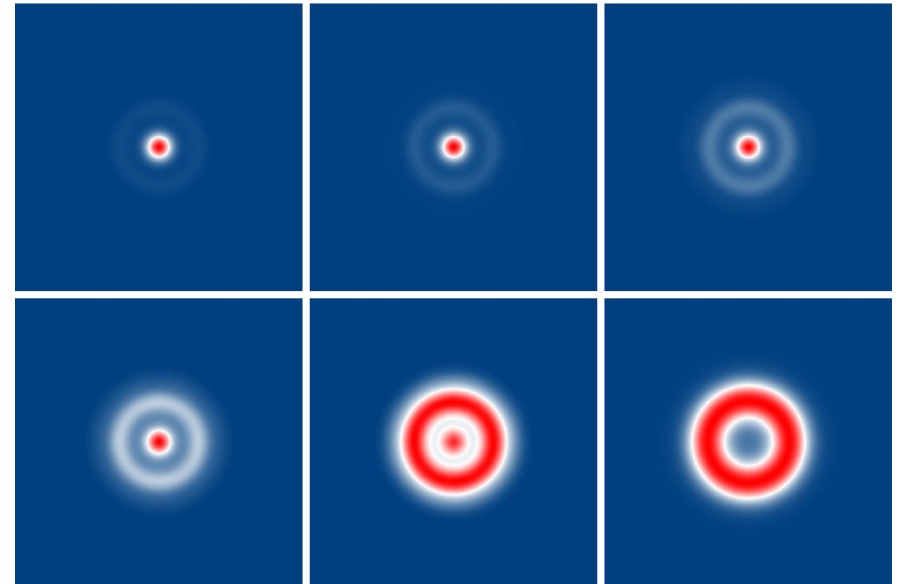


Gauss-Bessel Beam Shaper [Power Control]

From Gaussian to Bessel-like Beams
with Power Control

Part of the Beam Shaping Solution Guide

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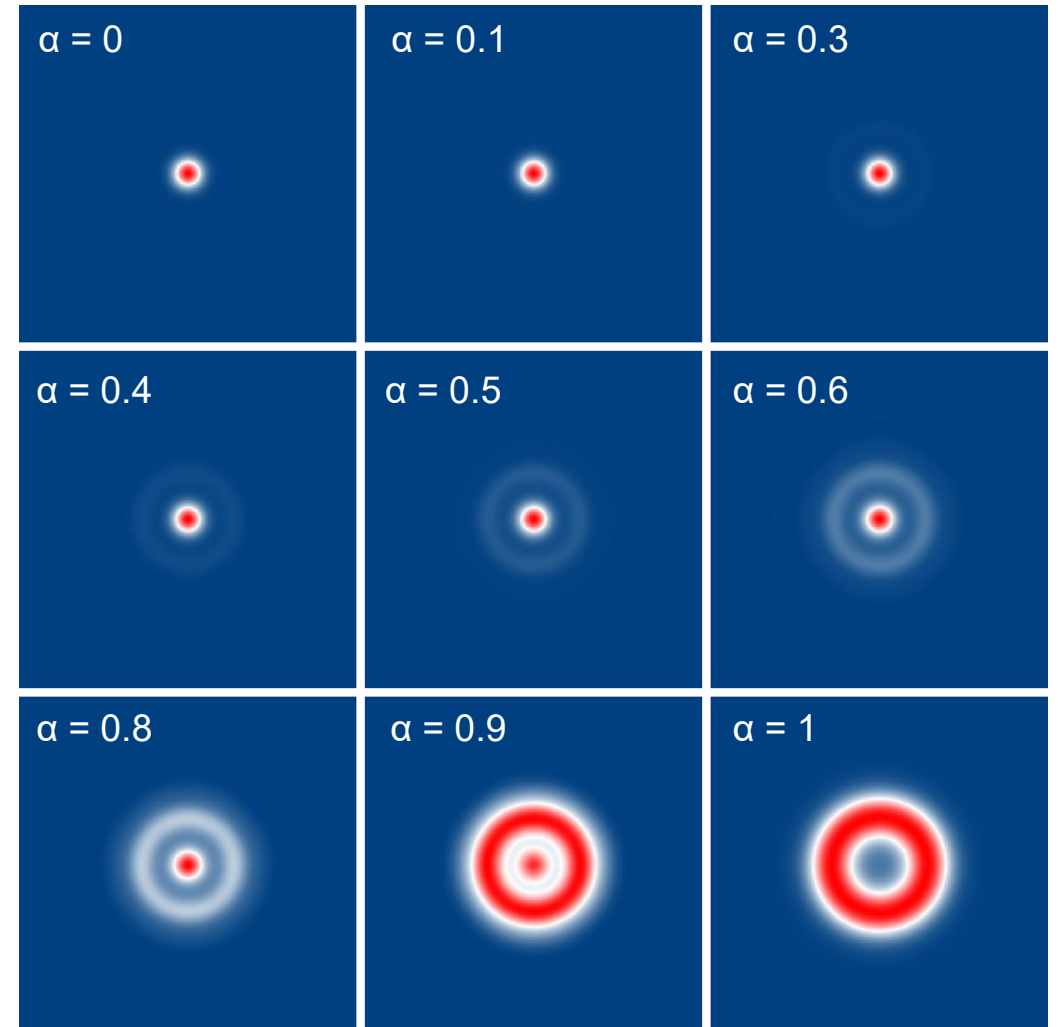
Executive Summary

❓ Can we control the power distribution between the central spot and the surrounding rings of a Gauss-Bessel beam?

✔ Yes. By adjusting the scale factor α , the beam transitions from a pure Gaussian ($\alpha = 0$) to a Bessel-like profile ($\alpha = 1$), redistributing power between the central spot and the rings.

📈 Key Observations

- $\alpha = 0$: pure Gaussian beam (all power in central spot)
- $\alpha = 1$: Bessel-like beam with multiple rings and reduced central peak
- Intermediate α : smooth transition of power between central spot and rings



Introduction

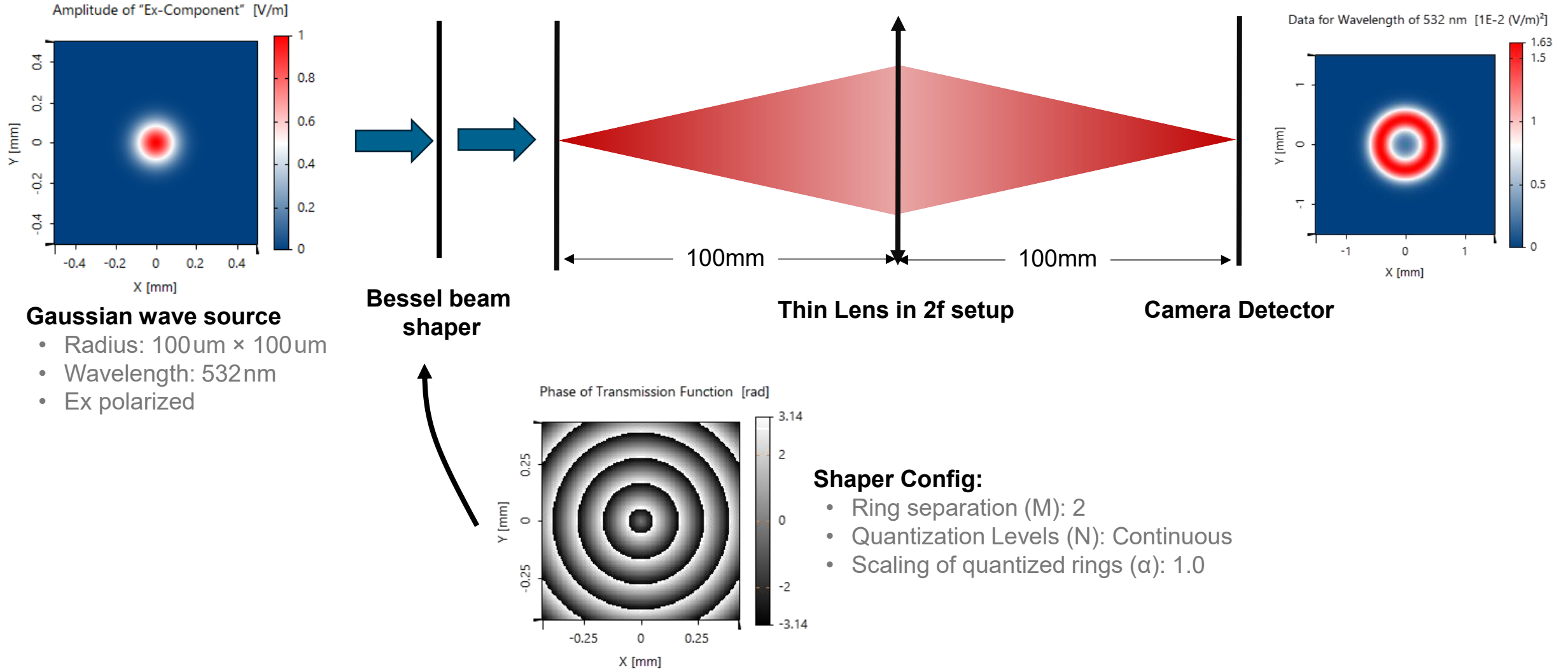
💡 What This Use Case Demonstrates

- Modeling of a Gauss-Bessel beam shaper with power control
- Continuous power control via modulation depth parameter α
- Quantization effects on the beam profile: binary ($Q = 2$), 4-level, 8-level, and continuous phase
- Field propagation through a $2f$ setup

🔧 System Overview

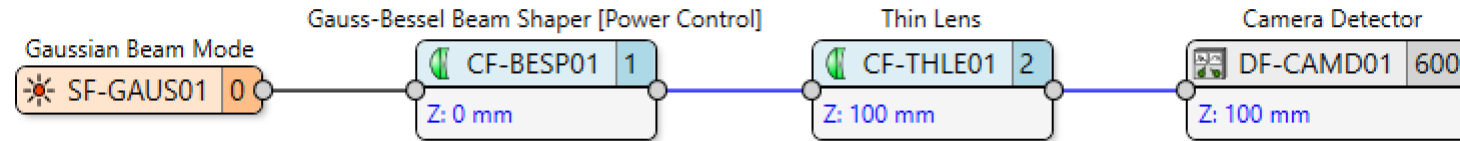
- Collimated Gaussian beam illuminates a quantized radial phase mask (Gauss-Bessel shaper)
- Shaper placed at front focal plane of a lens; intensity observed at back focal plane
- Phase scaling factor α controls energy split between central Gaussian spot and Bessel-like rings
- Quantization level Q determines number and structure of rings

Optical System Overview



System Configuration

System Layout



Digital Twin Mapping

Real Asset	Digital Twin	Description
Laser	SF-GAUS01	532 nm, waist 100 μm , collimated
Phase mask	CF-BESP01	$M = 2$, $\alpha = 1.0$, $Q = 0$ (continuous), Sampling Acc.=2
Fourier lens	CS-LENS01	Focal length $f = 100$ mm
Camera	DF-CAMD01	3×3 mm ² , 1024 \times 1024 pixels, at $z = f$

Results – Phase Scaling Parameter Run

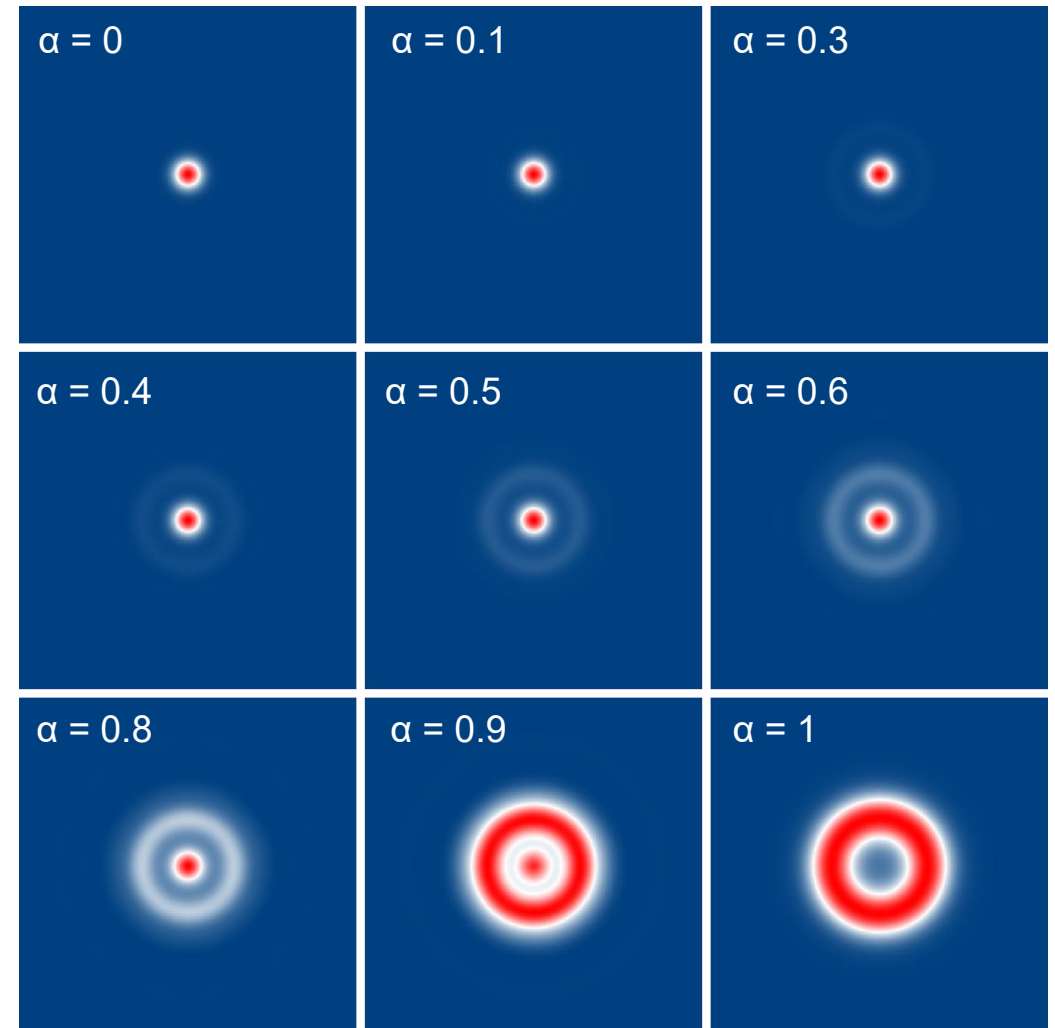
📈 Power Control via α

α	Observation
0.0	Pure Gaussian spot, no rings
0.7	Central spot brightens, rings weaken
0.85	Central spot appears, rings remain strong
1.0	Bessel-like ring, central intensity nearly zero

The full parameter run from $\alpha = 0$ to 1 in 9 steps shows a smooth transition.

💡 Physics Insight

- α scales the phase modulation depth; the shaper transmission is $\exp(i\alpha\phi_{\text{ideal}})$.
- For $\alpha < 1$, the field contains both an unmodulated Gaussian component and a modulated Bessel-like component.



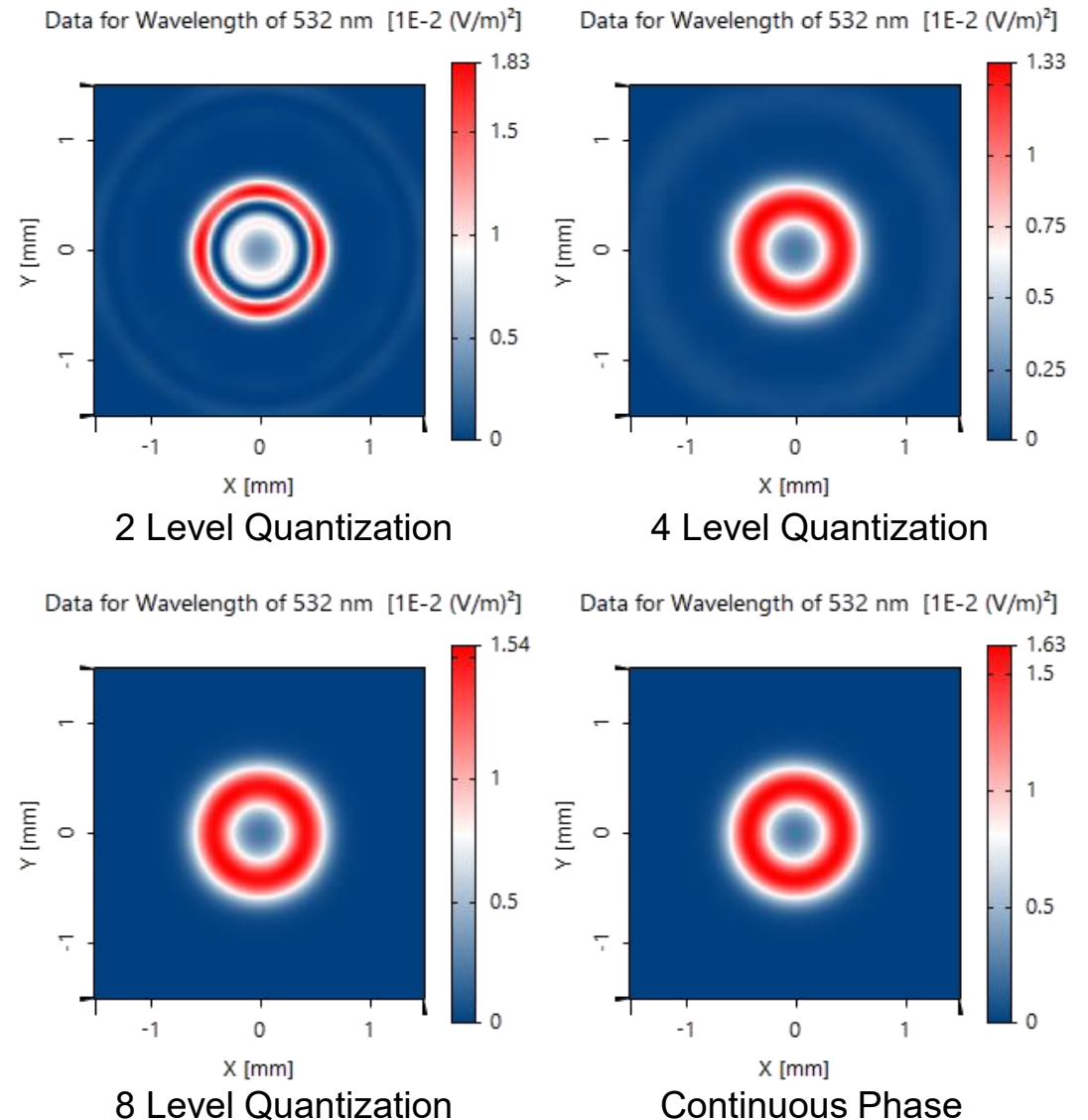
Results – Different Quantization Levels

Quantization Effects ($\alpha = 1$)

Q	Observation
2 (binary)	Multiple rings; double-peaks visible
4	Fewer higher orders, first ring dominant
8	Nearly ideal Bessel-like ring
0 (continuous)	Ideal Bessel-like ring, single ring

Physics Insight

- Lower Q introduces quantization noise, generating additional diffraction orders.
- Binary phase ($Q = 2$) acts as a radial square wave, producing odd orders with double-peak radial structure.
- Higher Q approximates the ideal continuous phase, concentrating energy into the first Bessel-like ring.



Demonstration Workflow

Step-by-Step Workflow

1. **Setup:** Add Gaussian source (SF-GAUS01).
2. **Shaper:** Place CF-BESP01 at the front focal plane of the lens.
3. **Lens:** Add lens (CS-LENS01) with $f = 100$ mm at distance f from shaper.
4. **Detector:** Place detector (DF-CAMD01) at the lens's back focal plane.
5. **Configure:** Set $M = 2$, Divergent = false, Sampling Accuracy = 2.
6. **Simulate:**
 - Run a parameter run for α from 0 to 1 in 9 steps with $Q = 0$.
 - Separately configure the beam shaper with $Q = 2, 4, 8, 0$ with $\alpha = 1$. Run field tracing for each case.
7. **Analyze:**
 - Create overview images from the Parameter Sweep to visualize the power control.
 - Observe the intensity profiles from the Camera Detector for different quantization levels.

References

Specification Sheets

- SF-GAUS01 — Gaussian Beam Source
- CF-BESP01 — Gauss-Bessel Beam Shaper [Power Control]
- CS-LENS01 — Thin Lens
- DF-CAMD01 — Camera Detector