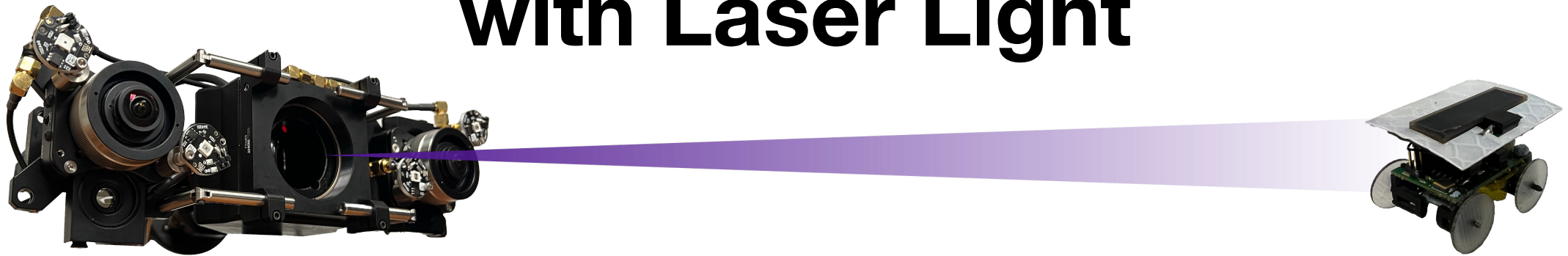


Set Phasers to Stun: Beaming Power and Control to Mobile Robots with Laser Light

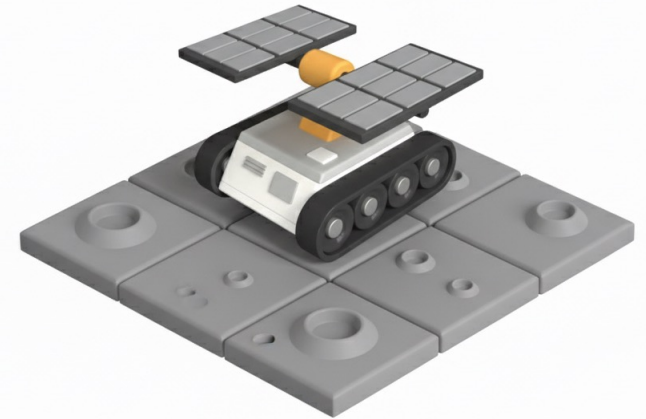


Charles J. Carver^{†2}, **Hadleigh Schwartz**^{†1}, Toma Itagaki¹, Zachary Englhardt³, Kechen Liu⁴, Megan Graciela Nauli Manik¹, Chun-Cheng Chang³, Vikram Iyer³, Brian Plancher⁵, Xia Zhou¹

[†] Co-Primary Authors

¹Columbia University ²Massachusetts Institute of Technology ³University of Washington ⁴Princeton University ⁵Dartmouth College

Potential of Mobile, Autonomous Robots



How do we **power** these robots?

✗ Charging wires

✗ Large batteries

Wireless Power Delivery



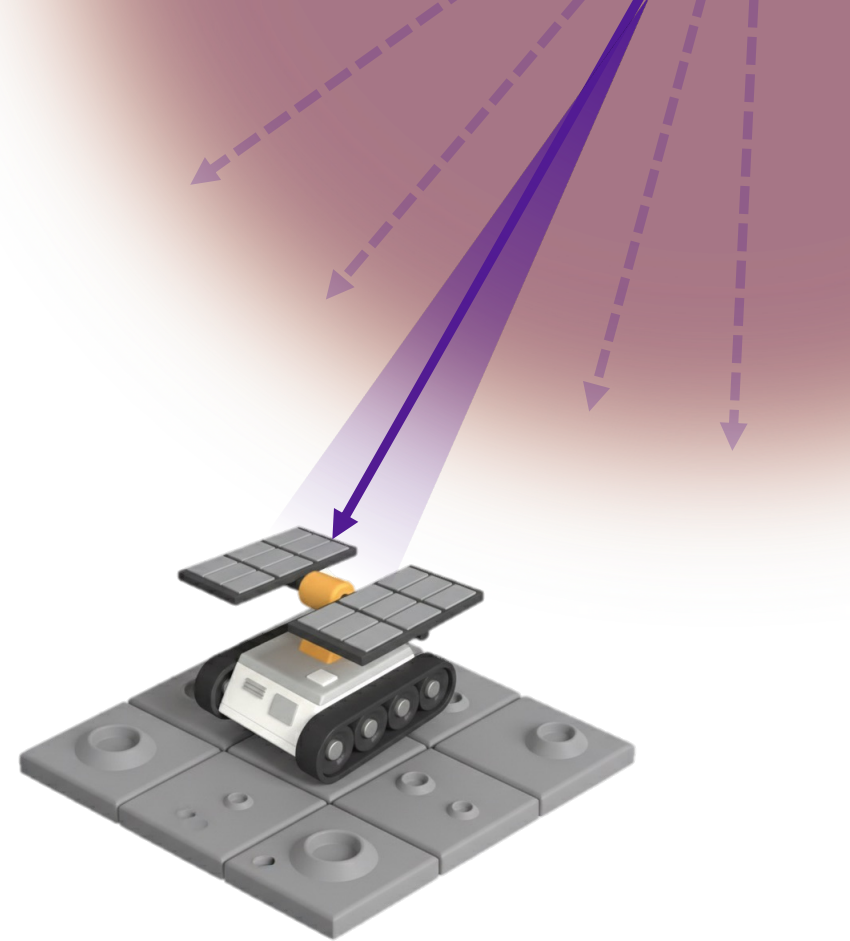
✗ Solar

Operational
constraints



✗ RF/LEDs

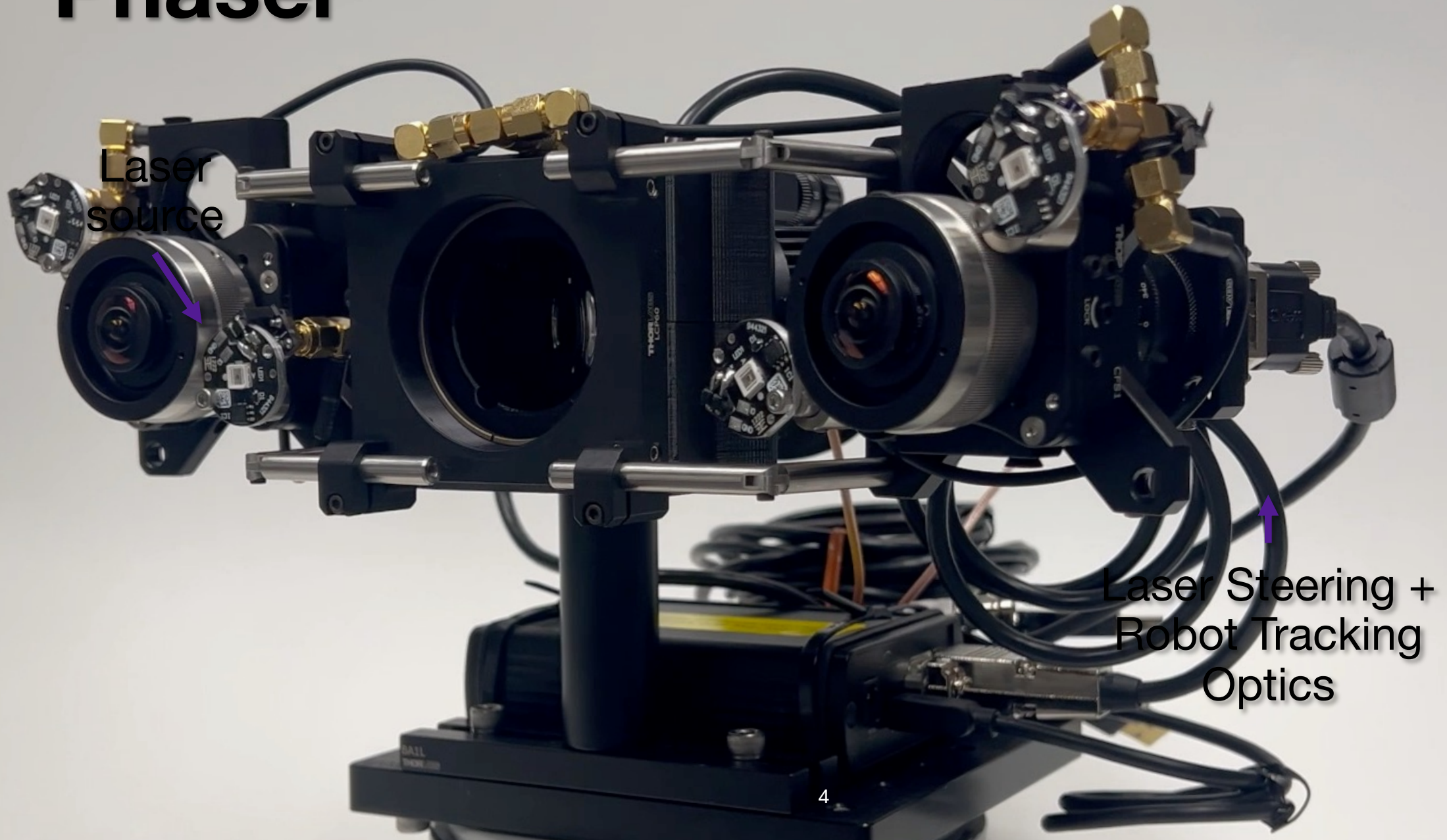
Energy diffused
→ inefficiency



✓ Lasers

Concentrated power
Mobility?

Phaser



Infrared View

Laser light

Real-Time Speed

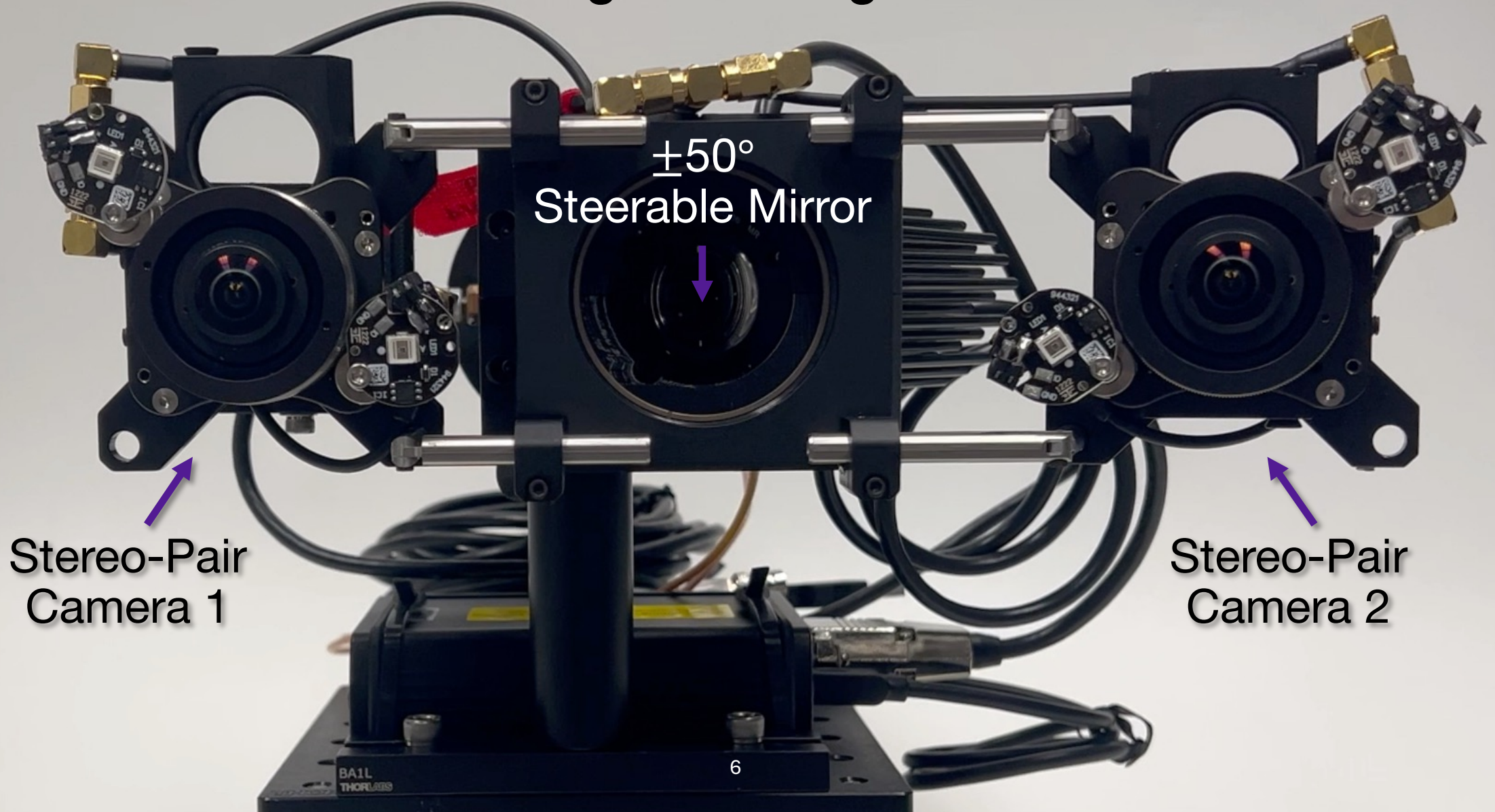
Optical receiver

Battery-free robot
(Johnson et al., MobiCom
2023)

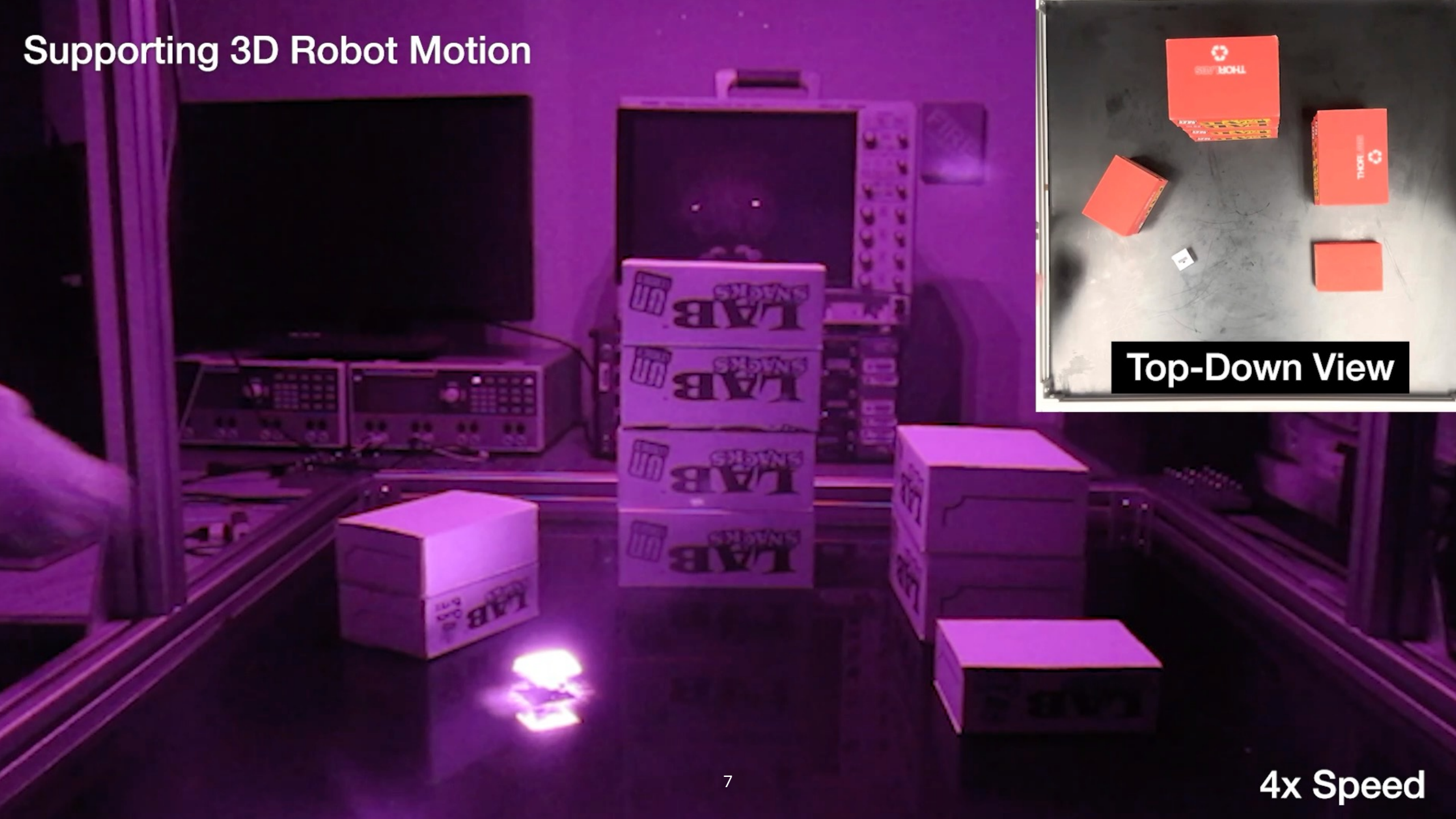
RGB View

Phaser Design

#1 Stereo-Vision Tracking + Steering



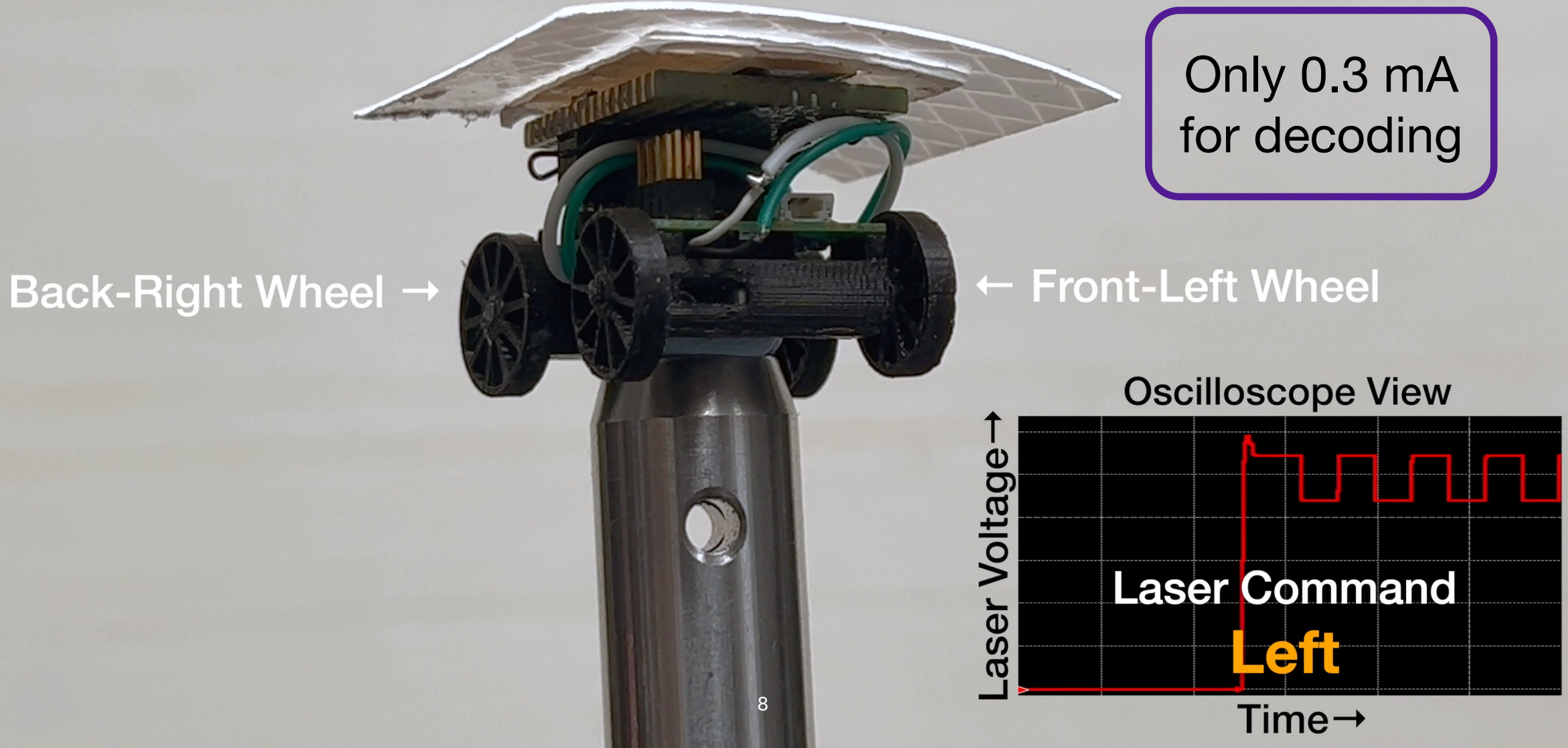
Supporting 3D Robot Motion



Top-Down View

Phaser Design

#2 Low-Power Optical Communication

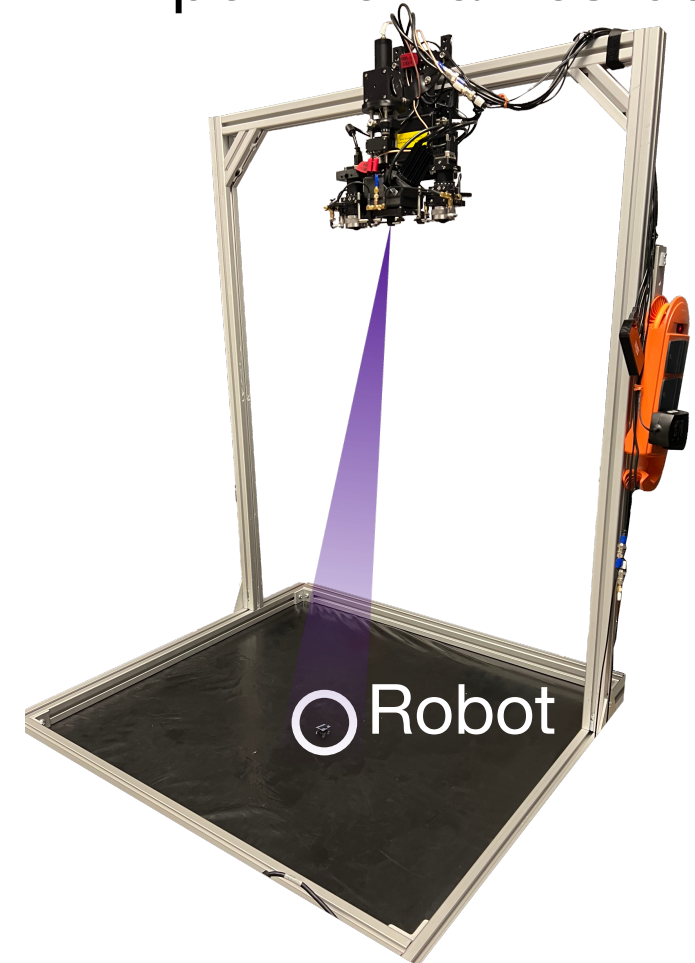


Evaluation

Optical **power densities** > 1 sun
(100 mW/cm²) across robot
velocities and 3D trajectories

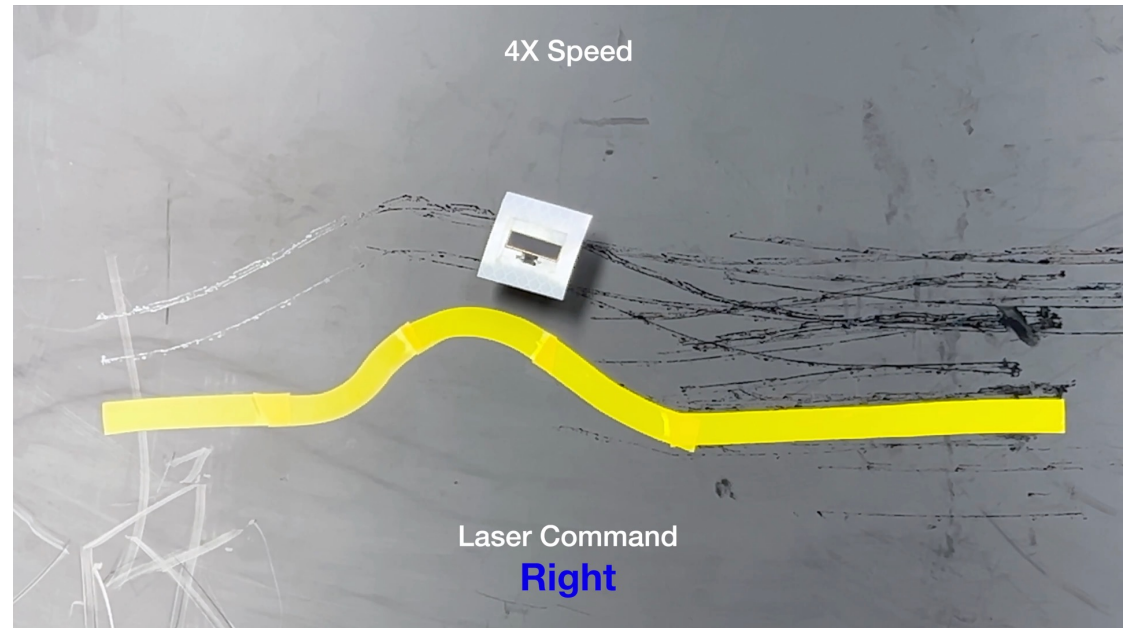
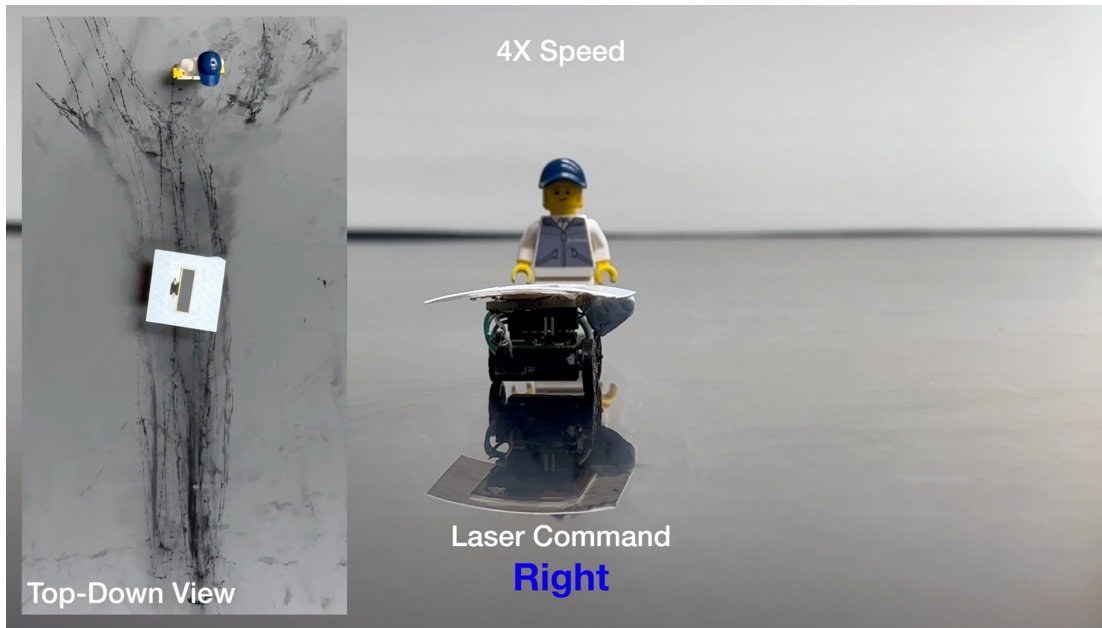
Communication with $< 10^{-3}$ bit
error rate (**error-free data**) at any
position within 5 m

Experimental testbed

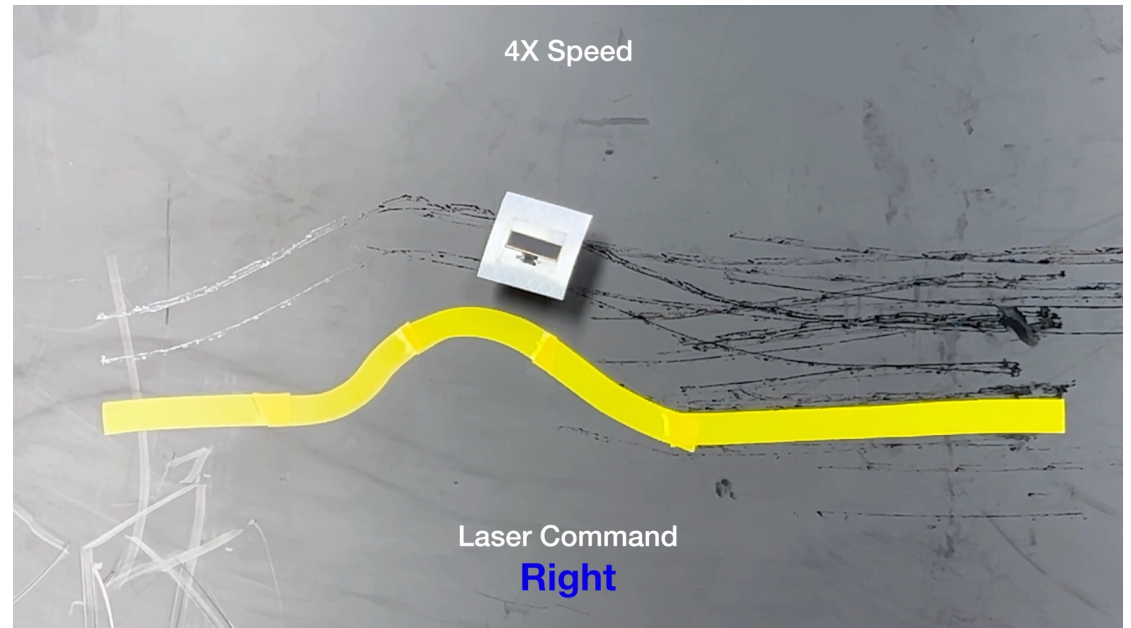
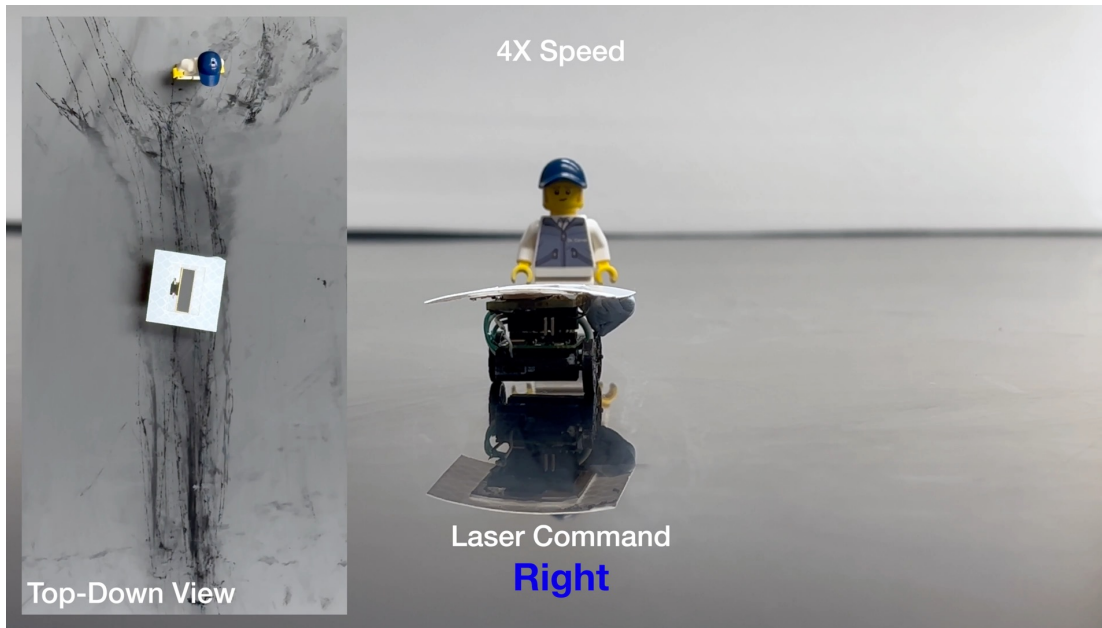


Evaluation

Obstacle Avoidance and Path Following

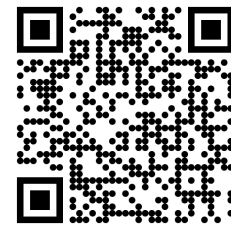


Thank you!



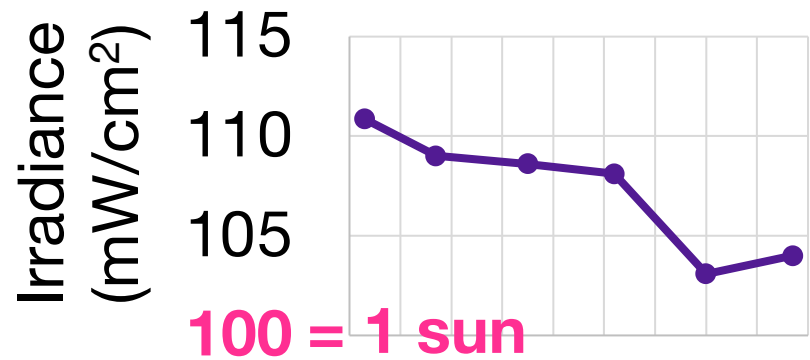
Code, demo, and more on:

<https://mobilex.cs.columbia.edu/phaser/>



Backup

Evaluation

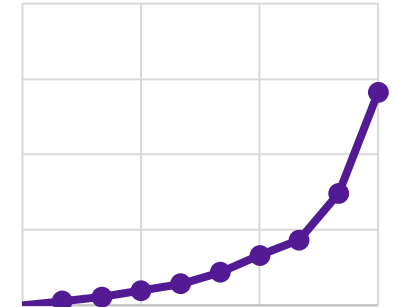
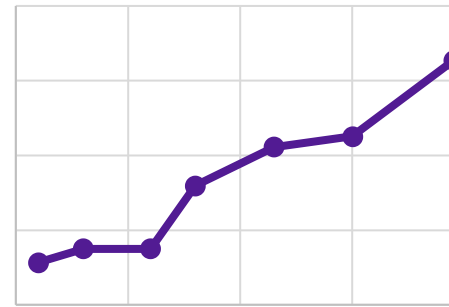


Robot
Velocity (cm/s)

✓ Delivers > 1 sun across
robot velocities/3D locations

BER

1E-3
1E-4
1E-5
1E-6
1E-7



✓ Error-free communication at
any positions up to 5 m