Amsterdam
ecoc 2012

OPTCOM

Record-high ODN power budget (more than 38 dB) in self-coherent reflective PON at 1.25 Gbit/s after propagation through 80 km installed fibers

G. Rizzelli[(1)], V. Ferrero[(1)], S. Straullu [(2)], S. Abrate[(2)], F. Forghieri[(3)] and R. Gaudino[(1)]

(1) Politecnico di Torino,
Corso Duca degli Abruzzi 24, 10129 Torino, Italy,
E-mail: roberto.gaudino@polito.it

(2) Istituto Superiore "Mario Boella" (ISMB),
Via P. C. Boggio 61, 10138 Torino, Italy

(3) CISCO Photonics,
Via Philips 12, 20059, Monza, Milan, Italy

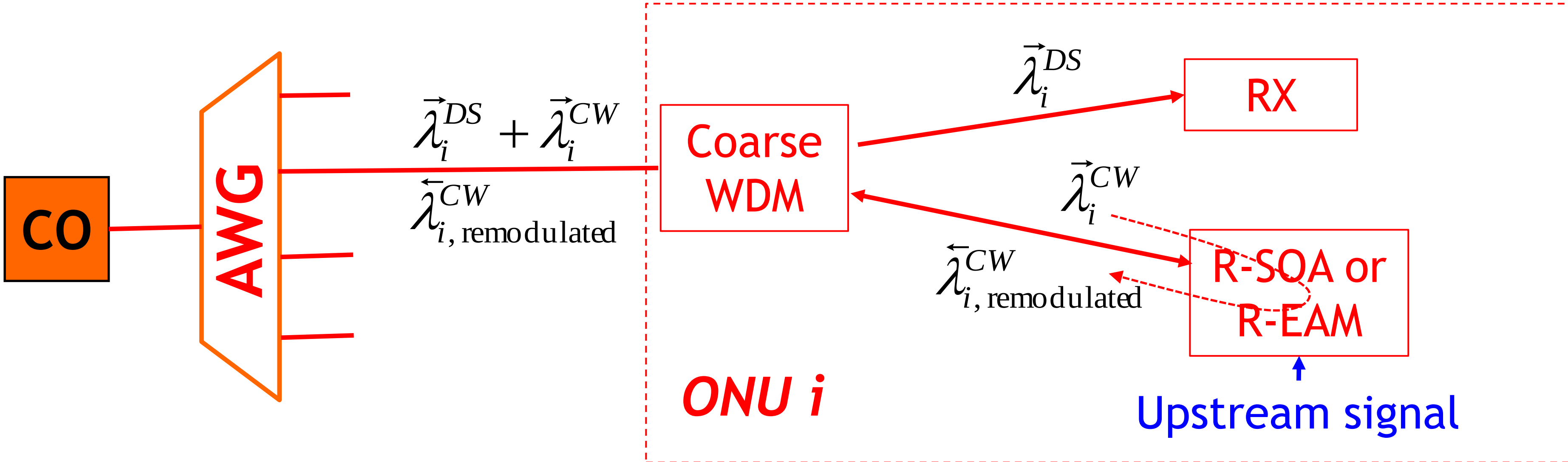
Target and Outline

- **TARGET:**
  - Optimization of reflective PON upstream path using self-coherent detection at OLT

- **OUTLINE of the presentation:**
  - Scenario and rationale of self-coherent OLT
  - Experimental setup
  - Results and system optimization
  - Conclusions

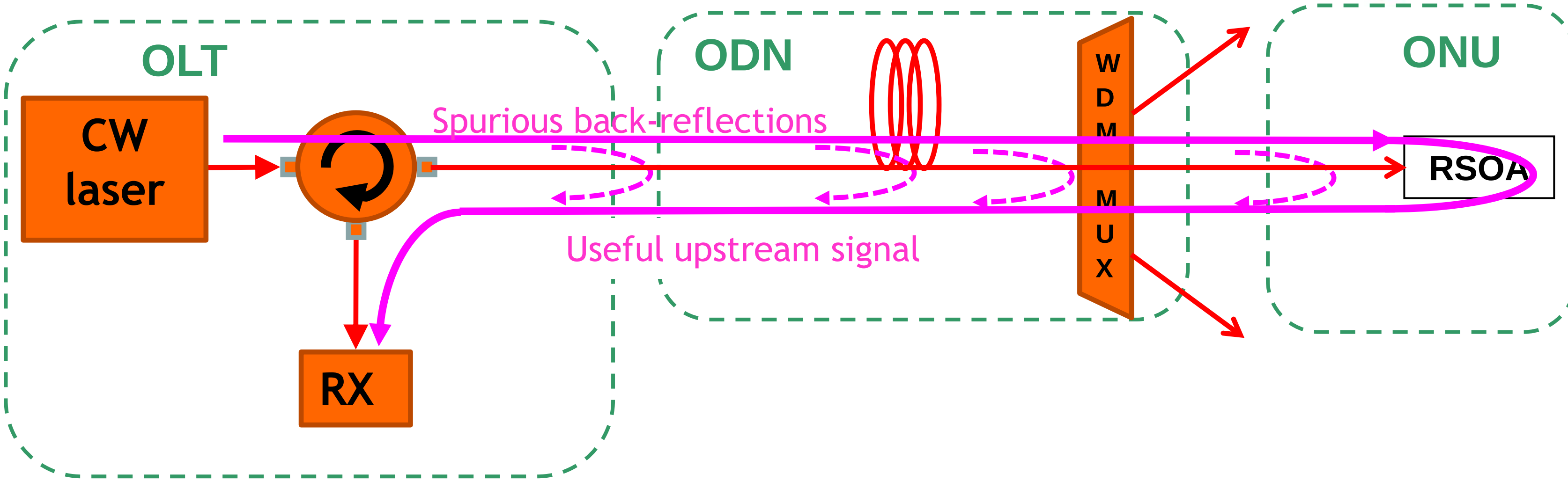
Introduction and scenario

WDM reflective PON: basic principle



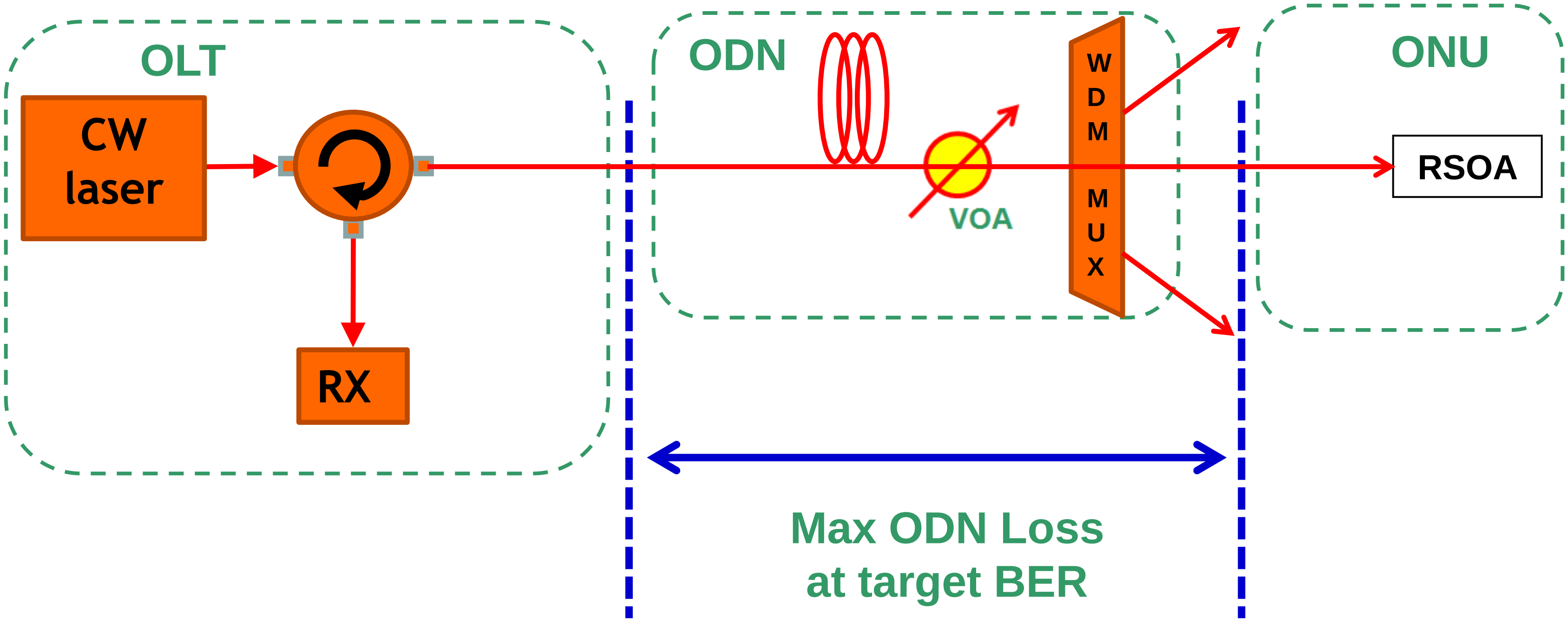
- Each ONU receives two wavelengths:
  - A downstream modulated wavelength carrying the data to be received by the ONU
  - A downstream CW wavelength that is upstream modulated by a reflective device
    - In this paper, we focus ONLY on this upstream transmission

WDM-PON using RSOA



- <u>PROs:</u> Reflective WDM PON architectures allow **colorless** and **laser-less ONU** (the upstream transmission wavelength is generated at the OLT side)
  - A reflective device (typically an **RSOA**) is used to **reflect**, **amplify** and **modulate** signal at the ONU
- <u>CONs:</u> These architectures greatly suffer from upstream transmission impairments
  - This is mainly due to spurious back-reflections, particularly Rayleigh Back-Scattering (RBS)

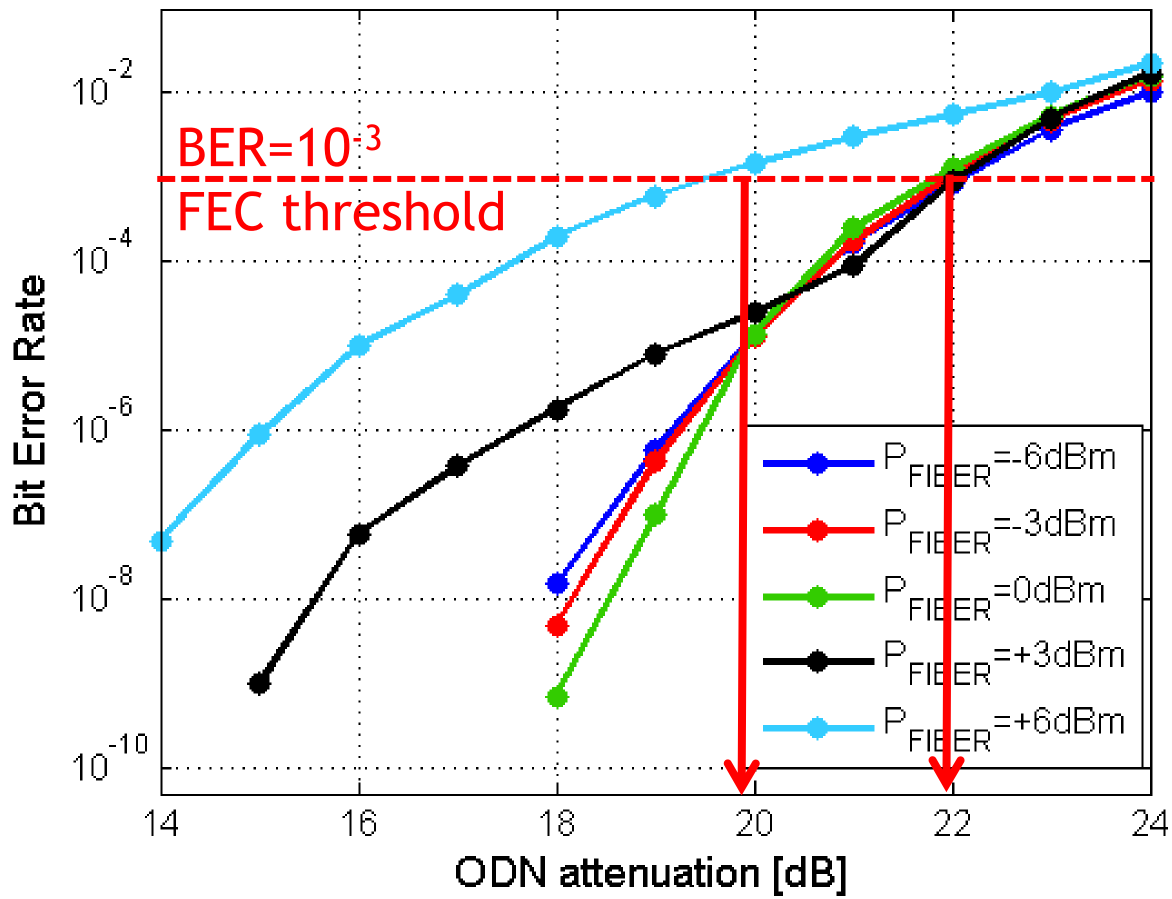
A figure of merit: maximum ODN Loss



Typical performance using direct detection (DD)

- We show a typical results for 1.25 Gbps upstream transmission and direct detection

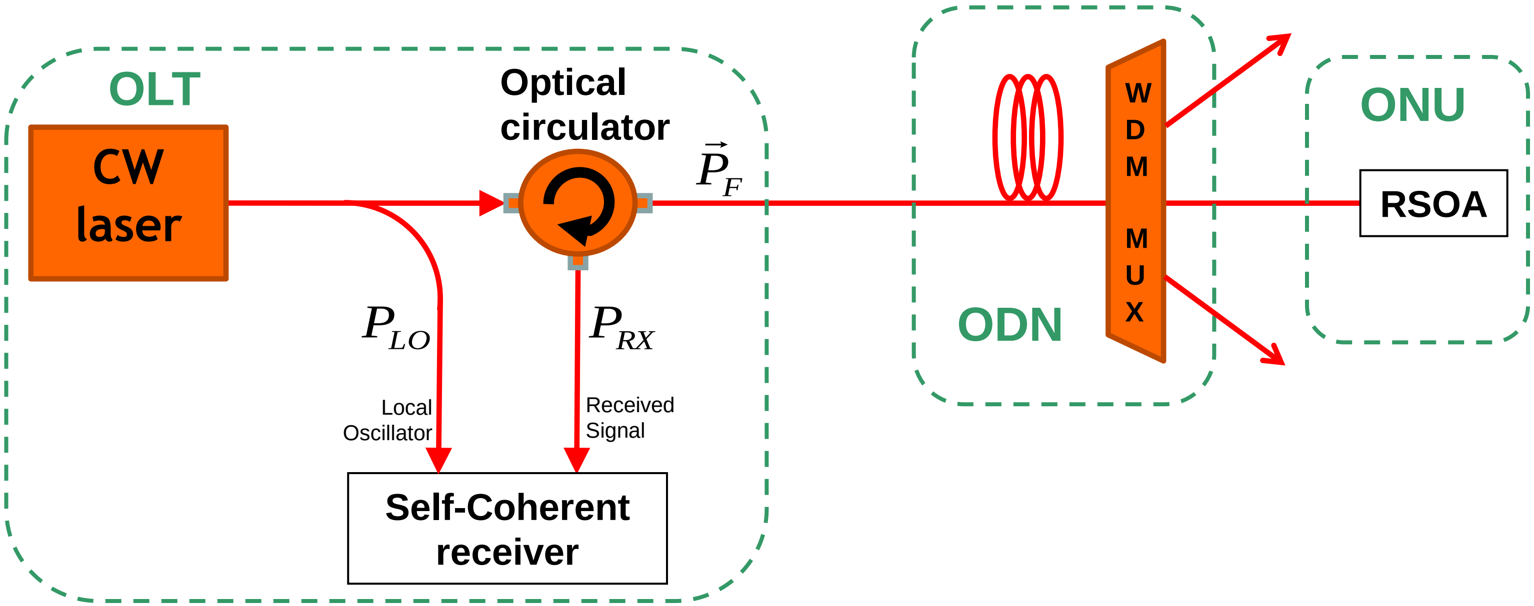
- We used in these measurements an optically amplified direct detection receiver, with back-to-back sensitivity at BER=10^{-3} around -40dBm



Using direct detection

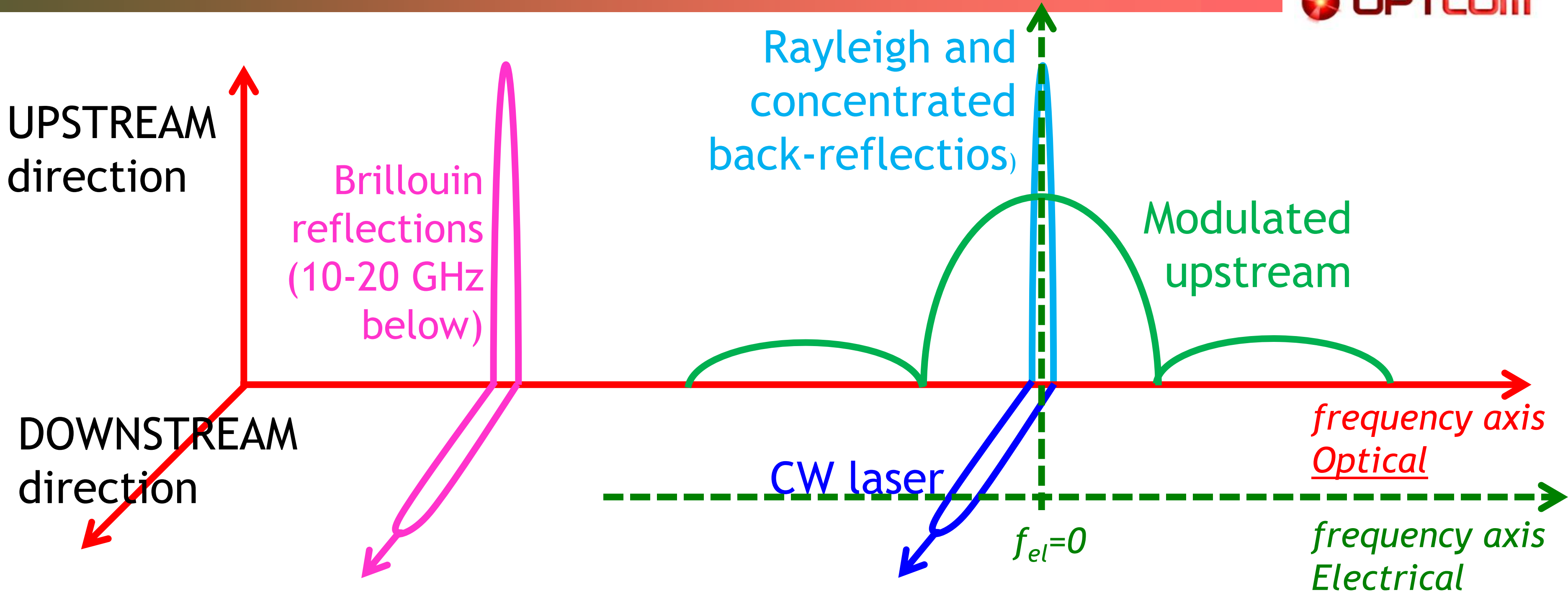
- The achievable 20-22 dB ODN loss in our experiment is mostly limited by spurious back-reflections
  - The useful upstream signal is exactly at the same wavelength of the downstream CW seed signal
- These two components beat together after photo-detection (generating “coherent crosstalk”)

Self-coherent receiver at OLT



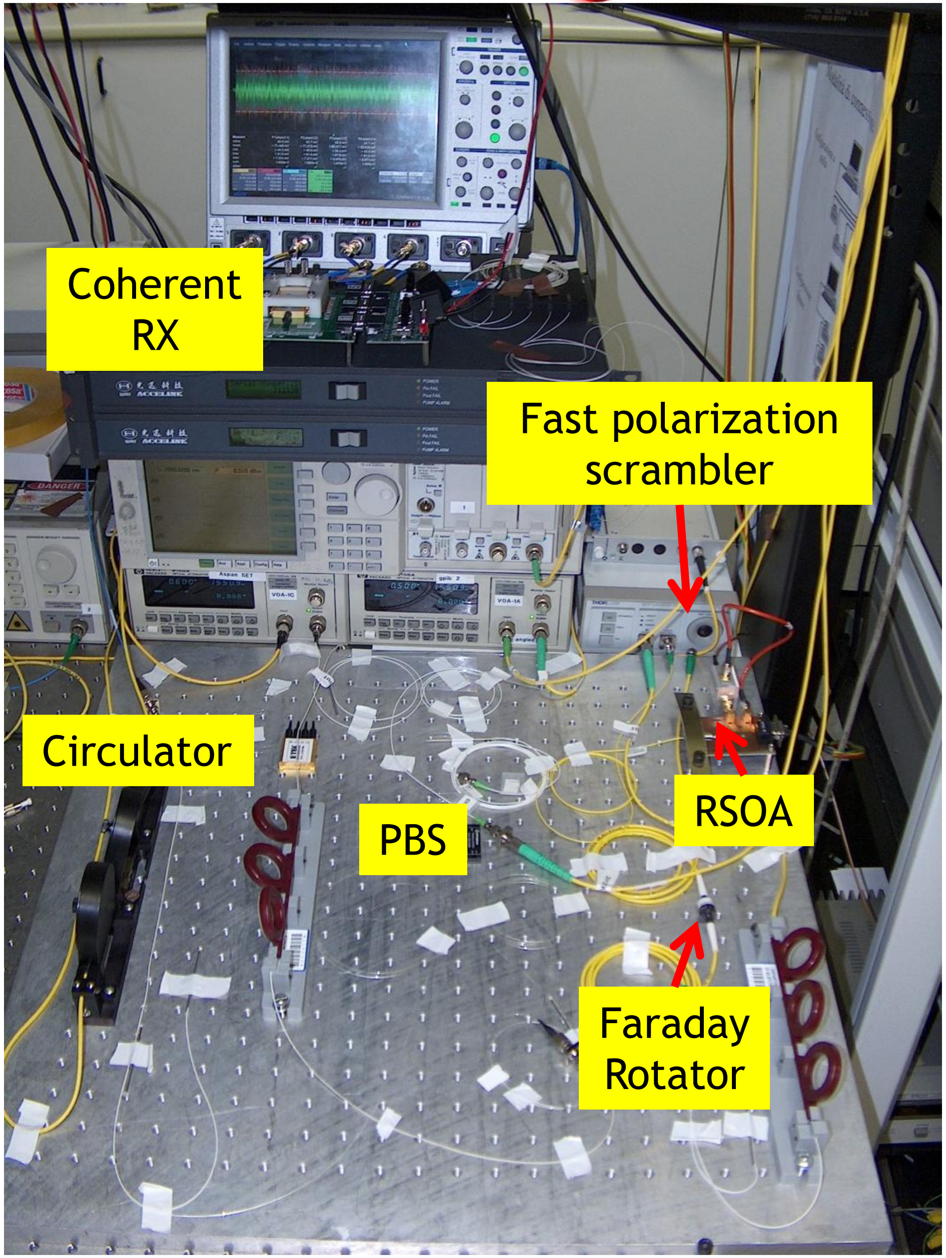
- Features:
  - Significantly improved sensitivity compared to DD
  - Possibility to counteract transmission impairments by digital signal processing (DSP)
  - The local oscillator signal comes for free…

The different contributions to reflections



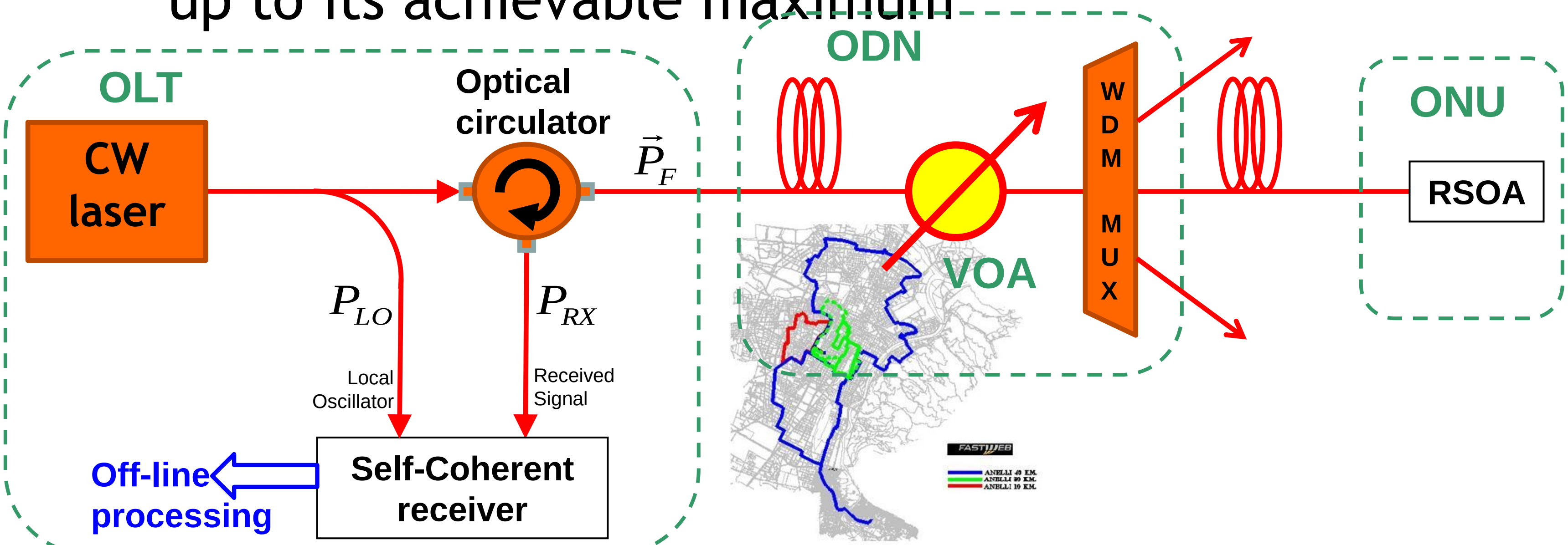
- Using a self-coherent receiver:
  - The RBS reflection appears as added close to DC →it can be filtered out by electrical high-pass filters
  - The upstream Brillouin component (if relevant) is out of band

Experimental results



Experimental setup

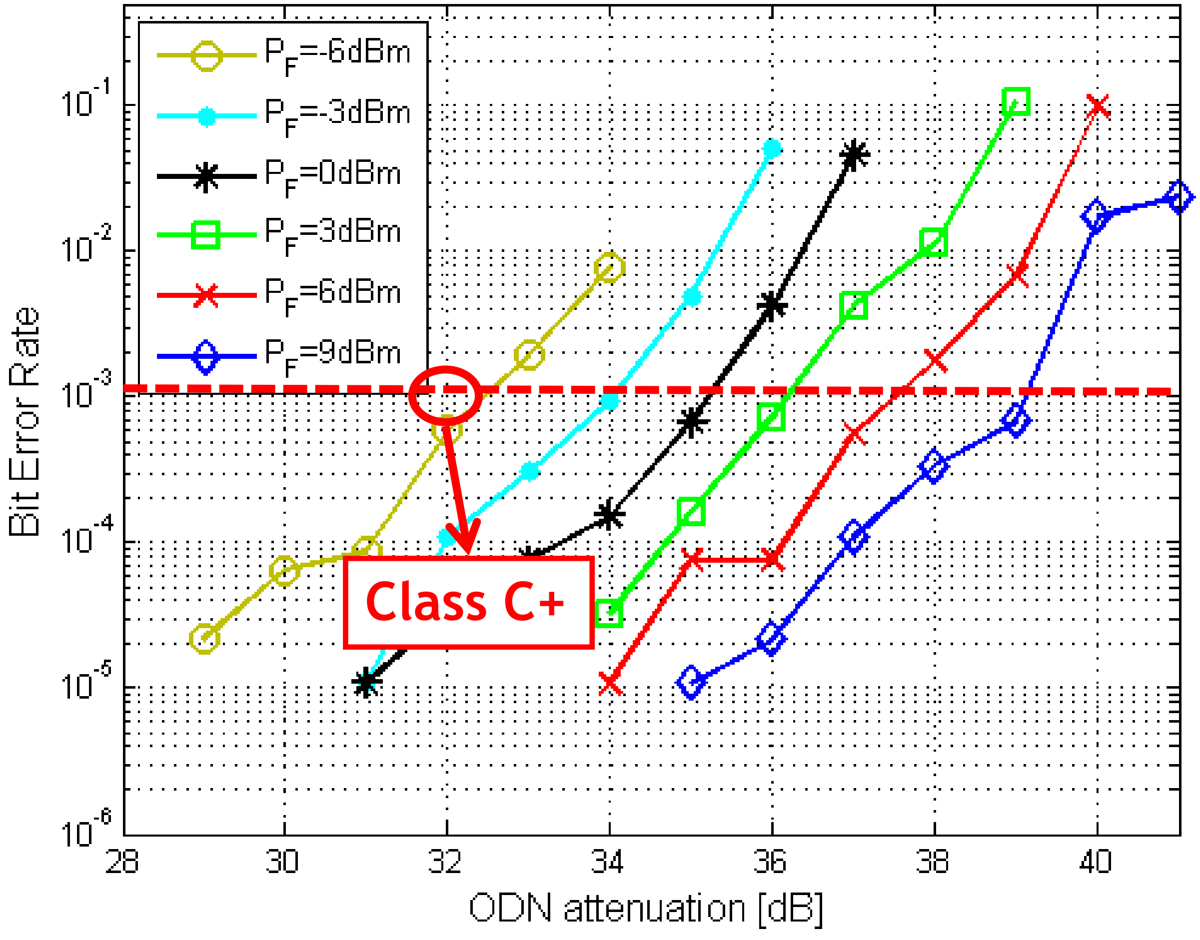
- Experiments on upstream transmission
  - 1.25 Gbit/s, off-line processing self-coherent detection
  - Variable lengths of real installed SMF fibers (buried dark fibers, Fastweb metro network)
  - Insertion of extra attenuation to increase ODN loss up to its achievable maximum



Testbed rings layout in Torino

11Km transmission with self coherent receiver

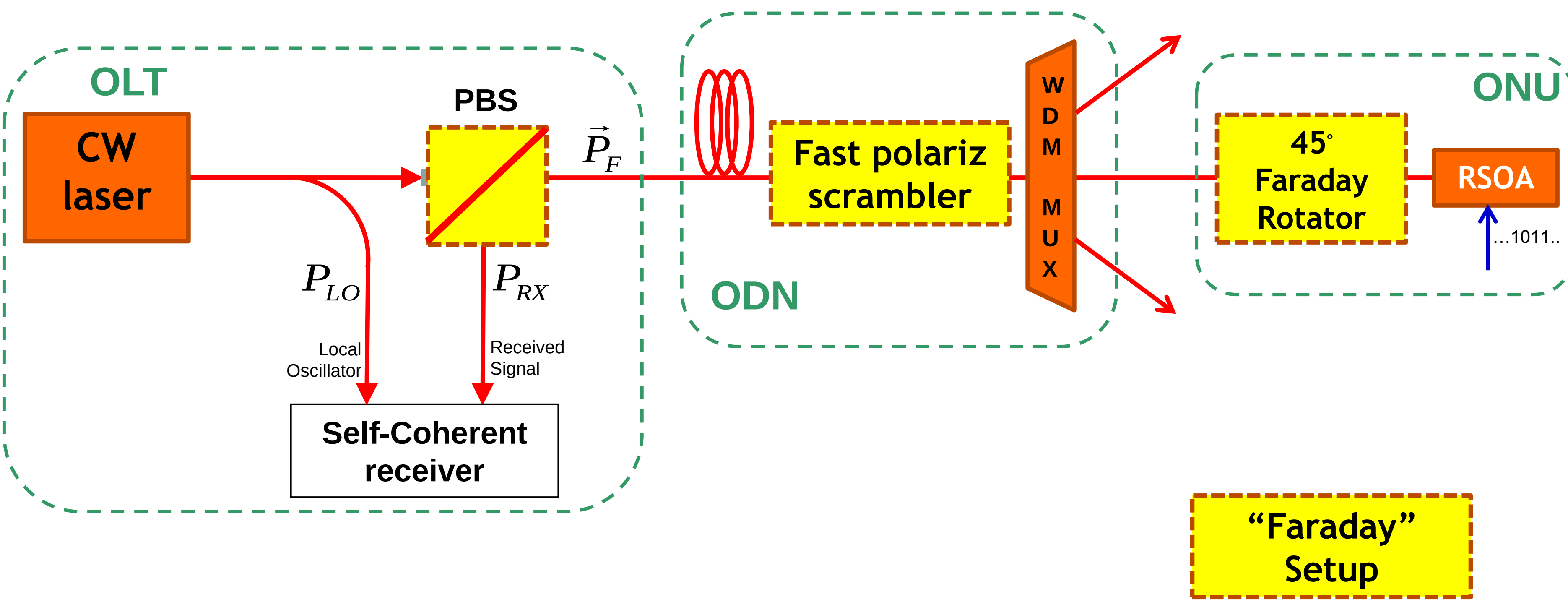
- BER vs. ODN loss for different launched power



The “Faraday” setup

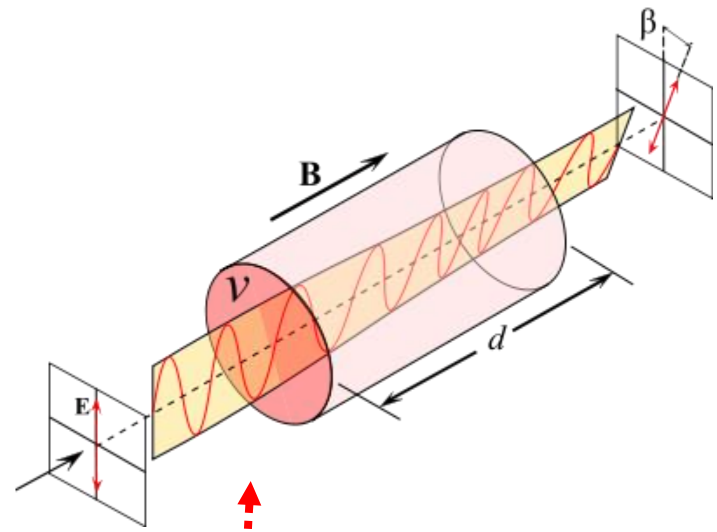
"Faraday setup" at ONU

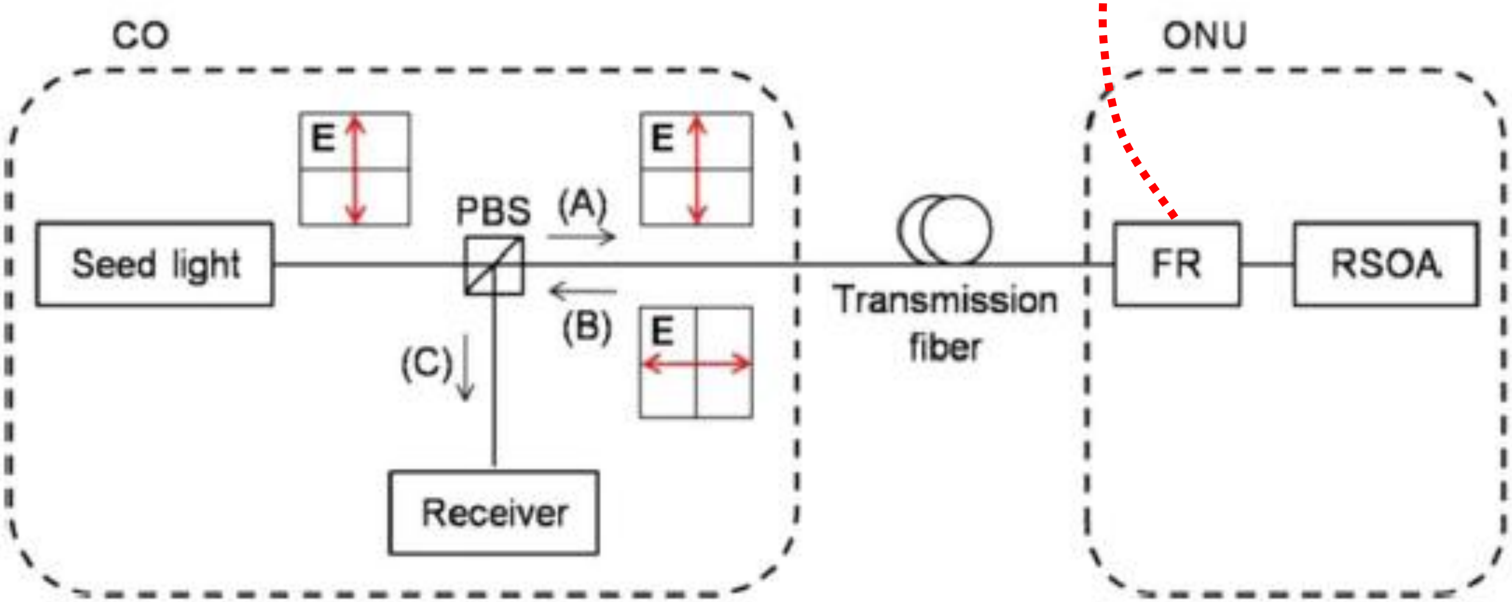
- A further improvment can be obtained by introducing a Faraday Rotation at the ONU site



Faraday rotation

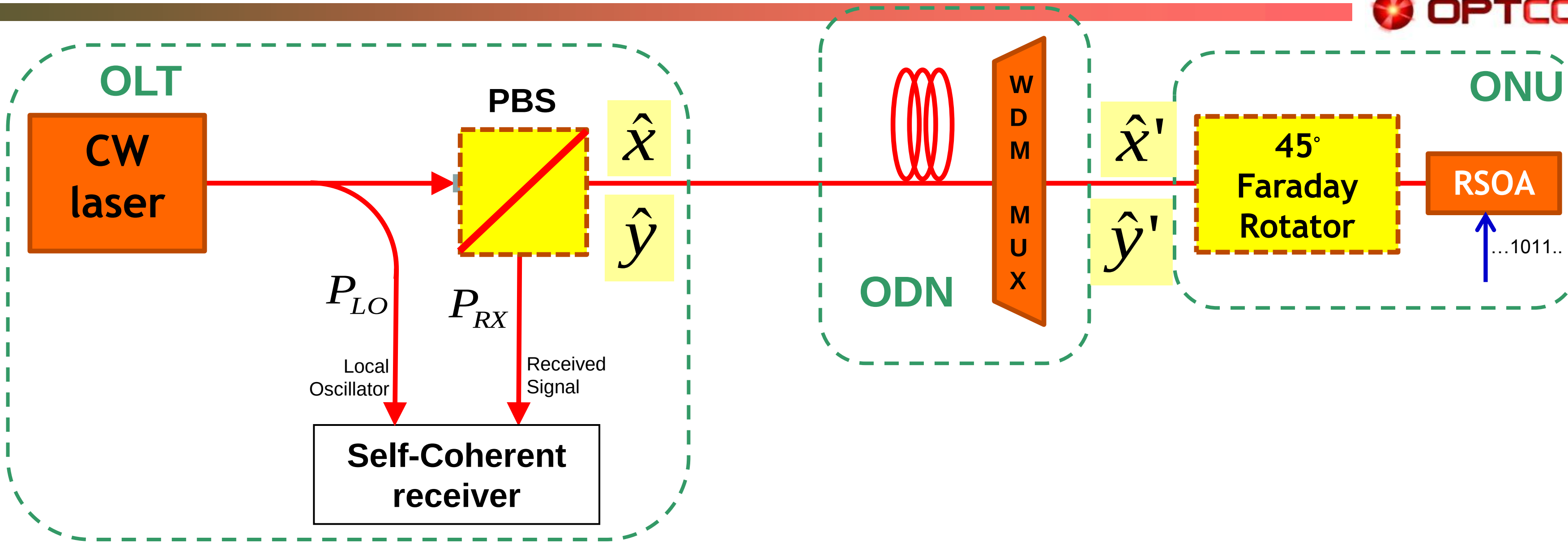
A Faraday rotation at the ONU side forces the upstream modulated signal polarization to be orthogonal to the downstream CW seed signal in any ODN link section





Picture taken from: Cho, K.Y. et al., "Long-Reach Coherent WDM PON Employing Self-Polarization-Stabilization Technique", IEEE JLT, Feb. 2011

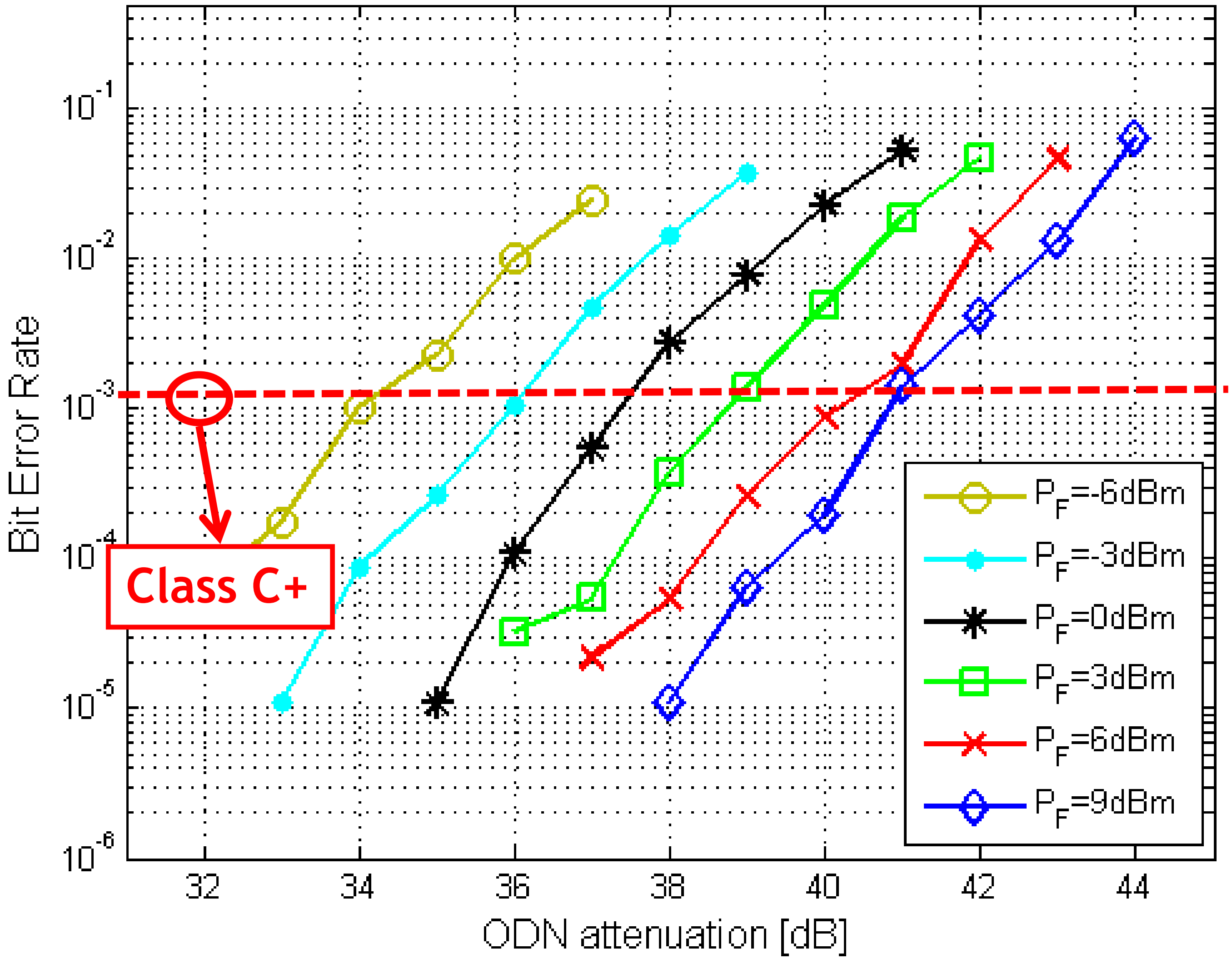
"Faraday setup" at ONU



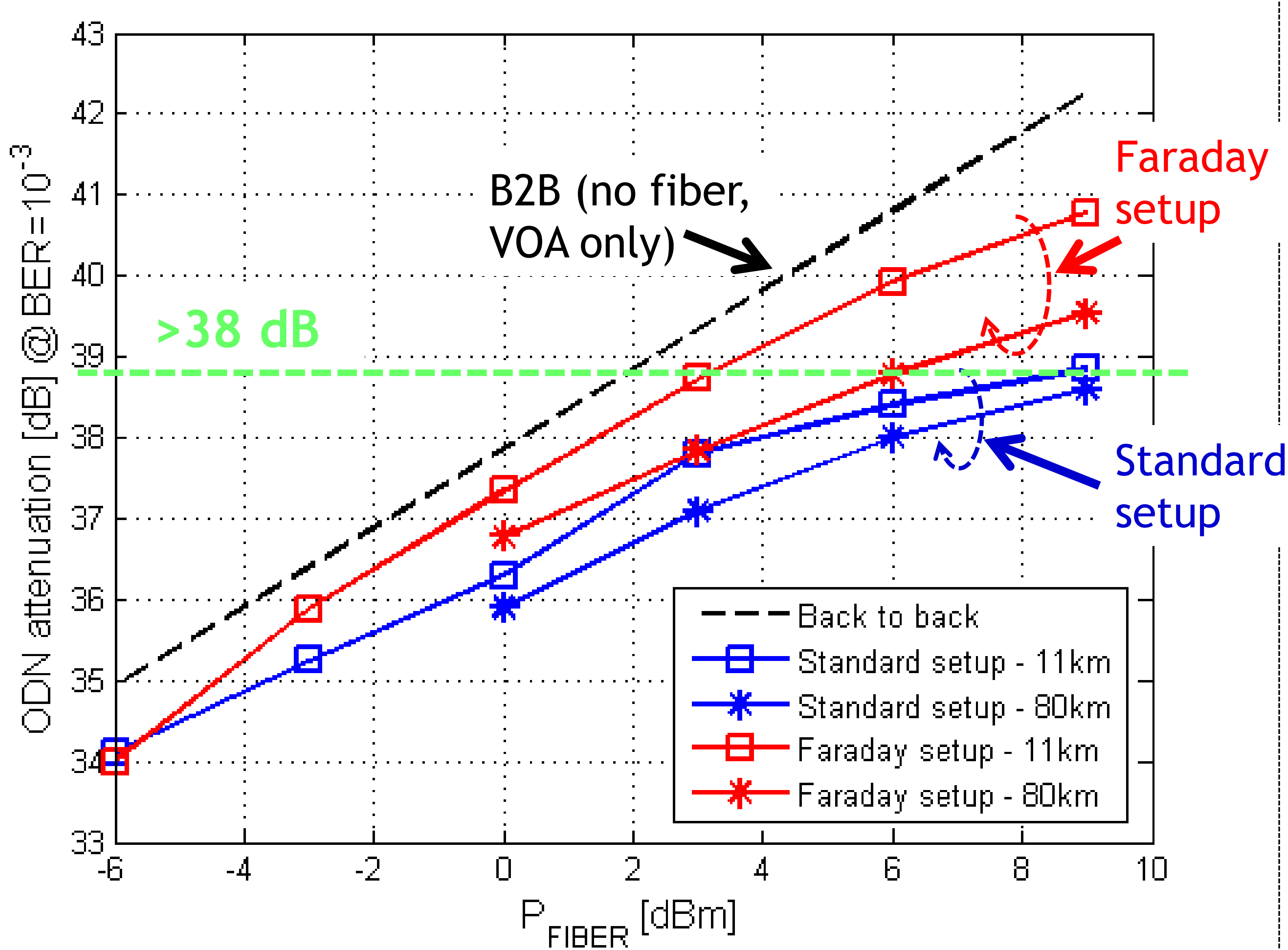
- Using the polarization notation above:
  - The received useful signal is always on y-polarization
    - The circulator can be substituted by a PBS, and the coherent receiver can be single-polarization
  - The RBS is mostly unpolarized, but its polarized components is on the x-polarization

Coherent "Faraday" Setup

- BER vs. ODN loss for different launched power



Comparing the two setups at 11 and 80 Km



CONCLUSION

Conclusions

- Coherent receivers at the OLT can greatly increase the performance of reflective PON architectures
  - 1-2 more dB can be gained with Faraday setup
  - Very high ODN loss (>38dB) can be tolerated
- Recently, we have further optimized the systems to reach 100 Km and 42 dB ODN loss
  - For further information, please see our <u>**post-deadline paper Th3D.6**</u>

Optimization of self-coherent reflective PON to achieve a new record 42 dB ODN power budget after 100 km at 1.25 Gbps

S. Straullu[2], S. Abrate[2], F. Forghieri[3], V. Ferrero[1] and R. Gaudino[1]

[1] Politecnico di Torino, C.so Duca degli Abruzzi 24 – 10129 Torino, Italy, roberto.gaudino@polito.it
[2] ISMB, Istituto Superiore Mario Boella, Via P.C. Boggio 61 – 10138 Torino
[3] CISCO Photonics, Via Philips 12, 20059, Monza, Milan, Italy

Amsterdam ecoc 2012

OPTCOM

Thank you for your attention!

Record-high ODN power budget (more than 38 dB) in self-coherent reflective PON at 1.25 Gbit/s after propagation through 80 km installed fibers

G. Rizzelli[1], V. Ferrero[1], S. Straullu [2], S. Abrate[2], F. Forghieri[3] and R. Gaudino[1]

(1) Politecnico di Torino,
Corso Duca degli Abruzzi 24, 10129 Torino, Italy,
E-mail: roberto.gaudino@polito.it

(2) Istituto Superiore "Mario Boella" (ISMB),
Via P. C. Boggio 61, 10138 Torino, Italy

(3) CISCO Photonics,
Via Philips 12, 20059, Monza, Milan, Italy