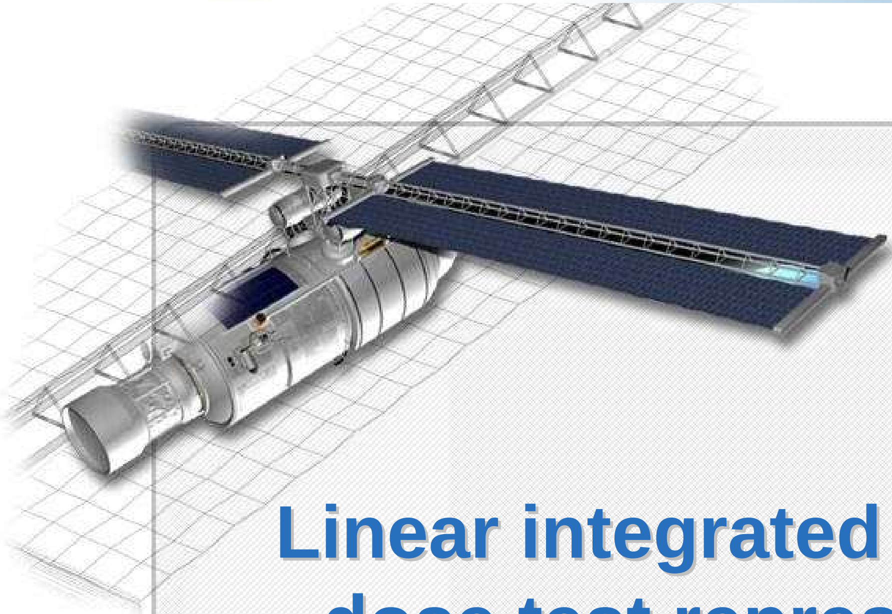


Linear integrated circuit cumulated dose test representativeness for high energy electron environment applications

Anne Samaras

Purpose of the study

The aim of the study is to evaluate the representativeness of usual cumulated dose test procedures for device qualification used for severe electron space environment applications

Devices under test

The devices under test are four Linear devices from National Semicondutor

Type	Function	Manufacturer	Qual. level
LM139J	Volt. comparator	National Semi.	Commercial
LM111H	Volt. comparator	National Semi.	Commercial
LM117H	Volt. regulator	National Semi.	Commercial
LM124AWG	Op. amplifier	National Semi.	Radhard ELDRS 100 krad

Electrical Parameters Tested

Parameter	LM139J	LM111H	LM117H	LM124AWG
Icc	x	x		x
±Iib	x	x		x
Iio	x	x		x
Vio	x	x		x
CMRR	x	x		x
PSRR	x			x
Avs				x
Isink	x			
Vsat	x			
Iadj			x	
Vref			x	
Vrline			x	
Vrload			x	

Irradiation Test Conditions

- **The aim of the test campaign is to compare the degradation measured under ^{60}Co and neutron irradiation to the effects of a high energy electron beam**

Source	Degradation	Place	Facility
^{60}Co	TID	Louvain-La-Neuve (Belgium)	UCL
Neutron	TNID	Mol (Belgium)	SCK CEN
Electron	Both TID and TNID	Orsay (France)	IPN

Irradiation Test Conditions

- $TNID_{electron} = TNID_{1MeV\ neutron}$
  - NIEL values calculated with NEMO (ONERA/DESP)
  - $Fluence_{electron} \Rightarrow Equivalent\ Fluence_{1MeV\ neutron}$

- $Flux_{electron} = 1.10^9 cm^{-2}.s^{-1}$ for the 3 commercial devices
- $Flux_{electron} = 3.10^9 cm^{-2}.s^{-1}$ for the radhard device
- $Flux_{1MeV\ neutron} = 2{,}86.10^8 cm^{-2}.s^{-1}$

Irradiation Test Conditions

- $TID_{electron} = TID_{^{60}Co}$
  - electron LET calculated with ESTAR (NIST)
  - $Fluence_{electron}$ ⇨ Equivalent $TID_{^{60}Co}$
- Dose $rate_{electron} = 60\ rad.s^{-1}$ for the 3 commercial devices
- Dose $rate_{electron} = 170\ rad.s^{-1}$ for the radhard device
- Dose $rate_{^{60}Co} = 230\ rad.h^{-1} = 6.4\ 10^{-2}\ rad.s^{-1}$

Irradiation Test Conditions

LM139J, LM111H and LM117H Irradiation Test Plan

e45MeV Fluence cm^{-2}	e45MeV Energy MeV	e45MeV TNID $MeV.g^{-1}$	e45MeV TID krad
0	45	0	0
$1,80.10^{11}$	45	$2,39.10^{7}$	10.3
$2,70.10^{11}$	45	$3,59.10^{7}$	15.5
$3,50.10^{11}$	45	$4,66.10^{7}$	20.0
$4,70.10^{11}$	45	$6,25.10^{7}$	26.9
$6,70.10^{11}$	45	$8,91.10^{7}$	38.4
$8,80.10^{11}$	45	$1,17.10^{8}$	50.4

n1MeV Fluence cm^{-2}
0
$2,10.10^{10}$
$3,15.10^{10}$
$4,08.10^{10}$
$5,48.10^{10}$
$7,82.10^{10}$
$1,03.10^{11}$

^{60}Co TID krad
0
10
15
20
Not done
38
50

Irradiation Test Conditions

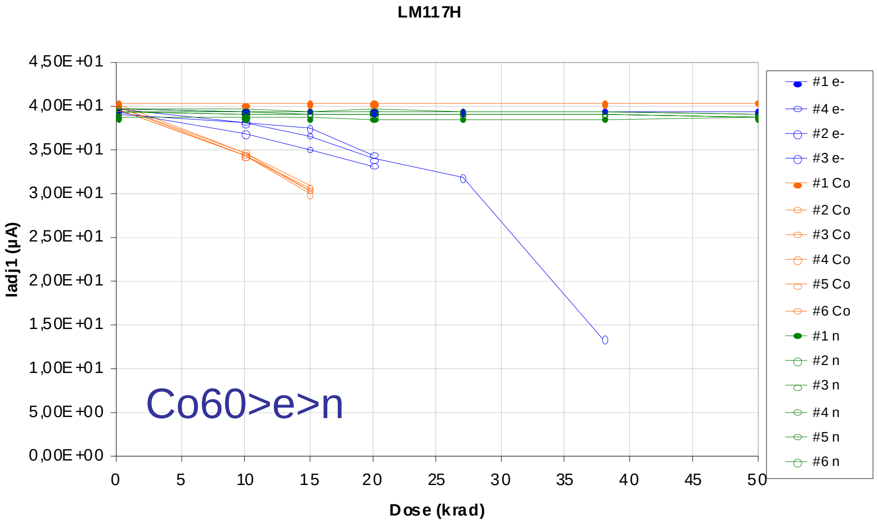
LM124AWG Irradiation Test Plan

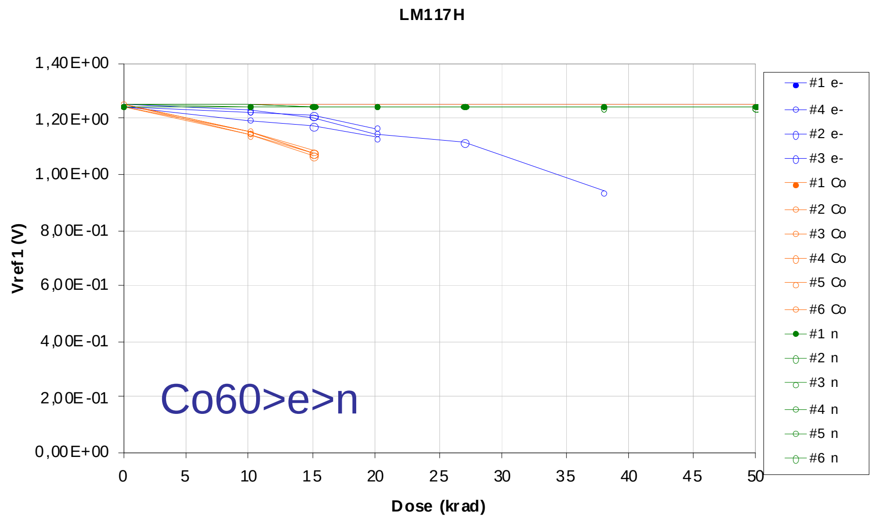
e45MeV Fluence cm^{-2}	e45MeV Energy MeV	e45MeV TNID $MeV.g^{-1}$	e45MeV TID krad
0	45	0	0
$8,80.10^{11}$	45	$1,17.10^{8}$	50
$8,80.10^{11}$	52	$1,20.10^{8}$	55
$1,23.10^{12}$	45	$1,64.10^{8}$	71
$1,75.10^{12}$	45	$2,33.10^{8}$	100
$1,75.10^{12}$	45	$2,35.10^{8}$	105
$2,62.10^{12}$	45	$3,48.10^{8}$	150

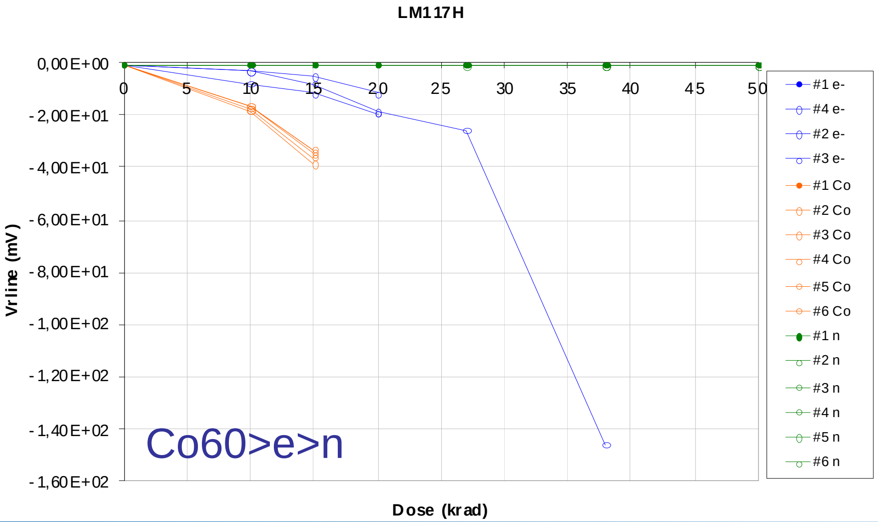
n1MeV Fluence cm^{-2}
0
$1,03.10^{11}$
$1,05.10^{11}$
$1,44.10^{11}$
$2,04.10^{11}$
$2,06.10^{11}$
$3,06.10^{11}$

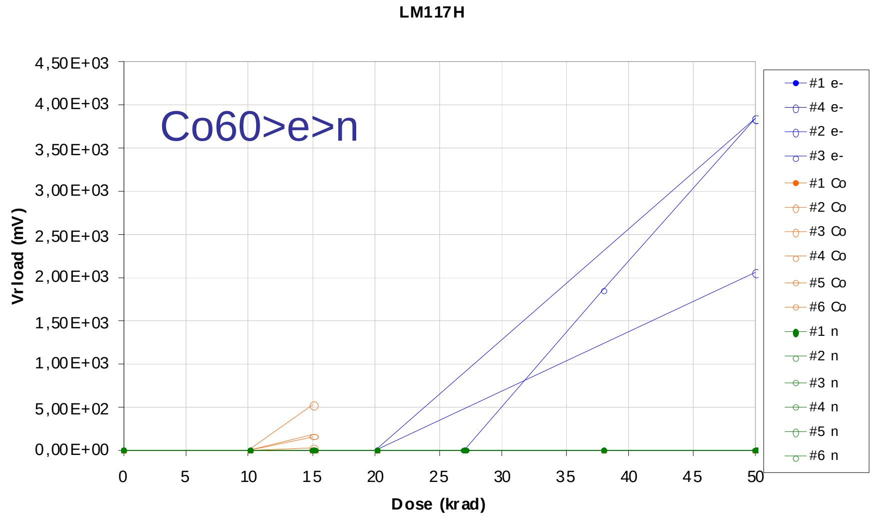
^{60}Co TID krad
0
50
55
71
76
109
149

LM117H Test Results

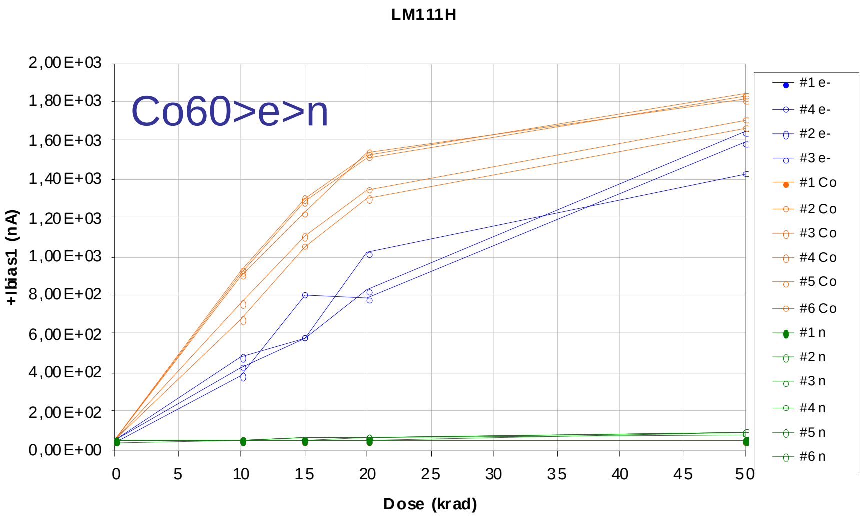


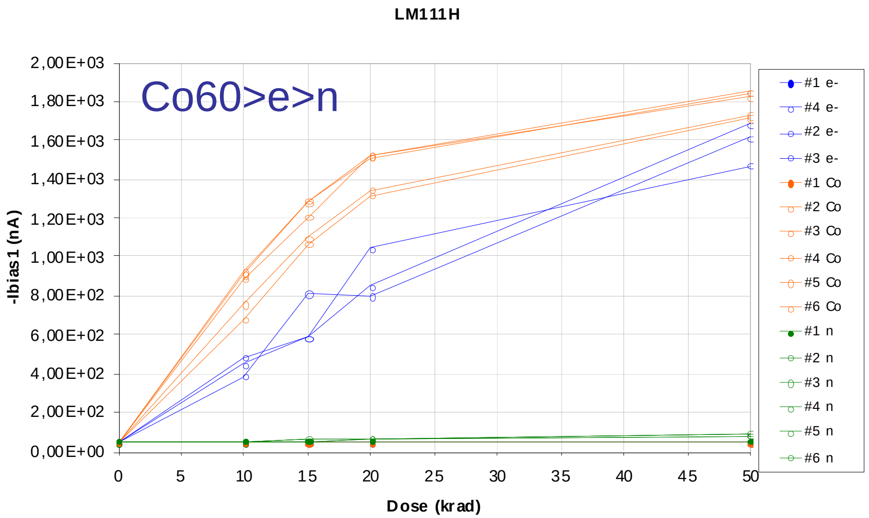


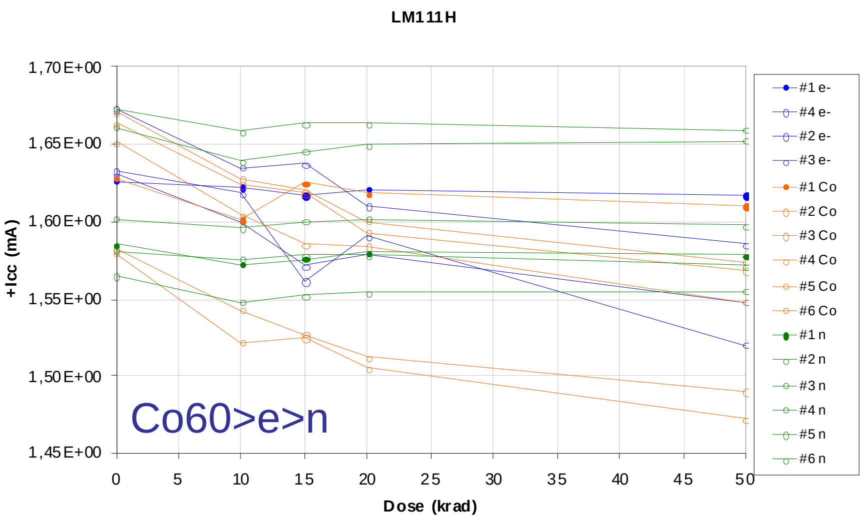


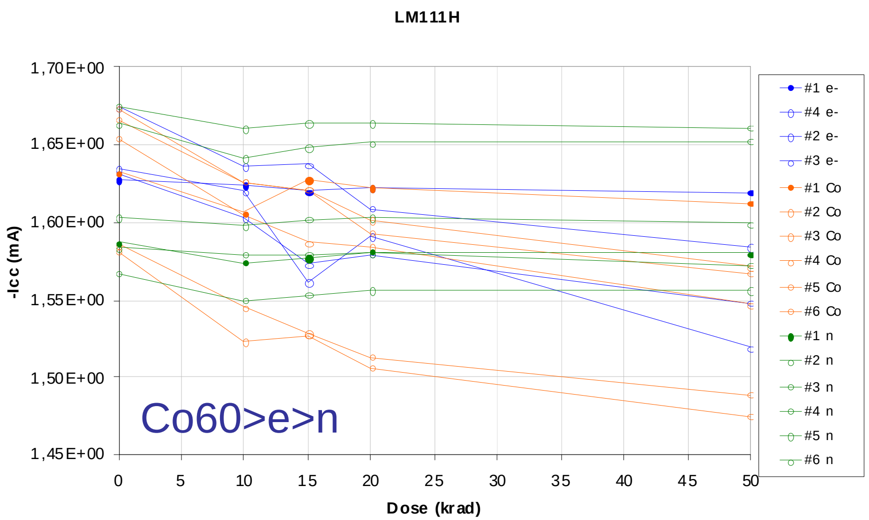


LM111H Test Results

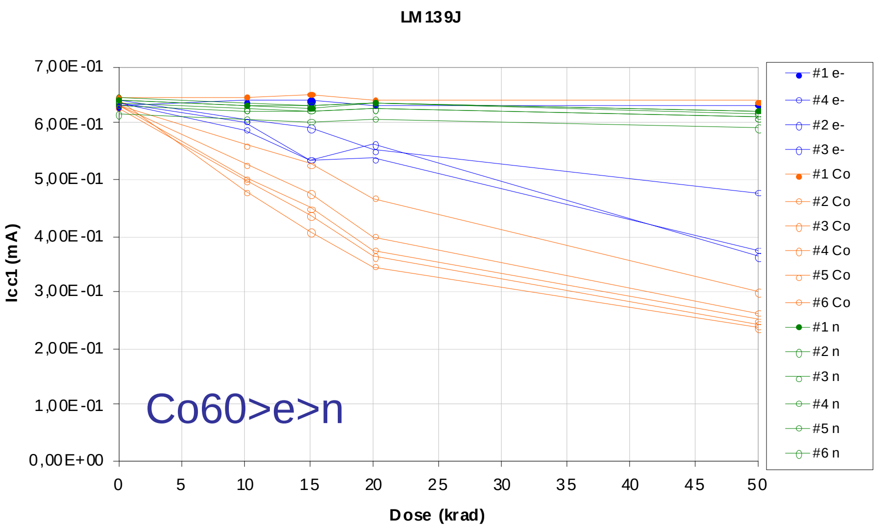


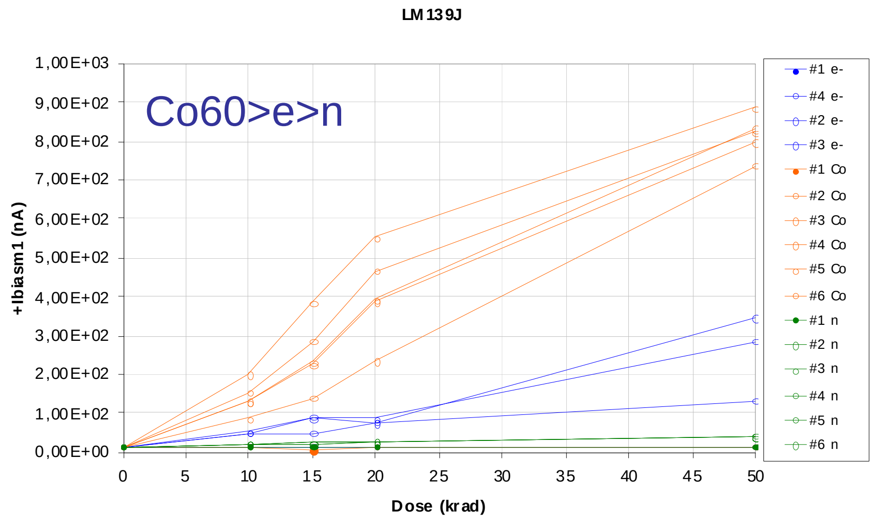


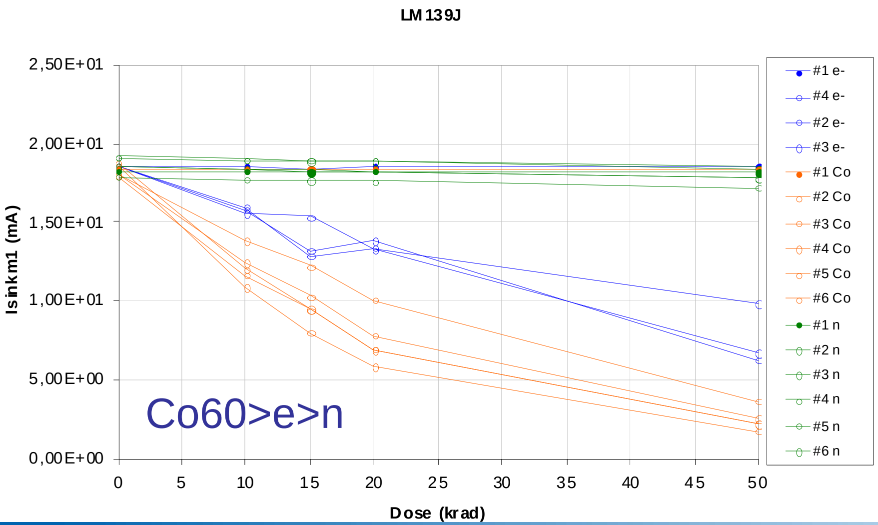


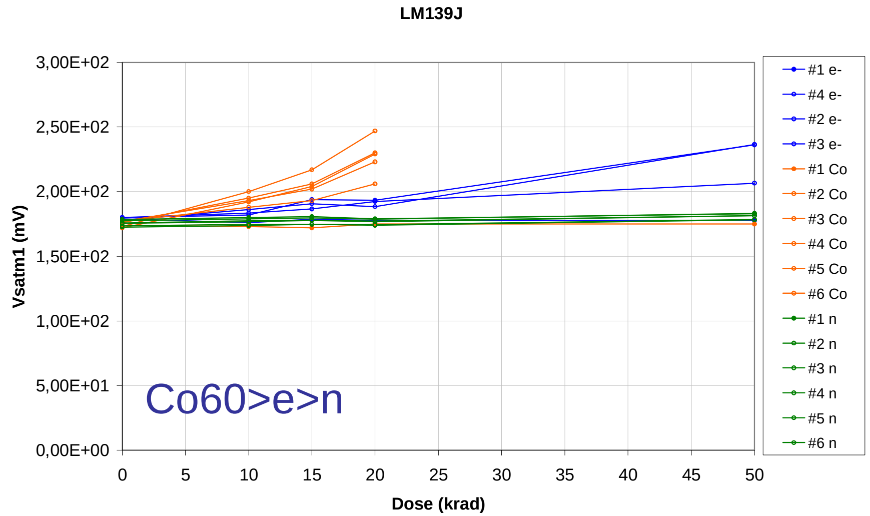


LM139J Test Results

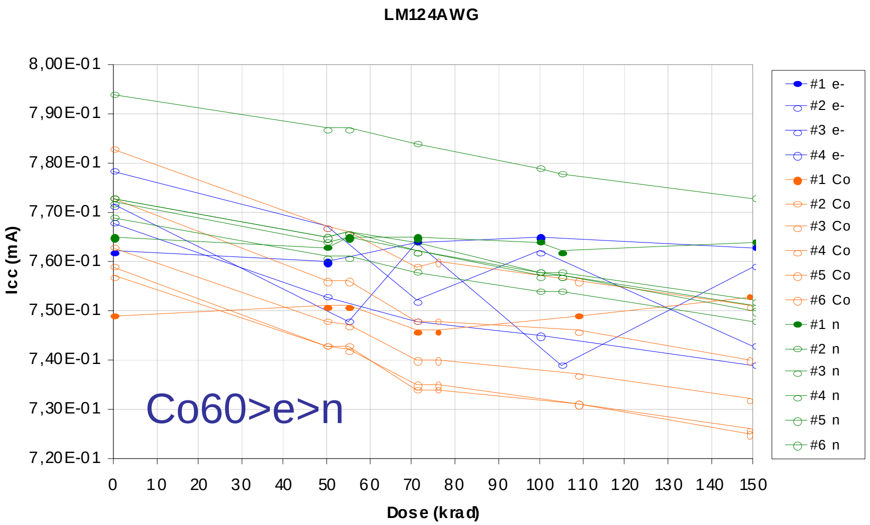


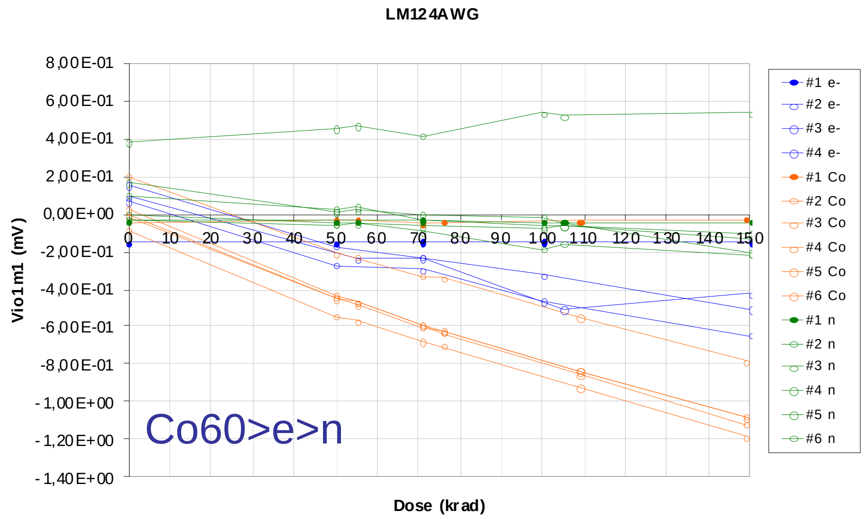


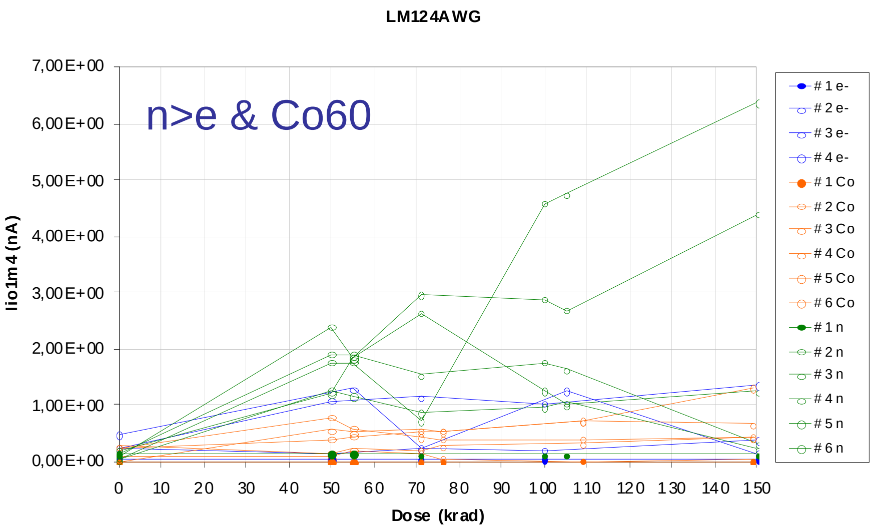


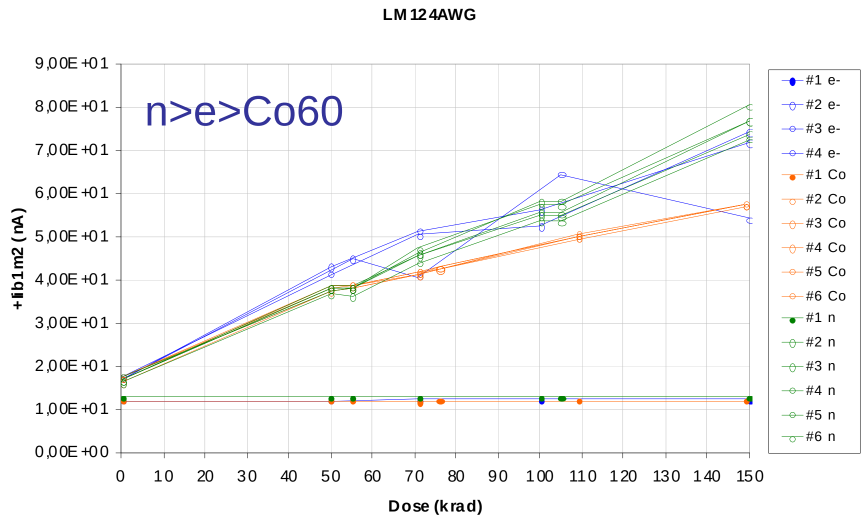


Radhard LM124AWG Test Results

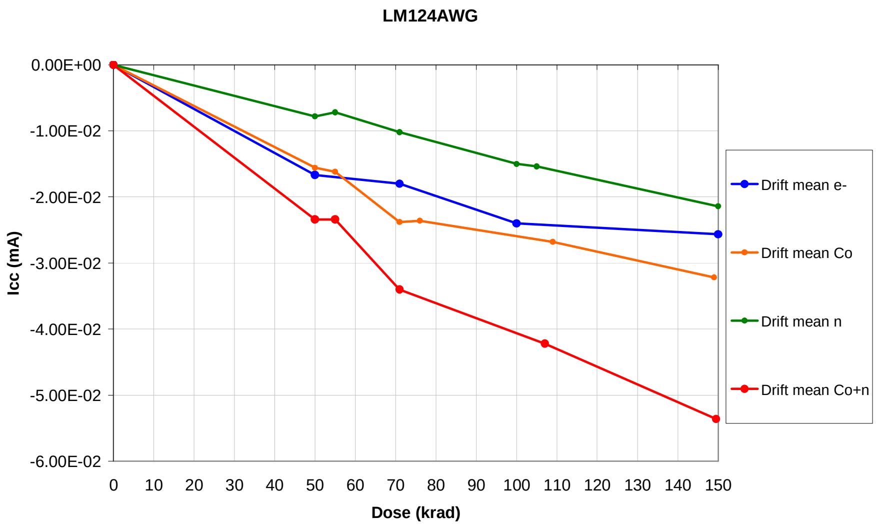


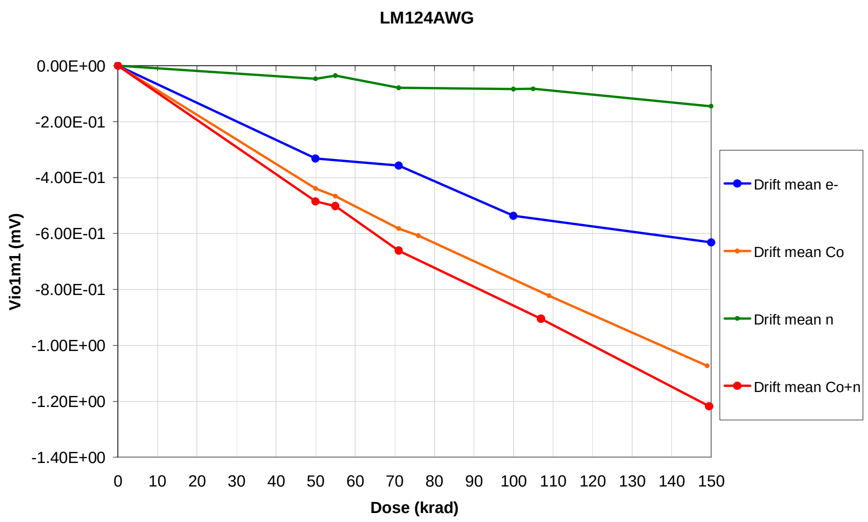


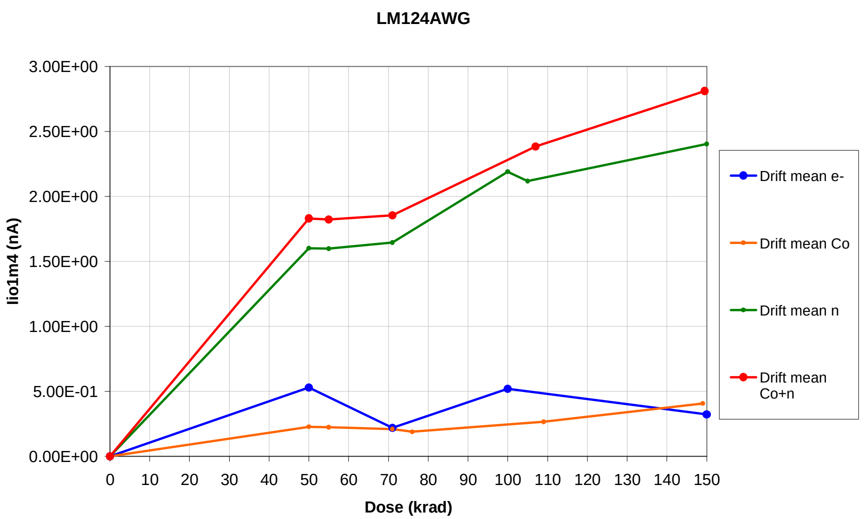


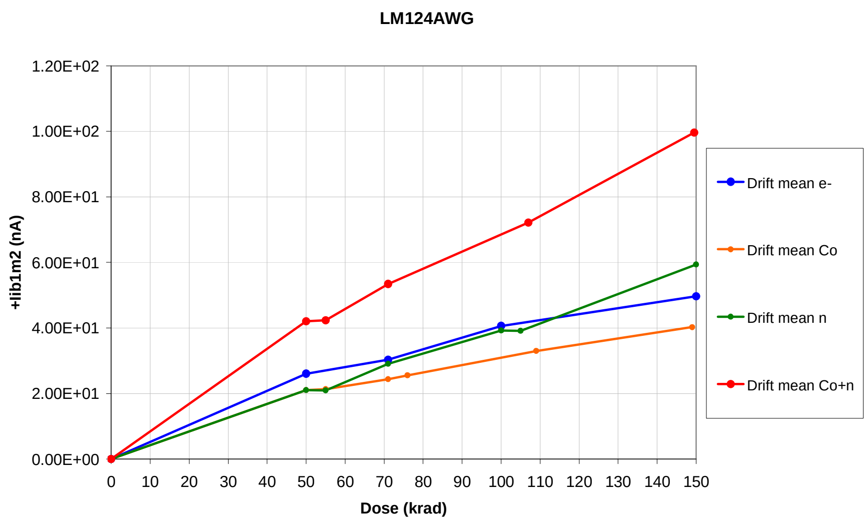


Radhard LM124AWG Test Results









Conclusion

Commercial Devices

- **The ^{60}Co drift is predominant.**
- **The e45MeV drift is lower than the ^{60}Co drift**
  - ⇨ The greater degradation observed under ^{60}Co is due to a dose rate effect
- **The n1MeV drift is lower than the e45MeV drift**
  - ⇨ The device displays a drift due to TID before the TNID level is high enough to add a significant contribution

Conclusion

- **RadHard Devices**
  - Significant contribution of the non-ionizing dose
  - Several trends are observed, depending on the electrical parameter measured

Conclusion

- The behaviour of the linear integrated circuits under high energy electron beam depends on the qualification level
- The degradation due to high energy electron is lower, or in the same order of magnitude, as the cumulated drift under ^{60}Co and 1MeV neutrons

⇨ In the perspective of qualifying devices for severe electron environment space application, the ^{60}Co low dose rate test combined with neutron irradiation should be conservative for linear devices

Perspective

- **Linear devices could be subject to ELDRS under electron beam**

⇨ **Performing electron low dose rate irradiation could complete this study and ensure that standard test methods (^{60}Co and 1MeV neutrons) are conservative for device qualification under severe electron environments**

➧ Data Workshop RADECS 2013 :

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QUESTIONS

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