WP07-JRA3, Cumulative radiation effects on electronics - Results of task 7.2: TID

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https://indico.cern.ch/event/1348465/

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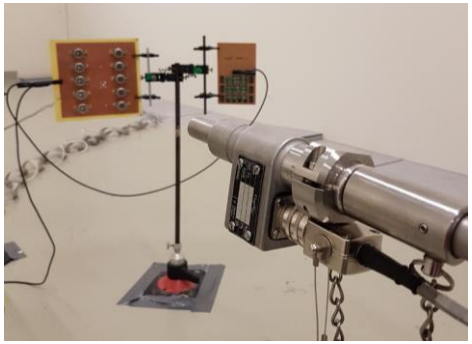
Nowaday TID testing

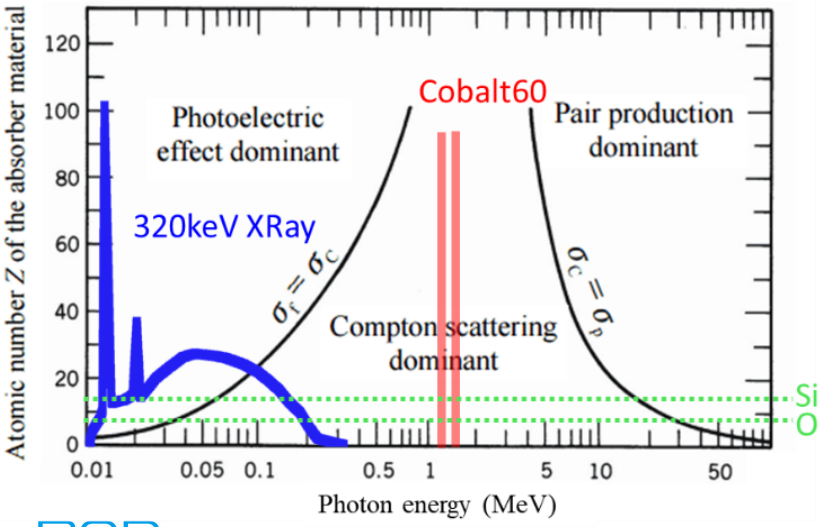
- To perform TID nowadays, we mainly use:

- Cobalt-60
- Cesion-137
- X-rays generator of 10keV

- From:

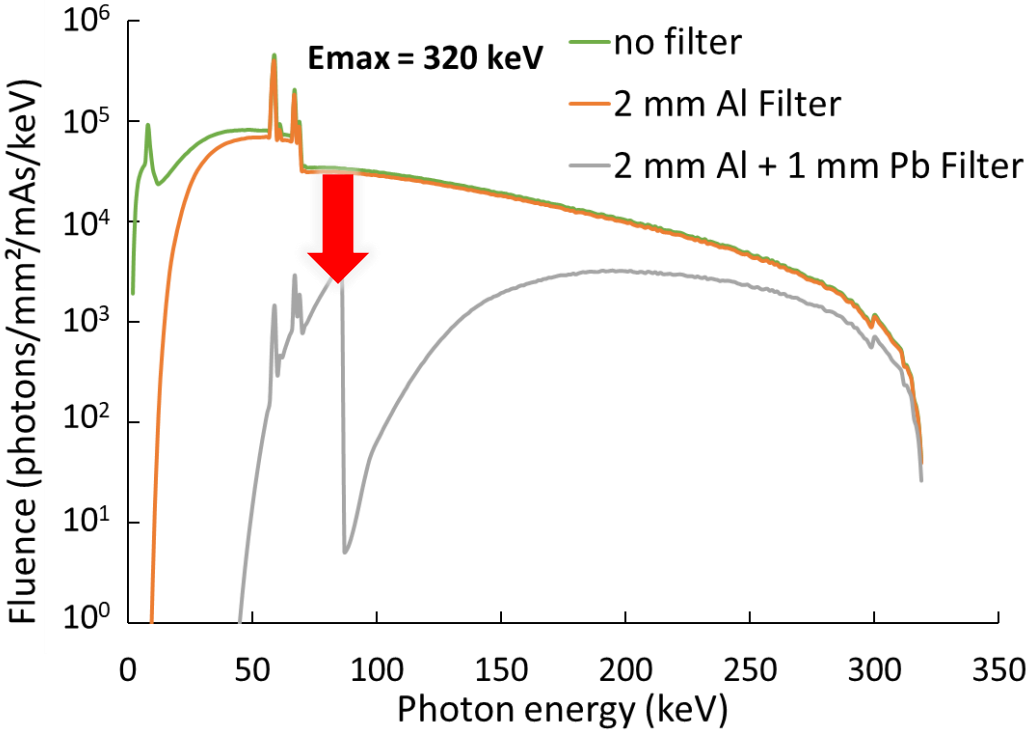
[MIL-STD-883,2004]
[ESA ESCC 22900, 2016]
[ASTM F 1892,1998]
[ASTM F 1467,2018]





Pros X-rays	Cons X-rays
easier radiation safety issues	lower energies
cheaper	→ But can be filtered !
easy to collimate	
higher dose rate reduced testing time	

X-rays spectrum filter simulation



Simulation performed with TASMICS

- 2 mm Al Filter:

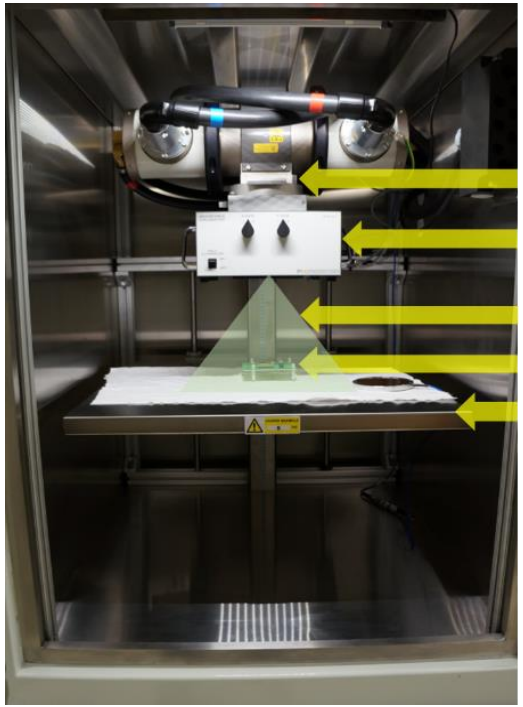
-Al is commonly use with X-rays in TID [*ASTM F1892*]

-Easier dosimetry without <20keV energies

- 2mm Al + 1 mm Pb Filter:

-The lead filter reduces low energies well below 100keV while only slightly altering high energies

Facilities and irradiation conditions



XRAD320 Facility

- 2 Cobalt 60 conditions to investigate the dose rate effect.
- 2 X-rays conditions to study the effect of filtering on the dose deposition in the components.

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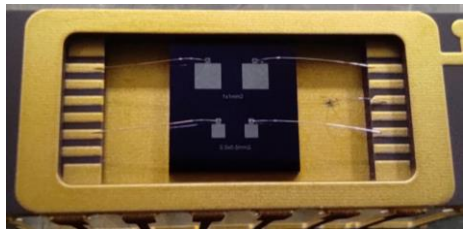
Irradiation conditions

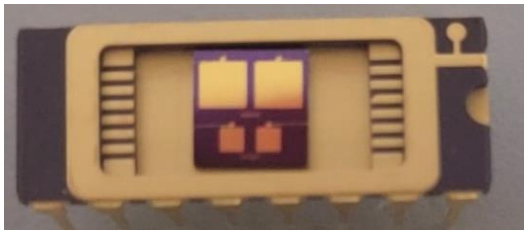
Condition	Type	Filter	Dose Rate	Length source-target
1	Cobalt-60	Nothing	5,57Gy(Air)/h	310 mm
2	Cobalt-60	Nothing	0,62Gy(Air)/h	1000 mm
3	X-rays	2 mm Al	15Gy(Air)/h	400 mm
4	X-rays	2 mm Al + 1 mm Pb	15Gy(Air)/h	400 mm

MOS Capacitor parameters

Mos Capacitor Parameters				
Parameter	**100 nm Large**	**100 nm Small**	**50 nm Large**	**100 nm Small**
Size (mm²)	2x2	1x1	2x2	1x1
Area (mm²)	4.00	1.00	4.00	1.00
Ox. thickness (nm)	100.00	100.00	50.00	50.00

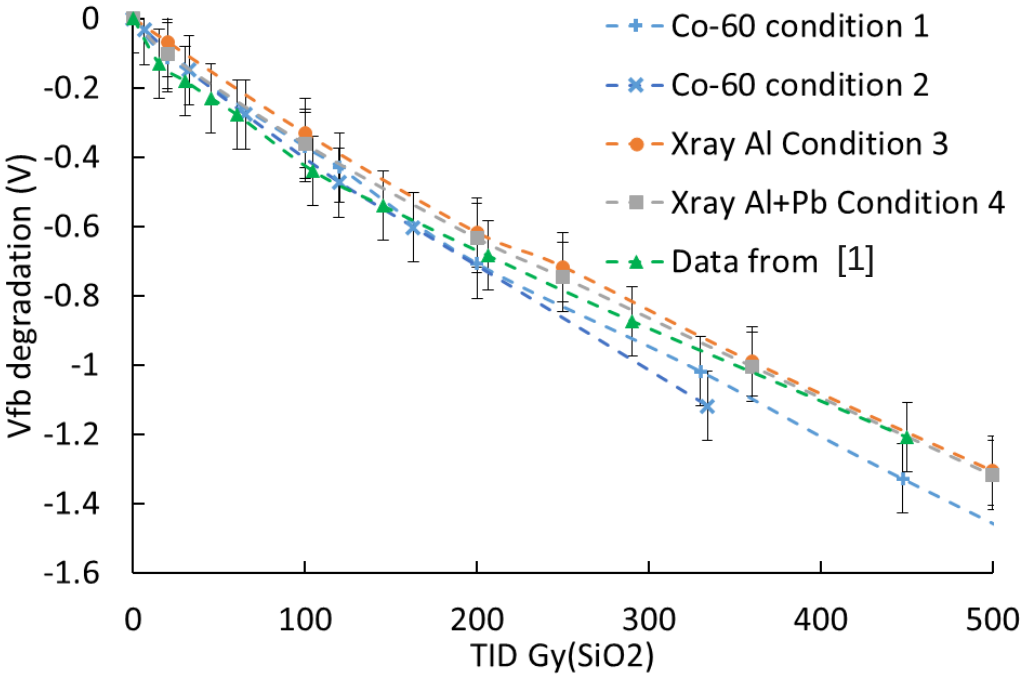


1µm Al metalization



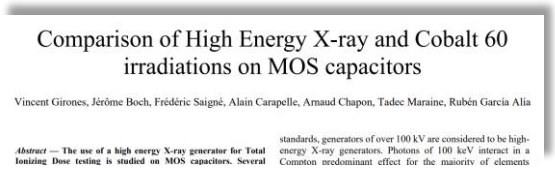
1µm Au metalization

MOS Capacitor results Al metallization



100 nm MOS capacitors with an area of 1x1 mm2 and Al metalization

- → High-energy X-rays show the same degradation as Co-60.
- → The use of lead filter gives the same results
- → Results presented at RADECS2023 and published in IEEE TNS.



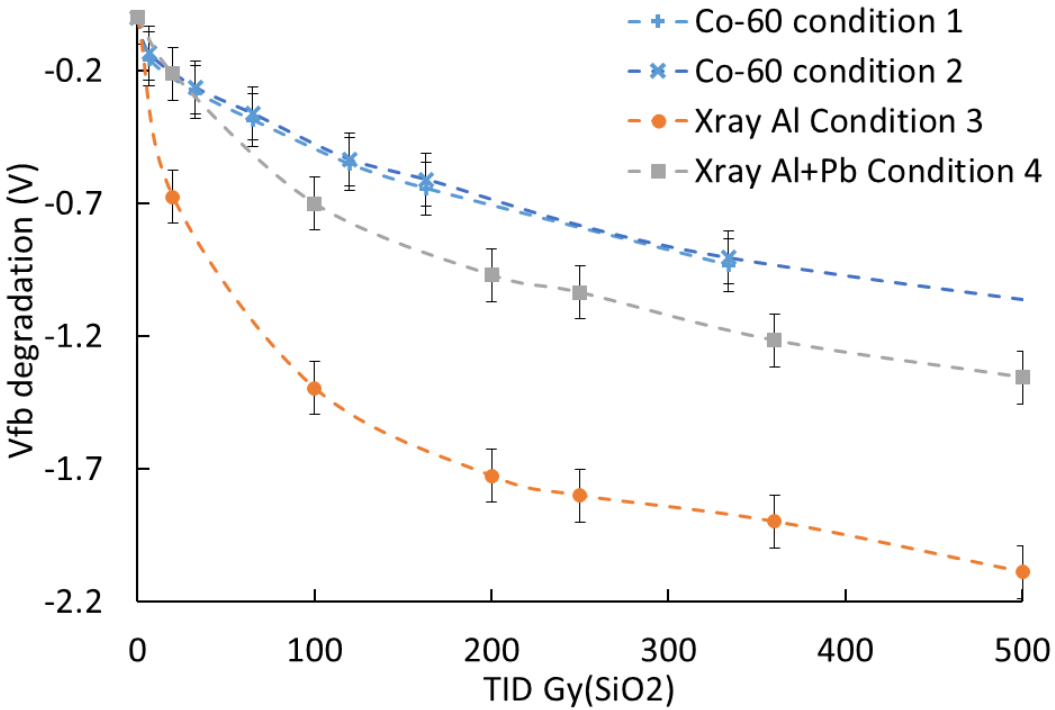
Comparison of High Energy X-ray and Cobalt 60 irradiations on MOS capacitors

Vincent Girones, Jérôme Boch, Frédéric Saigné, Alain Carapelle, Arnaud Chapon, Tadec Maraine, Rubén García Alía

Abstract — The use of a high energy X-ray generator for Total Ionizing Dose testing is studied on MOS capacitors. Several standards, generators of over 100 kV are considered to be high-energy X-ray generators. Photons of 100 keV interact in a Compton predominant effect for the majority of elements

[1] V. Girones et al., "Comparison of High Energy X-ray and Cobalt 60 irradiations on MOS capacitors," in IEEE Transactions on Nuclear Science, doi: 10.1109/TNS.2024.3366432

MOS Capacitor results Au metallization



100 nm MOS capacitors with an area of 1x1 mm2 and Au metalization

→ The use of complex materials (high Z) such as in BEOL (back end of Layers) increase the dose enhancement and therefore the differences between all conditions.

→ But which is greatly reduced with a lead filter.

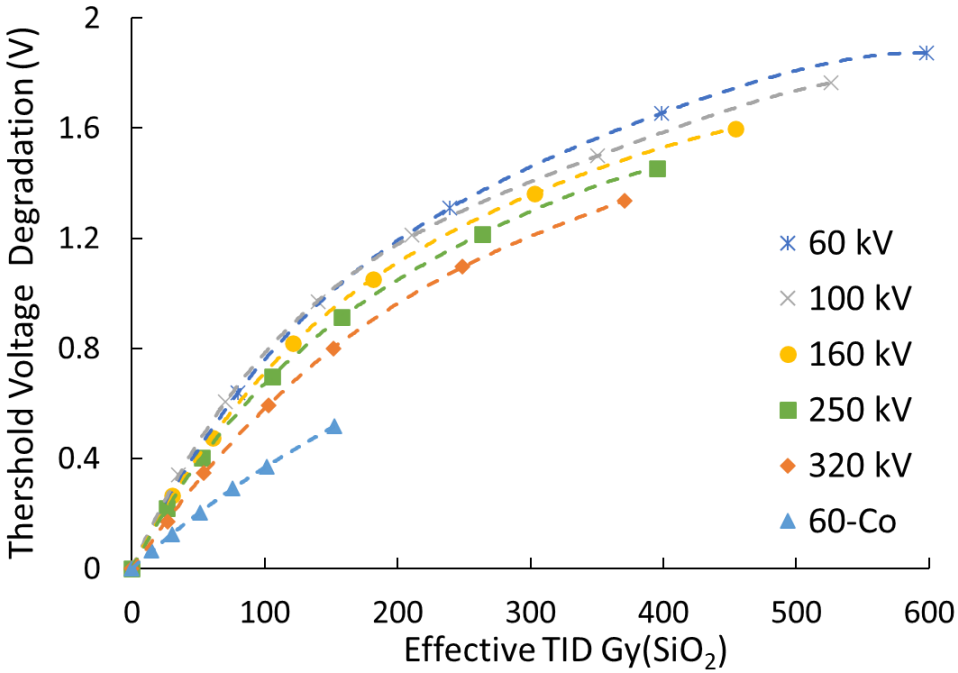
→ The results have been proposed for an abstract to RADECS 2024

Impact of gate metallization for Total Ionizing Dose Testing of MOS capacitors

Vincent Girones, Jérôme Boch, Damien Lambert, Frédéric Saigné, Tadec Maraine, Frederic Wrobel, Sylvain Girard, Alain Carapelle, Arnaud Chapon, Rubén García Alía

***Abstract*— The Total Ionizing Dose effect is studied on MOS capacitors for two metallization (aluminum and gold). Both high** Moreover, high energy X-ray generators offer the possibility to test packaged devices due to high penetration depths.

Results on generic MOS transistors

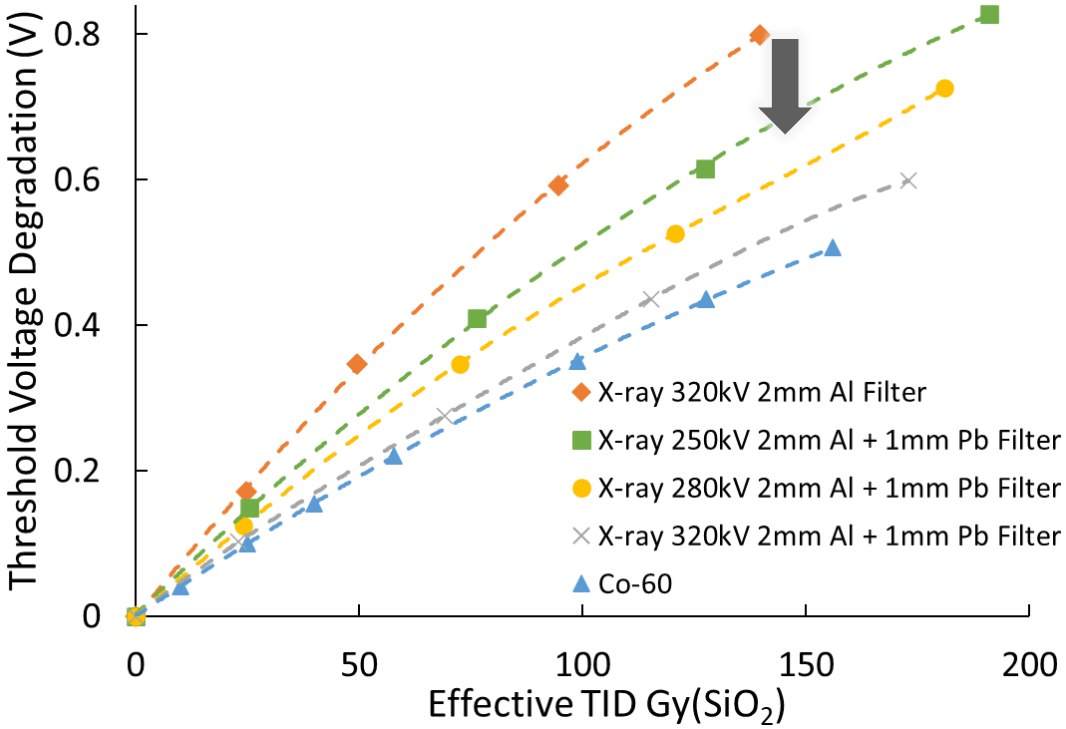


DMN601K NMOS

- There is a gap between the Co-60 result and X-rays results for our generics NMOS and PMOS.

→ But higher is the energy of the X-rays generator closer we are from the Co-60 result.

Results of filtered High energy X-rays

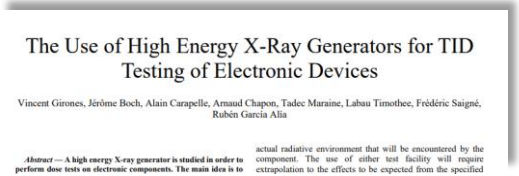


DMN601K NMOS

- There is a gap between the Co-60 result and X-rays results for our generics NMOS and PMOS.
- However, lead-filtered beam at 250 kV only, gives better result than 320 kV filtered with aluminum.

→ Filtering low-energy photons gives better results than simply increasing the energy of the X-rays generator.

→ Results presented at RADECS2022 and published in IEEE TNS.

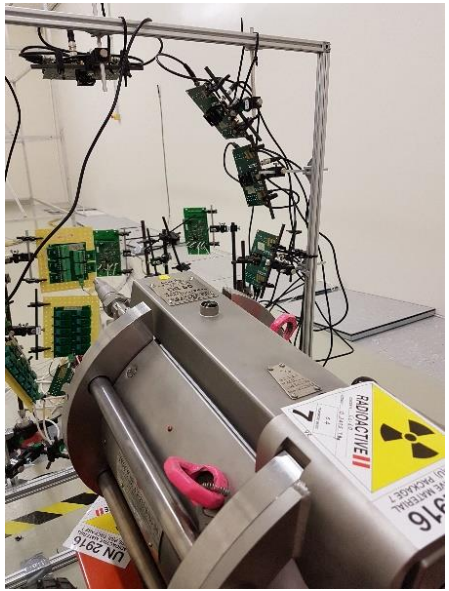


The Use of High Energy X-Ray Generators for TID Testing of Electronic Devices

Vincent Girones, Jérôme Boch, Alain Carapelle, Arnaud Chapon, Tadec Maraine, Labau Timothee, Frédéric Saigné, Rubén García Alía

Abstract — A high energy X-ray generator is studied in order to perform dose tests on electronic components. The main idea is to actual radiative environment that will be encountered by the component. The use of either test facility will require extrapolation to the effects to be expected from the specified

Thanks for your attention!



Cobalt 60 Irradiator
Source: UM

3.5 MeV e-beam Accelerator
Source: ATRON

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