SEE Modelling / Prediction

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2nd Radecs Thematic Workshop

"LET-Requirements and Testing for Space Applications"

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Outline

- Basics of SEE rate Modelling
- Playing with RPP method using CREME96
- Examples; Device data with IRPP method using CREME96
- Conclusions

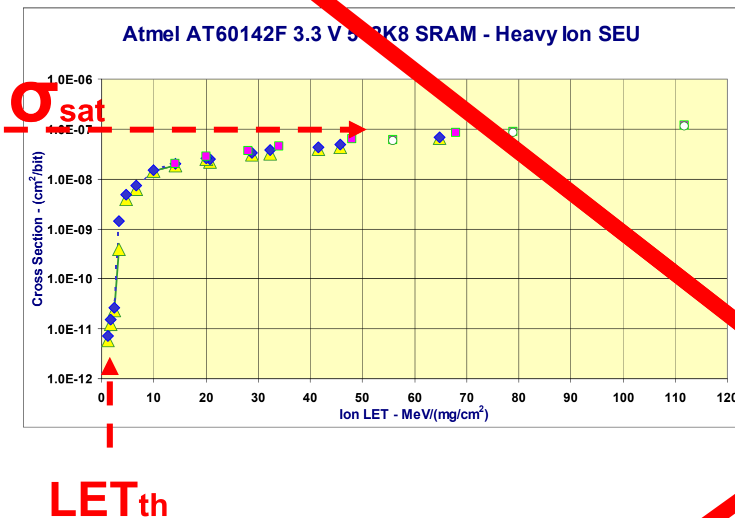
This presentation addresses only Heavy ion SEE modelling

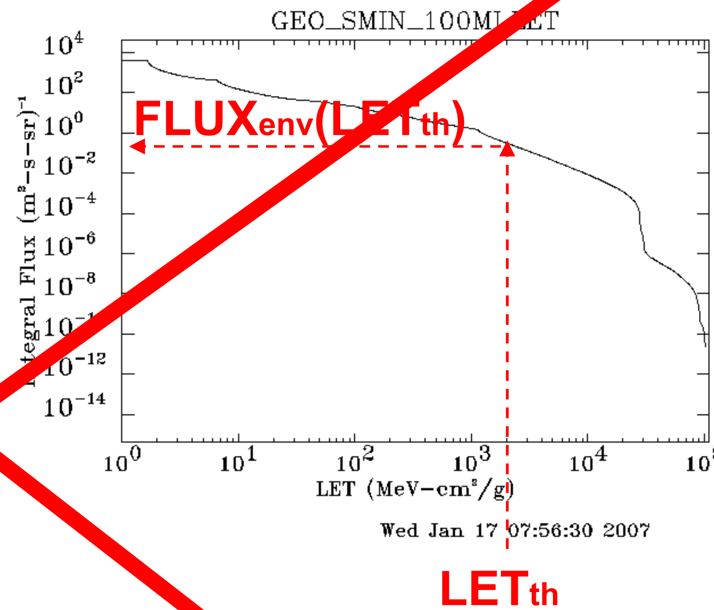
All predictions have been made in CREME96. We expect similar results in any other tool using RPP/IRPP method

Correlation to flight data is unknown. It only shows the outcome of the modelling.

Basics of Heavy ion SEE rates Predictions

Accelerator Test Data + Space environment Model





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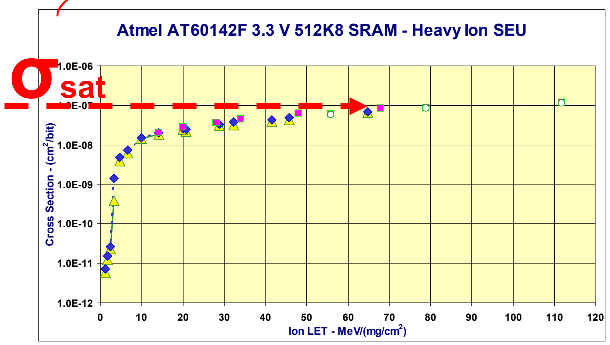
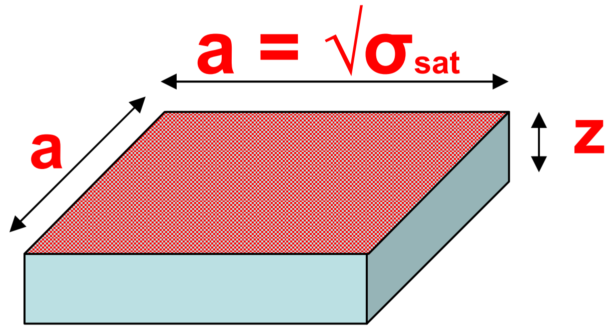
Predicted SEE rate in Space = $FLUX_{env}(LET_{th}) * \sigma_{sat}$

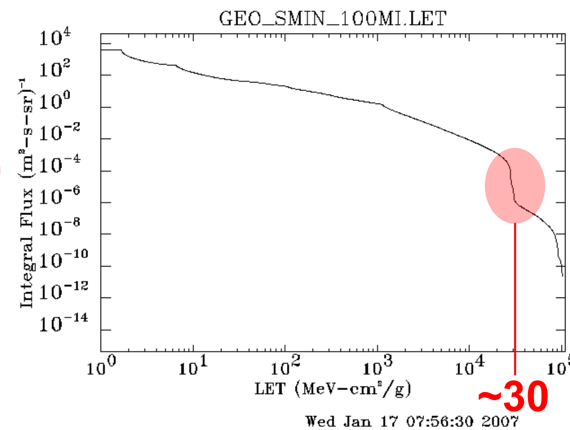
This is a 2D – Model

Space is 3-dimensionell

Basics of Heavy ion SEE rates Predictions 3D-Modelling (RPP&IRPP Method)







Accelerator Test Data + Sensitive Volume(SV) (RPP dimension) + Space environment

=>

RPP / IRPP method:

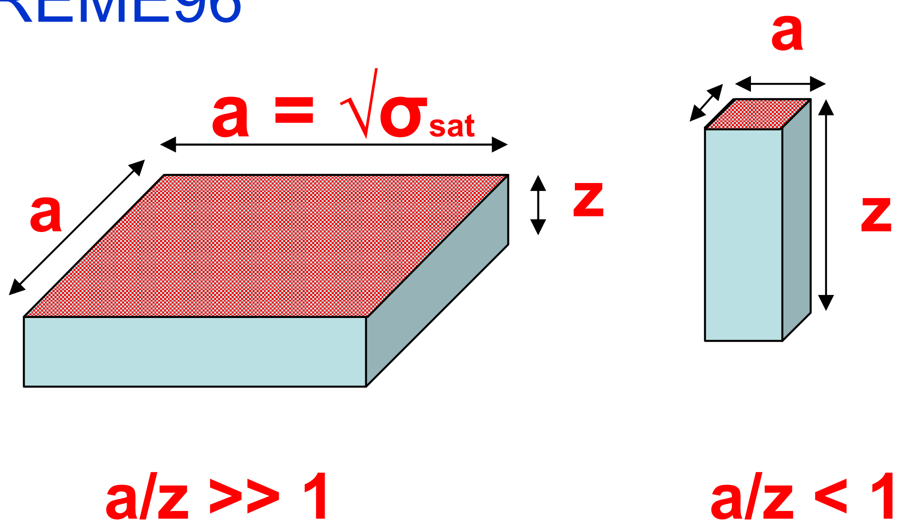
Integrating the environment in all directions into the SV, deriving if specific Ion path leave charge enough for an upset. Critical charge is derived from accelerator test data (IRPP)/ LET_{th}(RPP).

Predicted SEE rate in Space

Playing with RPP method using CREME96

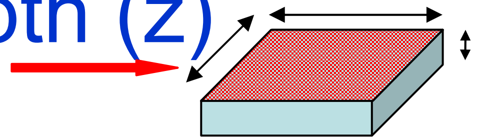
(Critical charge method)

- All calculations made in CREME96
  - Geosynchronous Orbit
  - Atomic number 1-92
  - Solar Quiet conditions
    - Solar Minimum
  - 100mil Aluminium shielding
- Device Input parameters
  - σ_{sat} Saturation cross section
  - LET_{th}
  - Z Sensitive depth



=> Critical charge for upset $Q_c(Si) = 0.0103 \times LET_{th} \times Z$

Playing with the sensitive depth (z) at a big flat SV

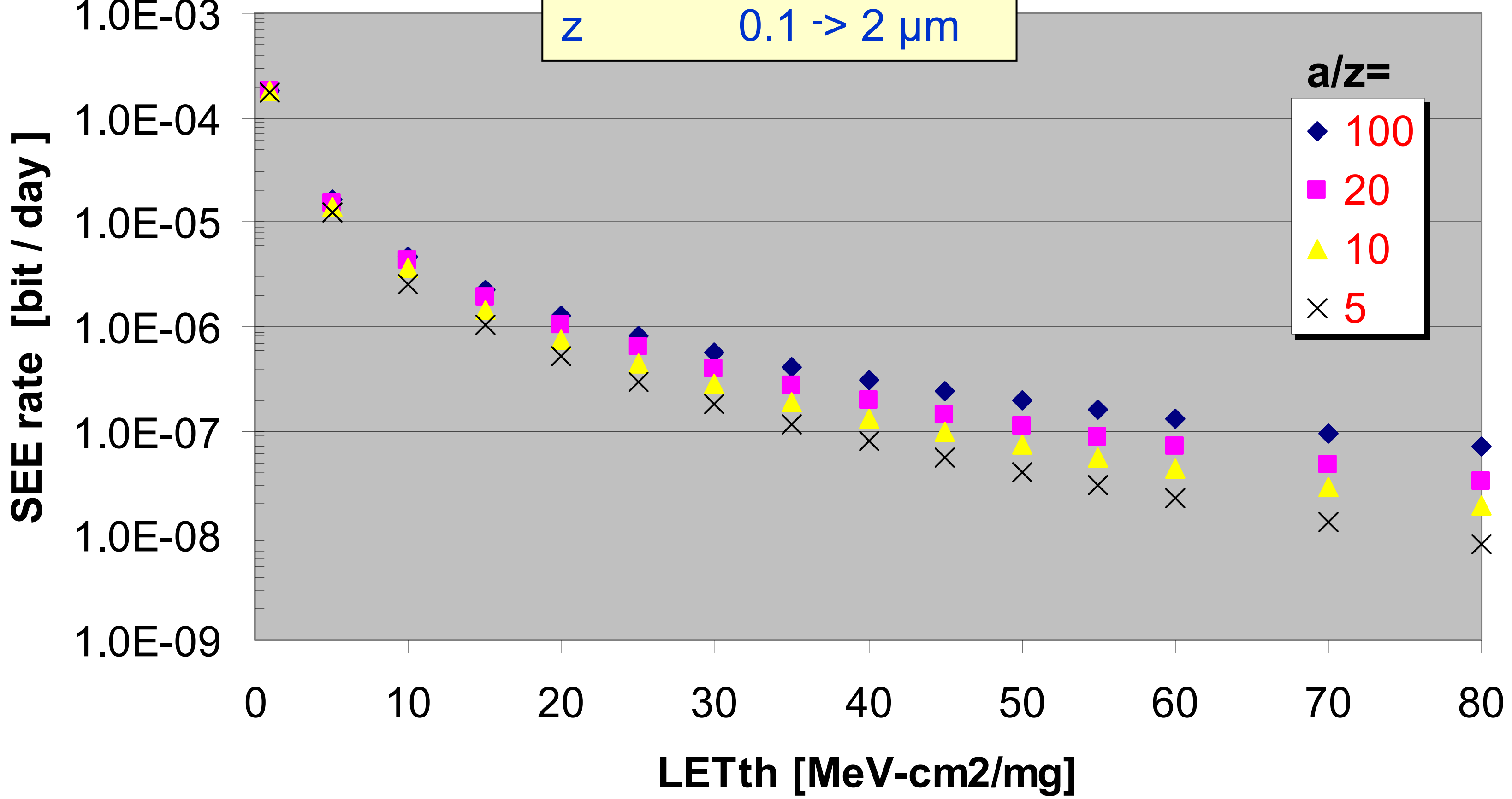


a/z >> 1

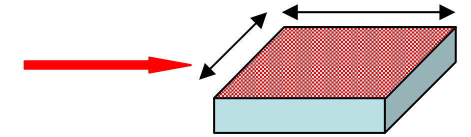
Horizontal direction to SV worst case path

=> small dependency on z

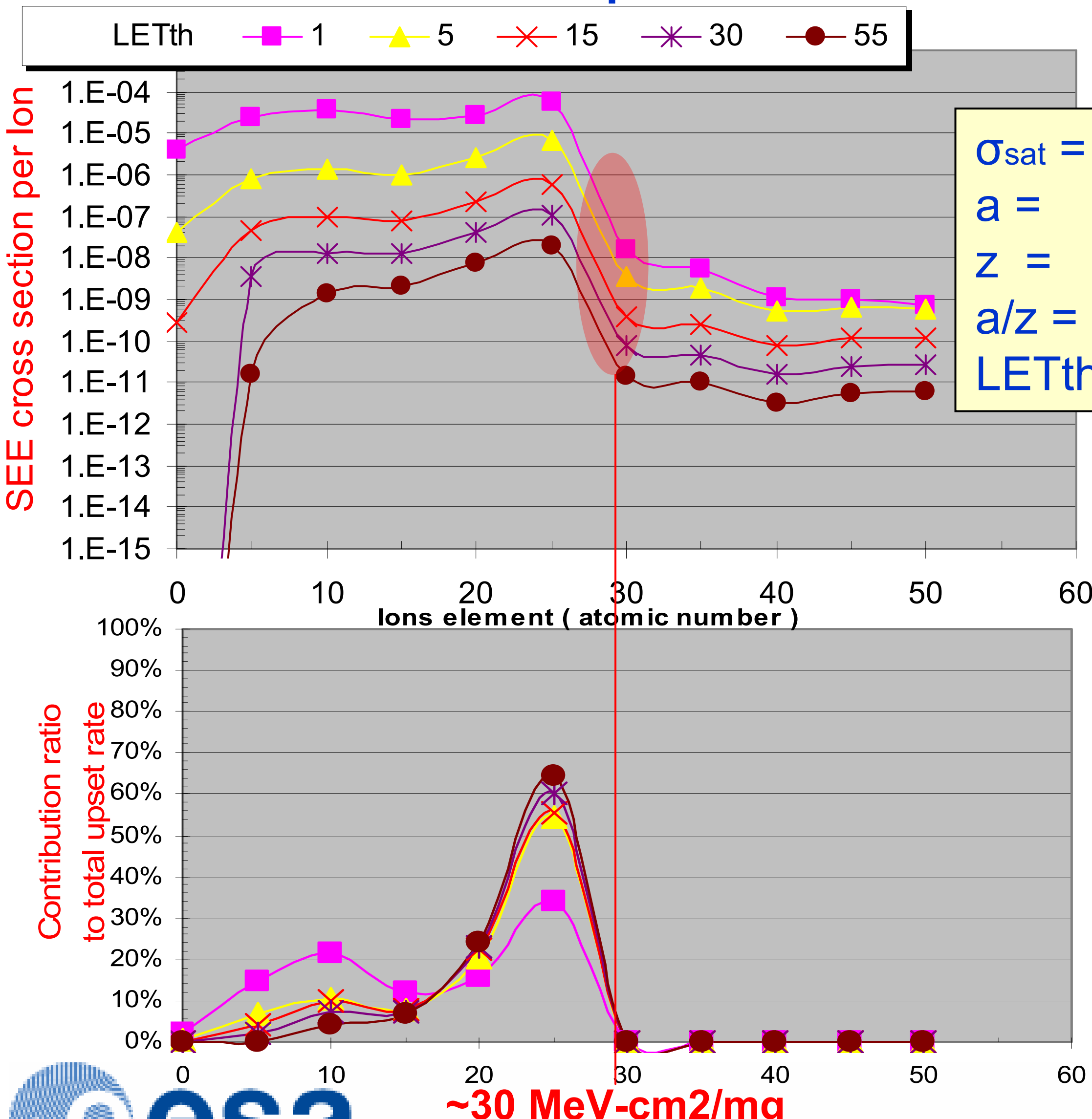
σ_{sat} =	100 µm2
a =	10 µm
z	0.1 -> 2 µm



Contribution to SEE rate of Each Ion Element of Space Environment



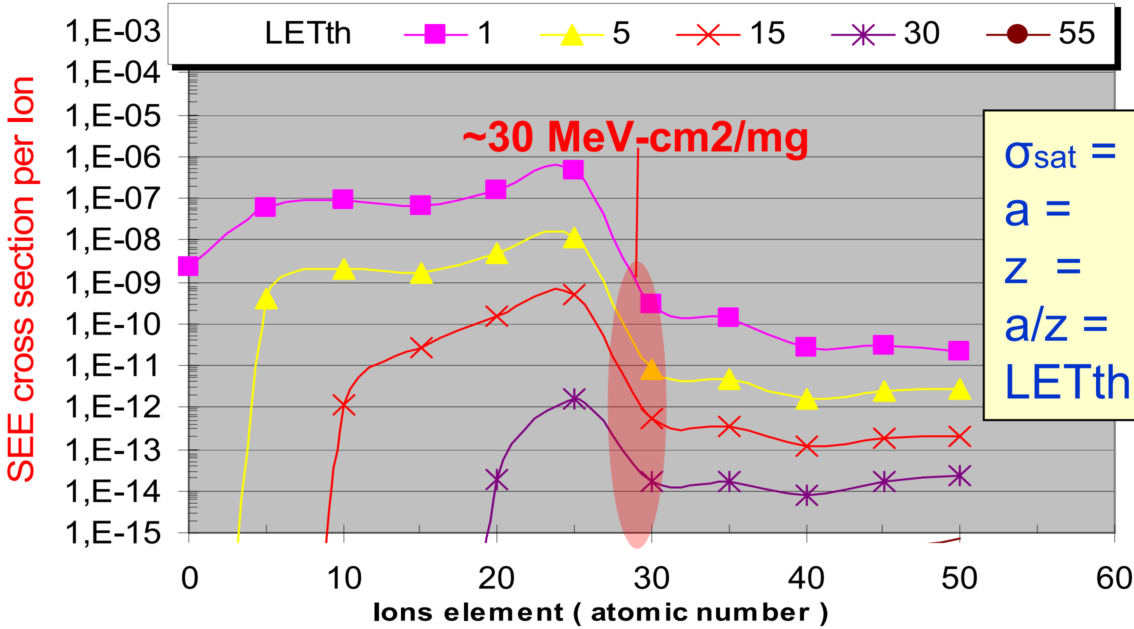
a/z >> 1

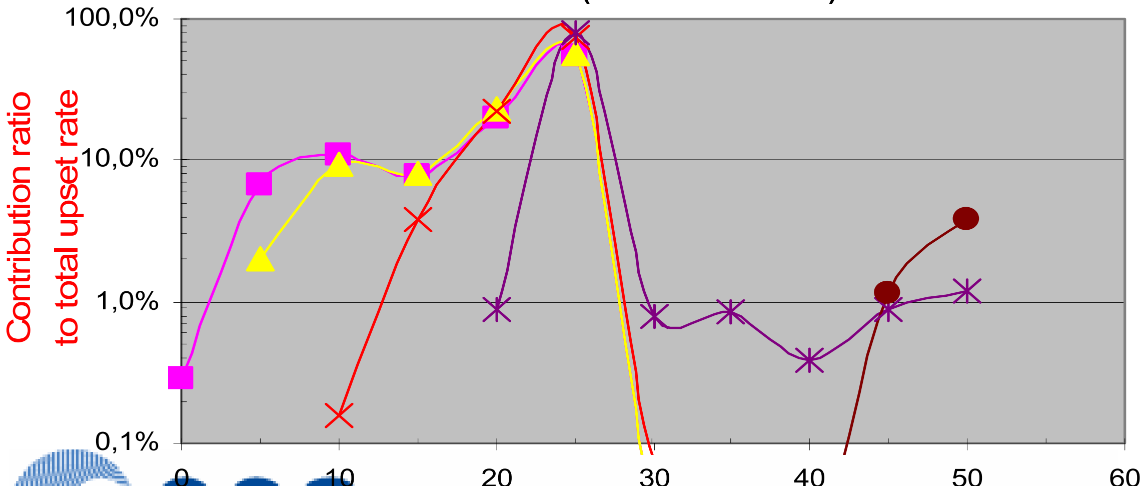


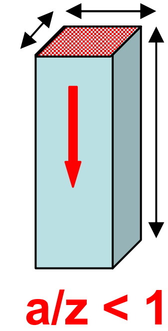
σ_{sat} =	100 µm2
a =	10 µm
z =	2 µm
a/z =	5
LETth	1 -> 55 MeV-cm2/mg

- Even for LETth of 55, the main contribution of upsets comes from lighter ions (with max LET of 30)
  - Horizontal ion paths into the SV give the main contribution to SEE rate
    - This is a worse path compared to acceleration data.

Contribution to SEE rate of Each Ion Element of Space Environment



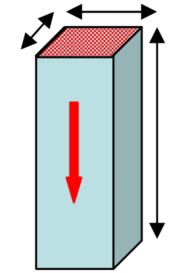




σ_{sat} =	1 µm2
a =	1 µm
z =	2 µm
a/z =	0.5
LETth	1 -> 55 MeV-cm2/mg

- For LETth of 55, no contribution of upsets comes from lighter ions (with max LET of 30)
  - Horizontal ion paths into the SV give no contribution to SEE rate
    - The worse ion path is vertical into SV. Same as in accelerator test data

Playing with the sensitive depth (z) at a small SV



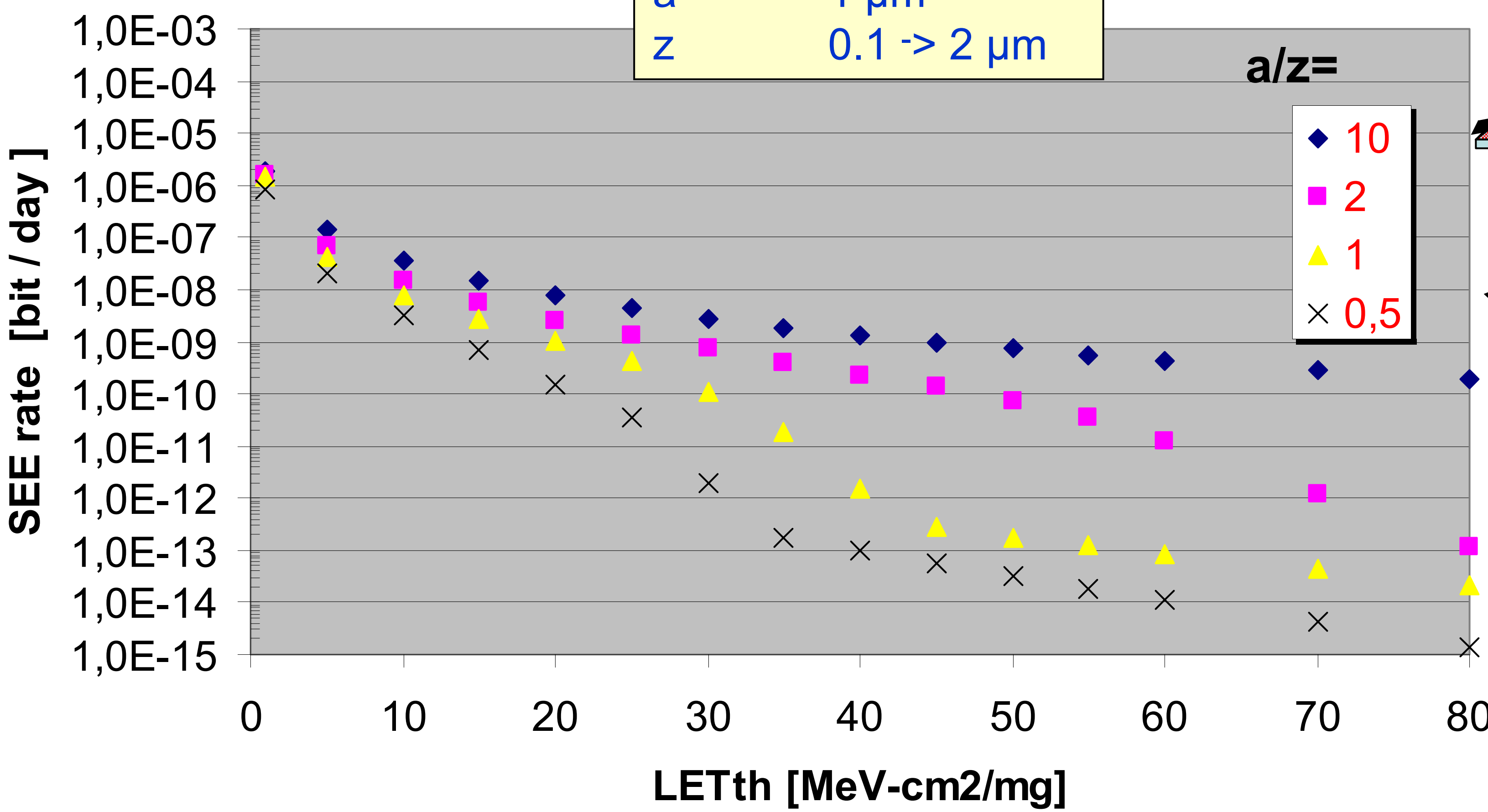
a/z < 1

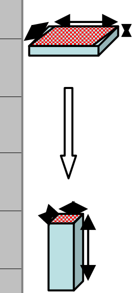
Vertical direction to SV worst case path

⇒Huge dependency on z

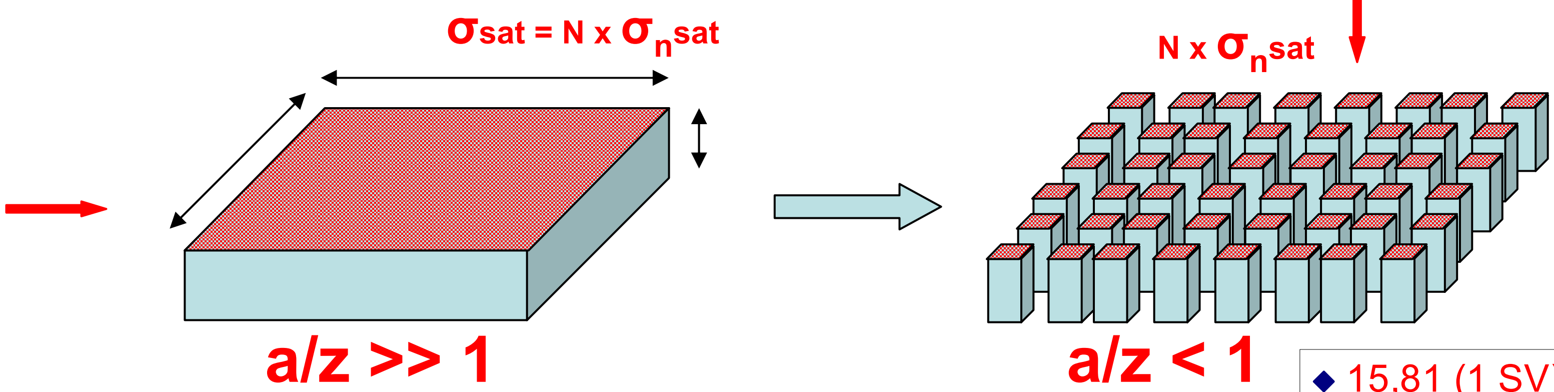
⇒Especially for higher LETth

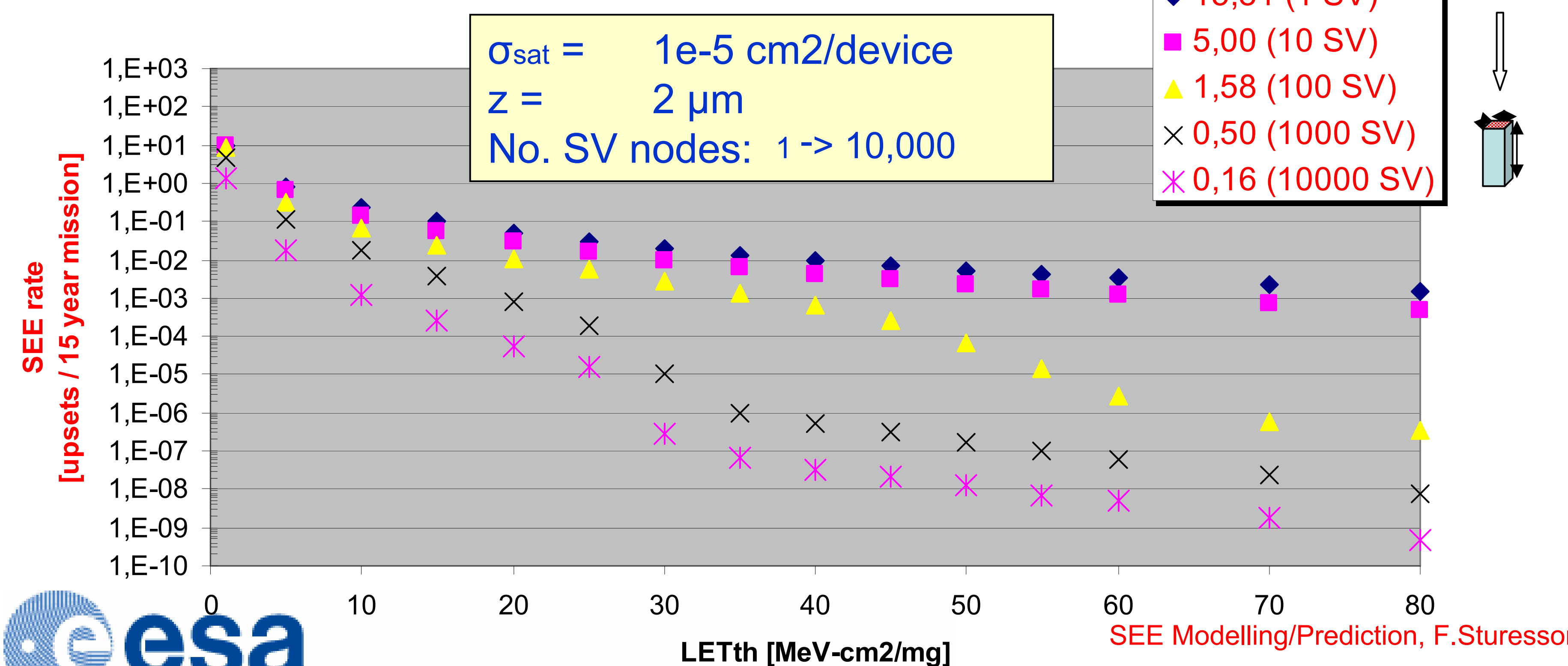
σ_{sat} =	1 µm2
a =	1 µm
z	0.1 -> 2 µm





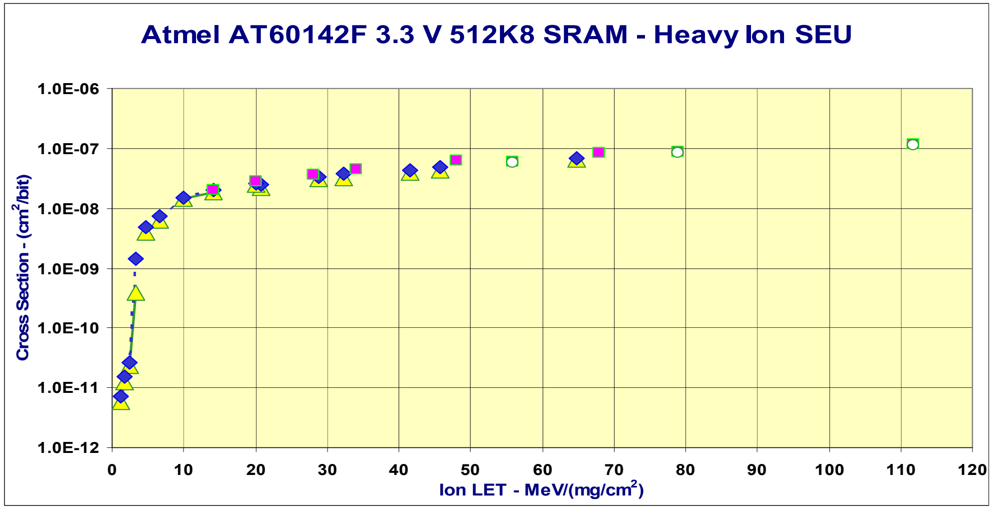
Playing with the number of SV

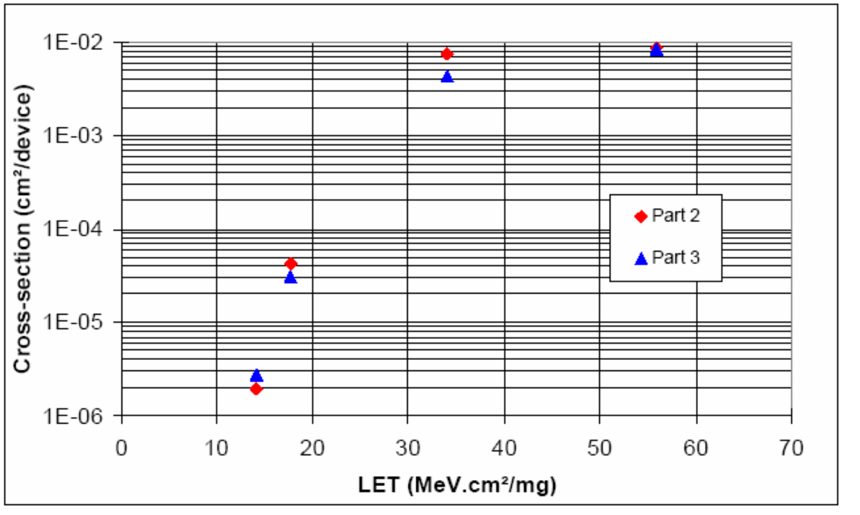




Example data using Integral-RPP method (IRPP)

- Weibull parameters into same space environment (CREME96)





Atmel AT60142F 512K8 SRAM

Used weibull fit:

- Onset = 1.5 MeV-cm2/mg
- Power = 1.29
- Width = 436.4
- σsat = 6e-7 cm2/bit

Atmel AT40K FPGA -Cfg memory cells

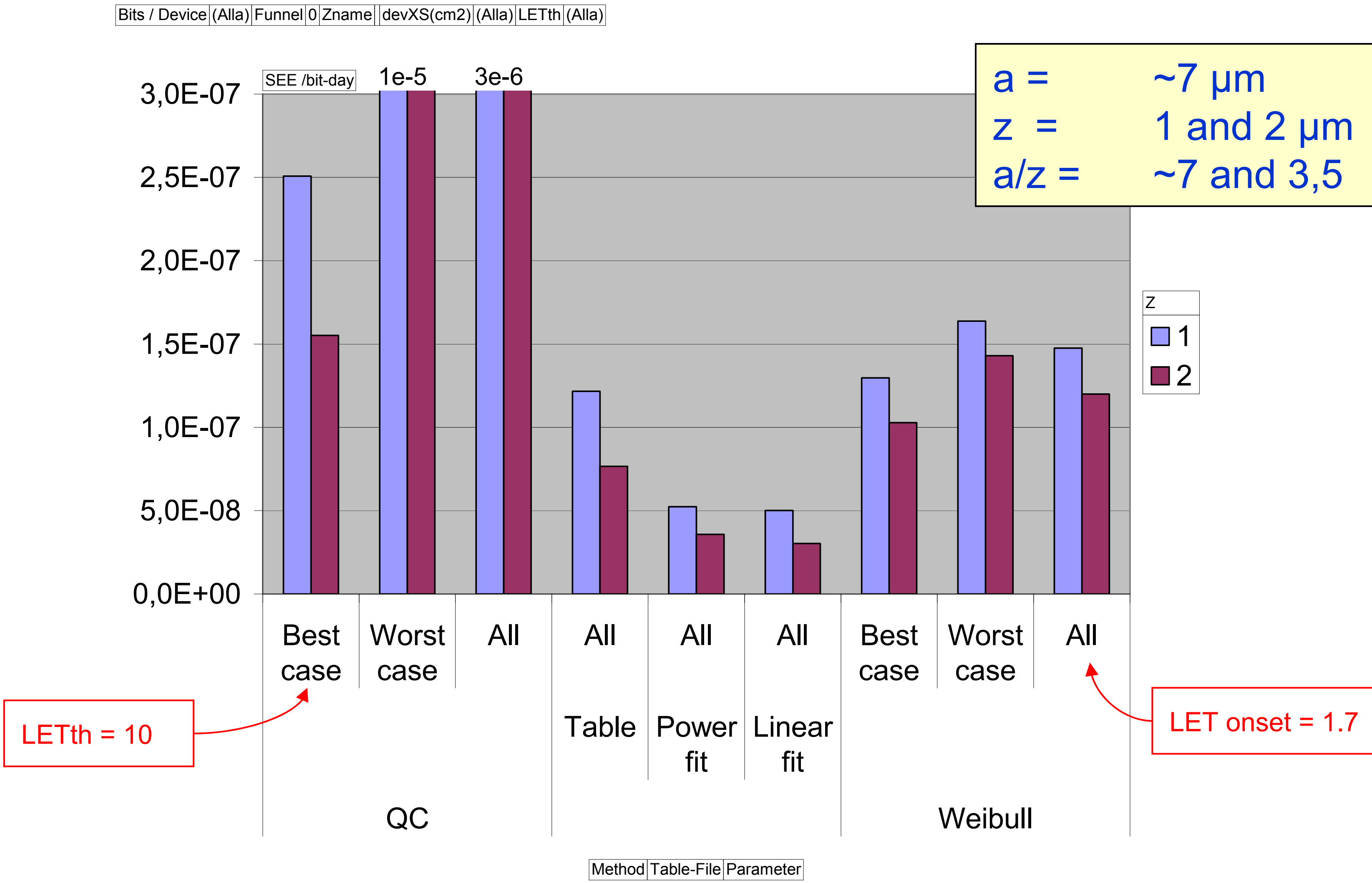
Used weibull fit:

- Onset = 9.7 MeV-cm2/mg
- Power = 4.6
- Width = 25
- σsat = 2.5e-8 cm2/bit

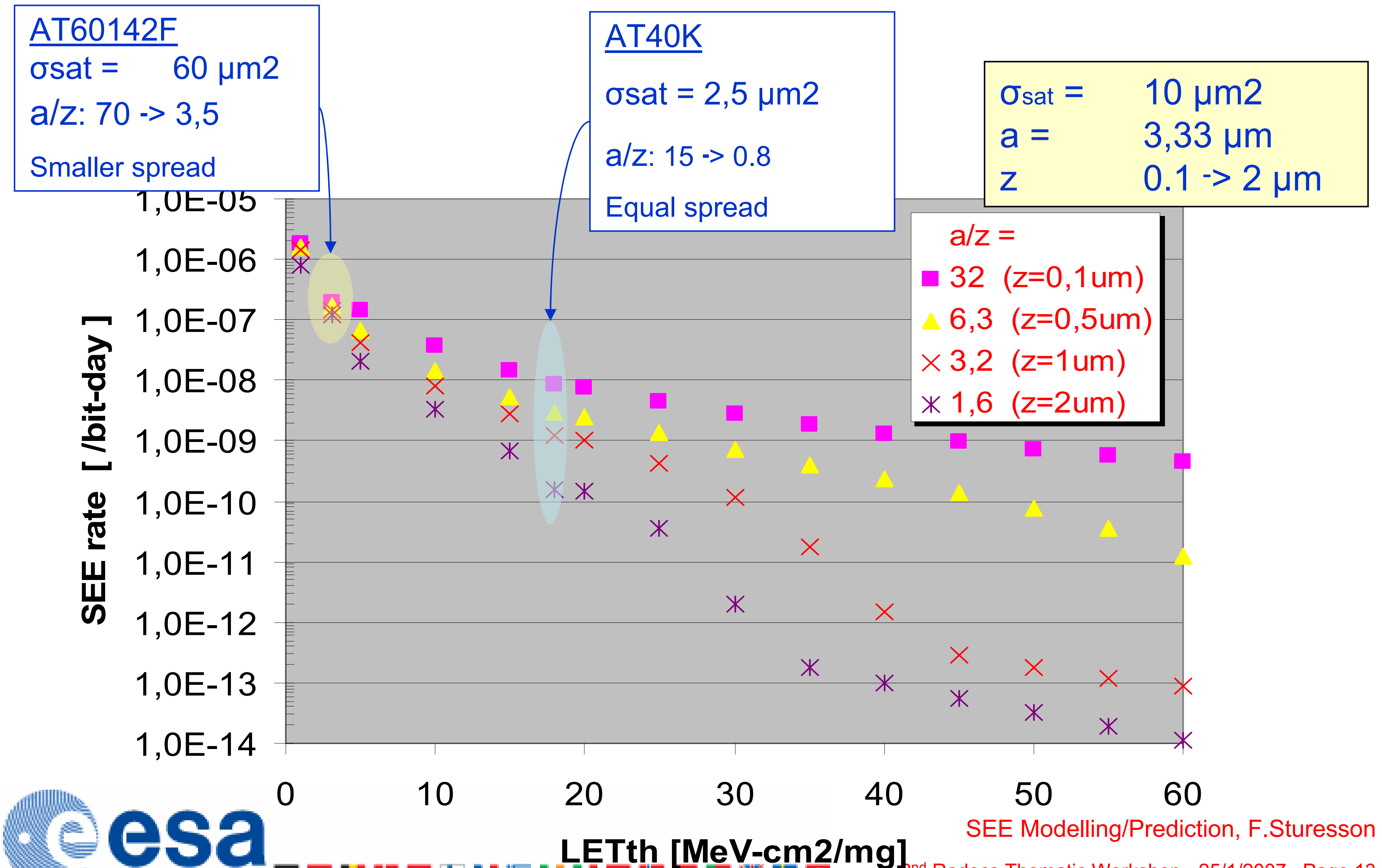
Predicted SEE rates with different fitting of test data using CREME96

AT60142F

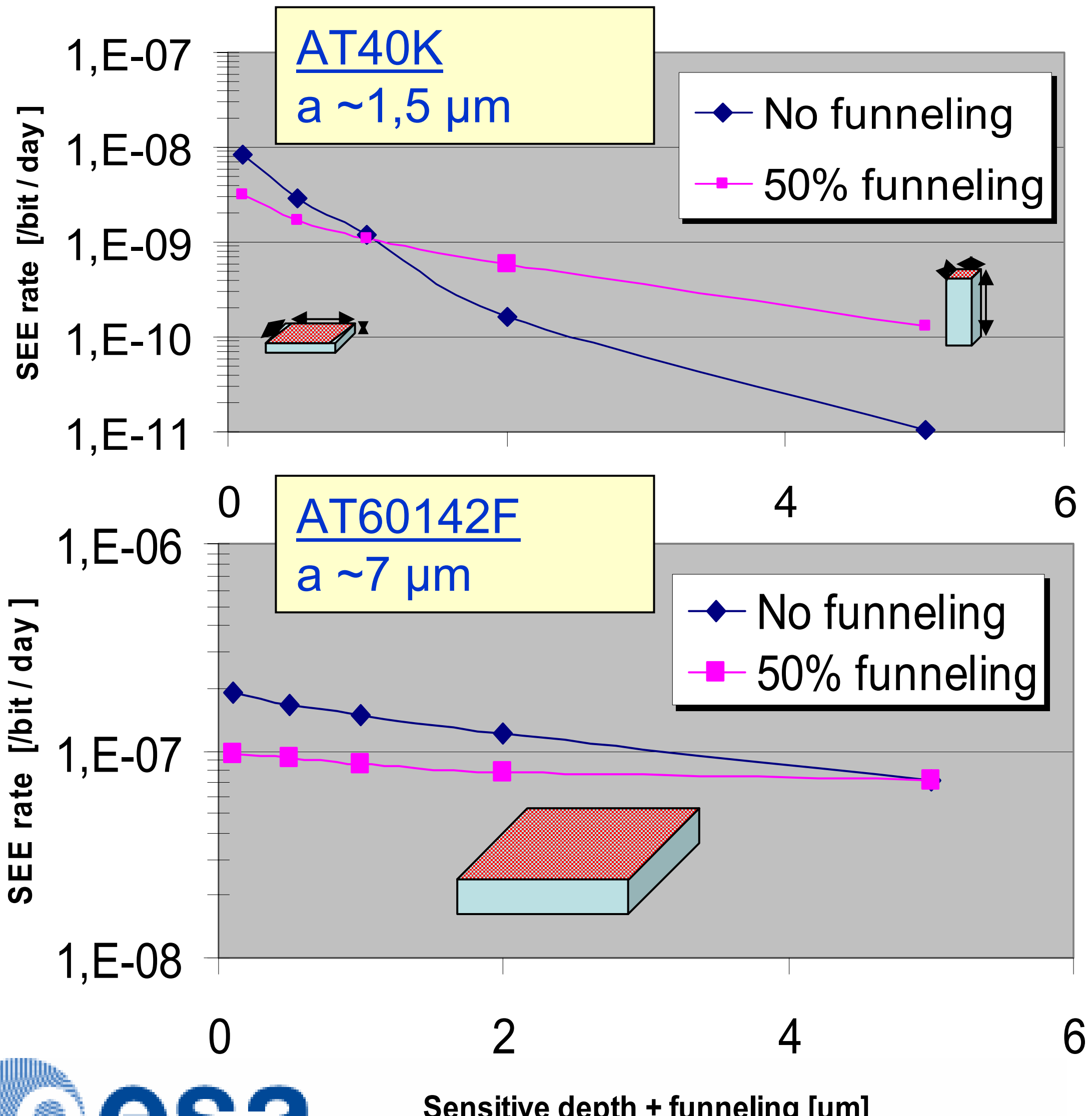
a = ~7 µm
z = 1 and 2 µm
a/z = ~7 and 3,5



Playing with the sensitive depth (z) IRPP Method



Playing with the sensitive depth (z) and funnel IRPP Method



- Effect of Funnel switch “polarity” when going from flat SV to deep SV

Conclusions & Topics for the Round Table

- With the IRPP/RPP method, basically no ions above Iron contributes to the predicted SEE rate.
  - Is this also the case in space?
- For higher LET thresholds (above 20-30 MeV-cm2/mg) and shrinking technologies it is impossible to do reliable SEE rate predictions!?!
  - At least when we test as we do today
- We have requirements for LET threshold and Fluence (1E+7 ions/cm2)
  - But with shrinking technologies the final SEE rate is more dependent on the geometry of the sensitive volume
  - For older technologies it might have been relevant to use LET threshold as screening parameter, but how relevant is it for shrinking technologies?