Optium

Breakthrough Technology for Optical Transmission

Optical Mode Filtering with EDC

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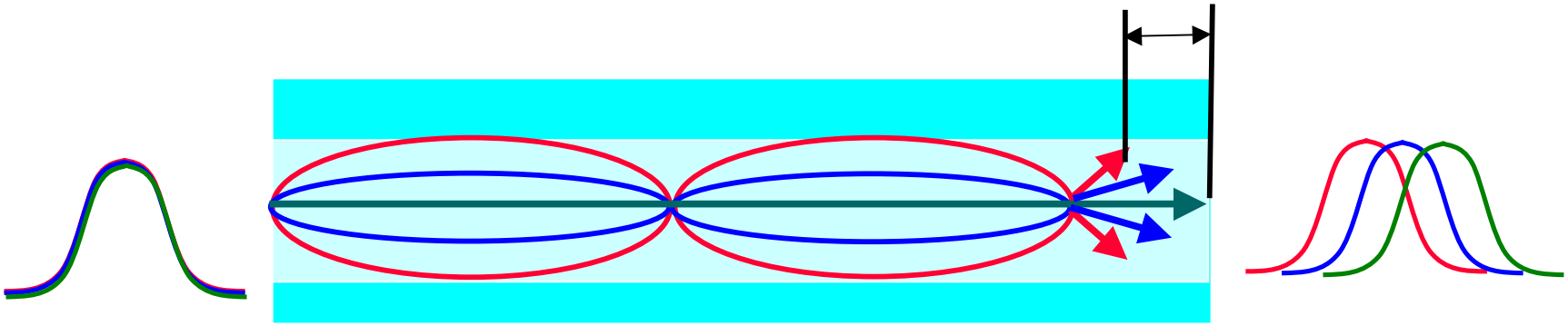
Agenda

- Objectives
- Review of Mode Filtering
- Impulse Response Characterization
- Environmental Effects
- Next Steps

Objectives

- 300m is required by OEM systems customers (99%)
- Solution must be compatible with XFP : POWER
- Mode filtering can reduce complexity of EDC
  - Reduce cost
  - Reduce power
  - Improve manufacturability
  - Increase Link Length to minimum of 300m (99%)

MMF propagation



- Bandwidth of MMF depends on: fiber index profile[1] and launch condition[2]
- Laser sources with a large spectrum of narrow longitudinal modes may cause modal noise[3]

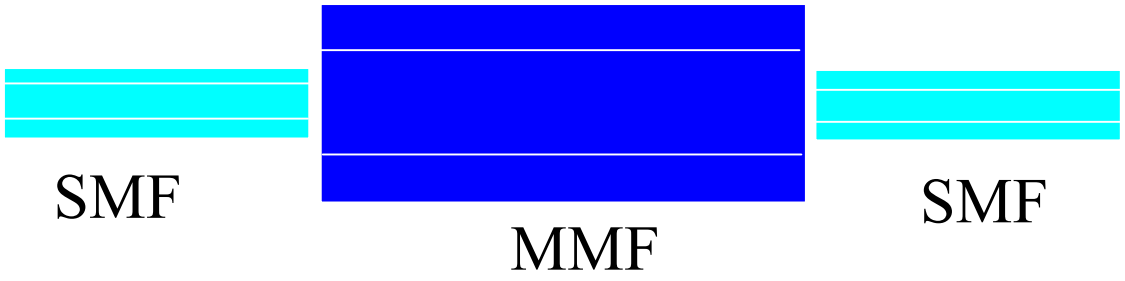
[1]L. Raddatz *et. al.*, *IEEE Photon. Technol. Lett.*, vol. 10, 1998
[2]M. Webster *et. al.*, paper CWD6, CLEO'99, 1999
[3]R. Dandliker *et. al., J. Lightwave Technol.,* vol LT-3, 1985

Scheme in Optical Domain

Idea

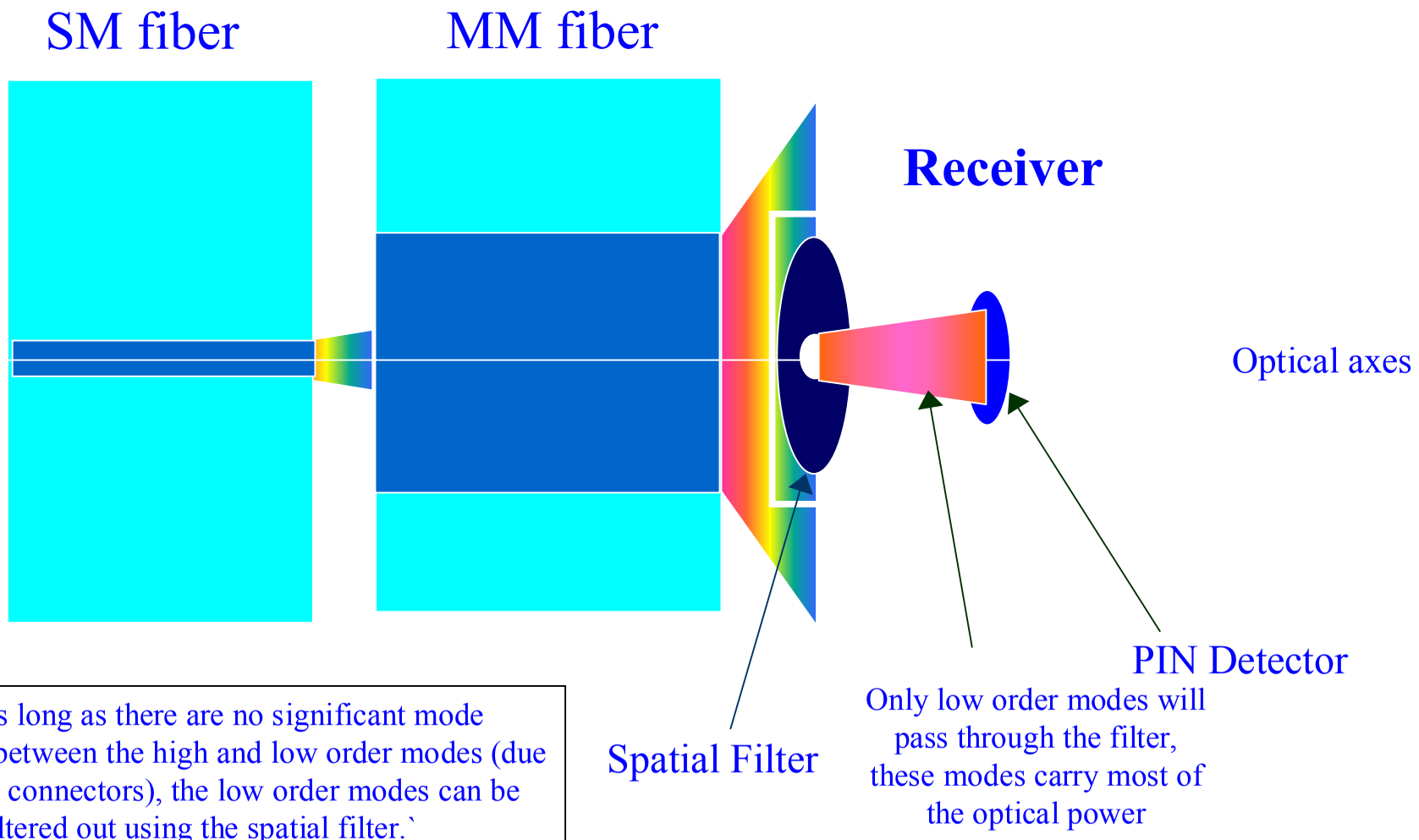
- Reduce the number of propagated modes
- Recover a limited number of modes on reception

Approach



- small beam, center launched
- modal filtering

Single mode launch:



Note: As long as there are no significant mode mixing between the high and low order modes (due to offset connectors), the low order modes can be easily filtered out using the spatial filter.`

Fundamental Mode Propagation in MM fiber

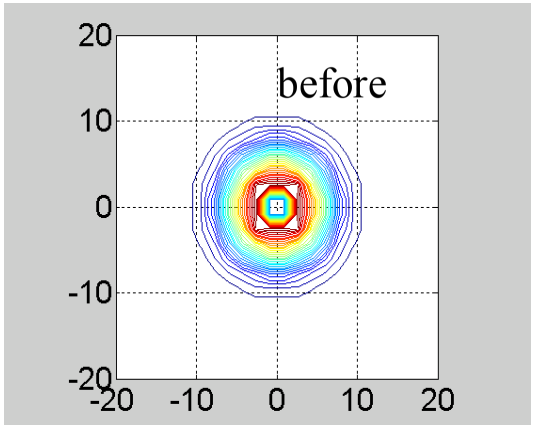
- Propagation in the fundamental mode has been studied in the last few years sensor applications, for example :

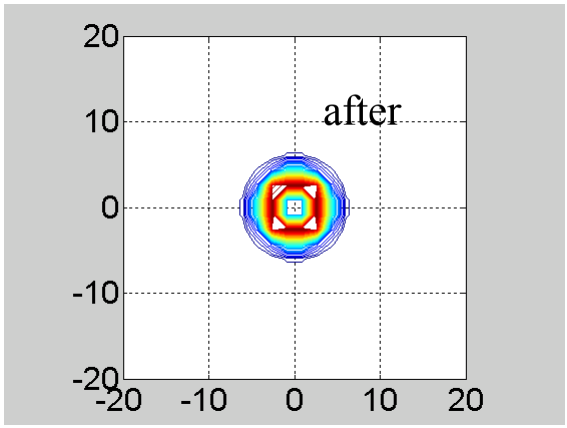
  "Propagation of Fundamental Mode in Curved Graded Index Multimode Fiber and Its Application in Sensor Systems," Journal of Lightwave Technology, March 2000.

Summary:

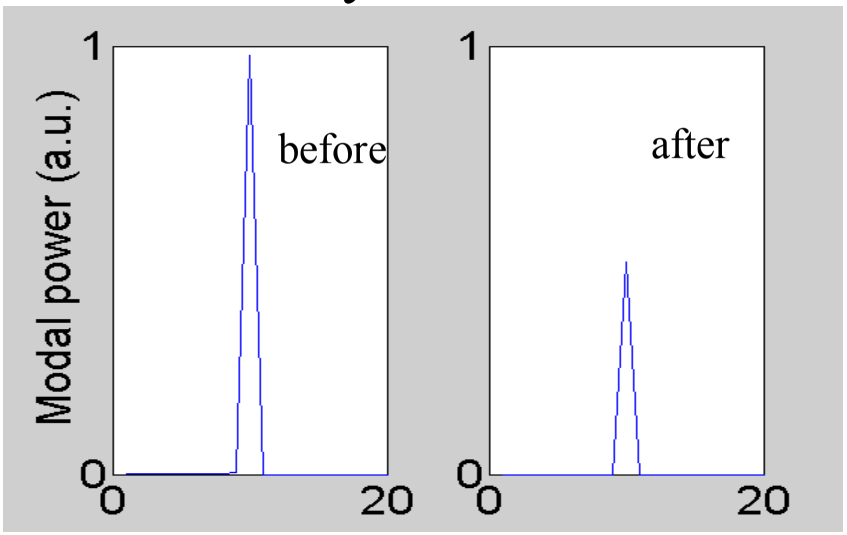
1. The propagation loss due to mode out coupling is 0.1-0.4dB/km at 1310nm
2. There is a critical bend radius where all propagated power is lost, but this value is very low for the fundamental modes, ~5mm
3. Strongly bending of MM fiber does not cause coupling of fundamental modes to higher order modes, because Δβ's of each mode remain constant in the bent condition for lowest order modes
4. Bending of the fiber attenuates the higher order modes, i.e. bending acts as a low pass modal filter!!
5. Mode mixing, if present, will be small

Center launched (9 μm receiver)

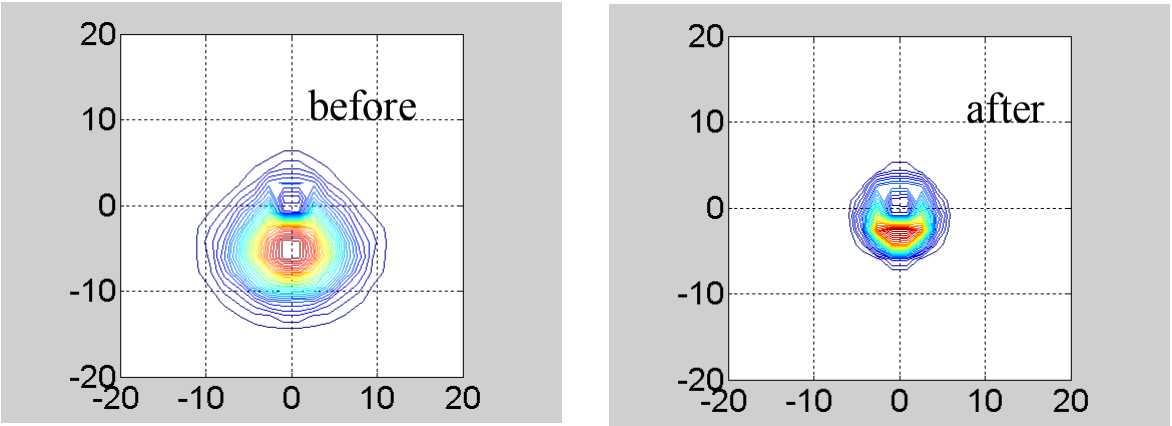




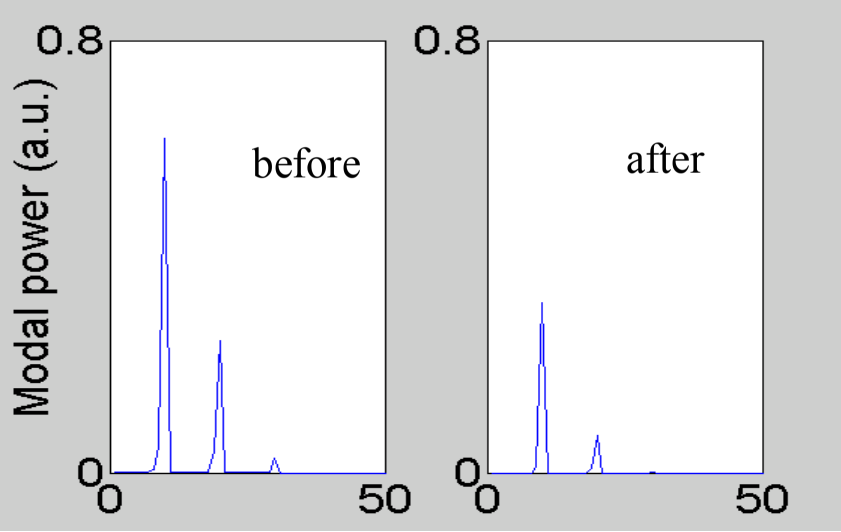
Intensity distribution



5 μm offset launched (9 μm receiver)

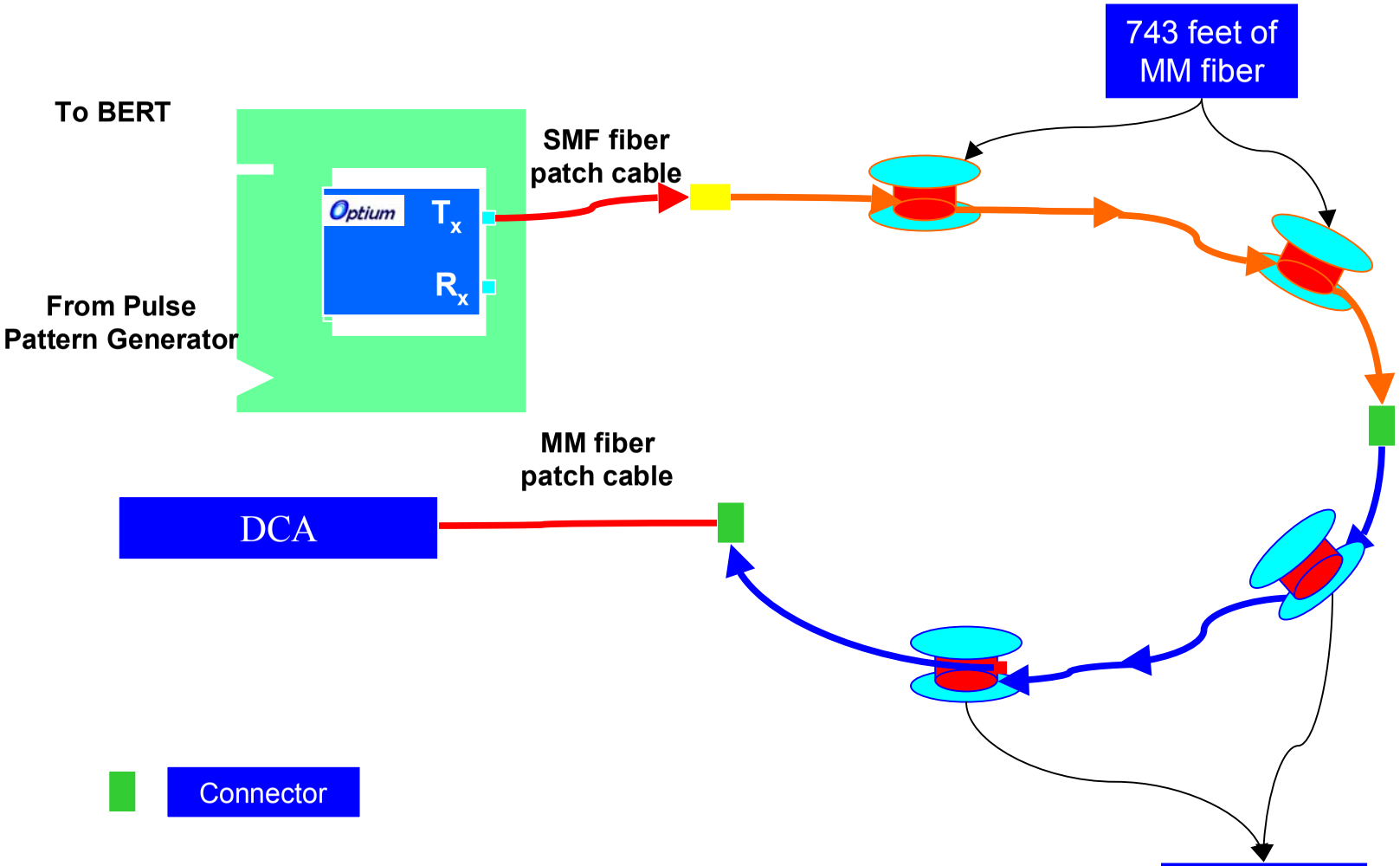


Intensity distribution



Mode index

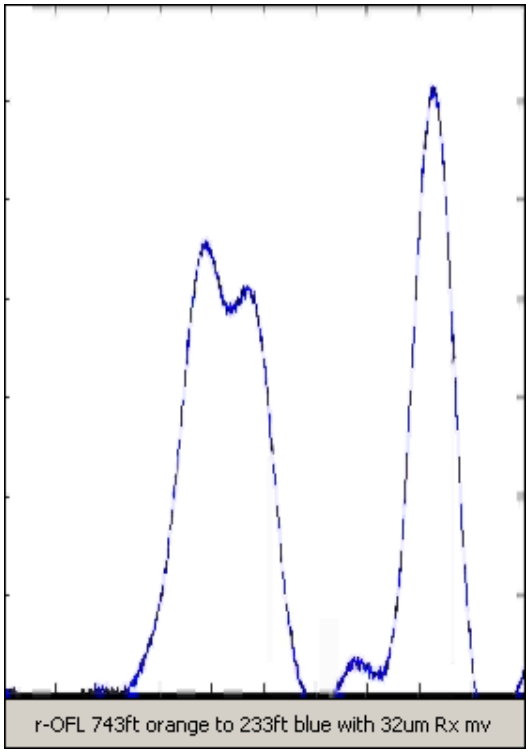
Experiment setup



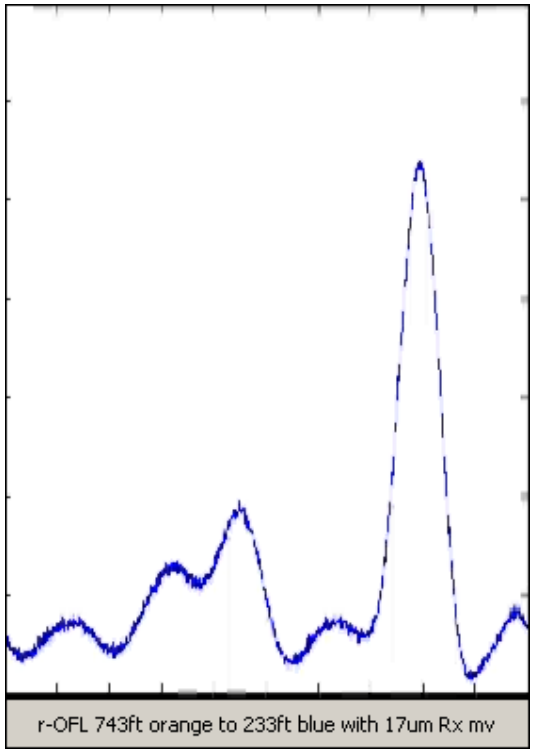
Filtering effect of different apertures

r-OFL launching and variation is due to the bending of fibers (This is not normal operation)

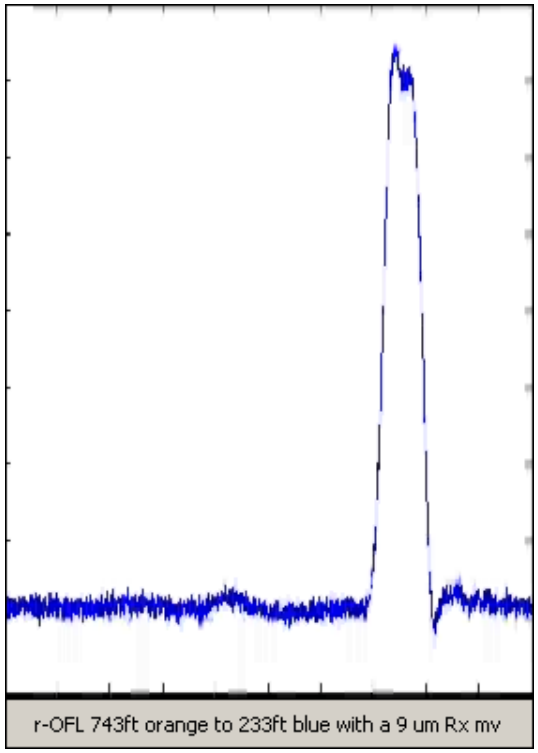
32um



17um

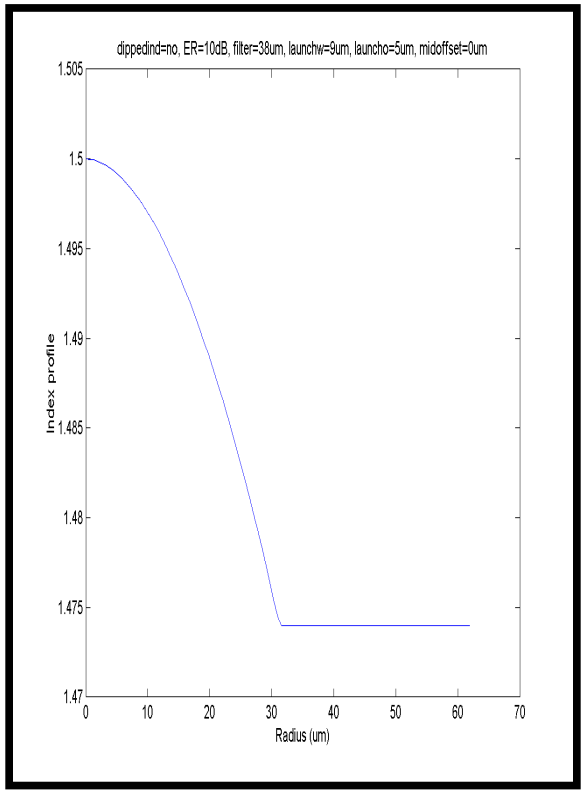


9um

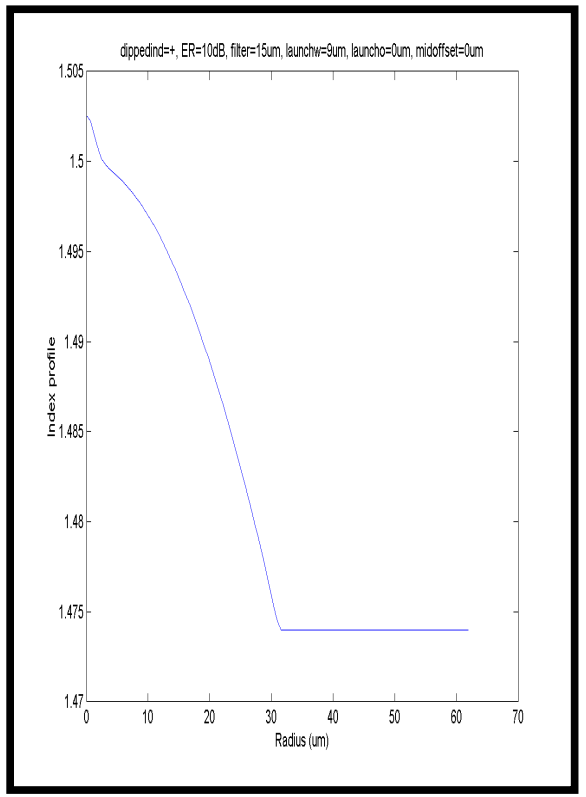


Simulation Index Profiles

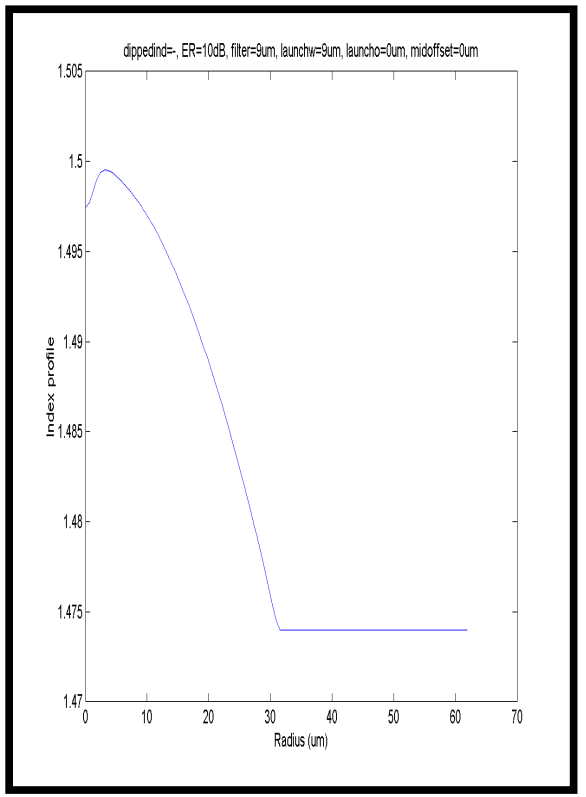
Case I



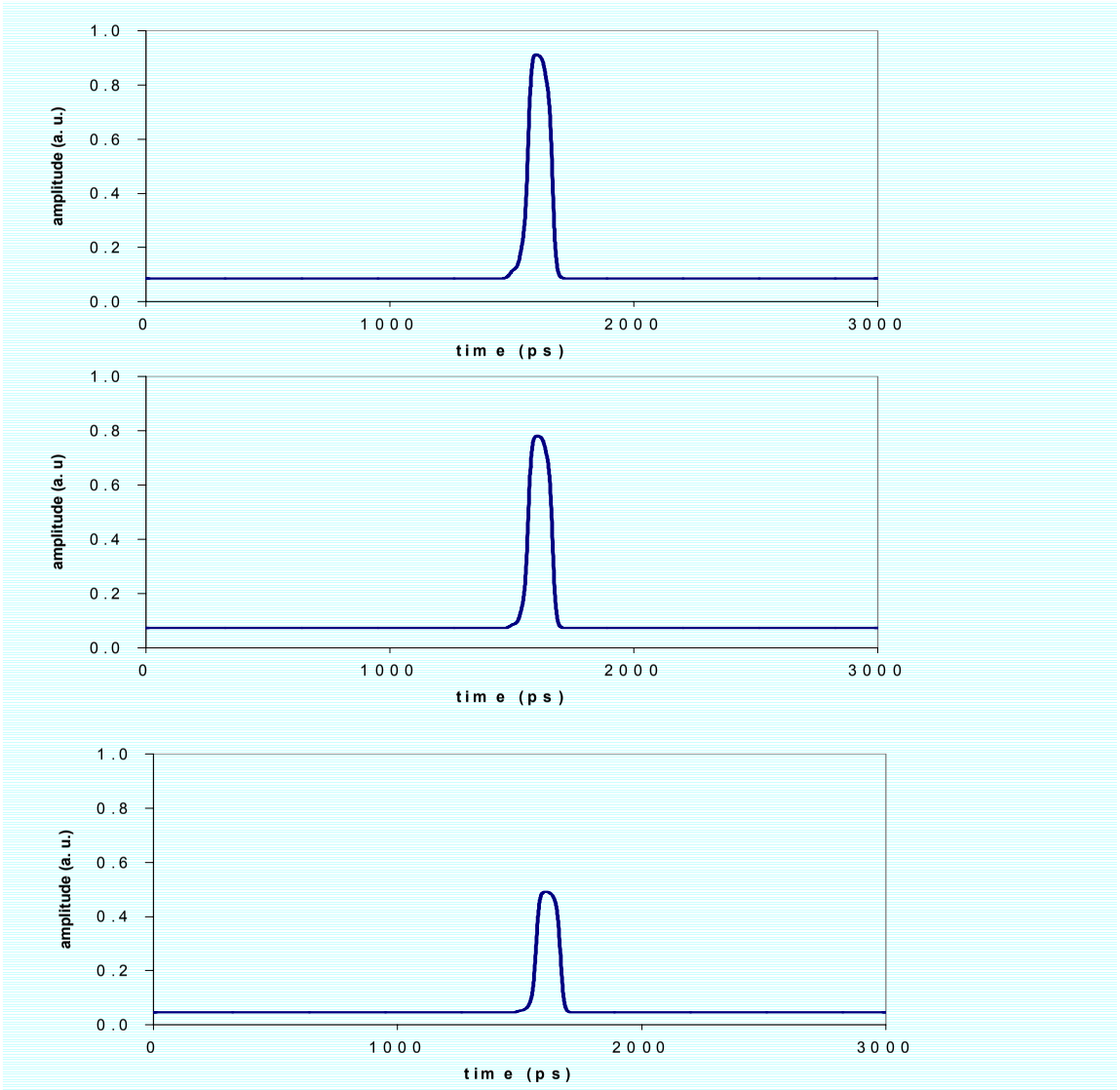
Case II



Case III



Case I: 3 μm offset at input, after receiver

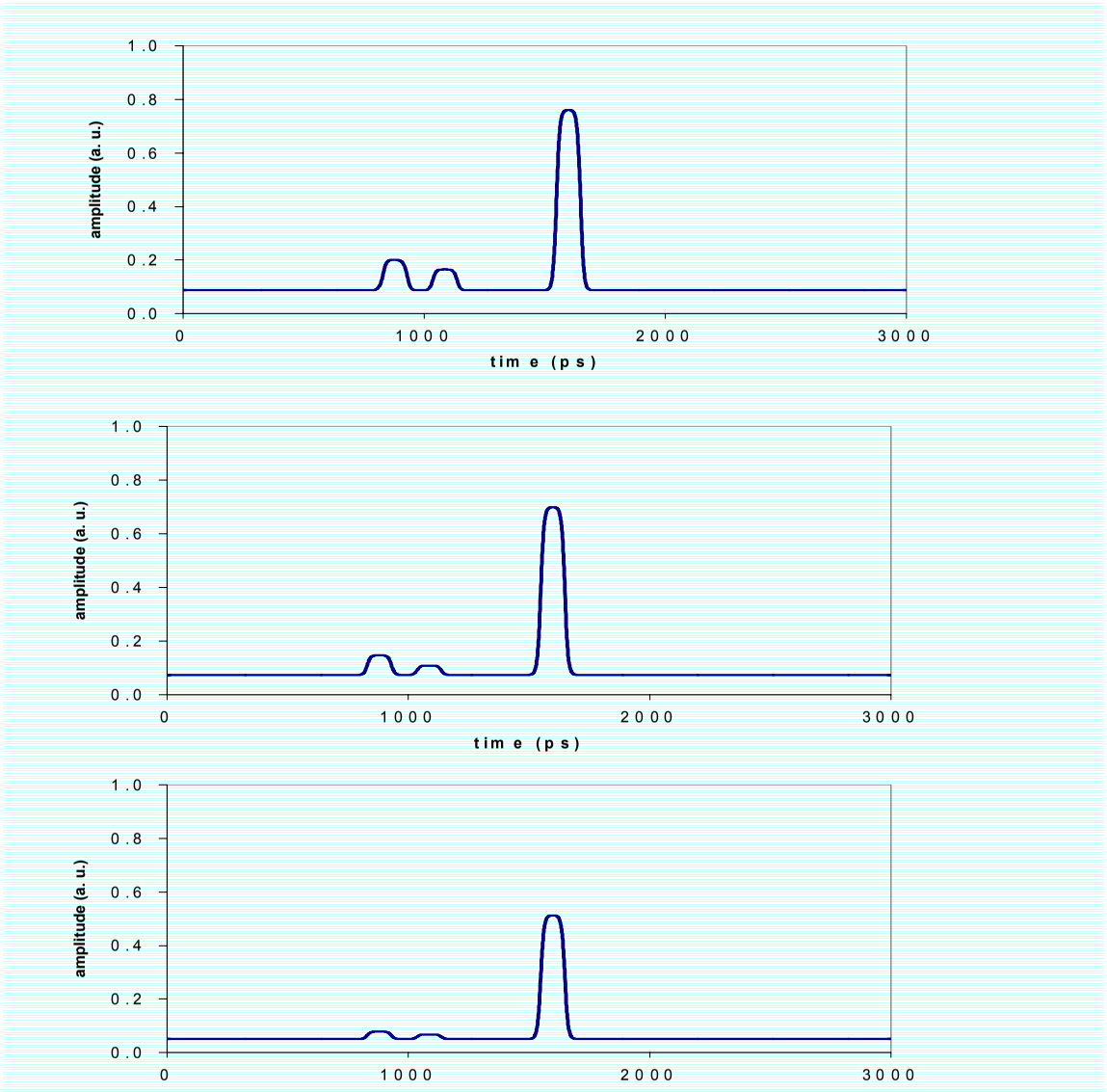


38 μm

15 μm

9 μm

Case II: 3 μm offset at input, after receiver



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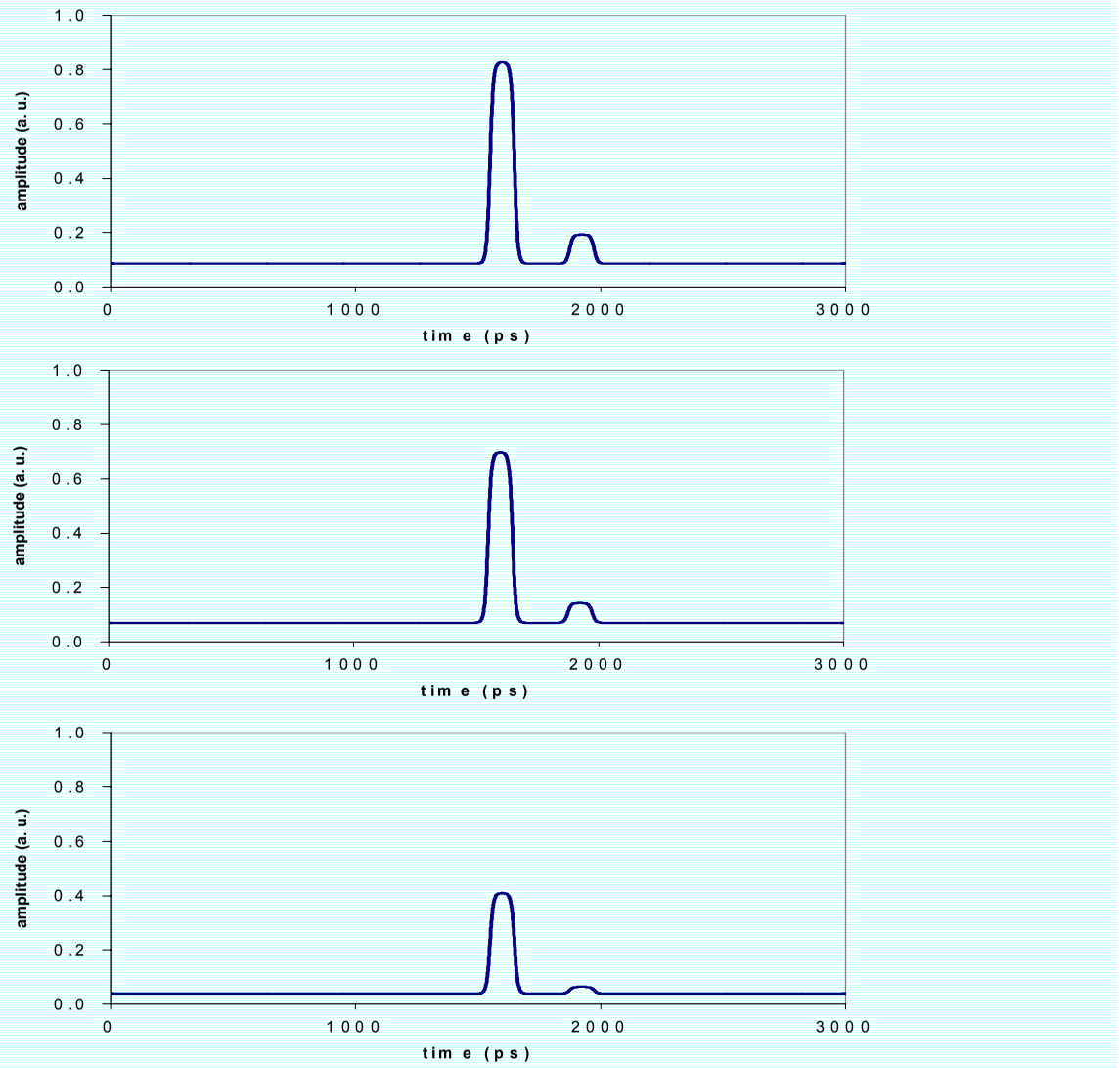
Case III: 3 μm offset at input, after receiver



38 μm

15 μm

9 μm

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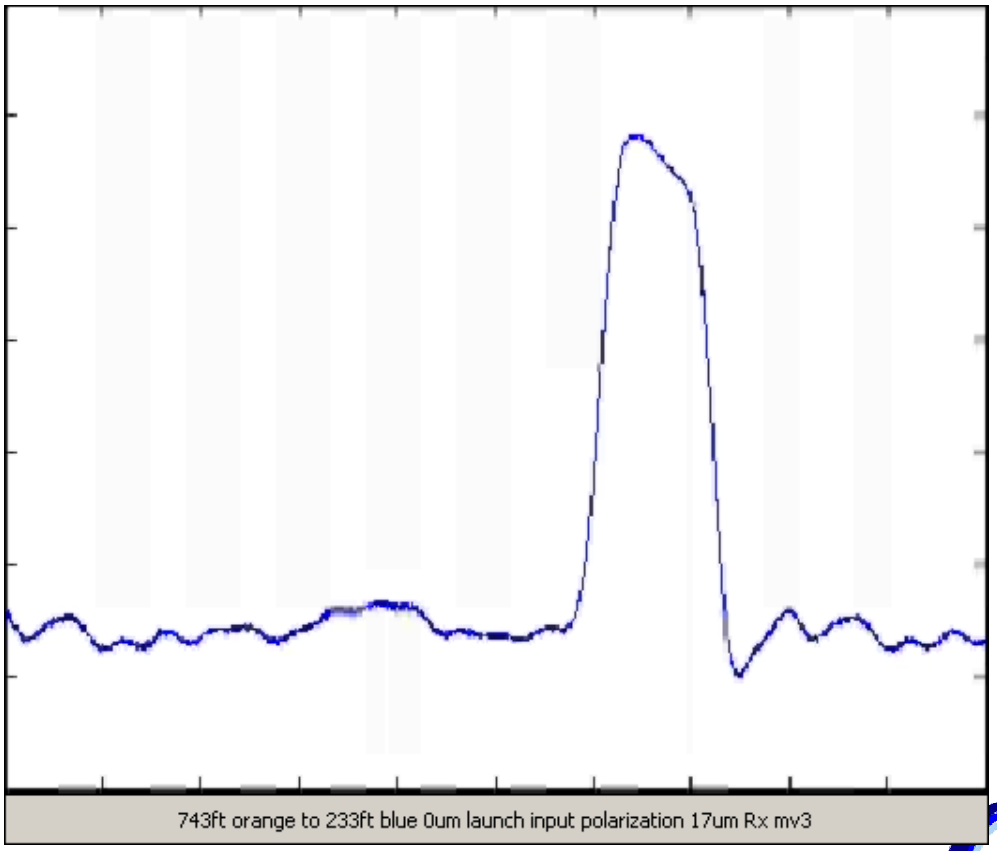
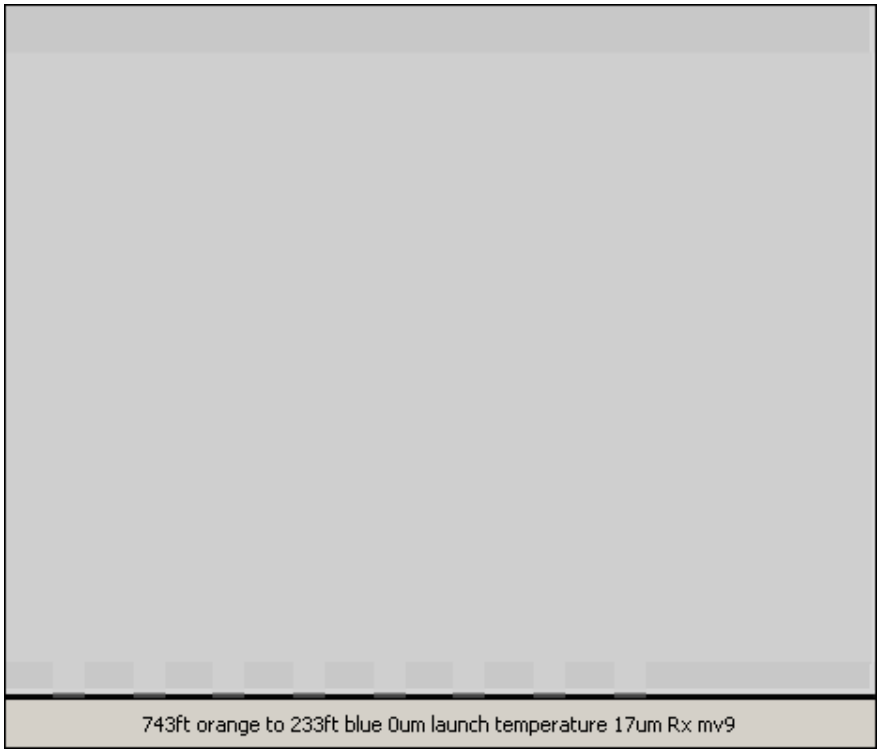
Impulse response: Polarization Dependence

- Vary the input polarization state
- Receiver aperture: 17 μm

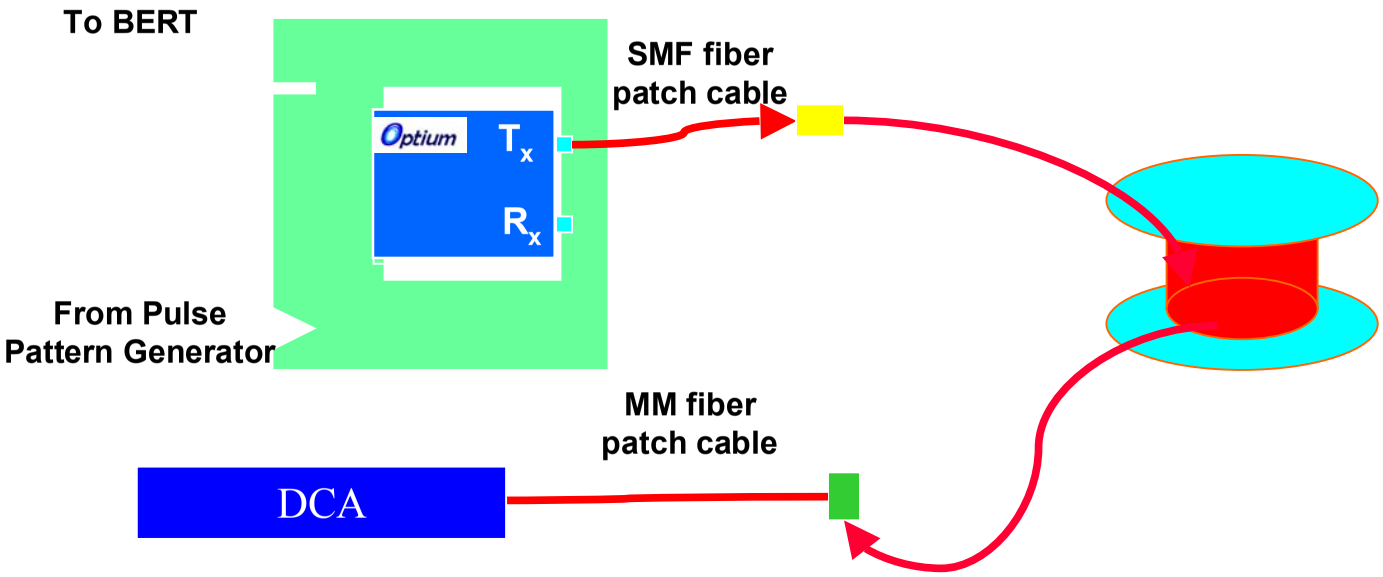


Impulse response: Temp Ramp

- Vary the temperature (-10 °C to 85 °C)
- receiver aperture: 17 μm



Industry Fibers: Experiment setup

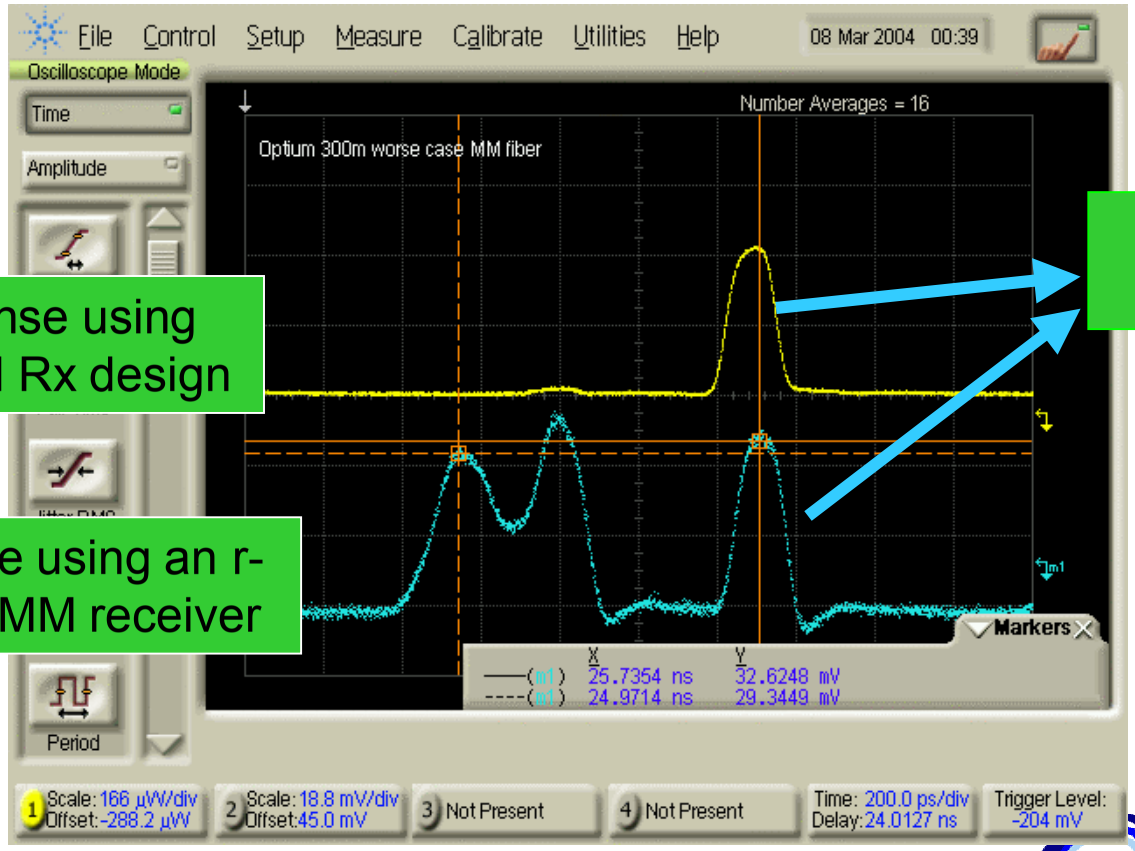


- **Optium's MM fiber**
- **JDSU MM fiber**
- **Broadcom MM fiber**
- **Infineon MM Fiber**
- **TIA 1296 Round Robin Fibers**

Test case I: Optium's worse case MM fiber

Fiber length : 300 m

Note: This fiber is a non index dipped fiber (high order modes arrive early), severe BW problems.



Impulse response using Optium's Tx and Rx design

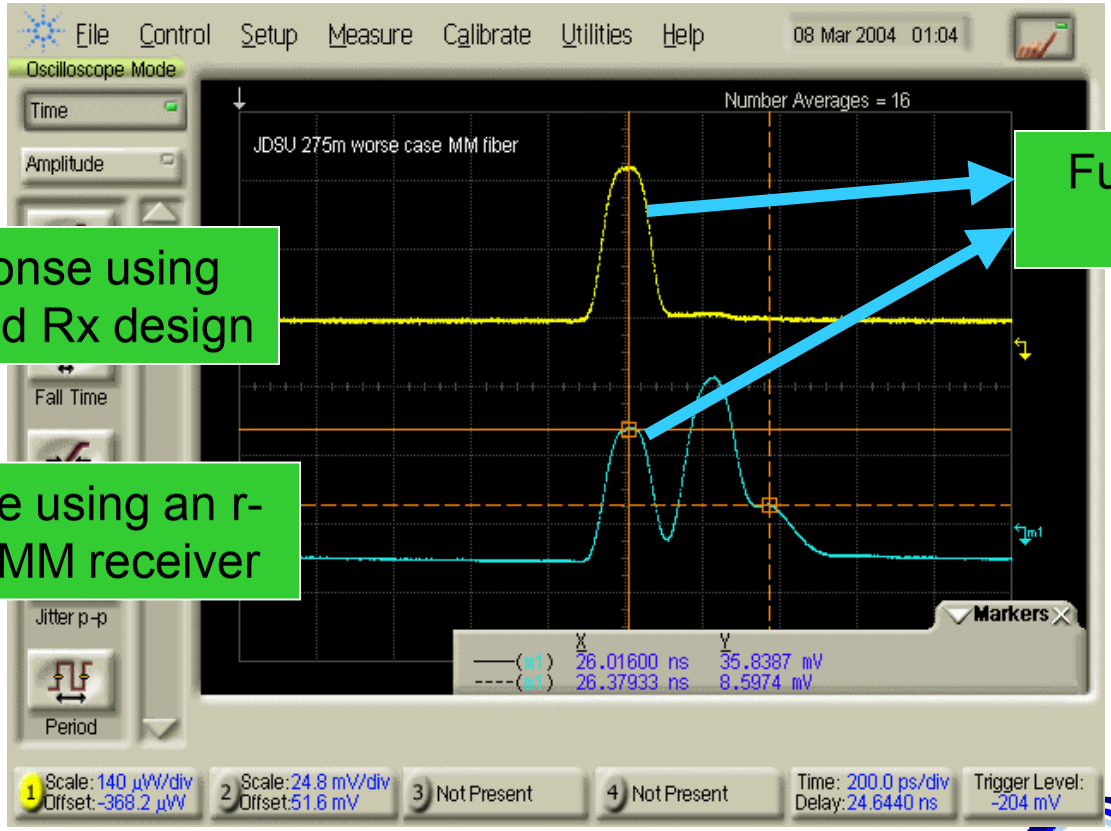
Impulse response using an r-OFL with 50 um MM receiver

Fundamental modes

Test case II: JDSU worse case MM fiber

Fiber length : 275 m

Note: This fiber is an index dipped fiber (high order modes arrive late), severe BW problems.



Impulse response using Optium's Tx and Rx design

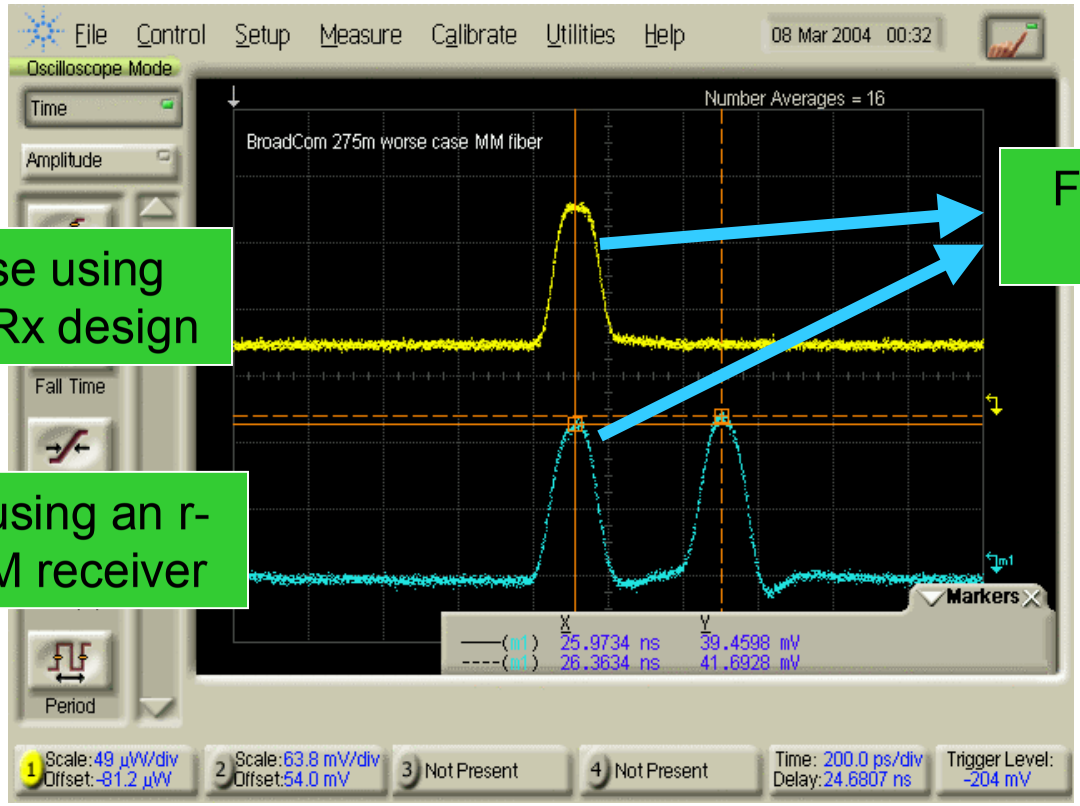
Fundamental modes

Impulse response using an r-OFL with 50 um MM receiver

Test case III: Broadcom worse case MM fiber

Fiber length : 275 m

Note: This fiber is an index dipped fiber (high order modes arrive late), severe BW problems.



Impulse response using Optium's Tx and Rx design

Impulse response using an r-OFL with 50 um MM receiver

Fundamental modes

Summary

- 300m is required by OEM systems customers (99%)
- Any standard must be compatible with XFP
  - POWER, Size
- Mode filtering can be used to reduce complexity of EDC by cleaning up the impulse response
- Optium will generate a proposal with a team of:
  - Systems manufacturers, IC suppliers, transceiver manufacturers, optical device manufacturers
- Optium will work within IEEE licensing guidelines