On the use of DFB Lasers for Coherent PON

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Target and Outline

- **TARGET:**
  - Optical coherent receivers are proposed for some NG-PON2 architecture
  - In this scenario, we investigate on the use of DFB lasers (rather than more expensive ECL lasers)
- **OUTLINE of the presentation:**
  - Scenario
  - Experimental setup
  - Results and DSP optimization
  - Conclusions

Coherent receivers in NG-PON2

- Several research centers have started to propose coherent receivers in PON. Just to name a few:

Pubblication / Authors	Coherent receiver position
Demonstration of a Coherent UDWDM-PON with Real-Time Processing OSA/OFC/NFOEC 2011 **Sylvia Smolorz[1], Erich Gottwald[1], Harald Rohde[1], David Smith[2], Alistair Poustie[2]** *1 Nokia Siemens Networks GmbH &Co KG, St. Martinstr. 76, 80240 Munich, Germany* *2 CIP Technologies, Adastral Park, Martlesham Heath, Ipswich, IP5 3RE, U.K.* *sylvia.smolorz@nsn.com*	OLT and ONU
Long-Reach Coherent WDM PON Employing Self-Polarization-Stabilization Technique K. Y. Cho, K. Tanaka, T. Sano, S. P. Jung, J. H. Chang, Y. Takushima, *Member, IEEE*, A. Agata, Y. Horiuchi, M. Suzuki, *Fellow, IEEE*, and Y. C. Chung, *Fellow, IEEE, Fellow, OSA* JOURNAL OF LIGHTWAVE TECHNOLOGY, VOL. 29, NO. 4, FEBRUARY 15, 2011	OLT only, self coherent

Coherent receivers in NG-PON2

Pubblication / Authors	Coherent receiver position
A Novel Symmetric Lightwave Centralized WDM-OFDM-PON Architecture with OFDM-Remodulated ONUs and a Coherent Receiver OLT **Ming-Fang Huang, Dayou Qian and Neda Cvijetic** *NEC Laboratories America, Princeton, NJ 08540, USA* *mhuang@nec-labs.com* ECOC Technical Digest © 2011 OSA	OLT only
Self-Coherent Single Wavelength SC-FDMA PON Uplink for NG-PON2 OFC 2012 OW4B.4 **B. Charbonnier(1), A. Lebreton(1), S. Straullu(3), V. Ferrero(2), A. Sanna(2), R. Gaudino(2)** *(1) France Télécom R&D Réseaux d'Accès (RESA) - ANA/ASHA* *(2) Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129 Torino, Italy, roberto.gaudino@polito.it* *(3) Istituto Superiore "Mario Boella" (ISMB), Via P. C. Boggio 61, 10138 Torino, Italy*	OLT only, self coherent

Target of our work

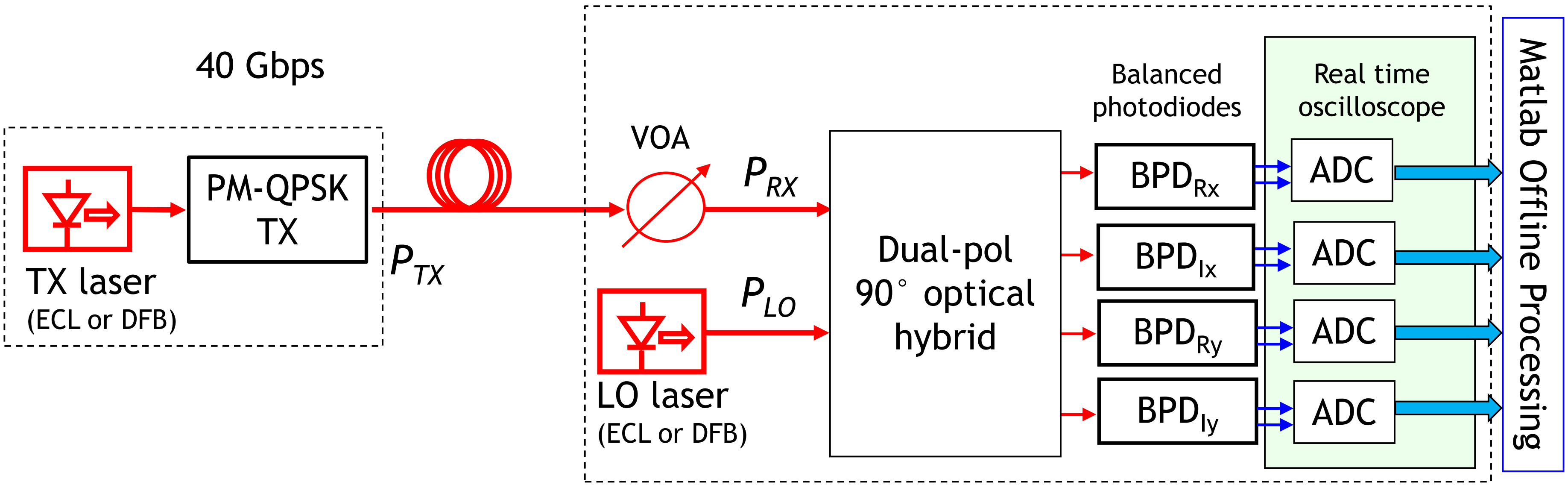
- Most of the coherent PON demonstrators so far have used external-cavity lasers (ECL), due to their very narrow linewidth, thus giving negligible phase noise penalty

- In our work, we investigated on the use of commercial, lower cost DFB lasers

- We focus on PM-QPSK transmission at 40 Gbit/s (10 Gbaud)
  - Experiments
  - DSP parameter optimization

EXPERIMENTAL SETUP

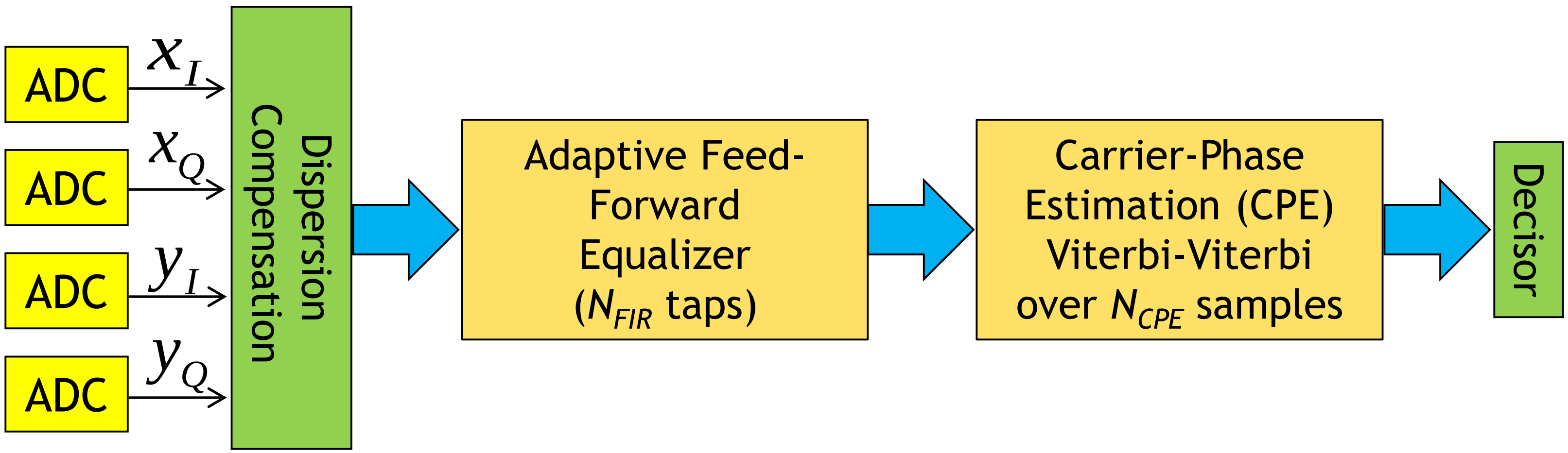
System parameter



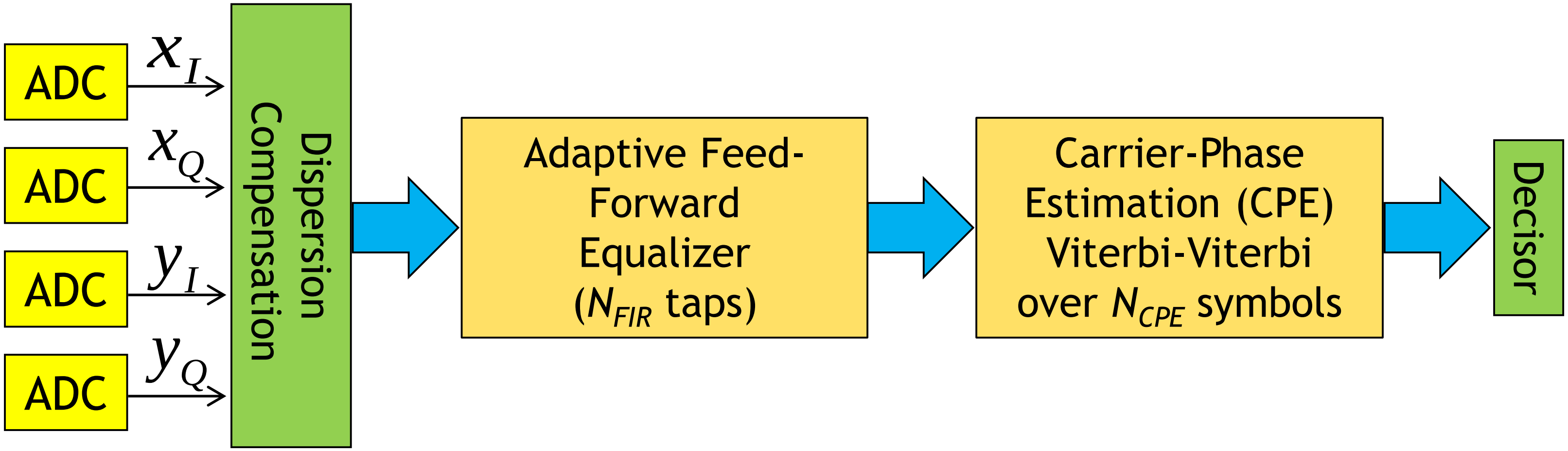
- The used system is a 40 Gbps PM-QPSK system
- We use a coherent receiver WITHOUT optical amplification
  - Local oscillator power = 12 dBm

Digital signal processing

- The digital signal-processing (DSP) section in the coherent receiver is a quite standard algorithm based on
  1. CMA adaptive equalization
  2. Viterbi-Viterbi Carrier-Phase estimation (CPE)



Digital signal processing



The two free parameters we used in our optimizations are:

- Equalizer memory in number of samples $\boxed{N_{FIR}}$
- CPE memory in number of samples $\boxed{N_{CPE}}$

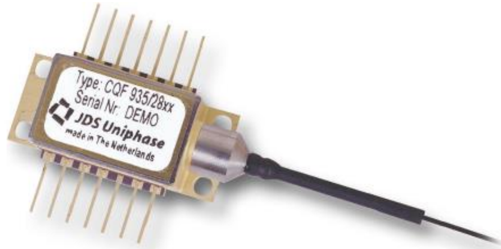
The used lasers

- <u>Laboratory ECL lasers</u> (linewidth in the KHz range) for both the transmitter and Local Oscillator
  - Used as a reference

OR

- <u>Commercial DFB lasers</u> (again both for TX and LO)
  - JDS-Uniphase CQF935/208-19305
    - We obtained similar results with several other commercial DFB lasers for WDM

CQF935/208 Series
1550 nm CW DFB Lasers with PM Fiber for WDM Applications



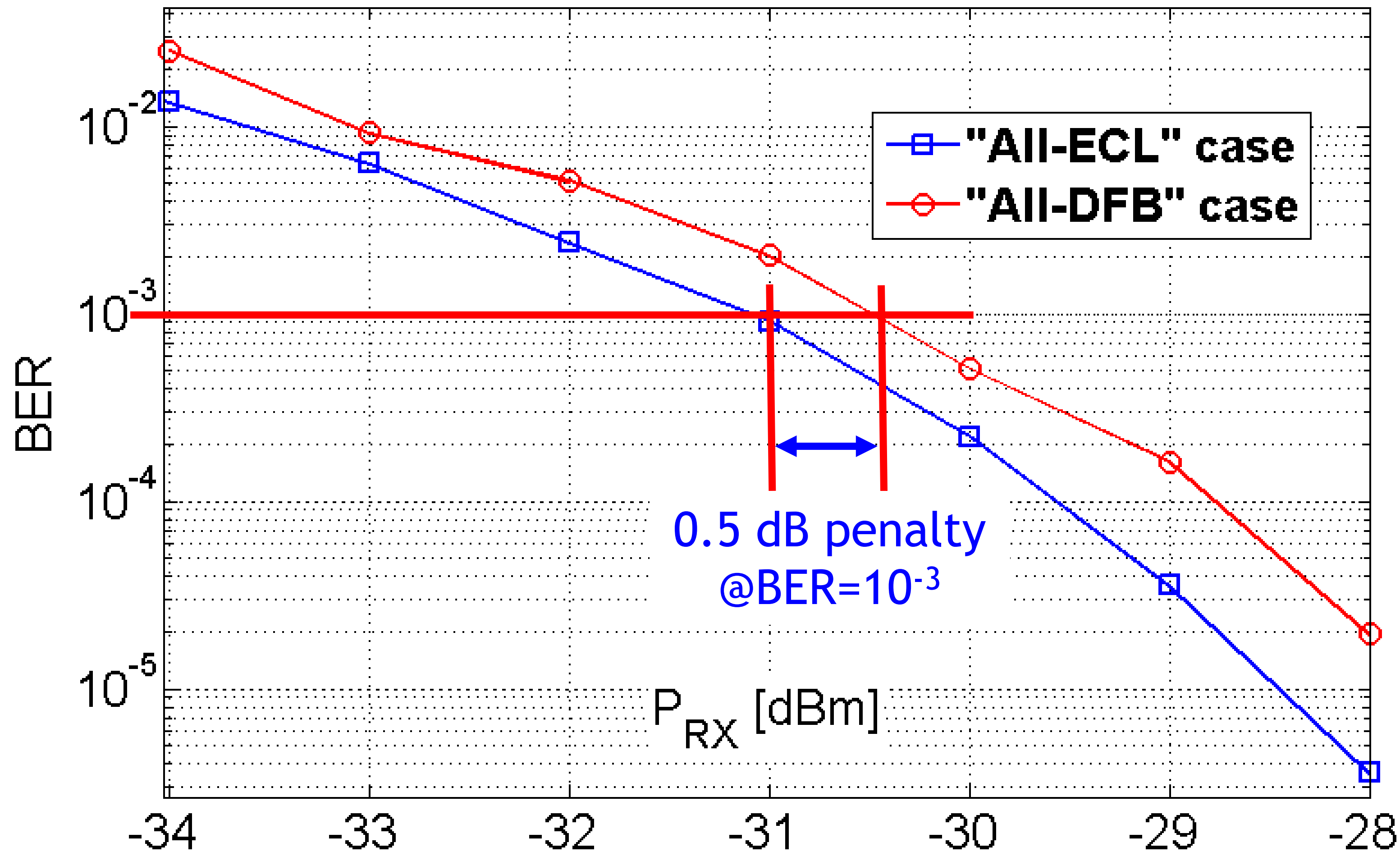
EXPERIMENTAL RESULTS

We compared the following two situations:

1. **"All-ECL" case** (ECLs for both the transmitter and the local oscillator)

2. **"All DFB" case** (DFBs for both the transmitter and the local oscillator)

Back-to-back measurements



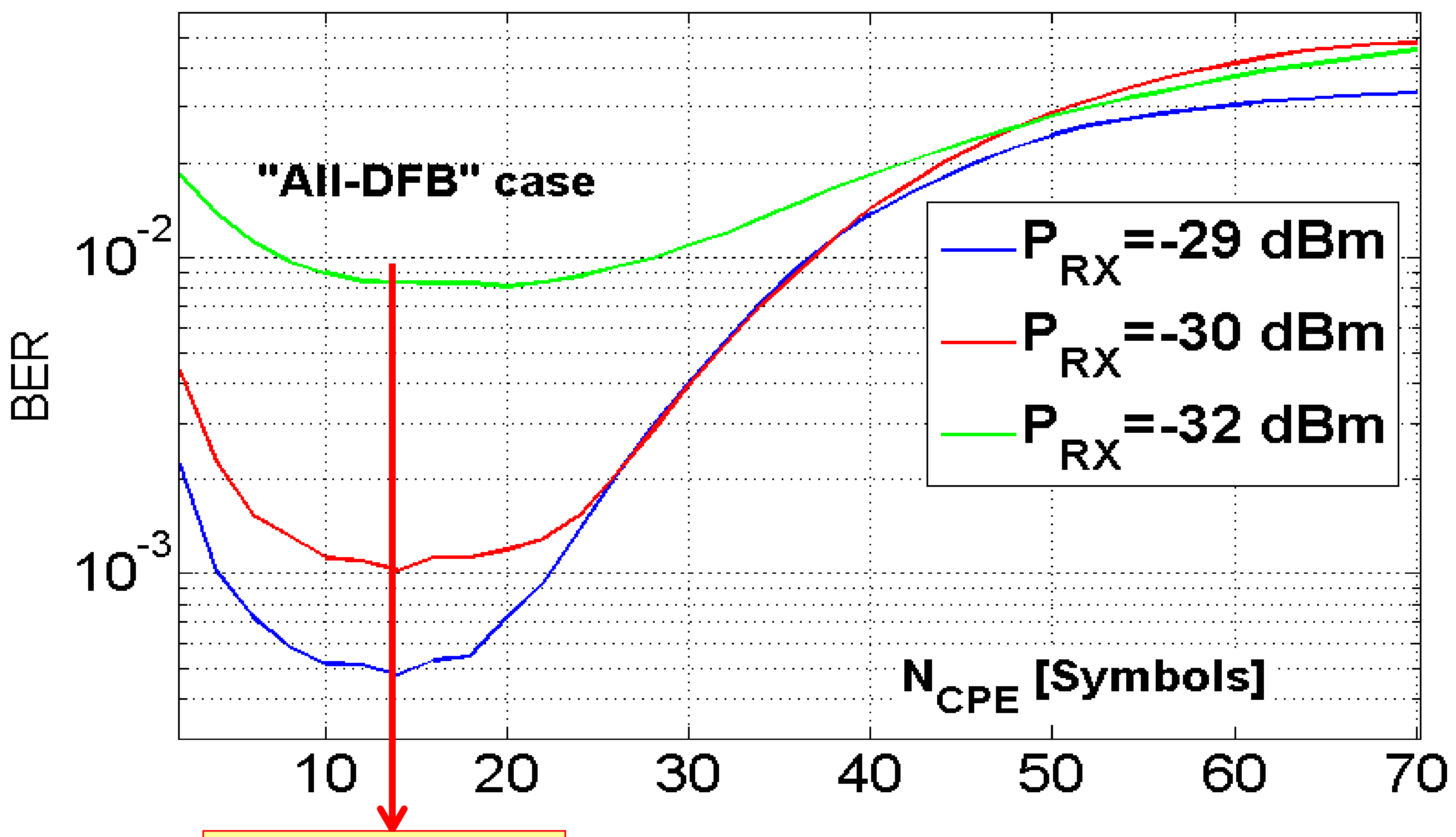
Received Optical Power

Optimization of the DSP parameters

- These results were obtained after an optimization of two free DSP parameters:

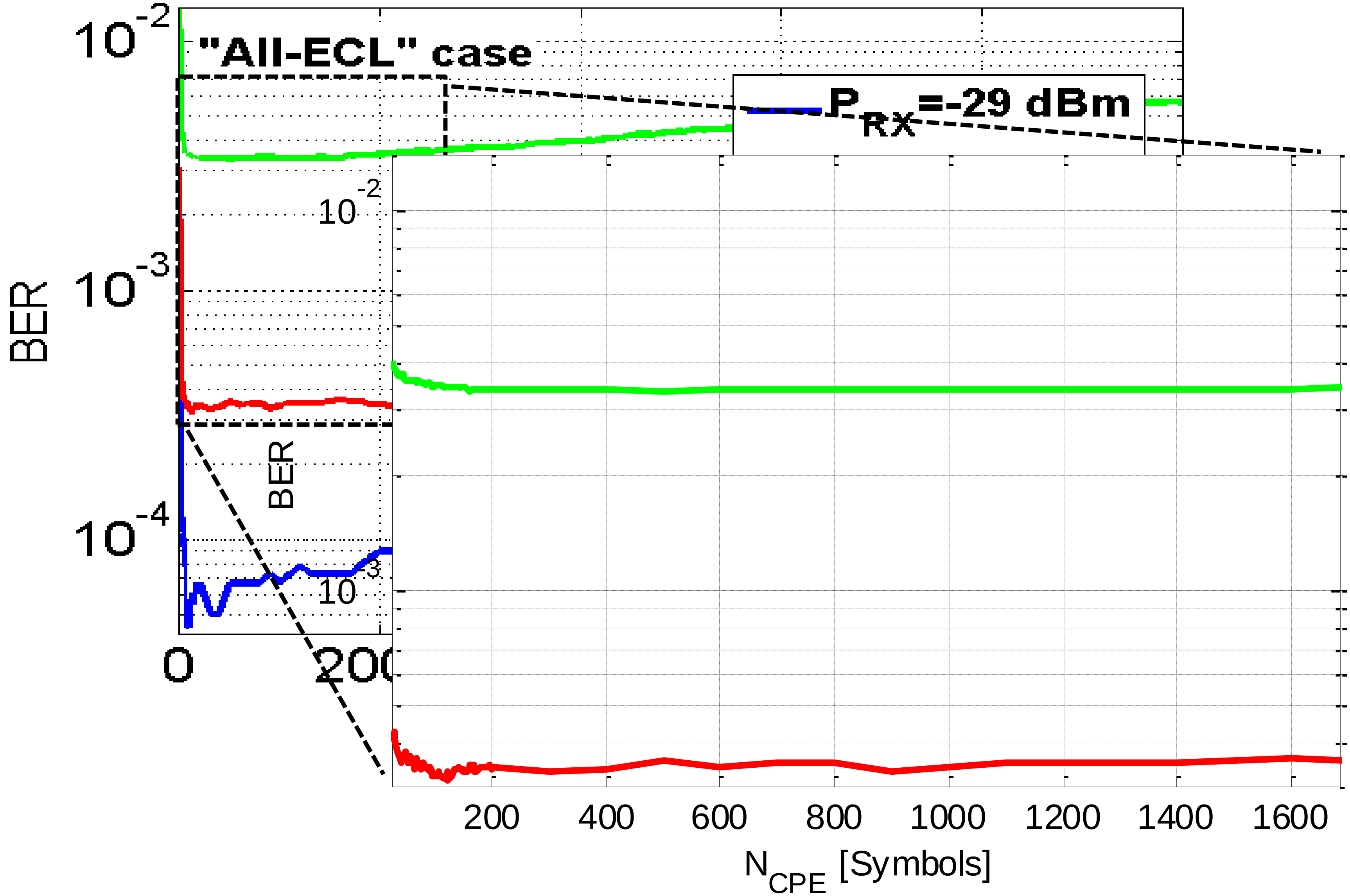
1. The length of the adaptive equalizer filter N_{FIR}
2. The memory of the CPE algorithm N_{CPE}

Optimizing vs. N_{CPE}

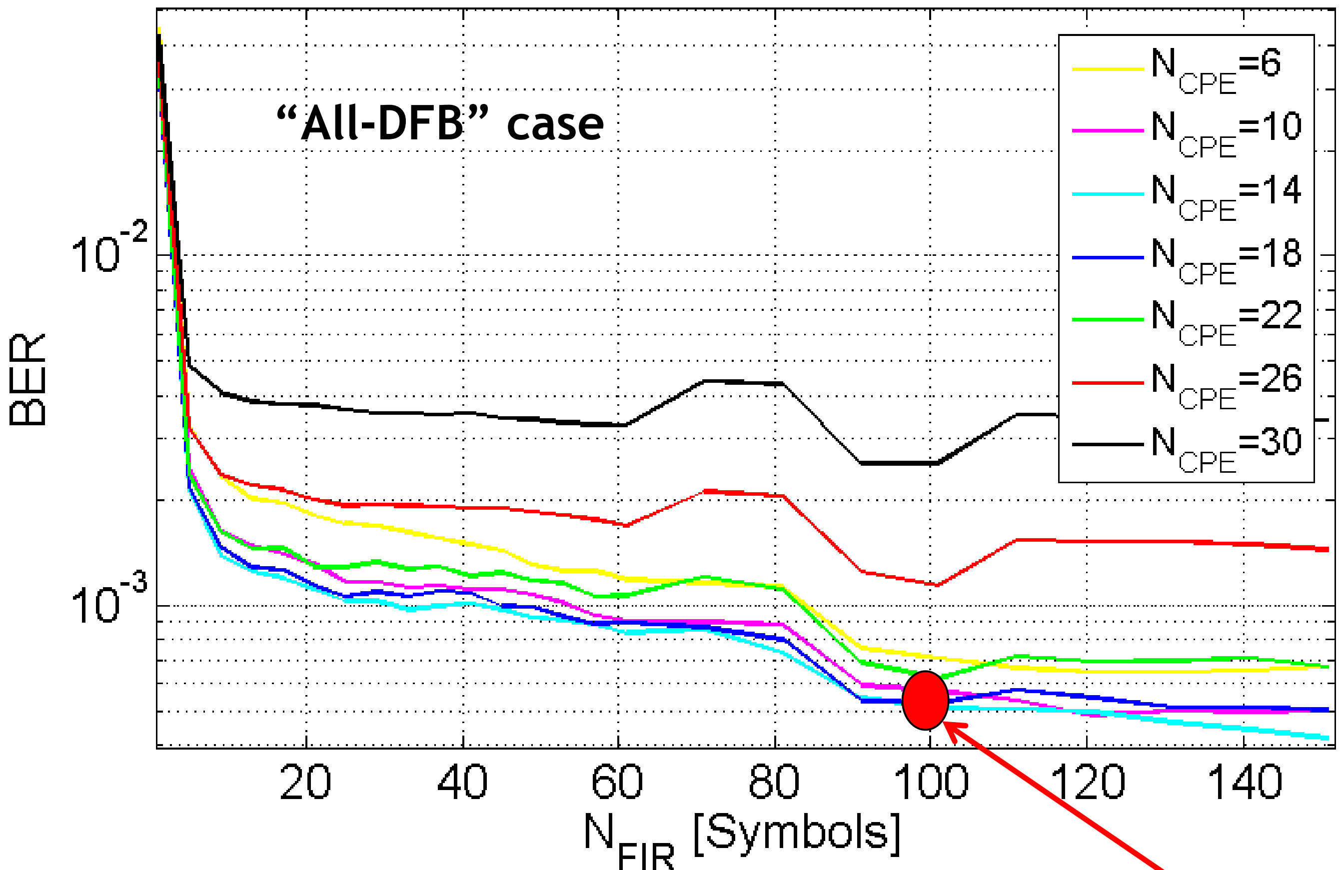


$$N_{CPE}^{optimal} \approx 14$$

Optimizing vs. N_{CPE}



Optimizing vs. N_{FIR}



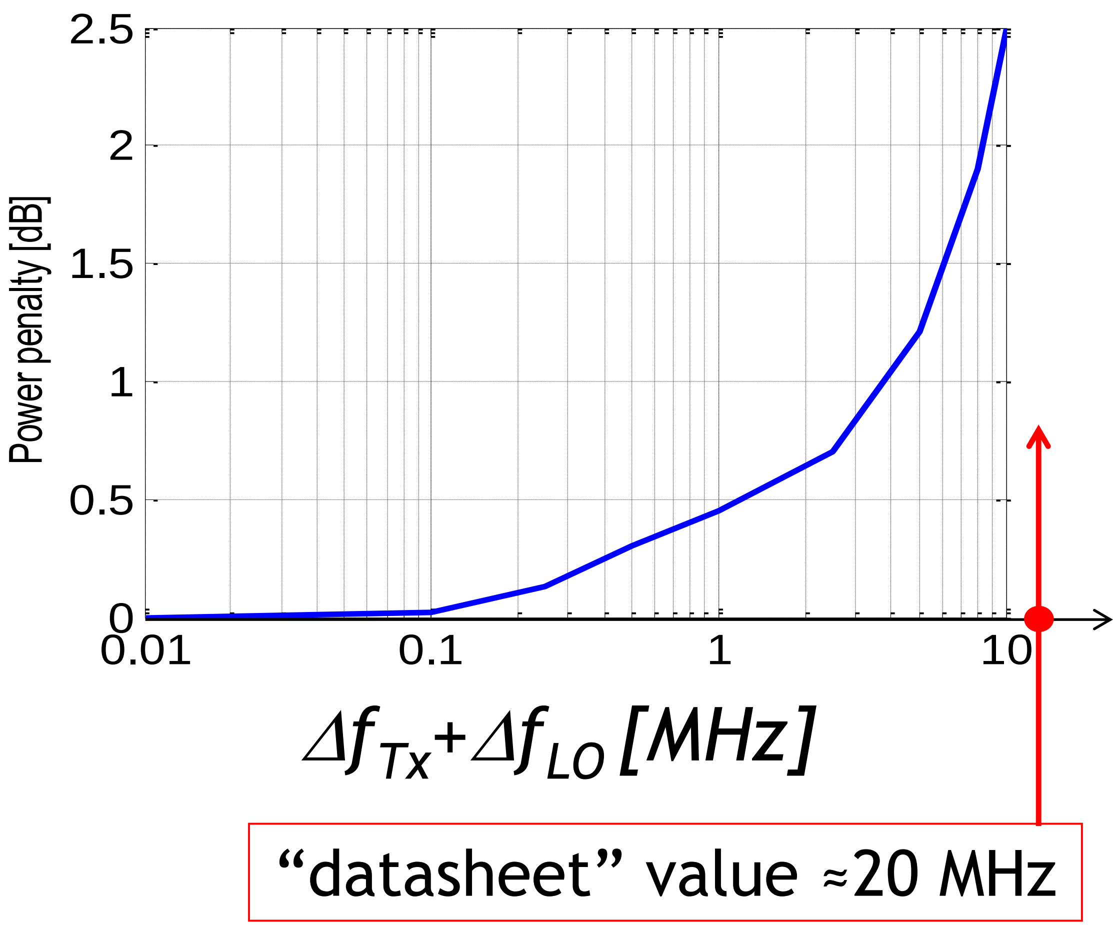
The values we used in previous sensitivity graph

COMMENTS ON THE RESULTS

Comparison with simulation

Laser linewidth definition

- We simulated the impact of phase noise on the considered system as a function of the laser linewidth (for the used Viterbi-Viterbi CPE algorithm)



- The datasheet of the used **DFB lasers indicates a 10MHz linewidth**

- But with this value the system should not work!

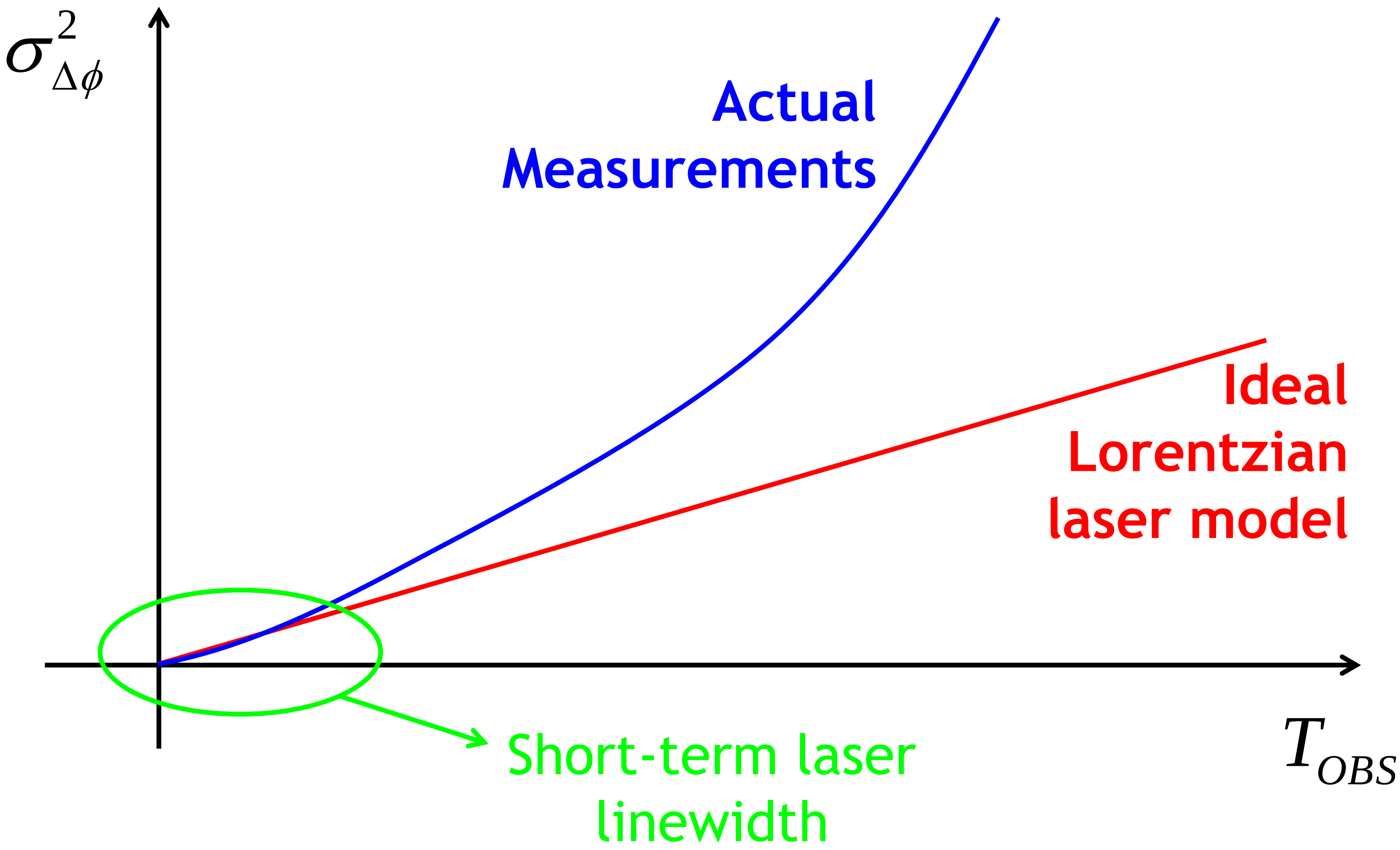
Measuring the lasers linewidth

… back in the lab to measure the linewidth!

- We used the following approach:
  - The phase evolution was obtained using the data collected with the coherent receiver (turning off the signal modulation)
  - We used the following formula (Lorentzian laser model)

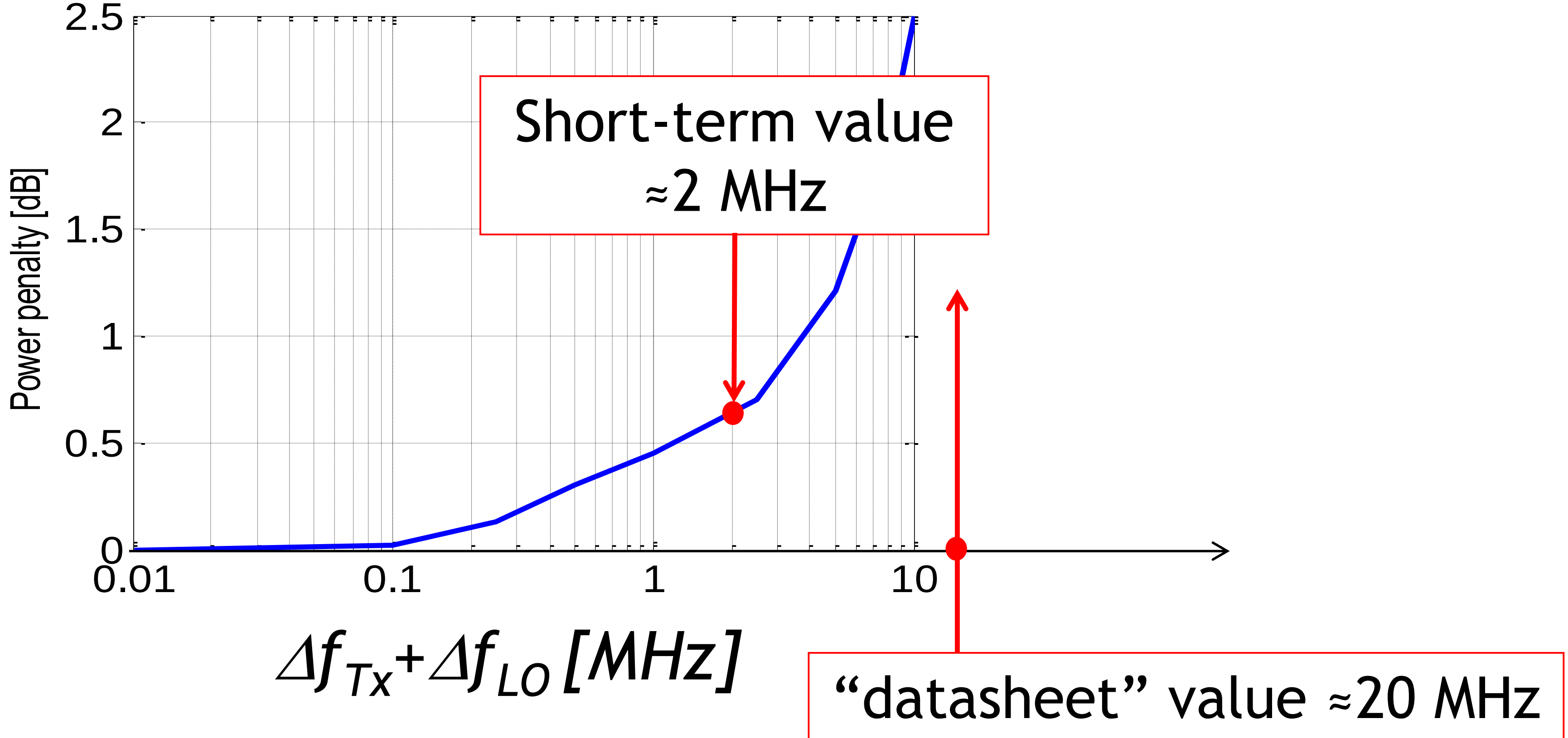
$$\sigma^2_{\Delta\phi} = 2\pi \cdot \Delta f \cdot T_{OBS} \Rightarrow \boxed{\Delta f = \frac{\sigma^2_{\Delta\phi}}{2\pi T_{OBS}}}$$

Linewidth vs. T_{OBS}



Laser linewidth definition

- We found that the "short term" phase noise is actually much lower than what is declared in the datasheet
- When estimated over a few nanosecond (the memory of the CPE), the phase noise corresponds to a "short term" linewidth of about 1 MHz



CONCLUSION

Conclusion

- We showed that for 10 Gbaud PM-QPSK modulation the used of commercial DFB laser does not give significant penalty provided that DSP parameters are optimized
- This result holds also for other modulations (single polarization QPSK, OOK, BPSK) that are proposed for some NG-PON2 solutions, for the same baud rate (10 Gbaud)
- Other more complex modulation formats (such as coherently received OFDM) would be much more demanding in terms of laser linewidth

Thank you for your attention!

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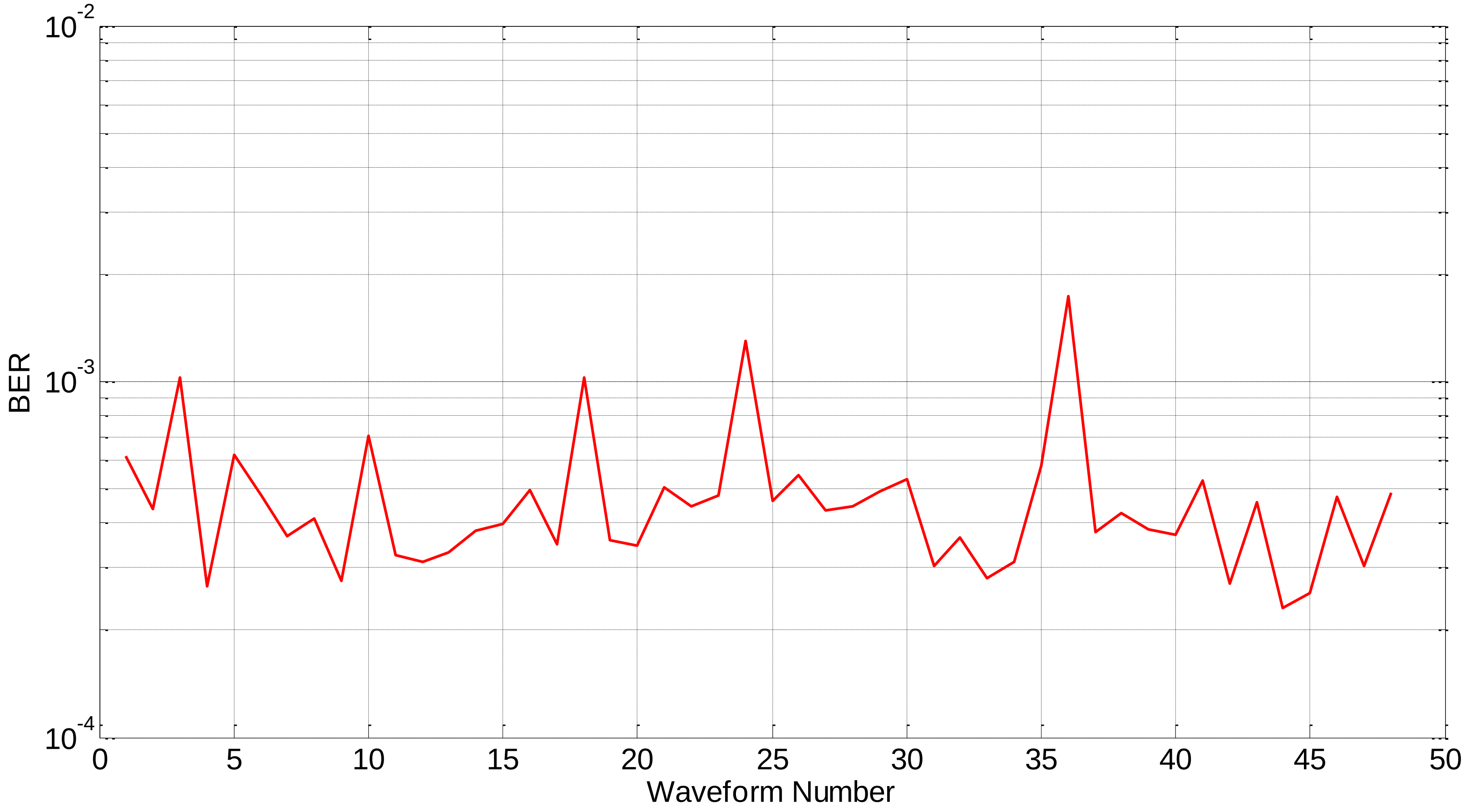
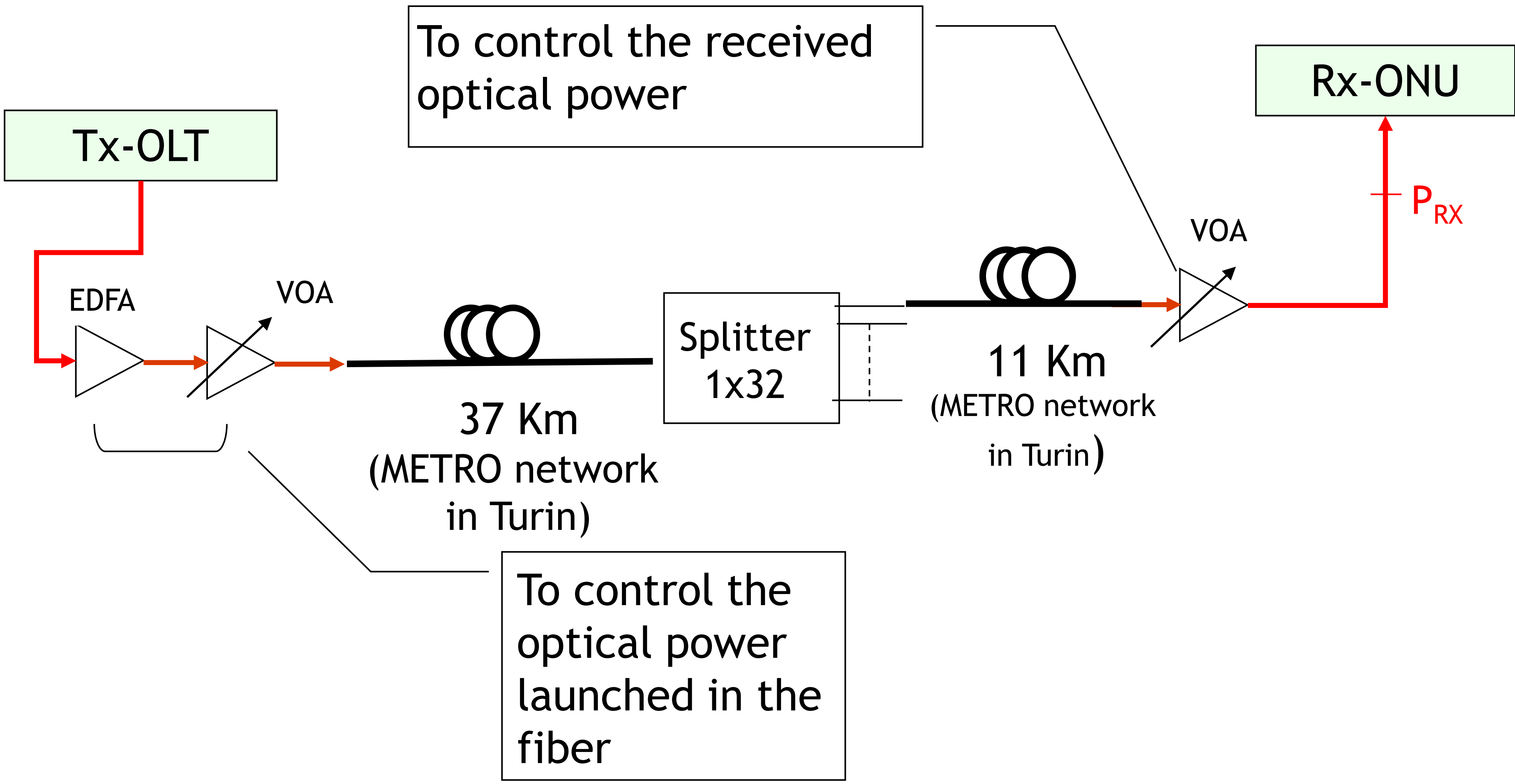
BACK-UP SLIDE
(FROM TILAB WORK)

Long term measurements

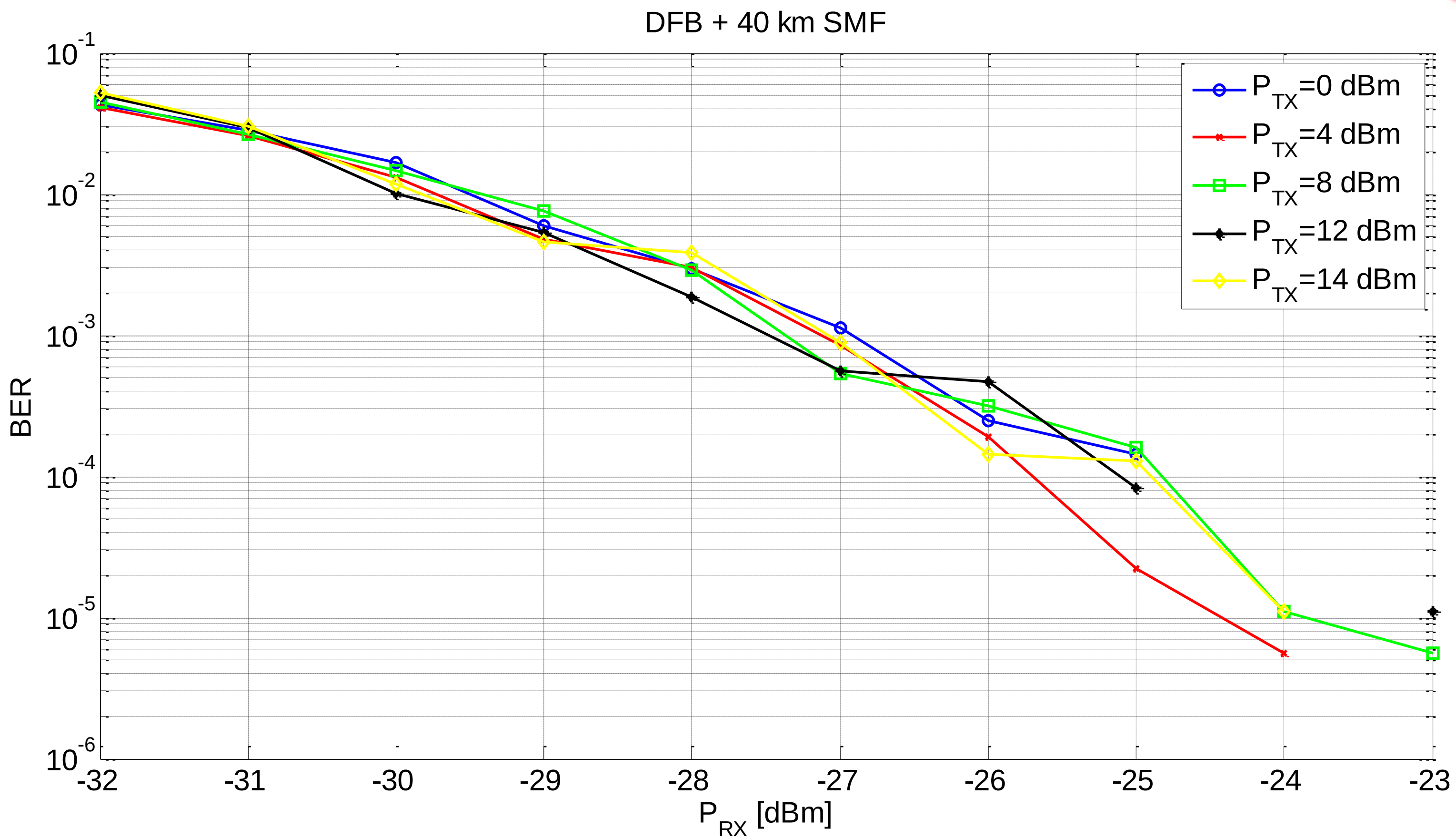


- About 8 minutes interval between consecutive acquisition

Measurement set-up with two fiber link and EDFA at Tx



DFB + 40 km SMF (may 2011)



- Previously extracted waveforms (DFB Mitsubishi) post-processed with "new" DSP.
- P_{RX} values could be inaccurate due to 1.7 dBm correction between Power Meter and Oscilloscope measurement.