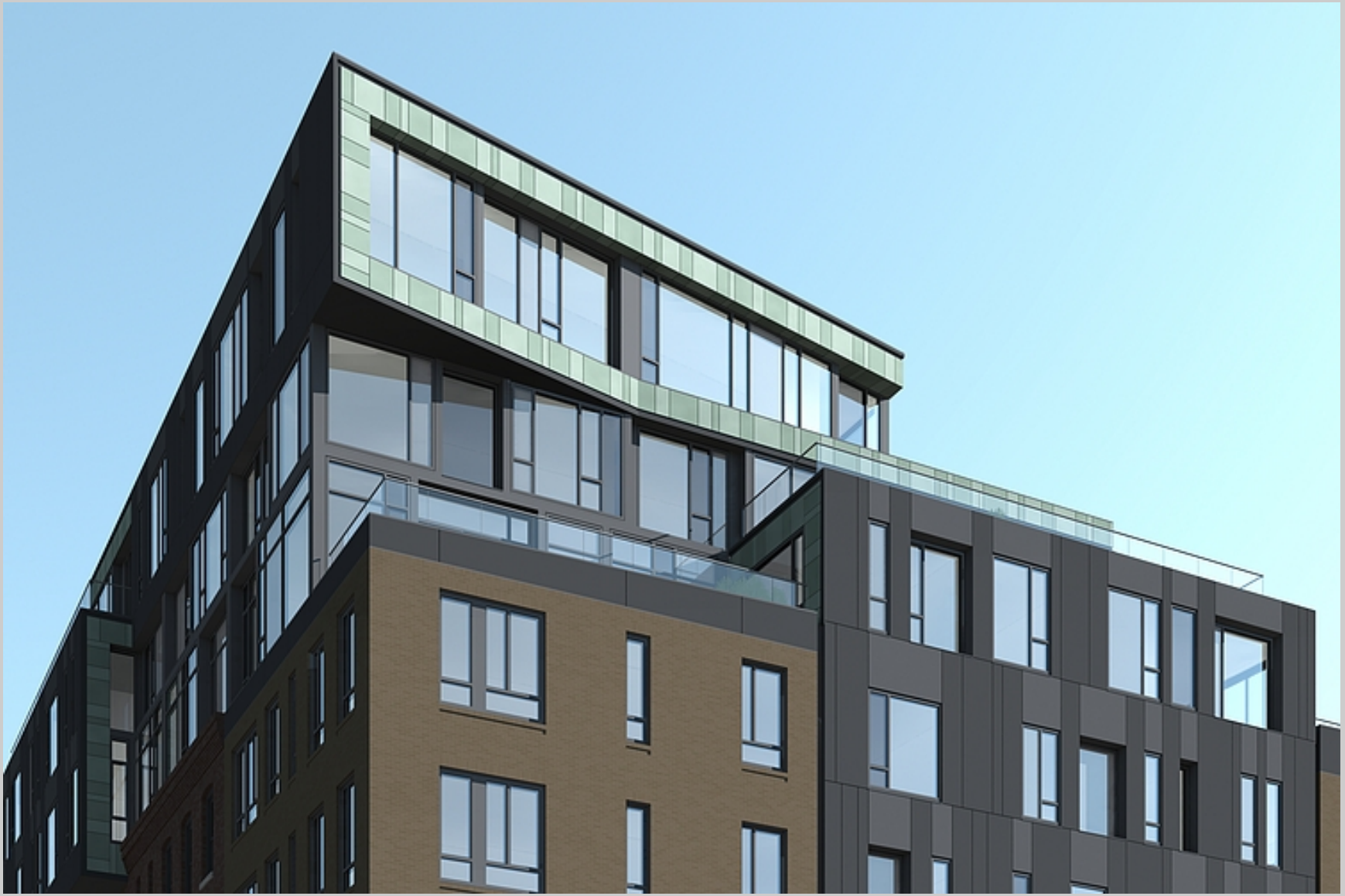
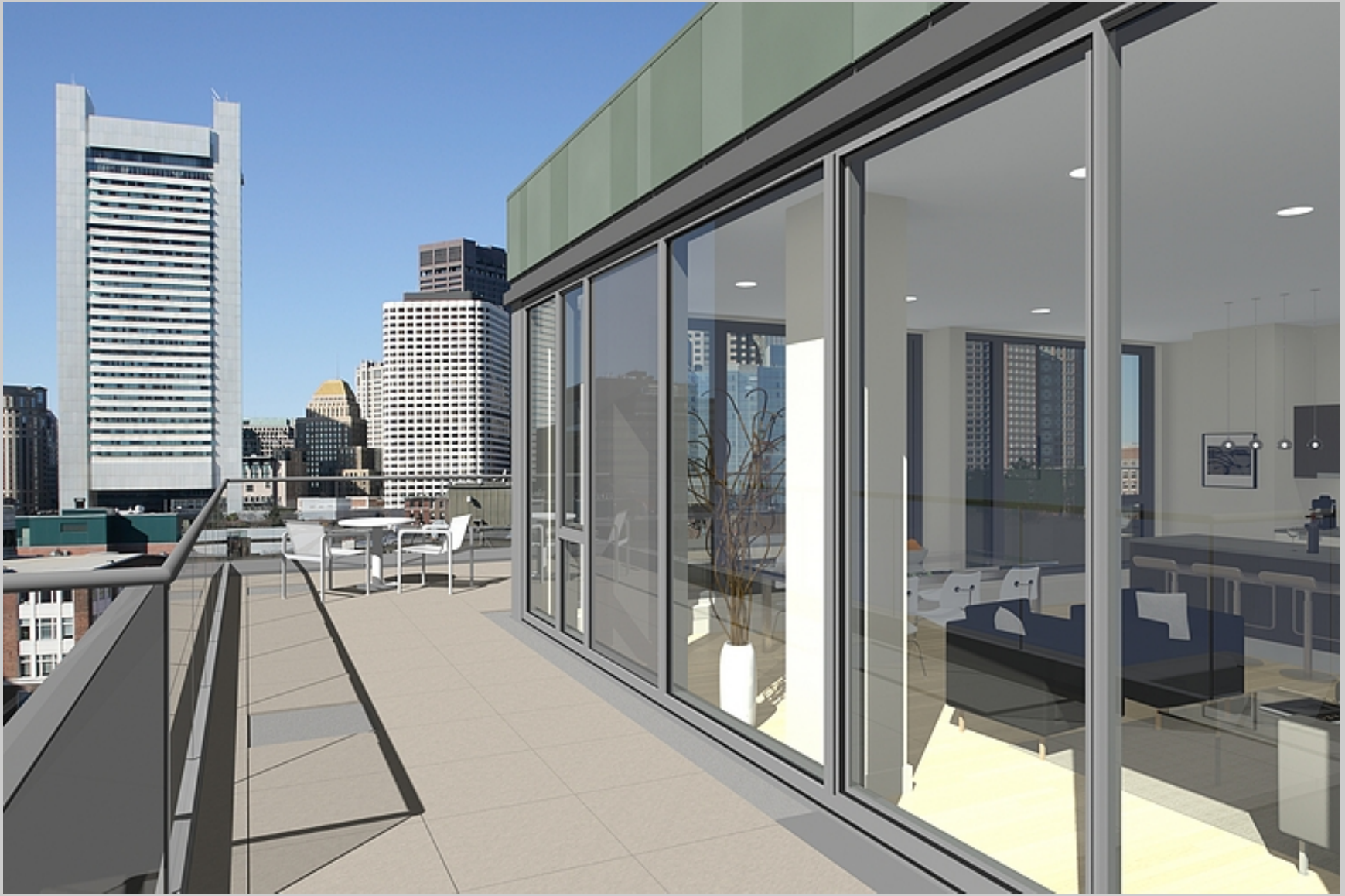
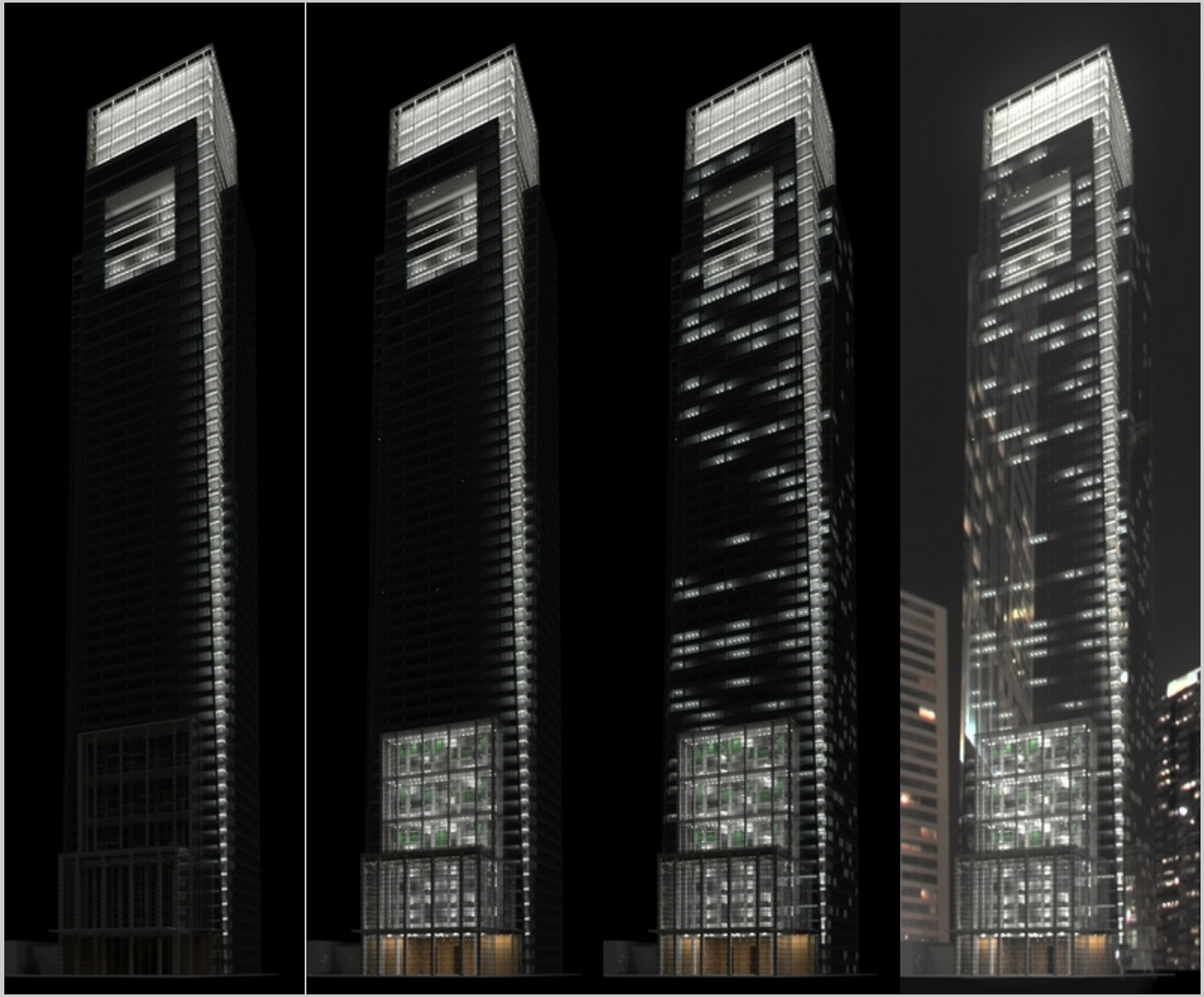
BUILDING BETTER GLASS MATERIALS IN RADIANCE

Using Optics 5 and the *glaze* script in Radiance

Developing suitable material descriptions for glazing systems that include coatings, frits, interlayers and multi-layer makeups is a recurring topic for Radiance users. Transmittance, differing front and back side reflectances and angular dependencies are key performance characteristics necessary for a suitable material description. The Optics 5 application developed at LBNL is designed to evaluate a wide range of properties in complex glazing makeups. The application utilizes the International Glazing Database (IGDB) which is comprised of measured spectral optical data and thermal data for over 2800 glazing products. Utilizing data output from Optics 5, it is possible to build a database that can be processed by the Radiance glaze command to produce suitable Radiance material descriptions. This presentation will demonstrate the work-flow from Optics 5 to Radiance for generating a custom database that can then be processed by the Radiance glaze command as well as examples of resulting material descriptions.







What is the problem?

Radiance glass material type

- Optimized for single layer uncoated glazing
- Same reflectance front and back
- Transmittance must be translated to the Radiance term for transmissivity

Architectural glazing systems

- Typically multiple layer insulating units
- Selected surface will very likely have some kind of coating applied
- Makeups will result in varying front and backside reflectances
- Addition of frits and laminates with interlayers will further complicate the makeup

The radiance *glaze* script can be used to generate suitable material descriptions for this type of system.

Performance data is readily available!

Performance data/specs from manufacturers

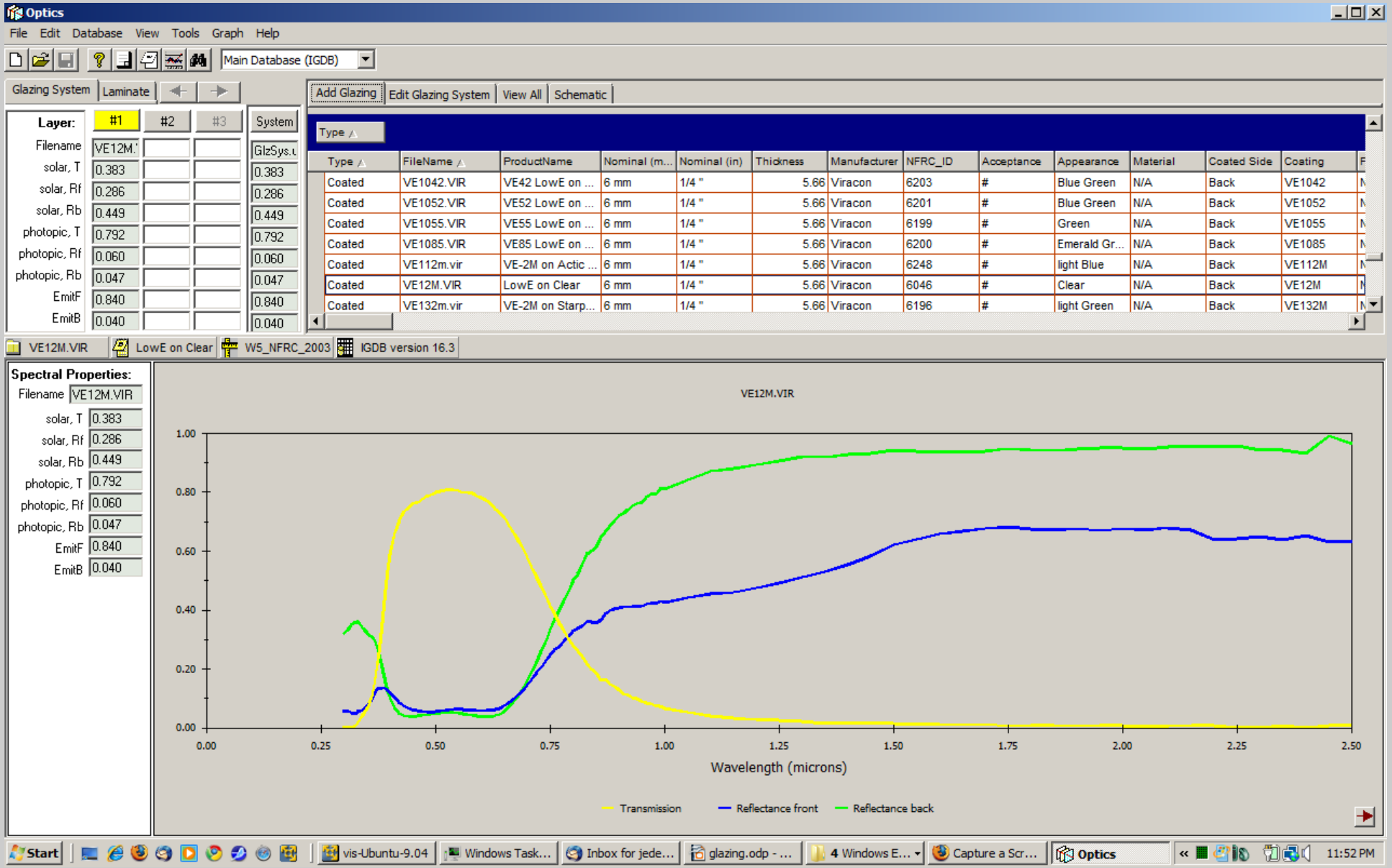
Applications for modeling/evaluating glazing system properties

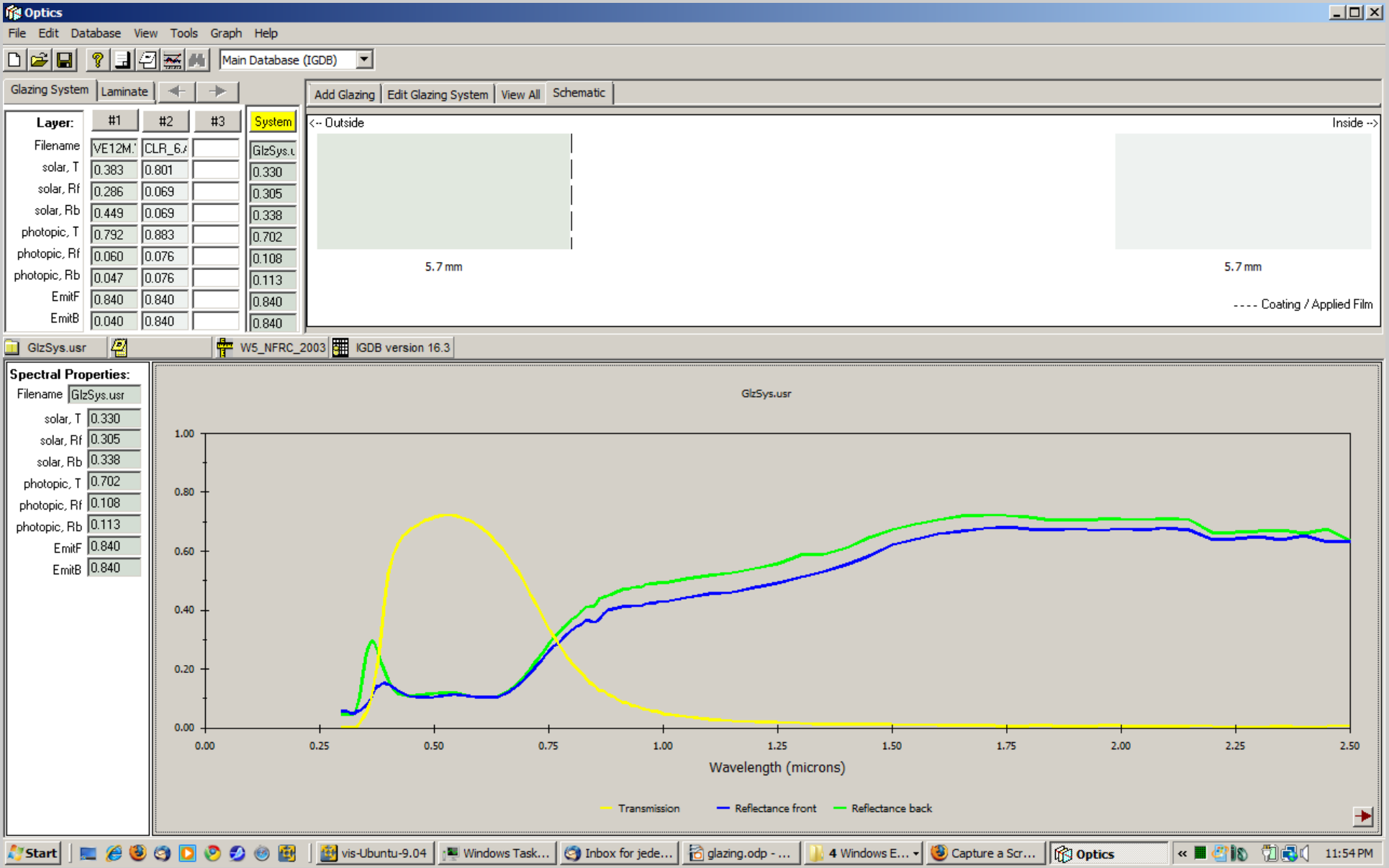
- Window 5/6
- Optics 5

Optics 5

- IGDB – over 2800 glazing products
- Includes spectral optical data and thermal data
- Product data can be combined to build composites systems
- Data can be exported in radiance format

Getting data out of Optics 5...




Optics
File Edit Database View Tools Graph Help
Main Database (IGDB)
Glazing System
Laminate
Layer:
#1
#2
#3
System
Filename
VE12M.
CLR_6.
GlzSys.
solar, T
0.383
0.801
0.330
solar, Rf
0.286
0.069
0.305
solar, Rb
0.449
0.069
0.338
photopic, T
0.792
0.883
0.702
photopic, Rf
0.060
0.076
0.108
photopic, Rb
0.047
0.076
0.113
EmitF
0.840
0.840
0.840
EmitB
0.040
0.840
0.840
Add Glazing
Edit Glazing System
View All
Schematic
<-- Outside
Inside -->
5.7 mm
5.7 mm
---- Coating / Applied Film
GlzSys.usr
W5_NFRC_2003
IGDB version 16.3
Spectral Properties:
Filename
GlzSys.usr
solar, T
0.330
solar, Rf
0.305
solar, Rb
0.338
photopic, T
0.702
photopic, Rf
0.108
photopic, Rb
0.113
EmitF
0.840
EmitB
0.840
GlzSys.usr
1.00
0.80
0.60
0.40
0.20
0.00
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
Wavelength (microns)
Transmission
Reflectance front
Reflectance back
Start
vis-Ubuntu-9.04
Windows Task...
Inbox for jede...
glazing.odp - ...
4 Windows E...
Capture a Scr...
Optics
11:54 PM

Example output from Optics 5

```
# FileName= STRPH_6.PPG
# Product Name= Starphire
# NFRC ID= 5004
# Manufacturer Name= PPG Industries
# Glazing Type= Monolithic
# Coated Side= Neither
# Transmittance= 0.911
# Front Reflectance= 0.082
# Back Reflectance= 0.083
# Thickness(mm)= 5.664
# Appearance= Ultra Clear

void  glass       ppg-strph-6_glass
0
0
3     0.988     0.993     0.990

void  BRTDfunc    ppg-strph-6_front
10
     0.081     0.082     0.085
     0.908     0.912     0.909
     0 0 0
     .
0
9 0 0 0 0 0 0 0 0 0

void  BRTDfunc    ppg-strph-6_back
10
     0.082     0.083     0.086
     0.908     0.912     0.909
     0 0 0
     .
0
9 0 0 0 0 0 0 0 0 0
```

```
# FileName= VE12M.VIR
# Product Name= LowE on Clear
# NFRC ID= 6046
# Manufacturer Name= Viracon
# Glazing Type= Coated
# Coated Side= Back
# Transmittance= 0.790
# Front Reflectance= 0.060
# Back Reflectance= 0.046
# Thickness(mm)= 5.660
# Appearance= Clear

void  glass       vir-ve12m_glass
0
0
3     0.824     0.880     0.810

void  BRTDfunc    vir-ve12m_front
10
     0.065     0.058     0.067
     0.756     0.808     0.744
     0 0 0
     .
0
9 0 0 0 0 0 0 0 0 0

void  BRTDfunc    vir-ve12m_back
10
     0.042     0.049     0.043
     0.756     0.808     0.744
     0 0 0
     .
0
9 0 0 0 0 0 0 0 0 0
```

Processing data to a format for Radiance...

Optics2glazedb – process radiance output from Optics 5 to format suitable for *glaze* script. Pass a set of files to the command, first must be for an uncoated glass that will server as the clear class for the set. This automates processing to the correct format!

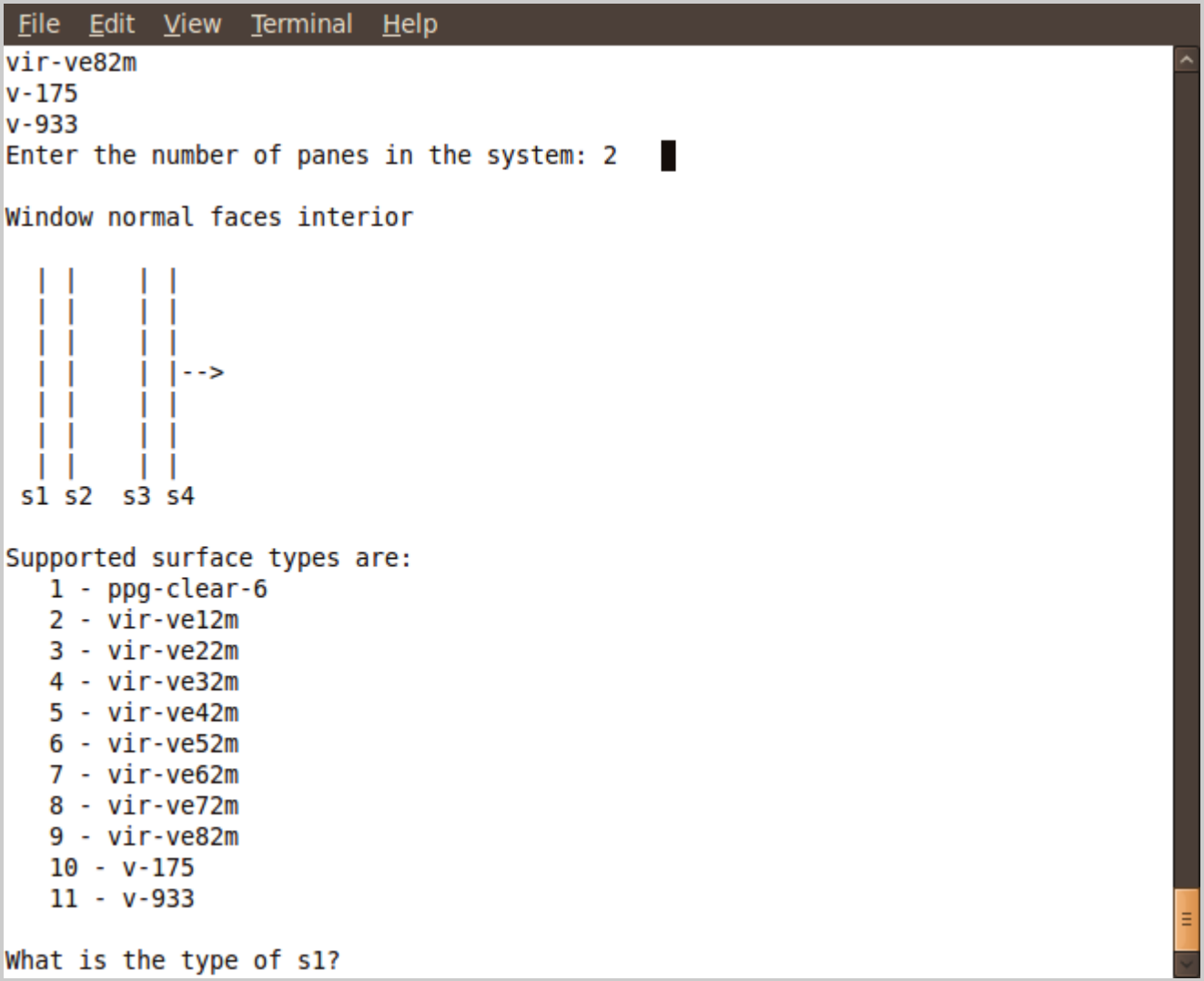
optics2glazedb ppg-clear-6.rad vir-ve12m.rad vir-ve22m.rad vir-ve32m.rad vir-ve42m.rad vir-ve52m.rad vir-ve62m.rad vir-ve62m.rad vir-ve72m.rad vir-ve82m.rad

Surface	Tr	Tg	Tb	Rcr	Rcg	Rcb	Rgr	Rgg	Rgb	Part
ppg-clear-6	0.86	0.896	0.882	0.081	0.086	0.089	0.081	0.086	0.088	0
vir-ve12m	0.756	0.808	0.744	0.042	0.049	0.043	0.065	0.058	0.067	0
vir-ve22m	0.584	0.715	0.627	0.027	0.041	0.032	0.054	0.056	0.059	0
vir-ve32m	0.381	0.395	0.388	0.016	0.02	0.017	0.05	0.049	0.054	0
vir-ve42m	0.502	0.458	0.39	0.022	0.023	0.016	0.053	0.052	0.054	0
vir-ve52m	0.41	0.536	0.59	0.017	0.028	0.028	0.049	0.05	0.056	0
vir-ve62m	0.586	0.709	0.644	0.03	0.043	0.036	0.058	0.059	0.066	0
vir-ve72m	0.436	0.673	0.671	0.026	0.04	0.038	0.049	0.053	0.062	0
vir-ve82m	0.5	0.648	0.505	0.022	0.036	0.024	0.052	0.055	0.056	0
v-175	0.21	0.21	0.21	0.59	0.59	0.59	0.33	0.33	0.33	1
v-933	0.09	0.09	0.09	0.21	0.21	0.21	0.15	0.15	0.15	1

NOTE: last two lines for frit data added by hand!

Building glazing materials *glaze...*

```
File  Edit  View  Terminal  Help
[jedev@vfs glazing]$ ./glaze -f viracon.frit.db
###
### WARNING: The first entry in the database file MUST be a correct description
for a CLEAR glass!
###

Adding glazing types from file viracon.frit.db :
ppg-clear-6
vir-ve12m
vir-ve22m
vir-ve32m
vir-ve42m
vir-ve52m
vir-ve62m
vir-ve72m
vir-ve82m
v-175
v-933
Enter the number of panes in the system:
```


File Edit View Terminal Help
vir-ve82m
v-175
v-933
Enter the number of panes in the system: 2
Window normal faces interior
		|-->
s1 s2 s3 s4
Supported surface types are:
1 - ppg-clear-6
2 - vir-ve12m
3 - vir-ve22m
4 - vir-ve32m
5 - vir-ve42m
6 - vir-ve52m
7 - vir-ve62m
8 - vir-ve72m
9 - vir-ve82m
10 - v-175
11 - v-933
What is the type of s1?

```
File  Edit  View  Terminal  Help
Enter the number of panes in the system: 2

Window normal faces interior

  | |    | |
  | |    | |
  | |    | |
  | |    | |-->
  | |    | |
  | |    | |
  | |    | |
 s1 s2  s3 s4

Supported surface types are:
   1 - ppg-clear-6
   2 - vir-ve12m
   3 - vir-ve22m
   4 - vir-ve32m
   5 - vir-ve42m
   6 - vir-ve52m
   7 - vir-ve62m
   8 - vir-ve72m
   9 - vir-ve82m
   10 - v-175
   11 - v-933

What is the type of s1? 1
What is the type of s2? 2
What is the type of s3? 1
What is the type of s4? 1
```

File Edit View Terminal Help

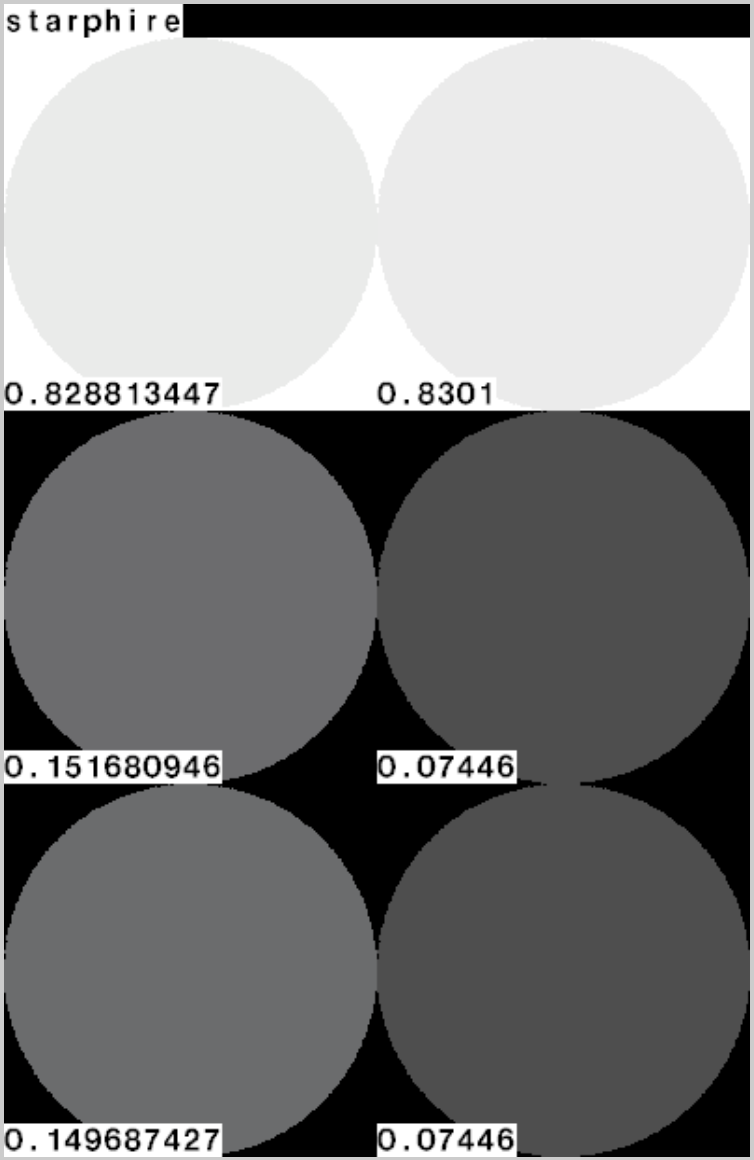
```
# $Revision: 2.7 $
# Loaded: viracon.frit.db
# Thu Oct 22 00:17:25 EDT 2009
# Material surface normal points to interior
# Number of panes in system: 2
# Exterior surface s1 type: ppg-clear-6
# Inner surface s2 type: vir-ve12m
# Inner surface s3 type: ppg-clear-6
# Interior surface s4 type: ppg-clear-6
# Exterior normal hemispherical reflectance: 0.113415413
# Interior normal hemispherical reflectance: 0.121470215
# Normal hemispherical transmittance: 0.699637633
#
void BRTDfunc glaze2_unnamed
10
if(Rdot,cr(fr(0.081),ft(0.86),fr(0.042)),cr(fr(0.065),ft(0.756),fr(0.081)))
if(Rdot,cr(fr(0.086),ft(0.896),fr(0.049)),cr(fr(0.058),ft(0.808),fr(0.086)))
if(Rdot,cr(fr(0.088),ft(0.882),fr(0.043)),cr(fr(0.067),ft(0.744),fr(0.089)))
ft(0.86)*ft(0.756)
ft(0.896)*ft(0.808)
ft(0.882)*ft(0.744)
        0 0 0
        glaze2.cal
0
9
        0 0 0
        0 0 0
        0 0 0

[jedev@vfs glazing]$
```

Example output from *glaze*

```
# Material surface normal points to interior
# Number of panes in system: 2
# Exterior surface s1 type: ppg-clear-6
# Inner surface s2 type: vir-ve12m
# Inner surface s3 type: ppg-clear-6
# Interior surface s4 type: ppg-clear-6
# Exterior normal hemispherical reflectance: 0.113415413
# Interior normal hemispherical reflectance: 0.121470215
# Normal hemispherical transmittance: 0.699637633
#
void BRTDfunc ve12m
10
if(Rdot,cr(fr(0.081),ft(0.86),fr(0.042)),cr(fr(0.065),ft(0.756),fr(0.081)))
if(Rdot,cr(fr(0.086),ft(0.896),fr(0.049)),cr(fr(0.058),ft(0.808),fr(0.086)))
if(Rdot,cr(fr(0.088),ft(0.882),fr(0.043)),cr(fr(0.067),ft(0.744),fr(0.089)))
ft(0.86)*ft(0.756)
ft(0.896)*ft(0.808)
ft(0.882)*ft(0.744)
0 0 0
glaze2.cal
0
9
0 0 0
0 0 0
0 0 0
```

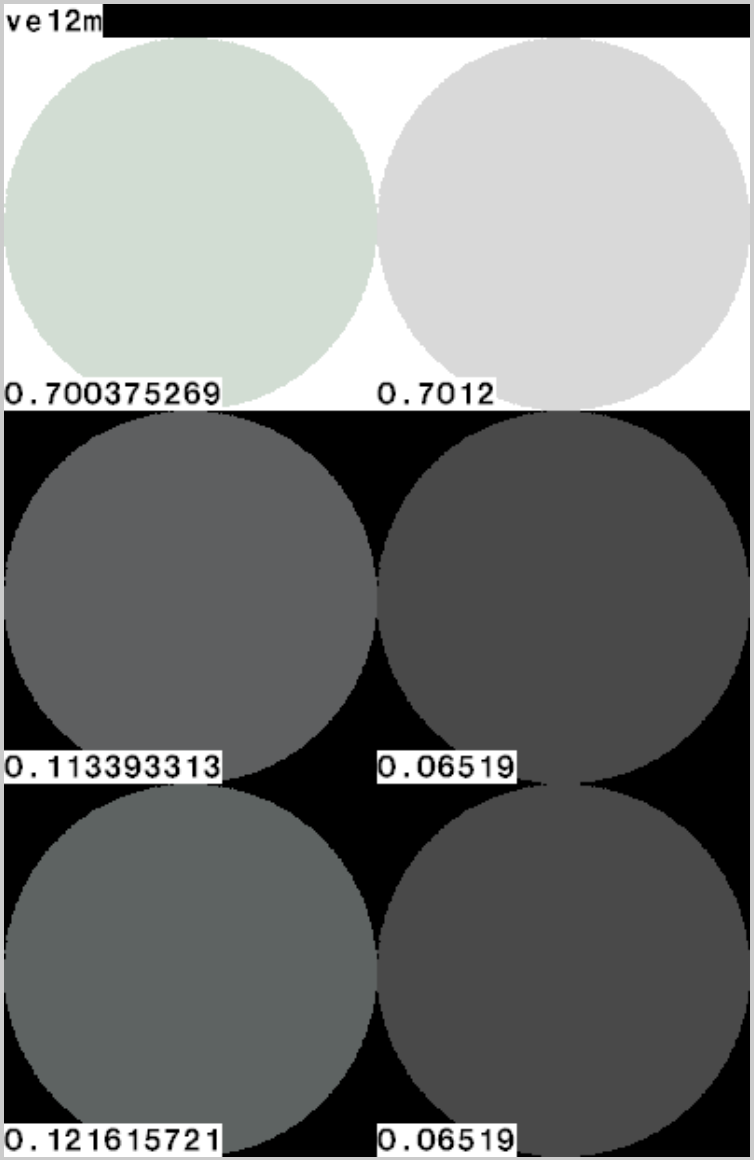
```
# Material surface normal points to interior
# Number of panes in system: 2
# Exterior surface s1 type: ppg-clear-6
# Inner surface s2 type: vir-ve12m
# Inner surface s3 type: v-175
# s3 coating coverage: .5
# Interior surface s4 type: ppg-clear-6
# Exterior normal hemispherical reflectance: 0.271044887
# Interior normal hemispherical reflectance: 0.221431686
# Normal hemispherical transmittance: 0.432775117
#
void BRTDfunc ve12m_v175
10
if(Rdot,cr(1*rclr,0.5*1*tclr,fr(0.042)),cr(fr(0.065),ft(0.756),0.5*rclr))
if(Rdot,cr(1*rclr,0.5*1*tclr,fr(0.049)),cr(fr(0.058),ft(0.808),0.5*rclr))
if(Rdot,cr(1*rclr,0.5*1*tclr,fr(0.043)),cr(fr(0.067),ft(0.744),0.5*rclr))
0.5*1*ft(0.756)*tclr
0.5*1*ft(0.808)*tclr
0.5*1*ft(0.744)*tclr
0 0 0
glaze2.cal
0
9
0.1245
0.122
0.121
0.16860312
0.19259488
0.16329312
0.07938
0.08484
0.07812
```

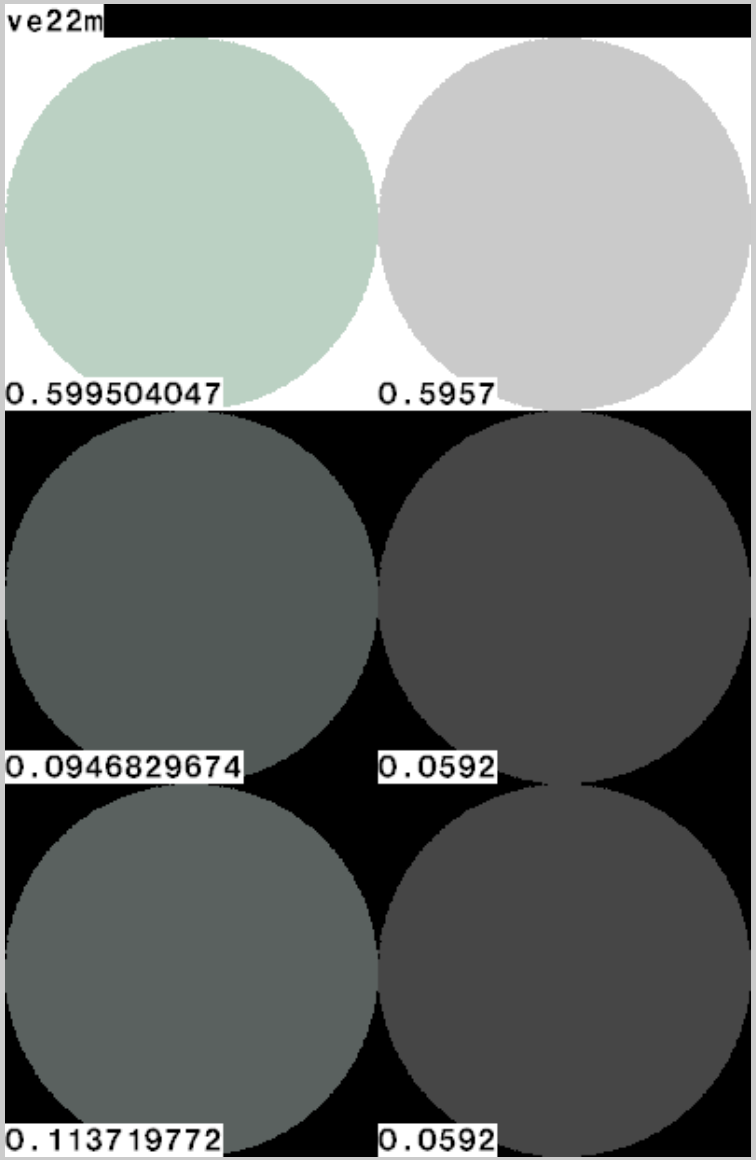
Comparing glass to *glaze* generated materials

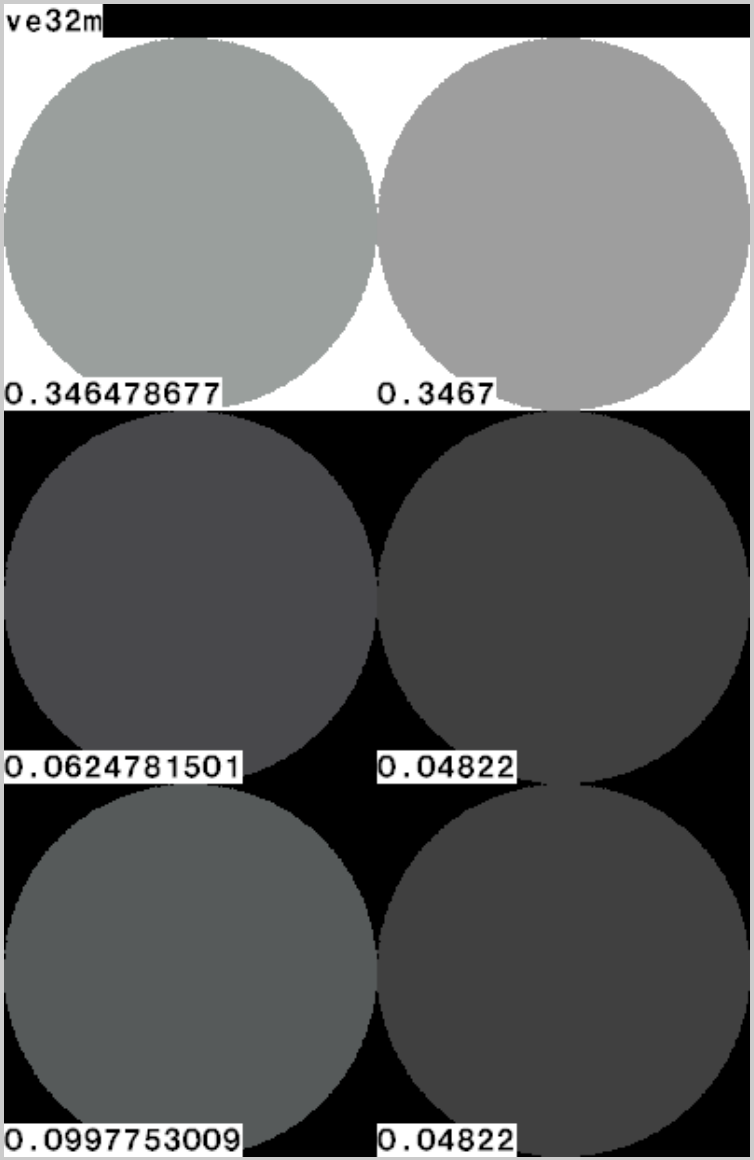


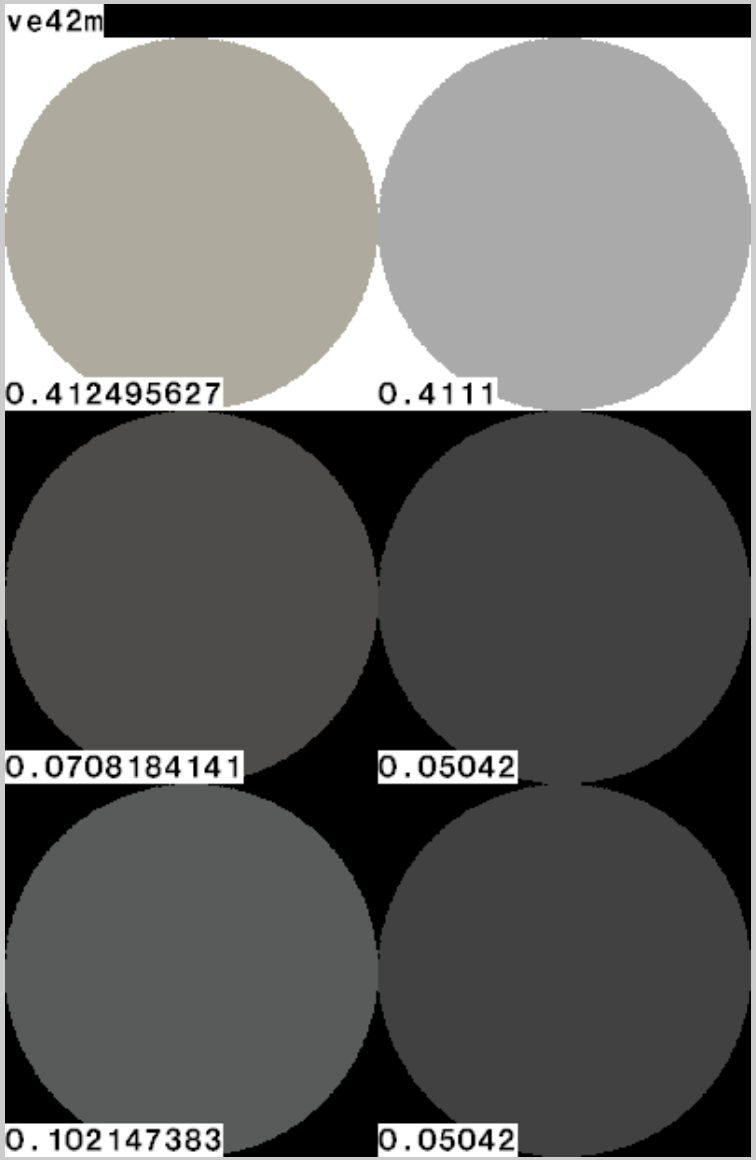
Visual/value checking

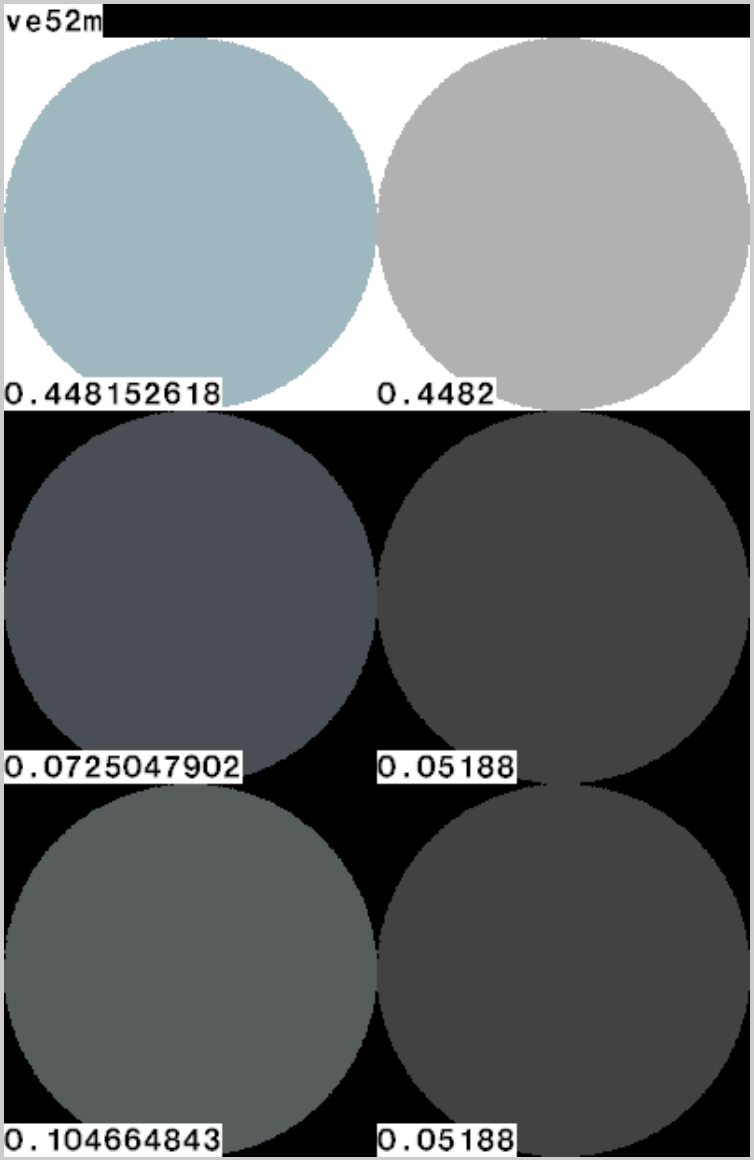
- Left side shows results from glaze generated material
- Right side shows results for glass material using the same transmittance
- Top shows transmittance
- Middle shows exterior reflectance
- Bottom shows interior reflectance

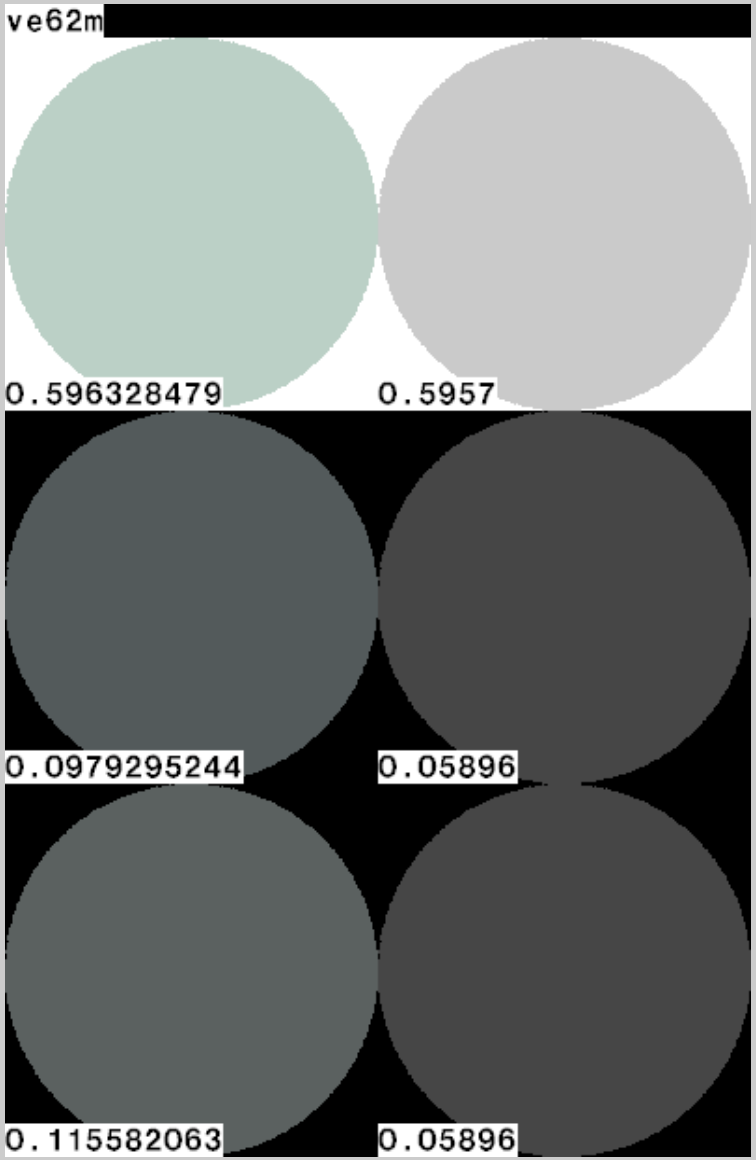

ve12m
0.700375269
0.7012
0.113393313
0.06519
0.121615721
0.06519

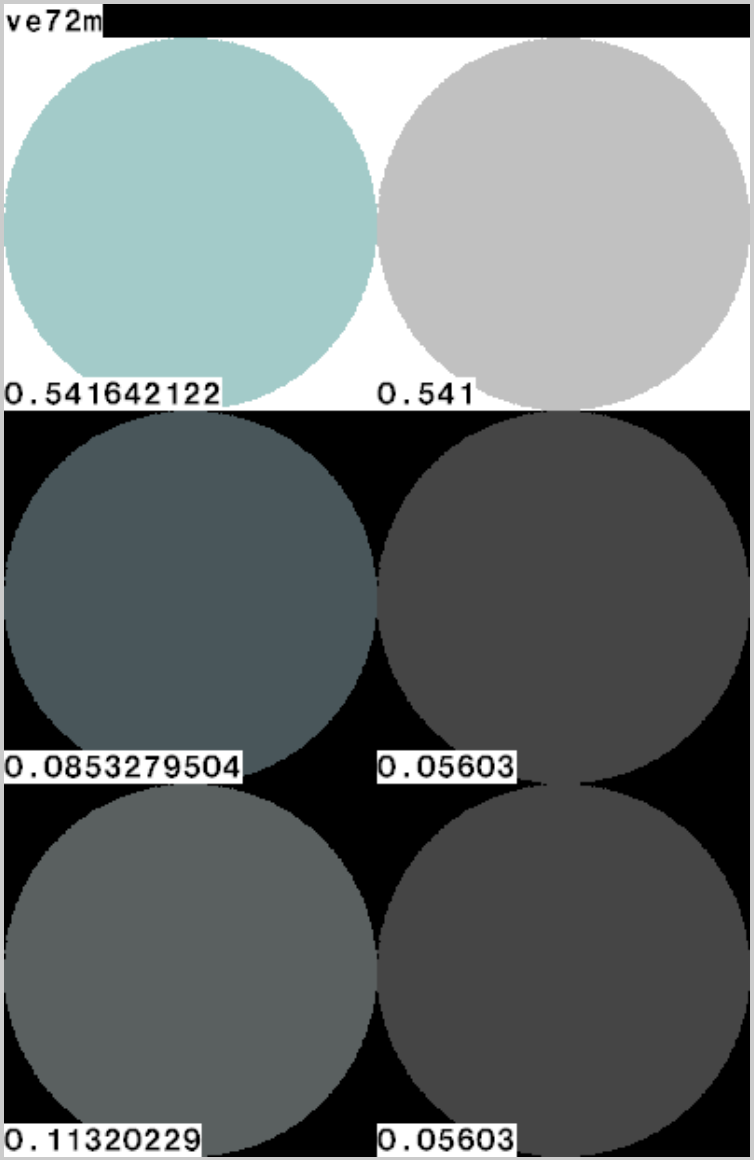

ve22m
0.599504047
0.5957
0.0946829674
0.0592
0.113719772
0.0592

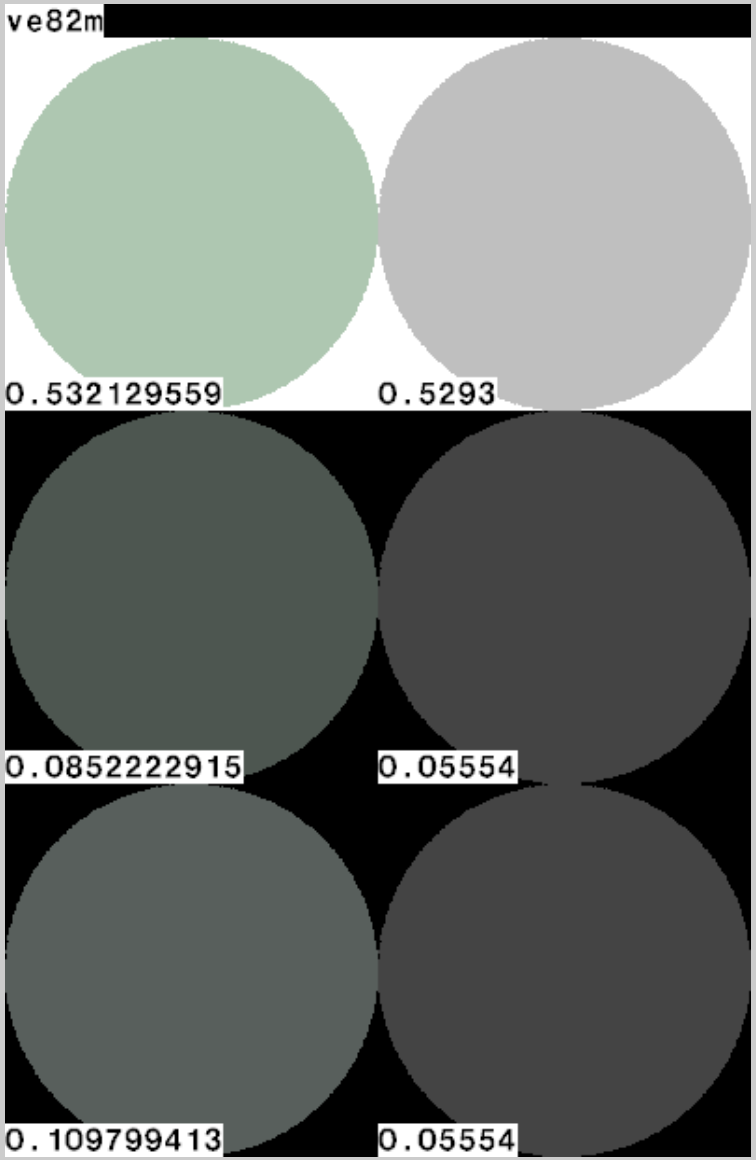

ve32m
0.346478677
0.3467
0.0624781501
0.04822
0.0997753009
0.04822

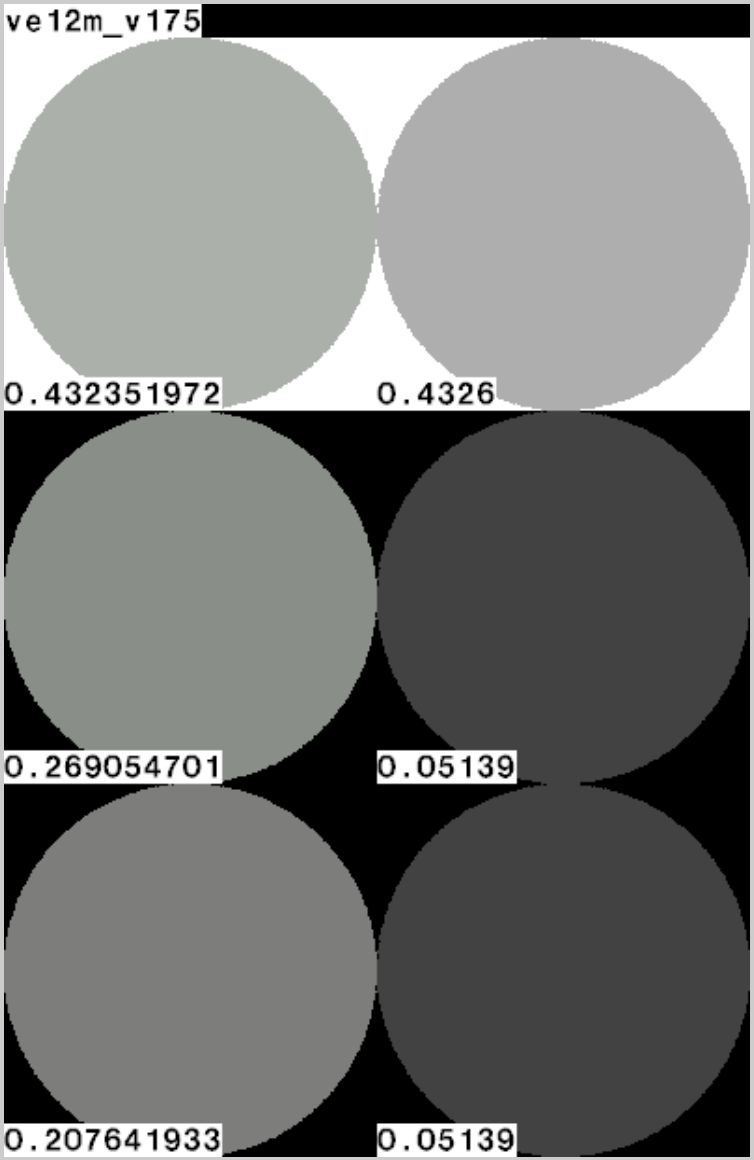

ve42m
0.412495627
0.4111
0.0708184141
0.05042
0.102147383
0.05042

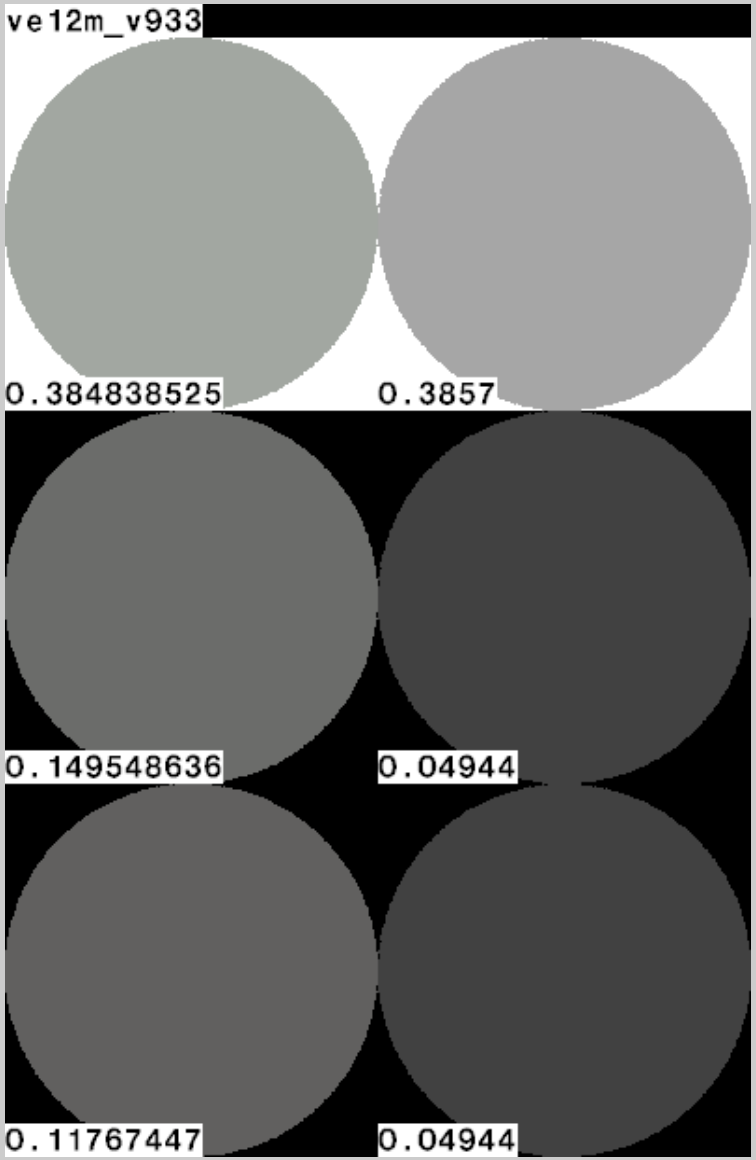

ve52m
0.448152618
0.4482
0.0725047902
0.05188
0.104664843
0.05188


ve62m
0.596328479
0.5957
0.0979295244
0.05896
0.115582063
0.05896

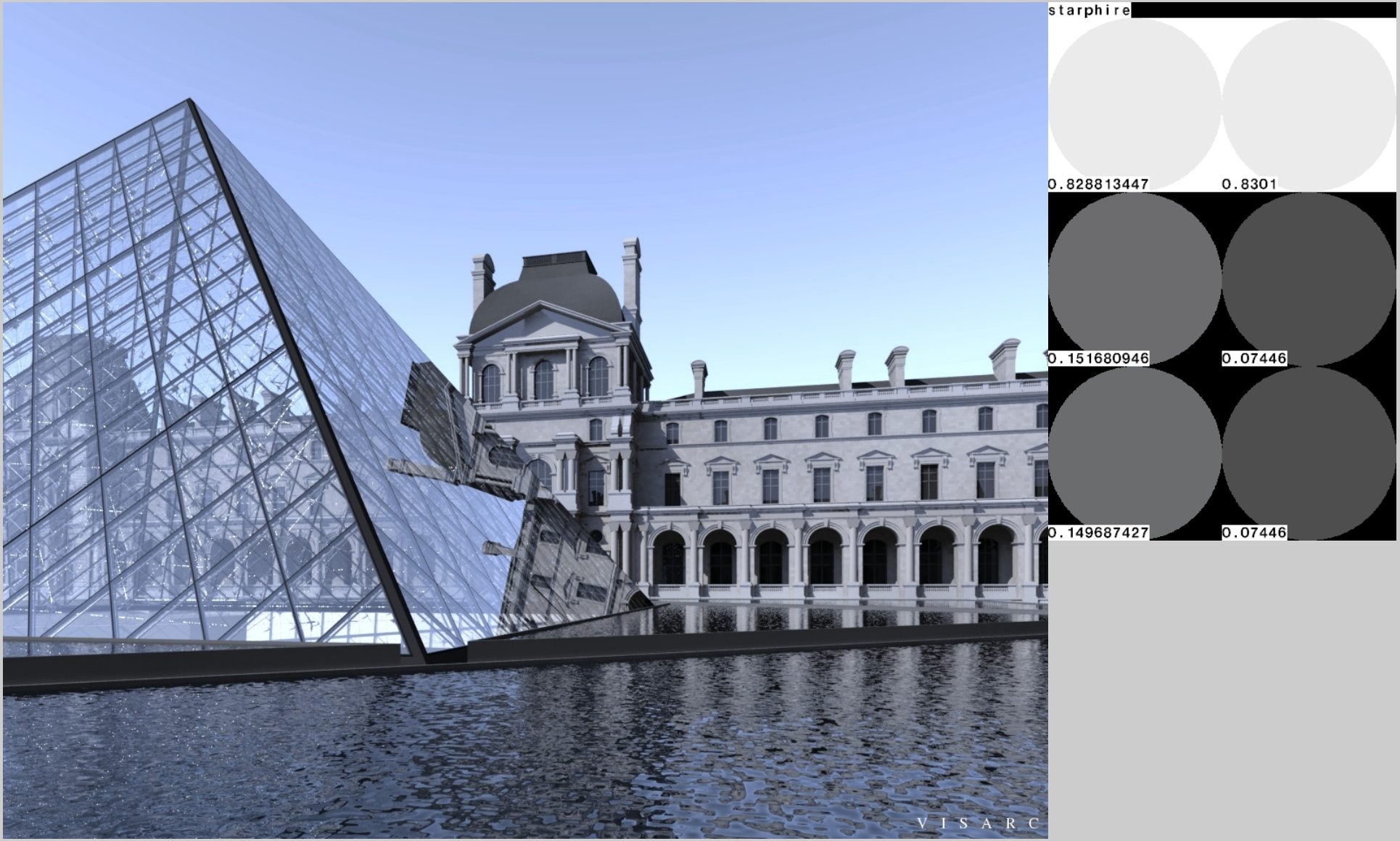

ve72m
0.541642122
0.541
0.0853279504
0.05603
0.11320229
0.05603


ve82m
0.532129559
0.5293
0.0852222915
0.05554
0.109799413
0.05554


ve12m_v175
0.432351972
0.4326
0.269054701
0.05139
0.207641933
0.05139


ve12m_v933
0.384838525
0.3857
0.149548636
0.04944
0.11767447
0.04944

Louvre


starphire
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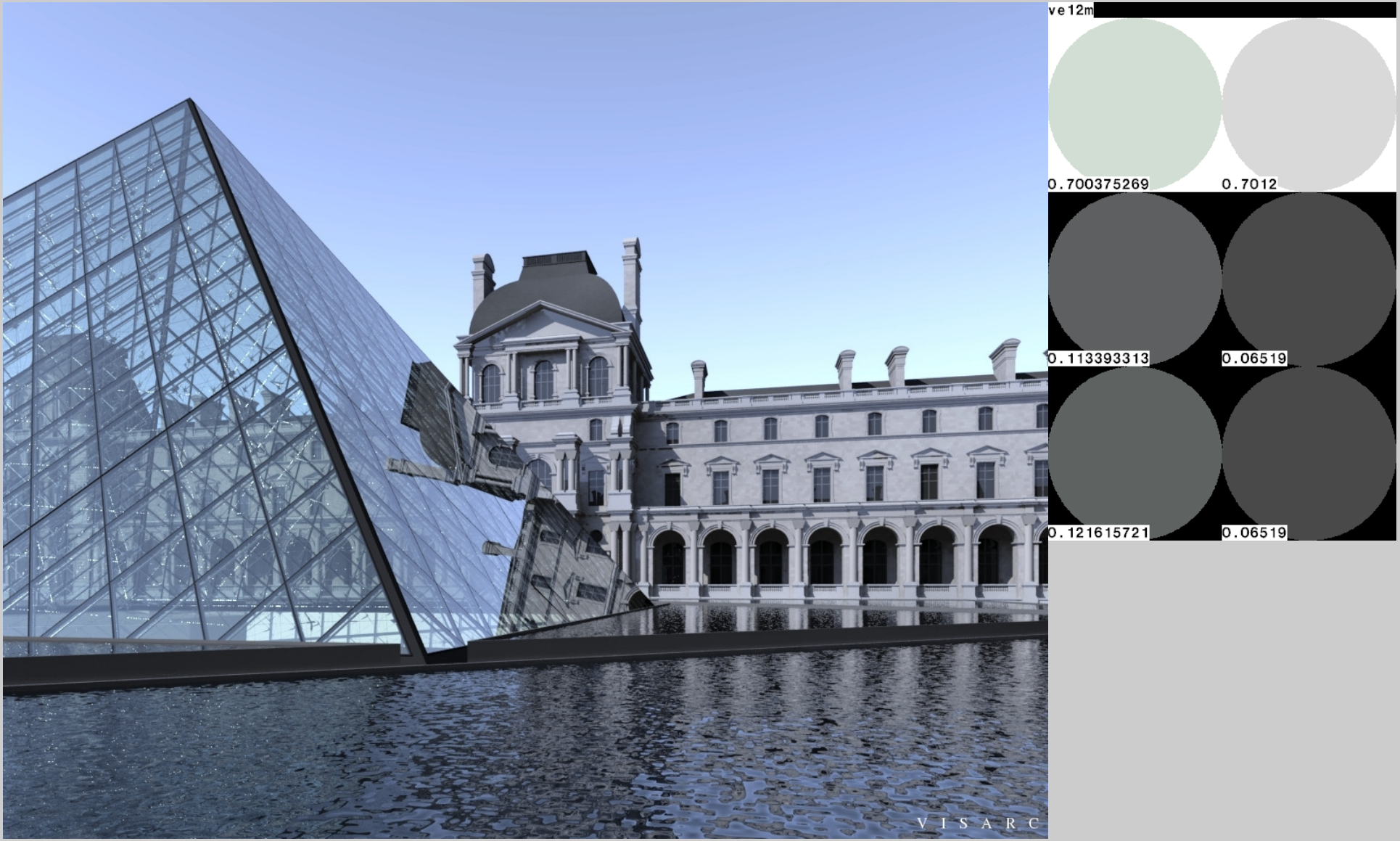
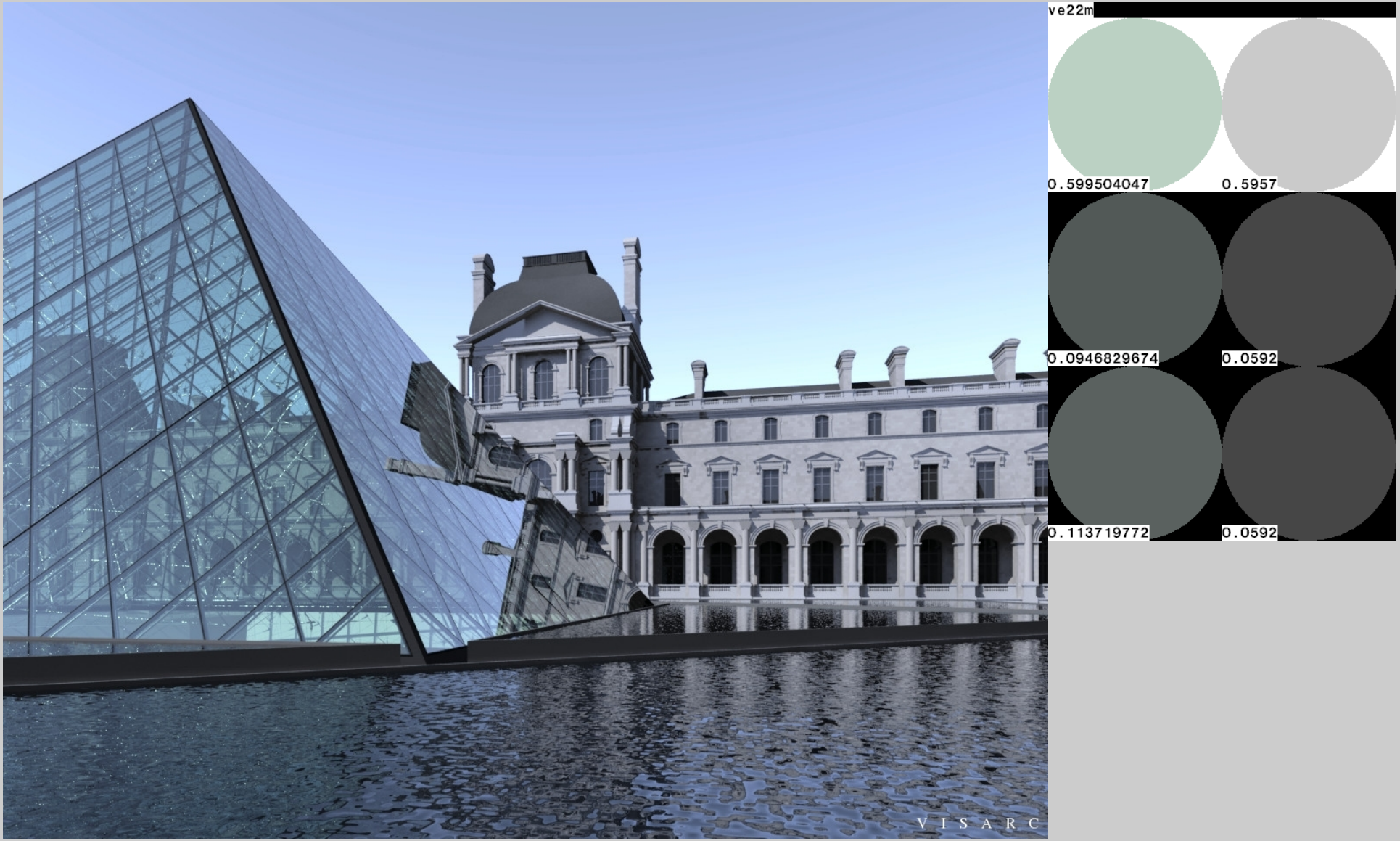
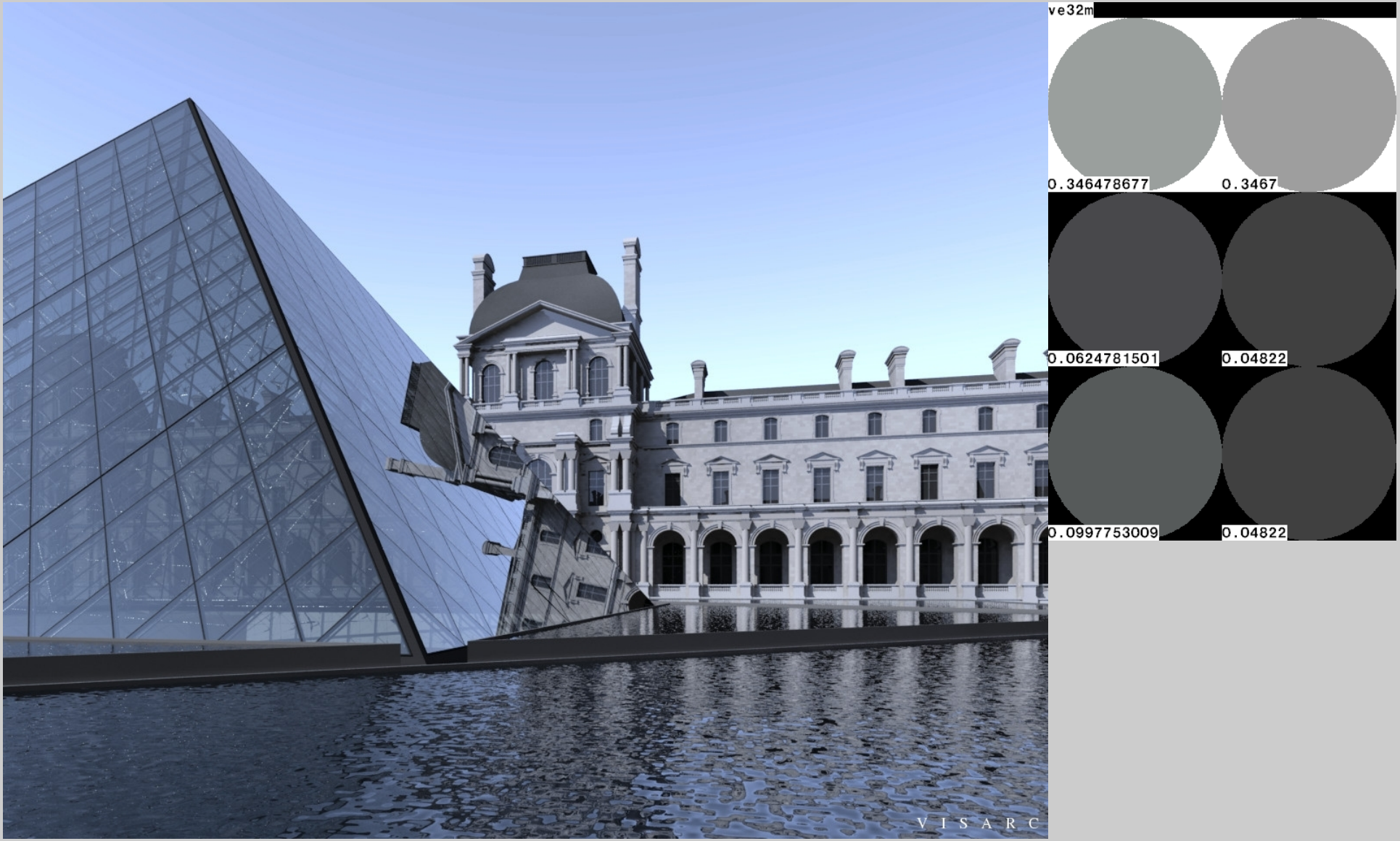
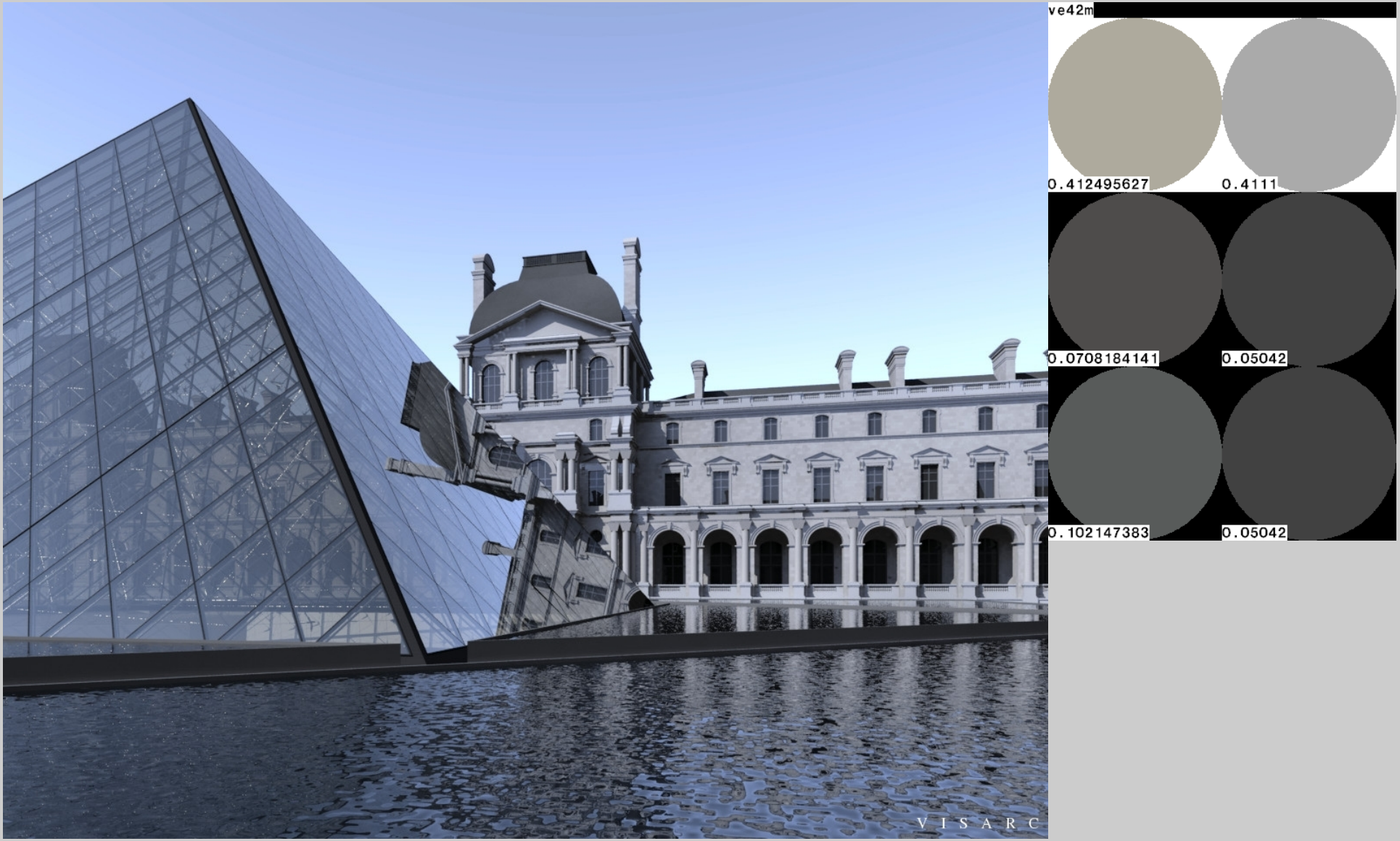
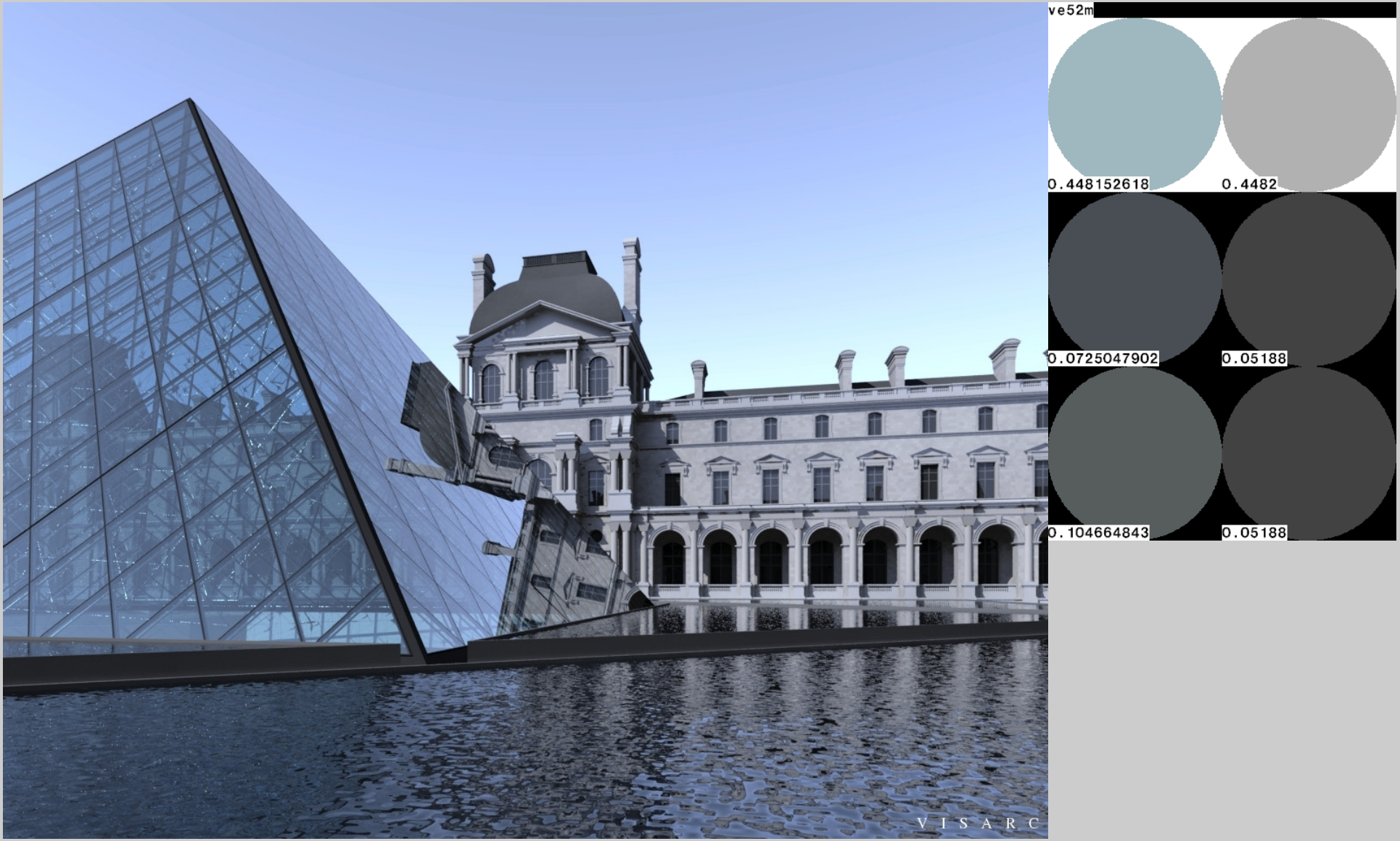
0.8301
0.151680946
0.07446
0.149687427
0.07446
VISARC

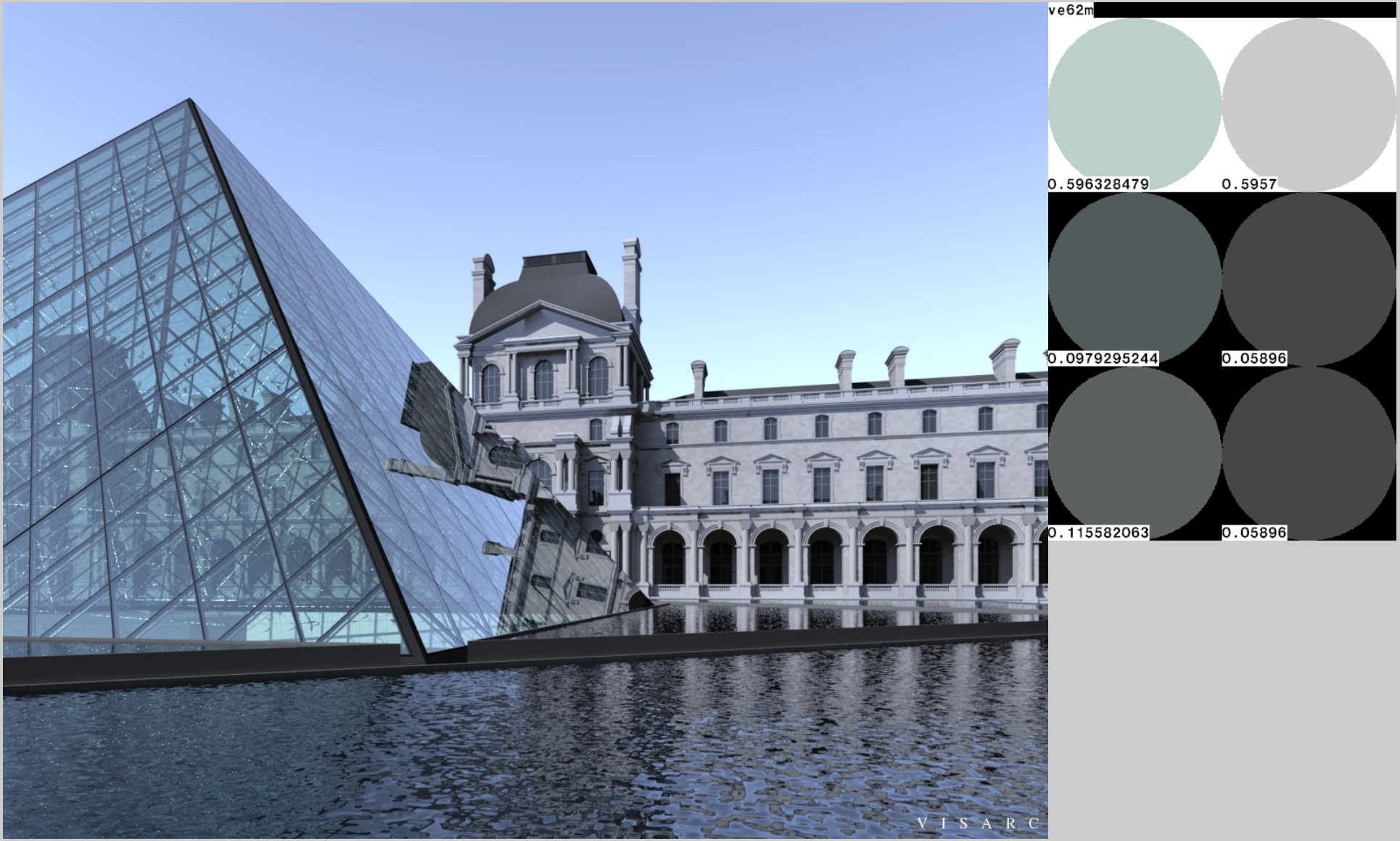

ve12m
0.700375269
0.7012
0.113393313
0.06519
0.121615721
0.06519
VISARC


ve22m
0.599504047
0.5957
0.0946829674
0.0592
0.113719772
0.0592
VISARC


ve32m
0.346478677
0.3467
0.0624781501
0.04822
0.0997753009
0.04822
VISARC


ve42m
0.412495627
0.4111
0.0708184141
0.05042
0.102147383
0.05042
VISARC


ve52m
0.448152618
0.4482
0.0725047902
0.05188
0.104664843
0.05188
VISARC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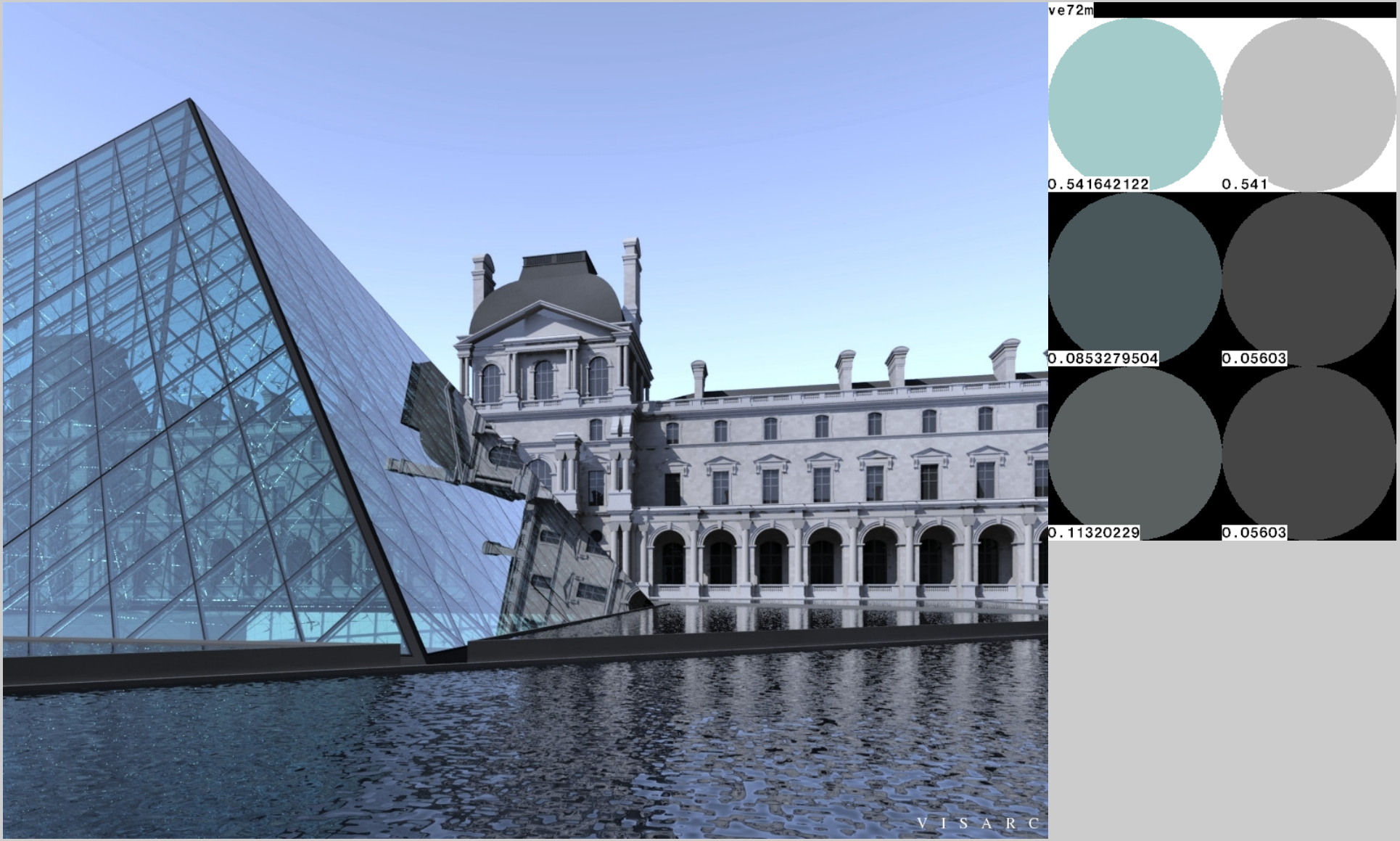
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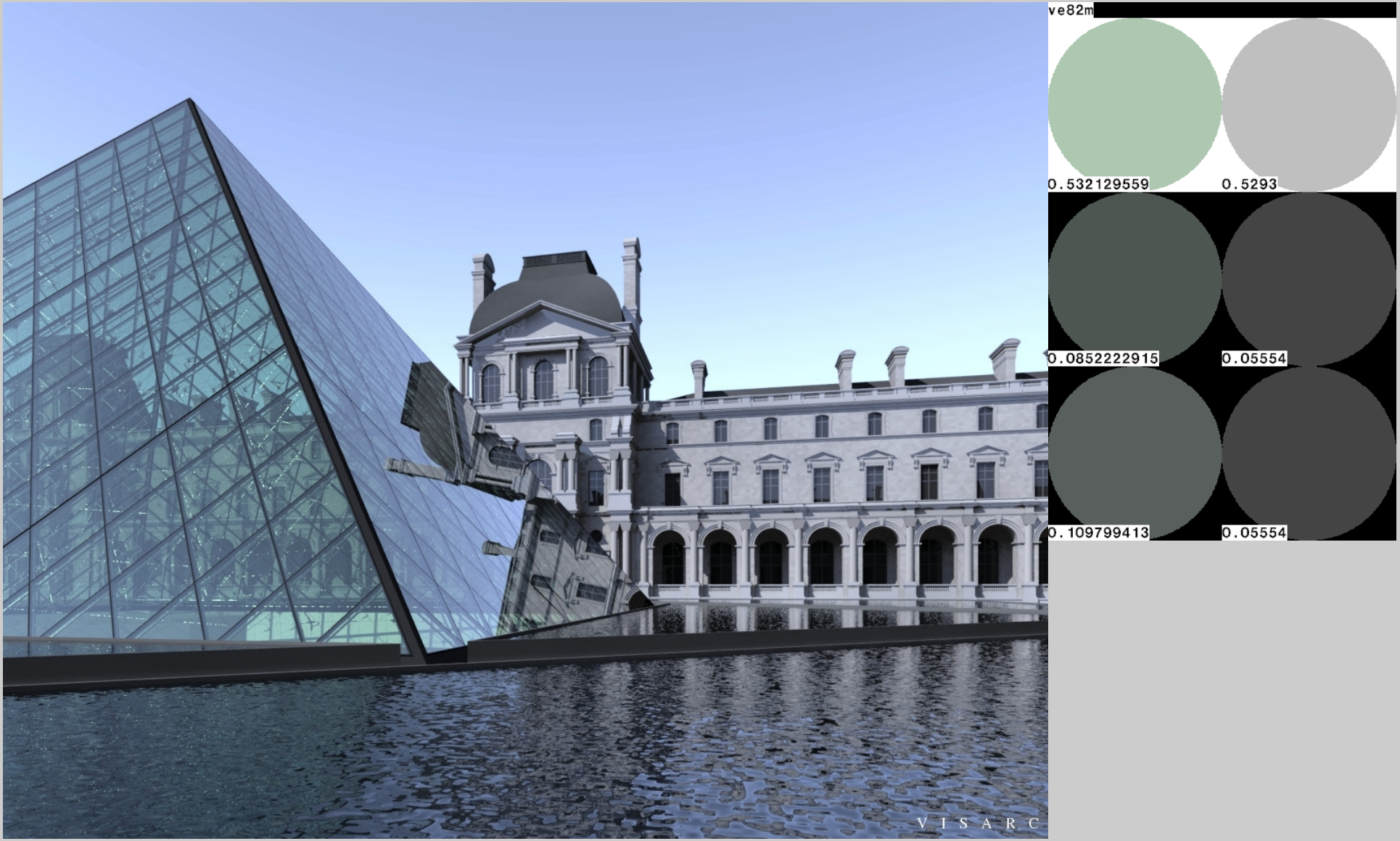
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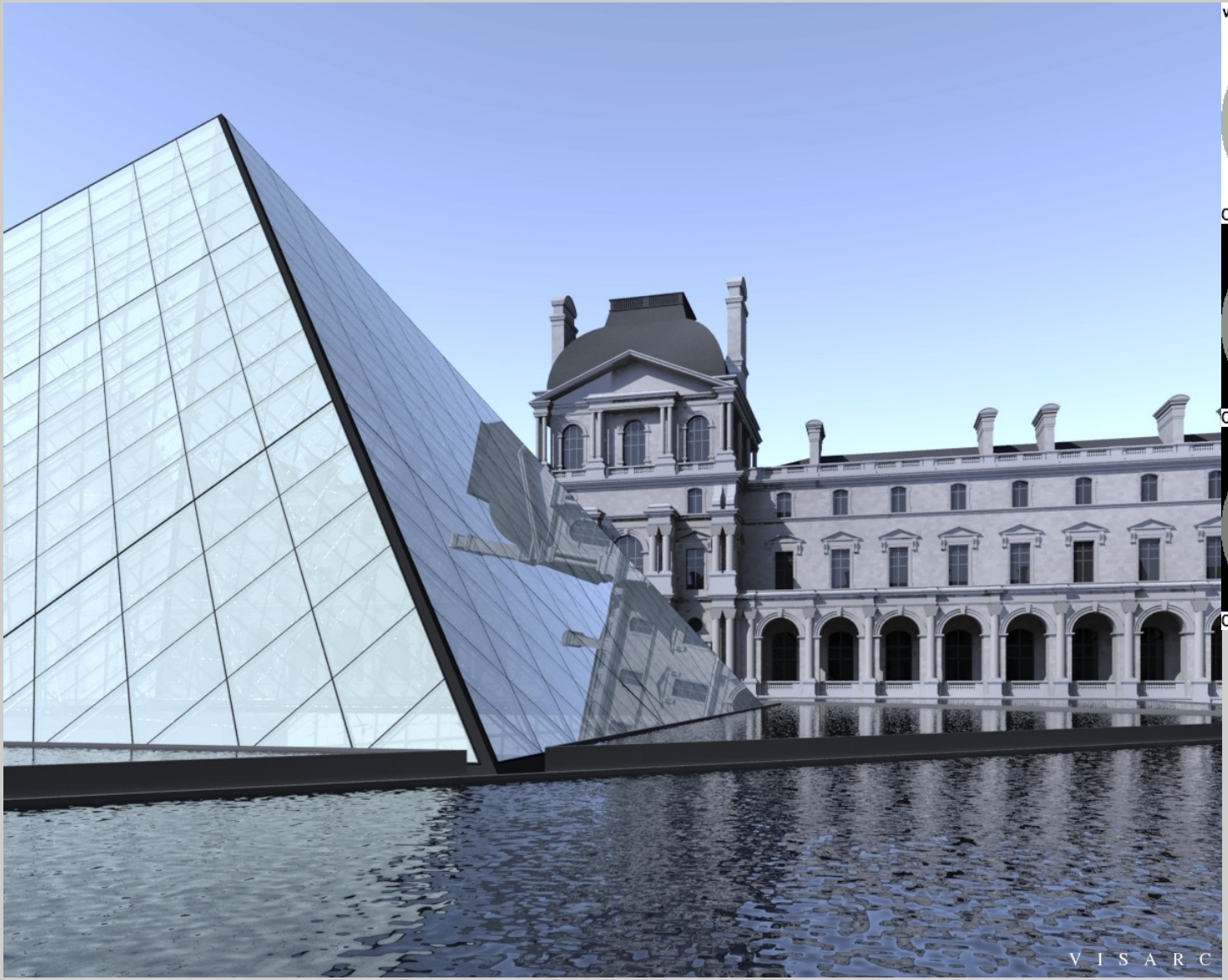
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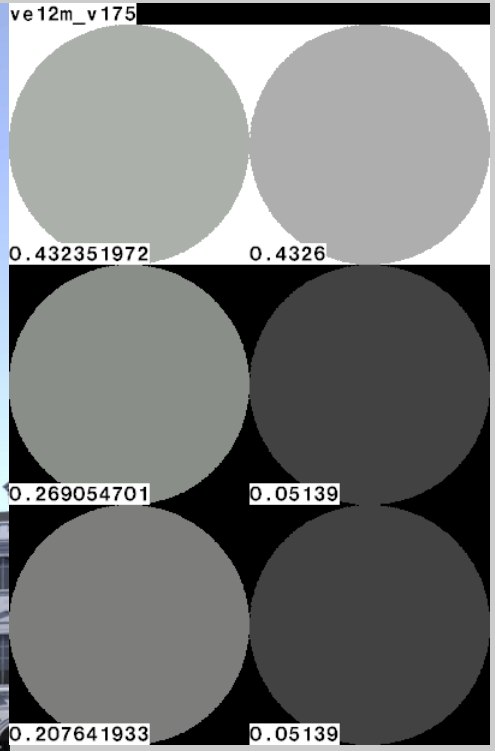
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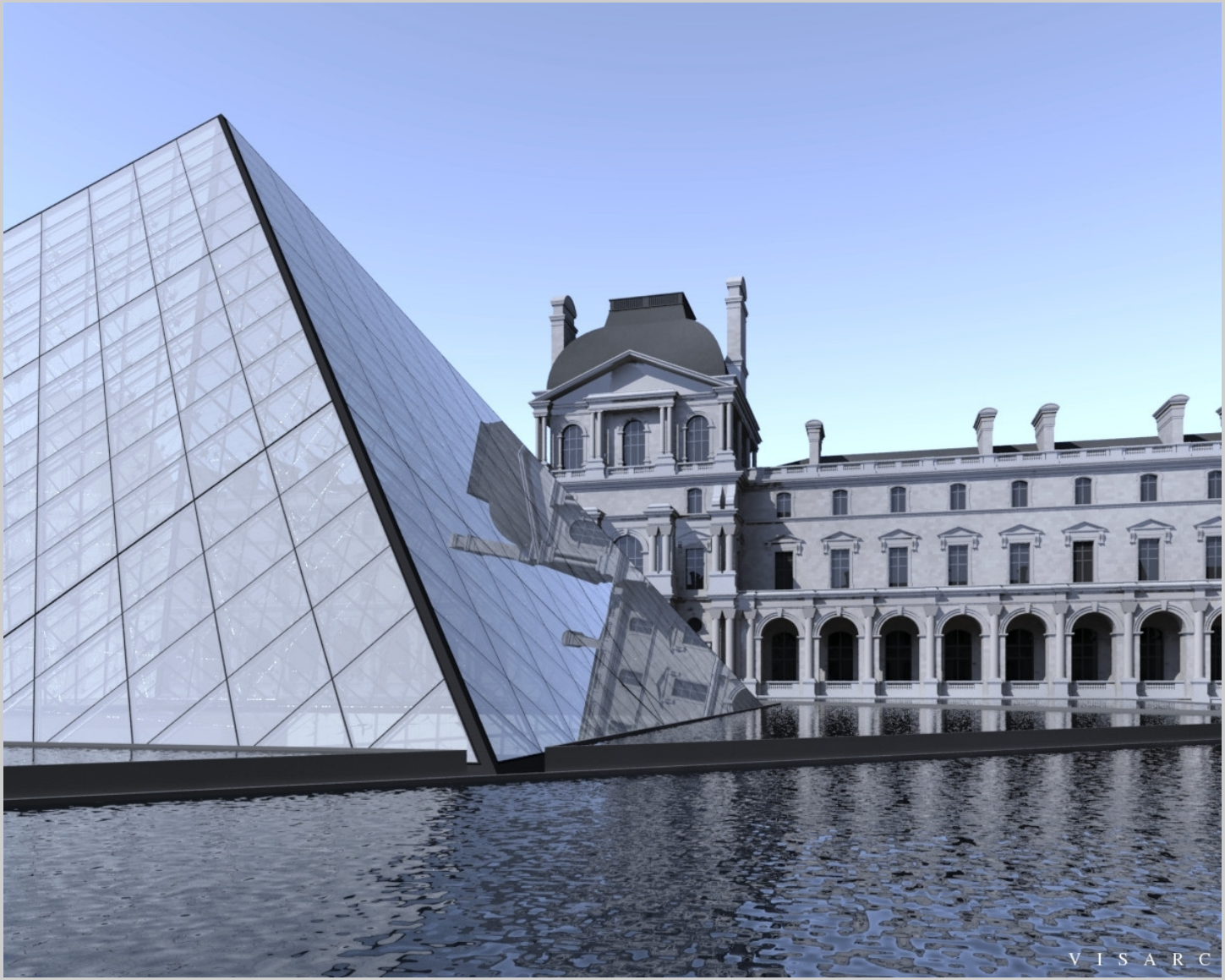
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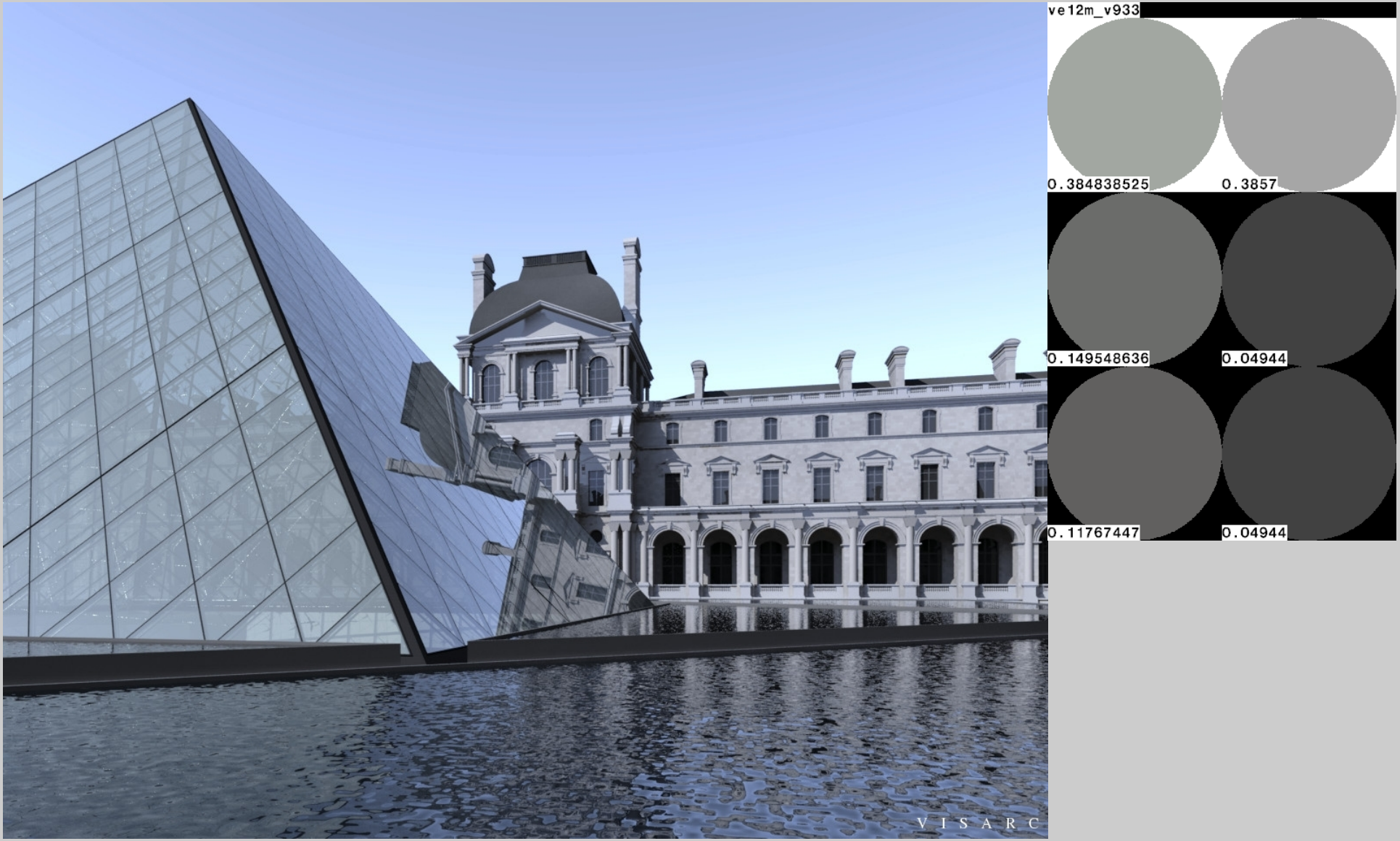
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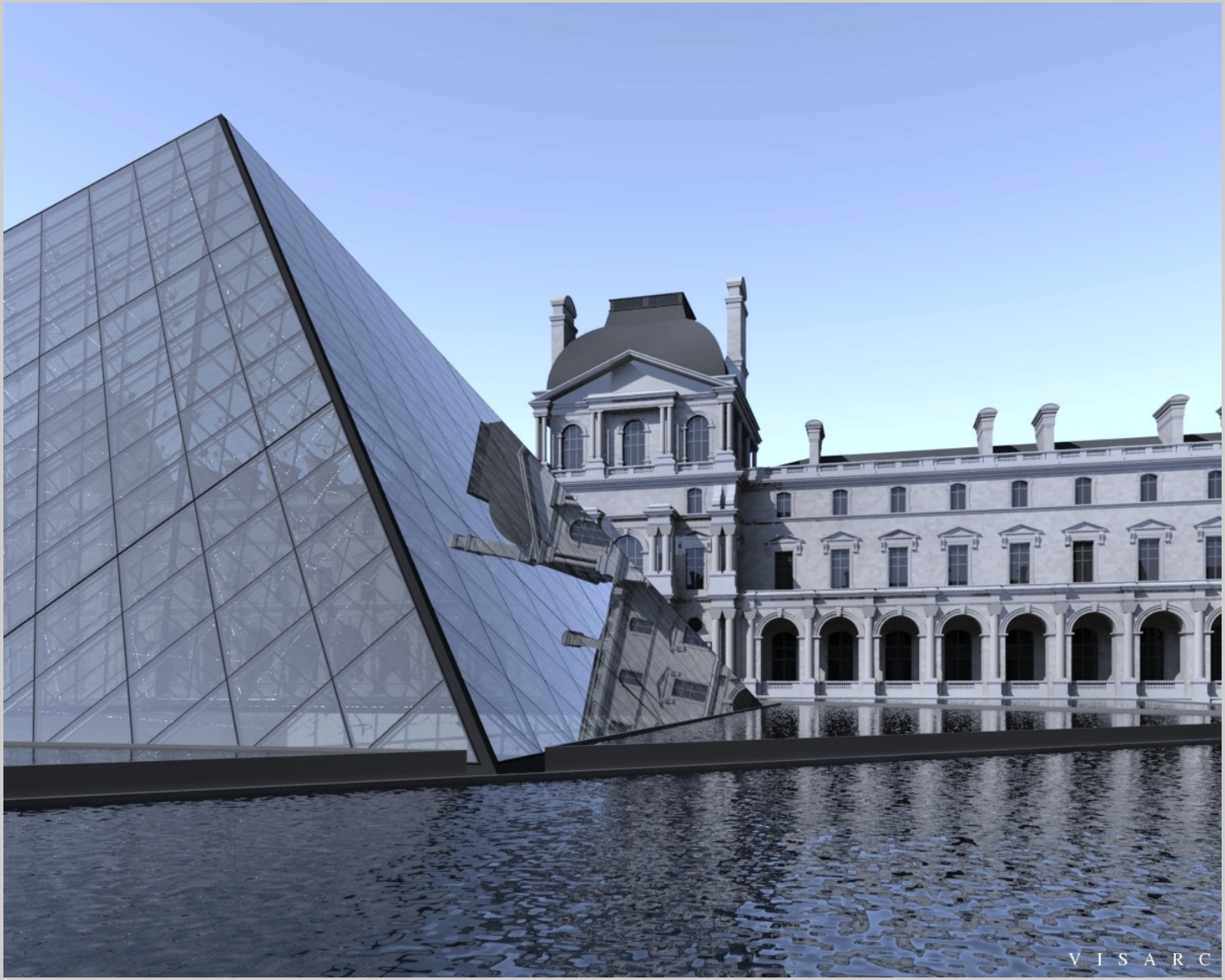
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