

100G Research Consortium

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 **ADVA**TM
Optical Networking

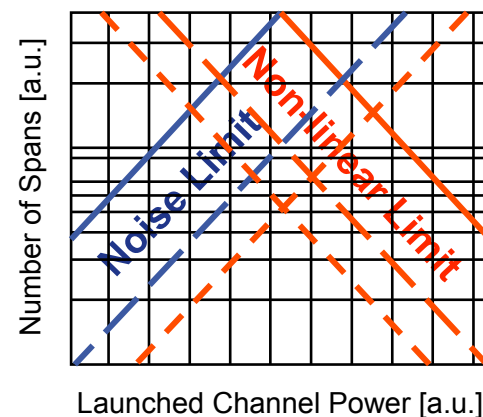
100G Development Status

- ▶ 100G Research fueled by
 - ▶ Increase in transmission capacity
 - ▶ High-bandwidth applications
 - ▶ New formats for HD video
 - ▶ Special applications: science, grid computing, others
- ▶ Numerous papers published at recent Optics conferences
- ▶ Standardization work in progress: IEEE, OIF, ITU-T
- ▶ Development underway
 - ▶ Electronics: amplifiers, A/D converters,...
 - ▶ Opto-electronic components: integrated modulators, receivers
 - ▶ Transponder modules



100G Transport Challenges

- ▶ For same reach and modulation format as 10Gb/s
 - ▶ 10dB OSNR penalty
 - ▶ 100x higher impact of GVD
 - ▶ 10x higher impact of PMD
 - ▶ More degradations by fiber nonlinearity
 - ▶ Incompatibility to optical filters and channel grid
- ▶ Serial transmission (100GbE per λ) expected to win on long term
- ▶ Needs advanced modulation, FEC, electronic signal processing
- ▶ *Likely different interface variants for metro and core*



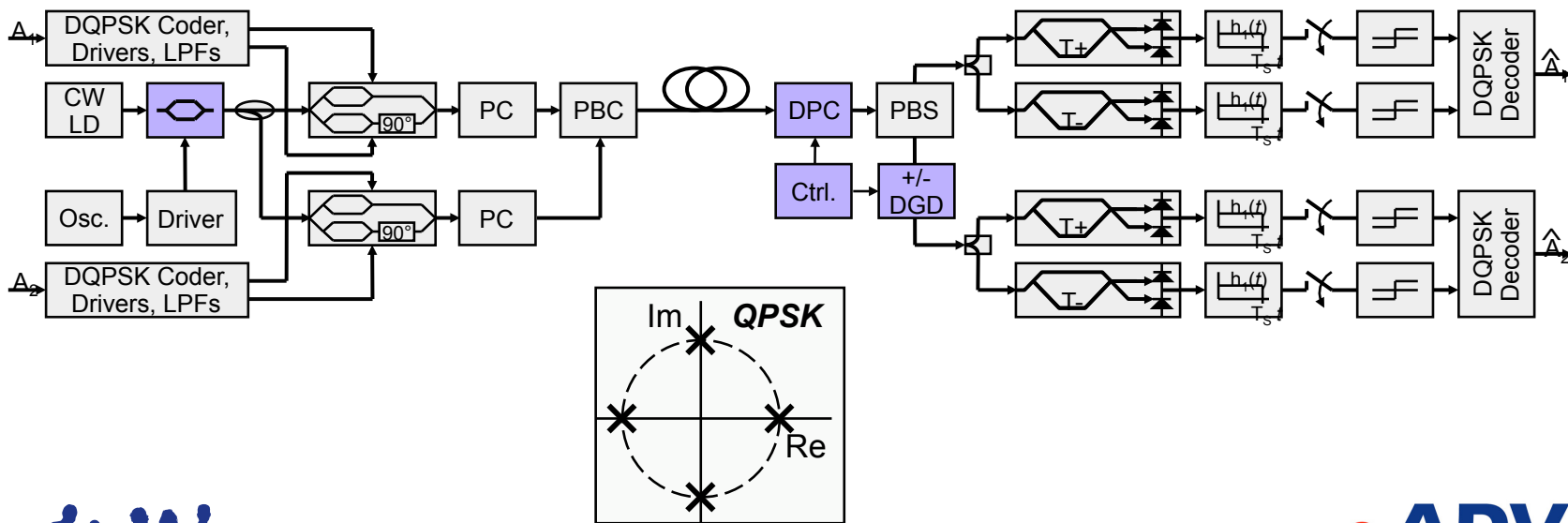
100G Research Status

- ▶ Mostly “hero” experiments – carefully managed test conditions
- ▶ Oscilloscope and PC instead of real receiver
- ▶ Impact of imperfect optical and electronic components not known
- ▶ Most avoid ROADMs
- ▶ Use SMF or dispersion-managed fiber
 - ▶ Impact of fiber parameters (dispersion, higher-order dispersion, mode-field diameter)
- ▶ Few studies dedicated to specific impairments at 100G
- ▶ Simulations to match experiments?



100G Modulation Format

- ▶ Use PM DQPSK modulation format
 - ▶ Narrow bandwidth, high noise tolerance, good PMD tolerance, less demanding on electronics
- ▶ Likely candidate for high capacity, long-reach 100G transmission under realistic network conditions
- ▶ Baseline for other modulation formats



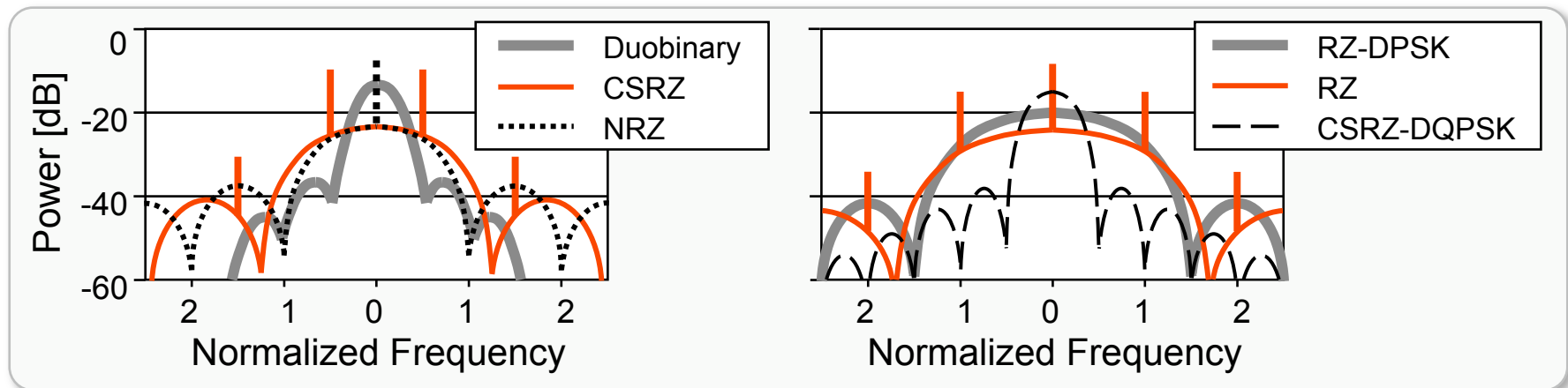
DWDM System Research Goals

- ▶ Develop test bed for 100G transmission
- ▶ Experiments matched by simulations
- ▶ Study 100G transmission under realistic network conditions
 - ▶ ROADMs
 - ▶ Different fiber types
 - ▶ Nonlinear effects
 - ▶ Dispersion maps
 - ▶ Polarization effects
 - ▶ Higher-order impairments



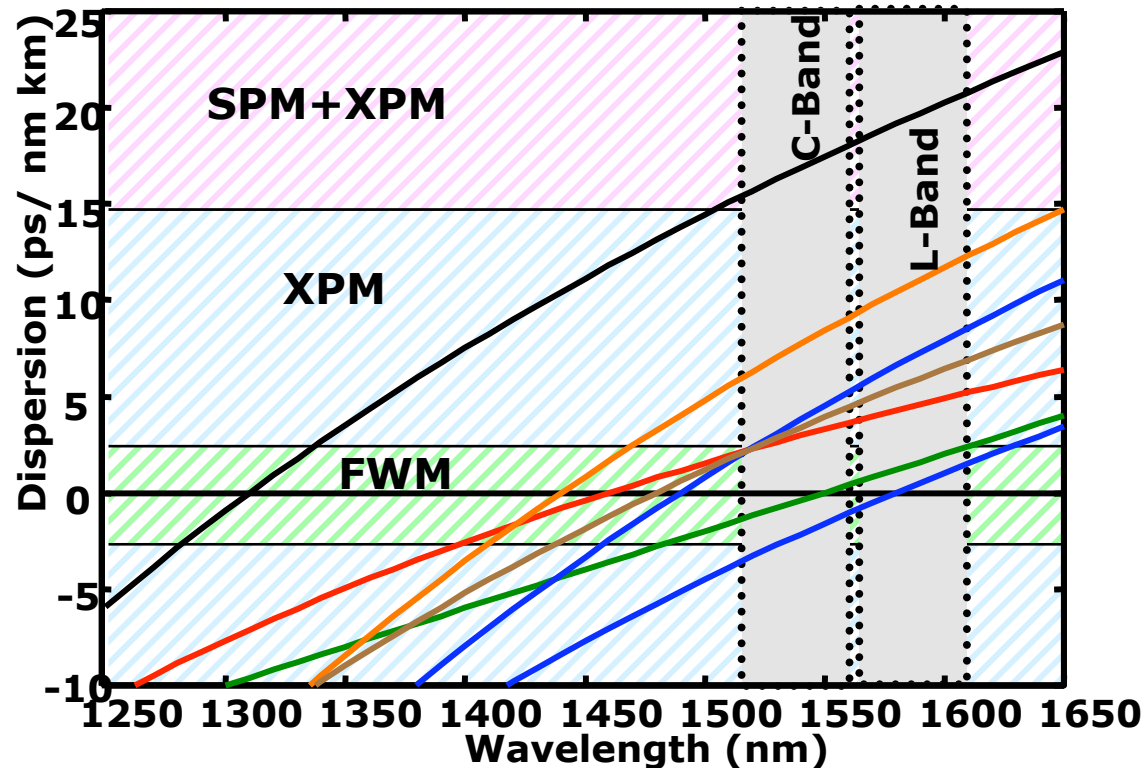
100G with ROADMs

- ▶ Pol. Mux. DQPSK – 27G symbol transmission rate – using today's ROADMs looks feasible
- ▶ Impact of existing ROADMs on 100G transmission
 - ▶ Passband width, amplitude and phase ripple
- ▶ New ROADM requirements for optimization of 100G propagation



Dependence on Fiber Type

- ▶ Networks use a variety of fiber types with different parameters
 - ▶ dispersion, dispersion slope, mode-field diameter, Raman gain coeff.



Standard Single Mode Fiber (SSMF)

Alcatel TeraLight

**Corning LEAF
Pirelli FreeLight**

OFS TrueWave

OFS TrueWaveRS

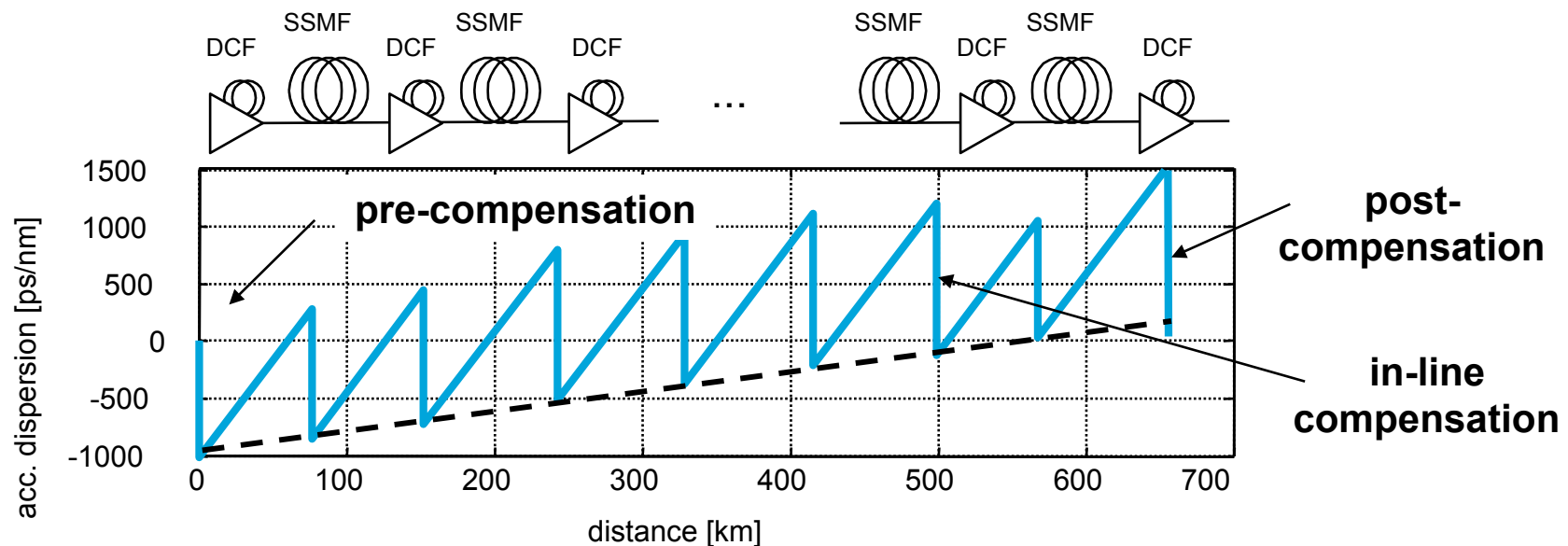
Dispersion Shifted Fiber (DSF)

Corning LS



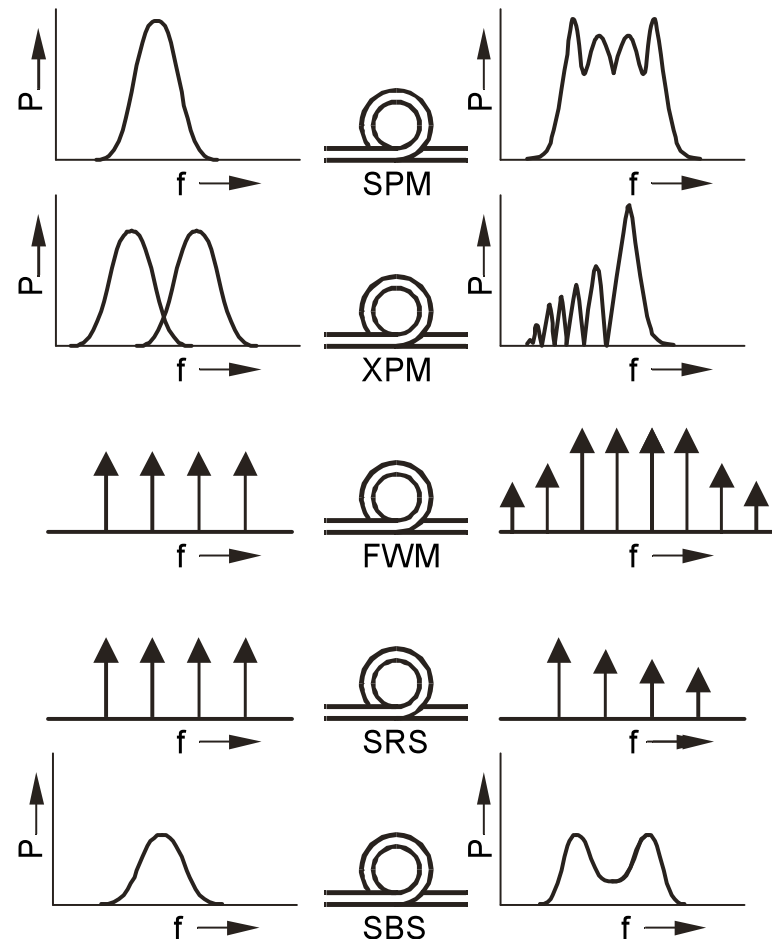
Dispersion Management

- ▶ Impact of DCM distribution along the optical path
- ▶ Determine optimum dispersion maps for 100G
- ▶ Tolerance to dispersion map variations
- ▶ Compatibility with existing dispersion maps used for 10G and 40G



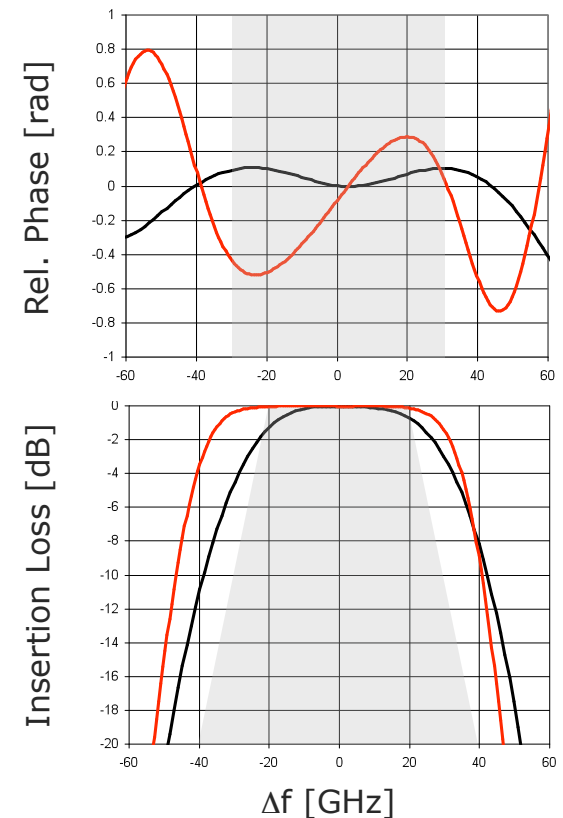
Nonlinear Fiber Effects

- ▶ Impose limitations on
 - ▶ Span distance
 - ▶ Total reach
 - ▶ Number of wavelengths
 - ▶ Wavelength spacing
 - ▶ DCM distribution
- ▶ Impact of 40G channels
- ▶ Combined effects:
 - ▶ Polarization + nonlinear
- ▶ Need analytical or empirical models for network design



Higher-order Distortion at 100G

- ▶ At 10 Gb/s and 40 Gb/s, transmission is mainly constrained by first-order effects (CD, PMD, NL)
- ▶ At >40 Gb/s, effects within the signal spectrum become important (intra-signal distortions)
 - ▶ Higher-order Chromatic Dispersion
 - ▶ Higher-order PMD
 - ▶ Wavelength-dependent attenuation
 - ▶ Intra-signal Raman scattering



Thank you

ADVANCE

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