# Aurelia Microelettronica S.p.A.

## <u>*LEGNARO 2005*</u>

## 'CAN BUS PHYSICAL LAYER RAD TEST'

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# PROJECT HISTORY

- This design arises from the need to provide space community with a CAN 2.0B protocol with embedded micro-processor and a CAN physical layer up to 1Mbit/s, since space community is adopting CAN communication systems for spaceaircraft and satellite applications.

- CAN ISO 11898 standard, that takes in Bosch 2.0 protocol, has a large use in automotive environment, and it is integrated in many commercial technologies, but no rad hard devices are available on the market

# TECHNOLOGY CHOICE

- ISO11898 imposes high voltage technology has to be used for CAN Transceiver implementation.

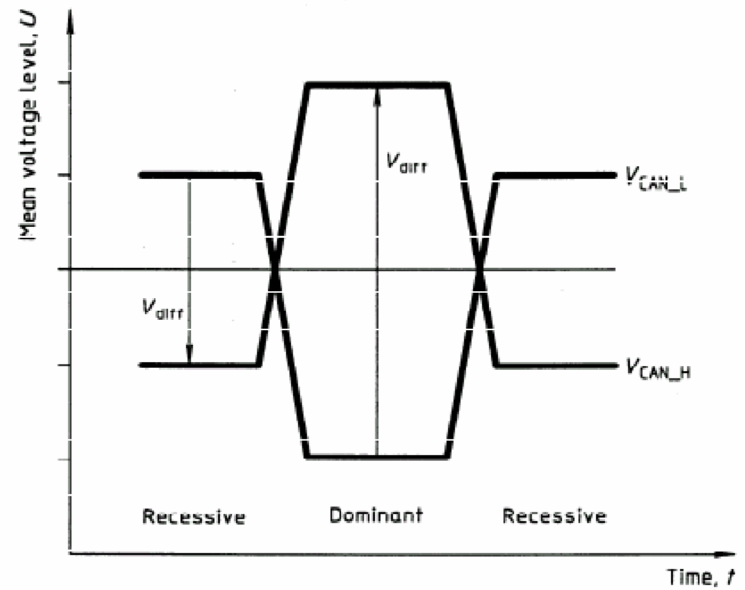
  Since no rad hard high voltage technology is available in Europe at low costs, AMS CXZ 0.8um high voltage technology has been selected: product has been rad hardened by design, and rad test has been performed after silicon out to characterize the transceiver behaviour in a radiation environment.

  Selected technology has been tested in a rad-hard environment to verify Single Event Effects performances
- Starting points for the design are:
  - Philips TJA1050 high speed and PCA82C250 transceiver datasheet
  - ISO 11898 CAN Standard

# ISO11898 Standard Main Requirements on CAN Physical Layer

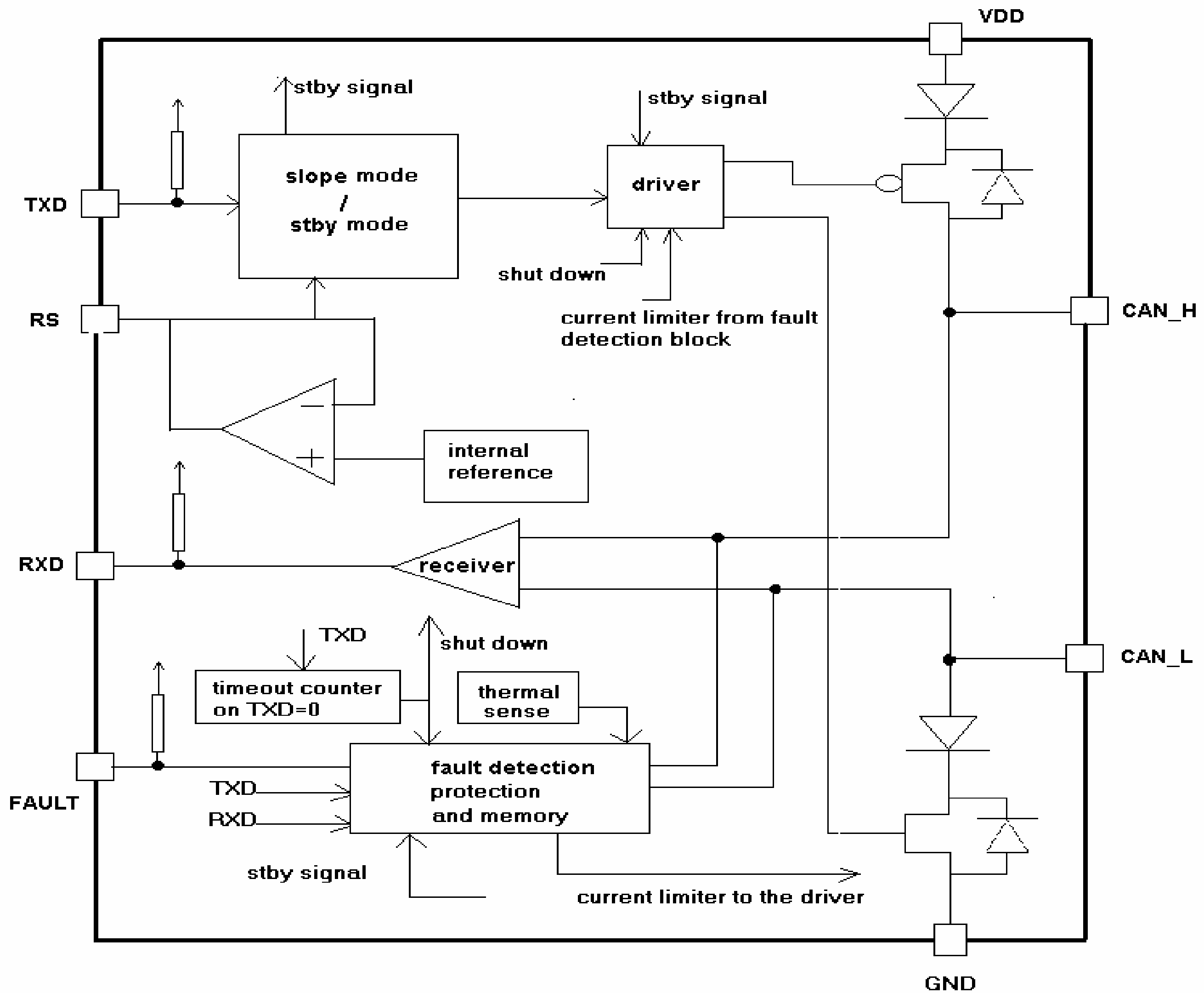
## Physical layer goals:

- To provide a differential representation of a logical bit on two bus wires according to a logic input pin TX , for EMI safe operation
- To assure transmission speed up to 1Mbps in the high speed version
- To provide common mode immunity in reception mode
- To measure the differential representation (recessive ? dominant ?)
- And return its logic value on a dedicated logic output pin RX
- To provide fault protection circuitry and diagnostics on the bus wires

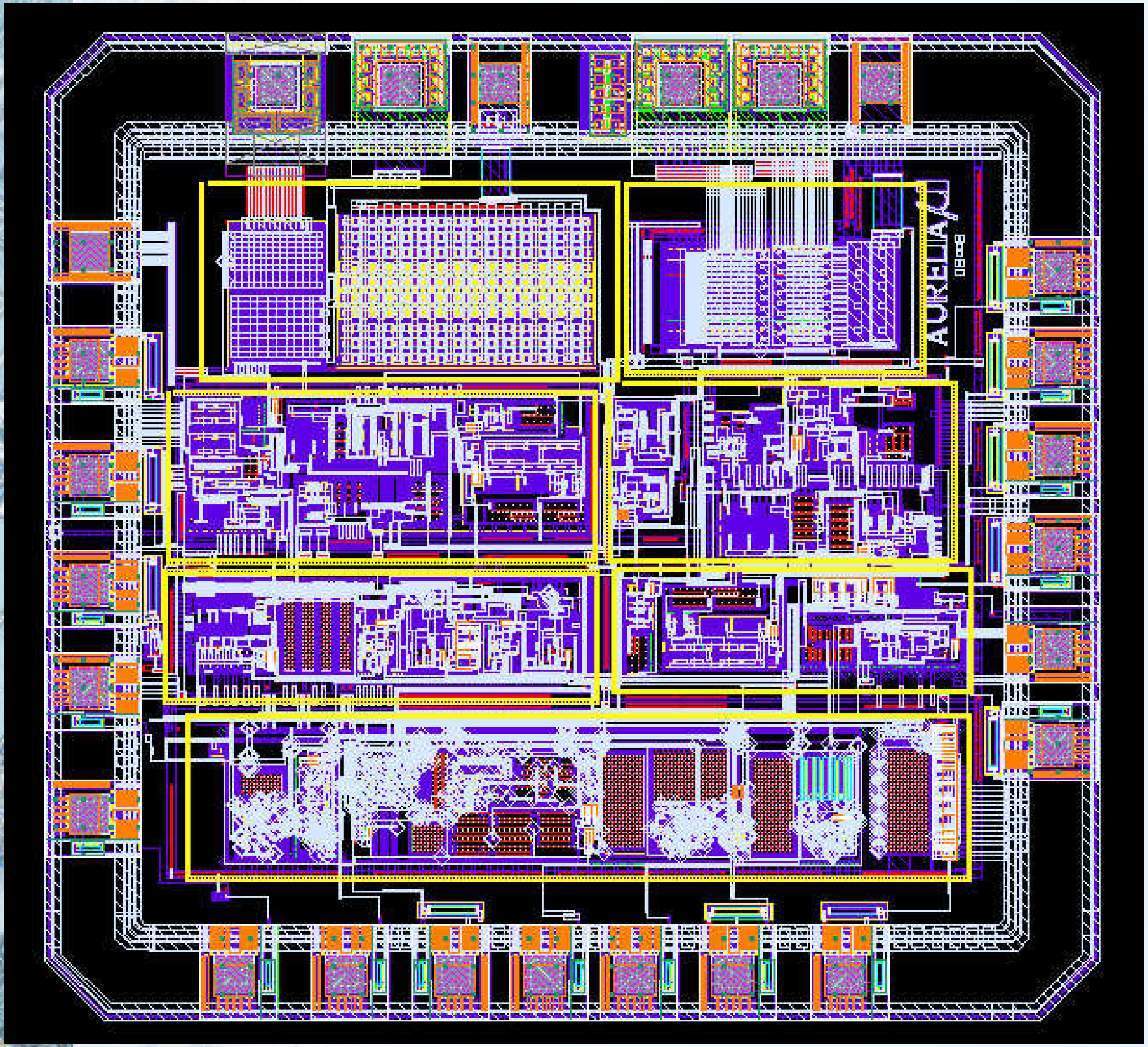


Physical bit representation

# CAN Transceiver Block Diagram



# Layout Photo




**Die Size:**

**2.5 X 2.4 mm2**

Technology:

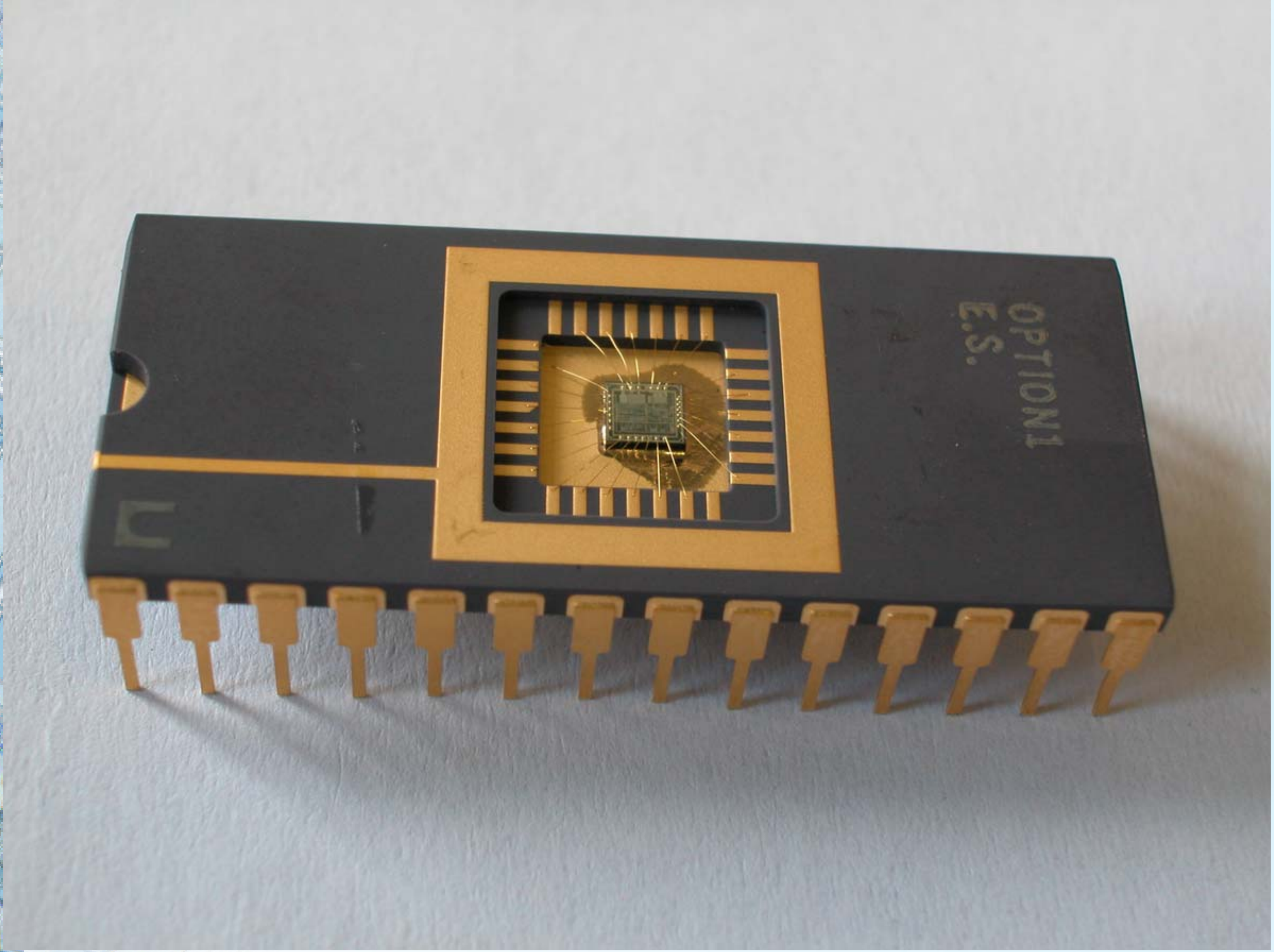
0.8um CXZ AMS

Number of masks: 17

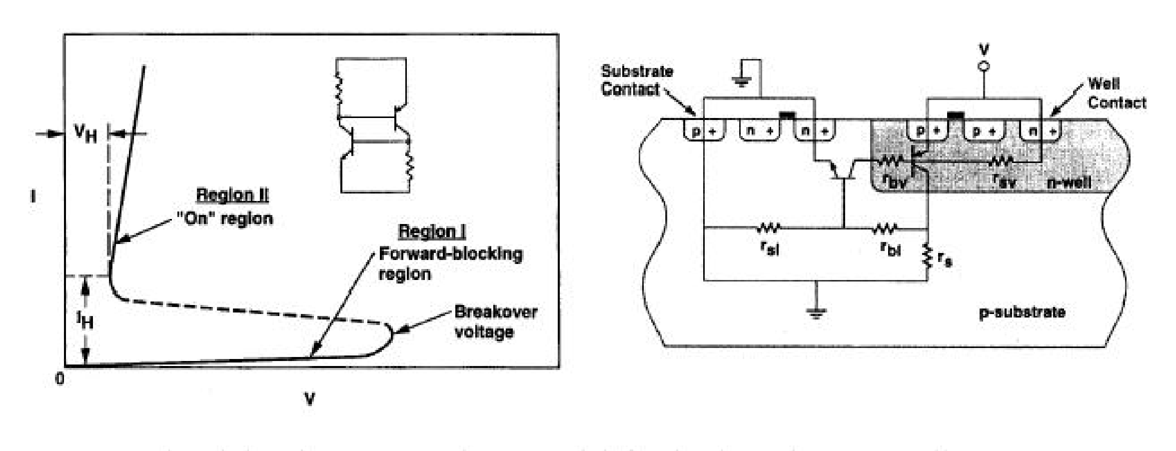
Assembled in ceramic DIL28,
but SO8 compatible

Only 8 pins have to be bonded, all the others are for test purposes only

# Chip Photo



# Layout main concerns:
# SEL and TID tolerance

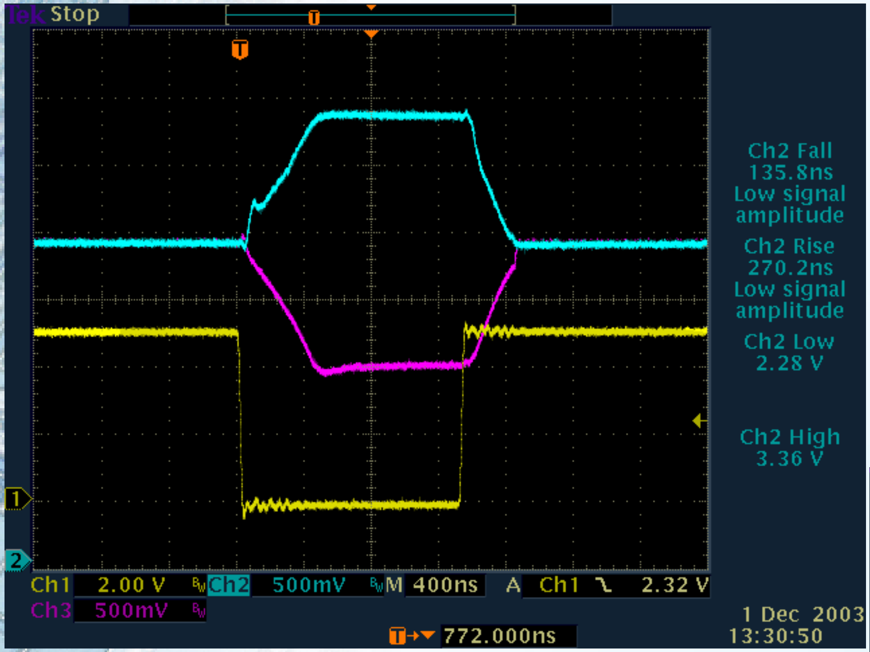



**Heavy SEL concern because of:**

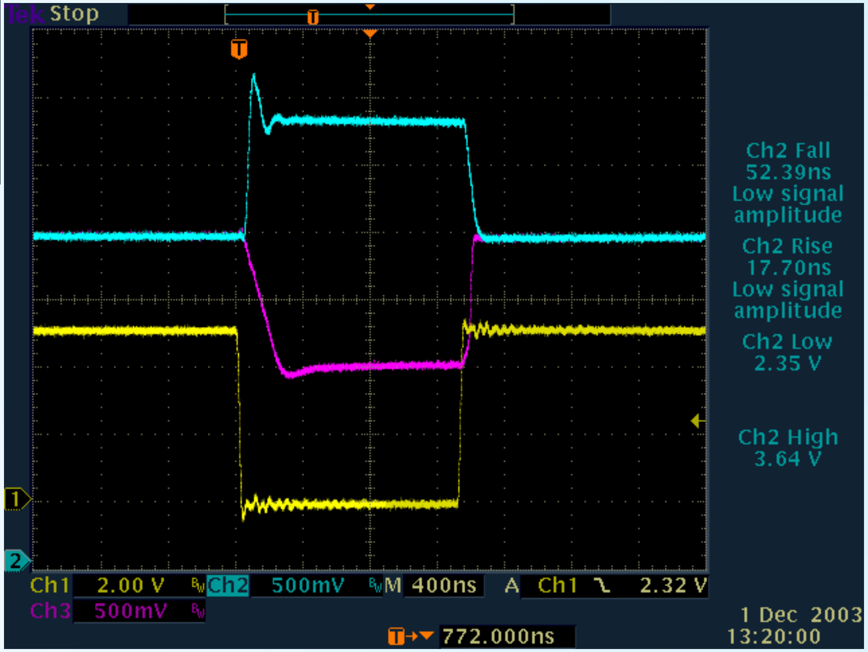
- **the HV process => high sub resistance (20 Ω ∗cm)**
- **Underground and overbattery specifications, that require direct polarization for HV n well cathodes**

**TID should heavily effect on static parameters, because of the relatively large tox (17nm)**

# Waveforms (2/3)




**Slew rate control mode**




**Uncontrolled mode, maximum speed**

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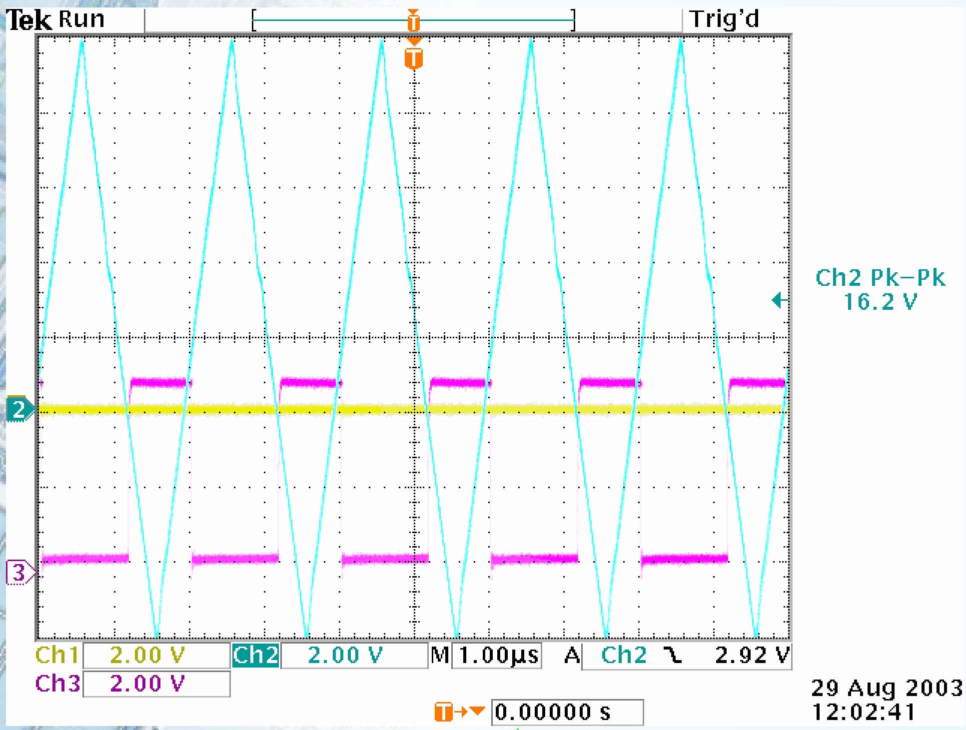
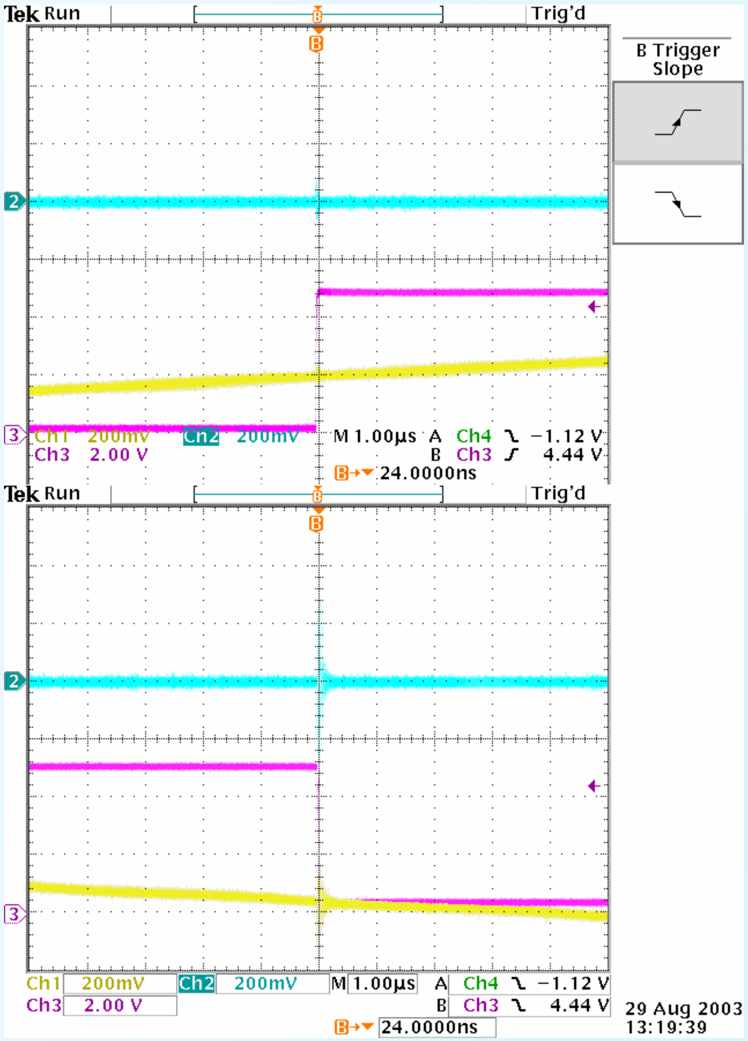
# Waveforms (3/3)

C.A.E.N. CAEN Group

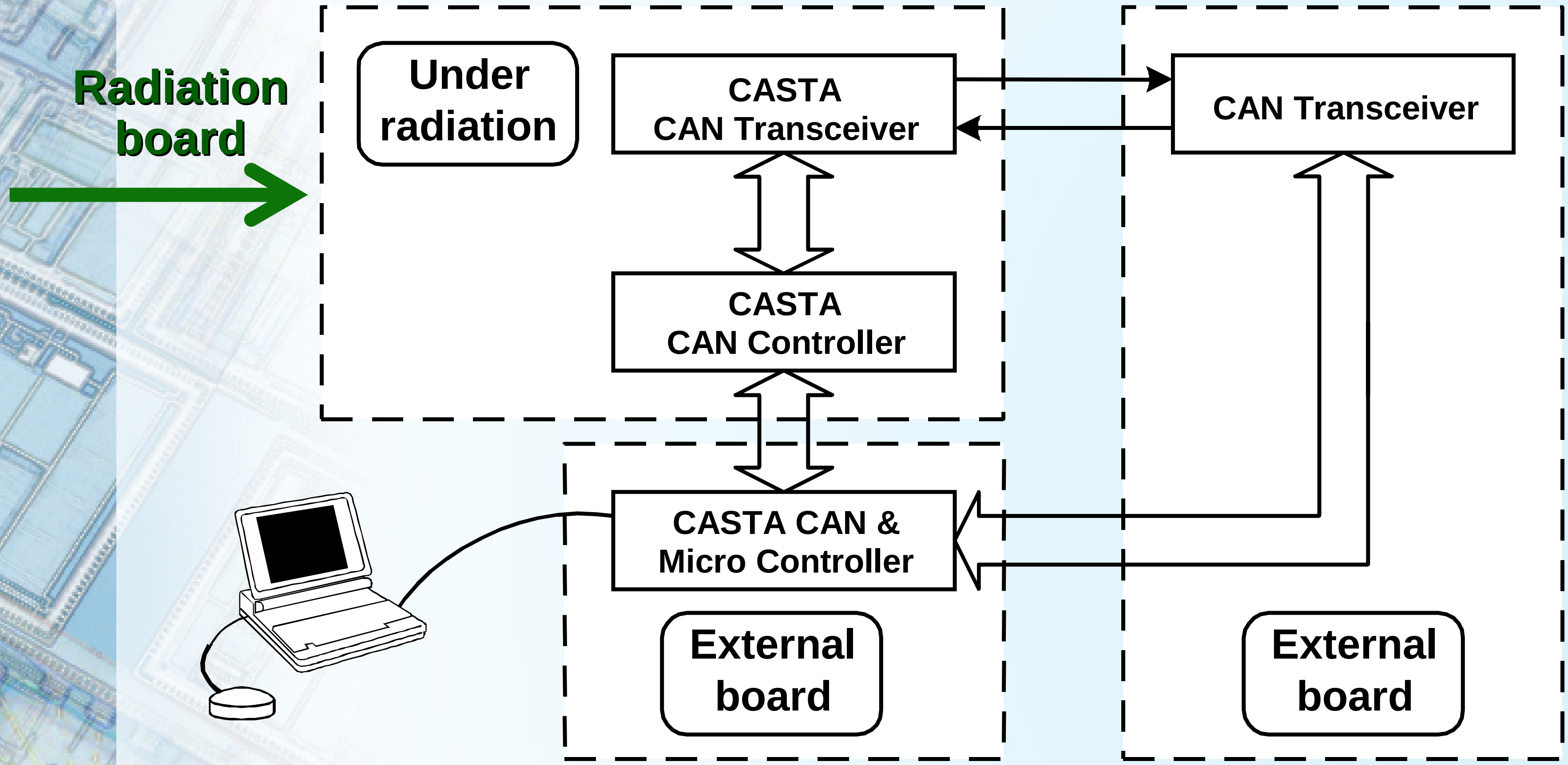


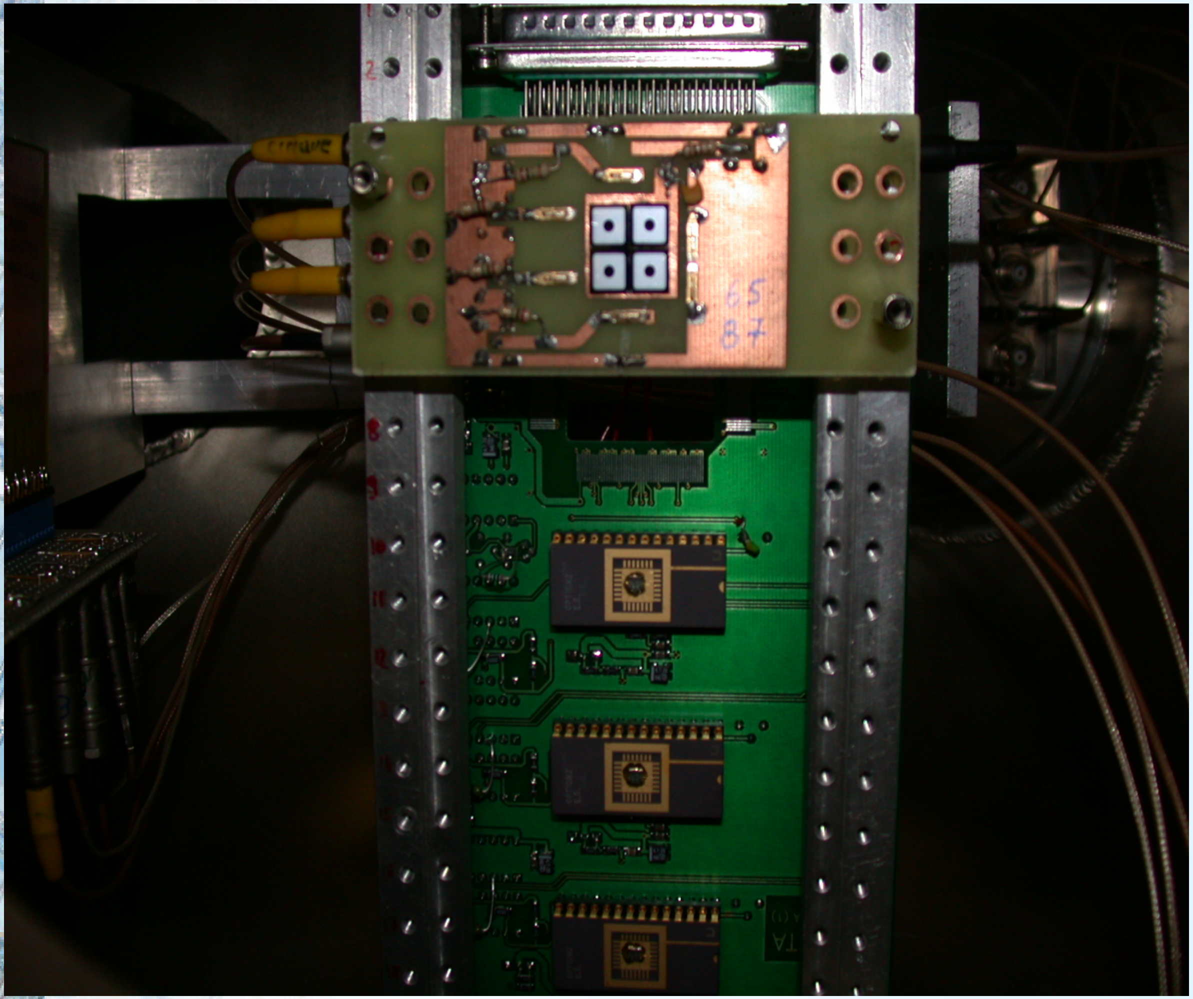

***Receiver common mode immunity test***

***Receiver thresholds test D/R and R/D***

# Irradiation Test Set Up



# Test setup session: mobile diodes on place holder are used for beam monitoring

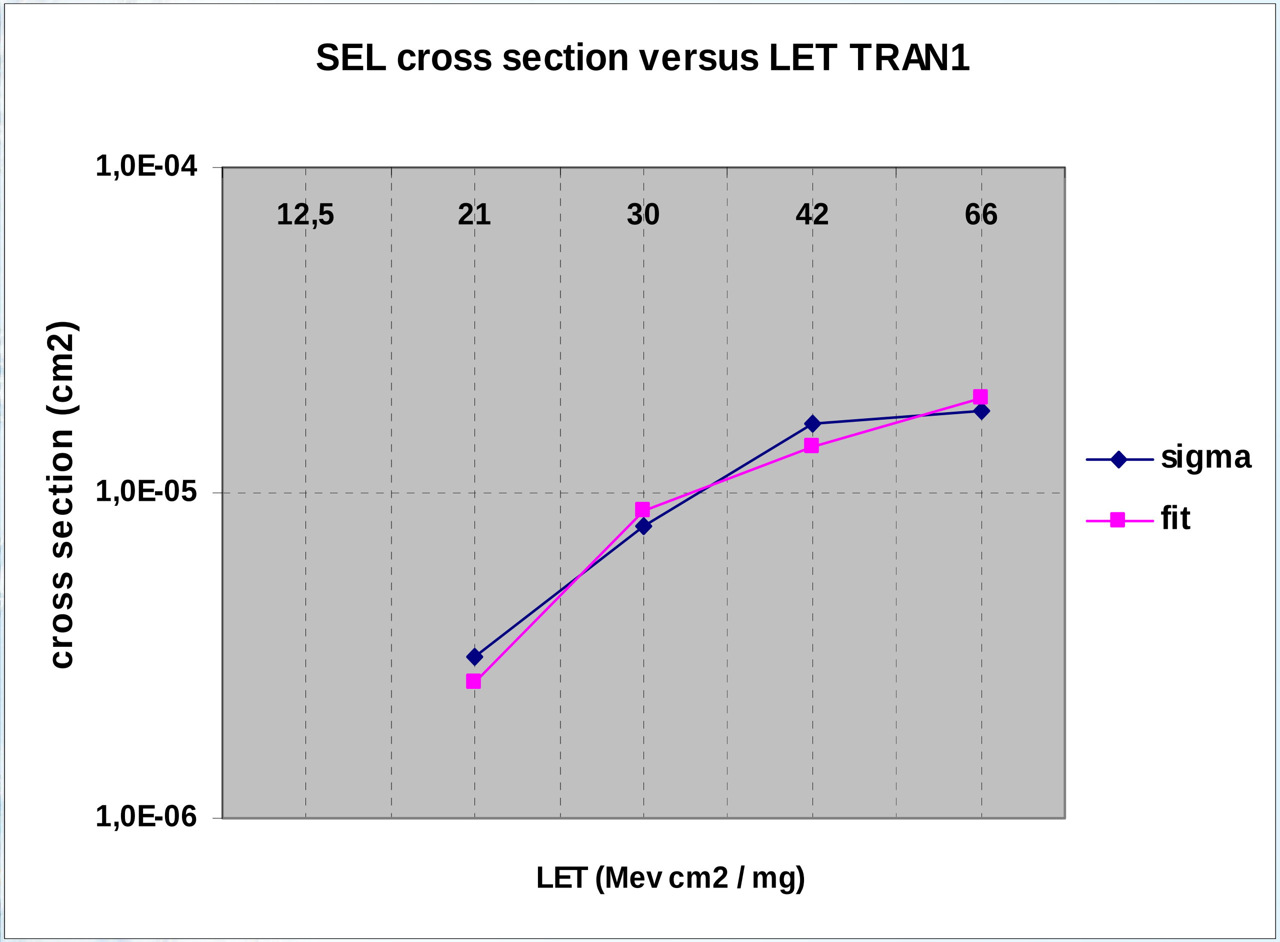


*On the board back side, commercial circuitry protects each device from latch up: current sense for shut off is fully programmable in the range 100mA/2A for each device*

# Heavy ions used during irradiation session

| Ion | Flow (ion/cm2 /s) | LET<br>Mev xcm2/mg |
|---|---|---|
| Chlorine 35 | 4000-25000 | 12.5 |
| Bromine 79 | 120-3000 | 42 |
| Iodine 127 | 100-650 | 66 |
| Titane 48 | 1200-13000 | 21 |
| Nickel 58 | 1600 | 30 |

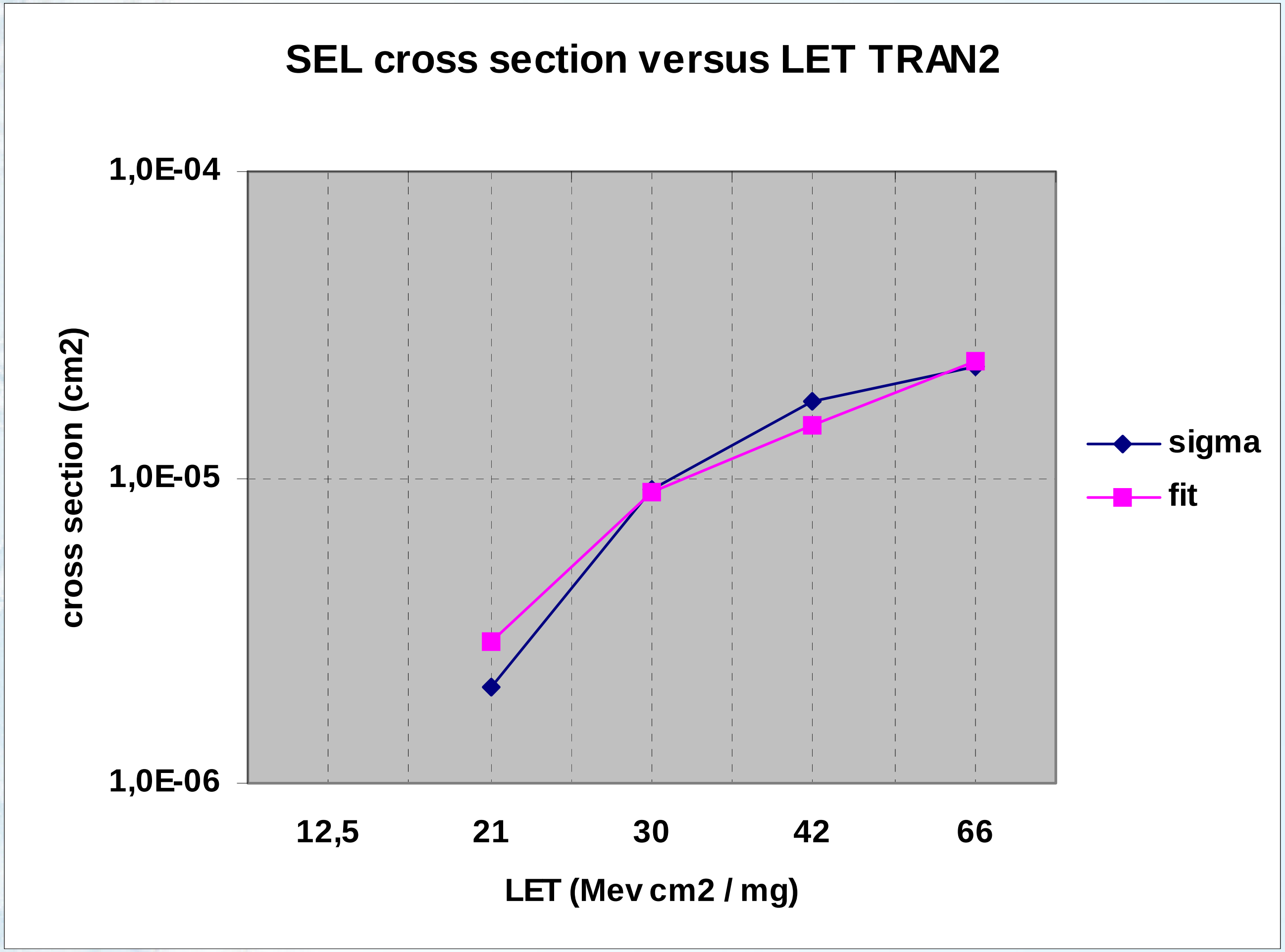
# SEL Cross section versus LET on Tran device Weibull distribution




**Weibull interpolated threshold for TRAN1 was 19 MeV cm2 / mg**

**Saturation cross section equals 2.7E-5 cm2**

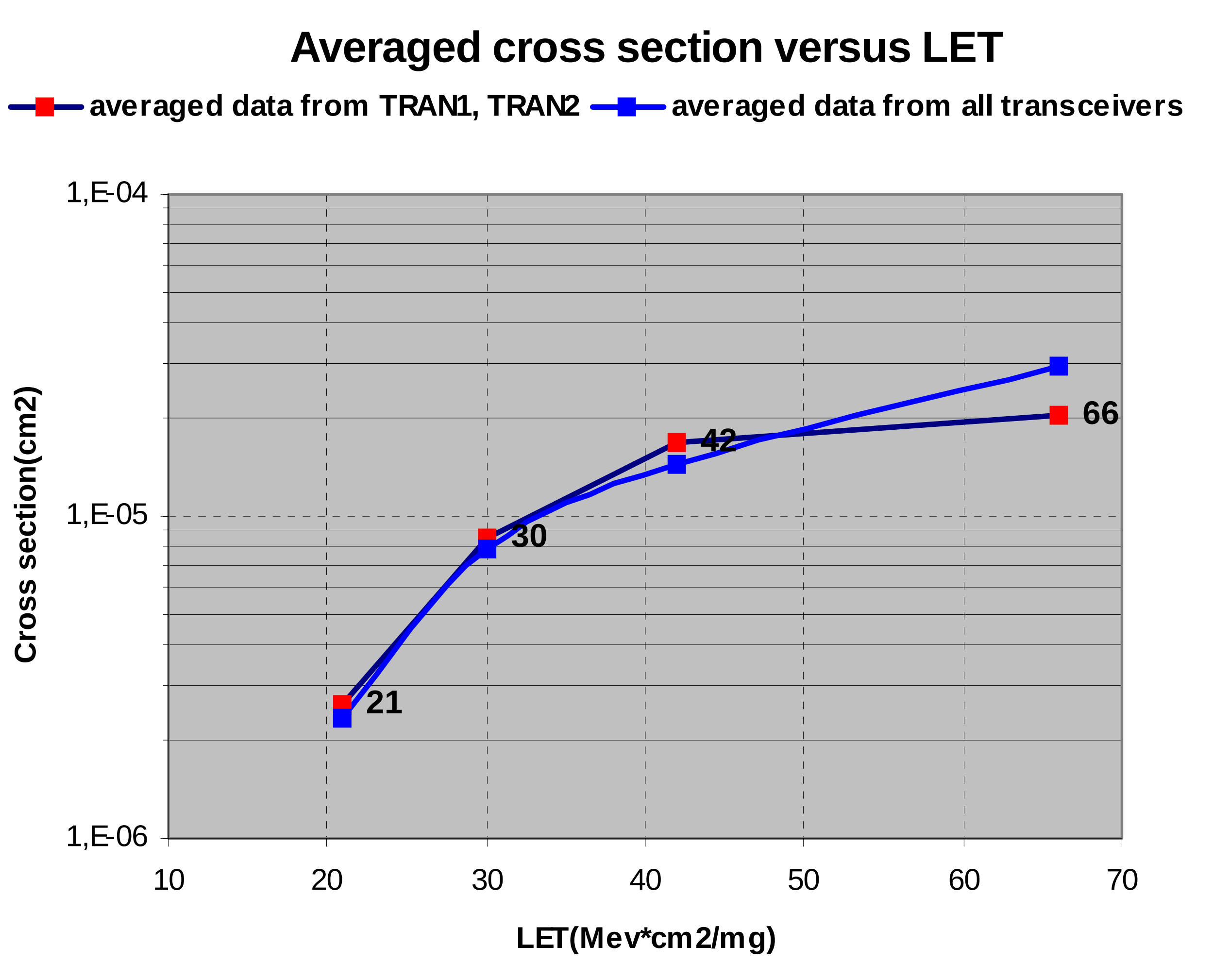
# SEL Cross section versus LET on Tran device Weibull distribution




**Weibull interpolated threshold for TRAN2 was 18 MeV cm2 / mg**

**Saturation cross section equals 3.14E-5 cm2**

# SEL Cross section versus LET on Tran device Weibull distribution

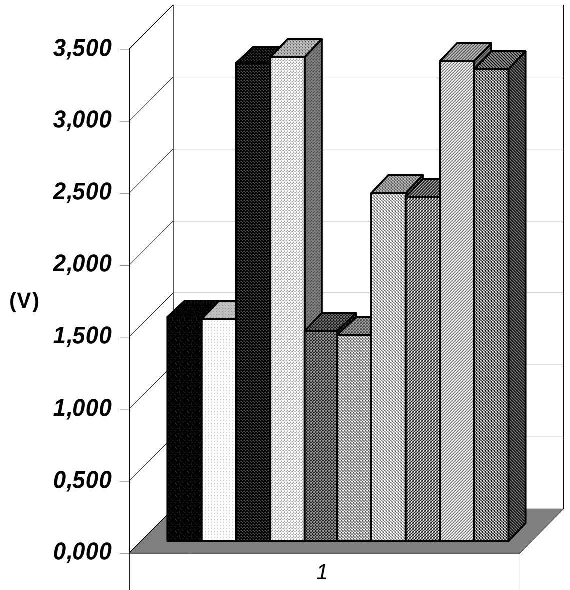


# Total dose table on Tran devices

| ion | TR1 dose (rad) | TR2 dose (rad) | TR3 dose (rad) |
|---|---|---|---|
| **Chlorine 35**<br>E=178MeV<br>LET=12.5 Mev*cm$^2$/mg | 6560 | 600 | 0 |
| **Bromine 79**<br>E=250 Mev<br>LET=42 Mev*cm$^2$/mg | 3203 | 2815 | 322 |
| **Iodine 127**<br>E=289 MeV<br>LET=66 Mev*cm$^2$/mg | 528 | 572 | 530 |
| **Titane 48**<br>E=200 MeV<br>LET= 21 Mev*cm$^2$/mg | 672 | 672 | 3360 |
| **Nickel 58**<br>E=210 MeV<br>LET=30 Mev*cm$^2$/mg | 4800 | 4800 | 4800 |
| **Total dose** | 15763 | 9459 | 9012 |

# Transceiver retesting after irradiation

comparing parameters before and after irradiation on TR1 (sample #20): total dose=15763 rad

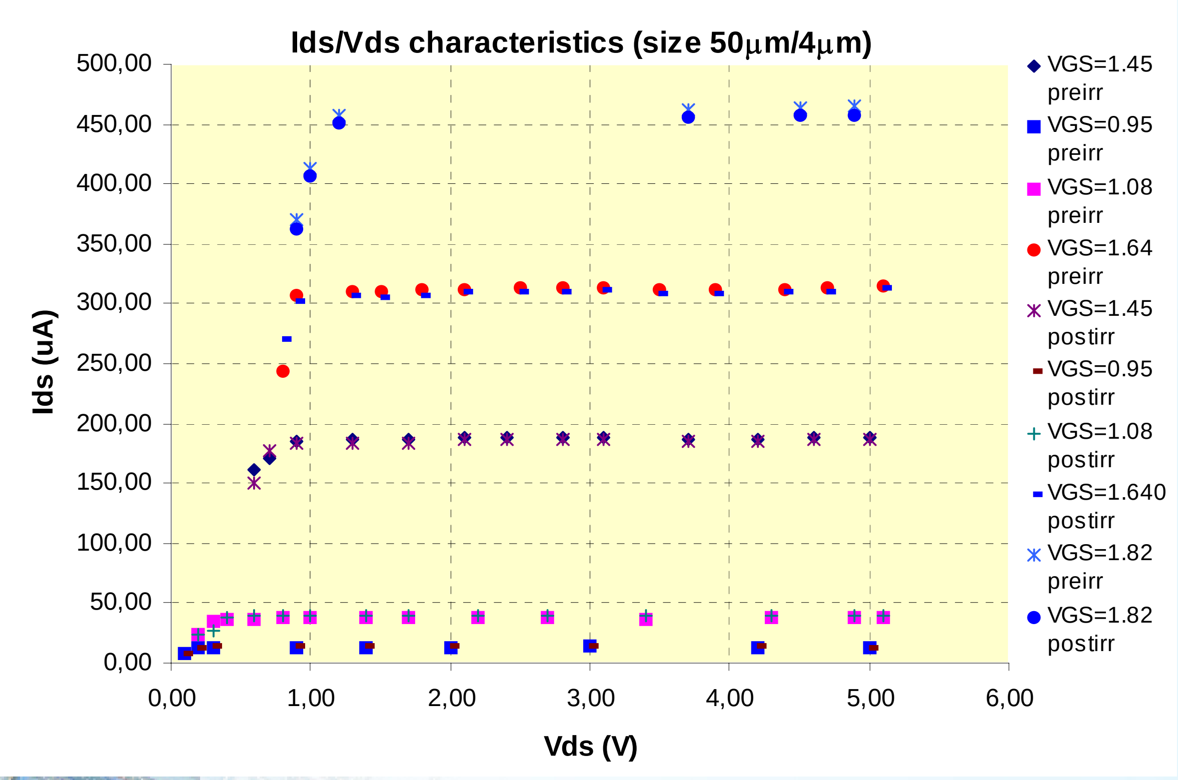



| | 1 |
|---|---|
| CAN_L post irr | 1,542 |
| CAN_L pre irr | 1,540 |
| CAN_H post irr | 3,301 |
| CAN_H pre irr | 3,350 |
| V15 post irr | 1,448 |
| V15 pre irr | 1,420 |
| V25 post irr | 2,411 |
| V25 pre irr | 2,375 |
| V35 post irr | 3,318 |
| V35 pre irr | 3,262 |

| | Percentage Gap (p_post-p_pre) /p_pre |
|---|---|
| CAN_L | +0.13% |
| CAN_H | -1.46% |
| V15 | +1.97% |
| V25 | +1.52% |
| V35 | +1.72% |

Electrical parameters did not shift as an irradiation effect

# Test structure retesting after irradiation




N-mos electrical characteristics did not move as a total dose effect: percentage errors with respect to the pre-irradiation measurement resulted inside the measurement accuracy.

Gate Drain Leakage current still resulted < 10nA

# Summary and conclusions

- An ISO11898 compliant CAN transceiver has been developed in commercial AMS 0.8um High Voltage technology and it has been tested in a radiation environment at SIRAD irradiation facility. Number of tested sample is 3.
- Extrapolated LET threshold from Weibull distribution resulted in 20MeV * cm2 /mg
- TID was measured in 15Krad. Leakage tests and static characteristics re-tracing after irradiation showed no degradation in performances

Finally, we thank A. Candelori (Padua INFN) and M. Ceschia (Padua DEI) for their work during test plan fixing, test setup and irradiation test

# Thanks for your attention!