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Spec-Gloss Surfels and Normal-Diffuse Priors for Relightable Glossy Objects

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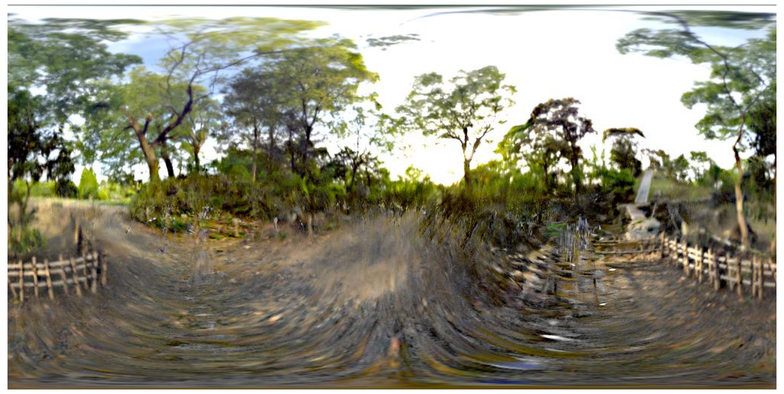
What is inverse Rendering?

Inverse Rendering → **Learned 3D Scene Decomposition** → **Downstream Tasks**

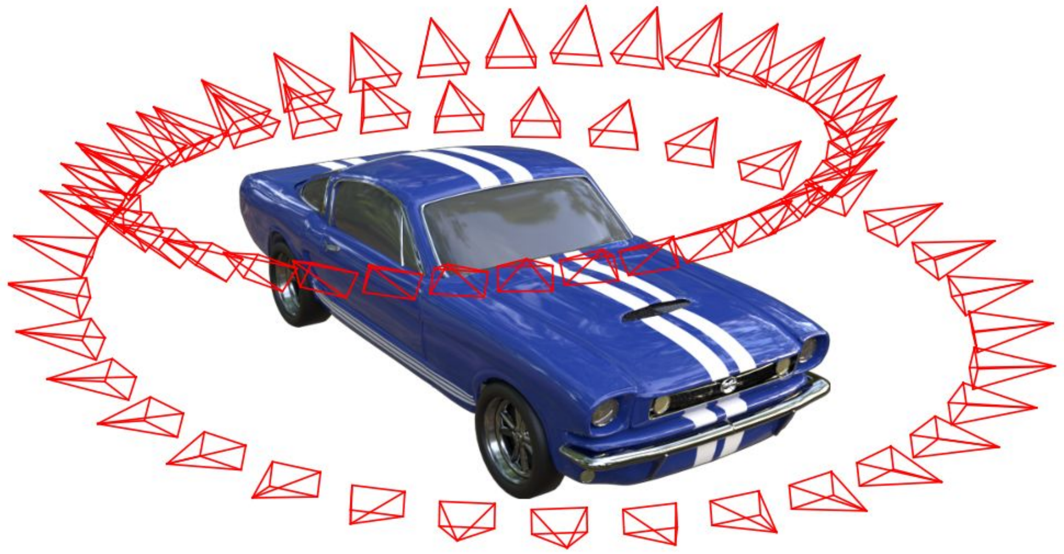
Training Views

albedo rough. F_0 normals

Recovered Scene Illumination



Novel View Synthesis



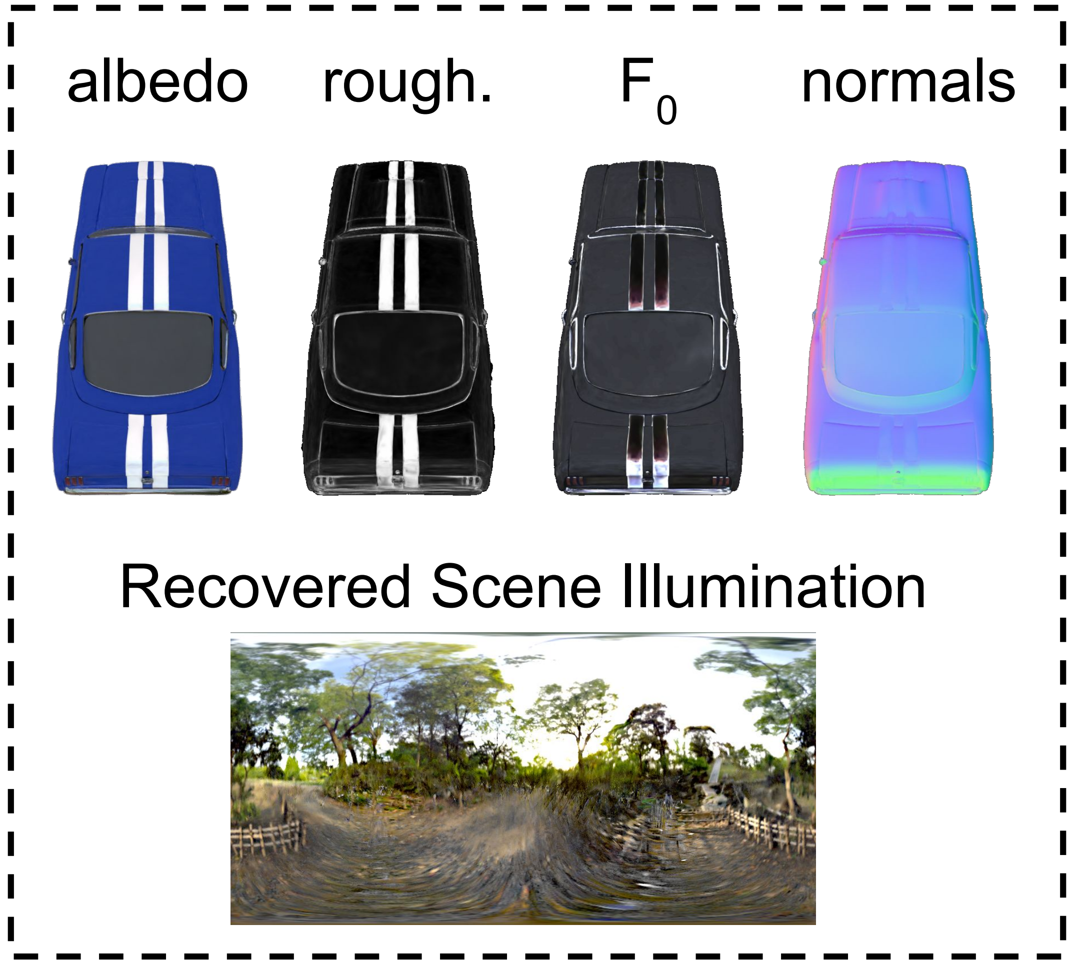
Scene Editing

Why does inverse rendering of glossy objects fail?

Inverse rendering is ill-posed because it jointly estimates

- **geometry** e.g. volumetric field, voxel grid, Gaussians
- **material properties** e.g. albedo, roughness, F_0
- **scene illumination** e.g. HDR envmap

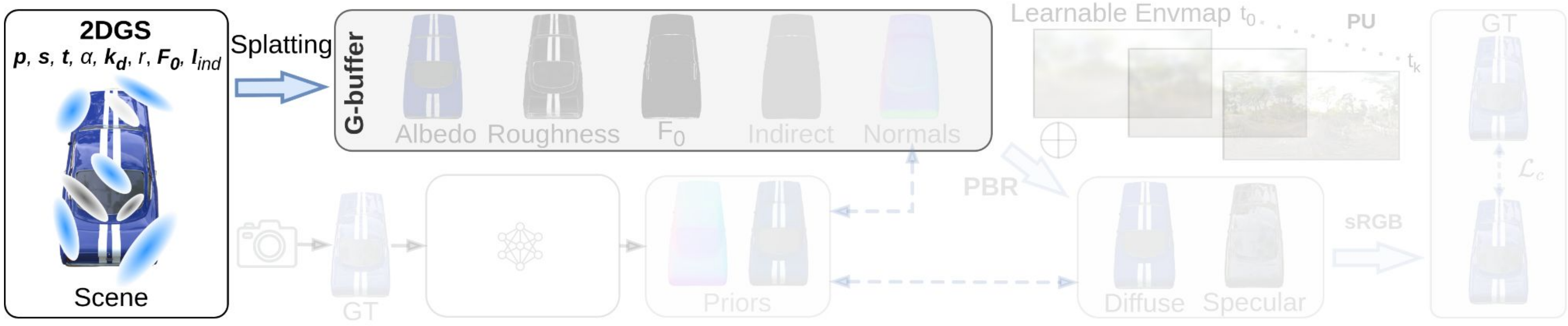
and is susceptible to local minima due to ambiguity from complex view-dependent effects.



This often leads to:

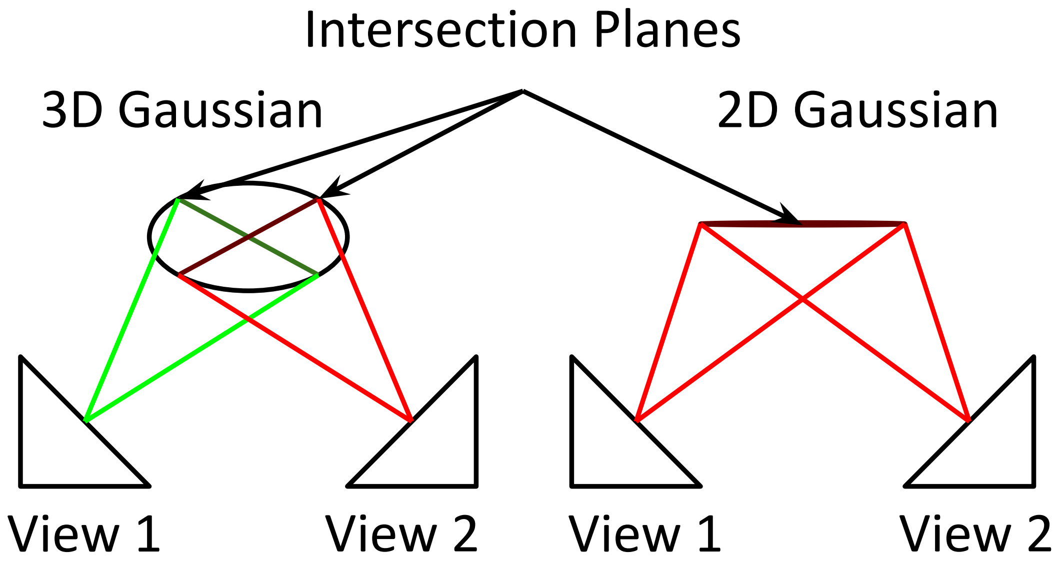
- Good novel view synthesis 😀, but
- Bad relighting / scene editing 🙁

Our pipeline (1/6): 2DGS + deferred shading



Why **2D Gaussians** and <u>not</u> **3D Gaussians**?

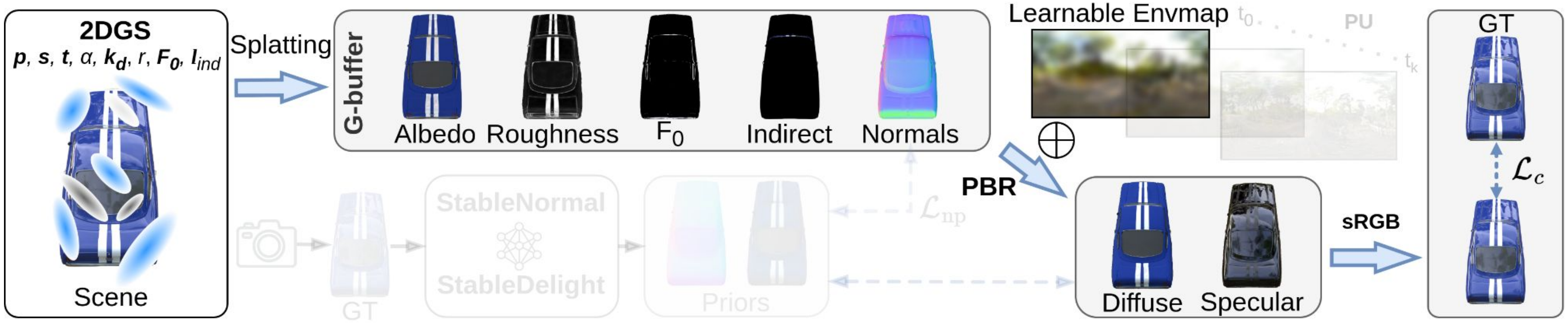
- View-consistent geometry
- Explicit normals as shortest axes of Gaussians



Why **deferred shading** (pixel-level) and <u>not</u> **forward shading** (Gaussian level)?

- Improved reconstruction of high-frequency reflections with less blurring
- Improved scaling on large scenes (millions of Gaussians)

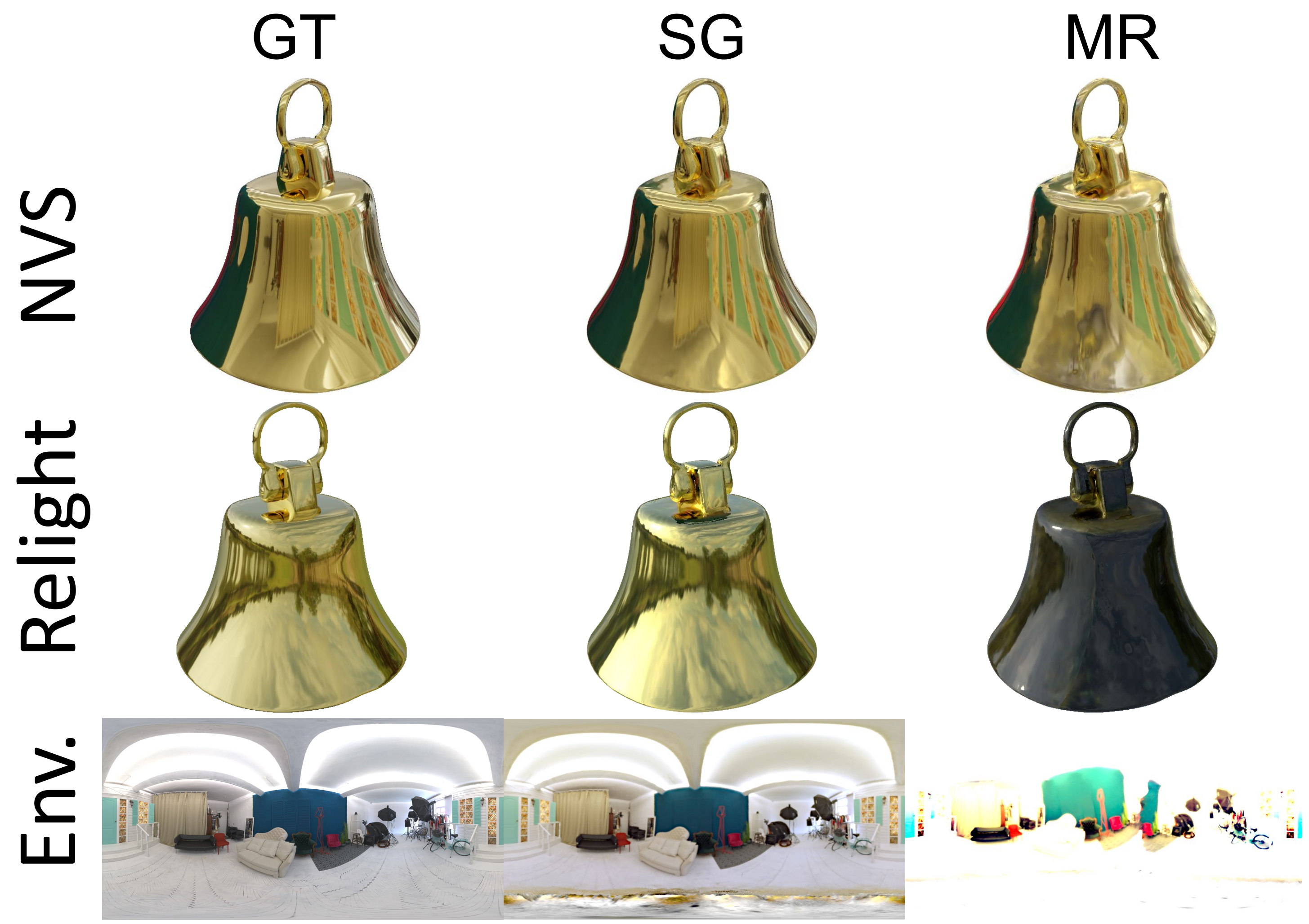
Our pipeline (2/6): Spec-Gloss Material Parameterization



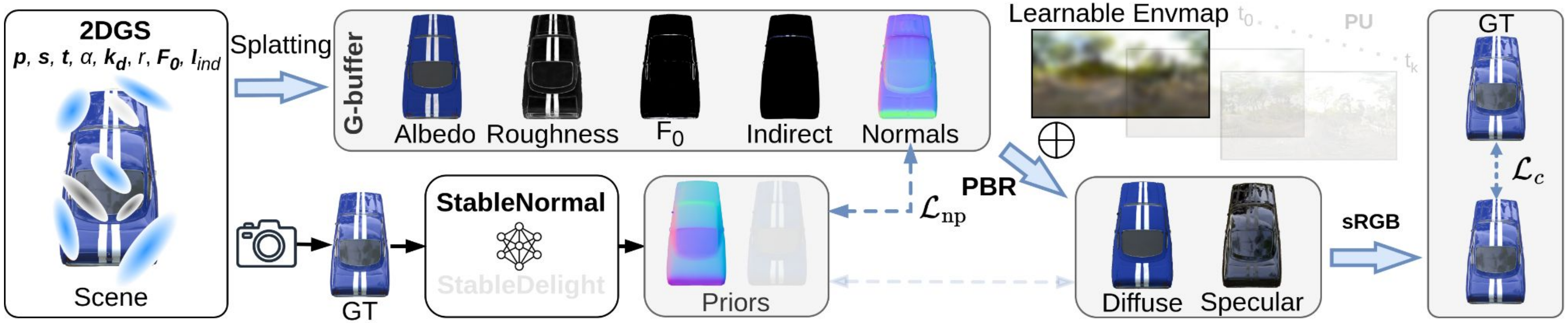
- The popular **Metallic-Roughness (MR)** parameterization entangles albedo / base-color (b) in specular appearance via F_0:

$$F_0(m,\boxed{b}) = (1-m)\cdot 0.04 + m\cdot \boxed{b}$$

- The **Specular-Glossiness (SG)** parameterization learns F_0 as a free parameter !!!



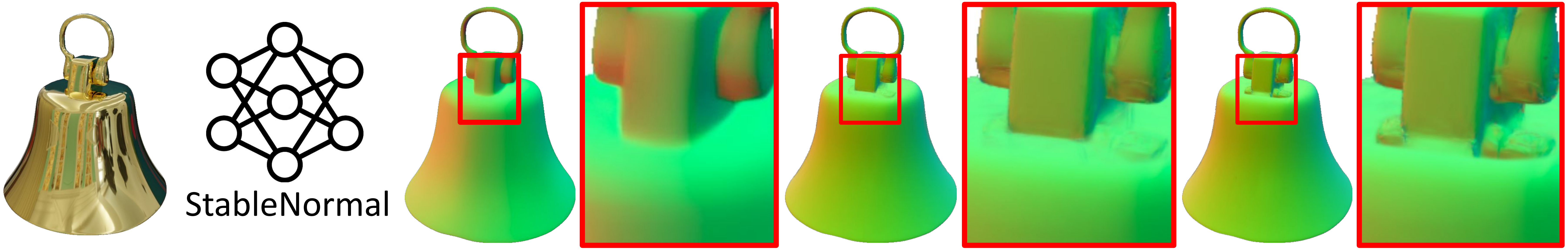
Our pipeline (3/6): Surface normal prior



RGB input → Normal Prior

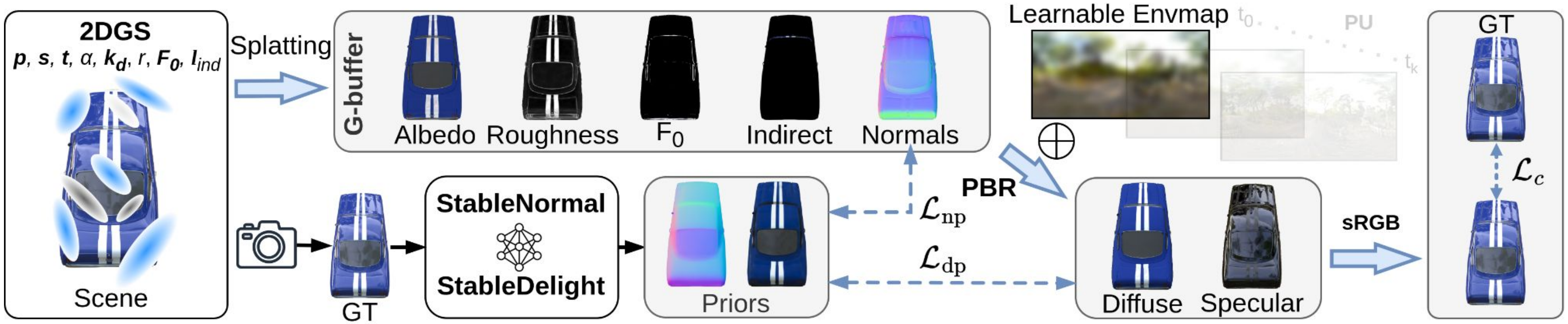
Learned Normals w/ Prior

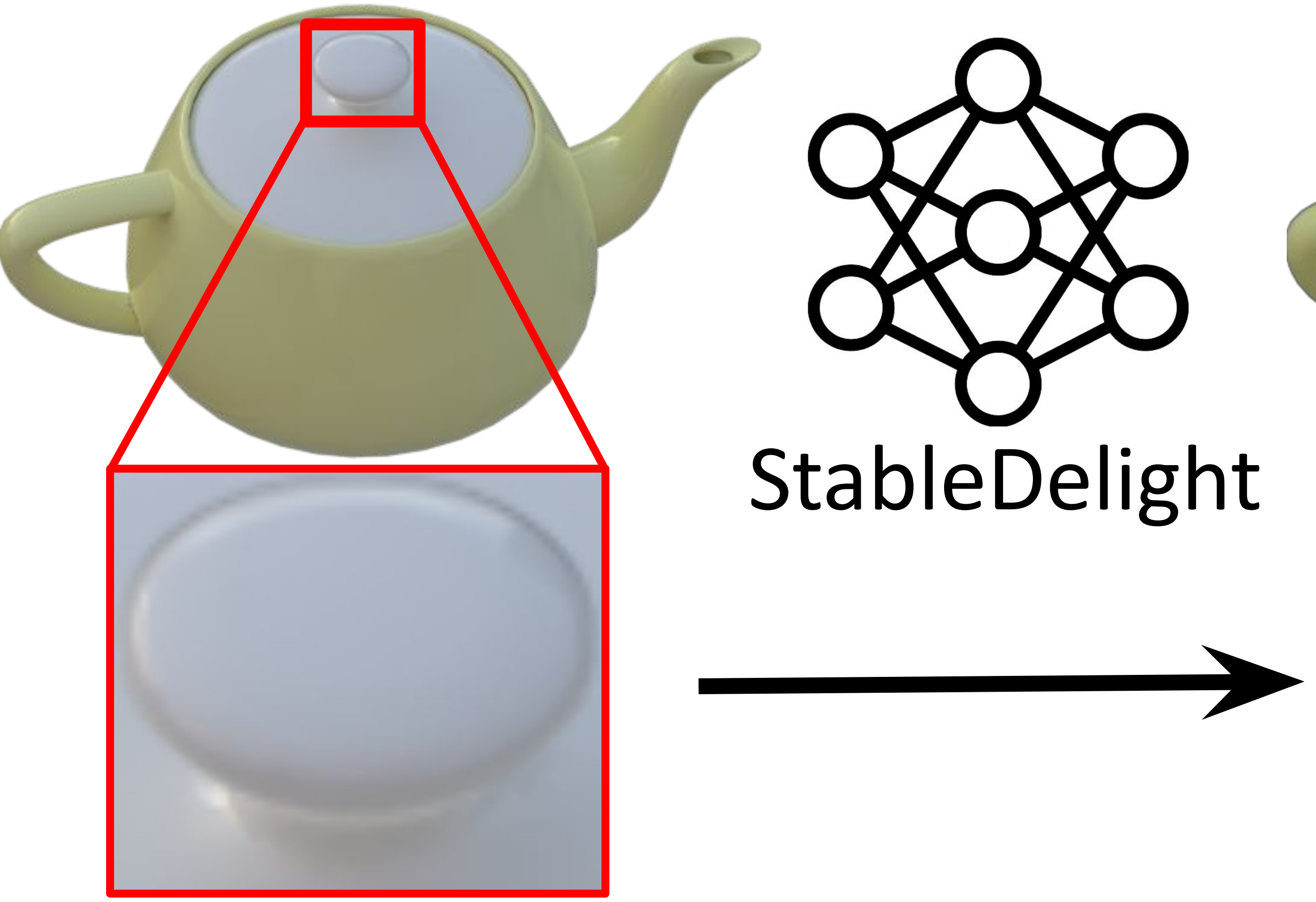
Learned Normals w/o Prior

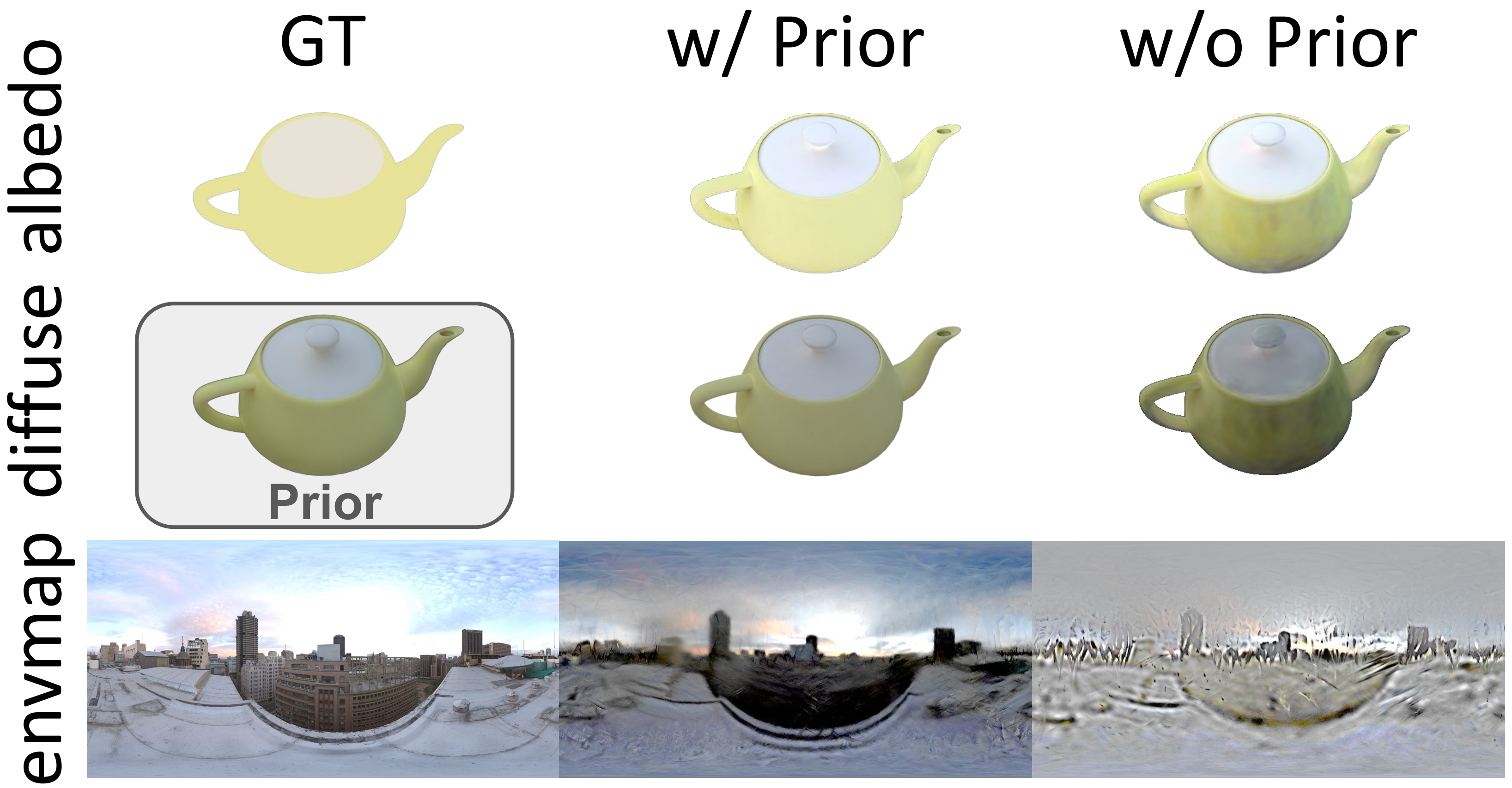


Ye, C., Qiu, L., Gu, X., Zuo, Q., Wu, Y., Dong, Z., … Han, X. (2024). StableNormal: Reducing Diffusion Variance for Stable and Sharp Normal. *ACM Transactions on Graphics (TOG)*.

Our pipeline (4/6): Diffuse color prior

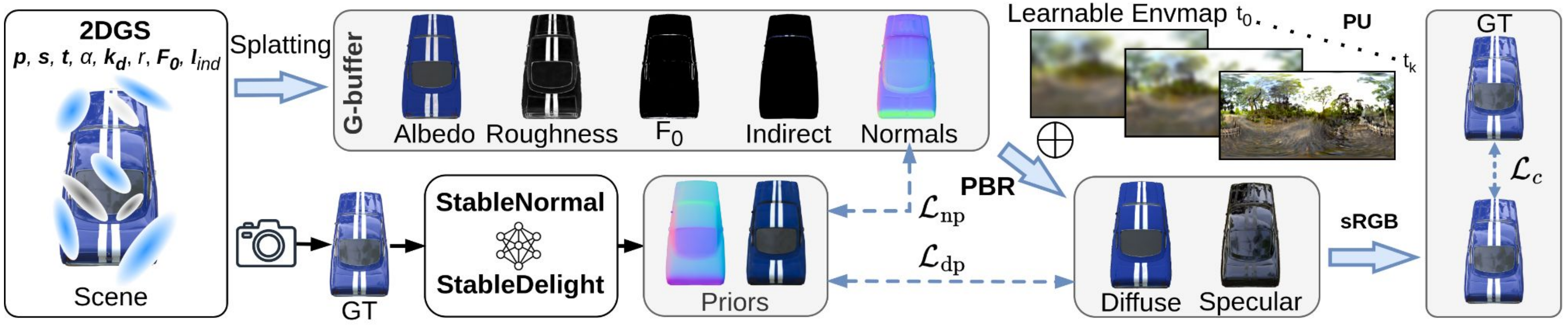






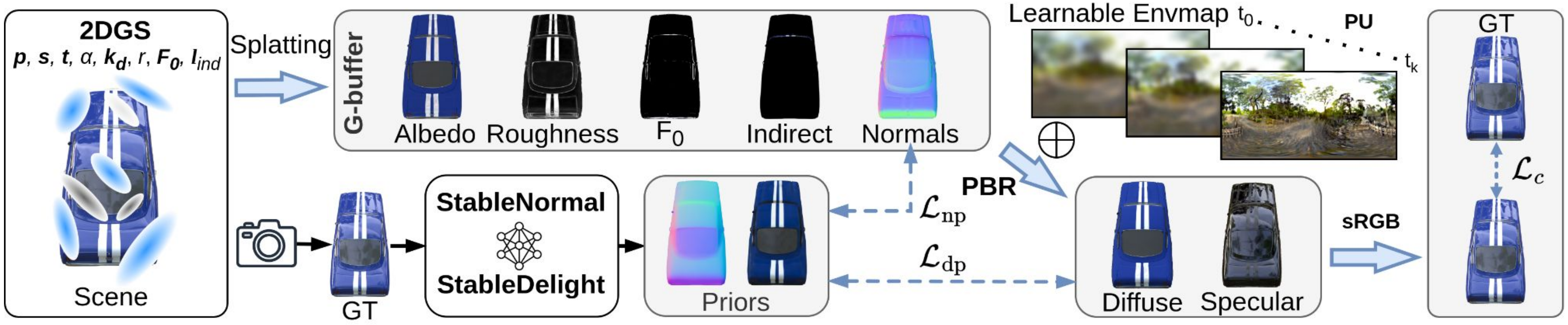
Stable-X. StableDelight: Revealing hidden textures by removing specular reflections (2025). https://github.com/Stable-X/StableDelight.

Our pipeline (5/6): Coarse-to-fine lighting optimization



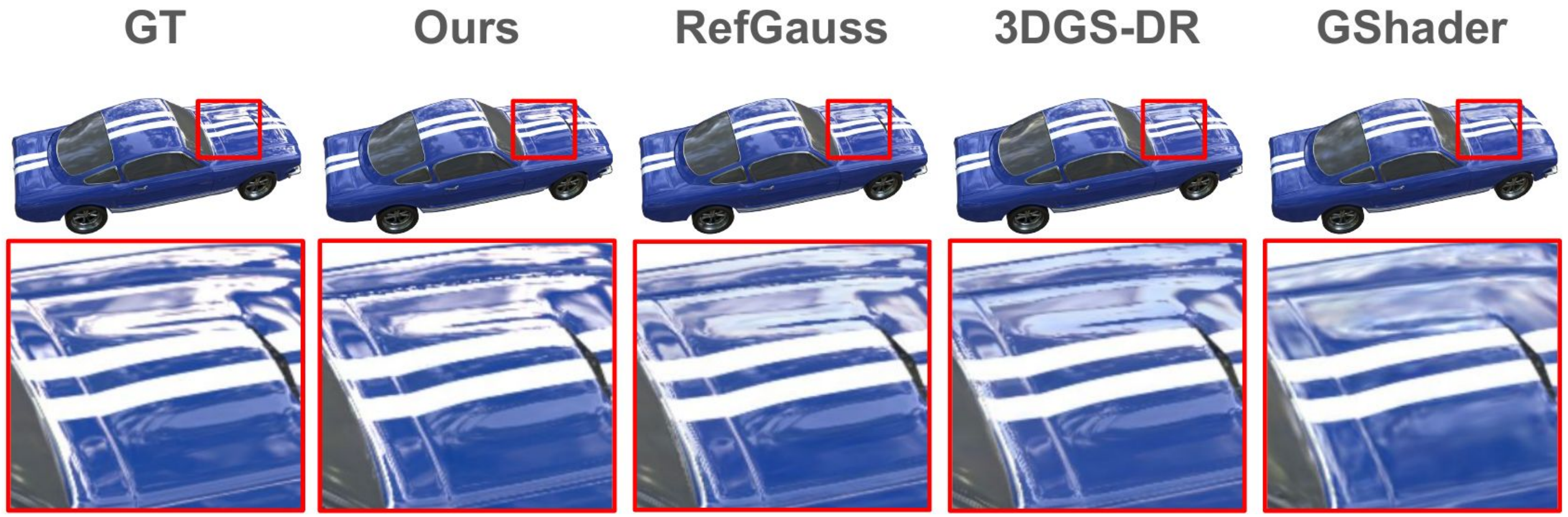
- **Envmap prefiltering** is the main bottleneck: higher res -> slower training
- Our method <u>starts from a low resolution</u> environment light cubemap (6×64×64) and **progressively upsamples** (**PU**) it every 15k iters until the full resolution (6×512×512)
- **PU** <u>halves training time</u> (2h -> 1h) without impacting envmap quality
- Facilitates recovery of **higher resolution envmaps** in reasonable time

Our pipeline (6/6): Negative-only Clipping (NOC)

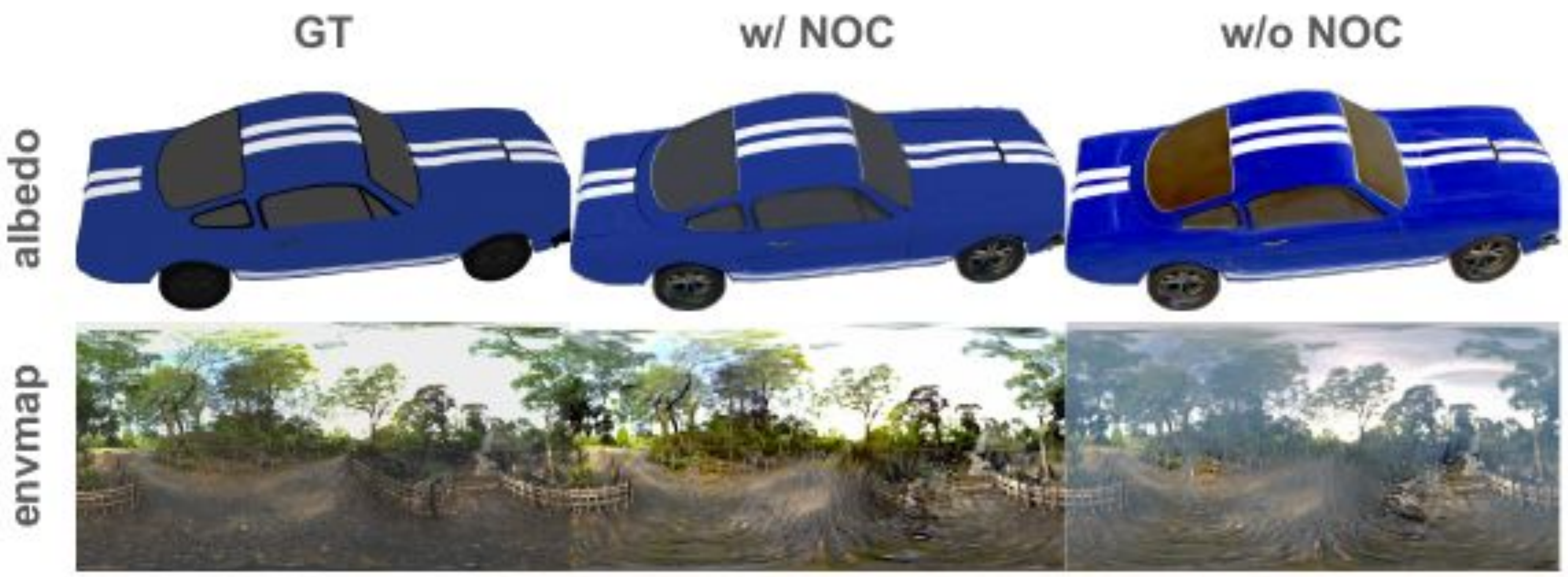


$$E \leftarrow \max(0, E_{\text{raw}})$$

Preserves sharp bright specular reflections!

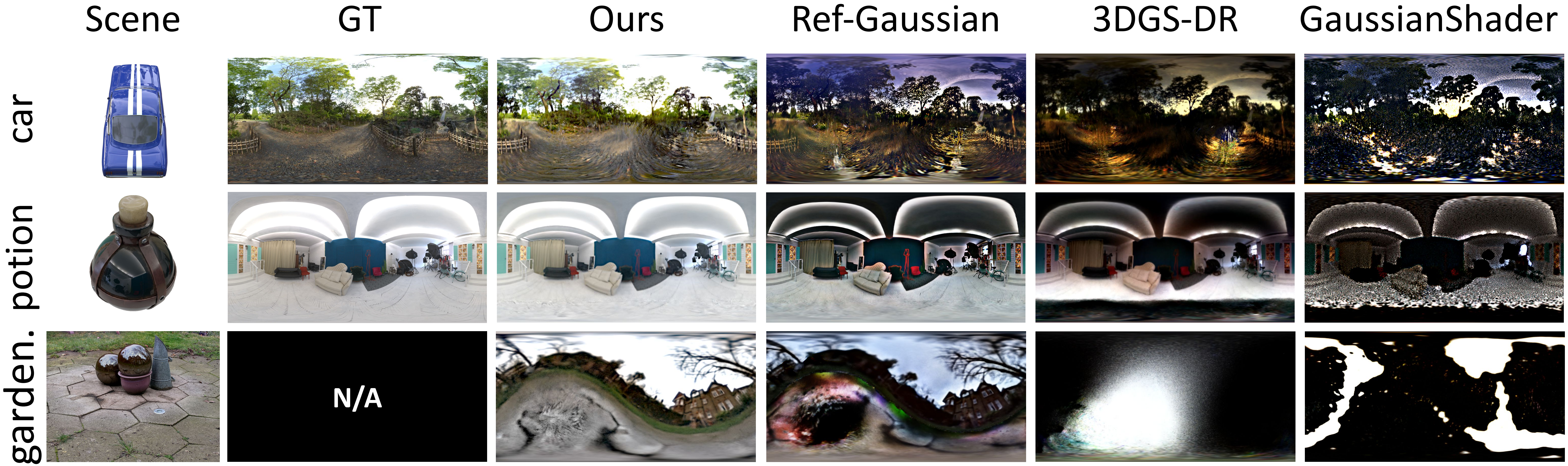


Improves albedo-lighting disentanglement!



Experimental Results

Envmap Recovery



- Superior envmap recovery compared to other Gaussian Splatting methods!
- Accurate envmap ⟶ better material properties ⟶ high-quality relighting!

Relighting Results

Relighting: bell

GT

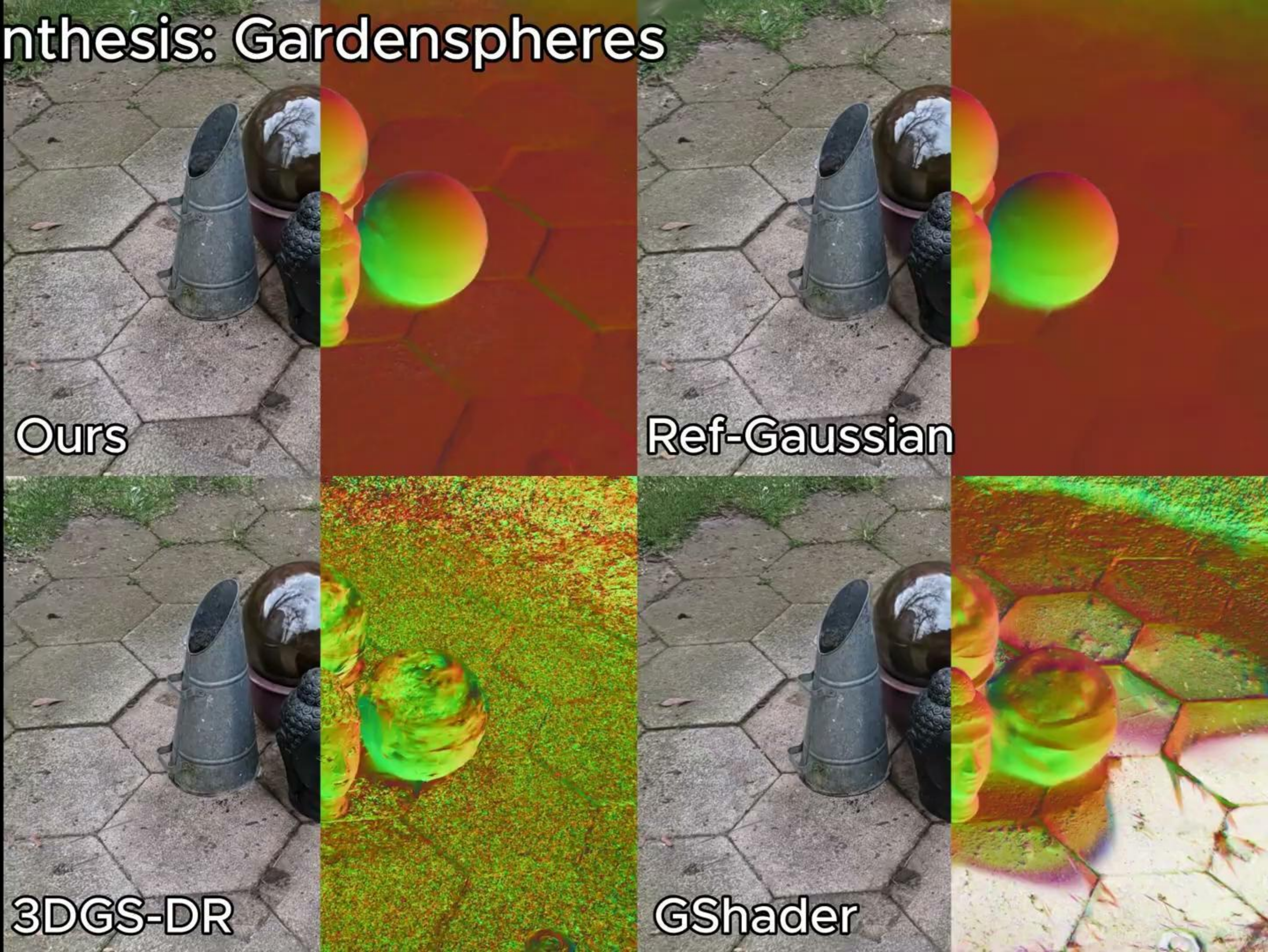
Applied Envmap

Ours (SG)

Ours (MR)

Novel View Synthesis Results

Novel View Synthesis: Gardenspheres



Novel View Synthesis: car

GT

Ours

Scene Editing Results

Original

Albedo Editing

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Thank you for your attention!
See you at **Poster Session 4-13**!

Project Page