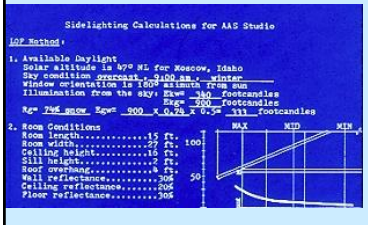
Daylight Design and Prediction Techniques II

Tate Modern
Herzog & de Meuron

1

Hand Calculations

Evolution from numeric to graphic…

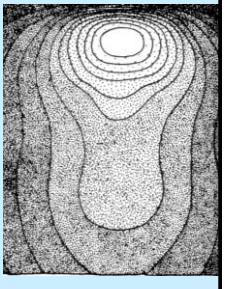


Sidelighting Calculations for AAS Studio

LOF Method:

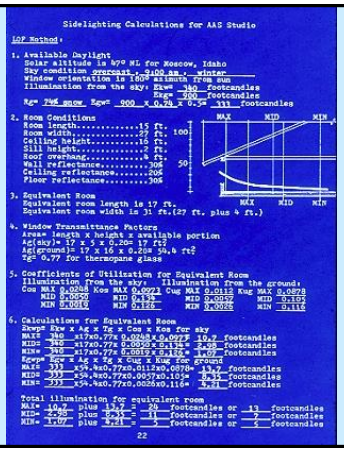
1. Available Daylight
   Solar altitude is 47° NL for Moscow, Idaho
   Sky condition overcast, 9:00 am, winter
   Window orientation is 180° azimuth from sun
   Illumination from the sky: Ekwt 340 footcandles
   Ekg= 900 footcandles
   Rg= 2% snow Egwt 900 x 0.24 x 0.5= 111 footcandles

2. Room Conditions
   Room length.....15 ft.
   Room width.....27 ft.
   Ceiling height.....15 ft.
   Sill height.....2 ft.
   Roof overhang.....4 ft.
   Wall reflectance.....30%
   Ceiling reflectance.....20%
   Floor reflectance.....30%



2

Lumen Method
By LOF



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3. Equivalent Room
   Equivalent room length is 17 ft.
   Equivalent room width is 31 ft.(27 ft. plus 4 ft.)

4. Window Transmittance Factors
   Area= length x height x available portion
   Ag(sky)= 17 x 3 x 0.20= 17 ft²
   Ag(ground)= 17 x 16 x 0.20= 54.4 ft²
   Tg= 0.77 for thermopane glass

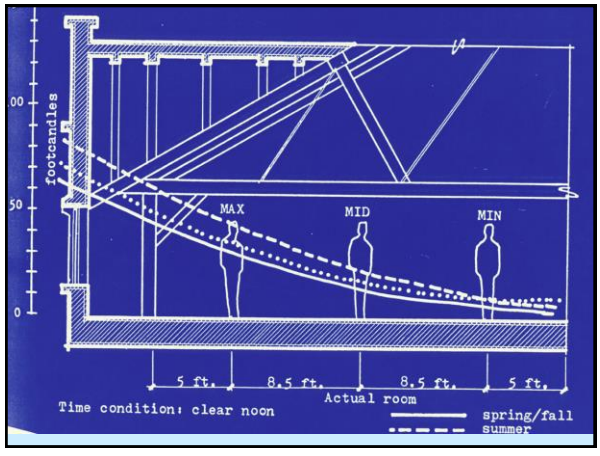
5. Coefficients of Utilization for Equivalent Room
   Illumination from the sky: Illumination from the ground:
   Cos MAX 0.0248 Kos MAX 0.0977 Cug MAX 0.0112 Kug MAX 0.0878
   MID 0.0050 MID 0.116 MID 0.0050 MID 0.105
   MIN 0.0019 MIN 0.116 MIN 0.0026 MIN 0.116

6. Calculations for Equivalent Room
   Ekwp= Ekw x Ag x Tg x Cos x Kos for sky
   MAX 340 x17x0.77x 0.0248 x 0.0977 10.7 footcandles
   MID= 340 x17x0.77x 0.0050 x 0.116= 2.35 footcandles
   MIN= 340 x17x0.77x 0.0019 x 0.116= 1.07 footcandles
   Egwp= Egw x Ag x Tg x Cug x Kug for ground
   MAX 231 x54.4x0.77x0.0112x0.0878= 13.7 footcandles
   MID= 231 x54.4x0.77x0.0050x0.105= 6.45 footcandles
   MIN= 231 x54.4x0.77x0.0026x0.116= 3.61 footcandles

   Total illumination for equivalent room
   MAX= 10.7 plus 13.7 = 70 footcandles or 13 footcandles
   MID= 2.35 plus 6.45 = 11 footcandles or 2 footcandles
   MIN= 1.07 plus 3.61 = 5 footcandles or 1 footcandles

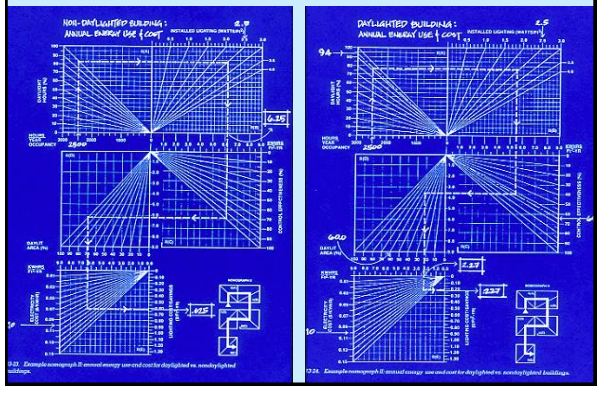
22

3



4

LBL Nomograph



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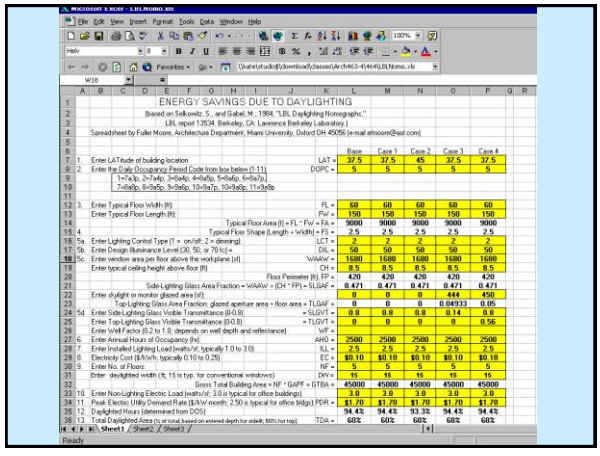


ENERGY SAVINGS DUE TO DAYLIGHTING

(Based on Selkowitz, S., and Gabel, M., 1984, "LBL Daylighting Nomographs," LBL report 17534, Berkeley, CA: Lawrence Berkeley Laboratory.)

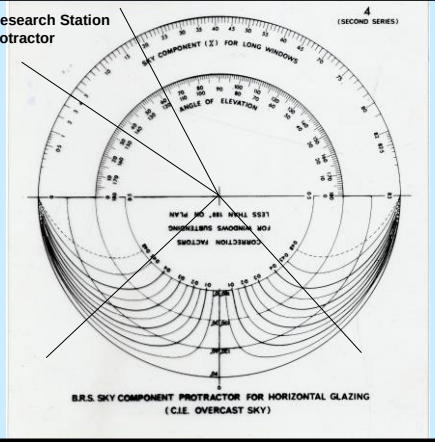
Spreadsheet by Fuller Moore, Architecture Department, Miami University, Oxford OH 45056 (e-mail: elmoore@aol.com)

			Base	Case 1	Case 2	Case 3	Case 4
1.	Enter LAT=rude of building location	LAT =	37.5	37.5	45	37.5	37.5
2.	Enter the Daily Occupancy Period Code from box below (1-11)	DOPC =	5	5	5	5	5
	1=7a3p, 2=7a4p, 3=8a4p, 4=8a5p, 5=8a6p, 6=9a7p, 7=9a8p, 8=9a5p, 9=9a6p, 10=9a7p, 10=9a8p, 11=9a8p						
3.	Enter Typical Floor Width (ft)	FL =	60	60	60	60	60
	Enter Typical Floor Length (ft)	FW =	150	150	150	150	150
	Typical Floor Area (f) = FL * FW = FA =		9000	9000	9000	9000	9000
4.	Typical Floor Shape (Length ÷ Width) = FS =		2.5	2.5	2.5	2.5	2.5
5a.	Enter Lighting Control Type (1 = on/off, 2 = dimming)	LCT =	2	2	2	2	2
5b.	Enter Design Illuminance Level (30, 50, or 70 fc) =	DIL =	50	50	50	50	50
5c.	Enter window area per floor above the work-plane (sf)	WAHV =	1680	1680	1680	1680	1680
	Enter typical ceiling height above floor (ft)	CH =	8.5	8.5	8.5	8.5	8.5
	Floor Perimeter (ft), FP =		420	420	420	420	420
	Side-Lighting Glass Area Fraction = WAHV ÷ (CH * FP) = SLGAF =		0.471	0.471	0.471	0.471	0.471
	Enter skylight or monitor glazed area (sf)		0	0	0	444	450
	Top-Lighting Glass Area Fraction: glazed aperture area ÷ floor area = TLGAF =		0	0	0	0.04933	0.05
5d.	Enter Side-Lighting Glass Visible Transmittance (0-0.8)	= SLGVT =	0.8	0.8	0.8	0.14	0.8
	Enter Top-Lighting Glass Visible Transmittance (0-0.8)	= TLGVT =	0	0	0	0	0.56
	Enter Well Factor (0.2 to 1.0, depends on well depth and reflectance)	WF =					
6.	Enter Annual Hours of Occupancy (hr)	AHO =	2500	2500	2500	2500	2500
7.	Enter Installed Lighting Load (watts/sf, typically 1.0 to 3.0)	ILL =	2.5	2.5	2.5	2.5	2.5
8.	Electricity Cost ($/kWh, typically 0.10 to 0.25)	EC =	$0.10	$0.10	$0.10	$0.10	$0.10
9.	Enter No. of Floors	NF =	5	5	5	5	5
	Enter daylighted width (ft, 15 is typ. for conventional windows)	DW =	15	15	15	15	15
	Gross Total Building Area = NF * GAPF = GTBA =		45000	45000	45000	45000	45000
10.	Enter Non-Lighting Electric Load (watts/sf, 3.0 is typical for office buildings)		3.0	3.0	3.0	3.0	3.0
11.	Peak Electric Utility Demand Rate ($/kW-month; 2.50 is typical for office bldgs) PDR =		$1.70	$1.70	$1.70	$1.70	$1.70
12.	Daylighted Hours (determined from DOS)		94.4%	94.4%	93.3%	94.4%	94.4%
13.	Total Daylighted Area (% or total, based on entered depth for side(s), 100% for top)	TDA =	68%	68%	68%	68%	68%

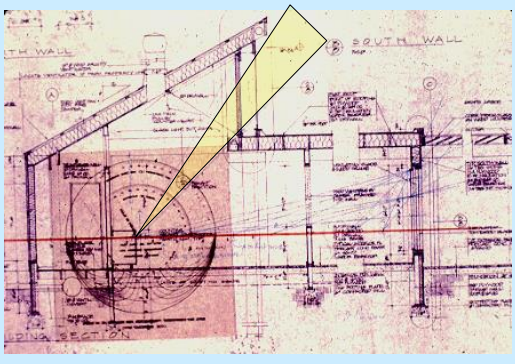
6

7

British Research Station
(BRS) Protractor

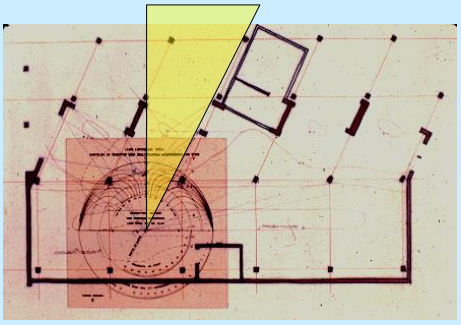


8



Section—measure altitude angles

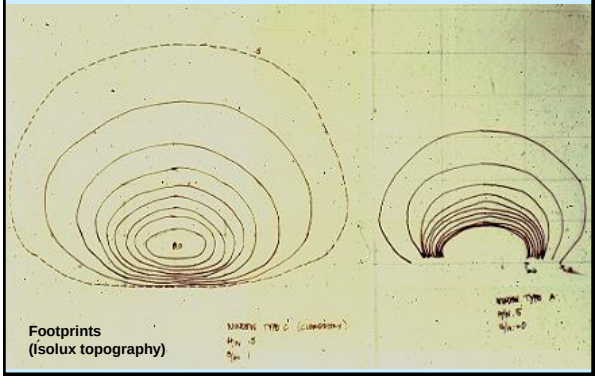
9



Plan—measure bearing angles

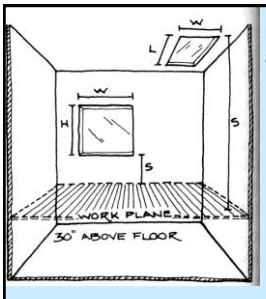
10

Graphic Daylight Design Method



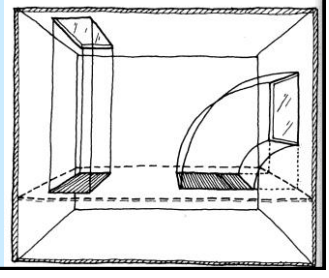
Footprints
(Isolux topography)

11



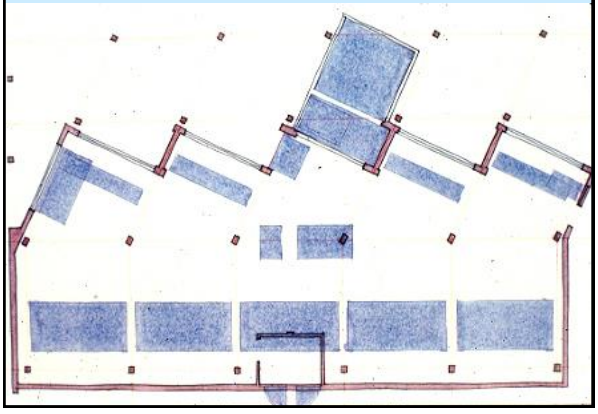
Locate windows, skylights and work plane…

…drop skylights and rotate windows to work plane



12

All apertures located on the work plane:



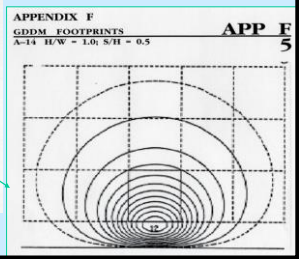
13

Use ratios to identify proper footprint for each aperture.

- **For skylights—L/W and S/W**
- **For windows—H/W and S/H**

Table E2.2.1 Index for Footprints Included in Appendix F

Windows			Skylights		
(H/W)	(S/H)	Footprint ID	(L/W)	(S/W)	Footprint ID
0.5	0.0	A-7	1.0	1.0	A-30
0.5	0.5	A-8	1.0	2.0	A-31
0.5	1.0	A-9	1.0	3.0	A-32
0.5	2.0	A-10	1.0	4.0	A-33
0.5	3.0	A-11	2.0	1.0	A-34
0.5	4.0	A-12	2.0	2.0	A-35
1.0	0.0	A-13	2.0	3.0	A-36
1.0	0.5	A-14	2.0	4.0	A-37
1.0	1.0	A-15			
1.0	2.0	A-16			
1.0	3.0	A-17			
1.0	4.0	A-18			
2.0	0.0	A-19			
2.0	0.5	A-20			
2.0	1.0	A-21			
2.0	2.0	A-22			
2.0	3.0	A-23			
2.0	4.0	A-24			


APPENDIX F

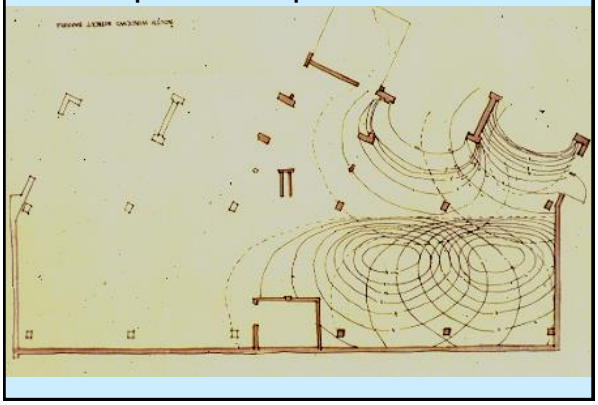
GDDM FOOTPRINTS

A-14 H/W = 1.0; S/H = 0.5

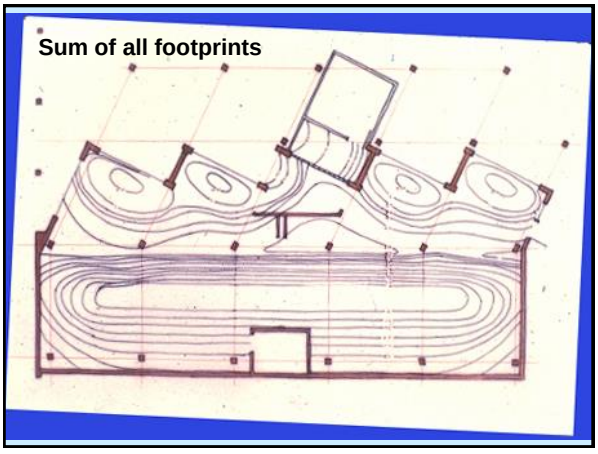
APP F 5

14

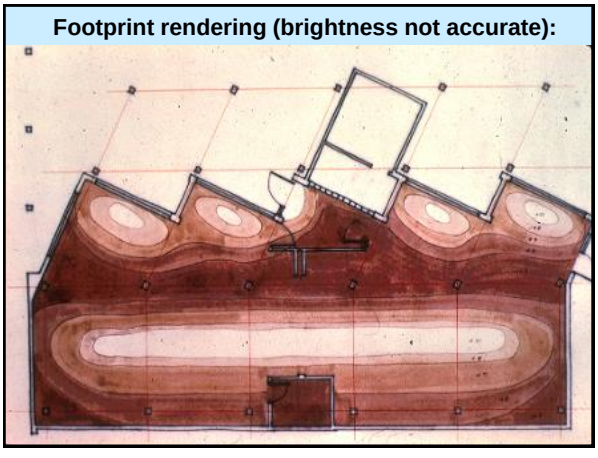
Four footprints on workplane:



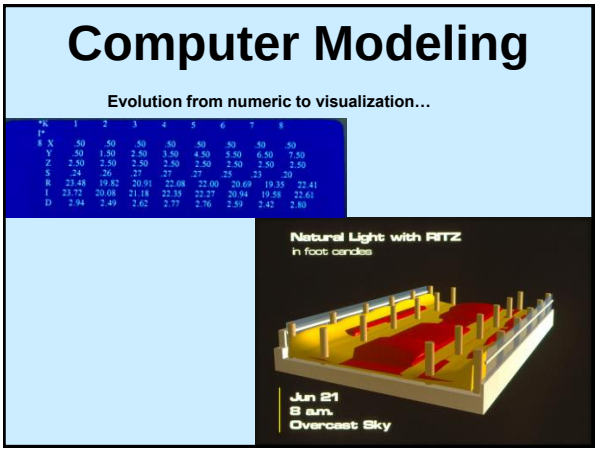
15


Sum of all footprints

16

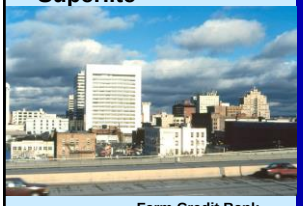

Footprint rendering (brightness not accurate):

17

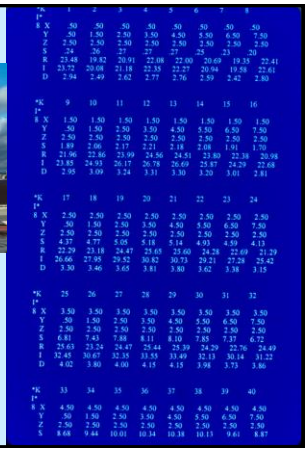

Computer Modeling
Evolution from numeric to visualization…
Natural Light with RITZ
in foot candles
Jun 21
8 a.m.
Overcast Sky

18

Superlite



Farm Credit Bank
Walker McGough



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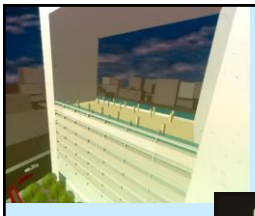
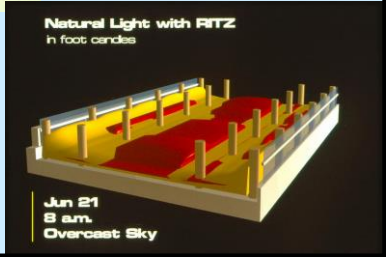
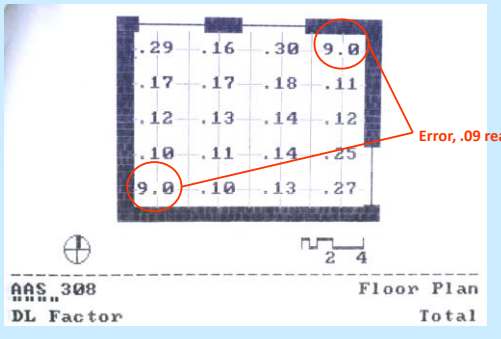




20

Microlite



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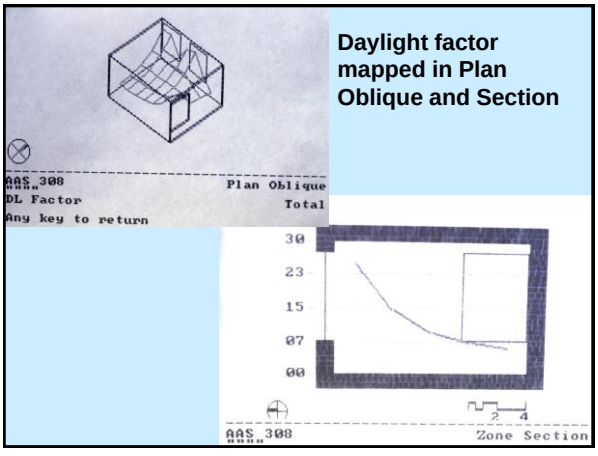
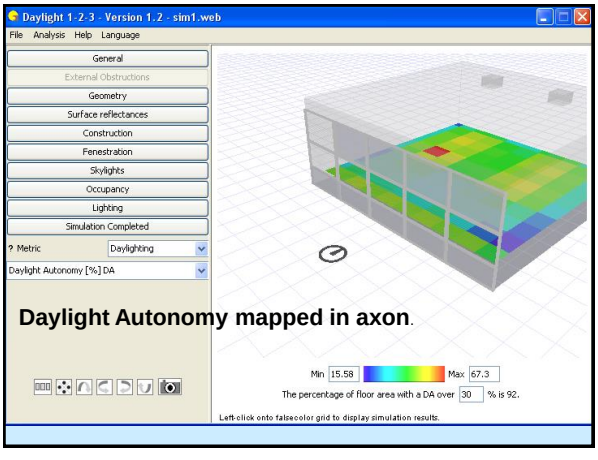
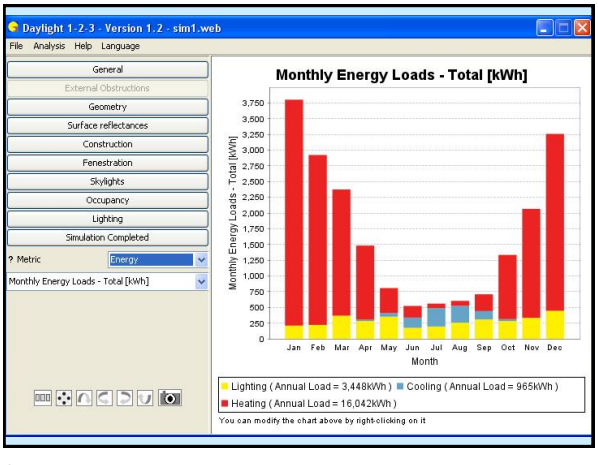

Daylight factor mapped in Plan Oblique and Section
AAS_308
Plan Oblique
DL Factor
Total
Any key to return
30
23
15
07
00
AAS_308
Zone Section

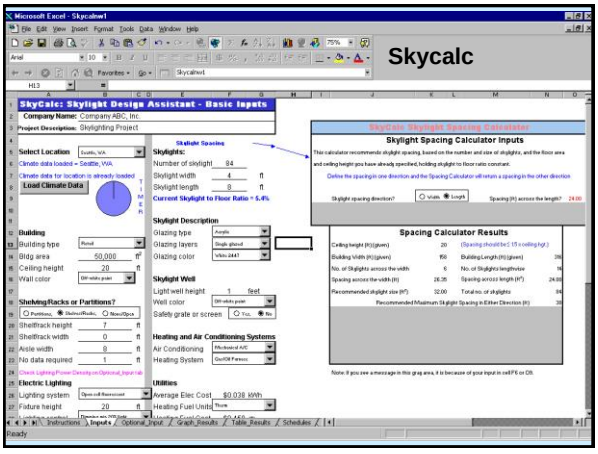
22


Daylight 1-2-3 - Version 1.2 - sim1.web
File Analysis Help Language
General
External Obstructions
Geometry
Surface reflectances
Construction
Fenestration
Skylights
Occupancy
Lighting
Simulation Completed
? Metric
Daylighting
Daylight Autonomy [%] DA
Daylight Autonomy mapped in axon.
Min 15.58
Max 67.3
The percentage of floor area with a DA over 30 % is 92.
Left-click onto falsecolor grid to display simulation results.

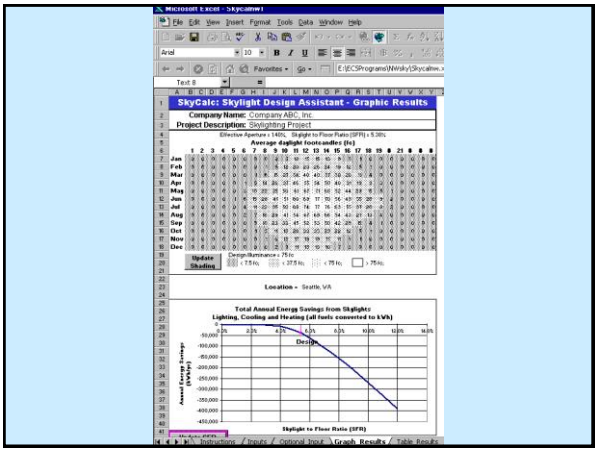
23


Daylight 1-2-3 - Version 1.2 - sim1.web
File Analysis Help Language
General
External Obstructions
Geometry
Surface reflectances
Construction
Fenestration
Skylights
Occupancy
Lighting
Simulation Completed
? Metric
Energy
Monthly Energy Loads - Total [kWh]
Monthly Energy Loads - Total [kWh]
Month
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Lighting (Annual Load = 3,448kWh)
Cooling (Annual Load = 965kWh)
Heating (Annual Load = 16,042kWh)
You can modify the chart above by right-clicking on it

24


Skycalc
SkyCalc: Skylight Design Assistant - Basic Inputs
Company Name: Company ABC, Inc.
Project Description: Skylighting Project
Skylight Spacing Calculator Inputs
Spacing Calculator Results

25


SkyCalc: Skylight Design Assistant - Graphic Results
Company Name: Company ABC, Inc.
Project Description: Skylighting Project
Total Annual Energy Savings from Skylights:
Lighting, Cooling and Heating (all fuels converted to kWh)

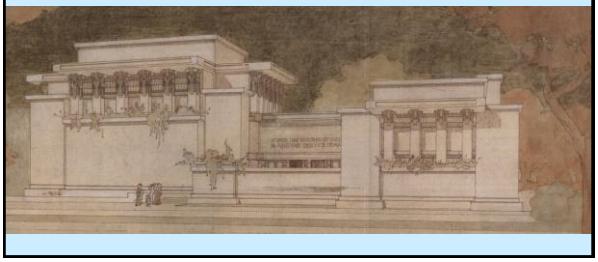
26


Lumen-Micro
Lumen-Micro Targa-16 results produce screen displays of simulated room lighting — in this example, two images
of the same corridor. It is shown lit by a traditional down-lighting system (on the left) and by wall sconces (on the right).
First attempt to render lighting in realistic color.

27

Frank Lloyd Wright's Unity Temple

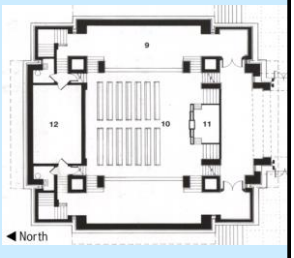
Oak Park, Illinois (1904)



28

Worship Space Floor Plan

The unity temple was commissioned by the Unitarian Universalist Church in Oak Park, IL, a congregation of some 400 members with a modest budget. Imaginative use of the limited space on the building site provided ample accommodation for the 400-member congregation in both the sanctuary and the parish hall.



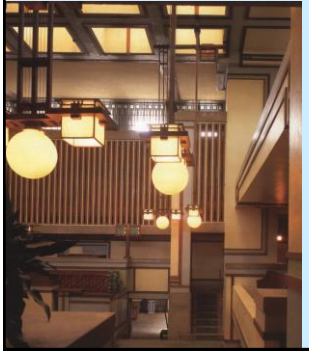
Room Size: 62 ft. x 62 ft.

Total Sq. Feet: 3,844

29

Interior Views

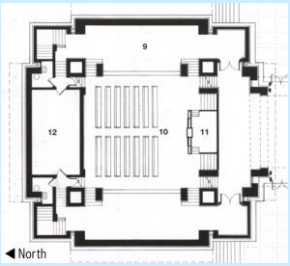
View towards pulpit (south).

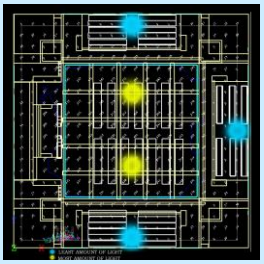


View of pulpit from side balcony.

30

Floor Plan Grid Calculation





Lumen Micro calculation date: June 21 @ 12:00pm

Location: 40 degrees Latitude, 100 degrees Longitude

Sky conditions: Clear

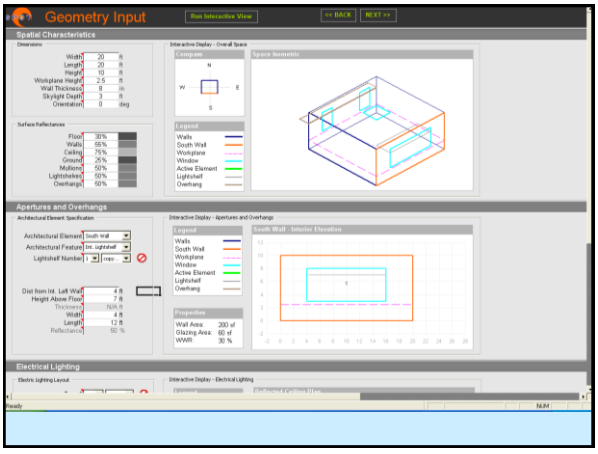
31

Lumen Micro Renderings

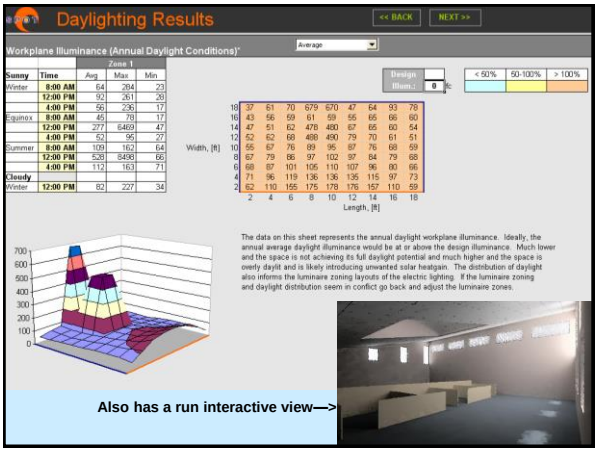
South View **Southwest View**

32

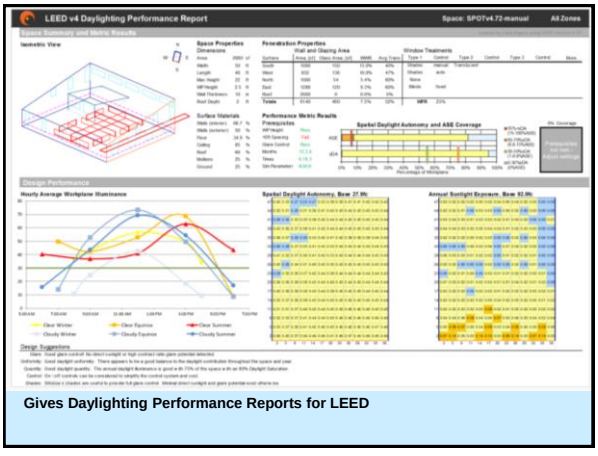
33


Geometry Input
Spatial Characteristics
Apertures and Overhangs
Electrical Lighting

34


Daylighting Results
Workplane Illuminance (Annual Daylight Conditions)*
Also has a run interactive view—>

35


LEED v4 Daylighting Performance Report
Gives Daylighting Performance Reports for LEED

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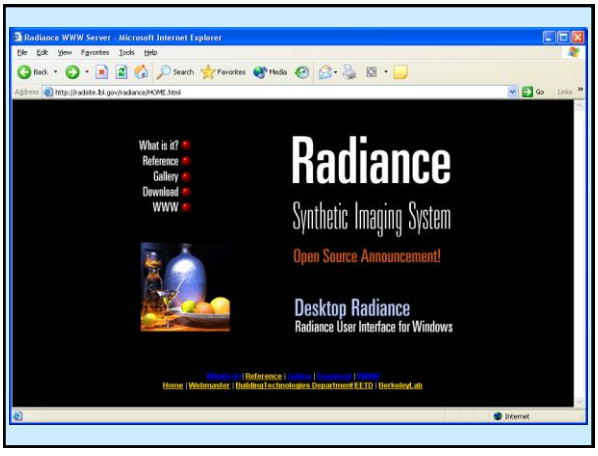
Radiance WWW Server - Microsoft Internet Explorer
What is it?
Reference
Gallery
Download
WWW
Radiance
Synthetic Imaging System
Open Source Announcement!
Desktop Radiance
Radiance User Interface for Windows

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Radiance
LBL

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Radiance simulations were used in the design of the UC Berkeley EBB.
ARCHITECTURAL RECORD
SE Corner vs. North Facade
Energy Biosciences Building
SmithGroupJJR / Loisos + Ubbelohde
University of California, Berkeley

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ARCHITECTURAL RECORD

Energy Biosciences Building

SmithGroupJJR / Loisos + Ubbelohde

University of California, Berkeley

Designers arrived at the installed lighting scheme after simulating the effect of daylight coming through the laboratory windows at various times of the day and year. The simulations included studies of illuminance (left) and luminance (slide 5), which show how much light surfaces receive and emit, respectively.

Simulation courtesy Loisos + Ubbelohde

Illuminance simulation

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ARCHITECTURAL RECORD

Energy Biosciences Building

SmithGroupJJR / Loisos + Ubbelohde

University of California, Berkeley

Designers arrived at the installed lighting schem after simulating the effect of daylight coming through the laboratory windows at various times the day and year. The simulations included studi of illuminance (slide 6) and luminance (left), whic show how much light surfaces receive and emit, respectively.

Luminance simulation

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ARCHITECTURAL RECORD

Energy Biosciences Building

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University of California, Berkeley

The electric lighting for the laboratories includes pendant luminaires placed between the lab benches for ambient light. Each work surface has its own LED task light equipped with an occupancy sensor that shuts the fixture off when researchers leave for extended periods.

Photo © Bruce Damonte

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Outcome: integrated electric lighting/daylighting scheme.

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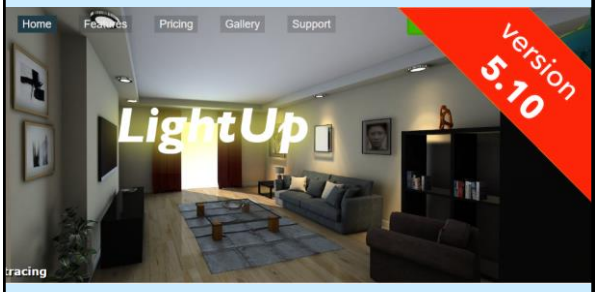
Lightup for Sketchup does electric and sun light



For 30-day free trial see https://www.light-up.co.uk/

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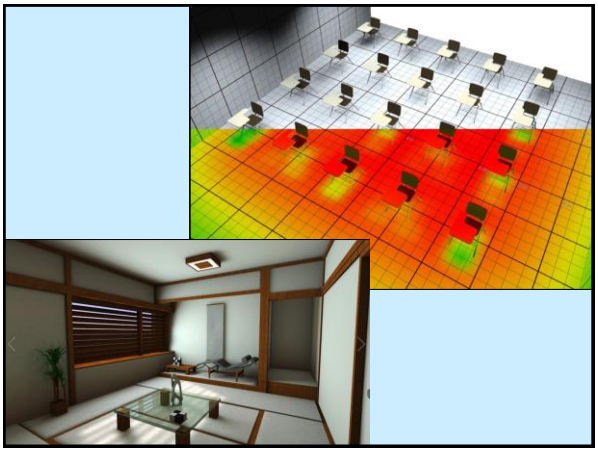

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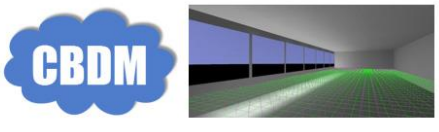

Climate-Based Daylight Modeling (CBDM)

The most meaningful method of assessing the performance of a space due to daylight is through the use of an annual simulation: the calculation of illuminance on the workplane for every day lit hour of an entire year (assuming 12 daylight hours/day, which is 4,380 unique calculations). Drum roll please… After at least seven years of development, we are extremely pleased to announce that the first release is ready for the public! This new technology will be available in June as a separate "add-on" application capable of processing an annual daylight simulation of your AGi32 or Revit model (using ElumTools) in an astonishingly fast matter of minutes as compared to hours or days for the only competitive solution. The result is accurate daylight illuminance for every illuminated hour of an entire year. From this data, a variety of statistical analyses can be performed yielding numerous daylight metrics, such as Daylight Autonomy (various flavors), Annual Sunlight Exposure and Useful Daylight Illuminance. The add-on software also provides a great interface for evaluating the results and formatting a personalized report. Stay tuned!

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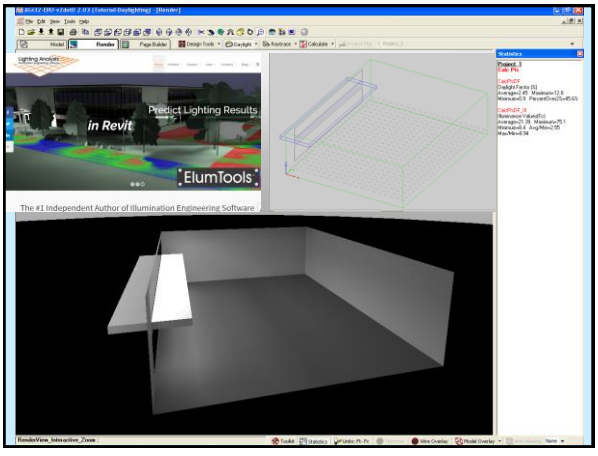
Predict Lighting Results
in Revit
ElumTools
The #1 Independent Author of Illumination Engineering Software

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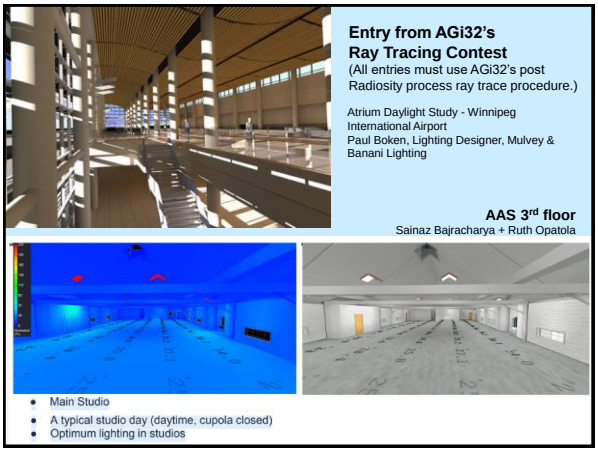
Entry from AGi32's
Ray Tracing Contest
(All entries must use AGi32's post
Radiosity process ray trace procedure.)
Atrium Daylight Study - Winnipeg
International Airport
Paul Boken, Lighting Designer, Mulvey &
Banani Lighting
AAS 3rd floor
Sainaz Bajracharya + Ruth Opatola
Main Studio
A typical studio day (daytime, cupola closed)
Optimum lighting in studios

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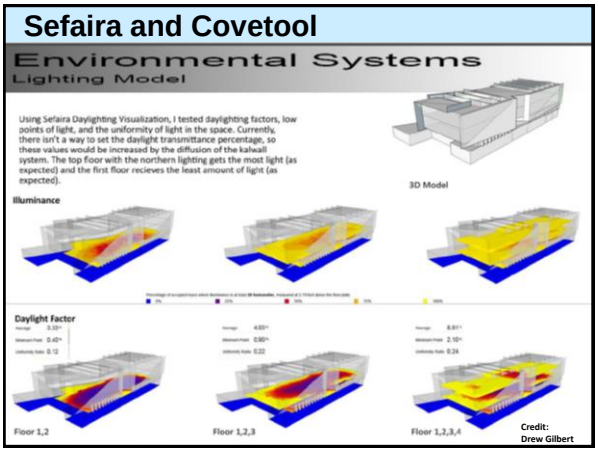
Sefaira and Covetool
Environmental Systems
Lighting Model
Using Sefaira Daylighting Visualization, I tested daylighting factors, low points of light, and the uniformity of light in the space. Currently, there isn't a way to set the daylight transmittance percentage, so these values would be increased by the diffusion of the kalwall system. The top floor with the northern lighting gets the most light (as expected) and the first floor recieves the least amount of light (as expected).
3D Model
Illuminance
Daylight Factor
Floor 1,2
Floor 1,2,3
Floor 1,2,3,4
Credit:
Drew Gilbert

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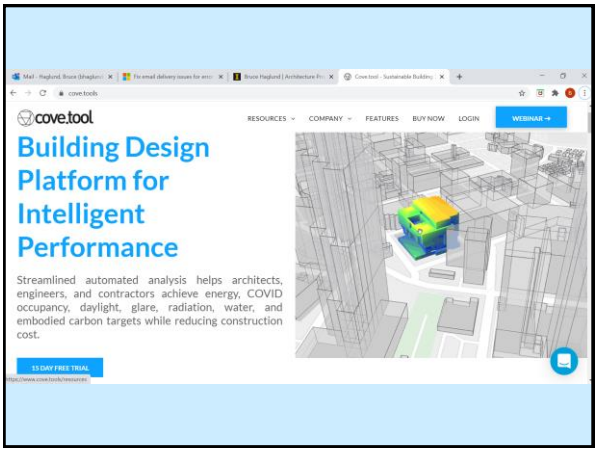

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Insight, a Revit plug-in

Whole building energy **Daylighting analysis** **Heating and cooling load**

More info: <https://www.autodesk.com/products/insight/overview>

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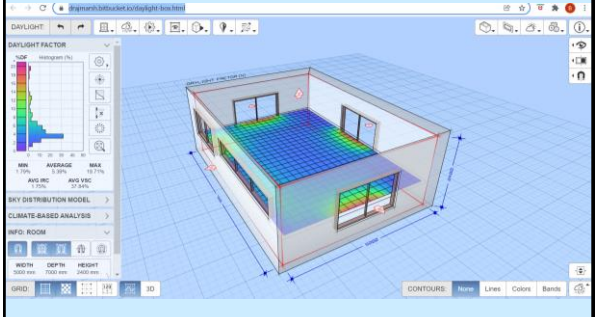
Dynamic Daylighting by AndrewMarsh.com

Free cloud-based, interactive modeling for rectilinear rooms



https://drajmarsh.bitbucket.io/daylight-box.html

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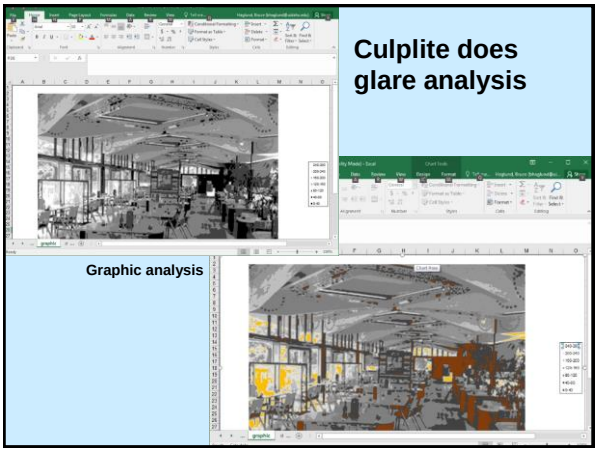
Culplite does glare analysis
Graphic analysis

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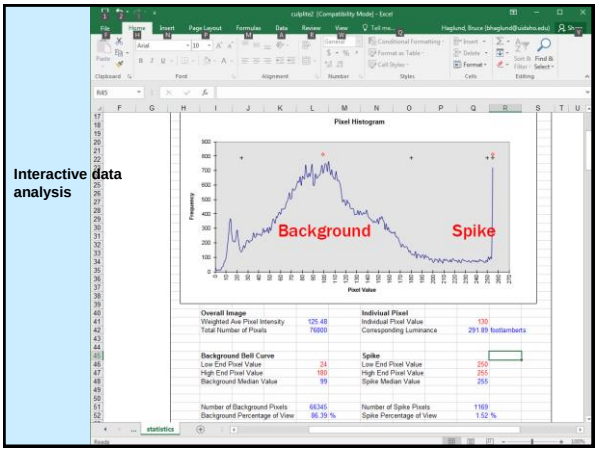
Interactive data analysis
Pixel Histogram
Background
Spike

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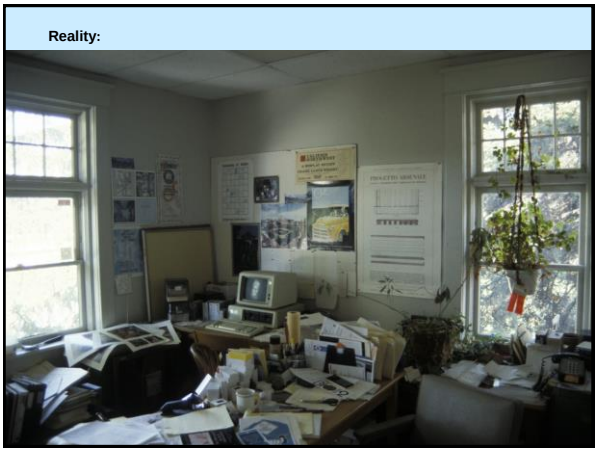
Reality:

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Next: more on physical models

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