Gaussian Beam Analysis from Position and Power Data

# Introduction

This report presents the analysis of experimental data consisting of power measurements as a function of angular position. The primary objective is to model the spatial distribution of the beam intensity using a Gaussian profile, determine the beam width (Full Width at Half Maximum, FWHM), and estimate the beam's wavelength under the assumption of a simplified Gaussian beam propagation model.

# Data Normalization

The raw position (in degrees) and power (in microwatts) measurements are normalized to values between 0 and 1. This is done to eliminate unit dependencies and ensure compatibility with the Gaussian fitting algorithm.

# Gaussian Fitting

A Gaussian function of the form A \* exp(-0.5 \* ((x - mu) / sigma)^2) is fitted to the normalized data using non-linear least squares optimization. The fit provides estimates of amplitude (A), center (mu), and standard deviation (sigma). From the standard deviation, the Full Width at Half Maximum (FWHM) is calculated using the relation: FWHM = 2.355 \* sigma.

# Beam Waist and Wavelength Estimation

Assuming the fitted Gaussian profile corresponds to a cross-section of a Gaussian laser beam, the beam waist (w₀) is derived as w₀ = FWHM / 2.355. Under the assumption that the Rayleigh range (z\_R) is known or approximated (e.g., z\_R = 1 in normalized units), the wavelength λ can be estimated using the Gaussian beam relation: λ = (w₀² \* π) / z\_R.

# Analysis and Application

The Gaussian fit and the computed FWHM provide insight into the beam divergence and focus characteristics. In laboratory settings, this approach is valuable for characterizing optical systems, laser alignment, and determining beam quality. Deviations from a Gaussian profile may indicate aberrations or misalignment.

# Conclusion

This analysis offers a systematic method to extract Gaussian beam parameters from experimental data. The resulting fit parameters, particularly the FWHM and estimated wavelength, are critical for understanding the spatial and optical properties of the beam under investigation.