EVM$_{RMS}$ measurement update

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DP-16QAM transmitter quality metric

In order to enable multi-vendor interoperability, the P802.3ct draft has to define the worst case for the quality of the transmitted DP-16QAM constellation. Ideally, a single metric that is correlated with OSNR penalty in the coherent receiver for a wide variety of possible transmitter impairments is needed.

In line with work going on in ITU-T SG15 and the OIF, the metric proposed for this is EVM_{RMS}.

A second issue for interoperability is to define a suitable metric to ensure that the end-to-end optical filter function of the link does not cause an excessive OSNR penalty for the DP-16QAM signal. Spectral excursion is a candidate for this.

This contribution reports the results of some new measurements aimed at investigating the correlation between EVM_{RMS} and OSNR penalty for a variety of impairments. Also included are some previous measurement results on spectral excursion for DP-16QAM.

Previous contribution

The Ad Hoc presentation anslow_3cn_01_181025 contained:

1. Measurement results on spectral excursion for DP-QPSK

2. Measurement results on spectral excursion for DP-16QAM

3. Measurement results on EVM_{RMS} for DP-QPSK

4. Initial measurement results on EVM_{RMS} for DP-16QAM

This contribution contains items 1 through 3 above in an Annex and reports on a more complete set of measurement results on EVM_{RMS} for DP-16QAM.

Error vector magnitude

Error vector magnitude is a measure of how far each transmitted constellation point is away from the ideal reference position.
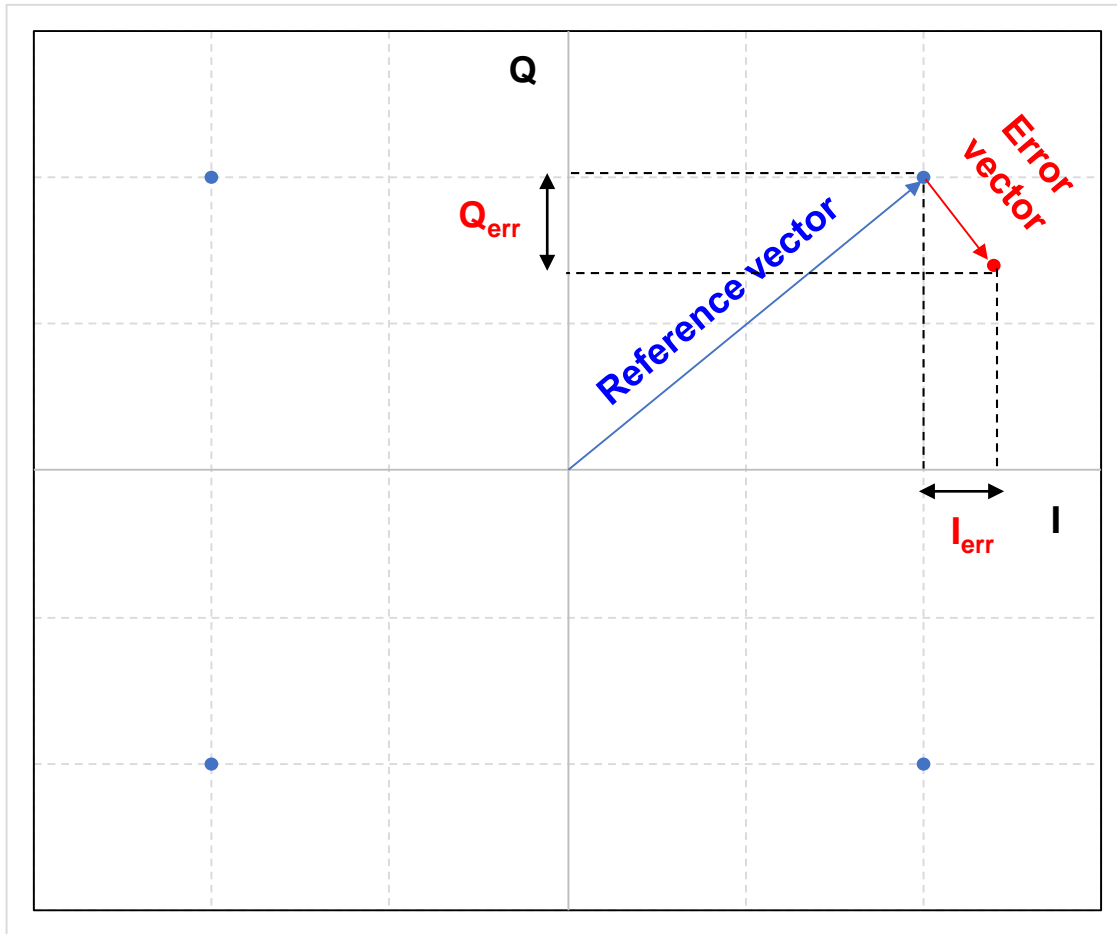
$$EVM(x) = \sqrt{I_{err}(x)^2 + Q_{err}(x)^2}$$

$$EVM_{RMS} = \frac{\sqrt{\frac{1}{N}\sum_{x=1}^{N} EVM(x)^2}}{|Ref\ vector|}$$

16QAM validation

Work in ITU-T SG15 is under way to try to extend the validation done for DP-QPSK to a similar set of impairments for the DP-16QAM modulation format.

The following slides show the constellations for DP-16QAM with the following impairments:

- Circle

- Noise

- Quadrature error

- IQ imbalance

Measurements were also done for IQ skew where the constellations look similar to the noise case.

DP-16QAM Circle impairment
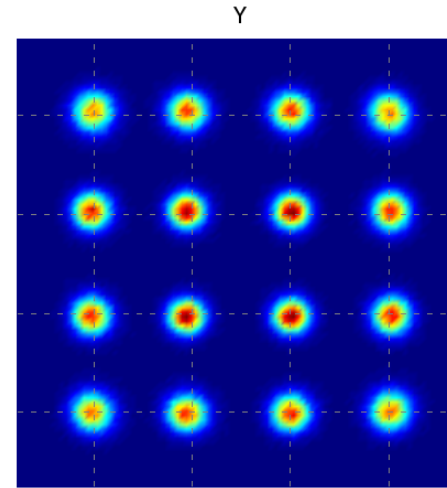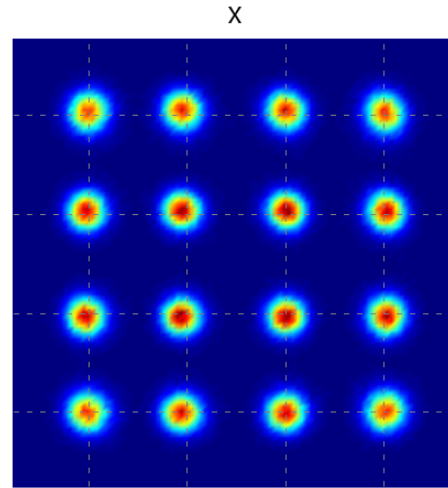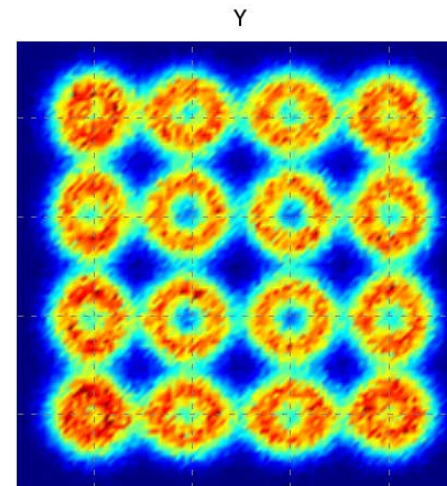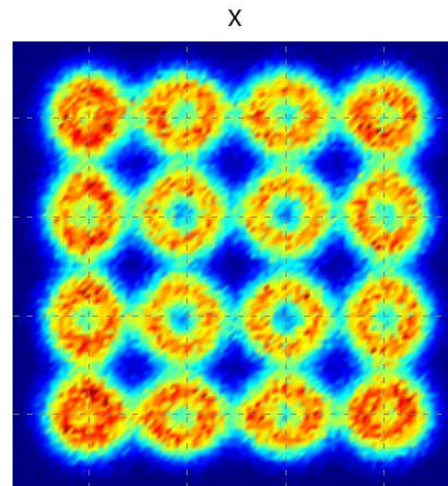
DP-16QAM Noise impairment
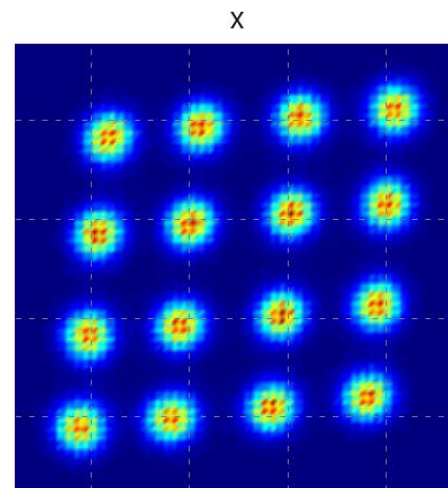
No added impairment

X

Y

Noise impairment

X

Y
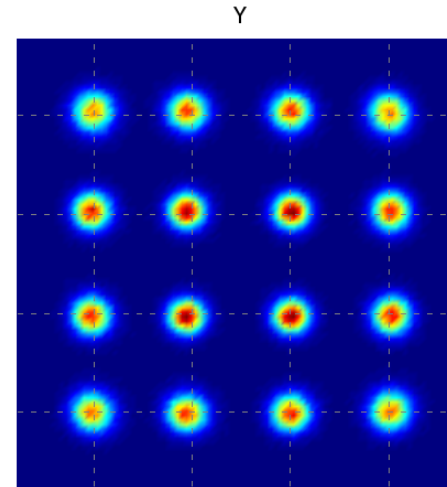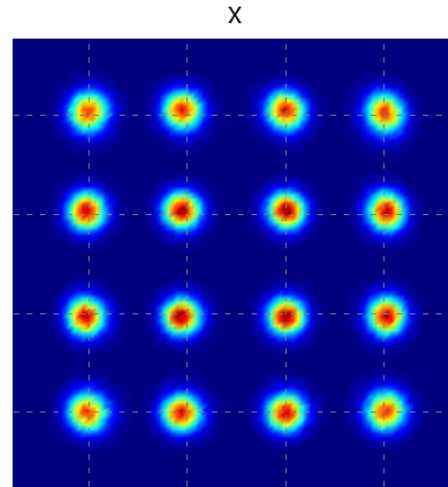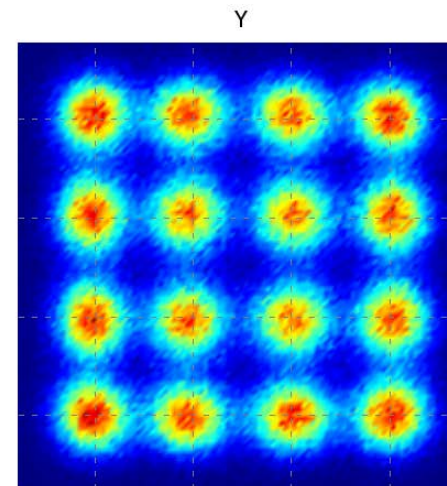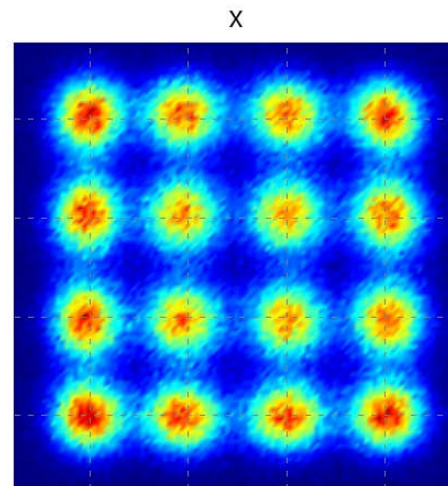
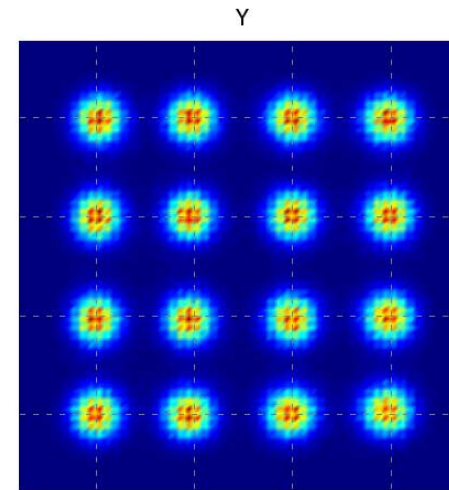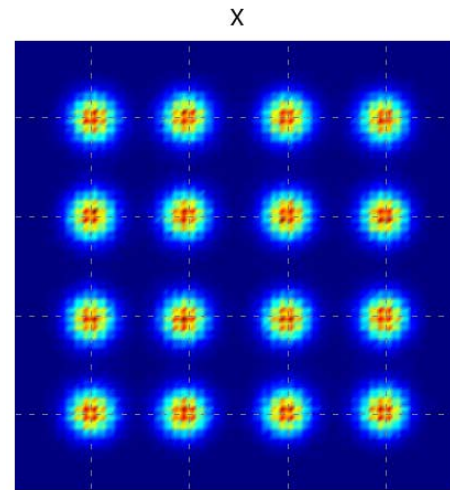# DP-16QAM Quadrature error

No added impairment

X

Y
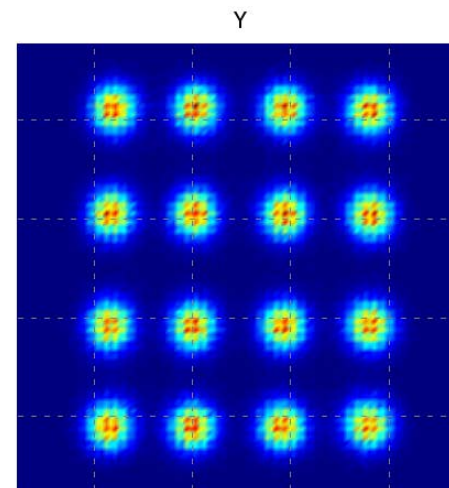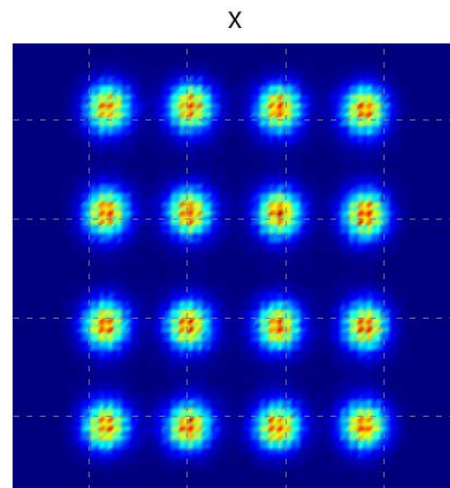
Quadrature error

X
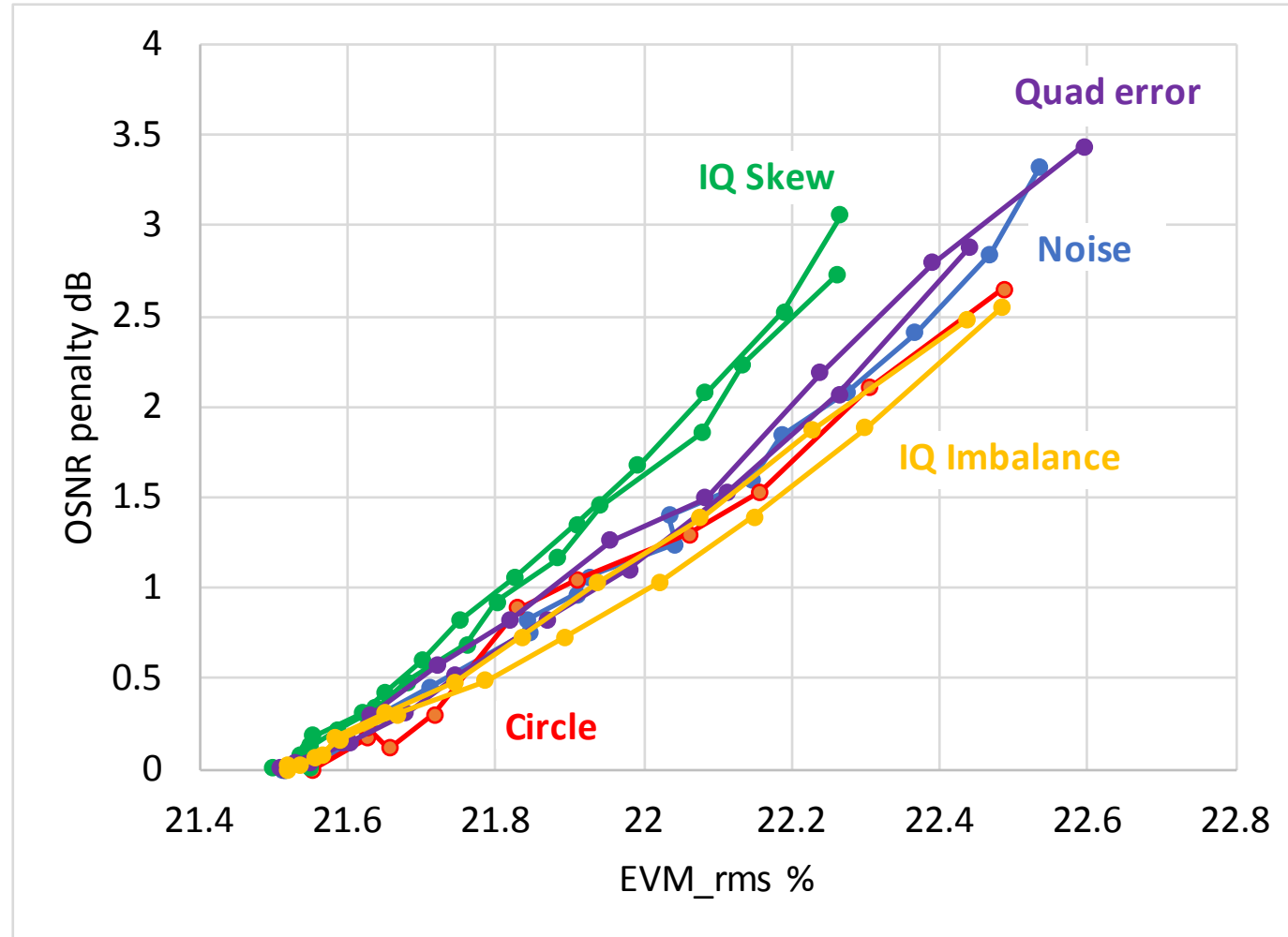
Y
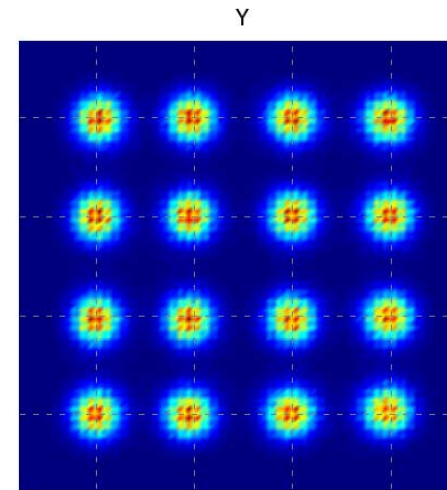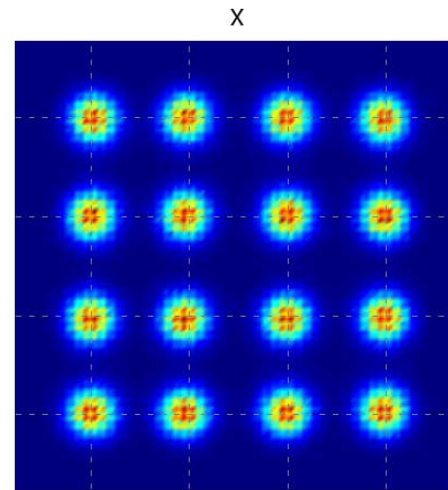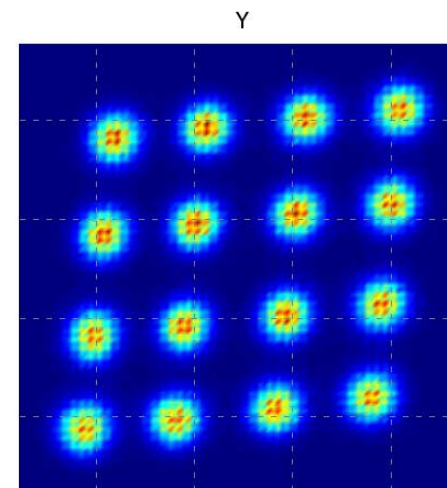
DP-16QAM IQ imbalance

No added impairment

X

Y

IQ imbalance

X

Y

DP-16QAM OSNR Penalty vs. EVM$_{RMS}$

Further work

The curves for all of the impairments shown on the previous slide have a reasonable correlation between the EVM_{RMS} metric and the measured OSNR penalty, particularly when the penalty is below 1 dB. This suggests that EVM_{RMS} is a promising candidate metric for defining the quality of a DP-16QAM constellation.

Further work is required to:

- Measure EVM_{RMS} with I-Q offset to confirm whether this has to be excluded as for QPSK.

- Measure EVM_{RMS} with a wide variety of impairments using other DP-16QAM implementations to confirm that these measurements are reproducible.

Annex

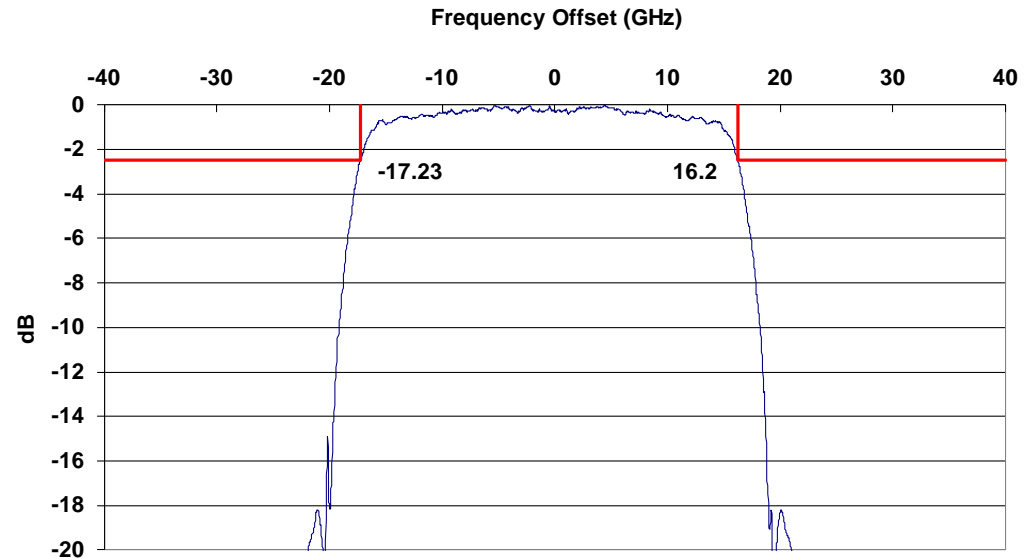# Spectral excursion

Spectral excursion investigation

To investigate the effect of a mismatch between the transmitter spectrum and the end-to-end filter function of the link, measurements have been performed where the transmitter wavelength is deliberately offset with respect to the filter function.
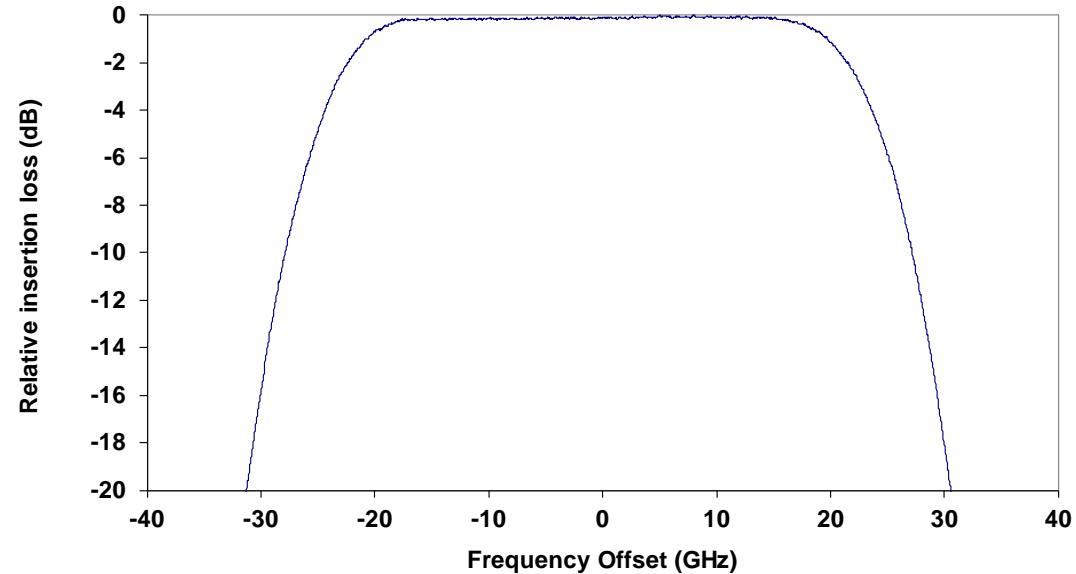
Noise

| Tx | → | **Coupler** | → | **Wavelength Selective Switch (WSS)** | → | **Rx** |
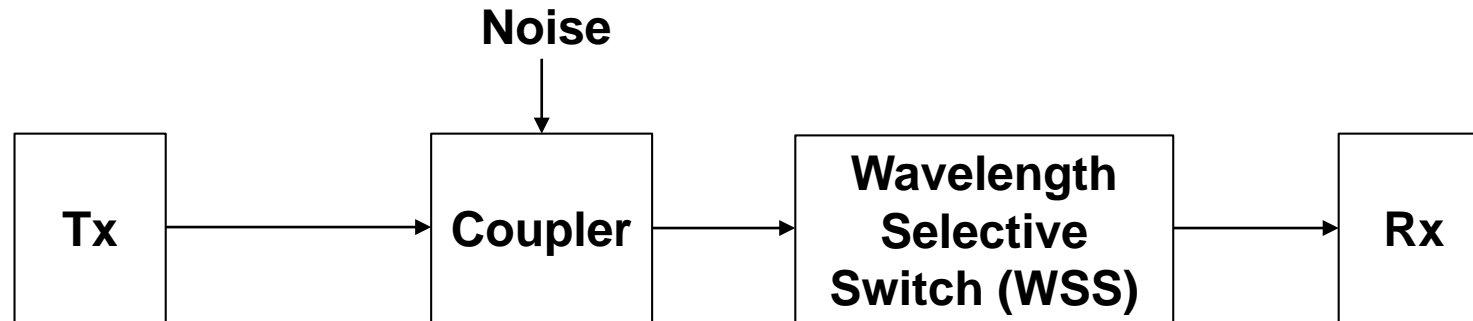
One example of this measurement for DP-QPSK is shown on the following slides.

DP-QPSK Tx spectrum and filter function

DP-QPSK transmitter spectrum

WSS filter function

DP-QPSK Spectral excursion result
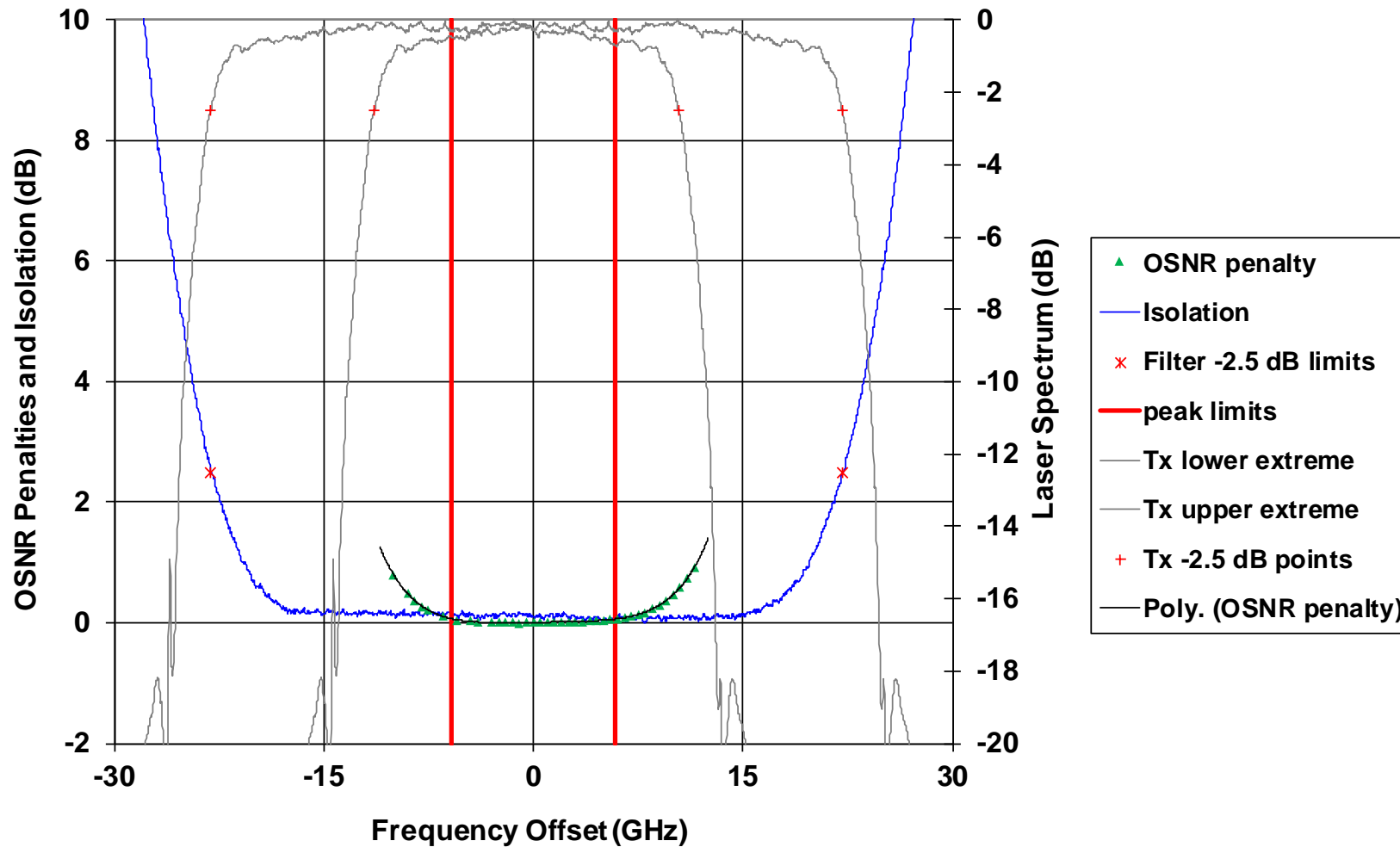
Spectral excursion criterion

This investigation was carried out with a variety of DP-QPSK implementations with the result that the spectral excursion criterion was defined to be that the -2.5 dB points of the transmitter spectrum have to remain within the same frequency bounds as the -2.5 dB points of the end-to-end filter function.
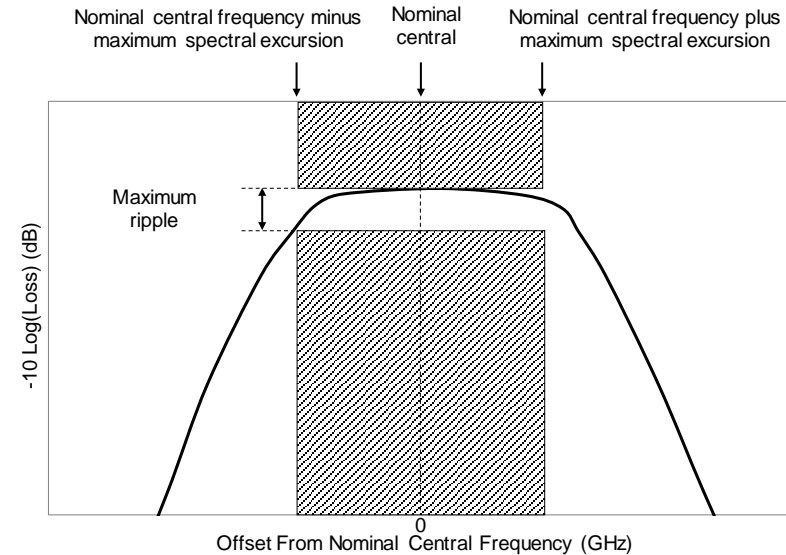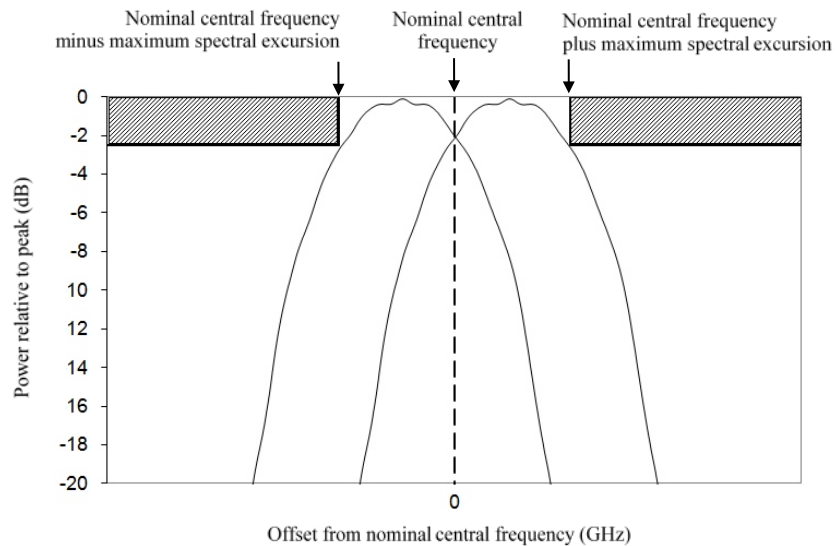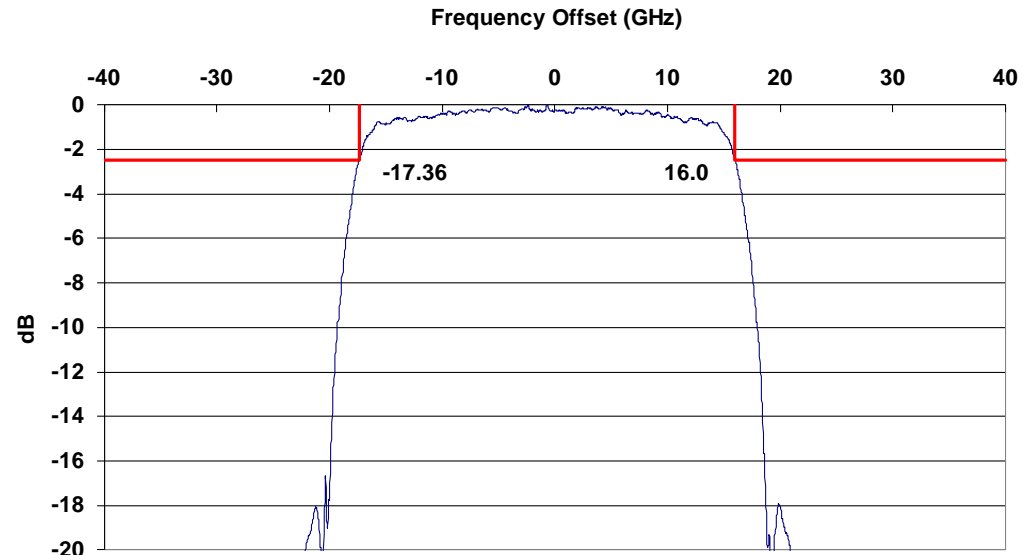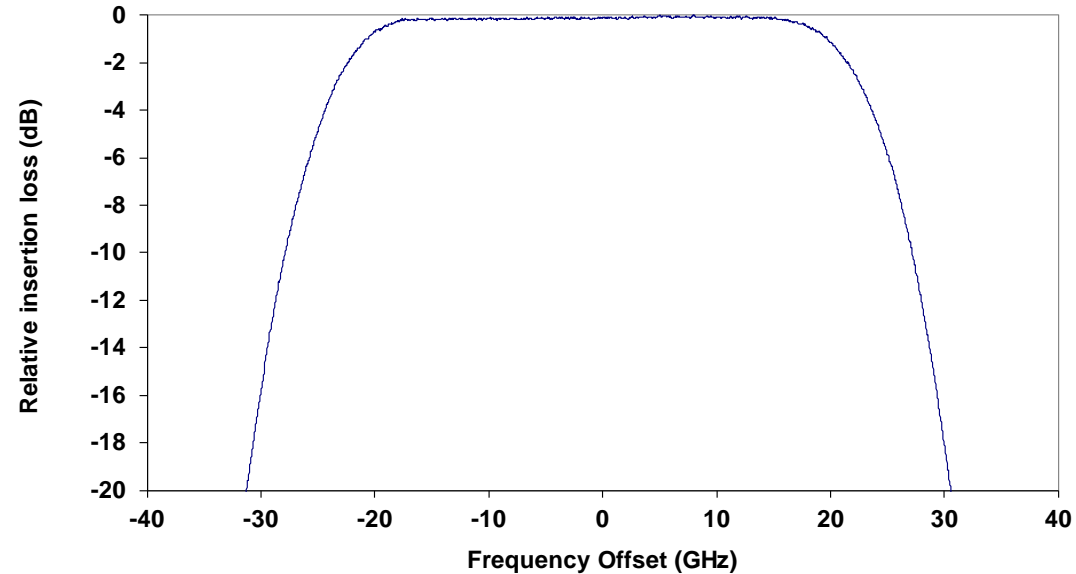
DP-16QAM spectral excursion

Having established this criterion for DP-QPSK signals, work has now started to confirm whether the same criterion can be used for DP-16QAM signals.

One example of this measurement for DP-16QAM is shown on the following slides.

DP-16QAM Tx spectrum and filter function

DP-16QAM transmitter spectrum

WSS filter function

DP-16QAM Spectral excursion result
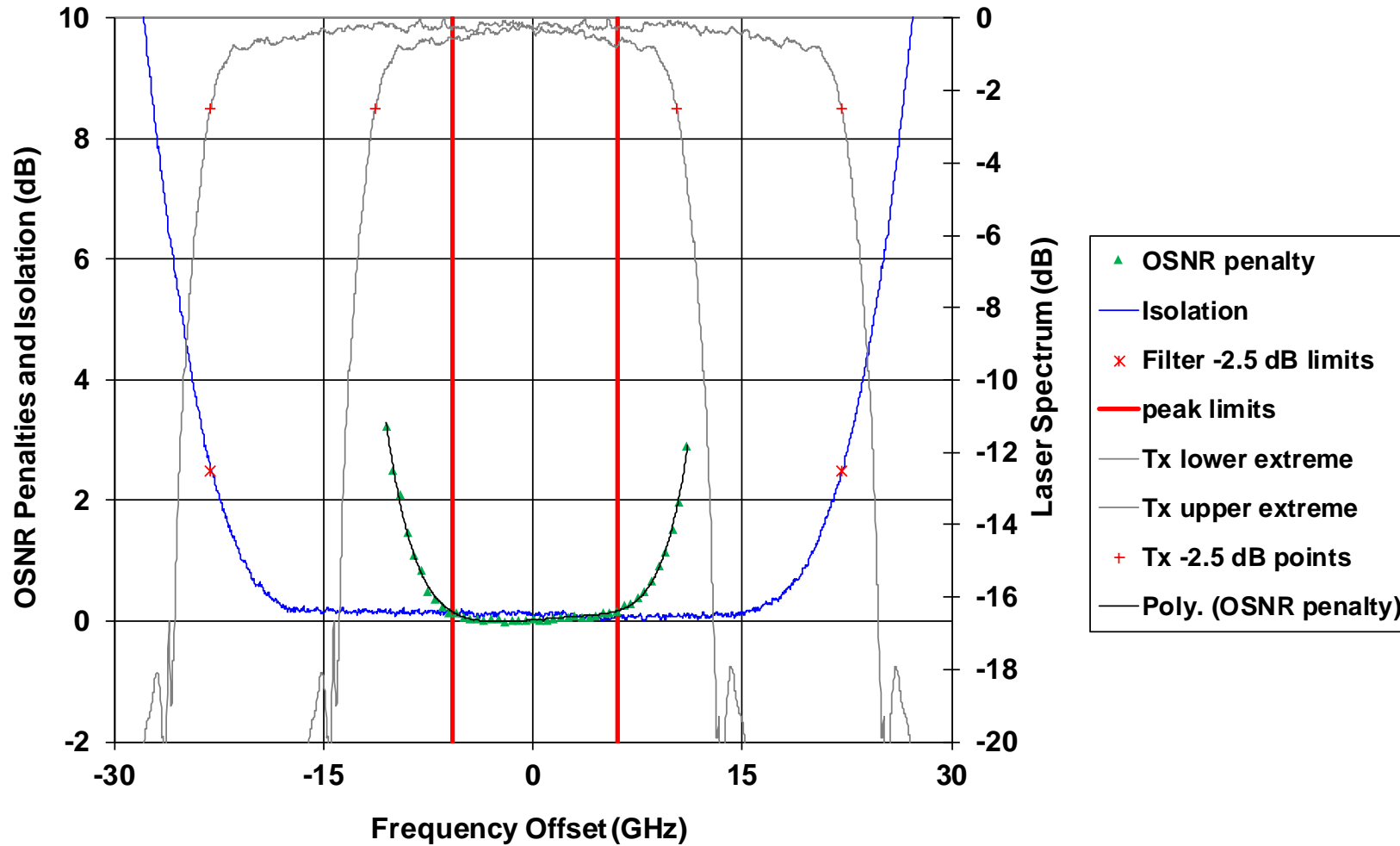
Error Vector Magnitude (EVM$_{RMS}$) for DP-QPSK

EVM$_{RMS}$ validation

A variety of measurements have been performed by ITU-T SG15 Q6 members to try to establish that there is a reasonable correlation between the EVM$_{RMS}$ metric being developed by Q6 and the OSNR penalty measured by a coherent system receiver for a variety of different impairments.

The following slides show example constellations for
DP-QPSK with the following impairments:

- Circle

- Noise

- Quadrature error

- I-Q imbalance

- I-Q offset

DP-QPSK Circle impairment

No added impairment

X

Y

Circle impairment

X

Y
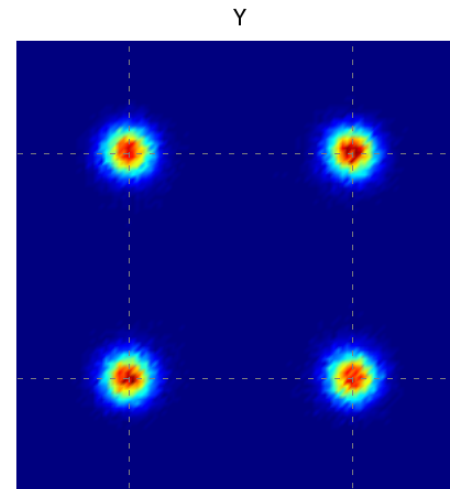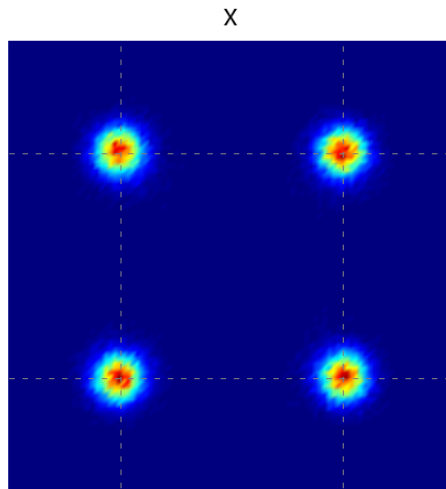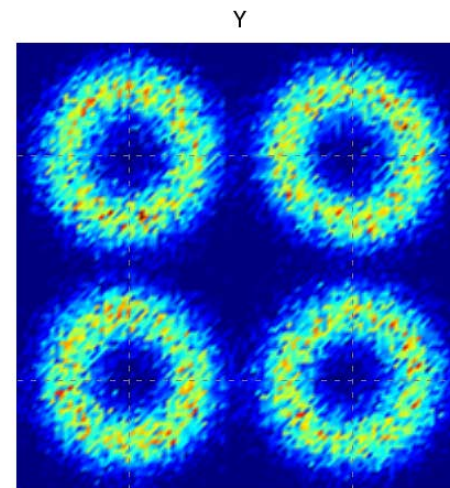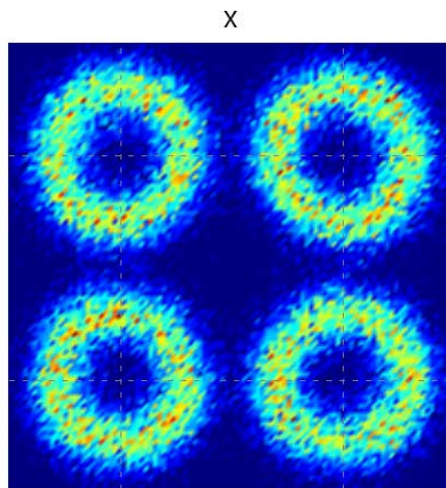
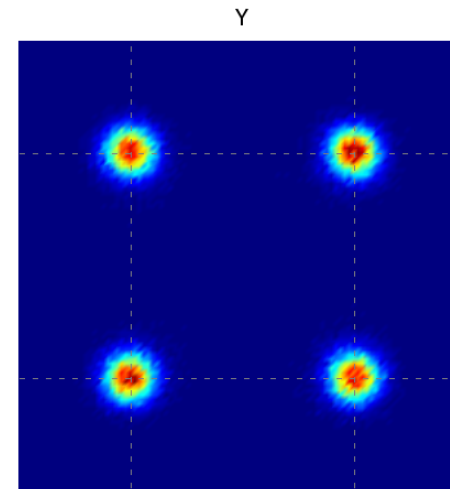# DP-QPSK Noise impairment

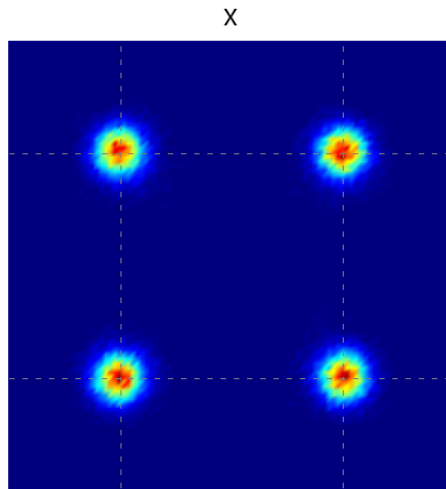**No added impairment**

X

Y

Noise impairment

X

Y
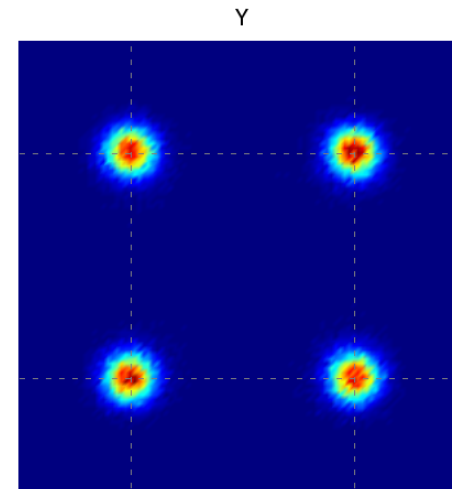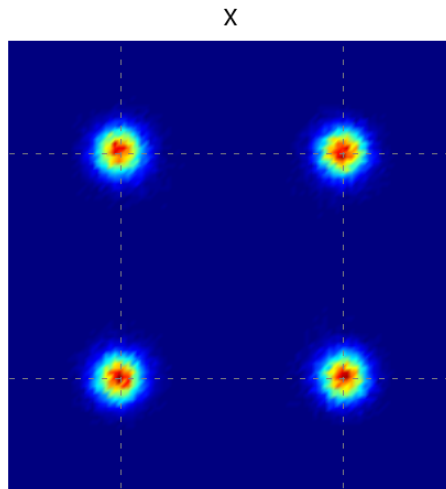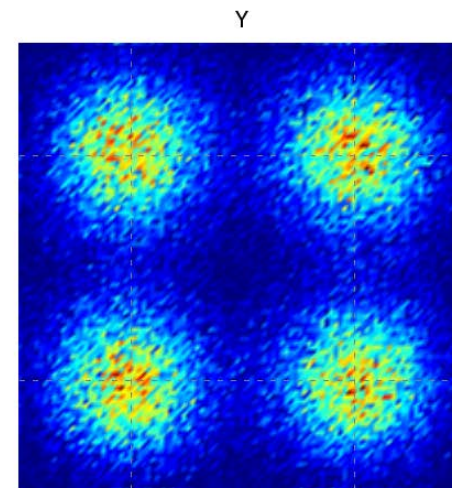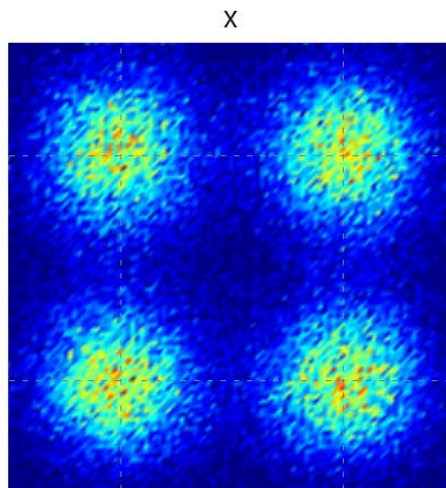
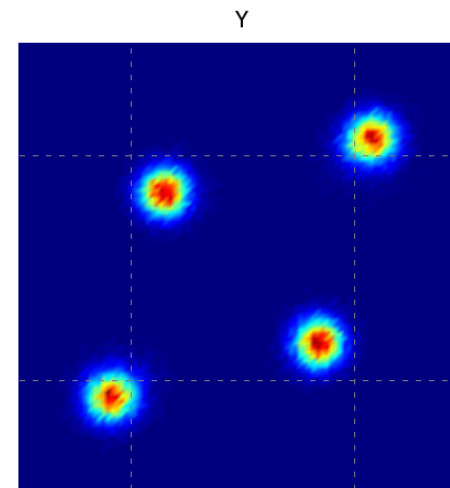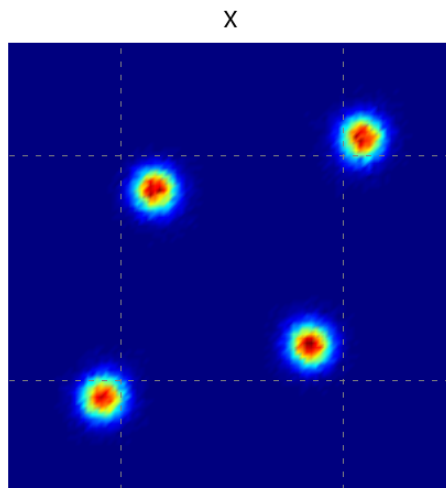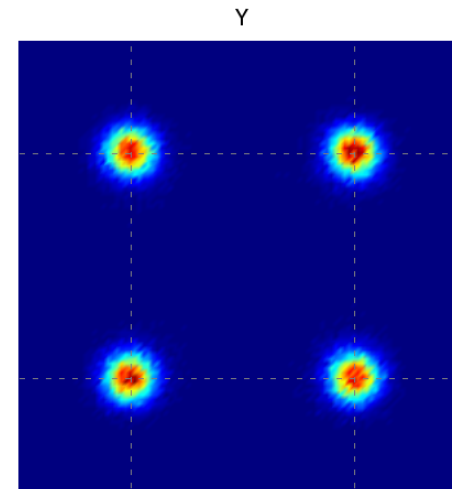# DP-QPSK Quadrature error impairment

No added impairment
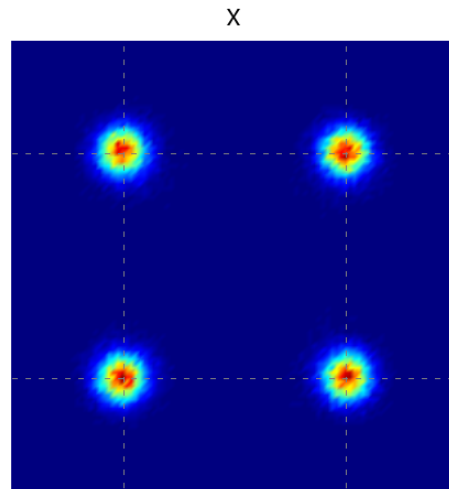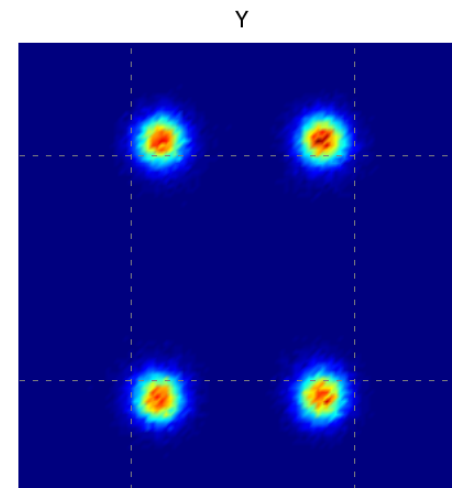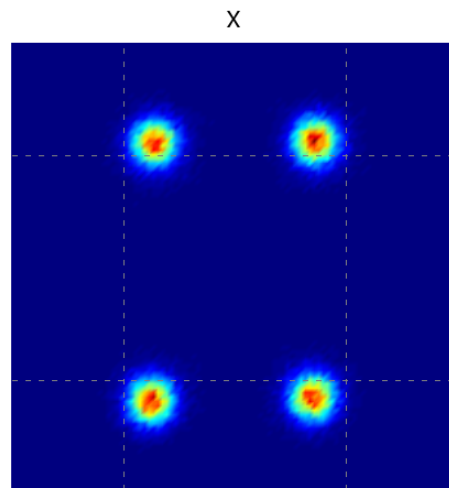
X

Y

Quadrature error impairment

X

Y

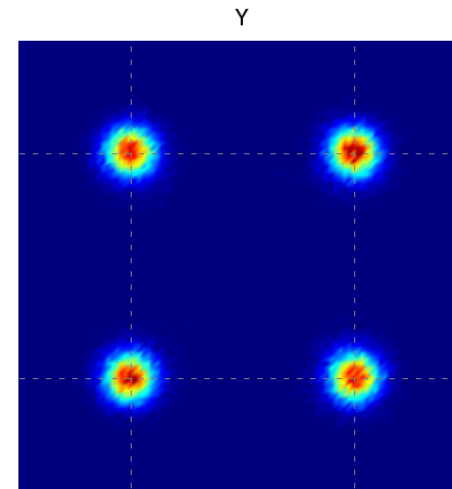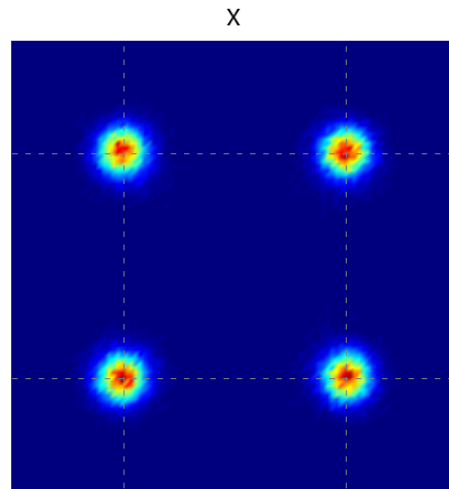# DP-QPSK I-Q imbalance impairment

No added impairment

X

Y

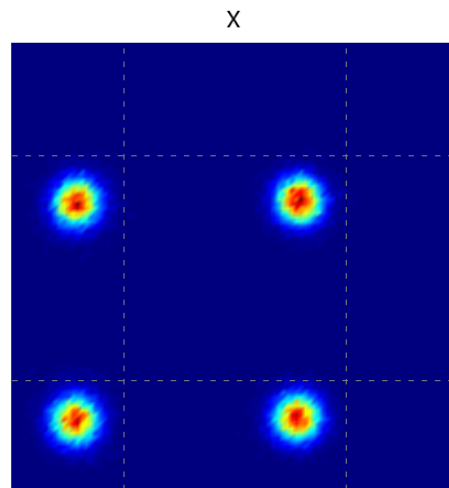**I-Q imbalance impairment**

X

Y

DP-QPSK I-Q offset impairment

**No added impairment**

X

Y

I-Q offset impairment
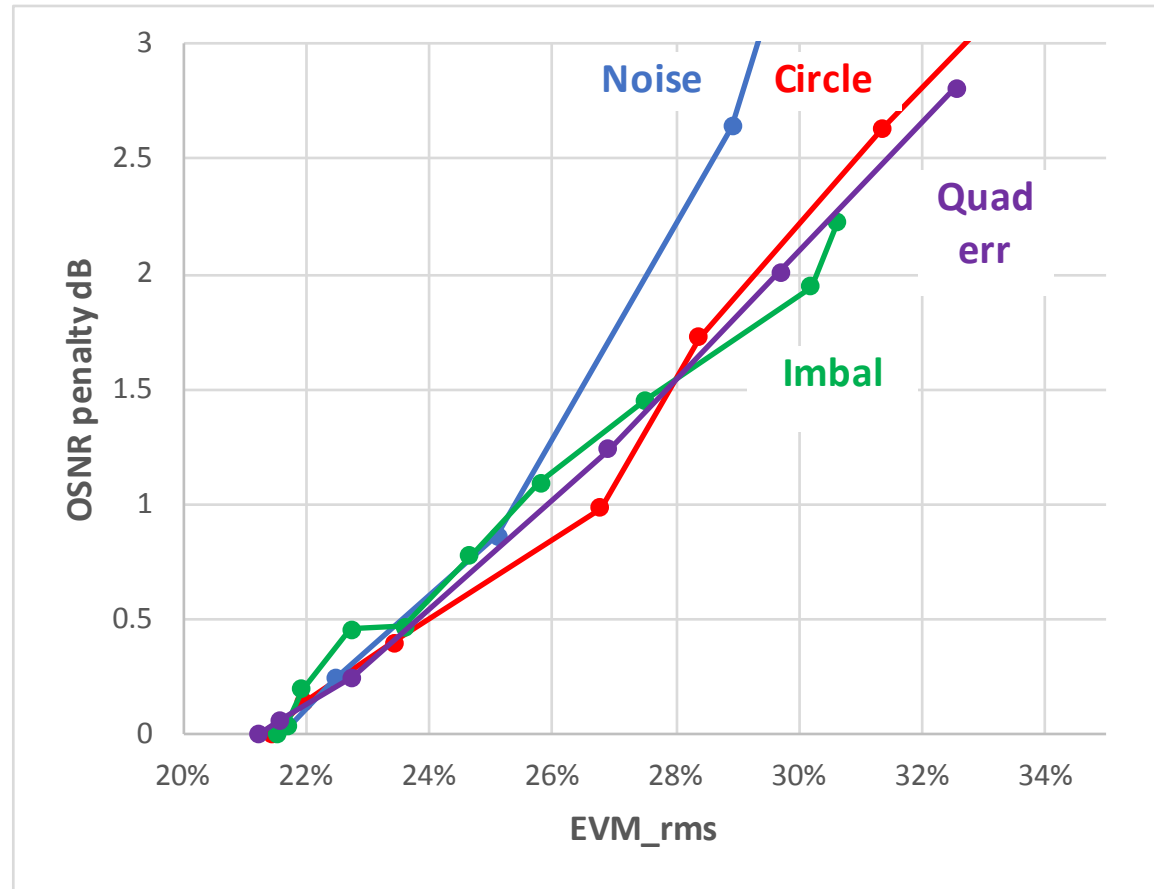
X

Y
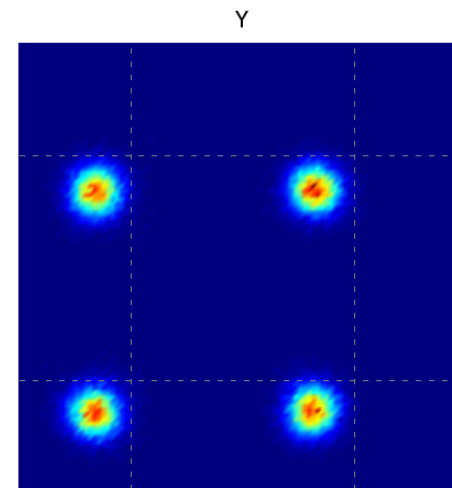
DP-QPSK I-Q offset result

While most of the impairments show a similar curve when OSNR penalty is plotted vs EVM_{RMS} the curve for I-Q offset was found to be significantly different.

Consequently, any I-Q offset is removed from the measured data prior to the calculation of EVM_{RMS} and a separate limit for I-Q offset is applied.

All of the other impairments are plotted on the next slide.
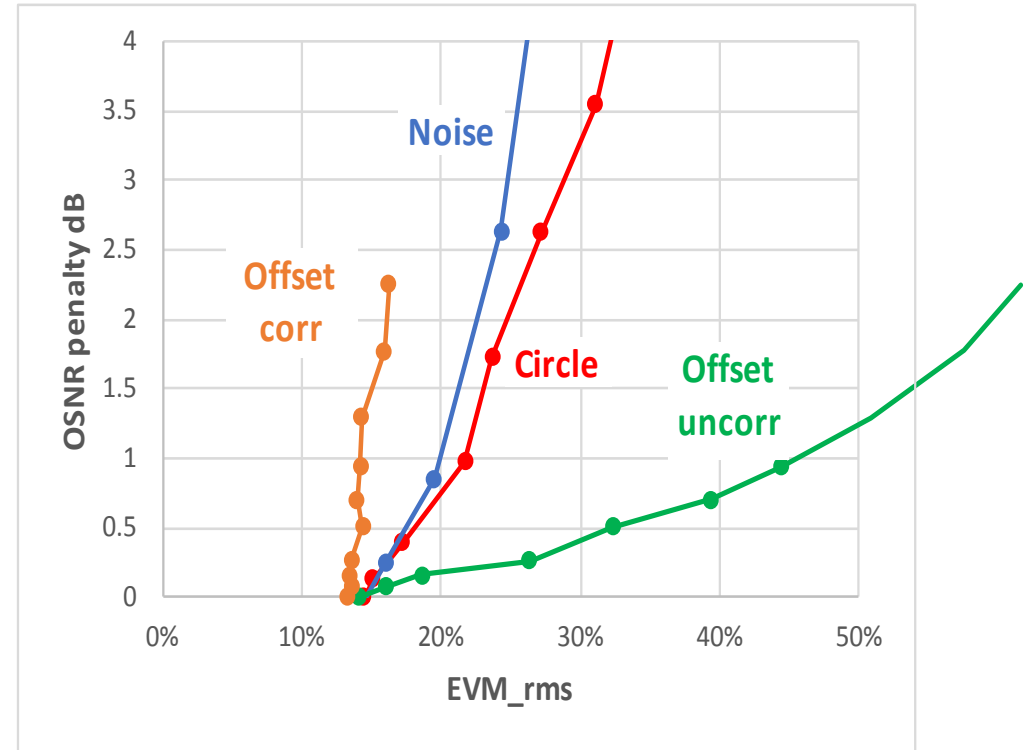
DP-QPSK OSNR Penalty vs. EVM$_{RMS}$

Thanks!