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Radiation Testing of Several COTS Parts to be Used as Protection Devices

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Presented by S. Dubos

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Outline

- Introduction and study objectives
- Presentation of the pre-selected devices
- Qualification sequence and test results
- Rate prediction with OMERE
- Conclusion

Introduction and study objectives

- COTS are pre-dominant in New Space equipment' Bill Of Materials
  - In TRAD BOM analyses: from less than 10% of COTS in 2014 to more than 50% in 2024
- Time and budget constraints = those COTS can't be all qualified to radiation
- In a « better-than-nothing » approach, protection devices integrated on the boards should at least be immune to destructive SEEs
- Objectives of the study:
  - Select several Overcurrent protection, Overvoltage protection and Watchdog devices
  - Evaluate their susceptibility to SEEs under heavy ions
  - Identify SEL/DSEE immune devices

Presentation of the pre-selected devices

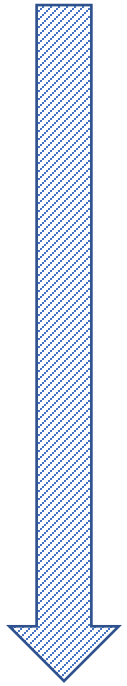
- 12 devices selected with ESA to undergo radiation testing:
  - ➢Several Overvoltage (OV)/Overcurrent (OC)/Watchdog protection devices:

MPN	Mfr.	Function	Process
MAX890LESA+	Analog Devices	OC	PMOS
MAX4840AEXT+	Analog Devices	OV	BiCMOS
LTC4361CTS8	Analog Devices	OV/OC	CMOS
TPS25940ARVCR	Texas Instruments	OV/OC	BiCMOS
LTC4222CG	Analog Devices	OV/OC	BiCMOS
INA226AIDGSR	Texas Instruments	Current/power monitor	CMOS

MPN	Mfr.	Function	Process
MAX823TEUK+	Analog Devices	Watchdog	BiCMOS
ADM1270ARQZ	Analog Devices	OV/OC	DMOS
MAX17523ATE+	Analog Devices	OV/OC	BiCMOS
LT6108IMS8	Analog Devices	OV	Bipolar
TPS3820-33DBVR	Texas Instruments	Watchdog	BiCMOS
MAX14572	Analog Devices	OV/OC	BiCMOS

Qualification sequence and test results

- Qualification sequence:



- Procurement of the samples (with as much traceability information as possible)
- X-ray screening (for delidding strategy)
- Development of test setups and test boards
- Redaction of Irradiation Test Plan, validated with ESA
- Delidding and functional tests, with biasing conditions defined with ESA
- Parts are ready for the qualification

Qualification sequence and test results

- SEE test sequence:

➢ First assessment with Cf-252:

- ➢ Ion with LET~43 MeV.cm²/mg (& short range)
- ➢ Ideal to reject the most sensitive parts

VASCO facility at TRAD

Qualification sequence and test results

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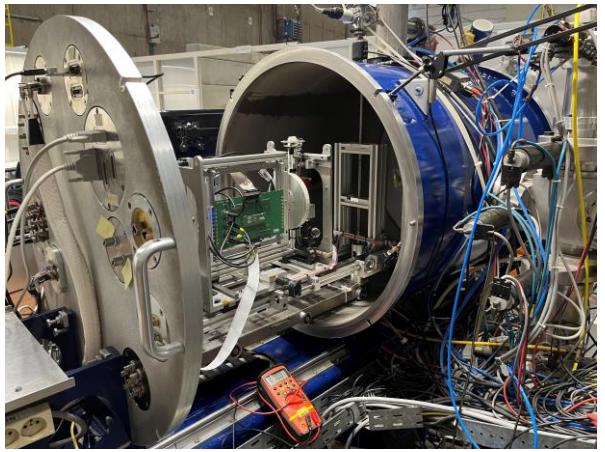
VASCO facility at TRAD

➢ <u>Qualification with Heavy-ions:</u>
  - ➢ Tests according to ESCC 25100
  - ➢ 2 campaigns at UCL & RADEF



UCL Heavy ion facility

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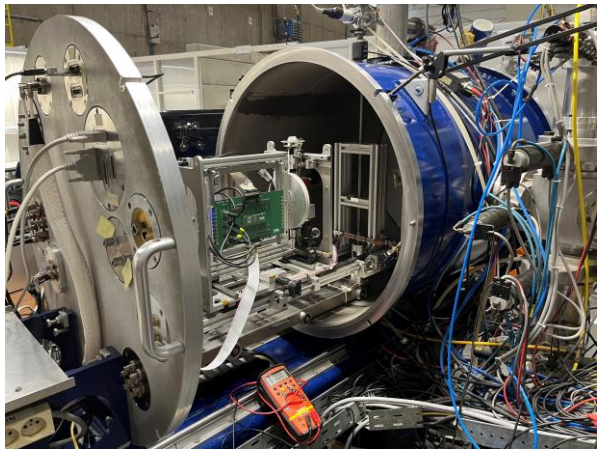
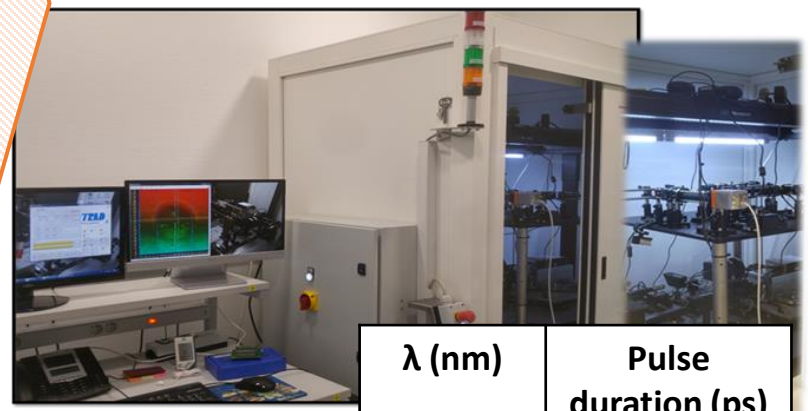


UCL Heavy ion facility

➢ Final assessment with Laser:
  - ➢ Only on SEL immune part
  - ➢ Objective: Have a reference point for future lots



λ (nm)	Pulse duration (ps)
1064	400

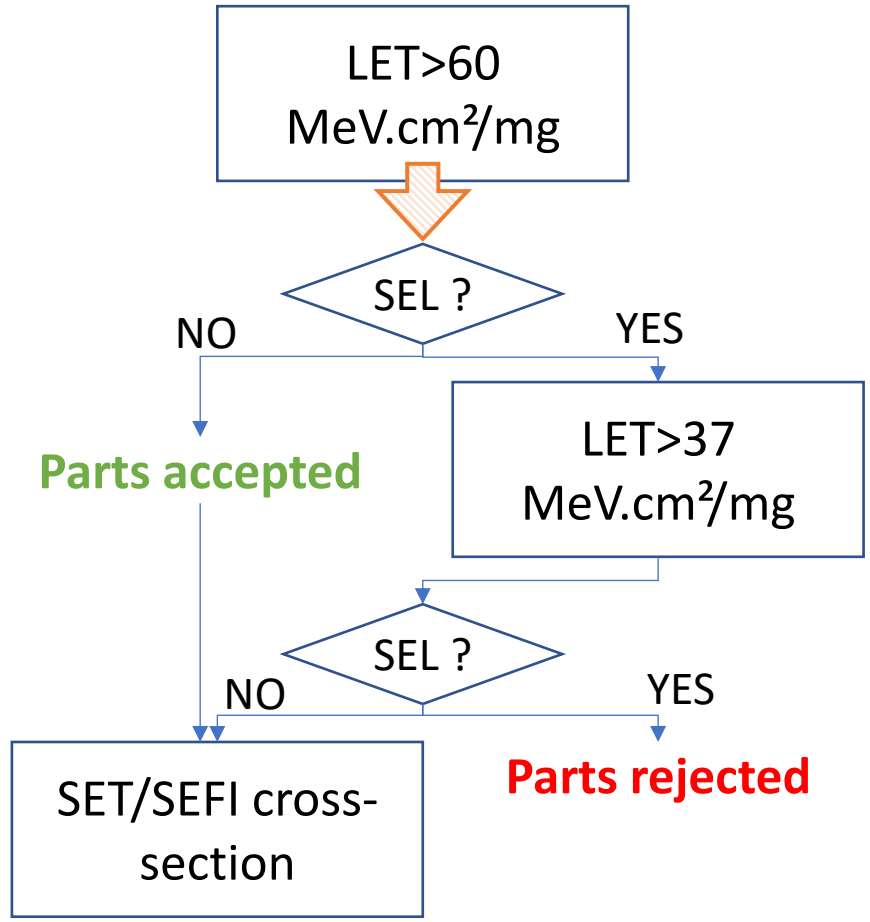
LISA facility at TRAD

Qualification sequence and test results

- Strategy for biasing/testing conditions:
  - ➢ Biasing:
    - ○ Max. rating

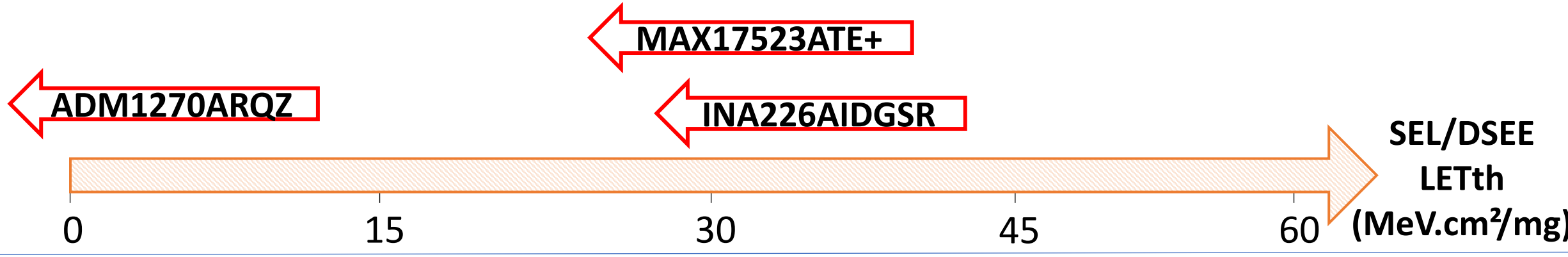
      Or
    - ○ Tailored rating
  - ➢ Every part at high temperature
  - ➢ Under heavy ions:
    - ○ Mainly focused on SEL/Destructive SEEs
    - ○ One or two outputs per references monitored for SET acquisitions and SEFI

Heavy-ion sequence



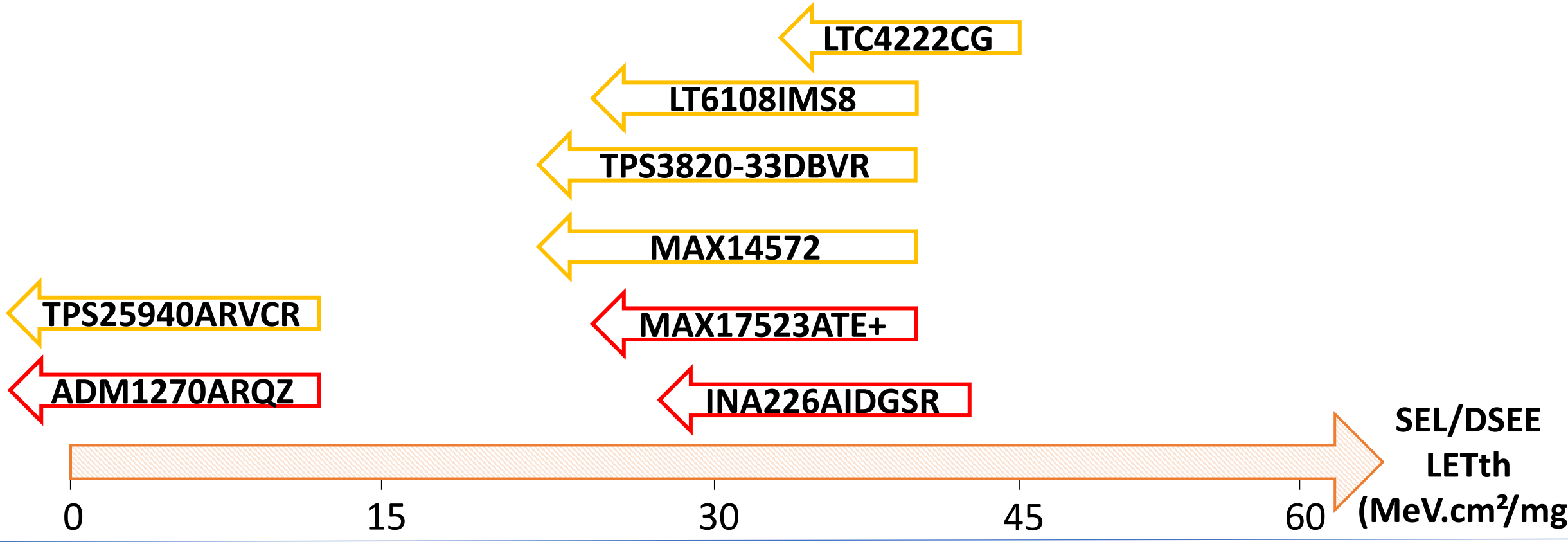
Qualification sequence and test results

- Overview of tests results:
  - ➢Some destructive SEE (DSEE) already observed under Cf-252
  - ➢¼ of devices fail with the Cf-252: two were still tested at RADEF and results are consistent, as they fail at low LET values



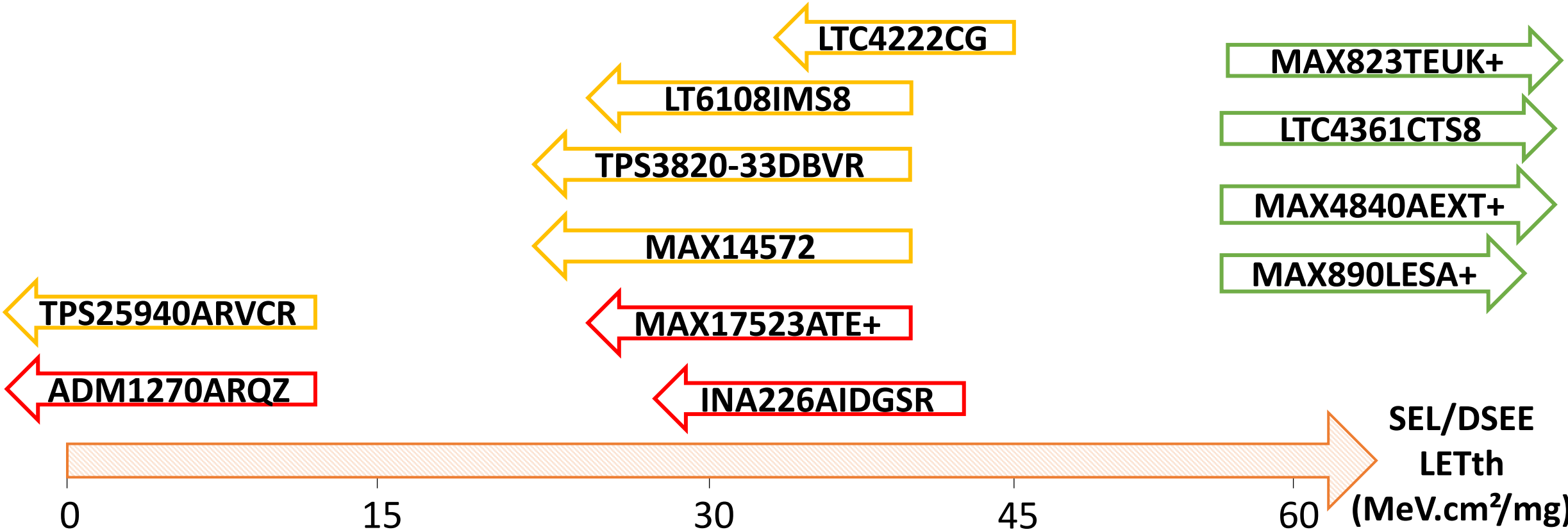
Qualification sequence and test results

- Overview of tests results:
  - ➢Some failures only observed at UCL or RADEF:



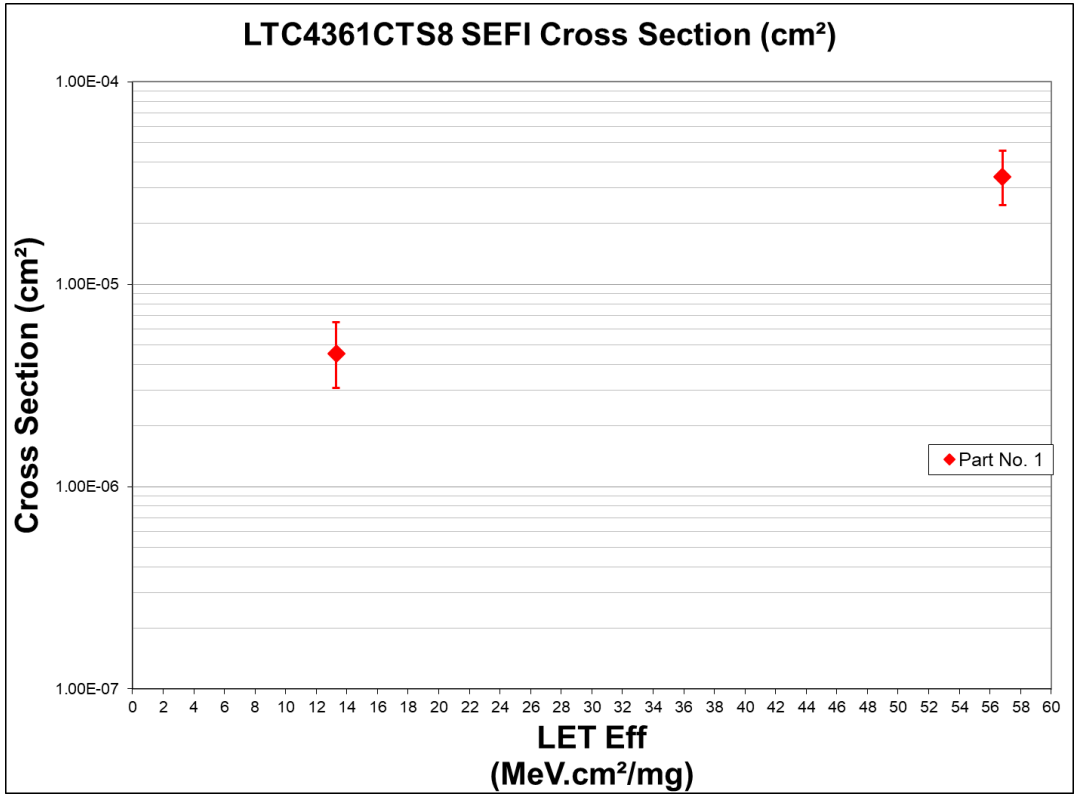
Qualification sequence and test results

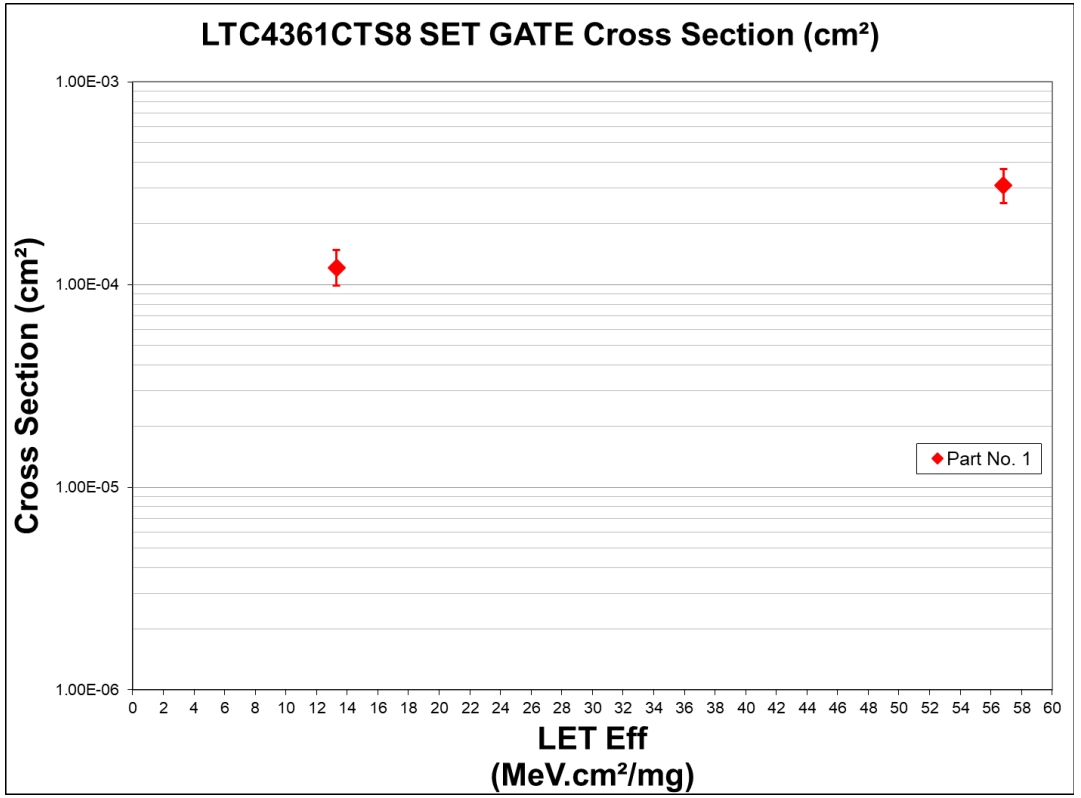
- Overview of tests results:
  - ➢Four devices do not exhibit SEL/DSEE: 3 OV/OC & 1 watchdog



Qualification sequence and test results

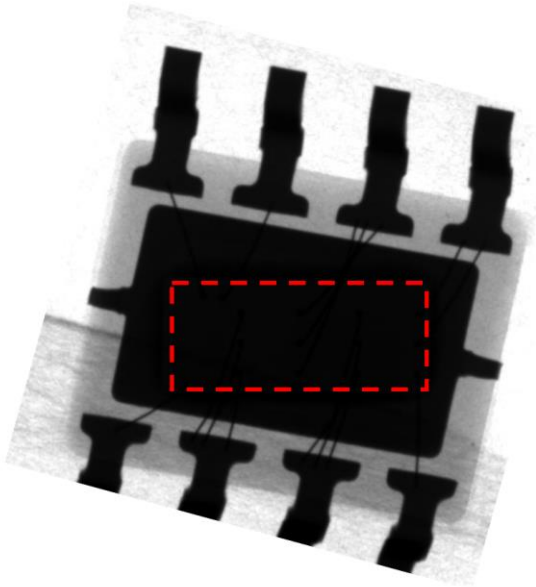
- The robust parts were tested for SET/SEFIs:
  - ➢ Example with the LTC4361:
    - ○ Cross-sections available for both SEFI & SET (Gate output)



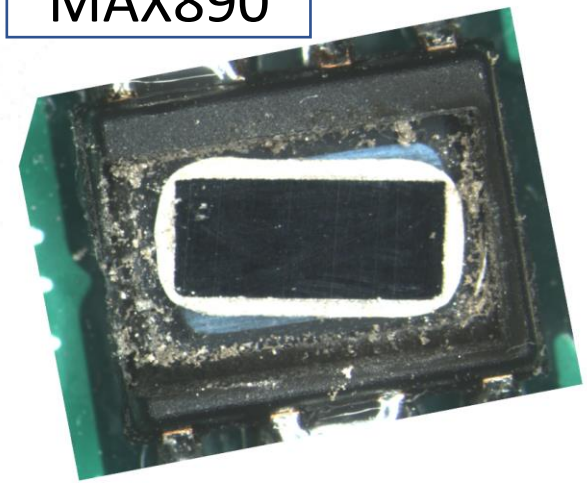


Qualification sequence and test results

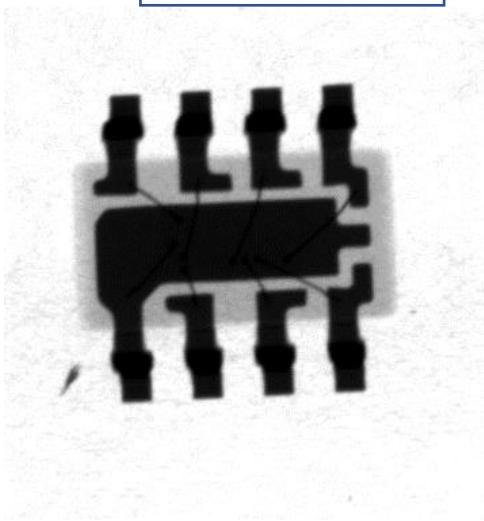
- Laser testing performed on the robust parts to have a reference point for future procurement
  - ➢ Backside preparation for Single Photon Absorption (SPA)
    - Ex. with the MAX890 and with the LTC4361

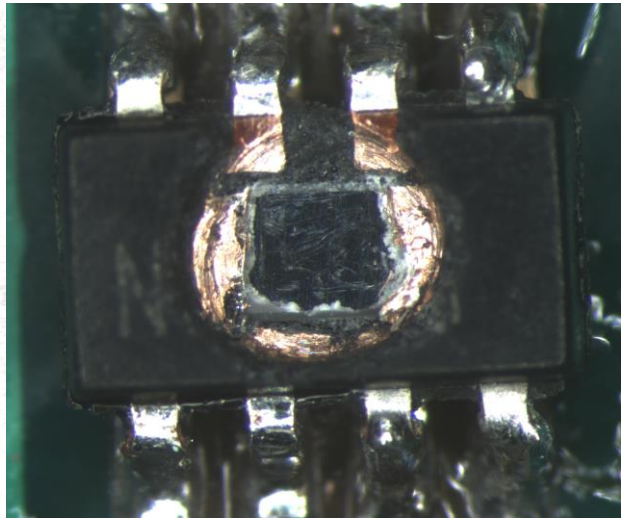


MAX890



LTC4361

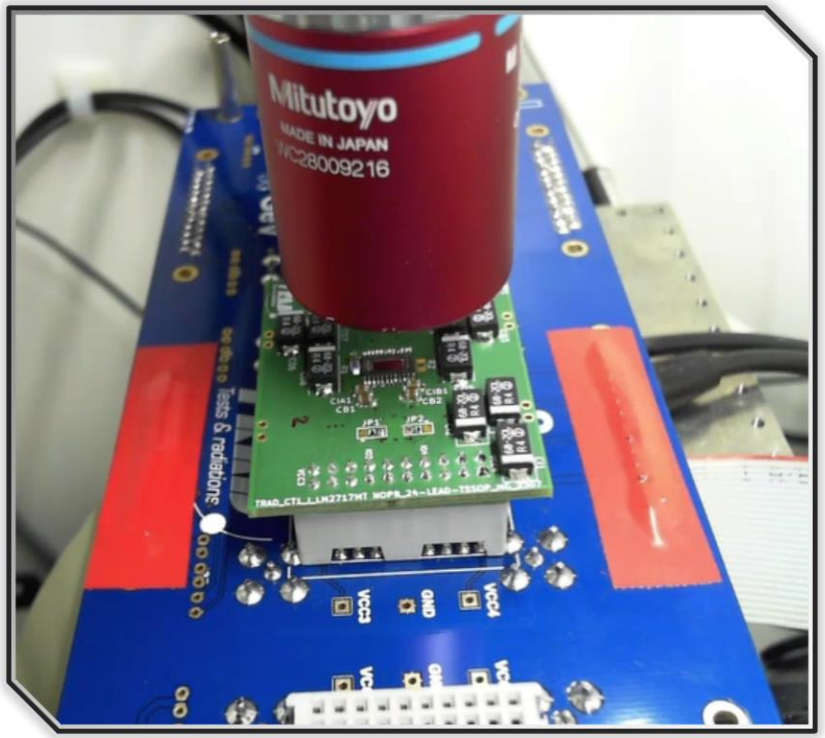




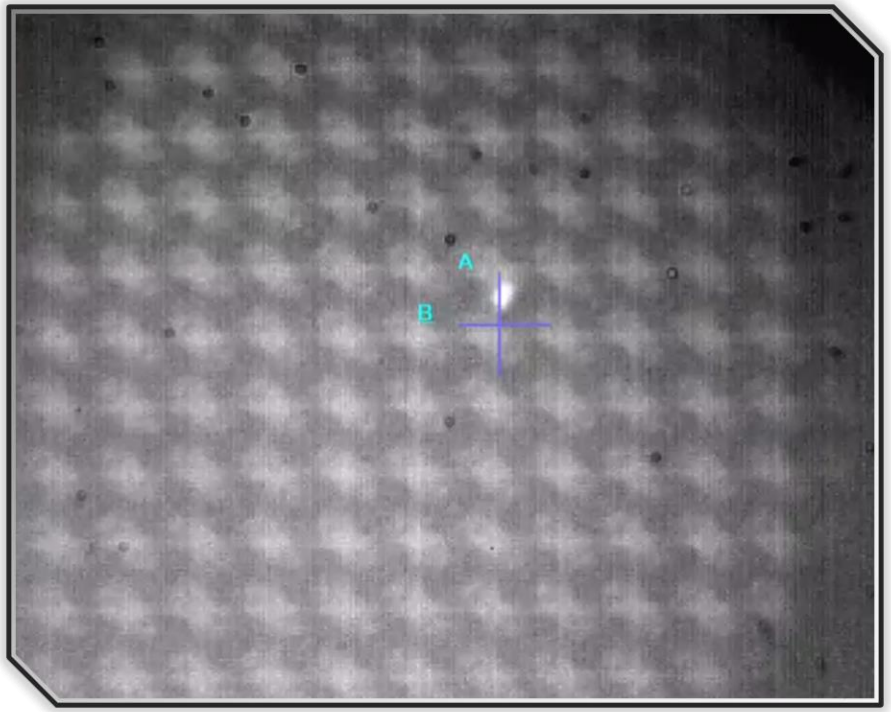
Qualification sequence and test results

- Testing approach with Laser:
  - ➢ Backside screening of the die:

Inside the laser cabin:

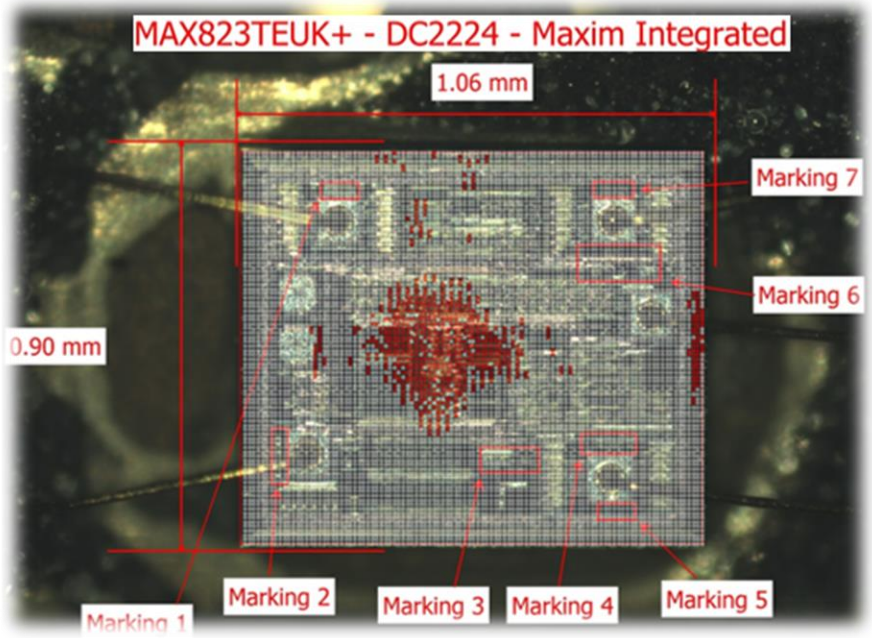


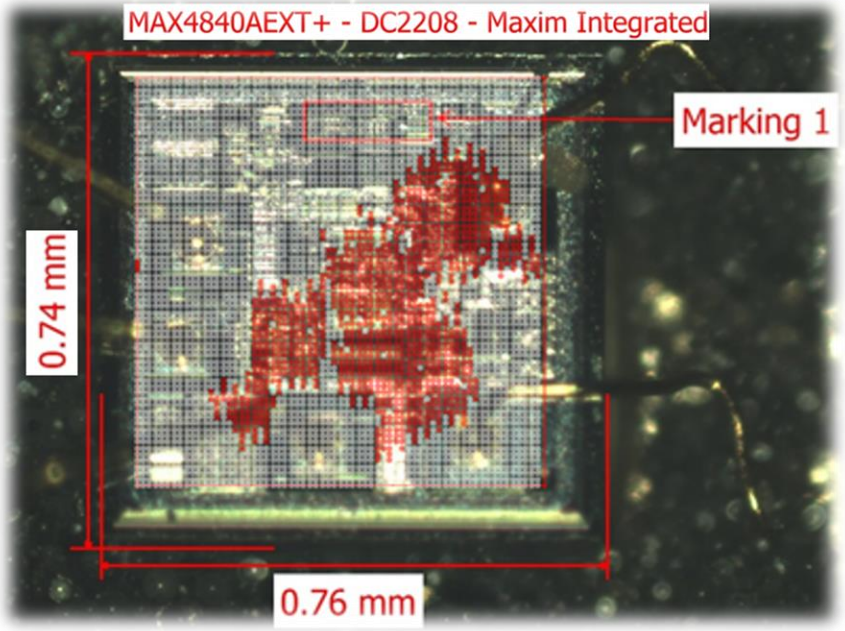
On the IR camera:



Qualification sequence and test results

- Results are consistent with Heavy-ion:
  - ➢No SEL/DSEE at high Laser pulse energy (~3 nJ/pulse in the active region)
- Mapping of sensitive areas can be performed:
  - ➢Red dots indicate SET sensitive areas





Rate prediction with OMERE

- Rate performed on the four robust devices, for SET/SEFI:
  - ➢For a steady LEO (600km, i=98°) and GEO environment

Device	SEE type	LEO steady (/device/day)	GEO steady (/device/day)
MAX890LESA+	SET OUT	8.6E-5	4.1E-5
	SET FAULT	4E-6	1.4E-5
MAX4840AEXT+	SET GATE	1.3E-3	6.6E-4
	SET FLAG	3.1E-5	2.7E-5
LTC4361CTS8	SET GATE	2.9E-3	1.5E-3
	SEFI	8.5E-5	5E-5
MAX823TEUK+	SET RESET	3.1E-3	2E-3

Conclusion

- Among 12 devices, only 4 were identified as immune to SEL/DSEE:
  - ➢Future testing could be considered, by exploring different biasing conditions (& temperature)
  - ➢TID testing could be considered also on robust devices

- SEE qualification remains a hard constraint for identifying robust COTS parts

- Results presented in details in 2024 RADECS paper (to be published)

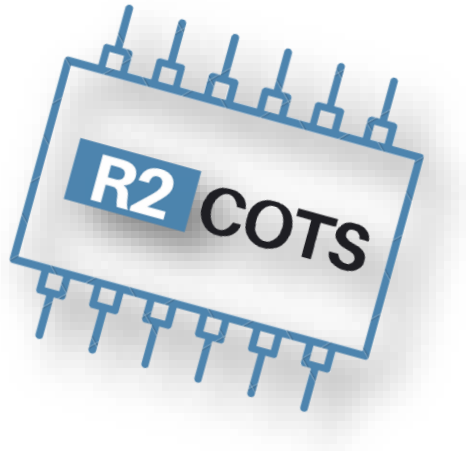
Conclusion

- The complete test reports for these 4 references are available at:

https://esarad.esa.int/

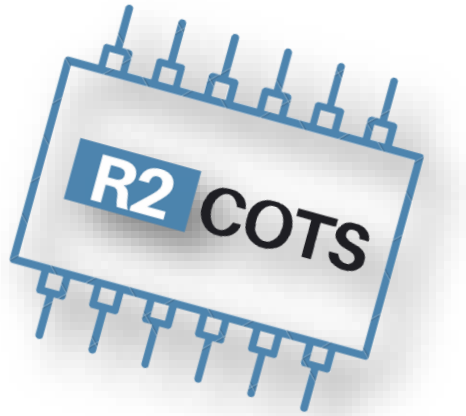
Conclusion

- And for more qualified COTS devices:
  - ➢ R2COTS service from TRAD (Radiation & Reliability on Commercial-Off-The-Shelf): www.R2COTS.com
  - ➢ Class 3+ Space Ready COTS:
    - ○ Qualification on lots for TID
    - ○ Immune to DSEE/SEL through heavy ion testing
    - ○ Light screening for Non AEC Q or EP product
  - ➢ COTS with full traceability reported in JD (die revision, mask set, wafer fab, diffusion lot, assembly lot, screening, radiation data …)



Conclusion

- And for more qualified COTS devices:
  - An active catalogue of more than **100 COTS** devices, from BJT to ADC/DAC, memories, POL etc.
  - A quick availability
  - An ongoing CNES/TRAD study started in 2025 to expand this catalogue with more than **50 devices** per year (with the plan to have **500-800 ref.** in the future)



Thank you for your attention

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