WELCOME!

Thank you for your curiosity about why we see round images of the Sun through non-round holes!

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

Section 1: How to Use the 3-Hole PUNCH Pinhole Projector

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

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:

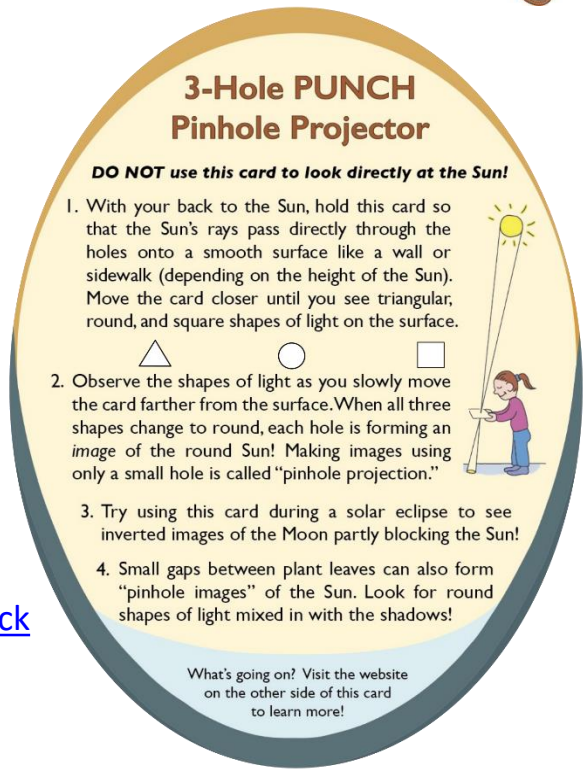
Insights gained?

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

Essential viewing:

6-minute “how-to-facilitate” video

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

Outreach for the **NASA** PUNCH mission

Polarimeter to UNify the Corona and Heliosphere

Home | About | Science | Media | Outreach

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

Outreach for the **NASA** PUNCH mission

Introducing Bhanu

[BAH-noo]

Bhanu means "ray of light" in Sanskrit

Bhanu helps guide our way through these Sections. You are in Section 1 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	interactively 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]

Outreach for the **NASA** PUNCH mission

1. How to Use the 3-Hole PUNCH Pinhole Projector

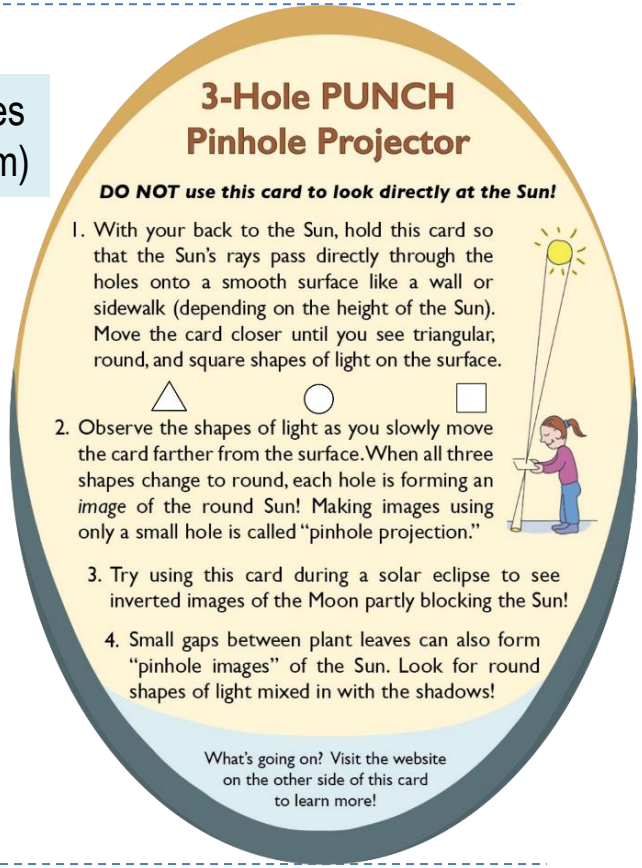
Bahnu says: **"**Pinhole" describes a projector or camera that does not use a hard lens but only a small hole or gap to make images of the Sun or other objects. A "pinhole" does **not** have to be pin-sized to create an image of the Sun, nor does it have to be round!

Section 5: Appendix C explains the difference between a lens-less "pinhole" and a lens and helps you to appreciate more what a lens is doing to make a clear image.

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

Introducing the *3-Hole PUNCH* Pinhole Projector

6 inches (~15 cm)

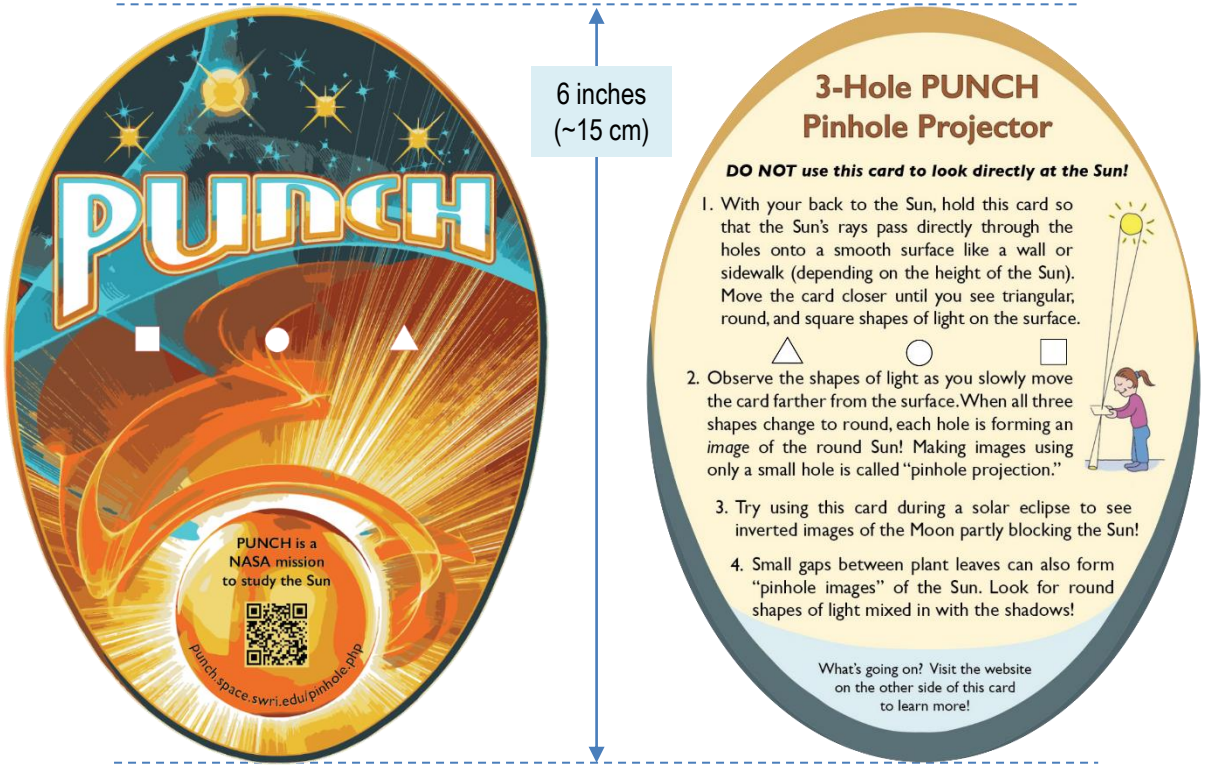


FRONT BACK

The NASA PUNCH Outreach team has developed the *3-Hole PUNCH Pinhole Projector* so you can have fun exploring how small, *non-round* holes can project *real* images of the *round* Sun. This can be done on any sunny day, not only when the Sun is eclipsed by the Moon!

Introducing the
3-Hole PUNCH Pinhole Projector

Our projector is printed on card stock with three small (~5 mm) holes of different shapes: square, round, and triangular.



FRONT BACK

Our design has carefully considered the size, position, and spacing of the "pinholes" so that the projector can work well indoors or outdoors in broad daylight. **Section 5**: **Appendix D** explains our design trade-offs.

Using the PUNCH Pinhole Projector

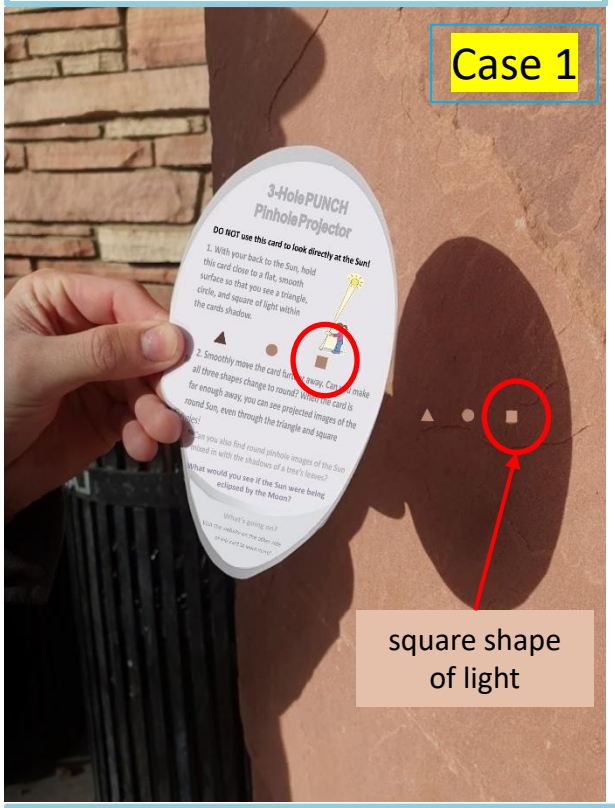
NEVER EVER look at the Sun through the holes in the card!

Outreach for the **NASA** PUNCH mission

JO is using a vertical wall as the *smooth flat projection surface* because the Sun is lower in the sky. If the Sun were higher, then a horizontal surface like a sidewalk might work better.

Outreach for the **NASA** PUNCH mission

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



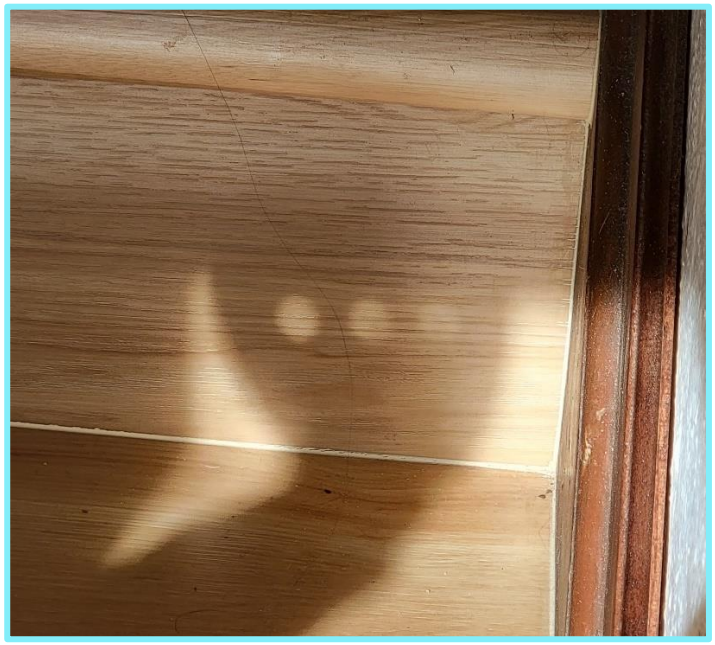
2. Projector **farther away from surface**. All three shapes of light are round and fuzzier.

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

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)?

Indoor Use of the PUNCH Pinhole Projector

You can try out using the projector where sunlight streams through a window. You will get the same effects as outdoors, but there is less stray light indoors compared to broad daylight. Thus, as you move the projector farther away from the projection surface you can more easily perceive larger, dimmer, and somewhat sharper images. The projected image size can become much larger than the hole size.



Play with your Projector in different situations to see what can happen!

Using an Indoor Light Fixture as a Light Source Instead of the Sun

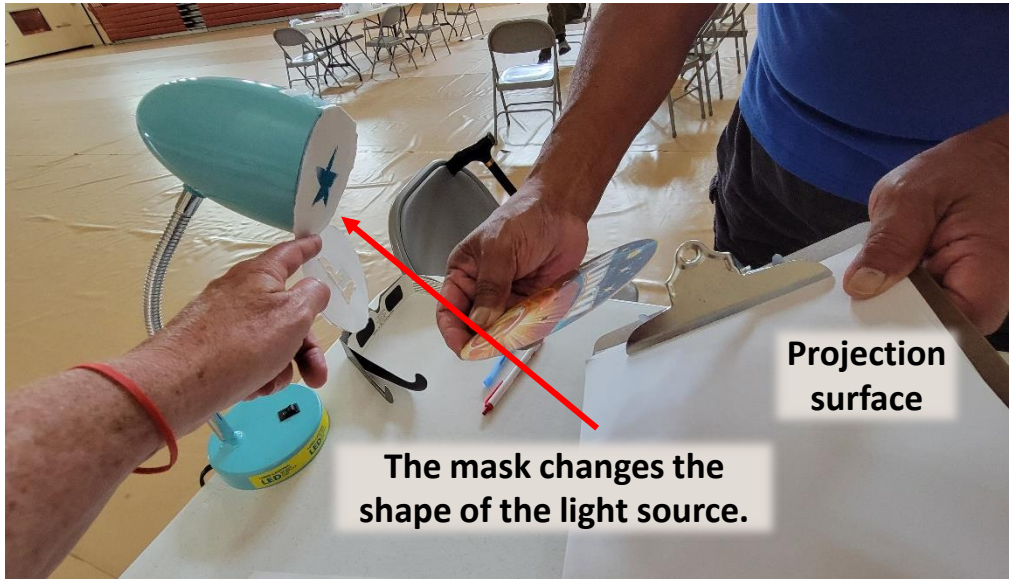
Being observant and playful leads to cool discoveries!

RK demonstrates our pinhole projector indoors for Adler visitors.

In Dec 2022, PUNCH team members and collaborators contributing to a public engagement program at the Adler Planetarium in Chicago discovered that our projector could project images of the ceiling lights! As you can see below, at the Adler, **the spotlights in the ceiling are star-shaped!***

The projections are star-shaped because the light source is star-shaped.

Pinhole Projection Using a Masked LED Lamp as the Light Source Instead of the Sun

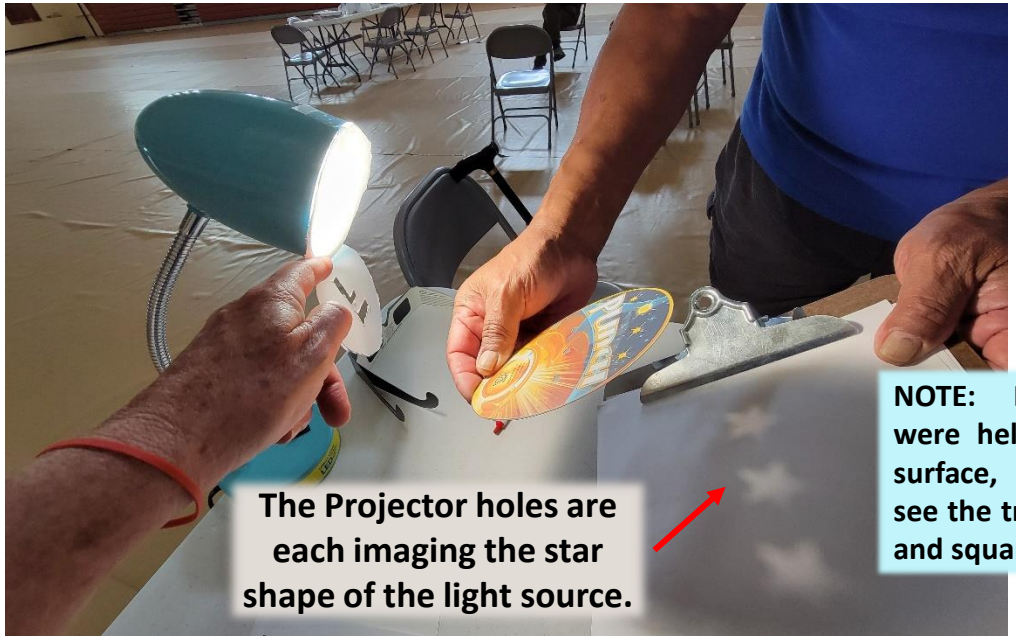


Lamp OFF

Try using our projector with a (**low-temperature**) LED light fixture.

Use a cut out to alter the shape of the light source.

NOTE: See Section 5, Appendix A for a neat demo using the F-shaped mask.

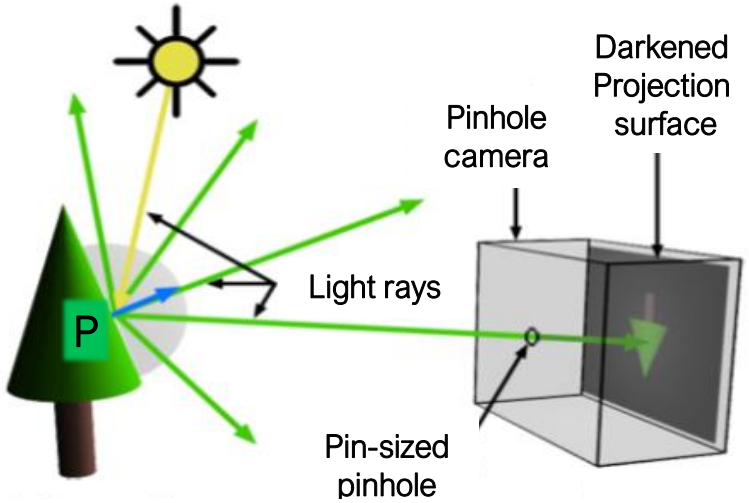


Lamp ON

NOTE: If the Projector were held closer to the surface, we would still see the triangular, round, and square-shaped holes.

What is the difference between our Pinhole *Projector* and a Pinhole *Camera*?

Set-up for a Pinhole Viewer or *Camera*



Adapted from Figure 3
https://www.scratchapixel.com/lessons/3d-basic-rendering/3d-viewing-pinhole-camera

Set-up for a Pinhole *Projector*

Important differences are the size of the hole and whether the projection surface must be in the dark rather than working in broad daylight. See Table on the next slide.

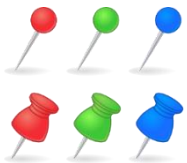
Section 5: Appendix D provides details about our design trade-offs and why our pinhole *projector* has larger holes than pinhole *cameras* which have pin-sized holes.

What is the difference between our Pinhole *Projector* and a Pinhole *Camera*?

Outreach for the **NASA** PUNCH mission

Compare the images on the previous slide to help interpret the Table

	Pinhole *Camera*	Pinhole *Projector*
Size of Hole	Pin-sized hole	Larger holes (~5 mm)
Object being imaged	Can be the Sun but is usually an object reflecting the Sun's light	Can be the Sun or other bright light source, even indoor lighting fixtures
Projected images	To see the dim image formed through a tiny hole, you must enclose the projection surface in a space that is completely dark.	Images can be seen in broad daylight. They appear on a projection surface in the shade of projector.
Photography	Photos can be created using light-sensitive paper or film on the projection surface	Does not record photos

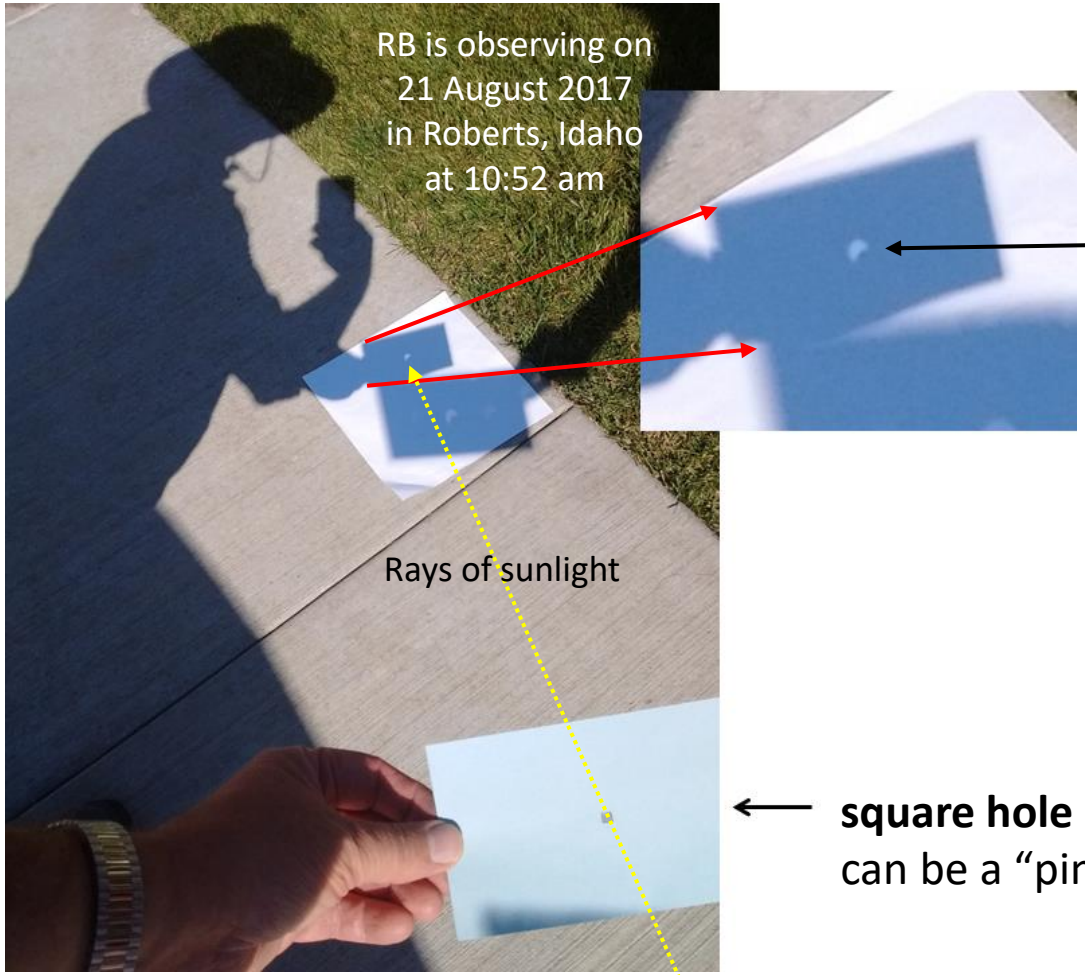


Bahnu says: Prove that a pin-sized hole won't create an image of the Sun that you can see in broad daylight. Use a pin or thumb tack to poke a hole in our projector so you can compare what happens with a pinhole-sized hole vs the 5mm holes of the Projector. Remember that **Section 5**: **Appendix D** explains our design trade-offs.

Pinhole Projection of the Sun

Observing the 2017 solar eclipse using a simple pinhole projector with a single square hole.

Outreach for the **NASA** PUNCH mission



Pinhole image of the round Sun being eclipsed by the Moon during the 2017 Great American Eclipse

square hole in a 3 x 5” card can be a “pinhole” projector

During solar eclipses it is easier to tell that we are seeing real pinhole images of the eclipsed Sun among the shadows of leaves.

Gaps between tree leaves make wonderful pinhole image displays as the Moon eclipses the Sun.

Upper left image by Cantavestrella. See Credits & Acknowledgements.

Outreach for the **NASA** PUNCH mission

ADDITIONAL INFORMATION

Link for Feedback

Valuable References

Credits & Acknowledgements

Links to PUNCH & PUNCH Outreach Products

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

PLEASE GIVE US YOUR FEEDBACK

We take all feedback very seriously and are using it to keep improving our projector and this presentation.

Outreach for the **NASA** PUNCH mission

Please scan the QR code or go to this URL to give us feedback

https://tinyurl.com/PinholeFeedback

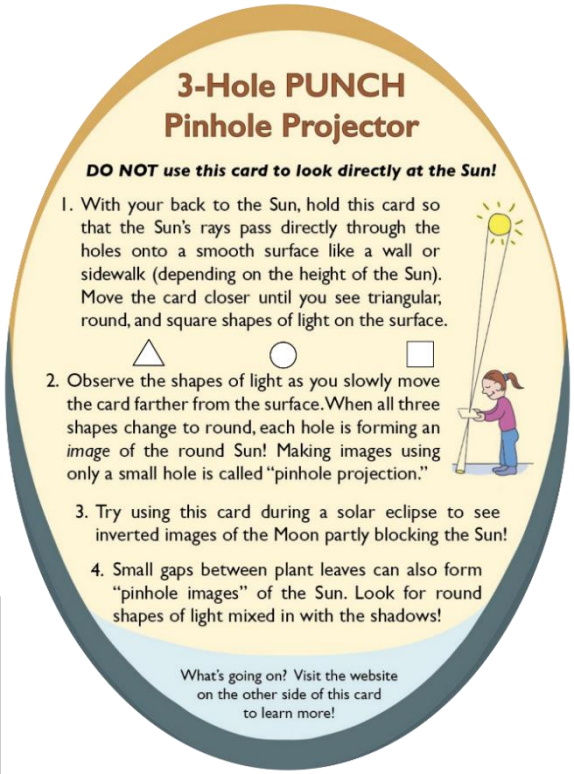
FRONT

Insights gained?

Remaining questions?

Ideas for improvements?

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

Primary Authors of the Explanatory Presentations:

Cherilynn Morrow, Robert Bigelow, and Mike Zawaski

cherilynn.morrow@gmail.com , arca965@gmail.com, and mjzawaski@gmail.com

Research & Development Team for the *3-Hole PUNCH Pinhole Projector*

Cherilynn Morrow (editor-in-chief, concept development, field testing, photos)
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)

Craig DeForest (PUNCH PI, product review and approval, field tester)
Sarah Gibson (PUNCH Project Scientist, product review and approval)
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.

Please proceed to Section 2:

Observing Pinhole Images of the Sun in Our Everyday Environments

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