

Experimental observations to be explained

Extension : Propagation through a single silicon cone

In this extension, we study the propagation of the focused beam (from the previous section) through a *single conical structure* made of silicon and placed on a flat silicon surface. The goal is to observe how the beam is transmitted and reshaped after leaving the cone into air.

Geometry

- A flat silicon interface is located at $z = 0$.
- A single cone is centered at $(x = 0, y = 0)$ and extends into air over a height of $h_{\text{cone}} = 10 \mu\text{m}$.
- The cone base diameter is $D_{\text{base}} = 5 \mu\text{m}$ at $z = 0$ and linearly tapers to $D_{\text{top}} = 1 \mu\text{m}$ at $z = h_{\text{cone}}$.
- The cone is at a center of a "pool" of $10 \mu\text{m}$ diameter.
- The refractive index of silicon is n_{Si} (use literature value at the chosen wavelength), and $n_{\text{air}} = 1$.

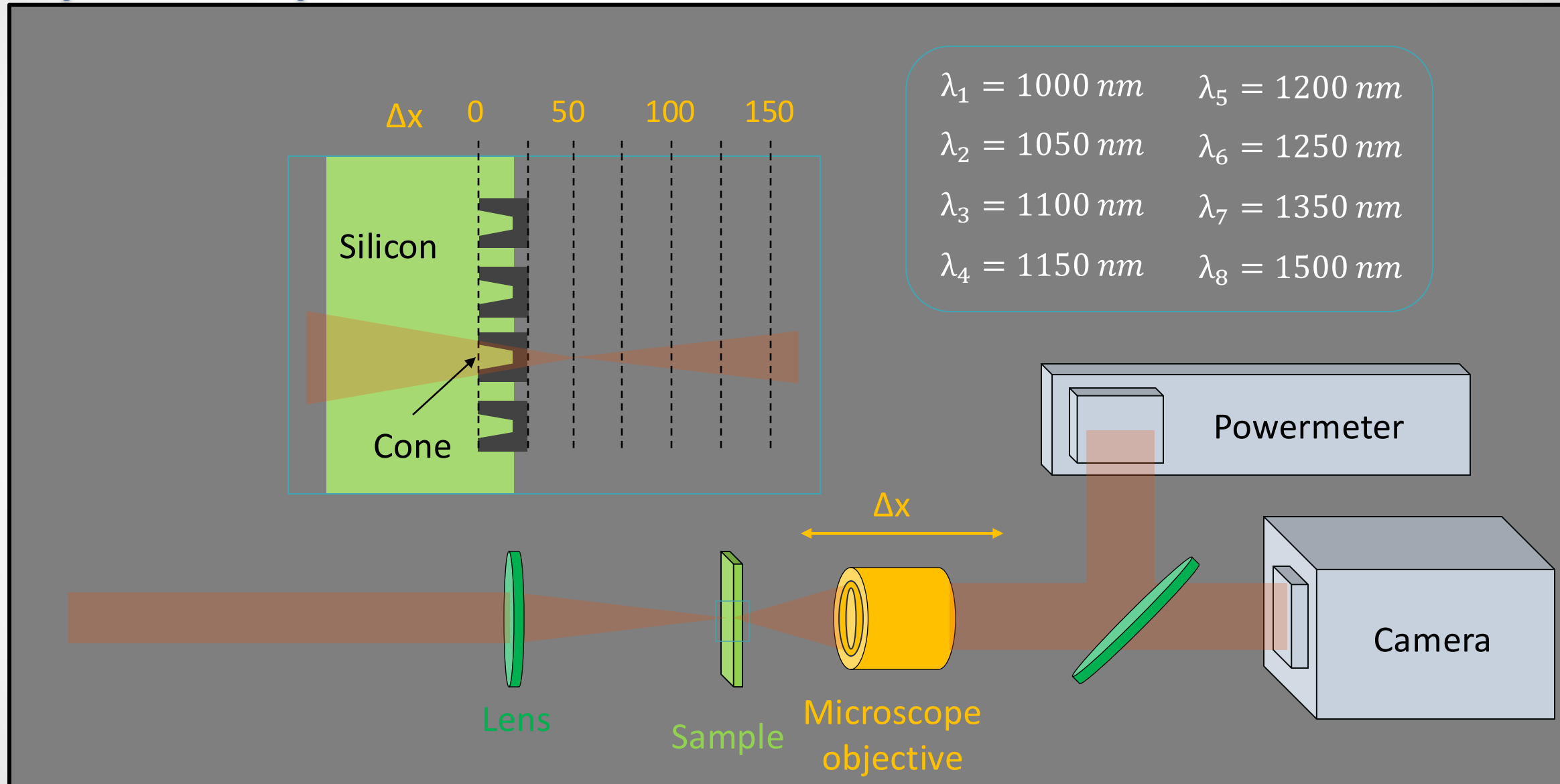
Propagation scenario

- The focused Gaussian beam reaches the rear silicon surface and propagates forward.
- After crossing the flat silicon interface and the cone volume, the field emerges in air.
- Simulate the transmitted beam in air up to $z = 200 \mu\text{m}$ above the cone tip.

Numerical task

1. Define a refractive index map $n(x, y, z)$ that describes one single silicon cone inside a pool.
2. Inject the focused Gaussian field that fill the pool and the cone and propagate using your BPM code including the $\Delta n(x, y, z)$ phase term.
3. Visualize the beam cross-section in air at different z positions (from 0 to $200 \mu\text{m}$ above the cone).
4. Plot a longitudinal (x, z) cut showing how the beam is modified by the cone.
5. Comment on the beam distortion or focusing/defocusing effect induced by the conical structure.
6. Explain the experimental results, in particular concerning the observed ring.
7. Upload your matlab/python files and a pptx file on ENT showing your results and comments.

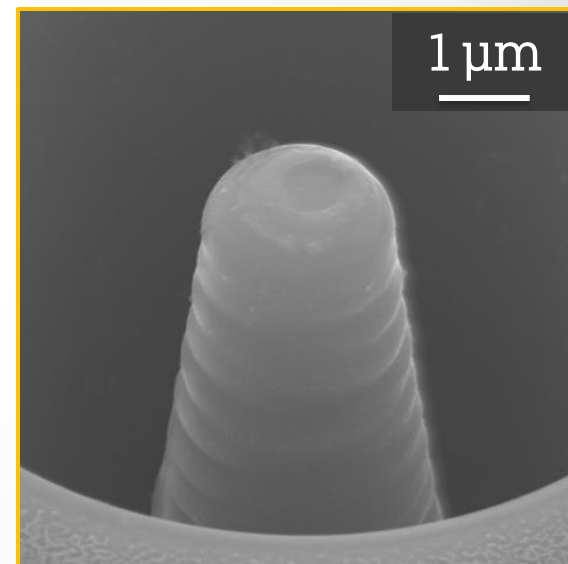
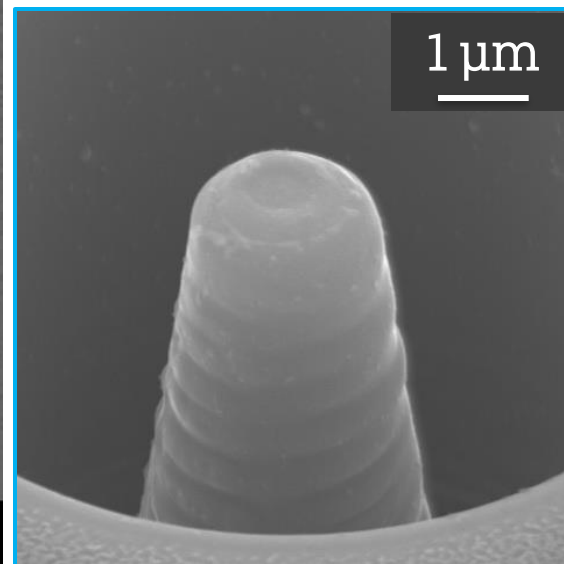
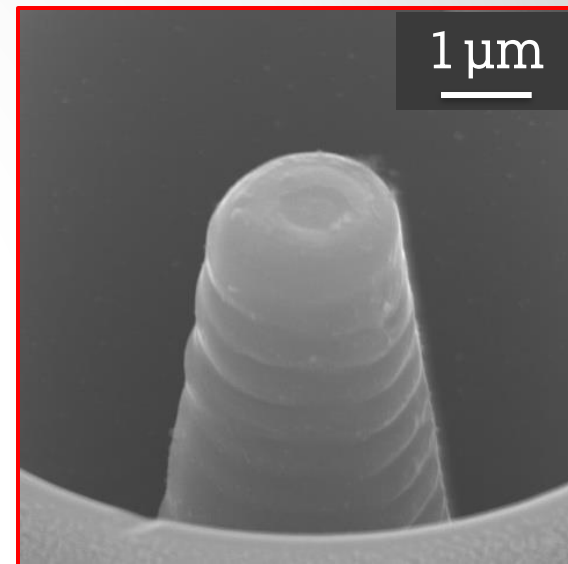
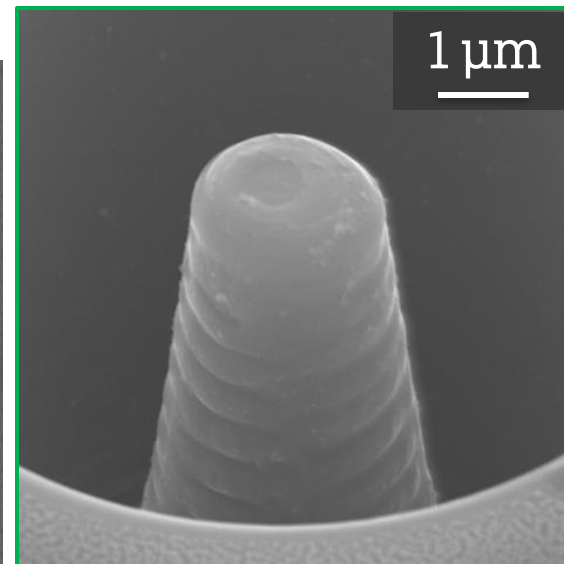
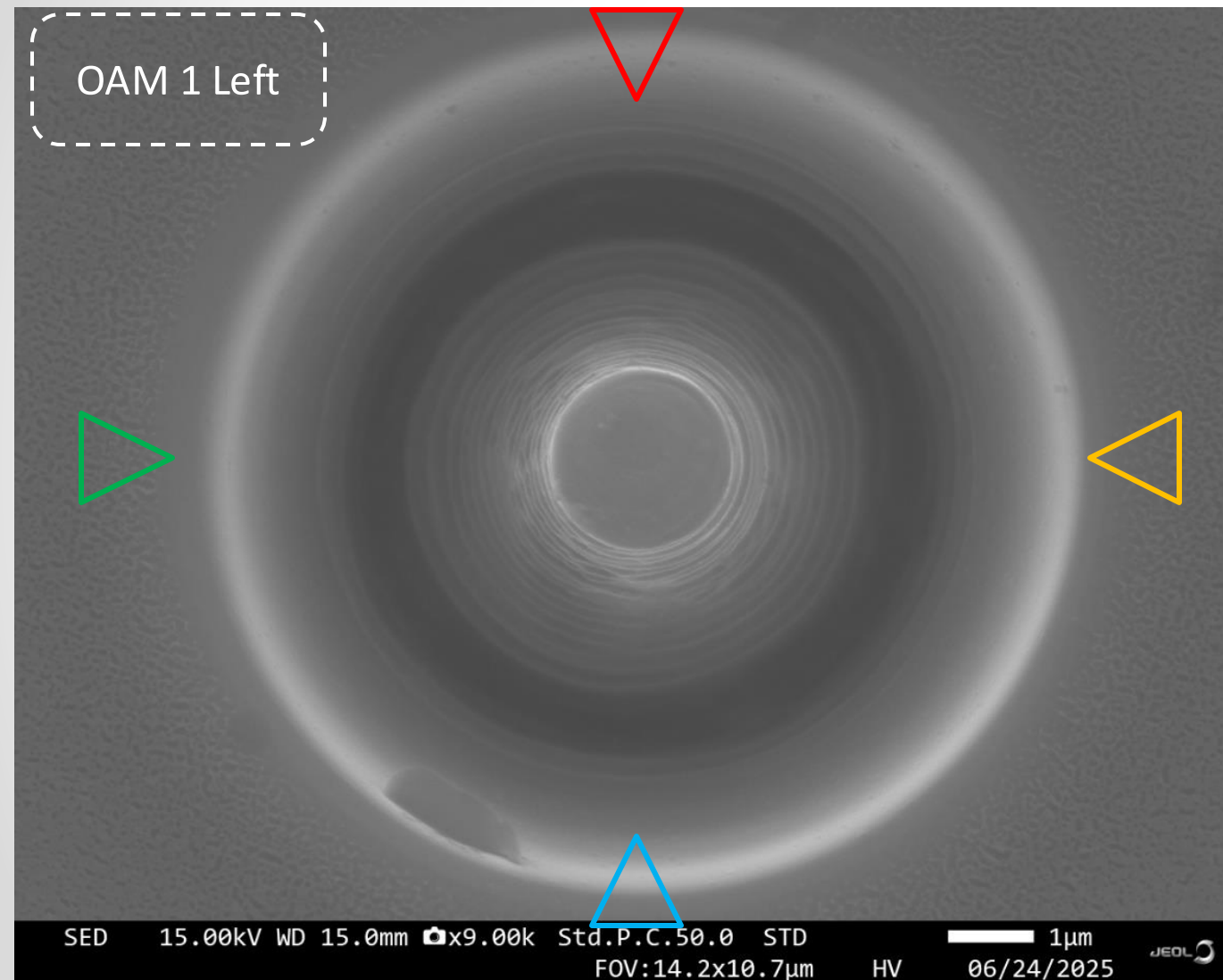
Setup for optical characterisation



$F4 = 0.8 \text{ J/cm}^2$

Third sample :
 $D_{\text{cone}} = 1.5 \mu\text{m}$

OAM 1 Left

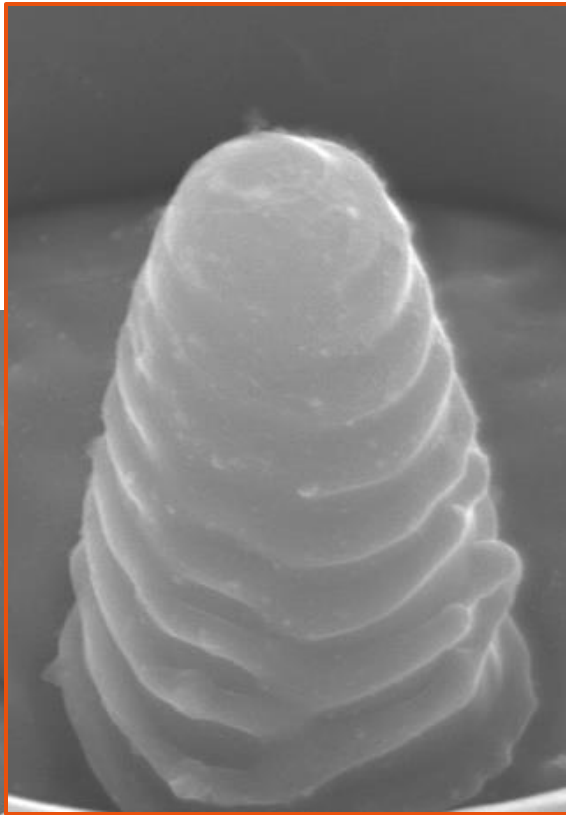
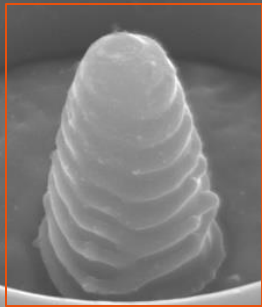


OAM Left & right

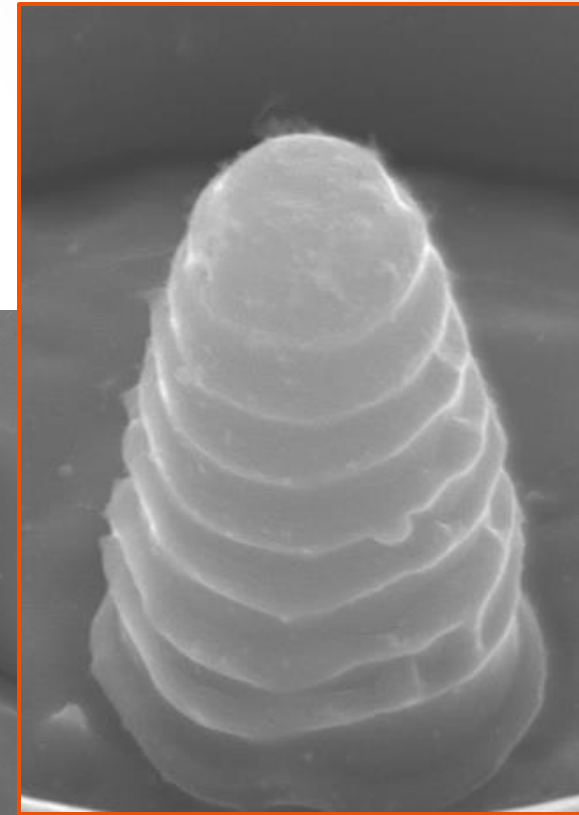
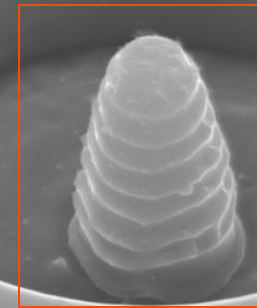
$$F3 = 0.7 \text{ J/cm}^2$$

$$\text{Third sample : } D_{\text{cone}} = 800 \text{ nm}$$

OAM 1 Left

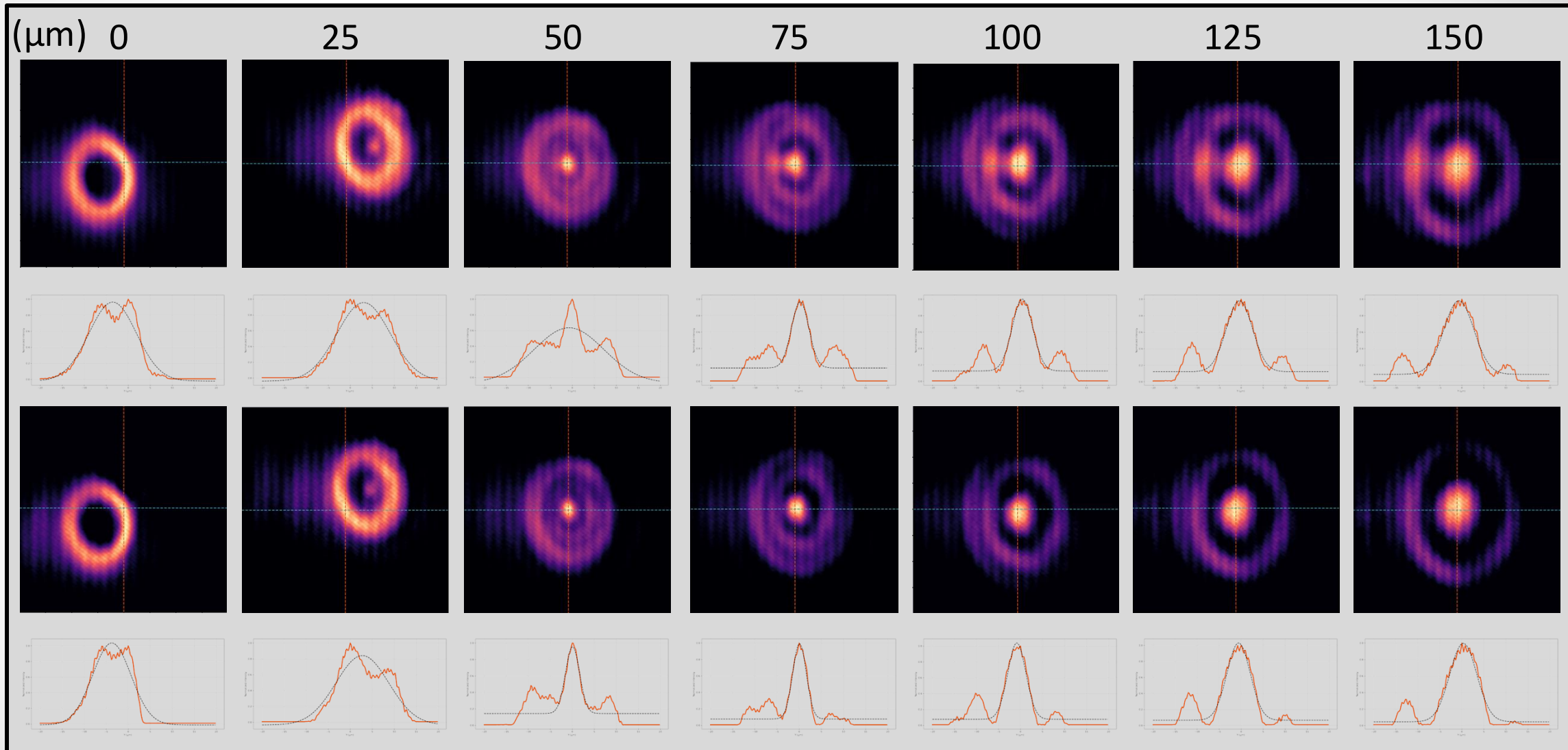


OAM 1 Right



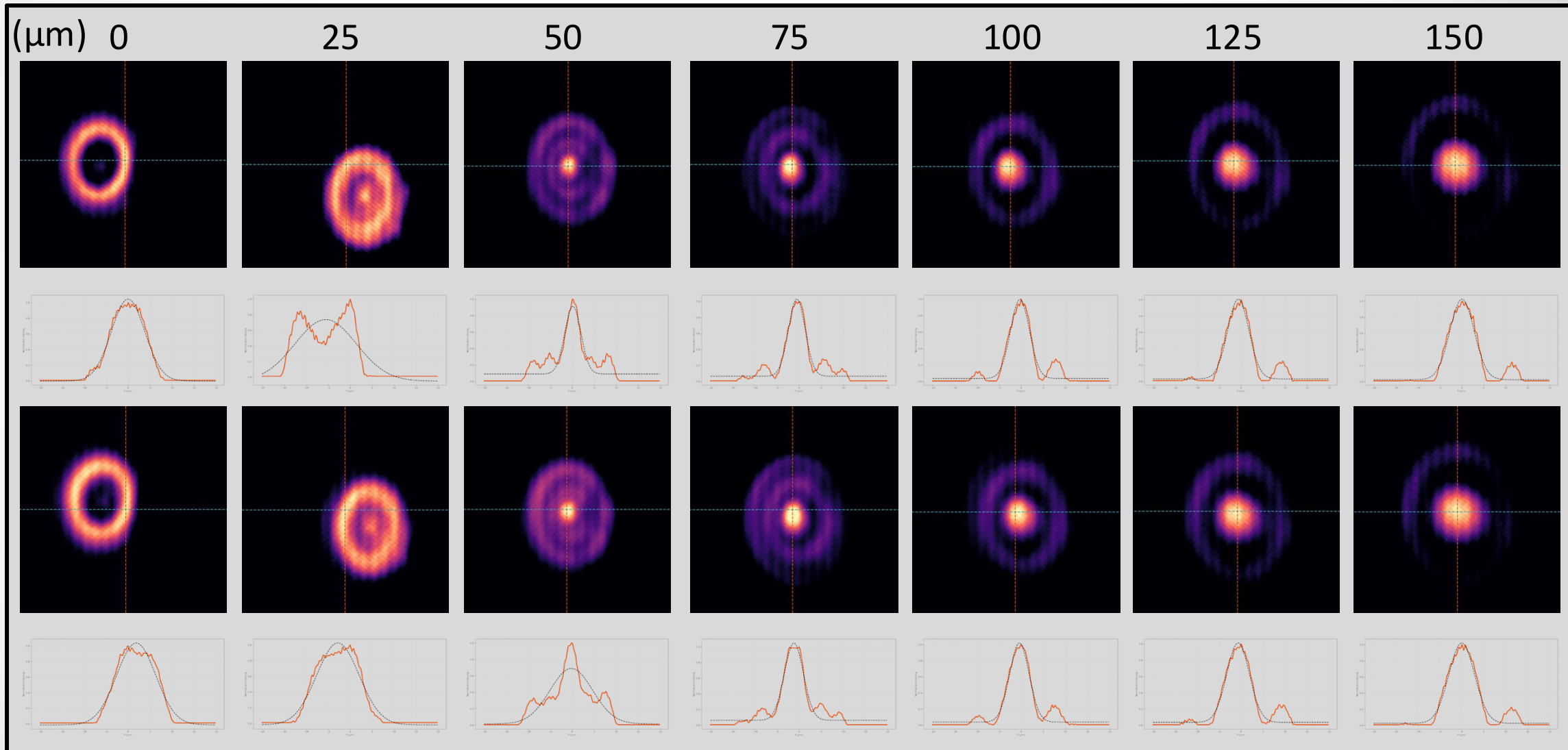
Result for 1000 & 1050 nm

$$D_{\text{cone}} = 1000 \text{ nm}$$



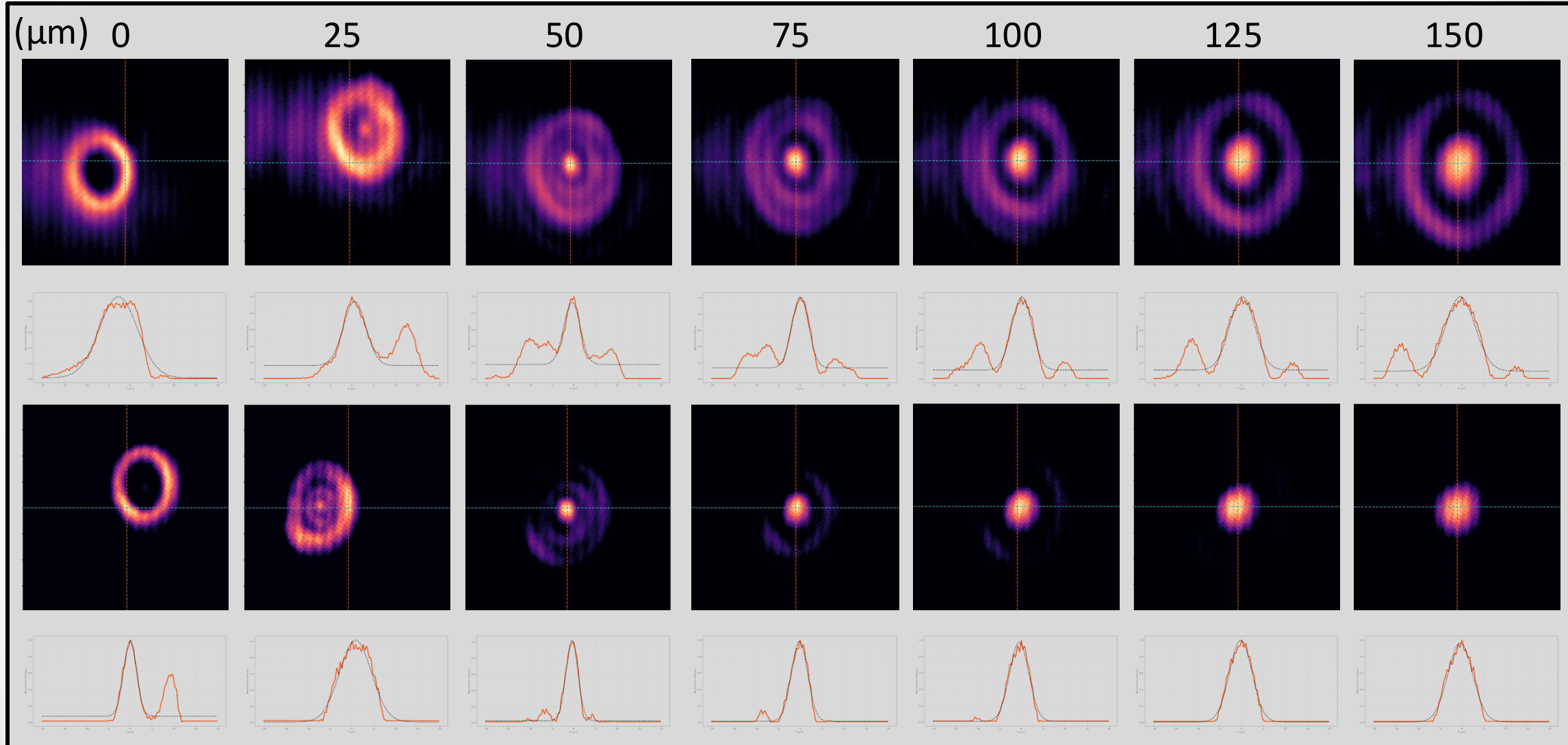
Result for 1000 & 1050 nm

$$D_{\text{cone}} = 800 \text{ nm}$$



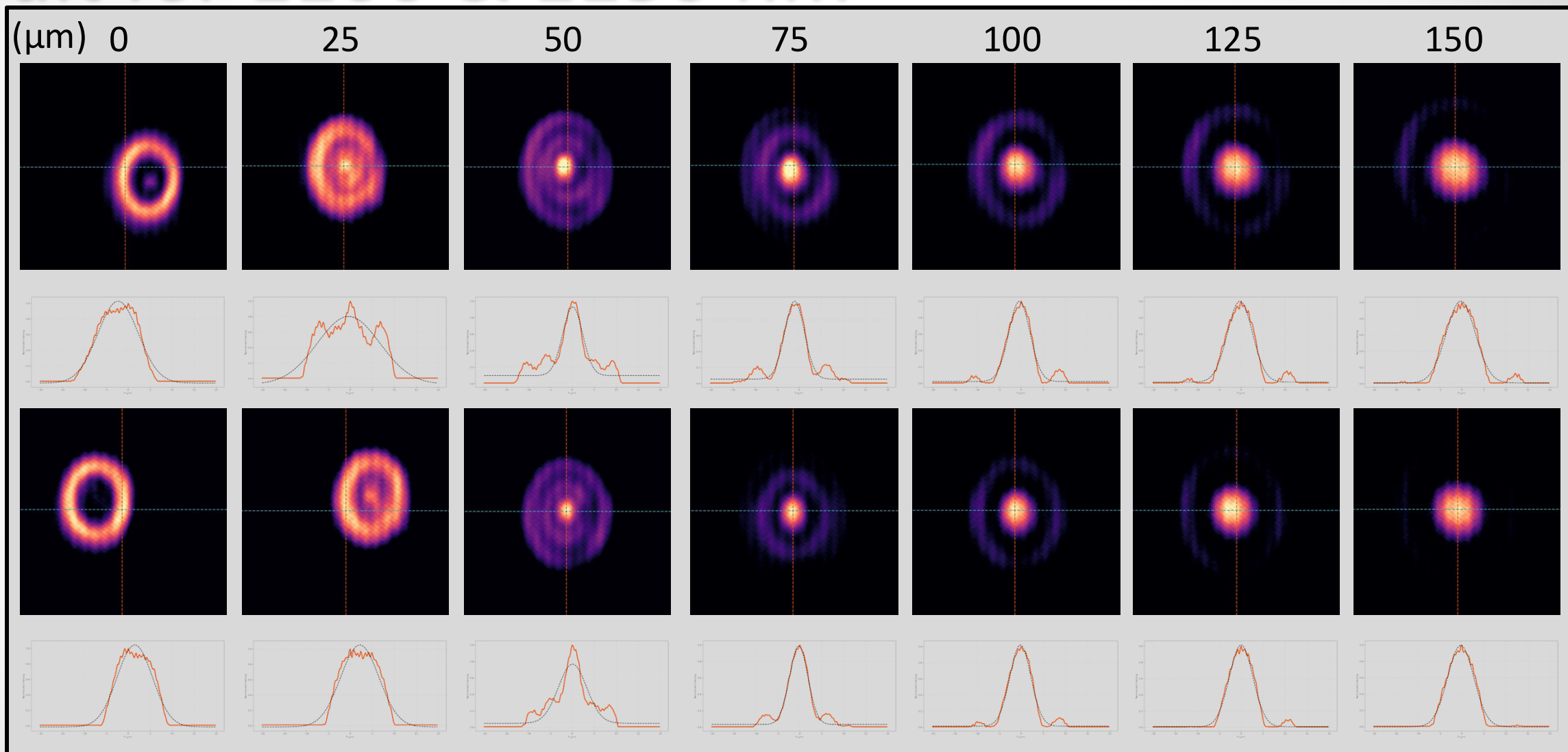
Result for 1100 & 1150 nm

$$D_{\text{cone}} = 1000 \text{ nm}$$



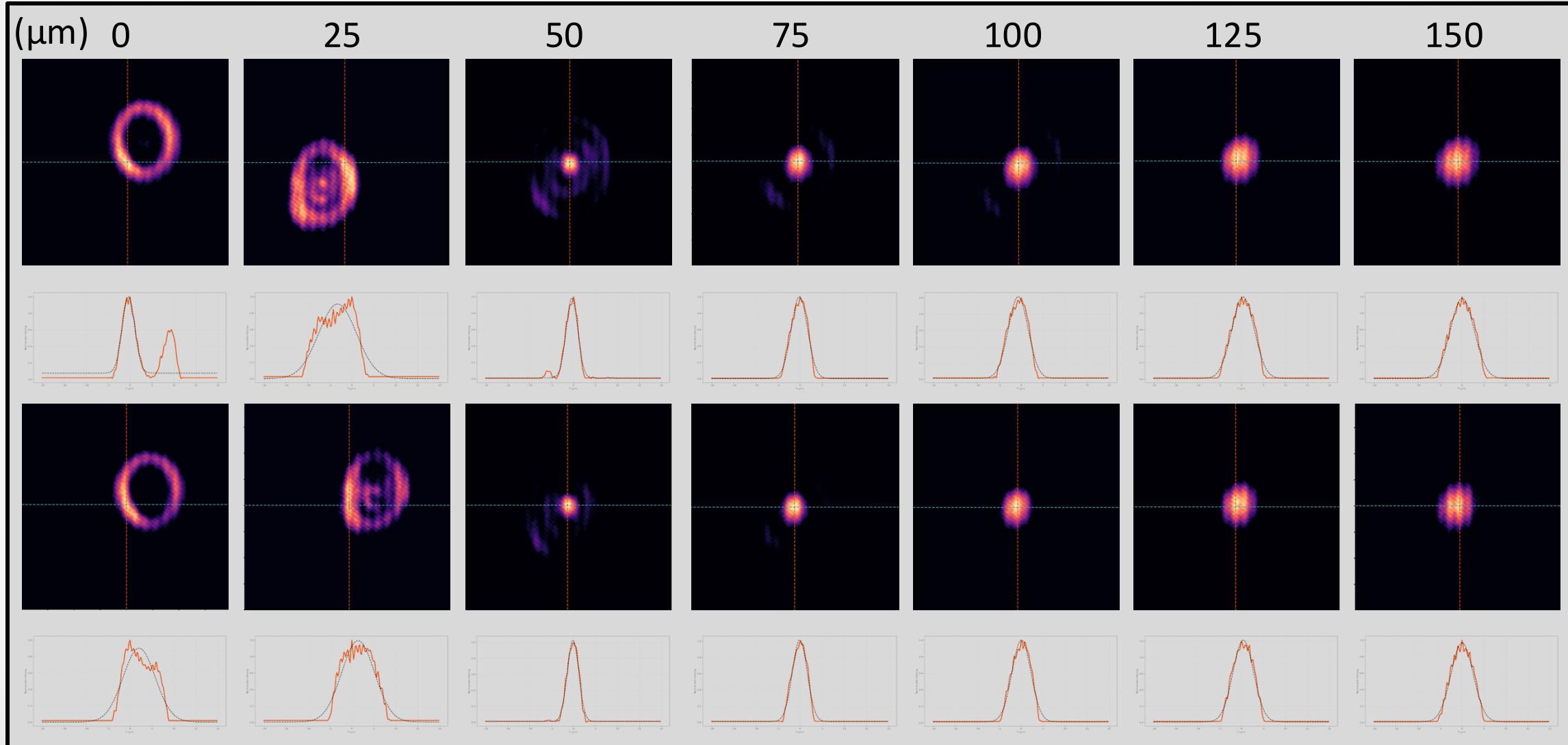
$$D_{\text{cone}} = 800 \text{ nm}$$

Result for 1100 & 1150 nm



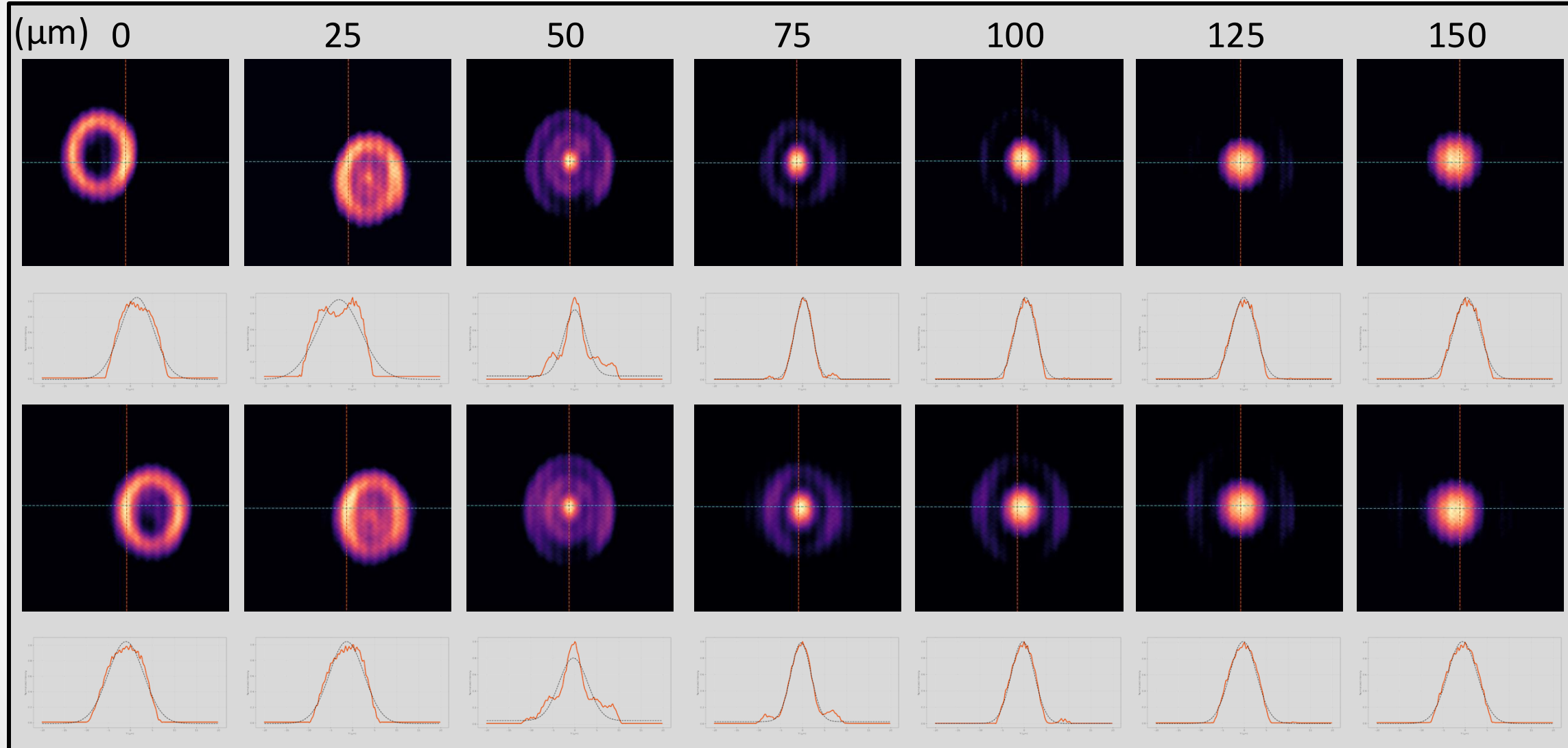
$$D_{\text{cone}} = 1000 \text{ nm}$$

Result for 1200 & 1250 nm



$$D_{\text{cone}} = 800 \text{ nm}$$

Result for 1200 & 1250 nm



Result for 1350 & 1500 nm

$$D_{\text{cone}} = 1000 \text{ nm}$$

