Fibre Optic Nonlinear Technologies [FONTE] - A European Industrial Doctorate [GA766115]

Document Details

Title	Deliverable 7.3 Final Report on Publications and Public Engagement Activities completed
Deliverable number	D7.3
Deliverable Type	Report (public)
Deliverable title	Final Report on Publications and Public Engagement Activities completed
Work Package	WP7 – Impact, Dissemination and Outreach
Description	A complete overview of publications and Public Engagement Activities completed during the lifetime of project FONTE
Deliverable due date	31/05/2022
Actual date of submission	24/05/2022
Lead beneficiary	Aston
Version number	V1.0
Status	FINAL V1.0

Dissemination level

PU	Public	X
CO	Confidential, only for members of the consortium (including Commission Services	

Project Details

Grant Agreement	766115
Project Acronym	FONTE
Project Title	Fibre Optic Nonlinear Technologies
Call Identifier	H2020-MSCA-ITN-2017
Project Website	fonte.astonphotonics.uk
Start of the Project	1 June 2018
Project Duration	48 months

Consortium

Aston University

NOKIA Bell Labs

TELECOM ParisTech

TU Delft

DTU Technical University of Denmark

EC Funding

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 766115

Executive Summary

This deliverable details the **Scientific Research Output** of the FONTE project and dissemination measures taken in terms of peer-reviewed publications, conference papers and talks, public deliverables as well as less formal settings of dissemination via seminars and event posters. The main aim of these **Dissemination Activities** is to *publicize the project's research results*, raising their profile and maximising the impact of FONTE's research results by making them freely available and easily discoverable to the predominantly academic audience. FONTE's 4 ESRs completed all 17 scientific deliverables, published 8 peer reviewed journal papers (including 1 book chapter contribution) and 17 conference proceedings. In addition FONTE ESRs presented 29 conference and workshop talks and published two software packages as well as codes underlying publication. Complete details of this scientific output including full **Open Access** links are given within this deliverable.

Furthermore, this deliverable details the **Public Engagement Activities** completed within the project. These aim to *inform stakeholders about the project*, its overarching aims and results achieved, as well as make research conducted in FONTE more accessible to all sectors of society, from primary school pupils to academics, the industrial sector and finally the general public. FONTE conceived and delivered 22 Public Engagement Activities to a diverse audience, ranging from dedicated outreach activities, presence on social media platforms and research networks, to the publication of brochures, posters, newsletters etc among others. Where possible a quantification of the effectiveness of reaching the target audience is included in this deliverable. Full details within this report.

This report covers the entirety of the 4-year FONTE European Industrial Doctorate (EC GA 766115).

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

LIST OF ACRONYMS

AiPT	Aston Institute Of Photonic Technologies
CORDIS	Community Research and Development Information Service (an EC platform)
EC	European Commission
EID	European Industrial Doctorates
ESR	Early Stage Researcher
GA	Grant Agreement
FONTE	Fibre Optic Nonlinear Technologies
ITN	Innovative Training Network
NFT	Nonlinear Fourier Transform
NBL	Nokia Bell Labs (NBL)
OA	Open Activity
OTAW	Open-To-All Workshop
SyGMa	System for Grant Management (an EC platform)

1 CONTEXT OF THE FONTE EID PROJECT

H2020 European Industrial Doctorate FONTE [Fibre Optic nonlinear Technologies] is a doctoral-level training network funded by the EC under Horizon2020 Marie Skłodowska-Curie ITN Action. The programme trains 4 Early-Stage Researchers (ESRs) and focuses on the development of disruptive nonlinear techniques and approaches to fibre-optic communications beyond the limits of current technology. The project aims to make important innovative steps in development of the technique of the nonlinear Fourier transform (NFT) and its implementation in the practical communication systems.

FONTE ESRs benefits from rich interactions between academia and industry, with a strong focus on industrial experience, exemplified by their 18 months secondment to world-leading ***Nokia Bell Labs (NBL)***, one of the largest and most recognised research organisations focusing on communications technology and conducting fundamental research in this field.

Furthermore, FONTE ESRs profit from a comprehensive training programme featuring inter-sectorial and multidisciplinary technical courses, which is complemented by a bespoke transferable skills training throughout their PhD.

This report details the **Scientific Project Output** in form of public deliverables, peer-reviewed publications, conference talks and invited contributions as well as and other scientific communication in less formal settings such as local seminars. Furthermore, this report summarised the **Public Engagement Activities** undertaken by the consortium, in particular outreach activities, social media interactions, blogs and websites maintained by ESRs and finally posts and newsletters published by the consortium. Where possible the effectiveness of the activities is assessed through measures such as participation in events, registration for OTA workshops and symposia, geographic distributions of audience reached, followers on social media, impressions (number of times a tween has been viewed), downloads of material from the website, clicks to specific links published etc.

2 SCIENTIFIC PROJECT OUTPUT AND ITS DISSEMINATION

FONTE EID is a small project with 4 Early Stage Researchers (ESRs), a fact that is reflected by the amount of research output. Project results have been disseminated to the scientific community through scientific deliverables (section 2.1), published peer-reviewed journal papers (section 2.2), conference proceedings (section 2.3), conferences talks and invited talks (section 2.4), local seminars etc (sections 2.5 to 2.8). Together, the 4 ESRs of FONTE have published an impressive 8 peer reviewed journal papers (including 1 book chapter contribution), with additional research output in preparation for submission to scientific journals. They have presented their research in leading international photonics conferences, such as the *European Conference on Optical Communication (ECOC)* and *Optical Fiber Communications Conference and Exhibition (OFC)*, in 29 peer-reviewed conference talks and posters and 17 conference proceeding.

Open Access (OA) of research output is a strong commitment in FONTE. In accordance with the GA, FONTE makes all its research output either gold or green OA by default and the EC funding is acknowledged throughout. All published research output is also freely available on the FONTE website in the section "*Dissemination & Communication*" https://fonte.astonphotonics.uk/dissemination/

Crucially, all published research output is also placed in local (Open Access) repositories and archives to increase its visibility and make it discoverable:

- **Aston Research Explorer** https://research.aston.ac.uk/,
- **TU Delft Research Information Portal** https://pure.tudelft.nl/portal/ ,
- **DTU Orbit** https://orbit.dtu.dk/
- **Archives Ouvertes HAL-TP** https://hal.telecom-paris.fr/
- **General Open Repository ZENODO** https://zenodo.org/
- **Software Repository GitHub:** https://github.com

Uniquely, FONTE encourages its ESRs to make OA the ***actual presentations slides and posters*** presented at conferences by deposition the slides/posters presented in the **ZENODO** repository https://zenodo.org/, where they are allocated a DOI which can be brought into SyGMa, linking this content to the project output on CORDIS.

In addition, simulation and modelling packages, as well as computer codes underlying published results have been developed and made available in OA Zenodo and GitHub (section 2.5).

Amongst the research output the highest-cited[1] papers to date (M48) have been peer-reviewed publications number 2.3.12 [first author FONTE ESR V. Bajaj], 2.2.6 [second author FONTE ESR V. Neskorniuk] and 2.2.9 [first author FONTE ESR S.M. Ranzini], with 27, 26 and 13 citations respectively.

2.1 PUBLIC SCIENTIFIC DELIVERABLES

All scientific deliverables have been completed and submitted the European Commission via the Funding and Tender Portal/SyGMA, and have simultaneously been made public and Open Access on the Project website at https://fonte.astonphotonics.uk/deliverables-public. All scientific deliverables foreseen in FONTE have been completed:

- D1.1 Review and optimization results for the NIS NFT-based systems
- D1.2 New modulation techniques for NFT systems
- D1.3 Numerical verification advanced modulation techniques
- D2.1 Report on major impairments in NFT-based transmission
- D2.2 Software implementations of the developed robust NFT algorithm
- D2.3 Numerical and experimental validation of the robust modulation formats
- D3.1 Survey of machine learning algorithms for optical performance monitoring
- D3.2 System identification and parameter estimation
- D3.3 Performance analysis of monitoring techniques based on machine learning
- D4.1 Principles of linear and nonlinear frequency-division multiplexing
- D4.2 Multi-user communication and information theory
- D4.3 Capacity limits of NFDM optical fibre networks
- D5.1 Transmission regime definition and plan of experiments
- D 5.2 Experimental transmissions of NFT-based systems, including (1) the NFDM systems and (2) the nonlinear inverse synthesis systems
- D5.3 Quantification of performance degradation due to components imperfection
- D5.4 NFT-WDM transmission systems
- D5.5 Achievable rate and transmission distance of the NFT-based communication system

[1] All citations assessed on 03 May 2022 via Google Scholar

All scientific project deliverables are open access and freely available through both the project website https://fonte.astonphotonics.uk/deliverables-public/ and the European Commission's CORDIS platform at https://cordis.europa.eu/project/id/766115.

2.2 PEER-REVIEWED FULL JOURNAL PAPERS INCLUDING BOOK CHAPTERS

(most recent on top)

2.2.1 *[Invited paper; under review]*
A. Shahkarami, M. Yousefi, and Yves Jaouen, "Complexity Reduction in Bi-RNN-based Nonlinearity Mitigation in Dual-Pol Fiber-Optic Transmissions Using Latent Space of CNNs", Journal of Optical Fiber Technology.

2.2.2 *[Accepted/awaiting publication]*
F. Da Ros, S.M. Ranzini, Y. Osadchuk, A. Cem, B.J. Giron Castro, and D. Zibar, 2022. Reservoir-computing and neural-network-based equalization for short reach communication. In 2022 *Proceedings OSA Advanced Photonics Congress 2022*. IEEE
DOI: (awaiting details) Open Access (awaiting details)

2.2.3 *[invited contribution to book; Accepted/awaiting publication]*
A. Shahkarami, M. Yousefi, and Yves Jaouen, 2022. "Efficient Deep Learning of Kerr Nonlinearity in Fiber-Optic Channels Using a Convolutional Recurrent Neural Network", Deep Learning Applications, vol. 4, Springer Nature.
DOI: (awaiting details) Open Access (awaiting details)

2.2.4 Bajaj, V., Buchali, F., Chagnon, M., Wahls, S. and Aref, V., 2022. Deep neural network-based digital pre-distortion for high baudrate optical coherent transmission. *Journal of Lightwave Technology*, *40*(3), pp.597-606.
DOI: 10.1109/JLT.2021.3122161, Open Access here and via repository
Cited by 2

2.2.5 Ranzini, S.M., Dischler, R., Da Ros, F., Bülow, H. and Zibar, D., 2021. Experimental investigation of optoelectronic receiver with reservoir computing in short reach optical fiber communications. *Journal of Lightwave Technology*, *39*(8), pp.2460-2467.
DOI: 10.1109/JLT.2021.3049473,
Open Access link here
Cited by 7

2.2.6 Freire, P.J., Neskornuik, V., Napoli, A., Spinnler, B., Costa, N., Khanna, G., Riccardi, E., Prilepsky, J.E. and Turitsyn, S.K., 2020. Complex-valued neural network design for mitigation of signal distortions in optical links. *Journal of Lightwave Technology*, *39*(6), pp.1696-1705.
DOI: 10.1109/JLT.2020.3042414, Open Access link here
Cited by 26
The code underlying this publication has been published Open Access link here

2.2.7 Bajaj, V., Chimmalgi, S., Aref, V. and Wahls, S., 2020. Exact NFDM transmission in the presence of fiber-loss. *Journal of Lightwave Technology*, *38*(11), pp.3051-3058.
DOI: 10.1109/JLT.2020.2984041, Open Access Link here.
Cited by 8

2.2.8 Da Ros, F., Ranzini, S.M., Bülow, H. and Zibar, D., 2020. Reservoir-computing based equalization with optical pre-processing for short-reach optical transmission. *IEEE Journal of Selected Topics in Quantum Electronics*, *26*(5), pp.1-12.
DOI: 10.1109/JSTQE.2020.2975607, Open Access link here.
Cited by 8

2.2.9 Ranzini, S.M., Da Ros, F., Bülow, H. and Zibar, D., 2019. Tunable optoelectronic chromatic dispersion compensation based on machine learning for short-reach transmission. *Applied Sciences*, *9*(20), p.4332.
DOI: 10.3390/app9204332, Open Access link here
Cited by 13

2.3 PEER-REVIEWED CONFERENCE PROCEEDINGS

(most recent on top)

2.3.1 *[Accepted/awaiting publication]*
F. Da Ros, S.M. Ranzini, Y. Osadchuk, A. Cem, B.J. Giron Castro, and D. Zibar, 2022. Reservoir-computing and neural-network-based equalization for short reach communication. In 2022 *Proceedings OSA Advanced Photonics Congress 2022*. IEEE
DOI: (awaiting details) Open Access (awaiting details)

2.3.2 Vladislav Neskorniuk, Andrea Carnio, Domenico Marsella, Sergei K. Turitsyn, Jaroslaw E. Prilepsky, Vahid Aref, 2022. Model-Based Deep Learning of Joint Probabilistic and Geometric Shaping for Optical Communication. In 2022 *Conference on Lasers and Electro-Optics (CLEO)*, OSA Technical Digest (Optica Publishing Group, 2022), paper (SW4E.5)
DOI: (awaiting details) Open Access here
Cited by 0

2.3.3 Bajaj, V., Chagnon, M., Wahls, S. and Aref, V., 2022, March. Efficient Training of Volterra Series-Based Pre-distortion Filter Using Neural Networks. In 2022 *Optical Fiber Communications Conference and Exhibition (OFC)* (pp. 1-3). IEEE.
DOI: (awaiting details) Open Access here
Cited by 0

2.3.4 Shahkarami, A., Yousefi, M.I. and Jaouen, Y., 2021, December. Efficient Deep Learning of Nonlinear Fiber-Optic Communications Using a Convolutional Recurrent Neural Network. In *2021 20th IEEE International Conference on Machine Learning and Applications (ICMLA)* (pp. 668-673). IEEE [selected paper]
DOI: 10.1109/ICMLA52953.2021.00112, **Open Access** here.
Cited by 0

2.3.5 Shahkarami, A., Yousefi, M.I. and Jaouen, Y., 2021, October. Attention-Based Neural Network Equalization in Fiber-Optic Communications. In *Asia Communications and Photonics Conference* (pp. M5H-3). Optical Society of America. ISBN: 978-1-957171-00-5.
DOI: 10.1364/ACPC.2021.M5H.3, Open Access here.
Cited by 0

2.3.6 Neskorniuk, V., Carnio, A., Bajaj, V., Marsella, D., Turitsyn, S.K., Prilepsky, J.E. and Aref, V., 2021, September. End-to-End Deep Learning of Long-Haul Coherent Optical Fiber Communications via Regular Perturbation Model. In *2021 European Conference on Optical Communication (ECOC)* (pp. 1-4). IEEE.
DOI: 10.1109/ECOC52684.2021.9605928, **Open Access** link here and in ArXive
Cited by 3

2.3.7 Bajaj, V., Buchali, F., Chagnon, M., Wahls, S. and Aref, V., 2021, June. 54.5 Tb/s WDM Transmission over Field Deployed Fiber Enabled by Neural Network-Based Digital Pre-Distortion. In *Optical Fiber Communication Conference* (pp. M5F-2). Optical Society of America.
DOI: n/a**, Open Access** link and download here
Cited by 4

2.3.8 Neskorniuk, V., Buchali, F., Bajaj, V., Turitsyn, S.K., Prilepsky, J.E. and Aref, V., 2021, June. Neural-Network-Based Nonlinearity Equalizer for 128 GBaud Coherent Transcievers. In *Optical Fiber Communication Conference* (pp. Th1A-30). Optical Society of America.
DOI: n/a, **Open Access** link here
Cited by 1

2.3.9 Benyahya, K., Ghazisaeidi, A., Aref, V., Chagnon, M., Arnould, A., Ranzini, S., Mardoyan, H., Buchali, F. and Renaudier, J., 2021, June. On the Comparison of Single-Carrier vs. Digital Multi-Carrier Signaling for Long-Haul Transmission of Probabilistically Shaped Constellation Formats. In *2021 Optical Fiber Communications Conference and Exhibition (OFC)* (pp. 1-3). IEEE.
DOI n/a, **Open Access** link here and in ArXive
Cited by 2

2.3.10 Da Ros, F., Ranzini, S.M., Dischler, R., Cem, A., Aref, V., Bülow, H. and Zibar, D., 2021, March. Machine-learning-based equalization for short-reach transmission: neural networks and reservoir computing. In *Metro and Data Center Optical Networks and Short-Reach Links IV* (Vol. 11712, p. 1171205). International Society for Optics and Photonics.
DOI: 10.1117/12.2583011, **Open Access** link here
Cited by 1

2.3.11 Ranzini, S.M., Dischler, R., Da Ros, F., Bülow, H. and Zibar, D., 2020, December. Experimental demonstration of optoelectronic equalization for short-reach transmission with reservoir computing. In *2020 European Conference on Optical Communications (ECOC)* (pp. 1-4). IEEE.
DOI: 10.1109/ECOC48923.2020.9333372, **Open Access** link here
Cited by 5

2.3.12 Bajaj, V., Buchali, F., Chagnon, M., Wahls, S. and Aref, V., 2020, December. Single-channel 1.61 Tb/s optical coherent transmission enabled by neural network-based digital pre-distortion. In *2020 European Conference on Optical Communications (ECOC)* (pp. 1-4). IEEE.
DOI: 10.1109/ECOC48923.2020.9333267, **Open Access** link and pdf here
Cited by 27

2.3.13 Neskorniuk, V., Freire, P.J., Napoli, A., Spinnler, B., Schairer, W., Prilepsky, J.E., Costa, N. and Turitsyn, S.K., 2020, December. Simplifying the Supervised Learning of Kerr Nonlinearity Compensation Algorithms by Data Augmentation. In *2020 European Conference on Optical Communications (ECOC)* (pp. 1-4). IEEE.
DOI: 10.1109/ECOC48923.2020.9333417, Open Access link here
Cited by 0

2.3.14 Freire, P.J., Neskornuik, V., Napoli, A., Spinnler, B., Costa, N., Prilepsky, J.E., Riccardi, E. and Turitsyn, S.K., 2020, December. Experimental Verification of Complex-Valued Artificial Neural Network for Nonlinear Equalization in Coherent Optical Communication Systems. In *2020 European Conference on Optical Communications (ECOC)* (pp. 1-4). IEEE.
DOI: 10.1109/ECOC48923.2020.9333293, Open Access link here
Cited by 2

2.3.15 Ranzini, S.M., Da Ros, F., Bülow, H. and Zibar, D., 2020. Optoelectronic signal processing for chromatic dispersion mitigation in direct detection systems. In 22nd International Conference on Transparent Optical Networks. IEEE.
DOI: NA, Open Access here.
Cited by 2

2.3.16 Bajaj, V., Chimmalgi, S., Aref, V. and Wahls, S., 2019. Exact nonlinear frequency division multiplexing in lossy fibers. In *2020 European Conference on Optical Communications (ECOC)*, Dublin, Ireland, Sep. 2019
DOI: 10.1049/cp.2019.0940, Open Access link here
Cited by 3

2.3.17 Ranzini, S.M., Da Ros, F. and Zibar, D., 2019, September. Joint low-complexity opto-electronic chromatic dispersion compensation for short-reach transmission. In *2019 IEEE Photonics Conference (IPC)* (pp. 1-2). IEEE
DOI: 10.1109/IPCon.2019.8908278, Open Access link here
Cited by 3

2.4 PEER-REVIEWED CONFERENCE TALKS, INCLUDING INVITED CONTRIBUTIONS

On many instances the actual slides presented at conferences are available open access and have been included in the below:

2.4.1 F. Da Ros (*presenter*)
Invited Presentation at 2022 Advanced Photonics Congress SPPCom
Title: Reservoir-computing and neural-network-based equalization for short reach communication *(including work by SM Ranzini)*
24-28 July 2022, Maastricht, Netherlands
DOI (awaiting); Open Access (awaiting)

2.4.2 Vladislav Neskorniuk (*presenter*)
Presentation at 2022 Conference on Lasers and Electro-Optics (CLEO)
Title: Model-Based Deep Learning of Joint Probabilistic and Geometric Shaping for Optical Communication (SW4E.5)
15-20 May 2022, San Jose, California, USA
DOI (awaiting); **Open Access** here

2.4.3 Vinod Bajaj (*presenter*)
Presentation at 2022 Optical Fiber Communication Conference (OFC)
Title: Efficient Training of Volterra Series-Based Pre-Distortion Filter Using Neural Networks
6-10 March 2022, San Diego, California, USA
DOI: 10.5281/zenodo.6335505; **Open Access** here; **Open Access presentation slides** here

2.4.4 Vahid Aref (*presenter*)
Presentation at 2021 Workshop on Neuromorphic High-Speed Communications (NeuCoS 2021)
Title: Applications of Deep Learning for Coherent Optical Communications *(incl. work by FONTE ESRs)*
9 December 2021; online
DOI (not available); **Open Access** (awaiting)

2.4.5 Francesco Da Ros *(presenter)*
Presentation at 2021 Workshop on Neuromorphic High-Speed Communications (NeuCoS 2021)
Title: Reservoir Computing for Short-reach Optical Communication *(incl. work by Stenio Ranzini)*
9 December 2021; online
DOI: 10.5281/zenodo.5793747 ; **Open Access presentation slides** here

2.4.6 Francesco Da Ros (*presenter*)
Presentation at 1st Workshop on Neuromorphic Photonics
Title: Machine Learning algorithms for optimized data transmission links (*incl. work by Stenio Ranzini*)
6-7 December 2021, online
DOI:10.5281/zenodo.5785594; **Open Access presentation slides** here

2.4.7 Abtin Shahkarami (*presenter*)
Presentation at IEEE 20th International Conference On Machine Learning And Applications (ICMLA2021)
Title: Efficient Deep Learning of Nonlinear Fiber-Optic Communications Using a Convolutional Recurrent Neural Network (Paper M5H.3)
DOI 10.5281/zenodo.5871715; **Open Access presentation slides** here

2.4.8 Francesco Da Ros (presenter)
Presentation at the 9th International Workshop on Fiber Optics in Access Networks (FOAN 2021)
Title: Machine Learning in Photonics *(including work by SM Ranzini)*
26-27 October 2021; Ljubljana, Slovenia
DOI 10.5281/zenodo.5793320; **Open Access presentation slides** here

2.4.9 Abtin Shahkarami (*presenter*)
Presentation at OSA 2021 Asia Communications and Photonics Conference (APC)
Title: Attention-Based Neural Network Equalization in Fiber-Optic Communications
24-27 October 2021; Shanghai; China
DOI: here **Open Access presentation slides** here;

2.4.10 Vladislav Neskorniuk (*presenter*)
Invited Presentation at 2021 European Conference on Optical Communication (ECOC) (special ML workshop)
Title: Machine learning methods for nonlinearity mitigation in the physical layer of fiber-optic communication links
13-16 September 2021; Bordeaux; France
DOI: 10.5281/zenodo.5528637; **Open Access presentation slides** here

2.4.11 Vladislav Neskorniuk (*presenter*)
Presentation at 2021 European Conference on Optical Communication (ECOC)
Title: End-to-End Deep Learning of Long-Haul Coherent Optical Fiber Communications via Regular Perturbation Model
13-16 September 2021; Bordeaux; France
DOI 10.1109/ECOC52684.2021.9605928; **Open Access** here

2.4.12 Vladislav Neskorniuk (*presenter*)
Poster at 2021 Optical Fiber Communication Conference (OFC)
Neural-Network-Based Nonlinearity Equalizer for 128 GBaud Coherent Transcievers
6–11 June 2021, Washington, DC, United States
DOI 10.1364/OFC.2021.Th1A.30; **Open Access** here

2.4.13 Vinod Bajaj (*presenter*)
Presentation at 2021 Optical Fiber Communication Conference (OFC)
Title: 54.5 Tb/s WDM Transmission Title: Over Field Deployed Fiber Enabled by Neural Network-Based Digital Pre-Distortion
6–11 June 2021, Washington, DC, United States
DOI: 10.1364/OFC.2021.M5F.2; **Open Access** here

2.4.14 Benyahya, A. *(presenter)*
Presentation at 2021 Optical Fiber Communication Conference (OFC)
Title: On the Comparison of Single-Carrier vs. Digital Multi-Carrier Signaling for Long-Haul Transmission of Probabilistically Shaped Constellation Formats (*including work by SP Ranzini*)
6–11 June 2021, Washington, DC, United States
DOI: 10.1364/ofc.2021.m3h.6 , **Open Access** here

2.4.15 Francesco Da Ros (*presenter*)
Invited Plenary Speaker at 2021 SBFoton International Optics and Photonics Conference (IOPC) 2021
Title: Advancing photonic systems through machine learning
31 May-2 June 2021, Sao Paulo, Brazil
Open Access Watch it here

2.4.16 F. Da Ros *(presenter)*
Invited Presentation at SPIE Photonic West 2021
Title: Machine-learning-based equalization for short-reach transmission: neural networks and reservoir computing *(including work by SM Ranzini)*
6-12 Mar 2021, United States
DOI: 10.1117/12.2583011, **Open Access** here

2.4.17 Vladislav Neskorniuk (*presenter*)
Presentation at DigiCOSME/Gdr-ISIS workshop *(co-chair)*
A novel data augmentation technique to reduce the complexity of receiver-based DSP in optical telecommunications
25 March 2021; Paris; France
DOI: 10.5281/zenodo.5528621; **Open Access presentation slides** here

2.4.18 Abtin Shahkarami (*presenter*)
Presentation at DigiCOSME/Gdr-ISIS workshop.
Title: Efficient equalization in nonlinear fiber-optic communications using a convolutional recurrent neural network
25 March 2021; Paris; France
DOI: 10.5281/zenodo.5871037; **Open Access presentation slides** here

2.4.19 Vinod Bajaj (*presenter*)
Presentation at European Conference on Optical Communications (ECOC2020) (Highly scored submission)
Title: Single-channel 1.61 Tb/s Optical Coherent Transmission Enabled by Neural Network-Based Digital Pre-Distortion
Brussels, Belgium 6-10 December 2020
DOI:10.1109/ECOC48923.2020.9333267, **Open Access** here

2.4.20 Stenio M Ranzini (*presenter*)
Presentation at European Conference on Optical Communications (ECOC2020)
Title: Experimental Demonstration of Optoelectronic Equalization for Short-reach Transmission with Reservoir Computing
Brussels, Belgium 6-10 December 2020
DOI 10.1109/ECOC48923.2020.9333372; **Open Access** here

2.4.21 Vladislav Neskorniuk (*presenter*)
Presentation at European Conference on Optical Communications (ECOC2020)
Title: Simplifying the Supervised Learning of Kerr Nonlinearity Compensation Algorithms by Data Augmentation
Brussels, Belgium 6-10 December 2020
DOI: 10.1109/ECOC48923.2020.9333293, **Open Access** here

2.4.22 Stenio M. Ranzini (*presenter*)
Invited Presentation International Conference on Transparent Optical Networks (ICTON2020)
Title: Optoelectronic signal processing for chromatic dispersion mitigation in direct detection systems
Bari, Italy; 19-23 July 2020
DOI 10.5281/zenodo.3982018, **Open Access** here

2.4.23 Darko Zibar *(presenter)*
Short Course at Optical Networking and Communication Conference (OFC2020)
Title: Hands-on: Machine Learning in Optical Networks OFC2020
San Francisco, California, USA; 9 March 2020
(course CANCELLED due to COVID-19)

2.4.24 Darko Zibar *(presenter)*
Invited workshop at Nelson Mandela University, Port Elizabeth, South Africa; 12-14 Feb 2020
Title: Machine Learning Techniques *(Including work by Stenio Ranzini)*
DOI n/a; **Open Access** n/a

2.4.25 Darko Zibar *(presenter)*
Invited presentation at the 27th International Conference on Software, Telecommunications and Computer Networks (SoftCOM 2019);
Title: Machine Learning Techniques for Next-generation Optical Communication Systems *(Including work by Stenio Ranzini)*
Split; Croatia; 19-21 September 2019
DOI n/a; **Open Access** n/a

2.4.26 Vinod Bajaj *(presenter)*
Invited presentation at the Nonlinear Fourier Transform Workshop (NFT2020);
Title: Exact NFDM Transmission in the Presence of Fiber-Loss
Delft, Netherlands, 4-5 Feb 2020
DOI 10.5281/zenodo.3742852, **Open Access presentation slides** here

2.4.27 Francesco Da Ros *(presenter)*
Invited presentation at ERC conference Photonic Reservoir Computing and Information Processing in Complex Networks;
Title: Neural Network based Hybrid Optical-Digital Equalization for Short-reach Transmission. *Including work by Stenio Ranzini*
Trento; Italy; 4-6 December 2019
DOI 10.5281/zenodo.3742852, **Open Access presentation slides** here

2.4.28 Vinod Bajaj *(presenter)*
Presentation at 45th European Conference on Optical Communication ECOC2019,
Title: Exact nonlinear frequency division multiplexing in lossy fibers
Dublin; Ireland; 22-26 September 2019
DOI 10.1049/cp.2019.0940, **Open Access** here

2.4.29 Stenio M. Ranzini (*presenter*)
presentation at 2019 IEEE Photonics Conference (IPC)
Title: Joint low-complexity opto-electronic chromatic dispersion compensation for short-reach transmission.
San Antonio, TX USA; 29 Sept to 3 Oct 2019
DOI 10.1049/cp.2019.0940, Open Access here

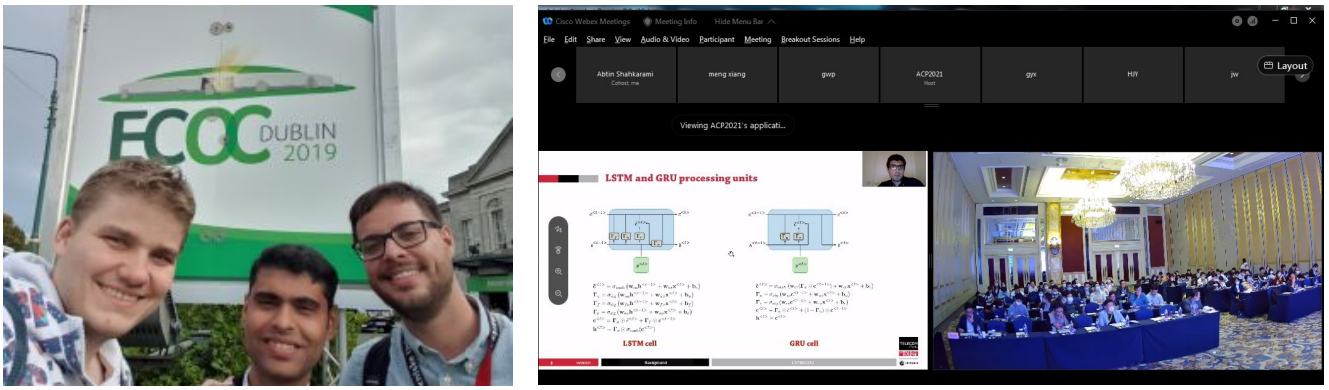


Figure 1: FONTE ESRs at ECOC2019 conference (left) and ESR4 presenting at ACP2021

2.5 PUBLISHED SOFTWARE PACKAGES AND COMPUTER CODES FOR MODELLING AND SIMULATION

2.5.1 A **Software package** to model the single-pol and dual-pol fiber-optic channels governed by nonlinear Schrödinger equation (NLSE) and coupled NLSE, accompanied with TX and RX DSP chain implementation has been developed by FONTE ESR Abtin Shahkarami (Telecom Paris/TPT).
NLS equation is solved using split-step Fourier method in this library. The TX and RX DSP chain module, for single-polarization, includes 9 modules: 1. Modulation; 2. RRC Pulse shaping; 3. Sampling; 4. Matched filtering; 5. Chromatic dispersion compensation; 6. Digital back-propagation; 7. Carrier phase estimation; 8. Detection and 9. Demodulation.
For dual-polarization systems, an additional 2 modules are implemented: i. Polarization multiplexation and demultiplexation; ii. Radius-directed-equalization (RDE) -based multiple-input-multiple-output (MIMO) algorithm to compensate for the PMD)
The extensive software package including all modules and documentation is available OA on GitHub at https://github.com/FONTE-EID/fiber-optic-transmission-system-modeling which FONTE and the EC contribution fully acknowledged in the underlying documentation.
The codes developed in this software package underlie published work by Abtin Shahkarami, in particular publications, 2.3.4 and 2.3.5.

2.5.2 The NFDMLab repository, developed by Sander Wahls' research group at the Delft Center for Systems & Control (TU Delft, Netherlands), is an existing open source software environment that simulates fiber-optic data transmissions using nonlinear Fourier transforms. The goals and architecture of NFDMLab have been described in [2].

[2] M. Brehler, C. Mahnke, S. Chimmalgi and S. Wahls, "NFDMLab: Simulating Nonlinear Frequency Division Multiplexing in Python," Optical Networking and Communication Conference & Exhibition (OFC), paper M3Z.13, Mar. 2019

FONTE ESR Vinod Bajaj (TU Delft) developed the DDF branch, an extension to the NFDMLab, to simulate exact nonlinear frequency division multiplexing (NFDM) transmission for dispersion decreasing fibers (DDF). The additional features simulate transmission over dispersion decreasing fiber links and modifies continuous and discrete spectrum modulators accordingly. Two examples each for discrete and continuous spectrum (b-coefficient) modulation are added. These examples were also used to generate results published in the conference and journal paper.

The FONTE acknowledgement and EC contribution statement can be found at https://github.com/FastNFT/NFDMLab/blob/DDF/Documentation/index.rst, where it will be integrated in the main master branch of the software package with the next update.

2.5.3 The python **computer code** written to generate the results published in 2.2.6 '*Complex-valued neural network design for mitigation of signal distortions in optical links*' have been made available **Open Access** via the ZENODO repository here

2.6 PHD THESIS

Of the 4 ESRs in FONTE one has submitted his PhD thesis, with the remaining 3 being currently in preparation.

2.6.1 Ranzini, S.M., 2021. Optoelectronic receiver in short reach optical fiber communications.(PhD Thesis). DOI: n/a, Open Access here

2.7 POSTERS

Uniquely, FONTE encourages its ESRs to make Open Access ***posters*** presented at conferences, by deposition the final version in the **ZENODO** repository https://zenodo.org/, where they are allocated a DOI which can be brought into SyGMa, linking this content to the project output on CORDIS.

2.7.1 Ranzini, S.M., 2019. Tunable Optoelectronic Chromatic Dispersion Compensation Based on Machine Learning for Short-Reach Transmission. Poster presented in the Workshop on Next-Generation Cloud Infrastructure; 25-26 Nov 2019; Microsoft Cambridge, UK. **Open Access poster** here

2.7.2 Ranzini, S.M., 2019. Optical Neural Network and Reservoir Computing for Optical Fiber Communications. poster given at the ERC international workshop 'Photonic Reservoir Computing and Information Processing in Complex Network' Trento, Italy; 4-6 Dec 2019). **Open Access poster** here

2.7.3 Bajaj, V., 2019. Exact NFDM in Lossy Fibers. Poster presented at the Nokia Bell Labs Student Day 2019, Stuttgart, Germany. **Open Access poster** here**.**

2.7.4 Bajaj, V., 2021. Neural Networks-based Nonlinear Digital Pre-Distortion of High-Speed Coherent Optical Transmitter. Poster presented at TU Delft Thesis Market 2021, Delft, Netherlands. **Open Access poster** here**.**

2.8 INFORMAL SEMINARS AND TALKS

All ESRs regularly present their progress and latest results at *in-house* seminars at their local host and secondment institutions. This is an ongoing dissemination activity with individual events not listed separately in this report.

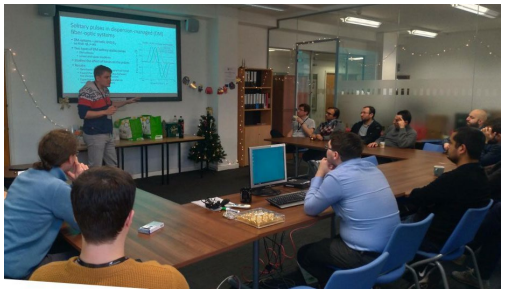


Figure 2: ESR1 presenting his research during group seminar at Aston University

3 PUBLIC ENGAGEMENT, INCL OUTREACH

Outreach and public engagement activities in FONTE are designed to engage a large and diverse audience from all spectrums of society, including the industrial sector.

The global COVID19 pandemic (2020-22) impacted on the type of public engagement activities FONTE was able to deliver, especially in the second half of the project, shifting the focus to virtual rather than in-person activities. As reported previously, FONTE engage with its target audience through in-person events, traditional broad stream media and social media such as Twitter, Blogs, YouTube and private websites, as well as professional social networks, such as LinkedIn and Research Gate.

Some of these interactions took advantage of the international nature of FONTE, with ESRs being capable of conversing in more than just one language. Thus, between them, FONTE ESRs engage with the public in bi-lingual blogs and websites featuring **English, French and Russian**. Newsletters were published in six languages: **English, French, Russian, Hindi, Persian, German**.

Figure 3: FONTE's Foreign Language Bulletins to increase engagement with the non-English speaking audience.

All 4 FONTE ESRs have lead a variety of individual and group activities and between them they have reached an audience of thousands of individuals from industry, school pupils, students, academics outside FONTE's immediate field of research and the general public at large.

All events and activities receive broad coverage on the Project website under section 'Dissemination and Communication' at https://fonte.astonphotonics.uk/dissemination/

3.1 ENGAGEMENT WITH INDUSTRY

Over the lifetime of the project the following activities took place to engage with the **industrial sector**:

- 9 Oct 2019: ESR V. Neskorniuk was part of the Aston at Photonex Europe 2019, one of the UK's premier events dedicated to photonics, imaging, lasers and optical technologies from pure research to development of bespoke advanced user solutions. AiPT was represented with a dedicated booth, manned by 5 members of AiPT (including **FONTE ESR1**) and well stocked with posters and flyers showcasing the latest research at the **Aston Institute of Photonic Technologie**s. The looped background presentation and multitude of information material gave ample talking points to visitors at the booth. More details here.
- 25 Nov 2019: ESR v. Bajaj participated at ***Bell Labs Students' Day*** (Germany), where he presented a poster on his research. The event included a session aimed at NBL staff members reviewing posters presented. More details here.

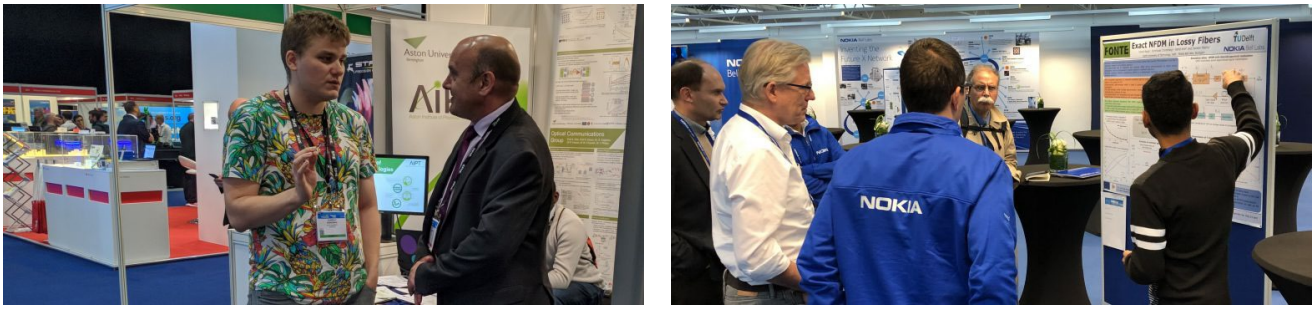


Figure 4: Engagement with Industry. ESRs in conversation with representative of IPG Photonics during Photonex (L) and Nokia Bell Labs (R)

3.2 ENGAGEMENT WITH PRIMARY/SECONDARY SCHOOL PUPILS

Over the lifetime of the project the following activities took place to engage with **school pupils** of all ages:

- 25 Oct 2019: ESR S. Ranzini engaged with secondary school pupils at the 2019 DTU Project Day in Copenhagen, DK. More details here
- 14 Feb-2020: ESR V. Neskorniuk visited the **Holy Cross Catholic Primary School** in Birmingham, UK, and a organised a fun day of activities demonstrated Optics at the school's School Careers Fair.

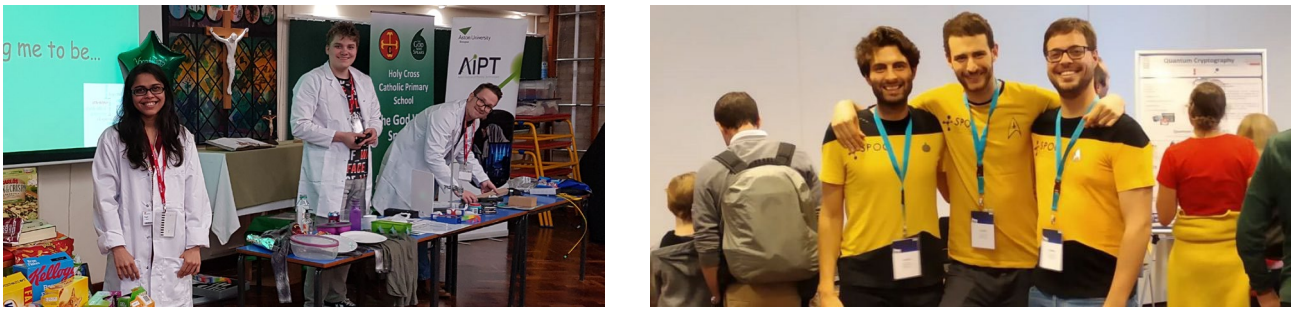


Figure 5: Engagement with schools. ESRs at outreach events targeting British primary (left) and Danish secondary school pupils (right).

The visit to the primary school took place a mere 3 weeks before the COVID19 pandemic forced a widespread lockdown of large sections of society throughout Europe, making in-person activities in schools

impossible for the following 24 months. Online and virtual engagement activities, however, continued, More event detailed here.

3.3 ENGAGEMENT WITH ERASMUS AND MASTER'S STUDENTS, INCL ACADEMIC SECTOR BEYOND FONTE

Over the lifetime of the project the following activities took place to engage with the **academic sector** beyond the project itself:

- 24 Feb 2020: Project manager leads activities to familiarise **Erasmus** students at Aston University, UK, with opportunities presented by MSCA and Initial Training Networks in particular. Details here
- 1 Dec 2020: **Science Pitches** from ESRs S. Ranzini, V. Bajaj and N. Neskorniuk uploaded to project website. Details here.
- 27 Oct 2020 ESR S Ranzini leads a **Brazilian Photonics Outreach Event** at his *alma mater* (in Portuguese).
- 24 March 2021: Project manager leads a similar activity this time online due to COVID and including 2 year groups of 3 **Erasmus Mundus Joint Master's Degree Programmes**, reaching 95 students in UK, Italy, Greece, France and Japan. ESRs S. Ranzini and V. Neskorniuk join for a 'view from within an ITN' session. Details here.
- 19 May 2021: FONTE's F. Da Ros becomes **OSA Ambassador** aiming to mentor and inspire the next generation of students and early career professionals. Details here.
- 16-21 May 2021: Aston Institute Of Photonic Technologies organised an informative and fun **IDL Summit** to celebrate the **International Day of Light 2021**
- 10 Nov 2021: V. Bajaj presents at the '**Thesis Market'**, a showcasing event for MSc Students at TU Delft (Netherlands).

It is particularly noteworthy that instead of the 3 OTA workshops FONTE committed to organising as per its grant agreement, FONTE was able to benefit from synergy with its sister MSCA ITNs coordinated by Aston Institute of Photonic Technologies ([3]), organising an impressive 14 Open-To-All workshops and symposia, attracting a wide academic audience from beyond FONTE. **Together these events were attended by 1150 academics from all over the world.** Publicizing these OTA events also represents an engagement activity with the academic sector, spreading the word *about* FONTE-as-a-project independently from the scientific results obtained *within* FONTE (i.e. dissemination).

Finally, engagement with the academic and industrial sector also happened organically whenever members of the FONTE consortium attended conferences or any other type of meeting, using these opportunities to talk *about* the project as well as their research within it.

[3] Projects REAL-NET, MOCCA, MEFISTA, POST-DIGITAL, MENTOR, WON, MULTIPLY, who have received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie Grant Agreements 813144, 814147, 861152, 860360, 956713, 814276 and 713694 respectively.

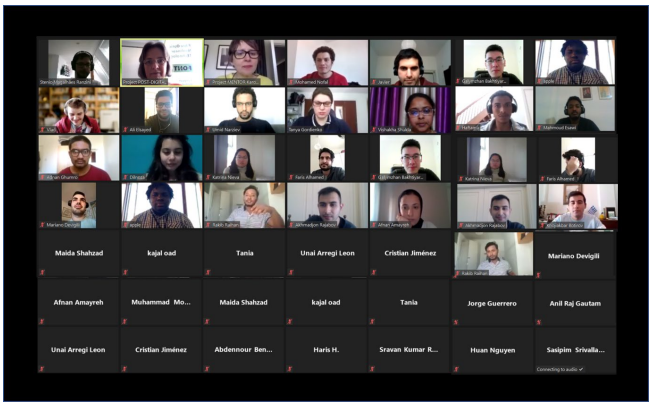


Figure 6: Engagement with undergraduate students. Project manager at outreach activities to Erasmus students in 2020 (top) and 2021 (left)

3.4 ENGAGEMENT WITH GENERAL PUBLIC

Over the lifetime of the project the following activities and events took place to engage with the **general public**:

- 11 Oct 2019: ESR S. Ranzini took part in the city-wide outreach '**Kulturnatten'** Culture Night in Copenhagen (DK) an event reaching a general audience of 69,000. Details here.
- 18 May 2020: ESR A. Shahkarami produced a **YouTube video** introducing himself and his hometown (in Persian), attracting 190 views. Details here.
- 1 Oct 2020: FONTE ESRs published **FONTE Foreign Language Bulletins in Russian, Persian, and German** to reach the widest possible non-English speaking audience. Details here.
- 7 Mar 2021: **FONTE at OFC2022** published, a handy booklet with details of all research presented by FONTE members at OFC conference, including abstracts. Details here.
- 20 Mar 2021: ESR A. Shahkarami and an ESR in another ITN talked **live on Instagram** about their research in two different H2020 Projects, reaching over 300 views.
- 16-21 May 2021: Aston Institute of Photonic Technologies organised a week-long celebration of the International Day of Light 2021. We publish a special **IDL2021 Brochure** including a section where FONTE ESRs describe how their research relates to the concept of «light». Details here.
- 1 Jun 2021: **FONTE 3rd Year Brochure** published and disseminated on social media. Details here.
- 23 Jun 2021: To celebrate International Day of Women in Engineering (INWED2021) and raise the profile of **Woman In Engineering**, EC Project Managers at AiPT produced a poster for dissemination on social media.
- 6 Sept 2021: **FONTE at ECOC2021** published, a handy booklet with details of all research presented by FONTE members at ECOC conference, including abstracts. Details here.
- 7 Oct 2021: FONTE published a brochure entitled '**Leveraging Technologies for a Better Tomorrow'**, focussing on meaningful research for today's societal challenges by spotlighting ESR S. Ranzini and the significance of his research addressing the Optical Network Capacity Crunch. Details here.

- 11 Mar 2022: Together with the **Optica Student Chapter** at Aston University, **FONTE** organised a 1-day Round Table Careers' event: '*Beyond PhD: Celebrating Women in STEM Careers*'. Details here.

3.5 SOCIAL MEDIA ACTIVITIES

FONTE uses various social platforms to engage with a wide and diverse audience. In our experience **Twitter** proved to be the most effective platform for fast, repeated and sustained engagement and consequently most effort was devoted to that platform. FONTE also has a presence on more professional-aligned social media platforms **ResearchGate** and **LinkedIn**. Additionally - and perhaps uniquely - FONTE also utilises the diverse origin of its ESRs to engage with an international audience in **several languages**, publishing material in **Portuguese, Russian, Persian** and **Hindi** both on the project website, its twitter feed and **bilingual** blogs and websites managed by the ESRs.

Twitter

FONTE's main Twitter feed is located at https://twitter.com/EidFonte. The twitter feed is populated at least weekly with FONTE output, activities or training events, details of upcoming conferences, webinars etc. as well as relevant retweets from other sources. At present over 460 individual tweets have been disseminated, generated over **200,000 impressions** - number of times users saw your tweet on their own twitter – averaging at over 200/day, demonstrating to success in reaching a wide and diverse audience.

The FONTE twitter account is currently followed worldwide by 340 photonics-related individuals, research groups and companies from 39 countries across the world. Outside the FONTE Consortium followers from the USA dominate with over 10% of all followers. On the other end of the spectrum we have followers from small countries not traditionally associated with a strong photonics community (Figure 7).

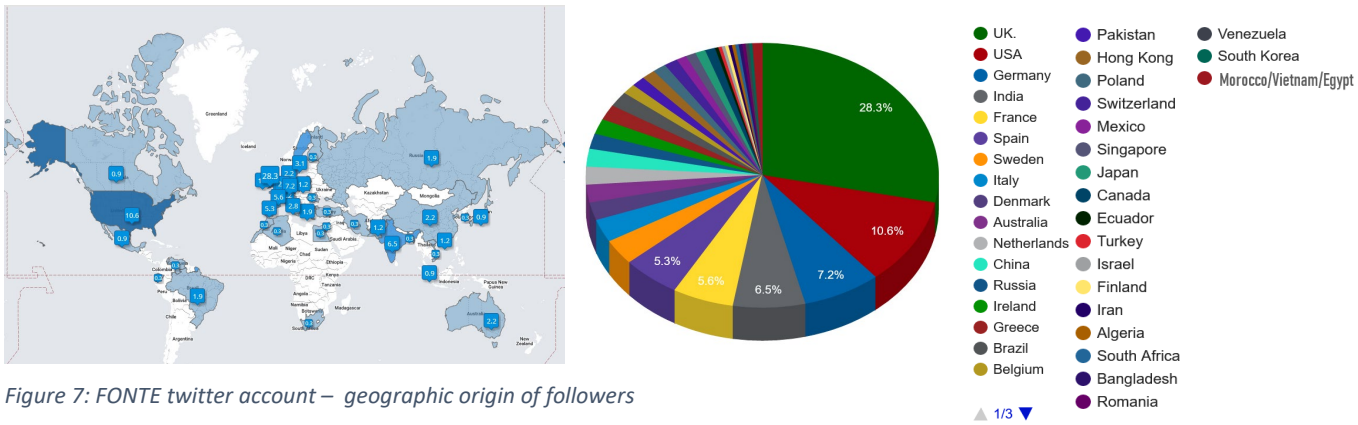


Figure 7: FONTE twitter account – geographic origin of followers

FONTE has worked tirelessly to build its follower base on twitter https://twitter.com/EidFonte. Among influential followers we count the **Editor of Nature Photonics Dr Rachel Won** (>2.7K followers), several photonics research labs, such as CEMES-CNRS (6.6K+ followers); Recherche_ECLyon (3.6K followers); Eggleton Lab at University of Sydney (700+ followers); Armani Lab at USC (700+ followers), commercial companies, such as American Elements, a Nanotech company with 32.3K followers, scientific output channels such as Photonics Online Meetup, pioneers in online conferences with 1.4K+ followers, Nanophotonics (a journal with 1400+ followers); Institute of Physics (700+ followers); and influential individuals such as (Professors) Paolo Biagioni (900+), Alexandra Boltasseva (1.3K), Salahuddin Nur (600+).

Twitter proved a useful engagement tool, which also allowed for some tracking of its effectiveness. For example, tweets ahead of Open-To-All workshops, introducing speakers one by one resulted in a daily spike of click-throughs and registrations on the OTAW website, thus correlating directly with twitter activity. Using Bit.Ly links in twitter announcements (linking to the registration webpage of OTAW) also allowed a degree of tracking how many registrations coming through the Twitter feed. For example, the Bit.Ly short handle used on twitter to the *Digital Signal Processing OTAW* was followed 146 times, while the Bit.Ly short handle leading directly to the registration page of the *DTU-Workshop* was opened 73 times, thus contributing about one third of all registrations received, with the remaining ones coming from direct (bit.ly independent) clicks to the registration. Undoubtedly Twitter contributed to reaching individuals and OTAW registrations from countries not part of the 'traditional' photonics community.

FONTE members also tweet individually about their science output (among other topics):

- Coordinator Sergei Turitsyn: @im_sergei / https://twitter.com/im_sergei
- WP Leader Darko Zibar: @DarkoZibar14 / https://twitter.com/DarkoZibar14
- WP Leader Sander Wahls: @SanderWahls / https://twitter.com/SanderWahls
- ESR1 Vladislav Neskorniuk: @VNeskorniuk / https://twitter.com/VNeskorniuk
- ESR2 Vinod Bajaj: @I_am_VinodBajaj / https://twitter.com/I_am_VinodBajaj
- ESR3 Stenio Ranzini: @stenio_ranzini / https://twitter.com/stenio_ranzini
- ESR4 Abtin Shakarami: @AbtinShahkarami / https://twitter.com/AbtinShahkarami

Blogs, Videos and FONTE-related personal websites

All FONTE ESRs have their own blogspot, where they post longer pieces of entertaining or reflective general interest, detailing their experience in the MSCA training network. These social media blogs complement the twitter feeds and appear directly on the FONTE website. Vlad (ESR1) is blogging bilingually in both English and Russian.

Research Gate, Orcid and LinkedIn

As one of the many means to share project research output, Fonte-EID also has a presence on the scientific online platform ***Research Gate*** at https://www.researchgate.net/project/FONTE-EID. In addition, all ESRs have individual ***LinkedIn*** accounts and ***ORCID*** to further widen the reach of their scientific output and make it easily discoverable.

Memberships and Ambassadorships

Several of the FONTE ESRs are members of the local **OSA SPIE student chapters** and participate in periodic engagement activities. For example, the **Aston OSA SPIE student chapte**r has organised an interactive workshop devoted to Machine Learning algorithms and neural networks. ESR1 is **STEM Ambassadors** for Science Technology Engineering and Mathematics at Aston University, while other FONTE ESRs are **Student Ambassadors** for their local universities, where they participate in activities such as open days.

3.6 TYPE AND SIZE OF TARGET AUDIENCES REACHED; QUANTIFICATION OF EFFECTIVENESS

Not all activities fit neatly into the above categories. To complete the picture Table 1 summary some additional engagement activities, and importantly lists the size of audience actually reached, as evidenced by:

- attendance of FONTE in-person and virtual events,
- registrations to FONTE OTAWs and symposia,
- print runs of brochures,

- downloads of documents and
- click-throughs to website material.

Not every activity can be quantified in terms of reach, thus in the case of activities linked to international conferences the size of the event is listed and clearly marked.

Taken together, the data in Table 1 clearly evidences the fact that FONTE was highly effective in reaching and engaging with a large and diverse audience, encompassing all spectrums of society, from school children and general public to SMEs, industry, university under- and postgraduate students including ESRs, and finally both junior and established academics.

Table 1: FONTE public engagement activities, with type and size of audience reached

Date	Event	Location	Details	Audience	Size of audience
06-Apr-22	DTU Workshop Booklet of Abstracts published	online and twitter	Our DTU-Workshop Booklet, giving information about the speakers and abstracts of talks given during our DTU Workshop has been published and distributed widely over social media. Download it here	Conference Attendees	150
07-Mar-22	Short Course at OFC2022	San Diego, California, US	FONTE WP Leader Darko Zibar , together with Massimo Tornatore (Politecnico di Milano, Italy) deliver a course at the Optical Networking and Communication Conference (OFC2021) entitled Machine Learning in Optical Networks (SC483)' .	OFC Conference Attendees	15,000 (size of conference)
01-Mar-22	FONTE at OFC 2022 Booklet of Abstracts published	online and twitter	Our Booklet of Abstracts, detailing talks and posters by FONTE consortium members during OFC 2022 Conference has been published and distributed widely over social media. Download it here	general public	126 downloads from twitter, plus downloads from website (unknown)
01-Sep-21	FONTE at ECOC 2021 Booklet of Abstracts published	online and twitter	Our Booklet of Abstracts, detailing talks and posters by FONTE consortium members during ECOC2021 Conference has been published and distributed widely over social media. Download it here	general public	
10-Nov-21	Thesis Market Event	TU Delft, Netherlands	Vinod BAJAJ presented a poster detailing his research in the DCSC 'Thesis Market' event to both existing staff and potential students. View it here	graduate and postgraduate students	30
27-Oct-21	Invited talk as OSA Guest lecturer at Warsaw University	virtual	Francesco Da Ros of DTU, in his capacity as OSA Ambassador for the Optical Society, gives an invited talk on Solving Photonics Problems With Machine Learning at Warsaw University Student Association of Optics and Photonics (Warsaw, Poland; 27 Oct '21).	postgraduate students	44
04-Oct-21	FONTE IEEE DAY Brochure published	online and twitter	Our Leveraging Technologies for a better tomorrow booklet to celebrate IEEE Day, spotlights the research of ESR Stenio Ranzini and its contribution to addressing the Optical Communications Capacity Crunch. It has been published and distributed widely over social media. Download it here	general public	377 twitter 'impressions'
01-Oct-21	DSP Workshop Booklet of Abstracts published	online and twitter	Our Booklet of Abstracts, giving information about the speakers and abstracts of talks given during our Digital Signal Processing of Optical Communication workshop (coorganised with REAL-NET) has been published and distributed widely over social media. Download it here	general public	332 twitter Impressions; 146 downloads from twitter, plus downloads from website (unknown)
19-Aug-21	Invited talk as OSA Guest lecturer at Bennett University	virtual	Francesco Da Ros of DTU, in his capacity as OSA Ambassador for the Optical Society, gives an invited lecture on Machine Learning in Photonic Systems at Bennett University (Uttar Pradesh, India; 19 Aug '21).	students	about 35
27-Jul-21	Invited talk as OSA Guest lecturer at Brno University	virtual	Francesco Da Ros of DTU, in his capacity as OSA Ambassador for the Optical Society, gives an invited lecture on Machine Learning in Photonic Systems at at Brno University (Czech Republic; 27 Jul '21).	students	about 35
20-Jul-21	invited talk	virtual	FONTE WP Leader Darko Zibar delivers an invited presentation 'Distance and spectral power profile shaping using machine learning enabled Raman amplifiers' at the 2021 IEEE Summer Topicals Meeting Series (SUM) virtual conference	Conference Attendees	

07-Jun-21	Short Course at OFC2021	virtual	FONTE WP Leader Darko Zibar , together with Massimo Tornatore (Politecnico di Milano, Italy) deliver a course at the Optical Networking and Communication Conference (OFC2021) entitled Machine Learning in Optical Networks (SC483)' .	OFC Conference Attendees	15,000 (size of conference
06-Jun-21	FONTE 3rd Year Brochure published	online and twitter	Our FONTE 3rd Year Brochure, summarising the third year of FONTE has been produced and distributed widely over social media. Download it here	general public	
21-May-21	IDL2021 Summit	online and twitter	A final event in the week-long International Day of Light celebrations, the 9 MSCA projects at AiPT organised a IDL2021 Summit on 21 May, with lectures, fun activities and a photo competition on the subject of 'Light'	general public, academics, graduate and postgraduate students	100
17-20 May 2021	Illuminate	Birmingham, UK	The SPIE Aston Student Chapter celebrates the International Day of Light with the Illuminate Event, a series of mini events around Aston University	general public, Academics, graduate and postgraduate students	50
16-May-21	IDL2021 Brochure published	online and twitter	Celebrating the International Day Of Light 2021 on 16 May FONTE in synergy with all other MSCA Projects coordinated at Aston Institute of Photonic Technologies has published a stunning brochure dedicated to Light. In it our ESRs explain how their research relates to the concept of 'Light'. View full brochure here	general public	
06-May-21	OSA Ambassador elected	DTU, Denmark	Francesco Da Ros of DTU Fotonik, has been selected as OSA Ambassador by the Optical Society (OSA) to mentor and inspire the next generation of students and early career professionals in the global optics and photonics community. Read full publication here	general public, students, early career professionals	
19-22 Apr 2021	NIP Workshop Booklet of Abstracts published	online and twitter	Our Booklet of Abstracts, giving information about the speakers and abstracts of talks given during FONTE's Nano and Integrated Photonics workshop (coorganised with MULTIPLY) has been published and distributed widely over social media. Download it here	general public, academics, graduate and postgraduate students	100
25-Mar-21	Invited talk at CNRS	online	Vladislav Neskorniuk gave an invited talk at the CNRS Machine Learning in Photonics workshop	academics	
01-Dec-20	Featured article in scientific press	online and twitter	The 'Machine Learning in Photonic System (MLiPS)' group, led by FONTE's Darko Zibar at DTU, featured in the IEEE PHOTONICS SOCIETY NEWSLETTER Dec 2020 issue. Outreach activities of our ESR S.M. Ranzini also received some coverage Feature article here. Read full feature article here	general public	
04-Nov-20	Course at BostonPhotonics.org	virtual	WP Leader Darko Zibar speaks at the Boston Photonics.org event about Machine Learning research in his group at DTU	junior academics	
01-Oct-20	Foreign Language Research Bulletins published (Russian, Portuguese, Persian, Hindi, German)	online and twitter	Using their international background, FONTE ESRs produced a series of Foreign Language Research Bulletins, covering FONTE, its goals and most recent research results. Languages covered are Russian, Portuguese, Persian, Hindi, and German.	general public	3390 twitter impressions with 3% engagement rate. 70 downloads via twitter, plus more from website (unknown)
01-Jul-20	FONTE Newsletter #3 produced	online and twitter	FONTE Newsletter Issue 3 produced and uploaded onto FONTE website	general public	

09-Mar-20	Short Course	San Diego, USA	WP Leader Darko Zibar delivers a course at the Optical Networking and Communication Conference (OFC2020) entitled 'Hands-on: Machine Learning in Optical Networks' (Note: event cancelled due to COVID-19)	OFC Conference Attendees	8000 (size of conference)
09-Mar-20	Invited Presentation	San Diego, USA	Francesco Da Ros (standing in for Darko Zibar, WP leader) delivers an invited presentation at the Optical Networking and Communication Conference (OFC2020) entitled 'The Role of Machine Learning for the Next-generation of Optical Communication Systems and Networks'	OFC Conference Attendees	8000 (size of conference)
28-Jan-20	Meeting at Institut Mines-Télécom	Paris, France	Presentation given by ESR Abtin Shahkarami : overview over FONTE Project	PhD students	16
16-Jan-20	News Release	San Diego, California, USA	OFC news release entitled 'Scientific and Technological Developments in Ground-breaking Technological Areas Lead the OFC 2020' includes the symposium 'The Role of Machine Learning for the Next-generation of Optical Communication Systems and Networks' lead by Darko Zibar	General scientific community	8000 (size of conference)
14-Jan-20	Seminar at Microsoft Research Labs	Cambridge, UK	WP Leader Darko Zibar delivered a seminar at Microsoft Research Lab (Cambridge) entitled 'Advancing classical and quantum communication systems using machine learning'	Researchers in Industry	about 20
13-Jan-20	Seminar at Cambridge University	Cambridge, UK	WP Leader Darko Zibar delivered a seminar at Cambridge University entitled 'Advancing classical and quantum communication systems using machine learning'	Academics, graduate and postgraduate students	about 35
01-Jan-20	FONTE Newsletter #2 produced	online and twitter	FONTE Newsletter Issue 2 produced and uploaded onto FONTE website	general public	
05-Dec-19	2019 Annual Research Conference at AiPT	Birmingham, UK	Presentation and poster at the 2019 AiPT Annual Research Celebration	Researchers in the field of Photonics	150
05-Dec-19	Seminar at SPIE Student Chapter	Birmingham, UK	ESR Vladislav Neskorniuk gave a seminar at the Aston SPIE Student Chapter about his research	Researchers, PhD students and Post Docs in the field of Photonics	15
25-26 Nov 2019	2019 Microsoft Research Cambridge PhD student Workshop on Next Generation Cloud infrastructure	Cambridge, UK	ESR Stenio M. Ranzini of DTU has participated in the Microsoft Workshop on Next Generation Cloud Infrastructure , where he was able to present his work to a cross-diciplinary team of Microsoft researchers and discuss the future of the cloud. The event was by invitation only!	Microsoft researchers and PhD researchers	60
25-Nov-19	2019 NBL Innovation Day	Stuttgart, Germany	ESR Vinod BAJAJ participated in the annual Innovation Day at Nokia Bell Labs, presenting a poster with his research findings and speaking to visitors to the event. Read full post here	Local High School Students, teachers, undergraduate and postgraduate students, researchers at NBL.	about 100
9-10 Oct 2019	Photonex Europe 2019	Coventry, UK	FONTE was present at Photonex 2019 , a major UK conference and trade exhibition, where project FONTE is represented in the AiPT booth by the Aston University's ERS1 Vladislav Neskorniuk who had a slide show and talked about his research .	Researchers & engineers from industry & academia. Presence of over 90 SMEs and companies	1,100
01-Oct-19	Brochure 'AIPT Educational Programmes 2019-20'	online and printed brochure for distribution	Produced an Education Postgraduate Opportunities Brochure detailing Educational Programmes and postgraduate opportunities at AiPT including project FONTE	Undergraduate and MSc students; scientists and Research Group leaders	1000 copies printed plus digital distribution
18-20 Sept 2019	Optical Solitons and Frequency Comb Generation 2019	Berlin, Germany	FONTE Coordinator Prof. S. Turitsyn invited speaker at this important conference and networking event, speaking to colleagues about FONTE	Scientists	30-35

01-Sep-19	Brochure 'AiPT Educational Programmes 2019-20'	Birmingham, UK	Produced a Brochure about Educational Programmes at AiPT, including project FONTE	Scientists; graduate and undergraduate students	500 copies printed plus digital distribution
July/Aug 2019	ErasmusPlus Staff Exchange involving FONTE	Kiev, Ukraine	Yaroslav Prylepskiy, FONTE WP1 leader and supervisor at Aston University, spearheads the organisation of an ErasmusPlus Staff Exchange Programme involving the National Technical University of Ukraine – Kyiv Polytechnic Institutey, one of the most prestigious institutions in the Ukraine. One of the aim of this exchange is disseminating FONTE project details, enriching research and collaboration ties, and delivering lectures & seminars to FONTE ESRs.	Ukranian Scientists	small
23-27 Jun 2019	CLEO EUROPE 2019	Munich, Germany	Produced a Poster and Banner about AiPT ITNs including FONTE for booth at CLEO Munich 2019 Conference .	Scientists; SMEs, companies	3,800
05-Jun-19	Research Gate	online	A FONTE Project Page was encoded on ResearchGate, social networking site for scientists and researchers)	Scientists	15 Mill users on ResearchGate
31-May-19	FONTE Newsletter #1 produced	Online	FONTE 'Kick-off' Newlsetter Issue 1 produced with information about the project and it's senior team and uploaded onto website	general public	
01-May-19	Brochure:' Research at AiPT'	Birmingham, UK	Produced a Brochure about Research at AiPT , including project FONTE. (activity BEFORE project start)	Scientists	500 copies produced plus digital distribution
3-7 Mar 2019	Optical Fiber Communication Conference OFC 2019	San Diego, USA	Produced and distributed a Flyer about FONTE at OFC 2019 and other conferences. (activity BEFORE project start)	Scientists; SMEs, companies	15,400 (size of conference)

4 APPENDIX - OUTREACH AND ENGAGEMENT ACTIVITIES – IMAGES

The images below illustrate some of the activities conducted within the project. All activities and additional info is available at the FONTE project website at https://fonte.astonphotonics.uk

International Women's Day 2022 (link to post)

11 Mar 2022

Together with the **Optica Student Chapter** at Aston University, **FONTE** is organising a 1-day Round Table Careers' event: *'Beyond PhD: Celebrating Women in STEM Careers'*

IDL Summit at AiPT

16-21 May 2021

A week-long celebration of the **International Day of Light** with lectures and activities.

Download brochures from here

Optical Society Ambassador

19 May 2021

As OSA Ambassador **Francesco Da Ros** will aim to mentor and inspire the next generation of students and early career professionals.

download newsarticle & interview here

Vinod presents at '*DCSC Thesis Market*'

10 Nov 2021

Vinod BAJAJ presented a TU Delft's Thesis Market, showcasing his research to both existing staff and MSc students.

download poster here

Foreign Language Bulletins

Oct 2020

To reach the widest possible audience FONTE ESRs have produced **research bulletins** in a number of languages.

view all individual brochures here

International Day of Light 2021 Brochure

16 May 2021

Celebrating the **International Day of Light** FONTE ESRs describe how their research relates to the concept of 'Light'.

download to view here

Internat. Day of Women In Engineering

23 Jun 2021

To celebrate INWED2021 and rainse the profile of **Woman In Engineering**, EC Project Managers at AiPT produced a poster.

download to view here

Figure 8: Some of the FONTE Outreach Activities

AiPT International Day of Light Summit 2021 (link to agenda)

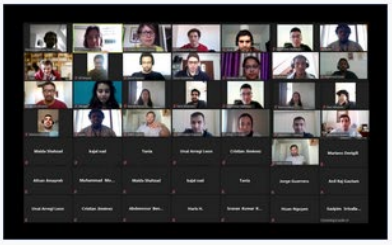
21 May 2021

A day of light-themed lectures and fun

Outreach to Smartnet, Pixnet and EMIMEO (link to post)

24 Mar 2021

ESR1 and ESR3 join Project Manager leading Outreach Event to 95 EMJMD students



ESR4 live discussion on Instagram (link to recording)

04 Mar 2021

Abtin Shahkarami (FONTE EID) & Elliot London (WON ETN) talking live on Instagramm about life under COVID lockdown and their research in two H2020 Project (t=13min)

Project Manger leads Outreach to ERASMUS students (link to post)

24 Feb 2020

ESR1 at Primary School 'Careers Fair and Science Day' (link to post)

14 Feb 2020

ESR2 at the 2019 NBL Student Day at Nokia (link to post)

26 Nov 2019

ESR3 at the Project Day in Copenhagen (link to post)

25 Oct 2019

ESR3 participating in the 2019 Culture Night in Copenhagen (link to post)

11 Oct 2019

ESR1 at Photonex2019: outreach to industry (link to post)

9 Oct 2019

FONTE's ESR Stenio M. Ranzinni (DTU) at Brazilian outreach event

University of Sao Paulo; 27 Oct 2020;

Download video (in Protuguese) before viewing

Figure 9: More Public Engagement and Outreach Activities

Figure 10: Some of the brochures produced by FONTE

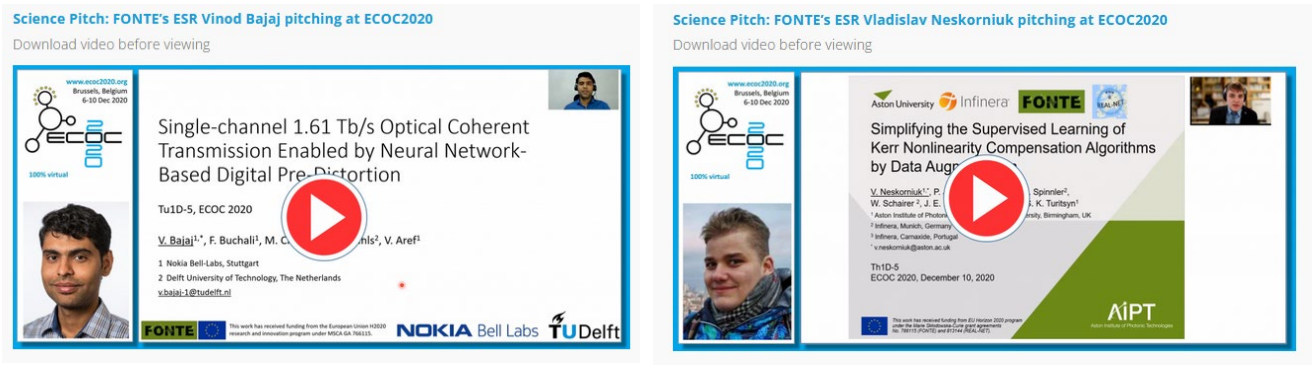


Figure 11: Engagement with fellow academics beyond FONTE. Science pitches by ESRs