Differential Modal Dispersion Emulator for 10Gb/s MMF Links

For

IEEE 802.3 10Gb/s on FDDI-grade MMF Study Group

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Introduction

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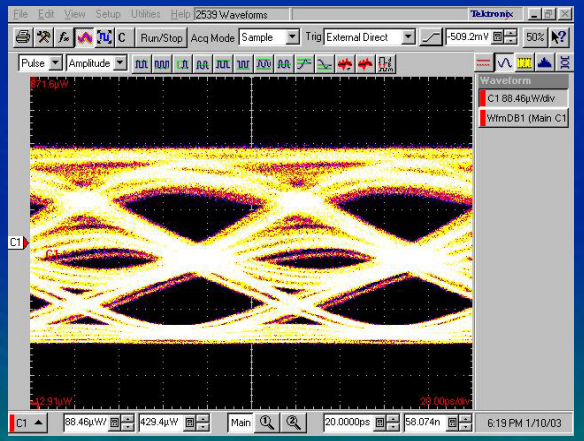
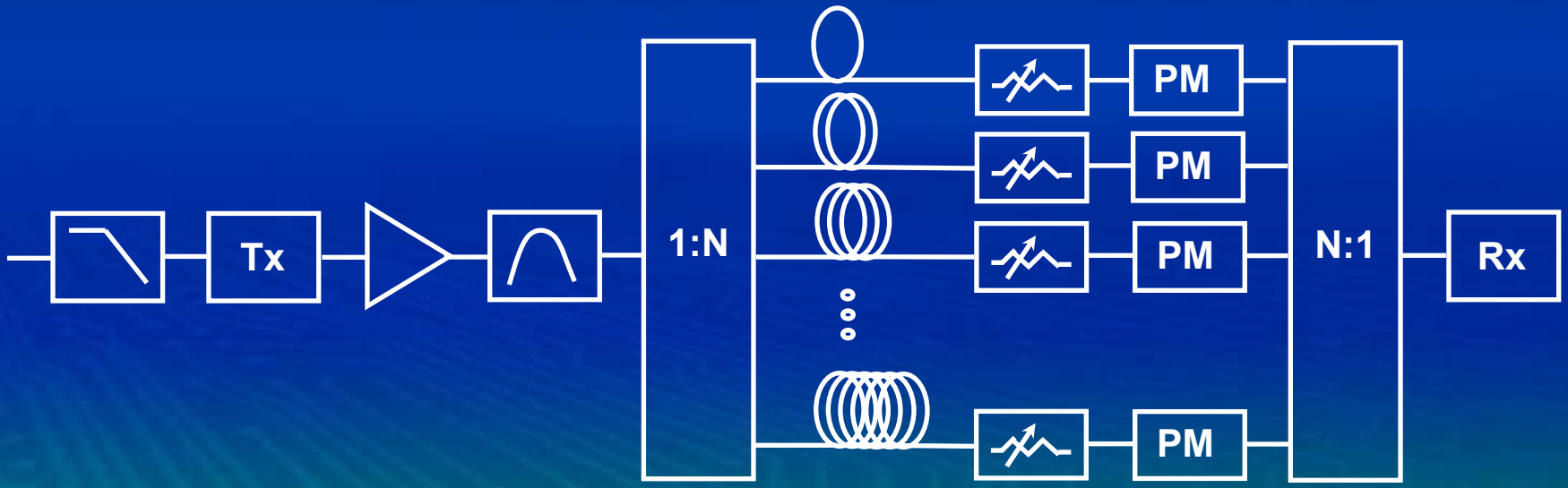


Architecture

- Method to reliably reproduce worst case modal dispersion
- SMF Transversal filter- concept
  - Split SMF to N delays, each with VOA, gain to compensate insertion loss
- Reference (DUT) Tx, electrically bandwidth limited
  - Can be any SMF pigtailed/pluggable Tx
- Reference (DUT) Rx
  - Can be any SMF/MMF pigtailed/pluggable Rx

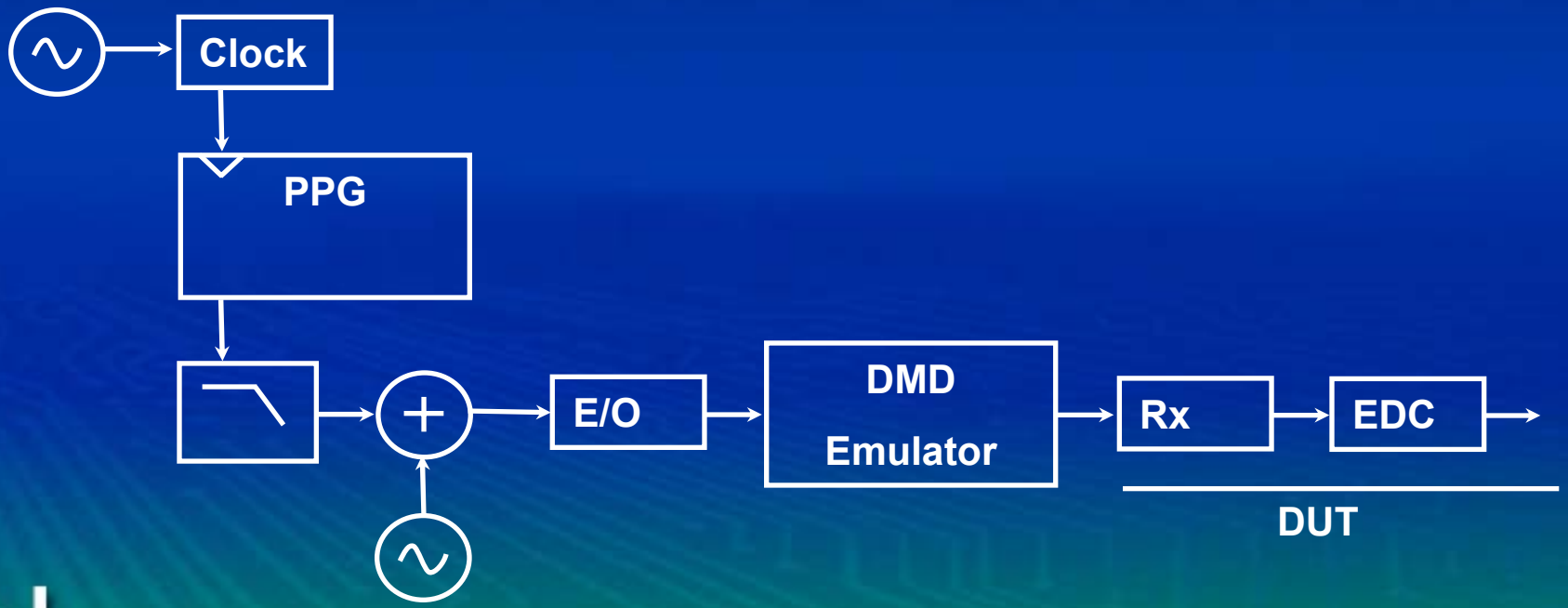


Capabilities and Limitations

- **This test bed can:**
  - **Create variable DMD to test Rx/EDC performance**
    - Weights are continuously variable
    - Delays are fixed, but by varying weights over time a variable delay can be approximated
- **This test bed cannot:**
  - **Evaluate different launch conditions**
  - **Evaluate the effects of spatial filtering (Rx optics)**

Possible Fit to Standard

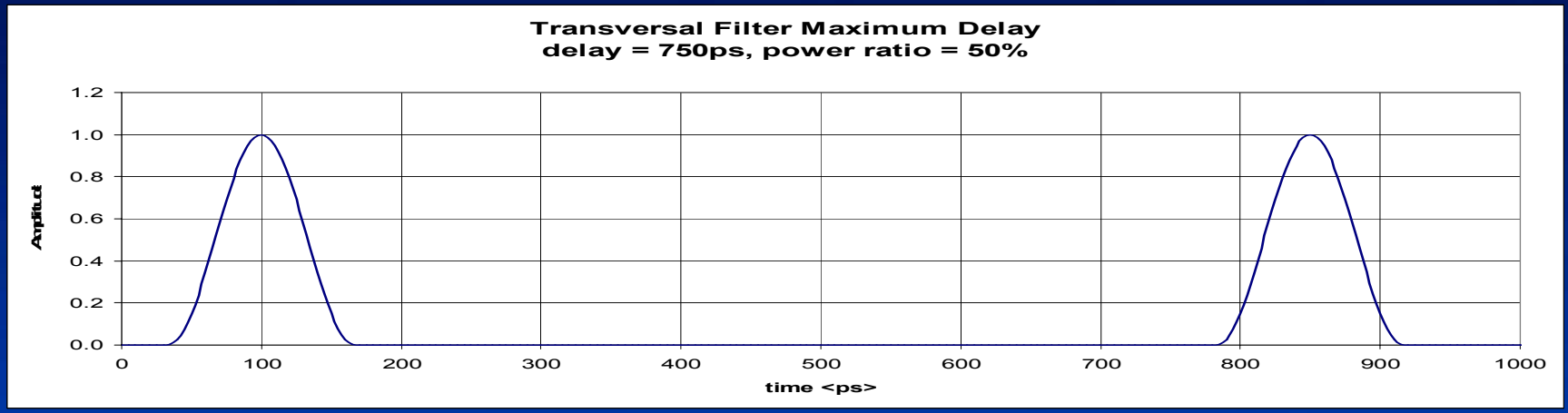
- Compare to 802.3ae 10GBASE-L Stressed Rx
  - Add DMD Emulator between E/O and Rx
  - Does not test compliance of Rx filtering
- 802.3ae TDP needs modification to evaluate launch
  - Add DMD characterization after known channel

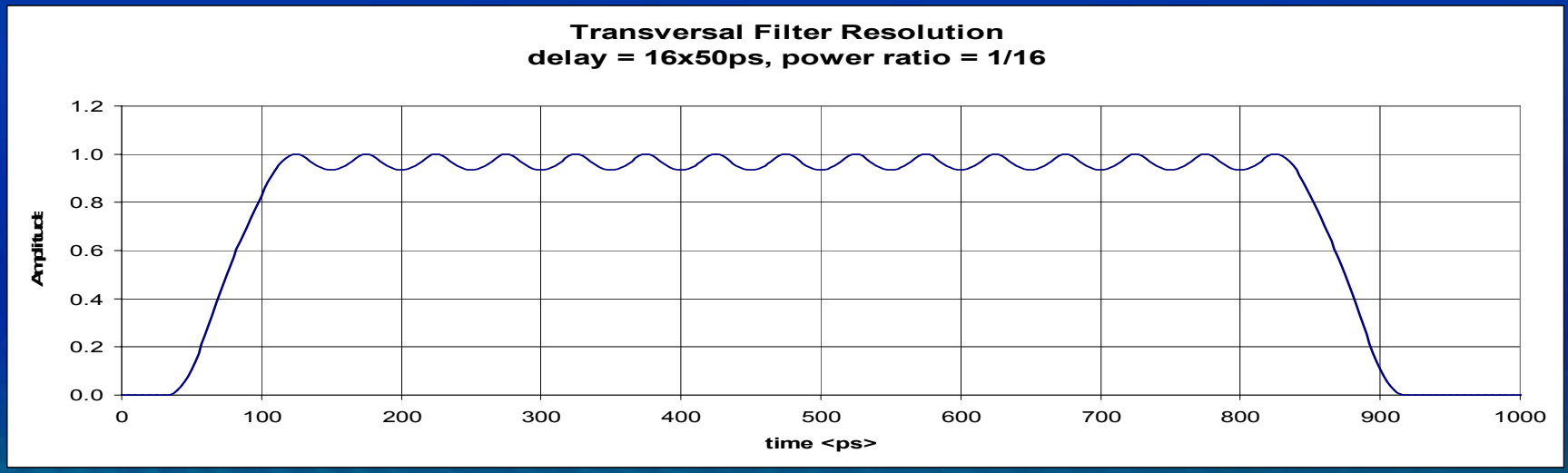


Tap Analysis

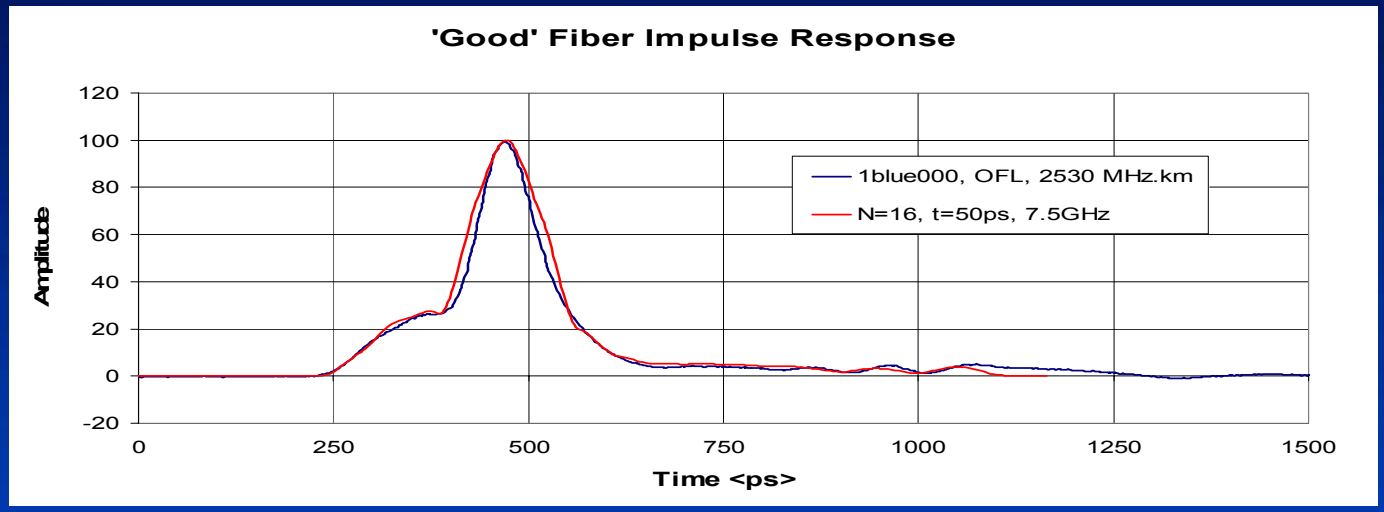
- N = 16 Taps
- Tap spacing 50ps
  - Speed of light in fiber, 2.01×10^8 m/s
  - Delay is 4.96ps/mm
  - Δl = 10.2 +/- 0.5mm = 50.3 +/- 2.5ps
- Maximum offset is 750ps
  - Empirical match to Round Robin fibers
- By weighting taps in real time, effective time delay variation is possible

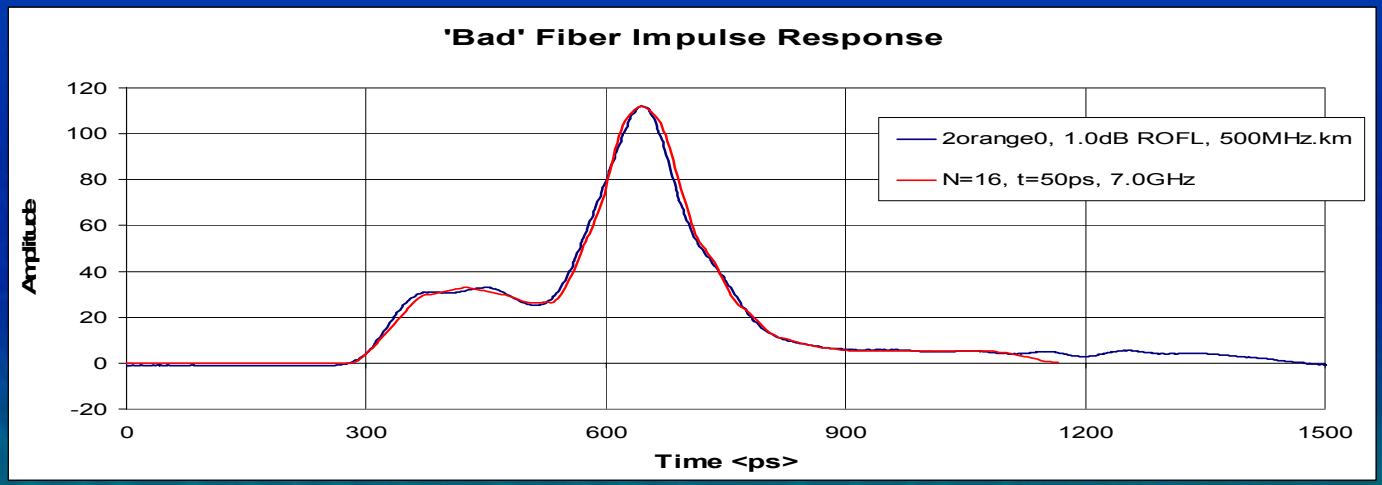
Tap Analysis



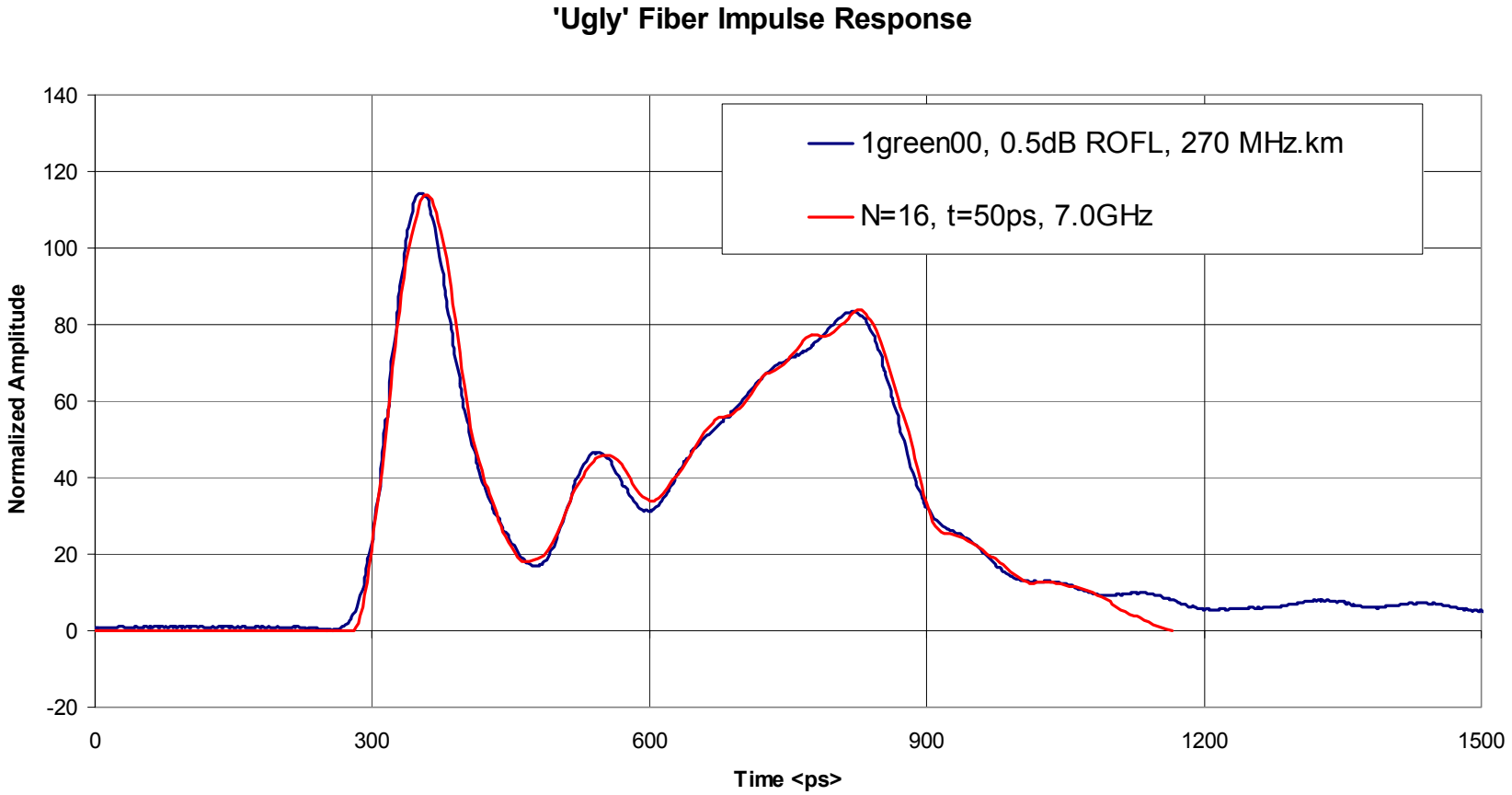


Modeling Round Robin Fibers 2530, 500 MHz*km

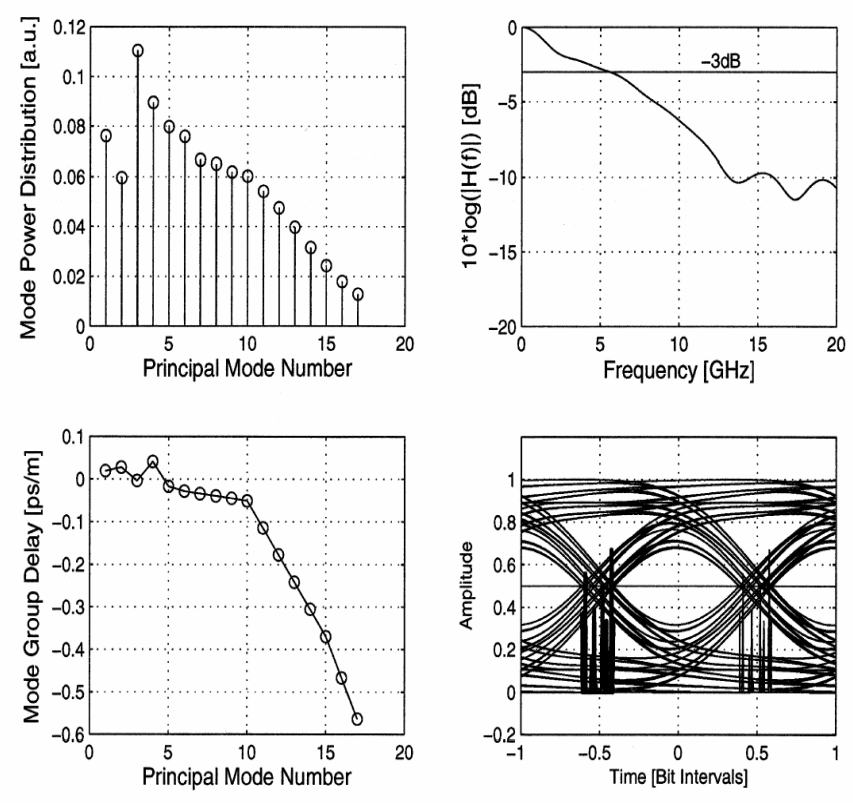




Worst of Round Robin Fibers 270 MHz*km



Tap Analysis- another example[2]



- Pepeljugoski, et al, 2003
- 17 Modes
- Maximum delay 180ps
- From eye diagram this is not the worst case that we have seen

Power Budget

- Compensate insertion loss with 1310nm SOA
- Provide Enough Rx Power to Test Overload

Tx Power	+2 dBm
SOA IL+Gain	+10 dB
Filter IL	-5 dB
Splitter IL	-2.5 dB
Attenuator IL	-1 dB
Power Meter IL	-1 dB
Combiner IL	-2.5 dB
Max Rx Power	0 dBm

EDC Test Bed- Future Development

- **Continue working with MMF Channel**
  - **Reference/DUT Tx**
    - Can be any SMF/MMF Tx
  - **Launch to MMF (center, offset, OFL, ROFL, other)**
    - Use patchcords
    - Leverage previous work
  - **Various (worst case) MMF links**
  - **Reference/DUT Rx**
    - Can be any MMF Rx (want all light, linear TIA or AGC)
    - Ideal Rx does not exist now, working with available parts
- **Calibrate SMF Channel to results**

References

1. *Understanding Multimode Bandwidth and Differential Mode Delay Measurements and Their Applications*, P. Kolesar, D. Mazzarese, Proceedings of the 51st IWCS, November 2002.
2. *Modeling and Simulation of Next-Generation Multimode Fiber Links*, P. Pepeljugowski, S. Golowich, A. Ritger, P. Kolesar, A. Risteski, Journal of Lightwave Technology, Vol. 21, No. 5, May 2003.