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

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https://indico.cern.ch/e/radnext-2023

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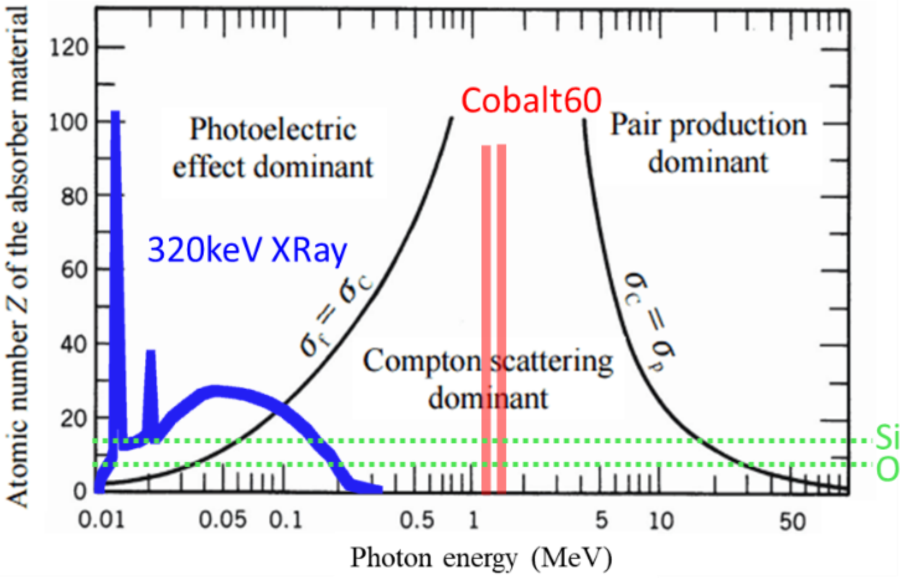
Brief reminder of the objective

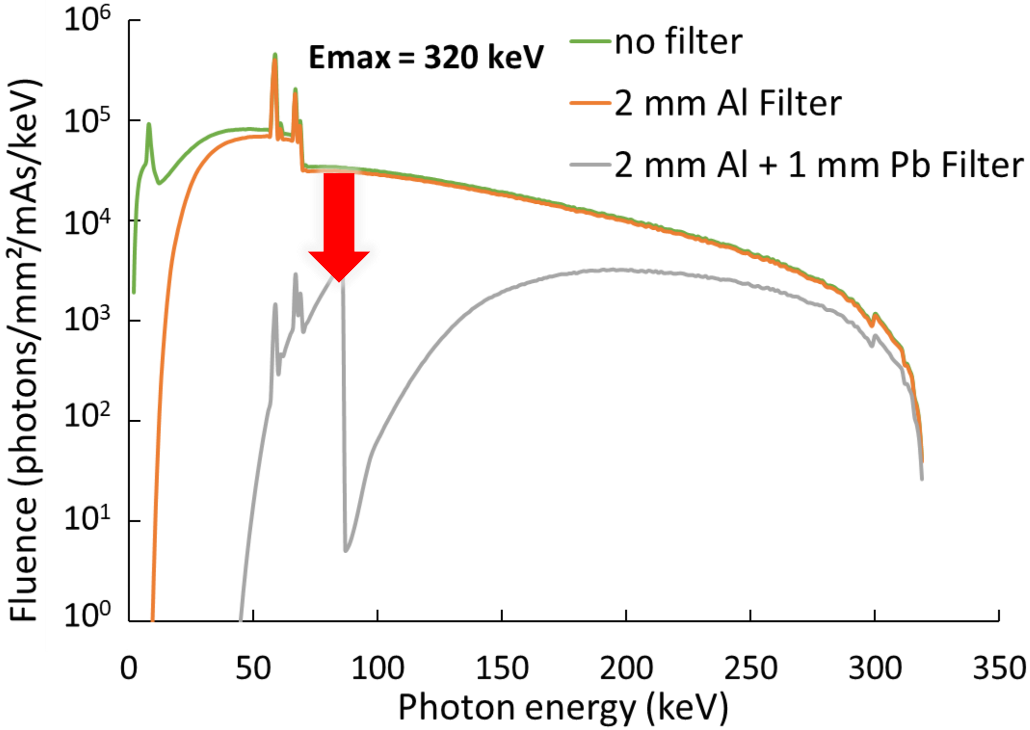
- Demonstrate the feasibility of using high-energy X-ray generators for TID testing of electronic devices (in comparison to cobalt60) and Determine the useful parameters (energy, filters…)

- Pros X-ray:
  - easier radiation safety issues
  - cheaper
  - easy to collimate
  - higher dose rate offering reduced testing time
- Cons X-ray:
  - lower energies

→ **But can be filtered !**



X-ray spectrum simulation



Simulation performed with TASMICS

- 2 mm Al Filter:

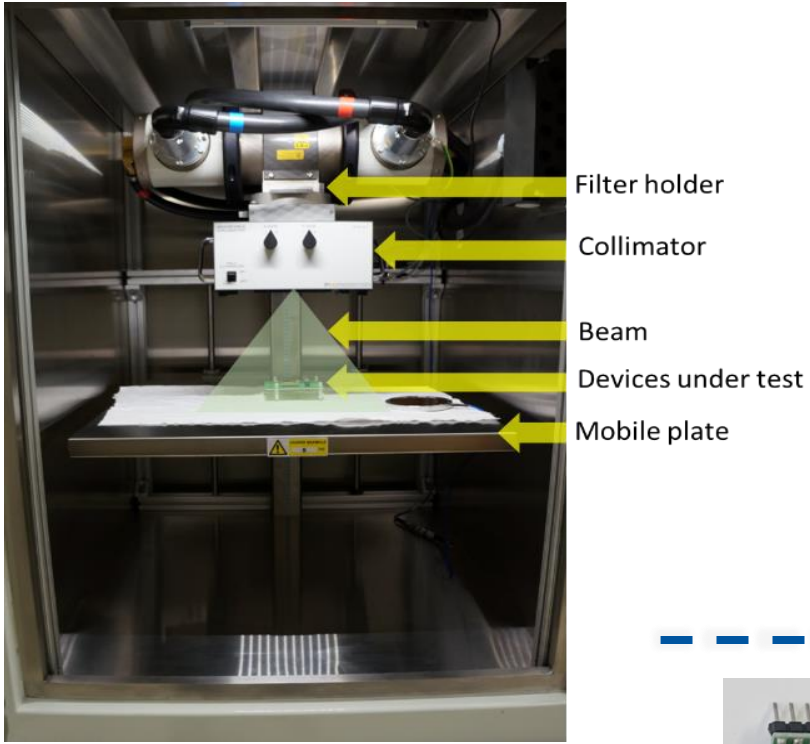
-Al is commonly use with X-ray in TID [*ASTM F1892*]

-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

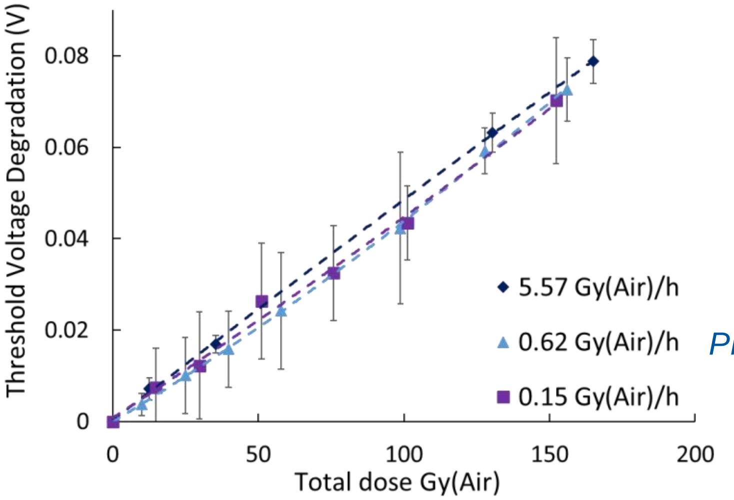
- 3 Cobalt 60 conditions to investigate there is no dose rate effect.
- 2 X-ray conditions to study the effect of filtering on the dose deposit in the components.

Irradiation conditions

Type	Filter	Dose Rate	Length source-target
Cobalt-60	Nothing	5,57Gy(Air)/h	310 mm
Cobalt-60	Nothing	0,62Gy(Air)/h	1000 mm
Cobalt-60	Nothing	0,15Gy(Air)/h	2000 mm
X-ray	2 mm Al	15Gy(Air)/h	400 mm
X-ray	2 mm Al + 1 mm Pb	15Gy(Air)/h	400 mm

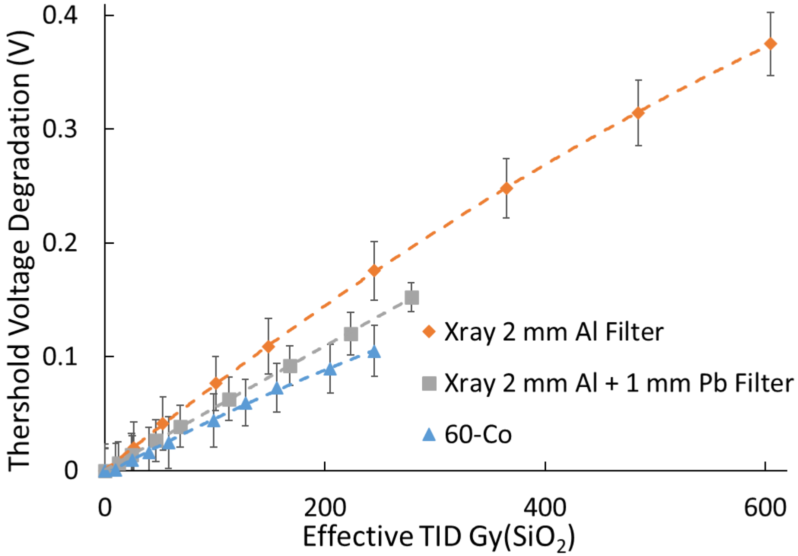
Generic SOT23 NMOS (DMN601K) & PMOS (DMP2004)

WP7 Task 7.2: first obtained results



Our generic NMOS and PMOS do not seem sensitive to Dose Rate in our working range

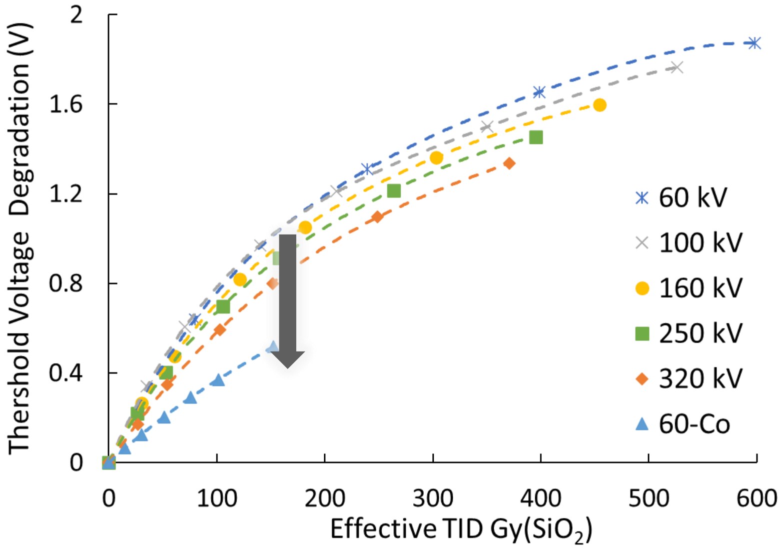
PMOS Transistors



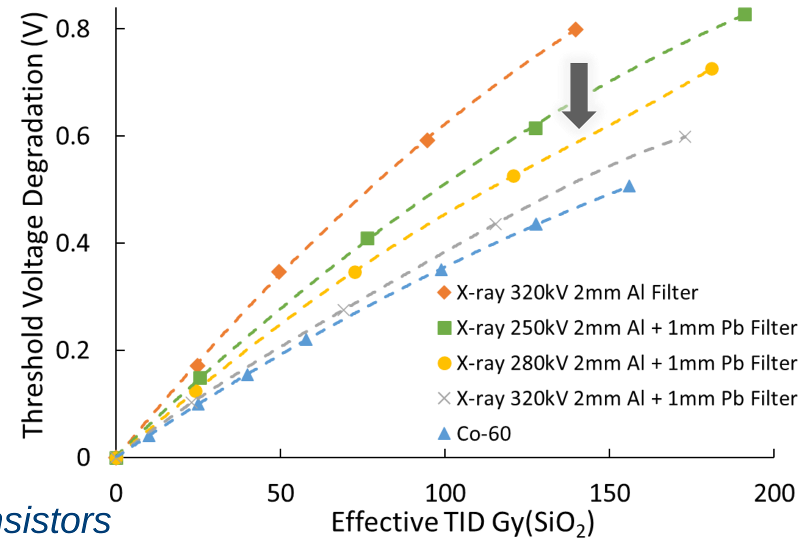
A difference can be observed between high energy Xray and Cobalt-60.
→ But which is greatly reduced with a lead filter

WP7 Task 7.2: main obtained results

The use of high energy X-rays generator

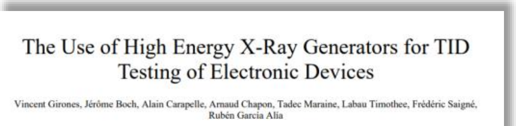


The use of filters



NMOS transistors

- We can get closer to the degradation obtained with cobalt by using an X-ray generator: we have to use (left) a high voltage for the generator, and (right) filters to cut low energy photons.
- Results presented at RADECS2022 and submitted to IEEE TNS.


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

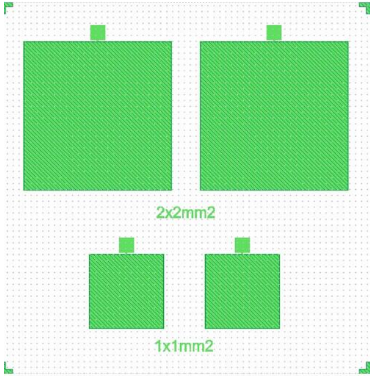
Vincent Girones, Jérôme Boch, Alain Carapelle, Arnaud Chapon, Tadec Maraine, Labau Timothee, Frédéric Saigné, Rubén Garcia Alia

MOS Capacitor parameters

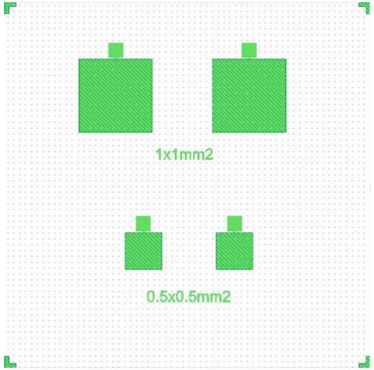
Mos Capacitor Parameters				
Parameter	**400n Large**	**400n Small**	**100n Large**	**100n Small**
Area (mm²)	4.00	1.00	1.00	0.25
Ox. thickness (nm)	400.00	400.00	100.00	100.00
Ox. capacity (pF)	345.15	86.29	345.15	86.29

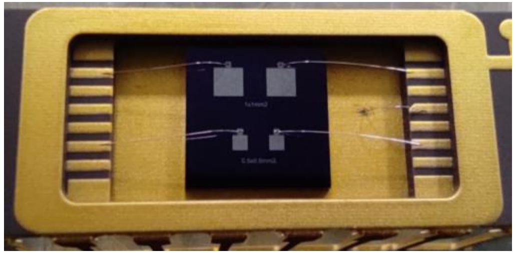
Masks:

400nm



100nm





MOS Capacitor results

- C/V characterization Mos capacitor:

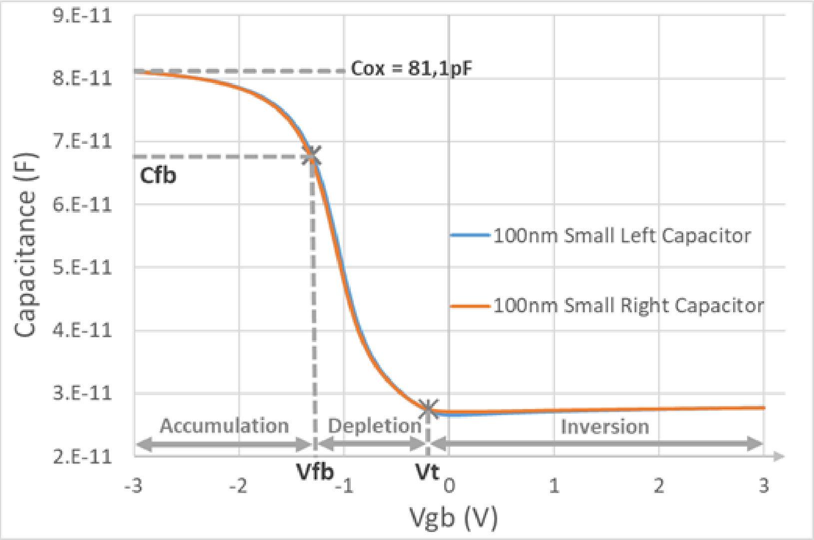
- 3 modes : accumulation, depletion, and inversion

- 3 extracted parameters: Cox, Cfb, Vfb

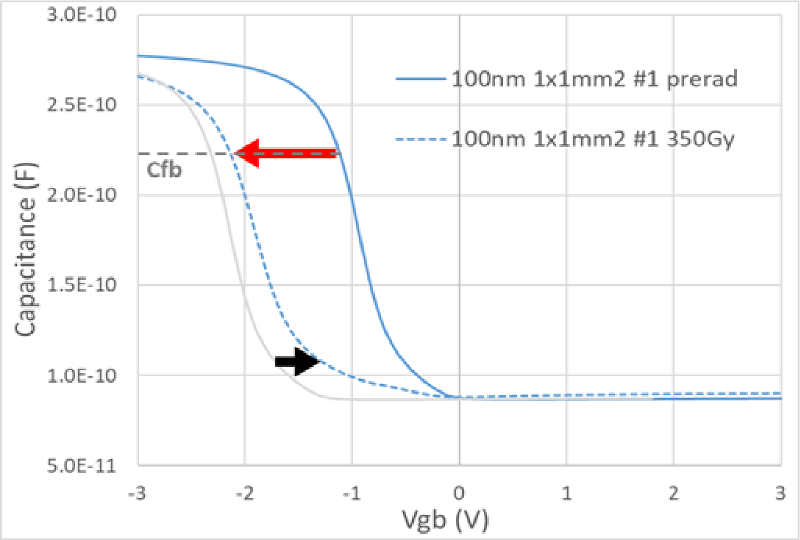
- Dose effect on Mos capacitor:

🡐 Flatband voltage drift : Oxyde trapped charges

→ Change of gradient: Interface trapped charges



PMOS Capacitor (400 nm Oxyde 1 mm² area)



PMOS Capacitor (100 nm Oxyde 1 mm² area)

WP7 Task 7.2: plans for the next months

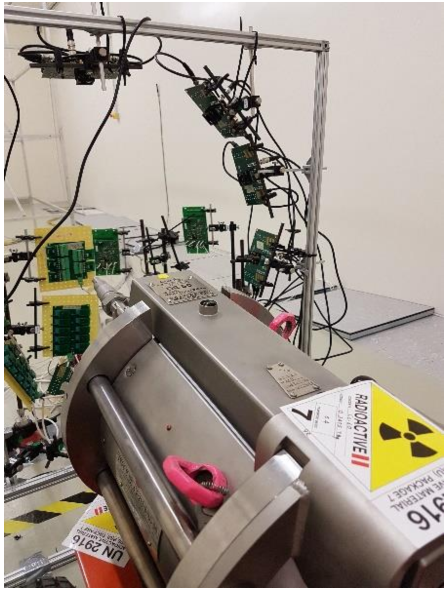
- Validate the obtained results on more components:
  - ✓ dedicated MOS capacitors from LAAS to extract physical information,
  - ✓ more complex devices (in link with WP6),
  - ✓ dosimeters (in link with WP5), …),

- Irradiation with higher energy photons up to 3.5MeV (ATRON accelerator),

- Geant4 and/or Fluka simulation (in link with WP8) to study the low energy photons attenuation in packages or upper layers of a devices.

- Writing the first milestone “X-ray ATRON Facility modelling”

Thanks for your attention!



Cobalt 60 Irradiator
Source: UM

3.5 MeV e-beam Accelerator
Source: ATRON