RHM

NAND flash test report

RHM-IDA-TN3-4

TU Braunschweig, Germany

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1 Overview

Between April and November, 2017, a test was performed to determine the influence of TID on the long-term data retention characteristics of SLC NAND Flash memories.

2 Test setup

Irradiation was performed from April 21 to April 24, 2017 at the Cobalt-60 facility of Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Germany. The source delivers a maximum dose rate of 2 krad/h at close range.

3 Samples

The tested devices are described in the following table.

Part ID	Manufacturer	Part number	Capacity	Per die	Feature size	Date code
Mic16	Micron	MT29F16G08ABACAWP-Z:C	16 Gbit	16 Gbit	Unknown	1622
Mic64	Micron	MT29F64G08AFAAAWP-ITZ:A	64 Gbit	32 Gbit	Unknown	1626

Mic64 is a dual-die device with the same 32-Gbit die as the 32-Gbit single-die device MT29F32G08ABAAAWP. For this device type, only the first die was tested.

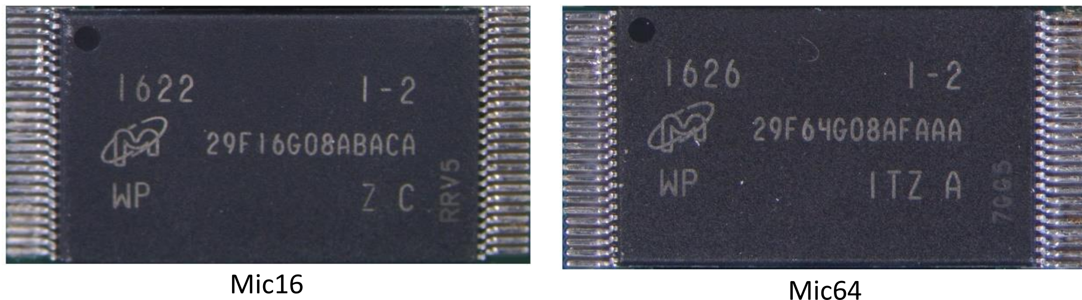


Figure 1: Package photos

The samples were prepared by soldering them to a carrier PCB to simplify handling and to interface with the IDA test equipment.

4 Test procedure

Before irradiation, the bad-block table of each sample was read and recorded separately. The samples were programmed with a checkerboard background pattern.

Three samples of each type were irradiated for 197629 seconds (≈55 hours) in unbiased mode to the dose values described in the following table. Two non-irradiated samples of each type were used for reference.

Nominal dose [krad]	Actual dose [krad]	Dose rate [krad/h]
10	10.14	0.185
20	20.36	0.371
30	30.83	0.562
40	41.11	0.749
50	51.58	0.940

60	62.06	1.130

All samples were irradiated simultaneously for the full time at different distances from the source, as shown in the following figure.

After the end of the irradiation, the samples were stored at room temperature and read at the following times:

- Immediately after irradiation
- After 2 weeks
- After 5 weeks
- After 7 weeks
- After 9 weeks
- After 11 weeks
- After 14 weeks
- After 18 weeks
- After 22 weeks
- After 26 weeks
- After 30 weeks

The exact dates of the read operations are given in D1-4.

The supply current was not measured.

5 Test results

The samples irradiated with 50 and 60 krad (nominal) were not functional after irradiation and are therefore not shown in this section. The same is true for one of the 64-Gbit samples irradiated with 40 krad.

The error count refers to the total number of bit errors in the whole device, excluding bad blocks (which were skipped).

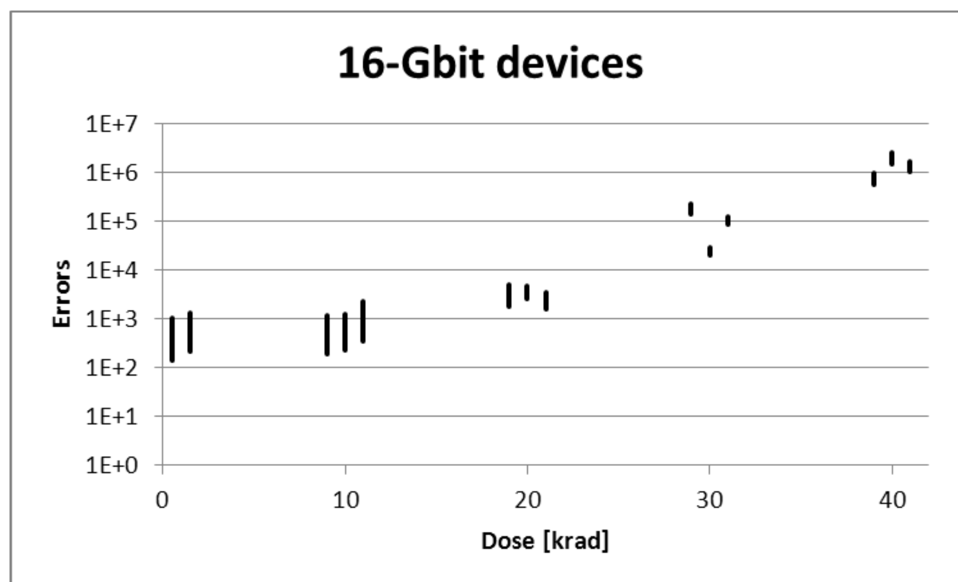
5.1 Overview

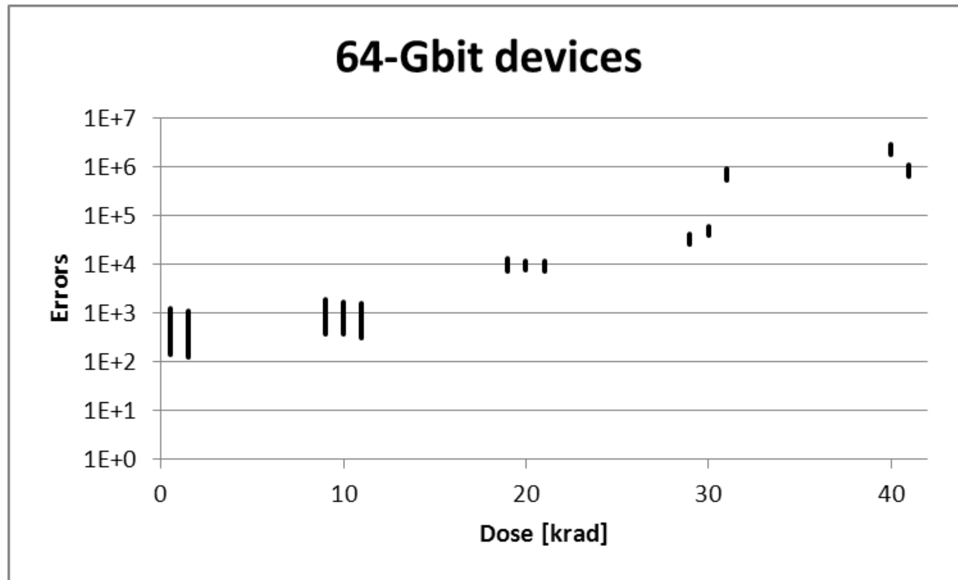
In the 30 weeks following the irradiation, the number of errors increased with time. This section gives an overview; the detailed error count vs. time will be shown in the next section.

In the following figures, each vertical line represents one sample, irradiated at the indicated dose. The line indicates the range from the lowest number of errors (directly after irradiation) to the highest number of errors (after 30 weeks). The values correspond to the detailed data shown in the next section.

Note that horizontal distance between the lines in each group serves to visually separate the individual lines and does not constitute a difference in dose; all samples within a group have been irradiated with the same dose.

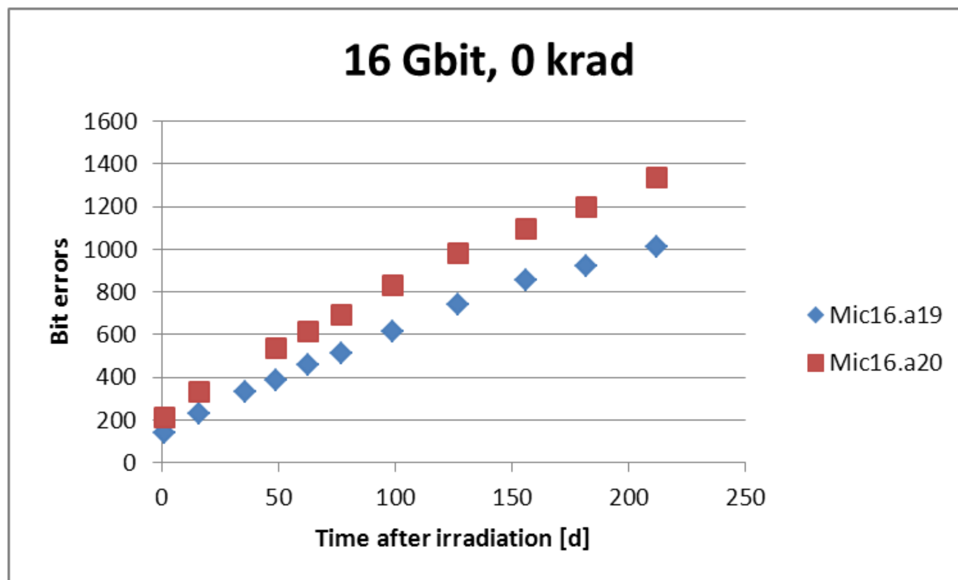
Also note that even without irradiation (the 0-krad samples), NAND Flash devices have bit errors.

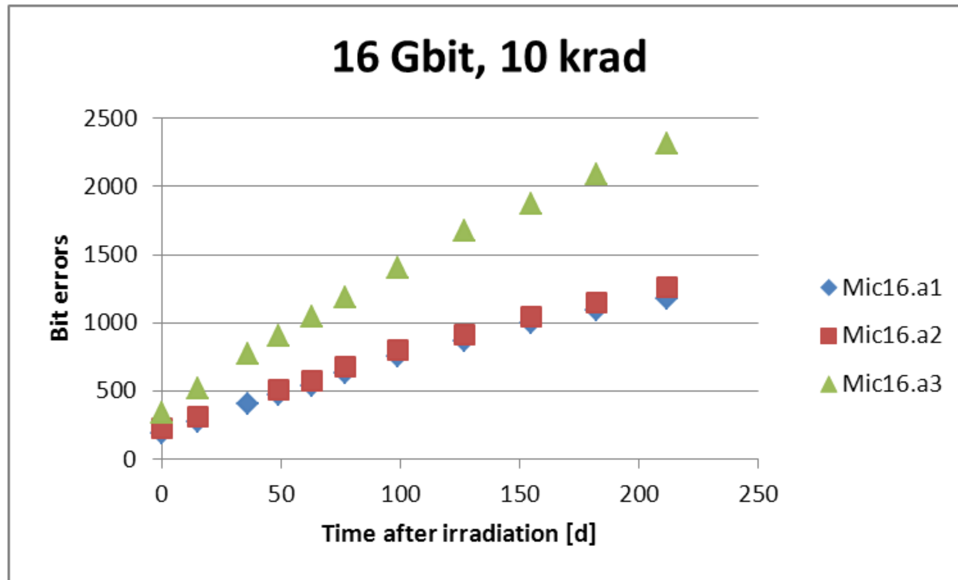


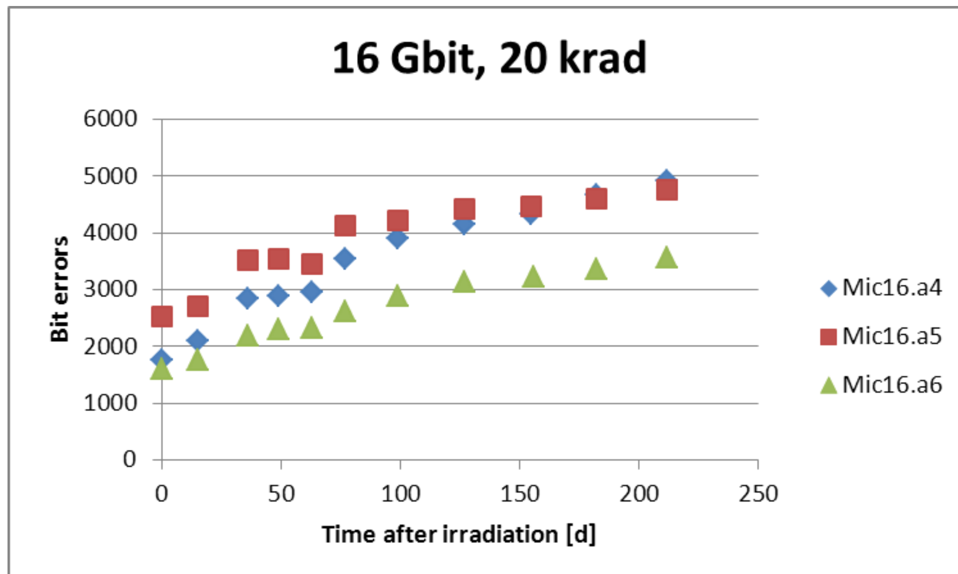


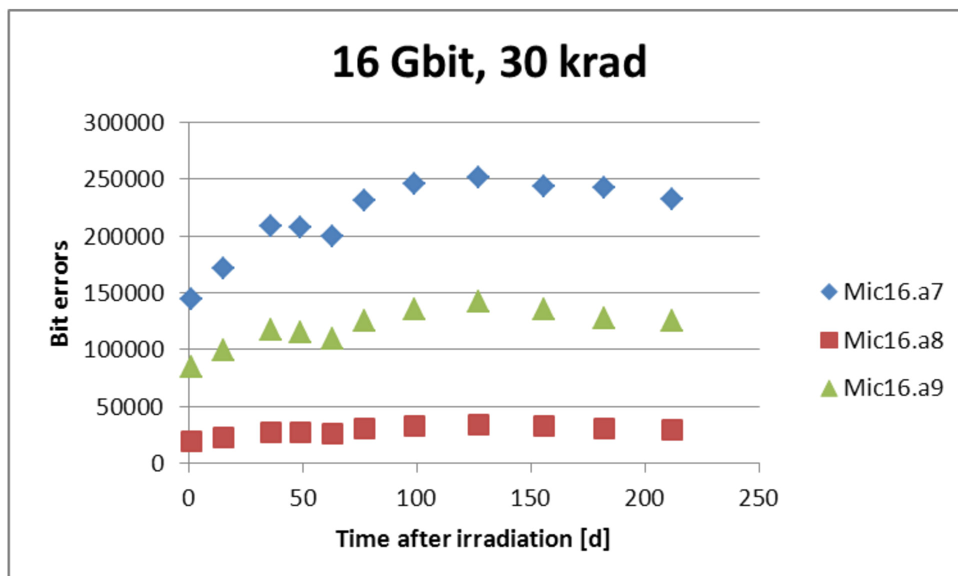
5.2 Details

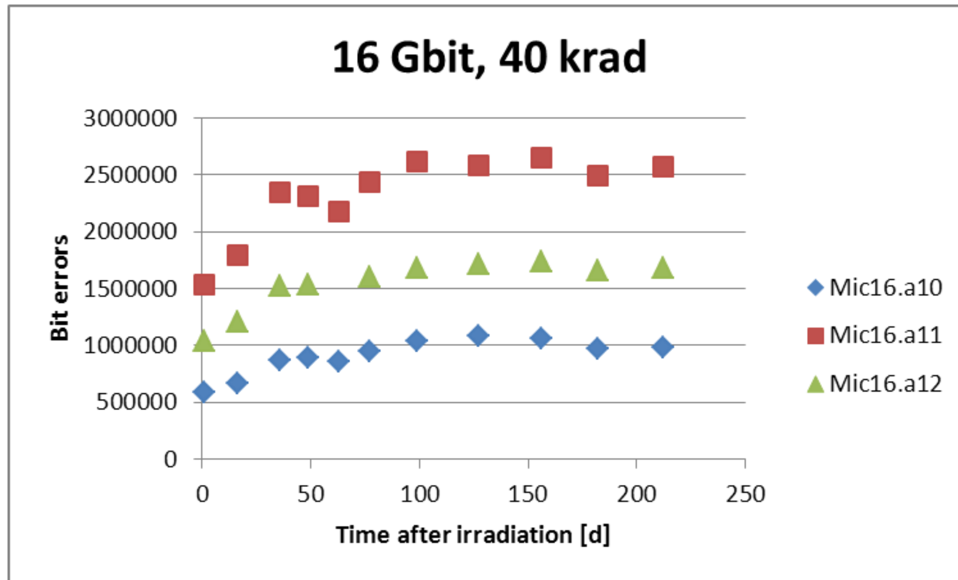
The following figures show the number of errors vs. time for each sample. The 16-Gbit samples for all dose values are shown before the 64-Gbit samples. Some values are missing due to test equipment misconfiguration.

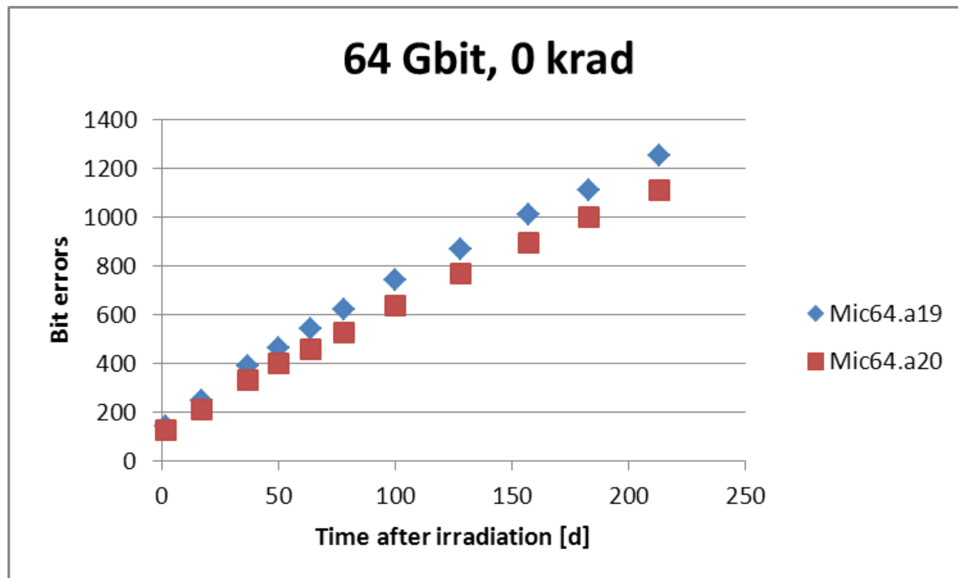


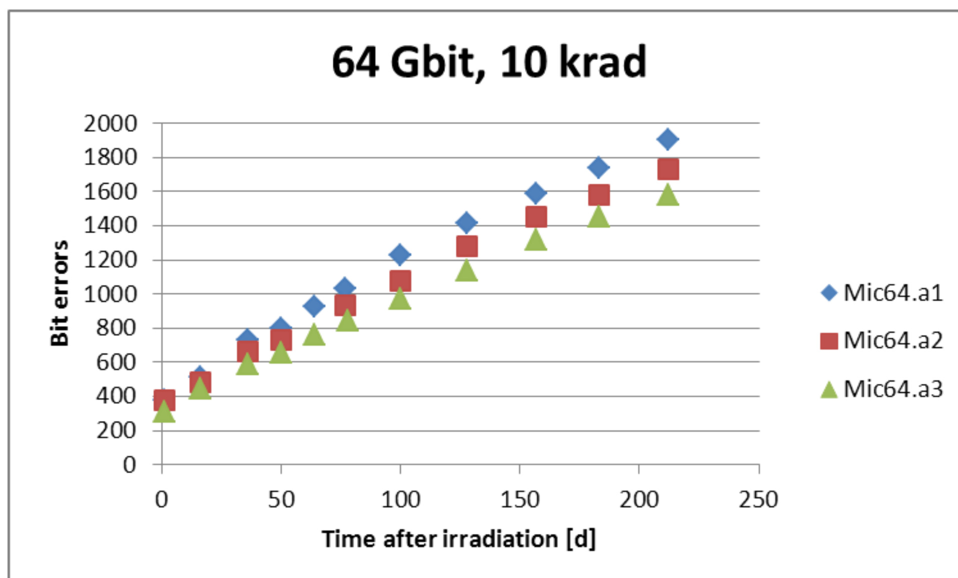

16 Gbit, 10 krad
Bit errors
2500
2000
1500
1000
500
0
0
50
100
150
200
250
Time after irradiation [d]
Mic16.a1
Mic16.a2
Mic16.a3

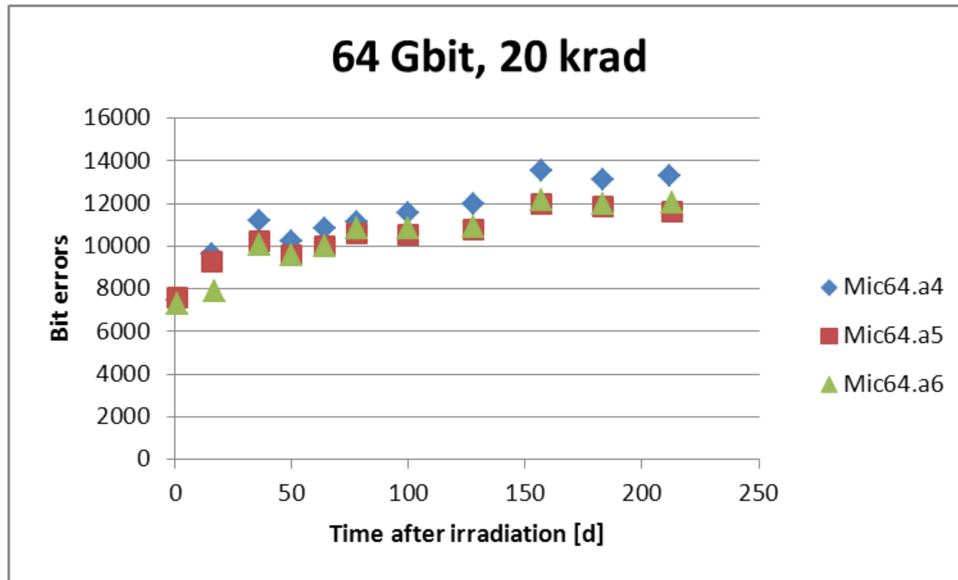

16 Gbit, 20 krad
Bit errors
6000
5000
4000
3000
2000
1000
0
0
50
100
150
200
250
Time after irradiation [d]
Mic16.a4
Mic16.a5
Mic16.a6


16 Gbit, 30 krad
Bit errors
300000
250000
200000
150000
100000
50000
0
0
50
100
150
200
250
Time after irradiation [d]
Mic16.a7
Mic16.a8
Mic16.a9

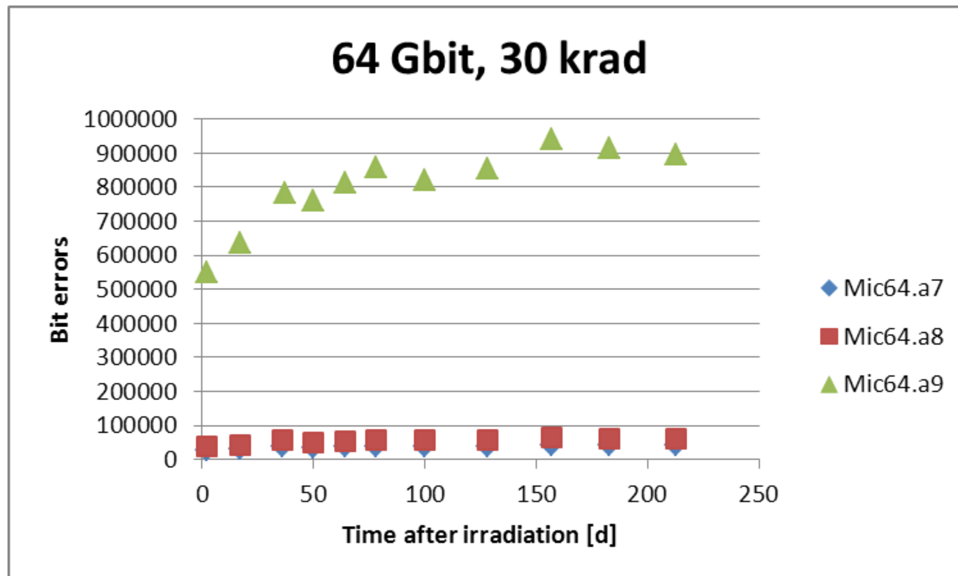

16 Gbit, 40 krad
Bit errors
3000000
2500000
2000000
1500000
1000000
500000
0
0
50
100
150
200
250
Time after irradiation [d]
Mic16.a10
Mic16.a11
Mic16.a12


64 Gbit, 0 krad
Bit errors
1400
1200
1000
800
600
400
200
0
0
50
100
150
200
250
Time after irradiation [d]
Mic64.a19
Mic64.a20

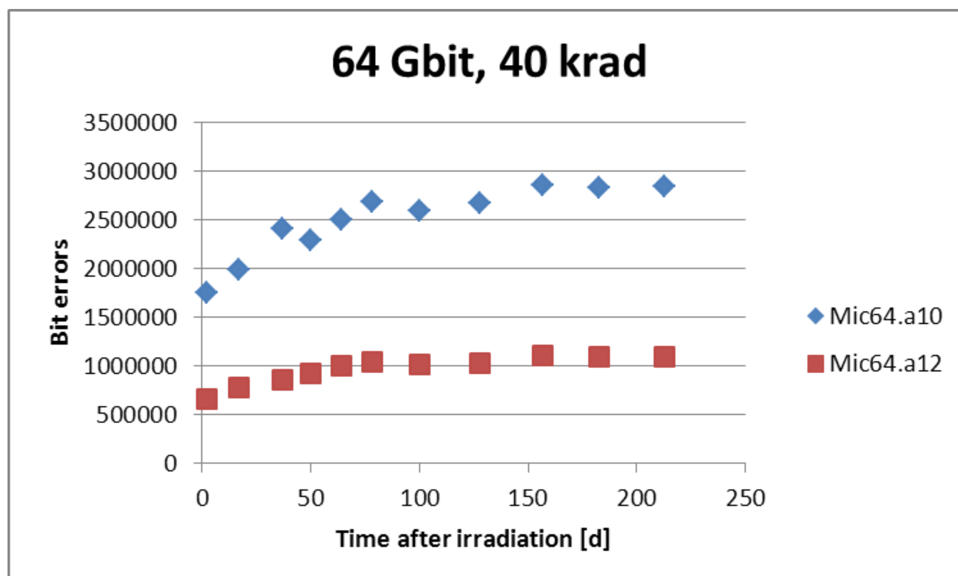

64 Gbit, 10 krad
Bit errors
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
50
100
150
200
250
Time after irradiation [d]
Mic64.a1
Mic64.a2
Mic64.a3



64 Gbit, 20 krad
Bit errors
16000
14000
12000
10000
8000
6000
4000
2000
0
0
50
100
150
200
250
Time after irradiation [d]
Mic64.a4
Mic64.a5
Mic64.a6



64 Gbit, 30 krad
Bit errors
1000000
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
0
50
100
150
200
250
Time after irradiation [d]
Mic64.a7
Mic64.a8
Mic64.a9



64 Gbit, 40 krad
Bit errors
3500000
3000000
2500000
2000000
1500000
1000000
500000
0
0
50
100
150
200
250
Time after irradiation [d]
Mic64.a10
Mic64.a12