Update from Channel Model Ad Hoc Sub Group Task 4

Preliminary results of PIE metrics calculations

Presented by Yu Sun

Participants of Task 4 group

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Motivation

- The ISI penalty or eye closure penalty is not straightforward predictor of EDC dispersion penalty
- PIE metrics have been used in previous study to predict dispersion penalty for
  - Linear Equalizer
  - Decision Feedback Equalizer
- PIE metrics depend on input pulse shape, propagation distance and launching condition

Goal of task 4: to quantify PIE metrics in the fiber channel model

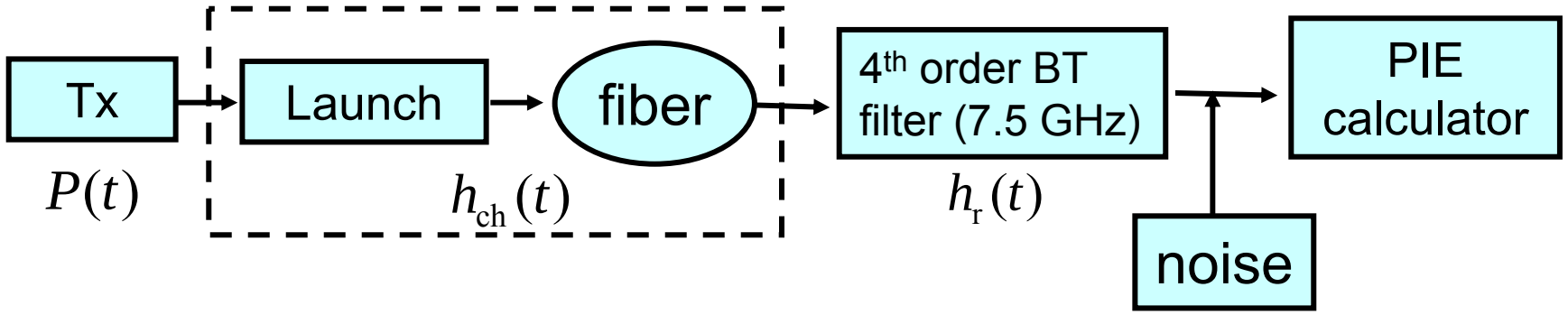
Outline

Preliminary results for OSL and CL:

- Dependency of PIE calculation on input pulse width
- PIE metrics calculations for single fiber span case
- Preliminary PIE calculations results for multi-connector link

All simulations based on latest release of Cambridge

Simulation setup and PEI calculation



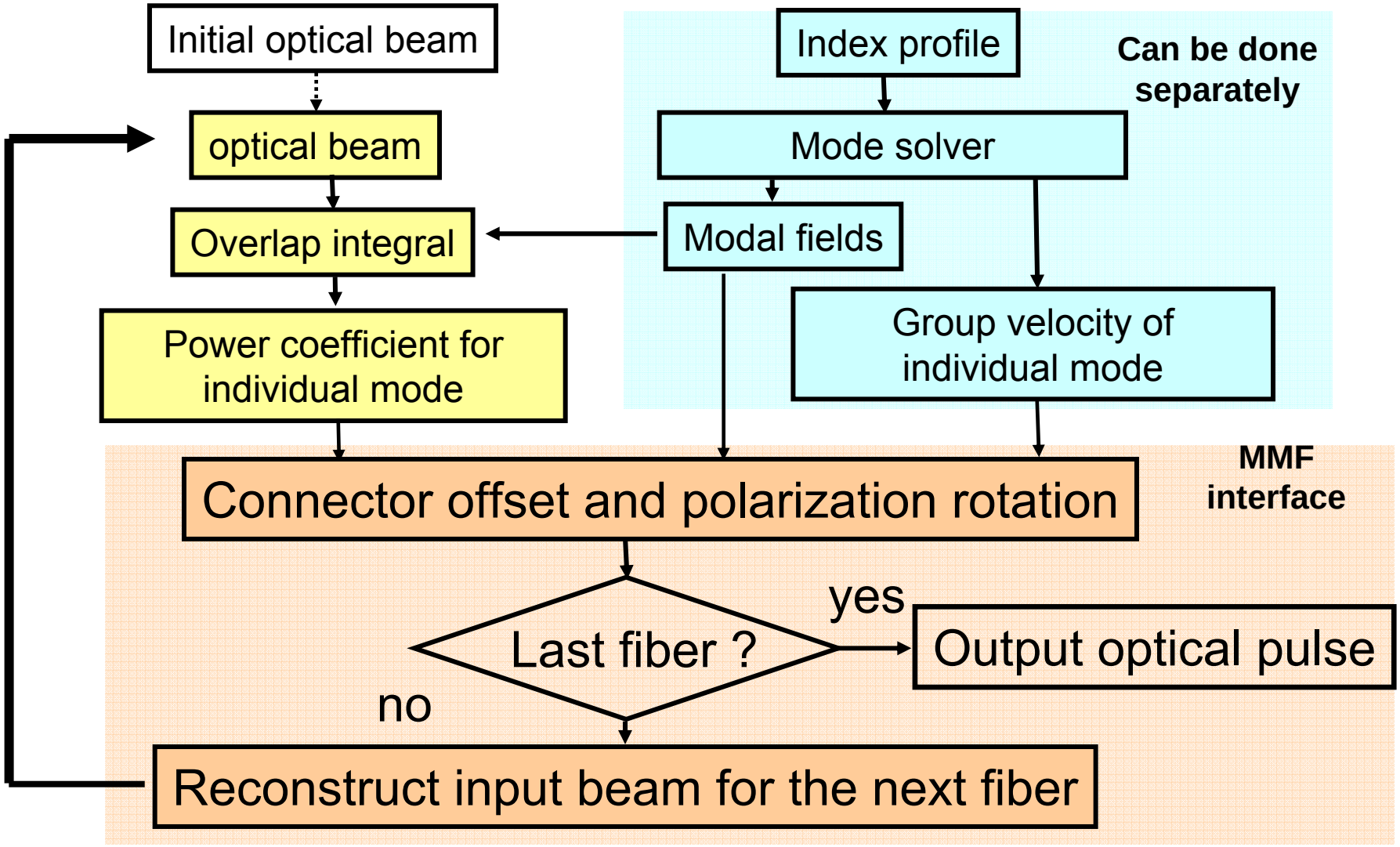
- Channel is simulated using in-house simulator (center launch) and Cambridge release 3.0 (OSL: 17μm, 20μm and 23μm)
- Composite pulse response $h(t) = p(t) * h_{ch}(t) * h_r(t)$
- Noise is a constant (bhoja_1_0704.pdf)

$$\sigma^2 = 10^{(\text{ESNR-2*optical dispersion penalty})/10}, \text{where}$$

$$\text{ESNR} = 17\text{dB}\ (\text{BER} = 10^{-12});$$

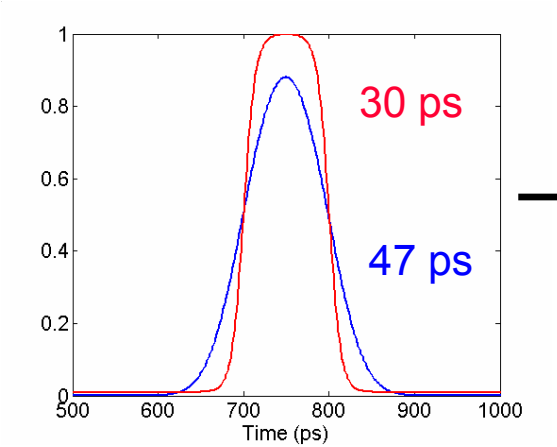
$$\text{optical dispersion penalty} = 6\text{dBo}$$

Channel modeling using in-house simulator



Dependency of PIE calculation on input pulse width

Effect of input pulse width on PIE metrics



Select fiber

Cambridge release 3.0
Offset
17, 20, 23μm

Tx

Channel response

Convolution process

Optical pulses

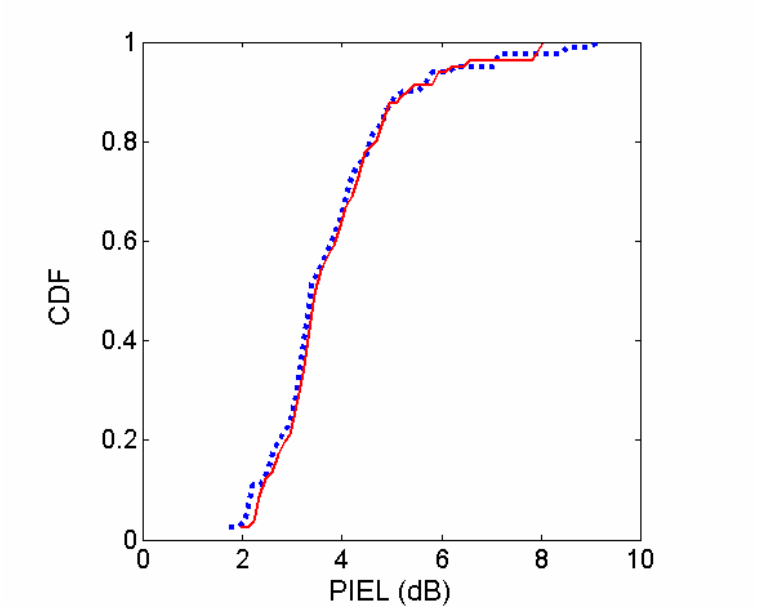
Rx and PIE calculator

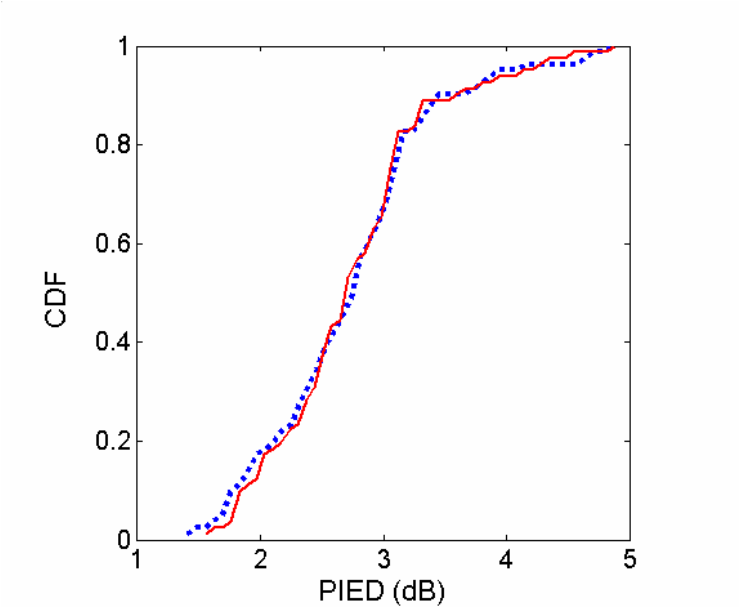
Choose the worst PIE from three offsets

The process is repeated for all 81 fibers.

PIE metrics calculation baseline comparison

John Ewen (JDSU) Yu Sun (Optium)

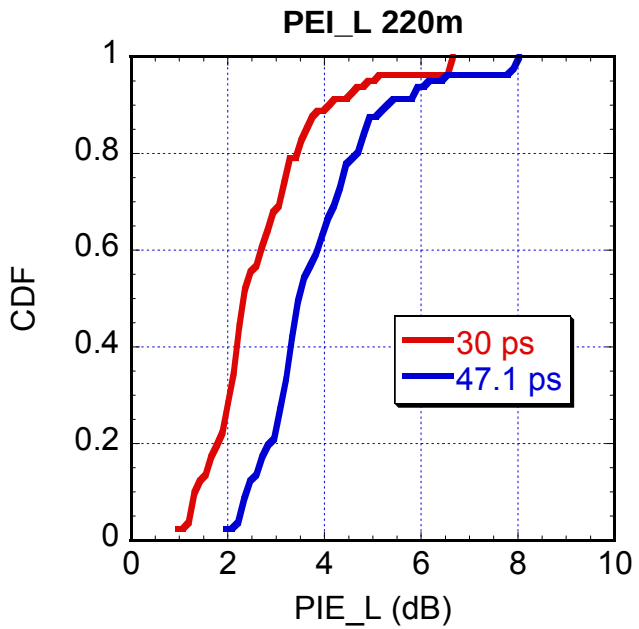


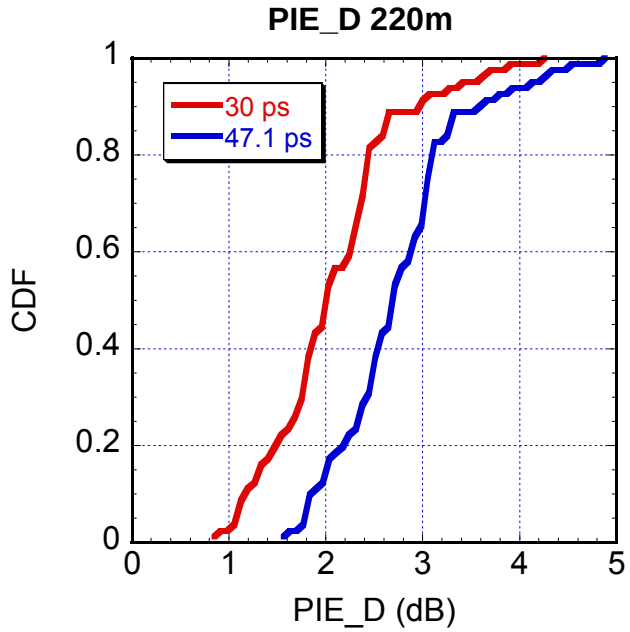


Key parameters:

- Tx output pulse rising time 47.1 ps (20-80%)
- Fiber length: 220 m
- OSL worst case

Effect of input pulse width on PIE metrics





80 % coverage	PIE_L	PIE_D
30 ps	3.5	2.4
47 ps	4.63	3.0

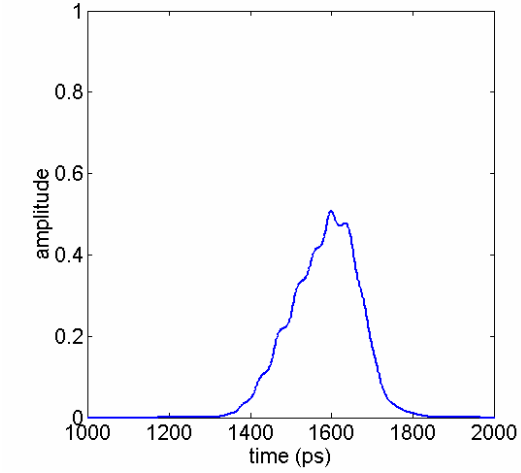
% of 4.5 dB	PIE_L	PIE_D
30 ps	92	100
47 ps	78	98.7

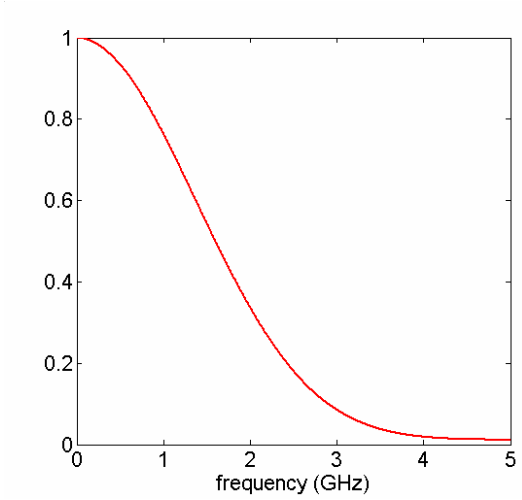
In all subsequent calculations 30 ps rising time pulse is used.

PIE metrics calculations for single fiber span case

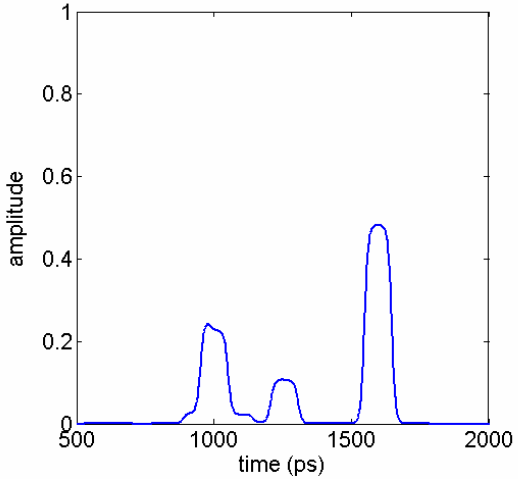
Examples of optical pulse (220m)

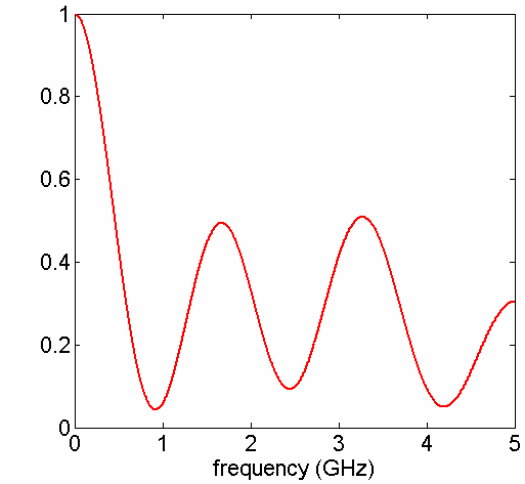
Offset launch: 17 µm



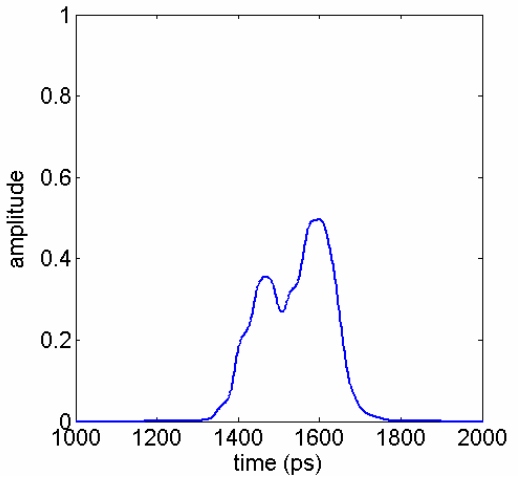


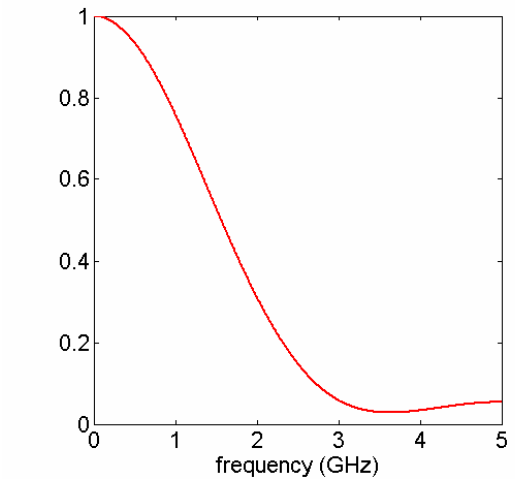
Center launch: +/-5 µm



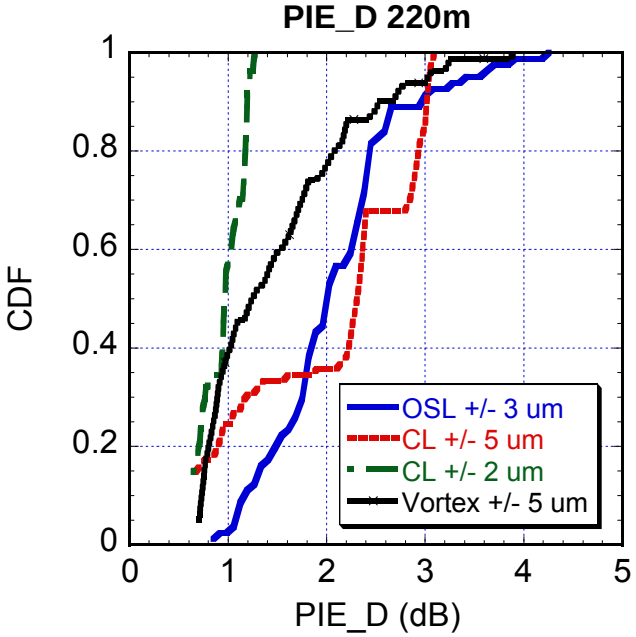


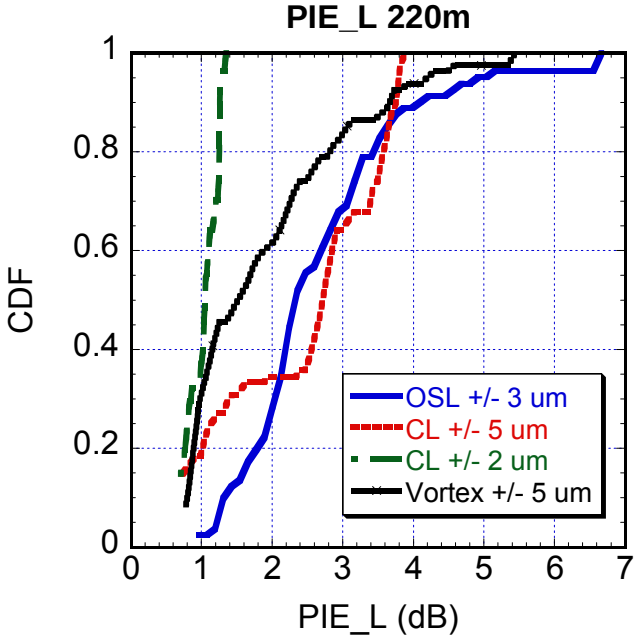
Vortex launch: M = 7, +/- 5 µm





PIE metrics of 220 m fiber

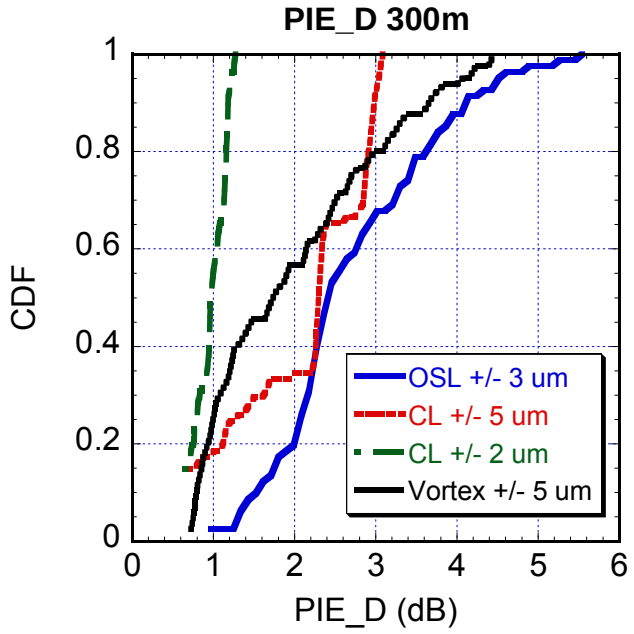


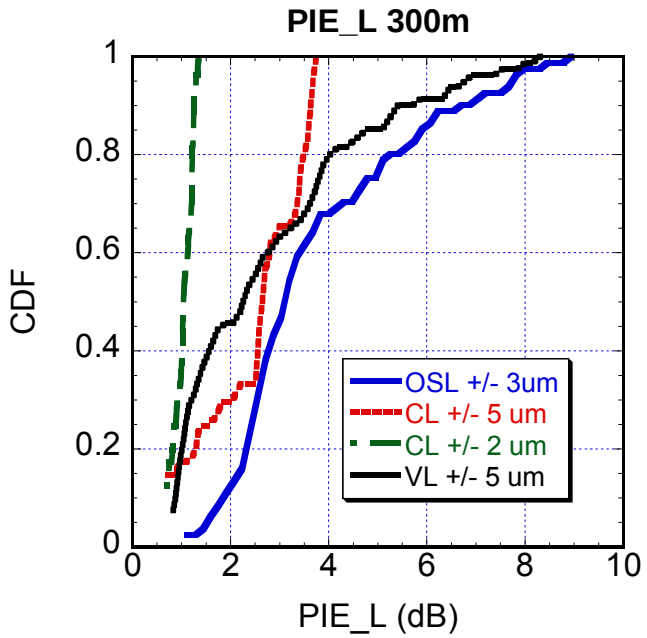


80 % coverage	PIE_L	PIE_D
OSL +/- 3 µm	3.5	2.4
CL +/- 5 µm	3.57	2.9
CL +/- 2 µm	1.25	1.17
VL +/- 5 µm	2.8	2.08

% of < 4.5 dB	PIE_L	PIE_D
OSL +/- 3 µm	92	100
CL +/- 5 µm	100	100
CL +/- 2 µm	100	100
VL +/- 5 µm	96	100

PIE metrics of 300 m fiber





80 % coverage	PIE_L	PIE_D
OSL +/- 3 µm	5.27	3.9
CL +/- 5 µm	3.5	2.9
CL +/- 2 µm	1.2	1.16
VL +/- 5 µm	4.0	3.0

% of < 4.5 dB	PIE_L	PIE_D
OSL +/- 3 µm	70	95
CL +/- 5 µm	100	100
CL +/- 2 µm	100	100
VL +/- 5 µm	83	100

Summary of PIE metrics for different launches

$$\Delta \text{ PIE} = \text{PIE}_{300m} - \text{PIE}_{220m}$$

80 % coverage	Δ PIE_L	Δ PIE_D
OSL +/- 5 µm	1.77	1.22
CL +/- 5 µm	-0.07	0
CL +/- 2 µm	-0.05	-0.01
VL +/- 5um	1.2	0.92

- PIE metrics of offset launch and Vortex launch degrade as the distance increase.
- PIE metrics for center launch is not sensitive to the change of fiber length.

Summary

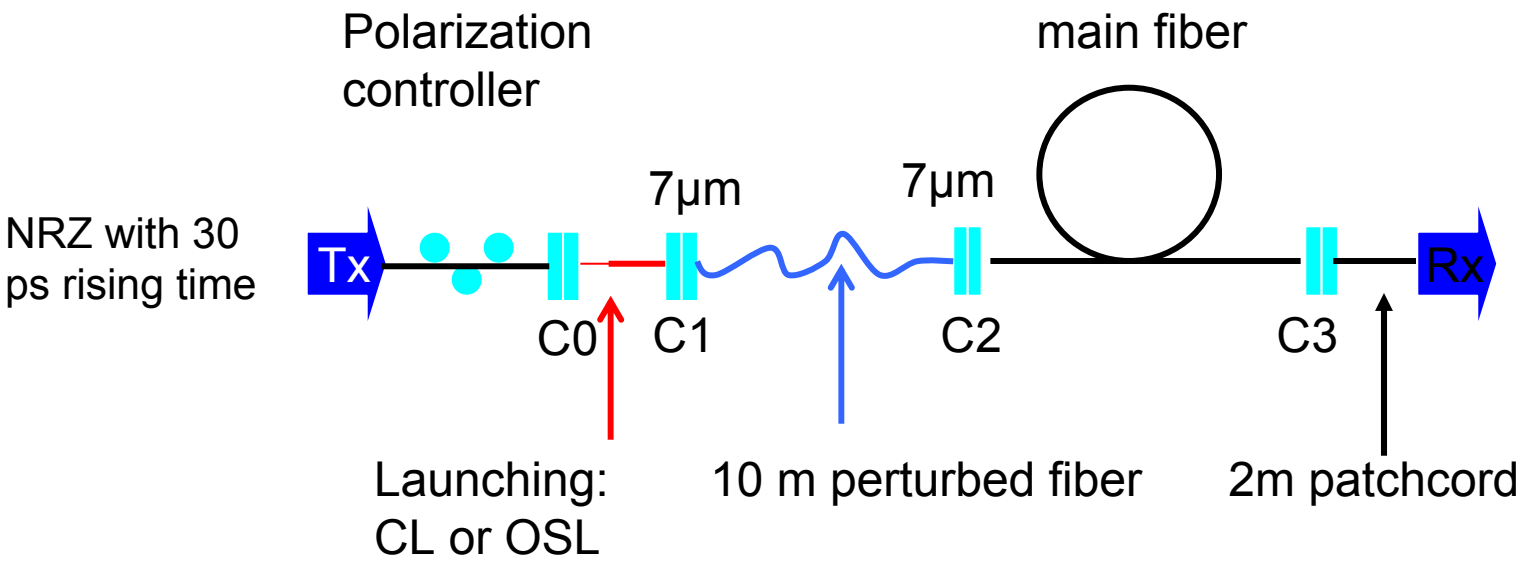
- The dependency of PIE values on pulse width and distance is studied.
- Tx with a fast rising time is needed for difficult channels.
- PIE metrics for center launch is not sensitive to the change of fiber length.

Next step:

To compare the tolerance to the connector offset of different launch conditions using PIE metrics

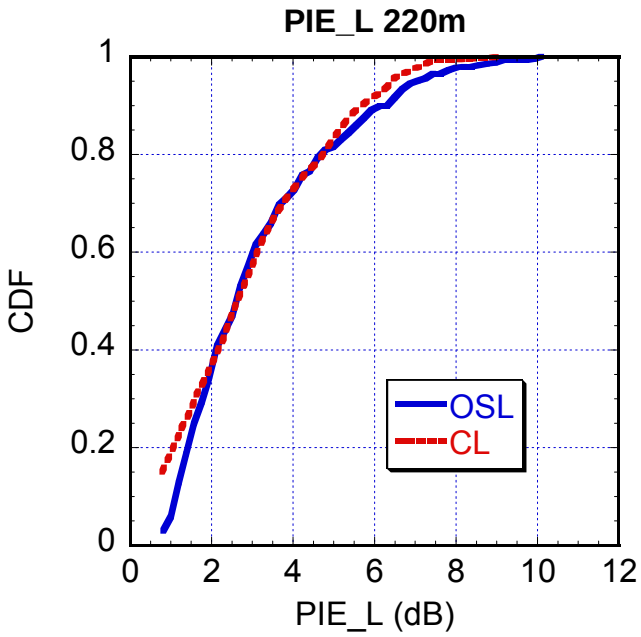
Preliminary PIE calculations results for multiconnector link

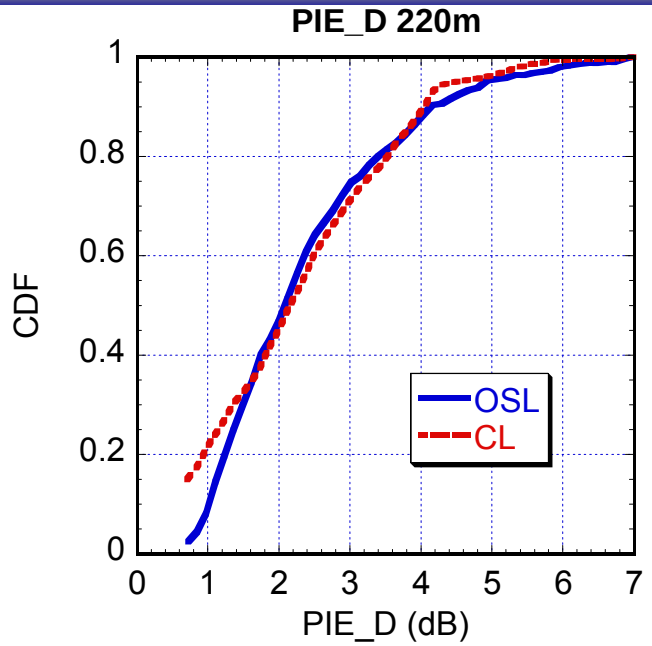
Multiple connector link



1. Tx: NRZ pulse with 30ps rising time
2. Fiber Length: 220m and 300m
3. Polarization rotation is considered
4. In house simulator is used (all high order modes are considered)

PIE metrics of 220 m fiber

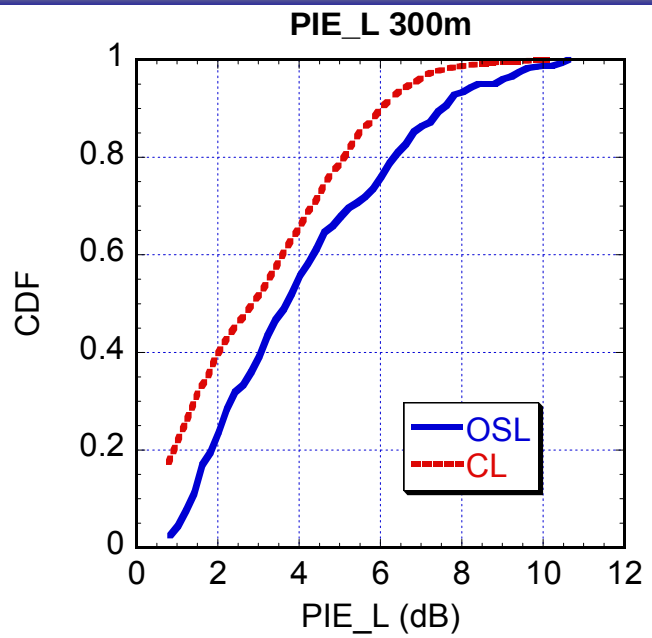


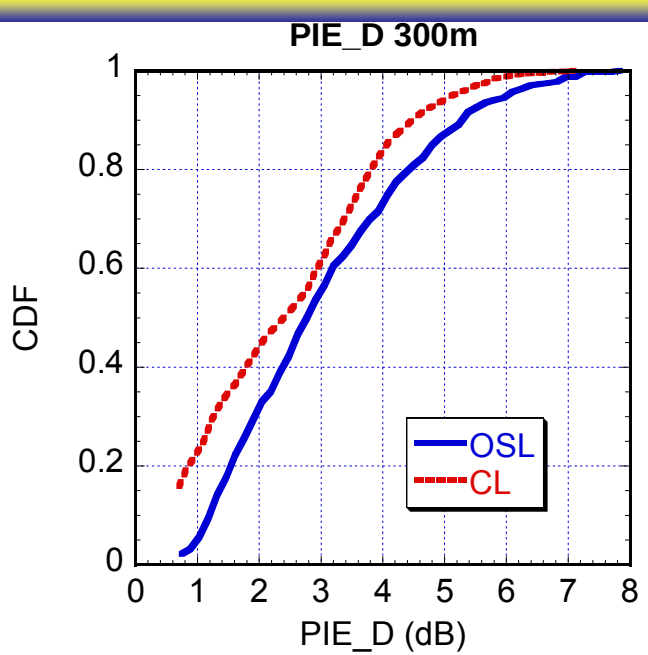


80 % coverage	PIE_L	PIE_D
OSL	4.8	3.39
CL	4.8	3.52

% of < 4.5 dB	PIE_L	PIE_D
OSL +/- 3 µm	77	92
CL +/- 5 µm	77	95

PIE metrics of 300 m fiber





80 % coverage	PIE_L	PIE_D
OSL	6.42	4.5
CL	5.16	3.83

% of < 4.5 dB	PIE_L	PIE_D
OSL +/- 3 µm	65	80
CL +/- 5 µm	72	90

Degradation of PIE metrics

$$\Delta \text{ PIE} = \text{PIE}_{300m} - \text{PIE}_{220m}$$

80 % coverage	Δ PIE_L	Δ PIE_D
OSL	1.62	1.11
CL	0.36	0.31

- PIE metrics of offset launch degrade as the distance increase.
- PIE metrics for center launch is not sensitive to the change of fiber length.

Conclusion

From the preliminary simulation results

1. Specification of launch condition need to consider the outcome of task 4
2. A modified encircled flux or other launching condition specification may be needed.

Feed back and suggestions are welcomed

The next task 4 group meeting: Oct 4th