# Welcome to Section 4:

# Explaining and Understanding How Pinhole Imaging Happens

NASA PUNCH website:
https://punch.space.swri.edu /

Scan here to access all PUNCH Outreach products or visit:
**https://punch.space.swri.edu/punch_outreach_products.php**

For questions or to request our 1-page monthly newsletter:
Contact PUNCHOutreach@gmail.com

Photo: Alan Friedman

# [*Really*] Understanding Pinhole Projection of the Sun

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## Follow along with our playful learning adventure!


FRONT

And **PLEASE** give us feedback on these questions at the link below:

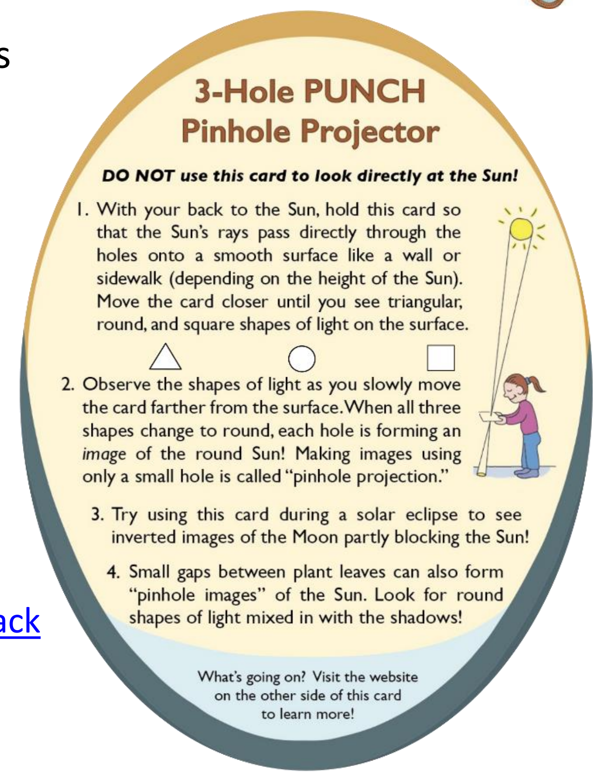
**Insights gained?**

**Remaining questions?**

**Ideas for improvements?**

[https://tinyurl.com/PinholeFeedback](https://tinyurl.com/PinholeFeedback)

**MARK 3 Version**
Final Release for use up to and including the Annular Eclipse on 14 Oct 2023




BACK

# Essential viewing:

## [6-minute "how-to-facilitate" video](https://punch.space.swri.edu/punch_outreach_pinholeprojector.php)

[ https://punch.space.swri.edu/punch_outreach_pinholeprojector.php ]

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Polarimeter to UNify the Corona and Heliosphere

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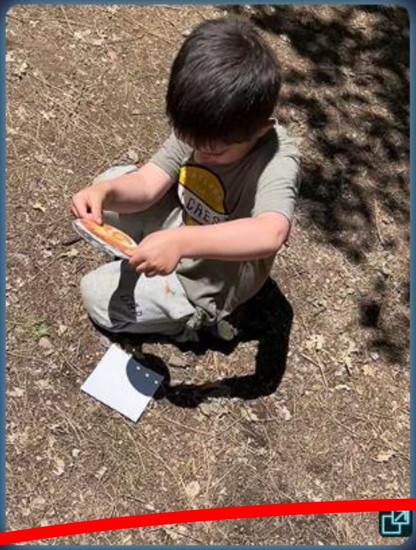
### 3-HOLE PUNCH PINHOLE PROJECTOR



The PUNCH Outreach team designed the 3-Hole PUNCH Pinhole Projector (3HPPP) so that everyone can experience and explore the wonder of how a small, lens-less hole of any shape works to create real images of the Sun or other bright light sources, both indoors and outdoors.

Image credit: Vivian White

**Our projector allows you to observe the Sun safely during eclipses or on any sunny day!**

The 3HPPP is NOT your ordinary pinhole projector nor a simple give-away like a sticker or button, but a powerful learning tool when safely and effectively facilitated.

This **6-minute "how-to" video** shares what we've learned about how to facilitate use of the 3HPPP to excite a lifetime of curiosity and wonder in learners of all ages.

# [*Really*] Understanding Pinhole Projection of the Sun

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## Introducing Bhanu

[BAH-noo]

Bhanu means "ray of light" in Sanskrit

**Bhanu helps guide our way through these Sections. You are in Section 4 of 5.**

| Section | Title of Section | Description of Section |
|---|---|---|
| 1 | How to Use the 3-Hole PUNCH Pinhole Projector | introduces the 3-Hole PUNCH Pinhole Projector, demonstrates how to use it both outdoors and indoors, and describes its differences from a pinhole camera/viewer. |
| 2 | Observing Pinhole Images of the Sun in Our Everyday Environments | teaches you how to observe the phenomenon of pinhole images of the Sun in our everyday world, both indoors and outdoors. |
| 3 | Exploring Pinhole Projection Using Your Own Hands | invites you to explore the behavior of pinhole projection by experimenting with your own hands (try both palms up!) |
| **4** | **Explaining and Understanding How Pinhole Imaging Happens** | **guides your quest for explanations and deeper understanding of how pinhole imaging happens. After this, you will *really* understand why small, lens-less holes can create images.** |
| 5 | APPENDICES A-E: More Insights & Fun Resources | offers more insights & resources (e.g., explaining the relationship between pinhole images and the view through "eclipse" glasses) |

**CONTACT:**
Dr. Cherilynn Morrow, Outreach Director for the NASA PUNCH mission [cherilynn.morrow@gmail.com]

# Pinhole Projection of the Sun

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## 4. Explaining and Understanding How Pinhole Imaging Happens

**Bahnu says: Find the courage to be confused!**

Lots of things worthy of our understanding are worth the discomfort of not understanding them at first. Confusion is a sign that you are on the path to a new insight. Persevere!

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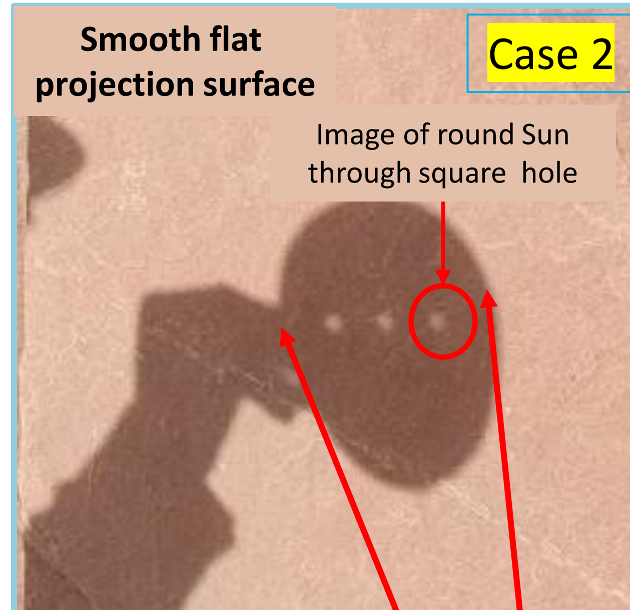
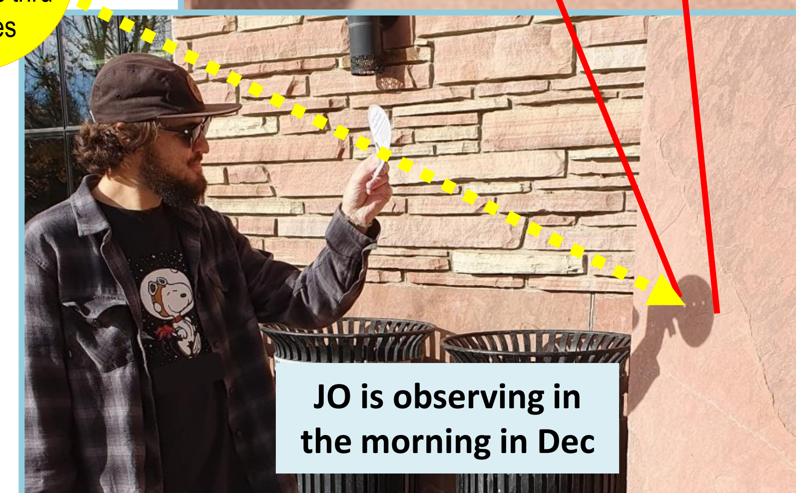
**1**. Projector **close to surface**. Triangle, round, and square shapes of light are sharp.


**2.** Projector **farther away from surface**. All three shapes of light are round and fuzzier.




Were you able to observe ***both*** Case 1 and Case 2?

Sunlight comes from this direction and passes thru the holes




**KEY QUESTION:** Why don't we see round images of the Sun when the projector is held closer to the projection surface (Case 1), but we *do* see them when we move it farther away (Case 2)?

# Pinhole Projection of the Sun

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**From our exploration of how pinhole projection of the Sun behaves we have collected two <u>key questions</u>:**

1. Why don’t we see round images of the Sun when the projector is held closer to the projection surface (Case 1), but we *do* see them when we move it farther away (Case 2)?

2. How can small, *non-round* holes formed by gaps between leaves, strands of a straw hat, fingers of our hands, and by our pinhole projectors create images of the *round* Sun?

# Pinhole Projection of the Sun

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If you are not familiar with ray tracing, OR if you would like to experience our novel way of preparing learners to understand ray tracing, please continue to the next slide.

If you are already familiar with *ray tracing*, go to slide 34.

# Pinhole Projection of the Sun

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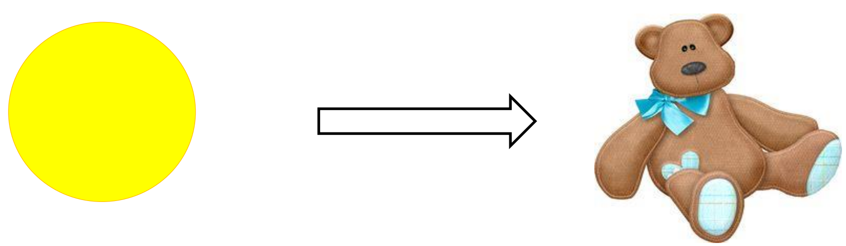
**From our exploration of how pinhole projection of the Sun behaves we have collected two <u>key questions</u>:**

**To address our two questions, we first need to study how light emitted or reflected from an object interacts with the "pinhole" card to reach a projection surface.**

**Bhanu will help. Because we should not look directly at the Sun, we will pretend that Bhanu is the Sun, and our eye is viewing Bhanu from the perspective of different positions on the projection surface.**

Sun Bhanu



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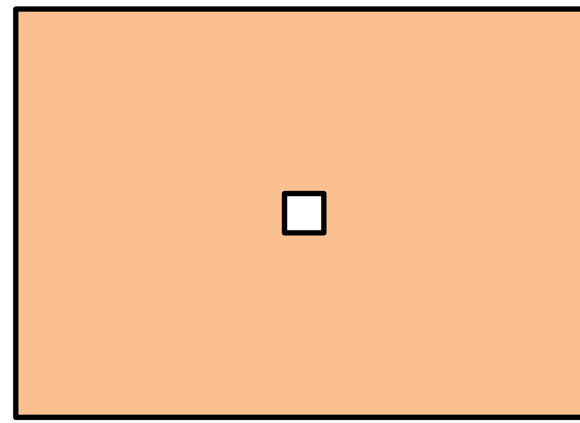
**To safely explore how light reflected from Bhanu passes through a pinhole to a projection surface, we view Bhanu through a small, non-round hole.**

**Bhanu**
[BAH-noo]
Bhanu means "ray of light" in Sanskrit



# NEVER look at the Sun through the holes in a pinhole projector!

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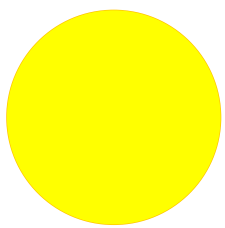
# To make your own observations find an object like Bhanu to view that can *represent* the Sun

An object about a foot (~30 cm) tall works well.
Your object should have different features at the top and bottom and ideally left and right.

Sun



Your object (our Bhanu)

Bhanu
[BAH-noo]
Bhanu means "ray of light" in Sanskrit

Bhanu is ideal for our exploration.
The bear has a brown head and blue feet, plus a bow on the left, but not on the right.

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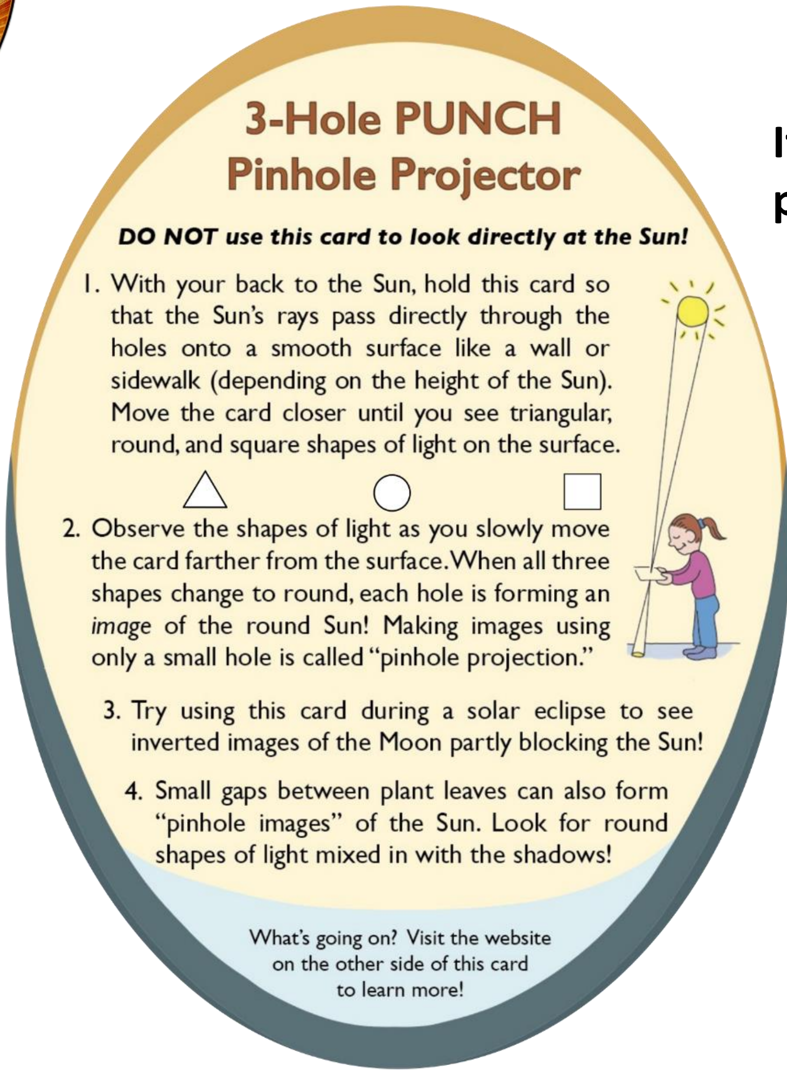
# Then find or create a small hole to use for this activity.


## 3-Hole PUNCH Pinhole Projector

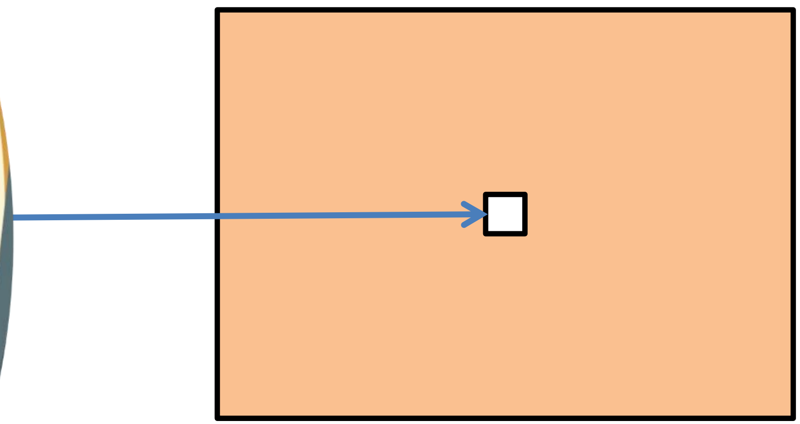
***DO NOT use this card to look directly at the Sun!***

1. With your back to the Sun, hold this card so that the Sun's rays pass directly through the holes onto a smooth surface like a wall or sidewalk (depending on the height of the Sun). Move the card closer until you see triangular, round, and square shapes of light on the surface.
2. Observe the shapes of light as you slowly move the card farther from the surface. When all three shapes change to round, each hole is forming an *image* of the round Sun! Making images using only a small hole is called "pinhole projection."
3. Try using this card during a solar eclipse to see inverted images of the Moon partly blocking the Sun!
4. Small gaps between plant leaves can also form "pinhole images" of the Sun. Look for round shapes of light mixed in with the shadows!

What's going on? Visit the website on the other side of this card to learn more!

BACK

**If you do not have a 3-Hole PUNCH pinhole projector, then make a card with small hole.**



You can use a 3 x 5 card or a section of a cereal box. Cut a small (~5 mm) square hole near the center of it.

# If you cannot use or make a card with a hole, then you can use a small gap in your fingers

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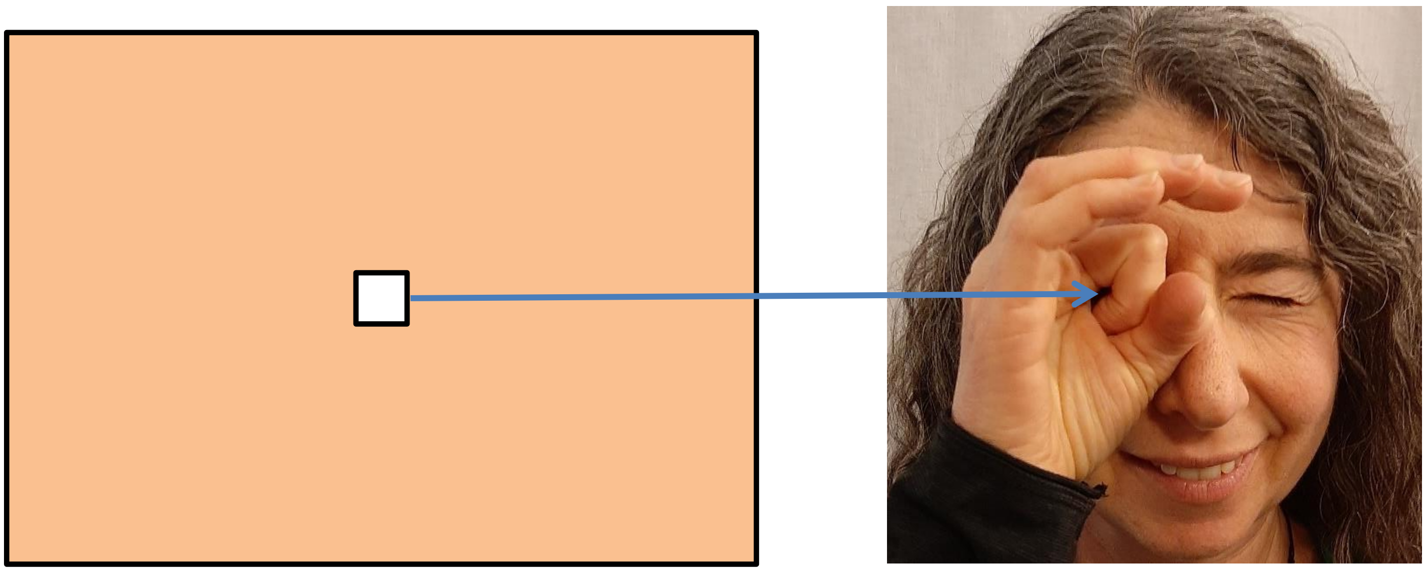

Any shape of small hole works for this activity.

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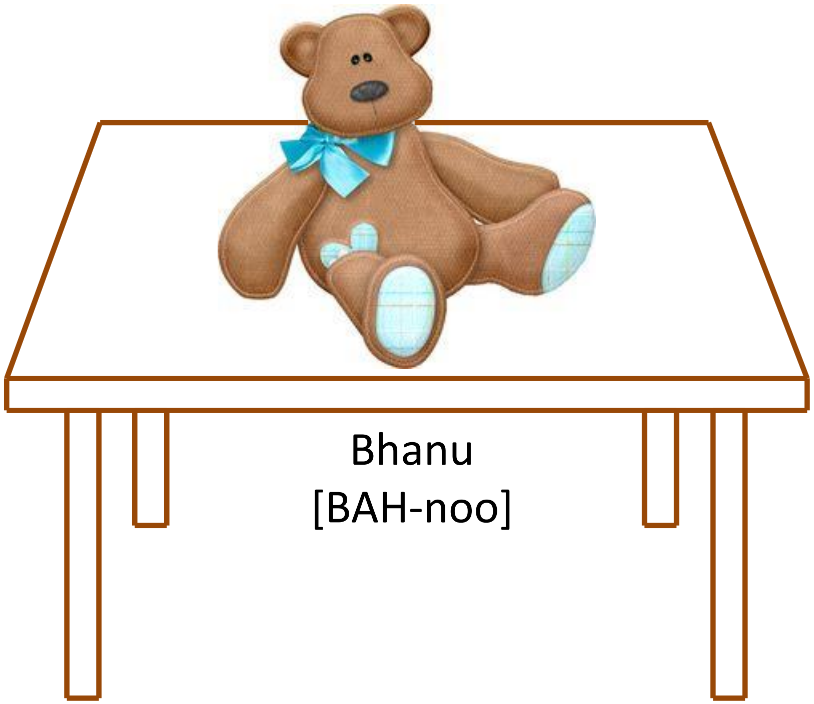
# Place the object you have selected a few feet away from you.




For an object about a foot (~30 cm) tall, a distance of 4 to 5 feet (1.2 to 1.5 m) away from you works well.

# Hold the card next to your eye and look through the hole at your chosen object

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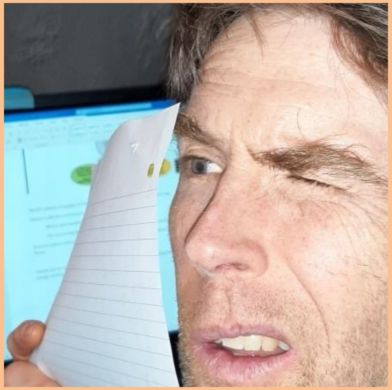
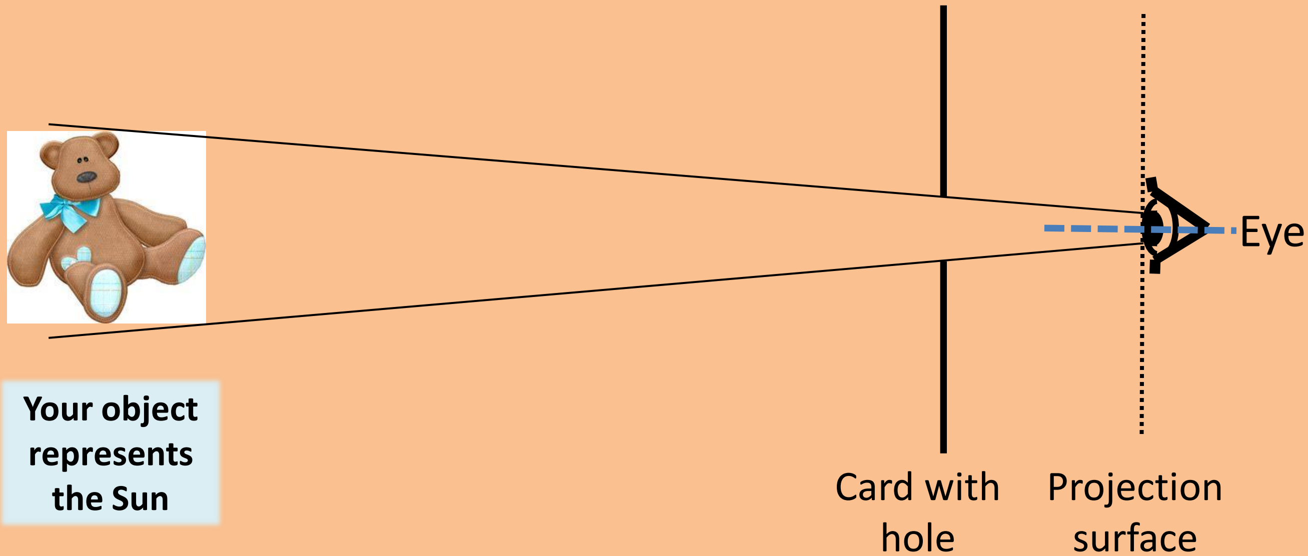
Make sure you can see *ALL* of your object. If you cannot see the whole object, then increase the distance between you and the object until you can.

MZ is using the hole in a piece of paper to follow along with this activity.






To learn how sunlight interacts with a pinhole, we view light reflected from your object (Bhanu) ***as if*** it were light emitted from the Sun. Your eye receives light ***as if*** it were a particular location on a projection surface.

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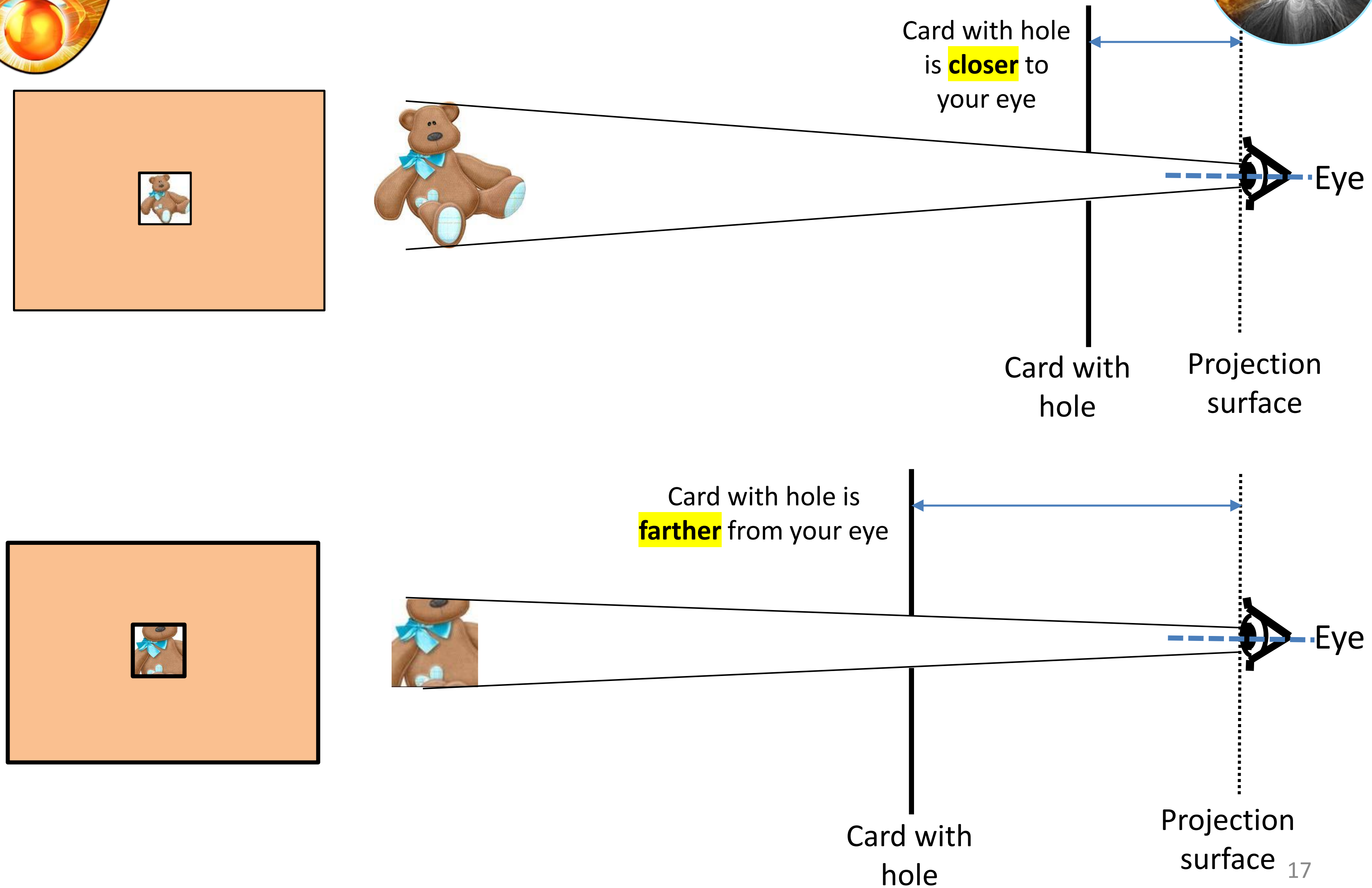
**Starting with the card close to your eye and seeing the whole object….**

**Move the card a bit farther away from your eye while looking at the object through the hole.**

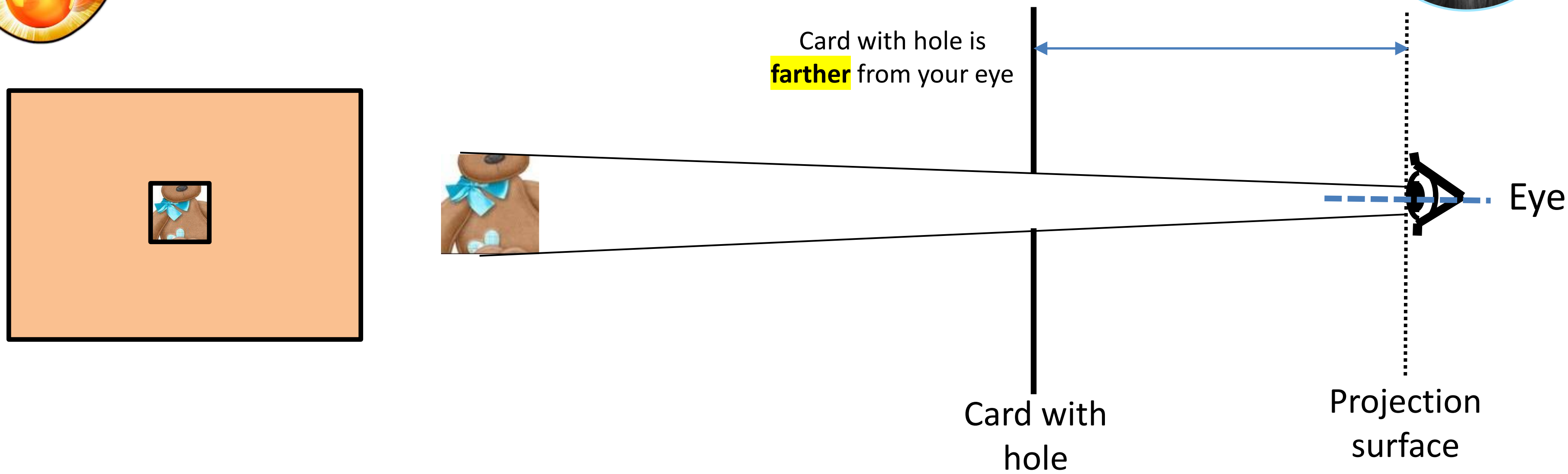
How far do you have to move the card from your eye before you can no longer see the whole object?

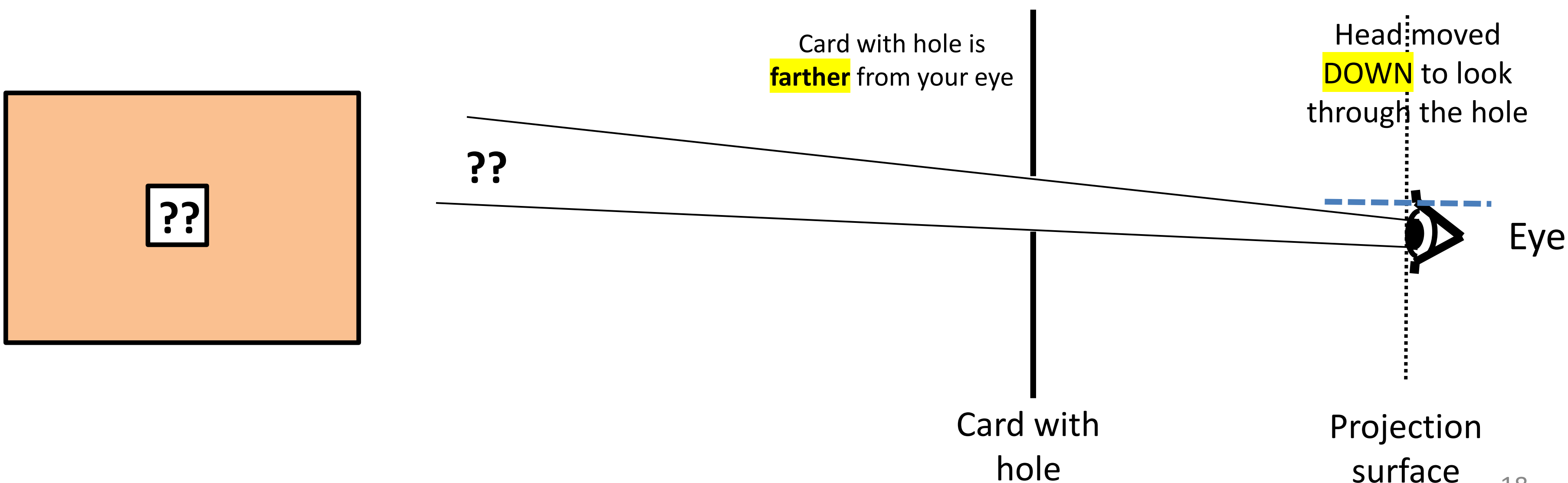
Notice that the farther away you hold the card, the less of the object you see directly through the hole.

# How much of the object you can see depends on the distance between your eye and the card with the hole



# What happens if we change the viewpoint of our eye?



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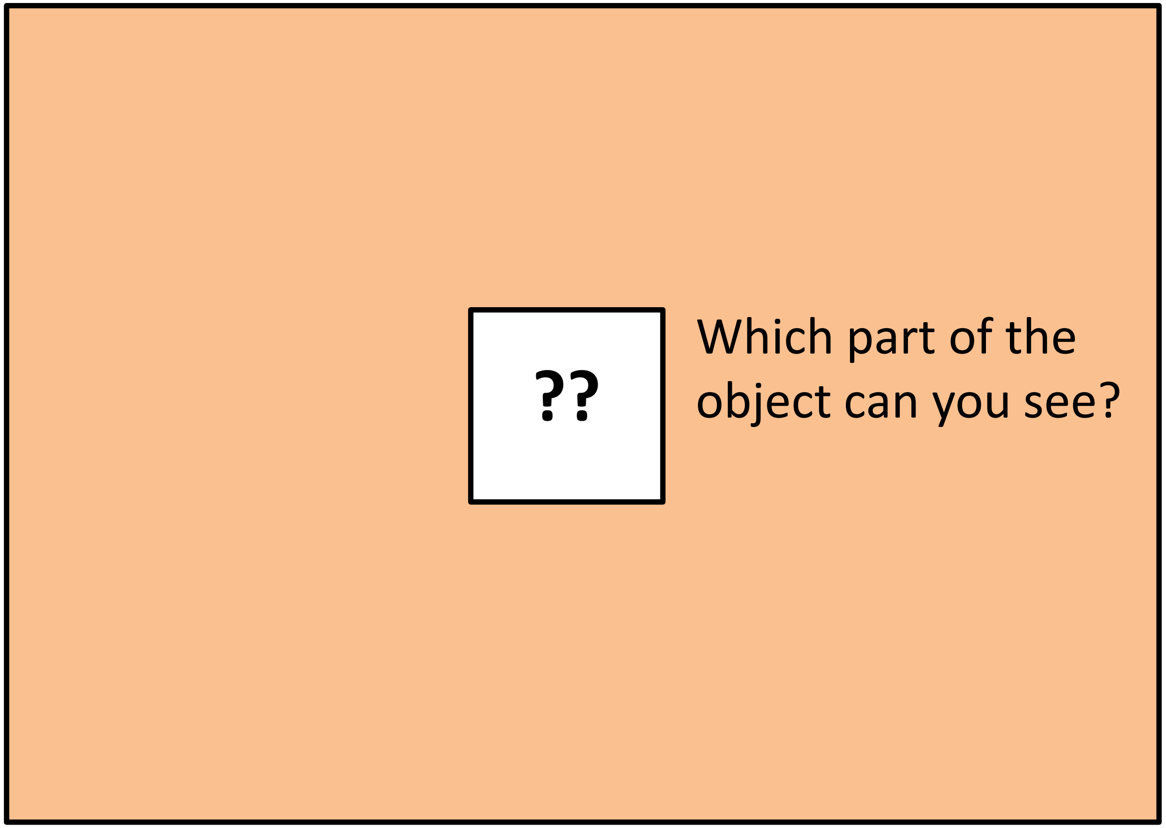
## To change the viewpoint of your eye through the hole…

1. Hold the card steady at a distance where you cannot see the whole object, but only the middle parts.
2. Move your head DOWN just a little bit while still looking at the object through the hole.



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**When you move your head DOWN while holding the card steady, you should be able to see the upper parts of the object.**

Which part of the object can you see?

**The top of the object**

**Keeping your card steady, now move your head UP just a bit while still looking at the object through the hole.**

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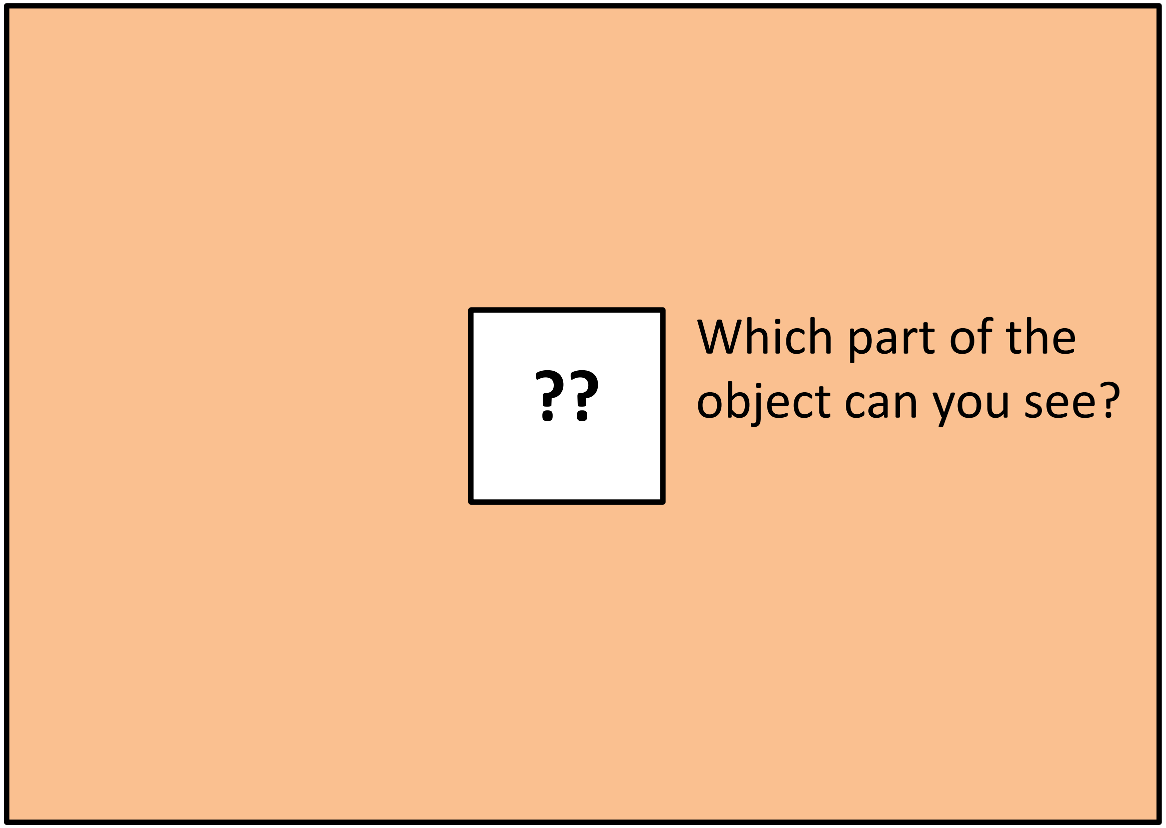

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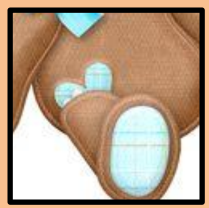
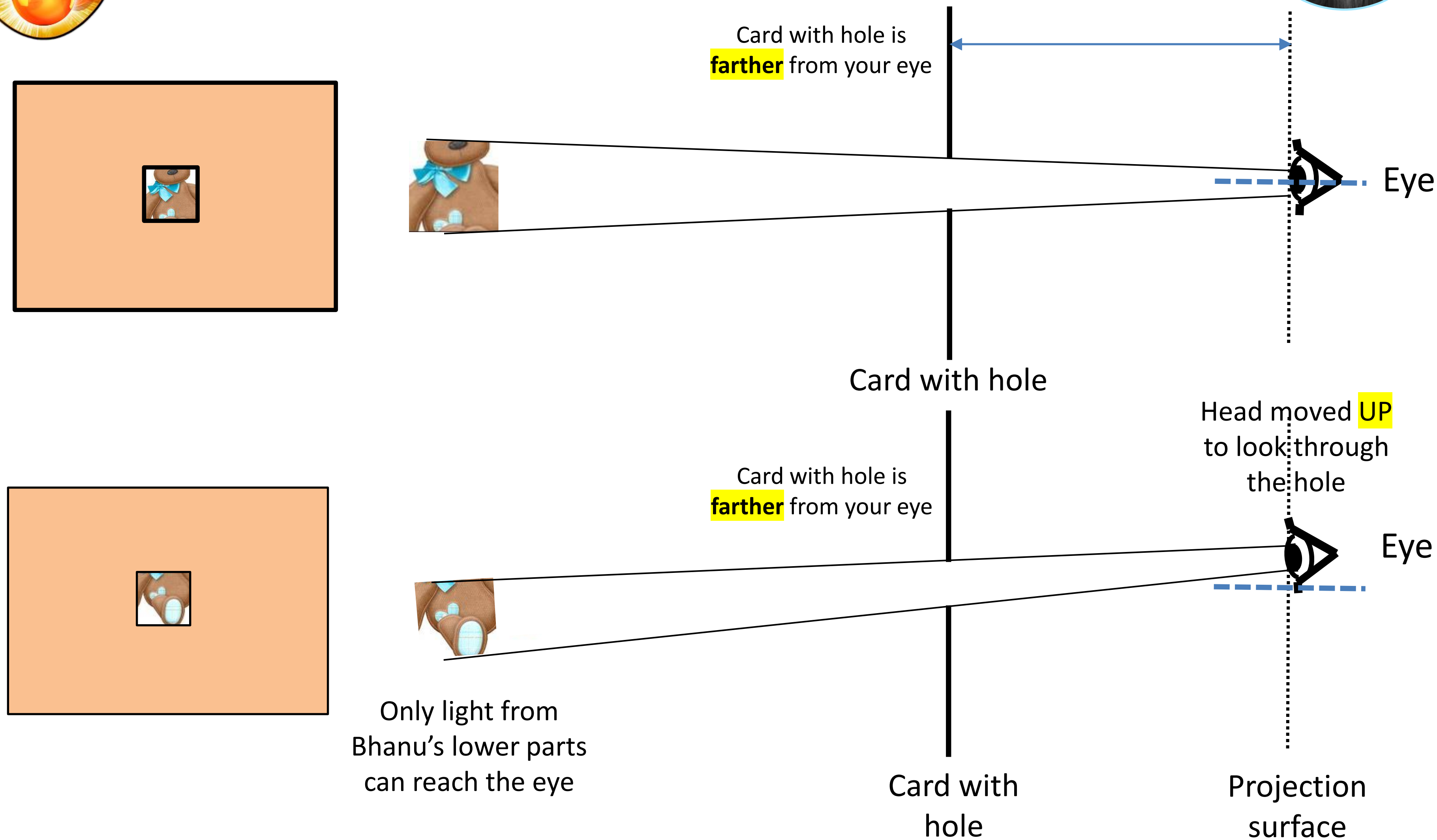
**When you move your head UP while holding the card steady, you should be able to see the lower parts of the object.**



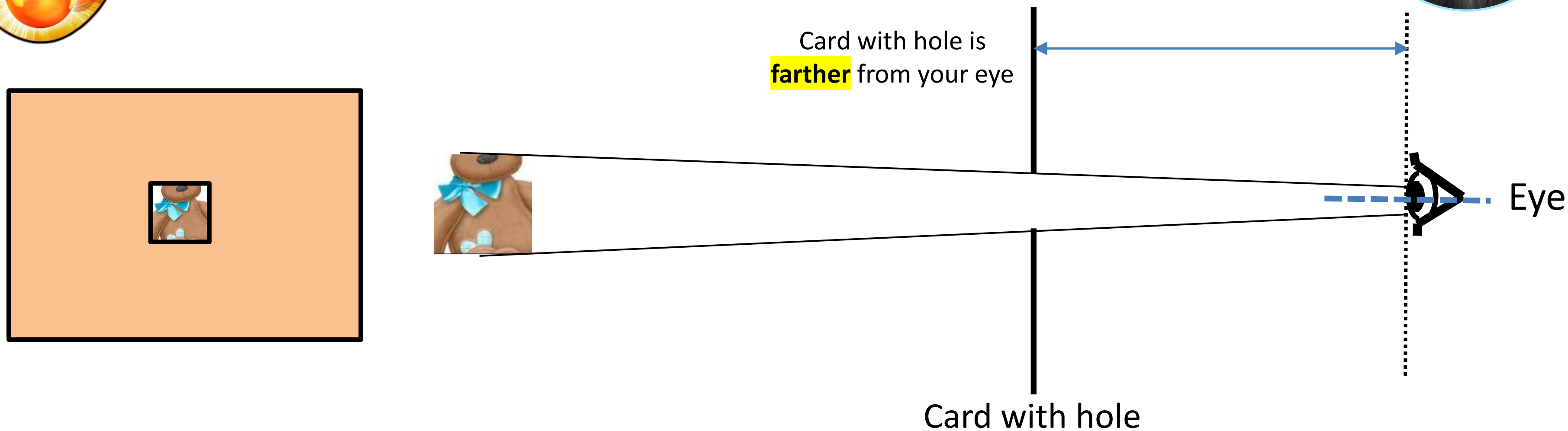
Which part of the object can you see?

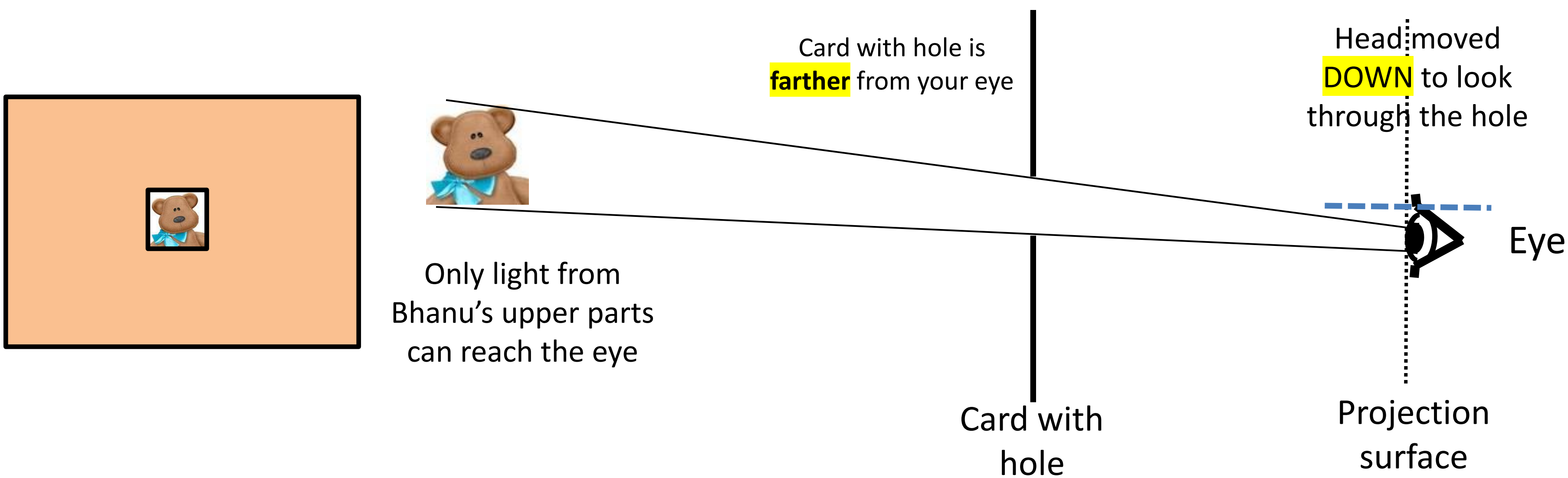
**The bottom**

**When the card is farther away from your eye and you move your head UP, you can see the lower parts of the object (including Bhanu's feet) through the hole.**



**When the card is farther away from your eye and you move your head DOWN, you can see the upper parts of the object (including Bhanu's head) through the hole.**



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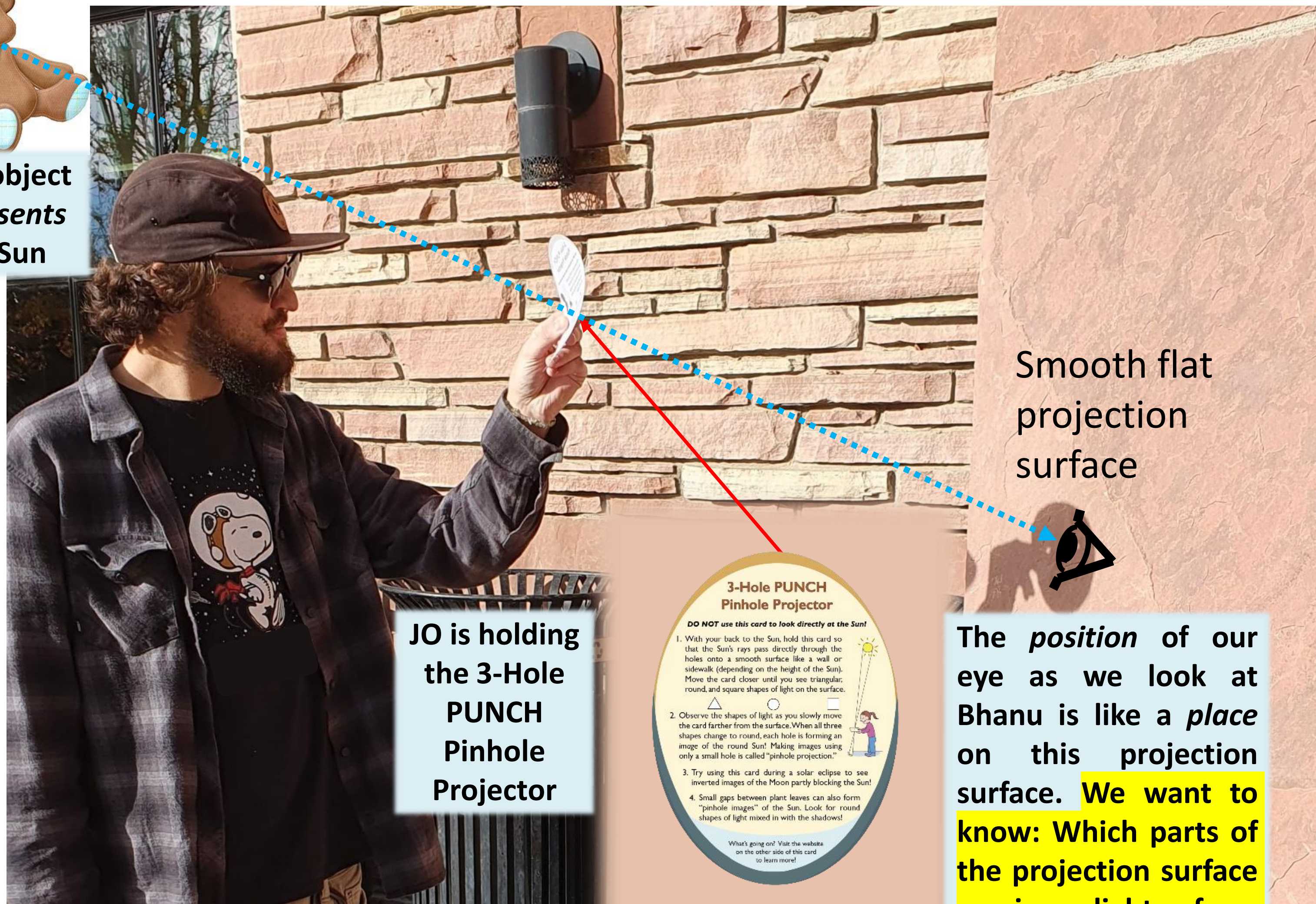
**NEVER EVER look at the Sun through the holes!** We are using Bhanu (your object) to represent the Sun. Bhanu is helping us to SAFELY learn how sunlight passes through the hole to reach the projection surface.

**Your object *represents* the Sun**




**JO is holding the 3-Hole PUNCH Pinhole Projector**

Smooth flat projection surface

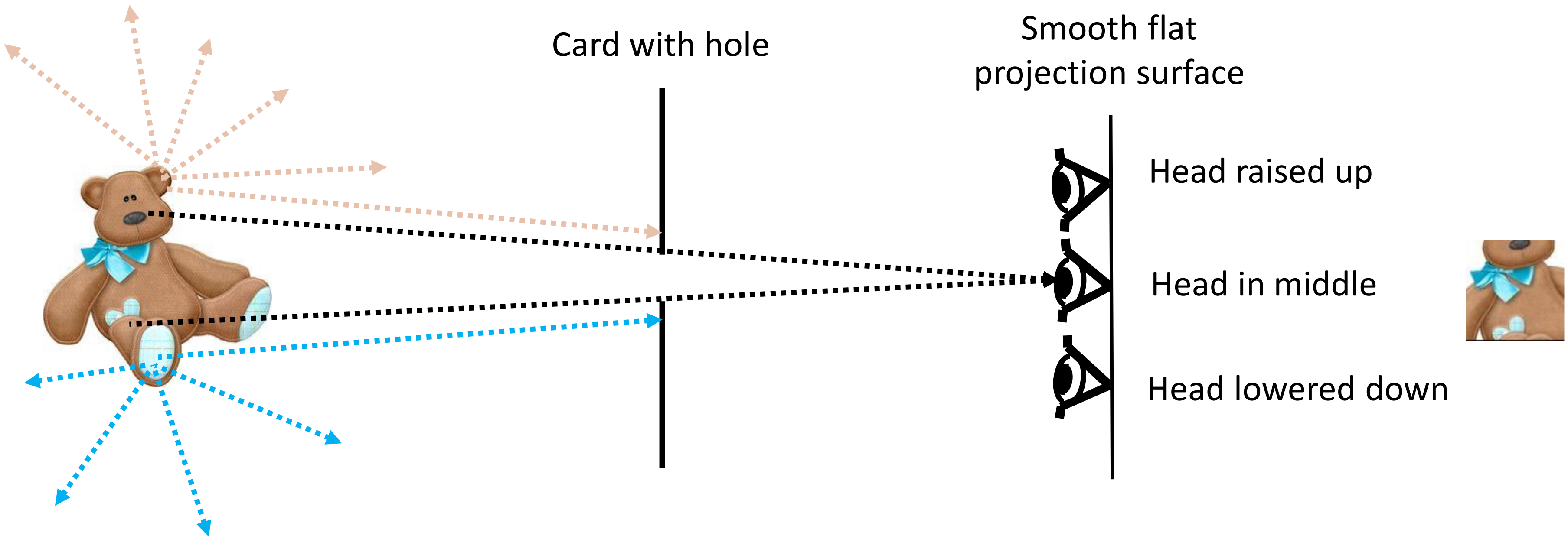
**The *position* of our eye as we look at Bhanu is like a *place* on this projection surface. We want to know: Which parts of the projection surface receive light from which parts of Bhanu?**

**NEVER EVER look at the Sun through the holes!**

# Seeing your object (Bhanu) from the different eye positions

Every point on your object (Bhanu) reflects light (from sources in the room) in all directions. This is shown at two points:

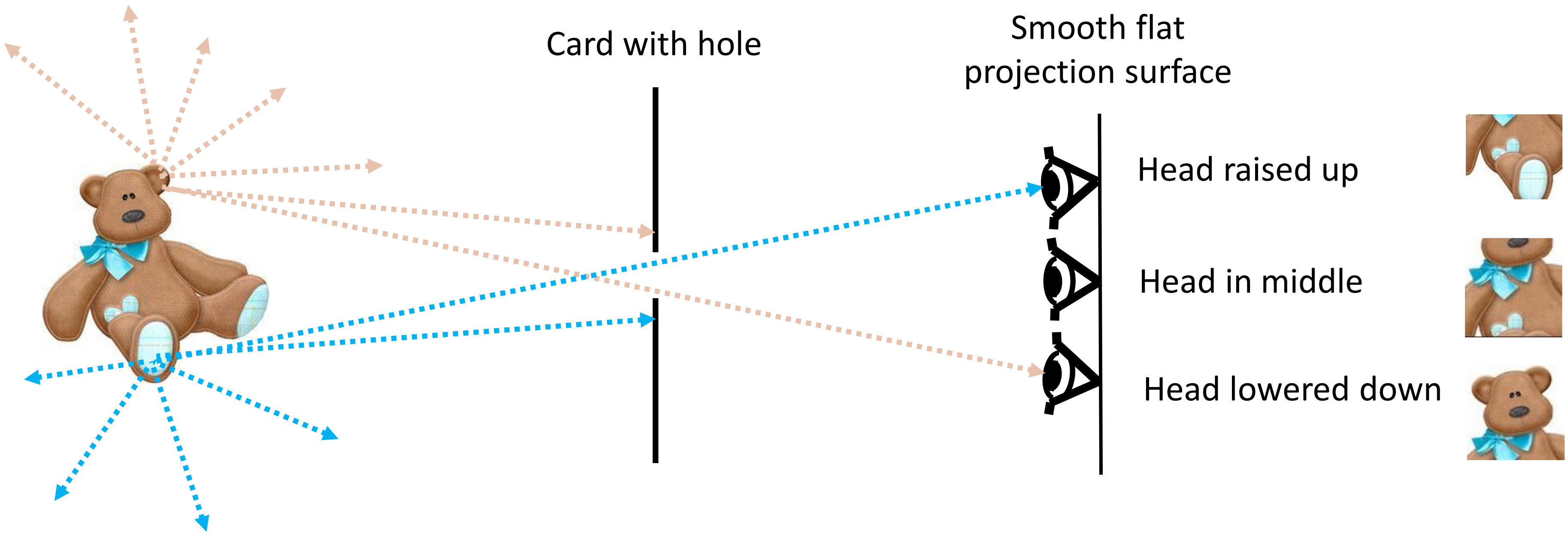
1) the tan lines from Bhanu's ear and
2) the blue lines from Bhanu's foot.




As you look at Bhanu through the hole from the "middle eye" viewpoint, your eye receives light only from the middle parts of Bhanu. This part of the projection surface cannot receive any light rays from Bhanu's ear (tan lines) or foot (blue lines) because they are blocked by the card.

# Seeing your object (Bhanu) from the different eye positions

The viewpoint of your eye is like a location on the projection surface.
**We want to know: Which parts of the projection surface receive light from which parts of Bhanu?**




When you looked through the hole at Bhanu from lower and higher viewpoints you could see that:

- only light from the upper parts of Bhanu would reach the lower parts of the projection surface, and
- only light from the lower parts of Bhanu would reach the upper parts of the projection surface.

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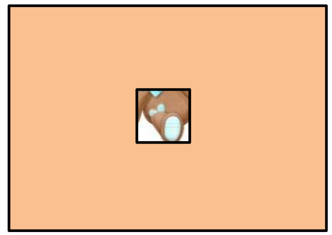
## Now return to your card with the hole:

1. Hold the card steady at a distance from your eye where you *cannot* see all of your object (Bhanu), but just the middle parts.

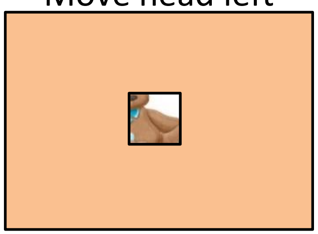
2. Move your head around to change your direction of viewing the object through the hole: up, down, left, right, and so on.

Move head up



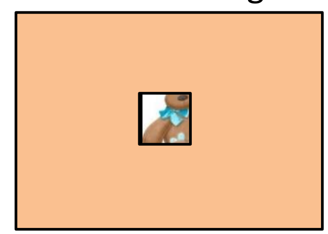
See Bhanu's feet

Move head left



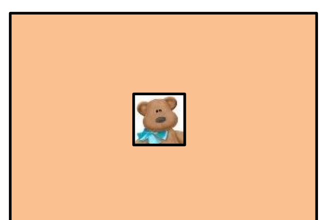
Don't see Bhanu's bow

Move head right



See Bhanu's bow

Move head down



See Bhanu's head

As you move your head around, notice that you can receive reflected light from all parts of the object, even though you cannot see the whole object from one single perspective.

# Pinhole Projection of the Sun

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To understand pinhole imaging of the Sun, keep the Bhanu activity in mind. It is important to hold this distinction between seeing the whole object at once from a single perspective (**Case 1**) and seeing only parts of the object from corresponding opposite perspectives (**Case 2**).

**Case 1**

**Case 2**

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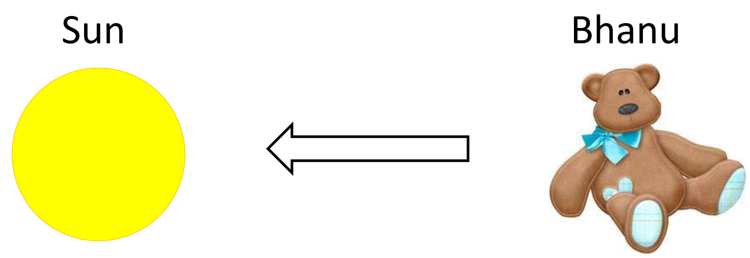
**For safety reasons during the previous activity, your object (our Bhanu) has *represented* the Sun. To advance our exploration we now turn Bhanu back into the Sun.**

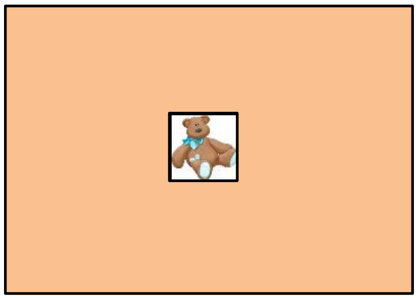
In the diagrams on the next three slides, Bhanu becomes the Sun.



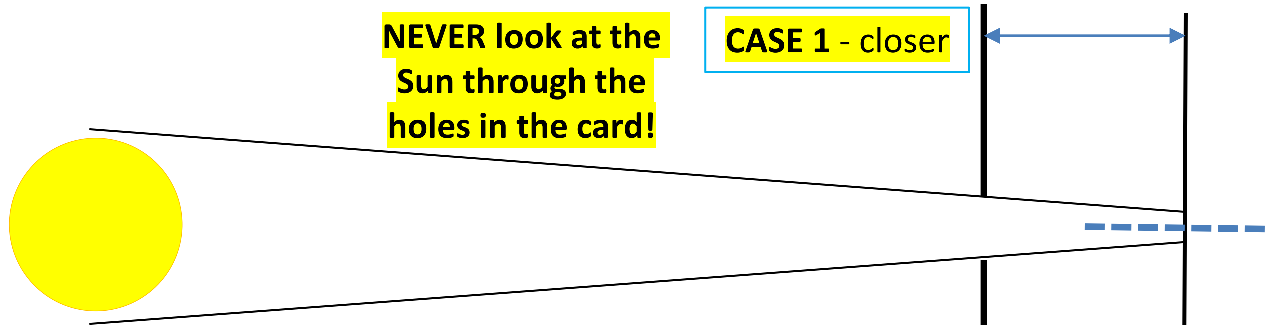

The different viewpoints of your eye while looking at Bhanu through the hole now return to being locations on a smooth flat projection surface that receives the Sun's light through the hole.

**NEVER look at the Sun through the holes in the card!**

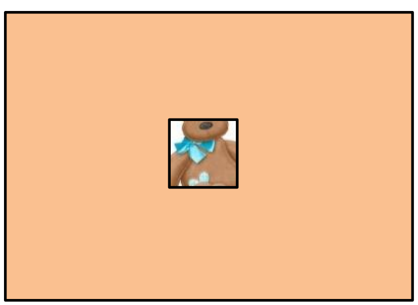
**The distance between the card with the hole and the smooth flat projection surface determines how much of the Sun's disk would be visible to the projection surface from a single viewpoint.**



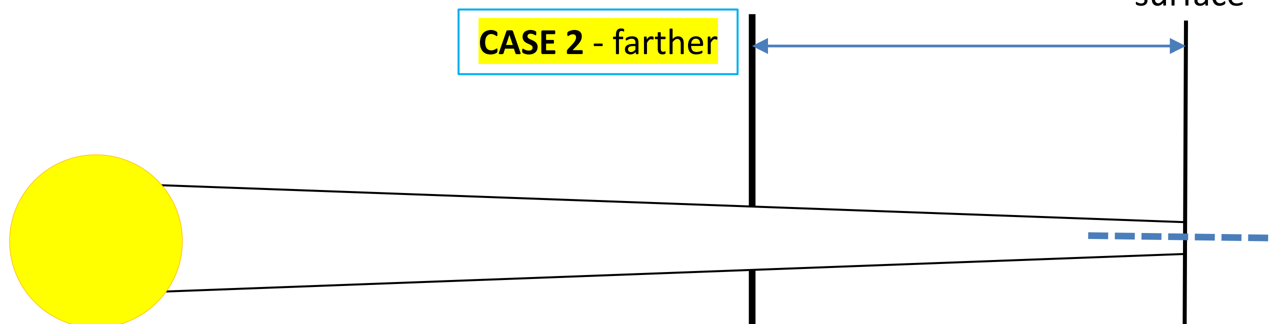
**Case 1** is like holding the card close to your eye and seeing ALL of the object at once




**In CASE 1,** the projection surface would receive light from **all of the Sun's disk** from a single viewpoint



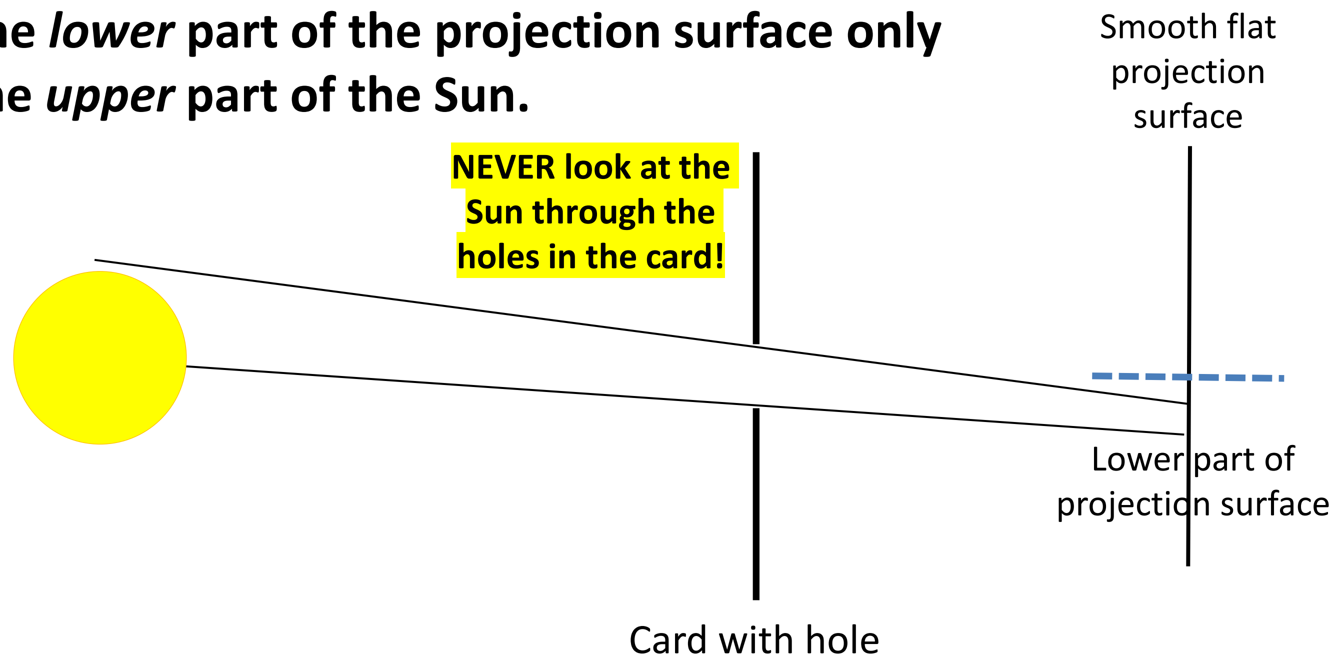
**Case 2** is like holding the card farther from your eye and seeing PART of the object



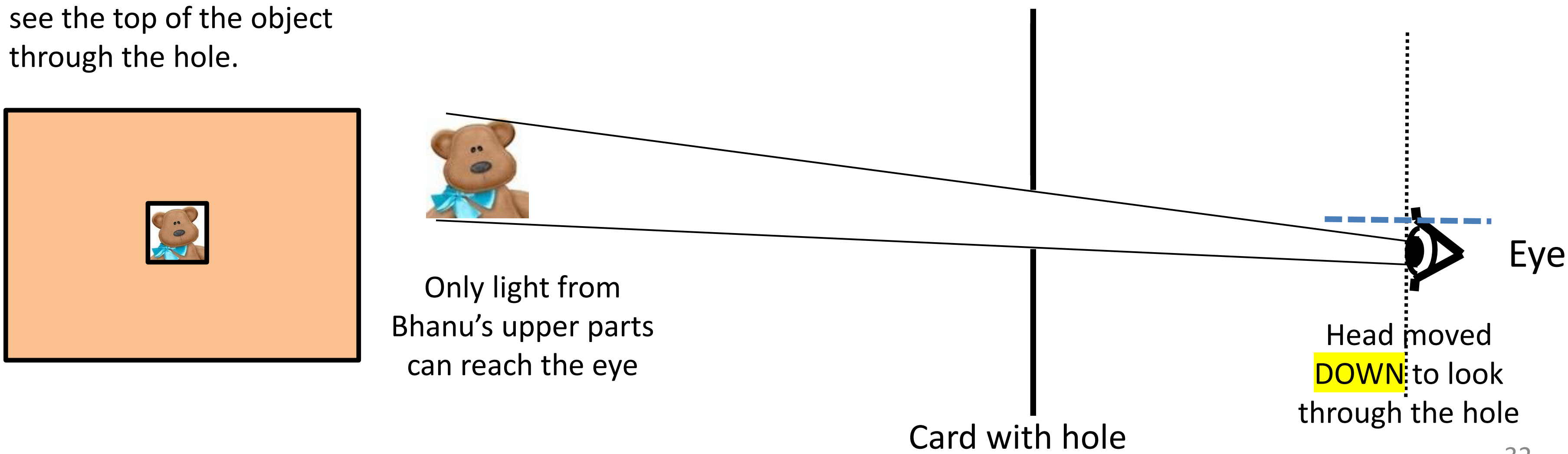

**In CASE 2,** the projection surface would receive light from **only part of the Sun's disk** from a single viewpoint.

**In Case 2, when the card with the hole is farther away from the projection surface, the *lower* part of the projection surface only receives light from the *upper* part of the Sun.**

Light from the **upper** part of the Sun would only reach the **lower** part of the projection surface.

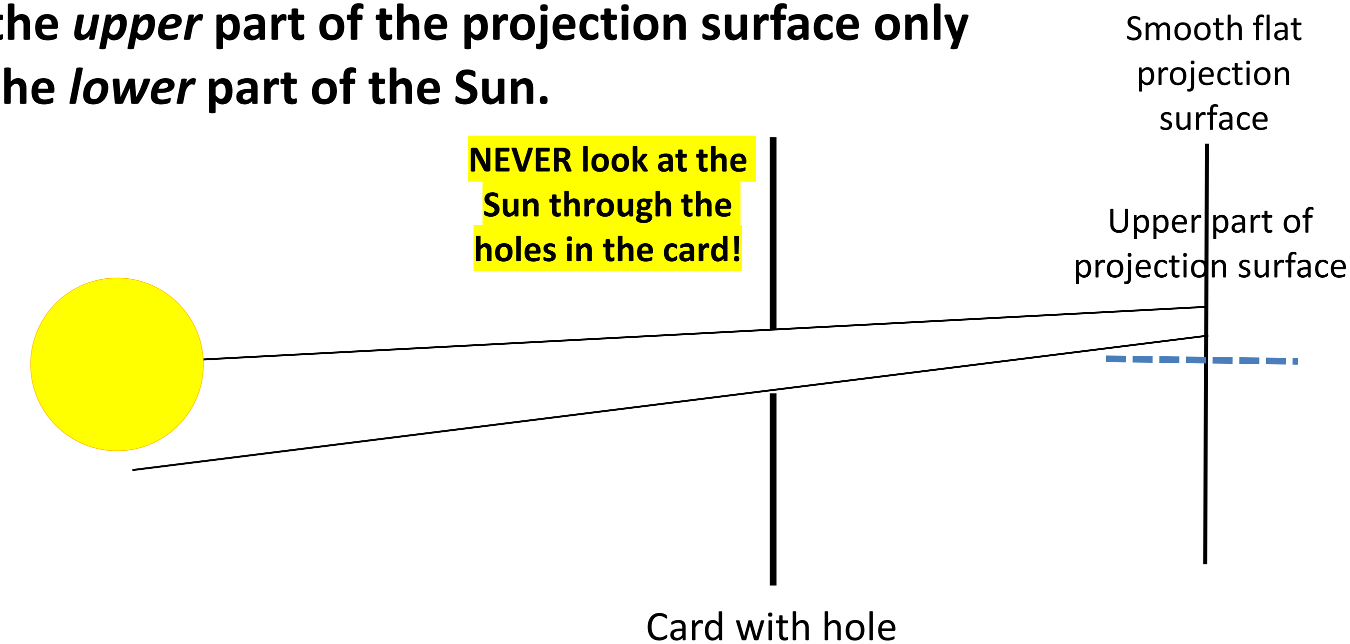



This is like when you lowered your head to see the top of the object through the hole.

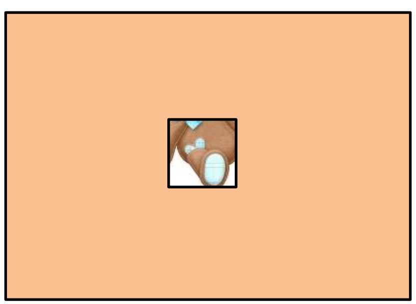


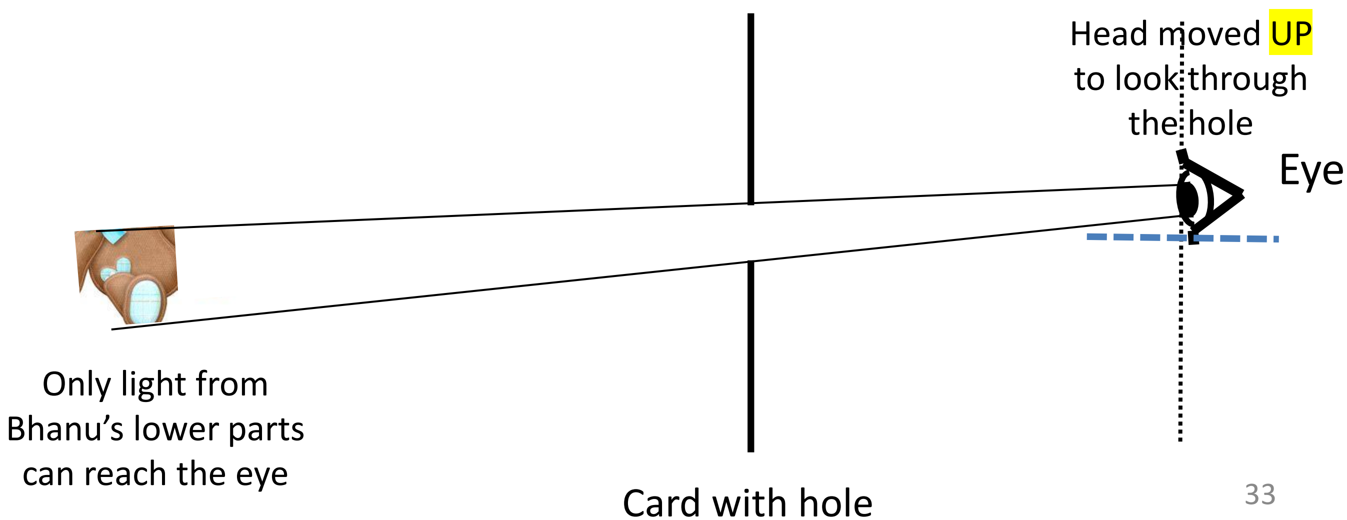
**In Case 2, when the card with the hole is farther away from the projection surface, the *upper* part of the projection surface only receives light from the *lower* part of the Sun.**

Light from the **lower** part of the Sun would only reach the **upper** part of the projection surface.




This is like when you raised your head to see the bottom of the object through the hole.



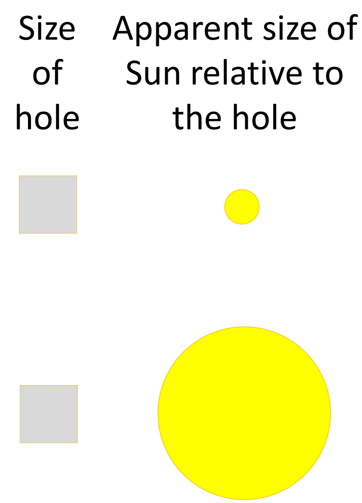


# Pinhole Projection of the Sun

PLEASE NOTE

The Sun is VERY far away compared to distances between the projection surface and the card-with-the-hole. Thus, it is impossible to make diagrams (such as those on the next slides) with the proper scale.

To make the principles of pinhole projection clear we adjust the size of the Sun in the diagrams. This allows us to illustrate how the *apparent* size of the Sun compares to the size of the hole (as seen from the projection surface).

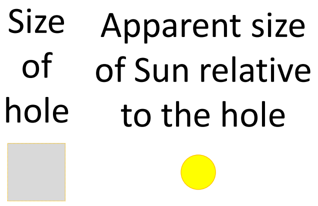



When there is a closer distance between the card-with-the-hole and the projection surface, the Sun appears smaller relative to the hole.

When there is greater distance between the card-with-the-hole and the projection surface, the apparent size of the Sun is larger relative to the hole.

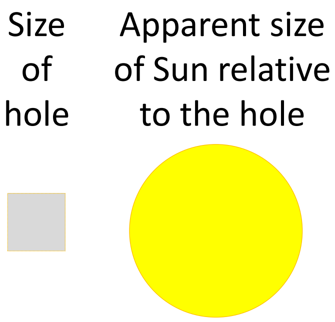
# Pinhole Projection of the Sun

If the projection surface is close enough to the card-with-the-hole then we get shapes of light and no imaging on the projection surface. [CASE 1]




This is like seeing the whole Bhanu from a single perspective.

If the projection surface is farther from the card-with-the-hole then we begin to get the imaging effect where light from particular parts of the Sun only reaches particular parts of the projection surface. [CASE 2]




This is like seeing only part of Bhanu from a single perspective.

# Pinhole Projection of the Sun

**Now we are ready to address our questions**

1. Why don’t we see round images of the Sun when the projector is held closer to the projection surface (Case 1), but we *do* see them when we move it farther away (Case 2)?

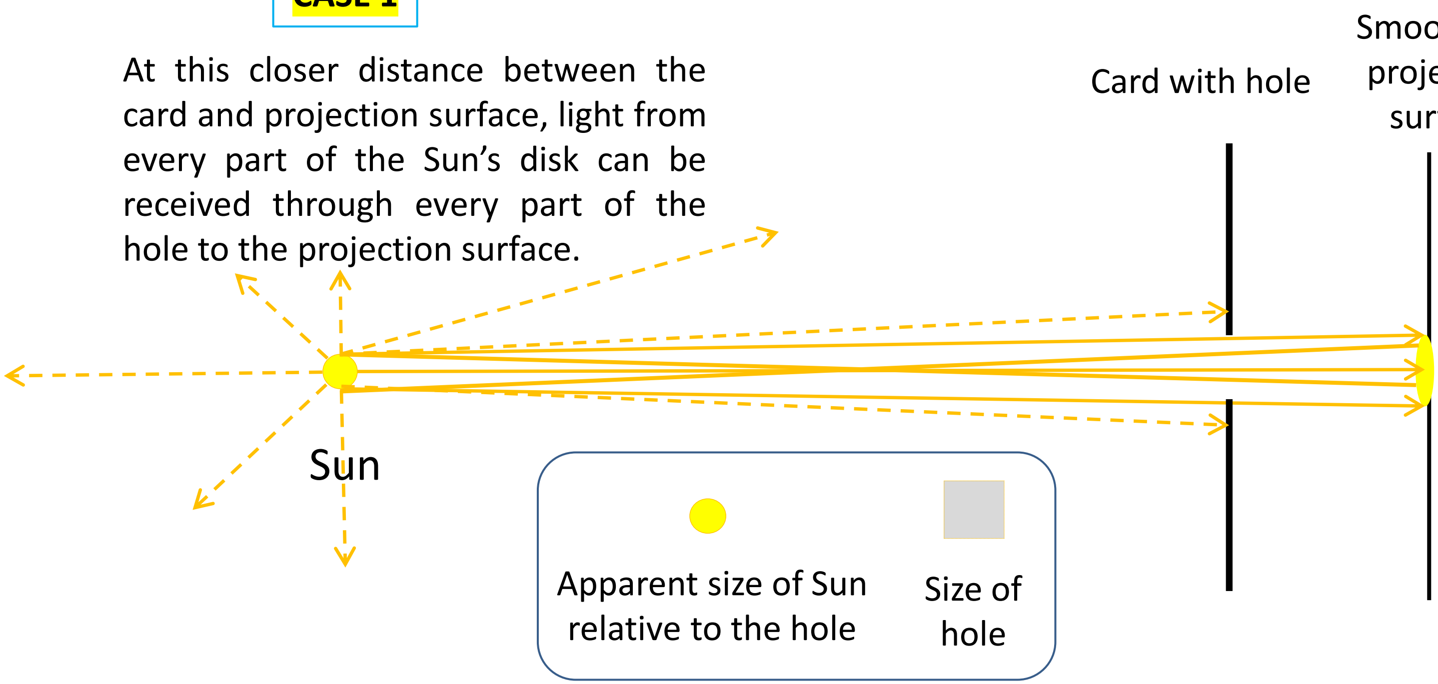
2. How can small, *non-round* holes formed by gaps between leaves, strands of a straw hat, fingers of our hands, and by our pinhole projectors create images of the *round* Sun?

# Pinhole Projection of the Sun

**Why don't we get solar images when the projector is held closer to the surface?**

**CASE 1**

At this closer distance between the card and projection surface, light from every part of the Sun's disk can be received through every part of the hole to the projection surface.




**CASE 1**

When the Sun's apparent size is smaller than the hole, we see a square shape of light on the projection surface

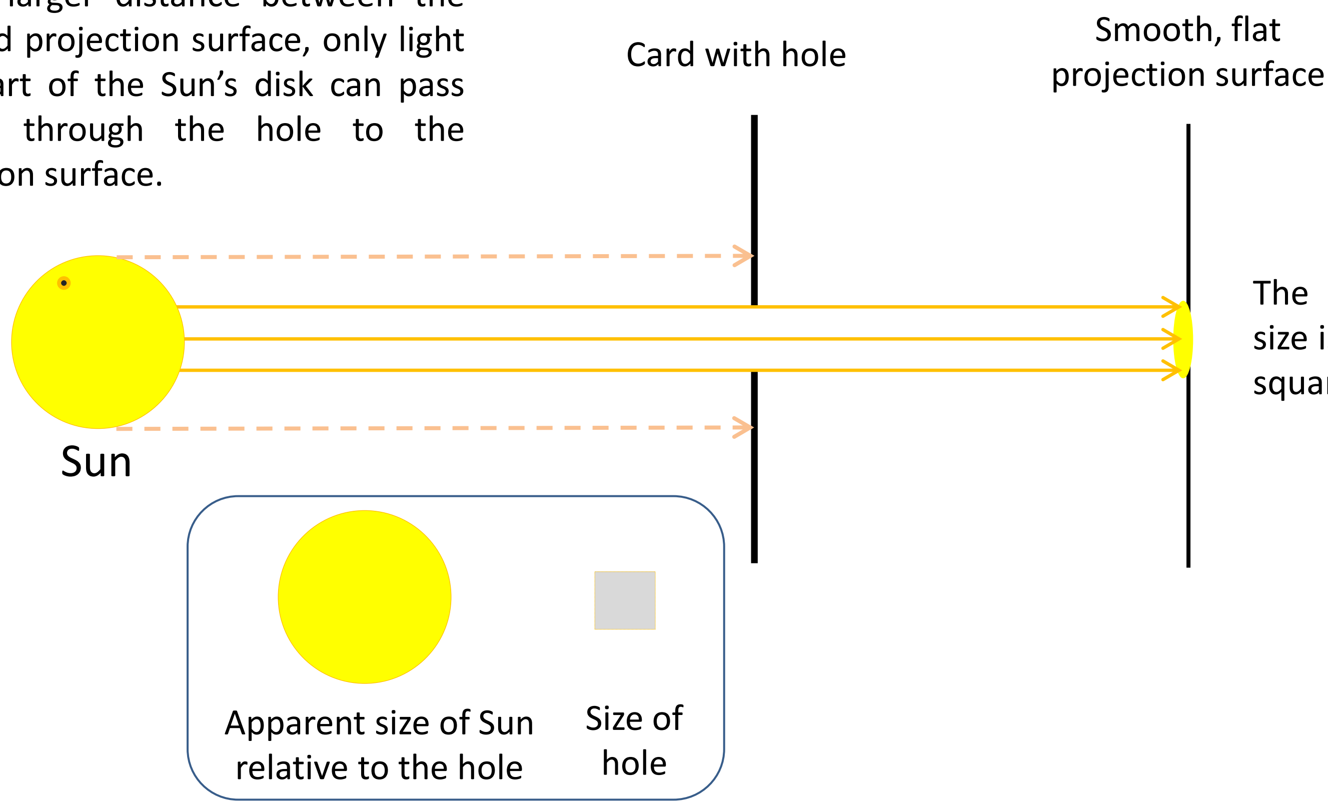
In **CASE 1**, light from every part of the Sun can pass through every part of the hole. So, light from any part of the Sun can reach every part of the projection surface that is directly behind the hole. Light from everywhere on the Sun fills the hole, making a shape of light on the projection surface with the same shape as the hole.

# Pinhole Projection of the Sun

**How can small, *non-round* holes create images of the *round* Sun?**

**CASE 2**

At this larger distance between the card and projection surface, only light from part of the Sun's disk can pass directly through the hole to the projection surface.




The Sun's apparent size is larger than the square hole.

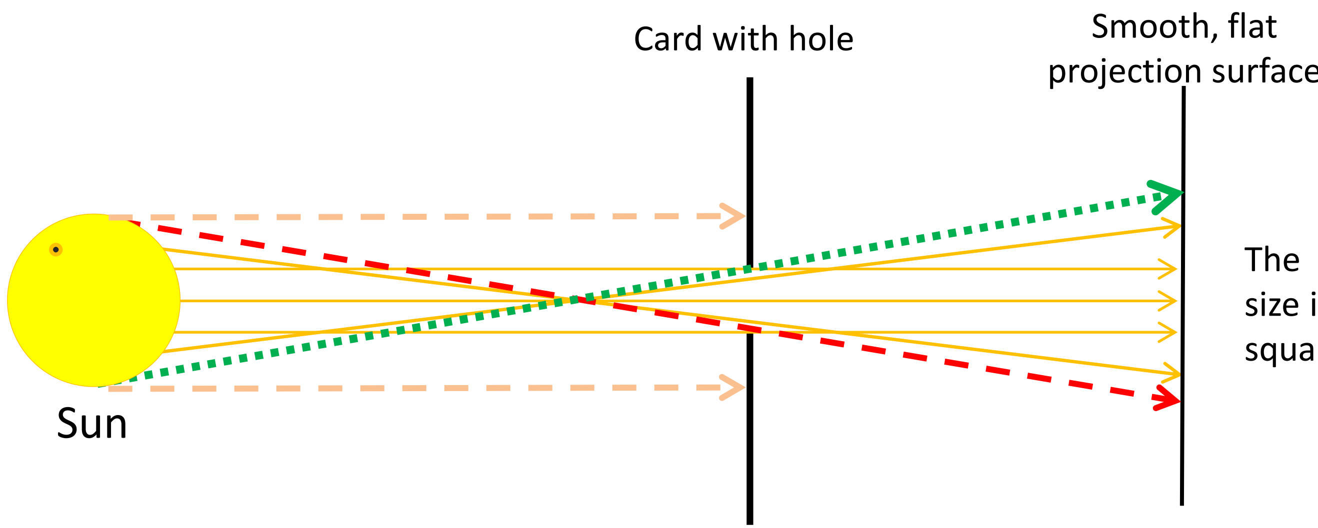
In **CASE 2**, only light from near the center of the Sun can pass through the hole to the projection surface. *Parallel* rays coming from the outer parts of the Sun (dashed lines) are blocked by the card. BUT…

# Pinhole Projection of the Sun

**How can small, *non-round* holes create images of the *round* Sun?**

**BUT**…light rays coming in at an *angle* from the outer parts of the Sun *can* pass through the hole to reach the projection surface.

Bhanu was the Sun so we could learn how this works.




**CASE 2**

The Sun's apparent size is larger than the square hole.

Light from the upper part of the Sun arrives at the bottom part of the projection surface (**red dashed line**). And light from the lower part of the Sun arrives at the top part of the projection surface (**green dotted line**).

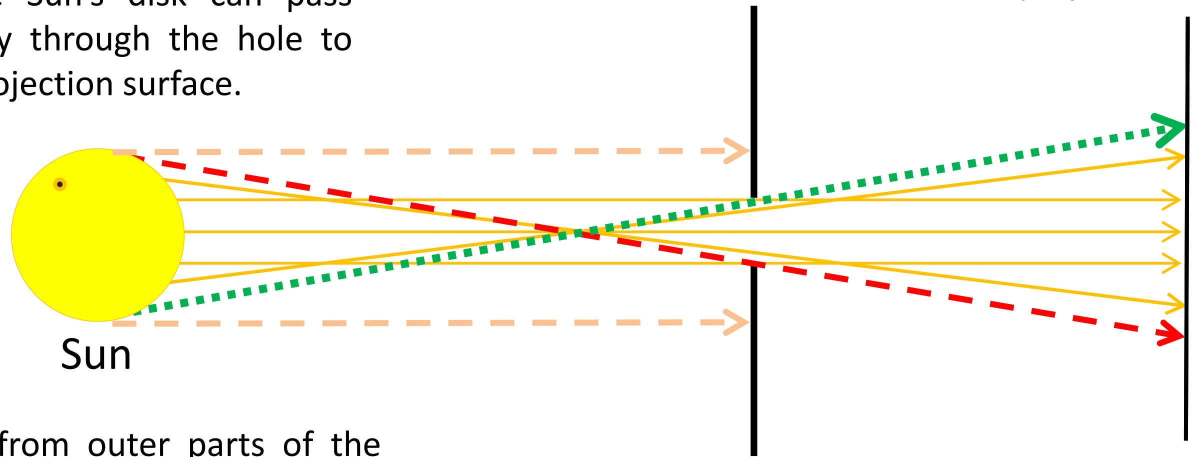
*Recall when we pretended Bhanu was the Sun. You shifted your head up to see the bottom of Bhanu (eye at green arrow tip), and you shifted your head down to see the top of Bhanu (eye at red arrow tip).*

# Pinhole Projection of the Sun

**How can small, *non-round* holes create images of the *round* Sun?**

**CASE 2**

Only light from the inner part of the Sun's disk can pass directly through the hole to the projection surface.




**CASE 2**

We see a circular shape of light on the projection surface

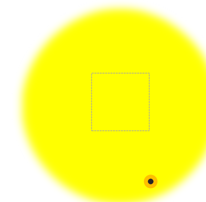


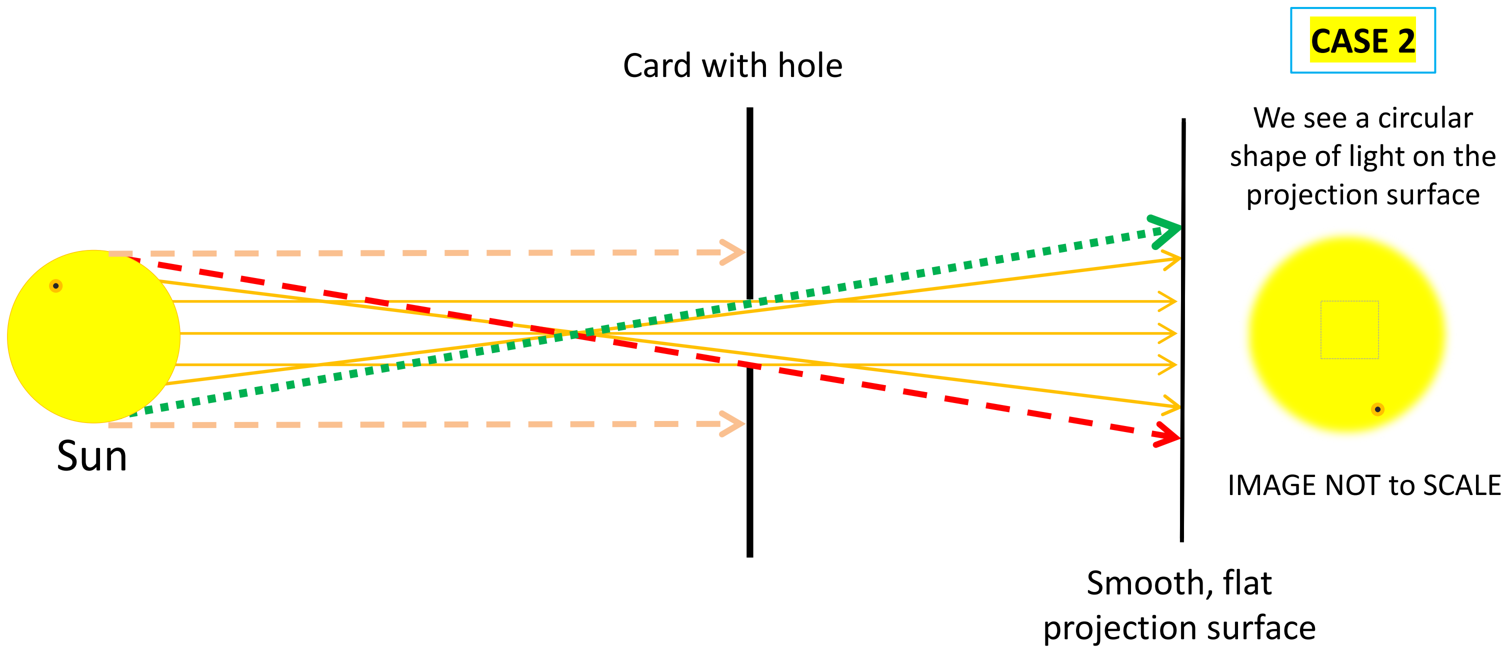
IMAGE NOT to SCALE

Light from outer parts of the Sun's disk can only reach the projection surface at an angle.

Because the Sun's disk is round, sunlight from outer parts of the Sun forms a ring of light that surrounds the central shape of light. In this case, we start to form a fuzzy, inverted image of the round Sun through the square hole (or any other shape of hole with comparable size).

# Pinhole Projection of the Sun

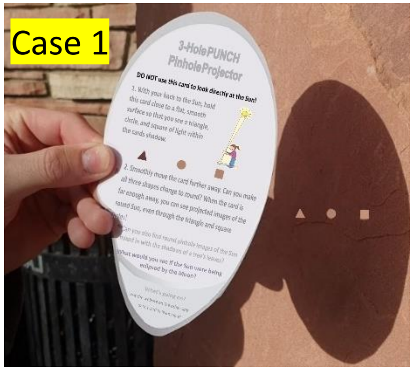
**How can small, *non-round* holes create images of the *round* Sun?**




**We start to see an image of the Sun because there begins to be *correspondence* between light coming from a particular region of the Sun and light received at a particular (opposite) region of the projection surface (top-to-bottom, left-to-right)**. This correspondence is key to image formation. The tighter the correspondence, the sharper the inverted image on the projection surface. In Case 1, there is no such *correspondence and so no image forms.*

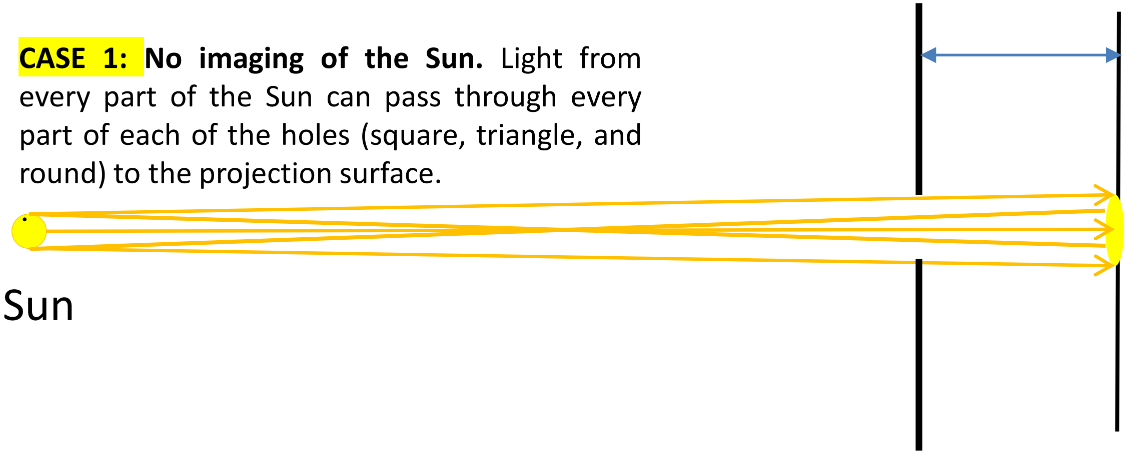
# Pinhole Projection of the Sun

**How can small, *non-round* holes create inverted images of the *round* Sun?**




Projector held closer to the smooth, flat projection surface => see hole shapes of light.

**CASE 1: No imaging of the Sun.** Light from every part of the Sun can pass through every part of each of the holes (square, triangle, and round) to the projection surface.




See hole-shaped light shapes on projection surface

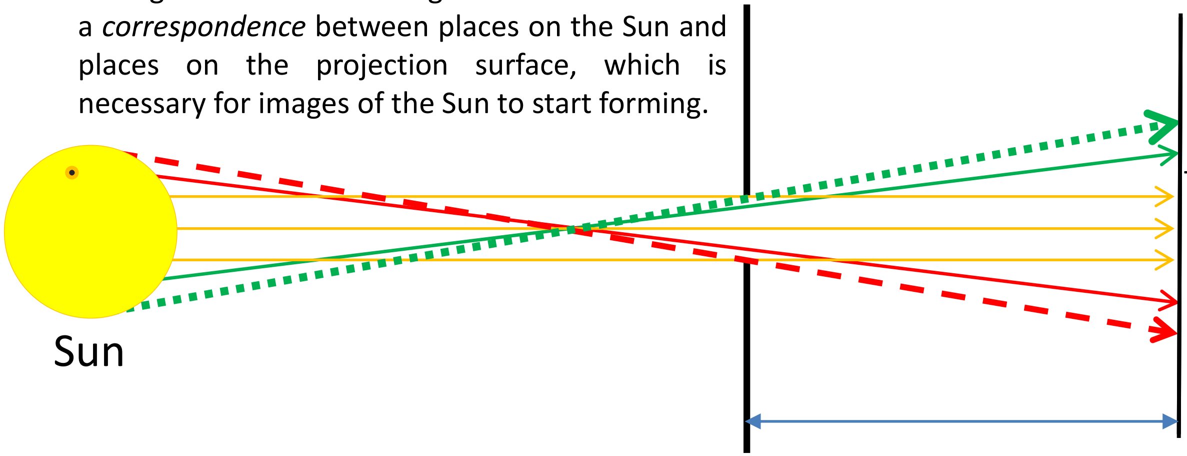
**CASE 1**

Card with hole is **closer** to surface

Smooth flat projection surface


Projector held farther from the smooth, flat projection surface => fuzzy, inverted images of the round Sun.

**CASE 2: Start to form images of the Sun.** Light from outside the center of the Sun must pass through the holes at an angle. This starts to force a *correspondence* between places on the Sun and places on the projection surface, which is necessary for images of the Sun to start forming.




The 3 holes each make a fuzzy round shape of light on the surface

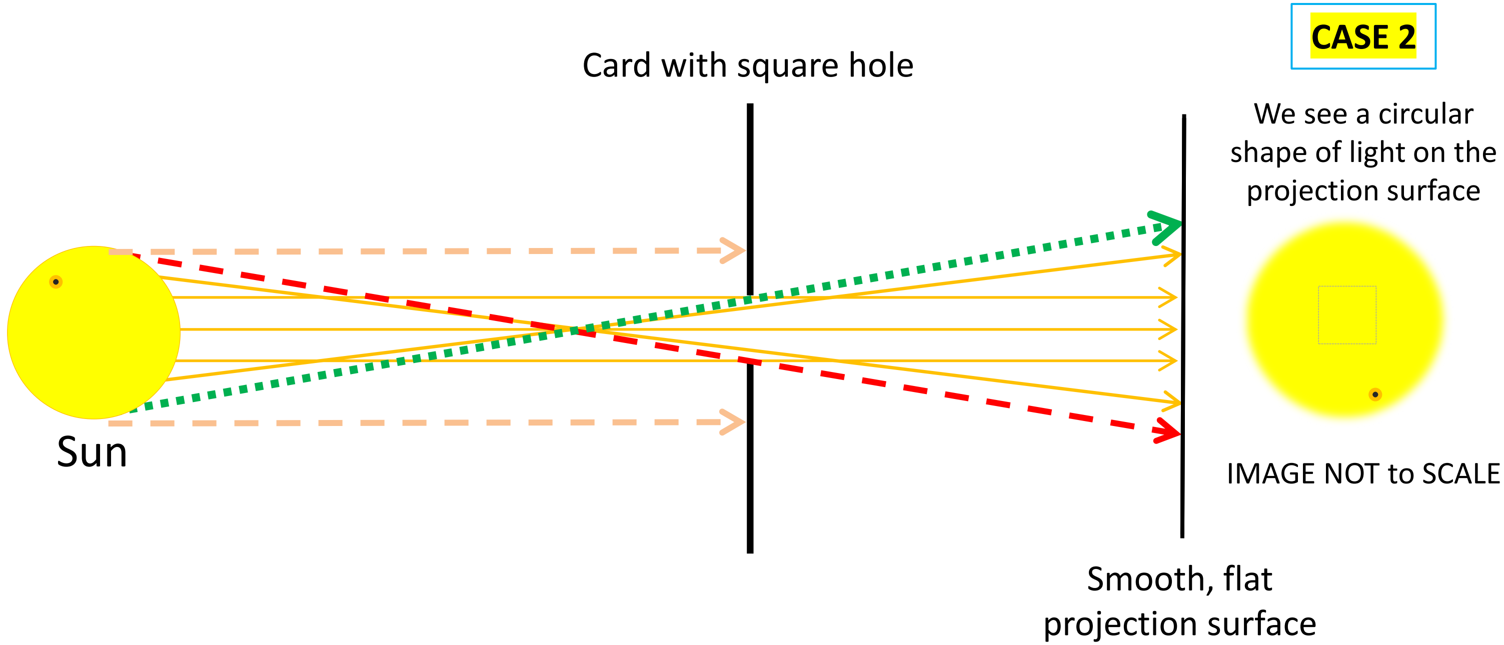
**CASE 2**

Card with hole is **farther** from surface

Smooth flat projection surface

# Pinhole Projection of the Sun

**Pinhole Images seen on the projection surface are “inverted” both top-to-bottom and left-to-right.**




Q: Why do we see an <u>*inverted*</u> image when light from an object is projected through a pinhole onto a surface?

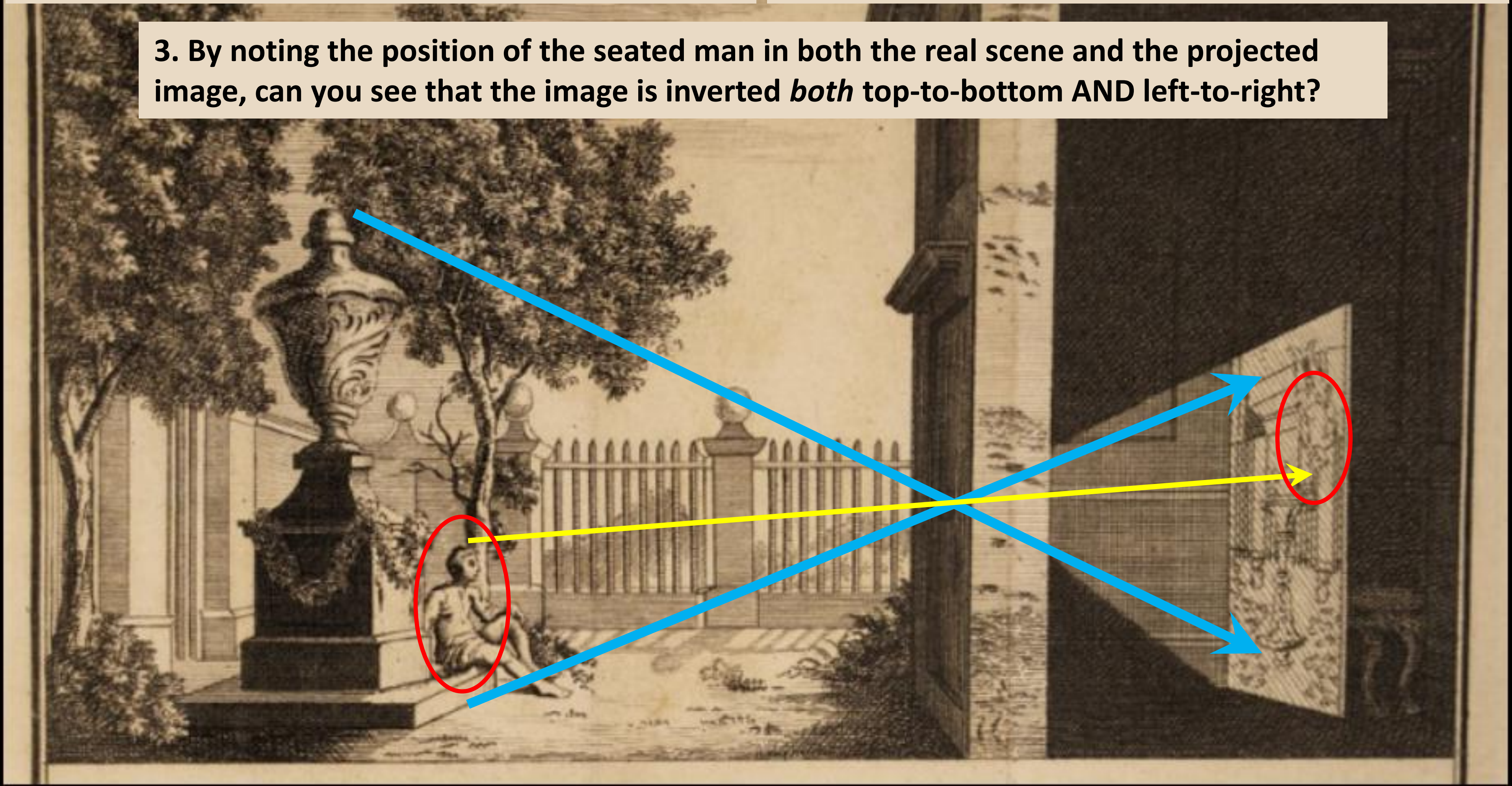
A: Because light from the Sun passes through the hole and arrives at the *opposite* side of the projection surface, top-to-bottom AND right-to-left. [Note the little sunspot]

Our pinhole projector is based on the same principles as the famous "camera obscura" effect. The image in the darkened space is inverted both top-to-bottom AND left-to-right.

**1. Use the blue lines to find the top & bottom of the statue in both the real scene and the projected image on the board in the darkened area.**

**2. Use the yellow line to find the head of the person in both the real scene and the projected image on the board in the darkened area.**

**3. By noting the position of the seated man in both the real scene and the projected image, can you see that the image is inverted *both* top-to-bottom AND left-to-right?**



Also see: https://en.wikipedia.org/wiki/Camera_obscura

# How are Pinhole Images of Eclipses Inverted?

# See Section 5: APPENDIX A

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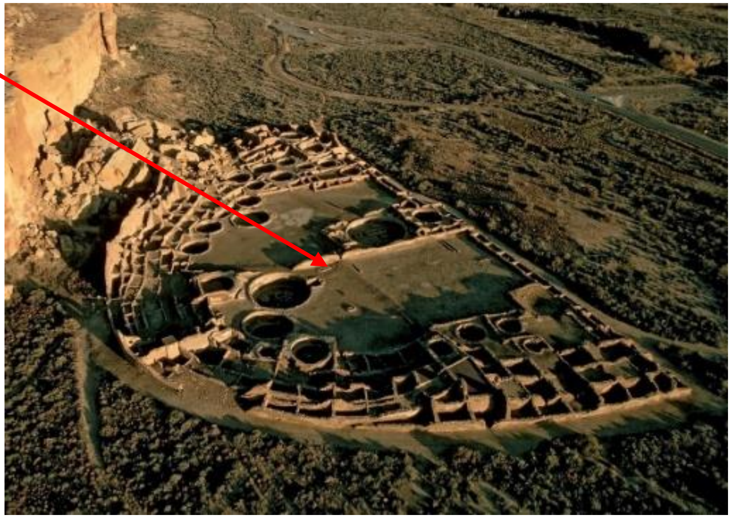
### Discovering How Pinhole Images of Eclipses are Inverted

- An indoor demo using the 3-Hole PUNCH Pinhole Projector with an F-shaped light source [Super neat! Don't miss it!]
- A 3-slide demo using images from the 2017 solar eclipse
- A 6-slide interactive inquiry using images from the 2012 Annular Eclipse seen from Pueblo Bonito, Chaco Canyon, NM

Pinhole images through gaps at elbows

View through solar protection glasses



See how these contemporaneous images of the eclipsed Sun are the same but inverted left-to-right and top-to-bottom

# Why are our Projector Images Fuzzy? Why Aren't They in Focus?

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## See Section 5: APPENDIX B

### What Does it Mean to be in Focus?

# THANK YOU!

**Thank you for your curiosity about pinhole projection!**

**We hope you've gained some enjoyable insights and will continue to explore!**

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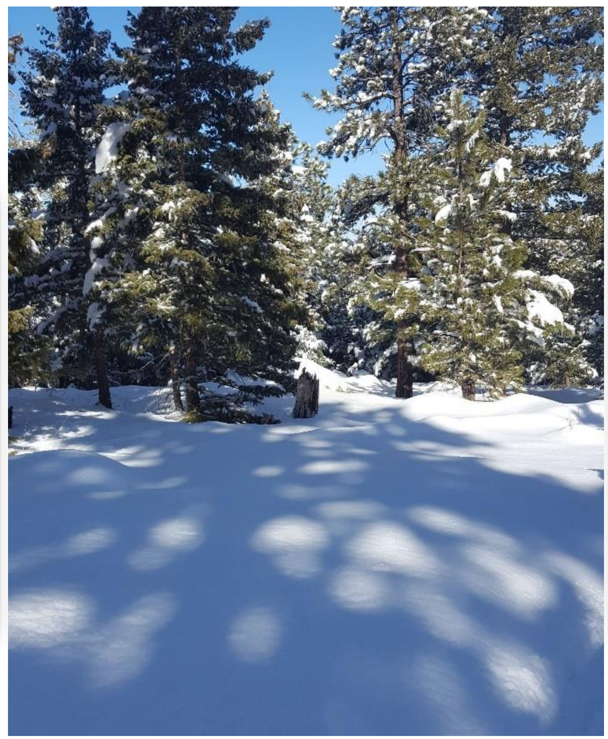
PLEASE SEE **ADDITIONAL INFO On the Next Slides (Section 5)**



Bhanu

**Pinhole Images of the Sun are Everywhere.**

**Keep an eye out every sunny day!**

Outreach
for the
**NASA**
PUNCH
mission

# ADDITIONAL INFORMATION

Link for Feedback

Valuable References

Credits & Acknowledgements

Links to PUNCH & PUNCH Outreach Products

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# [*Really*] Understanding Pinhole Projection of the Sun

Outreach for the **NASA** PUNCH mission

## Follow along with our playful learning adventure!


FRONT

And **PLEASE** give us feedback on these questions at the link below:

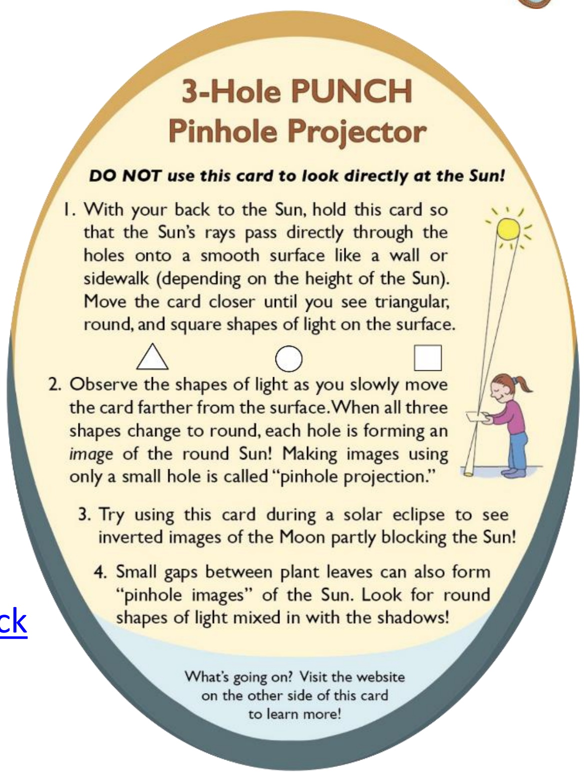
**Insights gained?**

**Remaining questions?**

**Ideas for improvements?**

https://tinyurl.com/PinholeFeedback

**MARK 3 Version**
Final Release for use up to and including the Annular Eclipse on 14 Oct 2023




BACK

# Valuable References

1. Lenses and Pinholes: What Does "In Focus" Mean?

A brief and clear explanation about what it means to be "in focus":
https://www.physicsforums.com/insights/lenses-pinholes-focus-mean/

2. How a Pinhole Camera Works (Part 1)

Excellent diagrams:
https://www.scratchapixel.com/lessons/3d-basic-rendering/3d-viewing-pinhole-camera

3. Real image: Collection of focus points made by converging light rays

We love the simple but insightful stick-figure:
https://www.wikiwand.com/en/Real_image

4. Your Eyes See Upside Down and Reversed

Lucid explanation by an eye doctor (MD) relating human eye to a pinhole camera:
https://bceye.com/retinal-image-inverted-reversed/

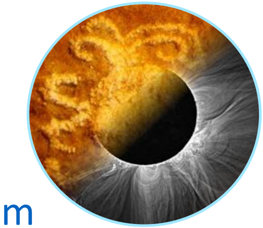
5. Camera Obscura

The history of this wondrous effect, including reference to a possible paleo-camera:
https://en.wikipedia.org/wiki/Camera_obscura http://paleo-camera.com/archeo-optics/

6. Making, Measuring and Testing the "Optimal" Pinhole

A thorough and playful journey through the technical details of pinhole photography:
https://www.35mmc.com/26/10/2020/making-measuring-and-testing-the-optimal-pinhole-pinhole-adventures-part-3-by-sroyon/

# Credits & Acknowledgements



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Robert Bigelow (concept development, technical specifications, text reviewer, photos)

Briana Ingermann (graphic design, text developer, field testing, procurement of printing, photos)

Mike Zawaski (reviewer/consultant on explanatory presentation, graphic support, photos)

Sanlyn Buxner (head of field testing and evaluation, photos)

Jason Trump, Nina Byers, Geoff Skelton (text reviewer, field testing, reviewer of explanatory presentations)

Marisa Bevington & Marialis Rosario Franco (text reviewers, Spanish language translation)

GB Cornucopia, Bobbye Middendorf, Jeremy Osowski, Stacy Wolff (text reviewers, field testers, photo collaborators)

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Nicki Viall (PUNCH Mission Scientist, field tester, product review and approval)

Ronnie Killough (PUNCH Program Manager, field tester)

Gilly Gilbert (PUNCH Associate Investigator, field tester)

Countless others (who participated in field testing events and gave us their feedback)



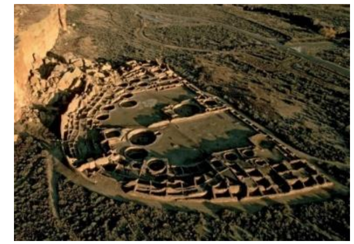
Thank you also to our web developer Don Kolinski for posting and updating our work on the PUNCH website.

Outreach for the **NASA** PUNCH mission

# 5. APPENDICES

## A. Discovering How Pinhole Images of Eclipses are Inverted

Using images from the 2017 and 2012 Eclipses



## B. Why are the 3-Hole PUNCH Pinhole Projector Images Fuzzy?

What does it mean to be in focus?

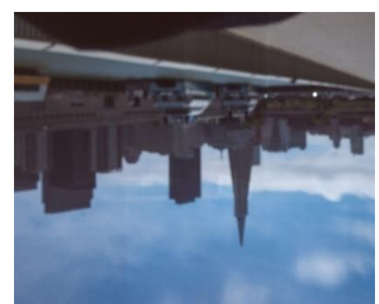
## C. What is the Difference Between a Pinhole and a Lens?

Finding new appreciation for what the lens of an eye or a camera is doing

## D. Why Doesn't Our Pinhole Projector Have Pin-Sized Holes?

Includes: DESIGN TRADE-OFFs for our Pinhole Projector

## E. A Shortlist of Our Favorite Pinhole-Related Resources



# Please proceed to Section 5:

# Appendices A-E
# more insights and fun resources

NASA PUNCH website:
https://punch.space.swri.edu /

Scan here to access all PUNCH Outreach products or visit:
**https://punch.space.swri.edu/punch_outreach_products.php**

For questions or to request our 1-page monthly newsletter:
Contact PUNCHOutreach@gmail.com



Photo: Alan Friedman