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Toronto, Canada, July 21-23

Zero-Phase Phasor Fields for Non-Line-of-Sight Imaging

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Agencia Estatal de Investigación

WISCONSIN
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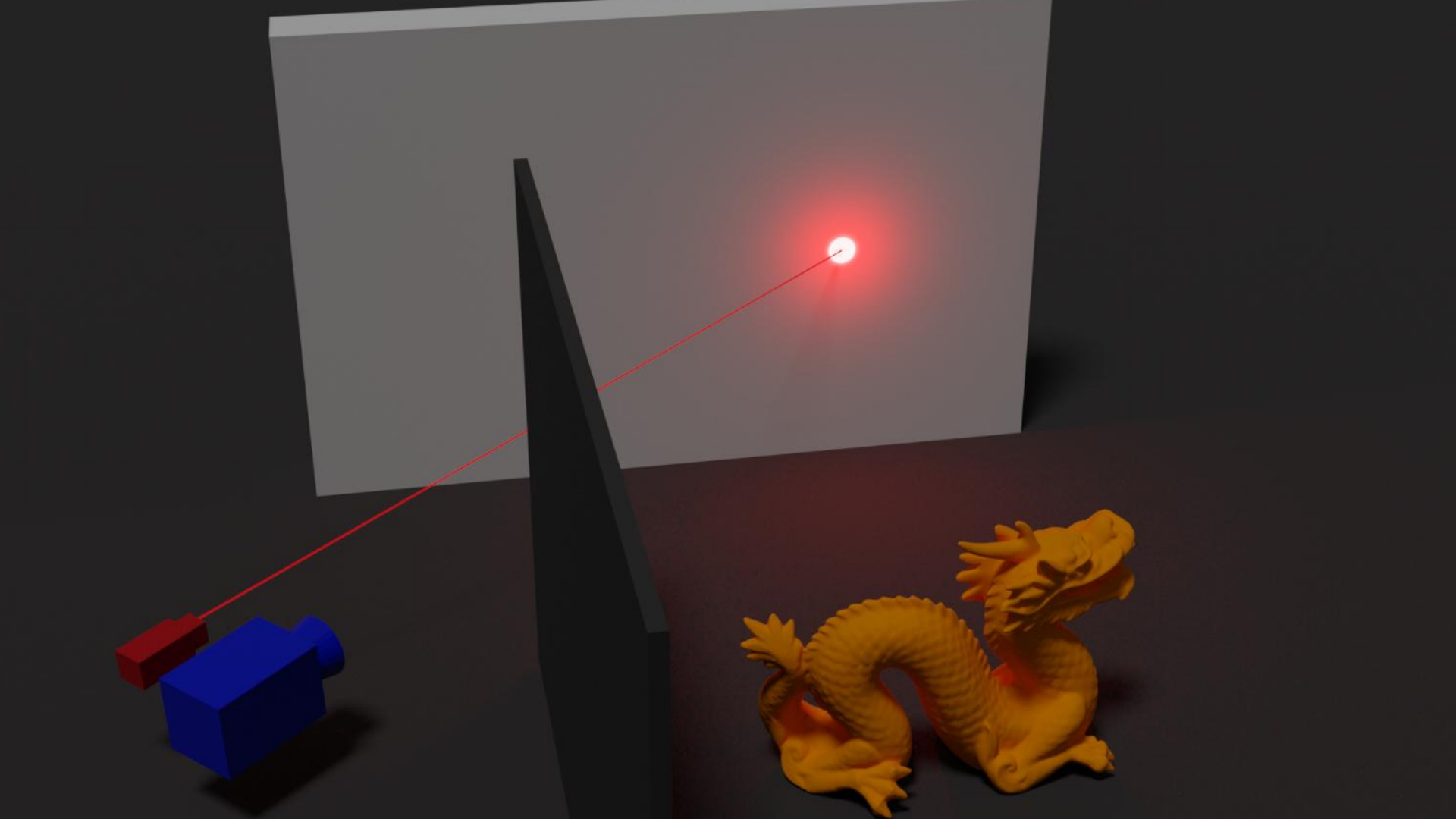
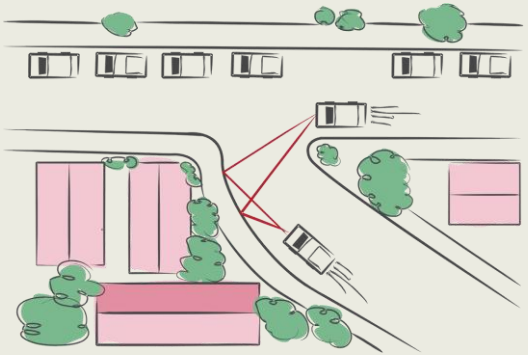
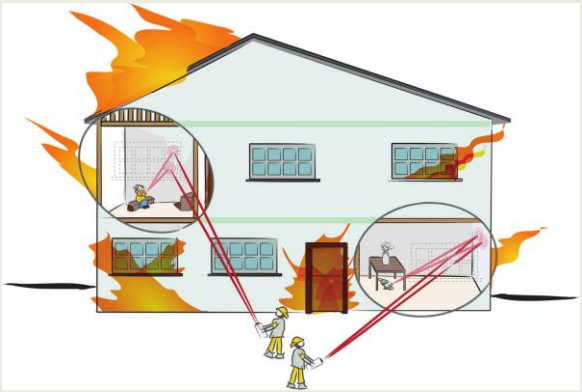


NLOS Imaging applications

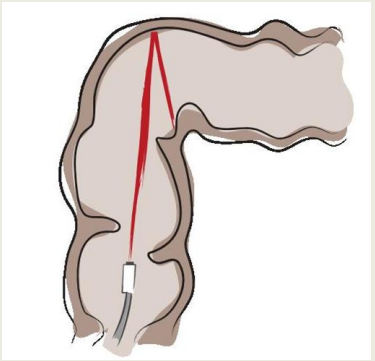
Driving safety



Rescue operations



Medical imaging



Figures adapted from previous work [7]

[7] Maeda, T., Satat, G., Swedish, T., Sinha, L., & Raskar, R. (2019). Recent advances in imaging around corners. *arXiv preprint arXiv:1910.05613*.

Introduction

Hidden scene

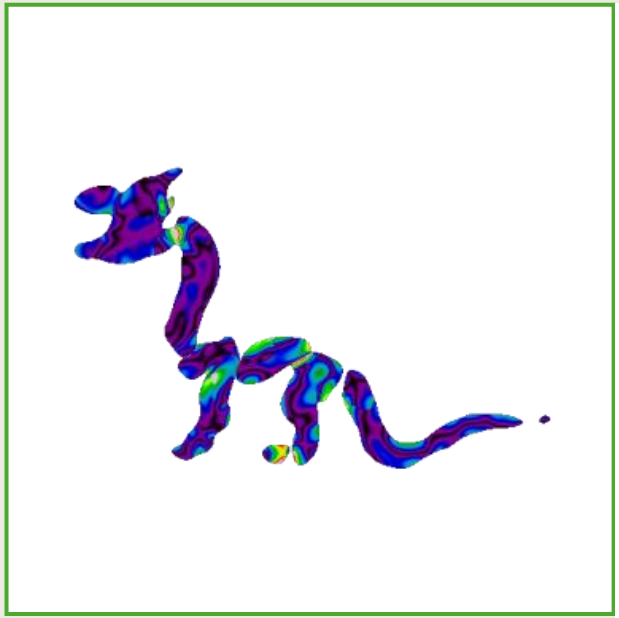
Imaged dragon

Correct depth

Dataset from Lindell et al. 2019

Introduction

Ours error in depth

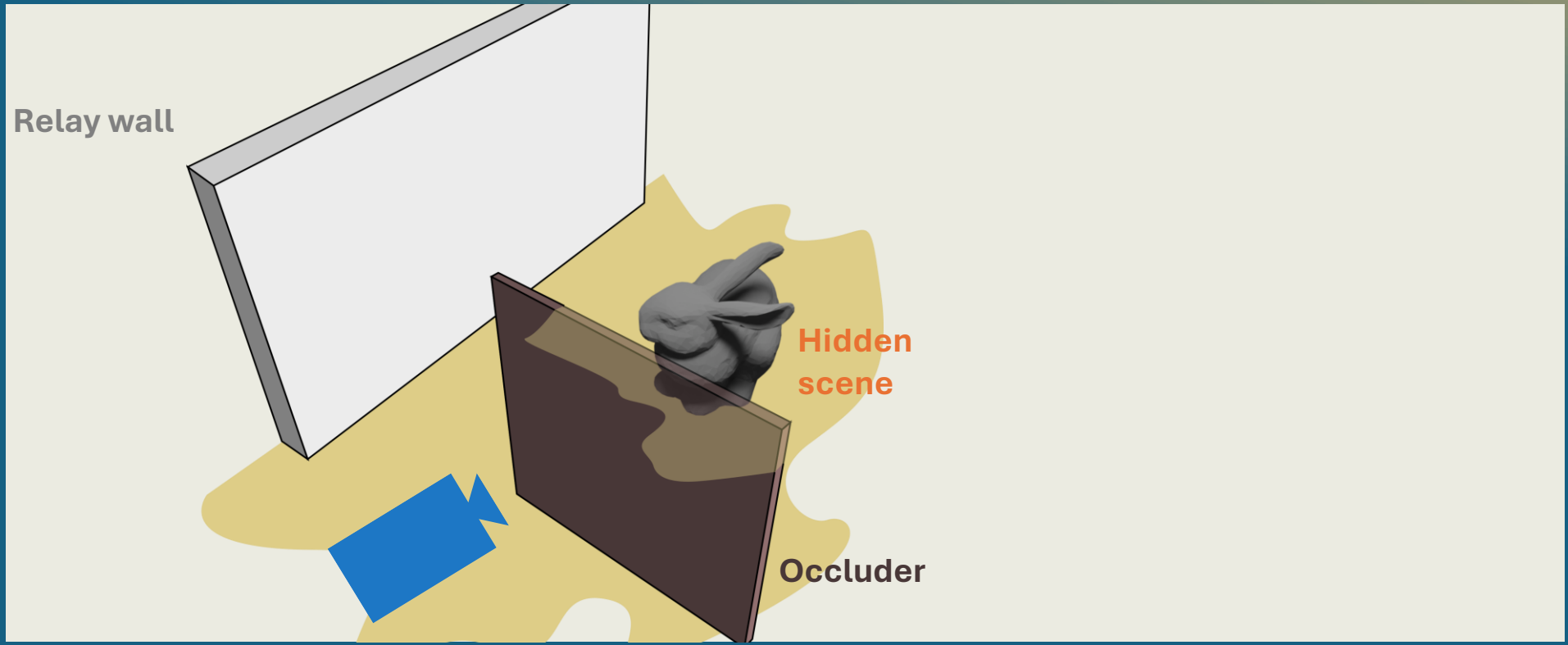


Error in depth

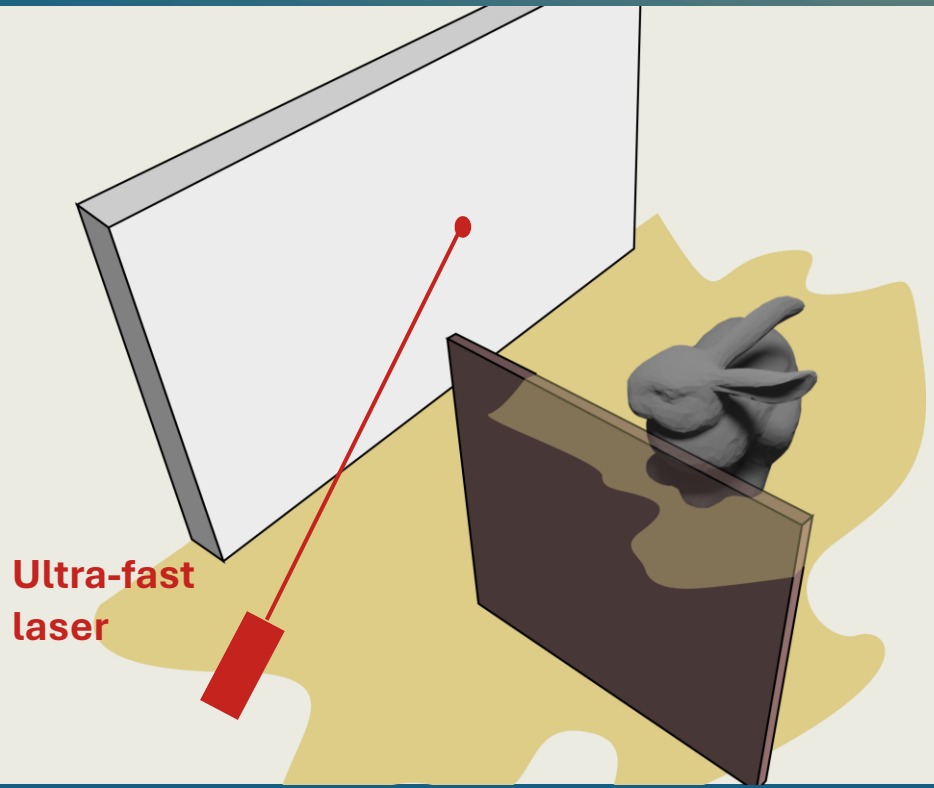
Correct depth

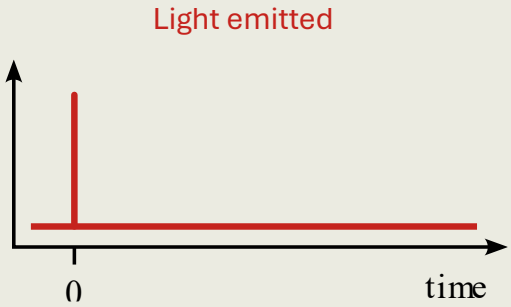
Dataset from Lindell et al. 2019

Non-Line-of-Sight (NLOS) Imaging

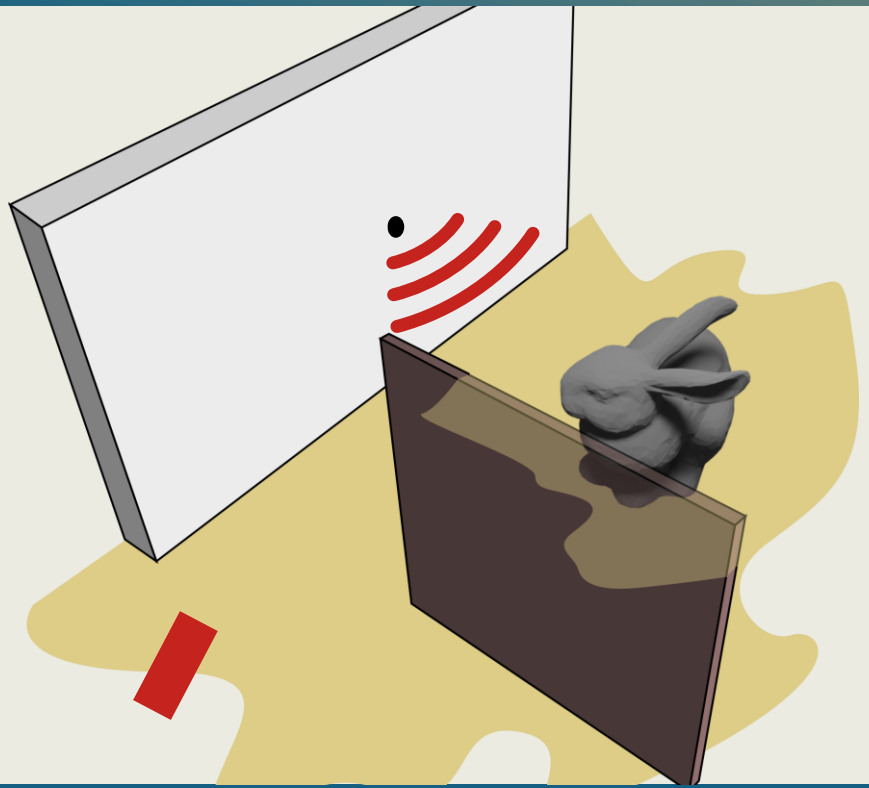


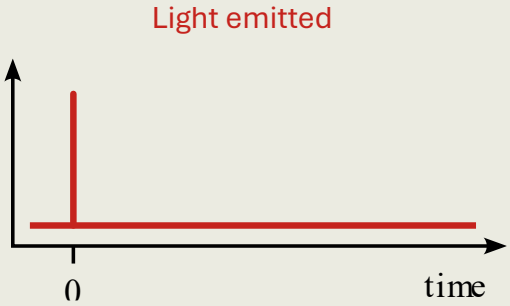
Non-Line-of-Sight (NLOS) Imaging



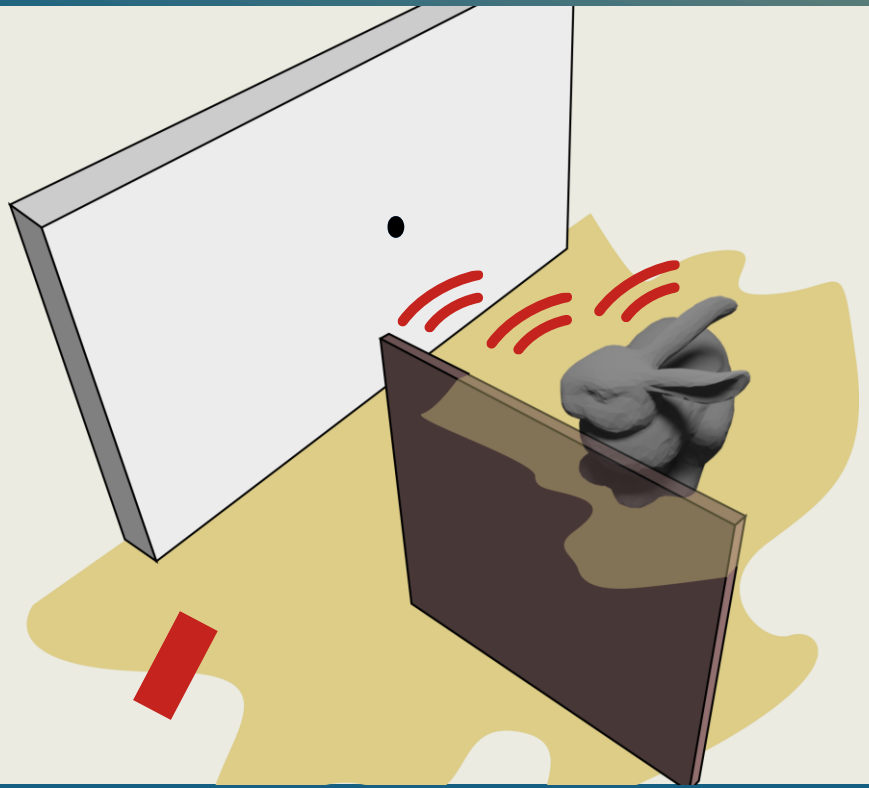


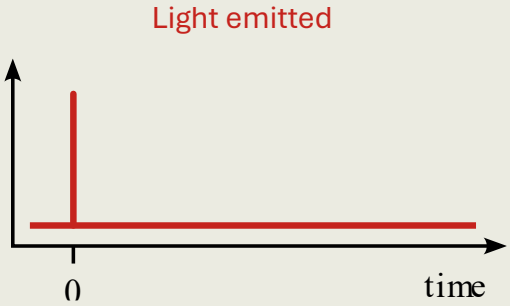
Non-Line-of-Sight (NLOS) Imaging



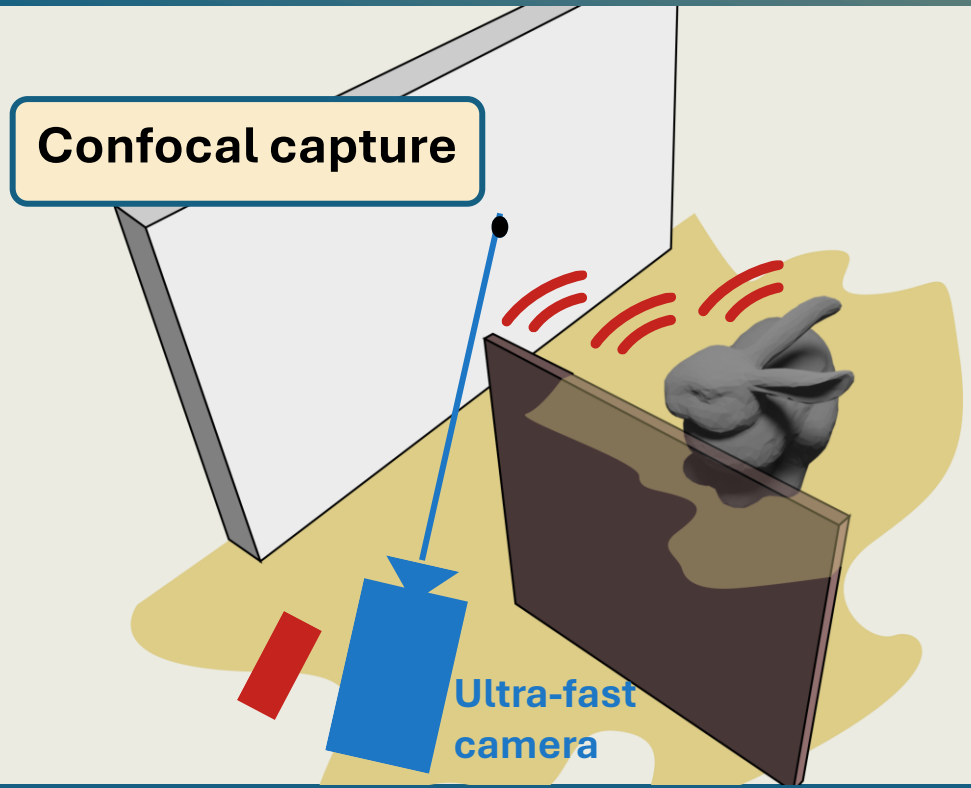


Non-Line-of-Sight (NLOS) Imaging

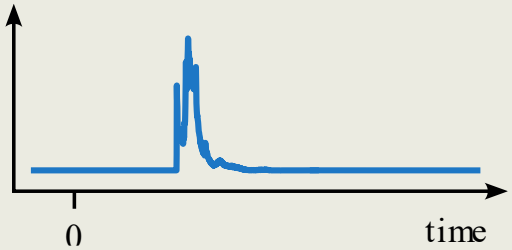




Non-Line-of-Sight (NLOS) Imaging

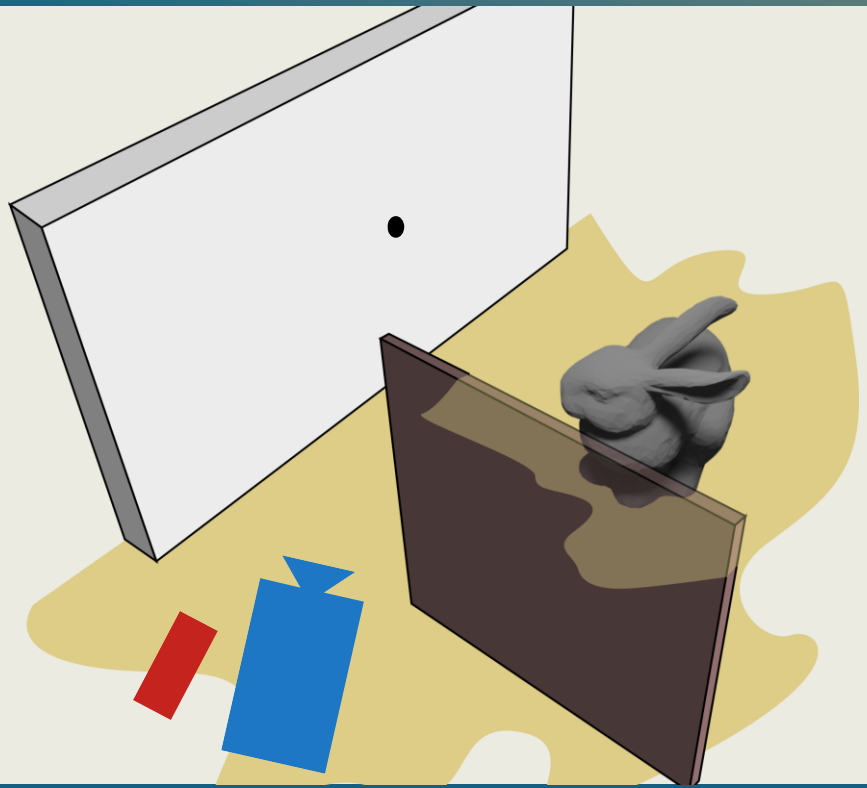


Transient imaging:
picosecond resolution;
captures light in motion



Captured signal

Non-Line-of-Sight (NLOS) Imaging

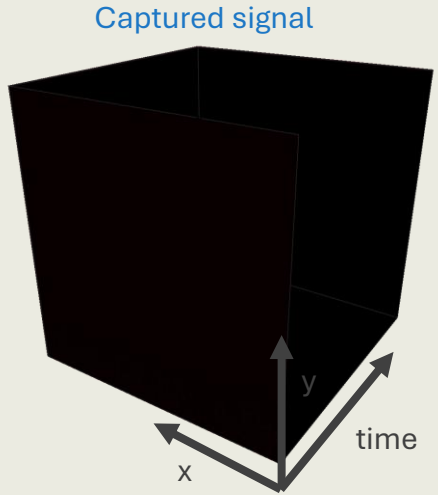


We capture a grid of points.

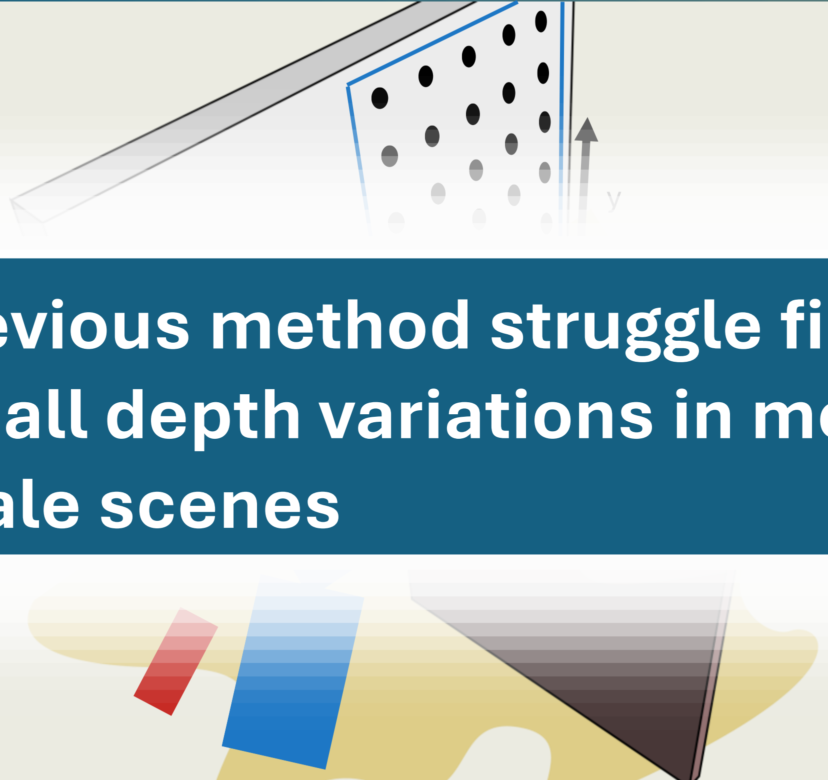
Non-Line-of-Sight (NLOS) Imaging

How to employ this?

We capture a grid of points.



Non-Line-of-Sight (NLOS) Imaging



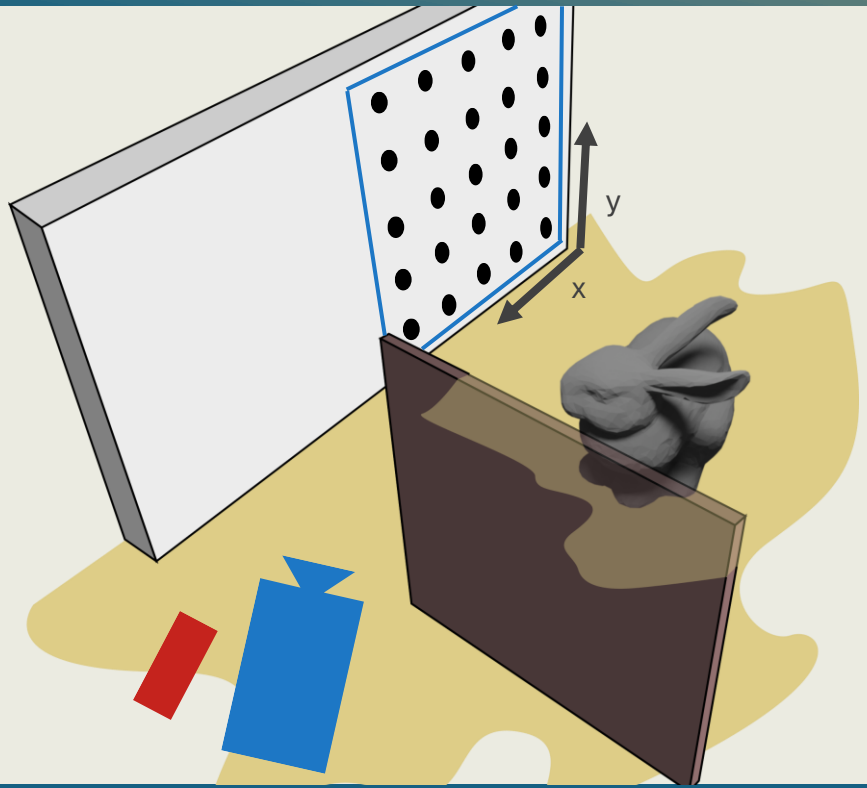
Previous method struggle finding small depth variations in meter scale scenes

NLOS methods

- *Filtered Back Projection [1]*
- *Light Cone Transform [2]*
- *F-K migration [3]*
- *Fermat Paths [4]*
- *Phasor Fields formulation [5]*
- *Etc. Etc*

recognition (pp. 6800-6809).

Non-Line-of-Sight (NLOS) Imaging



NLOS methods

- *Filtered Back Projection [1]*
- *Light Cone Transform [2]*
- *F-K migration [3]*
- *Fermat Paths [4]*
- *Phasor Fields formulation [5]*
- *Etc. Etc*

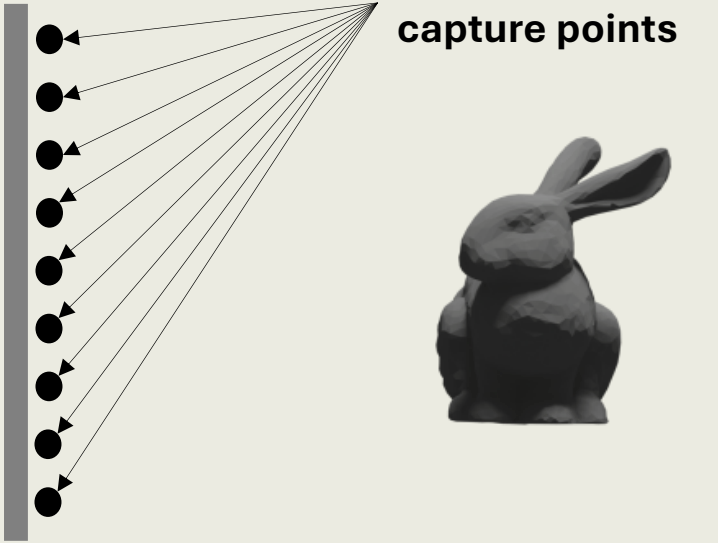
Background: The Phasor Fields Formulation

Lateral view of the setup

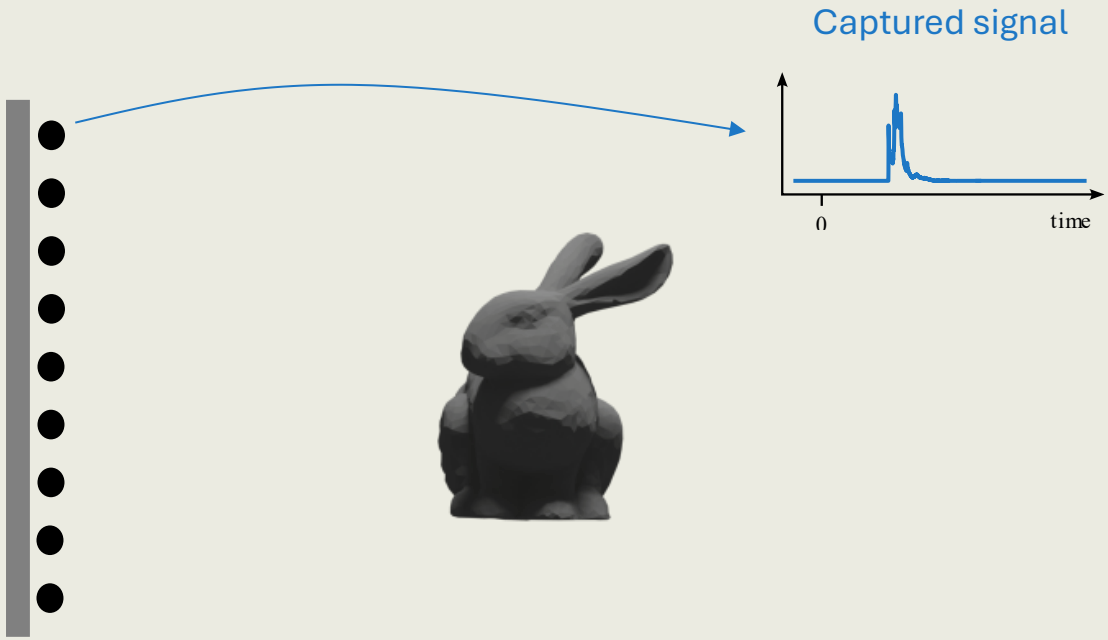
Relay wall

Hidden scene

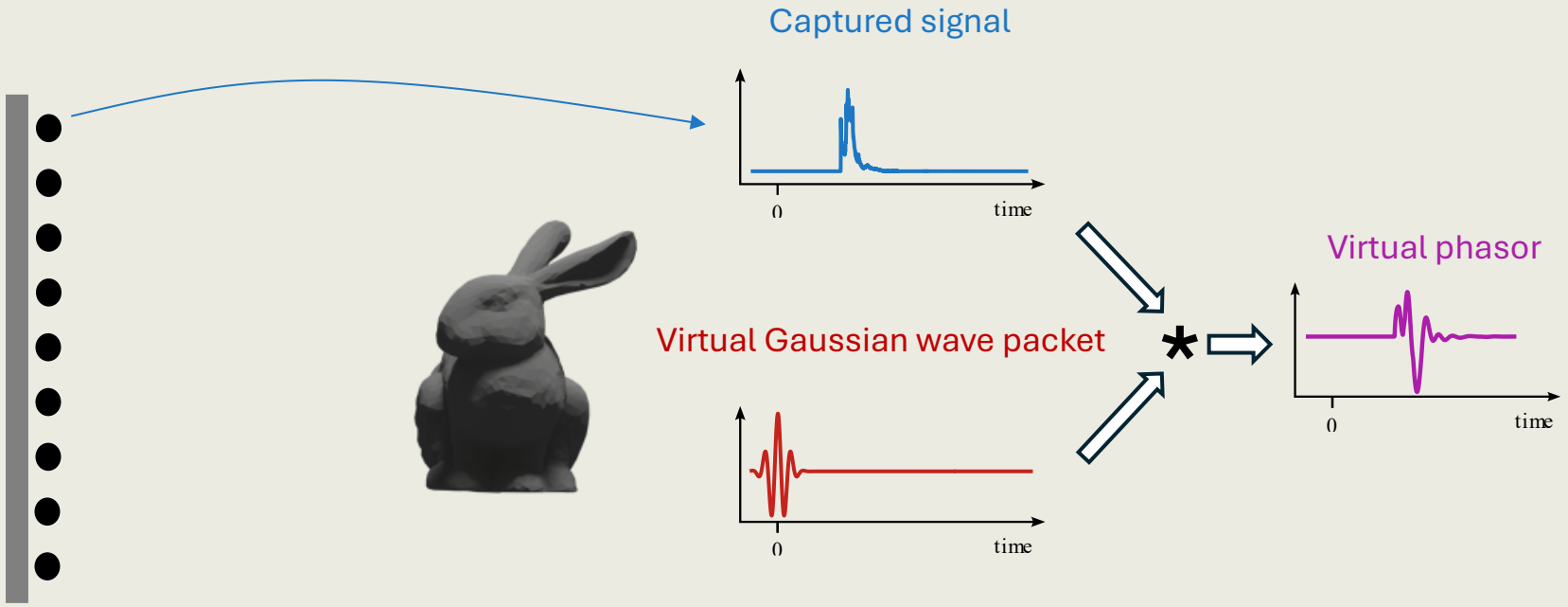
Background: The Phasor Fields Formulation



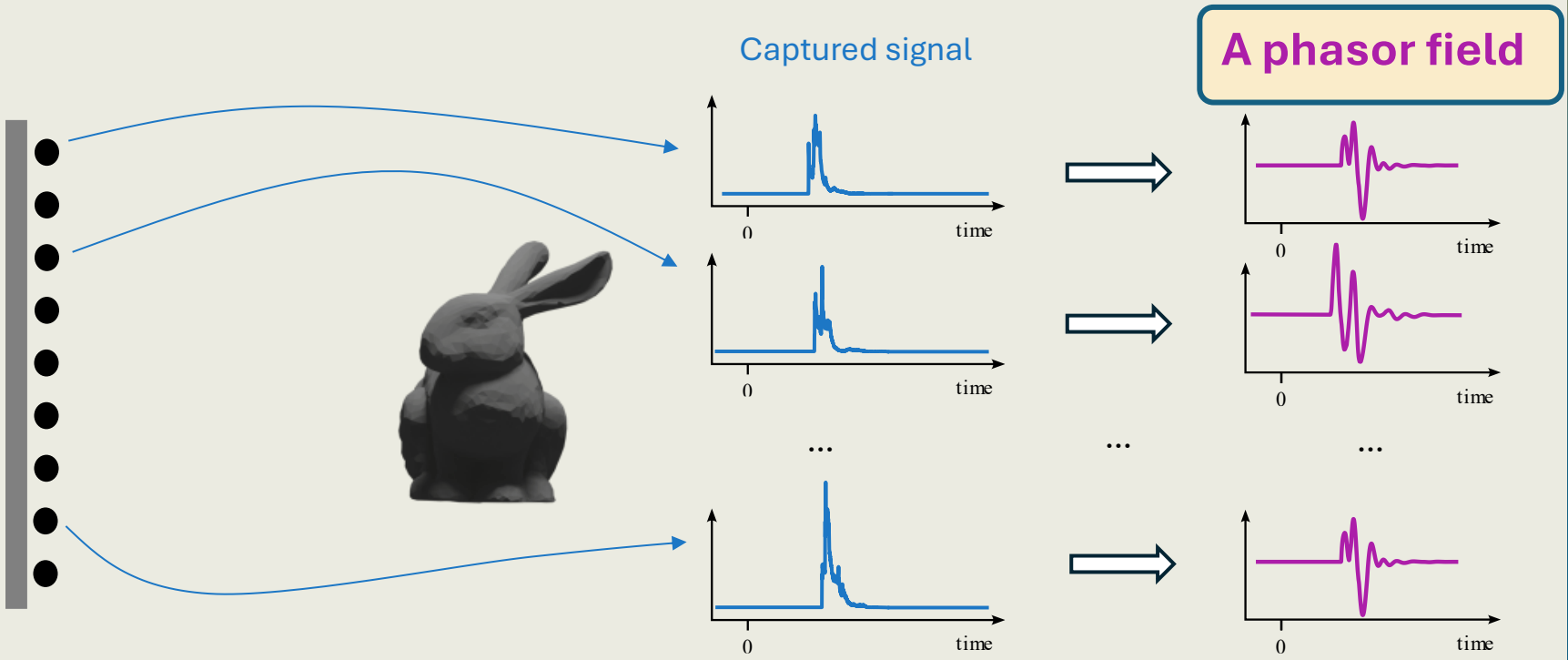
Background: The Phasor Fields Formulation



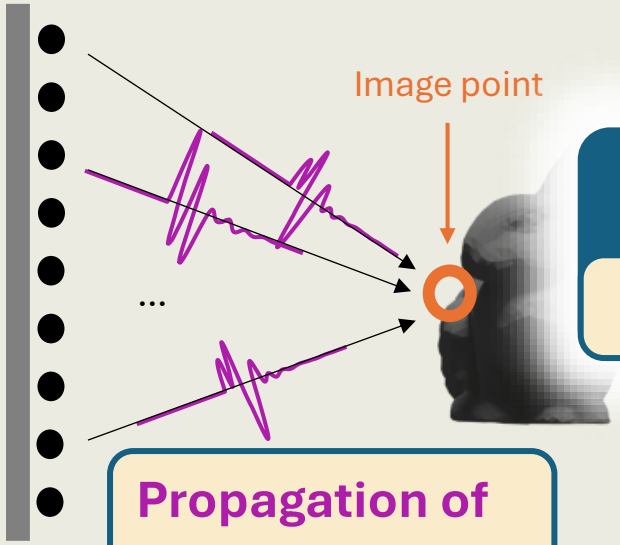
Background: The Phasor Fields Formulation



Background: The Phasor Fields Formulation



Background: The Phasor Fields Formulation

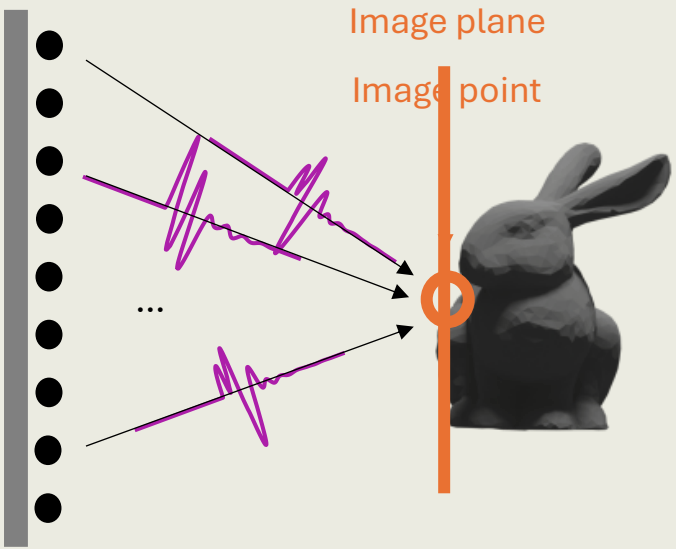


The imaged point is a phasor:

amplitude + phase

Propagation of the phasor field

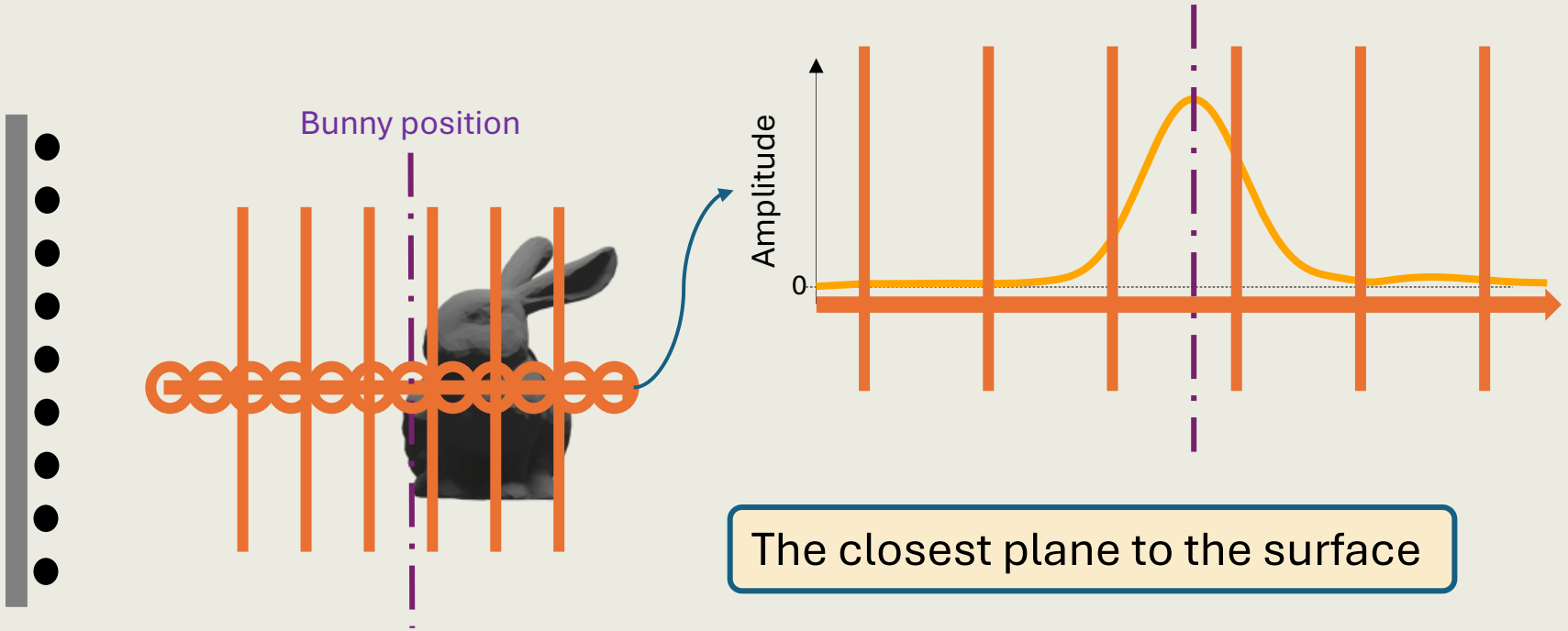
Background: The Phasor Fields Formulation



Efficient Phasor Fields implementations exist to **propagate plane to plane** [6]

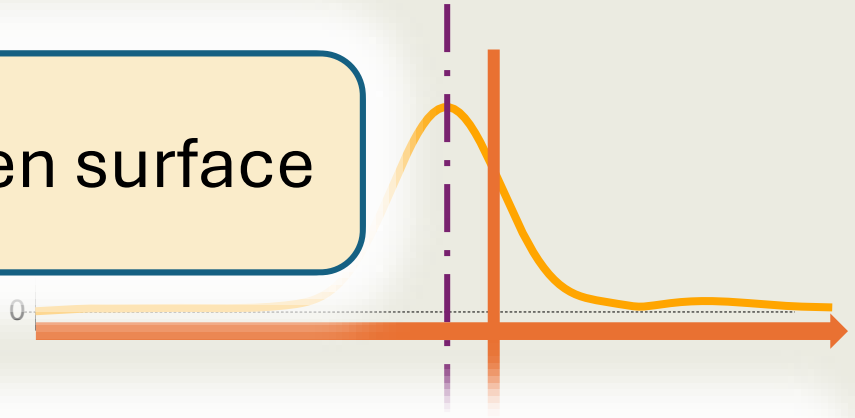
[6] Liu, X., Bauer, S., & Velten, A. (2020). Phasor field diffraction based reconstruction for fast non-line-of-sight imaging systems. Nature communications, 11(1), 1645.

Finding geometry with Phasor Fields



Finding geometry with Phasor Fields

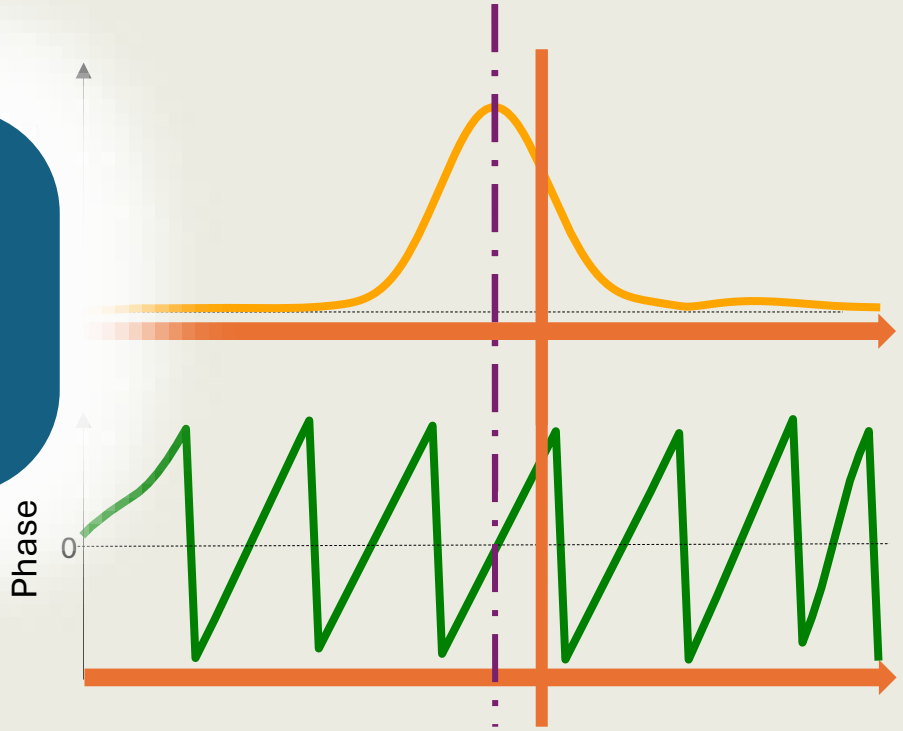
- Plane away from hidden surface



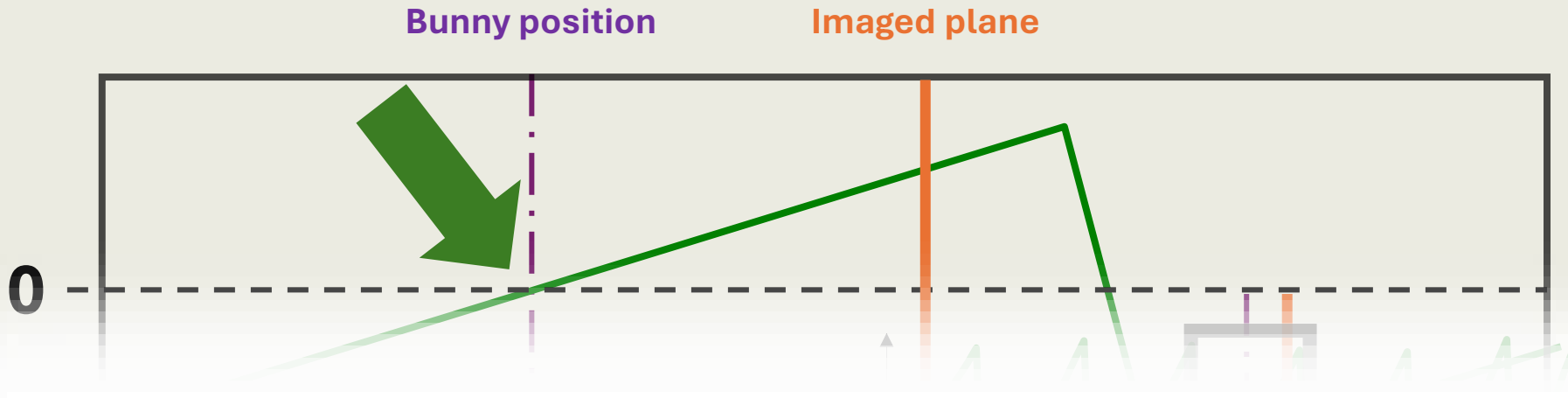
More resolution = more planes ***= more execution time***

Our Zero-Phase Phasor Fields

We employ the phase, discarded by previous methods

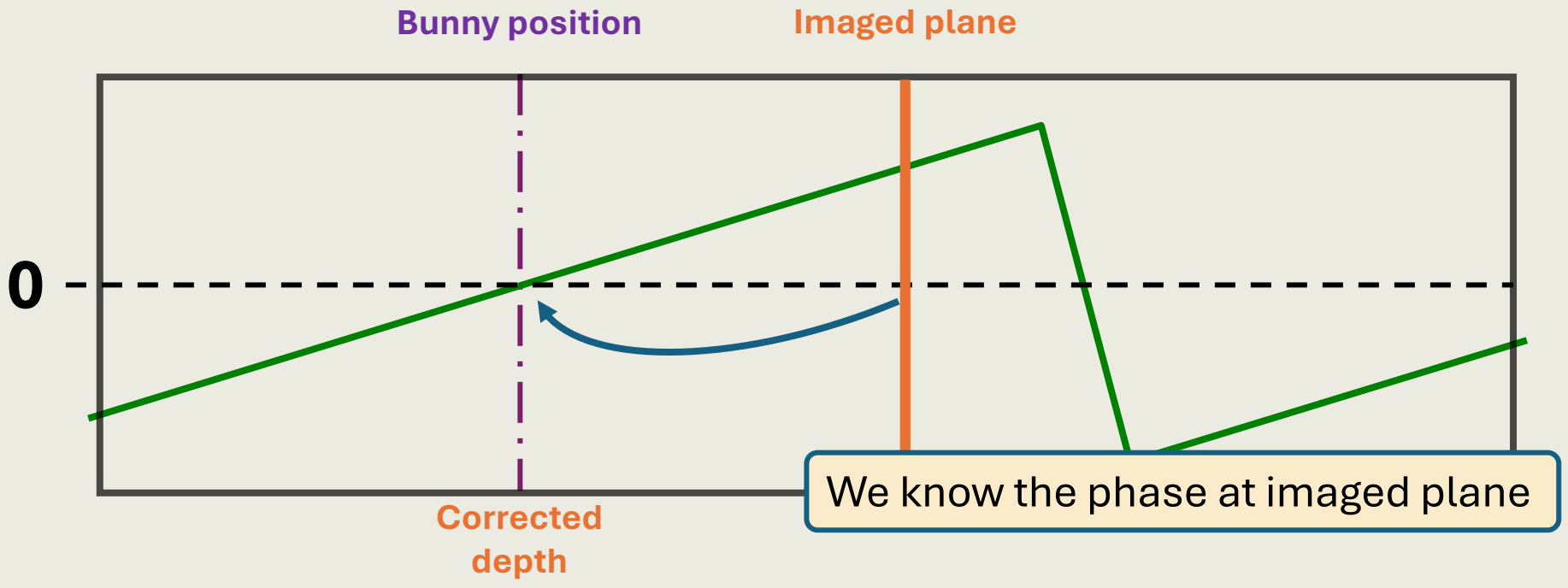


Our Zero-Phase Phasor Fields



The imaged phase crosses to zero at the true surface positions

Our Zero-Phase Phasor Fields

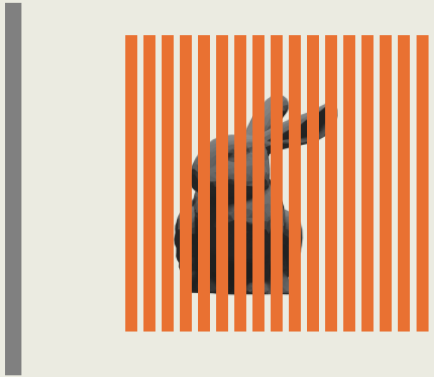


Summarizing methods

Phasor Fields (PF)

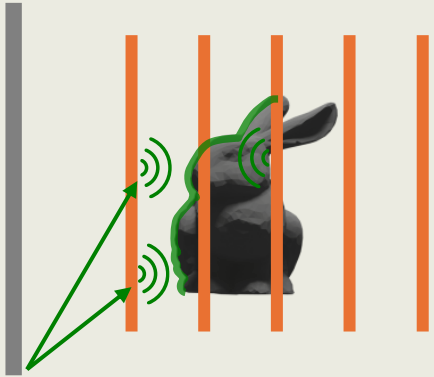
Image planes, then select maximum in depth

Dense PF



Increase depth precision by increasing imaged planes

Our Zero-Phase Phasor Fields

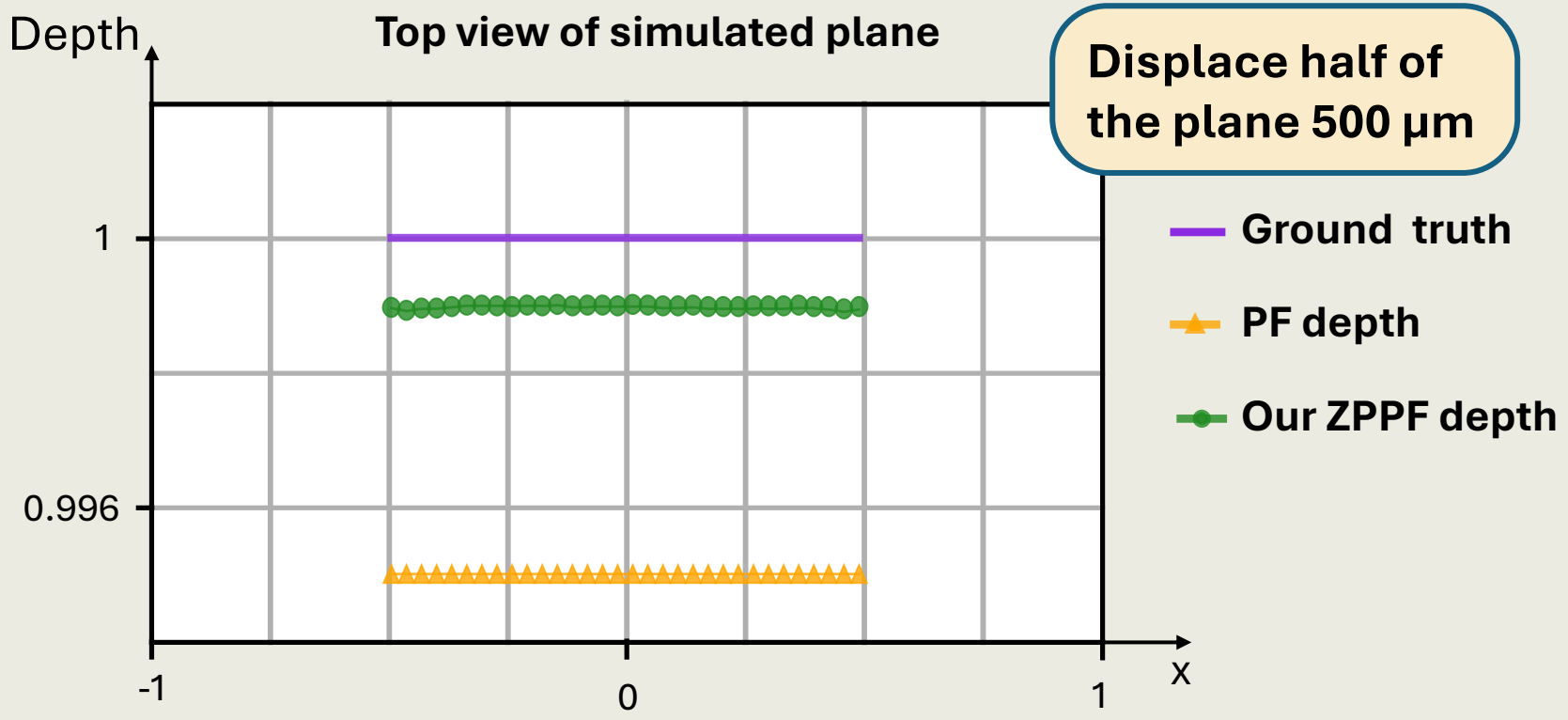


Phase correction

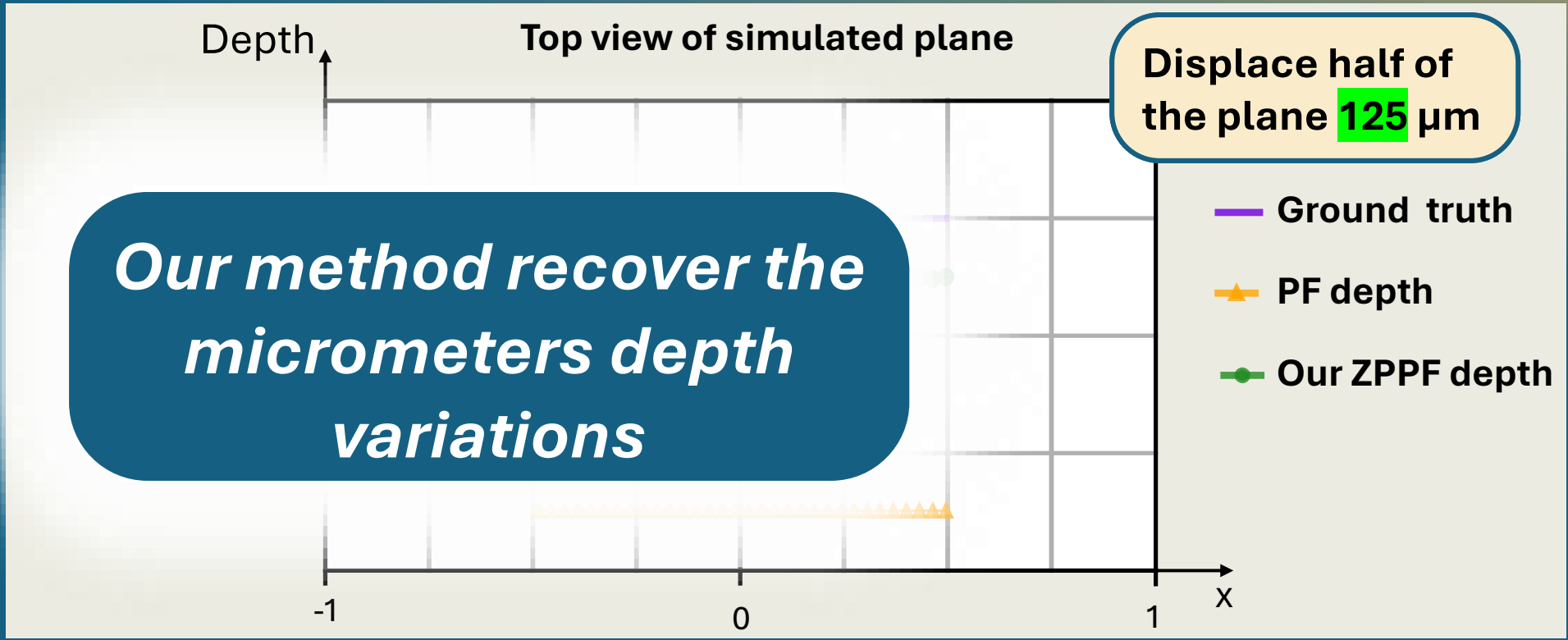
Image planes, selects maximum, and corrects depth

Results

Results – simulated plane at 1 m

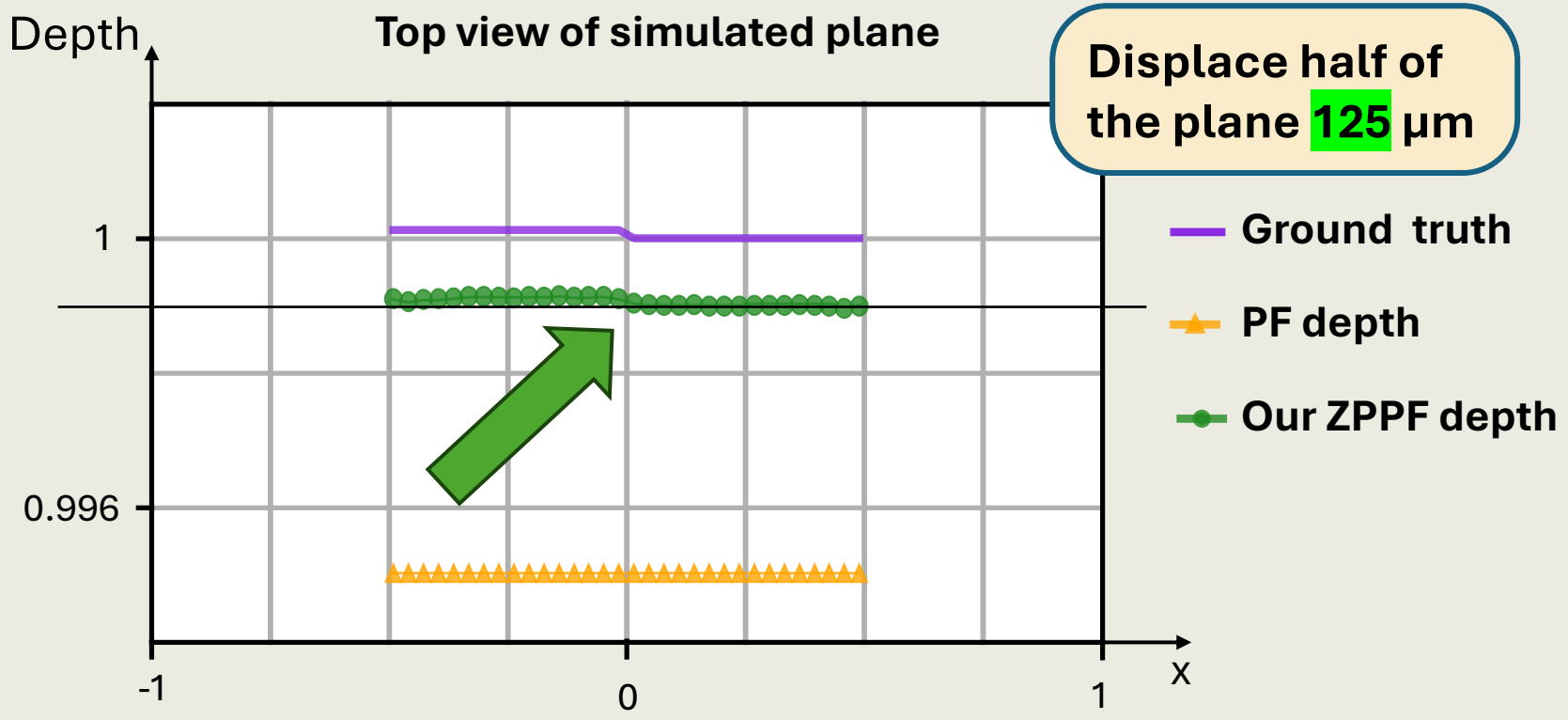


Results – simulated plane at 1 m



Our method recover the micrometers depth variations

Results – simulated plane at 1 m



Results – Depth recovery of real dataset

Data from publicly available dataset [3]

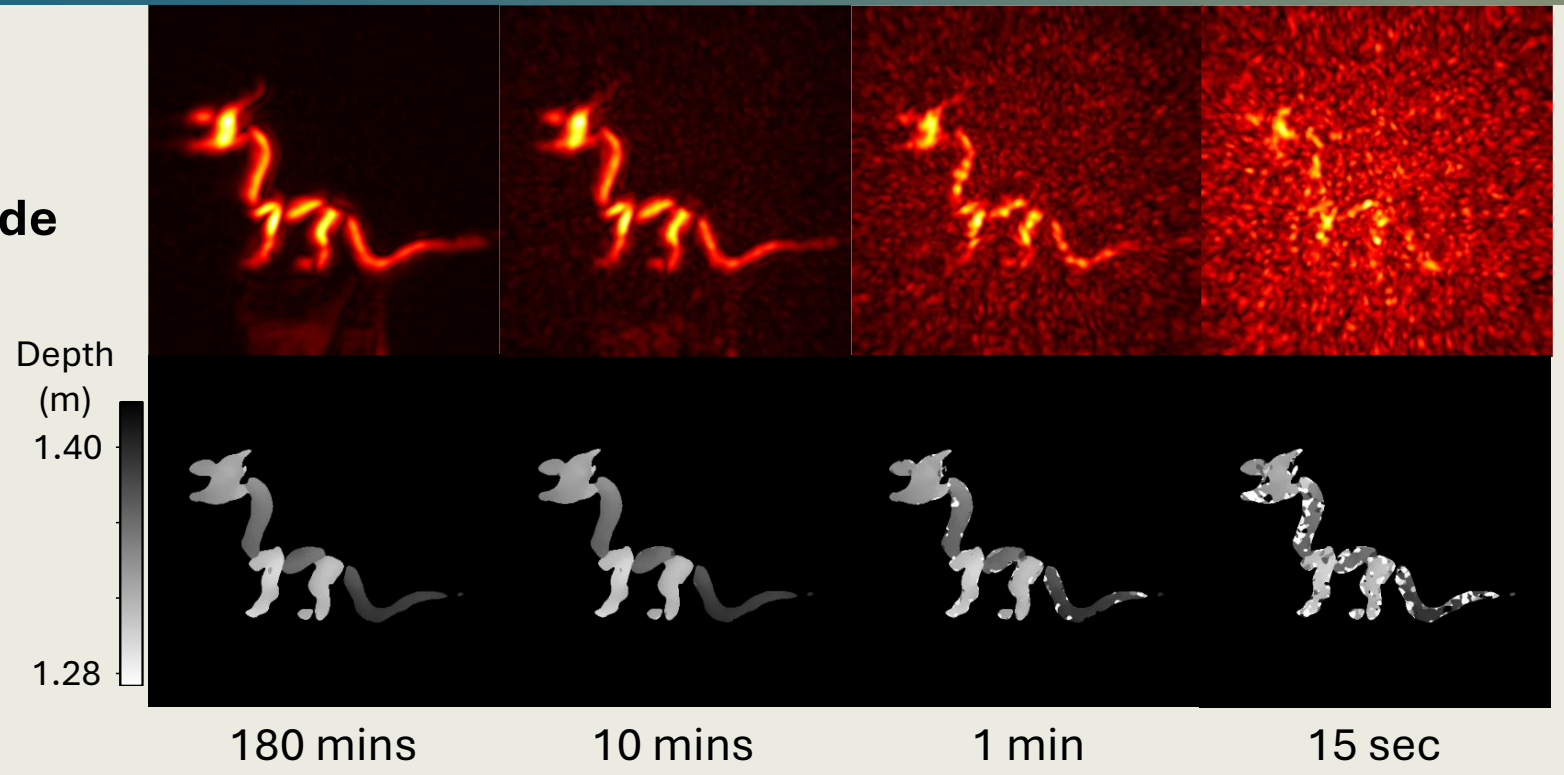
2' 4"

2' 10"

Hidden scene | **Dense PF depth** | **PF depth diff.** | **Ours depth diff.**

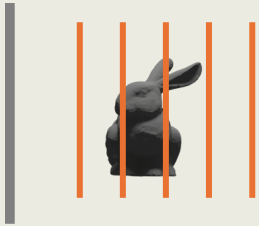
[3] Lindell, D. B., Wetzstein, G., & O'Toole, M. (2019). Wave-based non-line-of-sight imaging using fast fk migration. ACM Transactions on Graphics (ToG), 38(4), 1-13.

Results – decreasing signal to noise ratio



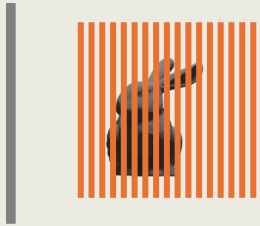
Conclusions

Phasor Fields (PF)



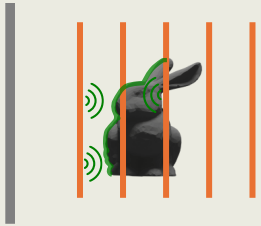
- Efficient in time
- Efficient memory consumption
- Low depth precision

Dense PF



- Inefficient in time
- Inefficient memory consumption
- High depth precision

Our Zero-Phase Phasor Fields



- Efficient in time
- Efficient memory consumption
- High depth precision

Conclusions

- We develop a method that efficiently estimates depth.
- Depth recovery using phase is robust to noise.

- Future work and limitations:
  - Derive for non-confocal.
  - Phase correction works when the imaged plane is close enough.
  - Small mismatches occur, possibly due to near-field diffraction.

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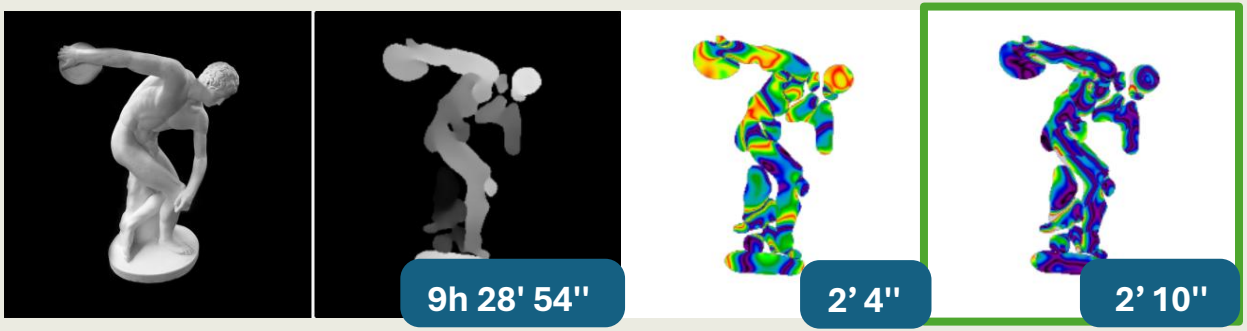

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