

Edge Coupler

Week 1

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Objective

- Generate, simulate and optimize an edge multi-modal edge coupler

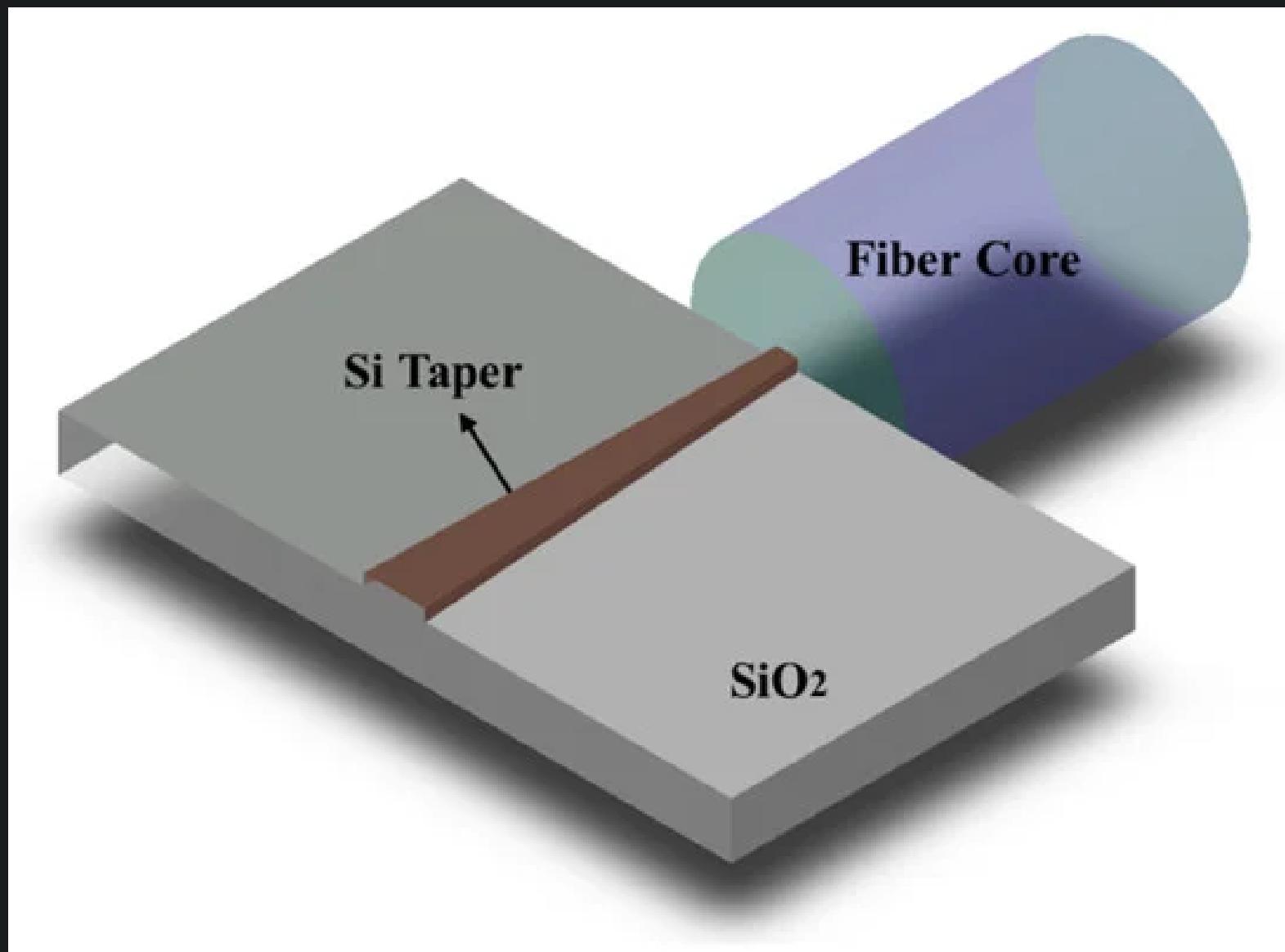


Figure 1: Schematic of optical interconnects between fiber and photonic chip.
Font: [1].

First attempts



Dimentions and shapes

- For this component, the base article [2] graphics will be used as initial parameters and optimized on the latter weeks.
- The shapes to be analized are: linear, exponential and quadratic.
- The dimentions to be first analized are lenght and width.



Dimensions and Shapes



Figure 2: The inverse taper (a) linear inverse taper (b) exponential inverse taper (c) quadratic inverse taper. Font: [2].

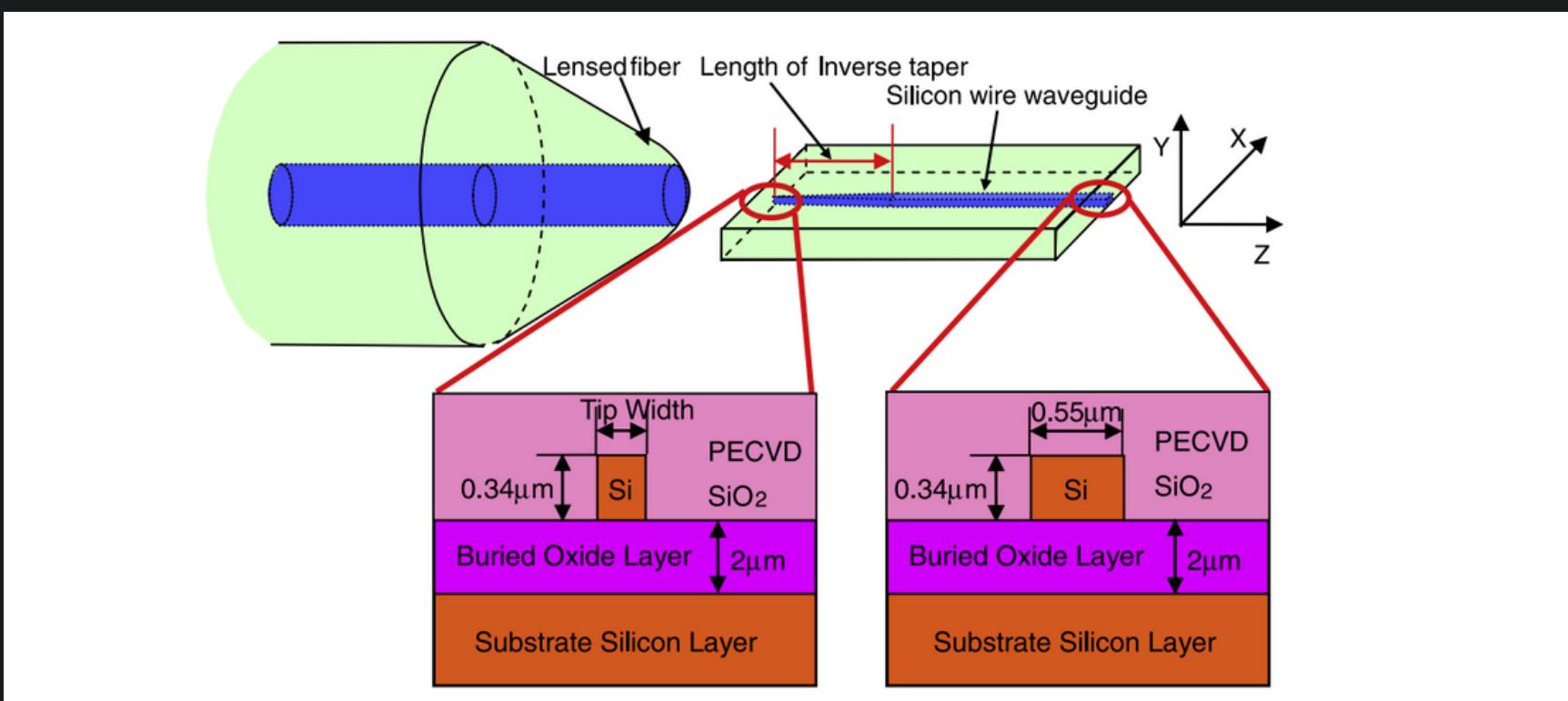


Figure 3: Coupling model between taper-lensed fiber and inverse taper; the insertion are cross sectional schematic of inverse taper tip and the embedded silicon wire waveguide. Font: [2].

General Graphics

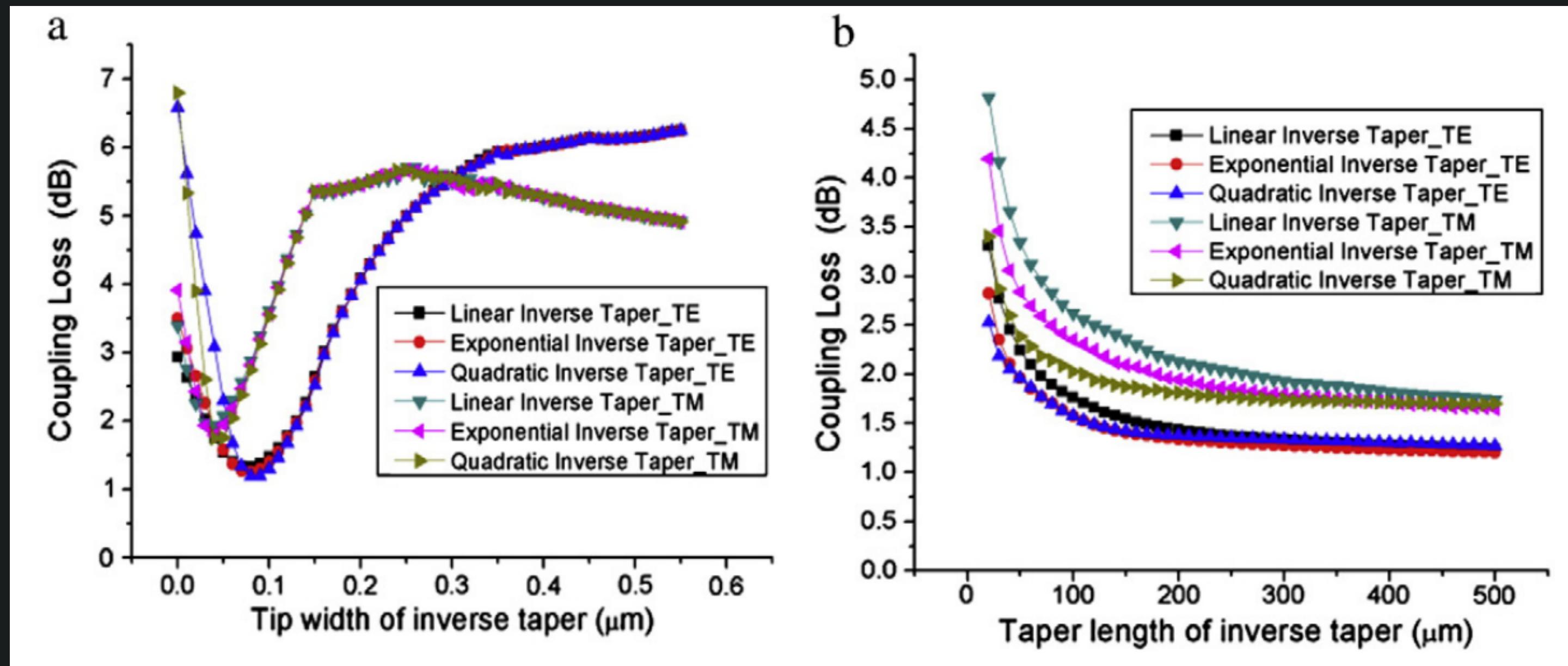


Figure 4: The effect of inverse taper gradient line shape function (a) 300 μm long inverse taper with varied tip width (b) 0.07 μm tip width for TE mode and 0.04 μm tip width for TM mode with varied taper length. Font: [2]

Linear Taper



Linear Taper

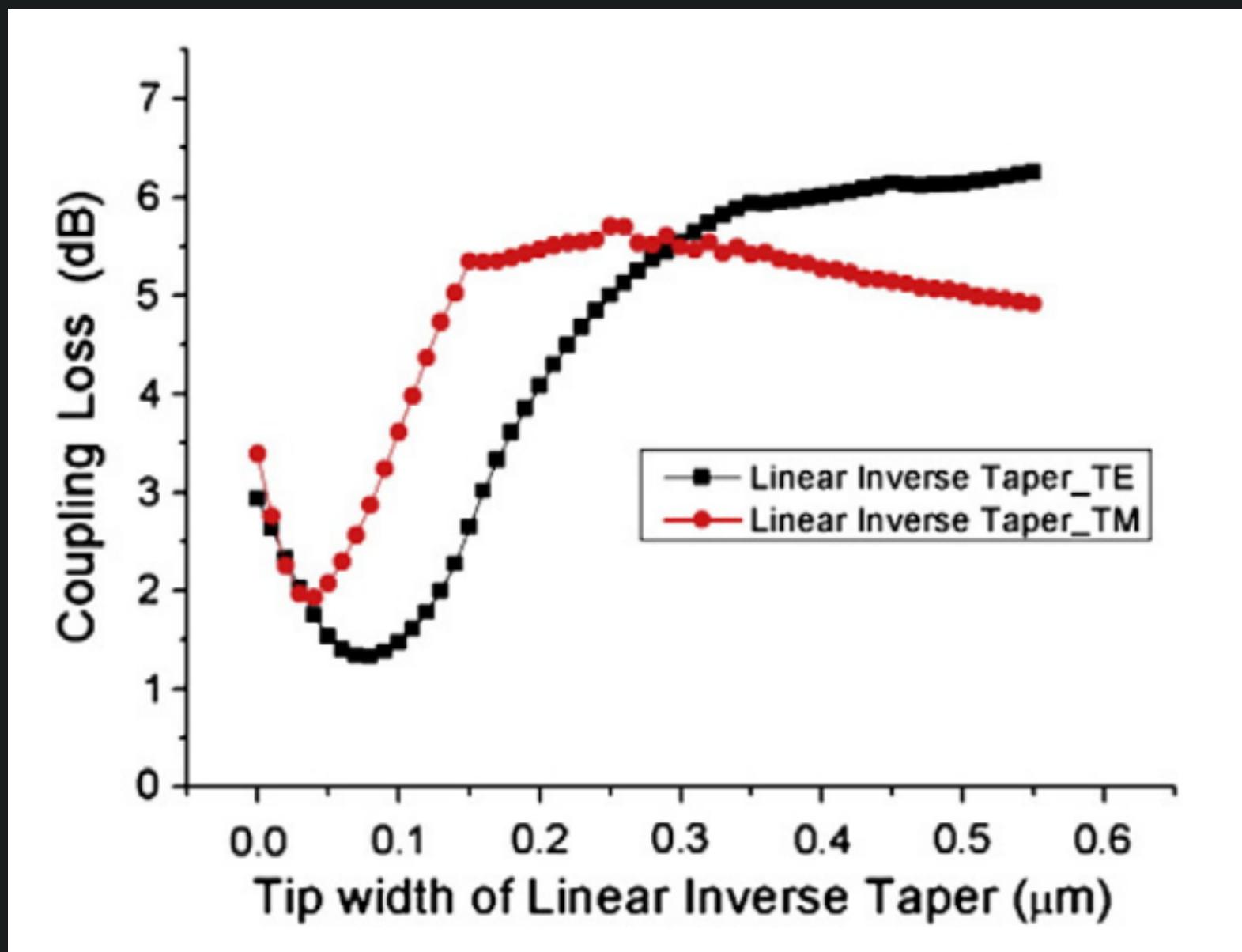


Figure 5: The effect of taper tip width on the coupling loss of linear inverse taper.

Font: [2].



Dimentions

- For the initial simulation, the linear taper will have $0.04\mu\text{m}$ as it is an optimized size for both TE and TM modes.
- The initial lenght will be $200\mu\text{m}$, as the loss begins to be more stable on that lenght.



Linear Taper (Core)

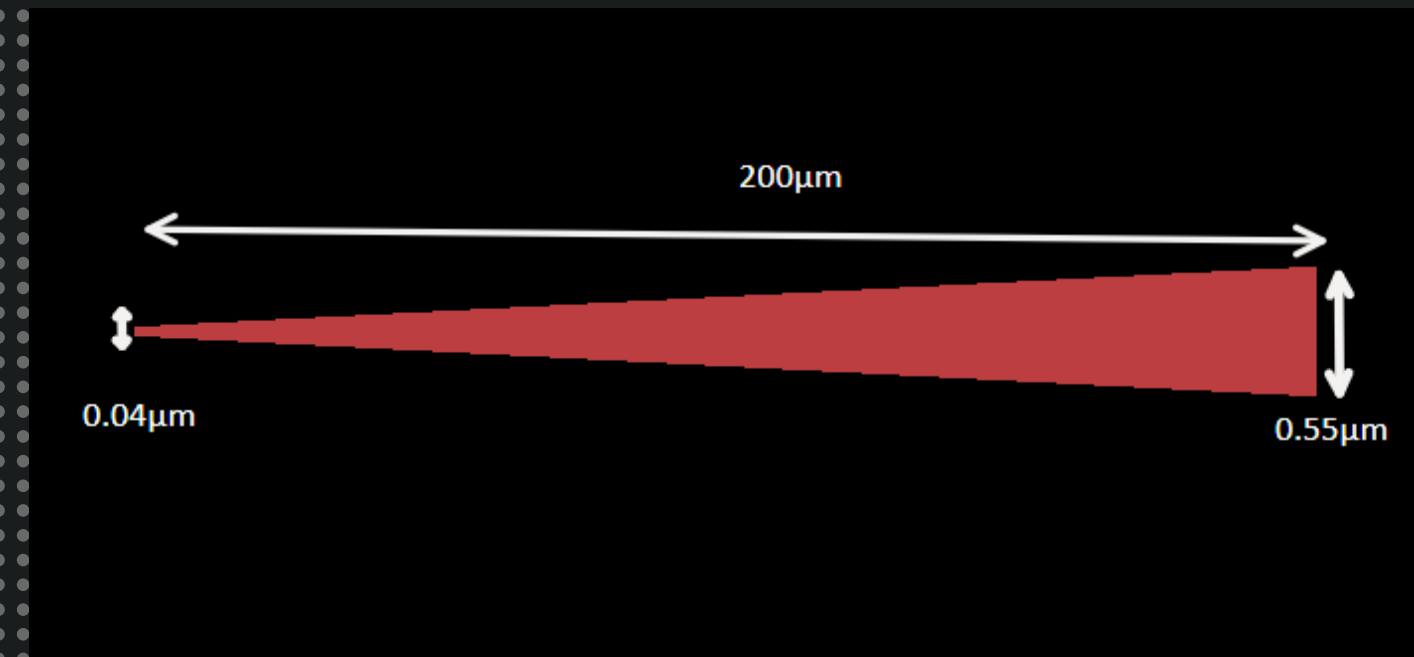


Figure 6: Linear Taper core (XY View), different X scale for illustration only

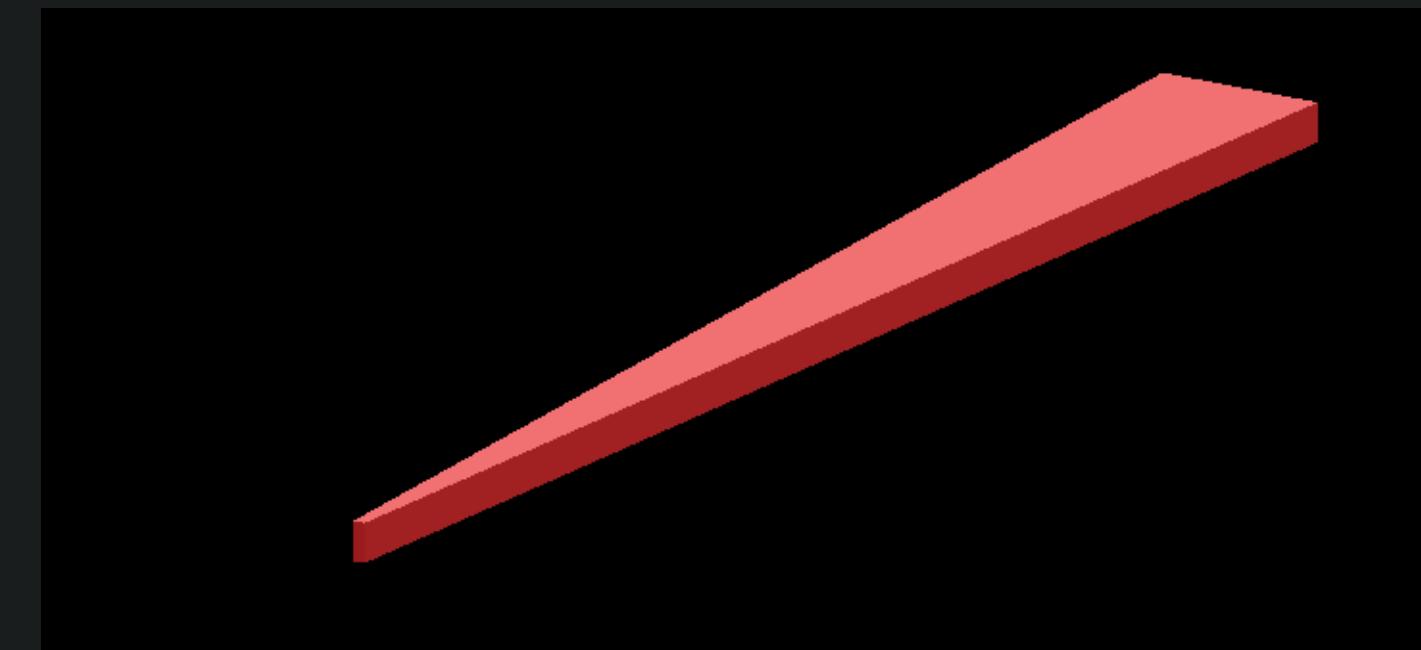


Figure 7: Linear Taper core (Perspective View)

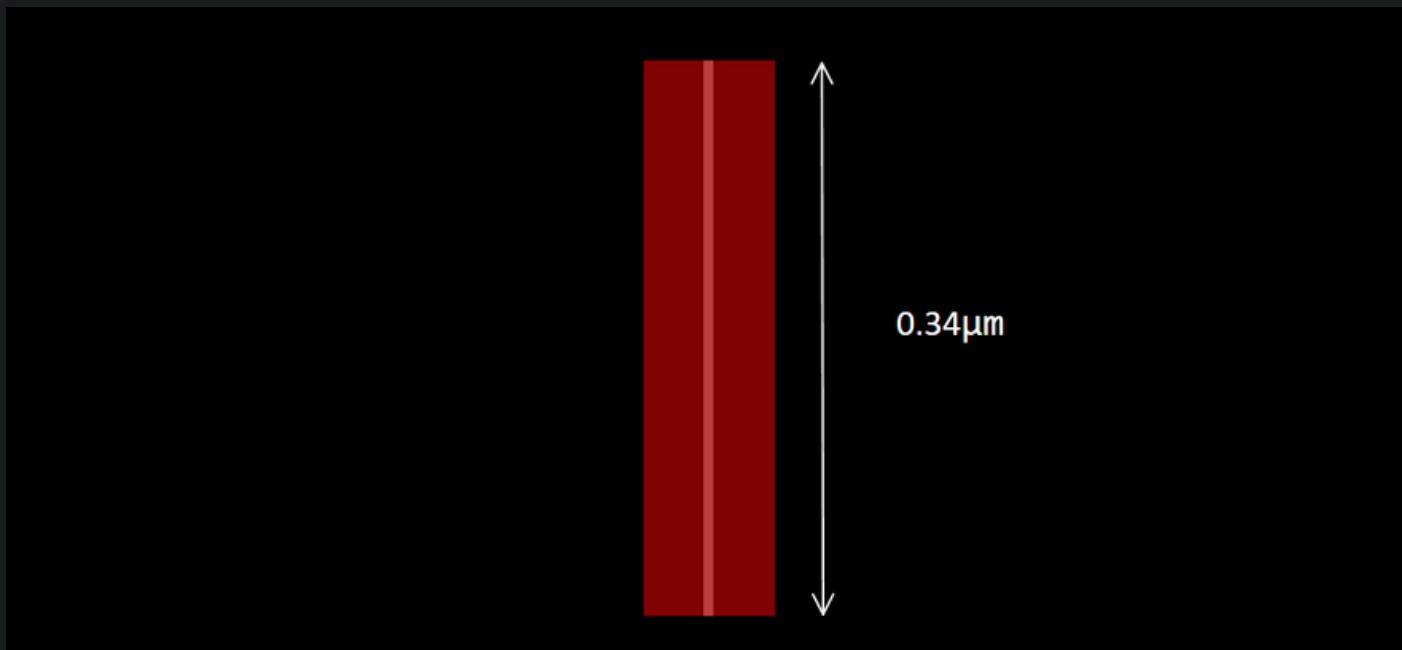


Figure 8: Linear Taper core (YZ View)



Exponential Taper



Exponential Taper

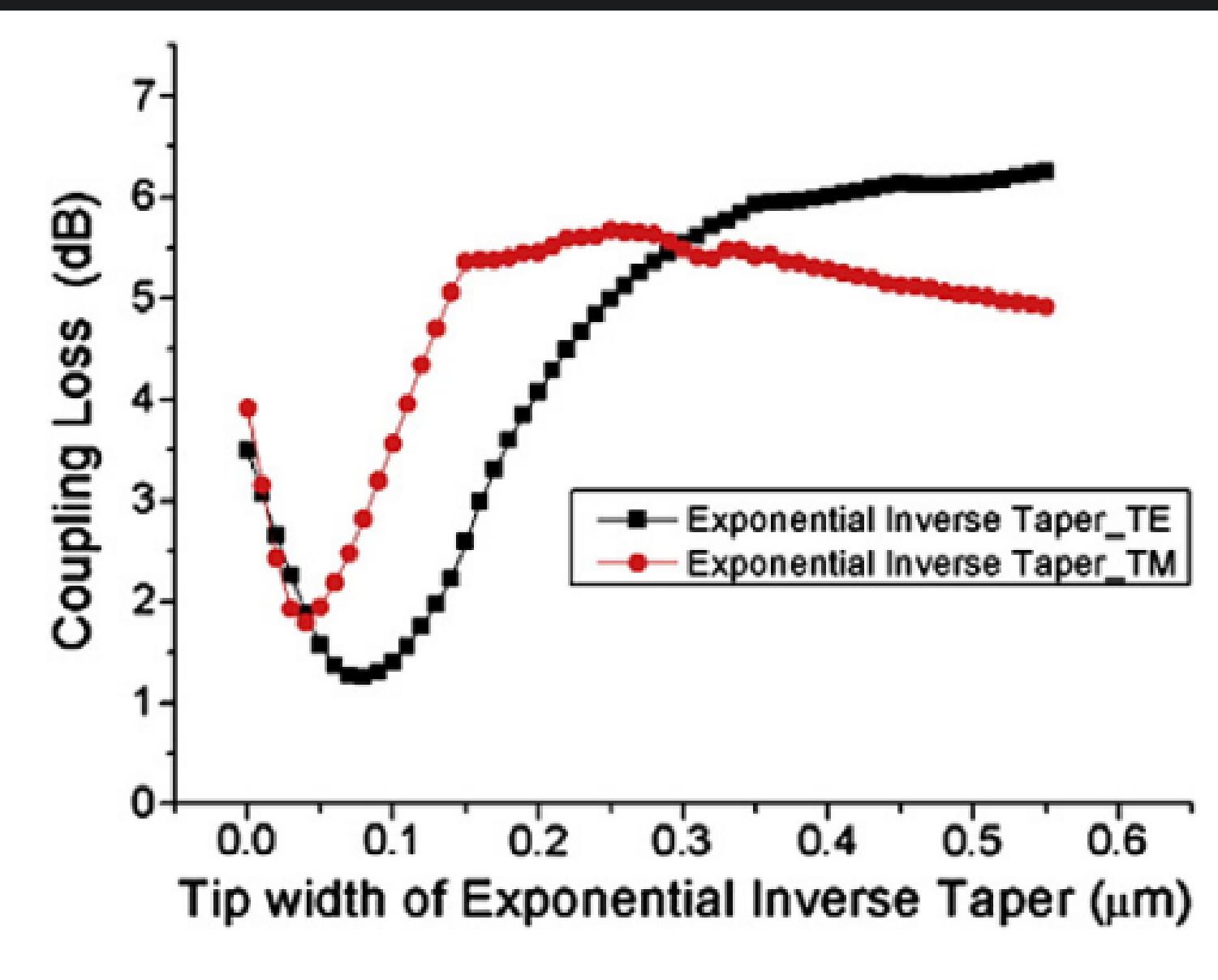


Figure 9: The effect of taper tip width to coupling loss for exponential inverse taper.
Font: [2].



Dimentions

- For the initial simulation, the exponential taper will have $0.04\mu\text{m}$ as it is an optimized size for both TE and TM modes.
- The initial lenght will be $200\mu\text{m}$, as the loss begins to be more stable on that lenght.



Exponential Taper (Core)

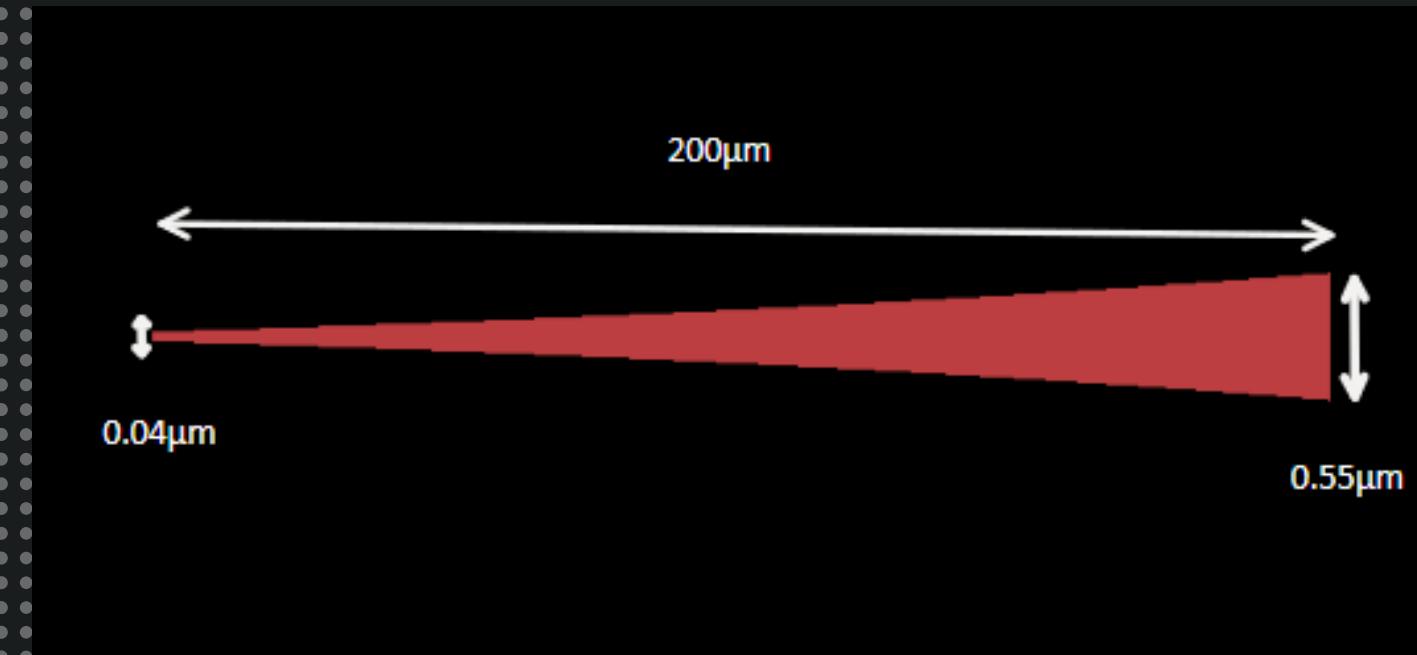


Figure 10: Exponential Taper core (XY View), different X scale for illustration only

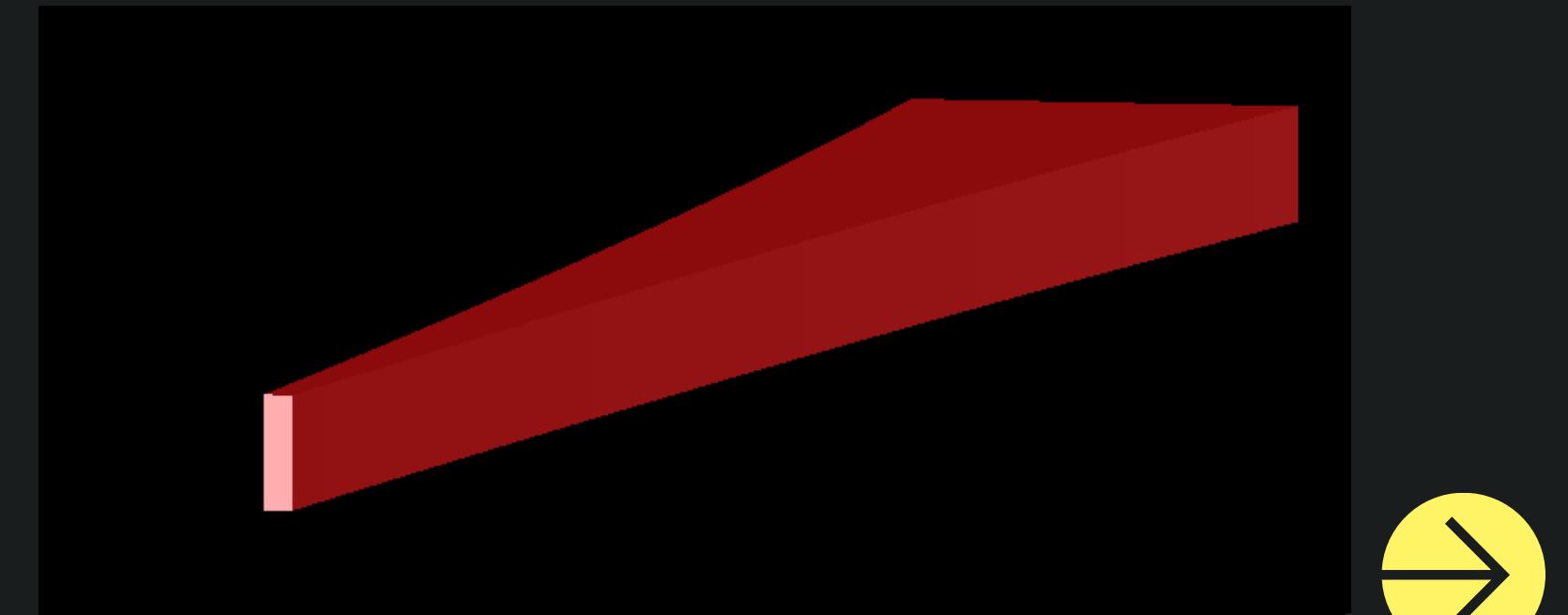


Figure 11: Exponential Taper core (Perspective View)

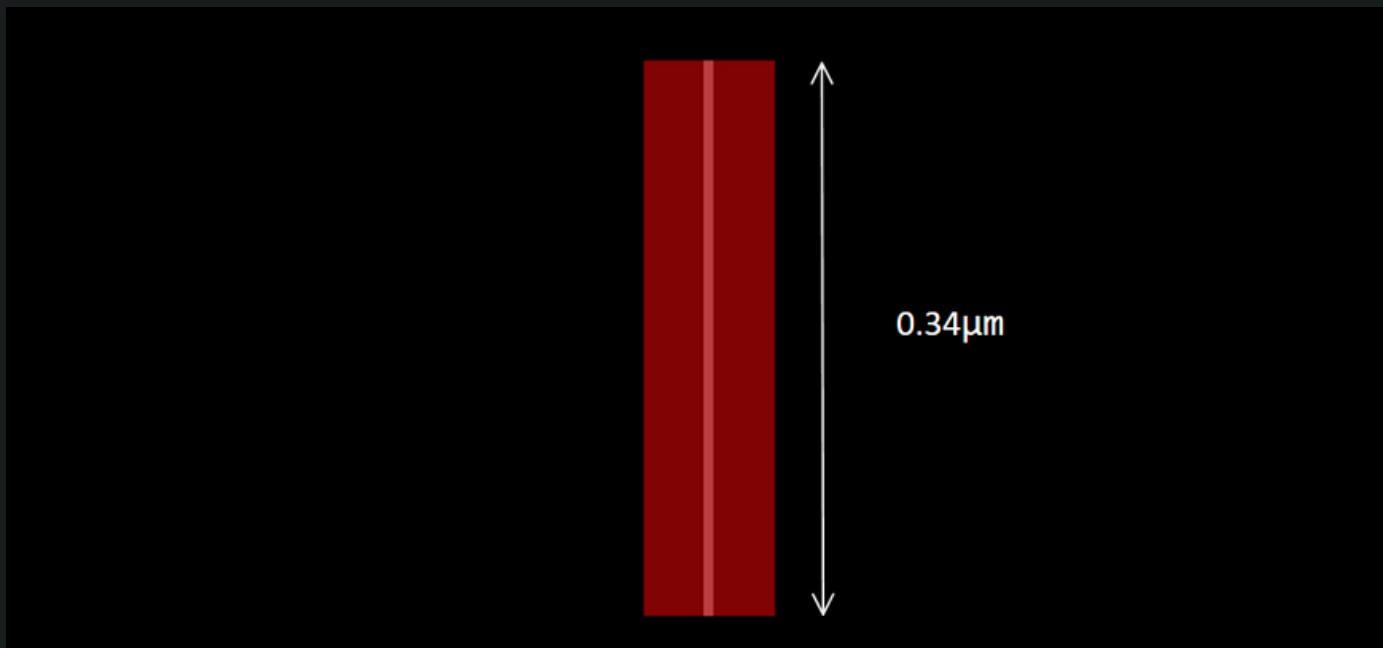


Figure 12: Exponential Taper core (YZ View)

Quadratic Taper



Quadratic Taper

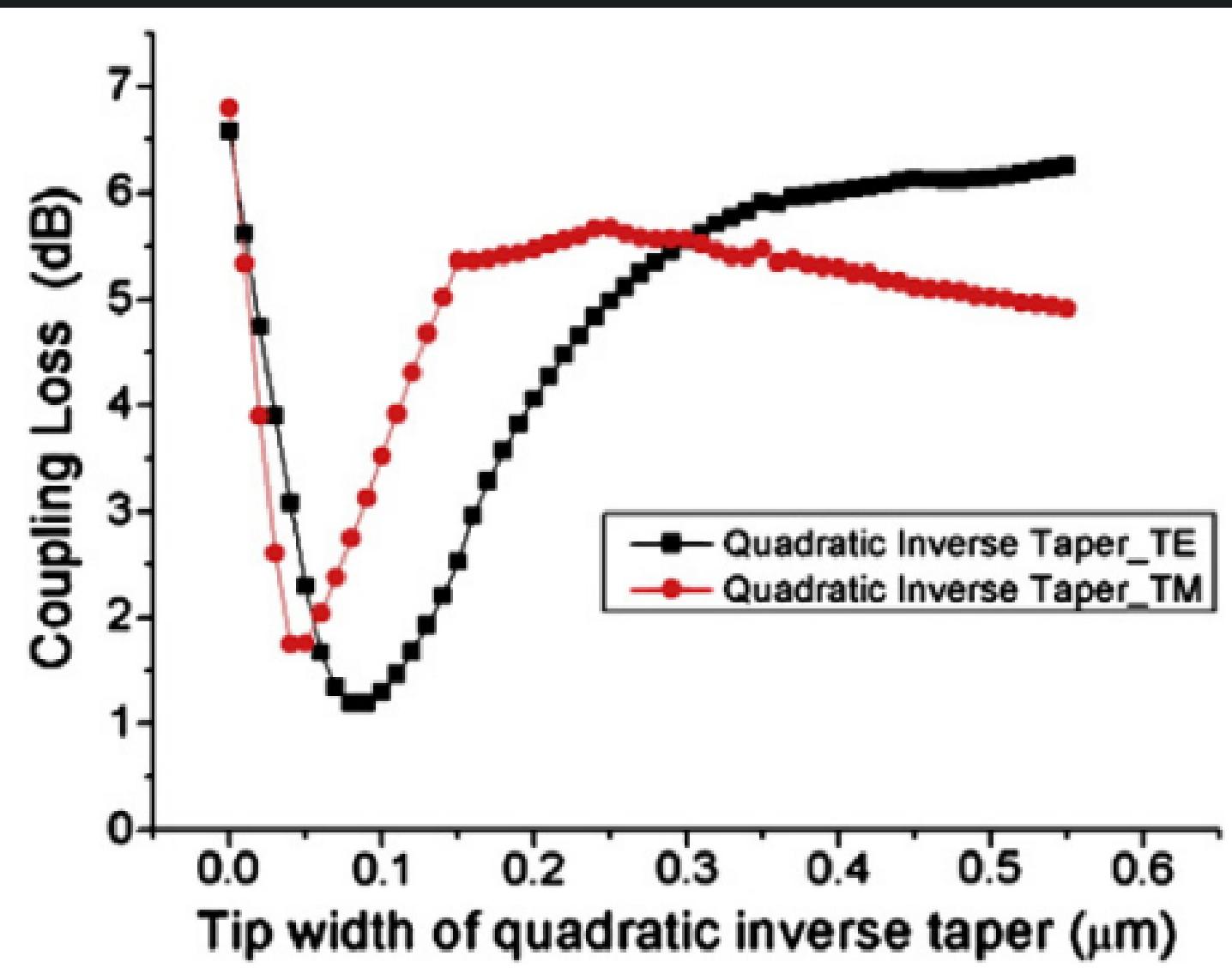


Figure 13: The effect of taper tip width to coupling loss for exponential inverse taper.
Font: [2].



Dimentions

- For the initial simulation, the quadratic taper will have $0.04\mu\text{m}$ as it is an optimized size for both TE and TM modes.

- The initial lenght will be $200\mu\text{m}$, as the loss begins to be more stable on that lenght.



Quadratic Taper (Core)

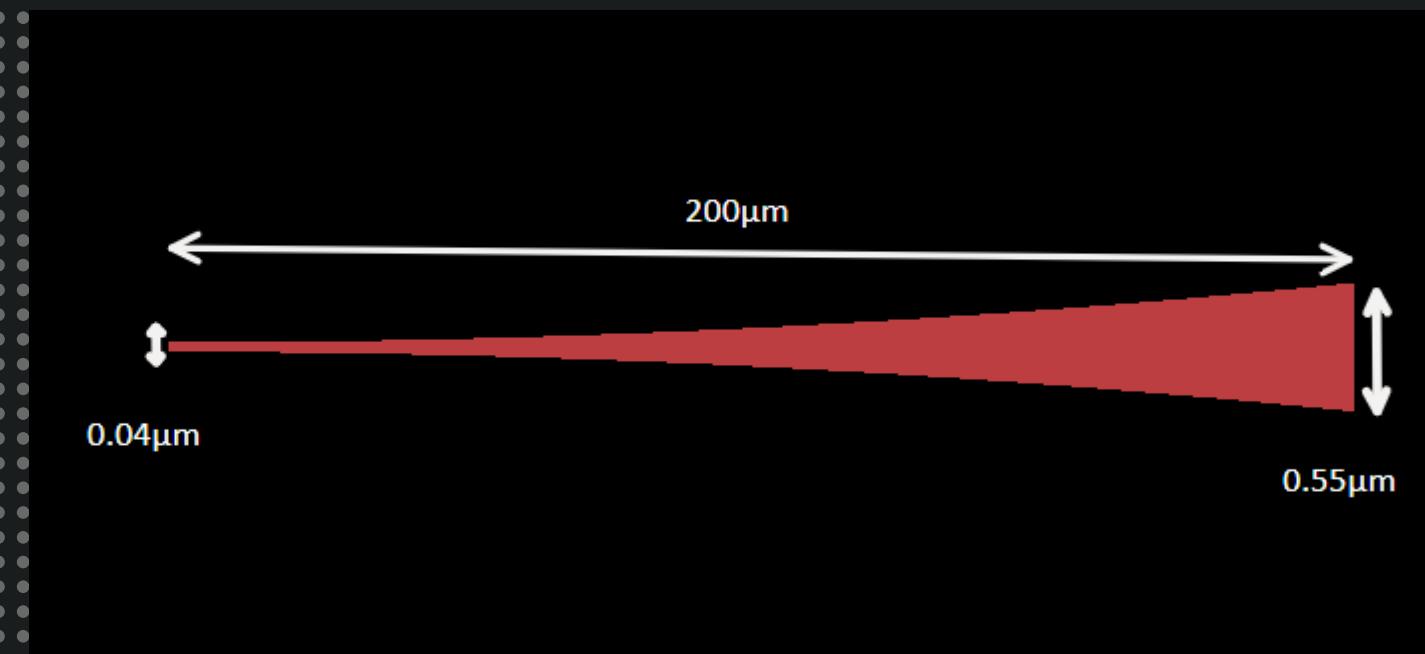


Figure 14: Exponential Taper core (XY View), different X scale for illustration only



Figure 15: Quadratic Taper core (Perspective View)

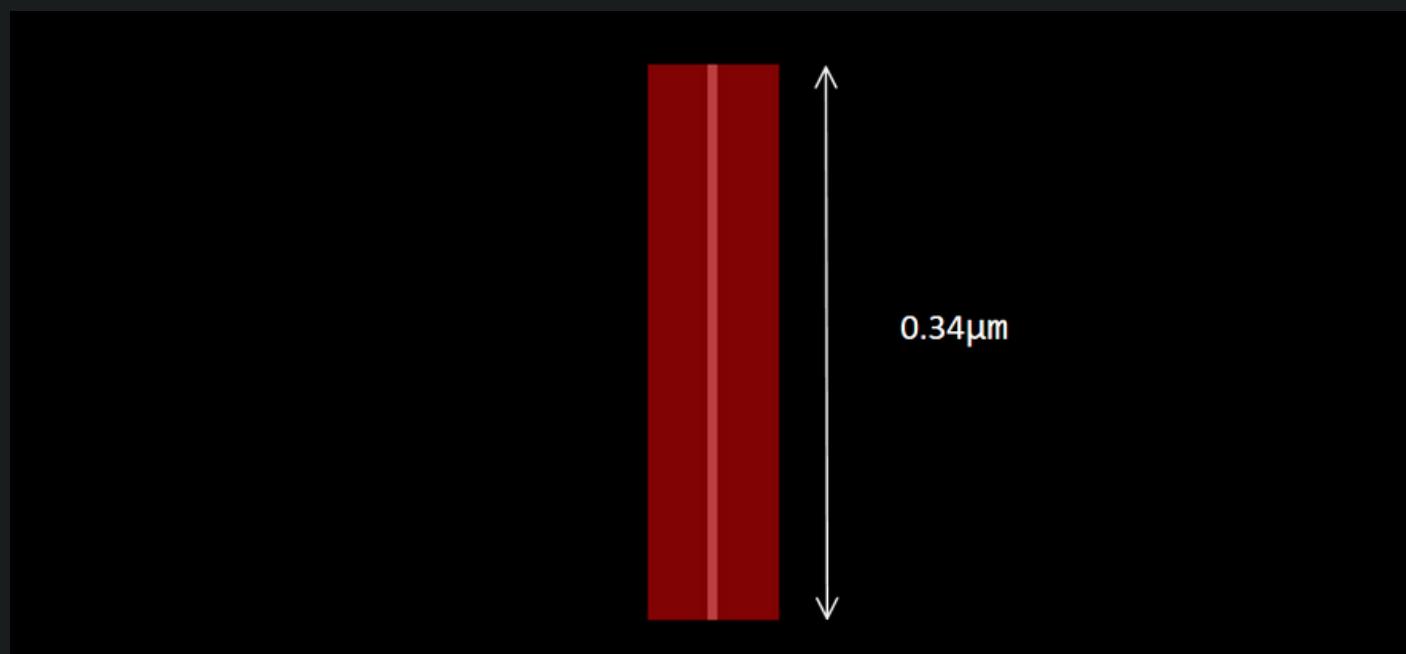


Figure 16: Quadratic Taper core (YZ View)

Using the linear taper



Component

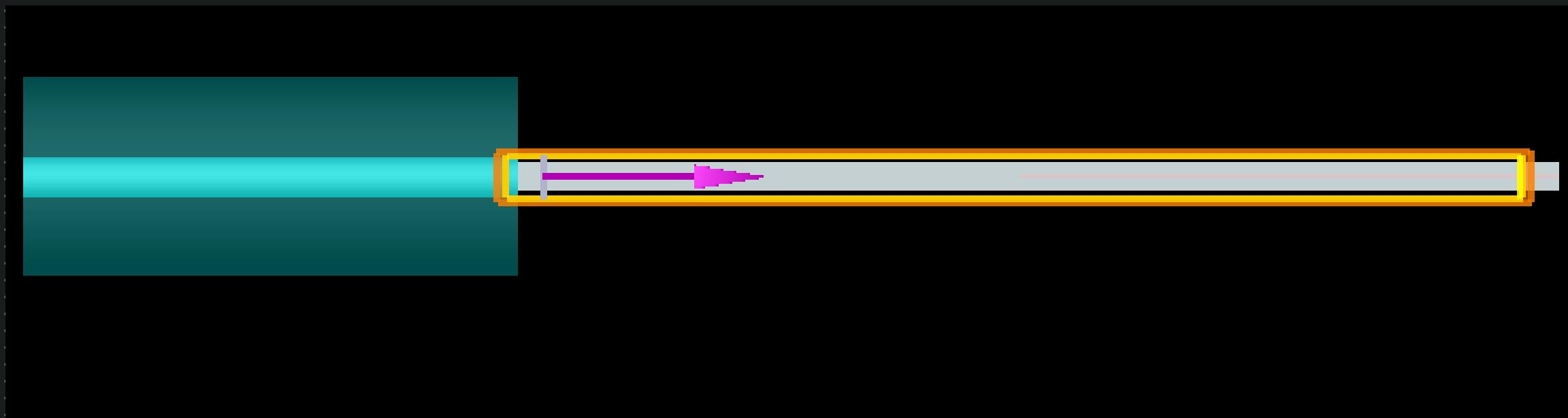


Figure 17: Component XY View (Linear)

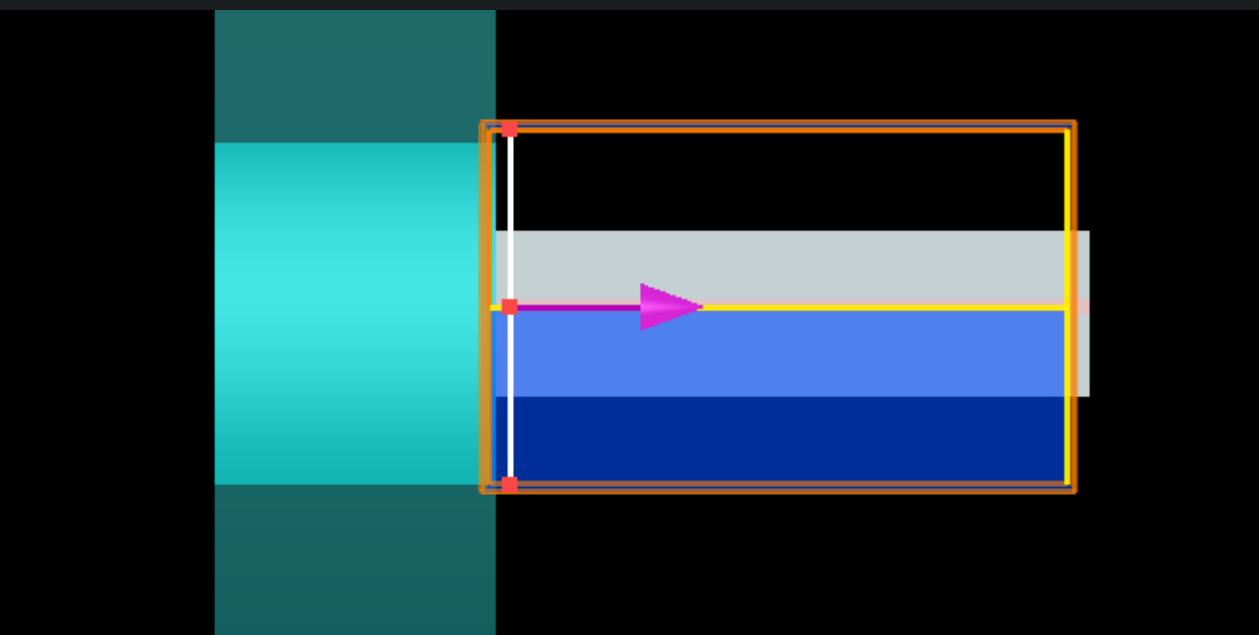


Figure 18: Component XZ View (Linear)

Component

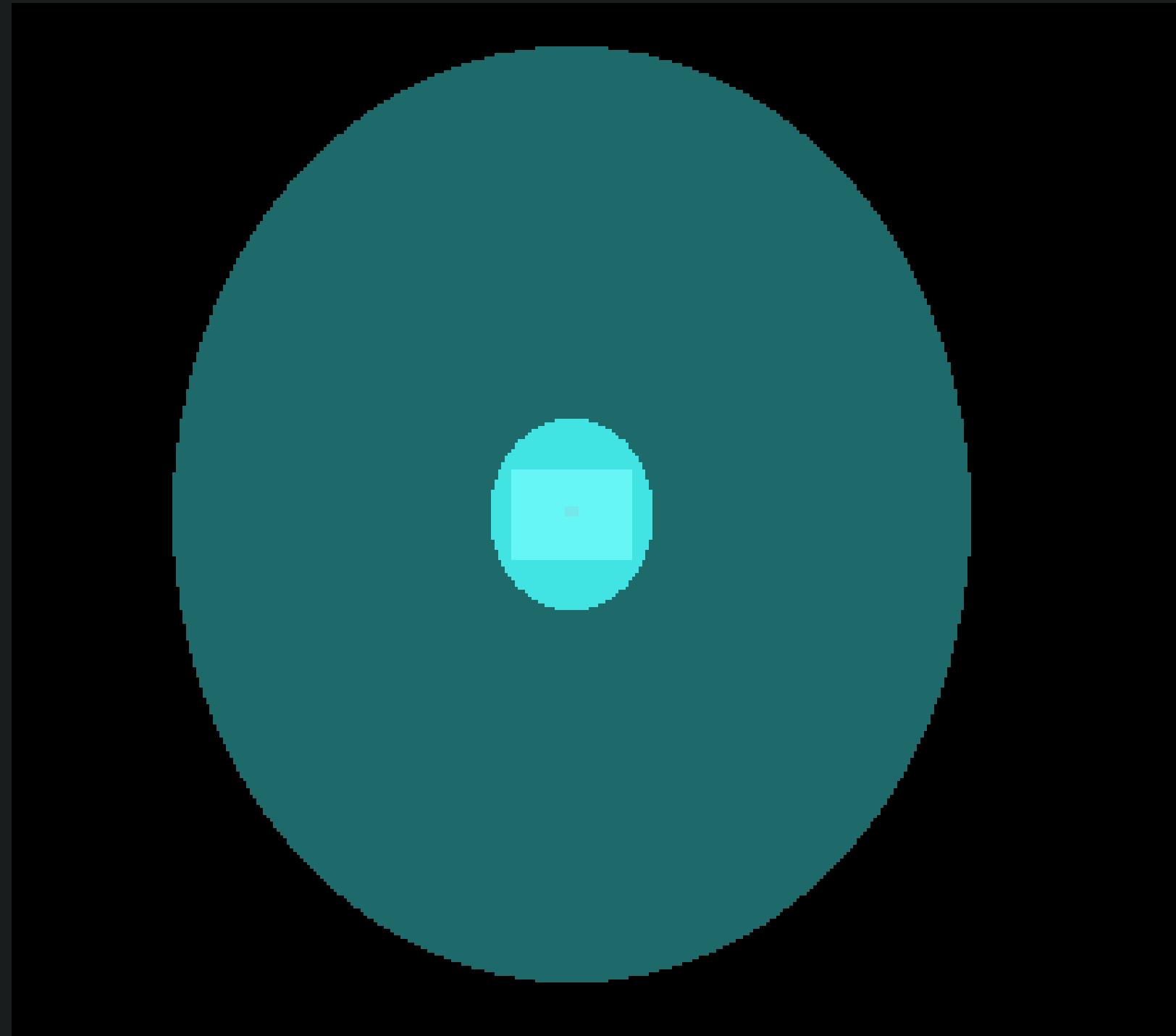


Figure 19: Component YZ View (Linear)

Fiber fundamental modes (TE)

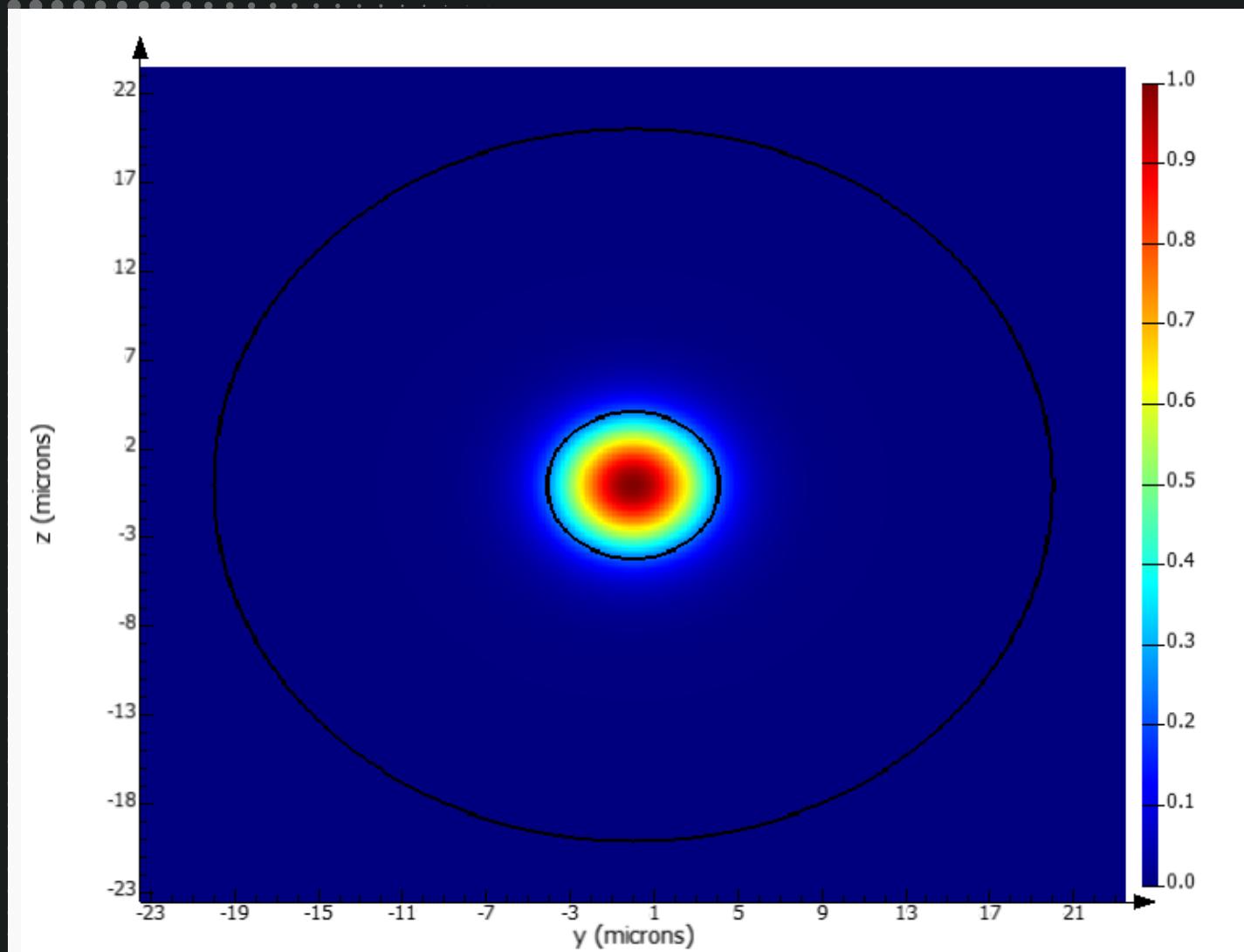


Figure 20: Fiber TE0 mode (Linear)

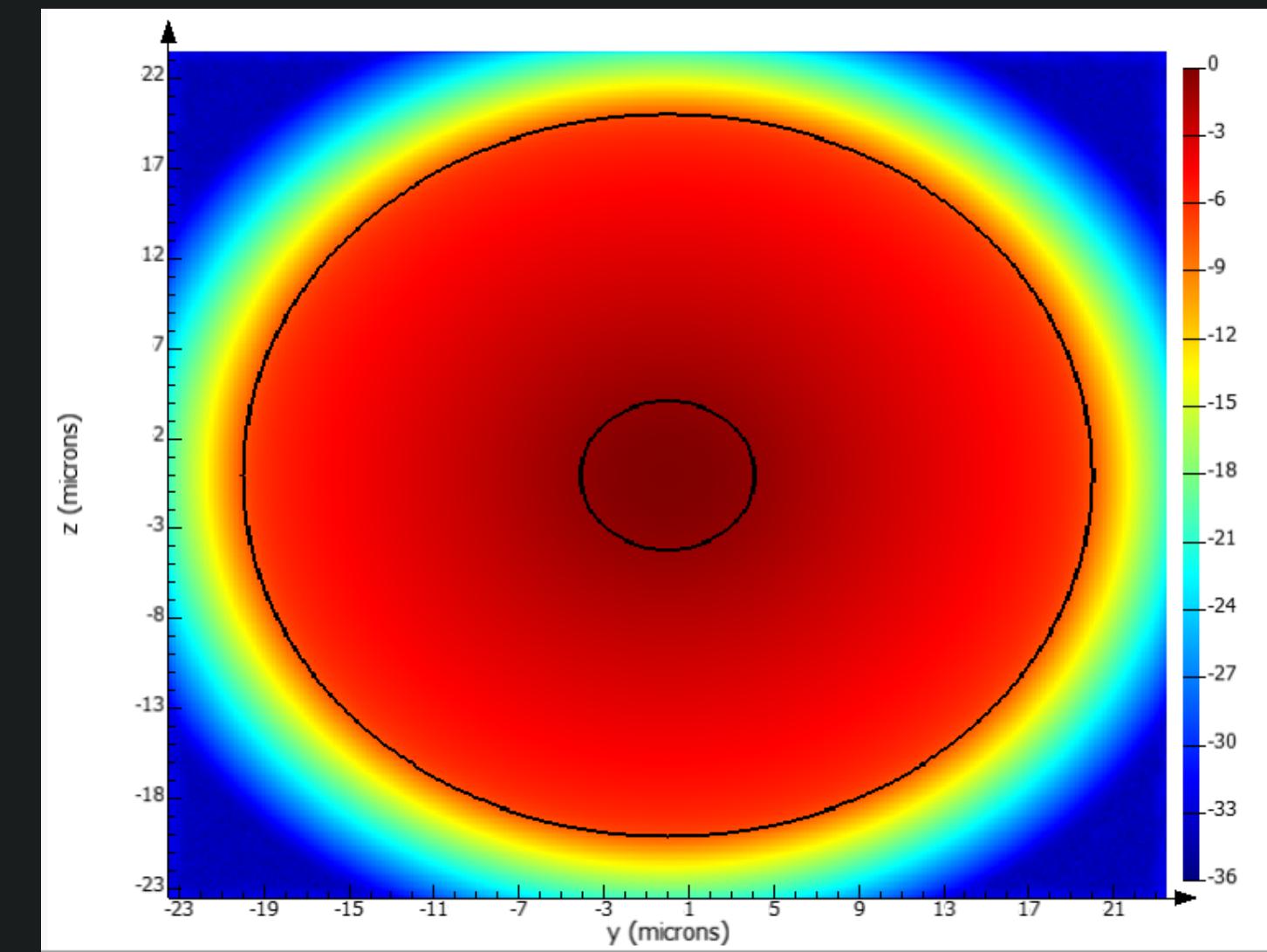


Figure 21: Fiber TE0 mode (Logarithmic)



Fiber fundamental modes (TM)

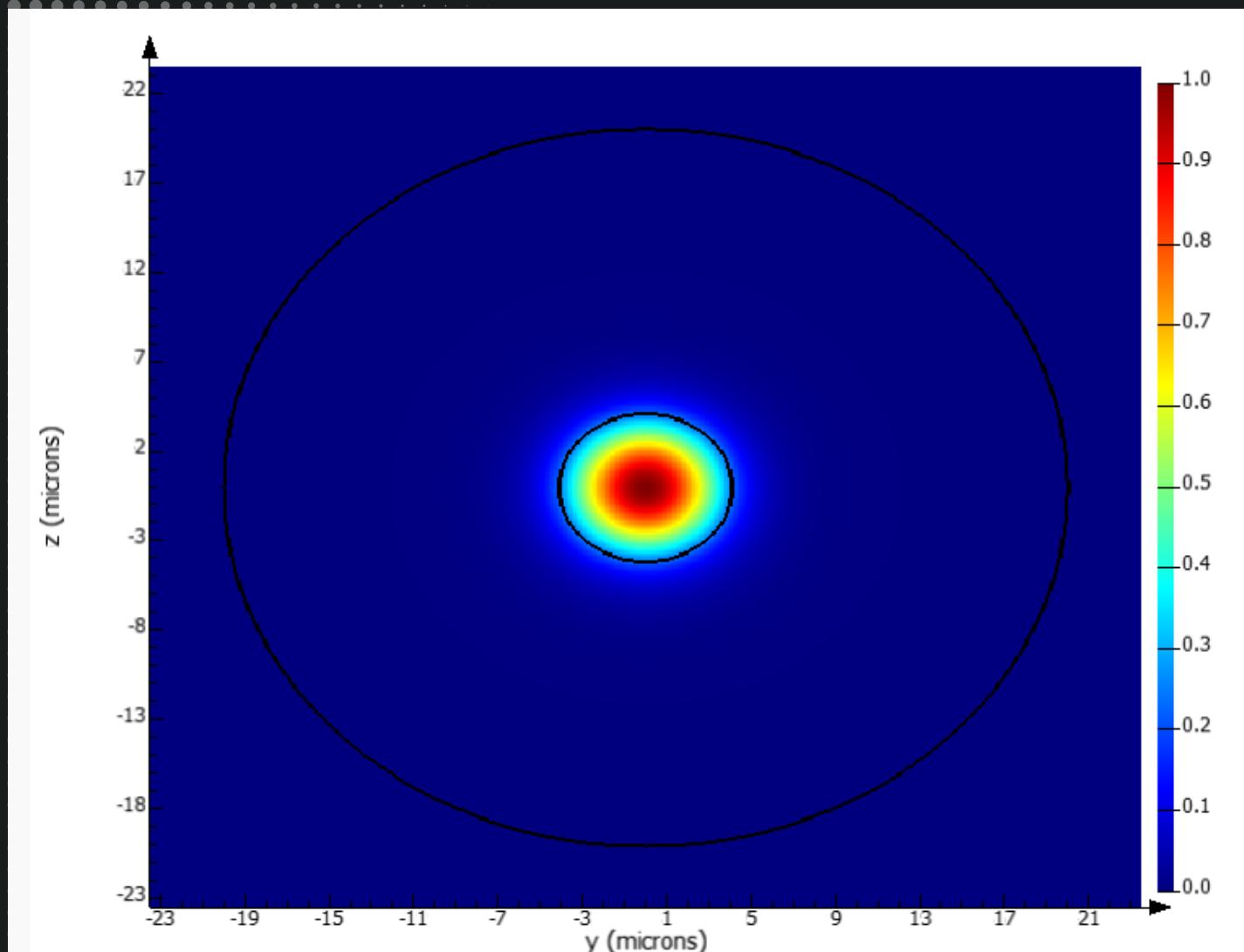


Figure 19: Fiber TM0 mode (Linear)

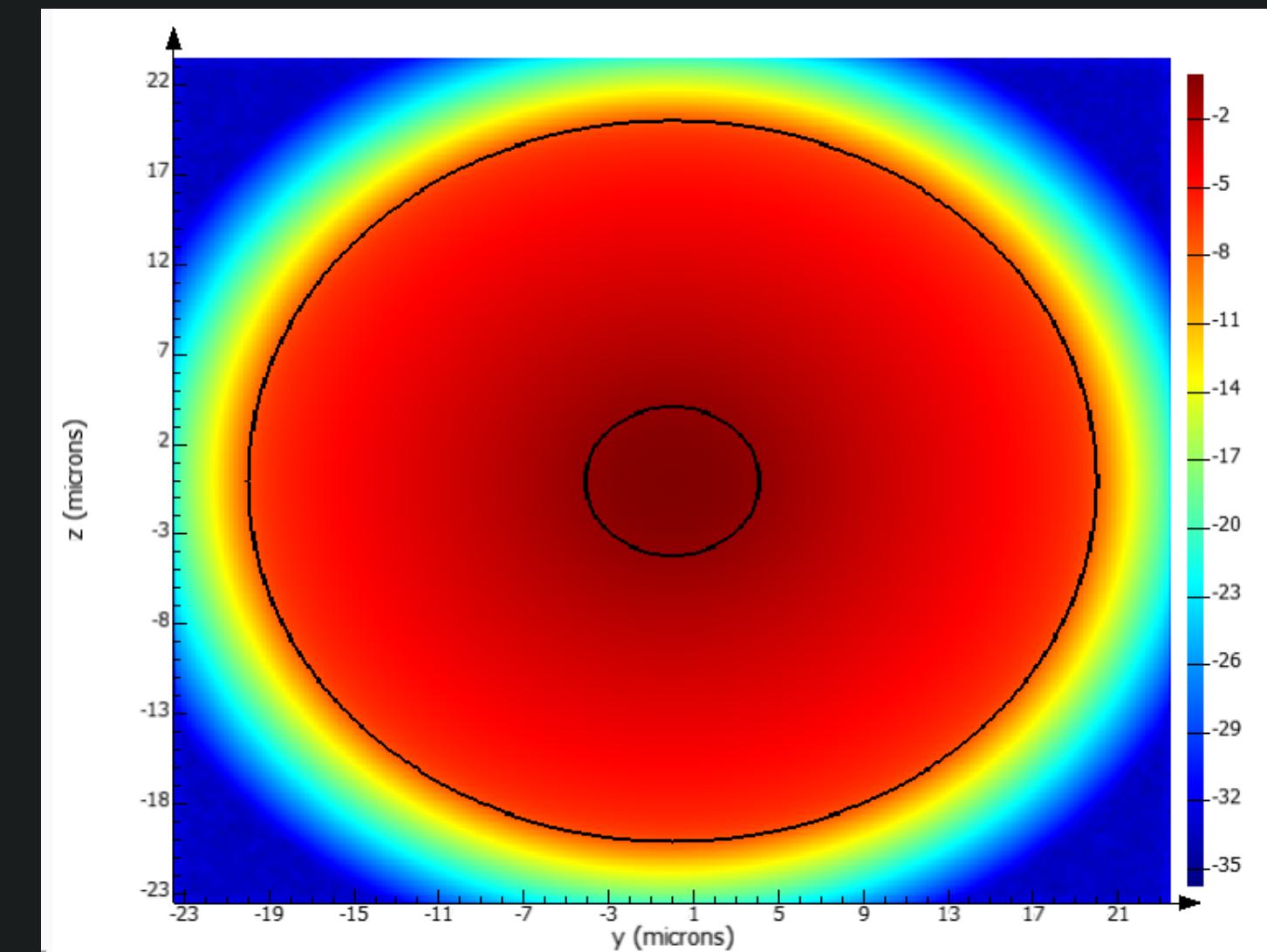


Figure 19: Fiber TM0 mode (Logarithmic)



Taper fundamental modes (TE)

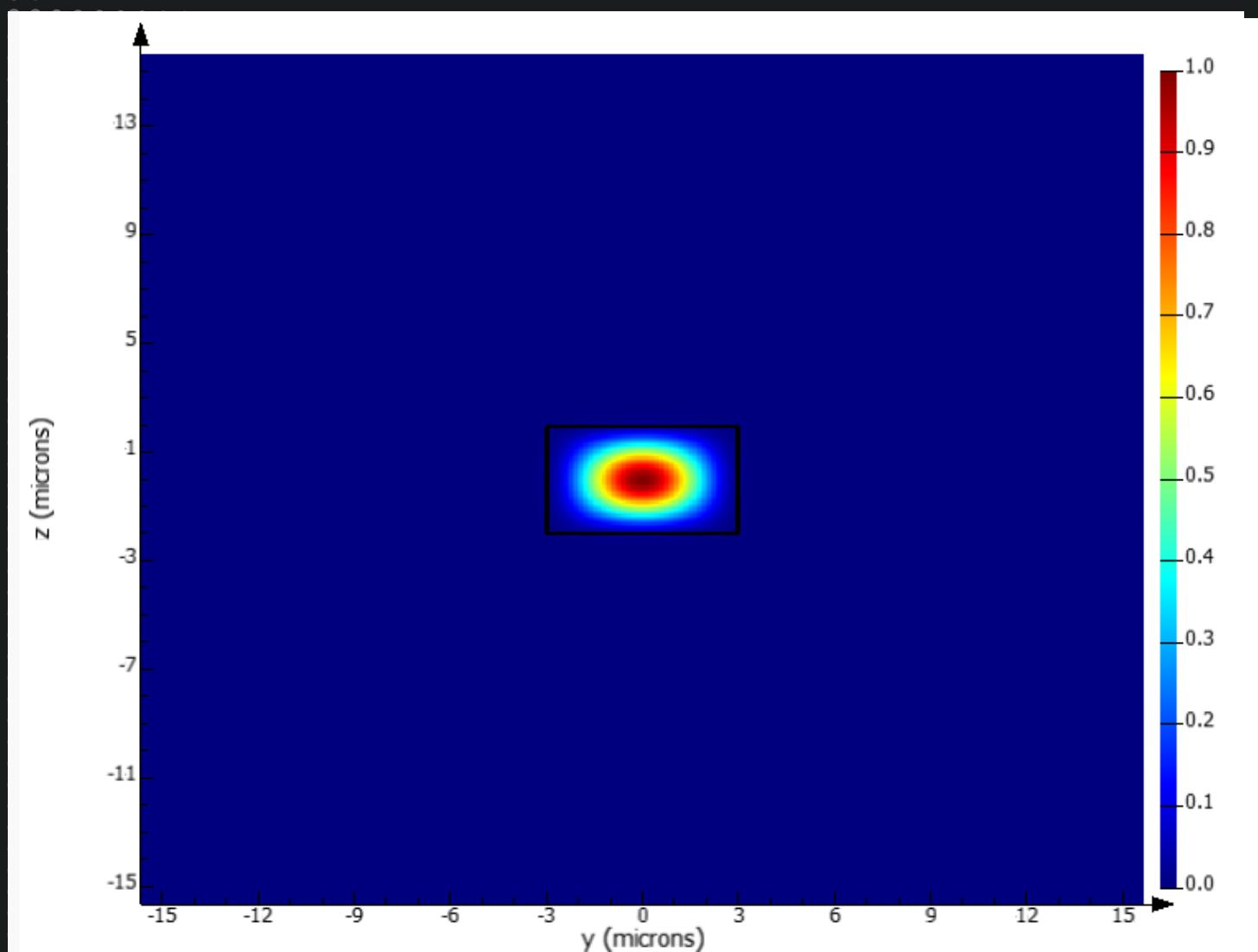


Figure 22: Taper TE0 mode (Linear)

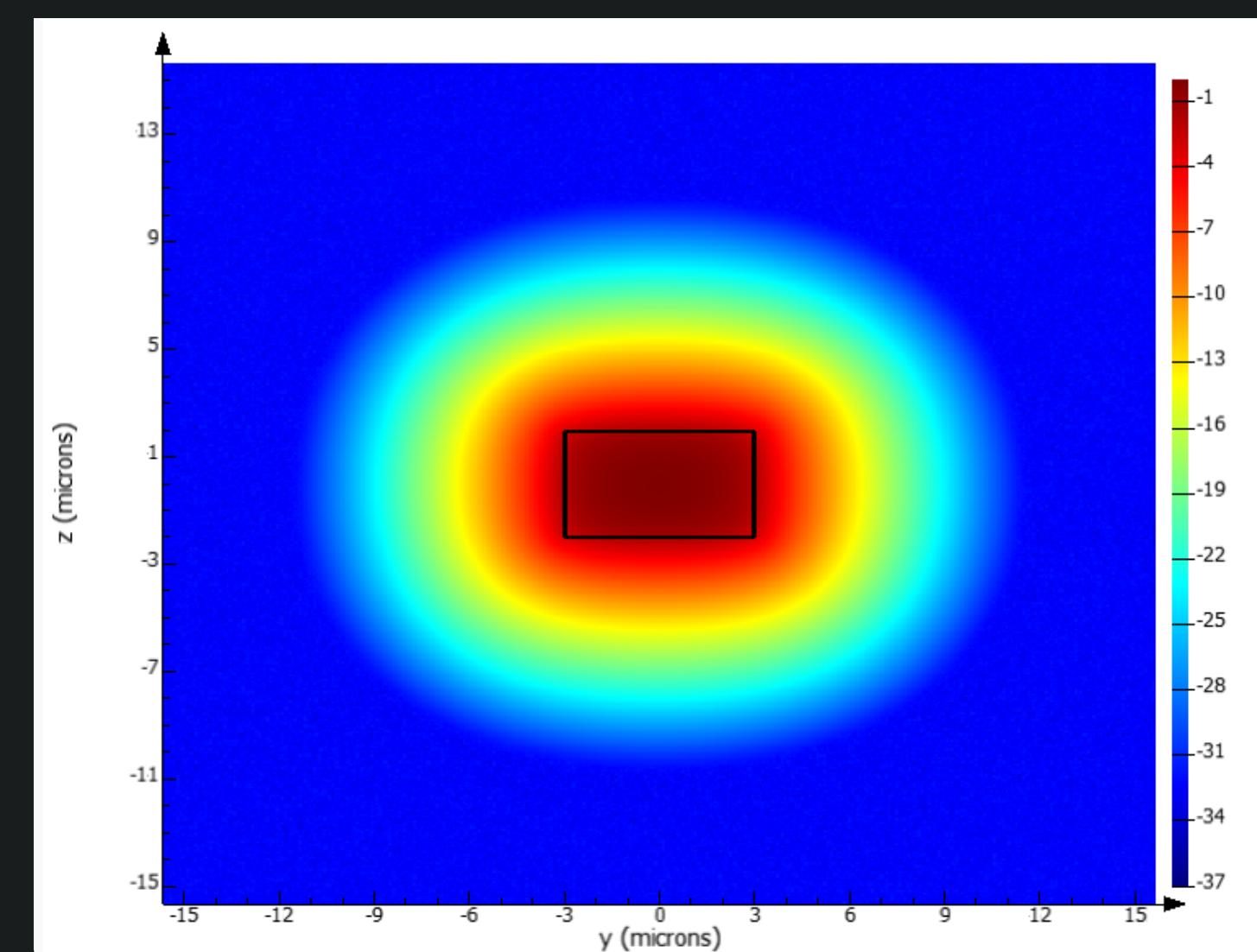


Figure 23: Taper TE0 mode (Logarithmic)

Taper fundamental modes (TM)

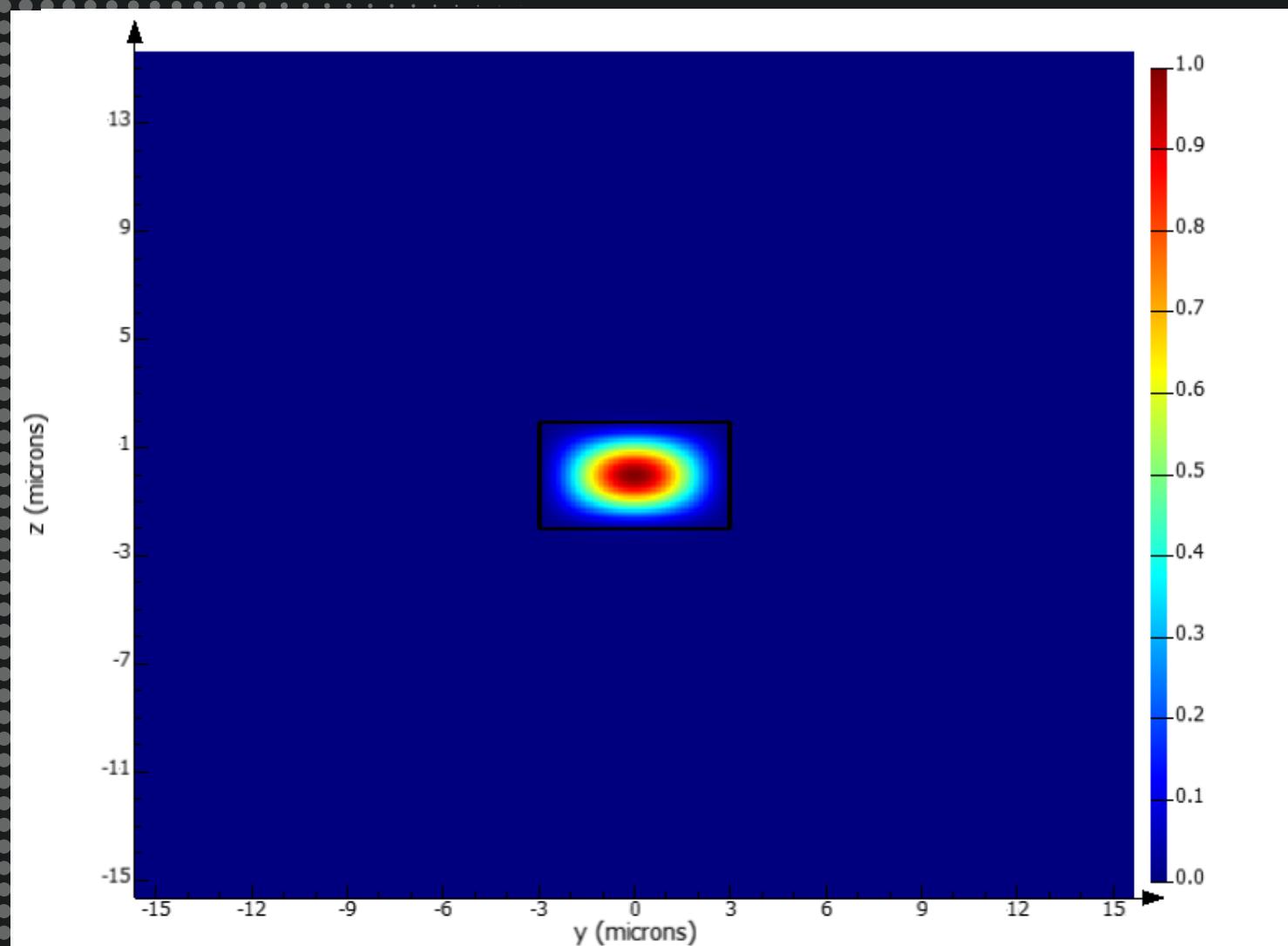


Figure 24: Taper TM0 mode (Linear)

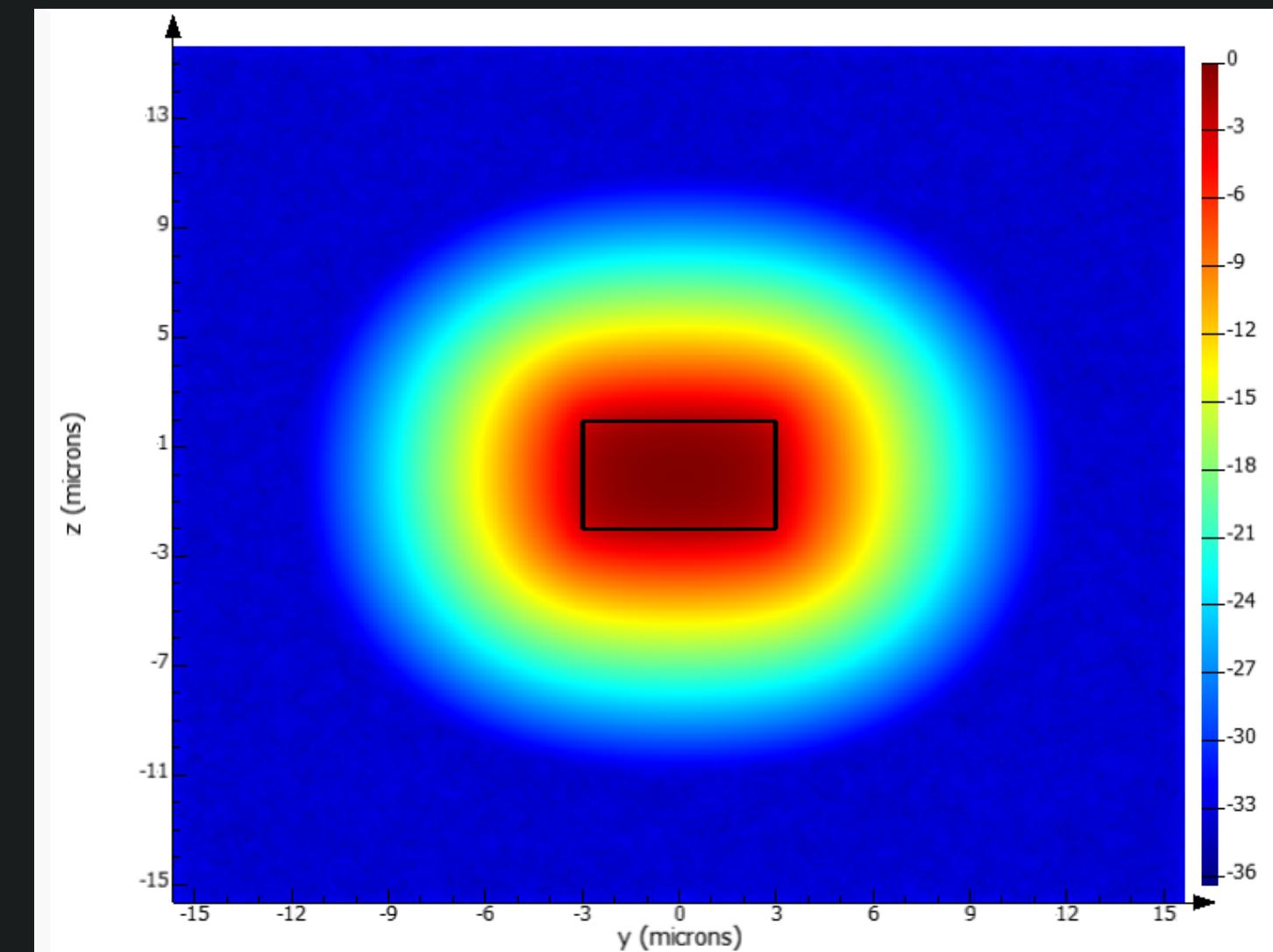


Figure 25: Taper TM0 mode (Logarithmic)

Field TE Mode

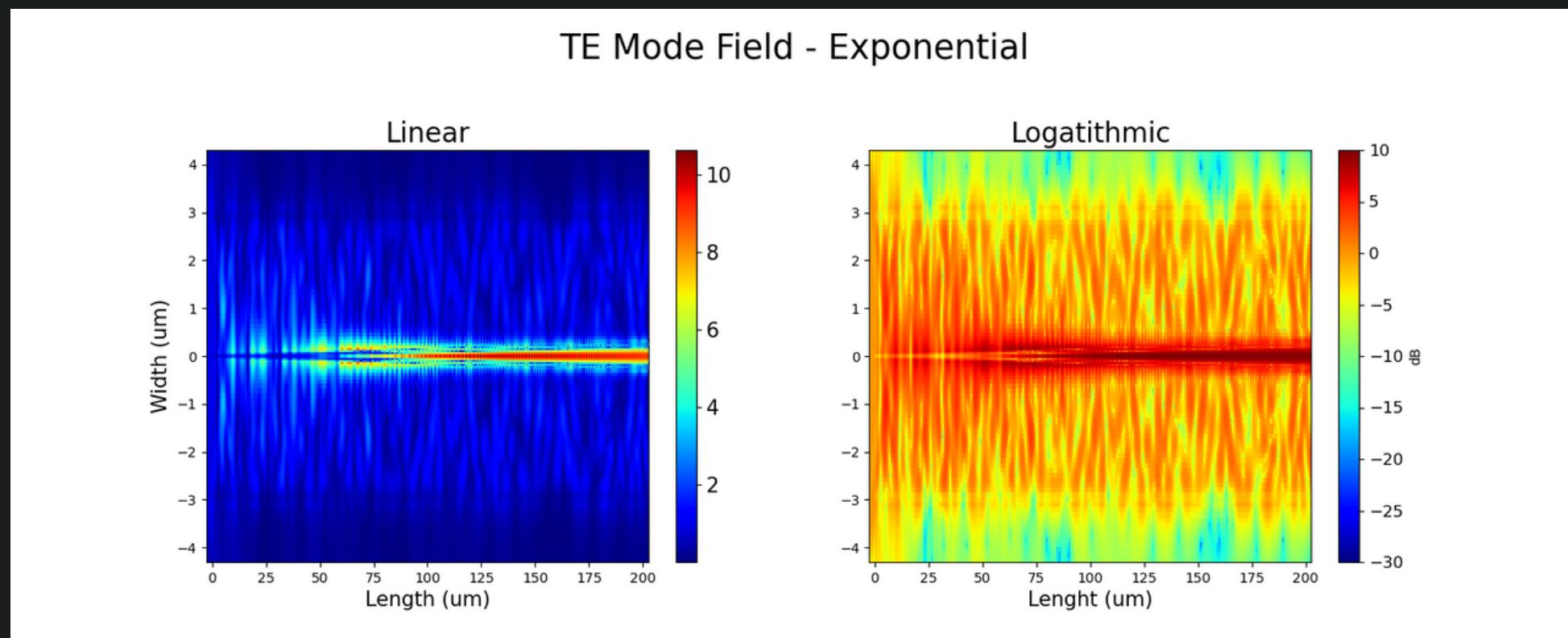


Figure 26: Taper TE0 mode Field (Linear)



Field TM Mode

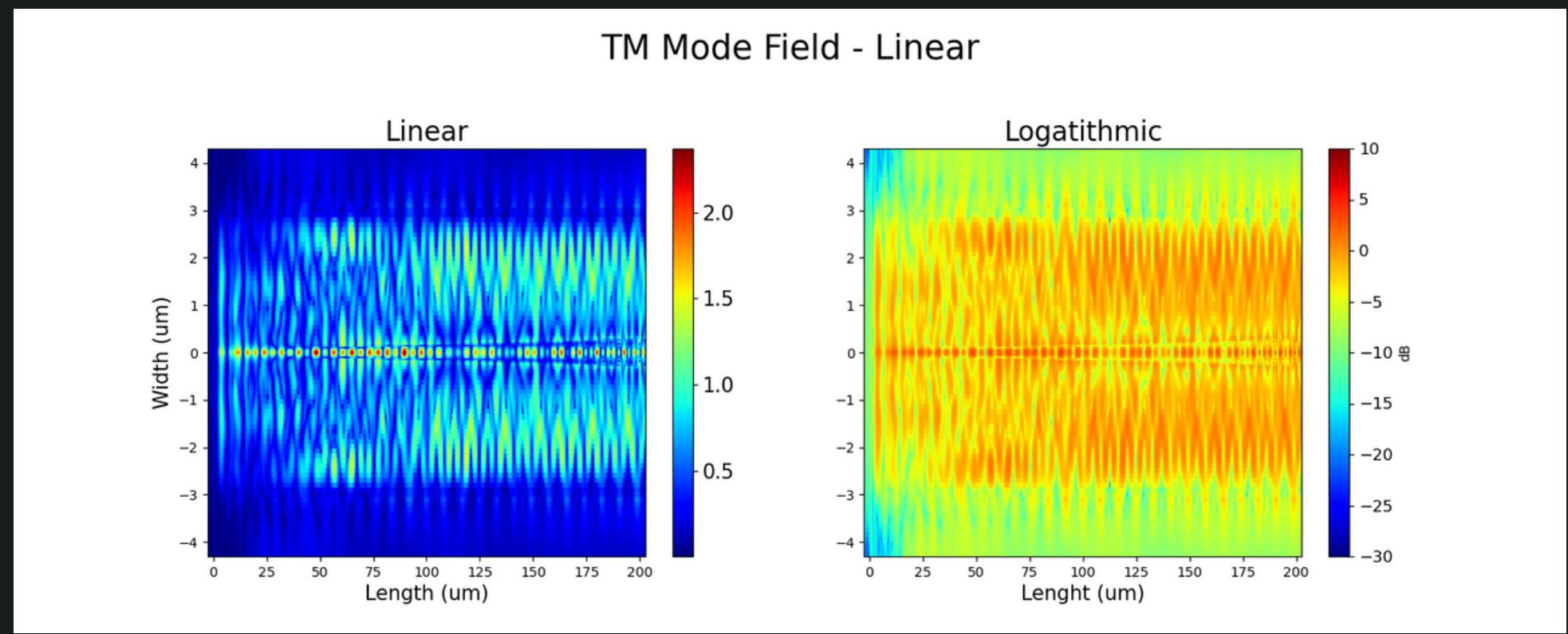


Figure 27: Taper TM0 mode Field (Linear)



Insertion Loss

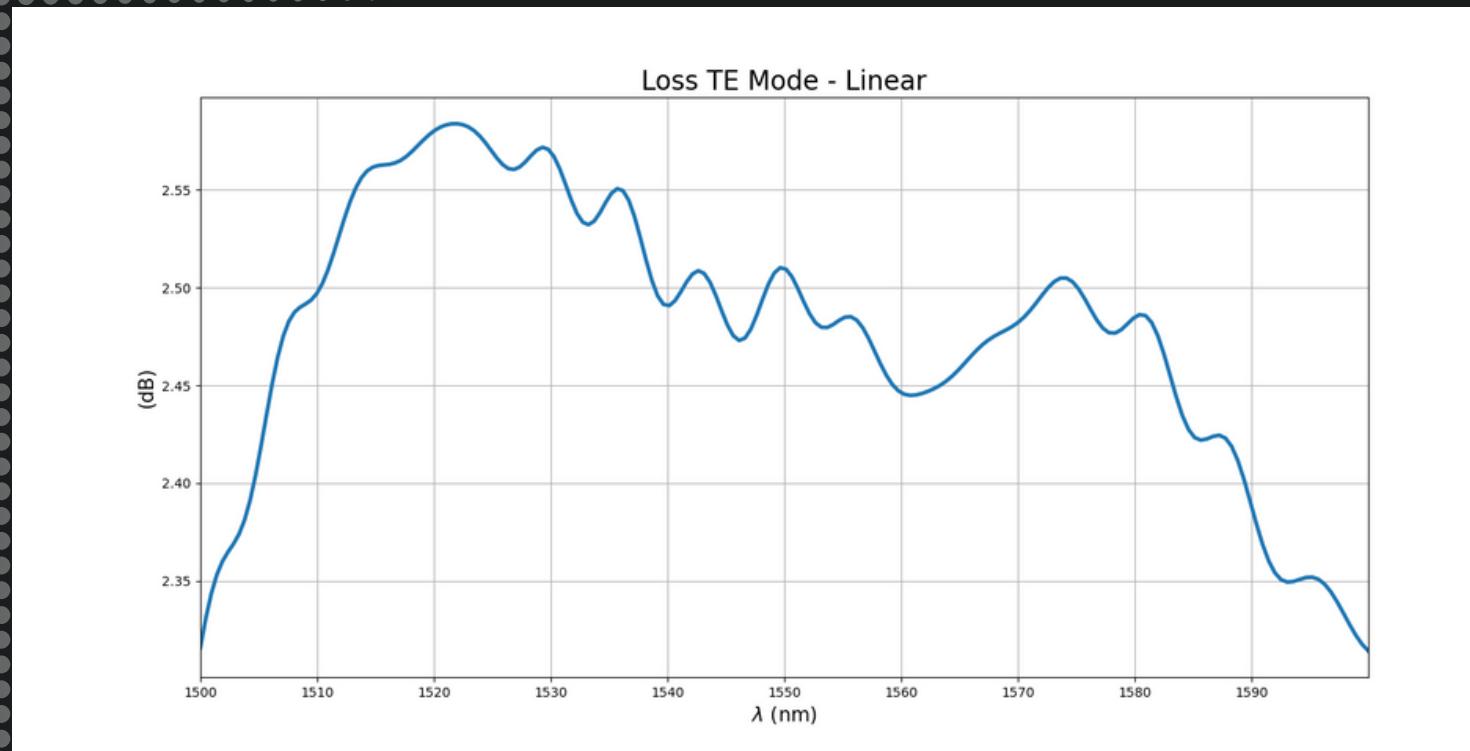


Figure 28: Insertion Loss TE Mode (Linear)

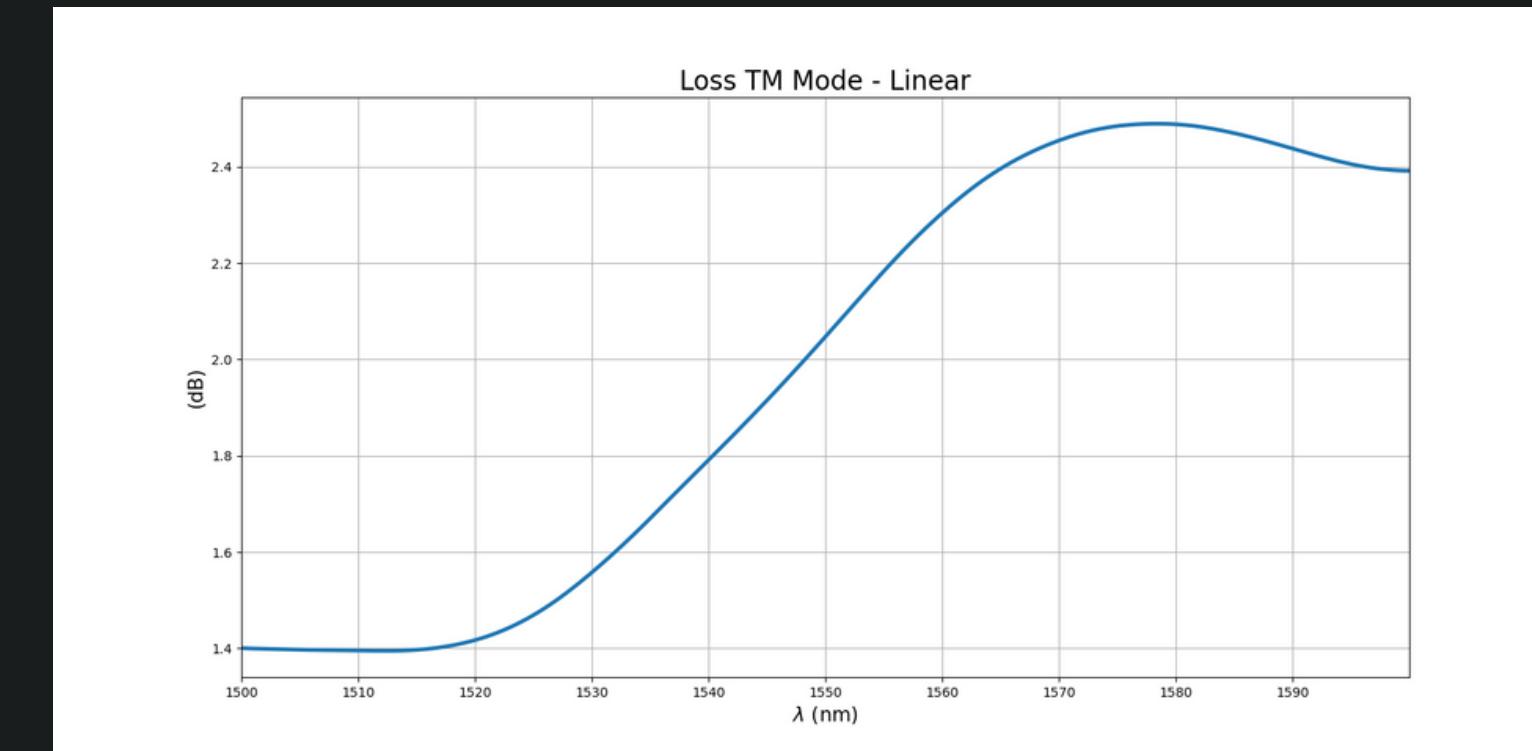


Figure 29: Insertion Loss TM Mode (Linear)



Conclusion

- The TM mode loss result is unexpected due to the field. This result divergence may be occurring because of an error on my simulation settings and will be fix on the following week.
- The TE mode result seems more accurate, but the taper has a lot of reflection.
- The output monitor window will be reduced and the simulation settings revised.
- The other shapes will be analyzed as i fix my errors.

References

- [1] Mu, Xin, et al. "Edge couplers in silicon photonic integrated circuits: A review." *Applied Sciences* 10.4 (2020): 1538.
- [2] Ren, Guanghui, et al. "Study on inverse taper based mode transformer for low loss coupling between silicon wire waveguide and lensed fiber." *Optics Communications* 284.19 (2011): 4782-4788.