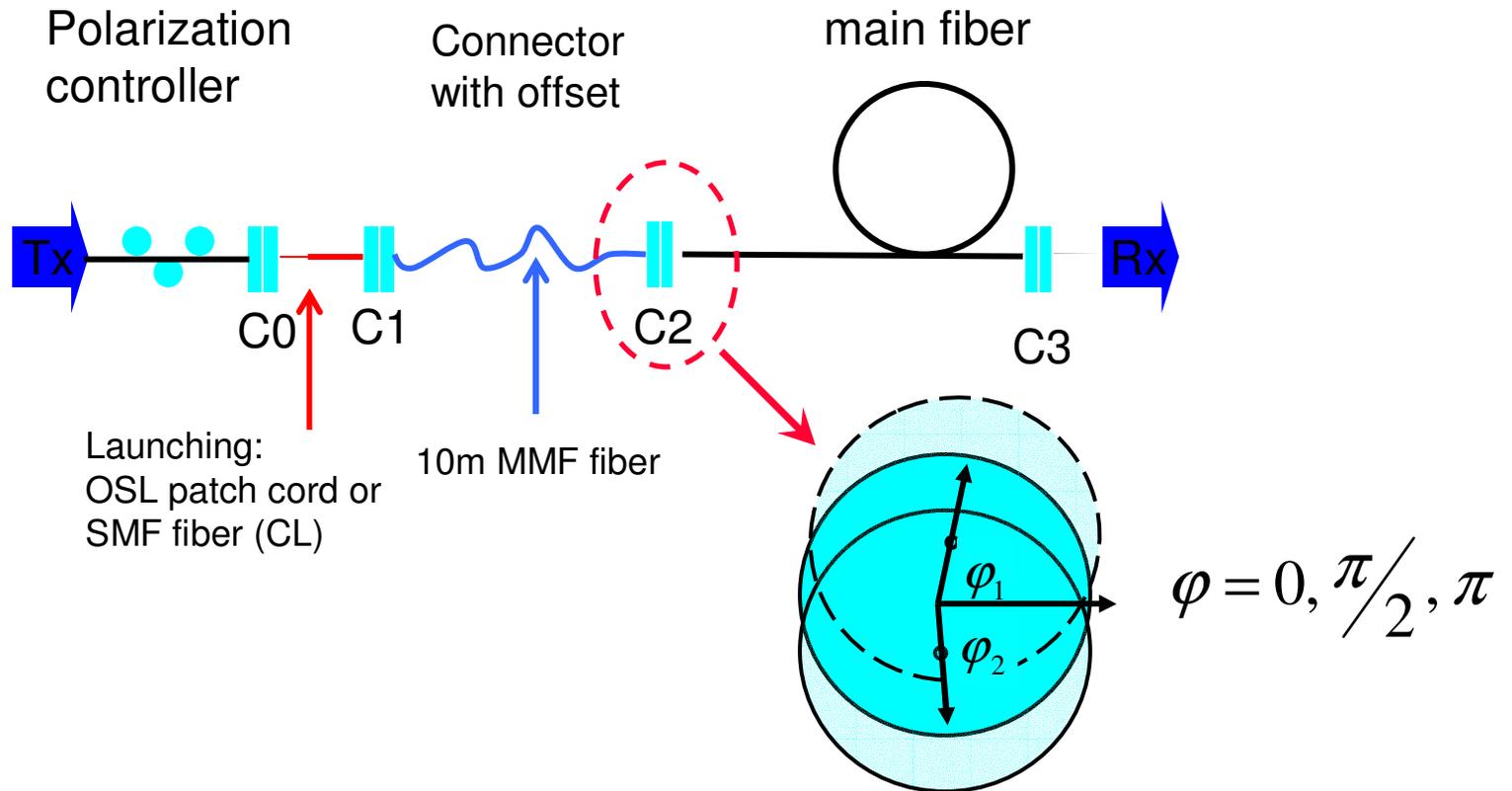




# **PIE-D statistics Comparison Between Averaged Mode and Individual Mode Computation Method**

**Yu Sun**

# Link setup



Two connectors C1 and C2 are considered

Worst case	$7 \mu\text{m}$	$7 \mu\text{m}$
Average case	$5 \mu\text{m}$	$5 \mu\text{m}$

# Background

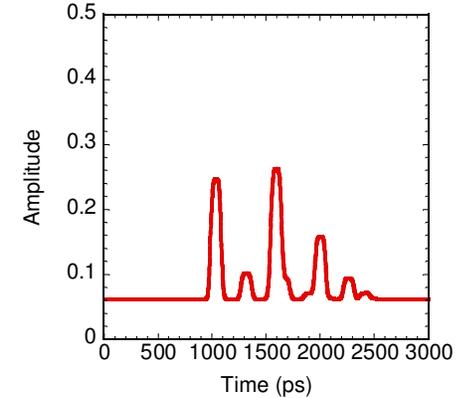
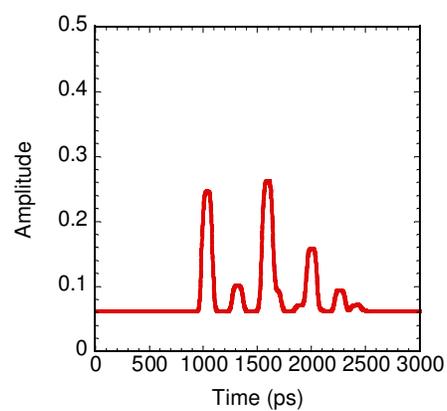
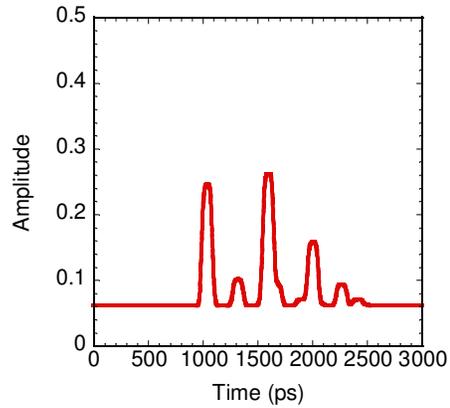
In Ottawa meeting, task 4 group discussed two method of how to simulation the connectors in multimode fiber link

	<b>Averaged mode</b>	<b>Individual mode</b>
<b>Mixing among modal groups</b>	None	None
<b>Mode mixing in one modal group</b>	100%	none
<b>Transfer matrix of connectors</b>	$N \times N$ Number of modal groups	$M \times M$ Number of modes
<b>Dependency of connector rotation</b>	no	yes

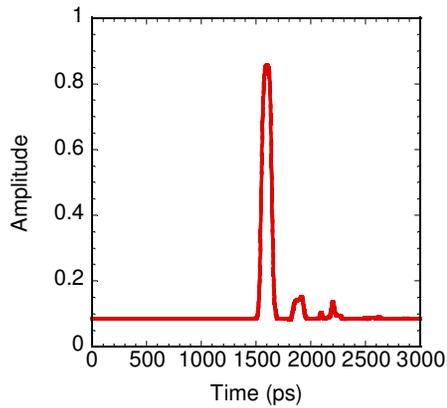
# Background

Comparison of pulse responses from one fiber

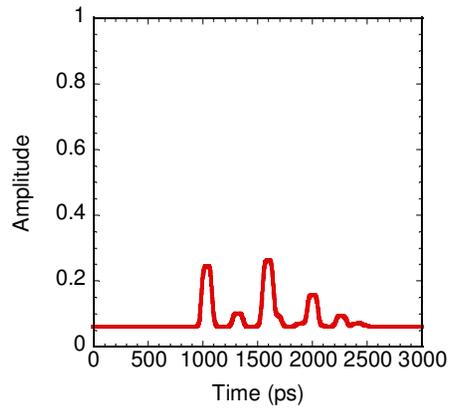
Results of averaged mode method



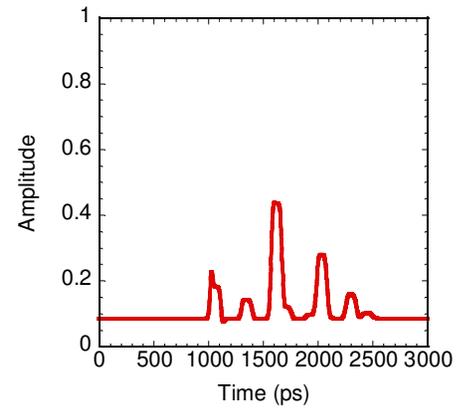
Results of individual mode method



Rotation 1

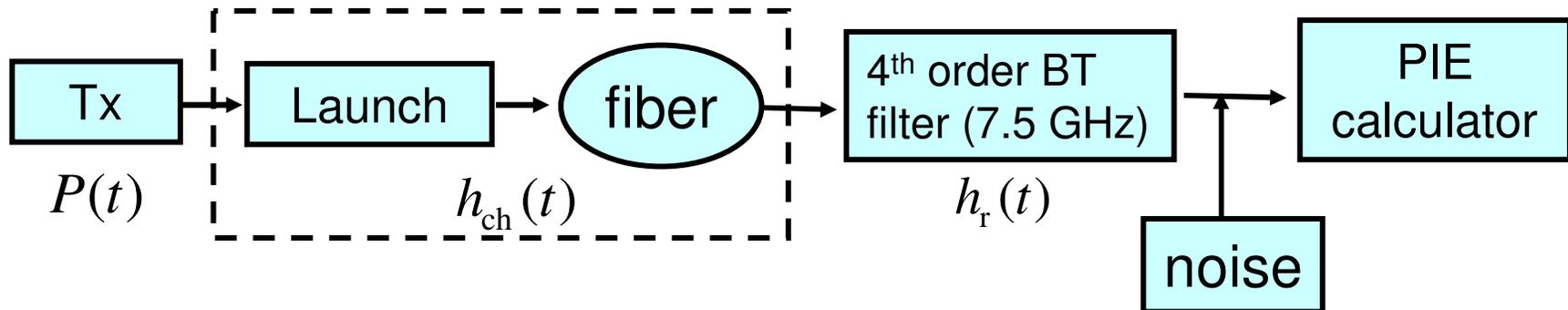


Rotation 2



Rotation 3

# PIE calculation



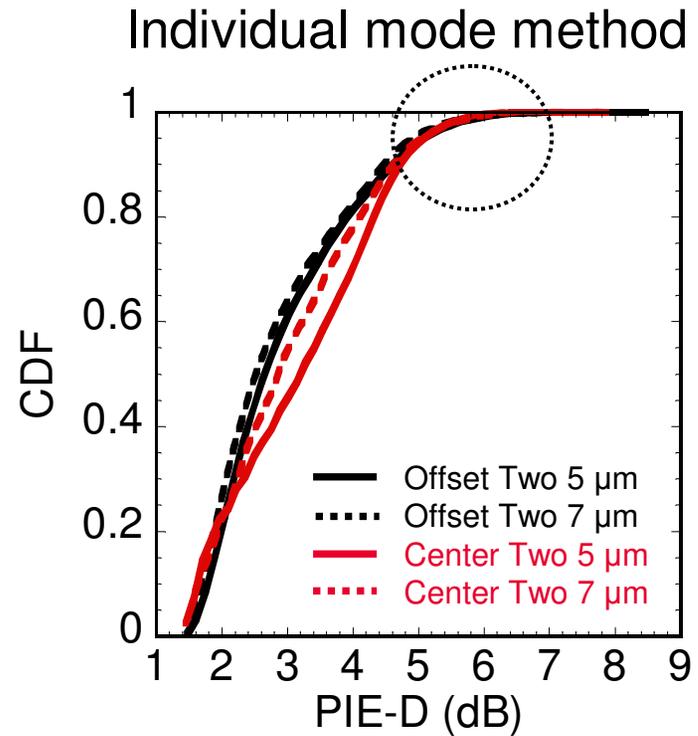
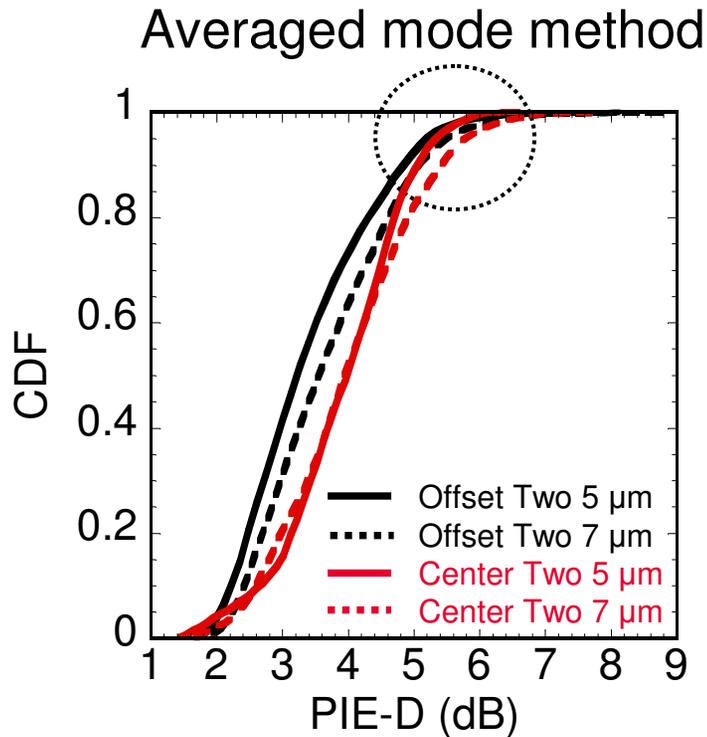
- Channel is simulated using **MGP and GEN54YY delay set**
- Composite pulse response  $h(t) = p(t) * h_{ch}(t) * h_r(t)$
- Input pulse: Gaussian with 47.1 ps rising time (20% - 80%)
- Noise is a constant (bhoja\_1\_0704.pdf)

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

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

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

# Comparison of PIE-D

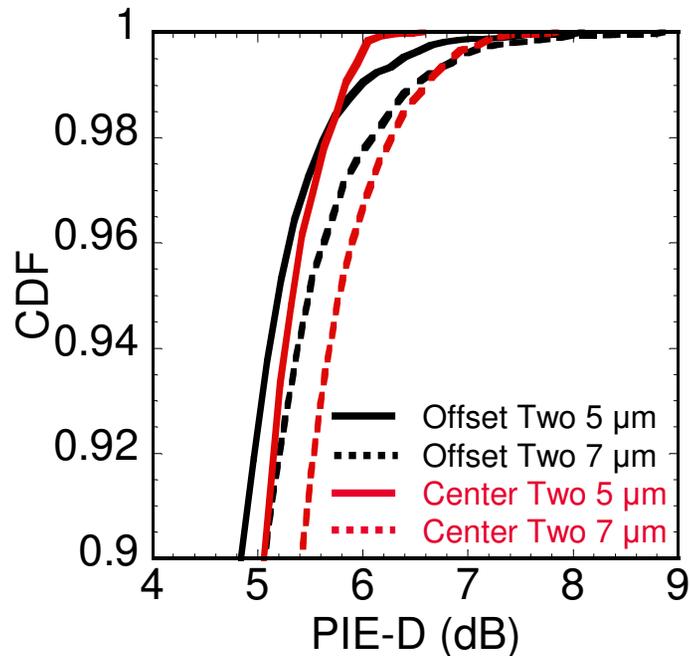


99 percentile of two methods under different offset combinations

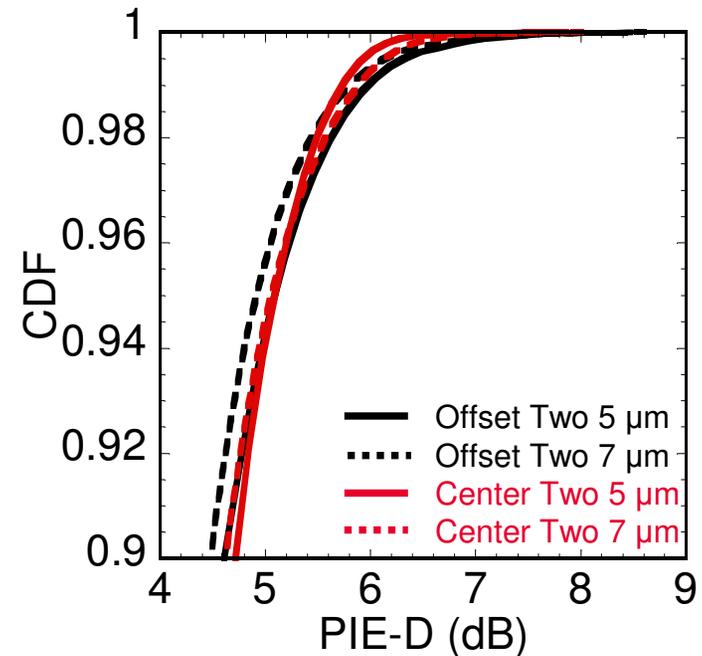
	Offset		Center	
	two 5 $\mu\text{m}$	two 7 $\mu\text{m}$	two 5 $\mu\text{m}$	two 7 $\mu\text{m}$
<b>Averaged mode method</b>	<b>6.001</b>	<b>6.539</b>	<b>5.84</b>	<b>6.67</b>
<b>Individual mode method</b>	<b>6.045</b>	<b>5.829</b>	<b>5.76</b>	<b>5.93</b>

# Comparison of PIE-D

Averaged mode method



Individual mode method



99 percentile of two methods under different offset combinations

	Offset		Center	
	two 5 um	two 7 um	two 5 um	two 7 um
<b>Averaged mode method</b>	<b>6.001</b>	<b>6.539</b>	<b>5.84</b>	<b>6.67</b>
<b>Individual mode method</b>	<b>6.045</b>	<b>5.829</b>	<b>5.76</b>	<b>5.93</b>

# Conclusion

---

1. In general, the averaged mode method (TIA) is more pessimistic than individual mode method
2. The 99% coverage of two methods is very close in the average offset case
3. Though the detailed impulse response characteristics resulting from the two computational methods are different, they will draw the same conclusion based on 99 percentile value