

New Developments at Solemma in Handling Common Radiance Bottlenecks

@24th International Radiance Workshop

Presentation: J. Alstan Jakubiec

Solemma Team: Jon Sargent, Stephen Wasilewski, Timur Dogan, Violeta Lialios-Bouwman, Demi Chang, Violetta Jusiega, Christoph Reinhart

Who is Solemma?

We are an international group of designers, building scientists, educators and environmental performance consultants dedicated to crafting tools using cutting edge, research-validated methods.

Our mission is to deliver software that solves the evolving challenges of designers, creates innovations which prioritize the health and productivity of people, and positively impacts the long-term sustainability of our planet.



What is ClimateStudio?

A Radiance-based daylight simulation tool that aims to be:

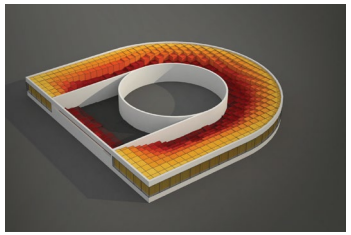
- Exceptionally fast,
- Accurate,
- Handle complexity, and
- Easy to use.

Also an EnergyPlus-based thermal simulation tool which is not included in this presentation.

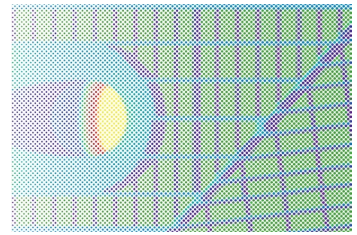


2012: MIT, Cambridge

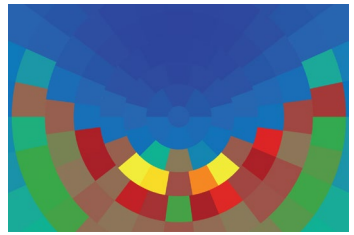
DIVA 1.0



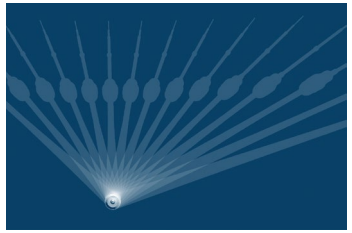
2013: Thornton Tomasetti, NYC
DIVA 2.0



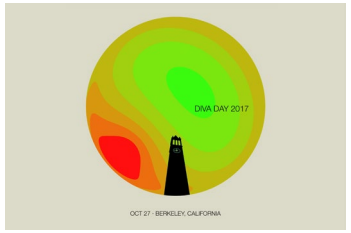
2014: City Hall, Seattle
DIVA 3.0



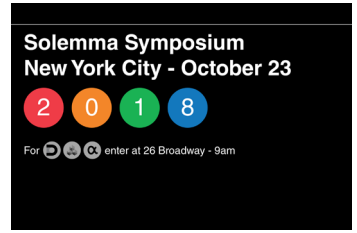
2015: Architectural Association



2016: University of Toronto
DIVA 4.0



2017: Berkeley, California
ALFA



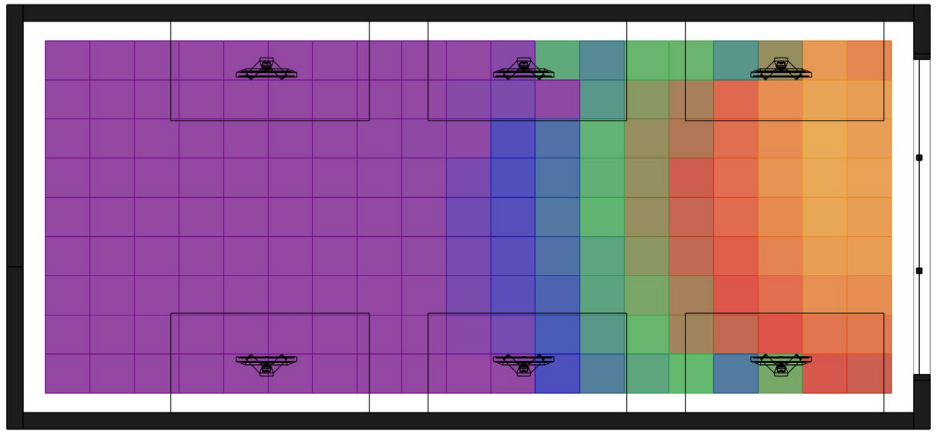
2018: Cornell, NYC



2020: HOK, Los Angeles
ClimateStudio 1.0

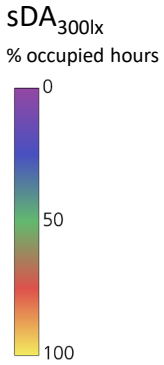
ClimateStudio Released

The past DIVA / Daysim & ambient cache simulations



1 min 26 s

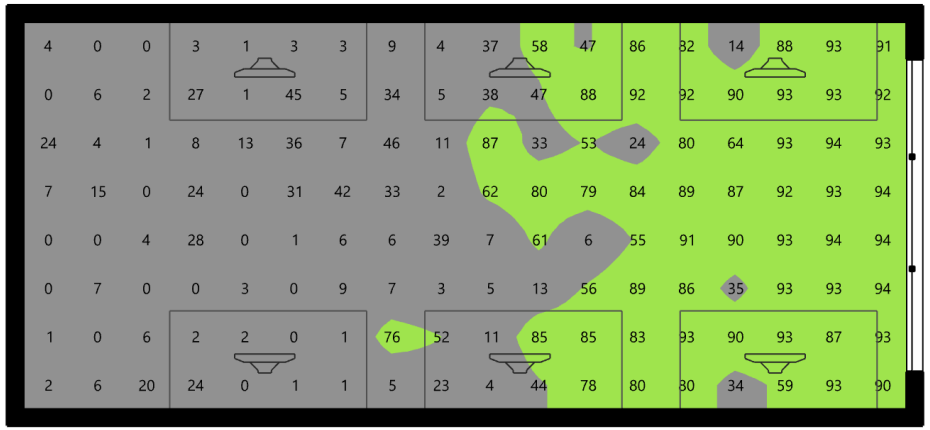
(Intel i9-11950H, single core)



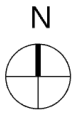
-ab 6 -aa 0.1 -ad 256 -as 512 -ar 100 -lw 0.004

All rays in a single command, wait until completion.

ClimateStudio 1.0 Procedural ray pass calculations







00.5 SECONDS

1 PASS

40

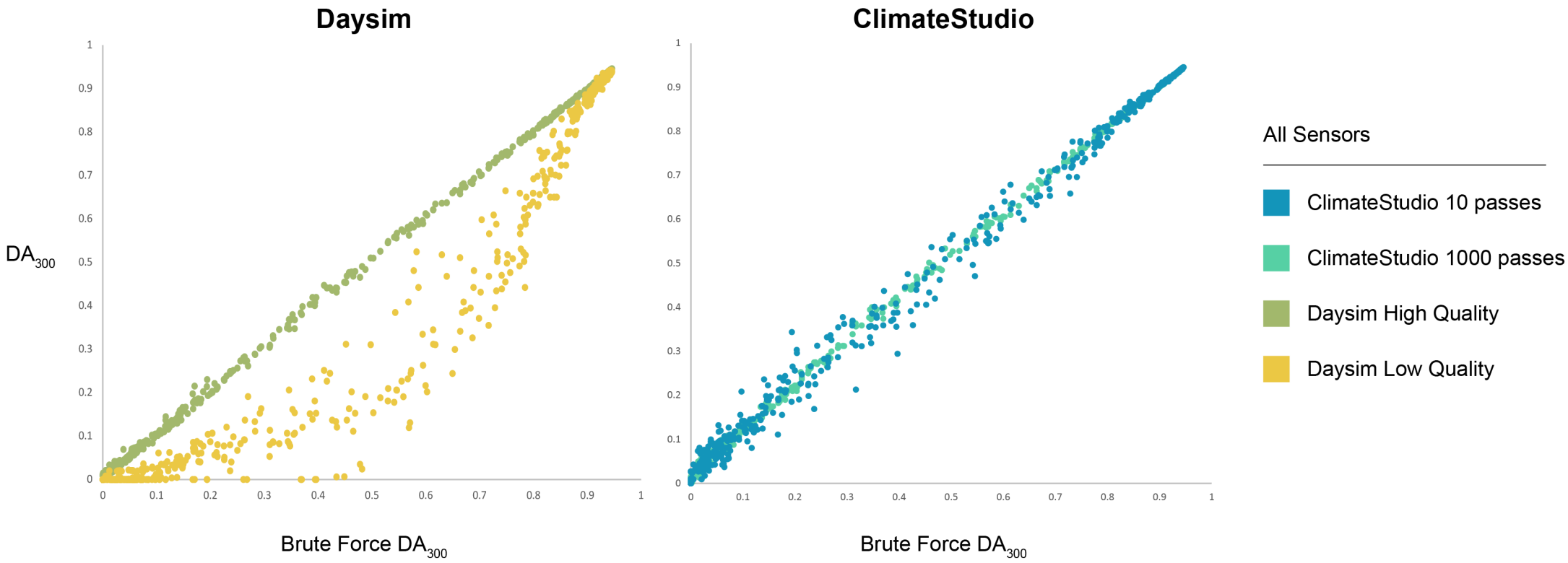
sDA

95% Confidence Interval

-ab 6 -aa 0 -ad 1 -lw 0.0001

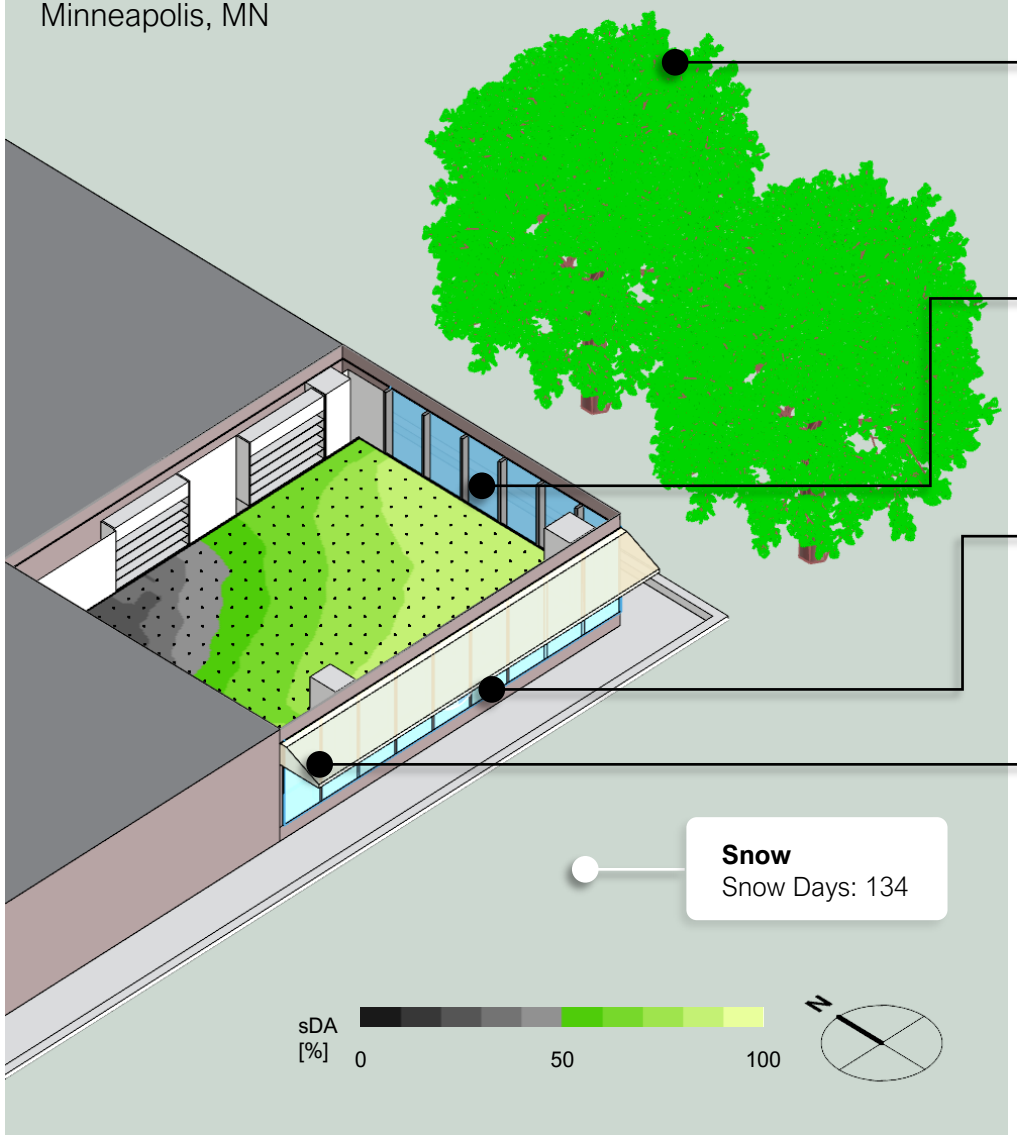
64 rays / pass

ClimateStudio 1.0 Annual validation

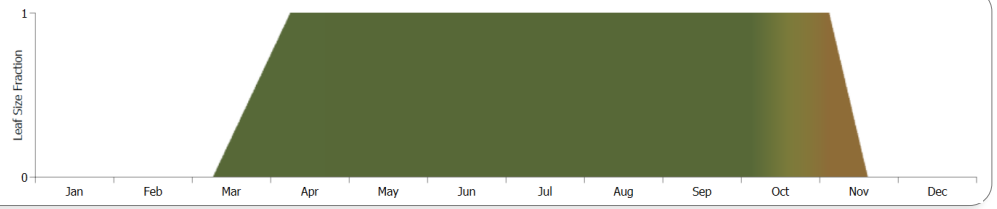


Complexity Dynamic objects and dynamic lighting (2024)

Corner Office: + Deciduous Trees
Minneapolis, MN

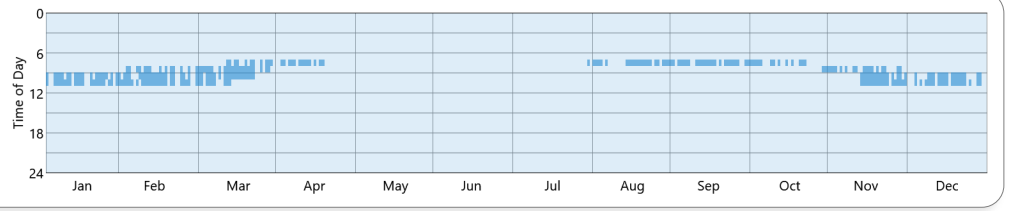


Fraxinus Americana
Mar 11 – Nov 20



East Shade
LM-83
Time Open: **91%**

closed open



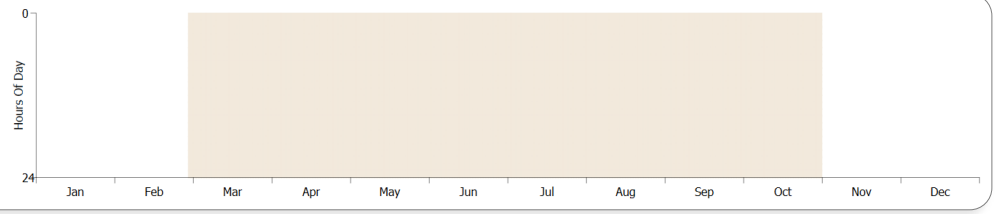
South Shade
LM-83
Time Open: **79%**

closed open



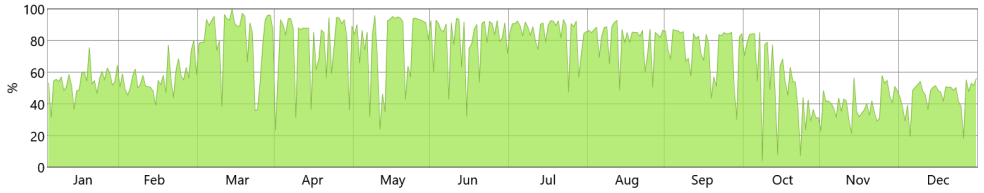
South Awning
Mar - Oct

material present



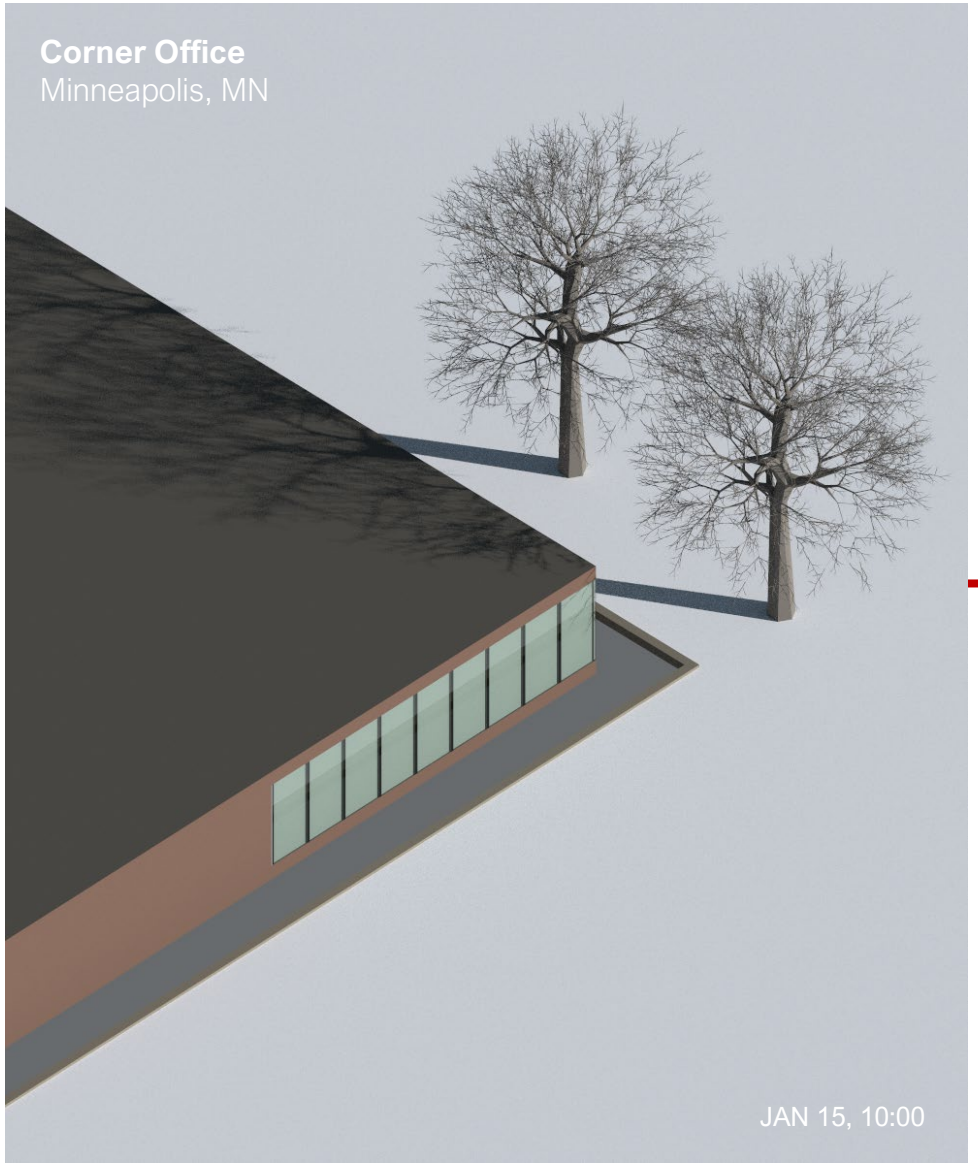
sDA **81.3%**

mean daylit area



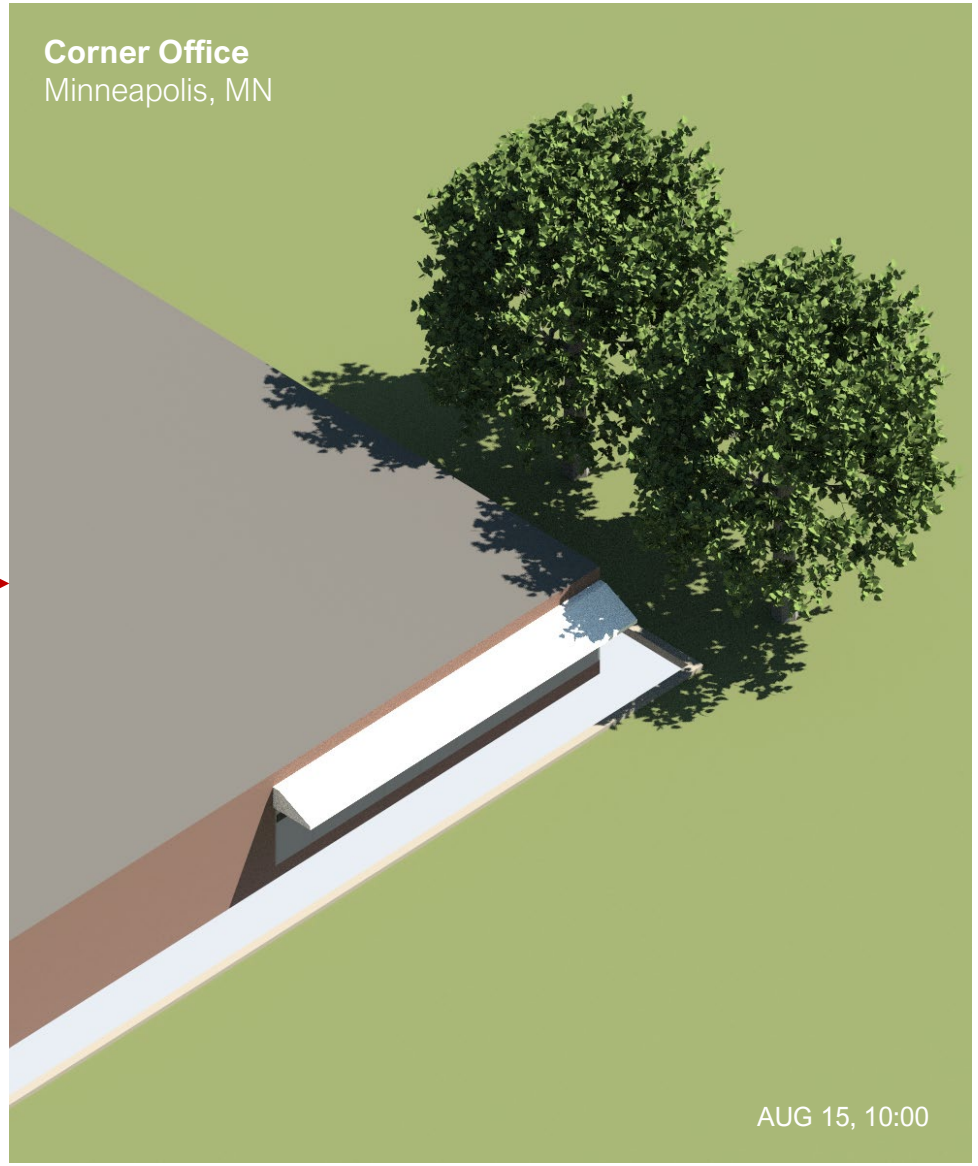
SOLEMMA

Complexity Dynamic objects and dynamic lighting (2024)



from to

In a single, annual CBDM simulation



Take a look at some ClimateStudio speed-ups in lighting simulation

1. **Addressing oconv and simulation startup bottlenecks**

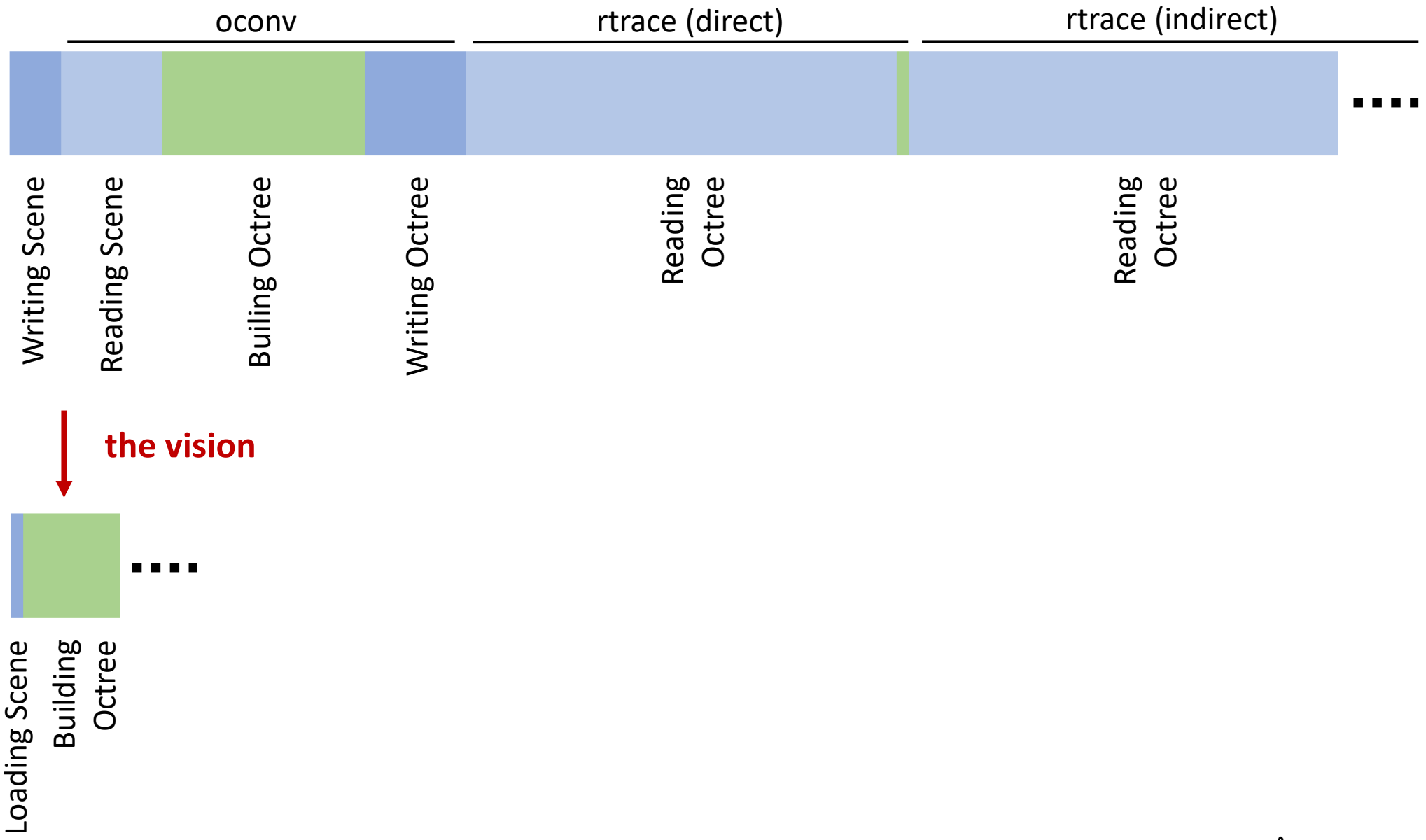
2. **IES / electric lighting simulation speed ups**

3. **Path tracing multi-threading changes in ClimateStudio 2.5**

Addressing oconv and simulation startup bottlenecks



Stephen Wasilewski



ClimateStudio ≤2.4

Radiance on the command line passes information via standard I/O…

```
scene$ oconv scene.rad > scene.oct
scene$ cat rays | rtrace scene.oct > results
```

… ClimateStudio effectively did the same thing

Which limited how we could pass, store, and reuse information

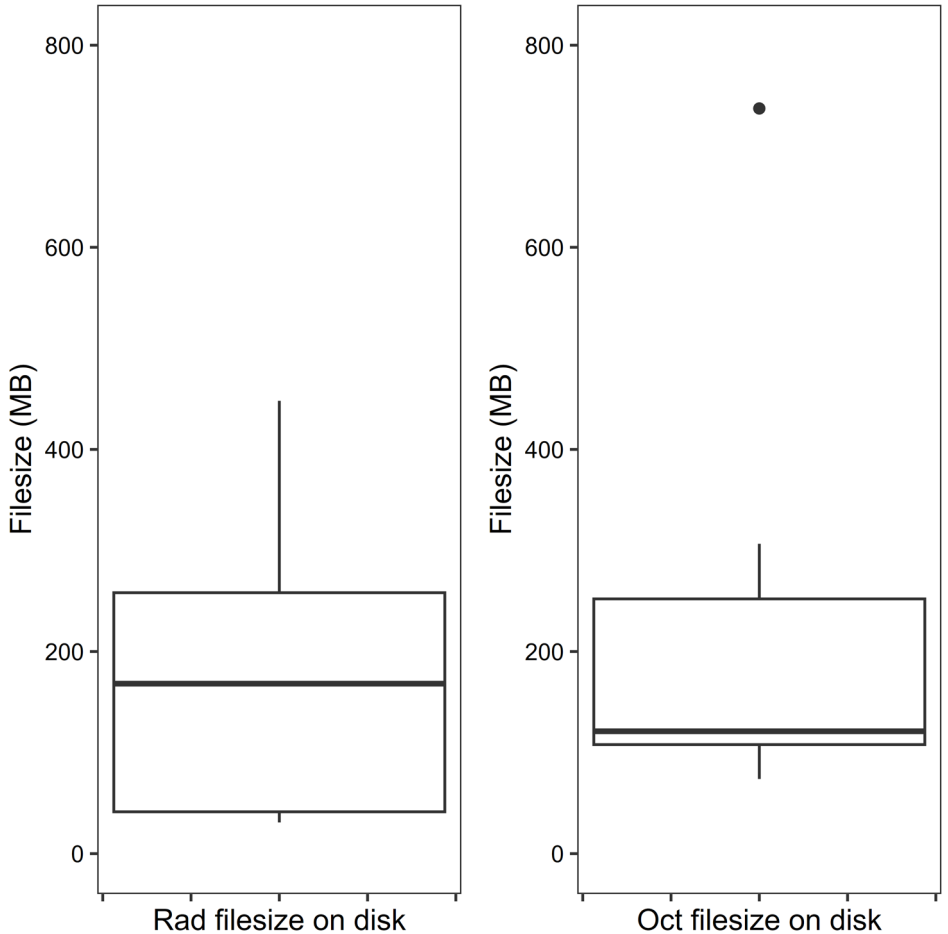
ClimateStudio ≥2.5

Now we can directly interface with radiance and maintain a global scene state.

```
LoadRadScene(); // copy CS model to radiance object structure
BuildOctree(MaxCPUThreads); // build scene acceleration structure (multi-thread!)
...
double[] result = BasicTrace(rays, thread); // traces some rays
```

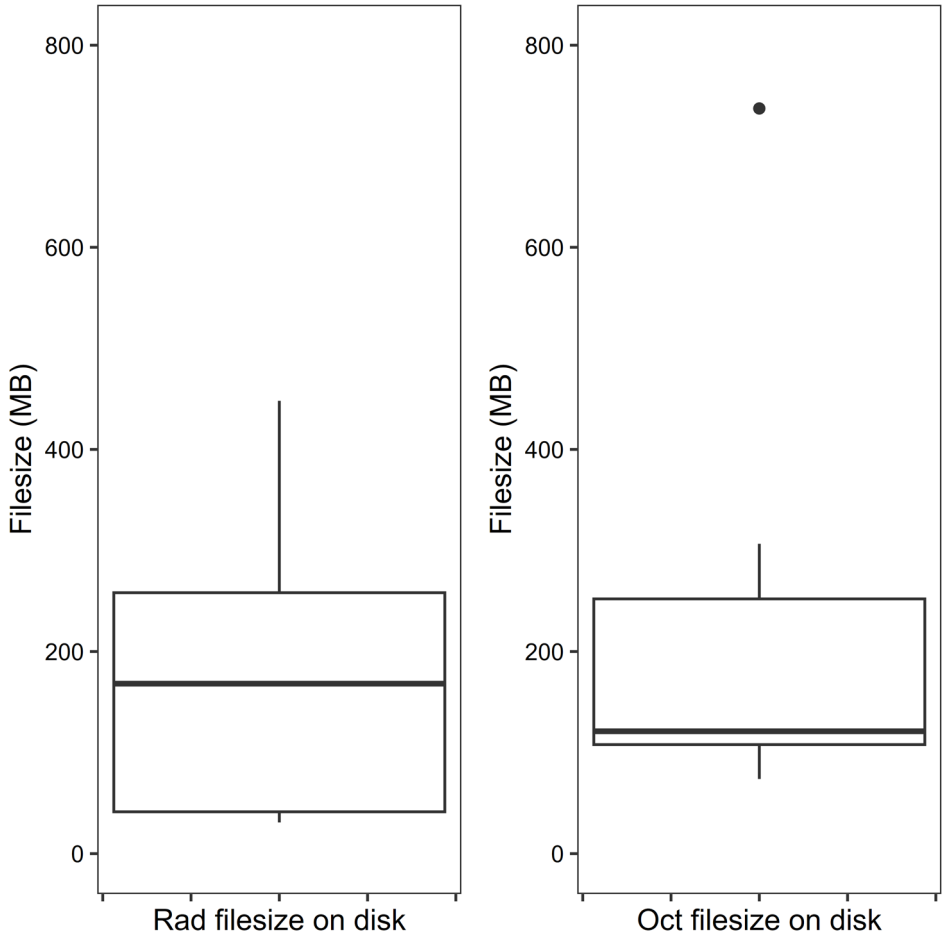
Our API can make multi-threaded calls, and update render settings and sources within the same scene.

Demonstration Oconv and simulation startup time

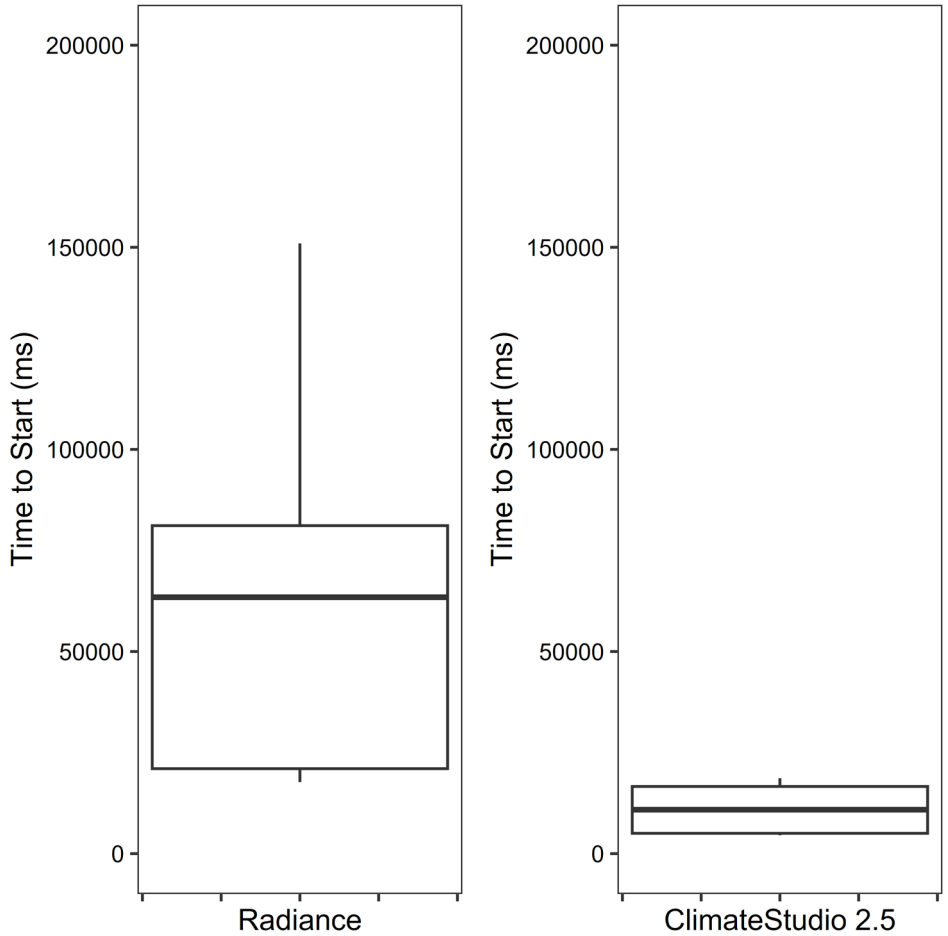


9 large .rad files / models for testing

Demonstration Oconv and simulation startup time



9 large .rad files / models for testing

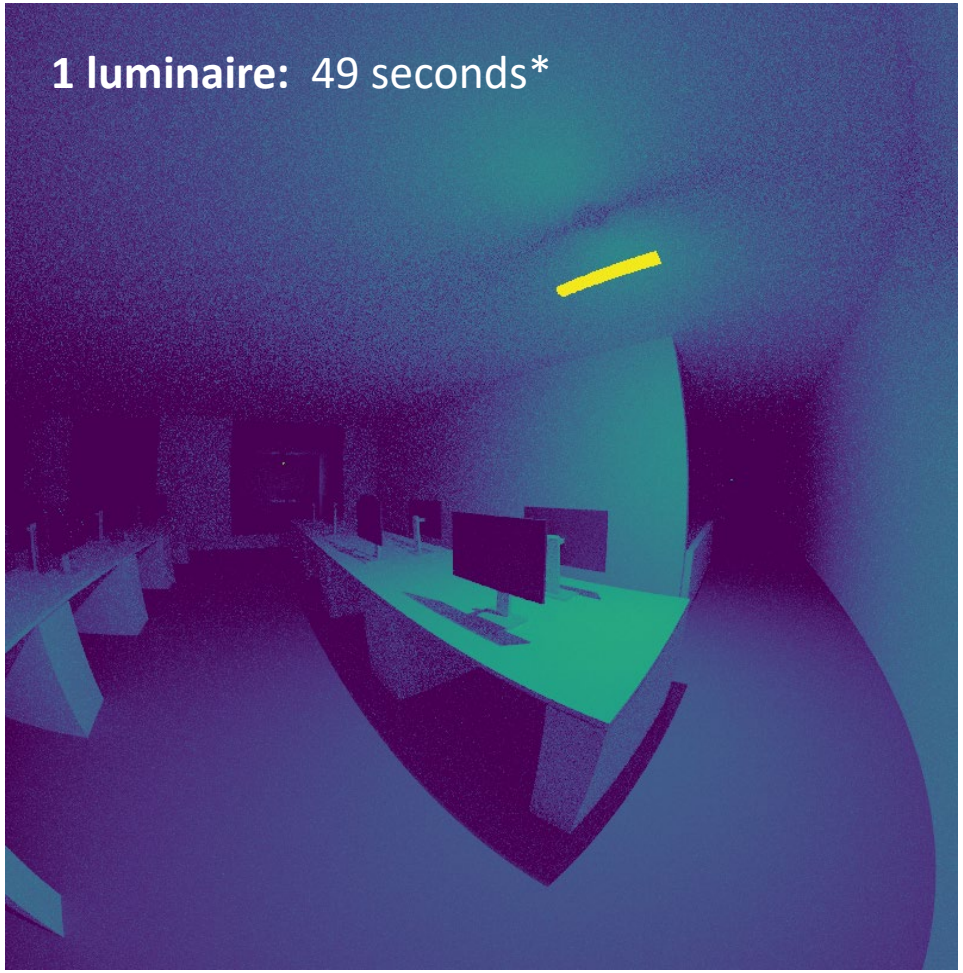


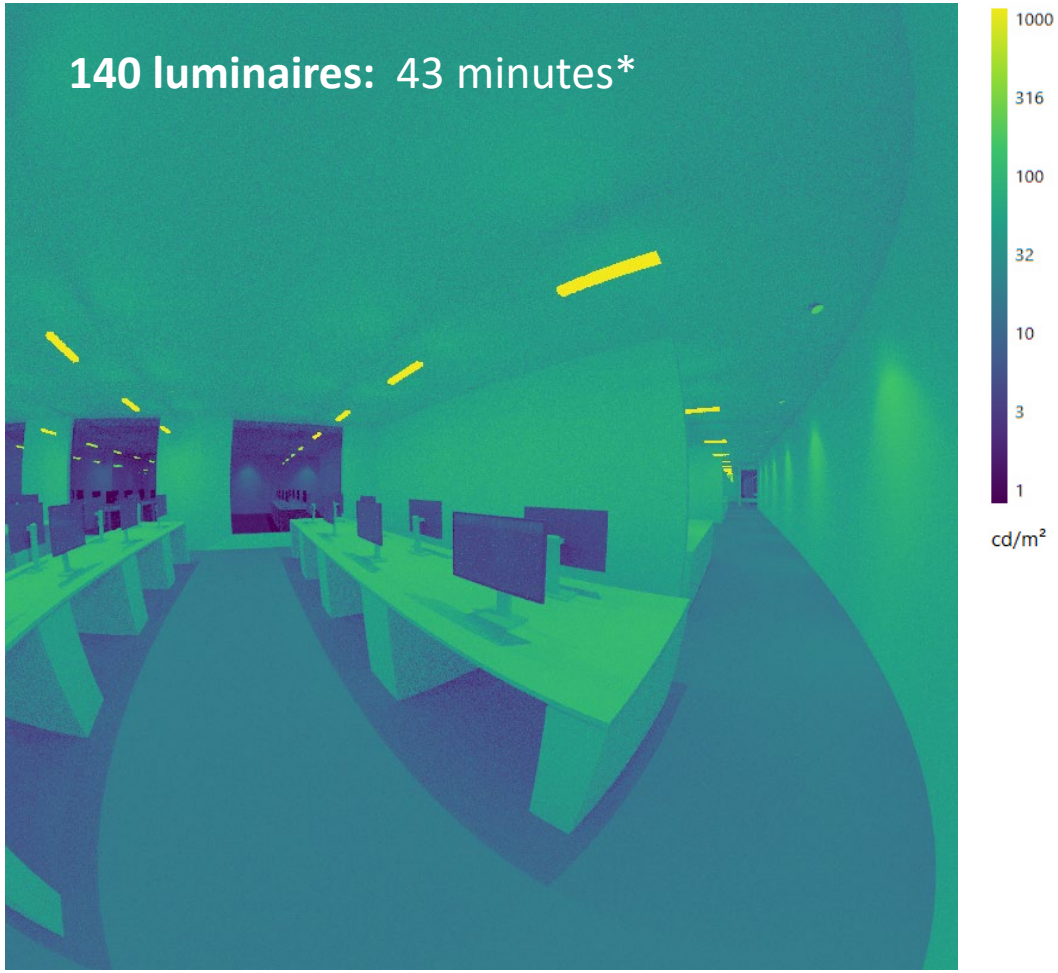
Time consumed by oconv + rtrace startup
in a CBDM calculation

IES / electric lighting simulation speed ups



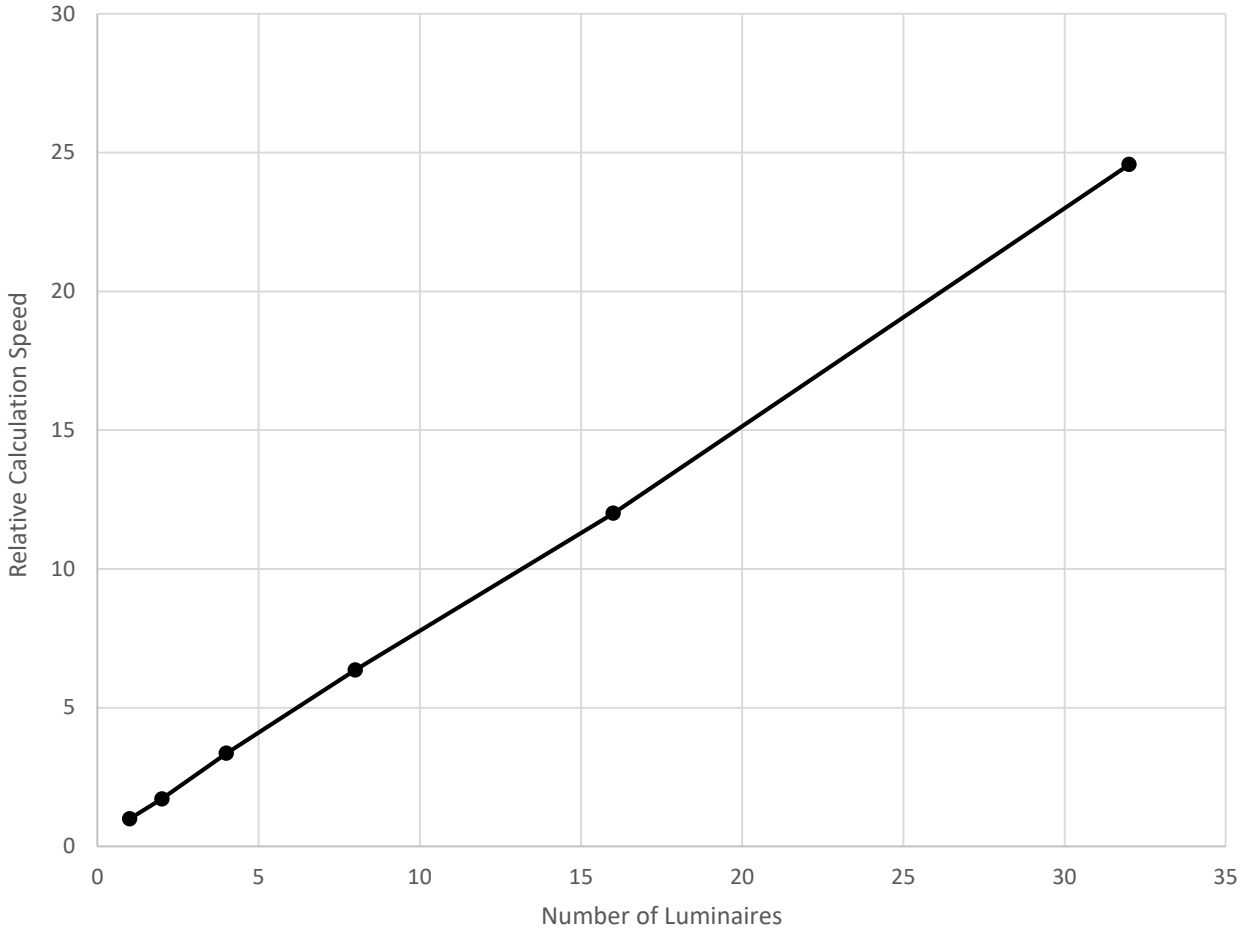
Jon Sargent





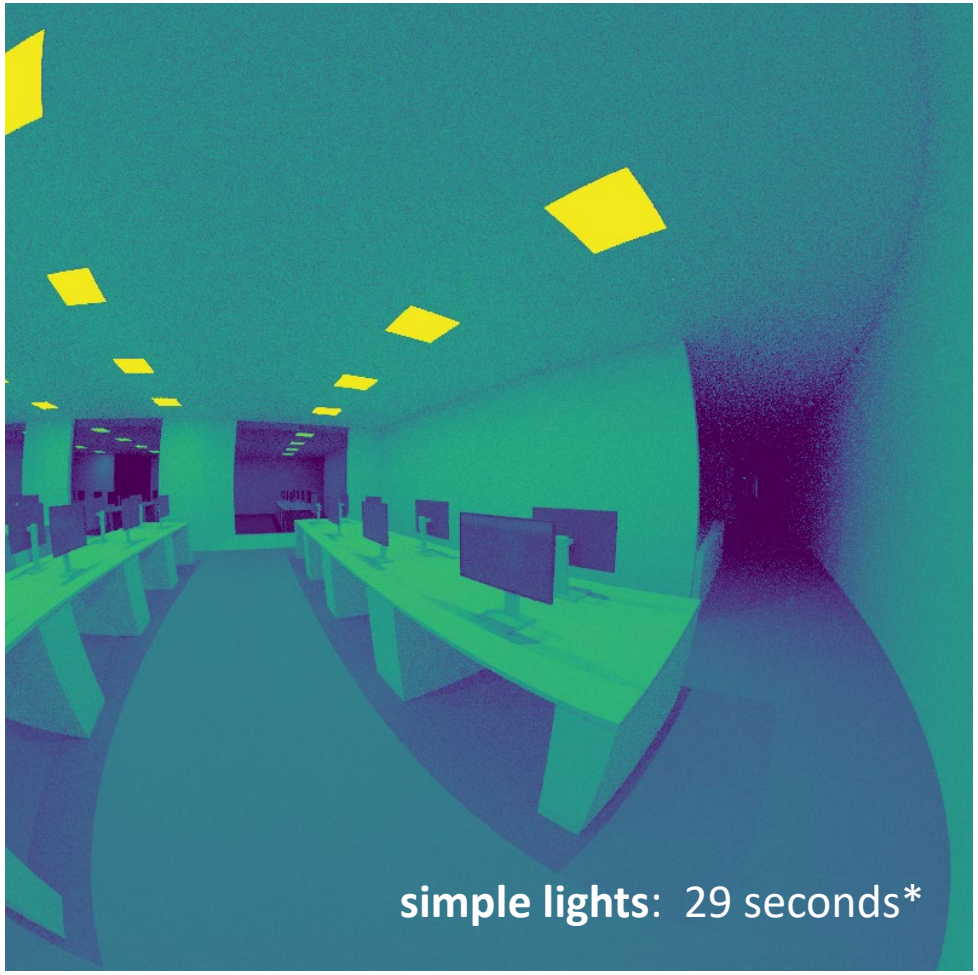
**rtrace –ds 0 –dj 0 (10 spp, 16 CPU cores)*

IES / electric lighting simulation speed ups



**Result shown for luminaires within a single room.*
Slowdown depends on numerous variables -- including luminaire placement – but time always increases with fixture count.

Causes – Brightdata function is slow



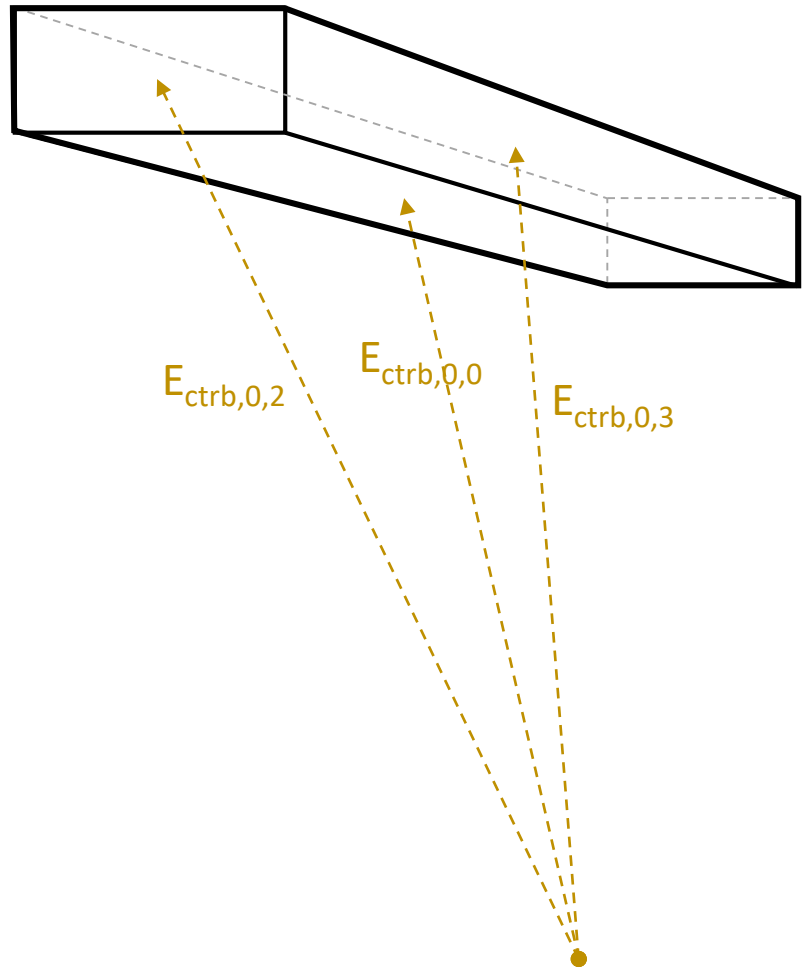


**rtrace –ds 0 –dj 0 (16 lights, 10 spp, 16 CPU cores)*

Causes – IES2RAD produces many sources

2) **Multiple “sources” per luminaire**

Radiance does a separate lookup for each, no matter how far away!

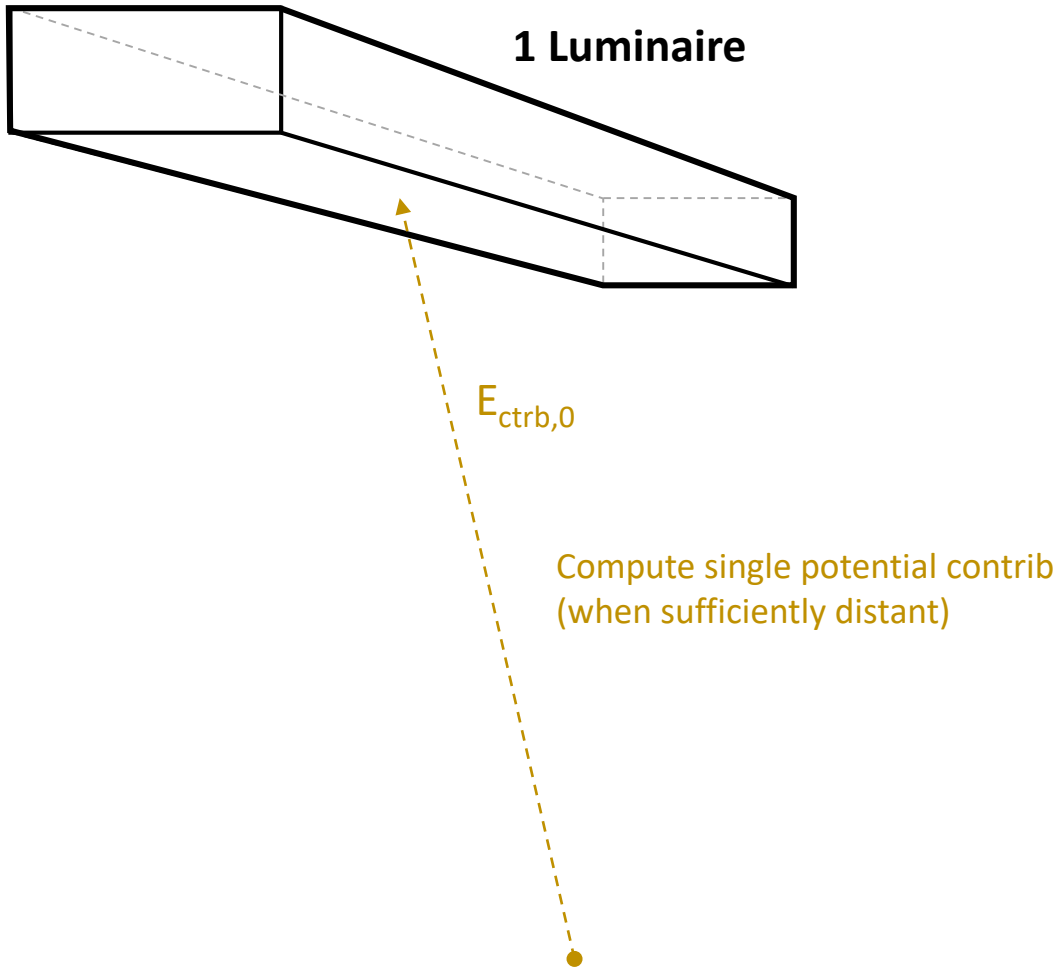


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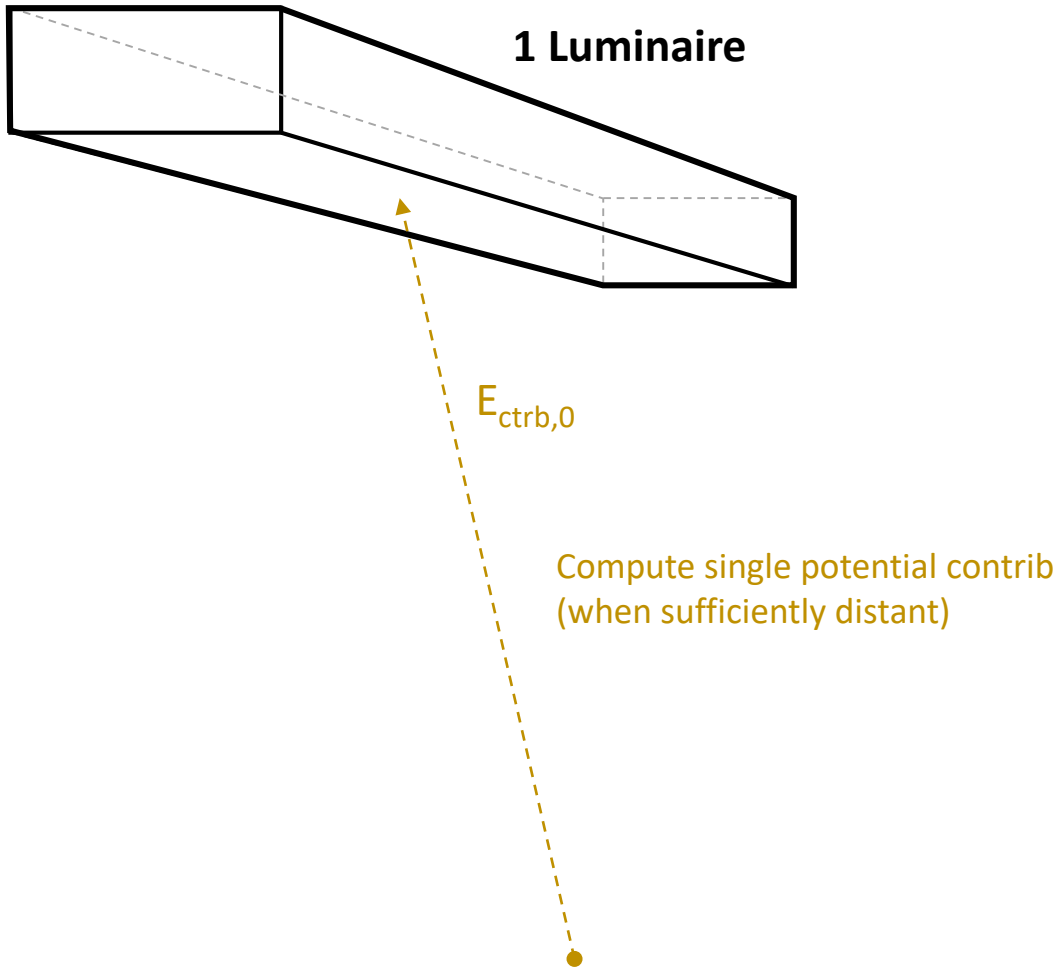
SOLUTION: Multi-face LUMINAIRE source.



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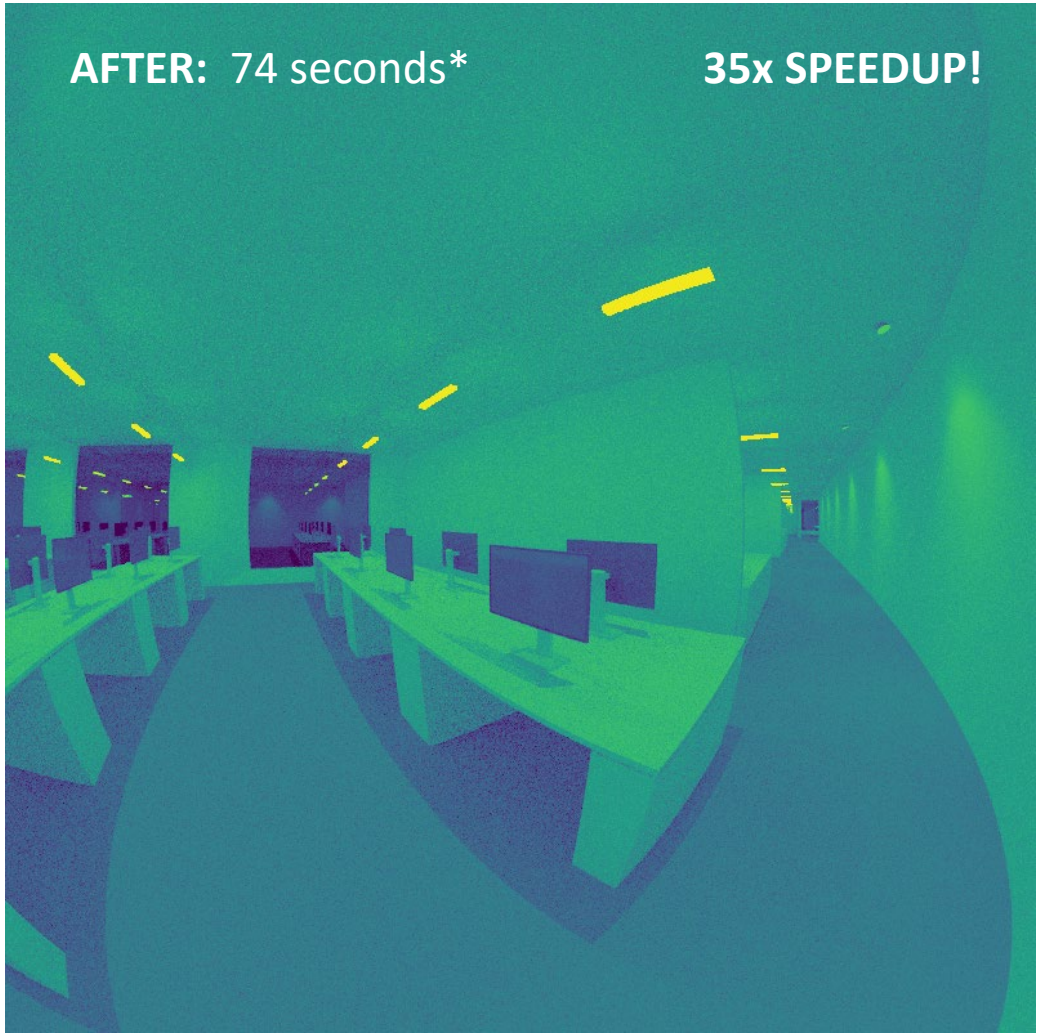


SOLUTION: Multi-face LUMINAIRE source.

AND don’t trace a shadow test to every luminaire for each ray / path.

Combined solutions

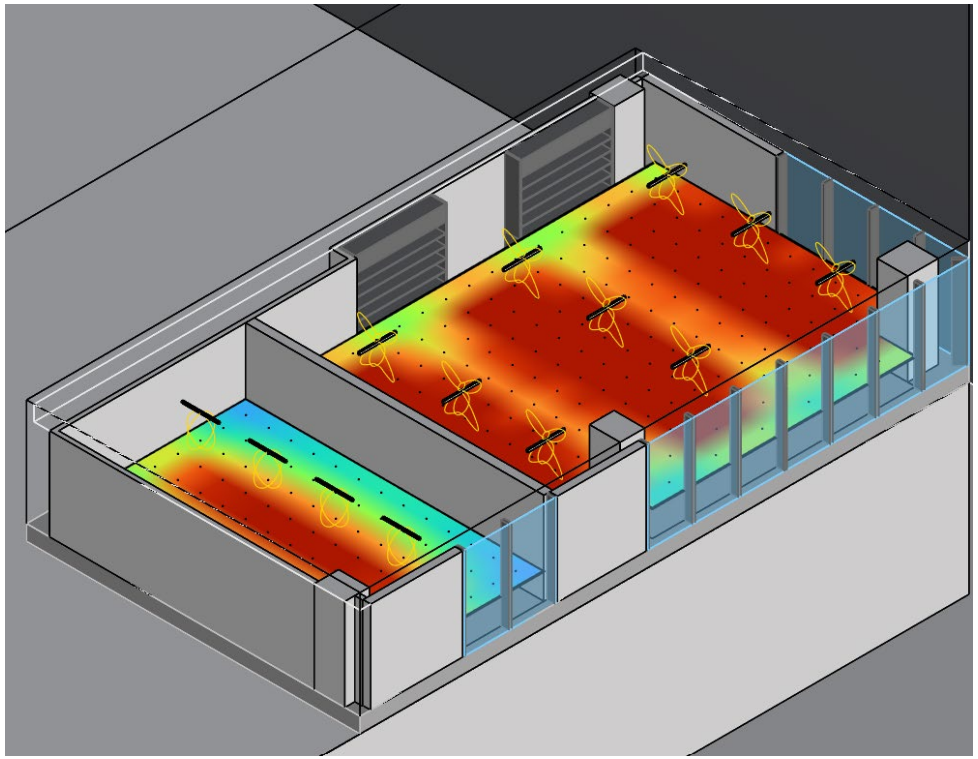




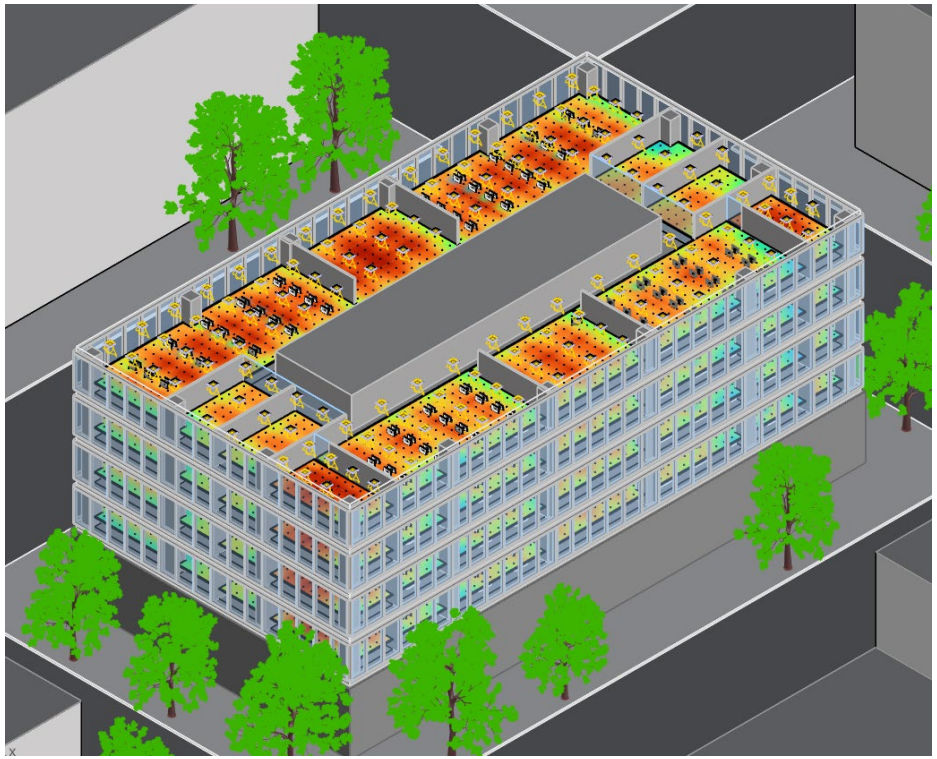


rtrace –ds 0 –dj 0 (10 spp, 16 CPU cores)

Benchmarking



Small model
13 luminaires / 22 sources

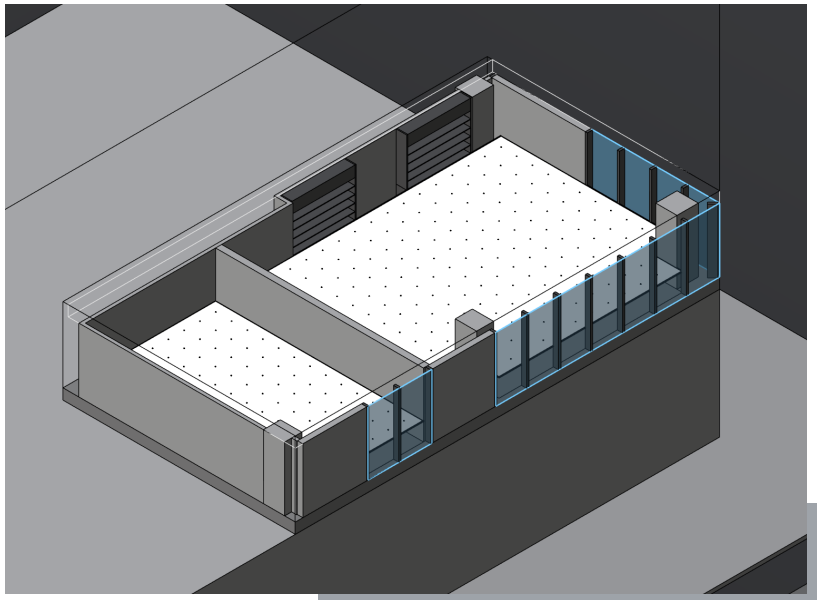


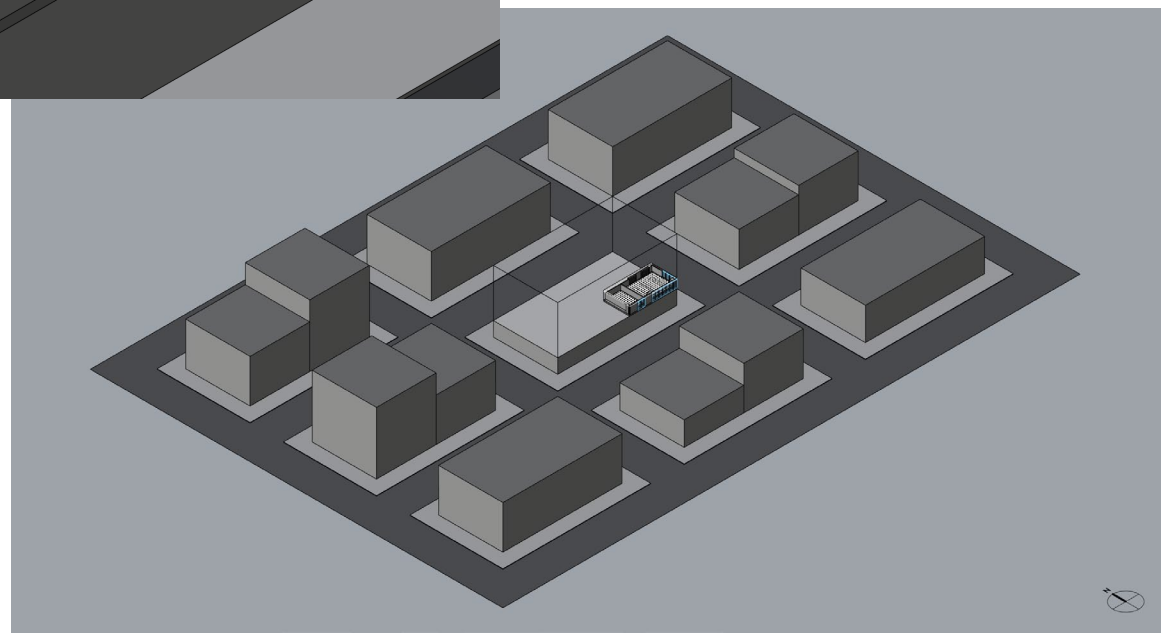
Medium model
544 luminaires / 544 sources

0 500

illuminance (lx)

Test Models Small

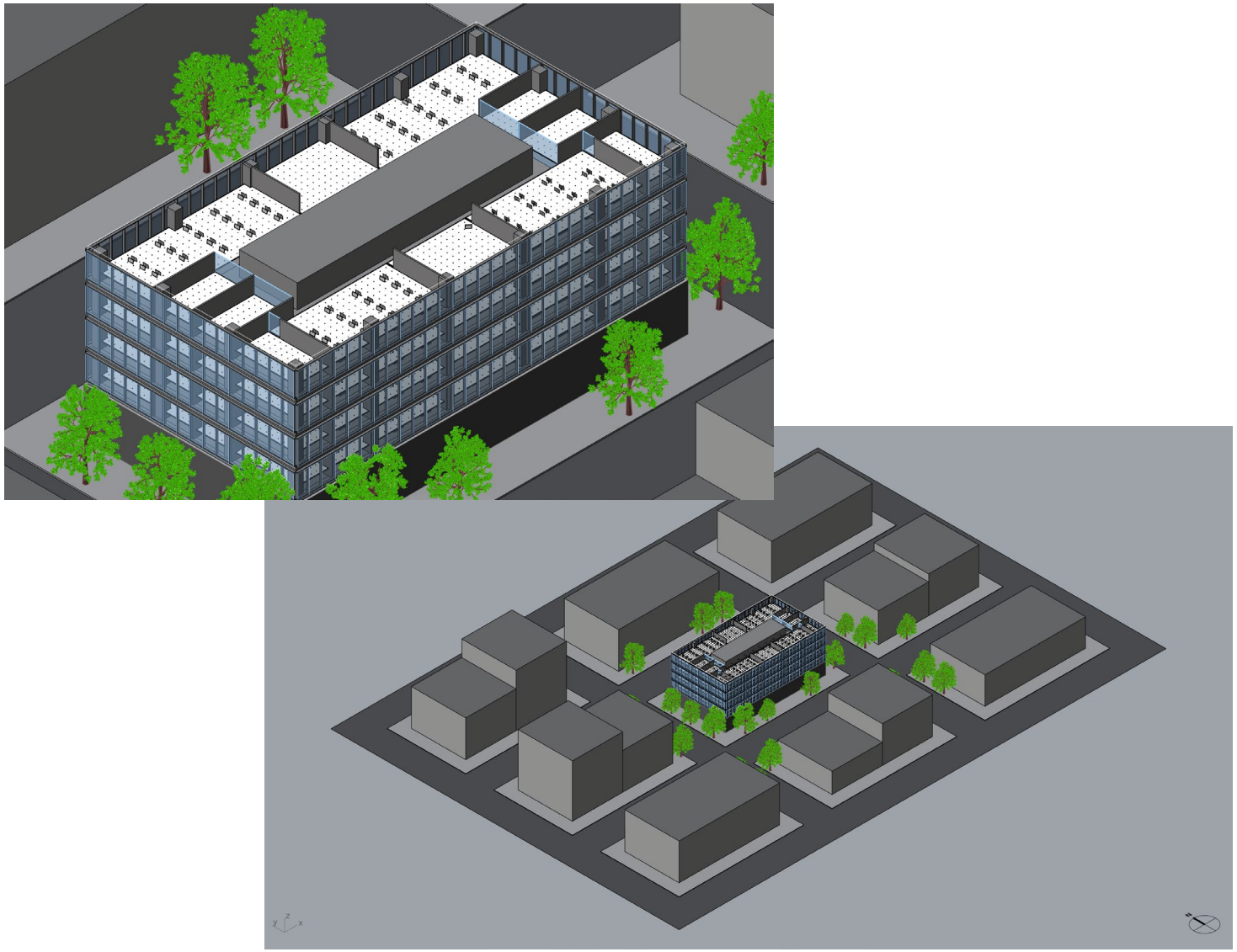




- Objects in octree: 686
- Octree Filesize: 0.11 MB
- Sensors: 315
- Bounding box: 242 m · 173 m · 26 m

Small sample model

Test Models Medium



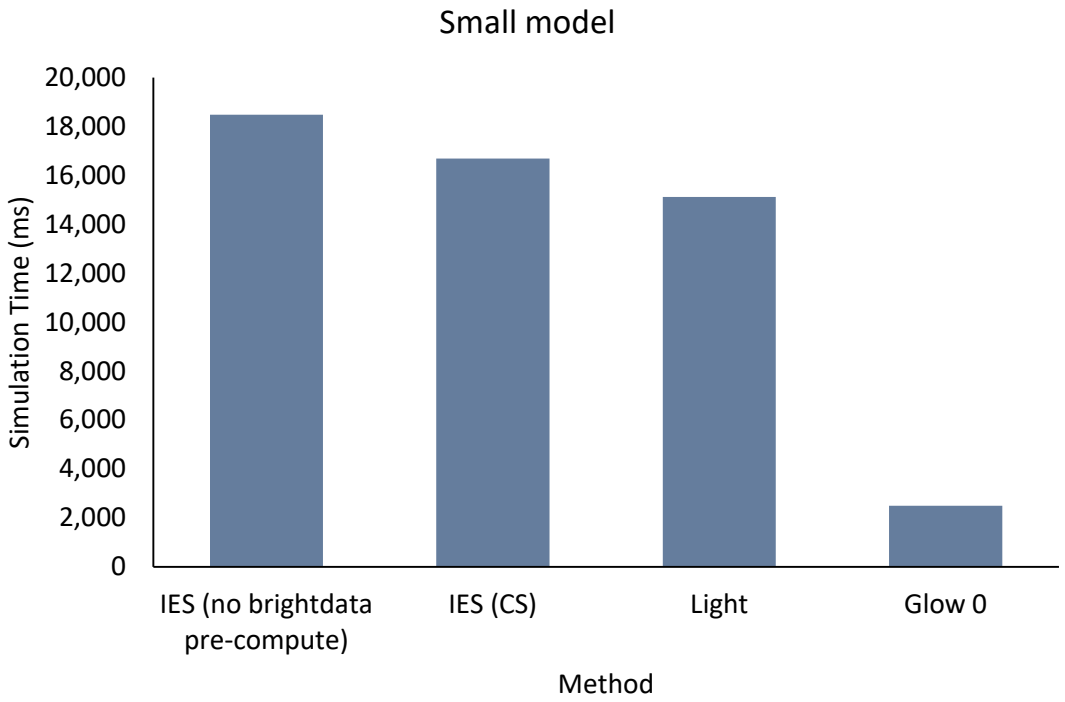
- Objects in octree: 2,549,428
- Octree Filesize: 3.99 MB
- Sensors: 5,808
- Bounding box: 242 m · 173 m · 26 m

Medium sample model

Benchmarking threaded lighting calculations (rtrace)

Rays with `-aa 0 -lw 0.0001` × 4,096 times / sensor

Laptop computer / AMD Ryzen AI 7 Pro 360 (8 core)

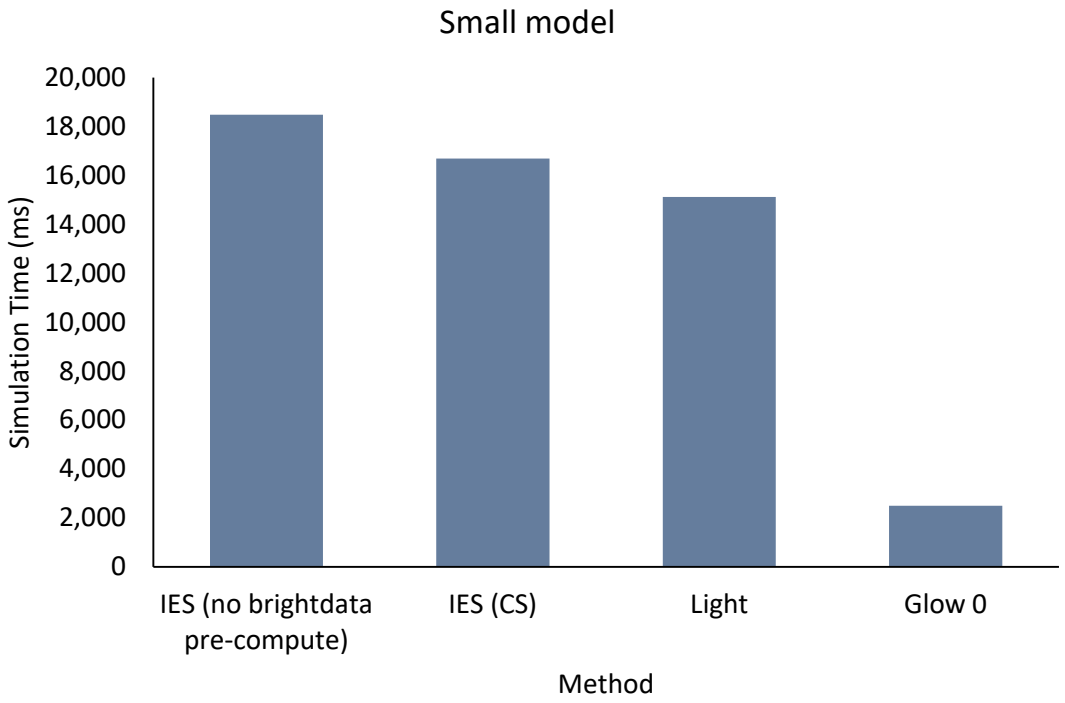


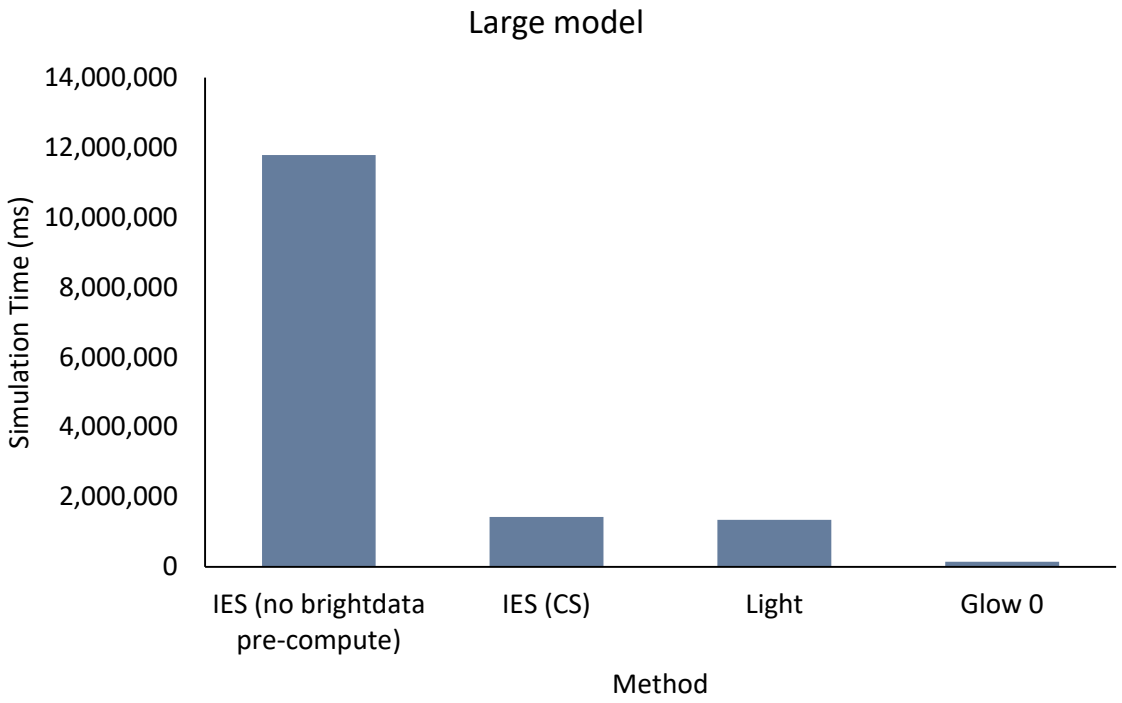
IES overhead is not very large for a model with few luminaires.

Benchmarking threaded lighting calculations (rtrace)

Rays with `-aa 0 -lw 0.0001` × 4,096 times / sensor

Laptop computer / AMD Ryzen AI 7 Pro 360 (8 core)



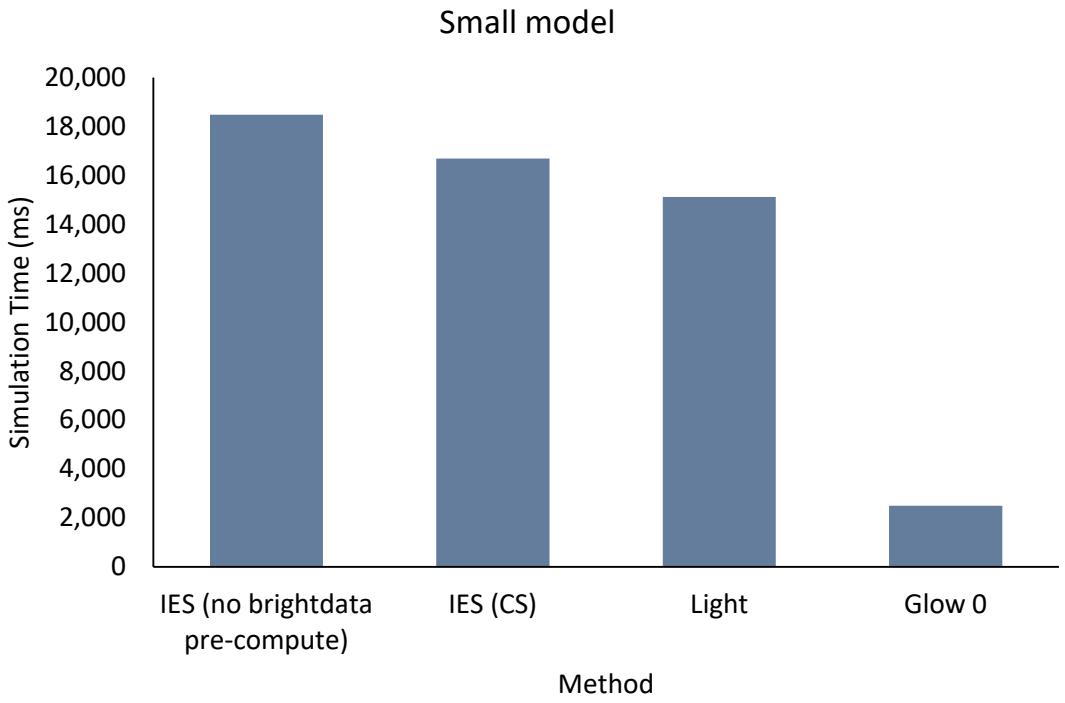


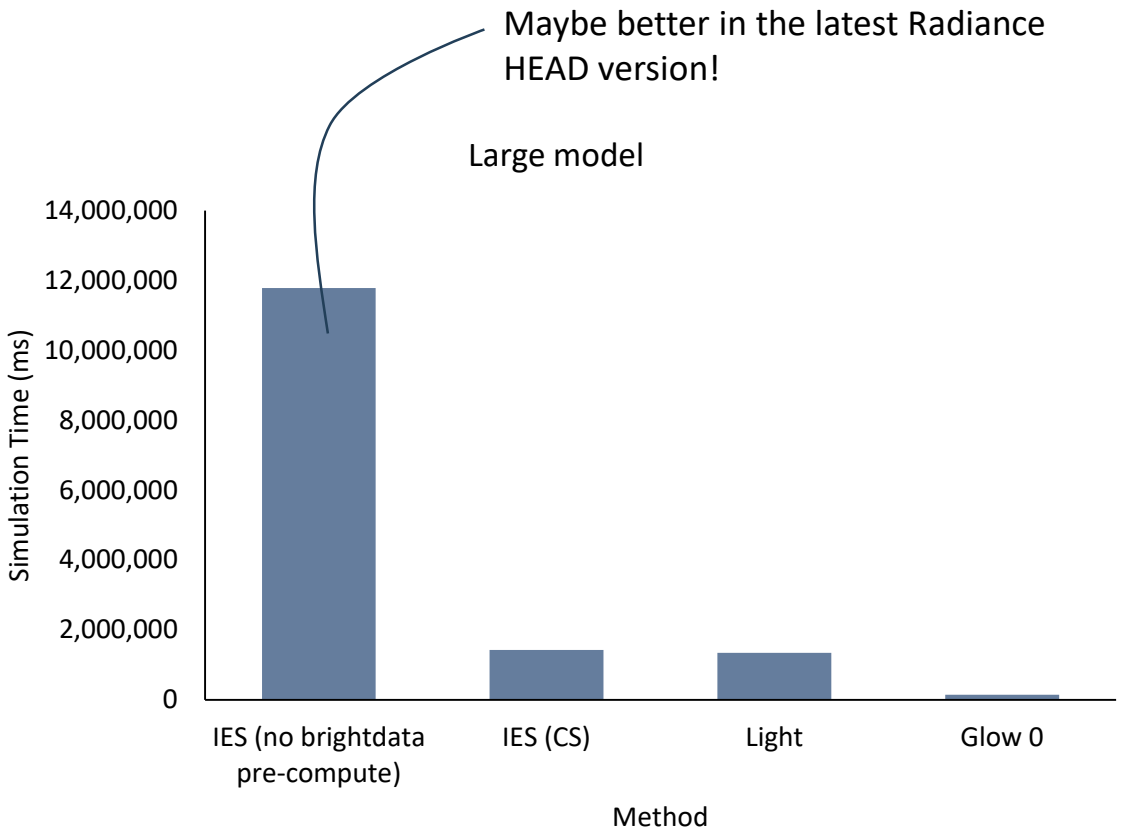
But the simulation overhead is massive for a significant amount of luminaires.

Benchmarking threaded lighting calculations (rtrace)

Rays with `-aa 0 -lw 0.0001` × 4,096 times / sensor

Laptop computer / AMD Ryzen AI 7 Pro 360 (8 core)





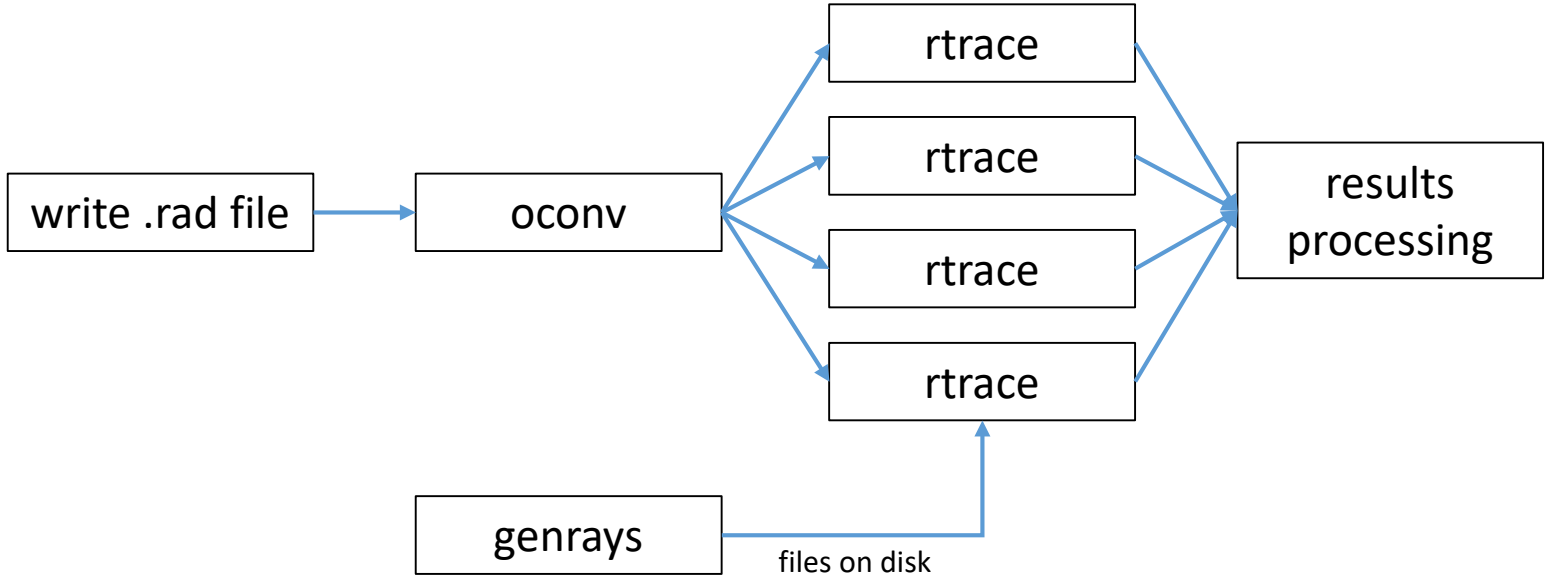
But the simulation overhead is massive for a significant amount of luminaires.

Path tracing multi-threading changes in ClimateStudio 2.5



Stephen Wasilewski

Old Windows multithreading Process

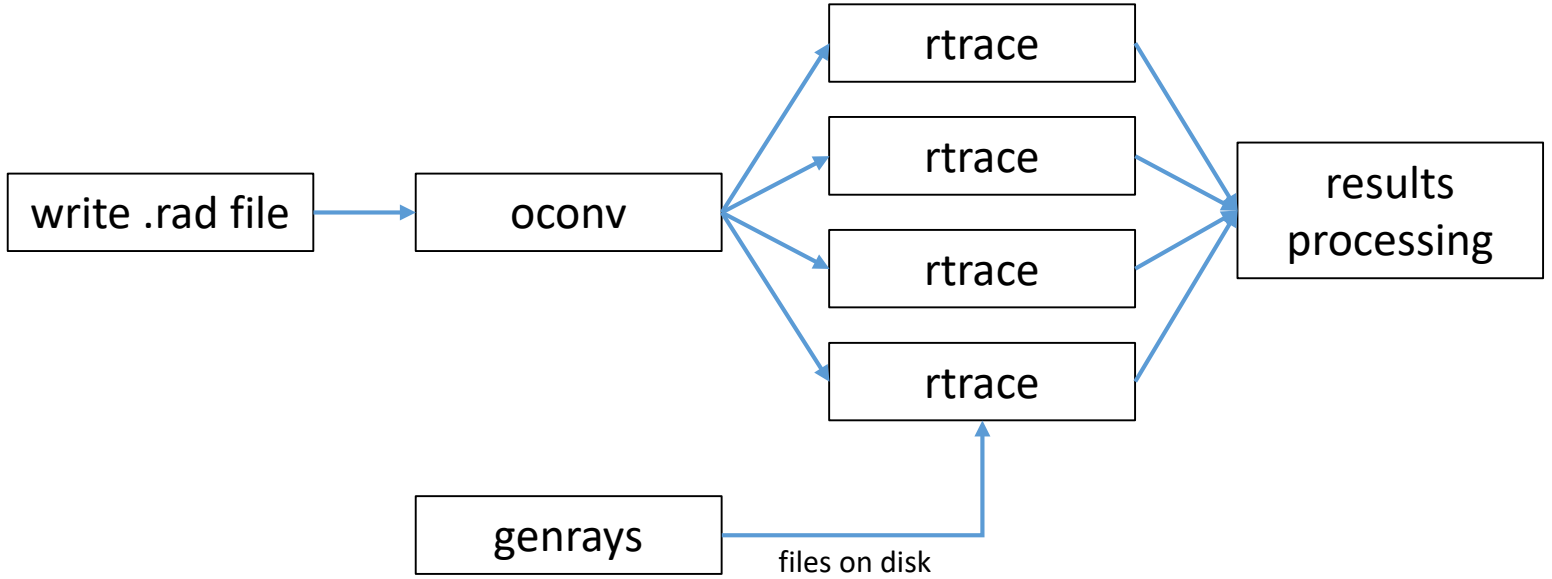


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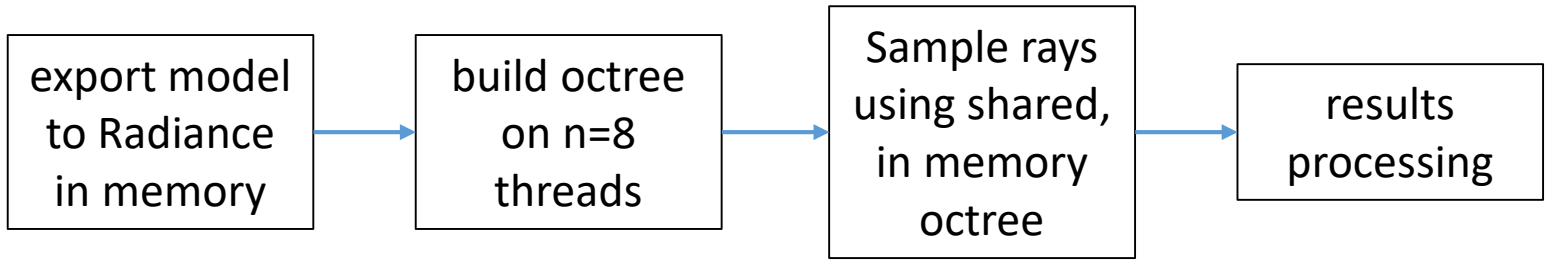


Stephen Wasilewski

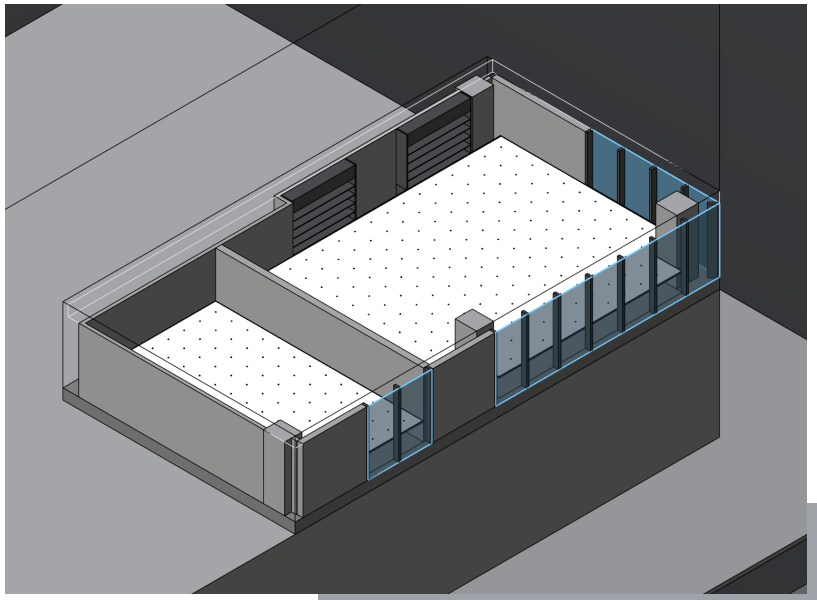
Old Windows multithreading Process

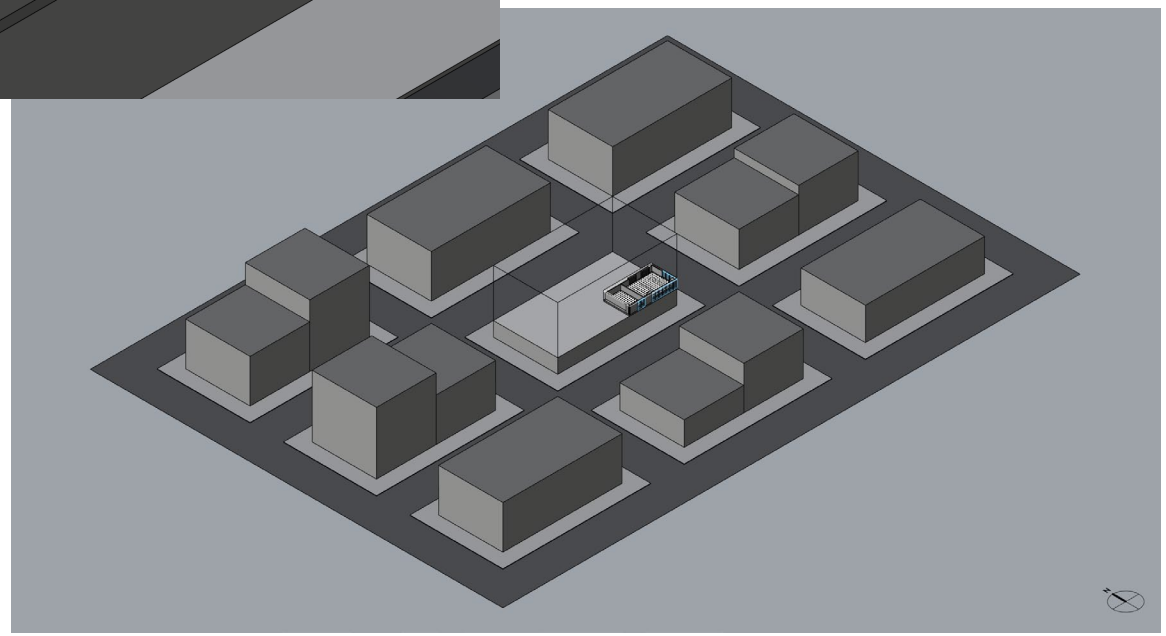


New in memory "Radiance API" method



Test Models Small

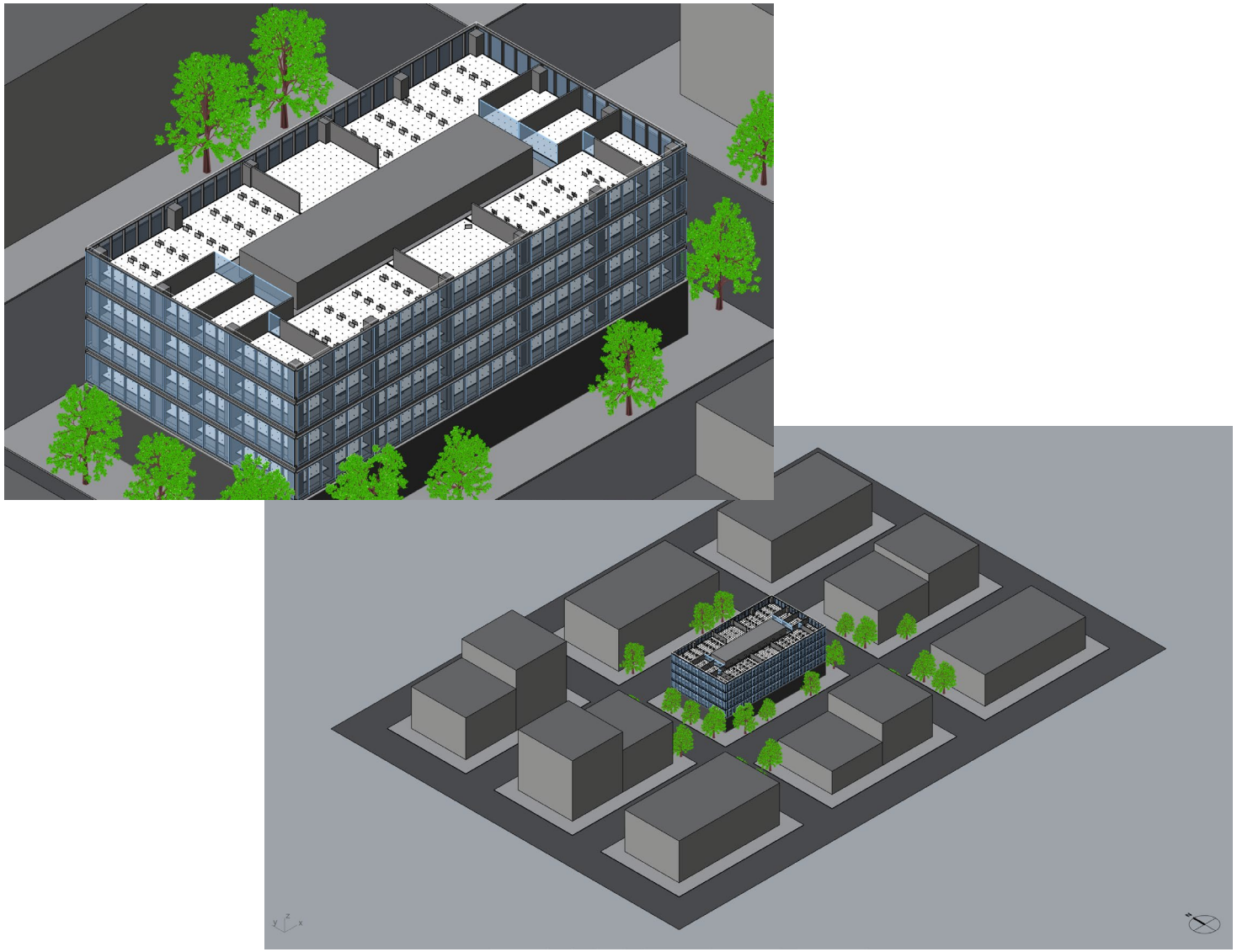




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Small sample model

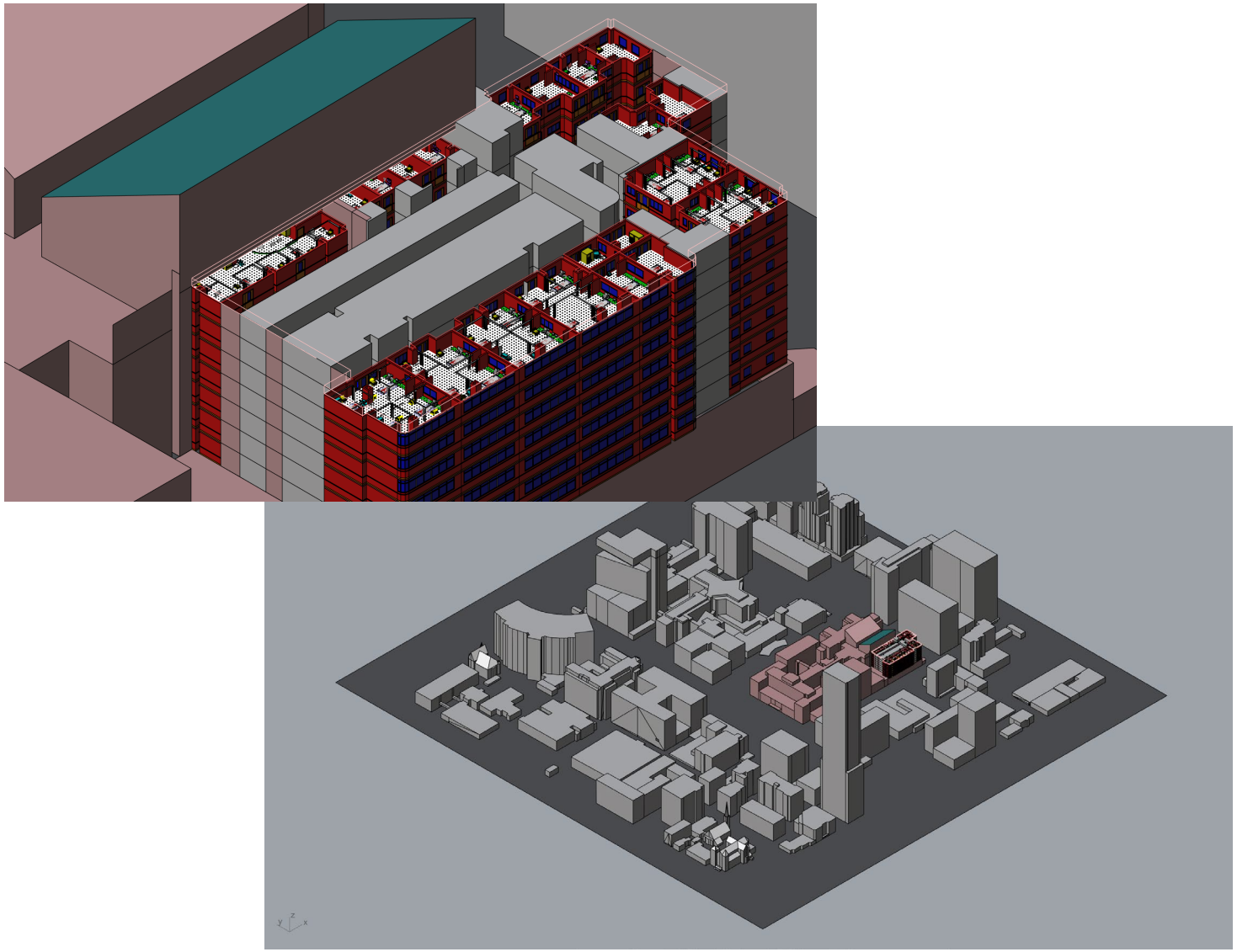
Test Models Medium



- Objects in octree: 2,549,428
- Octree Filesize: 3.99 MB
- Sensors: 5,808
- Bounding box: 242 m · 173 m · 26 m

Medium sample model

Test Models Large



- Objects in octree: 10,449,238
- Octree Filesize: 156.81 MB
- Sensors: 14,168
- Bounding box: 695 m · 734 m · 207 m

Large sample model

Memory benefits Large model

Name	Status	46% CPU	86% Memory	4% Disk	0% Network
rtrace.exe		6.2%	1,105.9 MB	0 MB/s	0 Mbps
rtrace.exe		6.2%	1,102.1 MB	0 MB/s	0 Mbps
rtrace.exe		6.2%	1,108.4 MB	0 MB/s	0 Mbps
rtrace.exe		6.2%	1,111.6 MB	0 MB/s	0 Mbps
rtrace.exe		6.1%	1,098.7 MB	0 MB/s	0 Mbps
rtrace.exe		6.1%	1,100.9 MB	0 MB/s	0 Mbps

Old Windows multithreading process

- Memory increases with thread count
- (12 threads used swap space for this model!)

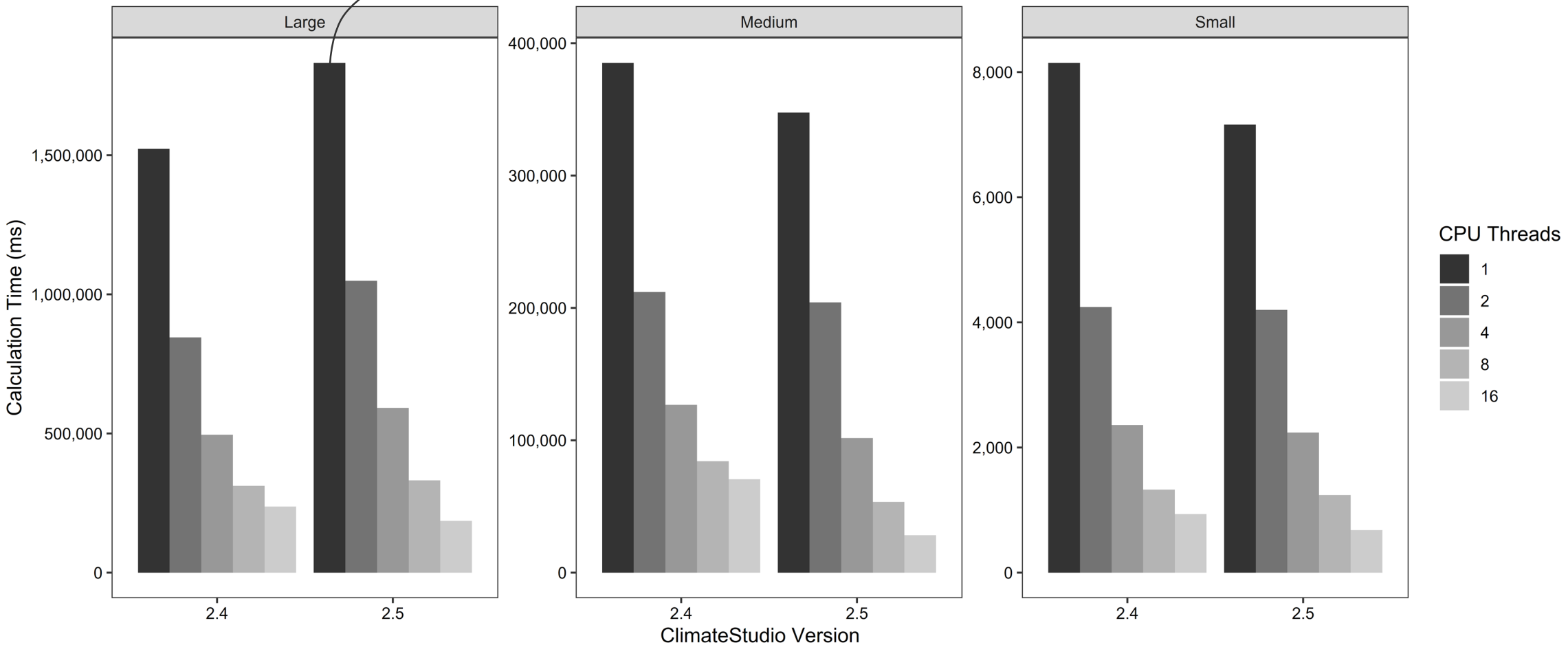
Name	Status	42% CPU	82% Memory	2% Disk	0% Network
Rhino 8		37.1%	10,446.6 MB	0 MB/s	0 Mbps
[Large] SickKids - v2.3dm ...	Efficiency ...				

New multithreading process

- Memory use is more stable with thread count

Direct + diffuse raytracing calculation benchmark

Model still duplicated in memory to handle dynamic objects, and direct trace is heavier when wrapped up with the ambient calculation raytrace at low thread counts. ~SW



4,096 rays / sensor. Does not include oconv / scene loading time.

AMD Ryzen 9 7950X / 16 Core CPU



Thank you!

@24th International Radiance Workshop

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