
## SEVENTH FRAMEWORK PROGRAMME

# Report on Deliverable D02.1
# BONE schools 2008

### FP7-ICT-216863/FER/R/PU/D02.1

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**Abstract:**

This deliverable describes organization end execution of BONE schools 2008 (Master and Summer school) that took place at Faculté Polytechnique de Mons (rue de Houdain 9, B-7000 Mons, Belgium) in the week of October 13-17, 2008.
Success indicators are also reported.

Keyword list:
Education, Master study, light propagation, electronic signal processing, optical signal processing

# Clarification:

## *Nature of the Deliverable*

R Report
P Prototype
D Demonstrator
O Other

## *Dissemination level of Deliverable:*

PU Public
PP Restricted to other programme participants (including the Commission Services)
RE Restricted to a group specified by the consortium (including the Commission Services)
CO Confidential, only for members of the consortium (including the Commission Services)

# Disclaimer

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# 1. Executive Summary :

Two co-located events have been organized by WP02 in October 2008 (13-17) at FPMs (partner 03) premises (Faculté Polytechnique de Mons, rue de Houdain 9, B-7000 Mons, Belgium): the first BONE **Master School** and the first BONE **'Summer' School**. On Tuesday the 14th October 2008 afternoon took place the **WP02 meeting**.

The **Master school** consisted in two intensive days (October 13-14, 2008) of tutorials (12 hours) devoted to Optical fibre technology and propagation. Organization of Master school is in line with fulfilling one of the main objectives in BONE/WP02 "spreading excellence within and outside the project through the organization and execution of common Master study in Optical Communications and Networks combining benefits of teaching in situ, teleteaching or application of learning tools". Selected topic is a part of Master study course curriculum No.1 *Introduction to Optical Networks – Light propagation* Participants had the opportunity to optionally extend the Master school on October 15-17 with a program of practical classes (9 hours). In the period of 4 months after Master School there will be an in-line exam that would allow students to collect ECTS for their doctoral or Master courses.

All tutorials of Master school were transmitted in real time to TELECOM-Bretagne enabling interactive teaching. Also all tutorials were stored on server of BONE Directory service enabling delayed video-streaming for all BONE users.

The **Summer school**, that took place October 15-17, 2008, was dedicated to the theme **'The role of electronics and signal processing in optics'**. This theme is linked with the WP15 (Virtual Centre of Excellence on Transmission Techniques) workpackage and received the support of WP15 leader, Periklis Petropoulos (ORC, United Kingdom). Lecturers coming from the BONE NoE proposed in-depth tutorials on several aspects linked to this very hot topic. Time slots have also been allocated to give the opportunity to PhD students and researchers attending the Summer school to present their preliminary or final work results in oral or poster sessions.

The number of registered participants to the **Master school**, meaning that they were physically present in Mons premises, is 43. They came from 9 different countries and from 10 BONE partners. There was also one participant coming from outside of the BONE project. On the top of those 43 participants, must be added the 25 TELECOM-Bretagne Master students who were participating using videoconferencing. **This raises the total number of participants to 68, which is a success indicator for such an event.** Among the participants, 37 followed only the theoretical courses (October 13-14, 2008) and 31 followed the full ECTS program. The latter category is shared between those who had practical classes in Mons (6) and the TELECOM-Bretagne Master students who had them in Brest (25).

The number of registered participants to the **Summer school** is 25. They came from 11 different countries and from 15 BONE partners. There was one participant coming from outside of BONE project.

# 2. General introduction

Through its WP02 teaching activities, as described in Part B of BONE proposal, the BONE project set as one of its major goals the dissemination of its expertise and know-how to the wider audience possible, noticeably by the way of specific courses and workshops.

In this frame, two co-located events have been organized by WP02 in October 2008 (13-17) at FPMs (partner 03) premises (Faculté Polytechnique de Mons, rue de Houdain 9, B-7000 Mons, Belgium): the first BONE Master School and the first BONE 'Summer' school.

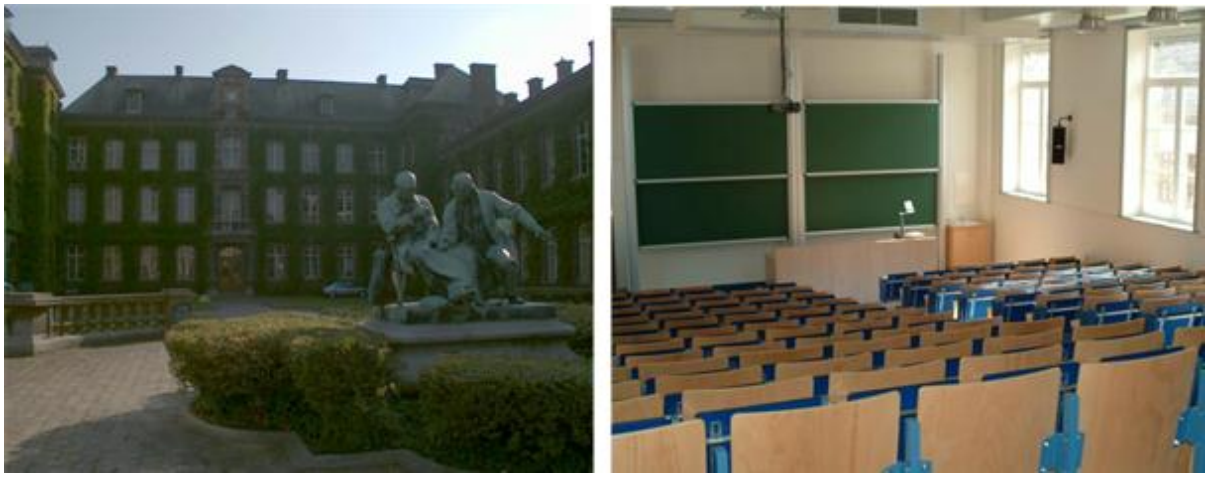

**Figure 1: BONE schools venue**

The **Master school** consisted in two intensive days (October 13-14, 2008) of tutorials (12 hours) devoted to Optical fibre technology and propagation. Organization of Master school is in line with fulfilling one of the main objectives in BONE/WP02 "spreading excellence within and outside the project through the organization and execution of common Master study in Optical Communications and Networks combining benefits of teaching in situ, teleteaching or application of learning tools". Selected topic is a part of Master study course curriculum No.1 *Introduction to Optical Networks – Light propagation* Participants had the opportunity to optionally extend the Master school on October 15-17 with a program of practical classes (9 hours). In the period of 4 months after Master School there will be an in-line exam that would allow students to collect ECTS for their doctoral or Master courses.

All tutorials of Master school were transmitted in real time to TELECOM-Bretagne enabling interactive teaching. Also all tutorials were stored on server of BONE Directory service enabling delayed video-streaming for all BONE users.

The Summer school, that took place on October15-17, 2008, was dedicated to the theme **'The role of electronics and signal processing in optics'**. This theme is linked with the WP15 (Virtual Center of Excellence on Transmission Techniques) workpackage and received the support of WP15 leader, Periklis Petropoulos (ORC, United Kingdom). Lecturers coming from the BONE NoE proposed in-depth tutorials on several aspects linked to this very hot

topic. Time slots have also been allocated to give the opportunity to PhD students and researchers attending the Summer school to present their preliminary or final work results in oral or poster sessions.

A specific web site (http://www.telecom.fpms.ac.be/BONE_Schools/) has been developed by local organizers to disseminate all information relative to both BONE schools and to allow in-line registration.

# 3. BONE schools organization committees

## *3.1 Master school committee*

Academic people of SET (Service d'Electromagnétisme et de Télécommunications) of FPMs as well as all BONE Master school teachers constituted the Master school committee:

- Sébastien Bette, FPMs, Belgium
- Karin Ennser, USWAN, United Kingdom
- Kevin Heggarty, WP02 co-leader, TELECOM-Bretagne, France
- Patrice Mégret, FPMs, Belgium
- Branko Mikac, WP02 leader, FER, Croatia
- Véronique Moeyaert, FPMs, Belgium
- Michel Morvan, TELECOM-Bretagne, France
- Carmen Vazquez, UC3M, Spain
- Marc Wuilpart, chairman, FPMs, Belgium

## *3.2 Summer school committee*

Academic people of SET (Service d'Electromagnétisme et de Télécommunications) of FPMs as well as some BONE Summer school lecturers, together with some very active WP15 partners constituted the Summer school committee:

- Sébastien Bette, FPMs, Belgium
- Izzat Darwazeh, UCL, United Kingdom
- Kevin Heggarty, WP02 co-leader, TELECOM-Bretagne, France
- Guido Maier, POLIMI, Italy
- Patrice Mégret, FPMs, Belgium
- Branko Mikac, WP02 leader, FER, Croatia
- Véronique Moeyaert, chairperson, FPMs, Belgium
- Periklis Petropoulos, ORC, United Kingdom
- Ioannis Tomkos, AIT, Greece
- Marc Wuilpart, FPMs, Belgium

Local organizing committee (FPMs)

- Olivier Aubry
- Sébastien Bette (webmaster)
- Patrice Mégret
- Véronique Moeyaert
- Mariline Mura
- Marc Wuilpart

# 4. BONE Master school

## *4.1 Goal of first BONE Master school and targeted audience*

The general goal of BONE schools is to disseminate the Network of Excellence knowledge. Particularly, BONE Master schools are aimed to test 'life' the courses that were developed by within teaching working packages in the frame of e-Photon/ONe and e-Photon/ONe+ NoEs (2004-2008)
(see - https://www.e-photon-one.org/ephotonplus/intranet/Intranet.Generar?seccio=1_1_16_3_2).

In the frame of this first BONE Master school, WP02 decided to test the slides of e-Photon/ONe+ course n°1 (leader: Michel Morvan, TELECOM-Bretagne, France; co-leader: Marc Wuilpart, FPMs, Belgium) entitled **'***Introduction to Optical Networks – Light propagation***'** (files are available here:
https://www.e-photon-one.org/ephotonplus/intranet/Intranet.Generar?seccio=1_1_16_3_2_2).
Among the available set of slides belonging to course n°1, 12 hours of theoretical courses have been selected. Teachers from the BONE community have accepted to give the courses, using and improving the set of slides that were previously developed. Namely, they are (cf. paragraph 4.4): Prof. Karin Ennser (USWAN, United Kingdom), Prof. Kevin Heggarty (TELECOM-Bretagne, France), Prof. Patrice Mégret (FPMs, Belgium), Prof. Michel Morvan (TELECOM-Bretagne, France), Prof. Carmen Vazquez (UC3M, Spain) and Prof. Marc Wuilpart (FPMs, Belgium).

Moreover, 3 practical classes (3 times 3 hours) related to the theoretical courses were especially developed at this occasion under the responsibility of Prof. Marc Wuilpart, Dr Victor Garcia Muñoz and Dr Gautier Ravet, all from FPMs. The titles of the practical classes are respectively **'Optical time domain reflectometry'**, **'Polarization effects in optical fibres'** and **'Nonlinear effects in optical fibres'**. Participants were free to choose those complementary hours and were divided into different groups to facilitate the learning.

On the top of it, an in-line exam will take place on a voluntary basis. Participants having successfully passed their exam will receive a 'Certificate of success' from the school organizer describing all their courses within BONE Master school. It will allow them to claim for ECTS following the local rules of their own University.

The targeted audience was mainly two-folds, although the event was also open to non-BONE members:

1. Master school students of BONE Universities;
2. PhD students willing to improve their knowledge in the Master school theme and/or to collect ECTS in the frame of their doctoral training.

The first BONE school encountered some success with more than 65 participants coming from 9 different countries. Particularly, FPMs and TELECOM-Bretagne (by videoconferencing – see paragraph 4.5.1) enrolled their respective regular Master students to this BONE event, making it as an official part of their respective Master training.

## *4.2 Master school theoretical courses and practical classes contents*

The titles and contents of the Master school courses consisted in:

- **Why optical fibres and optical networks?**
  - History of optical telecommunications
  - Long distance and short distance networks
  - Examples
- **Waveguide propagation in optical fibres**
  - Geometric approach: internal reflection, propagation modes …
  - Electromagnetic approach: propagation modes, Maxwell equations, waveguide equations, step index fibres, modes solutions, guided modes …
  - Single mode fibres: mode field diameter, birefringence…
- **Optical fibre fabrication techniques**
  - Material
  - Performances
  - Fibre extrusion
- **Attenuation in optical fibres**
  - Black box approach
  - Absorption losses
  - Diffusion losses
  - Macro and micro bending losses
- **Dispersion in optical fibres**
  - Group delay
  - Intramodal dispersion
  - Types of index profiles and types of fibres
  - Intermodal dispersion
  - Polarisation Mode Dispersion
- **Polarization in optical fibres**
  - State of polarisation: polarised and unpolarised light, polarisation ellipse, Jones formalism, Stoke formalism
  - Birefringence
  - Beat length
  - Mode coupling
- **Non-linear effects**
  - Non-linear optics formalism
  - Second order harmonic generation
  - Non-linear refraction index: Kerr effect, SPM, XPM
  - Four wave mixing

  - Inelastic processes: spontaneous Raman diffusion, stimulation Raman Diffusion, Brillouin diffusion and retrodiffusion
- **Polymer Optical fibres**
  - Material
  - Characteristics
  - Applications

These courses were optionally completed by 3 different practical classes:

- **Optical time domain reflectometry**: single-mode optical links characterization and defects detection
- **Polarization effects in optical fibres**
- **Nonlinear effects in optical fibres**

## *4.3 Master school schedule*

Paragraphs 4.3.1 to 4.3.6 describe precisely the schedule of the first BONE Master School, with or without the complementary practical classes. As shown, get-together events were also organized in order to improve social aspects and facilitate technical discussions among participants.

### *4.3.1 Day 1 - Monday October 13th 2008*

| | |
|---|---|
| 08h15 - 08h45 | Registration |
| 08h45 - 09h00 | Welcome address by FPMs authorities (Prof. P. LYBAERT, Dean) and Master school chairman (Prof. M. WUILPART) |
| 09h00 - 10h30 | Why optical fibres and optical networks? (K. HEGGARTY, Telecom-Bretagne, France) |
| 10h30 - 10h45 | Break |
| 10h45 - 12h15 | Waveguide propagation in optical fibres (P. MEGRET, FPMs, Belgium) |
| 12h15 - 13h30 | Hot lunch |
| 13h30 - | Waveguide propagation in optical fibres (P. MEGRET, FPMs, |

| | |
|---|---|
| 15h00 | Belgium) |
| 15h00 - 15h15 | Break |
| 15h15 - 16h45 | Dispersion in optical fibres (M. MORVAN, Telecom-Bretagne, France) |
| 16h45 | End of DAY 1 |
| 19h00 - late | Welcome dinner with the Professors in a restaurant of Mons. |

### *4.3.2 Day 2 - Tuesday October 14th 2008*

| | |
|---|---|
| 09h00 - 10h30 | Optical fibre fabrication techniques + Attenuation in optical fibres (K. ENNSER, USWAN, United Kingdom) |
| 10h30 - 10h45 | Break |
| 10h45 - 12h15 | Polarization in optical fibres (M. WUILPART, FPMs, Belgium) |
| 12h15 - 13h30 | Hot lunch |
| 13h30 - 15h00 | Non-linear effects (M. MORVAN, Telecom-Bretagne, France) |
| 15h00 - 15h15 | Break |
| 15h15 - 16h45 | Polymer Optical fibres (C. VAZQUEZ, UC3M, Spain) |
| 16h45 | End of DAY 2 |

### *4.3.3 Day 3 - Wednesday October 15th 2008*

| | |
|---|---|
| 09h00 - 12h00 | Practical classes for ECTS students only (Prof. M. Wuilpart, Dr G. Ravet, Dr V. Garcia-Muñoz, all from FPMs)<br>- Group 1: Optical time domain reflectometry: single-mode optical links characterization and defects detection<br>- Group 2: Polarization effects in optical fibres |
| 12h00 - 13h30 | Lunch/Free time |
| 13h30 - 16h30 | Practical classes for ECTS students only (Prof. M. Wuilpart, Dr G. Ravet, Dr V. Garcia-Munoz, all from FPMs)<br>- Group 1: Polarization effects in optical fibres<br>- Group 2: Nonlinear effects in optical fibres |

### *4.3.4 Day 4 - Thursday October 16th 2008*

| | |
|---|---|
| 09h00 - 12h00 | Practical classes for ECTS students only (Prof. M. Wuilpart, Dr G. Ravet, Dr V. Garcia-Munoz, all from FPMs)<br>- Group 1: Nonlinear effects in optical fibres<br>- Group 2: Optical time domain reflectometry: single-mode optical links characterization and defects detection |
| 12h00- 13h30 | Lunch/free time |
| 13h30 - 16h30 | Possibility to participate to the Summer school |

### *4.3.5 Day 5 - Friday October 17th 2008*

| | |
|---|---|
| 09h00 - 12h00 | Possibility to participate to the Summer school |
| 12h00 | End of BONE schools |

### *4.3.6* *Exam* -26/01/2009

| | |
|---|---|
| 10h00 - 12h00 | Online exam. |

## *4.4 Master school teachers*

Master school teachers were exclusively coming from the BONE community, with a majority of courses endorsed by teachers who were part of e-Photon/ONe+ course n°1. All names and biographies are listed in the following sub-paragraphs (from 4.4.1 to 4.4.6)

### *4.4.1 Prof. Karin Ennser, USWAN, UK – k.ennser@swansea.ac.uk*

Karin ENNSER (M'97) received the B.S. and M.S. degrees in electrical engineering from the State University of Campinas, Campinas, Brazil, in 1990 and 1993, respectively, and the Ph.D. degree in electrical engineering from the Technical University of Berlin, Berlin, Germany, in 1998. From 1998 to 2000, she was with Corning Inc., Corning, NY, as a Senior Research Scientist, working on devices and system aspects of DWDM networks. From 2000 to 2003, she was with Pirelli Telecom Cavi e Sistemi S.p.A., Italy, as a Product Development Manager of telecom optical fiber. From 2003 to 2006, she was with the National Laboratory of Photonic Networks, Italian Inter-University Consortium on Telecommunications, Italy, as the Head of Research in the area of optical components and system applications. She is currently Associate Professor with the Institute of Advanced Telecommunications, University of Swansea, U.K. Her main topics of interest are transient gain dynamics in doped fiber and waveguide amplifiers, optical signal processing, transmission system design and performance issues.

### *4.4.2 Prof. Kevin Heggarty, Telecom-Bretagne, France kevin.heggarty@telecom-bretagne.eu*

Kevin HEGGARTY is Associate professor at TELECOM-Bretagne.He received his B.A. in Natural Sciences from the University of Cambridge (UK) in 1987, his M.Sc.in Telecommunications and Information Systems from the University of Essex (UK) in 1988 and his doctorate from the Ecole Nationale Supérieure des Télécommunications (ENST) in Paris (FRANCE) in 1991. At the TELECOM Bretagne he ran the ENST Bretagne European Masters course in Optical Telecommunications and Datacoms Networks. His research interests include non-display applications of spatial light modulators, the design and fabrication of diffractive micro-optical elements and their applications in optical telecommunications and optical information processing in general.

### *4.4.3 Prof. Patrice Mégret, FPMs, Belgium patrice.megret@fpms.ac.be*

Patrice MEGRET (born in 1964) received his PhD. degree in Applied Sciences in 1993 from the Faculté Polytechnique de Mons, Belgium. Since 2001, he is full professor at the Faculté

Polytechnique de Mons where he teaches basic electricity, microwaves and optical telecommunications. He has supervised 11 PhD theses. His main research interests are in the metrology of optical transmission quality, on optical fibre metrology like dispersion, polarization, fiber sensors, fiber lasersand on laser dynamics. Patrice MEGRET has been president of the IEEE LEOS Benelux Chapter from 2003 to 2005, is associate member of URSI and author and co-author of more than 300 publications in journals and conference proceedings. Since October 2005, he is head of the Electromagnetism and Telecommunication Department of Faculté Polytechnique de Mons.

### *4.4.4 Prof. Michel Morvan, Telecom-Bretagne, France michel.morvan@telecom-bretagne.eu*

Michel MORVAN is senior lecturer at the ENST-Bretagne. He has over 15 years of experience in optical transmission and SDH/WDM networking first as research engineer at France Telecom R&D and then as network architect at Sycamore Networks. He lectures on optical components and transmission systems, system design and simulation as well as optical networking. His research activities are focused on optical transmission, especially modulation formats, and optical network architectures.

### *4.4.5 Prof. Carmen Vazquez, UC3M, Spain – cvazquez@ing.uc3m.es*

Carmen VAZQUEZ received the M.S. degree in Physics (Electronics) in 1991 from Complutense University of Madrid, and her Ph.D. degree at Telecommunications Engineering School in 1995 from Polytechnic University of Madrid (UPM). In 1991 she enjoys a fellow at TELECOM (Denmark), working in erbium doped fiber amplifiers. From 1992 to October 1995 she worked at Optoelectronics Division of “Telefónica Investigación y Desarrollo” in Madrid. She was involved in III/V integrated optics devices characterization, design and fabrication. In October 1995, she joined Carlos III University where she is currently working as an Associate Professor, Vice-Rector of Quality, Infrastructures and Environment and as a co-responsible of the Displays and Photonics Applications Group. She has been Head of the Electronics Technology Department 3 years. Her research activities and interests cover a wide range of subjects related to optical communications including optical signal processing, ring resonators, plastic optical fibers (POF), broadband access networks based on GI-POF, RF filters, switches, LC devices, fiber sensors, WDM and CWDM networks. She is a member of the IEEE (SM´05), SPIE, OSA and has published over 70 papers in international refereed journals and conferences. She has participated in ESPRIT, RACE and IST projects and networks such as PLANET, OMAN, HEMIND, LC PHOTONET, SAMPA, etc. She is the recipient of the extraordinary doctorate prize of the Polytechnic University of Madrid in 1995.

### *4.4.6 Prof. Marc Wuilpart, FPMs, Belgium – marc.wuilpart@fpms.ac.be*

Marc WUILPART (born in 1976) received his PhD. degree in Applied Sciences in 2003 from the Faculté Polytechnique de Mons, Belgium. He is an assistant professor in telecommunications at the Faculté Polytechnique de Mons. His main interests are in spatially distributed measurements of the polarisation properties, chromatic dispersion and Raman gain. Marc WUILPART was chairman of a study group of EU action COST 265 and is the chairman of a working group of the COST action 299 FIDES.

## 4.5 On the use of Communication Technologies at the Master school

ICT technologies have been widely used during the first BONE Master School. Precisely, the FPMs local organization, alone or together with the BONE directory service (Walter Cerroni – UNIBO, Italy) has realized:

1. A two days-long permanent videoconference connection between FPMs (Belgium) and TELECOM-Bretagne (France) premises to allow TELECOM-Bretagne Master school students to follow and participate to the courses located in Mons;
2. An 'on-fly' synchronization between the video and the slides presentation that allowed FPMs to diffuse by video streaming, from the password protected BONE directory service, each Master school course right from its end;
3. The storage of all teachers slides presentation.

The following three paragraphs (4.5.1 to 4.5.3) describe precisely those three action points.

### *4.5.1 Videoconferencing between FPMs and TELECOM-Bretagne*

As stated in the BONE project WP02 activities description, *'at least two distance teaching experiments, as teleconferences, of selected module will be performed in the period of project*'. This has already been realized in the frame of the first BONE Master School. Indeed, 25 Master students from TELECOM-Bretagne (Brest, France) were fully connected by videoconferencing during the two days of theoretical courses (see **Figure** 2).

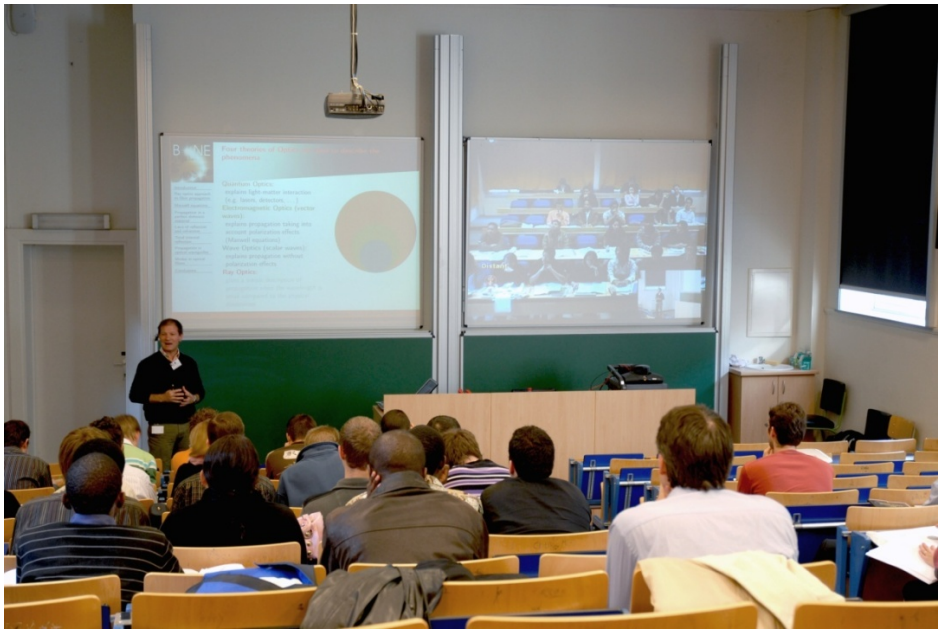

**Figure 2: Prof. P. Mégret (FPMs, Belgium) teaching his course. TELECOM-Bretagne Master students projected on the right handside blackboard.**

Moreover, the practical classes especially developed for the Mons BONE Master School have been adapted to be reused with the TELECOM-Bretagne laboratories equipments.

### *4.5.2 Video courses streaming and storage*

During each course, the synchronization between the respective video images and slides presentation has been realized by FPMs technical staff. It allowed diffusing the contents by videostreaming just after each course.

In order to prevent non-BONE members to connect freely to those sources, the diffusion start weblink has been chosen to be the password protected BONE directory service, thanks to Walter Cerroni and its UNIBO (Bologna, Italy) team. Doing so, we can access to a logfile containing connections reports during and after the event. The logfile link is the following: https://ict-bone.unibo.it/accesses.php?event=mschool2008&ord=time.

At the time of writing this deliverable, video courses storage is still on the BONE directory service but will be transferred as soon as possible on the private part of the general BONE website www.ict-bone.eu.

### *4.5.3 Storage of presentation files*

Each course presentation file in power point and/or pdf format has been stored on the private part of the general BONE website www.ict-bone.eu, as well as the practical classes' protocols.

## *4.6 Master school exam*

After the event, an in-line exam will be organized by TELECOM-Bretagne thanks to their Moodle teaching platform tool, under the responsibility of Keving Heggarty.

Master school teachers were asked to provide multiple choice questions and answers, either theoretical or exercises. The exam schedule will be strict and will last two hours.

The date of the 26/01/2009 has been fixed sufficiently far from the Master school event to allow participants to study their courses. Participants to this exam will be:

1. Those having registered for the full ECTS program (theoretical courses + practical classes + exam);
2. TELECOM-Bretagne Master students on a 'must do' basis;
3. FPMs Master students on a voluntary basis.

## *4.7 Master school official documents*

Two different types of certificate have/will be distributed in the frame of the first BONE Master School:

1. Certificate of participation (see an example in annex 1): this certificate describing the content of the theoretical courses was distributed to all Master school

participants. Depending on local ECTS evaluation rules, this is sometime sufficient to allow participants to collect ECTS for their doctoral training.

2. Certificate of success: this certificate will be distributed to all participants having followed theoretical courses, practical classes and having successfully passed the in-line exam.

## 4.8 Master school participation

Figure 3 shows the repartition table of Master school participants depending on their provenance and on the program they followed.

| Country | Entity | Number of non-ECTS participants | Number of full ECTS program | Total number of participants |
|---|---|---|---|---|
| Belgium | FPMs | 22 + 7 | 0 | 28 |
| | Multitel(*) | 1 | 0 | 1 |
| Croatia | FER | 0 | 1 | 1 |
| France | TELECOM-Bretagne | 2 | 25 (videoconferencing) | 25 + 2 = 27 |
| Hungary | BUTE | 0 | 1 | 1 |
| Poland | AGH | 1 | 1 | 2 |
| Portugal | IT | 0 | 2 | 2 |
| Turkey | BILKENT | 1 | 0 | 1 |
| United Kingdom | ORC | 0 | 1 | 1 |
| | USWAN | 1 | 0 | 1 |
| | UCL | 2 | 0 | 2 |
| **9** | **10 + 1(*)external** | **37** | **25 + 6 = 31** | **43 + 25 = 68** |

**Figure 3: Repartition of the Master school audience among partners.**

The number of registered participants to the Master school, meaning that they were physically present in Mons premises, is 43. They came from 9 different countries and from 10 BONE partners. There was also one participant coming from outside of BONE. On the top of those 43 participants, must be added the 25 TELECOM-Bretagne Master students who were participating to the event using videoconferencing. **This raises the total number of participants to 68, which is a success indicator for such an event.**

Among the participants, 37 followed only the theoretical courses (October 13-14, 2008) and 31 followed the full ECTS program. The latter category is shared between those who had practical classes in Mons (6) and the TELECOM-Bretagne Master students who had them in Brest (25).

We can expect that there will be at least 31 registrations for the in-line exam, some more registrations coming from FPMs Master students who could enter the exam on a voluntary basis to have access to the BONE Master school ‘Certificate of Success’.

# 5. BONE Summer school

## 5.1 Goal of BONE Summer school and targeted audience

The general goal of BONE schools is to disseminate the Network of Excellence knowledge. Particularly, **BONE Summer schools**, aligned on the philosophy of e-Photon/ONe Summer schools, are aimed to accelerate the training of PhD students as well as to encourage collaborations between them. In this purpose, in-depth tutorials on a subject related to one of the BONE WP are proposed, as well as special session for PhD students.

In this particular case, the first BONE Summer school, that took place on October 15-17, 2008, was dedicated to the theme **'The role of electronics and signal processing in optics'** that is linked with WP15-Virtual Centre of Excellence on Transmission Techniques activities. In this frame, lecturers coming from our BONE NoE proposed tutorials on several aspects linked to this very hot topic. Namely, they are: Prof. Izzat Darwazeh (UCL, United Kingdom), Dr Francesca Parmiggiani (ORC, United Kingdom), Prof. Pierpaolo Boffi (POLIMI, Italy) and Dr Darko Zibar (DTU Fotonik, Denmark).

Time slots have also been allocated to give the opportunity to PhD students and researchers attending the Summer school to present their preliminary or final work results in oral or poster sessions.

The targeted audience was mainly BONE PhD students and BONE senior researchers, although the event was also open to non-BONE members.

The first BONE Summer school encountered some success with more than 25 participants coming from 11 different countries.

Pdf versions of presentation files have been stored on the private part of the general BONE website www.ict-bone.eu.

## 5.2 BONE Summer school schedule

Paragraphs 5.2.1 to 5.2.3 describe precisely the schedule of the first BONE Summer school. As shown, get-together events were also organized in order to improve social aspects and to facilitate technical discussions among participants.

### *5.2.1 Wednesday October 15th 2008*

| | |
|---|---|
| 12h30 - 13h30 | Registration |
| 13h30 - | Welcome address by FPMs autorities (Prof. C. CONTI, |

| | |
|---|---|
| 14h00 | Rector) and by BONE WP02 leader (Prof. Branko MIKAC, FER, Croatia) |
| 14h00 - 15h30 | Invited presentation - Applications of Fibre Bragg Gratings on optical signal processing (Dr Francesca PARMIGIANI, ORC, United-Kingdom) |
| 15h30 - 16h00 | Break |
| 16h00 - 17h20 | Presentation of oral papers by school participants - Chairman: Prof. Patrice MEGRET (head of SET, FPMs, Belgium)<br>• Digital Signal Processing for optical OFDM Transmission (L. Fernández del Rosal, Fraunhofer Institute for Telecommunication - HHI, Germany)<br>• New generation of FEC for optical communications (S. Mumtaz, TELECOM ParisTech, France)<br>• Implementation of GMPLS network and future enhancements towards recovery mechanisms (K. Monist, K. Wajda, AGH, Poland)<br>• Assessment and Minimization of Four-Wave Mixing in WDM Systems (J. Reis(1), B. Neto(1), G. Tosi Beleffi(2), P. André(1), A. Teixeira(1), (1) IT - Portugal & (2) ISCO - Italy) |
| 17h00 | End of day 1 |
| 19h00 - late | School dinner in town (restaurant 'La table du Boucher', rue d'Havré 49, 7000 Mons (www.latabledubоucher.be)) |

### *5.2.2 Thursday October 16th 2008*

| | |
|---|---|
| 08h30 - 09h00 | Registration |
| 09h00 - 10h30 | Invited presentation - Generation and detection of Optical CDMA signals using electronic techniques - Part I (Prof. Izzat DARWAZEH, UCL, United-Kingdom) |

| | |
|---|---|
| 10h30 - 11h00 | Break |
| 11h00 - 12h30 | Invited presentation - Generation and detection of Optical CDMA signals using electronic techniques - Part II (Prof. Izzat DARWAZEH, UCL, United-Kingdom) |
| 12h30 - 14h15 | Lunch/free time |
| 14h15 - 16h00 | Invited presentation - DSP based coherent receivers for wireline and wireless optical communication systems (Dr Darko ZIBAR, DTU Fotonik, Denmark) |
| 16h00 - 16h30 | Break (in parallel with poster session) |
| 16h00 - 17h00 | Poster session<br>• Determining the Maximum Power Level in Optical Fibers (D. Mazroa, S. Zsigmond, T. Cinkler, BUTE, Hungary)<br>• Enhanced OCDMA security by code scrambling (V. Sacchieri(1), P. Teixeira(2), A. Teixeira(2), G. Cincotti(1), (1) URoma3, Italy & (2° IT, Portugal)<br>• Study of the temporal characteristics of an optical frequency comb generator (S. Liu, T.T. Ng, P. Petropoulos, D.J. Richardson, ORC, United-Kingdom)<br>• Mode coupling length estimation for plastic optical fibers (D. Barrera(1), M. Llera(2), L. Falco(2), S.Sales(1), (1) UPVLC, Spain & (2) Haute École Arc Ingénierie, Switzerland)<br>• Experimental Demonstration of the Reduction of PDL and DGD in Fibre Bragg Gratings by Using a Twisted-Fibre for the Inscription' (S. Bette, C. Caucheteur, V. García-Muñoz, R. Garcia Olcina, M. Wuilpart, S. Sales, P. Mégret, FPMs & UPVLC, Belgium & Spain)<br>• Optical-frequency domain reflectometry: roadmap for high-resolution distributed measurements (K. Yüksel, M. Wuilpart, P. Mégret, FPMs, Belgium) |
| 17h00 | End of day 2 |

| | |
|---|---|
| 17h30 - 19h | Guided tour in English of Mons - meeting at 17h15 in front of the Tourism Office, Grand Place |

***5.2.3 Friday October 17th 2008***

| | |
|---|---|
| 08h30 - 09h00 | Registration |
| 09h00 - 10h30 | Invited presentation - Advanced optical modulation formats for very-high bit-rate transport networks (Prof. Pierpaolo BOFFI, POLIMI & CoreCom, Italy) |
| 10h30 - 11h00 | Break |
| 11h00 - 12h30 | Invited presentation - Optical and electronic processing for the generation of chromatic dispersion-tolerant modulation formats in metropolitan applications (Prof. Pierpaolo BOFFI, POLIMI & CoreCom, Italy) |
| 12h30 | End of the school |

## *5.3 BONE Summer school tutorial program and lecturers*

Five in-depth tutorials were proposed to the BONE Summer school attendees on subjects related to the theme 'Role of electronics and signal processing in optics'. The precise titles are the following:

1. Generation and detection of Optical CDMA signals using electronic techniques - Professor Izzat Darwazeh (UCL, United Kingdom)
2. Applications of Fibre Bragg Gratings on optical signal processing - Dr Francesca Parmigiani (ORC, United Kingdom)
3. DSP based coherent receivers for wireline and wireless optical communication systems - Dr Darko Zibar (DTU Fotonik, Denmark)
4. Advanced optical modulation formats for very-high bit-rate transport networks - Prof. Pierpaolo Boffi (POLIMI & CoreCom, Italy)
5. Optical and electronic processing for the generation of chromatic dispersion-tolerant modulation formats in metropolitan applications - Prof. Pierpaolo Boffi (POLIMI & CoreCom, Italy)

The content of each tutorial, as well as the lecturer biography, are detailed in paragraphs 5.3.1 to 5.3.5.

### *5.3.1 Generation and detection of Optical CDMA signals using electronic techniques - Professor Izzat Darwazeh (UCL, United Kingdom)*

- **Abstract:** It has been argued that electronics is the key bottleneck in high speed optical communication systems. With the development of high speed and high integration density electronics, driven by the ever growing demand of faster computing engines, this vision is being challenged. Today's electronics aid optical communications in developing systems to operate at rates exceeding 40 Gbits/s. This talk will address the use of electronics in enabling optical receivers and transmitters, for core and access networks. A specific focus will be on new techniques developed at University College London for the encoding and decoding of fast OCDMA signals using electronics. We will describe the circuit design technique for integrated circuits capable of encoding and decoding high-speed spread spectrum signals. The distributed transversal topology used allows operation at speeds close to the cut-off frequency of the transistors employed the design and operating principle of Monolithic Microwave Integrated Circuit (MMIC) compatible with 40 GBit/s systems applications and suitable for generation and detection in 40 GChip/s CDMA systems. In addition, modified circuits suitable for compensating for Group Velocity Dispersion in multi wavelength OCDMA networks will be described.

- **Prof. Izzat Darwazeh** holds the University of London Chair of Communications Engineering in the Department of Electronic and Electrical at UCL. He obtained his first degree in Electrical Engineering from the University of Jordan in 1984 and the MSc and PhD degrees, from the University of Manchester Institute of Science and Technology (UMIST), in 1986 and 1991, respectively. He worked as a research Fellow at the University of Wales - Bangor -UK from 1990 till 1993, researching very high speed optical systems and circuits. He was a Senior Lecturer in Optoelectronic Circuits and Systems in the Department at Electrical Engineering and Electronics at UMIST. He moved to UCL in October 2001 where he is currently the Head of Communications and Information System (CIS) group and the Director of UCL Telecommunications for Industry Programme. He is a Fellow of the IET and a Senior Member of the IEEE. His teaching covers aspects of wireless and optical fibre communications, telecommunication networks and high speed integrated circuits and MMICs. He lectures widely in the UK and overseas. His research interests are mainly in the areas of wireless system design and implementation, high speed optical communication systems and networks, microwave circuits and MMICs for optical fibre applications and optical access networks and in mobile and wireless communication circuits and systems. He has authored/co-authored more than 120 research papers. He has co-authored (with Luis Moura) a book on Linear Circuit Analysis and Modelling (Elsevier 2005) and is the co-editor of the IEE book on Analogue Optical Communications (IEE 1995). He collaborates with various telecommunications and electronic industries in the UK and overseas and has acted as a consultant to various academic, industrial, financial, legal and government organisations.

### *5.3.2 Applications of Fibre Bragg Gratings on optical signal processing - Dr Francesca Parmigiani (ORC, United Kingdom)*

- **Abstract:** Fibre Bragg gratings have been fabricated and used for many applications in fibre optic communication systems, such as dispersion compensation in long-haul fibre networks and add-drop multiplexing of WDM channels, to name but two. Following recent advances in fibre Bragg grating fabrication technology, it has become possible to fabricate reflective filters with accurately controlled complex phase and amplitude responses, the so called superstructured fibre Bragg gratings, SSFBGs. This allows the capability of manipulating the temporal and spectral shape of an incoming broadband signal. This in turn, facilitates better control within optical nonlinear switches and, thus, enhances the performance of nonlinear processing systems. This tutorial will review some application examples which combine pulse shaping in fibre Bragg gratings with highly nonlinear fibre (HNLF)-based optical switches.
- **Dr Francesca Parmigiani** was born in Milan, Italy. She graduated with the degree in electronic engineering at Politecnico di Milano, Milano, Italy, in 2002, and received the Ph.D. degree in optical communication systems at the Optoelectronics Research Centre (ORC), University of Southampton, Southampton, U.K in 2006. She is currently a Research Fellow at the ORC, working within the EU IST project TRIUMPH. Her research interests include ultra-fast all-optical sampling techniques, pulse shaping using specialized fiber Bragg gratings, and all-optical nonlinear processing and switches mainly in optical fibers. Her research has produced more than 40 peer reviewed publications.

### *5.3.3 DSP based coherent receivers for wireline and wireless optical communication systems - Dr Darko Zibar (DTU Fotonik, Denmark)*

- **Abstract:** Optical coherent technologies combined with more advanced modulation formats have superior performance prospects allowing for the placement of a large number of high capacity channels very close to each other due to its high spectral efficiency, and intrinsic channel selectivity of coherent detection. Using DSP it is possible to compensate for various transmission impairments and thereby allow longer reach, more flexibility and higher capacity. Additionally, the capacity of wireless communication systems is growing as well and optical fibre is gradually becoming a preferred transmission medium for transport and distribution of wireless signals as well. Due to this convergence between wireless and wireline networks, reconfigurable receiver's structures are very attractive and DSP based receivers could potentially offer a good solution. However, many challenges still remain to be solved.
  This tutorial will cover main aspects of digital coherent receivers for wireline and wireless communication systems. The focus will be on the algorithms for signal demodulation, impairments compensation and digital clock recovery
- **Dr Darko Zibar** was born on September 9th, 1978, in Belgrade former Yugoslavia. He received the M.Sc. degree in Telecommunication in 2004 from the Technical University of Denmark and the Ph.D. degree in 2007 from the Department of Communications, Optics and Materials, COM-DTU within the field of optical communications. He was a Visiting Researcher with Optoelectronic Research Group led by Prof. John E. Bowers, at the University of California, Santa Barbara (UCSB) from January 2006 to August 2006, and January 2008 working on coherent receivers

for phase-modulated analog optical links. Currently, he is employed at DTU Fotonik, Technical University of Denmark as the postodoctoral research fellow. His research interests are in the area of wireline and wireless coherent optical communication systems, with the emphasis on digital signal processing.
Darko Zibar is a recipient of the Best Student Paper Award at the IEEE Microwave Photonics Conference (MWP) 2006, for the work on a novel linear optical phase demodulator based on a sampling phase-locked loop.

### *5.3.4 Advanced optical modulation formats for very-high bit-rate transport networks - Prof. Pierpaolo Boffi (POLIMI & CoreCom, Italy)*

- **Abstract:** The desire for higher and higher per-fiber transport capacity in optical WDM networks has led to continuously increase the transmission bit-rate. To mitigate the impact of fiber transmission impairments, electronic signal processing can be exploited at the receiver. Digital signal pre-distortion at the transmitter is starting to become possible and coherent detection, allowing electronic processing to make use of the optical phase information, is experiencing renewed interest. For 40 or 100 Gb/s bit-rate, the capabilities of electronic processing are still limited to electronic complexity and speed. Hence, advance modulation formats have become key to the design of future high bit-rate systems by allowing good tolerance to linear and nonlinear fiber impairments and by achieving high spectral efficiency. For example, multilevel phase shift keying formats appear very promising to increase the bit-rate. Moreover, to double the transmission capacity, multilevel formats can be combined to other transmission techniques such as polarization multiplexing (POLMUX). Nowadays, the scientific community widely recognizes that POLMUX together with differential quadrature phase shift keying (DQPSK) format is the potential solution to achieve transmission at very high transmission bit-rate such as 100 Gb/s. We'll review advance modulation formats for high bit-rate applications and in particular POLMUX DQPSK. We'll present DQPSK generation and detection by means of originally designed optical delay interferometers. Unless coherent detection, POLMUX direct detection is achieved thanks to optical polarization tracking and stabilization. We'll discuss POLMUX DQPSK transmission performance both at 40 Gb/s and 100 Gb/s over uncompensated links in order to understand the propagation robustness of the presented solution.
- **Prof. Pierpaolo Boffi** received his 'laurea' degree in Electronic Engineering from Politecnico di Milano (Italy) in 1991 and his Ph.D. degree in 1996 in Telecommunication Engineering from the same University. Since 2005 he has been Assistant Professor in the Dipartimento di Elettronica e Informazione at the Politecnico di Milano. From 1995 to 2004 he was a researcher at Corecom – Consortium for Research in Optical Processing and Switching Milan, where now he has the position of Scientific Assistant for the Optical Systems Activities. During 1997 he was visiting research at the Department of Electrical Engineering of the California Institute of Technology, Pasadena (CA). In 2000 he was Faculty Director of the Specialist Training Master "Optical communication systems and networks" organized by Poliedra – Politecnico di Milano. He is author of more than 75 publications on international journals and conference proceedings and of 14 international patents. His current interests include multilevel modulation formats and polarization multiplexing

techniques for long-haul systems with high spectral efficiency, and novel optical solutions for fiber dispersion compensation in metropolitan networks applications.

### *5.3.5 Optical and electronic processing for the generation of chromatic dispersion-tolerant modulation formats in metropolitan applications*
***Prof. Pierpaolo Boffi (POLIMI & CoreCom, Italy)***

- **Abstract:** Taking into account that most existing optical networks for metropolitan applications was designed to operate at 2.5-Gb/s, it has been required that the new 10-Gb/s systems could be deployed in the existing fiber infrastructure without the necessity to employ expensive dispersion compensating fibers. As a consequence, new modulation formats demonstrating very high tolerance to chromatic dispersion have been employed, such as the duobinary (PSBT) format and the so-called CAPS format. Recently, in order to reduce the cost per transmitted information bit, the use of chirp-managed laser (CML) has been proposed to reach large uncompensated fiber distance without external modulation. We'll review the above-cited formats focusing our attention on the electrical and optical processing performed during signal modulation and necessary to achieve high chromatic dispersion robustness. Propagation performance is shown at 10 Gbit/s both by simulation and by experimentation.
- **Prof. Pierpaolo Boffi** received his 'laurea' degree in Electronic Engineering from Politecnico di Milano (Italy) in 1991 and his Ph.D. degree in 1996 in Telecommunication Engineering from the same University. Since 2005 he has been Assistant Professor in the Dipartimento di Elettronica e Informazione at the Politecnico di Milano. From 1995 to 2004 he was a researcher at Corecom – Consortium for Research in Optical Processing and Switching Milan, where now he has the position of Scientific Assistant for the Optical Systems Activities. During 1997 he was visiting research at the Department of Electrical Engineering of the California Institute of Technology, Pasadena (CA). In 2000 he was Faculty Director of the Specialist Training Master "Optical communication systems and networks" organized by Poliedra – Politecnico di Milano. He is author of more than 75 publications on international journals and conference proceedings and of 14 international patents. His current interests include multilevel modulation formats and polarization multiplexing techniques for long-haul systems with high spectral efficiency, and novel optical solutions for fiber dispersion compensation in metropolitan networks applications.

## *5.4 BONE Summer school PhD program*

BONE PhD students had the opportunity to present their preliminary or final thesis results to their peers during the Summer school. The aim of this initiative was two-folds: to stimulate interactions between participants (either PhD students or senior researchers) and to train PhD students to English oral scientific communications. To do so, time slots for oral or poster presentations were kept in the schedule (cf. paragraph 5.2).

PhD students were allowed to choose their favourite type of session, with the limitation of time slots numbers for oral presentations.

Both following paragraphs list the oral and poster presentations proposed by the participants.

### *5.4.1 Oral presentations*

- *Digital Signal Processing for optical OFDM Transmission,* (L. Fernández del Rosal, Fraunhofer Institute for Telecommunication - HHI, Germany)
- *New generation of FEC for optical communications,* (S. Mumtaz, TELECOM ParisTech, France)
- *Implementation of GMPLS network and future enhancements towards recovery mechanisms,* (K. Monist, K. Wajda, AGH, Poland)
- *Assessment and Minimization of Four-Wave Mixing in WDM Systems,* (J. Reis(1), B. Neto(1), G. Tosi Beleffi(2), P. André(1), A. Teixeira(1), (1) IT - Portugal & (2) ISCOM - Italy)

### *5.4.2 Poster session*

- *Determining the Maximum Power Level in Optical Fibers,* (D. Mazroa, S. Zsigmond, T. Cinkler, BUTE, Hungary)
- *Enhanced OCDMA security by code scrambling,* (V. Sacchieri[(1)], P. Teixeira[(2)], A. Teixeira[(2)], G. Cincotti[(1)], (1) URoma3, Italy & (2) IT, Portugal)
- *Study of the temporal characteristics of an optical frequency comb generator,* (S. Liu, T.T. Ng, P. Petropoulos, D.J. Richardson, ORC, United-Kingdom)
- *Mode coupling length estimation for plastic optical fibers,* (D. Barrera[(1)], M. Llera[(2)], L. Falco[(2)], S.Sales[(1)], (1) UPVLC, Spain & (2) Haute École Arc Ingénierie, Switzerland)
- *Experimental Demonstration of the Reduction of PDL and DGD in Fibre Bragg Gratings by Using a Twisted-Fibre for the Inscription',* (S. Bette[(1)], C. Caucheteur[(1)], V. García-Muñoz[(1)], R. Garcia Olcina[(2)], M. Wuilpart[(1)], S. Sales[(2)], P. Mégret[(1)], (1) FPMs, Belgium & (2) UPVLC, Spain)
- *Optical-frequency domain reflectometry: roadmap for high-resolution distributed measurements,* (K. Yüksel, M. Wuilpart, P. Mégret, FPMs, Belgium)

**Figure 4: V. Sacchieri (URoma3, Italy) explaining her poster content to Dr F. Parmigiani (ORC, United Kingdom).**

## 5.5 BONE Summer school participation

**Figure** 5 shows the repartition table of Summer school participants depending on their provenance and their participation to the content of the school.

| Country | Entity | Number of participants | Presentation of one (or several) course(s), paper(s) or poster(s) |
|---|---|---|---|
| Belgium | FPMs | 4 | Yes |
| | Multitel (*) | 1 | |
| Croatia | FER | 1 | |
| Denmark | DTU Fotonik | 1 | Yes |
| France | TELECOM-Bretagne | 1 | |
| | TELECOM-ParisTech | 1 | Yes |
| Germany | Fraunhoffer, HHI | 1 | Yes |
| Hungary | BUTE | 1 | Yes |
| Italy | POLIMI | 1 | Yes |

| | | | |
|---|---|---|---|
| | UniRoma3 | 1 | Yes |
| Poland | AGH | 1 | Yes |
| Portugal | IT | 2 | Yes |
| Spain | ITEAM | 2 | Yes |
| United Kingdom | ORC | 2 | Yes |
| | USWAN | 1 | |
| | UCL | 3 | Yes |
| **11** | **15 + 1 (*)** | **25** | |

**Figure 5: Repartition of Summer school participants.**

The number of registered participants to the Summer school is 25. They came from 11 different countries and from 15 BONE partners. There was also one participant coming from an entity, MULTITEL (Belgium).

A certificate of participation was distributed to each participant at the end of the Summer school. An example can be found at Annex 2.

Attendance lists of the Master school are given at Annex 5 (15th of October 2008), Annex 6 (16th of October 2008) and Annex 7 (17th of October 2008).

The quality of technical exchanges (cf. Figure 6 for illustration) was at a very high level and certainly reinforced the collaboration among partners. It is also noticeable that 12 partners out of 15 provided talks of different natures, that indicates a very high implication of those partners in this activity in particular, and in WP02 activities in general.

**Figure 6: Fruitful discussions during the Summer school.**

# 6. Co-located event: WP02 meeting

On Tuesday the 14th October 2008 afternoon took place the WP02 meeting in parallel with the Master school courses. It was chaired by the WP02 leader, Branko Mikac (FER, Croatia).

The agenda was the following:

1. Deliverables and milestones;
2. Curriculum and teaching materials of BONE Master Study;
3. Scoring system for evaluation of WP02 activities.

Results of discussions were presented by Kevin Heggarty (TELECOM-Bretagne, France), WP02 co-leader, at the BONE plenary session in Rome, the 21th of October 2008.

# 7. Conclusions

As conclusion, we must state that WP02 fully completed its task foreseen for the D02.1 deliverable. Moreover, some aspects that were not mandatory at this stage of the project were already realized:

1. Distance learning by videoconferencing (only foreseen for 2-out-of-3 BONE Master schools);
2. Video streaming and video courses storage;
3. A co-located event, called BONE ‘Summer’ school, devoted to PhD student training and interactions.

# Annex 1: Example of Master School certificate of participation

FACULTY of ENGINEERING, MONS - FACULTE POLYTECHNIQUE DE MONS
Electromagnetism and
Telecommunication Department

POLYTECH.MONS

## CERTIFICATE of PARTICIPATION

This document is to state that Ozren Lapcevic (University of Southampton – United Kingdom)

has attended the MASTER SCHOOL 2008 of the BONE European Network of Excellence, which was held during the week of 13th to 17th of October 2008 at the Faculté Polytechnique de Mons, rue de Houdain, 9, B-7000 Mons, Belgium.

The thematic of the courses (12 hours in total) was 'Optical Fibre Technology and Propagation'.

The different course modules are listed and detailed below:

- Why optical fibres and optical networks?
- Waveguide propagation in optical fibres
- Optical fibre fabrication techniques
- Attenuation in optical fibres
- Dispersion in optical fibres
- Polarization in optical fibres
- Non-linear effects
- Polymer Optical fibres

Mons, the 17th of September 2008

Véronique MOEYAERT
*Local Organizing Committee*

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F.P.Ms

# Annex 2: Example of Summer School certificate of participation

FACULTY of ENGINEERING, MONS - FACULTE POLYTECHNIQUE DE MONS
Electromagnetism and
Telecommunication Department

POLYTECH.MONS

## CERTIFICATE of PARTICIPATION

This document is to state that Bowen CAO (University College of London – United Kingdom)

has attended the SUMMER SCHOOL 2008 of the BONE European Network of Excellence, which was held the 15, 16th and the 17th of October 2008 at the Faculté Polytechnique de Mons, rue de Houdain, 9, B-7000 Mons, Belgium.

Mons, the 17th of October 2008

Véronique MOEYAERT
*Local Organizing Committee*

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