



Introduction and Motivation

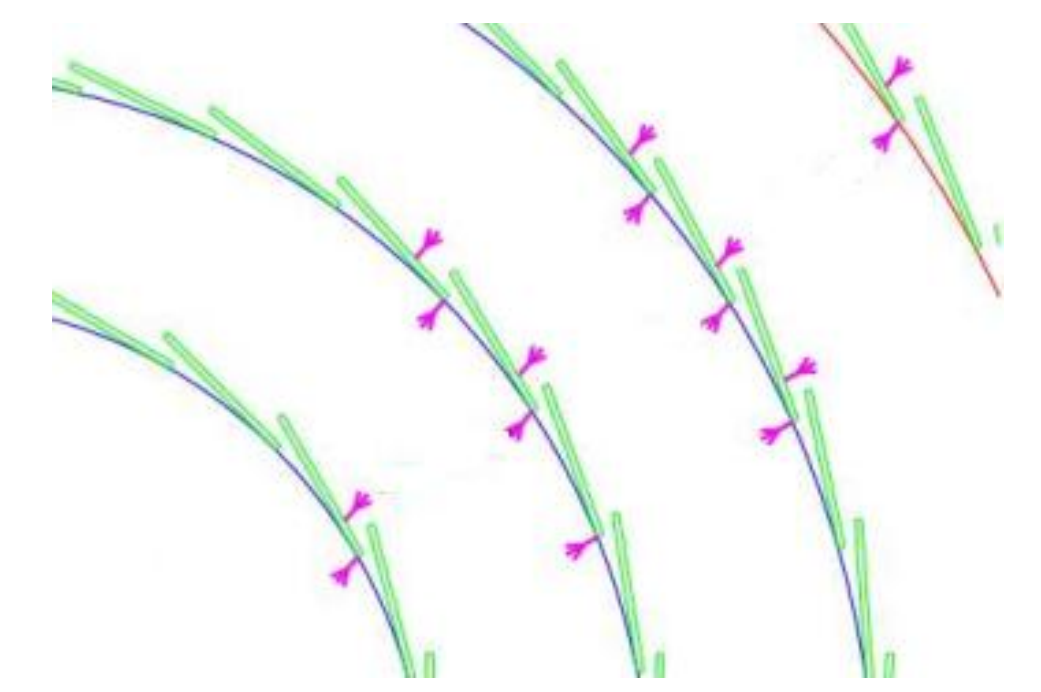
This poster presents the irradiation hardness investigations for the 60 GHz transceiver chips

Motivations to propose the replacement of ATLAS wired readout links with the wireless:

- Cost reduction
- Simplified installation and repair
- Reduction in dead material
- Reduced latency: Radial readout instead of axial



(a)

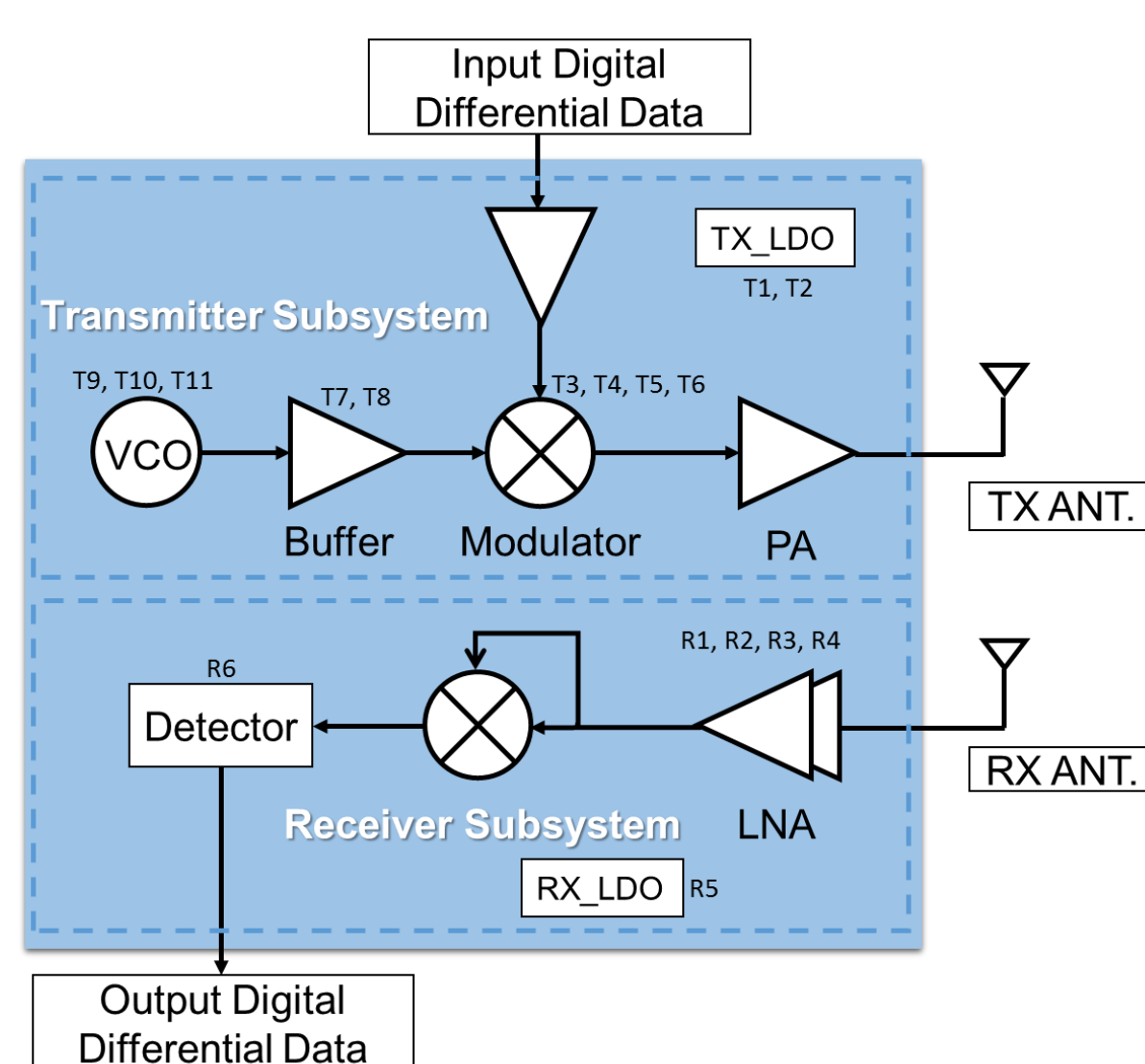


(b)

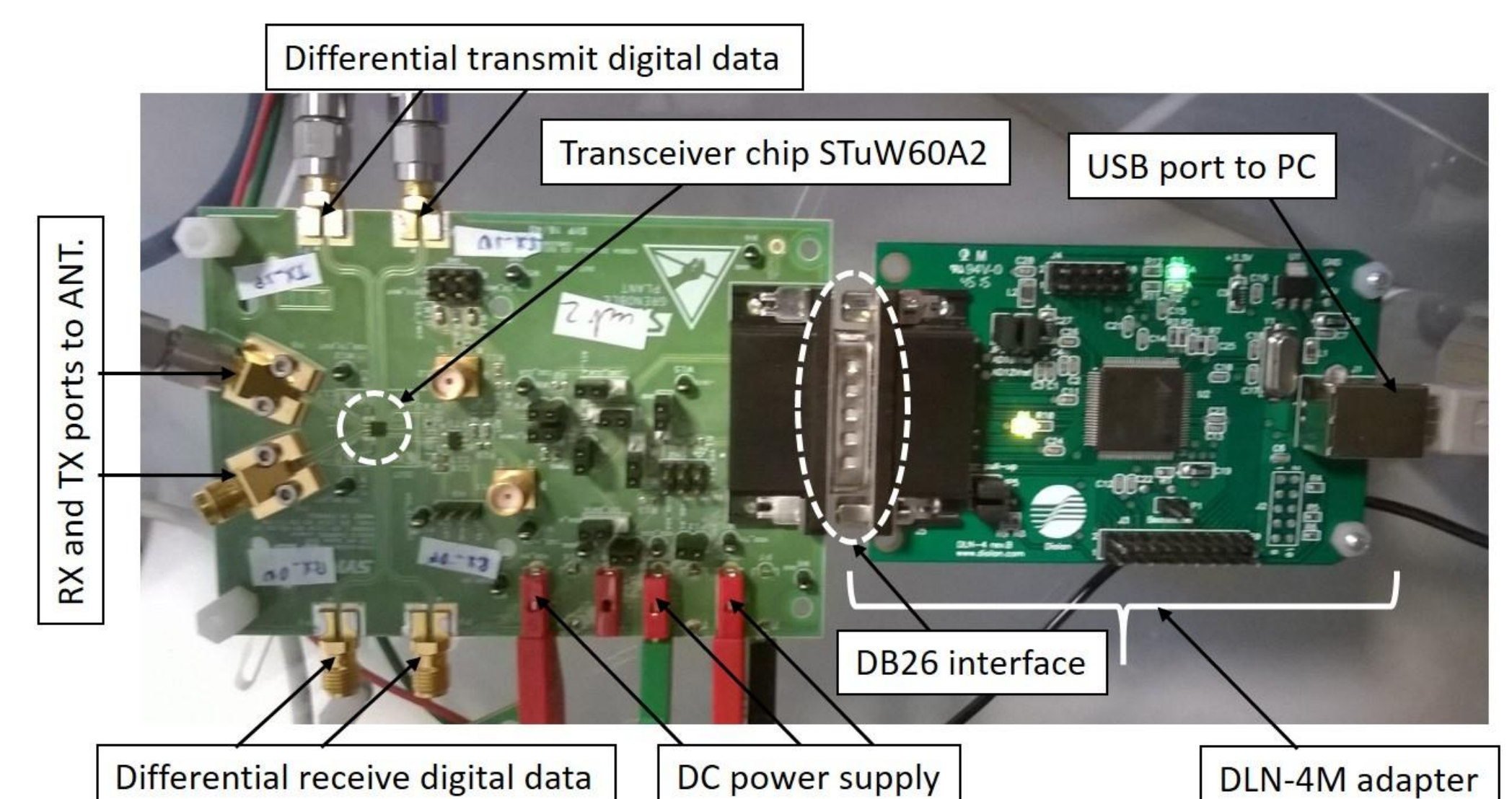
Fig. 1 (a) ATLAS inner detectors: cables contribute significantly in active detector volume (b) Proposed 60 GHz wireless links to totally / partially replace cables

60 GHz CMOS Transceiver (TRX) Chips

- The TRX chips under investigation has been manufactured by ST-Microelectronics in 65 nm CMOS technology
- Chip is packaged in a 25-ball very thin profile, fine-pitch ball grid array (VFBGA) with $2.2 \times 2.2 \times 1.0 \text{ mm}^3$ dimensions
- Uses on-off keying (OOK) modulation
- 2 x PCBs with TRX and drive electronics have been prepared for pre- and post-irradiation chip characterization



(a)



(b)

Fig. 2 (a) Transceiver chip block diagram. (b) Transceiver chip mounted on evaluation board, while DLN-4M adapter providing DB-26 to USB interface

Irradiation Experiment

- ❖ 60 GHz transceiver chips irradiation is performed at Åbo and CERN
- ❖ 2 x chips are irradiated at both places, one in TX mode and one in RX mode

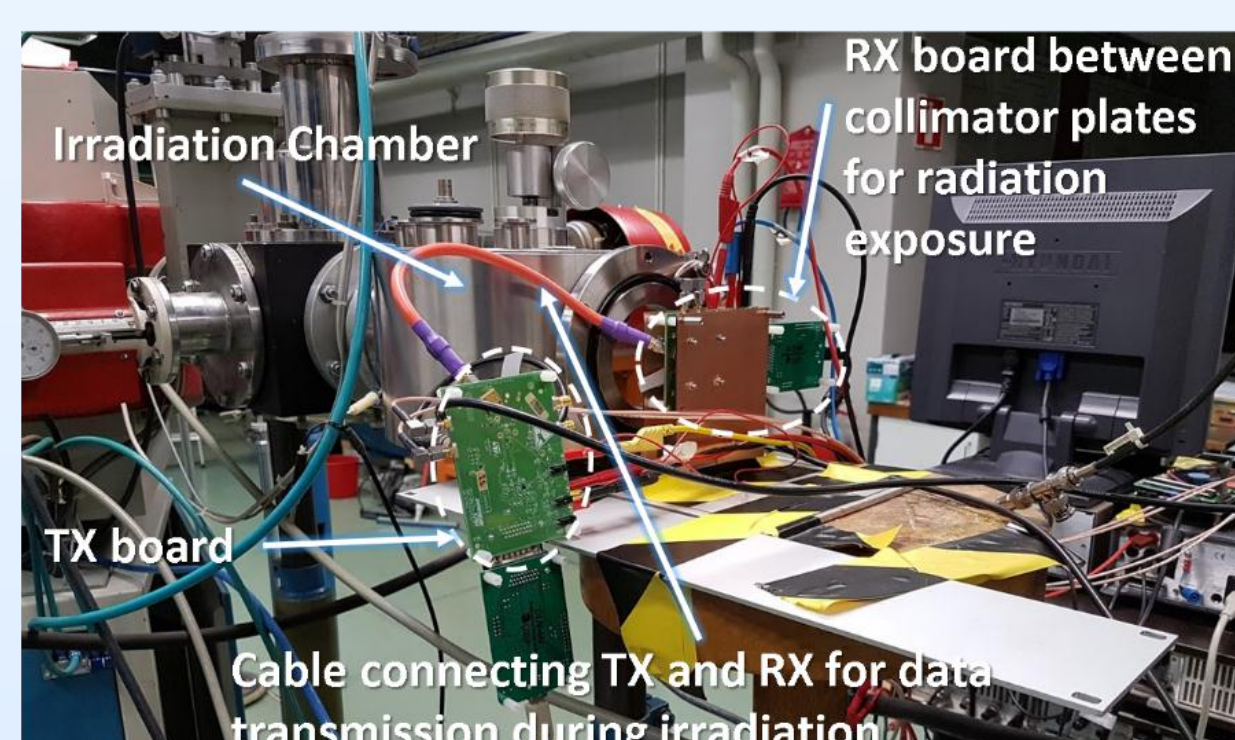
Åbo University, Finland 17 MeV Protons

➤ RX Transceiver:

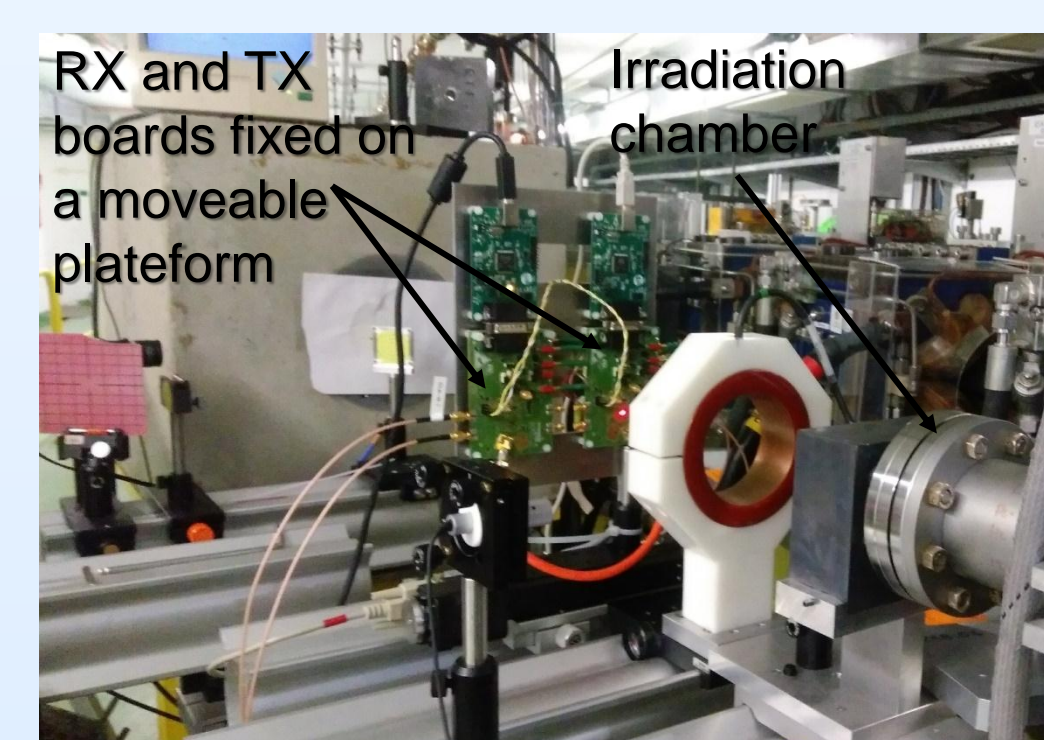
TID: 7.4 Mrad
Fluence: $1.4 \times 10^{14} N_{eq}/cm^2$

➤ TX Transceiver:

TID: 4.2 Mrad
Fluence: $0.8 \times 10^{14} N_{eq}/cm^2$



(a)



(b)

Fig. 3 (a) Proton irradiation experimental setup at Åbo Akademi University, Finland (b) Electron irradiation experimental setup at CLEAR, CERN

CLEAR, CERN 196 MeV Electrons

➤ RX Transceiver:

TID: 33.2 Mrad

❖ TX Transceiver:

TID: 38.7 Mrad

Post Irradiation Analysis Summary

Proton Irradiation at Åbo

- Small downshift of 10 MHz in the center frequency, however, it doesn't affect the communication as RX uses envelope detection
- 4.5 dB and 1 dB reduction in RX gain and TX power respectively
- RX envelope detector and digital interface remained unaffected
- 5 Gbps wireless communication was achieved with few cm reduced range

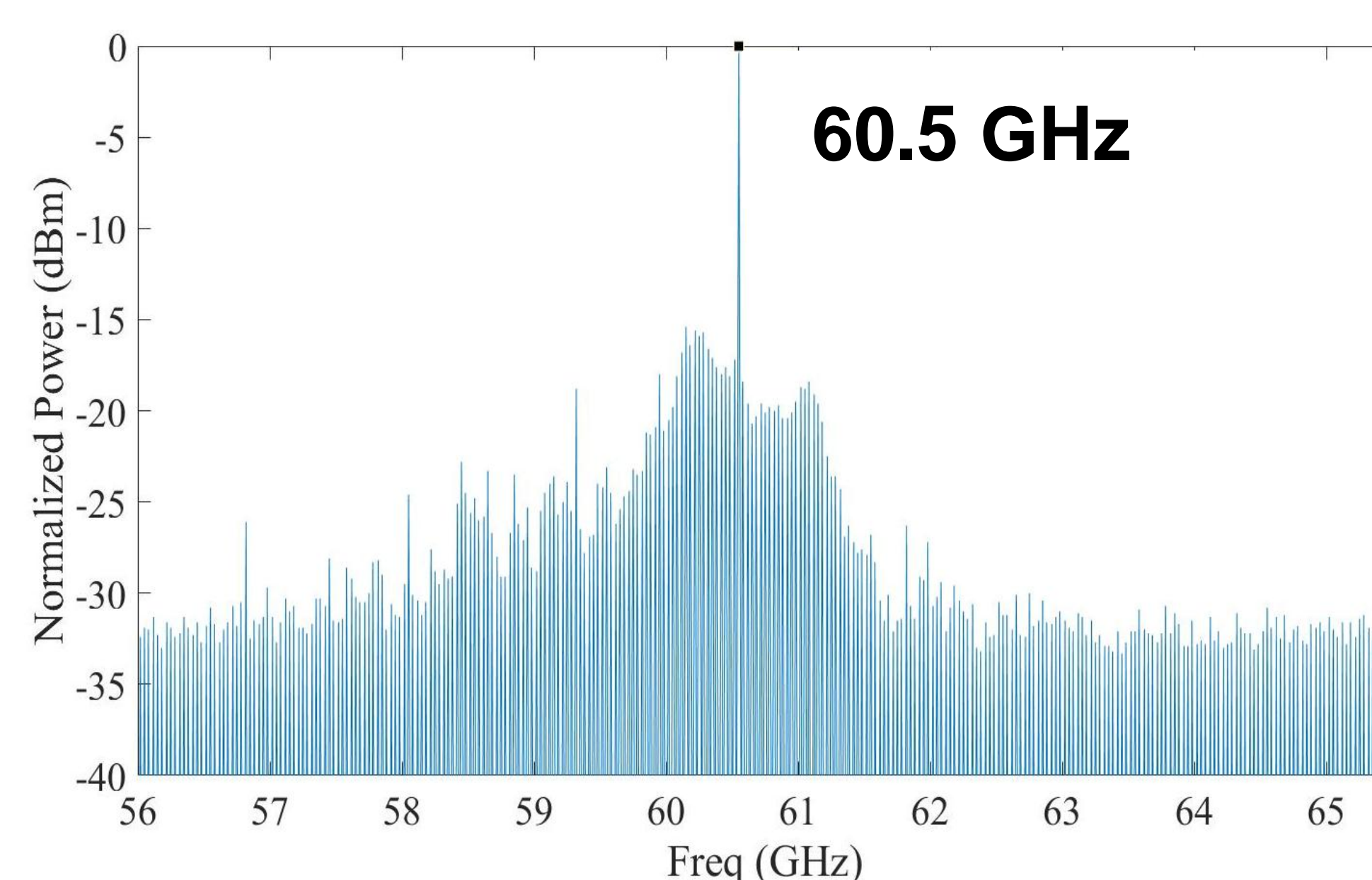


Fig. 4 Normalized power spectrum of 5 Gbps data transmission while transmitter was set on continuous wave mode.

Electron Irradiation at CLEAR

- About 80 MHz upshift in the center frequency
- Transmitter output power reduced by 4 dB while receiver sensitivity degraded by 6 dB; overall 10 dB link budget degradation
- Degradation of circuits bandgaps (voltage reference)
- Digital interfaces also impacted by bandgap alteration, with change in duty cycle