Wavelength Tuneable Laser Beam Shaping Optics

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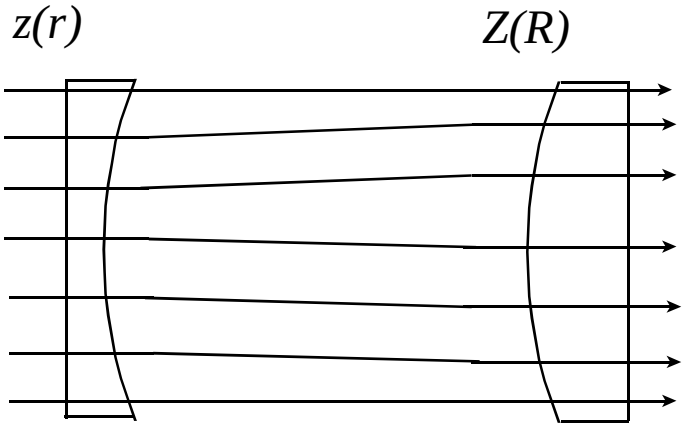
Beam Shaping Theory

Following J.A. Hoffnagle and C.M. Jefferson, *Appl. Opt.* **39**, pp 5488–5499, 2000.

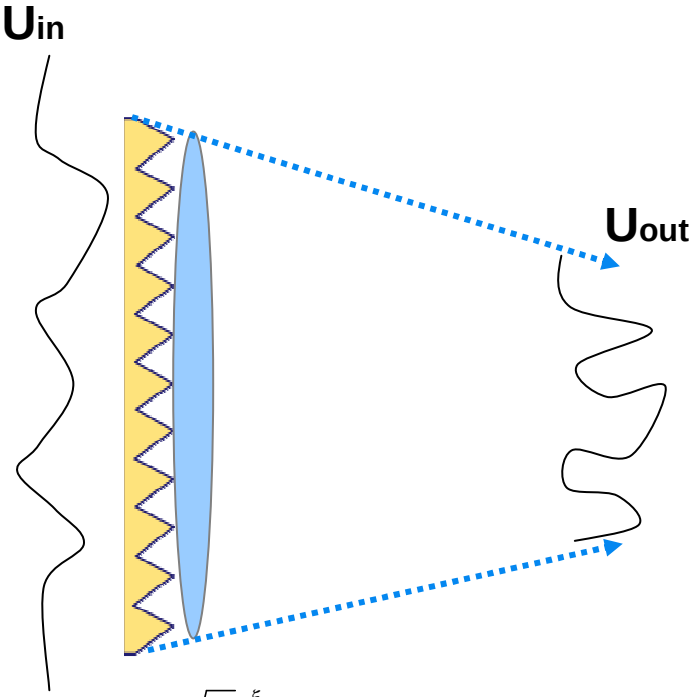
Following F.M. Dickey and S.C. Holswade, *Opt. Eng.* **35**, pp 3285–3295, 1996.



$$\int_0^r f(x)xdx = \int_0^R g(x)xdx$$

$$z(r) = \int_0^r \left\{ (n^2 - 1) + \left(\frac{(n-1)d}{h(x) - x} \right)^2 \right\}^{-1/2} dx$$

$$Z(R) = \int_0^R \left\{ (n^2 - 1) + \left(\frac{(n-1)d}{h^{-1}(x) - x} \right)^2 \right\}^{-1/2} dx$$

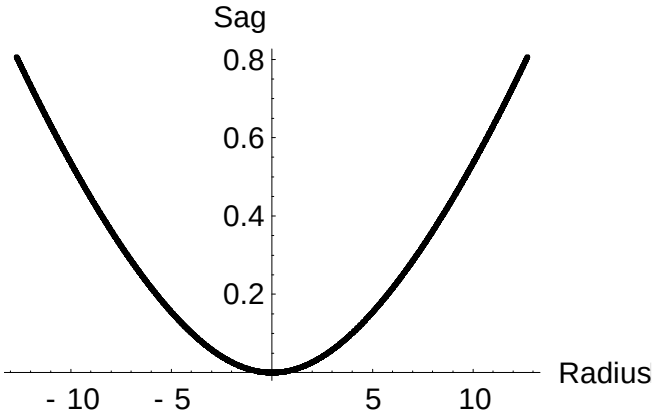


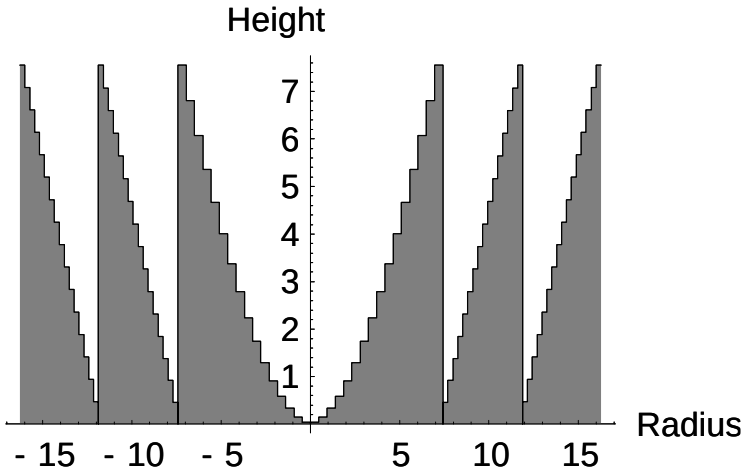
$$\phi(\xi) = \frac{\sqrt{\pi}}{2} \int_0^{\xi} \sqrt{1 - \exp(-\rho^2)} d\rho$$

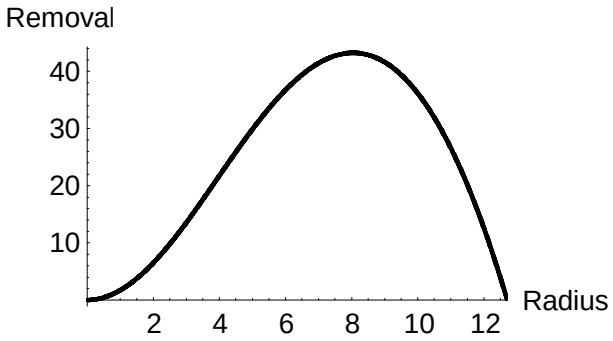
$$\xi = \frac{\sqrt{2}r}{r_0}$$

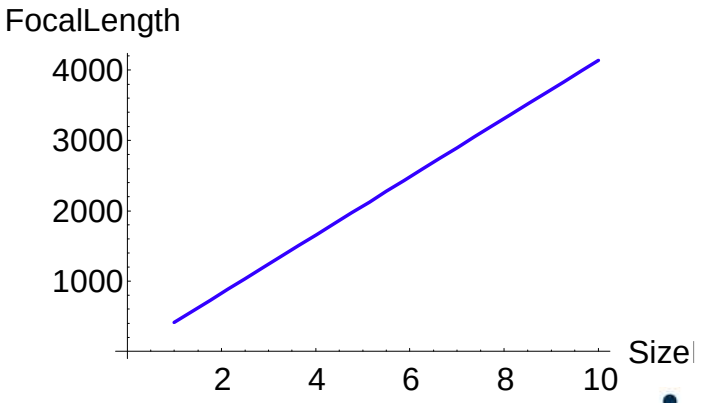
$$\beta = \frac{2\sqrt{2\pi} r_0 y_0}{f\lambda}$$

Design



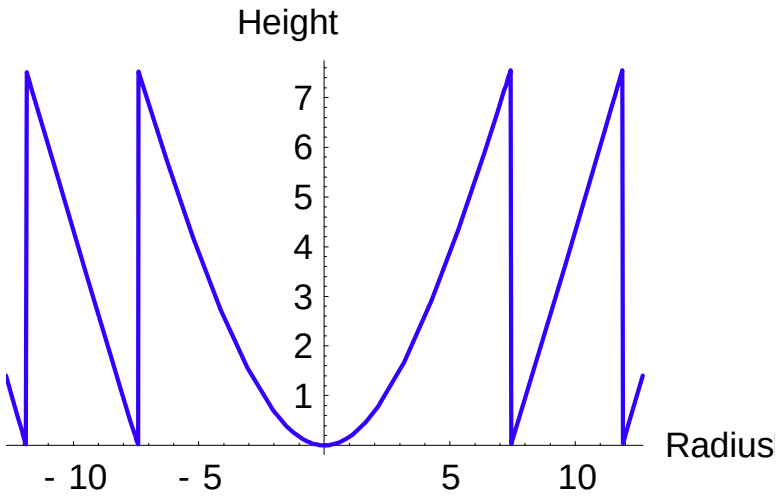


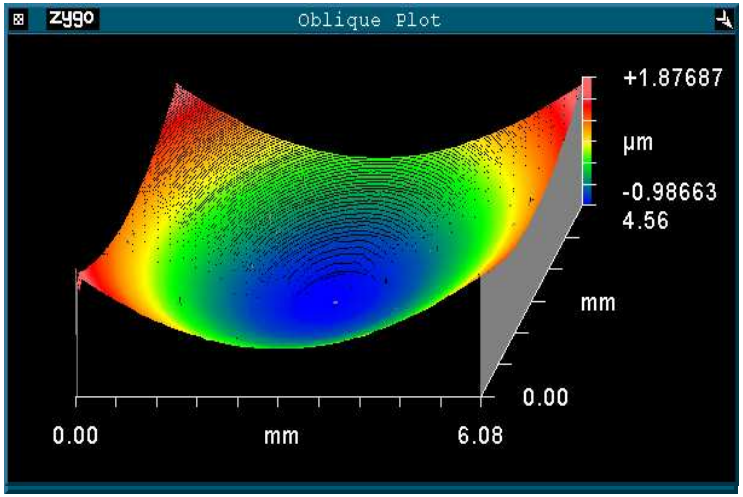




Diffractive Shaper

Design and fabrication in ZnSe



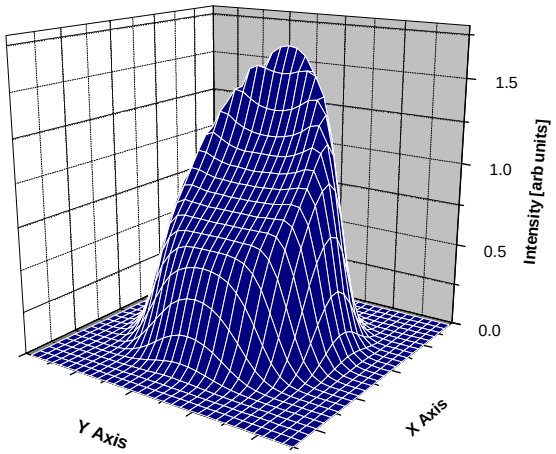


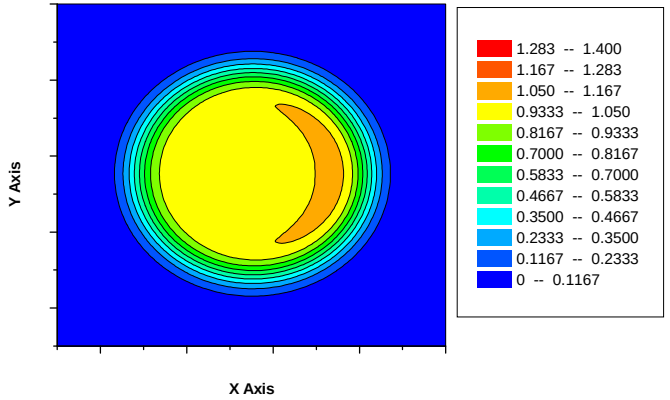
- Kinoform
- 100% efficient (theory)
- Height is a function of wavelength
- Zone spacing is a function of element design

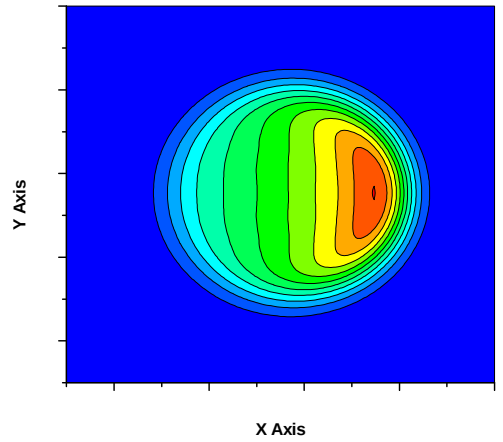
Results

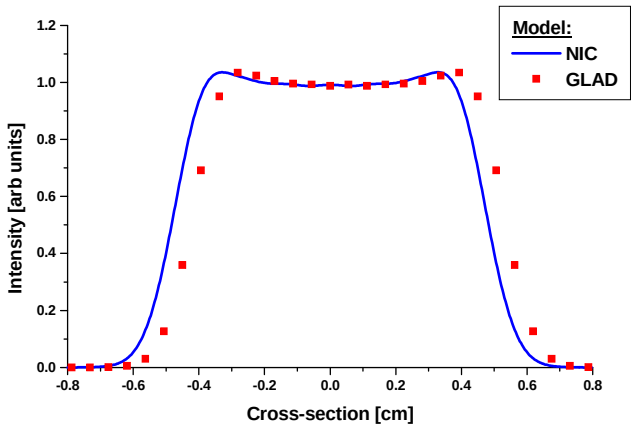
Kirchoff–Fresnel Model

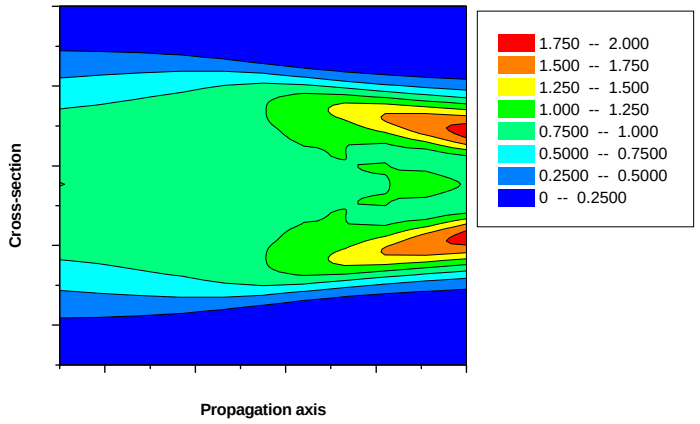
Test code against known results: Incorrect beam sizes, misaligned optics etc

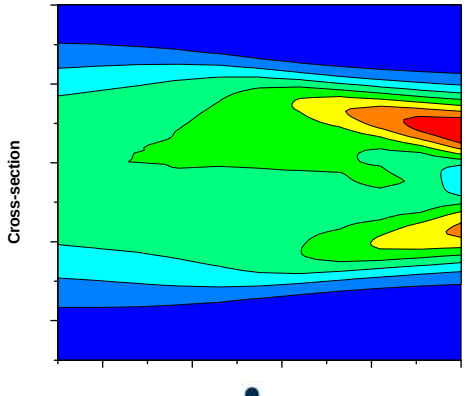






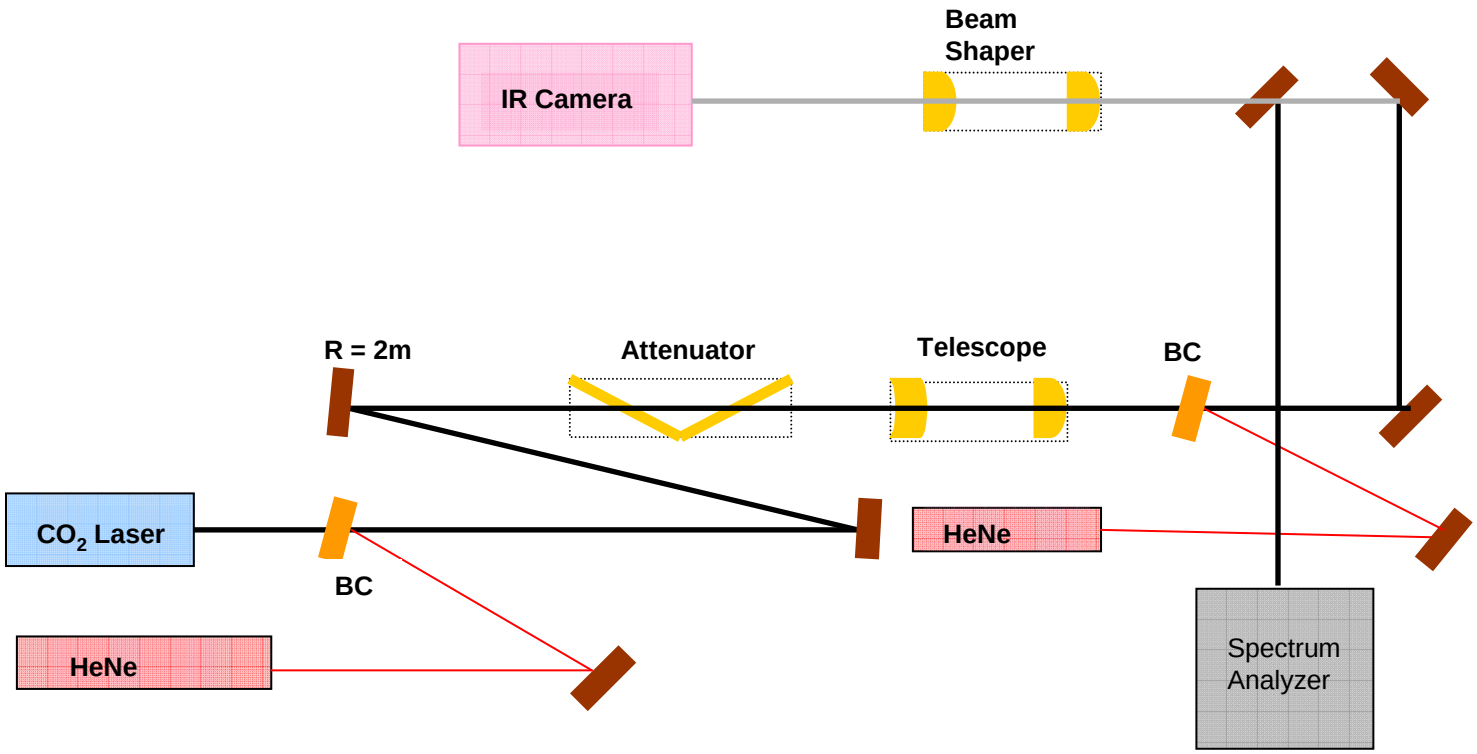






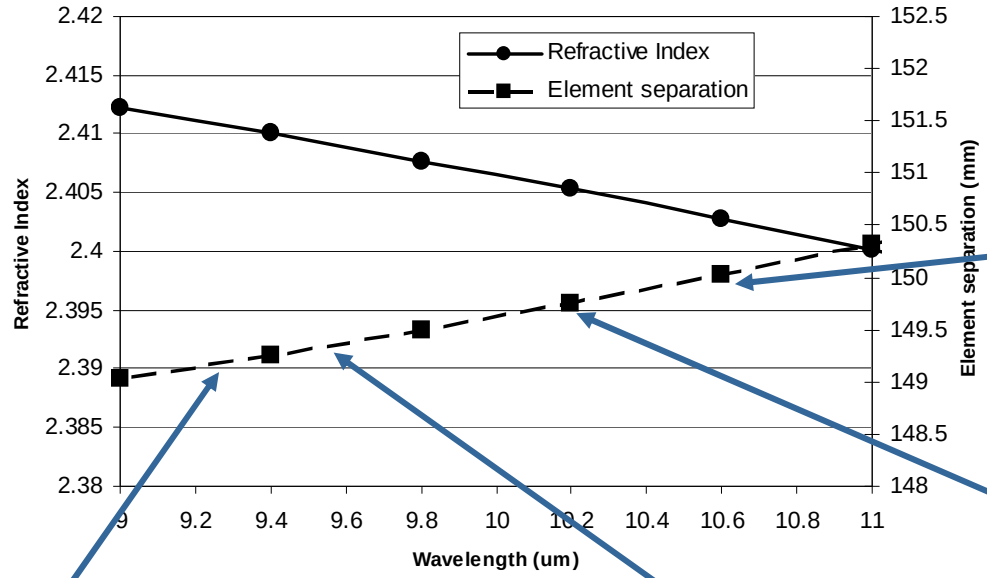
Experiment

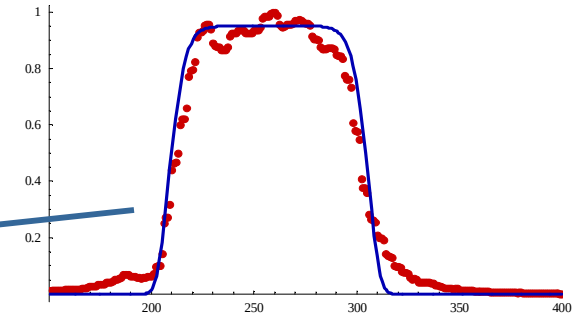
Or how not to do an experiment!

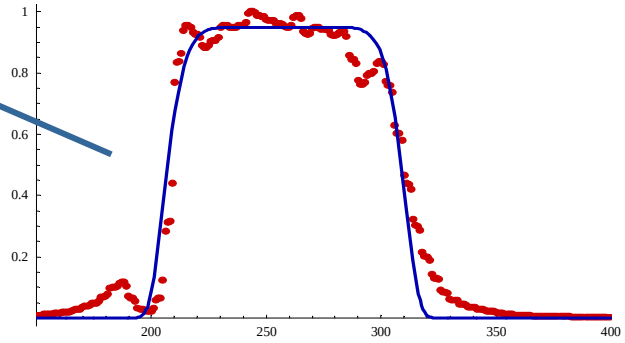


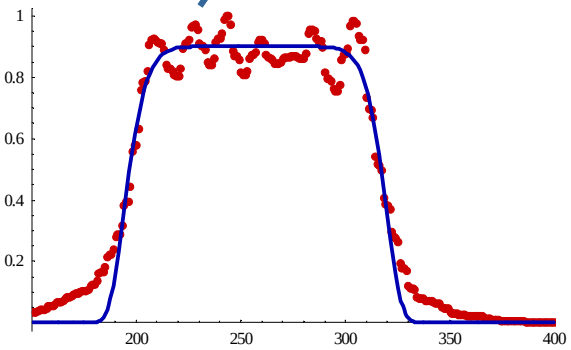
Wavelength Tuneability

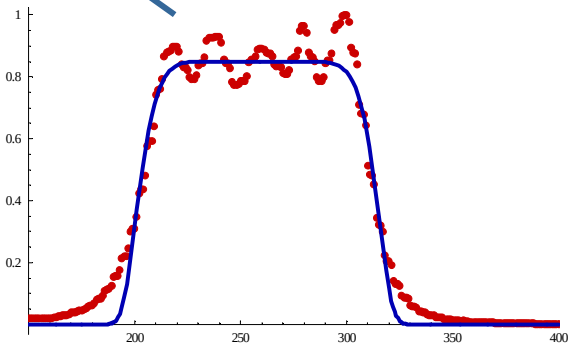
What happens if we pass a non-design wavelength through the element?



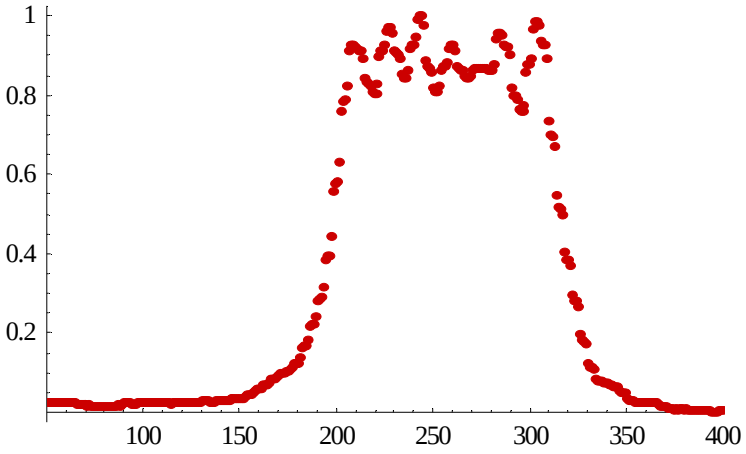




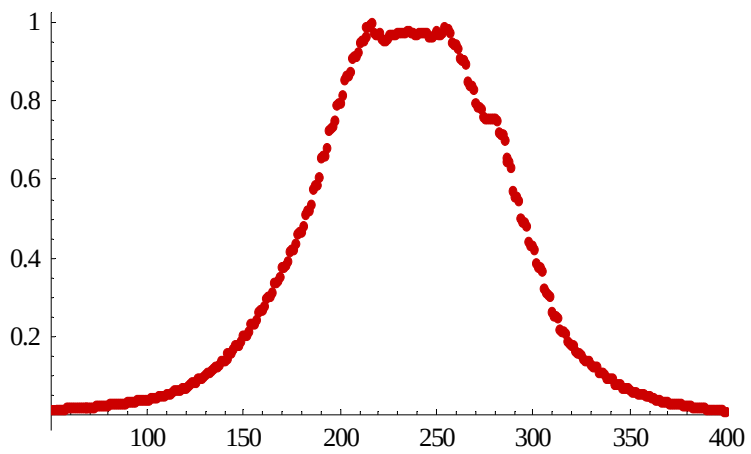




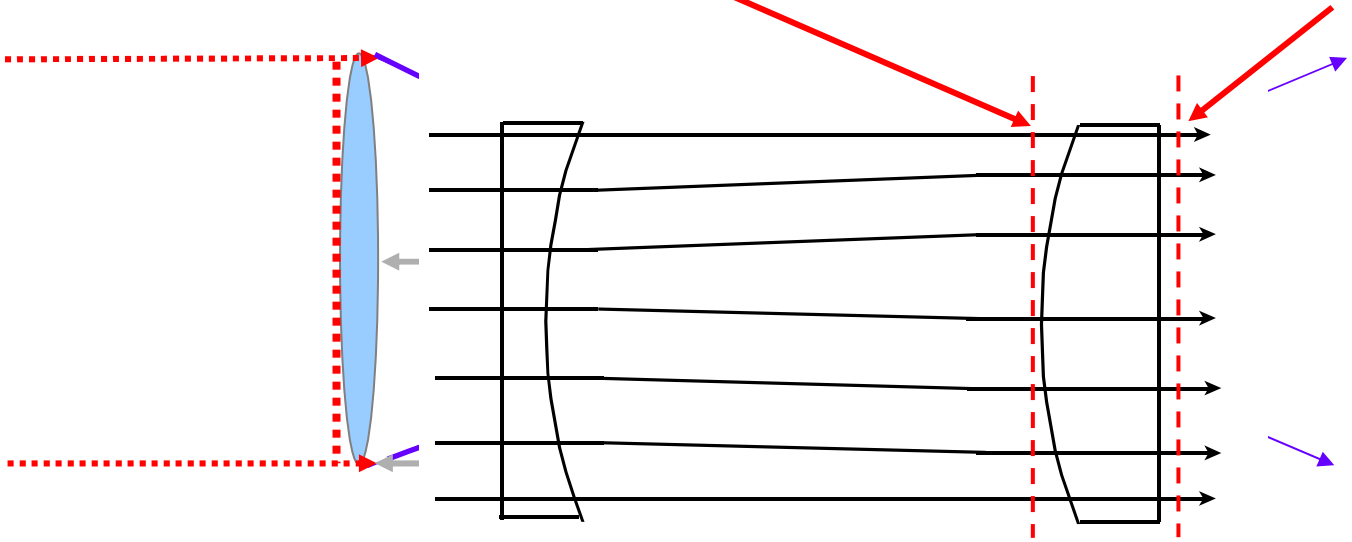
Propagation Effects



Just before 2nd element



Just after 2nd element



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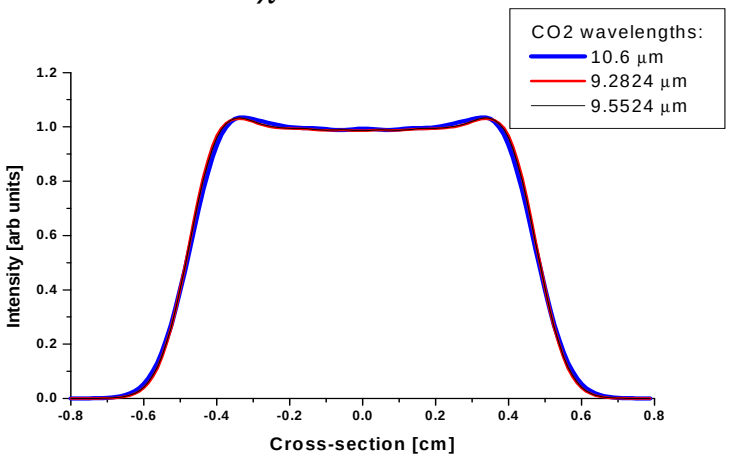
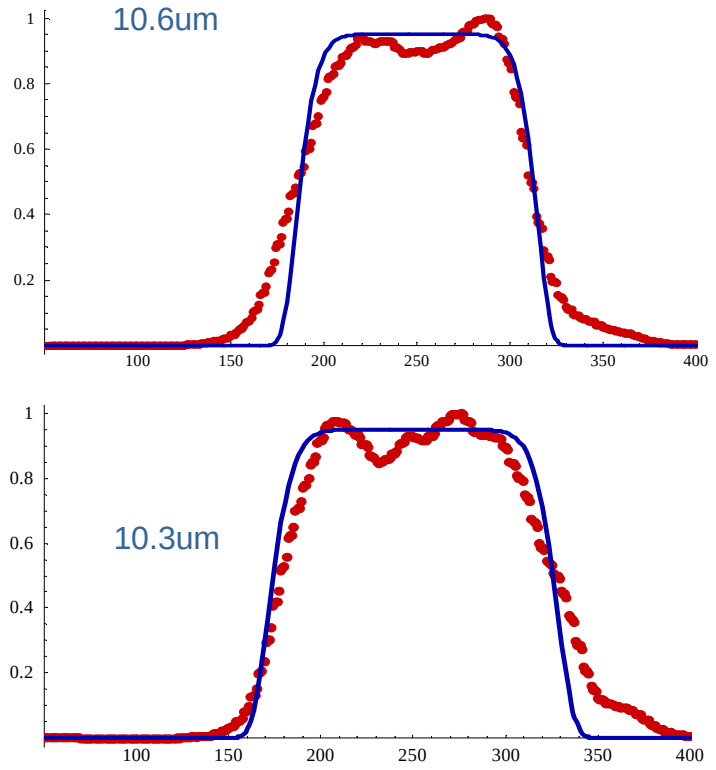
Wavelength Tuneability

What happens if we pass a non-design wavelength through the DOE?

$$\Delta\phi = \frac{2\pi}{\lambda}(n-1)h$$





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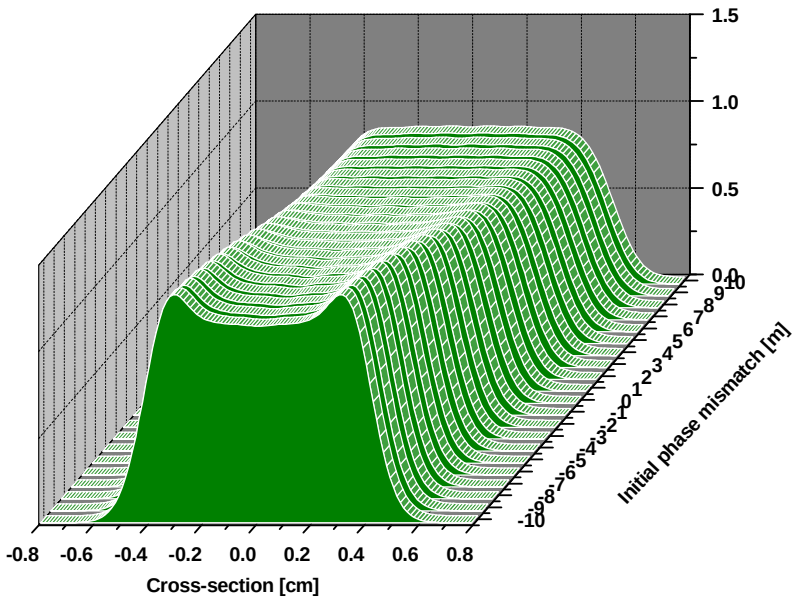
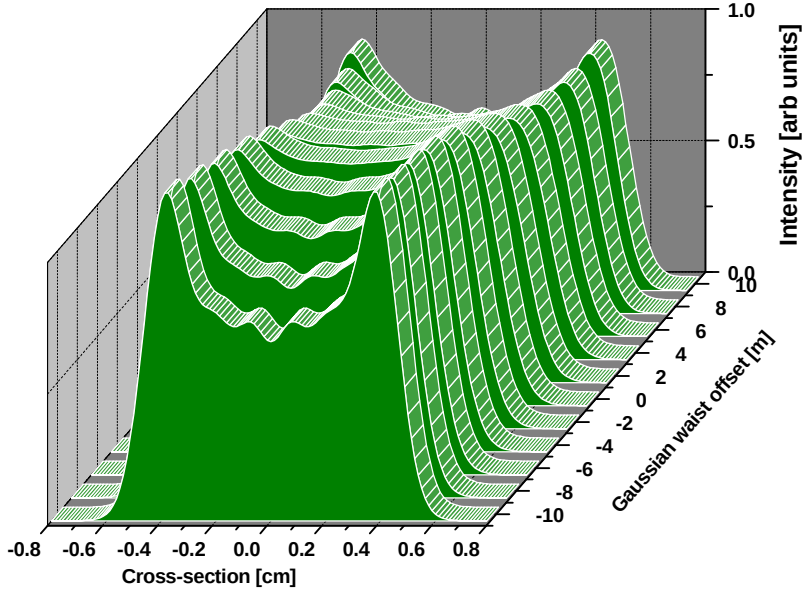
Beam Quality

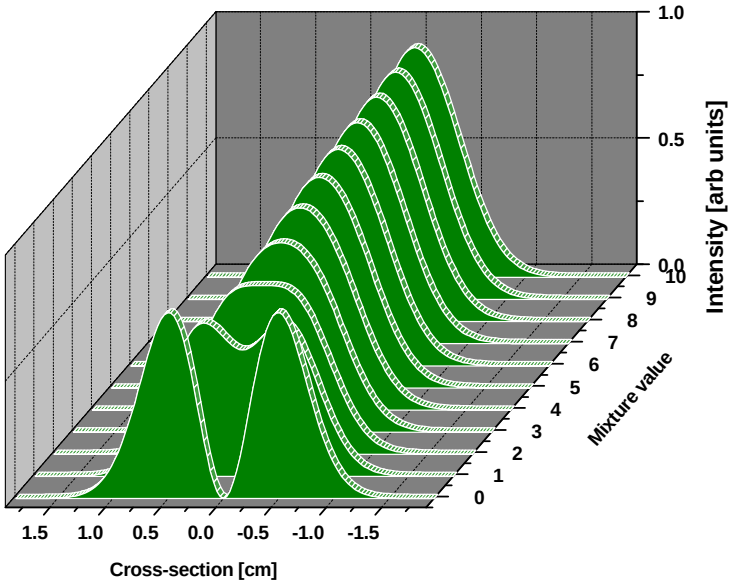
Phase, beam size and beam shape

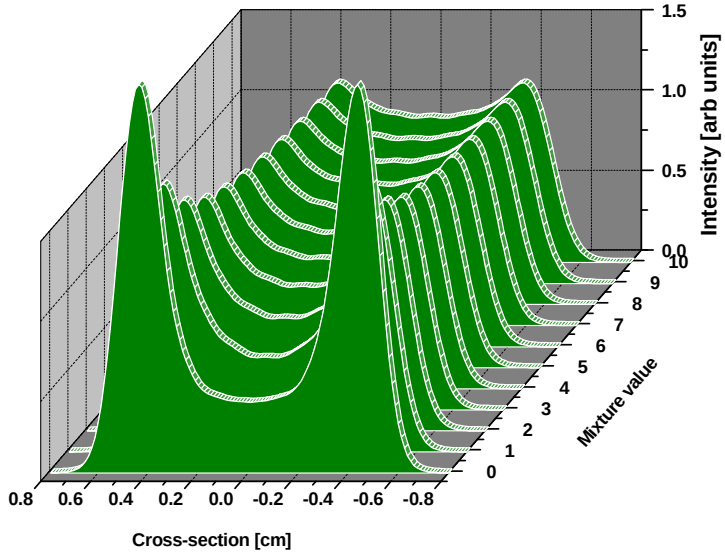




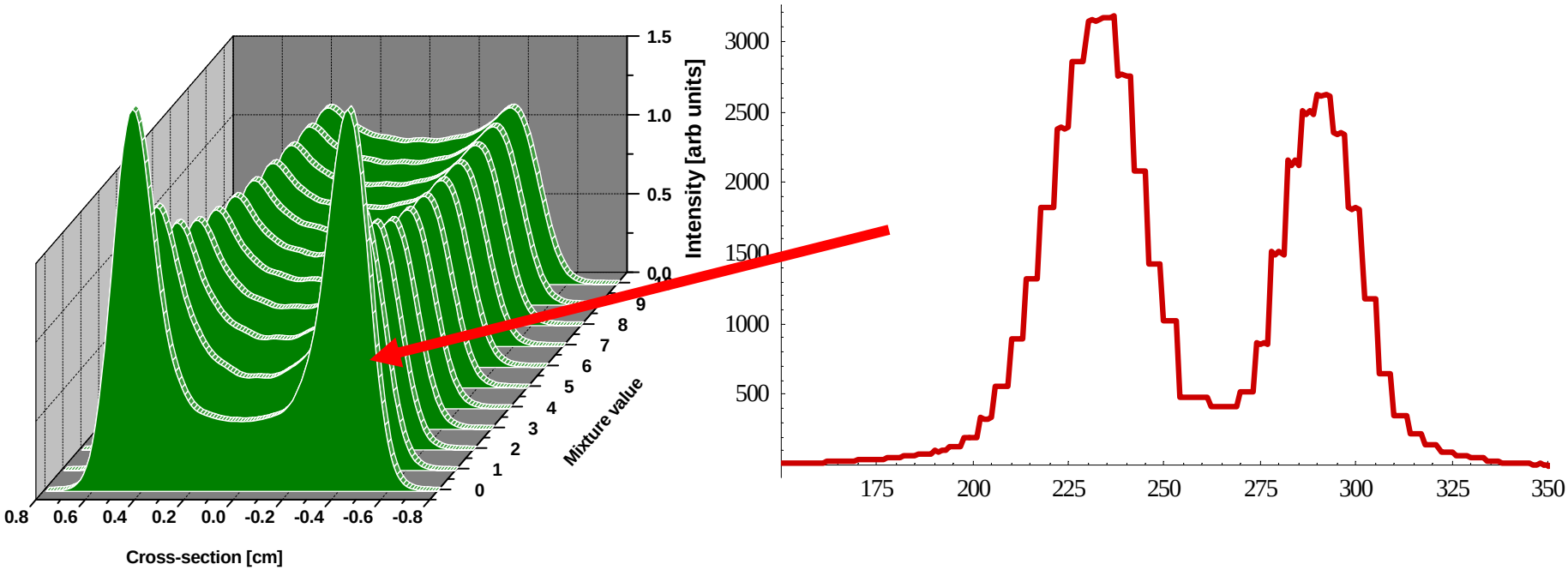
Beam Quality

What happens if the M^2 of the beam is > 1?





Non-design Mode



Conclusion

- Both designs show wavelength tuneability
  - Demonstrated both experimentally and numerically
- Refractive element shows some anomalies
  - Intensity correctly reproduced, but not phase
- Future work
  - Consider impact of β on performance of designs

Questions