2nd RADECS Thematic Workshop :
"LET-Requirements and Testing for Space Applications"

In flight observed Single Event Effects

R. Mangeret, T. Bouchet // Jan. 2007

All the space you need

EADS astrium

Introduction

- Necessity to assess the system robustness against space radiation environment induced effects
  - Total Ionising and Non Ionising Dose calculation (TID, TNID also called Displacement Damage), Single Event Effects (SEE)

- This is possibly done for SEE through Space radiation environment modelling together with error rate prediction
  - Use of static models representing dynamic events
    - Very often, a “potentiometer” is integrated in the model (confidence level for JPL91 or ESP, weather index for CREME86…)
  - Prediction calculation process uses some hypothesis (sensitive volume definition for example)

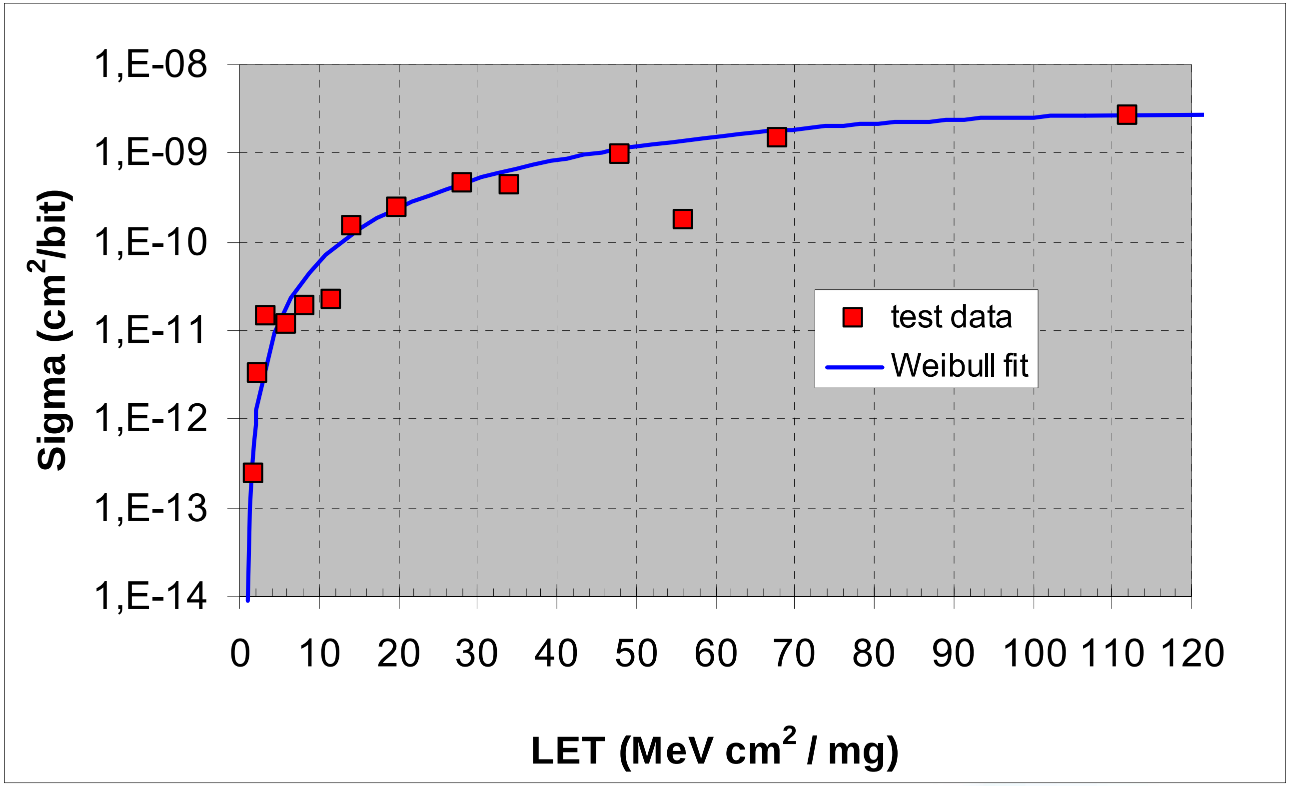
- Comparing predicted error rates with in flight ones is a mean to acquire confidence in the applied process.

Case under study

- Observed Single Event Upsets (SEU) rates recorded on a SRAM are compared to predicted ones.
- Such device is protected by an EDAC (Error Detection and Data Correction), and cyclic scrubbing is performed. Therefore, SEUs have no consequence on equipment functionality.
- Device has been fully characterised for SEU at ground level (heavy ion and proton SEE testing).
- In orbit observation period represent more than 20 years.

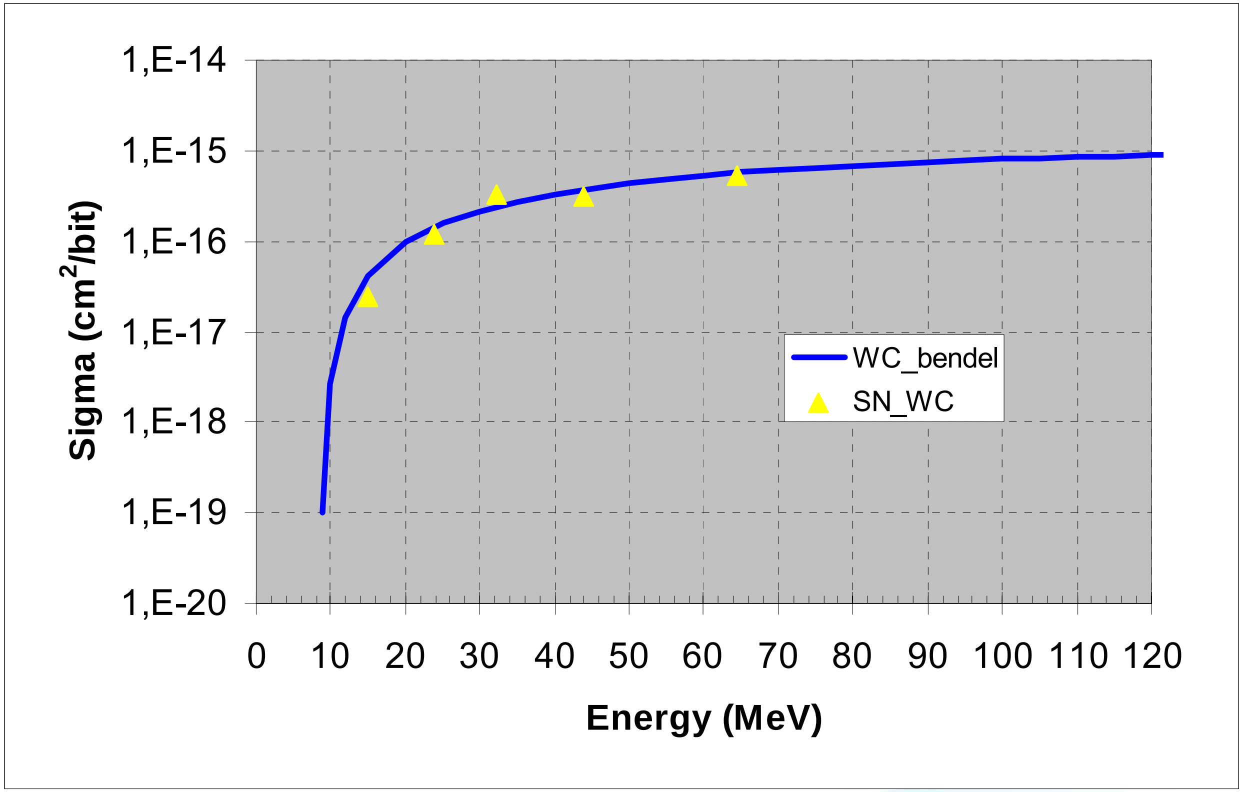
Radiation ground characterization 1/2

- Heavy ion SEE test data are available



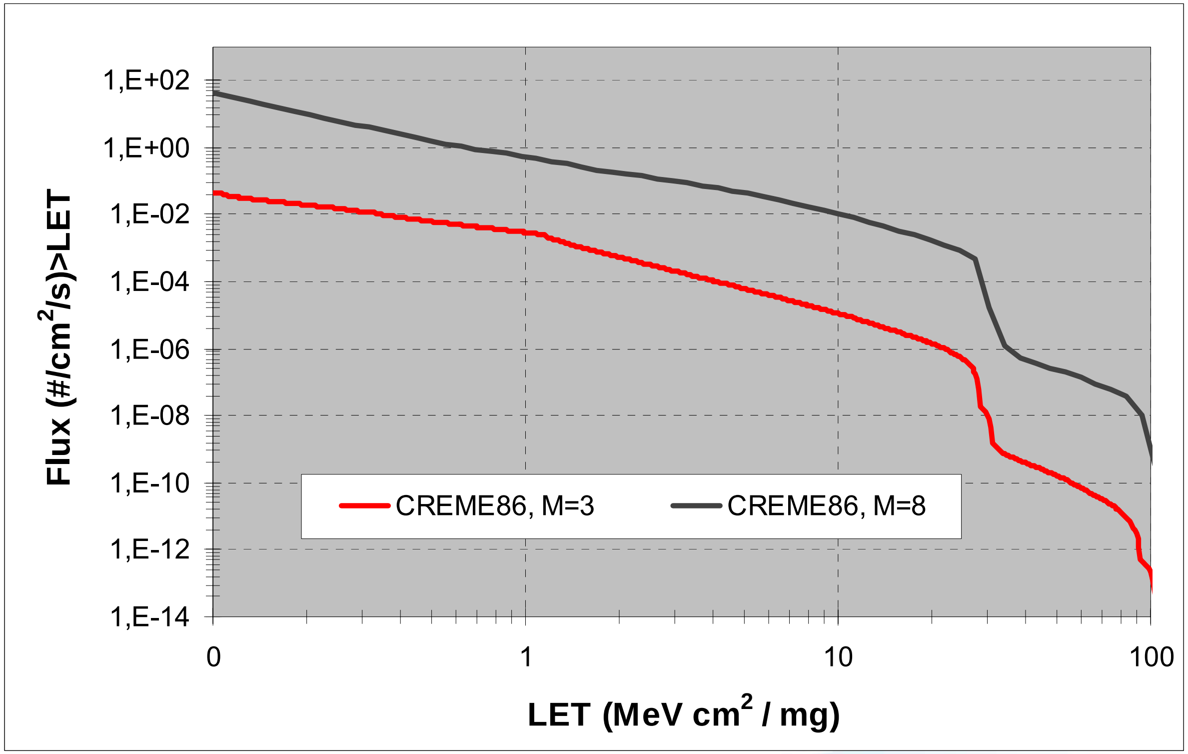
Radiation ground characterization 2/2

- Protons test data are available as well, up to a proton energy of 60 MeV



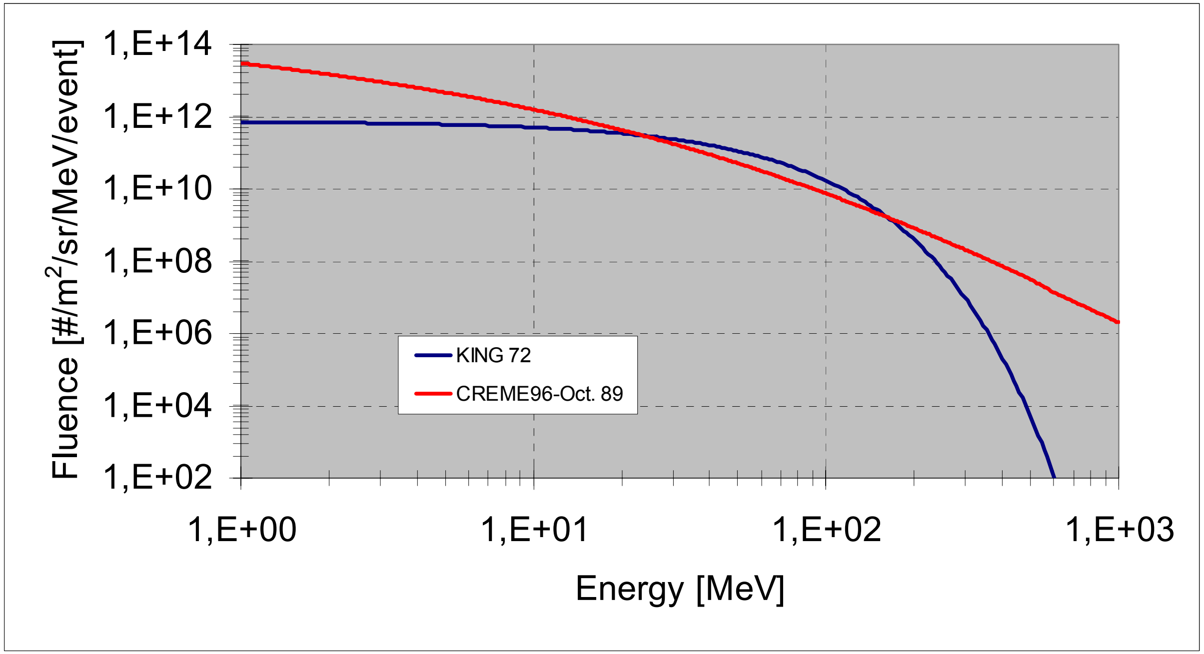
Space radiation environment modelling 1/2

- Specified heavy ion models are obtained thanks to CREME86 with the “M” weather index set to 3 for GCR and 8 for Solar Ions



Space radiation environment modelling 2/2

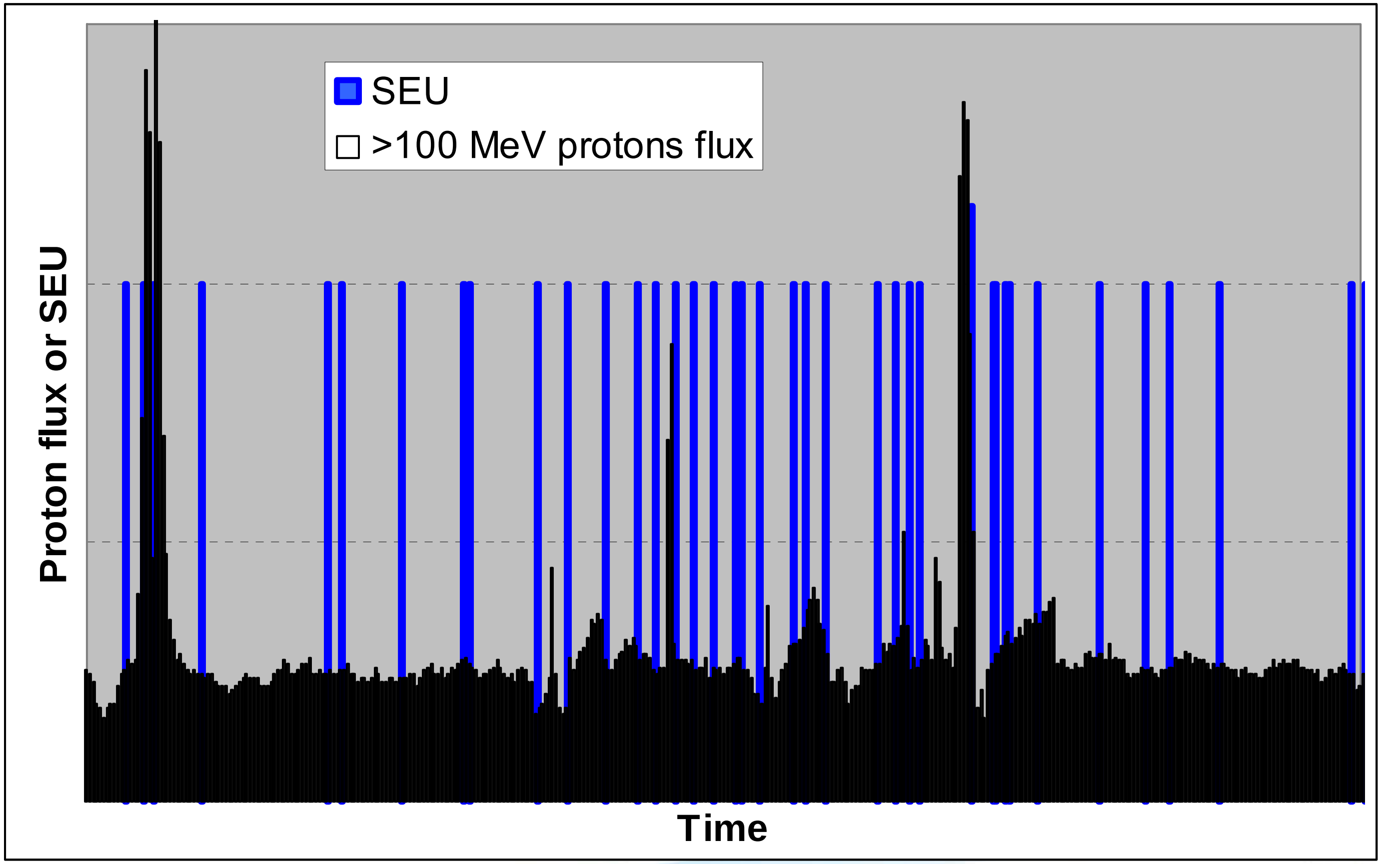
- Specified flare proton models are based either on October 89 either on August 72 flare.



- On top of flare protons, galactic proton model from CREME96 has been used.

In flight observation of SEUs

- More than 100 SEUs recorded, averaged **SEU rate is about 10^{-9}/bit.day**



EADS astrium

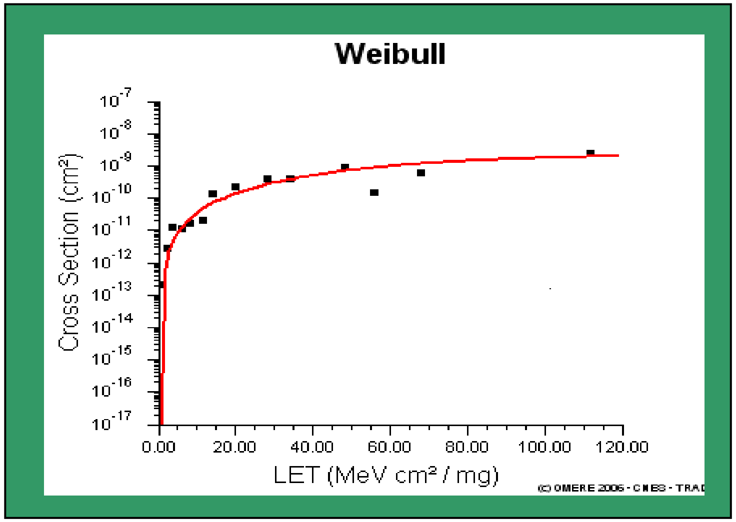
SEU rate prediction method

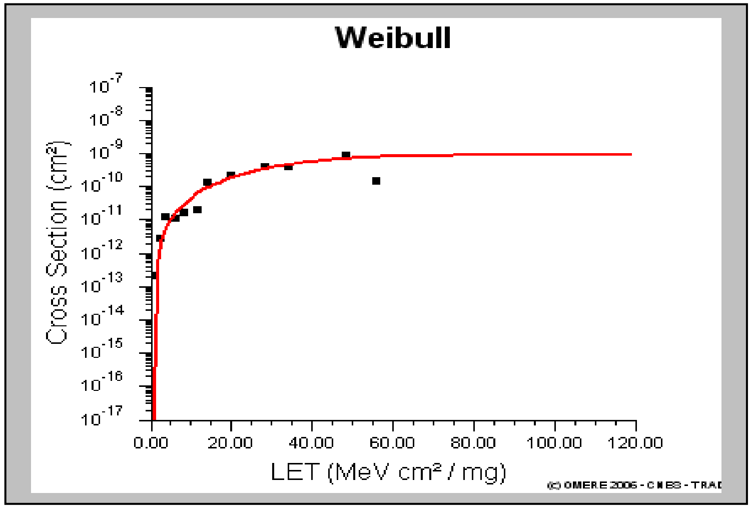
- SEU rate prediction performed, using radiation environment models presented in previous slides
  - OMERE tool used
  - Sensitive volume assimilated to a parallelepiped whose thickness is 2 µm
  - Heavy ion Test data fitted by Weibull function
  - Proton test data fitted by Bendel 2 parameters function

- SEU rate obtained in this configuration is **about 10^{-8} SEU/bit.day**
  - Specified rate is one order of magnitude above observed rate, even though proton SEE testing is potentially not conservative.

SEU rate prediction – LET influence 1/2

- First example, LET value influence on testing data
  - Case 1 : LET up to 112 MeV.cm²/mg (tilted device),
  - Case 2 : 2 last data point removed, LET up to 55.9 MeV.cm²/mg, new fit





- SEU rates obtained with such characterization curves are
  - About 7 10^{-11} SEU/bit.day for the first case
  - About 4 10^{-11} SEU/bit.day for the second case

SEU rate prediction – LET influence 2/2

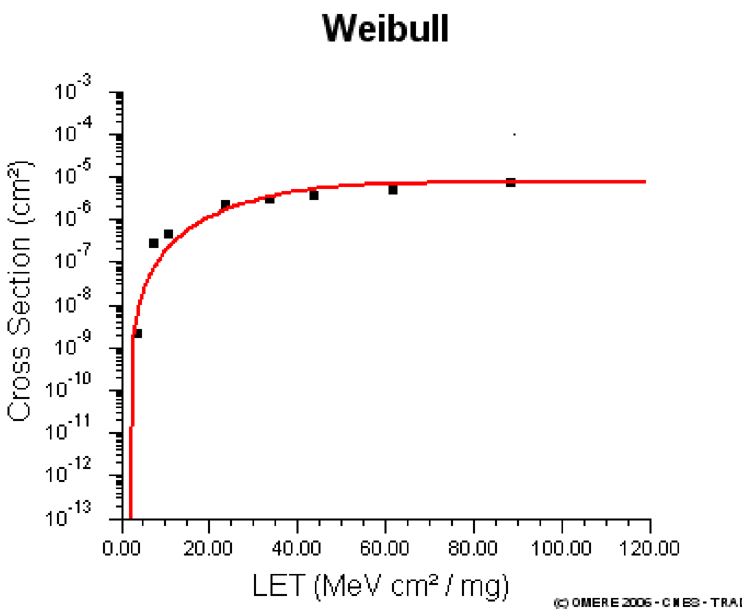
- Second example, LET value influence on LET spectrum (M=3)
  - Case 1 : LET spectrum up to 100 MeV.cm^2/mg
  - Case 2 : LET spectrum up to 60 MeV.cm^2/mg
  - Case 3 : LET spectrum up to 30 MeV.cm^2/mg
  - Case 4 : LET spectrum up to 10 MeV.cm^2/mg
  - Case 5 : LET spectrum up to 1 MeV.cm^2/mg
- SEU rates obtained with case 1 testing data and such spectra are :
  - About 7 10^{-11} SEU/bit.day for cases 1 to 3
  - About 5 10^{-11} SEU/bit.day for case 4
  - About 1 10^{-12} SEU/bit.day for case 5

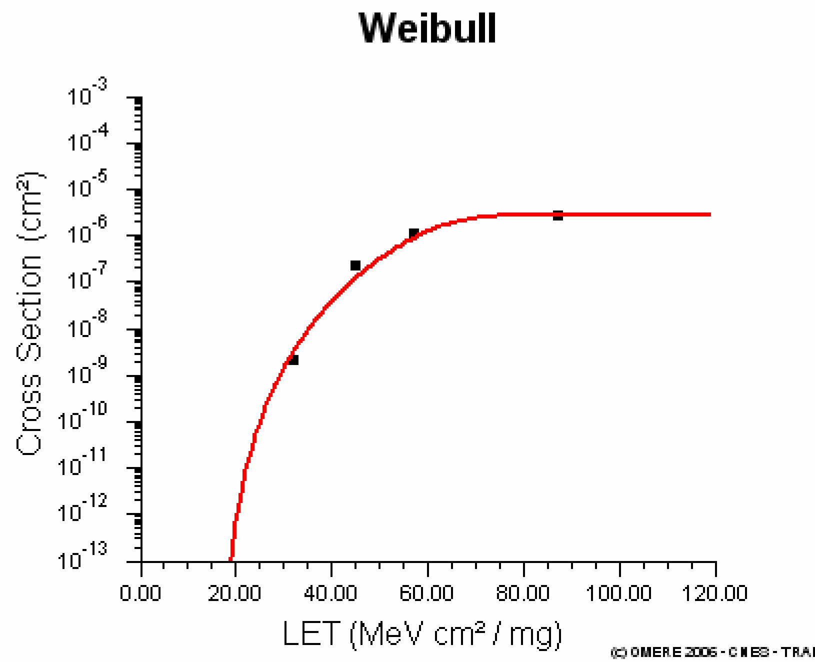
Conclusion

- When using specified models, SEU rates are in this case overestimated by about one order of magnitude

- About the LET influence
  - When removing the high LET test data point, the impact on SEU rate is a decrease of about 40%.
  - From the second example, it turns out that contribution of heavy ion whose LET is above 30 is negligible regarding SEU rate.
    - 40% decrease observed in the first case is due to the modification of the fitting function in the very low LET values (< 5 $MeV.cm^2/mg$) regardless that testing data are unchanged.

LET influence – follow on





- SEU rates obtained with 1/ full spectrum, 2/ LET < 15 MeV.cm²/mg
  - 1/ $8\ 10^{-6}$ SEU/bit.day — $1.65\ 10^{-7}$ SEU/bit.day
  - 2/ $7.6\ 10^{-6}$ SEU/bit.day — $1.34\ 10^{-7}$ SEU/bit.day