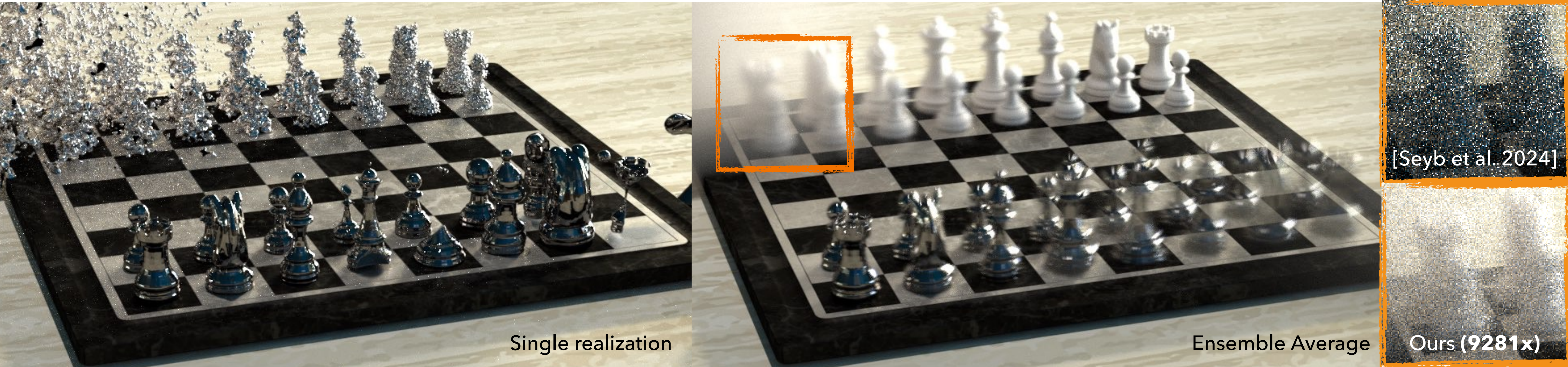
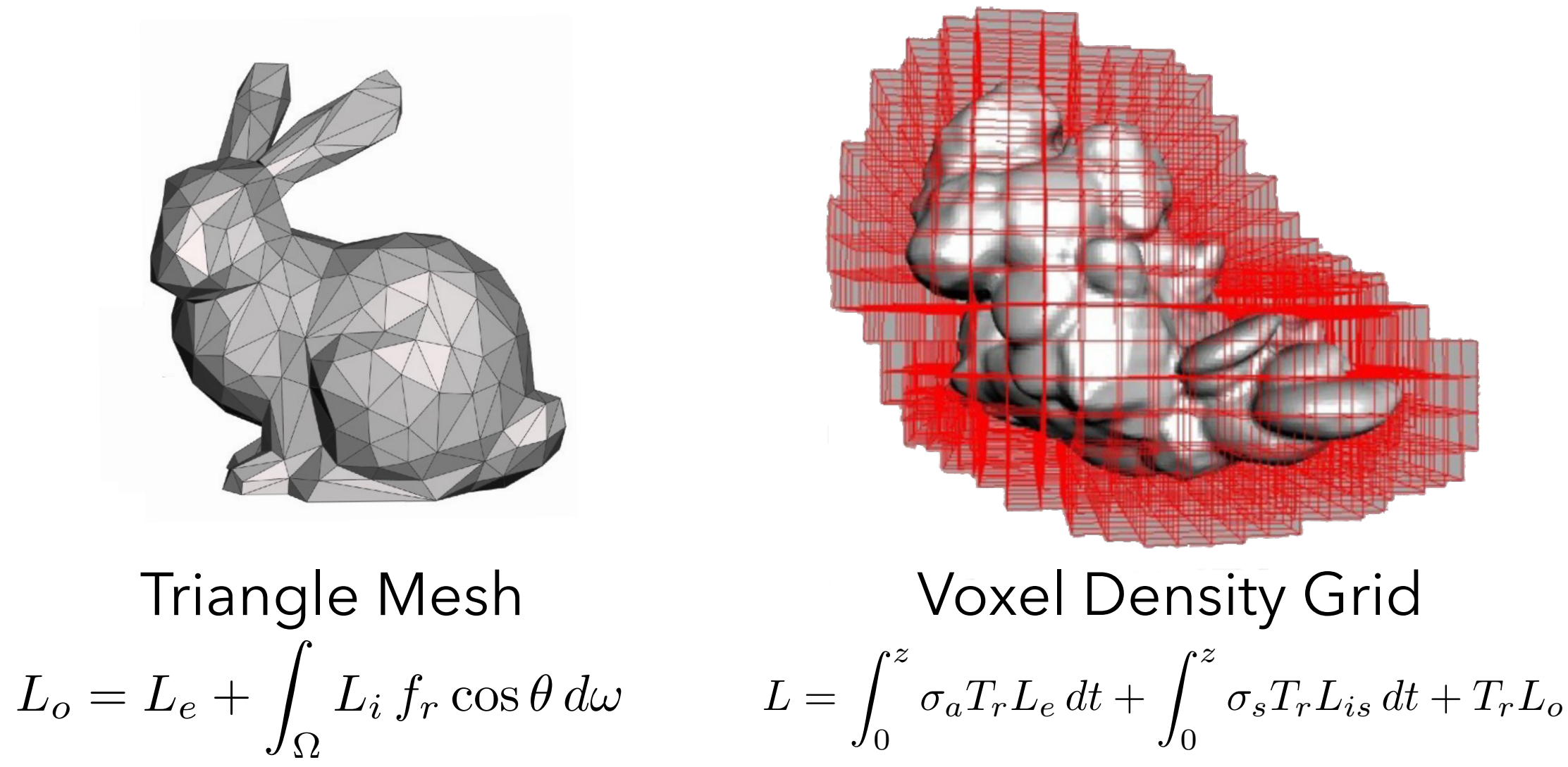


We enable the **practical** rendering (even on the **GPU!**) of **Gaussian process implicit surfaces** – a unified representation for surfaces, volumes, and a rich continuum in between.

This work was supported by NSF awards 1844538 and 2440472.

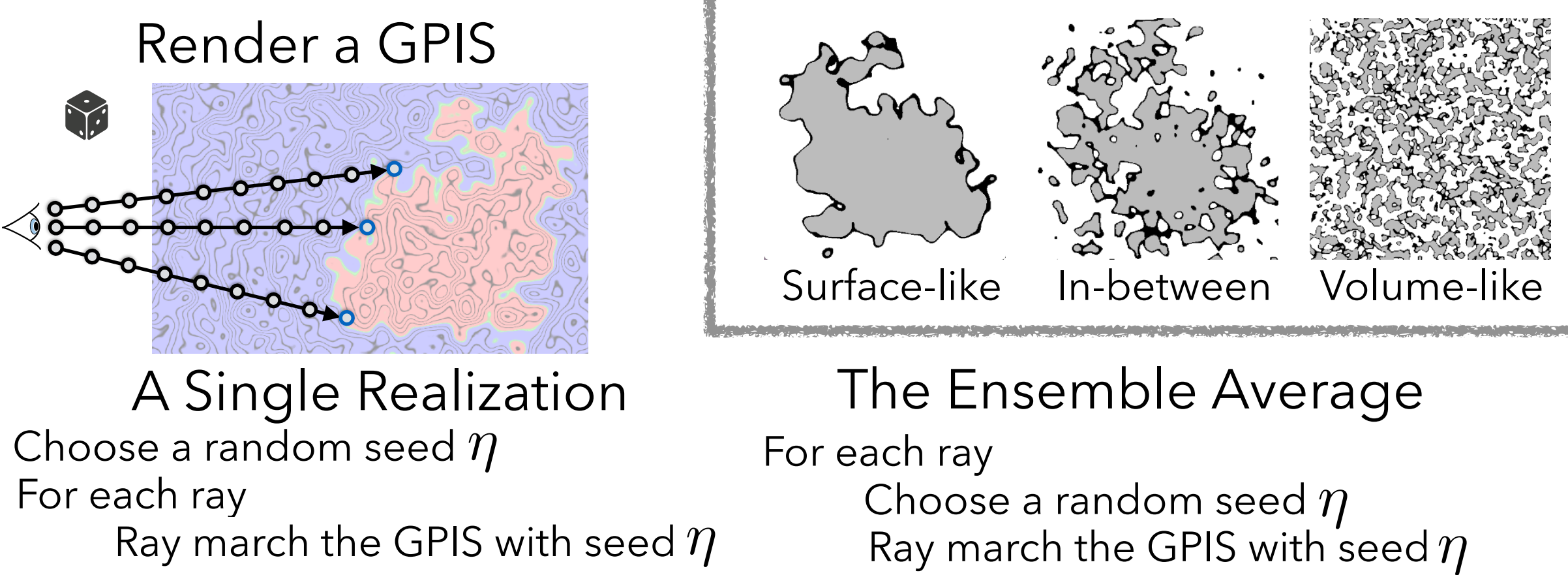
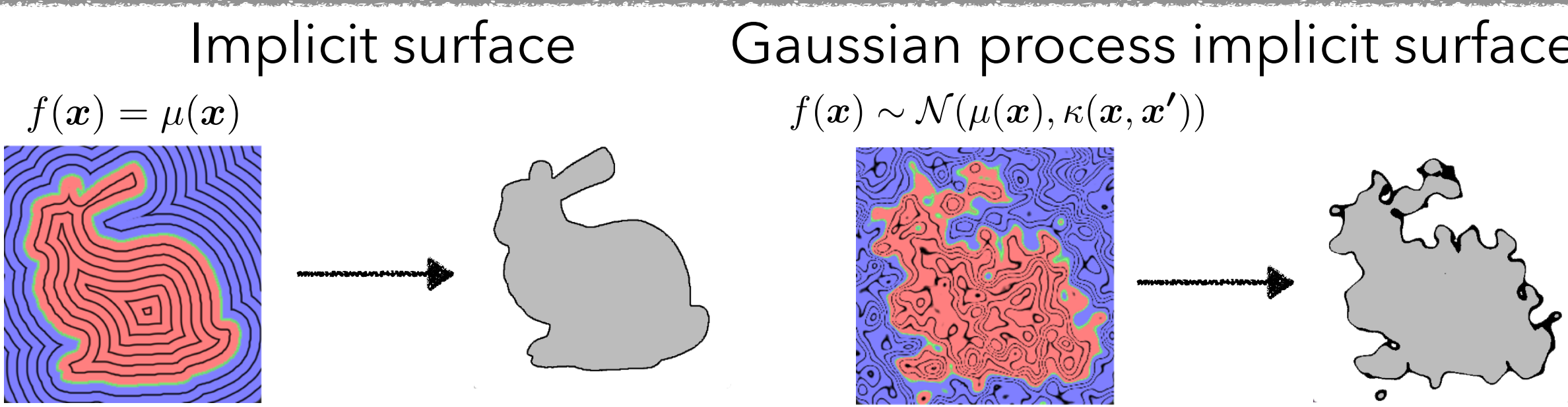
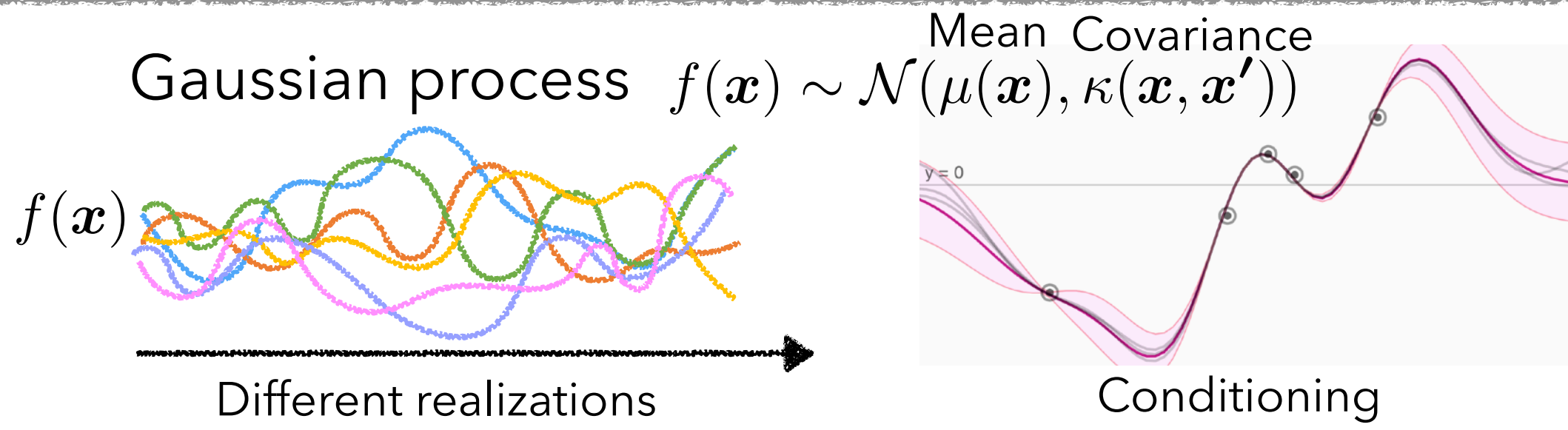
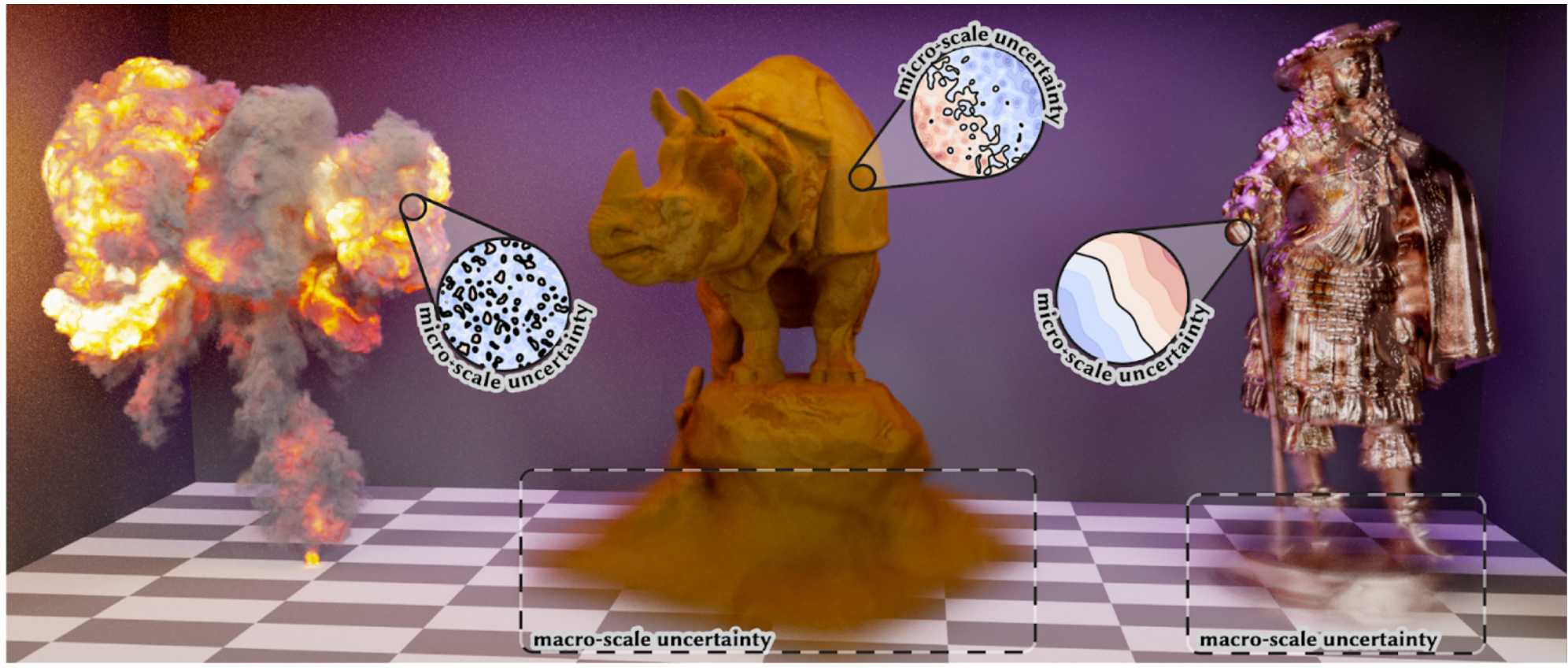


Motivation: Surfaces vs. Volumes

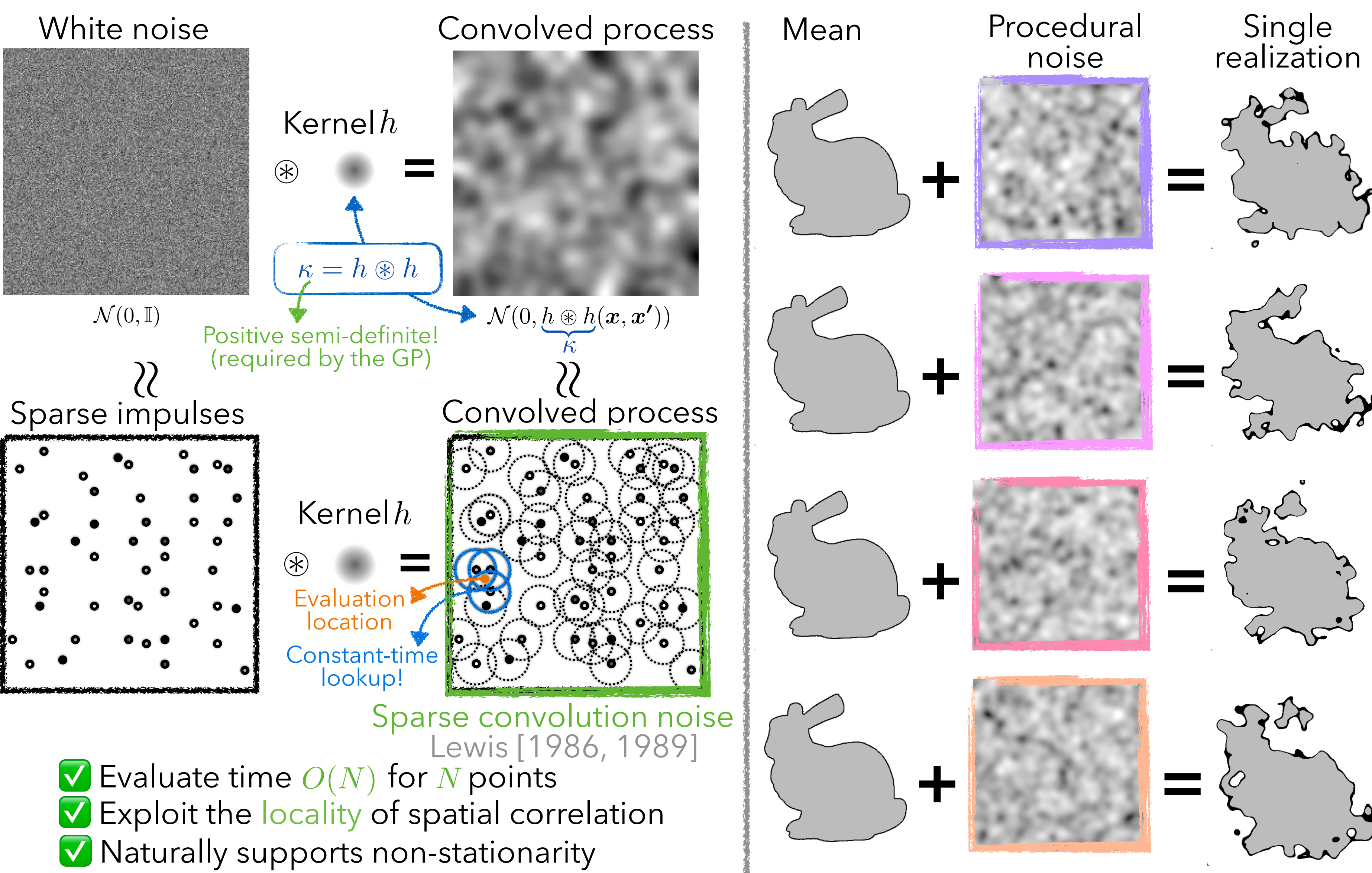


Background: Gaussian Process Implicit Surface (GPIS)

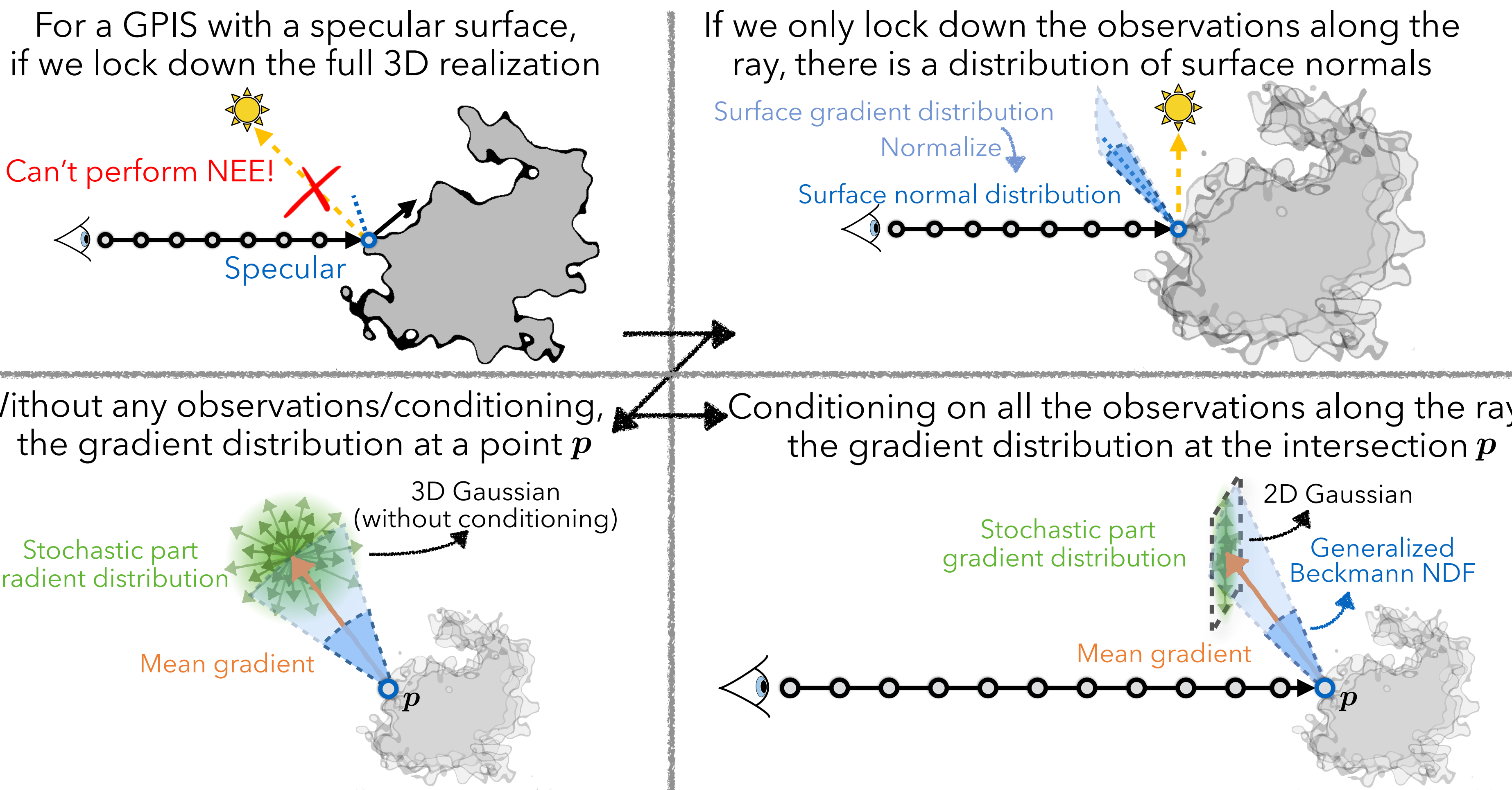
A theory of light transport [Seyb et al. 2024]



Contribution 1: Gaussian Process $\approx$ Procedural Noise



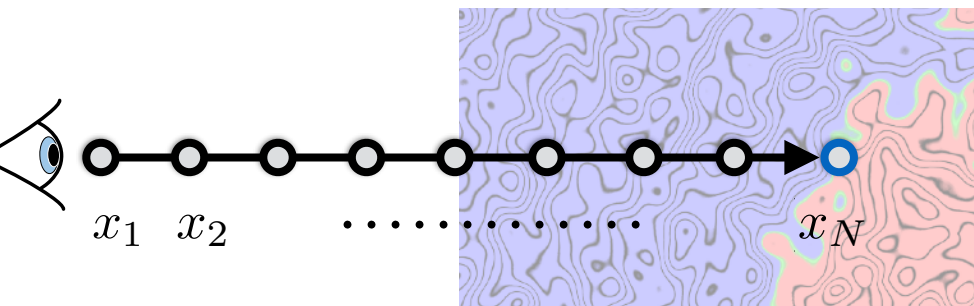
Contribution 2: Next-event Estimation for GPISes



Problem: Rendering GPISes is Hard

[Seyb et al. 2024]

- ✗ Slow: $O(N^3)$ (Often $N \geq 100$)
- ✗ Difficult to implement
- ✗ No Guarantee on PSD

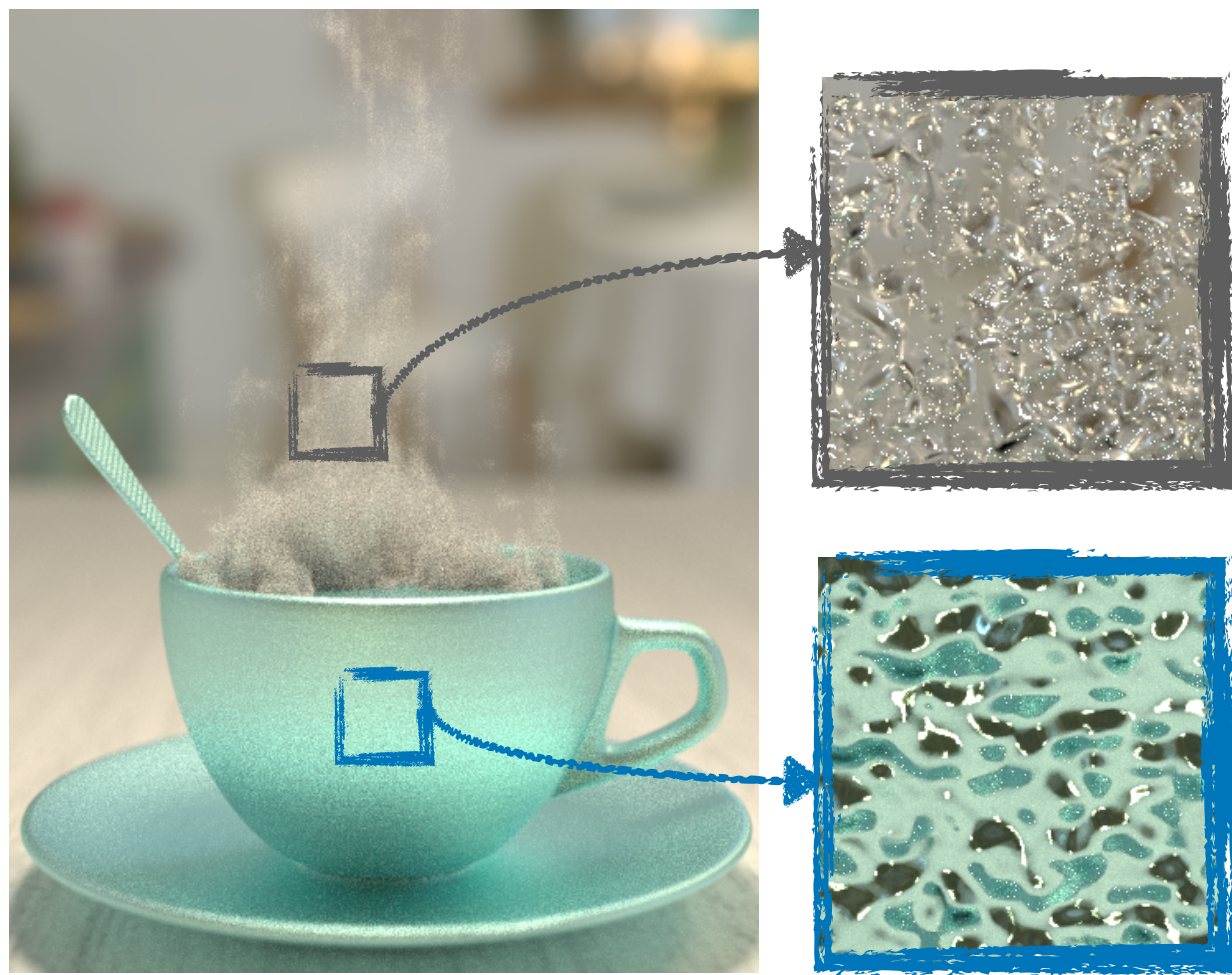


- Requires sampling all values together
- Need to compute the square root of the covariance matrix κ

$$\sqrt{\kappa(x, x')} = \sqrt{\begin{bmatrix} \kappa_{11} & \kappa_{12} & \dots & \kappa_{1N} \\ \kappa_{21} & \kappa_{22} & \dots & \kappa_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ \kappa_{N1} & \kappa_{N2} & \dots & \kappa_{NN} \end{bmatrix}}$$

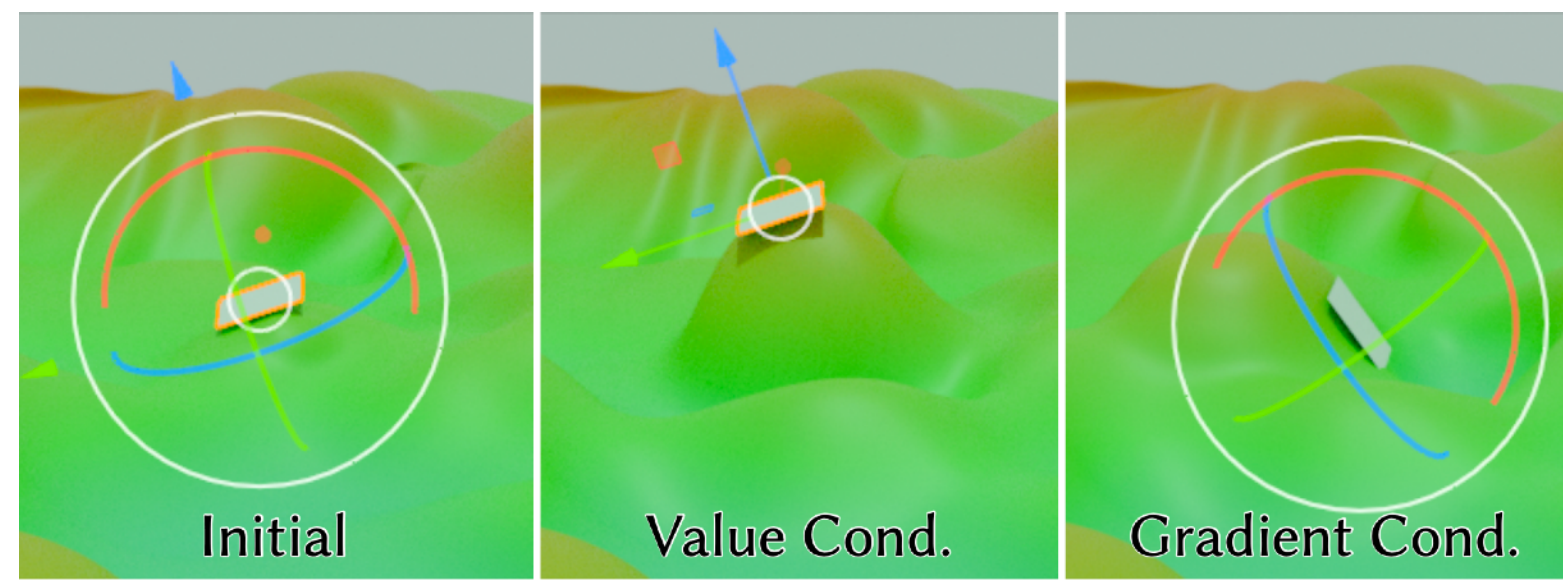
★ Our Work

- ✓ Fast: $O(N)$
 - ✓ Simple to implement
 - ✓ Guarantees PSD
- Even possible on the GPU!



Contribution 3: Conditioning for Procedural Noise

- Unlike in prior work, no conditioning method readily available for our procedural noise formulation
- Import pathwise update [Journal and Huijbregts 1978, Wilson et al. 2020] from geostatistics and ML
- Can shape a GPIS to:
 - (1) Pass through a certain location
 - (2) Have a certain orientation



Limitations & Future Work:

- Reciprocity & BDPT
- Differentiability
- Authoring tools (geometry, texture, appearance)

References:

- [1] From microfacet to participating media: A unified theory of light transport with stochastic geometry. Seyb et al. 2024.
- [2] Methods for Stochastic Spectral Synthesis. Lewis. 1986.
- [3] Algorithms for Solid Noise Synthesis. Lewis. 1989.
- [4] Mining Geostatistics. Academic Press. Journal and Huijbregts 1978.
- [5] Efficiently Sampling Functions from Gaussian Process Posteriors. Wilson et al. 2020.

& Shadertoy demo online!

