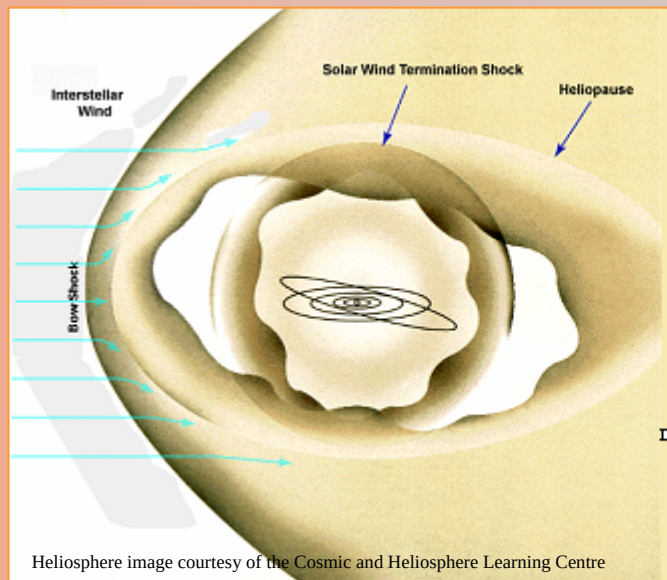
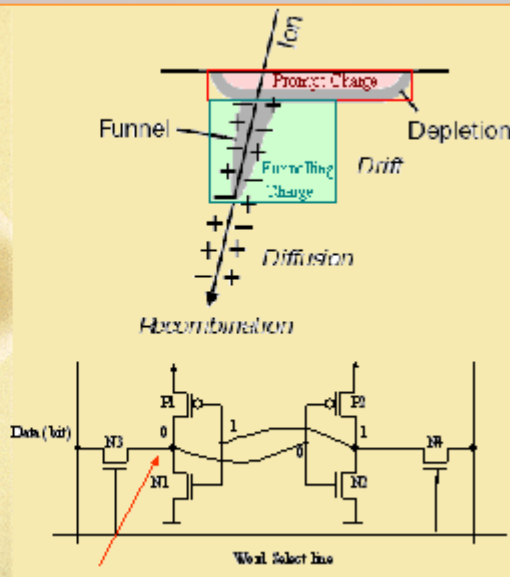
Modelling SEE on Components

CODES: component degradation simulation tool



Heliosphere image courtesy of the Cosmic and Heliosphere Learning Centre



A.Keating

ESA Project:
18121/04/NL/CH

Outline

- Aim
- Project overview
- Modelling Philosophy
- Physics and Mechanisms
- GEANT 4 Physics vs Device Physics
- Device Functioning Module
- Conclusions

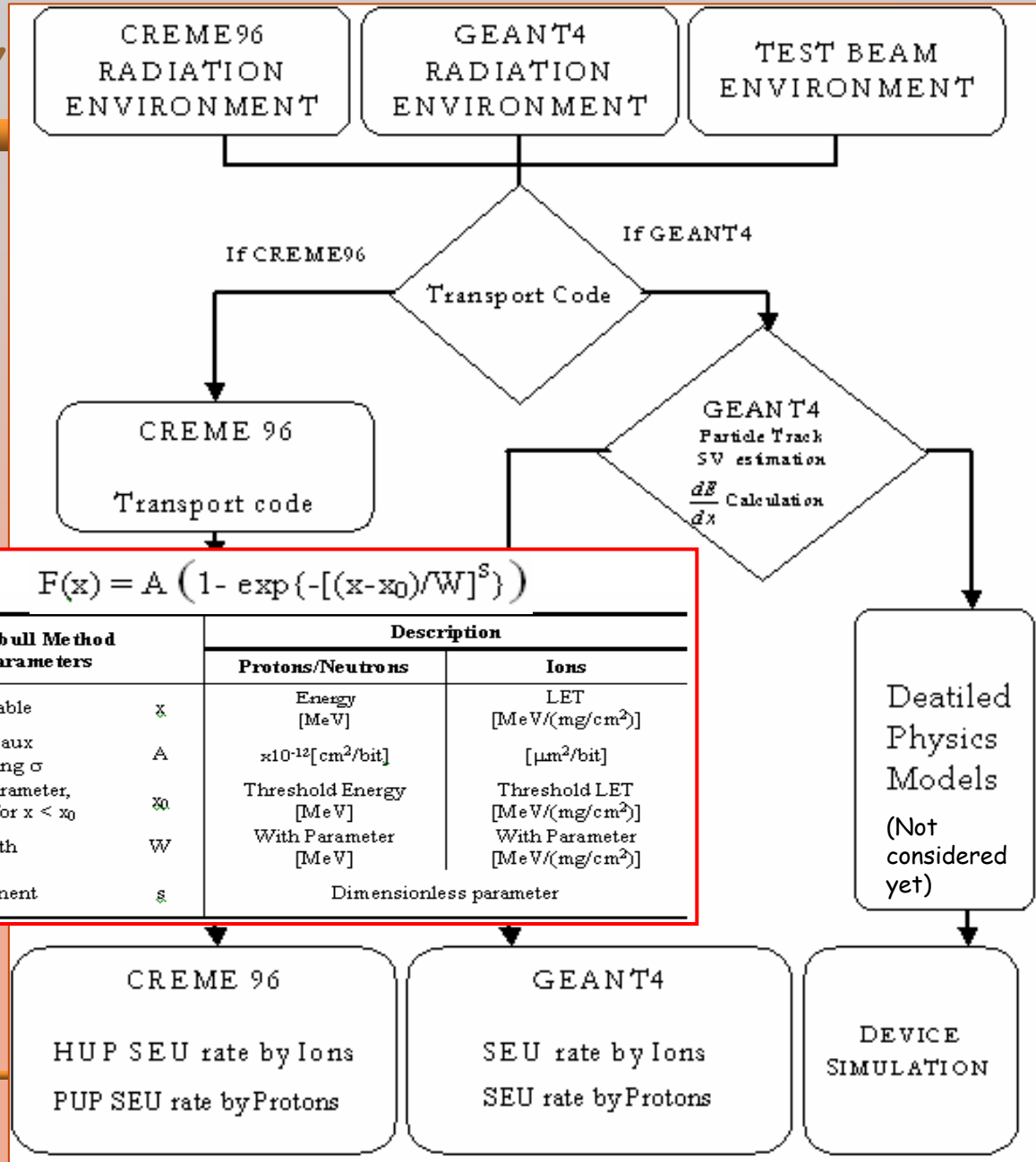
CODES aim

The current activity aims at:

- Expanding the capabilities of previously developed component simulation tool
- SEU rate predicting in specific components,
- Generalising it for a family of components,
- Make it valuable for new technology scales
- Simulation of the physics of the SEU inside the device
- Produce experimental verification
- Allow the different radiation input scenarios

Previous Tool Overview

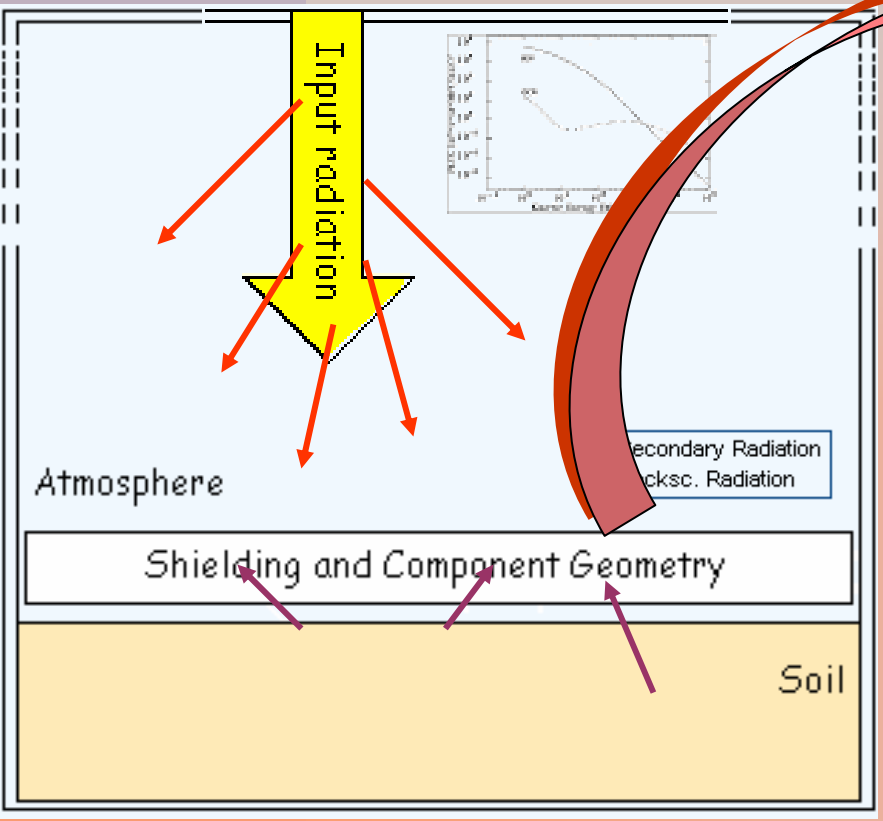
- MarsREC SEU Module:

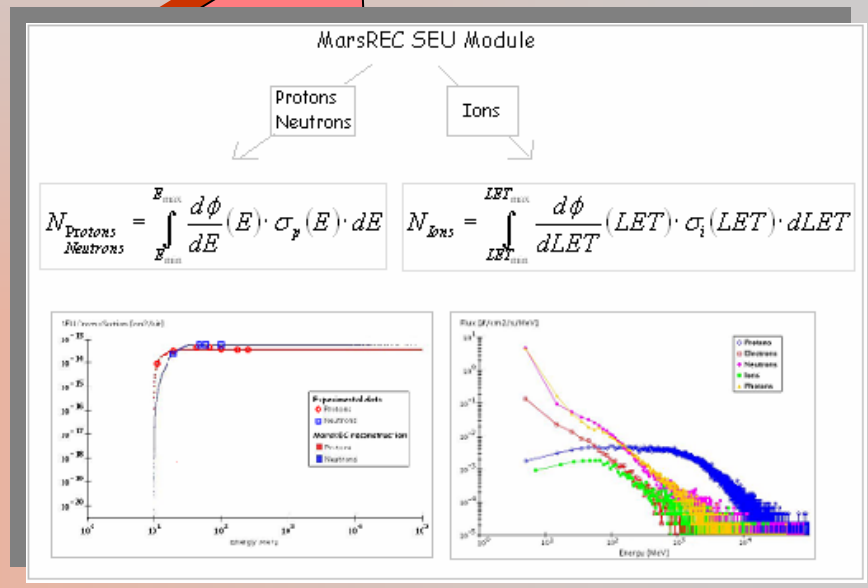


$$F(x) = A\left(1 - \exp\{-[(x-x_0)/W]^s\}\right)$$

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	

MarsREC SEU Module Philosophy





SEU prediction

- mission specifications under different RE

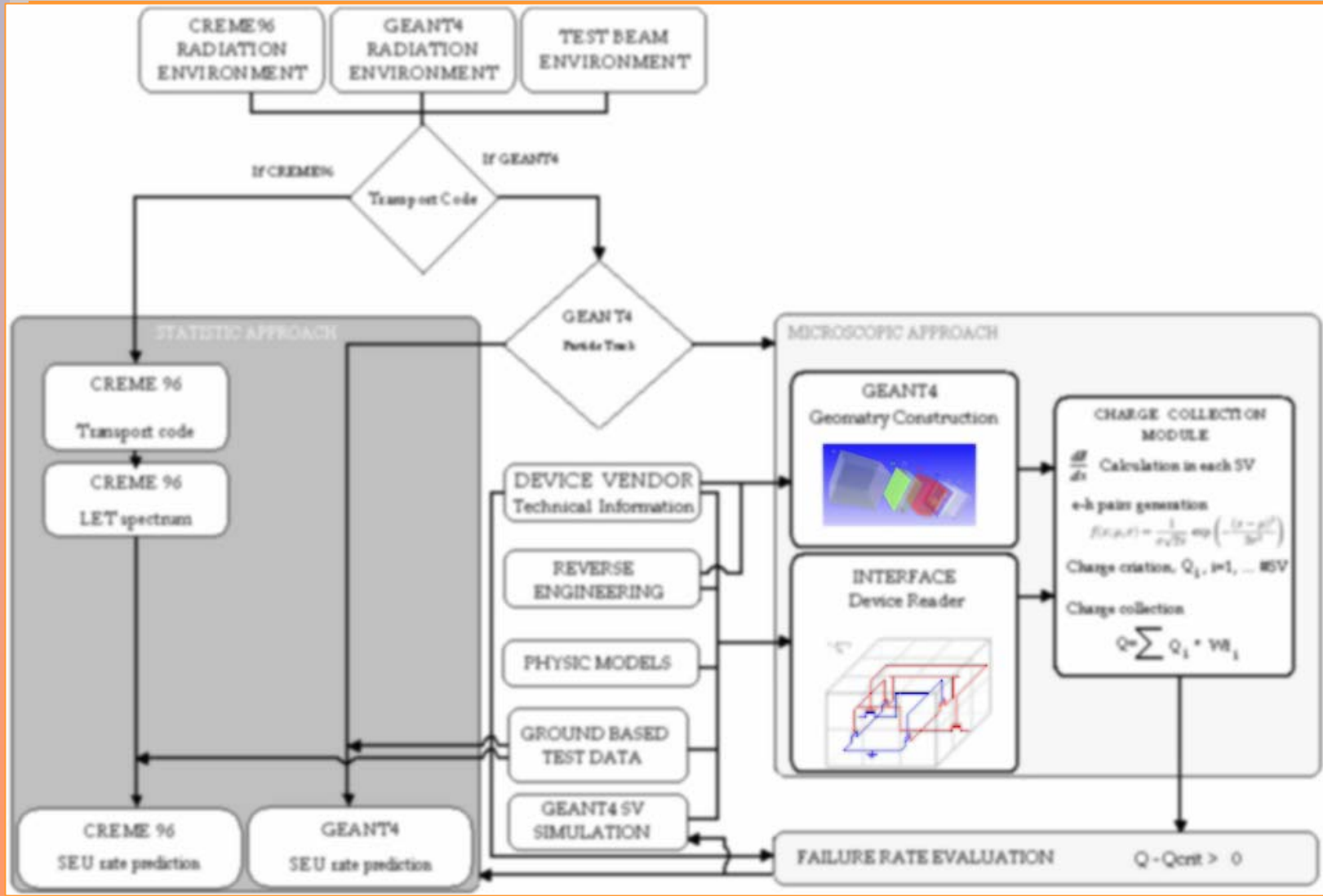
However

- No detailed modelling of SEE physics in the device!

Modelling SEU: Problems and challenges

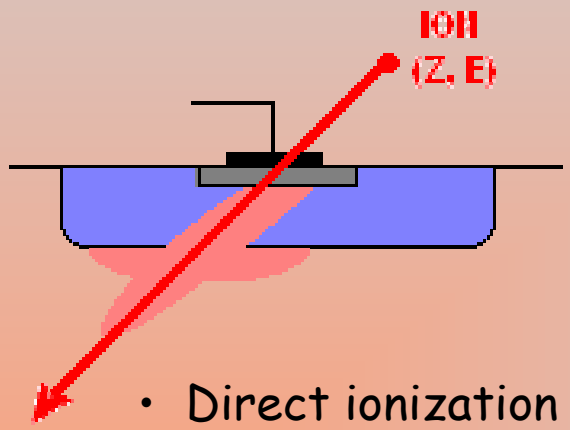
- How to implement the device active behaviour in a tool capable of Monte Carlo tracking of primary and secondary particles?
- Use Geant4 to track the interaction of the incoming radiation with the device
- Establish an interface capable of describing device physics and functioning
- Investigate the Sensitive Volume

CODES Philosophy

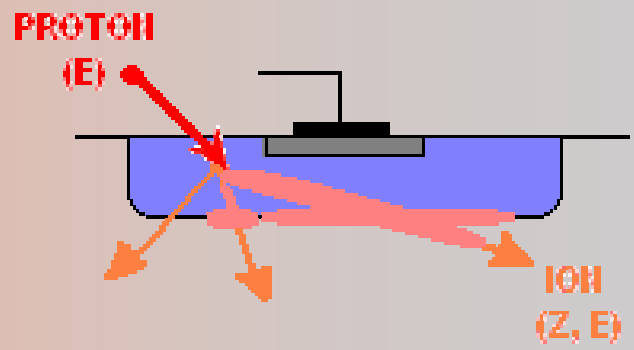


Direct and Indirect Processes

- The two distinct processes induced by ions and protons/neutrons require different analysis methods



- Direct ionization

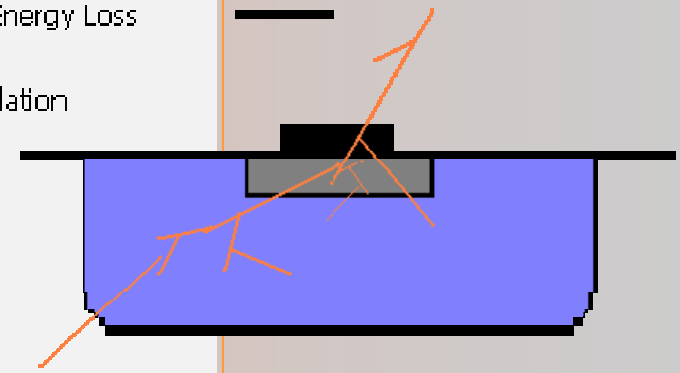


- Indirect Ionization

- GEANT4 allows the tracking of :
  - primary and secondary radiation
  - energy deposition

GEANT4 Physics

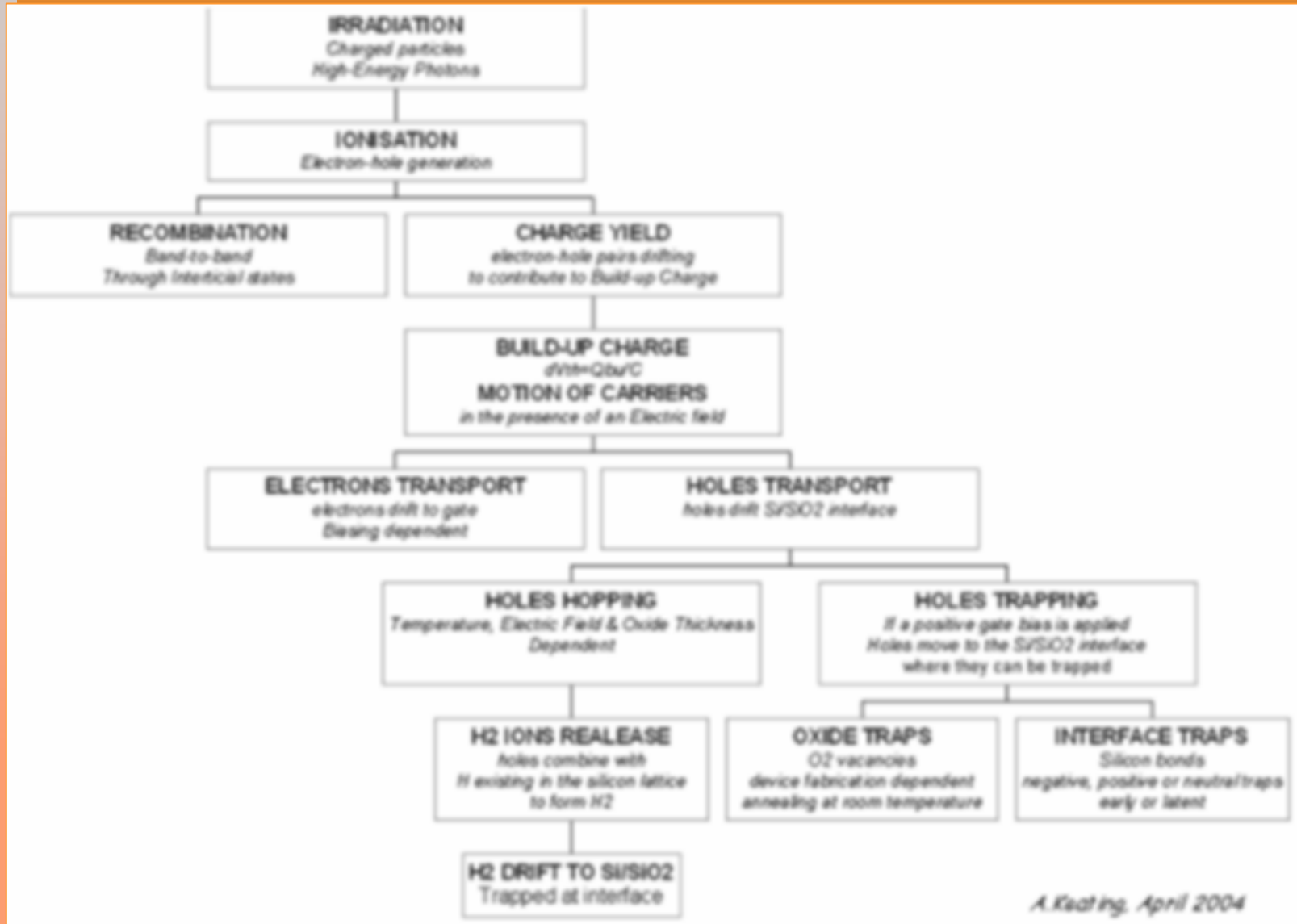
Physics	Models & Processes		Applications
Electromagnetic	Multiple Compton Rayleigh	Scattering	Direct & Indirect SEE Ionising Energy Loss
	Electron Muon Hadron Ion	Ionisation	LET calculation
	Bremsstrahlung		
	e+e- annihilations and production		
	Photo-electric effect		
	Gamma conversion		



- Monte Carlo tool
- Processes from ~1 PeV to ~100 eV
- Used in high-energy physics, in space research, and in medical

Physics	Models & Processes	Applications
Hadronic	Elastic	Secondary production
	Precompound (2-100MeV)	
	Bertini Cascade (< 10MeV-10GeV)	Ion interactions
	Binary Cascade (10MeV-~GeV)	
	Parameterised	Indirect SEE
	Electromagnetic dissociation	
	Abrasion/ablation	
	Gamma- and Lepto-Nuclear	
	Low energy Neutrons (< 20MeV)	

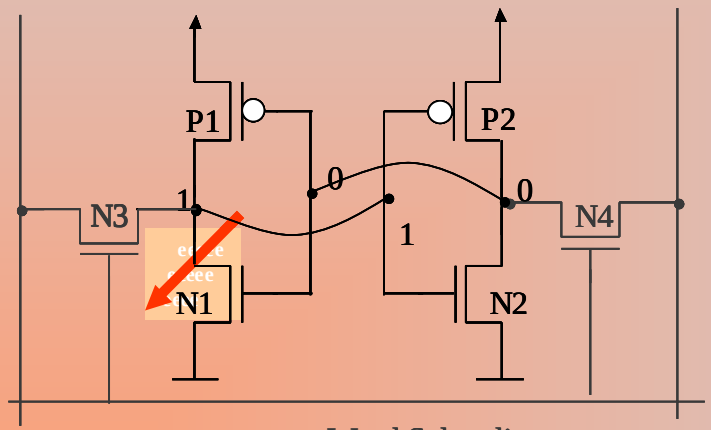
Physics and Mechanisms

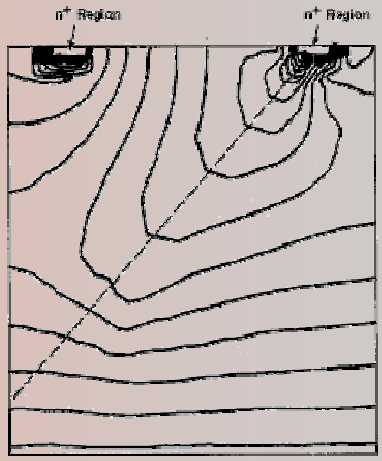


Device Response

- The device behaviour depends on the field (ξ), Incoming particle LET (λ) and on the angle of incidence (θ)

$$Q_{collected} = f(\xi, \lambda, \theta) > Q_{crit}$$

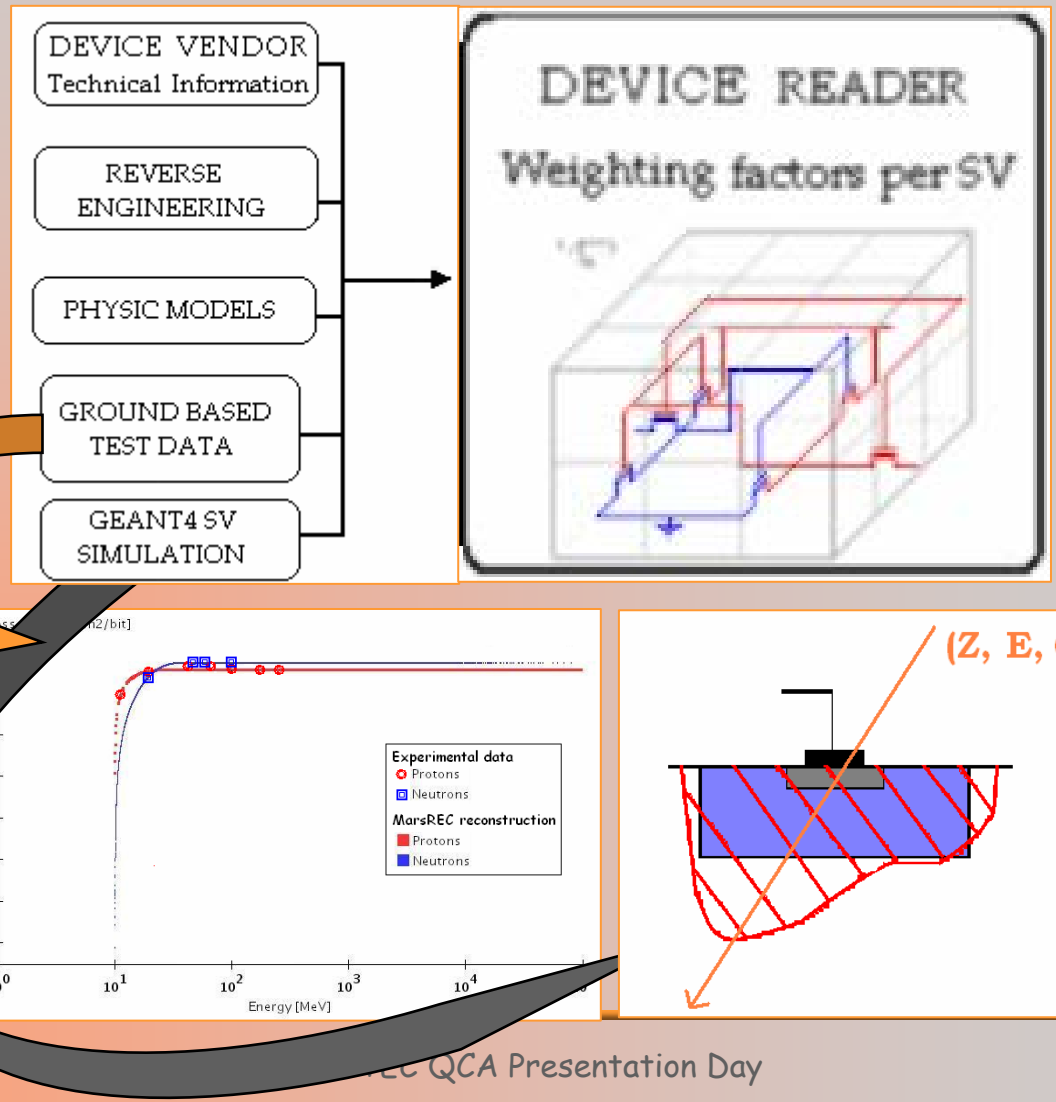




- The critical charge depends on the node capacitance, voltage and the response time of the device

$$Q_{crit} = C_{node} \cdot V_{node} + \tau_{switch} \cdot I_{restore}$$

Interfacing



Conclusions

- CODES two years activity -Started in November 2006
- CODES Philosophy is defined
- Powerful tool : contribute to the analysis of SEE effects
  & Sensitive Volume

The next step:

- Implement and validate the concept using:
  - Experimental & Ground based test data,
  - Deposited Dose maps of the device
  - Reverse engineering

Positive Interaction is welcome!