Radiation Evaluation of DDR/DDRII SDRAM Memories

by

EADS Astrium GmbH, Germany

IDA TU Braunschweig, Germany

Hirex Engineering, Toulouse, France

European Space Agency/ESTEC, TEC-QCA, The Netherlands

Radiation Evaluation of DDR/DDRII SDRAM Memories

EADS Astrium

- Memory Procurement Aspects

IDA (contracts with Astrium and ESA)

- Upgrade of Radiation Test Bed (memory tester)
- Perform Radiation Testing

Hirex Engineering (contract with ESA)

- Sample Preparations
- Upgrade of Memory Test System
- Perform Radiation Testing

European Space Agency/ESTEC

- To Provide Test Facilities
- To Coordinate all activities

Radiation Evaluation of DDR/DDRII SDRAM Memories

AGENDA - I.

ESA/ESTEC

- Welcome and Introduction

EADS Astrium

- Mass Memory Products for Space Applications
- Memory Procurement Aspects

IDA

- Radiation Test Bed (memory tester)
- Radiation Testing

Hirex Engineering

- Sample Preparations
- Memory Test System
- Radiation Testing

Radiation Evaluation of DDR/DDRII SDRAM Memories

AGENDA - II.

ESA/ESTEC

- Test Facilities
- Test Samples/Test Conditions
- Radiation Test Plan/Time Frame
- Support Activities

EADS Astrium

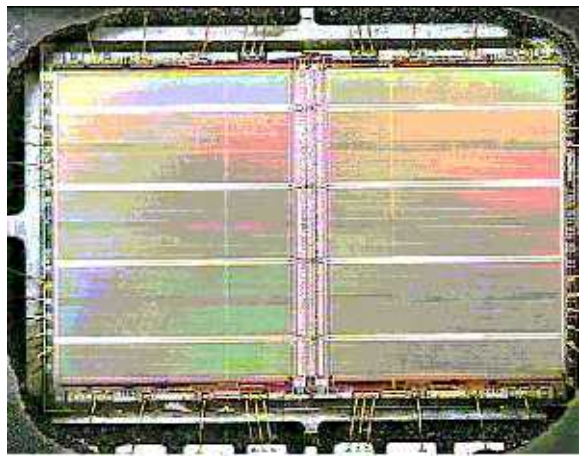
- Memory Module Concepts and Development
-

TBD Presentations

- Other Mass Memory Related Activities (FLASH)
- Project Presentations

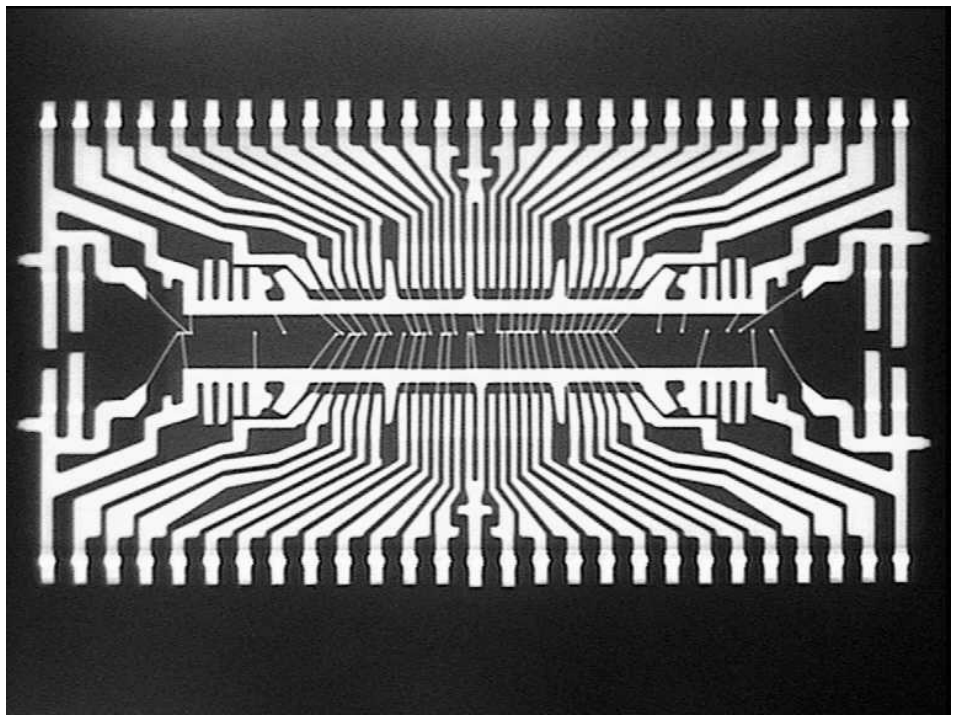
Radiation Evaluation of Components for Space Aapplications I.

- **TID Co-60 Testing**
  - No device preparation required
- **Displacement damage and SEE Proton Testing**
  - No device preparation required
- **SEE Heavy ion Testing**
  - Device preparation required



Radiation Evaluation of Components for Space Applications – II.

Today, nearly all memories are assembled with centre bond pads and a lead frame on top of the die.

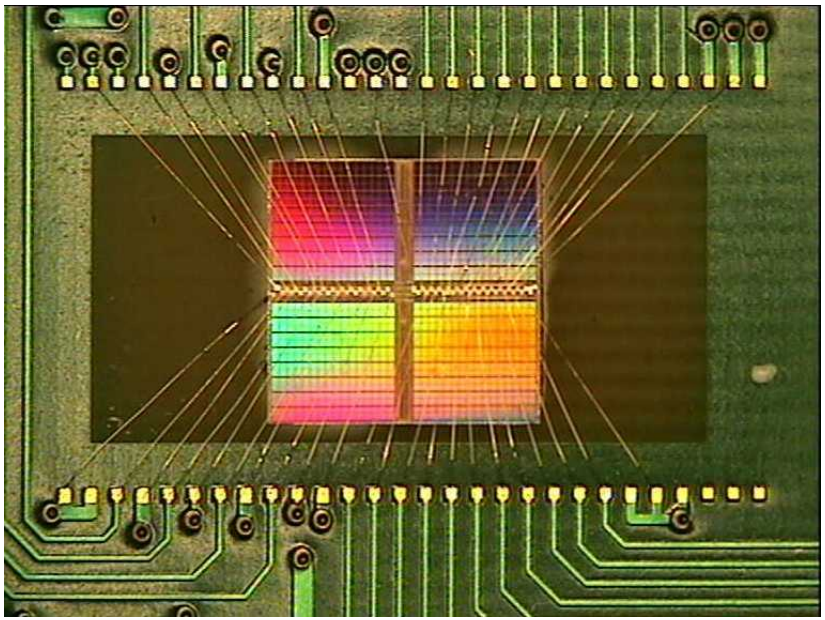


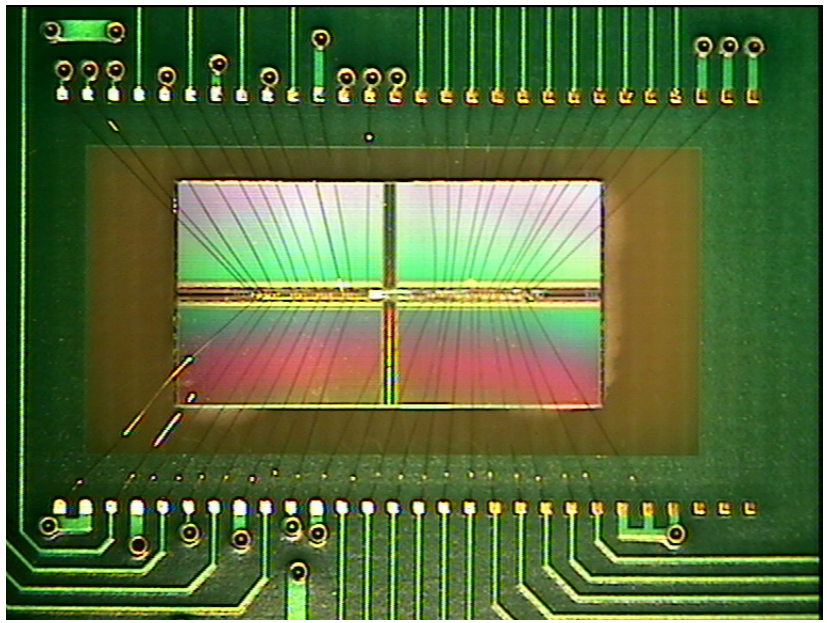
X-ray of Hitachi 256-Mbit SDRAM in 54-pin TSOP (plastic package).

Etched/re-bonded Preparation Method

Etched/re-bonded (Micron 128-Mbit and Hyundai 256-Mbit)

- To Chemical etch the package
- Remove the lead frame
- Re-bond the bare die to a test board
- Irradiation from the front

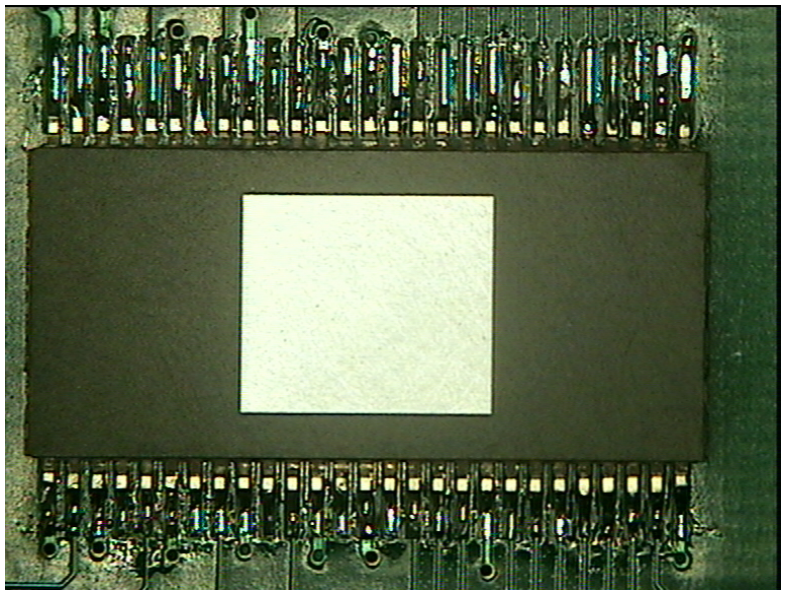


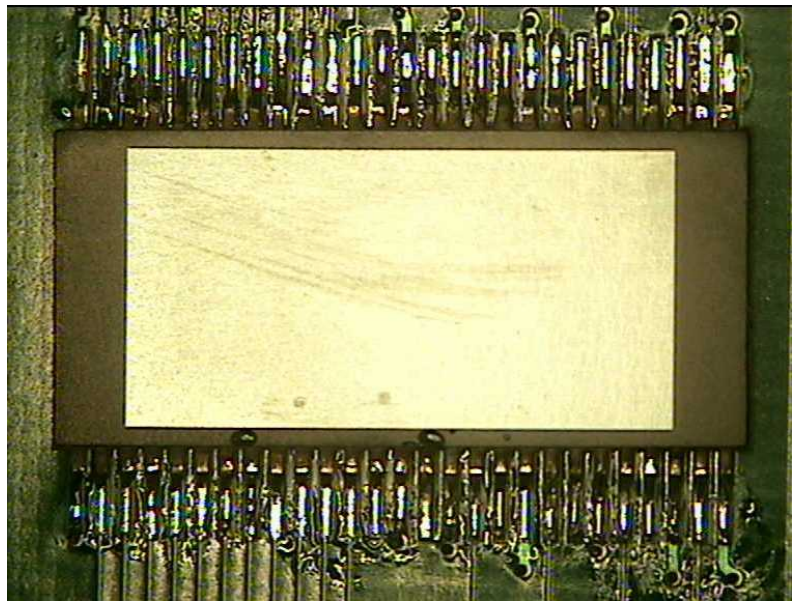


Back Thinning Preparation Method

Back thinned (Micron 128-Mbit and Hyundai 256-Mbit)

- To thin the back of the package/die to about 50 µm
- Main assembly remains untouched
- Requires irradiation from the back
- Accelerator Ion penetration problem





Radiation Evaluation of DDR/DDRII SDRAM Memories

3-D-Plus - Main Observations (Thinned Devices)

SEL Testing of 512 Mbit SDRAMs - July 2004.

- Samsung SEL at LET 40 MeV/(mg/cm^2)/85ºC.
- Infineon SEL at LET 40 MeV/(mg/cm^2)/85ºC/50ºC
- Elpida no SEL at LET 80 MeV/(mg/cm^2)/125ºC (current jumps interpreted as SEFIs)

SEE Testing of Elpida 512 Mbit SDRAMs - Dec. 2003.

- Th LET: SEU ~ 2.0/SEFI ~5.0 MeV/(mg/cm^2)

SEE Testing of Samsung 512 Mbit SDRAMs - Dec. 2003.

- Th LET: SEU ~ 6.0/SEFI ~8.0 MeV/(mg/cm^2)

Radiation Evaluation of DDR/DDRII SDRAM Memories

3-D-Plus - Main Observations (Die Re-bonded)

SEL Testing of 1 Gbit DDR SDRAMs - April 2005.

- Samsung no SEL at LET 80 MeV/(mg/cm^2)/85ºC.
- Micron no SEL at LET 80 MeV/(mg/cm^2)/85ºC.

SEFI Testing of 1 Gbit DDR SDRAMs - April 2005.

- Samsung and Micron no unrecoverable SEFI up to a LET of 80 MeV/(mg/cm^2)/25ºC.

SEU Testing of 1 Gbit DDR SDRAMs - April 2005.

- Samsung and Micron both experienced a significant number of “Stuck Bits”.

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SEL Testing of 512 Mbit DDR SDRAMs - April 2005.

- Samsung SEL at LET 80 MeV/(mg/cm^2)/85ºC

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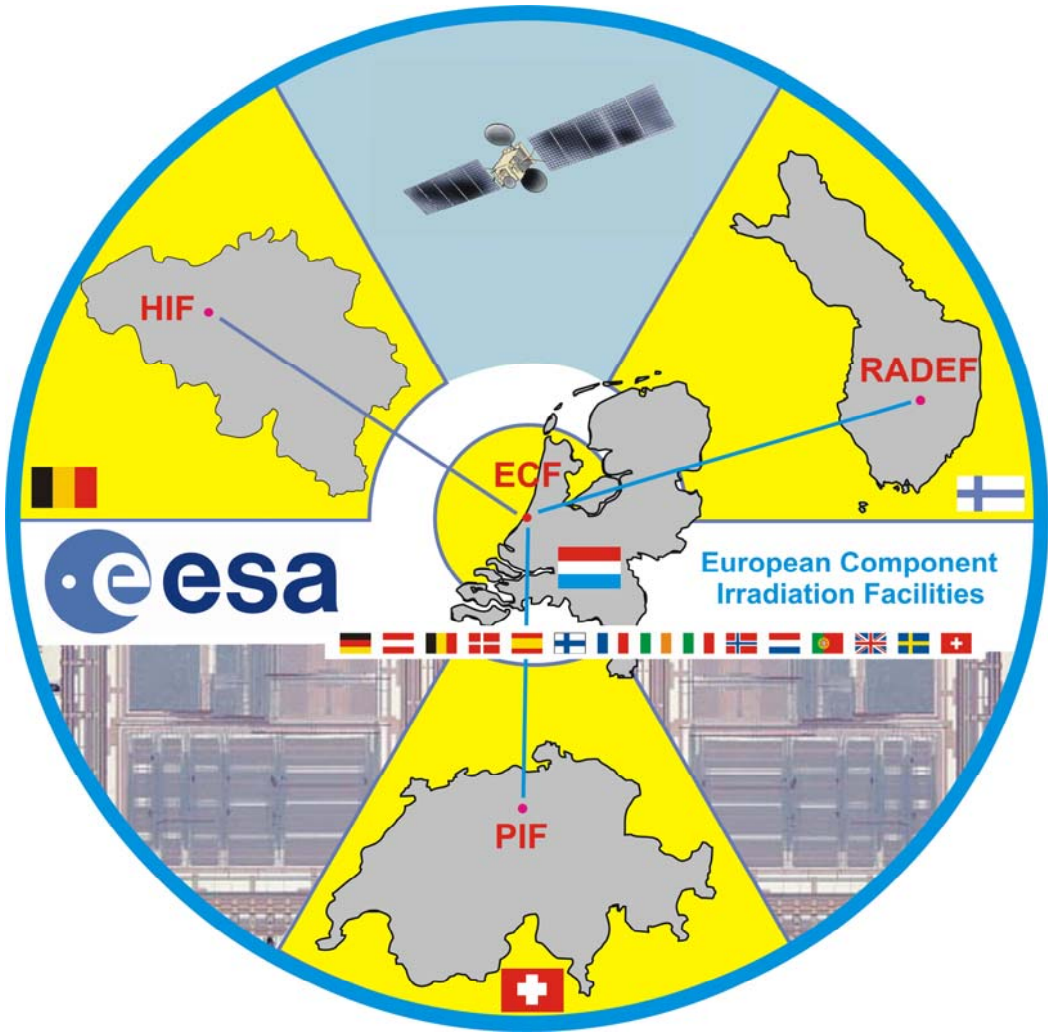
European Component Irradiation Facilities - I.



Radiation Evaluation of DDR/DDRII SDRAM Memories

European Component Irradiation Facilities :

- Proton Irradiation Facility (PIF), – Paul Scherrer Institut, (PSI), Switzerland
- Heavy-ion Irradiation Facility (HIF) – UCL, Belgium
- RADiation Effects Facility (RADEF) – University of Jyväskylä, Finland
- ESTEC Co-60 Facility (ECF) – Noordwijk, The Netherlands

European Component Irradiation Facilities – PIF
Proton Irradiation Facility, Paul Scherrer Institut (PSI).

PIF Main Features High/Low Energy

A) General

- Flux/Dosimetry ~5 % absolute accuracy
- HIF compatible sample frame is fixed on XY table
- Irradiation take place in air

B) High Energy PIF

- Energy range: 30 to 254 MeV
- Initial Energies: 254, 100 and 60 MeV.
- Maximum Proton flux (254 MeV): 2.5E8 p/cm2/sec
- Beam spot ~90 mm diameter
- Beam uniformity > 90 %

European Component Irradiation Facilities – PIF
Proton Irradiation Facility, Paul Scherrer Institut (PSI).

PIF Main Features

C) Low Energy PIF

- Initial Energies: 6 to 71 MeV
- Maximum Proton flux : 5E8 p/cm2/sec
- Beam spot ~50 mm diameter
- Beam uniformity > 90 %

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European Component Irradiation Facilities – HIF
Heavy-ion Irradiation Facility – UCL, Belgium.

Ion Cocktail M/Q=4.94	Energy MeV	Range µm Si	LET MeV(mg/cm²)
$^{10}B^{2+}$	41	80	1.7
$^{15}N^{3+}$	62	64	2.97
$^{20}Ne^{4+}$	78	45	5.85
$^{40}Ar^{8+}$	150	42	14.1
$^{84}Kr^{17+}$	316	43	34.0
$^{132}Xe^{26+}$	459	43	55.9
UCL – Ion Cocktail #1 produced for ESA			

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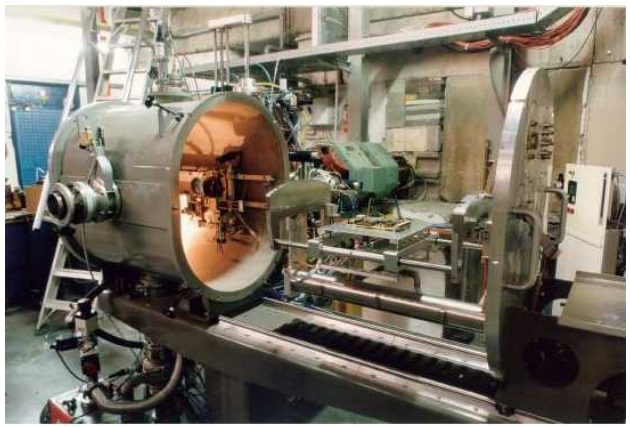

Ion Cocktail M/Q=3.3	Energy MeV	Range µm Si	LET MeV(mg/cm²)
$^{13}C^{4+}$	131	266	1.2
$^{22}Ne^{7+}$	235	199	3.3
$^{28}Si^{8+}$	236	106	6.8
$^{40}Ar^{12+}$	372	119	10.1
$^{58}Ni^{18+}$	567	98	20.6
$^{83}Kr^{25+}$	756	92	32.4
UCL – Ion Cocktail #2 produced for ESA 2004			

European Component Irradiation Facilities – RADEF
RADiation Effects Facility – Jyväskylä, Finland.

Ion Cocktail M/Q=3.7	Energy MeV	Range µm Si	LET MeV(mg/cm²)
$^{15}N^{4+}$	139	218	1.7
$^{20}Ne^{6+}$	186	149	3.5
$^{30}Si^{8+}$	278	132	6.0
$^{40}Ar^{12+}$	372	117	10.0
$^{56}Fe^{15+}$	523	99	18.0
$^{82}Kr^{22+}$	768	96	30.0
$^{131}Xe^{35+}$	1217	97	53.0
JYFL – Ion Cocktail produced for ESA April 2005			

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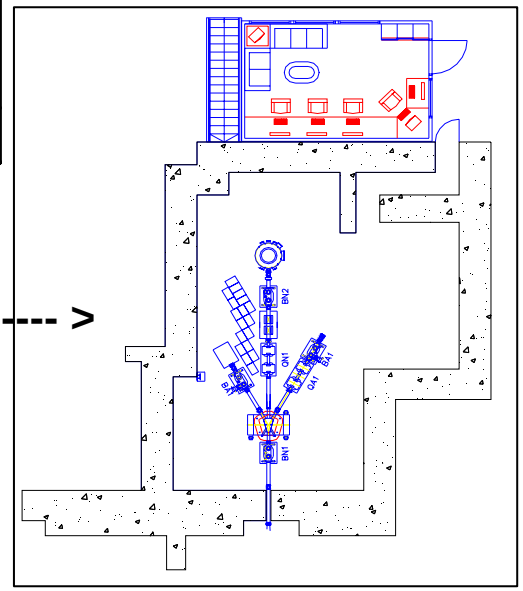
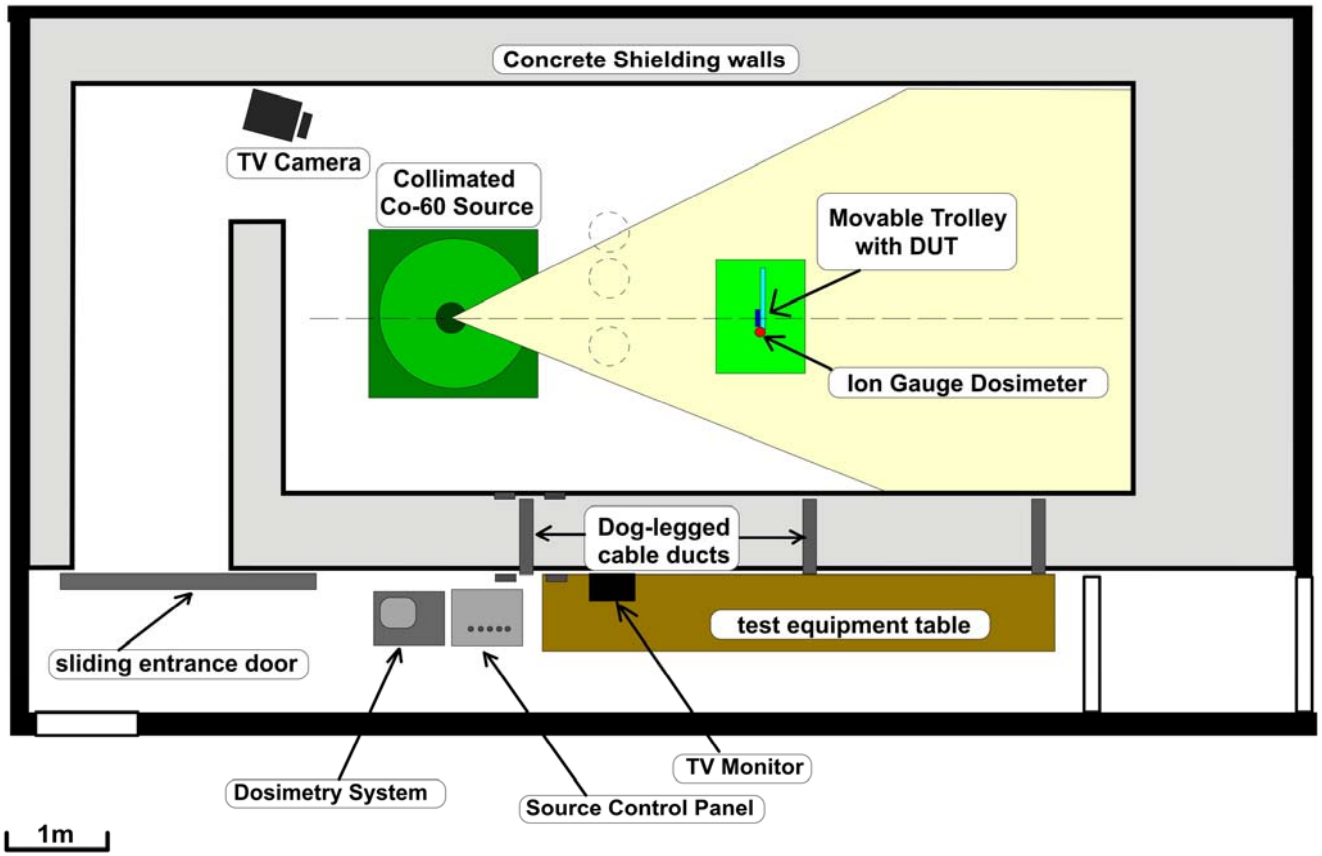
Proton beam line------ >

up to 65 MeV.



ESTEC - Radiation Effects and Analysis Techniques Section

European Component Irradiation Facilities – ESTEC TID (Co-60).



Estec 2000 Ci Co-60 Facility

DDR/DDRII SDRAM: Test Samples (Initial proposed)

- **SDRAM**
  - 256 M-bit/512M-bit
  - 3 manufacturer/3 types
  - 15 pc/manufacturer

- **DDR**
  - 256M-bit/1G-bit
  - 3 manufacturer/3 types
  - 15 pc/manufacturer

- **DDR II**
  - 256M-bit/2G-bit
  - 3 manufacturer/3 types
  - 15 pc/manufacturer

DDR/DDRII SDRAM: Radiation Test (Initial proposed)

- **SEE Heavy ion**
  - 3 Samples/Manufacturer/Type
  - Static Auto-refresh
  - Static Self-refresh
  - Dynamic
- **SEE Proton**
  - 3 Samples/Manufacturer/Type
  - Static Auto-refresh
  - Static Self-refresh
  - Dynamic
- **TID (Co-60)**
  - 5 + 1 Ref. Samples/Manufacturer/Type
  - TID Steps: 0, 10, 20, 30, 50, 70 & 100 Krad(Si)

To be completed in 2006

DDR/DDRII SDRAM: Support Activities

- **Tyndall National Institute, Ireland**
  - **Reverse Engineering of IC's**
- **MBDA, UK**
  - **Memory SEE Studies using Laser Techniques**
- **ONERA-DESP, France**
  - **Study of Hard Errors (Stuck Bits) in Memories**