



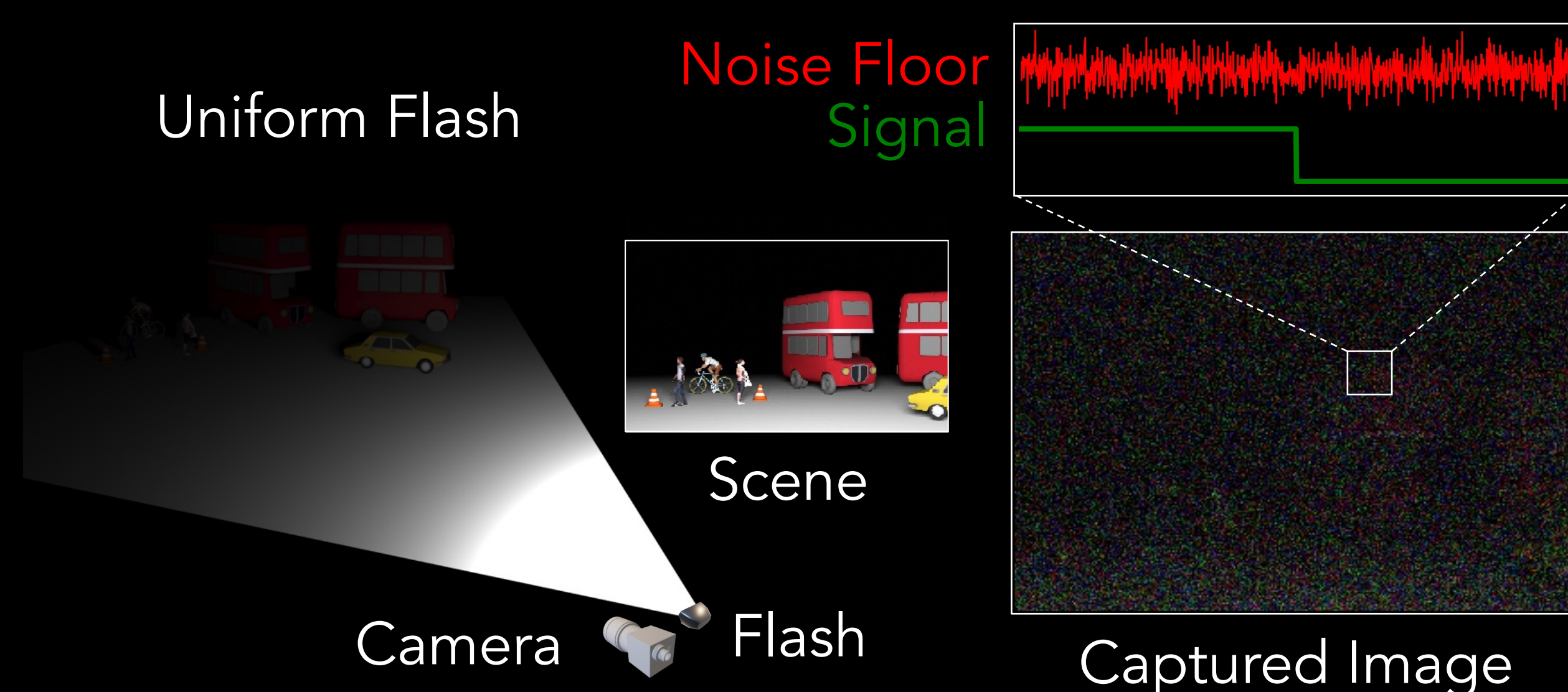
Seeing Far in the Dark with Patterned Flash

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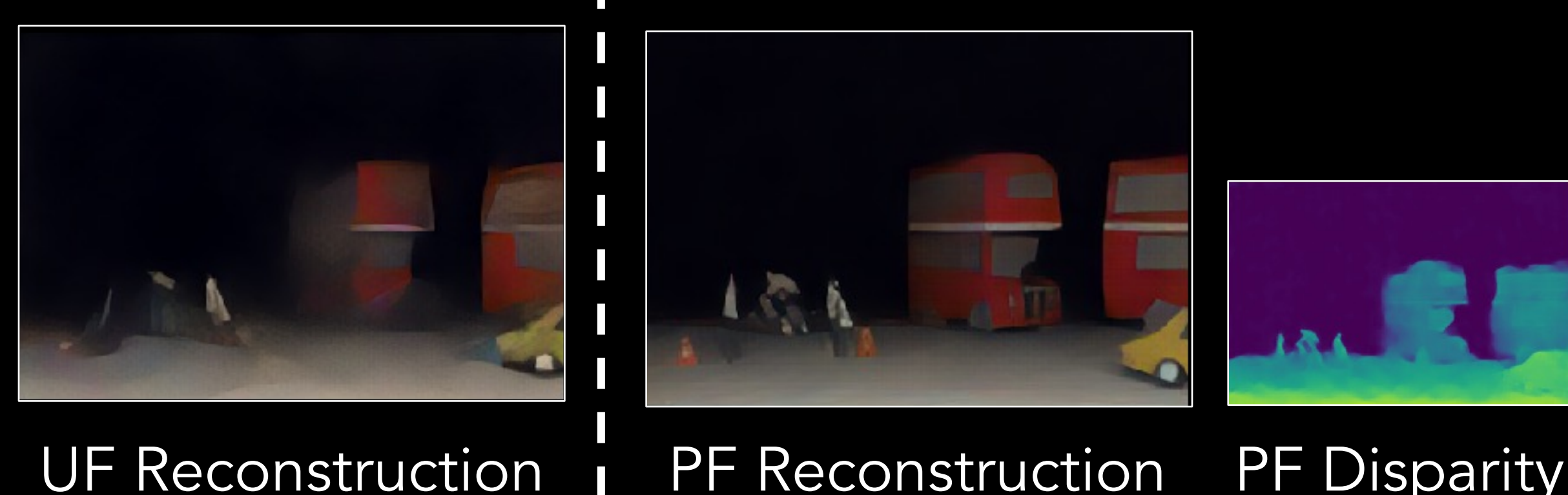
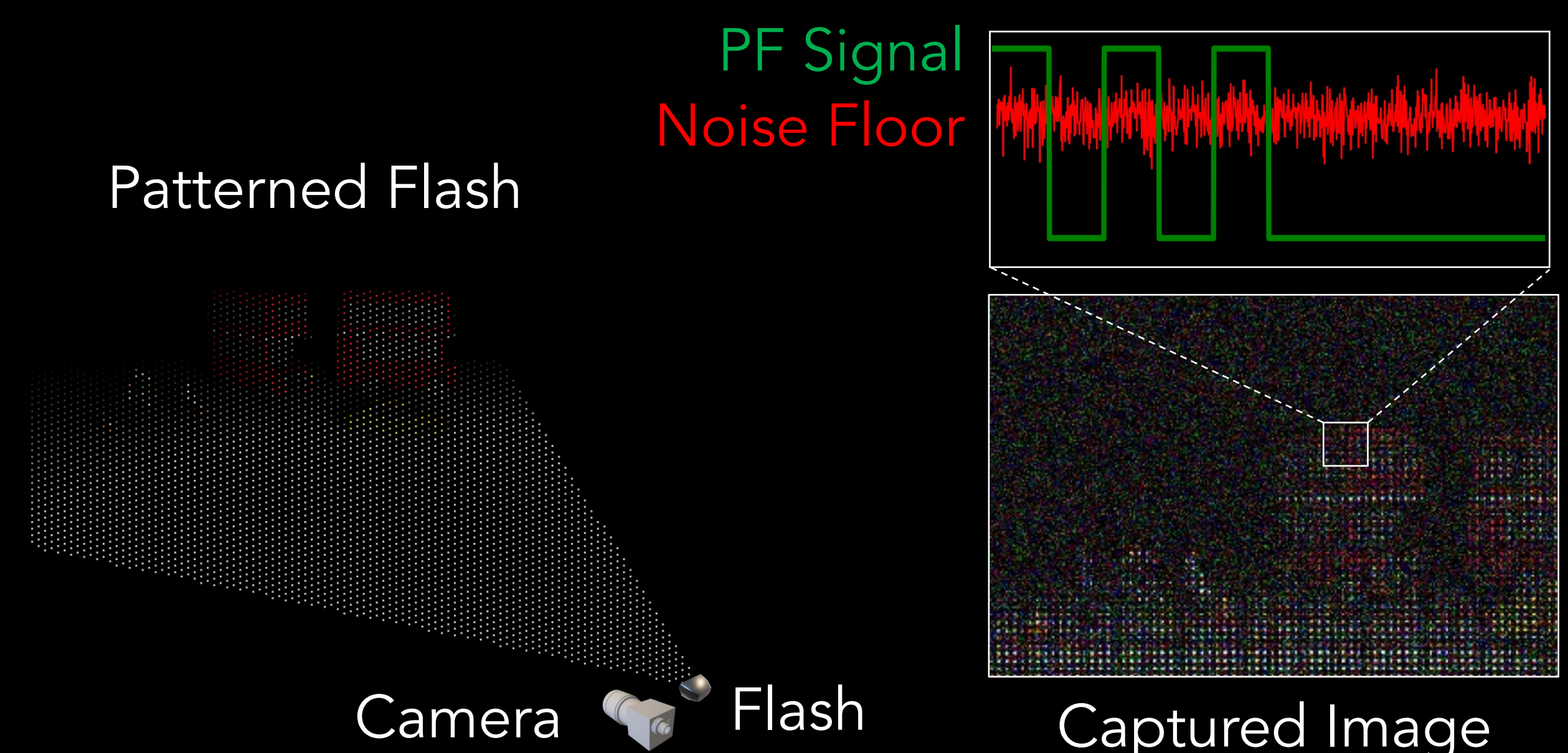


Problem in Uniform Flash



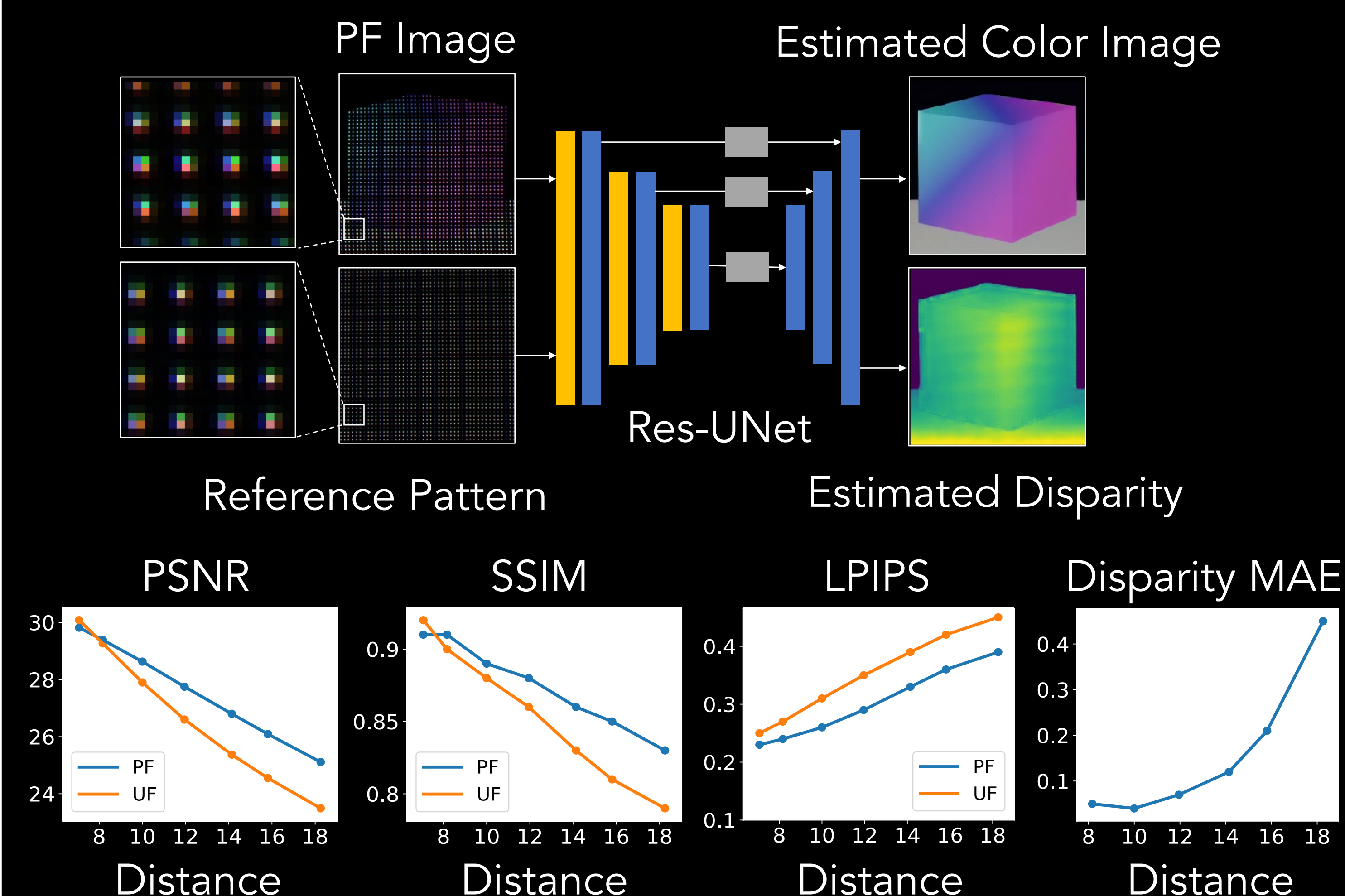
- Flash light falls off with $1/\text{depth}^2$
- Flash signal overwhelmed by sensor noise

Patterned Flash



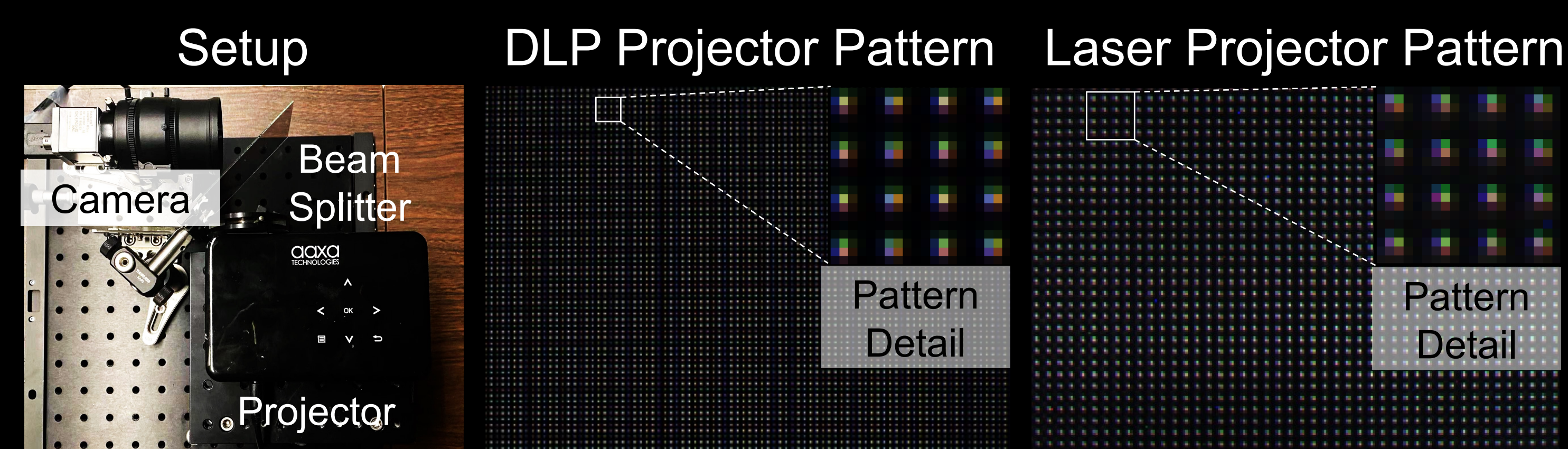
- Patterned flash concentrates light into a dot array for higher signal-noise ratio
- Patterned flash is a structured light system that supports depth estimation

Algorithm



- Joint image reconstruction & depth estimation
- In simulations:
 - PF achieves better image restoration quality
 - PF achieves sub-pixel disparity accuracy

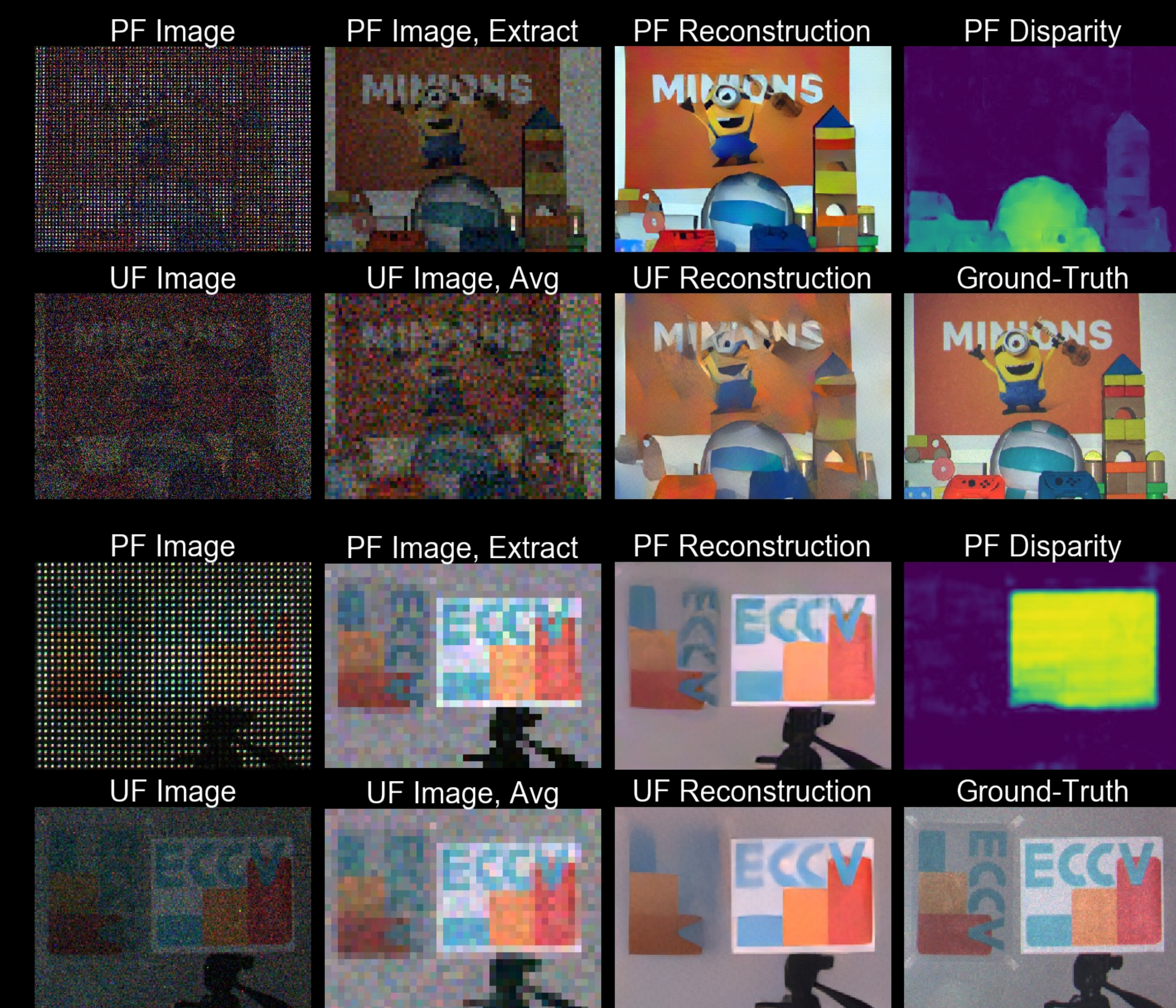
Hardware Prototype



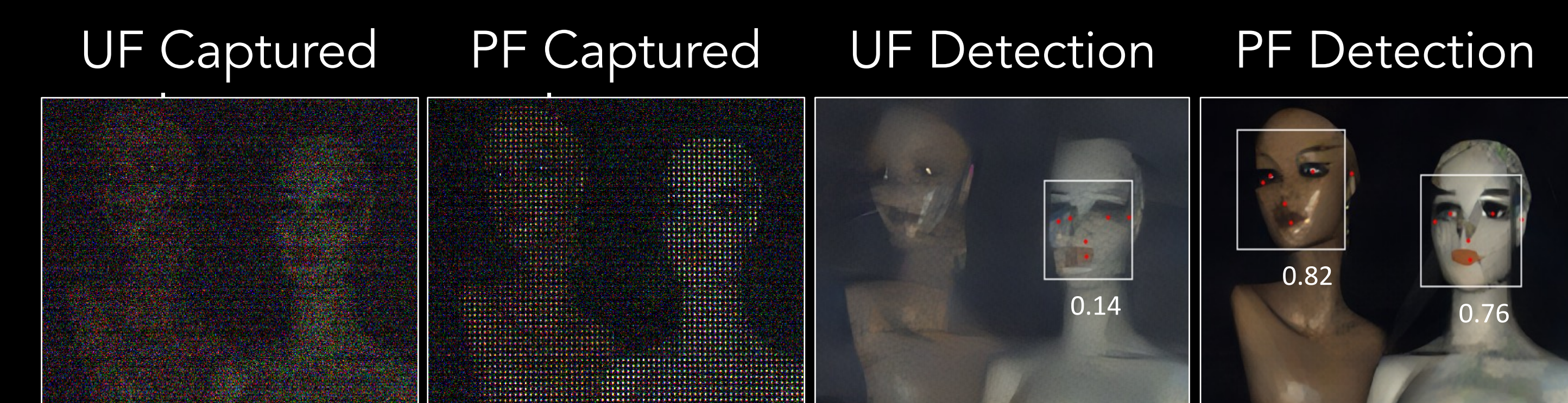
- Setup: camera, projector, beam splitter (for easily adjusting baseline only)
- Regular pattern vs. random pattern
 - Better image restoration quality
 - More ambiguity in disparity estimation
- DMD projector & Laser projector

Image Restoration

- PF resolves fine details and avoids reconstruction artifacts compared to UF



Applications



- Low-light face detection (Google MediaPipe)
- Flash/No-flash imaging
- Other imaging modalities (e.g. IR imaging)
- Other hardware implementations
 - MEMS scanner, VCSEL array, Diffractive optical element (DOE), ...