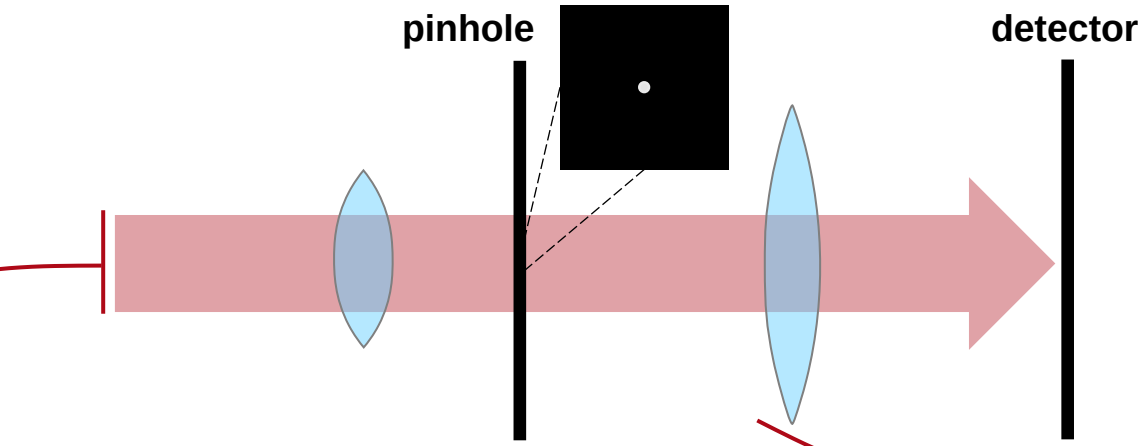
Circularly Serrated Aperture for Beam Apodization

Abstract

Modern optical applications in various industry sectors demand for laser beams with uniform energy distribution (flat-top beams). It is known that beams with steep edge profiles are more susceptible to developing diffraction ripples. These ripples may intensify in certain optical systems like amplifiers through self-focusing effects. In this use case, we seek to tackle this challenge by introducing a serrated beam apodizer. Beam apodization plays a key role in the design of high-energy lasers and beam delivery systems. Using amplitude-only apertures in high-energy optical systems leads to higher durability compared to apertures fabricated with deposition techniques.

Modeling Task

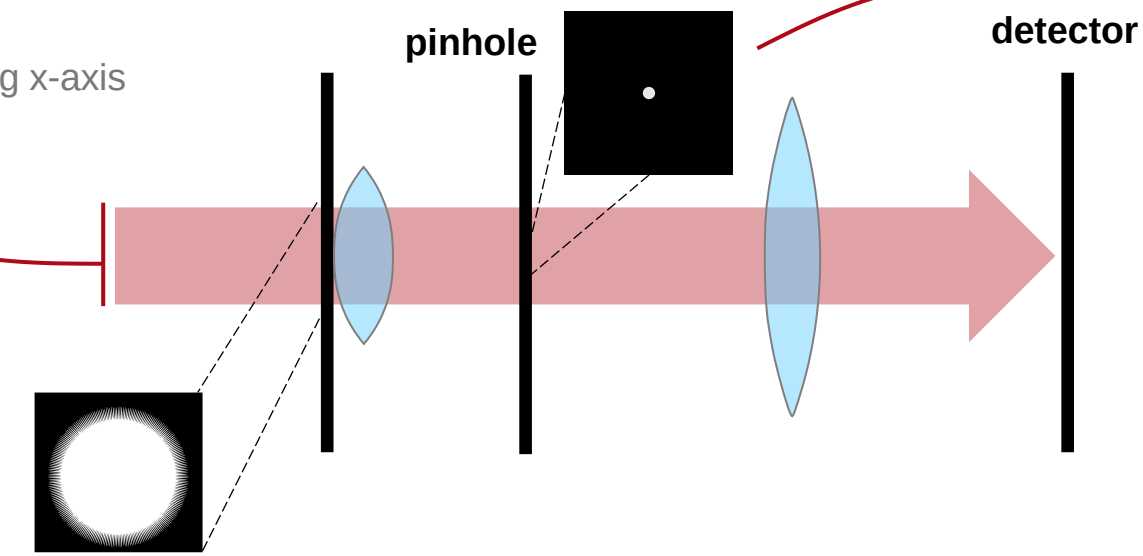
a) reference setup



plane wave
- wavelength: 532 nm
- shape: elliptic
- diameter: 10 × 10 mm
- linearly polarized along x-axis

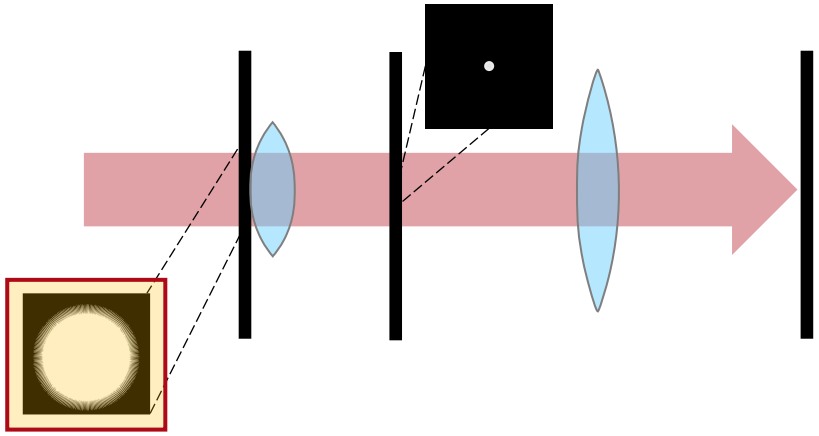
lens system
- focal length lens 1: 33 mm
- focal length lens 2: 165 mm
- pinhole diameter: 100 µm

b) setup with beam apodizer

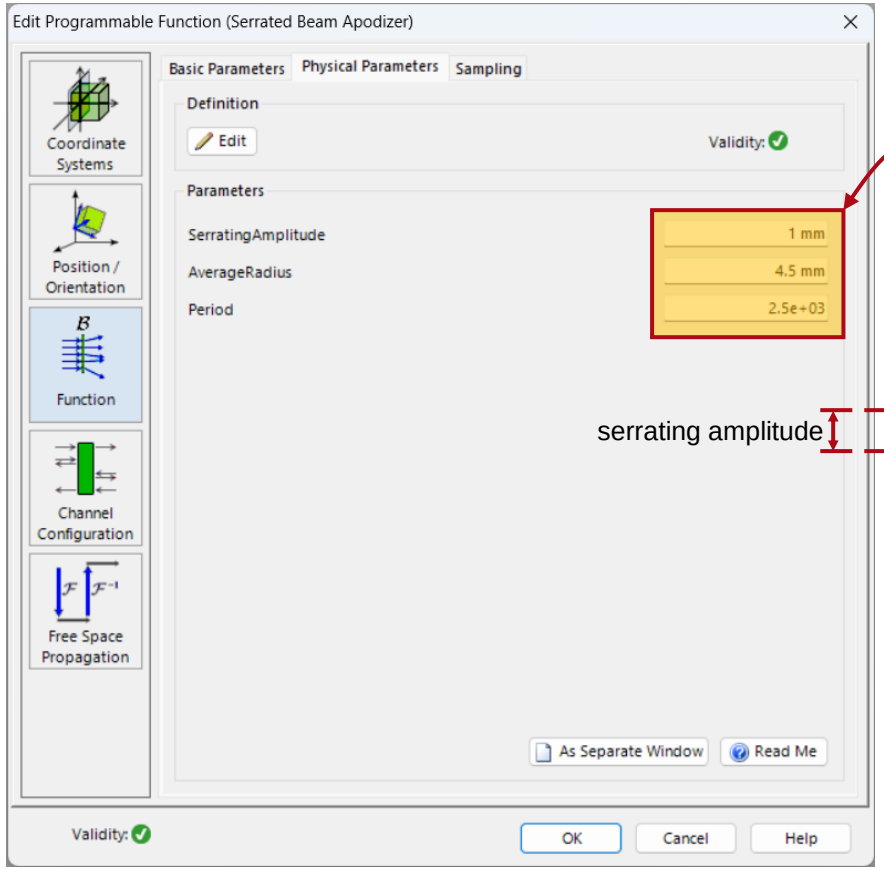


serrated aperture
- shape: circular
- serrating amplitude: 1 mm
- average radius: 4.5 mm
- number of ridges: 2500

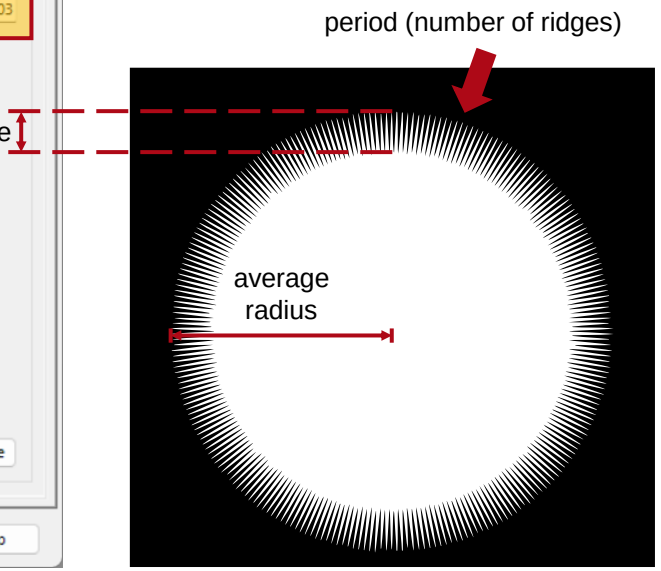
Programming Serrated Aperture Using Programmable Function



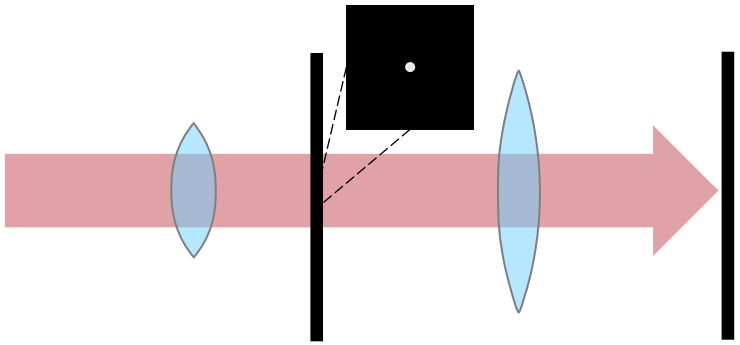
The *Programmable Function* is used to model the serrated aperture. This allows the definition of a position-dependent, complex-valued function on a single plane, which is then multiplied onto the incoming field.

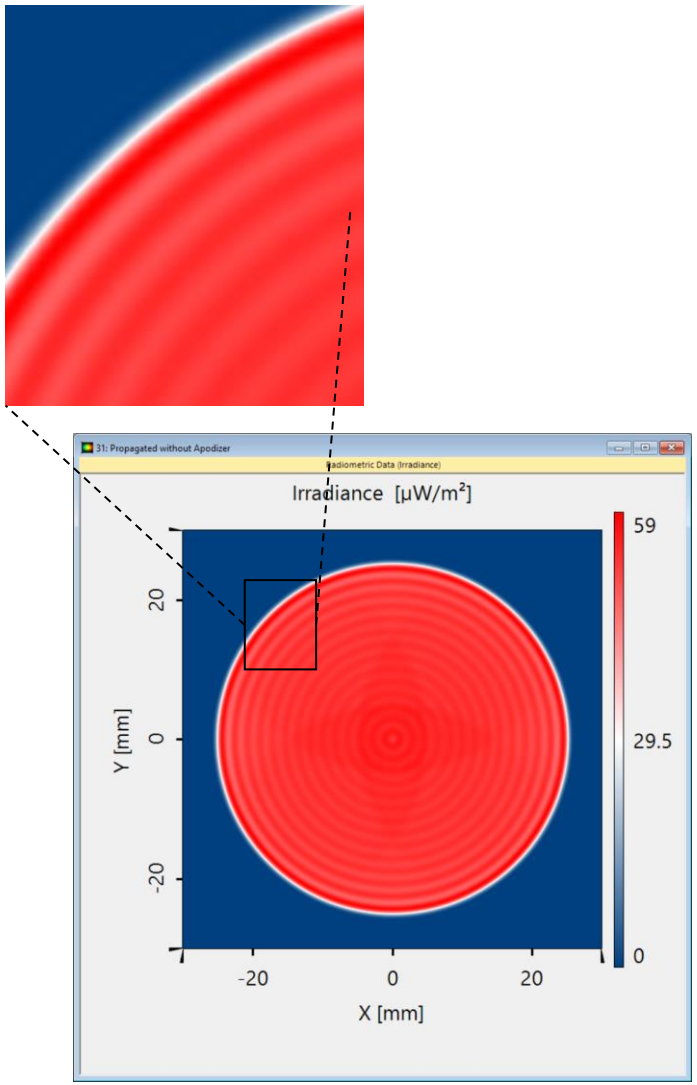


The parameters of the serrated aperture can be adjusted here.



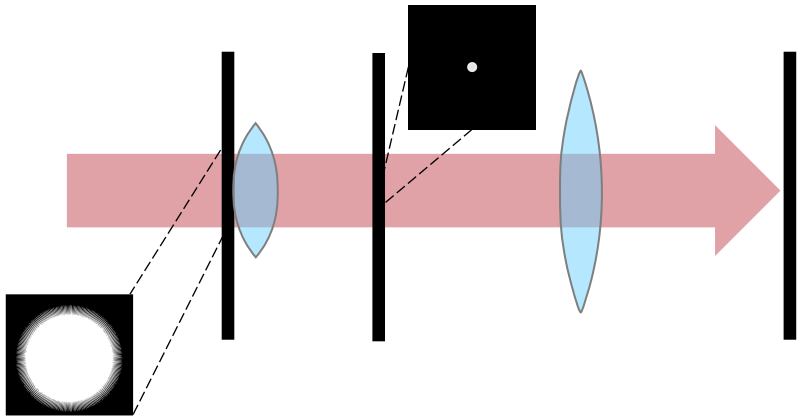
Propagated Beam Excluding Beam Apodizer

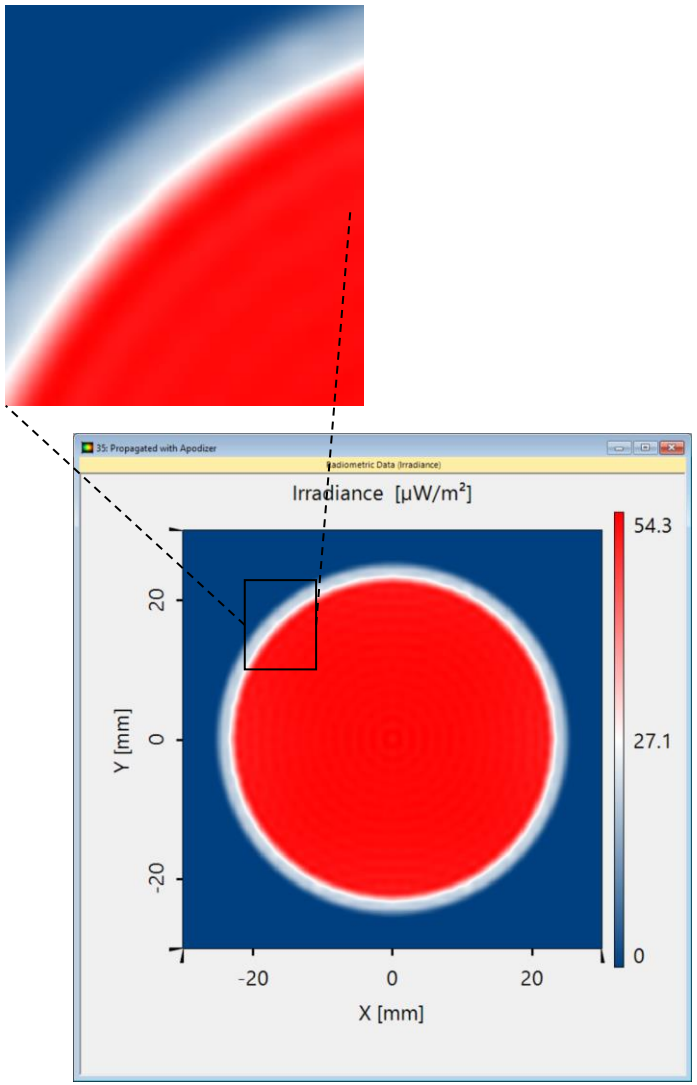




As the beam travels through the arrangement without the serrated aperture, ripples introduced by diffraction can be observed.

Propagated Beam Including Beam Apodizer

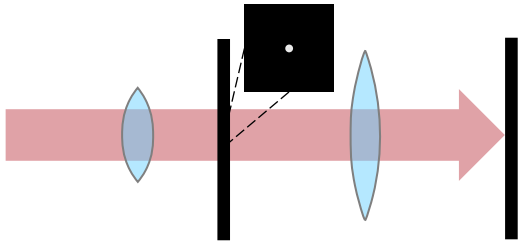


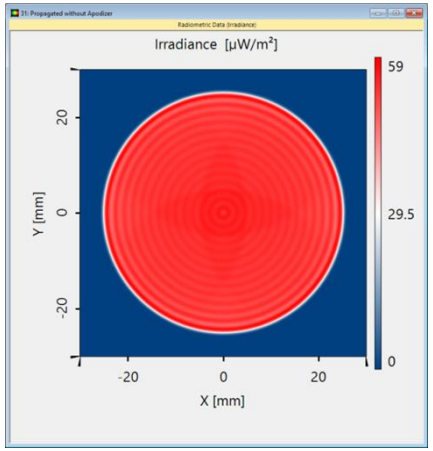


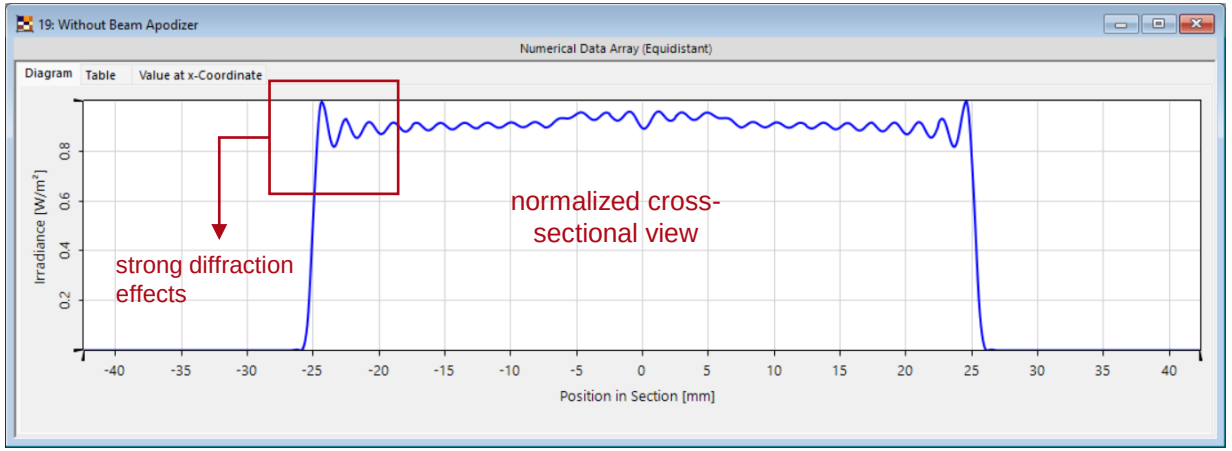
The introduction of the serrated aperture eliminates the visible diffraction ripples of the propagated beam.

Results Comparison

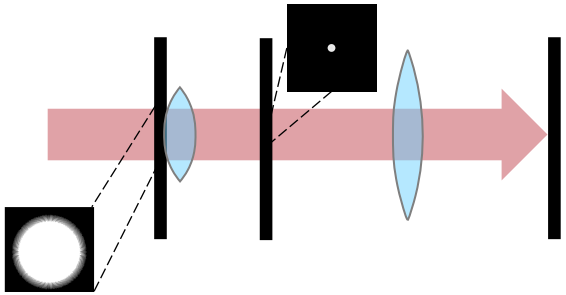
a) reference setup

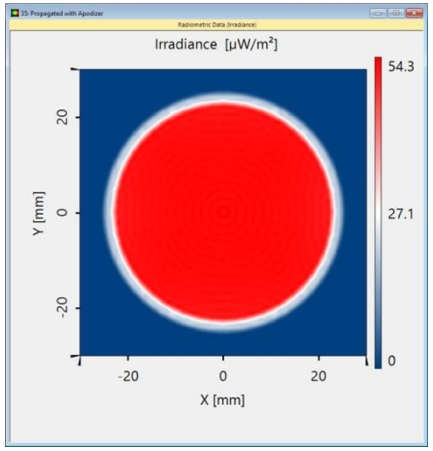


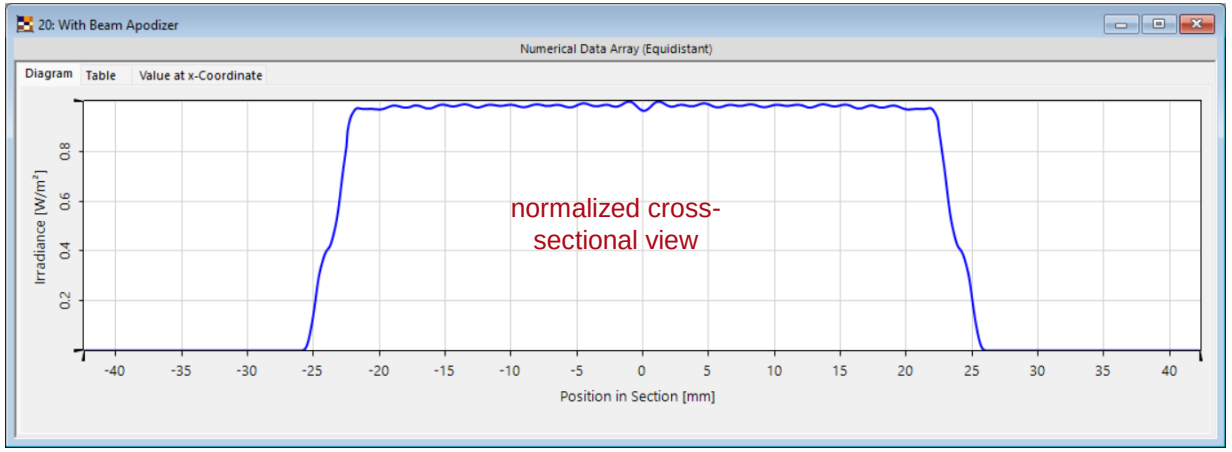




b) setup with beam apodizer



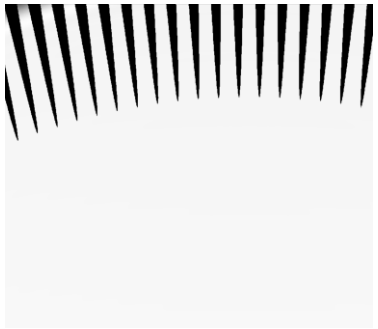


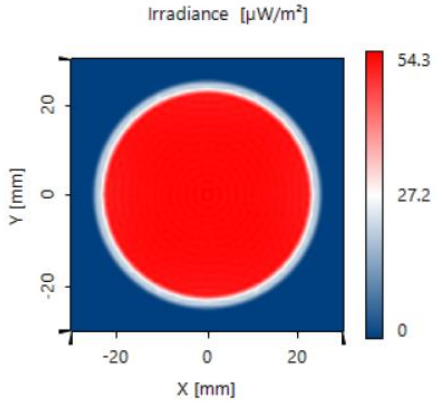


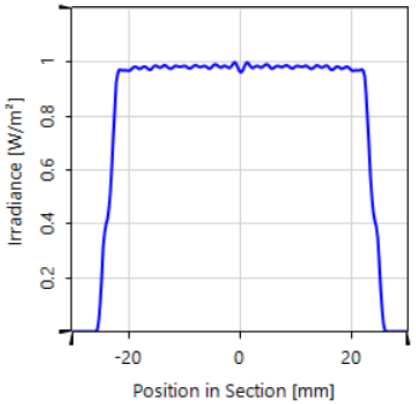
Comparison with Literature

aperture parameters

shape: circular
serrating amplitude: 1 mm
average radius: 4.5 mm
number of ridges: 2500







aperture parameters

shape: rectangular
serrating amplitude: 1 mm
outer boundary: 10×10 mm
number of ridges: ~2500

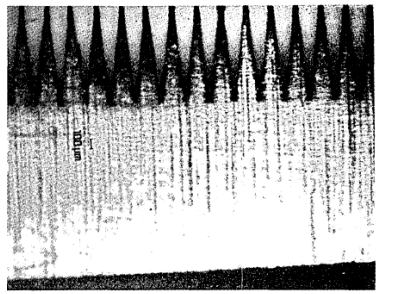
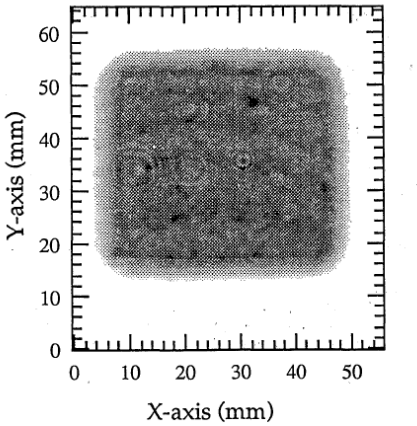
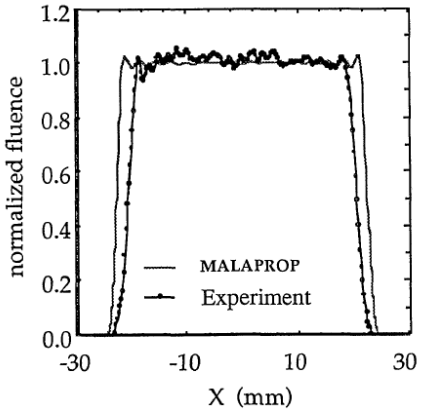


Fig. 4. Photograph of a section of the serrated aperture utilized in the Beamlet laser system. The precision limit on laser cutting has resulted in some roughness on the serrations.





We conduct a qualitative comparison between our simulation results and those presented in a research paper. It is evident that both demonstrate similar behavior, indicating that a serrated aperture can effectively suppress the diffraction ripples of the propagated laser beam.

Reference

Jerome M. Auerbach and Victor P. Karpenko, "Serrated-aperture apodizers for high-energy laser systems," Appl. Opt. **33**, 3179-3183 (1994)

Document Information

title	Circularly Serrated Aperture for Beam Apodization
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required packages	-
software version	2023.2 (Build 2.30)
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