IMPROVED PYRAMID WAVEFRONT SENSOR USING A DIFFRACTIVE OPTICAL LAYER

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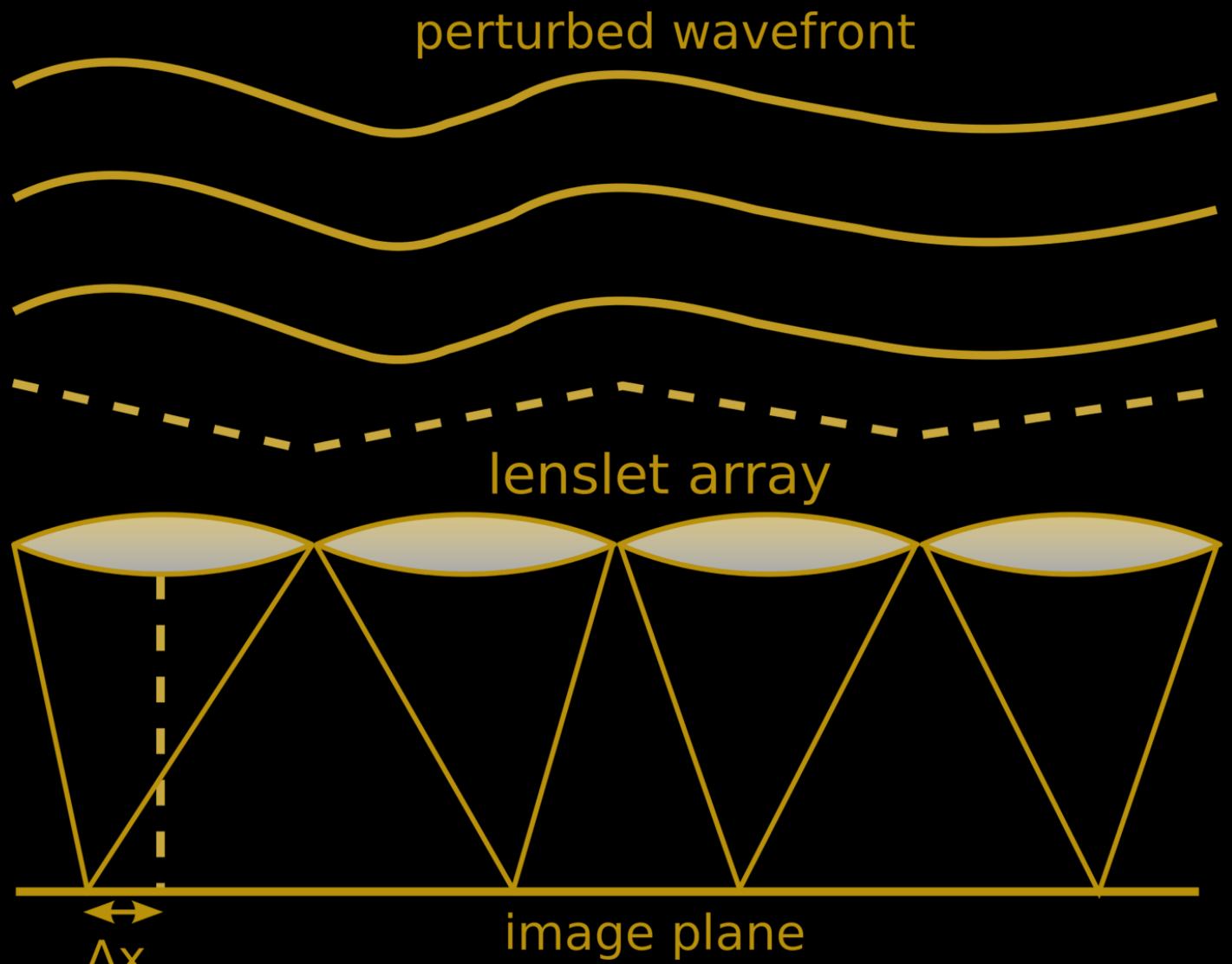
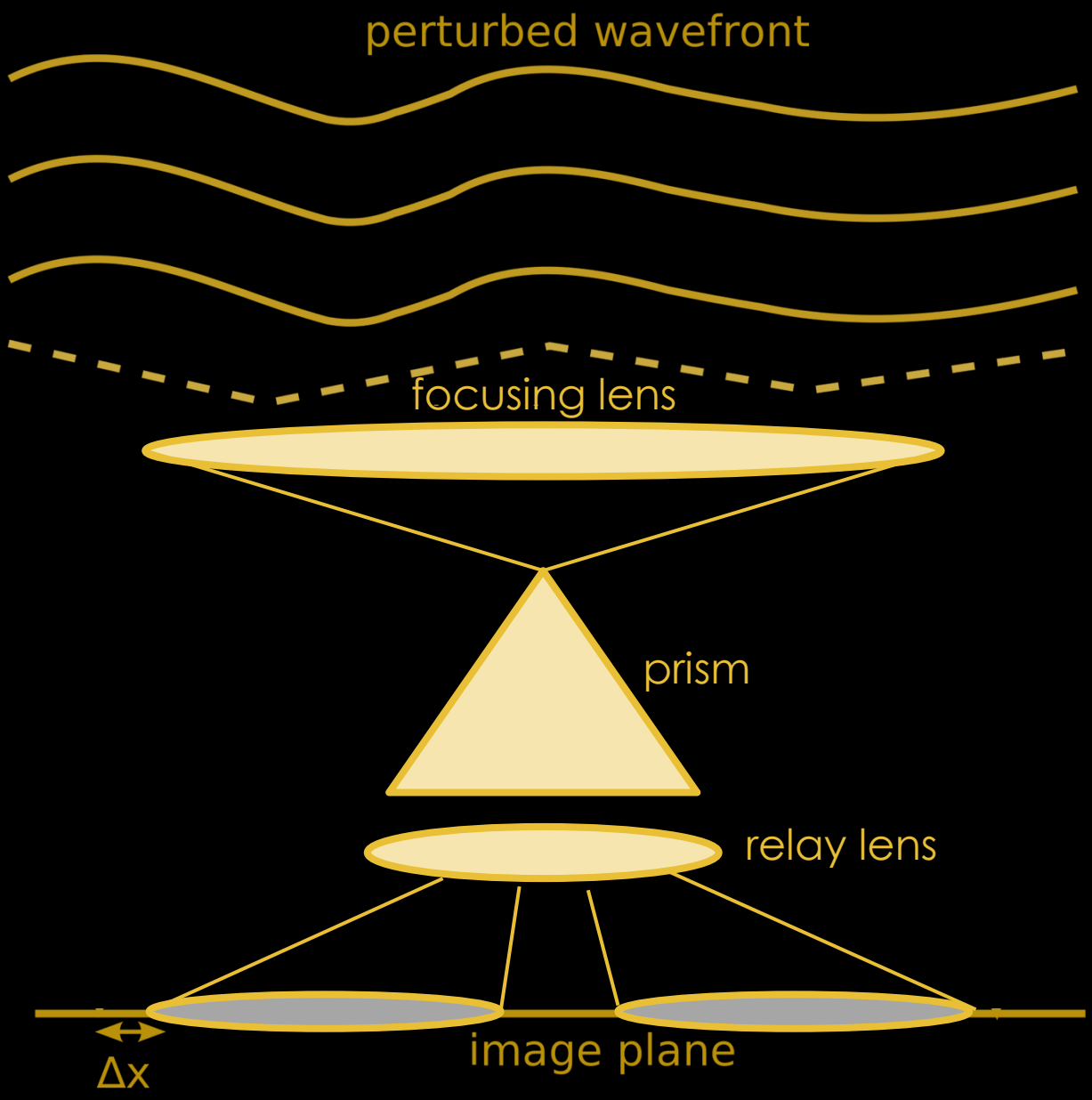
Universidad Industrial de Santander

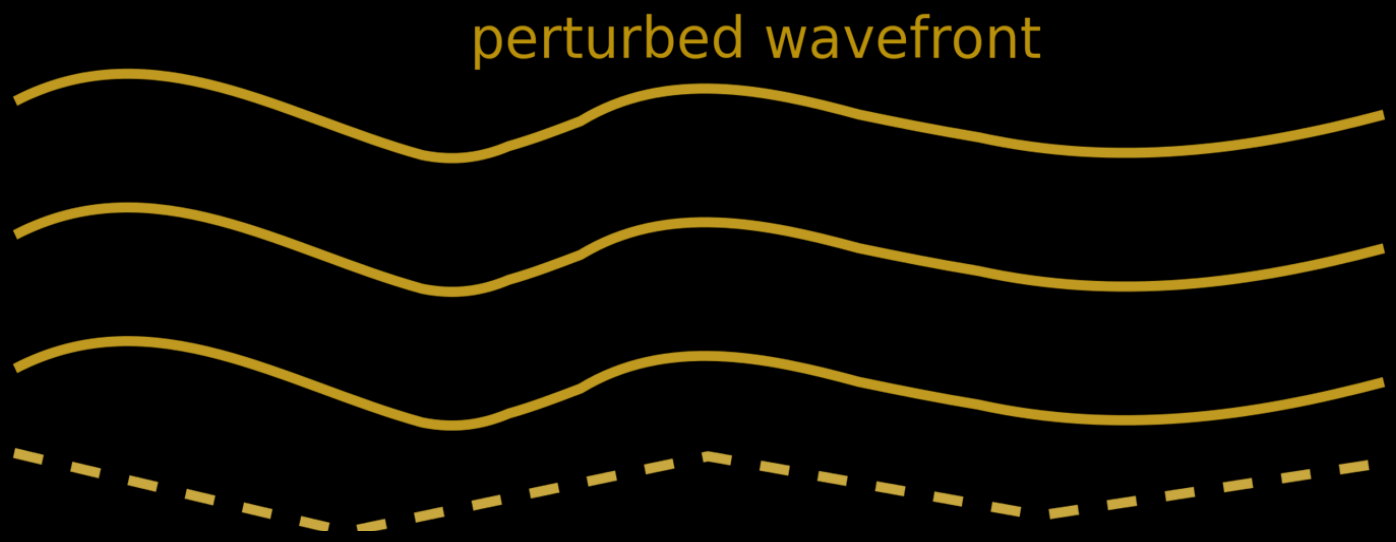
SHACK-HARTMANN WAVEFRONT SENSOR



PYRAMID WAVEFRONT SENSOR



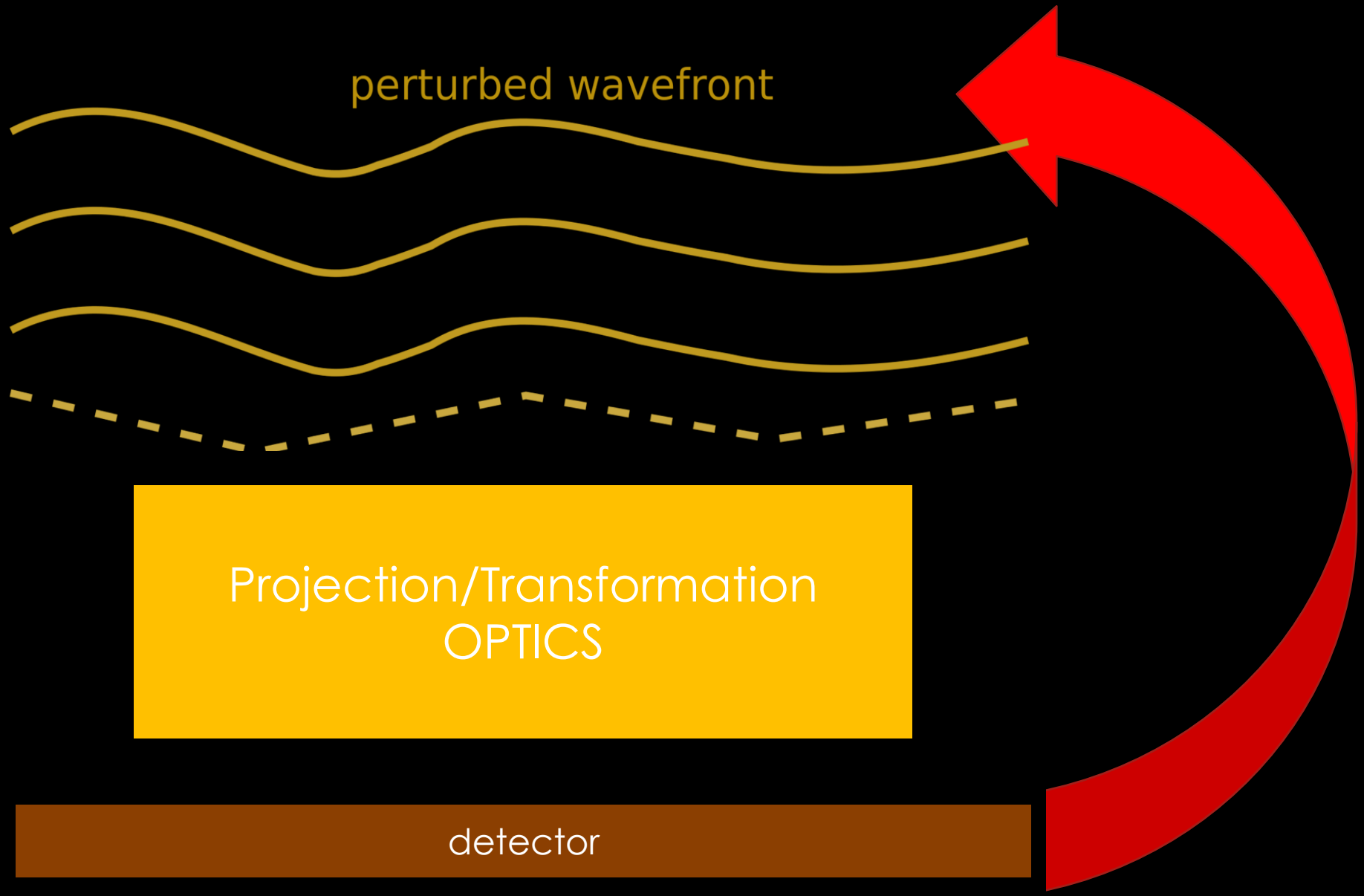
WAVEFRONT SENSING



Projection/Transformation
OPTICS

detector

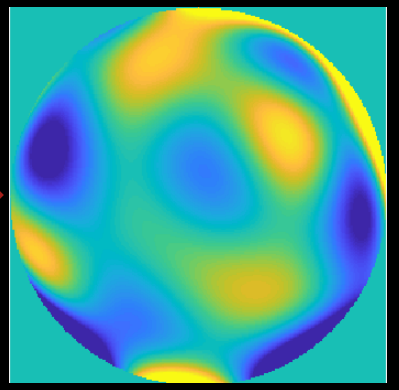
WAVEFRONT SENSING



WAVEFRONT ESTIMATION

WFS MEASUREMENT

INVERSE PROBLEM MODEL



ESTIMATION

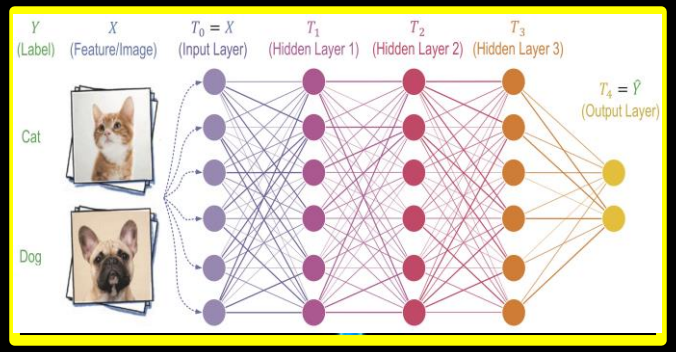
WAVEFRONT ESTIMATION

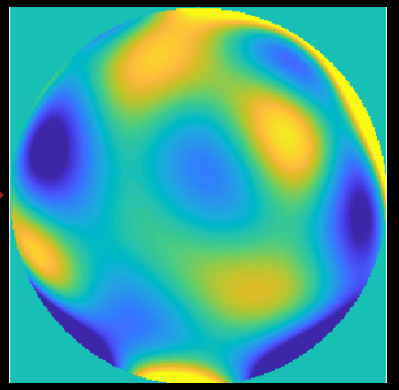
WFS MEASUREMENT

ESTIMATION

WAVEFRONT ESTIMATION

DEEP NEURAL NETWORK

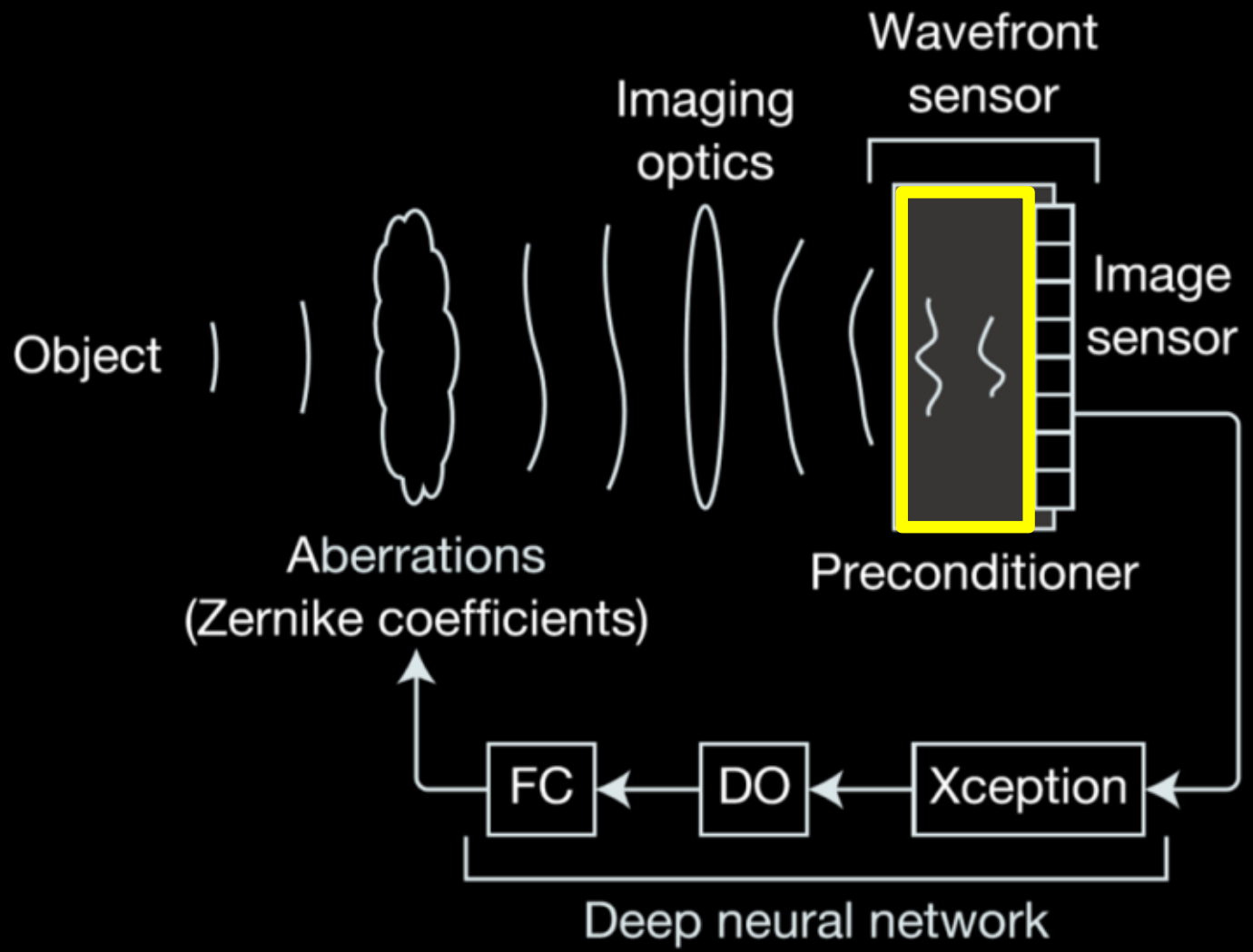




WFS MEASUREMENT

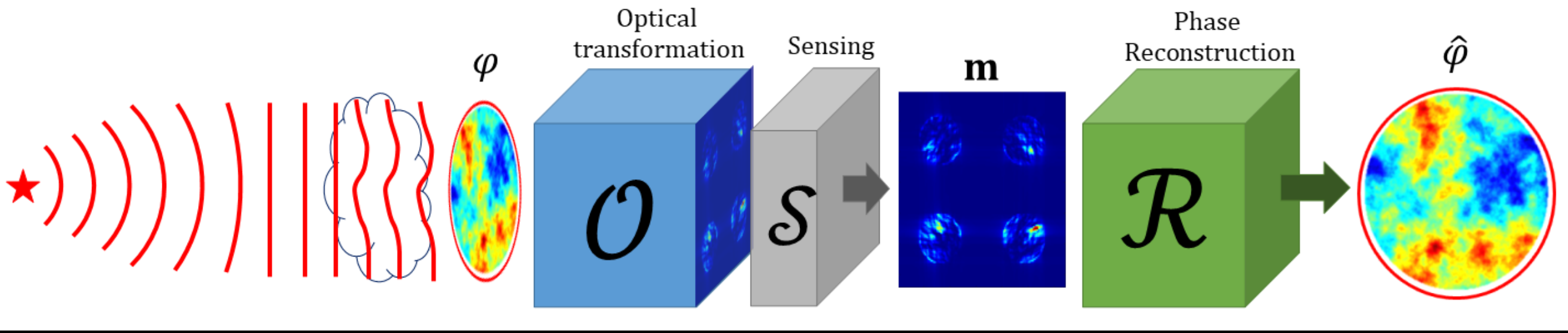
ESTIMATION

DEEP LEARNING WAVEFRONT SENSOR



Y. Nishizaki, M. Valdivia, R. Horisaki, K. Kitaguchi, M. Saito, J. Tanida, and E. Vera, "Deep learning wavefront sensing," Optics Express 27, 240-251 (2019).

GENERALIZED WFS



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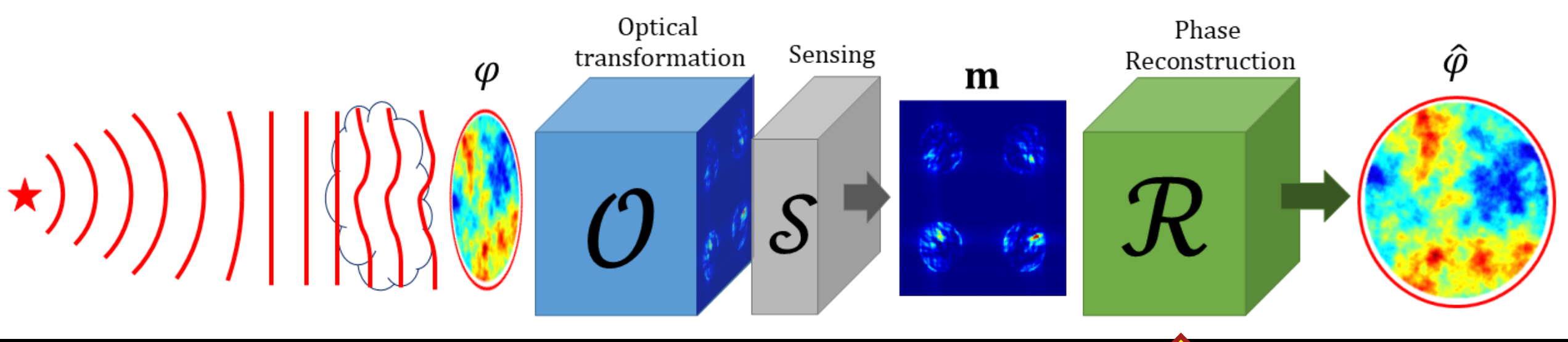
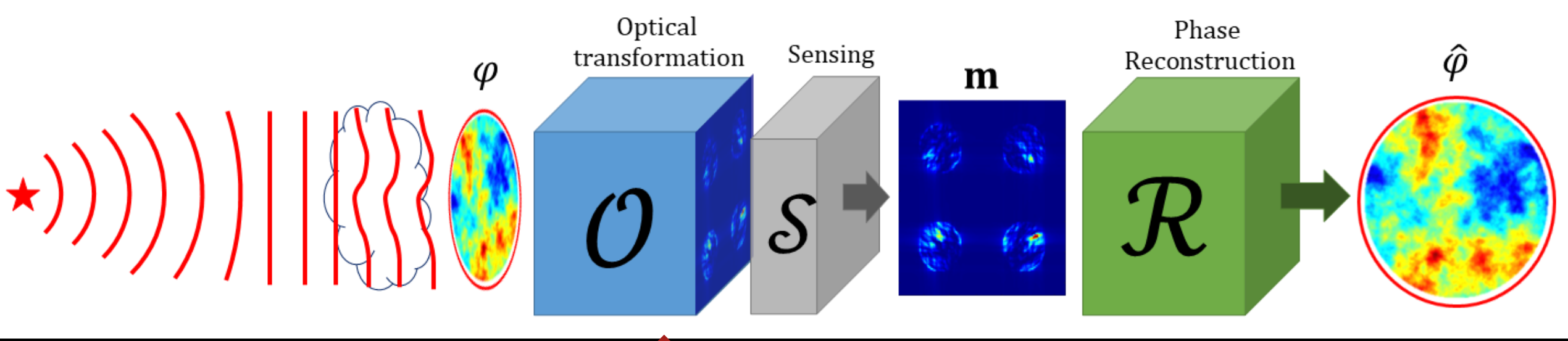


1

GENERALIZED WFS



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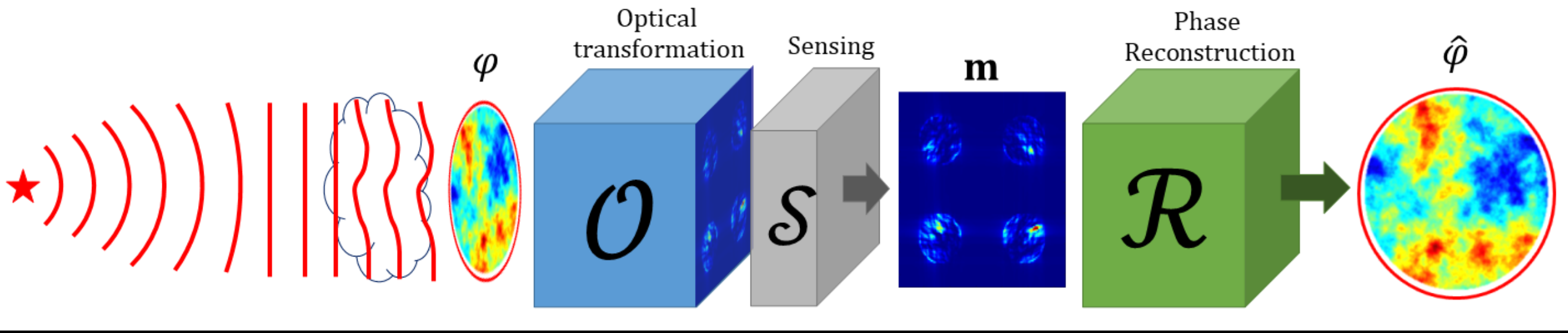
GENERALIZED WFS



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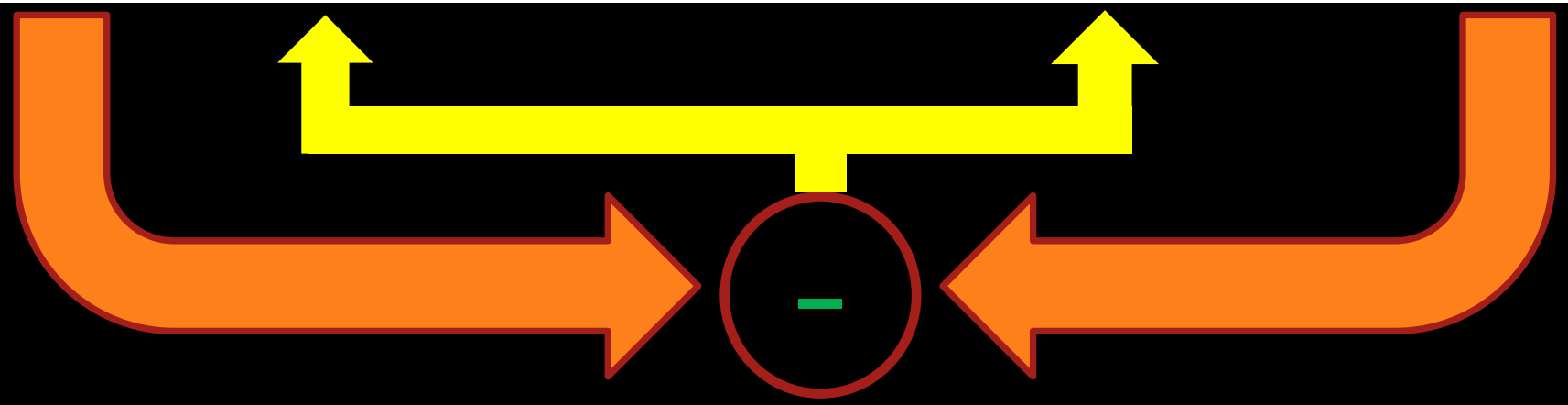
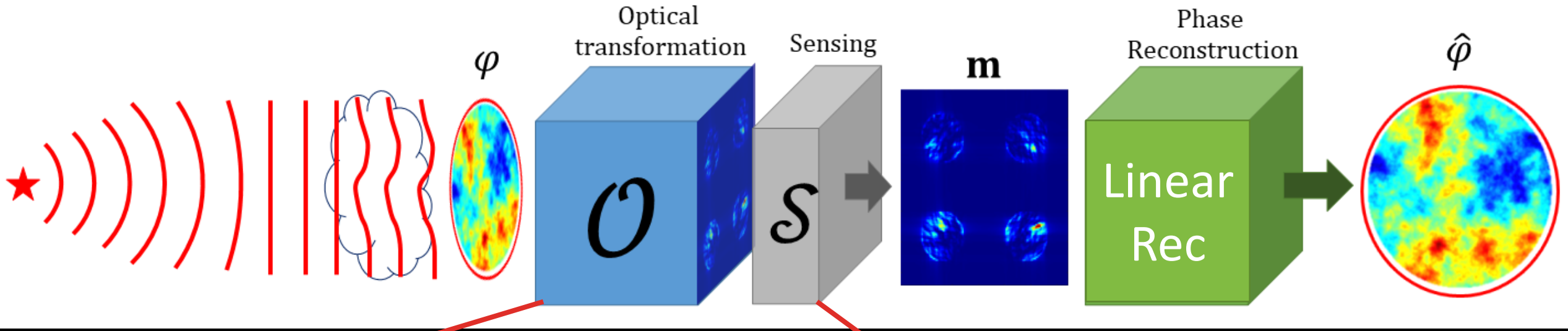
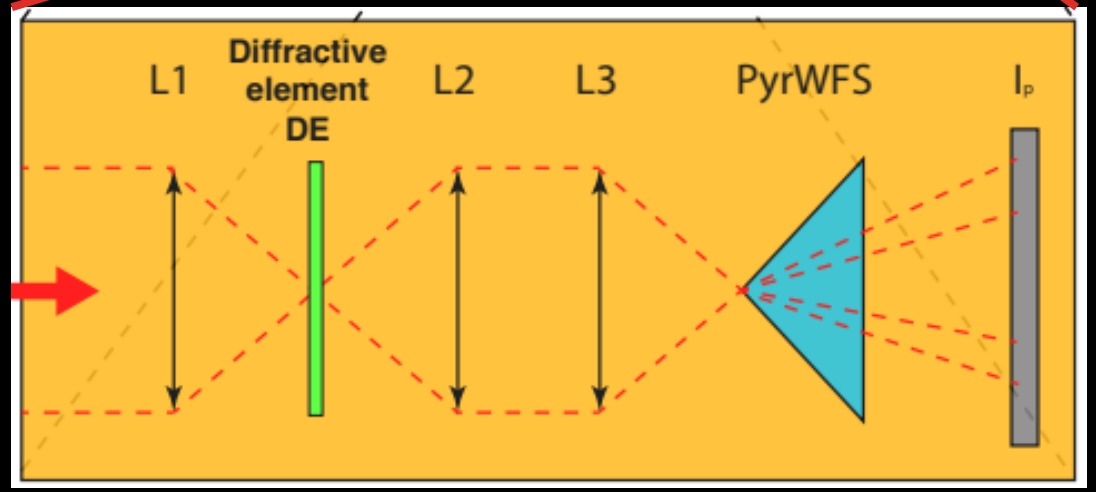
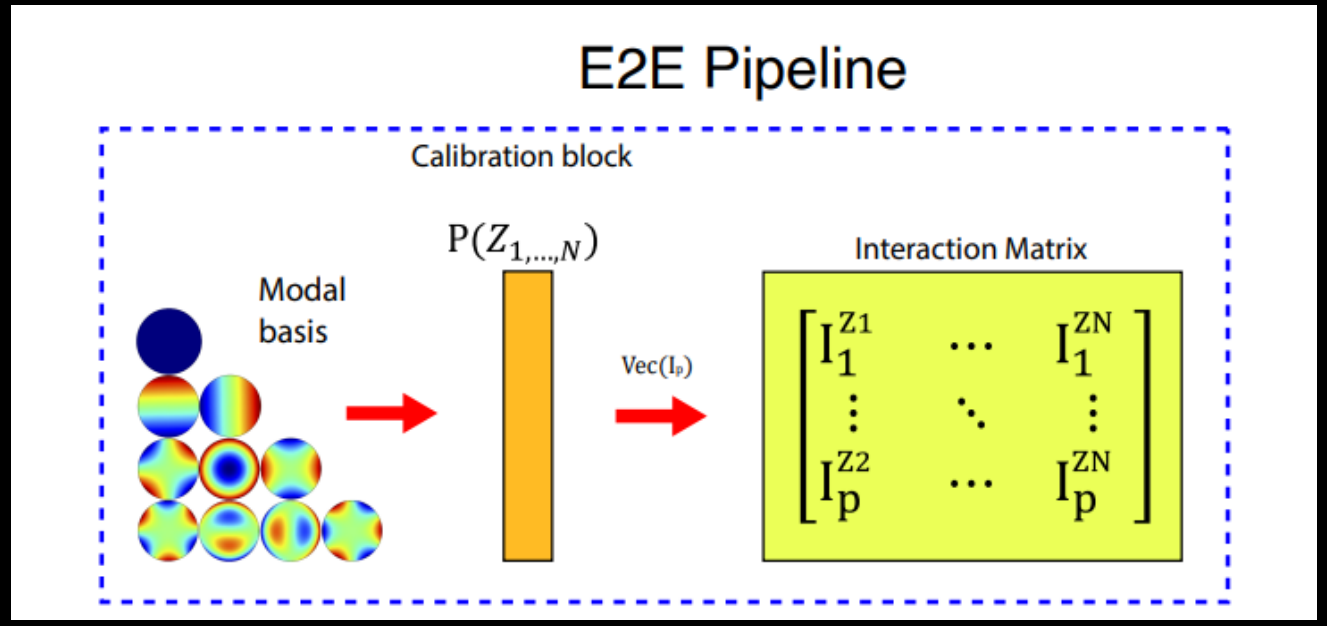


GENERALIZED PWFS





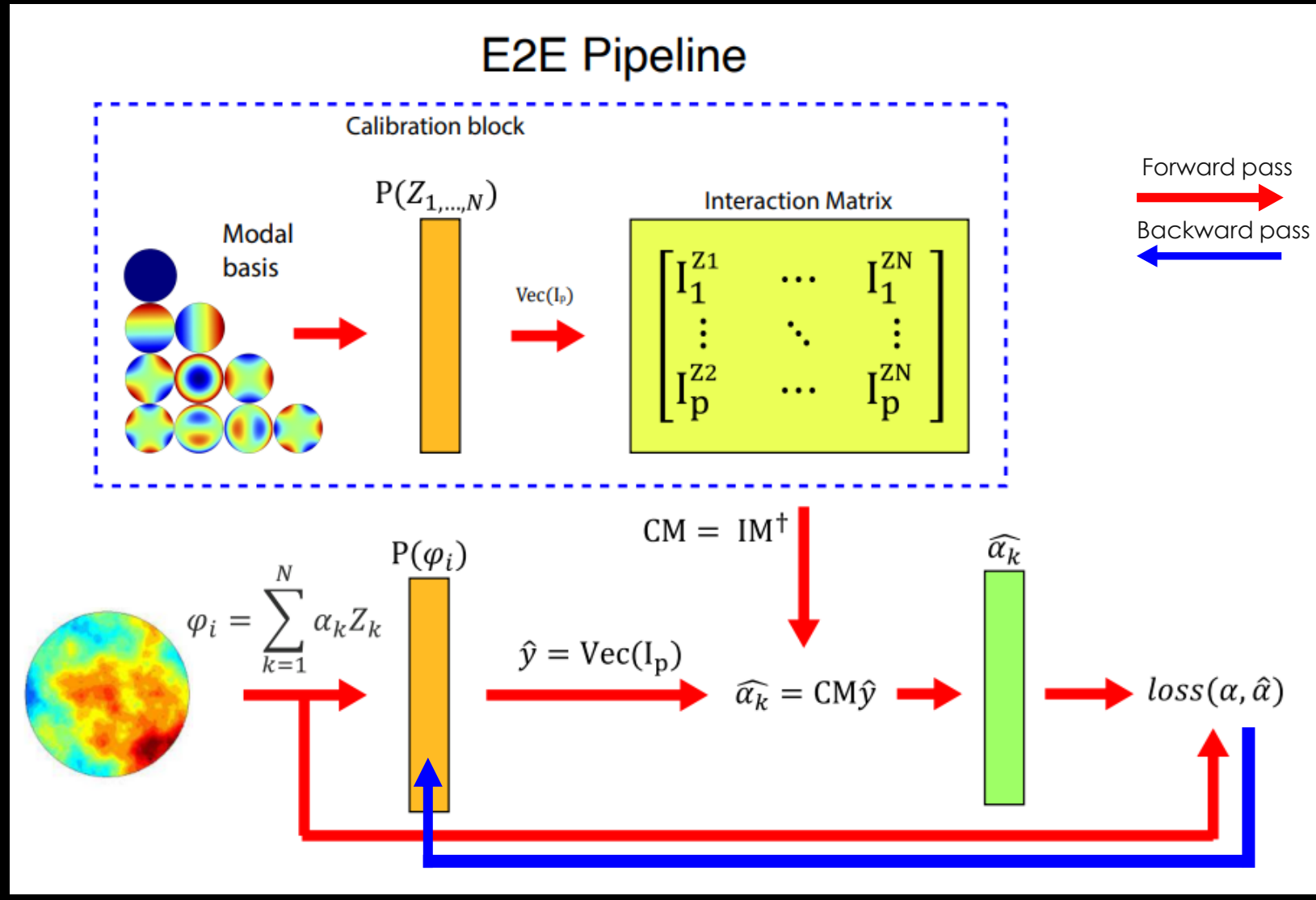
END-TO-END TRAINING FOR THE IMPROVED PWFS



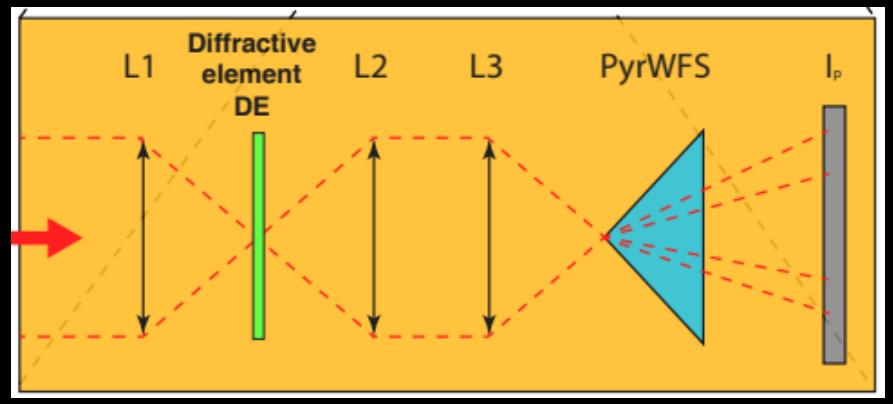
END-TO-END TRAINING FOR THE IMPROVED PWFS

Incoming wavefront

φ_i

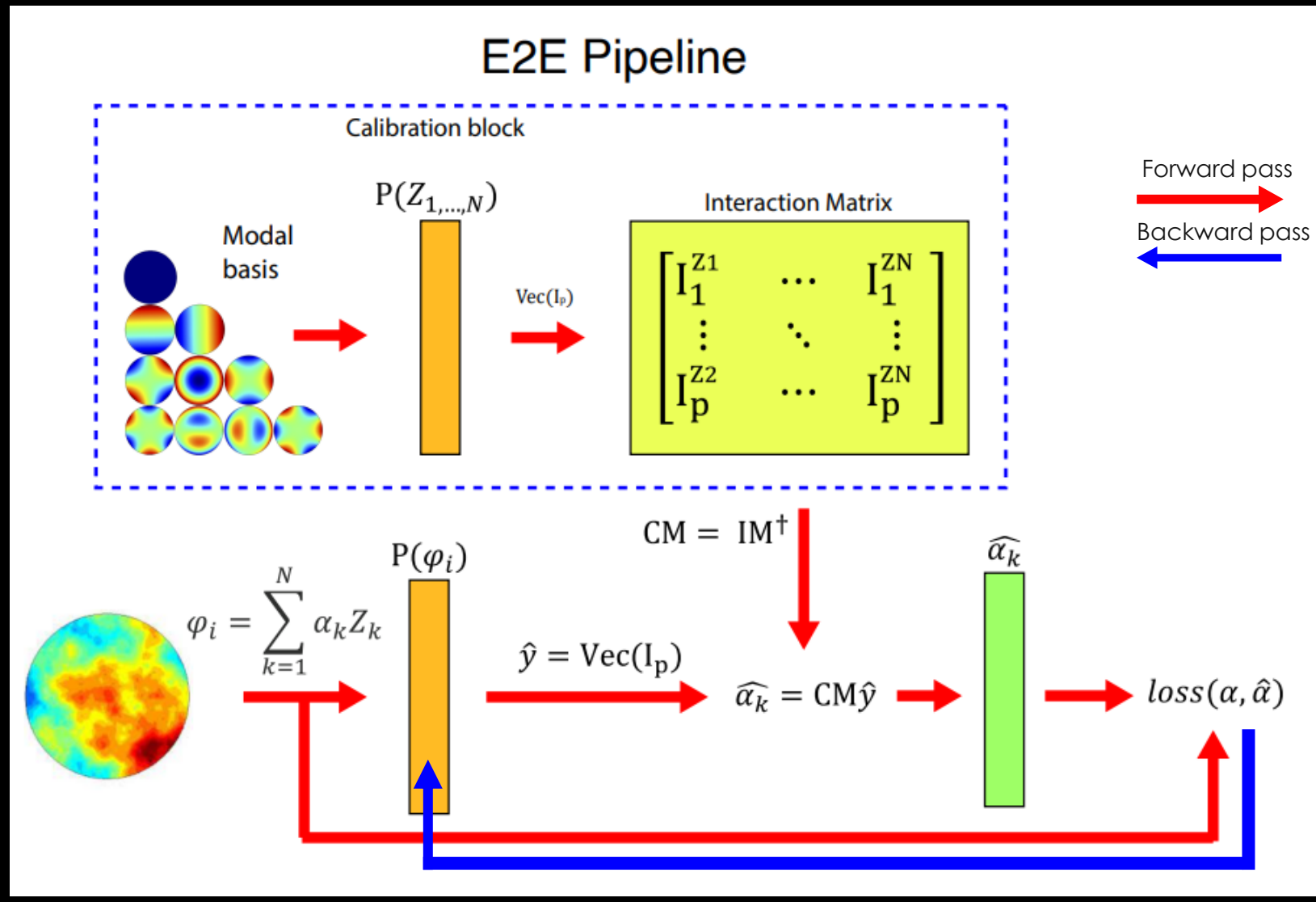


END-TO-END TRAINING FOR THE IMPROVED PWFS

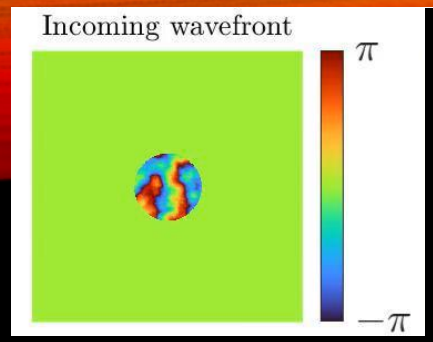


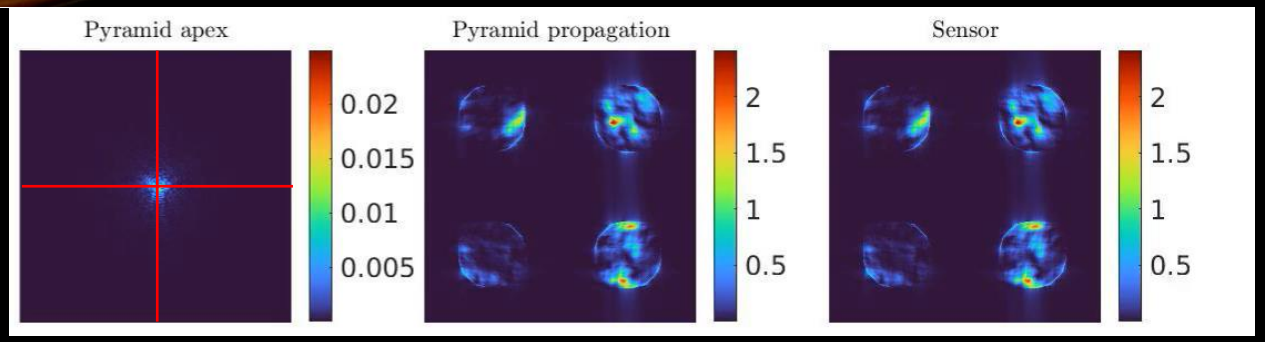
Incoming wavefront

φ_i



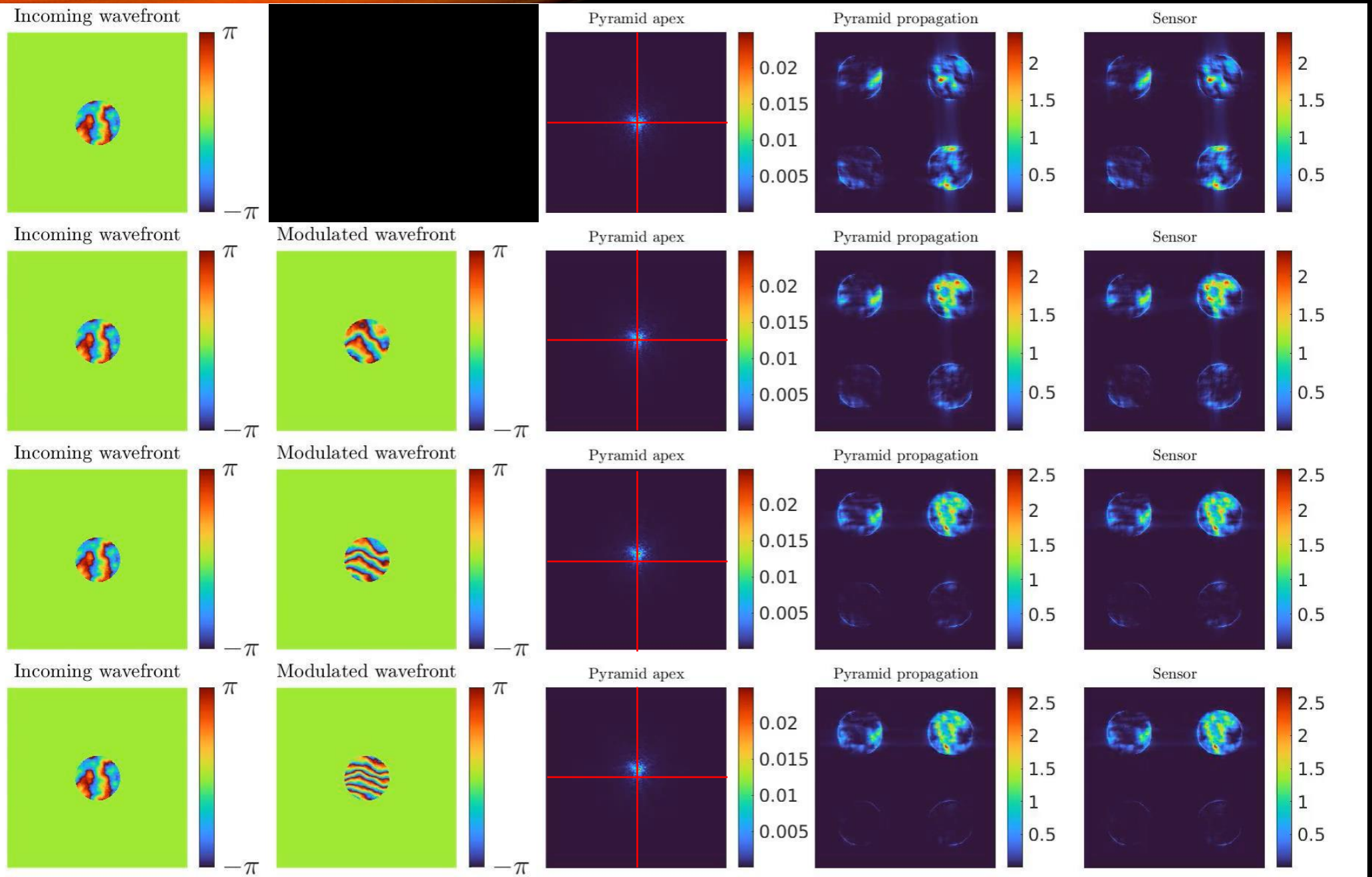
PWFS SIMULATION





Unmodulated

PWFS SIMULATION



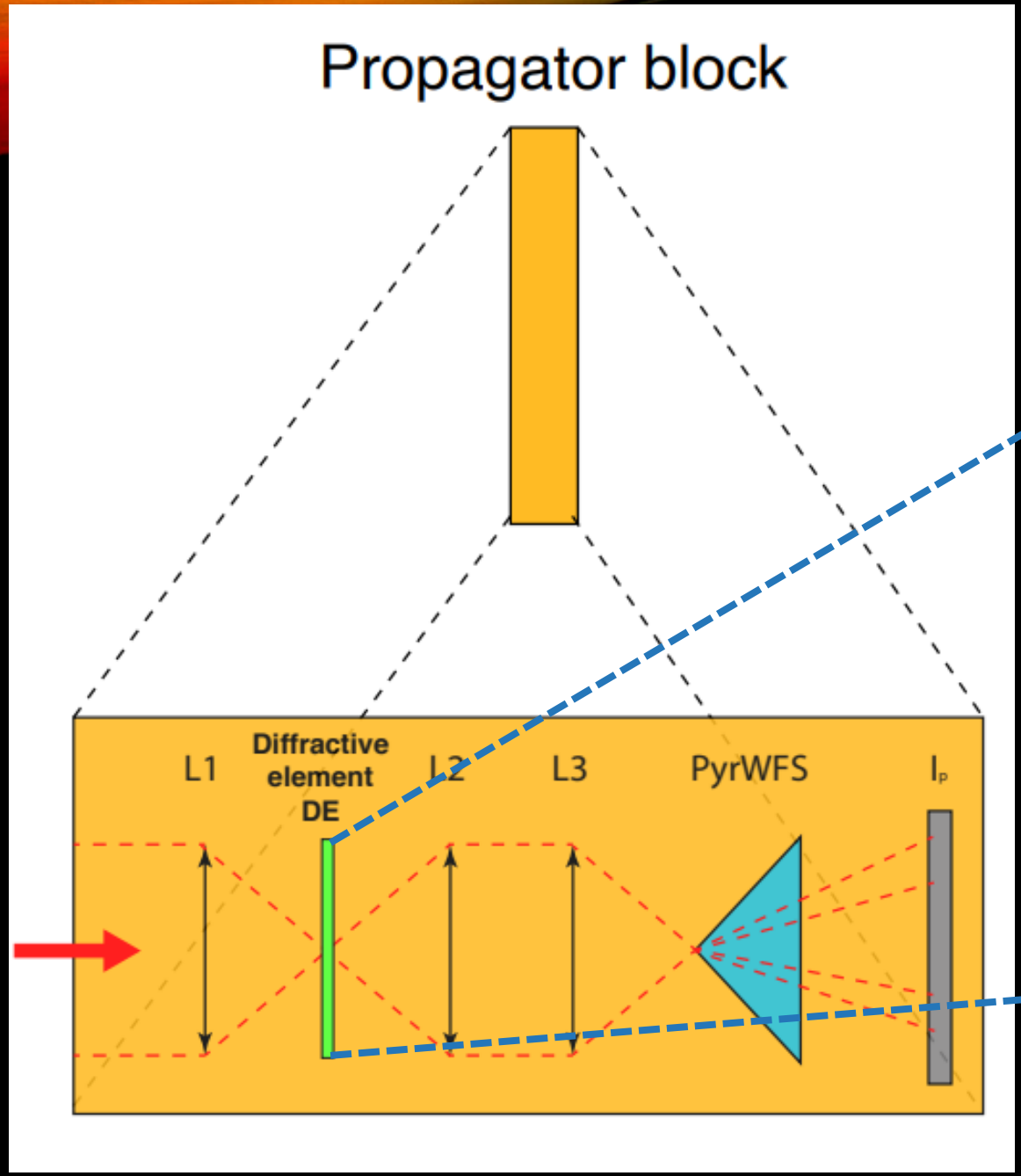
Unmodulated

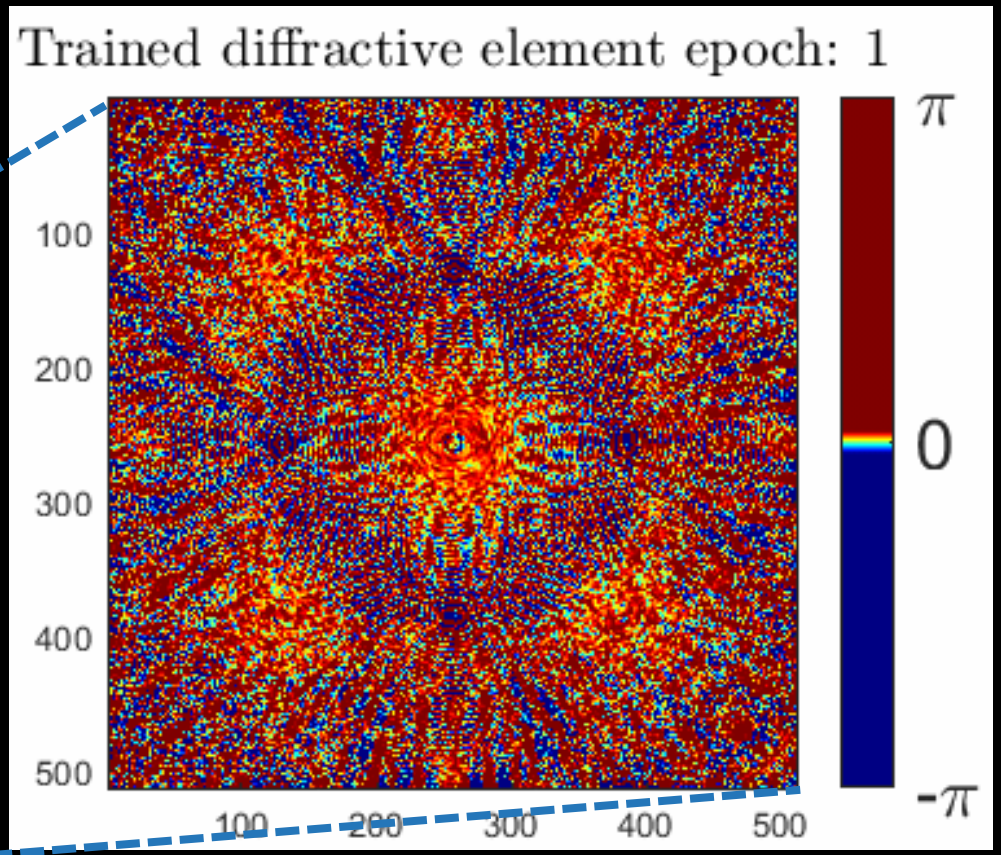
Mod = 2

Mod = 4

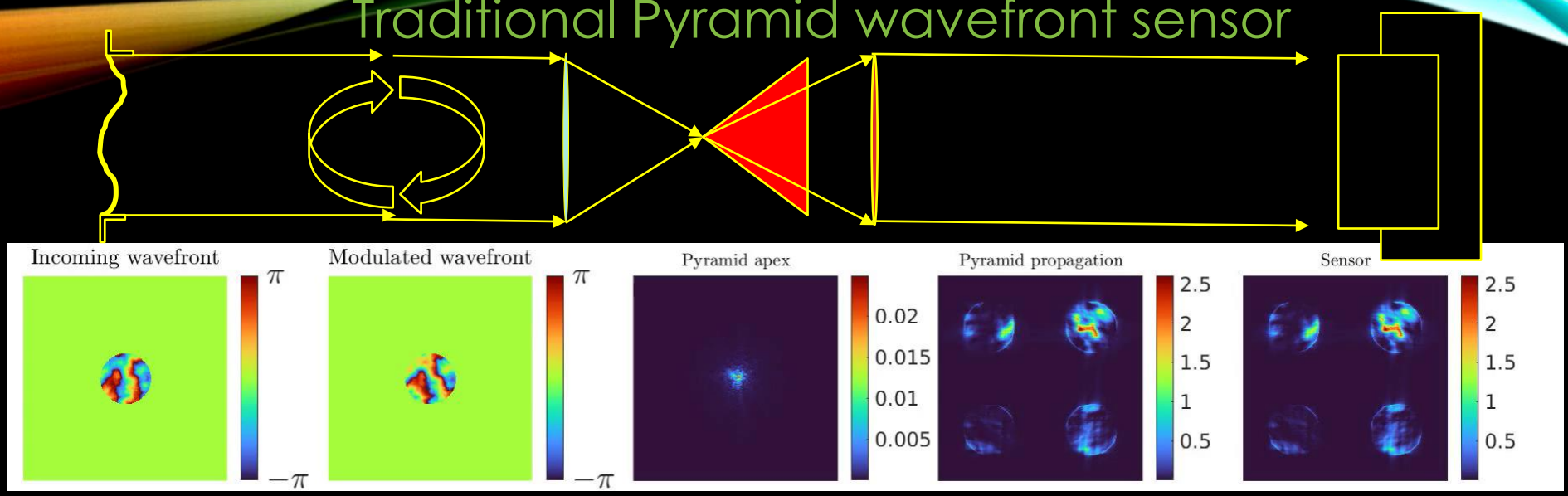
Mod = 6

END-TO-END TRAINING

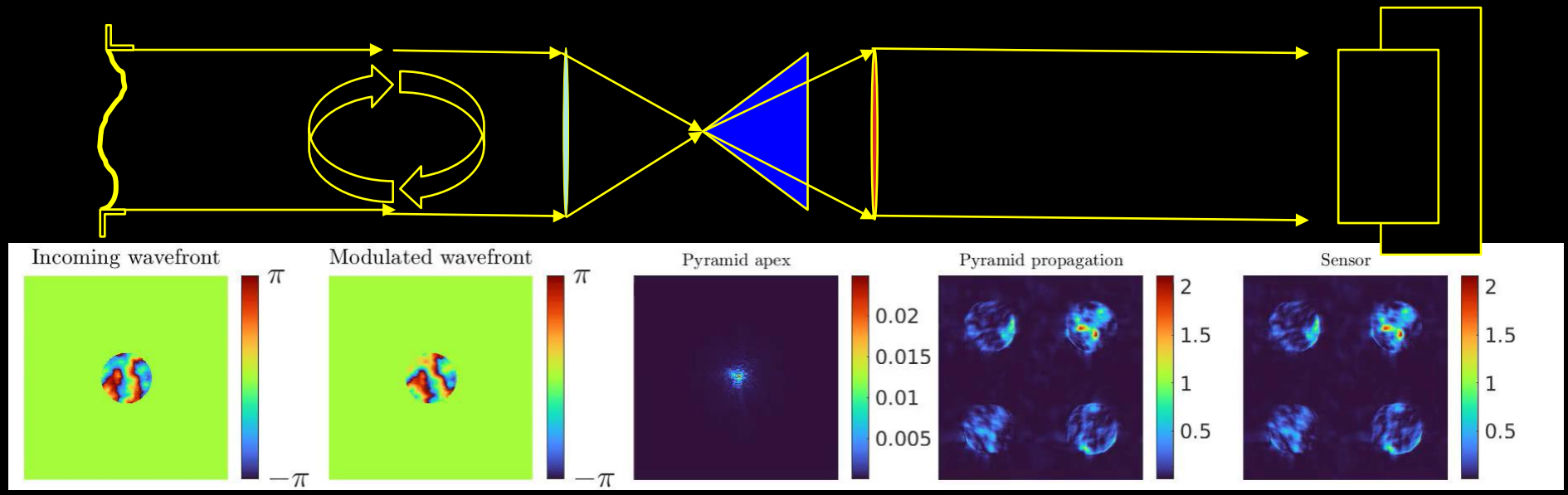




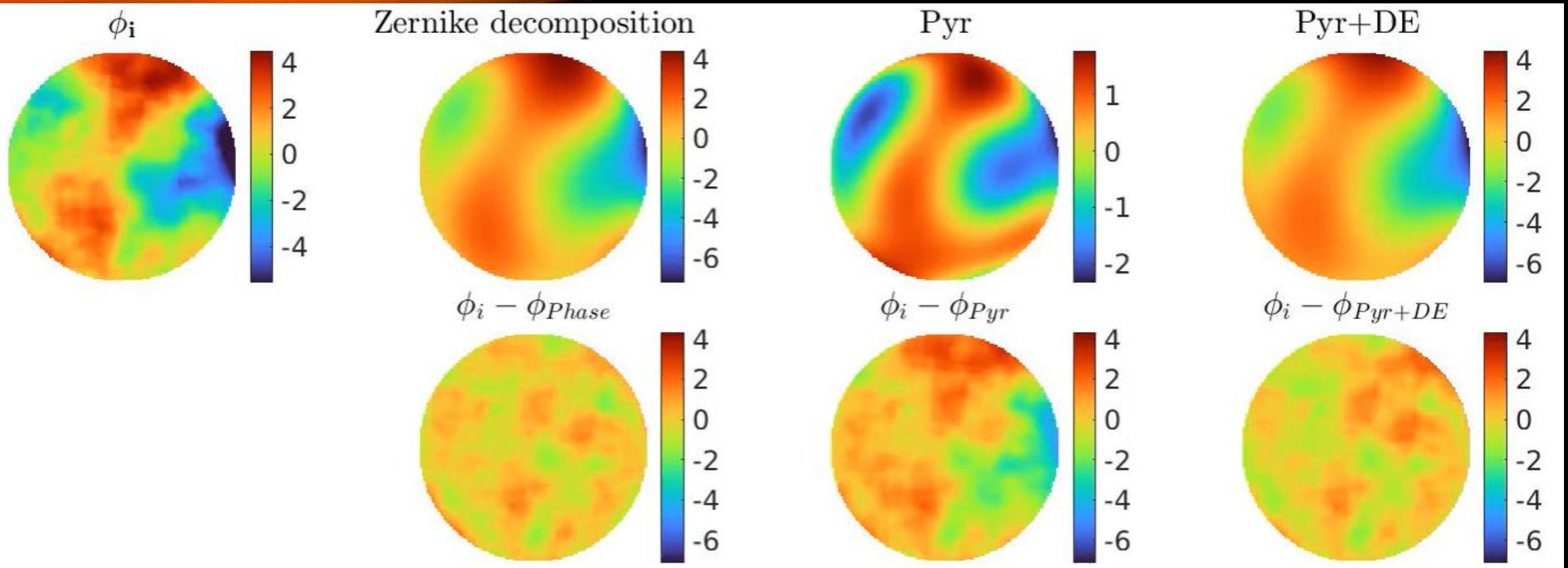
Traditional Pyramid wavefront sensor

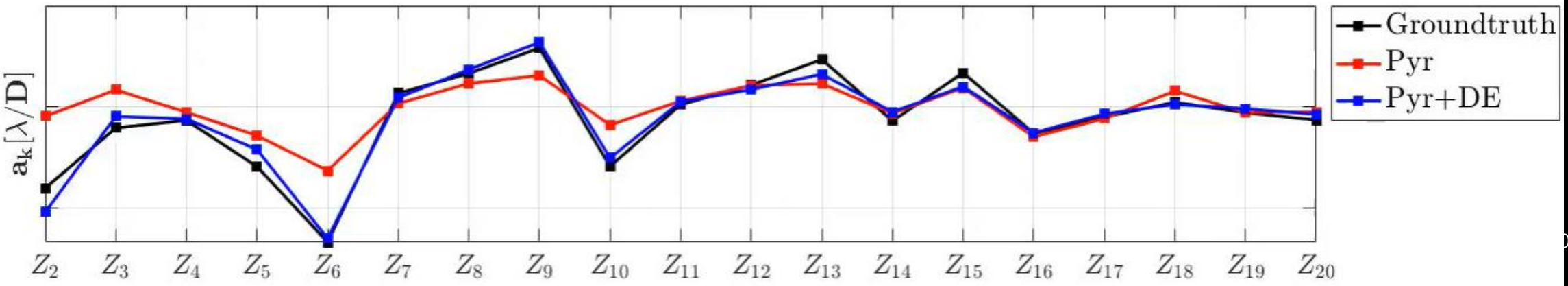


Preconditioned Pyramid wavefront sensor

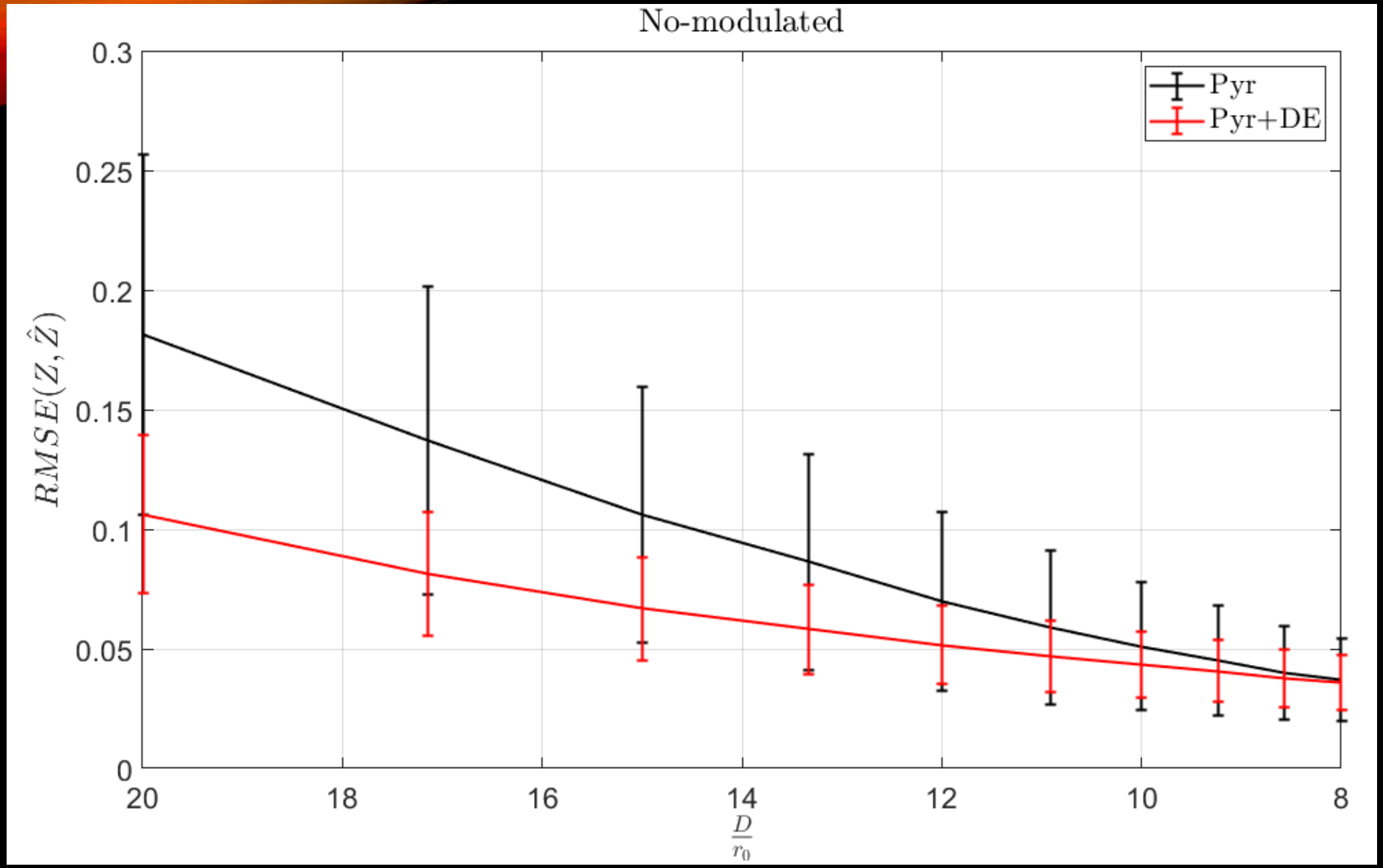


SIMULATION RESULTS

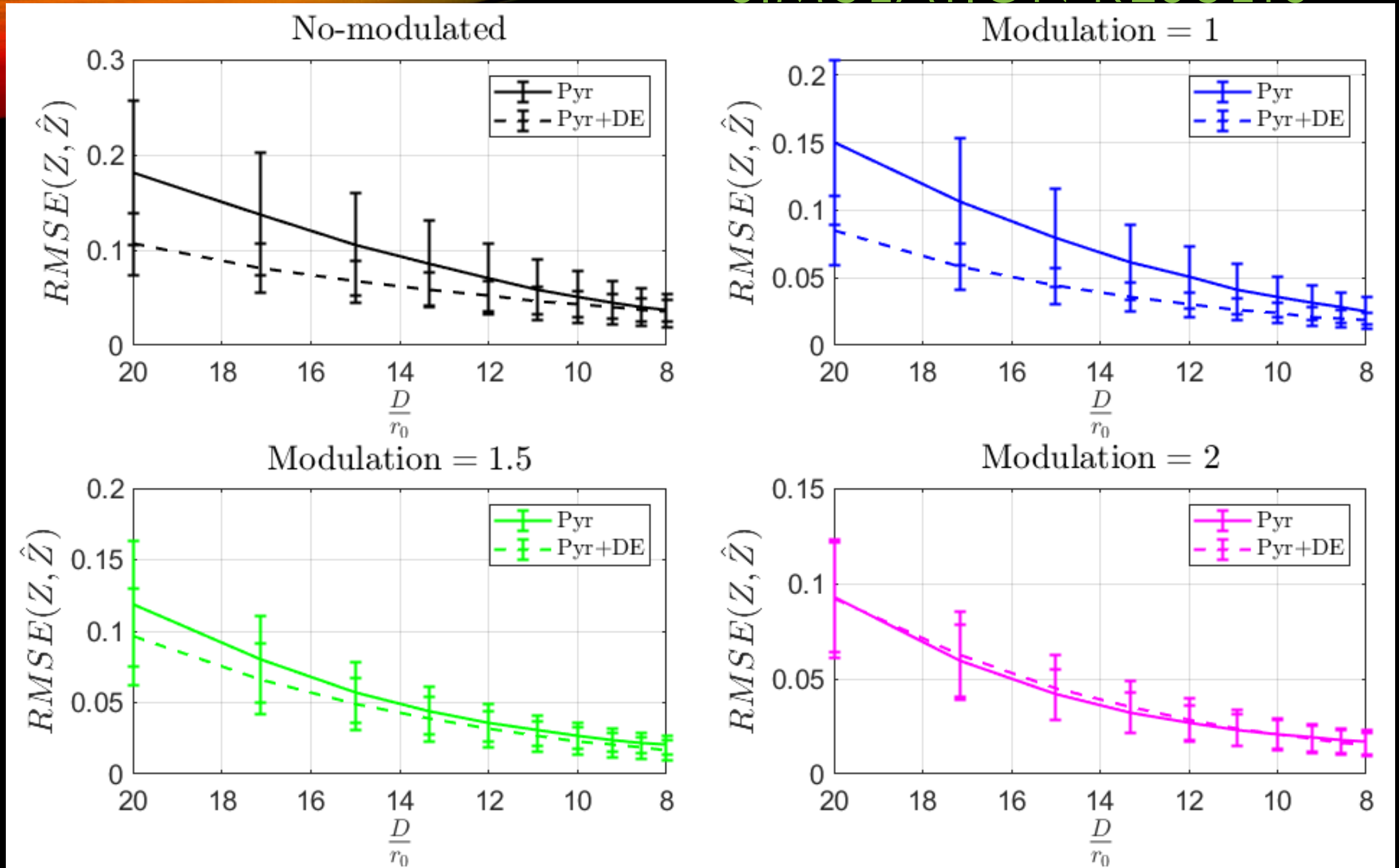




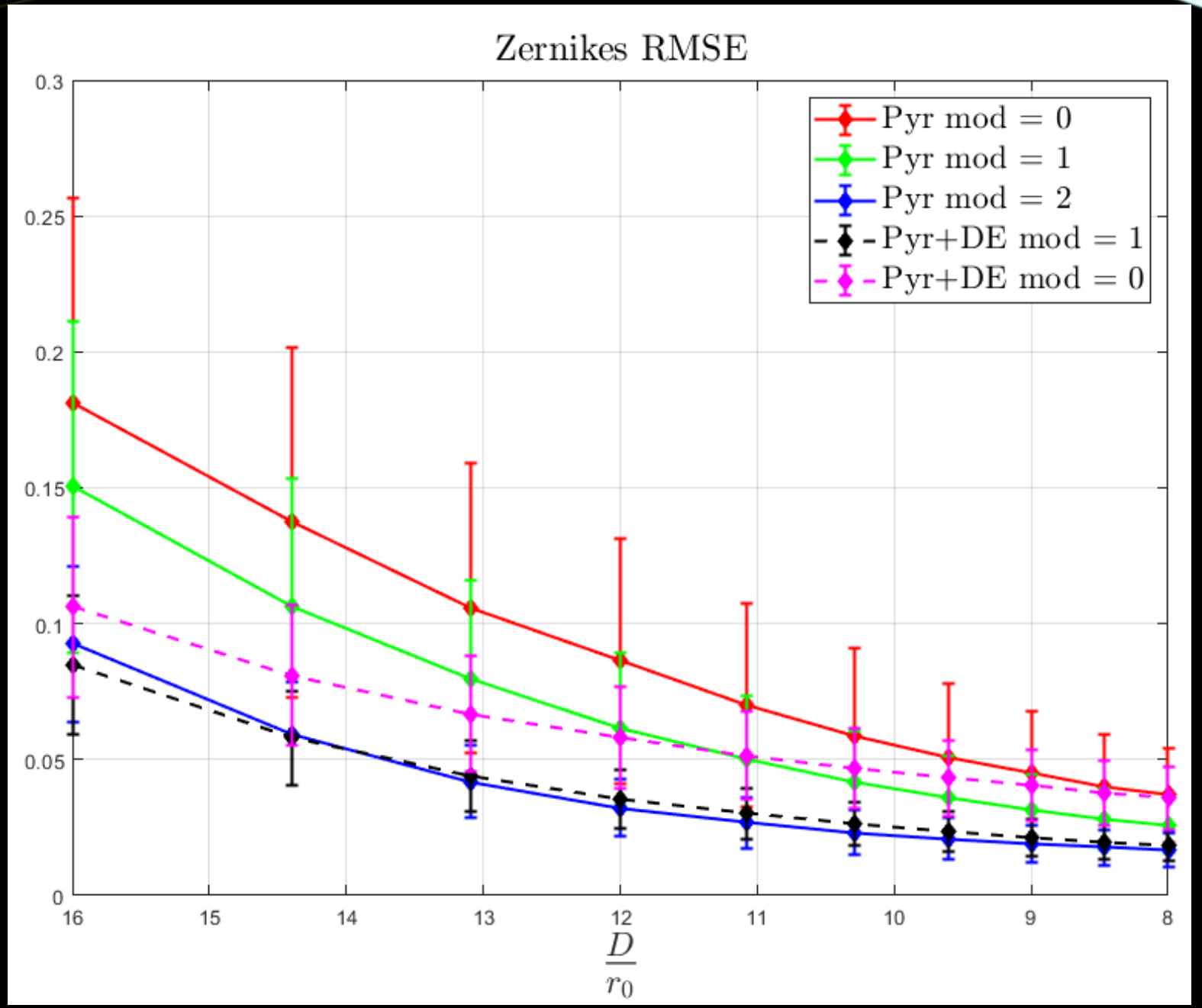
SIMULATION RESULTS



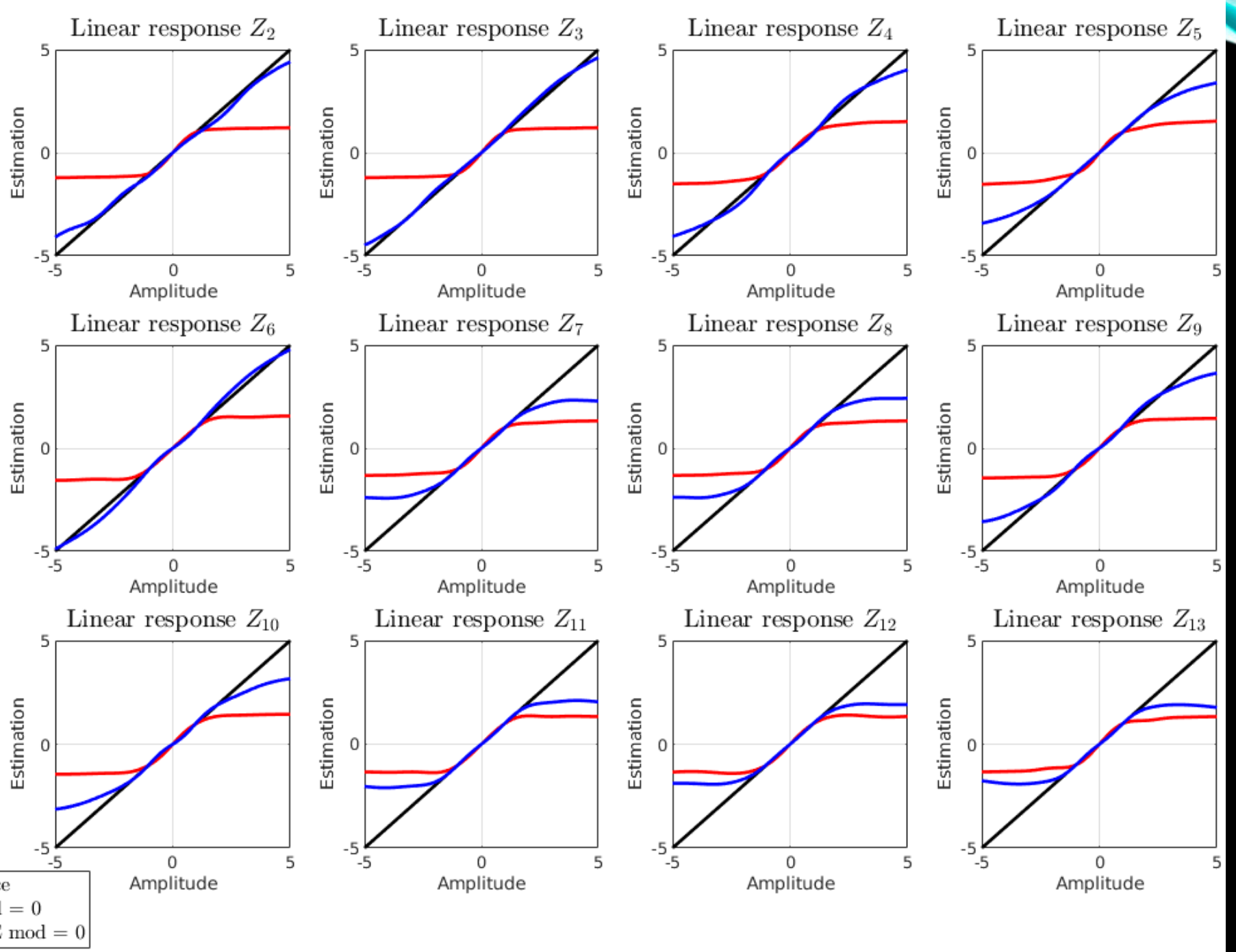
SIMULATION RESULTS



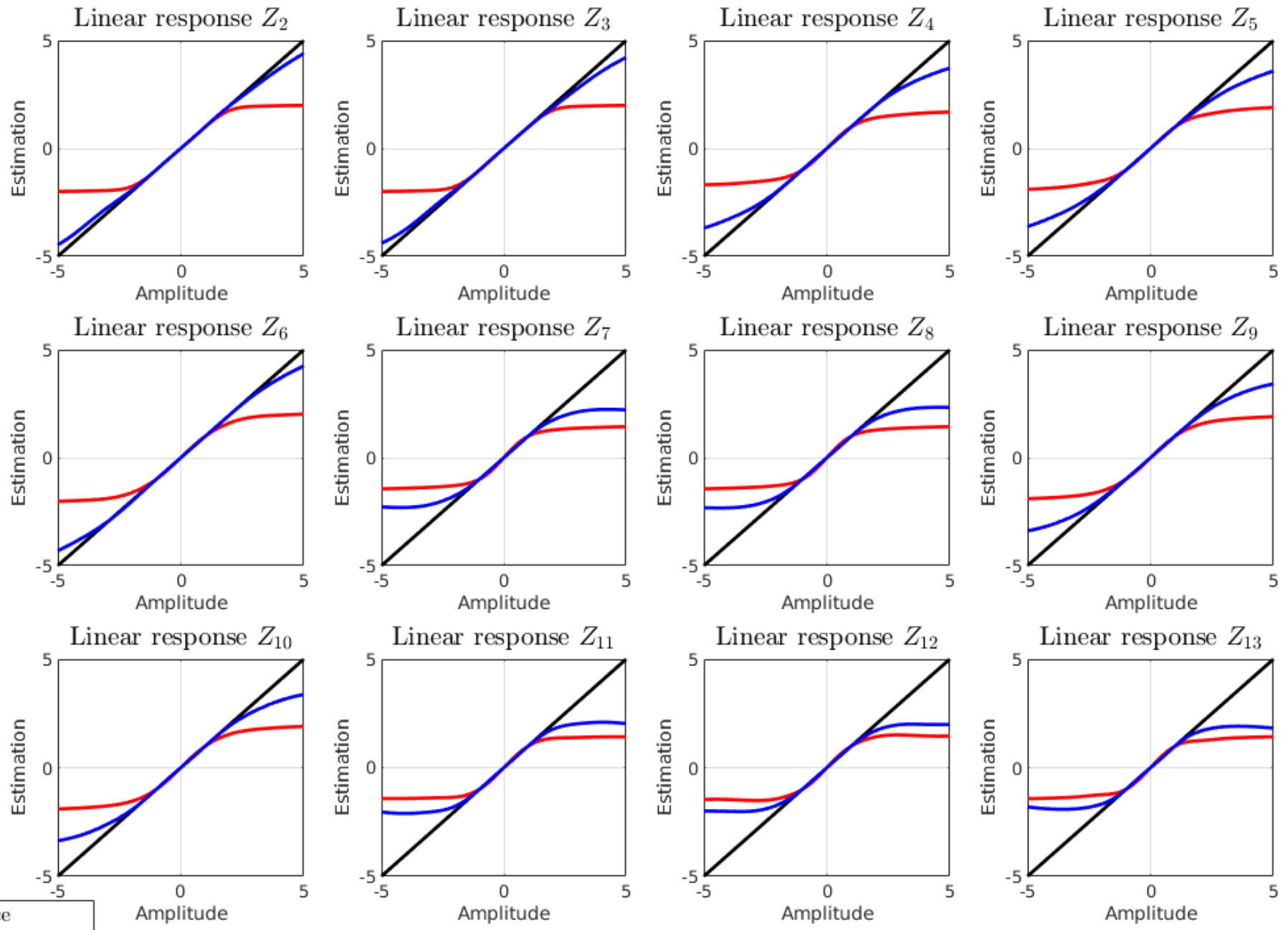
SIMULATION RESULTS

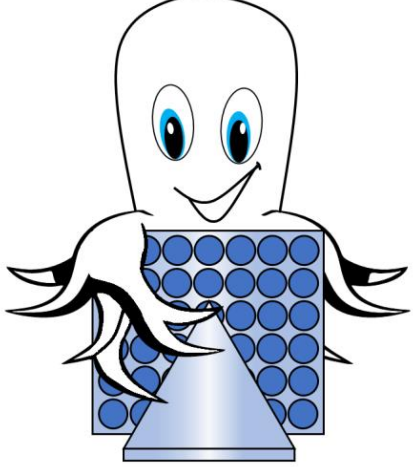


SIMULATION RESULTS WITHOUT MODULATION



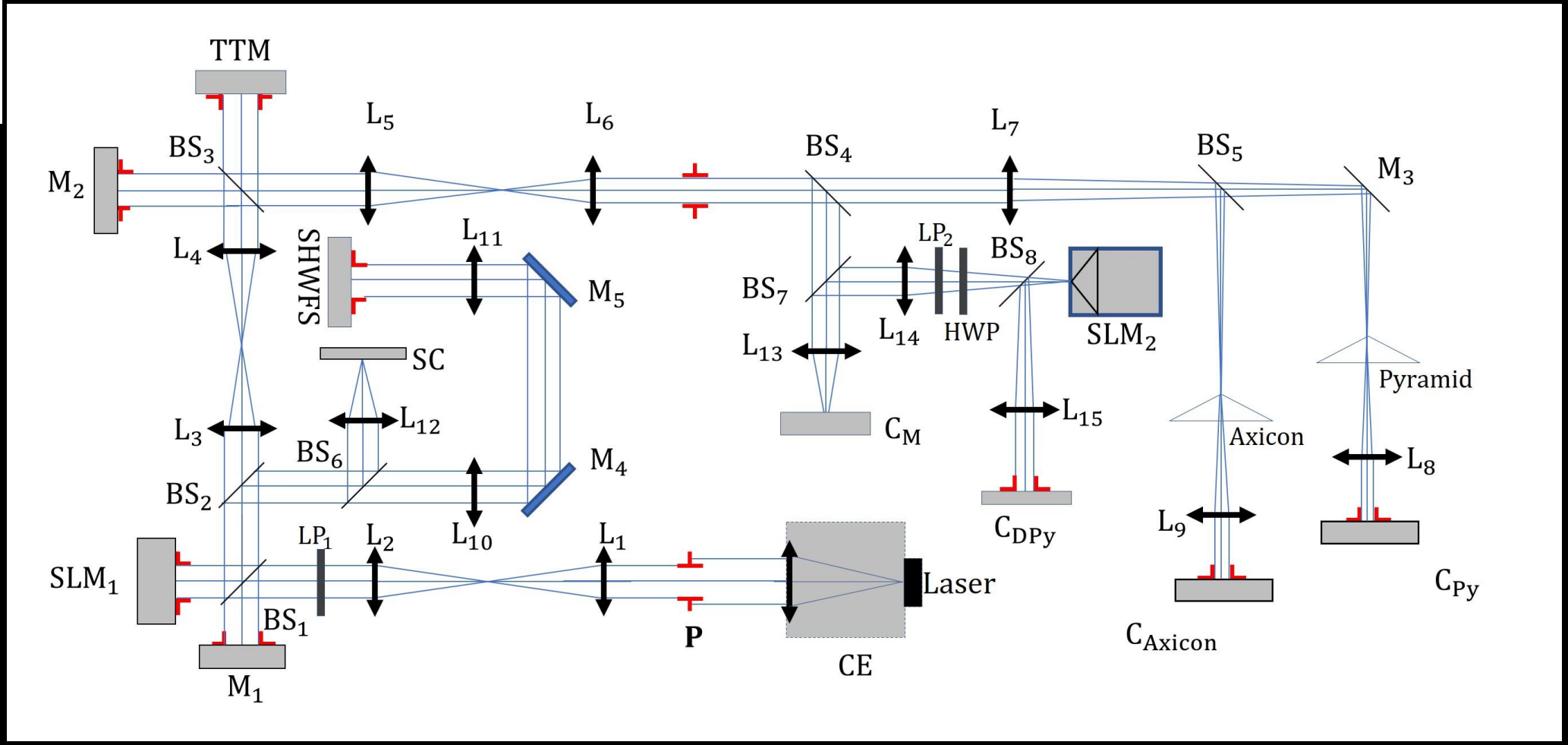
SIMULATION RESULTS WITH MODULATION



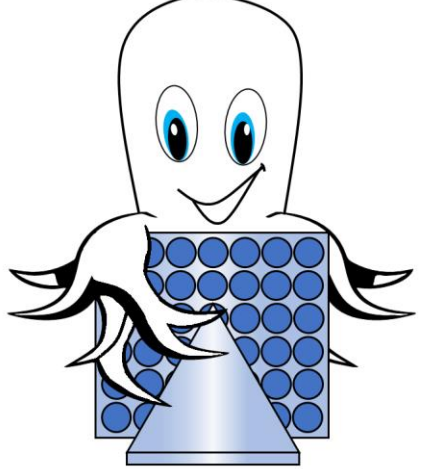


PULPOS

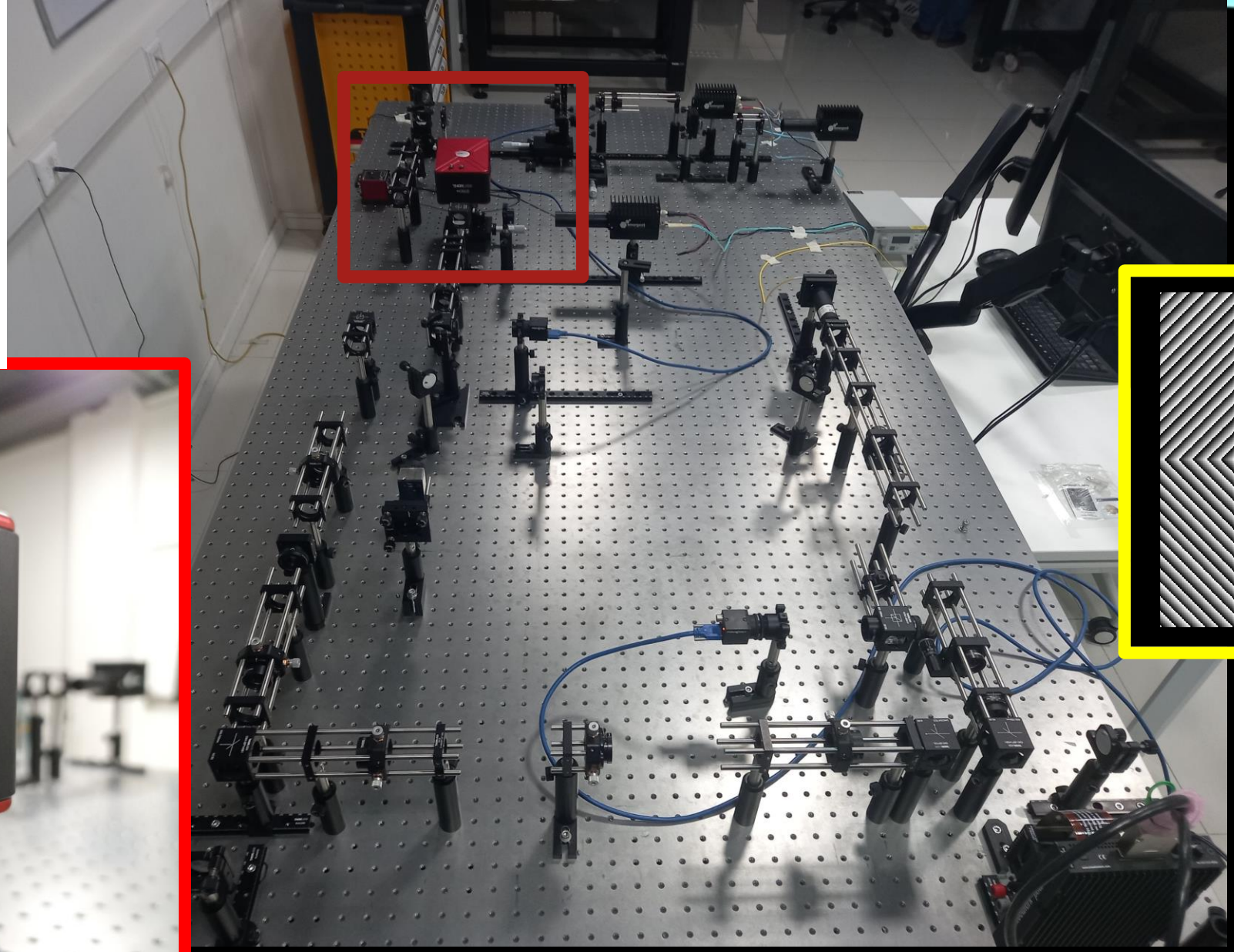
PULPOS AO BENCH

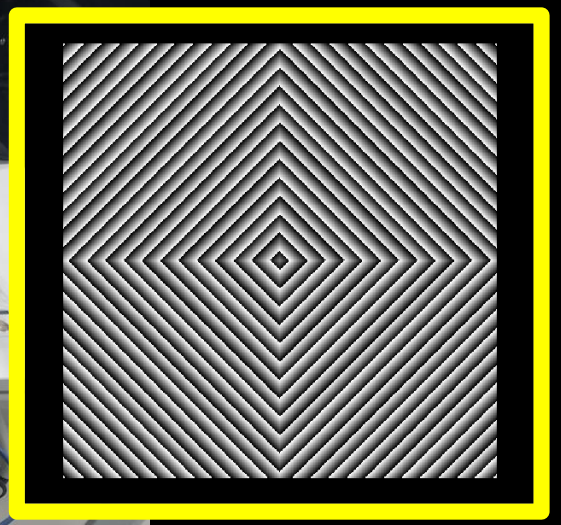


J Tapia, FP Bustos, C Weinberger, B Romero, E Vera , "PULPOS: a multi-purpose adaptive optics test bench in Chile", Proc. SPIE Adaptive Optics Systems VIII, 2022



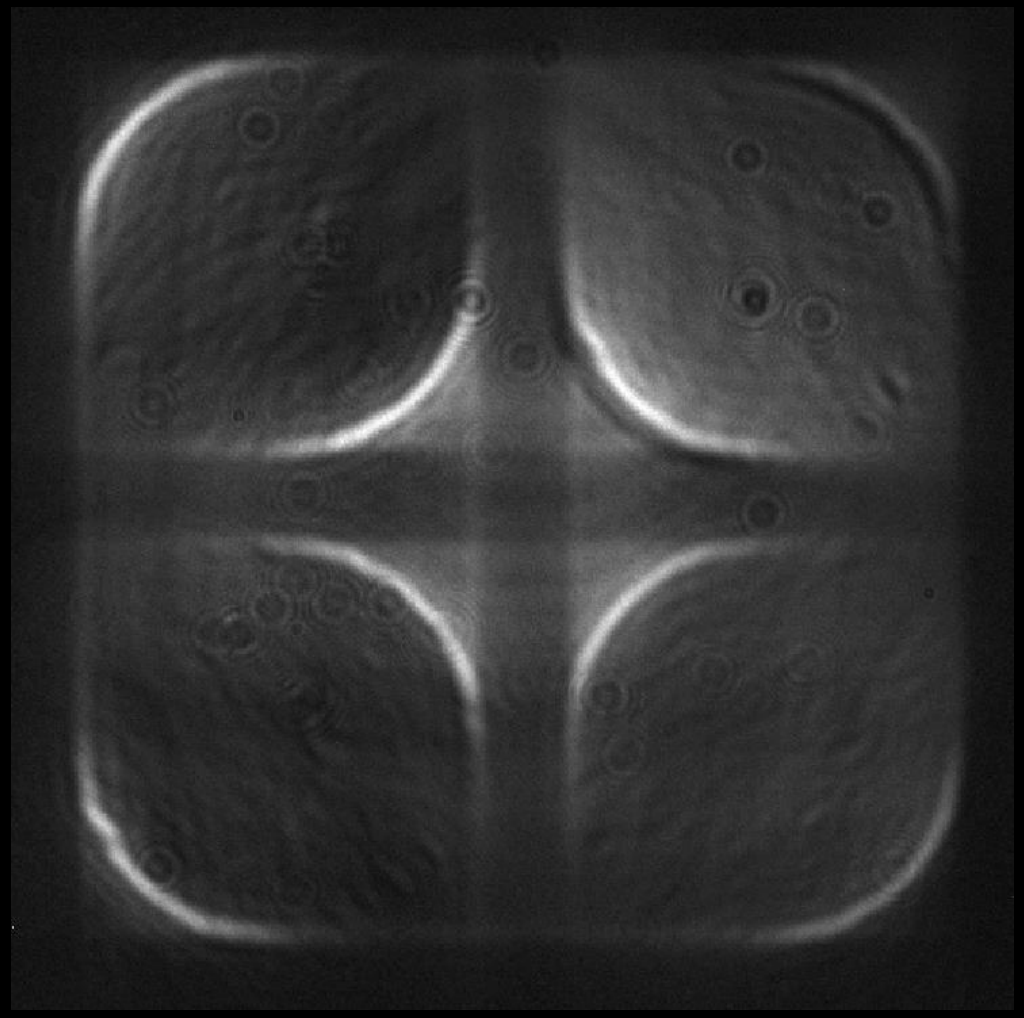

PULPOS
EXULUS-4K1



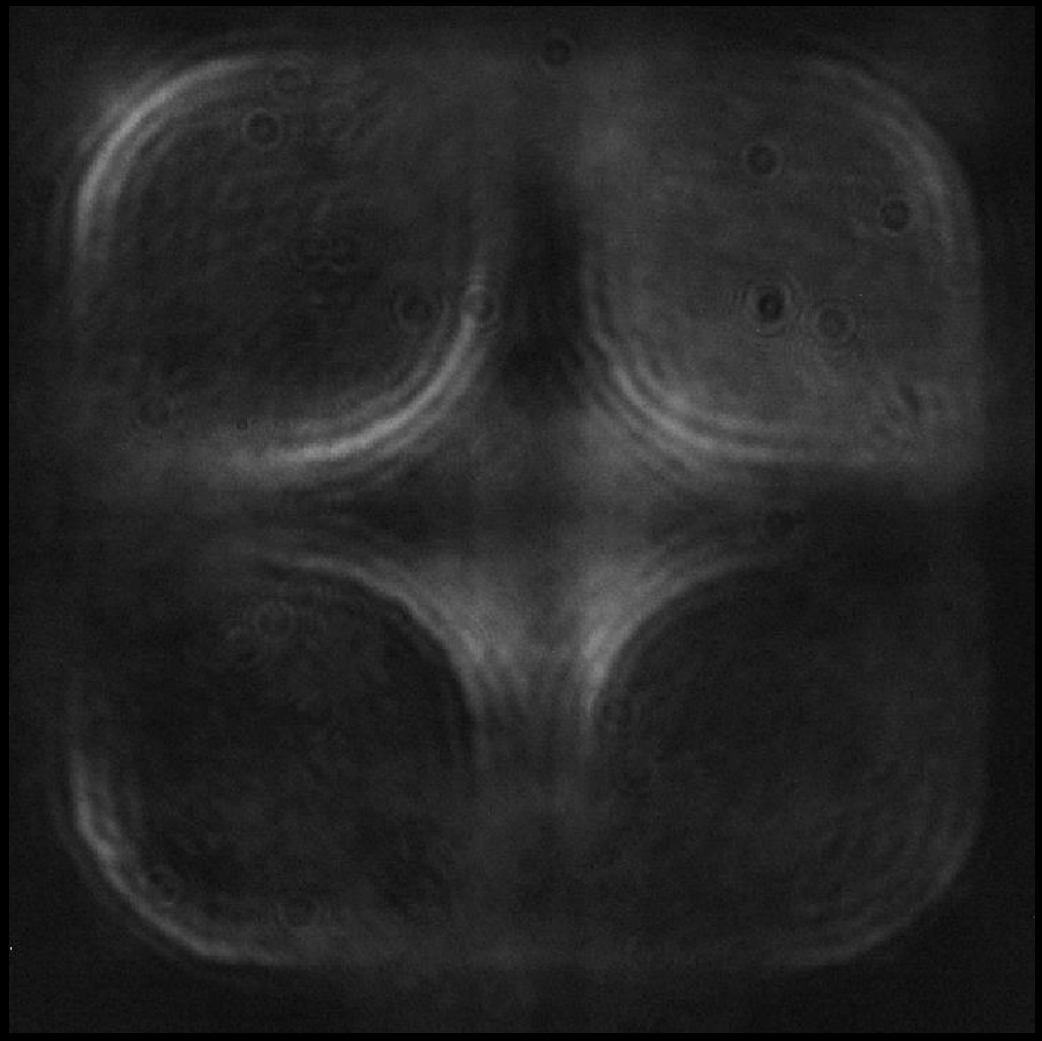


PULPOS FIRST LIGHT WITHOUT MODULATION

DIGITAL PYRAMID WFS

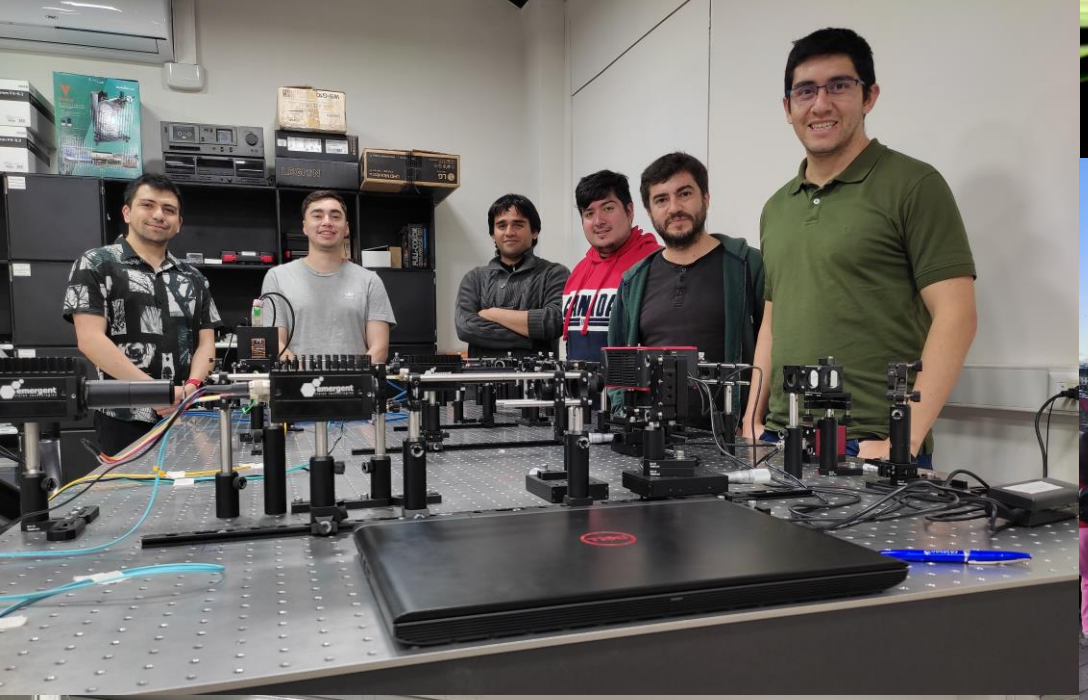


DIGITAL PWFS + DIFFRACTIVE MASK



CONCLUSIONS

- We know deep learning has opened the design space for wavefront sensors
- Using a data-diven approach we can train for
  1. better estimation given your WFS measurements
  2. better measurements given your WFS estimations
  3. both
- We can add a diffractive optical layer to the optical path of a PWFS that can work as an optical preconditioner
- Assuming the use of linear reconsruction, we can design the optical preconditioner using an End-2-End approach
- Simulation results suggest that the modified PWFS may
  - extend the linearity range of the original PWFS
  - require less modulation to obtain similar results
- We are currently working on the experimental demonstration using PULPOS



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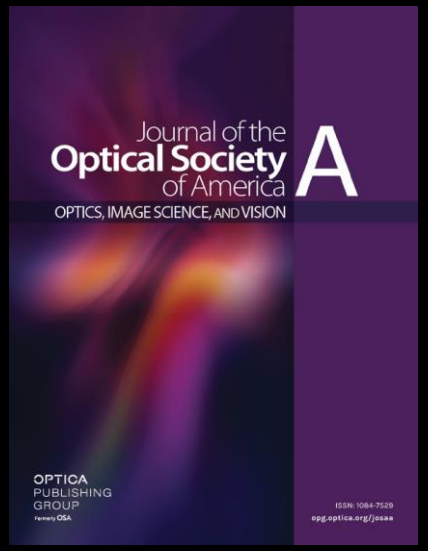

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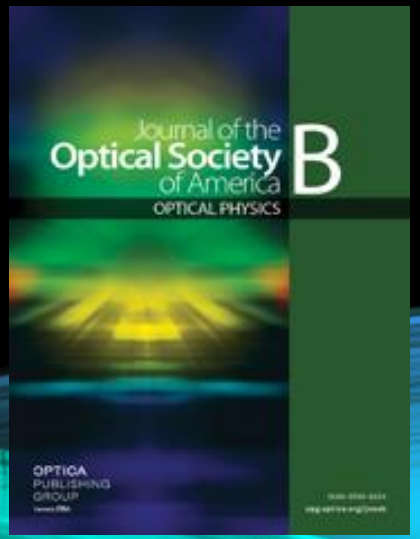

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