

Photonic lantern wavefront reconstruction in a multi-wavefront sensor single- conjugate adaptive optics system

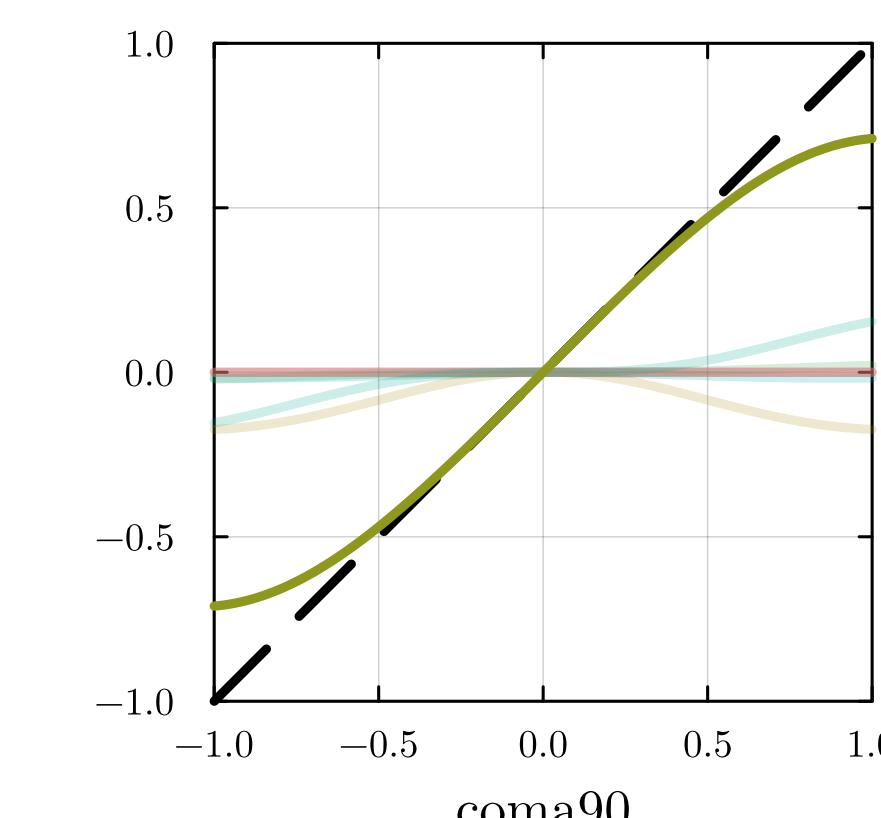
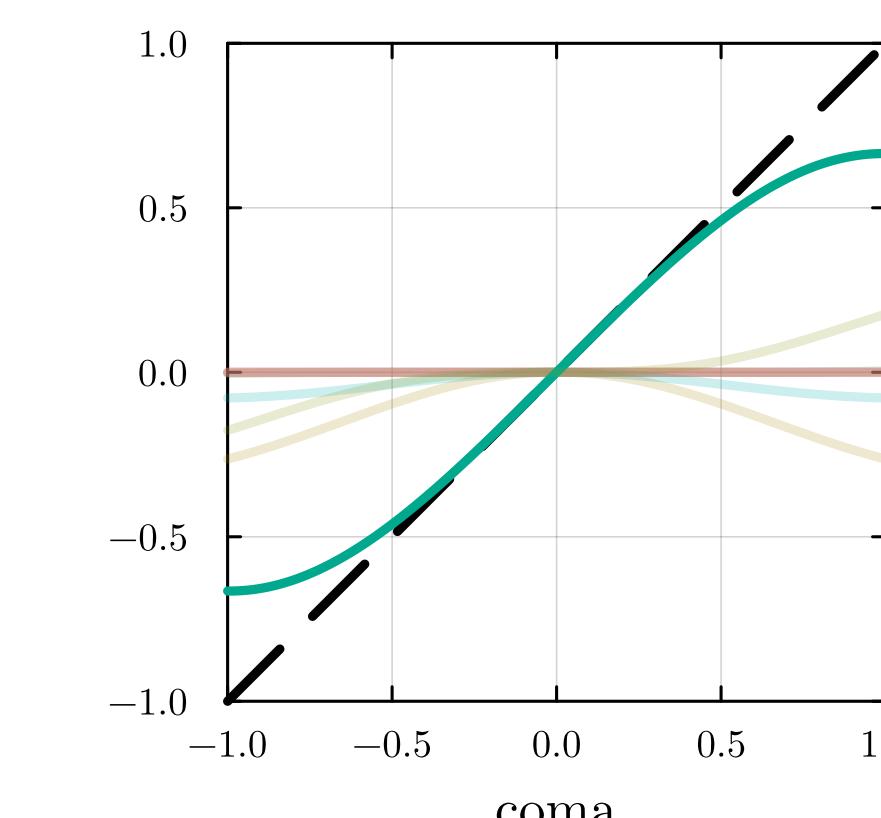
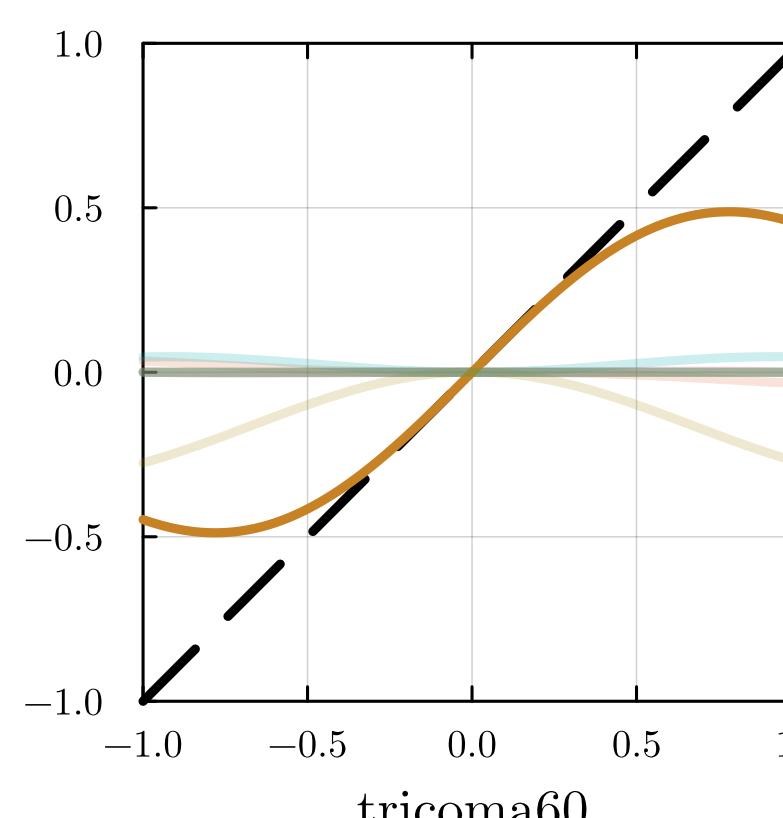
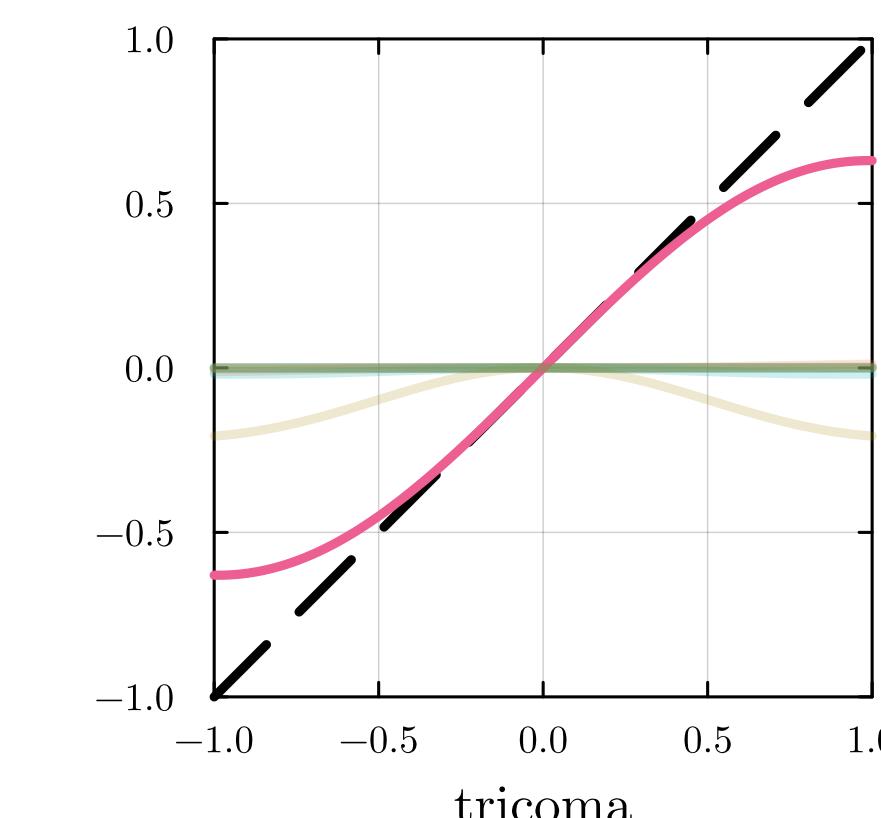
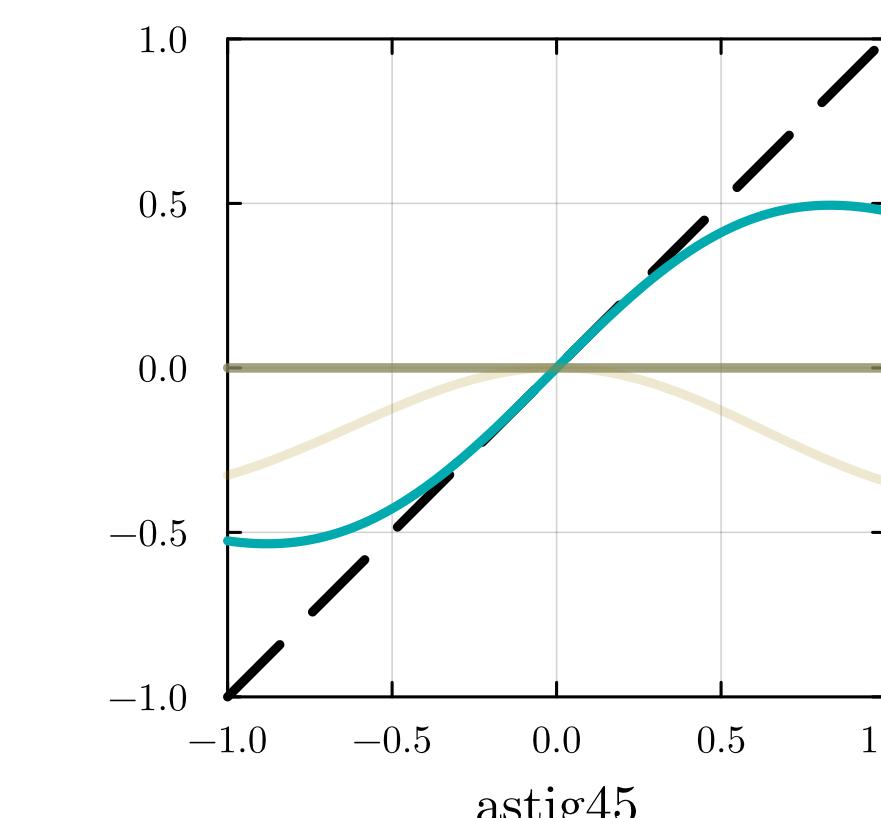
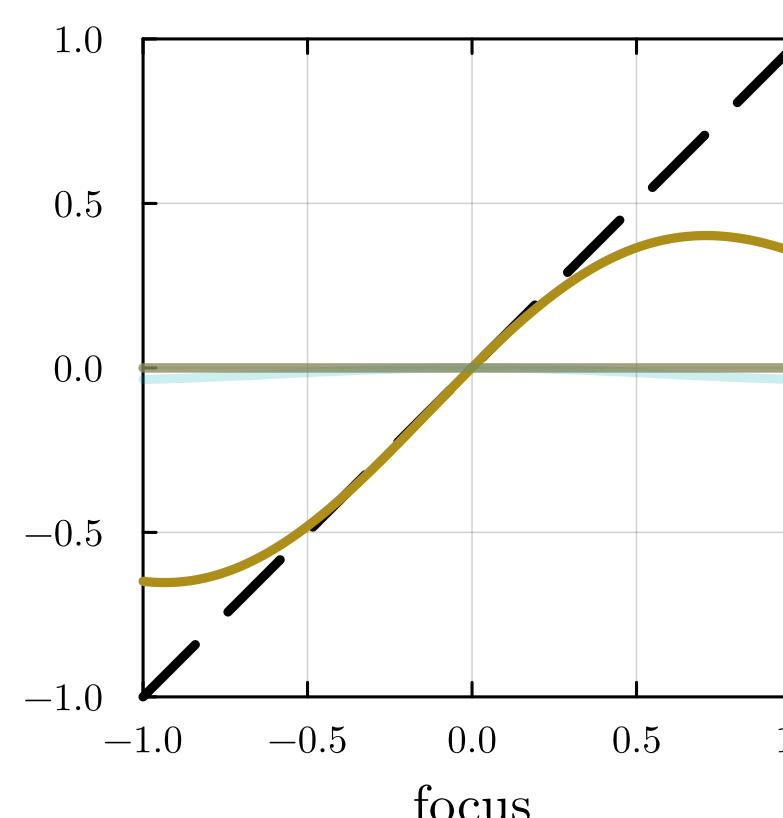
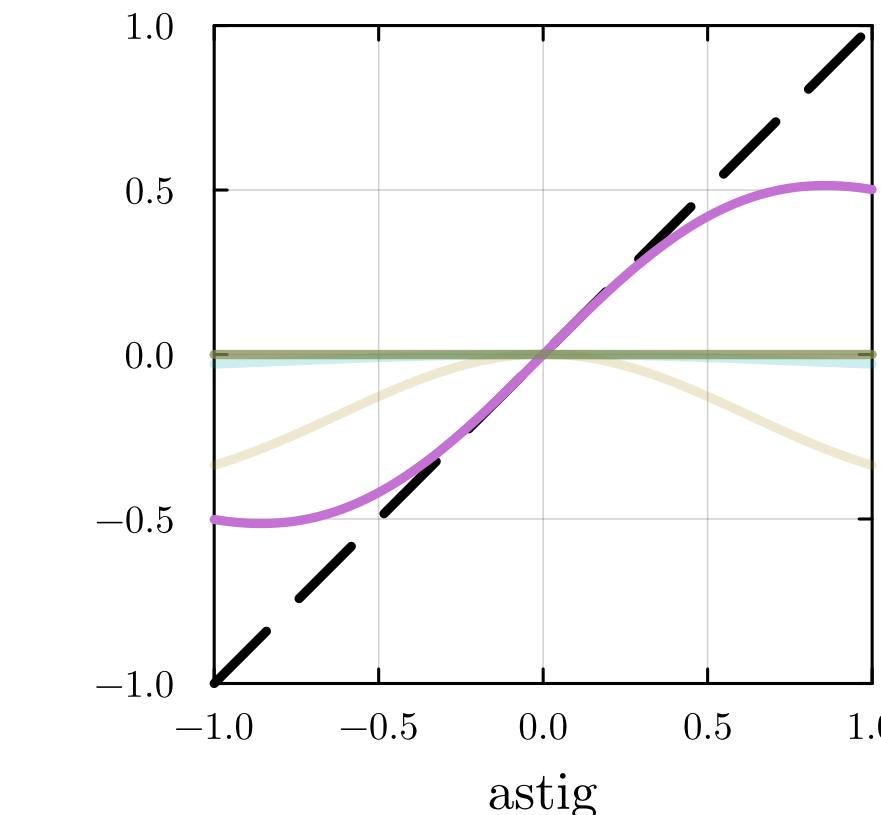
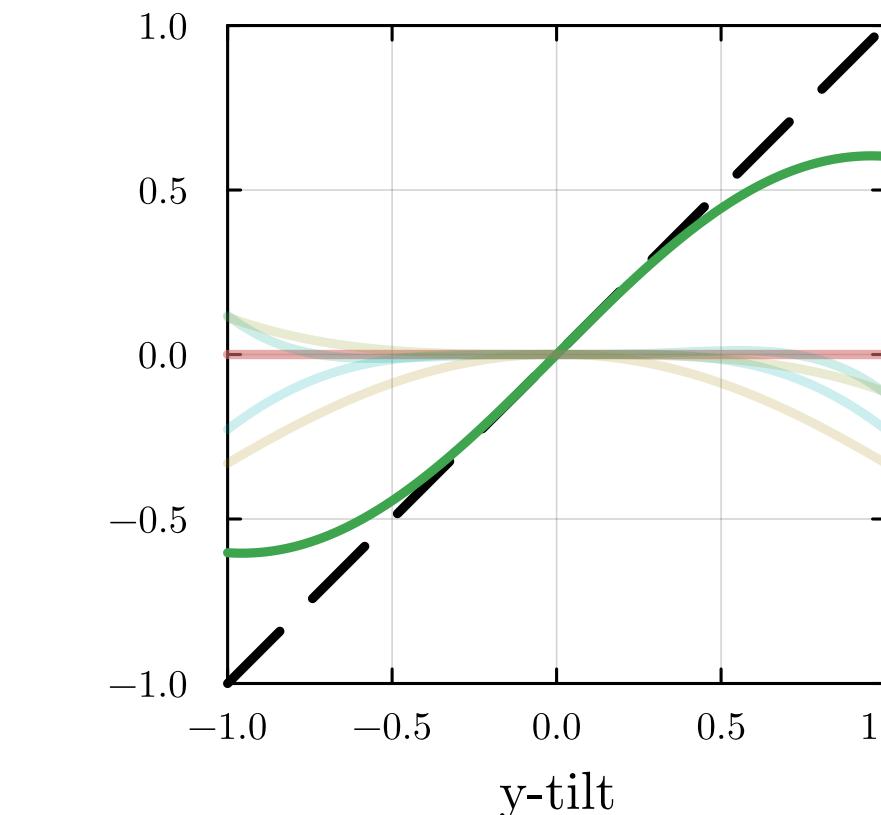
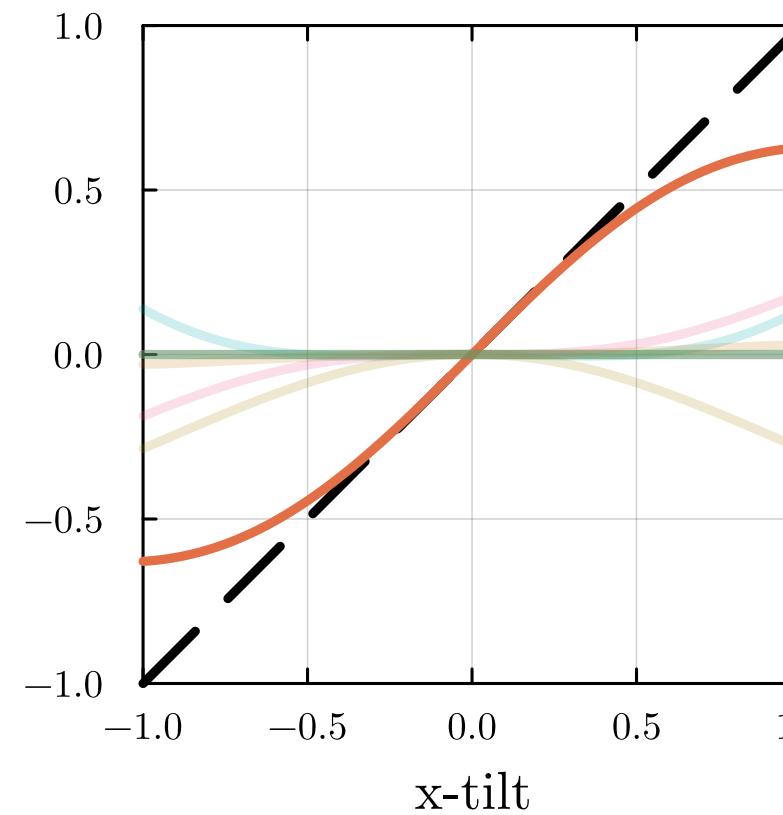
SPIE Astronomical Telescopes + Instrumentation, 2024

Aditya Sengupta, 2024-06-19

- Three methods for photonic lantern wavefront reconstruction
 - Linear reconstructor
 - Neural network
 - Gerchberg-Saxton algorithm
- Empirical characterization for model-based reconstructors
- Multi-WFS architecture and results

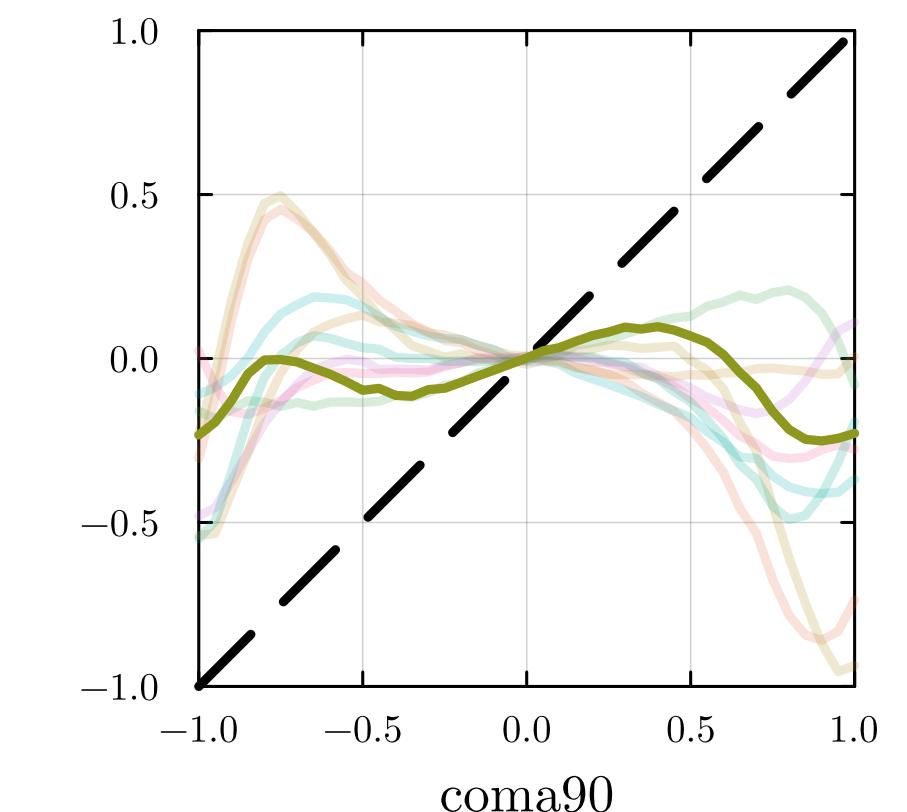
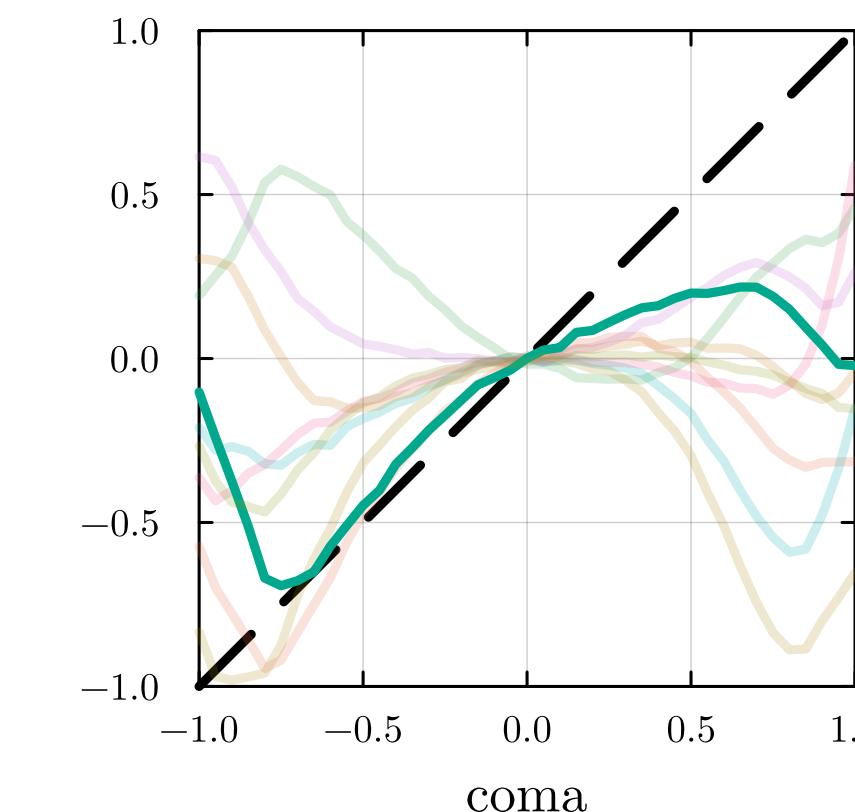
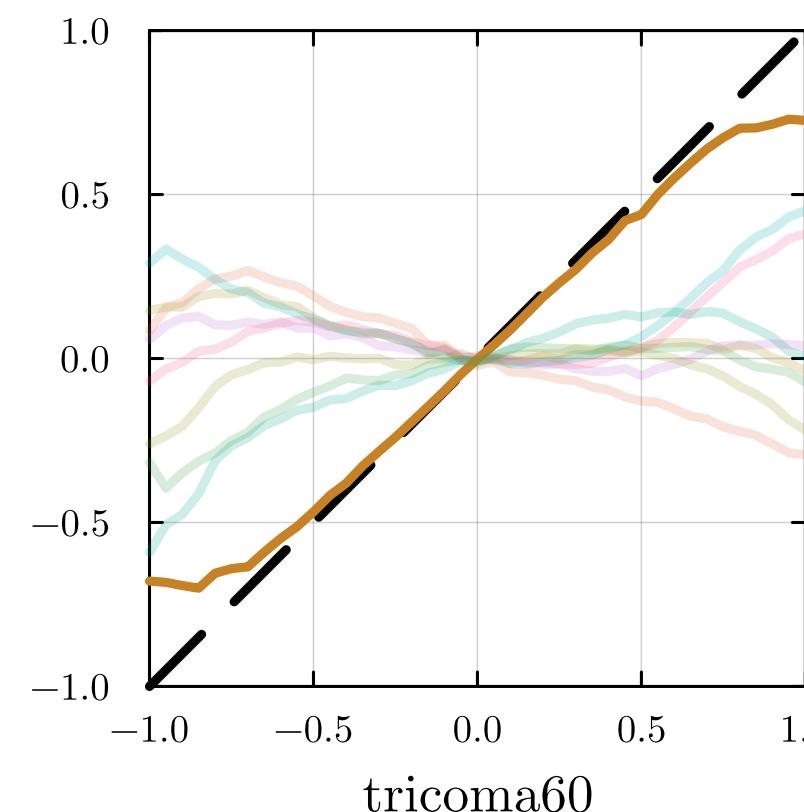
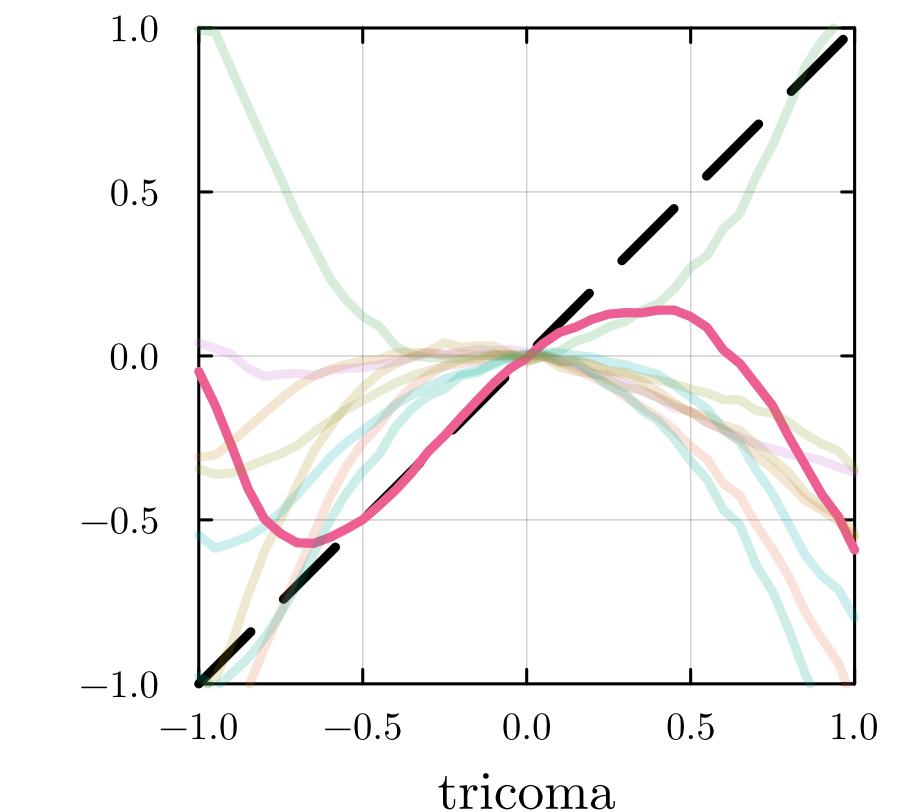
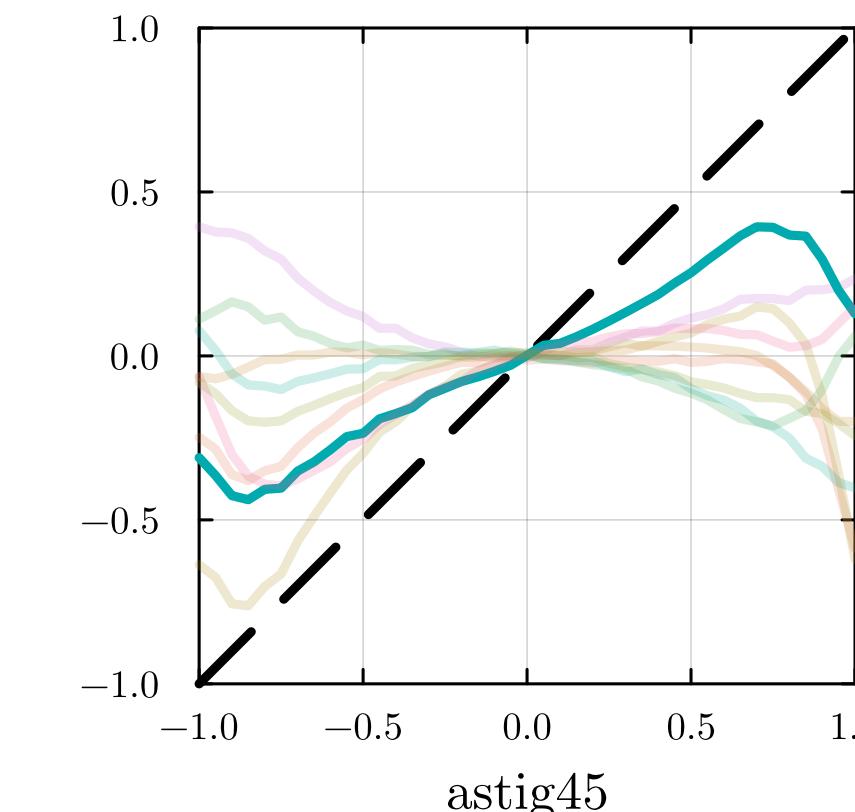
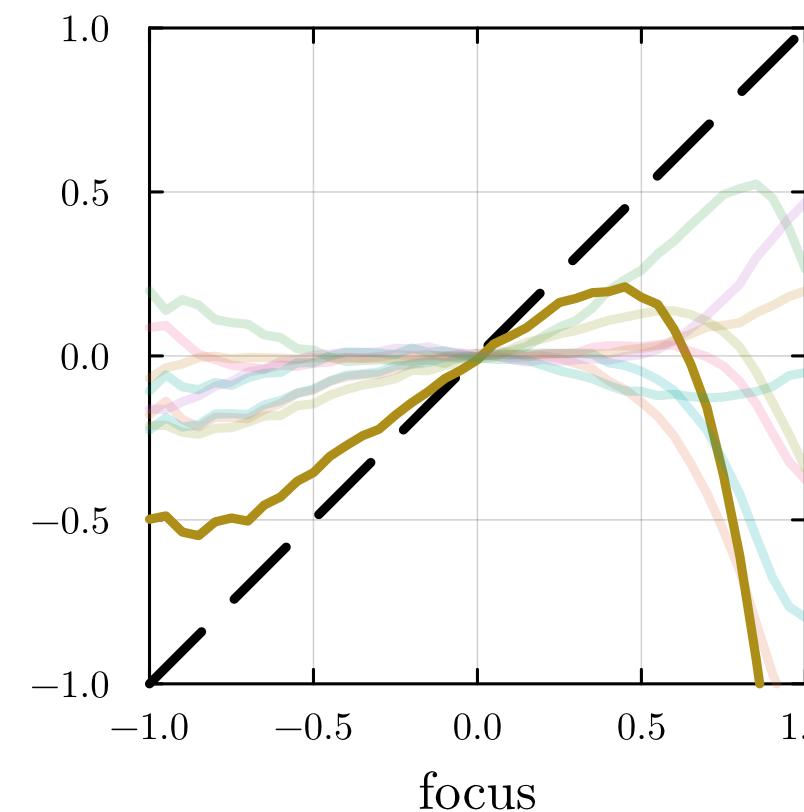
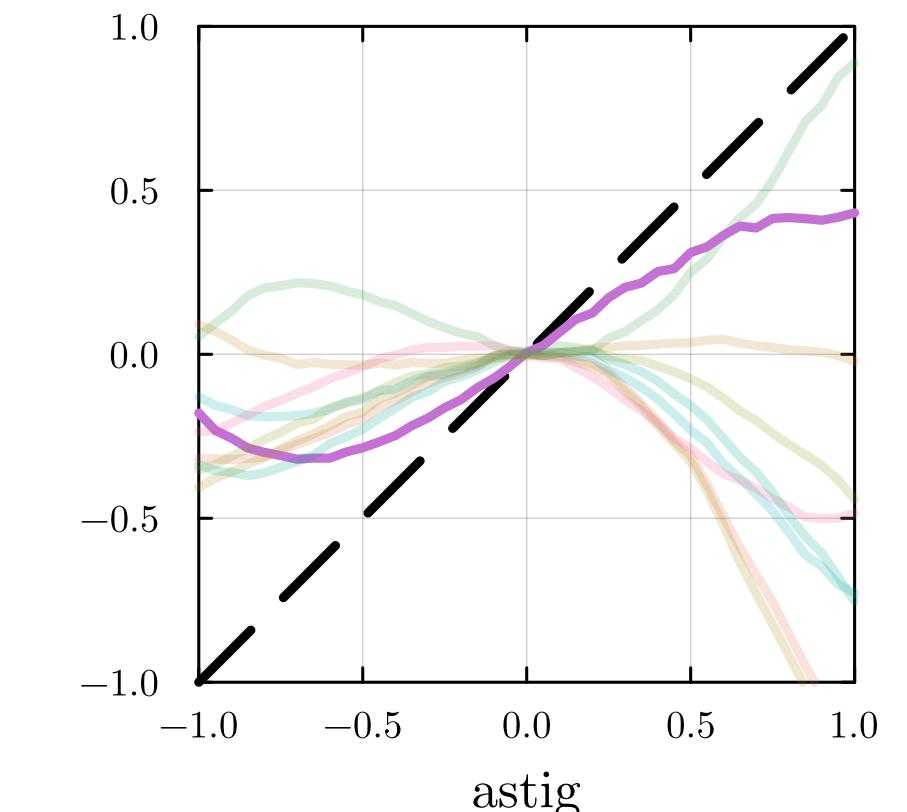
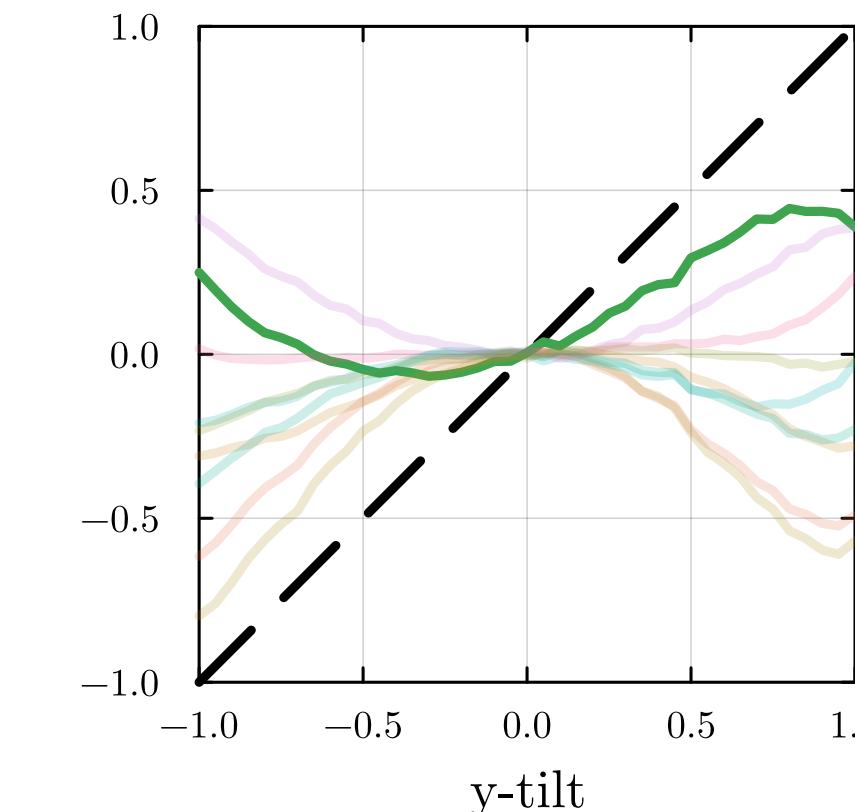
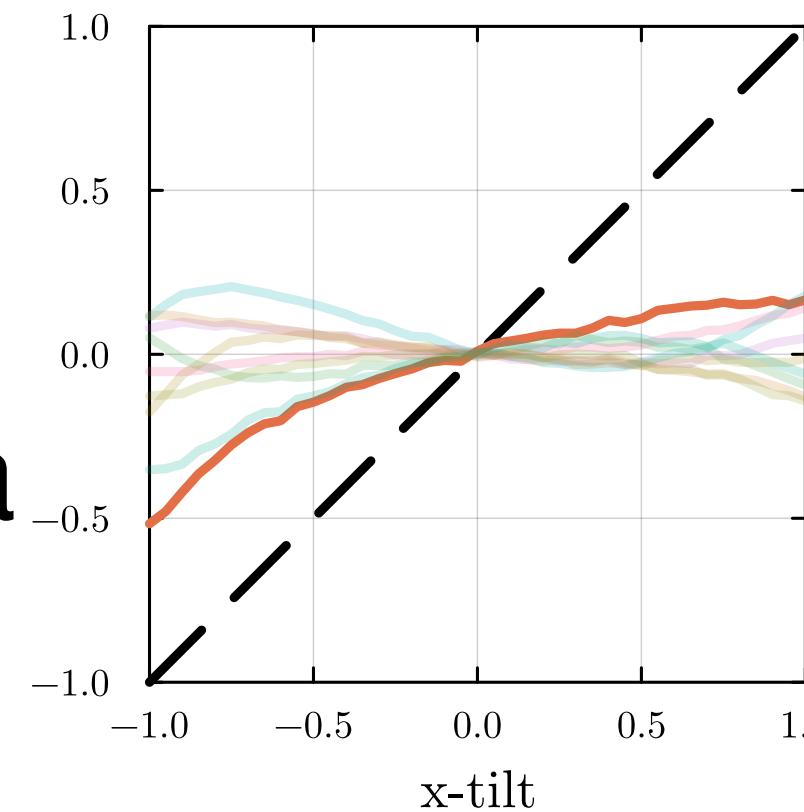
Photonic lantern linear reconstruction, simulated

- Usual AO procedure:
 - +/- pokes on each Zernike mode and record output slopes
 - Invert resulting interaction matrix —> command matrix
- Noticeable crosstalk terms

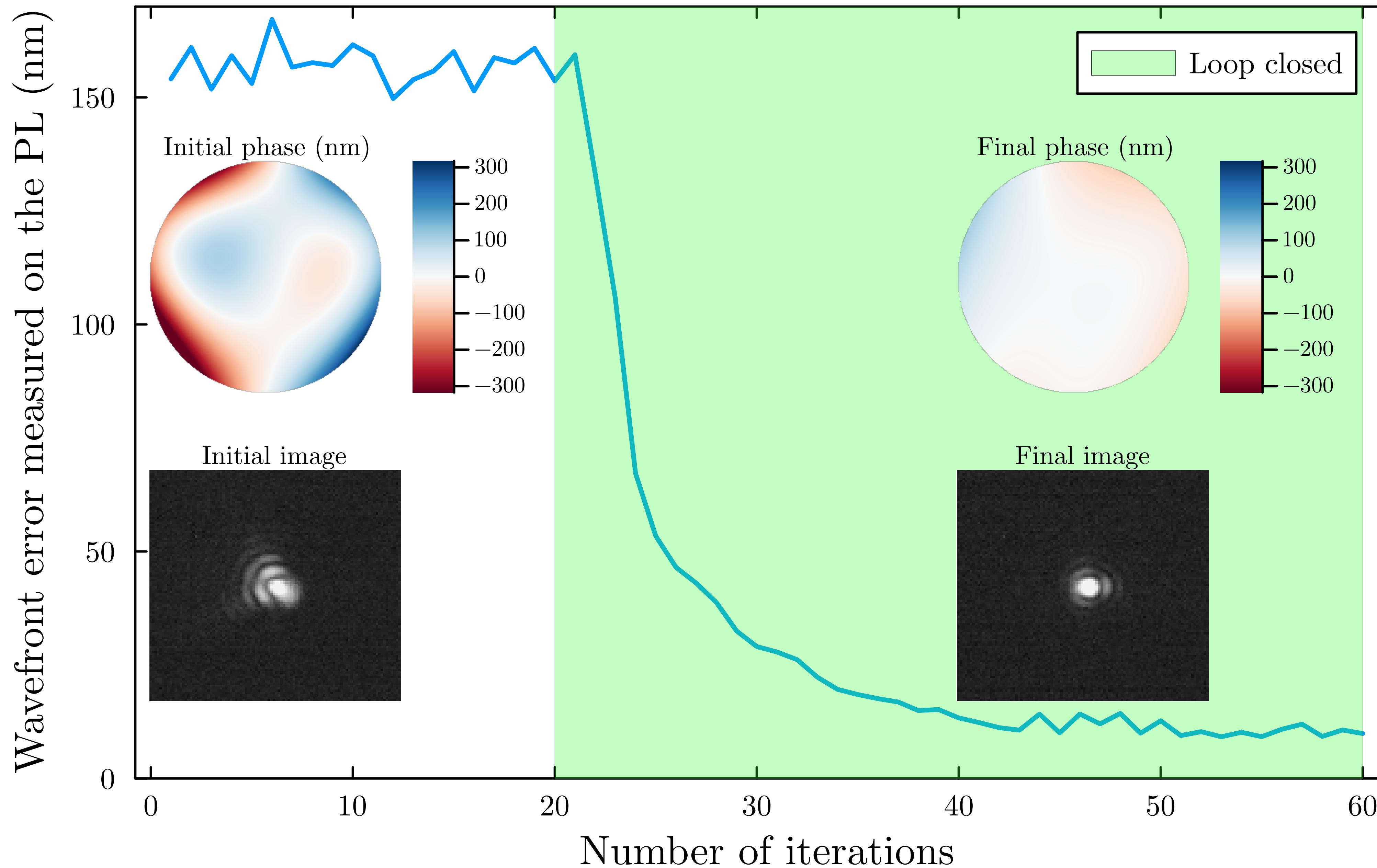


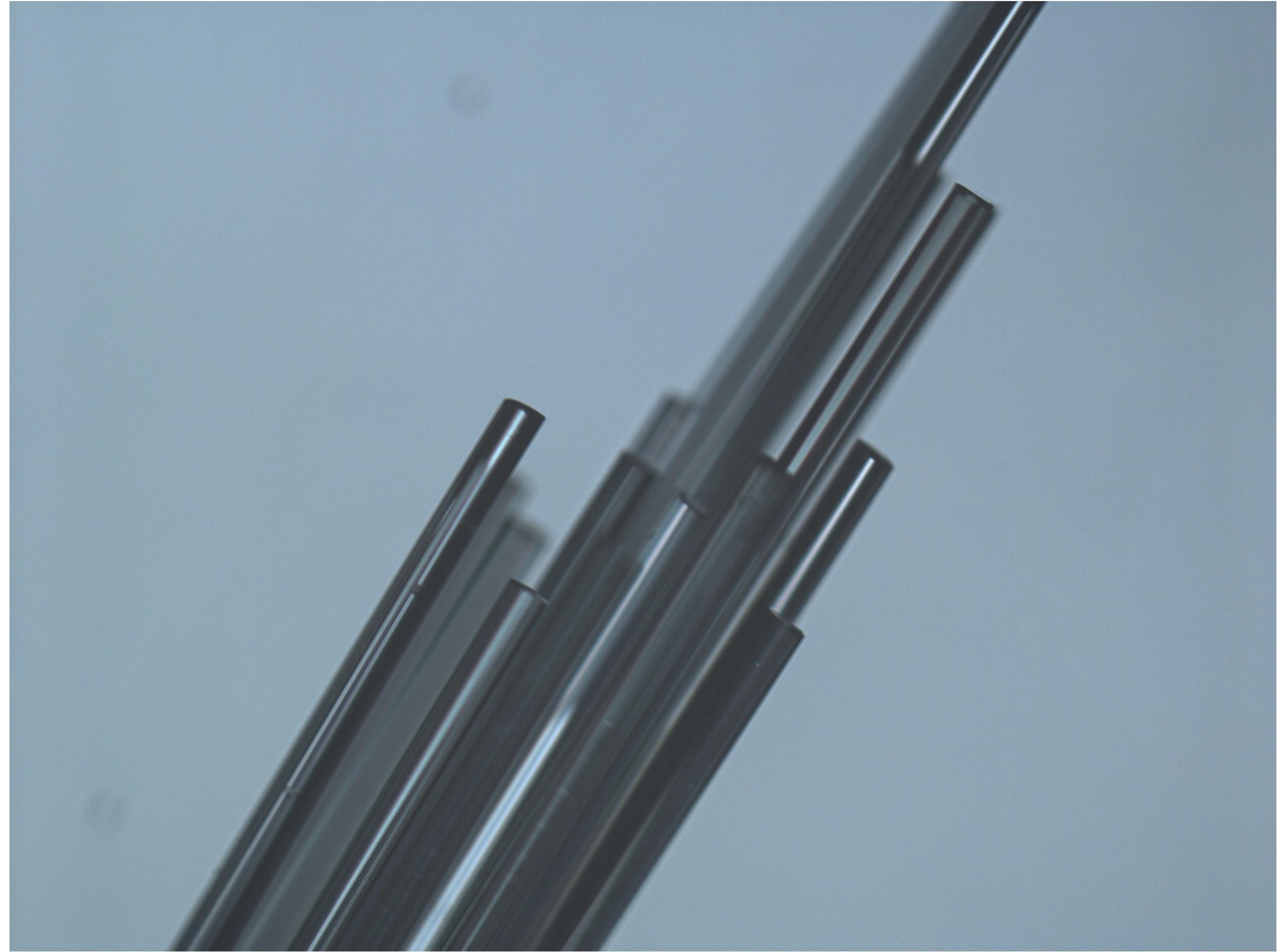
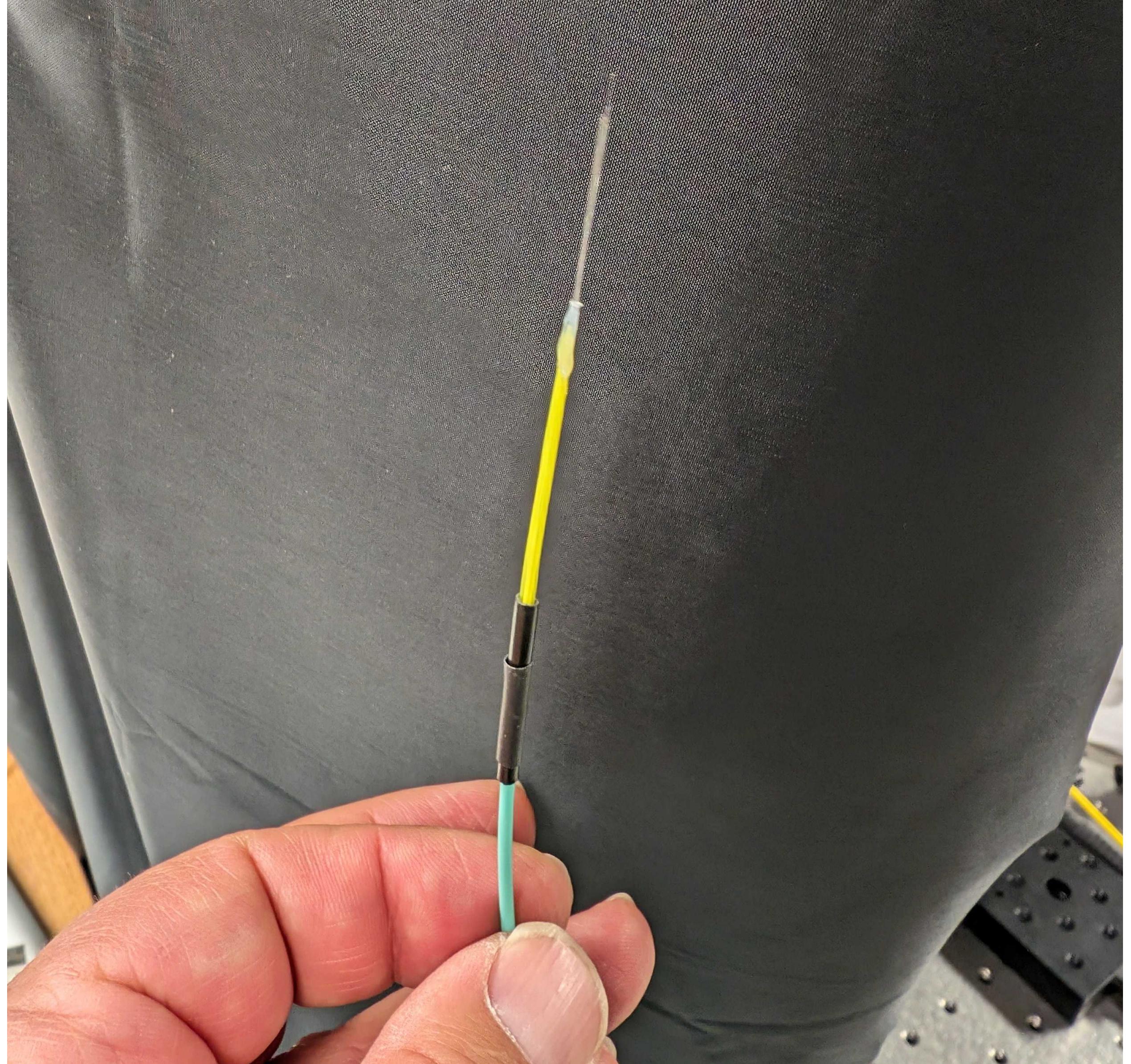
Photonic lantern linear reconstruction, SEAL

- Same procedure on SEAL: a lot more crosstalk
- PL operating off the design wavelength
 - SEAL is at 635 nm
 - Lantern designed for 1550 nm

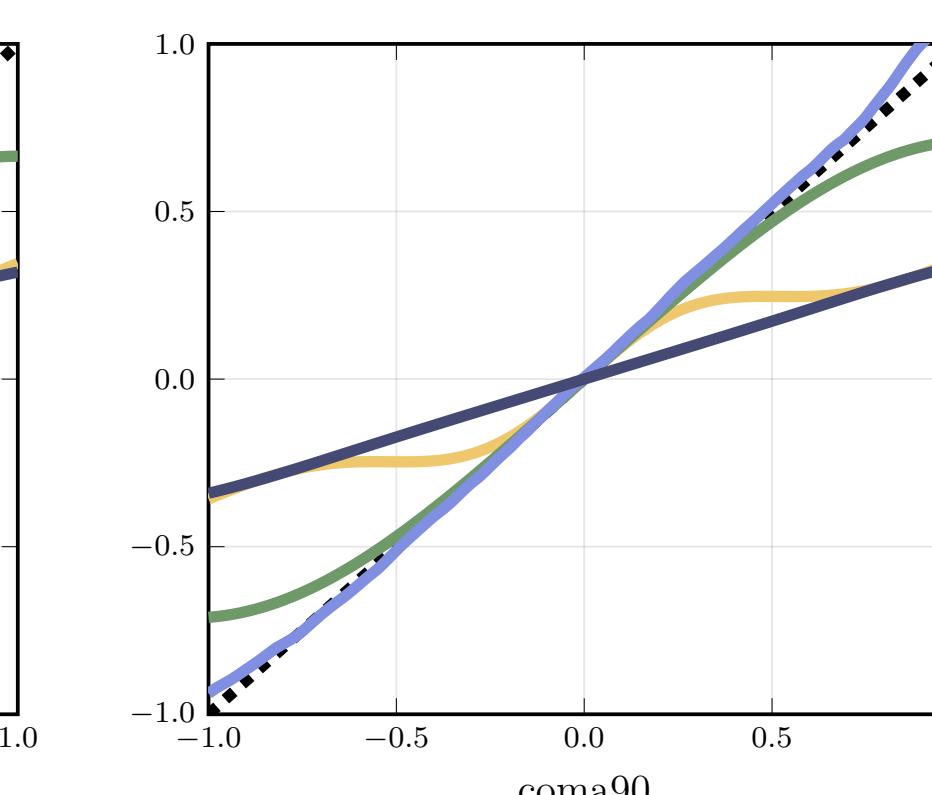
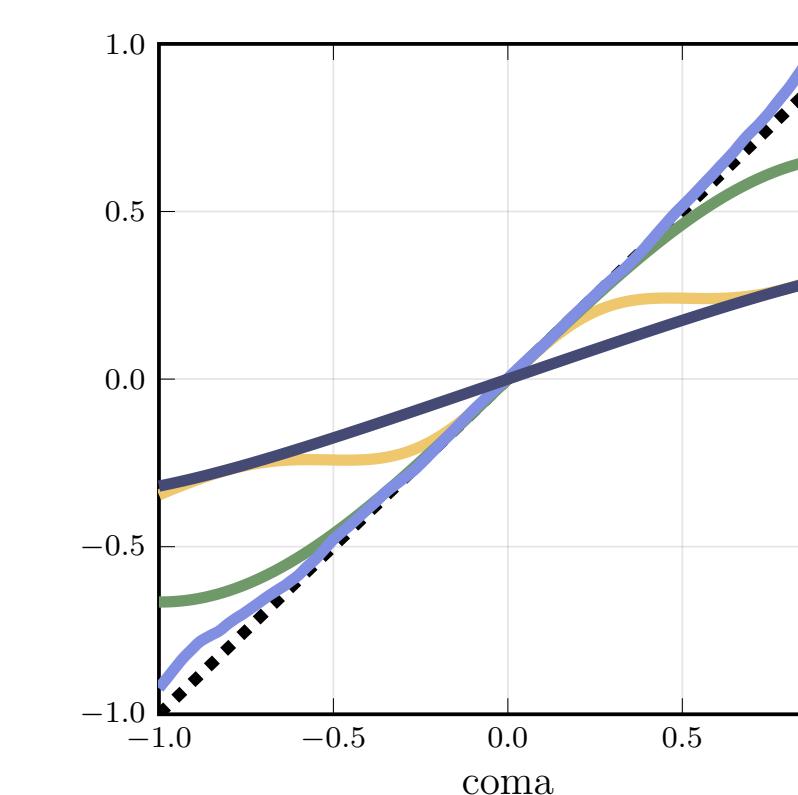
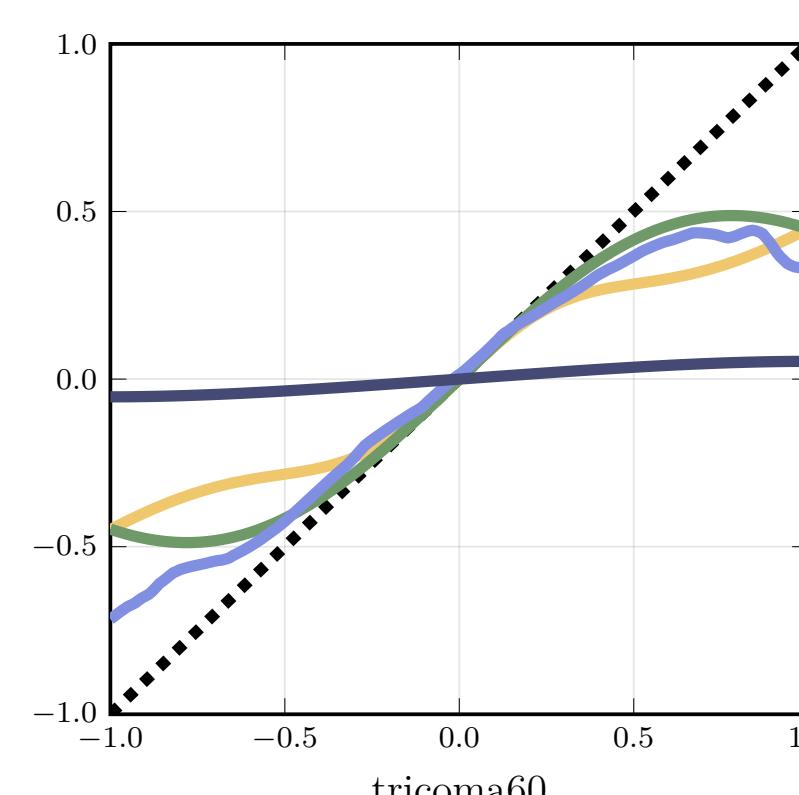
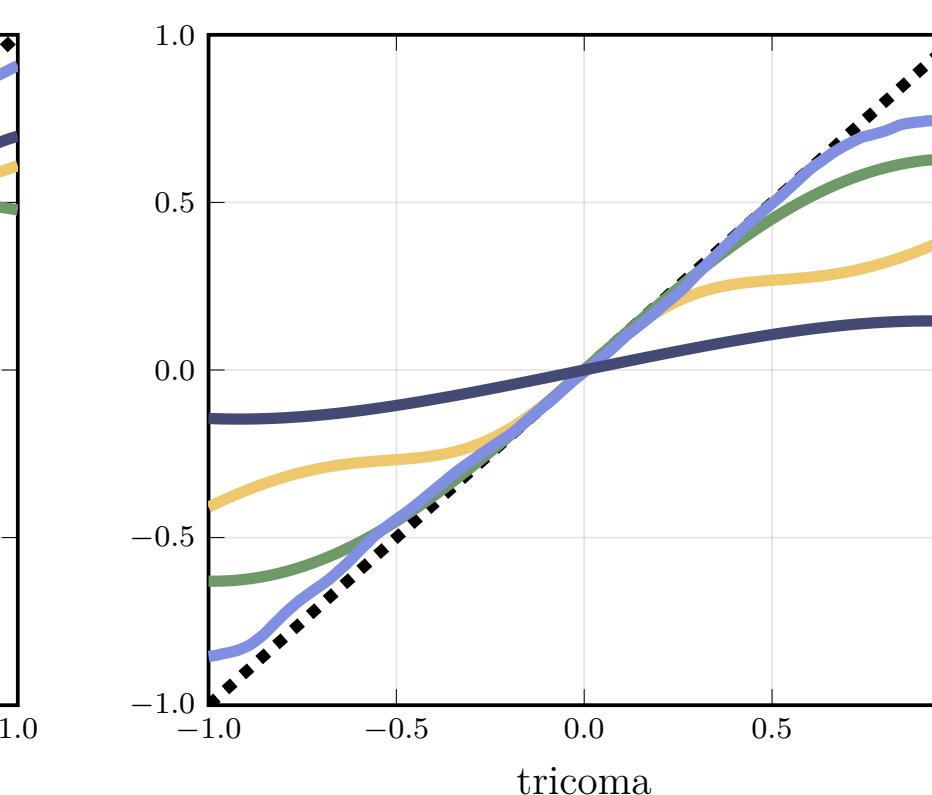
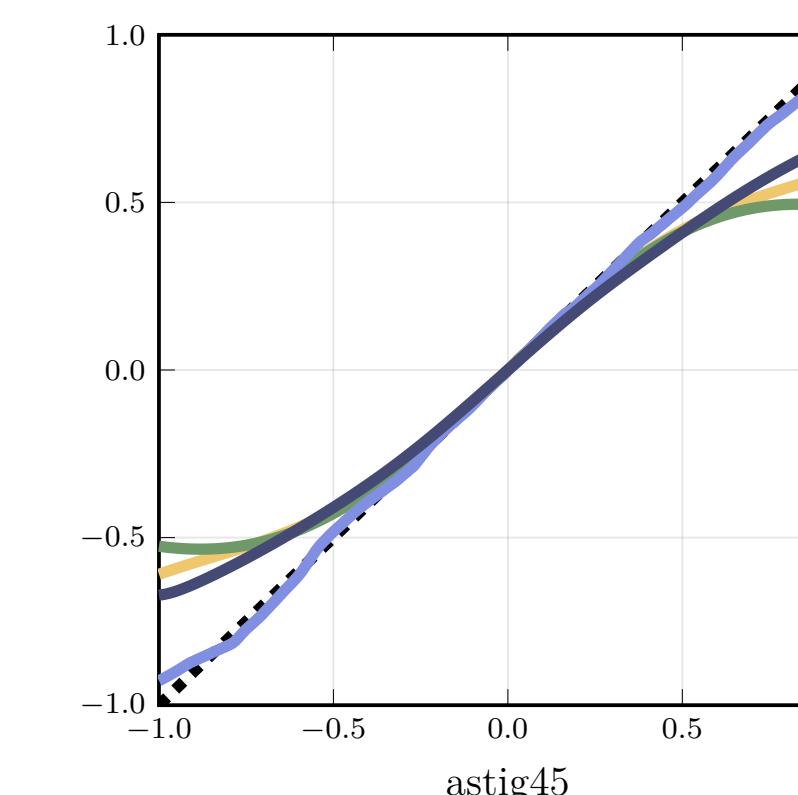
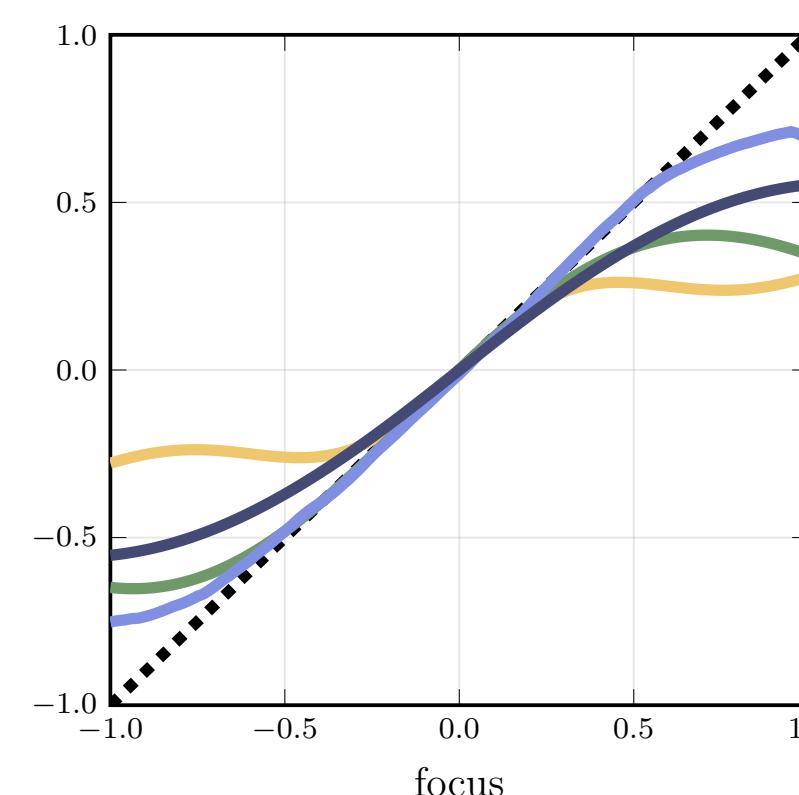
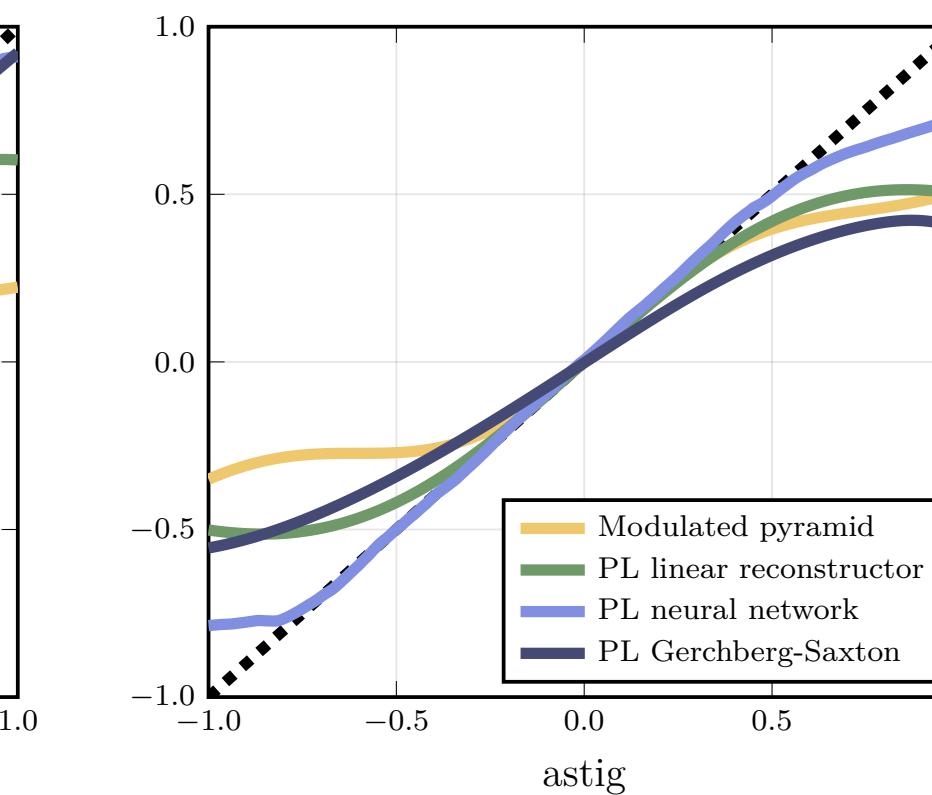
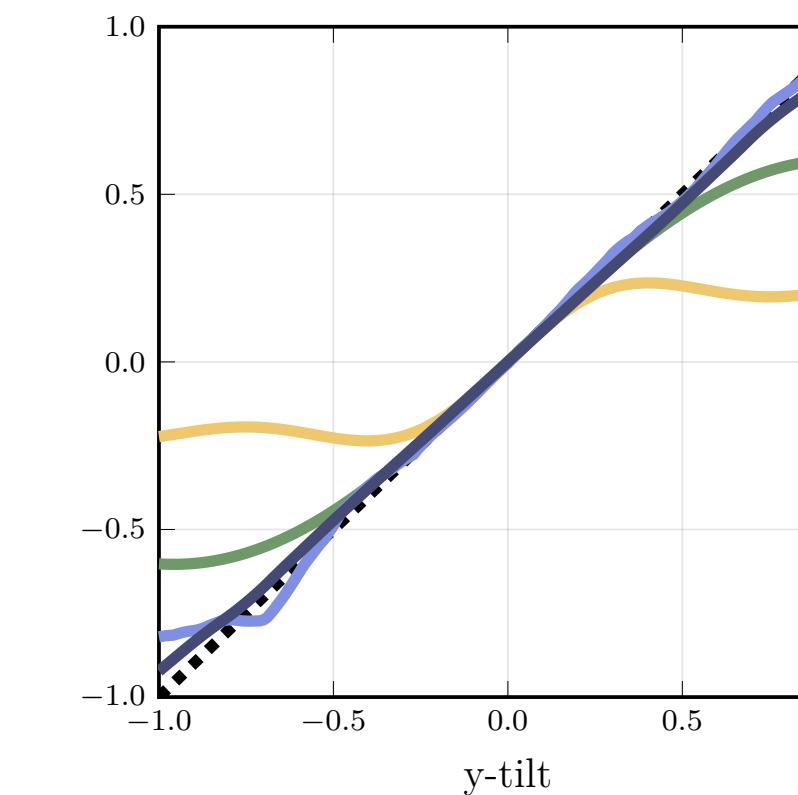
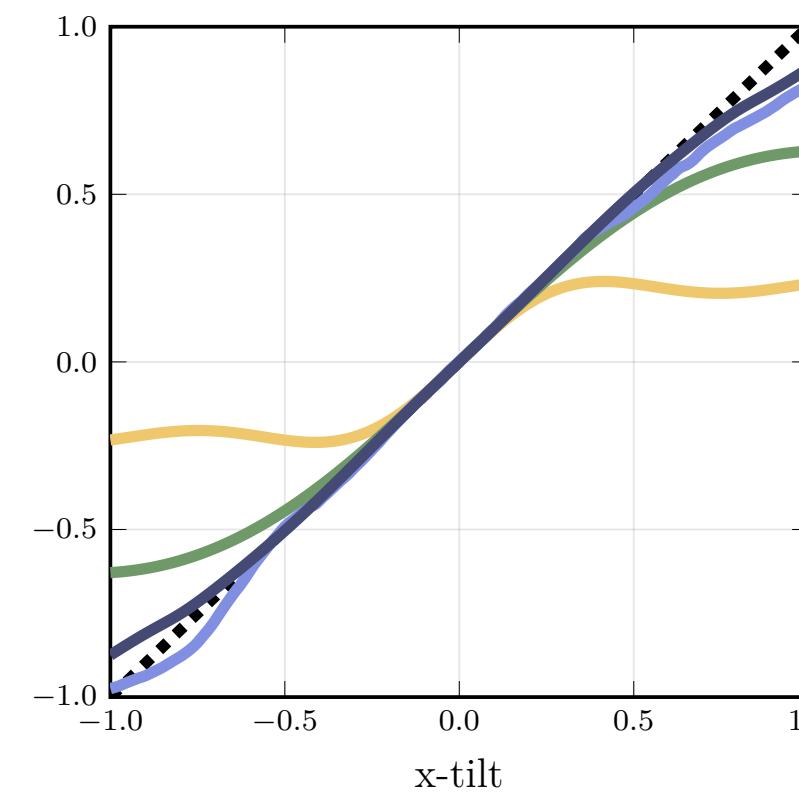


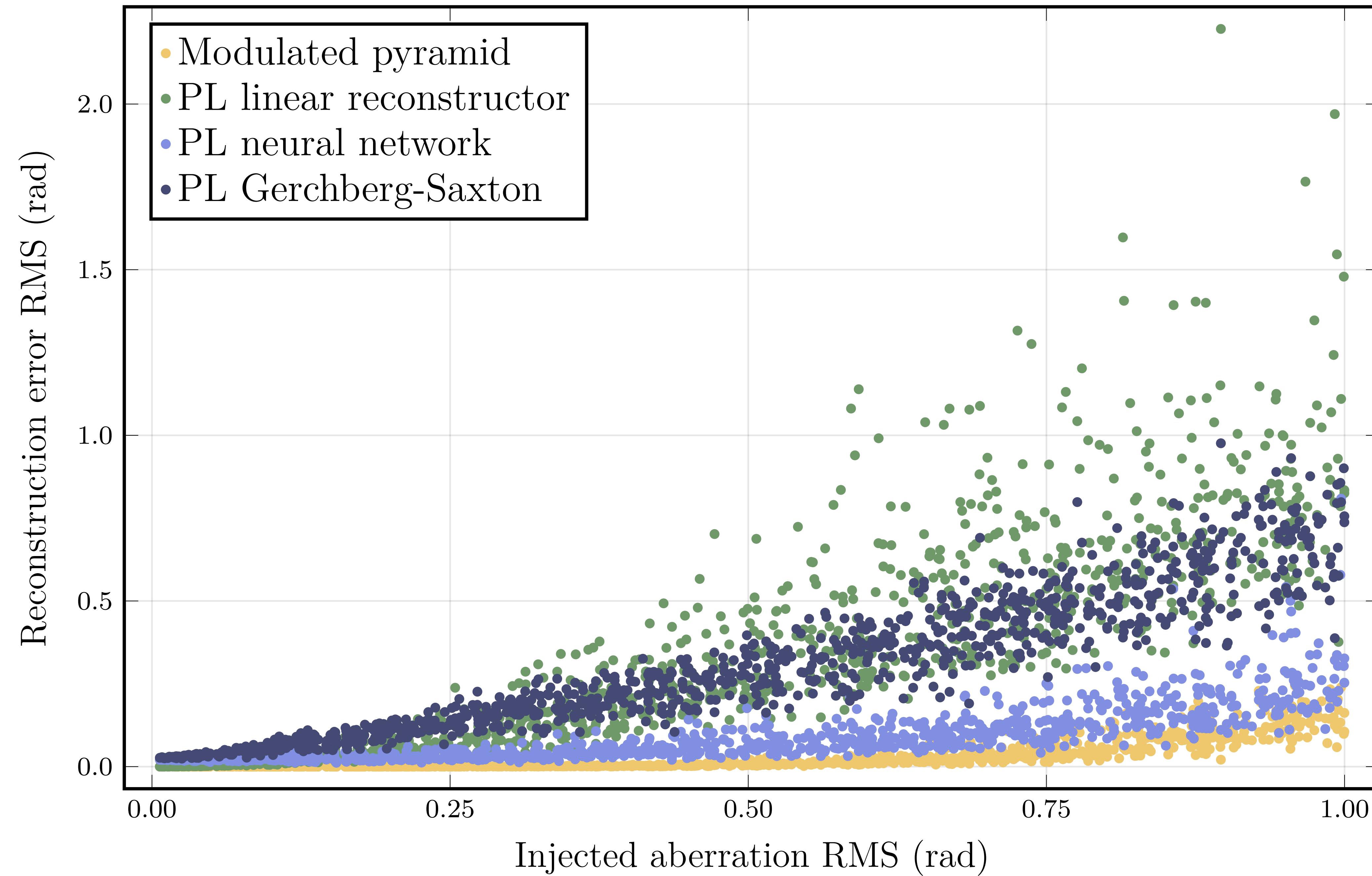
Correcting a static aberration with the photonic lantern





All PL reconstruction algorithms compared with the modulated pyramid

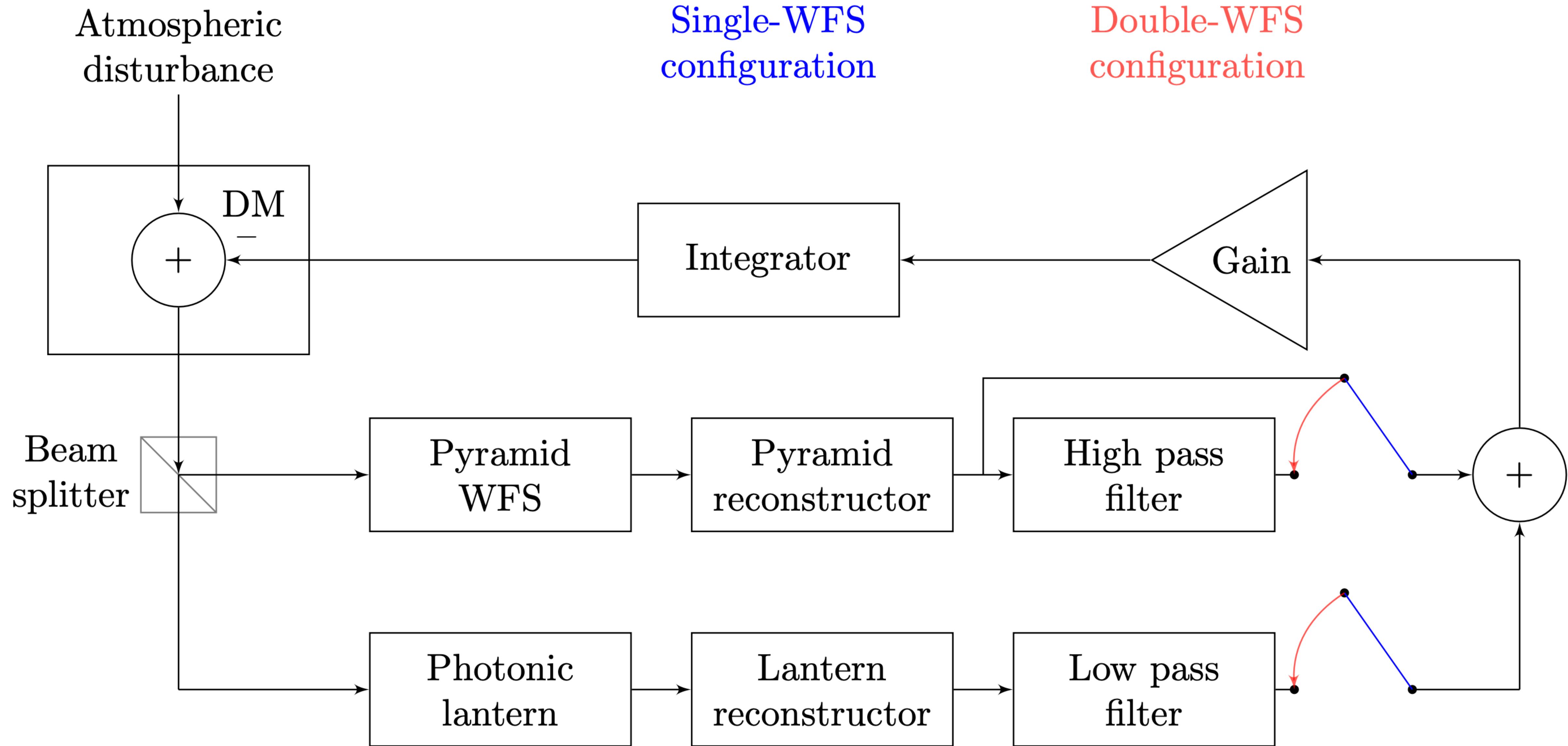




Empirical characterization algorithm

- PLs can be characterized at one wavelength with an NxN propagation matrix
- With a light source + DM, can we find this matrix?
 - Pick a basis of input phase screens –> electric fields
 - Propagate this basis, $\text{sqrt(PL intensities)}$ is the matrix up to phase differences
 - Do $N(N-1)$ linear combinations of the input basis to produce phase diversity and fully constrain the matrix phases
- Full algorithm in my paper!

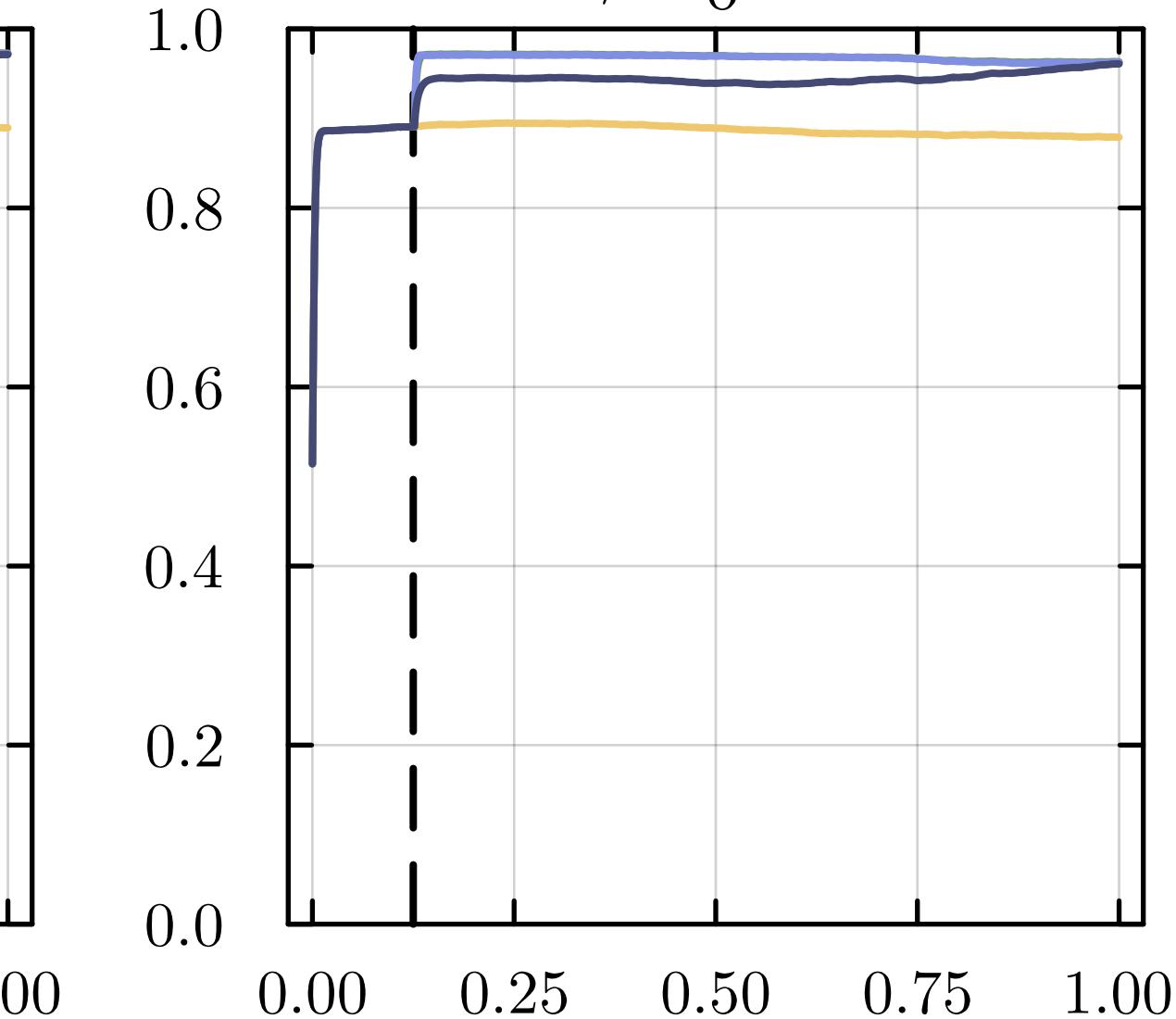
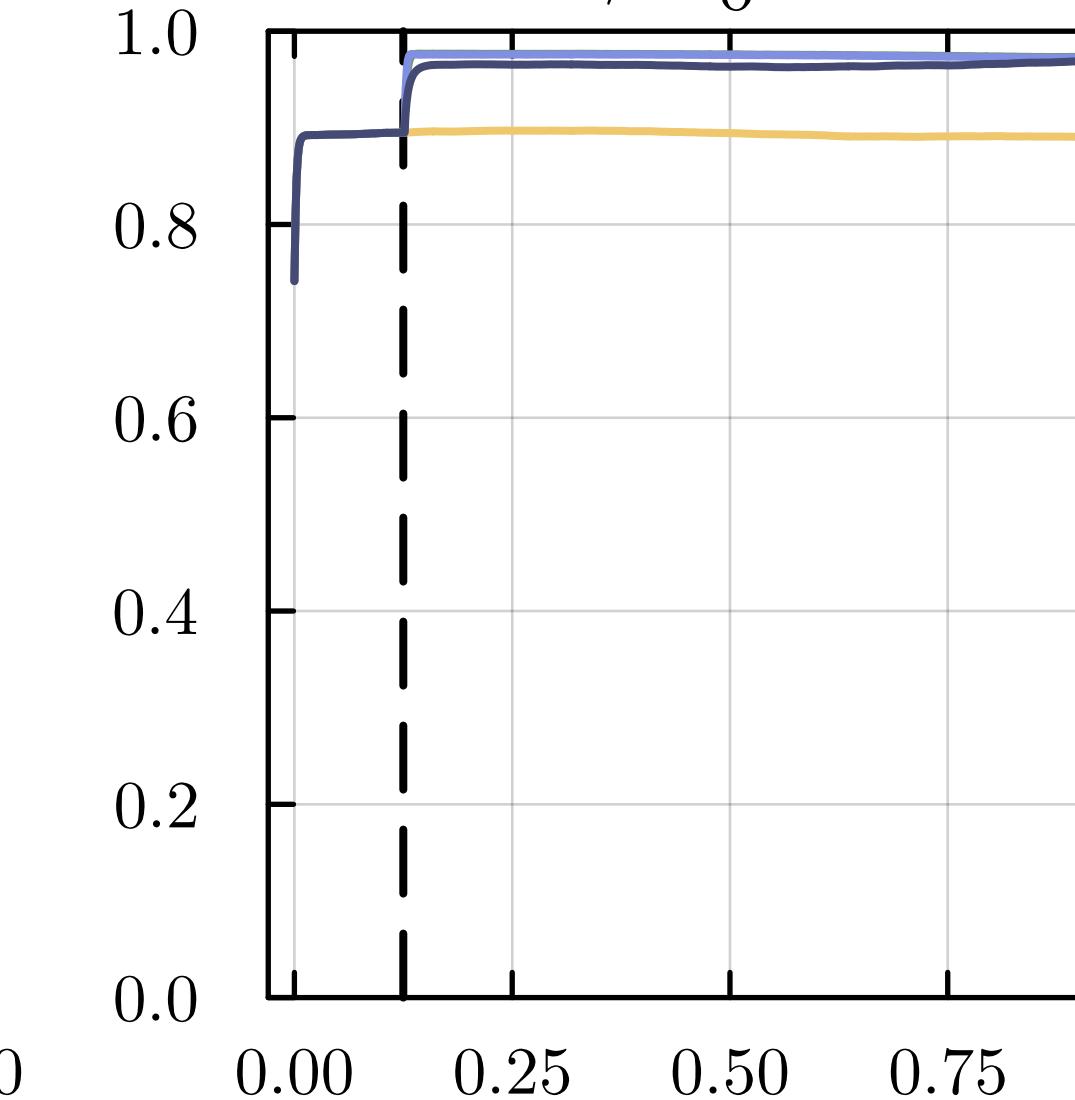
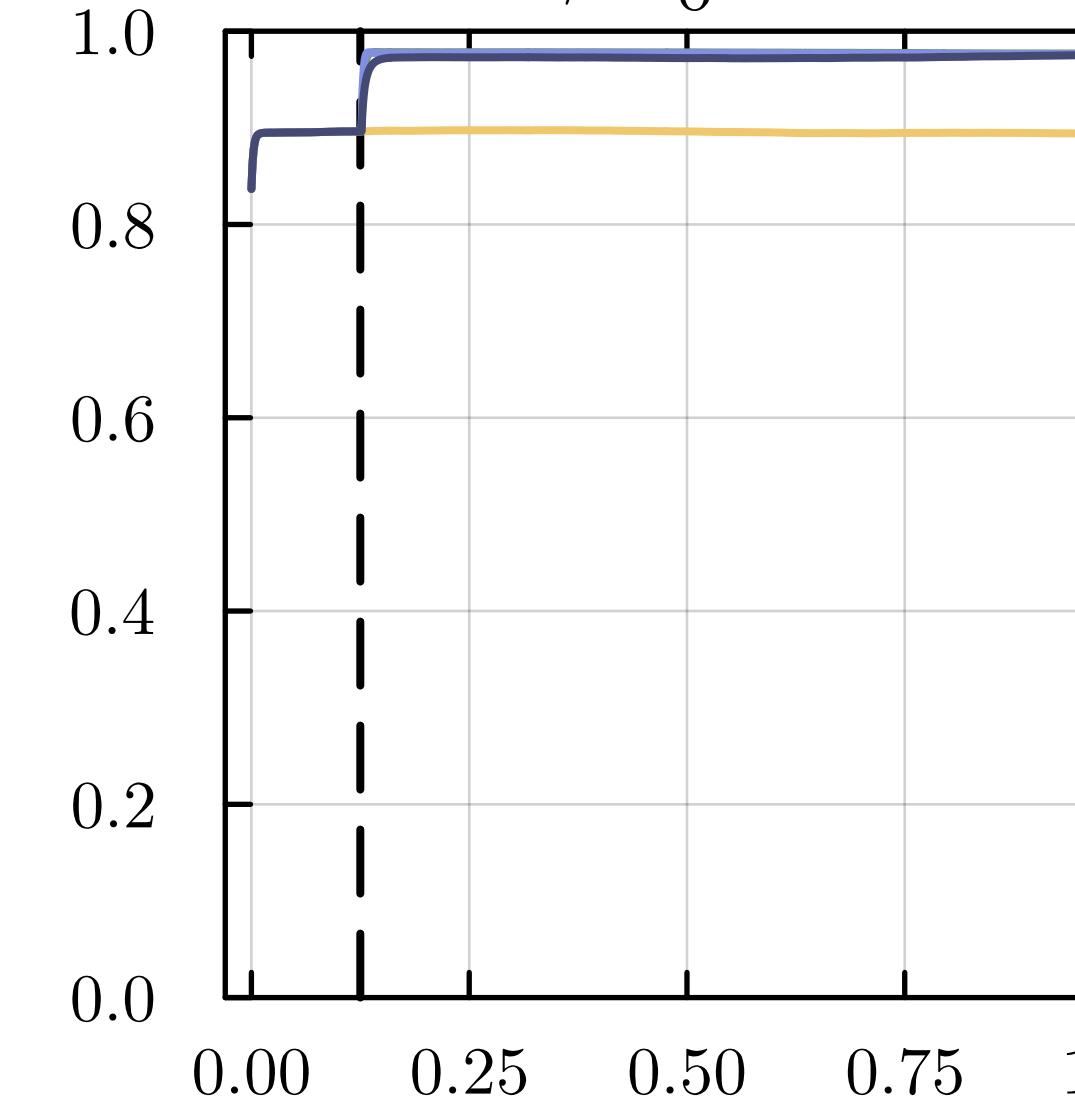
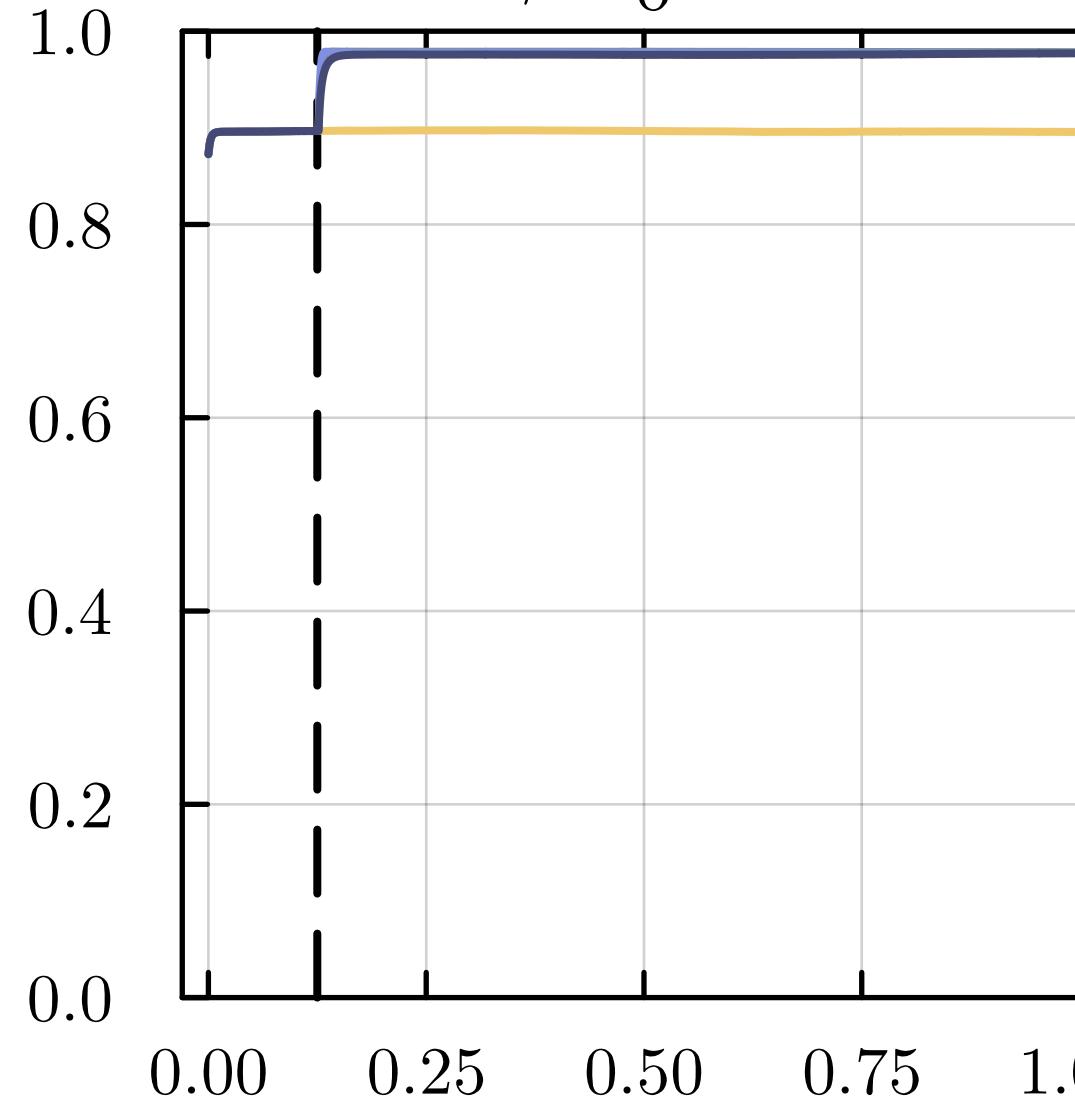
Write down gain, leak, loop rate, nmodes



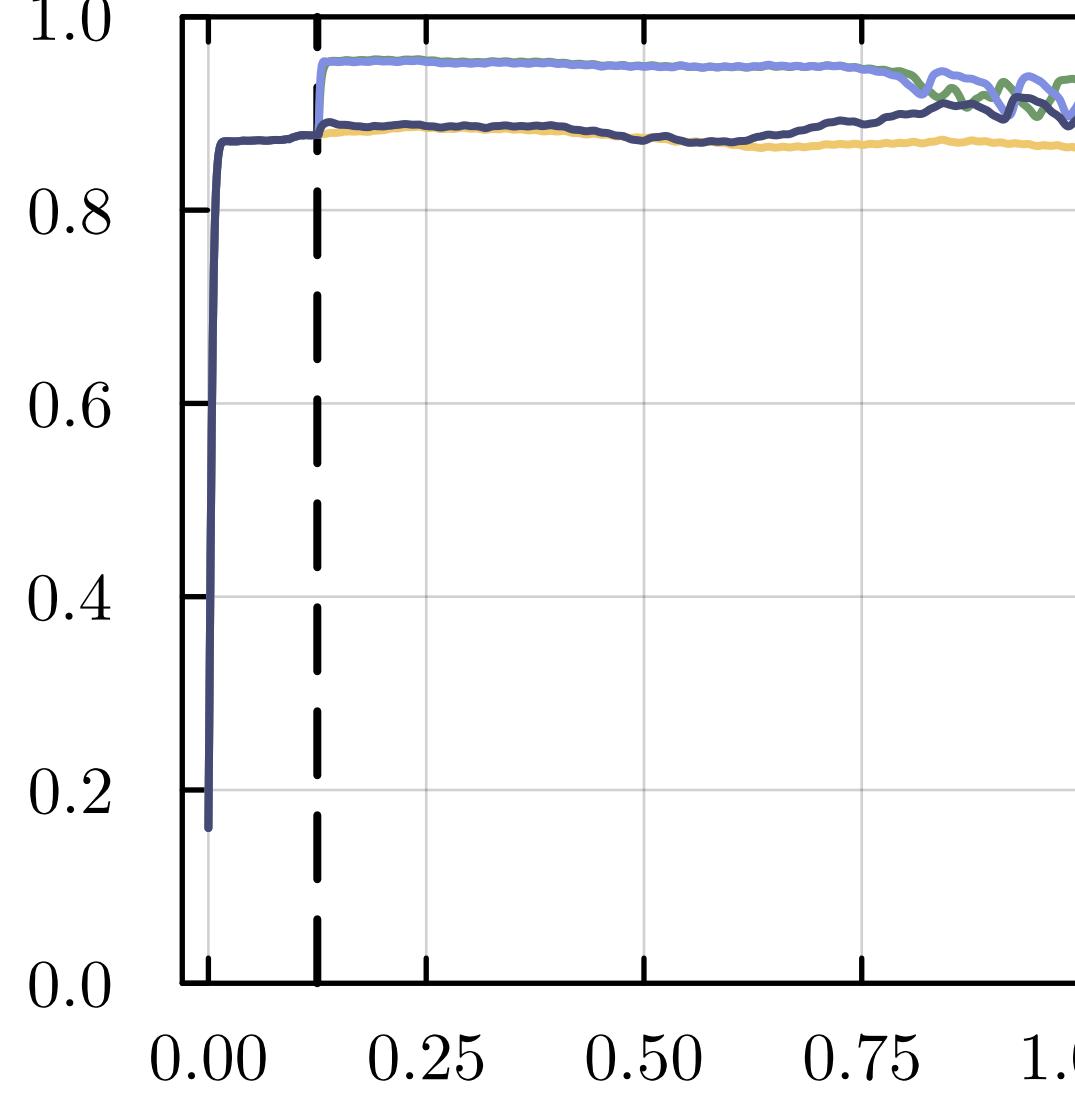
- PSF without and with NCPA

Strehl ratio over time (s) for varying reconstructors and atmospheres

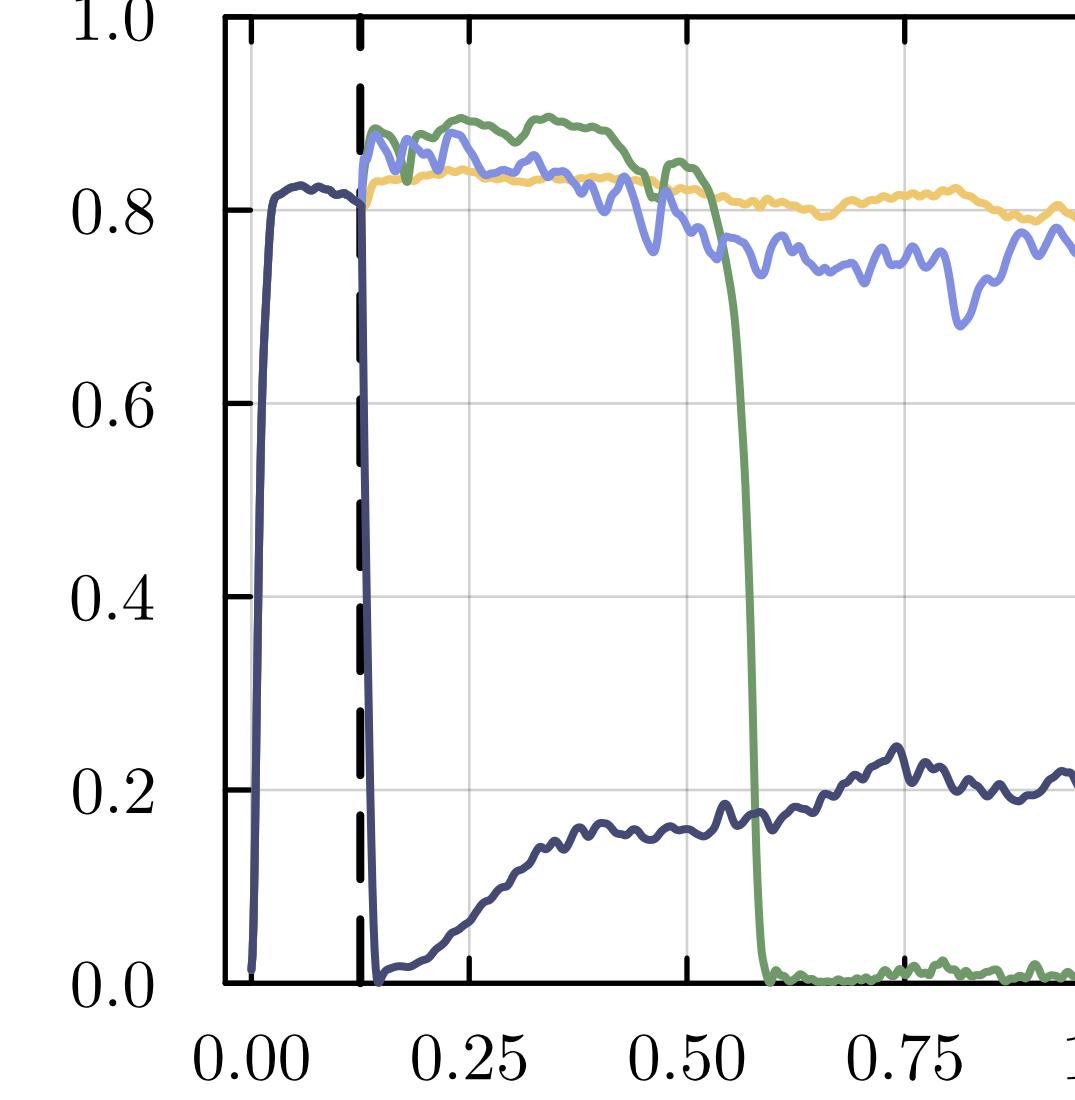
$D/r_0 = 1$ $D/r_0 = 2$ $D/r_0 = 4$ $D/r_0 = 8$



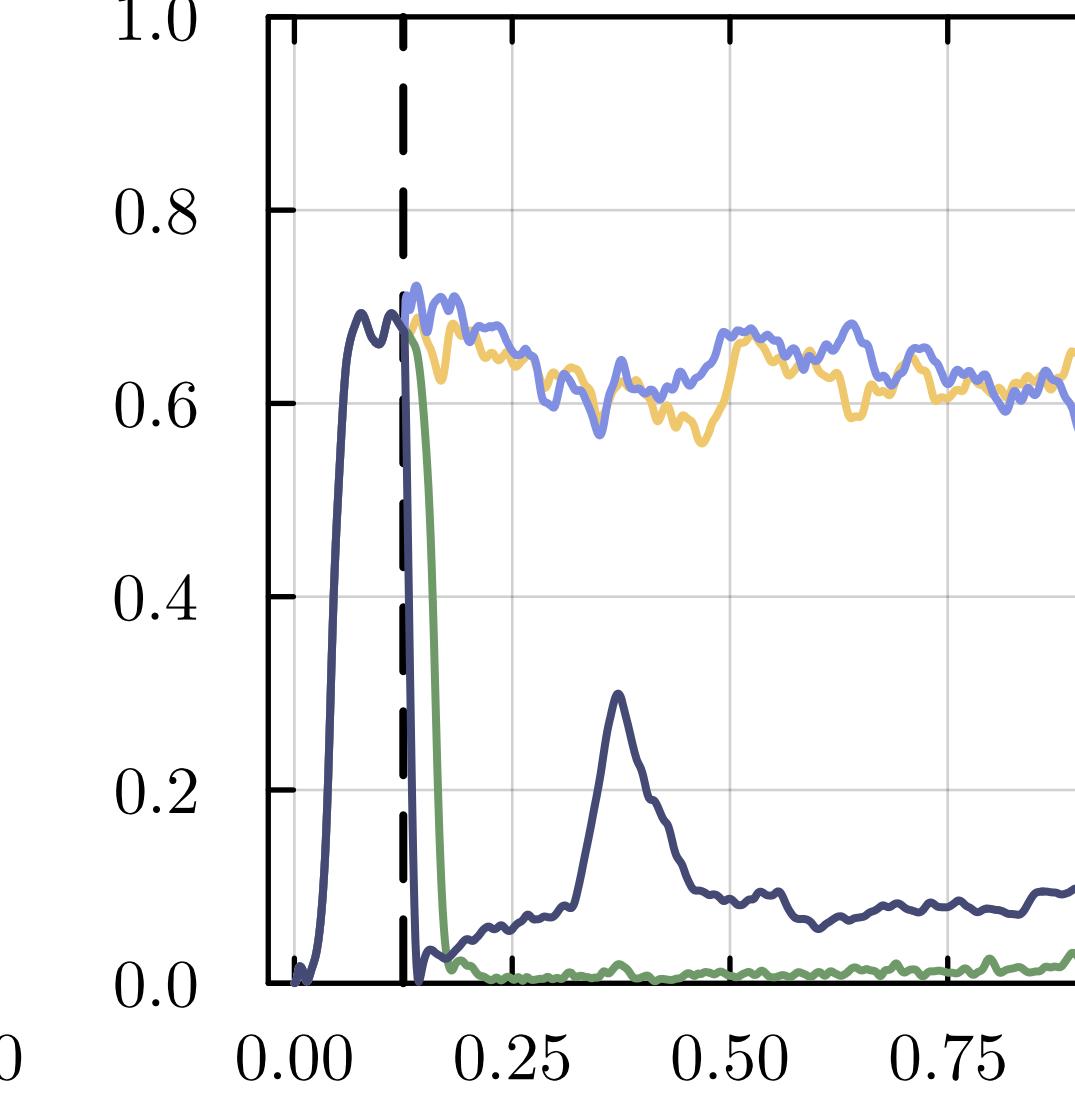
$D/r_0 = 16$



$D/r_0 = 32$



$D/r_0 = 64$



- No lantern (NCPA)
- Linear reconstructor
- Neural network
- Gerchberg-Saxton
- PL loop closed

