Initial Results from the Space Environment Data Acquisition Equipment aboard the International Space Station

Tateo Goka, and SEDA-AP Team
Kiyokazu Koga, Haruhisa Matsumoto, Yugo Kimoto, Shohich Ichikawa, Noriko Yamada, Hideyuki Watanabe, Miho Endo, Daichi Sakoh, Tatsuo Matsueda, and Takahiro Obara

Japan Aerospace Exploration Agency, 1-1, Sengen 2chome, Tsukuba-city, Ibaraki 305-8505

Abstract

Space Environment Data Acquisition equipment (SEDA), which was mounted on the Exposed Facility (EF) of the Japanese Experiment Module (JEM, also known as “Kibo”) on the International Space Station (ISS) , had developed to measure the space environment of the orbit of ISS. This payload module is called SEDA – Attached Payload (AP). SEDA-AP started to measure space environment on Aug. 2009. This paper reports the mission objectives, instrumentation, and initial measurement results of SEDA-AP.

1. Introduction

To support future space activities, it is very important to acquire space environmental data related to space radiation degradation of space parts and materials and spacecraft anomalies. Such data are useful for spacecraft design and manned space activity.

On several satellites of the Japan Aerospace Exploration Agency (JAXA) since the Engineering Test Satellite-V (ETS-V), Technical Data Acquisition Equipment (TEDA) and SEDA have been installed for obtaining the data described above (TEDA and SEDA were installed on 14 spacecrafts for over 20 years).

The SEDA-AP was launched by the Space Shuttle Endeavour (STS-127) on 16 July 2009 (JST) and attached to the JEM-EF on 24 July 2009 (JST). SEDA-AP started to measure space environment on 11 Aug. 2009. The SEDA-AP comprises common bus equipment supporting launch, RMS handling, the power/communication interface with JEM-EF, an extendible mast that extends the neutron monitor sensor 1 m separate from the bus structure, and equipment that measures space environment data. Figure 1 shows a picture of SEDA-AP and the Exposed Facility. Figure 2 depicts a perspective drawing of SEDA-AP.

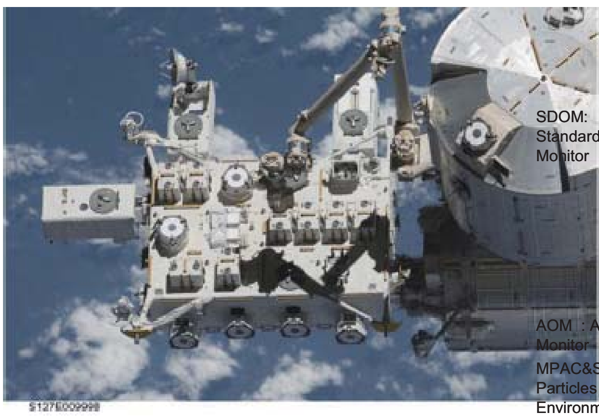


Fig. 1. Picture of the SEDA-AP(left) and EF on ISS/kibo

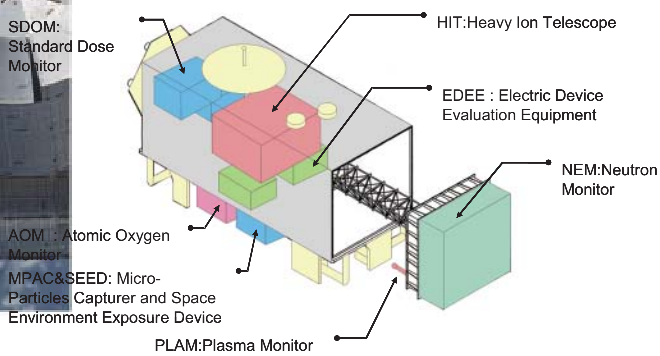


Fig. 2. Perspective drawing of SEDA-AP

2. Instrumentation

Figure 2 shows that SEDA-AP has eight environment monitoring sensors. Its total weight is about 480 kg; its dimensions are 1850 × 1000 × 800 mm (neutron monitor storing condition). An overview and the principle of each instrument are as follows.

2.1 Neutron Monitor (NEM)

Neutrons are very harmful radiation because of their strong permeability attributable to its electrical neutrality. The Neutron Monitor measures the energy of neutrons from thermal to 100 MeV in real time using a Bonner Ball Detector [1][2] and a Scintillation Fiber Detector [3]. The Bonner Ball Detector discriminates neutrons from other charged particles using 3He counters, which have high sensitivity to thermal neutrons. It also measures neutron energy using the relative response, which corresponds to different polyethylene moderator's thickness (6 pcs.). The Scintillation Fiber Detector measures the track of incident particles using a cubic arrangement sensor on which are heaped up 512 scintillator fibers. The sensor discriminates neutrons using differences of these tracks, and measures neutron energy by measuring its track length. Figure 3 depicts an image of NEM.

2.2 Heavy Ion Telescope (HIT)

Using a Solid State Detector, the Heavy Ion Telescope measures the energy distribution of heavy ions (Li–Fe), which cause single event anomalies and damage to electronic devices. The Solid State Detector converts loss energy of heavy ions in the detector to electrical signals. The HIT measures an incident particle's mass from loss energy in each layer (ΔE) and the total loss energy of each layer (E) using the $\Delta E \times E$ method. Figure 4 presents a picture of HIT.

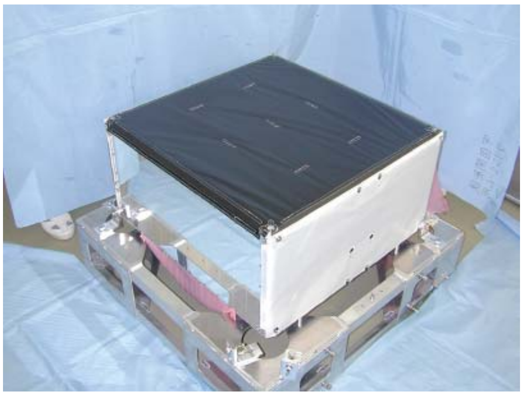


Fig. 3.　The picture of NEM

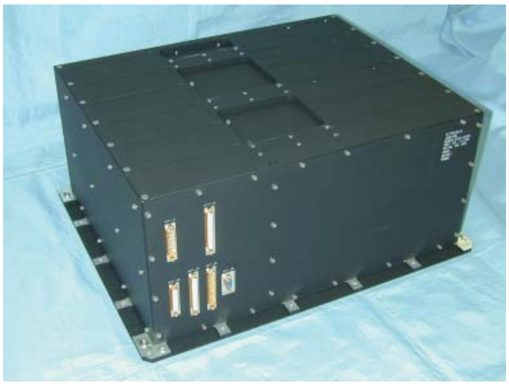


Fig. 4.　Photograph of HIT

2.3 Plasma Monitor (PLAM)

Using a Langmuir probe, Plasma Monitor measures the density and electron temperature of space plasma, which cause charging and discharge of the spacecraft. Figure 5 depicts the PLAM.

2.4 Standard Dose Monitor (SDOM)

The Solid State Detector and scintillator of the Standard Dose Monitor measure the energy distribution of high-energy light particles such as electrons, protons, and α particles, which cause single event anomaly and damage to electronic devices. Figure 6 shows a photograph of SDOM.

2.5 Atomic Oxygen Monitor (AOM)

The Atomic Oxygen Monitor (AOM) measures the amount of atomic oxygen on the orbit of the International Space Station. Atomic oxygen interacts with the thermal control materials and paints, thereby degrading their thermal control ability. The AOM measures the resistance of a thin carbon film that is decreased by atomic oxygen erosion [4]. Figure 7 shows a picture of an AOM.

2.6 Electronic Device Evaluation Equipment (EDEE)

The Electronic Device Evaluation Equipment measures single-event phenomena and radiation damage to electronic parts. Single-event phenomena are induced by the impact of an energetic heavy ion or proton. The occurrence of single-event phenomena is detected by bit flips of memorized data, the sudden increase of power supply current, etc. Figure 8 depicts the EDEE.

2.7 Micro-Particle Capturer (MPAC)

The Micro-Particle Capturer is a device used to capture micro-particles that exist on orbit. Silica-aerogel and gold plates are used to capture micro-particles. After the retrieval of MPAC, the size, composition, and collision energy, etc. of captured particles are evaluated [5].

2.8 Space Environment Exposure Device (SEED)

The Space Environment Exposure Device is a device used to expose materials for space use. After SEED retrieval, degradation of these materials caused by the space environment, such as high energy radiation, atomic oxygen and UV, will be evaluated. Figure 9 portrays a picture of both MPAC and SEED hardware [5].

Fig. 5. The picture of PLAM

Fig. 6. Photograph of SDOM

Fig. 7. Photograph of AOM

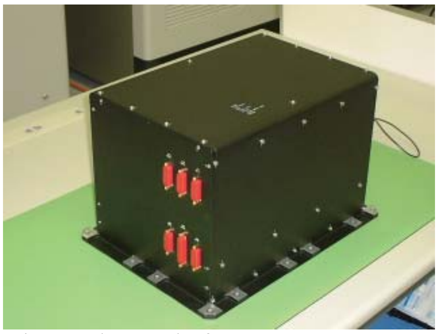


Fig. 8. Photograph of EDEE

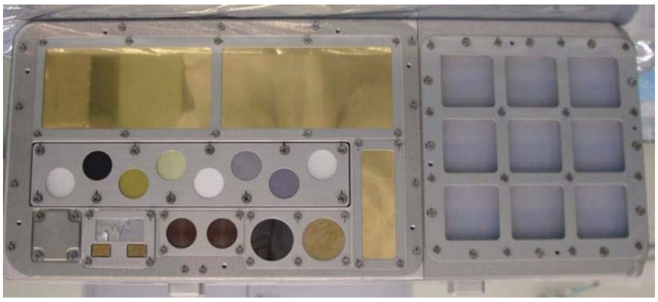


Fig. 9. Photograph of MPAC & SEED

3. Applications of the data

Applications of the data is as follows,

(1) Development of various space environmental data base for many utilization needs

- Making and maintenance of space environmental model for space craft design
- Support for astronauts exposed to space radiation
- Support for space weather forecasting
- Contributions to scientific fields
- Investigation of space radiation degradation of parts & materials and space craft anomalies caused by space environment
-

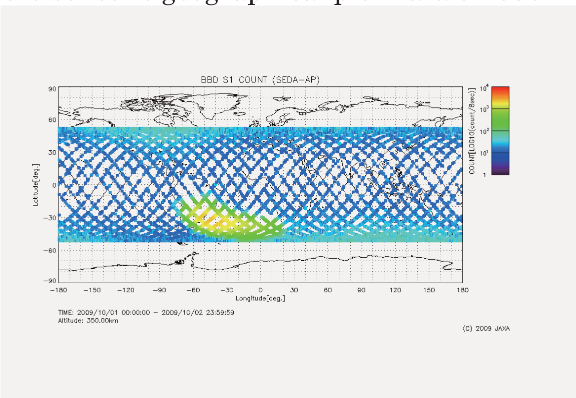
(2) On-orbit verification of the “Kibo” exposed facility utilization technology

- On-orbit verification of APBUS technology that utilizes the “Kibo” exposed facility
- On-orbit verification of experimental payload integration technology that utilizes the “Kibo” exposed facility

4. Measurement Results

4.1 BBND Nutron measurement results

Figure 10 shows BBND S-1 sensor’s geographical plot data, and Figure 11 shows BBND S-6 sensor’s geographical plot data on 350km altitude on 1 Oct.2009,



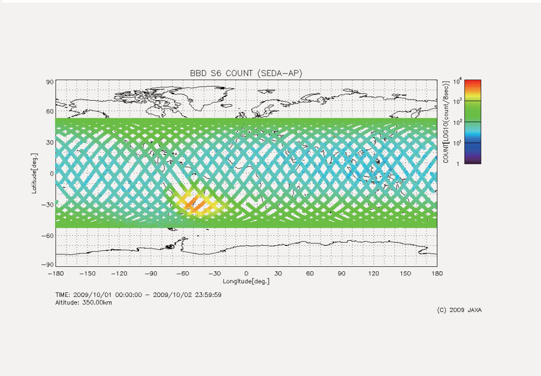


Fig. 10 BBND S-1 sensor’s geographical plot data　Fig. 11 BBND S-6 sensor’s geographical plot data

4.2 FIB Nutron measurement results

Figure 12 shows the neutron tracks actually obtained from the onboard sensor. The left side is Y direction of sensor, and the right side is X direction. The both direction has 256 (16x16) squares shows each scintillation fiber (6x3mm) output. Figure 13 shows proton tracks which started from the first layer of the fiber (in the case of the neutron measurement mode was off).

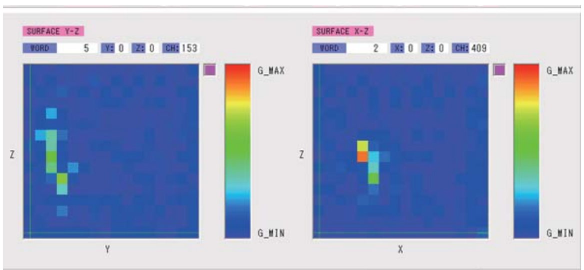


Fig. 12 a neutron track obtained on ISS

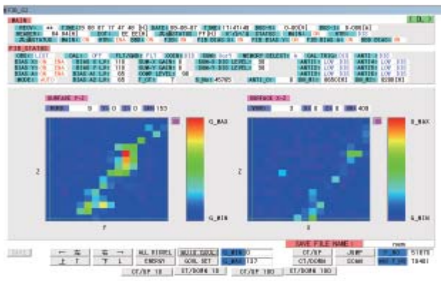


Fig. 13 a proton track obtaioned on ISS

4.3 SDOM Measurement results

Figure 14 shows electron (0.28-0.79MeV) measurement results of SDOM, that is overlapped on the world map. SAA (South Atlantic anomaly), radiation enhanced region related to the offset of earth magnetic field, and horn region of outer radiation belt are clearly shown. Figure 15 shows proton (0.78-1.09MeV) measurement results of SDOM, that is also overlapped on the world map. SAA (South Atlantic anomaly) are clearly shown.

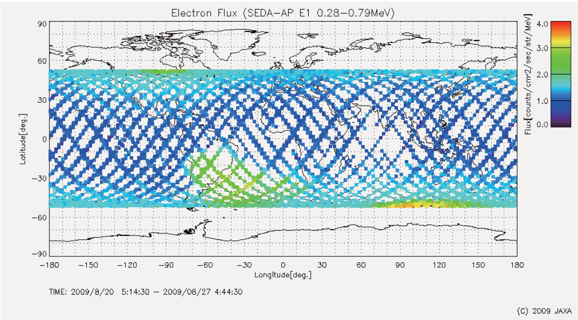


Fig. 14 SDOM Electrons (0.28-0.79MeV) plot data

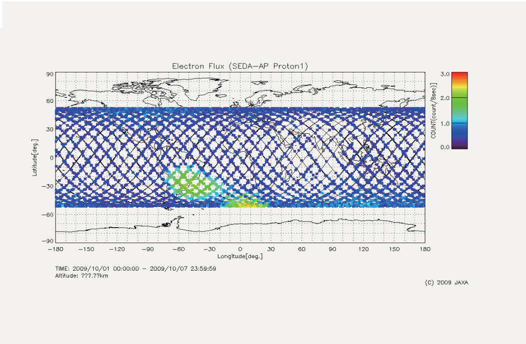


Fig. 15 SDOM Protons (0.78-1.09MeV) plot data

4.4 EDEE measurement results

EDEE Observed Results（2009/8/15~2009/10/23) are showed with the name of devices under test and Single Event Upset (SEU) , Single Event Latchup (SEL), and Single Event Burnout (SEB) measuremnt results, as following

– V70-MPU SEU/SEL : Not observed
– 1M SRAM SEU : 5 upsets observed/512K
  SEL : Not observed
– PowerMOSFET(@175V) SEB : Not observed

5. Summary

Space environment data in JAXA, which include data from SEDA-AP, are available to the public as data of the Space Environment and Effect System (SEES; http://sees.tksc.jaxa.jp). Those data will be used widely by academic and industrial users in laboratories, universities, JEM experiment investigators, and others in spacecraft operation, engineering fields, and scientific research. Data from SADA-AP will also be used to develop the Japanese space environment model [6].

References

[1]Matsumoto, H., T. Goka, K. Koga, S. Iwai, T. Uehara, O. Sato, and S. Takagi, Real-time measurement of low-energy-range neutron spectra on board the space shuttle STS-89 (S/MM-8), Radiation Measurements, 33, 321, 2001.

[2]Koshiishi, H., H. Matsumoto, A. Chishiki, T. Goka, T. Omodaka, Evaluation of neutron radiation environment inside the International Space Station based on the Bonner Ball Neutron Detector experimants, Radiation Measurements, 42, 1510-1520, 2007.

[3]Koga, K., T. Goka, H. Matsumoto, Y. Muraki, K. Masuda, and Y. Matsubara, Development of the fiber neutron monitor for the energy range 15-100 MeV on the International Space Station (ISS), Radiation Measurements, 33, 297, 2001.

[4]Galica, G. E.et.al, “Atomic Oxygen Monitor Based On Carbon Actinometers,” Proceedings of the 10th International Symposium on “Materials in a Space Environment” (ISMSE) and 8th International Space Conference on “Protection of Materials and Structures from the Space Environment” (ICPMSE), June 2006 (SP-616, September 2006)

[5] Yugo Kimoto, et. al,”Space Environment Effects on Materials at Different Positions and Operational Periods of ISS”, Proceeding of The 8th International Space Conference on “Protection of Materials and Structures from the Space Environment” (ICPMSE) May 2008

[6] Goka, T., H. Matsumoto, and S. Takagi, Empirical model based on the measurements of the Japanese spacecraft, Radiation Measurements, 30, 617, 1999.

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JAXA

RASEDA 12/17, 2008

SEDA-AP (Space Environment Data Acquisition Equipment - Attached Payload)

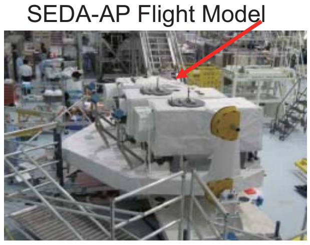
●MISSION OBJECTIVES

- Revising of Space Environment Model .
- Support of space radiation exposure management to astronauts from Solar Flares, and Galactic Cosmic Ray.
- Support of the space weather nowcast.
- Contribution to the space science.
- Elucidation of degradation, soft error of EEE parts and materials due to space environment.

●MISSION SUMMARY

SEDA-AP started to measure space environment at the Exposed Facility of Japanese Experimental Module （JEM) on 11 Aug. 2009.

SEDA-AP Flight Model



SEDA-AP on the ELM-ES (Carrier)

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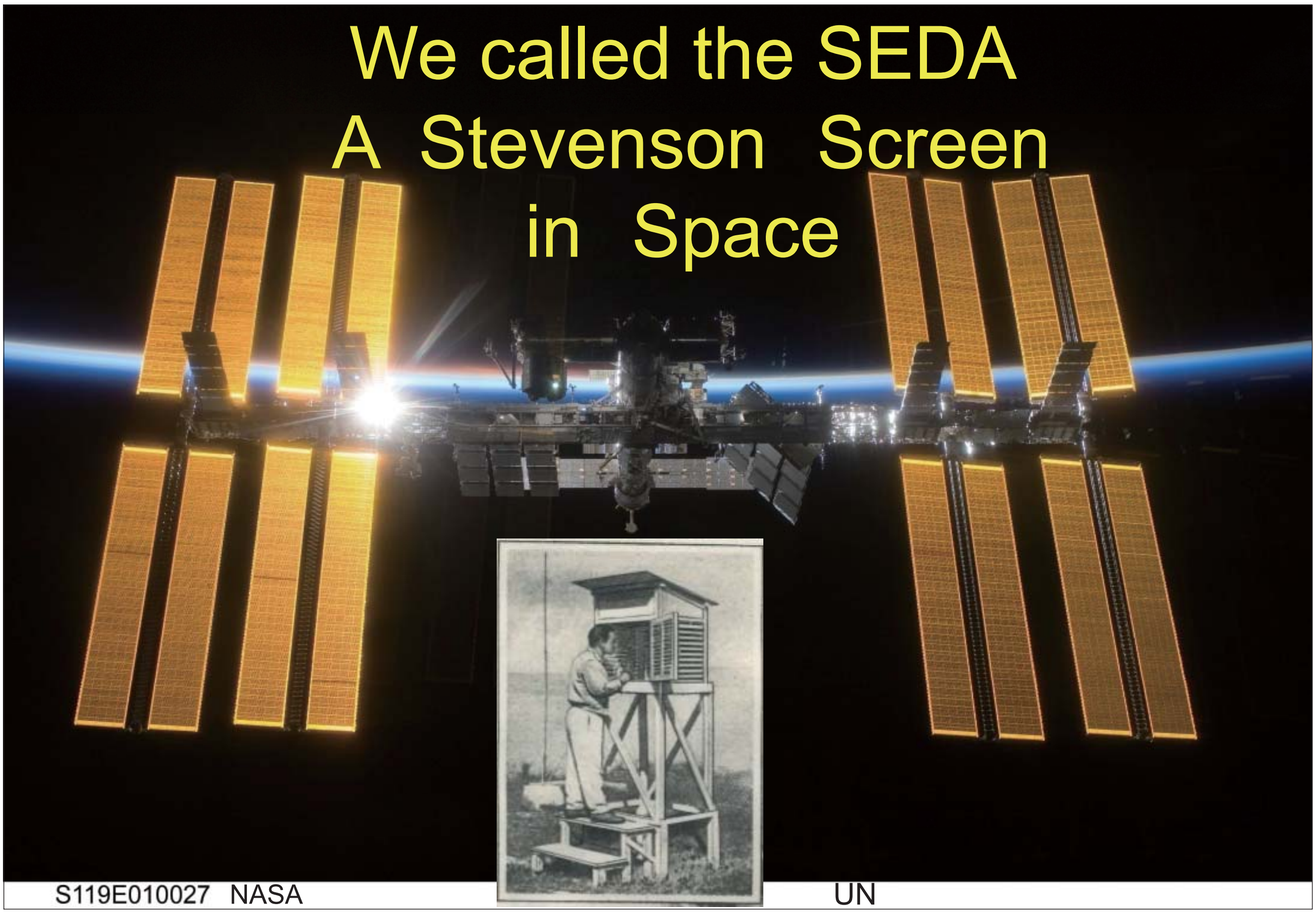
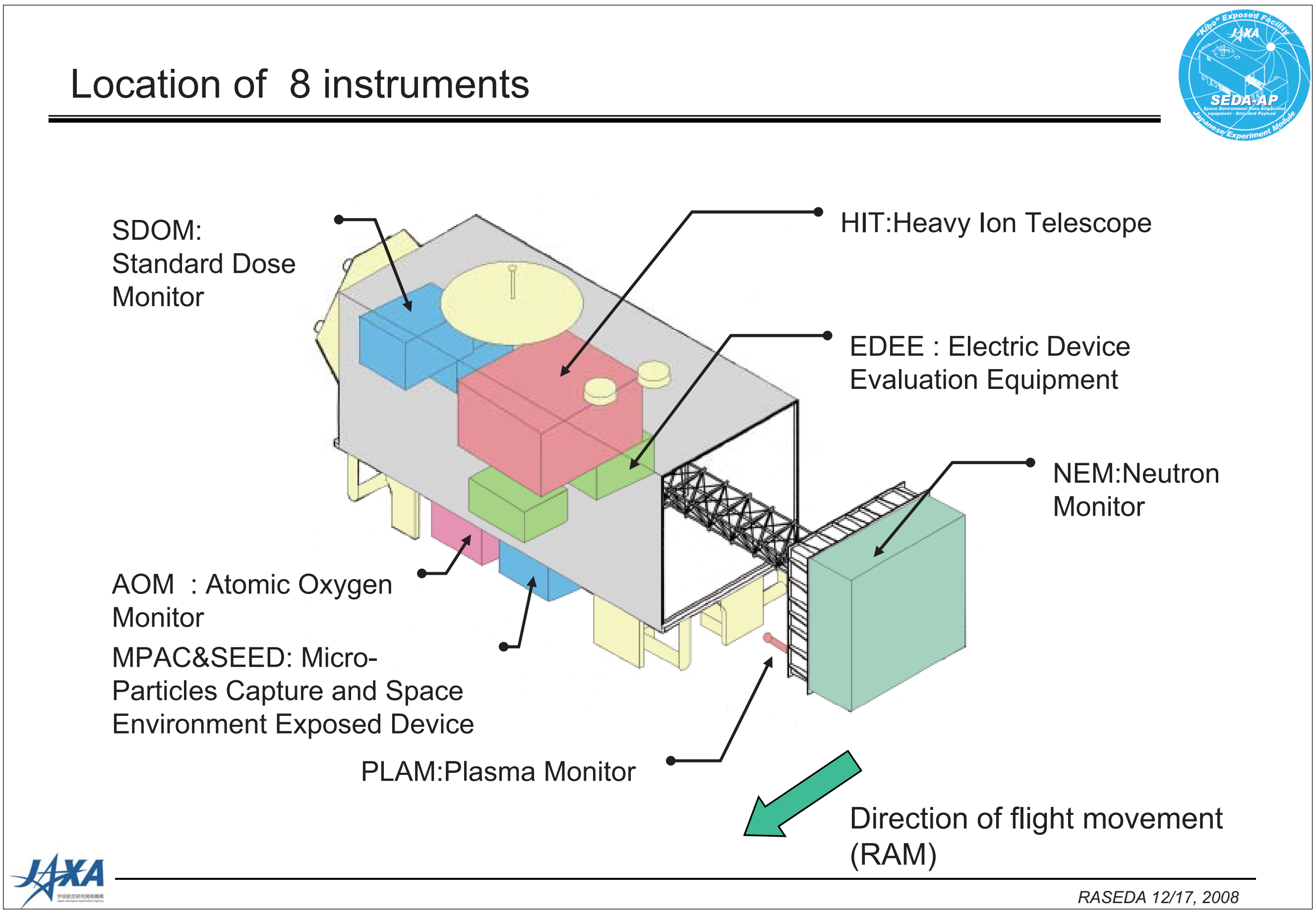

We called the SEDA
A Stevenson Screen
in Space
S119E010027 NASA
UN


Location of 8 instruments
SEDA-AP
SDOM:
Standard Dose
Monitor
HIT:Heavy Ion Telescope
EDEE : Electric Device
Evaluation Equipment
NEM:Neutron
Monitor
AOM : Atomic Oxygen
Monitor
MPAC&SEED: Micro-
Particles Capture and Space
Environment Exposed Device
PLAM:Plasma Monitor
Direction of flight movement
(RAM)
JAXA
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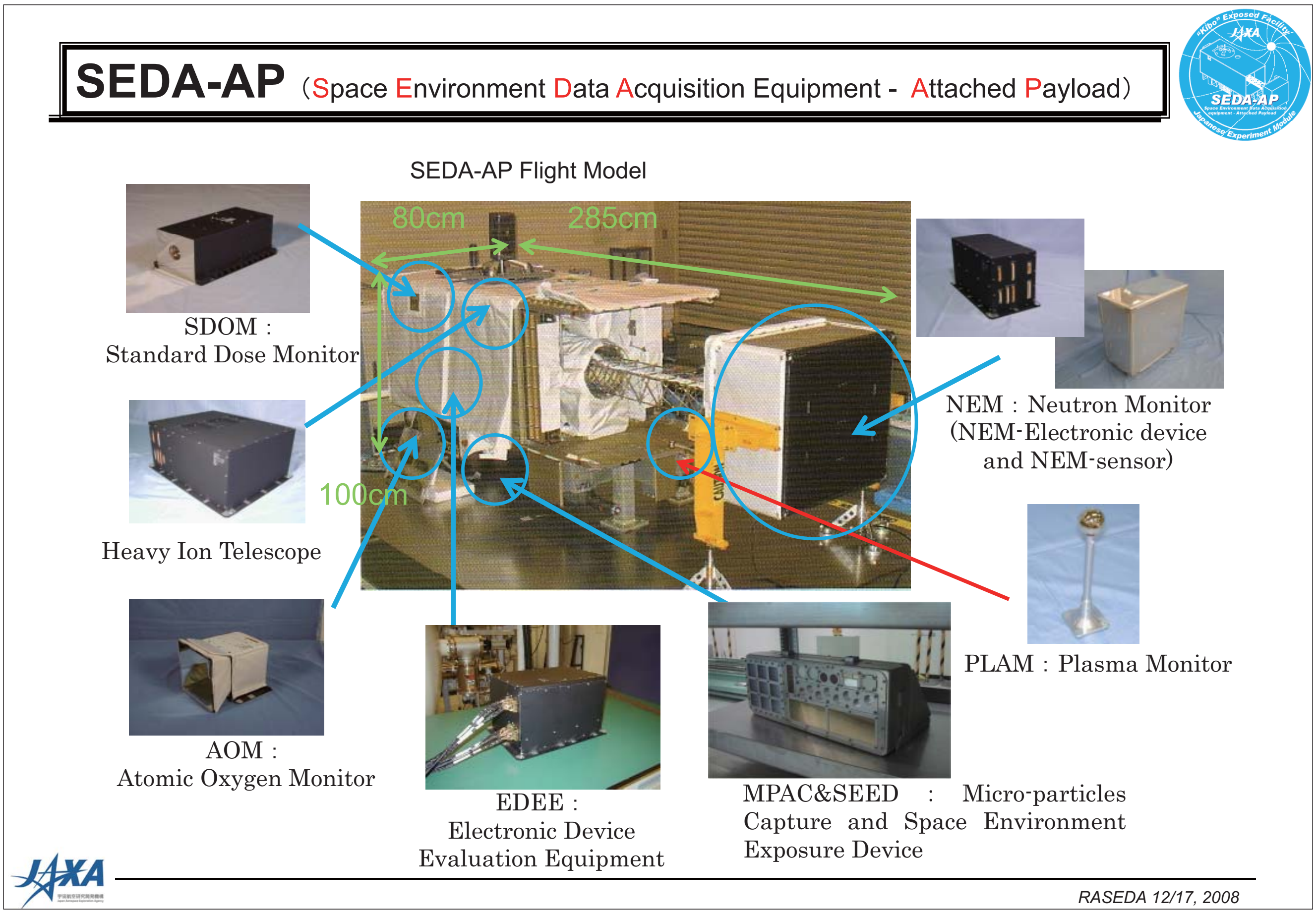
SEDA-AP (Space Environment Data Acquisition Equipment - Attached Payload)
SEDA-AP Flight Model
80cm
285cm
100cm
SDOM : Standard Dose Monitor
Heavy Ion Telescope
AOM : Atomic Oxygen Monitor
EDEE : Electronic Device Evaluation Equipment
MPAC&SEED : Micro-particles Capture and Space Environment Exposure Device
NEM : Neutron Monitor (NEM-Electronic device and NEM-sensor)
PLAM : Plasma Monitor
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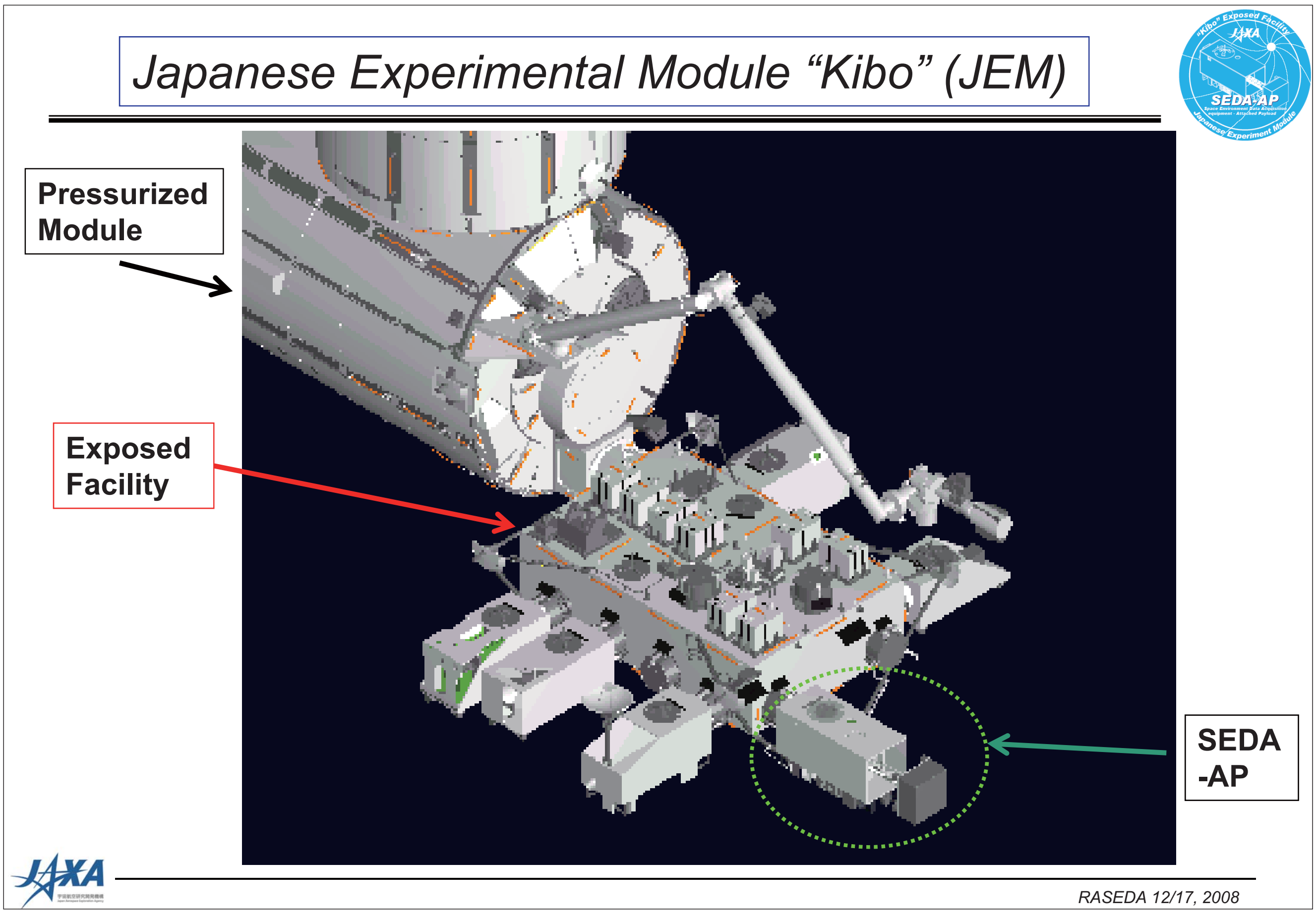
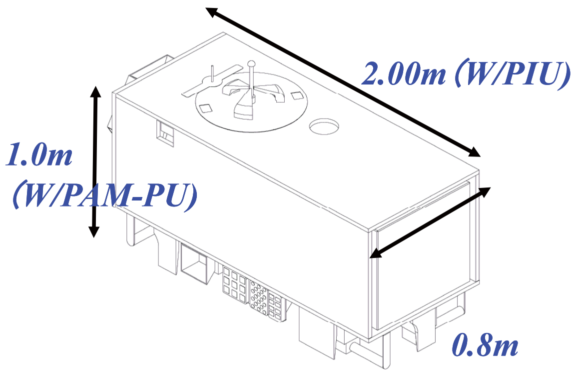
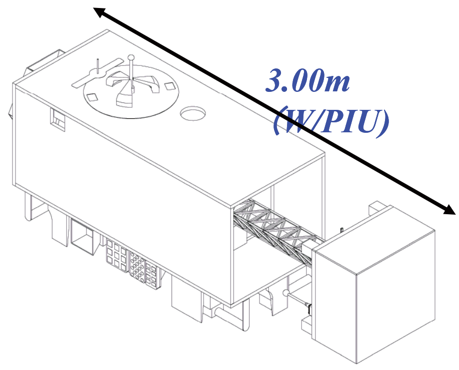

Japanese Experimental Module "Kibo" (JEM)
Pressurized Module
Exposed Facility
SEDA -AP
RASEDA 12/17, 2008

SEDA-AP System Overview



Launch/Return Configuration
(MST stowed)



On Orbit Configuration
(MST extended)

Total Weight	:	Approx. 450kg
On-orbit Power Consumption	:	Approx. 220W
Data Communication	:	MIL-STD-1553B)

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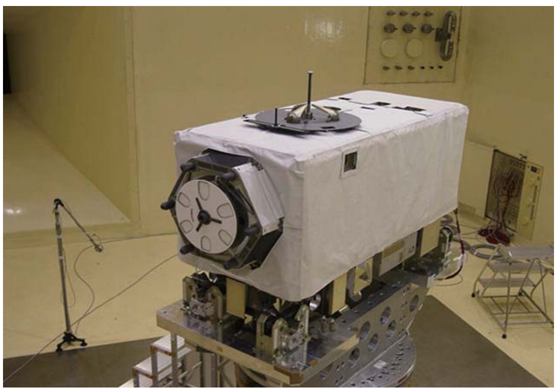
Picture of SEDA-AP



Launch Configuration

(NEM-S is stowed in the SEDA-AP structure)

On Orbit Configuration

(NEM-S is extended 1 m from the SEDA-AP structure)

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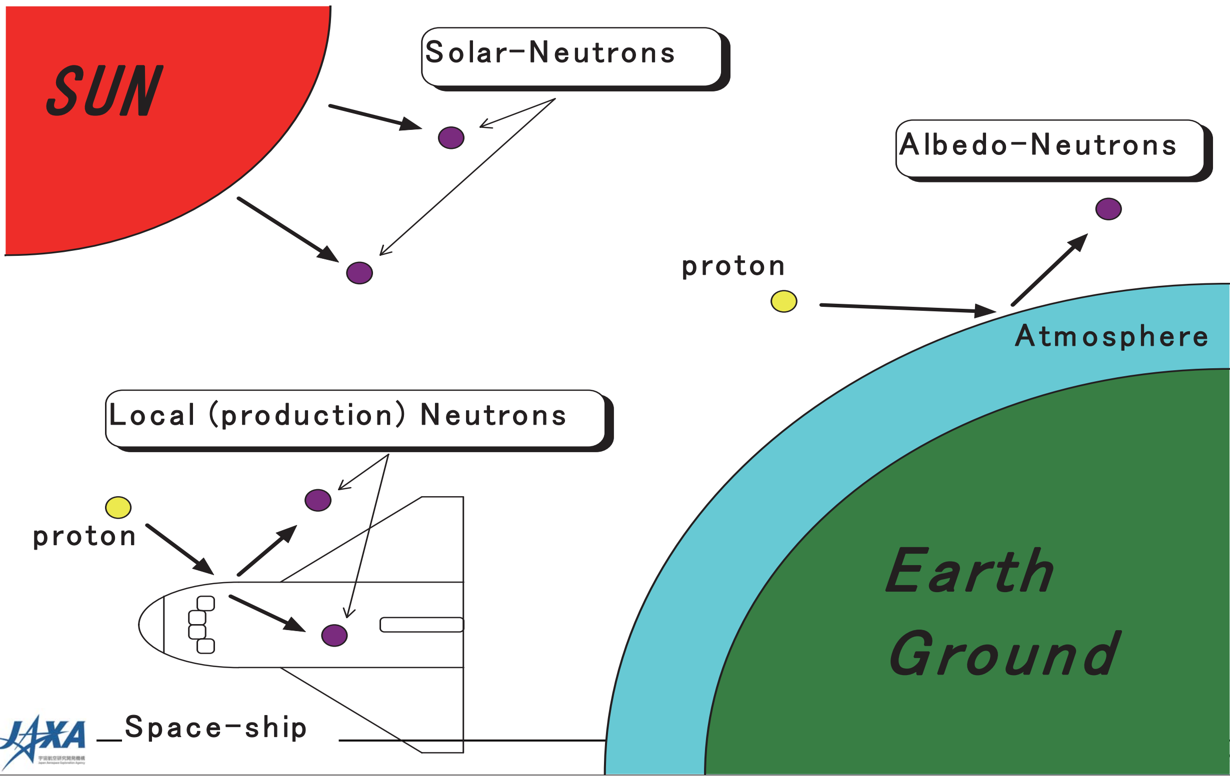
Outline of instruments

neutrons in space



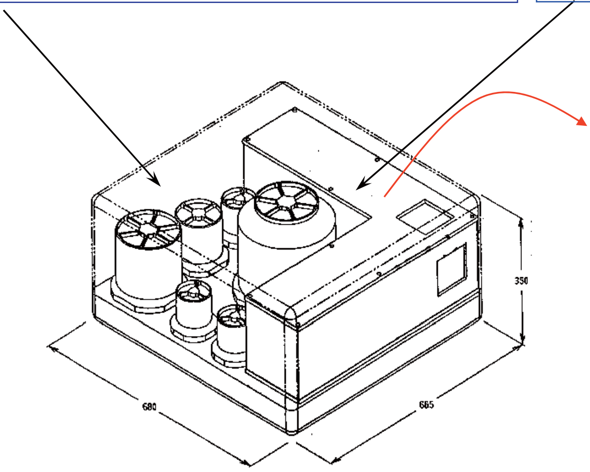
Two types of Neutron Monitor

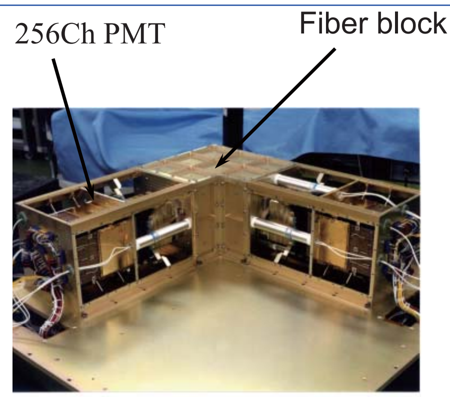
BBND：Bonner Ball Neutron Detector

Measurement energy range:
0.025eV(thermal neutron)～15MeV
Max. count number : 1×10^4 count/sec

FIB ：Fiber-type neutron detector

Measurement energy range: 15～100MeV
Max. event number : 50 event/sec





Engineering Model of FIB

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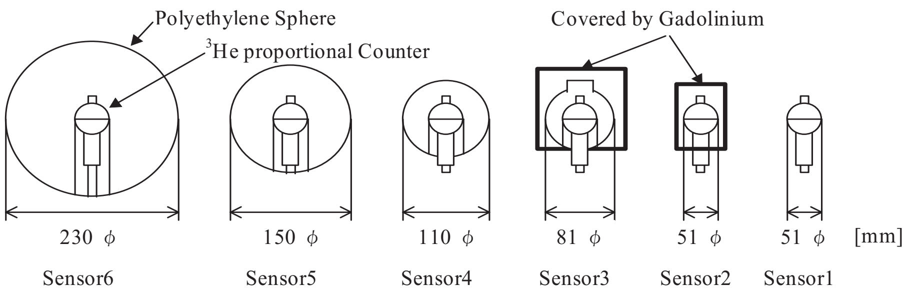
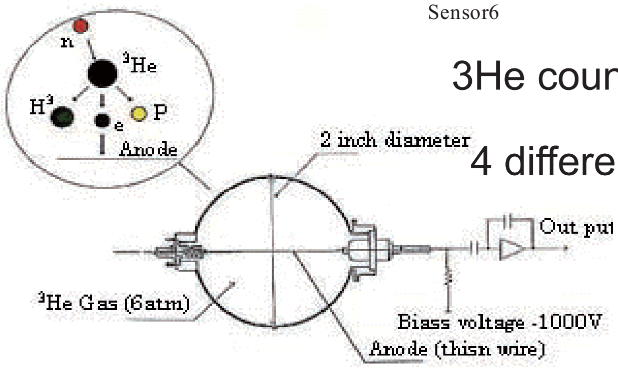
BBND：Bonner Ball Neutron Detector

0.025eV (thermal neutron)～15MeV



3He counter and polyethylene moderator

4 different thickness of polyethylene spheres (1.5cm, 3cm, 5cm, and 9cm)



3He counter

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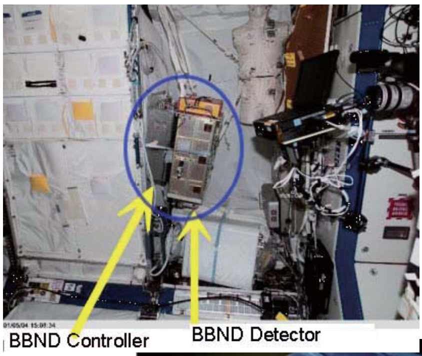
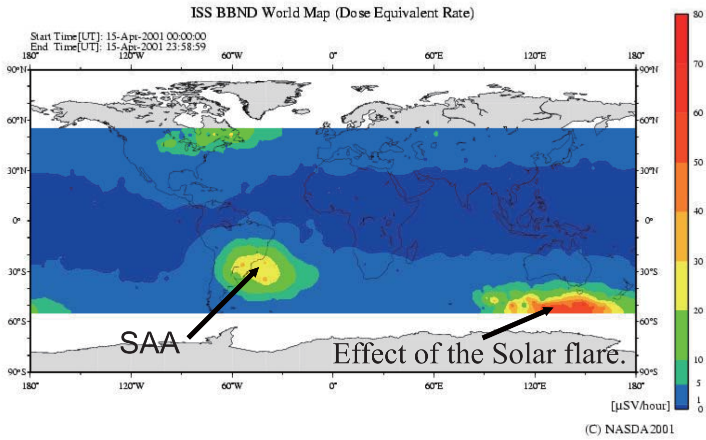
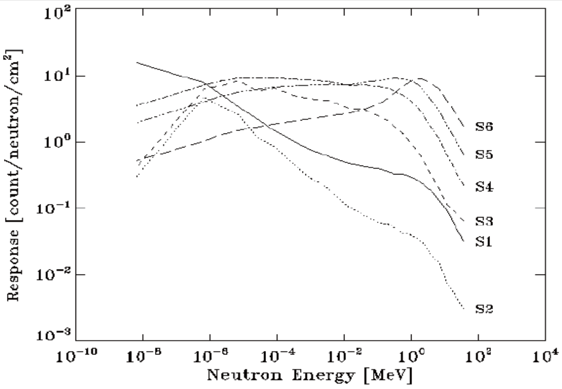
BBND PreFlight Data on board ISS and STS

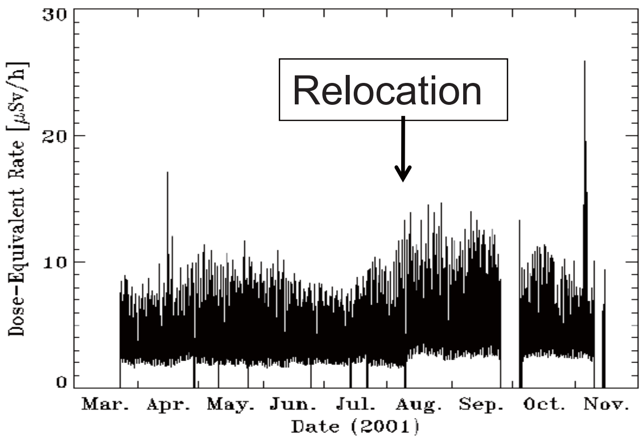
The first flight of BBND was carried out on board STS-89 (inside) in 1998, and next flight was done as a part of the HRF(Human Research Facility) on board ISS –US Lab. (inside) from March, 2001 to November 2001 (9 Moths).

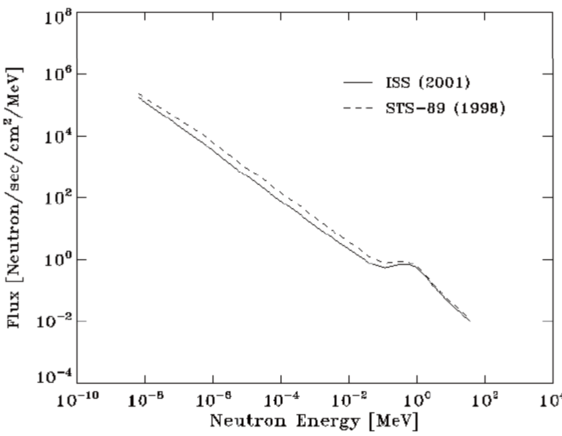


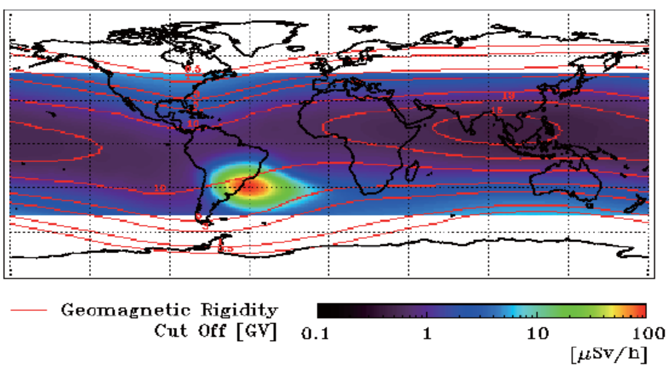


The measuring results (dose equivalent) on board ISS on April 15th, 2001.









BBND Pre Flight Data on board ISS and STS (inside)
(H.Koshiishi, et. al, Radiation Measurements, 42 (2007)

SEDA-AP
BBND Measurement Data

S-1 ~ S-2 Count Data

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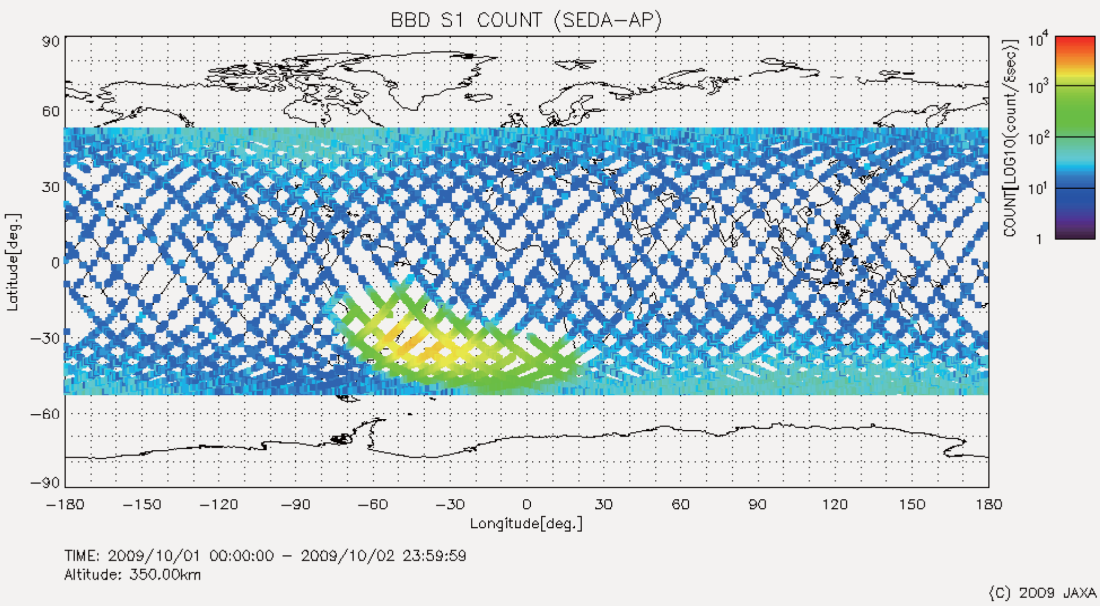
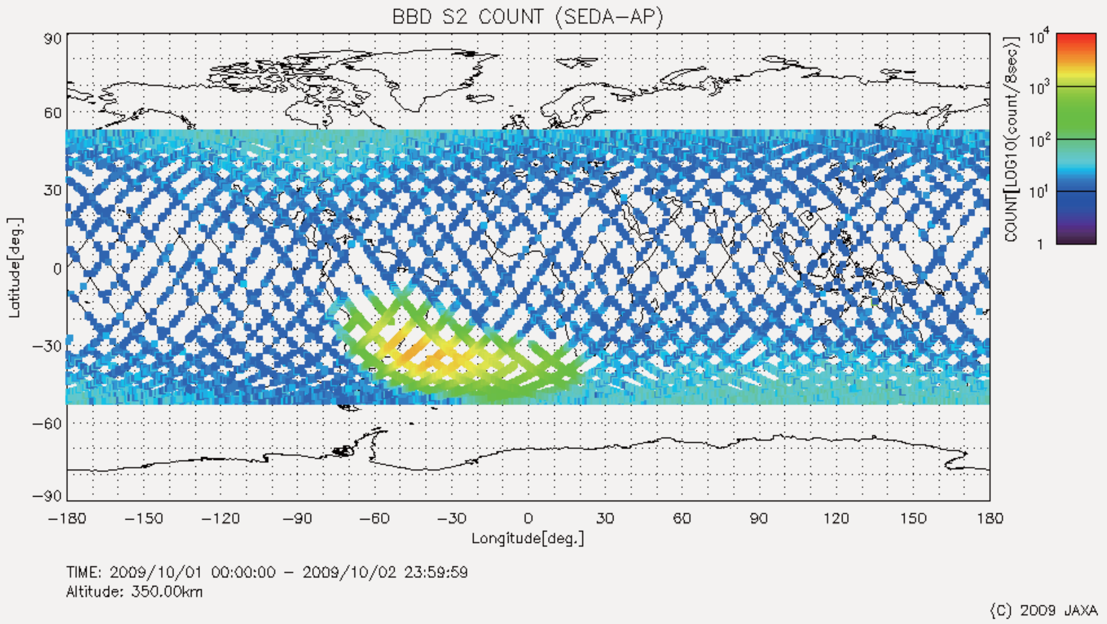
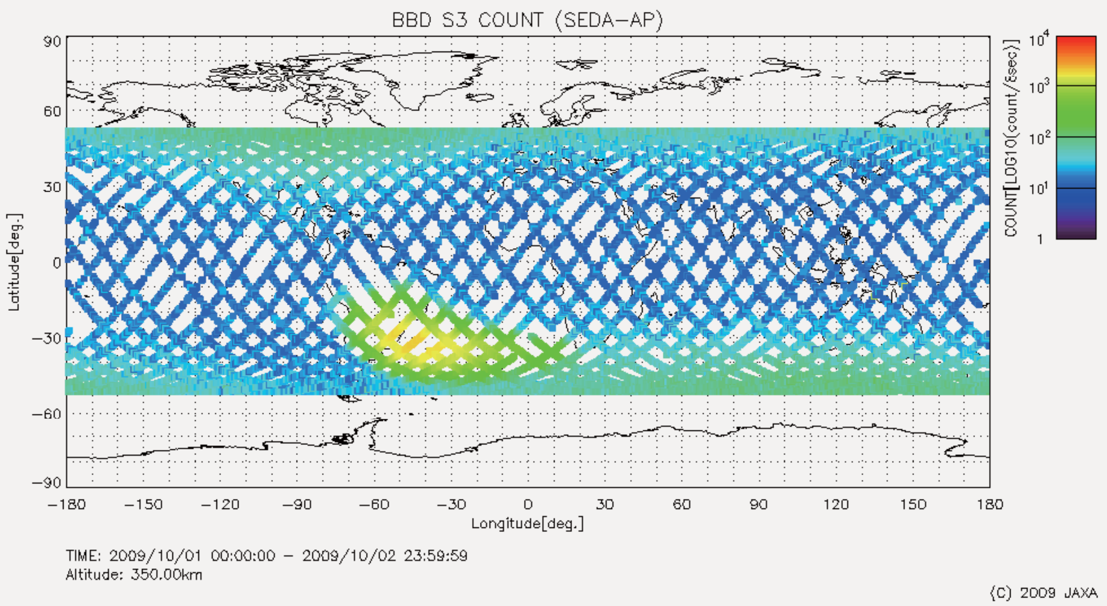
BBND S-1 Data



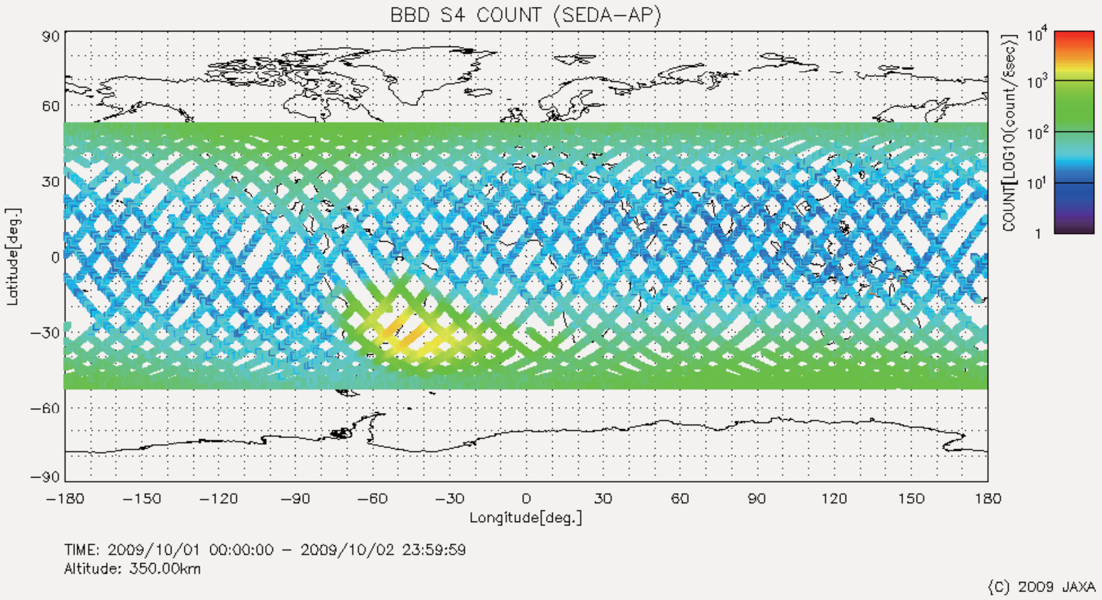
BBND S-2 Data



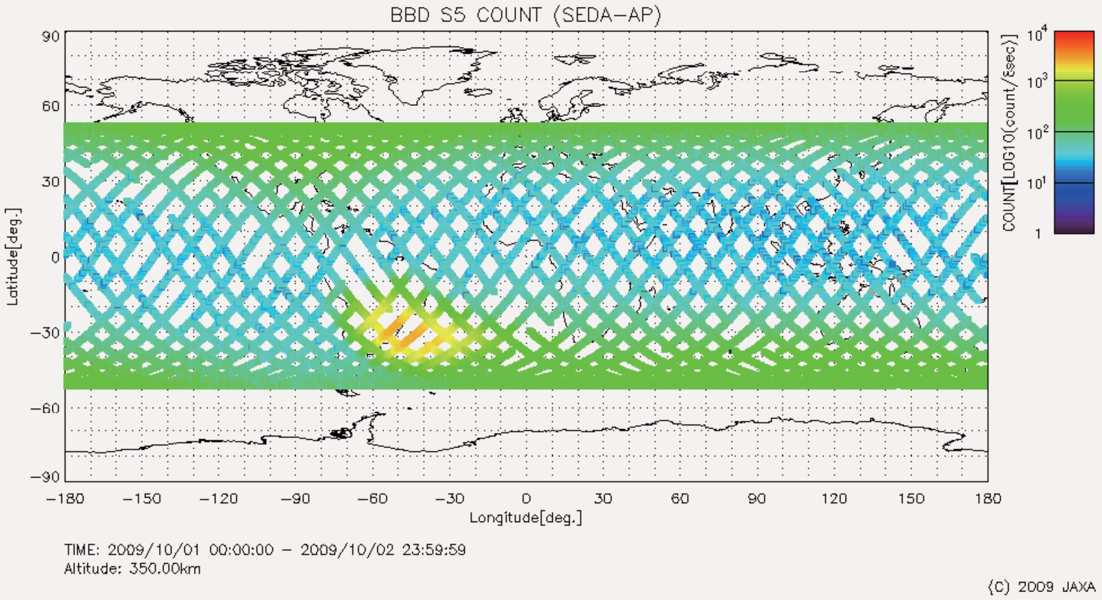
BBND S-3 Data



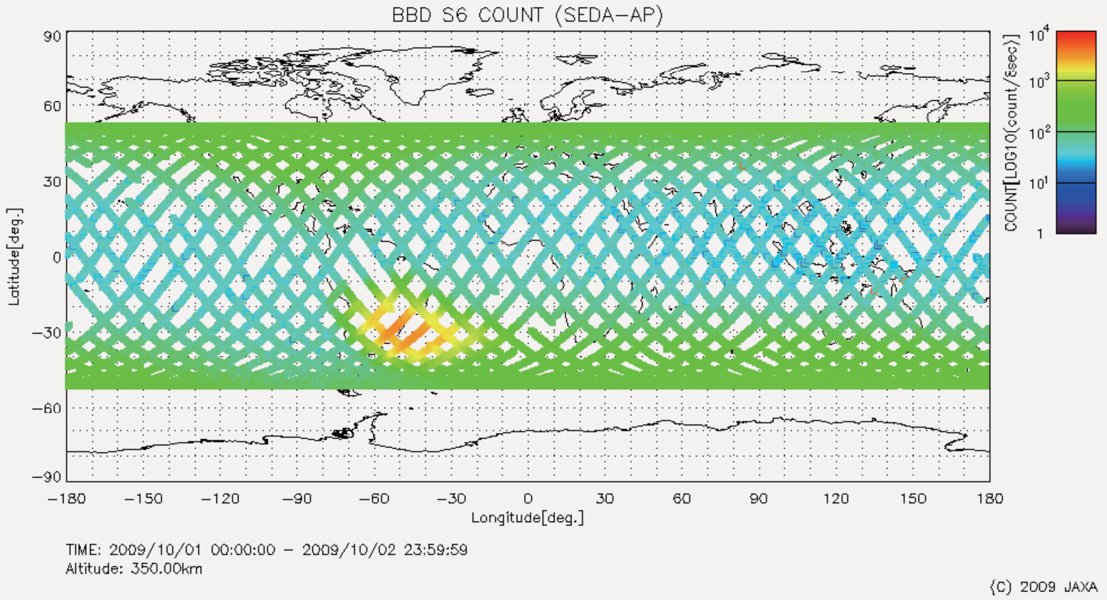
BBND S-4 Data



BBND S-5 Data



BBND S-6 Data



FIB : Fiber-type neutron detector

15～100MeV and Arrival Direction

This Detector measures neutron like a electrical version of Wilson Cloud Chamber using plastic scintillation fibers stacks (16X16 on X and Y planes)

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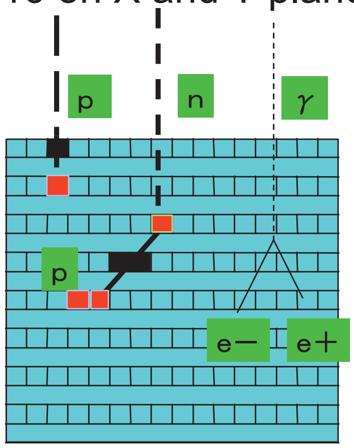
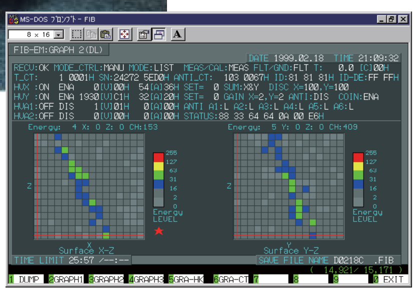


Principle of neutron detection

Fiber Block

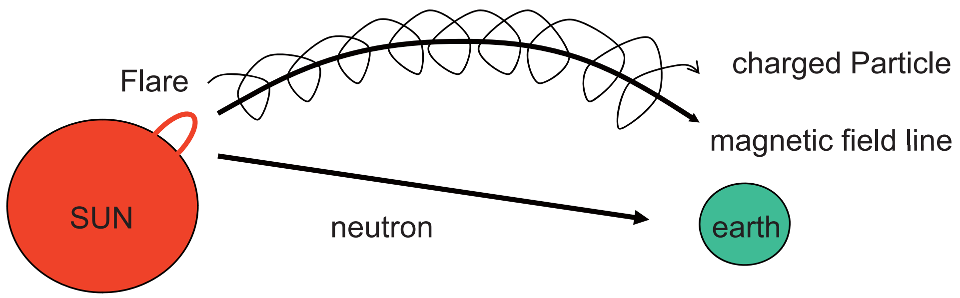


Example of proton track

RASEDA 12/17, 2008

Nowcast of the Solar flare charged particles

Measuring the Solar neutron from Solar flare is good indicator of predicting of high energy particle, because of the neutron is not affected by Solar magnetic field. We use this detector to inform astronauts on the arrival of strong charged particle radiation after about 1hour later (nowcast).



RASEDA 12/17, 2008

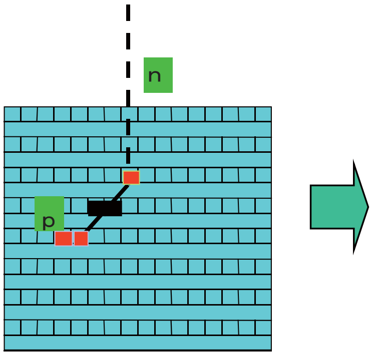
SEDA-AP
Fiber-type neutron detector

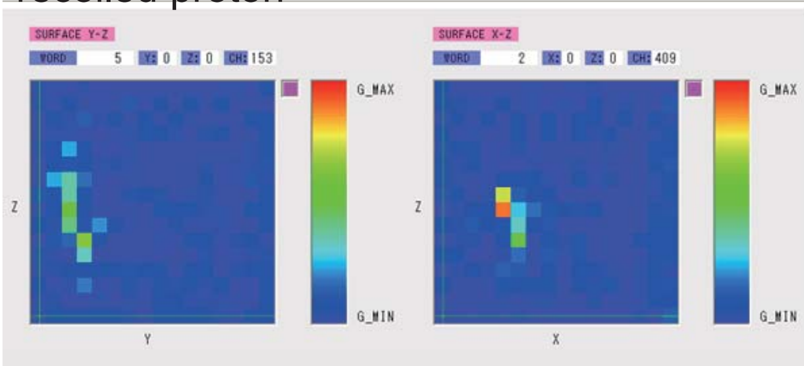
Proton data and Neutron data

RASEDA 12/17, 2008

Neutron Measurement results of FIB

This detector measures path of recoiled proton by using scintillation of cubic arrangement of plastic scintillation fiber.
The energy and arrival direction of an incident neutron could be determined by measuring path lengths and track of recoiled proton





Actuary obtained track of neutron (With Anti)

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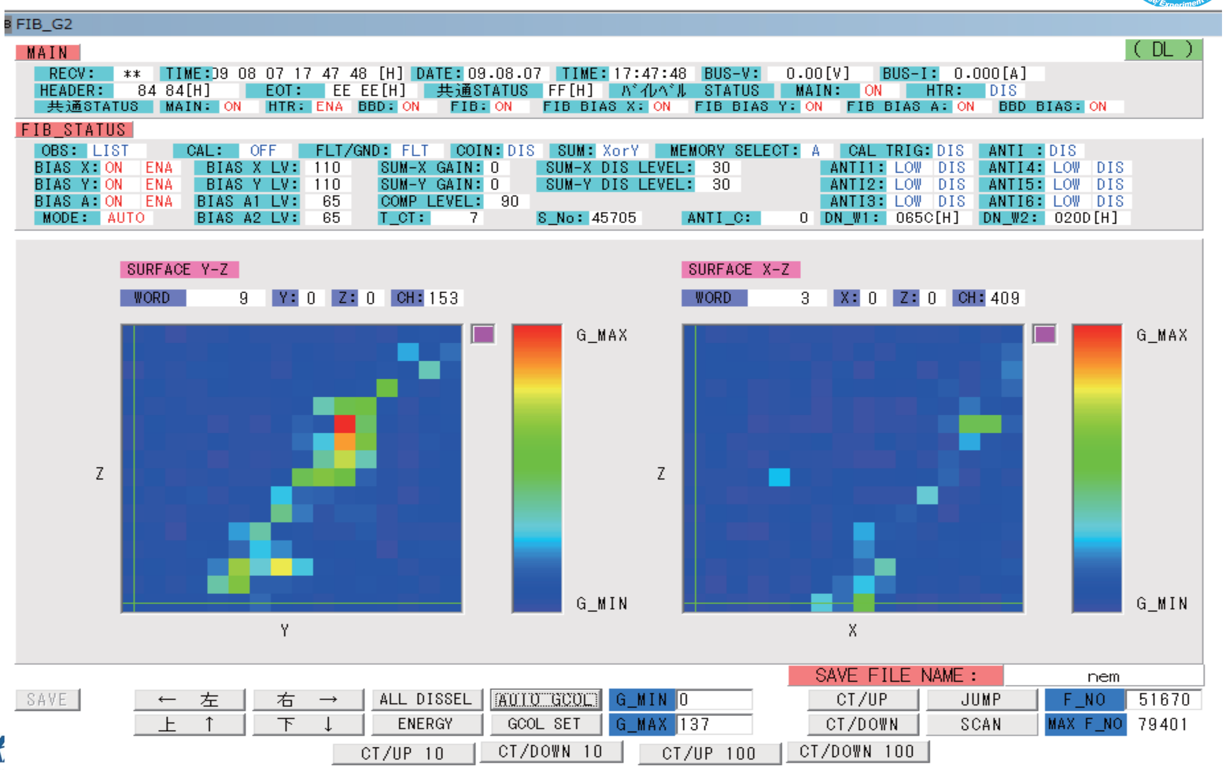
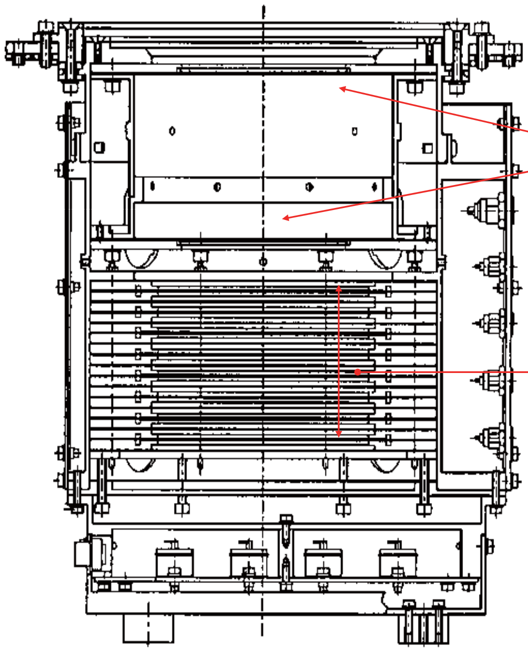
On Orbit Measurement Data (No-Anti, Proton Track Data)



HIT: Heavy Ion Telescope



Cross-sectional view of HIT sensor

Particle : Li ~ Fe
Li : 10 to 43 MeV/nuc
C : 16 to 68 MeV/nuc
O : 18 to 81 MeV/nuc
Si : 25 to 111 MeV/nuc
Fe : 34 to 152 MeV/nuc

Picture of HIT sensor

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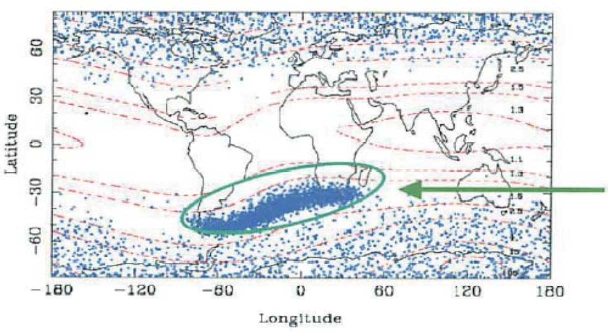
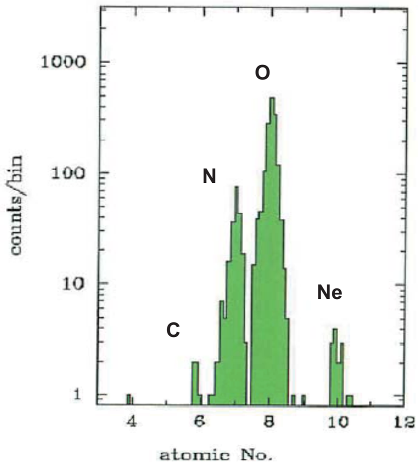
Same type of HIT sensor was installed on

ADEOS(MIDORI in Japanese) observed ACR

The geographic distribution: Oxygen





Elemental distribution of trapped nuclei.

T. Kohno, H. Miyasaka, et.al., Heavy ion observed with MIDORI satellite: trapped ACR, Radiation Measurements ,1999

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SEDA-AP
HIT
Measured
Count data

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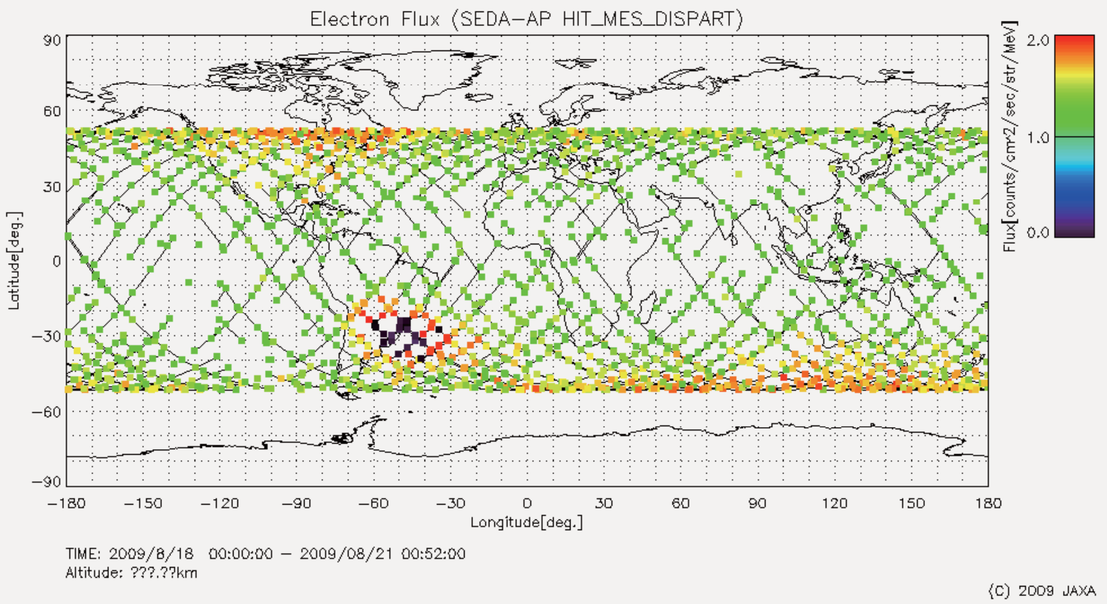

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FEATURE

Cosmic Rays Hit Space Age High

09.29.2009

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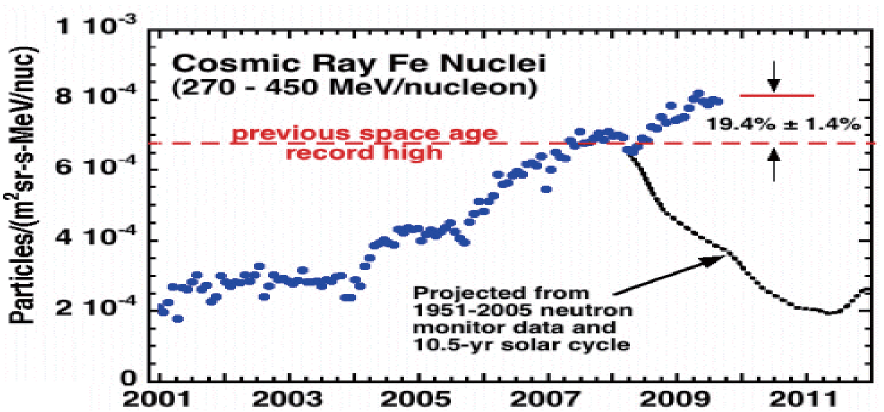
September 29, 2009: Planning a trip to Mars? Take plenty of shielding. According to sensors on NASA's ACE (Advanced Composition Explorer) spacecraft, galactic cosmic rays have just hit a Space Age high.

"In 2009, cosmic ray intensities have increased 19% beyond anything we've seen in the past 50 years," says Richard Mewaldt of Caltech. "The increase is significant, and it could mean we need to re-think how much radiation shielding astronauts take with them on deep-space missions."



Above: Energetic iron nuclei counted by the Cosmic Ray Isotope Spectrometer on NASA's ACE spacecraft reveal that cosmic ray levels have jumped 19% above the previous Space Age high. [larger image]

PLAM: Plasma Monitor

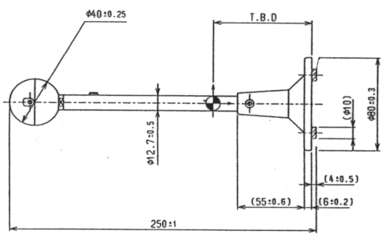


Figure of PLAM sensor

Purpose　The Plasma Monitor measures density and electron temperature of space plasma which causes charging and discharging of spacecraft.

Principle

The probe is a spherical metal electrode.

By analyzing the current-voltage characteristics in the plasma, the electron temperature, electron density, etc. are determined.

Specification

Langmuir probe
- High Gain: -0.2μA ~ +0.2μA
- Low Gain : -0.04μA ~ 0.4mA

Floating probe
- High Gain: ±5V
- Low Gain : ±100V

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PLAM: Plasma Monitor

Picture of PLAM

measures plasma density electron temperature using Langmuir probe

This is the Third Plasma Monitor.

Another Plasma Monitors are NASA's FPMU (Floating Potential Meas. Unit) and Russian's Obstanovka

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SEDA-AP Measured PLAM Current—Voltage Graph

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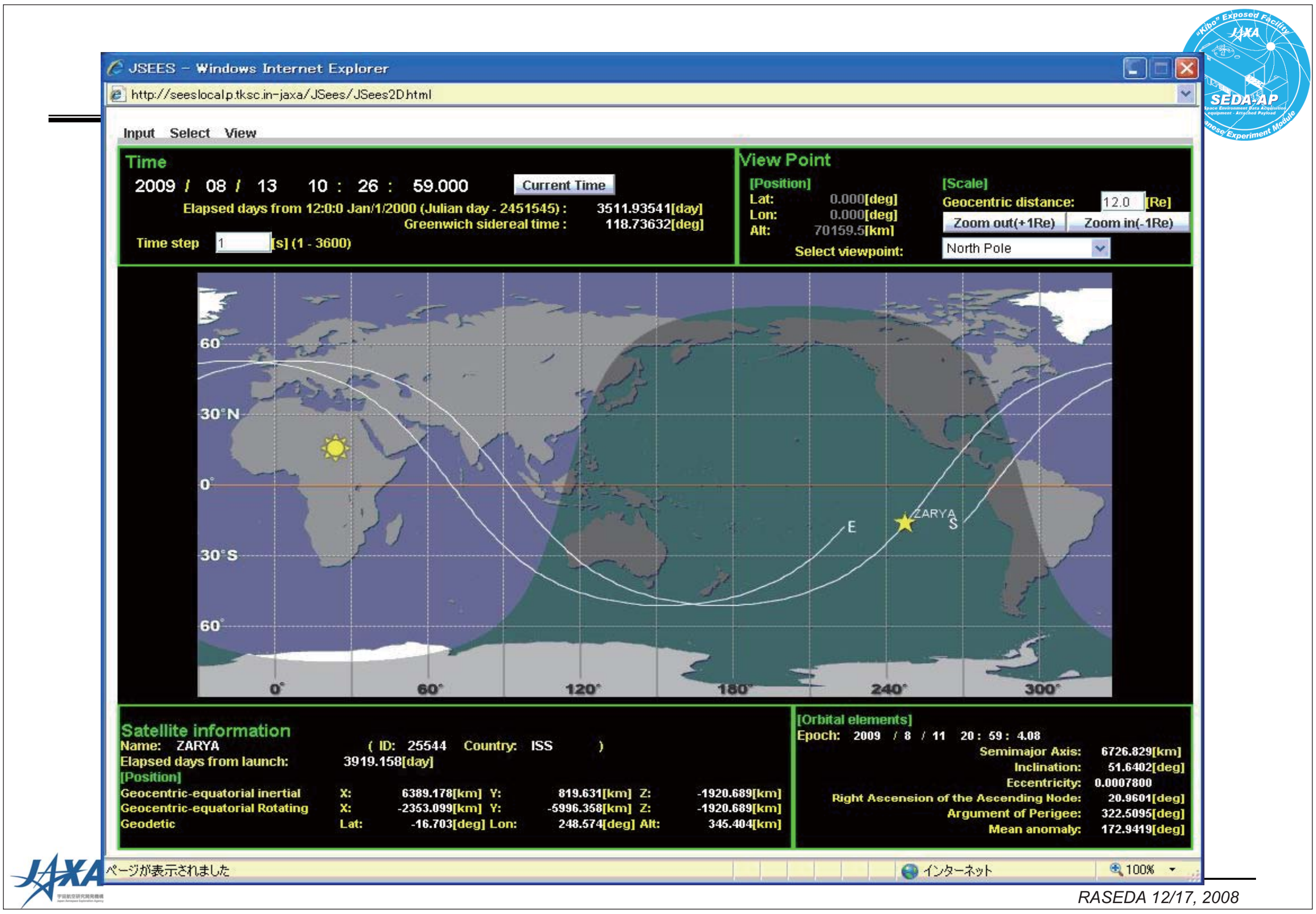
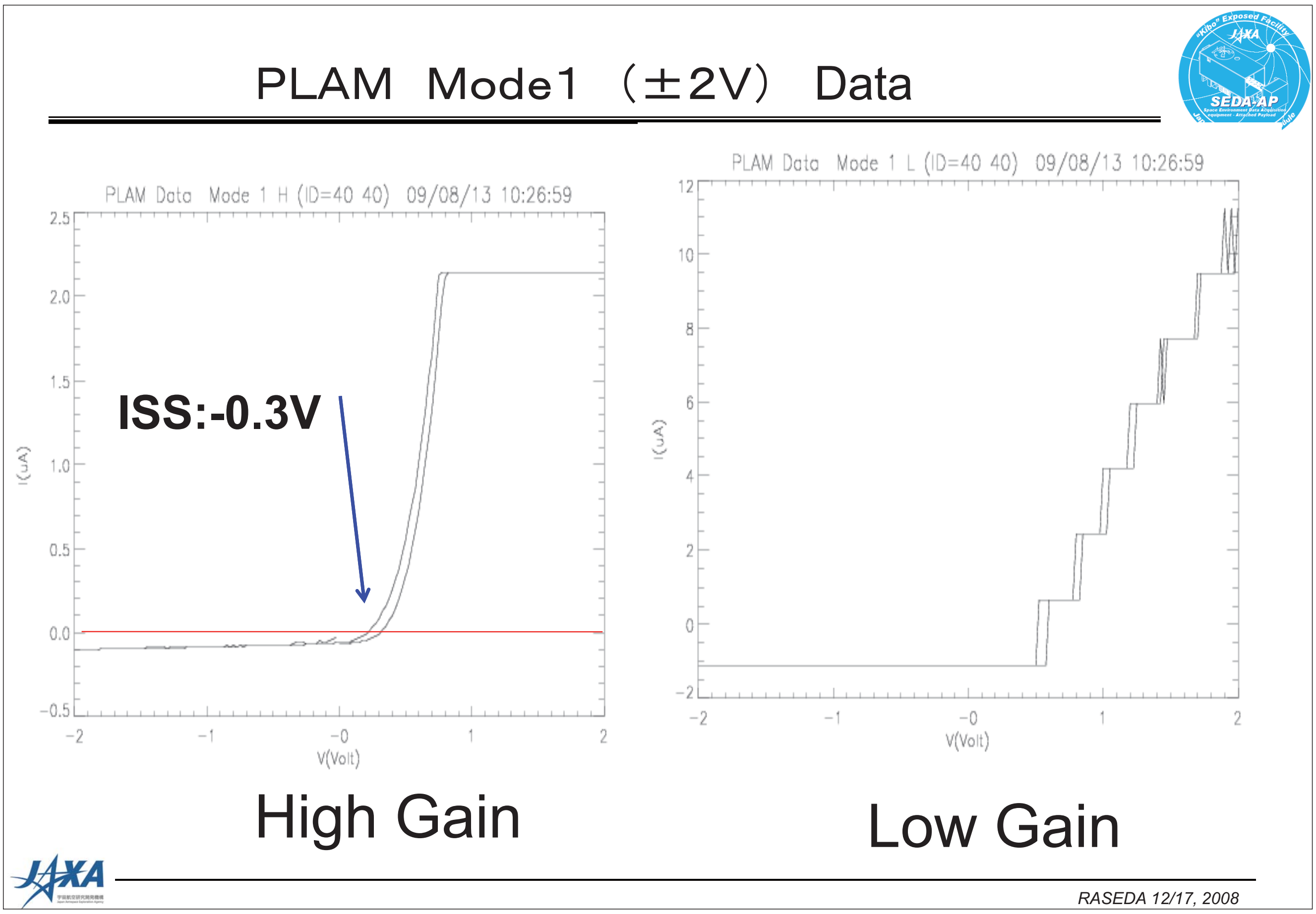
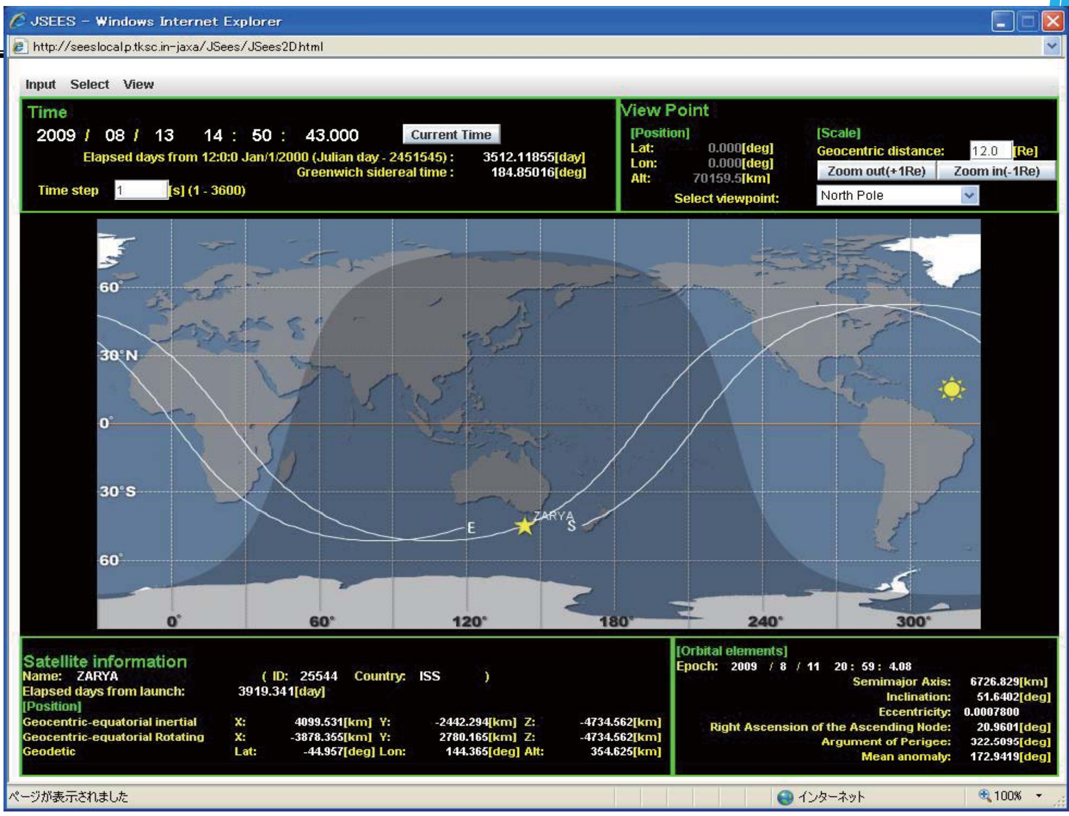

JSEES – Windows Internet Explorer
http://seeslocal.p.tksc.in-jaxa/JSees/JSees2D.html
Input Select View
Time
2009 / 08 / 13 10 : 26 : 59.000
Current Time
Elapsed days from 12:0:0 Jan/1/2000 (Julian day - 2451545) : 3511.93541[day]
Greenwich sidereal time : 118.73632[deg]
Time step 1 [s] (1 - 3600)
View Point
[Position]
Lat: 0.000[deg]
Lon: 0.000[deg]
Alt: 70159.5[km]
[Scale]
Geocentric distance: 12.0 [Re]
Zoom out(+1Re) Zoom in(-1Re)
Select viewpoint: North Pole
60
30°N
0
30°S
60
0°
60°
120°
180°
240°
300°
E
ZARYA
S
Satellite information
Name: ZARYA (ID: 25544 Country: ISS)
Elapsed days from launch: 3919.158[day]
[Position]
Geocentric-equatorial inertial X: 6389.178[km] Y: 819.631[km] Z: -1920.689[km]
Geocentric-equatorial Rotating X: -2353.099[km] Y: -5996.358[km] Z: -1920.689[km]
Geodetic Lat: -16.703[deg] Lon: 248.574[deg] Alt: 345.404[km]
[Orbital elements]
Epoch: 2009 / 8 / 11 20 : 59 : 4.08
Semimajor Axis: 6726.829[km]
Inclination: 51.6402[deg]
Eccentricity: 0.0007800
Right Ascension of the Ascending Node: 20.9601[deg]
Argument of Perigee: 322.5095[deg]
Mean anomaly: 172.9419[deg]
ページが表示されました
インターネット
100%
JAXA
SEDA-AP
RASEDA 12/17, 2008


PLAM Mode1 (±2V) Data
SEDA-AP
PLAM Data Mode 1 H (ID=40 40) 09/08/13 10:26:59
ISS:-0.3V
I(uA)
V(Volt)
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-2
-1
-0
1
2
PLAM Data Mode 1 L (ID=40 40) 09/08/13 10:26:59
12
10
8
6
4
2
0
-2
High Gain
Low Gain
JAXA
RASEDA 12/17, 2008



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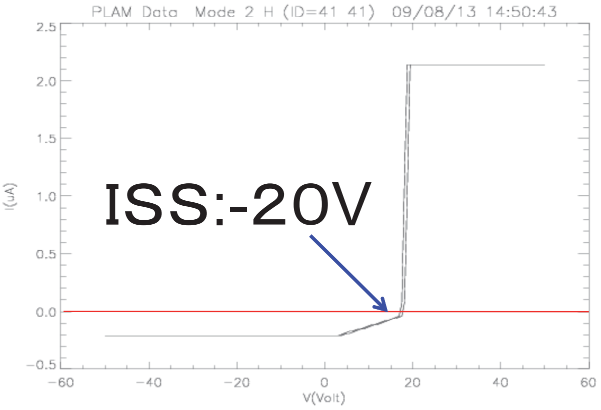
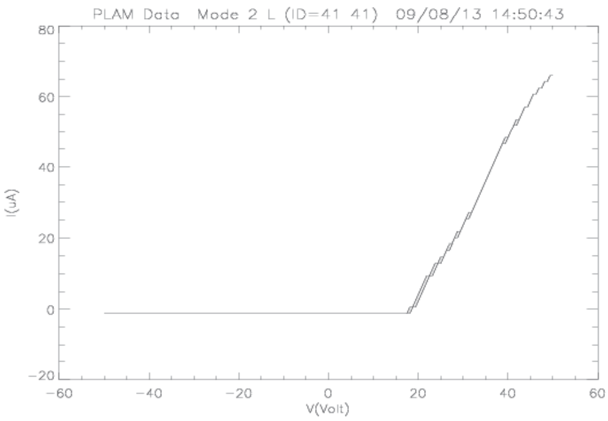
PLAM　Mode2　（±50V）　Data



High Gain



Low gain

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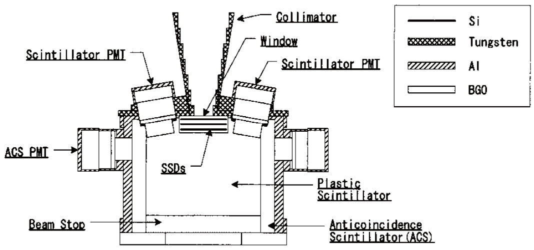
SDOM :Standard Dose Monitor

Picture of SDOM



Cross-sectional view of SDOM sensor

Purpose

Measurement data of radiation flux , and the Variation by solar activity. The acquisition data contribute to investigate radiation damage of space component and anomaly of spacecraft.

Principle

DOM consists of Some Si semiconductor detectors , measures the number and energy of incident particles, and distinguishes kinds of particles, using ΔE×E method's.

Specification

items	range	bin
Electron	0.5 to 50 MeV	7
Proton	1.0 to 250 MeV	15
Alpha	7 to 250 MeV	6
Heavy Ion	ID only	2

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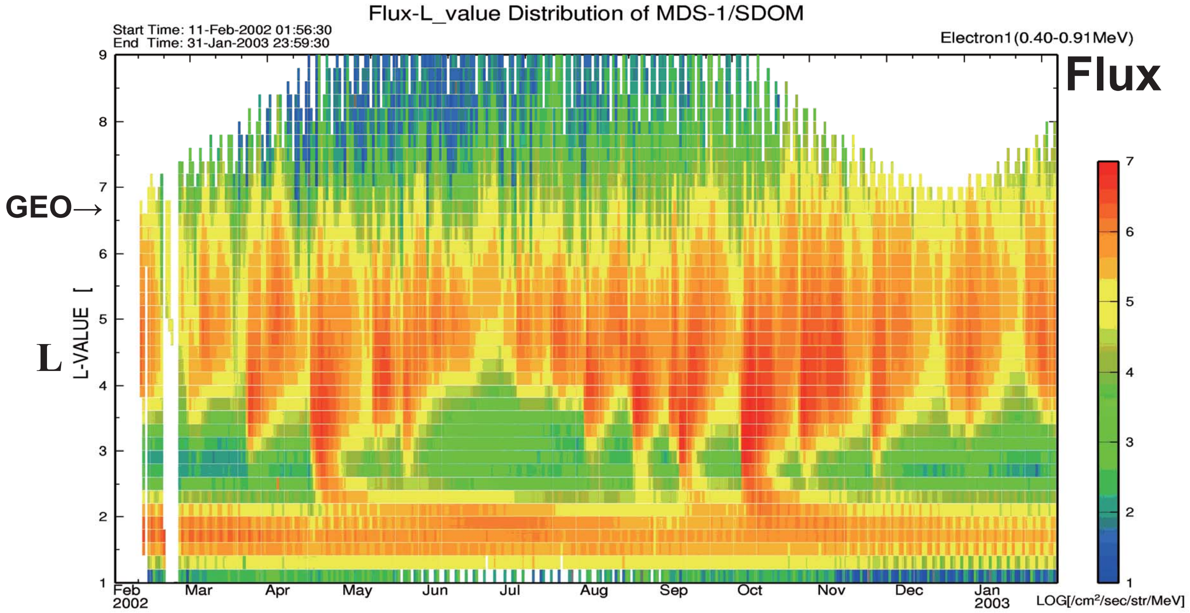
Same type of SDOM sensor is installed on MDS-1 (GTO)

Electron Flux (0.4~0.9MeV) L-t Diagram



Feb.2002 1 Year Feb.2003

(C)NASDA 2003

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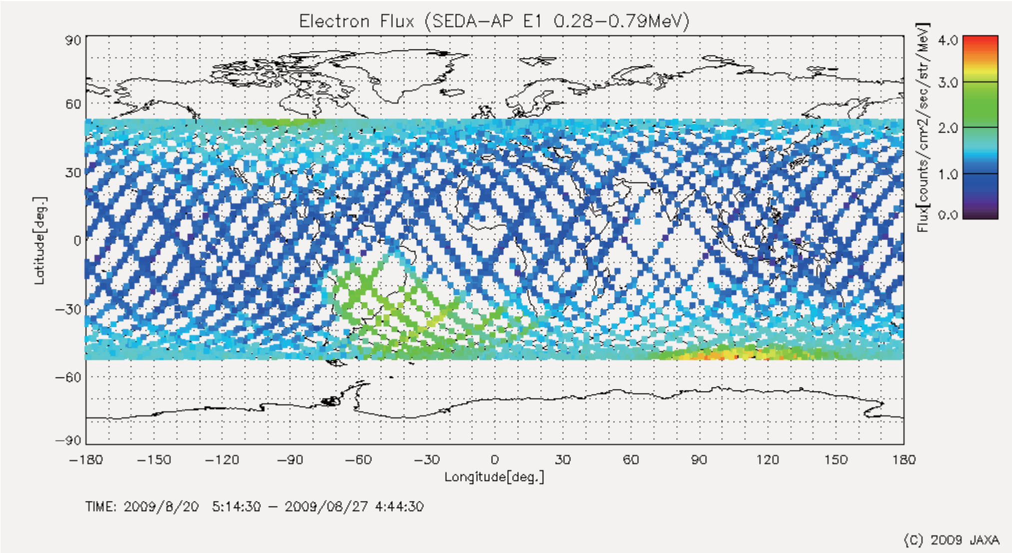
Measurement results of SDOM Electrons (0.28-0.79MeV)



This figure shows the high energy electron (0.28-0.79MeV) measurement results of SDOM, that is overlapped on the world map.
SAA (South Atlantic anomaly), radiation enhanced region related to the offset of earth magnetic field, and horn region of outer radiation belt are clearly shown.

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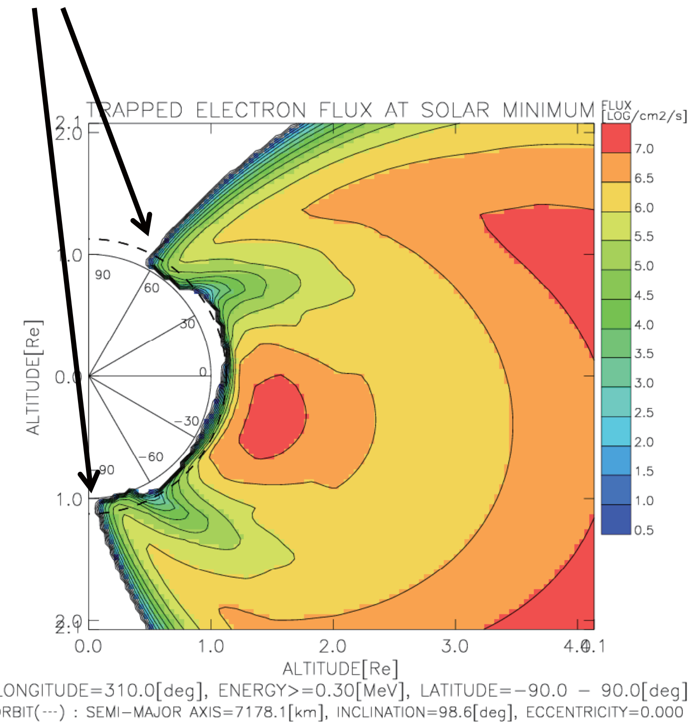
Horn region of Outer radiation belt



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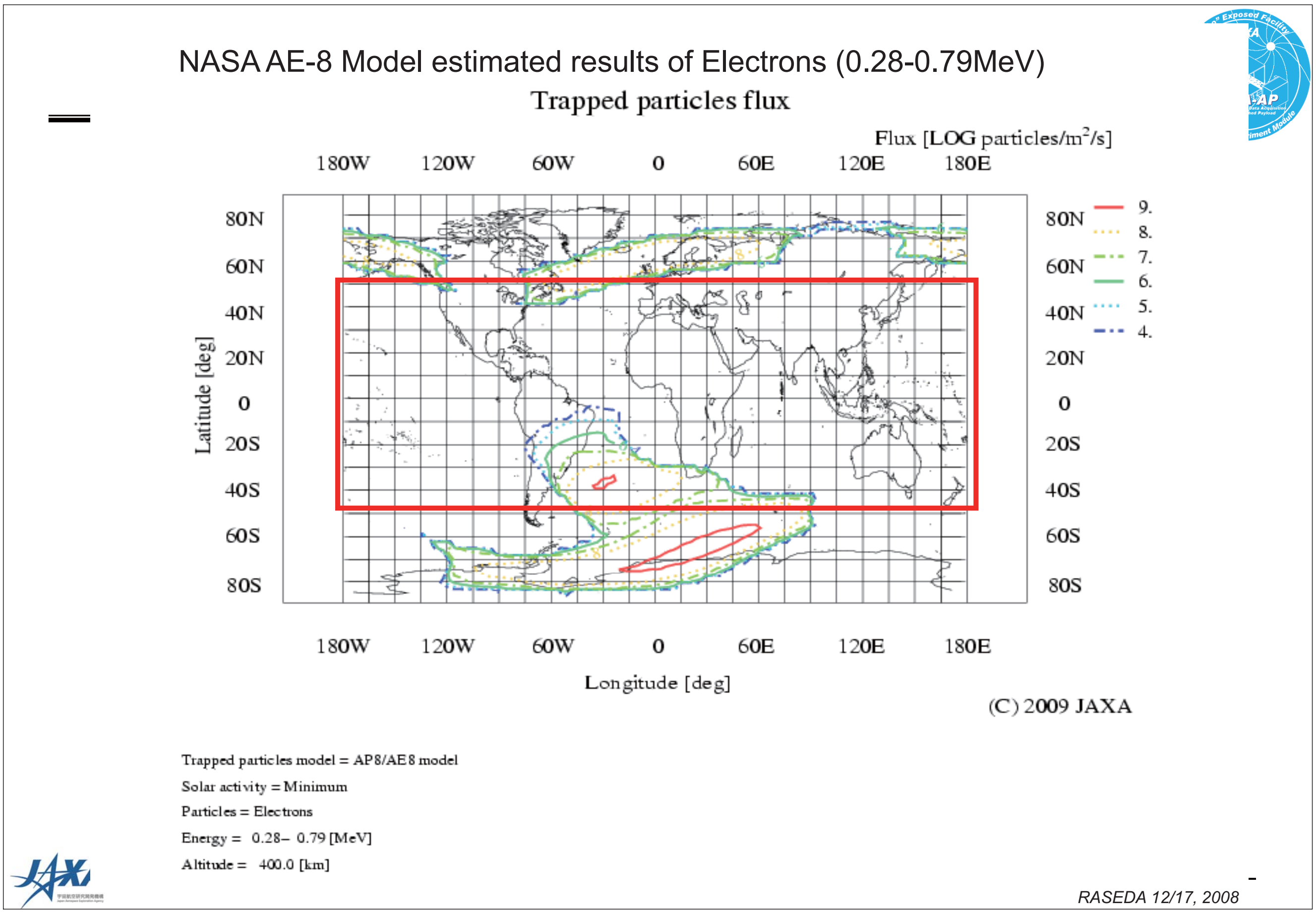
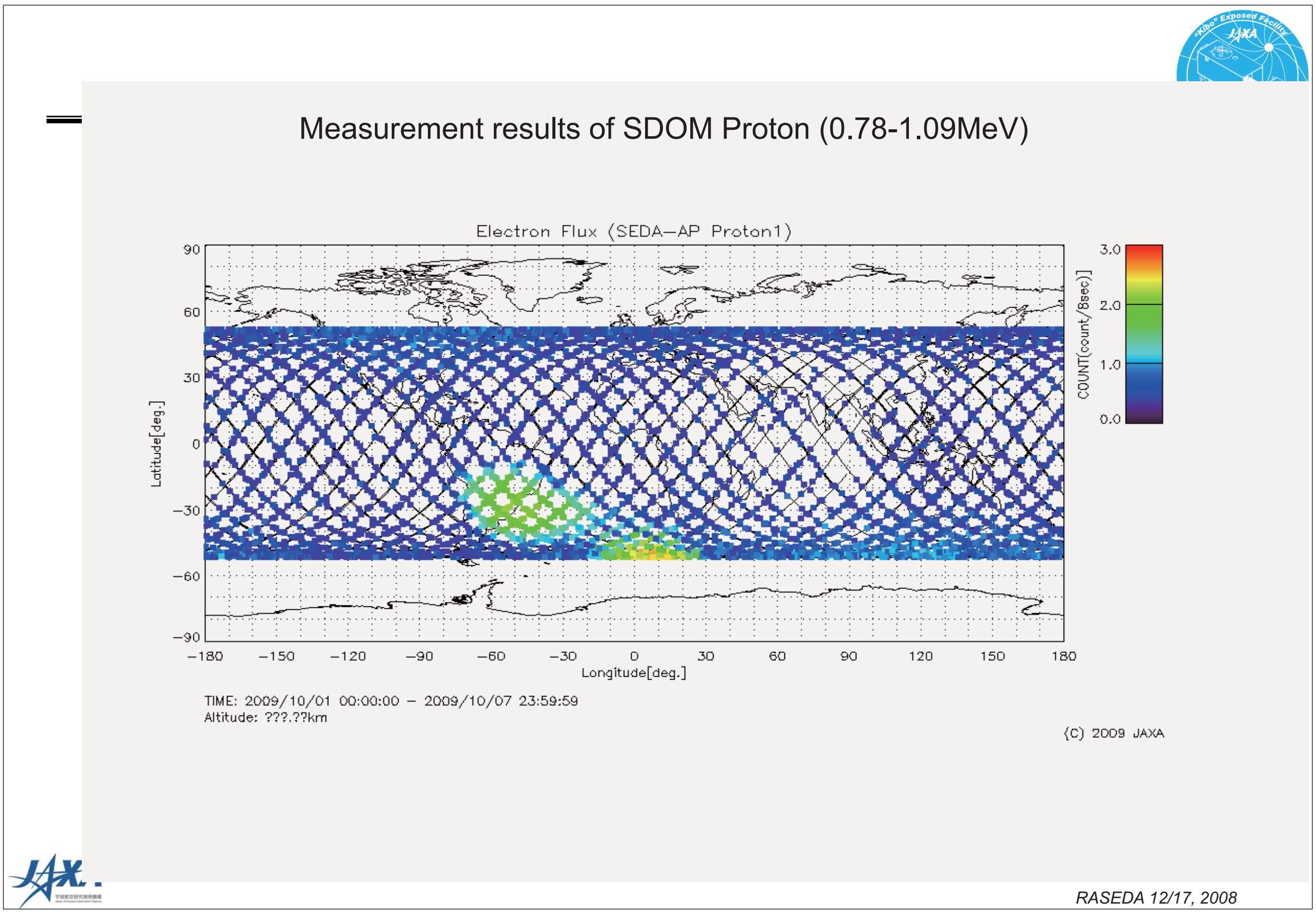
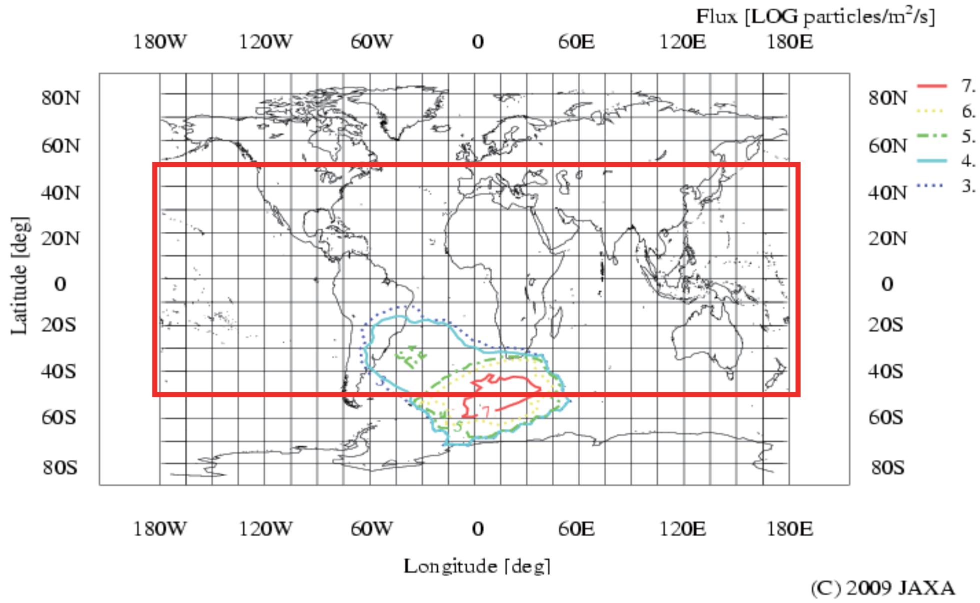

NASA AE-8 Model estimated results of Electrons (0.28-0.79MeV)
Trapped particles flux
Flux [LOG particles/m²/s]
180W 120W 60W 0 60E 120E 180E
80N 60N 40N 20N 0 20S 40S 60S 80S
Latitude [deg]
9. 8. 7. 6. 5. 4.
Longitude [deg]
(C) 2009 JAXA
Trapped particles model = AP8/AE8 model
Solar activity = Minimum
Particles = Electrons
Energy = 0.28– 0.79 [MeV]
Altitude = 400.0 [km]
RASEDA 12/17, 2008


Measurement results of SDOM Proton (0.78-1.09MeV)
Electron Flux (SEDA–AP Proton1)
90 60 30 0 −30 −60 −90
Latitude[deg.]
−180 −150 −120 −90 −60 −30 0 30 60 90 120 150 180
Longitude[deg.]
COUNT[count/8sec)]
3.0 2.0 1.0 0.0
TIME: 2009/10/01 00:00:00 – 2009/10/07 23:59:59
Altitude: ???.??km
(C) 2009 JAXA
RASEDA 12/17, 2008

NASA AP-8 Model estimated results of Proton (0.78-1.09MeV)

Trapped particles flux



Trapped particles model = AP8/AE8 model
Solar activity = Minimum
Particles = Protons
Energy = 0.78– 1.09 [MeV]
Altitude = 400.0 [km]

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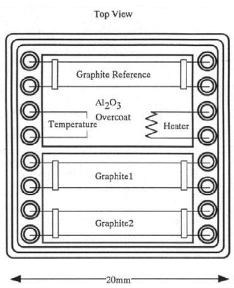
AOM: Atomic Oxygen Monitor

Picture of AOM



The functional diagram of Actinometers

Purpose

The Atomic Oxygen Monitor measures the fluence of atomic oxygen in the orbit of the space station.

The atomic oxygen interaction with the thermal materials and the paints causes the thermal design to be out of the control.

Function & Principle

AOM measures resistance of thin carbon film that is decreased by atomic oxygen erosion (Actinometer).

The rate of decreases is known by lab & flight data. The atomic oxygen fluence is calibrated by this data.

Specification

$3\times10^{17} \sim 3\times10^{21}$ atoms/cm^2

Distribution : 3×10^{17} atoms/cm^2

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SEDA-AP Measured AOM Data

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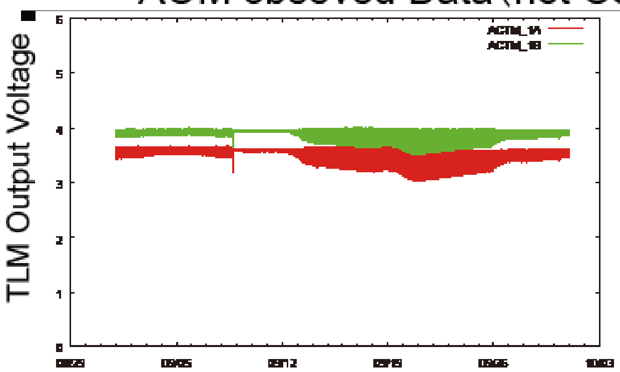
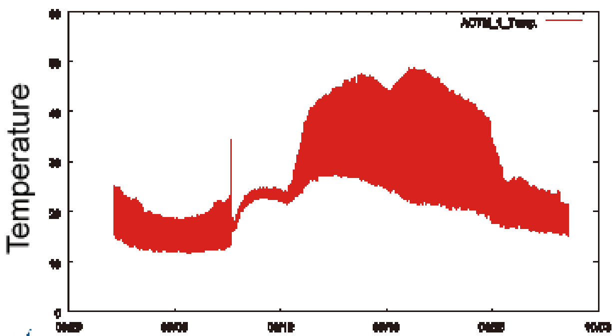
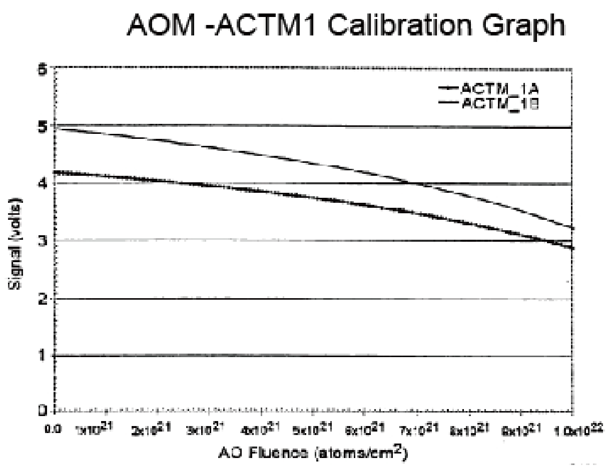
AOM obseved Data (not Compasated by Temperature)







After Temperature Compasation,
Ao Fluence is calcurated using
above Calibration Graph.

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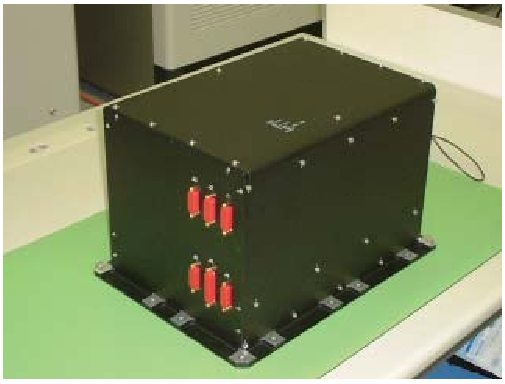
EDEE: Electric Device Evaluation Equipment



Picture of EDEE

Purpose

The purpose of EDEE is to monitor Single Event Effects (SEE) due to ionizing particles in space to electric devices used in JEM. Therefore, EDEE will carry several important devices among those used in JEM and evaluate their functions. The acquired data will be reflected upon trouble shoot if it happens in JEM, and also the improvement of the SEE prediction method on board.

Specification

EDEE carries four types of devices, Memory, Micro-Processor Unit (MPU), and Power MOSFET.

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EDEE (1/2)

- **Observed Results (2009/8/15~2009/10/23)**
  - V70-MPU　SEU/SEL : Not observed
  - 1M SRAM　SEU : 5 upsets observed/512K
    SEL : Not observed
  - PowerMOSFET(@175V) SEB : Not observed

1M SRAM SEU Rate

CREME96 Prediction	CREME96 Prediction	Observed SEU in orbit
1.84 [10^{-1}upset/(device･day)]	12.5 [upset/device]	10 [upset/device]

Threshold LET=5.4[MeV/(mg/cm2)], Saturated Cross Section : σs=3.3X10-7[cm2/bit]

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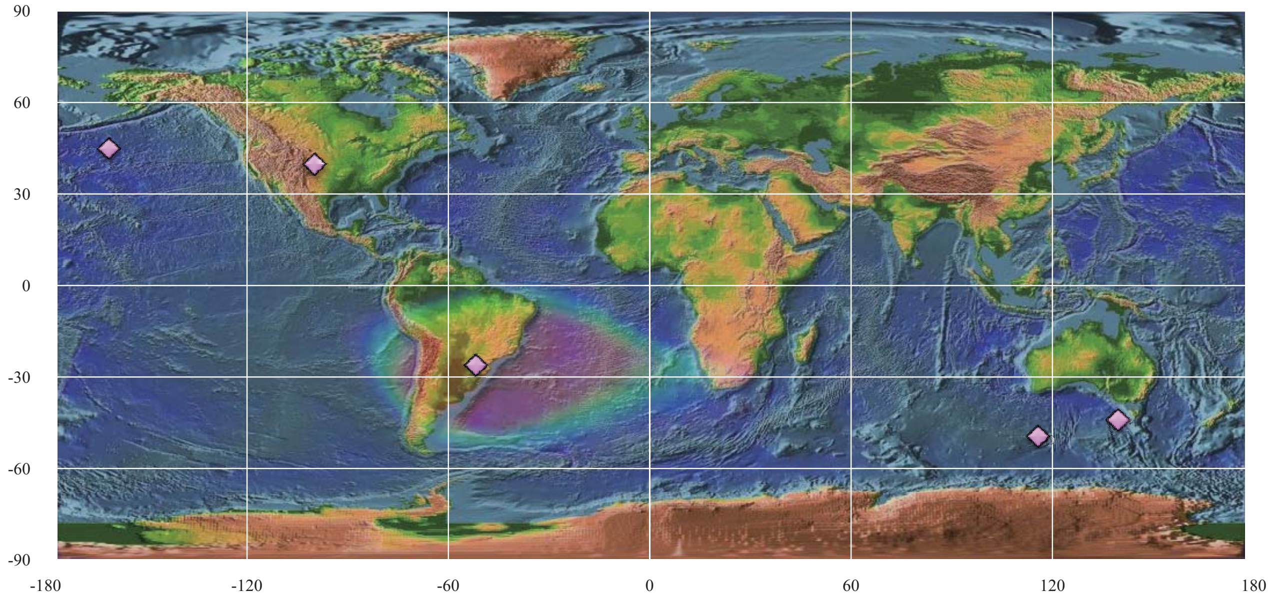
Observed SEU on EDEE (2/2)



Bit Error Location (5 points) map of SEUs (1M SRAM)

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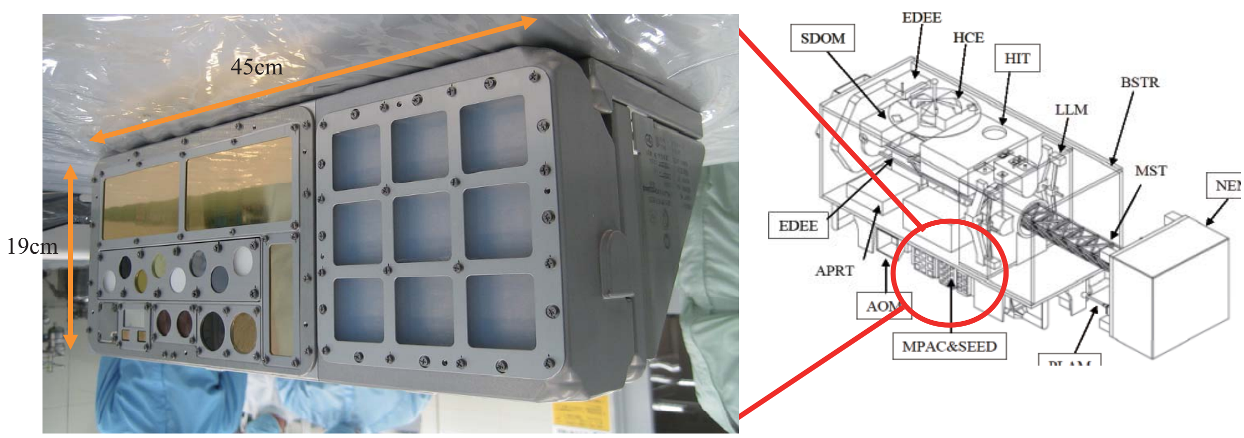
JEM/MPAC&SEED Mission



Mission objective of JEM/MPAC&SEED

– Capture space debris and micro-meteoroids on ISS orbit.
– Exposure the materials and evaluate degradation which caused by space environment such as atomic oxygen, ultra violet and space radiation.

＊ Exposure only. No electrical device

→ **Samples have to be retrieved to the ground and analyzed.**

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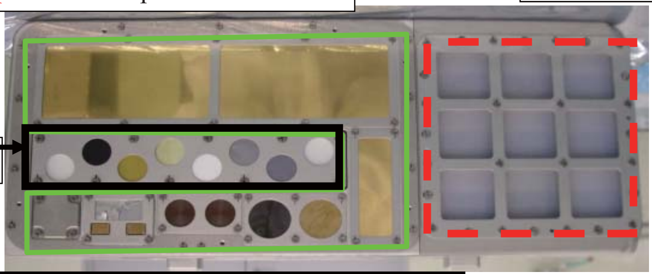
JEM/MPAC&SEED Samples

Gold plate on Sample Unit2

Silica-aerogel on Sample Unit1

SampleUnit3



Silica-aerogel and gold plate is for MPAC

SEED samples on Sample Unit 2&3
Solid lubricants / MoS_2 on Ti-6Al-4V
White paint / NOVA 500 ASTRO WHITE
Black paint / NOVA 500 ASTRO BLACK
Ge-coated Black Kapton
Black Kapton
Polysiloxane-Block-Polyimide Film
Modified Polyimide film/Siloxane Coated PI
ITO coated UPILEX-25S
UPILEX-125S

Space Environment Monitoring Materials on Sample Unit 2&3
UV monitor /(Urethane Sheet)/DUS-601
Dosimeter1/RADFET
Dosimeter2ALANINE-Dosimeter
Dosimeter3/TLD
AO monitor/VESPEL
Temperature/Thermo Label

53

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Precursor mission of MPAC&SEED, Service Module of ISS

SM/MPAC&SEED

Inspection of SM/ MPAC＆SEED inside ISS

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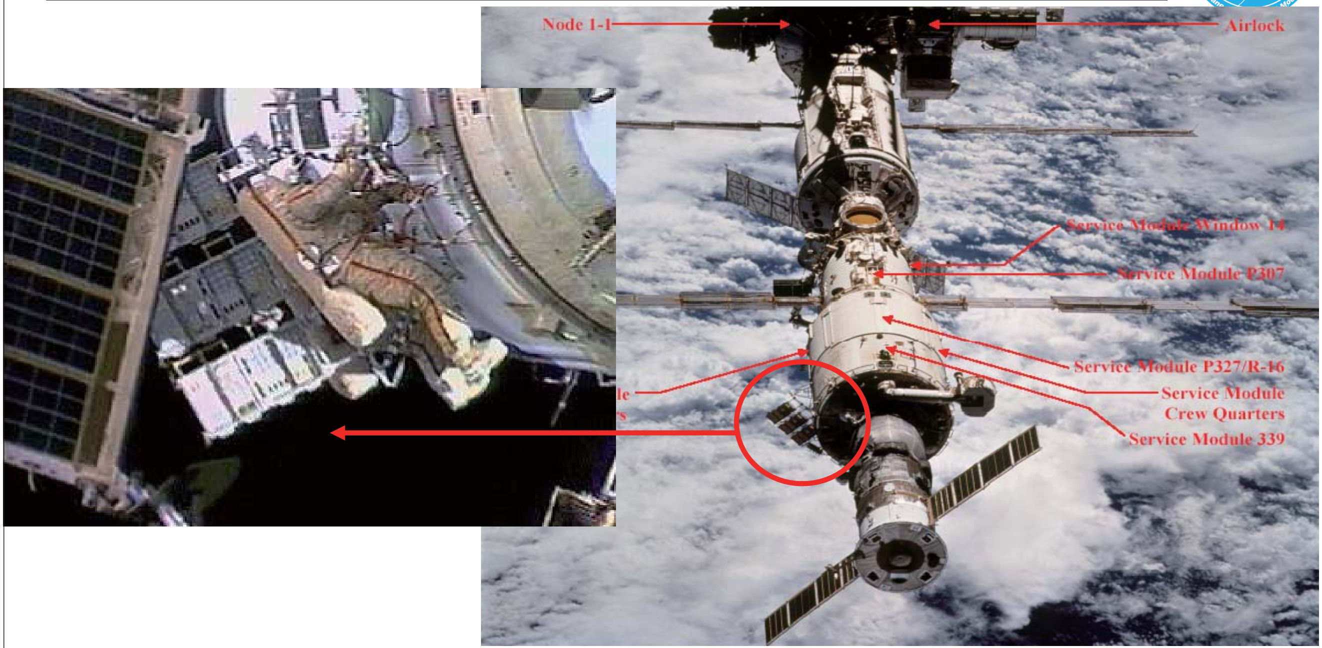
Precursor mission of MPAC&SEED, Service Module of Russia



Three sets of MPAC&SEED is installed outside of Russian service module by EVA activity.

Picture : NASA

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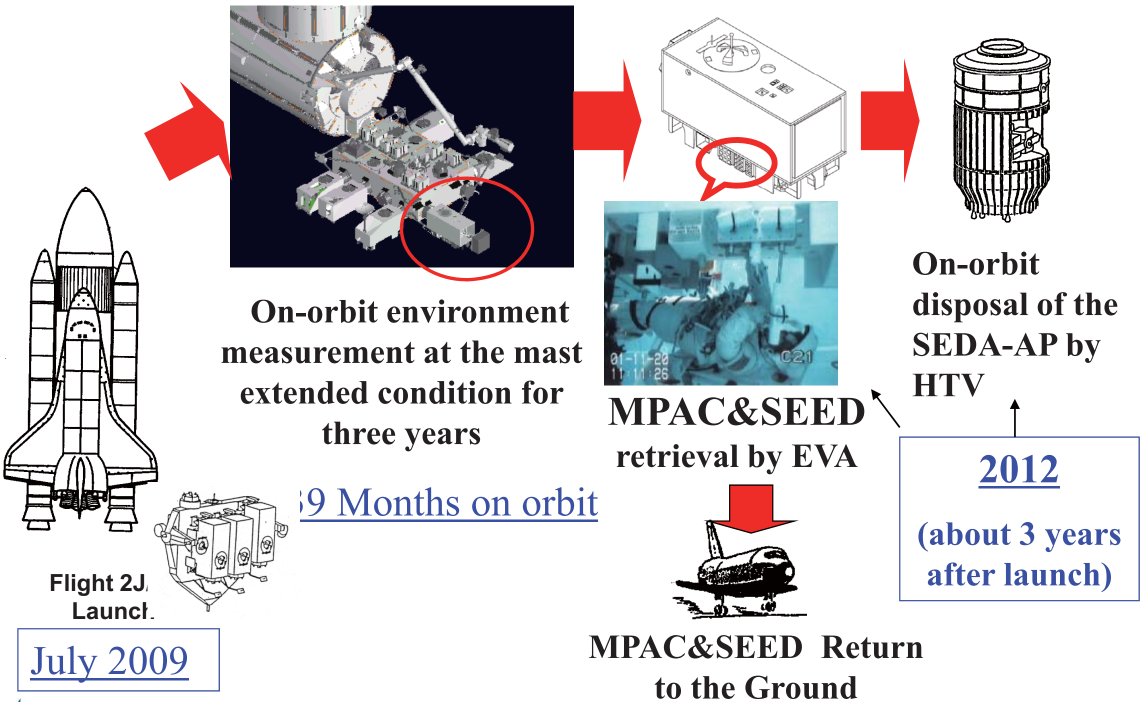
SEDA-AP Operation Overview - Base Line Scenario (Nominal) -



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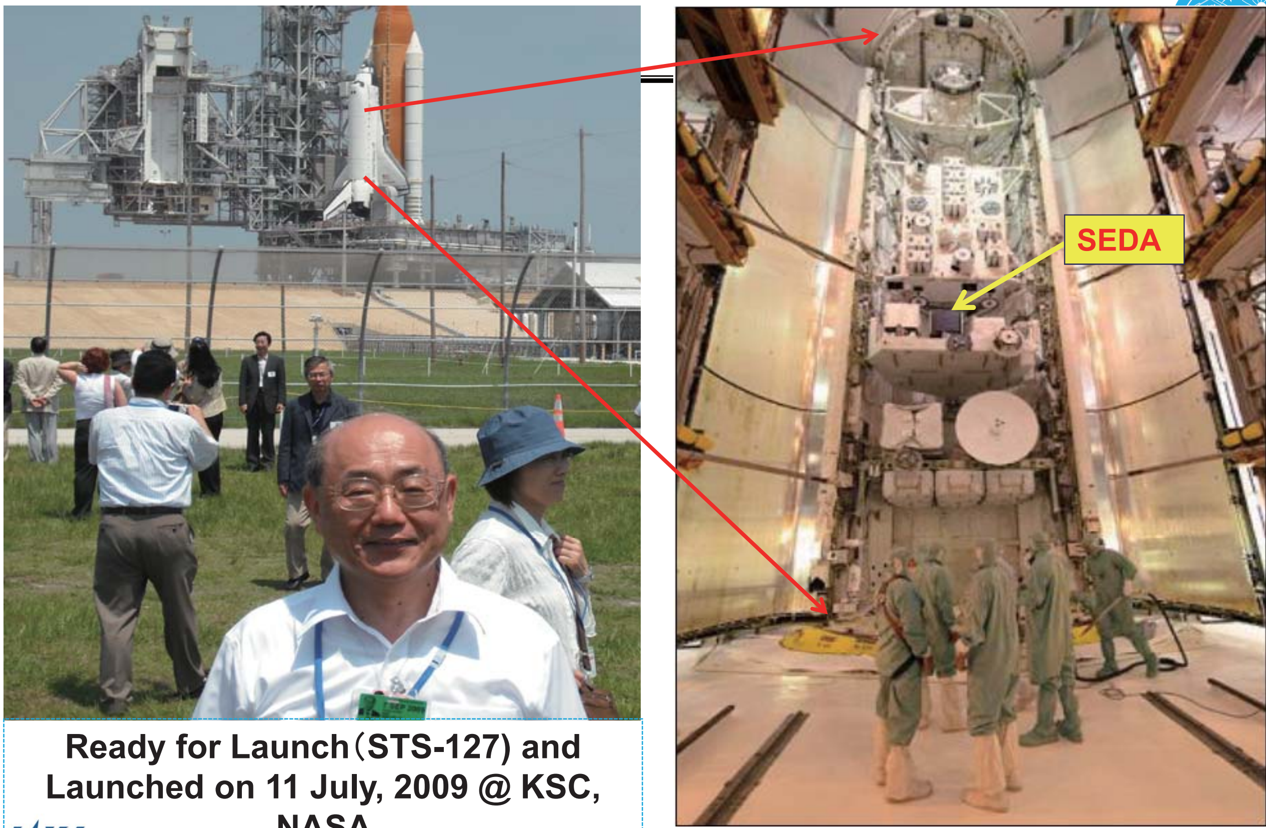

Ready for Launch (STS-127) and Launched on 11 July, 2009 @ KSC, NASA

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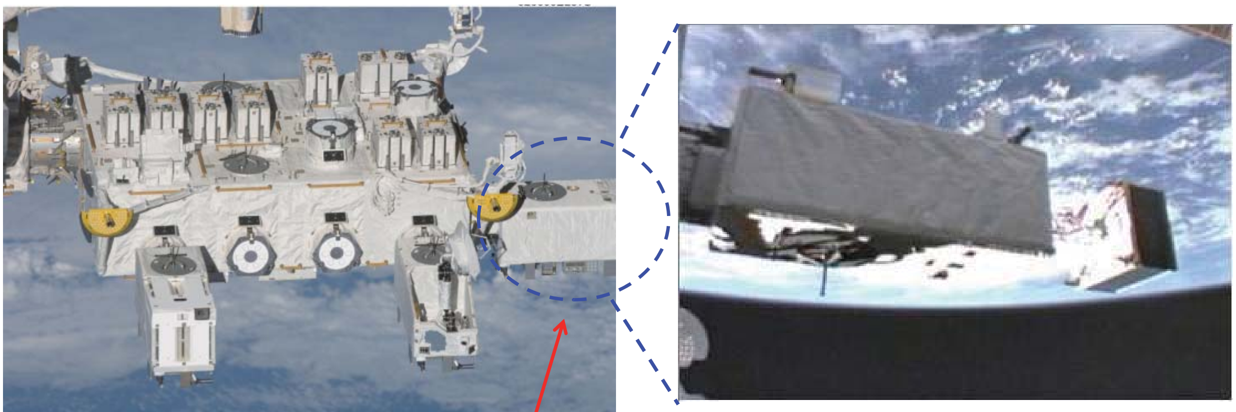
Exposed facility and SEDA-AP (Real Picture)



Exposed Facility of "Kibo"

SEDA-AP Mast extended

SEDA-AP

Provided by NASA

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Conclusion

Space environment data in JAXA, which include data from SEDA-AP, are available to the public as data of the Space Environment and Effect System
(SEES; http://sees.tksc.jaxa.jp)

Those data will be used widely by academic and industrial users in laboratories, universities, JEM experiment investigators, and others in spacecraft operation, engineering fields, and scientific research. Data from SADA-AP will also be used to develop the Japanese space environment mode

Contact

goka.tateo@jaxa.jp (PI of SEDA-AP)
koga.kiyokazu@jaxa.jp (Assistant PI of SEDA-AP)
obara.takahiro@jaxa.jp (Space Environment Group Leader)

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SEES (Space Environment Effects System)

- WWW base database
- Environment data
- 90 environment model
- Monitors description
- S/C Operation Alert

http://sees.tksc.jaxa.jp

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The SEES access statistics.

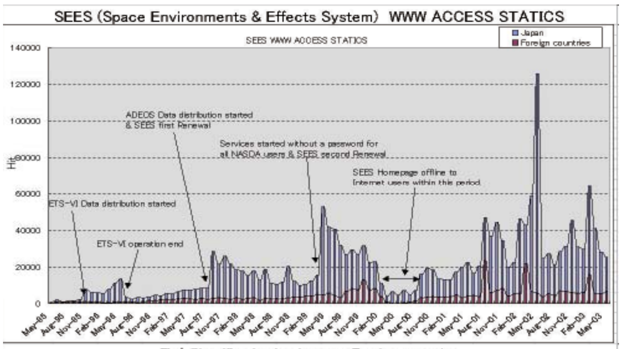
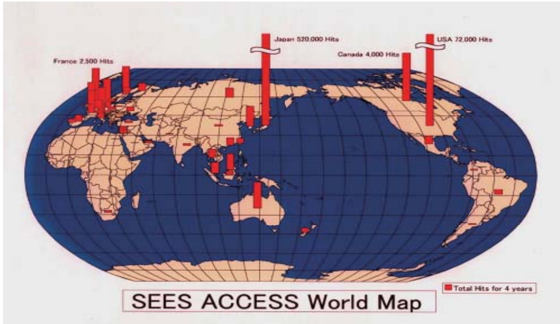


Fig1 Classification by Japan or Foreign countries



SEES ACCESS World Map

- 100 Countries.
- 1000 persons access every day.
- When a new satellite is launched, or when the space environment measurement data of the satellite is exhibited, the increase in the number of accesses