HIREX ENGINEERING®

Radiation Evaluation of Commercial Off-The-Shelf (COTS)

Non-Volatile Memories (NVRAMs)

Contract N° 13528/99/NL/MV, COO-1

D/TOS-QCA Final Presentation Day, January 30th 2001

J.F. PASCAL, F.X. GUERRE

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Evaluation Content

- Parts Selection
- Total Ionizing Dose
- Single Event Effects

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Outline Presentation

- Tested Products
- Total Ionizing Dose
- Single Event Effects

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Tested Products

- Non Volatile memories
  - FRAM
  - EEPROM
  - Flash
- RAM memories

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Total Ionizing Dose Evaluation

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TID Tested Products: Memories

Manufacturer	Type	Description
Ramtron	FM1808	32K x 8 FRAM
Atmel	AT28LV010	128K x 8 EEPROM
Xicor	X28C010	128K x 8 EEPROM
Hitachi	HN58C1001	128K x 8 EEPROM
Intel	E28F128J	16M x 8 Flash EPROM
Samsung	K9F2808U0M	16M x 8 Flash EPROM
IDT	IDT7025	8K x 16 DPRAM

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TID Tested Electrical Parameters

- Input, Output Leakage currents (Iil, Iih, Iozl, Iozh), Output Voltages (Voh, Vol)
- Supply currents (Operating, Standby TTL, Standby CMOS)
- Functional test @ max speed, 4 patterns

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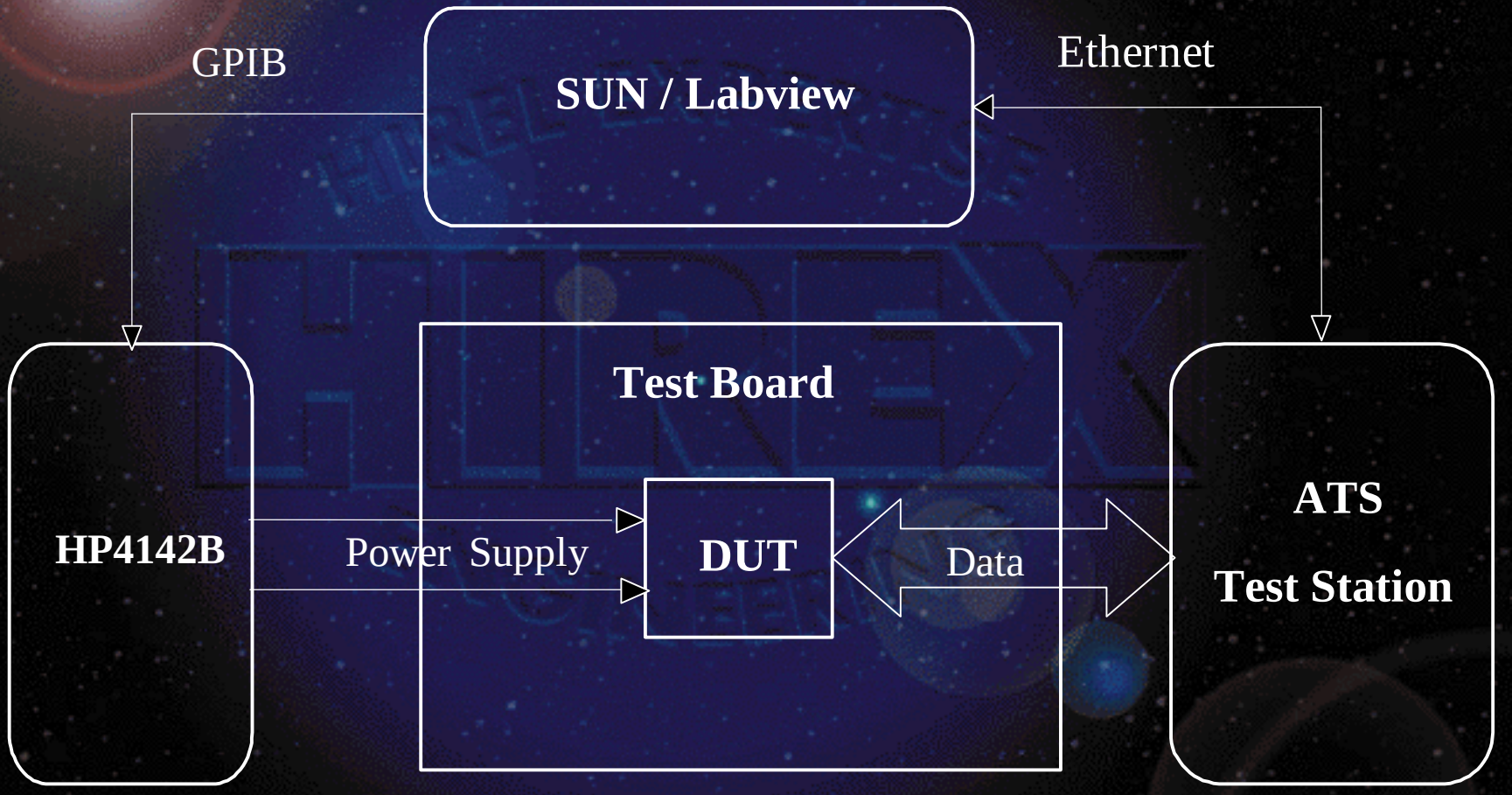
TID Test Programs Principle



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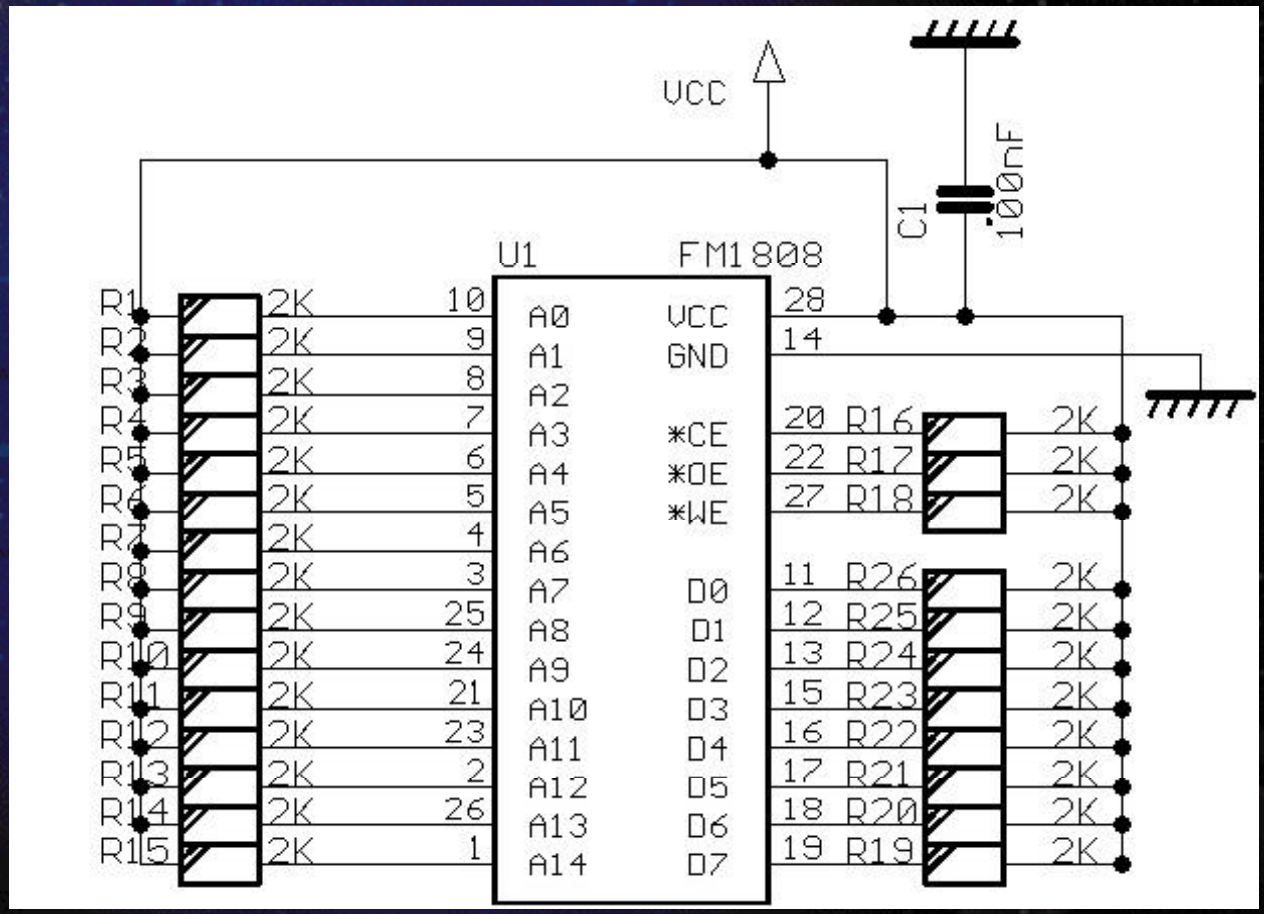
TID Bias Conditions: FRAM

FM1808



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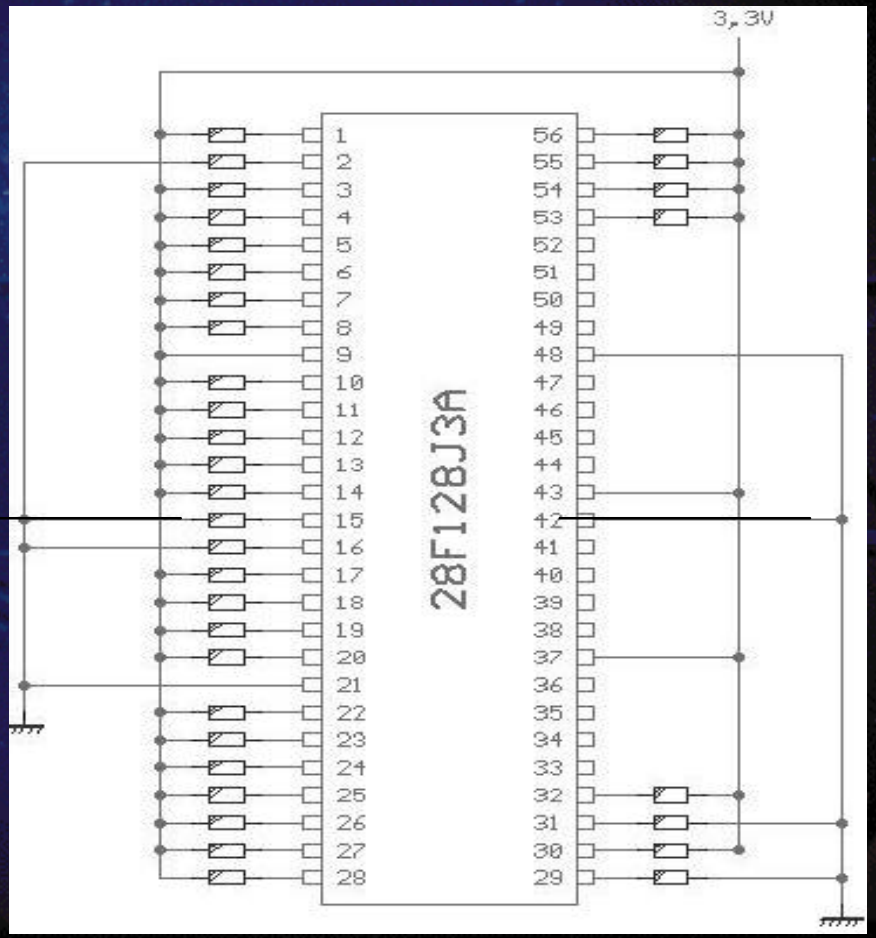
TID Bias Conditions: Flash

28F128J3A



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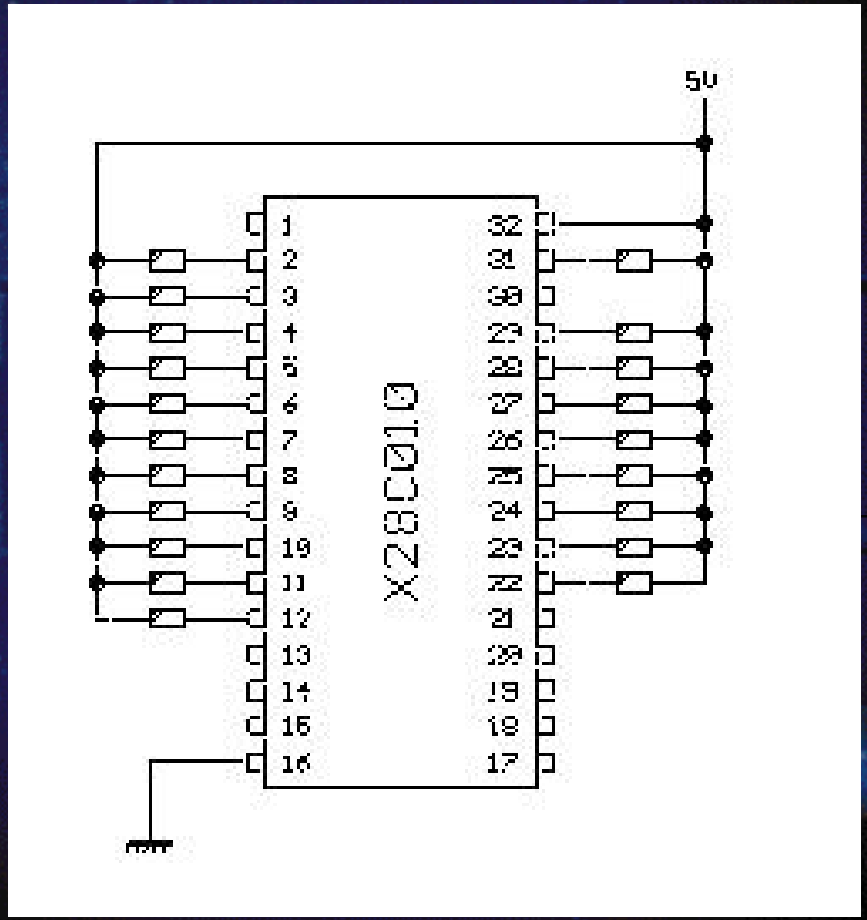
TID Bias Conditions: EEPROM

X28C010



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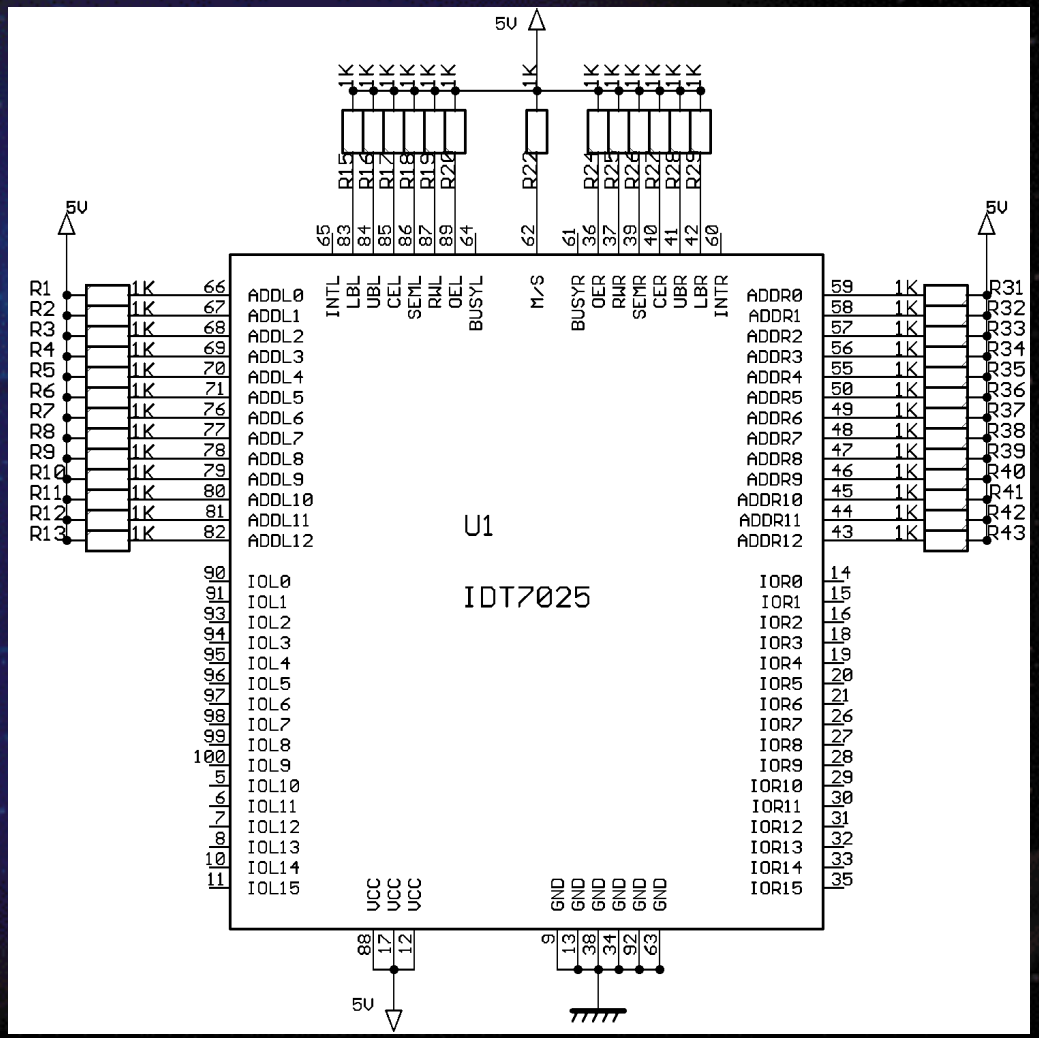
TID Bias Conditions: DPRAM

IDT7205



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TID Tests Conditions

- 5 Samples per type tested
- Dose rate: 200 rad(Si)/hour
- Irradiation and testing at room temperature
- CO60 Exposures at ONERA up to 50-60 Krad(Si) in 5 or 6 steps
- Annealing: 24H at 25°C & 168H at 100°C

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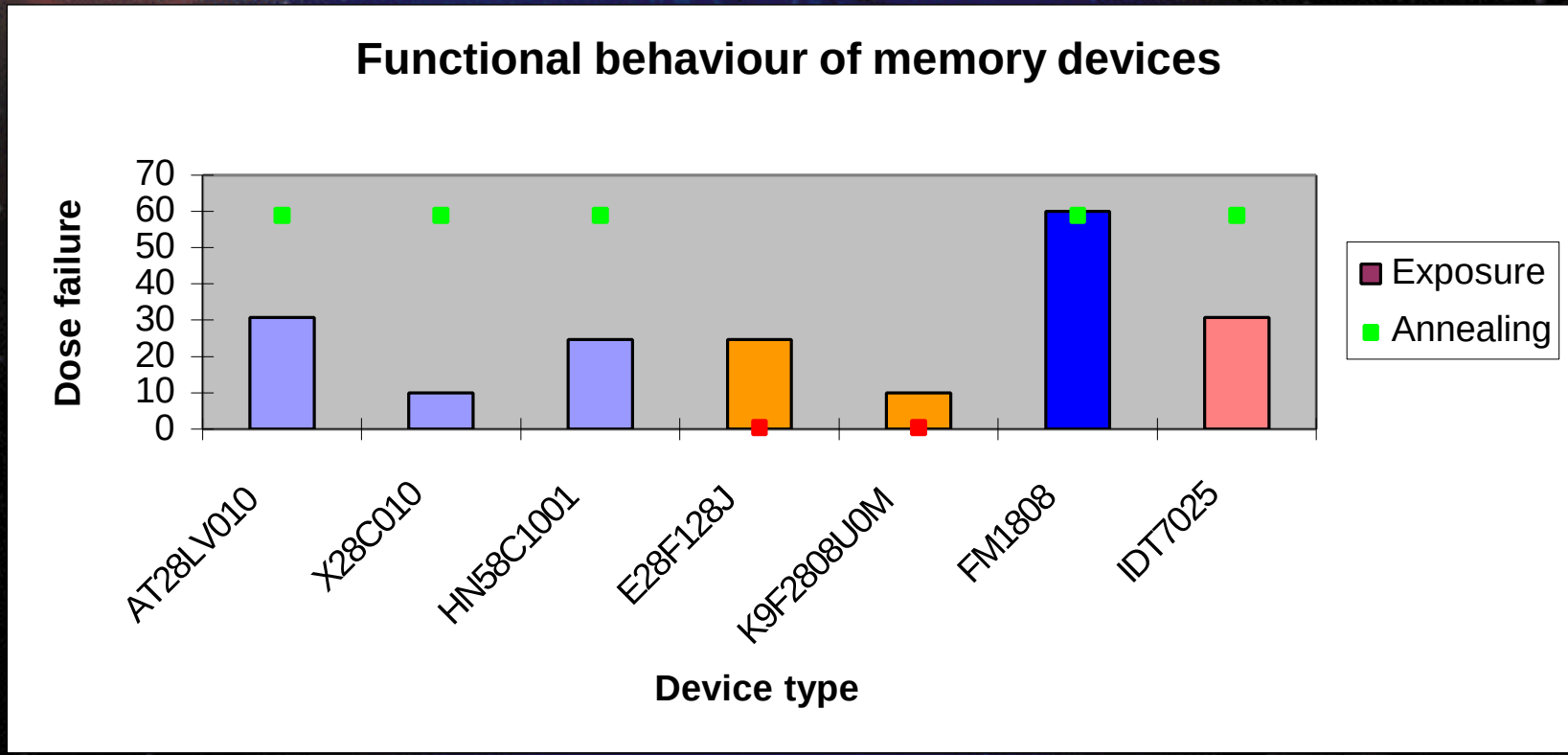
TID Test Results: Functional



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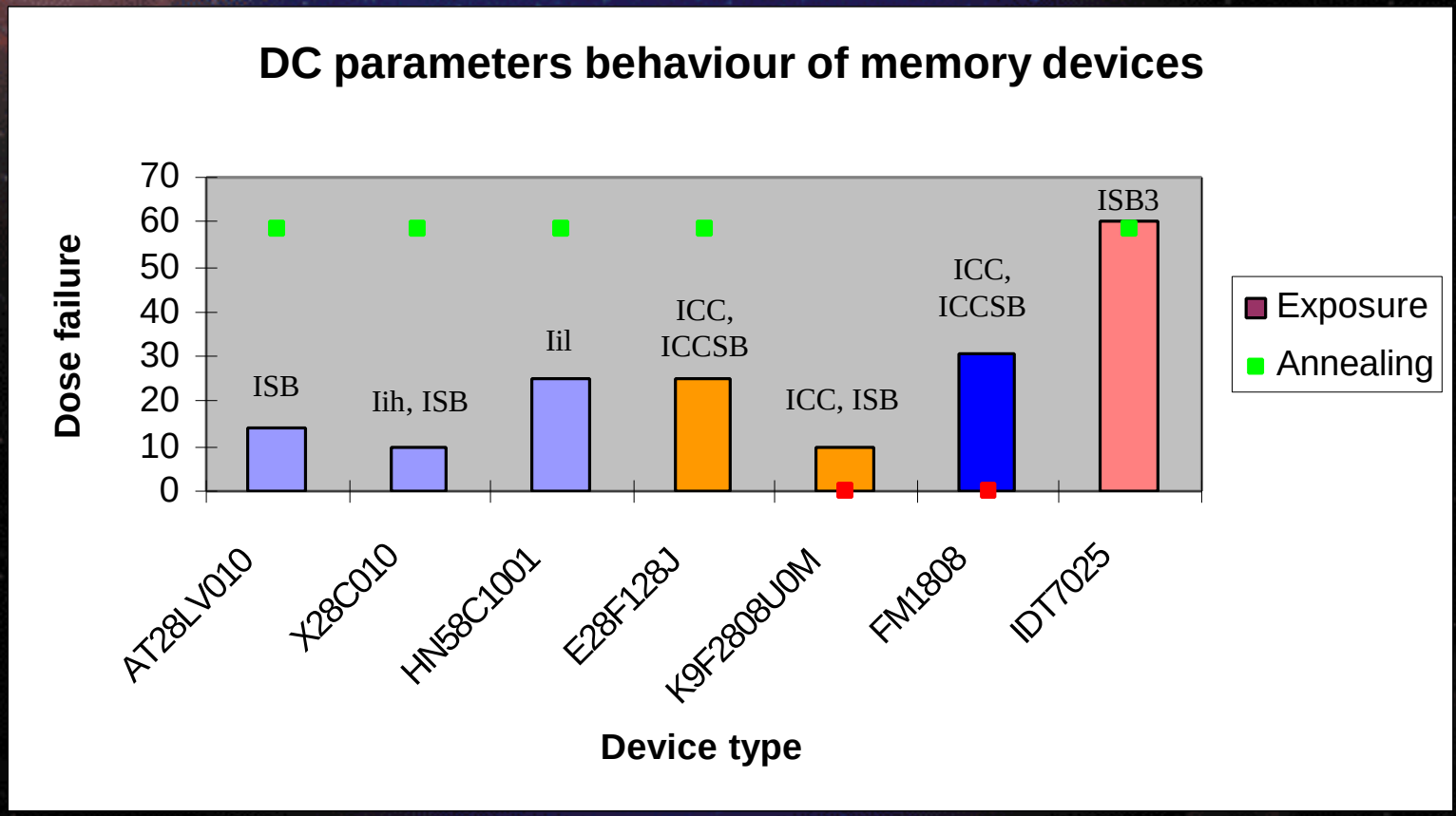
TID Test Results: DC parameters



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Single Event Effect
Evaluation of Non Volatile Memories
(NVRAMs)

Test performed in April 00 and September 00,
at the European Heavy Ion Facility (HIF),
Université catholique de Louvain, (Belgium)

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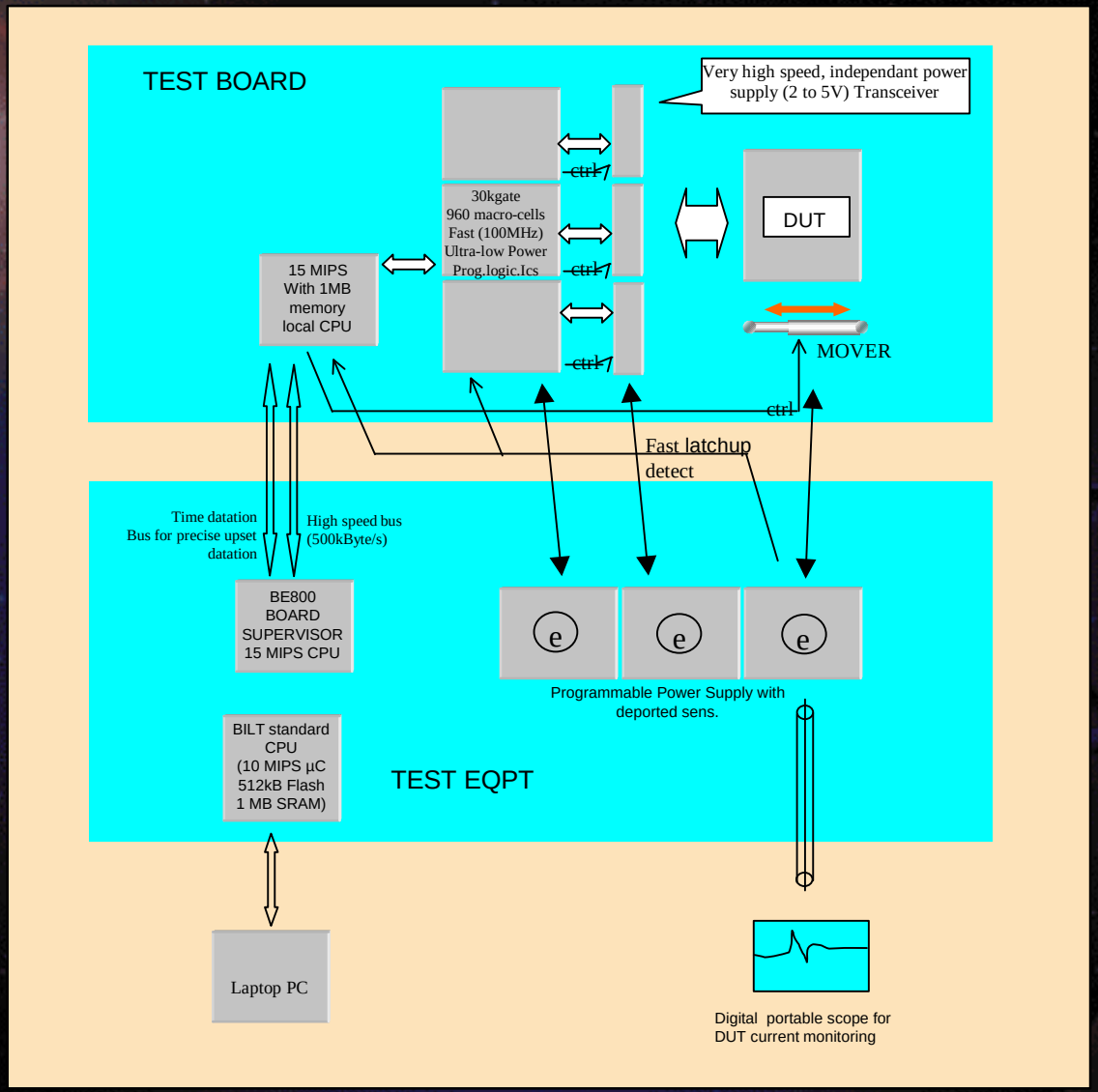

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NVRAM SEE Test Conditions

Static mode : **1 cycle**

- •Write the memory not exposed to the beam
- •Expose the DUT for the expected fluence
- •Read the memory not exposed to the beam

Read only mode: **Repetitive cycles**

- •Write the memory not exposed to the beam
- •Expose the DUT for the expected fluence
- •Read the memory continuously

Read / write mode: **Repetitive cycles**

- •Write the memory not exposed to the beam
- •Expose the DUT for the expected fluence
- •Read/write the memory continuously

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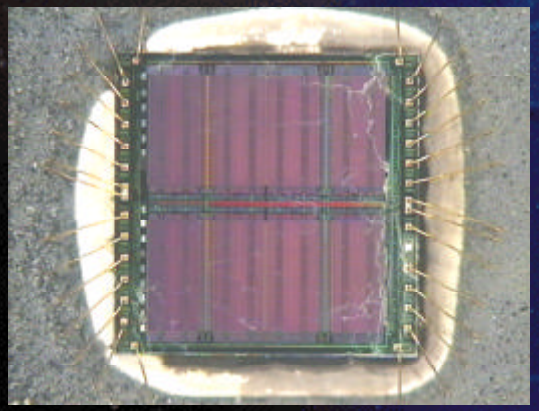
FM1808 RAMTRON



- Ferro-electric Random Access Memory(FRAM)
- FM1808-120-P
- 28-pin plastic DIP
- 32k x 8
- 5V operation
- 180ns cycle time
- Ferro-electric process
- Die : 4.6 mm x 4.6 mm

⇨ Non volatile but operates as a RAM for read and write

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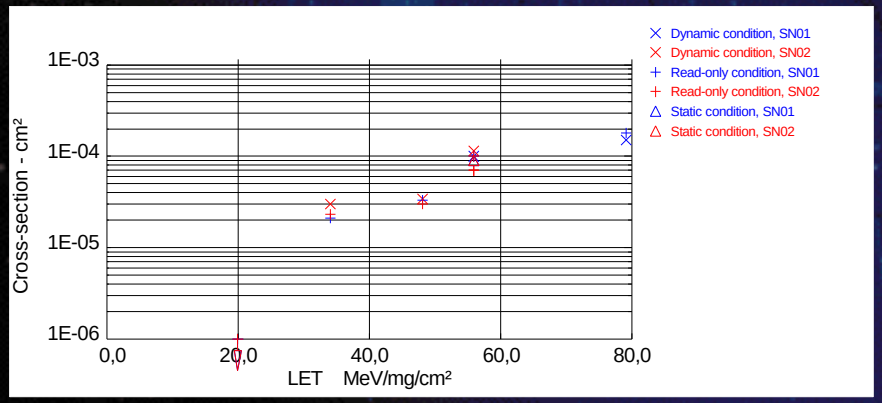
FM1808 SEE RESULTS

- Not sensitive to SEU up to an LET of 80 MeV/(mg/cm²)
- Sensitive to SEL
- In static mode, SEL does not affect the memory content



SEL Cross section

LET threshold between
20 and 34 MEV/(mg/cm²)

Asymptotic cross-section
1.8 E- 4 cm²

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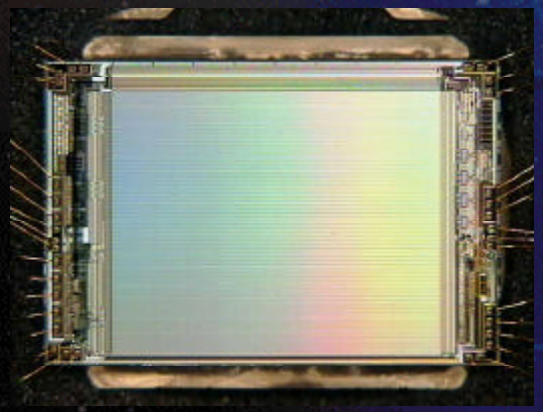
AT28LV010 ATMEL



- EEPROM
- AT28LV010-25PI
- 32-lead plastic DIP
- 128k x 8
- 3V3 operation
- 200ns Read Access Time
- 10ms max, Page Write Cycle Time
- CMOS
- Die : 9.2 mm x 6.2 mm

Internal error correction for improved data retention

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AT28LV010 SEE RESULTS

Static mode : **Krypton(34)**

- No SEU (tilt angle 0 deg.)

Read only mode: **Neon(5.9), Argon (14), Krypton(34)**

- No error Neon @ 60 deg
- 1st Functional error Argon @ 0 deg.
- No other type of error

Read / write mode: **Neon(5.9), Argon (14), Krypton(34)**

- 1st Functional error Neon @ 60 deg
- Few Page errors (128 bytes range)
- No Single error (1 single random bit at a random address)

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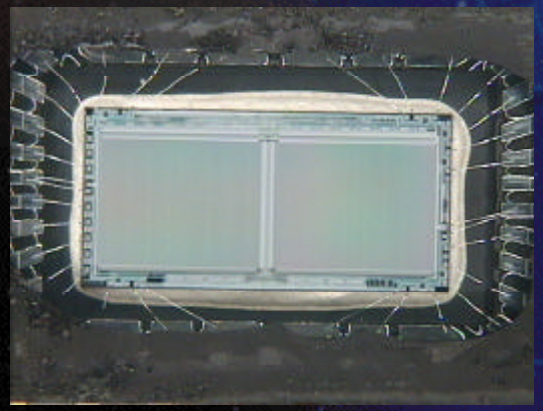
X28C010 XICOR



- EEPROM
- X28C010D-12
- 32-lead CERDIP
- 128k x 8
- 5V operation
- 120ns Read Access Time
- 10ms max, Page Write Cycle Time
- CMOS
- Die : 12.7 mm x 6.2 mm

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X28C010 SEE RESULTS

Static mode : **Krypton(34)**

- No SEU (tilt angle 0 deg.)

Read only mode: **Neon(5.9), Argon (14), Krypton(34)**

- 1st half-page (128 bytes) error Neon @ 0 deg.
- Few MEUs, > 1 bit at a random address, Neon @ 0 deg.
- 1st functional error Argon@ 0 deg.

Read / write mode: **Neon(5.9), Argon (14), Krypton(34)**

- Same behaviour as read only mode
- Single errors, 1 bit at a random address Neon@ 0. deg.

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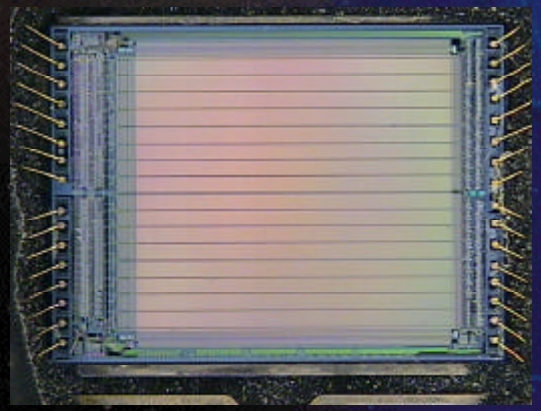
HN58C1001 HITACHI



- EEPROM
- HN58C1001FP-15
- 32-pin plastic SOP
- 128k x 8
- 5V operation
- 150ns Read Access Time
- 10ms max, Page Write Cycle Time
- MNOS (memory cells),CMOS (Logic)
- Die : 8.3 mm x 6.2 mm

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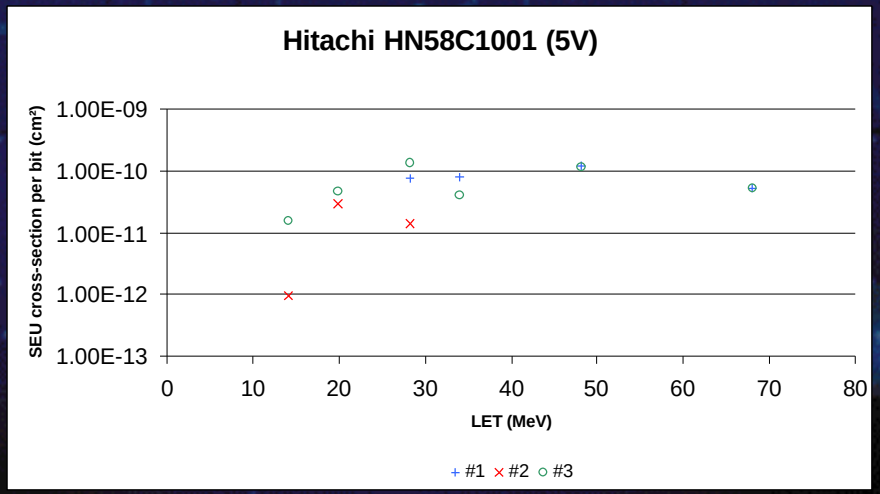
HN58C1001 SEE RESULTS

- **Read only mode:** **Argon (14), Krypton(34)**
  - No error Krypton@ 60 deg. (68)
- **Read / write mode:** **Argon (14), Krypton(34)**
  - 1st Page (128 bytes) error Krypton@ 0 deg.
  - Single errors, 1 bit at a random address Argon@ 0. deg.



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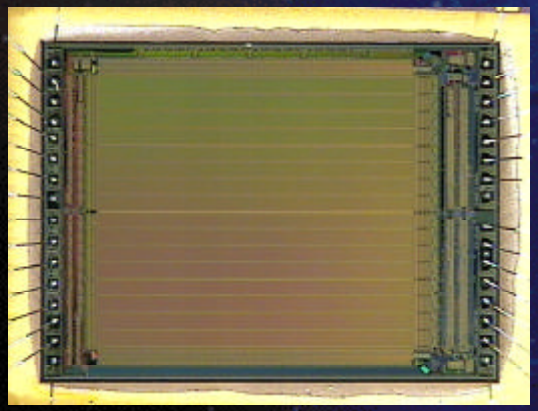
MEM8129 HMP



- EEPROM
- MEM8129JMB-15
- Ceramic JLCC
- 128k x 8
- 5V operation
- 150ns Read Access Time
- 10ms max, Page Write Cycle Time
- MNOS (memory cells),CMOS (Logic)
- Die : 8.3 mm x 6.2 mm

Hitachi die 58C1001

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MEM8129 SEE RESULTS

Static mode : **Krypton(34)**

- No SEU (tilt angle 0 deg.)

Read only mode: **Argon (14), Krypton(34)**

- No error Krypton @ 0 deg.

Read / write mode: **Argon (14), Krypton(34)**

- Permanent error Krypton@ 0deg.
  2 samples, stuck bits in a page
  Partial recovery over time (hours)

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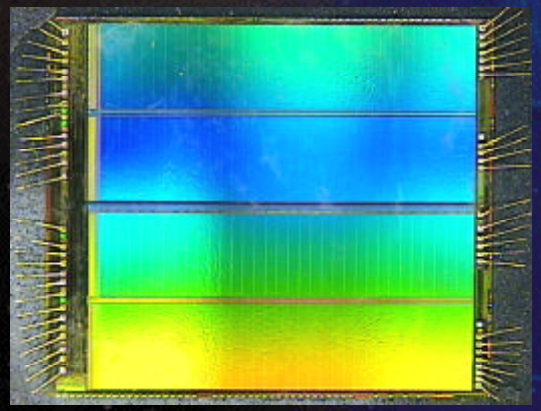
28F128J INTEL



- Flash
- E28F128J3A150
- 56-lead TSOP
- 128Mbit (128 blocks of 128kbytes)
- 3V operation
- 150ns Read Access Time
- 1.0 s min Block Erase Time
- 0.25µ ETOX VI Intel Process
- Die : 10.5 mm x 8.9 mm

Intel StrataFlash means 2-bit-per-cell technology

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28F128J SEE RESULTS

Static mode : **Argon (14)**

- SEU sensitive
- SEU is 2 consecutive bits error in the byte word
- Functional error, maxtime erase/write

Read only mode: **Argon (14)**

- Block 0 erased
- Functional error, max time erase/write, recover after Reset

Read / write mode: **Neon (5.9)**

- Block 0 erased
- Functional error, max time erase/write, recover after Reset
- Functional error, all blocks at 0, need to be powered off

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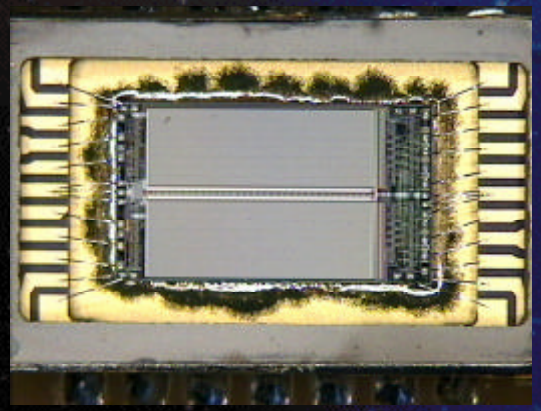
HM65687A TEMIC MHS



- CMOS Static RAM
- HM4-65687SB
- 22-Lead Rectangular LCC
- 64K x 1
- 5V operation
- 45 ns Access Time
- CMOS

One hirel sample from Envisat programme

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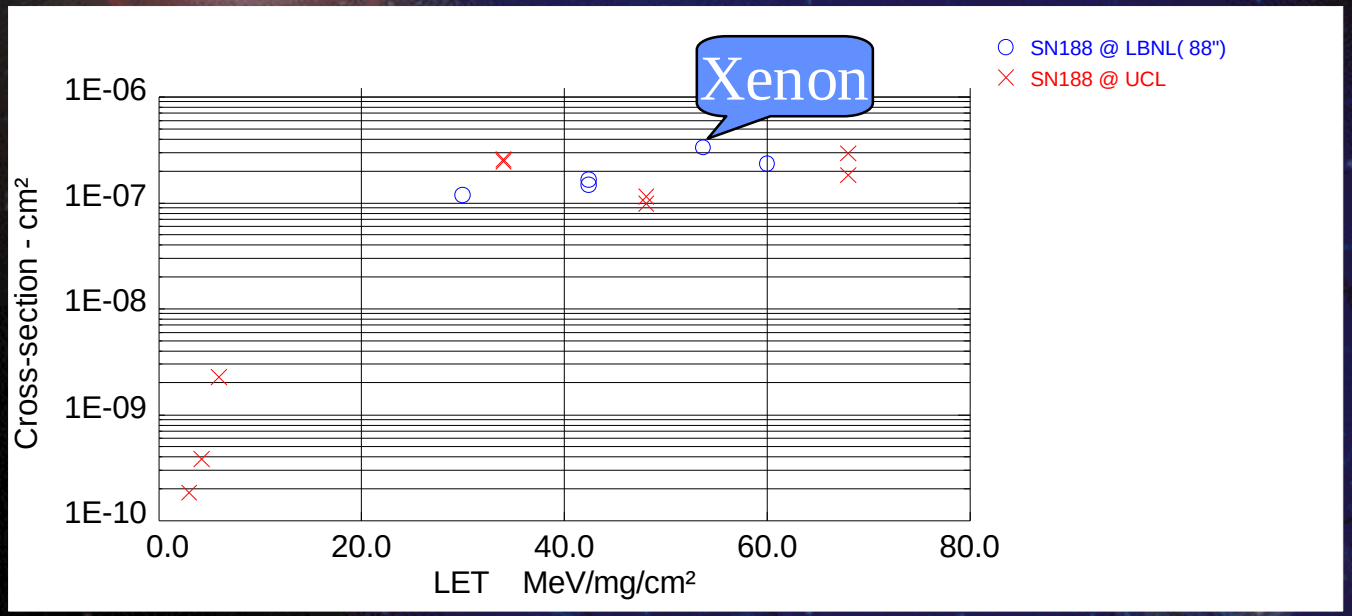
HM65687A SEE RESULTS



UCL

8 4-Kr @ 316MeV

LBNL

86-Kr @ 886MeV

LET Threshold ~3MeV/(mg/cm²)

Asymptotic cross-section ~3 E - 7 cm² per bit @ 68 MeV/(mg/cm²)

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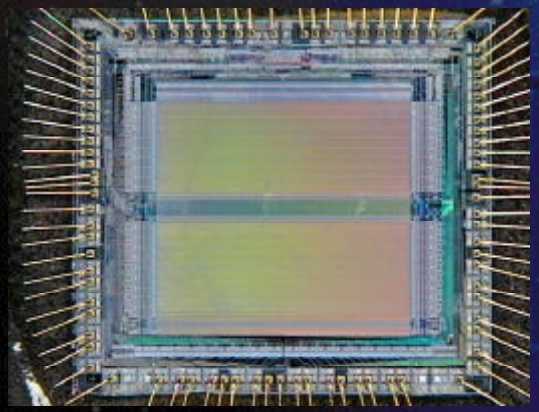
IDT7025 IDT



- Dual Port RAM
- IDT7025L35PFI
- 100-pin TQFP
- 8k x 16
- 5V operation
- 35 ns Read/Write Cycle Time
- CMOS
- Die : 4.8 mm x 5.4 mm

➡ Only one port tested

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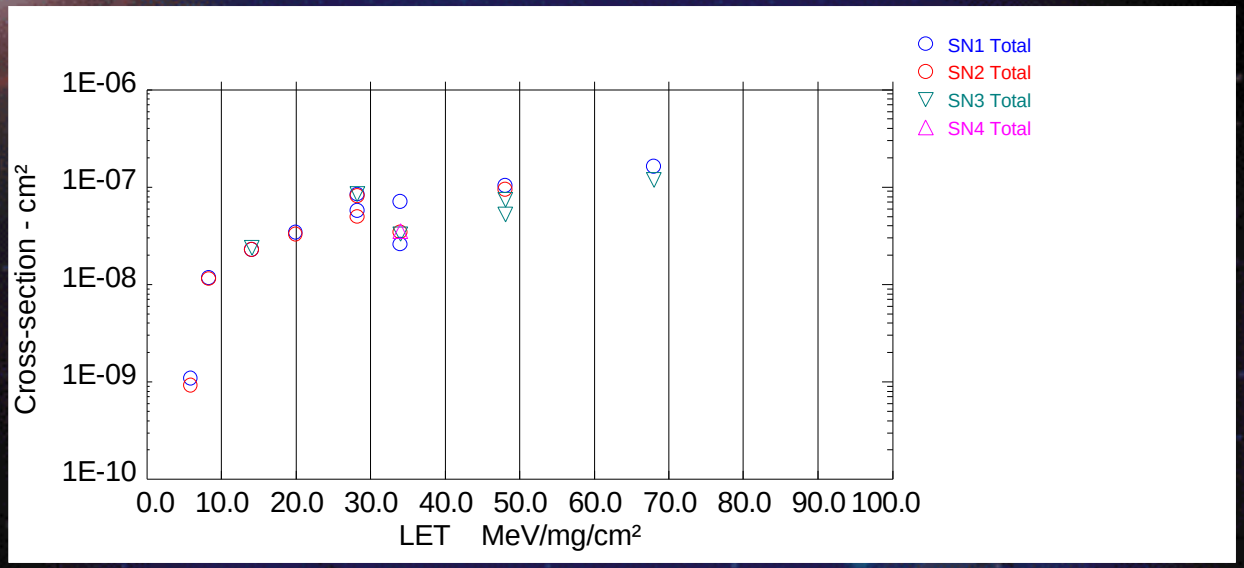
IDT7025 SEE RESULTS



- No SEL
- LET Threshold ~5.8MeV/(mg/cm²)
- Asymptotic cross-section ~1.2 E - 7 cm² per bit @ 68 MeV/(mg/cm²)
- 1st stuck bits Argon @ 60 deg.

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HX6228 HONEYWELL

- SRAM
- HX6228/TENC
- 32-lead Flatpack
- 128k x 8
- 5V operation
- 25ns Read/Write Cycle Time
- CMOS on SOI

Influence of temperature on SEE tolerance

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HX6228 SEE RESULTS

Ion 132-Xenon

Test temperature : ambiant (27°C), 85 °C, 125 °C

Results

- At normal incidence, no error
- With a tilt angle of 60 deg., LET 112MeV/(mg/cm²)

Temperature (°C)	Fluence (p/cm²)	SEUs	Sigma per bit (cm²)
27	1.50E+06	3	1.91E-12
85	5.00E+05	4	7.63E-12
125	1.50E+06	7	4.45E-12

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