

# How Many Galaxies Will Rubin See? Teacher Guide

This activity is designed to estimate the total number of galaxies in the observable Universe by estimating the total number of galaxies in one Rubin field of view.

## Teacher Notes

- The Cosmic Treasure Chest [image in Skyviewer](#) is measured in “Rubin’s field of view”. One Rubin field of view shows the amount of the observable Universe that Rubin Observatory captures each time an image is created by pointing the telescope at the night sky. It is equivalent to approximately 10 square degrees.
- The fully zoomed-out Cosmic Treasure Chest image is approximately 24 square degrees.
- The Legacy Survey of Space and Time will extend for ten years and over that period, each area of the main survey is expected to be visited about 800 times.
- Previous estimates for the total number of galaxies in the observable Universe were 200-300 billion galaxies. But [recent research](#) suggests that the number is more likely to be around two trillion galaxies.
- For a variation in Step 6, have each student report their galaxy counts and develop a class average. This could be used to do the remaining calculations.

## Prerequisites/ Starting Points

- If students do not understand the concept of a degree, first introduce that there are 360 degrees in a circle.
- Stars are mapped in a similar way that the Earth is mapped, but instead of using longitude (the imaginary lines that run from the North Pole to the South Pole on maps), celestial maps use right ascension, or RA, for short. Instead of using latitude (the lines that parallel the Equator), celestial maps use declination, or Dec. Like longitude and latitude, RA and Dec are measured in degrees.
- When calculating an area on a celestial map, multiplying the measured change in declination by the measured change in right ascension produces an area in square degrees.

# How Many Galaxies Will Rubin See? Student worksheet

1. Start by zooming all the way out to see the full Cosmic Treasure Chest image.
2. Now Zoom in so your view is equal to 1.0 Rubin field of view. One Rubin field of view shows the amount of the observable Universe that Rubin Observatory captures each time an image is created by pointing the telescope at the night sky. To Zoom, use the +/- buttons on Skyviewer or on your keyboard, or use your mouse or trackpad. Center the image so there are no black edges.
3. Click the Main Menu at the upper left corner of the Skyviewer. Go to Display, and verify that the coordinate format is decimal.
4. Now zoom into about 1/2000 - 1/4000 of Rubin's field of view.
  - a. Click on the grid icon, which is near the top right corner of the Skyviewer. A grid should appear on your view.
  - b. Click on the full screen button at the lower left. (It looks like a square and is directly above the Share icon.)
  - c. The grid is labeled with numbers in degrees along the horizontal and vertical lines of the image. Use these numbers to determine the height and width of one square.
  - d. Multiply the height and width of your square together to get the area of the square in units of square degrees.
5. Count and record the total number of galaxies in one square of this view. Do not count any stars. (Bright stars appear as bright objects with colored spikes.)
6. Divide the number of galaxies by the area of your square. This gives you an estimate of the number of galaxies in one square degree of this view.
7.
  - a. Multiply the number you estimated in Step 6 by 10. This will give you an estimate for the total number of galaxies in one Rubin field of view, which is about ten square degrees.
  - b. If you want to estimate the number of galaxies in the full Rubin's Cosmic Treasure Chest image, multiply the number you estimated in Step 6 by 24.
8. Now multiply the number from Step 7a by 2000 (the number of Rubin field of view images it takes to cover Rubin's full view of the Universe). This will give you an estimate for the total number of galaxies in the observable Universe that Rubin Observatory can detect from its location in the Southern Hemisphere. How many galaxies did you estimate for Rubin's entire view of the observable Universe?
9. There is still a significant portion of the entire observable Universe that Rubin cannot detect. The telescope in the Rubin Observatory can detect about half of the Universe that can be observed from the entire Earth. To get an estimate for the total number of galaxies in the entire observable Universe, multiply your number from step 8 by 2. How many galaxies did you estimate for the entire observable Universe?

This First Look image was produced by adding images over a period of 7 nights. The full length of the Legacy Survey of Space and Time is ten years. Over that time, Rubin Observatory estimates that *20 billion galaxies* will be observed. If you said the name of every galaxy in the survey at a rate of 1/sec, it would take more than 630 years!

# How Many Galaxies Will Rubin See? Sample Answer Key

This answer key is meant to show a sample set of answers, but should in no way be interpreted as the "correct answers"! The emphasis is on the process of the measurements and calculations. The answer key begins at step 4 of the student worksheet, since the previous steps are just background information and directions.

4. Now zoom into about 1/2000 - 1/4000 of Rubin's field of view.
  - c. The grid is labeled with numbers in degrees along the horizontal and vertical lines of the image. Use these numbers to determine the height and width of one square.  
These sample measurements were made using a 1/2000 field of view:  
RA measurements of the width of one square:  $186.70 - 186.68 = 0.02$   
Dec. measurements of the height of one square:  $6.90 - 6.88 = 0.02$
  - d. Multiply the height and width of your square together to get the area of the square in units of square degrees.  
 $0.02 \times 0.02 = 0.0004$  square degrees
5. Count and record the total number of galaxies in one square of this view.  
*74 galaxies. Note: the number of galaxies may vary considerably, depending on the size and density of galaxies in each square. It is advisable to collect these individual counts from each student and average them to get a more reliable estimate before proceeding to step 6.*
6. Divide the number of galaxies by the area of your square. This gives you an estimate of the number of galaxies in one square degree of this view.  
 $74 / 0.0004 = 185,000$  galaxies per sq. deg.
7.
  - a. Multiply the number you estimated in Step 6 by 10. This will give you an estimate for the total number of galaxies in one Rubin field of view, which is about ten square degrees.  $185,000$  galaxies per sq. deg.  $\times 10$  sq. deg.  $= 1,850,000$  galaxies
  - b. If you want to estimate the number of galaxies in the full Rubin's Cosmic Treasure Chest image, multiply the number you estimated in Step 6 by 24).  
 $185,000 \times 24 = 4,440,000$  galaxies
8. Now multiply the number from Step 7a by 2000 (the approximate number of Rubin field of view images it takes to cover Rubin's full view of the Universe). This will give you an estimate for the total number of galaxies in the observable Universe that Rubin Observatory can detect from its location in the Southern Hemisphere. How many galaxies did you estimate for Rubin's entire view of the observable Universe?

$1,850,000 \times 2000 = 3,700,000,000$  (3.7 billion) galaxies. *Note: The estimate for the galaxy count by the end of the ten year Rubin Observatory survey is 20 billion.*

9. There is still a significant portion of the entire observable Universe that Rubin cannot detect. The telescope in the Rubin Observatory can detect about half of the Universe that can be observed from the entire Earth. To get an estimate for the total number of galaxies in the entire observable Universe, multiply your number from step 8 by 2. How many galaxies did you estimate for the entire observable Universe?

$3.7 \text{ billion} \times 2 = 7.4 \text{ billion galaxies}$