Integrated Radiation Environment,

Effects and Component Degradation Simulation Tool (CODES)

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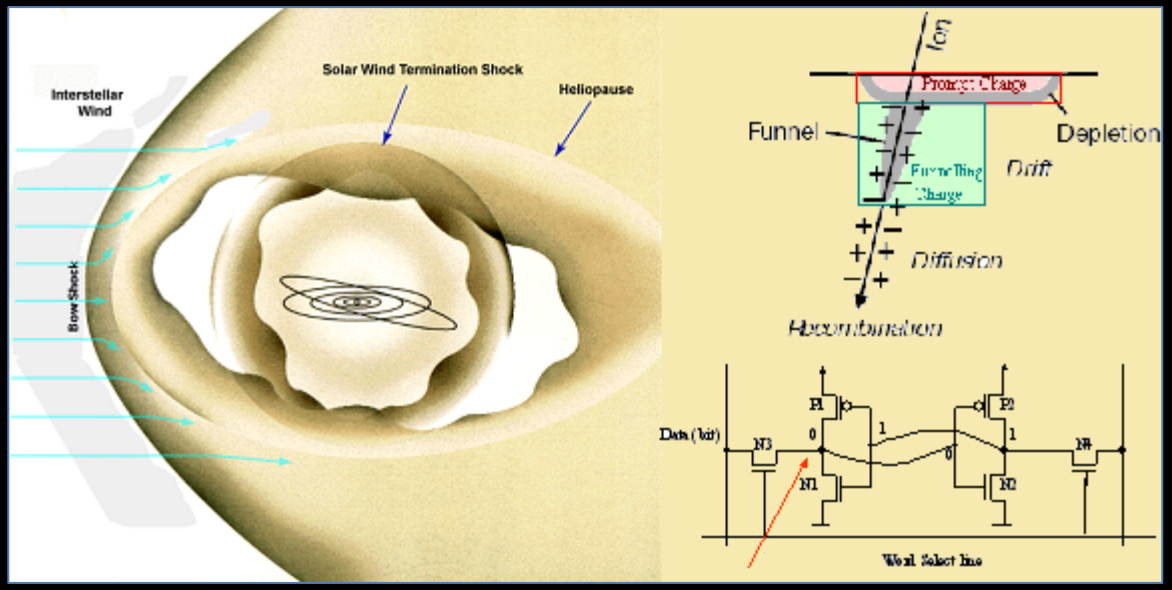
ESA Project:

22381/09/NL/PA

End: Dec 2011

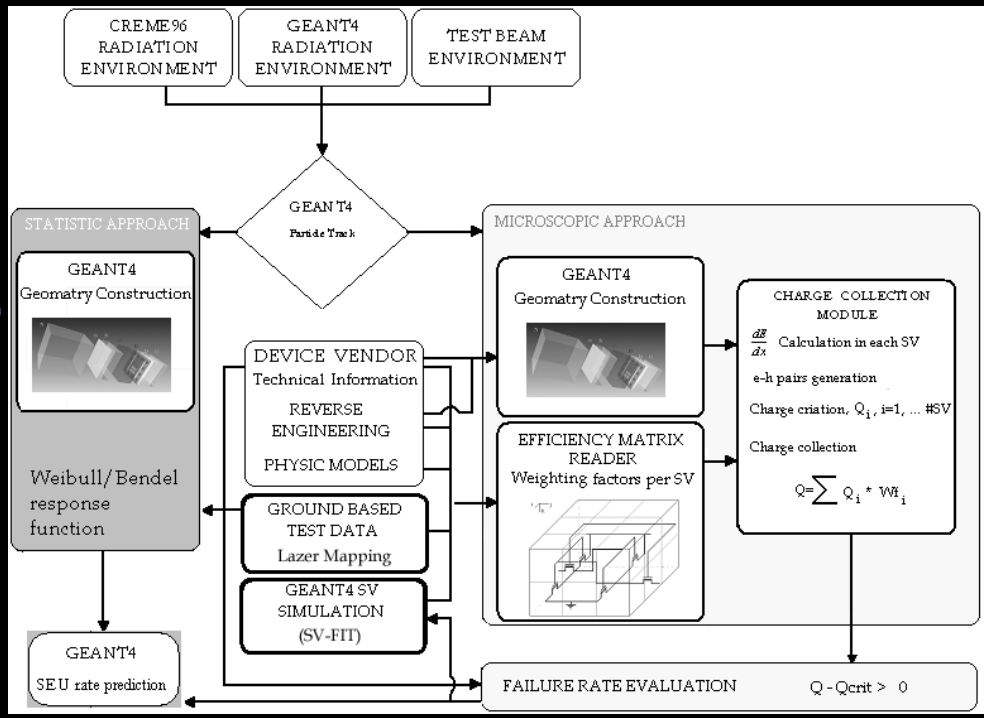


Outline

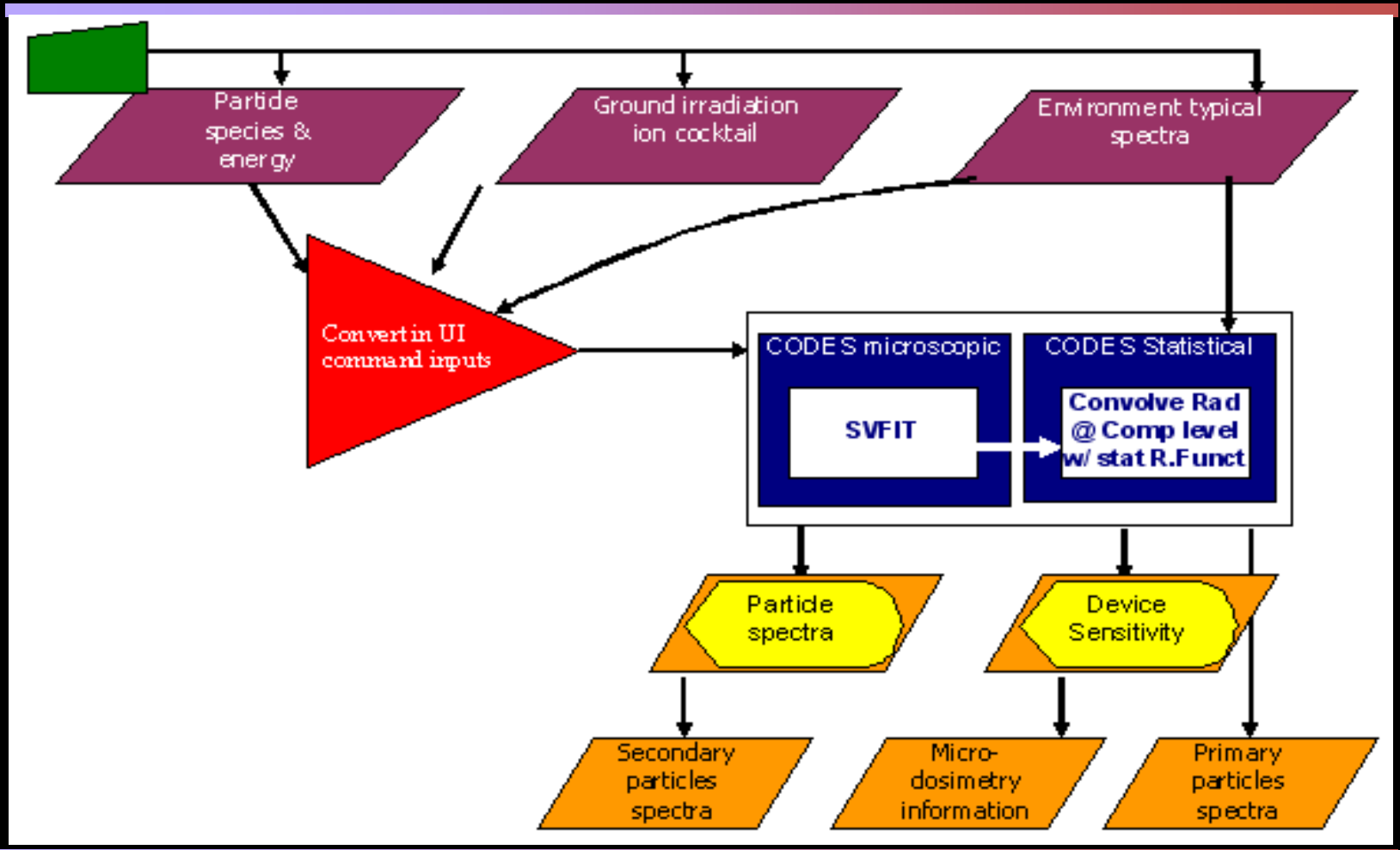
- CODES Philosophy
- CODES Modules : CODES, SVFIT, pre-processor
- Engineering top level interface
- Results on Reference SEU Monitor and TDM devices
  - Protons and ions
- Conclusions
- Further work

Philosophy

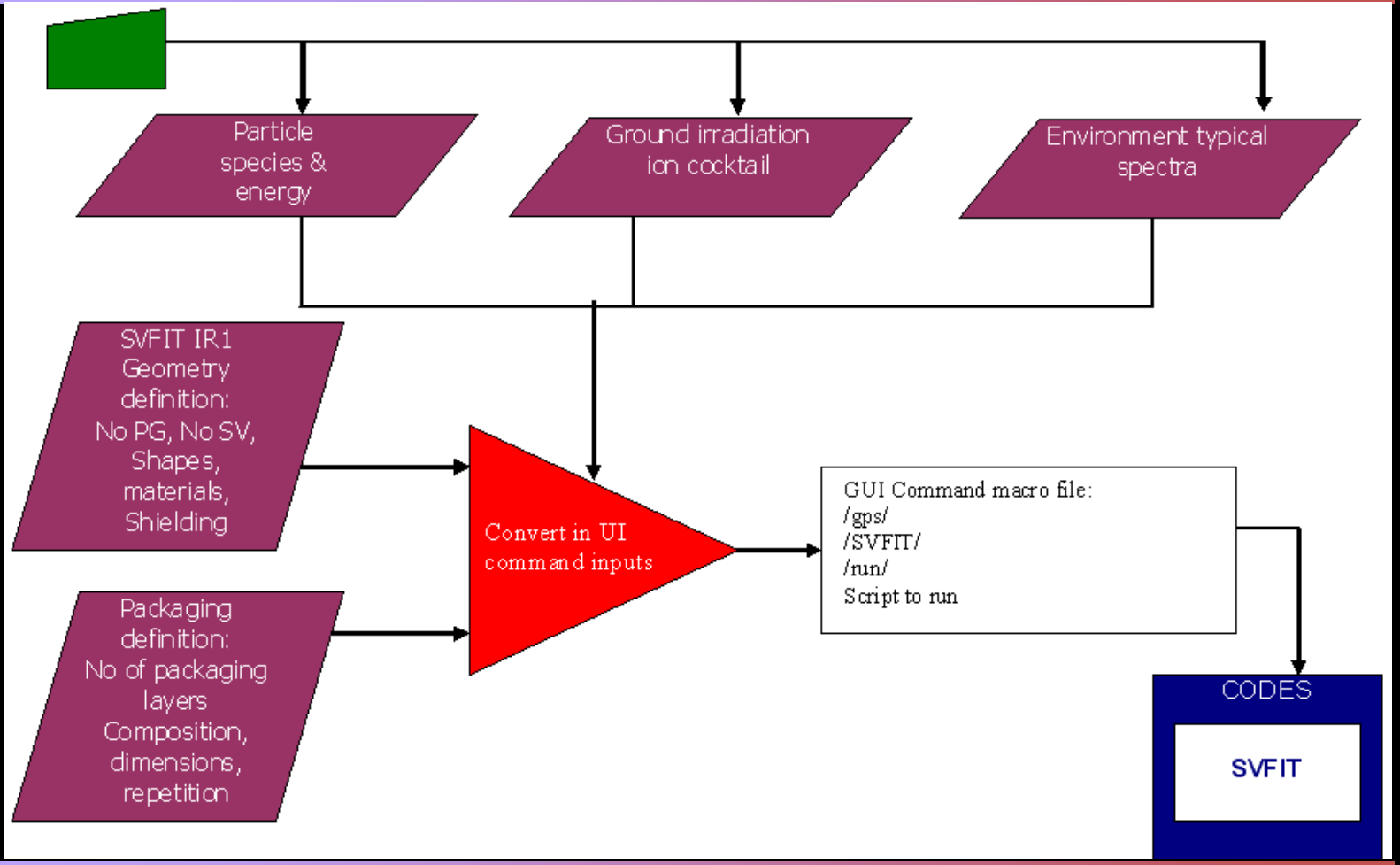
- *Top level Framework*: (CODES)
  - Environment radiation thru device geometry
  - Device response functioning
    - mCODES
    - sCODES
  - From input spectra to SEE rates
- *microscopic approach (mCODES)*
  - inputs: ion test data, device details
  - use of microsdosimetry to fit SV
- *statistical approach (sCODES)*
  - Weibull/Bendel Methods
  - Rpp or input SVFIT SV shape



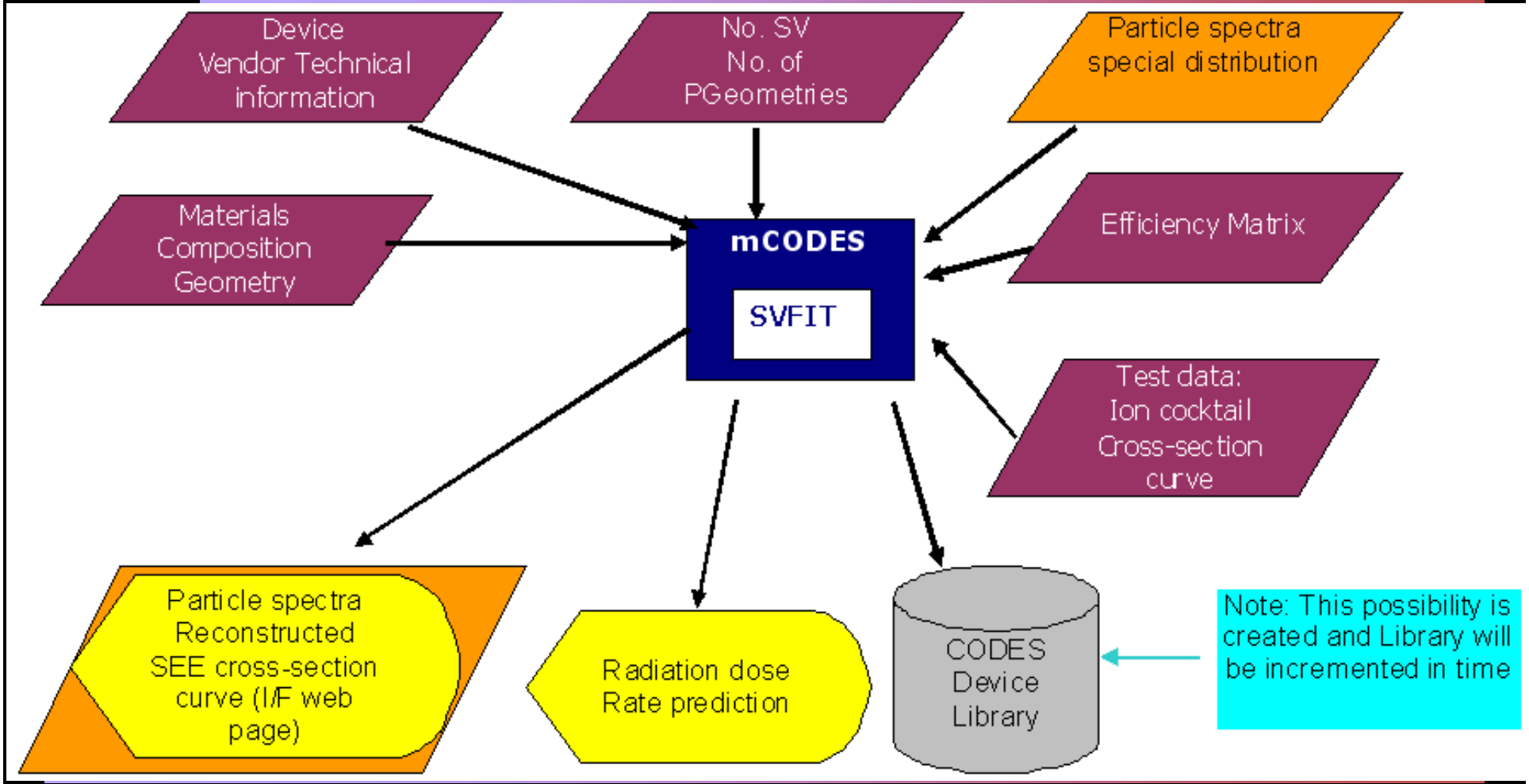
Source particle & output definition



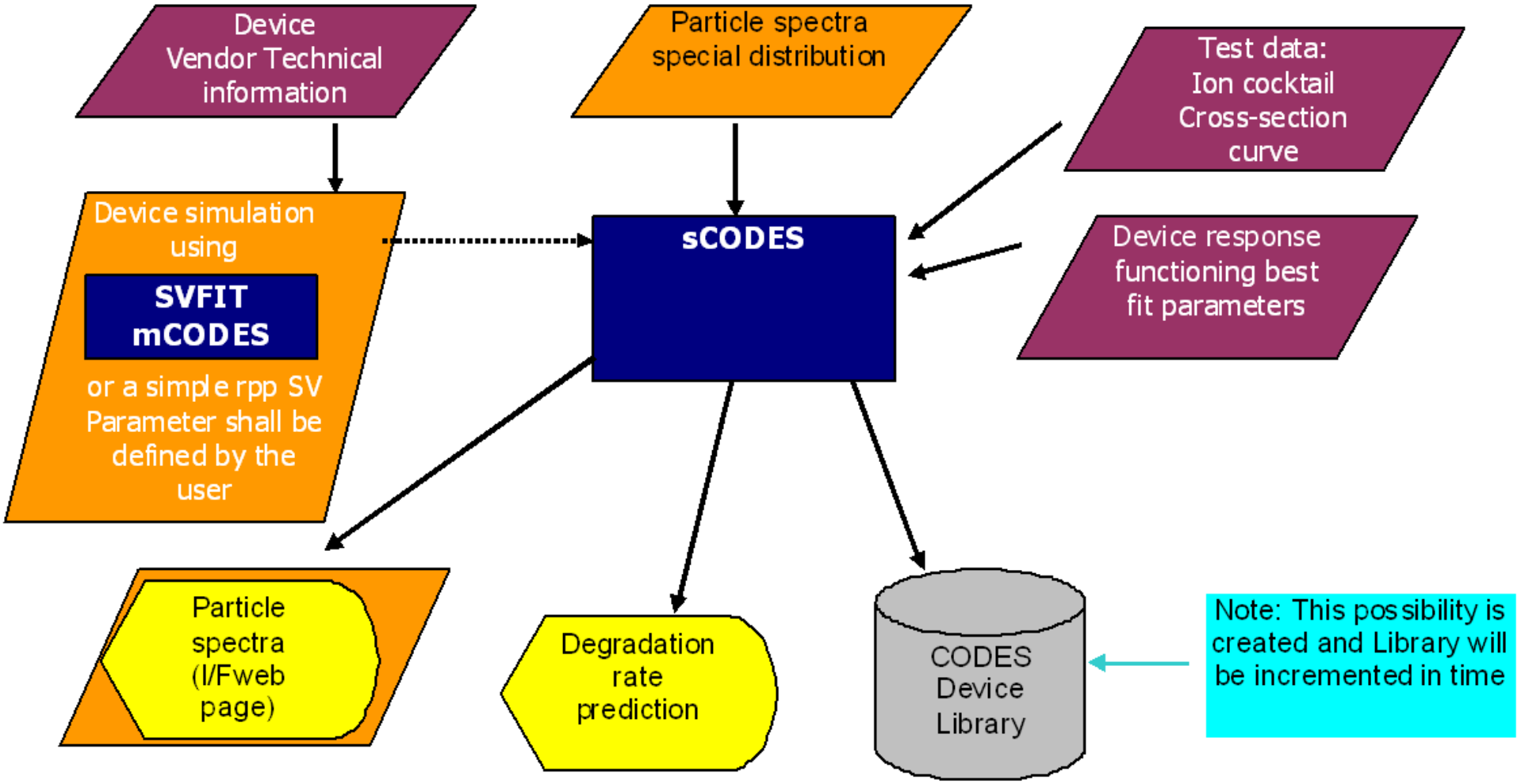
Particle Source and Geometry Pre-Processor



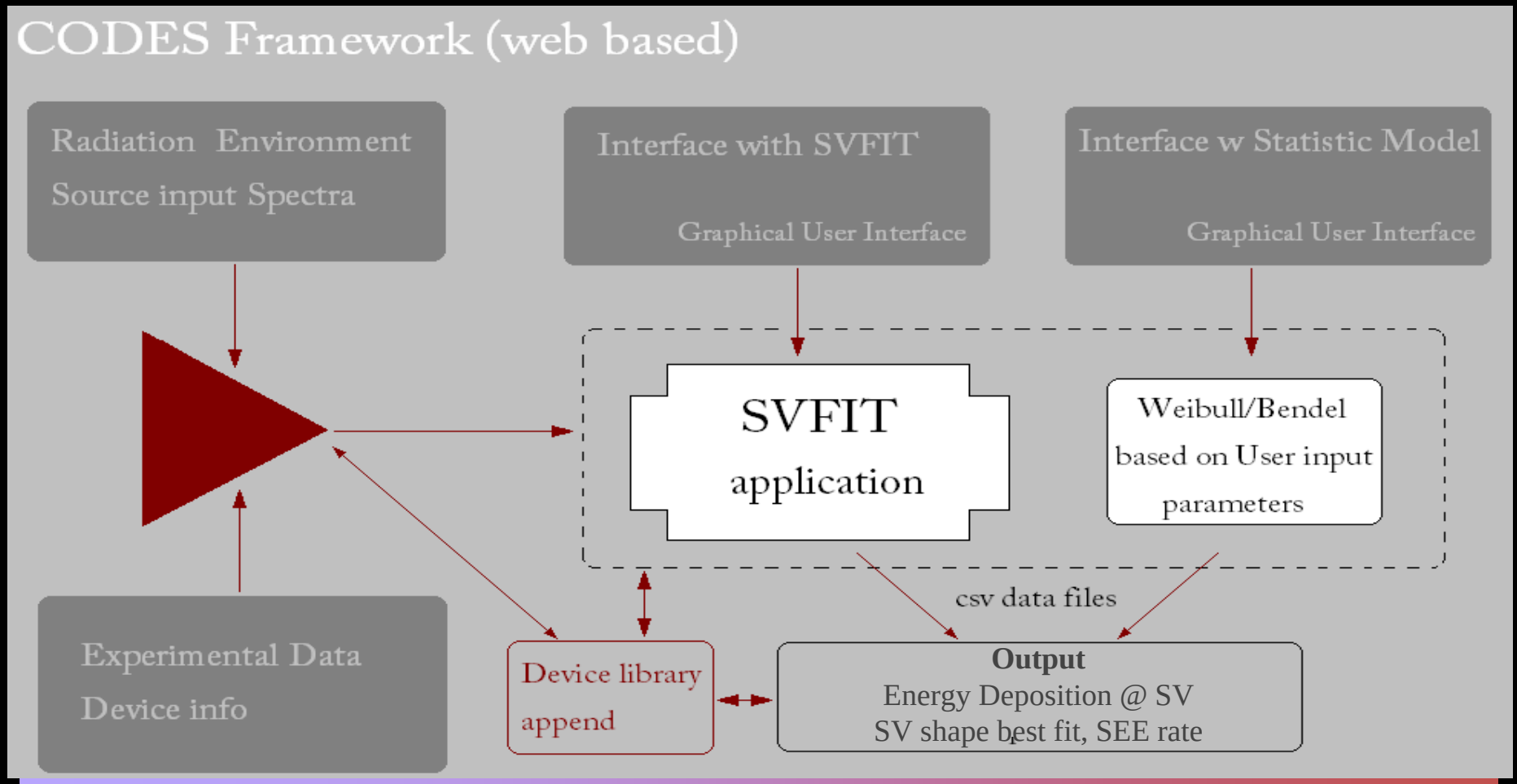
Microscopic CODES Module (mCODES)



Statistical CODES Module (sCODES)



Top Level Framework

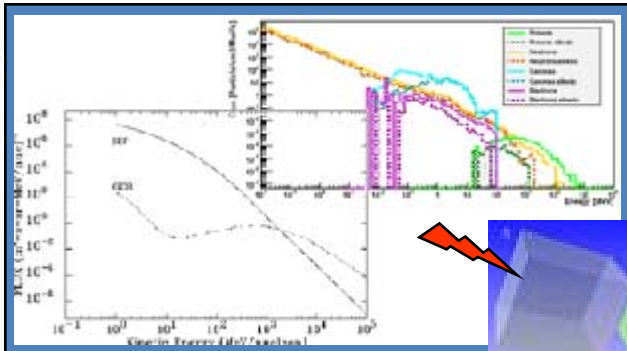


CODES framework

Prediction of Single Event Effects in EEE devices

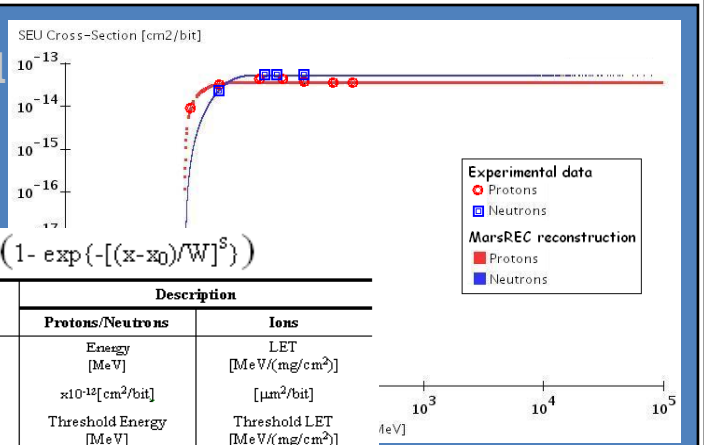
HOME | S CODES | M CODES | HELP

S CODES



Environment thru Device Geometry

Statistical Fit Data

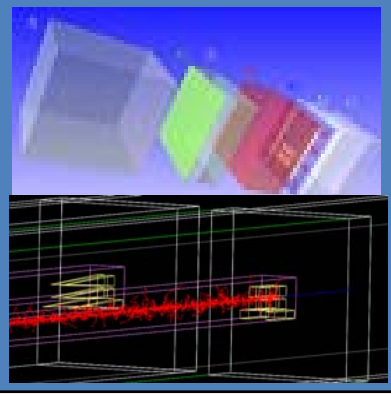


$$F(x) = A\left(1 - \exp\{-[(x-x_0)/W]^S\}\right)$$

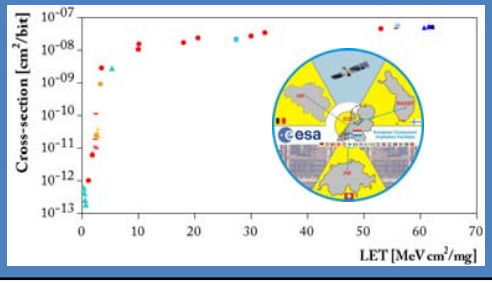
Weibull Method Parameters		Description	
		Protons/Neutrons	Ions
Variable	x	Energy [MeV]	LET [MeV/(mg/cm²)]
Plateaux Limiting σ	A	x10⁻¹²[cm²/bit]	[μm²/bit]
Onset parameter, F(x) = 0 for x < x₀	x₀	Threshold Energy [MeV]	Threshold LET [MeV/(mg/cm²)]
With	W	With Parameter [MeV]	With Parameter [MeV/(mg/cm²)]
Exponent	s	Dimensionless parameter	

Output SEU rate

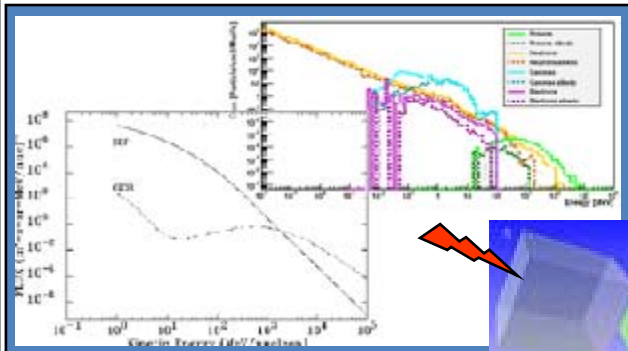
M CODES



SVFIT



Best Fit of Sensitive Volume Critical Energy -> LET th



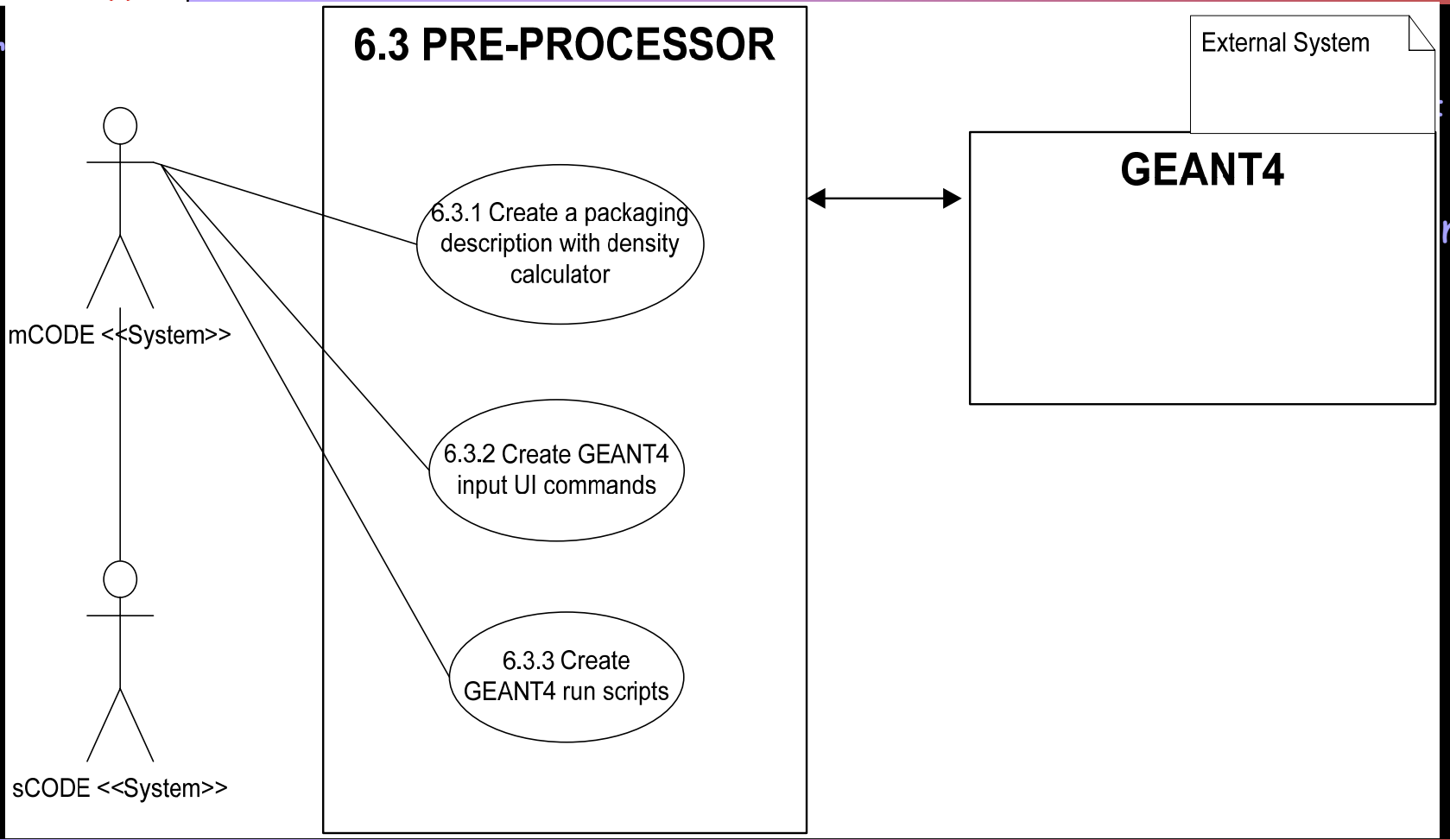
Environment thru Best fit device

Output SEU rate

Pre-Processor

Pr

-
-
-



Language, protocols and methods

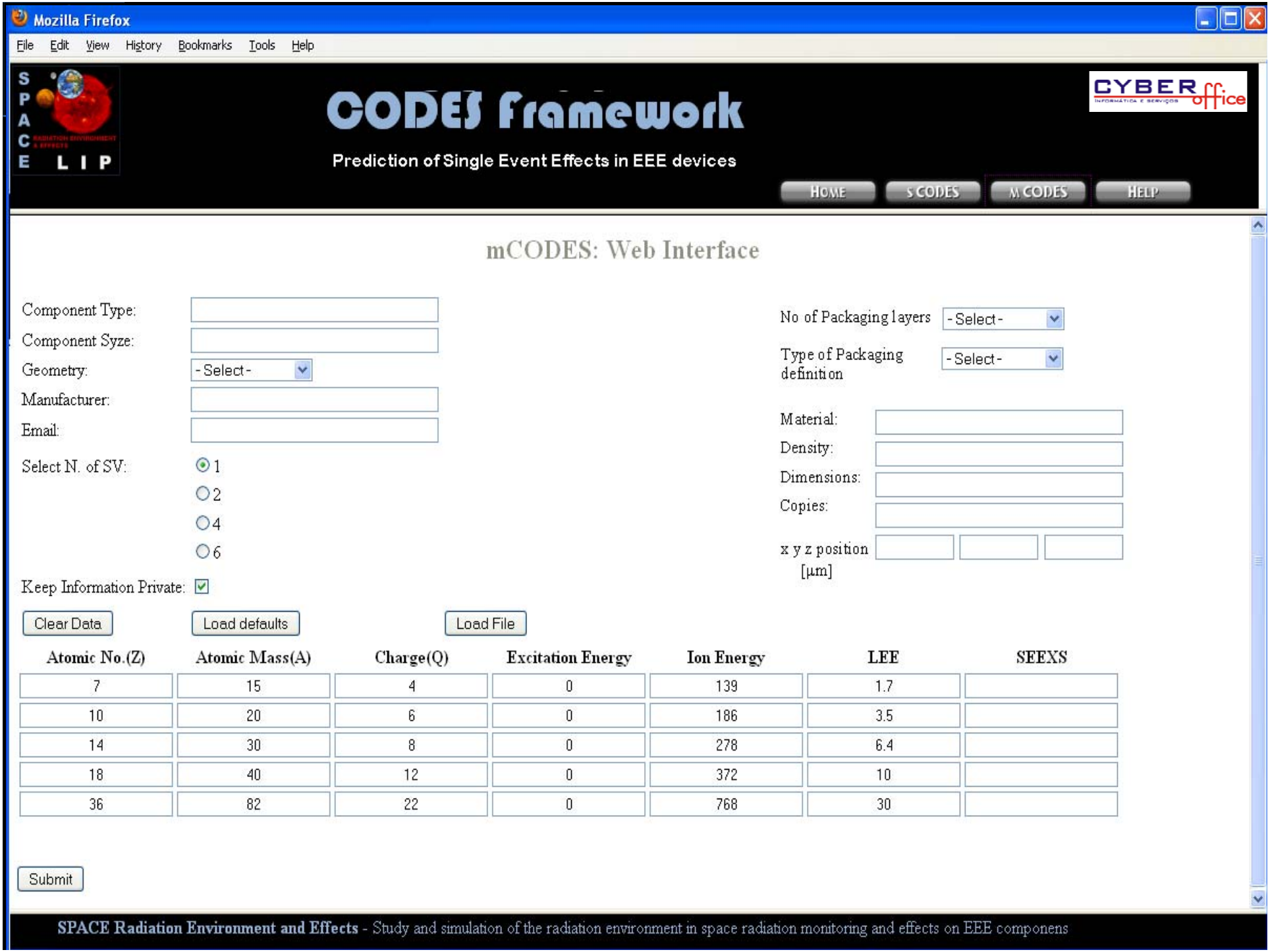
In order to provide an independent operation system user interface,

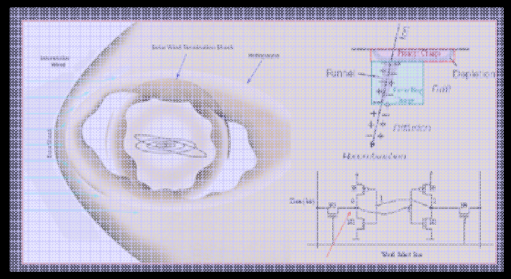
- CODES UI models are developed using html, java script and php.
- Sitting on a php server for deployment of the UI.
- Users are able to interact with UI via HTTP by using any modern browser.

Advantages

1. no need to distribute a client application
2. all access/restrictions to the framework are maintained in the server itself, having no need to duplicate users credentials or authorizations.

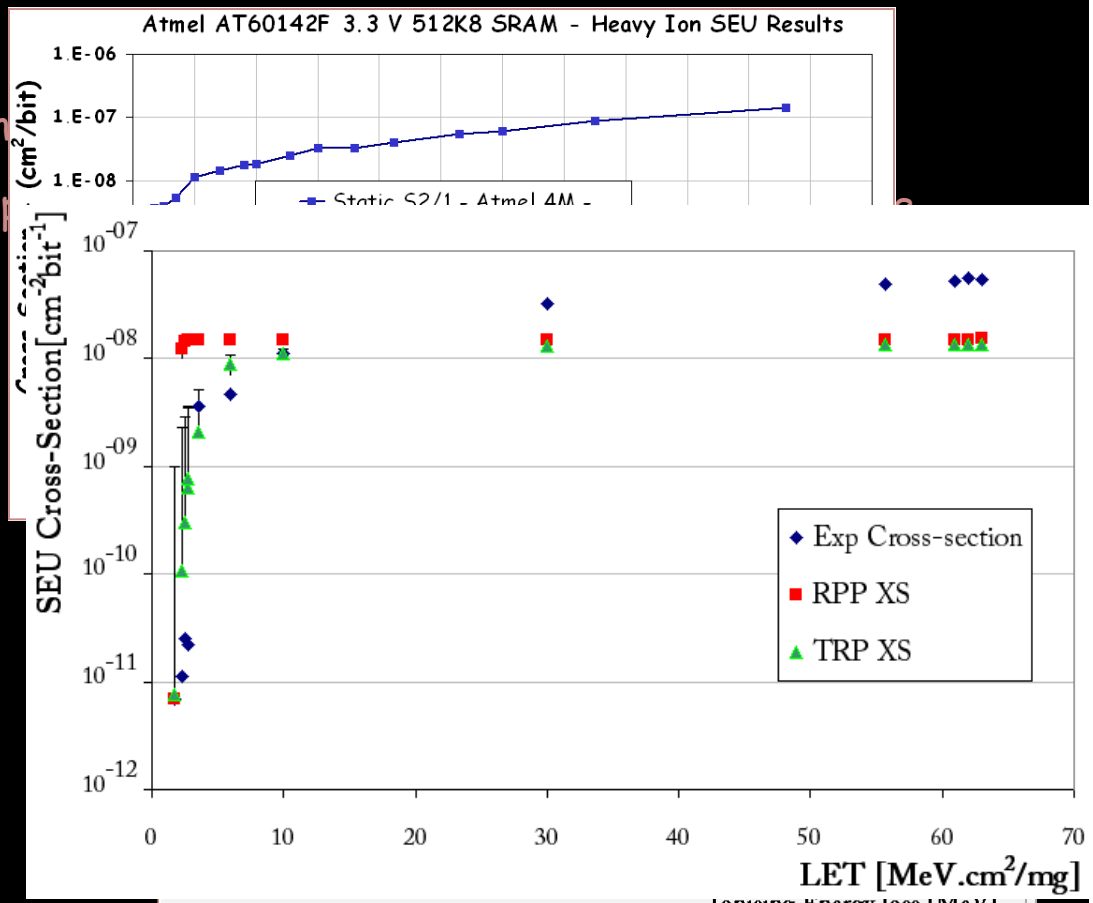
- Output serialized from the pre-processor into html tags, users will receive this data in the form of a text file with csv formatting.


Mozilla Firefox
File Edit View History Bookmarks Tools Help
SPACE LIP
CODES framework
Prediction of Single Event Effects in EEE devices
CYBER office
HOME
S CODES
M CODES
HELP
mCODES: Web Interface
Component Type:
Component Syze:
Geometry:
- Select -
Manufacturer:
Email:
Select N. of SV:
1
2
4
6
Keep Information Private:
No of Packaging layers
- Select -
Type of Packaging definition
- Select -
Material:
Density:
Dimensions:
Copies:
x y z position [μm]
Clear Data
Load defaults
Load File
Atomic No.(Z) | Atomic Mass(A) | Charge(Q) | Excitation Energy | Ion Energy | LEE | SEEXS
7 | 15 | 4 | 0 | 139 | 1.7
10 | 20 | 6 | 0 | 186 | 3.5
14 | 30 | 8 | 0 | 278 | 6.4
18 | 40 | 12 | 0 | 372 | 10
36 | 82 | 22 | 0 | 768 | 30
Submit
SPACE Radiation Environment and Effects - Study and simulation of the radiation environment in space radiation monitoring and effects on EEE componens



SV-FIT fundamentals

- Modular iterative tool
- Microdosimetry Monte-Carlo techn
- Device sensitive volume: charge dep collection.
- Input parameters:
  - Ion cocktails description
  - Irradiation test data
- SEU threshold definition
- SV shape modulation
- Output:
  - best SV shape to fit ion test data
  - Threshold Energy loss for SEE
  - Reconstructed SEE XS curve

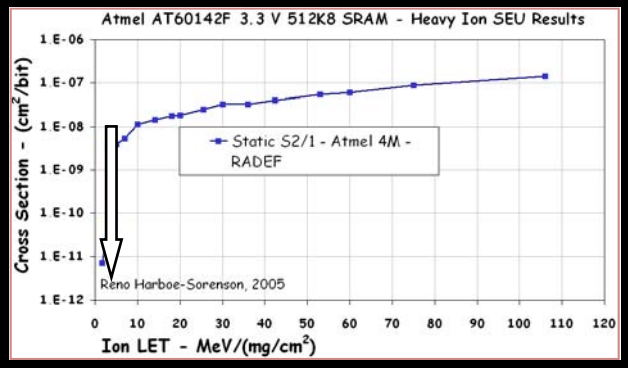


Critical energy Loss

Sensitivity threshold

- determined by the smallest perturbation (charge collection) that induces a detectable error on the output of the device.
- Called critical charge, *Qc*, or when expressed in unit of energy is defined as critical energy loss, *Ec*.
- It is given by the integration of the energy transferred from the incoming ion to the target along its track, *x* :

$$E_c = \frac{E_{th} Q_c}{q} = \int_{x=0}^{x=l} \frac{dE}{dx} \eta_c(x) dx$$



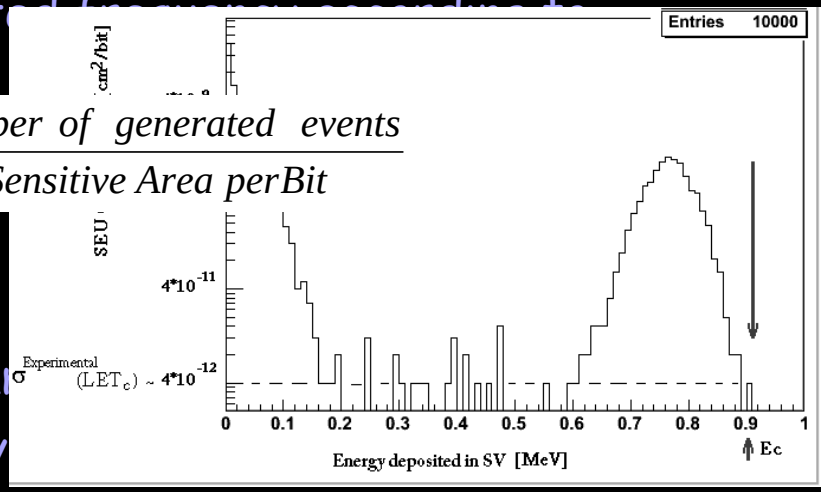
SEU Cross-section input

- The experimental SEU cross-section curve shall be interfaced with SVFIT code.
- The cross-section of the first ion is assumed to give the threshold

$$\sigma(LET_c) = \frac{Number\ \ of\ \ events(depE > E_c)}{Number\ \ of\ \ generated\ \ \ events} \cdot Sensitive\ Area\ perBit = \sigma^{\exp erimental}(LET_c)$$

- Into the code is converted into the expect

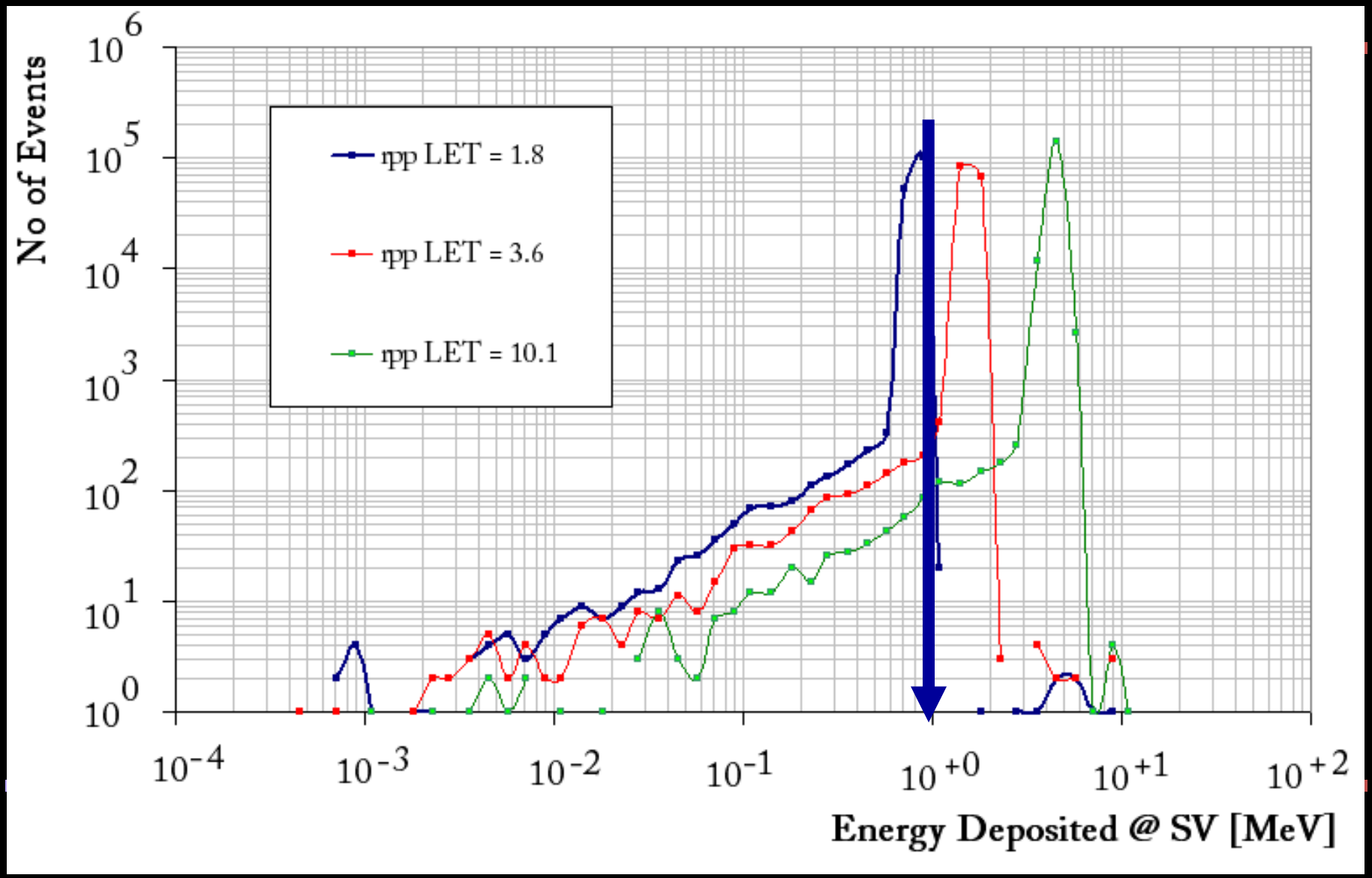
$$F(LET_c) = \sigma^{\exp erimental}(LET_c) \cdot \frac{Number\ \ of\ \ generated\ \ \ events}{Sensitive\ Area\ perBit}$$



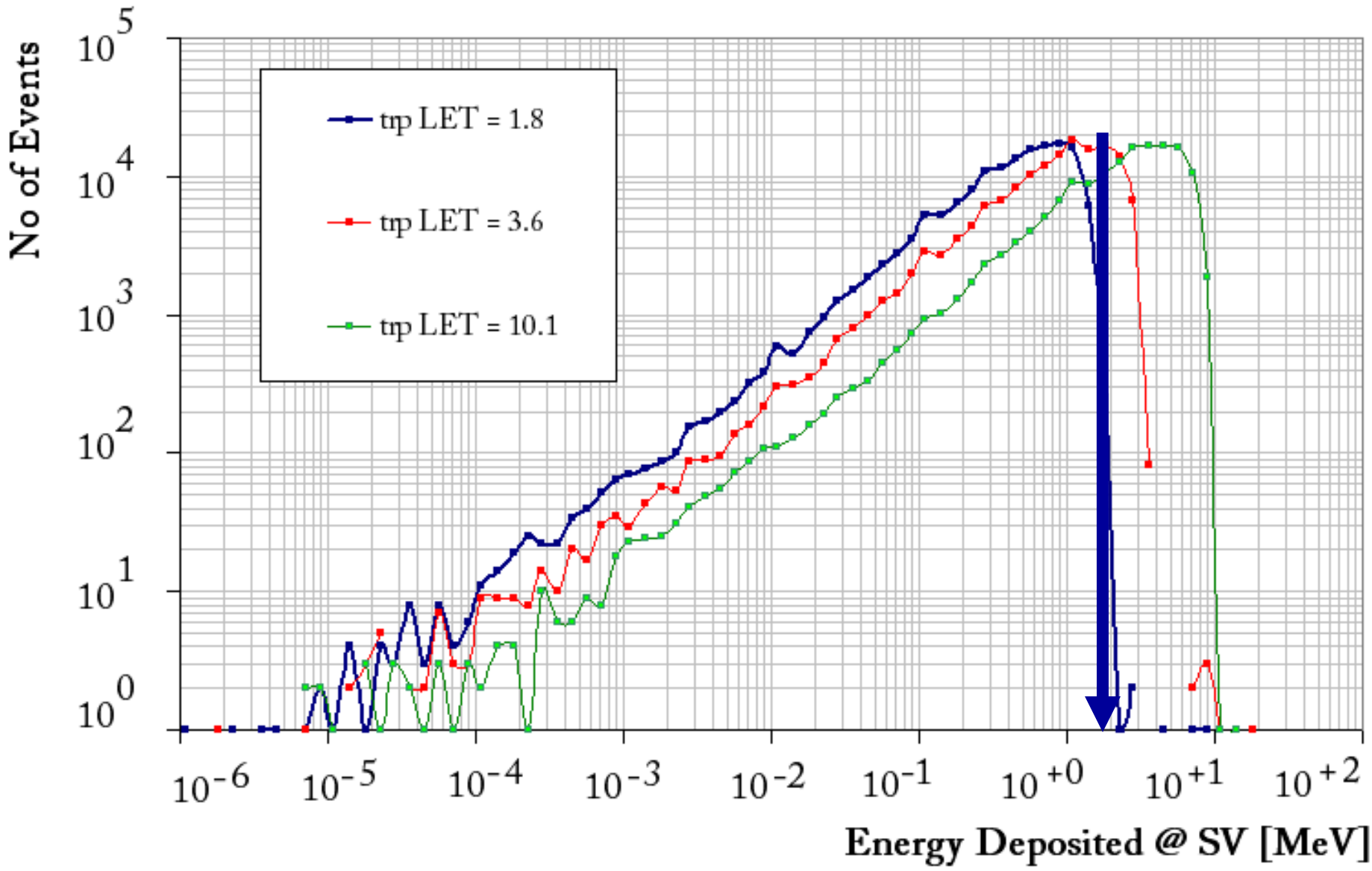
Critical energy is computed at RunAction level

- searching in the energy deposited histogra
the number of events equals the frequency

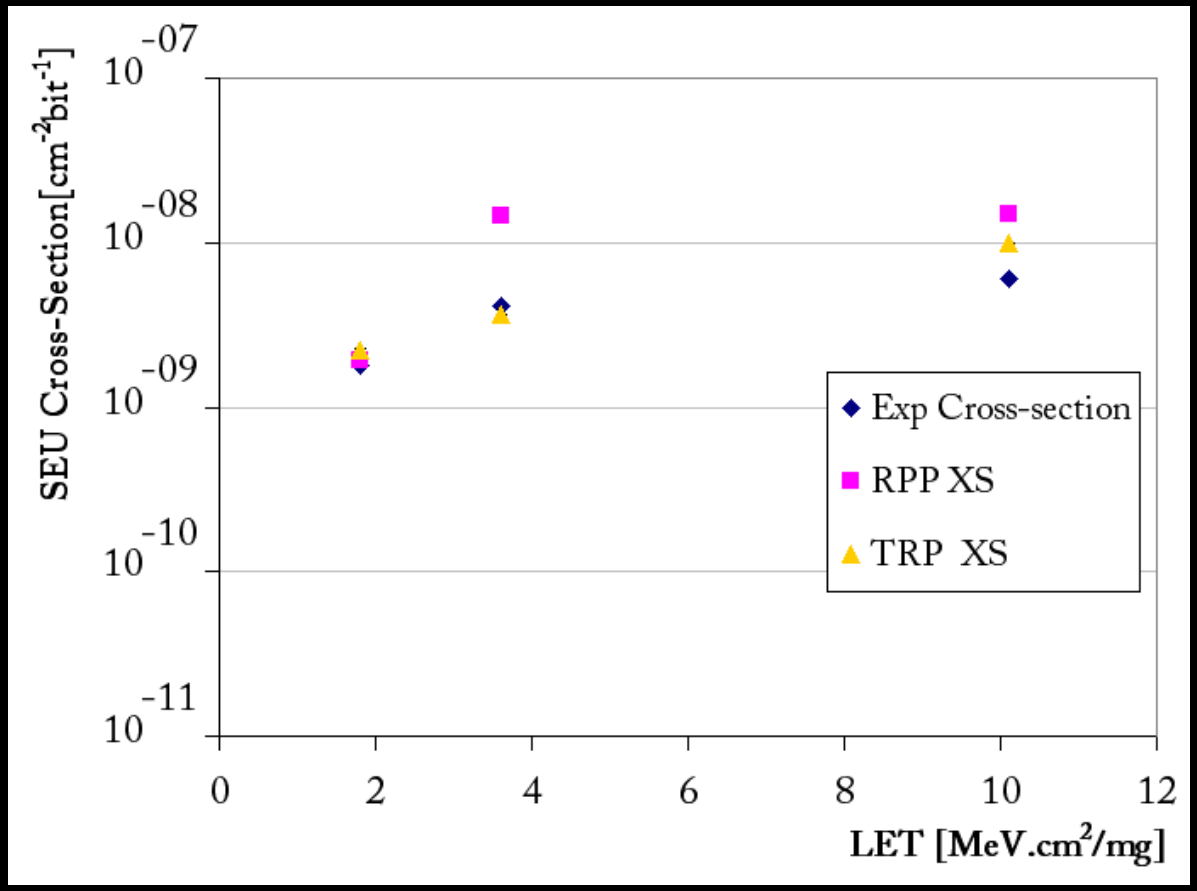
ISSI61 TDM @ Proba II: rpp



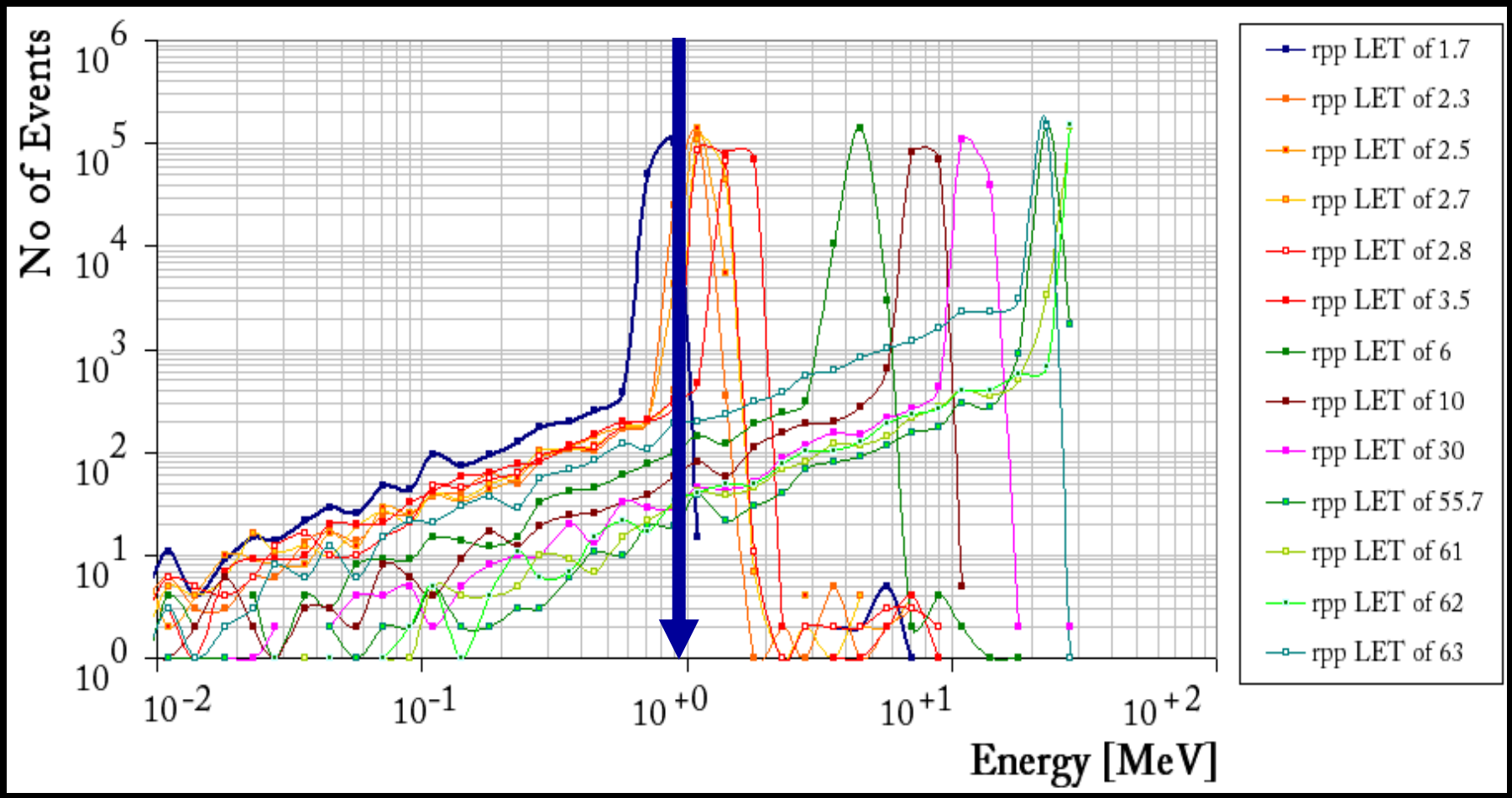
ISSI61 TDM @ Proba II: trp



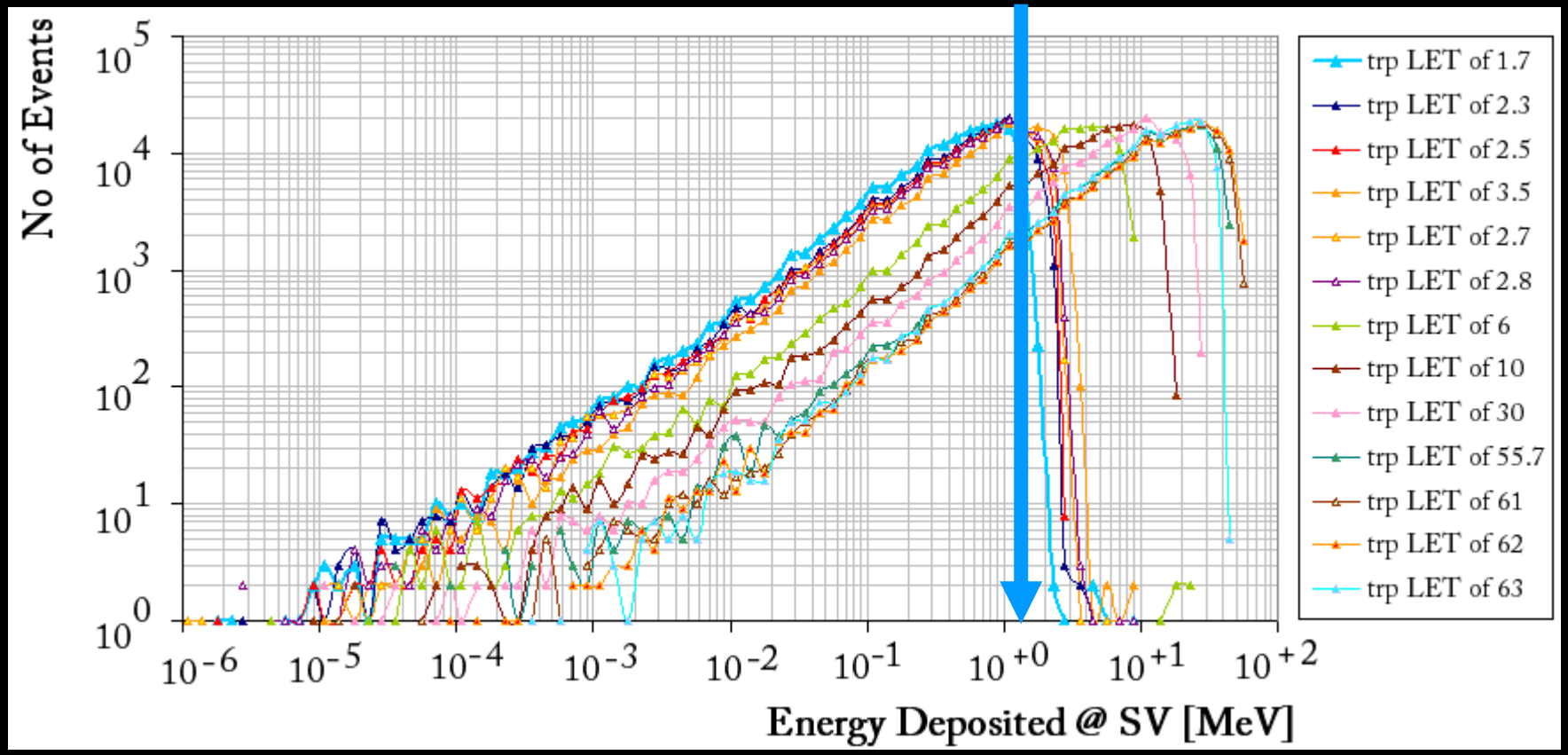
ISSI61: SEU Cross-section



Reference SEU Monitor: rpp

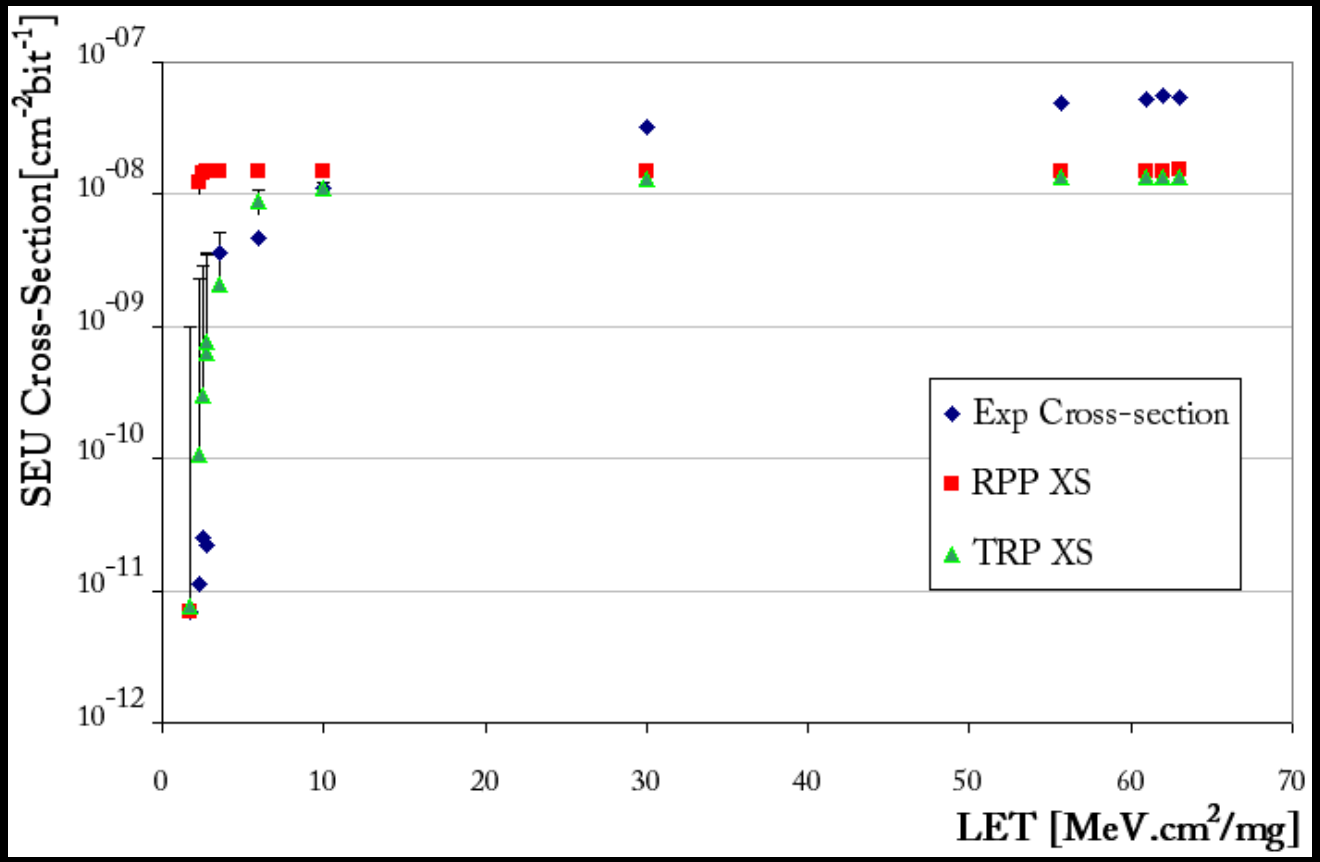


Reference SEU Monitor: trp

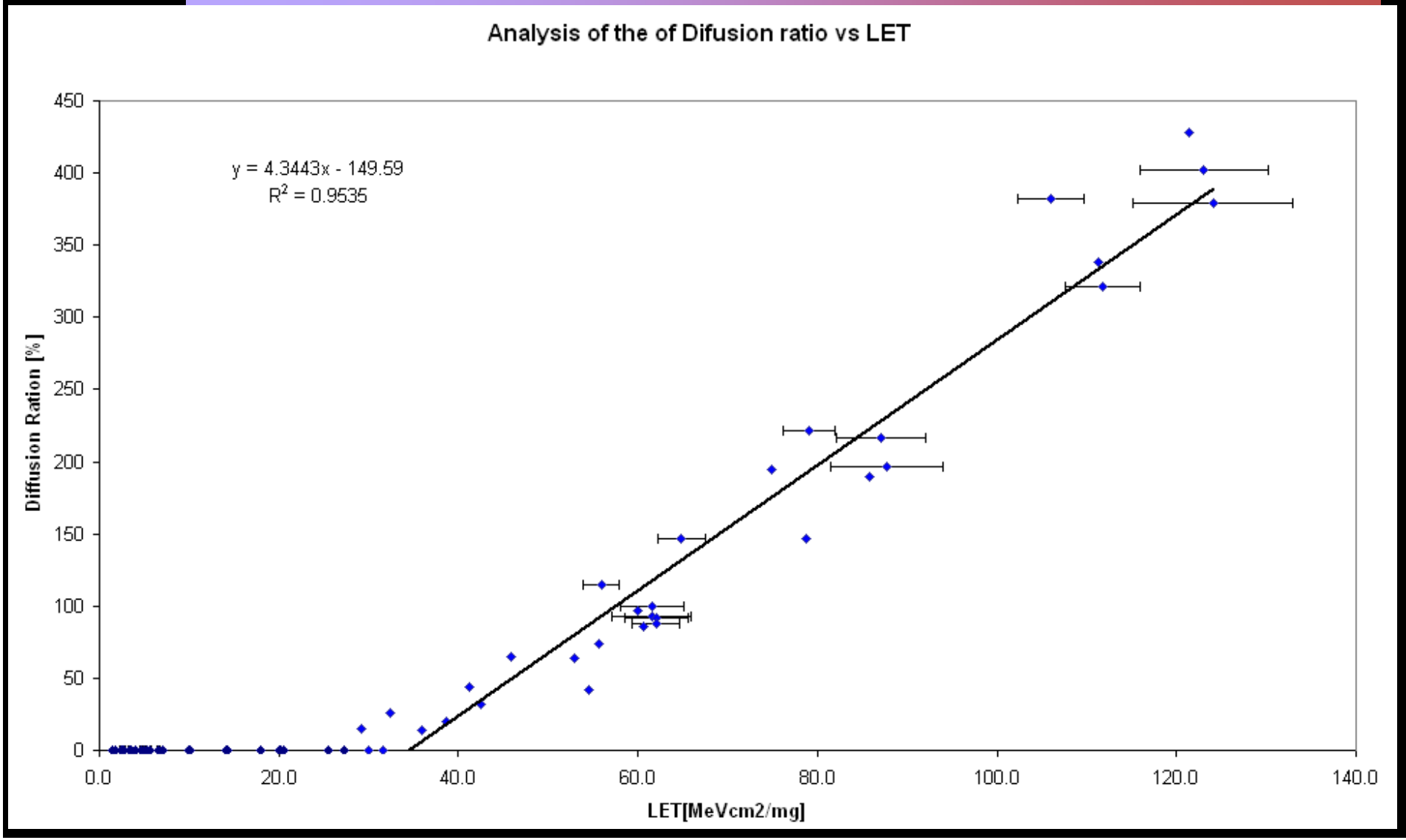


Heavy ions: SEU Monitor

- Very good fit up to the Knee:
  - trapesoidal SV (trp)
- Under estimation of non saturated data



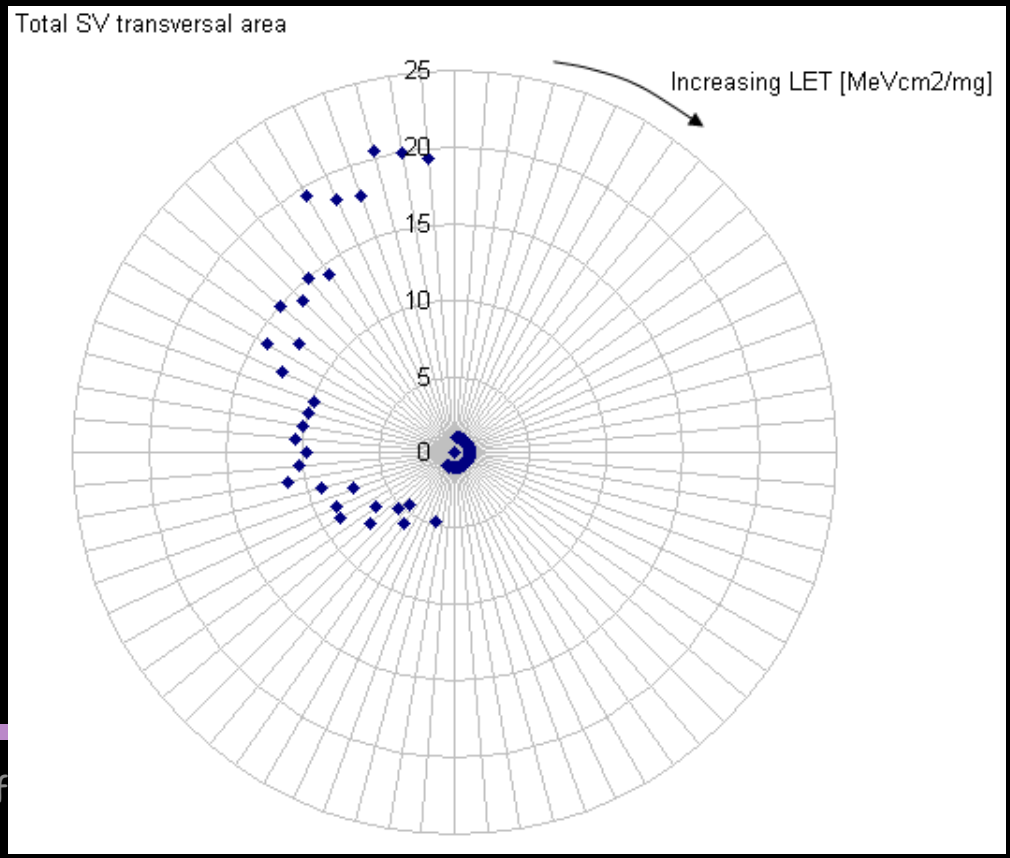
High LET XS increment



Area increment above LET knee

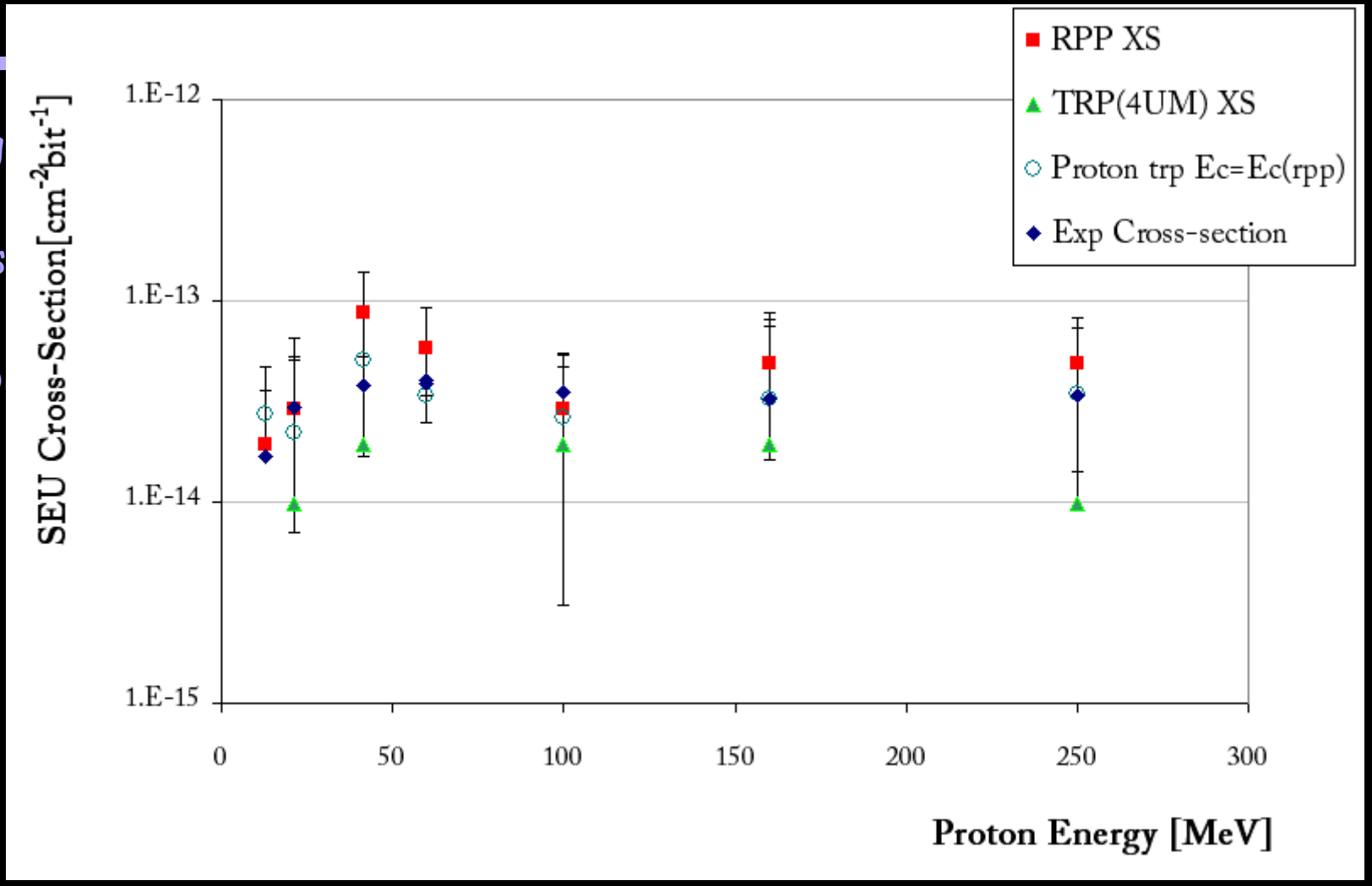
- Converted in units of Length
- This models the transversal area increment due to MBUs
- To be included in a later version of CODES

$$r_{eff}^{\ increment} = \sqrt{\frac{1}{\pi}\left[\sigma(LET) - \sigma_{sat}\left(LET = 30 MeVcm^2/mg\right)\right]} \cdot 10^4 [\mu m/bit]$$

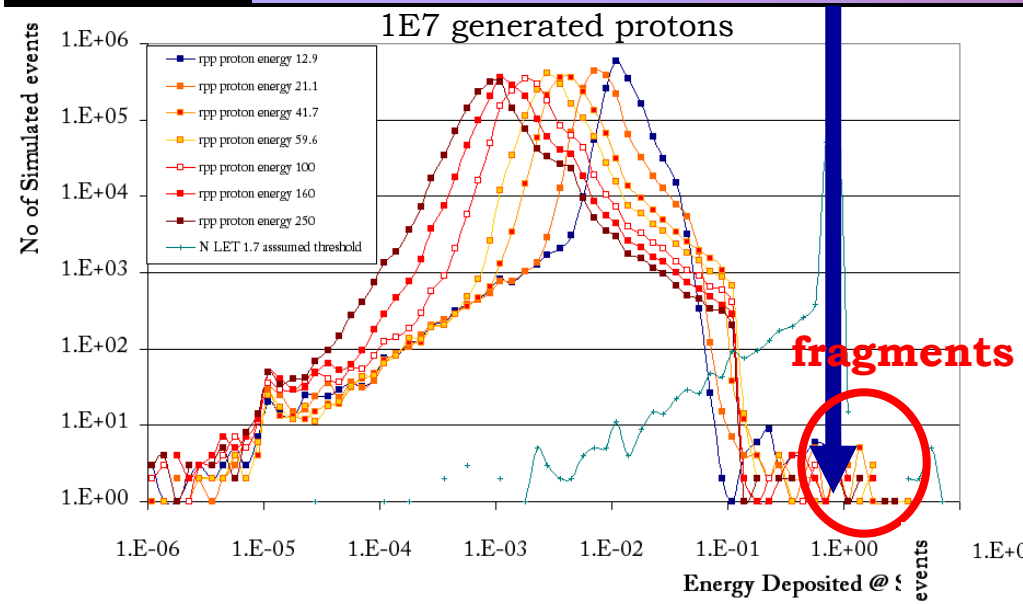


From Ion data to proton prediction

- Using
- The s
- Proto

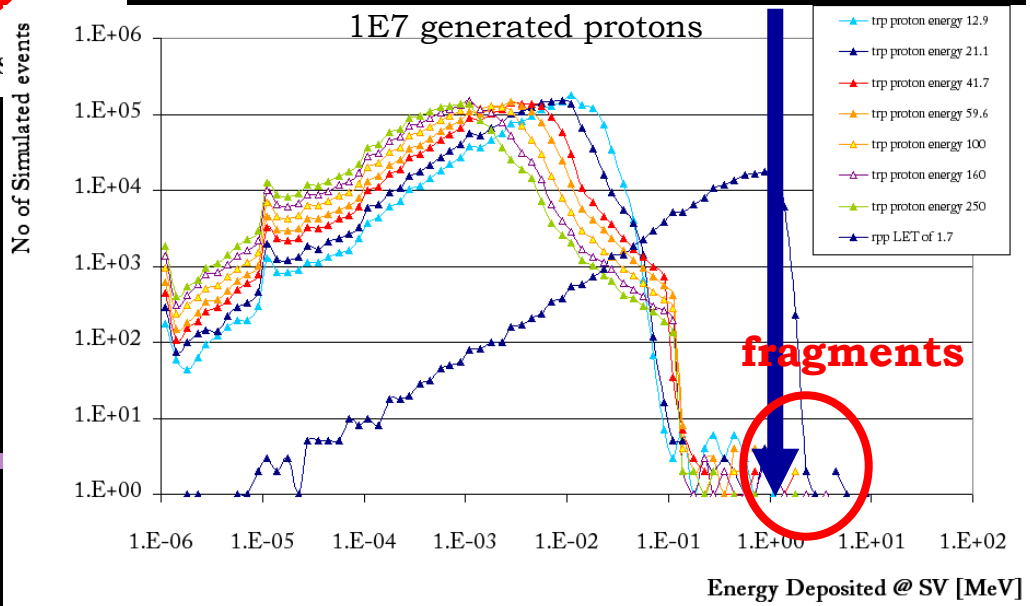


Energy deposited and fragmentation



- Rpp SV

- Trp SV

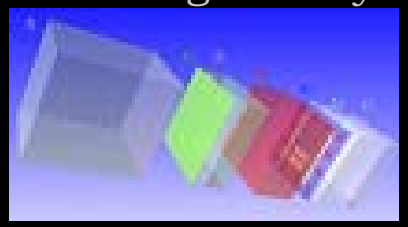


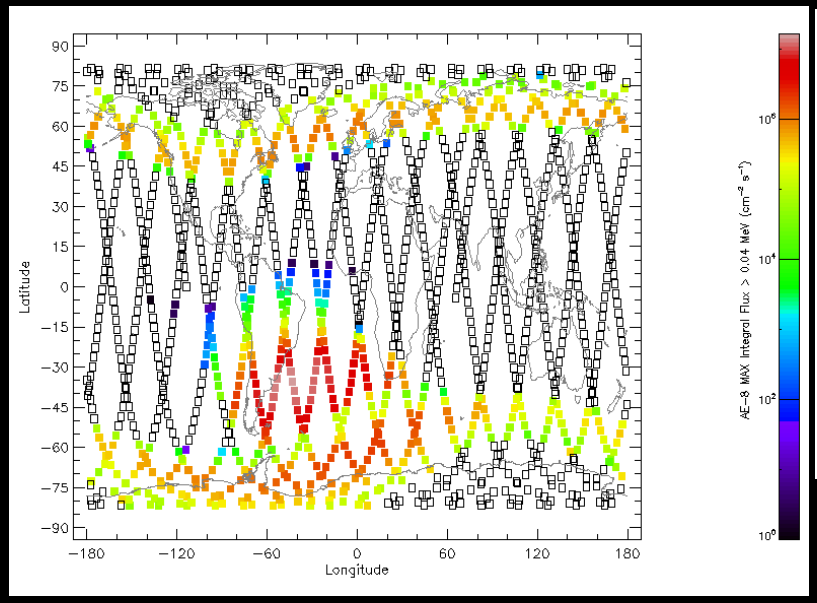
From SVFIT to SEU rate prediction

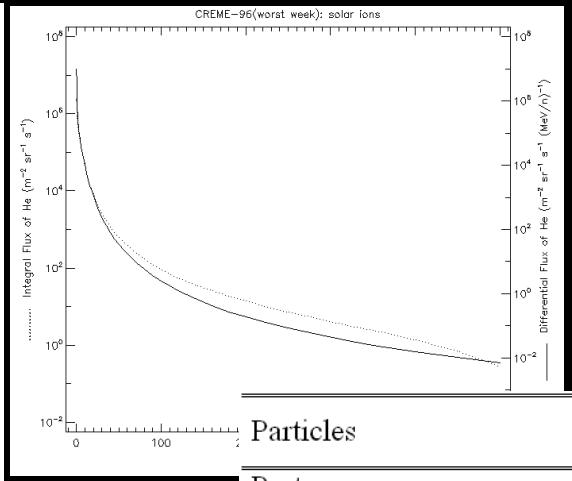
mCODES inputs

- SVFIT SV shape, dimensions and Ec ->
- Radiation environment spectra

Device geometry







Particles		SEU [#/device/s]
Protons		
Neutrons		
Ions	Oxygen	
	Carbon	
	Helium	

Conclusions

- CODES is a modular tool capable of predicting SEE rates for devices under different radiation environment conditions
- This predictions are based on microdosimetry in the device and analysis of energy loss thru the Sensitive Volume
- Allows a best fit of the SV shape, dimensions and sensitivity threshold
- A web based interface with a pre-processor is being implemented and will be ready for tests by end of July
- It has so far proved to be suitable as an Engineering framework
- All modules have been tested independently and are capable of fulfilling their requirements

Further work

Before end 2011

- Finalize and test web based interface and pre-processor
- Final upgrade of the modules
- Optimization
- Test top level interface
- Verify predictions with real in-flight data

…

- Tests for SEL have been made, however the best solution need to be frozen and implemented
- Future implementation of the diffusion model
- Expand the tool for other damage mechanisms