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Coherent Reflective PON architecture: can it be made compatible with TWDM-PON?

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Outline of the presentation

- An “one-minute” review of the recent ITU-T decision on adopting TWDM-PON for NG-PON2
- Another “one-minute” review on our previous works on self-coherent reflective PON architecture

- Self-coherent reflective PON architecture and TWDM-PON
- Demonstration of upstream burst-mode operation in reflective PON with up to 35dB ODN power budget

The recent FSAN decision on TWDM-PON

Is this the end of the reflective PON idea??

TWDM-PON key features

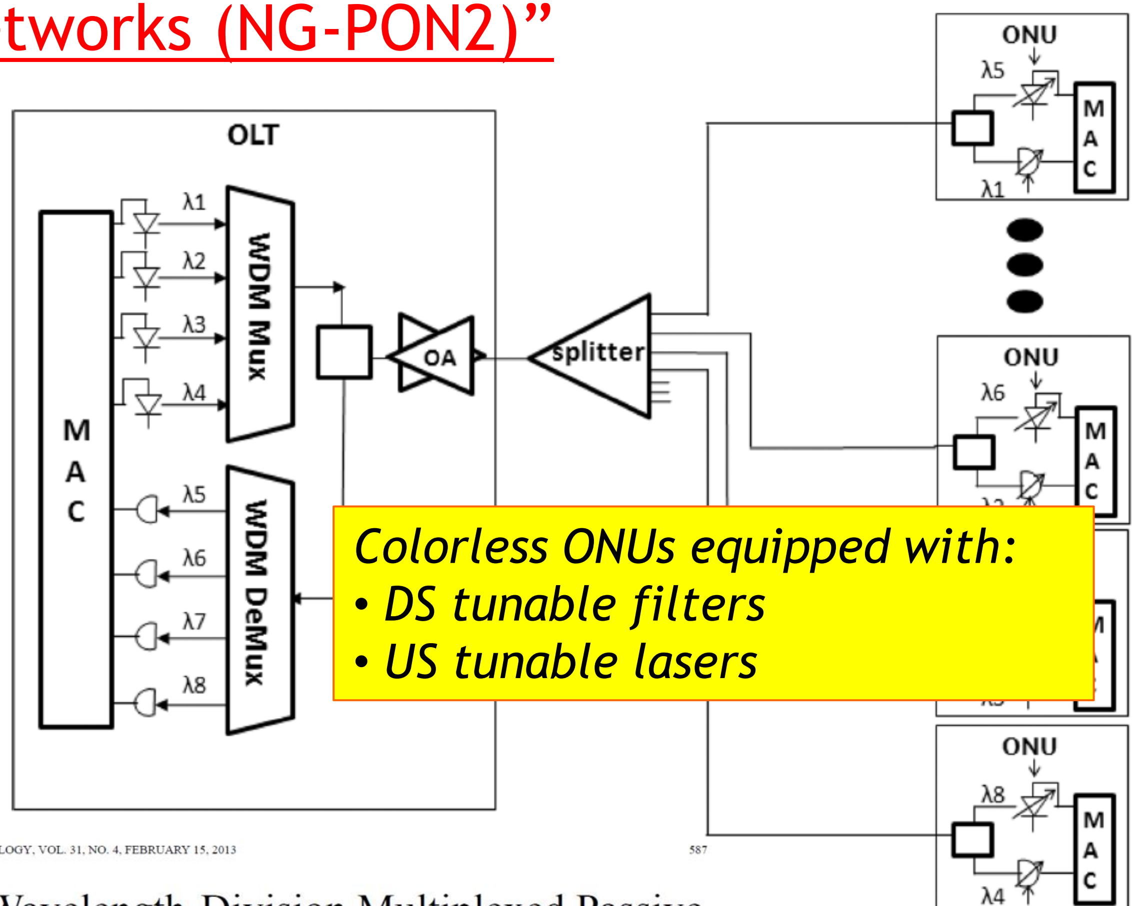
- 4 wavelengths per direction, 100 GHz spacing
  - Upgradeable to 8 wavelengths
- TDMA on each of the 4 wavelengths
  - Each lambdas is treated as an independent XGPON
- Splitter-based PON
  - No AWG in the ODN
  - ODN power budgets will be the same as GPON and XGPON, thus also including class C (32dB) and likely C+ (35 dB)
    - The TX/RX power budget requirements is actually even higher than the class, due to the additional optical filters required to handle WDM at the ONU and OLT

FSAN TWDM-PON architecture

- Recently defined by FSAN, now being processed by ITU, it will become ITU-T G.989.1 "40-Gigabit-capable passive optical networks (NG-PON2)"

FSAN
Full Service Access Network

ITU



Colorless ONUs equipped with:
- *DS tunable filters*
- *US tunable lasers*

Picture taken from:

JOURNAL OF LIGHTWAVE TECHNOLOGY, VOL. 31, NO. 4, FEBRUARY 15, 2013 587

Time- and Wavelength-Division Multiplexed Passive Optical Network (TWDM-PON) for Next-Generation PON Stage 2 (NG-PON2)

Yuanqiu Luo, *Senior Member, IEEE*, Xiaoping Zhou, Frank Effenberger, *Senior Member, IEEE*, Xuejin Yan, *Senior Member, IEEE*, Guikai Peng, Yinbo Qian, and Yiran Ma

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Can reflective PON still be applied in such scenario?

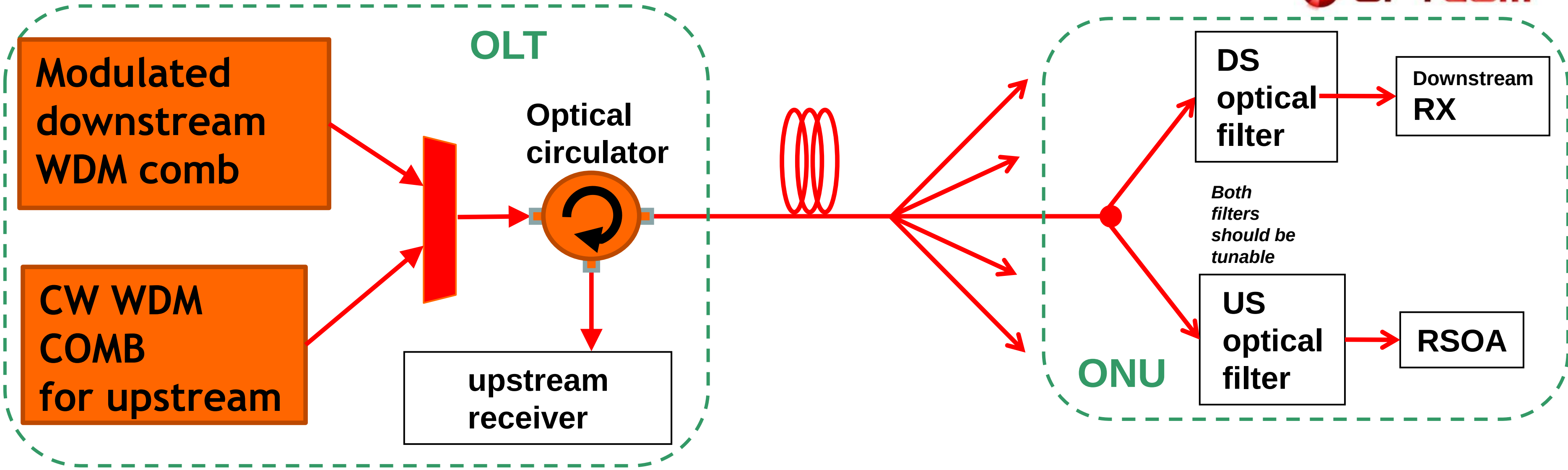
(At least) three issues should be addressed:

1. Stick with the splitter-based architecture (i.e. no AWG in the ODN)

2. US transmission should allow high ODN loss
   - Treated in details in some of our previous works

3. Make US TDMA possible even on reflective PON
   - Our new work and focus of this presentation

Reflective PON



- In the architecture above, the upstream wavelength grid is generated at the central office
  - Its accuracy is completely set by the OLT
  - ONU should lock its two optical filters on already existing wavelengths
  - In the longer term, this may allow DWDM using many closely spaced lambdas

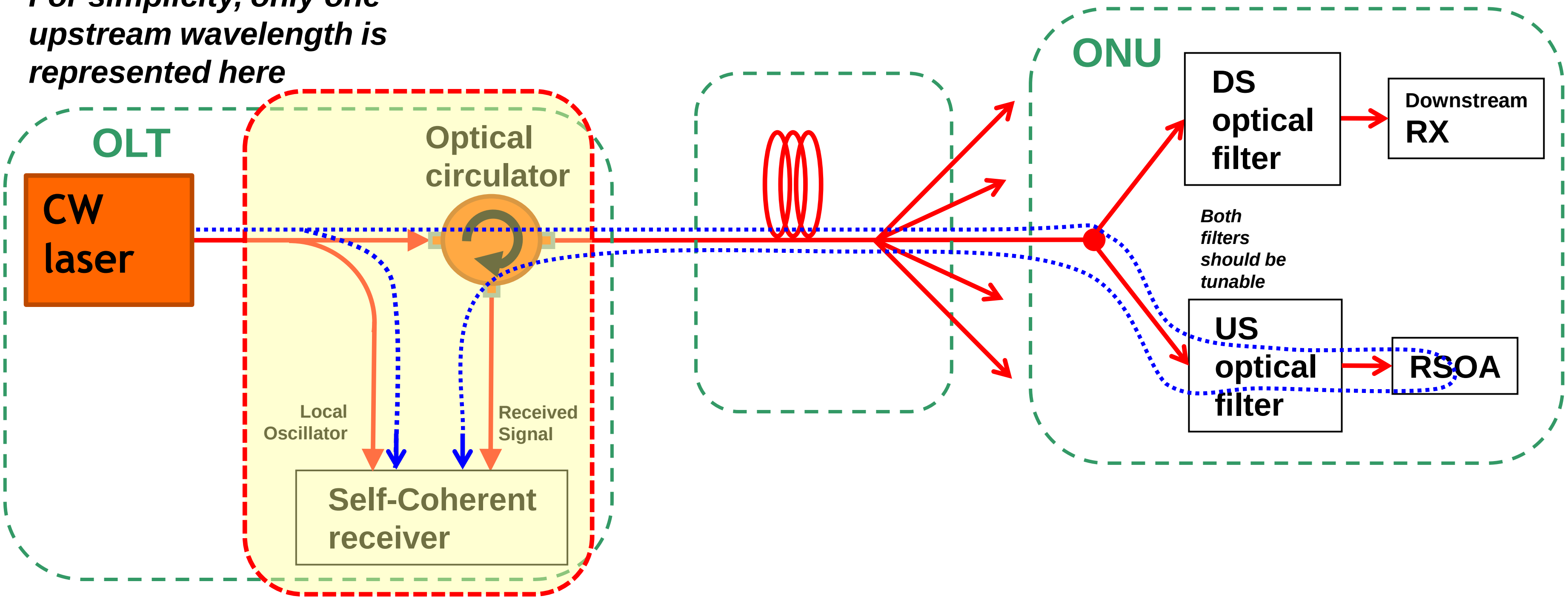
Achieving high ODN losses in reflective PONs

Introducing self-coherent detection on the upstream reflectively-modulated signals

Self-coherent reflective PON

- Proposed architecture

For simplicity, only one upstream wavelength is represented here



Experimental results:

RSOA as modulator
1.25 Gbit/s upstream
Installed metropolitan fiber testbed

ECOC 2012 posteadline paper Th3D.6

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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Our new results

Upgrade to upstream burst mode operation

Upgrade of the upstream bit rate to 2.5 Gbps per wavelength (as in ITU-T G.989.1 TWDM-PON)

Burst mode, self-coherent reflective PON

- The recipe's ingredients:

1. Burst-mode TX (using RSOA or other reflective modulators)

2. Coherent burst mode detection

New structure for the ONU

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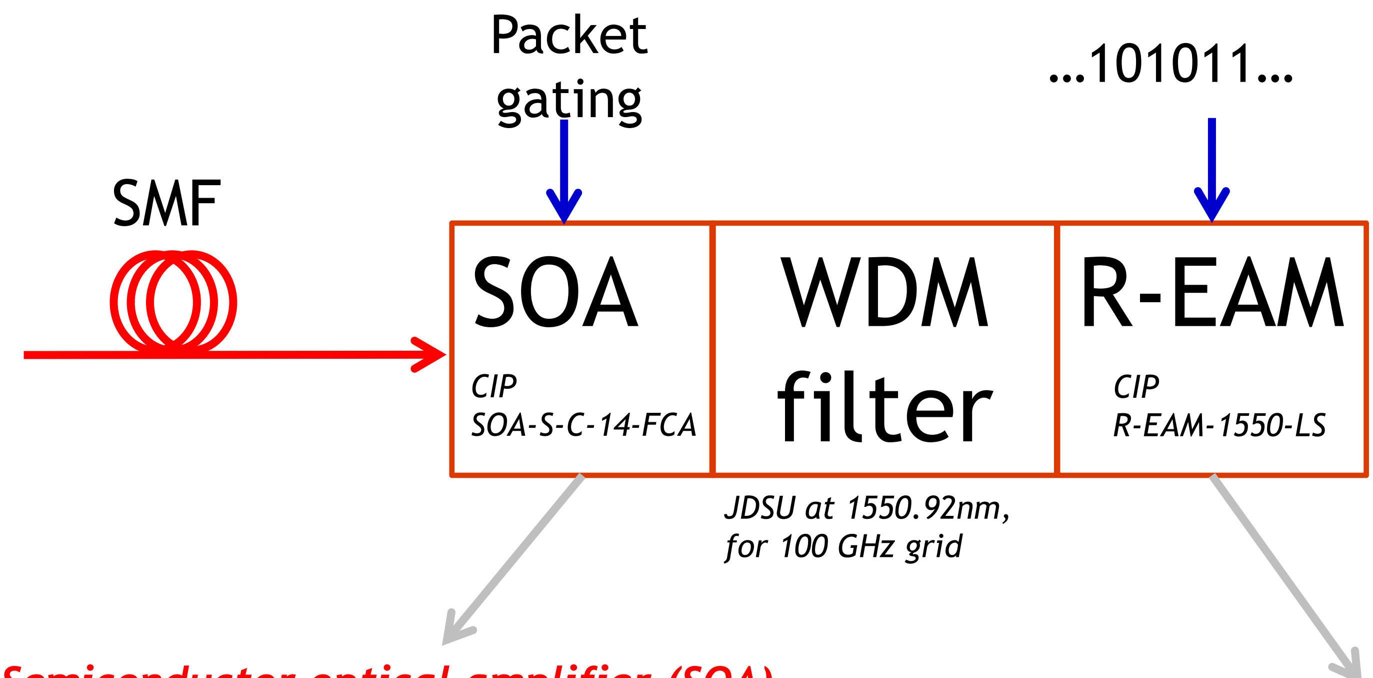
- SOA + R-EAM



Semiconductor optical amplifier (SOA)

- *Amplification* *(20 dB per single pass for 90mA bias current)*
- *Gating on the packets* *(2-3 ns raising time)*

Reflective Electro Absorption Modulator

Modulation bandwidth up to 6-7 GHz

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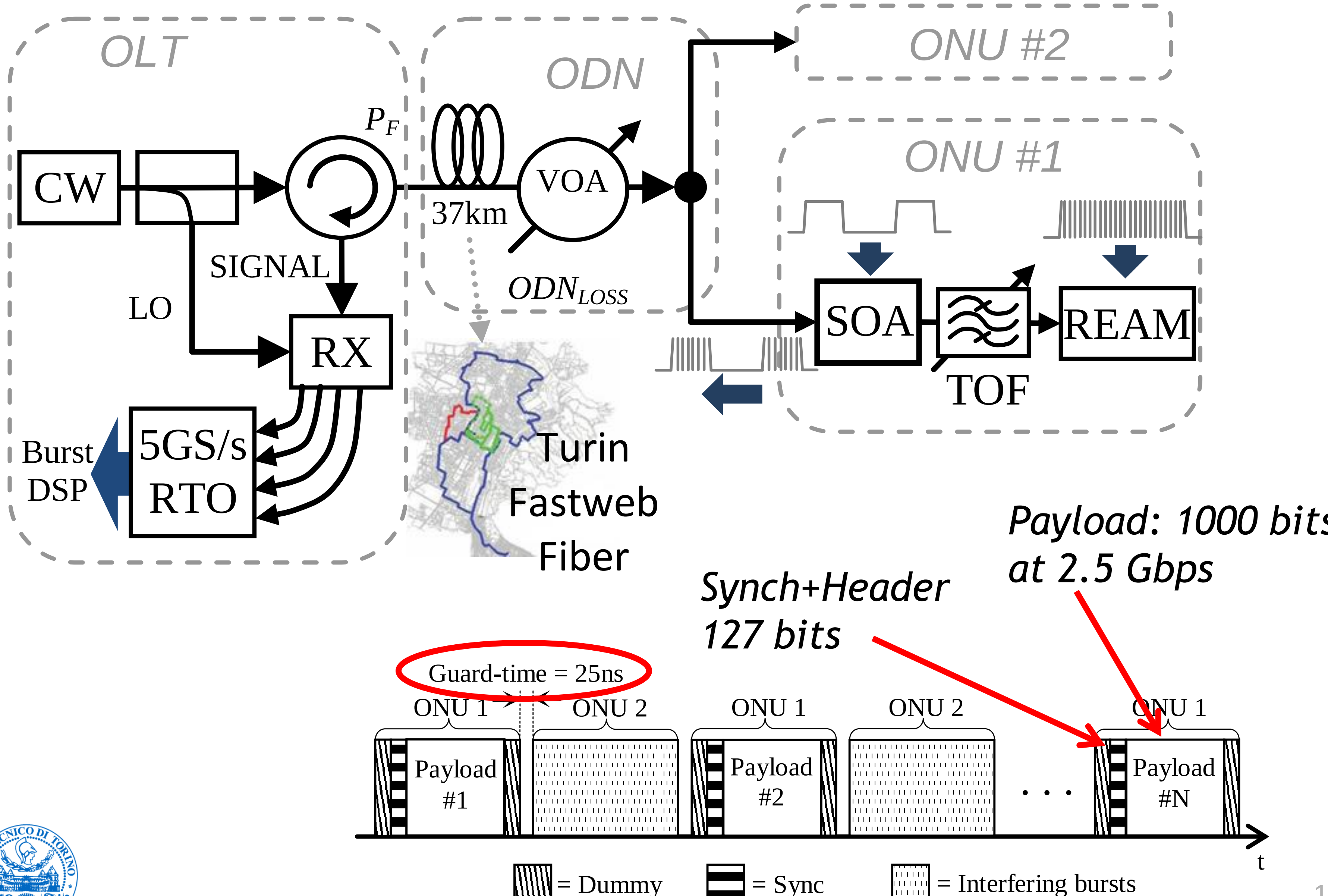
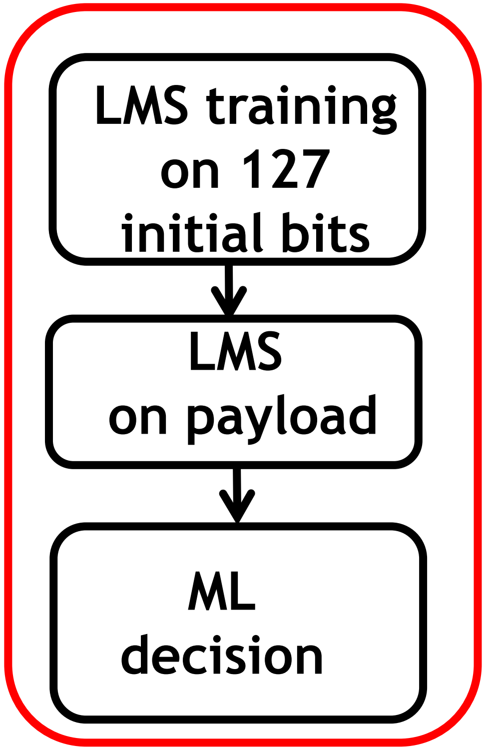
Experimental setup



Coherent burst mode receiver



- **LMS (training)**
  - The first **127 bits** in each bursts are used for synch and for an LMS equalizer algorithm in training mode
- **LMS (tracking)**
  - After the first 127 bits, the LMS algorithm is switched to “decision directed” to elaborate the payload of the burst
- Experiments used an off-line processing approach.
  - To obtain stable BER values, we estimate and average it over a large number of packets (approx. 1800 packets for each BER estimate)

Optimization of DSP coefficients for burst-mode

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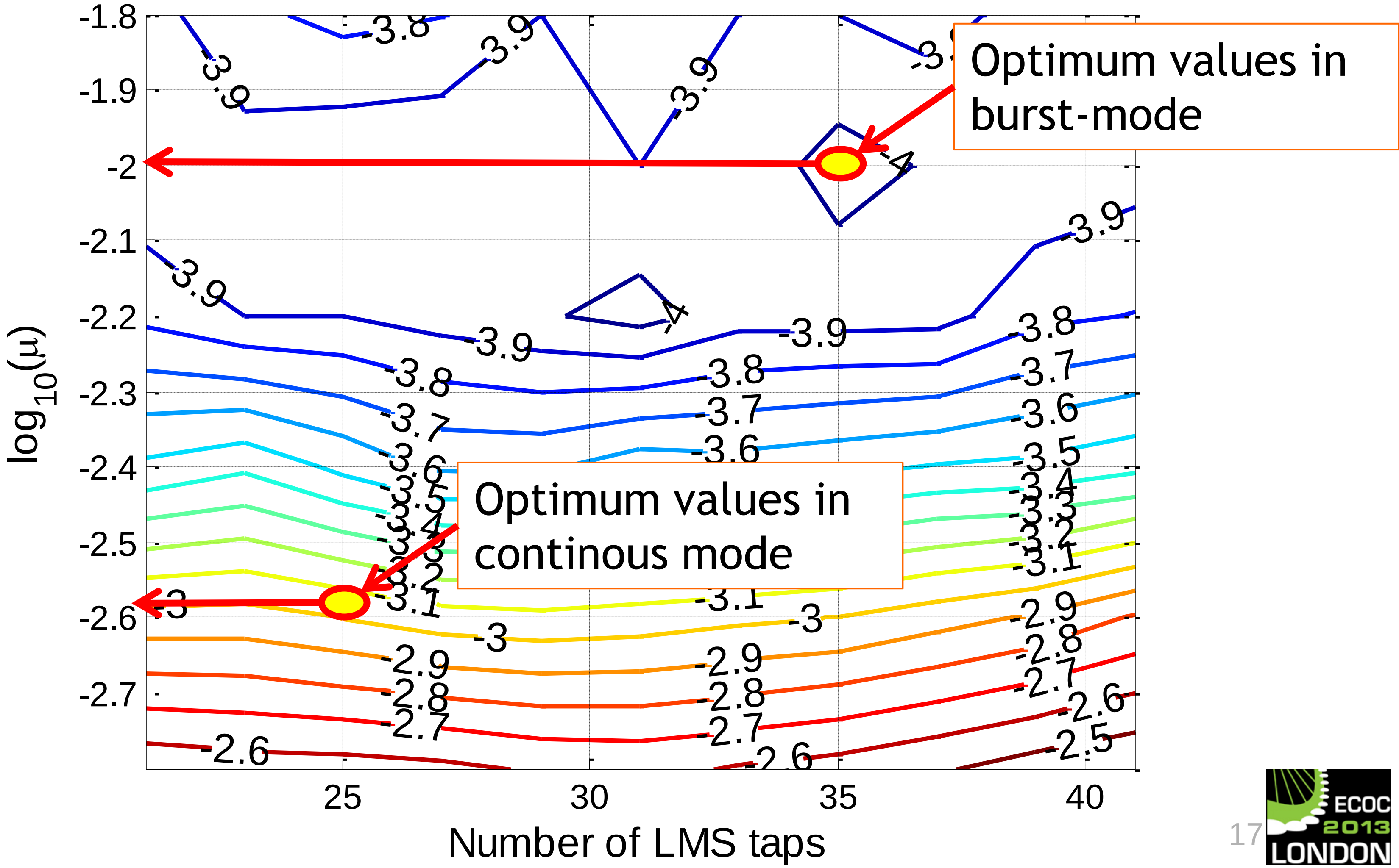
- BER vs. number of FIR filter taps and “speed” of the LMS adaptive equalizer



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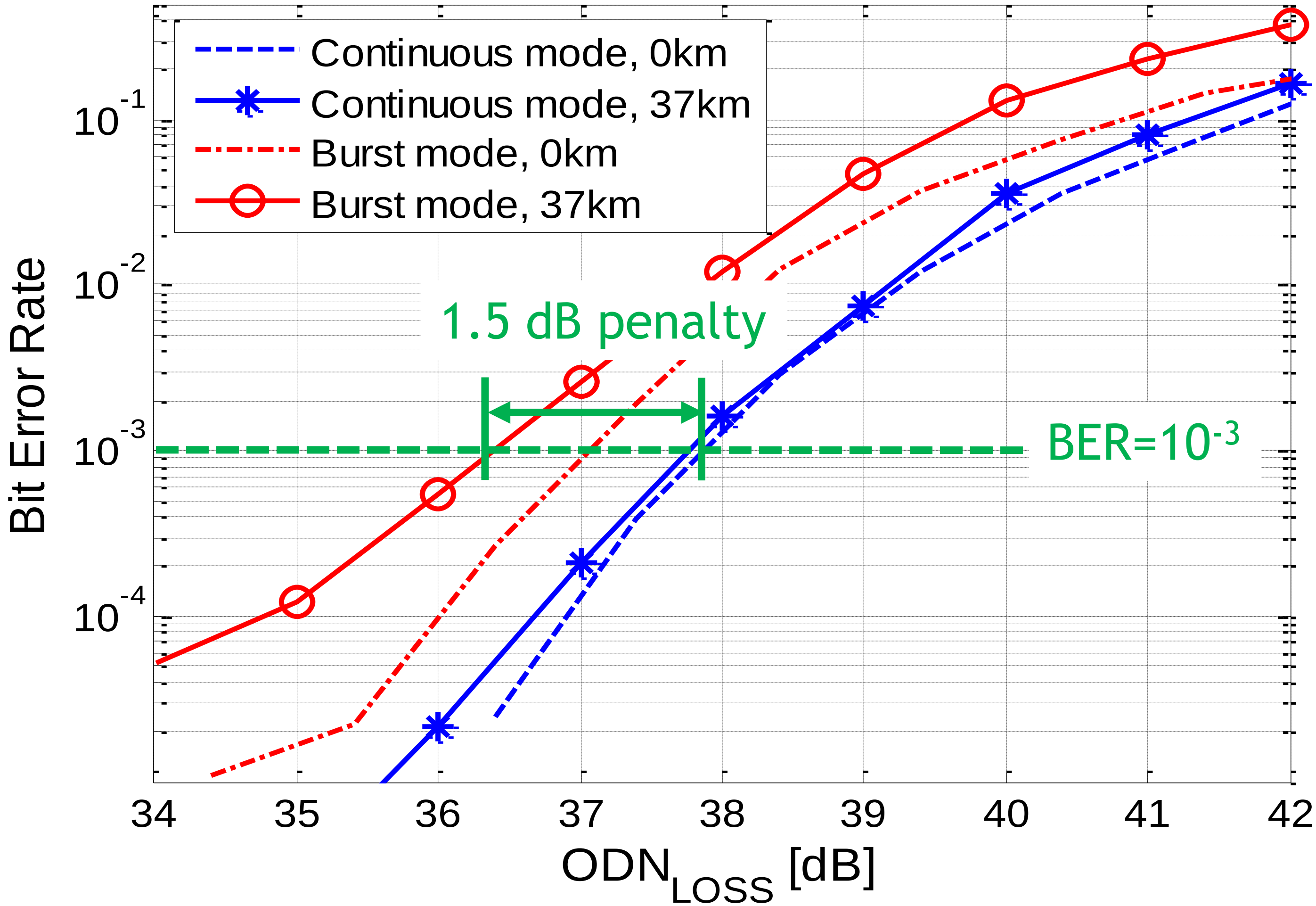
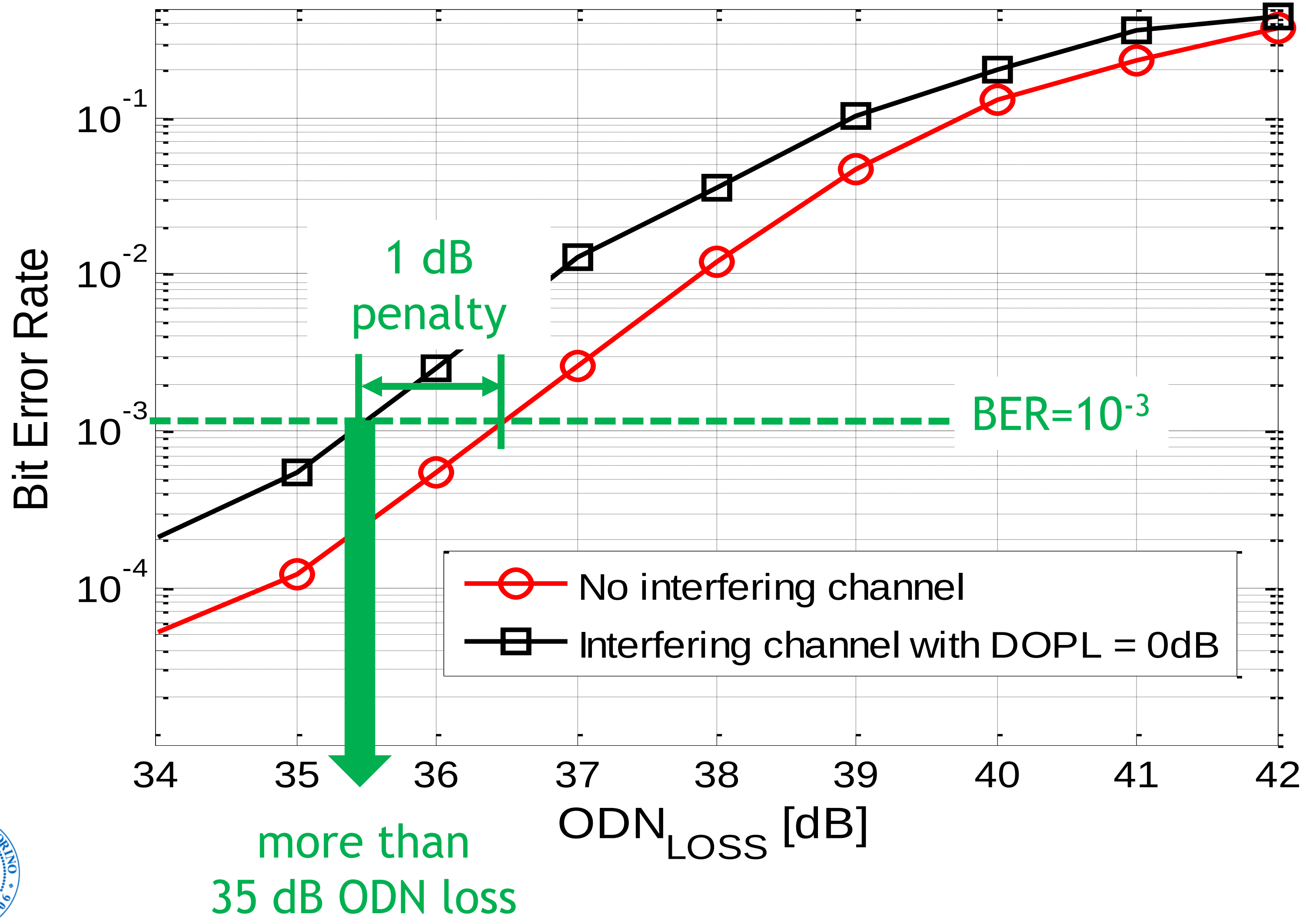
Results for a single ONU and different lengths

- BER vs. ODN loss, single ONU



Results for a two interfering ONUs

- BER vs. ODN loss, two ONU's, 25 ns guard time



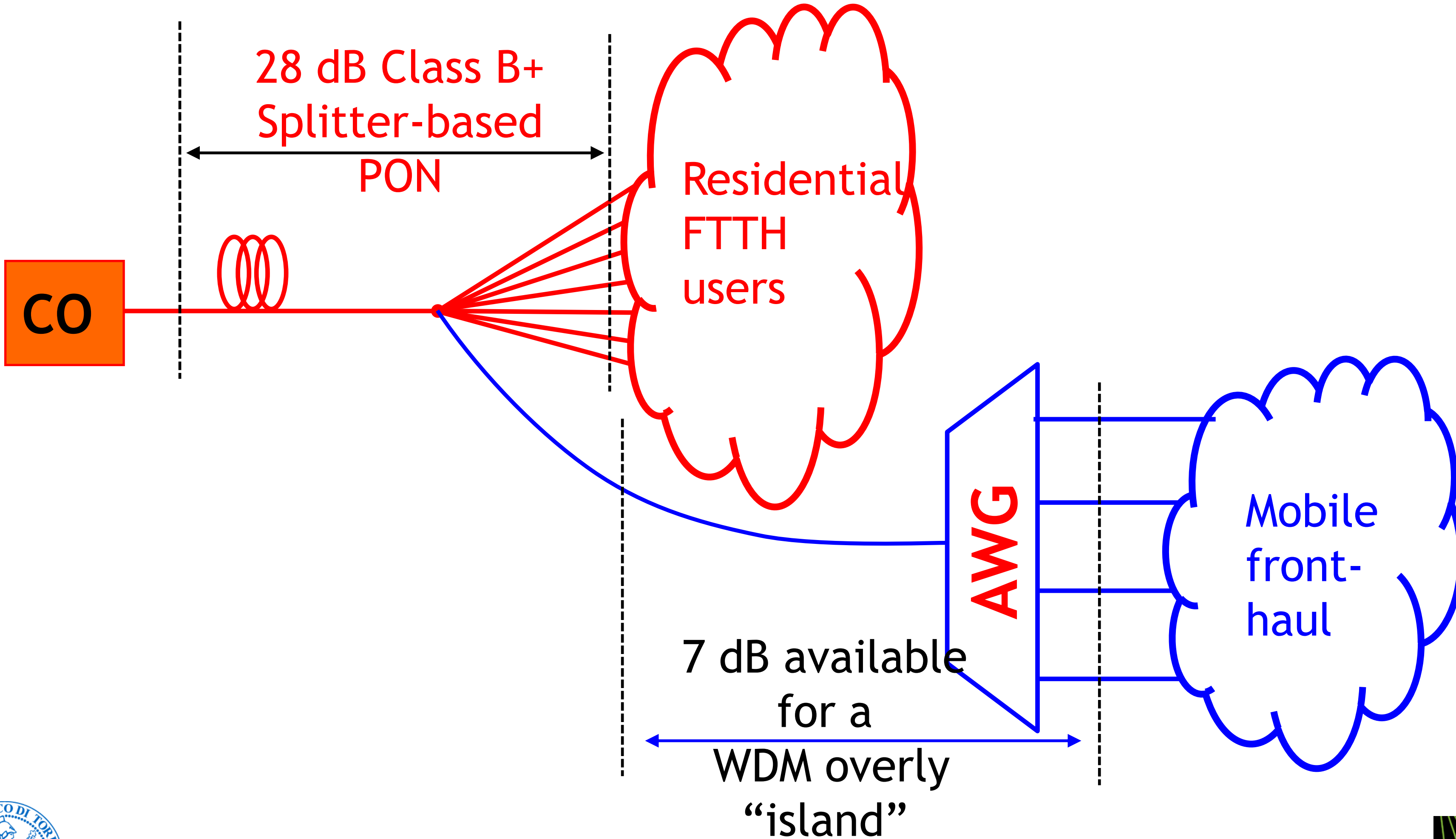
Ok, let’s summarize…

Self-coherent reflective PON

- We showed that self-coherent reflective PON:
  - Allows for high ODN-loss
    - Even 35dB, as required by class C+, can be achieved
  - Can be made burst mode for TDMA
  - Wavelength accuracy is set by the central office
    - No tunable lasers needed at ONU
    - Only tunable filters locked to incoming CW wavelengths needed at ONU
- This solution seems compatible with TWDM-PON, and easily scalable to DWDM with many lambdas

Envisioning mixed solution

- An available high ODN loss (>35dB) can open innovative mixed solutions, such as:



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Thank you for your attention!

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