Ensuring Mission Success: ESA's Approach to Radiation Challenges and Reliable Testing Methods

TWINRELECT
TWINNING FOR EXCELLENCE IN RELIABLE ELECTRONICS

Thomas Borel

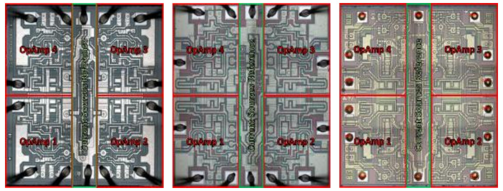
ESA ESTEC

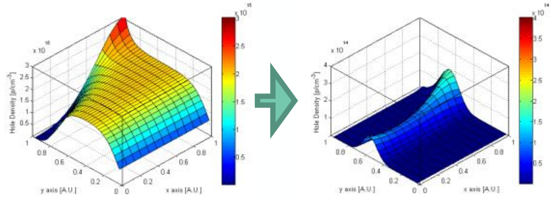
23/07/2025

About Myself

Education:

- B.Sc. – Electronic, Electrical Engineering and Automation
- M.Sc. – EEA – Space Engineering and Reliability
- Ph.D. – Radiation Effects EEE components
  - Location: *UM/IES/RADIAC* and *CERN/EN*
  - Funding: DGA/CERN
  - Thesis: “Study of synergistic effects in integrated circuits under ionizing and neutral space radiation environment”.
    - Comparative study of LM124 bipolar operational amplifiers from different manufacturer subjected to TID and DD
    - The study of the synergistic effect TID-ESD





About Myself

Professional:

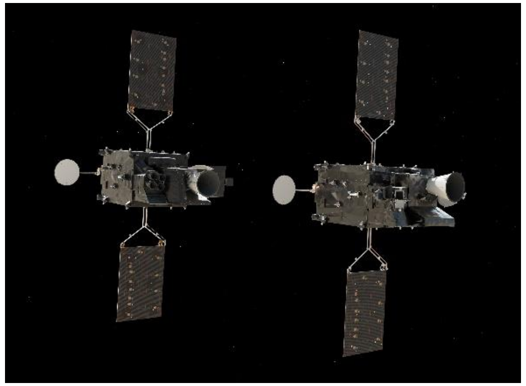
Location: ESA ESTEC – Noordwijk – The Netherlands

Position: Component test engineer (since 05/2019)

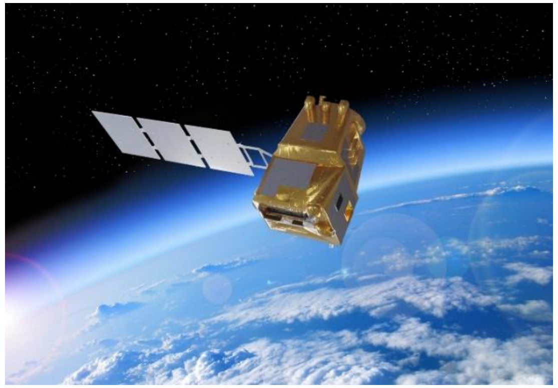
Radiation and Component Reliability team

Responsibilities:

- Radiation Hardness Assurance (RHA) support
  - Support European companies on ESA program (MTG, LSTM, ARRAKHIS, TRUTHS, Eagle-1, Aurora-D, AEOLUS 2…)
  - Support and development of R&D activities
- Laboratory
  - Operation Co60 Facility
  - Operation and PoC of SEE laser Facility
  - Preparation and Execution of test HI / Proton / TID



MTS-I & MTS-2



LSTM

Summaries

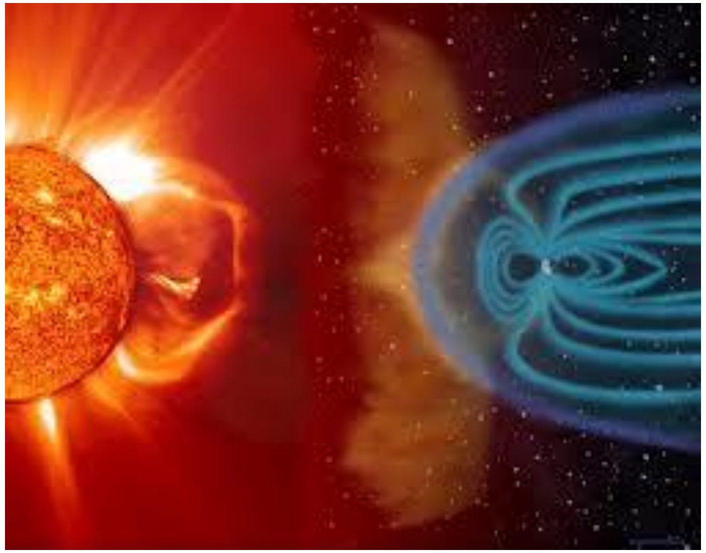
23/07: **Radiation Challenges and Reliable Testing Methods**

- Radiation testing - Generalities
- Standards test methods
- Alternatives test methods
  - Pulsed scanned methods (SEE Laser)
- Conclusion
- Questions ?

23/07: **ESA's Approach to RHA in Space Projects**

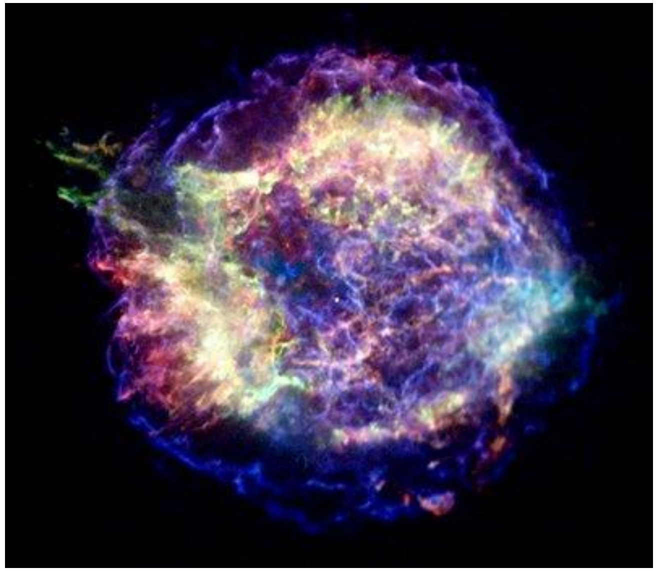
- The European Space Agency
- Radiation in Space and its impact
- ESA's R&D programs
- ESA Education office
  - Trainings
  - Programs
  - Early career opportunity

Radiation types & sources



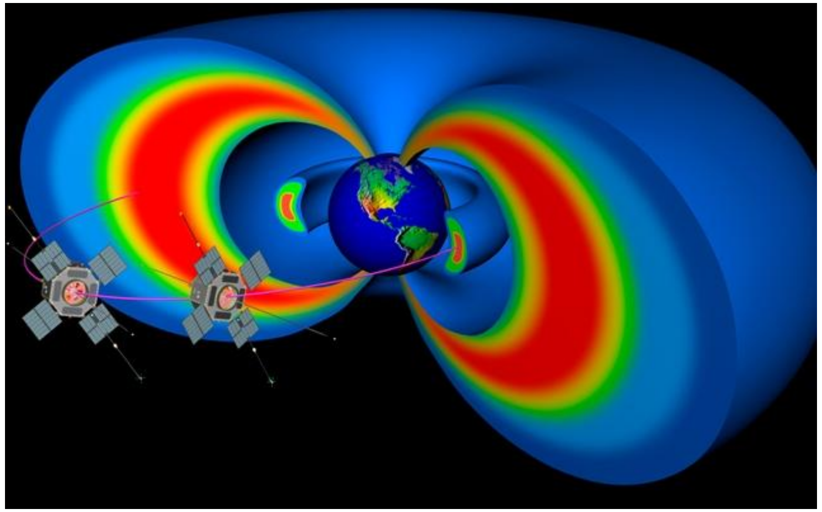
Van Allen belts:

- Internal
  (protons + electrons)
- External
  (electrons)



Solar Energetic Particles:

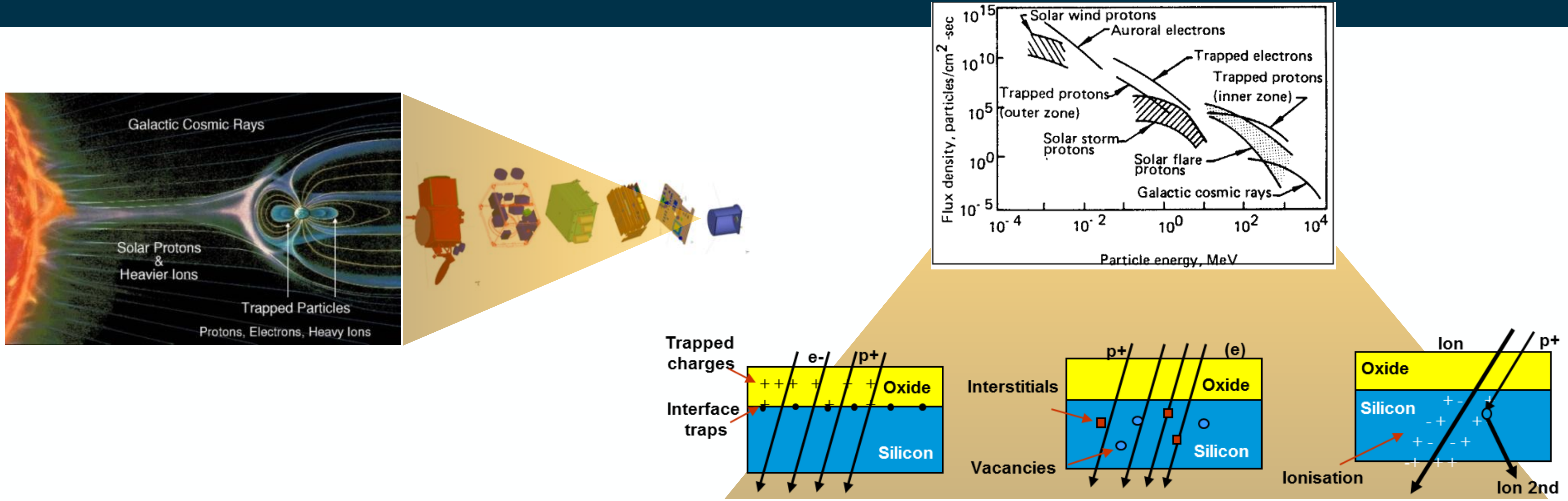
- Solar flares
  (electrons + protons/heavy-ions)
- Coronal Mass Ejections (CME)
  (protons + heavy-ions)



Cosmic Galactic Rays:

(protons & heavy-ions)

From space environment to EEE testing



Radiation/Matter interaction	Ionising process	Non ionizing process	Charge deposition
Radiation effects on semiconductors: 3 Mechanisms Model	Total Ionising Dose	Displacement Damage	Single Event Effects
Standard source to create these effects in LABORATORY	High energy **photons (60Co)**	High energy **protons**	High energy **heavy-ions & protons**

Radiation testing – General concepts 1/4

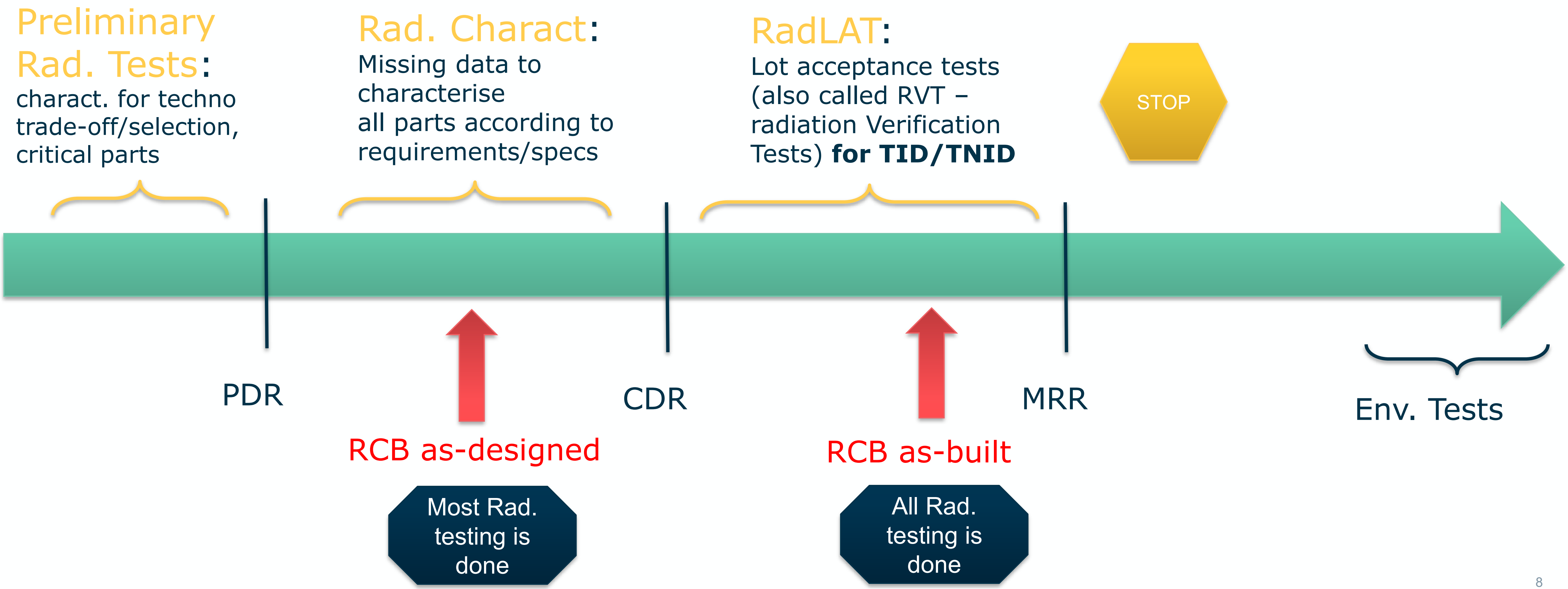
- **Why do we do radiation testing?**
  - When we don't know the behaviour ☺
  - To check a mitigation solution
  - To qualify a component
  - To ensure the same behaviour from an "older" component (i.e. from a different lot)
  - Not systematic: when applicable test data is available with traceability, it may be waived!

    1 2 3

- **How do we test?**
  - **Worst case approach** whenever possible
    - Why? Lots of unknowns = margins, (not always worst case is possible) => cannot be (always) rectified in Space!
    - What? Irradiation type, test conditions, temperature
    - Advantage: Results can be re-used in the future
    - Sometimes worst case is unknown and tests should be done in different configurations, or application condition
  - **"Test as you fly"** (…& "fly as you test") – **YES BUT**….
    - Why? Because cannot be done otherwise, to test a mitigation or full-system
    - What? Irradiation type, application condition (voltage, current, load, mode, frequency,…), temperature
    - Limitation: Test results cannot be re-used for other applications
    - Beware: For some aspects it doesn't make sense: fluence (see later), flux (accelerated testing)…

Radiation testing – General concepts 2/4

- **When do we do radiation testing?**



Radiation testing – General concepts 3/4

- **What do we test?**
  - **Components**
    - "Traditional/common" way
    - Advantage: test all conditions with statistics & can be tested early (some exceptions e.g. prog. devices)
    - Only active components (passive components are mostly insensitive)
  - **Boards or subsystems**
    - Depends on the situation (type of project, available resources, risk…)
    - Advantage: Testing everything in one-go
    - Disadvantage: Often done (too) late, often no/little samples, only applicable in the given test condition, not reusable, requiring enough observability
- **Other notions for radiation testing?**
  - Margin for TID: TIDS (the component TID perf.) should be higher than TIDL (env. calculated TID)
    - Why? Uncertainty in the environment, variability (lot-to-lot, intra-lot), conditions not fully representative…
  - Statistics on data for SEE
    - Why? Based on stochastic process, hence need to have enough events.
  - Samples
    - Inherent variability in response (in particular for TID but also SEE): large "enough" sample size for statistics
  - Traceability
    - Very important to test the same components (e.g. SET testing of LT431 two manuf. = different results)

Radiation testing – General concepts 4/4

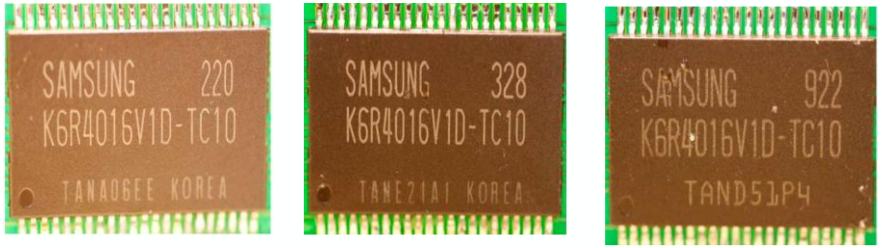
- **Important of understanding what is going on:**
  - Radiation testing is not straightforward…contrary to what some people may think!
  - Not (exactly/fully) representative of the radiation environment
  - Test artefacts:
    - Radiation testing are accelerated tests (fluxes may be lower in space)
    - Effects of the test set-up (e.g. long cables)
  - Testing/analysing the results:
    - Basic radiation effect mechanisms & impact of the test limitation (to avoid over/under-testing)
    - Knowledge in electronics for the set-up (obviously)
    - Working in a time-pressured environment (particularly true for SEE testing): preparation is key.

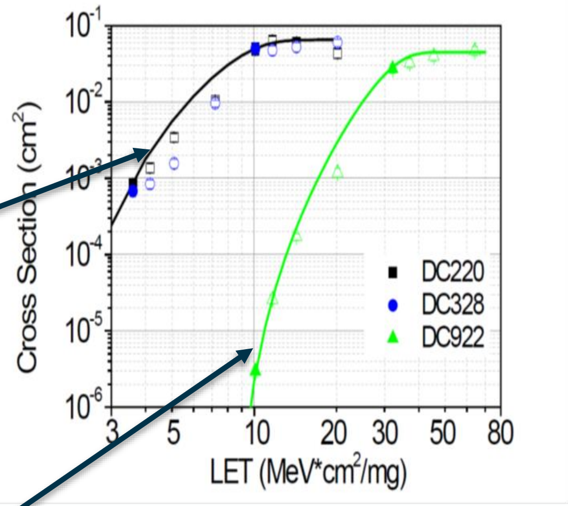
- **Heritage data instead of testing?**
  - Be careful with "flight heritage": very tempting but: did it really work well? Same environment? Same part? Same biasing conditions? Temperature? Enough statistics (samples/duration)? Could you detect all possible SEE types for this part/measuring the relevant parameters (TID/TNID)?

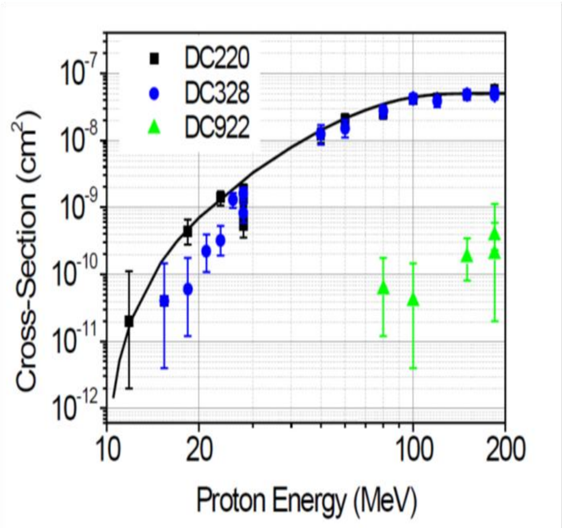
Radiation testing is NOT INTUITIVE:
it is important to have a good overall understanding (environment, particle-matter interaction, electronics, testing conditions) in order to avoid over, or worse, under-testing!

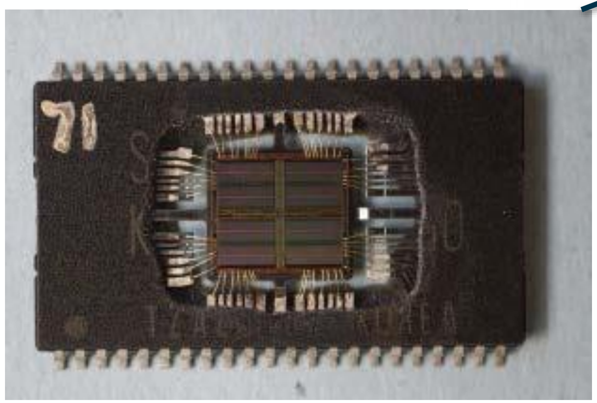
Traceability of COTS:

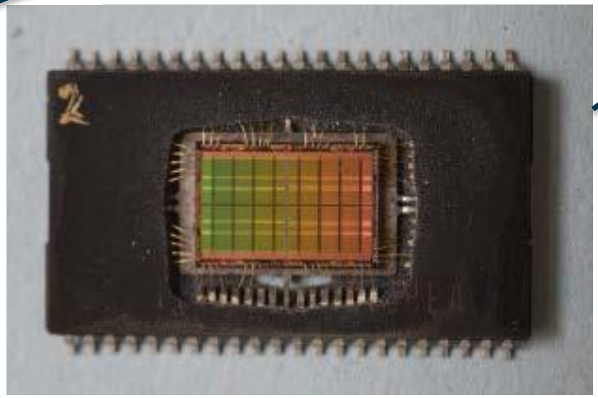
- Example of 4M SRAM K6R4016V1D on Proba-V







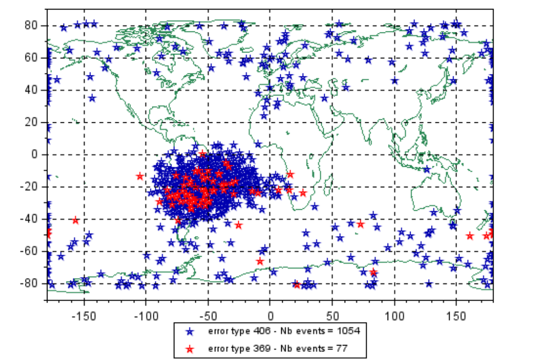




Die rev D – more sensitive to SEL

Die rev C – more robust to SEL

DC220 or DC328: ~ 1 SEL every 3 days on LEO polar orbit

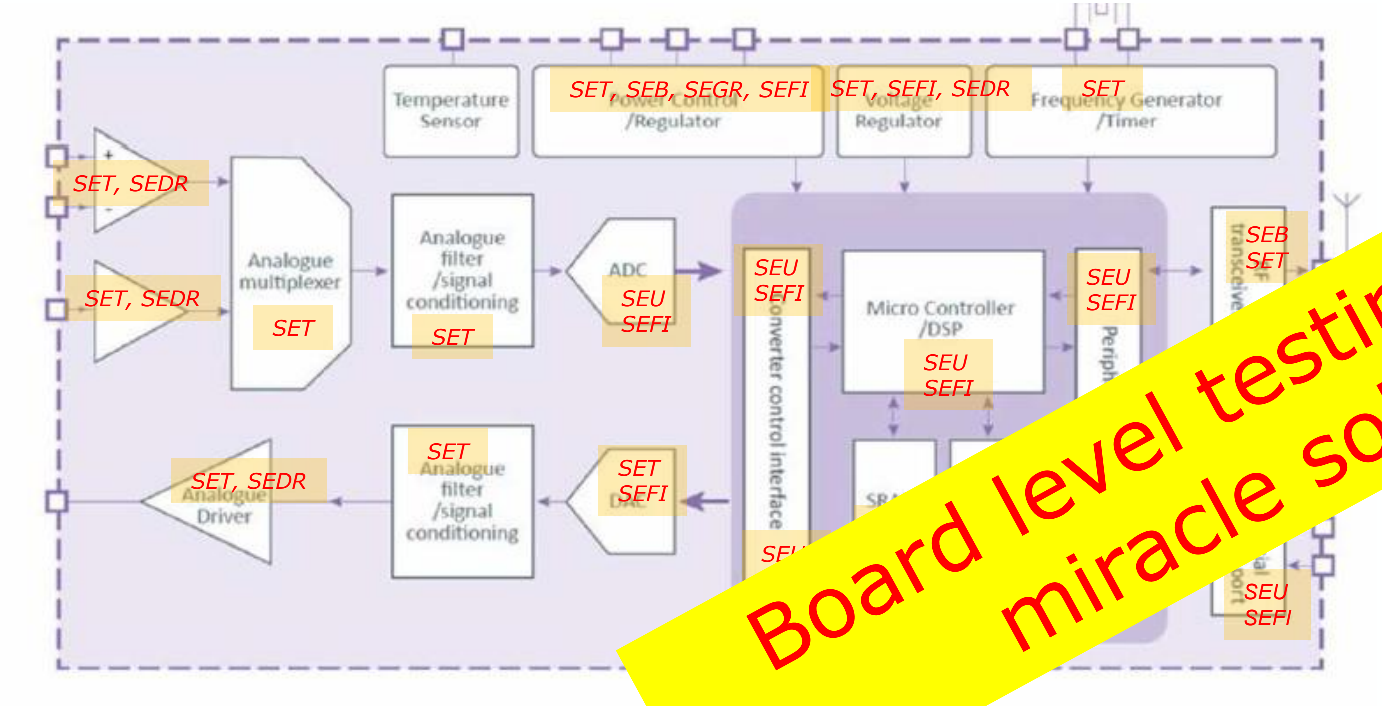


Board testing challenges – HI or P

Complex devices may be **sensitive to many different SEE types**

SEEs may **propagate** to other blocks / subsystems

Need to **monitor** many parameters within the board to understand what is going on



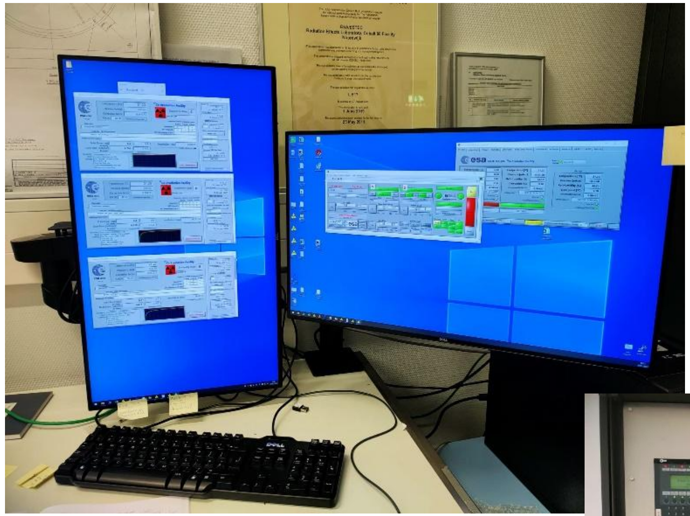
Source: www.swindonsilicon.co.uk

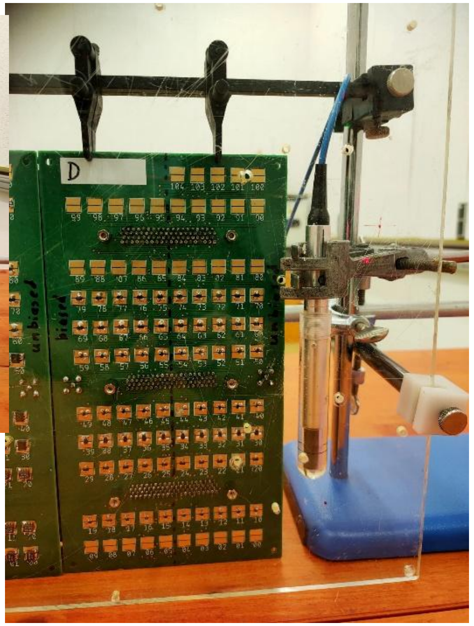
PSI (proton) testing: students CubeSat EPS board

Board level testing is NOT a miracle solution !

Standard test methods

Radiation testing – Co60 TID

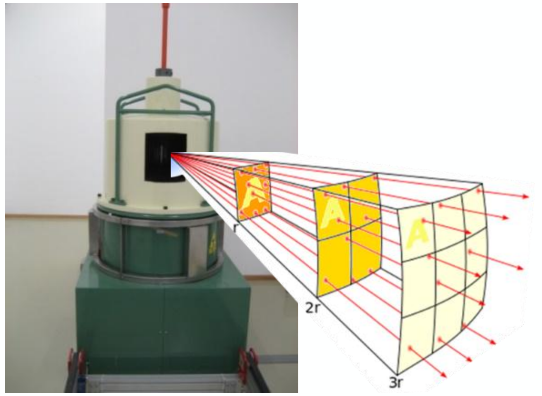




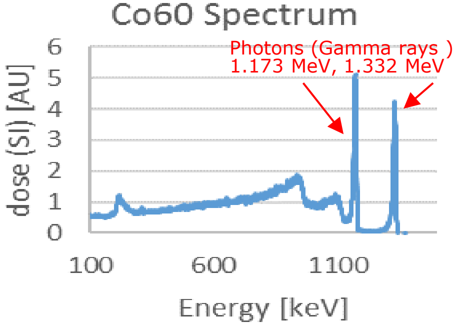
Control room - outside

Irradiation room - inside

TID test principle



https://estecCo60facility.esa.int



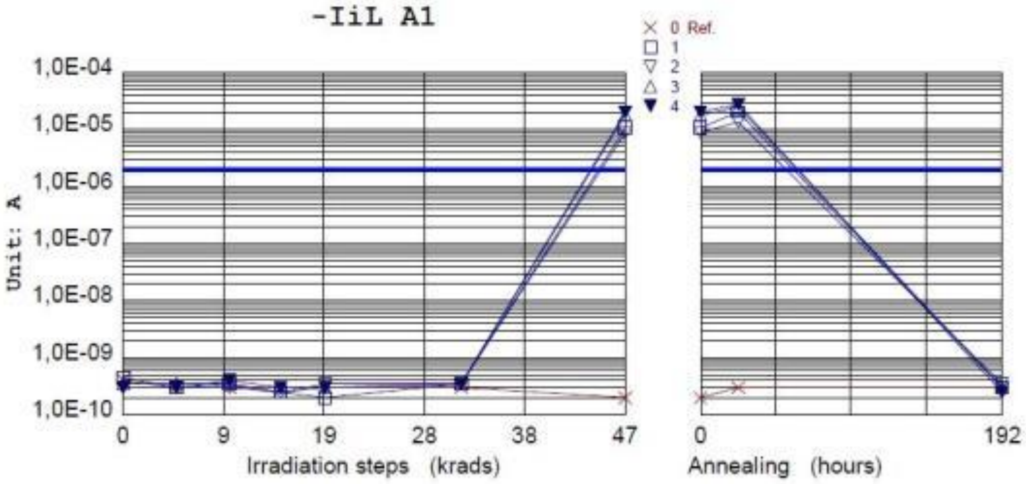
Initial Measurement

TID Irradiation

Interim Measurement

Annealing
RT & high Temp (for TID)

Final Measurement
Data analysis



DUT: Hitachi HM6216255H 4Mb static RAM. CMOS technology

Parameter: Negative input current low level

Dose rate: 200rad/h

Irradiation results: Out of specified limits between 32 and 47 krad

Annealing results: Following annealing parameter return to pre-irradiation levels

TID: Importance of the sample size

Fact: Inherent **lot-to-lot** and **part-to-part** variation

Question: How can few samples allow to predict the worst case behaviour or an entire group?

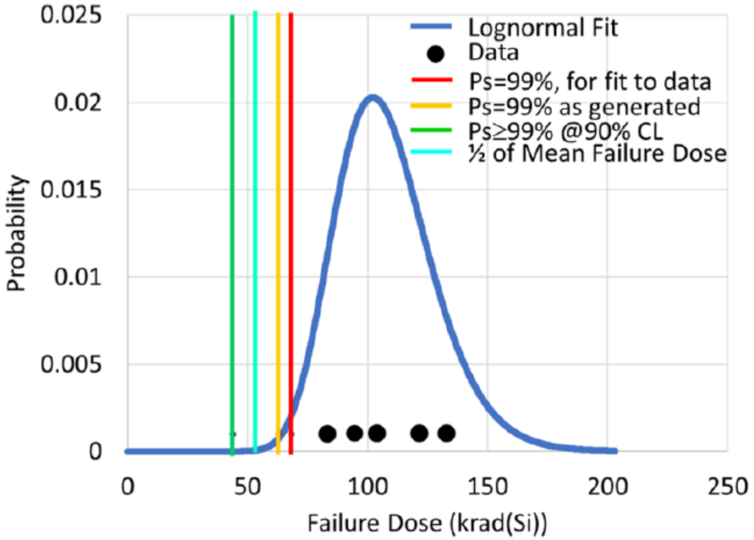
Lot-to-lot variation: need to characterise each lot (mainly)

Part-to-part variation: You **assume** a normal distribution to compute the "One-sided Tolerance" limit (Ktl) for a Ps=90% (or 99%) and C=90%

Problem: **How do you know that the failure distribution is following a normal distribution?**

Part of the RHA assessment

Ps: Probability of failure
C = Confidence level



[NASA/TM−20210018053, NESC-RP-19-01489, Avionics RHA Guidelines, July 21]

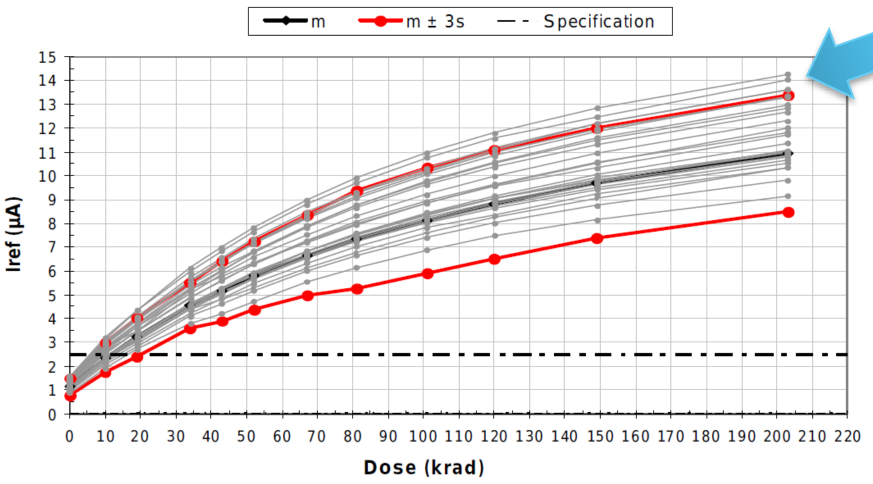


Fig. 9. Random selection of 5 devices among 30 devices. The common 3-sigma approach is applied. TL1431ACZ lot GE334152, –Iref - µA.

[Guillermin and al., RADECS 2016]

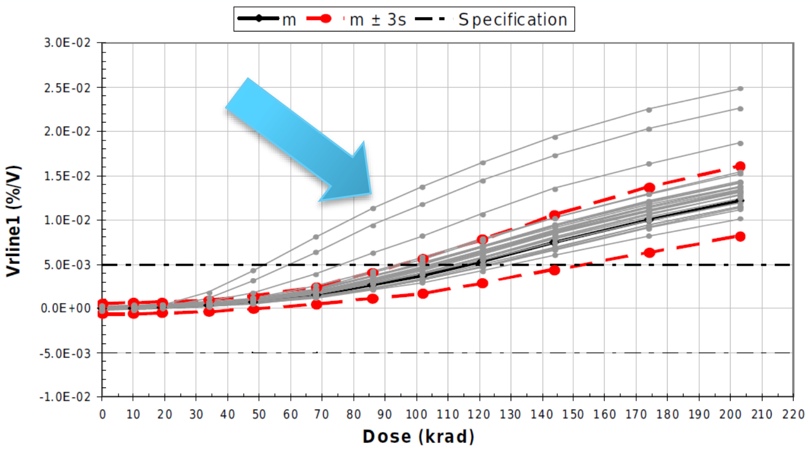
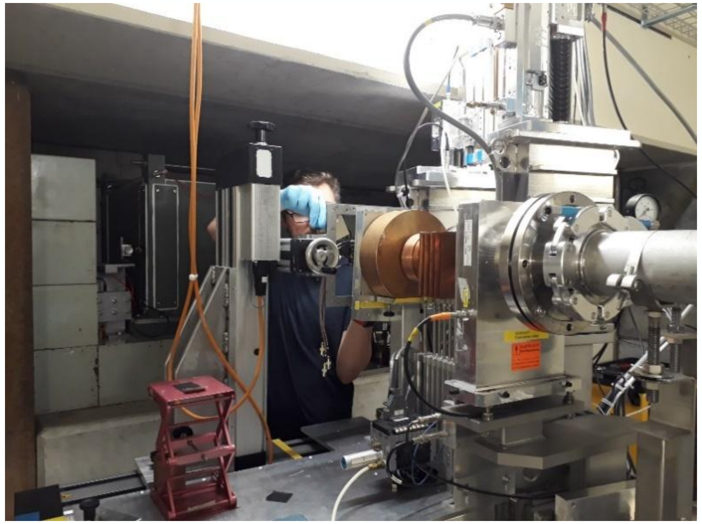
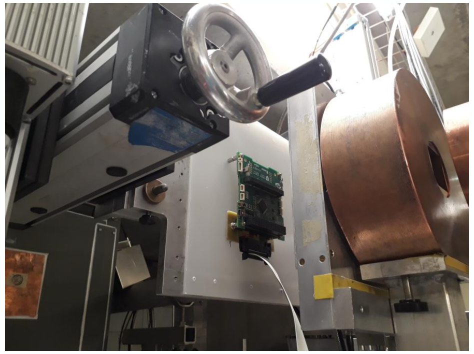
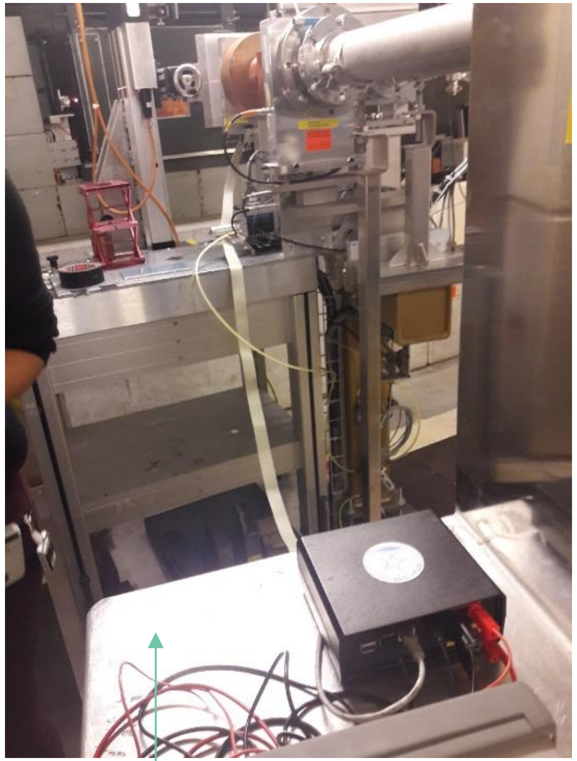


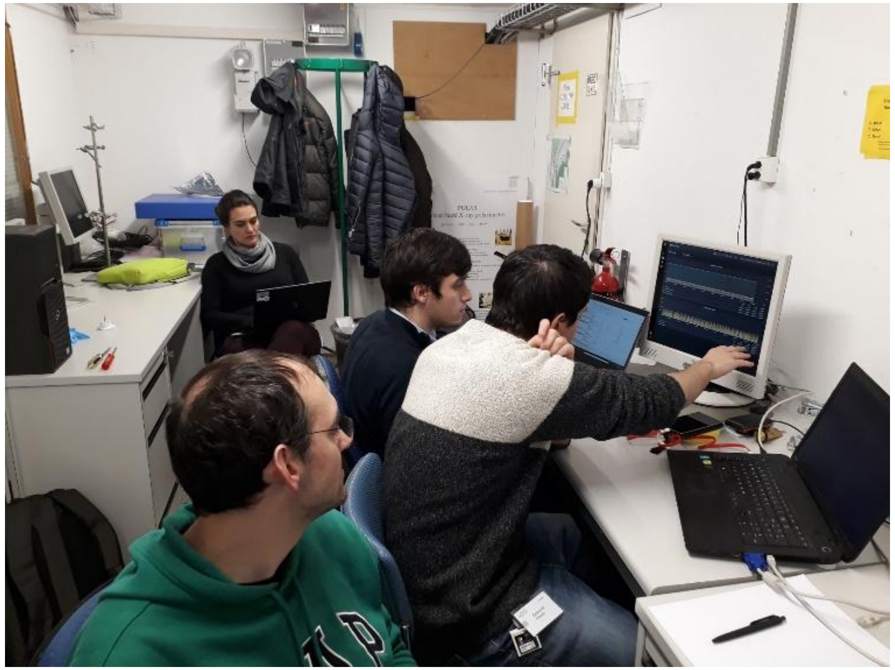
Fig. 8. Random selection of 5 devices among 30 devices. The common 3-sigma approach is applied. AD584SH lot 0226A, Vrline1 - %/V.

Proton testing (SEE) – Example of PSI









DD test campaign at PSI proton facility with a FYS CubeSats team (Nov 2018) to characterise a component

SEE test campaign at PSI proton facility with a FYS CubeSats team (Nov 2018) to characterise a subsystem PCB board

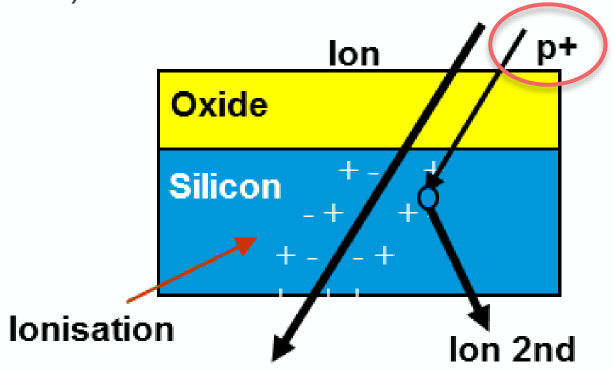
Radiation testing – Proton SEE

- **General concepts** mentioned earlier are applicable

- **Particularities of proton testing**
  - No need to delid parts (unless if very low energies)
  - Possibility to do broad beam testing due to collimation (e.g. to test a full PCB with several parts)
  - **Proton tests cannot reveal all types of possible SEEs** (in particular the destructive ones)

- **Representativeness of proton testing vs. space proton environment**
  - In LEO (Van Allen belts) or during SPE you find these high-energy protons
  - You can also have > 200 MeV, testing is usually limited to 200 MeV (facility limitations)

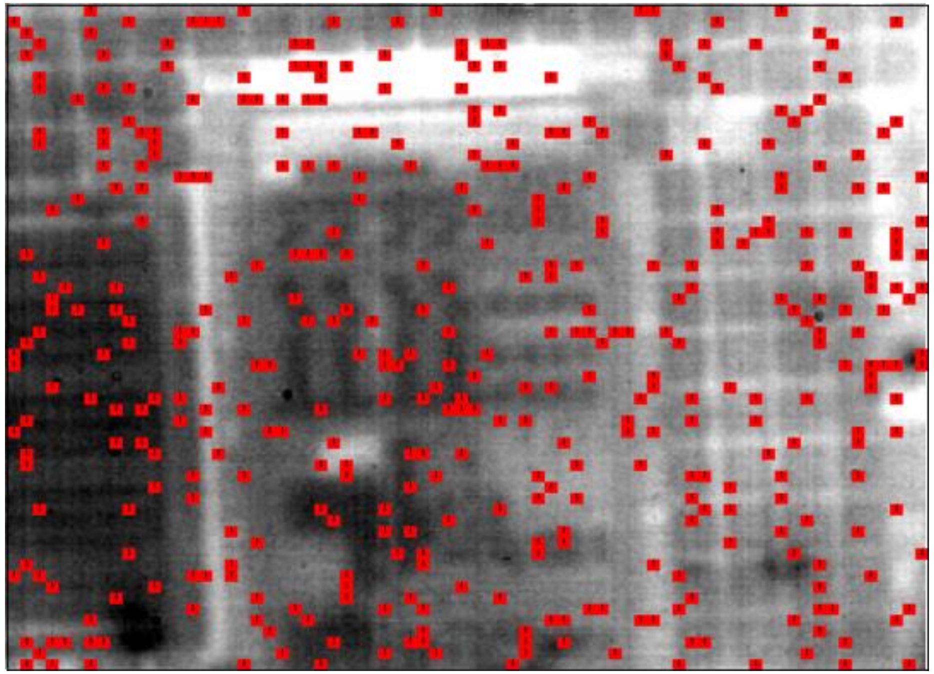
- **Challenges of proton testing**
  - Accumulation of TID during irradiation
  - Cost of beamtime (e.g. >800 euros/h) & Availability (booking in advance)
  - Time pressure during testing & safety protocol
  - Longer cabling, neutron background
  - Activation of the parts – cannot be used



Proton vs. Heavy-ion testing

60×70μm2 portion of Hitachi EDS5108 512 Mbit SDRAM

10^7 ions/cm^2 typical of HI SEE test



[Ladbury, Short Course, NSREC 2017]

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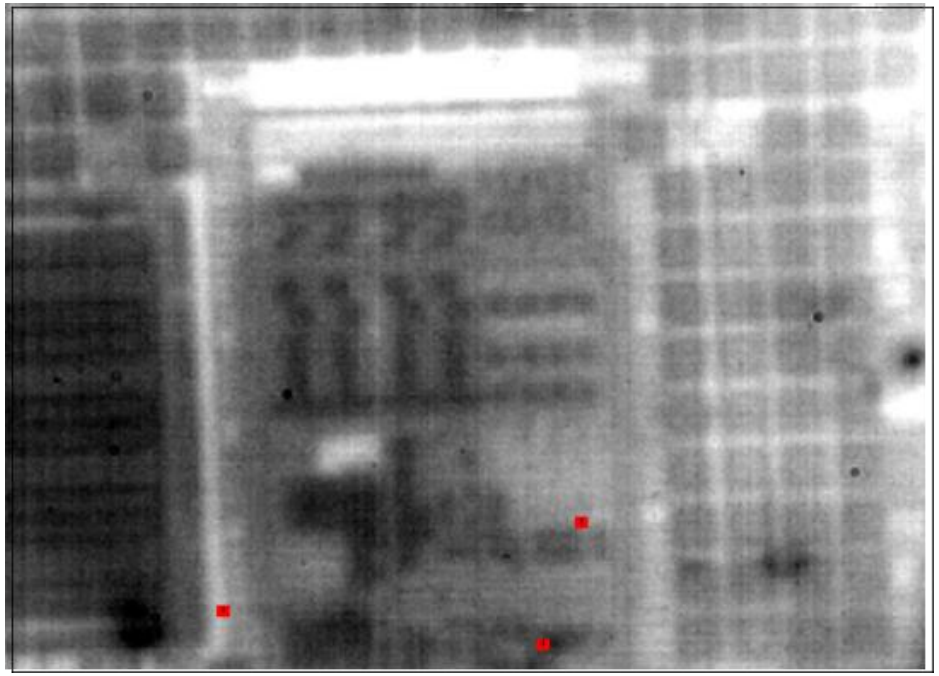
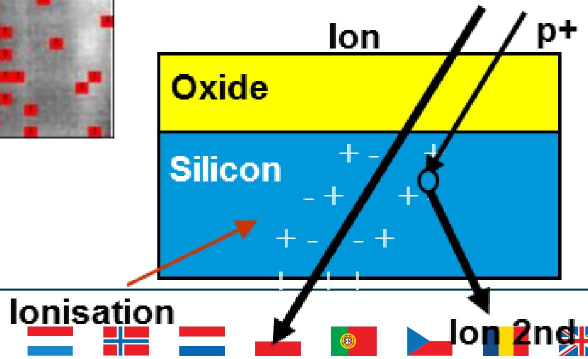
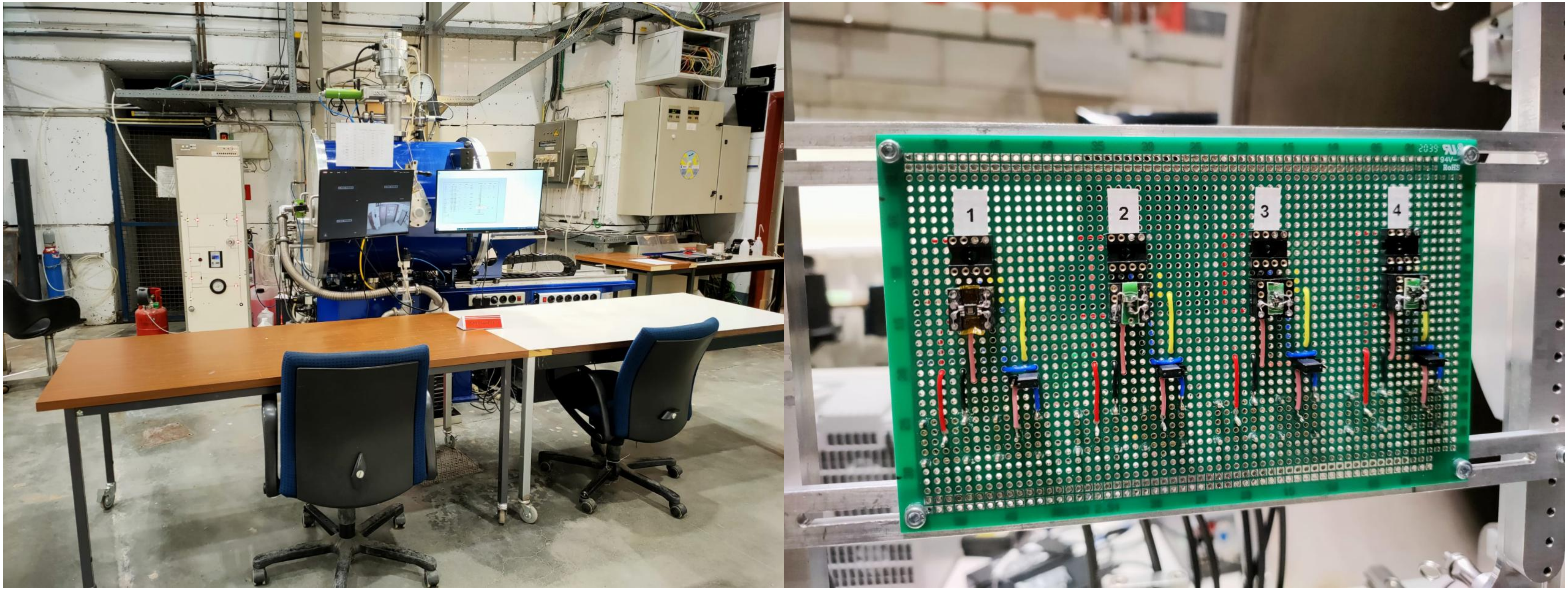
Recoil ions due to **10^{10} protons/cm^2**



[Ladbury, Short Course, NSREC 2017]

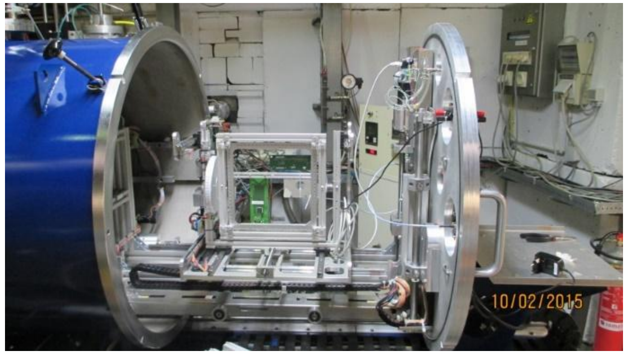


Heavy-ion testing (SEE) – UCLouvain Facility



Example of a test campaign: SET testing of Bandgap References @UCLouvain in Belgium Nov 2021

SEE test principle



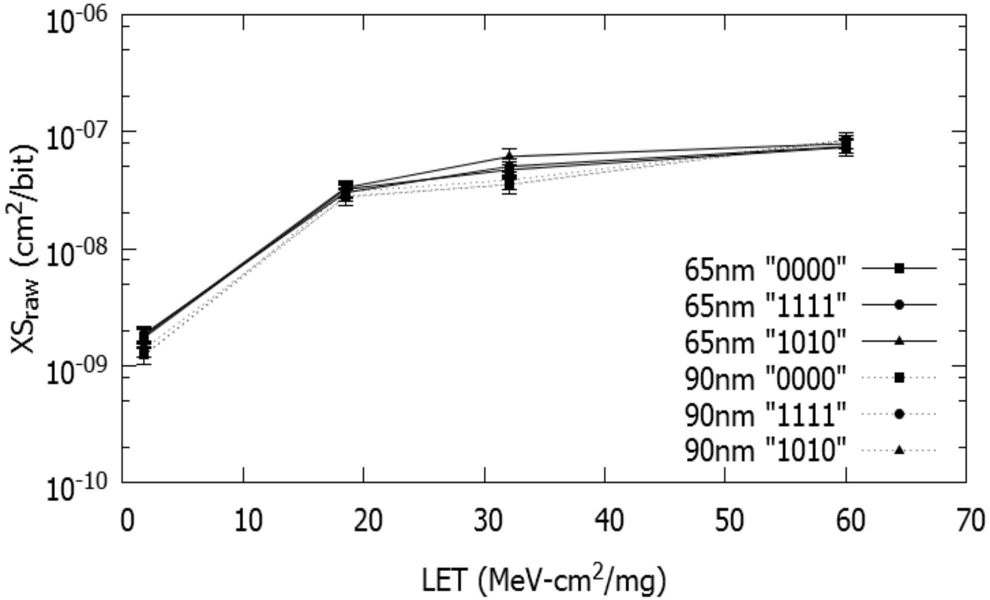
Initial Measurement

De-pressurise chamber

Selection of ion, Fluence, flux, part#

Start/stop run

Re-pressurise chamber



DUT: SRAM 90nm and 65nm

Parameter: SEU (bit flips) for different patterns

LET: 1.3 to 62 MeV.cm²/mg

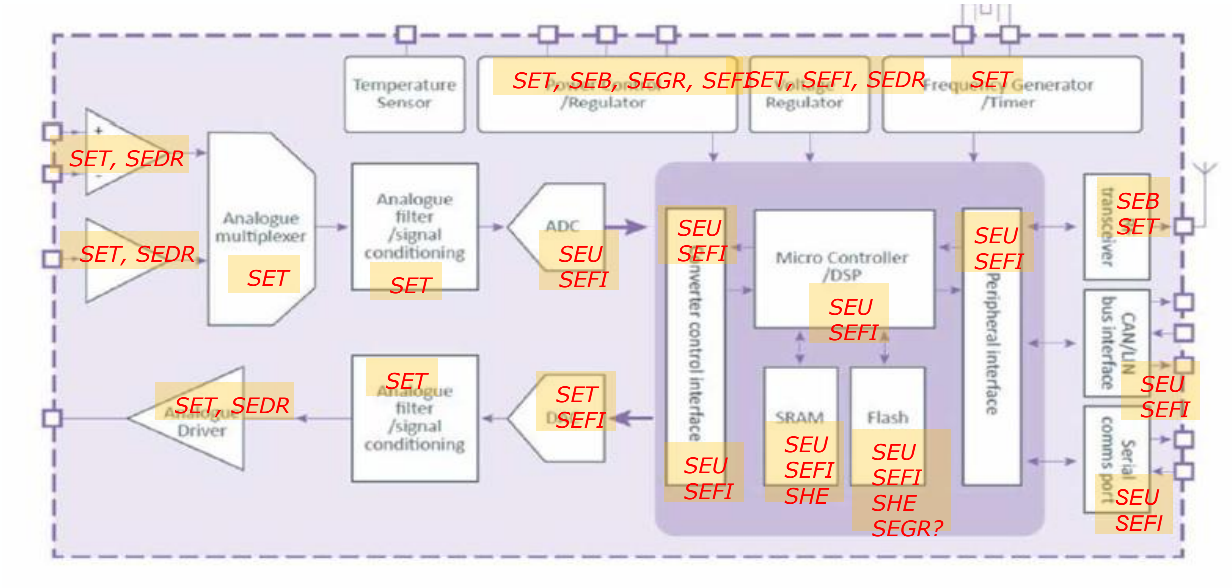
SEE results: SEU cross-section in cm²/bit which can be used to derive soft error rate.

Complex IC or Board testing challenges – HI or P

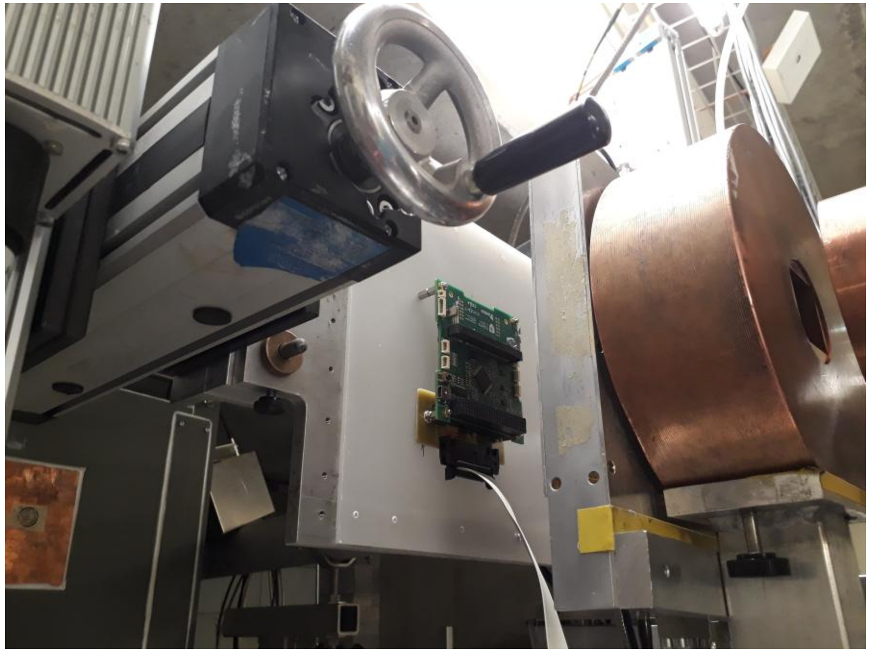
Complex devices may be sensitive to many **different SEE types**

SEEs may **propagate** to other blocks / subsystems

Need to **monitor** many parameters within the board to understand what is going on



Source: www.swindonsilicon.co.uk

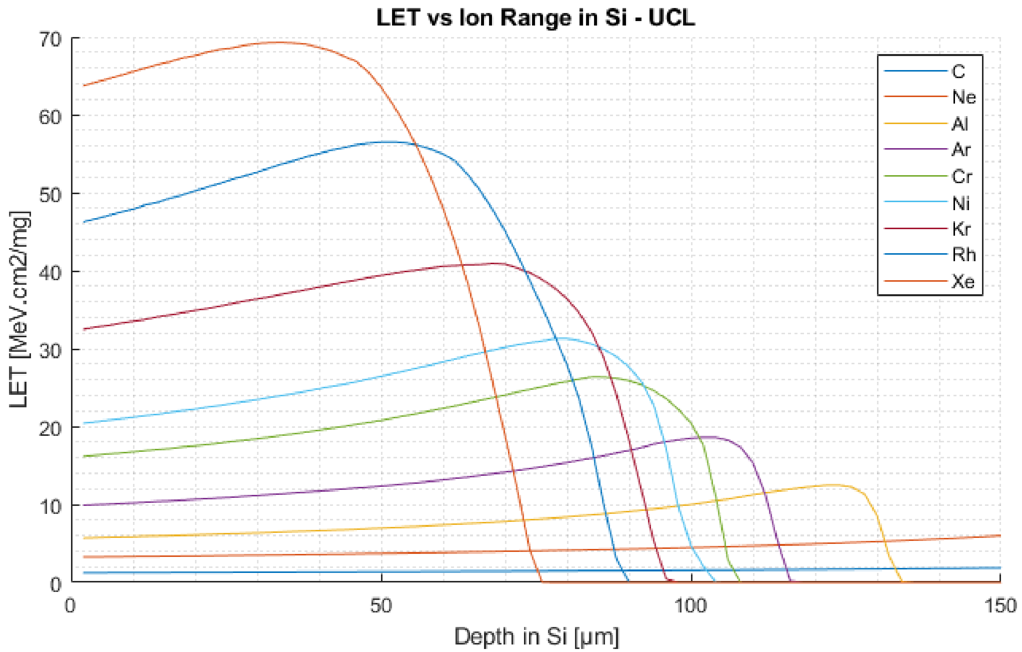


PSI (proton) testing: students CubeSat EPS board

Ion deposited charge: Linear Energy transfer (LET)

LET is a measure of the amount of energy, dE, lost by a particle in a specific material as it travels an incremental distance, dx, through that material.

$$LET = \frac{1}{\rho}\frac{dE_d}{dx} \quad [MeVcm^2/mg]$$



Note:
Heavy ion beam energy can be expressed as:
energy per nuclon (MeV/n) or Ion energy (MeV)

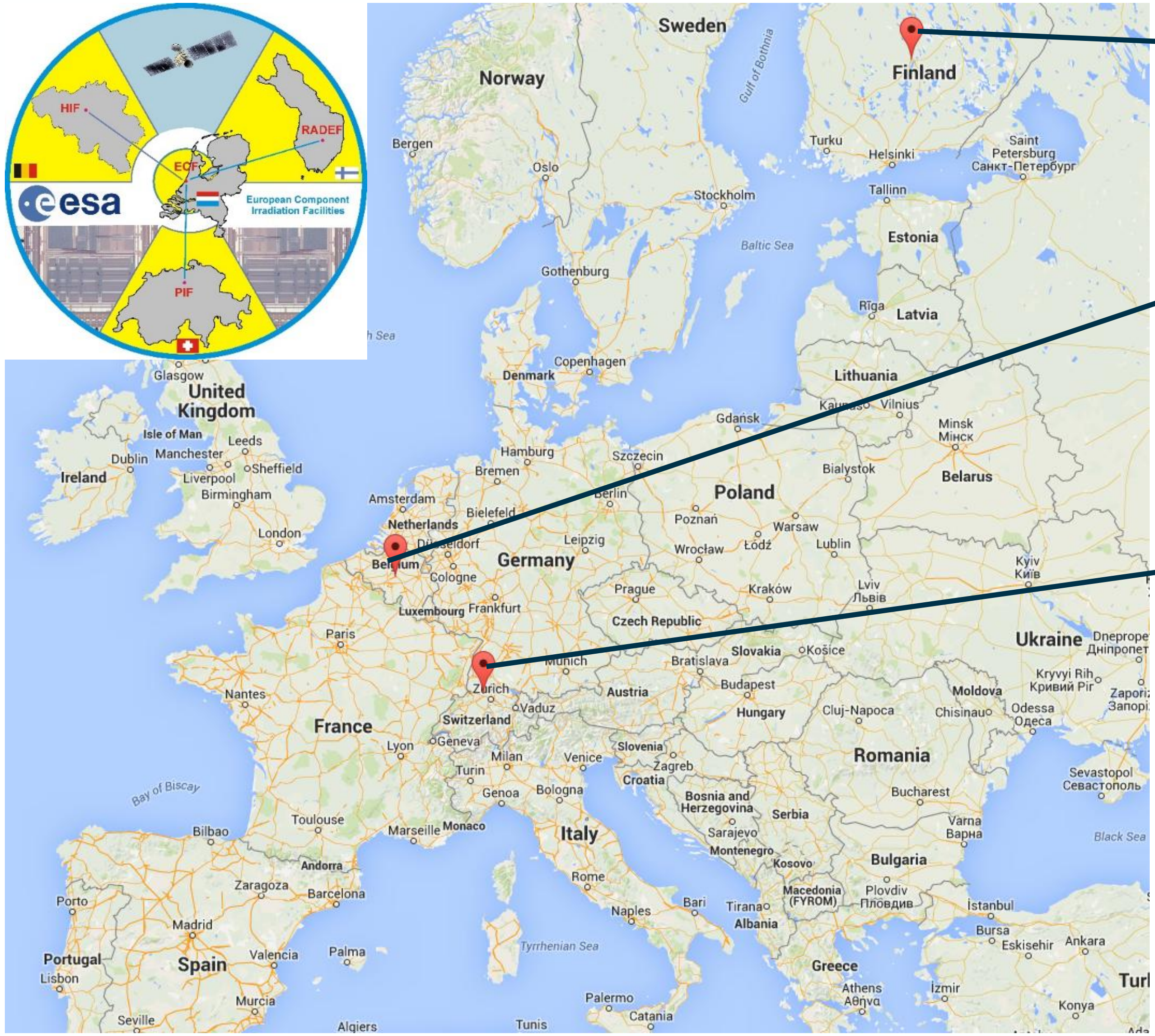
Ion energy = energy per nucleon * (protons+neutrons)

Different combination of
(Ion, energy, range)

⇩

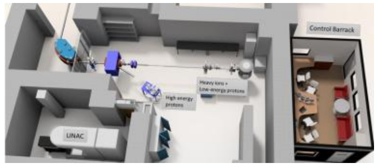
same LET with different range

Heavy-ion cocktail



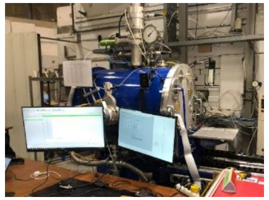
RADEF, JYFL
Jyväskylä, Finland

Heavy ions, protons, electrons



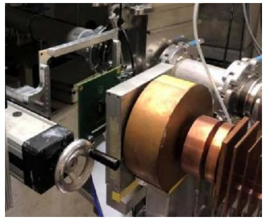
UCLouvain
Louvain-la-Neuve
Belgium

Heavy ions, protons



PSI
Villigen Switzerland

Protons, electrons

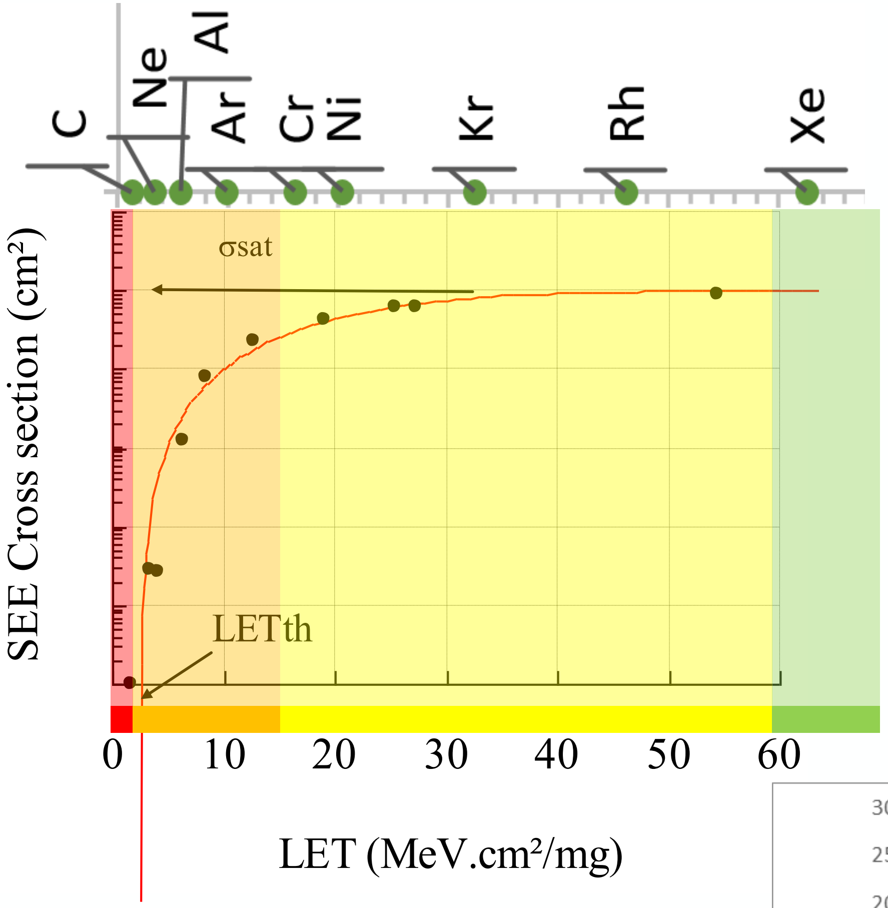


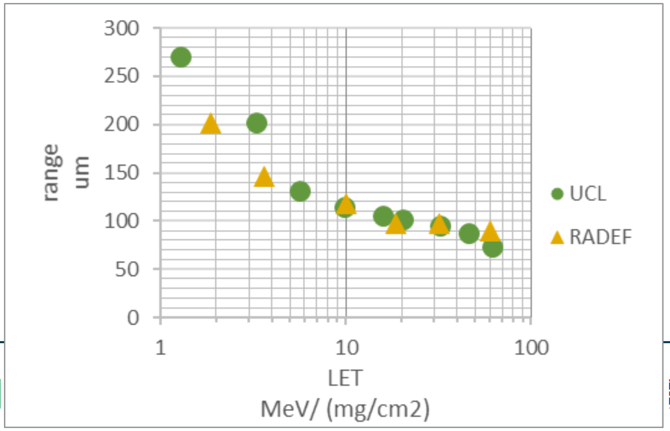
ESA TEC-QEC has been collaborating with these facilities for more than 25 years. PSI, UCL, since 1990-1992. RADEF since 2004 beam in 2007-2008

Aiming at continuous improvement of the quality of the beam, dosimetry and testing infrastructure

Stable flux and energy levels, high particle selectivity, accurate dosimetry, electrical/optical interfaces for cabling

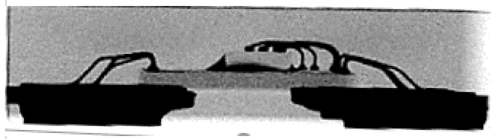
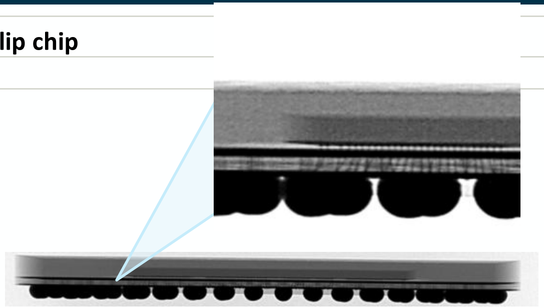
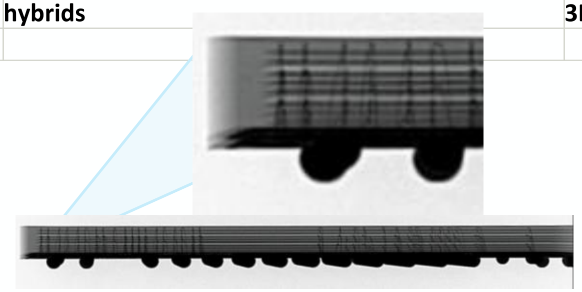
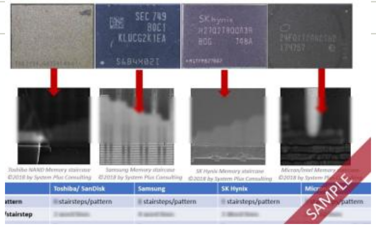
Heavy-ion cocktail





Facility	Ion	Beam energy [MeV]	Range [µm Si]	LET at surface [MeV/(mg/cm²)]
UCL	13 C 4+	131	269.3	1.3
	22 Ne 7+	238	202	3.3
	27 Al 8+	250	131.2	5.7
	36 Ar 11+	353	114	9.9
	53 Cr 16+	505	105.5	16.1
	58 Ni 18+	582	100.5	20.4
	84 Kr 25+	769	94.2	32.4
	103 Rh31+	957	87.3	46.1
	124 Xe 35+	995	73.1	62.5
RADEF	15 N 4+	139	202	1.87
	20 Ne 6+	186	146	3.63
	40 Ar 12+	372	118	10.1
	56 Fe 15+	523	97	18.6
	83 Kr 22+	768	97	32.2
	131 Xe 35+	1217	89	60

Critical constructions requiring higher HI range for SEE testing

	stacked dies	flip chip	hybrids	3D construction
				 from https://www.systemplus.fr
Current option	Plastic package removal dismount the construction risk of altering electrical characteristics & low yield	plastic package removal die backthinning risk of altering electrical characteristics & low yield (about 20%)	If possible (made of assembly of discrete parts) testing separately each die in a 2D configuration	tested with heavy ions after decapping
currently	Not possible to test without compromising the construction	Not possible to test without backthinning	Not possible to test without compromising the construction, but being discrete parts assembled, each part could or coul not be tested separately	Possible to test with decapping, however higher active volumes may become impossible to test (future trend)
Alternatives	High penetrating beam	High penetrating beam	High penetrating beam	High penetrating beam
Possible scenario with some sample preparation, not altering electrical construction	intermediate possibility: removal of plastic remaining the thickness of Si of the die(s), **For each layer:** **about 300um Si** **(+ 5um metallizations,** **25um bodwires)**	intermediate possibility to reach active area (located on the lower side of the die) : remove the plastic the remining material would be **- 300-400um of Si** **- heat sink up to 500um of Cu**	intermediate possiblity: remove mould keeping parts together, remaing the rest of the construction in the order of **5-20 millimiters** (really variable)	intermediate possibility: removal of plastic, remaining the active 3d volume (currently in this specific case the thickness is of some tens of um, **eg 5-20um**)
Without sample preparation	300um plastic package +for each layer :(300um Si + 5um metallizations, 25um bodwires)	300 um plastic package / 300 um metal lid 300um of Si	5-20 mm of Si, Plastic, metallization, bondwires, W plugs	300 um plastic

From A.Costantino – SERESSA 2022

Problematics / Challenges

Situation now

- Facility availability
- Component constructions
- Complexity of the logic
- Demand increasing (New Space)

Testing capabilities

- Classical facility overbooked
  - (UCL > 6 m ; RADEF > 3 m ; overseas ➔ Complex acces)

Alternative options

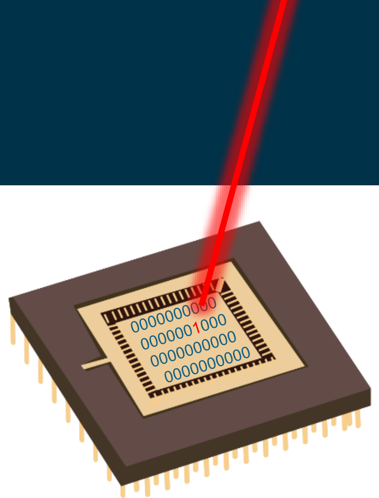
- Very High Energy facility - High penetration ➔ Low availability, Spilled beam, Contamination, …
- Pulsed scanned beams (Laser / X-Ray) ➔ Next chapter

Alternatives test methods

Case of a Pulsed laser

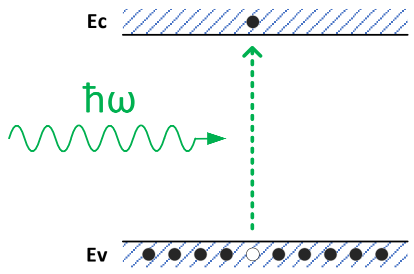
Why Using Laser ?

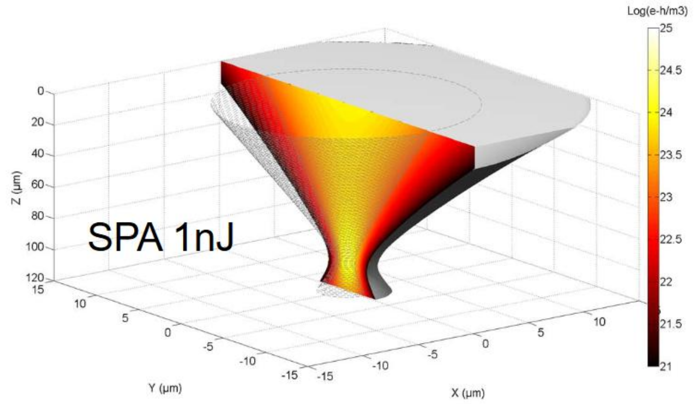
- Alternative method to test
  - Can generate SEE repeatably
  - Cope with unavailability of Heavy Ions (Alternative test method)
- Facility availability
  - More and more facility are available in EU/US (low waiting time)
  - Top Table equipment (“Anyone” could procure one)
- Financial aspect
  - Test campaign (couples thousands of € for a week of test)
  - Procurement of a SEE laser facility (couples hundreds of k€)
- Useful for
  - Screening of parts
  - Test bench validation
  - Fault Injection
  - Failure analysis
  - Security
  - Teaching



Single Photon Absorption (SPA)

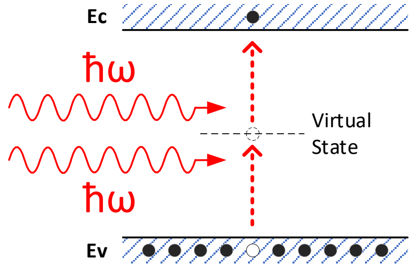
- Excitation above the semiconductor bandgap
- One photon enough to generate an e-h pair
- Optimal for chip level testing
- Energy loss in the bulk

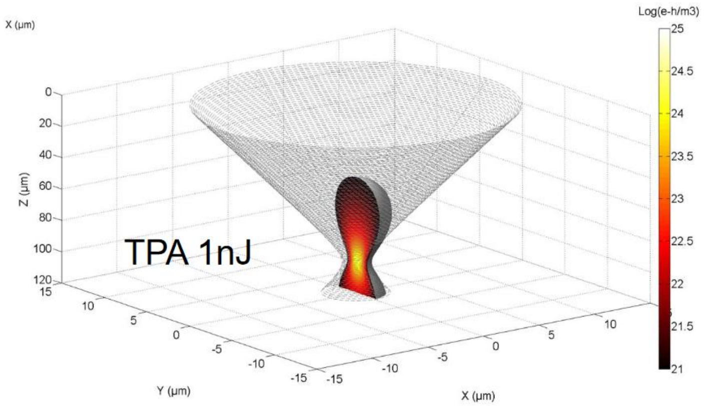




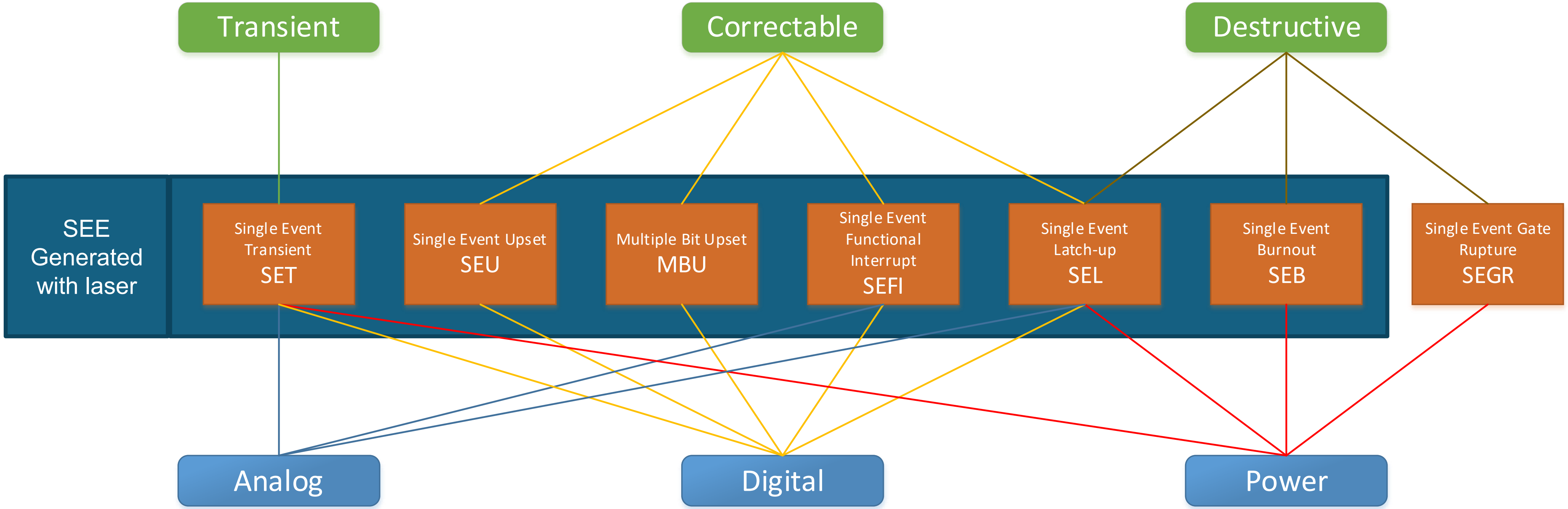
Two Photon Absorption (TPA)

- Excitation below the semiconductor bandgap
- Two photons needed to generate an e-h p
- Optimal for cell level testing
- High Zaxes sensitivity



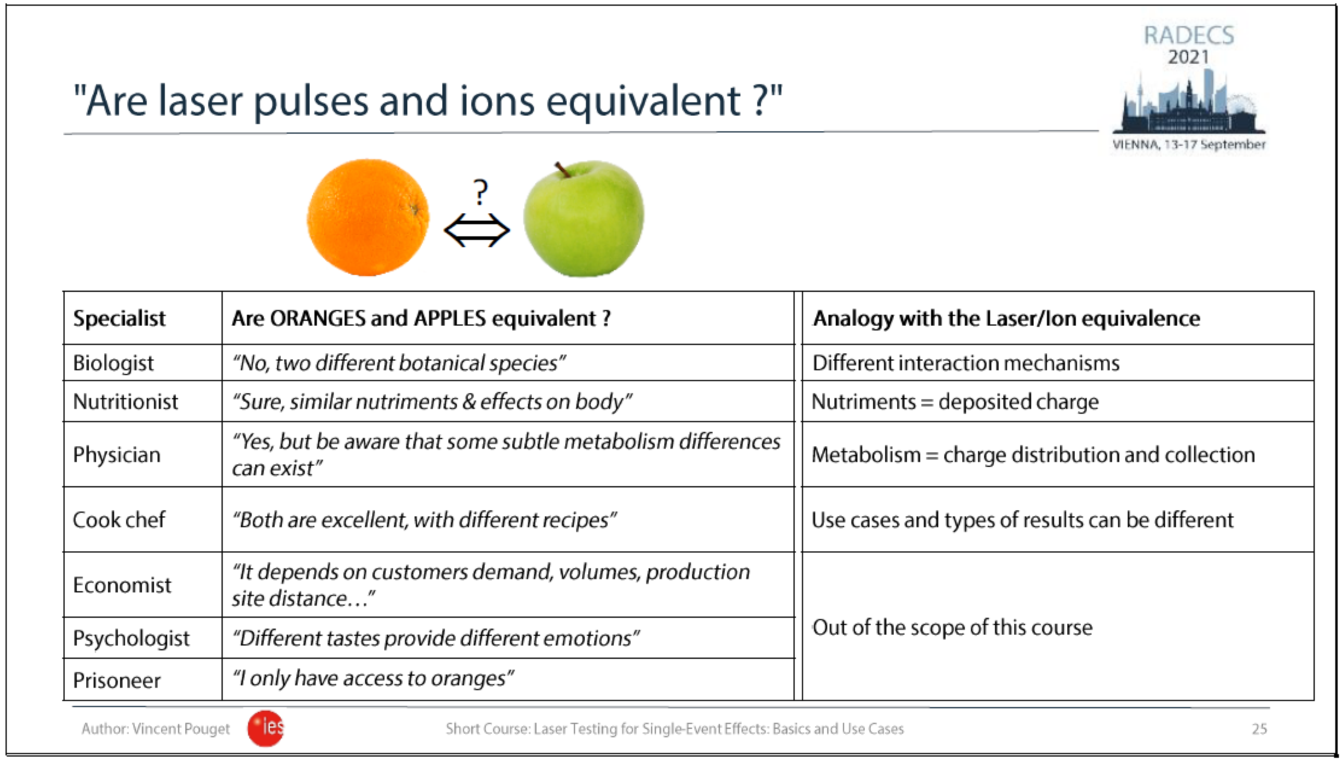


Single Event Effect with Laser



➔SEGR assumed to be originating from Ionization of the gate dielectric

Difference Heavy Ion / Laser for SEE testing

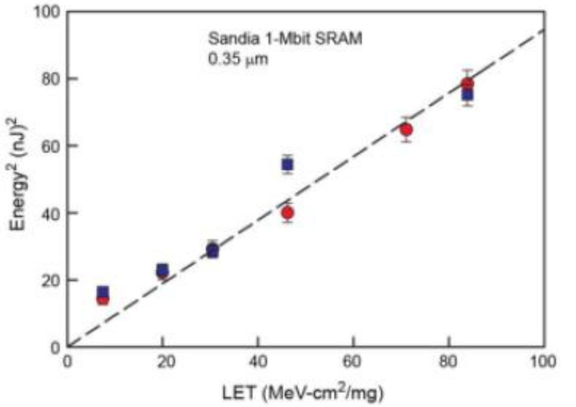


RADECS 2021
VIENNA, 13-17 September

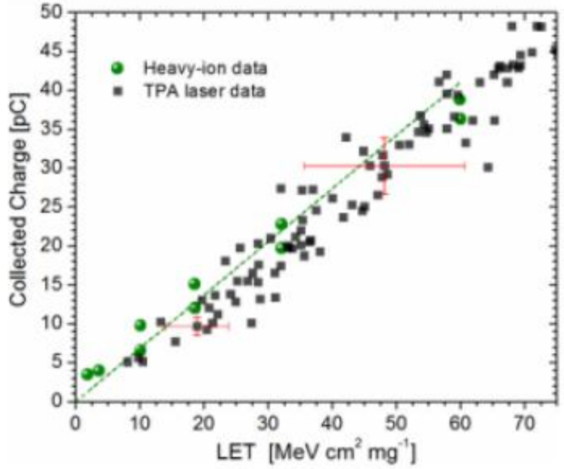
"Are laser pulses and ions equivalent ?"

Specialist	Are ORANGES and APPLES equivalent ?	Analogy with the Laser/Ion equivalence
Biologist	*"No, two different botanical species"*	Different interaction mechanisms
Nutritionist	*"Sure, similar nutriments & effects on body"*	Nutriments = deposited charge
Physician	*"Yes, but be aware that some subtle metabolism differences can exist"*	Metabolism = charge distribution and collection
Cook chef	*"Both are excellent, with different recipes"*	Use cases and types of results can be different
Economist	*"It depends on customers demand, volumes, production site distance…"*	Out of the scope of this course
Psychologist	*"Different tastes provide different emotions"*	
Prisoneer	*"I only have access to oranges"*	

Author: Vincent Pouget ies Short Course: Laser Testing for Single-Event Effects: Basics and Use Cases 25



J. R. Schwank et al., "Estimation of Heavy-Ion LET Thresholds in Advanced SOI IC Technologies From Two-Photon Absorption Laser Measurements," IEEE TNS, vol. 57, no. 4, pp. 1827-1834, Aug. 2010

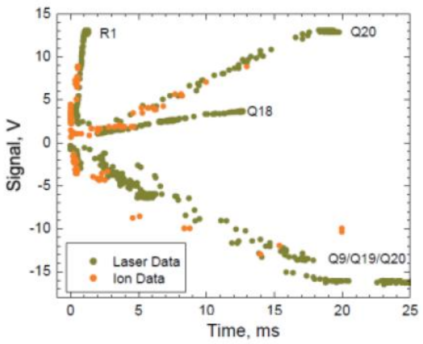


J. M. Hales et al., "Experimental Validation of an Equivalent LET Approach for Correlating Heavy-Ion and Laser-Induced Charge Deposition," in IEEE TNS, vol. 65, no. 8, pp. 1724-1733, Aug. 2018

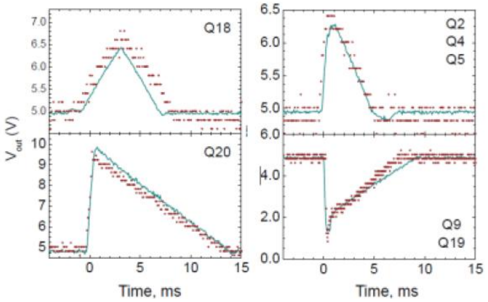
<u>In summary:</u>

- Two different interaction mechanism
- They both generate charges
- Laser do not ionize

Difference Heavy Ion / Laser for SEE testing

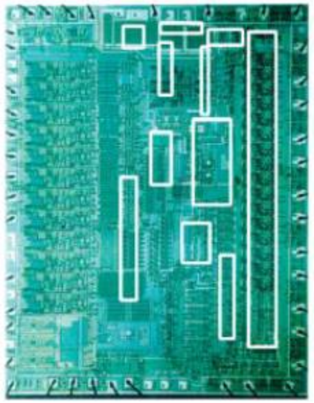


Distribution of amplitudes and widths of SETs generated in the LM124 with heavy ions and with pulsed laser light



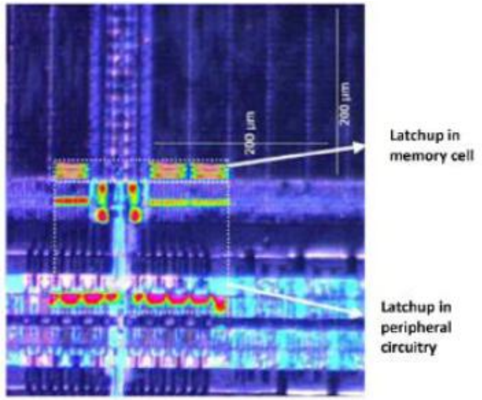
Comparison of SET generated by Xe ions (dotted lines) and 590nm optical pulses (solid lines)

S. Buchner *et al*, "Comparison of Single-Event Transients Induced in an Operational Amplifier (LM124) by Pulsed Laser Light and a Broad Beam of Heavy Ions,", Oct. 2004.



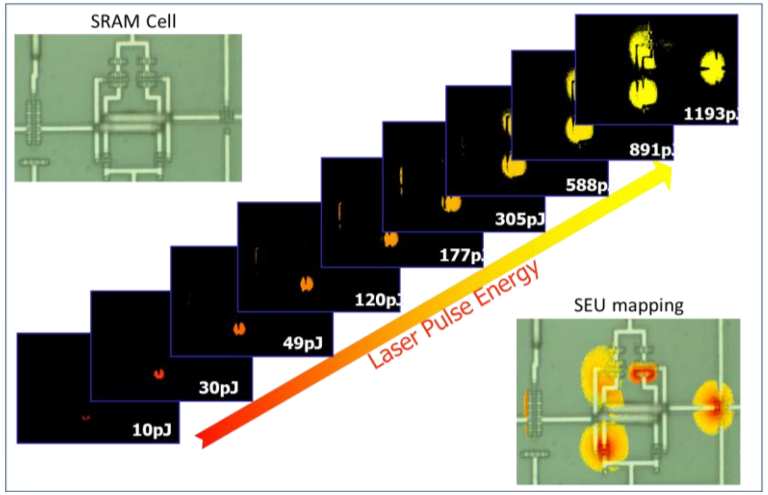
SEL sensitive areas indicated by white rectangles on the 3µm bulk CMOS DDC RDC19220

S. Buchner, L. Tran, J. Mann, T. Turflinger, D. McMorrow, A. Campbell, and C. Dozier, "Single-Event Effects in Resolver-to-Digital Converters," IEEE TNS, vol. 46, no. 6, pp. 1445-1452, Dec, 1999.

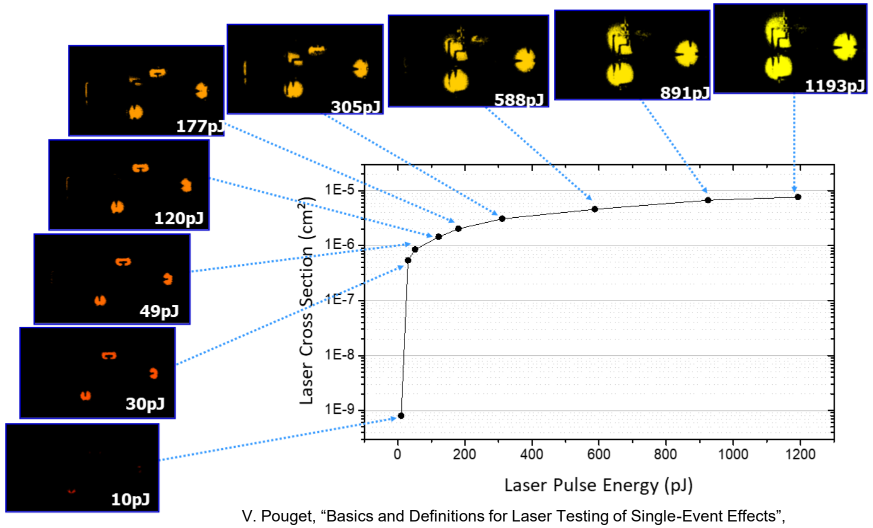


Laser threshold mapping of SEL in the HM628512B SRAM

S. Buchner, F. Miller, V. Pouget, and D. McMorrow, "Pulsed laser testing for Single Event Effect investigations", IEEE TNS 2013, vol. 60, no. 3.



Laser Cross section of an SRAM cell from mapping

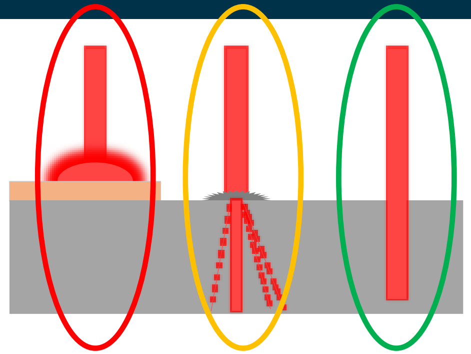


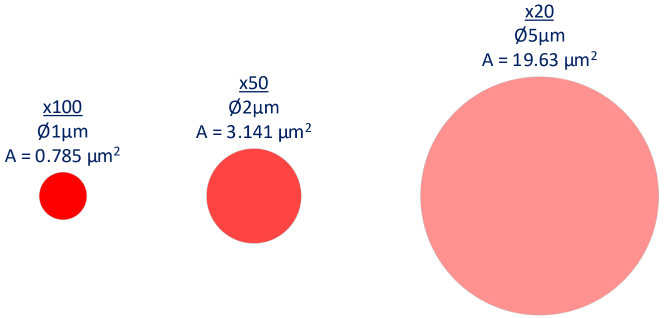
V. Pouget, "Basics and Definitions for Laser Testing of Single-Event Effects", RADLAS 2024

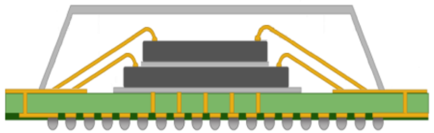
Limitations

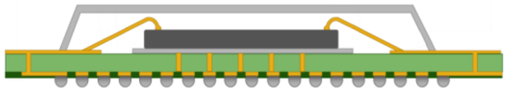
Limitation with SEE laser testing

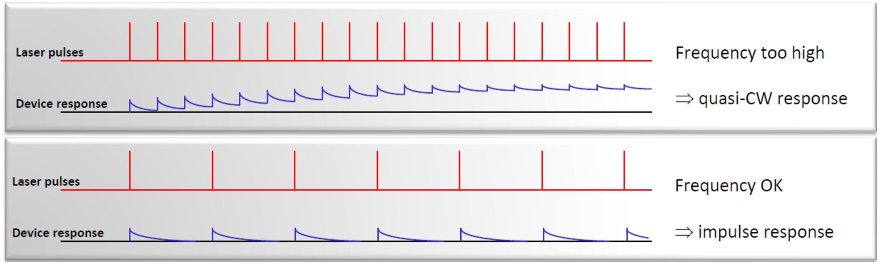
- Optical access
  - Metallisation blocks light
  - DUT preparation can have big impact
- Component construction
  - Highly integrated Devices
  - Some “Standard” package
- Spot Size
- Pulse frequency limited to 1KHz
  - Timing constraints
- Ion Laser correlation
- Lack of randomness
  - When using grid pattern
  - Time and space corelation






Stacked dies


Non-Flipped chip BGA

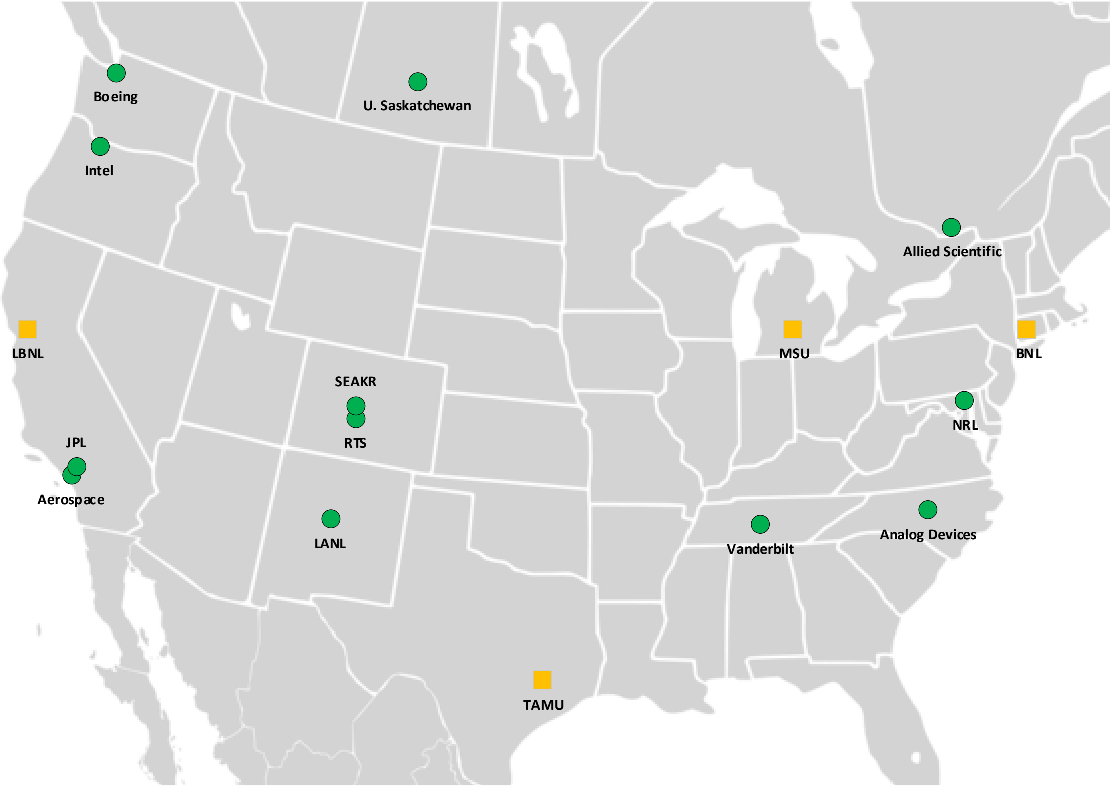


Facilities in US and EU

esa

Heavy Ion Facilities

Laser Facilities



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Single Event Effect Testing with Laser

Practical approach

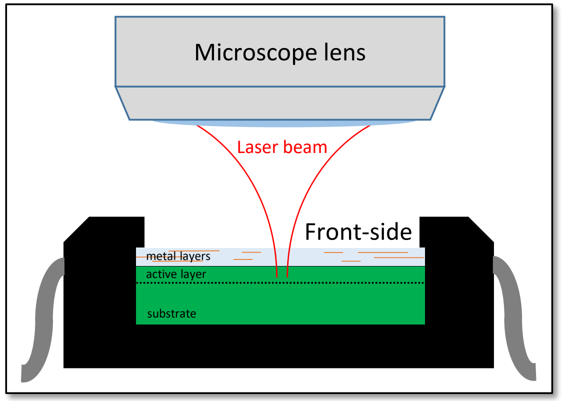
Practical approaches

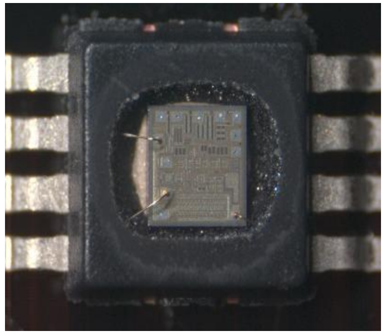
Front Side

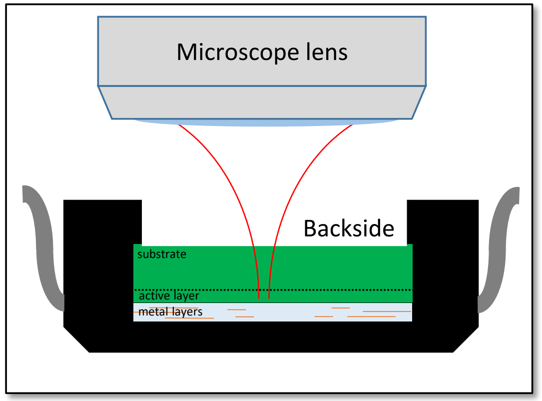
- Pro
  - Easy preparation
  - No change in board design vs HI
- Cons
  - Metallisation layer(s) block laser light
  - Simple structures only
- Useful for
  - Linear Techno

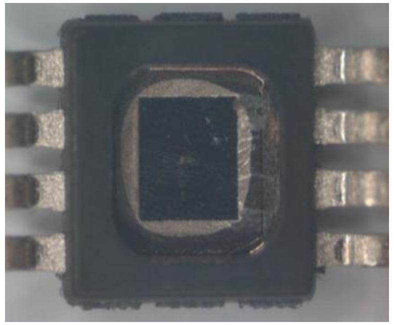
Back Side

- Pro
  - No metallisation
  - Access of the full chip
  - Estimation of a LET equivalent
- Cons
  - Adapted design
  - Die preparation more complex (milling + thinning (opt.) + polishing)
- Light through the Si bulk
  - PCB preparation (mirroring pinout or hole in the PCB)









Timeline

Timeline with SEE Laser testing:

Plastic removal:
&/or laser
&/or chemical etching
&/or plasma
+ (if backside)

Lead frame removal:
milling machine

Die preparation:
bulk preparation
& polishing

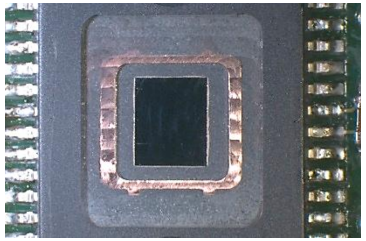
Mechanical installation:
preparation of holder
and board
focusing
planarity alignment

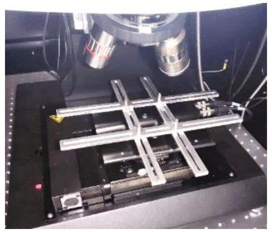
Electrical connections:
DUT -> Supply
DUT -> Instruments
DUT -> System SW

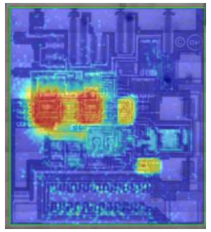
Select test type:
or Events screening
or Events counting
or Events mapping

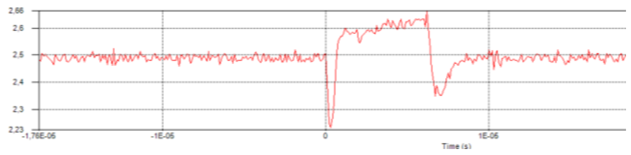
Select test parameters:
& Area
& Grid Size
& Energies
& Energy

Facility booking (Days or weeks) → Sample preparation (Several hours to 1 day) → Installation (1 - 2 h) → Testing: 1 - 3 days (automatic mapping would usually take several hours per energy)









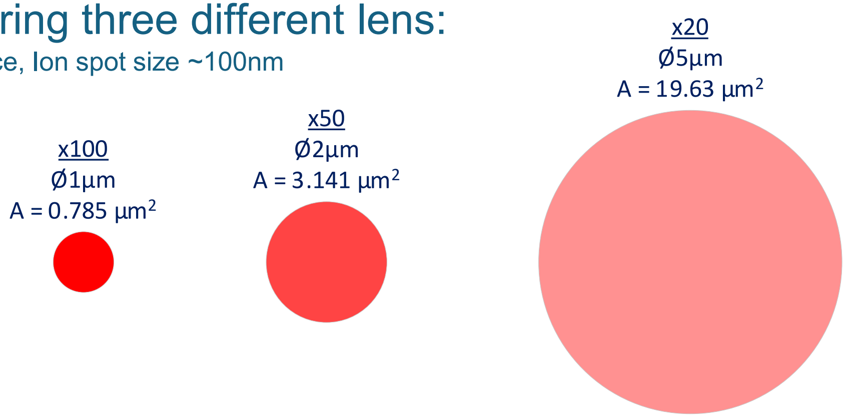
Comparison with Heavy Ion:

Facility booking (Several months) → Sample preparation (Several h) → Installation (30 min -1 h) → Testing: 8 - 10 hours (test could take about 2 **hours** per LET)

Spot Size vs Techno dependency

Spot Size:

- considering three different lens:
  For reference, Ion spot size ~100nm



Risks with wider spot size:

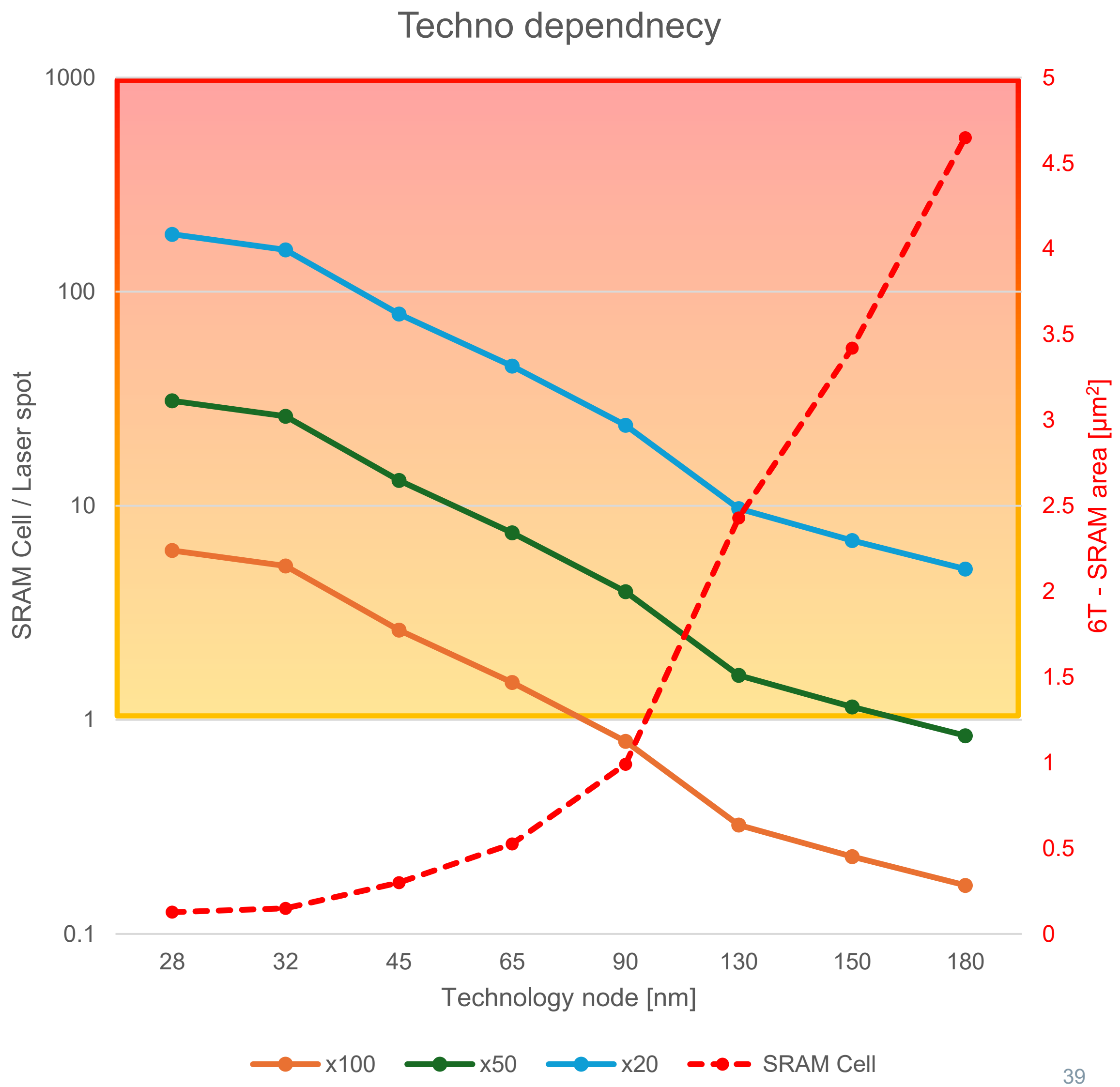
- Overestimation of cross section
- Test artefact
- Non-linearity

Observation:

- The lower the techno, the more transistor can be affected

&

- The lower the objective, the more transistor can be affected



Cross section equivalence

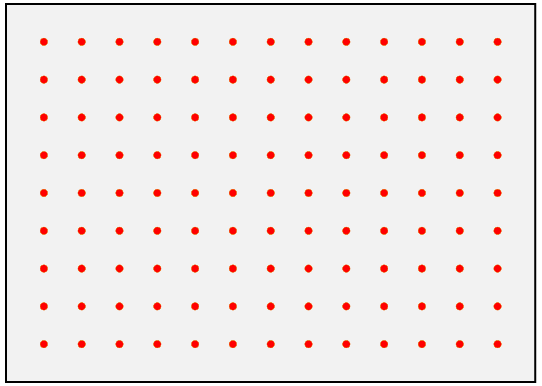
What is the cross section used for ?

- Translate the probability of interaction of a particle with a sensitive area

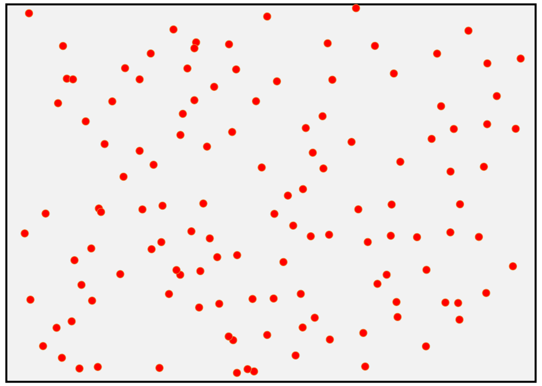
➔ Used to estimate a rate of event for a mission

Depending on the objective:

- For screening, cross section not really needed
- For counting, $\sigma_L = N/\Phi$ with Φ as effective laser pulse fluence
- For mapping, $\sigma_L = N\ s$ with s=dx.dy (grid size)



Grid Pattern



Random Pattern

Most of the applications uses grid patten

Random pattern more complex to implement

Statistically

- For 1x10^6 /cm^2 => corresponds to a grid size of 10µm x 10µm
- For 1x10^7 /cm^2 => corresponds to a grid size of 3.2µm x 3.2µm

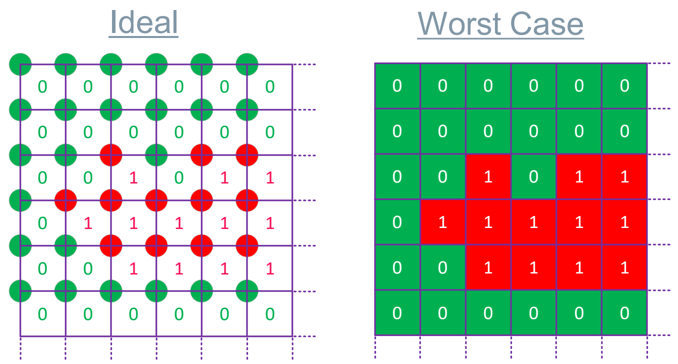
Uncertainty in physical cross section estimation

Important parameters:

- Spot size, grid size, test time

$$\text{Ideal Xsect} = N_{ERR} \times Spot\ area$$

$$\text{WC Xsect} = N_{ERR} \times Grid\ Cell\ area$$



<u>Ideally:</u> Scan the entire area ➔ Grid size = spot size (no overlap) ➔ ↑ Test Time

<u>In reality:</u> To reduce test time ➔ Increase grid size

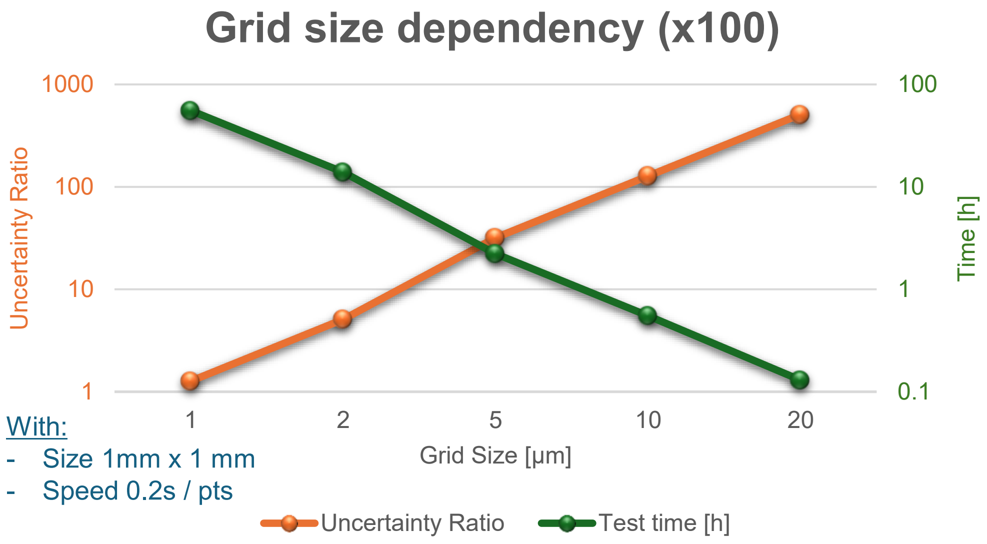
<u>Problem:</u> Scanning not random ➔ Some areas may be systematically missed

➔ underestimation of cross section

<u>Impact:</u> ↑ grid size ➔ ↑ uncertainty

$$\text{Uncertainty Ratio} = \frac{\text{Grid Cell Area}}{\text{Spot Area}}$$

<u>Trade-off:</u> *Test time* vs *Uncertainty* in cross section estimation

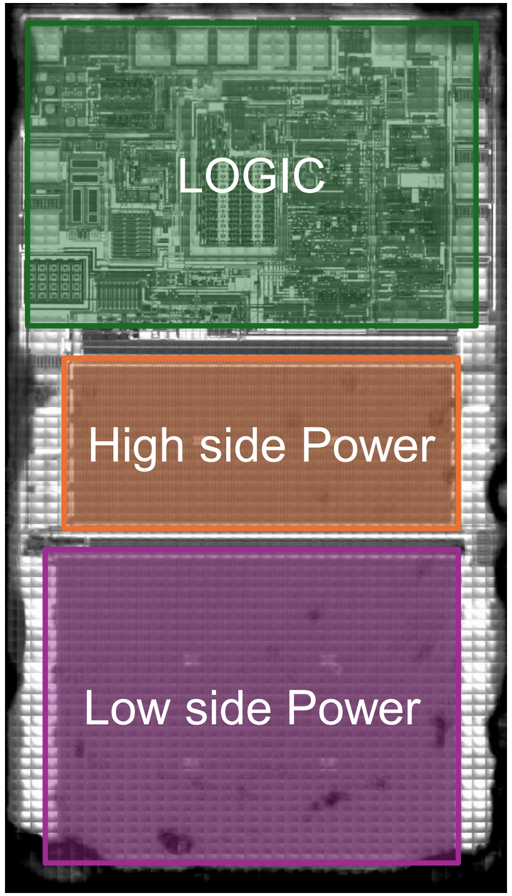


<u>What we want:</u> Highest Resolution in Lowest time

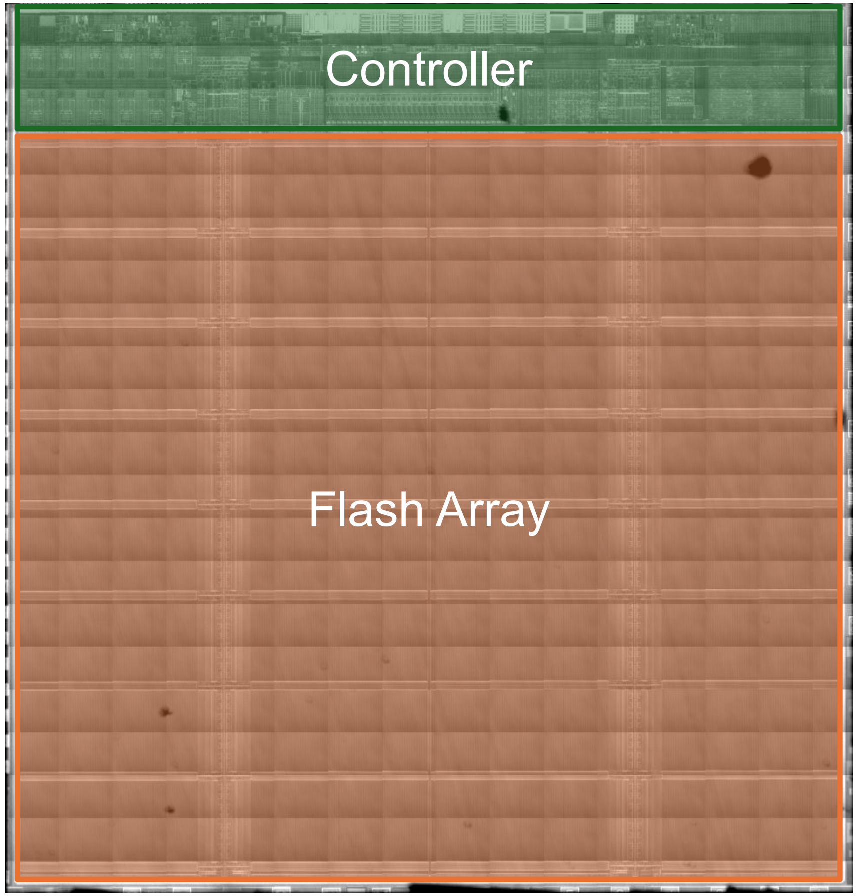
<u>Solution:</u> Reducing test area (When possible)

Definition of the Region of Interest

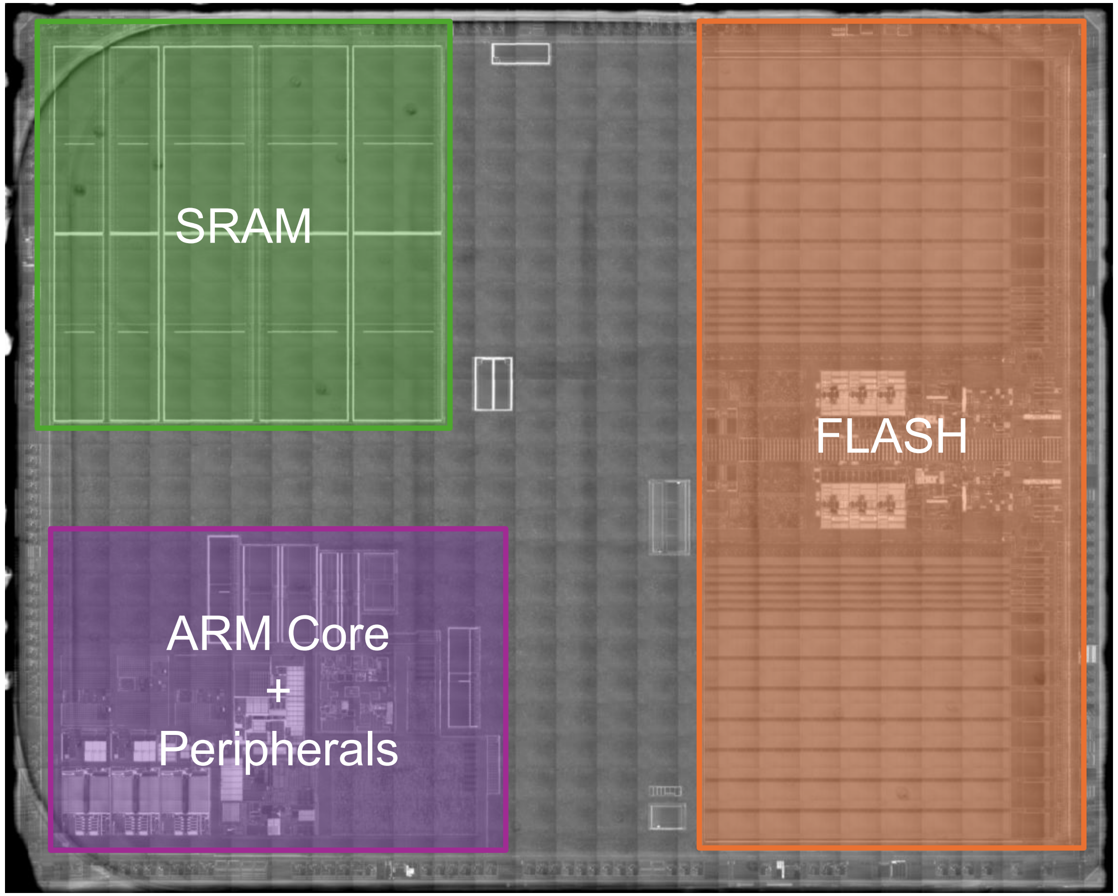
1 - Identification of structure of interest



Step Down Regulator
LT8610



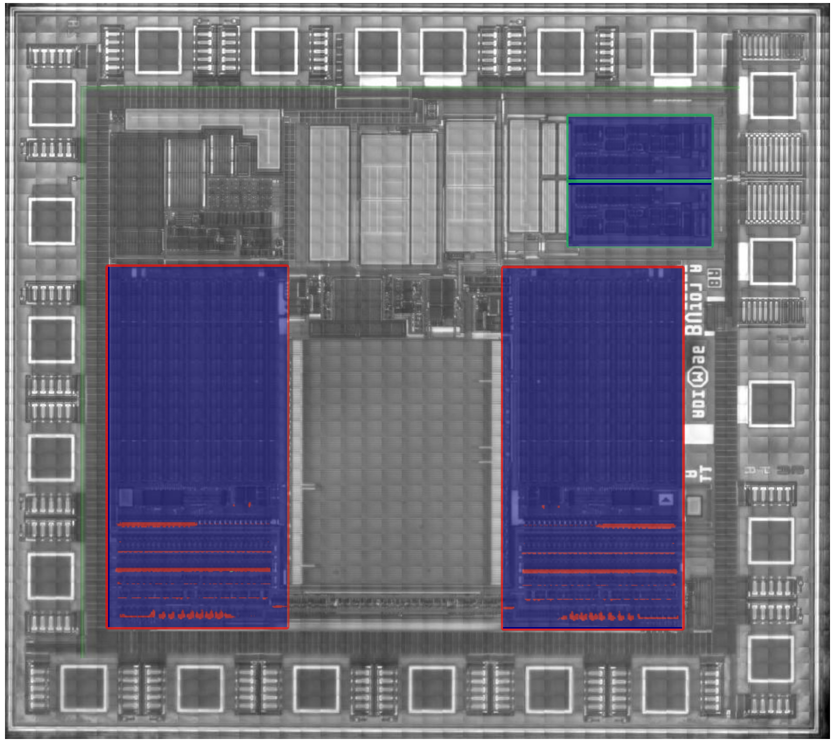
Flash Memory
IS25LP032



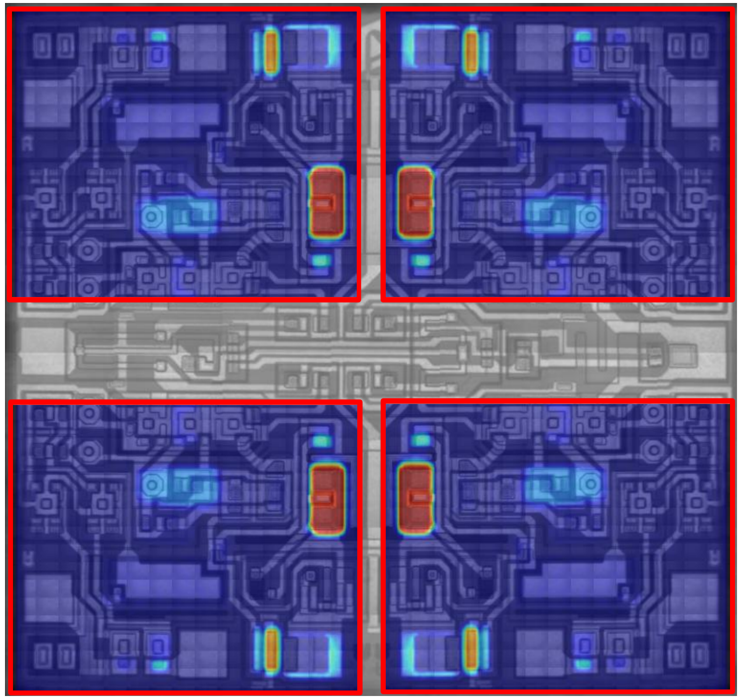
Microcontroller
STM32F407

Definition of the Region of Interest

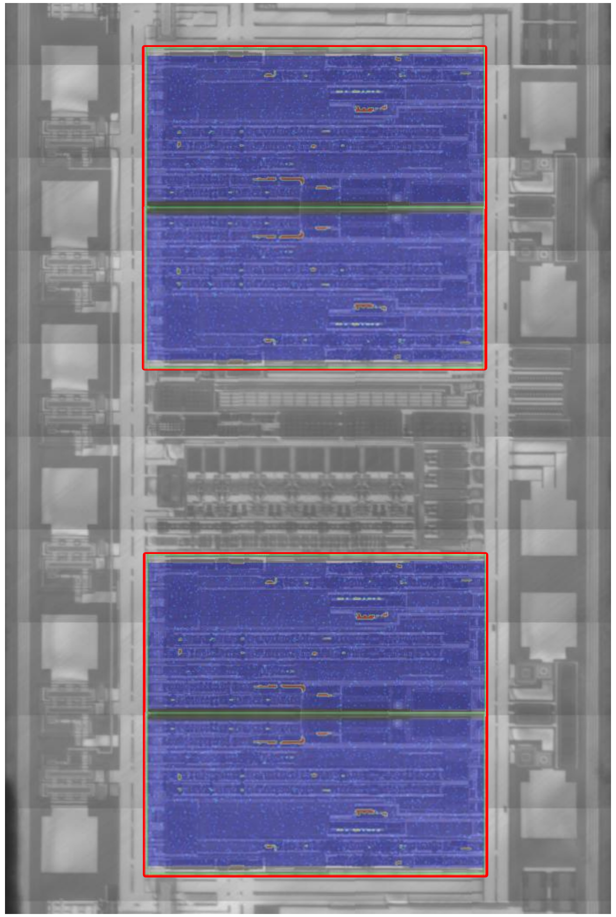
2 - Some devices have replicated structures



Digital-to-Analog converter
AD7801
2 Quadrant



Operational Amplifier
LM124
4 quadrant

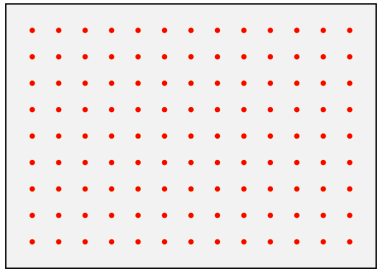


Digital Isolator
ADuM1301
4 channel

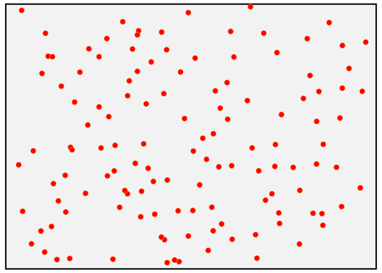
Scanning method

3 – Definition of the test objectives

- Screening:
    - Efficient for destructive event (SEL)
    - Go/NoGo test
    - No mapping, no Statistics ➔ Time efficient
    - Recommend pattern: Grid pattern
- Counting:
    - Error location not known
    - Knowledge of laser fluence and error count
    - Cross section assessment
    - Recommend pattern: Grid pattern or Random pattern
- Mapping:
    - Least time efficient
    - Error location known
    - Useful for SEU/SET analysis
    - Recommend pattern: Grid pattern



Grid Pattern



Random Pattern

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Conclusion

Conclusion

- Radiation is a domain of product assurance necessary to design on a satellite
    - Test data is needed in order to assess sensitivity

- Standard test methods exist, and it work ! But a lot of challenges are at play:
    - New Space increase
    - Usage of COTS component add an uncertainty
    - Component constructions are becoming more complex
    - Some testing are challenging

- Alternatives test methods exists, but it do not always work !
    - Alternatives tests methods (e.g. laser) are not (yet) used to assess sensitivity
    - Can be used for screening parts, test setup verification, fault injection, …
    - In test, optimisation of the *Time vs Uncertainty* trade-off is needed

What is important it to very well understand the component being tested AND the facility used

Produced by

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Thanks to:

- V. Gupta
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TWINRELECT
TWINNING FOR EXCELLENCE IN RELIABLE ELECTRONICS

Thank you !

Any questions ?