PHOTONICS BRETAGNE

Photonics Innovation Hub

PHOTONICS BRETAGNE

Hollow core fibre/cable for 6G

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Director

afaq ISO 9001 Qualité AFNOR CERTIFICATION

CRT centre de ressources technologiques

CRÉDIT IMPÔT Agréé CIR RECHERCHE

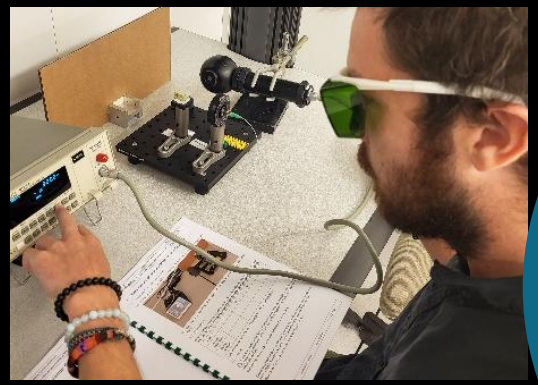
PHOTONICS BRETAGNE

PHOTONICS INNOVATION HUB

>20 years of expertise in Photonic Crystal fibers

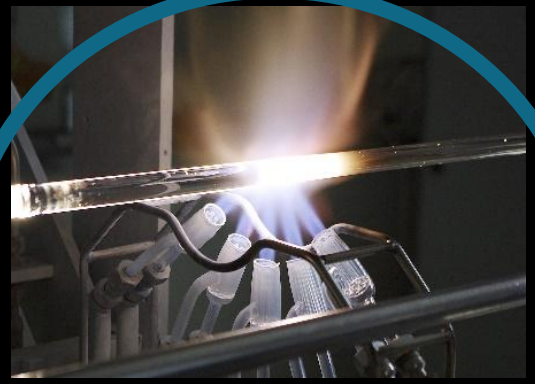
AN INNOVATIVE CLUSTER

SECTOR COORDINATION



TRAINING

A TECHNOLOGY PLATFORM (RTO)



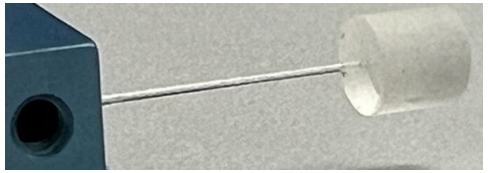
SPECIALTY OPTICAL FIBRES

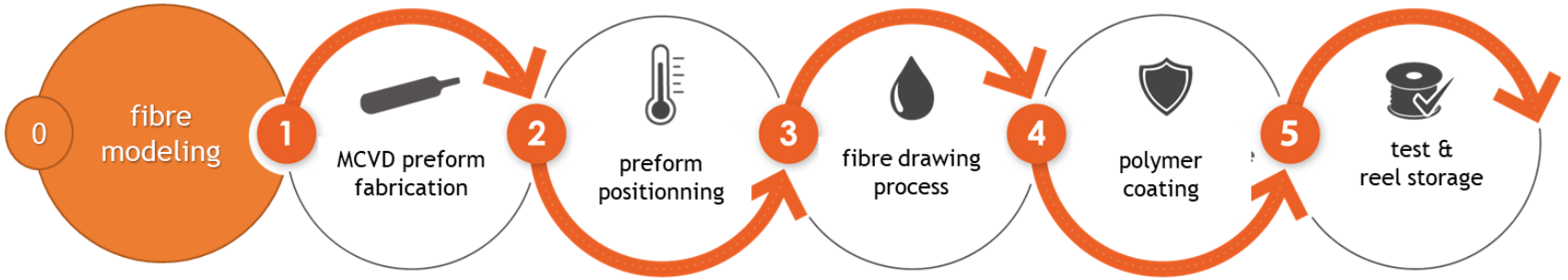
BIOPHOTONICS

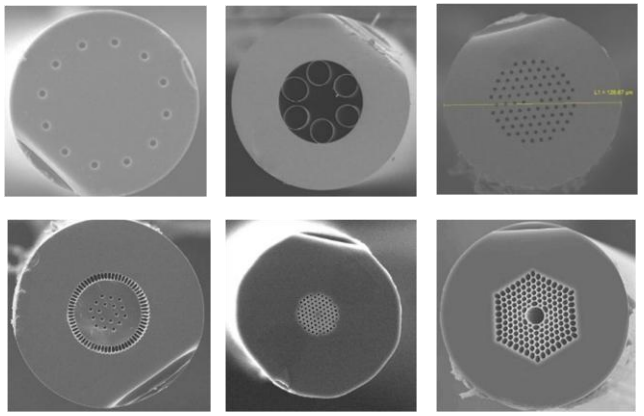
A RTO SPECIALISED IN OPTICAL FIBRES

CUSTOM SOLUTION FROM CONCEPTION TO INTEGRATION!

- A focus on **PCF** but also **MCF, Active, custom coating, components…**
- **Active/passive** fibers
- **Different doping** (Yb, Er, Bi, F, B, Ge…), Phase vapor deposition!
- **Draw tower Bragg gratings**
- **Metal coated fibers**
- **Stress rods, Capillaries**
- **Tapers, MFA, Fan In/Out, End-Cap…**
- **Simulation, Characterization, Consulting…**



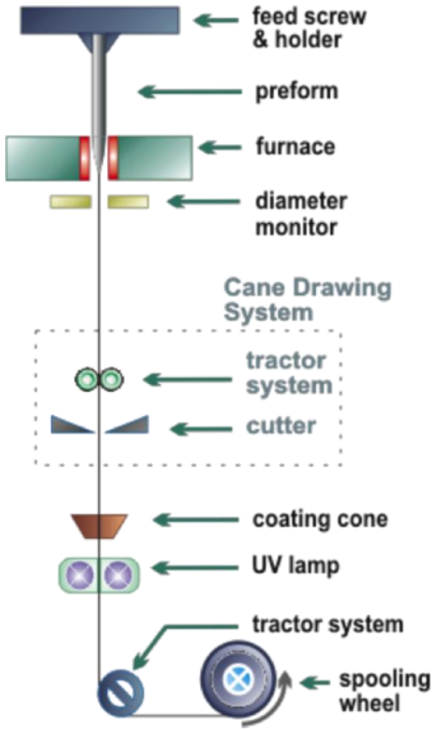




OUR FACILITY

MCVD/Phase vapor Lathe

Drawing tower



[Virtual tour: https://photonics-bretagne.plateforme360.fr](https://photonics-bretagne.plateforme360.fr)

OUR OFFER

RTO PHOTONICS BRETAGNE: SPECIALTY OPTICAL FIBRES

MICROSTRUCTURED FIBRES

SOLID-CORE

Supercontinuum | SUP *
Supercontinuum and nonlinear wavelength conversion

- Optimised for pumping near 780 nm and 1060 nm
- Low background loss
- Small effective area
- High nonlinear coefficient

Endlessly Single-Mode | ESM
White light delivery

- Single-mode at all wavelengths
- Wavelength-independent mode-field diameter
- Available in polarisation-maintaining version

All-Solid ESM | ASM
White light delivery

NEW

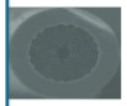
- All-solid microstructured cladding
- Single-mode at all wavelengths
- Low nonlinearity
- Available in polarisation-maintaining version

Airclad | ACF
Power delivery, spectroscopy

- Multimode
- Ultra-high numerical aperture

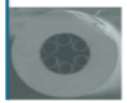
HOLLOW-CORE

Photonic Bandgap | HCF
Gas detection



- Different transmission bands in Near-IR with low background loss
- Ultra-low nonlinearity
- High damage threshold
- >98% of the optical power in the core
- Ultra-low bend loss

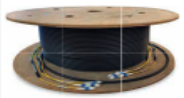
Anti-Resonant | ARF
Low latency transmission, power delivery



- Various spectral transmission bands (700-3150 nm) with ultra-low dispersion
- High damage threshold
- ~99% of the optical power in the core
- Nearly single-mode guidance

CABLE

Hollow-Core Fibre Optic Cables
Low latency data transmission



- Large bandwidth transmission at 1310 nm, over the full C/L bands and beyond
- Low loss
- Easy integration into existing networks

ACTIVE FIBRES

Passive version available on request

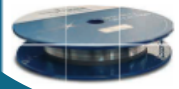
Ytterbium Doped | VLMA *
Very Large Mode Area
High power ultra-fast pulsed fibre lasers/amplifiers

PATENTED

- All-solid step-index fibre
- Truly single-mode polarization maintaining behaviour with 750 µm² mode area
- Photodarkening-free silica matrix

Bismuth Doped | BDF
Amplification in the O-Band

NEW



- Single mode fibre with Bismuth and Phosphorus codoping
- All-solid step index fibre design based on our all-vapor phase delivery process

METAL COATED FIBRES

Aluminum Coated Fibres | AL
Sensing, amplifiers, lasers

- Multi/single-mode fibres with aluminium or carbon+copper coating
- Wide temperature range and water/hydrogen sealing barrier

** Also plug-and-play modules available on request*

MULTICORE FIBRES

2,7, and 12 Cores | MCF
Sensing, telecom, lasers

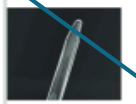
- Excellent fibre geometry
- Passive, photosensitive, erbium or ytterbium doped cores

COMPONENTS

Draw Tower Bragg Gratings
Temperature and strain sensors

- Single or multicore fibres
- Weak reflectivity
- Customisable FBG length and spacing

Boron Stress Rods
For polarisation maintaining fibres



- Highly doped
- Various core diameters and lengths

Capillaries
Combiners, biophotonics

- High precision homogeneous vertical drawing
- Pure or doped (fluorine, boron, germanium…) silica

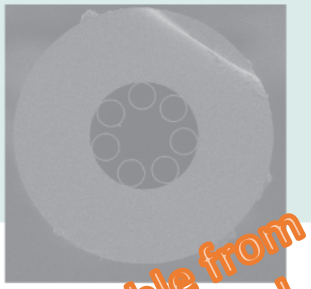
Telecom applications

ARF FIBERS

PHOTONICS BRETAGNE
Product line PERFOS

MICROSTRUCTURED FIBRES
ANTI-RESONANT HOLLOW CORE FIBRE

04/2021



ARF available from 700nm to 4µm!

Main characteristics

- High damage threshold
- Nearly single mode guidance
- Ultra low dispersion in the transmission bands

Applications

- Low latency data transmission
- Gas-filled AR hollow core fibre laser
- Molecular tracing, gas detection
- High power delivery for pico- and sub-picoseconds optical pulses

Optical signal in a hollow core anti-resonant fibre propagates in an air core surrounded by single ring of anti-resonant tube elements. Guidance is based on an anti-resonance from the thin glass membranes constituted by the non-touching tubes surrounding the hollow core. The extremely low overlap of guided power with the surrounding silica, less than $2x10^{-5}$, added to the mode effective area, confers to this fibre design record material non-linearity.

Fibre specifications

Fibre type *Optimised for*	ARF-40-240 *750 nm transmission*	ARF-33-160 *1064 nm transmission*	ARF-45-240 *1550 nm transmission*	ARF-40-230 *2 µm transmission*	ARF-120-400 *3 µm transmission*
Optical parameters					
Attenuation (dB/km)	<50 @ 750 nm	< 50 @ 1064 nm	< 35 @ 1550 nm	< 80 @ 2 µm	<70 @ 3µm
Transmission bandwidth (nm) (< 100 dB/km)	700 - 915	1000 - 1350	1450 - 1750	1600 - 2200	2900 - 3150
Mode field diameter (µm)	29 @ 750 nm	26 @ 1064 nm	37 @ 1550 nm	33.5 @ 2 µm	90 @ 3µm
Dispersion (ps/nm/km)	~0.8 @ 750 nm	~ 2 @ 1064 nm	~ 1 @ 1550 nm	~ 2 @ 2 µm	~0.8 @ 3µm
Mode overlap with core	> 99.99 %				
Numerical aperture	~0.02	~ 0.03			
HOM suppression (dB)	N.A.	10 (after 3 m)	10 (after 5 m)	> 25 (after 3 m)	N.A.
3 dB Bend loss radius (cm)	4 +/- 1 @ 750 nm	4 +/- 1 @ 1064 nm	6 +/- 1 @ 1550 nm	8 +/- 1 @ 2 µm	11 +/-1 @ 3µm
Physical/Material parameters					
Fibre material	Air Core				
Core diameter (µm)	38 +/- 2	33 +/- 2	46 +/- 2	40 +/- 2	119 +/- 2
Cladding diameter (µm)	71 +/- 3	66 +/- 3	99 +/- 3	105 +/- 3	233 +/- 3

Also NANF Design…

Advantages:

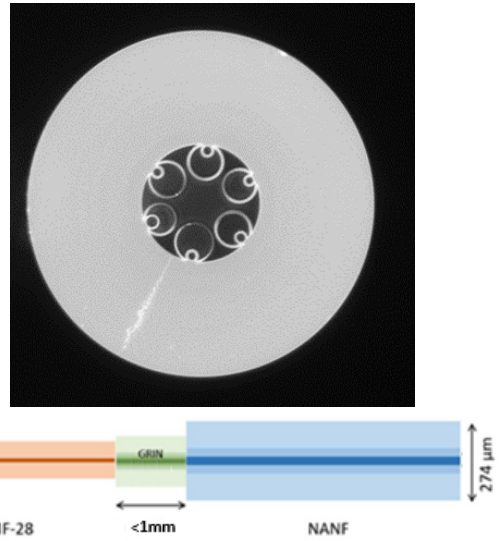
- Higher propagation speed ➔-30% latency
- Low nonlinearities➔High power capacity
- Low material & waveguide dispersion
- Loss now lower than standard telecom fibers!

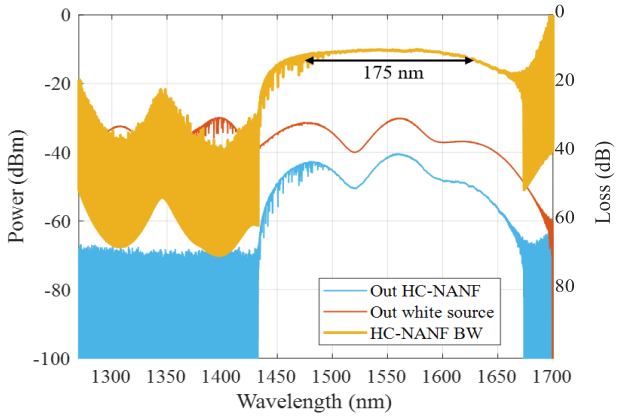
Challenges:

- Complex design
- Difficult manipulation, coupling…
- Expensive
- More IP than standard fibers…

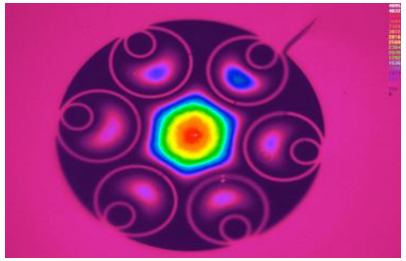
COLLABORATION WITH ORANGE

HOLLOW CORE FOR 6G





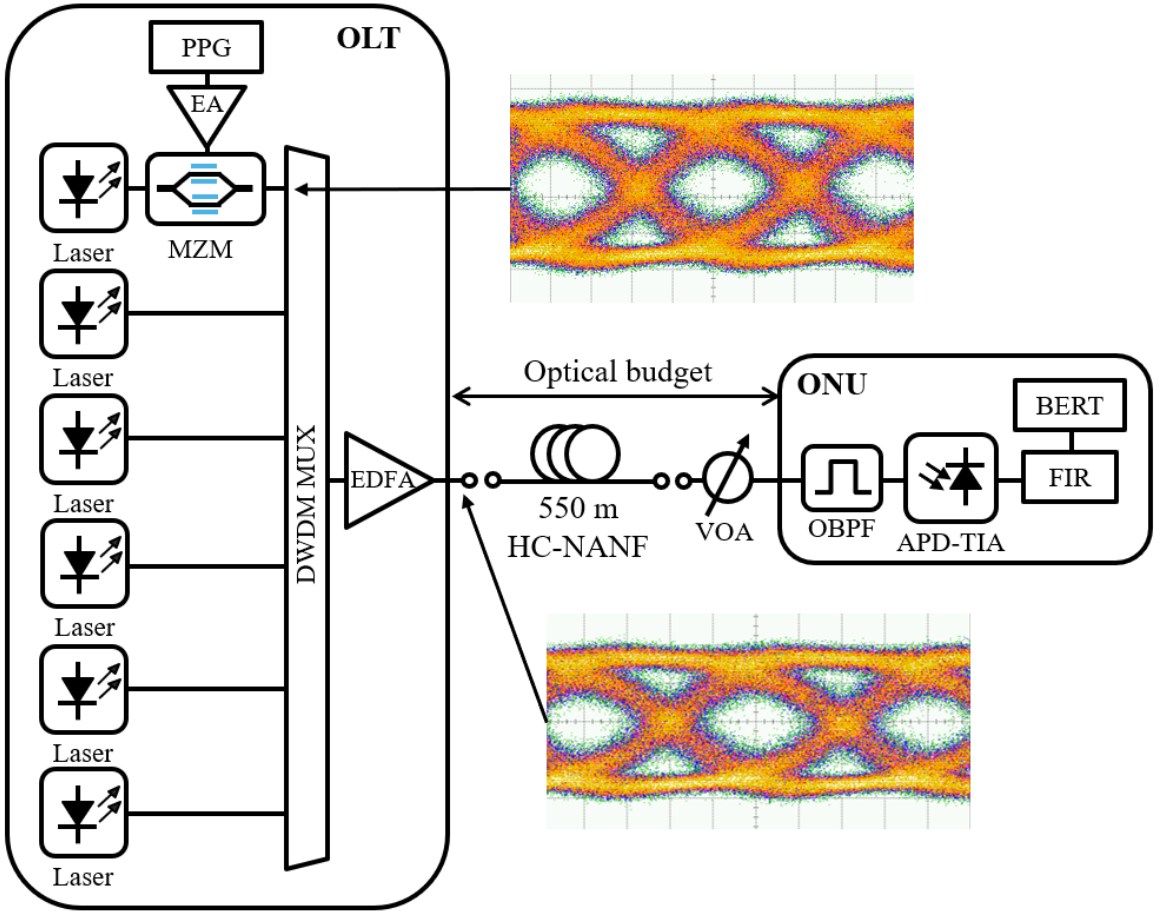
3 dB optical bandwidth centered at 1550 nm: 175nm



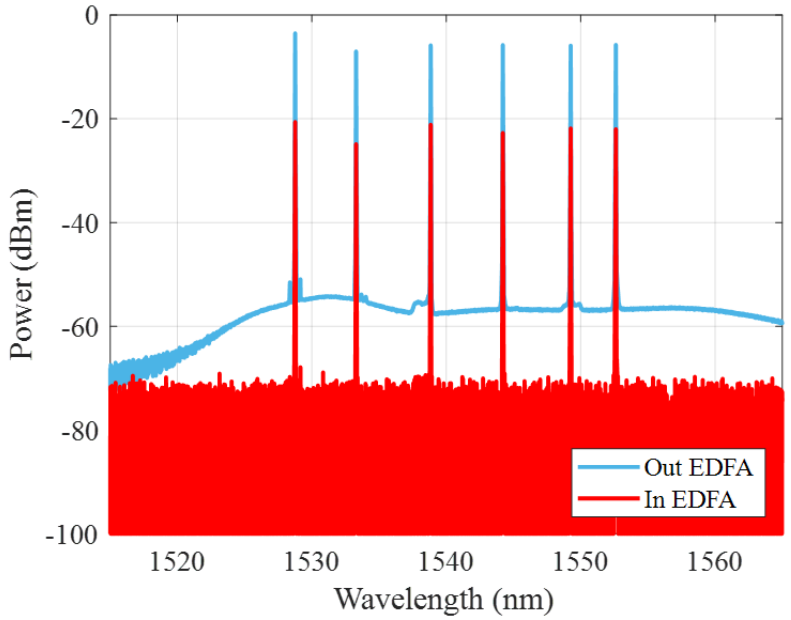
- **6G will require high bitrates and low latency optical link**.
- Hollow core fiber allows **low latency transmission** (3,3 µs/km vs 5 µs/km for standard single mode fiber) and high launched power enabling **high power budget link**.
- **Very high bitrate transmission** was already demonstrated in hollow core fiber.

COLLABORATION WITH ORANGE

HOLLOW CORE FOR 6G



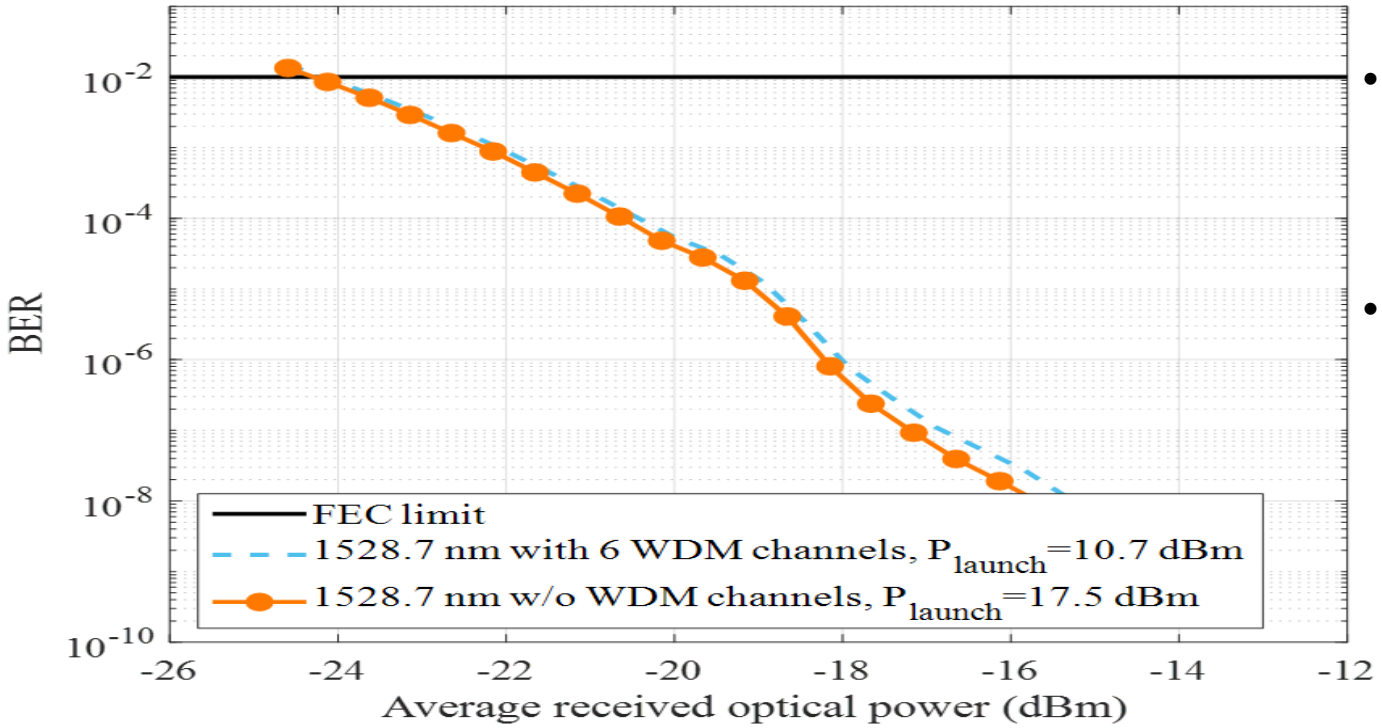
WDM experimental setup



- **Six lasers** and a **DWDM MUX (~4 nm spacing).**
- An **OBPF** (4 nm) is used to select a channel.
- **< 4 dB** WDM grid flatness.

COLLABORATION WITH ORANGE

HOLLOW CORE FOR 6G

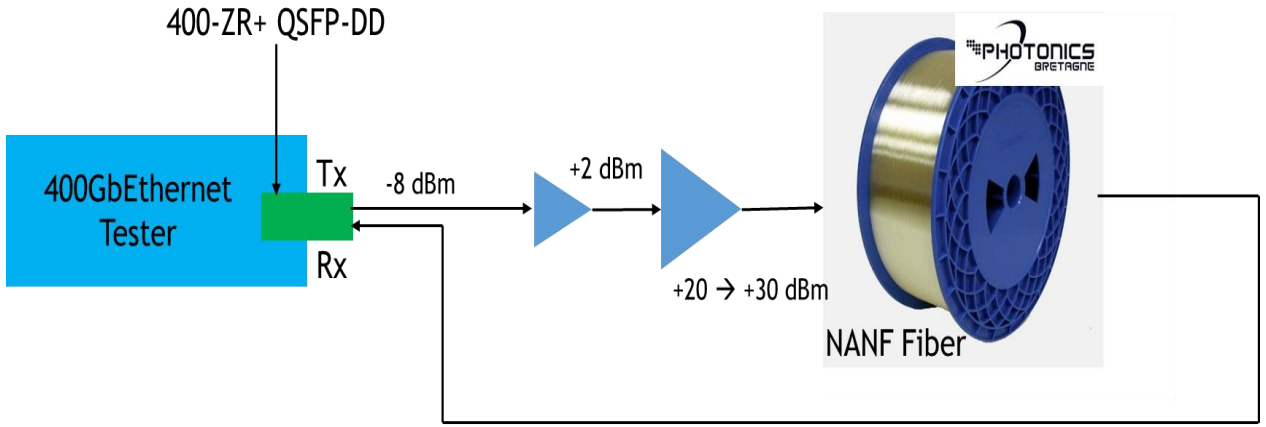


- Sensitivity of the receiver is not affected by the presence of the other channels.
- **WDM operation** implies sharing of the gain of the EDFA among all the channel -> Per channel launch power reduction.

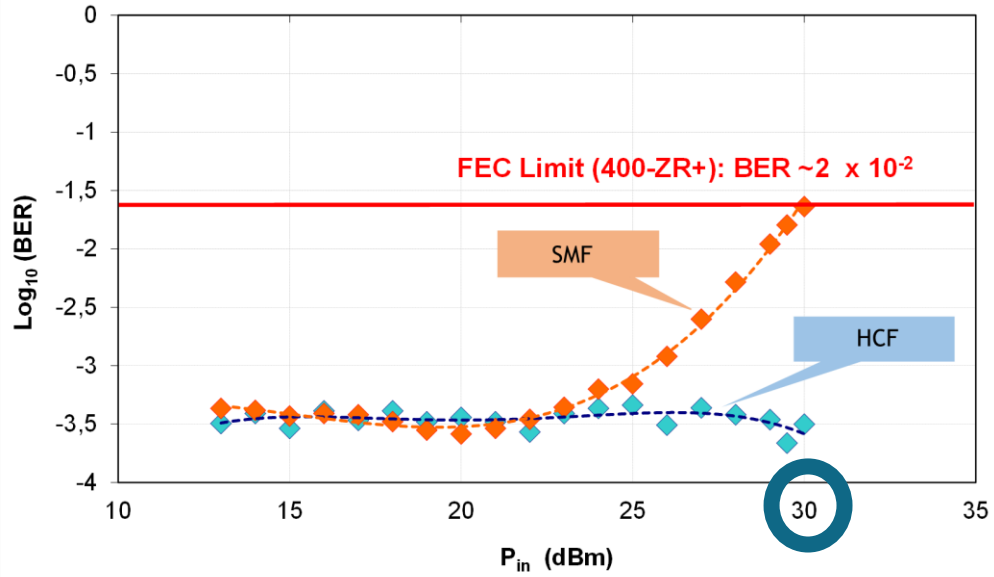
A real time **single wavelength and WDM transmission in 50 Gbit/s NRZ-OOK (C-Band) through a 550m long HC-NANF** was demonstrated.
Bidirectionnal transmission at 100Gbit/s in the O-Band also demonstrated in a different fiber!

COLLABORATION WITH ORANGE

HIGH POWER 400GBIT/S TRANSMISSION FOR LONG HAUL



Single wavelength experimental setup with 550m of NANF fiber



- **Power Signal ↗, OSNR ↗, Nonlinearity→**
- Much higher power budget possible with HCF!

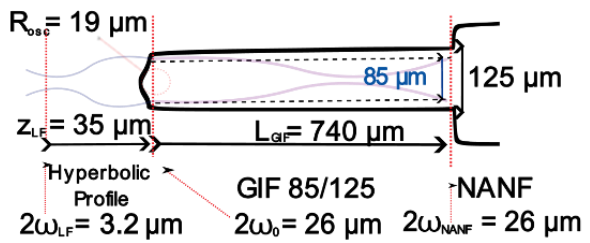
COLLABORATION WITH ORANGE

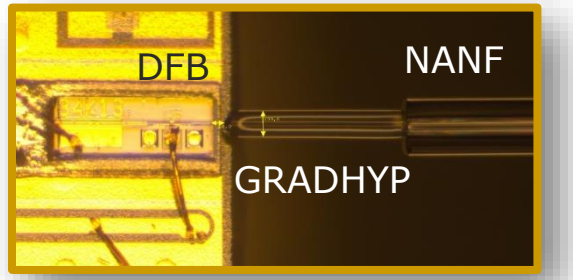
REDUCING COUPLING LOSS WITH HYPERBOLIC MICRO-LENS

Coupling light directly from a small MFD (3 µm) source (DFB) within the O-band (1310 nm) to a NANF (MFD:26µm).

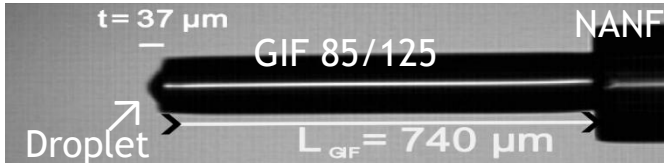
Thanks to an hyperbolic profile (GRADHYP):

- Adapting two very different MFD.
- Recover a flat wavefront.
- Practical working distance (~30 µm) instead of contact.
- Ideal hyperbolic profiles are free of spherical aberrations.
- Compact size (< 1 mm), not necessary to add an SMF section.

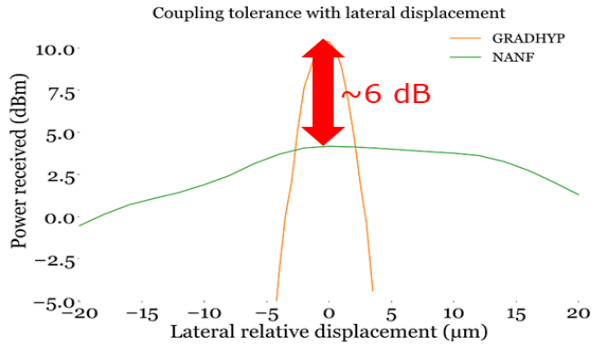




Coupling laser to GRADHYP



Final hyperbolic profile at GIF section + NANF.



GRADHYP improves by 6 dB the coupling efficiency compare to bare coupling.
Additionally, the **back reflections on GRADHYP are very low** (<50 dB)
Suitable for integration within the laser chip.

Power received after NANF butt-coupling: 4.2 dBm (IL_{NANF} = 9 dB).
Power received after GRADHYP: 10.3 dBm (IL_{GHYP} = 3.3 dB).

ARF PARCHCORD/CABLE

OUR FULLY CUSTOMIZED SOLUTIONS!

SPECSHEET
11/2024

PHOTONICS BRETAGNE
Photonics Innovation Hub

IDIL FIBRES OPTIQUES

CABLES

HOLLOW-CORE FIBRE OPTIC CABLES

IDIL and Photonics Bretagne launch a new range of anti-resonant hollow-core fibre optic cables. They combine low latency data transmission, high bandwidth connections and low loss; three features highly sought after by high frequency trading.

Product line PERFOS

MAIN CHARACTERISTICS

- Low latency data transmission
- High bandwidth transmission
- Easy to integrate into existing networks
- Custom lengths, number of fibres, connectors...

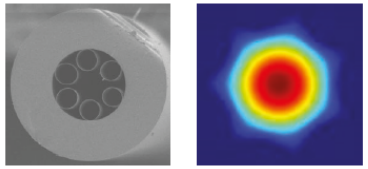
APPLICATIONS

- Telecom & 5G mobile networks
- Financial trading
- Data centre
- Cloud computing
- Quantum communication

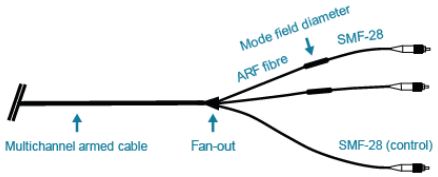
CABLE SPECIFICATIONS	Hollow-core cables
Operating Temperature Range (°C)	-40 to +60
Traction (N)	1000
Loss @ 1550nm (dB/km)	< 10
Transmission L=100m (Gb/s NRZ)	10
Inter Server Distance	From few meters to kms
Light Speed Gain (µs/km)	+ 1.7 (1)
Cable and Termination	For indoor and outdoor use

(1) 50 % faster than in solid core fibres

ARF : Anti-Resonant Fibres

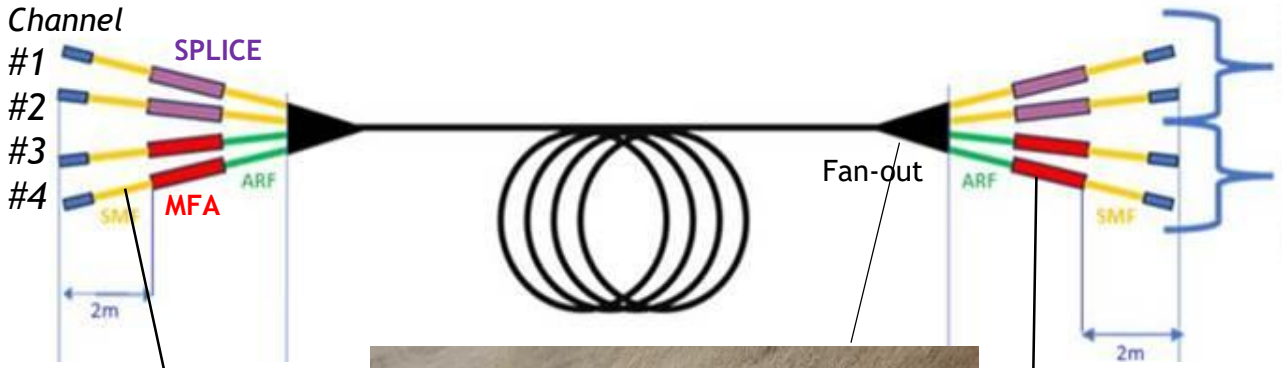


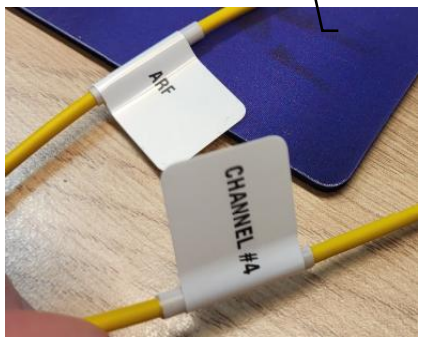
Example of fibre terminations



ARF PARCHCORD/CABLE

OUR LAST 4-FIBER 50M-CABLE!





- Integrating 2 SMF and 2 ARF
- L: 50m, Dcable: 7mm
- Tensile Strength >1000N
- Crush Load >400N/dm
- Operating Bending Radius> 250mm
- 4 LC/PC connectors on each end
- Typical Loss: 3dB on the ARF channels

ARF PARCHCORD/CABLE

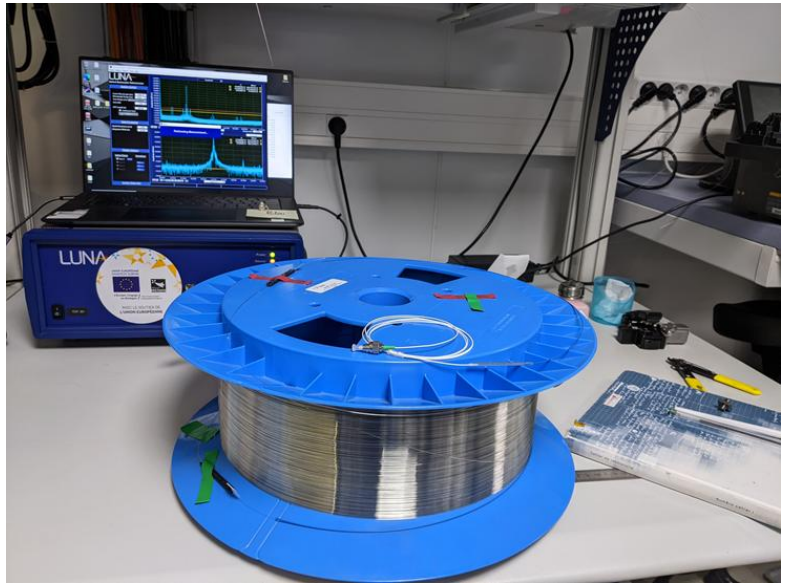
LATENCY MEASUREMENT

		SMF	ARF	
Length	**m**	48,9	0	48,9
Index		1,462	1	
Time	**ns**	238,3	0,0	238,3

SMF Channel

		SMF	ARF	
Length	**m**	4,2	44,7	48,9
Index		1,462	1	
Time	**ns**	20,5	149,0	169,5

ARF+ SMF Channel



69ns faster on the ARF+SMF channel over 50m!

Booth C1404

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THANKS

FOR YOUR ATTENTION !

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