Statistics of CD Parameters Modeling and Experiments

Jose Castro

jmca@panduit.com

Panduit
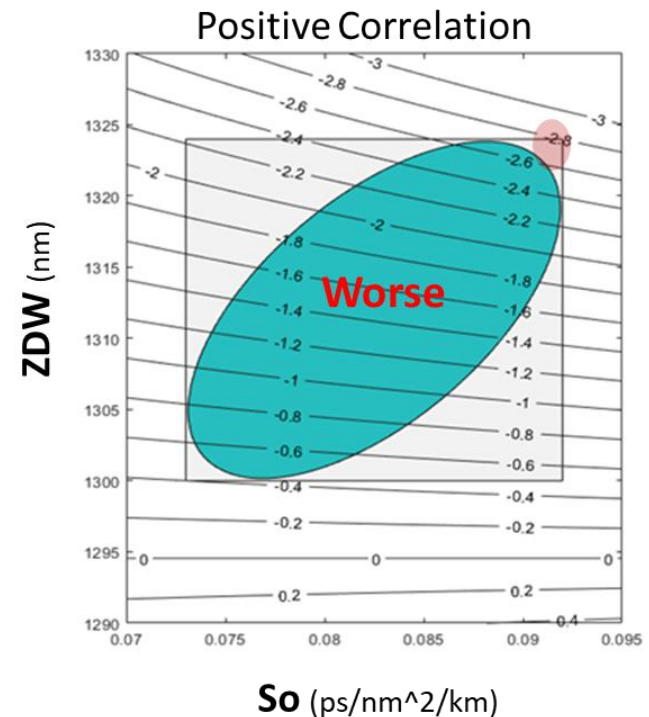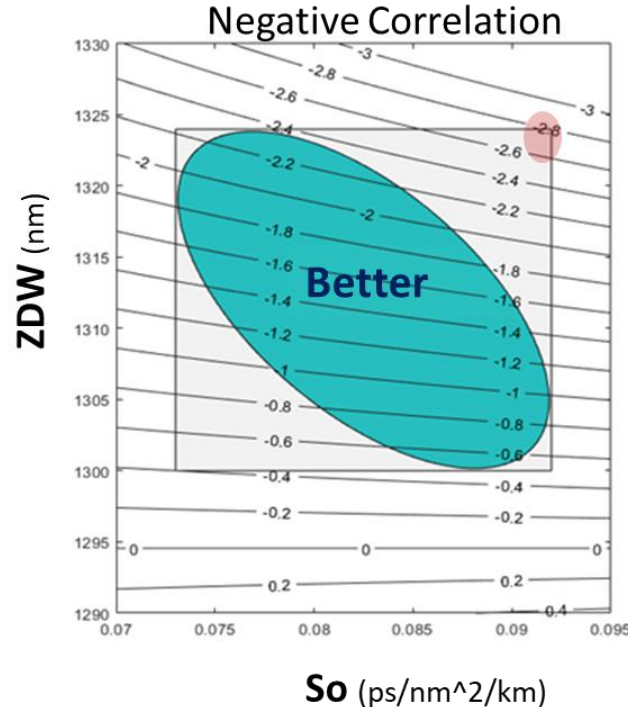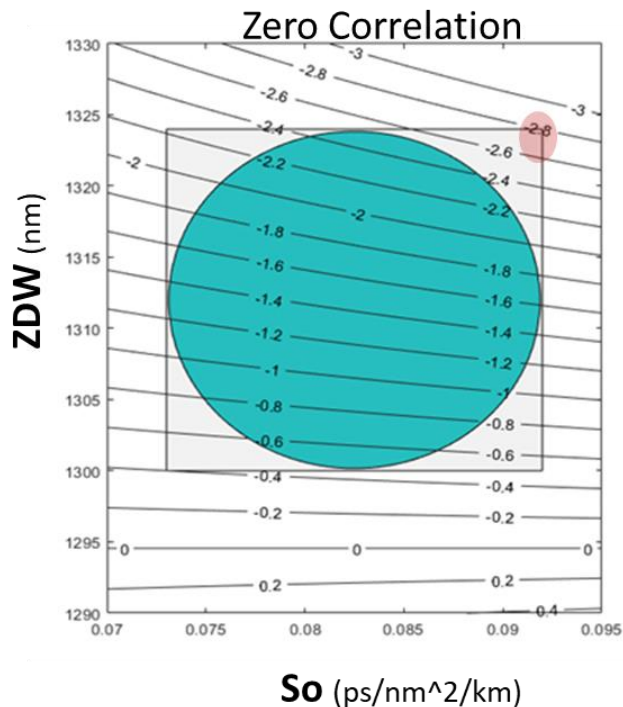
Earl Parsons

earl.parsons@commscope.com

CommScope

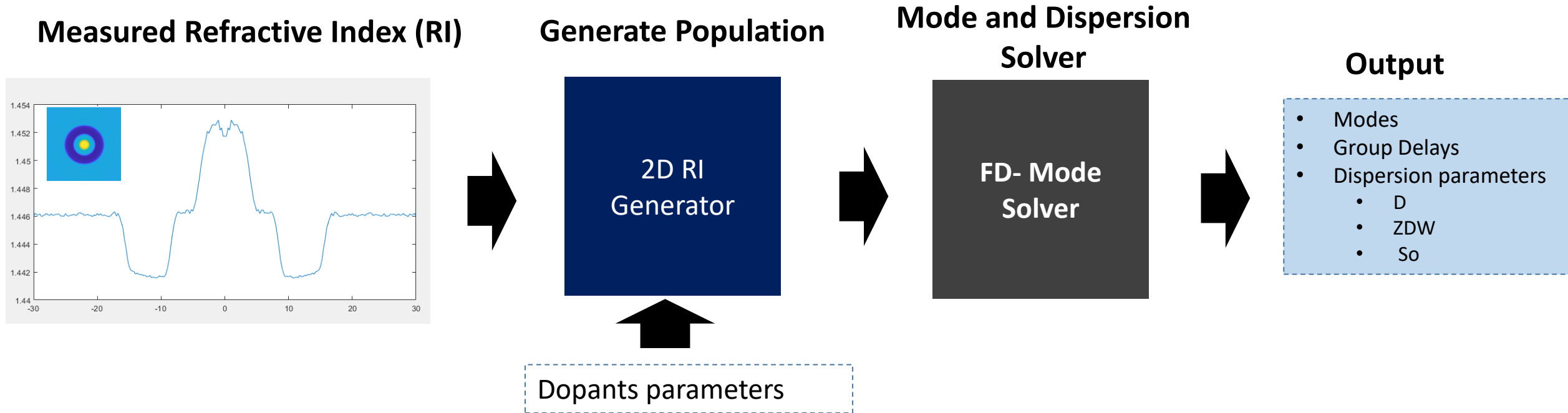IEEE P802.3dj Ad hoc Meeting, 22 February 2024

- This presentation provides supportive material for the optical channel model being developed in 802.3dj.

- Preliminary results based on model and experiments are just informative

Background

- The zero dispersion wavelength (ZDW) and dispersion Slope (So), have been modeled as bivariate normal distribution. The distribution assumes that the dispersion parameters are independent.
  - Mean and standard deviations values described in Cole_3dj_optx_01_230427, liu_3dj_01a_2307, and johnson_3dj_2307
- Correlation between ZDW and So can be important for statistics of channel dispersion.
- Here we show initial work aimed to understand the degree of correlation between ZDW and So.

Methodology

Measured Refractive Index (RI)

Generate Population

Mode and Dispersion Solver

Output

2D RI Generator

FD- Mode Solver

- Modes
- Group Delays
- Dispersion parameters
 - D
  - ZDW
  - So

Dopants parameters

Random noise added to measured refractive index of each fiber to increase population
Cut-off wavelength around 1260 nm is maintained to majority of simulated fibers

Fiber Population

- The refractive index (RI) profile of 11 fibers form three major vendors was measured.
    - Fibers are G.657 A1 and G.657 A2
    - Fiber were purchased around 2018.
- To study the dependence of ZDW and So several fibers are needed. Therefore, RI of each fiber was slightly modified, by random noise or distortion of the RI.
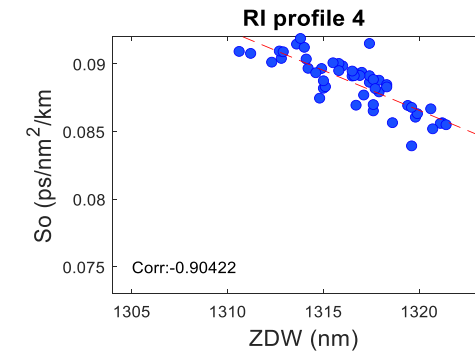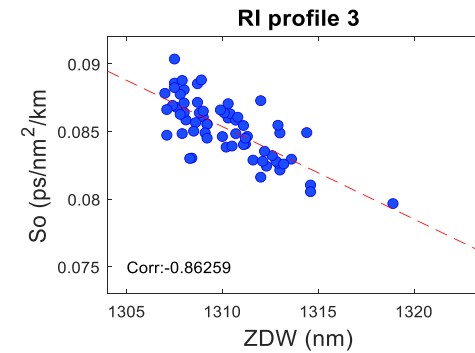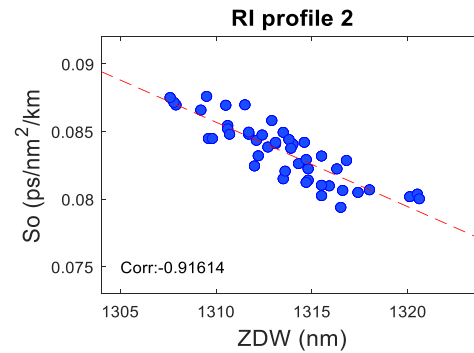   - The distortion was small and from a large set of generated fibers only the ones with cut-off wavelengths around 1260 nm were included in the simulation sets.

Refractive index of Measured
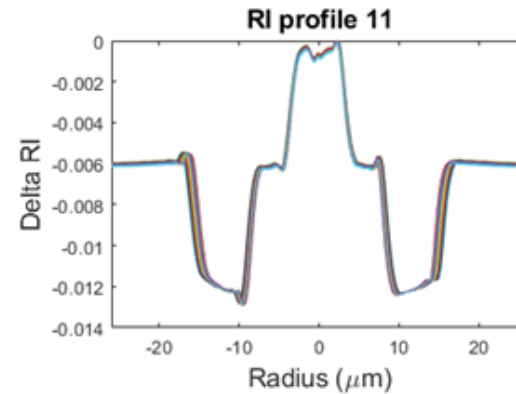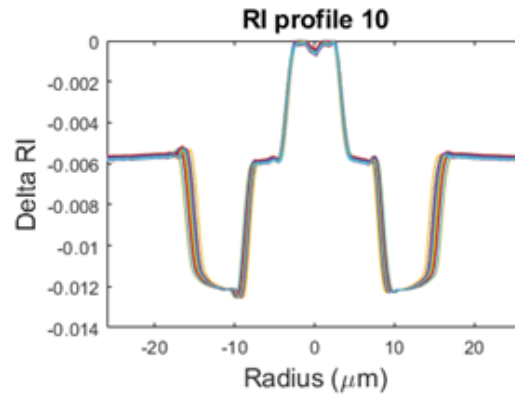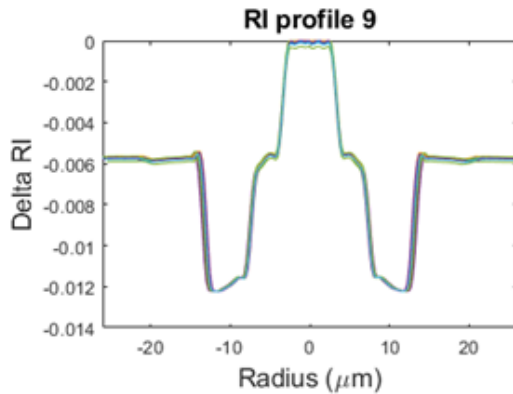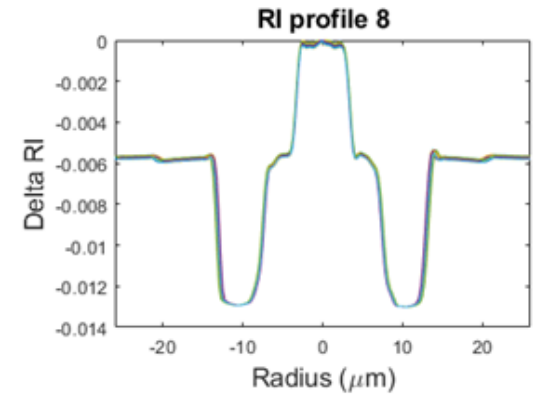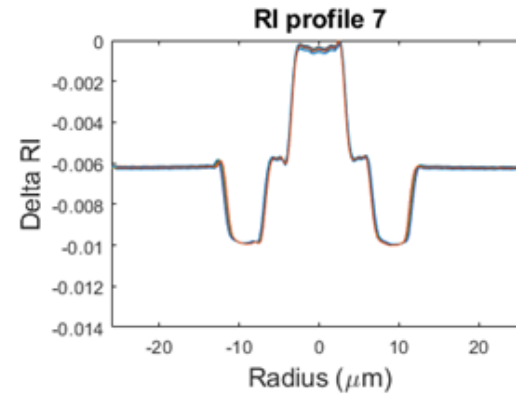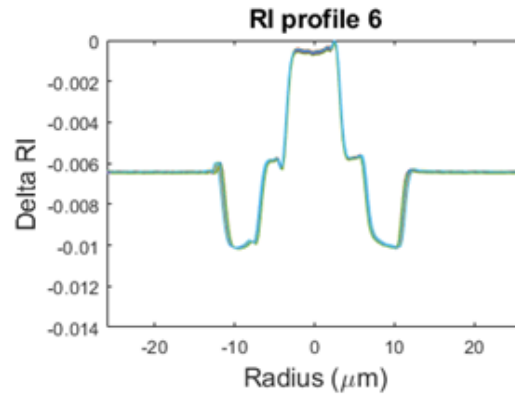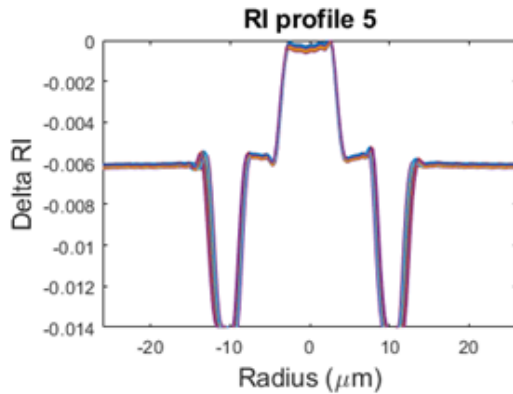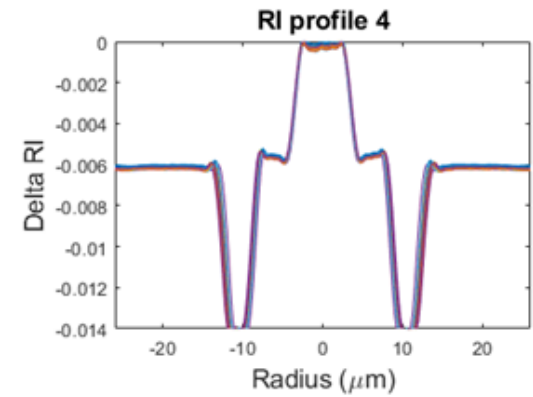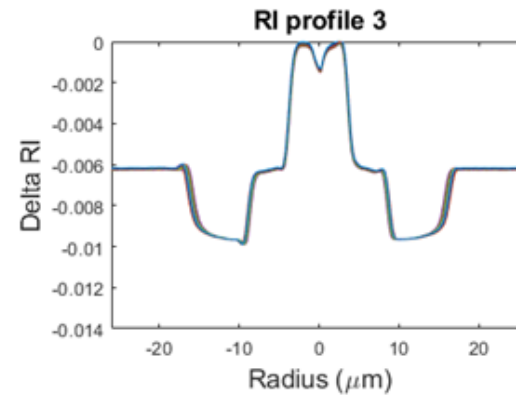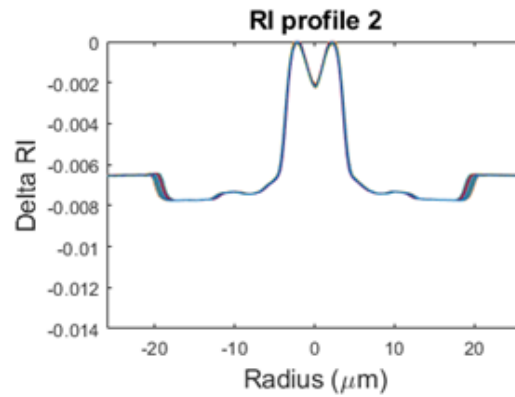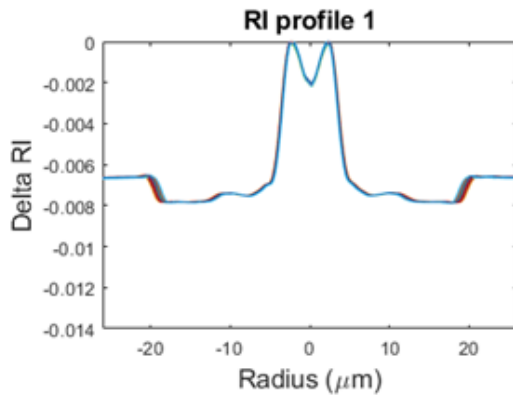
- Refractive index measured and distorted.
- The fibers with smaller trenches are G.657 A1 (first two).

Modeled Dispersion Parameters for each RI
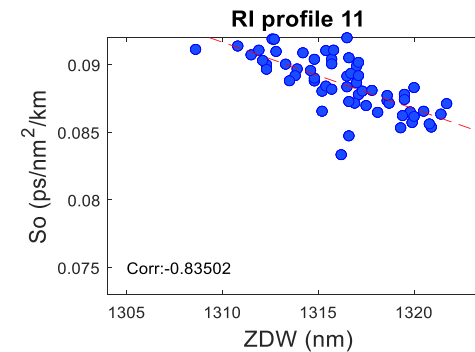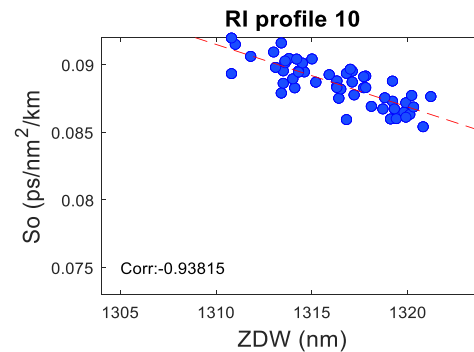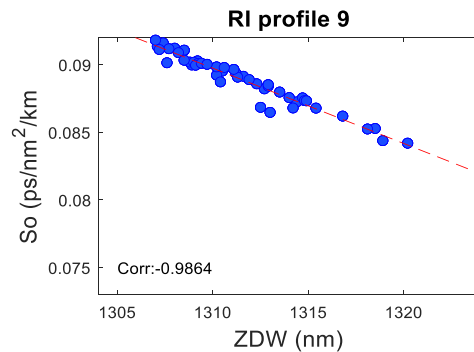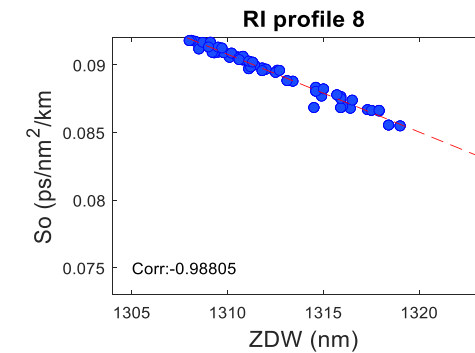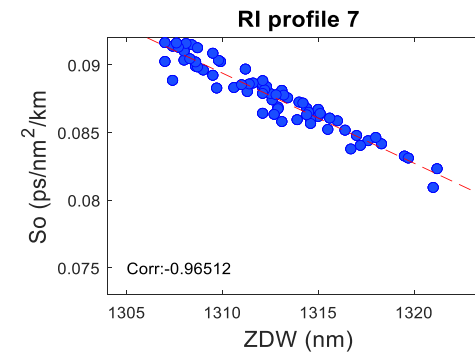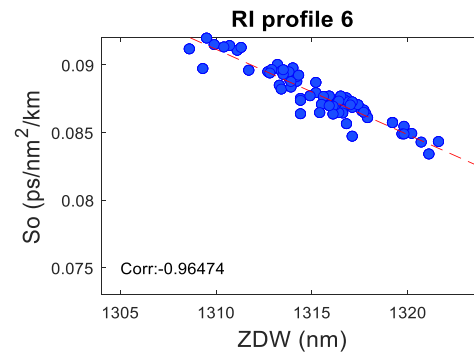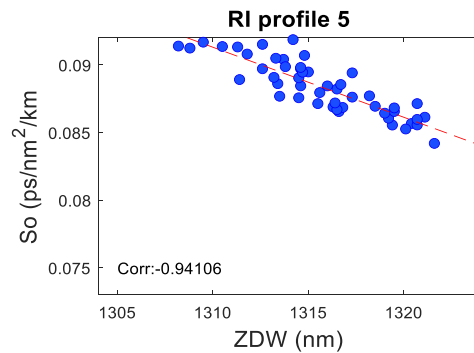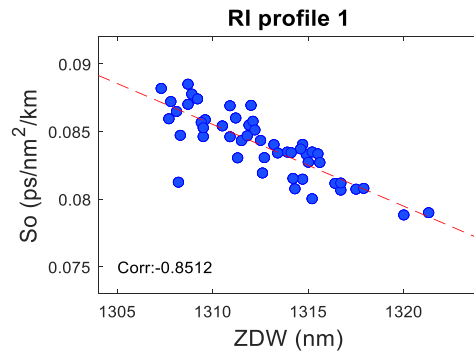
Grouping Fiber by Type and Vendors

- To capture RI manufacturing variations that could have neglected by the simulations, the fibers were grouped according to type and vendors.
- Six sets were produced:
  - Set 1 : RI 1 and RI 2
  - Set 2 : RI 3
  - Set 3 : RI 4 and RI 5
  - Set 4 : RI 6 and RI 7
  - Set 5 : RI 8 and RI 9
  - Set 6 : RI 10 and RI 11
- Only Set 1 correspond to G 657 A1, the rest were purchased as G.657 A2
- The simulated dispersion parameters (ZDW, So) and the RI of each Set is shown in the next slide.

Results for Grouped RI profile
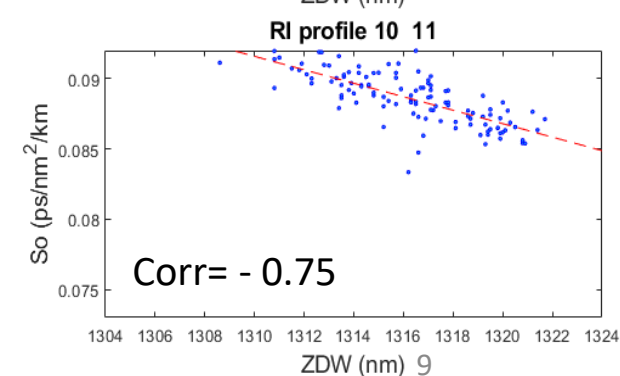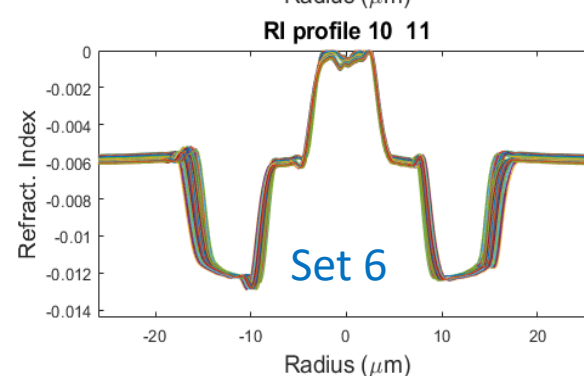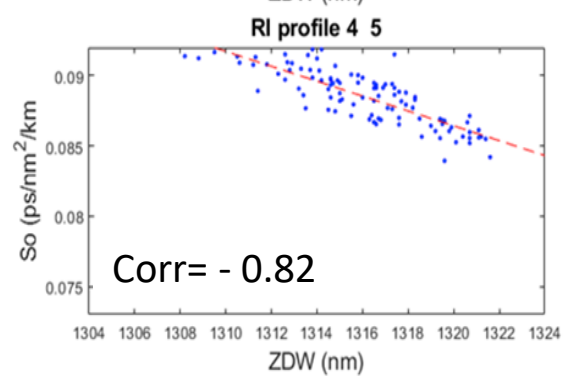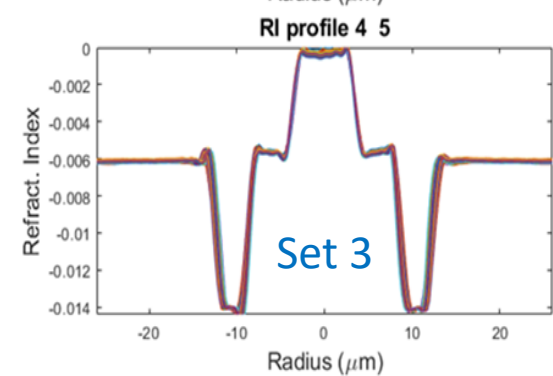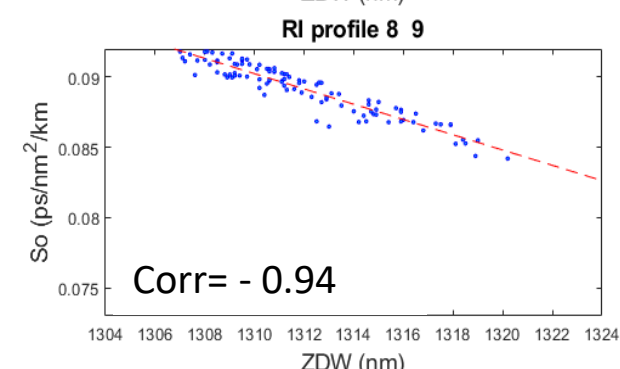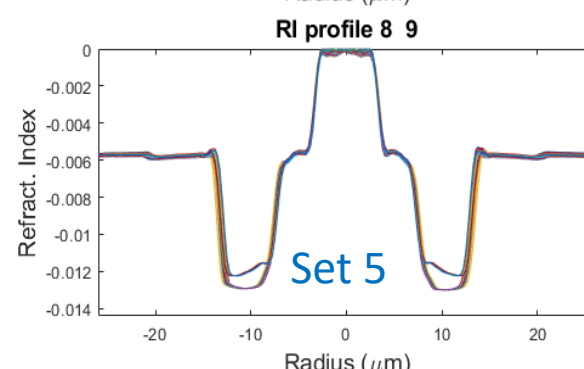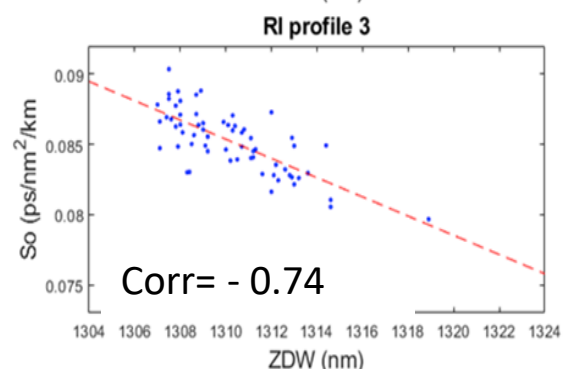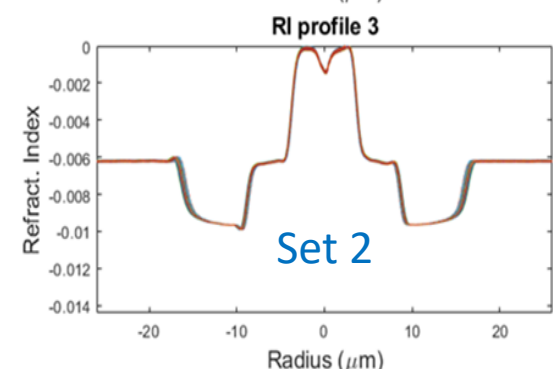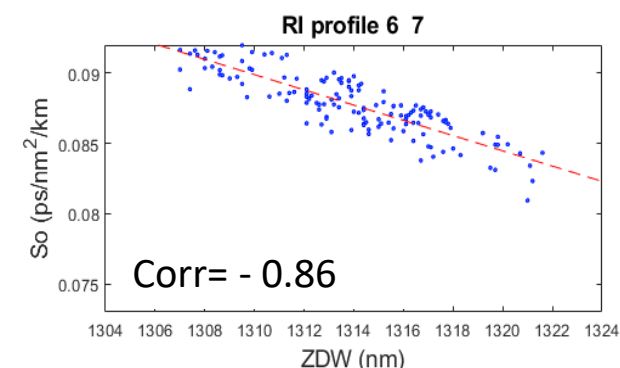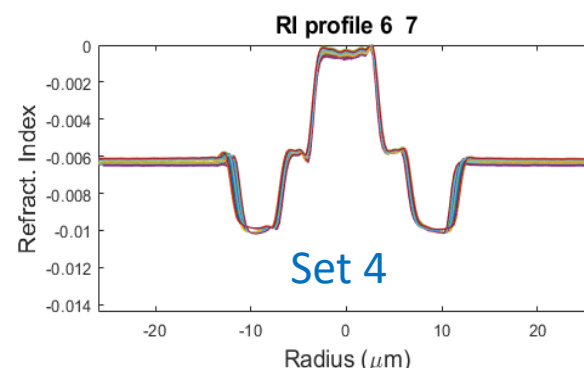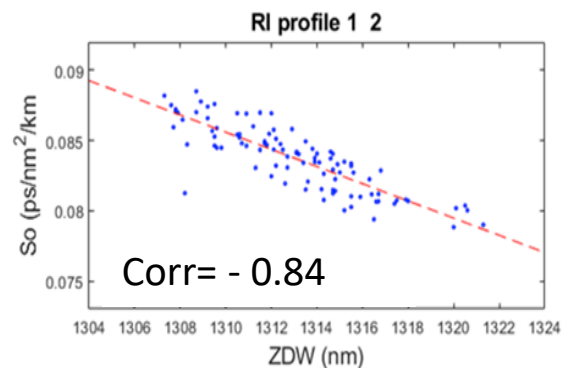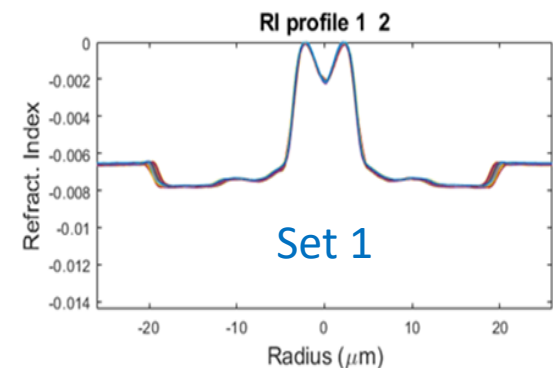
Real world data

- Analyzed zero dispersion wavelength and zero dispersion slope
- Values reported by fiber manufacturers
- 4 different manufacturers included
- Single fiber spools, not ribbon
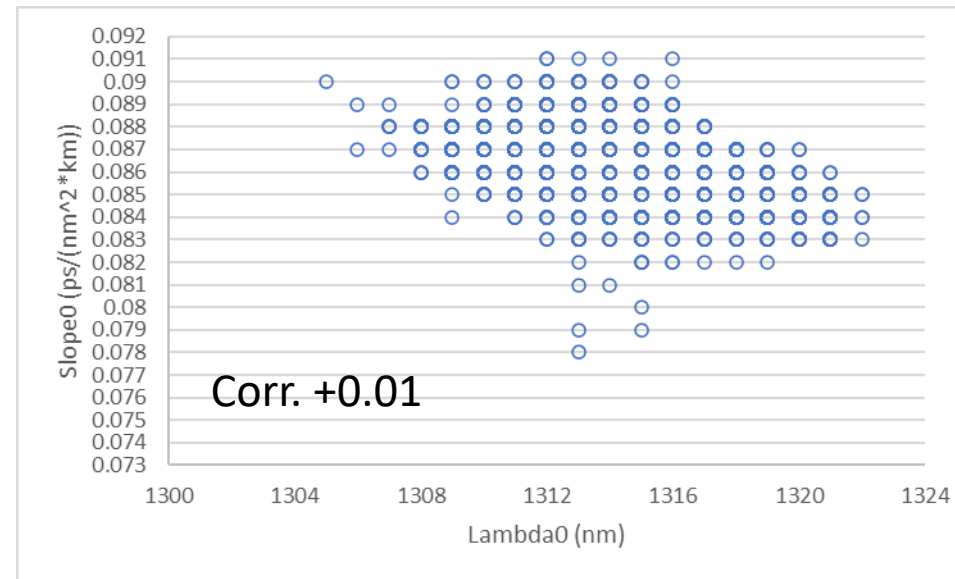- G.652.D/G.657.A1 – compliant with both
- Fibers shipped 2023
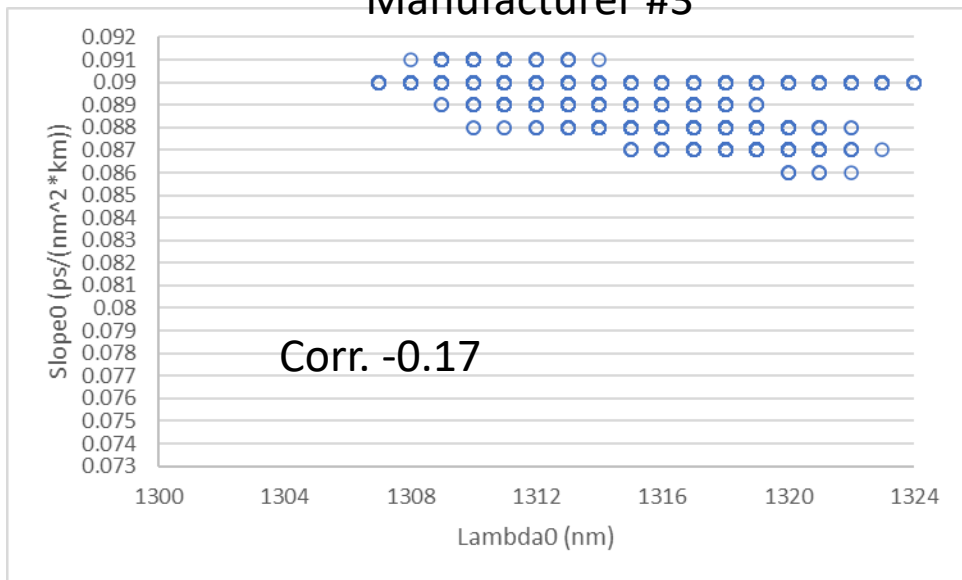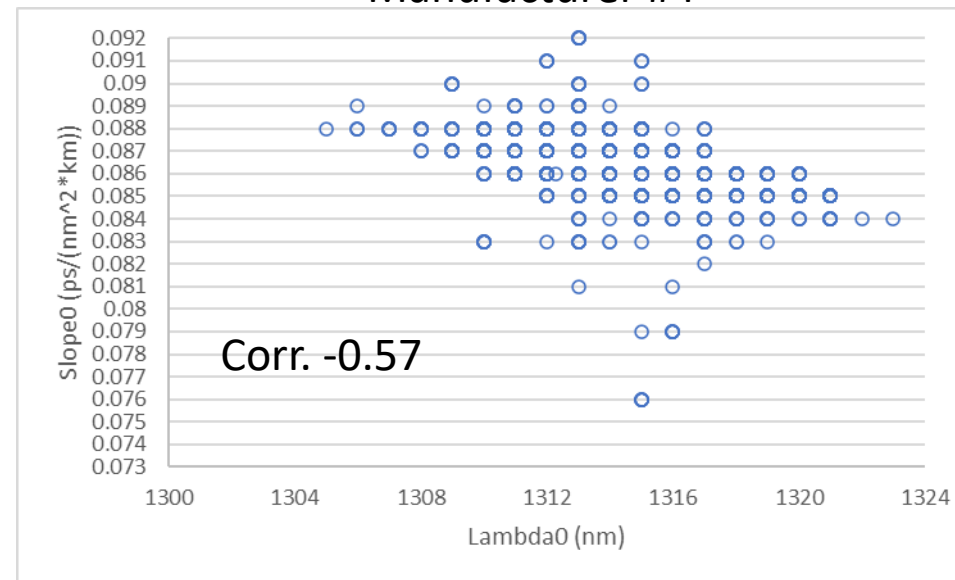- >10k fiber spools per manufacturer

Manufacturer #1 — Corr. -0.78
Manufacturer #2 — Corr. +0.01
Manufacturer #3 — Corr. -0.17
Manufacturer #4 — Corr. -0.57
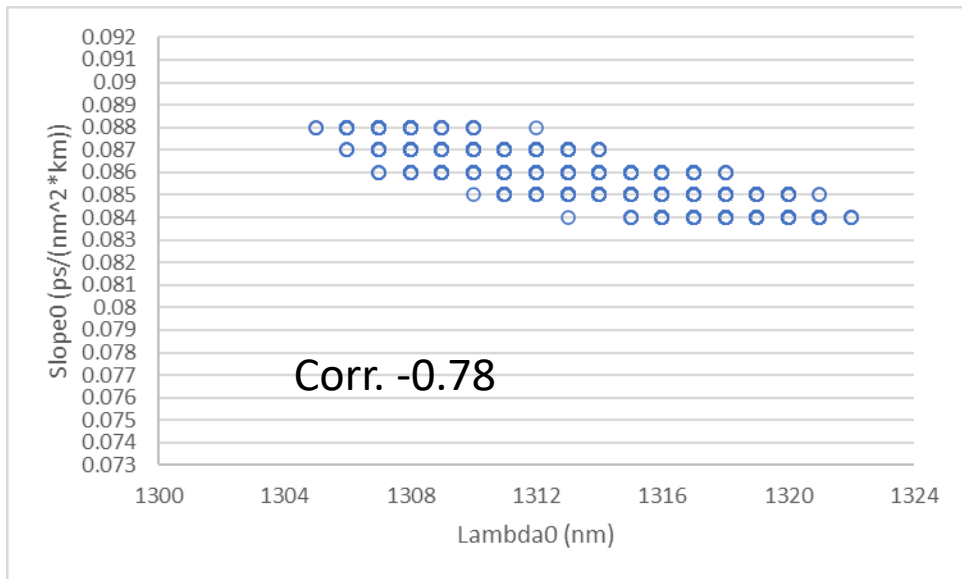
Summary and Conclusions

- Modeling of ZDW and So, shows a tendency for negative correlation
- Experimental data from four manufacturers show strong negative correlation, but only for two of them
  - Weak or negligible for the other two.
- Significant variations in manufacturing processes, or the inclusion of diverse fabrication methods within the same population group, could diminish the strength of the correlation.
- A negative correlation could reduce probability of sampling worst case negative dispersion. However, from presented data we cannot conclude that all the vendors have negative correlation between ZDW and So.