

# Insertion Loss

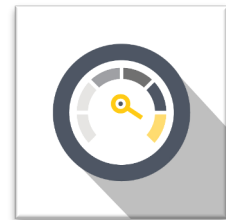
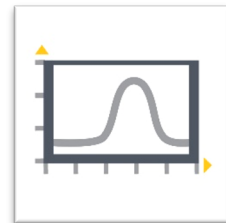
# About OptoTest

Designing fiber optic test equipment for 20 years

Specialize in measuring Insertion Loss and Return Loss

Tailor test equipment to the needs of the customer

We take pride in simplifying the test and measurement process for our customers to help increase efficiency



# Insertion Loss Overview

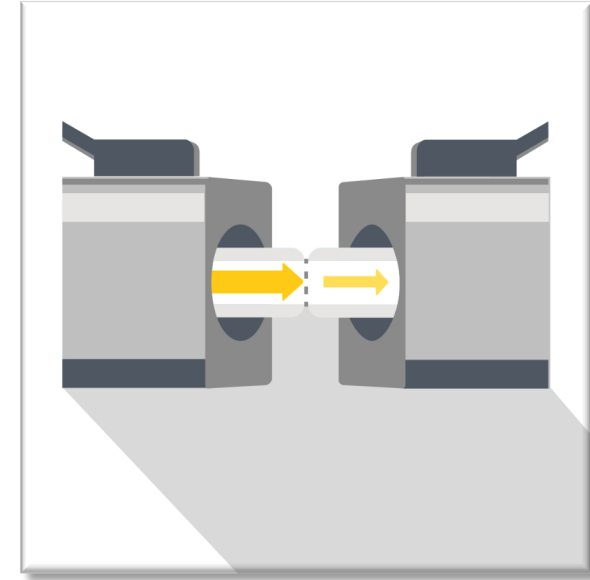
What is insertion loss

Where does it come from?

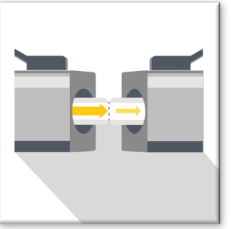
Single mode

Multimode fibers

Launch conditions in multimode fiber



# Insertion Loss



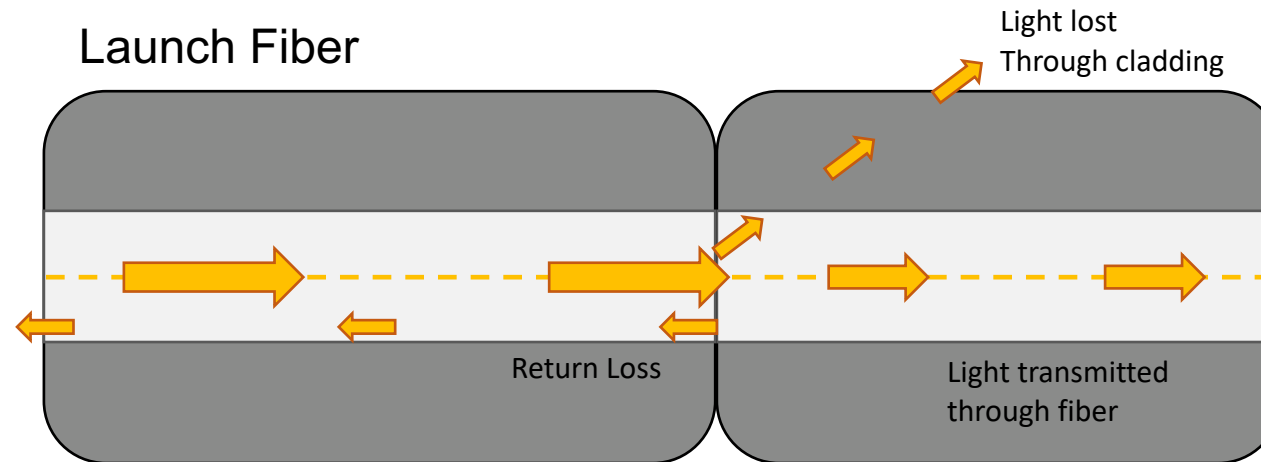
- Insertion loss (IL) in fiber optic cables is the amount of light lost with respect to the light going into the fiber optic cable
  - This is a value that typically is expressed in decibels (dB)

$$IL(dB) = 10 * LOG \left( \frac{P_{in}}{P_{out}} \right)$$

- A decrease in 50% power is about 3dB of insertion loss

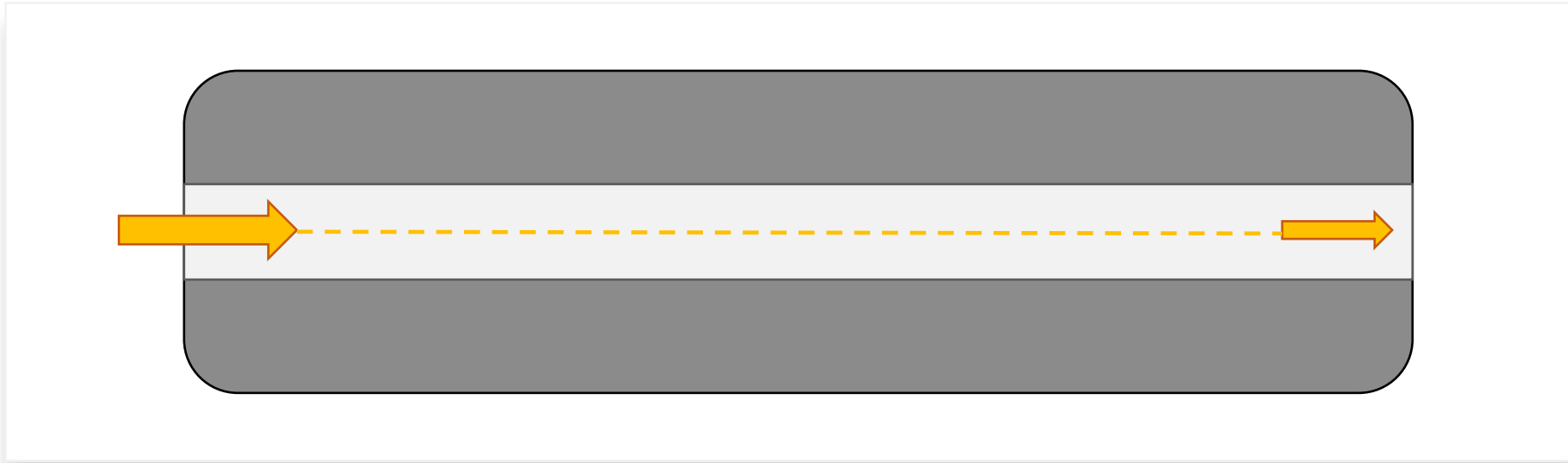
# Where Does Insertion Loss Occur?

- There are two main sources of loss in a fiber optic cable
  - The first is at connections where two fibers may mate together
    - Mated connections, fusion splices or mechanical splices
    - At an interface light can be reflection (return loss), lost through the cladding, or transmit down the fiber.
      - Reflected light and light that escapes through the cladding contribute to insertion loss.



# Where Does Insertion Loss Occur?

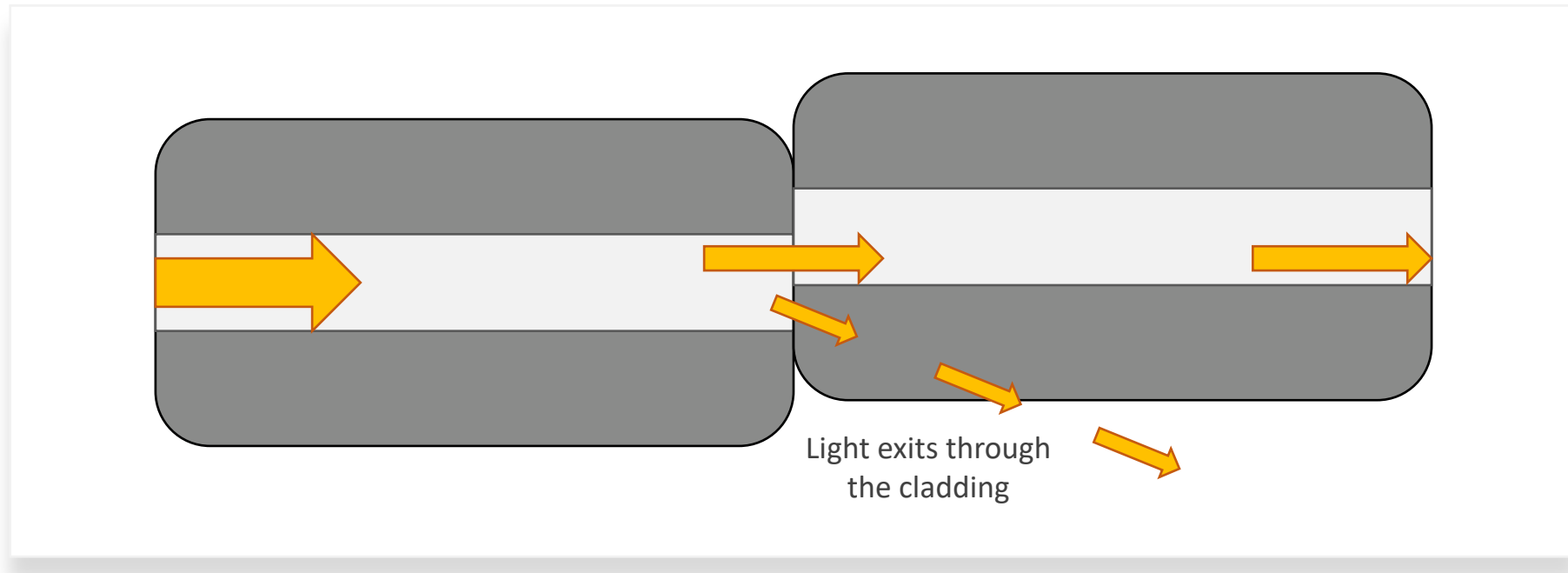
- The second source of loss is the fiber itself
  - Fiber has inherent attenuation due to absorption and scattering



- Attenuation is expressed in dB/km typically

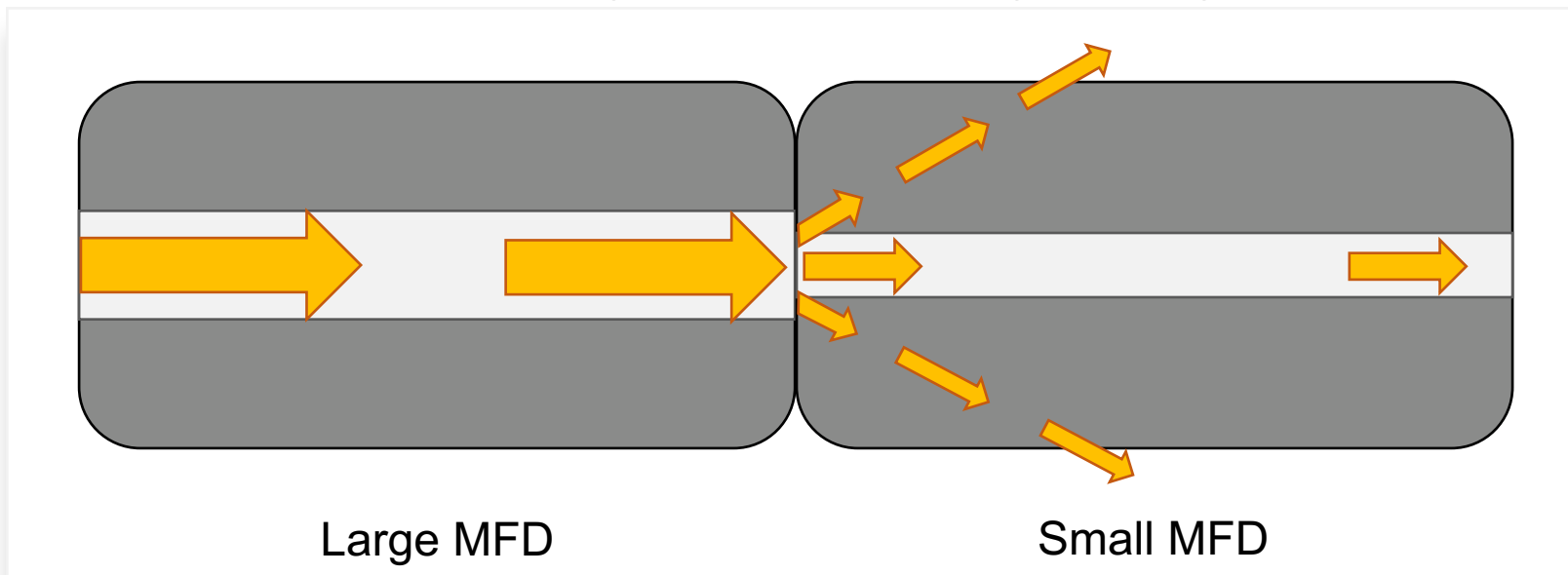
# Connection (Mating) Insertion Loss

- Connection loss comes in a few forms
  - Lateral misalignment
    - Light at the core/cladding overlap will escape through the cladding.



# Connection (Mating) Insertion Loss

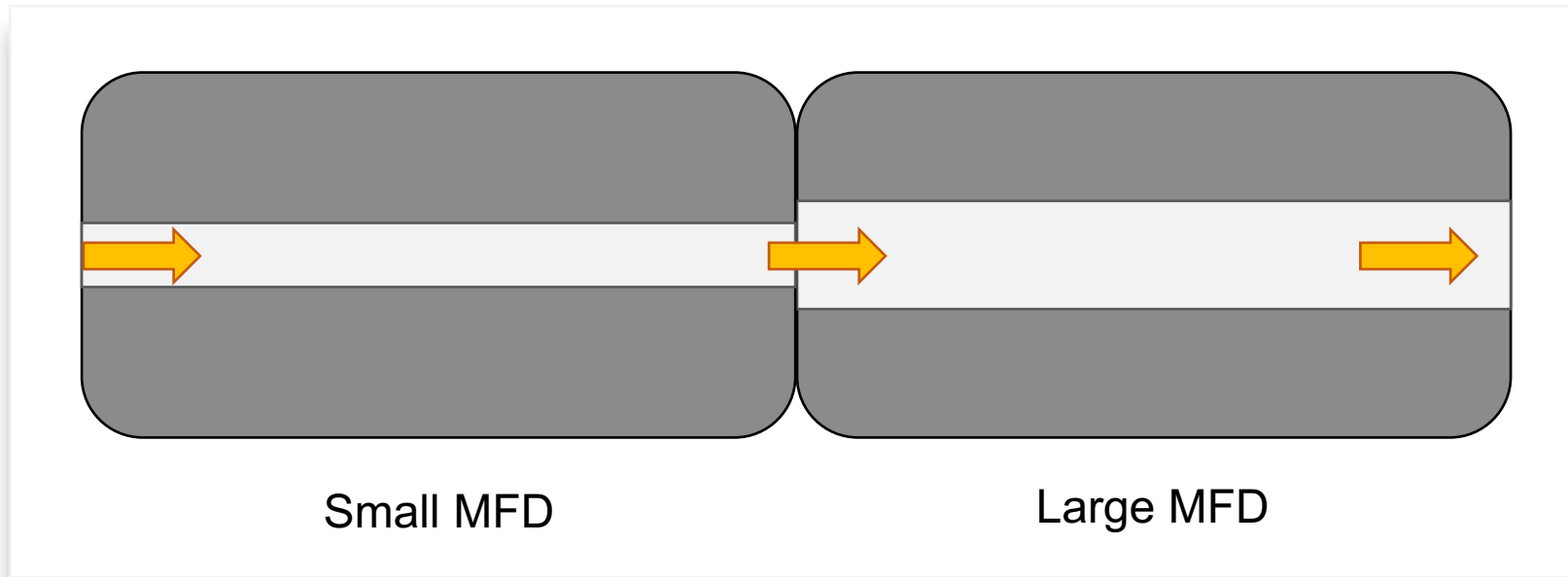
- Connection loss comes in a few forms
  - Mode field diameter mismatch
    - Mode field diameter describes the electric field intensity of the light exiting the fiber. This typically relates to how much light a fiber can accept for single mode fibers
    - Typically 9 to 12 $\mu\text{m}$  for a single mode fiber
    - Large MFD to Small MFD leads to large loss
    - The area at the core/cladding overlap leads to light exiting the fiber.





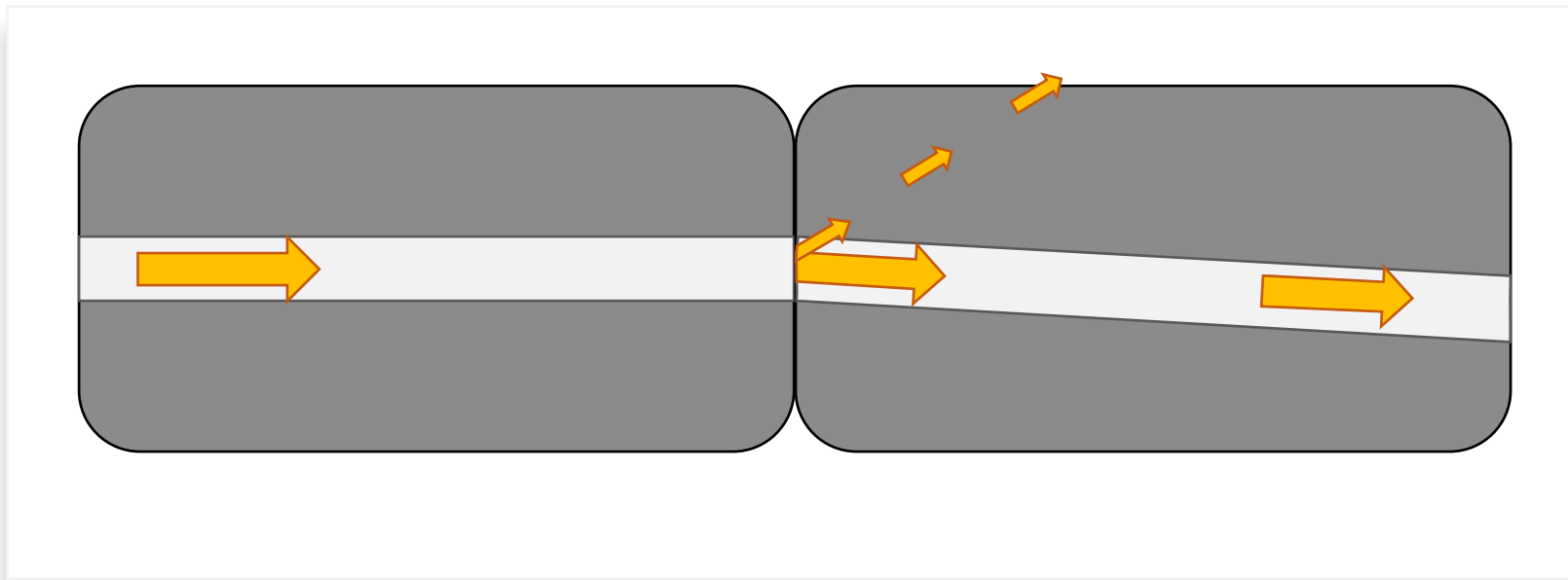
# Connection (Mating) Insertion Loss

- Connection loss comes in a few forms
  - Mode field diameter mismatch
    - Small MFD into Large MFD leads to low loss



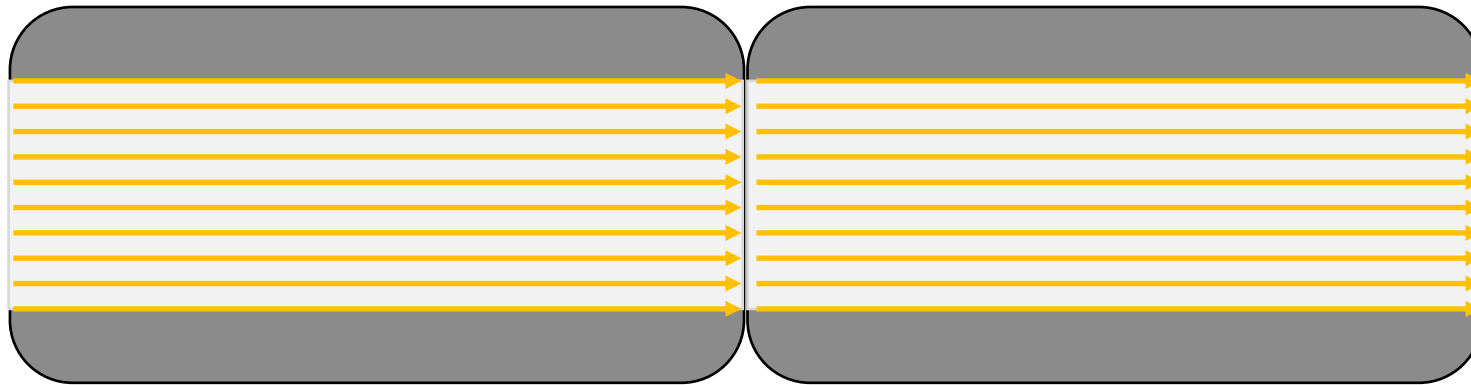
# Connection (Mating) Insertion Loss

- Connection loss comes in a few forms
  - Angular misalignment will induce loss in connections



# Multimode Insertion Loss

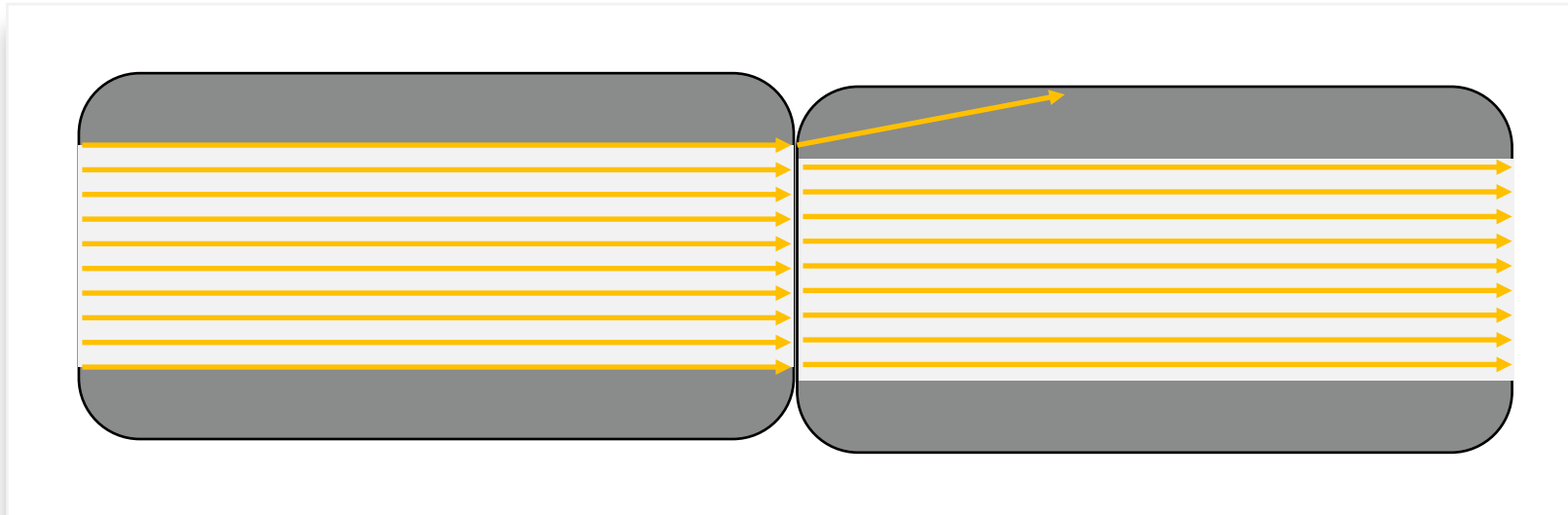
- Multimode links present a distinct problem when testing insertion loss
  - With single mode fiber there is only one mode that can induce loss. In multimode fiber there are many modes, and these modes can all affect the loss seen by a connection



Above is a perfectly aligned fully populated multimode fiber, which would result in negligible loss

# Multimode Insertion Loss

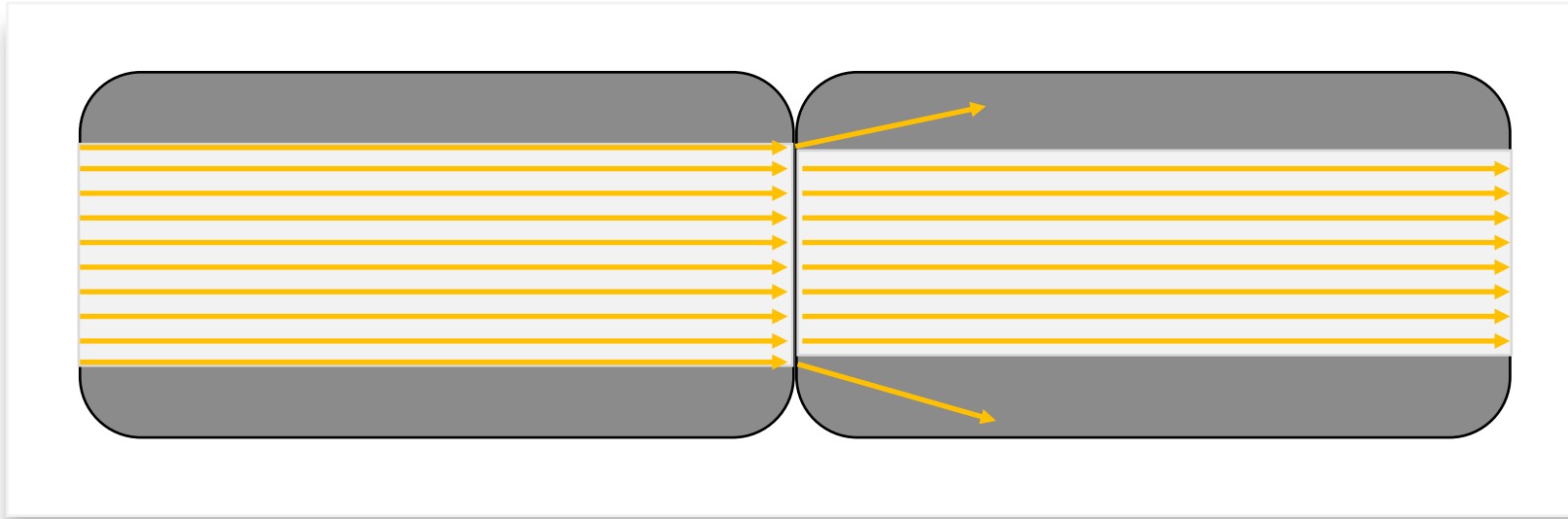
- Multimode links present a distinct problem when testing insertion loss
  - If light is propagating through the entire core small misalignments will induce loss



- The fiber on the right is misaligned slightly.
- Light is lost due to this small core alignment offset

# Multimode Insertion Loss

- Multimode links present a distinct problem when testing insertion loss
  - A core size mismatch will lead to losses similar to an MFD mismatch in single mode fiber

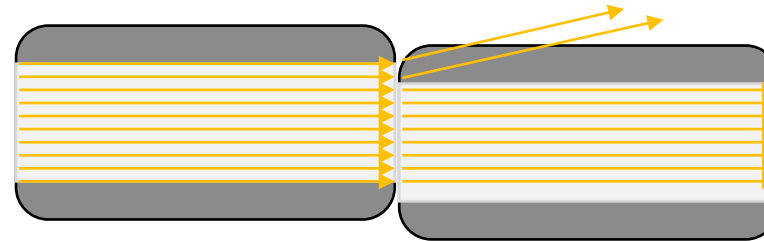


- The fiber on the right is slightly smaller than the fiber on the left.
- Light is lost at the core/cladding interface

# Multimode Insertion Loss

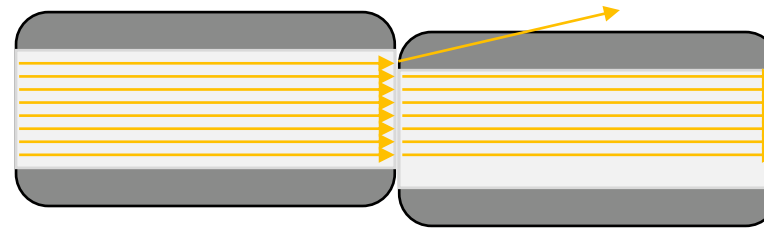
Multimode links present a distinct problem when testing insertion loss

- The loss of the connection is dependent on how filled the launch fiber is
- A more filled core on the launch fiber produces high loss
- A lower filled launch fiber produces low loss



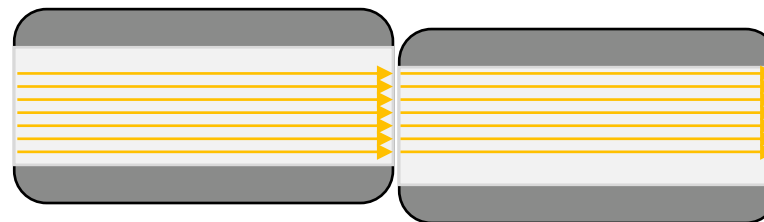
$$\text{Transmission Ratio} = \frac{8 \text{ modes}}{10 \text{ modes}} = 80\%$$

$$IL = 0.97 \text{ dB}$$



$$\text{Transmission Ratio} = \frac{7 \text{ modes}}{8 \text{ modes}} = 87.5\%$$

$$IL = 0.56 \text{ dB}$$

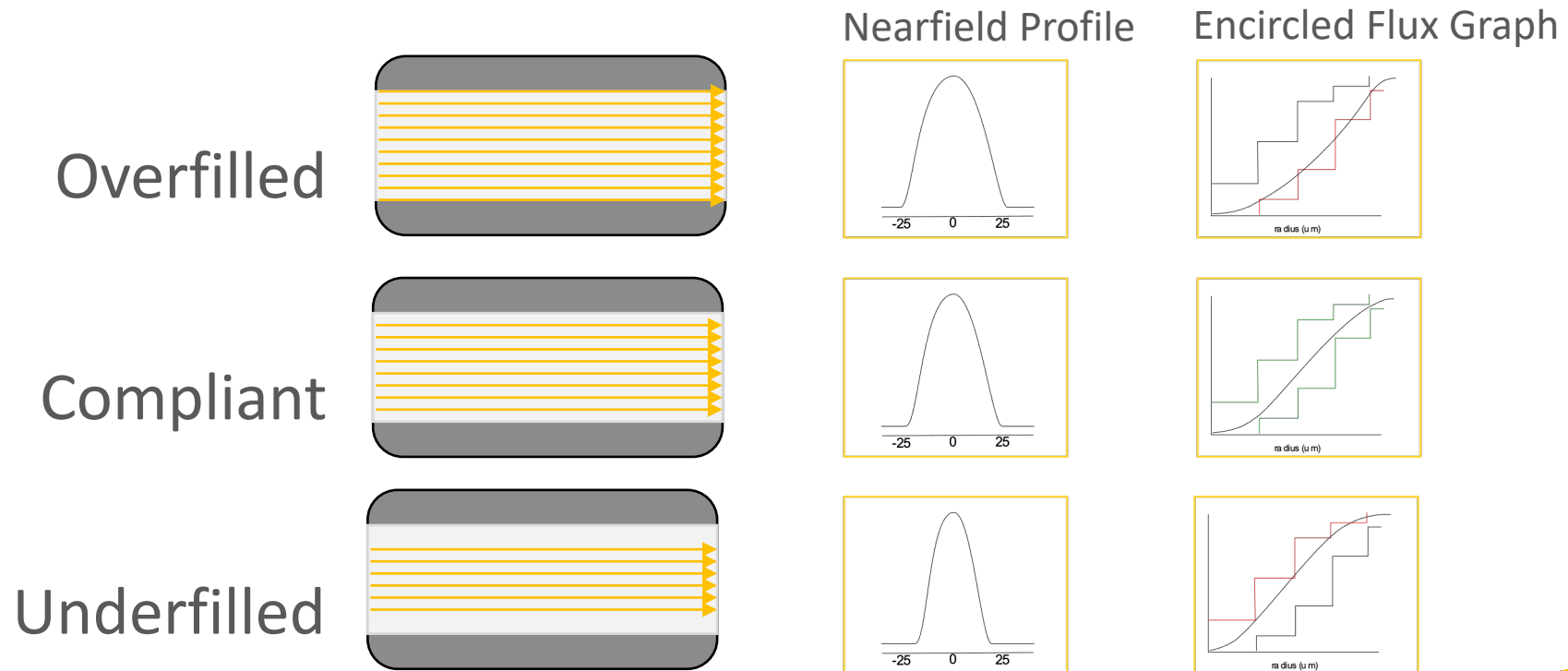


$$\text{Transmission Ratio} = \frac{6 \text{ modes}}{6 \text{ modes}} = 100\%$$

$$IL = 0 \text{ dB}$$

# Multimode Insertion Loss

- Due to insertion loss being highly dependent on launch fiber “fill,” standards were developed to harmonize the launch conditions for multimode IL measurements
  - Encircled Flux
    - In practice, loss only matters on installed cabling, so EF mimics a “worst-case” transceiver VCSEL source launch
      - Guarantees operability in the field when installed.
    - Helps to make multimode losses more reproducible across suppliers and test equipment

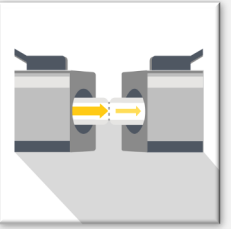


# Recap

- Insertion Loss represents the light lost through connections and through fiber
- Light at connections is lost due to
  - Lateral misalignments
  - Angular misalignments
  - MFD mismatches
- Light is lost through fiber due to absorption and scattering
  - Referred to as “attenuation:”
- Insertion loss in multimode fibers is extremely dependent on the light filling of the fiber
  - Launch conditions were standardized to make insertion loss measurements on multimode fiber more reproducible



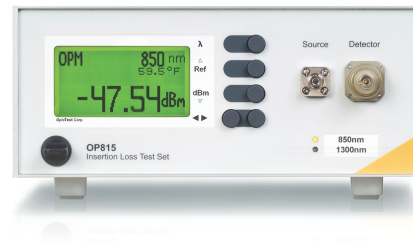
# Insertion Loss Measurement



✓ Fully automated, single or dual wavelength insertion loss Measurement

✓ Control through USB

✓ Wide Multimode source with controlled launch condition available for underfill, full fill or overfill

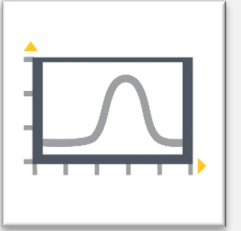


**OP815**  
Single Channel



**OP850**  
Multichannel (4 to 24 channels)

# Insertion Loss & Return Loss Measurement



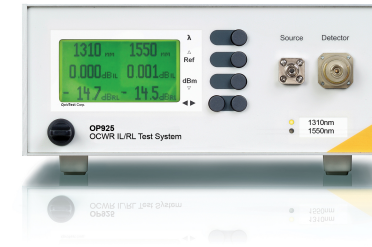
✓ Quickly measure IL, RL, & optical power

✓ Control through USB

✓ Wide dynamic range for RL measurements  
(single mode - 0 to -80db|multimode - 0 to -58db)



**OP940**  
Single Channel



**OP925**  
Single Channel



**OP940-SW**  
Multichannel  
(up to 24 channels)



**OP940-CSW**  
Multichannel



[www.OptoTest.com](http://www.OptoTest.com)

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