Measuring the Power of Laguerre-Gaussian Beams

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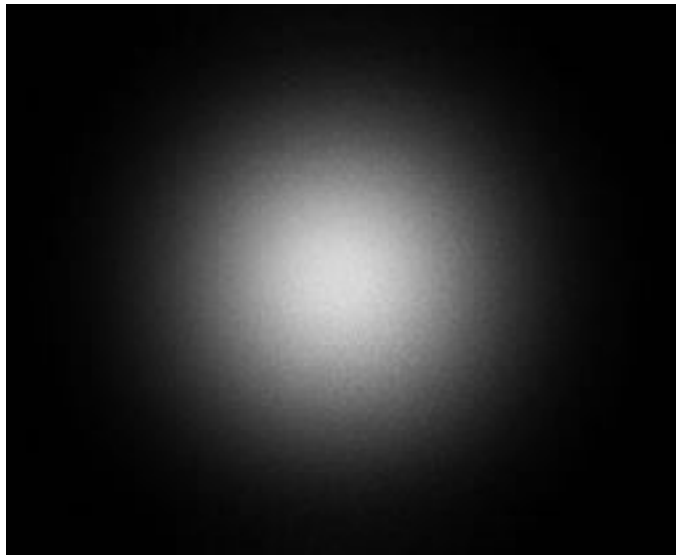
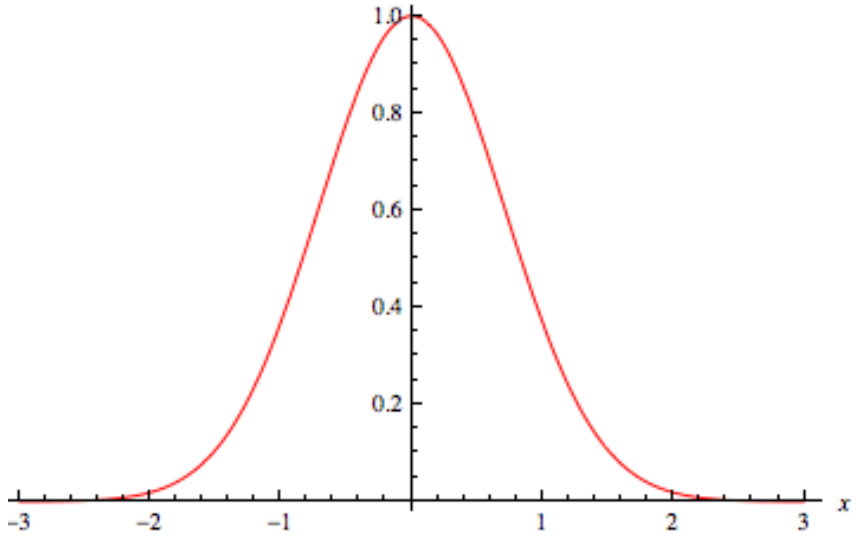
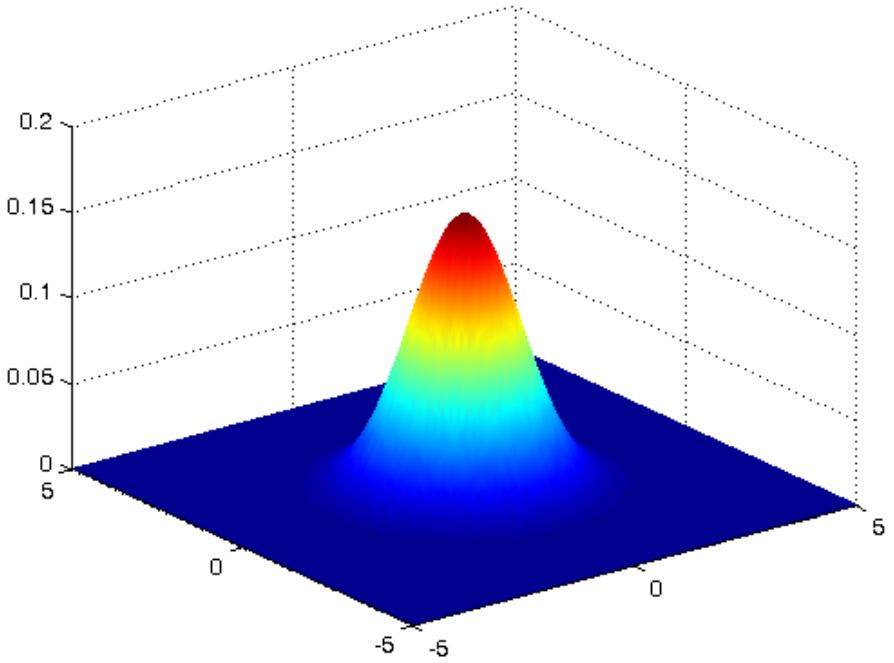
Experimental AMO

Gaussian Beam

- Electromagnetic radiation
- Modeled by Gaussian function
  - Intensity vs. radius

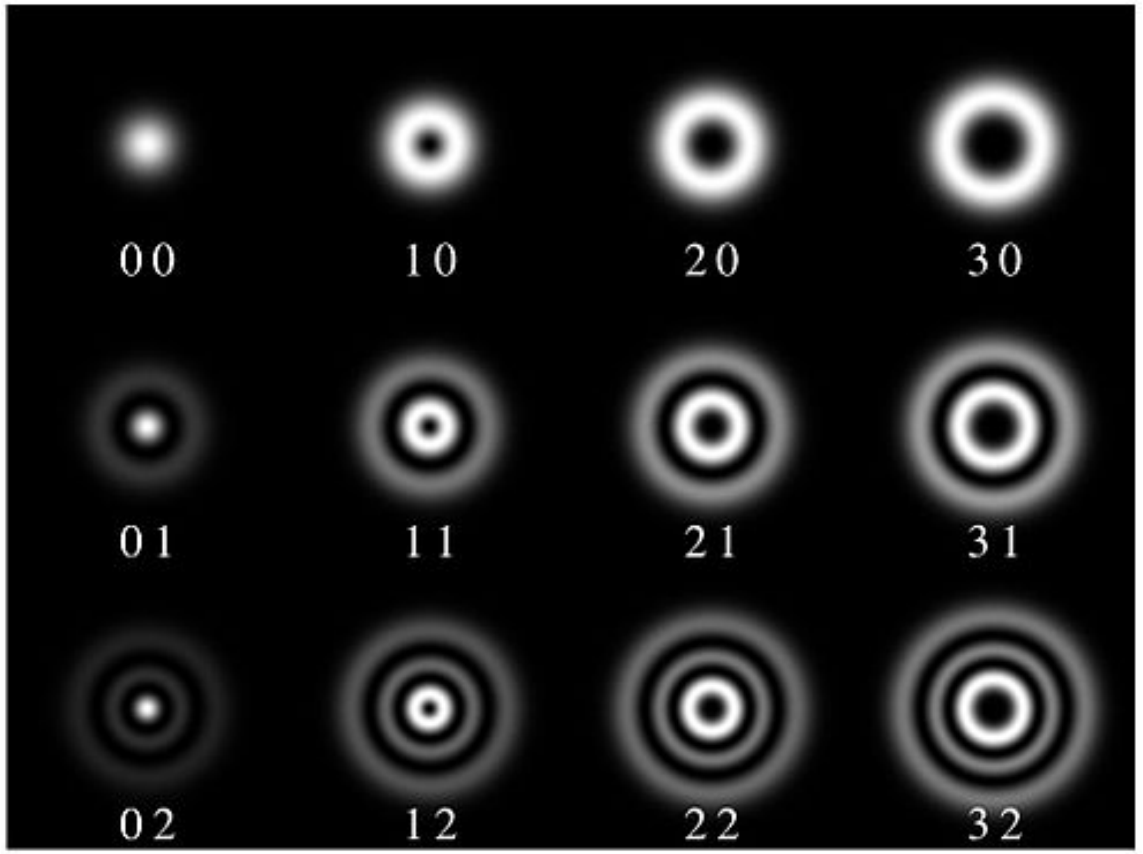






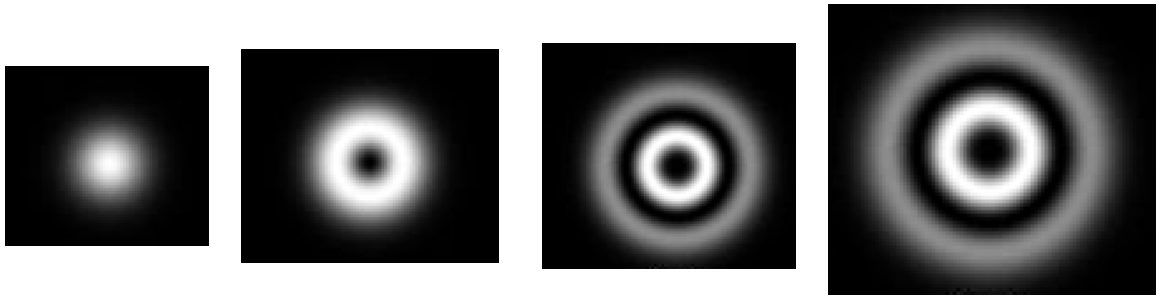
Laguerre-Gaussian (LG) Beams

- Higher-order modes of Gaussian
  - Modeled by Laguerre polynomial
  - Many different modes
- Diffractive optics
  - Pair of optics with patterns etched into them



Measuring Power

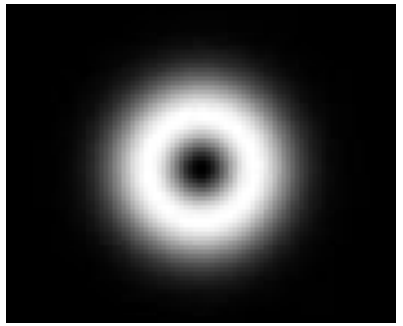
- Measured power as a function of propagation distance
  - Figure out how much power is preserved
- Gaussian, LG1-0, LG2-1, and LG10-1 beams



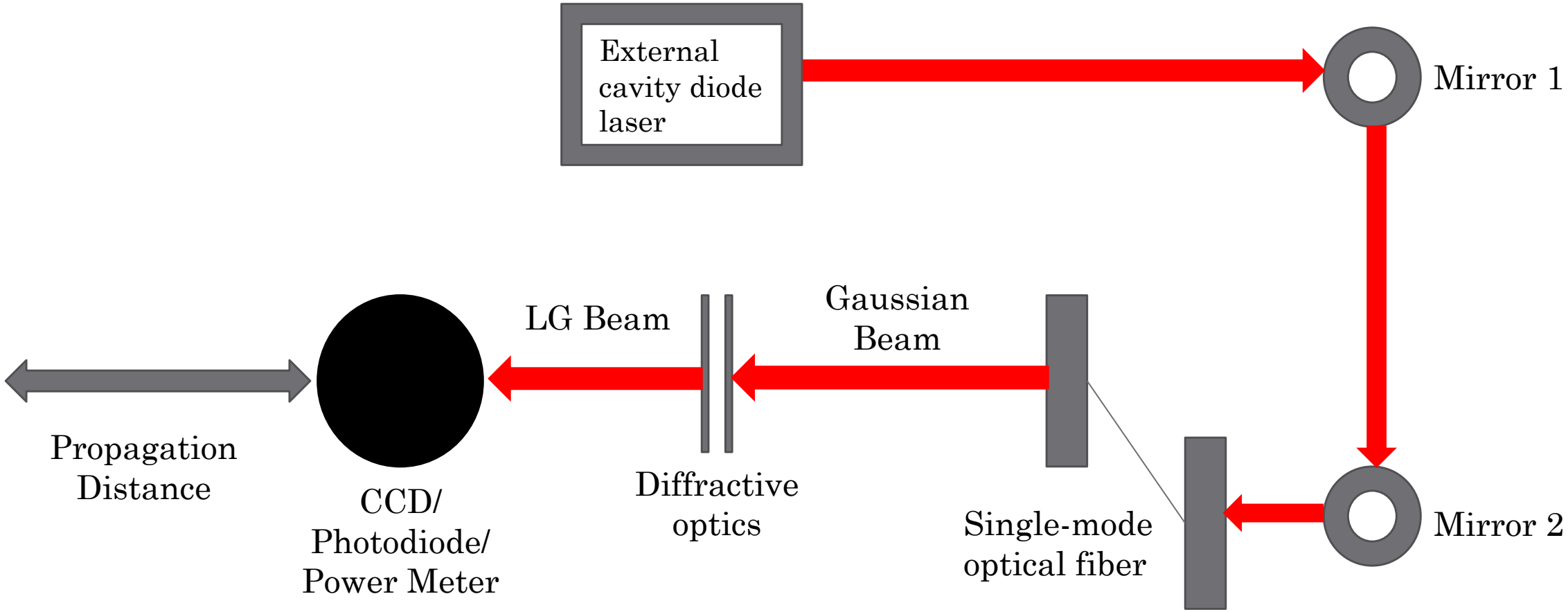
- Why is measuring power important?
  - Optical tweezers
  - Atmospheric sensing
  - Optical computers

3 Methods of Measurement

- CCD Camera
  - Camera used for detecting photons
  - Generates digital copy of light patterns
  - Pixels = power
- Photodiode
  - Converts light into electrical current
  - Allows voltage values to be read
- Power Meter
  - Measures beam power in watts or joules



Experimental Setup

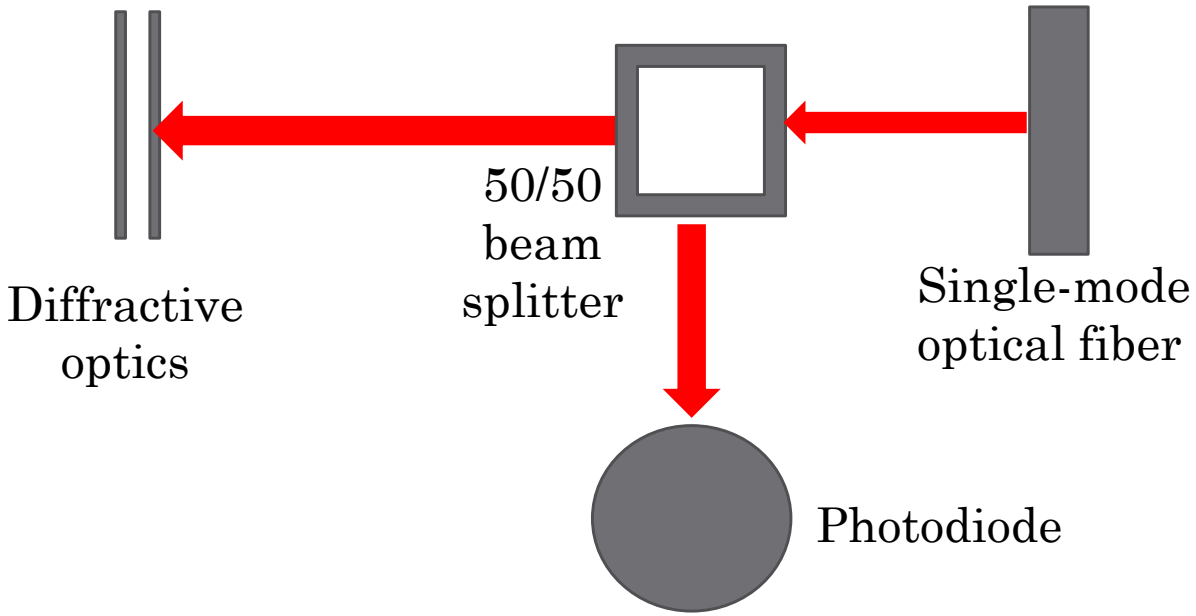


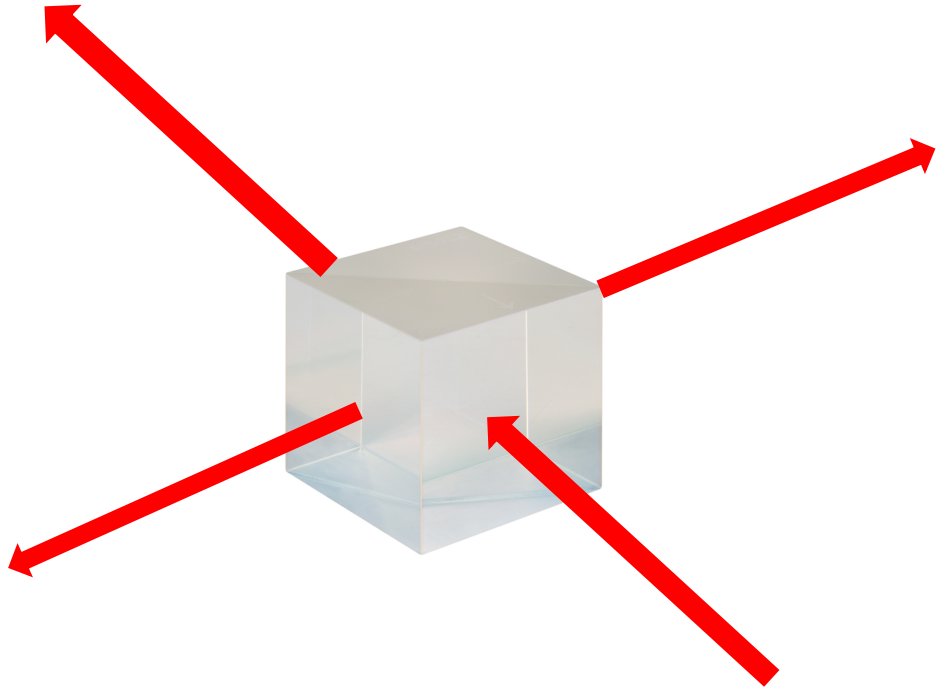
Expectations

- LG beam diffraction
  - Decrease in power as propagation distance increases
  - Beam size gets larger and dimmer
- Power of Gaussian beam should stay consistent
  - No diffraction, no changes
  - Beam size also stays the same

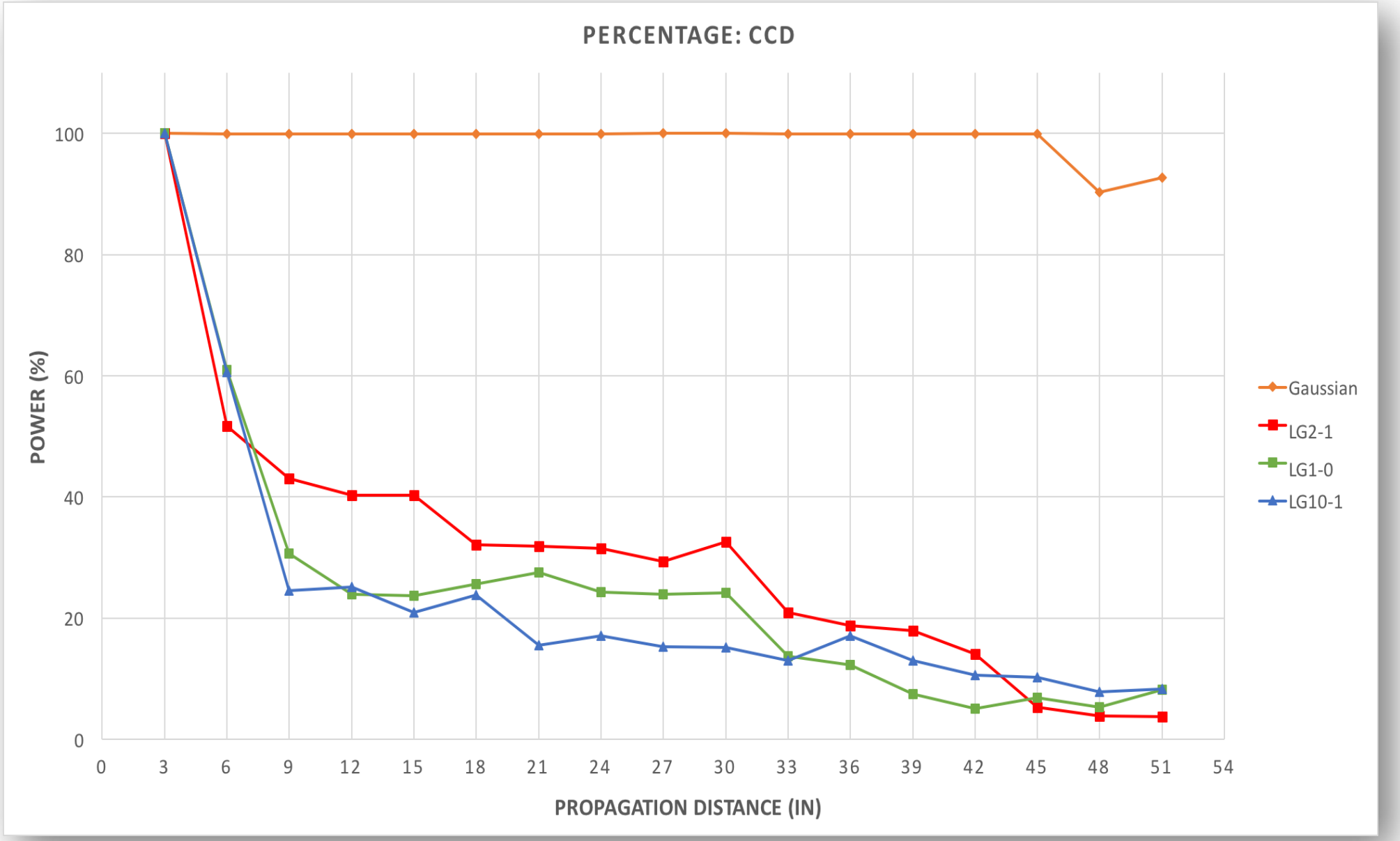
Method 1: CCD

- Fluctuations were an issue
- Photodiode + 50/50 beam splitter
- Monitor power consistency of beam while CCD in use
- New experimental setup:





CCD Data

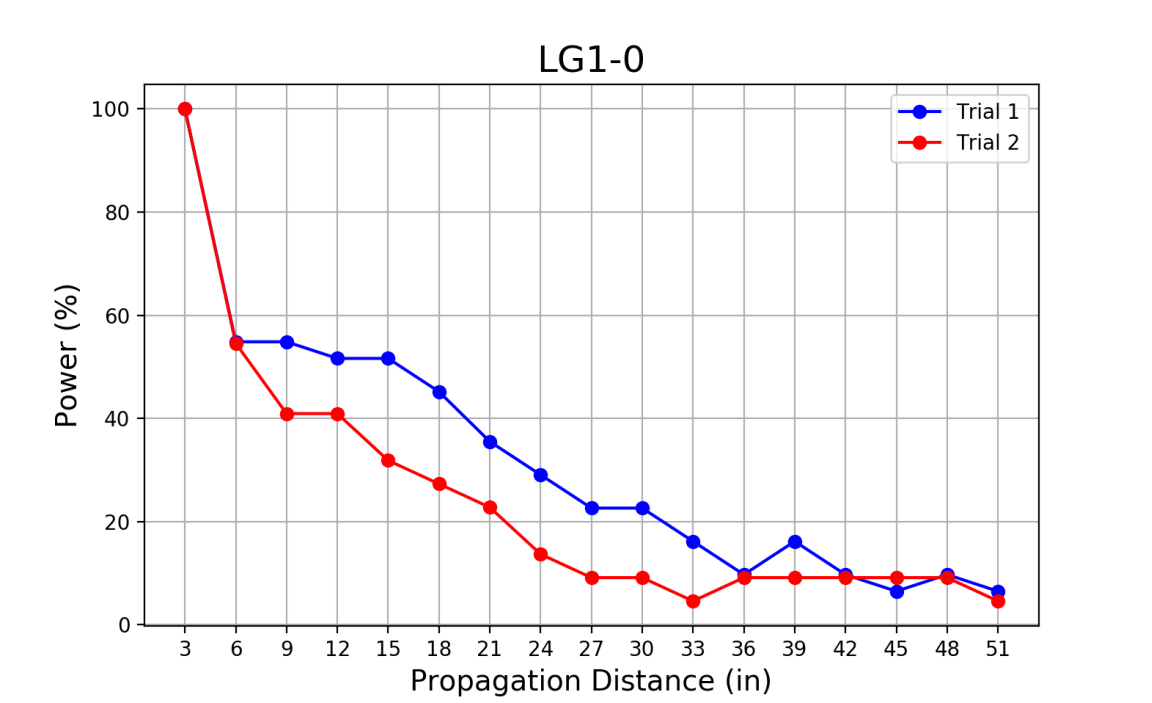

PERCENTAGE: CCD
POWER (%)
100
80
60
40
20
0
0
3
6
9
12
15
18
21
24
27
30
33
36
39
42
45
48
51
54
PROPAGATION DISTANCE (IN)
Gaussian
LG2-1
LG1-0
LG10-1

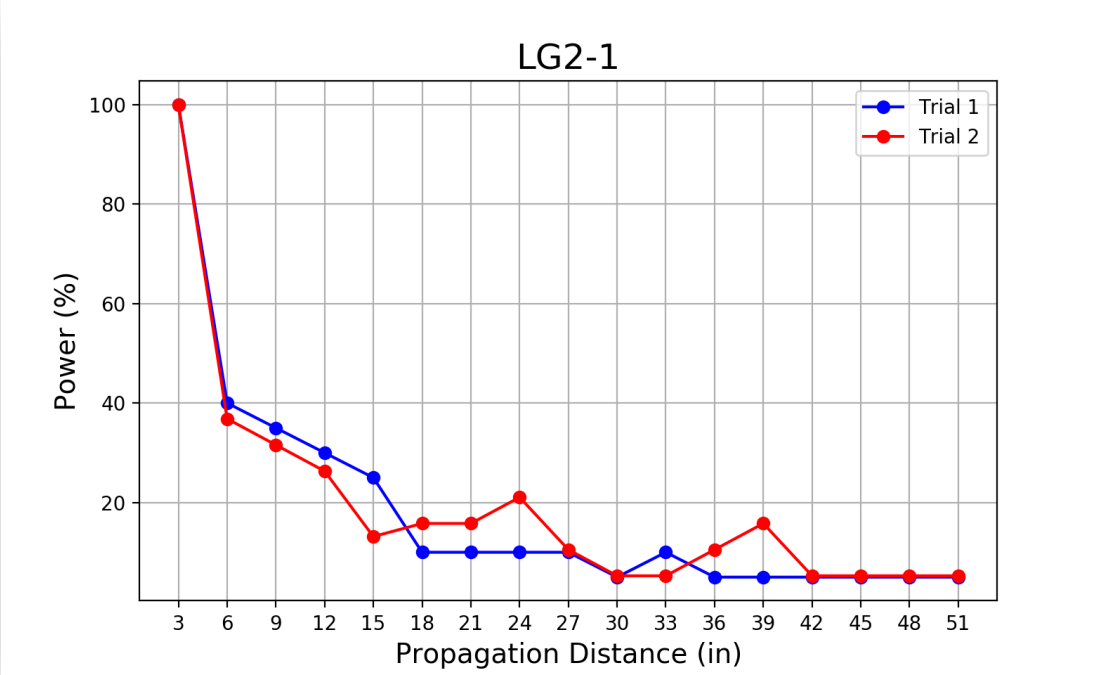
Method 2: Photodiode

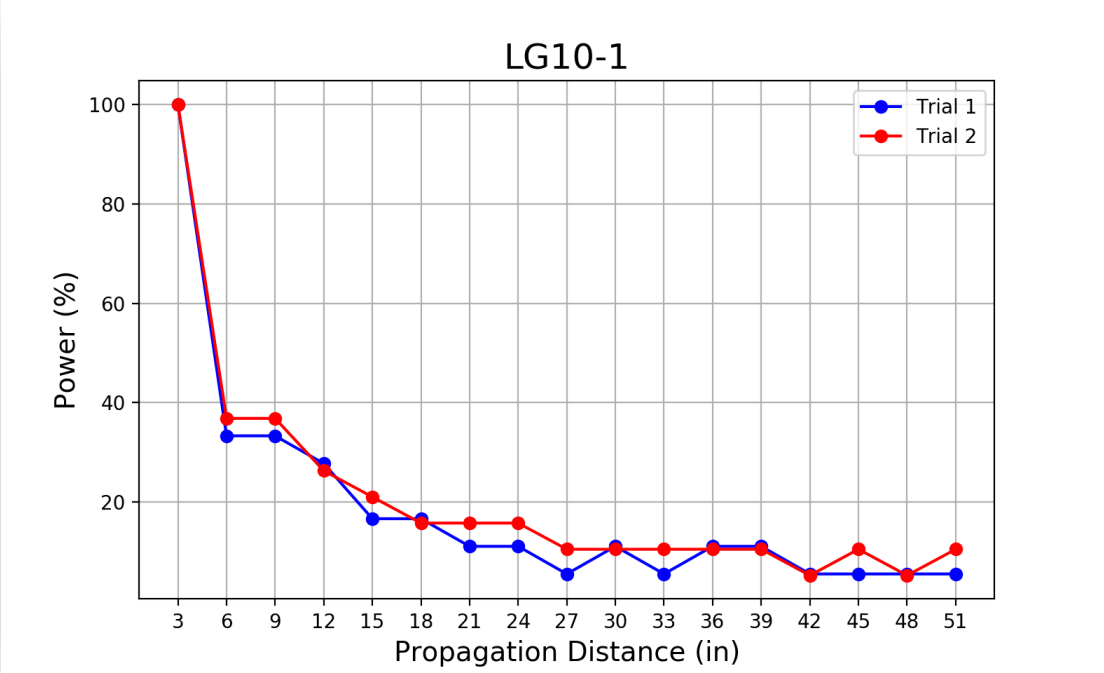
- Before: Photodiode measured power of whole beam
- Now: Photodiode measuring power as a function of propagation distance
  - Downside: Unable to monitor power consistency as efficiently
  - Only able to recognize significant fluctuations in electric current
- Large power fluctuations were common
  - Temperature changes in lab
  - Had to restart data runs

Photodiode Data

- LG data consistent with predictions

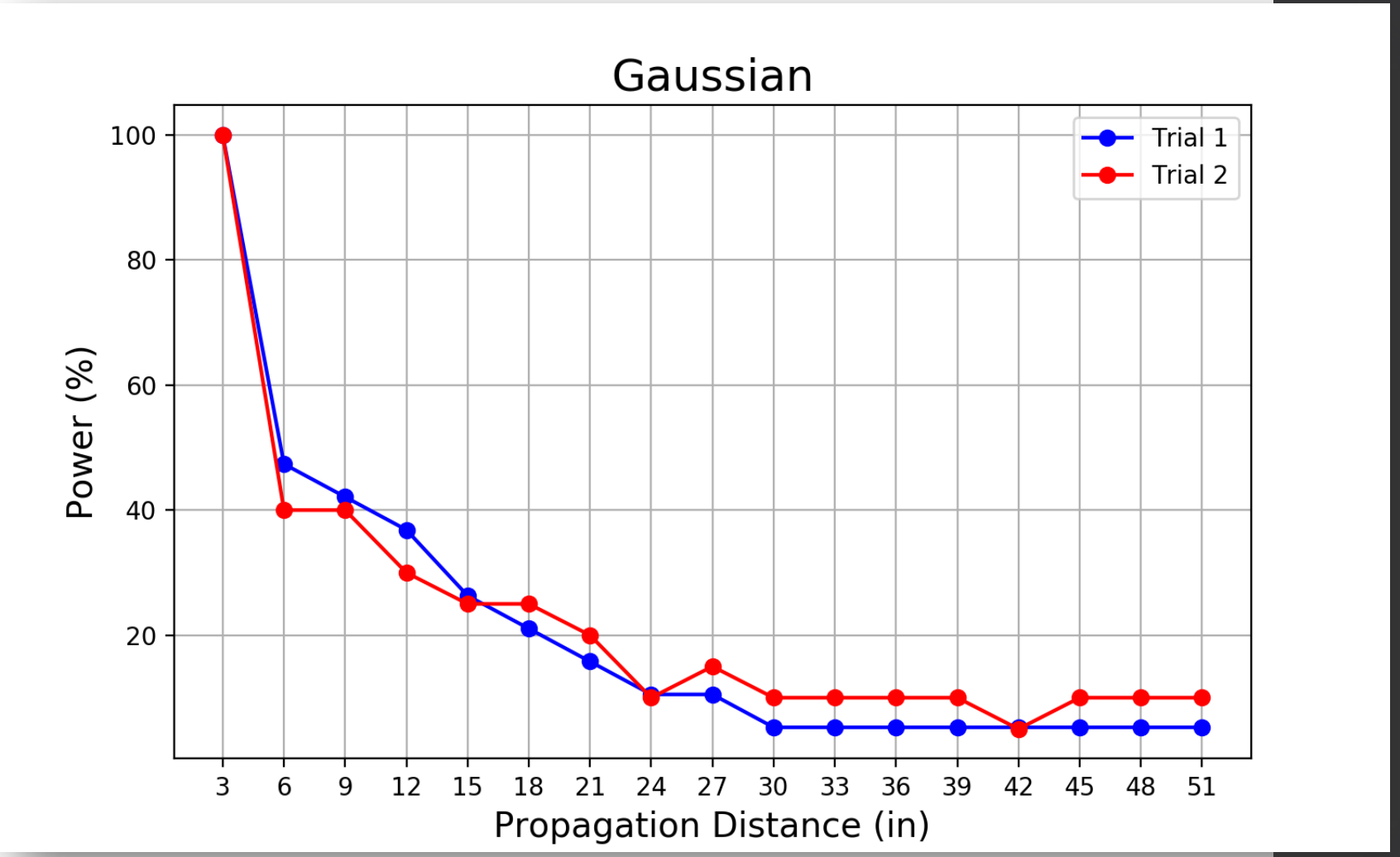






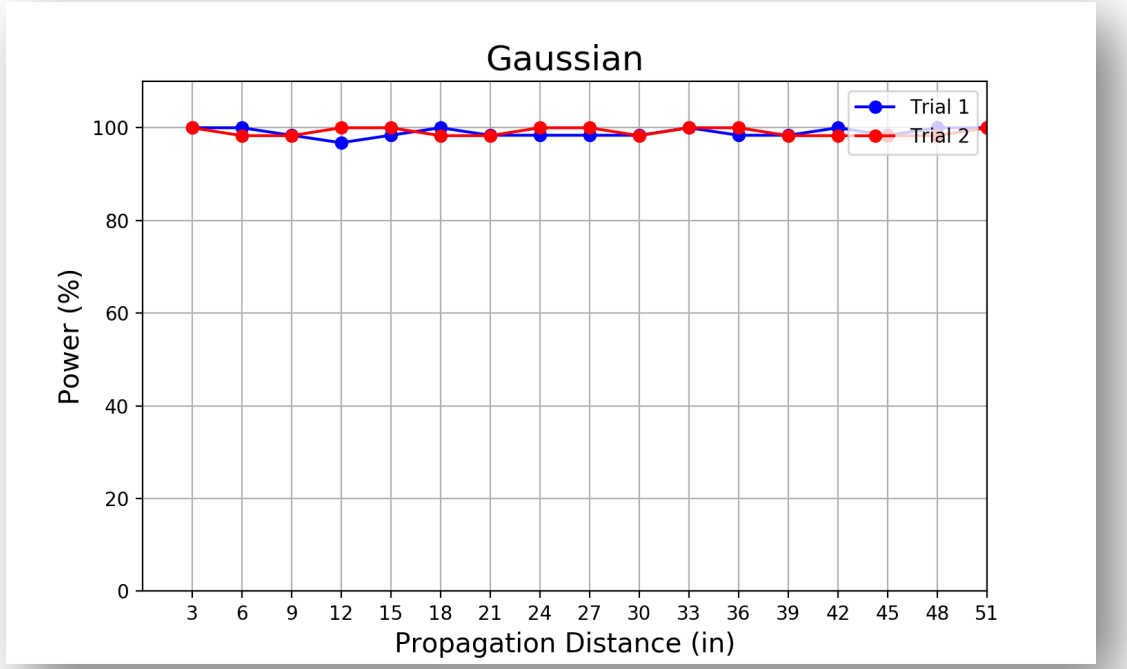
Photodiode Data

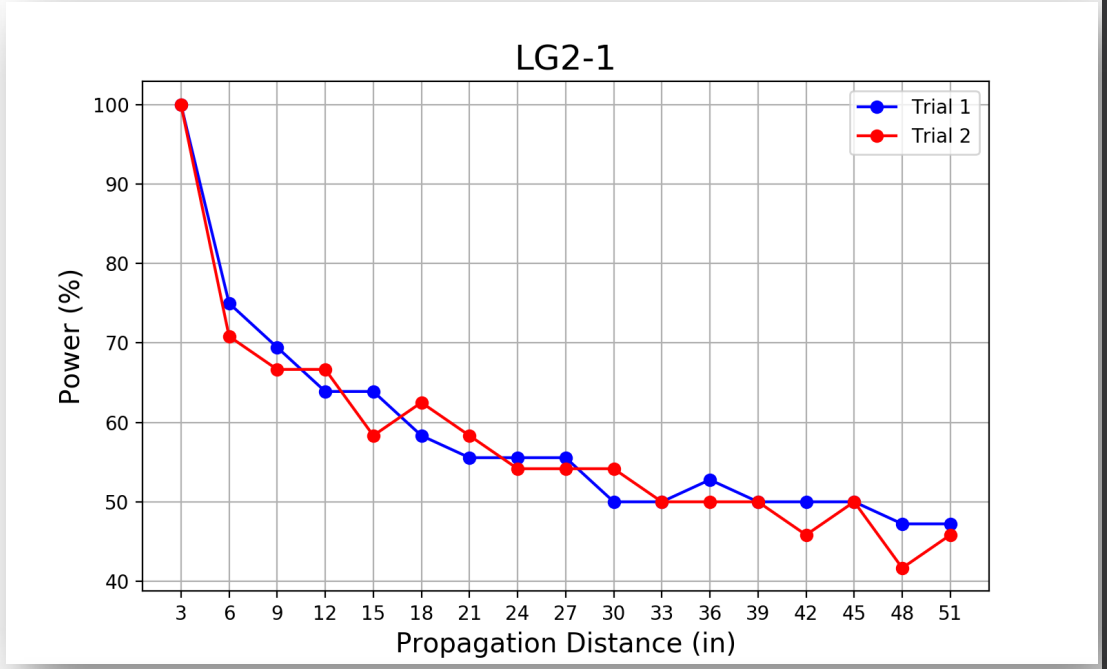
- Gaussian beam inconsistent, showing drop-off
- Interference of background data
- Background data increased as a function of propagation distance

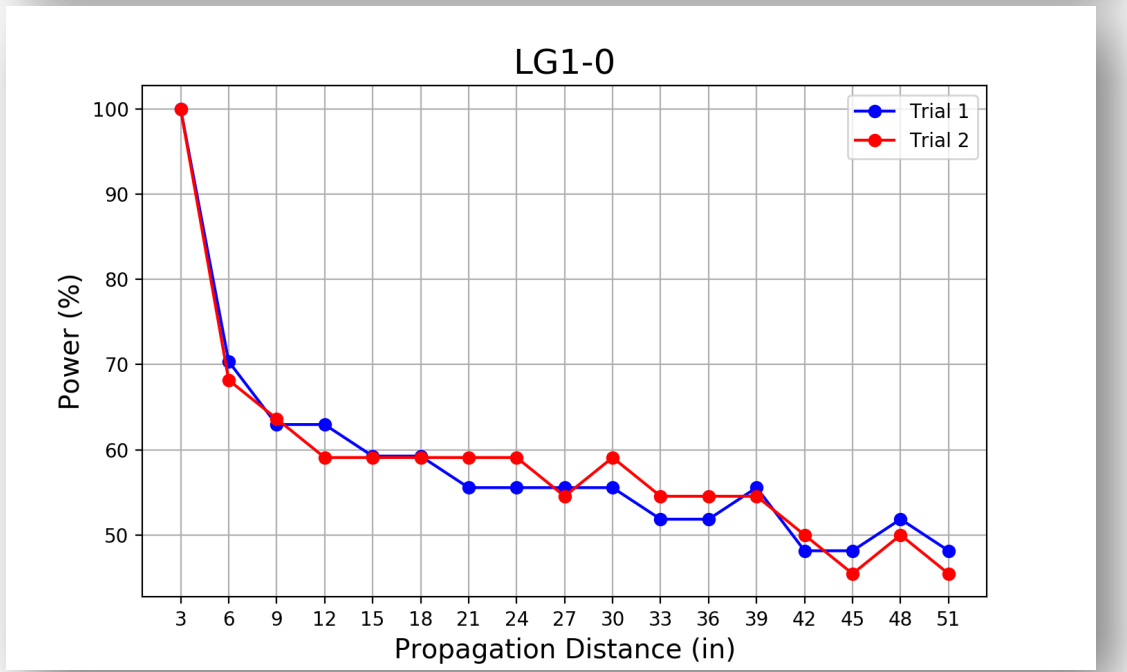


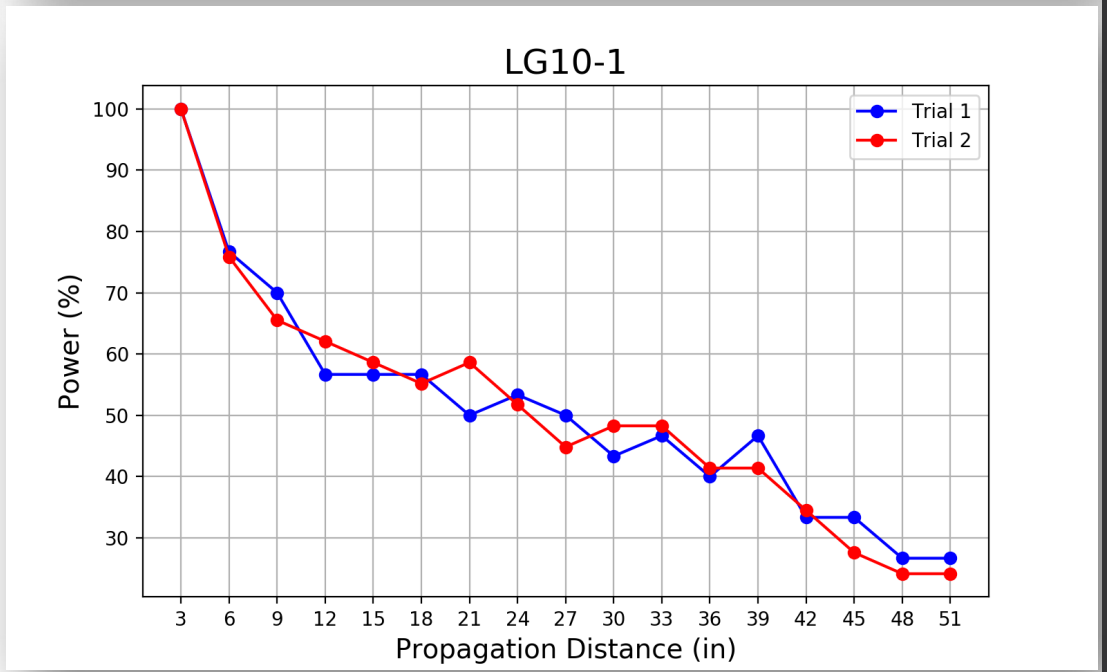
Method 3: Power Meter

- Using 50/50 beam splitter and photodiode again
- Power meter was able to zero out background at all distances
- Results were consistent with predictions, less dramatic drop-off than CCD


Gaussian
Trial 1
Trial 2
Power (%)
Propagation Distance (in)


LG2-1
Trial 1
Trial 2
Power (%)
Propagation Distance (in)


LG1-0
Trial 1
Trial 2
Power (%)
Propagation Distance (in)


LG10-1
Trial 1
Trial 2
Power (%)
Propagation Distance (in)

Conclusion

- Comparing data identified systematic errors: Background
- Photodiode sensitivity more useful in measuring overall power consistency
- CCD code can be adjusted to distinguish between beam and background
- Power meter gave most accurate results

Questions?