

INtelligent, **F**ast, **I**nterconnected and **E**fficient devices, for frontier exploitation in **R**esearch and **I**ndustry

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WORK PACKAGE: WP3

NATURE OF THE DELIVERABLE: R= Report, P = Prototype, D = Demonstrator, O = Other

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DISSEMINATION LEVEL: RE, CO

PU = Public N/A IN THE INFIERI CONTEXT

PP = Restricted to other programme participants (including the Commission Services) N/A IN THE INFIERI CONTEXT

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Abstract:

We designed, developed and tested a novel high-speed (2.5 Gb/s) Optical Wireless Communication (OWC) link for particle detectors in High Energy Physics (HEP). We considered as reference application scenario the Compact Muon Solenoid (CMS) detector at CERN LHC, where the OWC system is expected to provide a wireless link between inner layers and outer layers of the silicon strip sensors. The proposed OWC system can drastically reduce the complexity of the optical fiber network inside the CMS detector.

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Period covered: from 01/02/2013 to 31/01/2017

Project website: <http://infiери-network.eu>

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We successfully designed and demonstrated an OWC prototype based on a Vertical Cavity Surface Emitting Laser (VCSEL) working at 1550nm and a photodiode packaged with the quartz ball lens. The system provides 2.5 Gb/s data rate at 10 cm of transmission distance (comparable with the CMS inner tracker layers distance). The system also provides a very good misalignment tolerance values suitable for highly precise particles detectors architecture: we achieved a tolerance range of ± 1 mm thanks to the custom designed can cap for accurate packaging of the ball lens with the photodiode. This was done to maximize the collected light on the receiver.

We also tested all the optical components of OWC system under X-ray radiations with 238Mrad dose (Si as a reference) of dose. We performed these measurements at Padova University facilities. The test was particularly important for the lens, which is normally affected by ionizing radiations such as X-rays and gamma rays. No degradation was observed for the quartz lens under 238Mrad irradiation. Moreover, no degradation was detected for the VCSEL and photodiode. The setup of the transmission system and the setup for the radiation experiment are reported in Figure 1.

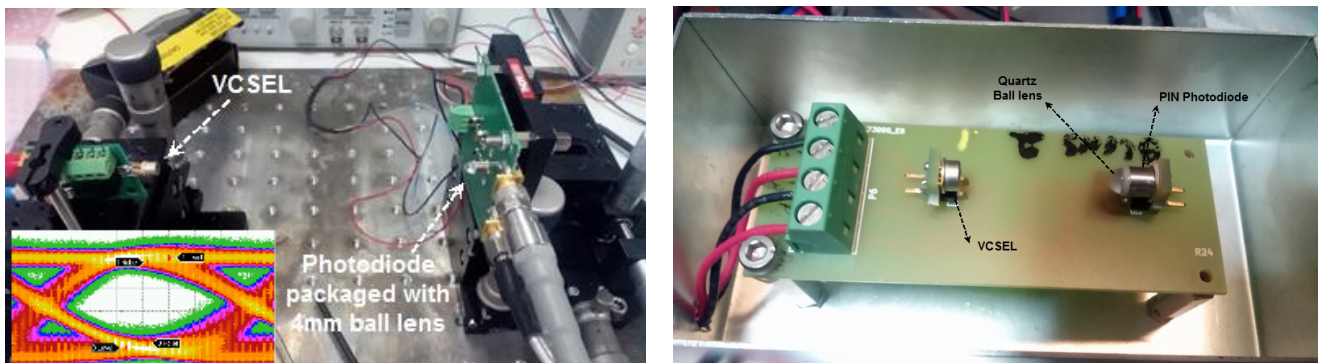


Figure 1 Left : 2.5 Gb/s OWC system prototype at 10 cm of distance, inset shows the eye diagram at aligned position. Right: PCB board with the VCSEL and photodiode packaged with quartz ball lens for X-rays irradiation test.

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Talks

- [1] Presentation on "Optical Wireless for data transmission" 1st INFIERI Summer school Oxford July 2013
- [2] PhD introductory presentation, 3rd INFIERI Workshop Madrid January 20-22 2014.
<https://indico.cern.ch/event/281636/contribution/3/8/material/slides/1.pdf>
- [3] Presentation on "Optical wireless multi-gigabit data transfer for CMS silicon tracker" 3rd INFIERI Workshop Madrid January 20-22 2014.
- [4] Presentation on "Feasibility of Optical Wireless transmission systems for CTA" 3rd INFIERI Workshop Madrid January 20-22 2014.
- [5] PhD progress report presentation for midterm review, 4th INFIERI Workshop Amsterdam December 2014.
- [6] Presentation on "Lab Test For OWC at SSSA and CERN Secondment prospects" 5th INFIERI Workshop Geneva April 27-29 2014
- [7] Presentation on "Recent Progress in Optical Wireless Communication" 5th INFIERI Workshop Geneva April 27-29 2014
- [8] Presentation on "SSSA ESR WP3 progress report and perspectives" 6th INFIERI Workshop Pisa October 27th-29th 2015.
- [9] Presentation on "SSSA ESR WP3 progress report" 7th INFIERI Workshop Lisbon April 12th-15th 2016.

Poster Presentations

- [1] W. Ali., "High Speed Data Transmission and Processing", at the 2nd International Summer School on "Intelligent Signal Processing for Frontier Research and Industry, INFIERI2014, Paris, July 14-25, 2014;
<https://indico.cern.ch/event/305730/session/28/contribution/74/material/slides/0.pdf>
- [2] W. Ali, "High Speed Data Transmission and Processing", at 4th "Intelligent Signal Processing for Frontier Research and Industry" (INFIERI) Workshop Amsterdam (The Netherlands) December 10-12, 2014.
<http://infieri-network.eu/sites/default/files/PosterWajahatAli.pdf>
- [3] W. Ali et al, "Optical Wireless Communication System for Particle Detectors in High Energy Physics" 13th Pisa Meeting Isola d'Elba May 24th-30th 2015.
- [4] W. Ali et al, "2.5 Gb/s Optical Wireless Communication Systems for Particle detectors in High Energy Physics", 3rd International Summer School on "Intelligent Signal Processing for Frontier Research and Industry, INFIERI 2015, Hamburg, September 14-25, 2015;
- [5] W. Ali et al, "2.5 Gb/s Simple Optical Wireless Communication Systems for Particle detectors in High Energy Physics", The 25th International workshop on Vertex Detectors 25-30 September 2016 La Biodola, Isola d'Elba, Italy.

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Publications:

- [1] Giulio Cossu, Ali Wajahat, Raffaele Corsini, Ernesto Ciaramella, "5.6 Gbit/s Downlink and 1.5 Gbit/s Uplink Optical Wireless Transmission at Indoor Distances (≥ 1.5 m)" Optical Communication (ECOC, 2014), 40th European Conference and Exhibition on Sept. 2014.
- [2] W. Ali et al., "High Speed Optical Wireless Data Transmission System for Particle Sensors in High Energy Physics", 2015 JINST 10 C08003.
- [3] W. Ali, R. Corsini, E. Ciaramella, R. Dell'Orso, A. Messineo, F. Palla, "Optical Wireless Communication system for particle detectors in high energy physics", Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Volume 824, 11 July 2016, Pages 245-247
- [4] Giulio Cossu, Wajahat Ali, Raffaele Corsini, and Ernesto Ciaramella, "Gigabit-class optical wireless communication system at indoor distances (1.5 – 4 m)," Opt. Express 23, 15700-15705 (2015)
- [5] W. Ali, et al, "2.5 Gb/s Simple Optical Wireless Communication System for Particle Detectors in High Energy", abstract accepted to be published in Proceedings of Science)
- [6] G. Konstantinou, W. Ali, et al., "Experimental demonstration of an optical wireless MRI compatible PET/SPECT insert front-end", to be published in NSS/MIC IEEE proceedings

Patent:

- [1] Wajahat Ali, et al., "Sistema de deteccin de radiacin gamma y sistema de resonancia magntica", Spanish patent ID: P201631388 (filed in October 2016)

PhD Thesis by Wahajat ALI, Defended December 1st 2016.