Zero Energy Buildings are Solar Responsive Buildings that Work

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SBSE Retreat

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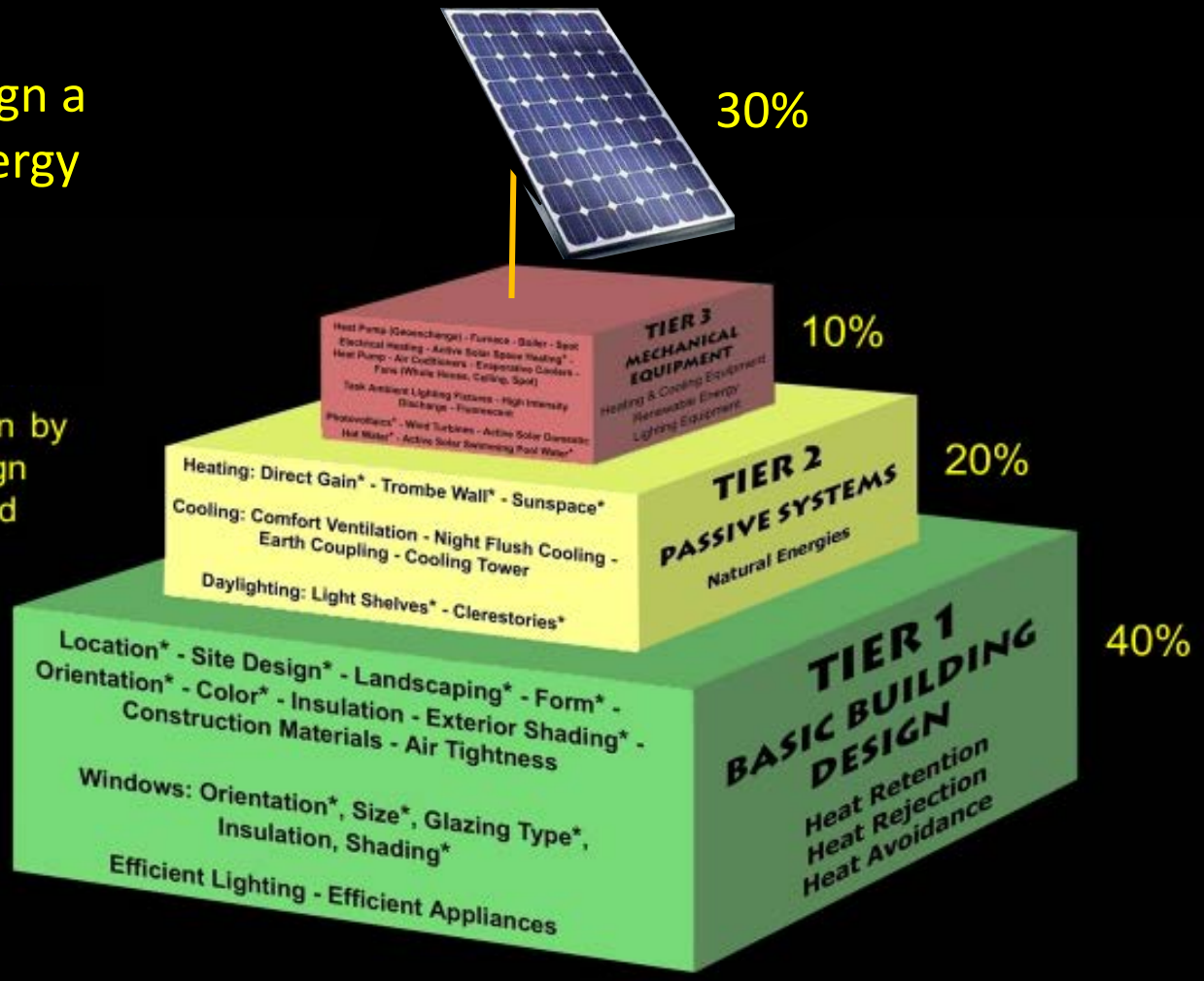
How to design a net-zero energy building

- 70% reduction by building design
- 30% produced With PV



THE 3 TIER APPROACH TO SUSTAINABLE HEATING, COOLING, AND LIGHTING OF BUILDINGS

* PART OF SOLAR RESPONSIVE DESIGN

Pick the low-hanging fruit first!

PV (photovoltaics) (highest cost)

Active solar

Ventilation (preheating or Solar chimney)

Daylighting (moderate cost)

Passive solar (low cost)

Shading (moderate cost)

Window size (free ?)

Window placement (free)

Building color (free)

Building orientation (free)

Even if the building can’t be oriented correctly, the windows can.

2019 COTE® Top Ten
Frick Environmental Center

Frick Environmental Center

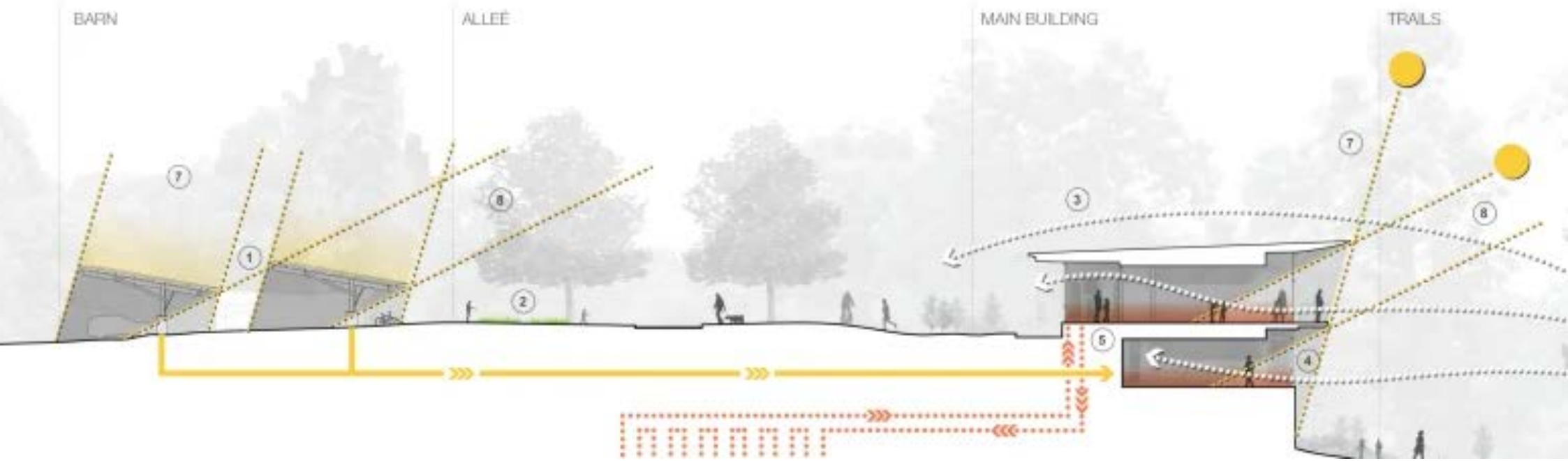
Architect: Bohlin Cywinski Jackson

1 Photovoltaic Array
2 Edible Garden
3 Natural Ventilation
4 Operable Windows
5 Floor Slab Heating
6 Geothermal Wells
7 Summer Solstice
8 Winter Solstice

7 Summer Solstice – June 21
8 Winter Solstice – December 21

-237,623kWh
TOTAL USED

90,289kWh
TOTAL NET (SURPLUS)

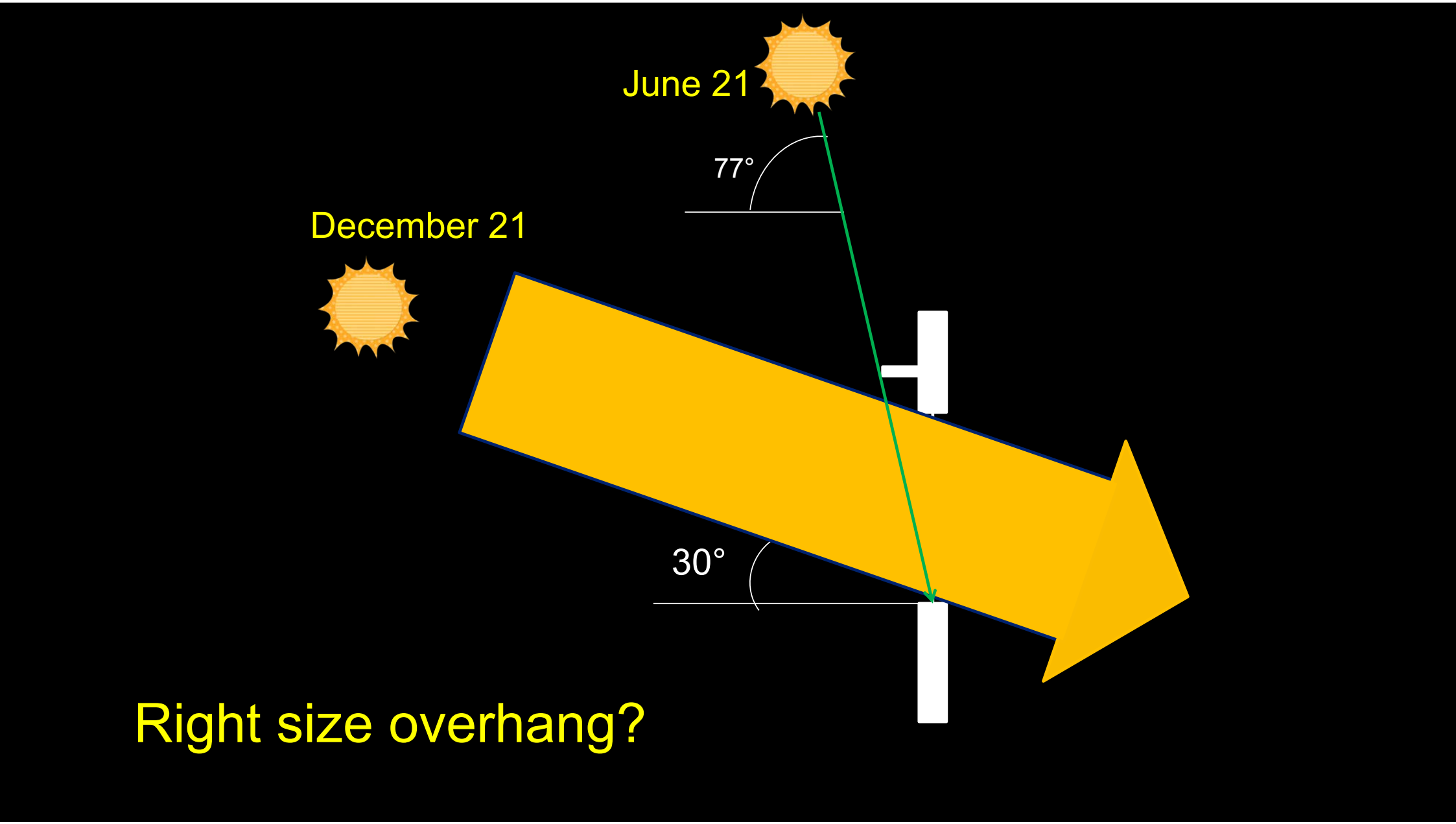


Goal:

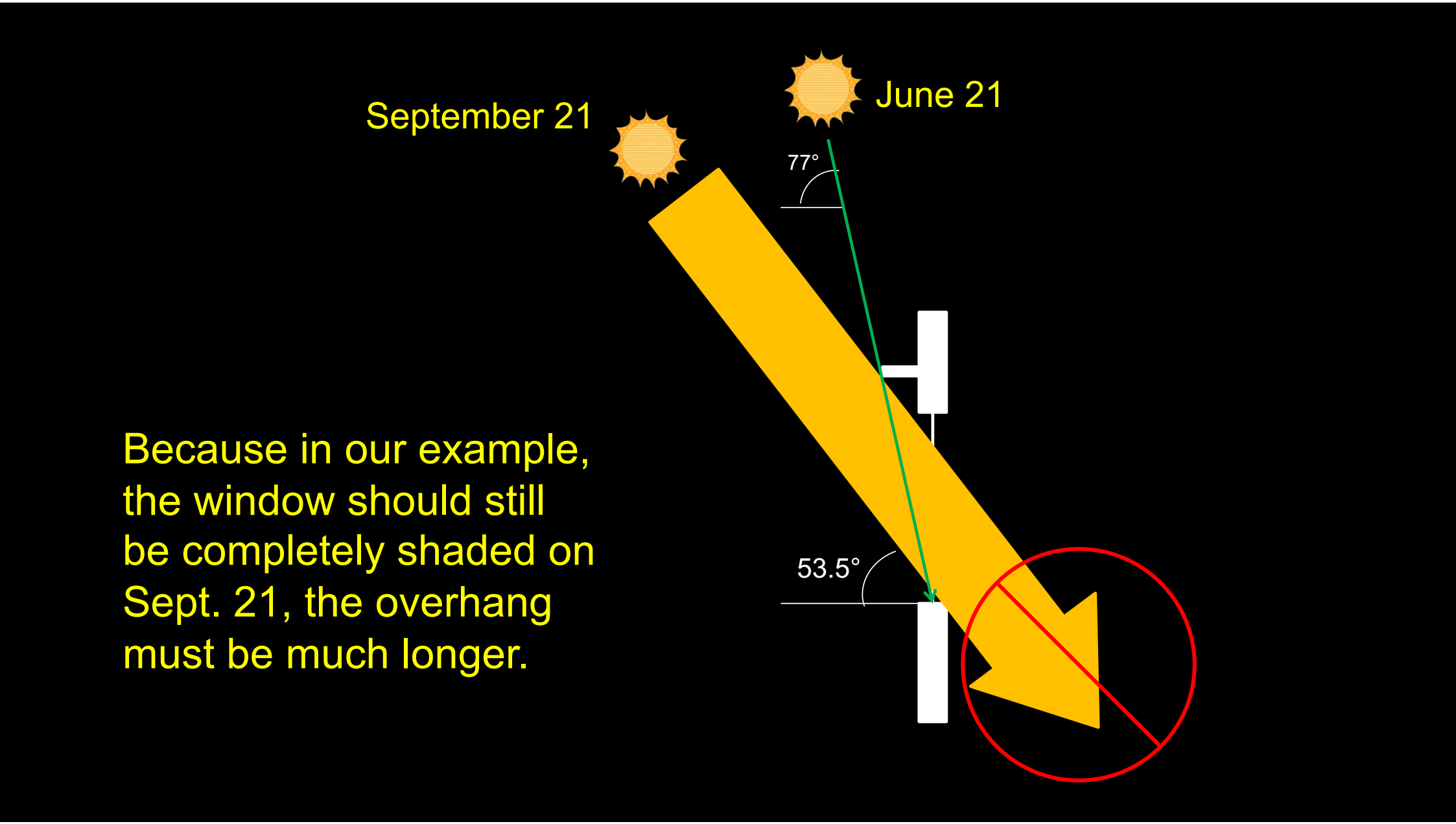
Design a fixed horizontal overhang for a south window located at 36° north latitude where cooling is still needed on September 21 and heating is still needed on March 21.

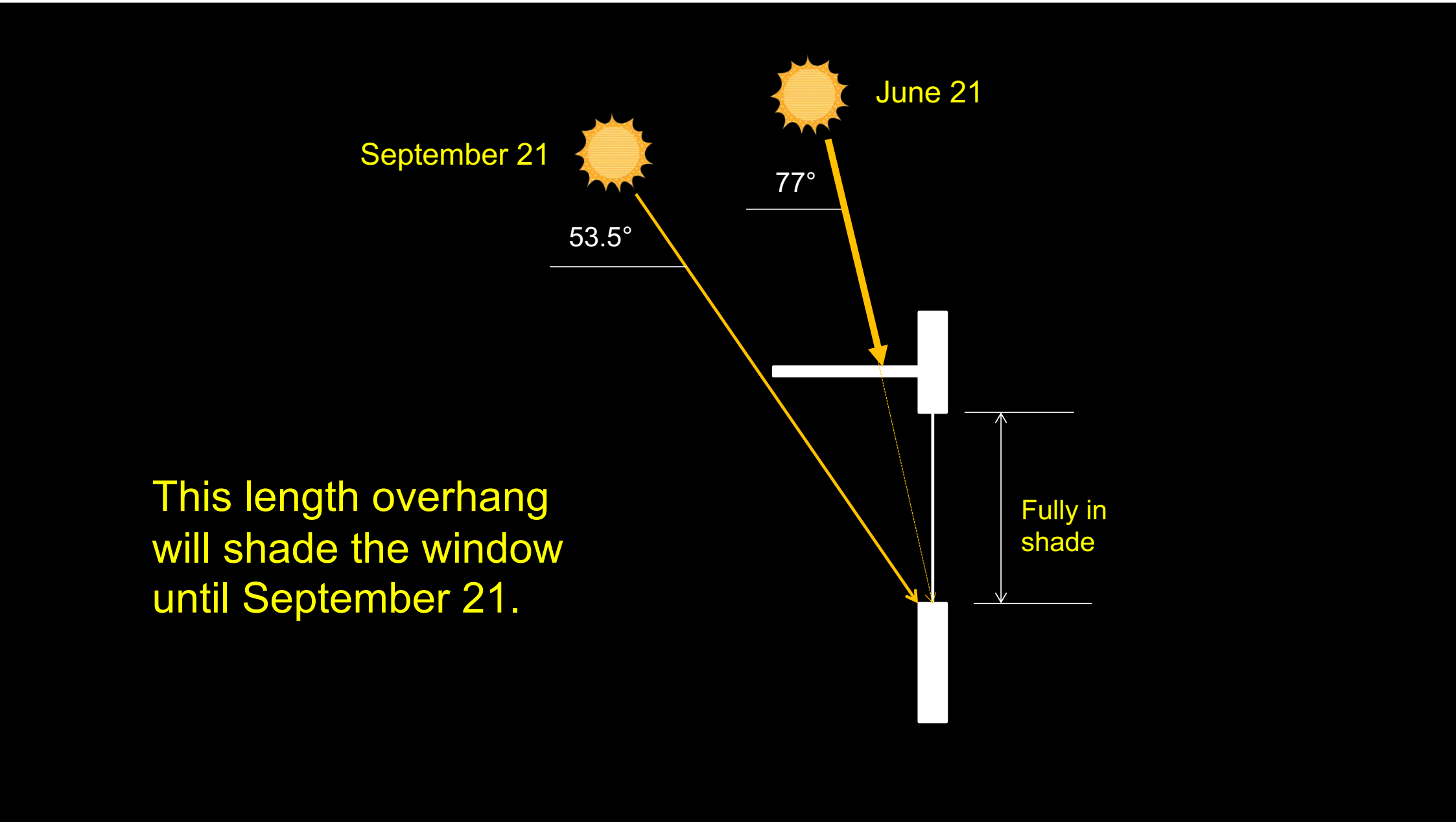
Thus, the windows should be completely shaded during the whole overheated period ending on September 21 and fully exposed to the sun during the whole underheated period ending on March 21.

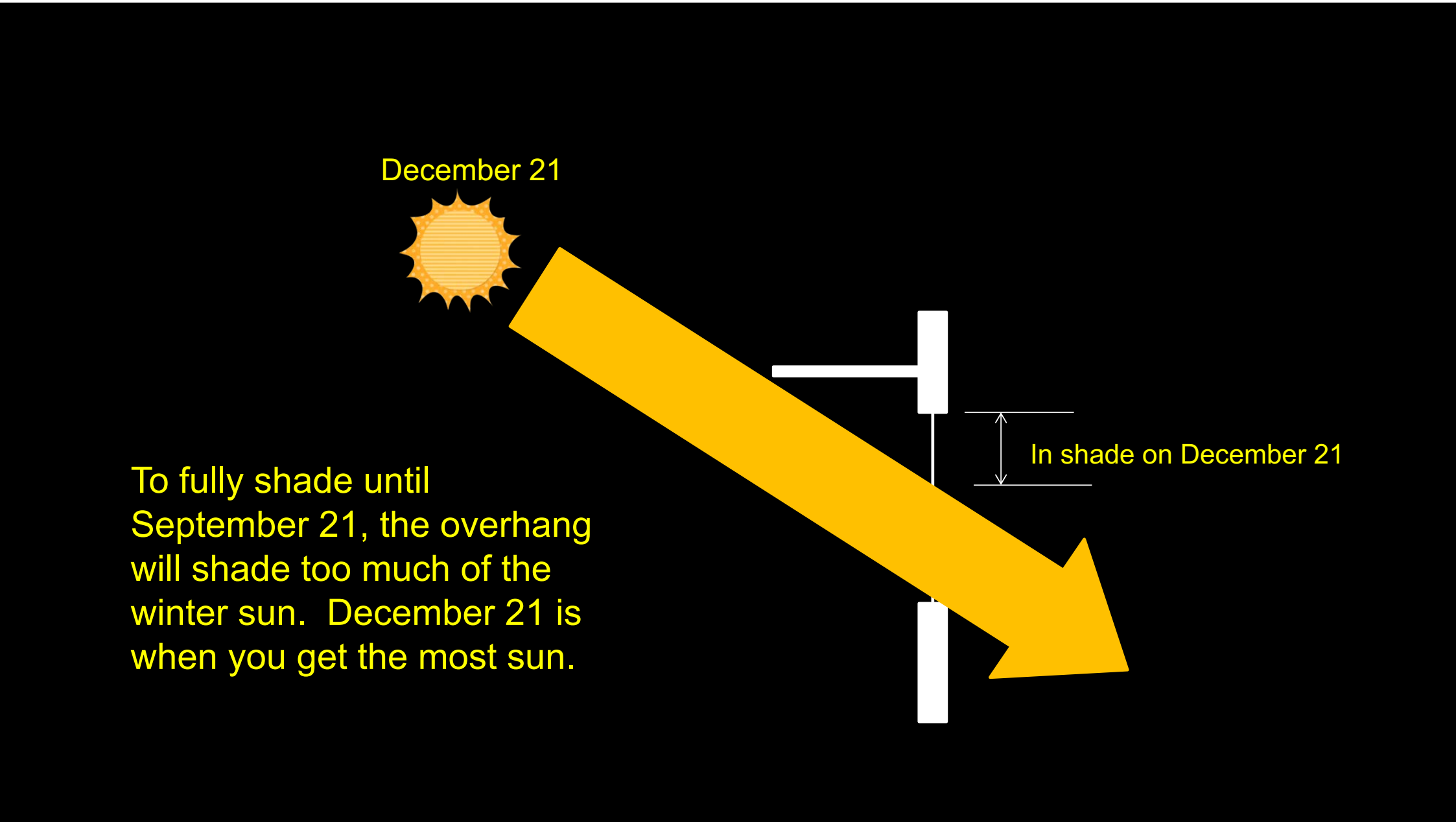
Note that the hottest months are July and August and not June, and the coldest months are January and February and not December.

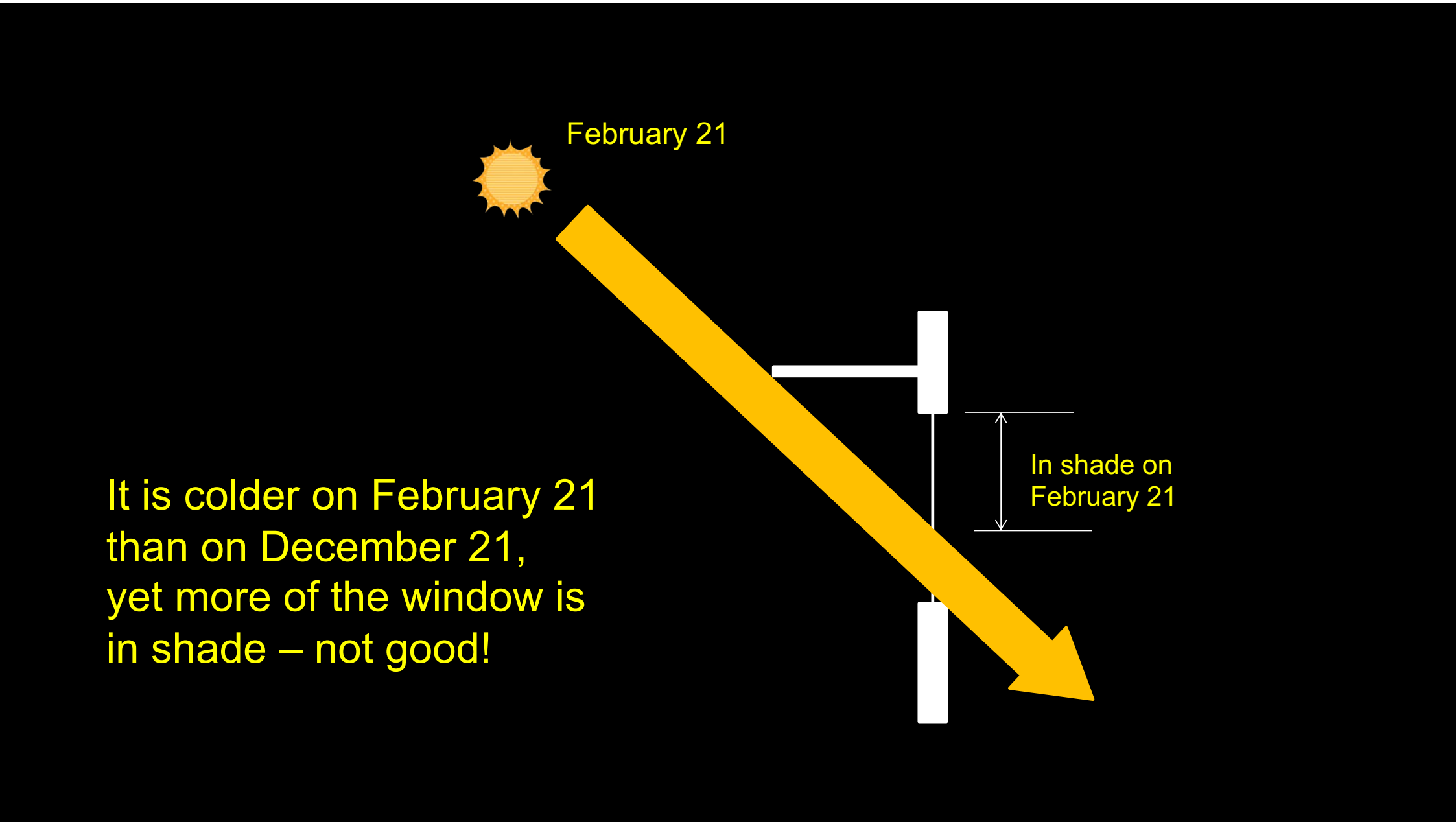


Right size overhang?

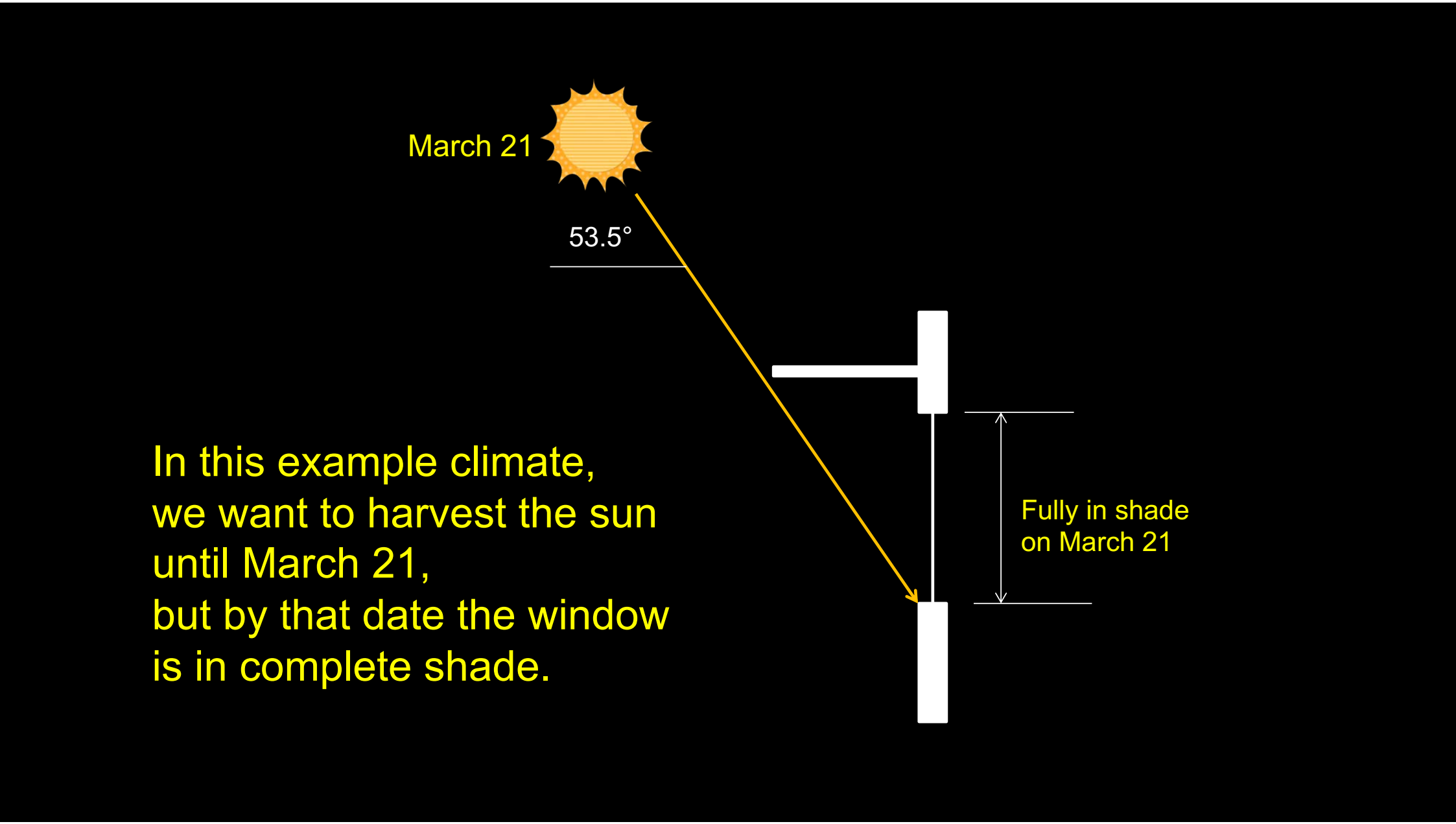

September 21
June 21
77°
53.5°
Because in our example, the window should still be completely shaded on Sept. 21, the overhang must be much longer.


June 21
September 21
77°
53.5°
Fully in
shade
This length overhang
will shade the window
until September 21.


December 21
In shade on December 21
To fully shade until September 21, the overhang will shade too much of the winter sun. December 21 is when you get the most sun.



It is colder on February 21
than on December 21,
yet more of the window is
in shade – not good!


March 21
53.5°
Fully in shade
on March 21
In this example climate,
we want to harvest the sun
until March 21,
but by that date the window
is in complete shade.

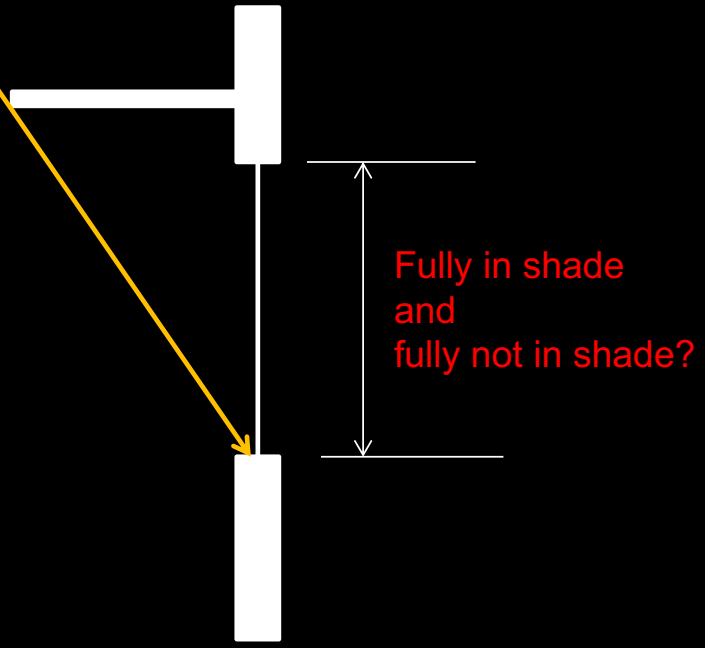
Myth 1

December and June 21 sun-angles should be used to design and present solar design.

Fact 1

Use the dates of the end of overheated and underheated periods of the year to maximize both shading and solar heating.

March 21
September 21



March 21 and September 21 have the same sun angle, but the shading requirements are completely different because the solar and thermal year are out of phase.

Myth 2

A fixed overhand can do a good job of both shading in summer and passive solar heating in the winter.

Fact 2

Only dynamic shading systems can produce the high performance that is now a requirement.

External venetian binds
are common in Europe

Occupants
adjust the blinds

Myth 3

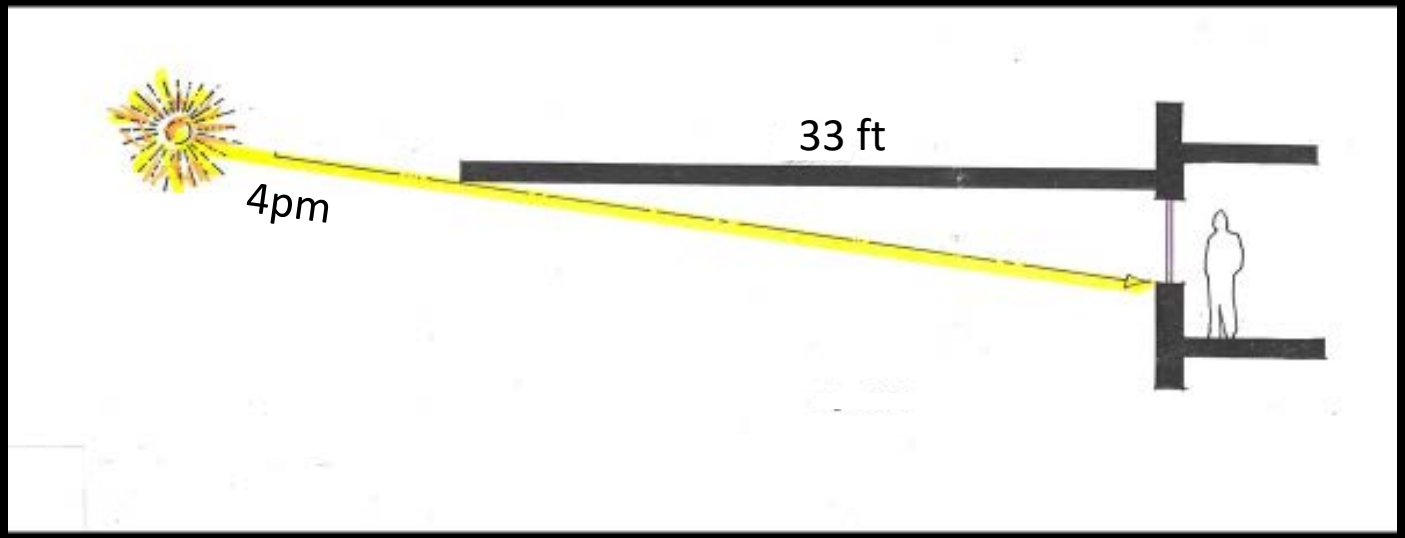
A horizontal overhand should be as wide as the window.

Fact 3

Overhangs should be about 30% wider on each side of a window. An alternative solution is to use vertical fins on each side of the overhang.

The length of the overhang needed to shade a west window until 4pm at a typical latitude is

How long must an overhang be to completely shade a west window on June 21? ∞



Myth 4

Because horizontal overhangs don’t work on east and west windows, the solution is to use vertical fins.

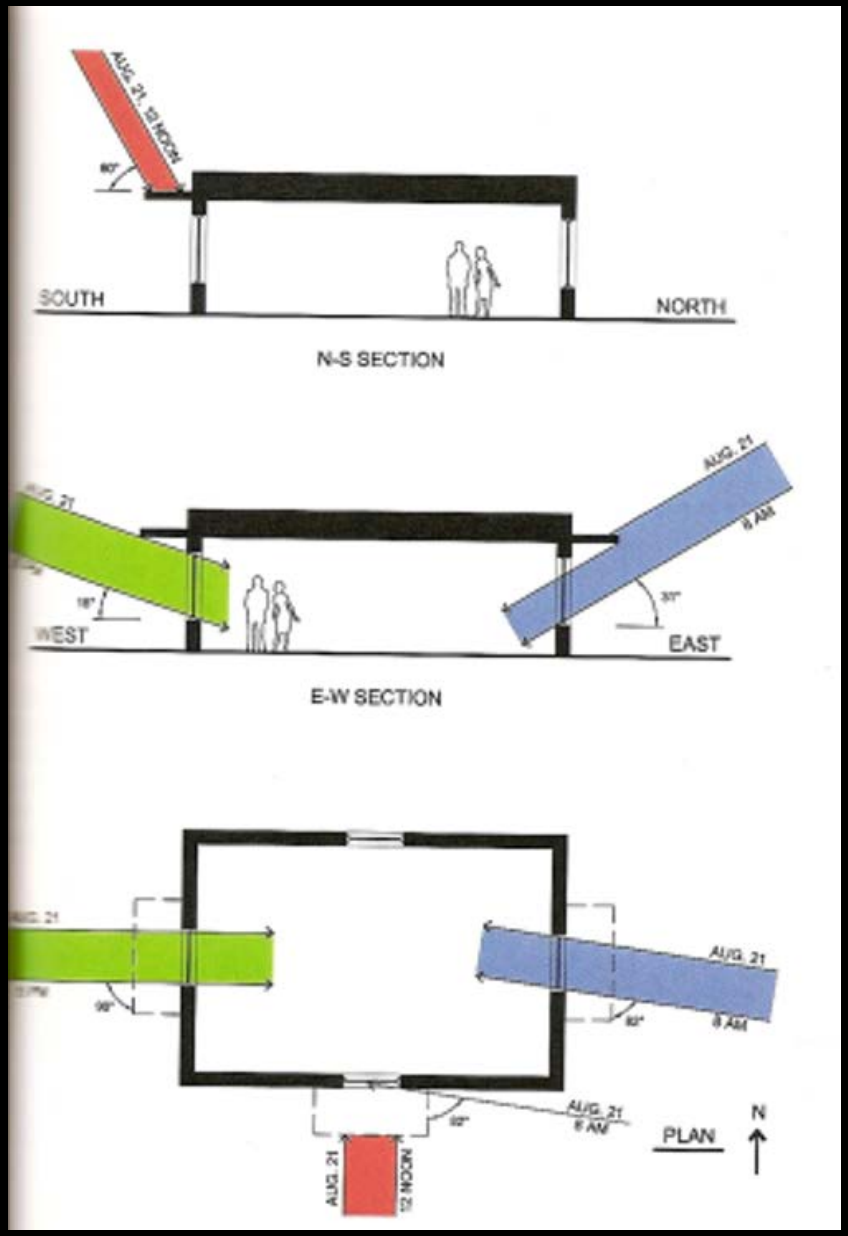
Fact 4

Vertical fins are no better than horizontal louvers on east and west windows. There is no good way to shade east or west windows without blocking the view much of the time.

Dynamic shading systems are far better than fixed devices on east and west windows, but they will still block the view somewhat.

Note how little the sun is shaded on these west windows in the early afternoon. As time passes, the sun will move further to the northwest, and these windows will get even less shade. Only later in the afternoon will the shading increases again.

Shade lines
early afternoon



Graphical method

When using graphical methods, showing sunrays is not good enough because they do not show the magnitude of the sun entering the windows. Thus, sunbeams should be drawn instead, and they should be drawn at end of both the overheated and underheated periods.

Myth 5

Drawings and computer images leave the students with long-term deep understanding of solar geometry and the ability to design high performance solar responsive buildings.

Fact 5

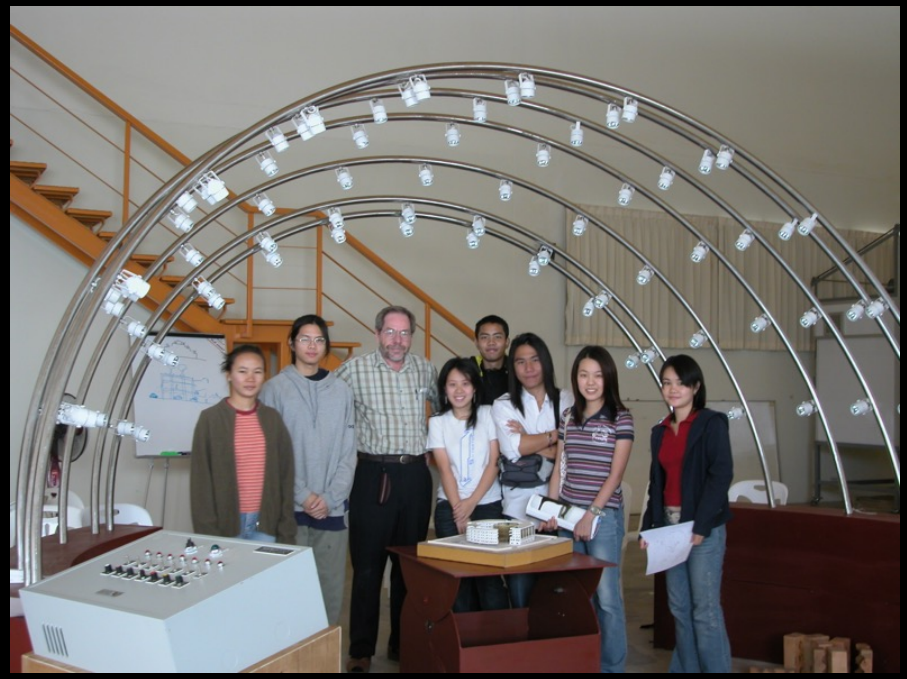
A picture is worth a 1,000 words, and a 3D model is worth a 1,000 pictures.

Physical models tested on a heliodon leave a deep and long-lasting impression of the value of solar responsive design and how to do it correctly. Their use, also motivates students.

Heliodons – Myth Busters

Conceptually clear heliodons simulate our everyday experience of the relationship of the sun and a building.

Sun Simulator Heliodon



Sun Emulator Heliodon

Very Low-cost Heliodons

Construction drawings are available for free at www.heliodons.org

Tabletop Heliodon Kit

Track to hold lamp

Solar Geometry
Demonstration Heliodon

No-guilt solar heated hot tub

Thanks for your attention

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