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Modal Beam Conditioning for Enhanced MMF Bandwidth

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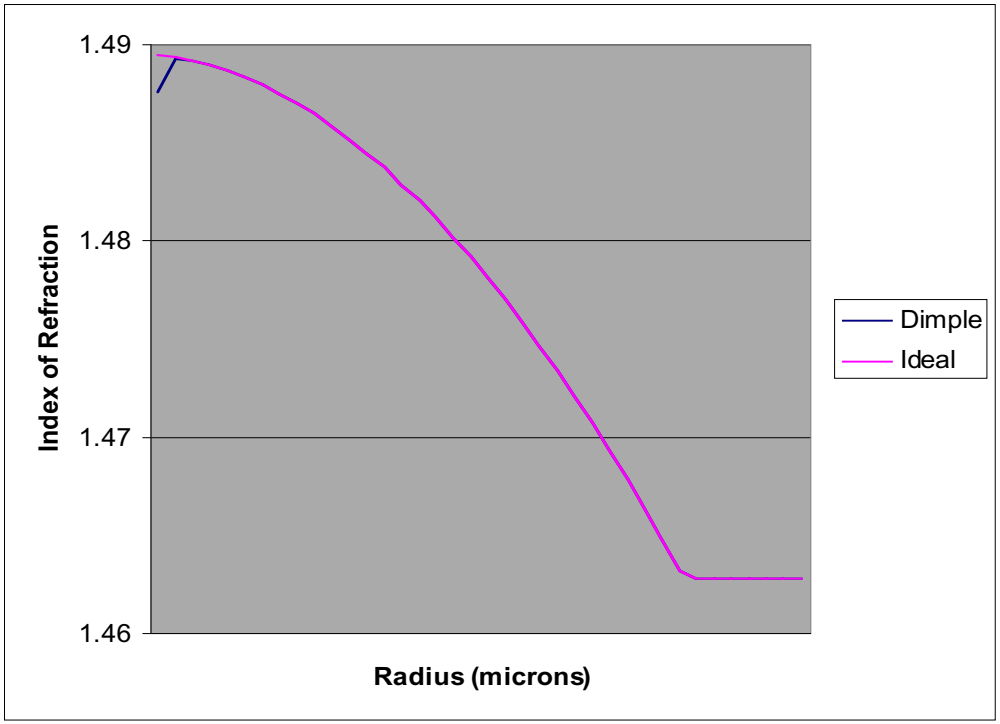
Installed base MMF Refractive Index Profile



"Dimple" causes modal dispersion

Modal Equation

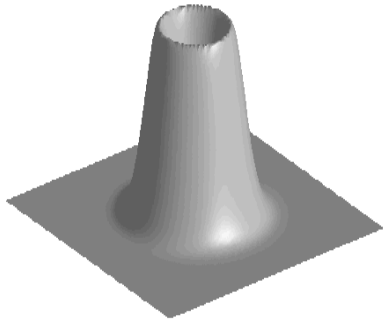
Waveguide modes are separable functions

$$u(r,\phi,z) = f_n(r)e^{jm\phi}e^{j\beta_{mn}z}$$

Where the f_ns are eigen-solutions to the following

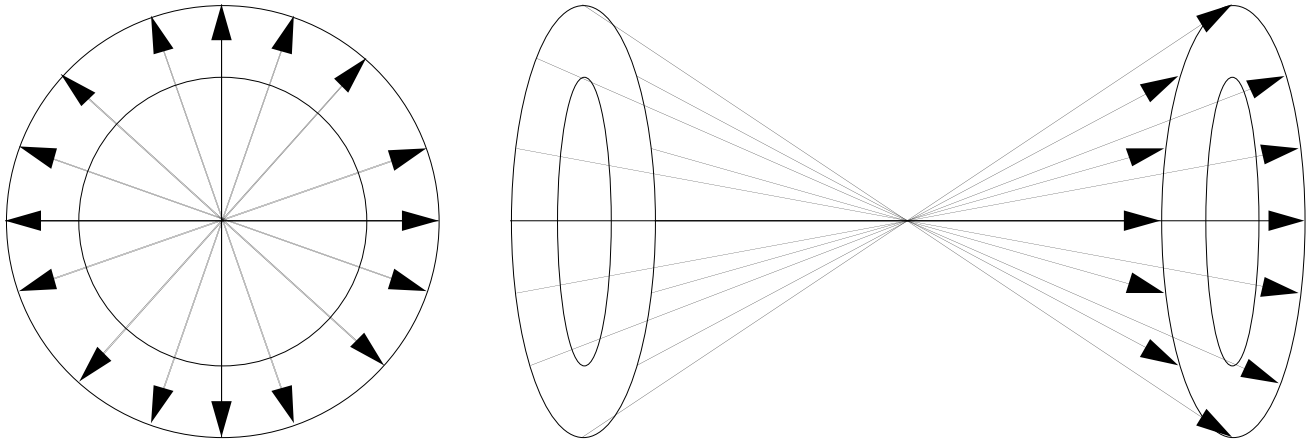
$$\frac{\partial^2 f_n}{\partial r^2} + \frac{1}{r}\frac{\partial f_n}{\partial r} + \left[n_{fiber}^2(r)k_0^2 - \beta_{mn}^2 - \frac{m^2}{r^2} \right] f_n = 0$$

There is a solution that propagates with spiral rays which avoid the center of the core: mode (2,1)

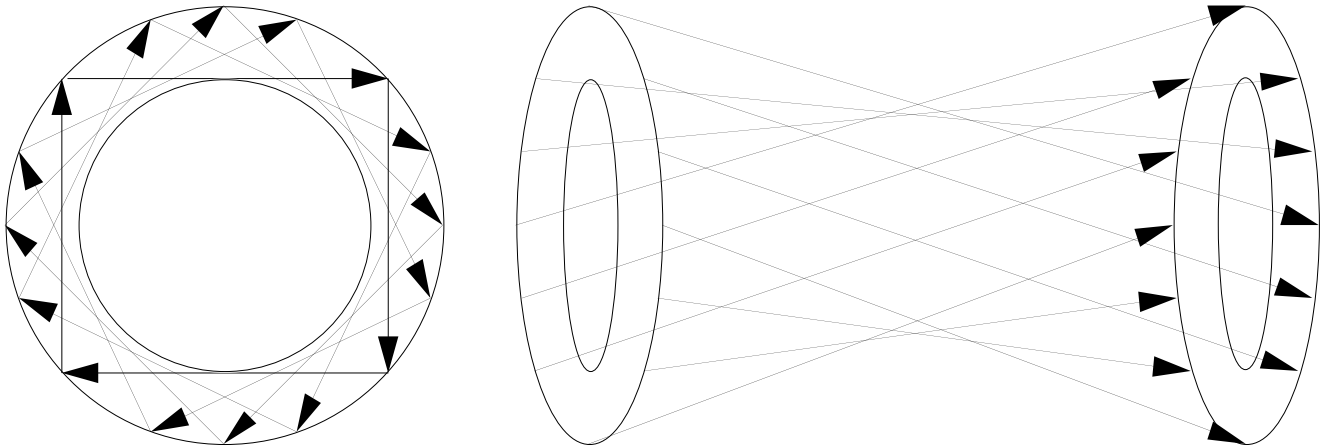


Donut launch ≠ Vortex launch

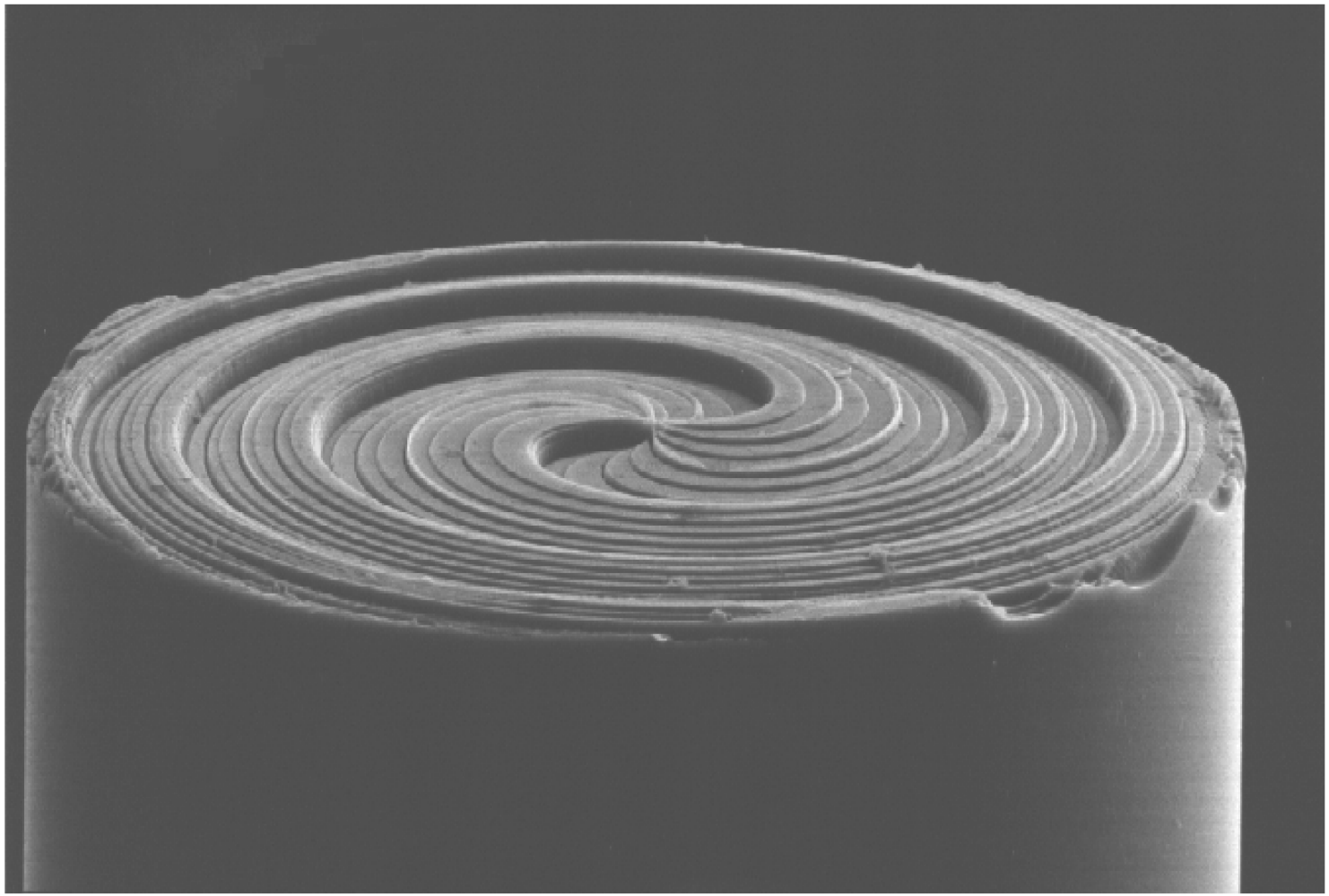
Donut rays do not map to fiber modes. Can cross the Core center.



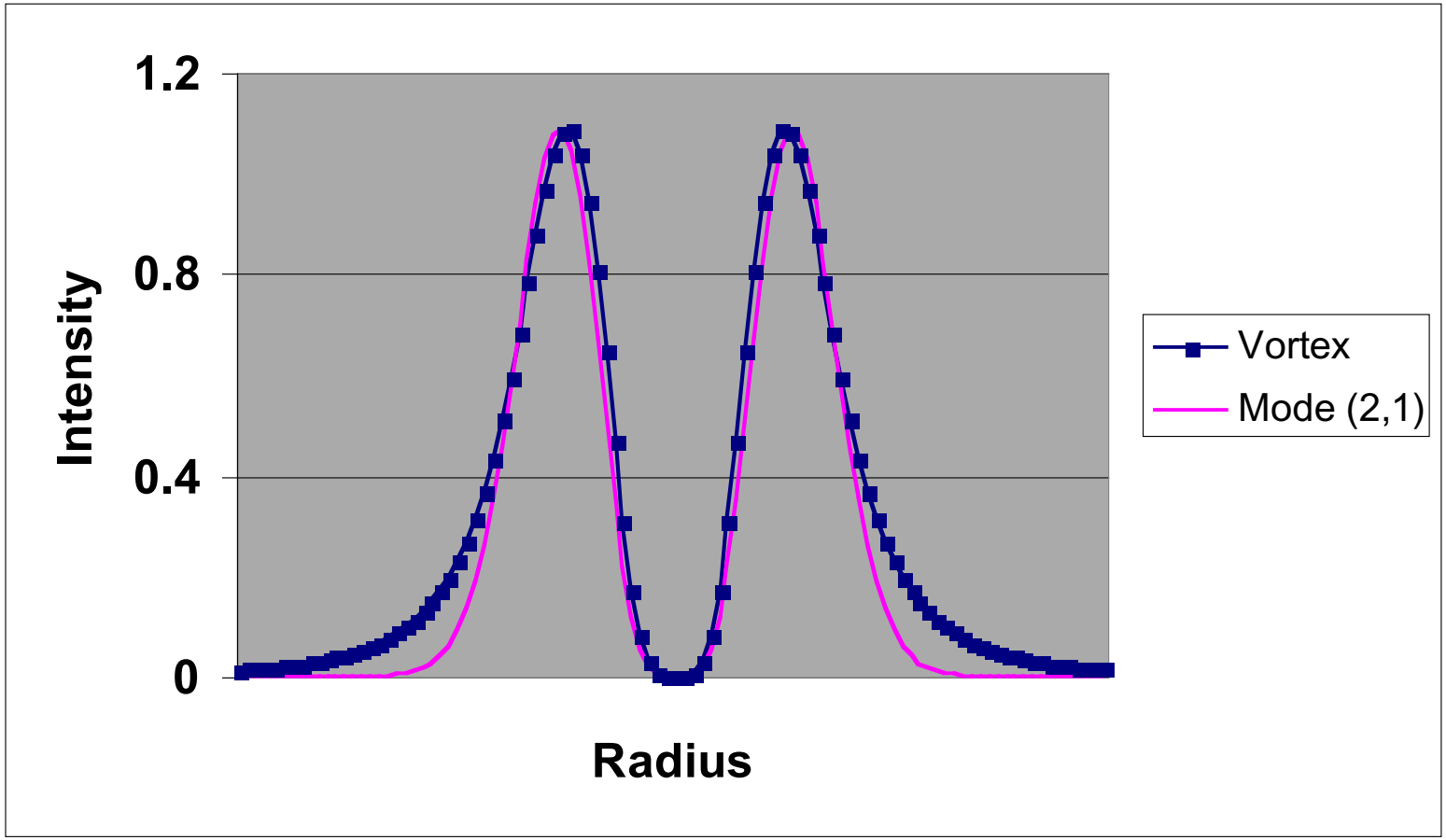
Vortex rays map to fiber skew rays which don't cross the core center



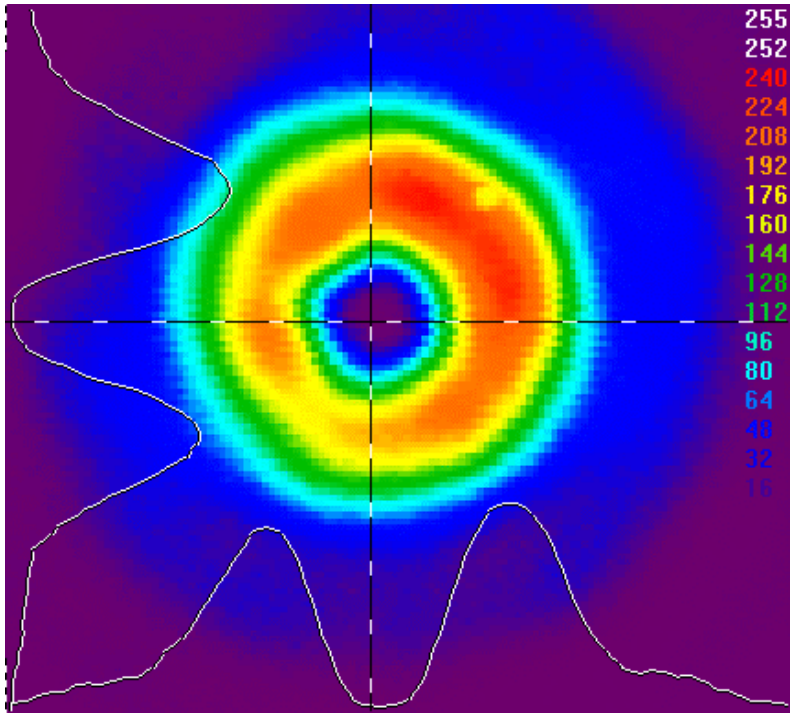
Vortex diffractive on a 125 µm fiber stub



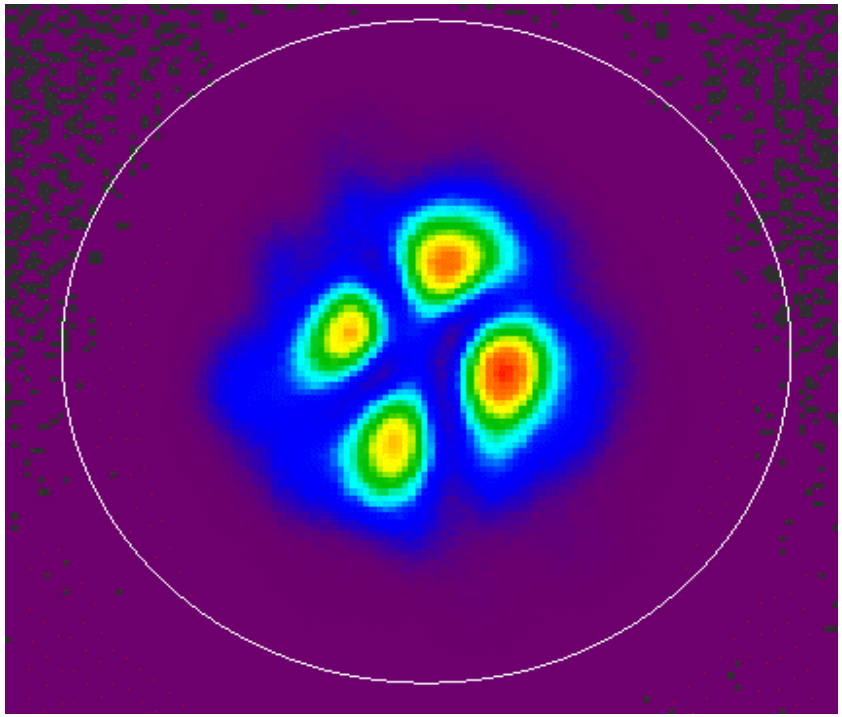
Vortex cross section closely matches optimum mode



Beam profiles



Launch Beam Profile



Excited modes in MMF core

Conclusion

- Vortex launch can target higher order modes
- Avoids modal dispersion of core centerline defect
- Solution for extracting more bandwidth from legacy MMF installations
- Could be implemented in the form of a patchcord, or integrated in the transceiver.