

# Intra-cavity Generation of High Order $LG_{p/l}$ Modes

Sandile Ngcobo<sup>1,2</sup>, Kamel Ait-Ameur<sup>3</sup> and Andrew Forbes<sup>1,2</sup>

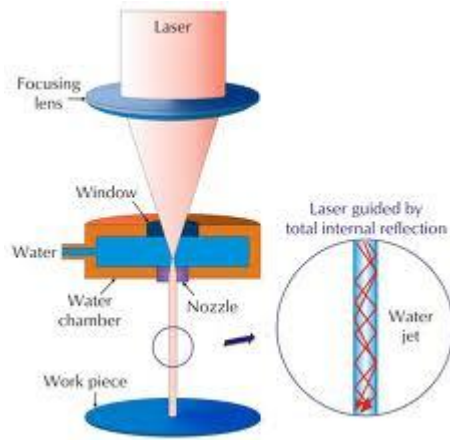
<sup>1</sup>*CSIR National Laser Centre, PO Box 395, Pretoria, 0001, South Africa*

<sup>2</sup>*School of Physics, University of KwaZulu-Natal, Private Bag X54001, Durban, 4000, South Africa*

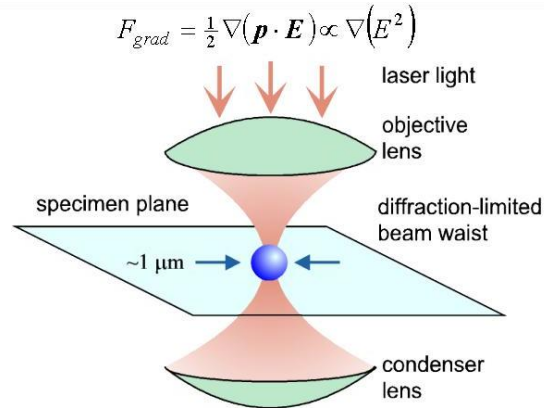
<sup>3</sup>*de Recherche sur les Ions, Les Matériaux et la Photonique, Université de Caen, ENSICAEN, F1450 Caen, France*

# Introduction

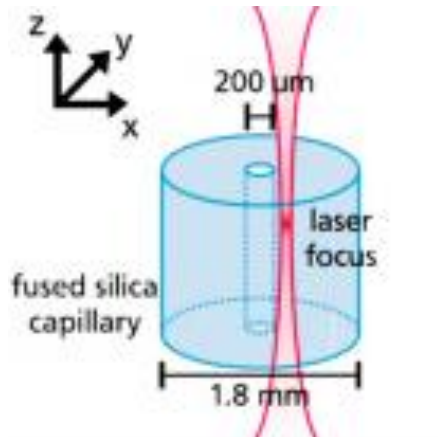
- Laser Cutting



- Optical Tweezers

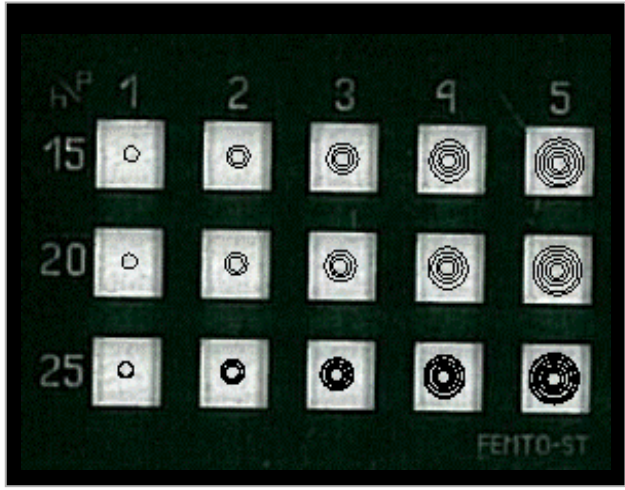


- Nonlinear Microscope



- Laser Ranging

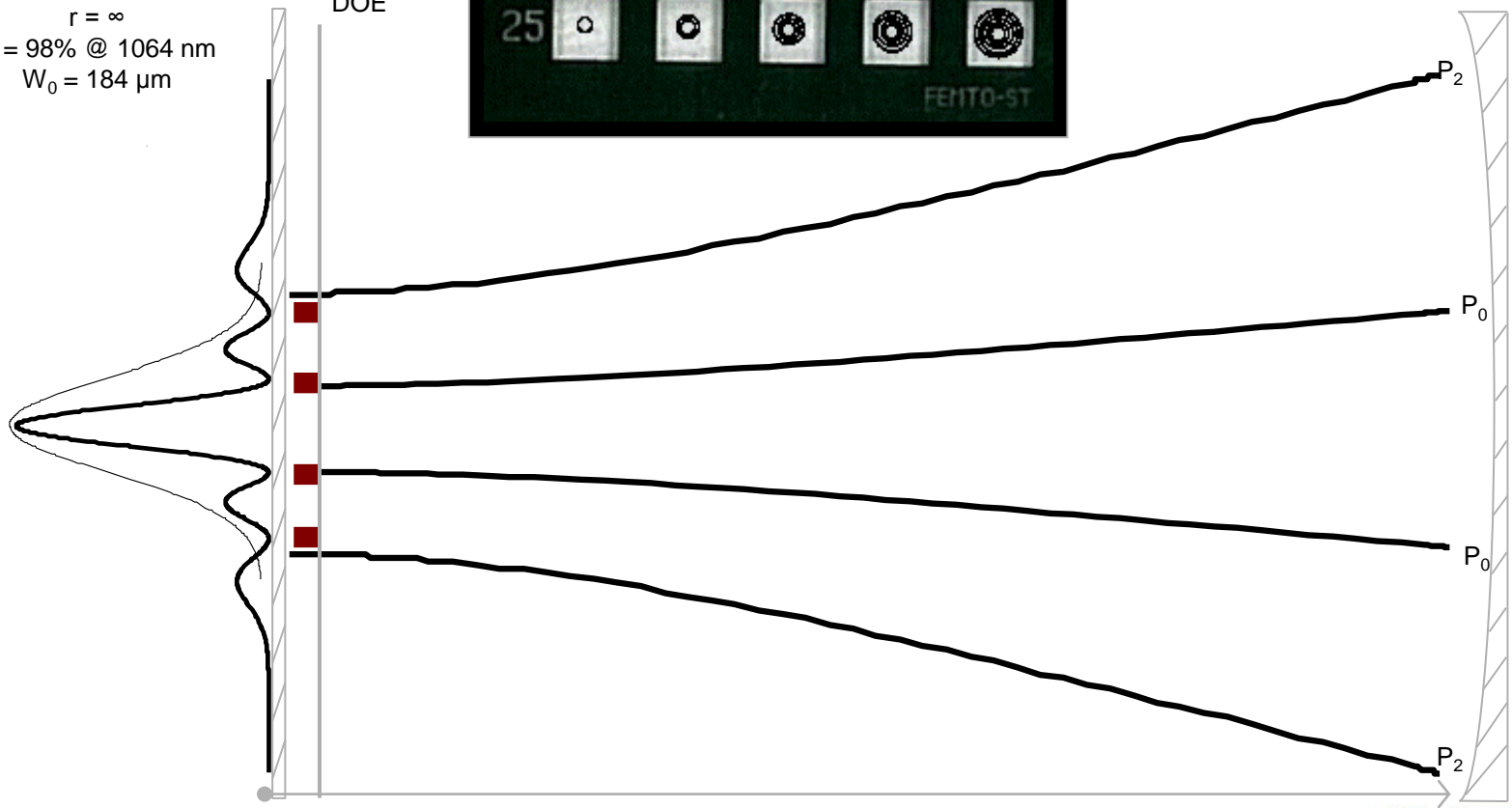




$r = \infty$   
 $R = 98\% @ 1064 \text{ nm}$   
 $W_0 = 184 \mu\text{m}$

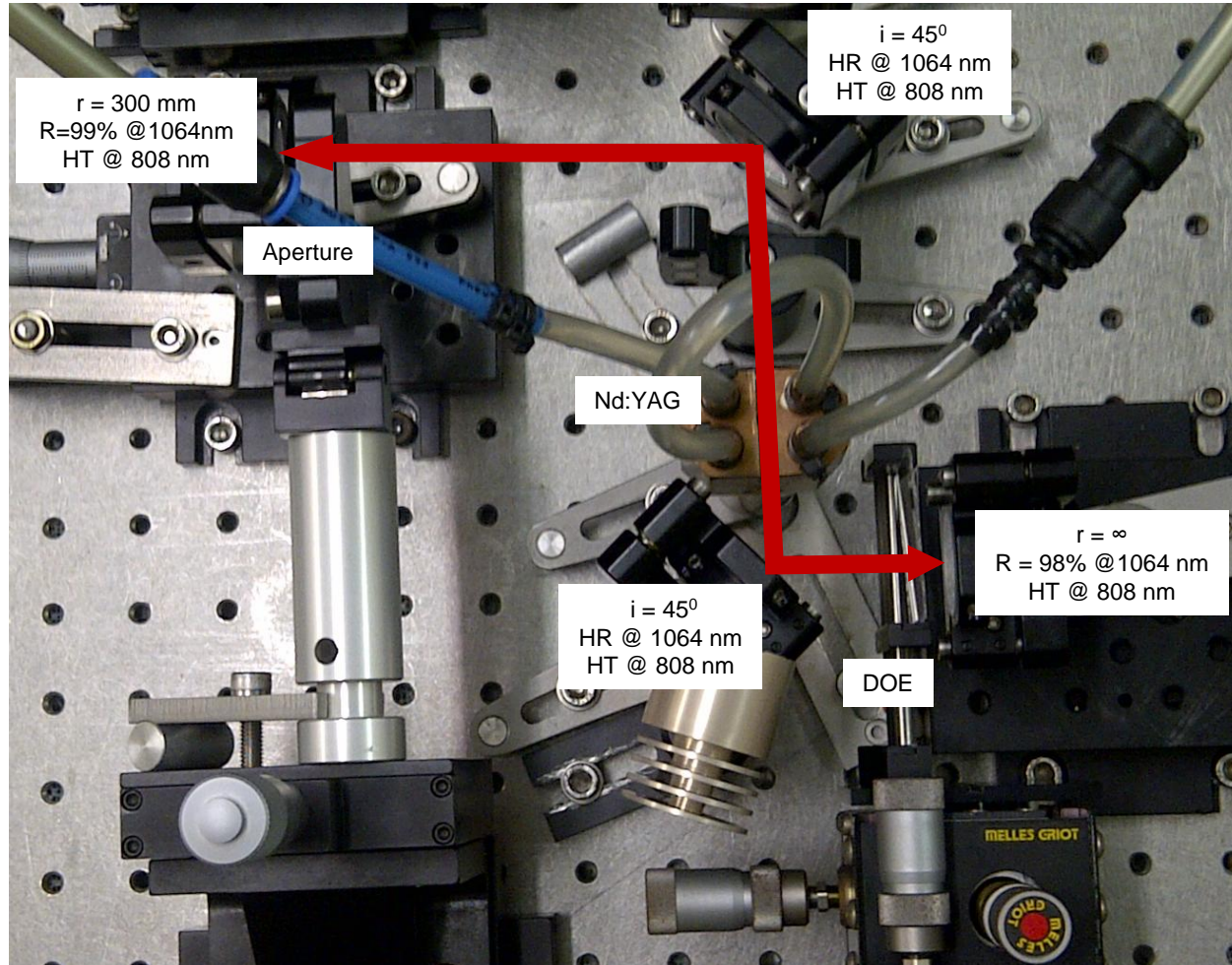
DOE

$r = 300 \text{ mm}$   
 $R = 99\% @ 1064 \text{ nm}$   
 $W_0 = 565 \mu\text{m}$

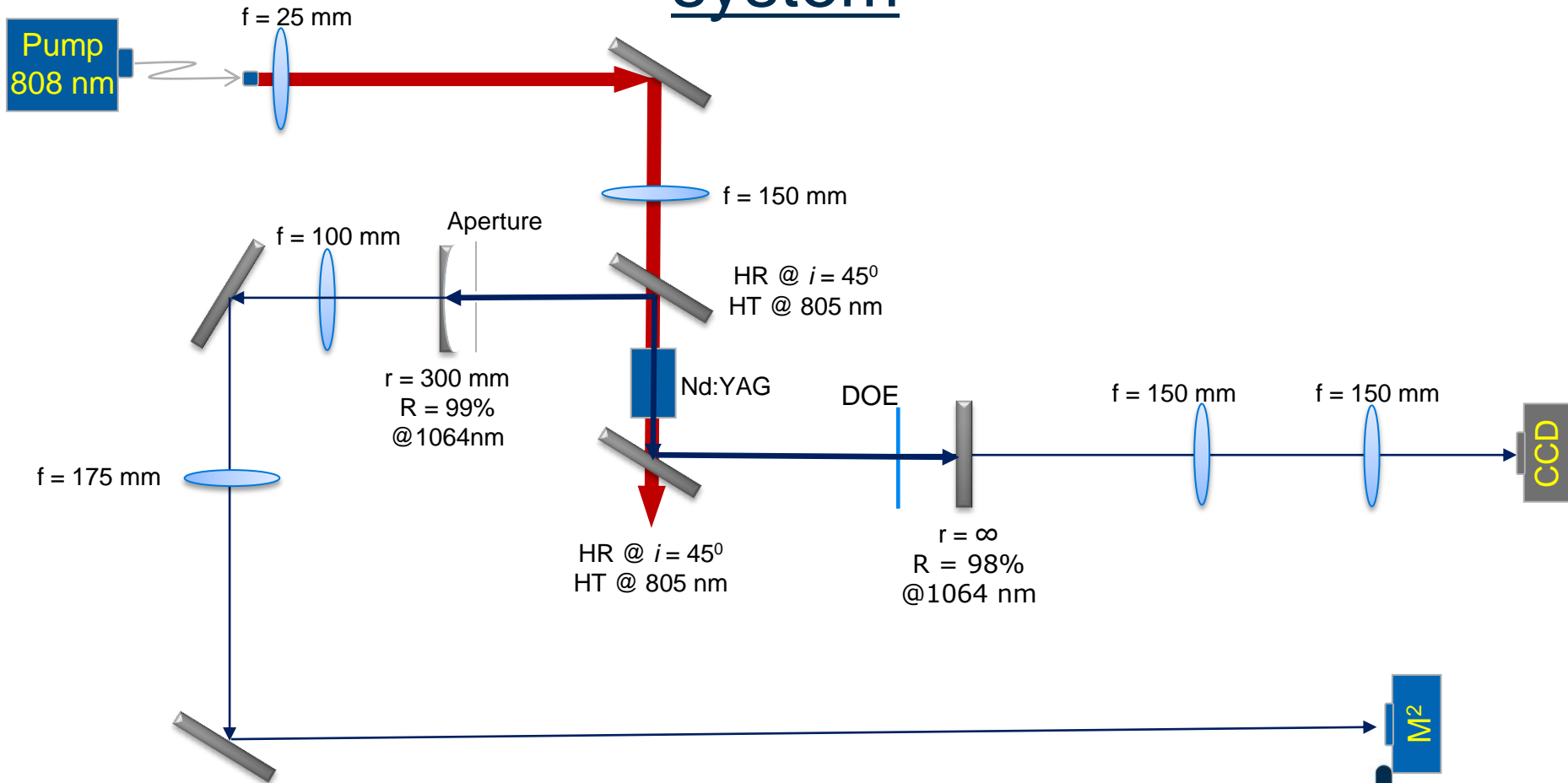


$Z = 260 \text{ mm}$

# Part 1 - Tested the concept on an Nd:YAG system

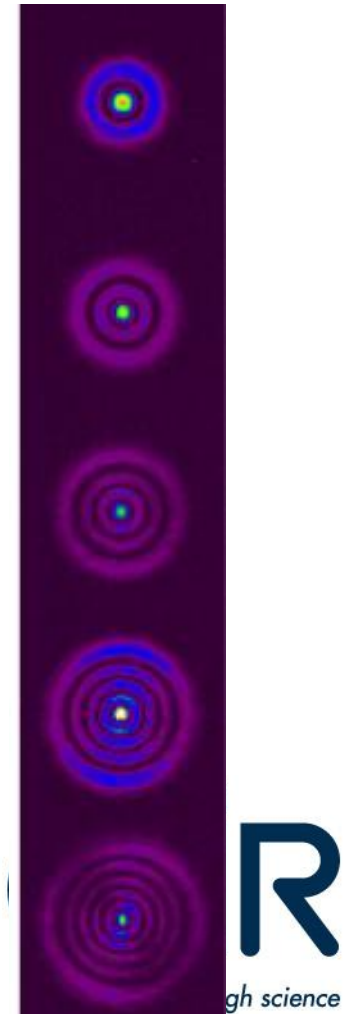
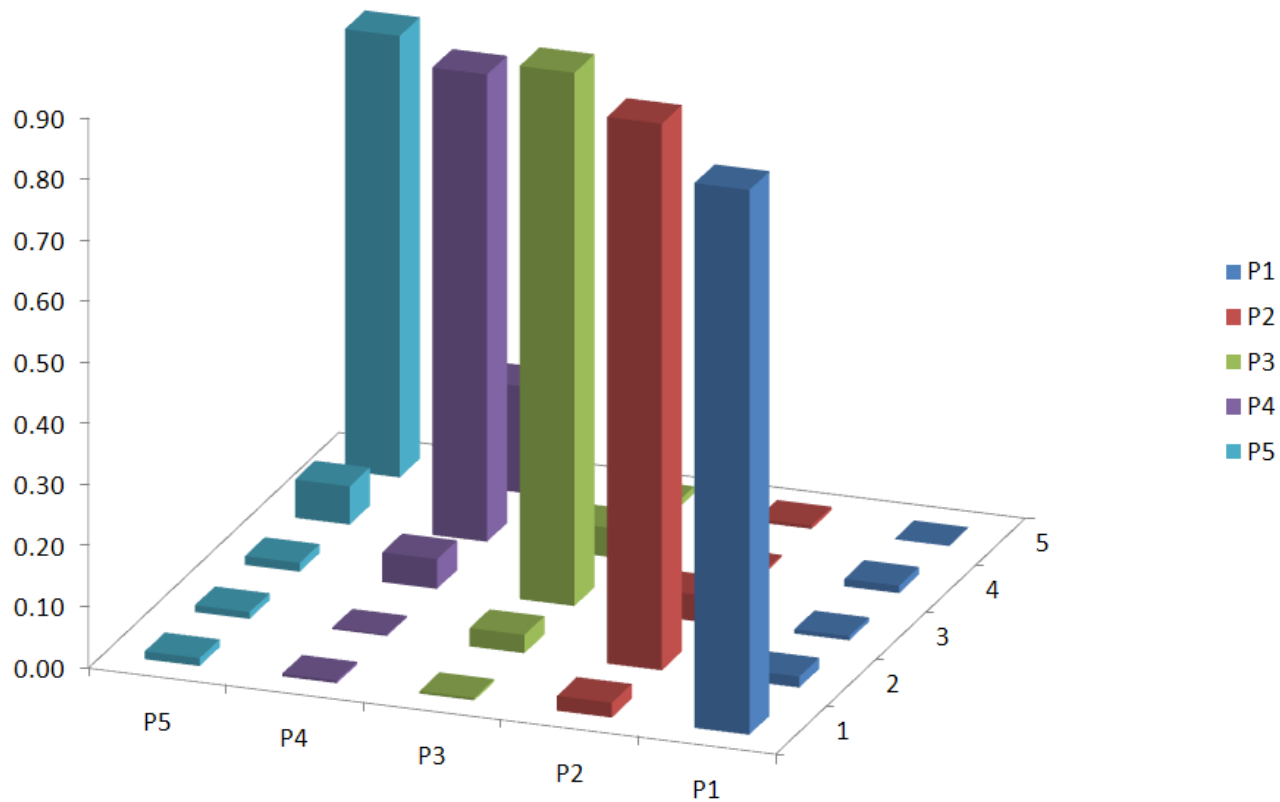


# Part 1 - Tested the concept on an Nd:YAG system

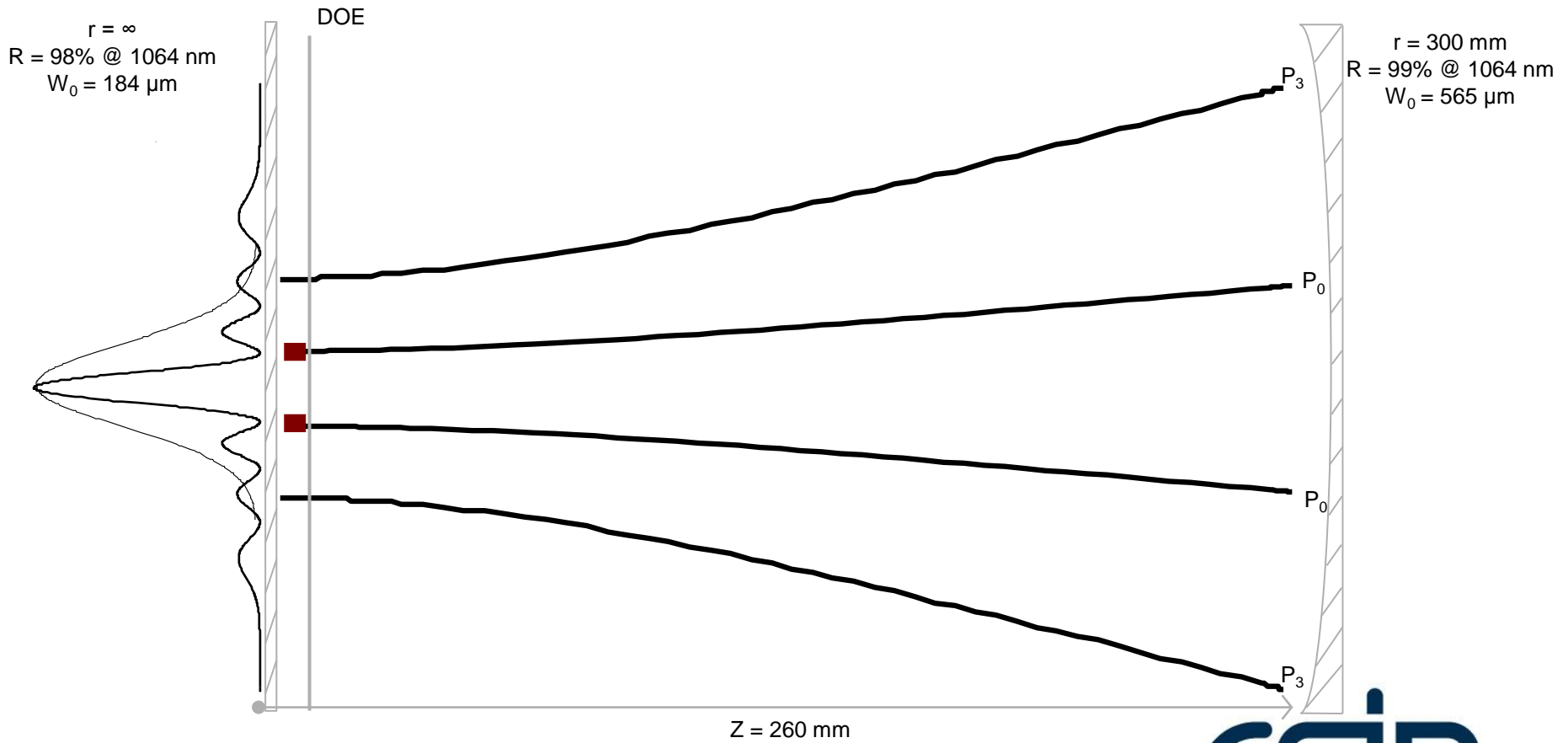


# Part 1 - Results

- Modal Decomposition of  $LG_{p0}$

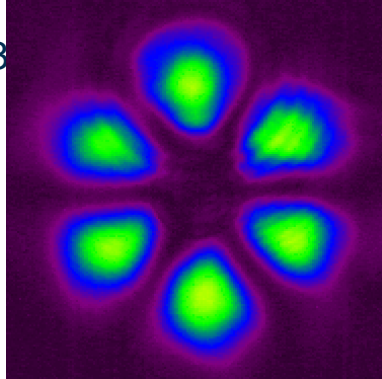


# Part 2 – Concept

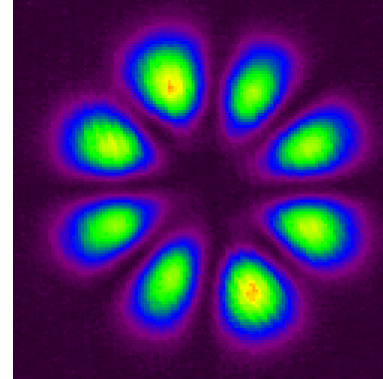


# Part 2 - Results

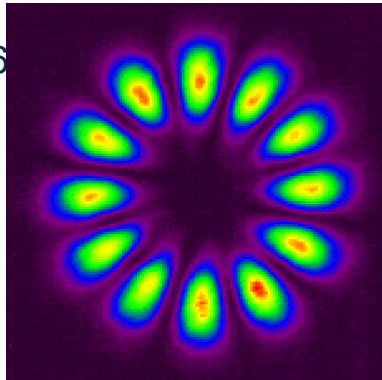
•  $LG_{0\pm3}$



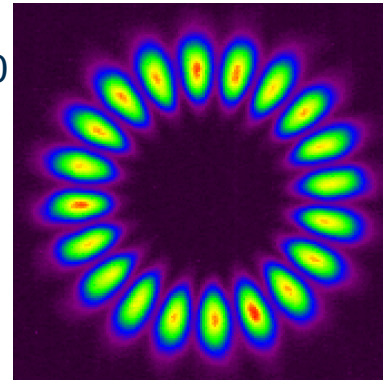
•  $LG_{0\pm4}$



•  $LG_{0\pm6}$



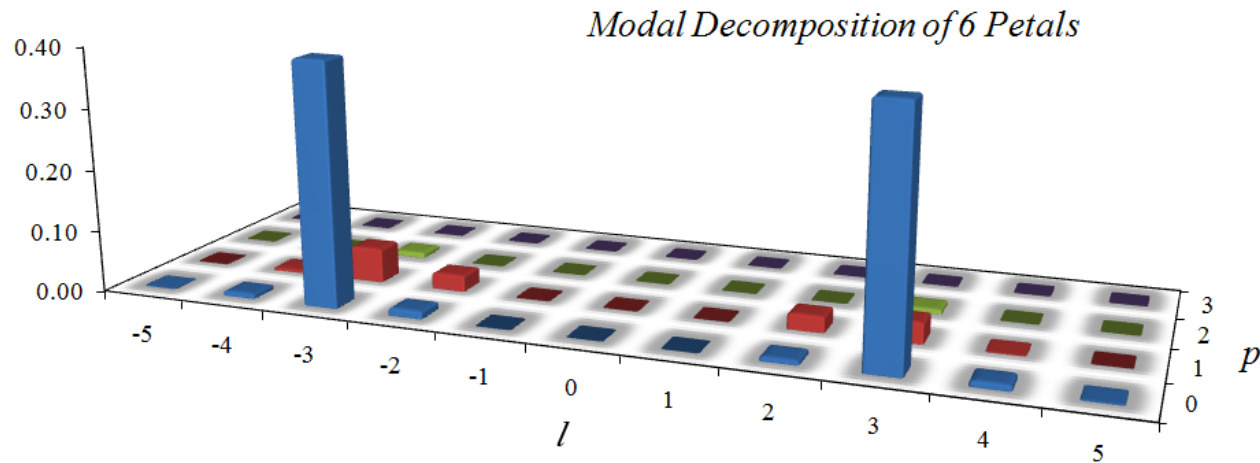
•  $LG_{0\pm10}$





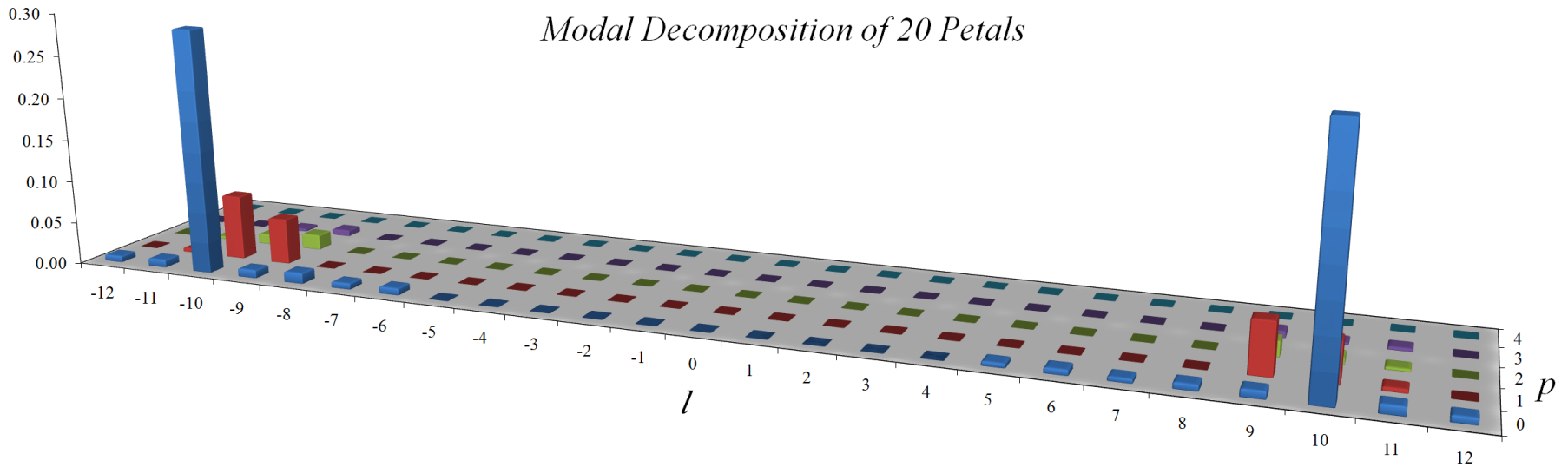
# Part 2 - Results

- Modal Decomposition of 6 petals  $LG_{0\pm 3}$



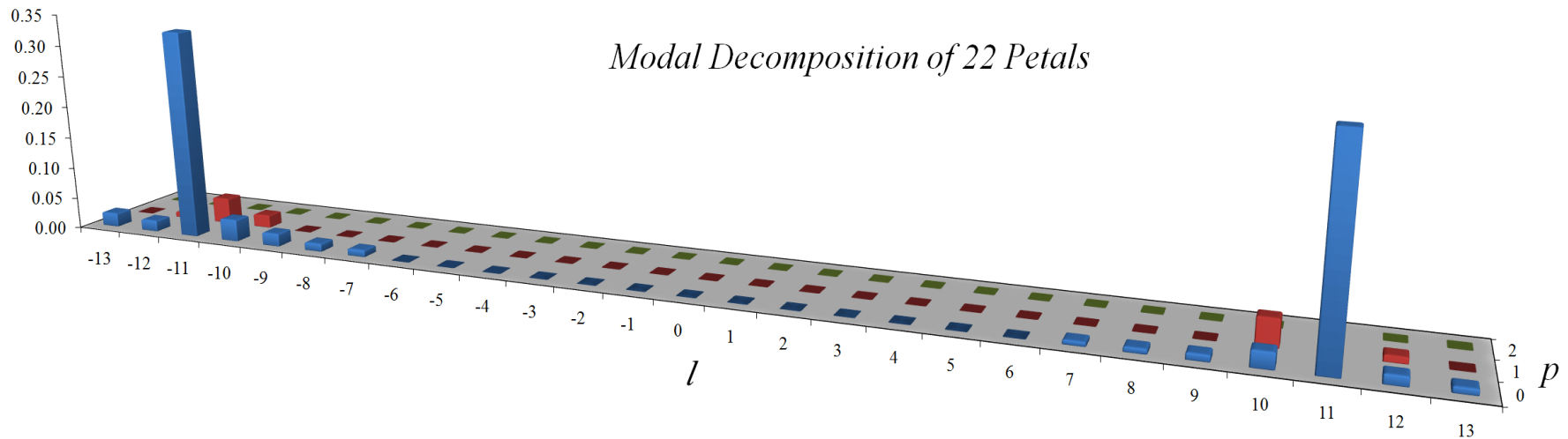
# Part 2 - Results

- Modal Decomposition of 20 petals  $LG_{0\pm 10}$



# Part 2 - Results

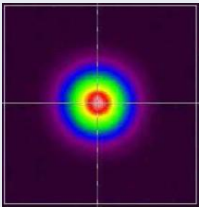
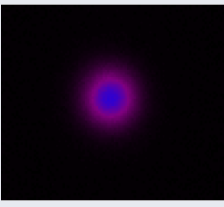
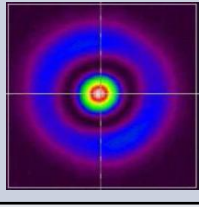
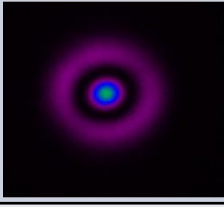
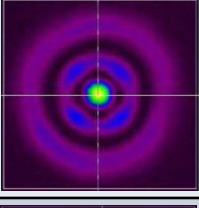
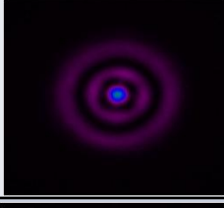
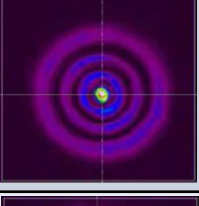

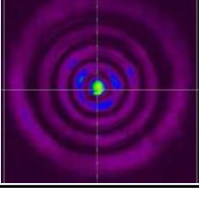
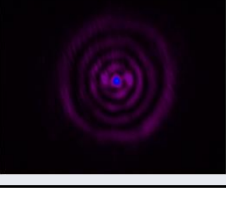
- Modal Decomposition of 22 petals  $LG_{0\pm 11}$



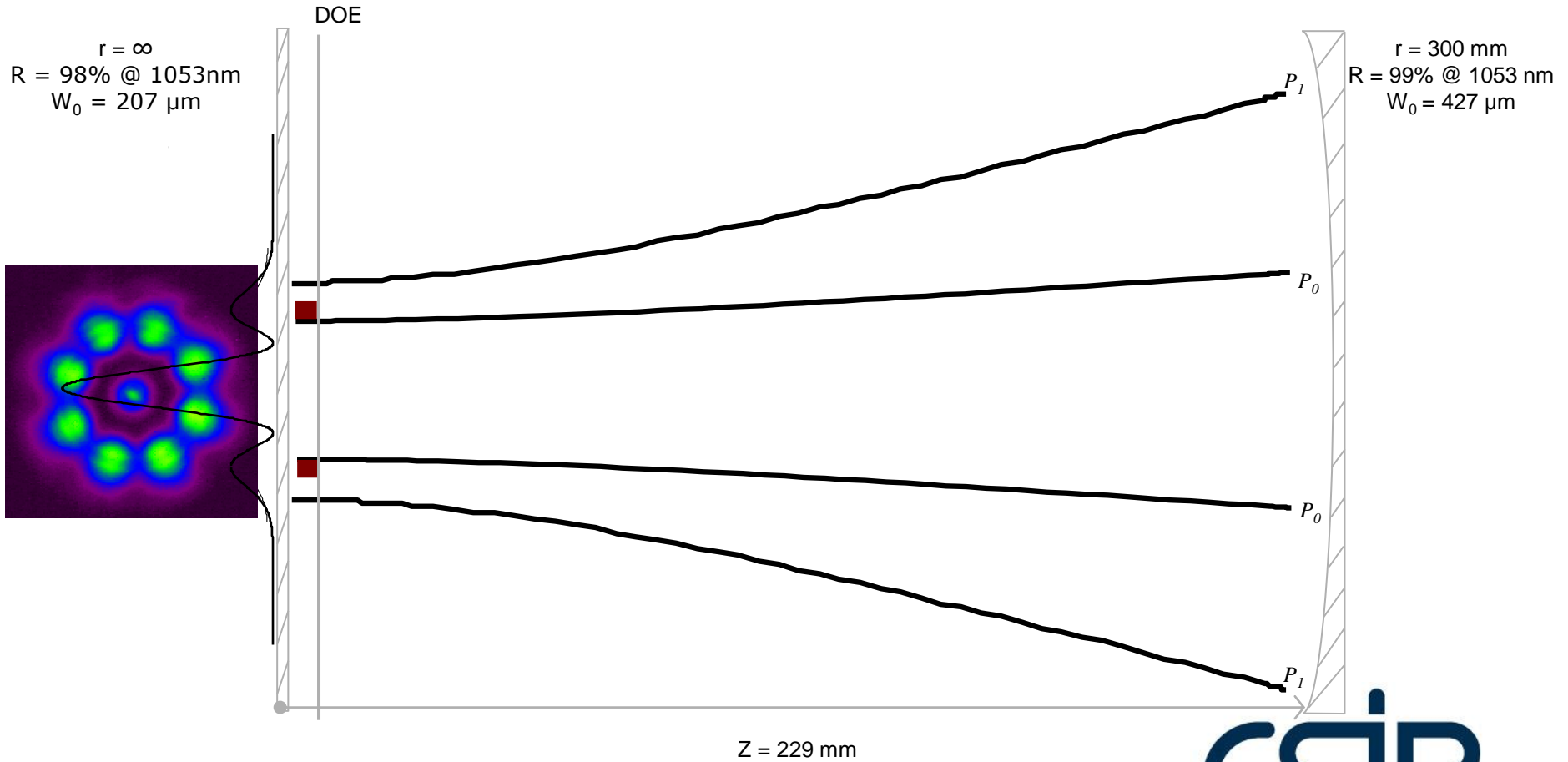
# Part 3 - Concept



# Part 3 - Results

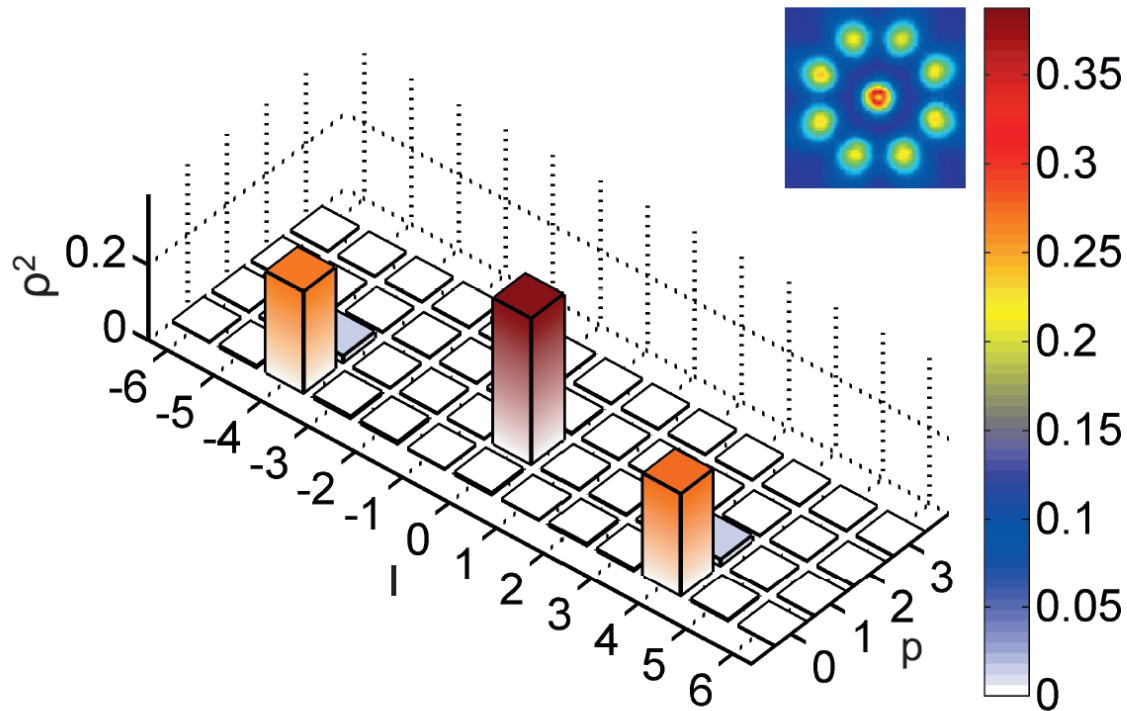
P	Near Field Beam Shape	Cavity Length (mm)	Beam Diameter on Flat Mirror			M <sup>2</sup>			Far Field Beam Shape
			Measured (um)	Calculated (um)	Difference (%)	Measured	Calculated	Difference (%)	
0		277	331	328	1	1.0	1.1	10	
1		220	1450	1420	2	3.0	3.2	5	
2		185	992	993	0.1	5.0	5.3	5	
3		277	911	868	5	7.0	7.2	3	
4		290	801	804	0.4	9.0	9.0	0	

# Part 4 – Concept



# Part 4 - Results

- Modal Decomposition of petals shows three modes of  $LG_{0+4}$ ,  $LG_{0-4}$  and  $LG_{10}$



# Conclusion

- Generation of high-order LG modes of different  $p$  and  $l$  combination is possible using a single ring method.
- High-order  $LG_{pl}$  modes are of high purity.

# Future Work

- Investigate further the reasons for the unexpected modes.