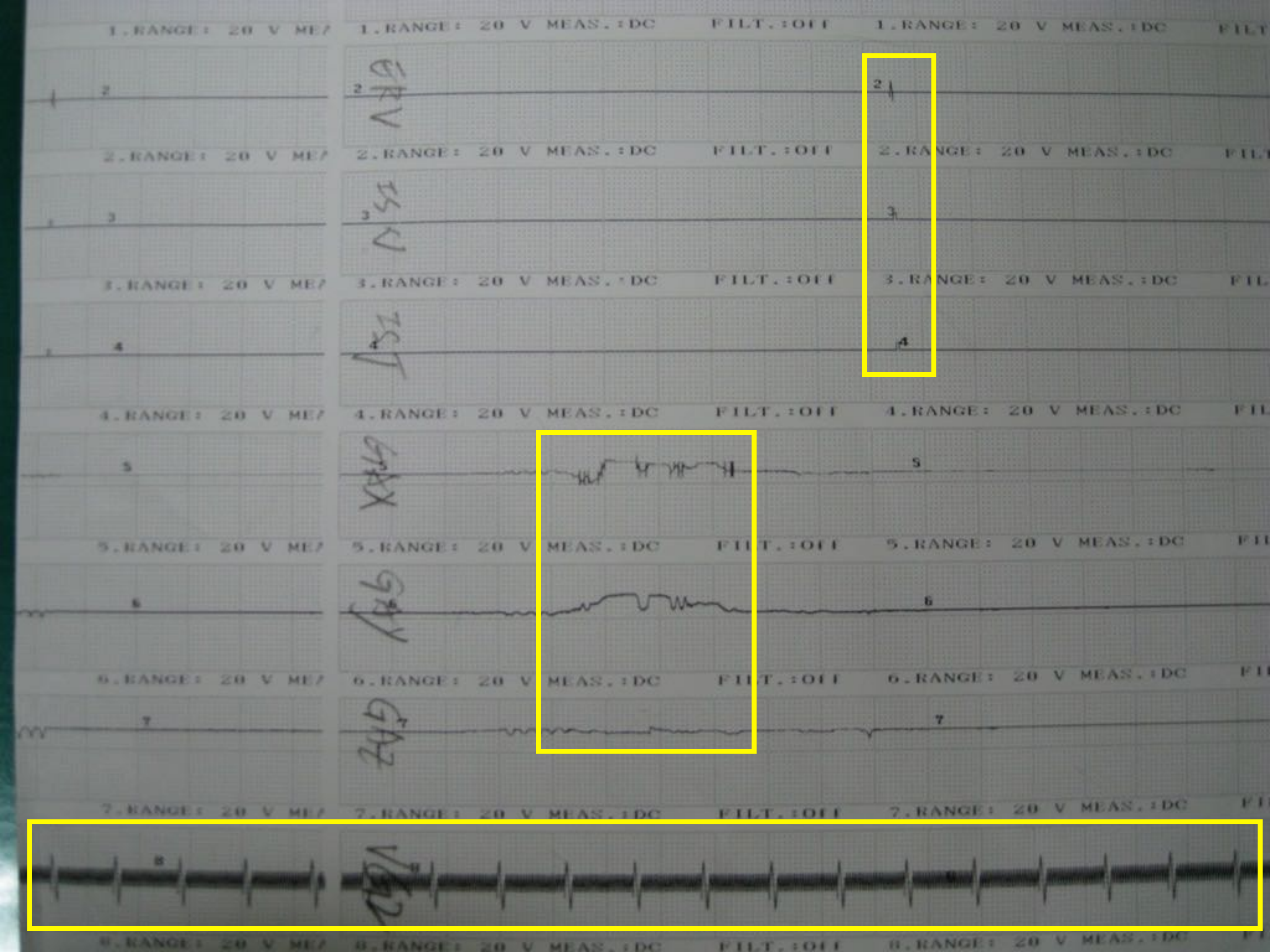
- Sampling rate: 1 kHz
- Resolution for a sample: 8 bits

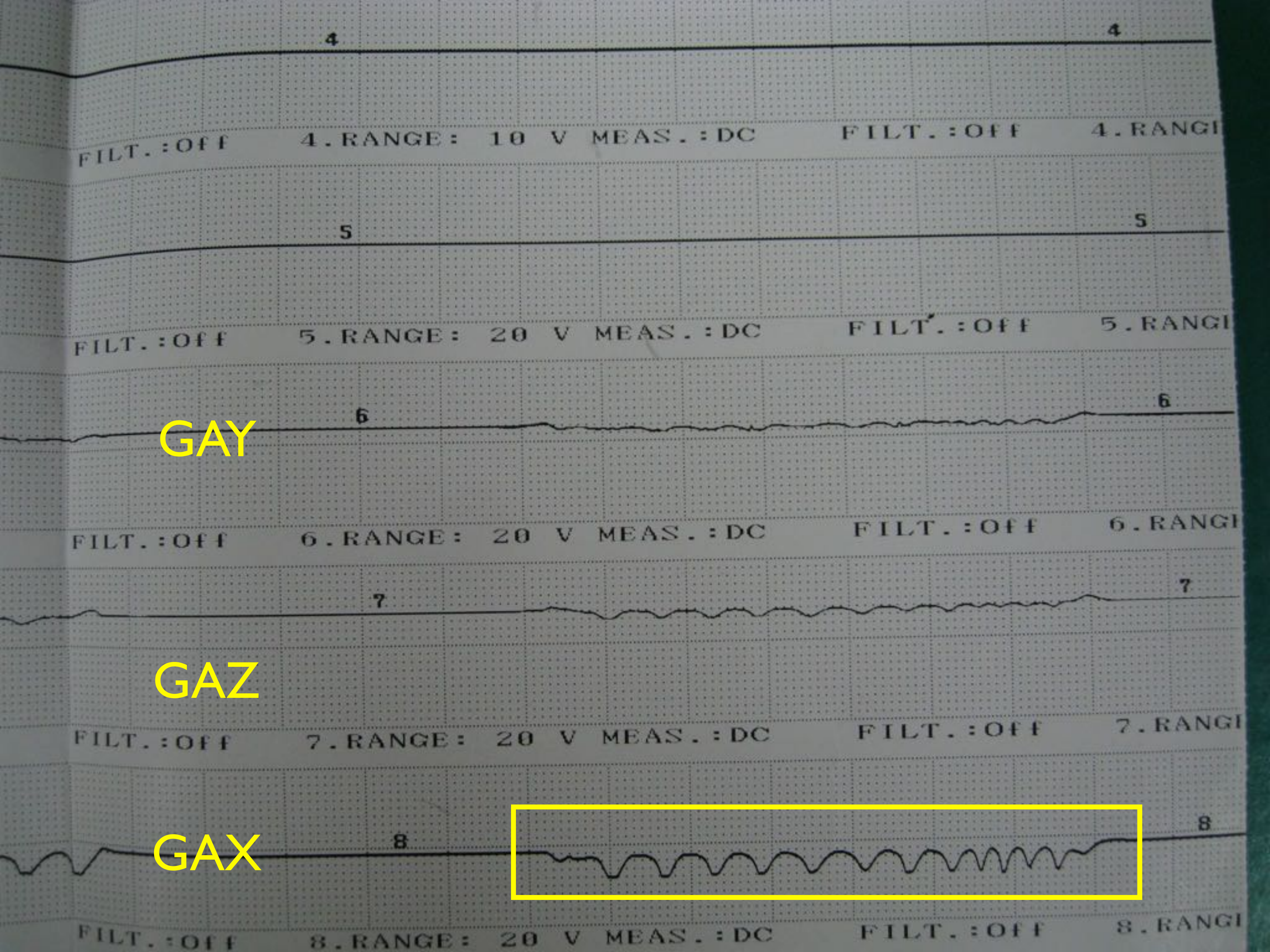

TC004
Agilent
6543A
DC POWER SUPPLY
95 財產清
TC004

Spikes detected in GAX


3 3.RANGE: 10 V MEAS.:DC FILT.:Off
4
4
4 4.RANGE: 10 V MEAS.:DC FILT.:Off
5
GAX
5
5 5.RANGE: 20 V MEAS.:DC FILT.:Off
6
GAY
6
6 6.RANGE: 20 V MEAS.:DC FILT.:Off
7
GAZ
7

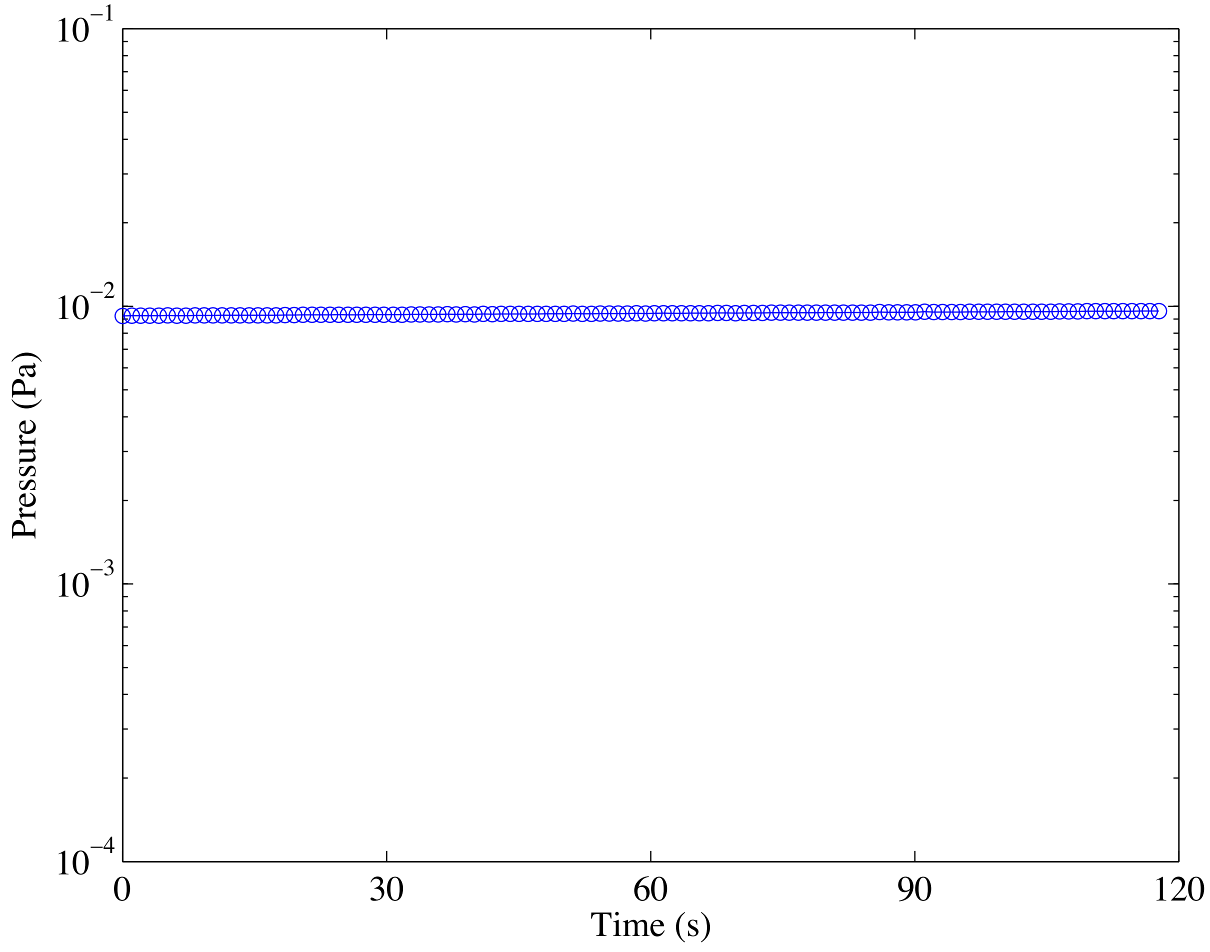

1. RANGE: 20 V MEAS.:DC FILT.:OFF
2. RANGE: 20 V MEAS.:DC FILT.:OFF
3. RANGE: 20 V MEAS.:DC FILT.:OFF
4. RANGE: 20 V MEAS.:DC FILT.:OFF
5. RANGE: 20 V MEAS.:DC FILT.:OFF
6. RANGE: 20 V MEAS.:DC FILT.:OFF
7. RANGE: 20 V MEAS.:DC FILT.:OFF
8. RANGE: 20 V MEAS.:DC FILT.:OFF


4
4
FILT.:Off
4.RANGE: 10 V MEAS.:DC
FILT.:Off
4.RANGI
5
5
FILT.:Off
5.RANGE: 20 V MEAS.:DC
FILT.:Off
5.RANGI
6
6
GAY
FILT.:Off
6.RANGE: 20 V MEAS.:DC
FILT.:Off
6.RANGI
7
7
GAZ
FILT.:Off
7.RANGE: 20 V MEAS.:DC
FILT.:Off
7.RANGI
8
8
GAX
FILT.:Off
8.RANGE: 20 V MEAS.:DC
FILT.:Off
8.RANGI

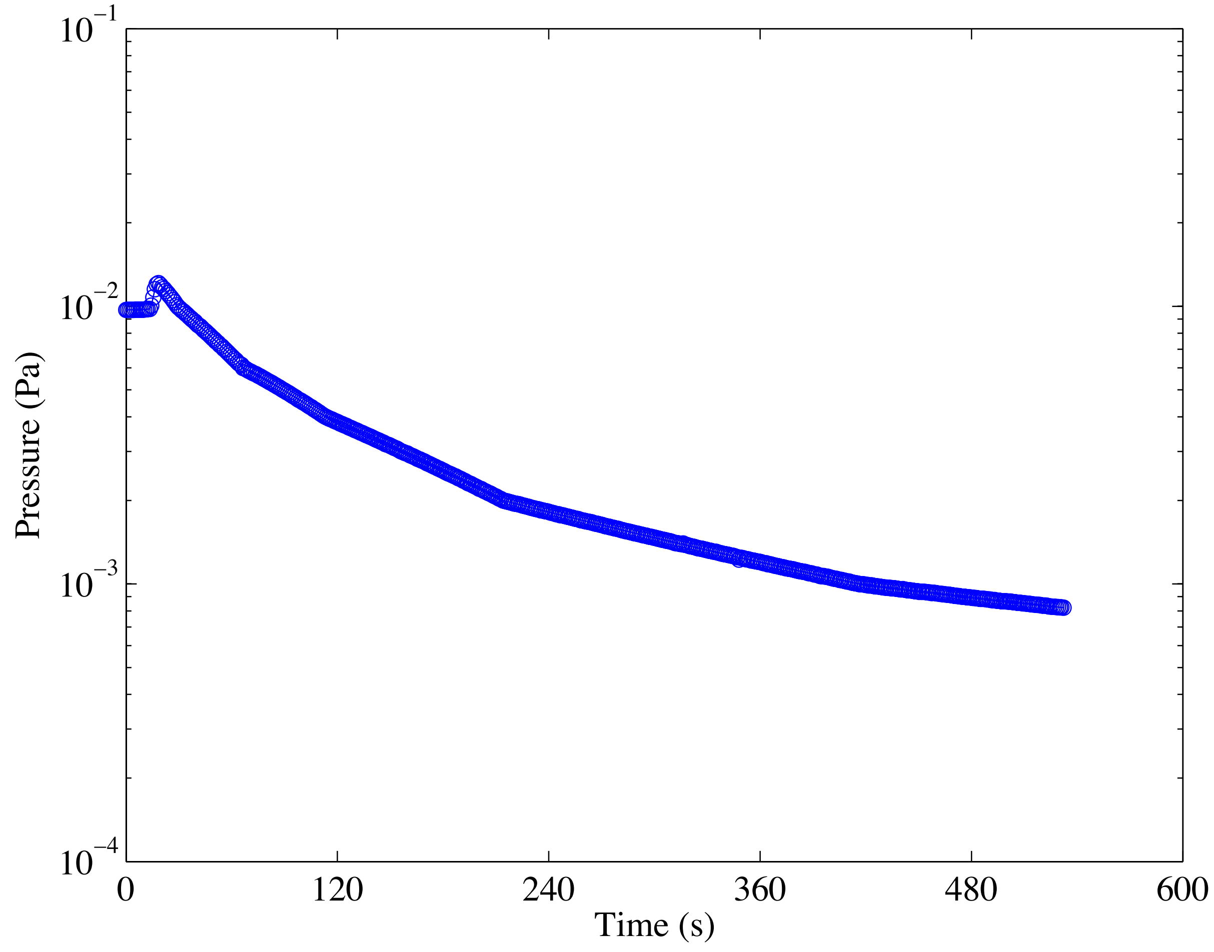
Test results

- CSIST did a great job to receive analog output signals from payload for SR7
- The interface between payload analog output and CSIST's A/D module is done
- The spikes shown in the GAX were caused by the recorder, not the interface between payload and CSIST's module

Air pressure

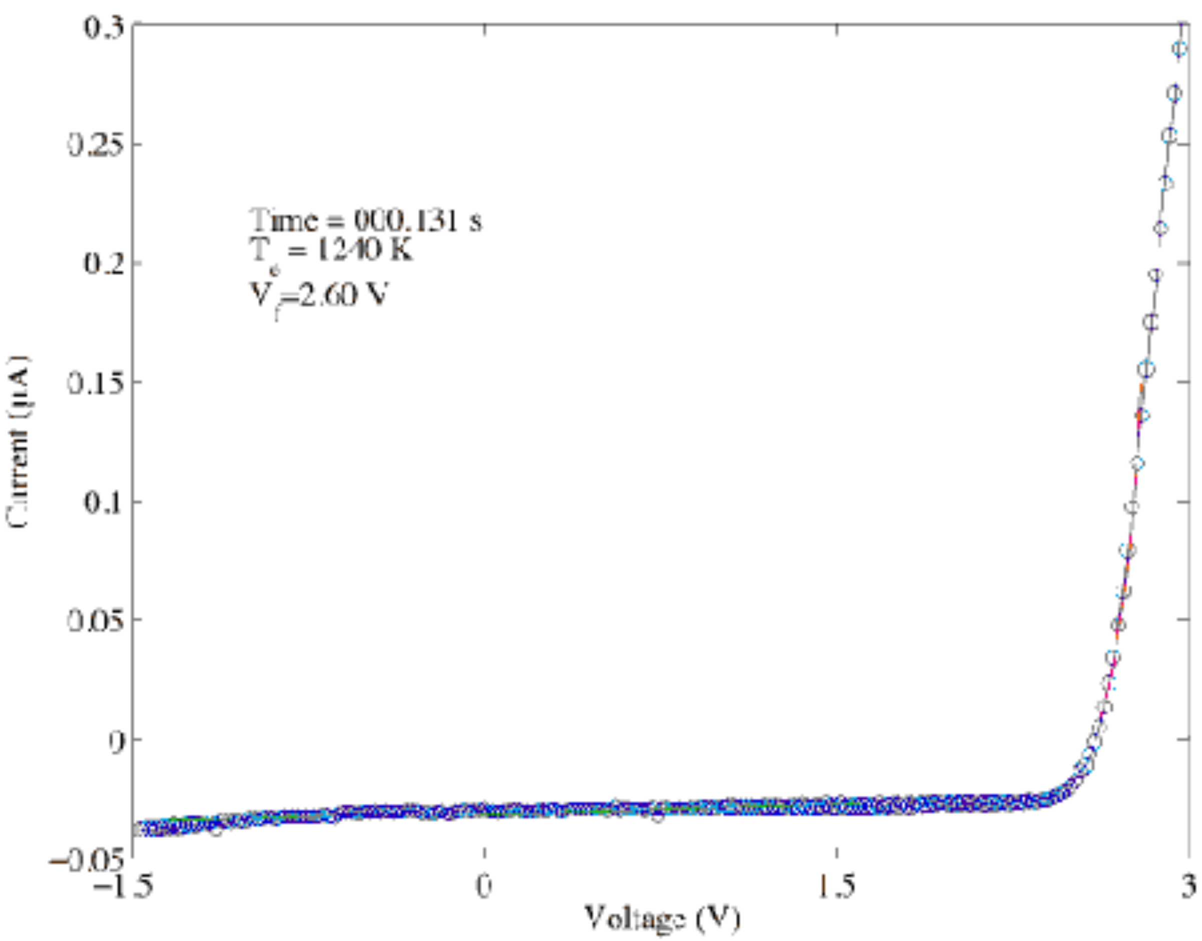


Stable

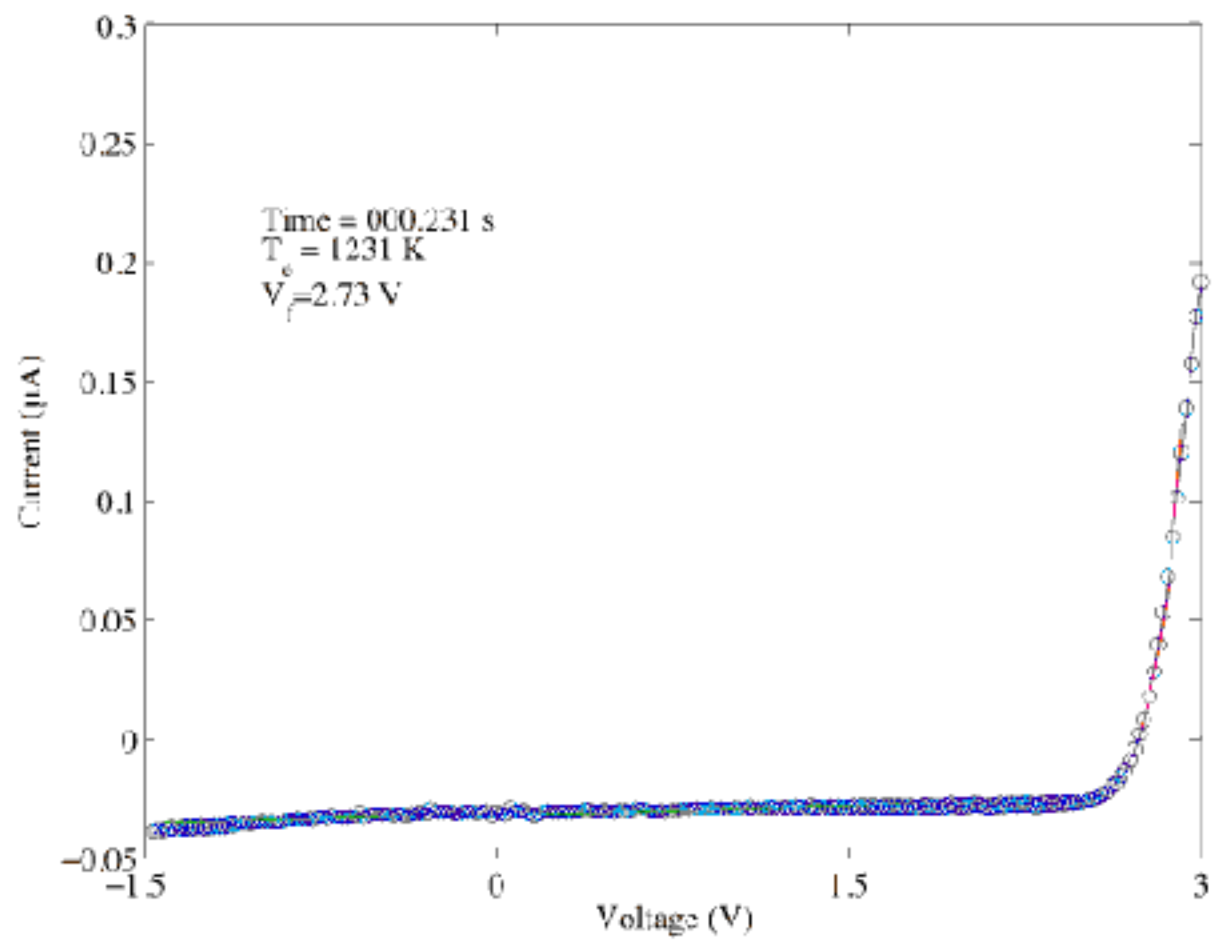


Decreasing

I-V curves

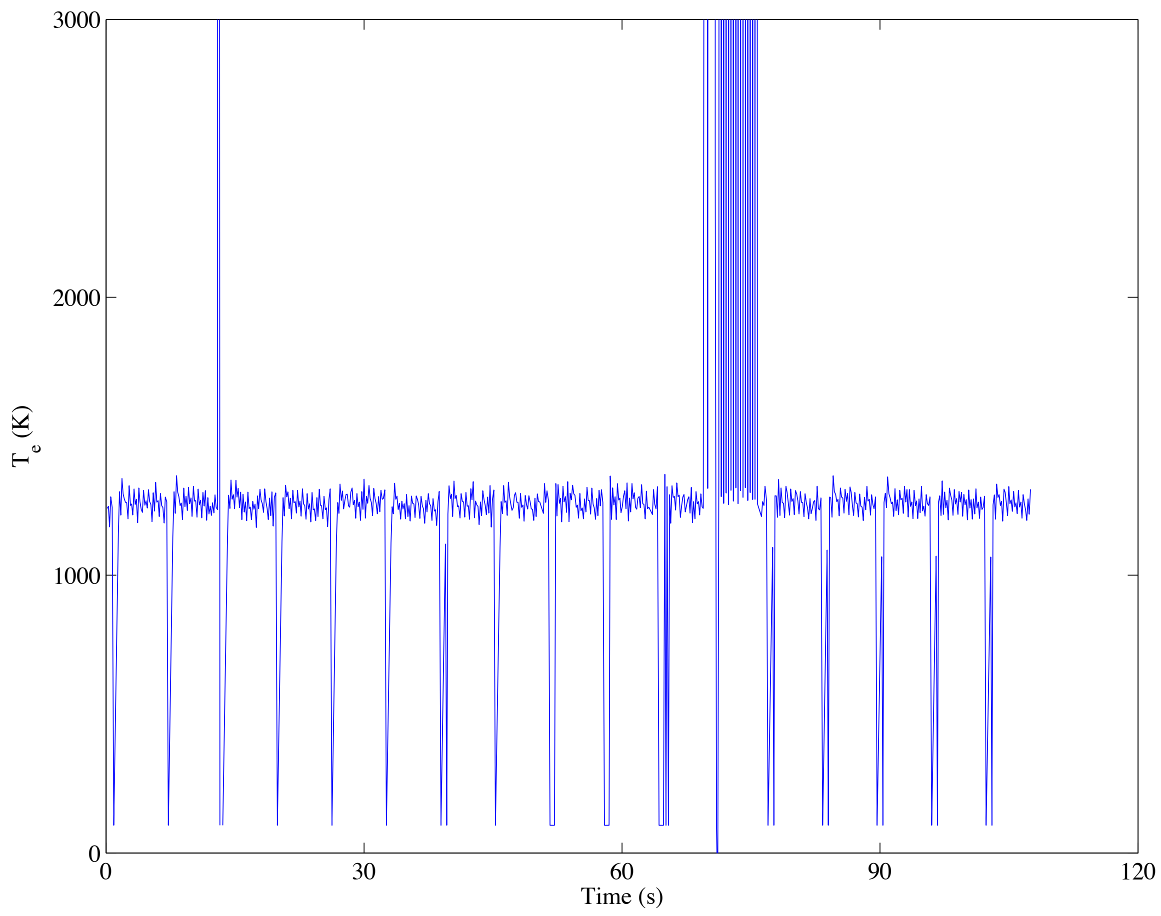


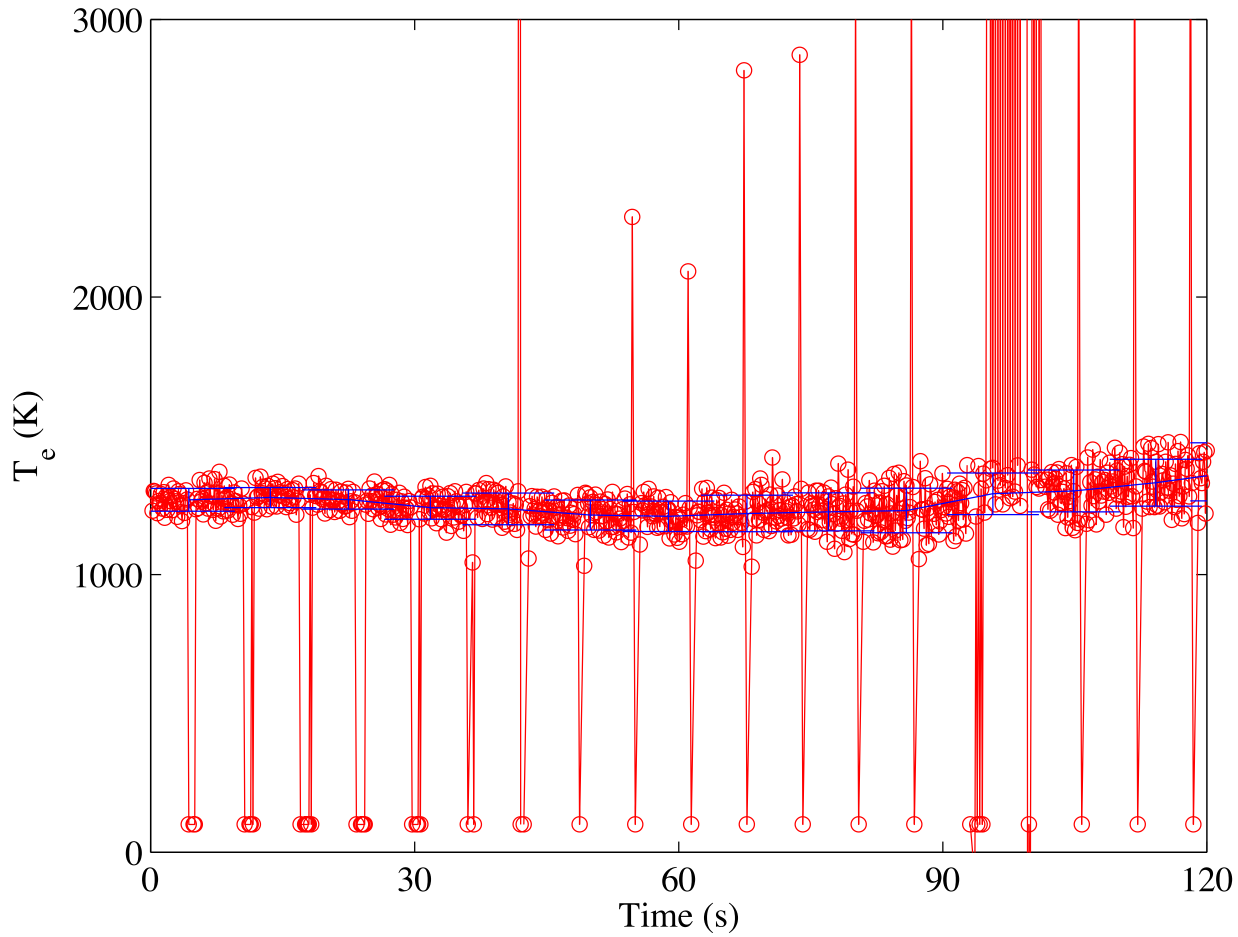
Stable



Decreasing

T_e in first 2 minutes



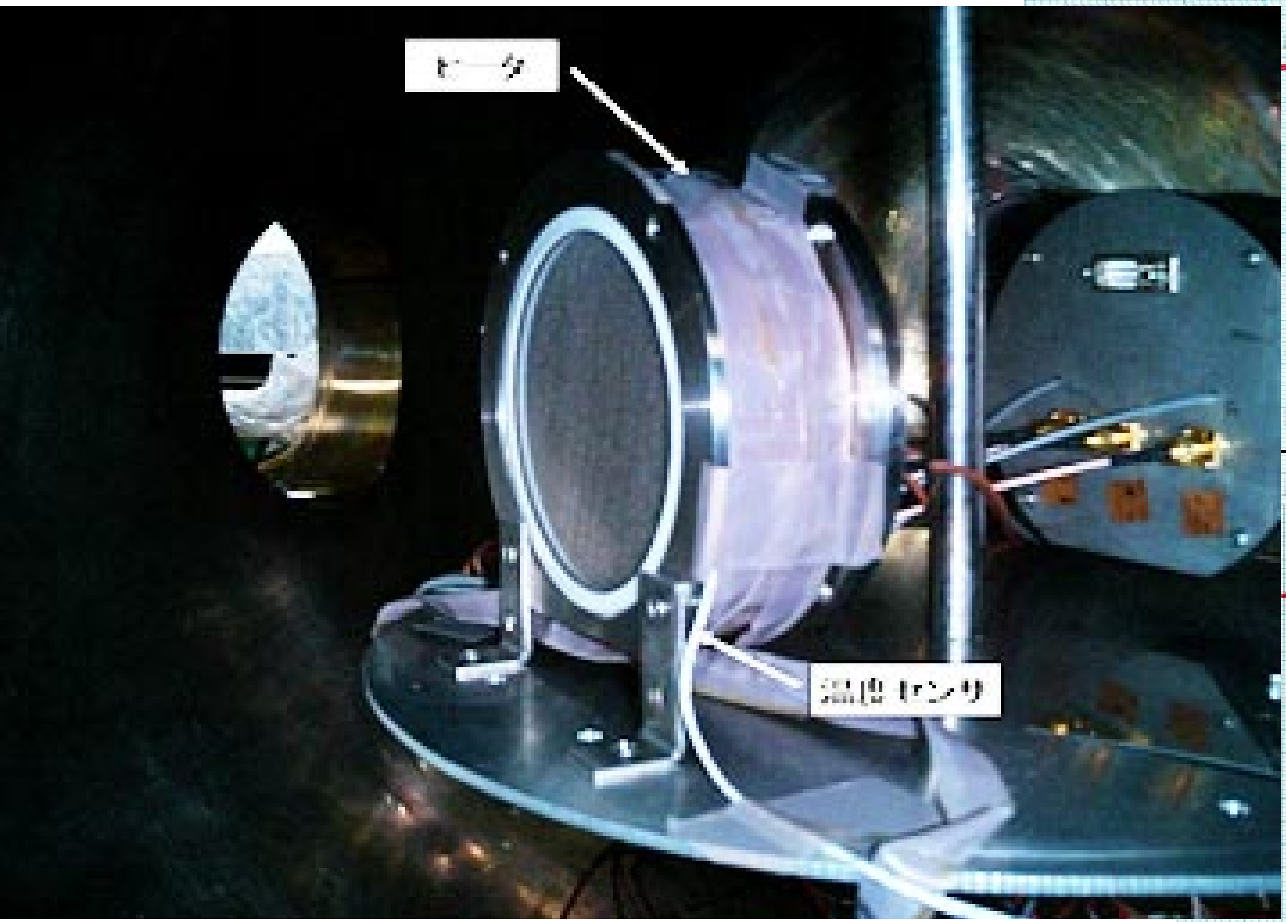


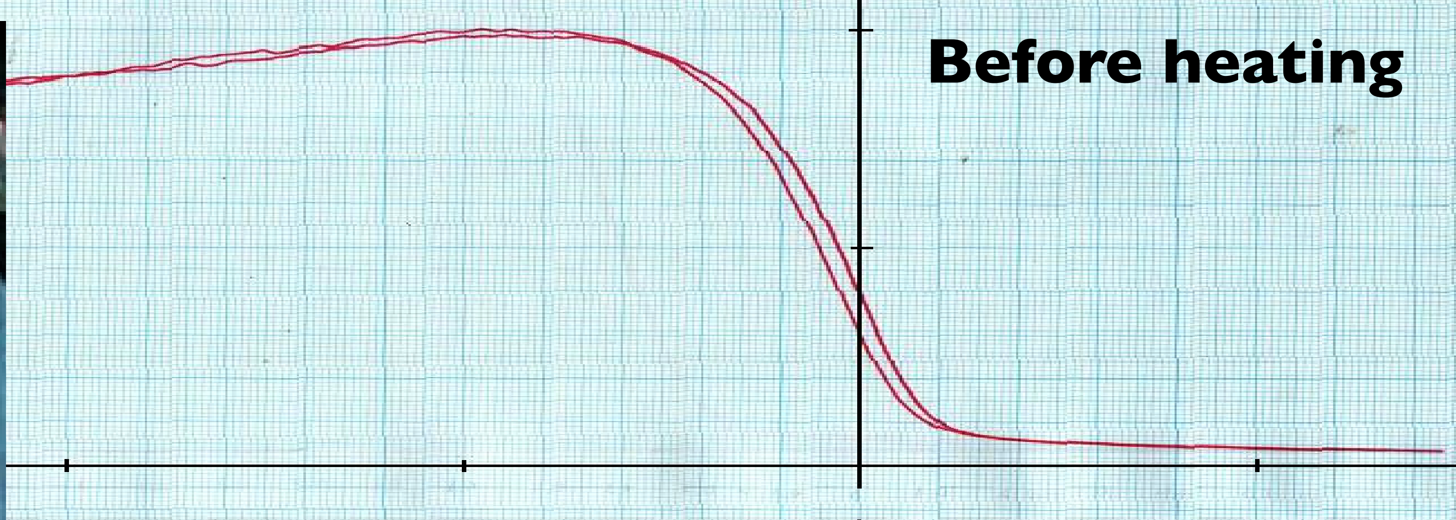
Stable

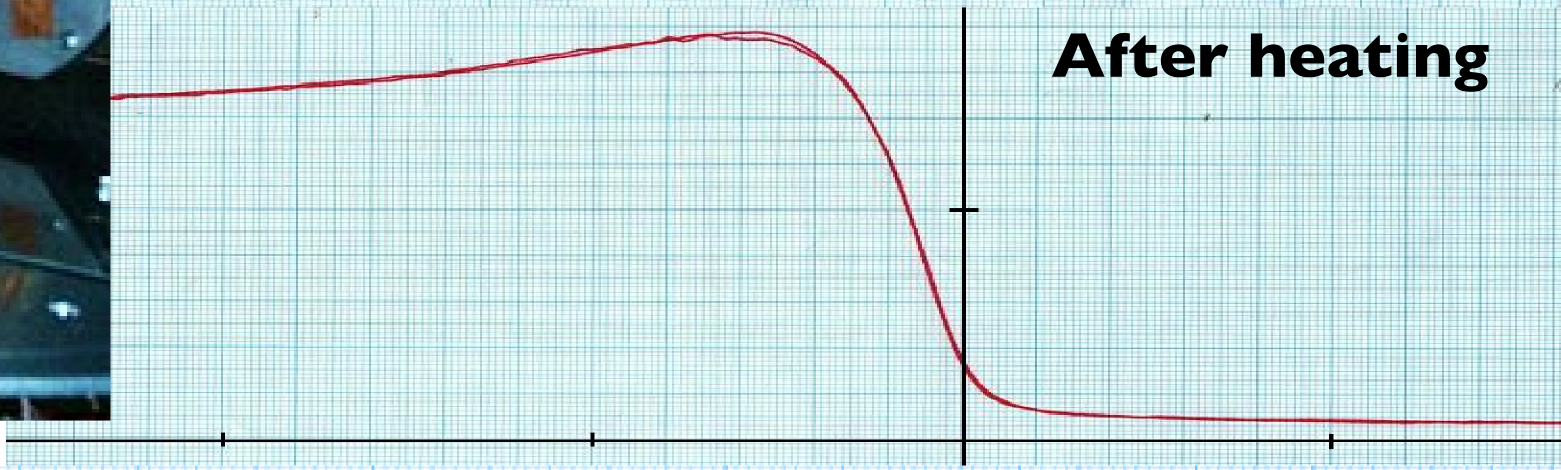
Decreasing

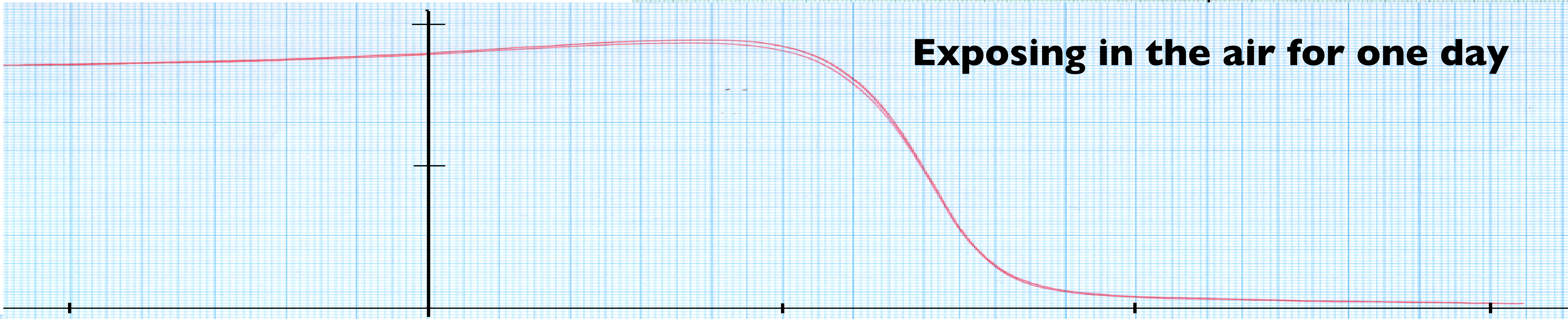
Results

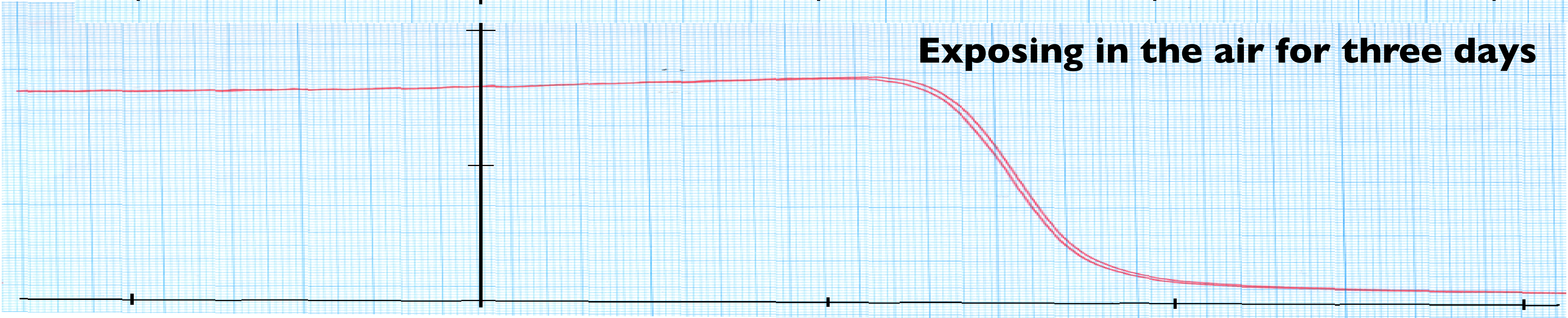
- Stable
  - Average T_e ~ 1260 K
  - Standard deviation of T_e ~ 40 K
- Decreasing
  - Average T_e ~ 1250 K
  - Standard deviation of T_e ~ 50 K


ヒータ
温度センサ


Before heating

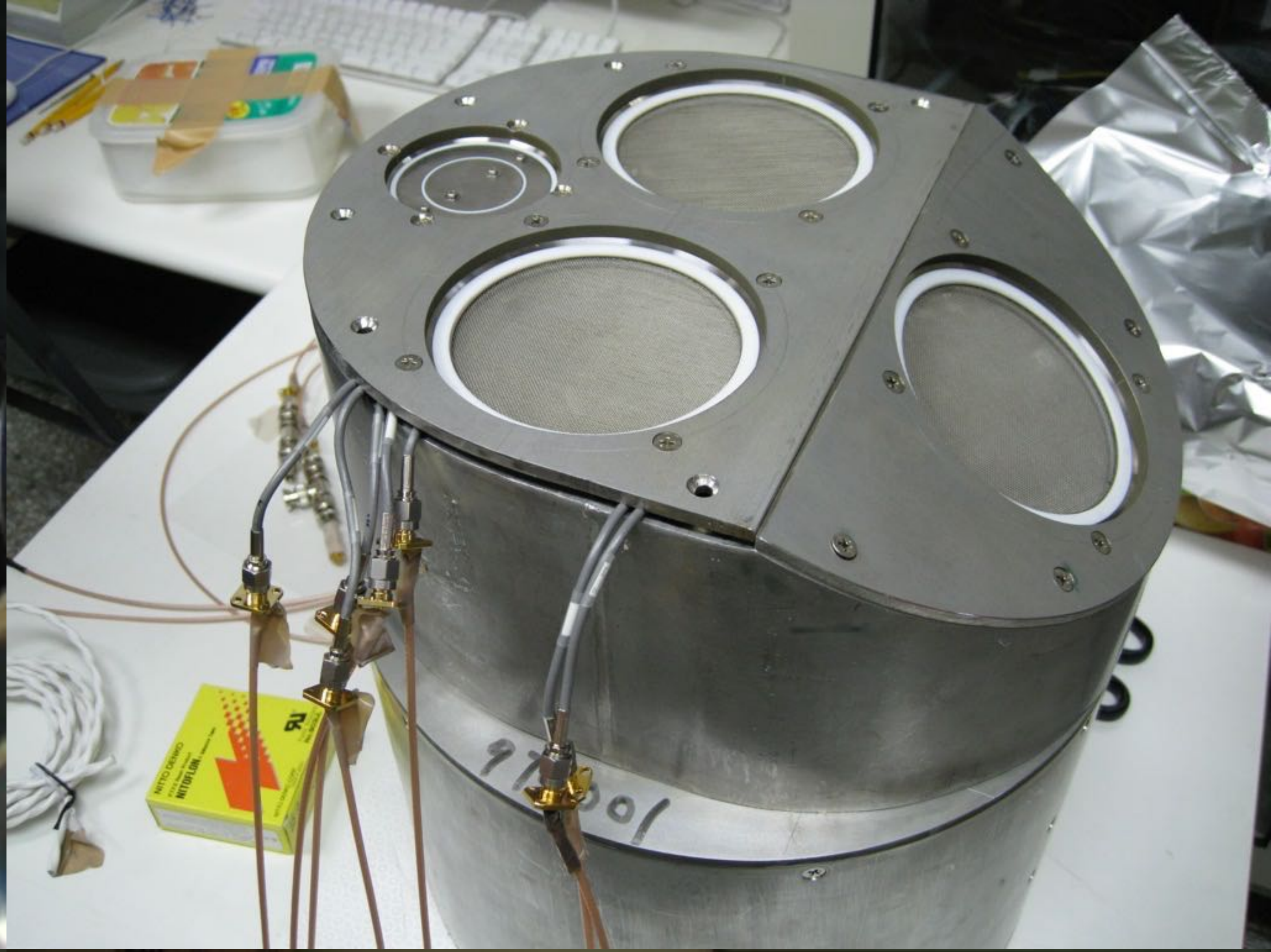

After heating

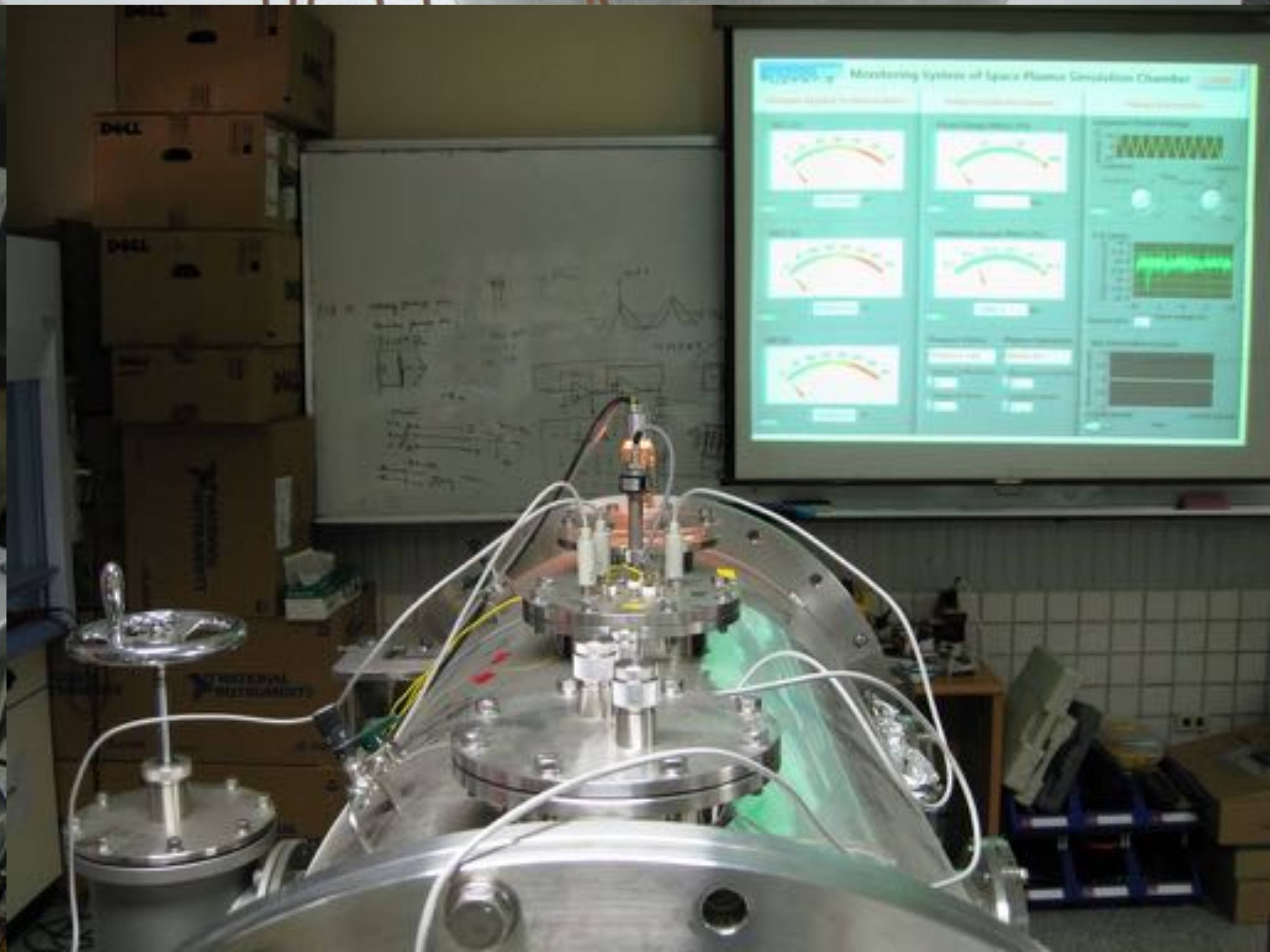

Exposing in the air for one day

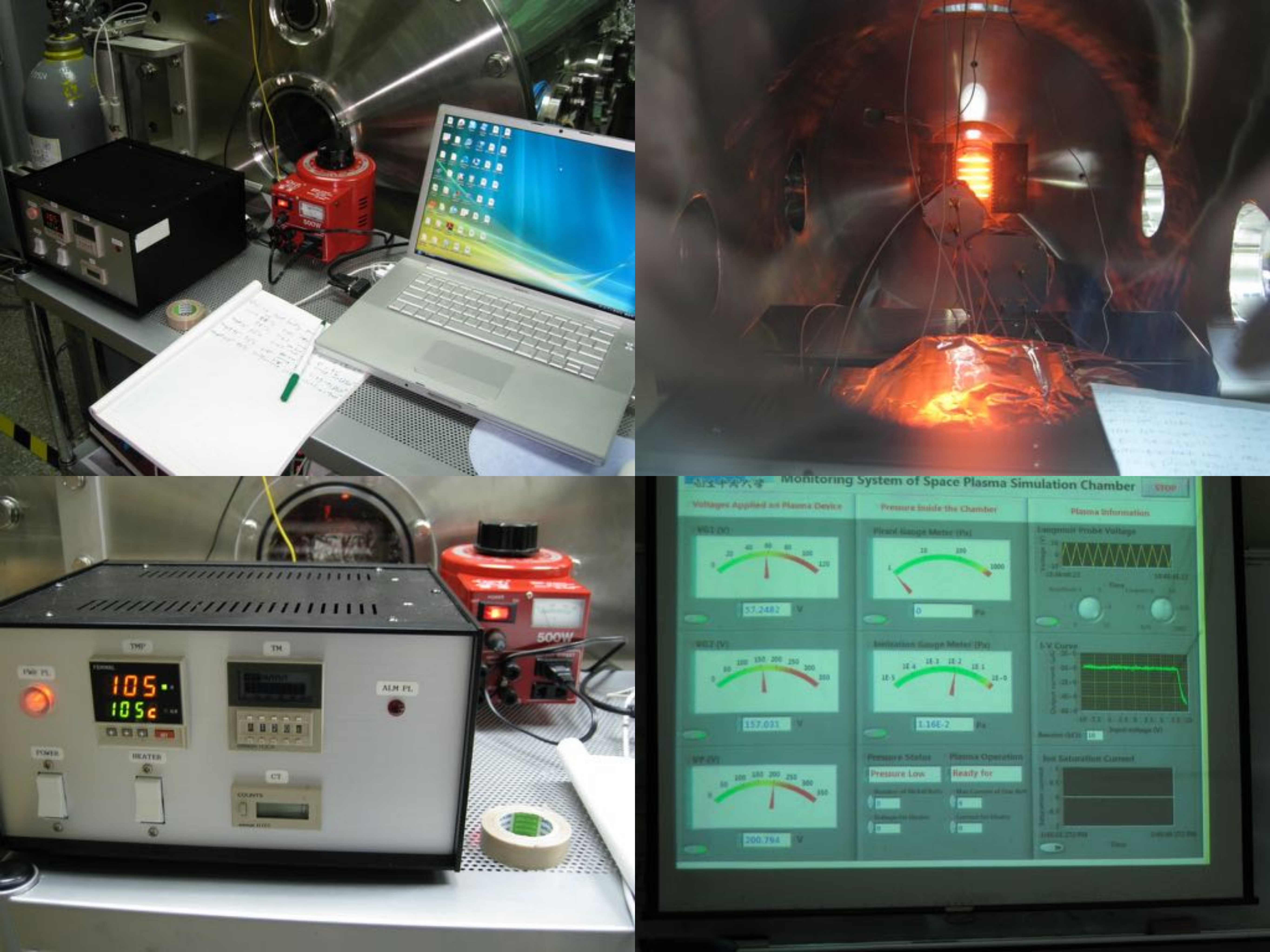

Exposing in the air for three days


500W

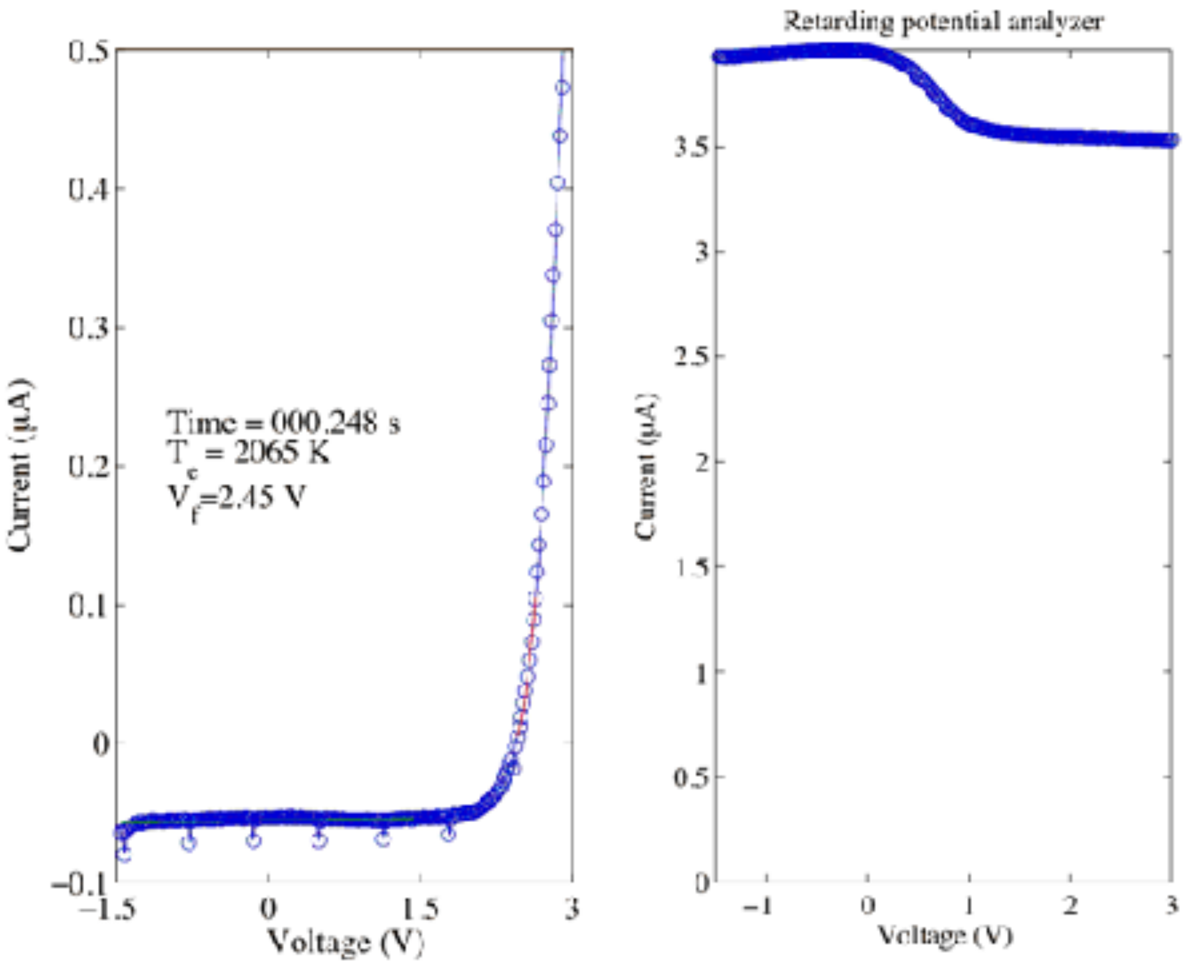

NITTO DENKO
NITOFLON



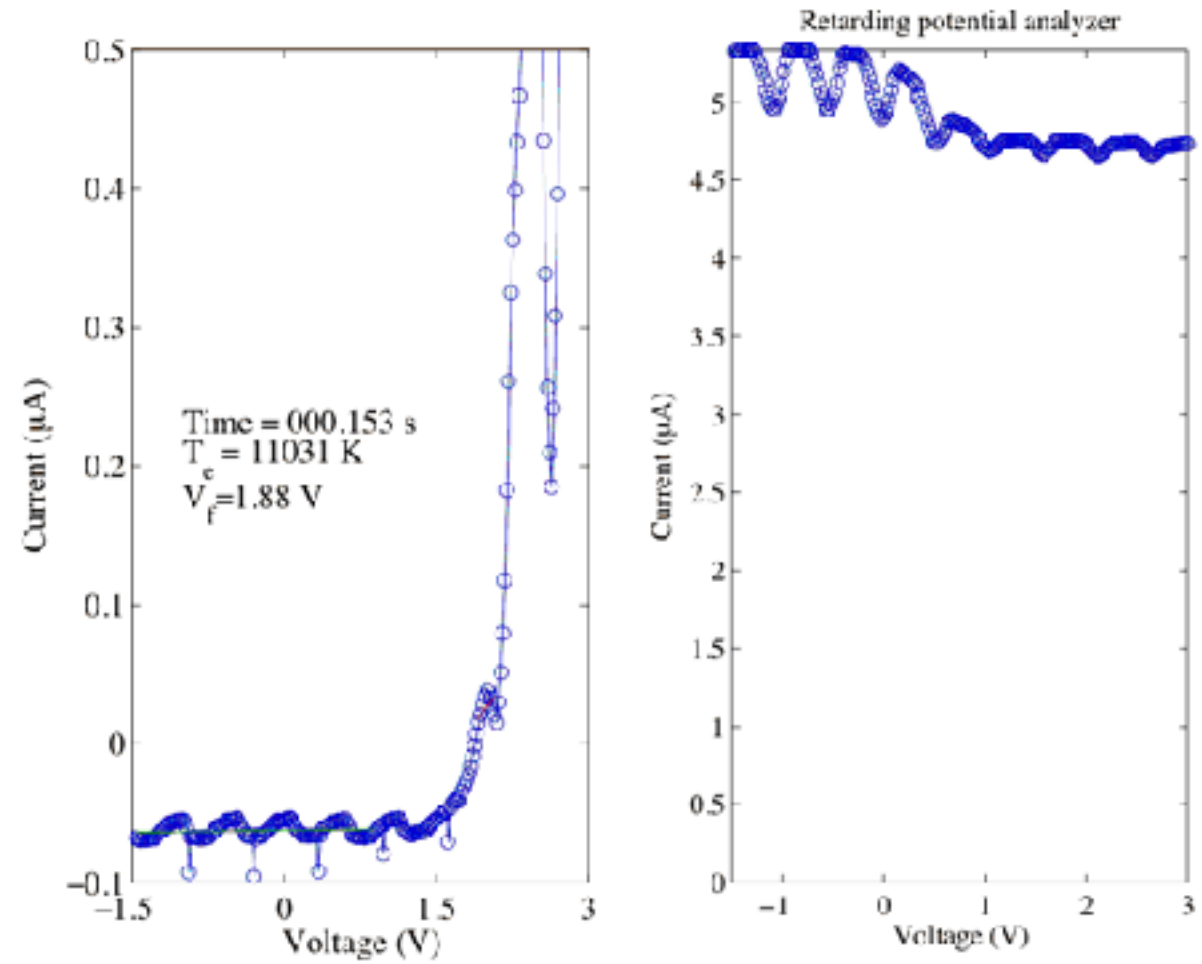

Monitoring System of Space Plasma Simulation Chamber
DELL
NATIONAL INSTRUMENTS


500W
PWR PL
TMP
105
105c
TM
ALM PL
POWER
HEATER
CT
COUNTS
Monitoring System of Space Plasma Simulation Chamber
STOP
Voltages Applied on Plasma Device
Pressure Inside the Chamber
Plasma Information
Langmuir Probe Voltage
I-V Curve
Pressure Status
Plasma Operation
Pressure Low
Ready for
Ion Saturation Current
57.2482
157.031
200.794
1.16E-2

Comparison of heating test



Before heating



After heating

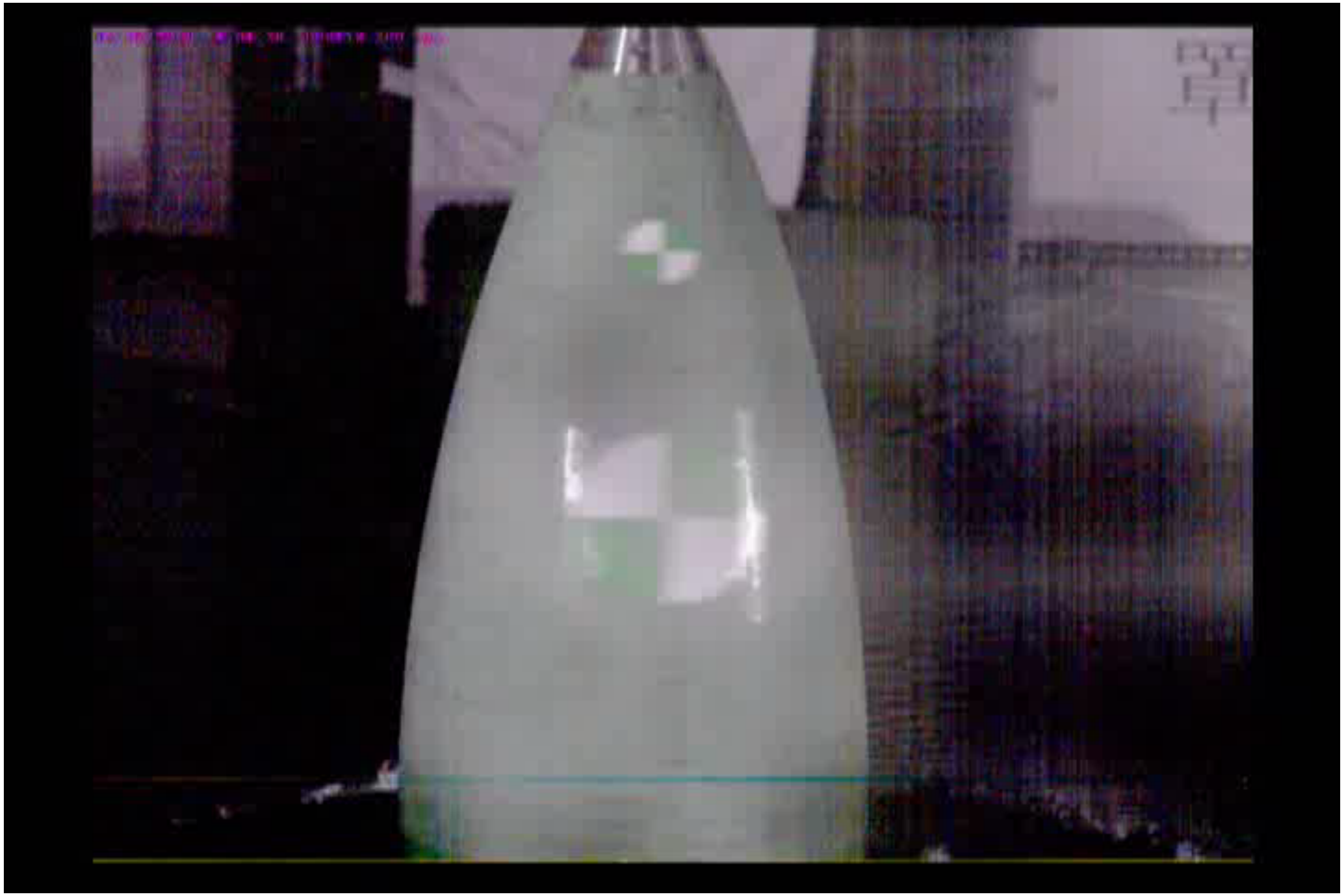
Digital signals

- Ion probe to IOP
- 38.4 kbps→ PASSED
- 76.8 kbps→ FAILED

Nose cone separation tests

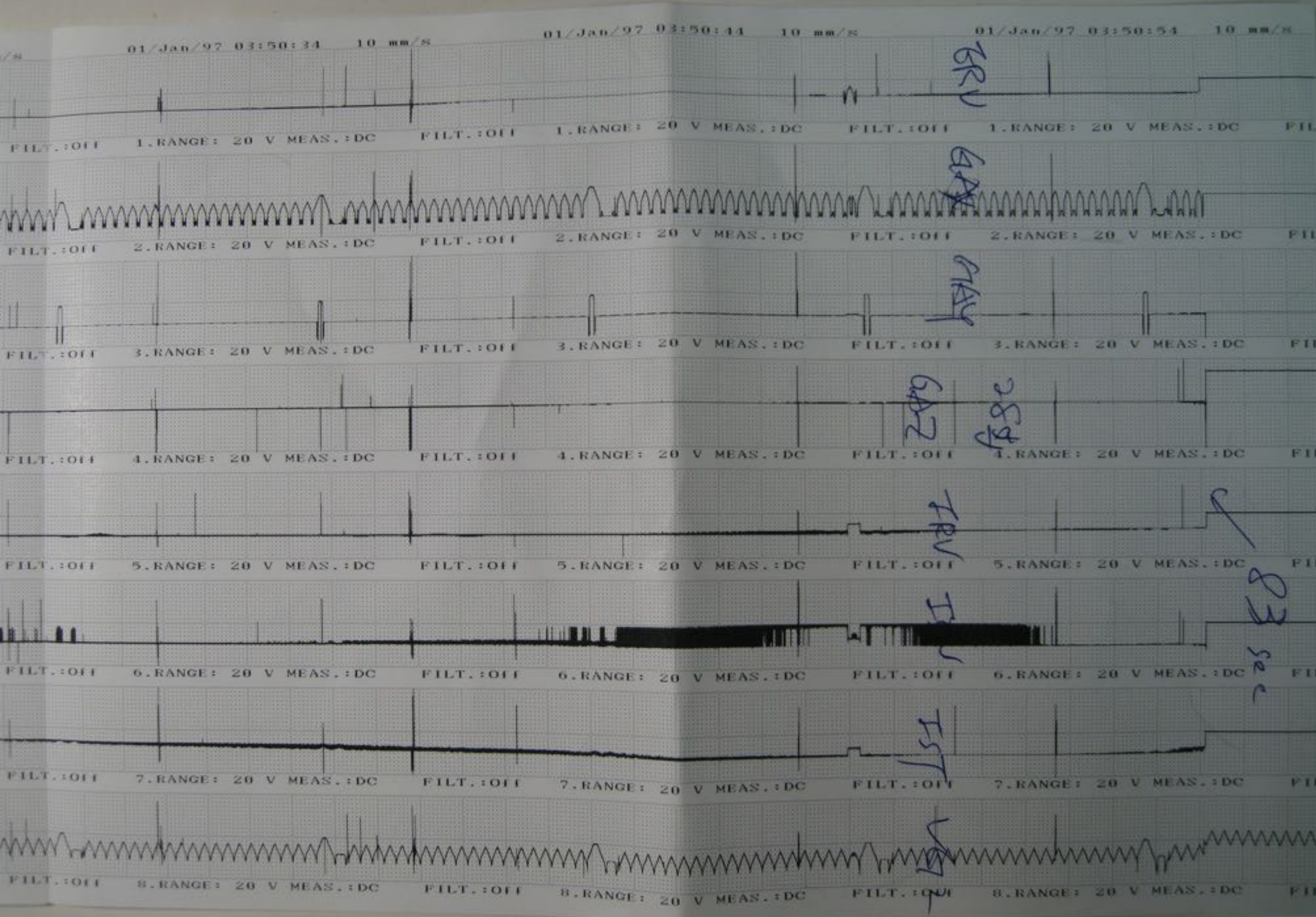
- 03/23/2009: nose cone separation without ion probe
- 03/30/2009: nose cone separation with ion probe

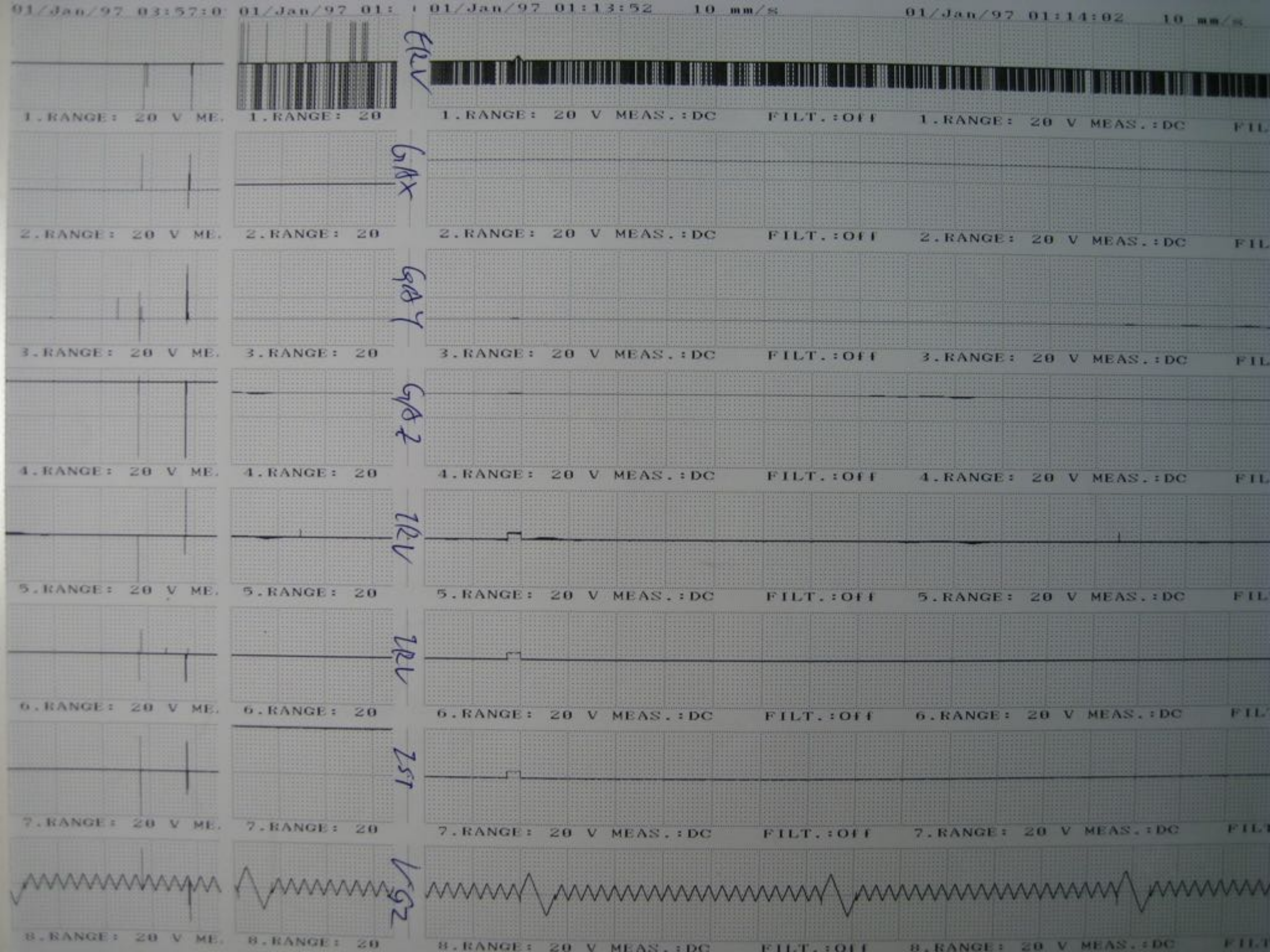

Scene Trigger [START] Frame
4 09/03/23 14:00:32 +002477
A PLAY 180.0 100 1/1500
ID Status Play Rec Shutter



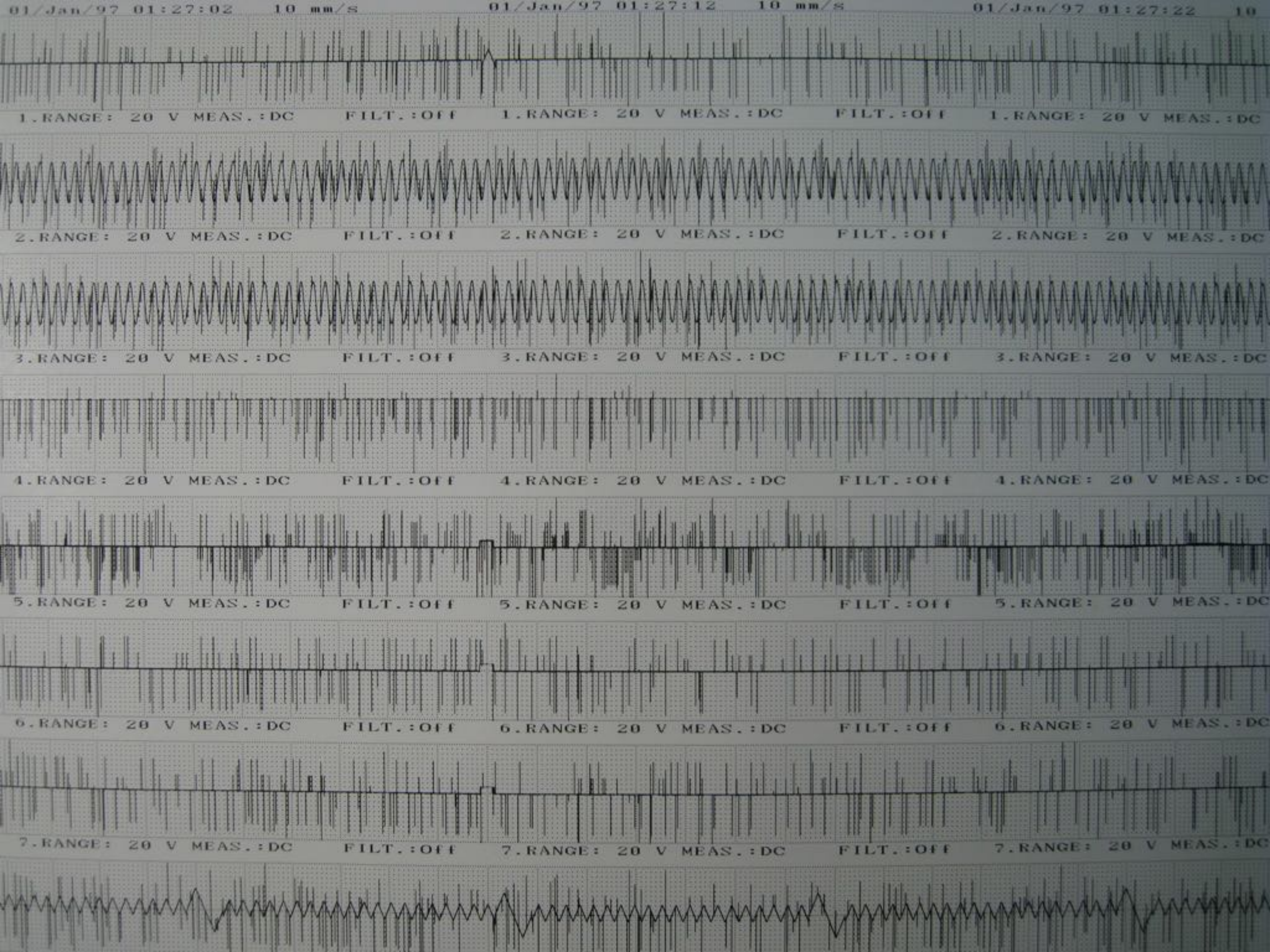
Rotation tests with IOP

- 05/27/2009 and 06/02/2009: incorrect data pattern from telemetry.
- 06/03/2009: payload data correct but IOP did not perform some procedures.


01/Jan/97 03:50:34 10 mm/s
01/Jan/97 03:50:44 10 mm/s
01/Jan/97 03:50:54 10 mm/s
FILT.:Off 1.RANGE: 20 V MEAS.:DC
FILT.:Off 2.RANGE: 20 V MEAS.:DC
FILT.:Off 3.RANGE: 20 V MEAS.:DC
FILT.:Off 4.RANGE: 20 V MEAS.:DC
FILT.:Off 5.RANGE: 20 V MEAS.:DC
FILT.:Off 6.RANGE: 20 V MEAS.:DC
FILT.:Off 7.RANGE: 20 V MEAS.:DC
FILT.:Off 8.RANGE: 20 V MEAS.:DC
83 sec


01/Jan/97 03:57:0
01/Jan/97 01:
01/Jan/97 01:13:52 10 mm/s
01/Jan/97 01:14:02 10 mm/s
1.RANGE: 20 V ME.
1.RANGE: 20
1.RANGE: 20 V MEAS.:DC FILT.:OFF
1.RANGE: 20 V MEAS.:DC FIL
2.RANGE: 20 V ME.
2.RANGE: 20
2.RANGE: 20 V MEAS.:DC FILT.:OFF
2.RANGE: 20 V MEAS.:DC FIL
3.RANGE: 20 V ME.
3.RANGE: 20
3.RANGE: 20 V MEAS.:DC FILT.:OFF
3.RANGE: 20 V MEAS.:DC FIL
4.RANGE: 20 V ME.
4.RANGE: 20
4.RANGE: 20 V MEAS.:DC FILT.:OFF
4.RANGE: 20 V MEAS.:DC FIL
5.RANGE: 20 V ME.
5.RANGE: 20
5.RANGE: 20 V MEAS.:DC FILT.:OFF
5.RANGE: 20 V MEAS.:DC FIL
6.RANGE: 20 V ME.
6.RANGE: 20
6.RANGE: 20 V MEAS.:DC FILT.:OFF
6.RANGE: 20 V MEAS.:DC FIL
7.RANGE: 20 V ME.
7.RANGE: 20
7.RANGE: 20 V MEAS.:DC FILT.:OFF
7.RANGE: 20 V MEAS.:DC FIL
8.RANGE: 20 V ME.
8.RANGE: 20
8.RANGE: 20 V MEAS.:DC FILT.:OFF
8.RANGE: 20 V MEAS.:DC FIL

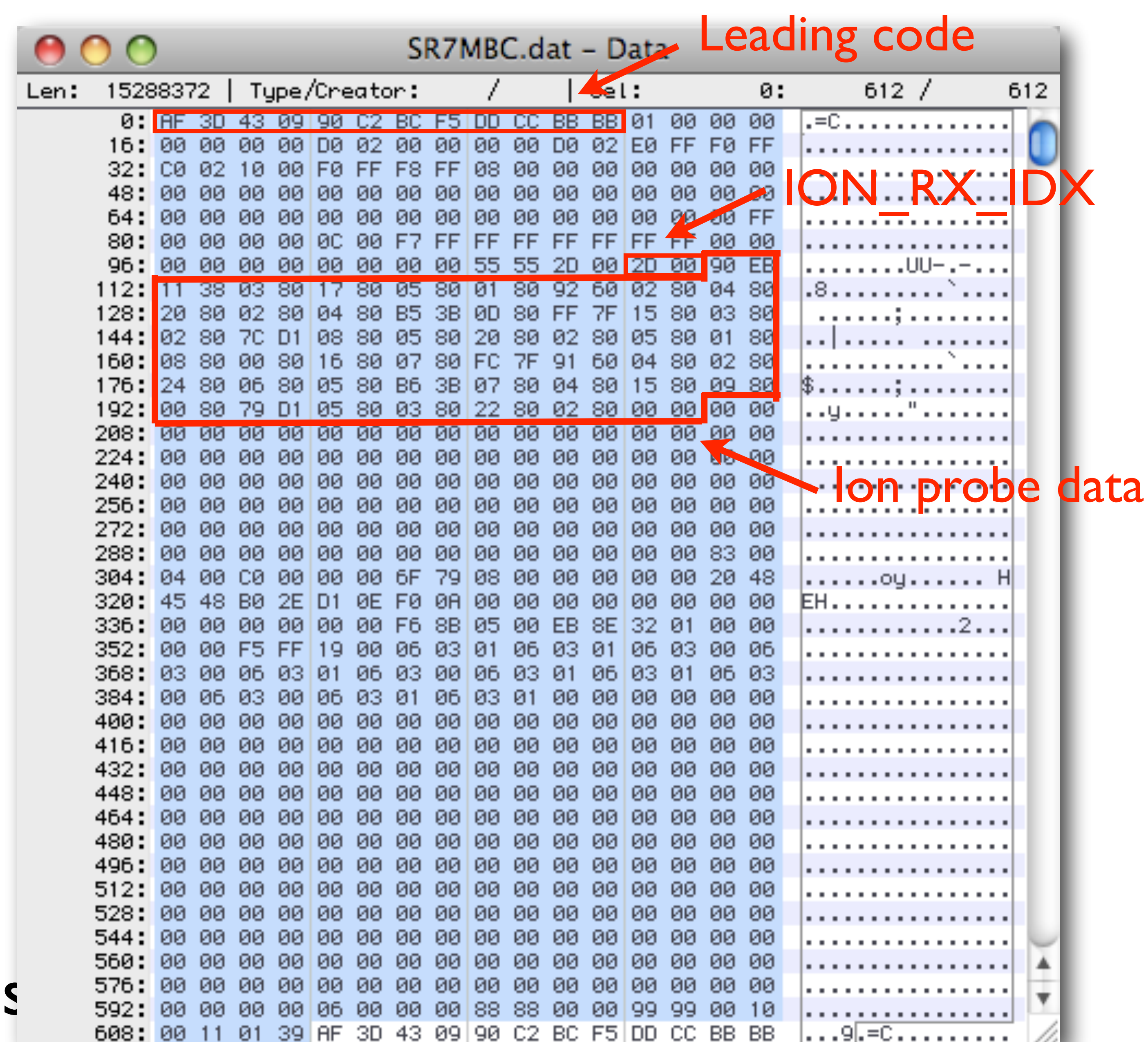

01:25:02 10 mm/s
01/Jan/97 01:25:12 10 mm/s
01/Jan/97 01:25:22 10 mm/s
20 V MEAS.:DC FILT.:Off 1.RANGE: 20 V MEAS.:DC FILT.:Off 1.RANGE: 20 V MEAS.:DC FILT.:Off
20 V MEAS.:DC FILT.:Off 2.RANGE: 20 V MEAS.:DC FILT.:Off 2.RANGE: 20 V MEAS.:DC FILT.:Off
20 V MEAS.:DC FILT.:Off 3.RANGE: 20 V MEAS.:DC FILT.:Off 3.RANGE: 20 V MEAS.:DC FILT.:Off
20 V MEAS.:DC FILT.:Off 4.RANGE: 20 V MEAS.:DC FILT.:Off 4.RANGE: 20 V MEAS.:DC FILT.:Off
20 V MEAS.:DC FILT.:Off 5.RANGE: 20 V MEAS.:DC FILT.:Off 5.RANGE: 20 V MEAS.:DC FILT.:Off
20 V MEAS.:DC FILT.:Off 6.RANGE: 20 V MEAS.:DC FILT.:Off 6.RANGE: 20 V MEAS.:DC FILT.:Off
20 V MEAS.:DC FILT.:Off 7.RANGE: 20 V MEAS.:DC FILT.:Off 7.RANGE: 20 V MEAS.:DC FILT.:Off
20 V MEAS.:DC FILT.:Off 8.RANGE: 20 V MEAS.:DC FILT.:Off 8.RANGE: 20 V MEAS.:DC FILT.:Off


01/Jan/97 01:27:02 10 mm/s
01/Jan/97 01:27:12 10 mm/s
01/Jan/97 01:27:22 10
1.RANGE: 20 V MEAS.:DC FILT.:Off
1.RANGE: 20 V MEAS.:DC FILT.:Off
1.RANGE: 20 V MEAS.:DC
2.RANGE: 20 V MEAS.:DC FILT.:Off
2.RANGE: 20 V MEAS.:DC FILT.:Off
2.RANGE: 20 V MEAS.:DC
3.RANGE: 20 V MEAS.:DC FILT.:Off
3.RANGE: 20 V MEAS.:DC FILT.:Off
3.RANGE: 20 V MEAS.:DC
4.RANGE: 20 V MEAS.:DC FILT.:Off
4.RANGE: 20 V MEAS.:DC FILT.:Off
4.RANGE: 20 V MEAS.:DC
5.RANGE: 20 V MEAS.:DC FILT.:Off
5.RANGE: 20 V MEAS.:DC FILT.:Off
5.RANGE: 20 V MEAS.:DC
6.RANGE: 20 V MEAS.:DC FILT.:Off
6.RANGE: 20 V MEAS.:DC FILT.:Off
6.RANGE: 20 V MEAS.:DC
7.RANGE: 20 V MEAS.:DC FILT.:Off
7.RANGE: 20 V MEAS.:DC FILT.:Off
7.RANGE: 20 V MEAS.:DC


01/Jan/97 01:33:02 10 mm/s
01/Jan/97 01:33:12 10 mm/s
01/Jan/97 01:33:22 10 mm
1.RANGE: 20 V MEAS.:DC FILT.:Off 1.RANGE: 20 V MEAS.:DC FILT.:Off 1.RANGE: 20 V MEAS.:DC
2.RANGE: 20 V MEAS.:DC FILT.:Off 2.RANGE: 20 V MEAS.:DC FILT.:Off 2.RANGE: 20 V MEAS.:DC
3.RANGE: 20 V MEAS.:DC FILT.:Off 3.RANGE: 20 V MEAS.:DC FILT.:Off 3.RANGE: 20 V MEAS.:DC
4.RANGE: 20 V MEAS.:DC FILT.:Off 4.RANGE: 20 V MEAS.:DC FILT.:Off 4.RANGE: 20 V MEAS.:DC
5.RANGE: 20 V MEAS.:DC FILT.:Off 5.RANGE: 20 V MEAS.:DC FILT.:Off 5.RANGE: 20 V MEAS.:DC
6.RANGE: 20 V MEAS.:DC FILT.:Off 6.RANGE: 20 V MEAS.:DC FILT.:Off 6.RANGE: 20 V MEAS.:DC
7.RANGE: 20 V MEAS.:DC FILT.:Off 7.RANGE: 20 V MEAS.:DC FILT.:Off 7.RANGE: 20 V MEAS.:DC
8.RANGE: 20 V MEAS.:DC FILT.:Off 8.RANGE: 20 V MEAS.:DC FILT.:Off 8.RANGE: 20 V MEAS.:DC

Data extraction from digital data from IOP

- Data obtained from telemetry
- Little ending arrangement
- ION_RX_IDX (1 word or 2 bytes) should be within 1 (0100H) to 96 (6000H)
- Ion probe data: 96 words or 192 bytes



IOP data retrieval

- num_of _frame = 24981
- count_error_[illegible]ge: 263
- count_error_[illegible] 1988
- word_error_overwrite = 2064
- Error rate = 9.01%
- Data loss rate = 0.086% to 2.19%

Thermal cycling tests

- 6/22-24: Thermal cycling test - 3 cycles
  - Lowest temperature: -40℃ power-off; -10℃ power-on
  - Highest temperature: +65℃ power-off; +50℃ power-on
  - Ion payload failed during the 3rd cycle at -10℃ power-on test, incorrect output data

Ion probe temperature tolerance

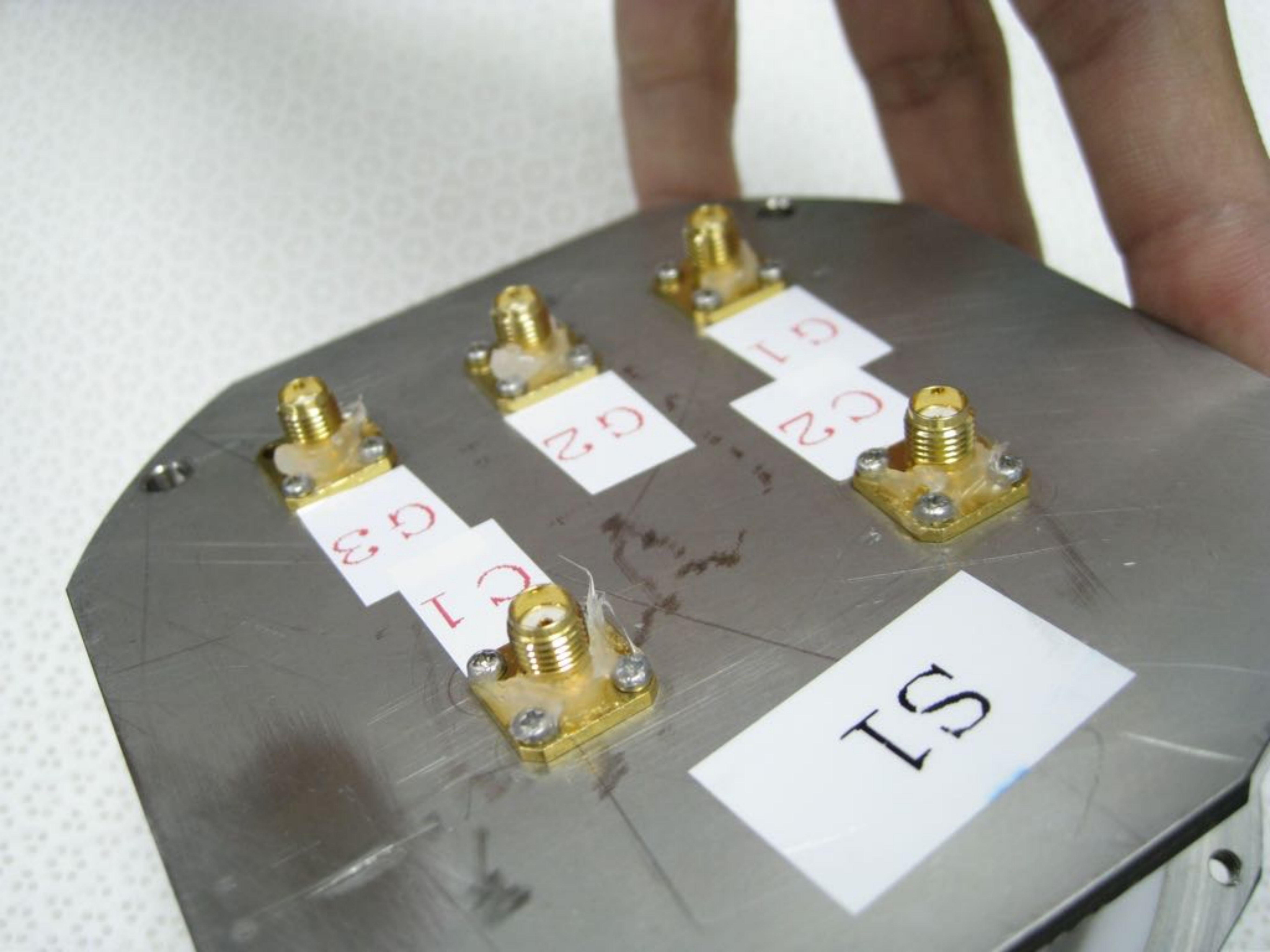
- Storage temperature: -10℃ to 70℃
- Operating temperature: 0℃ to 50℃

Thermal cycling tests (cont.)

- 6/25/2009: Thermal cycling test - 1 cycle
  - Lowest temperature: -10℃ power-off; 0℃ power-on
  - Highest temperature: +65℃ power-off; +50℃ power-on
  - Ion payload functions correctly

Vibration test

- 3.8 Grms, 10 minute, 3-axis
- Results during the test
  - Bit test failed
  - IRV from analog channel failed
  - ISN and IST unstable signal outputs
  - ERV performed OK
- All signals performed well before and after the test


G1
C2
G2
G3
C1
S1

Causes

- C2 skew connector of the RPA (IRV) was loosen.
- The nut and washer vibrated with payload will disturb the C1 signal.

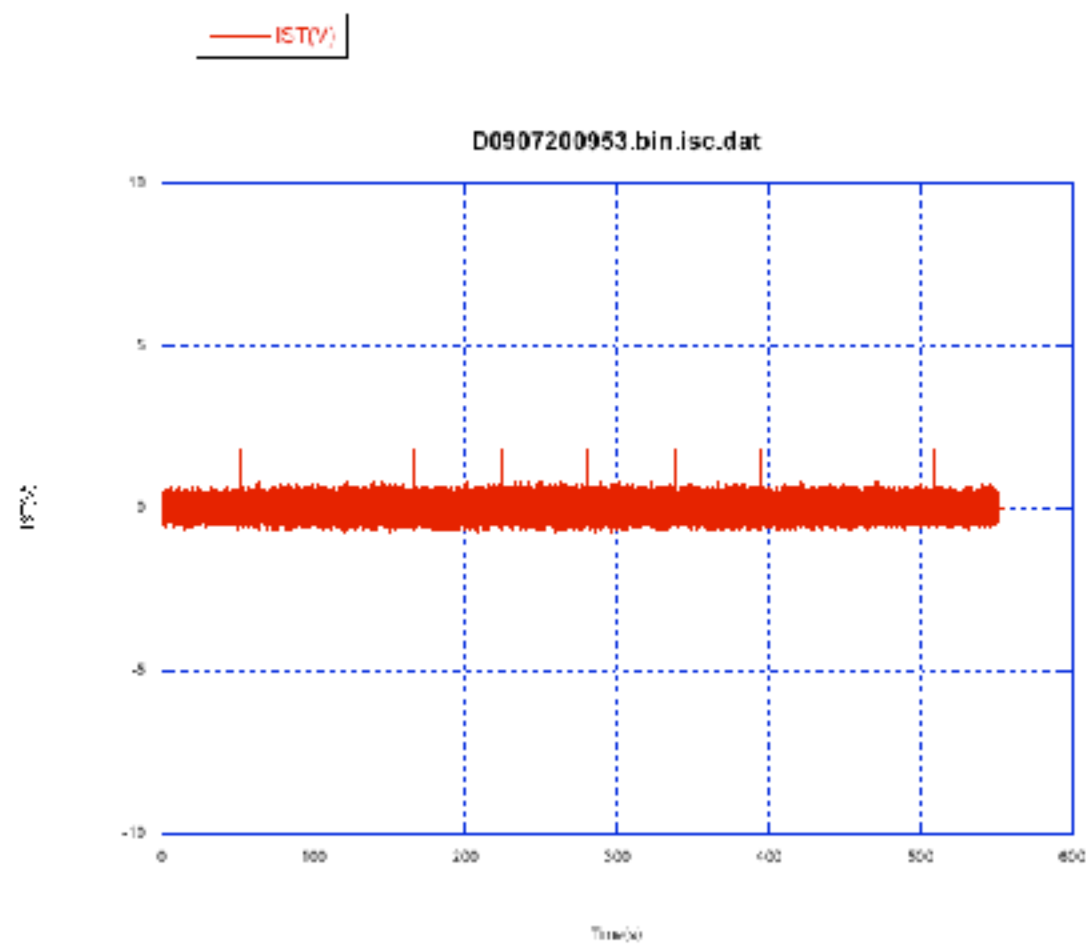
Performance test

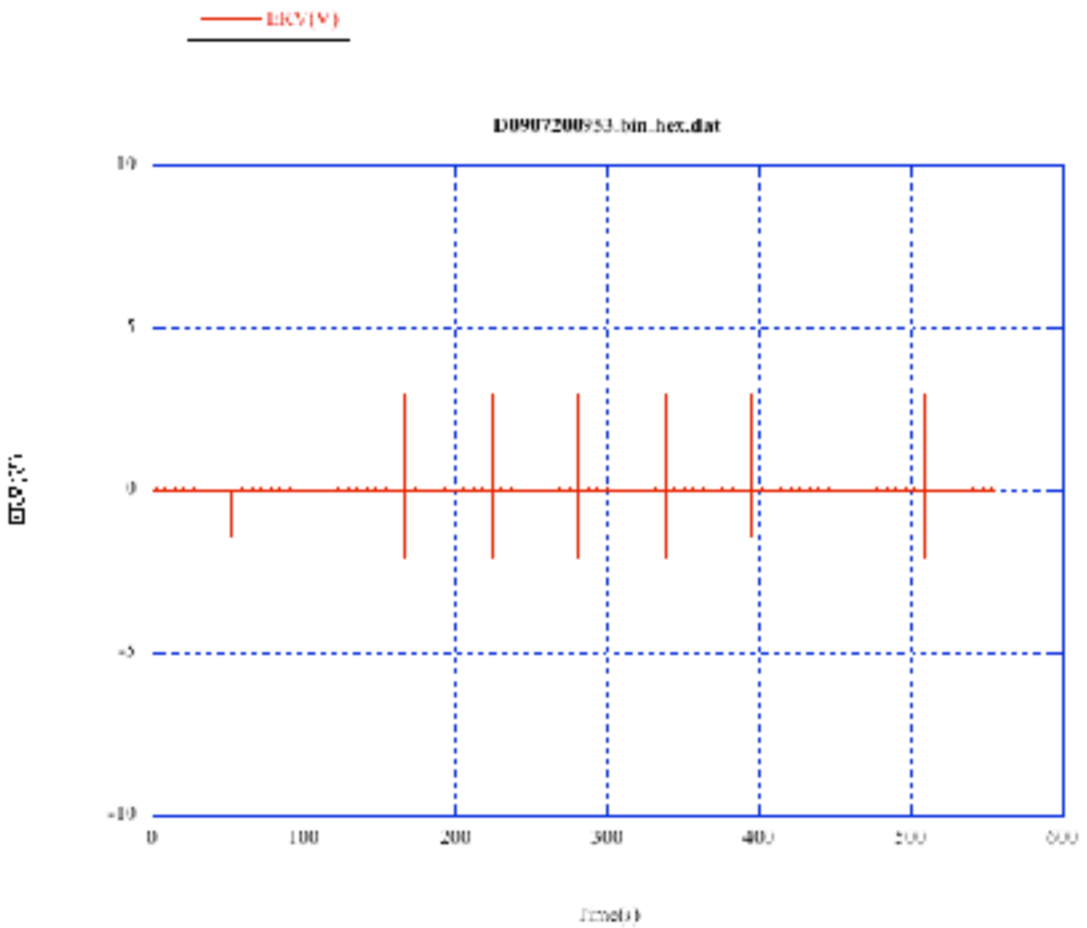
- Heater: 20V
  - TEST_1:VG1=80V,VG2=150V,VG3=200V, P=1.6x10^{-2} Pa
  - TEST_2:VG1=100V,VG2=150V,VG3=200V, P=1.6x10^{-2} Pa
  - TEST_3:VG1=120V,VG2=150V,VG3=200V, P=1.6x10^{-2} Pa
  - TEST_4:VG1=80V,VG2=150V,VG3=200V, P=2.4x10^{-2} Pa
  - TEST_5:VG1=100V,VG2=150V,VG3=200V, P=2.4x10^{-2} Pa
  - TEST_6:VG1=120V,VG2=150V,VG3=200V, P=2.4x10^{-2} Pa
- Heater: 24V
  - **TEST_7**:VG1=80V,VG2=150V,VG3=200V, P=2x10^{-2} Pa, normal RPA
  - **TEST_8**:VG1=80V,VG2=150V,VG3=200V, P~2.0x10^{-2} Pa, tilt RPA

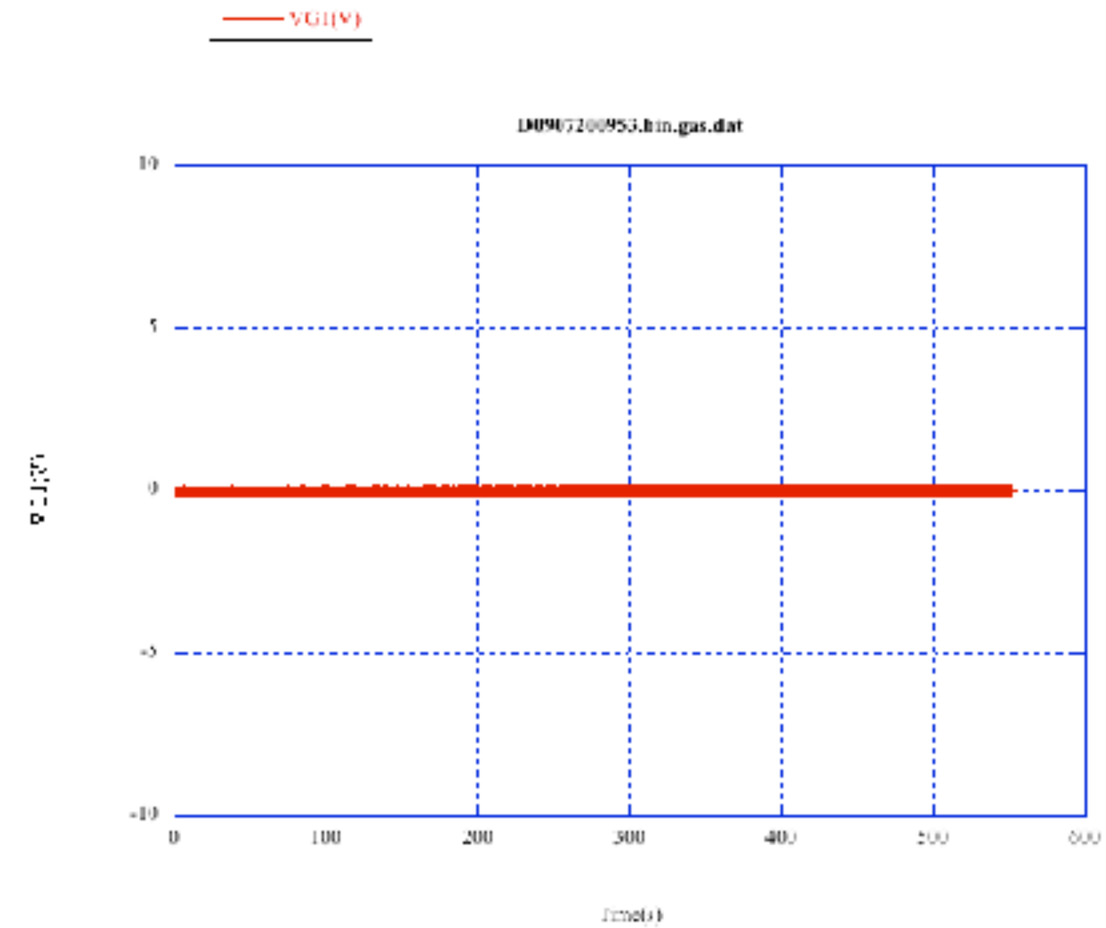

Plasma Information
Pressure Inside the Chamber
Voltages Applied on Plasma Device
Langmuir Probe Voltage
I-V Curve
Ion Saturation Current
Ready for
N/A
98.5665
197.315
252.68
1.86E-2
TEST_7
TEST_8

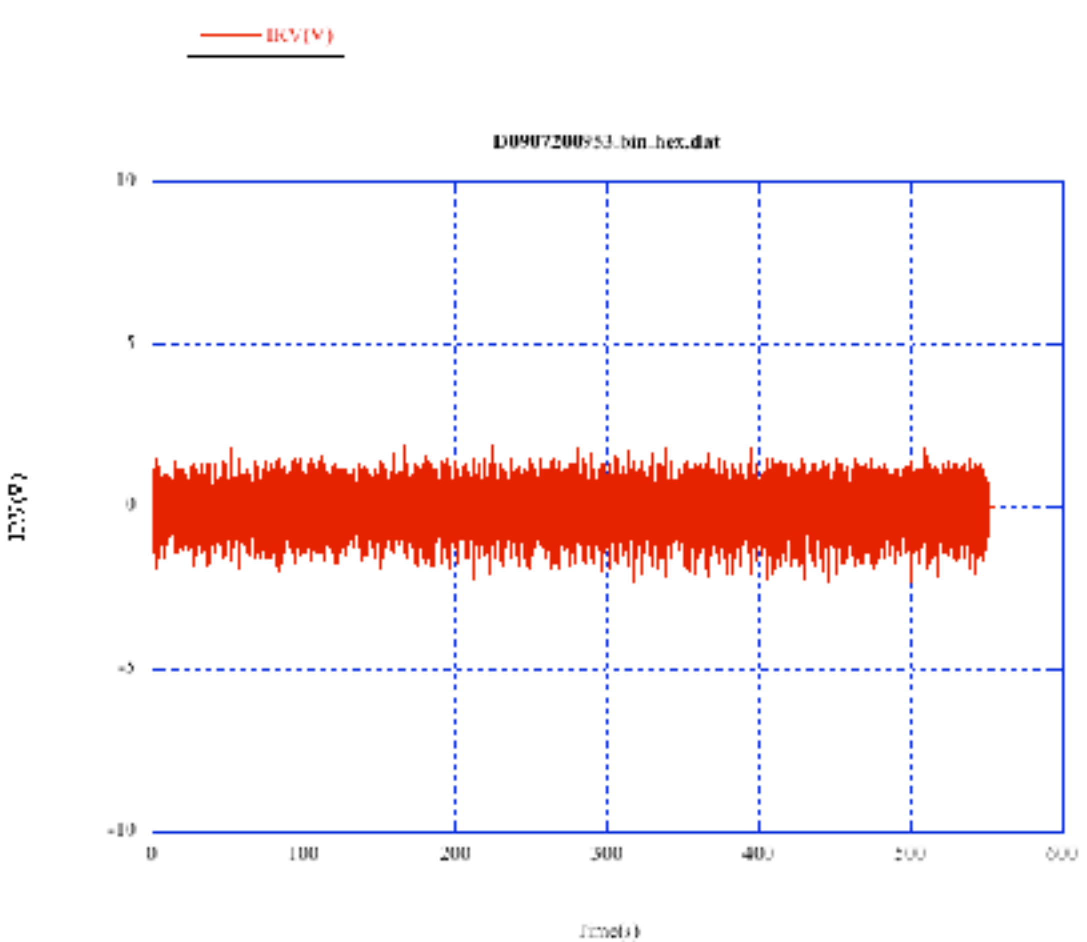
Vibration test - payload only

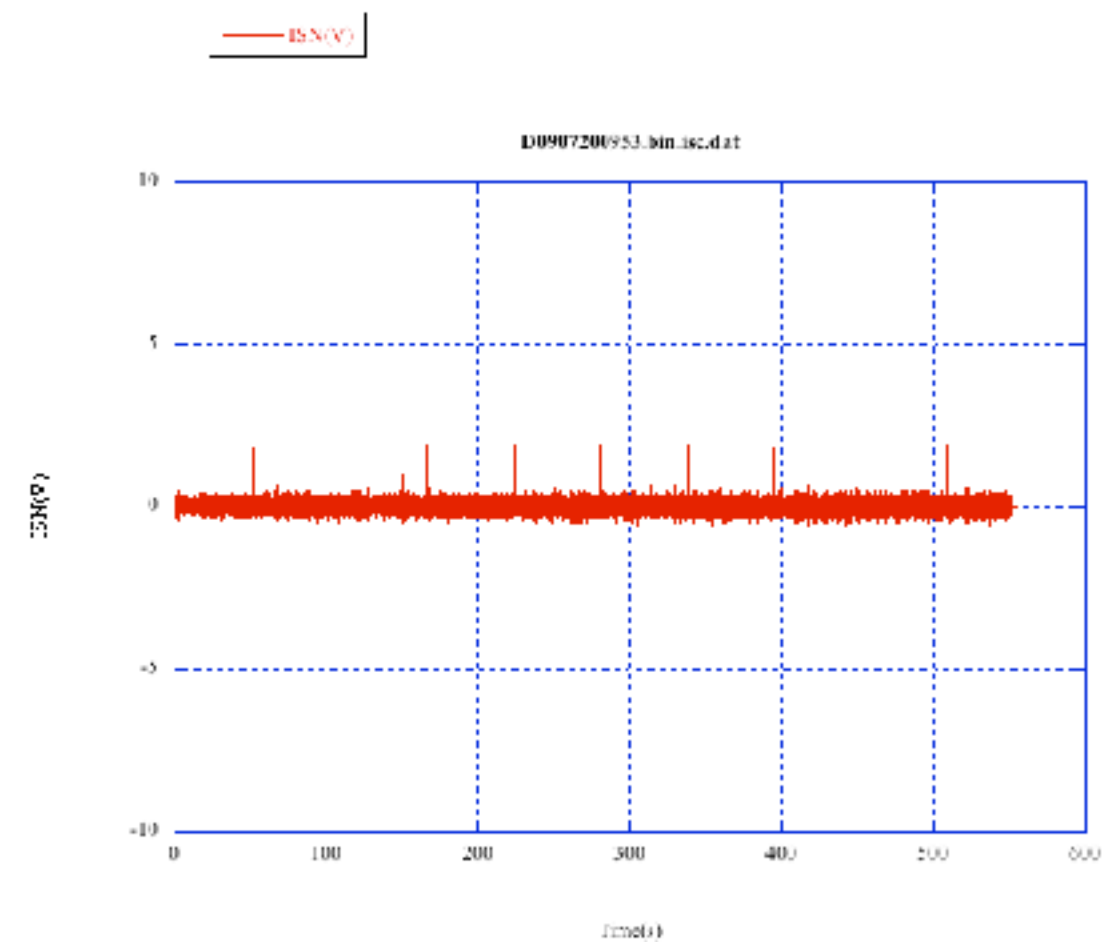
- 3.8 Grms, 10 minute, 3-axis




D0907200953.bin.hex.dat
10
5
0
-5
-10
0
100
200
300
400
500
600


D0907200953.bin.gas.dat
10
5
0
-5
-10
0
100
200
300
400
500
600

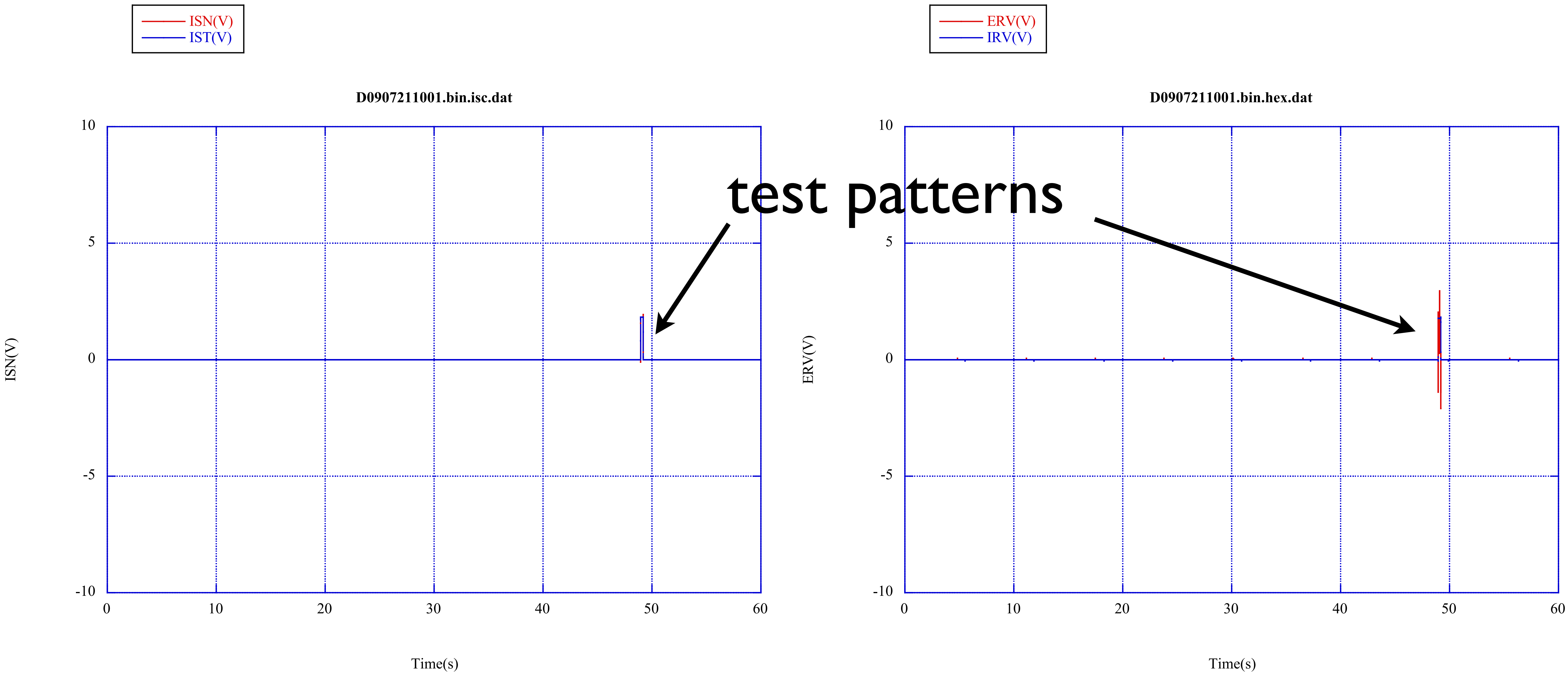

D0907200953.bin.hex.dat
10
5
0
-5
-10
0
100
200
300
400
500
600


D0907200953.bin.isc.dat
10
5
0
-5
-10
0
100
200
300
400
500
600

07/21/2009

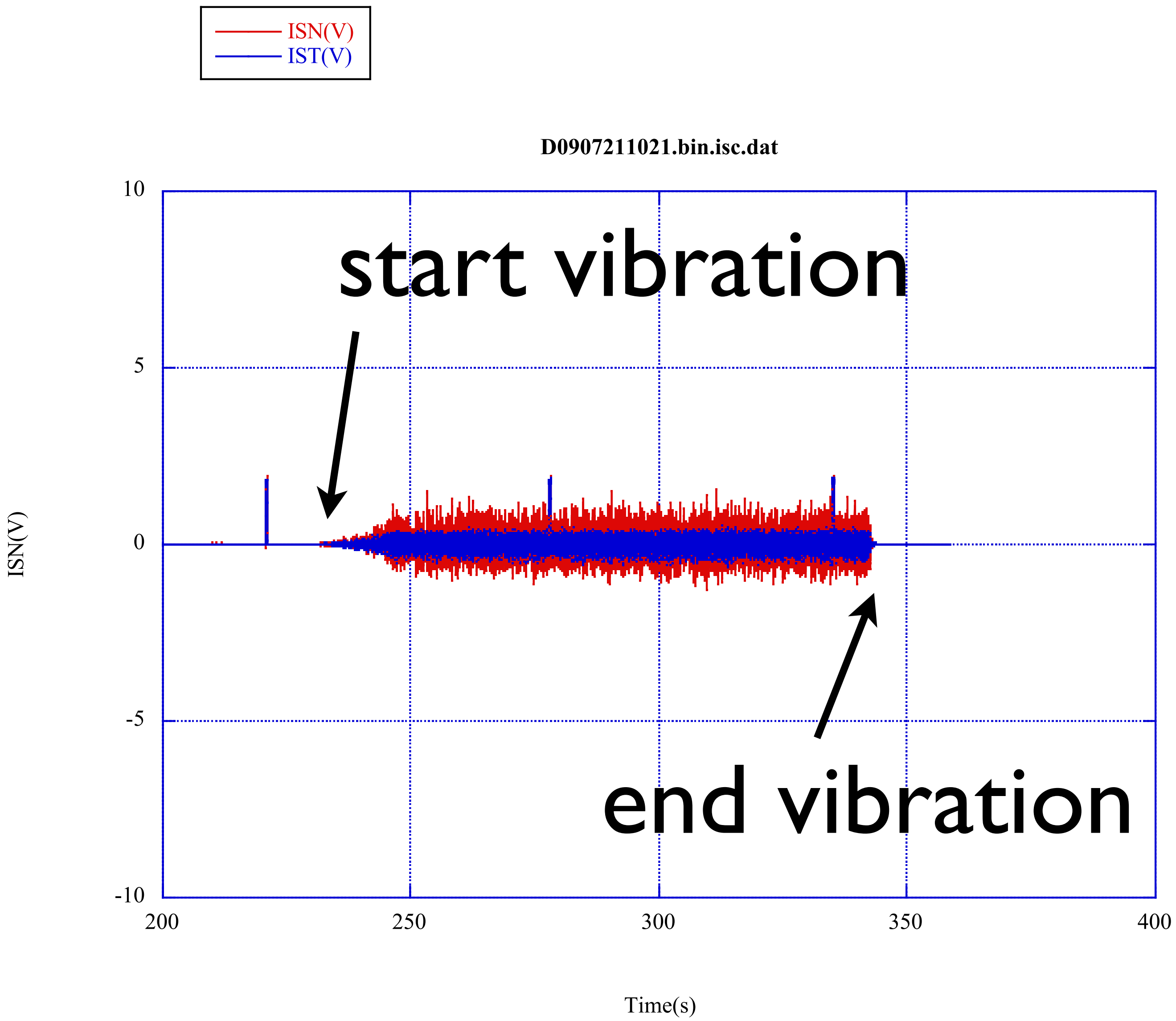
- Normal condition without vibration: D0907211001.bin
- Removing RPA (IRV) sensor from payload: D0907211021.bin
- Removing G3 cable from ISN sensor: D0907211040.bin
- Removing G1, G2, and G3 cables from ISN sensor: D0907211052.bin
- Removing G1, G2, G3, and C2 cables from ISN sensor: D0907211314.bin
- Removing G1, G2, G3, C2, and C1 cables from ISN: D0907211328.bin

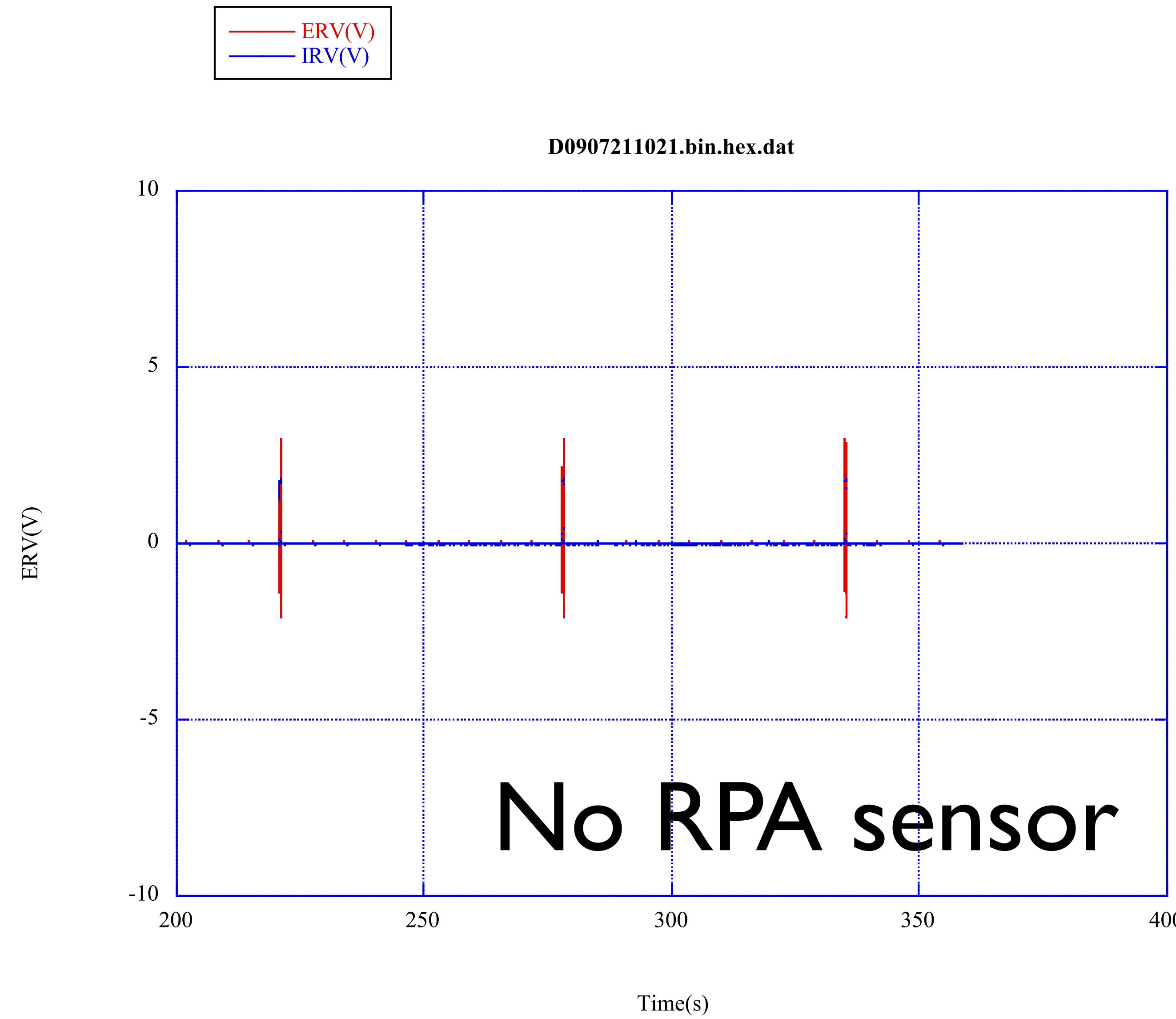
Normal condition without vibration



No fluctuation on four sensors

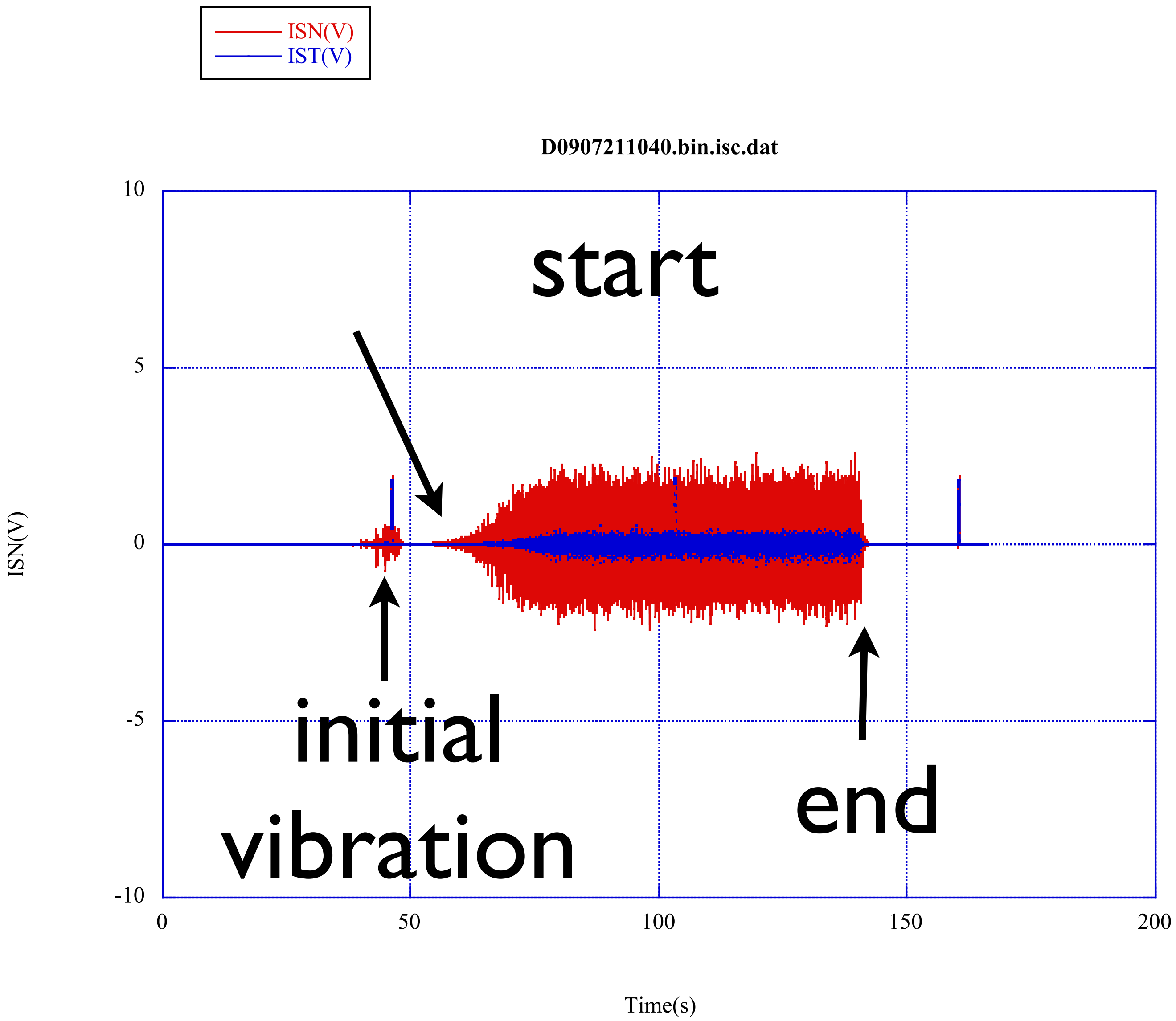
Removing the RPA sensor

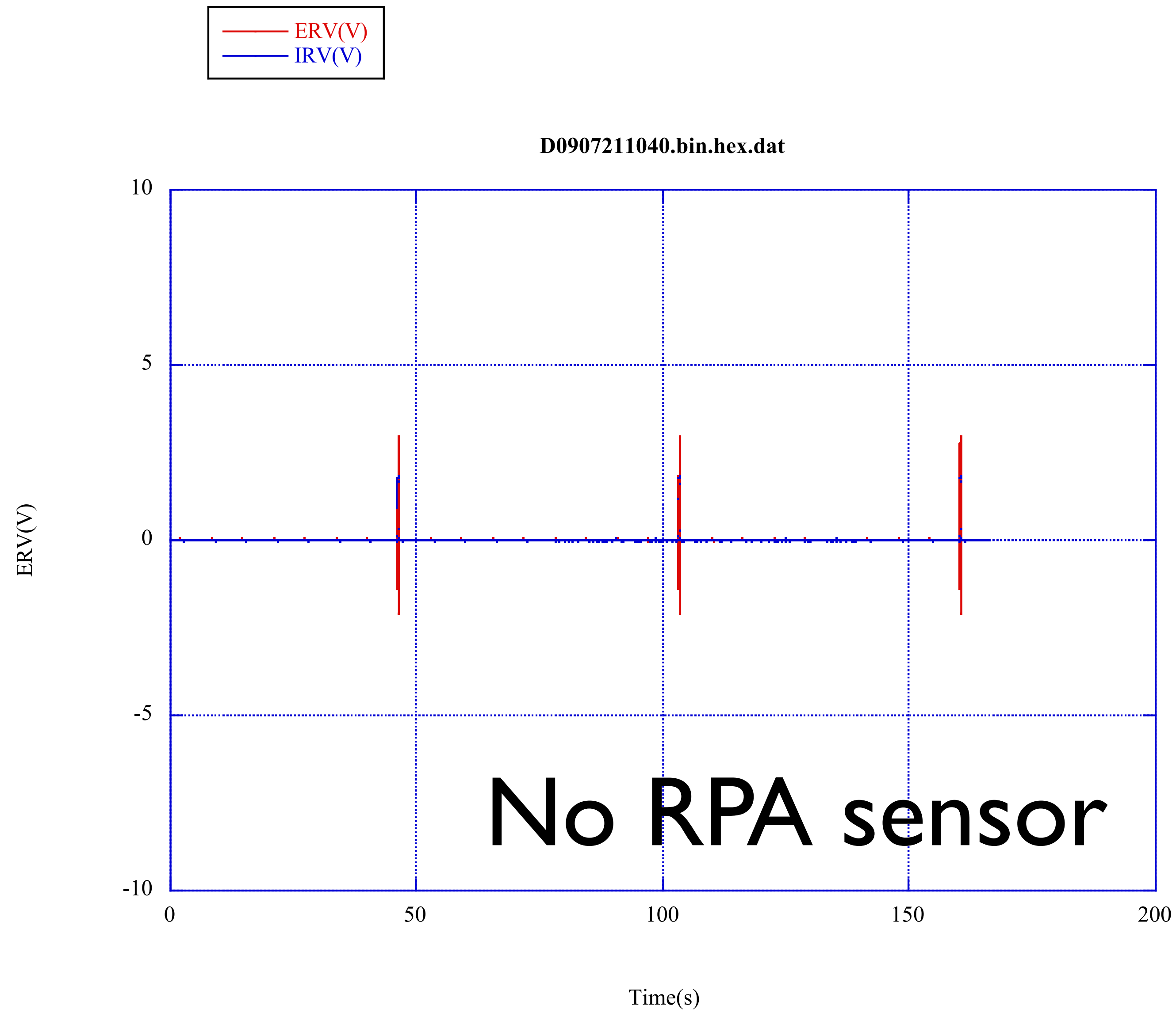




ISN and IST show fluctuation during the test

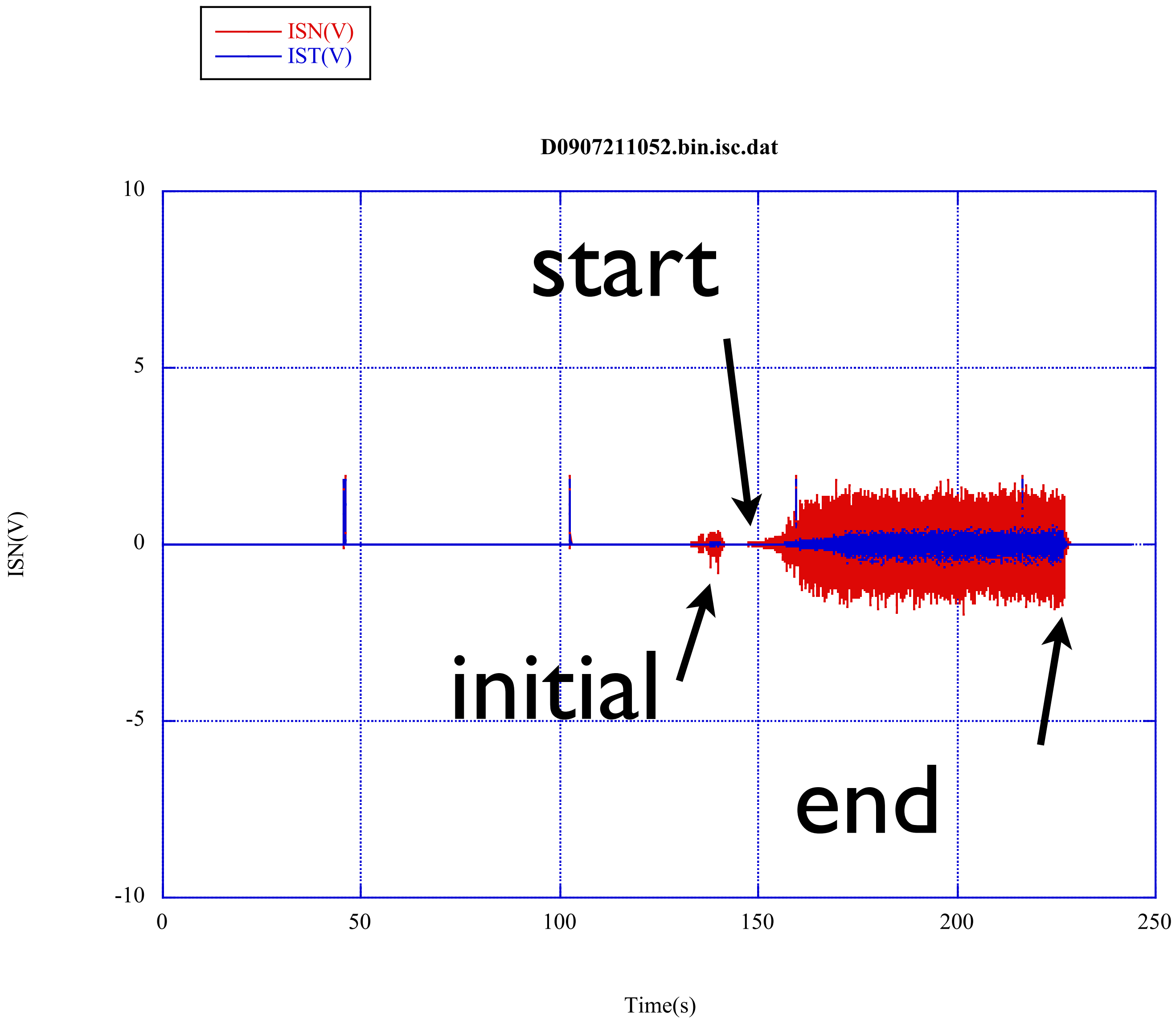
Removing G3 cable from ISN sensor

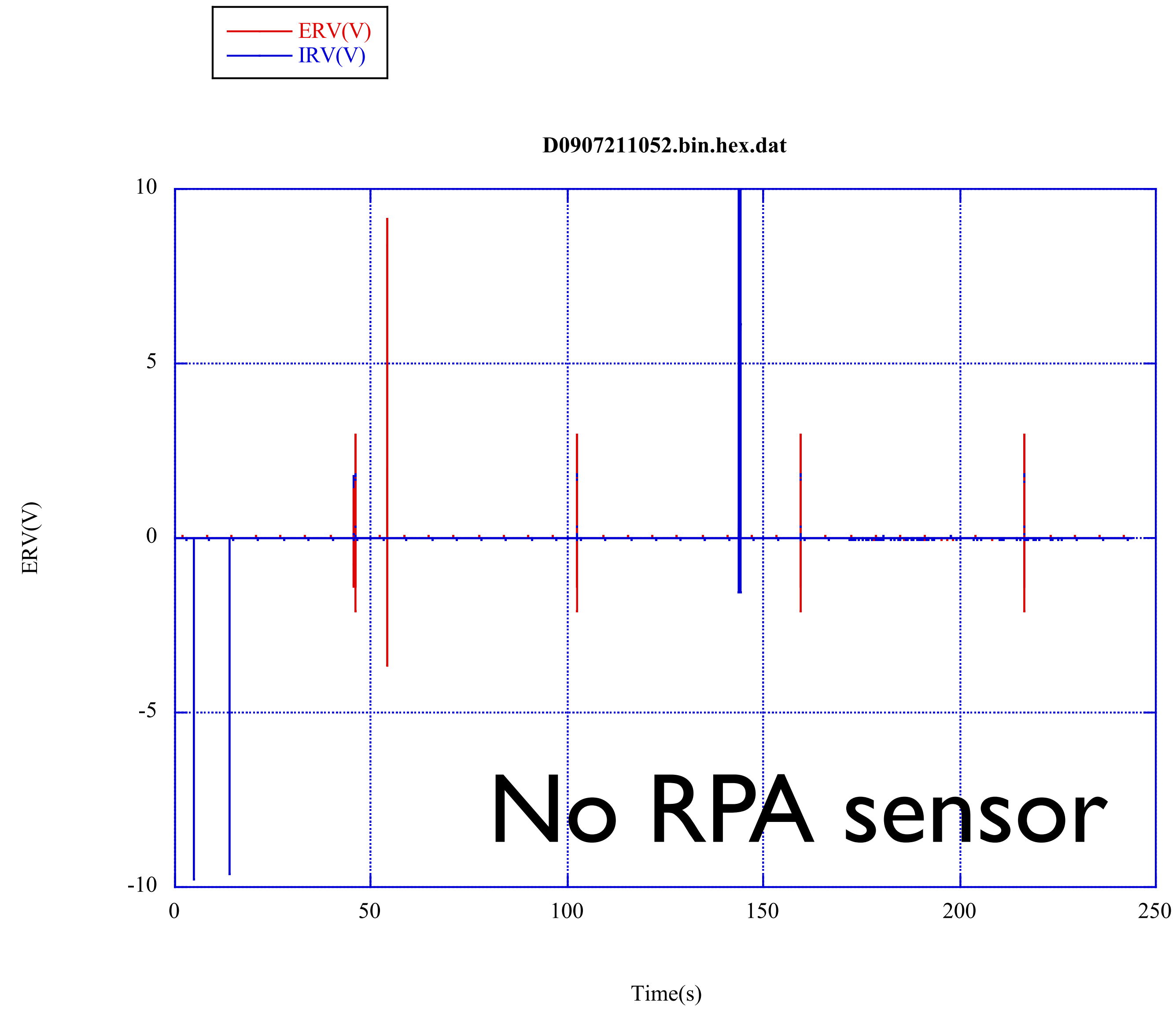




ISN and IST show fluctuation during the test

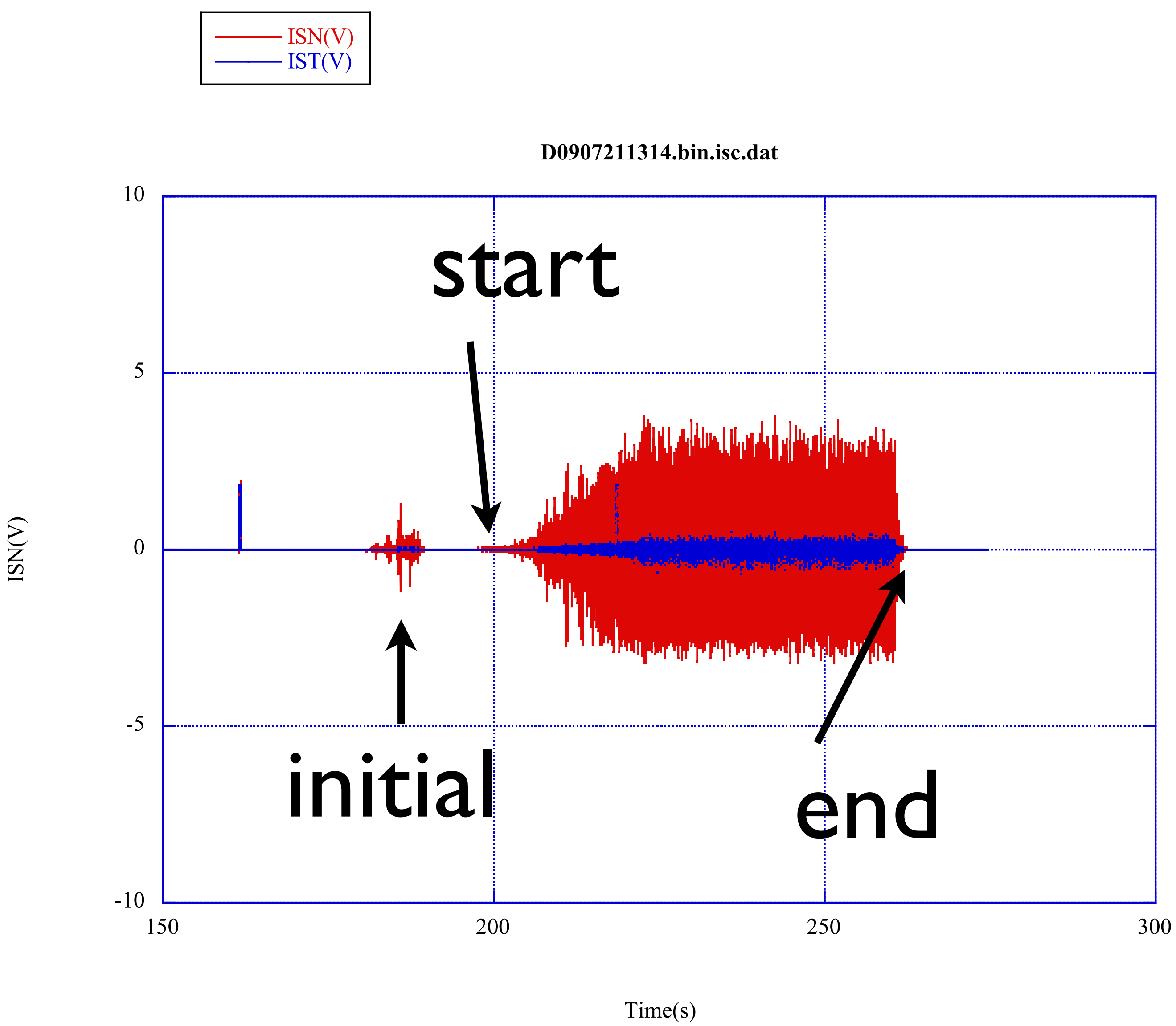
Removing G1, G2, and G3 cables from ISN sensor

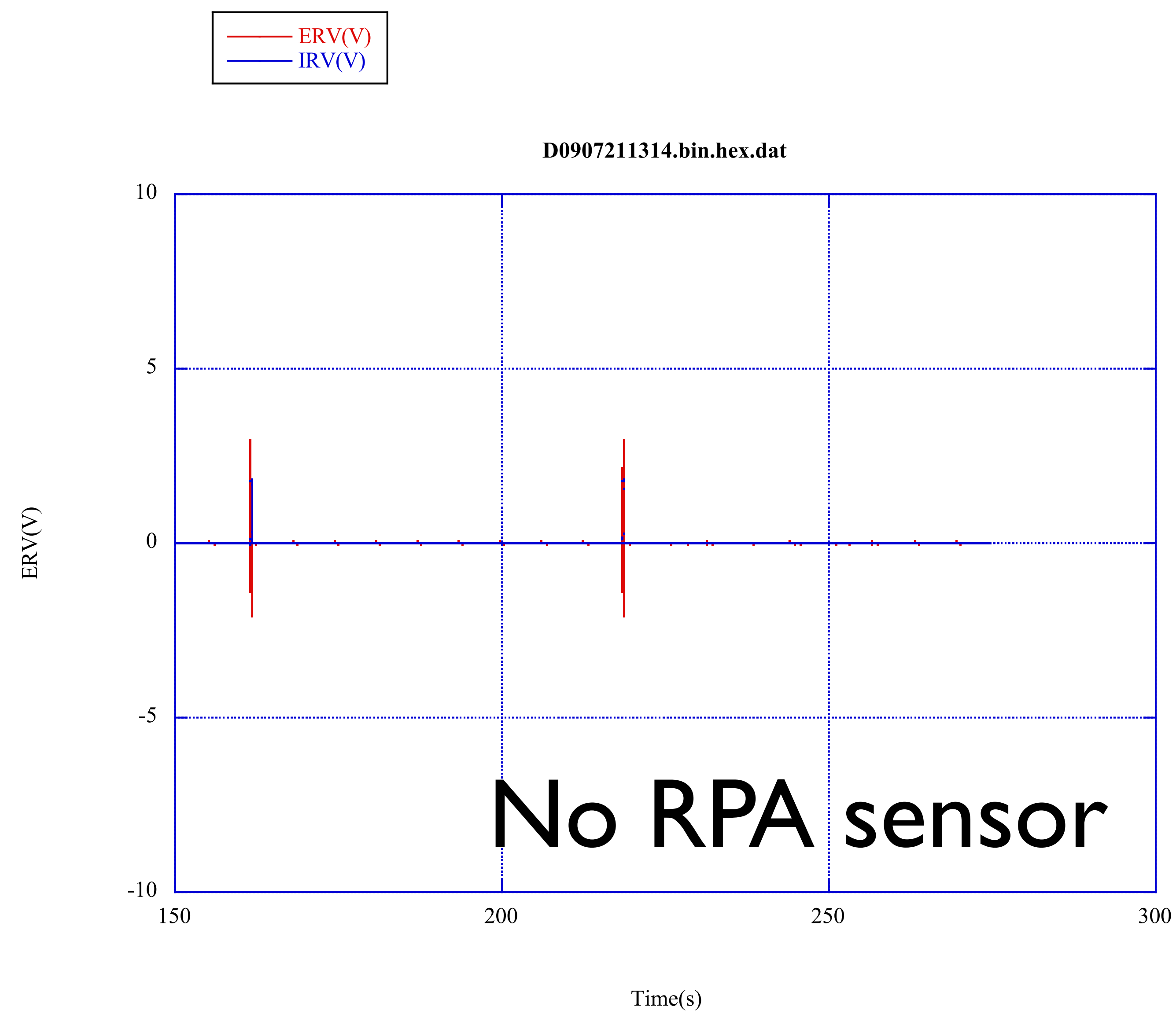




ISN and IST show fluctuation during the test

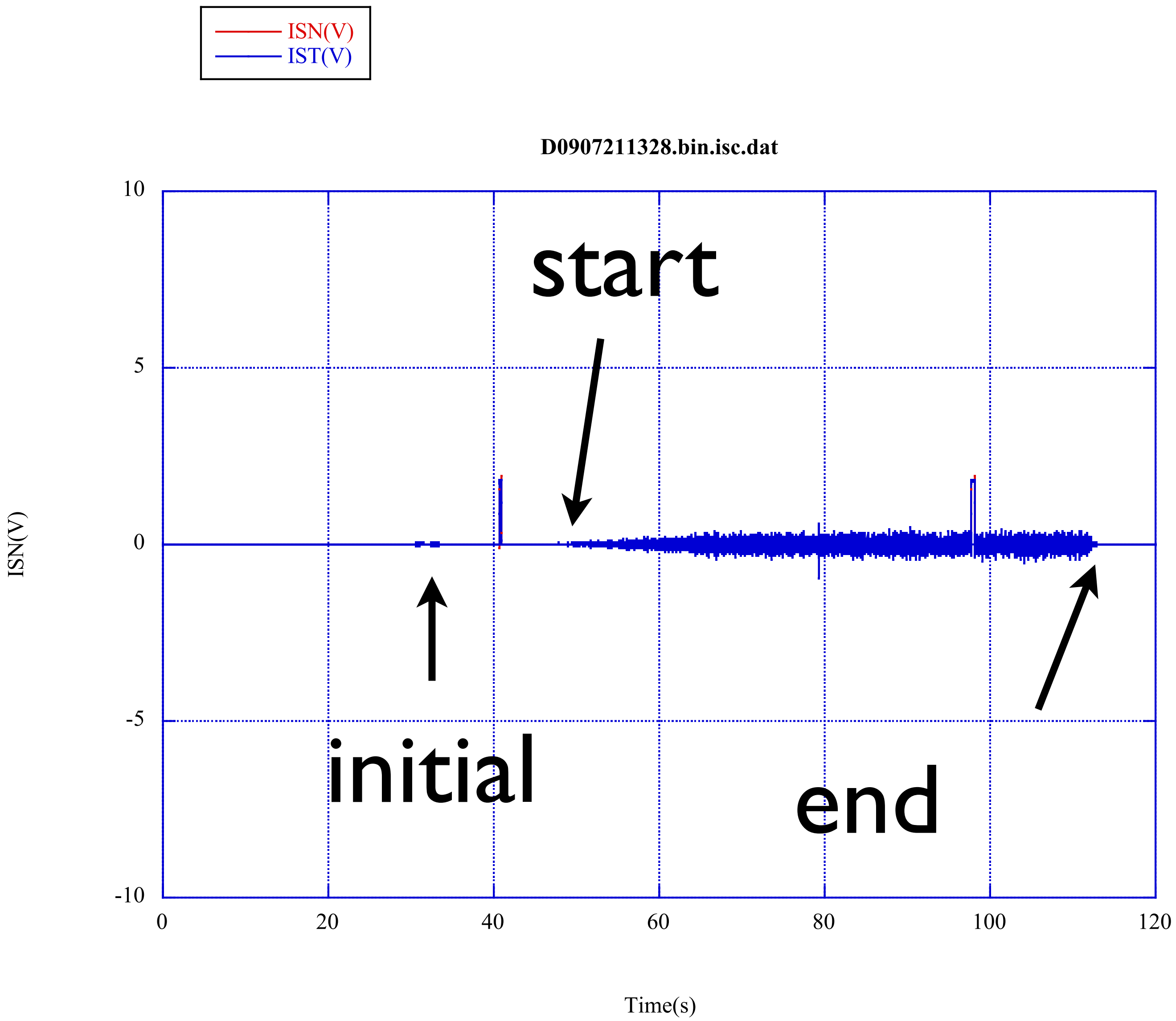
Removing G1, G2, G3, and C2 cables from ISN sensor

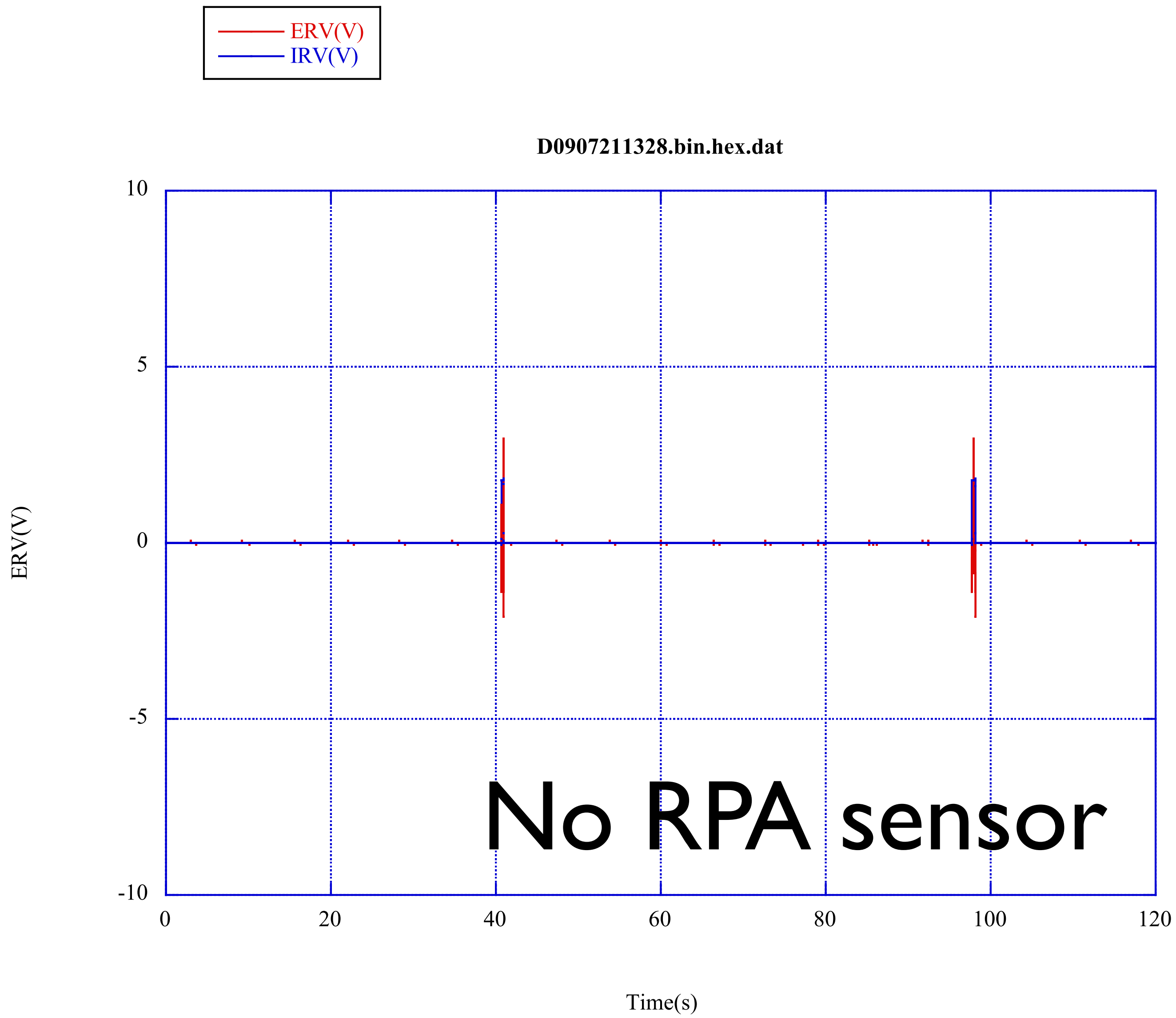




ISN and IST show fluctuation during the test

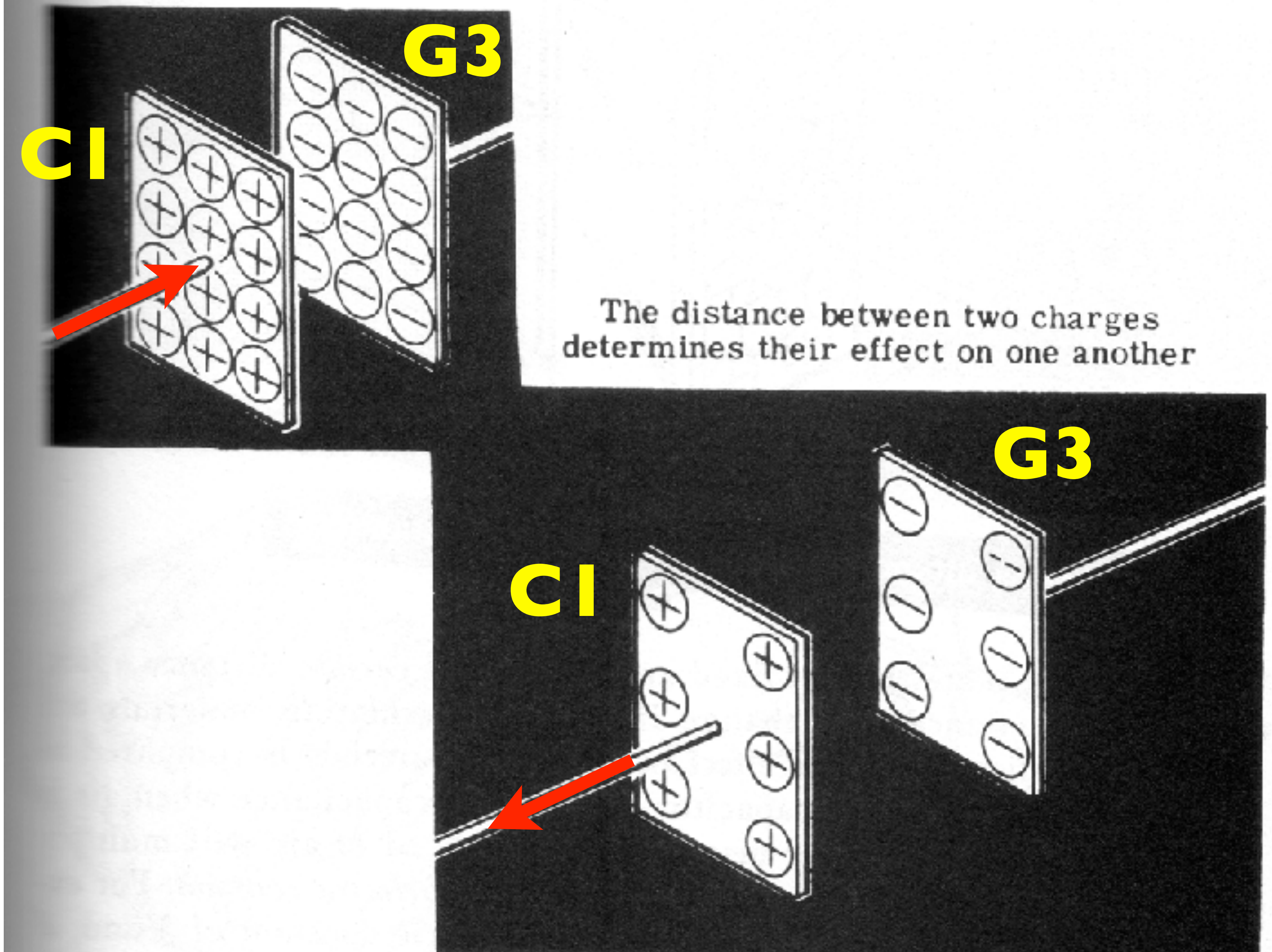
Removing all the cables from ISN sensor





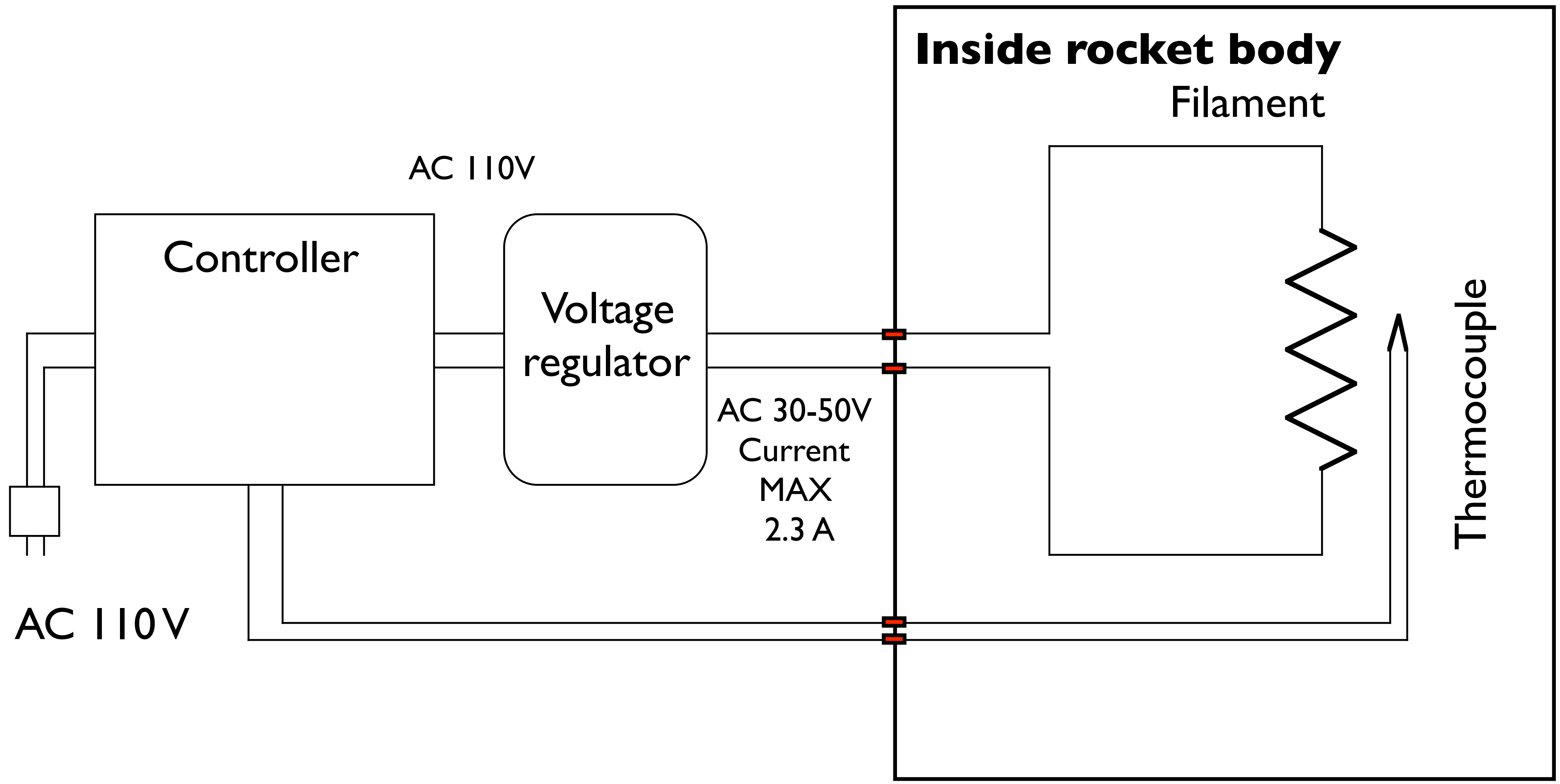
Only IST shows fluctuation during the test

INCREASING THE DISTANCE BETWEEN THE PLATES
DECREASES CAPACITANCE



The distance between two charges determines their effect on one another

DECREASING THE DISTANCE BETWEEN THE PLATES
INCREASES CAPACITANCE



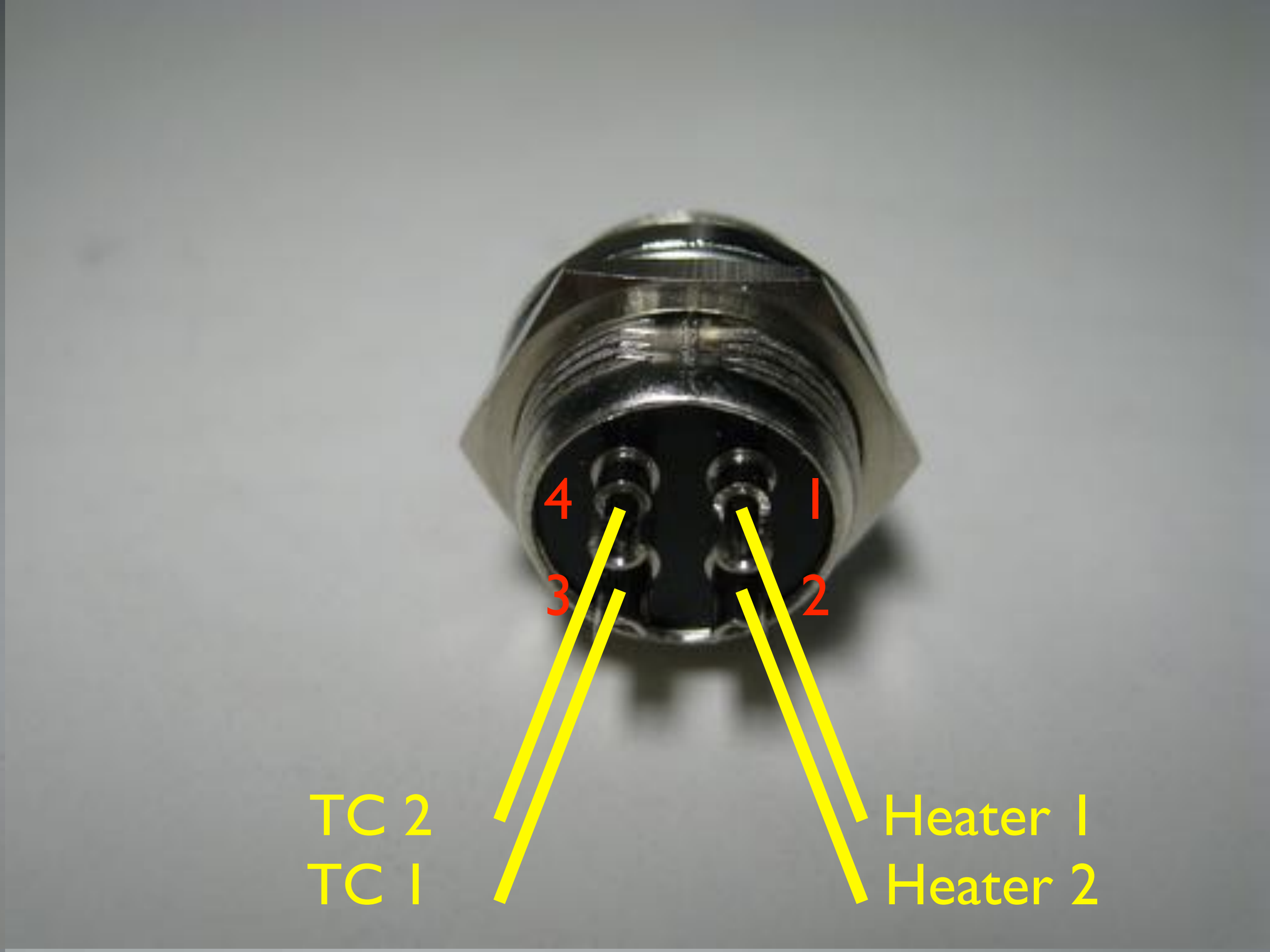
One feedthrough with 4 ports is required for heating device


500W

A feedthrough

- A feedthrough with 4 ports is required.
- The shell of the feedthrough will be connected with payload ground line.
- The feedthrough will be installed on the wall of rocket body and contact with conductive paint.


1
4
2
3


4
1
3
2
TC 2
TC 1
Heater 1
Heater 2


4
3
1
2


TC 2
TC 1
Heater 1
Heater 2

SOP for heating process

1. Installing filament and thermocouple around the **Langmuir probe** and the **retarding potential analyzer** only.
2. Connecting cables between the feedthroughs on the rocket body and filament / thermocouple.
3. Sealing the nose cone.
4. Filling in fresh N_2 gases.
5. Turning on heater controller and adjusting the voltage regulator to limit the temperature up to **110 °C** for **60 to 90 minutes**.
6. Turning off the voltage regulator and heater controller.
7. **Keeping dry N_2 gases flow continuously**.
8. Sensors can only be exposed in the air less than **24 hours**.

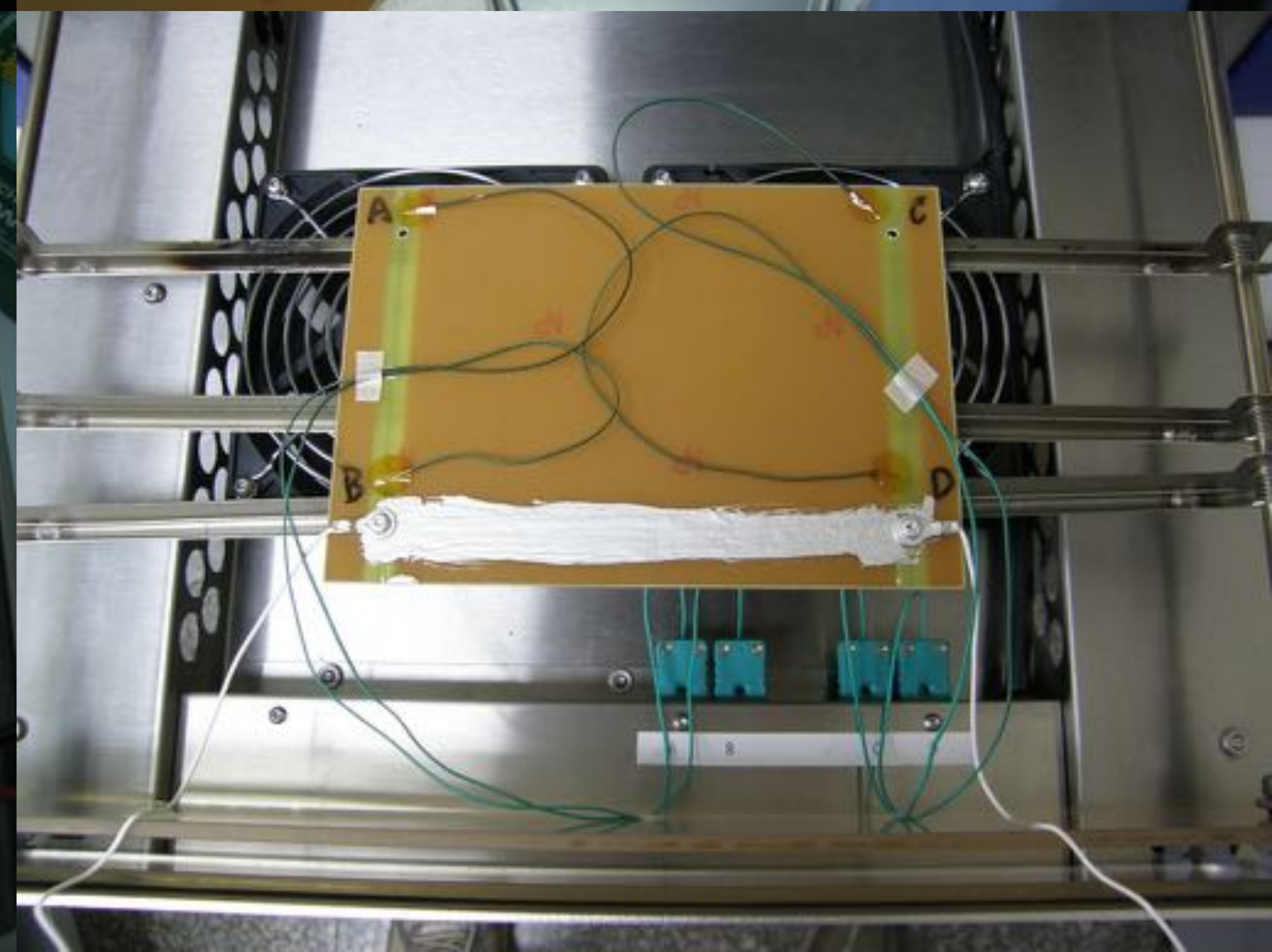
Conductive paint

- Electrically conductive materials: FUJIKURA KASEI DOTITE D-500
- Filter: Ag
- Binder Acrylic
- Volume resistivity: $8 \times 10^{-5}\ \Omega \cdot cm$
- Specific gravity: 2.5
- Flash point: 4℃

Conductive paint (cont.)

- Curing schedule: 25℃ x 3 hrs or 100℃ x 30 min
- Storage condition: room temperature
- Thinner: S・SP-2
- Applicable by brushing simply or air spraying


ELECTROCONDUCTIVES
DOTITE
TYPE D-500
NET 500g
Lot No. 08J2017
09年05月20日
EXPIRY DATE 20 May.2009
514620100500


7.770

A
C
B
D

Painting area

- The ratio of reference area to the collector should be larger than the ratio of electronic saturation current to ionic saturation current

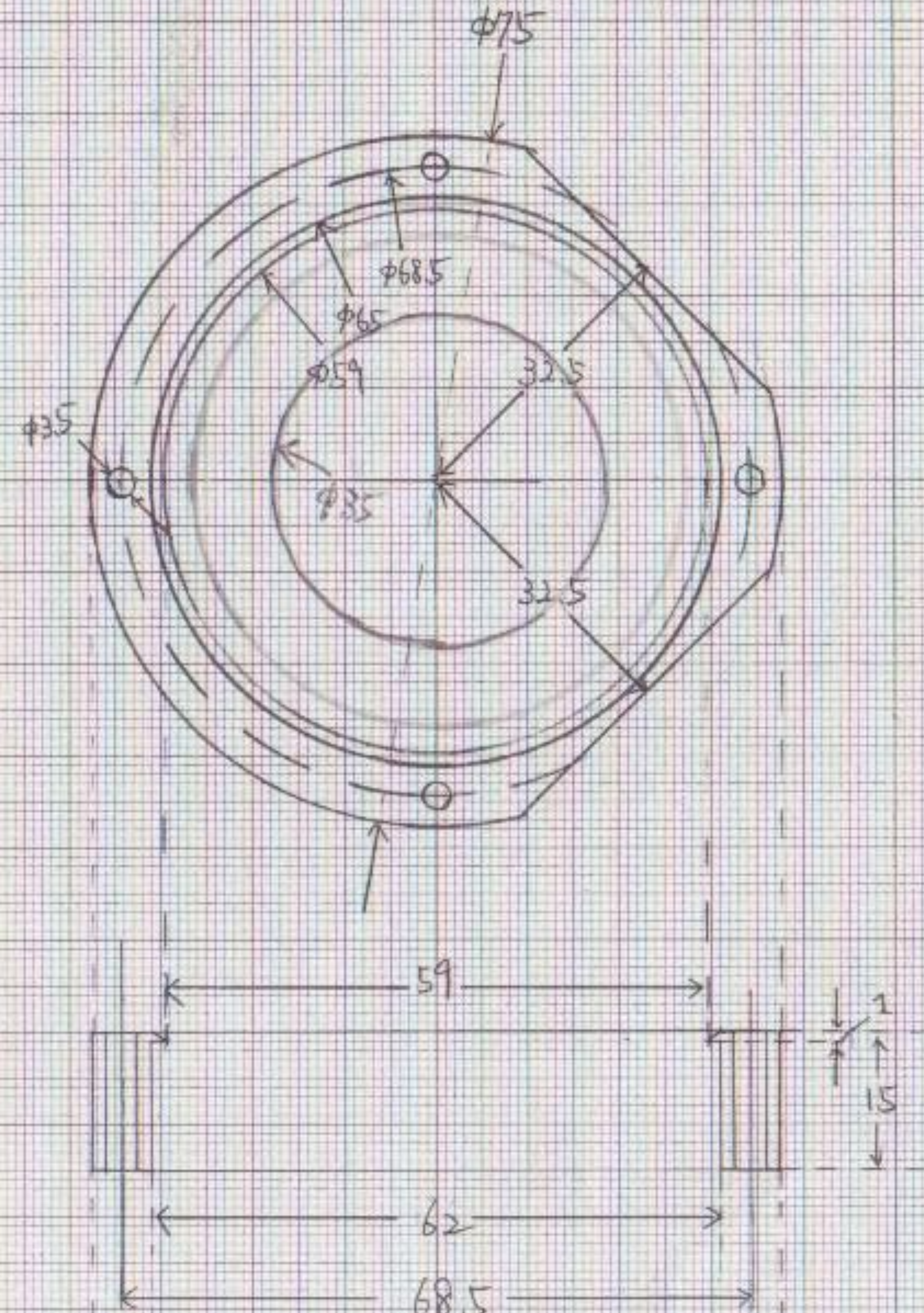
$$A > A_c\sqrt{\frac{M_i}{m_e}} = \pi\left(\frac{5.9 \text{ or } 3.5 \text{ cm}}{2}\right)^2 \sqrt{1837\times 30} \sim 6{,}418 \text{ or } 2{,}259 \text{ cm}^2$$

$$L > \frac{6{,}418 \text{ or } 2{,}259 \text{ cm}^2}{\pi\times 40 \text{ cm}} \sim 51 \text{ or } 18 \text{ cm}$$

- The thickness of the paint on the rocket body is

$$D \sim \frac{\dfrac{500 \text{ g}}{2.5 \text{ g}\cdot\text{cm}^{-3}}}{\pi\times 40 \text{ cm}\times(51 \text{ or } 18 \text{ cm})} \sim 0.3 \text{ or } 0.9 \text{ mm}$$

ステン



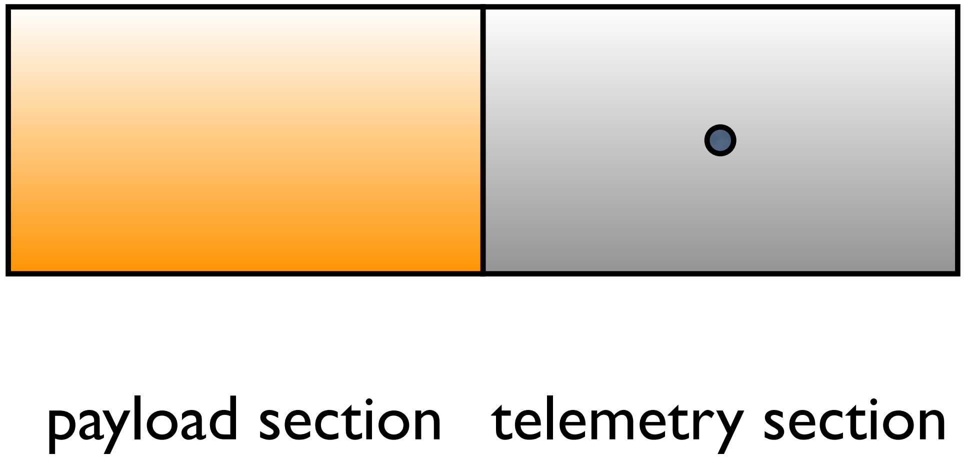
Estimations

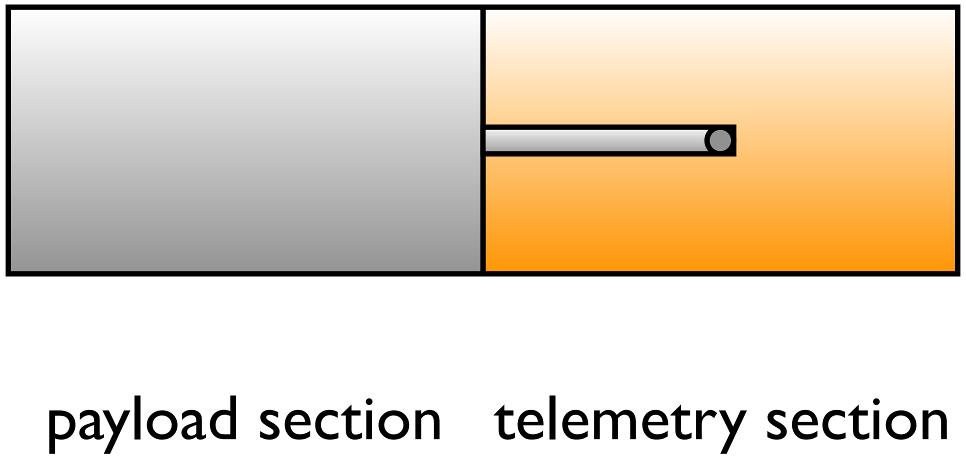
- Test results
  - The resistance reduced as the temperature going up.
  - As the temperature going for more than 100℃, the conducting paint will have very low resistivity.
  - After cool down, the resistivity is the lowest.
- Painting area:
  - Should be larger than 6,418 cm^2 or **51 cm** long on rocket body.
  - Thickness of the paint on the rocket body is **0.3 mm**.

SOP for conductive paint

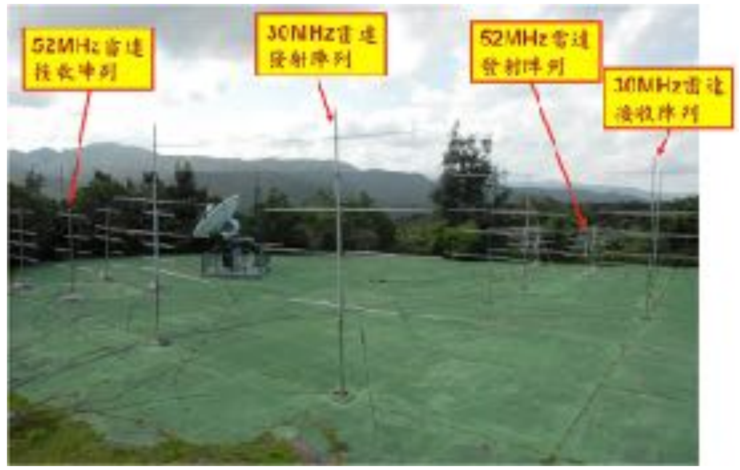
1. Cleaning up the surface for paint.
2. Air spraying 500 g of the conductive paint with **50 cm long and 0.3 mm thickness** around the rocket body.
3. Waiting for **3 hours** to cure the coating under room temperature.
4. Testing the conduction between the payload and the conductive paint.

Possible paintings

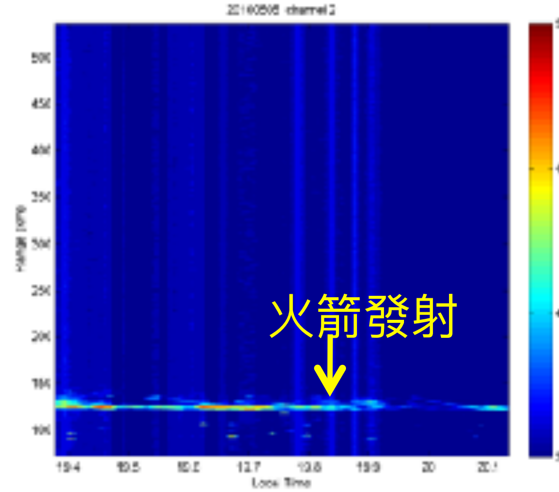




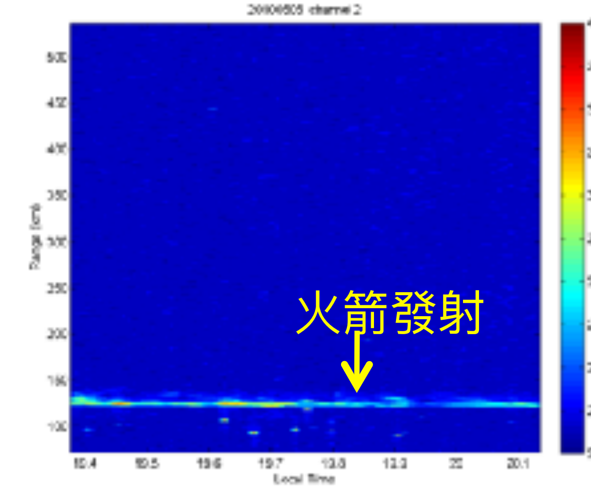
九鵬基地
雷達陣列

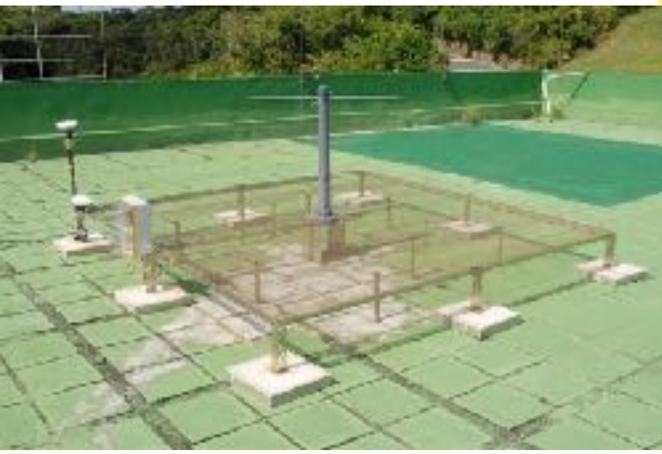


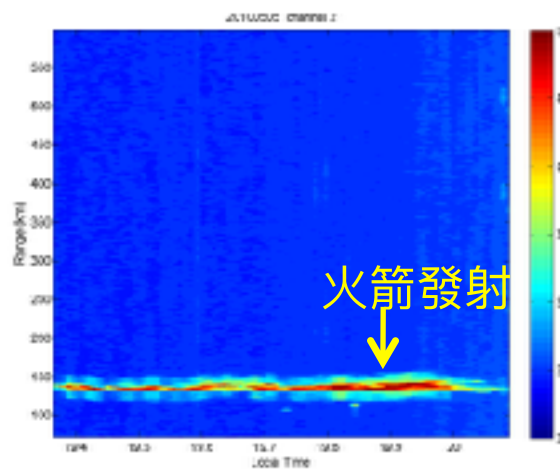
九鵬30 MHz雷達



九鵬52 MHz雷達



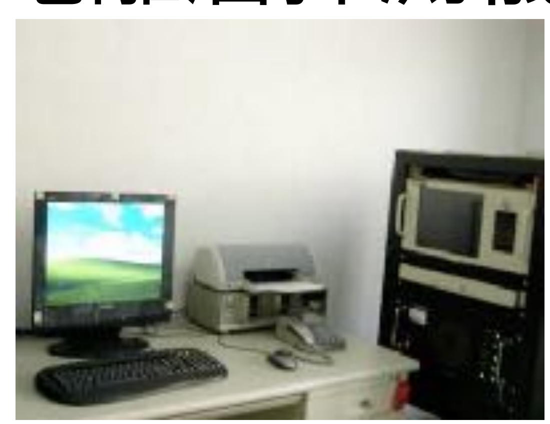


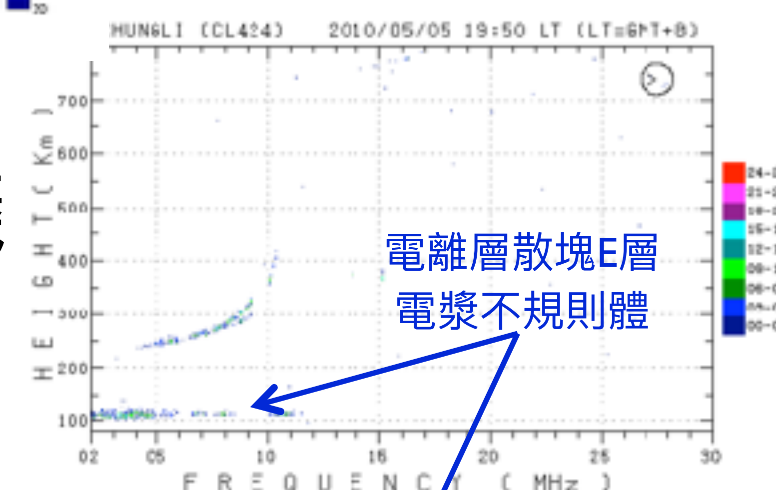


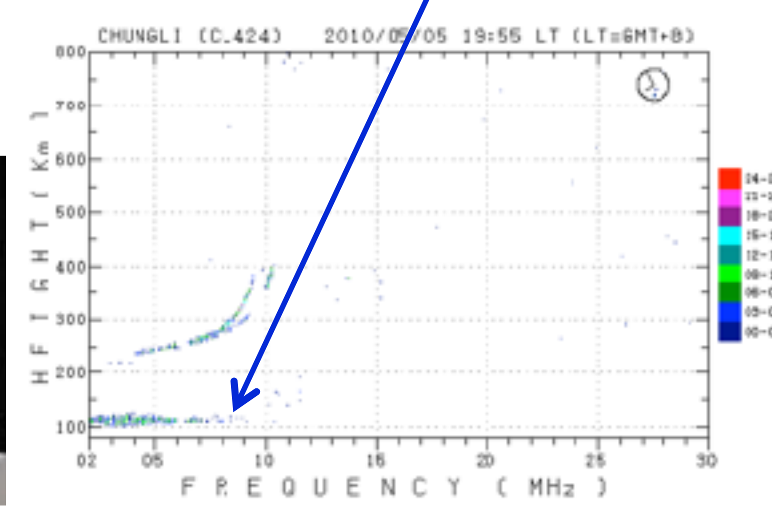
中央大學
52 MHz雷達

中大校園
雷達陣列

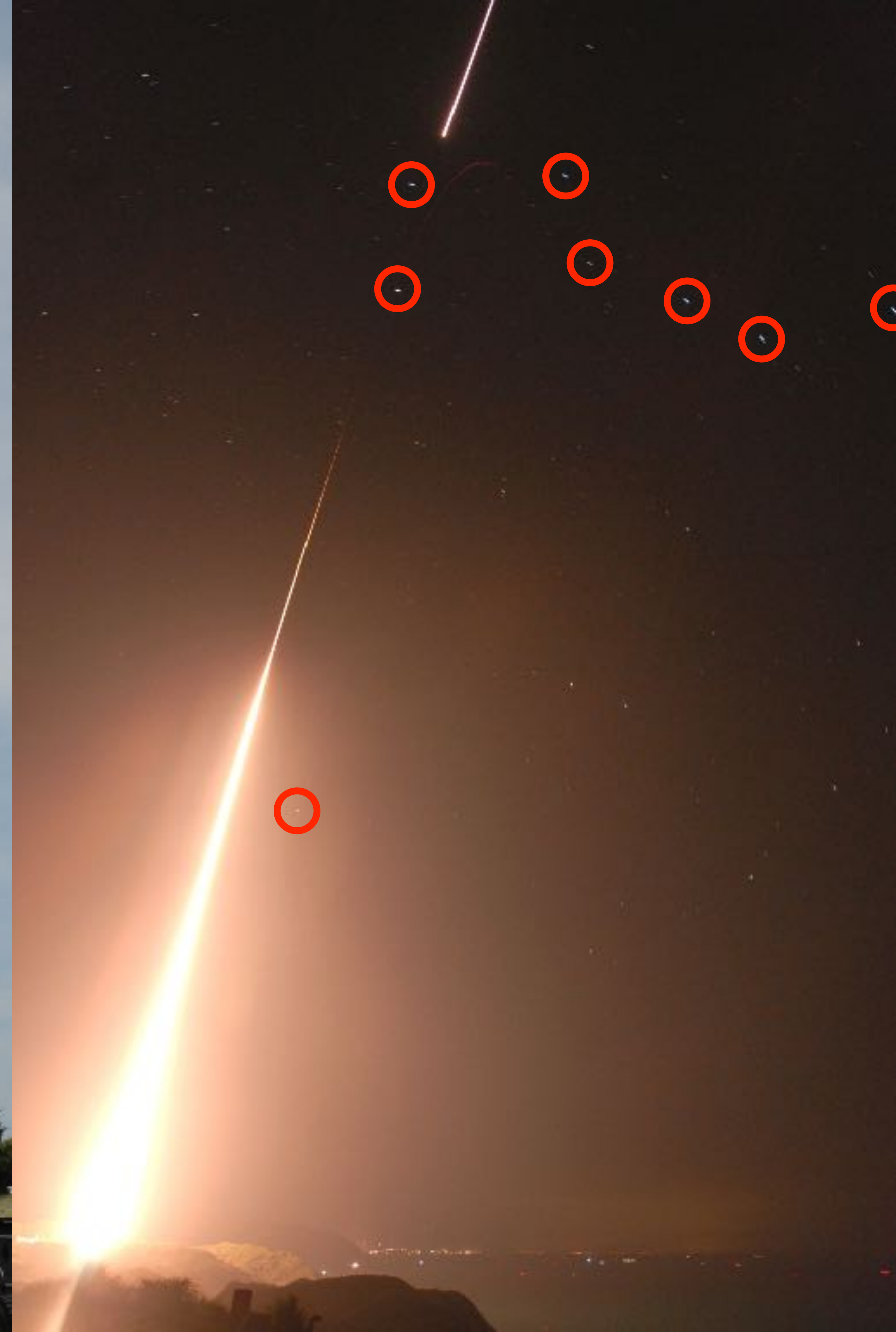
NCC
電離層探測儀







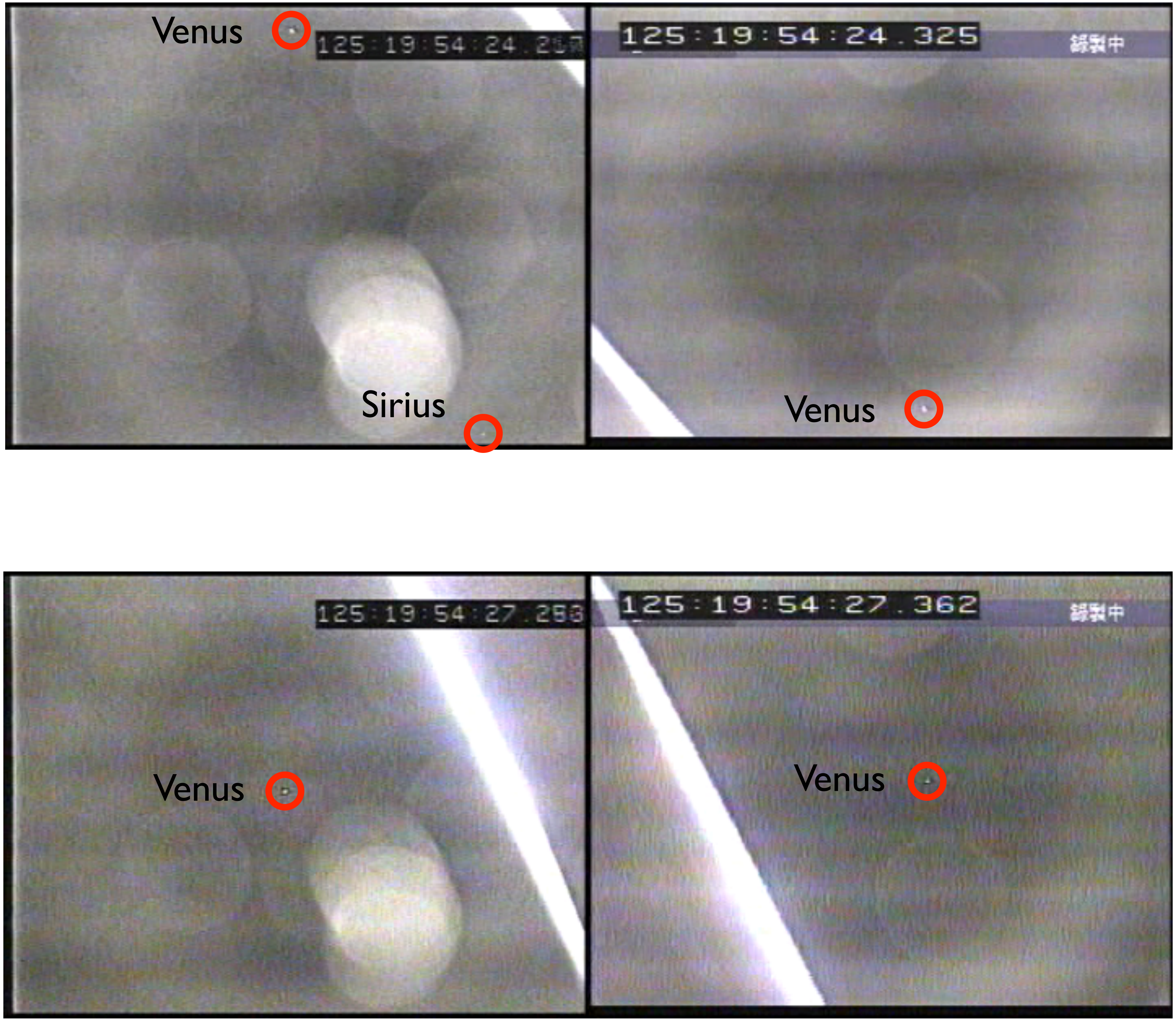

探空七號火箭



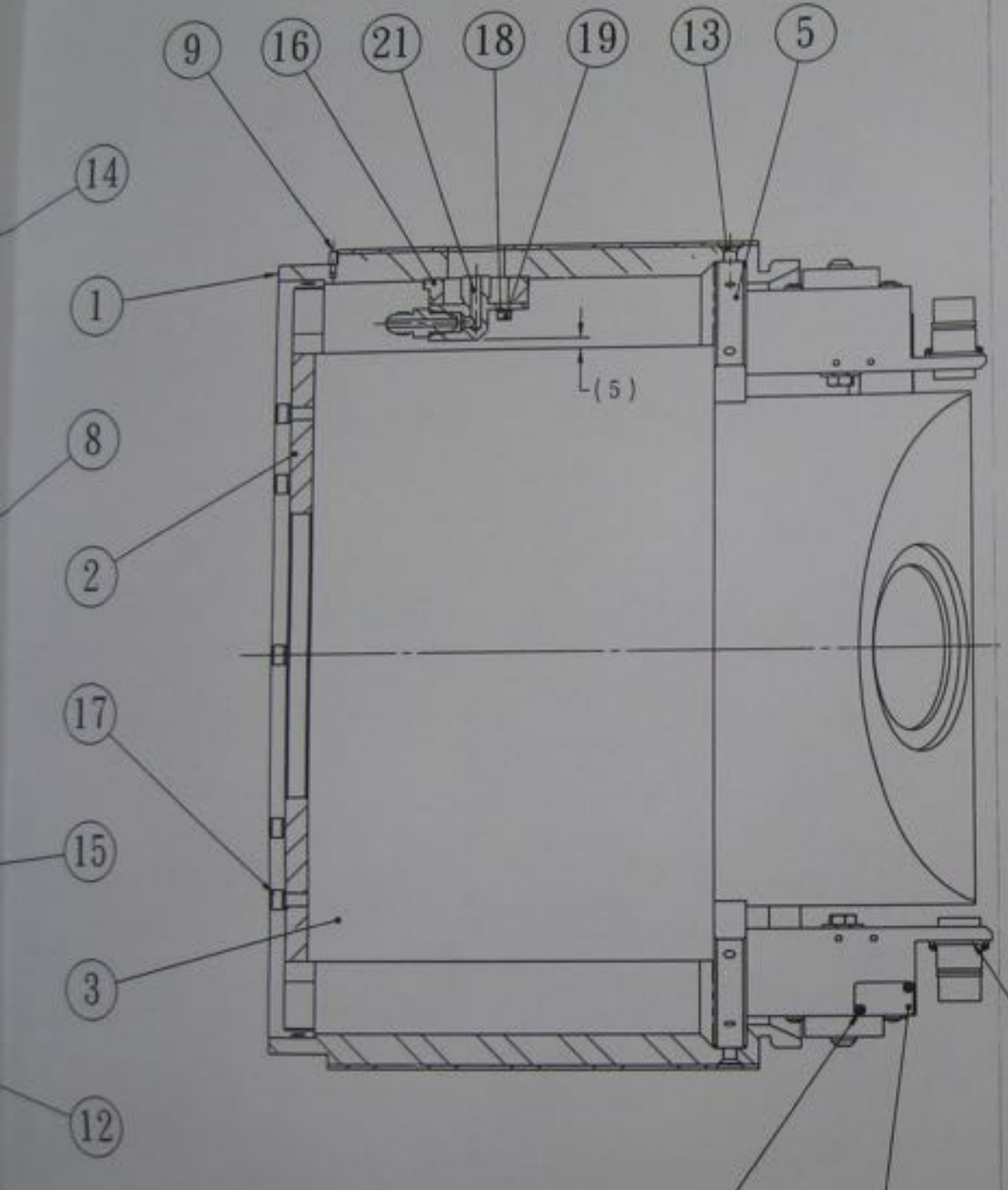

125:19:50:05.2


19:50:09.0
RG 0000000.00
AZ 119°10'
EL +062°58'

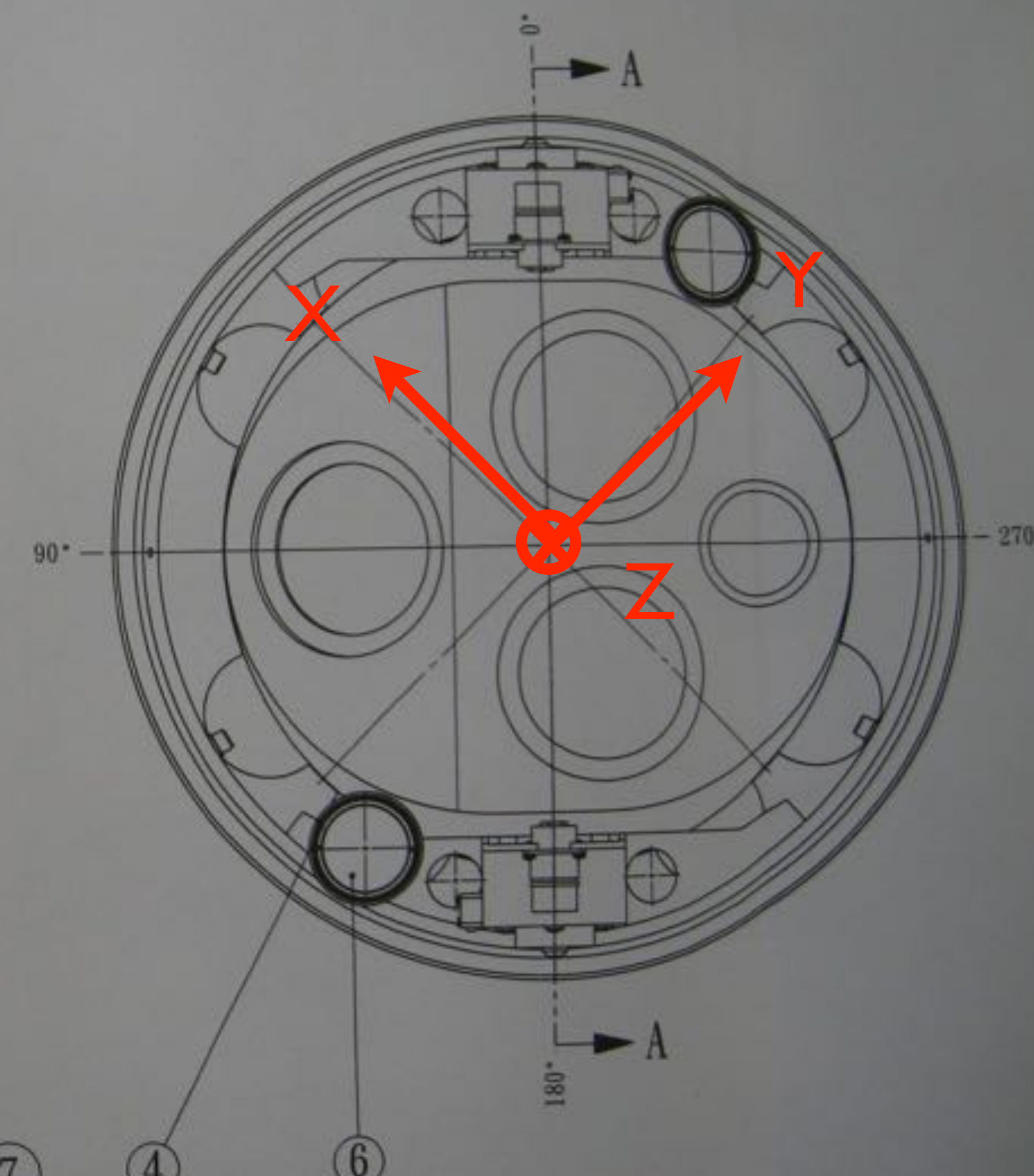

125:19:49:44.900
SP
0:02:39



Venus
Sirius
125:19:54:24.325
Venus
Venus
125:19:54:27.362
Venus



剖面視圖A-A

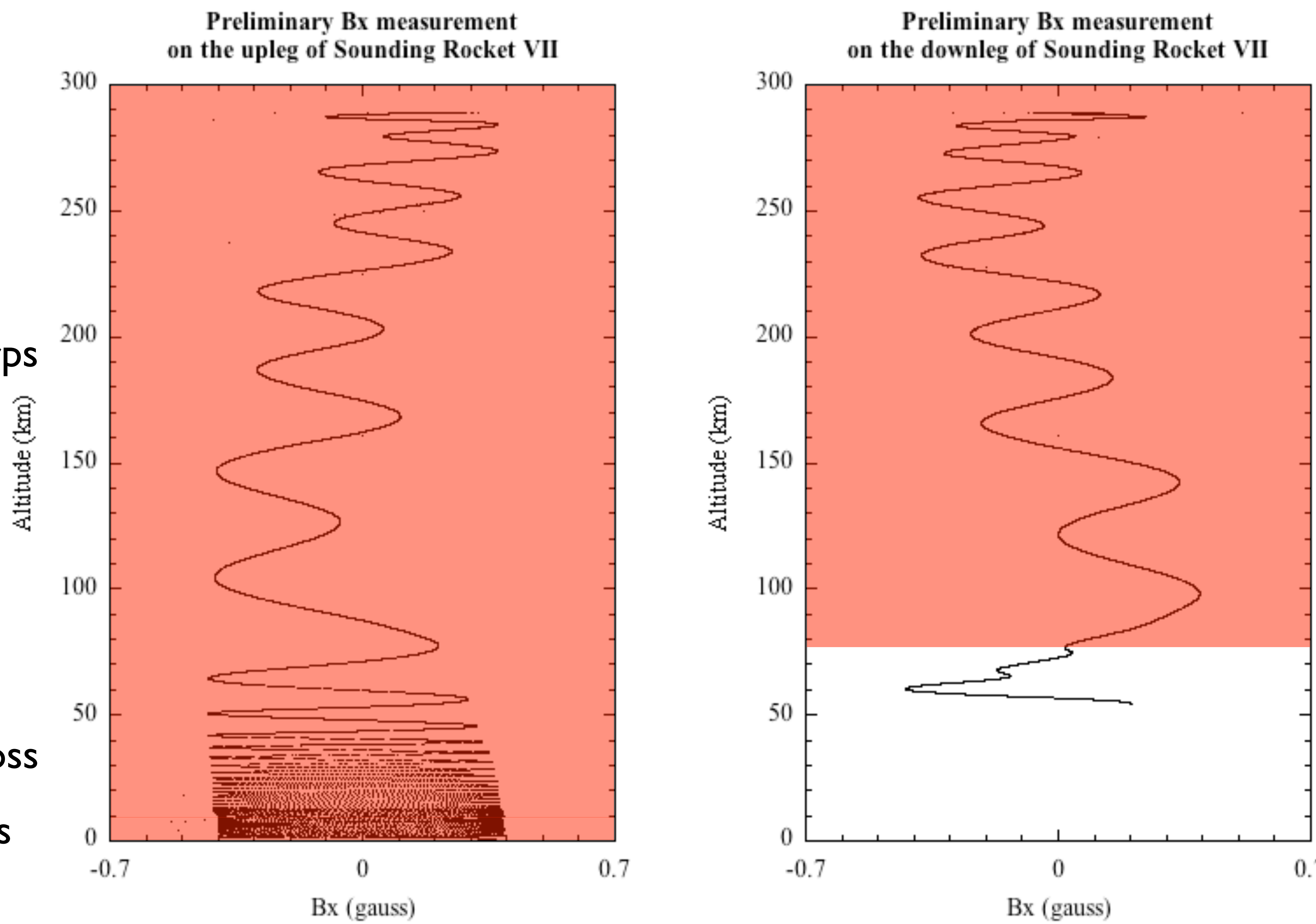


B_x

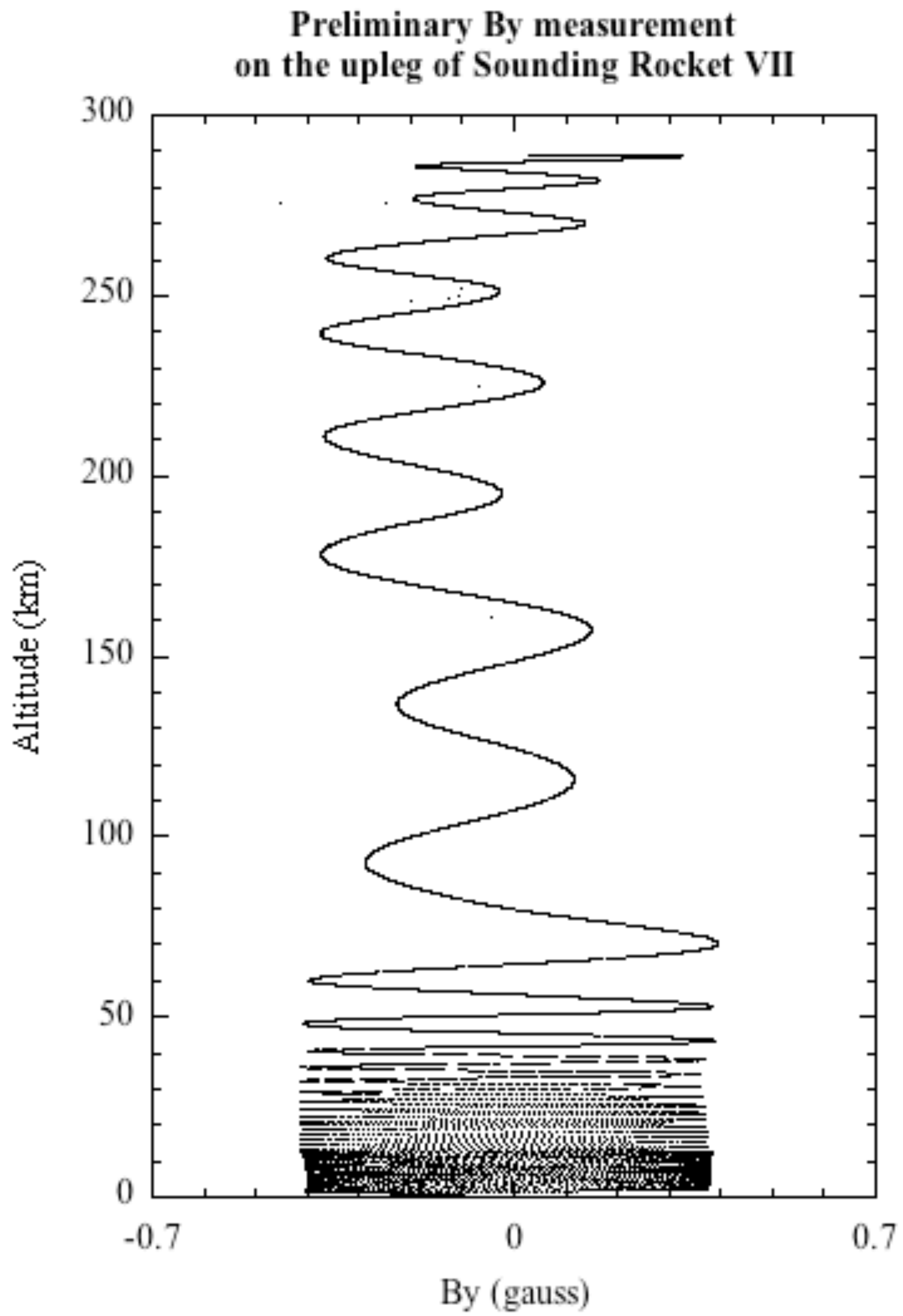
0.04 rps

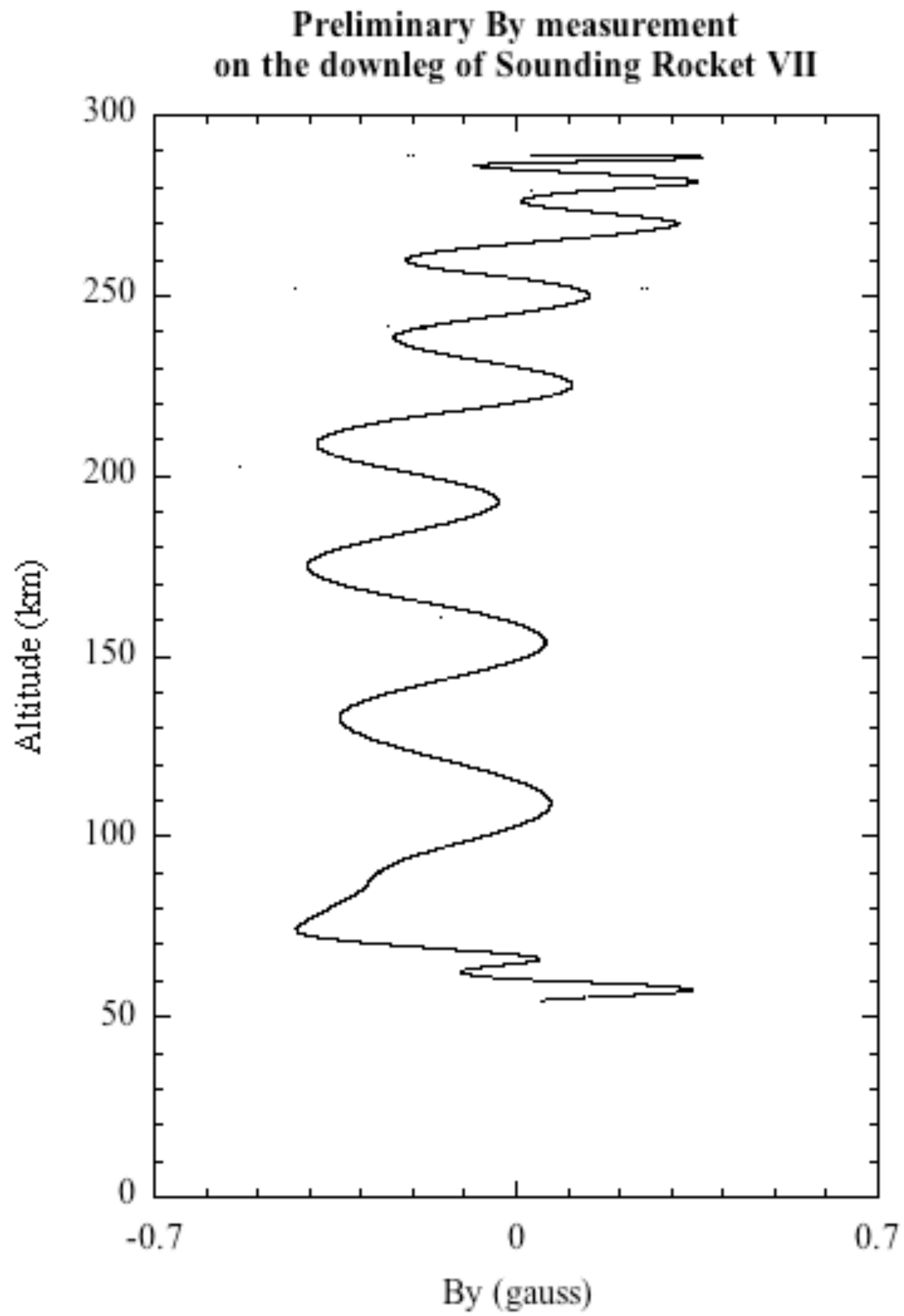
Spin loss

3 rps



B$_y$


Preliminary By measurement
on the upleg of Sounding Rocket VII
Altitude (km)
By (gauss)
300
250
200
150
100
50
0
-0.7
0
0.7

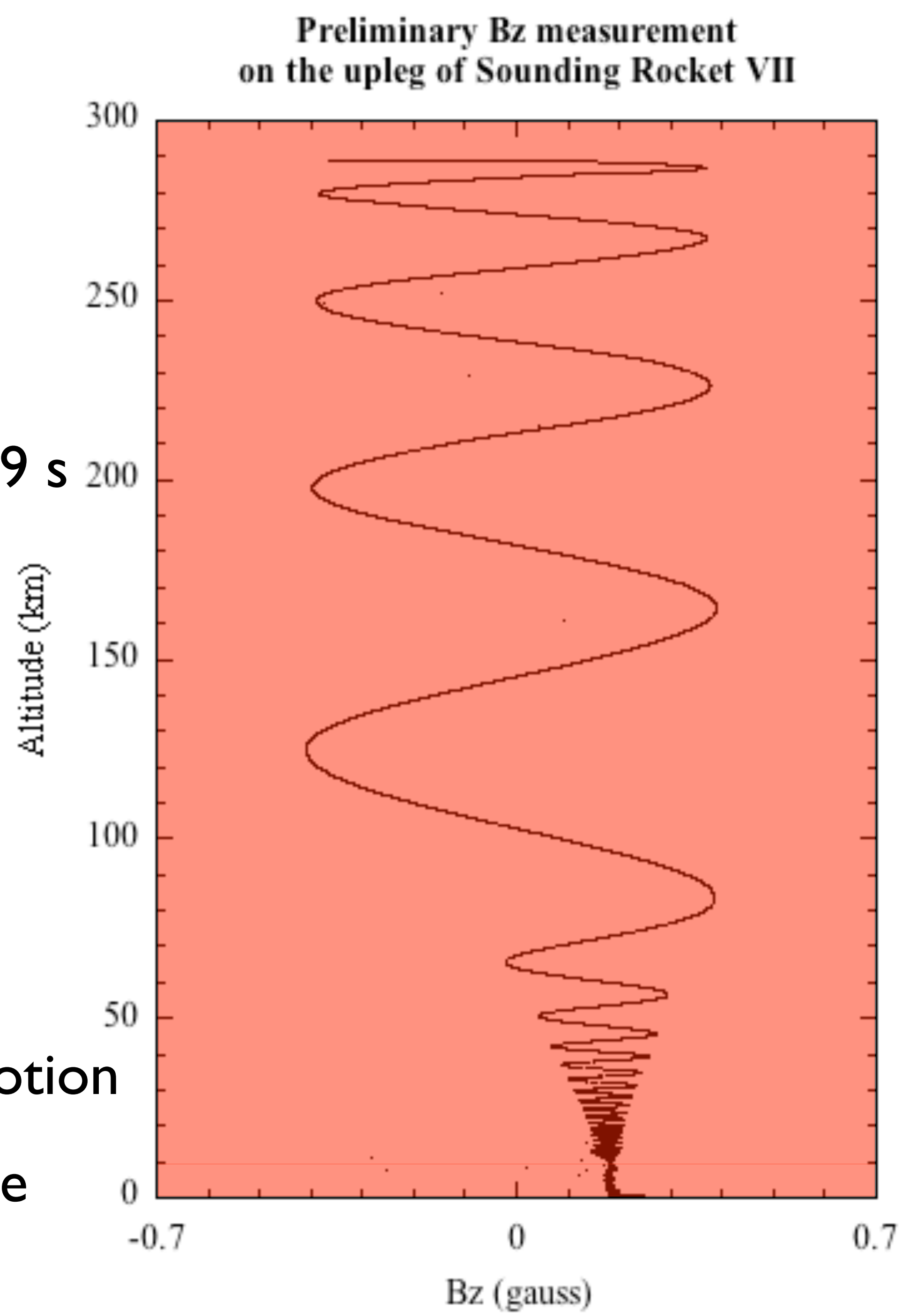

Preliminary By measurement
on the downleg of Sounding Rocket VII
Altitude (km)
By (gauss)
300
250
200
150
100
50
0
-0.7
0
0.7

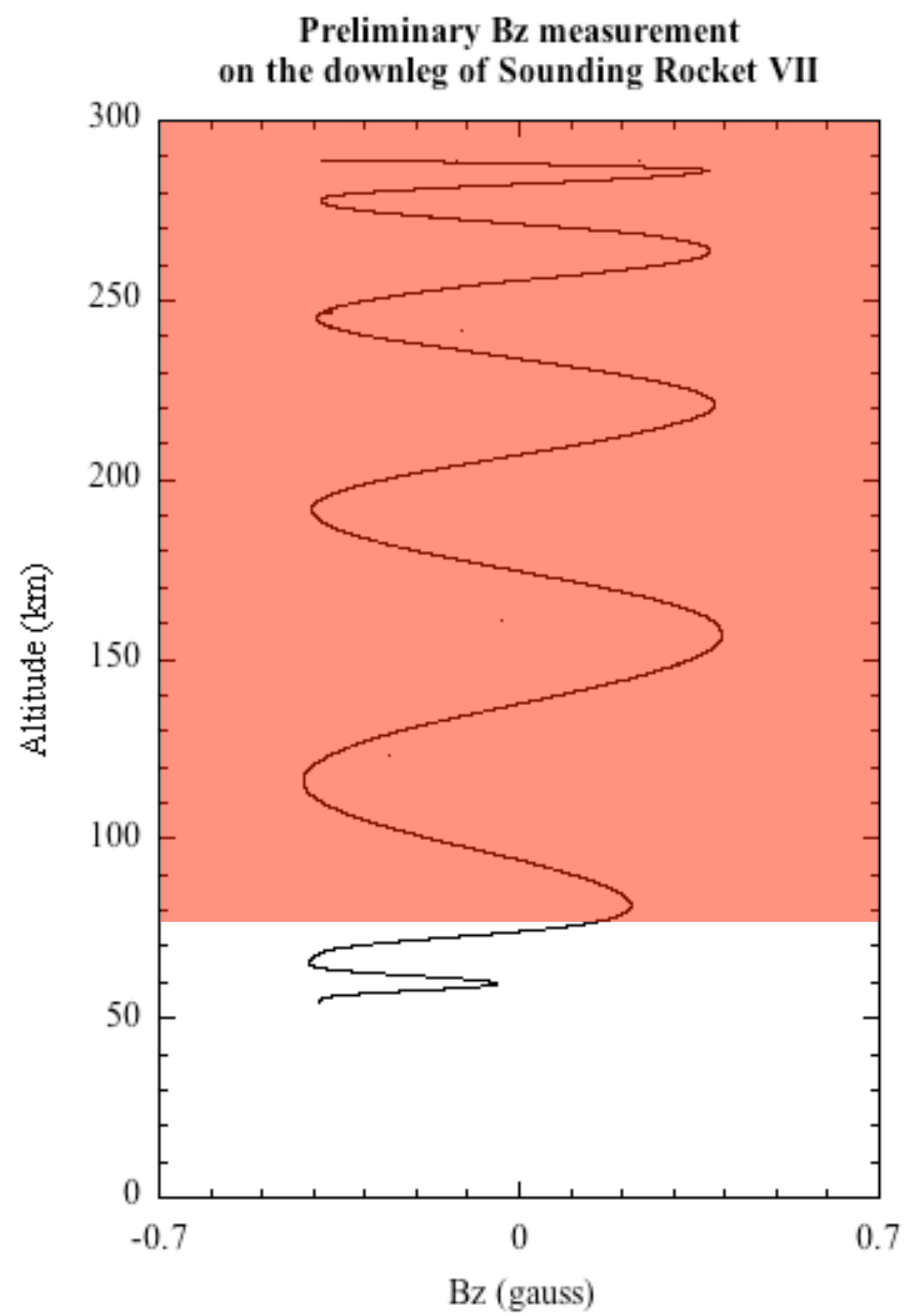
B_z

~90° and 49 s period

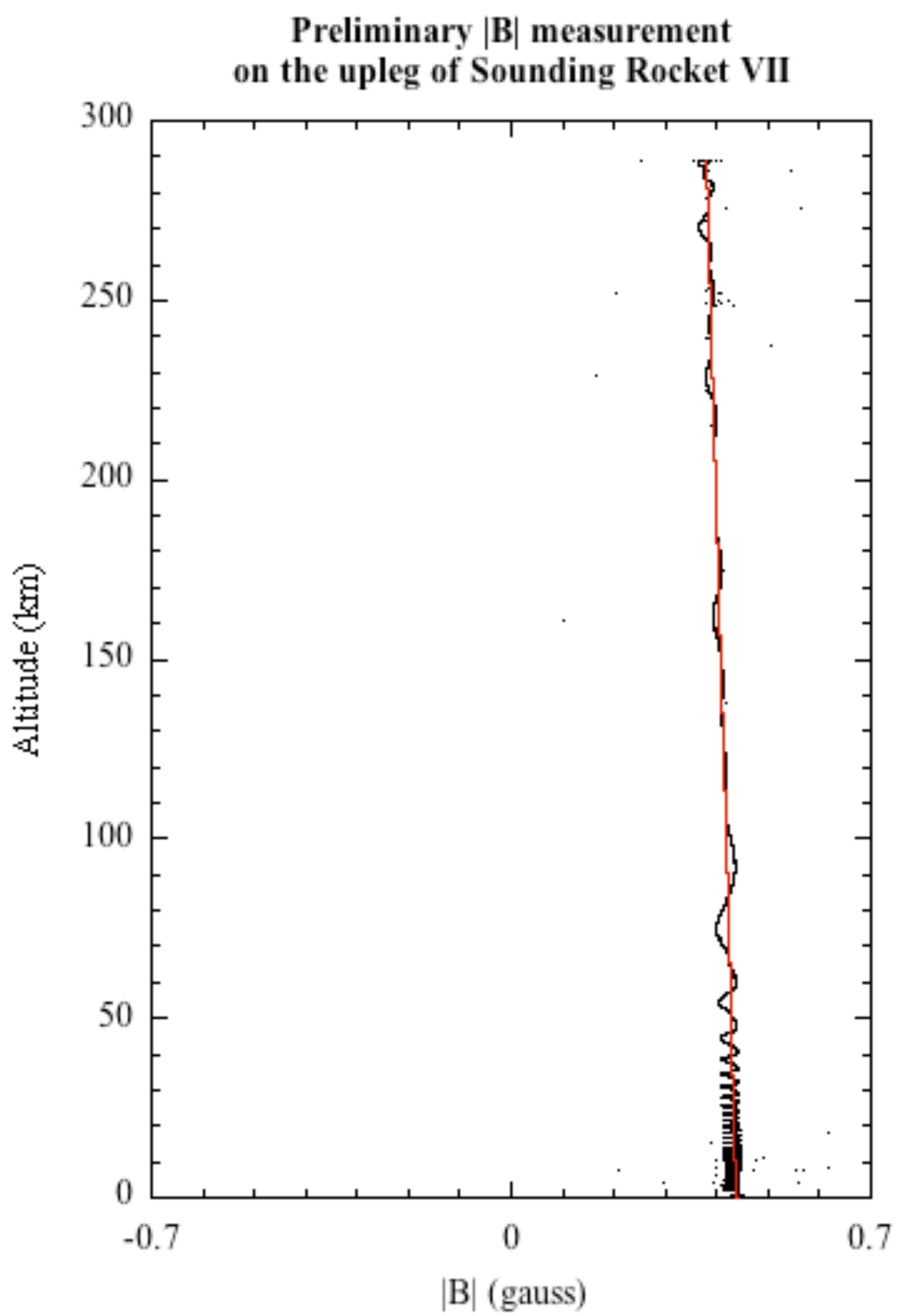
Coning motion

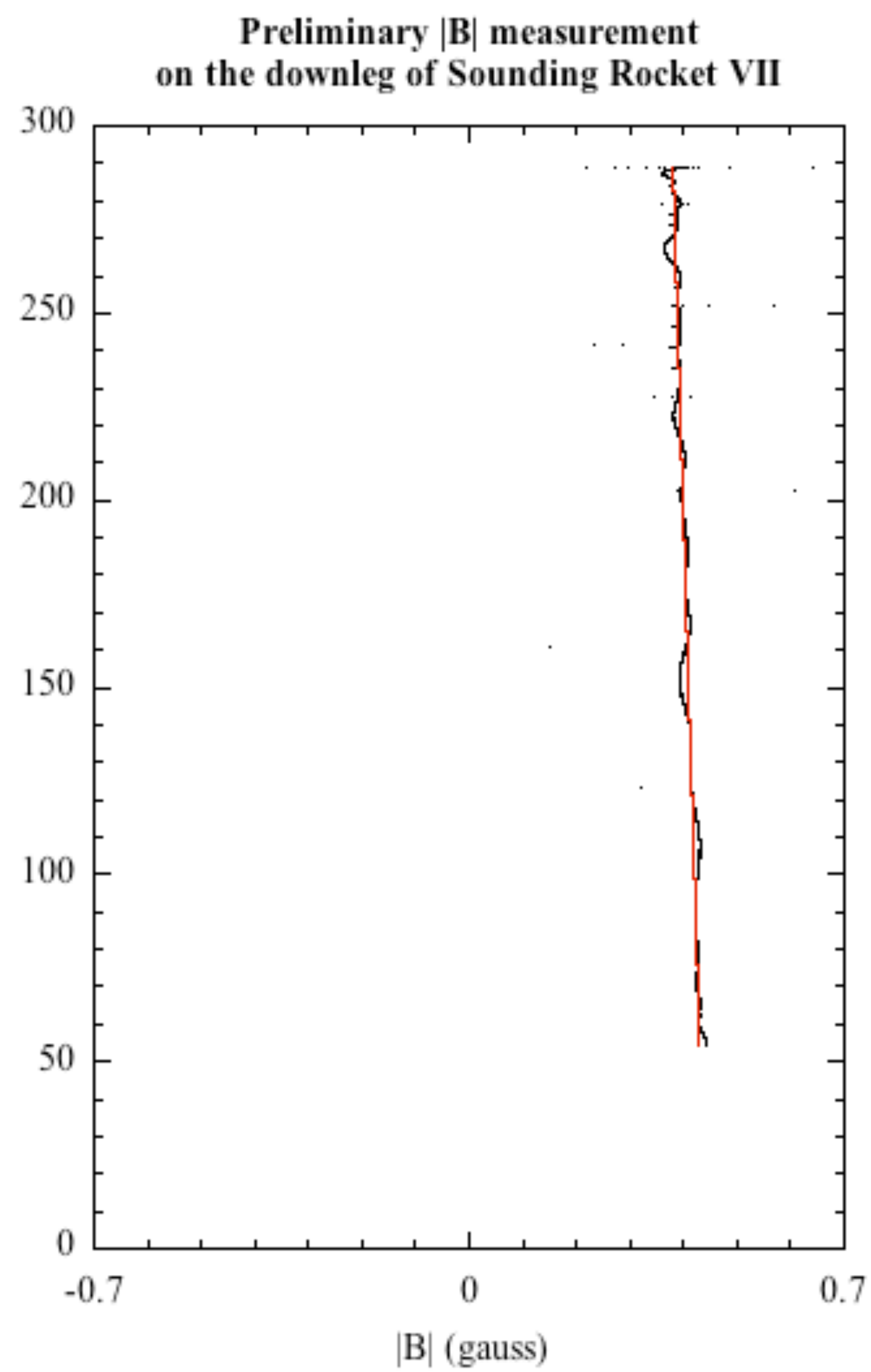
Stable



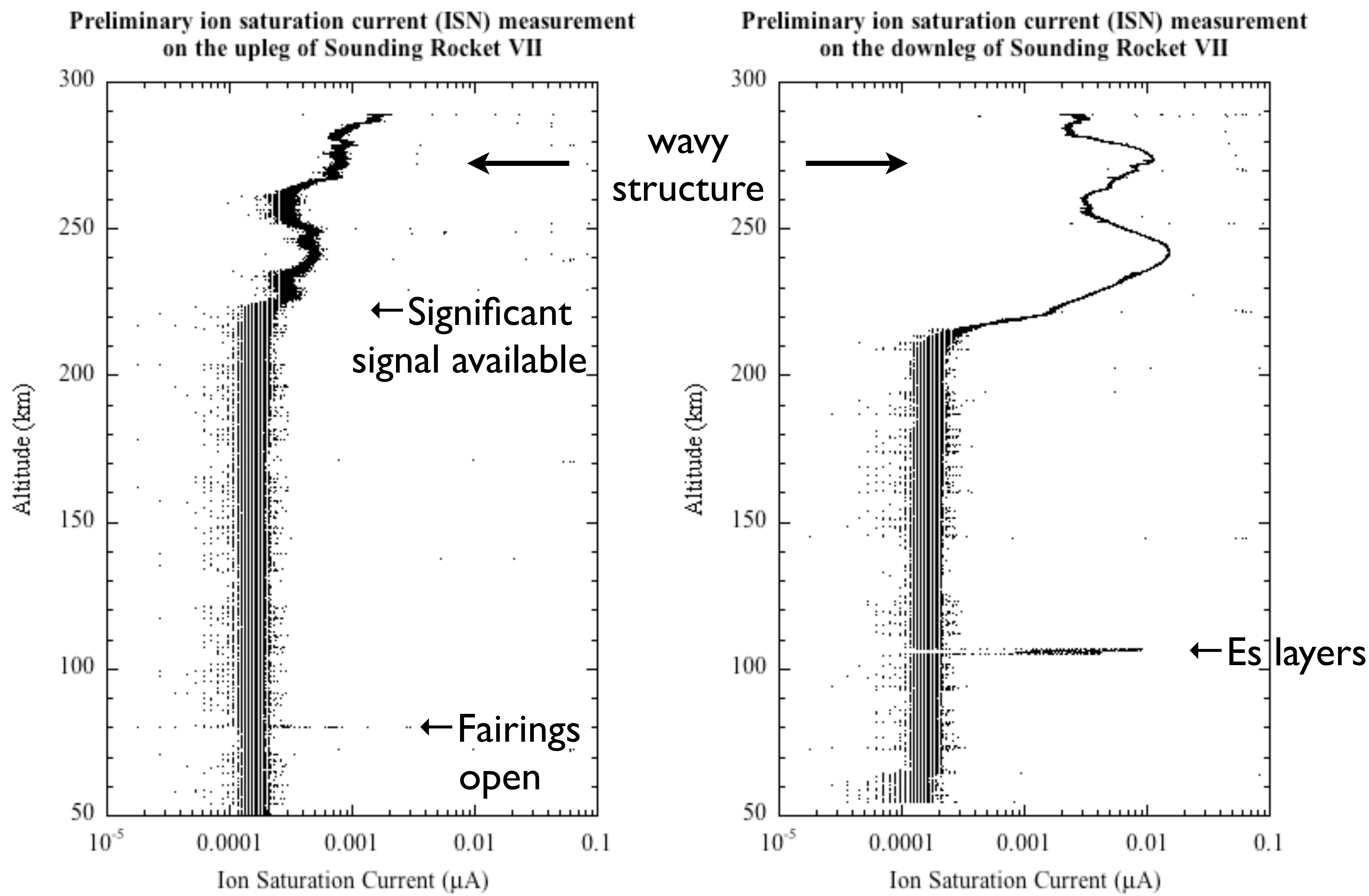


|B|

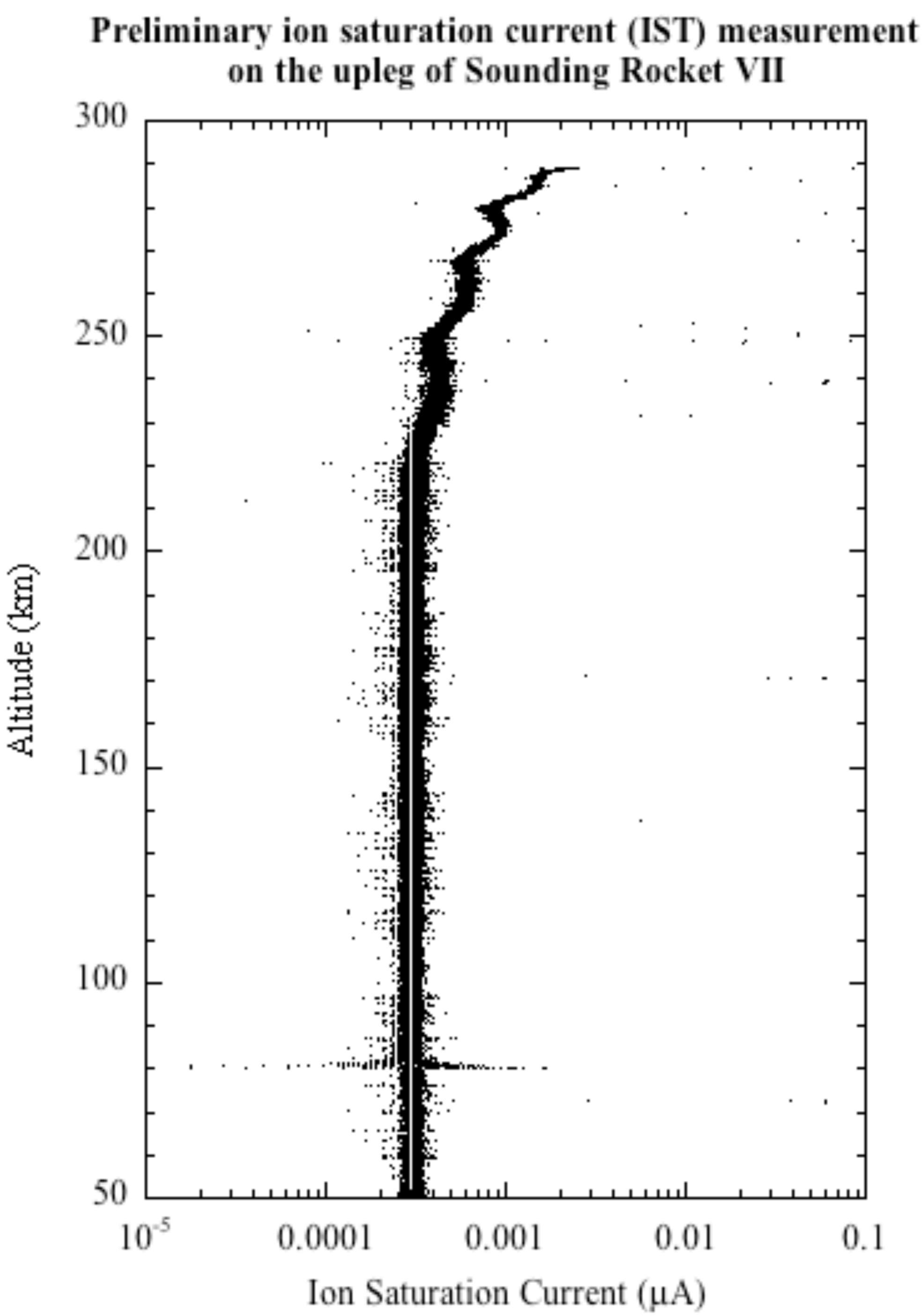

Preliminary |B| measurement
on the upleg of Sounding Rocket VII
Altitude (km)
300
250
200
150
100
50
0
-0.7
0
0.7
|B| (gauss)

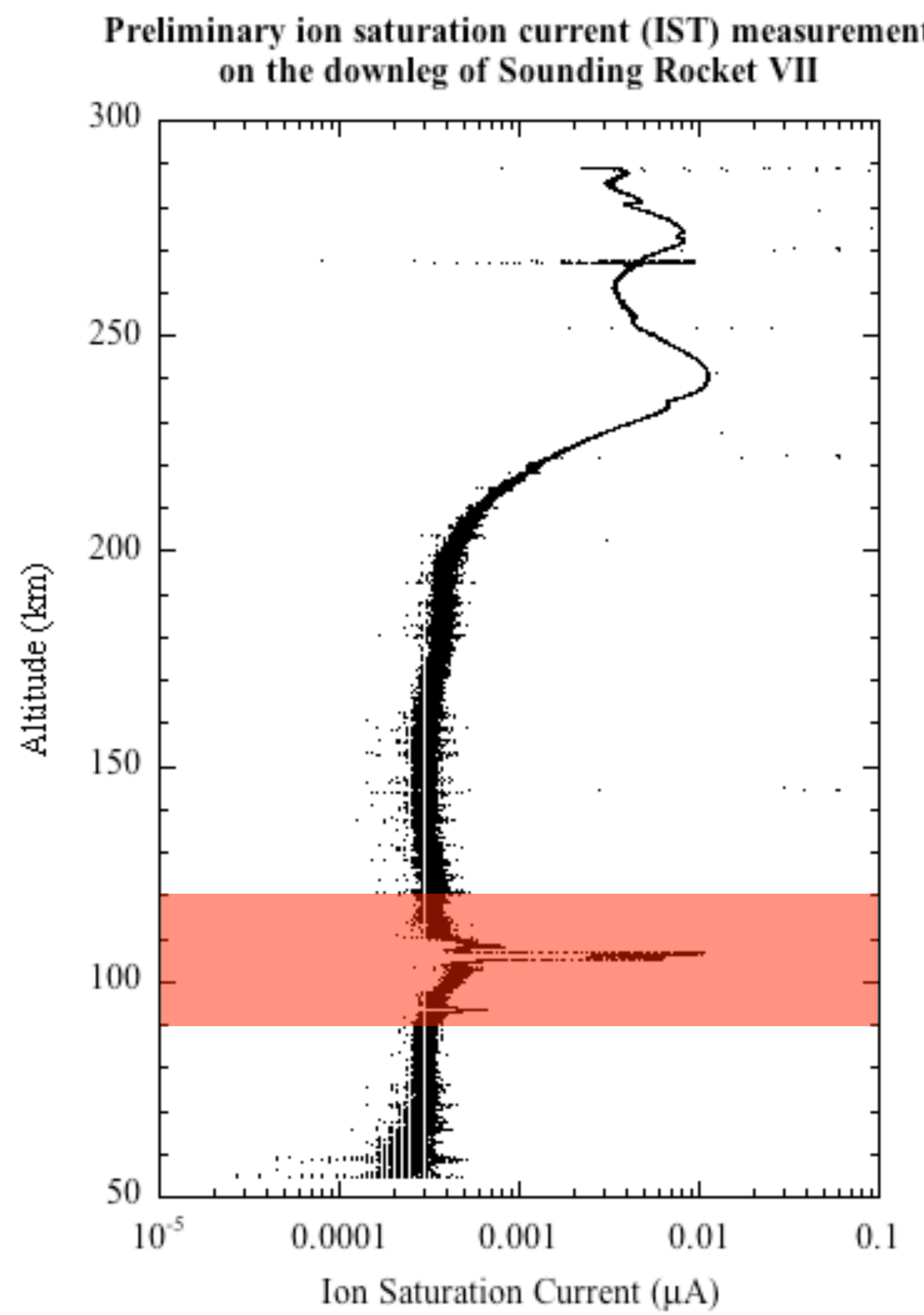

Preliminary |B| measurement
on the downleg of Sounding Rocket VII
300
250
200
150
100
50
0
-0.7
0
0.7
|B| (gauss)

正向離子捕獲計之電流讀數

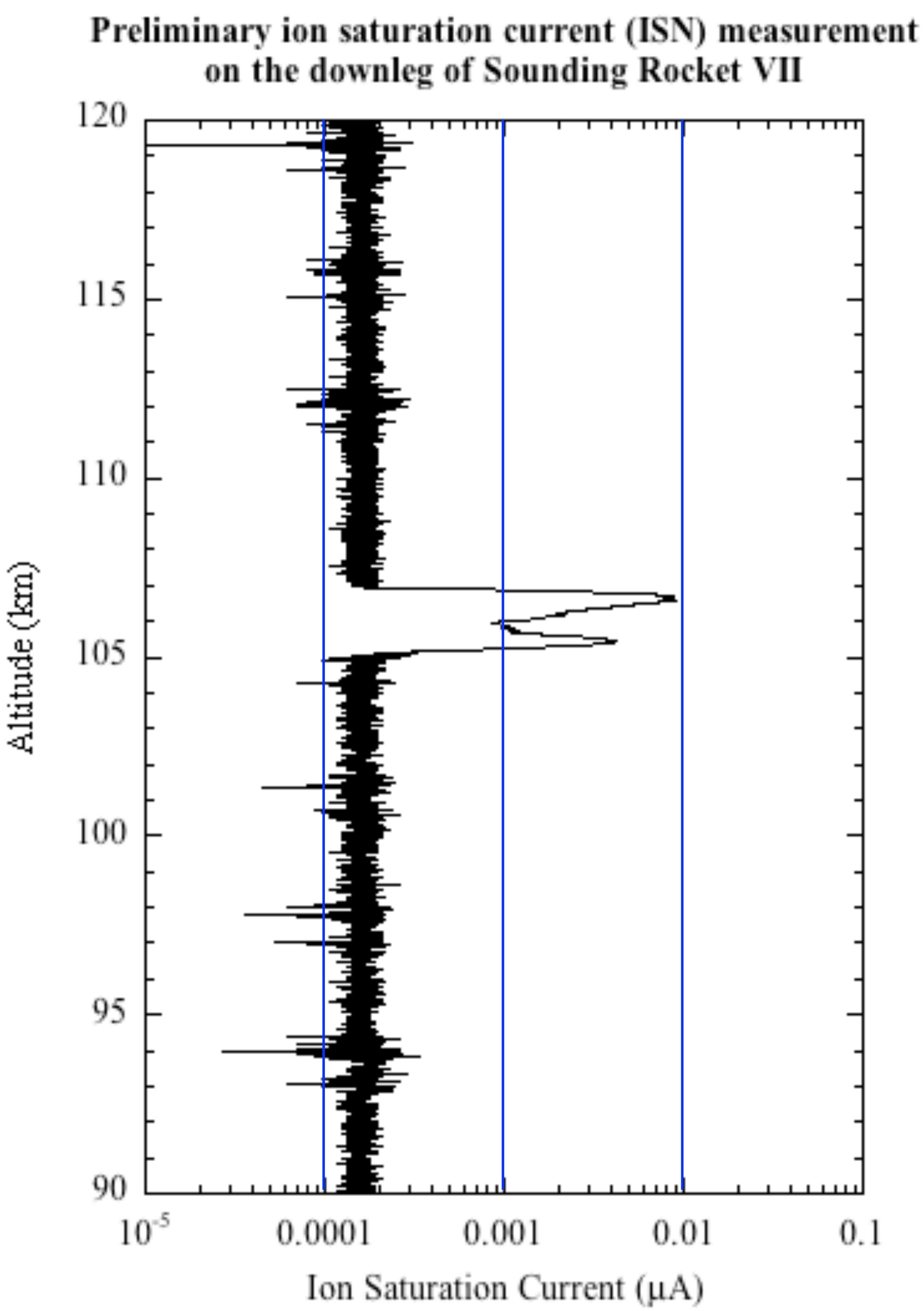


斜向離子捕獲計之電流讀數

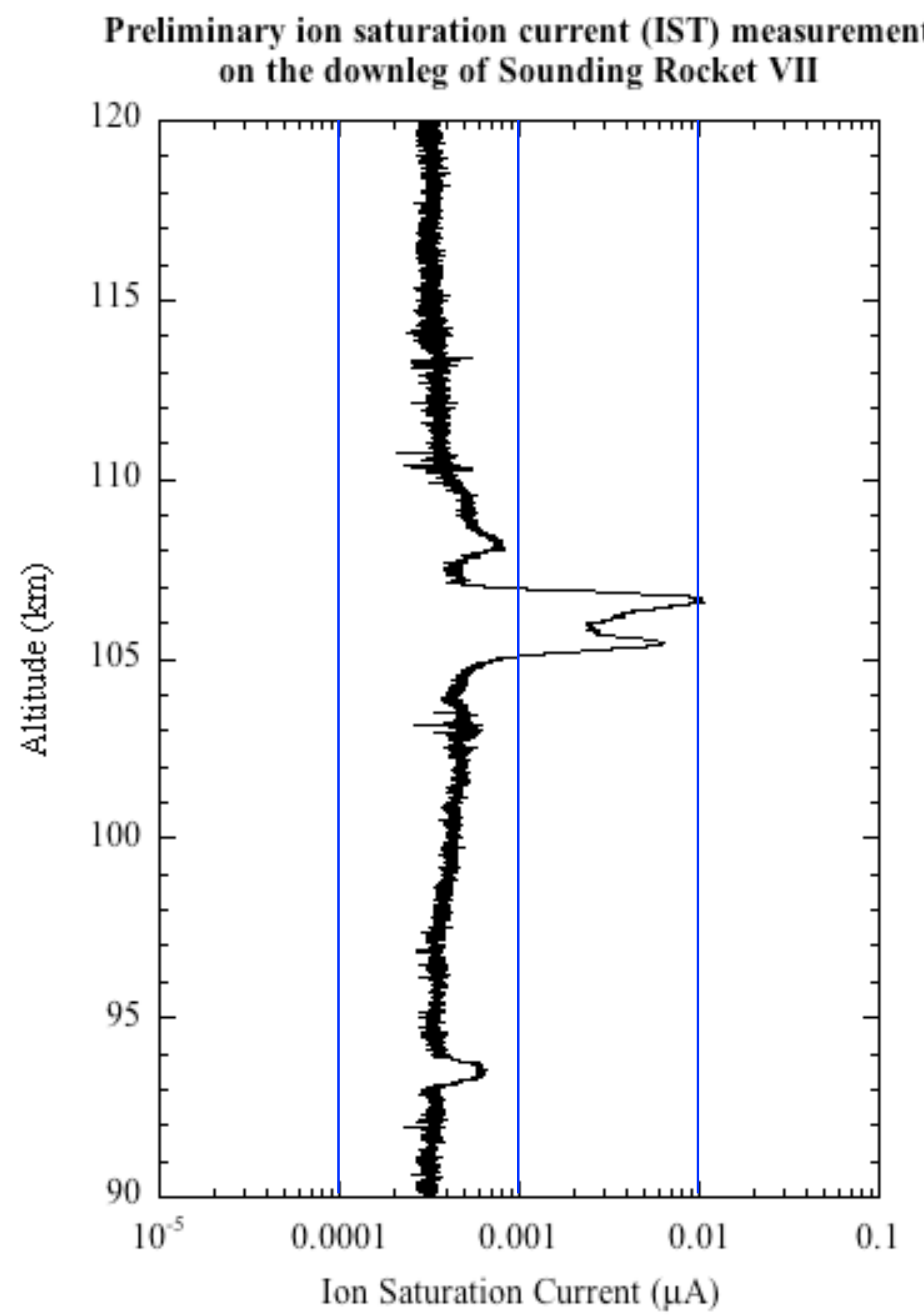




散塊 E 層

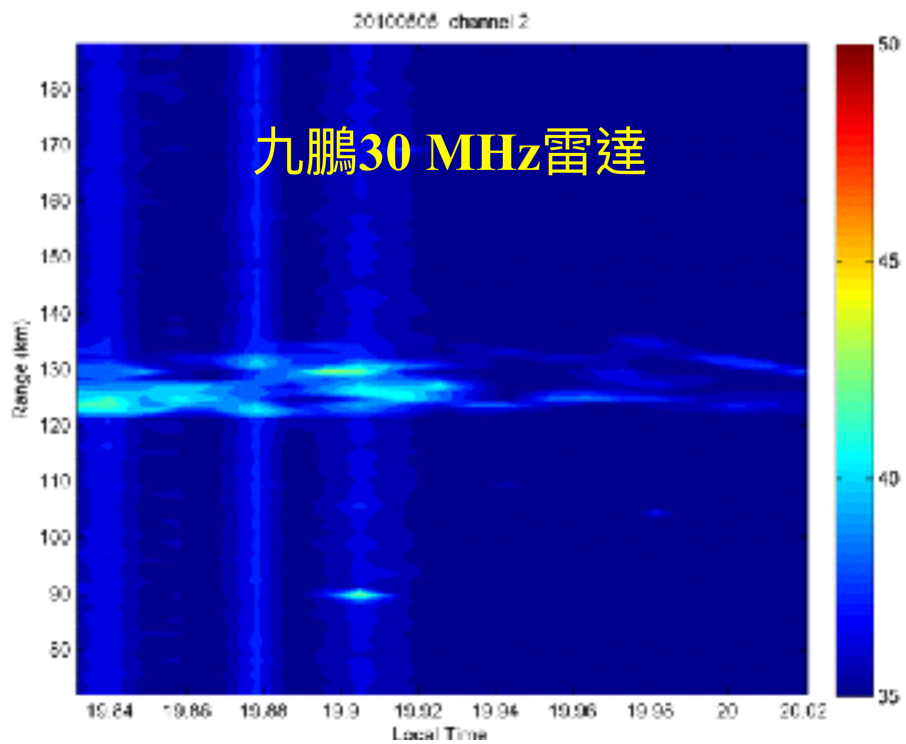


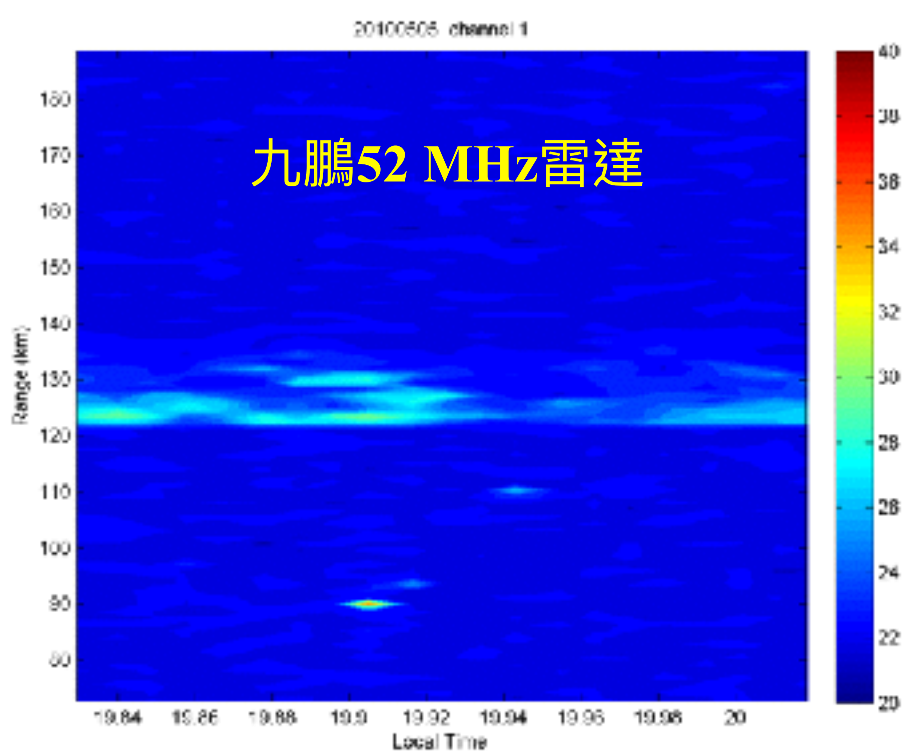
Preliminary ion saturation current (ISN) measurement
on the downleg of Sounding Rocket VII
Altitude (km)
120
115
110
105
100
95
90
10^{-5}
0.0001
0.001
0.01
0.1
Ion Saturation Current (μA)

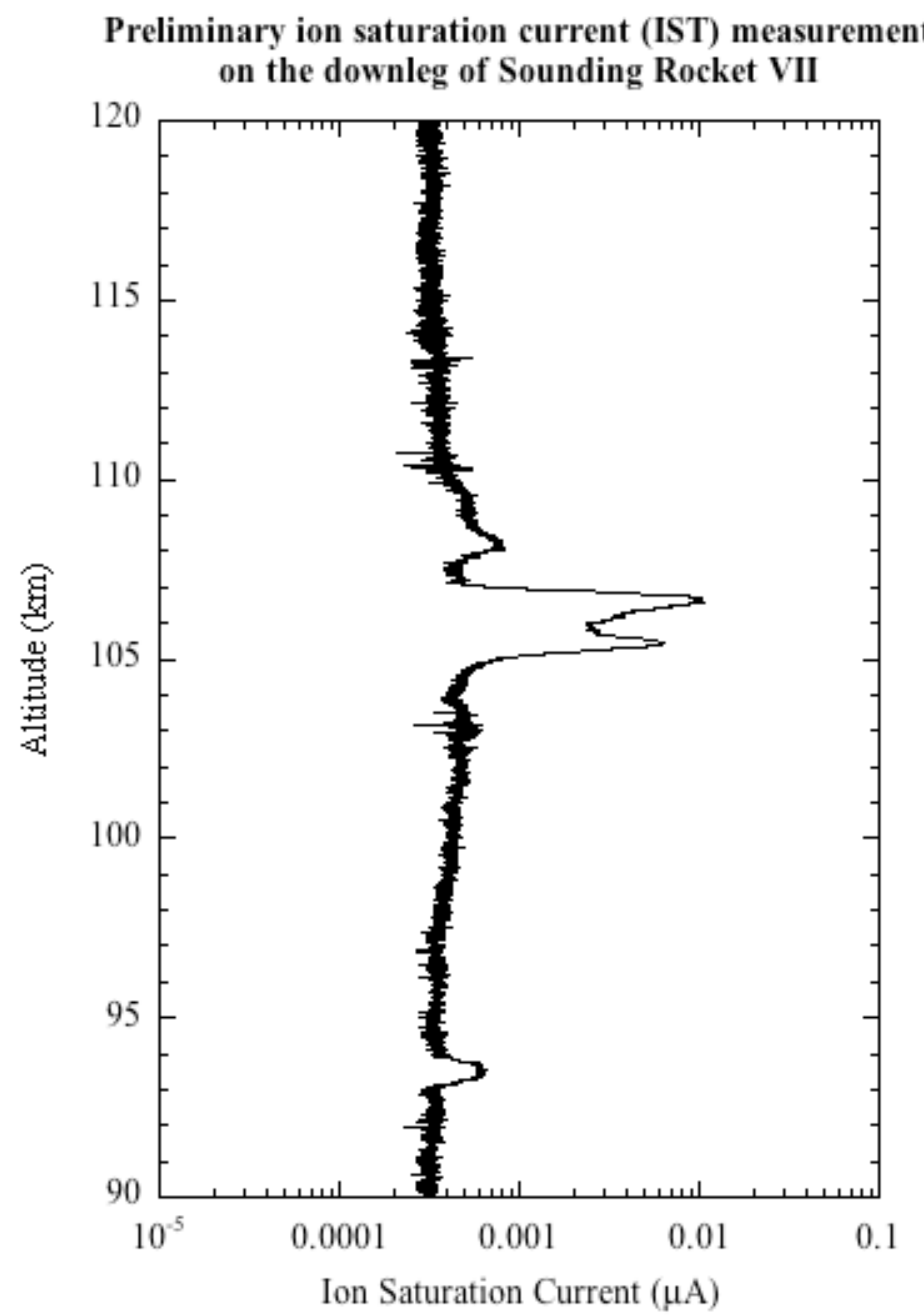


Preliminary ion saturation current (IST) measurement
on the downleg of Sounding Rocket VII
Altitude (km)
120
115
110
105
100
95
90
10^{-5}
0.0001
0.001
0.01
0.1
Ion Saturation Current (μA)

雷達觀測與現地量測之比較







結語

- 飛試過程中，科學酬載功能正常，並可達成指定之目標。
- 在探空七號火箭下降的過程中（在 105 – 107 公里間），離子捕獲計同時偵測到極強的離子流量。流量顯示，此應與雙層的高電漿密度分布有關。其電漿溫度，有待進一步分析。
- 在 93 – 94 公里間，亦有明顯之高離子流量。與地面同相散射雷達回波相比較，其出現時間與位置，與流星尾相關。

檢討與改進

- 此次飛試科學成果將繫於火箭飛行姿態之估量。火箭姿態的異常現象，會影響科學任務的目標與準確度。我們需要更多的時間嘗試，才可能解開可用之資料。
- 當火箭進行大幅度圓錐運動，雙離子捕獲器與三軸磁力計無法有效地決定姿態。在未來，將使用抗高轉速之三軸微機電陀螺儀（或雷射陀螺儀）搭配三軸磁力計來決定姿態。目前將與中科院合作，將在探空八號與九號進行相關測試。