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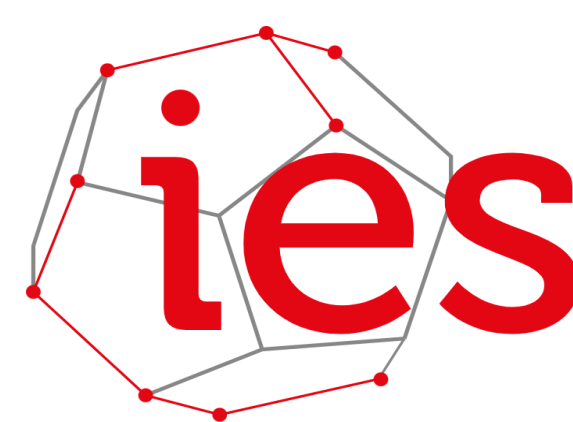
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Comparison of High Energy X-rays and Cobalt 60 irradiations on MOS capacitors

Vincent Girones¹, Jérôme Boch¹, Frédéric Saigné¹, Alain Carapelle², Arnaud Chapon³, Tadec Maraine¹, Rubén García Alía⁴.

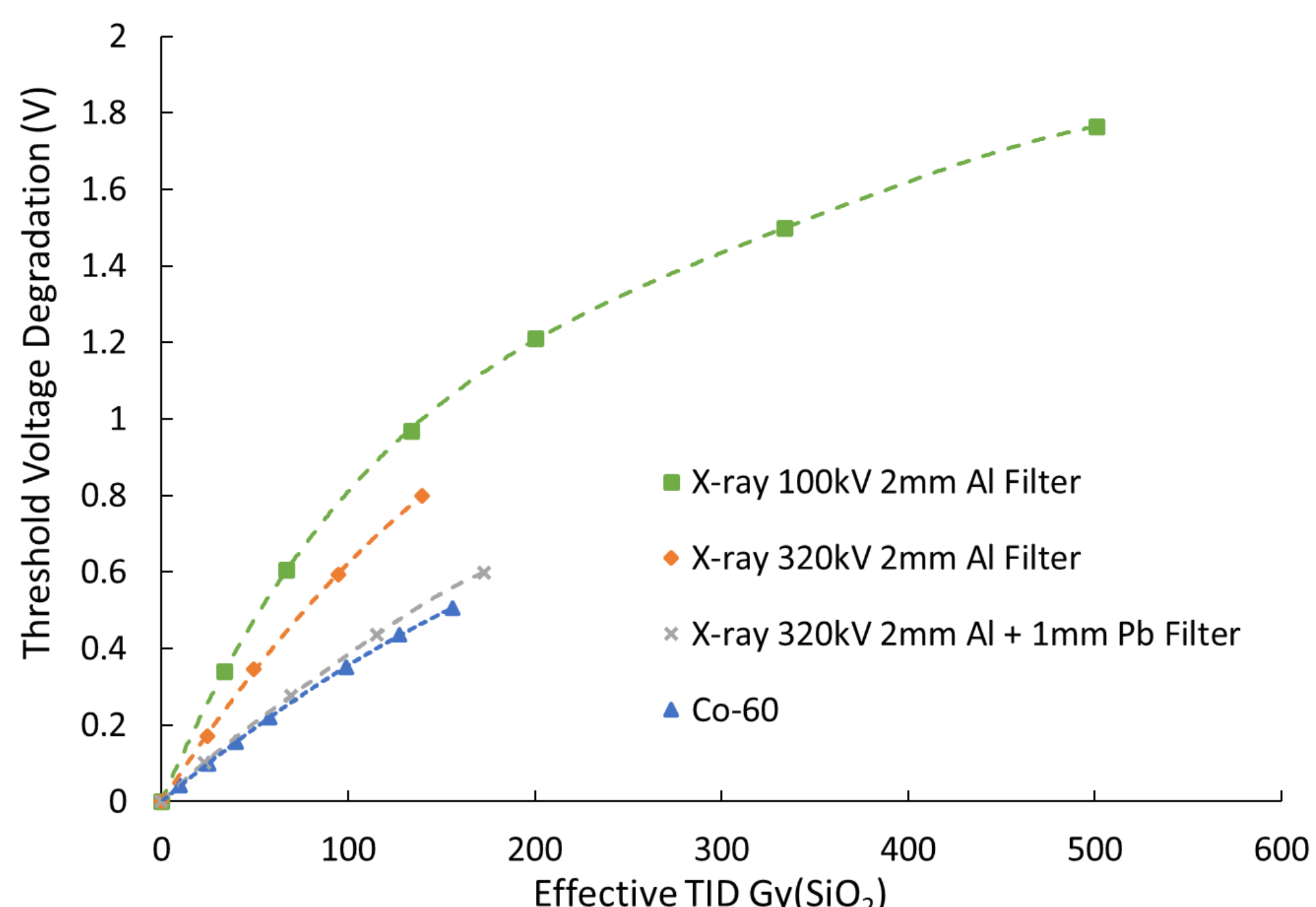
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PROJET COFINANÇÉ PAR LE FONDS EUROPÉEN DE DÉVELOPPEMENT RÉGIONAL

Introduction



Threshold voltage degradation versus effective TID for DMN601K NMOS transistors for the four investigated irradiation conditions

The use of a high energy X-rays generator has recently been proposed to performed TID testing [1]

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

The results showed a gap in cobalt-60 and high energy X-rays

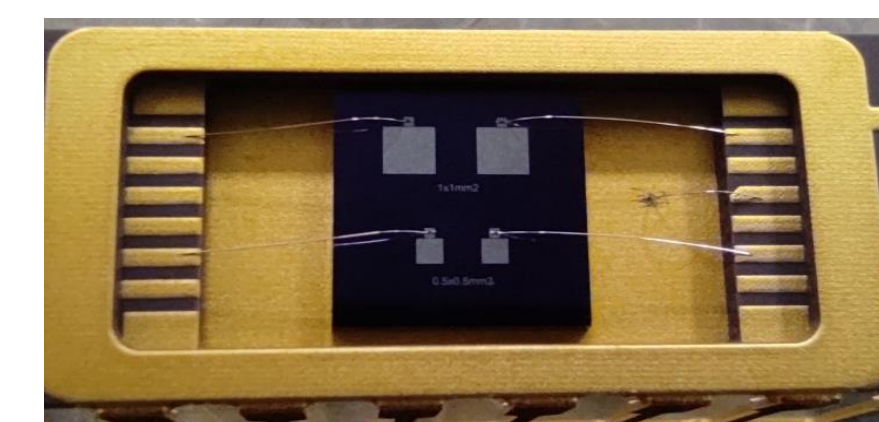
↳ The gap is reduced when high energy photons is used and when the X generator is filtered with lead

Tests were performed on commercial generic NMOS, PMOS and BJT devices.

↳ This allows the extraction of certain physical parameters

➔ Perform the same study on custom components; **MOS capacitor**. Where technological parameters are known

PMOS capacitor from LAAS



[1] V. Girones et al., "The Use of High-Energy X-Ray Generators for TID Testing of Electronic Devices," in IEEE TNS

Experimental parameters

Specific capacitors manufactured at LAAS:

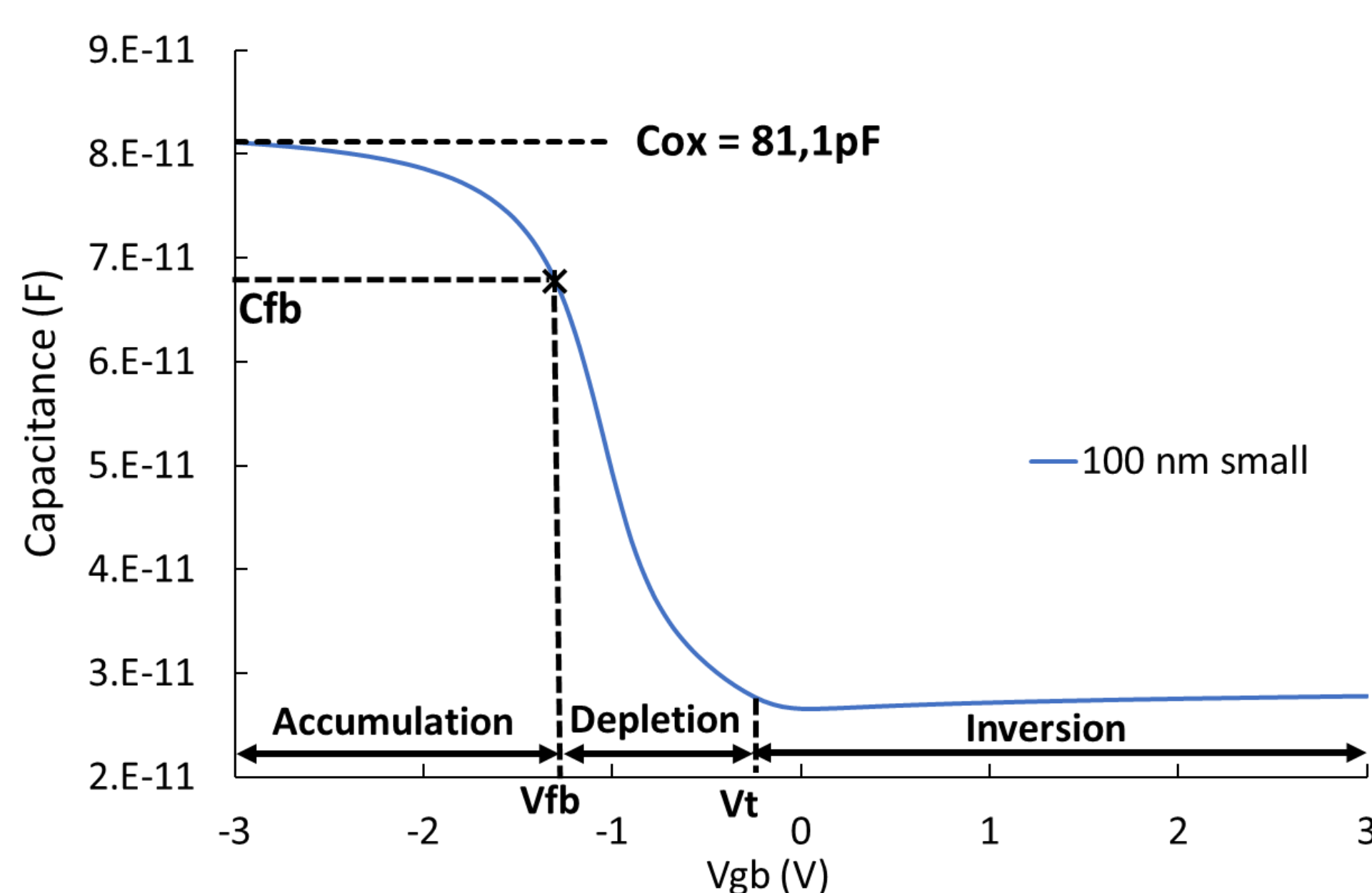
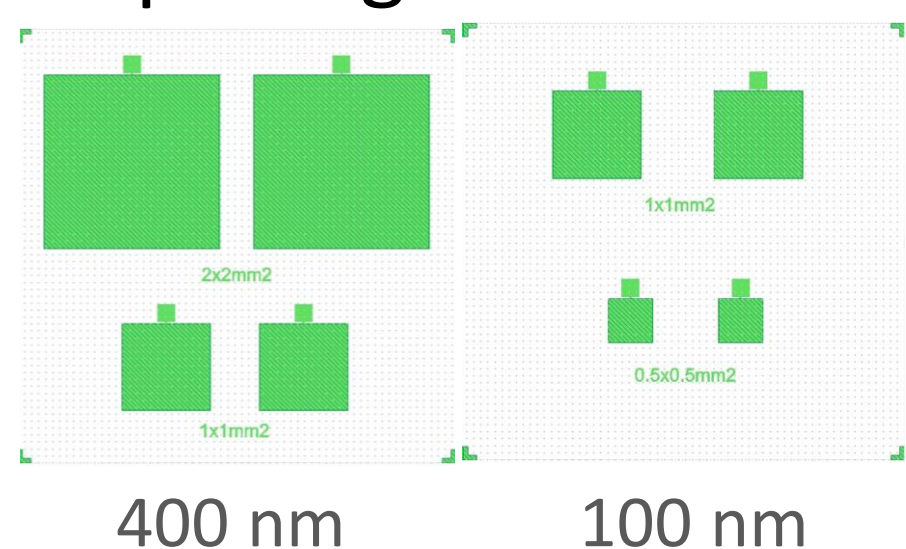
Build conditions	400n Large	400n Small	100n Large	100n Small
Size (mm ²)	2x2	1x1	1x1	0.5x0.5
Area (mm ²)	4.00	1.00	1.00	0.25
Al thickness (μm)	1.00	1.00	1.00	1.00
Ox. thickness (nm)	400.00	400.00	100.00	100.00
Ox. capacity (pF)	345.15	86.29	345.15	86.29

The following conditions are considered for TID study:

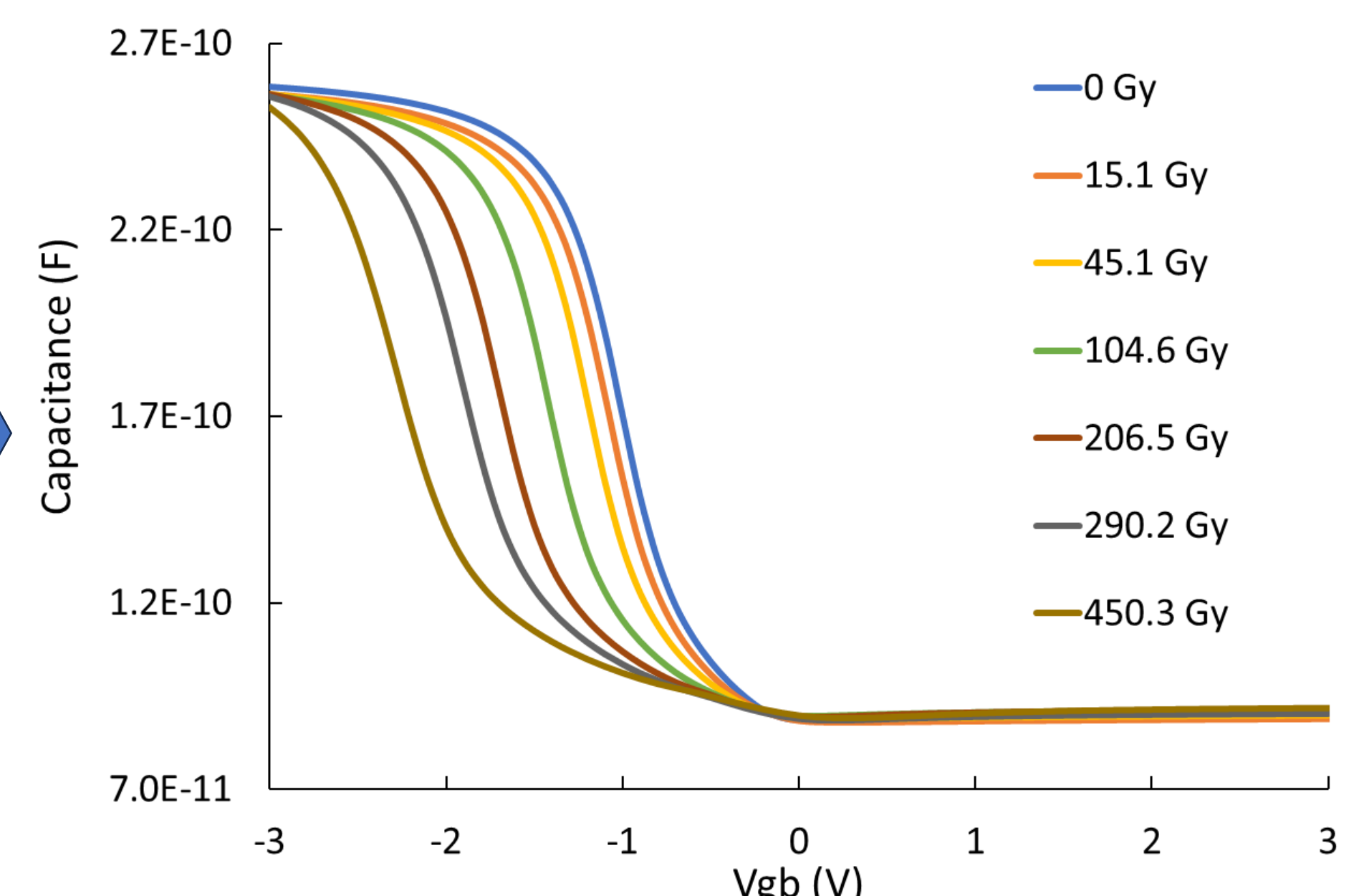
Type	Filter	Dose rate	Lenght Source-Target	Conditions n°
Cobalt-60	Nothing	0,15 Gy(Air)/h	1920 (mm)	1
Cobalt-60	Nothing	0,62 Gy(Air)/h	1000 (mm)	2
Cobalt-60	Nothing	5,28 Gy(Air)/h	330 (mm)	3
X-ray	2mm Al	30 Gy(Air)/h	400 (mm)	4
X-ray	2mm Al + 1mm Pb	30 Gy(Air)/h	400 (mm)	5

Parameters:

- P-type substrate
- SiO₂ oxide
- Aluminum metallization
- 2 capacitor surfaces
- 2 thickness 400nm & 100nm
- 4 MOS capacitors in a package, 20 packages studied

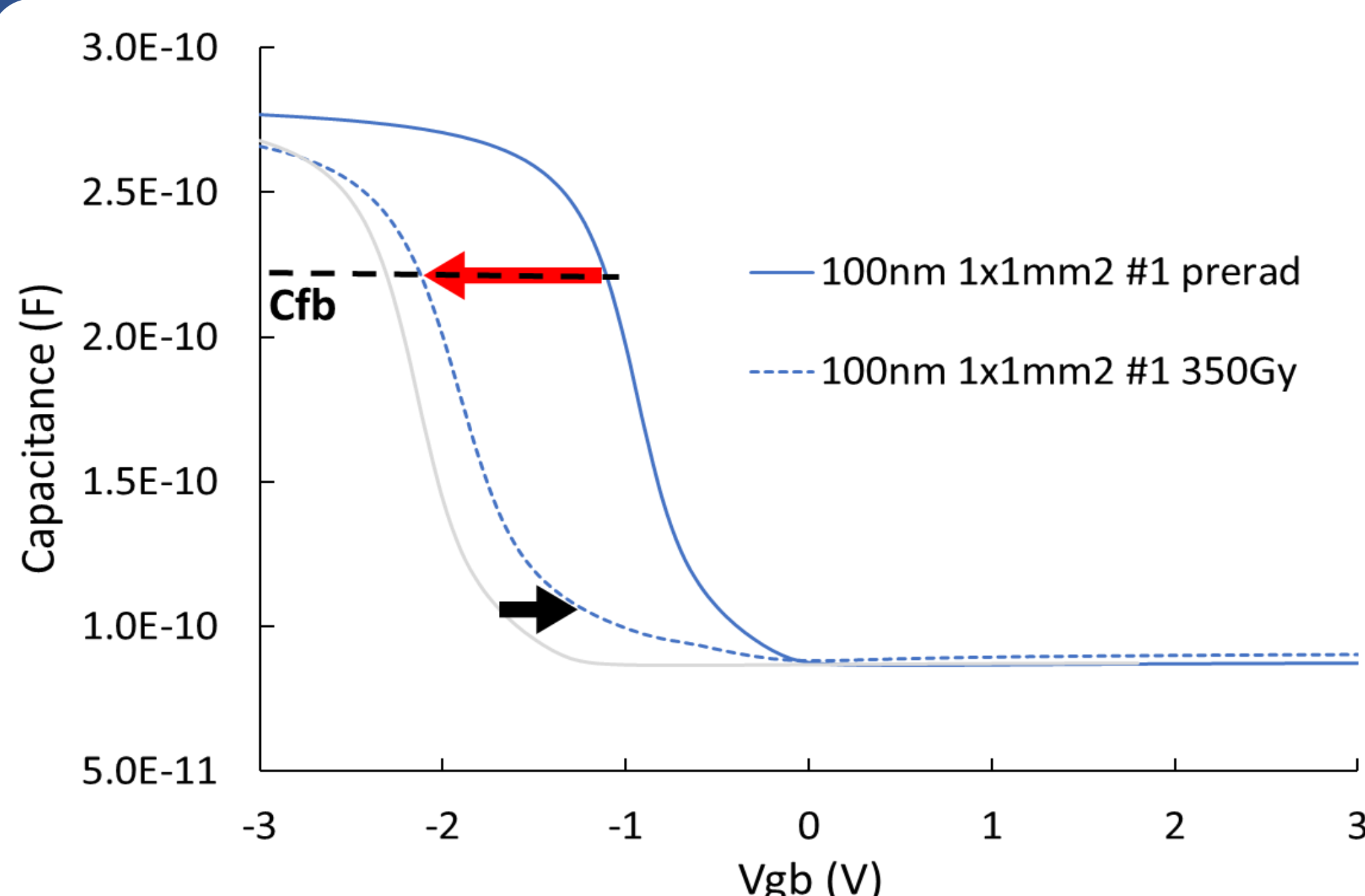


Standard C/V on 100 nm small MOS capacitors with 3 parameters extraction (Cfb, Vfb, Cox)



Dose effect for irradiation condition 2 on a 100 nm large MOS capacitor

Results



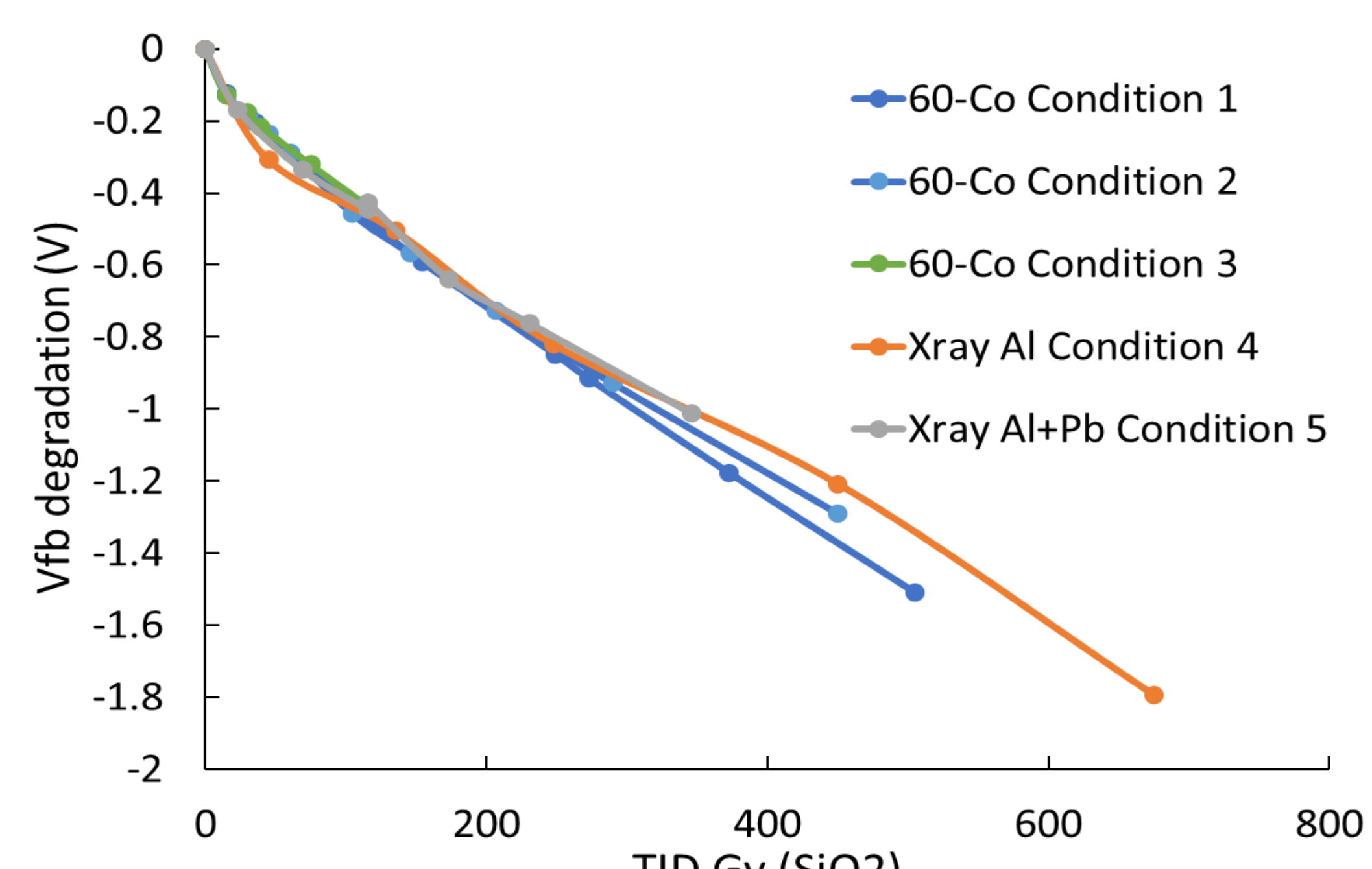
Standard TID effect on C/V for a MOS capacitor. 100 nm large with condition 5 350Gy(SiO₂) total dose

- Two effects are observed:
 - ← : shift of the flatband voltage
 - ↳ oxide trapped charges
 - : widening of the depletion region
 - ↳ interface trapped charges

We compare the prerad data with the measurements made at several irradiation points

The extracted data shows:

- Strong variation of the flatband voltage
- a slight change in the width of the depletion region



Comparison of the five irradiations comparison on 100 nm MOS capacitors large

Conclusion

For all the investigated devices, **no particular difference between the several irradiation conditions were observed**. This means that a high energy X-rays irradiation with a lead filter leads to the same degradation as 60-Co irradiation for the investigated MOS capacitors. This lack of gap between X-ray and Cobalt irradiations is explained by the structure of the studied components. Indeed, the MOS capacitors were manufactured with only one thin aluminum layer on the top of the oxide.