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Impact of Aging Degradation Mechanisms on the Radiation Susceptibility of Complex Integrated Circuits

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Training Workshop
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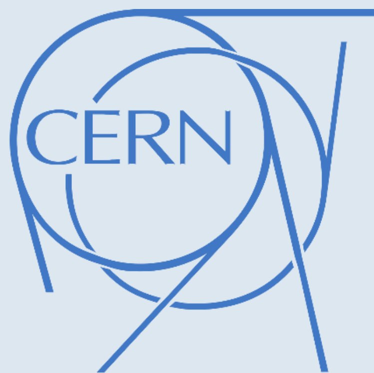

Reliability

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- Reliability is essential for safe operation and optimized efficiency within most critical applications: (space, avionics, automotive, accelerators).

- **Radiation** effects on electronics are and have to be considered.

Long-term Reliability

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- Long-term reliability of recent CMOS technologies is impacted by different **intrinsic aging degradation mechanisms** that progressively change their electrical characteristics: (BTI, HCI, TDDB...).

- Degradation induced by these mechanisms constitutes a reliability risk, both directly, by compromising the electronic functions, and indirectly, by weakening the circuit robustness to external effects like **radiation**.

Long-term Reliability

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Year	Technology Node (μm)
1990	
2000	
2010	
2020	

Technology Node (μm): 0.1, 0.01

Year: 1990, 2000, 2010, 2020

Radiation effects due to neutrons

90 nm

45 nm

Wear out aging mechanisms impacting the product lifetime

Project Objective

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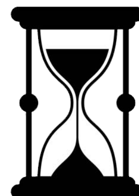
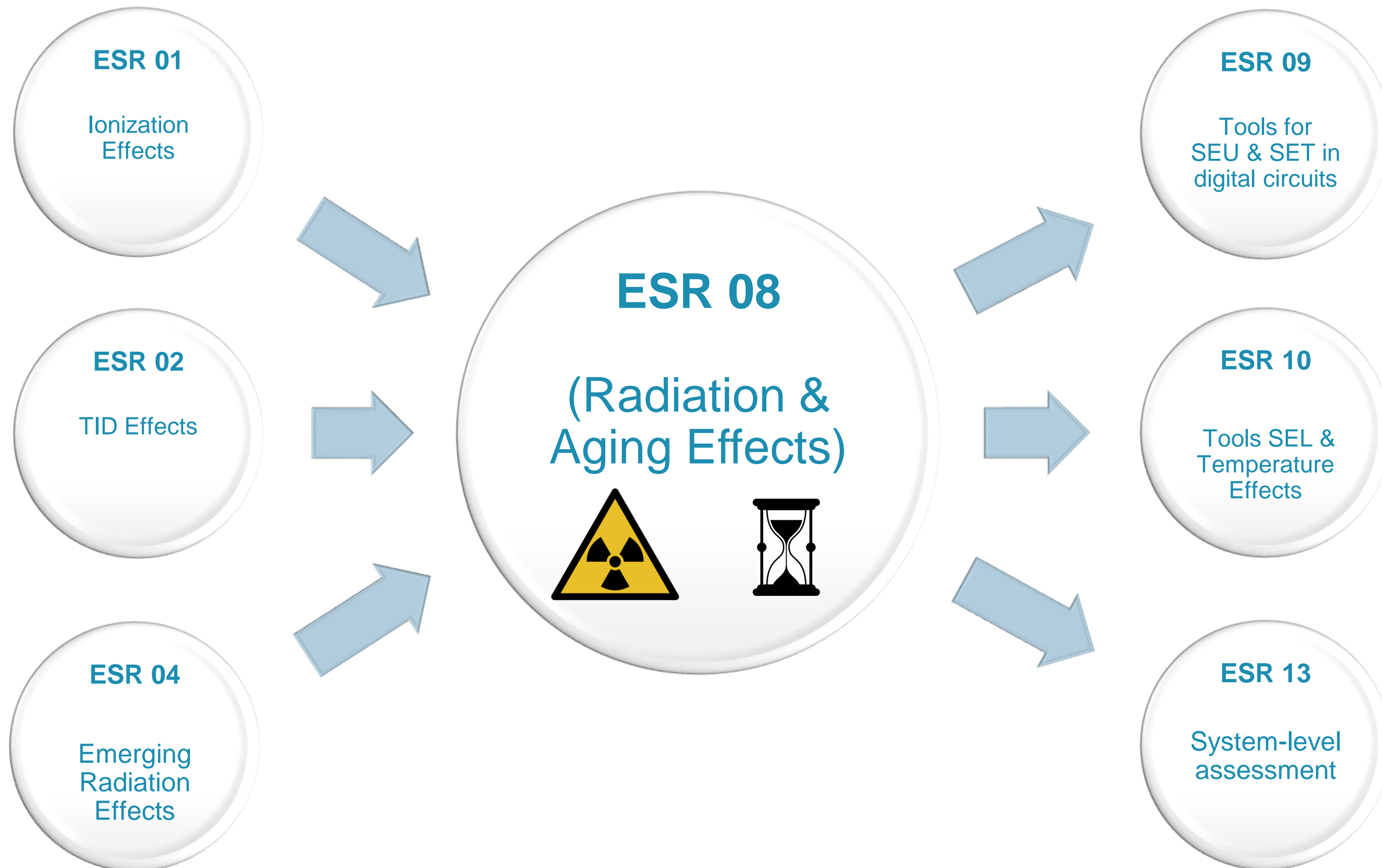
- Investigate the impact of *aging degradation mechanisms* on the *radiation susceptibility* of digital integrated circuits in advanced technology.



- Develop *dynamic models* to **radiation effects**, taking into account the intrinsic performance degradation due to the diverse **aging mechanisms**.

Interdependence Between ESR



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Collaboration with ST

- 28nm FD-SOI, is an innovative technology that leverages the established planar process while ensuring a continuation of the efficiency improvements projected by Moore's law.

- FD-SOI delivers:
  - ➢die size reductions,
  - ➢power reductions,
  - ➢increases in performance,
  - ➢increased functionality,

  without the need to add complex manufacturing.

FD-SOI

Radiation Effects on FD-SOI

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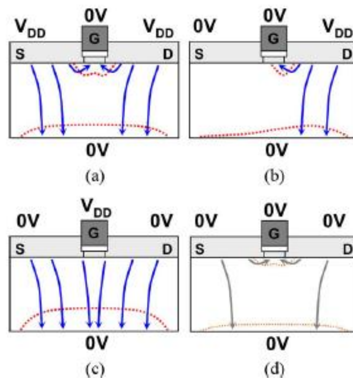
Trapped charges in BOX

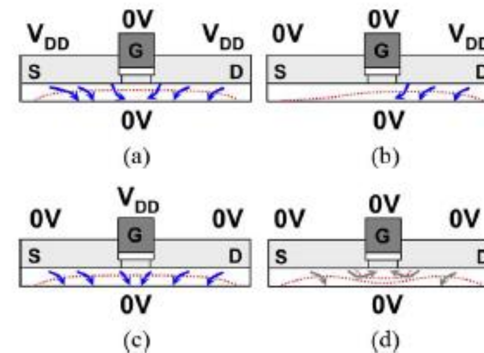
Thick BOX

1. More charge
2. Large V_{bb} shift
3. High variability across different devices



Ultra-thin BOX

1. Less charge
2. Small V_{bb} shift
3. Low variability



M. Gaillardin et al , Impact of SOI Substrate on the Radiation Response of UltraThin Transistors Down to the 20 nm Node

Project Plan

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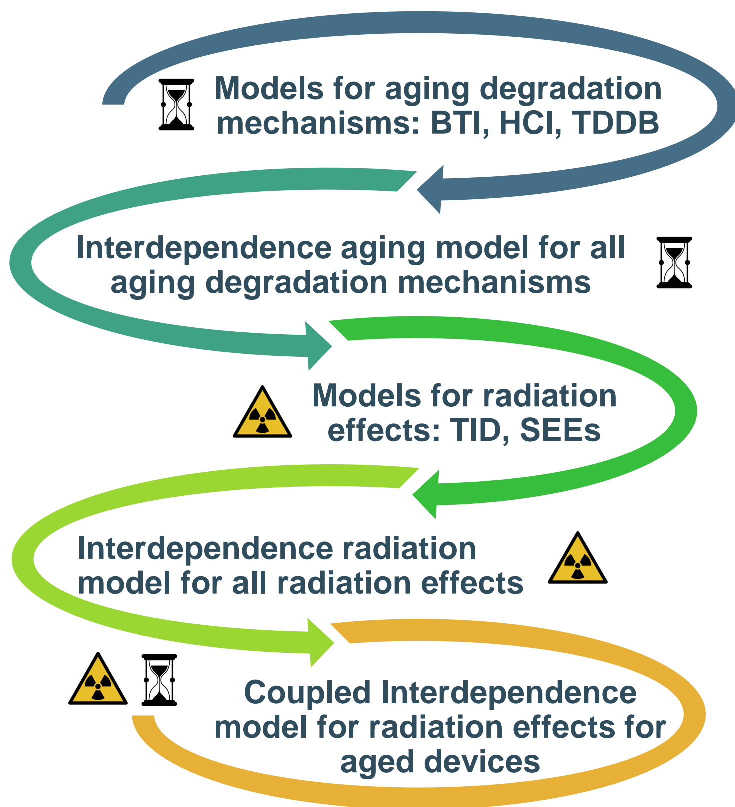
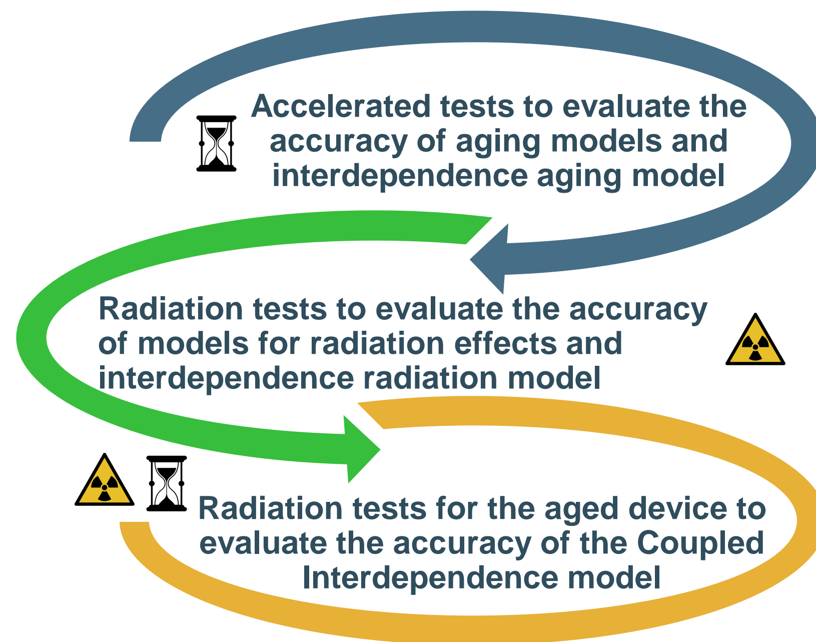
Develop Reliability Device Models



Accelerated Physical Tests



Progress

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- Develop dynamic **Reaction-Diffusion model** for ***Bias Temperature Instability*** (**BTI**) aging degradation mechanism.
- BTI increases the delay of transistors over time, causing the circuits speed to decrease, and this leads to delay faults.
- BTI is represented by incremental shift in |Vth|.

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Results

|Vth| Shift due to BTI aging degradation mechanism: