The *Radiance* **rtcontrib** Program

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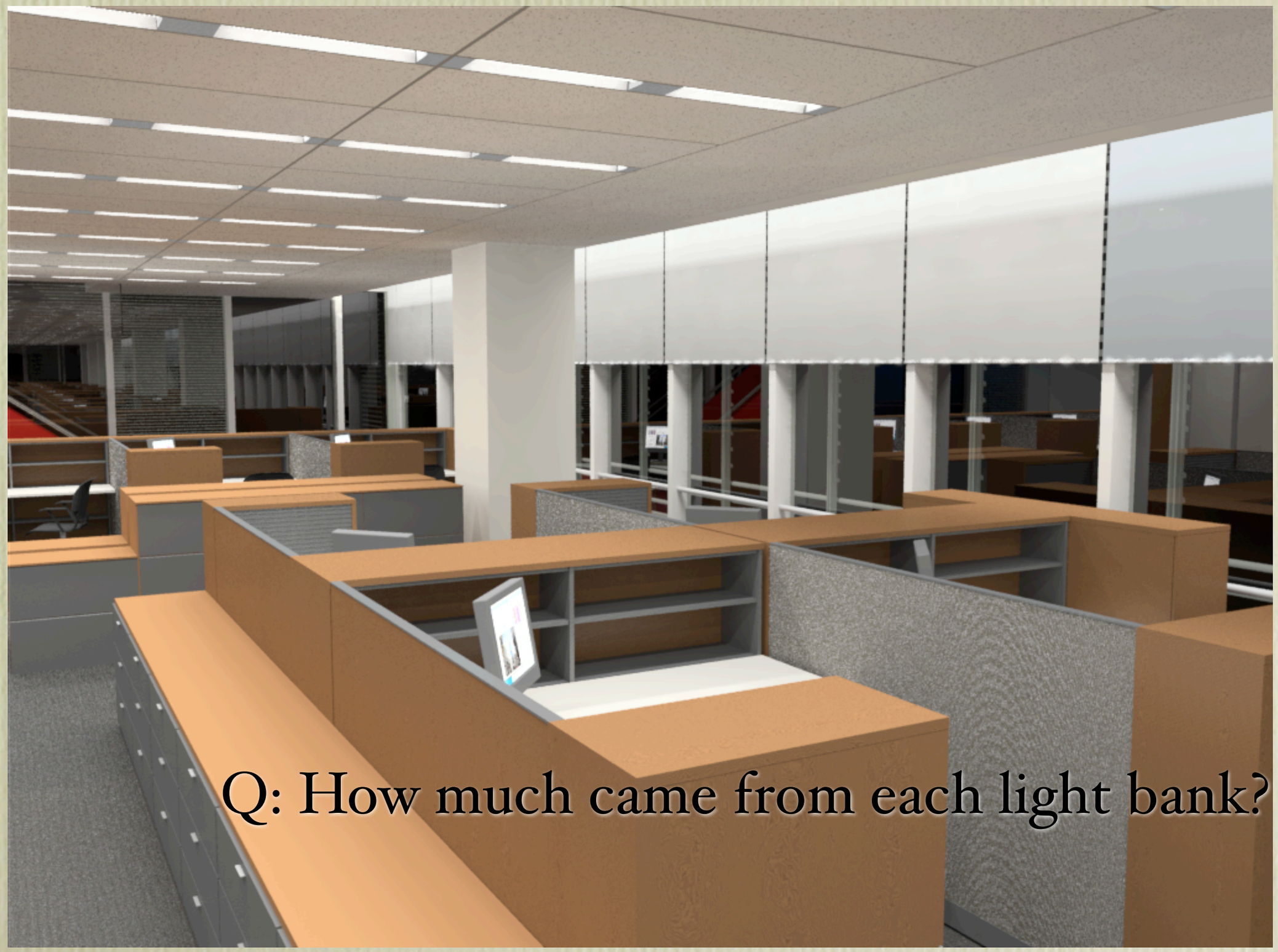
Anyhere Software

Basic Idea

- Normally, details about what sources contributed to a pixel are thrown away
- Saving this information allows different source contributions to be substituted
- More generally, the flux transfer between a point and any other point may be quantified

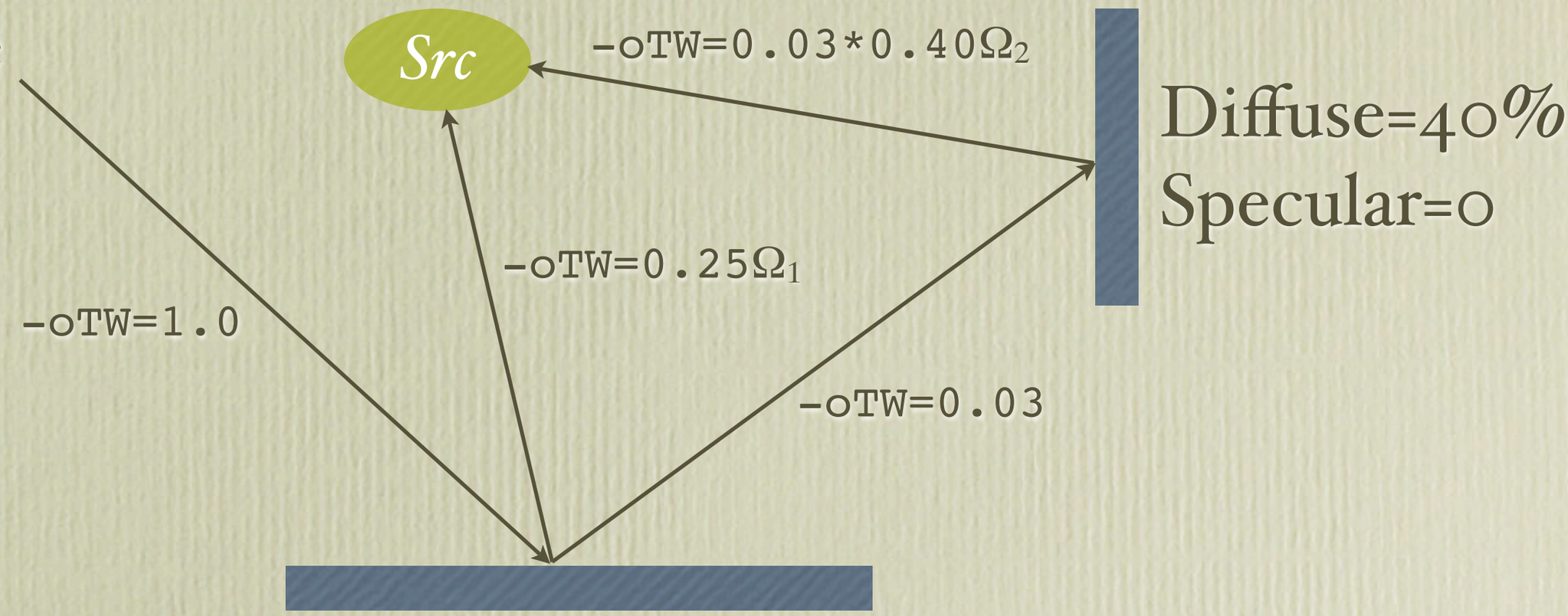
Quantifying Contributions



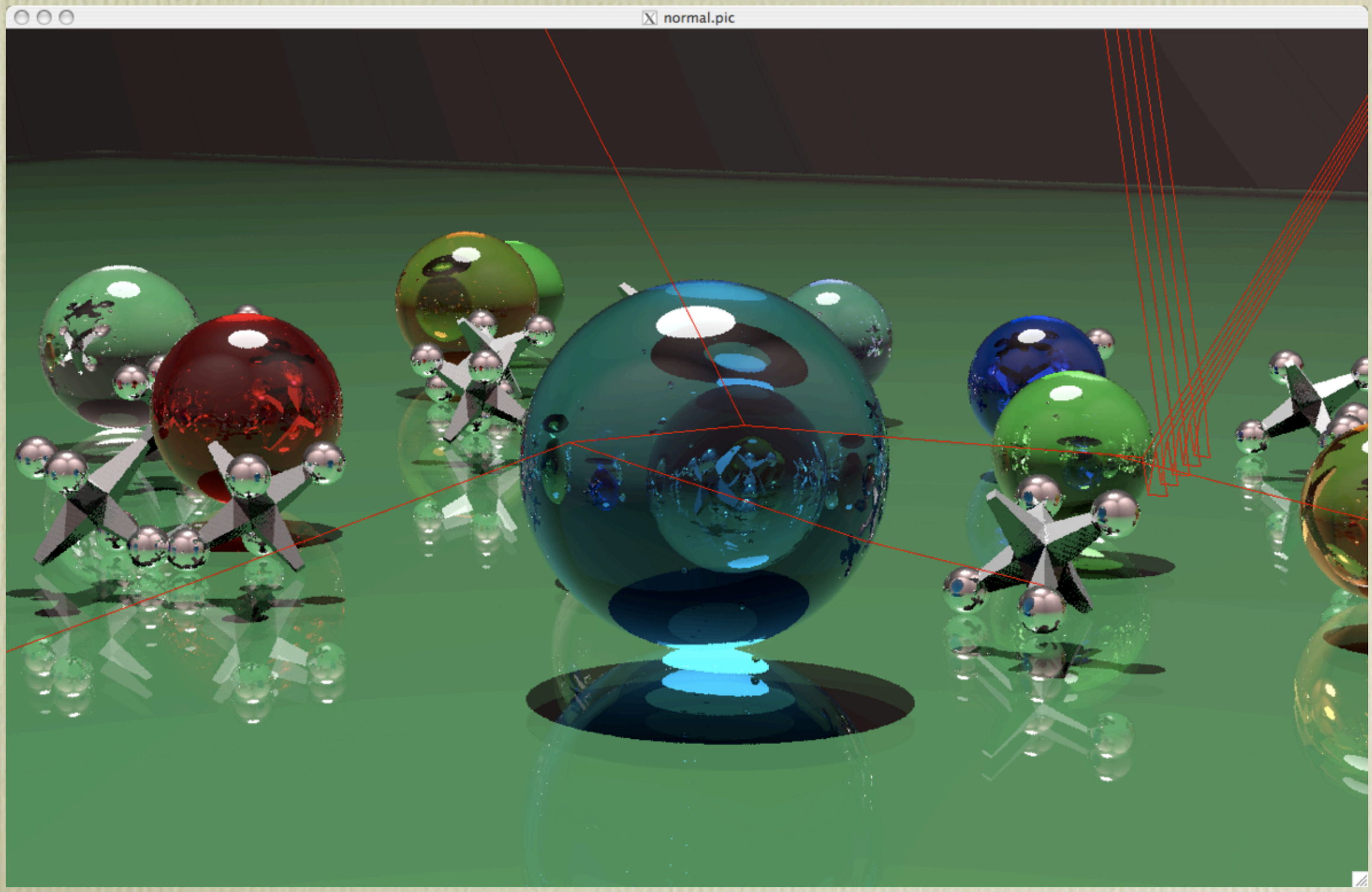
Contribution Coefficients

- A “contribution coefficient” is the fraction of a ray’s return value that will ultimately apply
  - This is closely related, but not equal, to the “ray weight” reported by `-otw`
- ‘`T`’ option for **rtrace** `-o` traces to light sources
- The ‘`W`’ option reports contribution coefficient

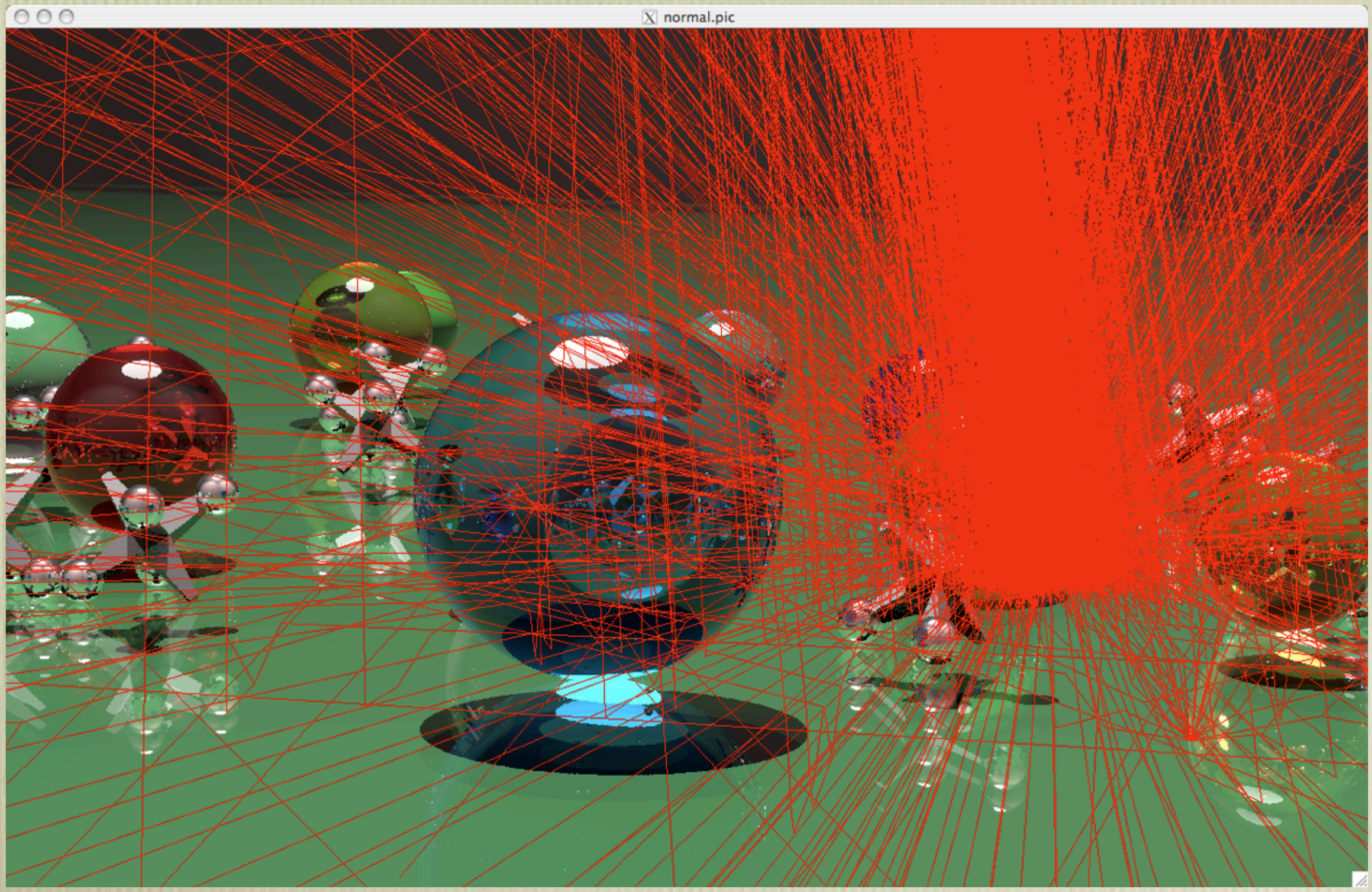
A Simple Example



Problem: Daughter Rays



Diffuse Interreflections



rtcontrib: Gather Rays

- Gather contributions & coefficients and sum them up logically
- Different applications require different sums:
  - Daylight coefficients sum at sky patches
  - Luminaire model may sum at lamp surface
- **rtcontrib** provides general mechanism, while **rtrace** handles actual ray-tracing

General Operation

- Looks like **rtrace** command, similar options
- Options tell **rtcontrib** where to collect values
  - required modifier name(s)
  - optional bin number based on ray direction and intersection point
- Output sent to one or more files or commands
  - specified by modifier name and bin number

Lighting Example

```
vwrays -ff -x 1024 -y 1024 -vf model.vp \
| rtcontrib -V+ -o part_%s.pic -m fluor1 -m fluor2 \
-ffc `vwrays -d -x 1024 -y 1024 -vf model.vp` -u+ model.oct
```

rtcontrib Options

General options:

`-n` *N* start *N* **rtrace** processes

`-r` recover previously aborted calculation

`-e` *expr* compile definitions string

`-f` *source* compile definitions file

} Used by `-b`

Modifier options:

`-o` *ospec* output specification — May contain '`!`' and '`%d`' or '`%s`'

`-b` *binv* bin number — Integer expression, or '`0`' to disable

Modifier specification:

`-m` *mod* modifier name

`-M` *file* modifier list from file

Lighting Example Dissection

```
vwrays -ff -x 1024 -y 1024 -vf model.vp \
| rtcontrib -o part_%s.pic -m fluor1 -m fluor2 \
-ffc `vwrays -d -x 1024 -y 1024 -vf model.vp` model.oct
```

Lighting Example Dissection

vwrays provides primary ray origins and directions (in floating point) for pictures to be generated by rtcontrib

```
vwrays -ff -x 1024 -y 1024 -vf model.vp \
| rtcontrib -o part_%s.pic -m fluor1 -m fluor2 \
-ffc `vwrays -d -x 1024 -y 1024 -vf model.vp` model.oct
```

Second invocation reports actual resolution (-x 1024 -y 690)

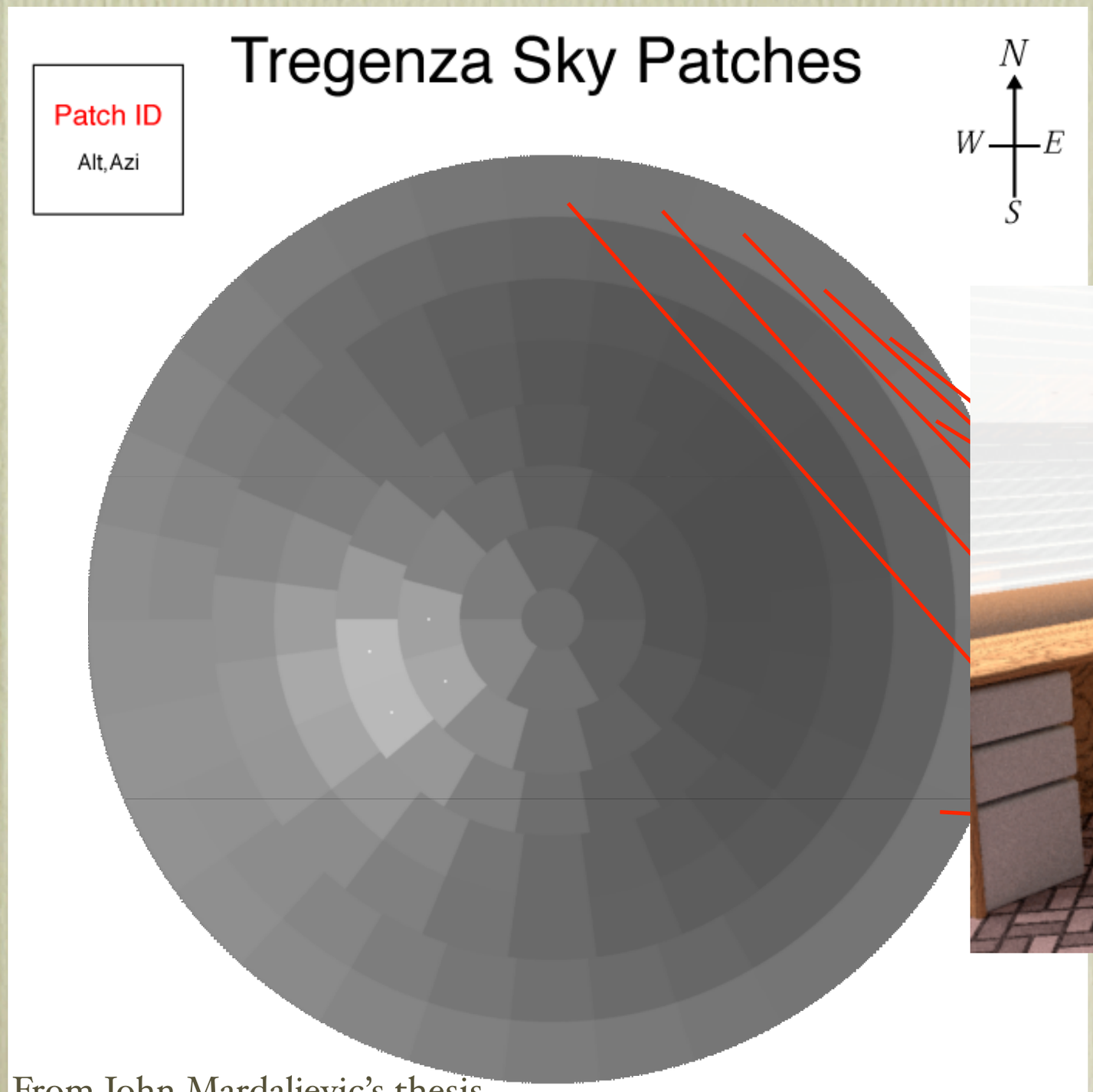
Lighting Example Dissection

Specifies output files and associated modifiers, creating `part_fluor1.pic` and `part_fluor2.pic`.

```
vwrays -ff -x 1024 -y 1024 -vf model.vp \
| rtcontrib -o part_%s.pic -m fluor1 -m fluor2 \
-ffc `vwrays -d -x 1024 -y 1024 -vf model.vp` model.oct
```

The `-ffc` option is an **rtrace** option telling **rtcontrib** to expect single-precision floats on input and produce RGBE colors on output.

Daylight Coefficients



From John Mardaljevic's thesis

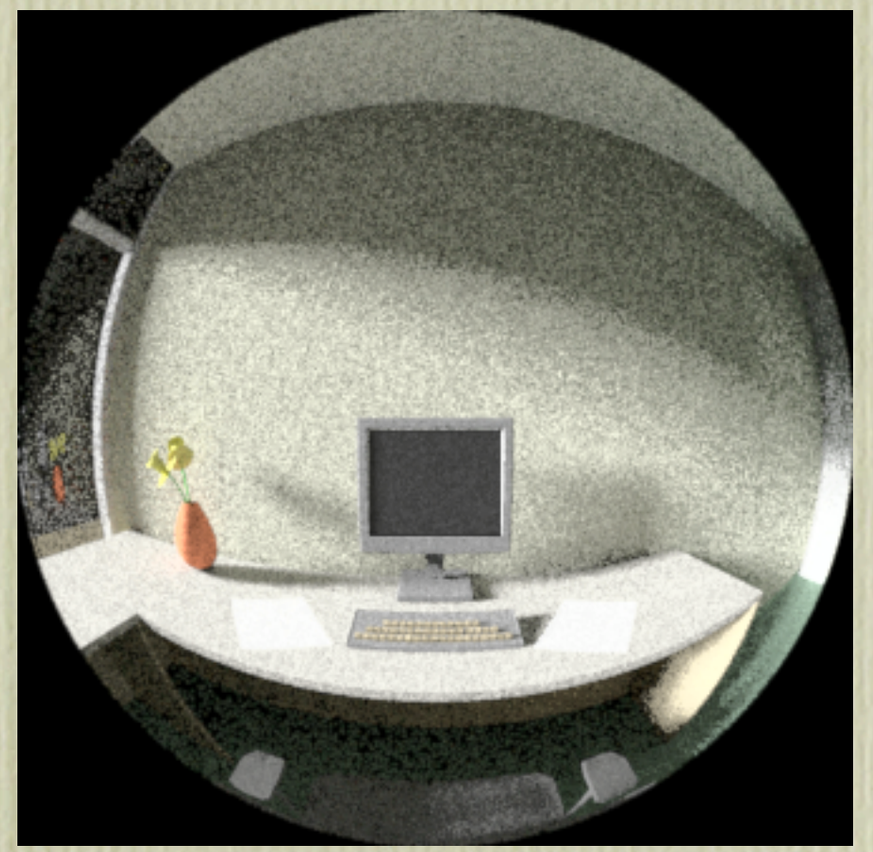
Daylight Coefficient Example

Blinds: up, top, down
@ 10° increments

Optional overhang

Upper & lower glass:
42 separate runs
of 146 sky patches
& 145 solar patches
One hemispherical
fisheye view

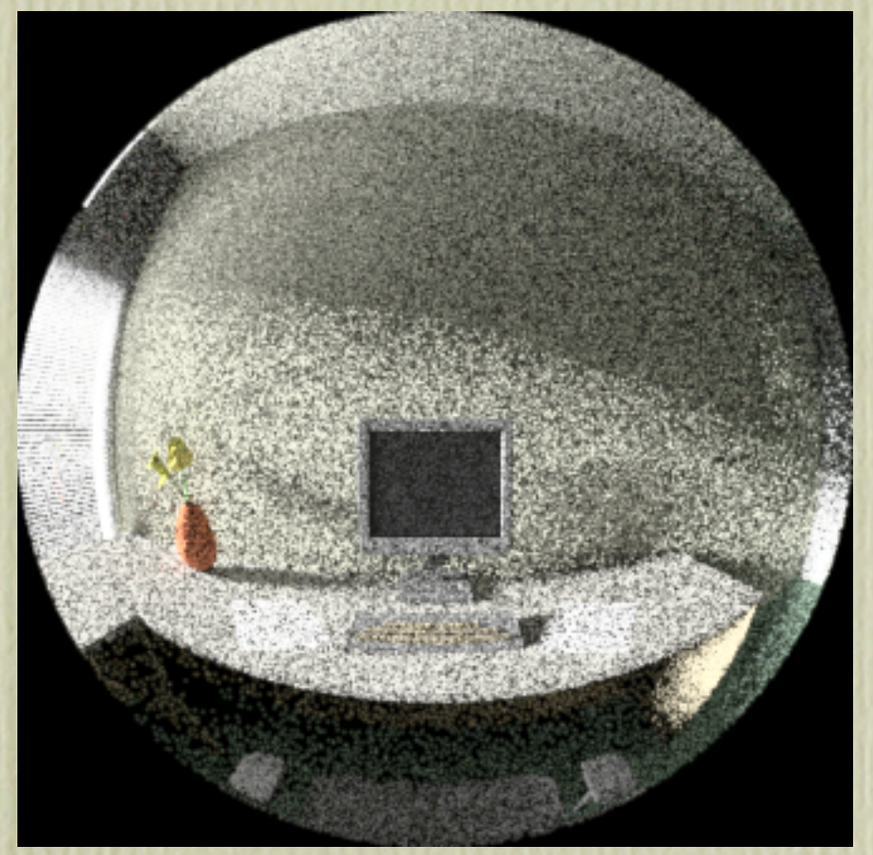
Example Contributions (1)



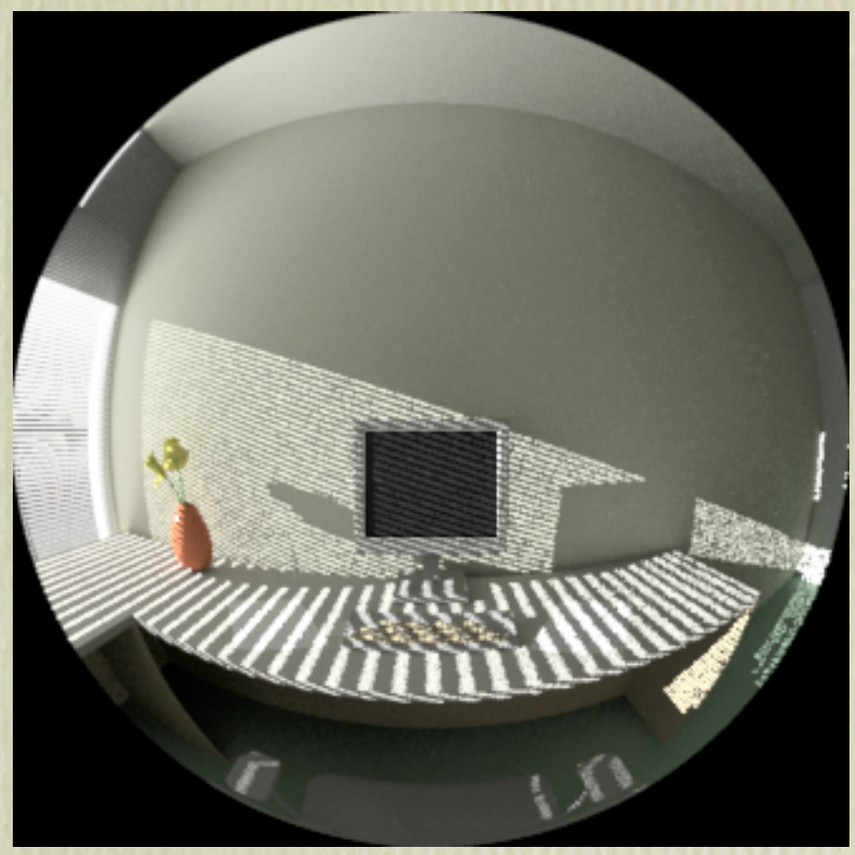
Sky patch 045
from lower glass
no overhang
no blinds

Sun patch 045
from lower glass
no overhang
no blinds

Example Contributions (2)



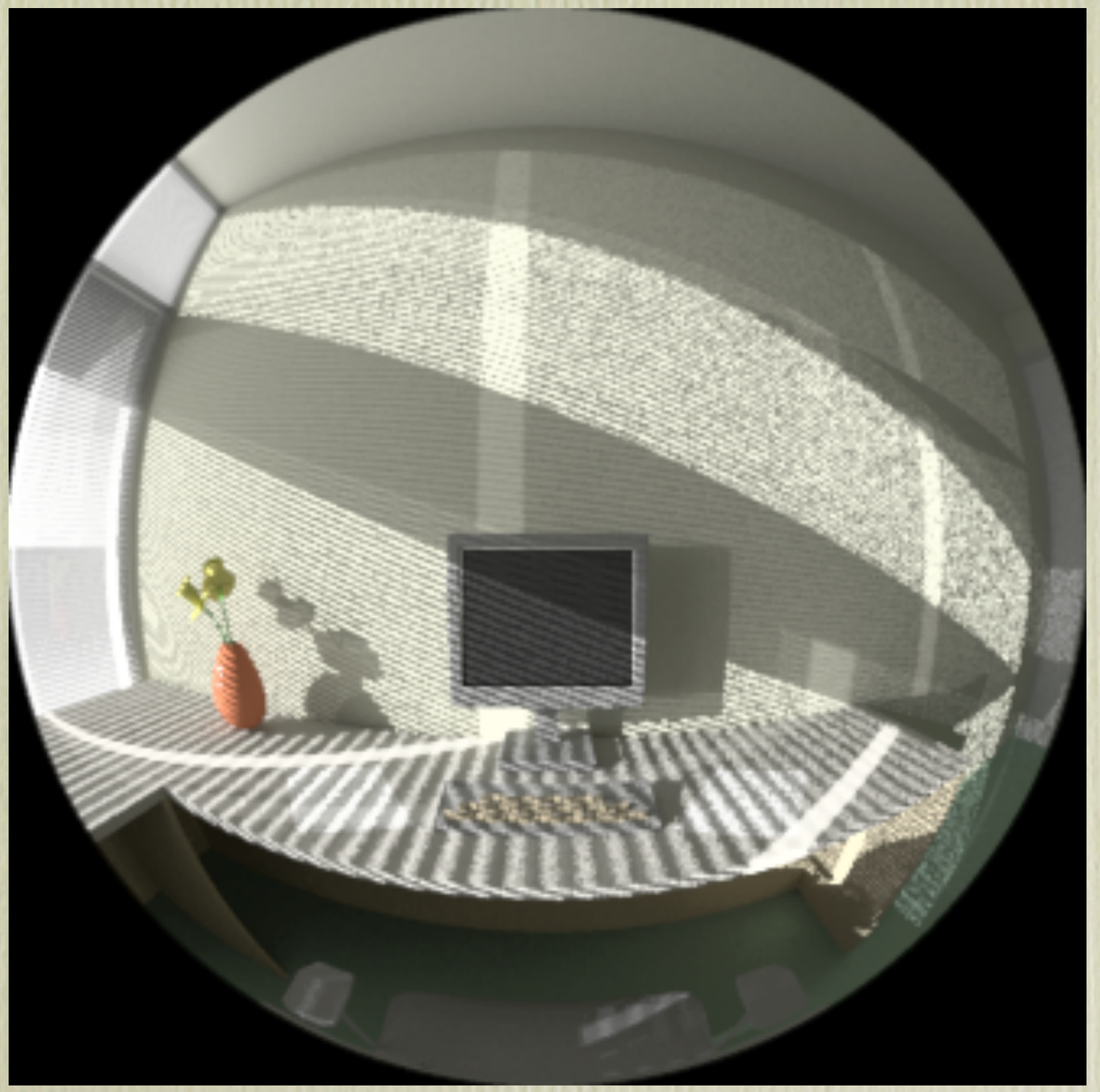
Sky patch 045
from lower glass
with overhang
blinds @ 20°



Sun patch 045
from lower glass
with overhang
blinds @ 20°

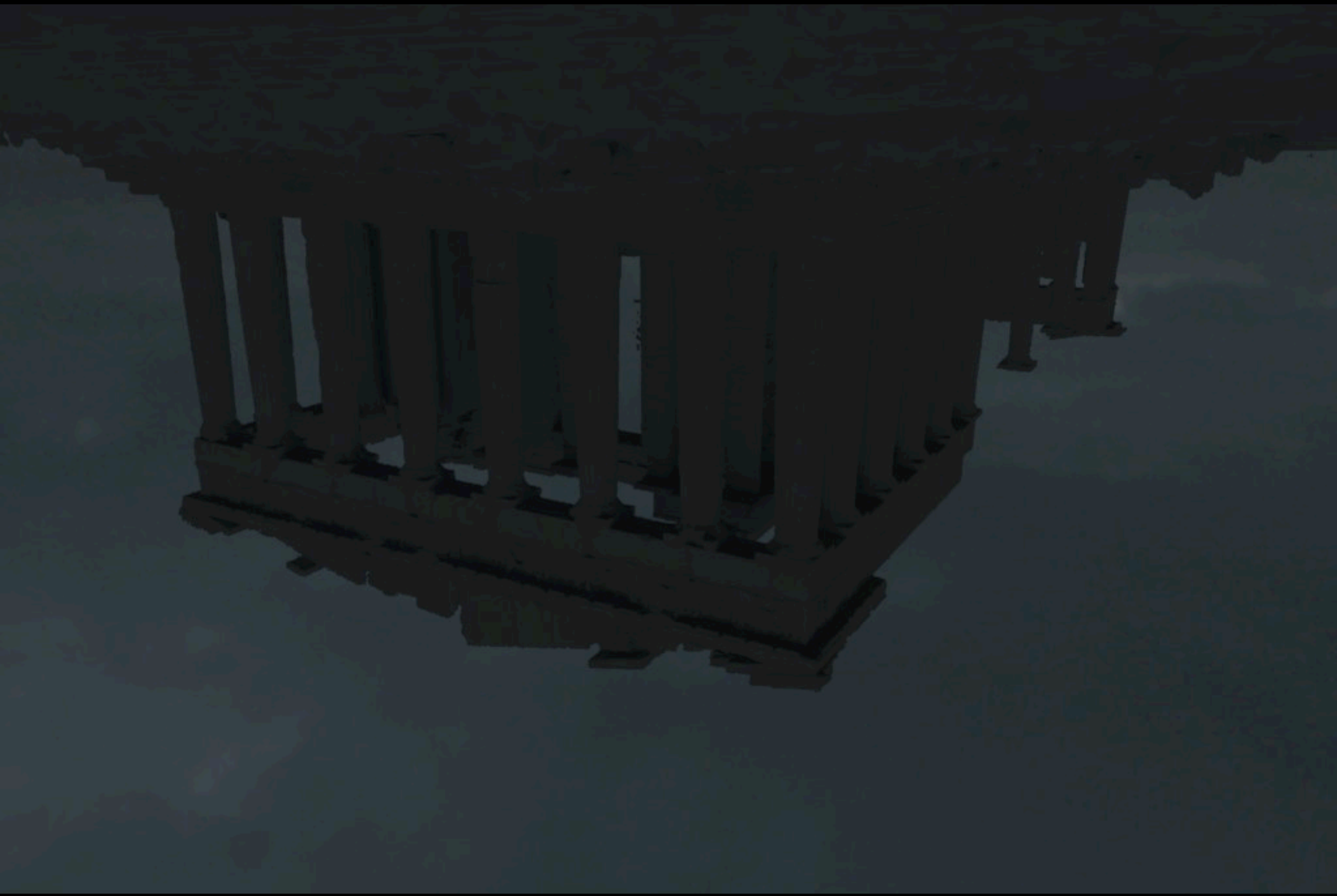
Combined Result

Dec 28
Overhang
10 am
blinds down
@ 10°



Example with Captured Sky

- Parthenon model created by Paul Debevec & Co. at USC's ICT from 100's of site laser scans
- Los Angeles sky captured by Jessi Stumpfel on the one cloudy day she could find
- **rtcontrib** run plus **pcomb** sums for 690 animation frames done in 6 hours on G5 Quad



Parthenon Rendering Method

- Run **rtcontrib** to compute each Tregenza sky patch DC contribution as a partial image
- Use low-resolution version of captured sky to compute Tregenza patch radiances
- Use radiance as coefficients in **pcomb** command to combine partial images

10:38

Tregenza
Patch 001

Actual Commands

```
rtcontrib -x 2048 -y 1361 -ffc -ab 2 -ad 1024 -f
tregenza.cal -b tbin -o p%d.hdr -m white -n 4
parth.oct < rays.flt
```

Then, for each frame time:

```
mksky.csh $time | oconv - > capsky.oct

rtrace -h -w -dv- capsky.oct < tregsamp.dat |
total -64 -m > pval.dat

pcomb -h `rcalc -o '-s ${$1} p${recno-1}.hdr'
pval.dat` > f$time.hdr
```

Example **pcomb** Command

```
pcomb -h -s 26.679 p0.hdr -s 17.0417 p1.hdr -s 16.7292 p2.hdr -s 17.2695 p3.hdr -s 17.0158 p4.hdr -s
16.9859 p5.hdr -s 17.3179 p6.hdr -s 17.3057 p7.hdr -s 16.9012 p8.hdr -s 17.1711 p9.hdr -s 17.005
p10.hdr -s 16.4502 p11.hdr -s 16.9732 p12.hdr -s 17.3672 p13.hdr -s 17.5727 p14.hdr -s 18.3379
p15.hdr -s 19.6837 p16.hdr -s 20.945 p17.hdr -s 22.1034 p18.hdr -s 23.4713 p19.hdr -s 24.4605 p20.hdr
-s 24.9192 p21.hdr -s 24.7394 p22.hdr -s 23.8799 p23.hdr -s 22.8255 p24.hdr -s 21.4208 p25.hdr -s
20.2332 p26.hdr -s 18.811 p27.hdr -s 17.9236 p28.hdr -s 17.5551 p29.hdr -s 16.943 p30.hdr -s 11.3134
p31.hdr -s 10.9923 p32.hdr -s 11.0595 p33.hdr -s 10.8431 p34.hdr -s 10.6877 p35.hdr -s 10.8235
p36.hdr -s 10.9221 p37.hdr -s 10.6787 p38.hdr -s 10.8518 p39.hdr -s 11.0184 p40.hdr -s 11.1377
p41.hdr -s 11.4171 p42.hdr -s 12.0989 p43.hdr -s 12.8039 p44.hdr -s 13.9147 p45.hdr -s 15.4106
p46.hdr -s 17.1459 p47.hdr -s 19.1204 p48.hdr -s 20.8152 p49.hdr -s 22.3375 p50.hdr -s 23.096 p51.hdr
-s 22.8274 p52.hdr -s 21.7096 p53.hdr -s 20.0354 p54.hdr -s 18.0616 p55.hdr -s 16.4738 p56.hdr -s
14.6816 p57.hdr -s 13.3963 p58.hdr -s 12.473 p59.hdr -s 11.6952 p60.hdr -s 9.06285 p61.hdr -s 8.58478
p62.hdr -s 8.28409 p63.hdr -s 8.16134 p64.hdr -s 8.02032 p65.hdr -s 8.10924 p66.hdr -s 8.21599
p67.hdr -s 8.4734 p68.hdr -s 8.77964 p69.hdr -s 9.56698 p70.hdr -s 10.5602 p71.hdr -s 12.0353 p72.hdr
-s 14.007 p73.hdr -s 16.7768 p74.hdr -s 19.7968 p75.hdr -s 22.7948 p76.hdr -s 24.3699 p77.hdr -s
23.7876 p78.hdr -s 21.216 p79.hdr -s 18.0321 p80.hdr -s 15.0926 p81.hdr -s 12.7871 p82.hdr -s 11.1515
p83.hdr -s 9.92927 p84.hdr -s 8.60844 p85.hdr -s 7.95365 p86.hdr -s 7.53902 p87.hdr -s 7.30563
p88.hdr -s 7.22913 p89.hdr -s 7.25486 p90.hdr -s 7.41717 p91.hdr -s 7.75376 p92.hdr -s 8.26077
p93.hdr -s 9.08944 p94.hdr -s 10.3667 p95.hdr -s 12.1716 p96.hdr -s 14.6882 p97.hdr -s 18.2808
p98.hdr -s 22.5925 p99.hdr -s 27.2209 p100.hdr -s 30.3359 p101.hdr -s 28.7542 p102.hdr -s 24.6012
p103.hdr -s 20.1185 p104.hdr -s 16.1143 p105.hdr -s 13.1023 p106.hdr -s 10.951 p107.hdr -s 9.62028
p108.hdr -s 9.18923 p109.hdr -s 8.22889 p110.hdr -s 7.61537 p111.hdr -s 7.45216 p112.hdr -s 7.52448
p113.hdr -s 7.91023 p114.hdr -s 8.79739 p115.hdr -s 10.3087 p116.hdr -s 12.6263 p117.hdr -s 16.4565
p118.hdr -s 22.6238 p119.hdr -s 31.9131 p120.hdr -s 41.3573 p121.hdr -s 36.2196 p122.hdr -s 25.4606
p123.hdr -s 18.206 p124.hdr -s 13.4968 p125.hdr -s 10.87 p126.hdr -s 10.6187 p127.hdr -s 9.24827
p128.hdr -s 8.69842 p129.hdr -s 9.03493 p130.hdr -s 10.3831 p131.hdr -s 13.2038 p132.hdr -s 18.6265
p133.hdr -s 29.4887 p134.hdr -s 43.2829 p135.hdr -s 32.612 p136.hdr -s 20.4952 p137.hdr -s 13.678
p138.hdr -s 13.1981 p139.hdr -s 11.1899 p140.hdr -s 12.8601 p141.hdr -s 19.2883 p142.hdr -s 27.1508
p143.hdr -s 19.9292 p144.hdr -s 16.5438 p145.hdr > f10-38.hdr
```

Using **dctimestep**

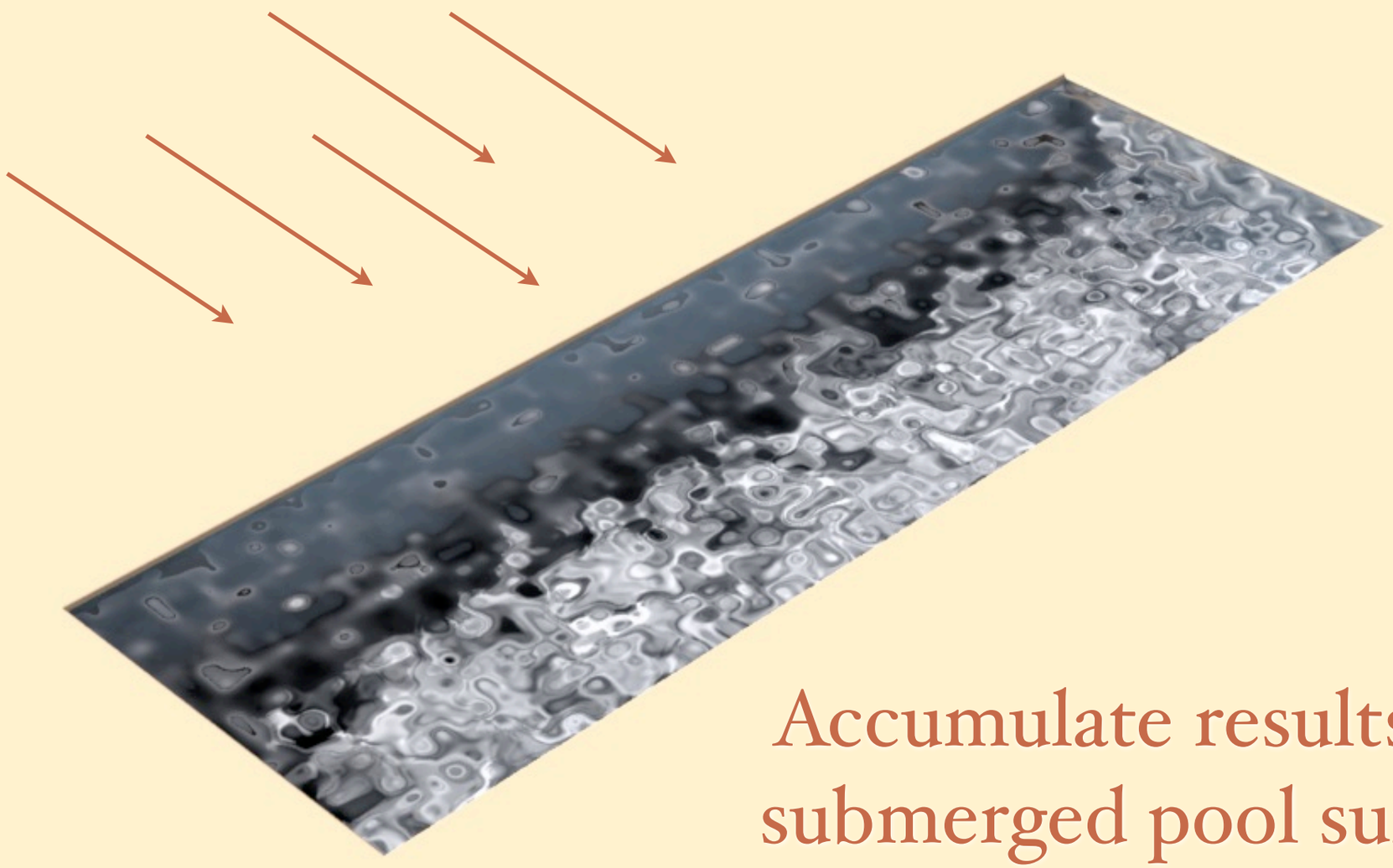
```
dctimestep p%d.hdr pval.dat > f10-38.hdr
```

Much faster!

This didn’t exist when the animation was done.

Computing Caustics (1)

Send rays from "sun"



Accumulate results on 5 submerged pool surfaces

Computing Caustics (2)

```
vwrays -pj .6 -vf pool_par.vf -x 500 -y 500 -ff \
              | rtcontrib -w -ffc -c 0 \
                          -f pool_coords.cal -o %s_caustics.pic \
                          -b floor_bin -bn 7500 -x 50 -y 150 -m floor \
                          -b s_wall_bin -bn 1500 -x 50 -y 30 -m s_wall \
                          -b n_wall_bin -bn 1500 -x 50 -y 30 -m n_wall \
                          -b e_wall_bin -bn 4500 -x 150 -y 30 -m e_wall \
                          -b w_wall_bin -bn 4500 -x 150 -y 30 -m w_wall \
                          catchscene.oct
```

Accumulate results

---

part of pool_coords.cal

```
        { south wall bins }
SWallXres : 50;
SWallZres : 30;
SWallWidth : 5 {meters};
SWallOrigX : -2.5;
SWallHeight : 3 {meters};
SWallOrigZ : -3.08;
s_wall_bin = floor(SWallXres*(Px - SWallOrigX)/SWallWidth) +
   floor(SWallZres*(1 - (Pz - SWallOrigZ)/SWallHeight))*SWallXres;
```

Computing Caustics (3)

```
void colorpict s_wall_pat
7 red green blue s_wall_caustics.pic . (Px--2.5)/3 (Pz--3.08)/3
0
0
```

```
s_wall_pat glow s_wall
0
0
4 5 5 5 0
```

The Care and Feeding of **rtcontrib**

- If you use **`-b`**, best to use **`-bn`** as well
- Careful where your place **`-m`** and **`-M`** options
- Tracking absolute flux values using **`-c`** requires careful distribution of incident rays
- Remember that contributions are triplet values
- Learn the difference between **`-V-`** and **`-V+`**
- Options must be appropriate to pure MC

What Is Pure Monte Carlo?

- No indirect cache (**`-aa 0`**)
- Uncorrelated sampling (**`-u+`**)
- Russian roulette termination (**`-lr`** ≤0)
- Other recommended settings:
  - **`-as 0 -dt 0 -dj 0.9 -sj 1`**
- **`-lw`** setting very important: `1/#paths`

No Ambient Cache?

- **rtcontrib** needs to know at any point what contribution will ultimately be made
- Ambient values are stored and reused later in an untraceable way
- *Daysim* avoids this issue by storing daylight coefficients in each ambient value
- **rtcontrib** more general and memory-efficient

Multiprocessing in **rtcontrib**

- Supported with **-n** option, but…
- Unless there are many interactions between each ray start and each monitored surface…
- **rtcontrib** process takes much of the time
- Non-linear speedup with multiple **rtrace**'s
- Net savings come from coefficient method

Number of Open Files

- Since many components are often desired, the number of open files may be a constraint
  - Raise max. open descriptors/process:
    - `ulimit -n 1024`, or
    - `limit descriptors 1024`
  - This may still be inadequate in some cases....

Recovery Options

- If output is to binary file(s) via `-o` option, &...
- Exact command is re-issued with `-r` option,
- Then **rtcontrib** attempts to append data
- So make sure old process is dead, first!
- If `-c 0` option is in effect, sums are updated
  - very useful for progressive calculations

General Sympathy

- **rtcontrib** is one of the most difficult commands to use in *Radiance*
- It is also one of the most powerful
- Think about learning **rpict** from scratch, again
- Along with **rtrace**…
- Then multiply by a factor of 2 or so

Please Ask

- Inquiries and suggestions are welcome
- There is much to be gained, but that first step…
- Axel Jacobs' tutorial is an excellent start
- Don't be shy about using the mailing list

Questions?