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

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Target and Outline

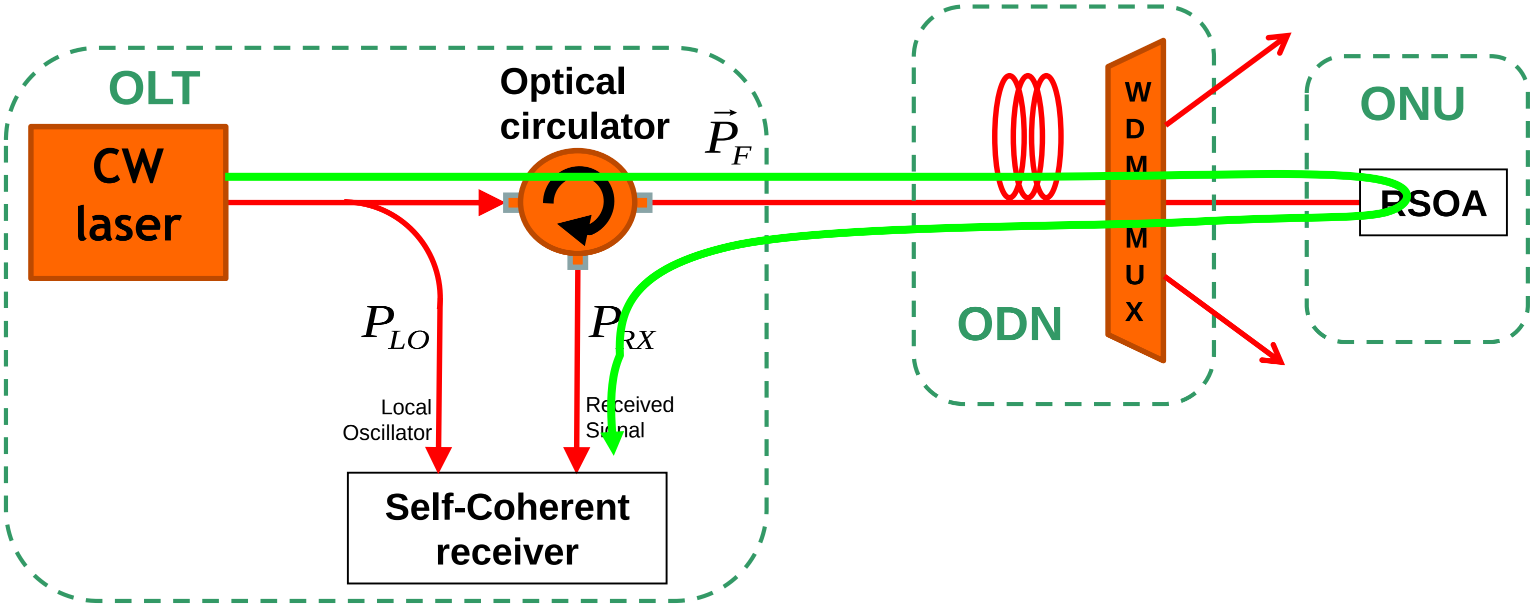
- SCENARIO: Optimization of reflective PON upstream path
  - Upgrades from results presented in regular paper We.1.B.3 on Introducing self-coherent detection at OLT

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

Reflective PON and self-coherent receivers

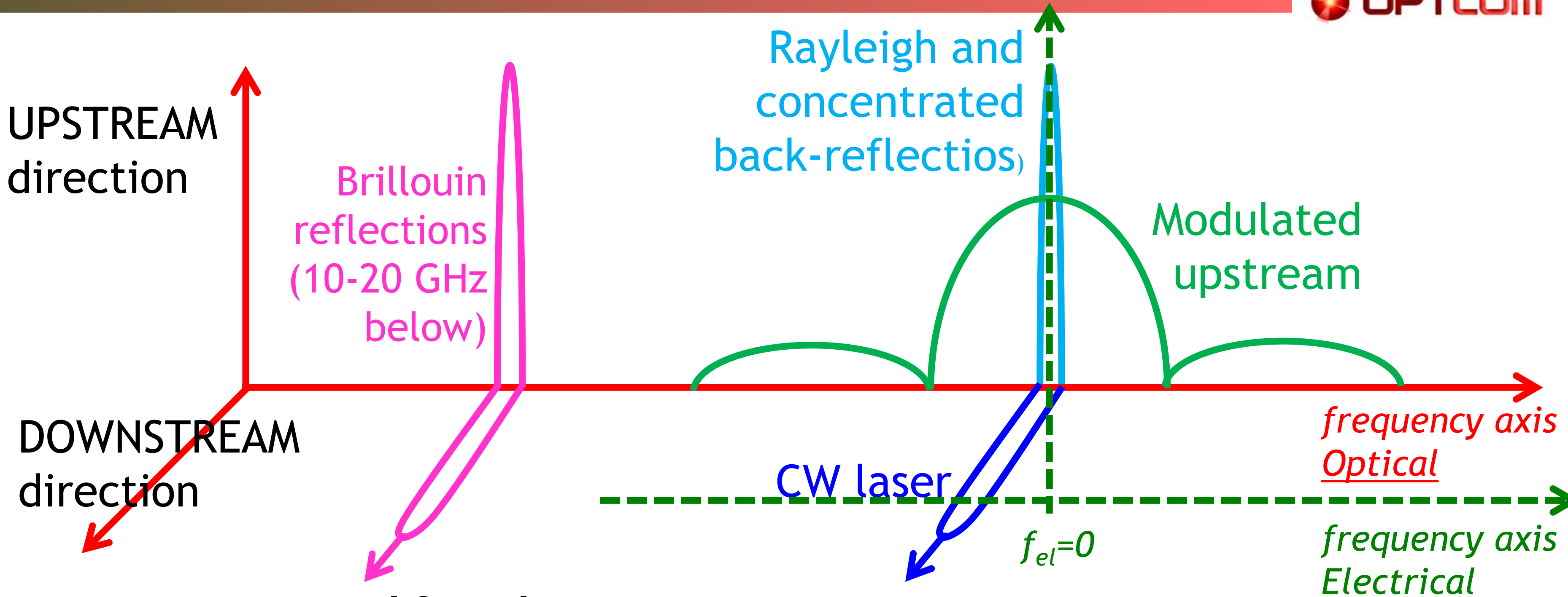
(from regular paper We.1.B.3)

Self-coherent receiver at OLT in reflective PON



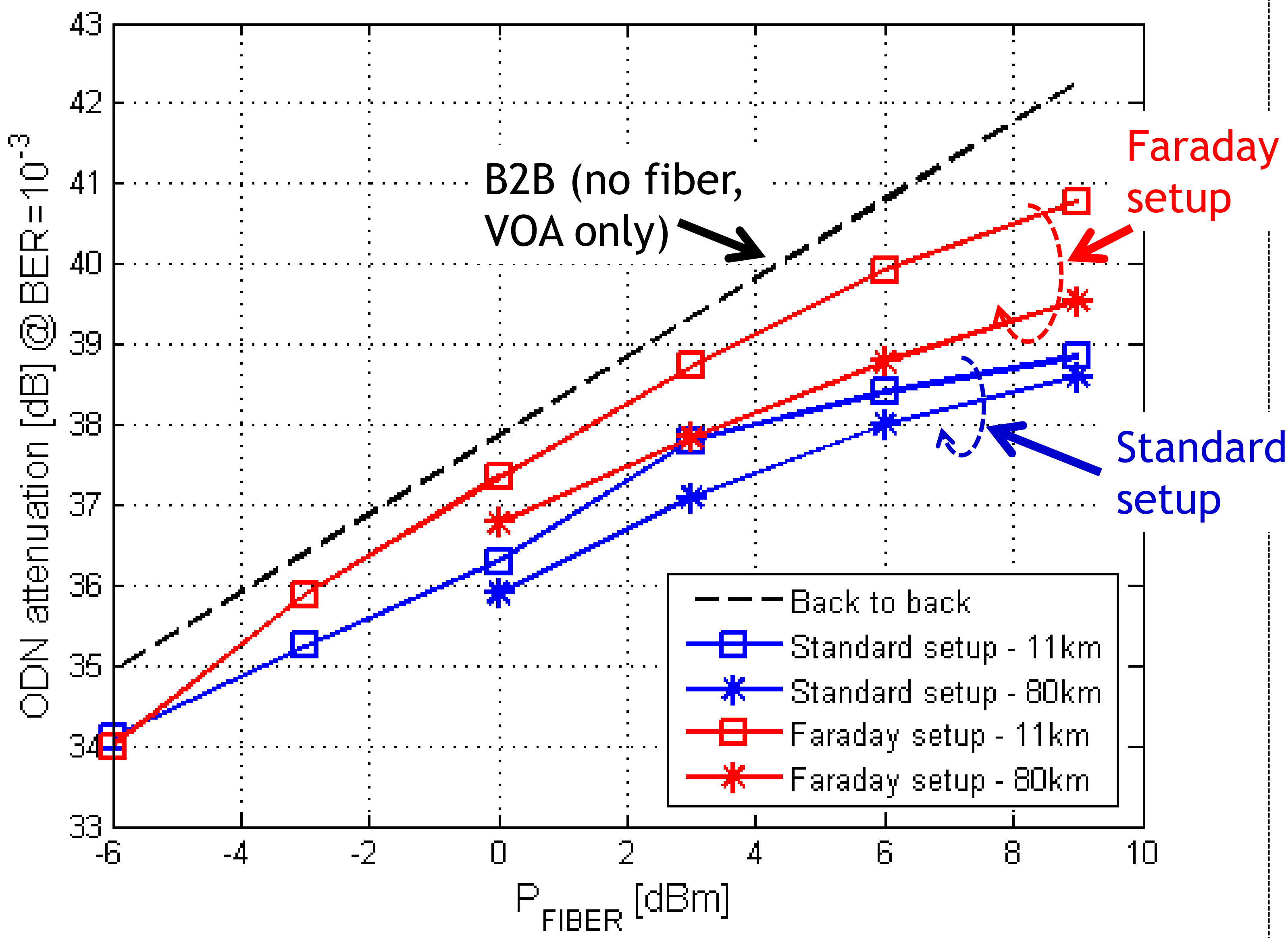
- Features:
  - Significantly improved sensitivity compared to DD
  - Possibility to greatly counteract transmission impairments by digital signal processing (DSP)
  - The local oscillator signal comes for free…

The different contributions to reflections



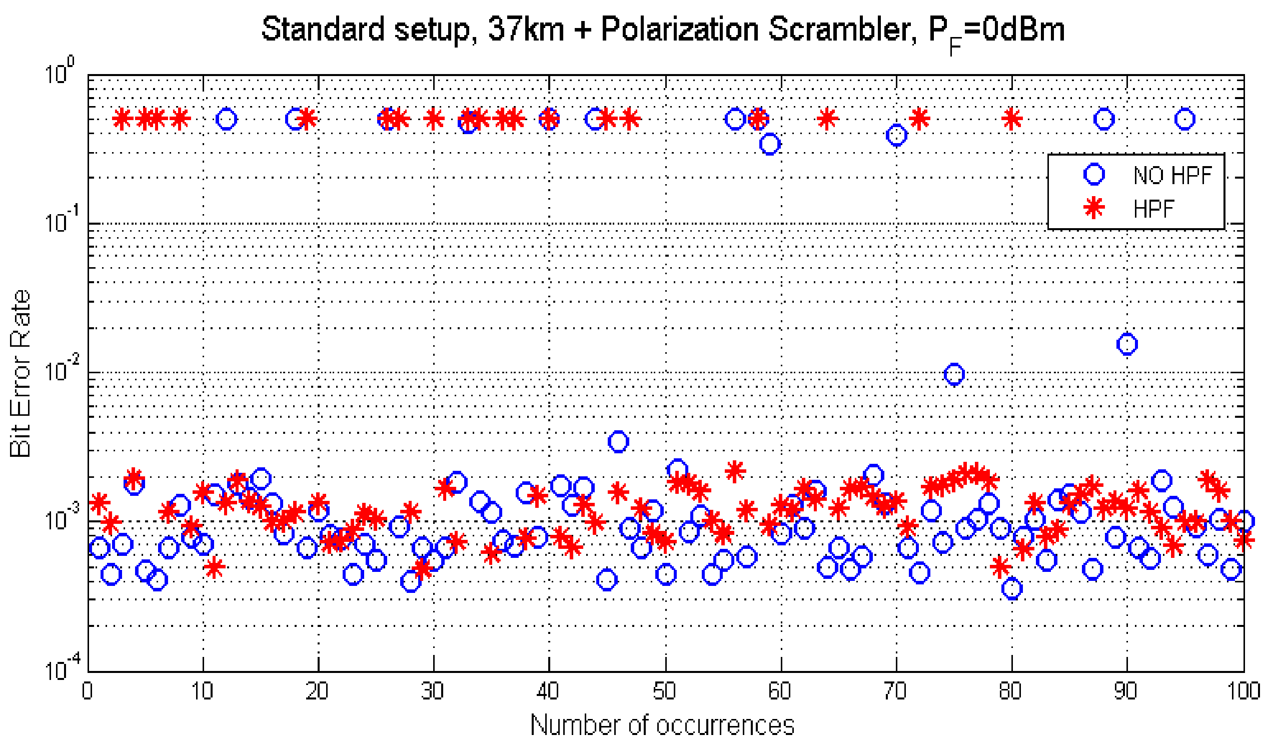
- Using a self-coherent receiver:
  - The RBS reflections appears as added close to DC →it can be filtered out by electrical high-pass filters
  - The upstream Brillouin component (if relevant) is out of band compared to the useful upstream signal

Best results from regular paper



Upgrades

- We performed BER repeated measurements when randomly changing the link birefringence
  - We found a significant variation of the BER results, including occasional “our of service” situations



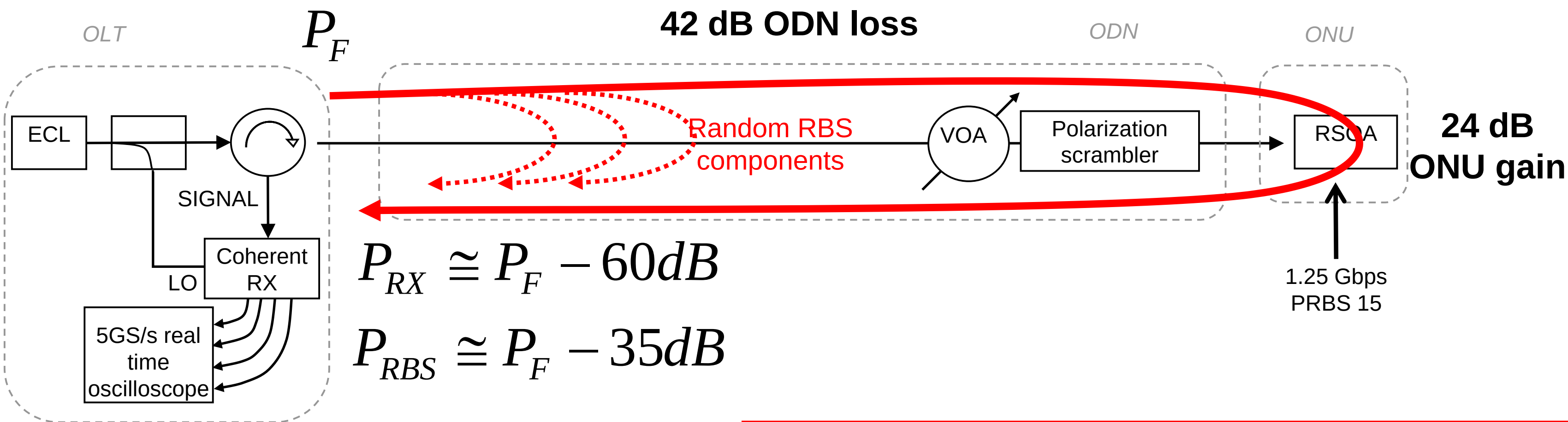
- We focused on understanding and solving this issue

The impact of spurious back reflections

The countermeasures

RBS levels - a theoretical assesment

- Let's assume the following values:
  - Target ODN loss = 42dB
  - ONU gain in this conditions = 24 dB
  - RBS 35dB below the launched power



$$P_{RX} \cong P_F - 60dB$$

$$P_{RBS} \cong P_F - 35dB$$

$$P_{RX} \cong P_{RBS} - 25dB \quad !!!$$

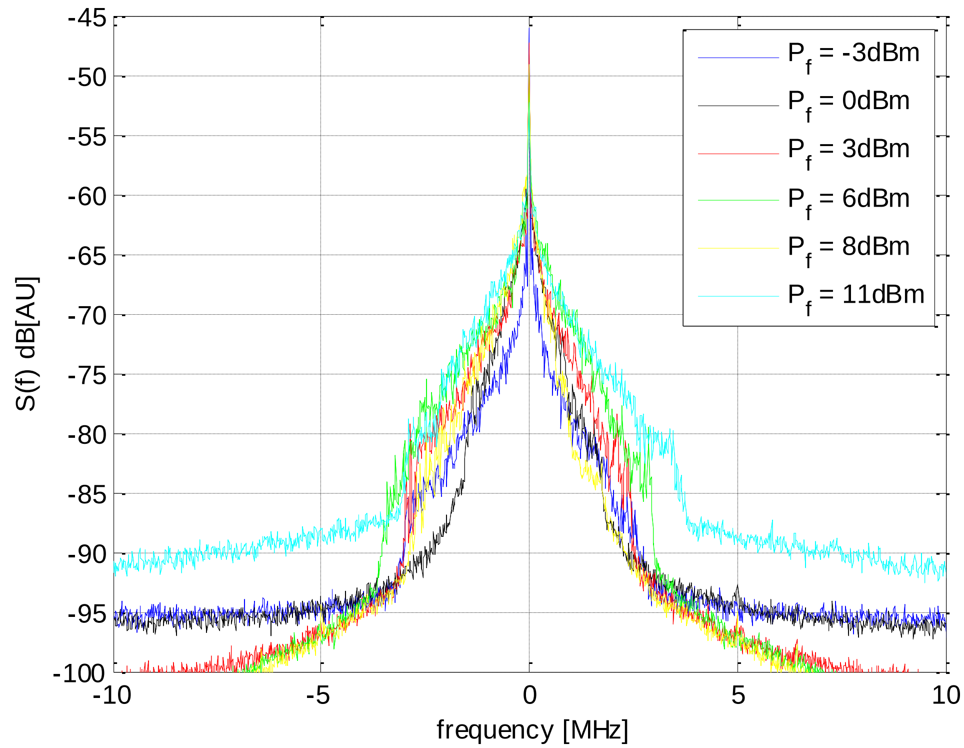
Impact of the RBS noise

- We attributed the time-variation in our BER measurements to the random nature of the RBS (in terms of both amplitude and polarization state)

Received RBS spectrum for different launched CW powers P_f

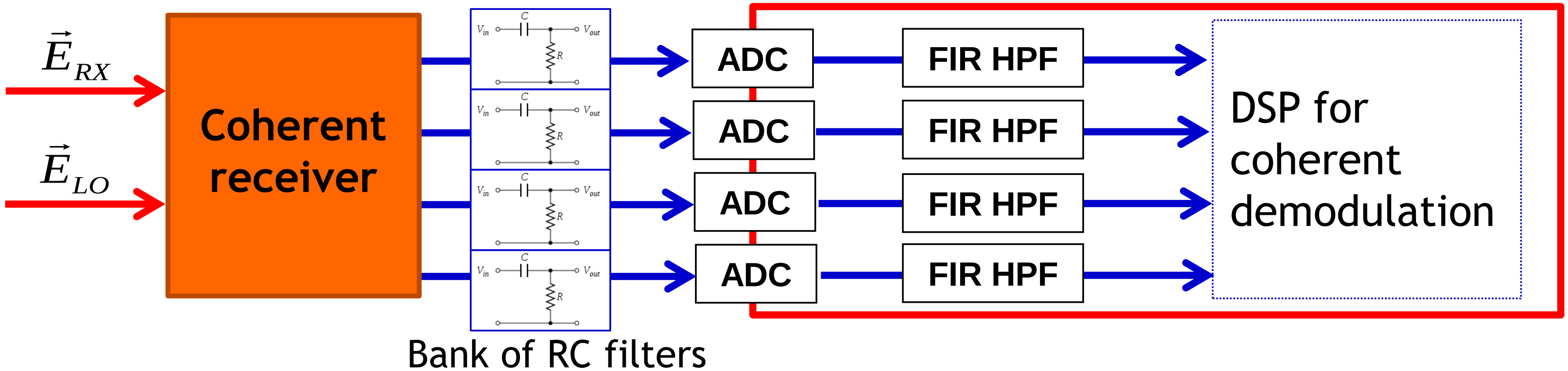
It is evaluated on the electrical signals after self-coherent detection

(modulated signal is off)



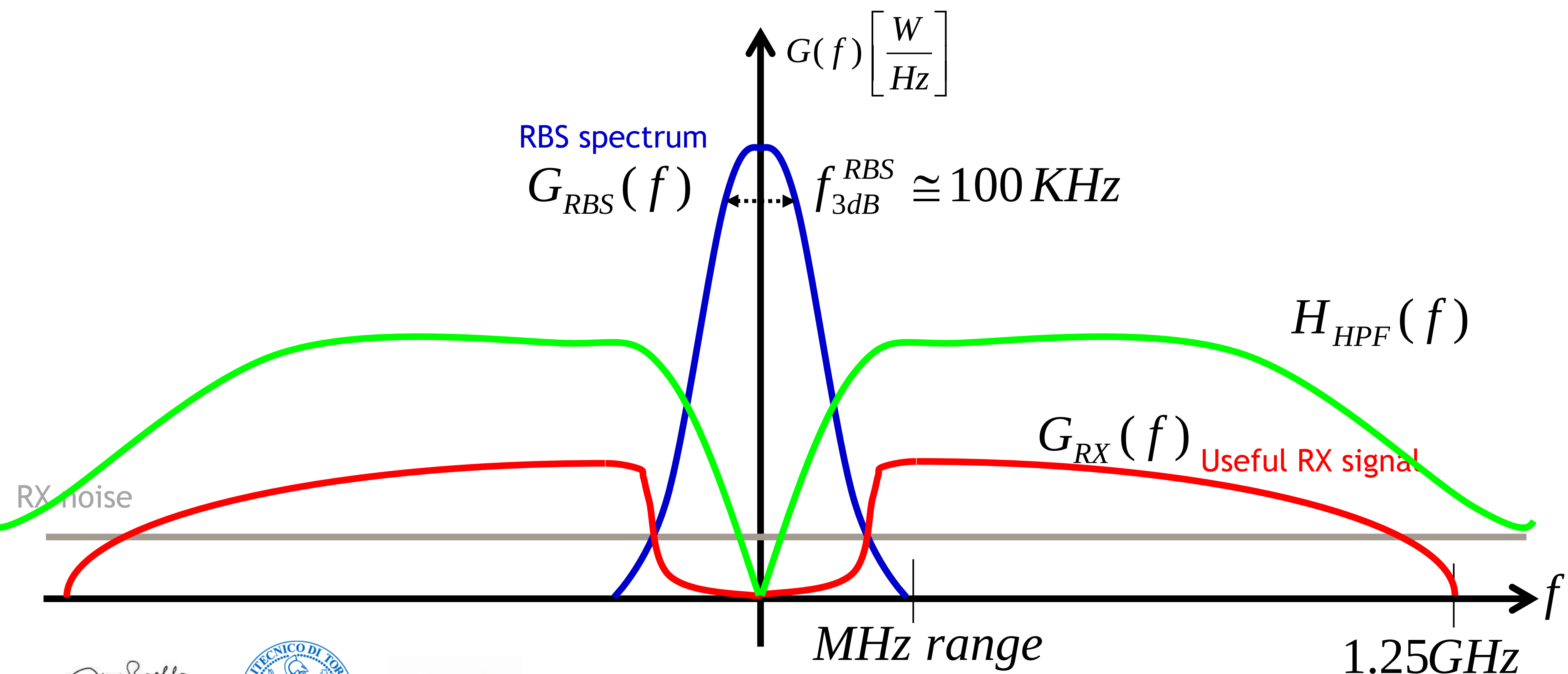
Filtering the RBS noise

- An optimized high-pass filter (HPF) in the coherent receiver was fundamental to solve the problem. Two possible options:
  - Digital filtering in the DSP section after the ADCs
  - Analog electrical filtering before the ADCs



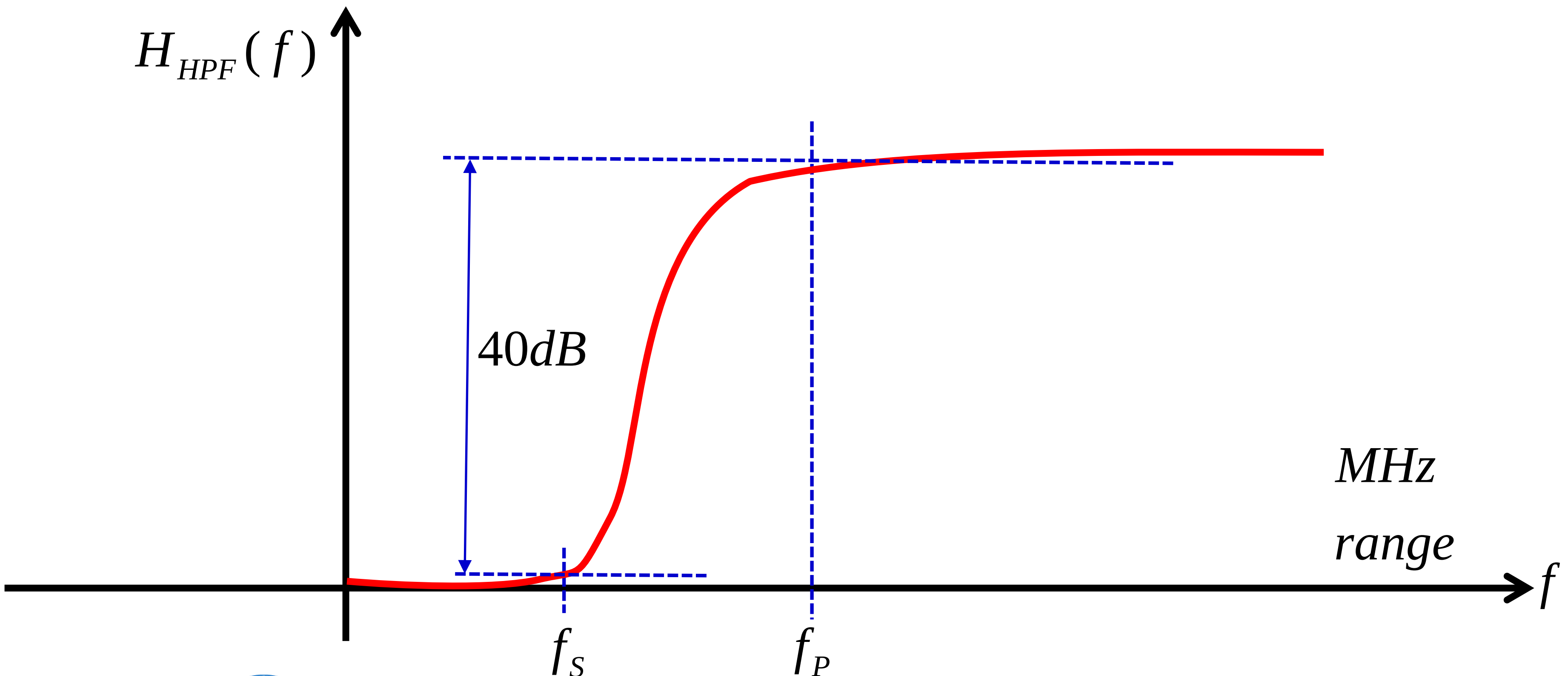
Introducing 8B/10B

- In order to allow a high frequency cut-off we introduced 8B/10B coding to minimize baseline wander effects on the useful signal



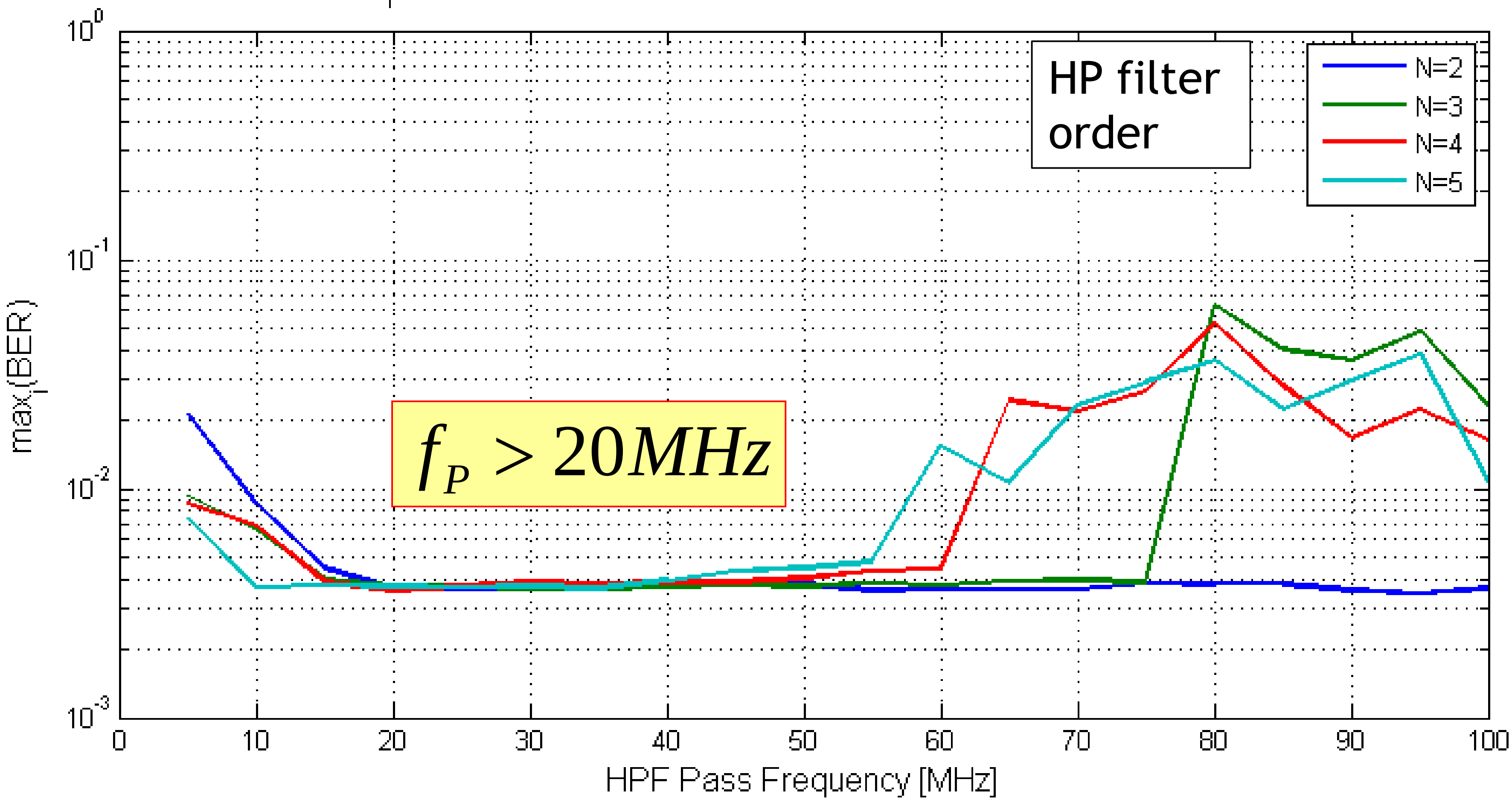
Optimization of the HPF in DSP

- We performed an extensive optimization of the cut-off frequencies of an HP filter



Optimization of the HPF in DSP

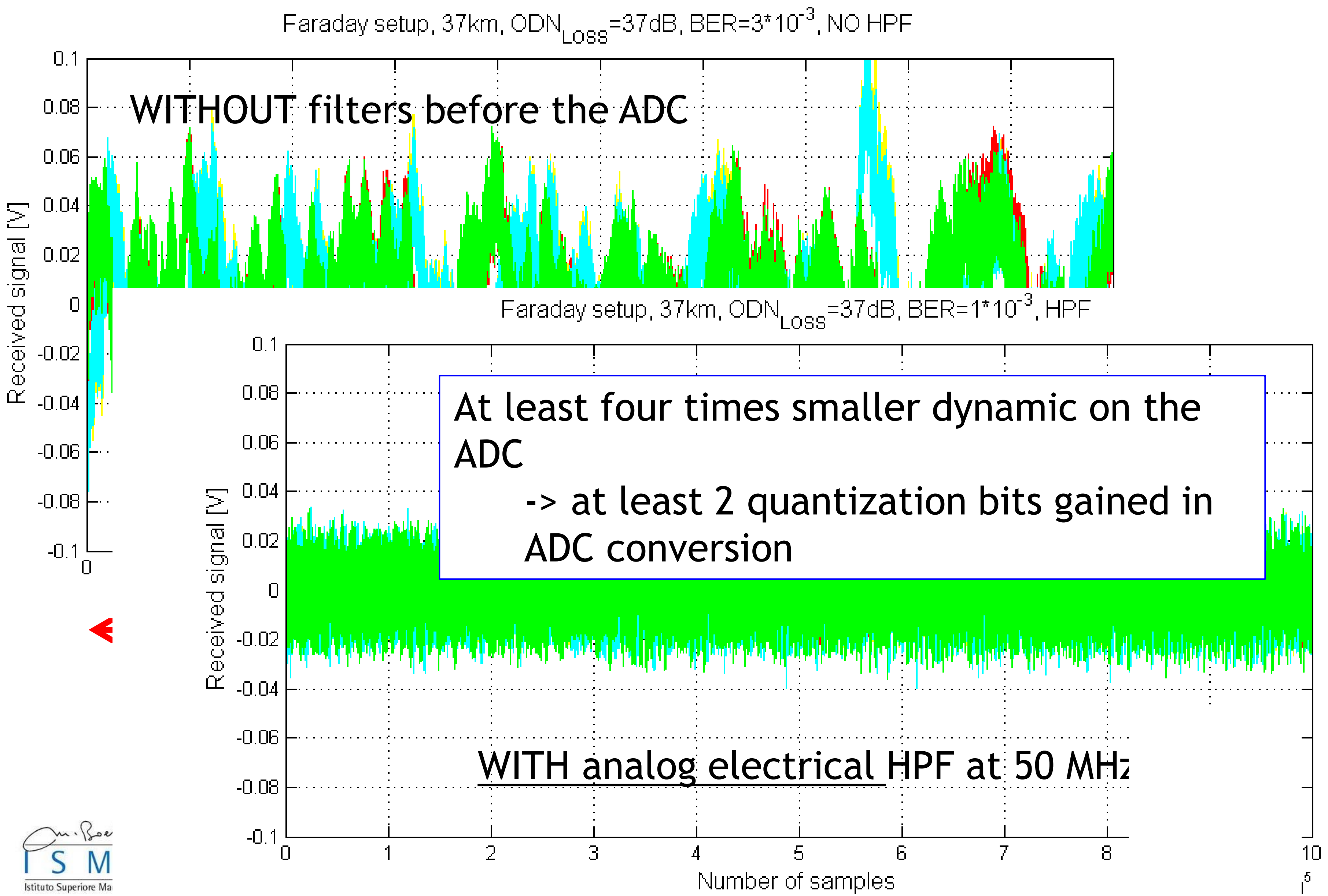
Standard setup, 80km, P_F=9dBm,



Filtering the RBS noise

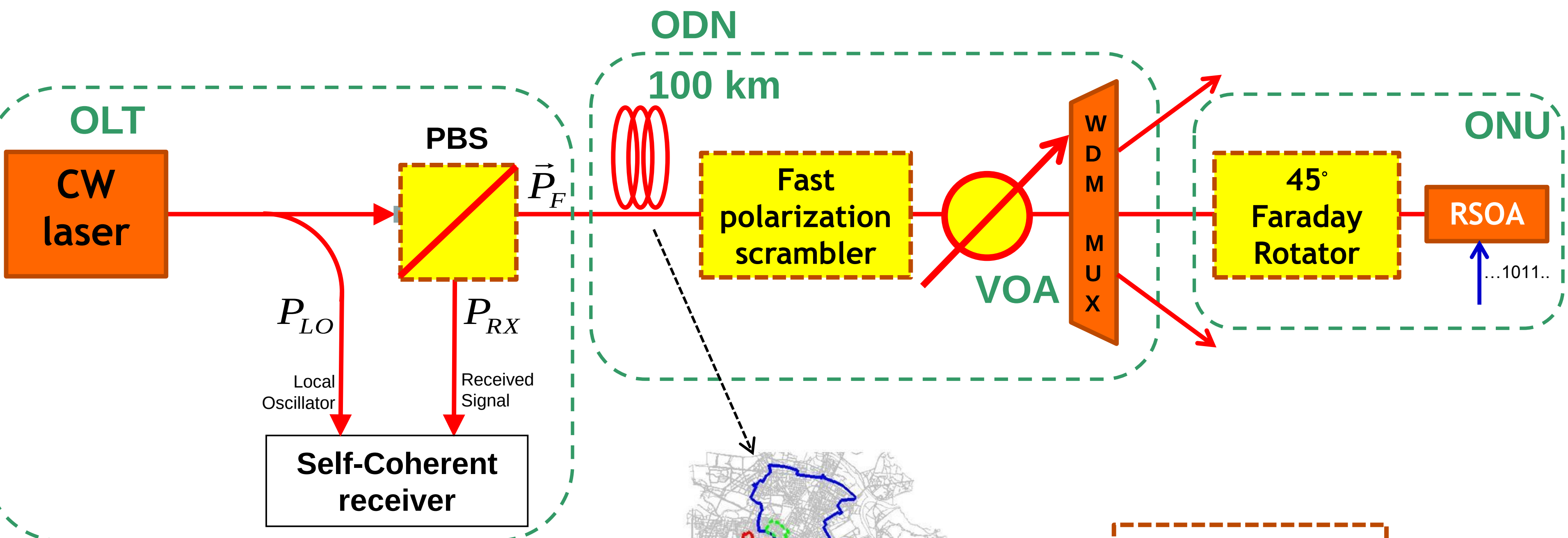
- In our regular paper we used only DSP high-pass filters
  - Even for optimized cut-off values (around 40-50 MHz), our experimental results were worst than expected (and showed the previously mentioned BER instabilities)
- We found that in some situations the RBS “noise” at low frequency was so strong that it saturated the ADC and/or generate quantization problems on the useful signal
  - This happened only on some specific polarization states between the signal and the RBS
- The problem was largely solved inserting <u>an analog electrical filter before the ADC</u>

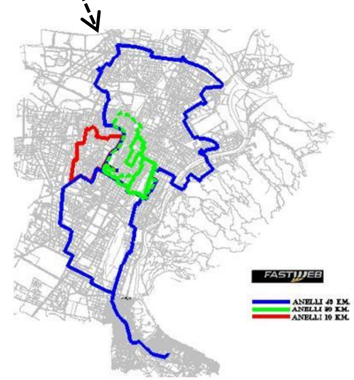
Received signals at ADC



Experimental results

Experimental setup



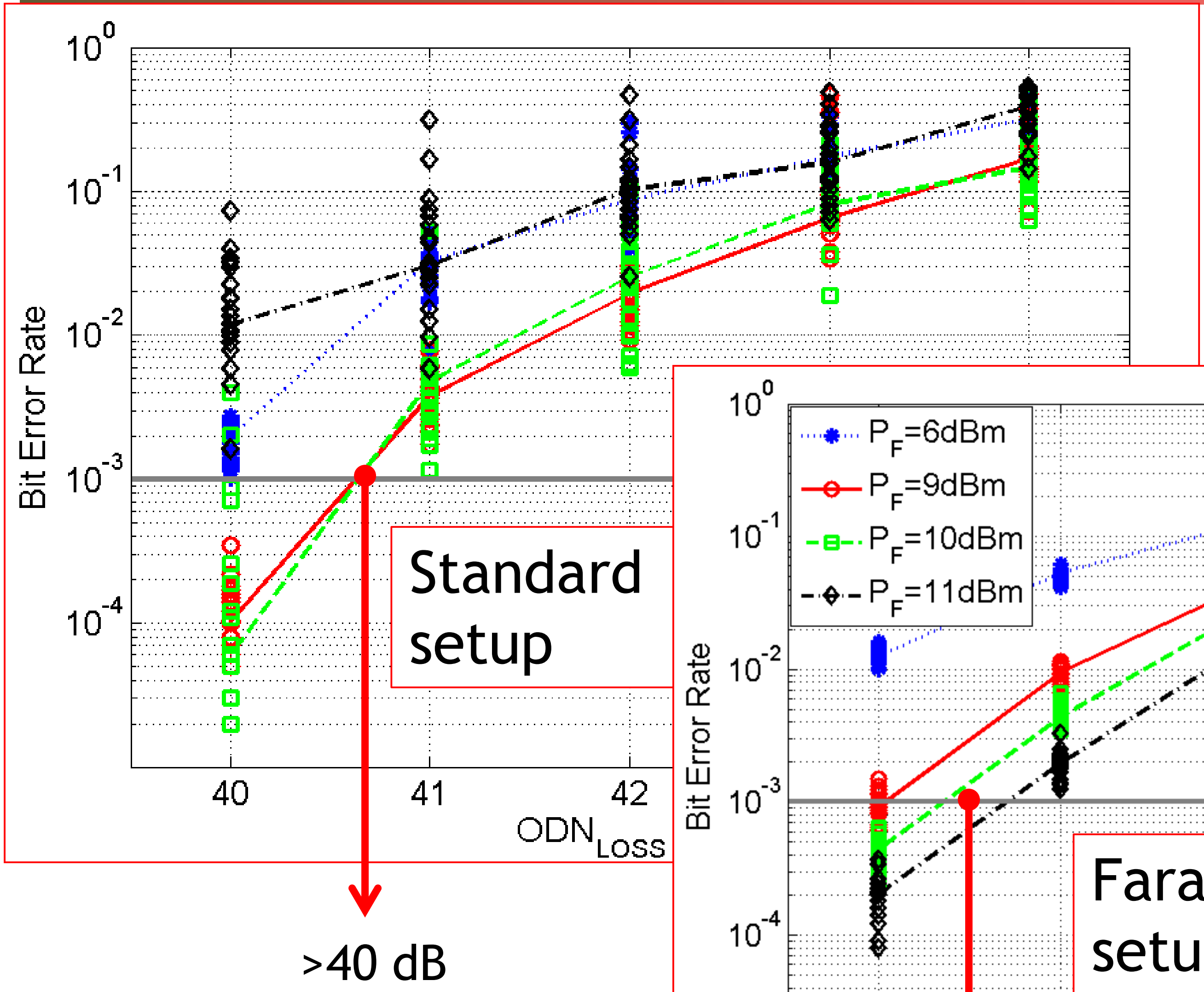


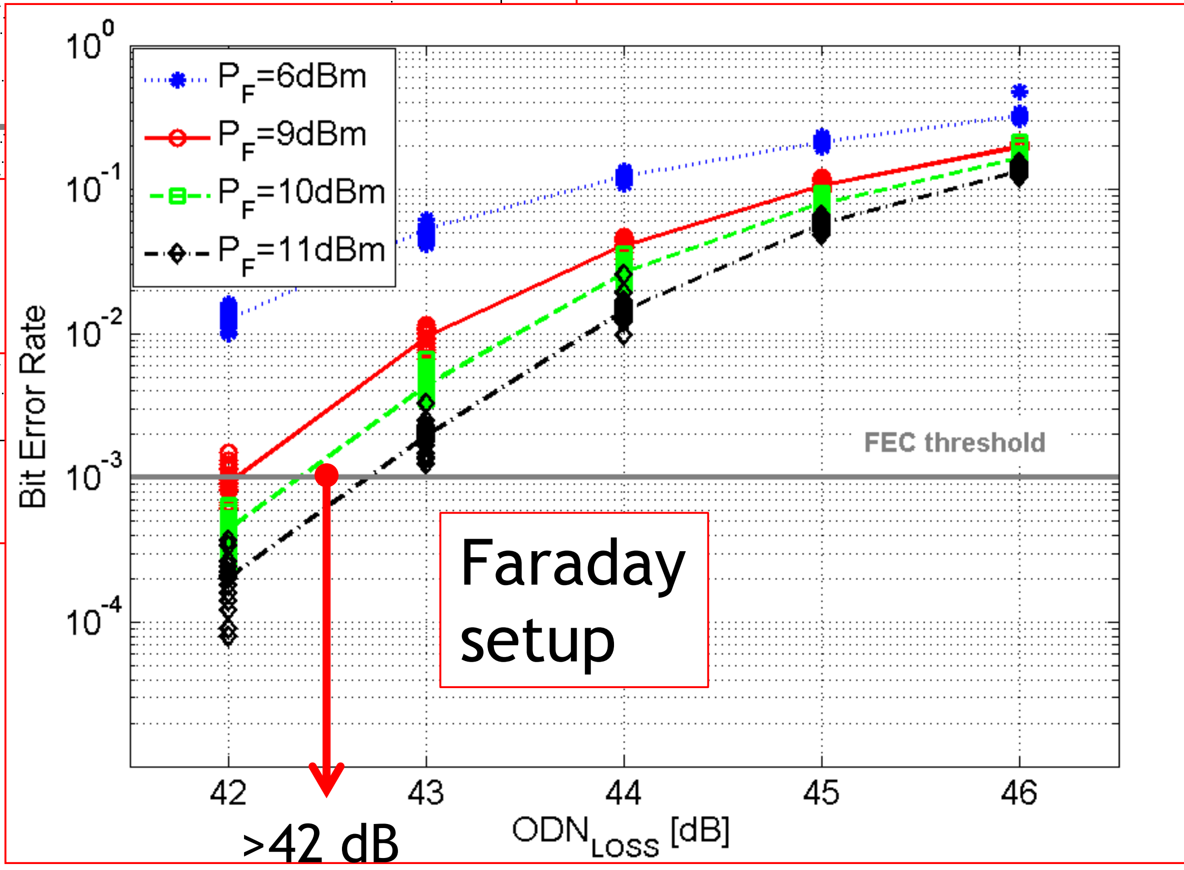
Testbed rings layout in Torino

“Standard” Setup

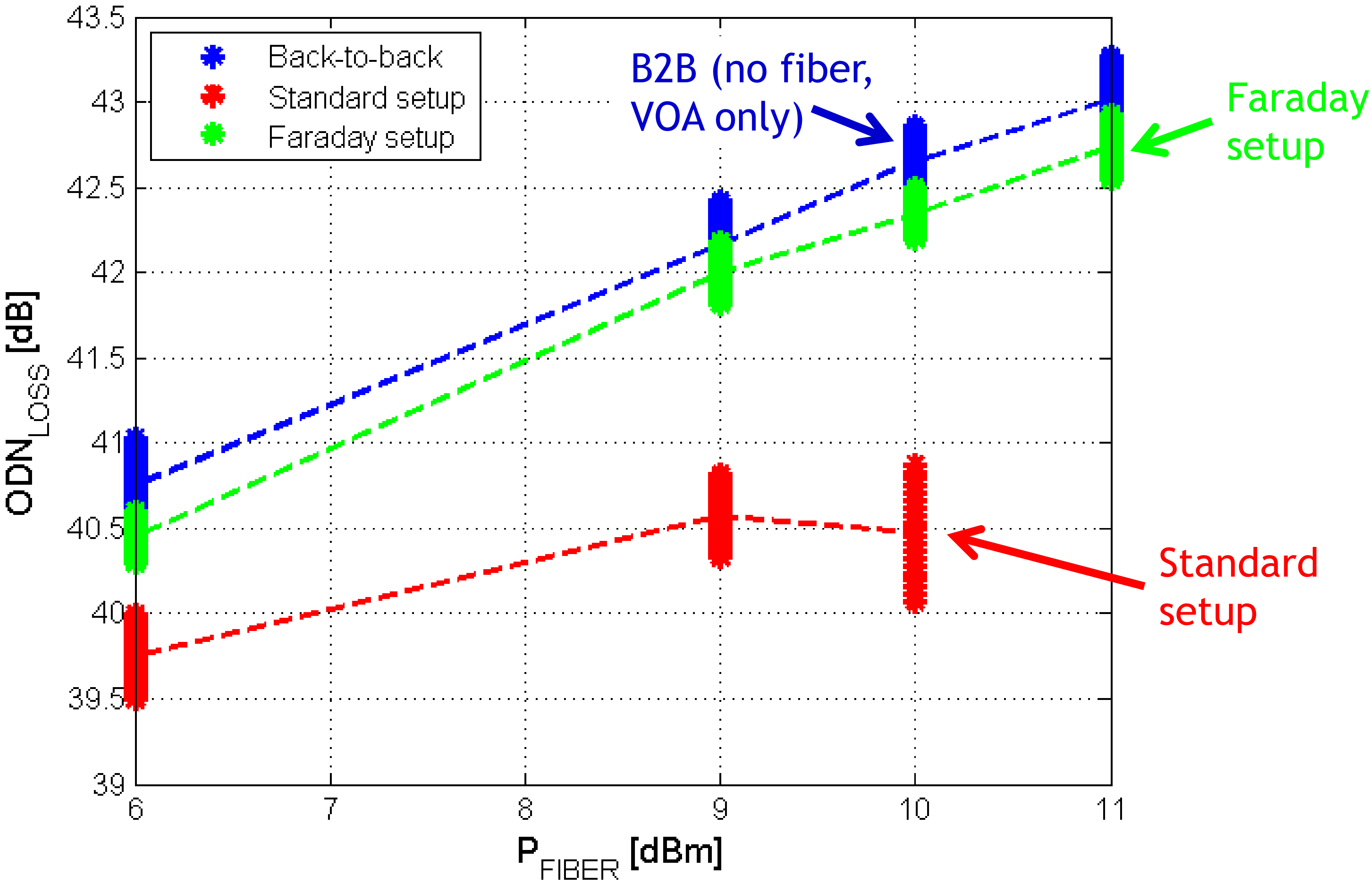
“Faraday” Setup

BER vs. ODN loss, different launched power

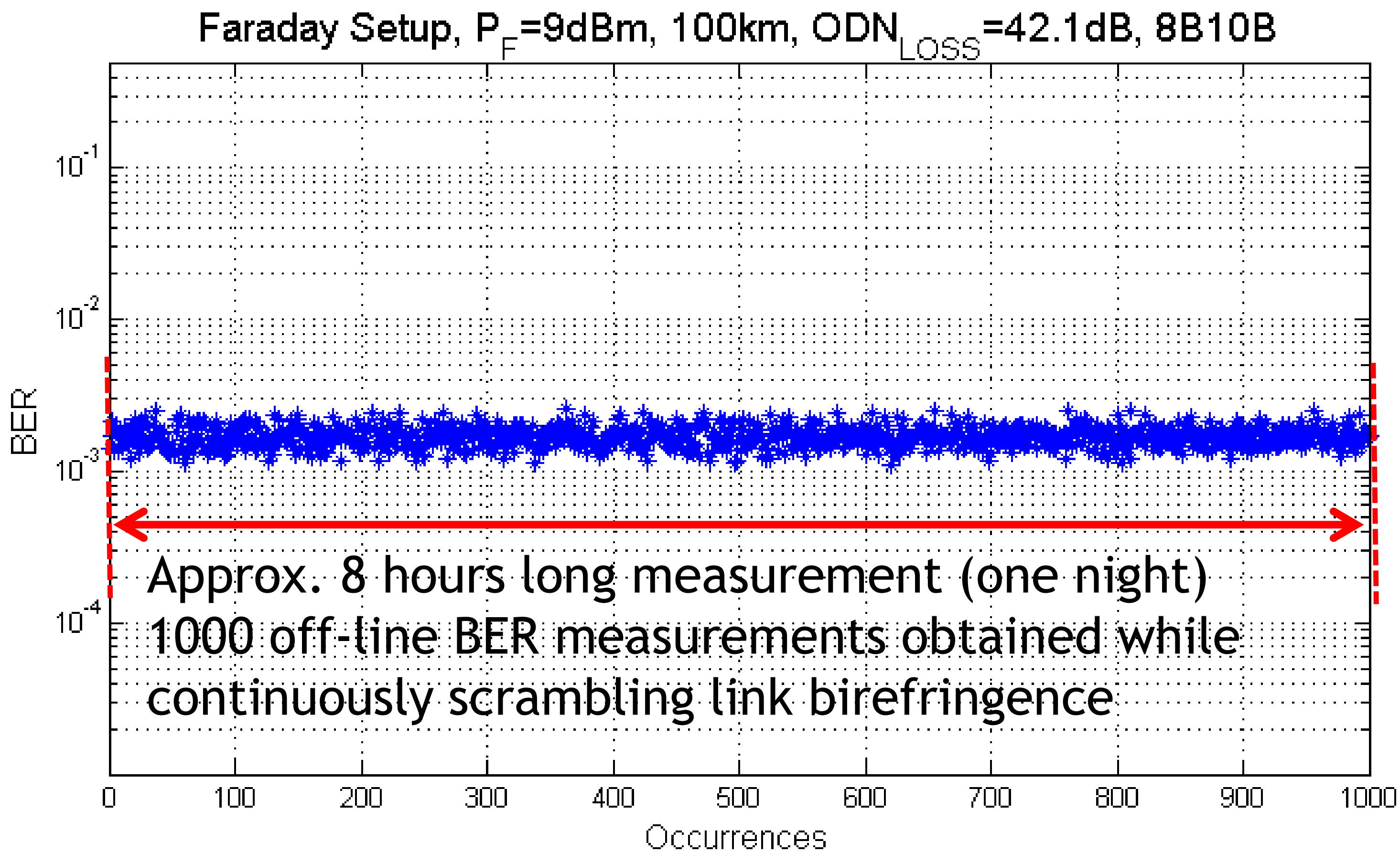




ODN loss vs. Lauched power at BER=10^{-3}



Long repeated measurement on BER



CONCLUSION

Conclusions

- We have show techniques to optimize self-coherent reflective PON systems
  - Analog and digital high-pass filtering
  - 8B/10B coding
  - Faraday rotation at ONU
- We showed that these techniques:
  - Solved the sporadic high-BER occurrences
  - Increase the achievable power budget to more than 42 dB ODN loss for an optimized setup (Faraday rotation and high launched power)
  - Even for a standard setup and lower launched power (such as 6dBm) we still achieve more than 39dB ODN loss

Thank you for your attention!

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