

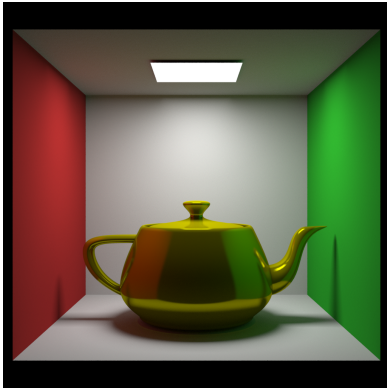
'The Compressorator' [1] was used to get MSE values. Our system configuration was: Inter Core i7-3770 (3.4 Ghz), 16 GB mem, GTX680 (2 GB видеопамяти) win7 64 bit. Images were rendered at 1024x1024 pixels. We compared further render systems:

1. Mental Ray (supplied with 3ds Max 2014)
2. IRay (supplied with 3ds Max 2014)
3. VRay RT 3.0
4. VRay 3.0
5. Corona Alpha v7
6. Octane 2.0
7. Hydra v1.9d

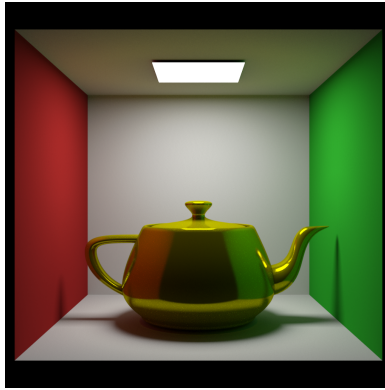
## **1. Teapot Cornell Box**

Simple geometry, but mostly all of GI effects are presented.

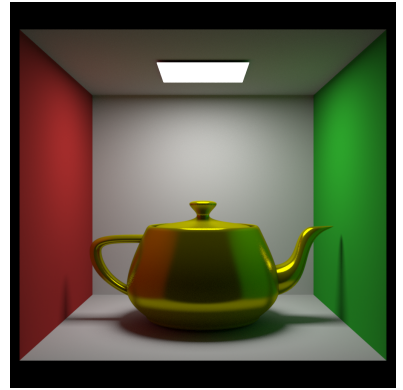
### **1.1. Path Tracing, no Caustics**



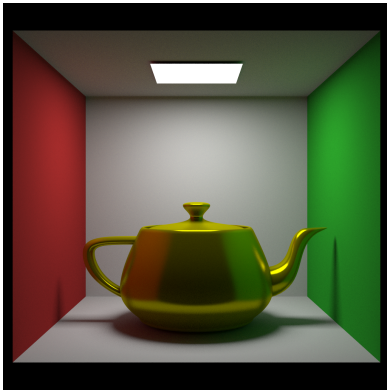
Mental Ray\*\*, 400 sec.  
MSE = 2.5



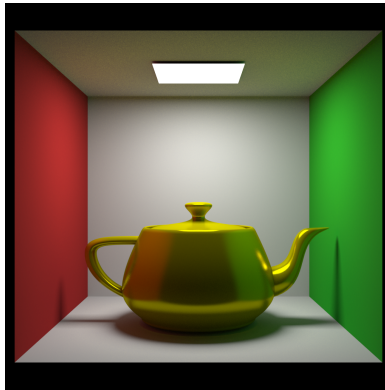
IRay\*, 360 sec.  
MSE = 2.3



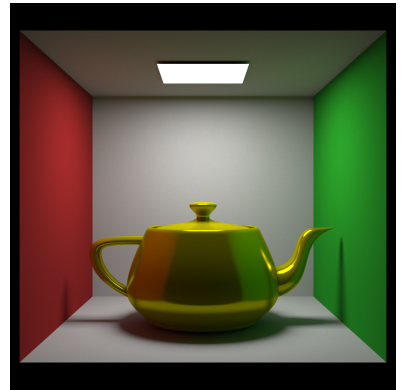
VRay RT3, 50 sec.  
MSE = 2.5



VRay3, 600 sec  
MSE = 2.5

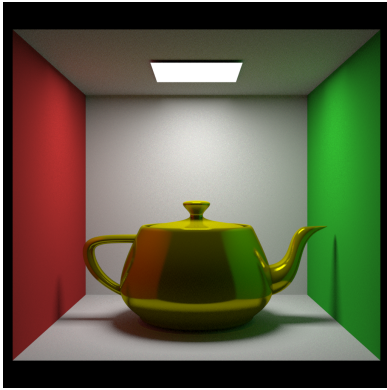


Corona\*, 300 sec  
MSE = 2.5

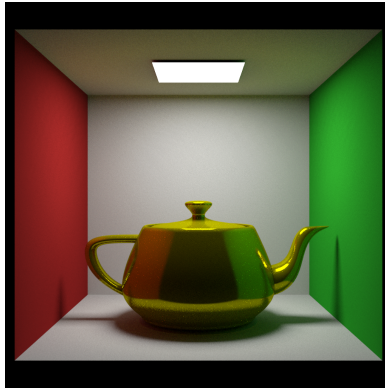


Hydra, 60 sec.  
MSE = 2.5

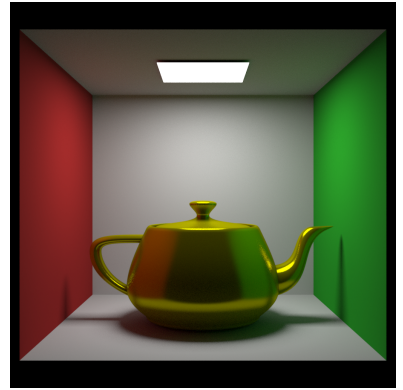
Рис. 1. 'Cornell Box'. 1024x1024. MSE  $\approx$  2.5.



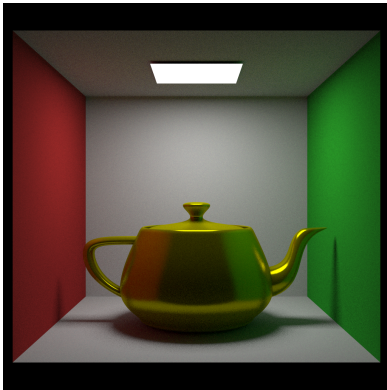
Mental Ray, 40 sec.  
MSE = 11.34



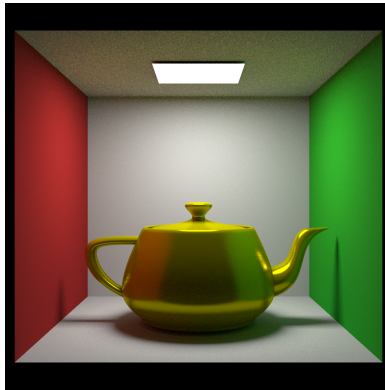
IRay\*, 40 sec.  
MSE = 5.9



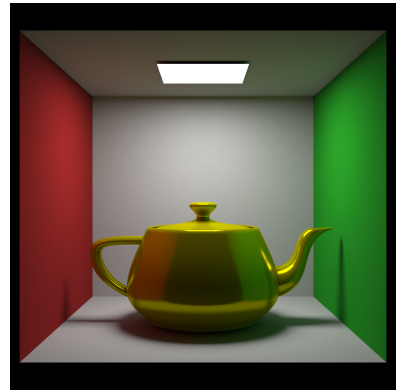
VRay RT3, 40 sec.  
MSE = 3.12



VRay3, 40 sec  
MSE = 6.6



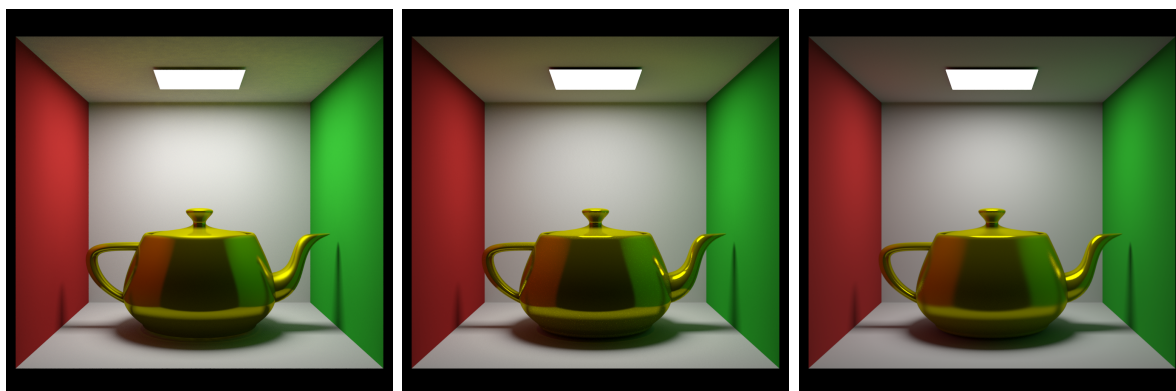
Corona\*, 40 sec  
MSE = 7.5



Hydra, 40 sec.  
MSE = 3.7

Рис. 2. 'Cornell Box' 1024x1024. (render time 40 sec).

## 1.2. Path Tracing + Caustics (by different methods)



Mental Ray, 1150 sec.  
MSE = 2.5

IRay, 360 sec.  
MSE = 2.3

VRay RT3\*, 240 sec.  
MSE = 2.5

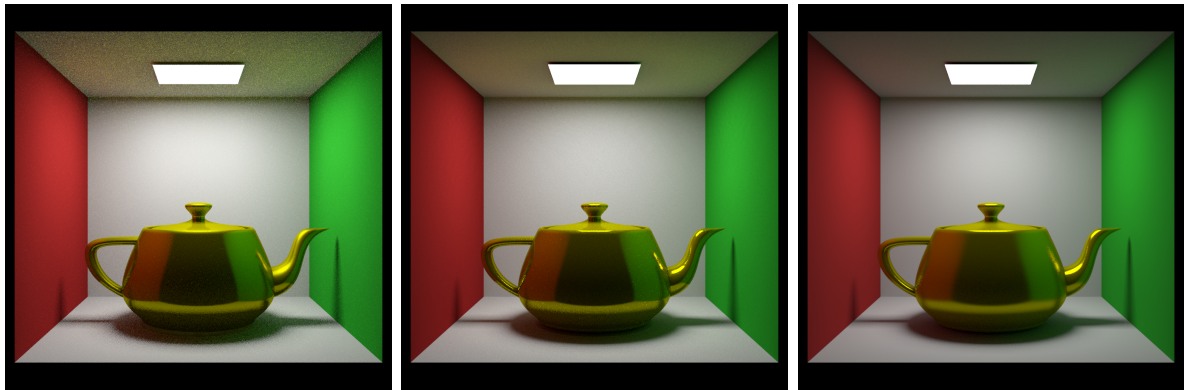


VRay3, 900 sec  
MSE = 2.5

Corona (VCM), 180 sec  
MSE = 2.5

Hydra, 120 sec.  
MSE = 2.5

Рис. 3. 'Cornell Box' with caustics. 1024x1024. MSE  $\approx$  2.5.



Mental Ray, 40 sec.  
MSE = 10.8

IRay, 40 sec.  
MSE = 6.0

VRay RT3\*, 40 sec.  
MSE = 10.6\*



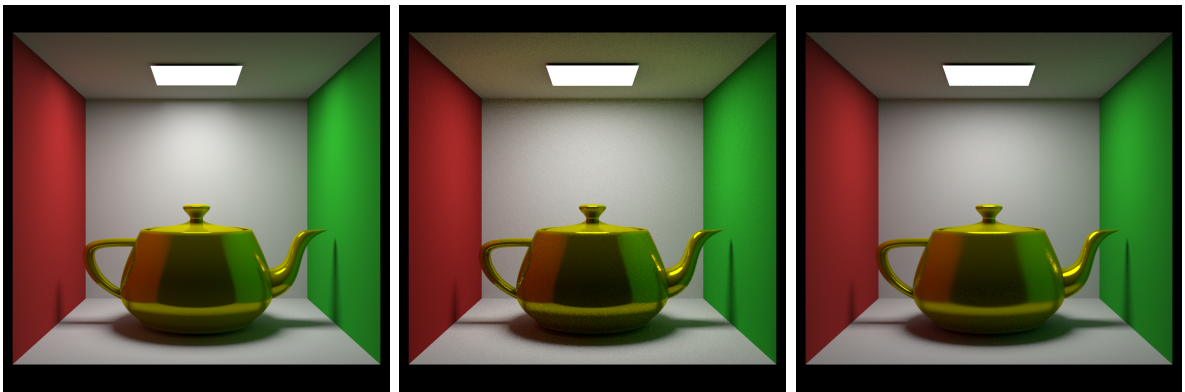
VRay3, 40 sec  
MSE = 17.3

Corona (VCM), 40 sec  
MSE = 6.7

Hydra, 40 sec.  
MSE = 4.3

Рис. 4. 'Cornell Box' with caustics (40 sec).

### 1.3. Irradiance Cache, no caustics



Mental Ray, 90 sec.  
MSE = 3.9

IRay \*, \*\*\*, 20 sec.  
MSE = 8.0

VRay RT3\*\*\*, 20 sec.  
MSE = 4.8



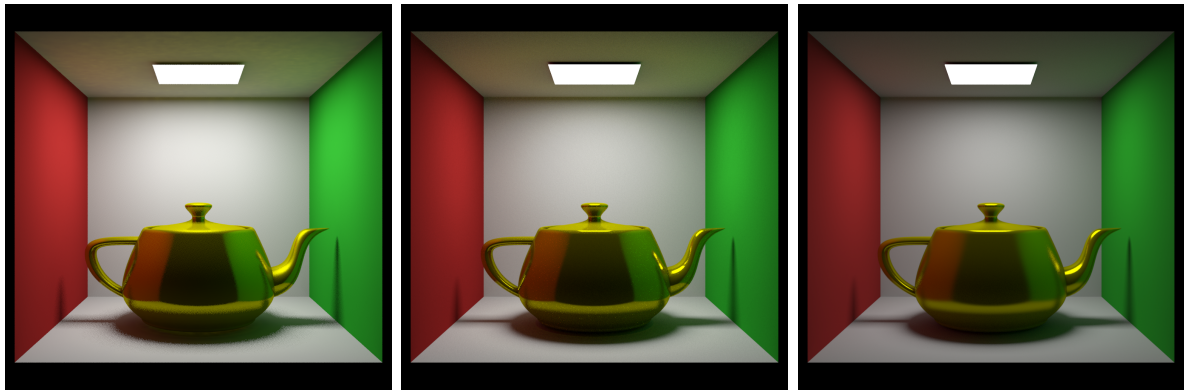
VRay3, 73 sec  
MSE = 8.5

Corona\*, 20 sec  
MSE = 9.22

Hydra, 20 sec.  
MSE = 3.0

Рис. 5. 'Cornell Box', Irradiance Cache. No caustics. 1024x1024. MSE  $\approx$  4.0.

### 1.4. Irradiance Cache + caustics



Mental Ray, 90 sec.  
MSE = 6.3

IRay <sup>\*\*\*</sup>, 100 sec.  
MSE = 3.9

VRay RT3<sup>\*\*\*</sup>, 100 sec.  
MSE = 10.5\*



VRay3, 240 sec  
MSE = 5.8

Corona (VCM), 100 sec  
MSE = 3.9

Hydra, 100 sec.  
MSE = 3.4

Рис. 6. 'Cornell Box', Irradiance Cache. No caustics. 1024x1024. ( $\approx$  100 sec).

## 2. Outdoor

Simple GI, but complex geometry. Test ray tracing speed.



Mental Ray, 360 sec.  
MSE = 3.3



IRay\*, 120 sec.  
MSE = 2.5



VRay RT3, 60 sec.  
MSE = 2.5



VRay3, 240 sec  
MSE = 5.5



Corona, 60 sec  
MSE = 2.7



Hydra, 60 sec.  
MSE = 2.7

Рис. 7. Outdoor. 1024x1024. MSE  $\approx$  2.5.



Mental Ray, 145 sec.  
MSE = 7.7



IRay, 120 sec.  
MSE = 2.52



VRay RT3, 120 sec.  
MSE = 1.76



VRay3, 127 sec  
MSE = 7.0



Corona, 120 sec  
MSE = 2.3



Hydra, 120 sec.  
MSE = 2.0

Рис. 8. Outdoor. 1024x1024. ( $\approx$  2 min).

### 3. Crytek Sponza

Strong indirect illumination.

#### 3.1. Irradiance Cache + Final Gathering



Mental Ray, 960 sec.  
MSE = 3.3



IRay, 1400 sec\*  
MSE = 3.8



VRay RT3, 600 sec\*  
MSE = 3.8



VRay3, 180 sec  
MSE = 3.8



Corona, 600 sec\*\*  
MSE = 3.8

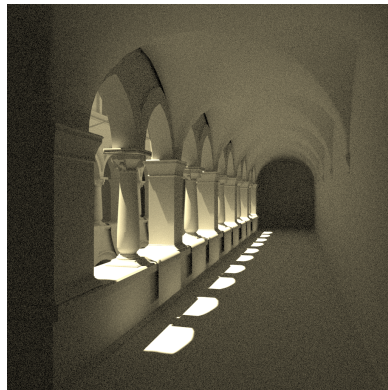


Hydra, 60 sec.  
MSE = 3.8

Рис. 9. 'Crytek Sponza'. 1024x1024. MSE  $\approx$  4.0.



Mental Ray, 60 sec.  
MSE = 16.4



IRay, 60 sec\*  
MSE = 27.7



VRay RT3, 60 sec\*  
MSE = 21.6



VRay3, 60 sec  
MSE = 7.3



Corona, 60 sec\*\*  
MSE = 12.6



Hydra, 60 sec.  
MSE = 3.78

Рис. 10. 'Cryptek Sponza'. 1024x1024. ( $\approx$  60 секунд).

## 4. Conference room

Many lights, strong indirect illumination.

### 4.1. Path Tracing



Mental Ray, 3000 sec.  
MSE = 4.8



IRay, 600 sec  
MSE = 4.8



VRay RT3, 600 sec  
MSE = 5.0



VRay3, 1000 sec  
MSE = 4.8



Corona, 180 sec  
MSE = 5.0



Hydra, 100 sec.  
MSE = 4.8

Рис. 11. Conference room. 1024x1024. MSE  $\approx$  5.0.



Mental Ray, 90 sec.  
MSE = 24.2



IRay, 60 sec  
MSE = 16.0



V-Ray RT3, 60 sec  
MSE = 18.0



V-Ray3, 60 sec  
MSE = 30.0



Corona, 60 sec  
MSE = 9.52



Hydra, 60 sec.  
MSE = 6.3

Рис. 12. Conference room. 1024x1024. Render time  $\approx$  60 sec.

## 4.2. Irradiance Cache



Mental Ray, 540 sec.  
MSE = 7.6



IRay, 600 sec\*  
MSE = 4.8



VRay RT3, 600 sec\*  
MSE = 4.5



VRay3, 300 sec  
MSE = 6.3



Corona, 180 sec\*\*  
MSE = 5.0



Hydra, 60 sec.  
MSE = 4.5

Рис. 13. Conference Room (Irradiance Cache). 1024x1024. MSE  $\approx$  5.0.



Mental Ray, 120 sec.  
MSE = 18.9



IRay, 60 sec\*  
MSE = 16.0



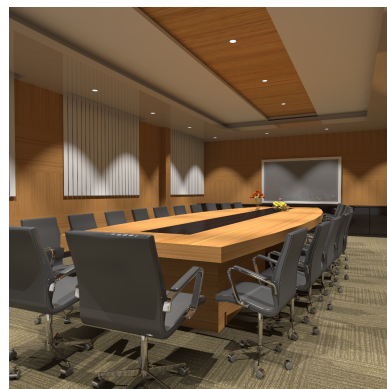
VRay RT3, 60 sec\*  
MSE = 18.0



VRay3, 120 sec  
MSE = 8.5



Corona, 60 sec\*\*  
MSE = 15.1



Hydra, 60 sec.  
MSE = 4.5

Рис. 14. Conference Room (Irradiance Cache). 1024x1024. Render time  $\approx$  60 sec.

## 5. Sky Portals

Complex primary lighting with a lot of sky portals.



Mental Ray, 330 sec.

MSE = 5.5

IRay, 480 sec

MSE = 5.3

VRay RT3, 900 sec

MSE = 5.0



VRay3, 240 sec

MSE = 5.8

Corona, 80 sec.

MSE = 4.8

Hydra, 120 sec.

MSE = 5.0

Рис. 15. Sky-Portals. 1024x1024. MSE  $\approx$  5.0.



Mental Ray, 110 sec.  
MSE = 11.6



IRay, 120 sec  
MSE = 11.1



VRay RT3, 120 sec  
MSE = 15.1



VRay3, 180 sec  
MSE = 7.3



Corona, 120 sec.  
MSE = 4.0



Hydra, 120 sec.  
MSE = 5.0

Рис. 16. Sky-Portal. 1024x1024. Render time  $\approx$  2 min.

## 6. MLT-like (hard lighting)

Narrow surface section strongly lit by a sun. Hard-sampling case.



Mental Ray, 900 sec.  
MSE = 15.1



IRay, 3600 sec  
MSE = 5.0



VRay RT3, 4800 sec  
MSE = 4.8



VRay3, 1000 sec  
MSE = 5.5



Corona, 600 sec.  
MSE = 5.0



Hydra, 720 sec.  
MSE = 5.0

Рис. 17. MLT-like. 1024x1024. MSE  $\approx$  5.0.



Mental Ray, 300 sec.  
MSE = 25.0



IRay, 300 sec  
MSE = 24.2



VRay RT3, 300 sec  
MSE = 26.0



VRay3, 480 sec  
MSE = 8.3



Corona, 300 sec  
MSE = 8.6



Hydra, 300 sec  
MSE = 8.3

Рис. 18. MLT-like. 1024x1024. Render time  $\approx$  5 min.

## 7. Water Caustics

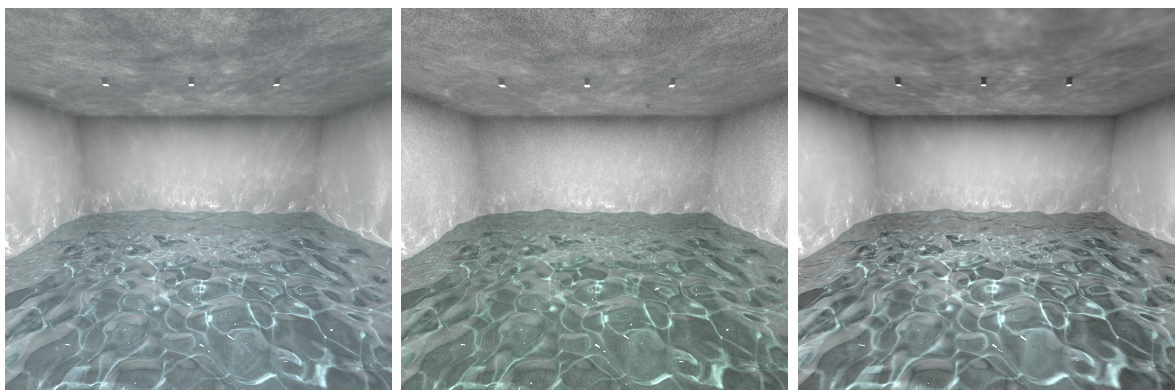
Hard sampling, Specular Diffuse Specular light paths).



Mental Ray, 180 sec.  
MSE = 8.0

IRay, 60 sec  
MSE = 11.6

VRay RT3, 60 sec  
MSE = 100.0



VRay3, 120 sec  
MSE = 7.8

Corona, 60 sec  
MSE = 10.5

Hydra, 60 sec  
MSE = 5.6

Рис. 19. Water Caustics. 1024x1024. Render time  $\approx$  1 min.

## 8. Compare with Octane

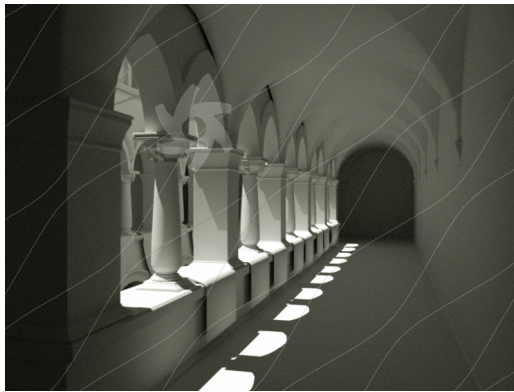
Used 640x480 due to demo limitations. Scaled performance.



Cornell Box (PMC), 60 sec (130 sec)  
MSE = 5.3



Outdoor, 120 sec (260 sec)  
MSE = 2.8



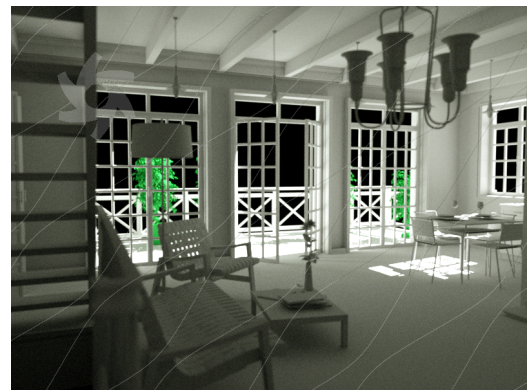
Cry Sponza, 600 sec (1300 sec)  
MSE = 5.3



Conference, 600 sec (1300 sec)  
MSE = 5.45



Sky Portal, 300 sec (650 sec)  
MSE = 4.4



MLT Like, 600 sec (1300 sec)  
MSE = 6.6

Рис. 20. Images rendered with Octane. MSE  $\approx$  4.0. 800x600. We show scaled to 1024x1024 time in braces.



Рис. 21. Caustics rendered with Octane PMC.  $MSE \approx 15.0$ . We show scaled to  $1024 \times 1024$  time in braces.

## 9. Performance comparison

Performance Index:

$$P_I = \frac{1}{MSE^2 * t} \quad (1)$$

Relative Performance Index:

$$P_{I(Rel)} = 100 * \frac{P_I}{MAX(P_{I(VRay)}, P_{I(MentalRay)}, P_{I(IRay)}, \dots)} \quad (2)$$

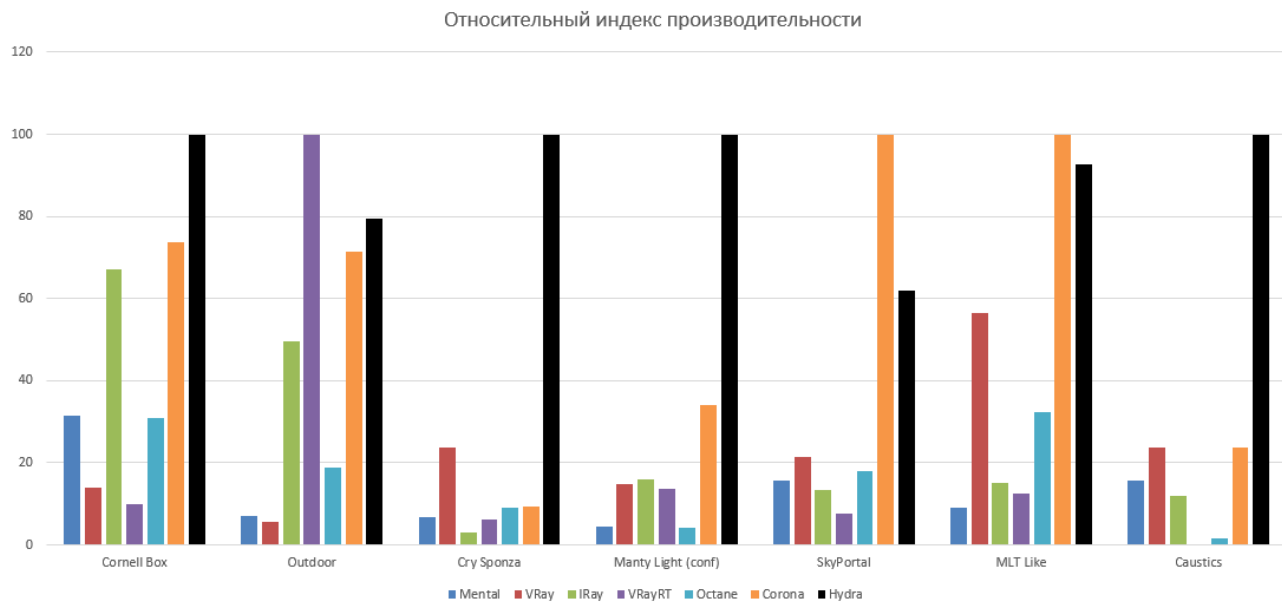


Рис. 22. Relative Performance Index (different scenes).



Рис. 23. Relative Performance Index (average by all scenes).

## Литература

1. AMD. The Compressorator. 2014. URL: <http://developer.amd.com/tools-and-sdks/archive/legacy-cpu-gpu-tools/the-compressorator/>.
2. Georgiev Iliyan, Krivánek Jaroslav, Slusallek Philipp. Bidirectional light transport with vertex merging // SIGGRAPH Asia 2011 Sketches. SA '11. New York, NY, USA: ACM, 2011. P. 27:1–27:2. URL: <http://doi.acm.org/10.1145/2077378.2077412>.