Design of a serrated aperture for the coherent beam combination using stimulated Brillouin scattering phase conjugation mirrors (SBS-PCMs)

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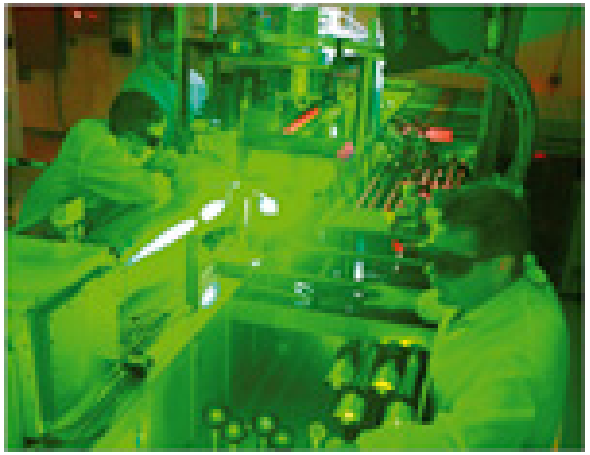
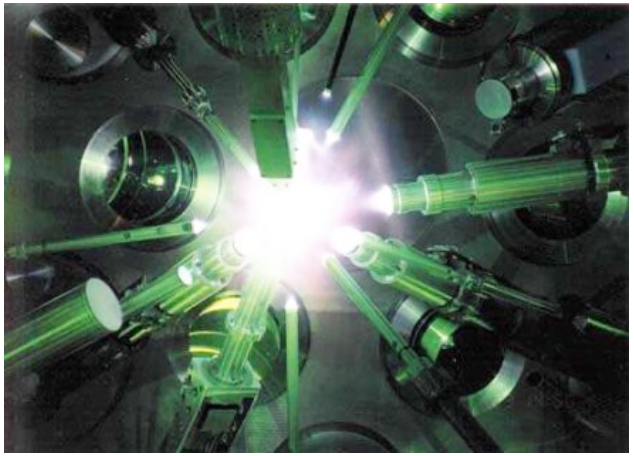
Tiled-aperture coherent beam combination laser

- High Energy and high repetition rate laser has various application

2D laser Processing

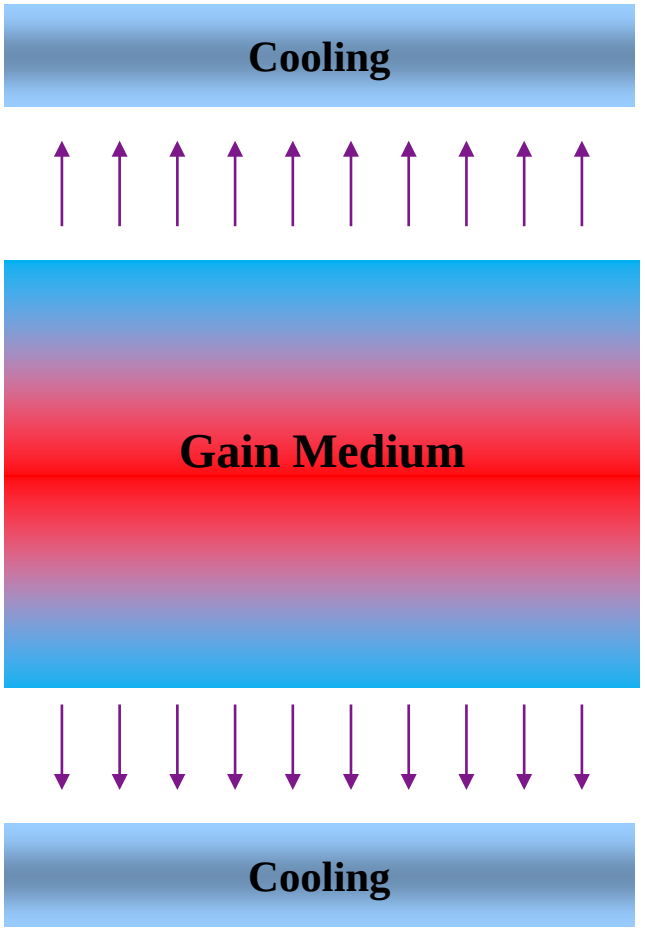


Laser Plasma Accelerator



Laser Inertial Fusion Energy (LIFE)

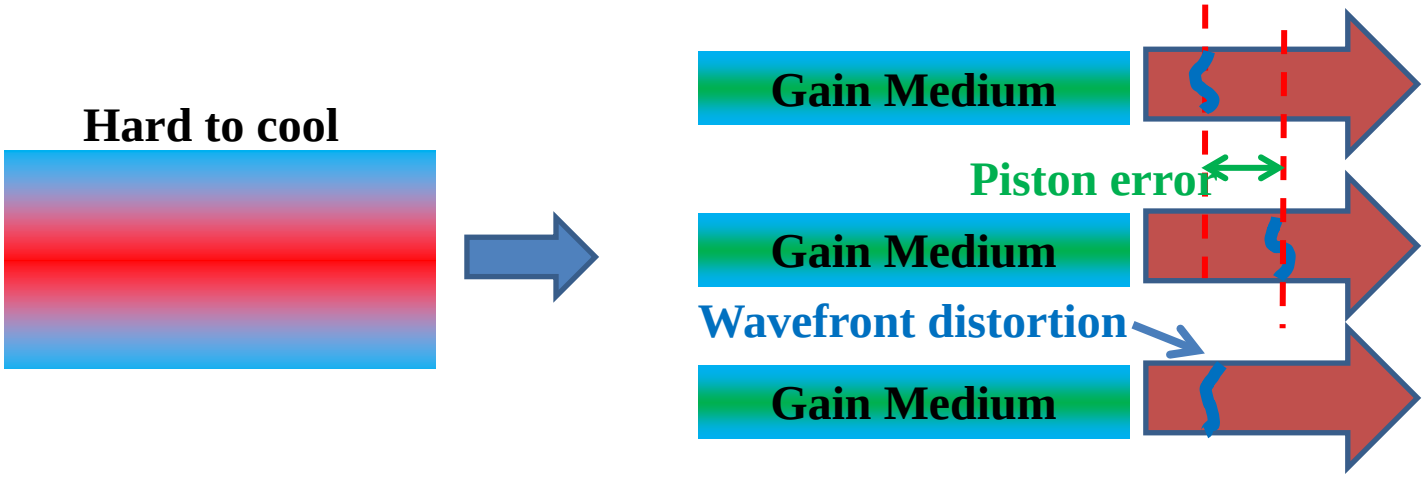
Tiled-aperture coherent beam combination laser



- Thermal lensing, Thermal birefringence
- Danger to gain medium and the other optics
- The cooling limits repetition rate of solid-state laser

Tiled-aperture coherent beam combination laser

- Beam combination Laser
  - easy to cooling the medium->High repetition rate!



- Wavefront distortion

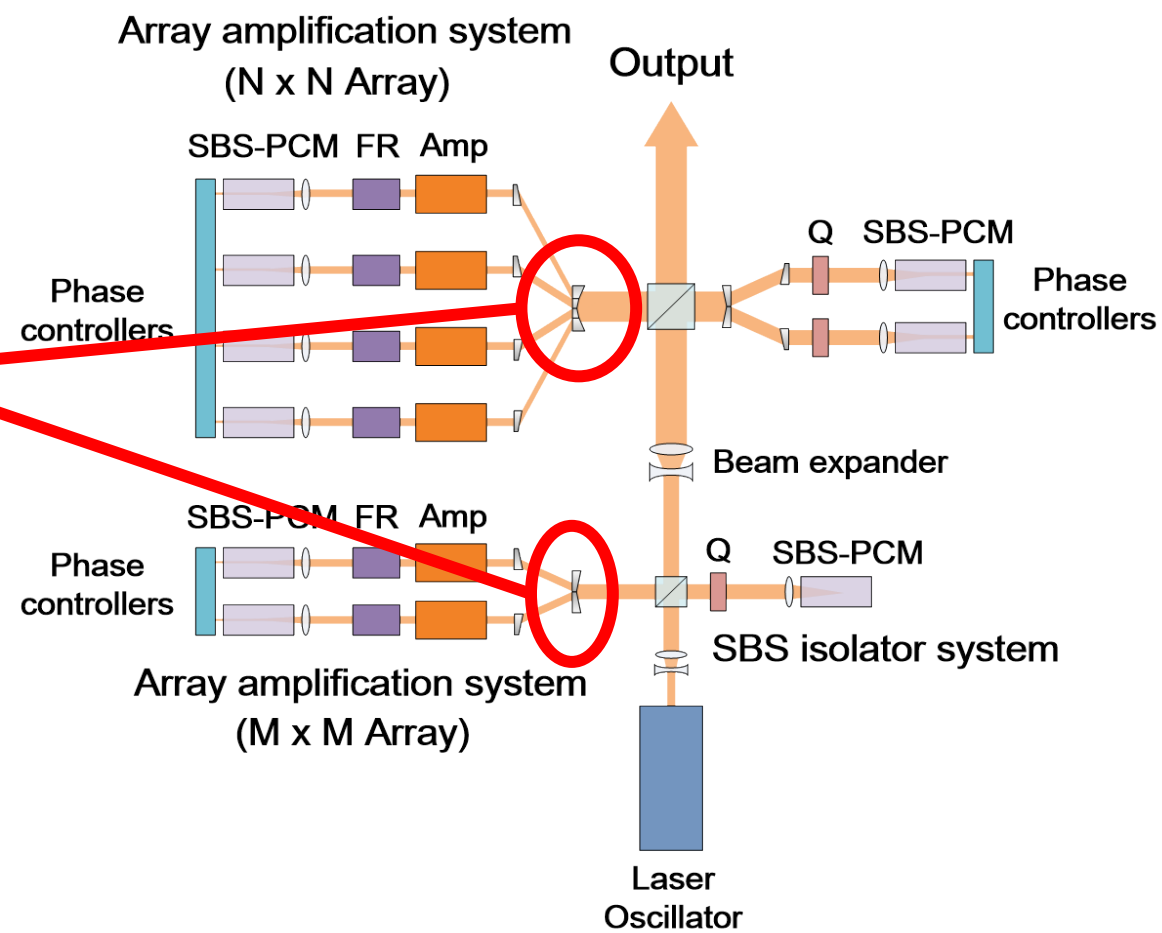
->Double-pass amplification using Stimulated Brillouin scattering Phase conjugate Mirrors(SBS-PCM)!

- Piston error, due to inherent problem of SBS

->self-phase-controlled SBS-PCM!

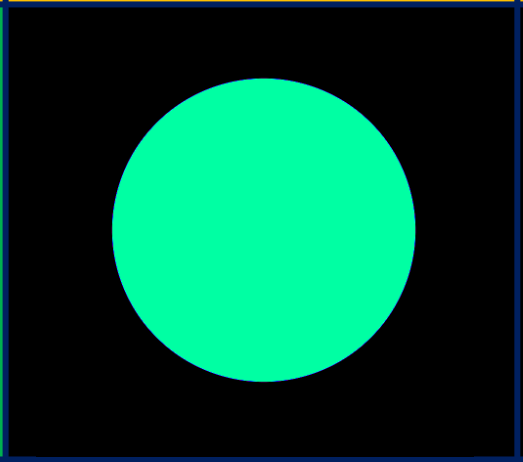
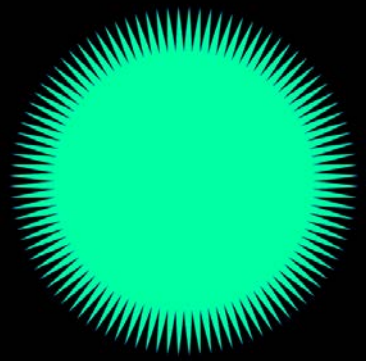
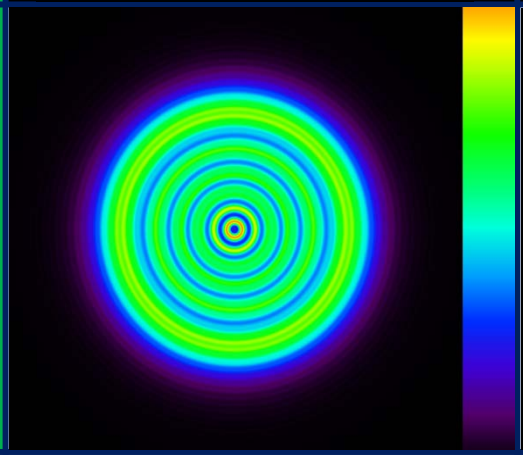
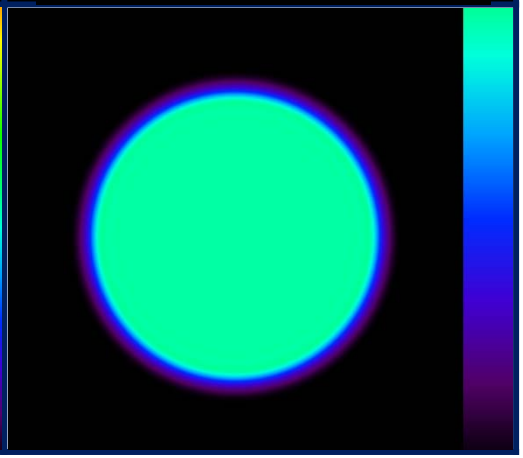
Tiled-aperture coherent beam combination laser using SBS-PCM

Beam divider
e.g) Prism divider,
Array mask
of the apertures,
…etc.



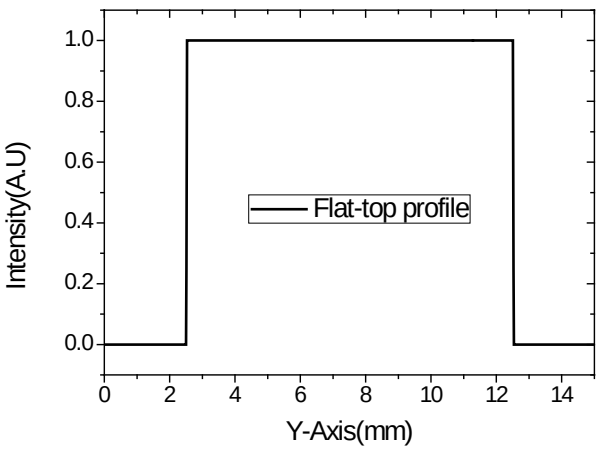
H. J. Kong, J. Y. Lee, Y. S. Shin, J. O. Byun, H. S. Park, and H. Kim, Opt. Rev. 4, 277 - 283, 1997.

Introduction to the serrated aperture

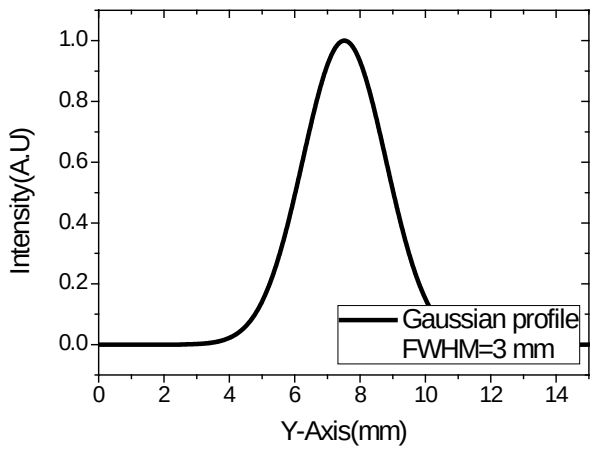
	Circular hard aperture	Circular serrated aperture
Aperture		
Beam profile after 2 m from the aperture		

Introduction to the serrated aperture

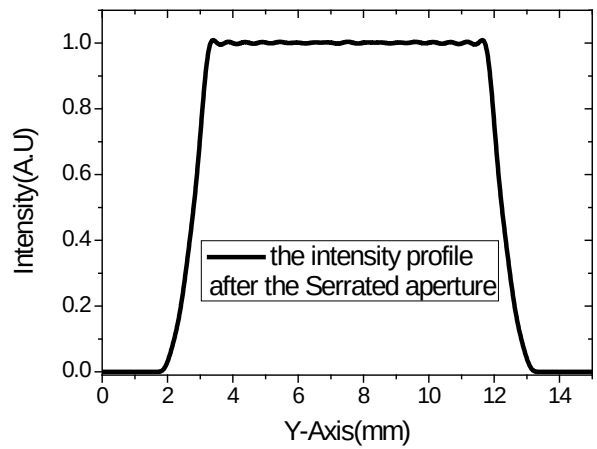
Flat-top profile



Gaussian profile

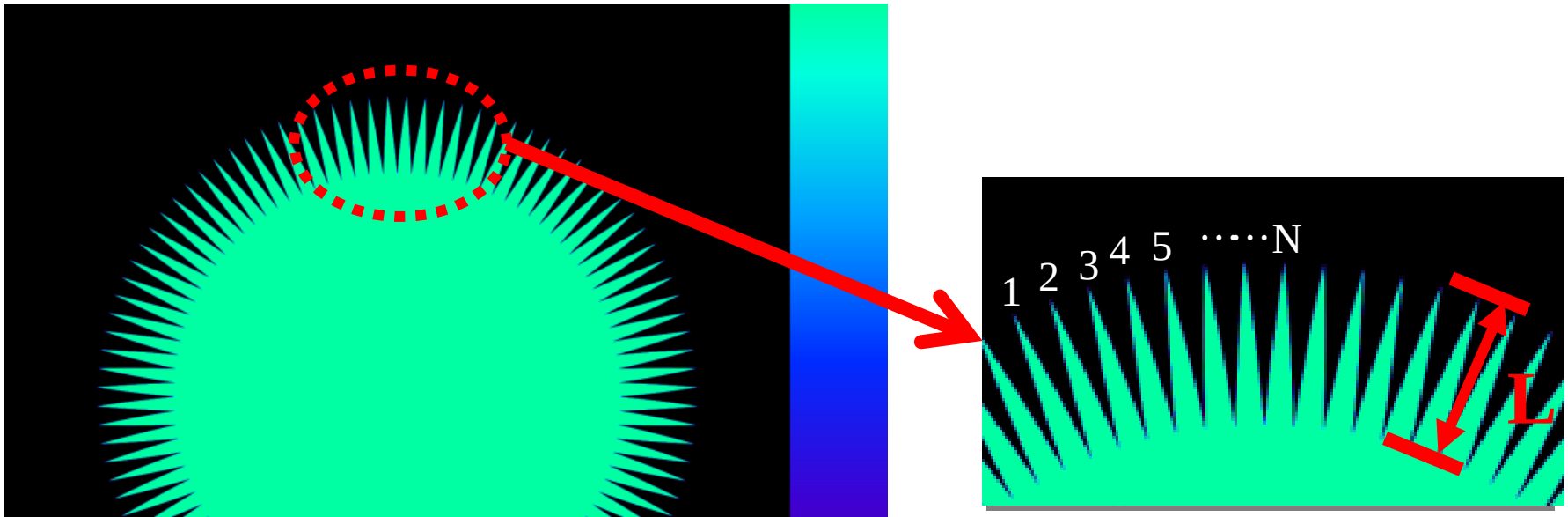


Beam profile
after the serrated aperture



- **Flat-top profile satisfies ideal fill factor; it extracts maximum energy from the amplifier**
- **Flat-top profile induces a strong intensity modulation; Cause of optical damage in optics**
- **Gaussian profile induces negligible diffraction if the beam size is small to aperture**
- **The fill factor of the Gaussian profile is poor; it cannot extracts maximum energy from the amplifier**
- **The serrated aperture can be a solution**

Simulation condition

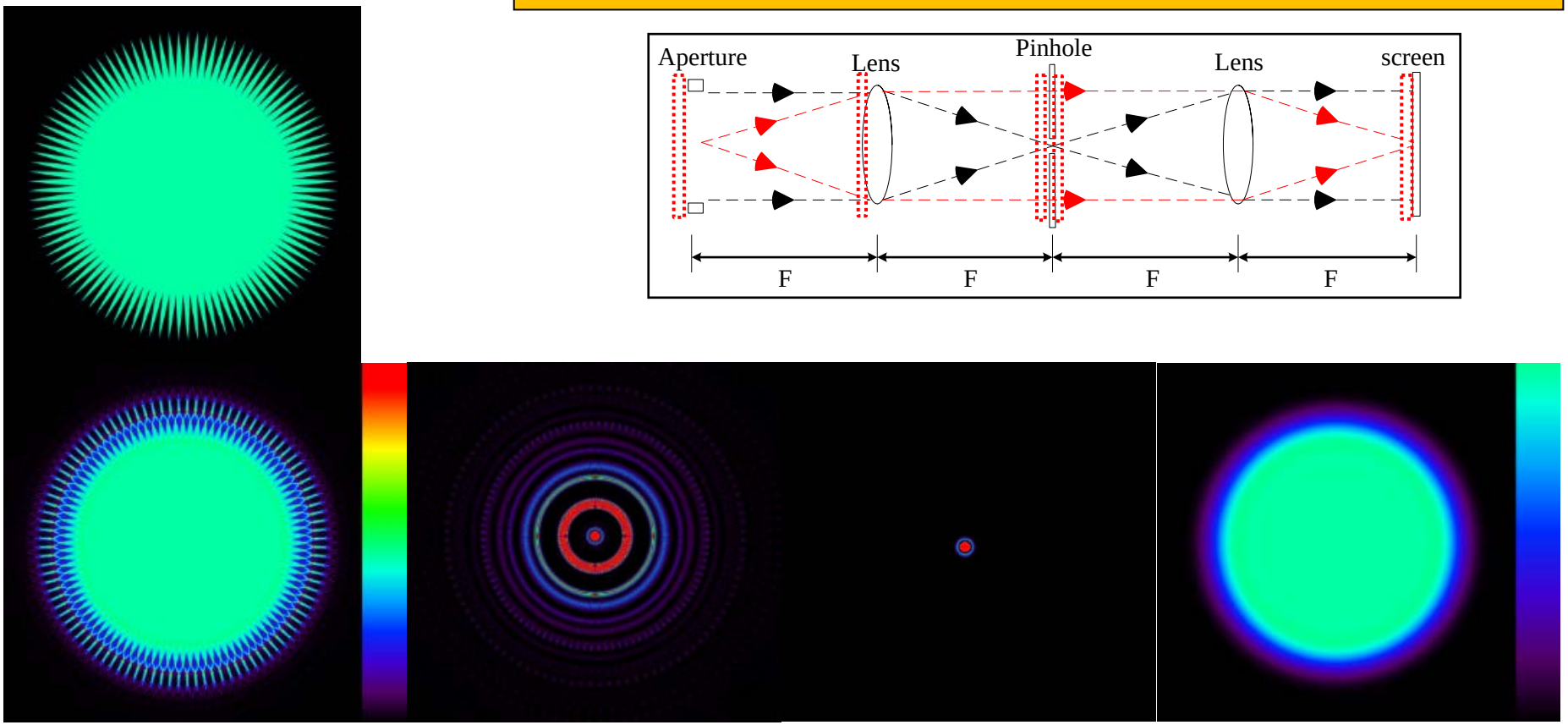


The side of the serrated aperture

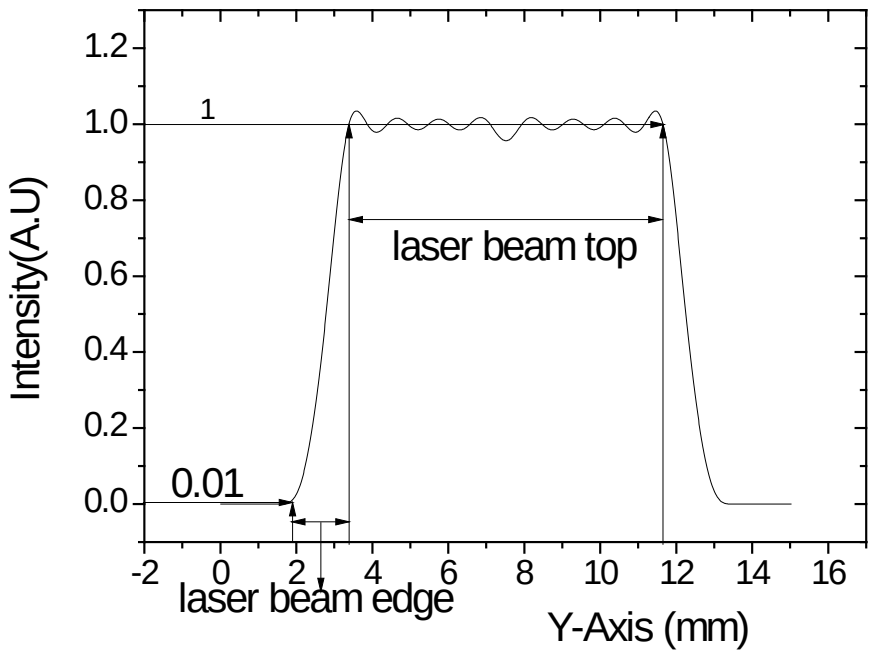
L : Length of the tooth
N: Number of the teeth

Simulation conditions

D: The diameter of pinhole
F: The focal length of lenses
Input beam: 1064nm flat-top beam
The diameter of aperture : fixed to 10mm of diameter

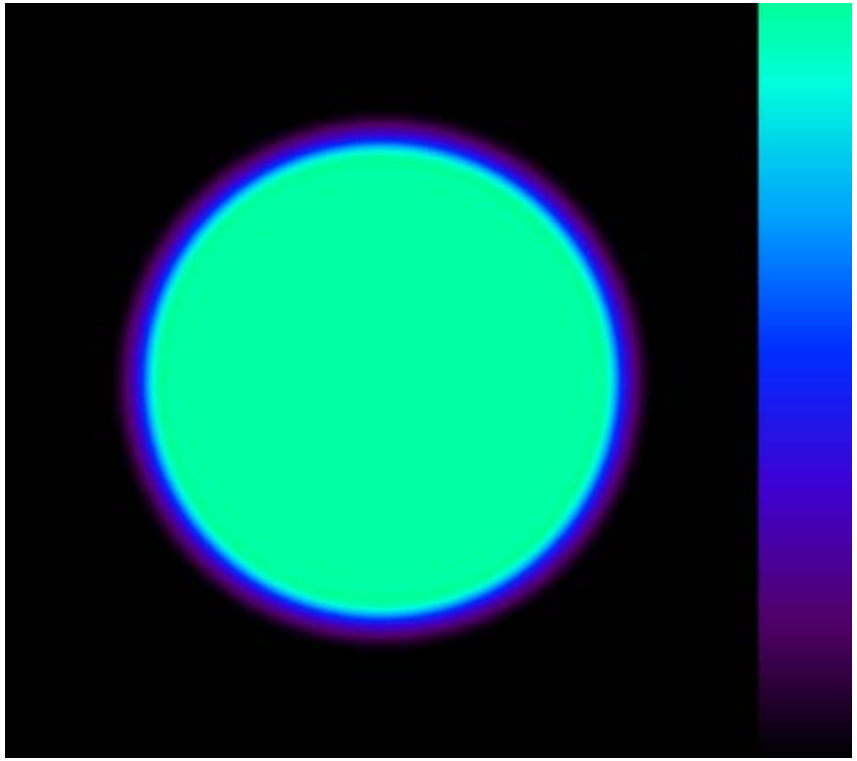


Simulation conditions

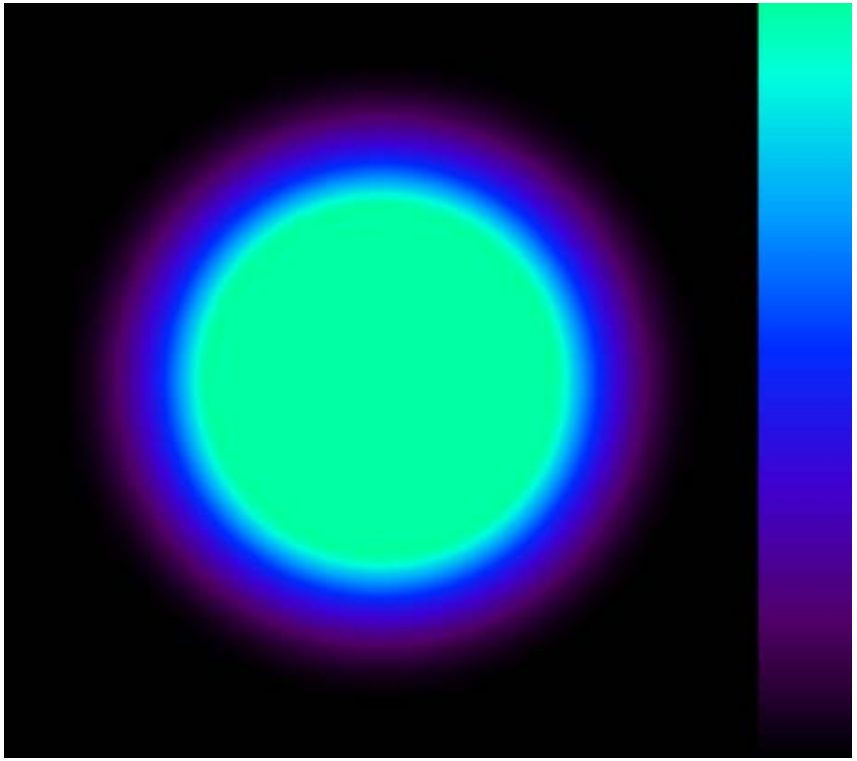


- Input intensity is defined as 1
- Laser beam top roughness : ratio of the standard deviation of the top to the average of the top
- Laser beam edge length : length of the range of the edge

Top roughness and edge length due to L



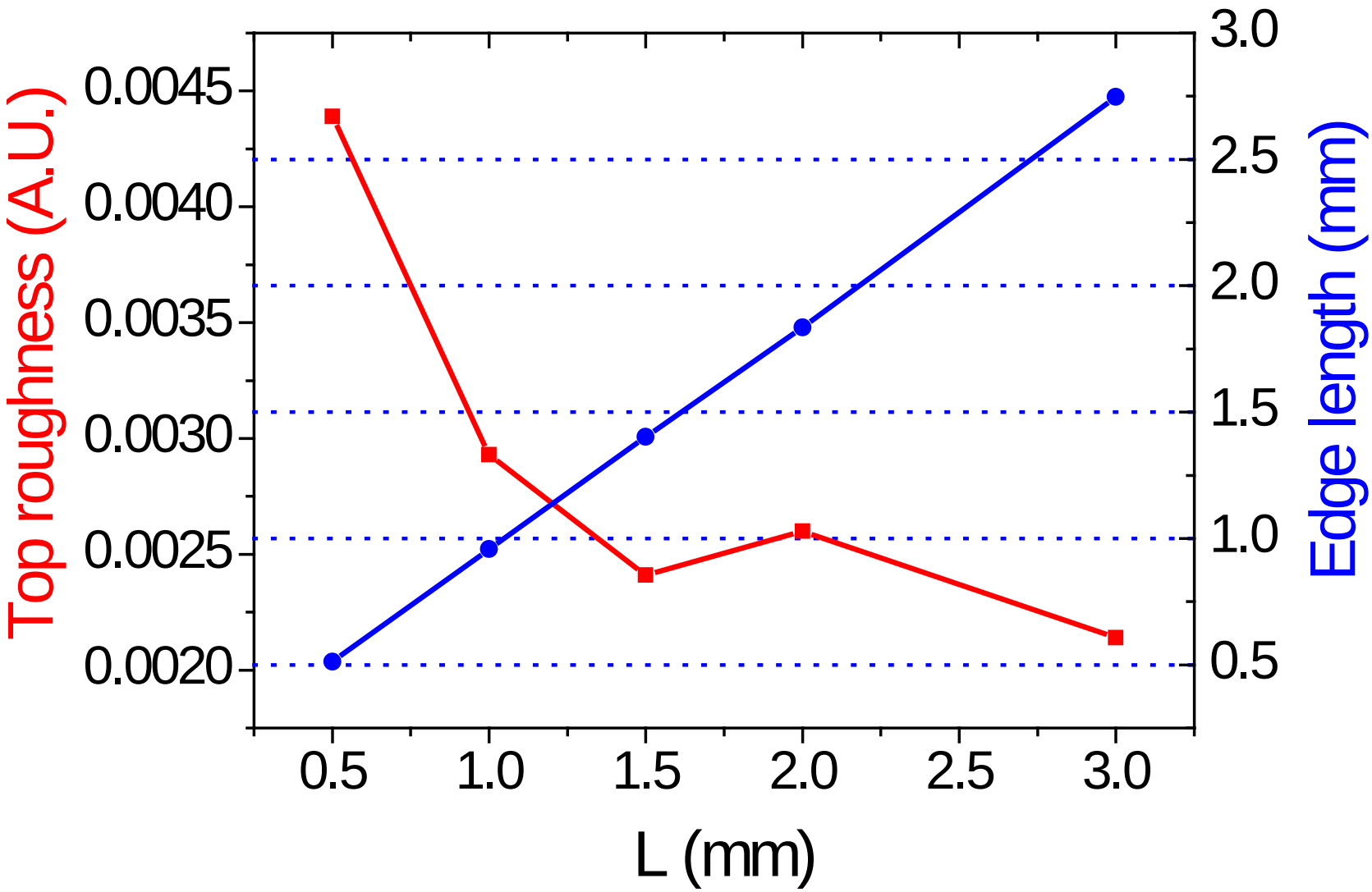
(a) L = 1 mm



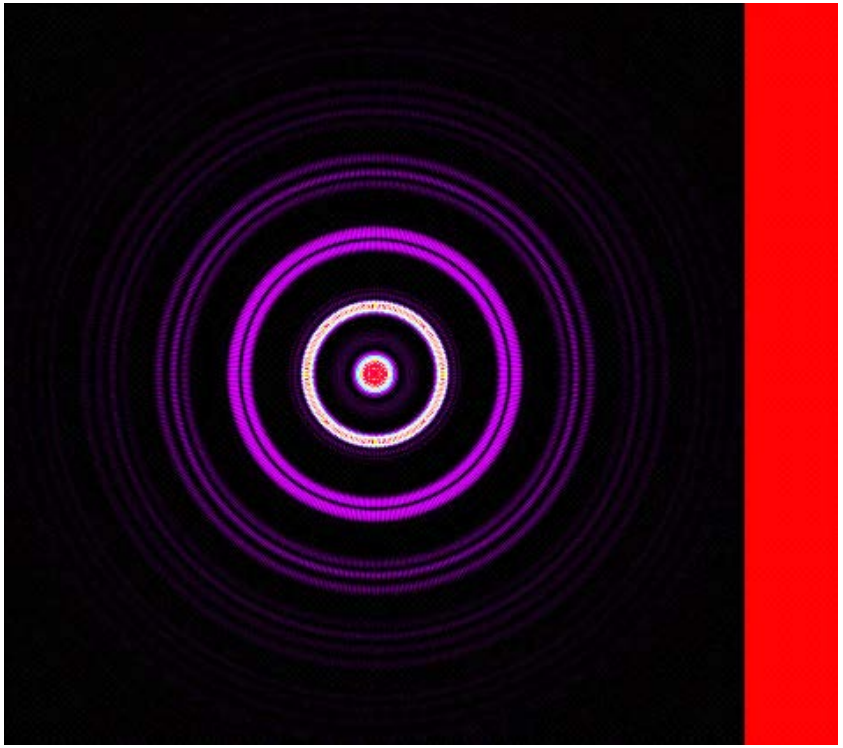
(b) L = 3 mm

- D, F, and N are fixed
-If L increases, the edge length increases.

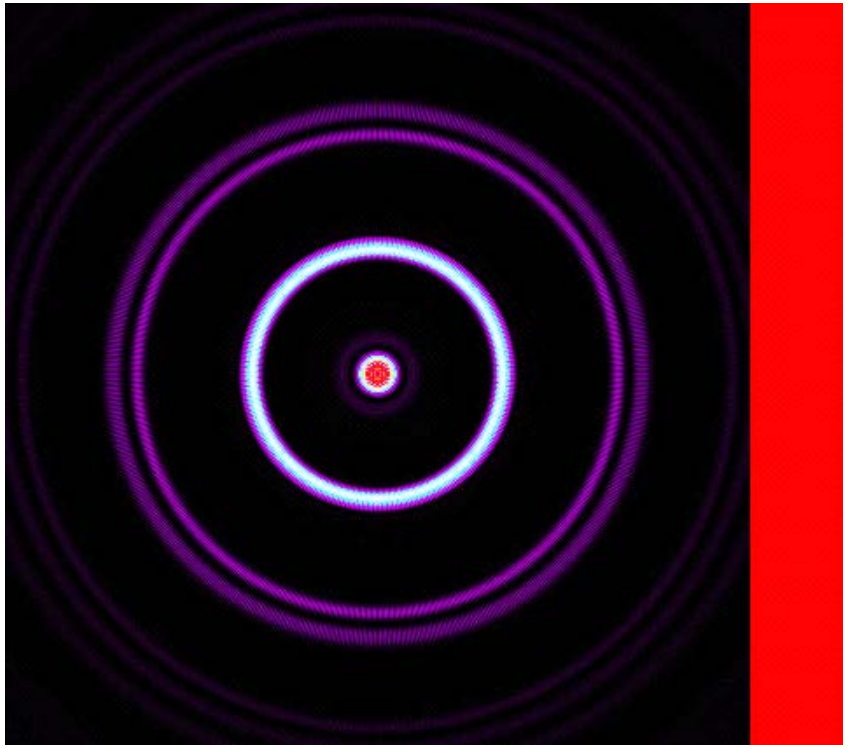
Top roughness and edge length due to L



Top roughness and edge length due to N



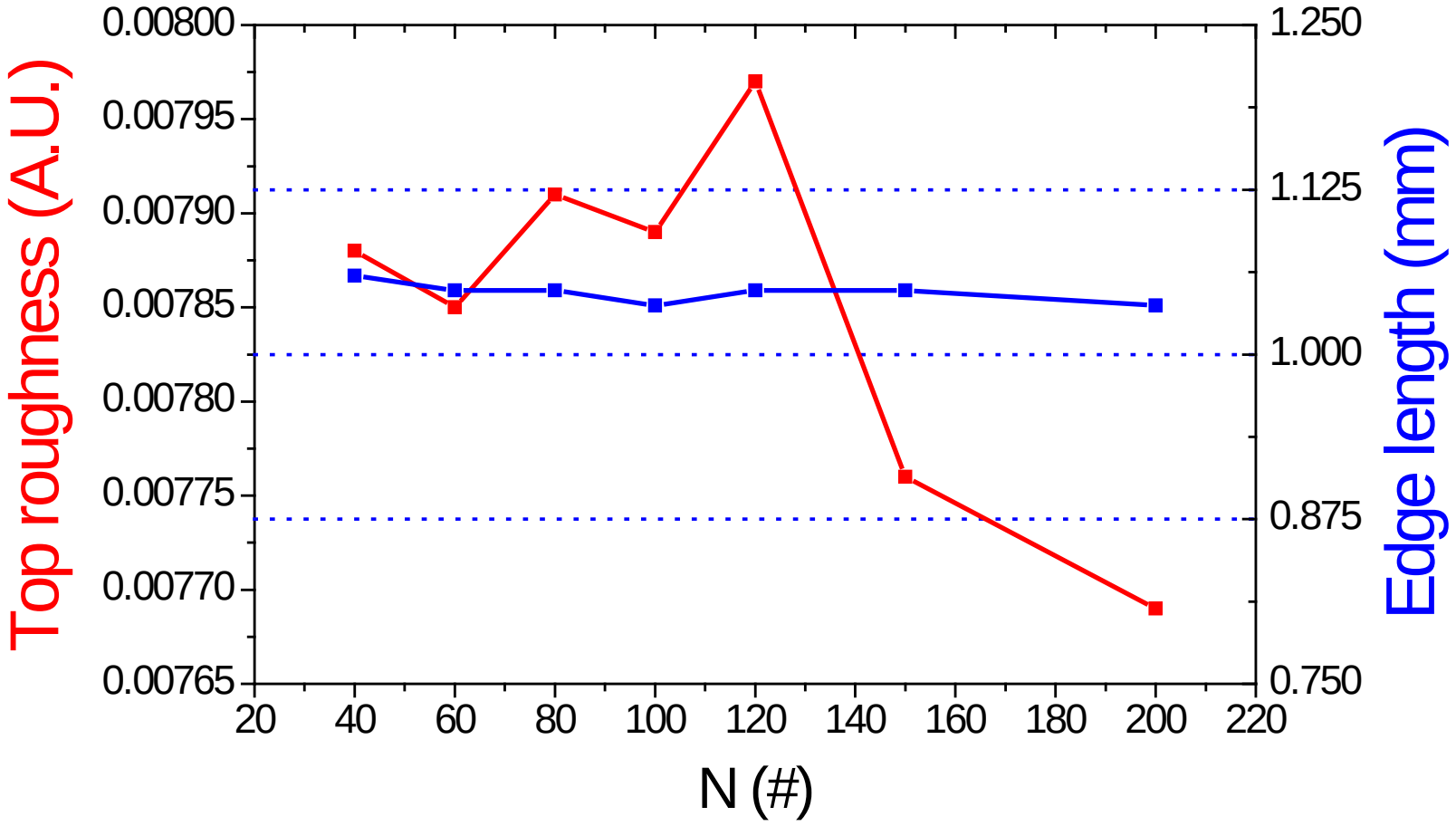
(a) N = 80



(b) N =150

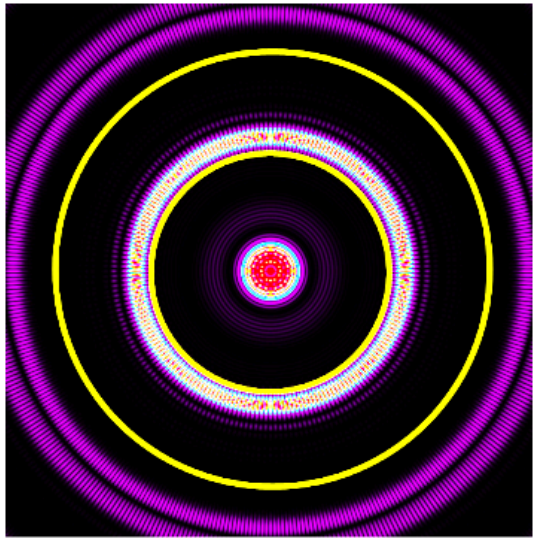
- D, F, and L are fixed
-For large N, Maximum value of D increases

Top roughness and edge length due to N

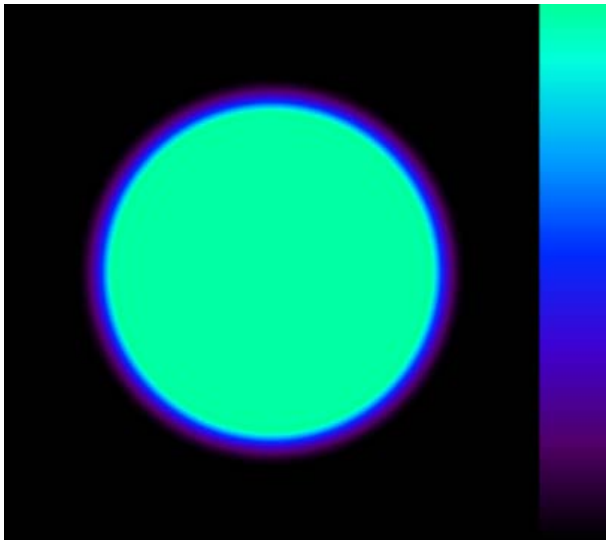


Top roughness and edge length due to D and F

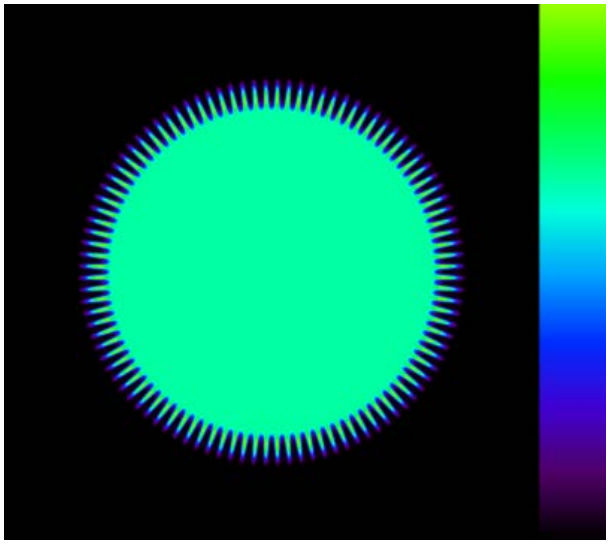
(a) far-field pattern of CSA



(b) D = 2.7 mm
F=0.5m

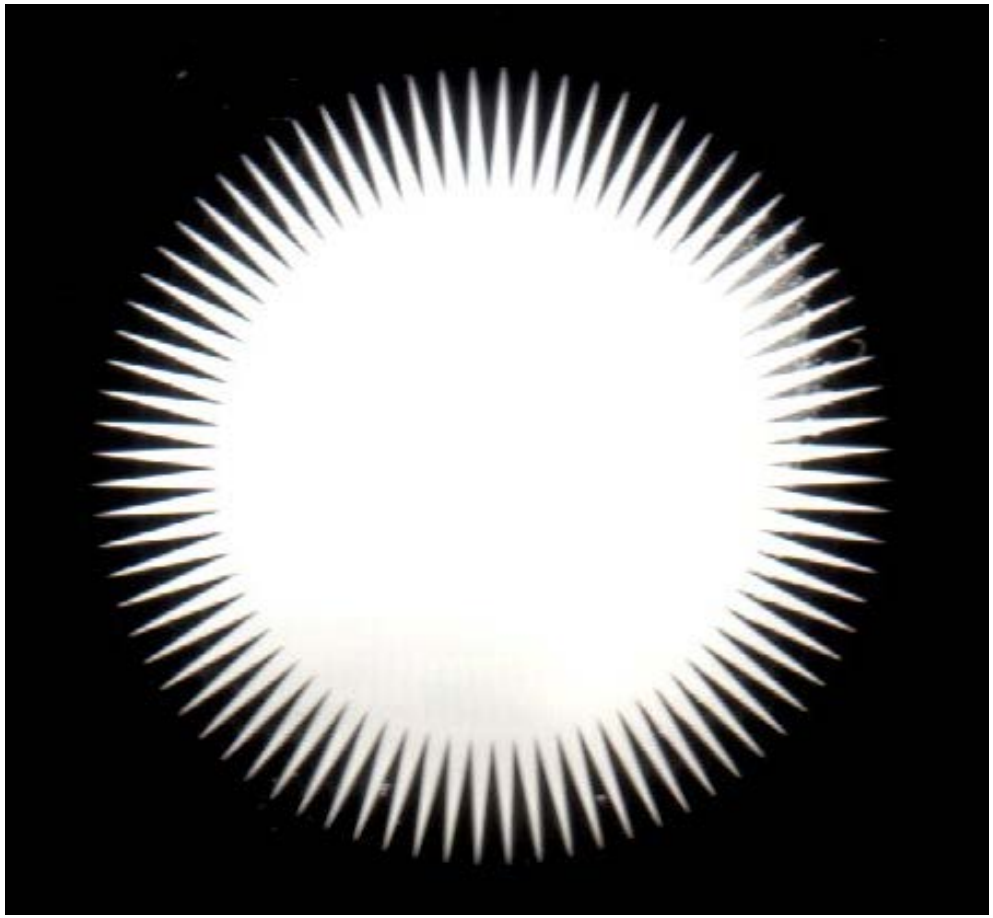


(c) D = 5.0 mm
F=0.5m



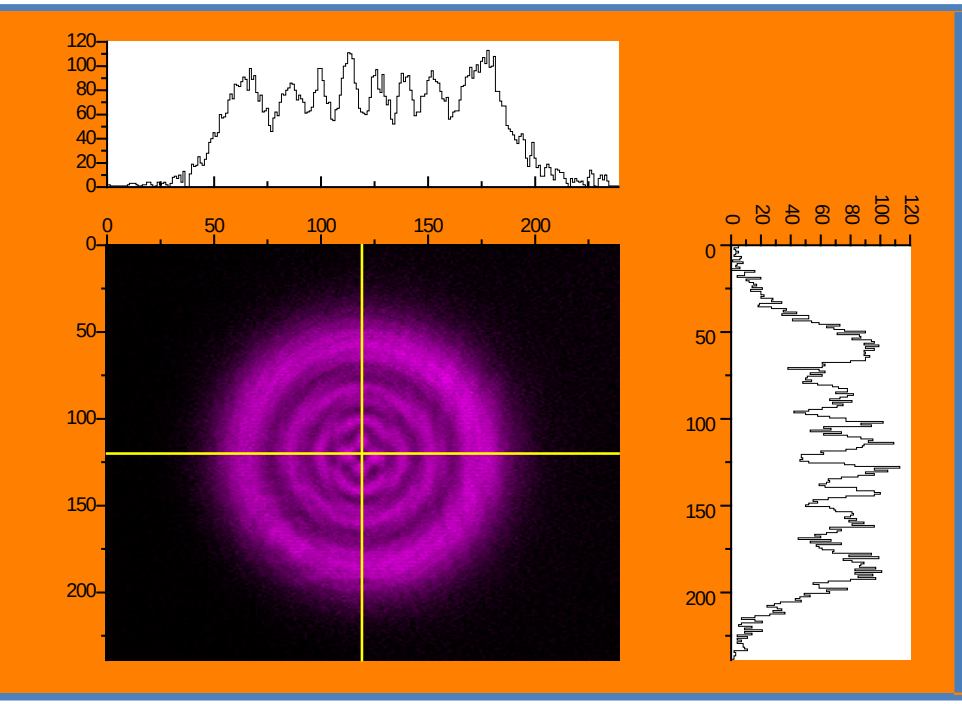
- N and L are fixed
- (a) Yellow circle are pinhole; in order, D=2.7 mm and 5.0 mm
- D for certain F determines the remained high spatial frequency components

Fabricated Serrated aperture

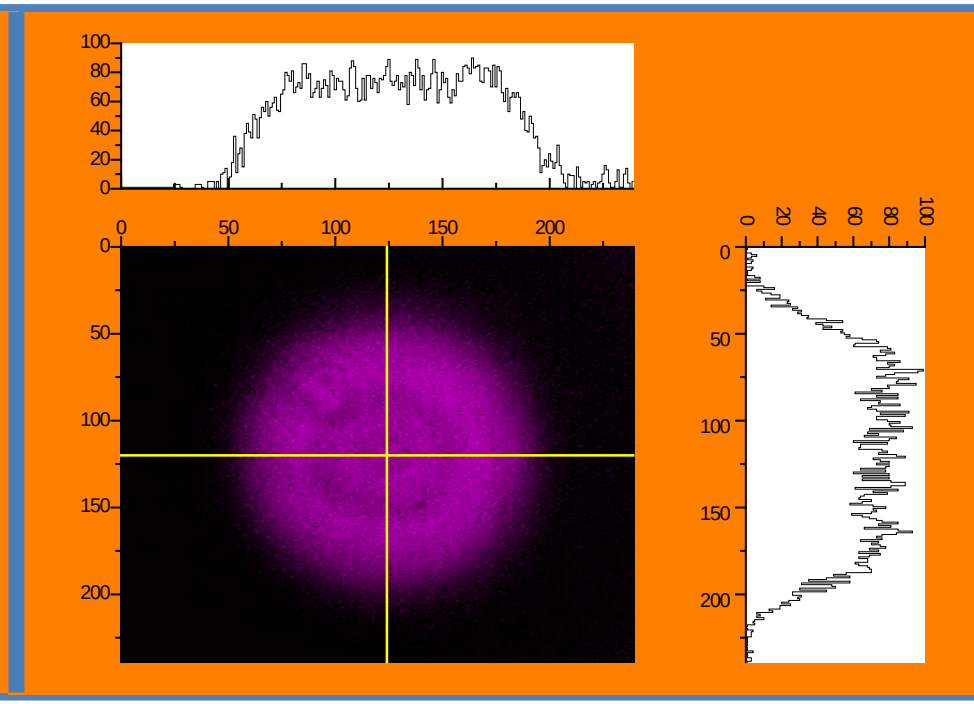


Serrated aperture on crom-coated Sodalime glass

Experimental results: Comparing between circular serrated aperture and circular hard aperture



Circular hard aperture



Circular serrated aperture

Conclusions

- **The parameters of the serrated aperture is investigated by simulations;**
  - **L is increased-> edge length is increased**
  - **N is increased-> bigger D is allowed**
  - **D for certain F determines the remaining high spatial frequency components**

- **The circular serrated aperture is produced and tested**
  - **Successfully improved beam profile than the circular hard aperture**

Thank you
for
your attention!