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PMD compensation in a 2´40Gbit/s, 212km, CS-RZ polarization multiplexed transmission experiment

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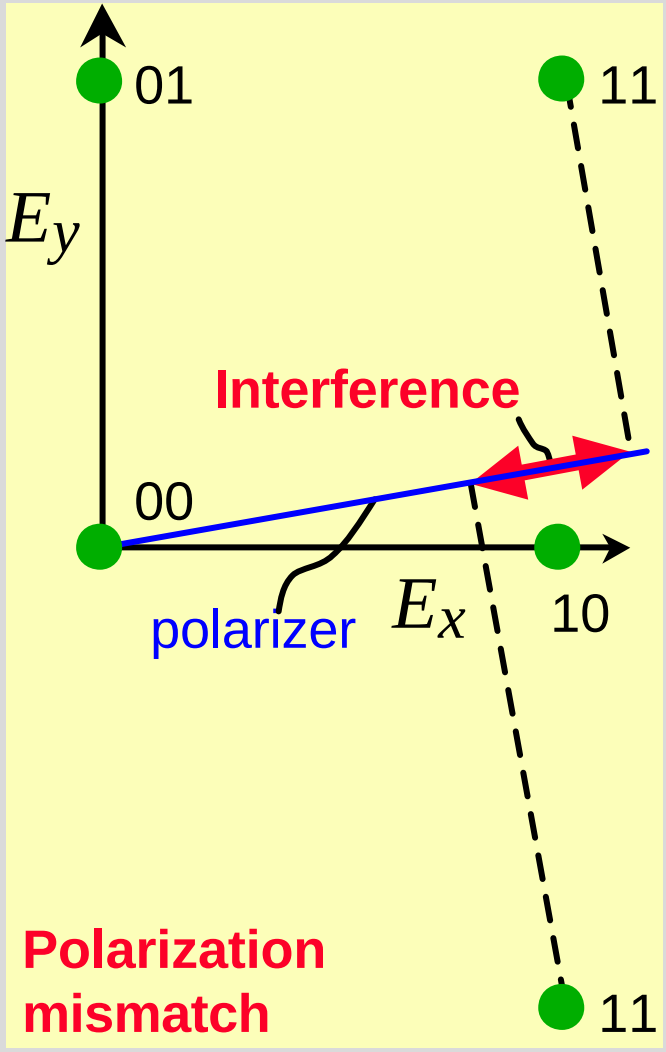
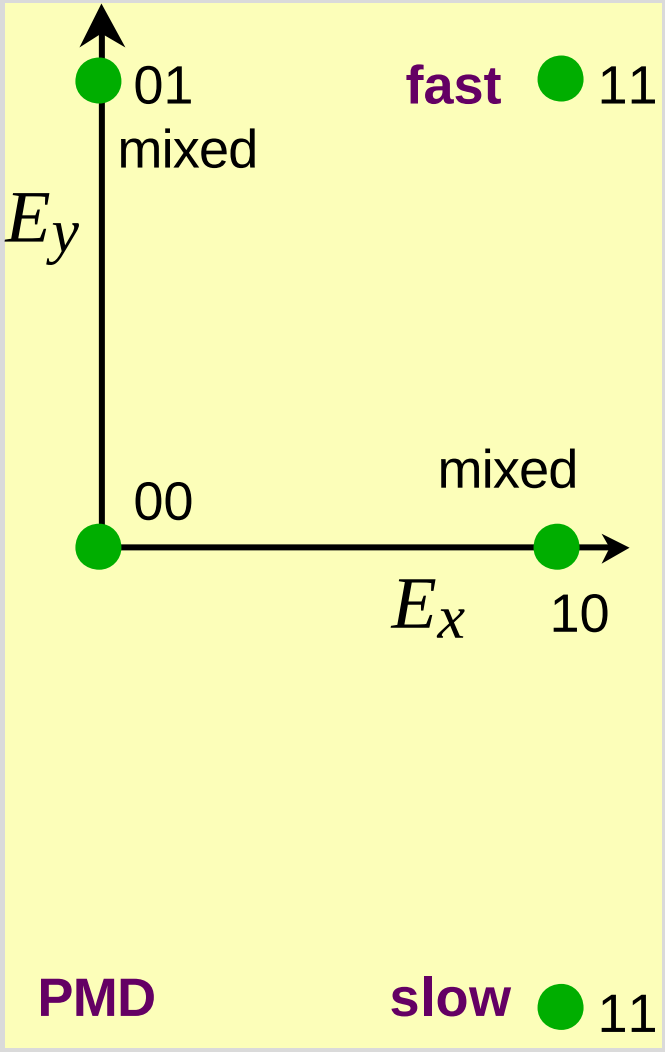
Motivation

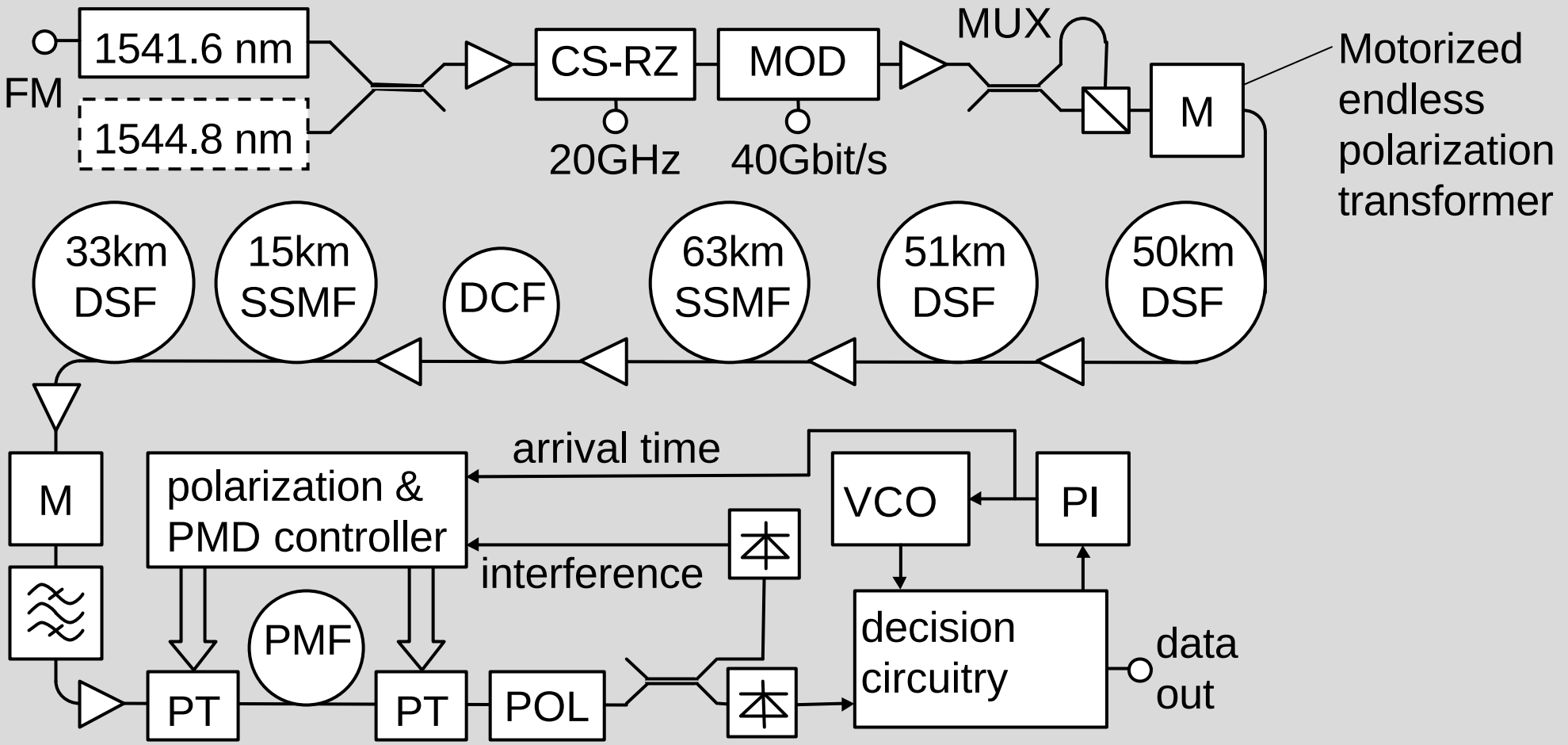
- Polarization division multiplex (PolDM) is attractive to double fiber capacity.
- DEMUX at the RX side requires endless polarization control.
- Referred to the same per-channel bit rate PolDM tolerates less PMD than standard transmission.
- PMD compensation is also required.
- No extra optics or high-frequency electronics should be needed to generate error signals.

Interference and RZ arrival time variation in the presence of interchannel phase modulation





Experimental setup

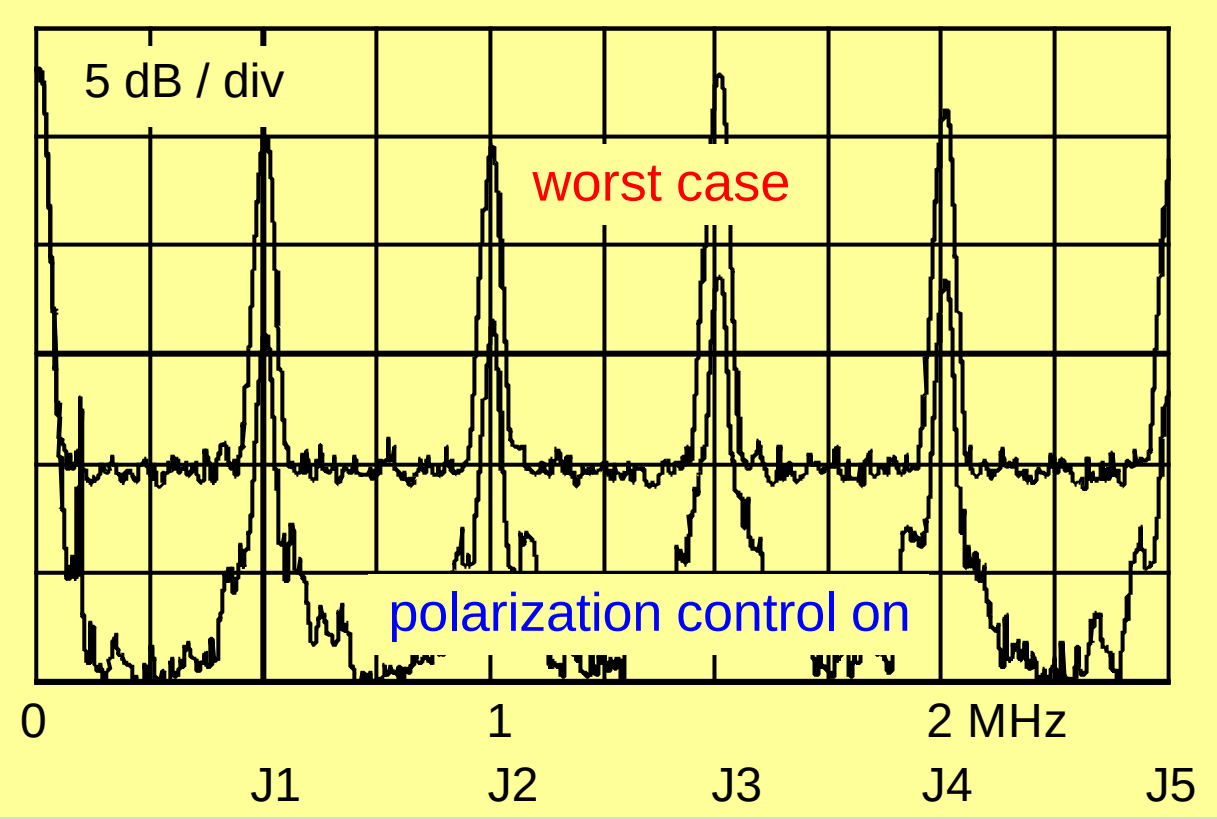


Bessel spectrum in control receiver

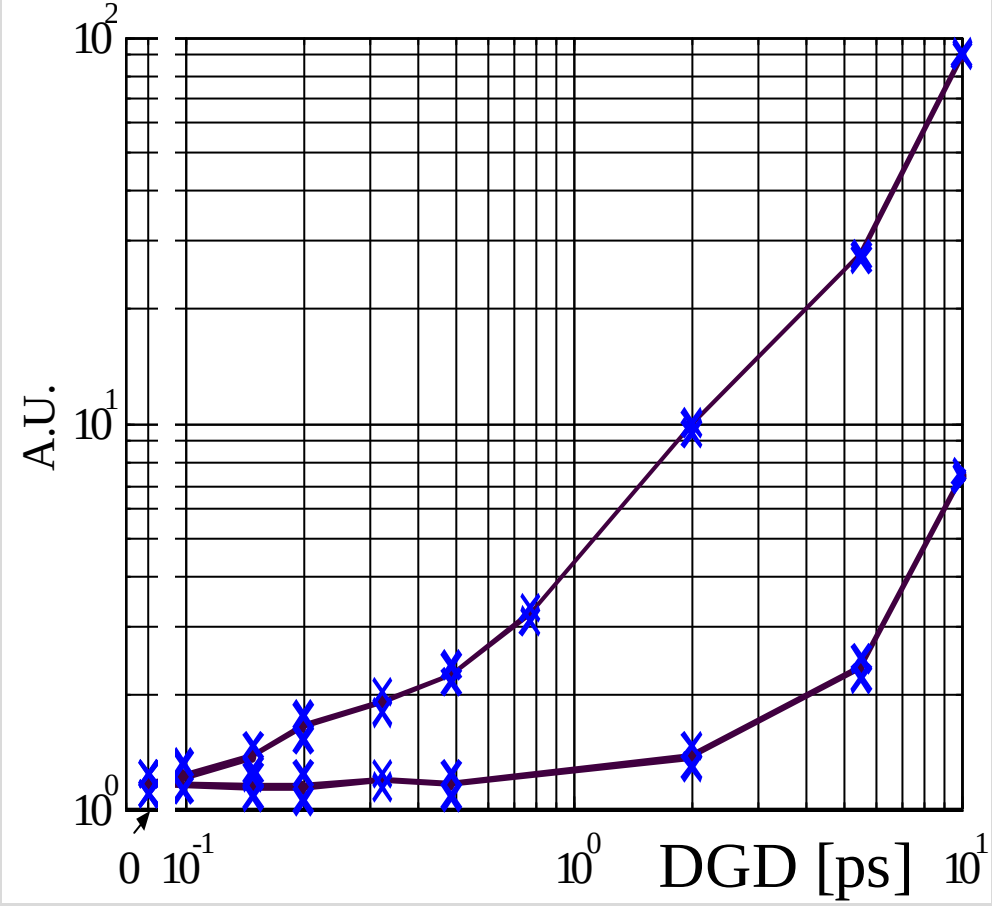
- Even vs. odd Bessel line powers fluctuate as function of mean interchannel phase difference.
- J2, J3, J4 are detected.
- Suitable power weighting makes signal independent of phase fluctuations and, to first order, of differential phase modulation index.

$$h \sim p\Delta f_{\text{peak}-\text{peak}} t = 4.2$$

240MHz 5.6ns

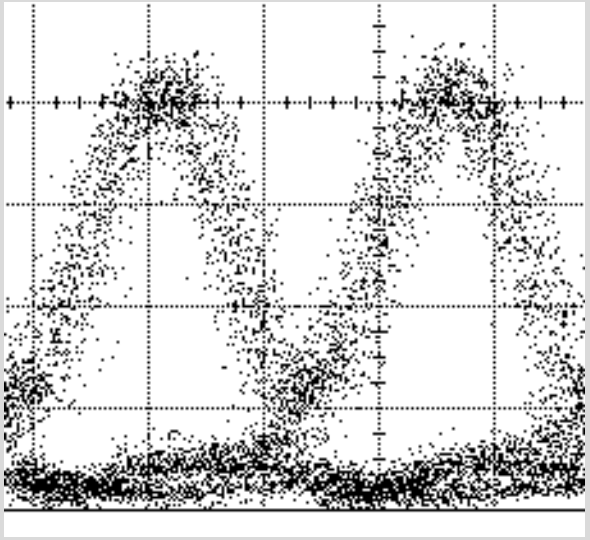


rms arrival time variation $\Delta\hat{t}_{rms}$ vs. DGD [ps]

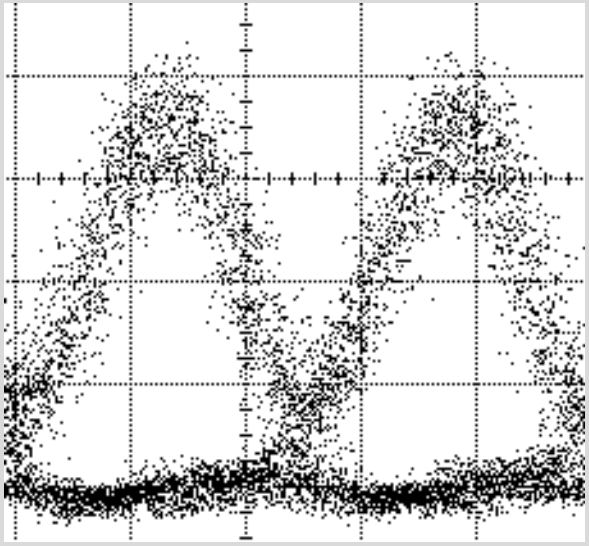


sensitivity 150fs, measured in 4.8µs

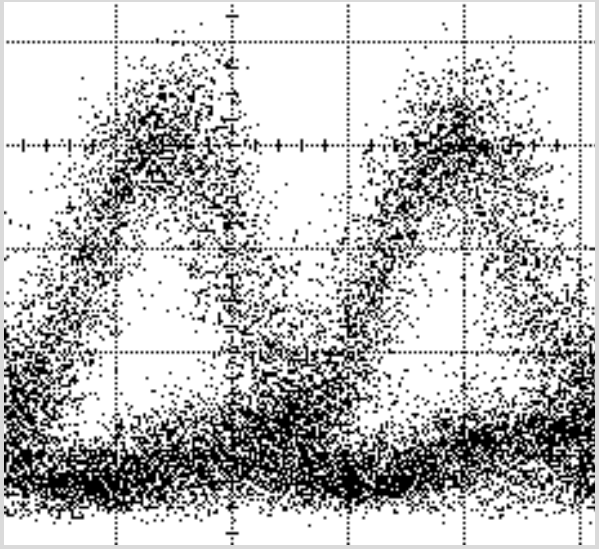
RZ PolDM eye diagrams with 212km of fiber



back-to-back

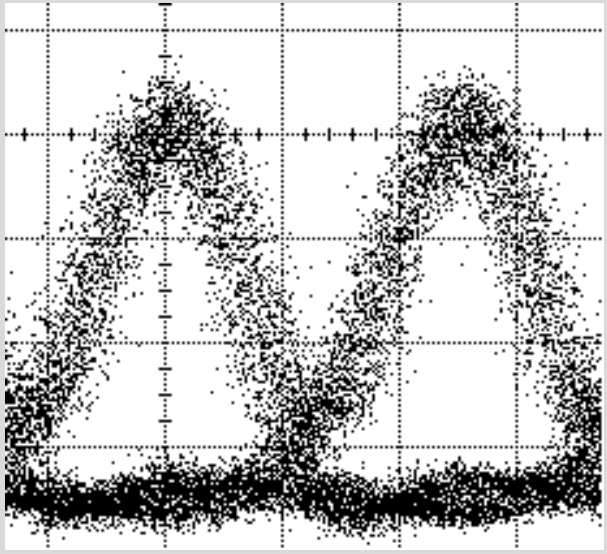


after 212km,
4ps in compensator

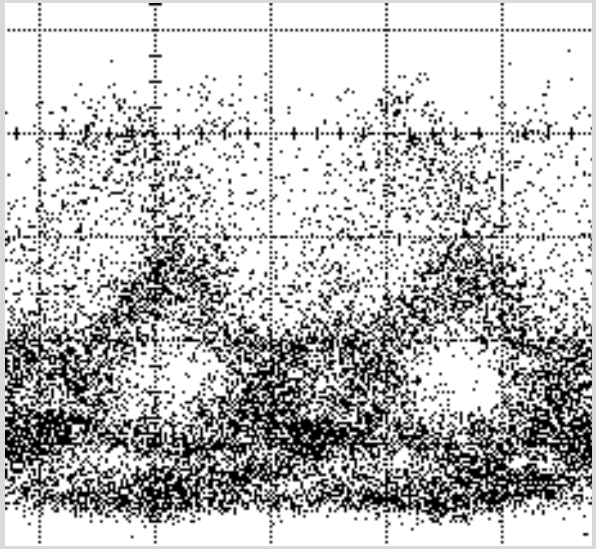


after 212km, without
PMD compensation

RZ PolDM eye diagrams with PMD emulator

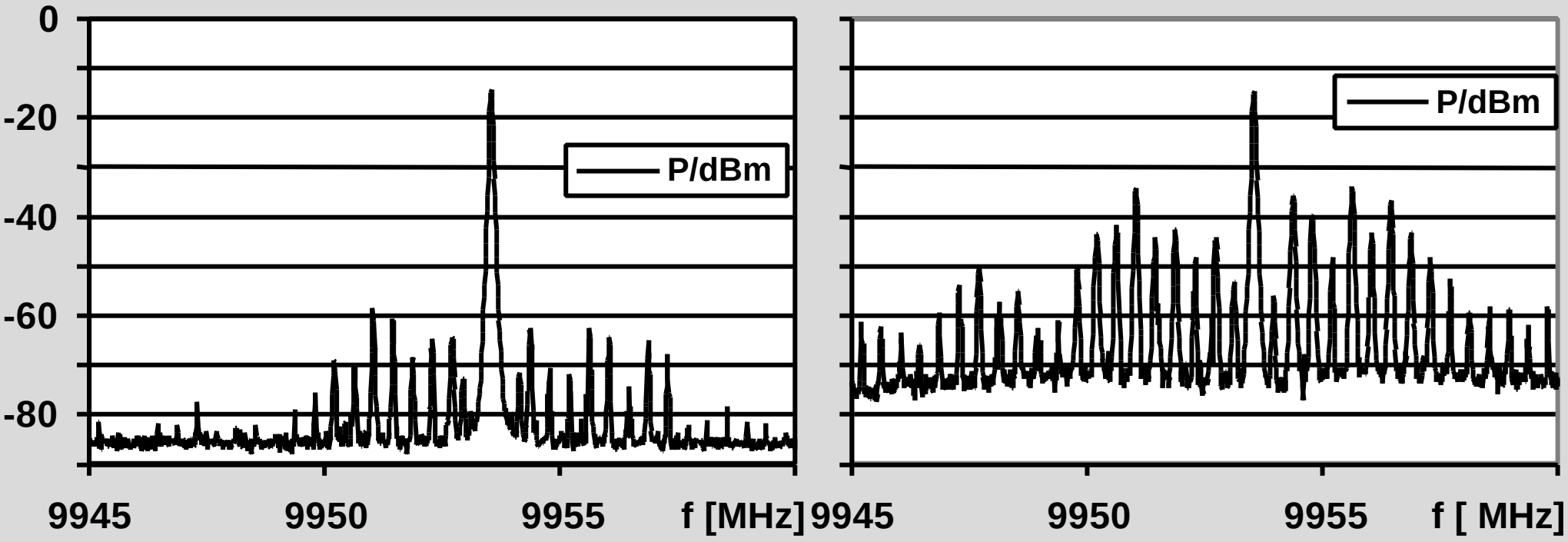


5.5ps in emulator,
5.5ps in compensator



same as left side but without PMD compensation

Prescaled clock spectra with PMD emulator



5.5ps in emulator,
5.5ps in compensator
~0.5ps residual PMD

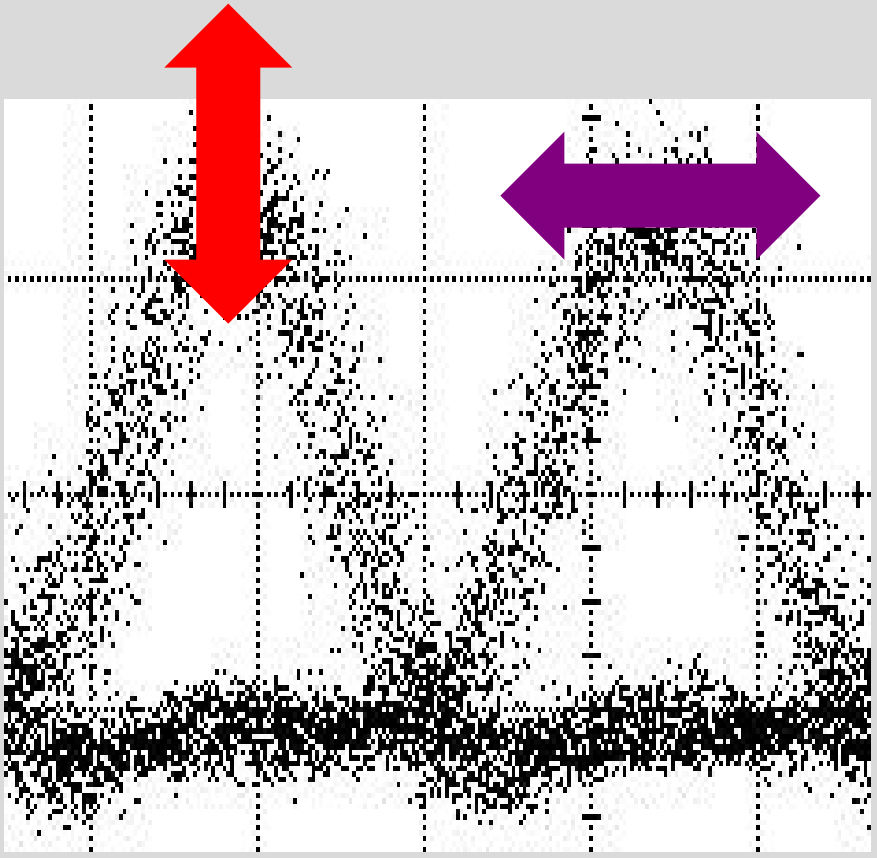
same as left side but without PMD compensation

Results

- 212km, 4ps in PMD compensator:
  - Error-free transmission over 212km in both polarization channels over 1 hour, in the presence of endless polarization changes of ~0.4rad/s
  - Additional finite polarization changes tolerable (stepper motor vibrations, manual fiber handling)
- PMD emulator, 5.5ps in PMD compensator:
  - 0, 2, 4, 5.5 and 6ps of DGD tolerated error-free, including endless polarization changes
  - Without PMD compensation transmission was error-free for 0 and 2ps, but not for ≥4ps.

Effects on RZ PolDM signals in the presence of interchannel phase modulation

Polarization mismatch



PMD

Summary

- 2×40Gbit/s CS-RZ polarization division multiplex transmission
- 212km of DSF + SSMF (+ DCF)
- Endless polarization control using interference detection scheme
- PMD compensation using arrival time detection scheme