Radiation Tolerance Tests for SFP+ Transceivers

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Abstract

The radiation tolerance of the electronics components used in the detector area is a key of the electronics systems at the hadron collider experiments. We present the results of gamma and neutron irradiation tests for two types of SFP+ transceivers from Broadcom and Finisar.

1. Introduction

High speed optical link is crucial for the electronics systems at the hadron collider experiments.
SFP+ transceivers are assumed to be used in the electronics system of thin gap chamber (TGC) of the ATLAS experiment at HL-LHC. All TGC hit signals will be sent to trigger boards, and muon tracks are reconstructed for trigger (Fig. 1).
The radiation level estimated for the TGC on-detector electronics is [1]:

- Total Ionizing Dose (TID): 7.3 Gy
- Non-Ionizing Energy Loss (NIEL): 2.2×10^{11} cm^{-2}

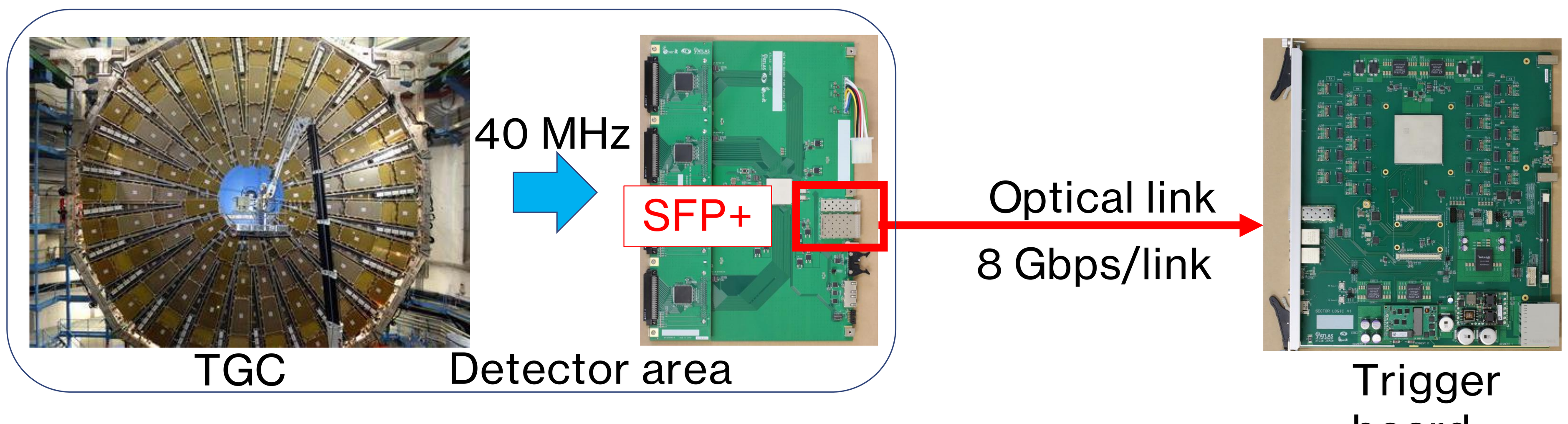

Figure 1: Overview of the TGC electronics systems for ATLAS experiment at HL-LHC.

2. Targets and Test Method

The targets are AFBR-709SMZ from Broadcom and FTLX8574D3BCV from Finisar. We irradiated gamma ray and neutrons for TID and NIEL tolerance tests, respectively. After the irradiation, we tested (Fig. 2):
A. the output power from transmitter using power meter and
B. the bit error ratio (BER) using loopback module.

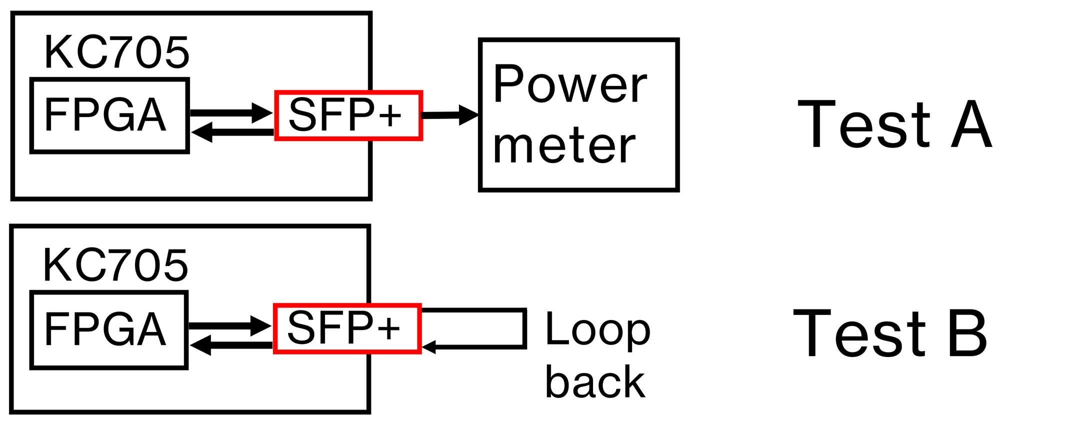

Figure 2: Block diagram of the SFP+ tests.

3. TID Test

We irradiated gamma ray to six AFBR-709SMZ and ten FTLX8574D3BCV modules at the Cobalt 60 facility at Nagoya University in Japan (Fig. 3).
Figure 4 shows the result of test A for AFBR-709SMZ.
We found no significant changes on the output power up to 600 Gy (350 Gy) for all the AFBR-709SMZ (FTLX8574D3BCV) modules.
Figure 5 shows a typical result of test B until the output power gets down to ~0 mW. Table 1 summarizes the results.

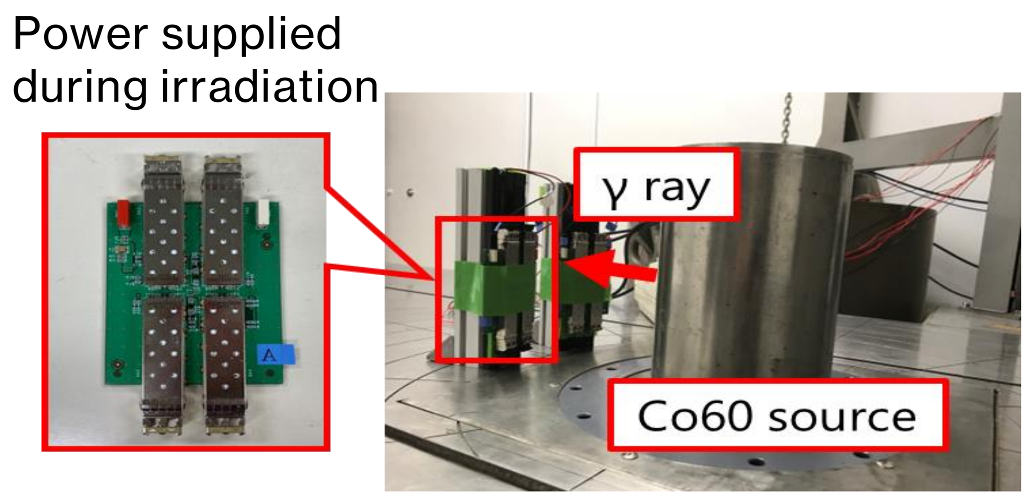

Figure 3: Photos of gamma irradiation.

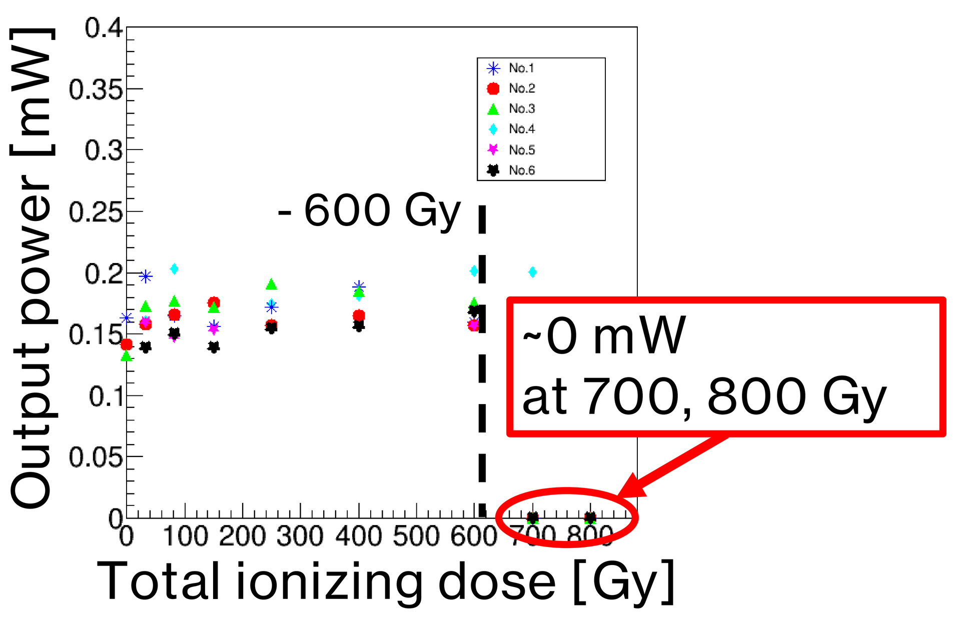

Figure 4: The result of test A.

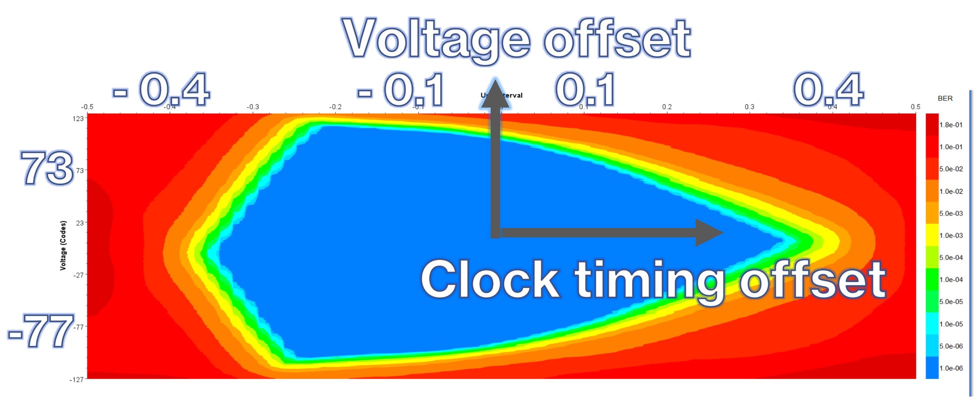

Figure 5: An example result of test B for AFBR-709SMZ. The eye scan after 50 Gy is shown.

	Number of tested devices	Requirement (including safety factor)	Confirmed
Broadcom	6	33 Gy	600 Gy
Finisar	10		350 Gy

Table 1: Summary of TID test. The confirmed shows the maximum dose for which functionality was confirmed, for the worst modules among the tested modules.

4. NIEL Test

We also irradiated neutrons to one module for each of AFBR-709SMZ and FTLX8574D3BCV using the tandem electrostatic accelerator at Kobe University (Fig. 6).
Neutrons are provided from Beryllium bombarded by Deuterons with an energy of 2.6-2.8 MeV. Figure 7 shows the result after 1.8×10^{12} cm^{-2}. Both modules passed the tests A and B.

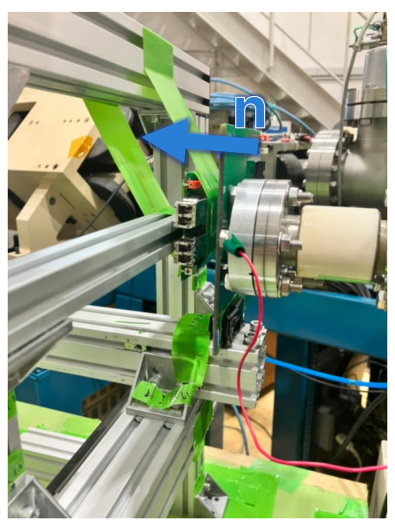

Figure 6: Photo around the Beryllium target.

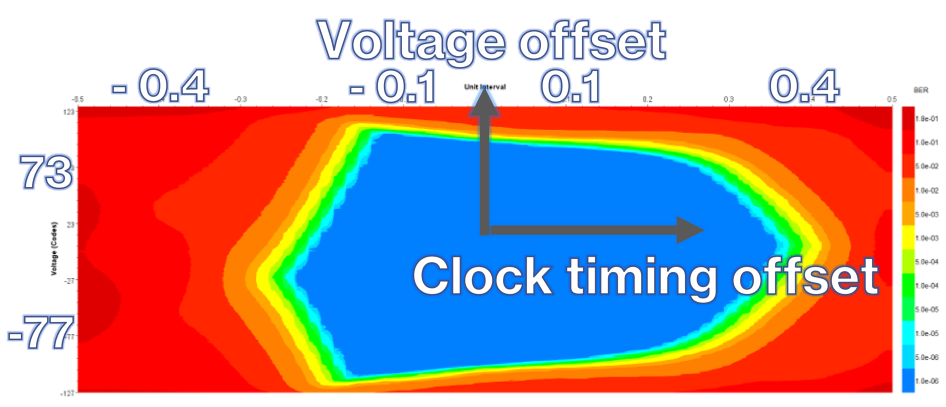

Figure 7: The results of test B for FTLX8574D3BCV. The eye scan after 1.8×10^{12} cm^{-2} irradiation is shown.

5. Summary

We irradiated gamma ray to six AFBR-709SMZ and ten FTLX8574D3BCV modules, and found that the worst AFBR-709SMZ (FTLX8574D3BCV) module survived at 600 Gy (350 Gy). We also irradiated neutrons to one module for each of AFBR-709SMZ and FTLX8574D3BCV, and found that both modules survived at 1.8×10^{12} cm^{-2}. They satisfy the requirements for TGC on-detector electronics of the ATLAS experiment at HL-LHC. The results can be referred to in designing the system and selecting SFP+ modules for the hadron collider experiments.

[1] Technical Design Report for the Phase-II Upgrade of the ATLAS Muon Spectrometer, CERN-LHCC-2017-017; ATLAS-TDR-026