Design and OAM&P aspects of a DWDM system equipped with a 40Gb/s PM-QPSK alien wavelength and adjacent 10Gb/s channels

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Design and OAM&P aspects of a DWDM system equipped with a 40Gb/s PM-QPSK alien wavelength and adjacent 10Gb/s channels

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SURFnet
NORDUnet Nordic Infrastructure for Research & Education
DTU Fotonik Department of Photonics Engineering

Outline

- History
- Design
- VPI off-line simulations
- Experimental results
- OAM&P
- Costs considerations
- Conclusion

History

- April 2009: SURFnet fosters the idea of deploying an alien wavelength.
  SURFnet purchases and install additional needed hardware
  Ready to go – September 2009

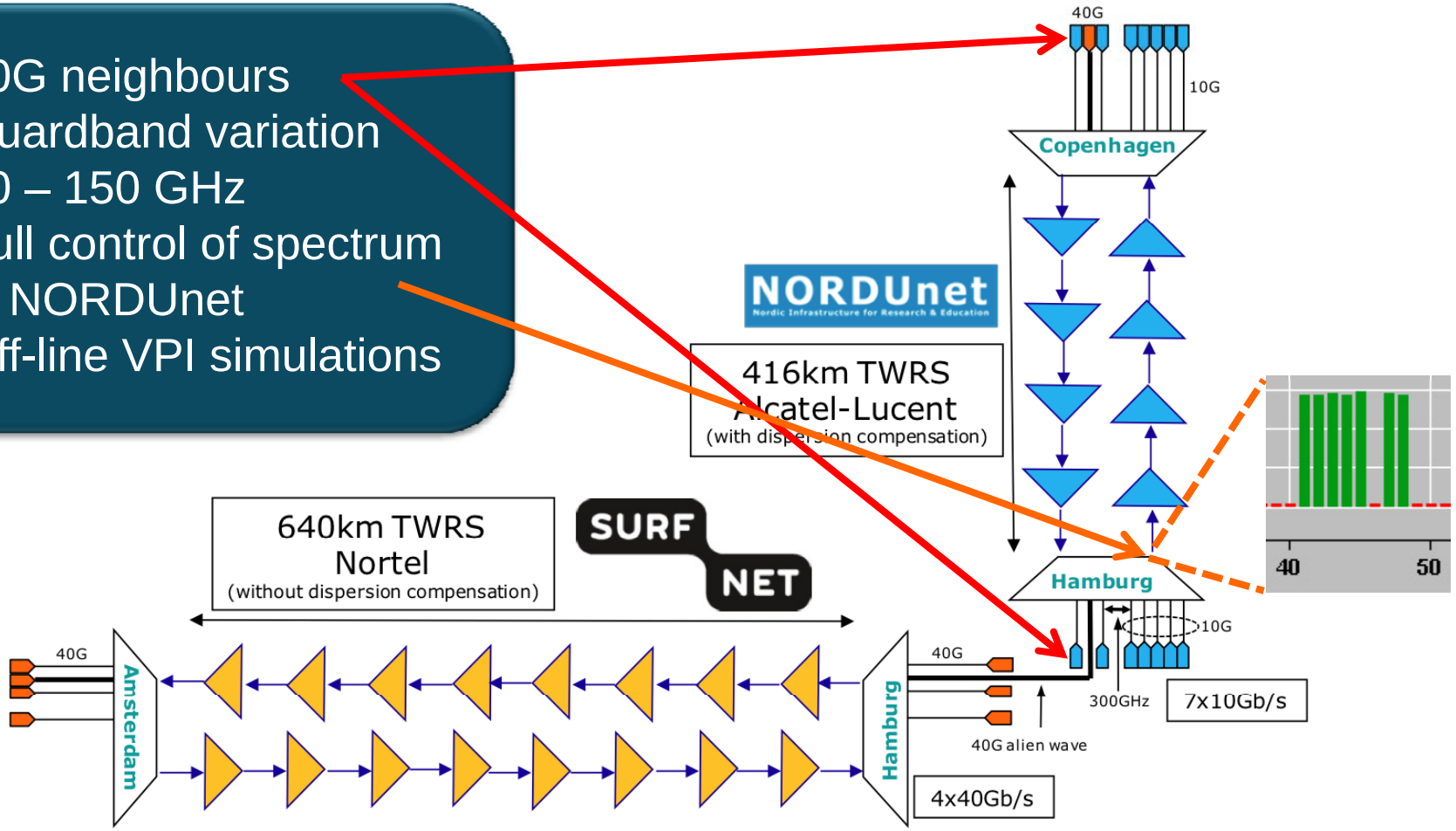
- November 2009: Hero experiment presented at SC, Portland Oregon.
  Ability of both network was tested
  Shortcomings identified
  Operated in un-optimized conditions; BER < 3,0 10^{-16}

- June 2010: TNC 2010, Vilnius, Lithuania.
  Simulations in Ciena Optical Modeller
  Optimized condition BER < 10^{-17}

- May 2011: TNC 2011, Prague, Czech Republic.
  Whats new?

System configuration May 2011

- 10G neighbours
- Guardband variation 50 – 150 GHz
- Full control of spectrum in NORDUnet
- Off-line VPI simulations



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VPI simulations

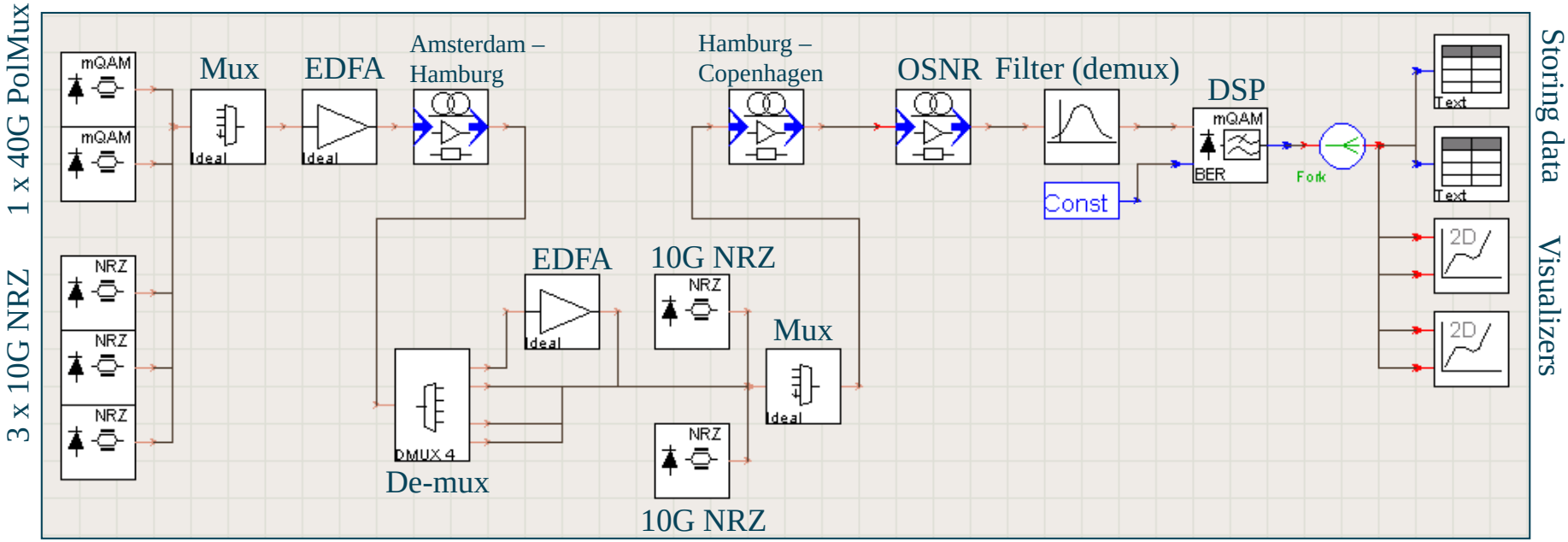
GOALS

- Verification of experimental results
- Facilitate design and control of current setup
- Investigate option for future Multi-domain/vendor simulation tool

CHALLENGES

- Obtaining all needed information about components
- Limiting the VPI model to include the most important aspects of the design

VPI configuration



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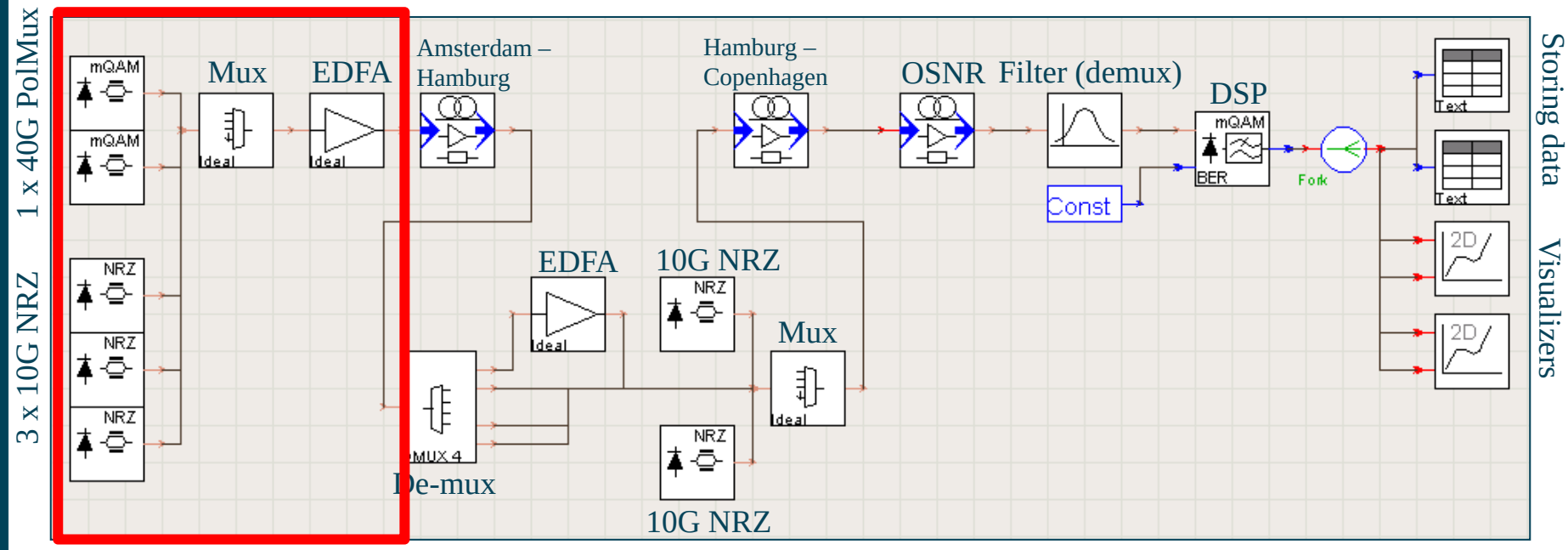
VPI: Amsterdam



- 40G PM-QPSK injection
- Additional 10G's
- MUX
- Pre-AMP

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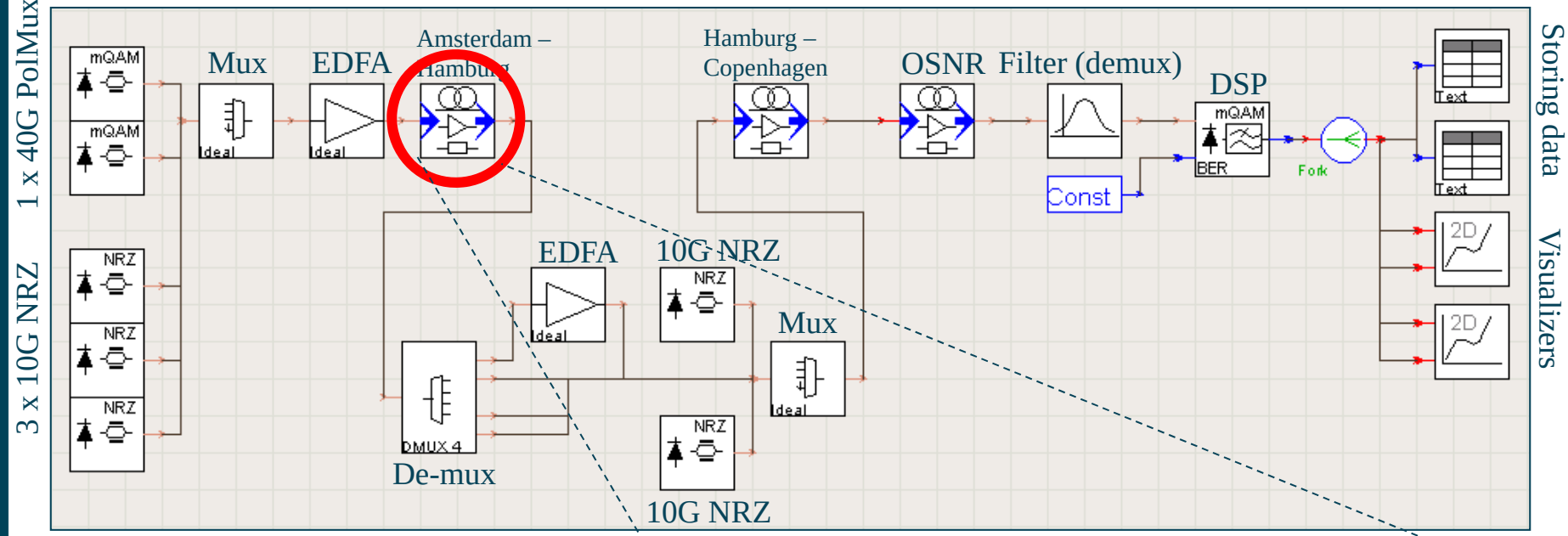
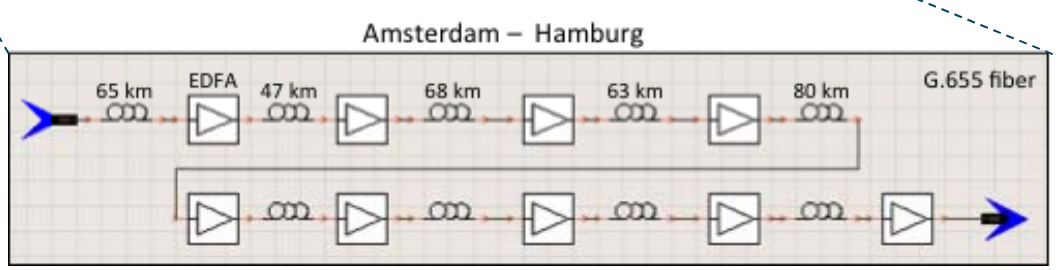
VPI: Amsterdam - Hamburg



- 640km TWRS
- 9 amps
- No CD compensation



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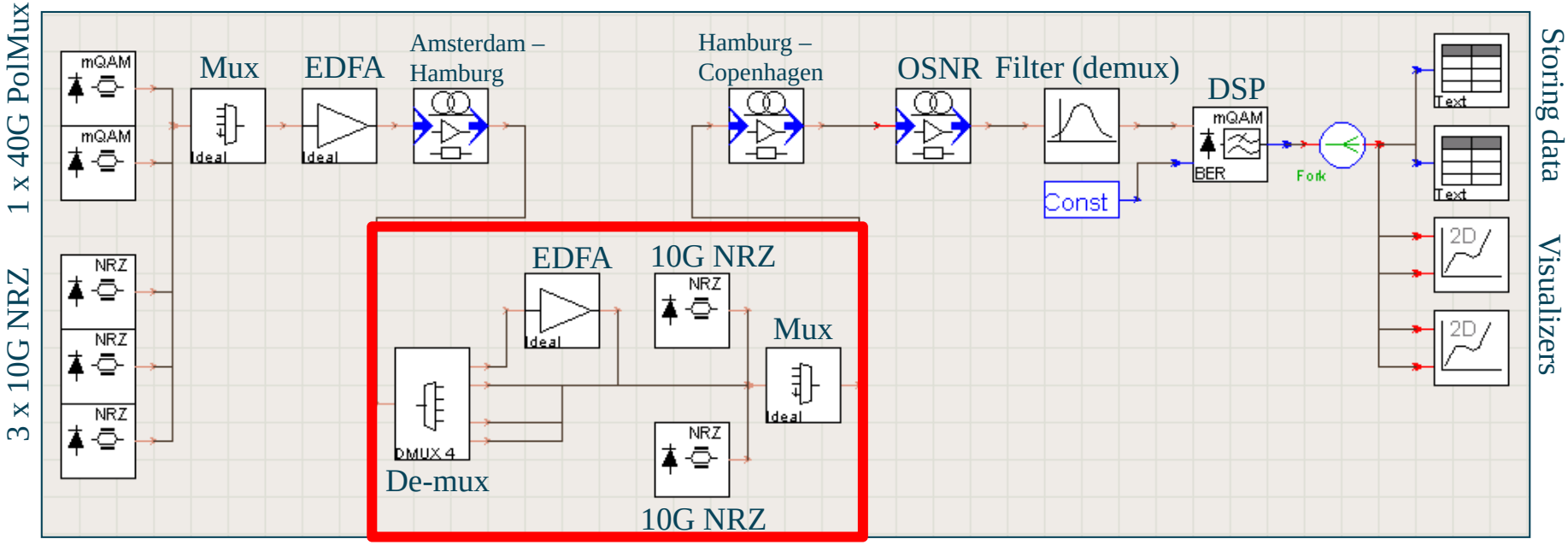
VPI: Hamburg



- DE-MUX
- Pre-AMP ALU
- 10G injection
- MUX

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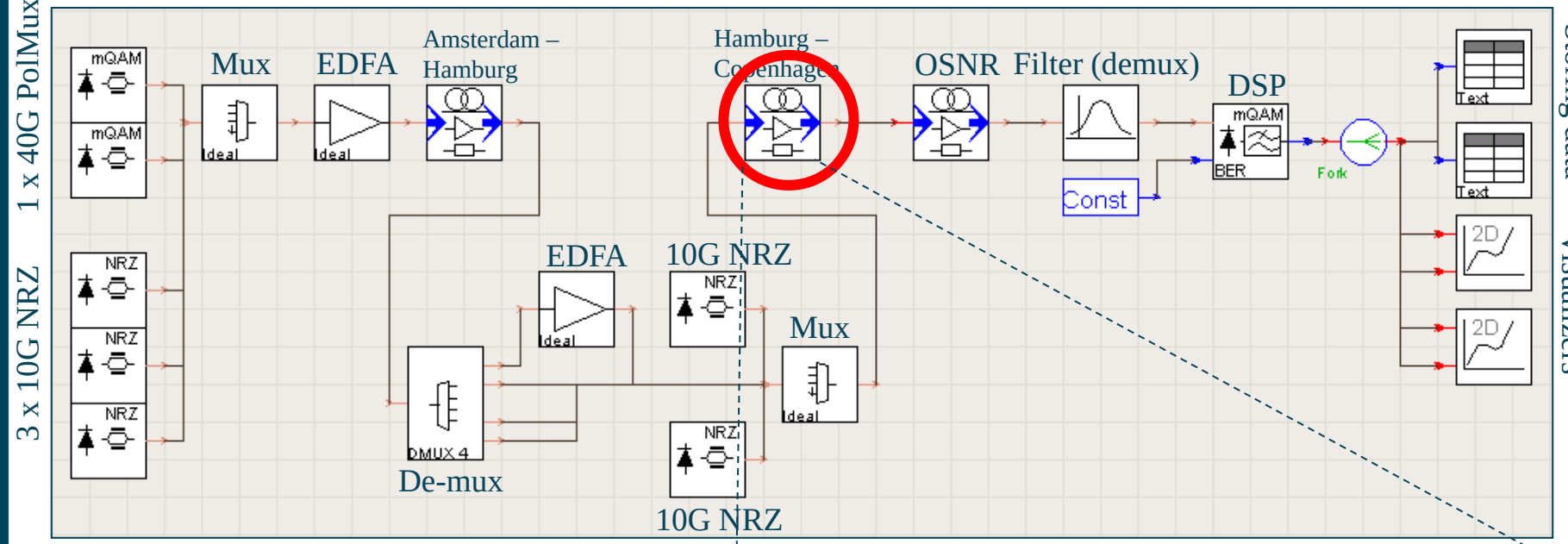
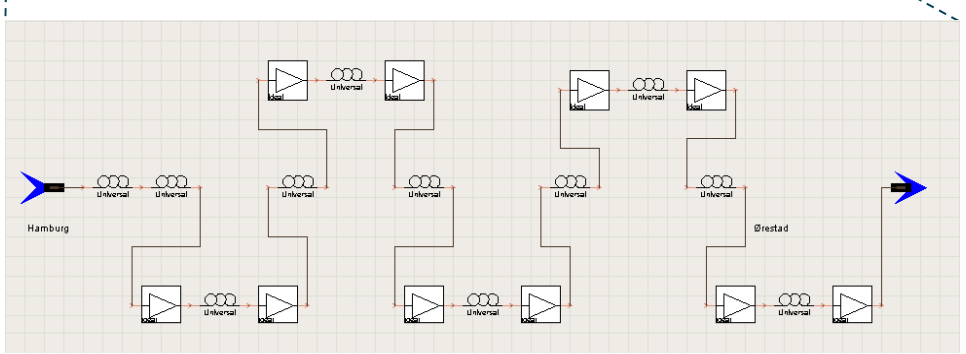
VPI: Hamburg - Copenhagen





- 416 km TWRS
- 5 amps (dual w. access)
- CD compensation

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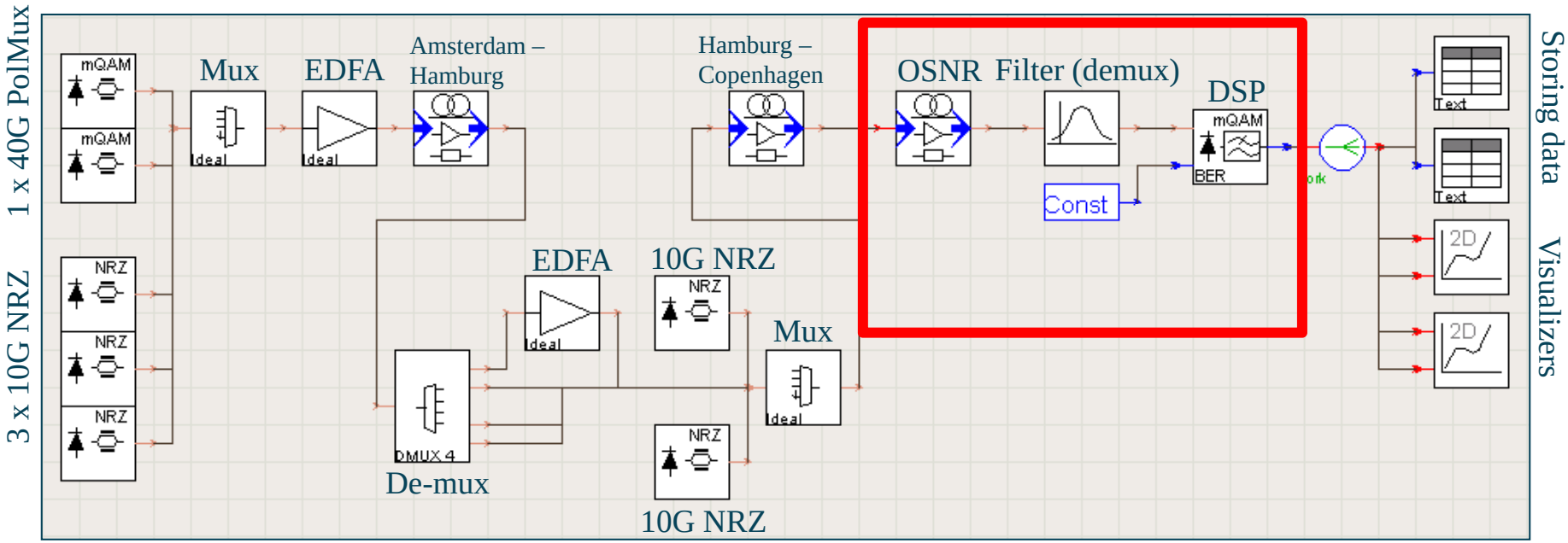
VPI: Copenhagen



- OSNR adjustment and control
- WSS represented by filter/demux
- PM-QPSK receiver with DSP

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VPI: Assumptions and Method

Assumptions

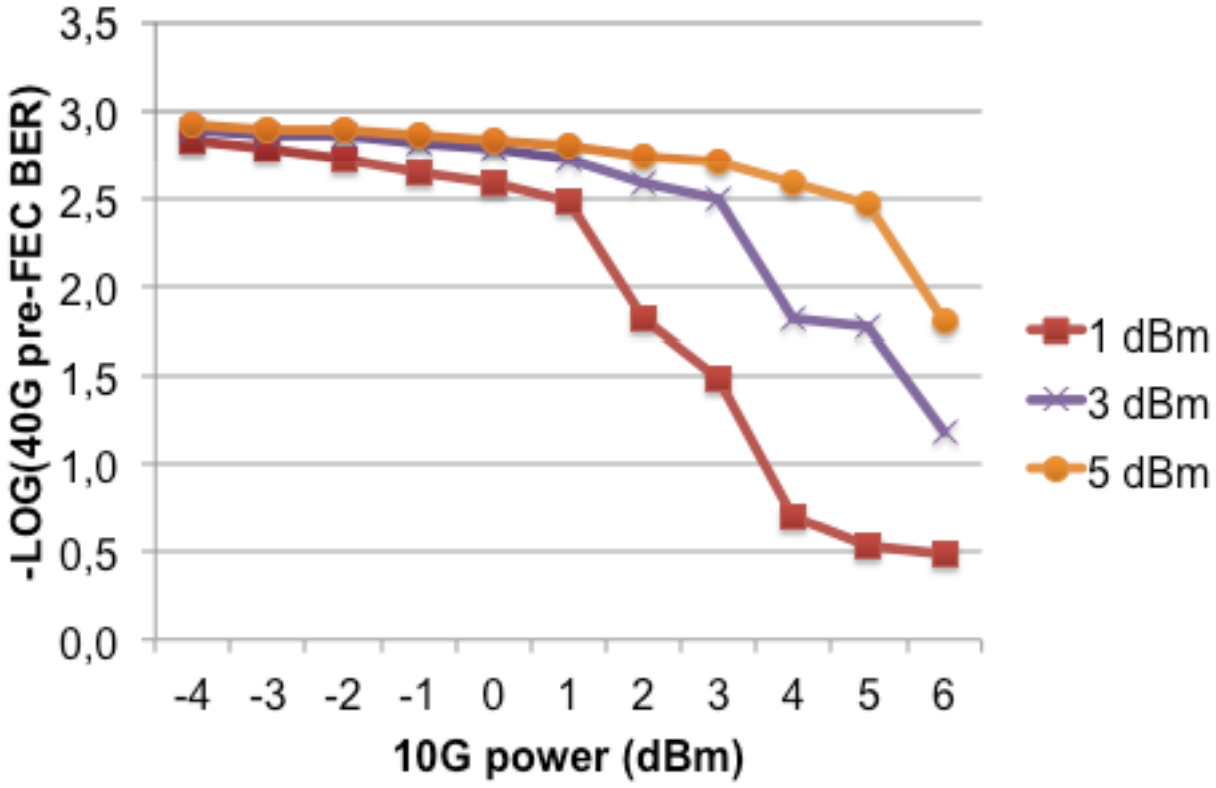
- Noise Figure (AMP) = 5
- OSNR at REC = 20
- PMD: 0.05x10-12 s/m½
- Nonlinearity index parameter (transmission fiber): 2.4x10-20 m2/W
- Nonlinearity index parameter (DCM fiber): 3.0x10-20 m2/W

Method

- Monte Carlo approach: 50.000 bits per data point
- Simulation time usage: With nonlinearities ~ 3-4 hours per data point. Without nonlinearities ~ 15 minutes.

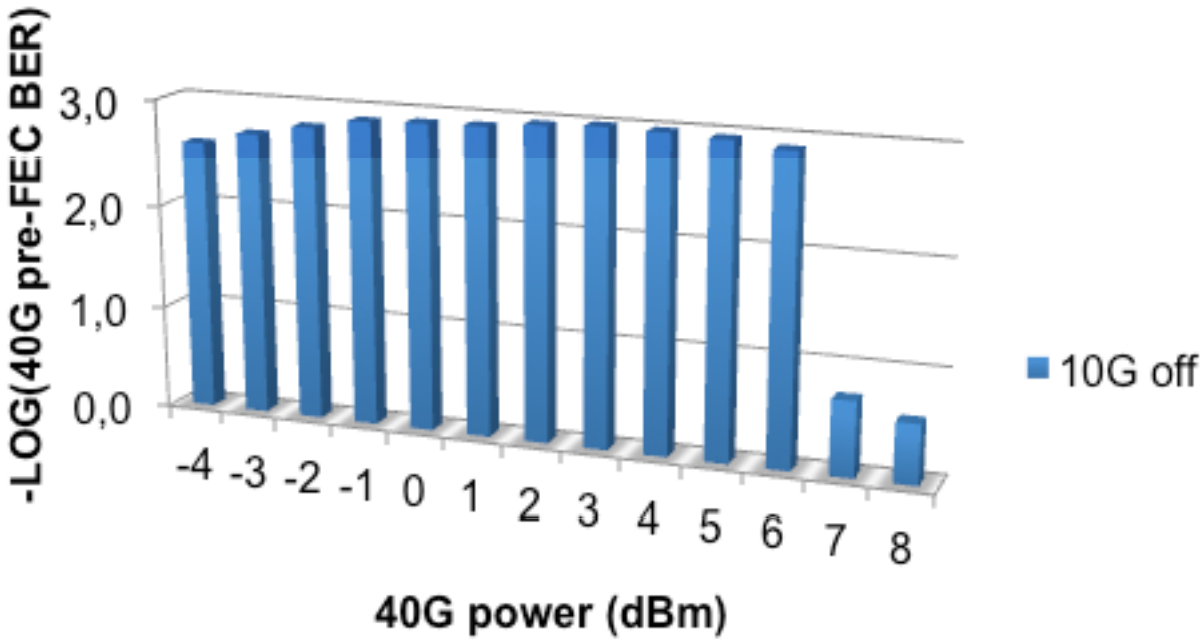
VPI Results:
10G variation w. constant 40G

- XPM
- Lack of SPM?



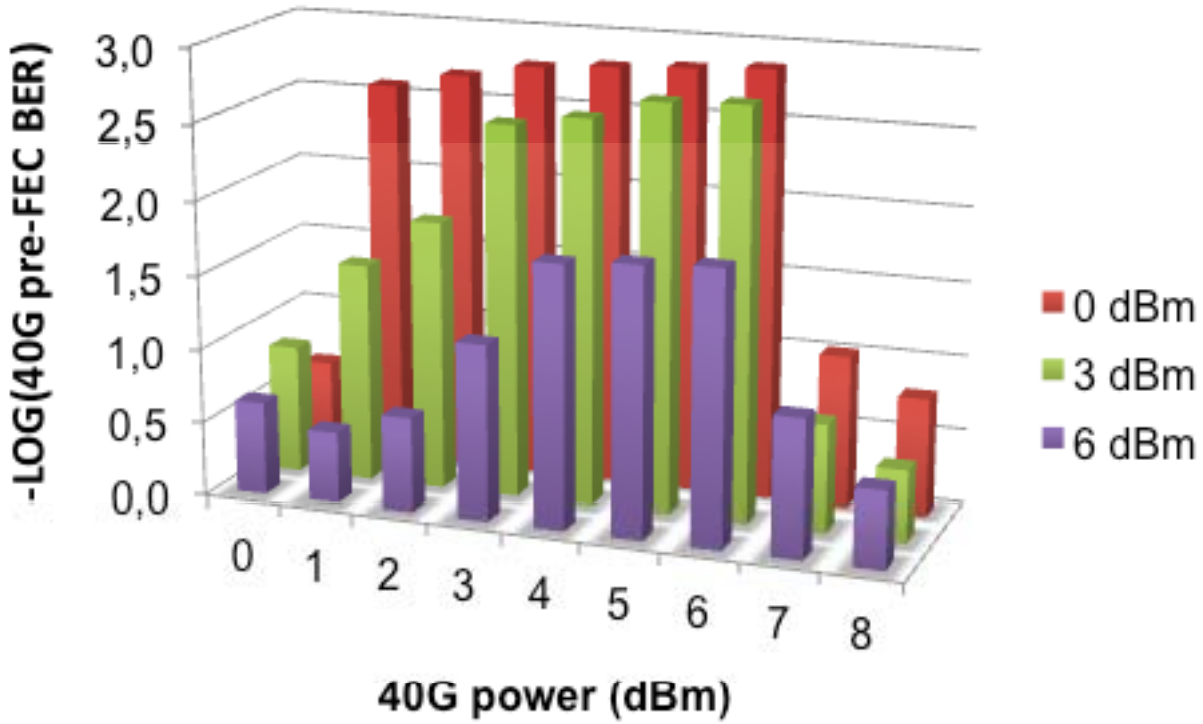
VPI Results:
10G off / 40G high power

- Strong SPM

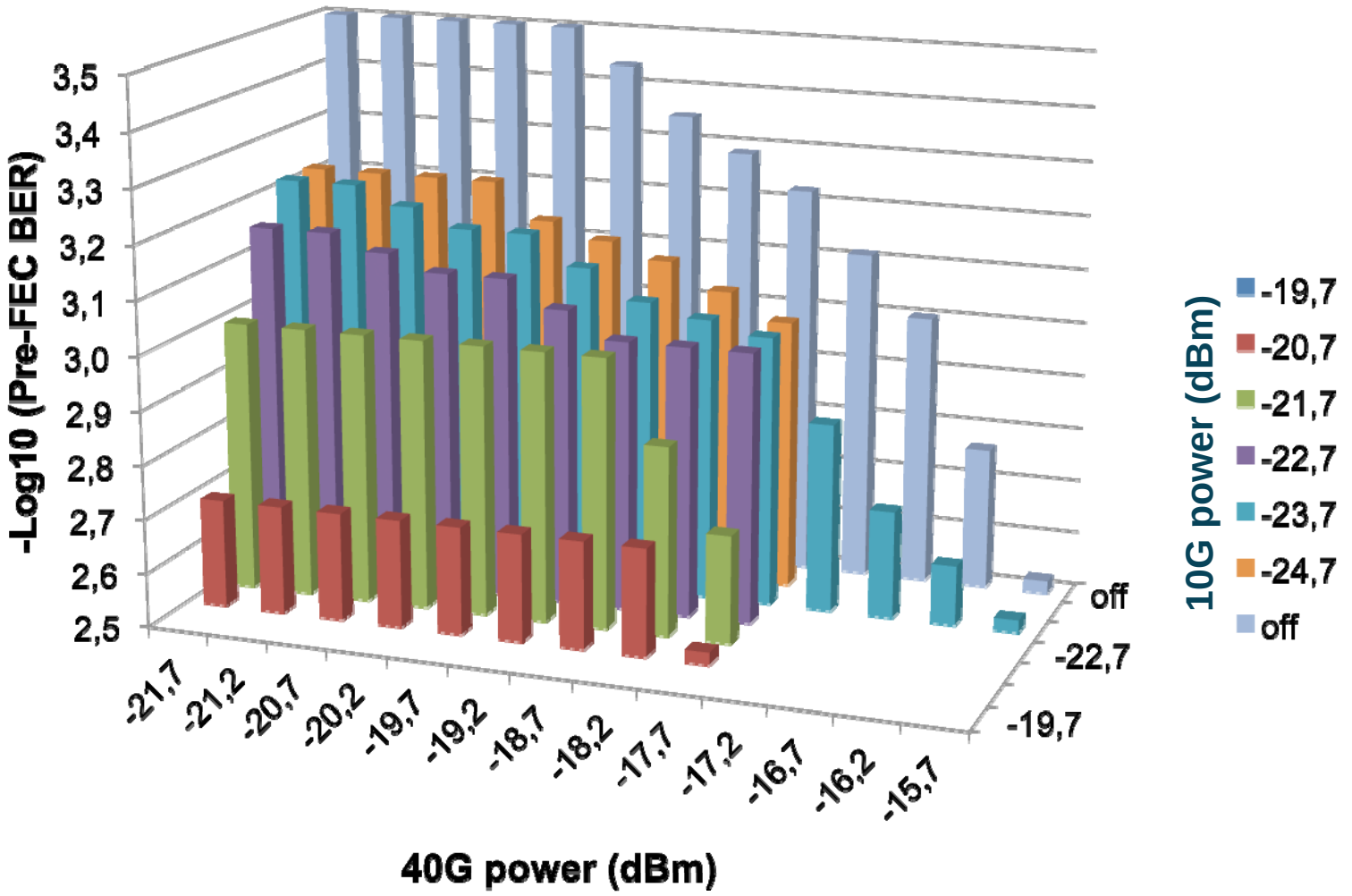


VPI results:
40G variation w. constant 10G

- XPM
- SPM



Experimental results: 50GHz spacing



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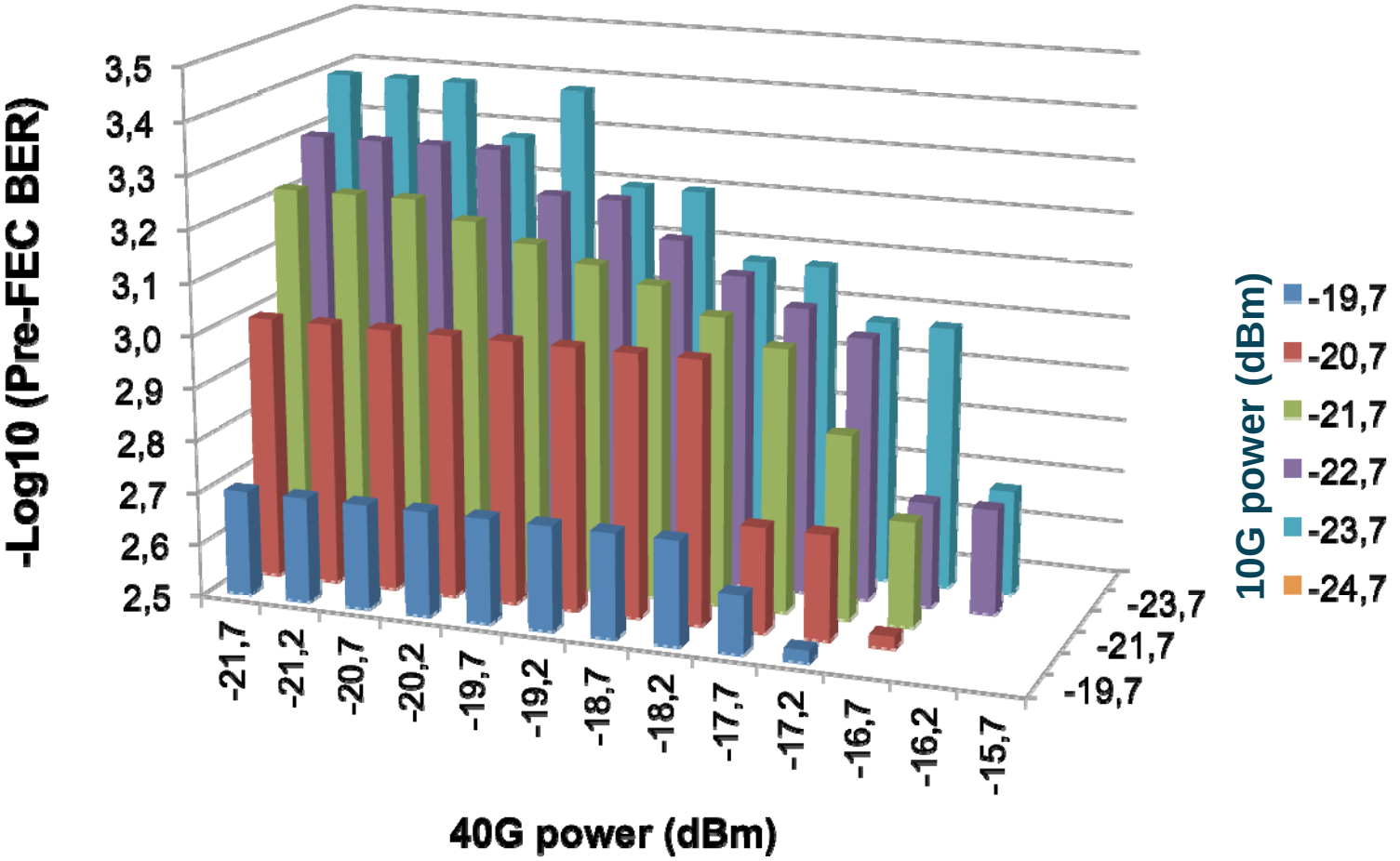
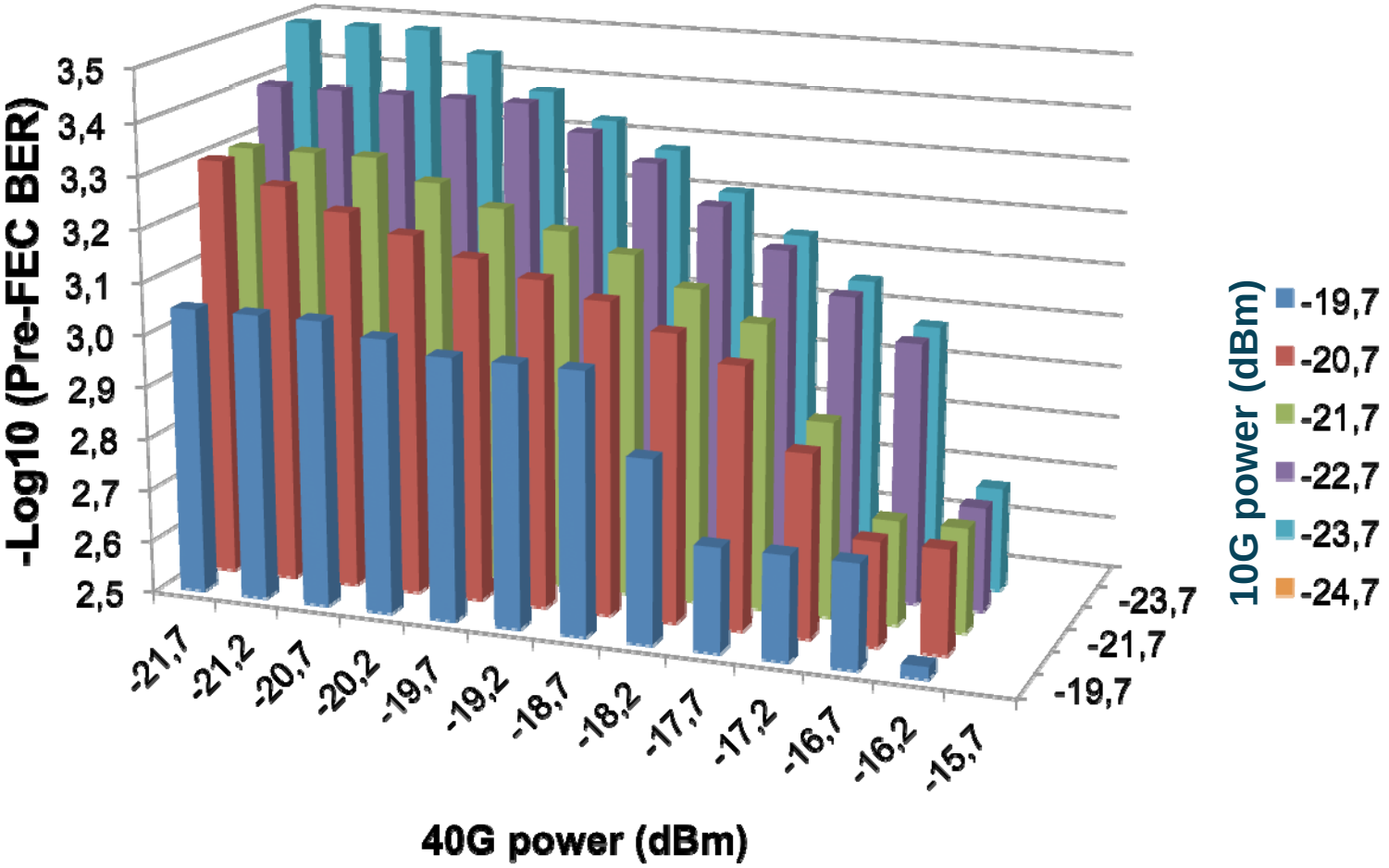
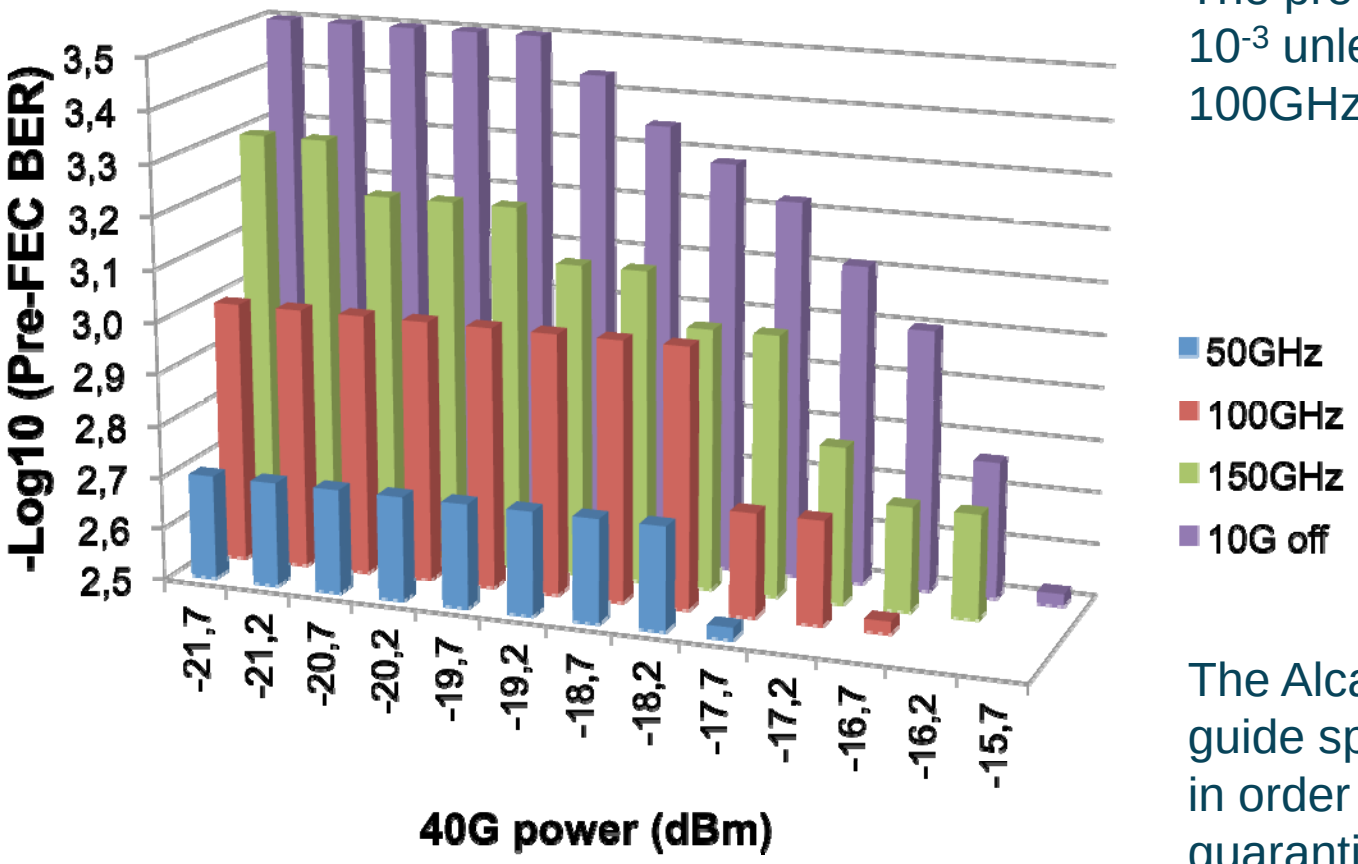
Experimental results: 100GHz spacing



Experimental results: 150GHz spacing



Experimental results:
50HGz to 150GHz @ 10G = -20,7 dBm



The pre-FEC BER is below 10^{-3} unless spacing is above 100GHz

The Alcatel-Lucent design guide specifies 10G = -17,2 in order to maintain guarantied performance according to traffic matrix!

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OAM&P - standardization

ITU Standardization

- G.698.1: Multichannel DWDM applications with single-channel optical interfaces
- G.698.2: Amplified multichannel dense wavelength division multiplexing applications with single channel optical interfaces

Scope & Info

- To provide optical interface specifications towards the realization of transversely compatible dense wavelength division multiplexing (DWDM) systems primarily intended for metro applications
- Applicable for 2,5G and 10G @ 100GHz / 50GHz spacing

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OAM&P - issues

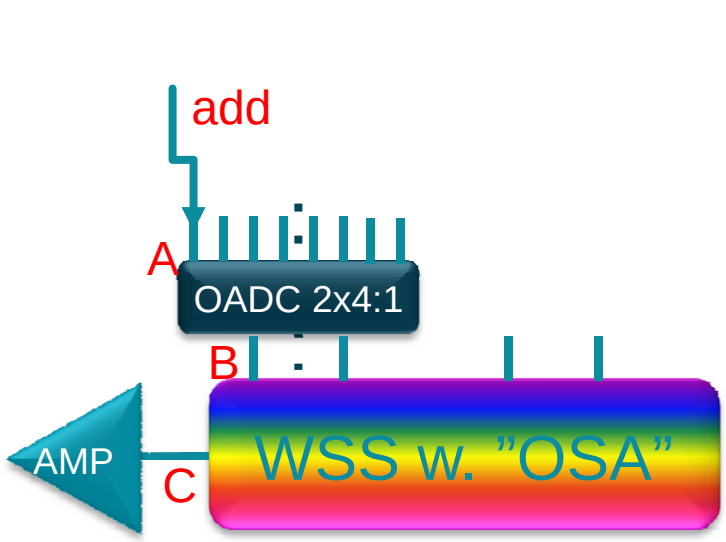
NREN ISSUES

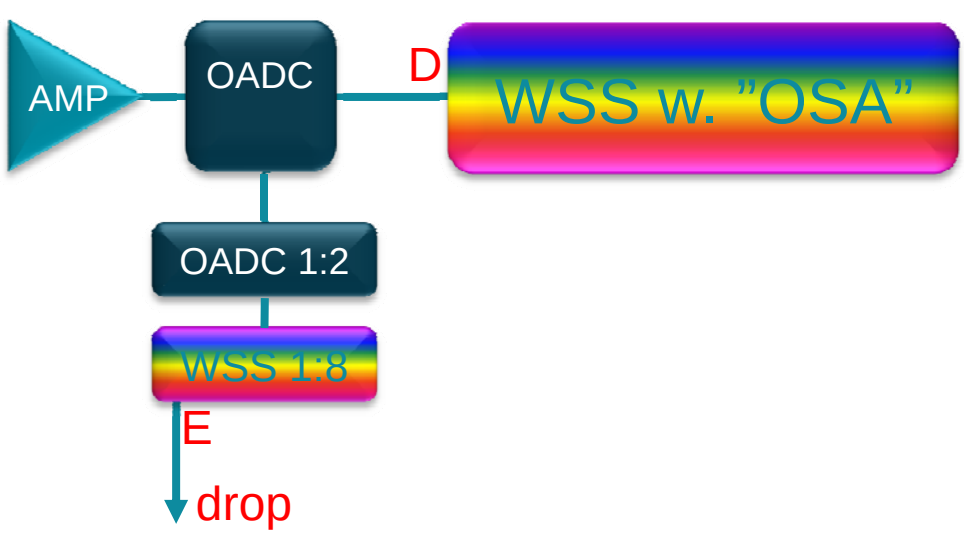
- No transverse compatibility for newer LH modulation schemes.
- No standardization targets LH/ULH applications
- No standardization targets OTS/OMS interworking

NREN TARGETS

- Full optical transparency
  - Bitrate
  - Modulation format
  - Spacing
- Full optical control
  - Power
  - Spectrum
  - Admission

OAM&P - setup





40Gb PM-QPSK	Bitr	Modu	GHz.	Powr	Spec	Addm
A. Add to System	✔	✔	✔	✗	✗	✗
B. Add to spectrum	✔	✔	✗	✗	✗	✔
C. Control spectrum	✔	✔	✗	✔	✔	✔
D. Monitor spectrum	✔	✔	✗	✗	✗	✗
E. Drop from system	✔	✔	✗	✔	✗	✗

OAM&P wrap up

SPECTRUM
Security ✔
Control ✔

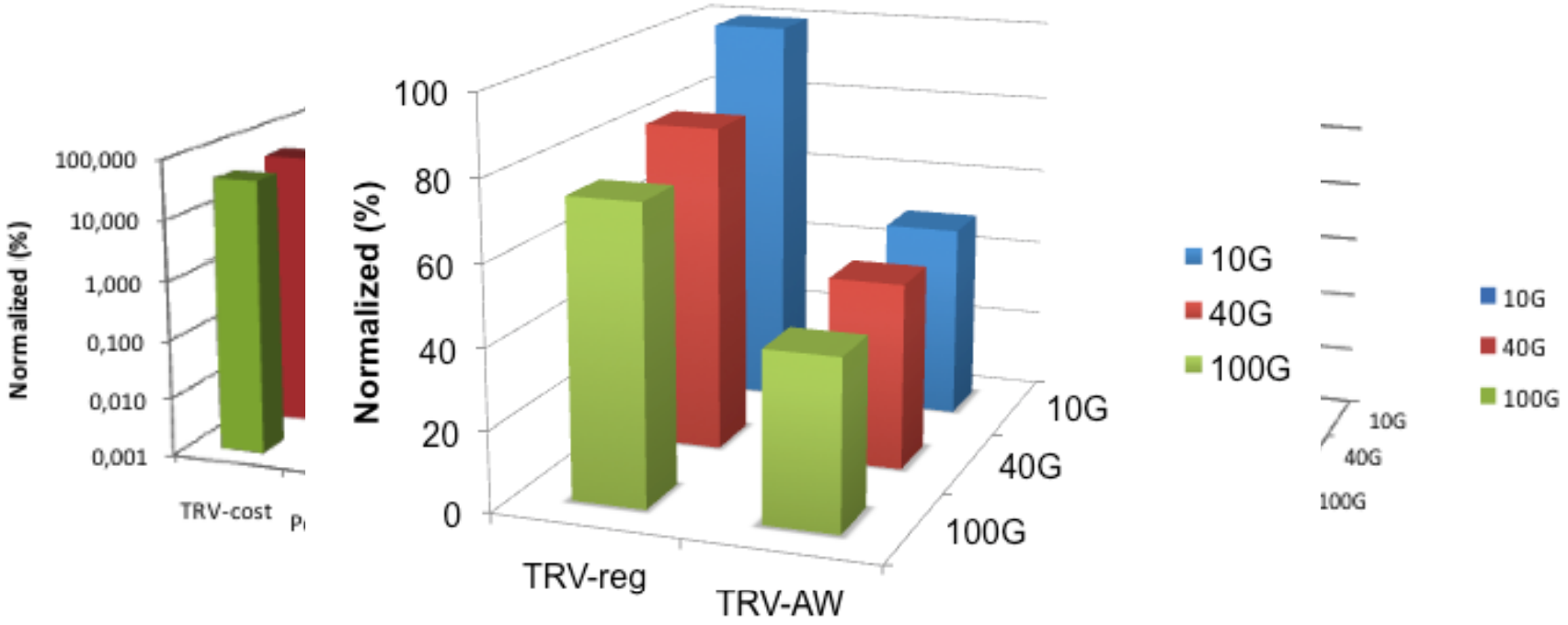
MANAGEMENT
Element Manager ✔
Network Manager ✗

ALARMS
Native system ✔
Alien system ✔

REMAINING CHALLENGE

- Communication between native and alien management/alarm systems
- Common optical design tool allowing joint network design between different platforms with predictable performance.

Cost considerations:
200G Amsterdam - Copenhagen



- 6 min/XFP
- 12 min/MUX
- 30 min/linecard
- 15 min/wave config
- 20/30 hours travel AW/REG

- Guard band neglected
- AW and native signals can co-exists (Joint design rules)
- Alarm and Management integration is possible

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Conclusion

- VPI simulation platform for alien wavelength evaluation conforms qualitatively with experimental results
- 40G PM-QPSK together with 10G NRZ shows large BER variations for varying power and guard band size
- OAM&P is adequate for this mix of products, few steps are needed for “normal operation”
- Costs is for this mix of products in favour of the AW approach

Acknowledgements

We also would like to thank SURFnet and the Gigaport3 project for their support to acquire the 40Gb/s equipment and integration work from Telindus and simulation support from CIENA.

We are grateful to NORDUnet for providing us with bandwidth and additional transponders on their DWDM link for this experiment.

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Thank you

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