

# Fermilabyrinth

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## Codecrackin'

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# Fermilabyrinth



**Warp Speed**



**Ghost Bustin'**



**Code Crackin'**



**Law 'n Order**

*Students - Educators - Lederman Science Center*

Security, Privacy, Legal



# Code Crackin'

METHODS: Colliding Particles Reveal Nature's Secrets.  
Patterns are the Clue.

Warp  
Speed

Law 'n  
Order

New  
Player

Ghost  
Bustin'

Diggin'  
Deeper



PLAY



PLAY



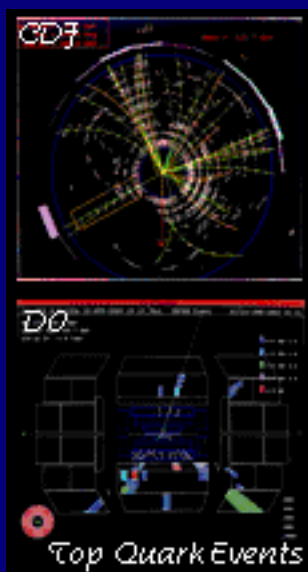
PLAY

Read  
the Story





## Methods: Scattering and Collisions Patterns are the Clue.



Scientists work by posing important new questions about the natural world. They develop theories, and invent tools and techniques to answer their questions and test their theories. Particle physicists are scientists who develop and test theories about the smallest particles of matter. Fermilab physicists create particles by accelerating protons and making them collide with particle targets. Sometimes the protons collide with fixed particle targets (hydrogen ions, iron, tungsten, for example); sometimes the protons collide head on with moving anti-protons. These collisions (also called events) create new particles. Scientists record and study how the newly created particles move away (or scatter) from the collision. By observing this behavior, scientists can learn about the particles and the forces that control their interactions, and sometimes discover particles not seen before.

[Code Crackin'](#)

# Read Particle Graffiti!



Control Room at the Collider Detector at Fermilab (CDF)

Today you're the physicist sitting in the control room at the CDF detector watching events as they appear on the computer screen. You are looking at the signatures of particles - "particle graffiti".

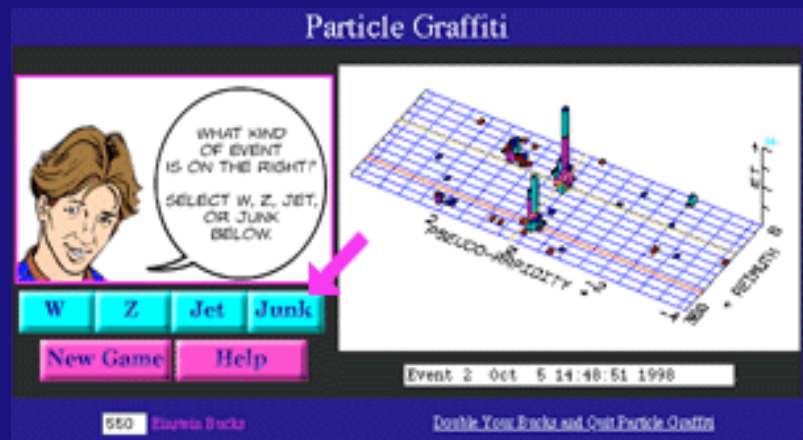
[Click to Continue](#)

....

Einstein Bucks

[Double Your Bucks and Quit Particle Graffiti](#)

Your job is to identify W, Z, Jet and background or junk events by clicking on one of the four buttons whenever a new event appears. You will get Einstein bucks for correctly identifying particles and lose them if you misidentify them.

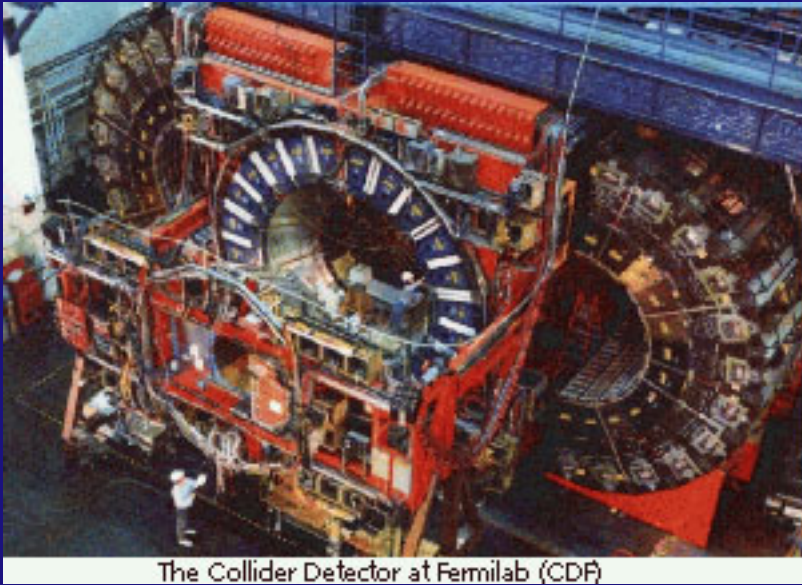


Remember if you get stuck, you can always click "Help".

[Click to Continue](#)

....





Physicists have made precise measurements of the masses of the W and Z particles. Using the CDF detector and the D0 detector, scientists discovered the top quark, the last quark to be observed.

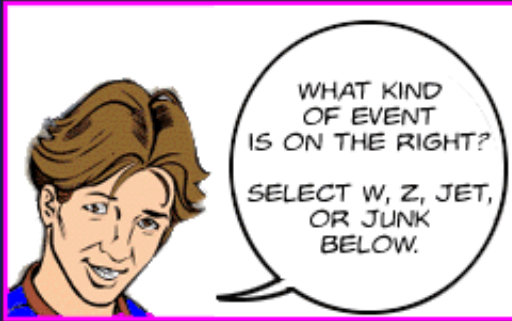
Let's see how a good a physicist you are.

Play [particle graffiti](#).

....



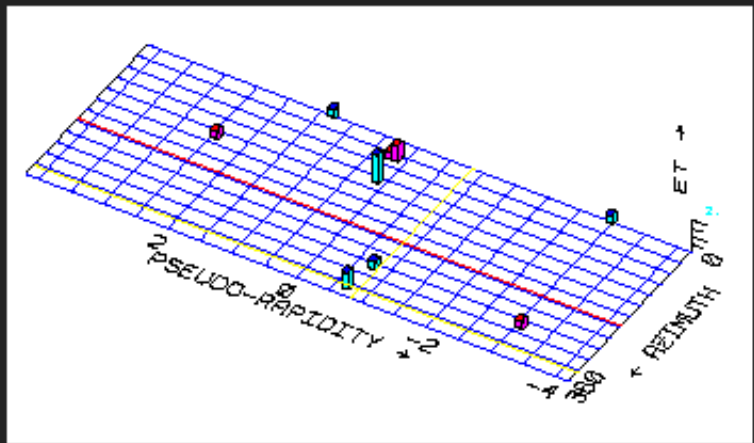
# Particle Graffiti



W   Z   Jet   Junk

New Game

Help



Event 1 Jul 5 15:36:24 2000

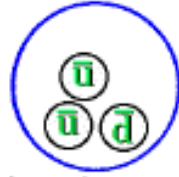
500 Einstein Bucks

[Double Your Bucks and Quit Particle Graffiti](#)

## How do physicists know they are seeing $W^+$ particles?

An up quark in a proton and  
antidown quark in an antiproton collide.

**Proton**



**Antiproton**

**Quarks**

**u** up

**d** down

**u** antiup

**d** antidown

**$W^+$**  W plus

**$\nu$**  neutrino

**$e^+$**  positron

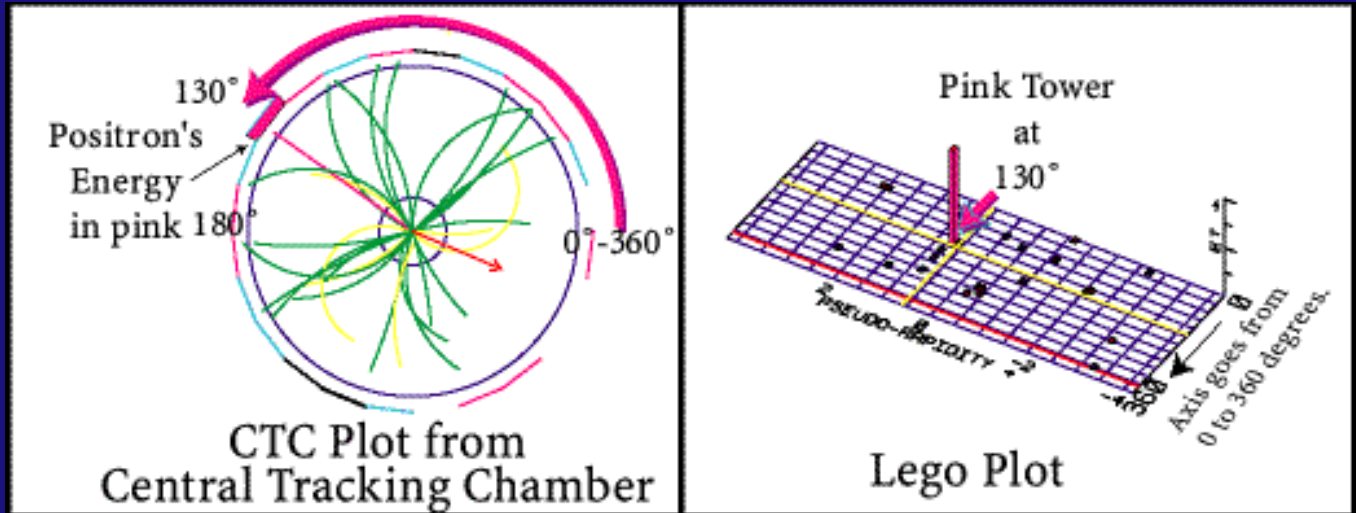
To see the animation again, reload the page.

[Click to Continue](#)

Text in animated gif-  
Making a  $W^+$  particle

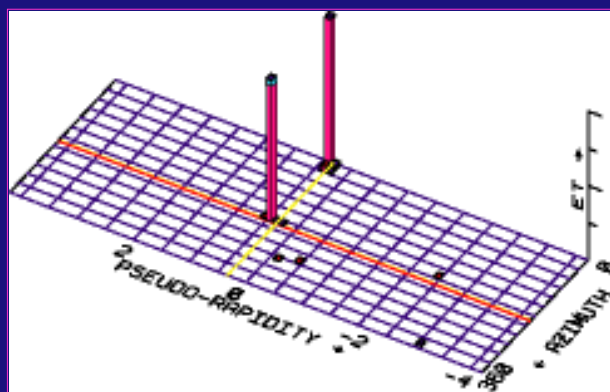
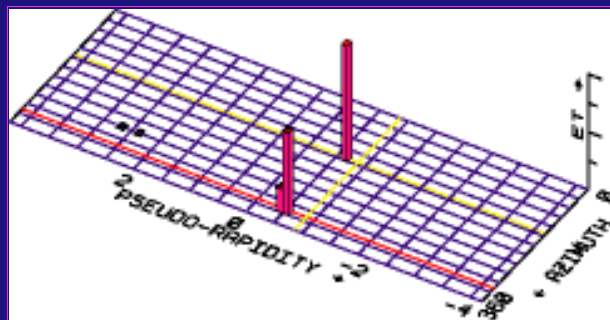
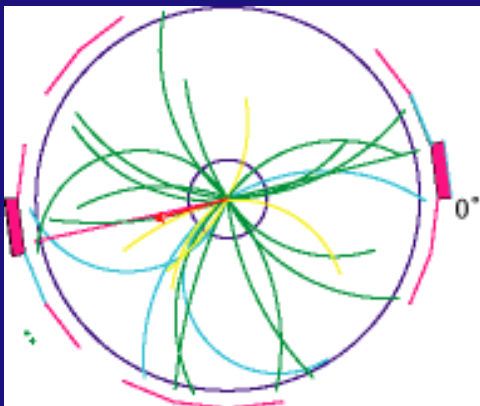
The up quark in a proton and the antidown quark in an antiproton collide.  
The collision produces a  $W^+$  plus Particle  
The  $W^+$  decays into a positron and neutrino.  
The positron deposits energy in the lead calorimeter.  
The positron's energy appears in pink in the plot.

## How does the positron appear in a lego plot?



[Click to see if you understand where \(in degrees\) the positron energy appears on each plot.](#)

Here's a CTC plot of a Z event. We have a positron and electron depositing energy in opposite sides of the detector. To double your Einstein bucks, click on the lego plot on the right that corresponds to this CTC plot. Look at the [previous plots for help](#).

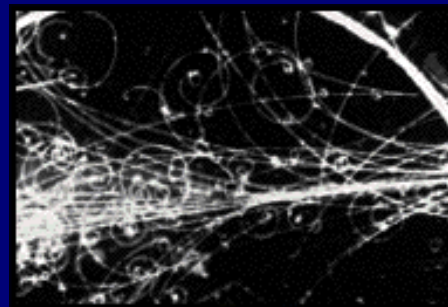


# To Print Your Einstein Bucks

- Click on the Window with your bucks. If you cannot see it, click on [Show Bucks](#).
- Select **Print** under the Browser **File** Menu.
- To check if you made the high score list, click [High Score](#).
- When you are done, click on [Quit Game](#).

# Play Particle Pool

PHYSICISTS STUDY TRAILS LEFT BY PARTICLES IN DETECTORS. HIT **CONTINUE** TO SET UP YOUR OWN COLLISIONS AND STUDY THEIR GHOST TRAILS ON THE VIDEO MONITOR.



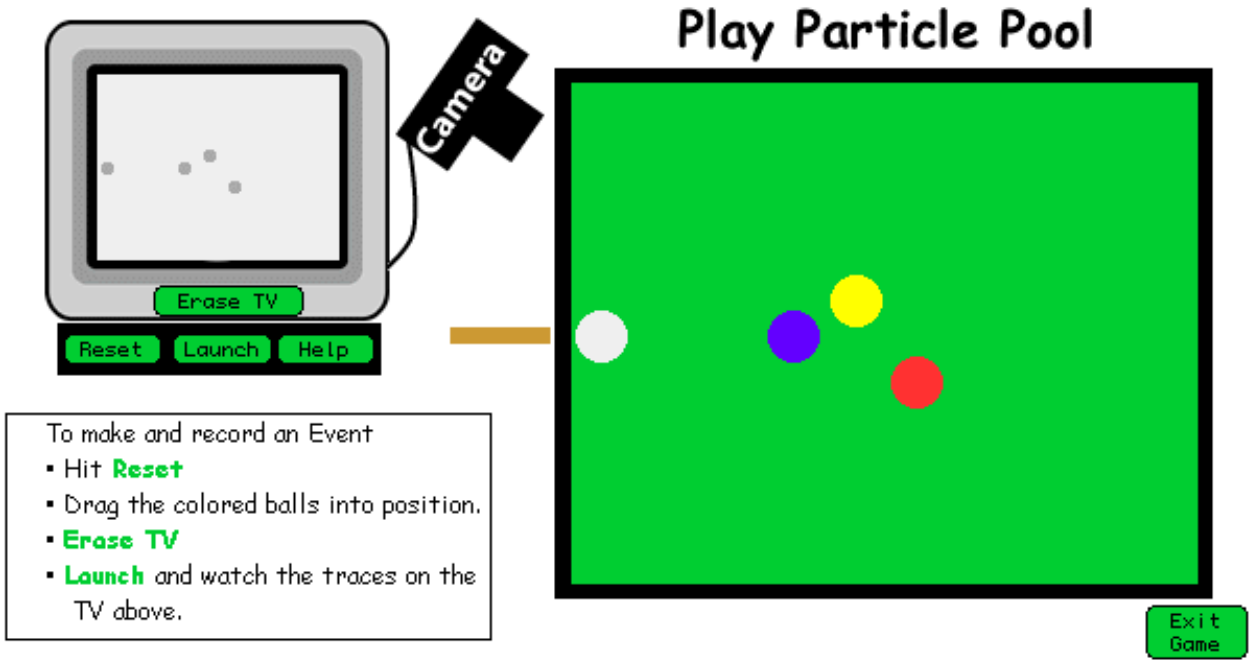
Tracks of Particles in a Bubble Chamber

**Continue**

This activity needs Shockwave. If you can't see the animation, click

You don't have Shockwave. Get it





[Code Crackin](#)



# Play Particle Pool

Which Setup (1, 2, or 3) makes the pattern below? Select it and hit **Launch** to test.

- Setup 1
- Setup 2
- Setup 3

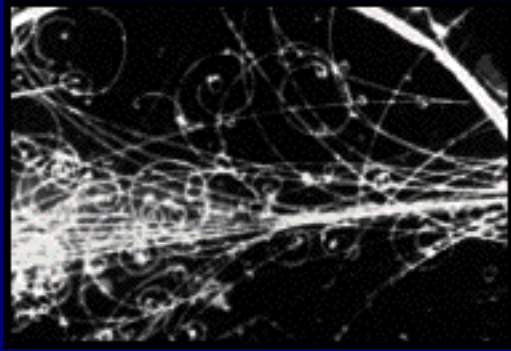
**New Pattern**

**Score \$400**

**Make Your Own Events** **Exit Game**

[Code Crackin](#)

# Adding a Magnet



Tracks of Particles in a Bubble Chamber

Look how some of the tracks in the bubble chamber picture are curved. Particle physicists discovered that they could make the trails of the particles more distinctive if they put a magnet in their apparatus. The paths of charged particles would bend. The direction a particle bent depended on whether the particle had a positive or negative charge. In Particle Pool, we had nothing comparable to a magnet so our tracks were straight.



Double Your Einstein Bucks.

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## Code Crackin'

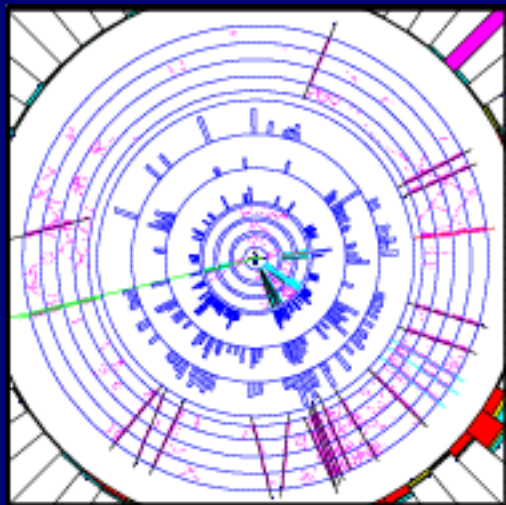
Web Maintainer: [ed-webmaster@fnal.gov](mailto:ed-webmaster@fnal.gov)

Last Update: May 9, 2000

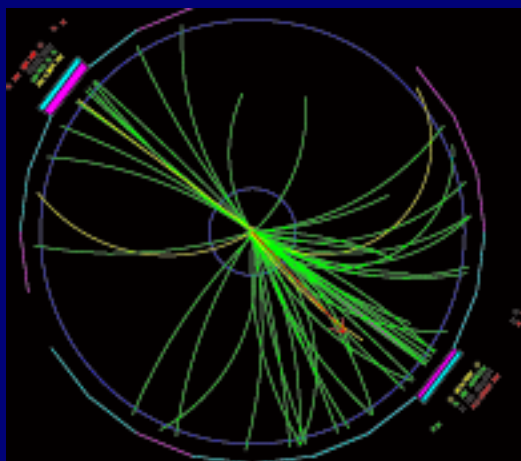
[http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle\\_pool/pp\\_moreinfo.html](http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle_pool/pp_moreinfo.html)

## Particle Pool - Double Your Einstein Bucks!!

Look at the tracks in events from the two collider experiments at Fermilab, D0 and CDF. Can you tell which one or ones used a magnet as part of the detector? Select the correct answer on the right and double your bucks!



D0 Event



CDF Event

Only  
D0

Only  
CDF

Both  
D0  
and  
CDF

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### Code Crackin'

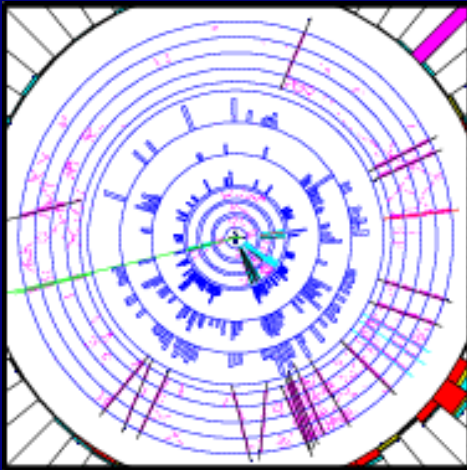
Web Maintainer: [ed-webmaster@fnal.gov](mailto:ed-webmaster@fnal.gov)

Last Update: May 9, 2000

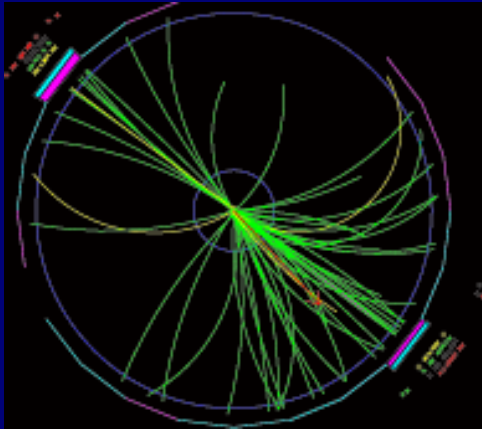
[http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle\\_pool/double\\_bucks.html](http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle_pool/double_bucks.html)

## Great! You now have Einstein Bucks!!

Only the CDF detector had a magnet when experimenters at CDF and D0 discovered the top quark. Many of the tracks in the CDF event are curved, but those in the D0 event are not. The next upgrade of the D0 detector has a magnet.



D0 Event



CDF Event



Print Your Bucks



[Go Back](#)

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Last Update: May 10, 2000

[http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle\\_pool/correct.html](http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle_pool/correct.html)

Fermilabyrinth  
Batavia, IL 60510

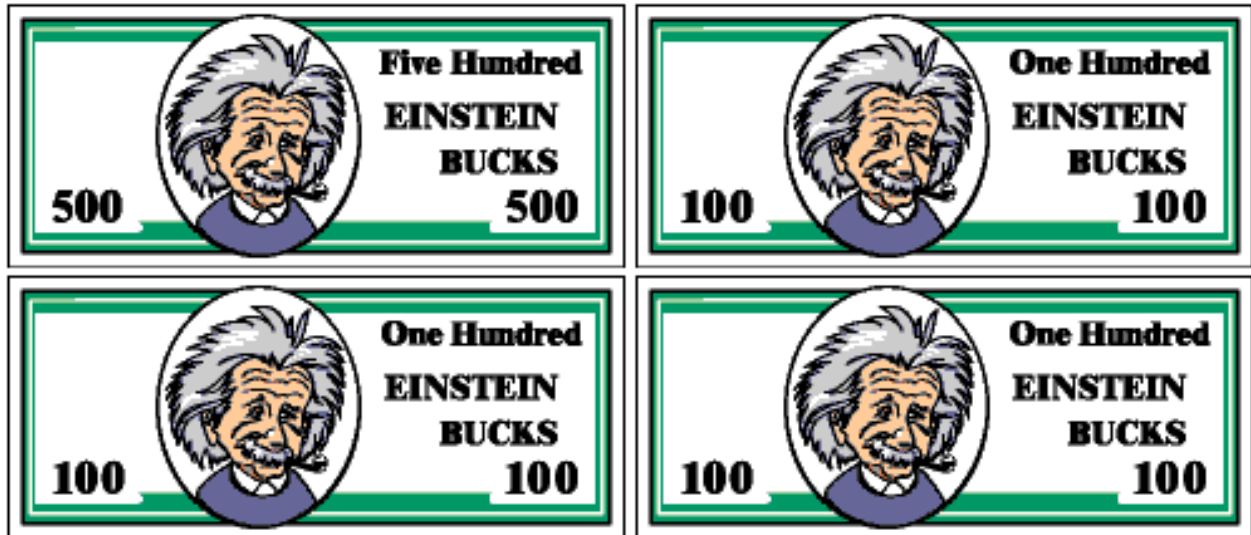
10/4/2001



Pay to the order of: Marilyn Fox

800 Einstein Bucks

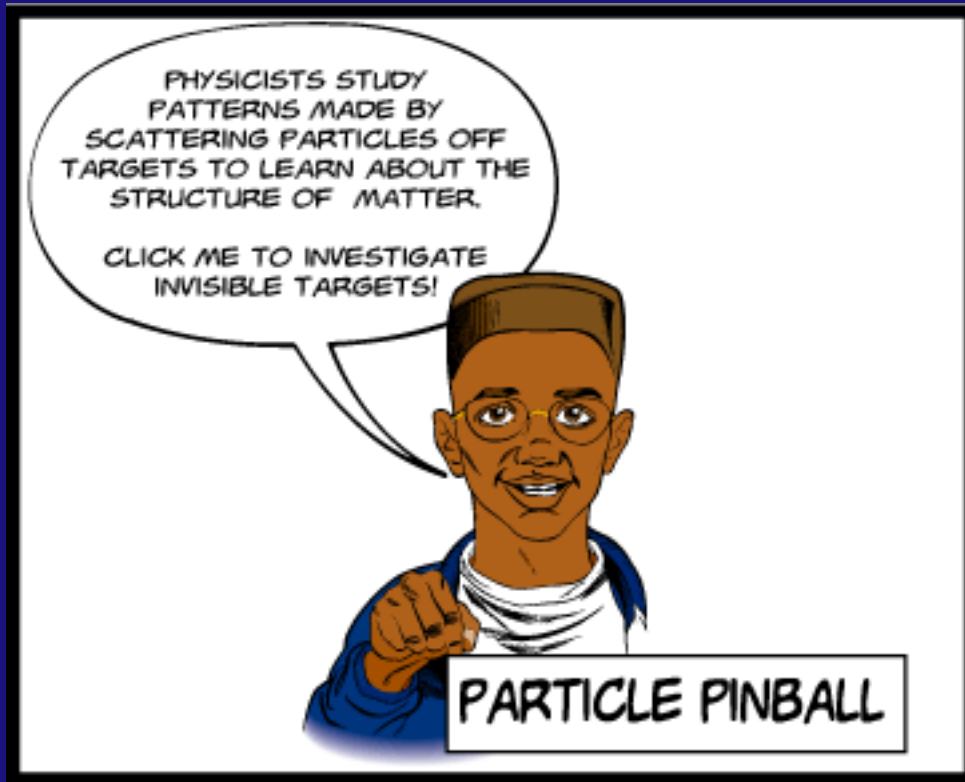
For: Particle Pool



[See The High Scores](#)

If you do not see your name on the check, try resizing the window. Close this window when you have printed out your Einstein bucks or have looked at the high scores.

# Particle Pinball - Recognizing Patterns



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[Code Crackin'](#)

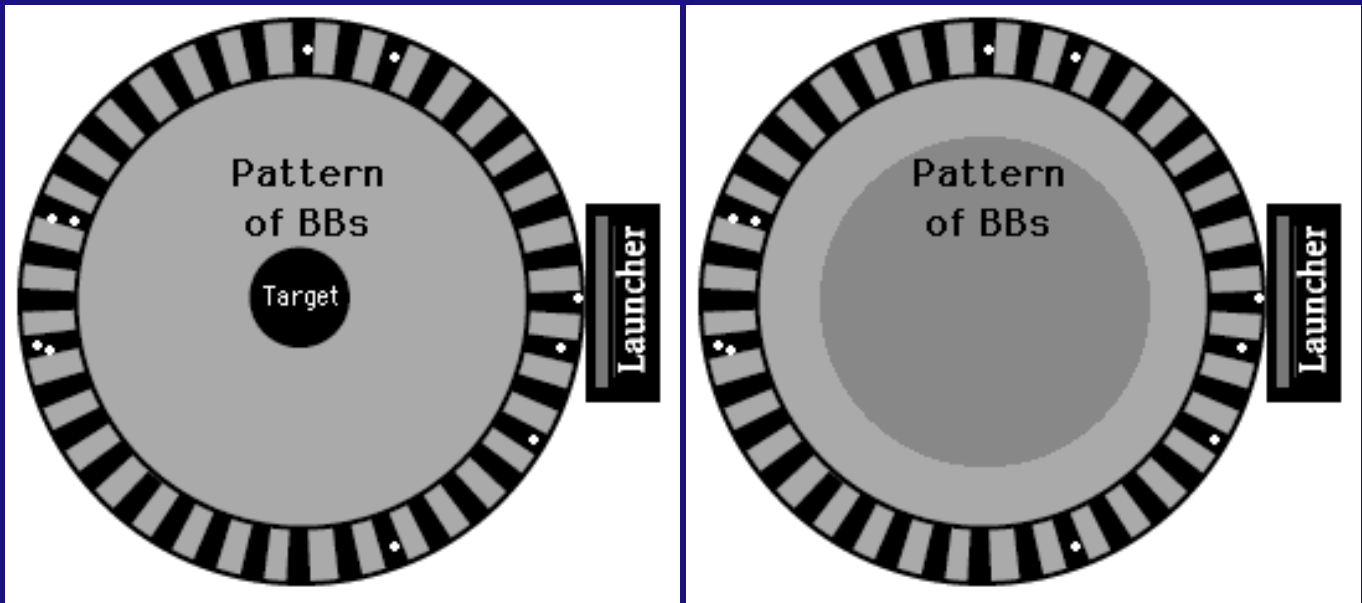
Web Maintainer: [ed-webmaster@fnal.gov](mailto:ed-webmaster@fnal.gov)

Last Update: April 25, 2000

[http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle\\_pinball/index.html](http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle_pinball/index.html)

# Particle Pinball - Recognizing Patterns

Look at the pattern made by BBs hitting a circular target. They produce a characteristic pattern as they pass by or careen off the target and land in the black bins around the outside. Can you recognize the patterns made by different hidden targets? To try, click on



[Code Crackin'](#)

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Last Update: April 20, 2000

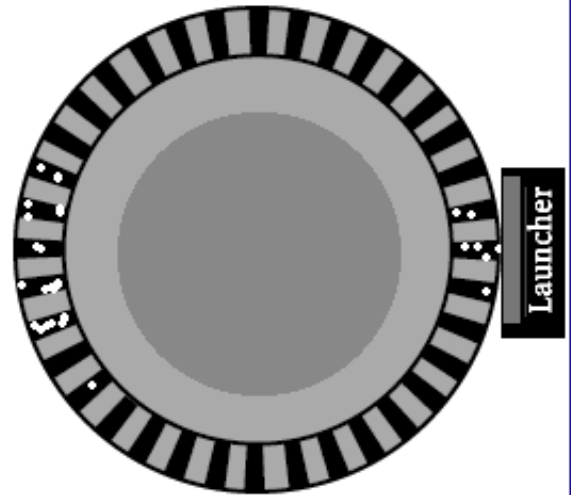
[http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle\\_pinball/activity.html](http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle_pinball/activity.html)



## Particle Pinball - Recognizing Patterns

### Experiment 1

- **Observe the pattern on the right:** The BBs hit a target hidden under the gray disk and scatter off of it to make a characteristic pattern. Watch carefully! If you need to see it again, click on
- **Match the pattern the BBs made with Patterns A,B, or C:** Click on
- **Click on the matching pattern ( Pattern A, B or C):**



Score: \$  Einstein Bucks  Tries

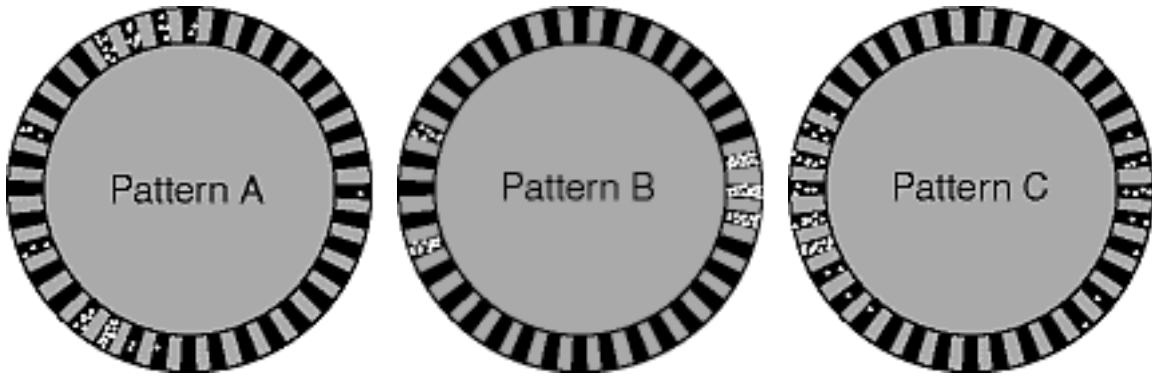
When you're done, click on

[Code Crackin'](#)

Web Maintainer: [ed-webmaster@fnal.gov](mailto:ed-webmaster@fnal.gov)

Last Update: April 22, 2000

[http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle\\_pinball/experiment1.html](http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle_pinball/experiment1.html)

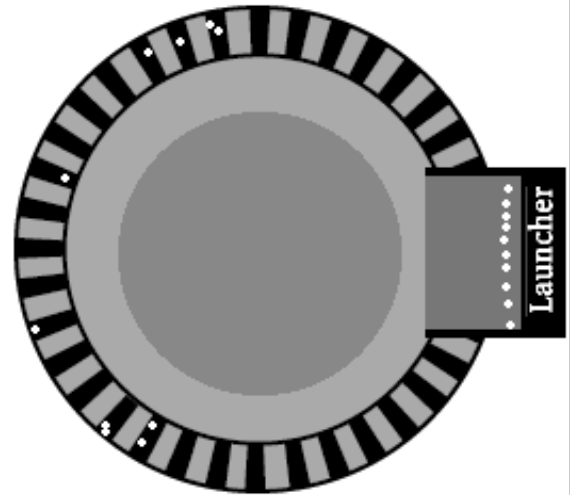


Click on the pattern above that matches your results in the experiment. Twice as many BBs made Patterns A, B, and C than in your experiment.

## Particle Pinball - Recognizing Patterns

### Experiment 2

- **Observe the pattern on the right:** The BBs hit a target hidden under the gray disk and scatter off of it to make a characteristic pattern. Watch carefully! If you need to see it again, click on
- **Match the pattern the BBs made with Patterns A,B, or C:** Click on
- **Click on the matching pattern ( Pattern A, B or C):**



Score: \$  Einstein Bucks  Tries

When you're done, click on

[Code Crackin'](#)

Web Maintainer: [ed-webmaster@fnal.gov](mailto:ed-webmaster@fnal.gov)

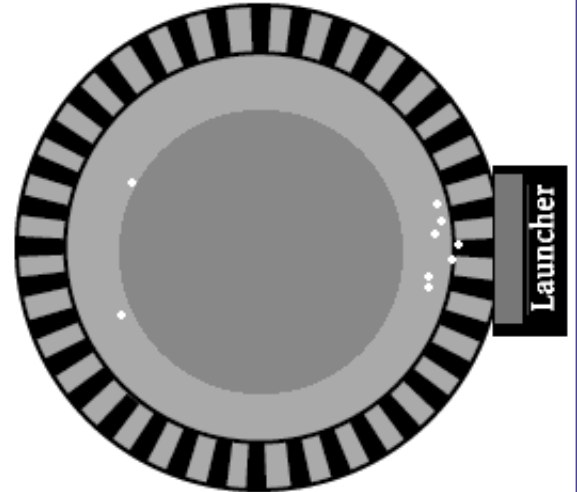
Last Update: April 22, 2000

[http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle\\_pinball/experiment2.html](http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle_pinball/experiment2.html)

## Particle Pinball - Recognizing Patterns

### Experiment 3

- **Observe the pattern on the right:** The BBs hit a target hidden under the gray disk and scatter off of it to make a characteristic pattern. Watch carefully! If you need to see it again, click on
- **Match the pattern the BBs made with Patterns A,B, or C:** Click on
- **Click on the matching pattern ( Pattern A, B or C):**



Score: \$  Einstein Bucks  Tries

When you're done, click on

[Code Crackin'](#)

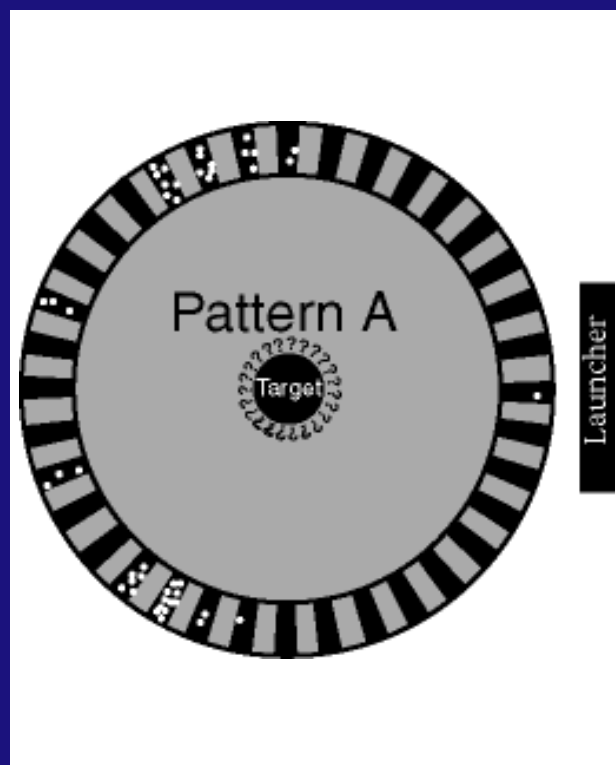
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Last Update: April 22, 2000

[http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle\\_pinball/experiment3.html](http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle_pinball/experiment3.html)

## Particle Pinball - Double Your Einstein Bucks!!

In Experiment 2, you made a pattern like Pattern A. When the gray disk was taken off to reveal the hidden target, what shape do you think it had? Was it a square, triangle, or three pegs? Click on the correct shape below.



[Code Crackin'](#)

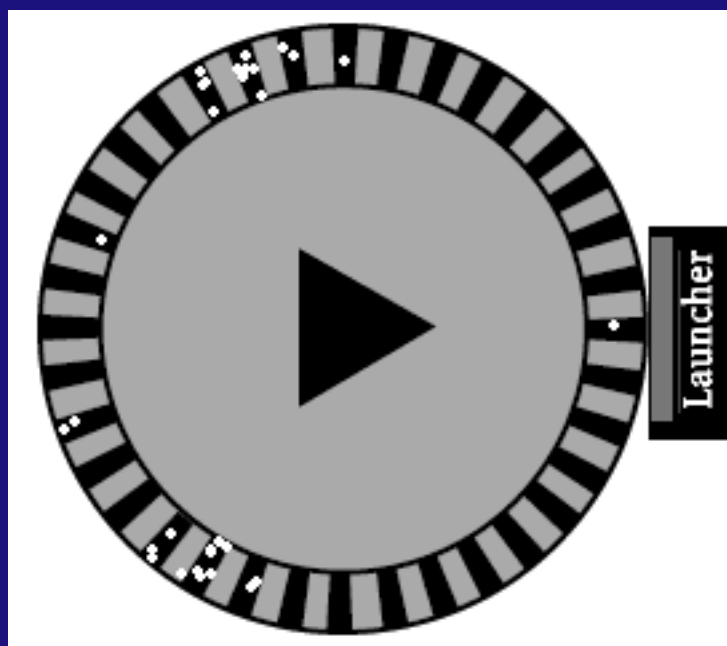
Web Maintainer: [ed-webmaster@fnal.gov](mailto:ed-webmaster@fnal.gov)

Last Update: April 20, 2000

[http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle\\_pinball/pinball\\_bucks1.html](http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle_pinball/pinball_bucks1.html)

# Sorry! You still have Einstein Bucks!!

Pattern A is made by the BBs hitting a triangle.



Print Your Bucks



[Go Back](#)

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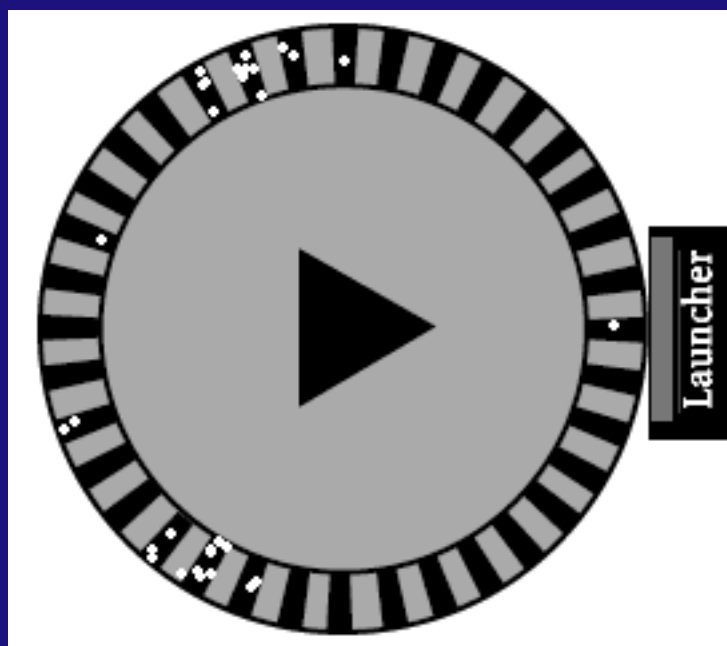
Web Maintainer: [ed-webmaster@fnal.gov](mailto:ed-webmaster@fnal.gov)

Last Update: April 24, 2000

[http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle\\_pinball/wrong1.html](http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle_pinball/wrong1.html)

Great! You now have Einstein Bucks!!

Pattern A is made by the BBs hitting a triangle.



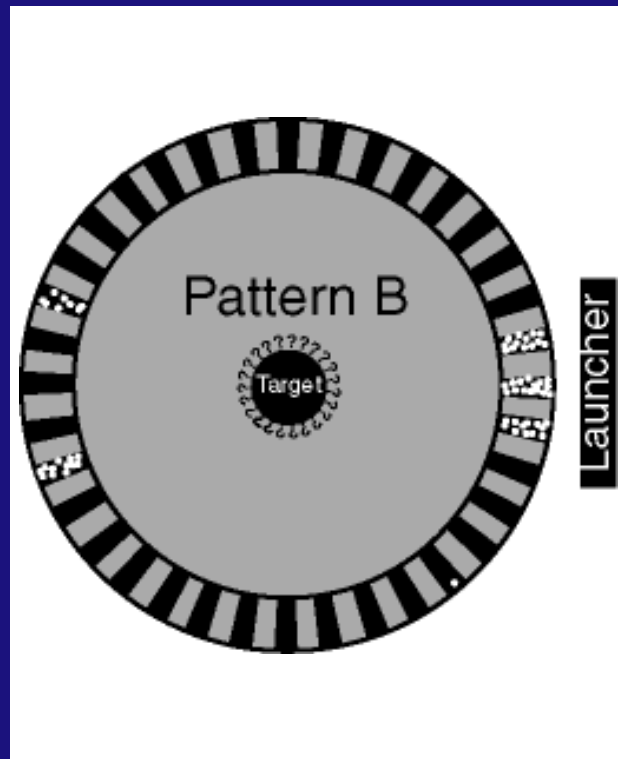
Print Your Bucks





# Particle Pinball - Double Your Einstein Bucks!!

In Experiment 3, you made a pattern like Pattern B. When the gray disk was taken off to reveal the hidden target, what shape do you think it had? Was it a square, triangle, or three pegs? Click on the correct shape below.



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## [Code Crackin'](#)

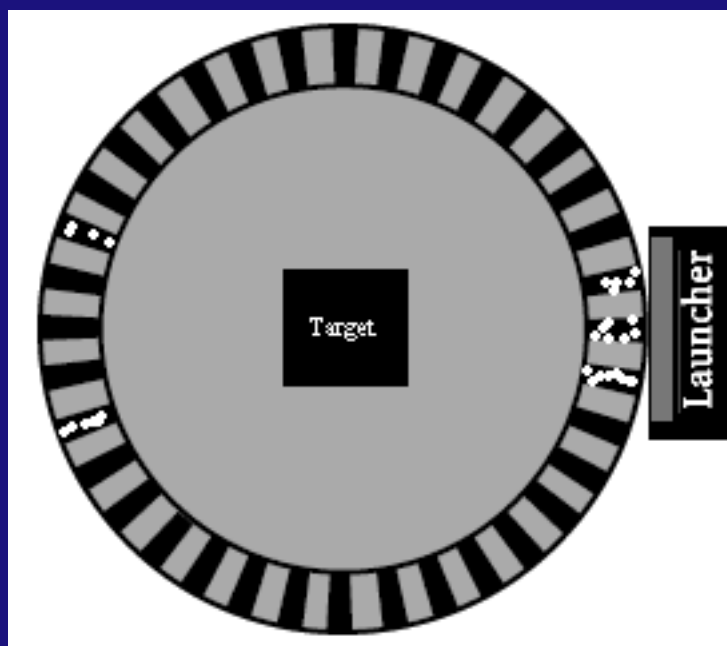
Web Maintainer: [ed-webmaster@fnal.gov](mailto:ed-webmaster@fnal.gov)

Last Update: April 24, 2000

[http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle\\_pinball/pinball\\_bucks2.html](http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle_pinball/pinball_bucks2.html)

# Sorry! You still have Einstein Bucks!!

Pattern B is made by the BBs hitting a square.



Print Your Bucks



[Go Back](#)

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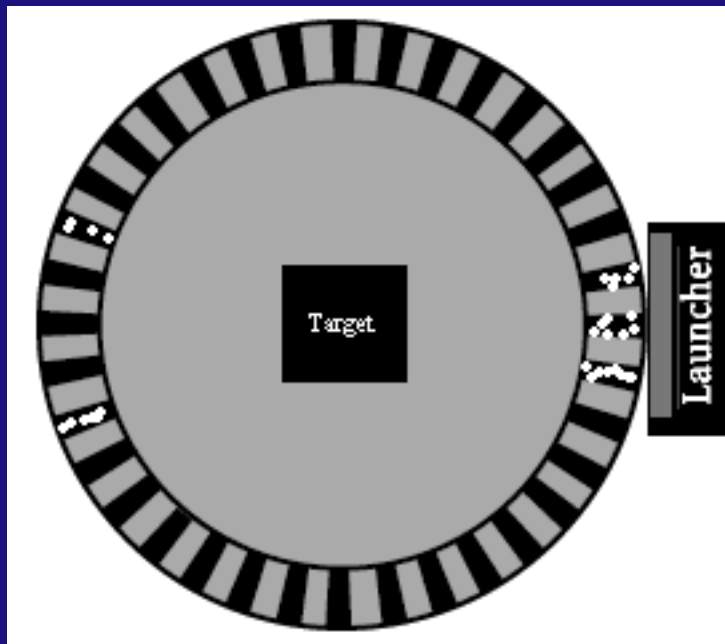
Web Maintainer: [ed-webmaster@fnal.gov](mailto:ed-webmaster@fnal.gov)

Last Update: April 20, 2000

[http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle\\_pinball/wrong2.html](http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle_pinball/wrong2.html)

Great! You now have Einstein Bucks!!

Pattern B is made by the BBs hitting a square.



Print Your Bucks



[Go Back](#)

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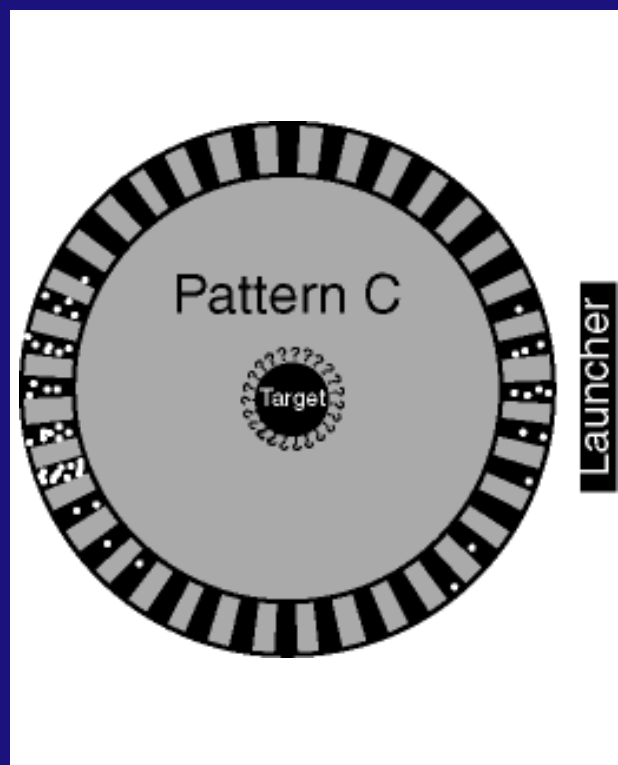
Web Maintainer: [ed-webmaster@fnal.gov](mailto:ed-webmaster@fnal.gov)

Last Update: April 20, 2000

[http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle\\_pinball/correct2.html](http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle_pinball/correct2.html)

## Particle Pinball - Double Your Einstein Bucks!!

In Experiment 1, you you made a pattern like Pattern C. When the gray disk was taken off to reveal the hidden target, what shape do you think it had? Was it a square, triangle, or three pegs? Click on the correct shape below.



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### [Code Crackin'](#)

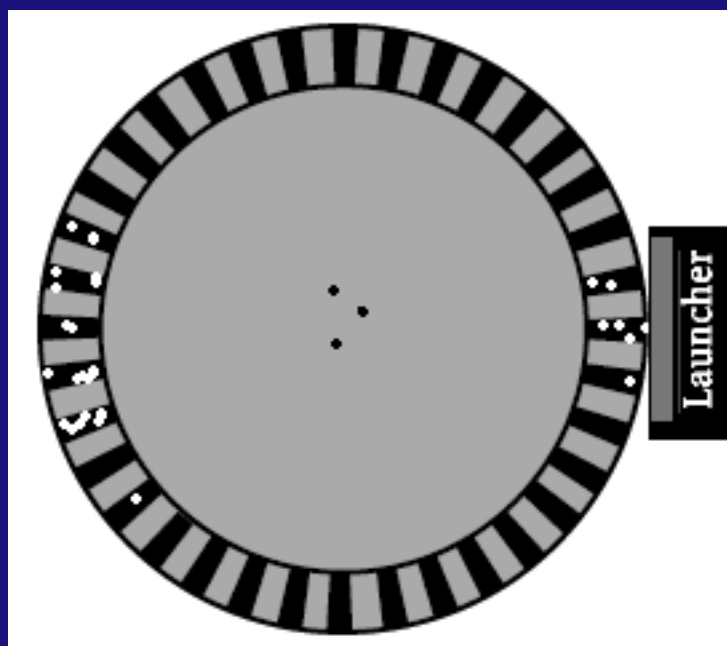
Web Maintainer: [ed-webmaster@fnal.gov](mailto:ed-webmaster@fnal.gov)

Last Update: April 20, 2000

[http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle\\_pinball/pinball\\_bucks3.html](http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle_pinball/pinball_bucks3.html)

Sorry! You still have Einstein Bucks!!

Pattern C is made by the BBs hitting three pegs.



Print Your Bucks



[Go Back](#)

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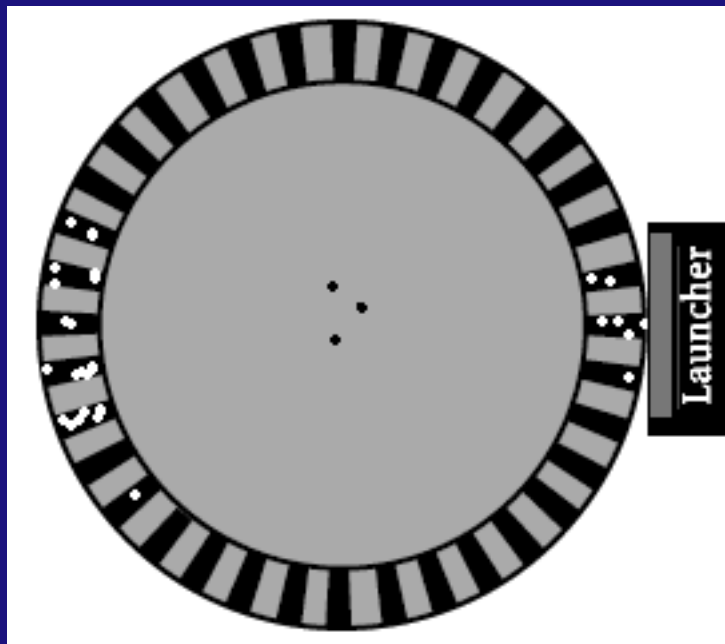
Web Maintainer: [ed-webmaster@fnal.gov](mailto:ed-webmaster@fnal.gov)

Last Update: April 24, 2000

[http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle\\_pinball/wrong3.html](http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle_pinball/wrong3.html)

Great! You now have Einstein Bucks!!

Pattern C is made by the BBs hitting three pegs.



Print Your Bucks



[Go Back](#)

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[http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle\\_pinball/correct3.html](http://www-ed.fnal.gov/projects/fermilabyrinth/games/codecrackin/particle_pinball/correct3.html)

Fermilabyrinth  
Batavia, IL 60510

10/5/01



Pay to the order of: Marilyn Fox

200 Einstein Bucks

For: Particle Pinball



[See The High Scores](#)

If you do not see your name on the check, try resizing the window. Close this window when you have printed out your Einstein bucks or have looked at the high scores.