CM23021-040

Result of Space Particle Monitor (SPM) on-Orbit Demonstration

IHI GROUP

06.17.2021

meisei electric co.,ltd. MEISEI

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Introduction

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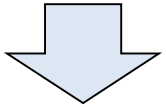
- The importance of radiation environment measurement is increasing in order to determine the cause of malfunctions and failures of equipment caused by space radiation and to avoid abnormalities caused by radiation.
- There is a demand for onboard space radiation environment measurement equipment to ensure the reliable operation of commercial satellites, etc., and the market is expected to grow as the number of commercial satellite launches increases.



- As one of the SERVIS (Space Environment Reliability Verification Integrated System) project under the Ministry of Economy, Trade and Industry (METI), we have developed a compact and low-cost particle energy spectrometer (SPM) with the cooperation of JSS.

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Overview of SPM (Principle of Measurement)

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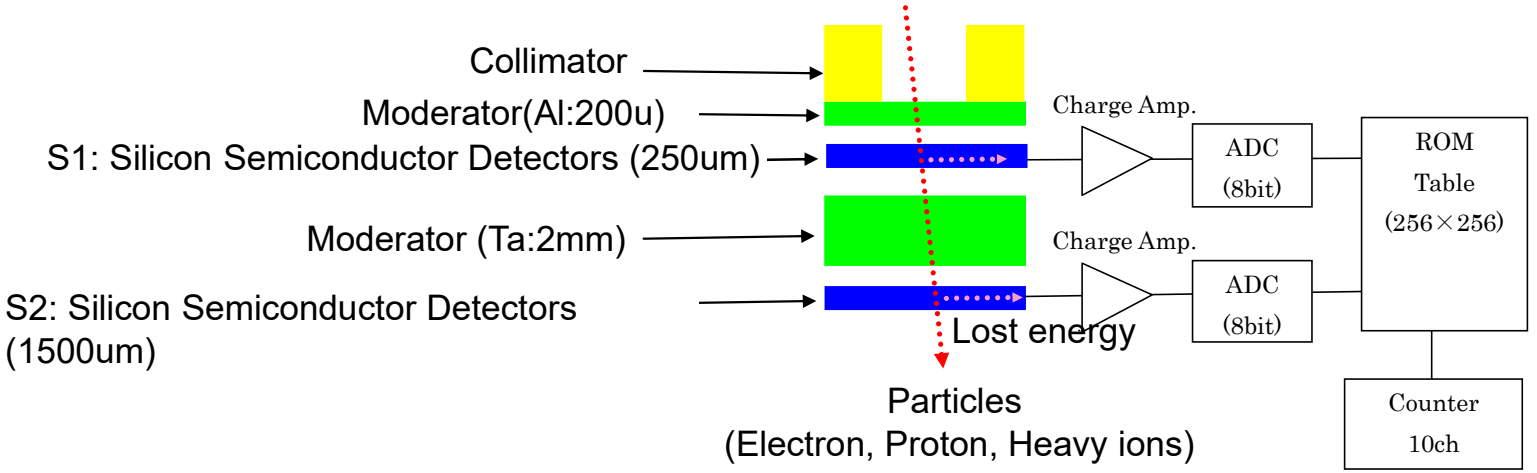
- Consists of two PIN-type silicon semiconductor detectors (S1 and S2) and a moderator (tantalum: Ta) between them.
- Wide range of particle measurements with a simple sensor configuration.



- Energy discrimination based on the combination of S1 and S2 lost energy when a particle passes through the detector.

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Overview of SPM（Specifications）

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SPM specifications

Power Supply voltage	+12V(45mA), -12V(20mA), +5V(60mA)
Communication	RS-422
Line type / Energy range	Electron (0.21MeV～) Proton (5.5MeV～300MeV) Heavy ion (7.12MeV/n～)
Field of view	41.2 degrees
Dimensions	102×132×46(mm) Not including protrusions
Mass	0.766kg Body Only
Power consumption	Max. 1.1 W
Data rate	370bps or more bps (in the case of 1 sec integration time)

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Overview of SPM（Measurement performance）

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- Electron
  0.21MeV～（2CH）
- Proton
  5.5～300MeV
  （6CH）
- Heavy ion
  7.12MeV/n～（2CH）

Counter No.	Particle	Energy Range
C-0	Electron	0.21～4.0 MeV
C-1	Electron	4.0MeV～
C-2	Proton	11～43.6 MeV
C-3	Proton	5.5～11 MeV
C-4	Proton	43.6～48.6 MeV
C-5	Proton	48.6～67 MeV
C-6	Proton	67～106 MeV
C-7	Proton	106～300 MeV
C-8	Heavy ion	7.12～11.8MeV/n
C-9	Heavy ion	51.5MeV/n～

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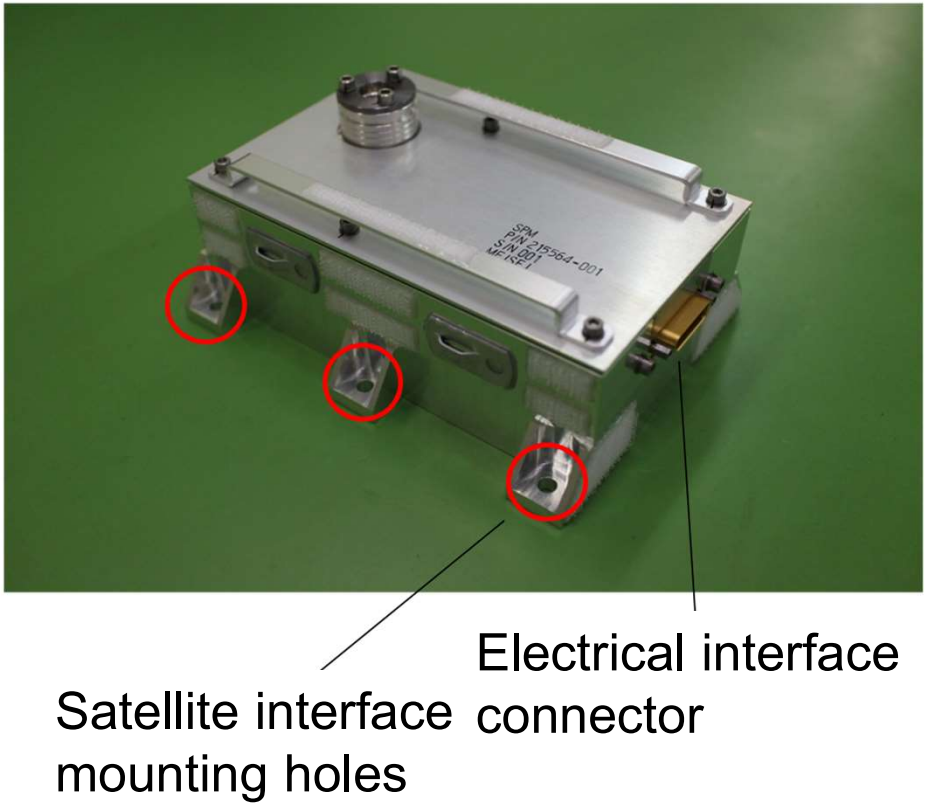
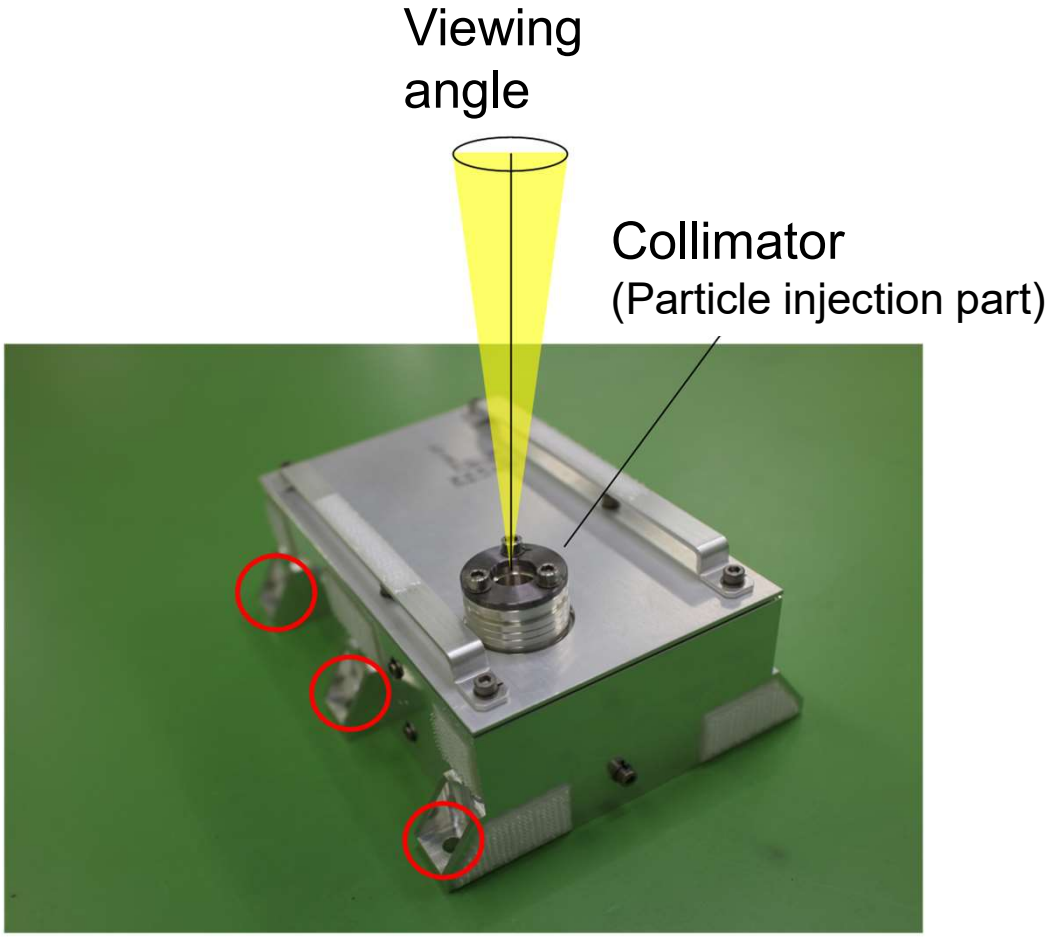
Appearance of SPM





Appearance of SPM

On-orbit demonstration

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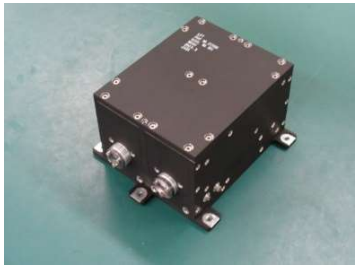
- The SPM is mounted on the Small Demonstration Satellite-1 (RAPIS-1), which constantly acquires radiation data in orbit and periodically transmits the data to the ground.
- The on-orbit demonstration is being carried out by comparing the data with the data acquired by the Technical Data Acquisition Equipment (TEDA), which is also on-board RAPIS-1.
- The TEDA is a radiation measurement instrument developed by Meisei Electric Co., Ltd. for use onboard scientific satellites, and has been used in orbit many times. (Examples: ETS-V, ADEOS, MDS-1, ADEOS-II, ALOS, GOSAT, QZS, JASON-2, JASON-3, QZS-2, QZS-4, etc.)

Equipped with ALOS

Equipped with JASON-2



Equipped with QZS

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Success Criteria

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Success criteria		Result
Minimum Success	The ability to perform On-orbit measurements of radiation, and acquire experimental telemetry data.	Achieved
Full Success	The ability to discriminate between electrons, protons, and heavy ions and to observe their energy content, and to obtain experimental telemetry data with the same trend compared to TEDA.	Achieved
Extra Success	The ability to obtain experimental telemetry data that can identify orbital radiation environments such as solar flares.	N/A (No major solar flares or other events of interest have occurred.)

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Achievement of minimum success

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- Supply voltage and current values confirmed.

  Same as in the ground test → SPM started normally

- Telemetry format confirmed.

  The correct format was sent.

- Calibration mode confirmed.

  Equivalent to ground test → Equipment integrity confirmed.

- Comparison with TEDA

  The event occurred at the same time. → Data of the particle can be acquired.

On-orbit measurements of radiation have been performed and experimental telemetry data has been obtained.

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Measurement results (Electron)

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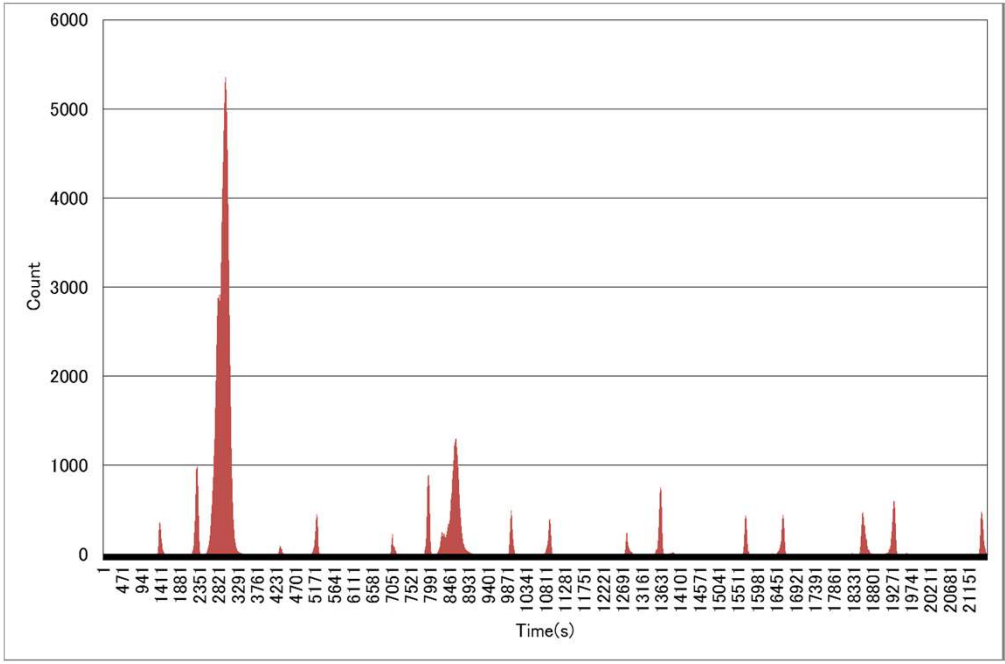
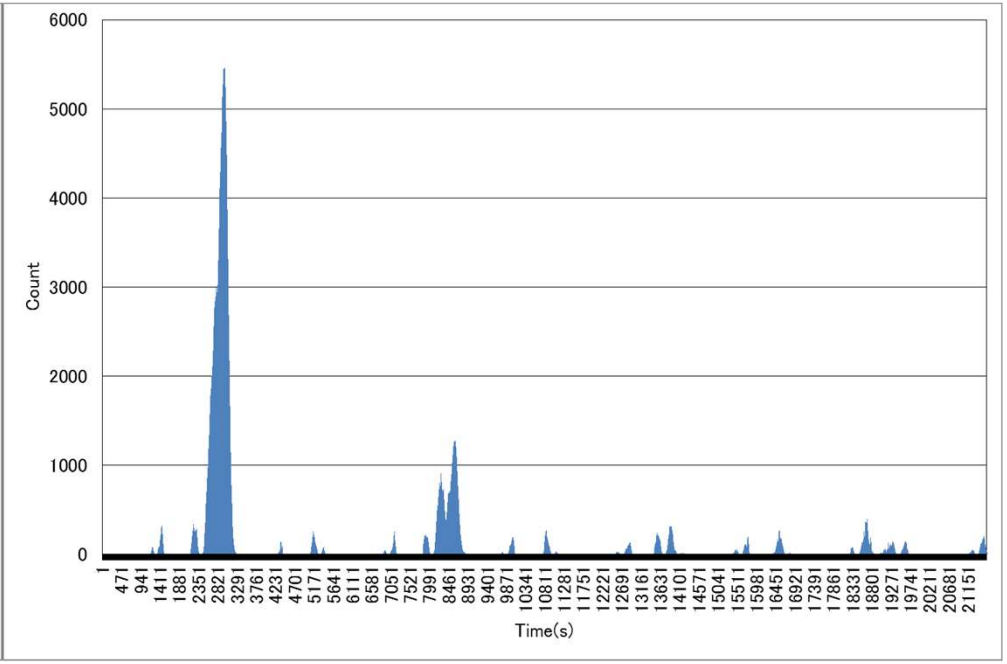
- Comparison with TEDA (Electron)
  The acquired data shows the same trend and the incident particle counts are consistent.
  →The processing time per event is equivalent for SPM and TEDA, and the sensor viewing angle and sensitive area for electronic measurement are almost the same, so it is judged to be reasonable.

Count of SPM electrons (*1)



Count of TEDA electron (*1)



※ 6hours of data with the arbitrary date and time set to 0s.

*1： Extract from TEDA data provided by JAXA

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Measurement results (Proton)

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- Comparison with TEDA (Proton)

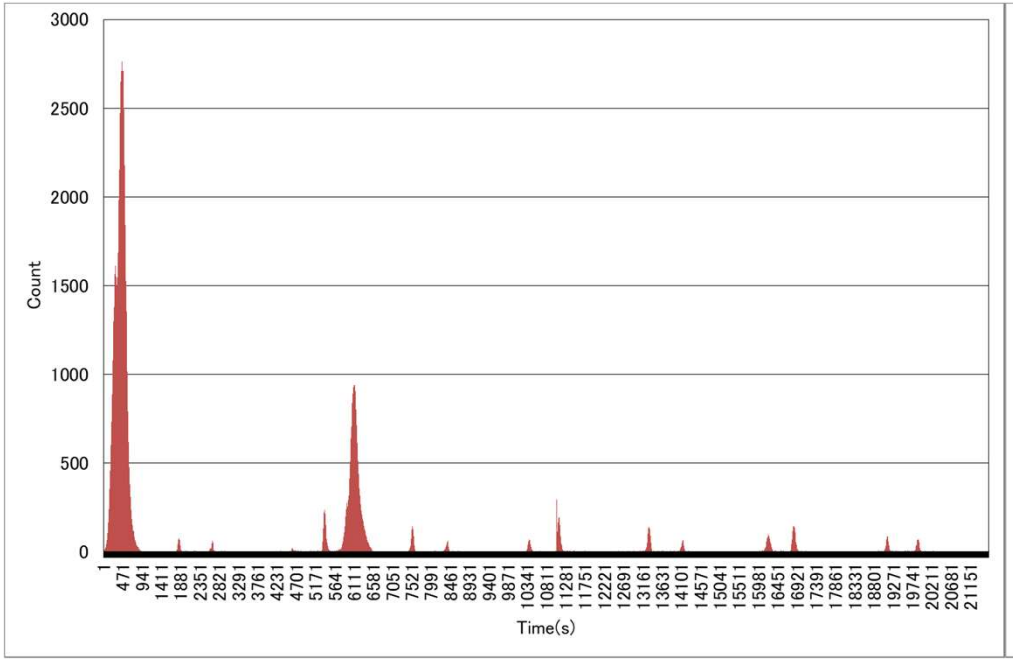
  The peak of the event can be seen at the same time.

  The difference in the number of counts will be evaluated by converting to FULX.

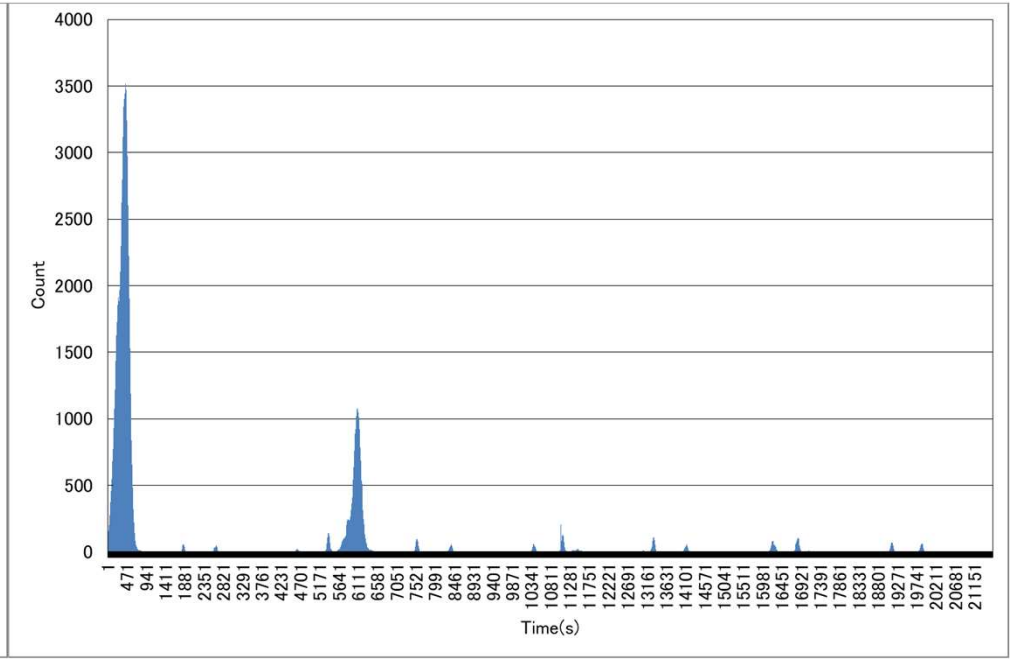
  (number of counts per unit area, solid angle, time and energy,

  unit: /cm2/sr/s/MeV）

Count of SPM proton counter



Count of TEDA proton counter (*1)



※ 6hours of data with the arbitrary date and time set to 0s.

*1： Extract from TEDA data provided by JAXA

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Comparison with TEDA (FULX)

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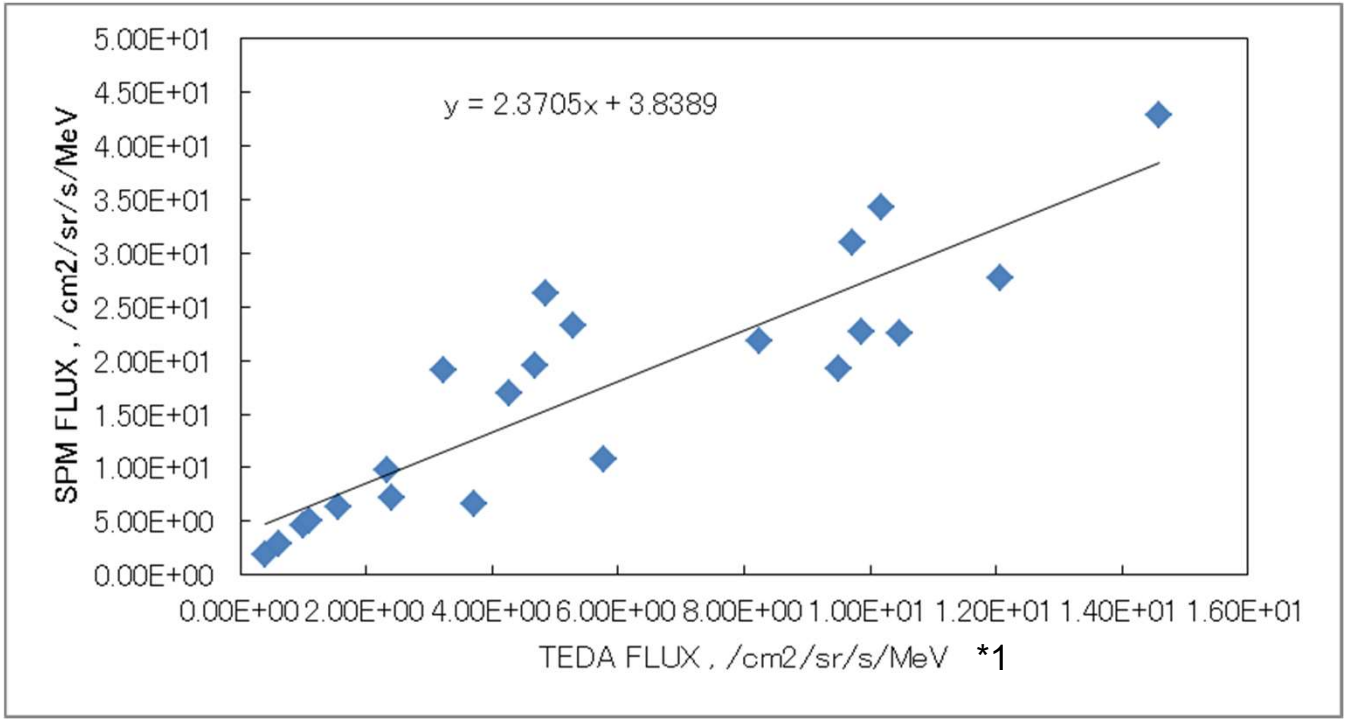
- The SPM counts were converted to FLUX and compared with TEDA. (Flux: Number of counts per unit area, solid angle, time, and energy. Unit: /cm2/sr/s/MeV)
- As shown in the figure below, when comparing the FLUX at arbitrary points, the ratios were similar at all points (approximately 2.4), and it was confirmed that SPM was able to acquire data with the same trend as TEDA.

※The counters that were compared were C-2, C-5, and C-6, which have the same measurement range as the TEDA counters.

※ The ratio of FLUX at any given point was plotted on a graph.

※ Since SPM and TEDA are mounted in the same direction, it is expected that data with the same trend will be acquired.



*1 : Extract from TEDA data provided by JAXA.

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Measurement results (Heavy ions)

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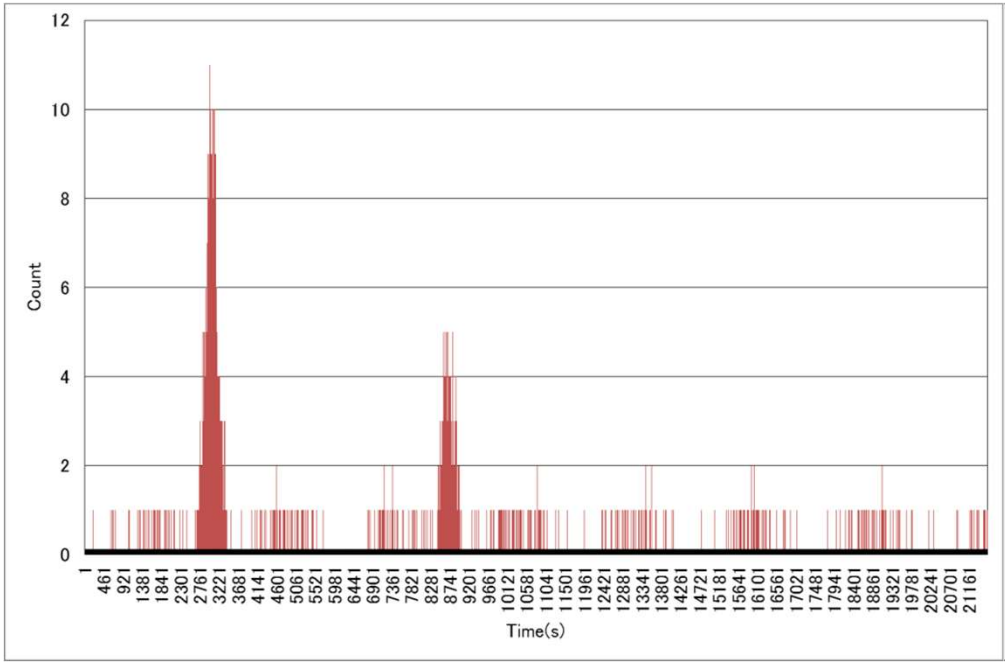
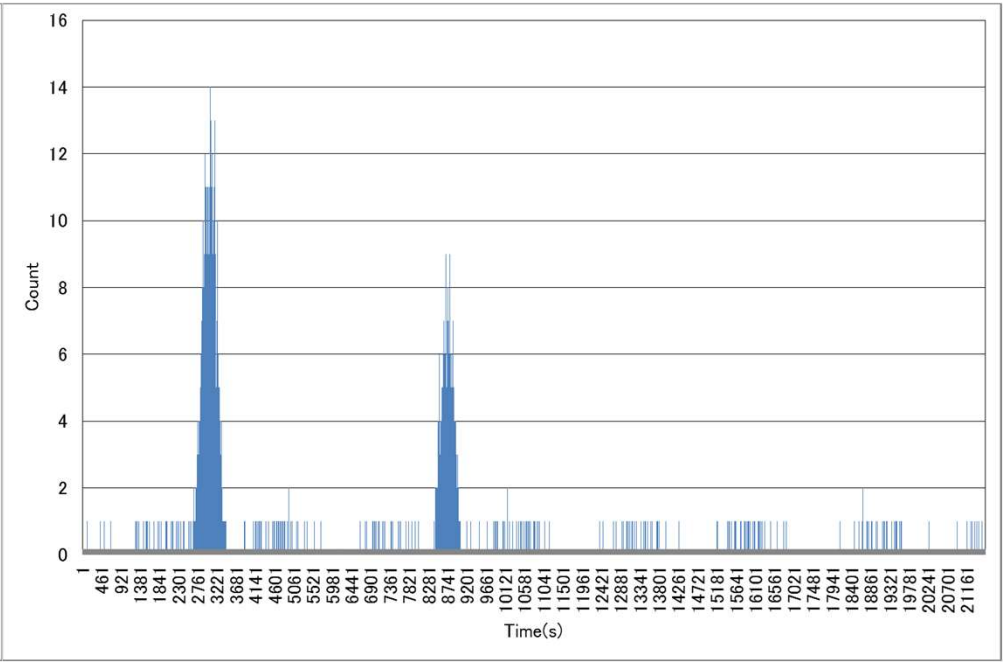
- Comparison with TEDA (Heavy ions)
  The acquired data shows the same trend and the count numbers are consistent.
  →Considering the difference in sensor viewing angle and sensitive area, and the difference in discrimination table settings, it is considered reasonable.

SPM Heavy Ion Counter Counts



TEDA Heavy Ion (He4) Counter Counts (*1)



※ 6hours of data with the arbitrary date and time set to 0s.

*1： Extract from TEDA data provided by JAXA

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Summary: Achieving Full Success

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- Discrimination of Electrons, Protons, and Heavy ions and observation of the amount of energies have been successful.
- In comparison with TEDA, data with the same trend can be obtained.
  - ✓ Electrons, Heavy ions: Validity confirmed by comparison of count numbers.
  - ✓ Proton: Validity confirmed from comparison of FLUX.
- As a result of confirming the data in the calibration mode before the end of the operation, the same results were obtained as in the ground test and in the early stage of the operation, and it was confirmed that there was no deterioration in the sensor and circuit system of SPM during the operation period.

It can be said that our SPM has sufficient measurement performance for the investigation of the cause of malfunction or failure of equipment due to space radiation, and for the measurement of the radiation environment to avoid abnormalities caused by radiation.

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Realize your dreams