

Development of an Autonomous Aurora Observation System in Antarctica

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Outline

- Current status of autonomous magnetometer operated by Japanese Antarctic Research Expedition (JARE)
- Test of hybrid power system for autonomous observation infrastructure
- Autonomous aurora observation system design
- Future plan of the autonomous aurora observation system

Important points in Autonomous Observation in Antarctica

(1) Electric power management in long dark winter months

(2) Data collection

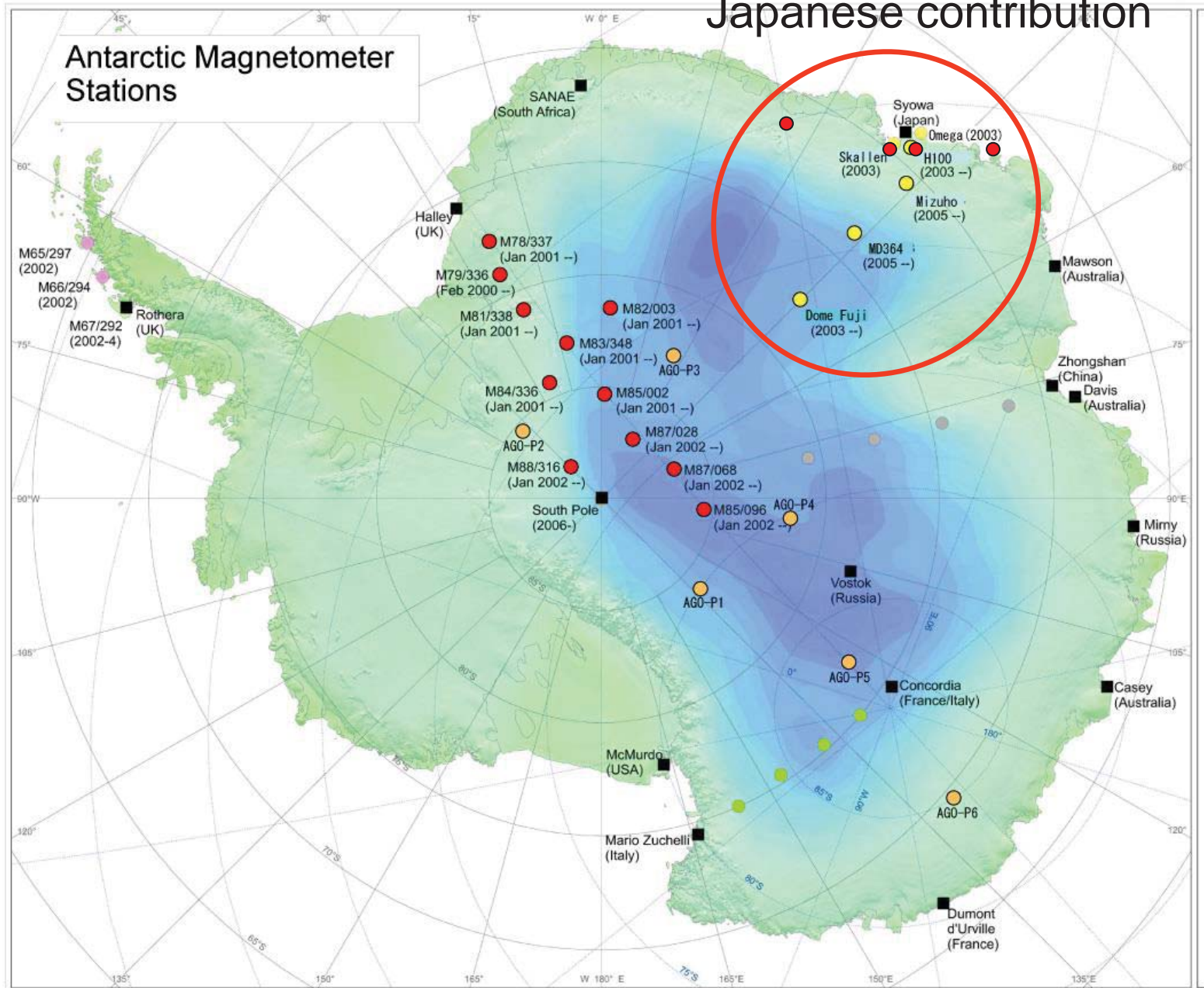
- Send a field team by snow motor, or aeroplane **expensive**
- Data transfer via satellite phone **communication cost**

(3) Performance below -40°C

- use heavy duty, MIL spec parts **expensive**
- Good insulation ($10\text{cm} \Leftrightarrow \Delta T = 20^{\circ}\text{C}$)
- Electric heating \rightarrow Power consumption $> 10\text{ W} \sim$

Antarctic Autonomous Magnetometer Network

Japanese contribution



Installation of NIPR-LPM

Jan. 2007: H57



Feb. 2009: Utsteinen



Jan. 2007: Skallen

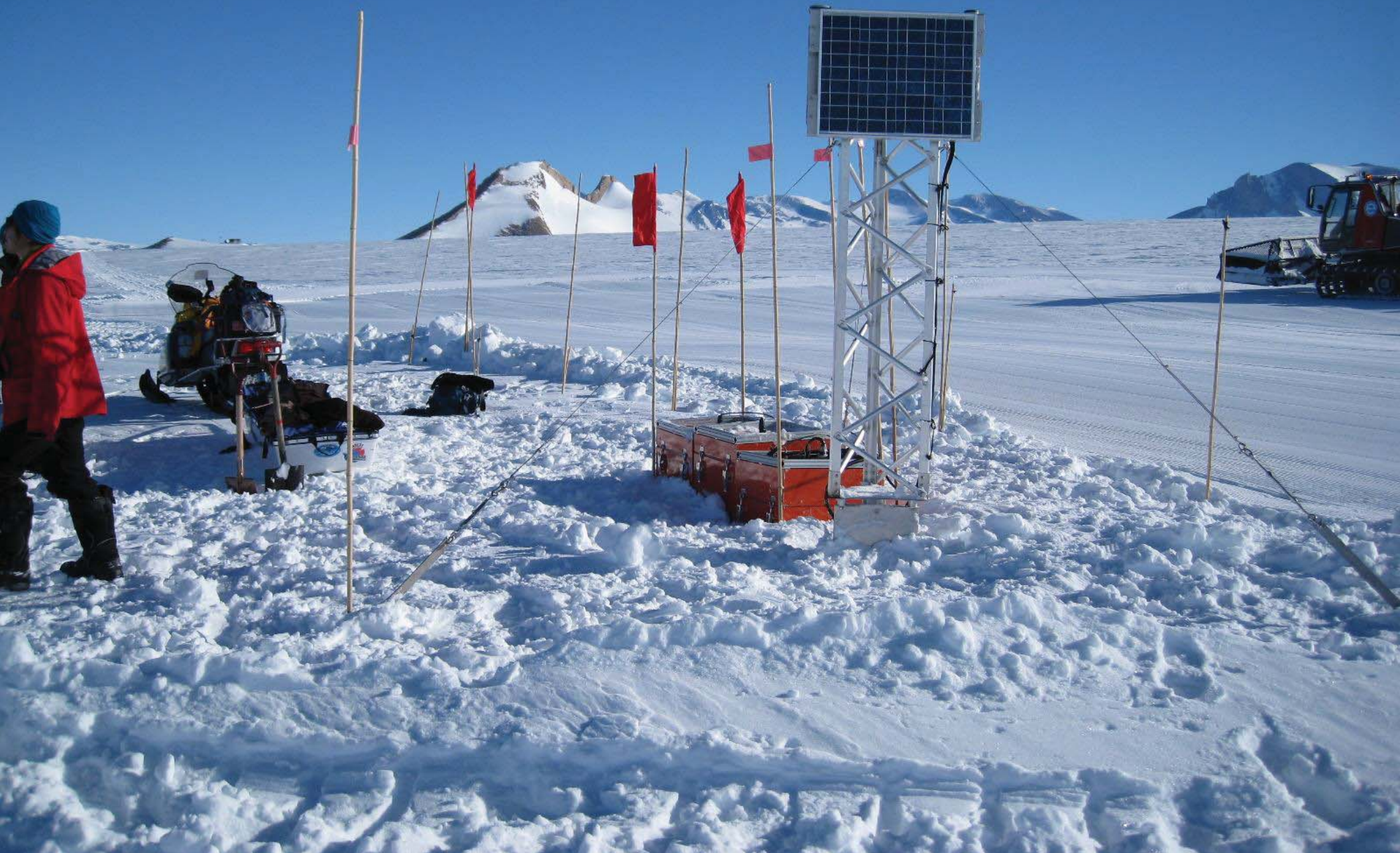


Mar. 2008: Amunsen Bay





LPM at Utsteinen, Princess Elizabeth Station, 2009-2014





Sensor



Sensor Case

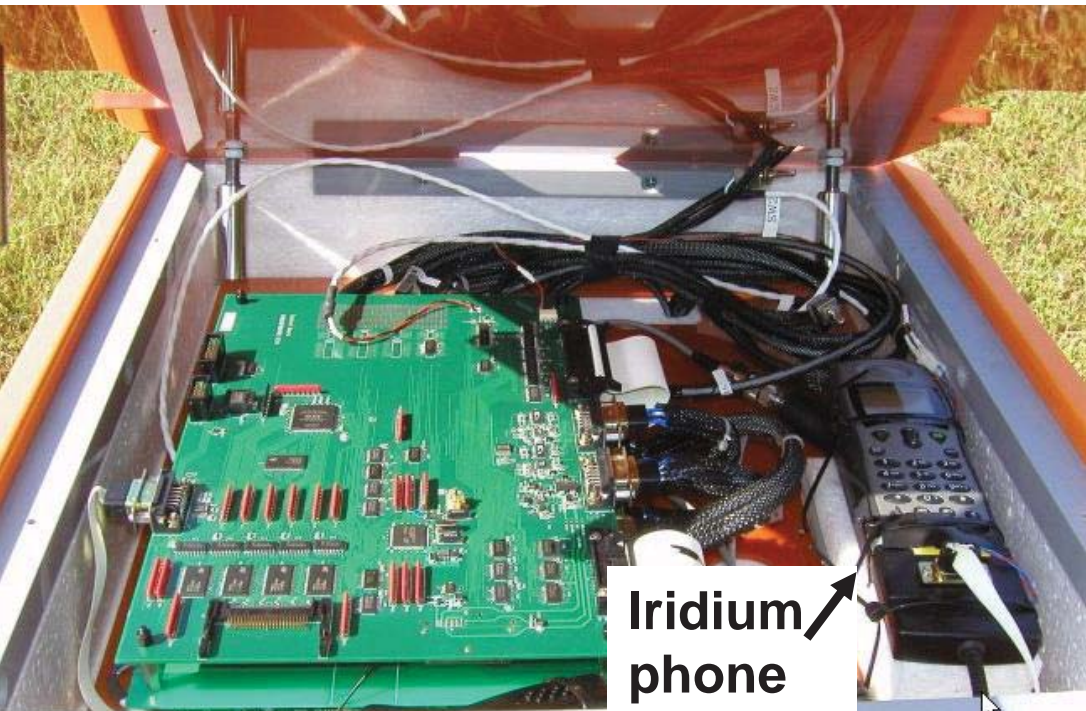
NIPR-LPM

Inside



Data logger electronics

Battery Box



Iridium phone

Total Power of 1W is difficult

because some component needs ~ 1 W, or more
GPS (0.75 W), Magnetometer (0.5 W), Iridium telephone (10 W)

intermittent operation

<Power On> only at necessary time !

		daily average
GPS :	twice a day, 30 min	→ 30 mW
Iridium phone :	once a day, 40 min	→ 280 mW
Magnetometer :	every second, 0.1s	→ 50 mW

Operation Table

	Data Availability	2007												2008												2009												2010												2011											
		1	2	3	4	5	6	7	8	9	1	0	1	2	1	2	3	4	5	6	7	8	9	1	0	1	2	1	2	3	4	5	6	7	8	9	1	0	1	2	1	2	3	4	5	6	7	8	9	1	0	1	2								
#6	Skalen	—————																																																											
#7	H57	—————																								-----																																			
#8	Amurzen Bay																									—————																																			
#10	Sor Rondane																									—————						-----						—————																							
#11	H68																									-----						—————																													
#13	Inhovde																									-----																																			

NIPR-LPM

Power consumption table

	Instrument name	Peak mW	Daily Avg mW
Intermittent Summer 380mW Winter 105mW	GPS	750	30
	Magnetometer	500	50
	Iridium phone	10000	280
	CPU	200	20
	CF memory	500	4.5
Continuous 78mW	Sig. conditioner		25
	FPGA		12
	RAM		10.5
	CF memory		1.0
	Power supply		30

Total Power	DC-DC conv. output	Battery
Summer	460 mW	770 mW
Winter	180 mW	300 mW

Actual value at - 40°C

600 mW

190 mW

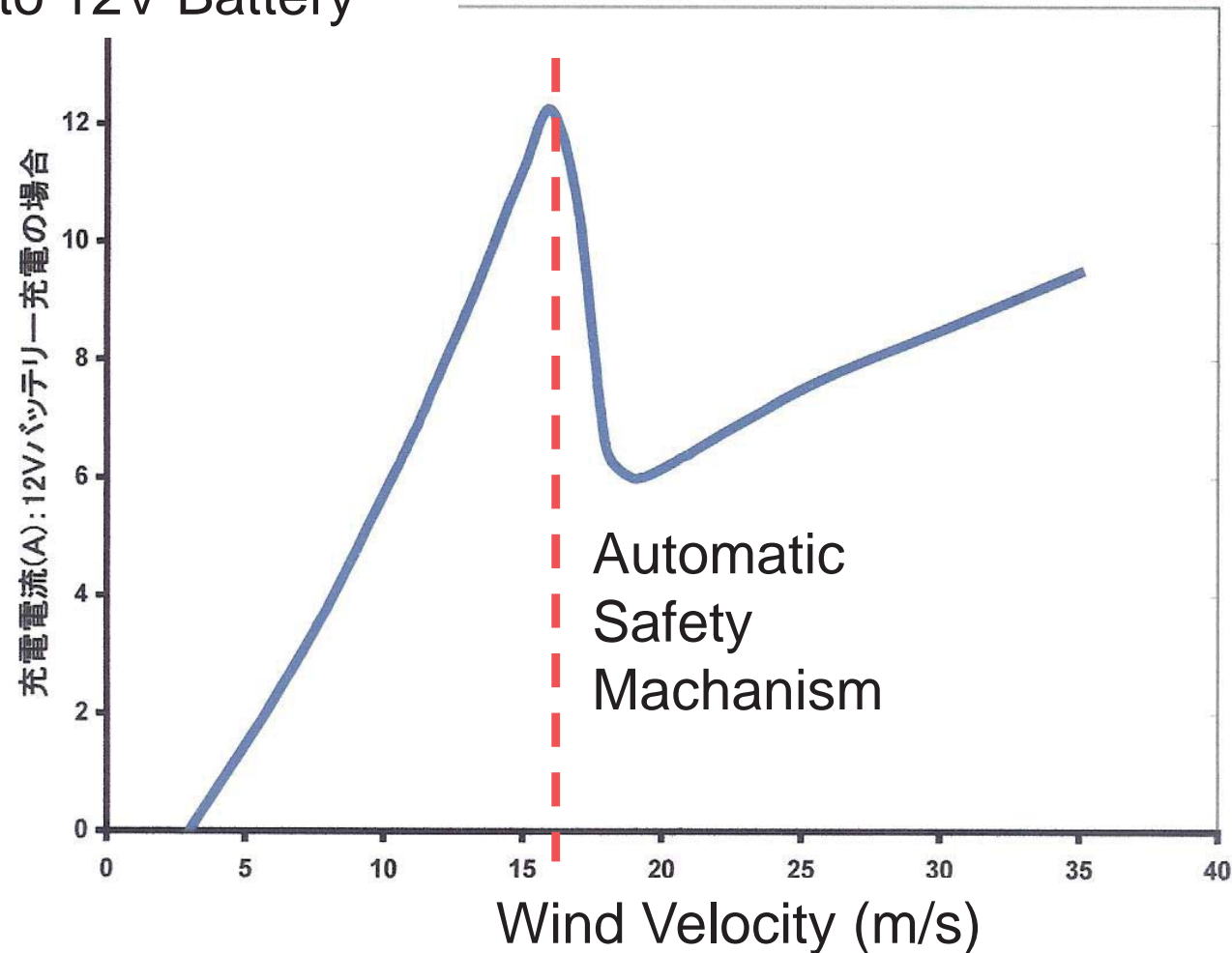
Summary

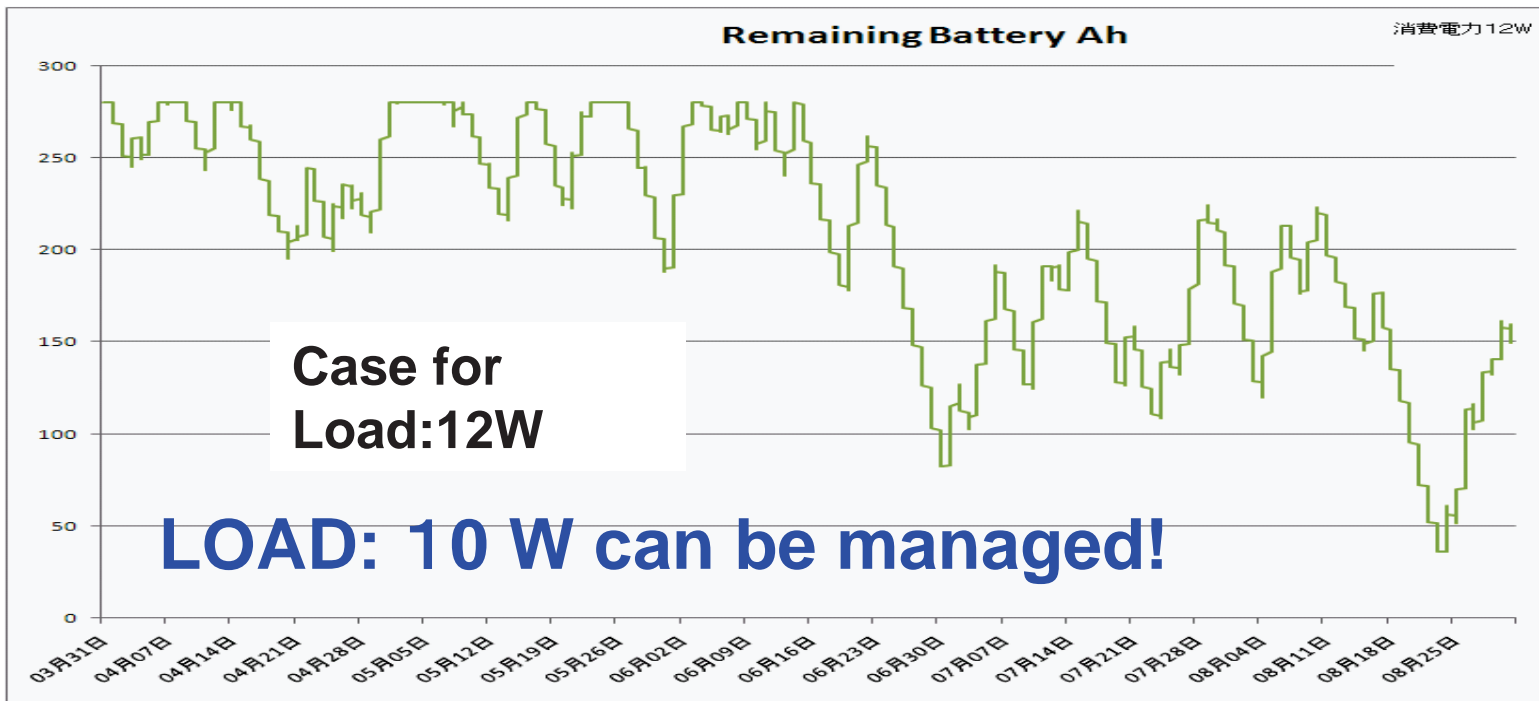
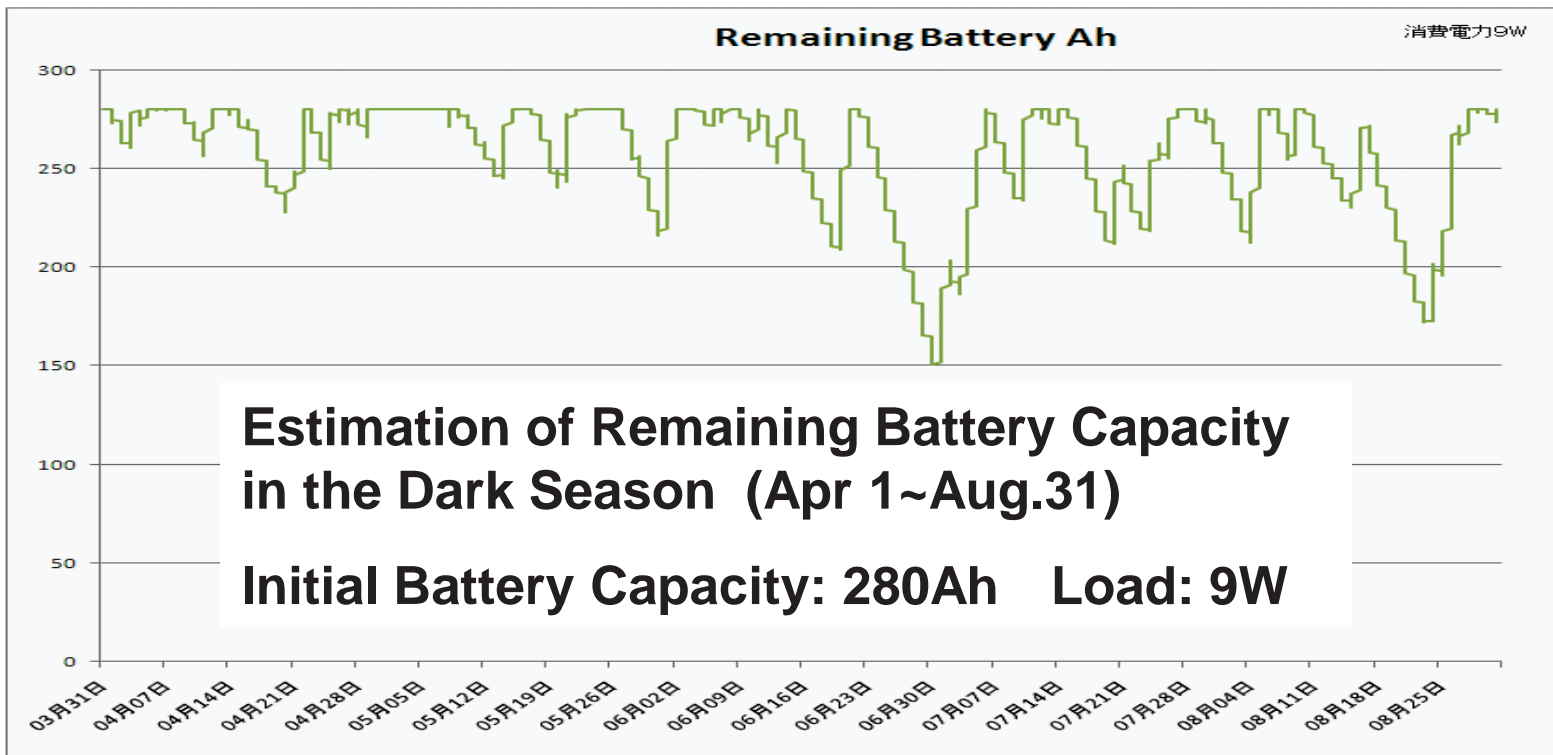
- Low power data logging system with satellite data transfer is developed.
- Stably work at -40°C in 2006 and 2007.
- To be used for larger scale magnetometer network observation near coastline in IPY period.
- More modification and test will be necessary for lower temperature deep inland operation.

Wind Generator FM910 (Rutland Corp., UK)

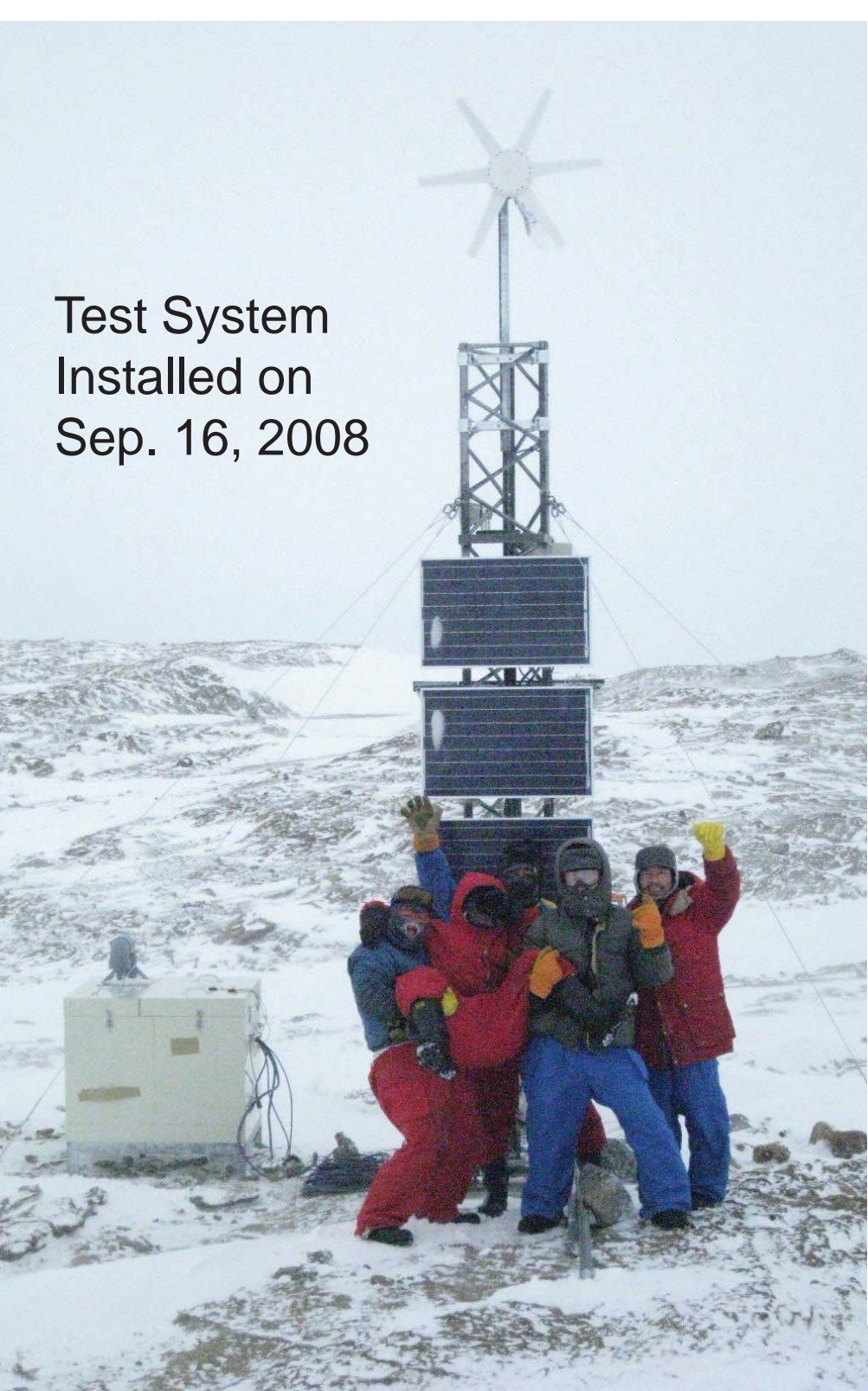


Charge Current
to 12V Battery

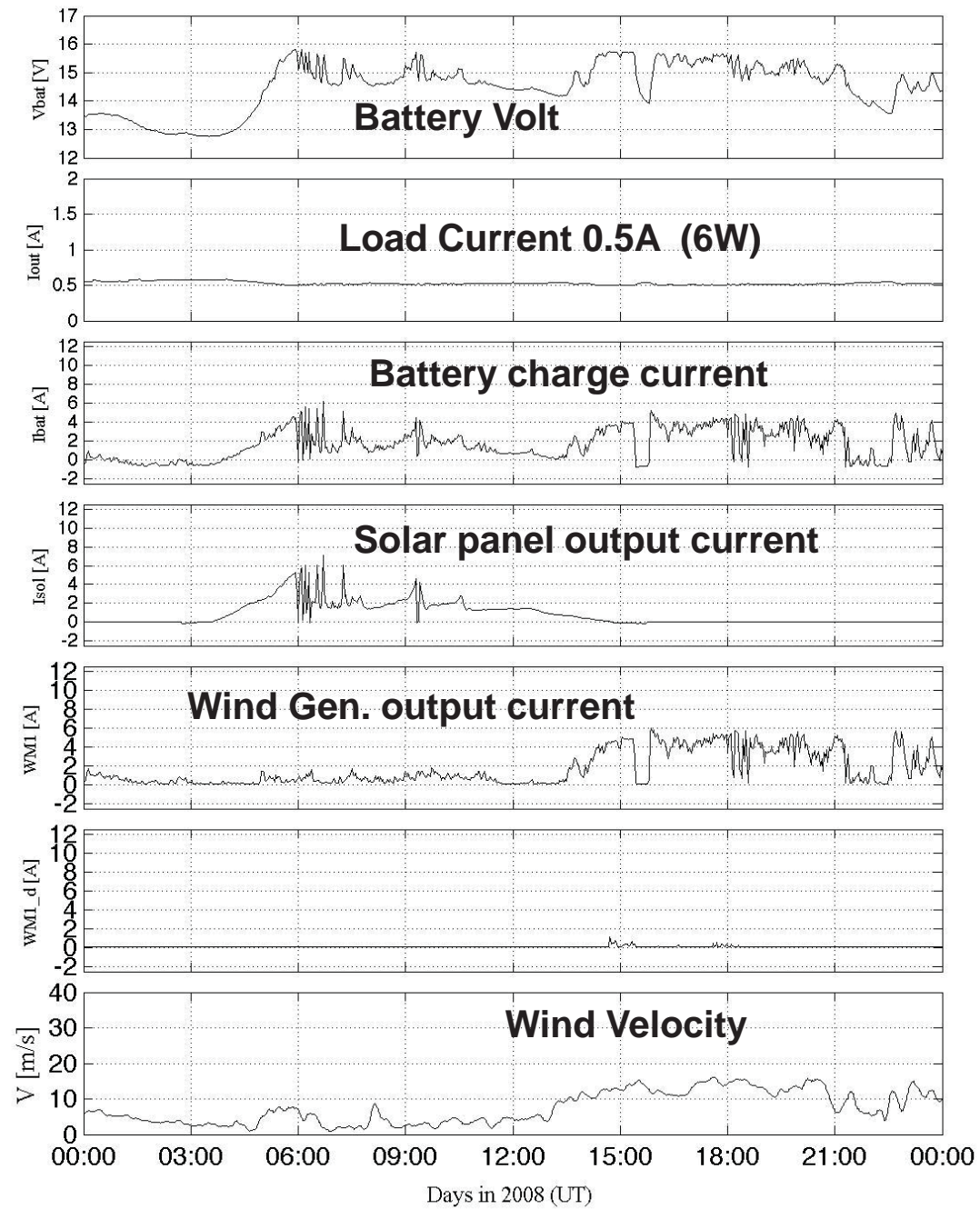




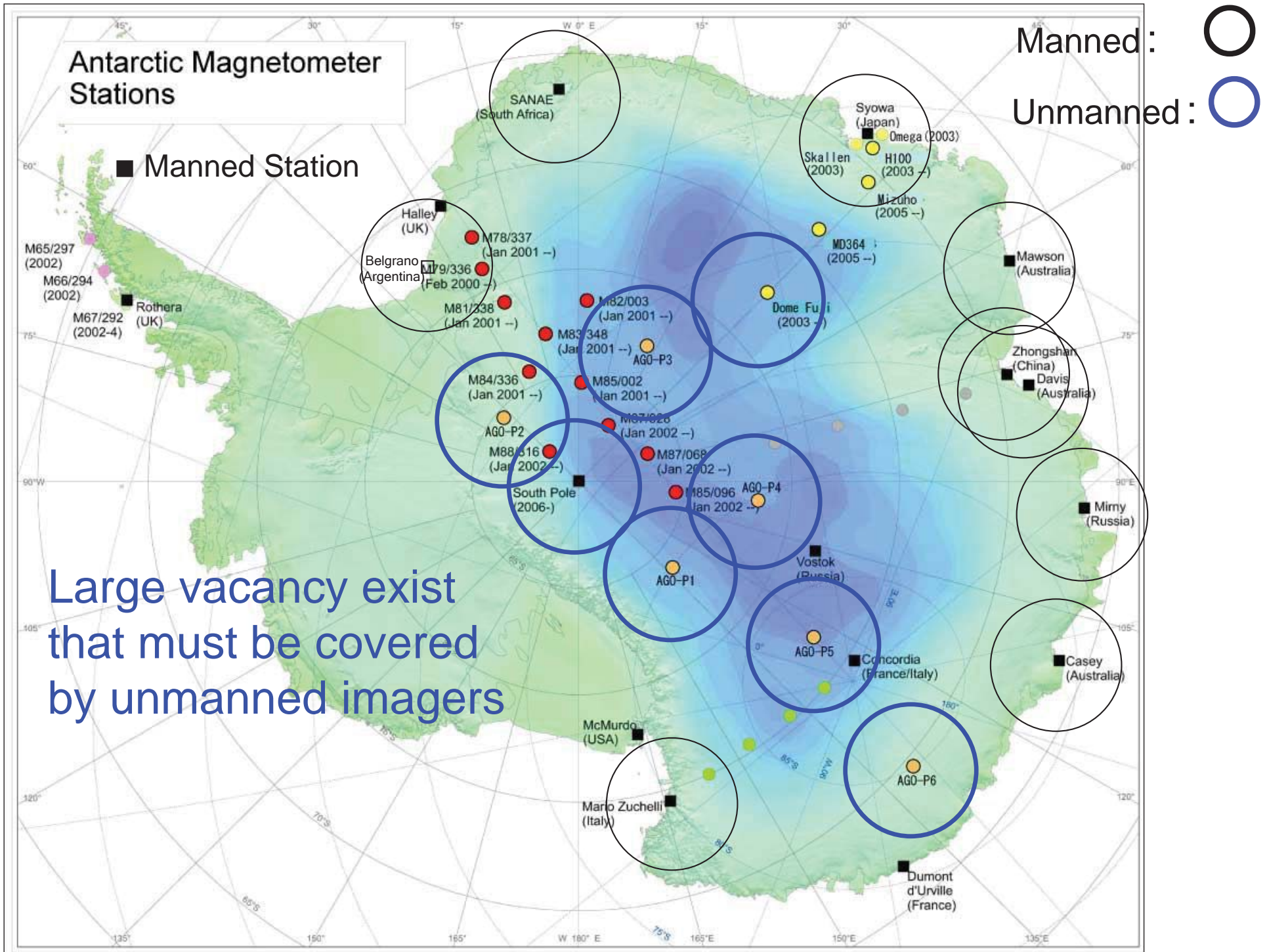
Test System
Installed on
Sep. 16, 2008



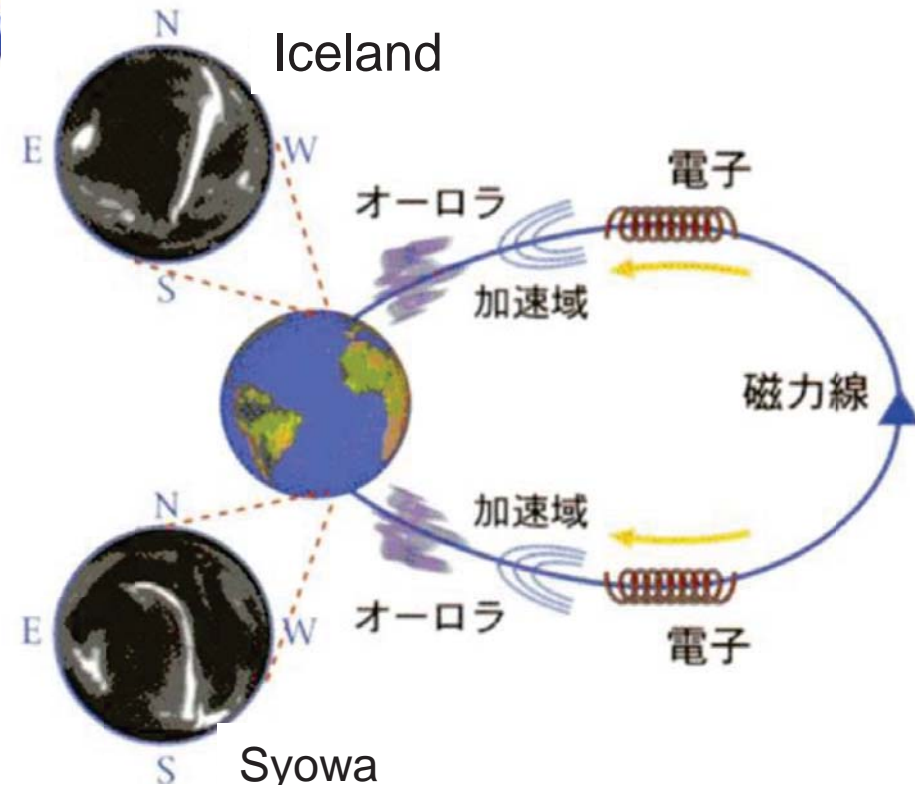
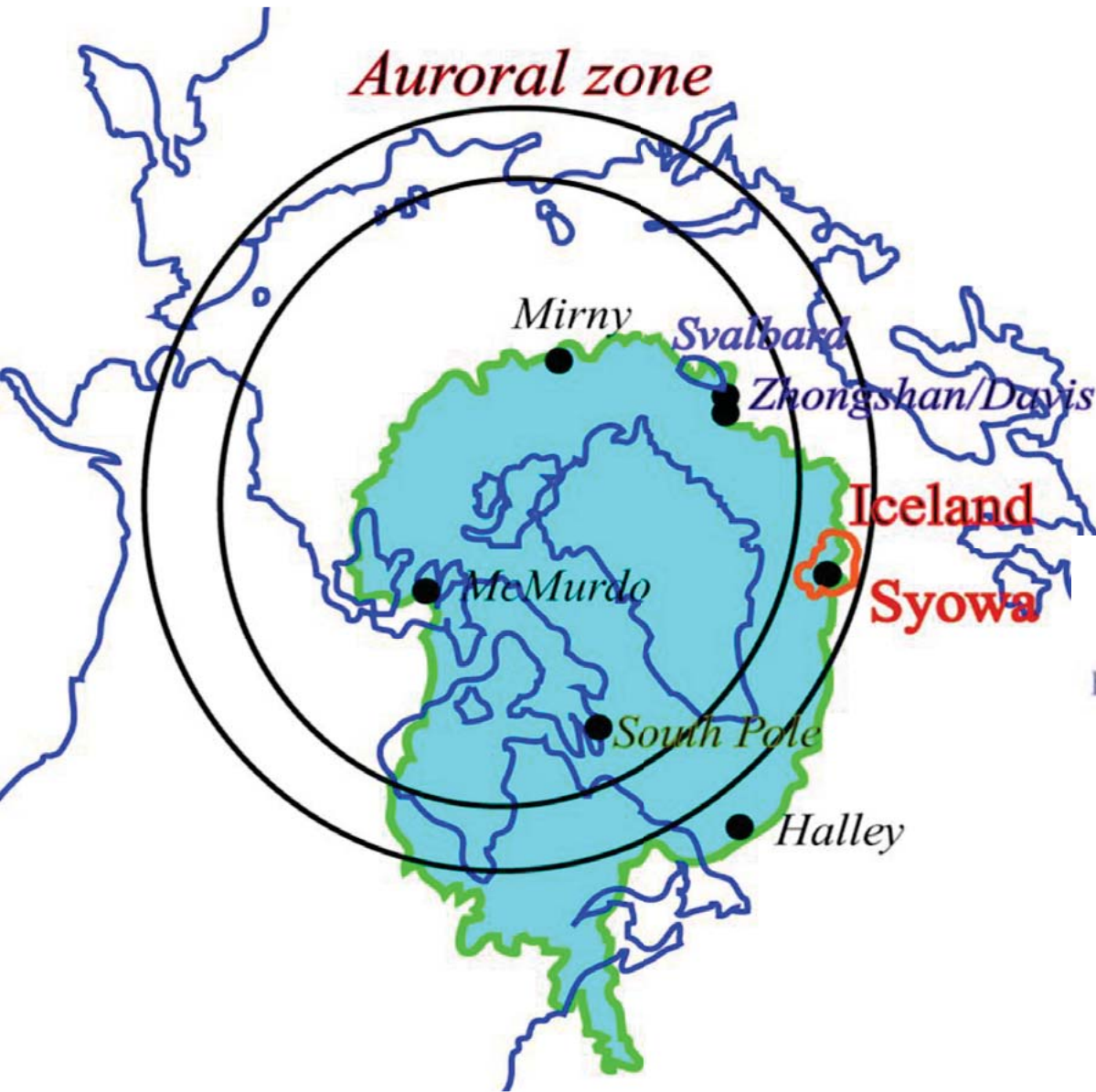
Performance of the Natural Energy Power Supply System



Automated Aurora Imager is necessary in Antarctica !

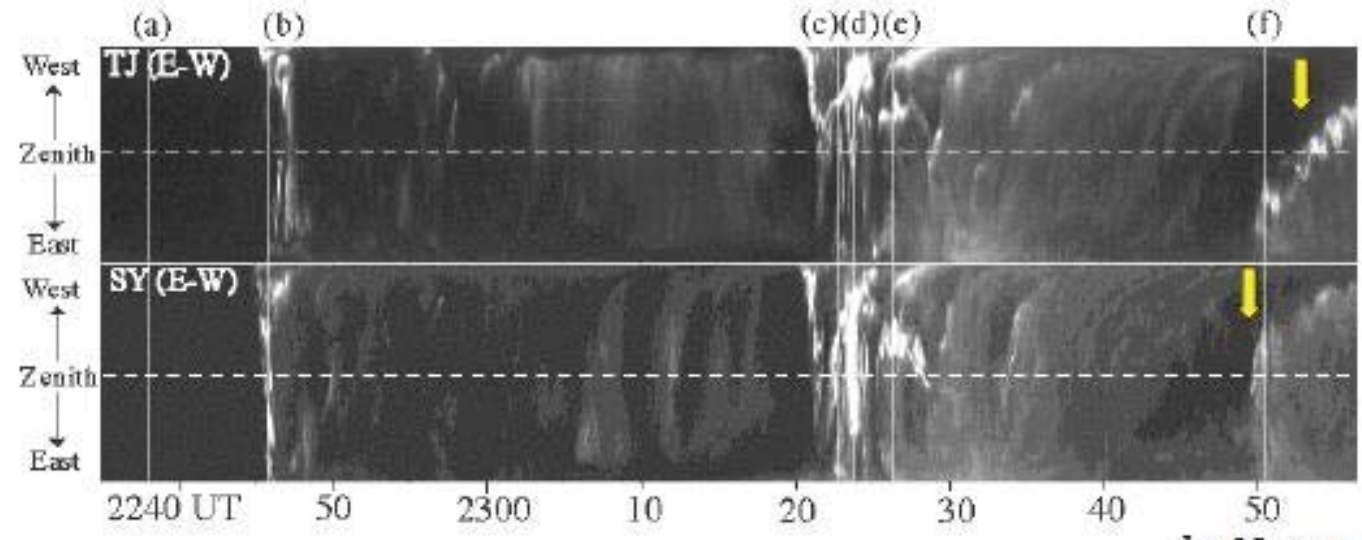
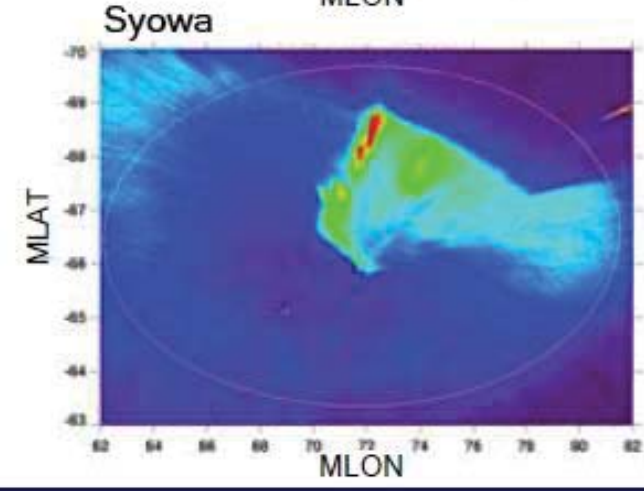
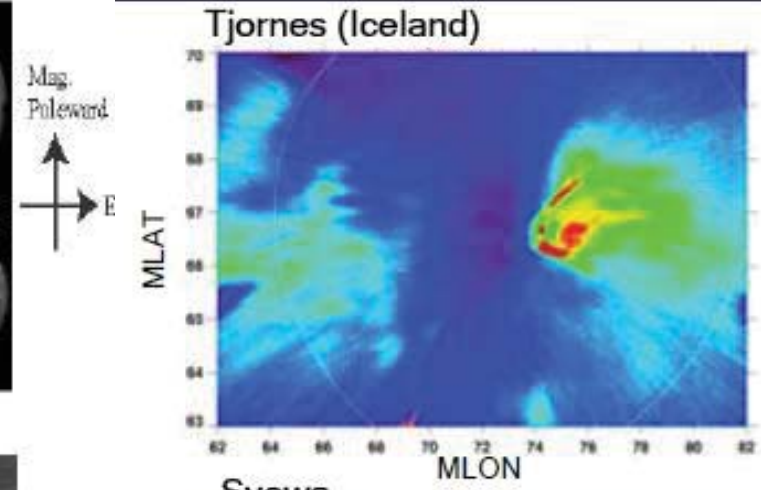
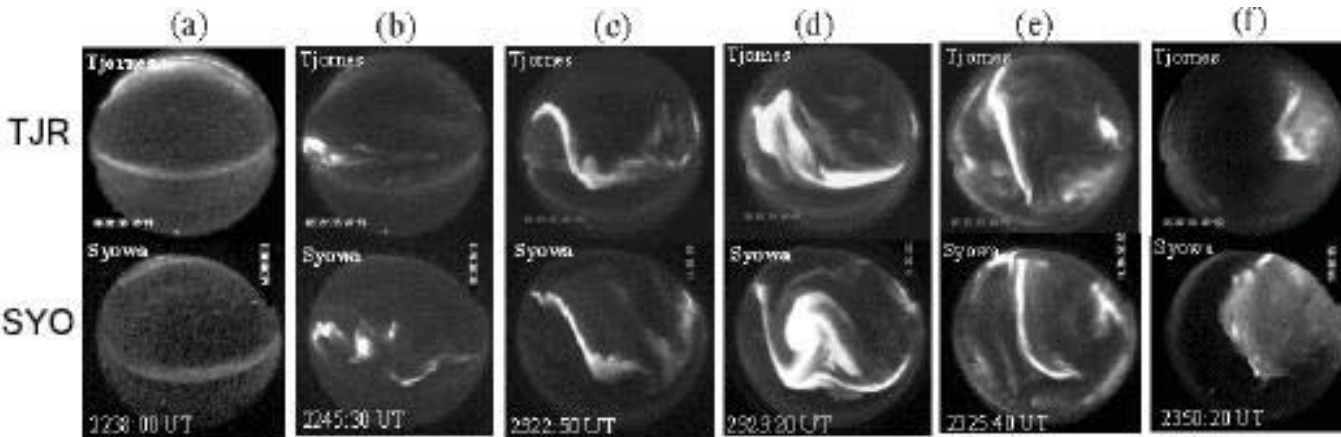


Is the Aurora in Arctic and Antarctic similar ?



Sep. 26, 2003

Very good conjugate aurora event

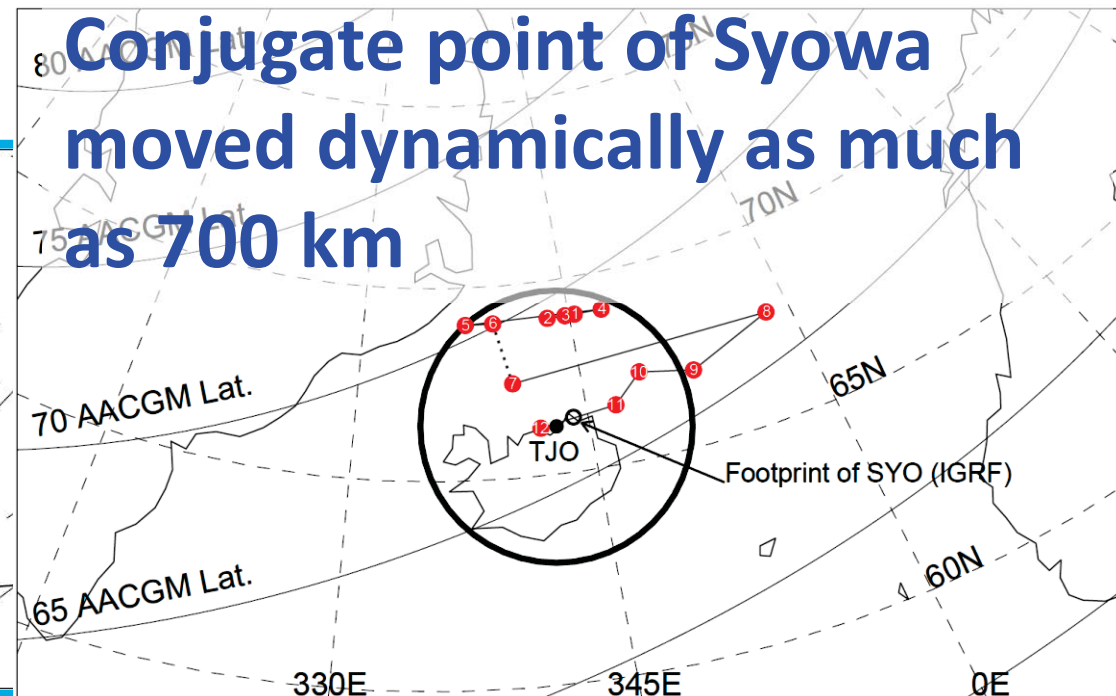
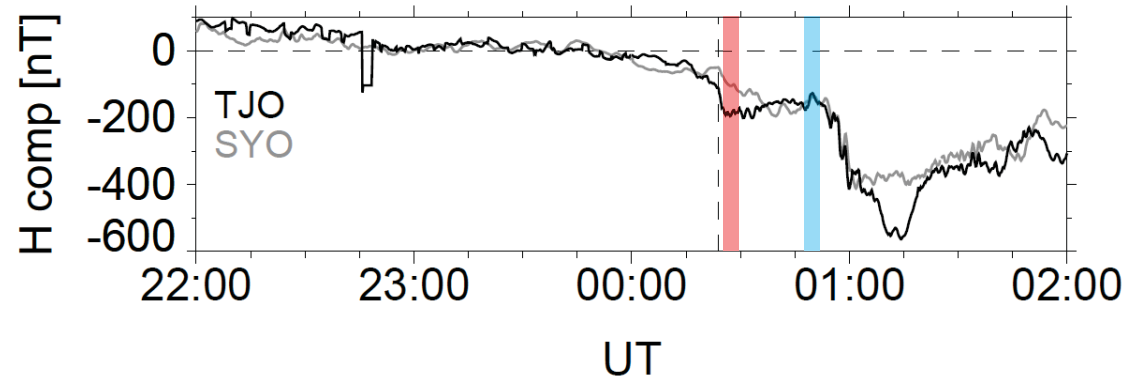
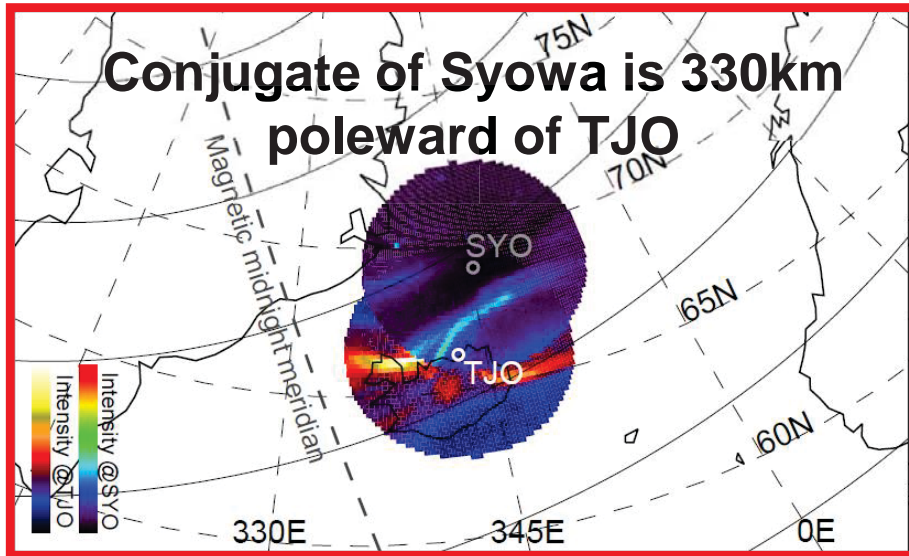


by Natsuo Sato

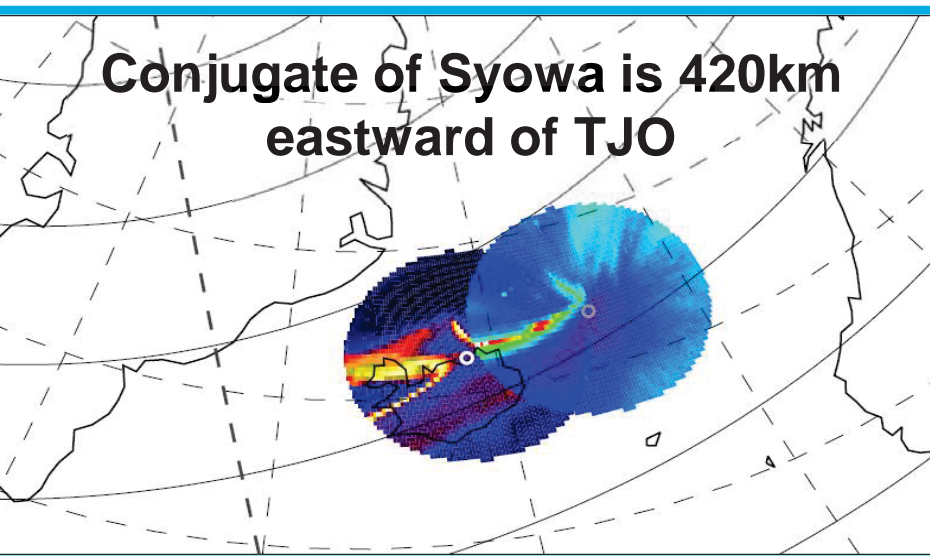
Sato et al., GRL, 2005

Suddenly at 22:50, location of conjugate aurora jumped as much as 4 deg.

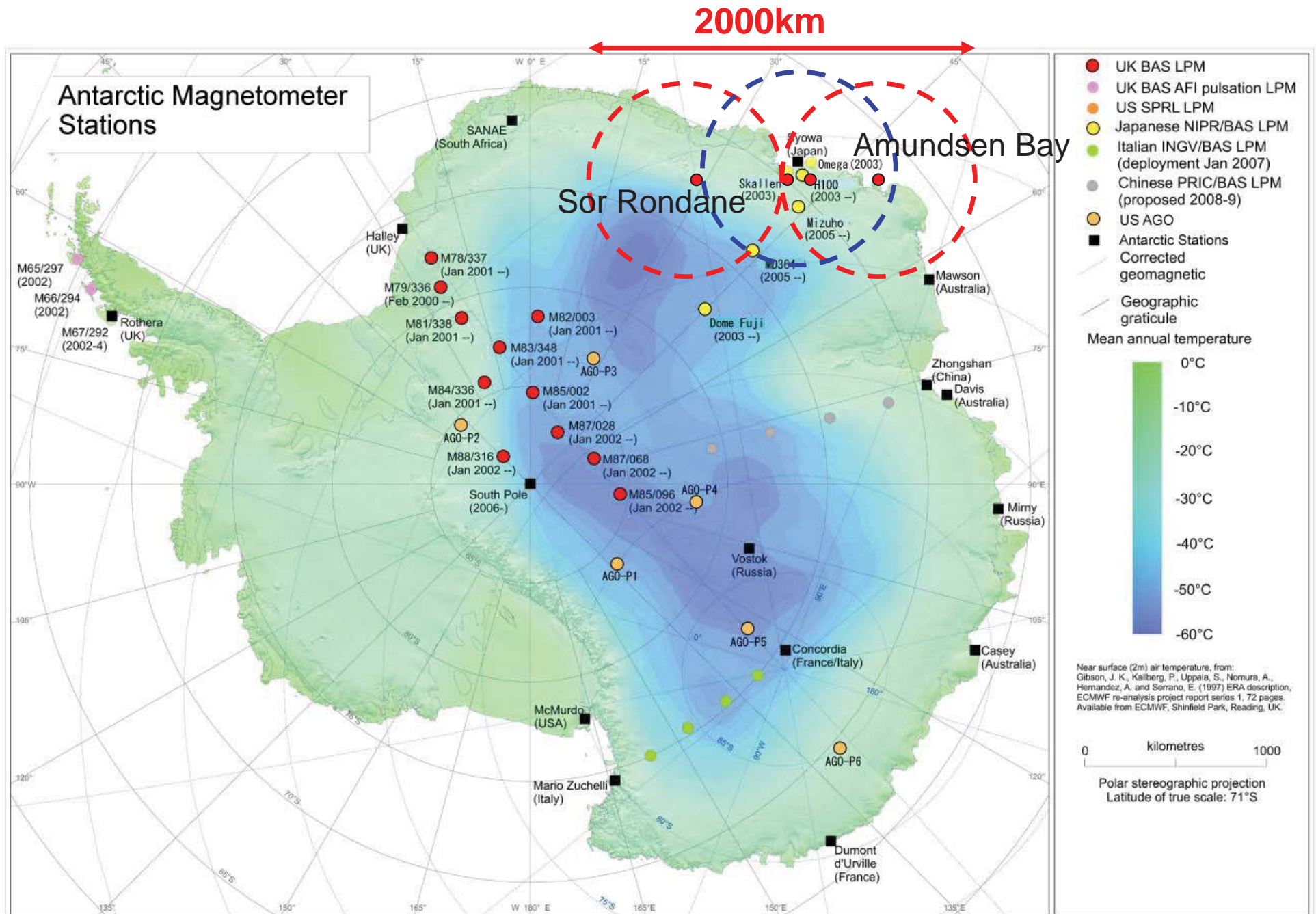
Determination of the conjugate point by adjusting the image to 'best fit'



Conjugate of Syowa is 420km eastward of TJO



Automated Aurora Imager is useful for tracking the motion of conjugate auroas



Concept of our Automated Aurora Imager System

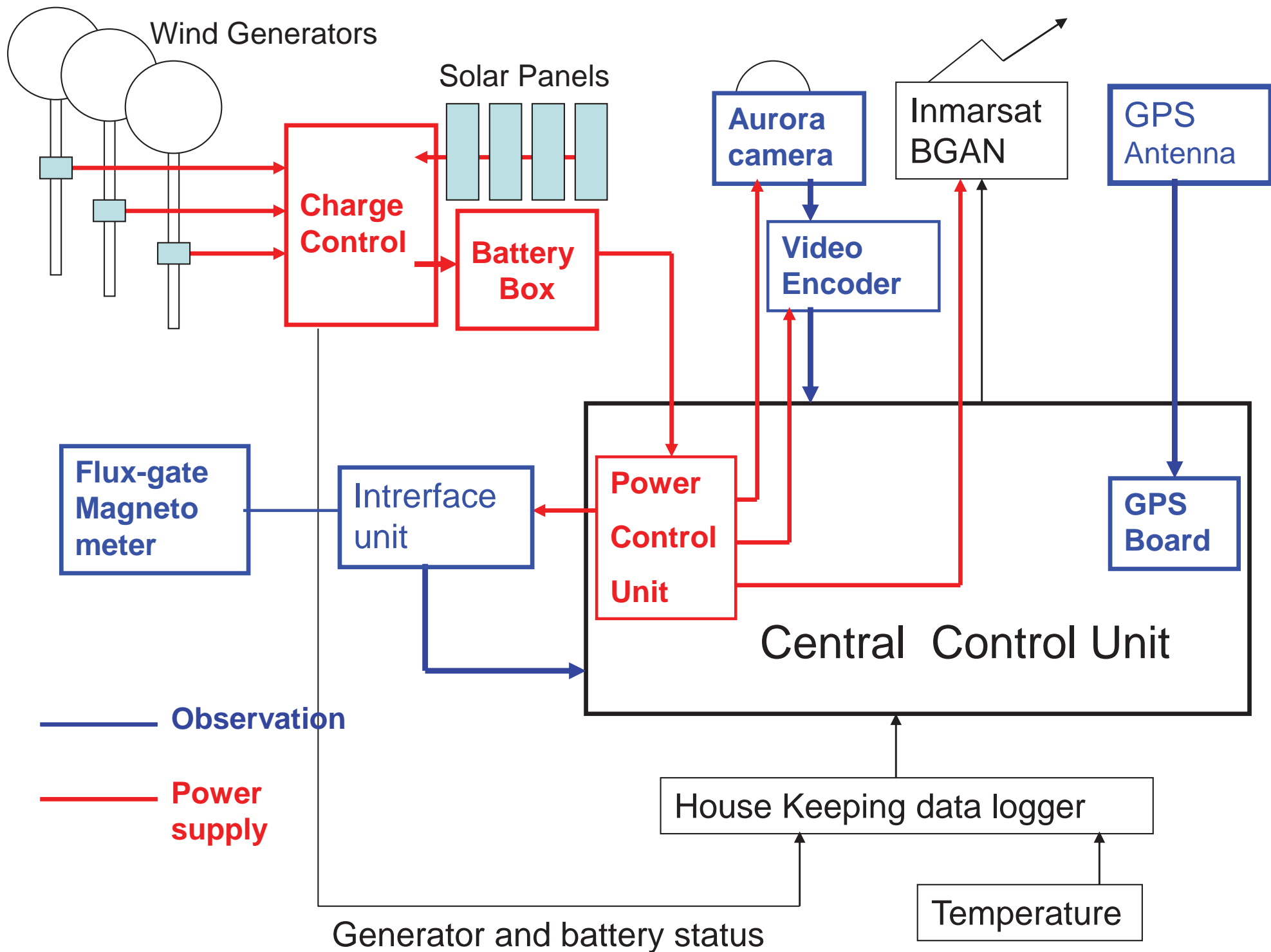
- Low-power All-sky Aurora Imager

Large data ⇒ Inmarsat BGAN telephone

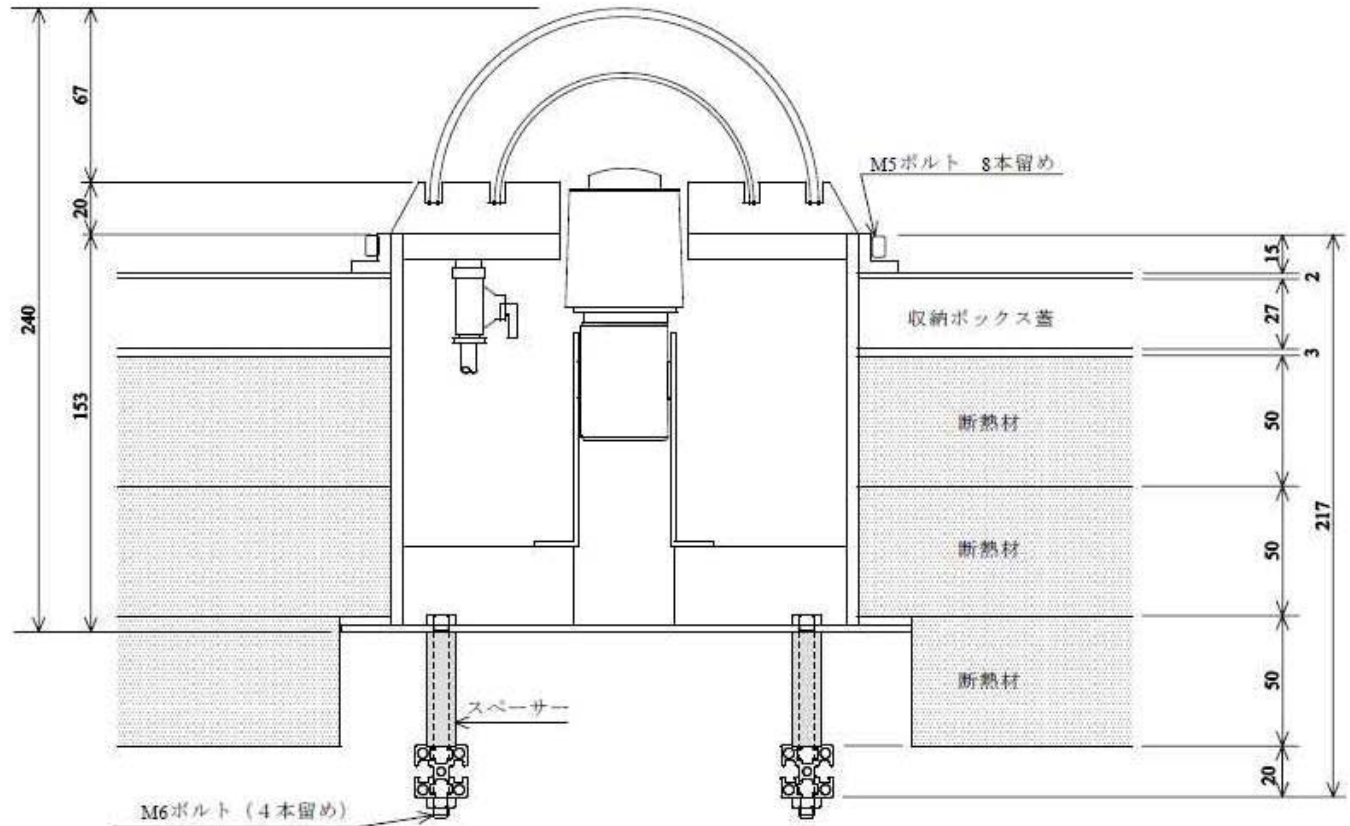
- add Flux-gate Magnetometer
- add Dual frequency GPS receiver for TEC observation

⇒ Medium power consumption (16 W)

Wind generator is necessary



Aurora Imager mount in insulation box





Flux-gate
Magnetometer



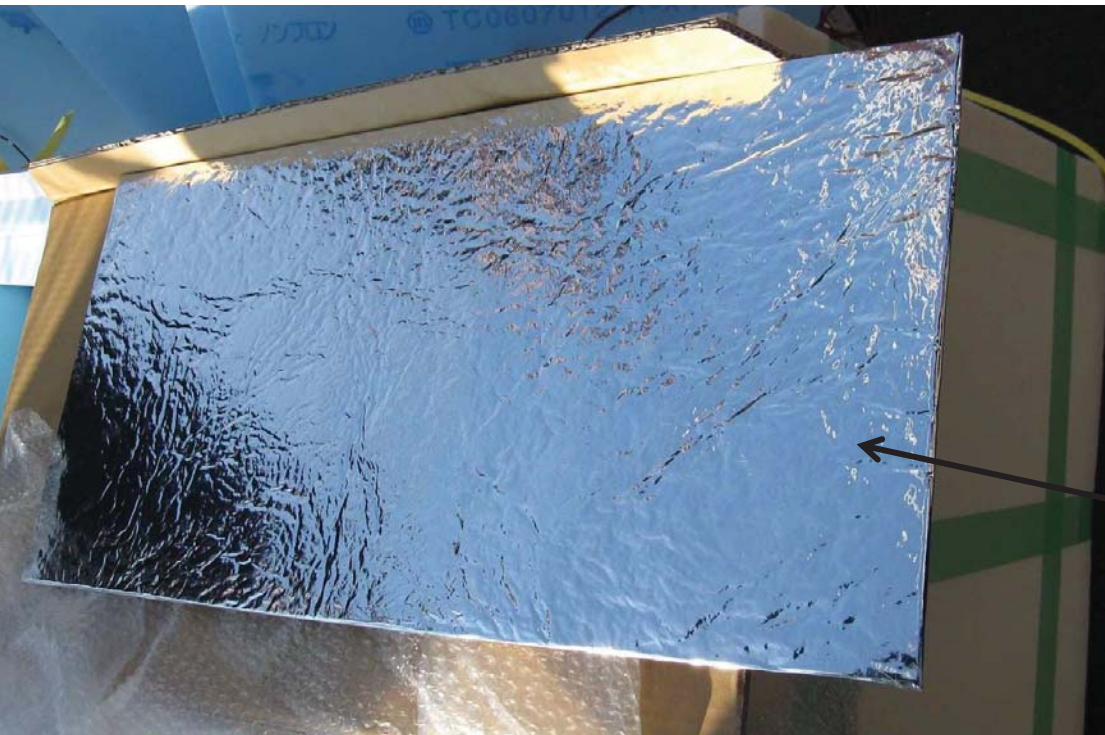
	Power supply Voltage	Power Consum	Working hours	Daily power consum	Workig temperature (°C)
	(DC V)	(W)	(h)	(Wh)	
Flux-gate Magnetometer	—	—	24	—	-40~+70
FGM I/F Unit	4~16	1.7	24	40.3	-20~+50
Aurora Camera	12±10%	2.2	24	52.8	-10~+50
Video Encoder	8~28	4.2	24	100.8	-40~+75
GNSS board	3.3+5%/-3%	2.3	24	55.2	-40~+75
HK data logger	9.6~16	0.35	24	8.4	-25~+50
Inmar BGAN	RX	5.7	2	11.4	-25~+55
	TX	14.0	1	14.0	
Central Cont Unit	5±5%	1.2	24	28.8	-20~+70
Hub	12~48	3.0	24	72.0	-40~+70

Sum

383.7

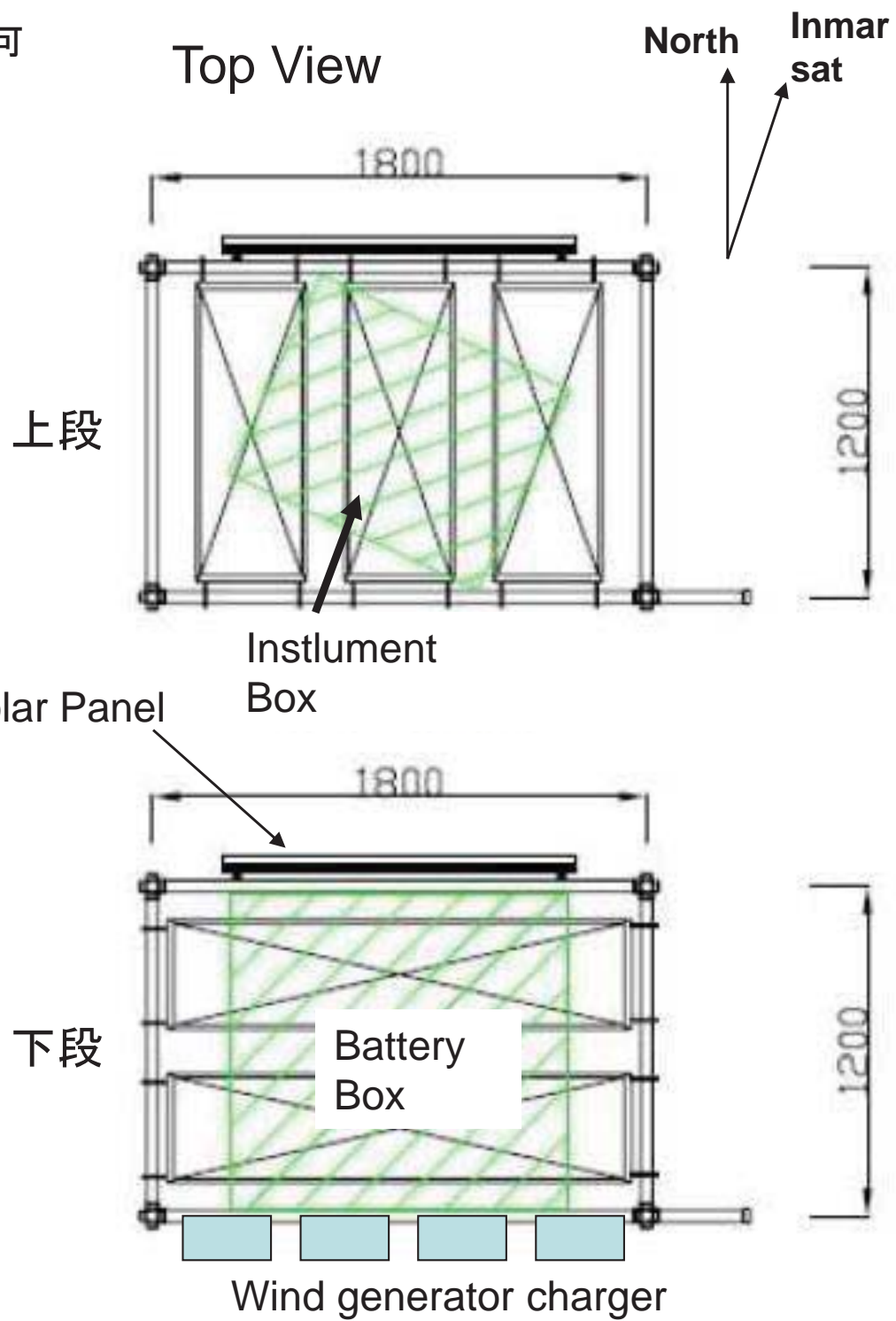
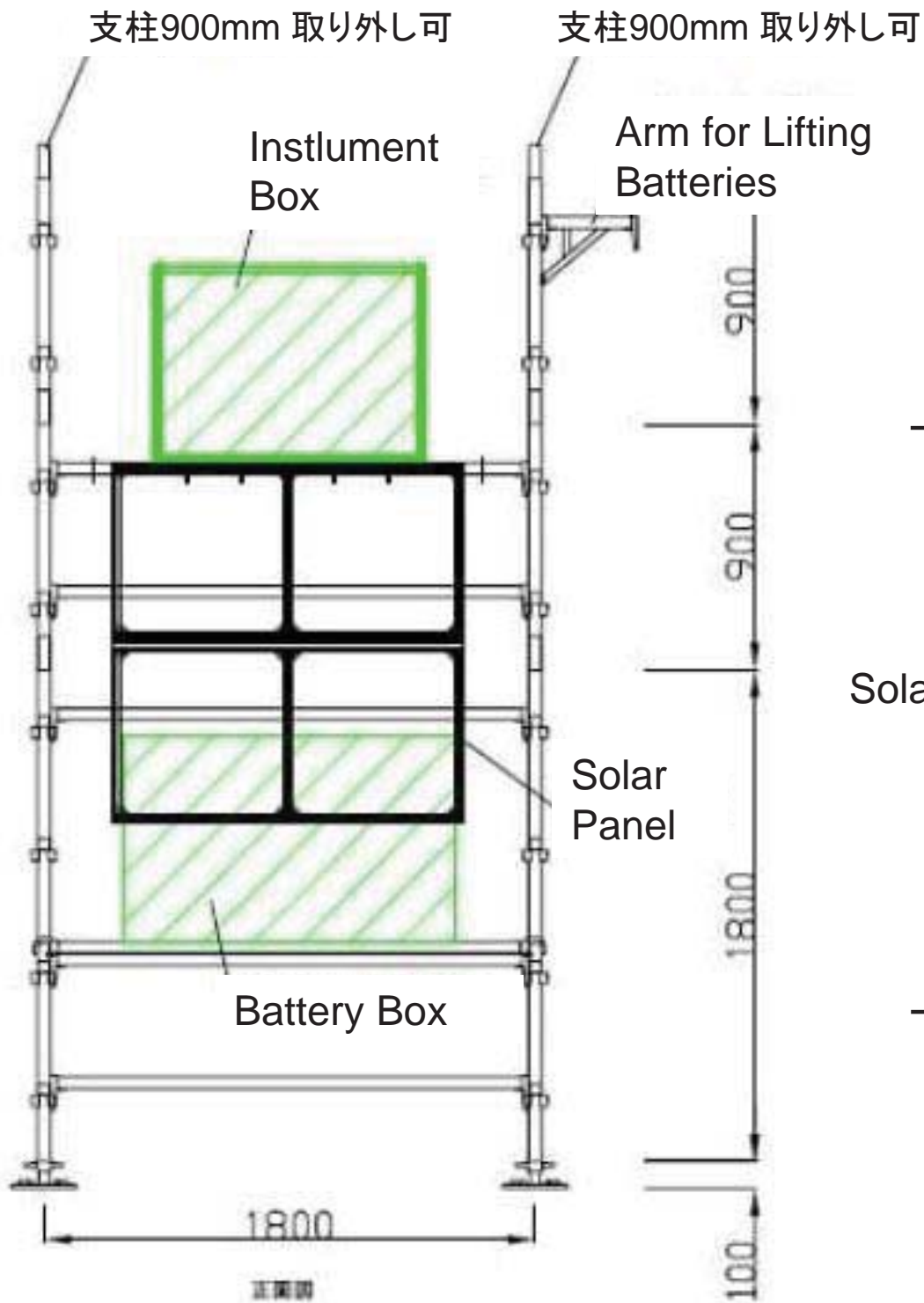
16 W

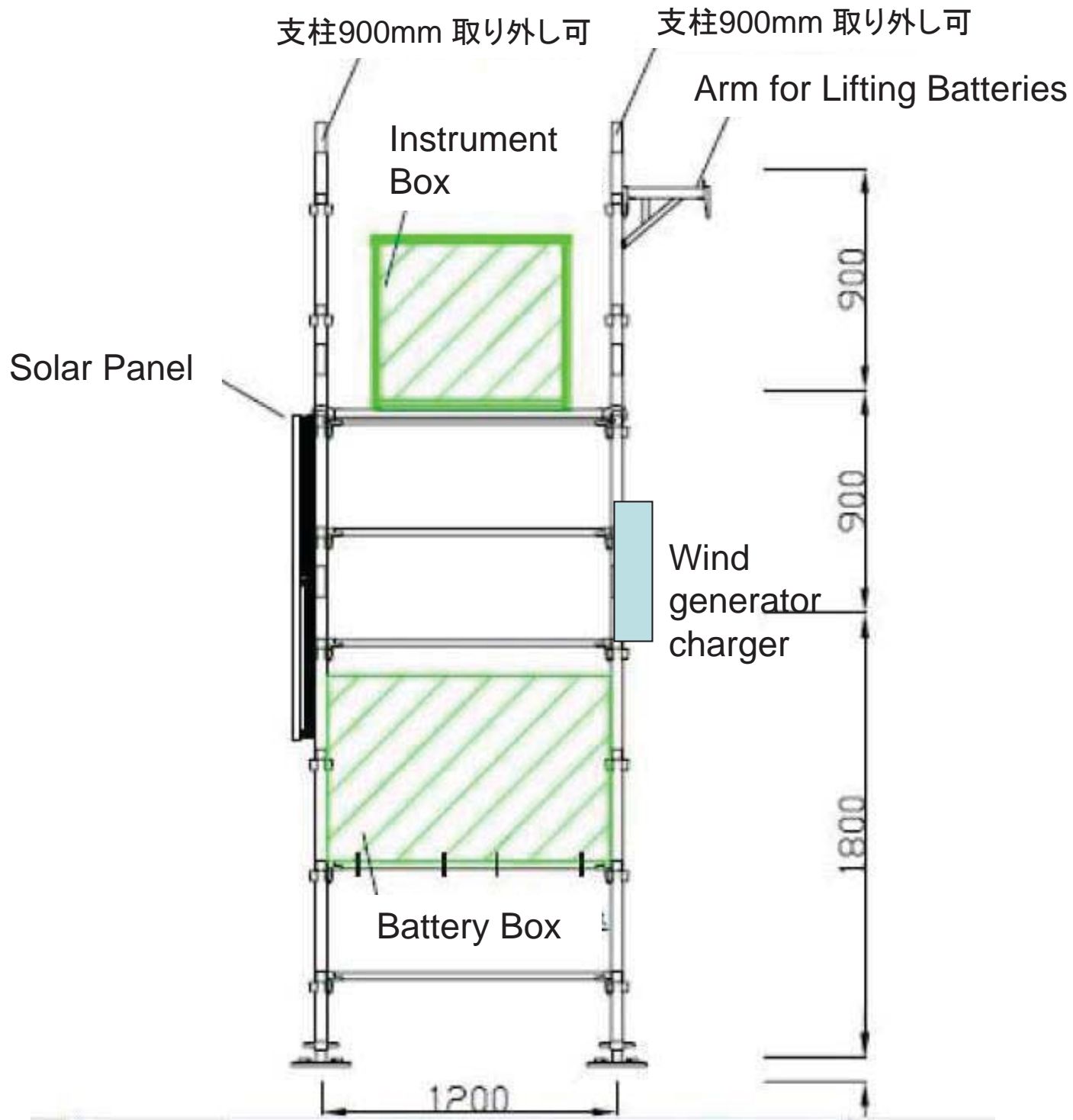
Insulation Test



Vacume insulator panel

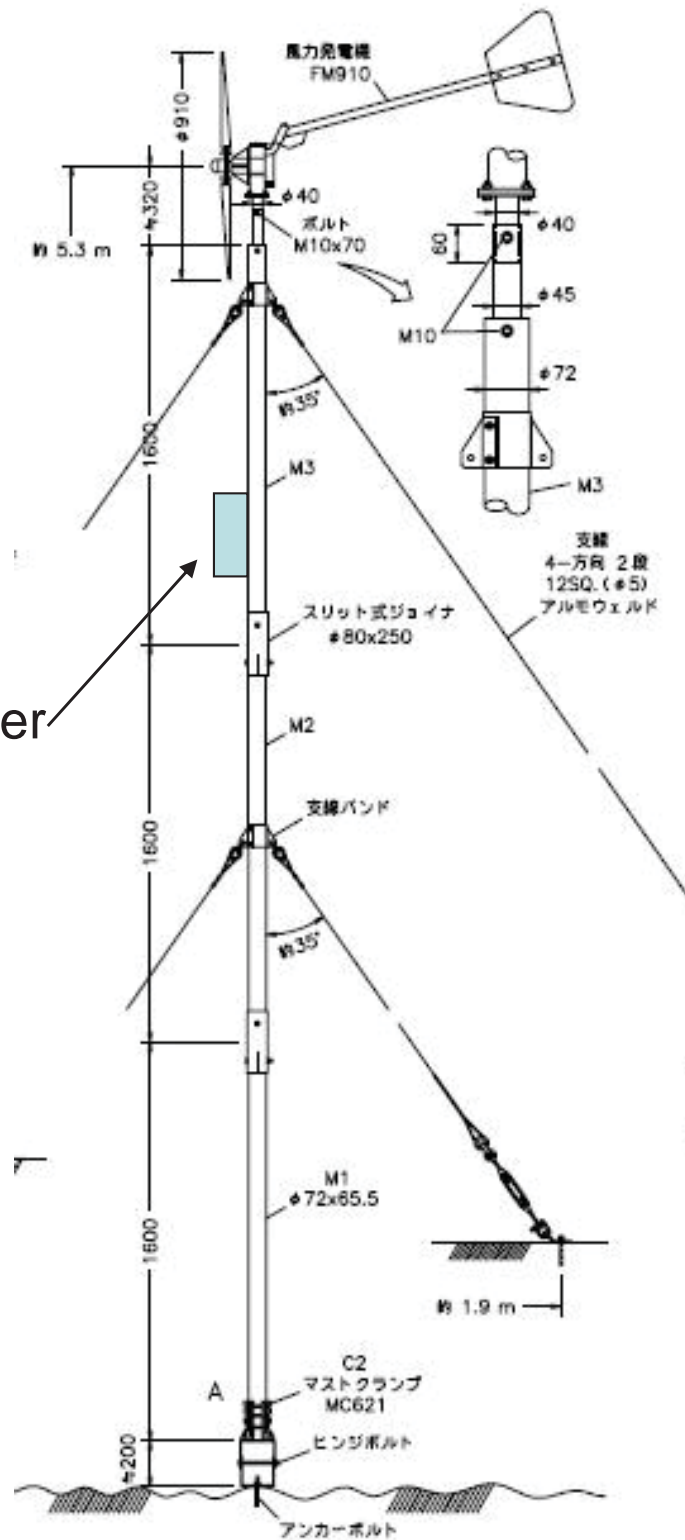








Rectifier



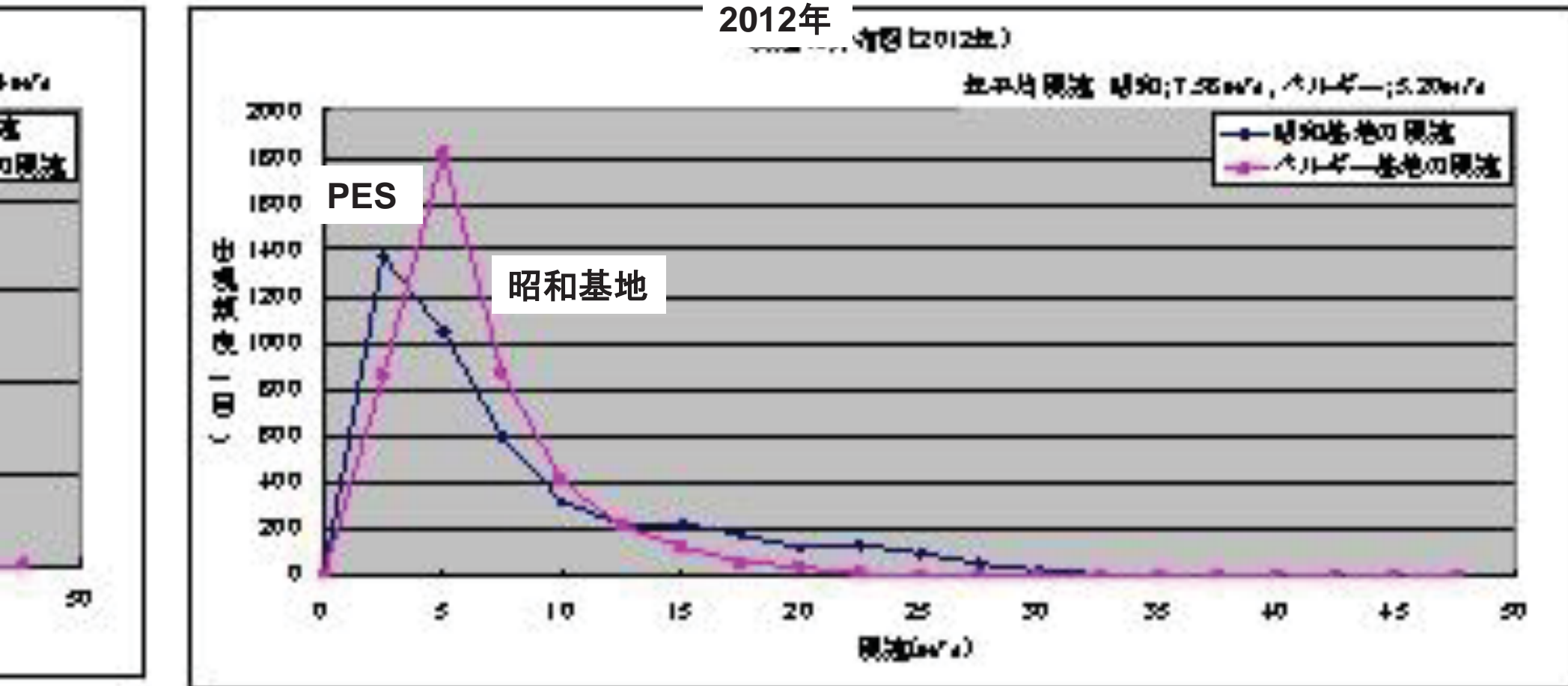
Wind Generator Rutland FM_910

Aluminum Mast
1.6m × 3
with guy wire

Wind Profile at Syowa and Princess Elizabeth Station (PES)

Wind at PES mostly $< 5\text{m/s}$

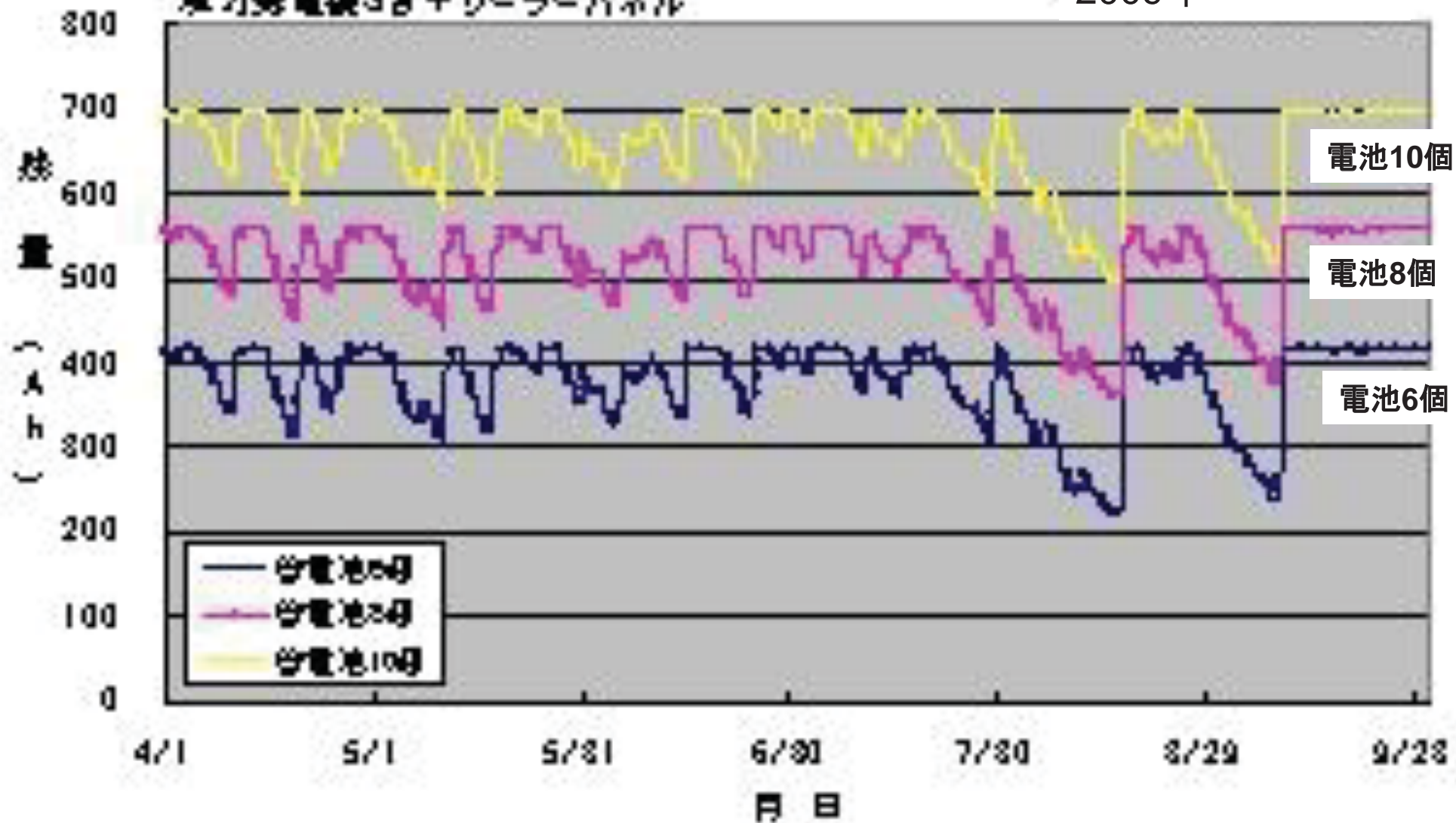
10m/s



冬期蓄電池容量の残量 (ベルギー基地風速データ使用)

風力発電機3台+ソーラーパネル

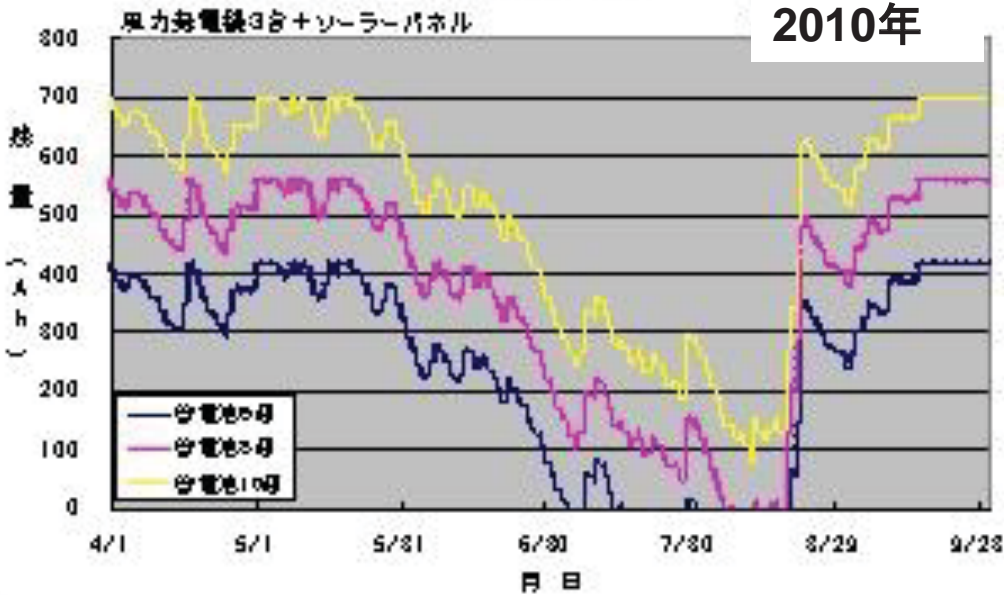
2009年



Estimated Remaining Charge of the Batteries at PES

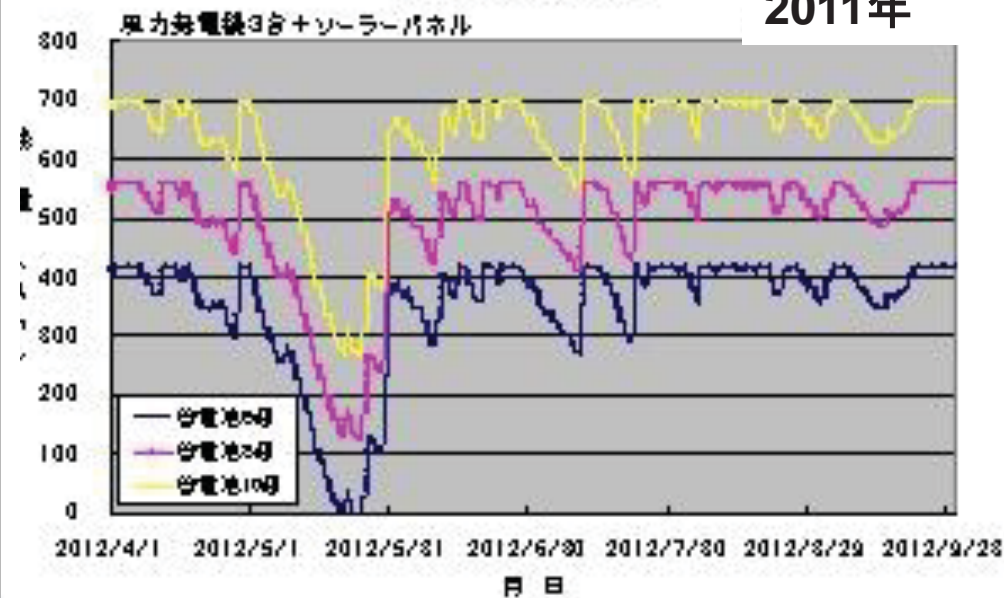
バッテリー残量の試算

2010年



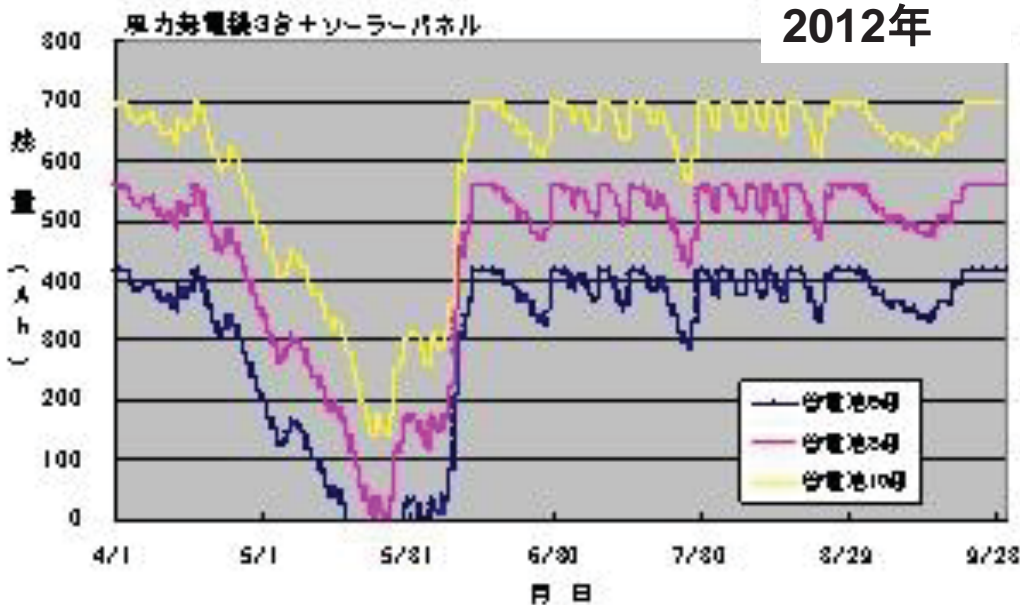
バッテリー残量の試算

2011年



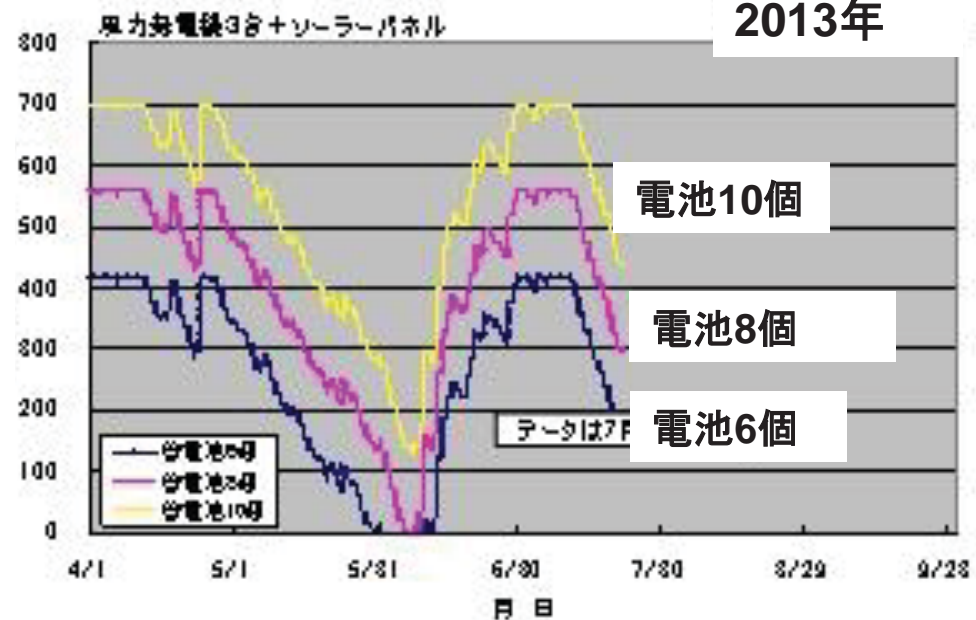
バッテリー残量の試算

2012年



バッテリー残量の試算

2013年



Estimated Power budget based on the Wind Profile at PES in 2008-2011

Average Power consumption of the Instruments 16 W

Wind Generator FM910 (40 W) * 3

Solar Panel GT136MS (60 W) * 4

Batteries Sun Lyte 12-5000X (100Ah) * 10

31kg * 10=310 kg

Battery
Box

ECO
Uni-Pak



箱外寸
1221 × 1145 × 750H

架台空間
1800 × 1200 × 900H

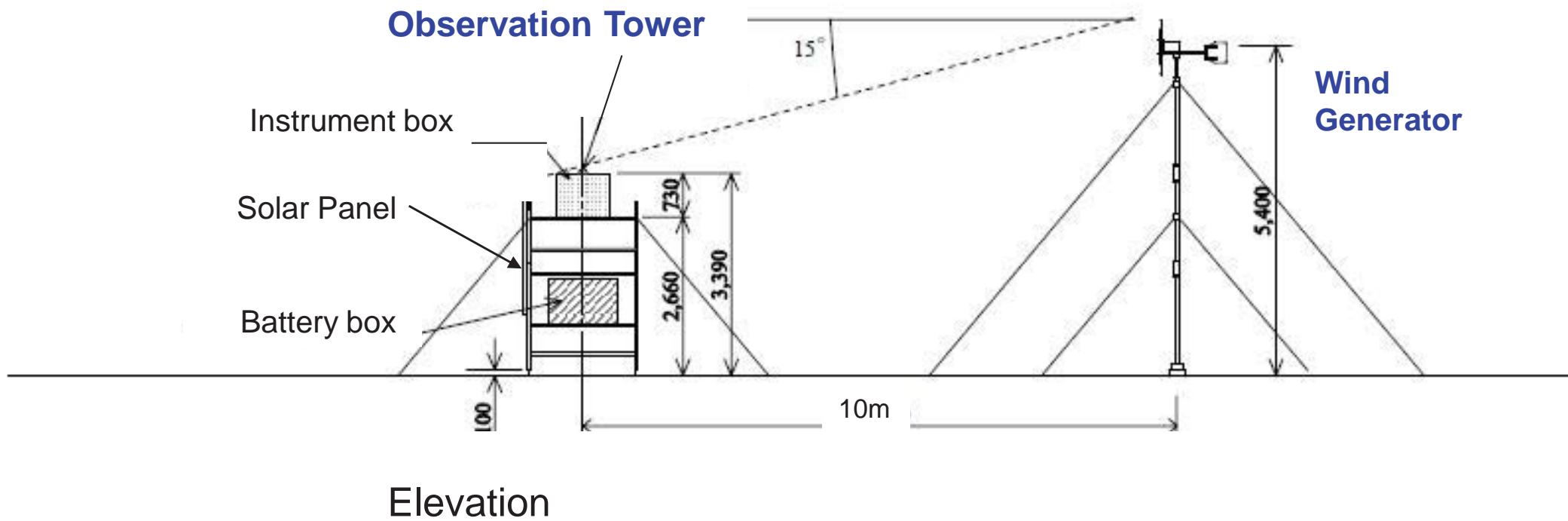
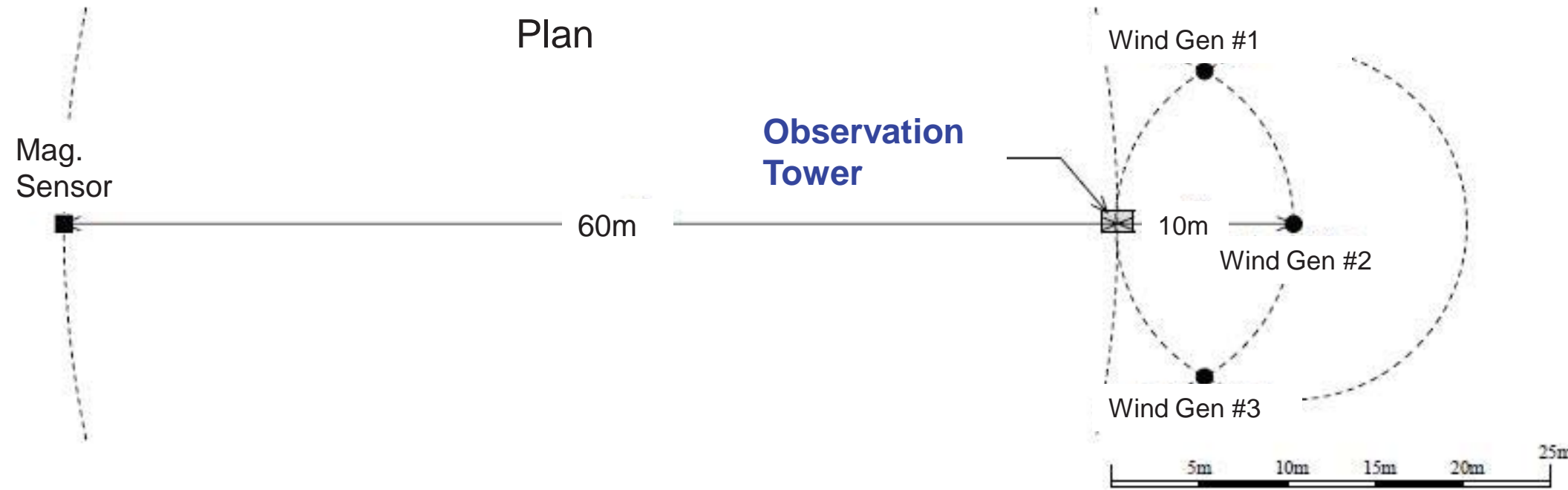
(キャスター付)

Control Box



Sealed Battery (100Ah) × 10





Summary

- Autonomous magnetometer system has been operated in Antarctica since 2007.
- Hybrid power supply system has been tested since 2008.
- Autonomous aurora observation system will be deployed in 2015-2016 and will start observation in April, 2016