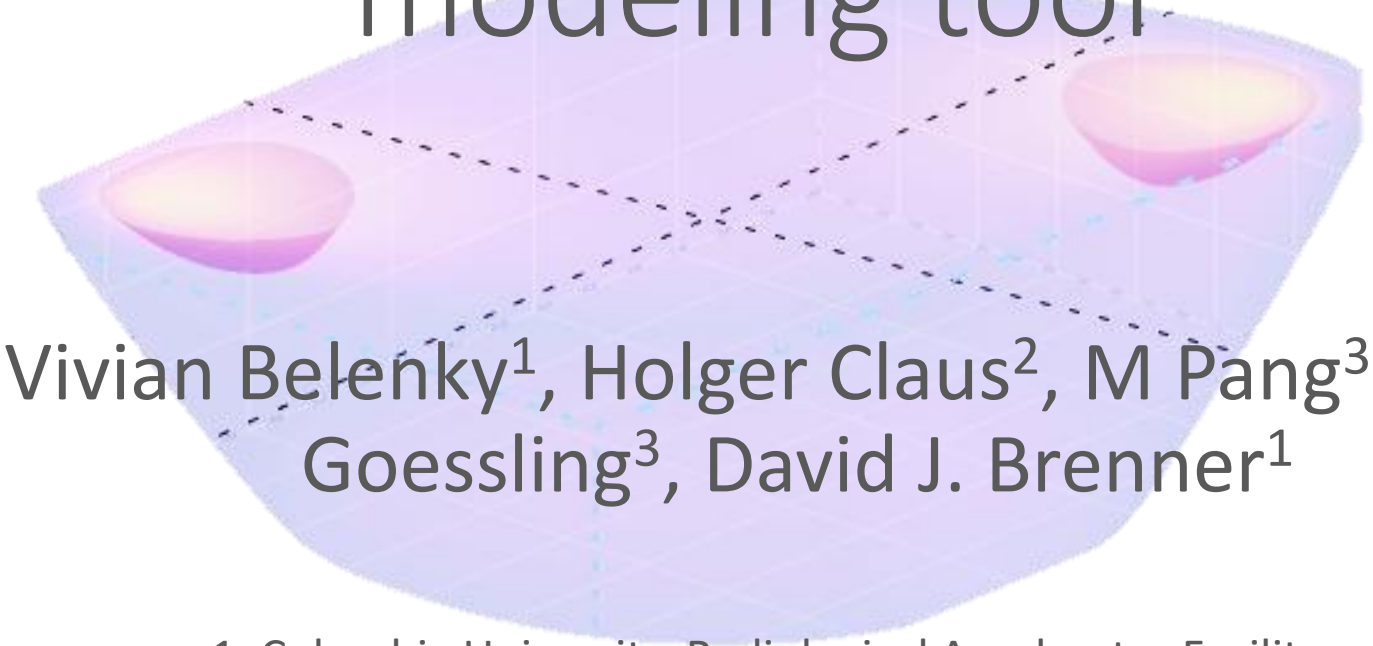
Illuminate:
A free and open source germicidal UV modeling tool



Vivian Belenky[1], Holger Claus[2], M Pang[3], Louis Goessling[3], David J. Brenner[1]

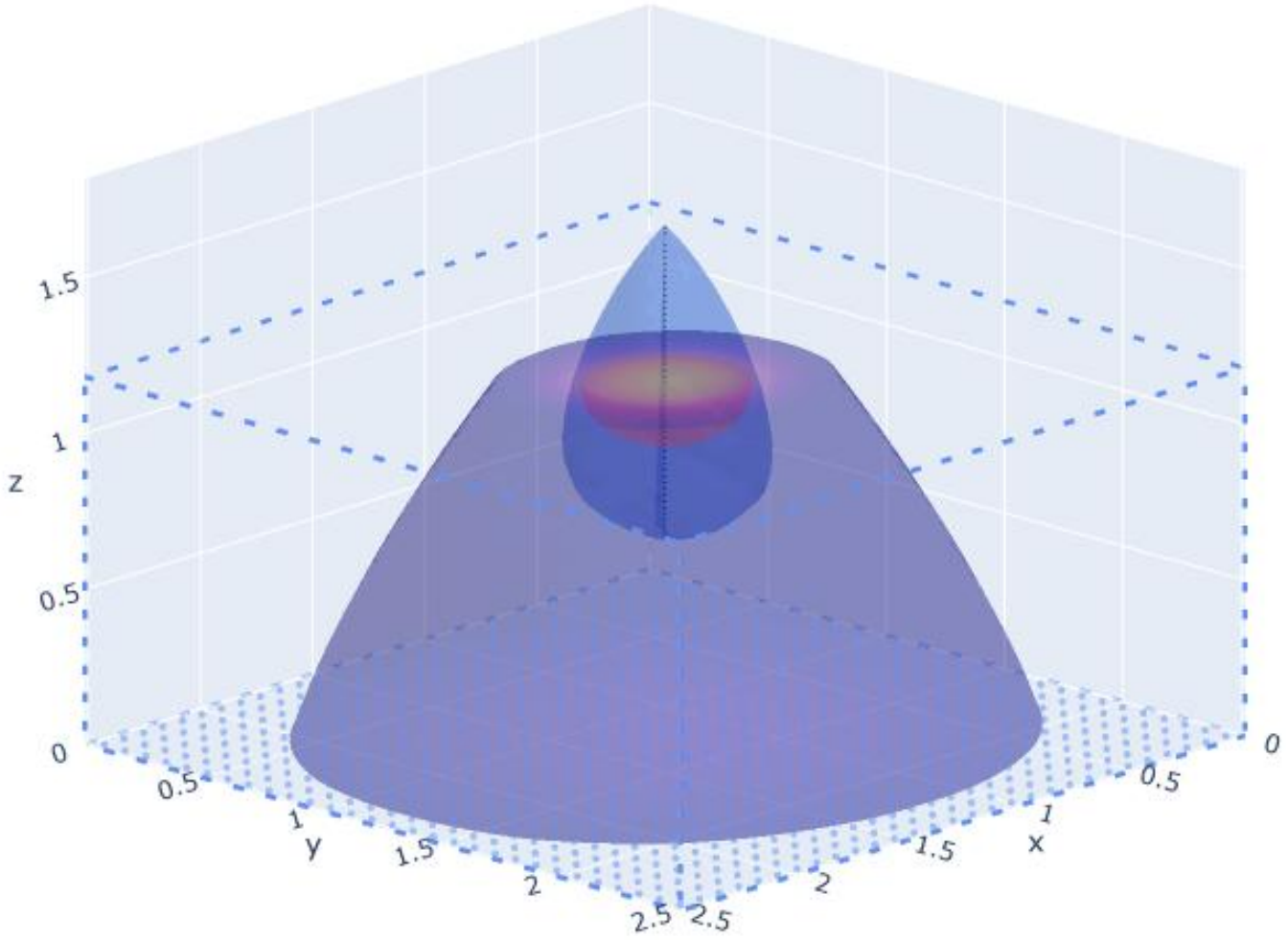
1. Columbia University, Radiological Accelerator Facility
2. USHIO America
3. The OSLUV Project

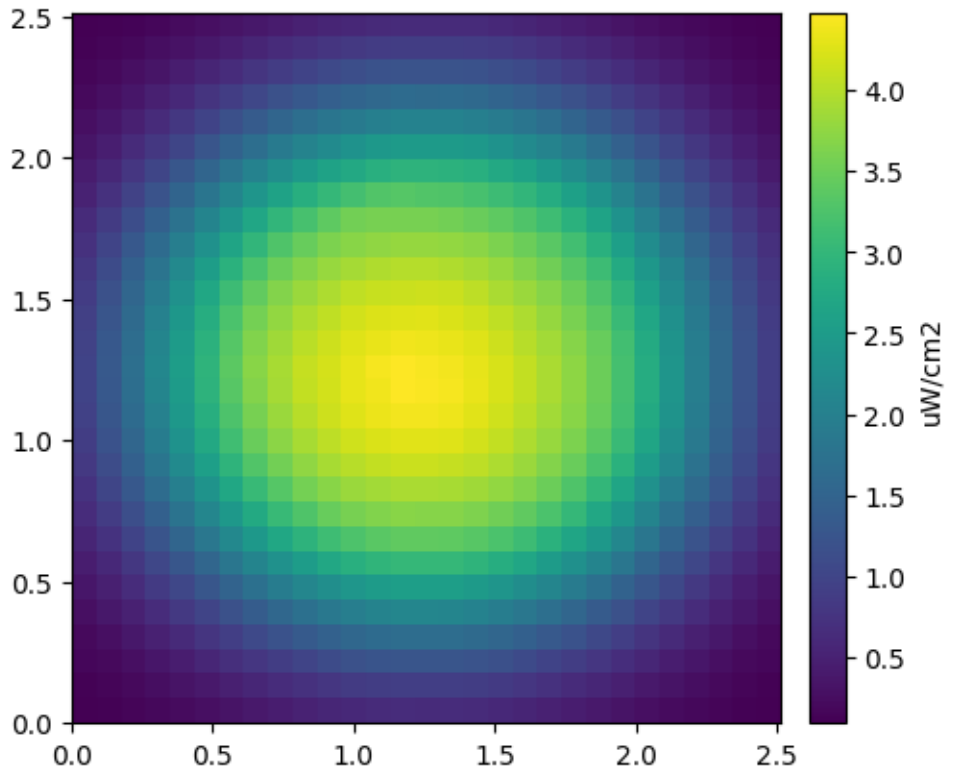
Why is there a need?

- Any GUV research has a critical need to accurately estimate fluence and irradiance
- Extensive irradiance measurements are not always practical; fluence can’t be accurately measured at all
- Software is available to model what can’t practically be measured:
  - Acuity Visual
  - ray tracing software
  - radiation transport solvers
- …but either requires expensive licenses, long computation times, or both

What does it do?

1. Model fluence and irradiance

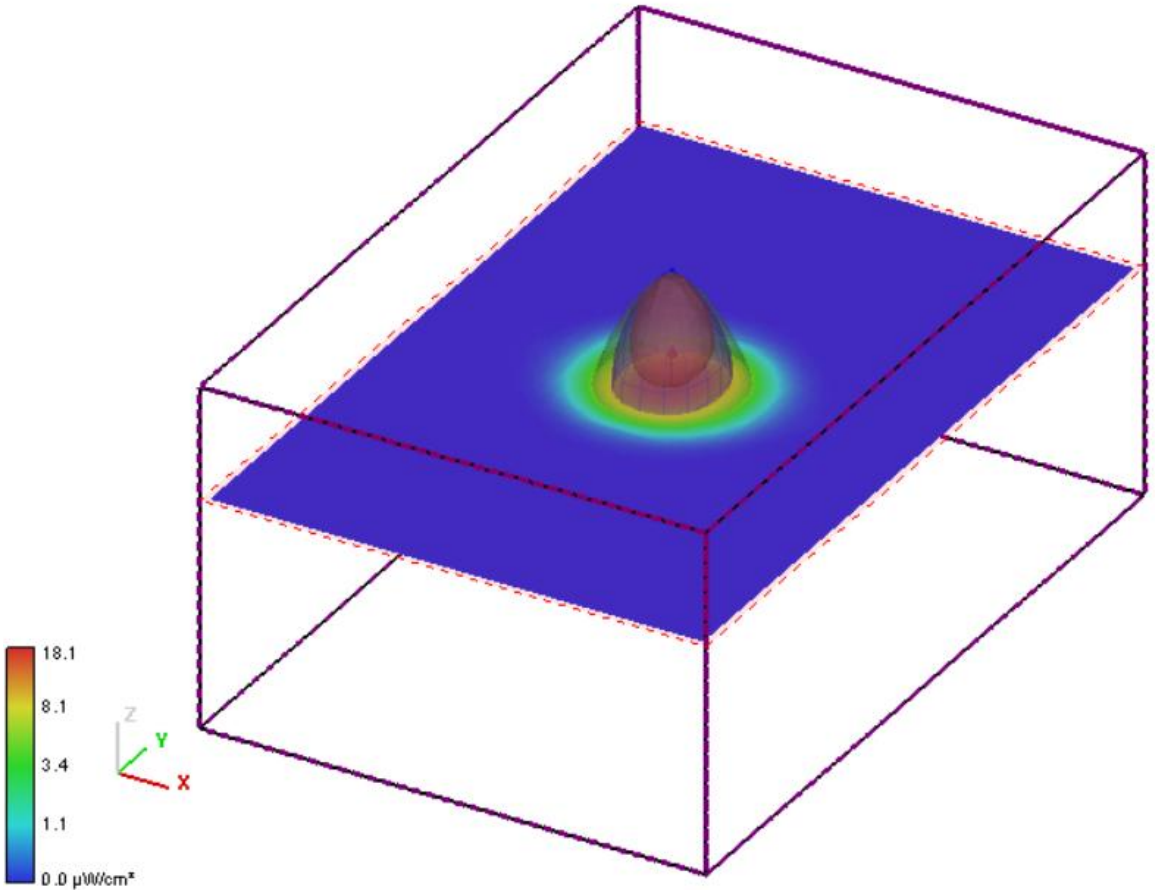




What does it do?

1. Model fluence and irradiance

- Validated against Acuity Visual results
- Eg: 4 x 6 x 2.7 meter room
- Calculation zones at 1.8 meters
- One B1 module mounted in center of ceiling

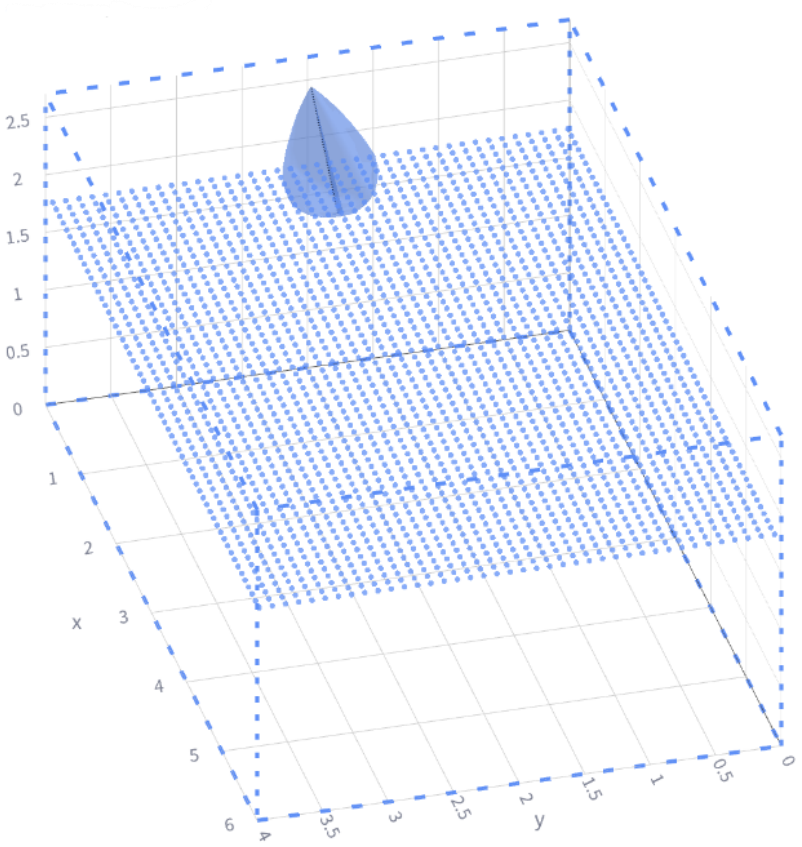


Calculation Type	Quantity	Illuminate	Acuity Visual	Difference	% difference
Fluence - Average	**Average**	0.535	0.53	0.005	0.93%
Planar Max	**Average**	0.554	0.504	0.05	9.03%
	Max	18.172	18.094	0.078	0.43%
Planar Norm	**Average**	0.505	0.5	0.005	0.99%
	Max	18.116	18.09	0.026	0.14%
Planar Max - No Offset	**Average**	0.5315	0.53	0.0015	0.28%
	Max	18.163	18.55	-0.387	-2.13%

What does it do?

2. Check proposed GUV installations against existing safety standards

Lamp type: KrCl (222 nm)



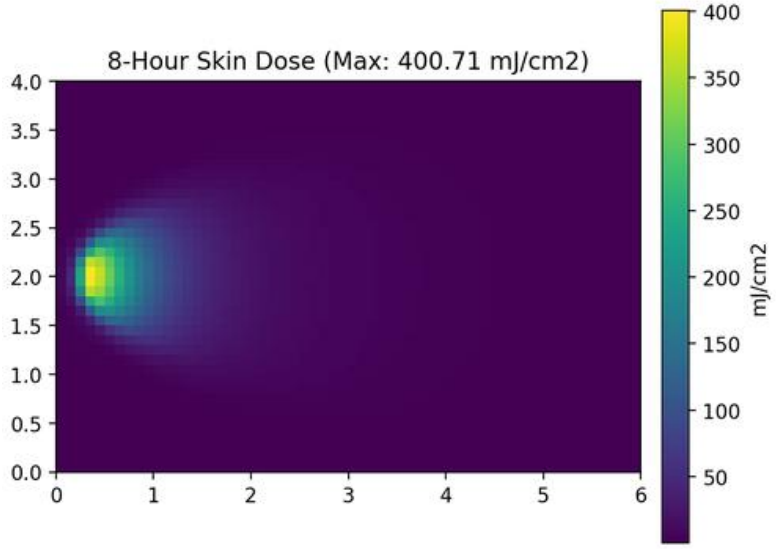
Photobiological Safety

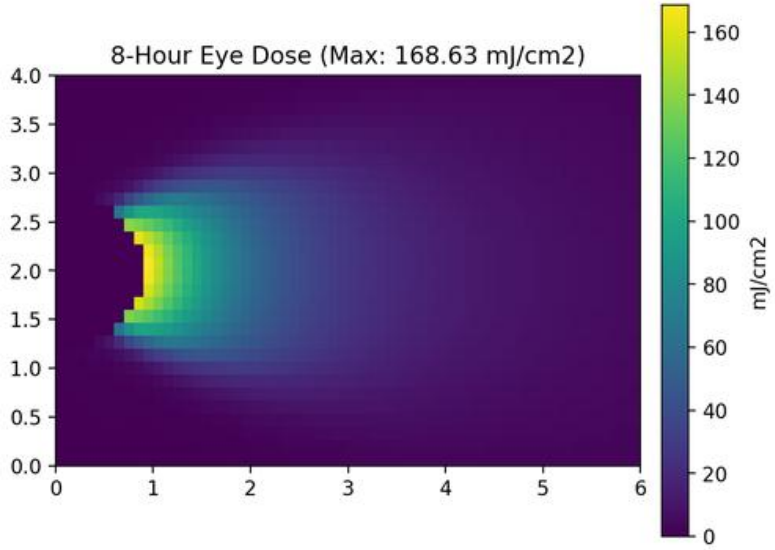
Select photobiological safety standard

ANSI IES RP 27.1-22 (America)

Max Skin Dose (8 Hours): 400.71 mJ/cm2

Max Eye Dose (8 Hours): 168.63 mJ/cm2 *(To be compliant with eye TLVs, this lamp must be dimmed to 85.4% of its present power)*

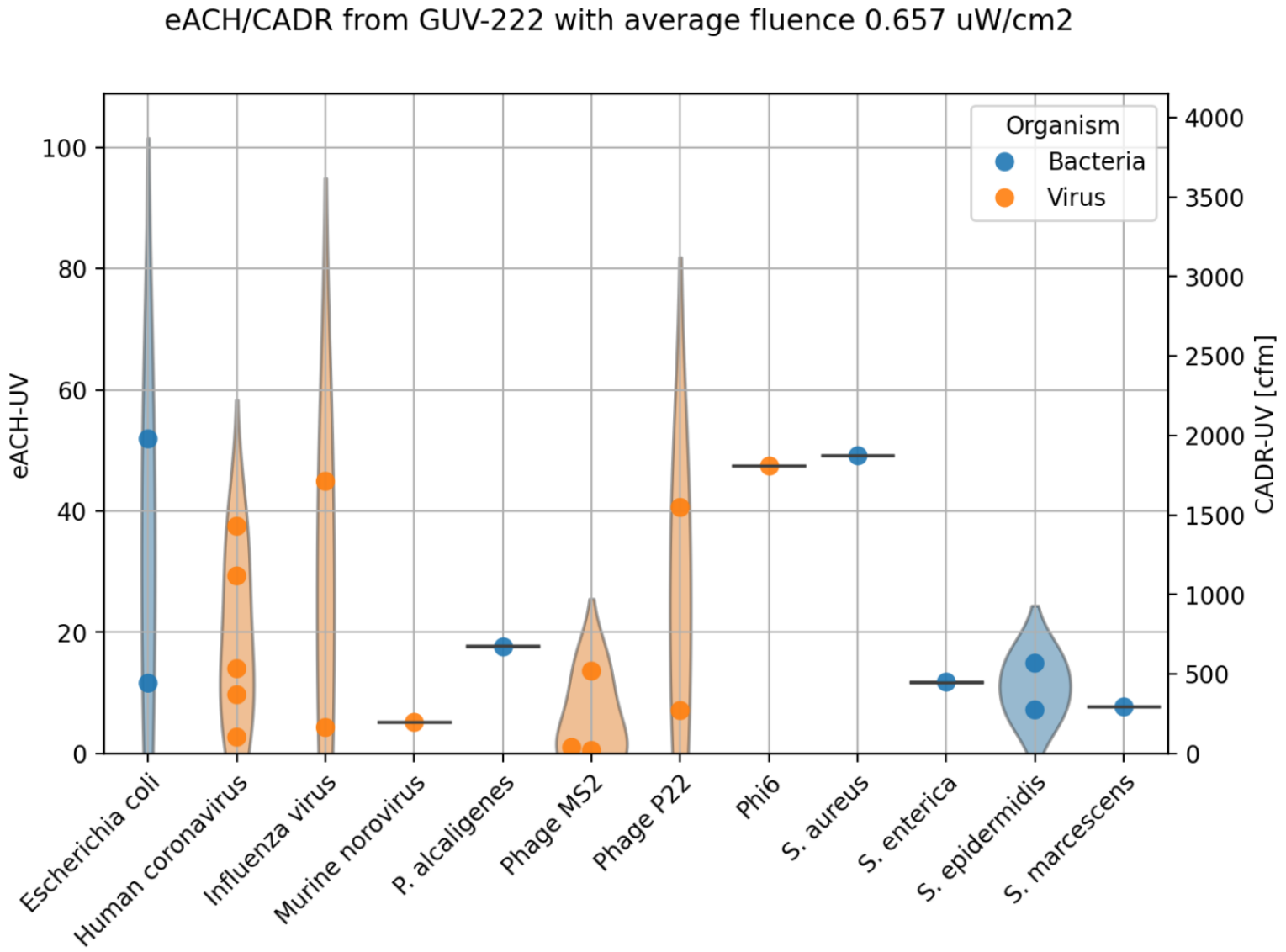




What does it do?

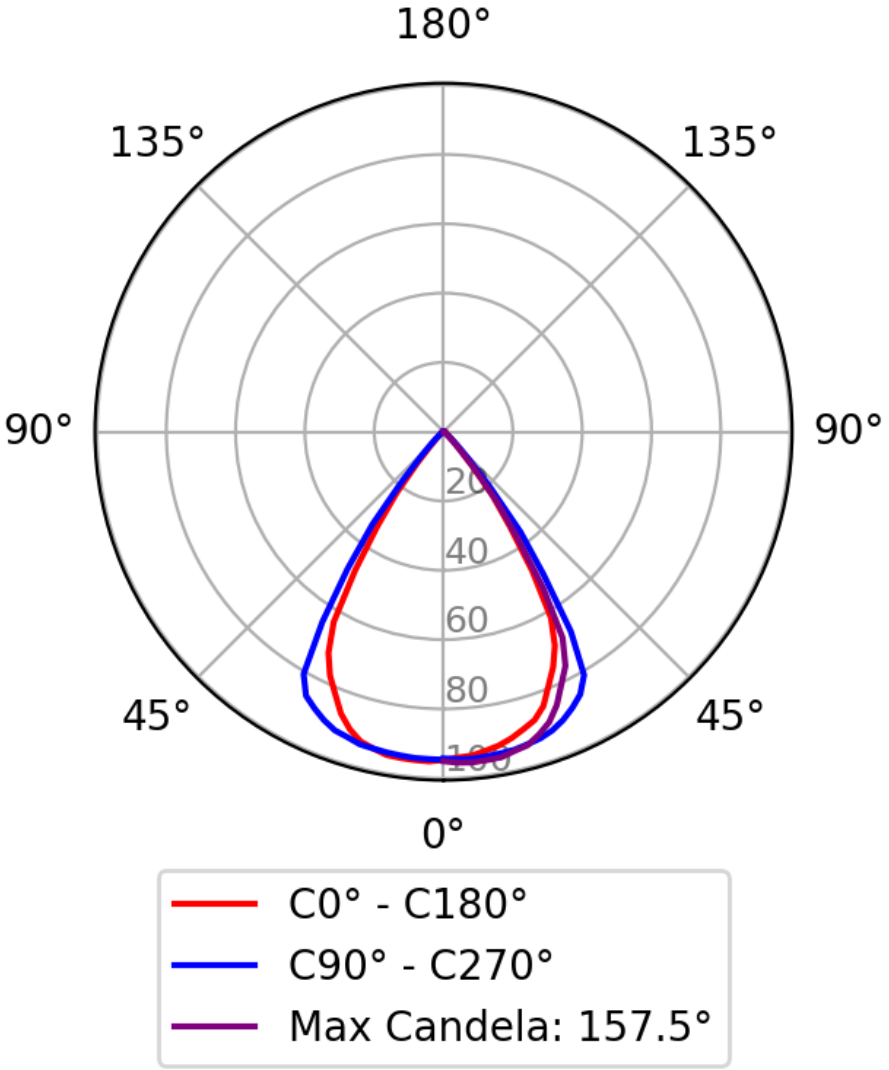
3. Estimate clean air delivery rate (CADR) provided by UV

- Data collated for wide range of wavelengths
- Linked to public database of sensitivity constants (k)
- https://shorturl.at/kcGeR



How does it work?

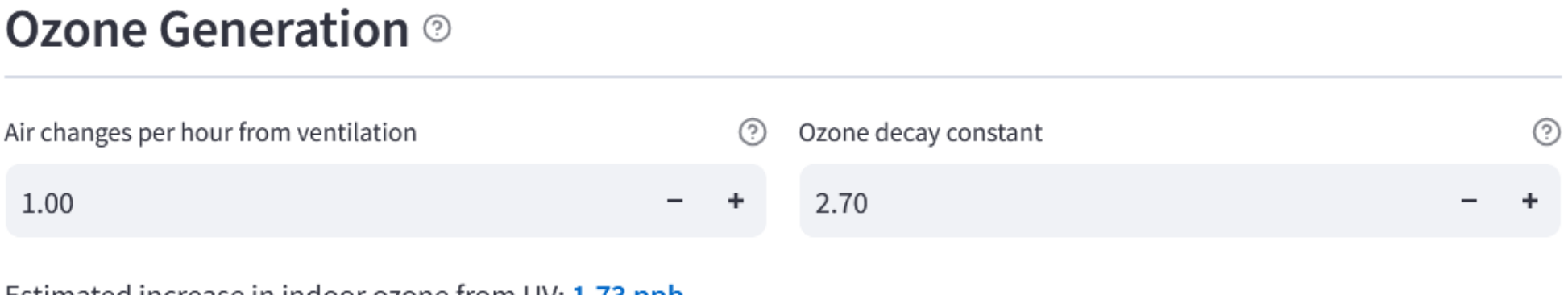
- Photometric (.ies) files
- Geometry of room, lamp(s) position, target surface
- Programming interface: Python
- Calculations: NumPy (C++)



How is it different from other software?

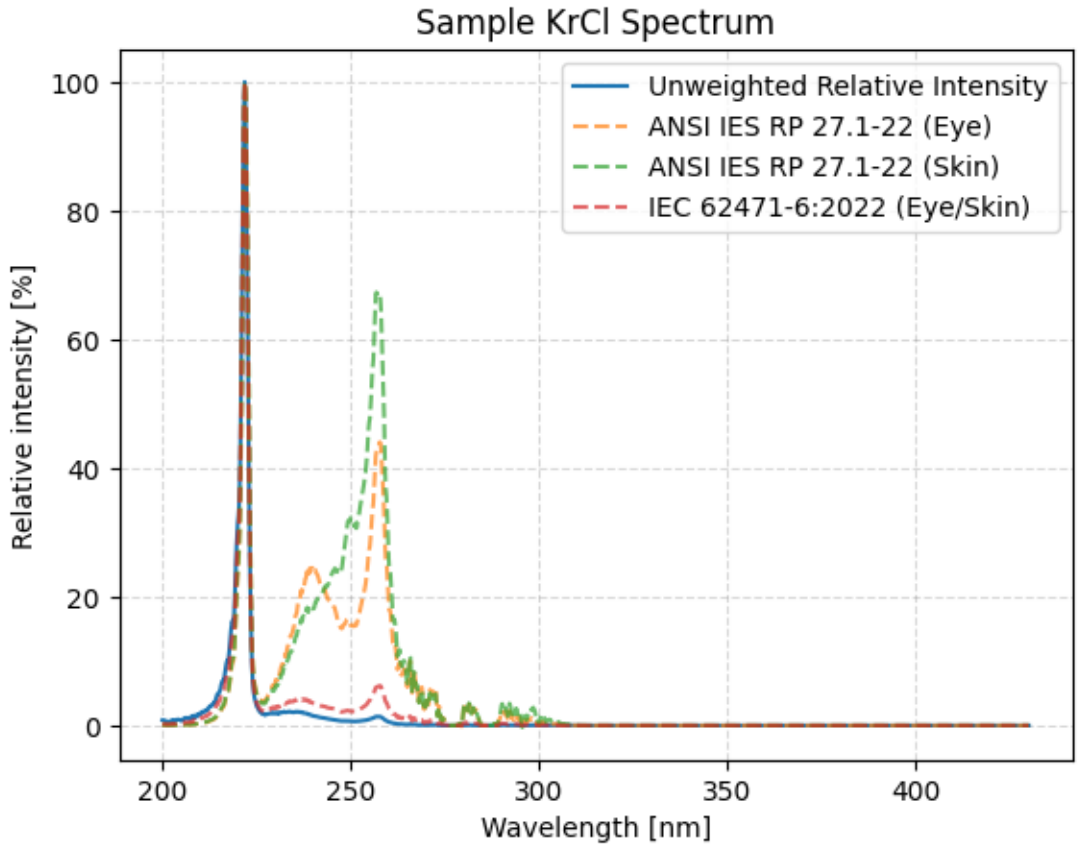
1. Designed with germicidal UV in mind

- Simple, fast, lightweight
- Easily calculate fluence rate field in room, as well as eye and skin dose
- Awareness of multiple different photobiological standards
  - ANSI/IES RP27.1-22
  - IEC 62471-6:2022
  - UL8802
  - GB 28235-2020 (coming soon)
- Extra features like ozone generation estimates



How is it different from other software?

2. Safety calculations take lamp spectra into account (lamp exposure limit)



Hours before skin TLV is reached:

With monochromatic assumption: **Indefinite (12.76)**

With spectral weighting: **3.75** *(To be compliant with skin TLVs, this lamp must be dimmed to 46.9% of its present power)*

Hours before eye TLV is reached:

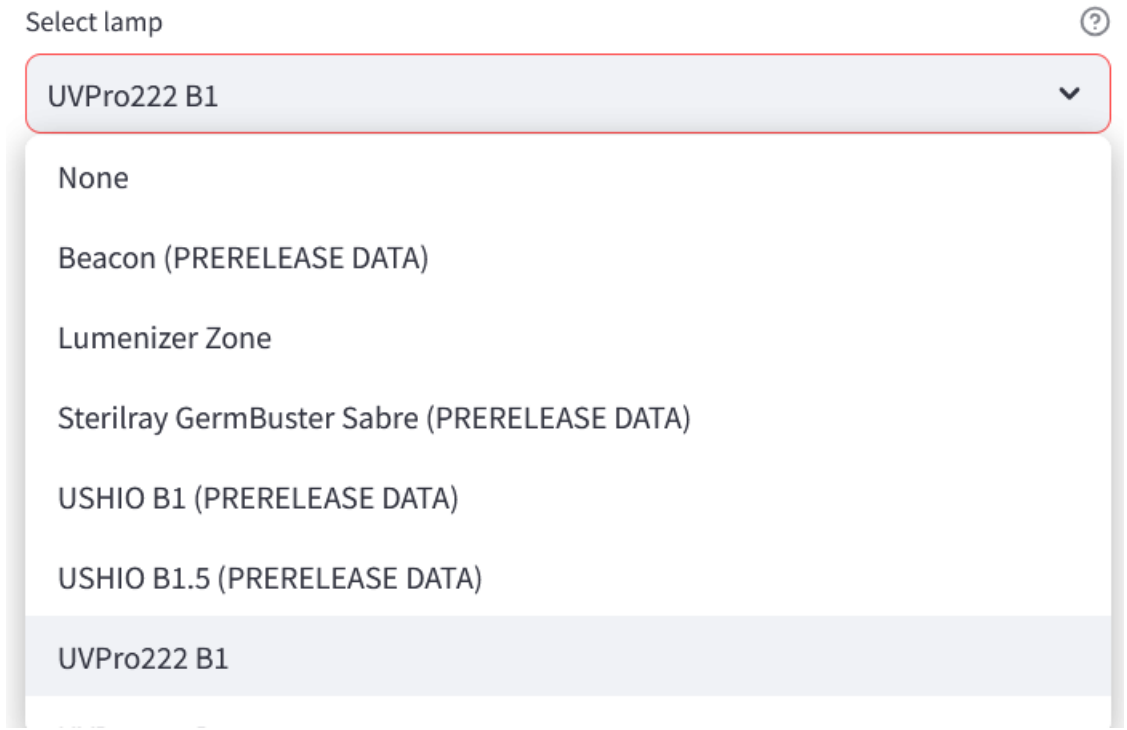
With monochromatic assumption: **Indefinite (9.87)**

With spectral weighting: **3.51** *(To be compliant with eye TLVs, this lamp must be dimmed to 43.9% of its present power)*

How is it different from other software?

3. Comes pre-loaded with measured, characterized far-UVC sources

- with links to full reports



Lumenizer Zone [DRAFT]

PHOTO/RADIO/SPECTRO/GONIOMETRIC ASSAY

The OSLUV Project
680 Transfer Road, Suite 3B, St. Paul, MN
<contact-assay@osluv.org>

Catalog ID 1e85a0e8-4704-4e11-afd2-8472ced14c89
Rev R03 — May 24, 2024

Contents

Quick Facts

Power & Pattern	
(All reported values after stabilization)	
Total UVC Optical Power	161.9mW
1m Peak Irradiance	19.5µW/cm²

Safety	
Power above 240nm	0.6mW (0.4%)
Equivalent 222nm Eye S(λ) Power	181.8mW
$w_s/S(222\text{nm})$ **(ANSI/IES Eye Limit)**	112.3%

How is it different from other software?

4. Free, open-source, and available online

Graphical user interface (GUI):
illuminate.osluv.org

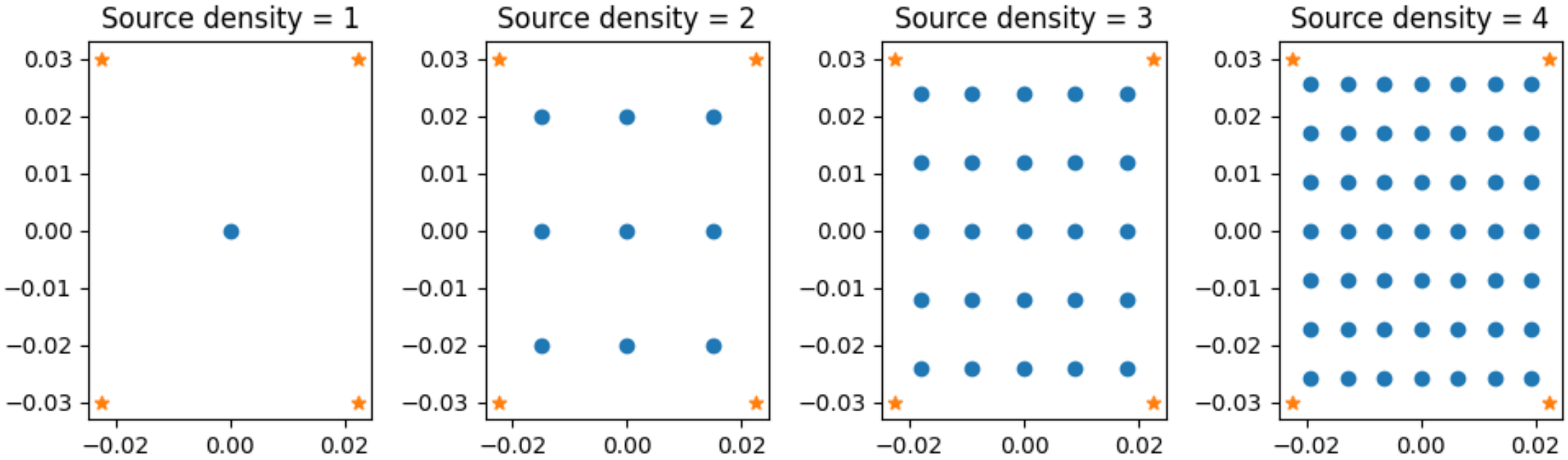
Python libraries:

IES file interface (PhotomPy):
github.com/jvbelenky/photompy

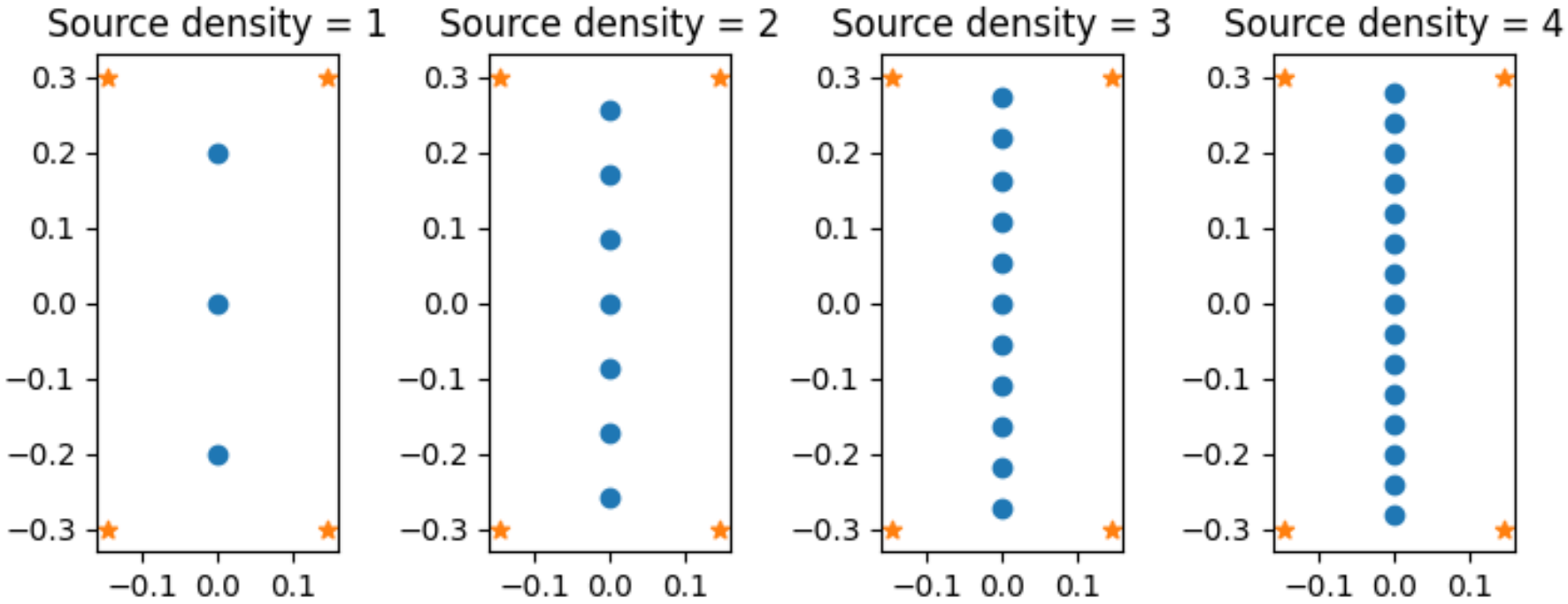
Fluence, irradiance, and all GUV calculations:
github.com/jvbelenky/guv-calcs

Other features – source discretization

- Single parameter (source density) determines fineness of emissive surface
- Always maintains center point
- Only enabled at distances < the photometric distance (x10 the longest side)



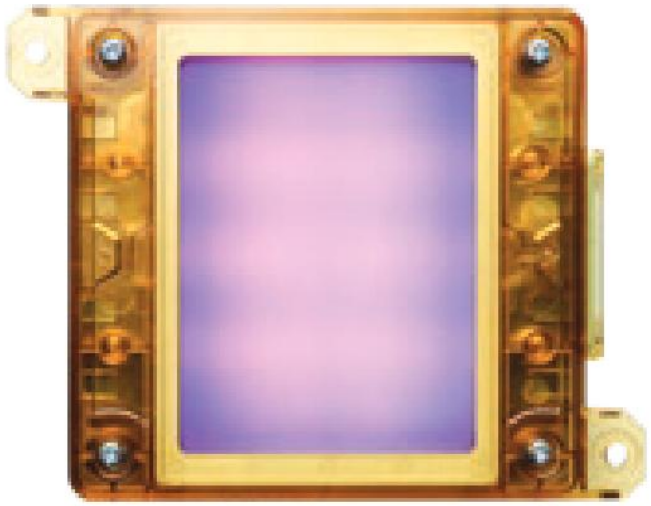
Other features – source discretization



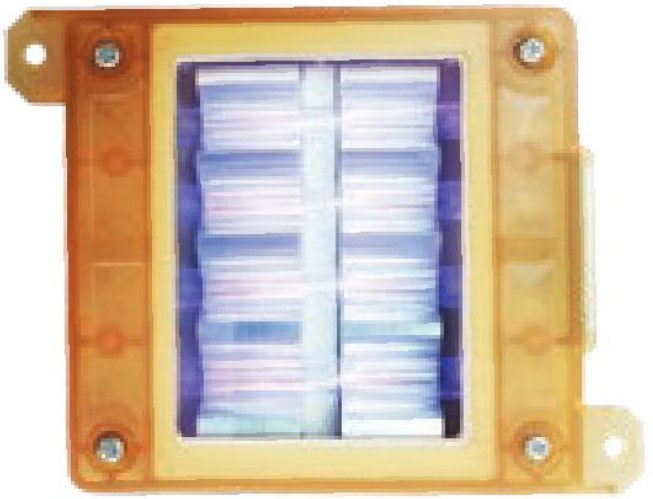
- For sources at least twice as long as they are wide (or vice versa)
- Source density = 0 results in point source for source of any dimensions (aka based on .ies file)

Other features – relative intensity map

- Specify a relative intensity map for source with non-uniform surface emission



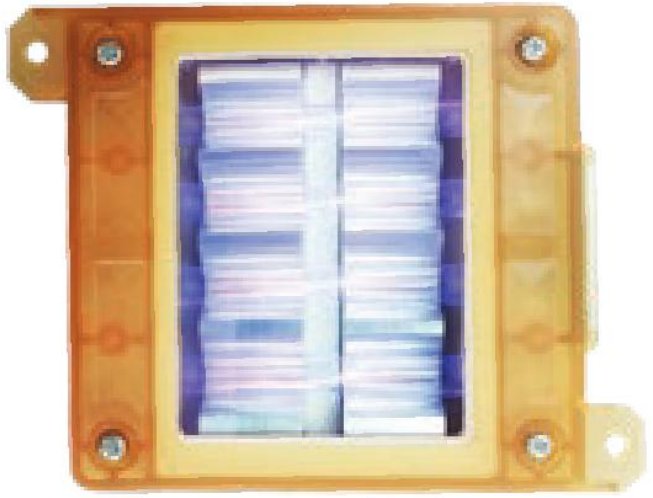
B1.5 Wide Beam Module



B1 Narrow Beam Module

Other features – relative intensity map

- Passed to a Lamp object (bundled with photometric file, optional spectrum file, position / orientation information, source density parameter)
- Measured values converted to relative values
- Sample 5x5 intensity map



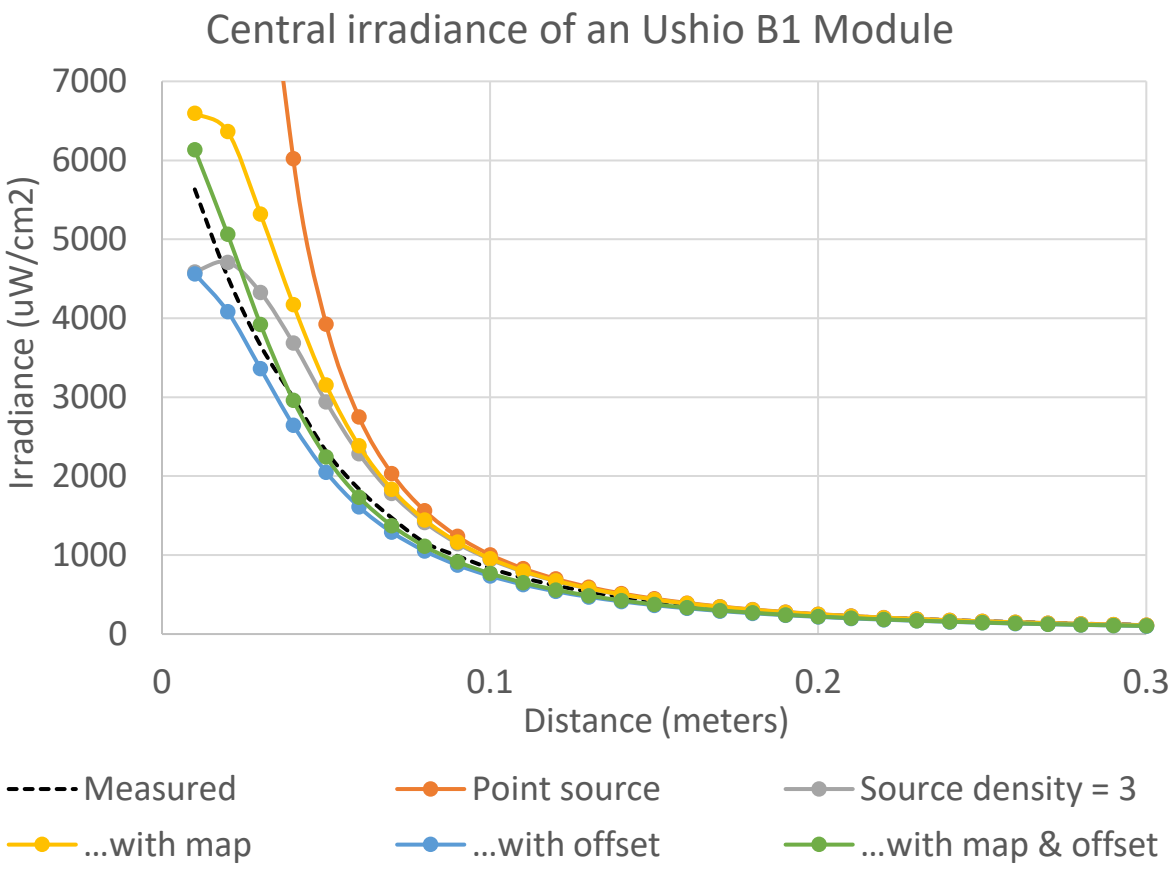
B1 Narrow Beam Module

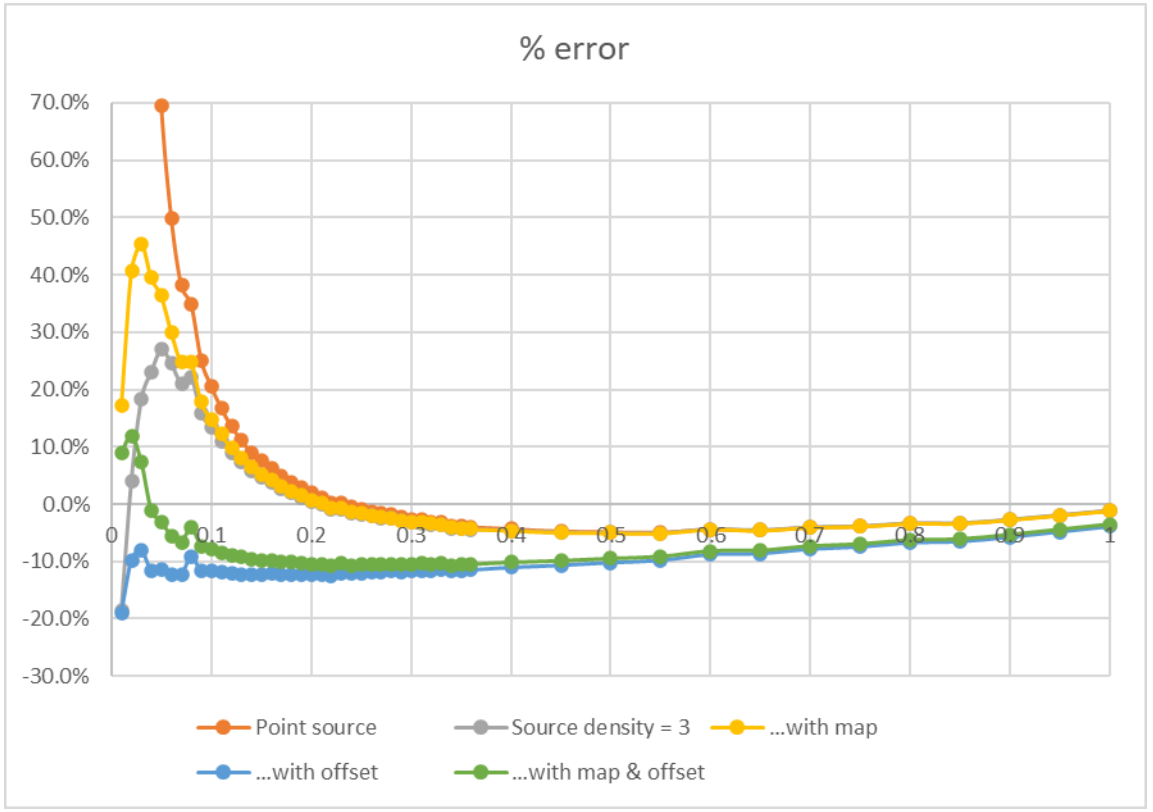
131	286.3	359.6	314	140.1
130.2	323.1	403.5	357.4	140.9
121.7	319.6	412.2	334.5	128.1
147.3	297.3	353.7	364.6	181.9
154	217	255.1	329	222.7

0.51	1.114	1.399	1.222	0.545
0.507	1.257	1.57	1.391	0.548
0.474	1.244	1.604	1.302	0.498
0.573	1.157	1.376	1.419	0.708
0.599	0.844	0.993	1.28	0.867

Near-field accuracy with all features

- Best results with source density of at least 3
- …with relative intensity map
- …accounting for the offset of the light source behind the glass





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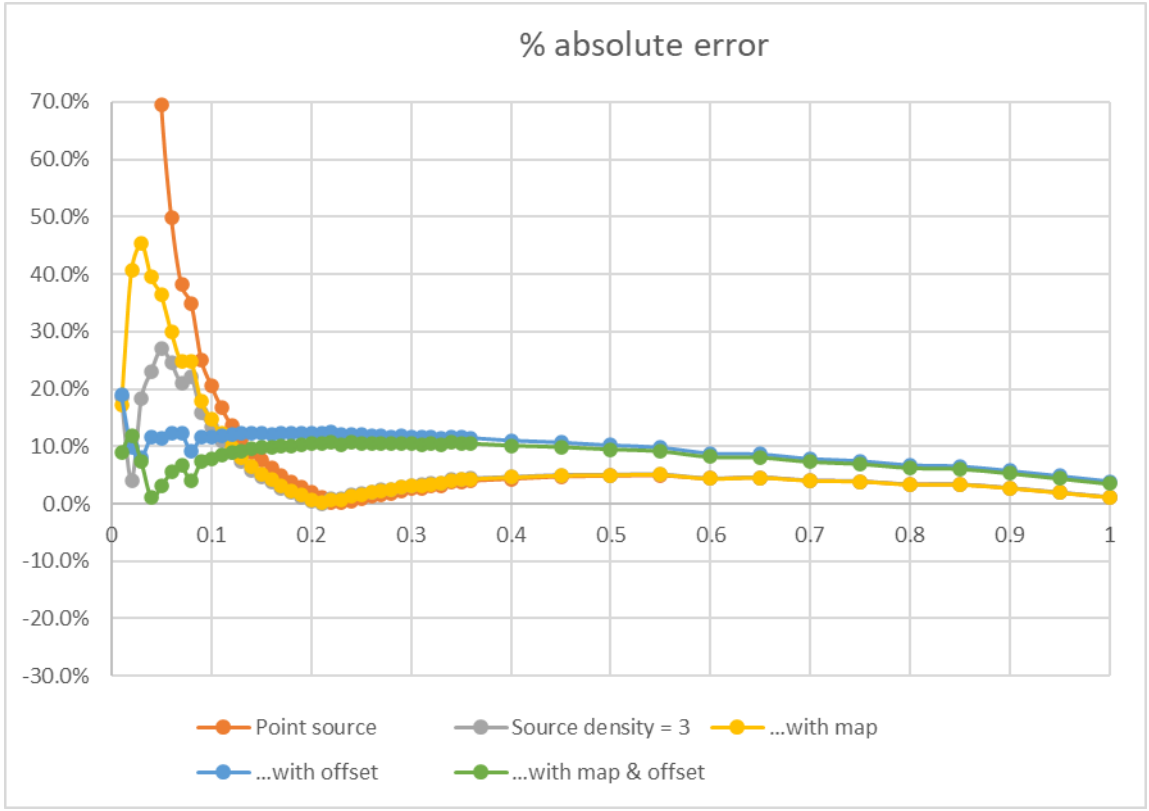
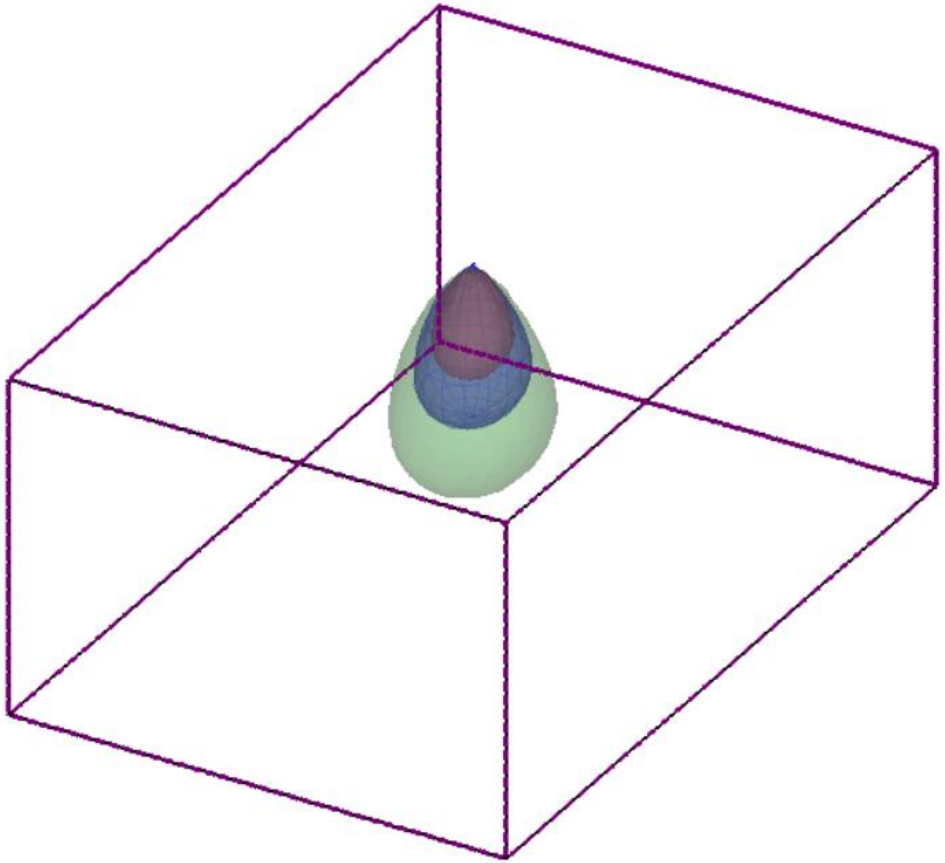


Total error sum

Point source	112753
Source density = 3	4817
…with map	8337
…with offset	3957
…with map & offset	2462

Features under development

1. Reflections
   - Error is small for typical UVC reflection values



Reflection	Average Fluence	% error
0%	0.53	-
5% (typical)	0.56	3.5%
20% (maximum)	0.66	20%

Features under development

1. Reflections
2. Shadows and obstacles
3. A faster, nicer website
4. Built-in risk modeling
5. A more complete indoor chemistry model
6. …and much more

Help wanted! Tell me what to work on next