LET Requirements in JAXA

January 25th, 2007

Satoshi Kuboyama
JAXA

Outline of the Presentation

- Flight Measurements
- Reference LET Spectrum
- Behavior of SEE Cross-Section
- Basic LET Requirements
- Practical SEE Testing in JAXA
- Issues
  - ✓ Range
  - ✓ Angle
- Conclusion

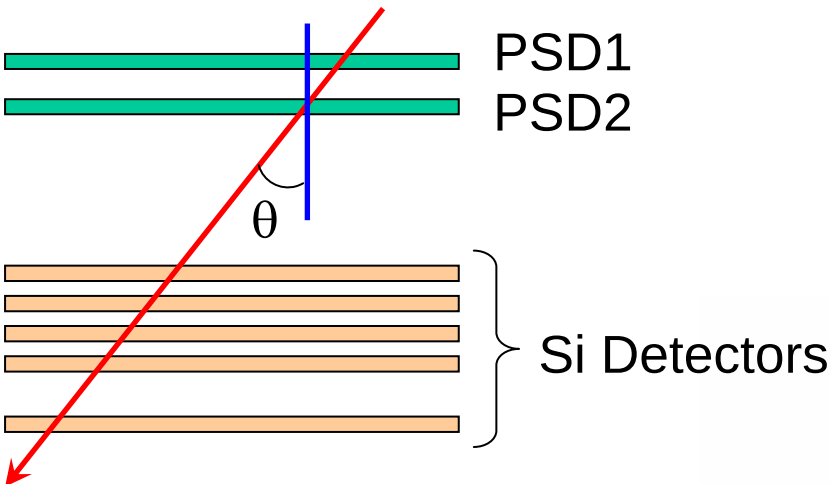
Flight Measurements (1/2)

- JAXA performed several flight measurements

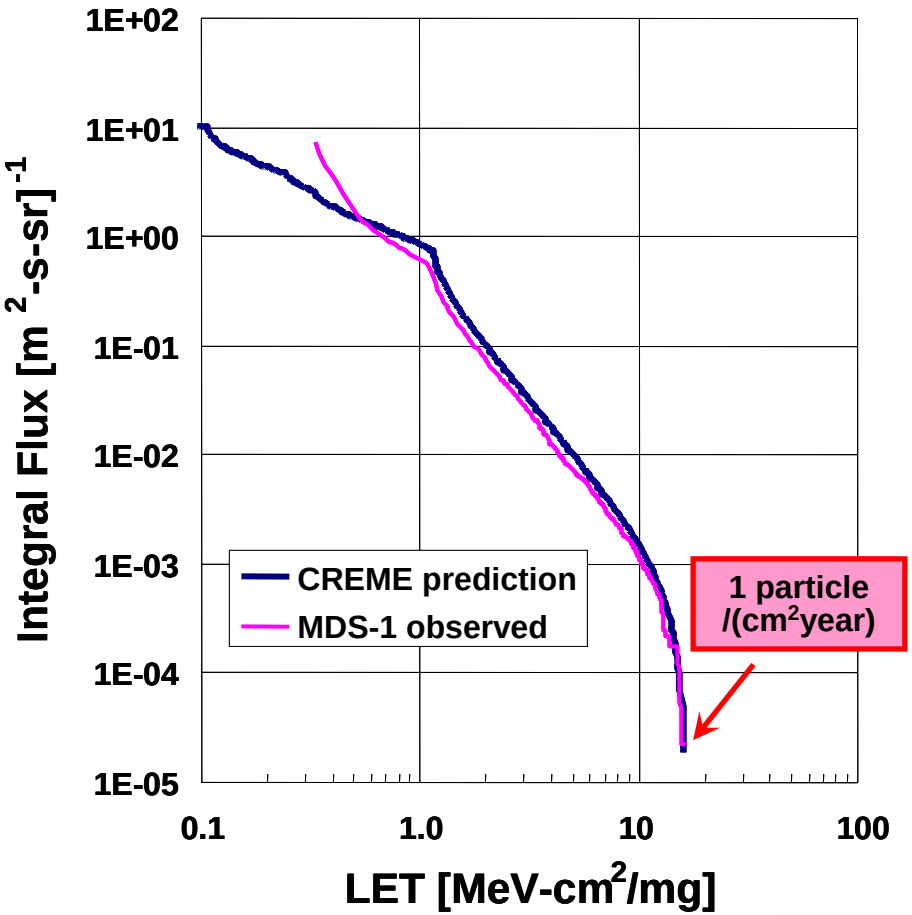
Specification of the Equipment for MDS-I

Structure: 2 Position Sensitive Detectors (PSDs) for incident angle correction + 16 Si detectors for LET calculation

Thickness of each detector:	~0.4 mm
Effective Sensing Area:	25 cm^2sr
Orbit:	GTO, Inclination 28°
Measurement Period:	2002/2 – 2003/9

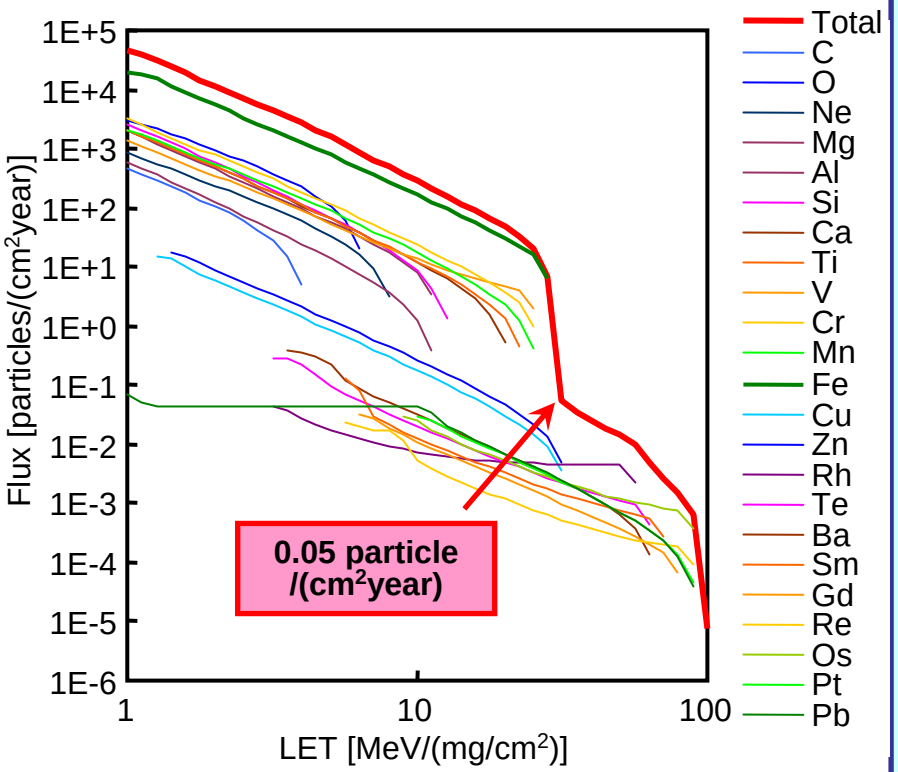


Flight Measurements (2/2)



- Only Fe and lighter ions were observed because of limited sensitive area and mission life.
- Measured LET spectrum was very consistent with CREME96 quiet model.

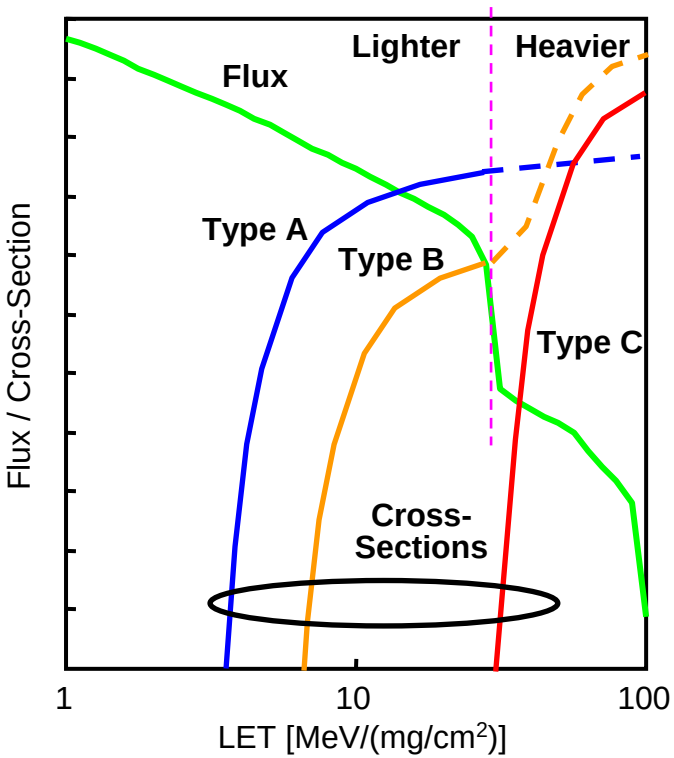
Reference LET Spectrum (CREME 96)



Decomposed LET Spectra

- Steep flux step around LET of 30 MeVcm^2/mg is responsible to Fe, Co and Ni ion group.
- Flux level of heavier ions (>Cu) are around 1 particle per 20 years per cm^2.
- If SEE cross-section for Ni ions with the worst LET is given as around 2e-2 cm^2, the SEE rate is around 100 fit, which is usually expected failure rate for LSI devices.

Behavior of SEE Cross-Section



LET Spectrum and
SEE Cross-Sections

A: SEE rate is dominated by the lighter ions (<Ni), because of steep decrease of heavier ion flux. Tests with heavier ions are not required

B: SEE rate can be dominated by heavier ions (>Cu). No actual case was experienced in JAXA.

C: SEE rate is dominated by the heavier ions. Tests with heavier ions are mandatory?

Basic LET Requirements

- Up to ~40MeV/(mg/cm^2), if SEEs are observed at smaller LETs. (For Type A)
- Over 40MeV/(mg/cm^2), SEEs are not observed up to 40MeV/(mg/cm^2). (For Type C)

- ✓ Range of the ion need to traverse the entire active region (epi-layer) of the device.
- ✓ Fluence level should be determined to ensure the SEE rate comparable to the failure rate expected for the device.

Practical SEE Testing in JAXA
Project Components

Bus Components:

- Highest reliability is required. So mainly proven parts are used and SEE tests are not performed.

Payload Components:

- New parts, which have insufficient SEE data, are used. However, expected reliability level is relatively low as compared with the bus components. So SEEs tests are usually up to LET of 40 MeVcm^2/mg.

Usually, projects have, not so much time and money for part level testing

Practical SEE Testing in JAXA
New Parts Program

Integrated Circuits:

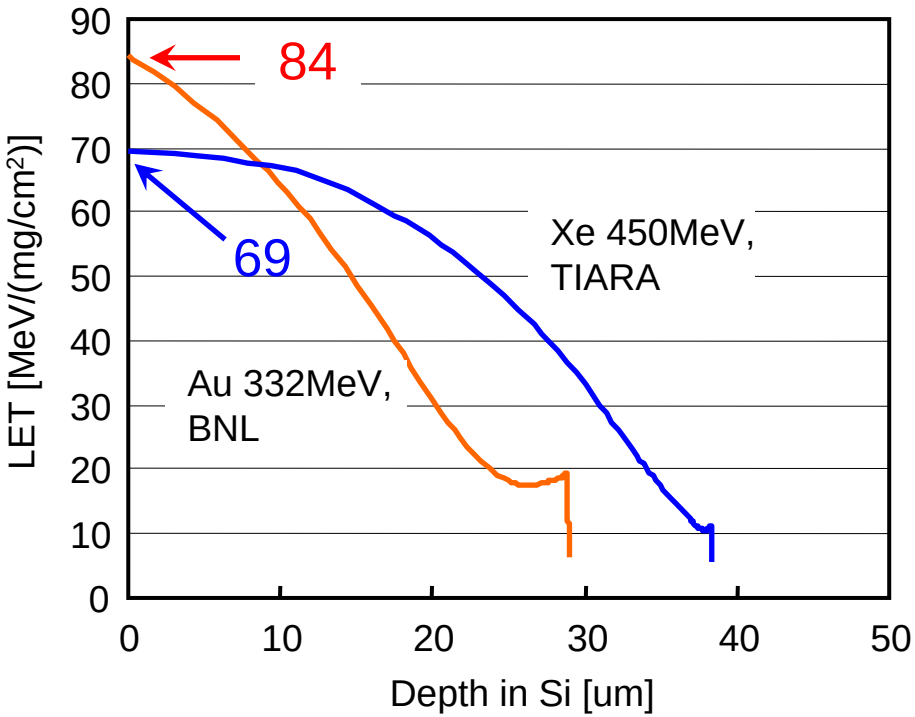
- JAXA is now focusing to SOI technology, that is inherently immune to SEL. No SEU/SET up to LET of 64 MeVcm^2/mg.
- There are no SEL rate prediction procedure for bulk CMOS technology when SEL is not observed up to LET of 64 MeVcm^2/mg (Xe ion).

Power Devices:

- Power devices have thick structure and the long range ions, which traverses the structure, are very limited.
- LET requirements for power devices should be discussed.

Issues – Range of ion

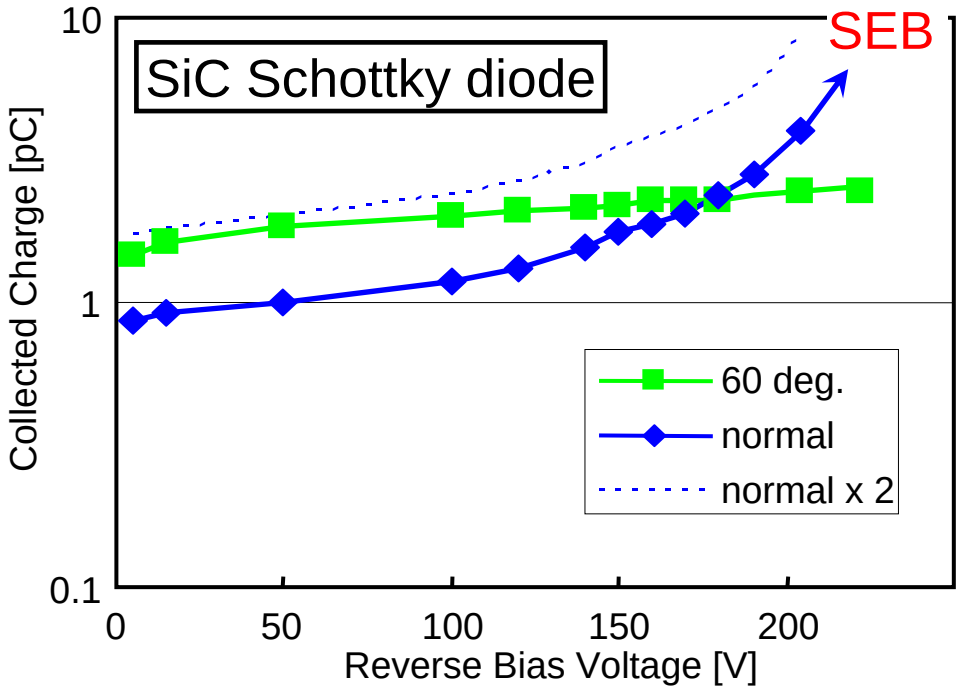
- Usually LET value is specified at the chip surface
- For thick structure device such as power devices and non-epi ICs, surface LET is not sufficient for correct testing

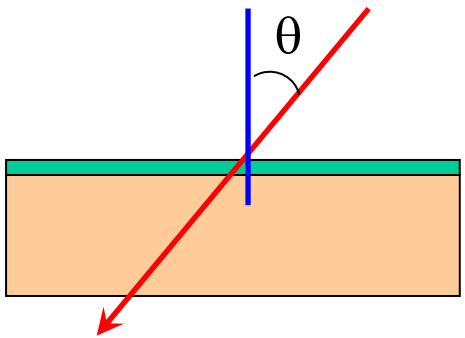


- SEL was observed with Xe ions only for some non-epi ICs
- Total energy is the key parameter instead of LET?
- Short range ions should be removed from the reference LET spectrum.

Issues – Angle of ion

- For power devices, angle between ion incidence and electric filed in the device is a key parameter





- In the low bias region, deposited charge with 60 deg. Incidence is almost twice the normal.
- However SEBs are never observed with the angle incidence.
- Ions with angle incidence should be removed from the reference LET spectrum.

Conclusions

- SEEs triggered by heavier ions (>Cu) are very rare.
- However, there is a possibility that SEE rate is dominated by those ions, if no SEE is observed with lighter ions (<Ni).
- For destructive SEEs (SEL, SEB, SEGR), SEE rate with those heavier ions must be accurately estimated to ensure the mission success.
- LET spectrum given by CREME96 is the surface LET. Some type of SEEs require other type of LET spectrum.
- There is a possibility that the use of appropriate LET spectrum reduce the test cost and ensure the proper margins, although they need further investigation.