

# Issues in DWDM Testing

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# Agenda

- › What your Equipment Measurement system doesn't tell you
- › Challenges with 100G
- › Other impairments in optical systems

# Rise of EMS

## Situation



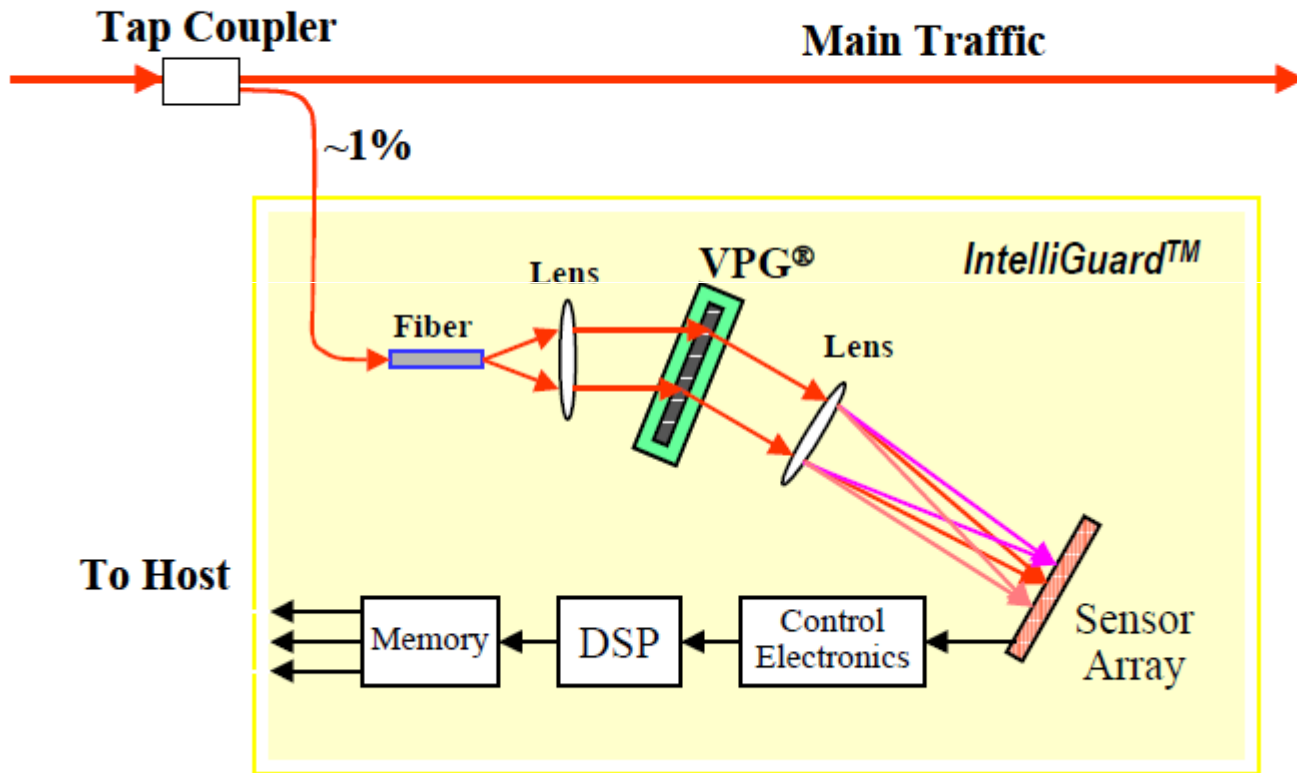
I don't need an OSA.  
My EMS will  
autobalance and  
optimise my system

- > **What is EMS?**
- > Uses **O**ptical **C**hannel **P**erformance **M**onitoring using embedded device in EDFA's, ROADMs etc to monitor channels.
  - > Provide Power, Wavelength & OSNR

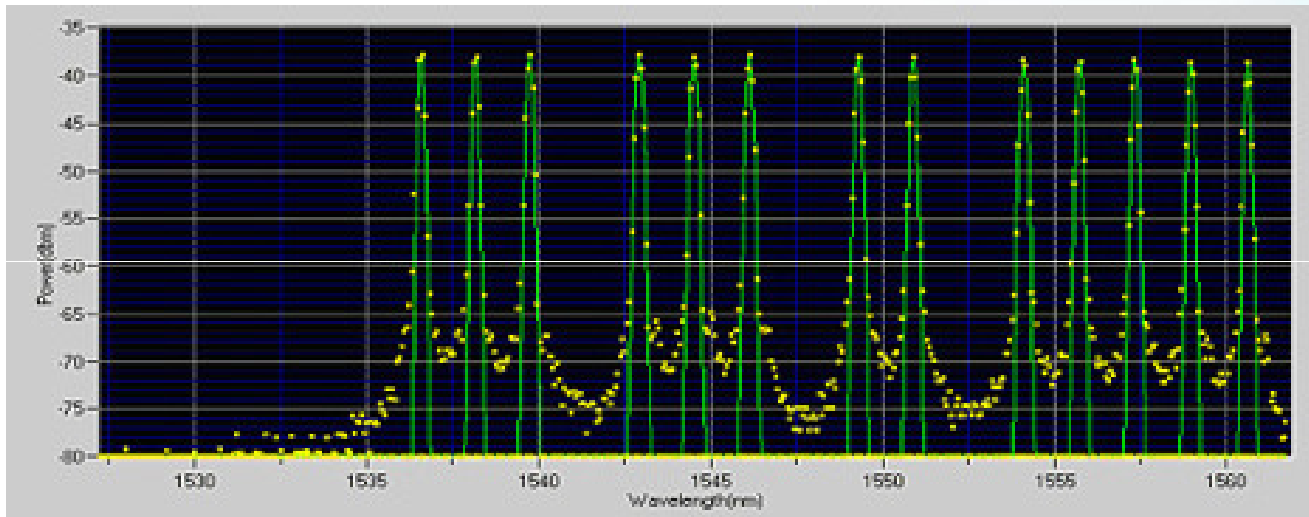


# Optical Channel Performance Monitoring

## Functional Schematic



# Optical Channel Performance Monitoring

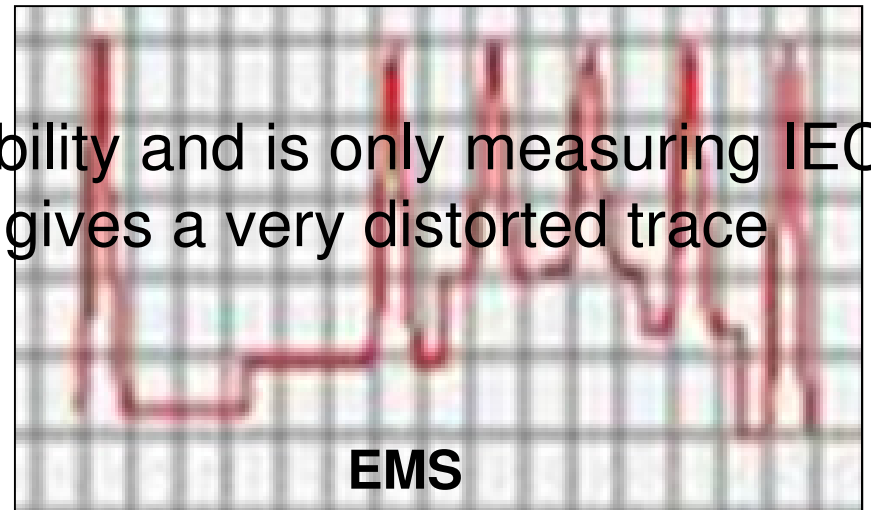
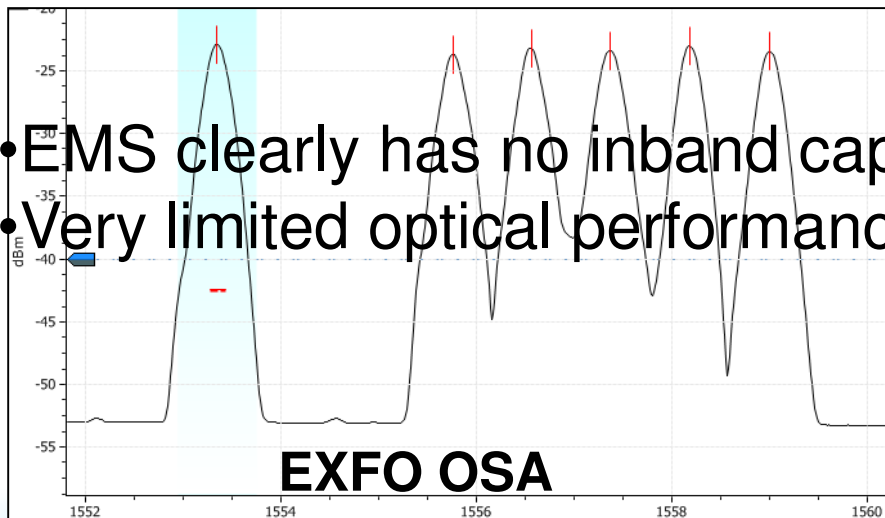


- › Example output from OCPM for 10G, 100GHz Channel Spacing

## An example of a major European operator

Ch. #	OSNR (dB)		
	EMS	EXFO	$\Delta$
1	35.3	23.4	11.9
2	30.1	24.2	5.9
3	22.0	24.9	2.9
4	21.2	24.0	2.8
5	27.4	28.0	0.6
6	36.9	27.9	9.0

- EMS clearly has no inband capability and is only measuring IEC
- Very limited optical performance gives a very distorted trace



## EMS Conclusion

EMS are very limited in accuracy (even where IEC valid)

Limited to 2.5 & 10G systems at 100GHz channel spacing

Not valid where we have ROADMs

Large errors at 50GHz channel spacing

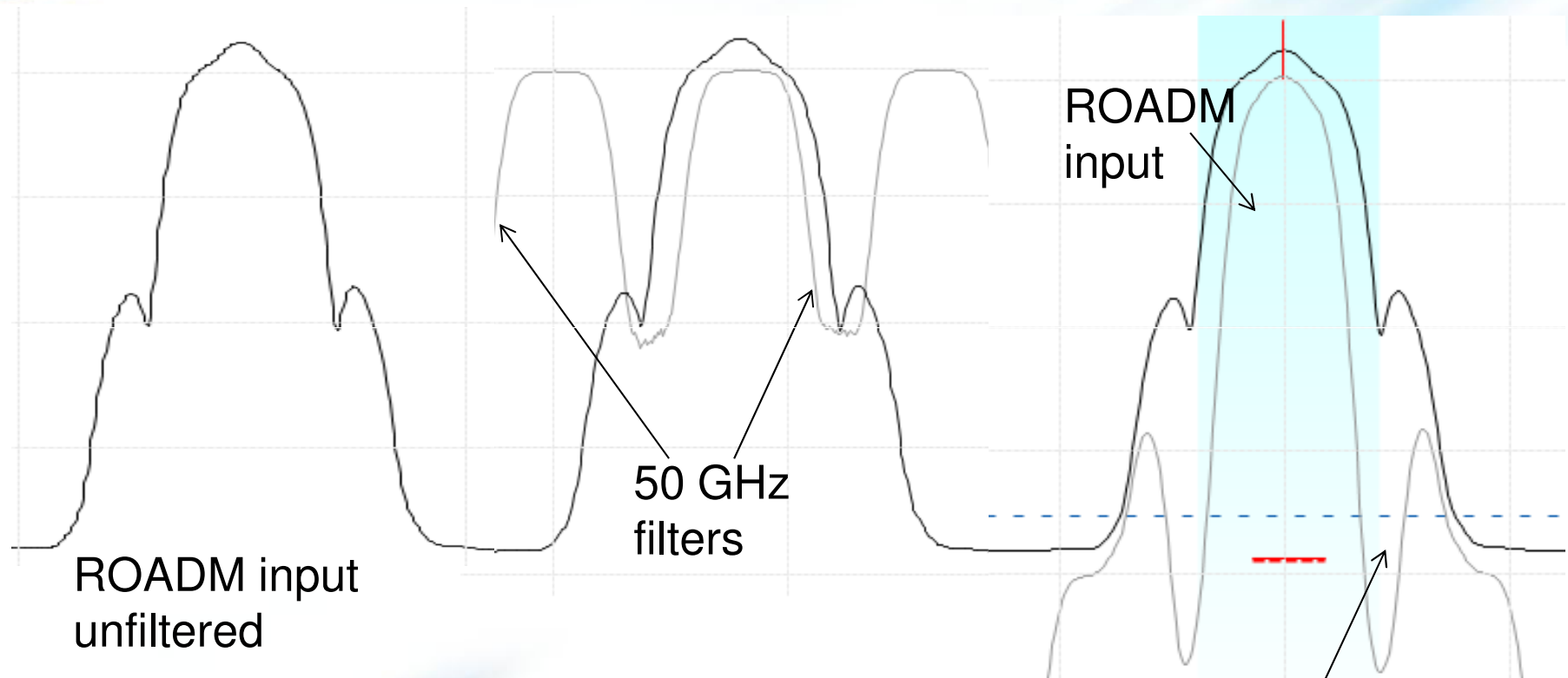
**An In-Band capable OSA is required to get an accurate picture of the network.**



# 100G OSNR story

# 100G signals filtering in ROADMs

100G signal



For 100G signals:

- ROADMs still cause noise shaping
- Filtered 100G signals larger than 50 GHz grid.

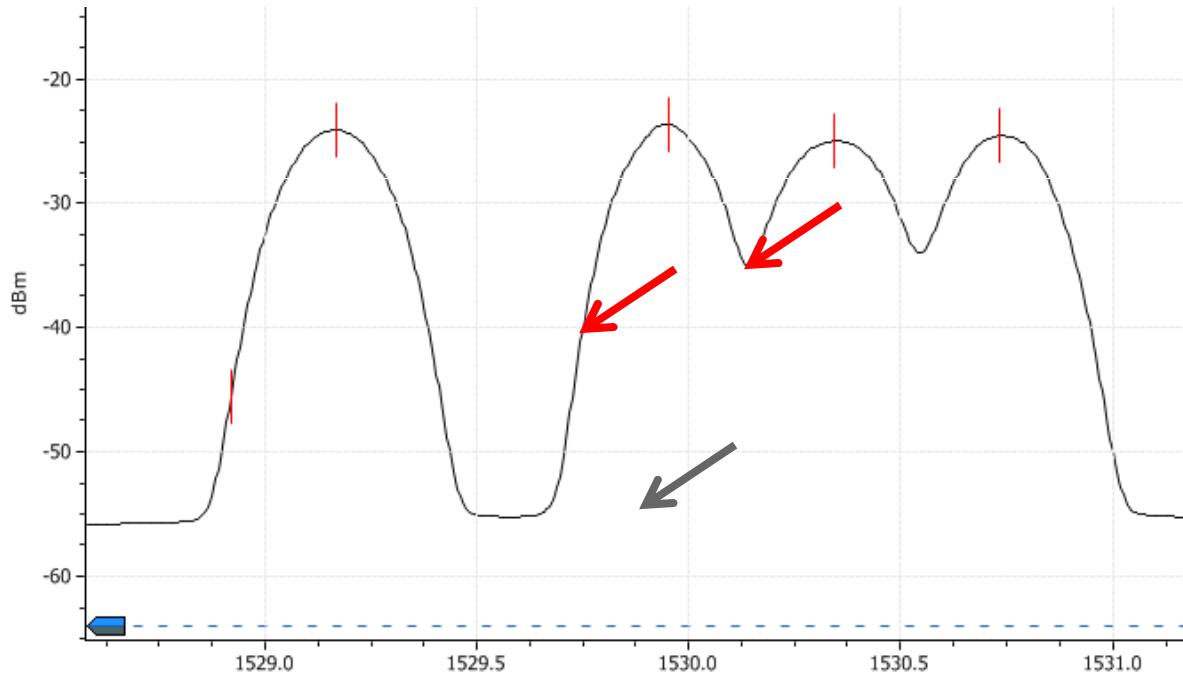
ROADM output,  
filtered.

**EXFO**

# Why IEC fails in coherent networks

## Case 1: Network operates at 40 Gb/s or 100 Gb/s

- Coherent 40G and 100G signals are closely spaced and overlap.
- The IEC interpolation method leads to an over-estimation of the noise level.
- It creates a false sense of problem.



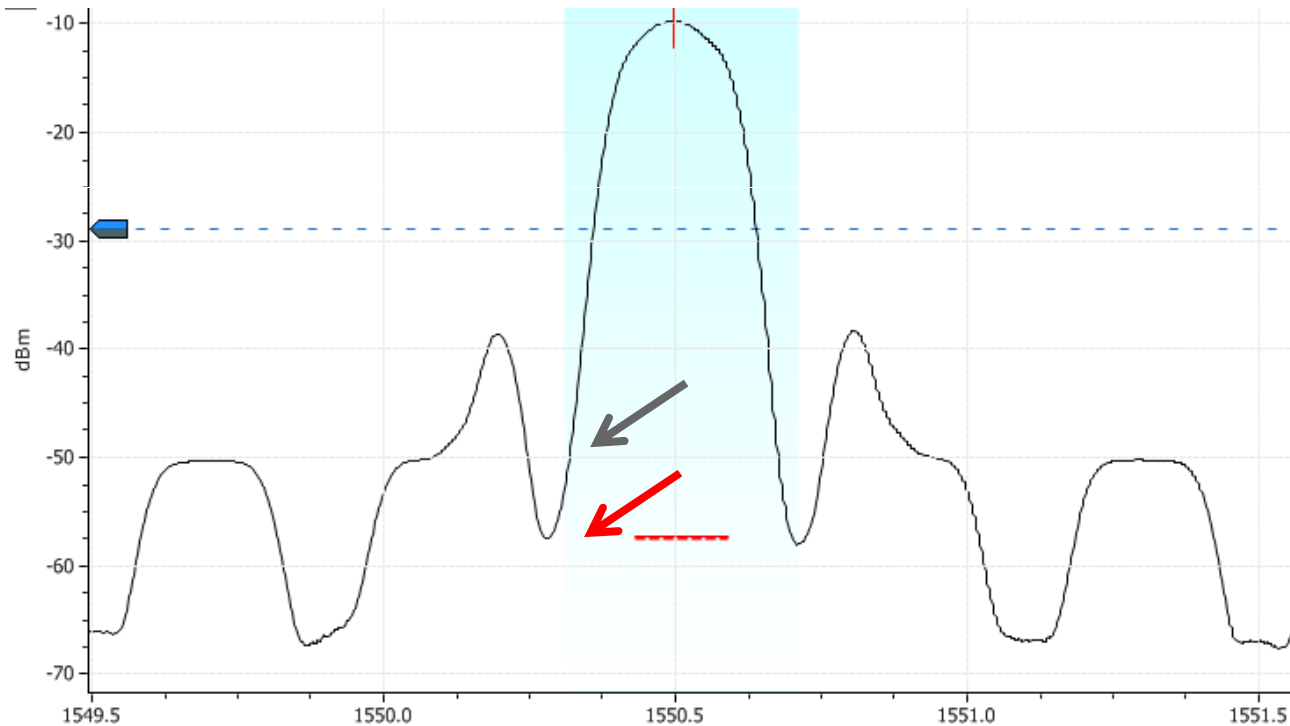
**Real noise level**

**IEC Noise level**

# Why IEC fails in coherent networks

## Case 2: ROADM present in network

- A ROADM contains filters that reduce inter-channel noise.
- The traditional interpolation method leads to an underestimation of the noise.
- It creates a false sense of security.



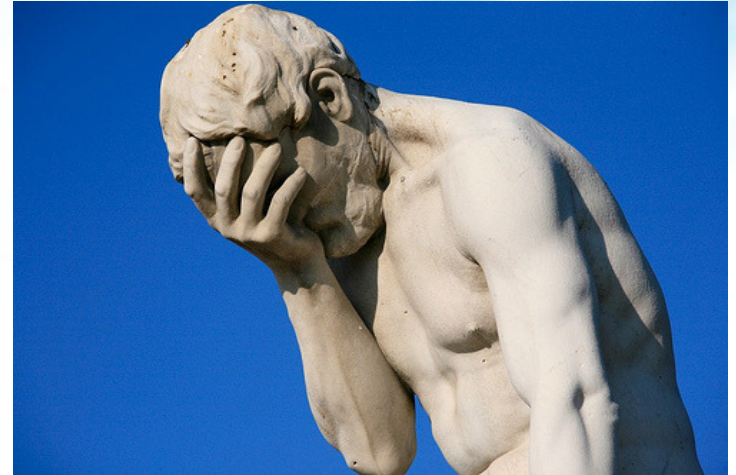
Real noise  
level

IEC Noise  
level



## Why OSA's fail in coherent networks

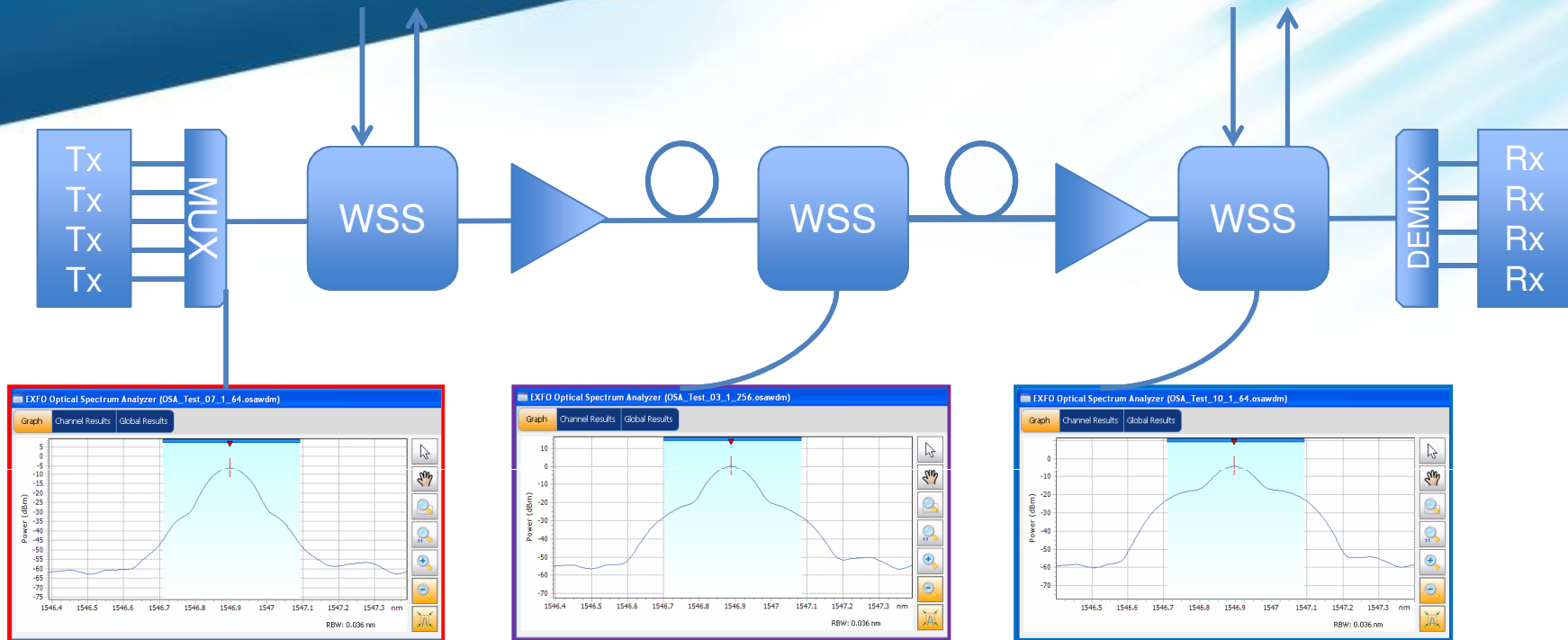
- > Same limitations apply for 100G
  - > ROADMs
  - > Spectrally wide
  - > Filtering
- > Polarization-based in-band OSNR does not work because signal looks unpolarized (two orthogonal pol's).
  - WDM-aware does not work
  - pol. nulling does not work



**Need coherent OSNR (reference-based!)**



# EXFO's approach – Reference-Based



Tap 1

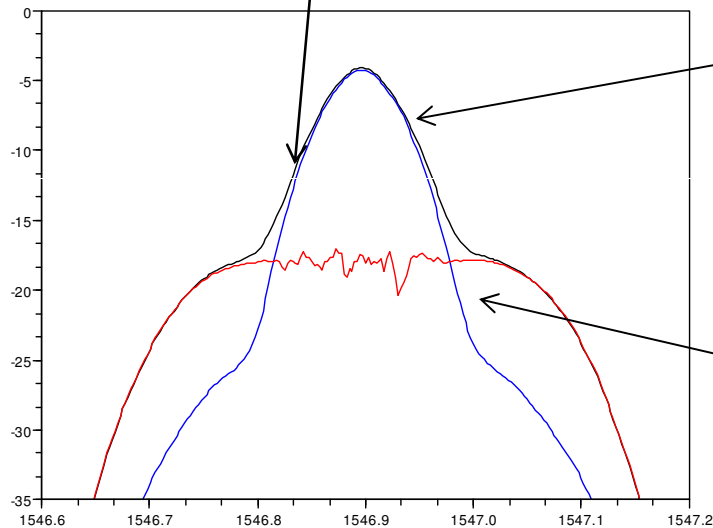
Tap 2

Tap 3

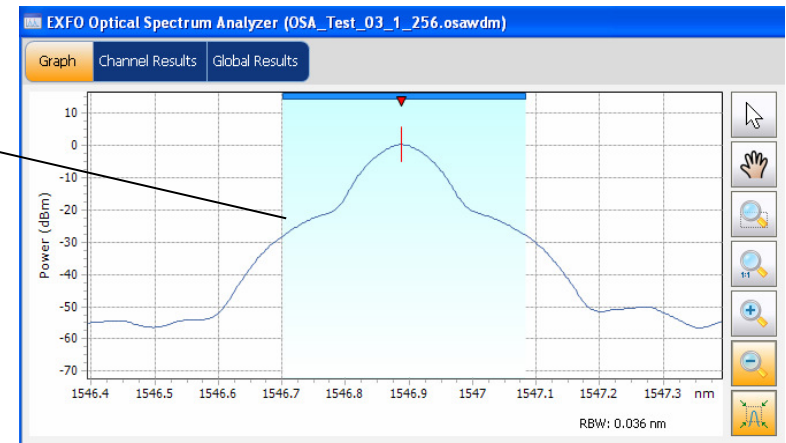
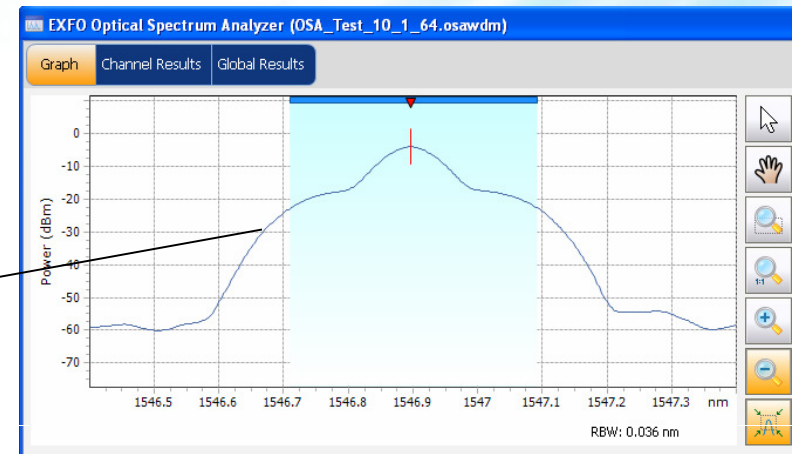
- Can measure via Taps -> No service interruption
- Rely on same Maths as WDM-aware
- Use reference-acquired shape (Tap 1)
- Find noise contribution

# EXFO's approach – Reference-Based

- Use Reference Measurement as signal shape to find noise



Tap 2



- Showing with Tap 2 to demonstrate reference with residual OSNR but works well of course with Tap 1

Tap 3

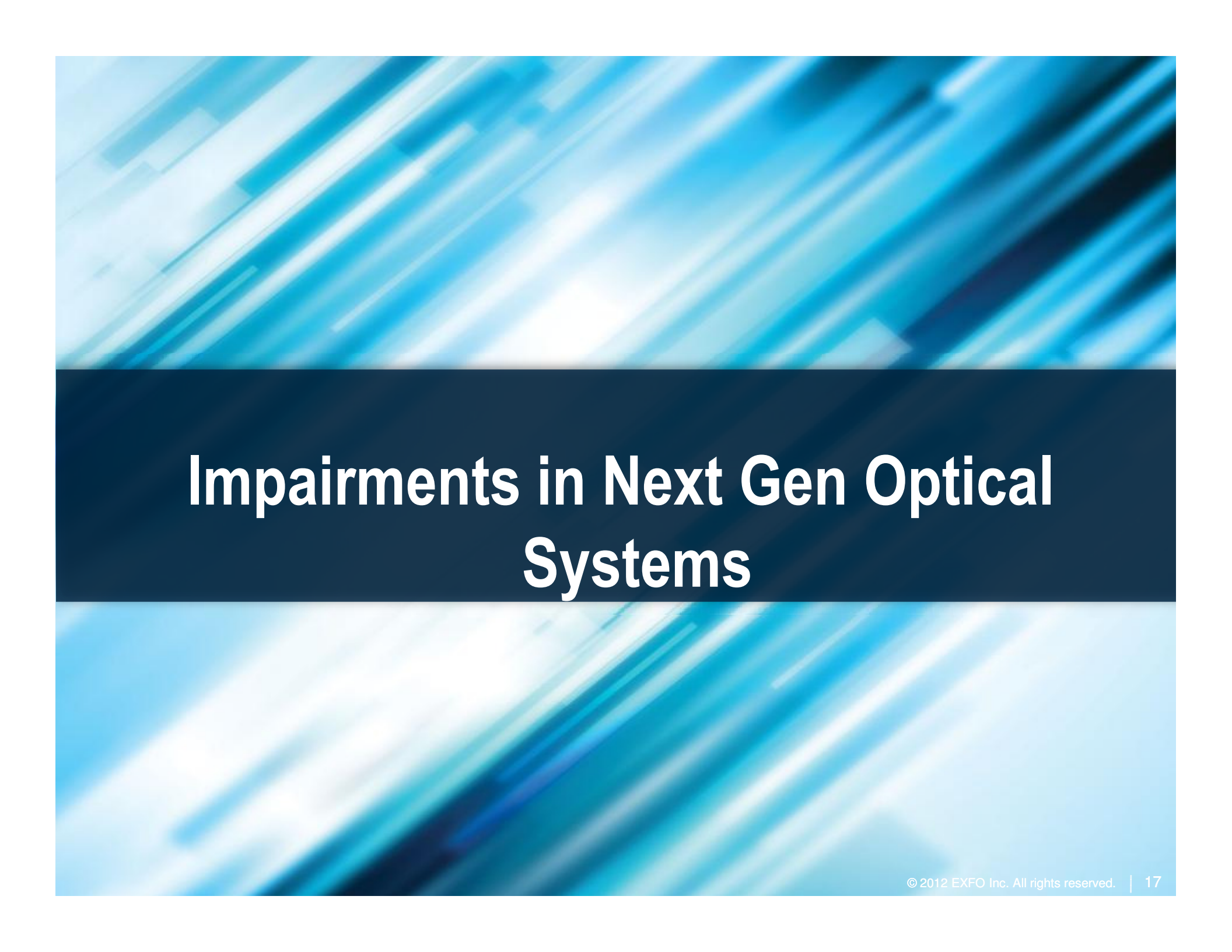


## So is coherent OSNR available?

- > EXFO now offers reference-based method as analysis service:
- > The customer acquires traces at the transmitter and at the location of interest with EXFO OSA.



- > **The ONLY solution available now in the market!!**

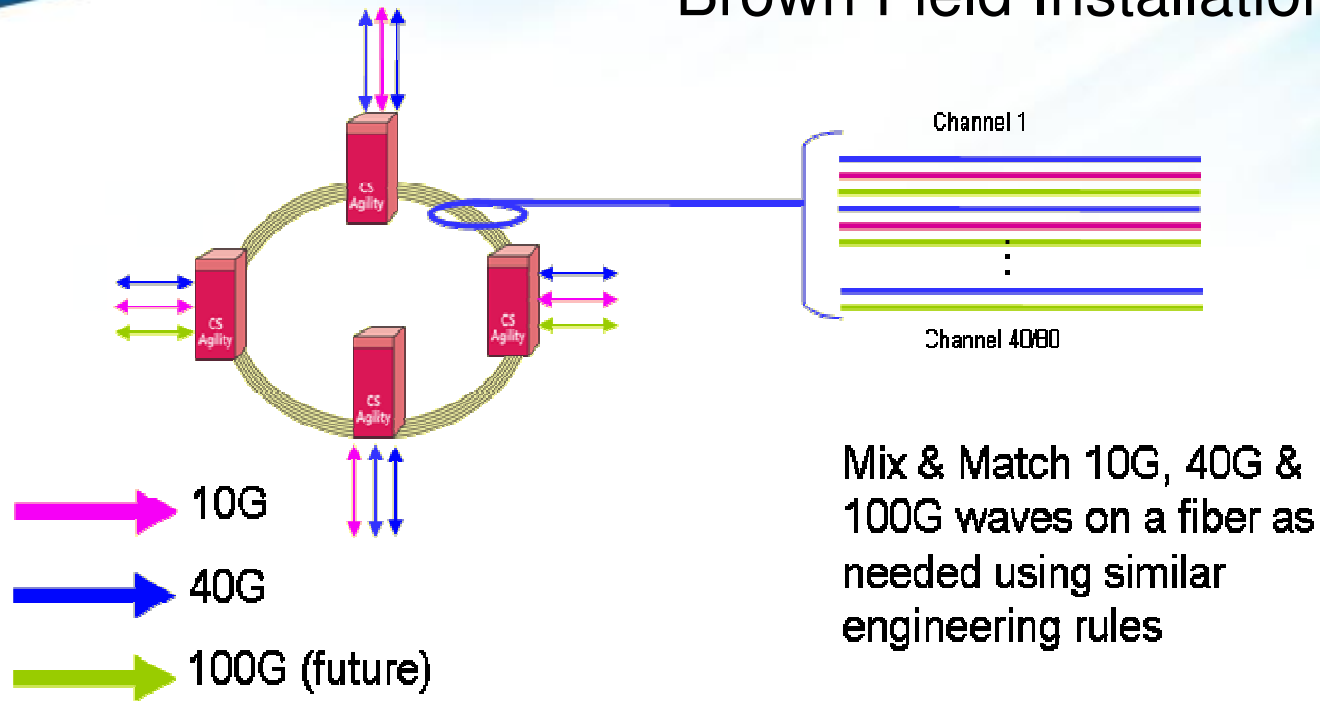


# Impairments in Next Gen Optical Systems



# Next Generation Optical System

## Brown Field Installation

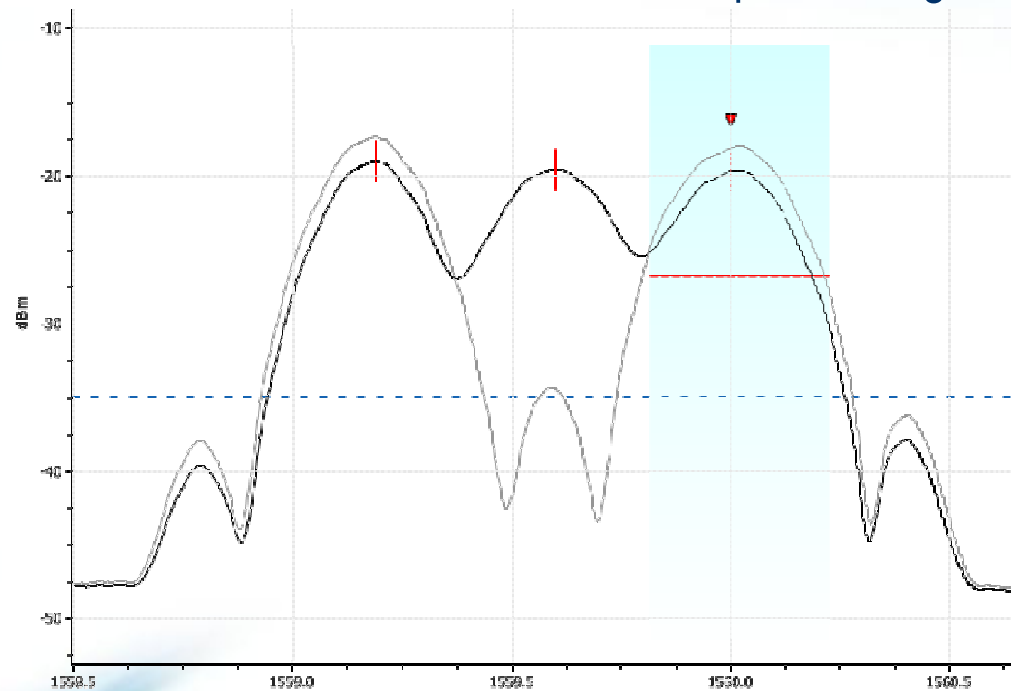


- > Increased network complexity
- > New impairments to consider



## Interchannel crosstalk:

- > In dense channel plans, when neighbor channels have a non negligible portion of their spectrum that extends within the channel bandpass of a given signal.



- > **OSNR based on ASE noise will give an OSNR that doesn't equate to the BER the system.**

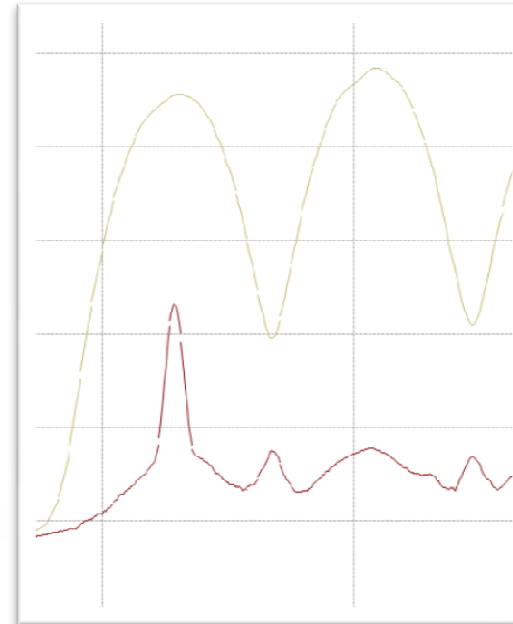
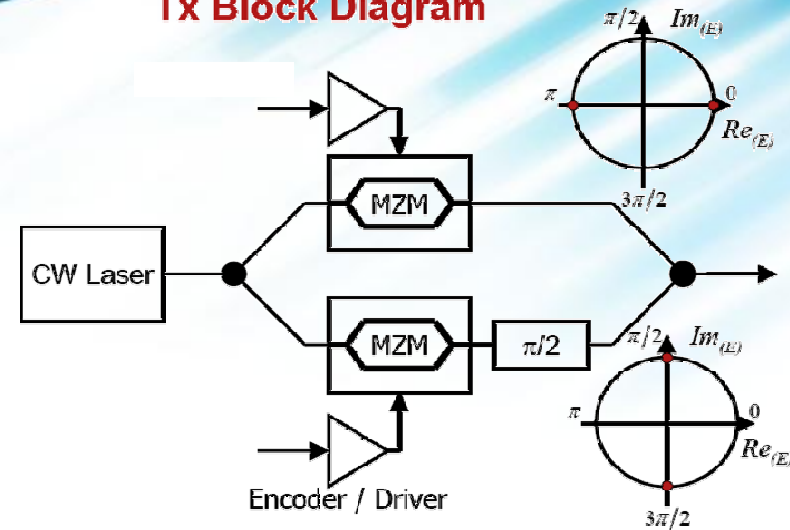
## Nonlinear Impairments:

- When signals interact with one another.
  - Have amplitude & phase modulation signals next to one another.
  - Gives rise to **cross-phase modulation**
- Lead to partial depolarization of neighbouring channels signals
  - **Behaves like additional noise on top of the ASE**
    - **can degrade BER**

# Carrier leakage

- In Phase modulated transmission, a CW source is modulated and is polarisation dependant.
- If poorly aligned – portion of signal transmitted though system unmodulated.
- **Wasted power & extra noise**

**Tx Block Diagram**



## Conclusion

- › Challenges in measuring OSNR in ROADM based networks
- › Challenges to overcome in measuring 100G OSNR
- › Other contributors include, non-linear impairments, X-talk, misaligned modulators.

**These will add to the noise and will effect BER.**

**Network operators want more visibility of their network**