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A Radiance Cache Method for Highly Glossy Surfaces (Additional Materials)

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This document contains more results and analysis. The first section contains results about the precomputation accuracy of $\tilde{F}_r$ while the second section illustrates some higher resolution renderings obtained with our method and additional results (Figure 8).

1 Approximation quality of $\tilde{F}_r$

Figures 1, 2 and 3 provide more data about the precomputation accuracy of $\tilde{F}_r$ with different solid angles (see Section 3.1 of the paper for more details). Table 1 summarizes the mean errors for each size of solid angles.

Memory size requirement With radiance caching, materials are also projected into space of hemispherical harmonics basis functions. This projection is done once for each material. However, the number of coefficients and memory storage are high with glossy surfaces, and memory-consuming for scenes containing a lot of different materials. The projection size S_{RC} (in bytes) can be estimated as:

$$S_{RC} = \#\theta_i \times \#\phi_i \times order^2 \times \#channels \times 4 \quad (1)$$

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		$\theta_e = \frac{2\pi}{5}$	$\theta_e = \frac{\pi}{4}$	$\theta_e = \frac{\pi}{20}$
$n = 40$	$\Omega_j = \frac{\pi}{10}$	0.85 %	0.56 %	0.51 %
	$\Omega_j = \frac{\pi}{30}$	0.12 %	0.07 %	0.06 %
	$\Omega_j = \frac{\pi}{60}$	0.03 %	0.015 %	0.01 %
	$\Omega_j = \frac{\pi}{100}$	0.009 %	0.005 %	0.004 %
$n = 100$	$\Omega_j = \frac{\pi}{10}$	1.9 %	1.7 %	1.6 %
	$\Omega_j = \frac{\pi}{30}$	0.58 %	0.5 %	0.47 %
	$\Omega_j = \frac{\pi}{60}$	0.17 %	0.18 %	0.17 %
	$\Omega_j = \frac{\pi}{100}$	0.066 %	0.045 %	0.046 %
$n = 200$	$\Omega_j = \frac{\pi}{10}$	2.6 %	2.48 %	2.42 %
	$\Omega_j = \frac{\pi}{30}$	1.21 %	1.16 %	1.2 %
	$\Omega_j = \frac{\pi}{60}$	0.38 %	0.44 %	0.4 %
	$\Omega_j = \frac{\pi}{100}$	0.18 %	0.16 %	0.18 %

Table 1: Mean error according to various configurations

where $\#\theta_i \times \#\phi_i$ are the number of directions taken to project the BRDF, $order^2$ is the number of coefficients and $\#channels = 3$ the Red, Green and Blue channels. In all our tests, we use $\#\theta_i \times \#\phi_i = 10000$ and $order = 20$ for a shininess $n = 40$ and $order = 29$ for a shininess $n = 100$. These parameters allow to obtain satisfying results with a memory cost of $S_{RC} = 46Mb$ for $n = 40$ and $S_{RC} = 96Mb$ for $n = 100$.

In comparison, with our fitting process (which is done once and for all for a material), the projection size S_{our} is given by

$$S_{our} = \#H \times \#AS \times k \times C \times 4 \quad (2)$$

where $\#H = 90$ is the number of elevation angles θ_e, $\#AS = 90$ the number of solid angle extents, k the number of generalized cosine lobes ($k = 1$ in the case of modified Phong fitting) and finally C are the fitted coefficients C_x C_y C_z n. Note that in case of isotropic materials, $C_x = C_y$. In all our tests, a material, regardless of its shininess coefficient, takes only $0.12Mb$ storage.

2 Rendering results

Figures 4, 5, 6, 7, 9,10 and 11 present the same results as in the paper, with a higher resolution. The reference, obtained with a path tracing method, is added to allow visual comparisons. Whenever possible, we made a comparison between Radiance Caching method (RC) and our method and provide RMSE and difference images.

Figure 8 shows a set of new results. We compare for the same record size the result quality of RC and our method, progressively increasing Phong shininess exponent (n). Note that noticeable artifacts appear with RC with an exponent $n = 80$ while our method provides convincing visual results even with a strong exponent ($n = 200$). These results show that our method remains robust with the borderline case $n = 1000$ and a high number of EAS.

The record size can be estimated for both RC and our method. Let us denote S_{RC} as the record size (in bytes) for Radiance Caching and S_{EAS} for our method:

$$S_{RC} = order^2 \times \#channels \times (grad + 1) \times 4 \tag{3}$$

where $grad = 2$ the translational gradient and

$$\begin{aligned} S_{EAS} = & (Irradiance + position + normal) \\ & \times \#EAS \times 4 \end{aligned} \tag{4}$$

where $Irradiance = position = normal = 3$ floats and $SolidAngle = 1$ float.

Moreover, our method can be extended to handle a large range of glossy BRDF models. The theory presented in the paper remains unchanged. For example, Figure 10 shows a glossy sphere made with a highly anisotropic Ward BRDF with $\alpha_x = 0.1$ and $\alpha_y = 0.5$. The sphere was rendered with 470 glossy records and approximated with 300 EASs per record ($RMSE < 1\%$). Figure 11 shows objects with different BRDFs (anositropic, micro-facet based, modified Phong and Lambertian). For perfectly specular objects, a pure Monte Carlo can be used (the pure mirror dragon in Figure 11).

Walkthrough animation rendering Radiance caching based method are well adapted to render pre-computed walkthrough animations. Indeed, the records created for one frame can be reused to render the other frames. Paying attention to the rendering process to avoid flickering (first create the cache for the complete animation and then render it), our method proceeds as the other radiance cache based methods as shown in the accompanying video. Rendering such an animation with Path Tracing is subject to high frequency flickering or considerable computation time.

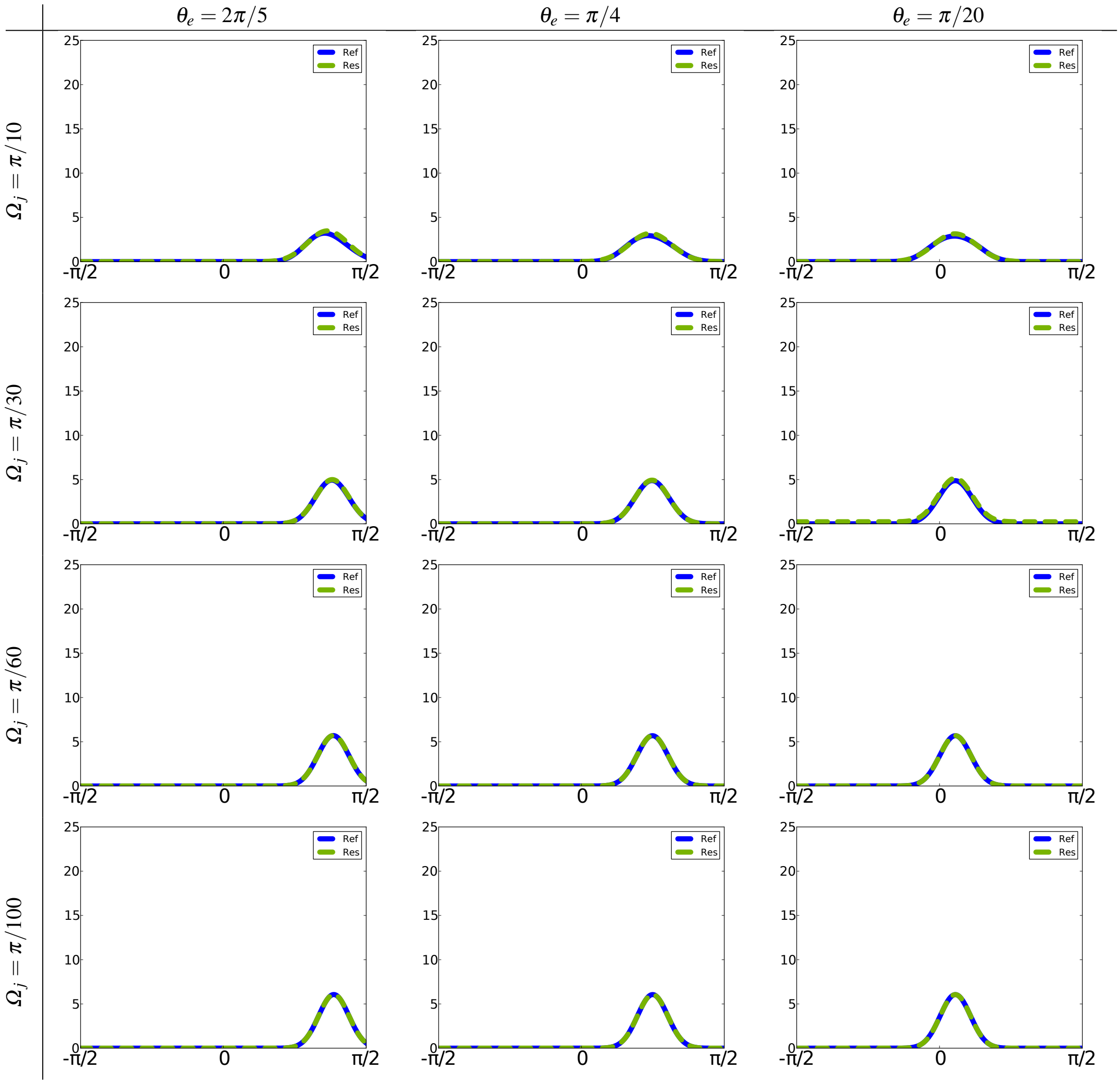

Fig. 1: Fitting quality for a modified Phong lobe with shininess $n = 40$. The green plot is for our fitting process and the blue one for the reference. In this case, $\Omega_j = \pi/10$ should be chosen.

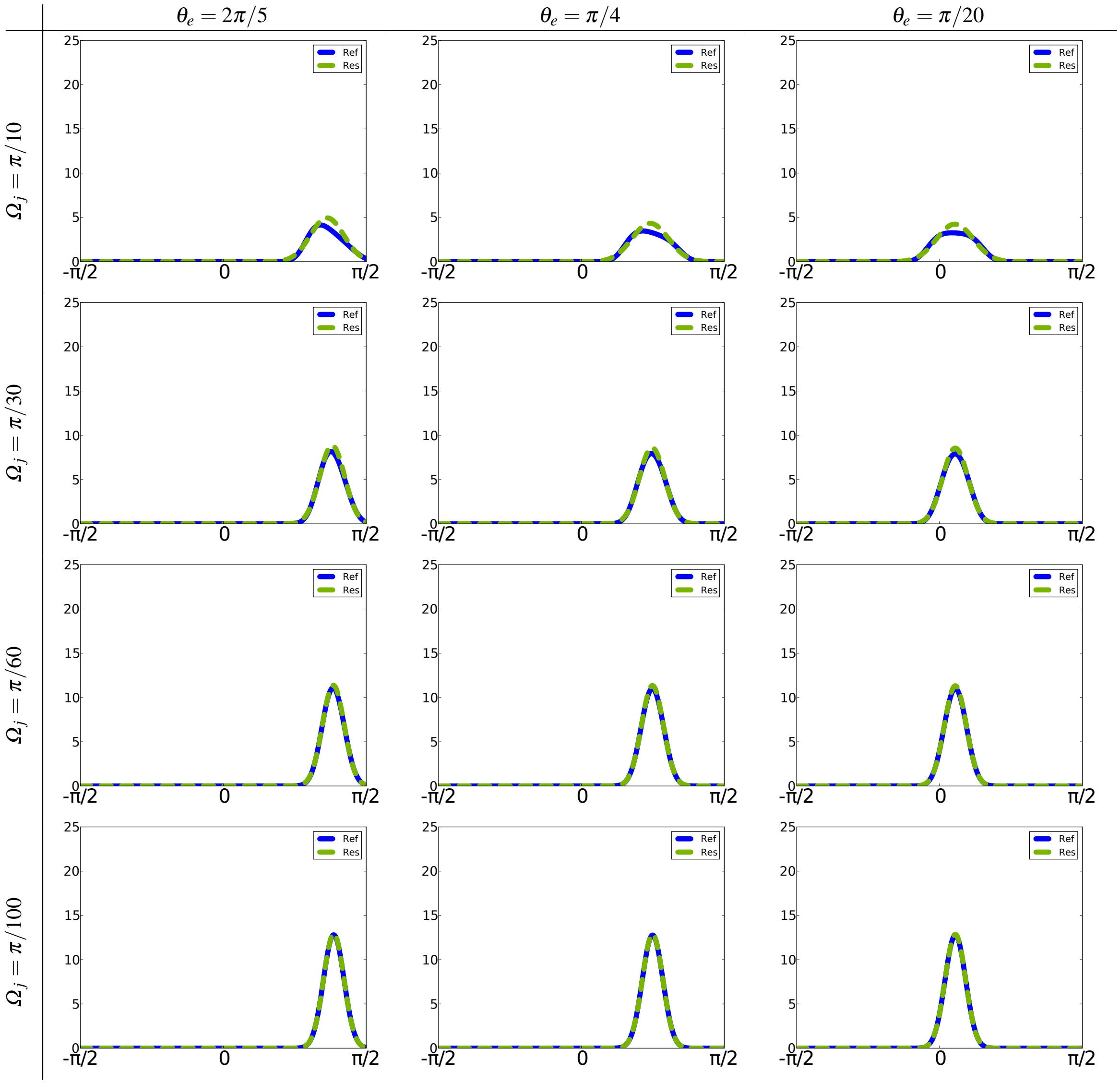

Fig. 2: Fitting quality for a modified Phong lobe with shininess $n = 100$. The green plot is for our fitting process and the blue one for the reference. An acceptable quality can be achieved with $\Omega_j = \pi/30$

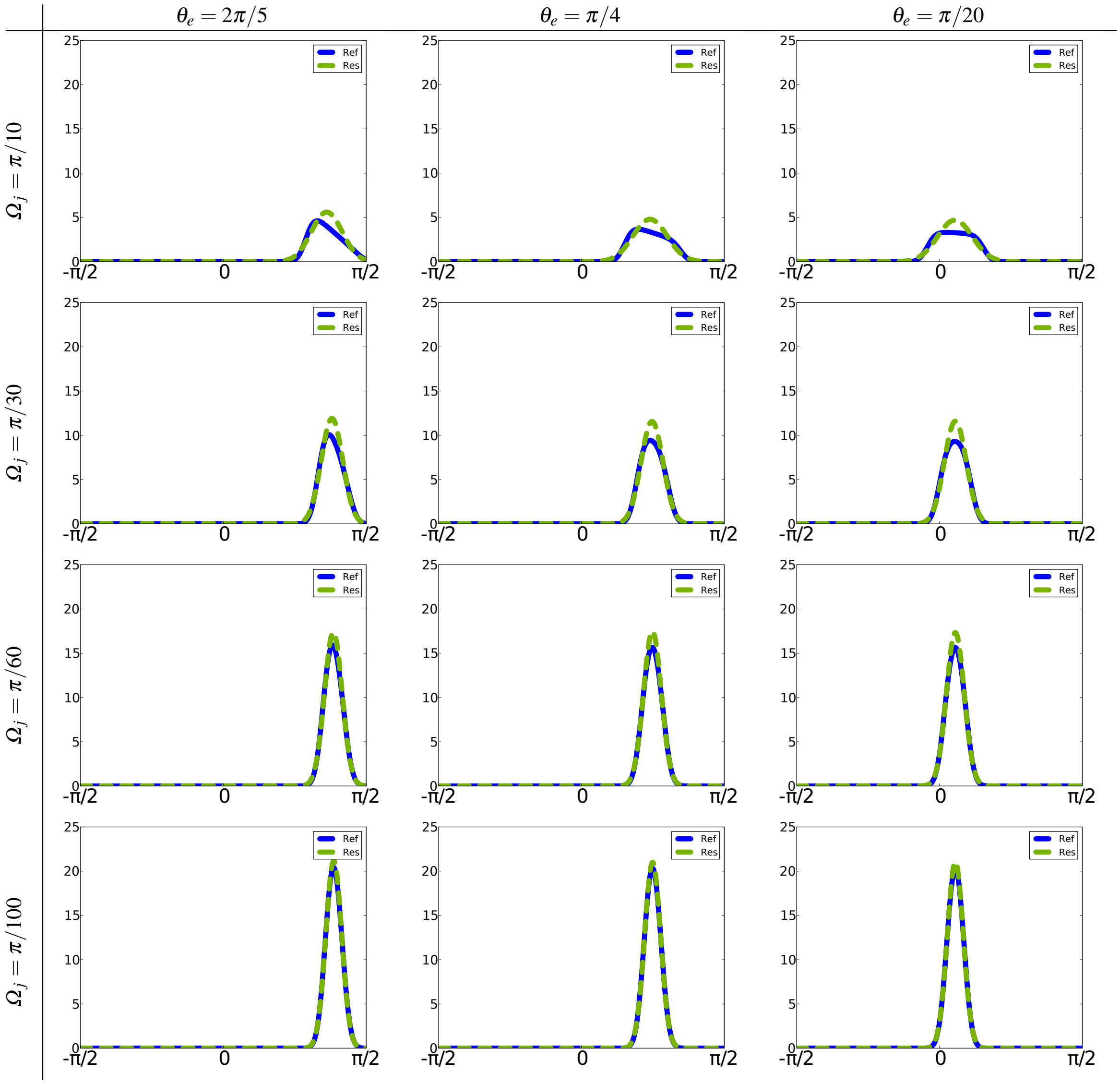

Fig. 3: Fitting quality for a modified Phong lobe with shininess $n = 200$. The green plot is for our fitting process and the blue one for the reference. In this case, $\Omega_j = \pi/100$ should be chosen.

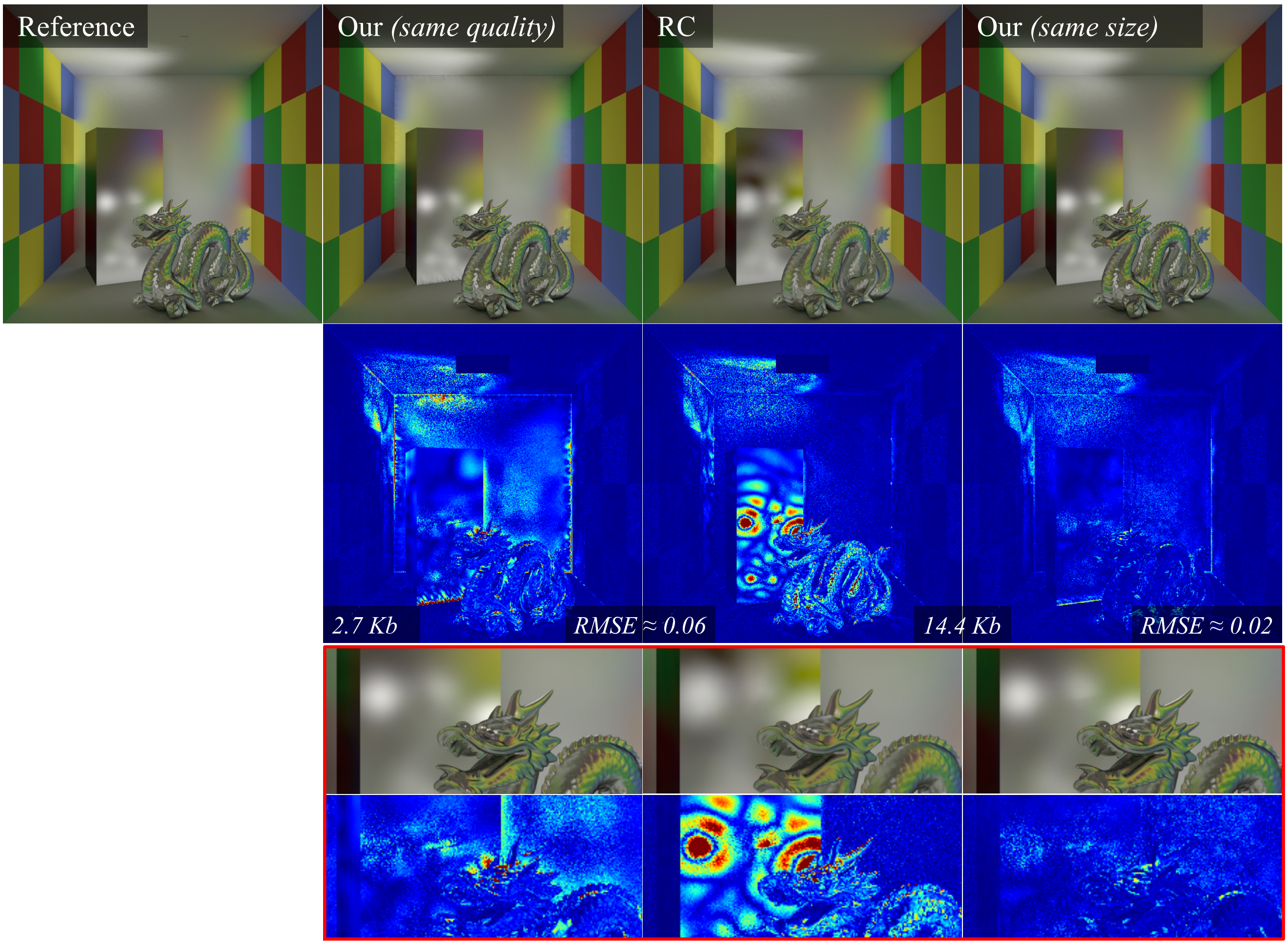

Fig. 4: *Dragon* scene.

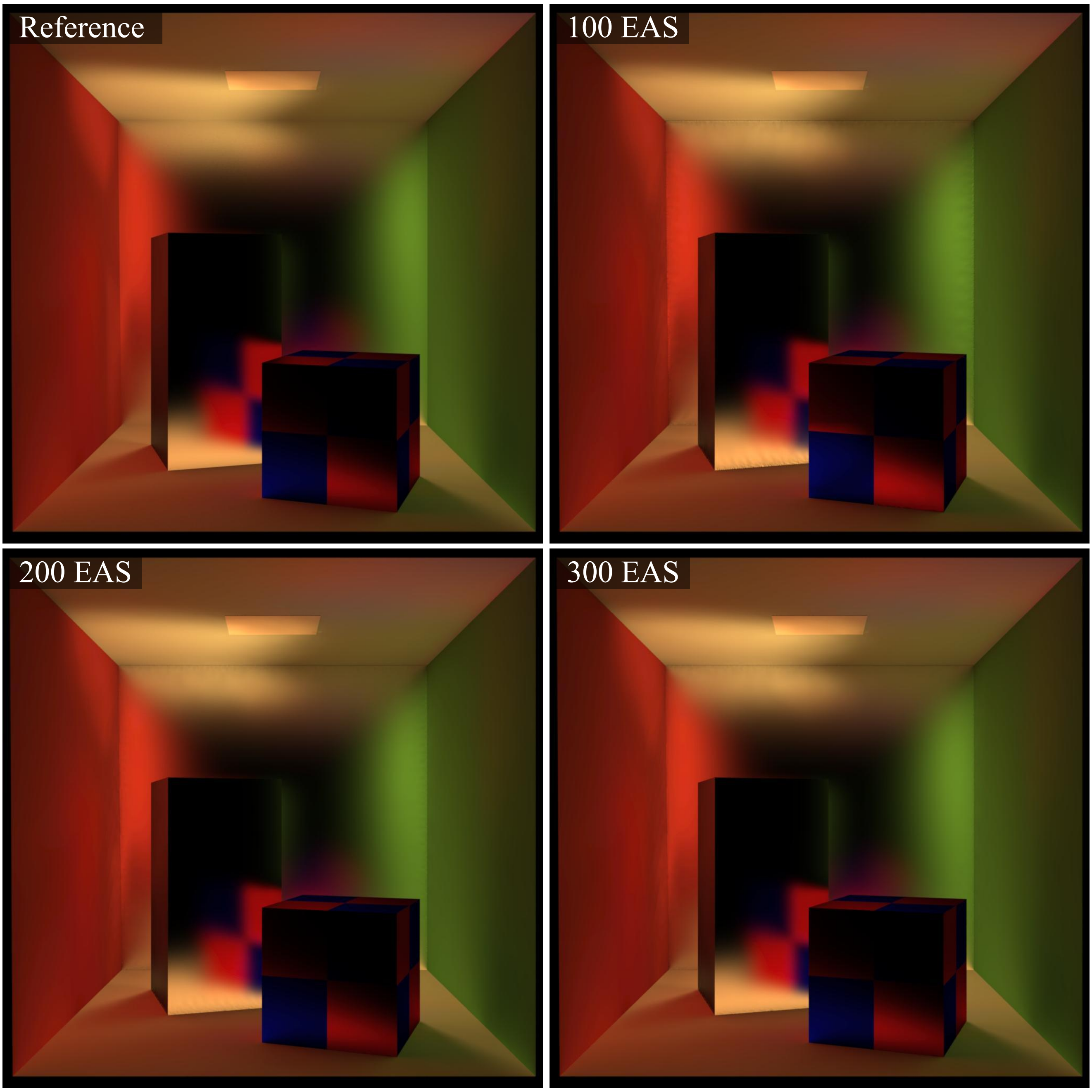

Fig. 5: *Cornell Box* scene: visual appearance depending on the number of EAS (*RMSE* $\ll 0.005$).

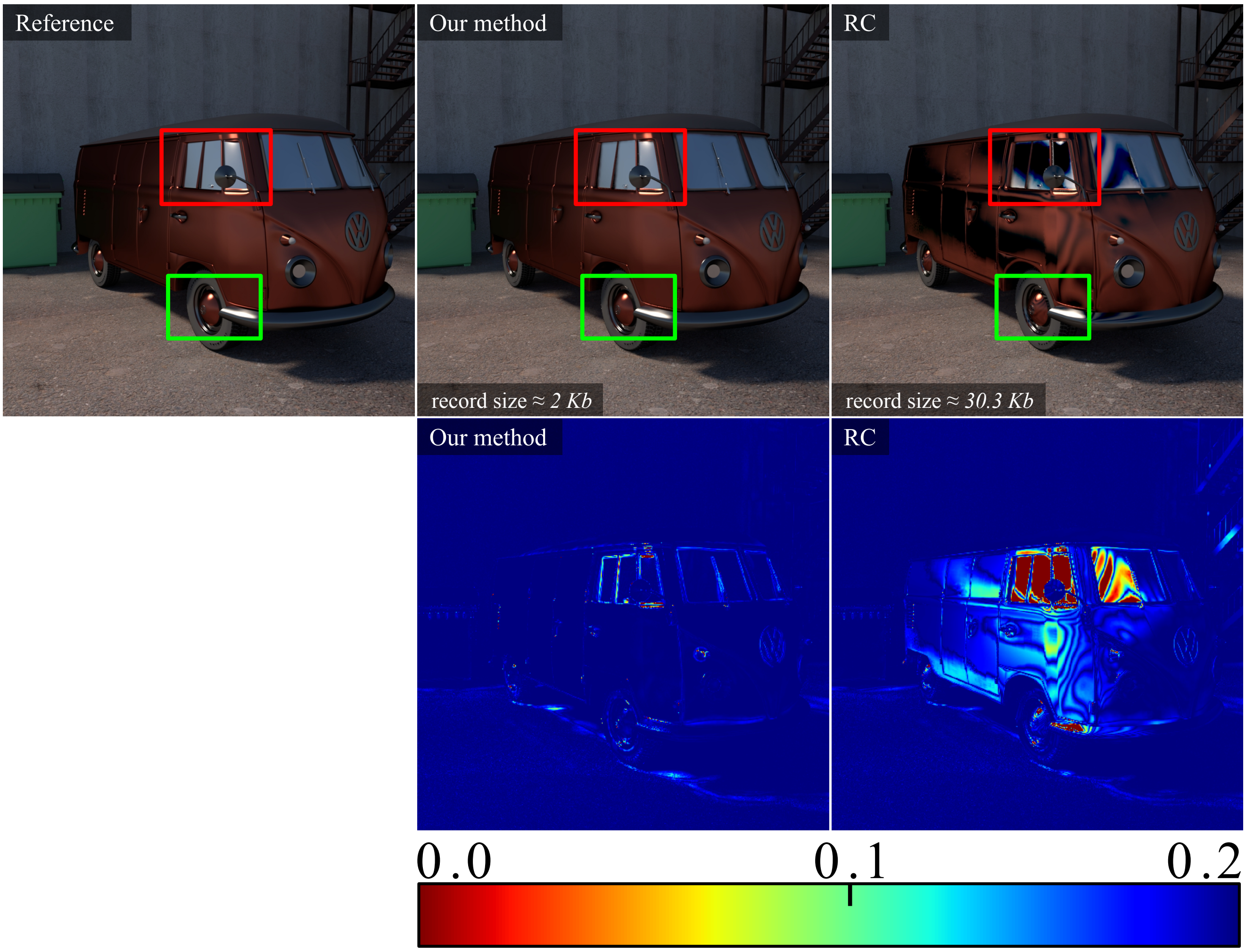

Fig. 6: *Car* scene.

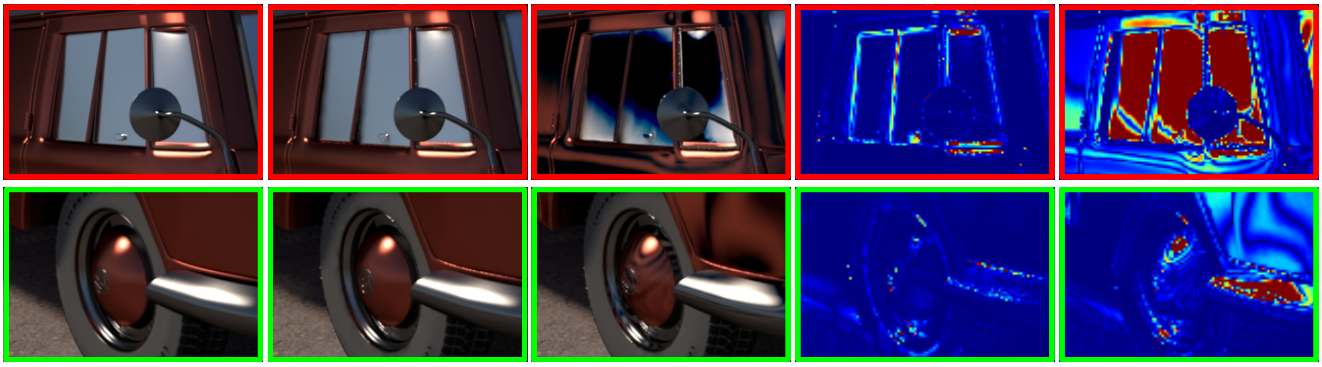

Fig. 7: *Car* scene close up.

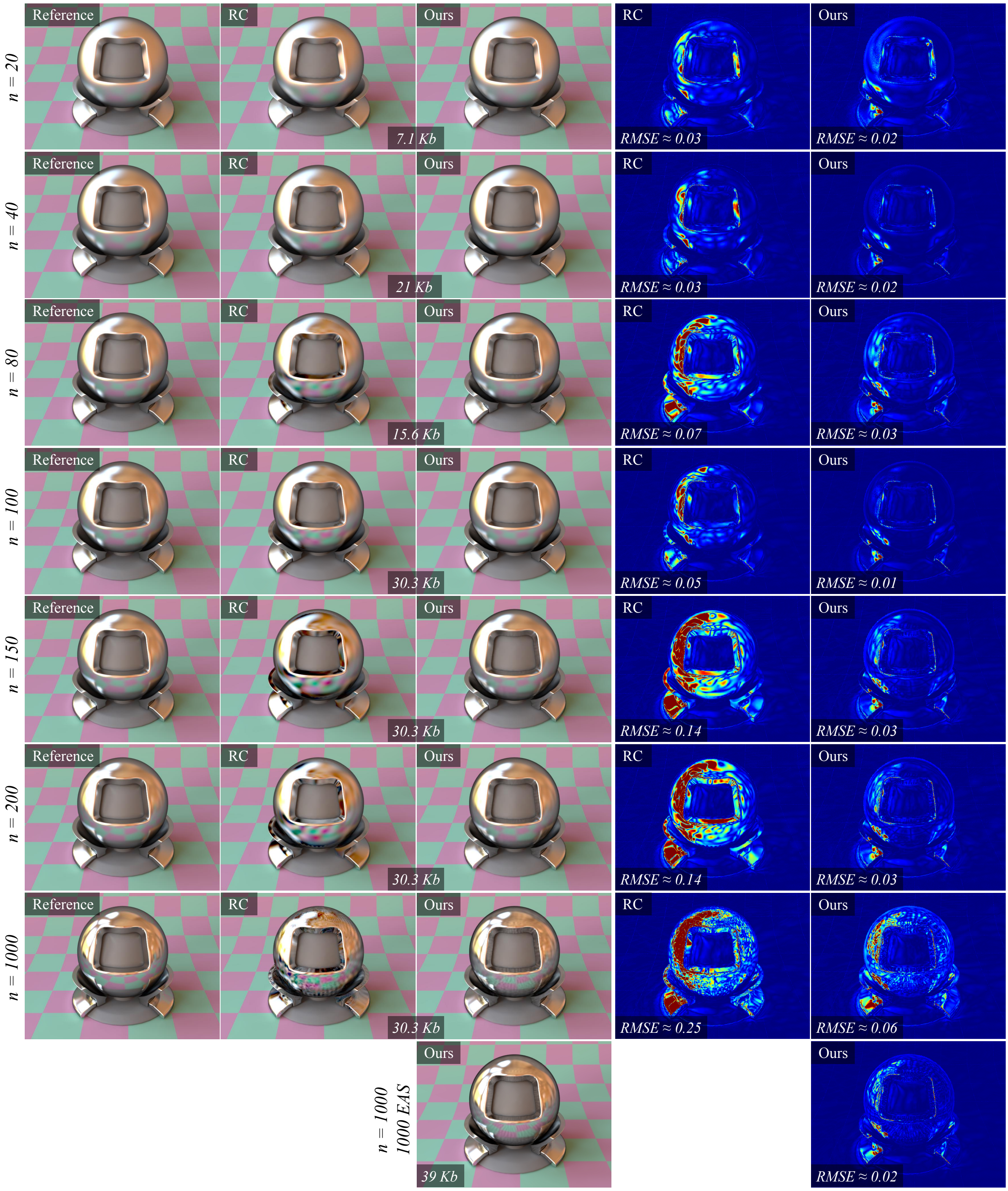

Fig. 8: *Matpreview* scene: comparison between our method and RC for various shininess. For each exponent n we have set the number of EAS so as to obtain the same record size as in RC. Last row shows the result given by our method with a high frequency BRDF ($n = 1000$) and 1000 *EAS*. Note that for this extreme case, our method still provides results with a low RMSE.

Fig. 9: *kitchen* scene.

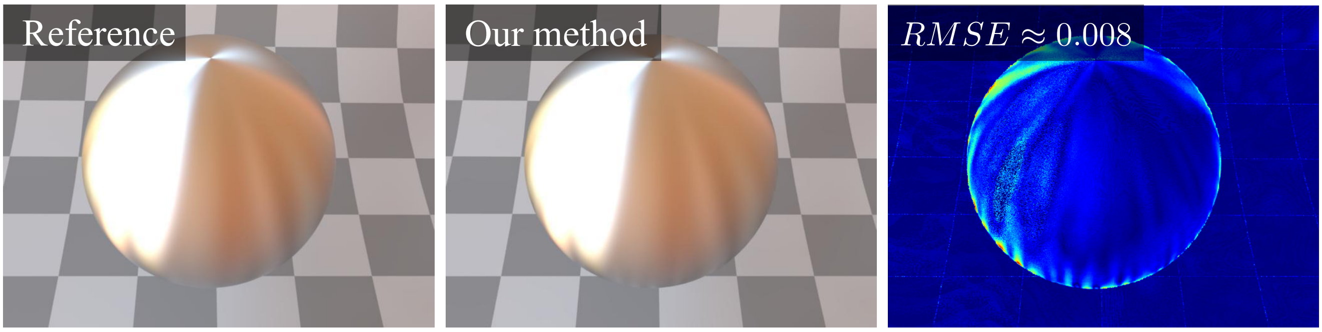

Fig. 10: Anisotropic sphere with anisotropic Ward BRDF ($\alpha_x = 0.1$ and $\alpha_y = 0.5$).

Fig. 11: Objects with different materials rendered with our method, except the pure specular dragon which is rendered with a path tracing technique.