High-Flux Count-Free Single-Photon 3D Cameras

Kaustubh Sadekar†, Vivek K Goyal*, David Maier†, Atul Ingle†
†Portland State University, *Boston University
ksadekar@pdx.edu, www.computational.camera

Resource-Constrained 3D Vision applications

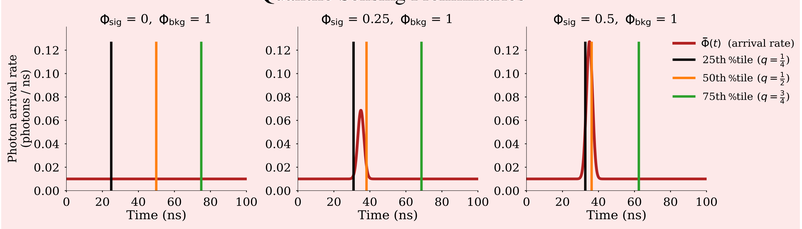

AR/VR Headsets


Autonomous Drones


Space Robots

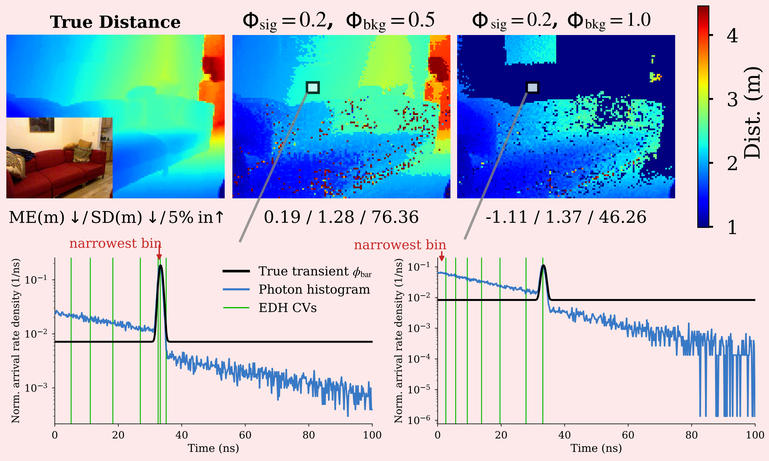
Limited Power | Limited Bandwidth | Limited Memory

Conventional vs Quantile-Sensing 3D Cameras



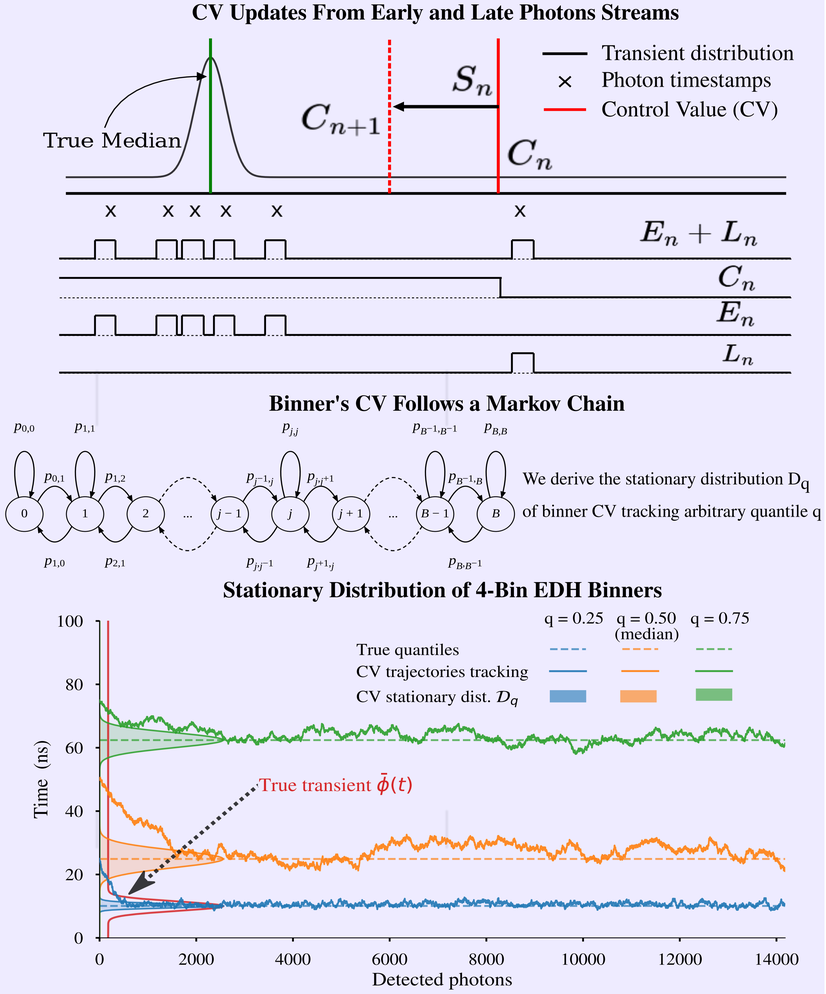
[1] *Ingle and Maier, ICCP 2023)*

Photon Data Compression Under Strong Pileup

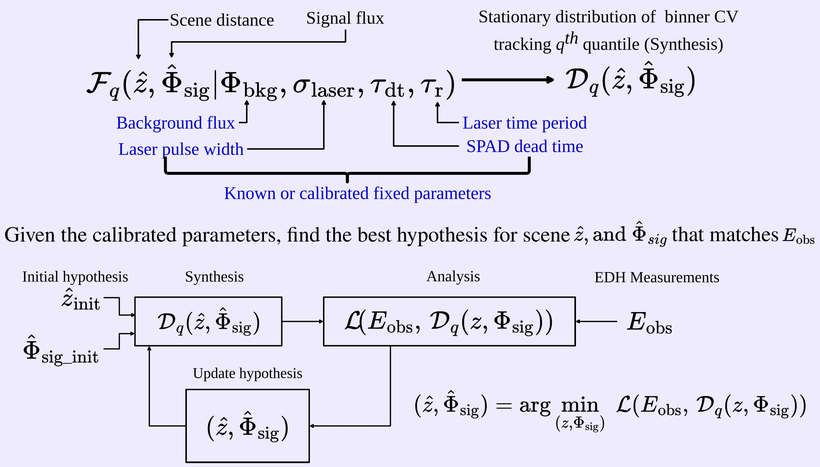


Narrowest bin of equi-depth histogram fails to capture the signal peak under strong pileup.

Probabilistic Model for an Equi-depth Histogrammer



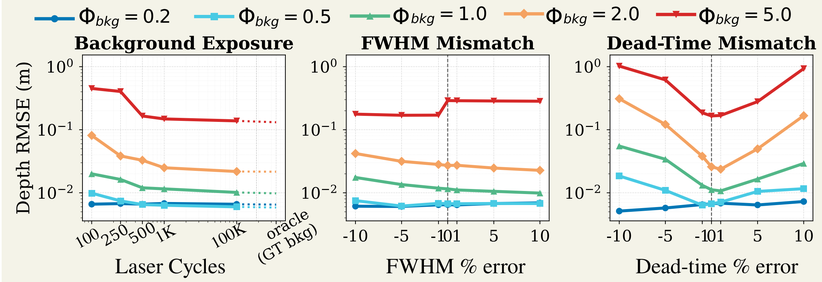
Our Analysis-by-Synthesis (AbS) Pipeline



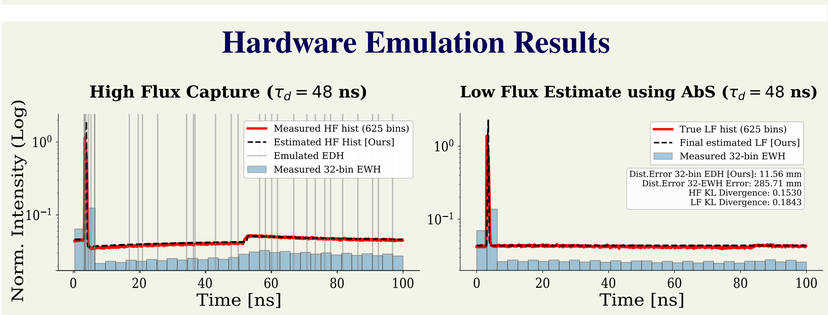
Given the calibrated parameters, find the best hypothesis for scene $\hat{z}$, and $\hat{\Phi}_{sig}$ that matches E_{obs}

$$(\hat{z}, \hat{\Phi}_{\text{sig}}) = \arg\min_{(z,\Phi_{\text{sig}})} \mathcal{L}(E_{\text{obs}}, \mathcal{D}_q(z, \Phi_{\text{sig}}))$$

Robustness to Model Mismatch and Calibration Errors

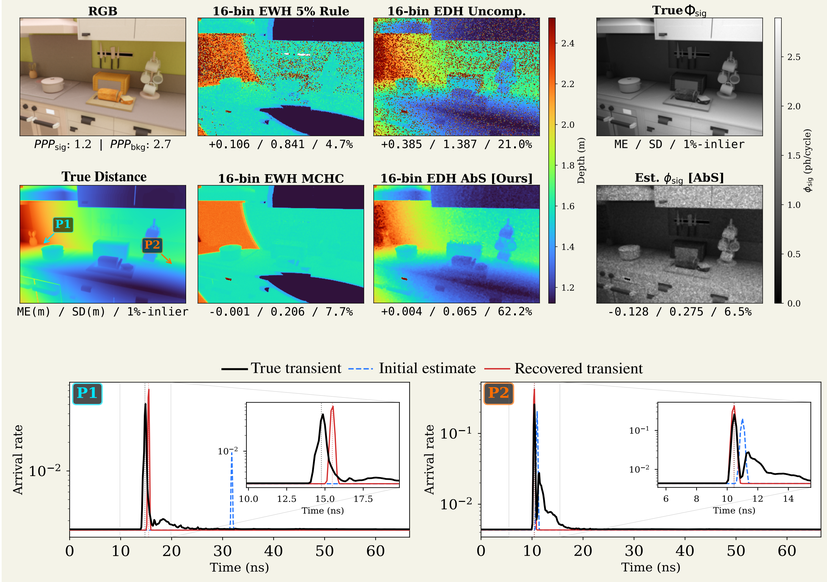


Hardware Emulation Results



Hardware emulation results on public dataset from Rapp et al. (Optica, 2021.) demonstrating the robustness of our AbS pipeline to non-ideal transients with real hardware noise

Full Scene Distance and Signal Flux Estimates



Our hardware-algorithm co-design unlocks the use of single-photon LiDARs for dense 3D imaging in resource-constrained applications and high photon flux conditions.

Funding: NSF Award #2138471