4D tracking of biological samples using lens-free on-chip in-line holography

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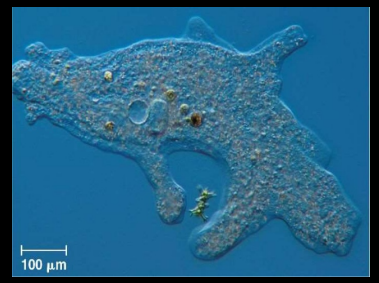
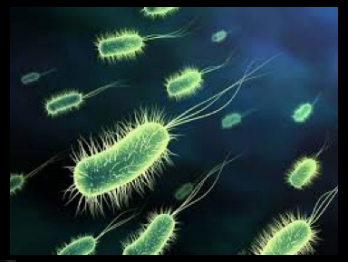
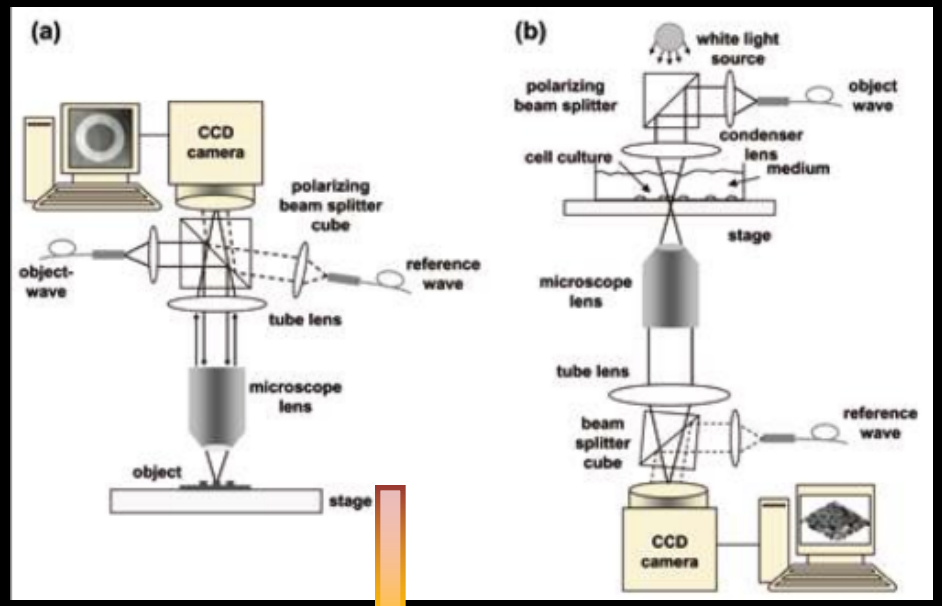
comp photo lab

modern microscopy



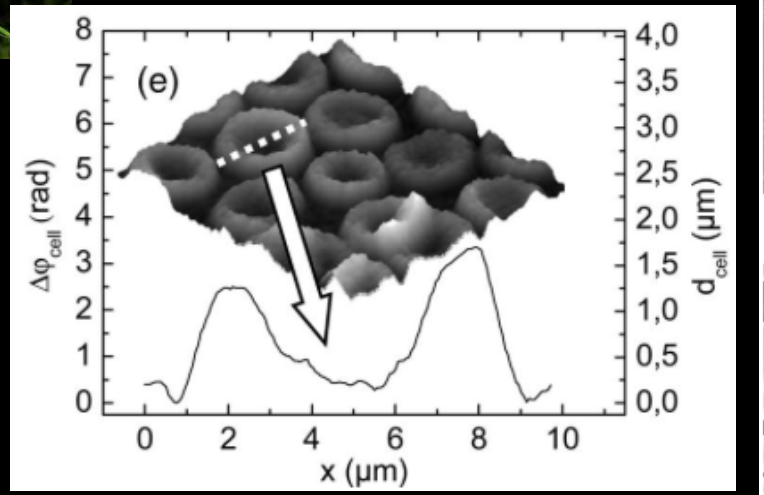


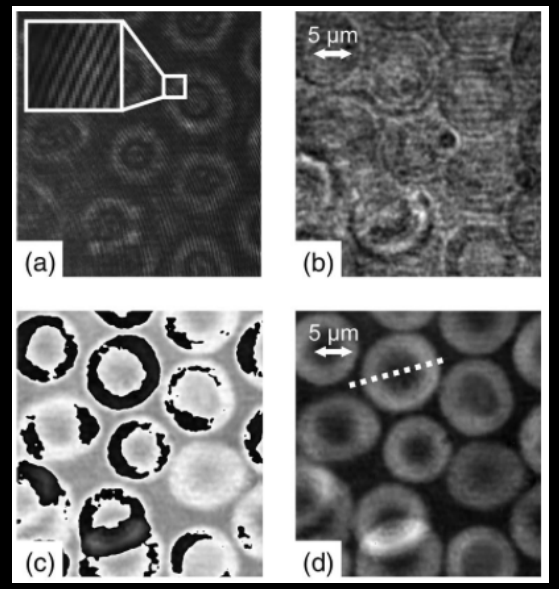
digital holographic microscopy



B. Kemper et al. 2007

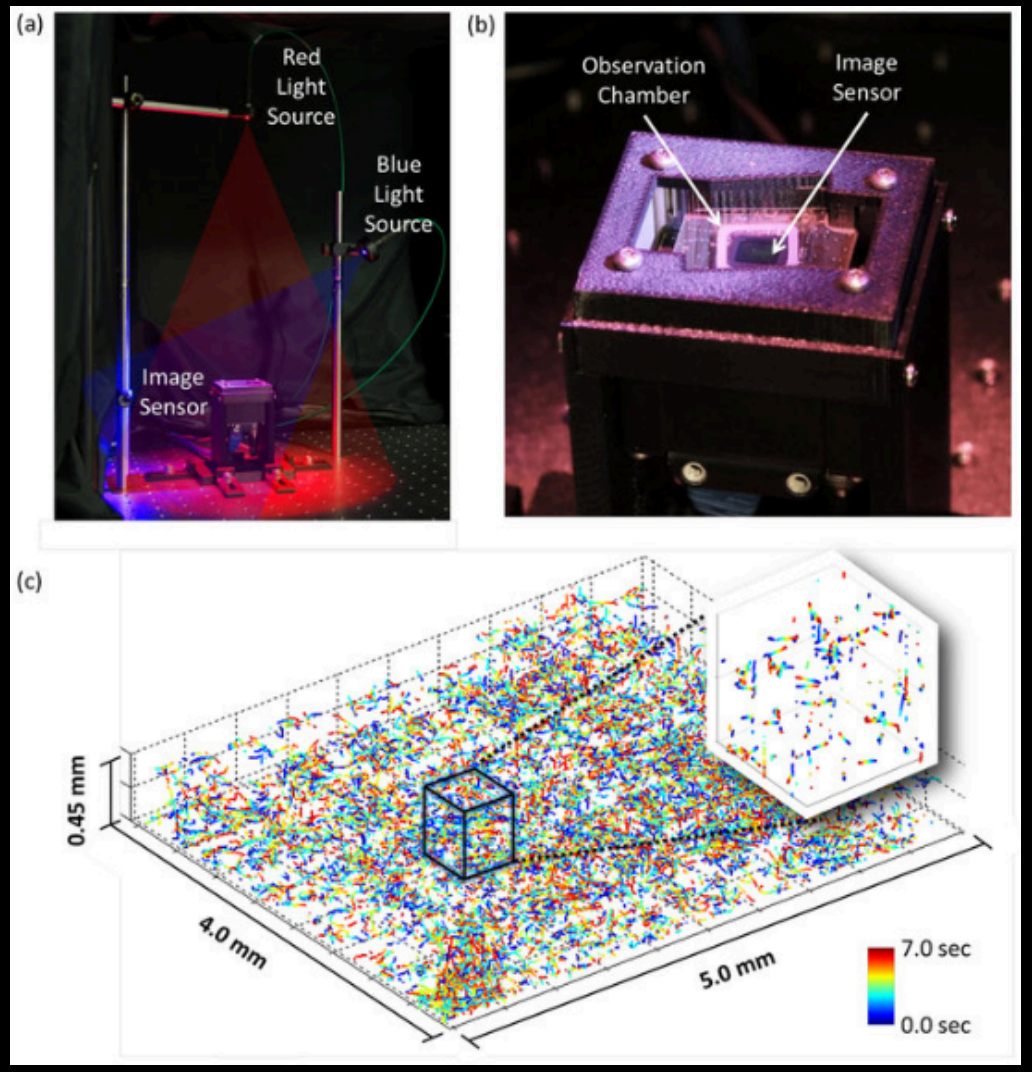
non-destructive
living cells

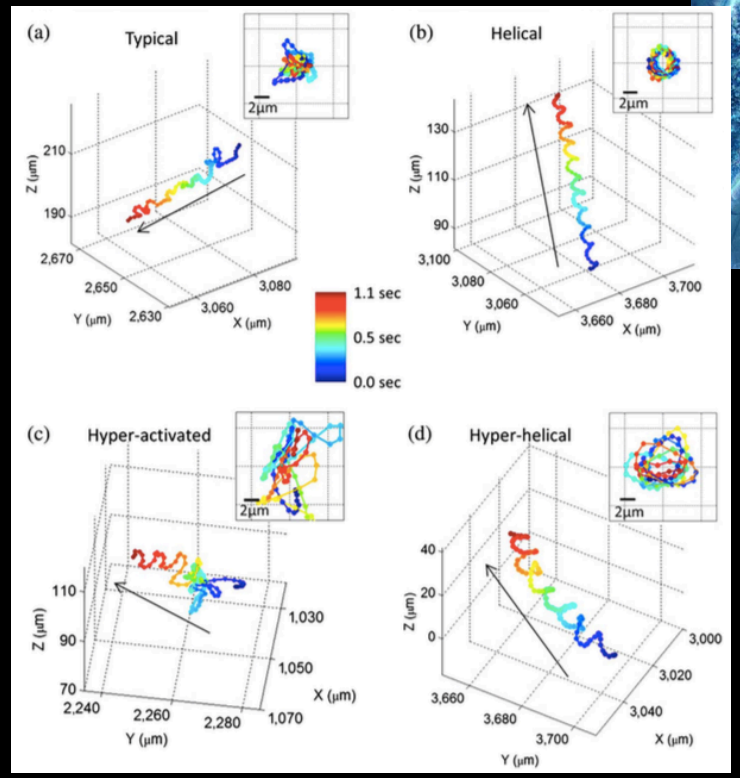




human blood cells B. Kemper et al. 2008

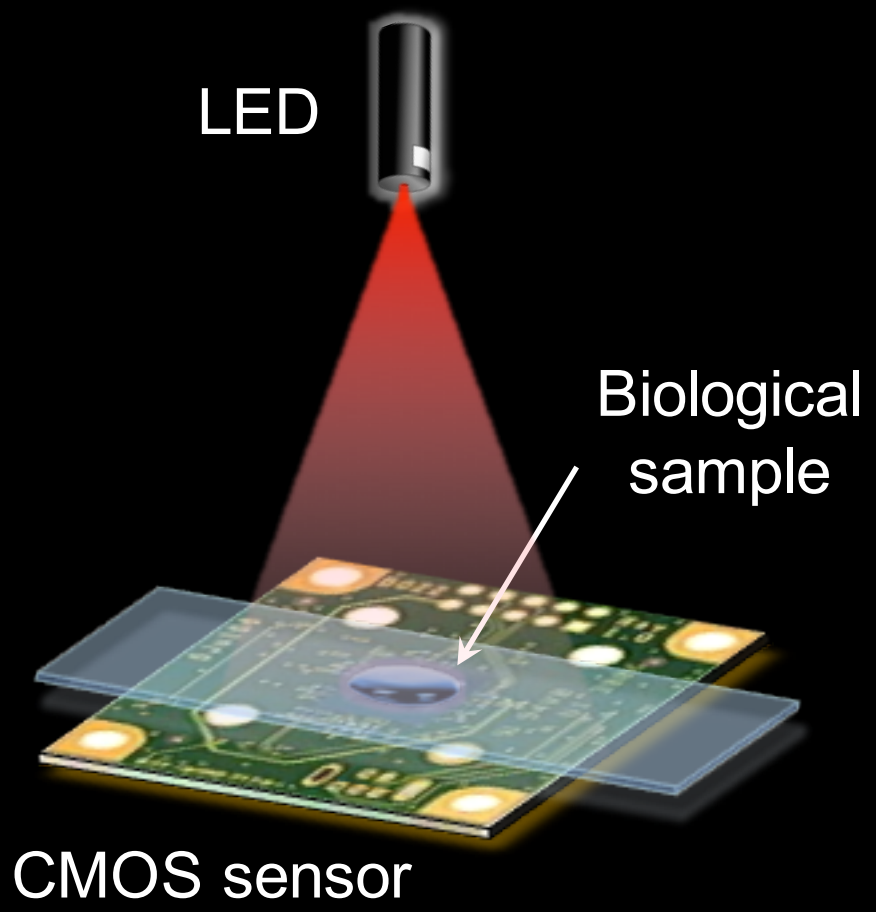
sperm, protozoa, etc.



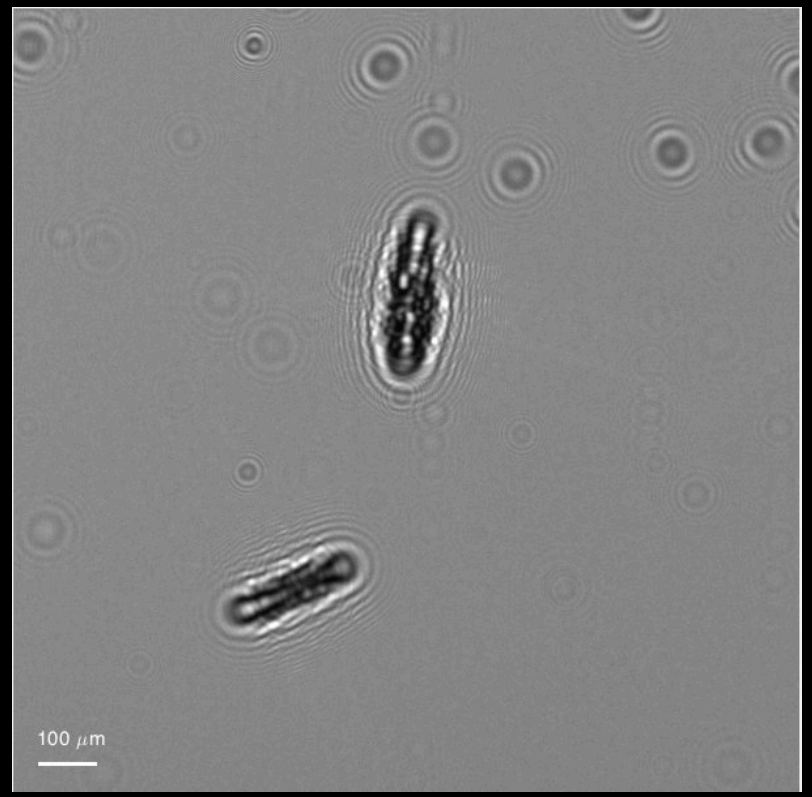


T. Su et al. *Sci. Rep.* 3 (2013)

On-chip setup



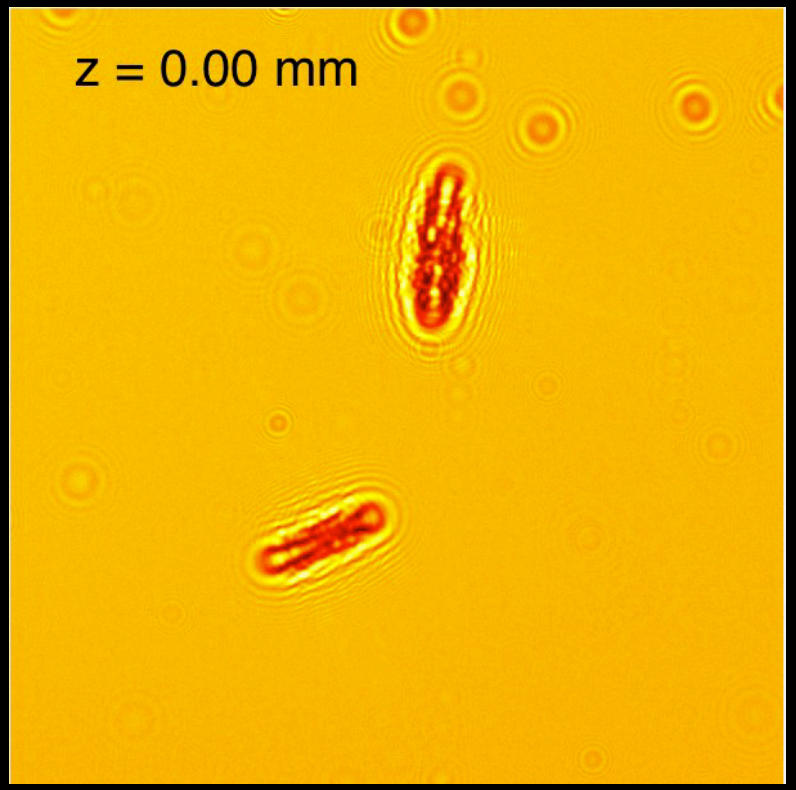
Blepharisma



large Field-of-View, compact, cost-effective
2.2x2.2 um pixel resolution

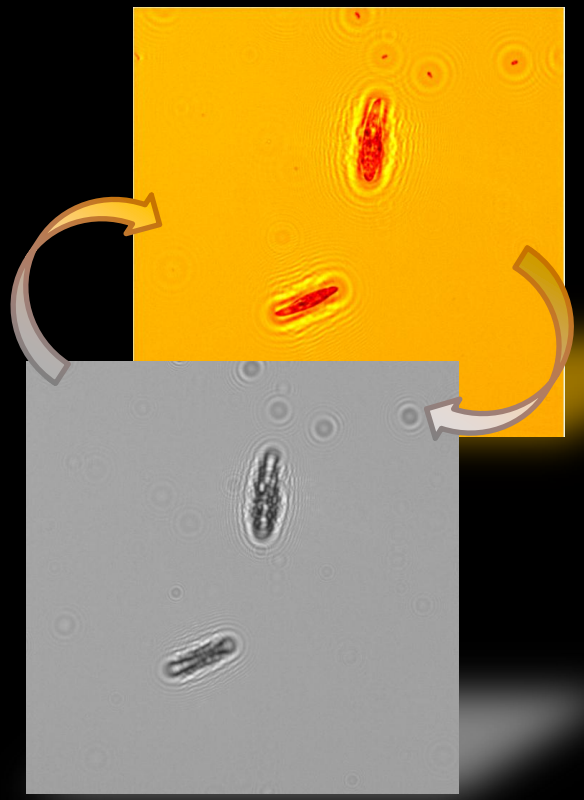
From hologram to object

back propagation $H(x,y;z) = \mathfrak{F}^{-1}\left\{\mathfrak{F}\{E(x,y)\}[k_x,k_y]\exp\left[iz\sqrt{k^2-k_x^2-k_y^2}\right]\right\}[x,y]$



refocusing

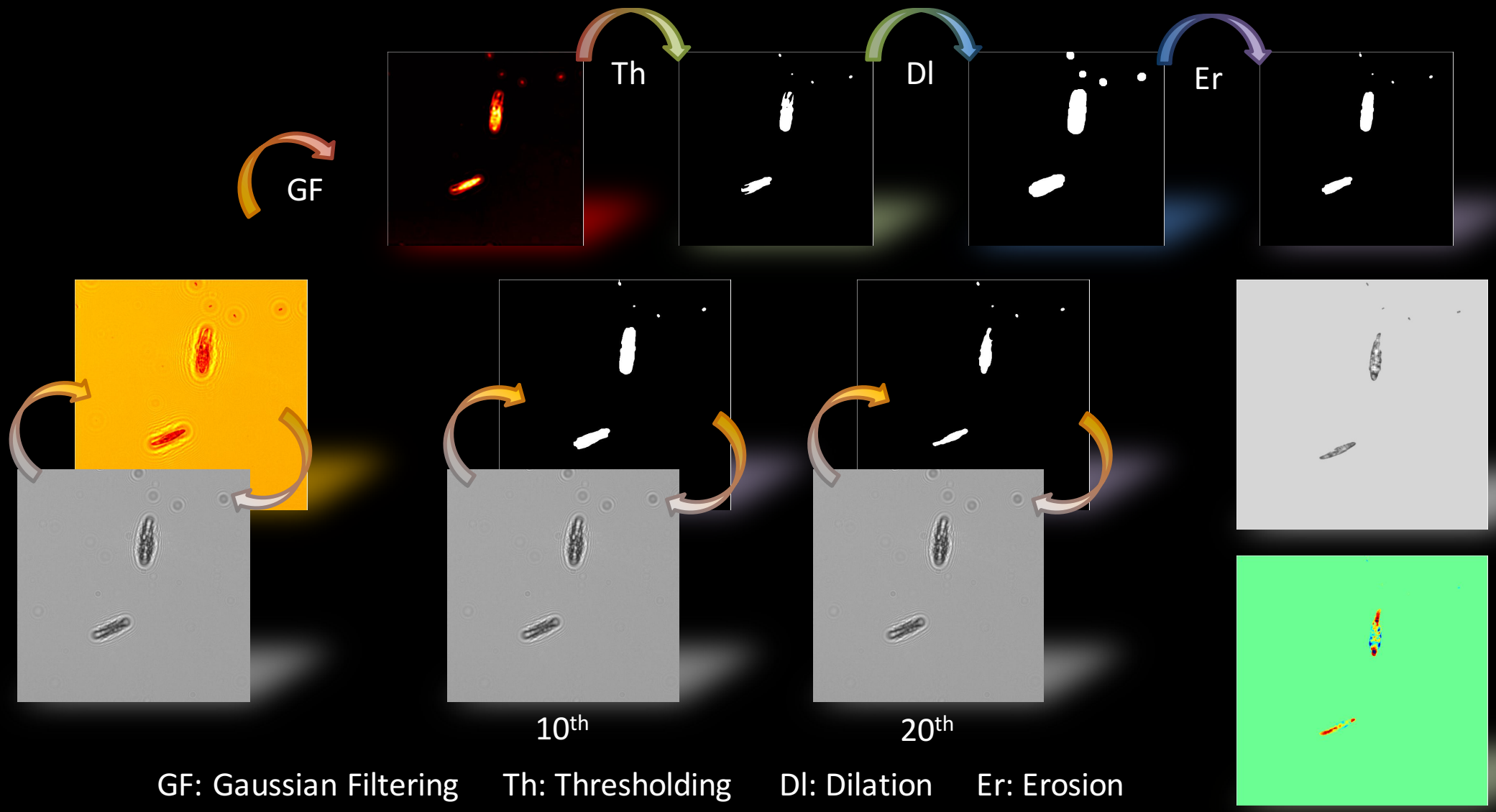
object plane



hologram plane

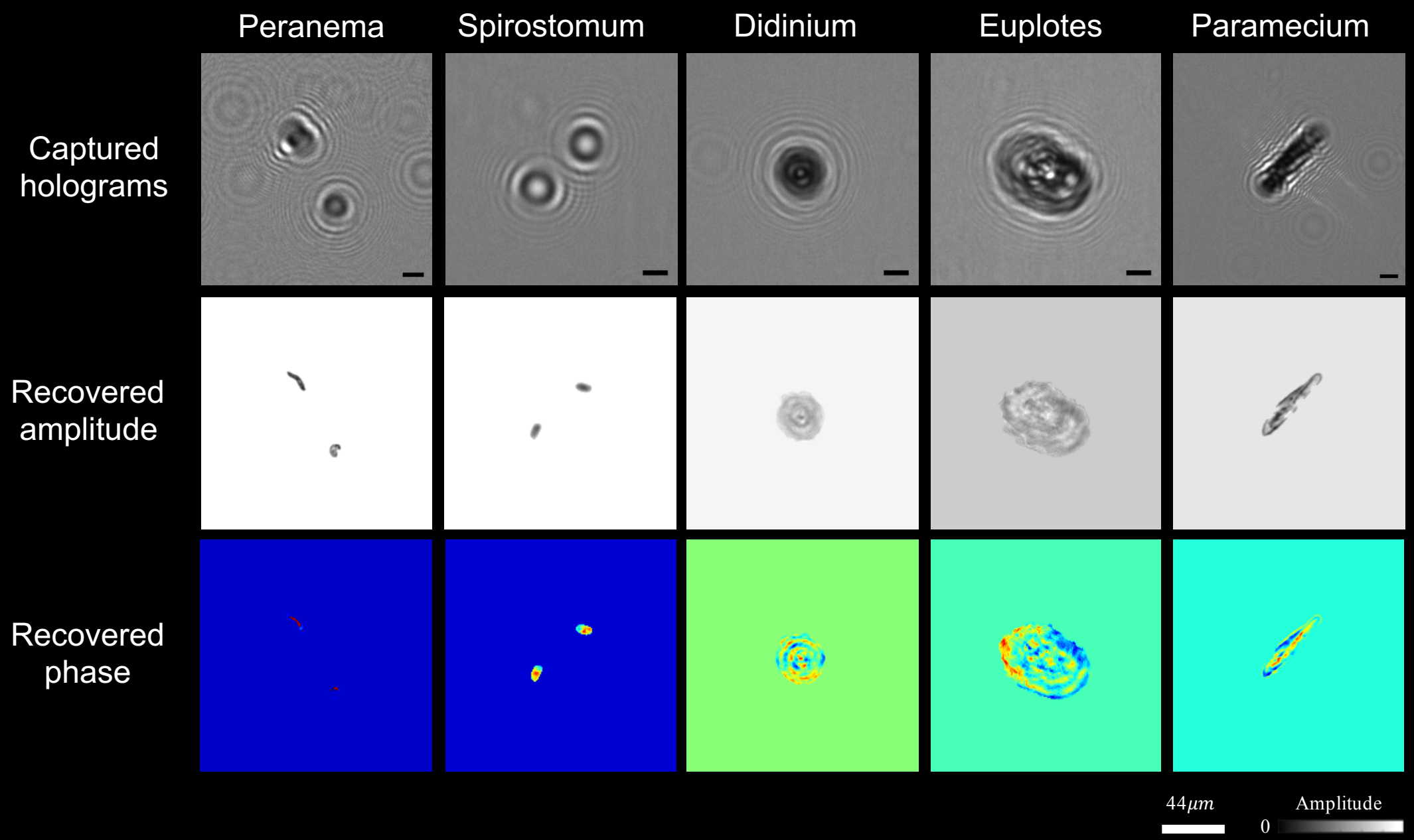
modified Gerchberg-Saxton phase retrieval

Phase retrieval

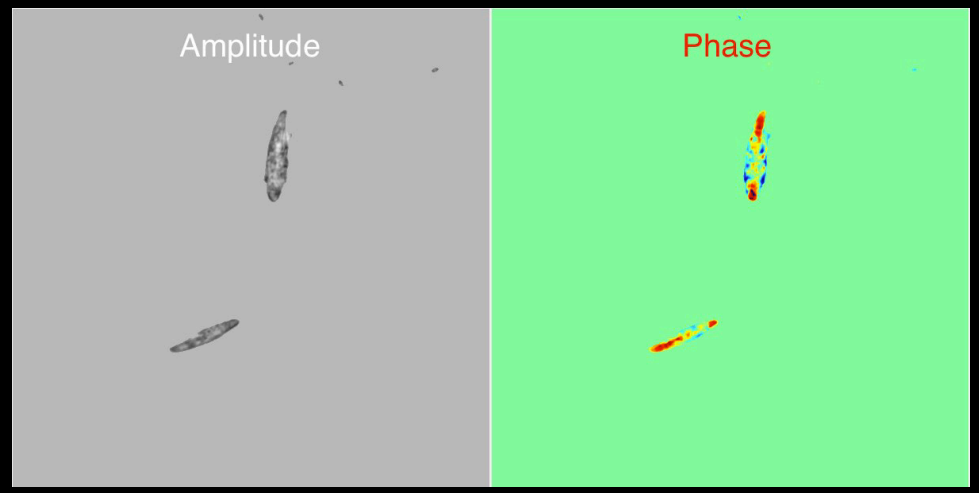


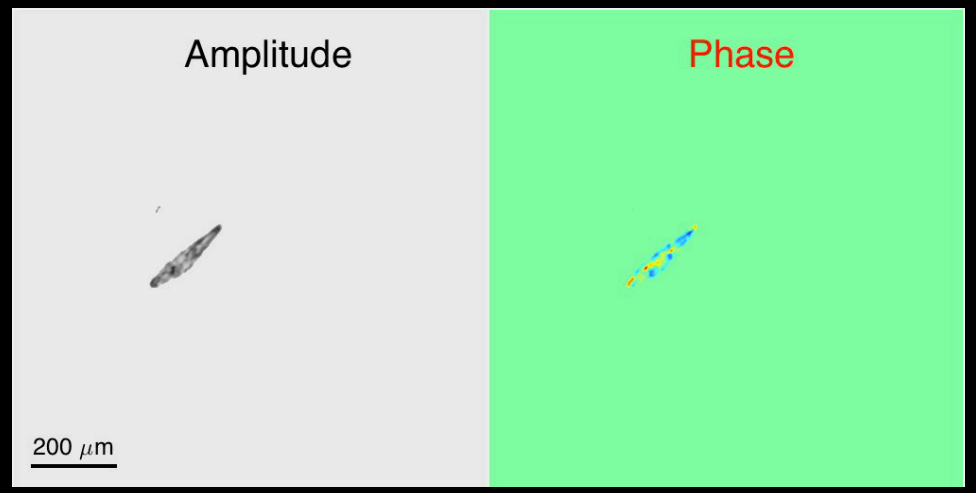
GF: Gaussian Filtering Th: Thresholding Dl: Dilation Er: Erosion

Lens-free on-chip imaging –phase retrieval gallery

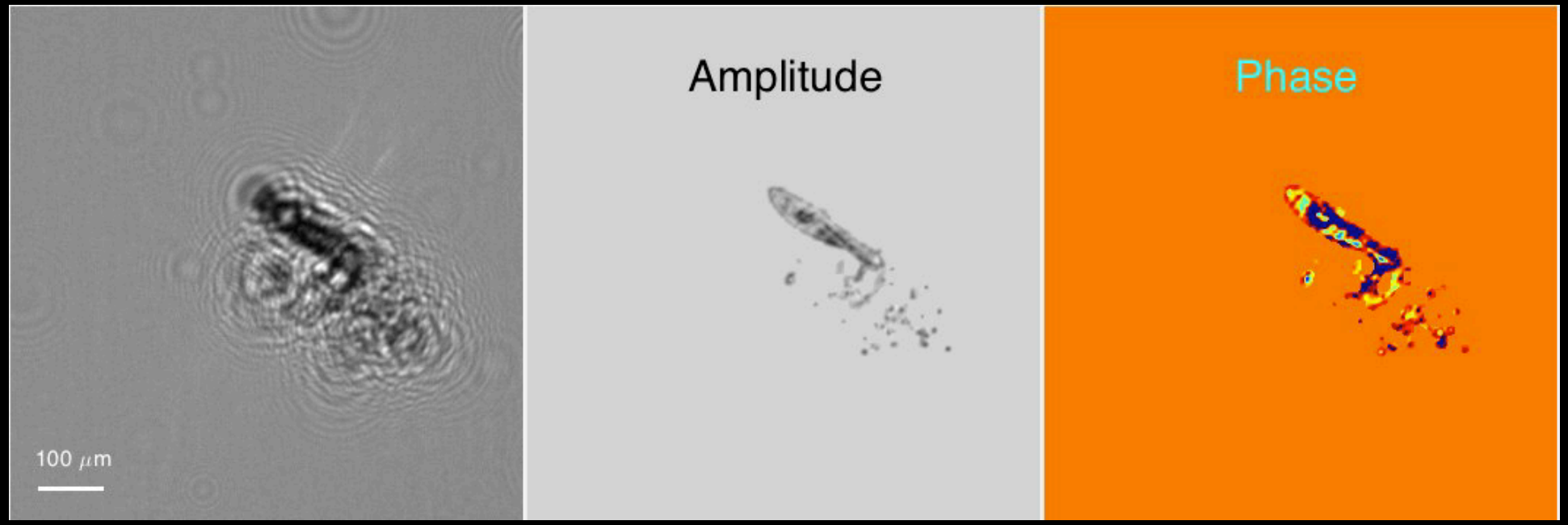


Blepharisma

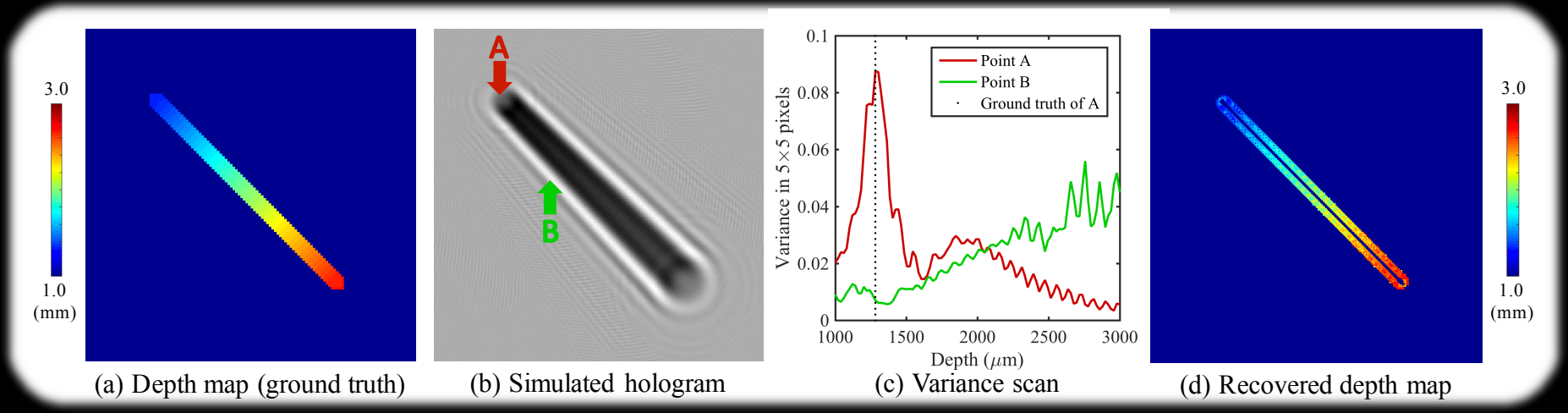




Paramecium

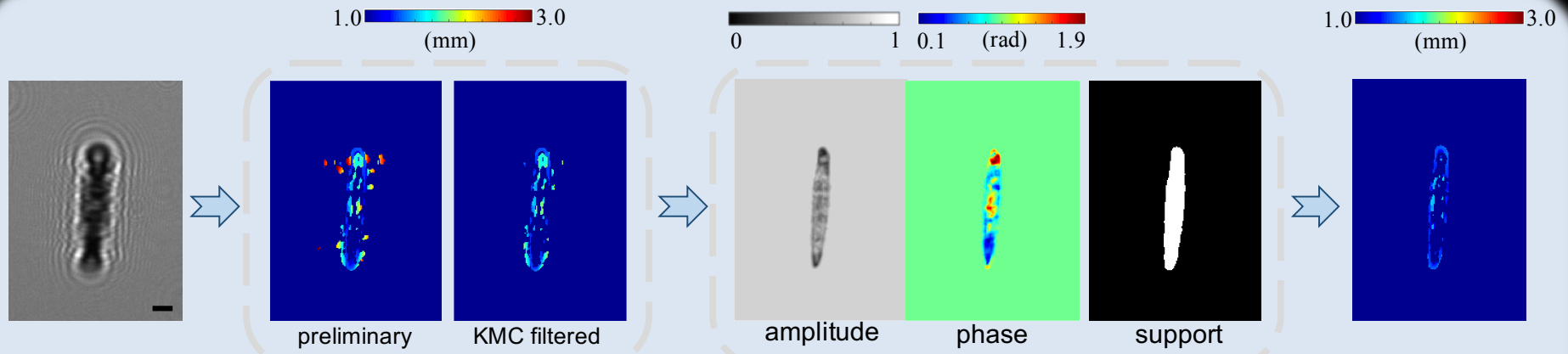


Tracking/profiling

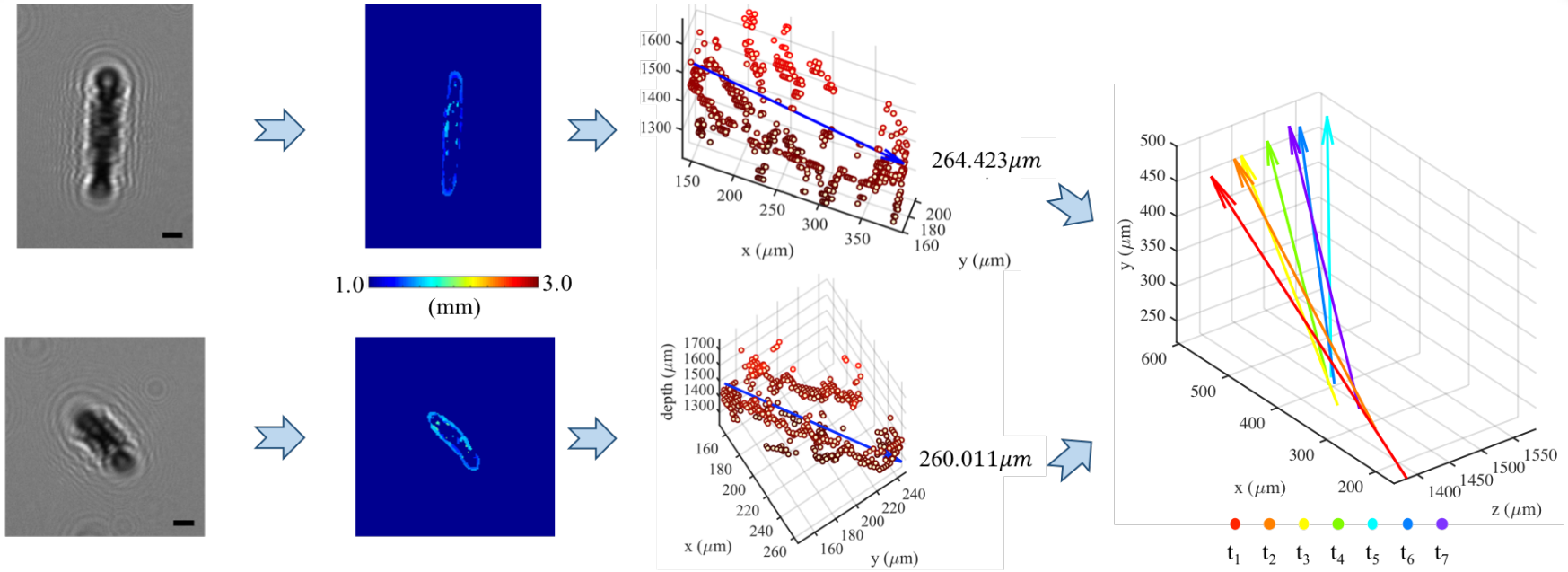


(a) Depth map (ground truth) (b) Simulated hologram (c) Variance scan (d) Recovered depth map

most recent comparative study: Mohammed et al. Appl. Opt. (2017)

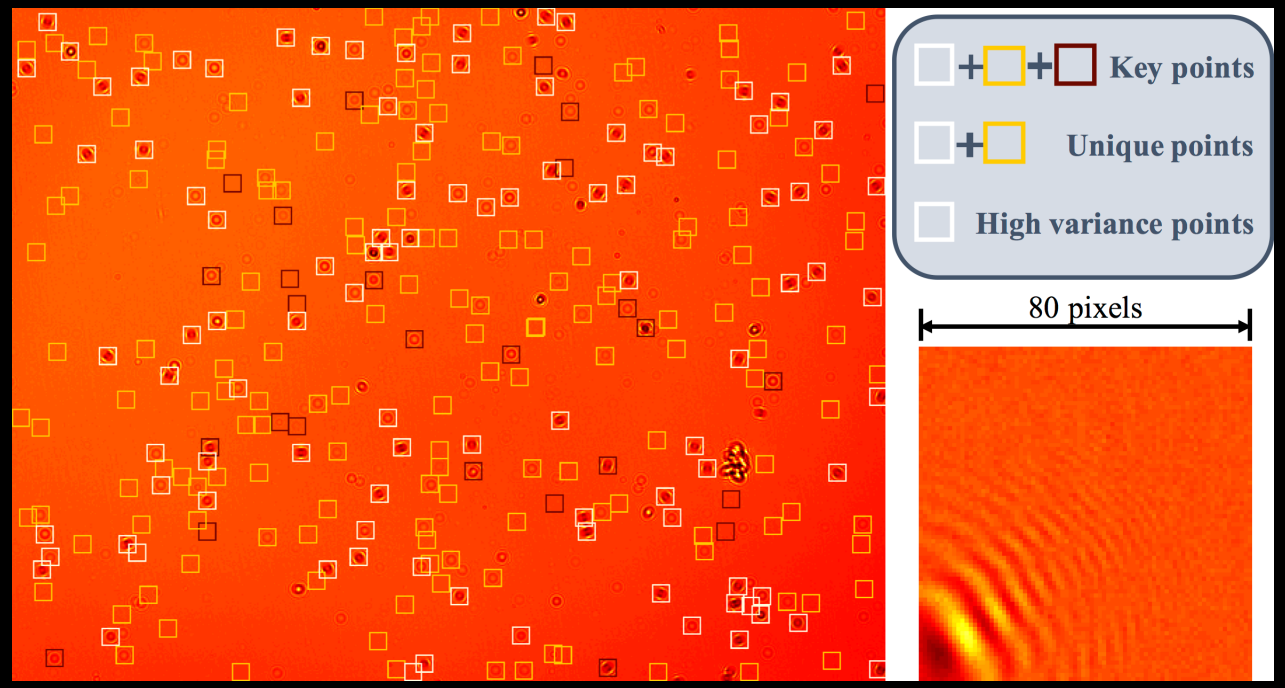


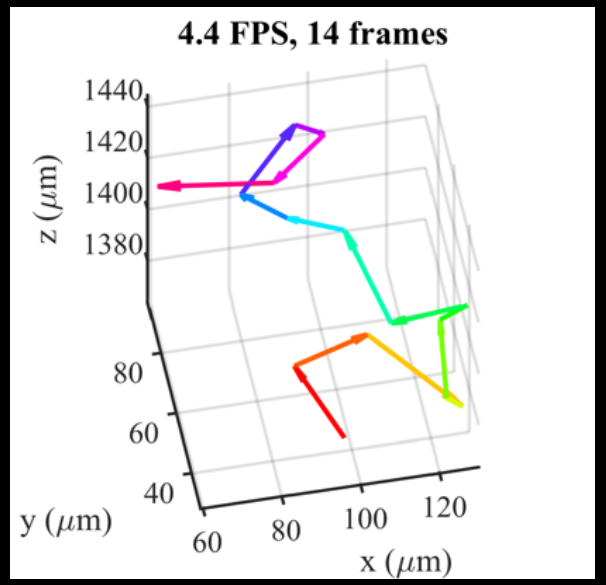
(a) Hologram (b) Depth estimation (c) Phase retrieval (d) Refined depth ma



a) The same Blepharisma t different time frames (b) Depth estimation near boundaries (c) Length estimation (d) 3D localization over time (4.4 FPS)

Tracking/profiling (Paranema)





Thanks for your attention!

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