4. Channel filtering and spacing

Flexible allocation of bandwidth per channel requires considering individual spectral requirements (i.e. bit-rate and modulation format) and the filter shape of the devices used for (de)muxing. In an all-optical network successive filter stages may result in a reduced end-to-end bandwidth, which may cause signal distortions with an associated power penalty [13]. On the other hand, if the allocated bandwidth is too wide for the transported channel spectral resources are wasted. In order to evaluate the effect of narrow filtering a 42.7 Gb/s RZ channel was passed through a co-centered filter. The filter bandwidth is decreased from 160 GHz down to 40 GHz while the spectrum, eye and sensitivity of the output signal are observed. Results are presented in Fig. 4(a). As the filter bandwidth is reduced the edges of the signal spectrum are attenuated. This gradually closes the eye and introduces an increasing power penalty. A 0.9-dB penalty is observed at 100 GHz filter bandwidth increasing rapidly for narrower bandwidths.

Additional considerations are required if channels are to be tightly packed e.g. 10G at 12.5-GHz spacing [14]. Here, highly selective filters are required to reduce inter-channel crosstalk. Figure 4(b) shows the performance of a 10G channel with an adjacent 10G channel at varying channel spacings demultiplexed using a WaveShaper as a filter with 10-GHz bandwidth. There is a flat region where the SNR (Q^2) shows little variation, from 50 GHz down to around 25 GHz. The penalty at 20-GHz spacing is 1 dB and increases rapidly for narrower channel spacings. Such degradation greatly depends on the selectivity of the filter used for channel (de)multiplexing; thus, it may be improved by using steeper filters. However, packing channels closer together also increases the interaction between them and may give rise to non-linear impairments such as XPM and FWM, which also constrain channel spacing.

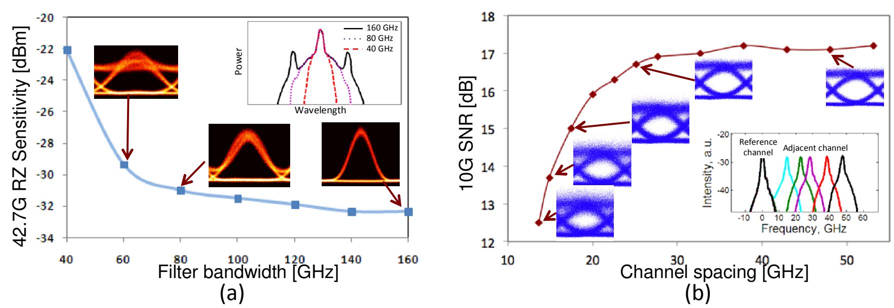

Fig. 4. (a) Filtering effects on 42.7 Gb/s RZ signal and (b) 10G SNR performance for varying channel spacings.

5. Conclusion

This paper presents results from the first gridless optical networking field trial with geographically scattered flexible-spectrum-switching nodes linked by 620-km of field installed fibres, and spectrum defragmentation functionality. We have successfully demonstrated flexible spectrum switching and transport of mixed traffic with different bit rates and modulation formats including 555G, coherent 100G and 40G, as well as intensity modulated and wavelength converted 10G and 40G signals with good end-to-end BER performance. All channels are switched and transported using custom spectrum slots to support varying bandwidth requirement and optimize utilization (e.g. 555Gb/s on a 650 GHz slot, 3 adjacent 10Gb/s signals with a 25GHz spacing).

Acknowledgments

This work is supported by the EC FP7, grant agreement No. 247674, STRONGEST and the EPSRC grant EP/I01196X: Transforming the Future Internet: The Photonics Hyperhighway. We would also like to thank Ciena, in particular, Tex Bennett, for their help and support to this work.