Looking Ahead to Citizen Science with the Rubin Observatory

Clare Higgs
Astronomy Outreach specialist
Rubin Education & Public Outreach Team
clare.higgs@noirlab.edu

Collaborators and Thanks to: Chris Lintott and the Rubin Citizen Science Support Team

What is Citizen Science?

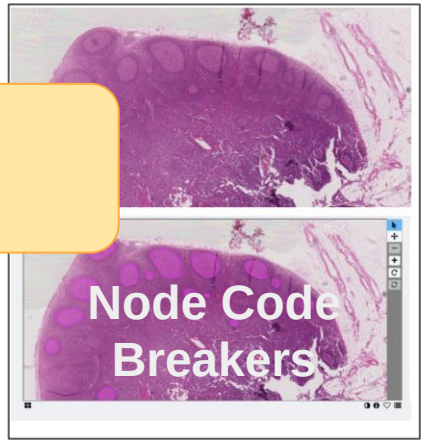
“a form of open collaboration where members of the public participate in the scientific process, including identifying research questions, collecting and analyzing the data, interpreting the results, and problem solving.” (Balcom 2015)

What is Citizen Science?

Data Collection

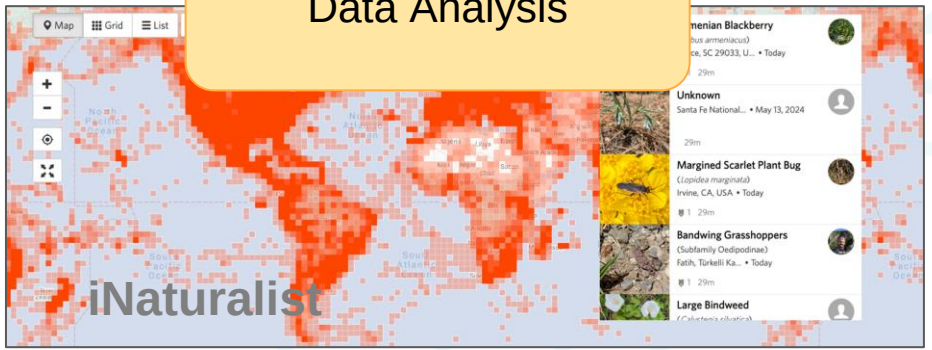
Credit: citizenscience.gov

Classification



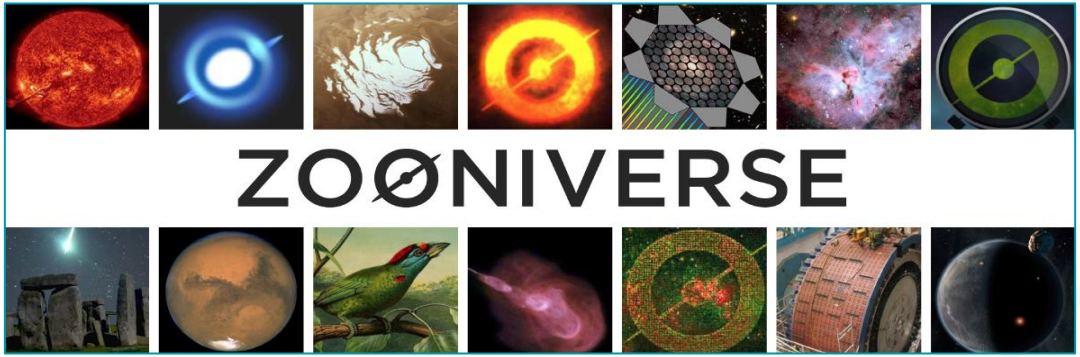
Credit: zooniverse.org

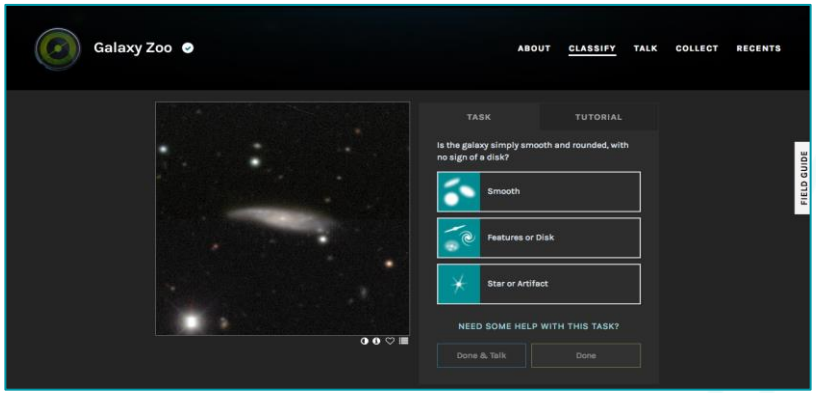
Data Analysis



Credit: inaturalist.org

The Zooniverse





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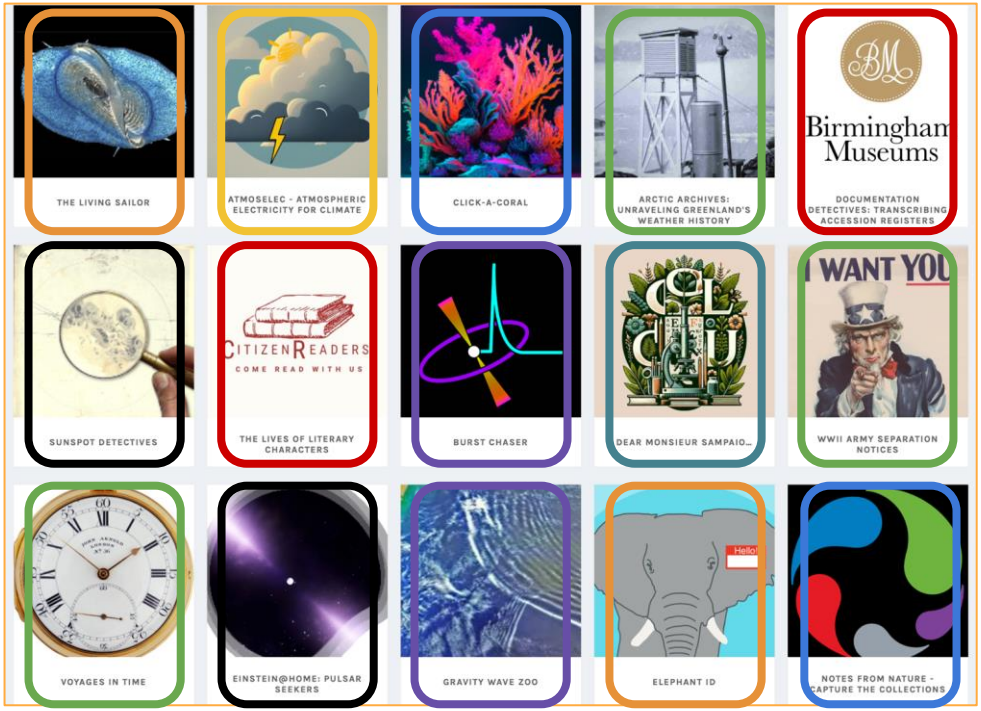
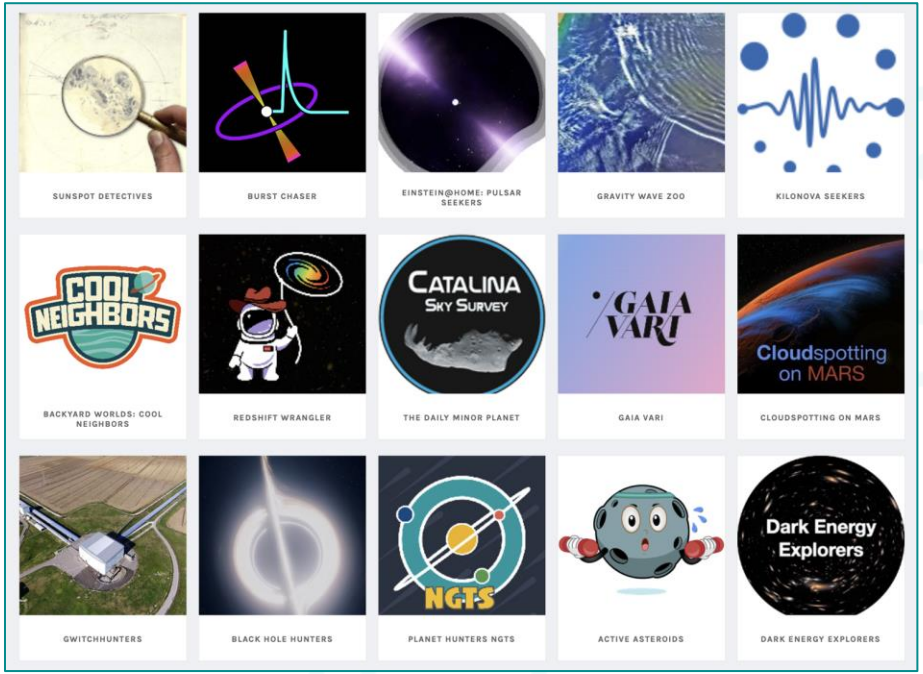


Credit: zooniverse.org

- Art
- Biology
- Climate
- History
- Language
- Nature
- Physics
- Social Sciences
- Space

What is Citizen Science in Astronomy?

- Classification and identification
  - E.g. Zooniverse projects
- Projects with contributed observations
  - E.g. SETI Institute + Unistellar Citizen Science
- Unique and powerful method
  - 450+ papers from the GalaxyZoo
- Meaningful to the scientific community and the public
  - Mutually beneficial and successful projects



Credit: zooniverse.org

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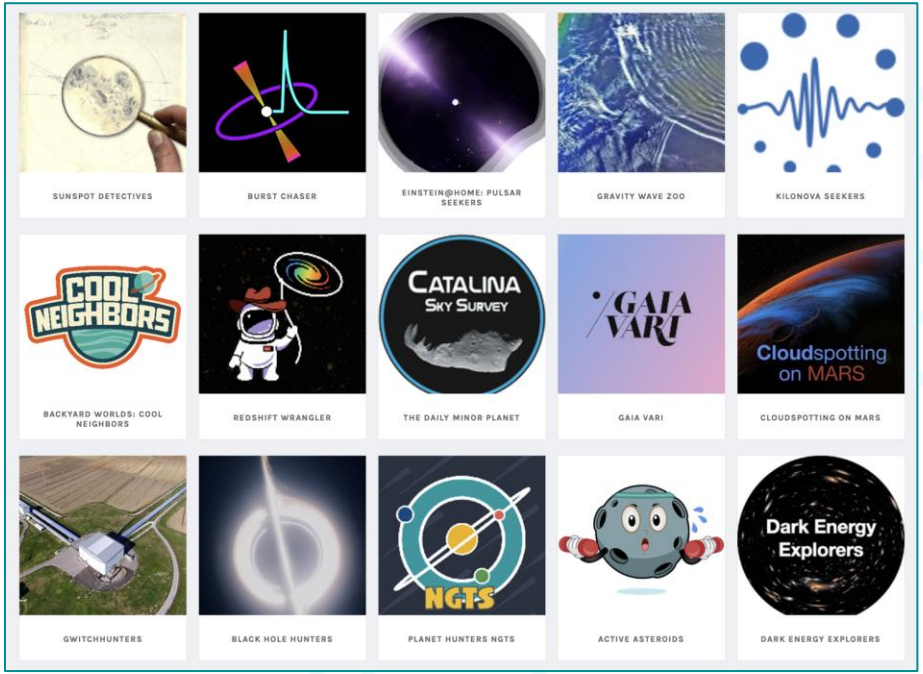

Credit: zooniverse.org

What is Citizen Science in Astronomy?

- Swapnaneel Dey
  - *Identifying unique stellar systems in imaging surveys with citizen science*
- Hayley Roberts
  - *Better Together: Enhancing Machine Learning Methods through Citizen Science with Zooniverse*
- Kameswara Bharadwaj Mantha
  - *Accelerating the Search for Rare Gems in Big Data: A Zooniverse Case Study using Citizen Science & Machine Learning*
- Nicolas Mazziotti
  - *Identifying Diffuse Galaxies through Citizen Science*
- Sarah Casewell
  - *Finding Jupiters in a Haystack with Citizen Science*

Why does the public want to participate?

People DO want to participate!

Why does the public want to participate?

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- Motivations include:
  - Engagement with the scientific process
  - New/fresh data brings people in
  - Engagement with scientists is a strong incentive
  - “Pretty pictures” are appreciated but not necessary

Raddick et al 0909.2925 & 1303.6886

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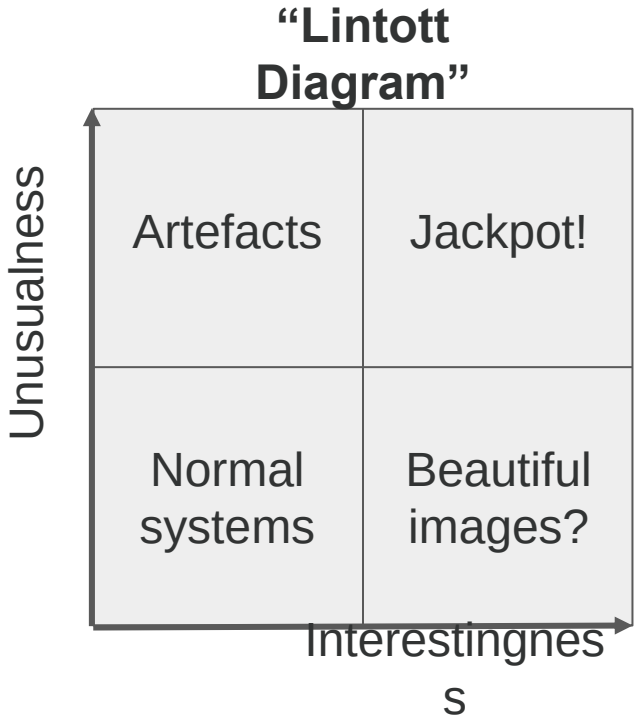
What insights can CitSci bring?



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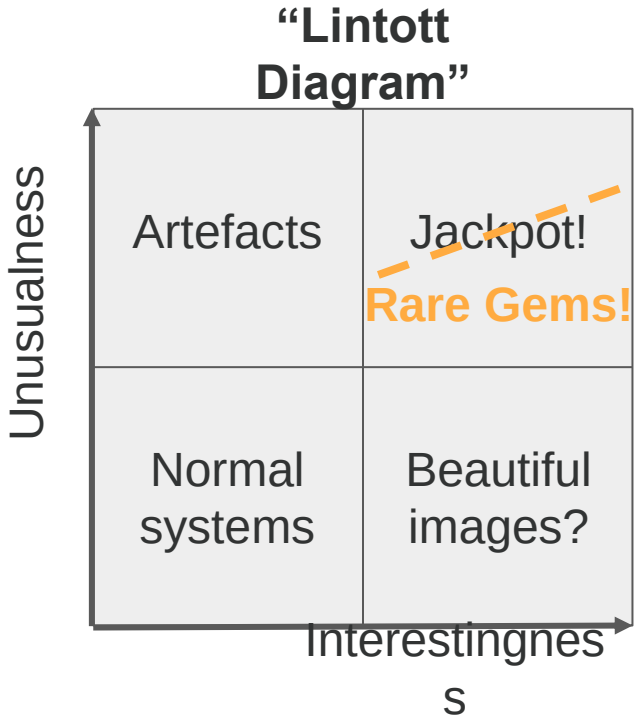
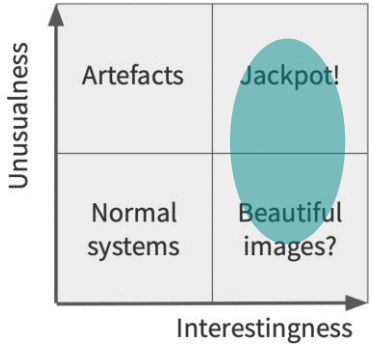


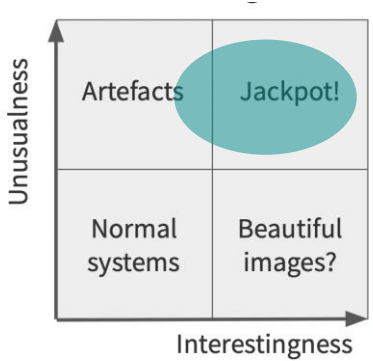
What is a “gem”?

Depends on who is asking!

For the public



For the science community



- Gems require some polishing - follow up is key to turn “cool rocks” into real gems!
- Other groups have other interests (press, amature astronomers etc) and that’s ok!

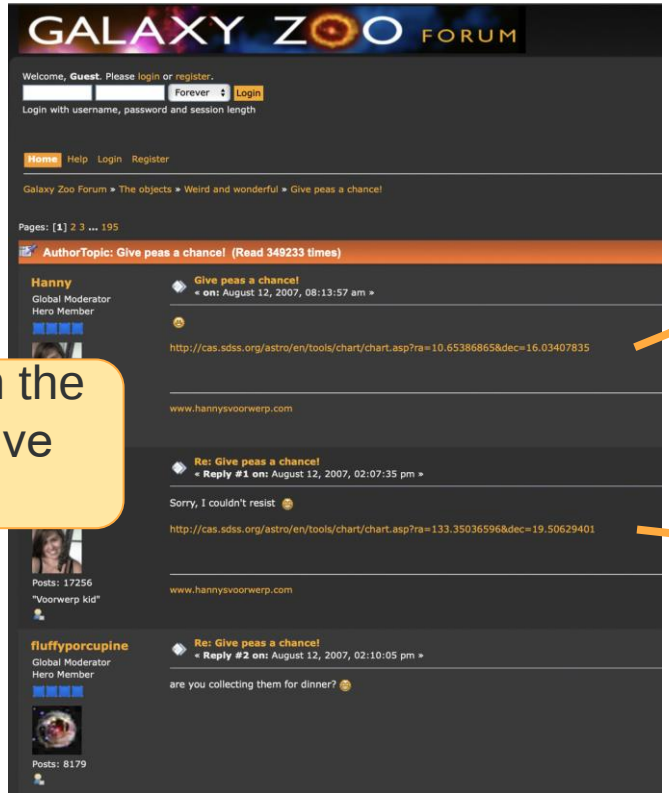
Example Gem #1 - Green pea galaxies

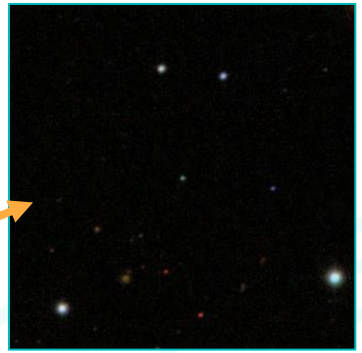
Cardamone et al. 2009
arXiv/0907.4155

- Class of extremely compact, star forming galaxies, appear green in SDSS data

Example Gem #1 - Green pea galaxies

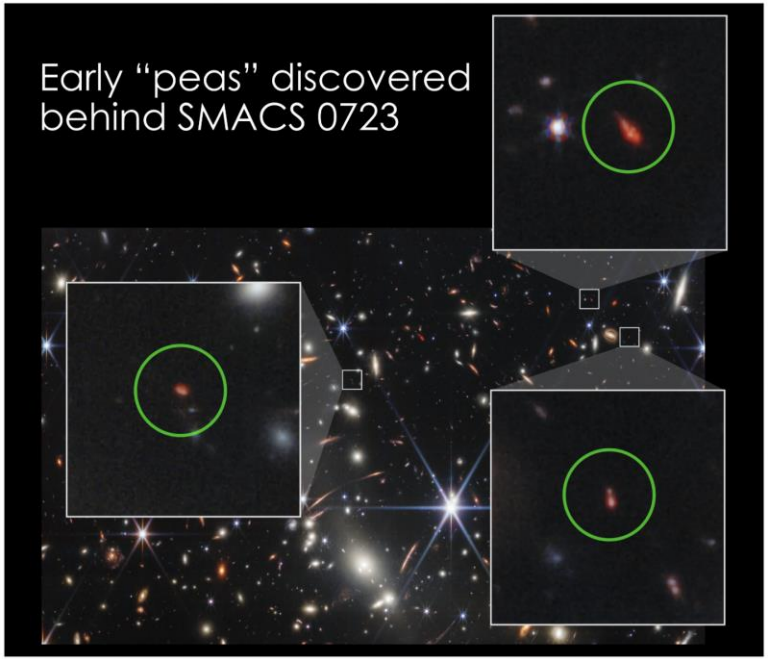
Discovered in 2007 in the GalaxyZoo chat: “Give peas a chance!”





Example Gem #1 - Green pea galaxies

- Green peas may provide insights into the type of galaxy that may have reionized the universe
- JWST is now imaging peas at higher redshift



Credit: NASA, ESA, CSA, and STScI

Example Gem #2 - Hanny's Voorwerp

- Targeted follow up observations showed strong emission lines, but no apparent source of ionization
- The first detection of a quasar light echo

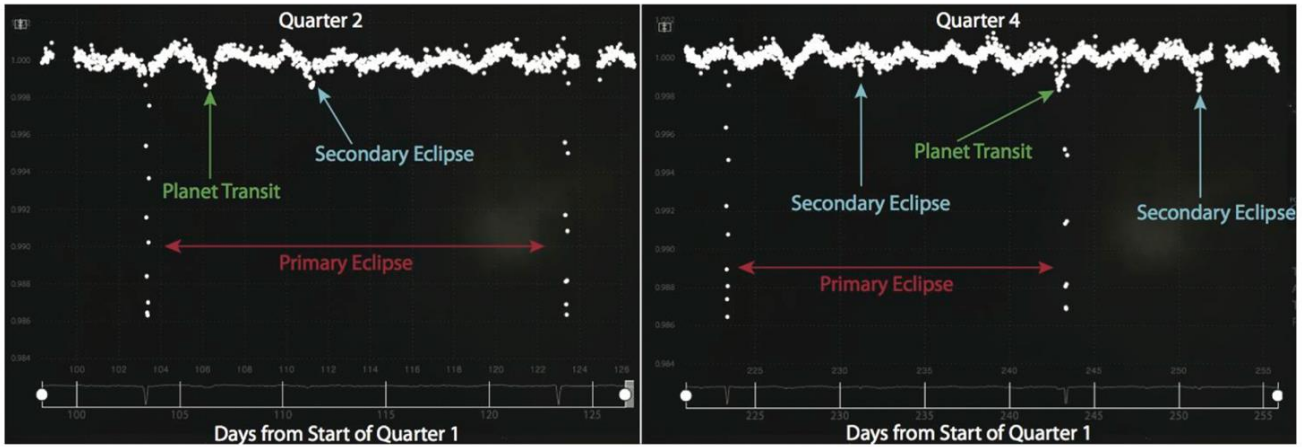
Lintott et al. arXiv/0906.5304

Example Gem #2 - Hanny's Voorwerp

One discovery leads to a whole new class

Lintott et al. arXiv/0906.5304

Example Gem #3 - Planet Hunters 1b

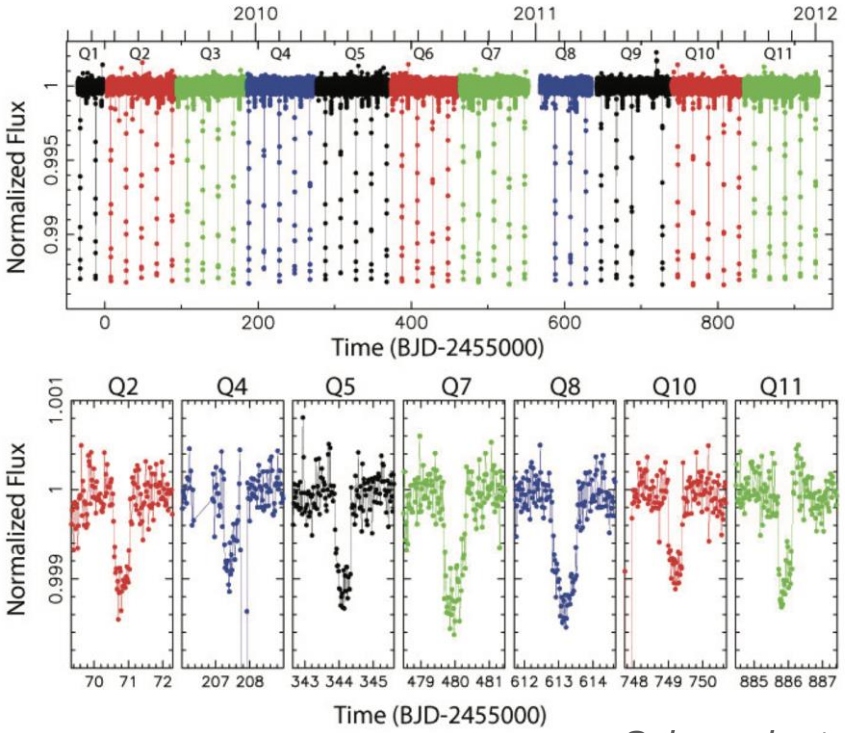


Schwamb et al. 2013

- the first known case of a quadruple star system with a transiting planet

Example Gem #3 - Planet Hunters 1b

- Reduced Kepler light curve for KIC 4862625
- Isolated individual identified transits of the planet across star Aa



Schwamb et al. 2013

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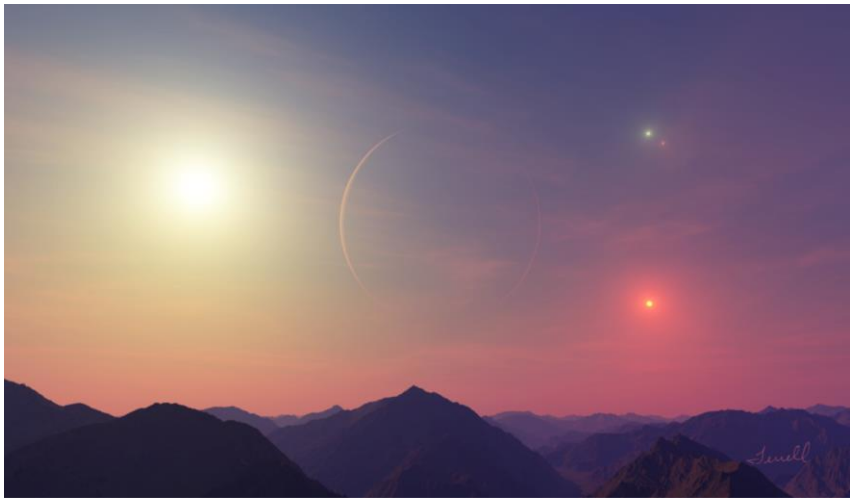
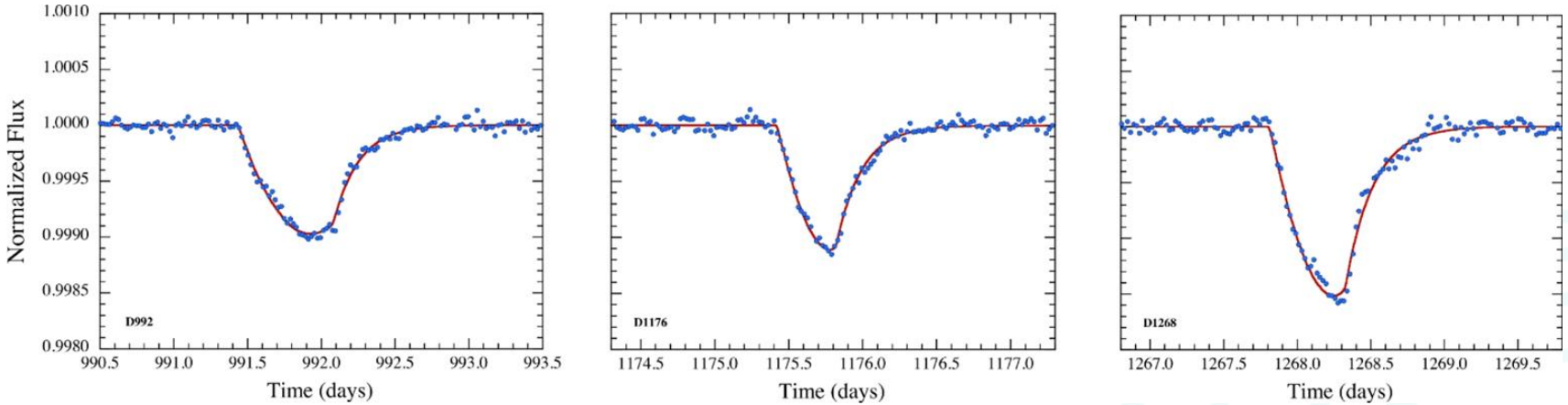


Credit: C. Lintott, The Zooniverse & Uni. of Oxford

Alpha Centauri B's planet and PH 1b system

Credit: The Economist

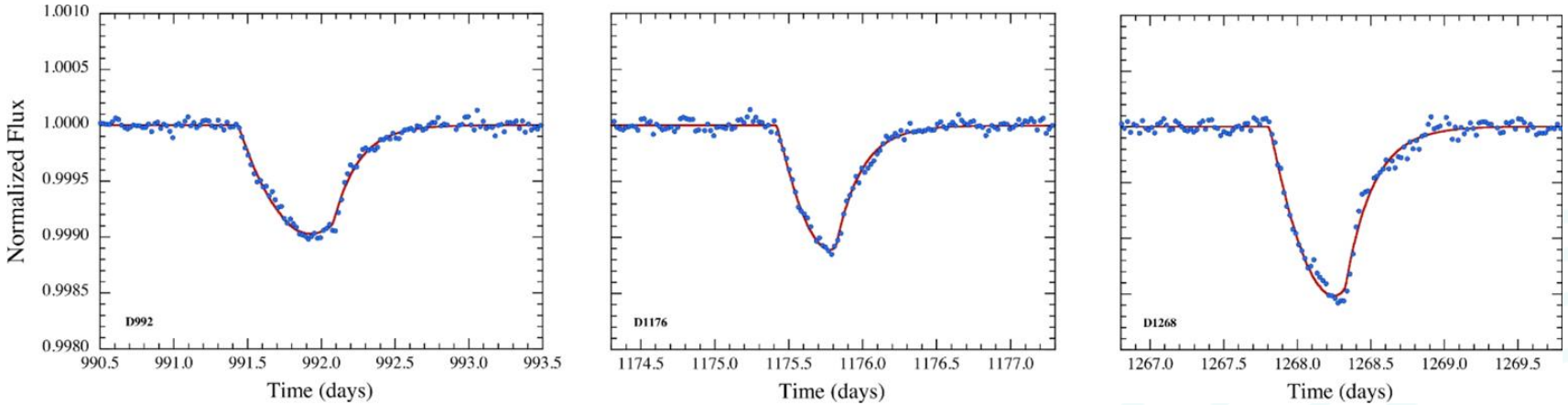
Example Gem #4 - Exocomets



- Using Kepler data, exocomet transits have a distinct asymmetric shape, and shallow ~0.1% depths

Rappaport, Vanderberg, Jacobs et al. 2017 arxiv/1708.06069

Example Gem #4 - Exocomets



In an effort to further explore the larger *Kepler* data set for isolated transits or aperiodic phenomena, one of us (TJ) undertook a detailed *visual* search of the complete Q1-Q17 *Kepler* light curve archive spanning 201250 target stars for Data Release 25

*Rappaport, Vanderberg, **Jacobs** et al. 2017 arxiv/1708.06069*

Vera C. Rubin Observatory

First light early 2025!

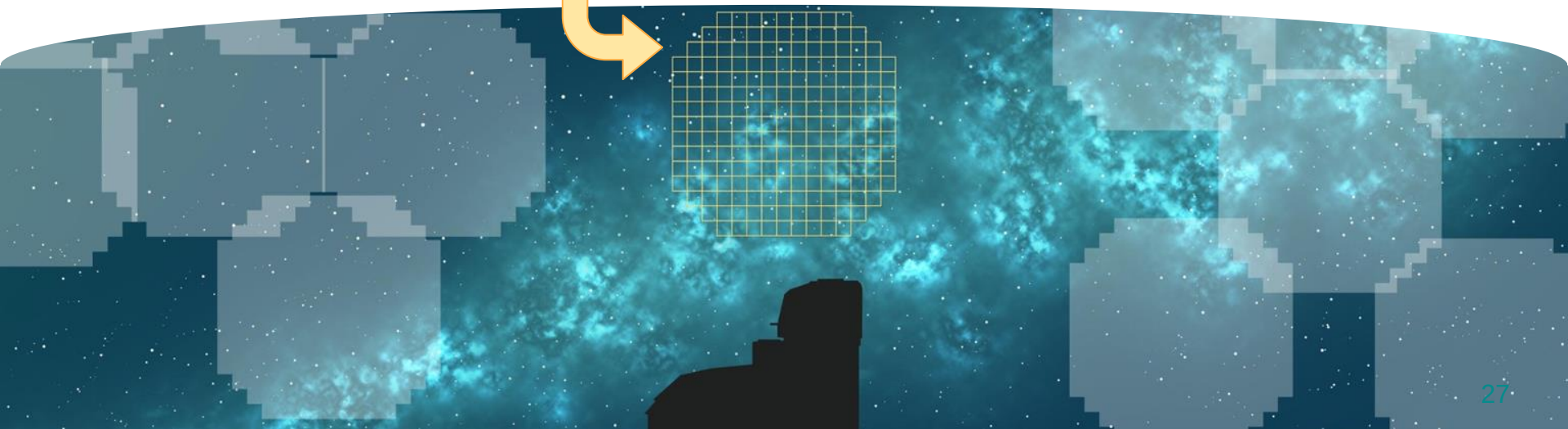
Hot off the press!!

Legacy Survey of Space and Time (LSST)

Survey the Southern sky every ~3 nights for 10 years

9.6 sq. deg. Field of view
Survey ~18 000 sq. deg.

Wide, fast, deep survey in 6 filters (*ugrizy*)

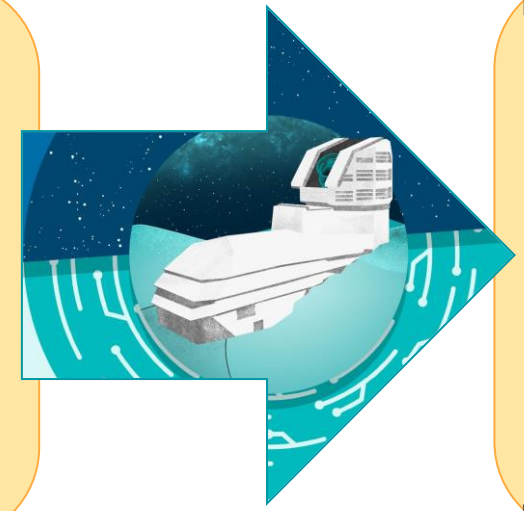


Research with the Rubin Observatory

Big data set! 20 TB data/night

Objects in the full LSST survey:

- 20 billion galaxies
- 17 billion resolved stars
- 6 million orbits of solar system bodies
- Alerts per night ~ 10 million



Key research areas:

- Probing dark energy and dark matter
- An inventory of the solar system
- Exploring the transient optical sky
- Mapping the Milky Way

… and much more!

Looking forward to Rubin

- Citizen Science with Rubin has been in mind since the early days…

Slides from AAS 222 Public Talk in 2013 given by Chris Lintott

Looking forward to Rubin

- Citizen Science with Rubin has been in mind since the early days…

*"EPO anticipates that the number of citizen science projects in the astronomy field will **increase dramatically** when LSST is operational, giving a whole new generation of citizen scientists **the opportunity to deepen their engagement with astronomy** using authentic data from LSST."* Ivezic et al. 2019

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- EPO Mission Statement:

*EPO provides **online data-driven experiences** that are accessible and approachable, adding real-world context and opportunities for people to **engage with Rubin Observatory and explore the Universe**.*

Rubin + Citizen Science from the start

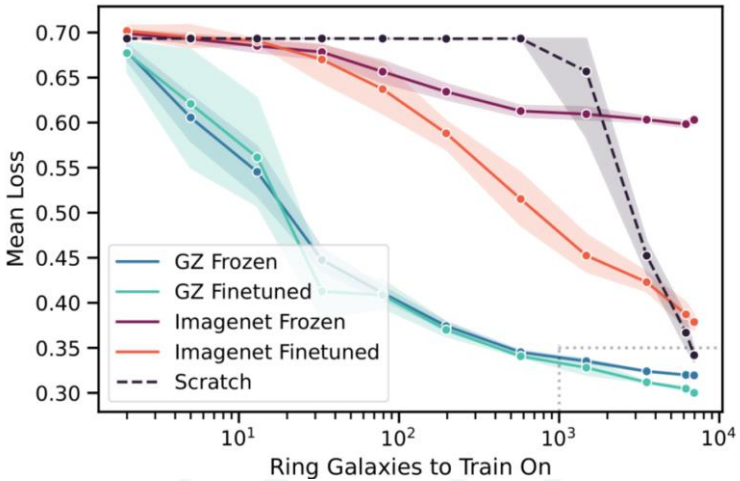
Why are Rubin and Citizen Science a great combination?

- Rubin is going to be:
  - the source of a huge amount of data
  - with a wide variety of science cases
  - with the intent to discover the unknown

What has changed since?

Machine learning

- Citizen Science and Machine learning are complementary, not exclusionary.
- For example, citizen science can:
  - Reduce training set size
  - Find interesting things



Walmsley et al. arXiv:2110.12735

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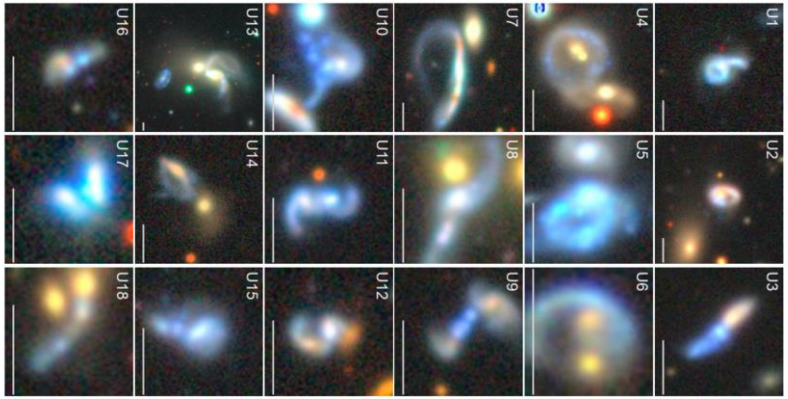

Etsebeth et al. 2024, arXiv: 2309.08660

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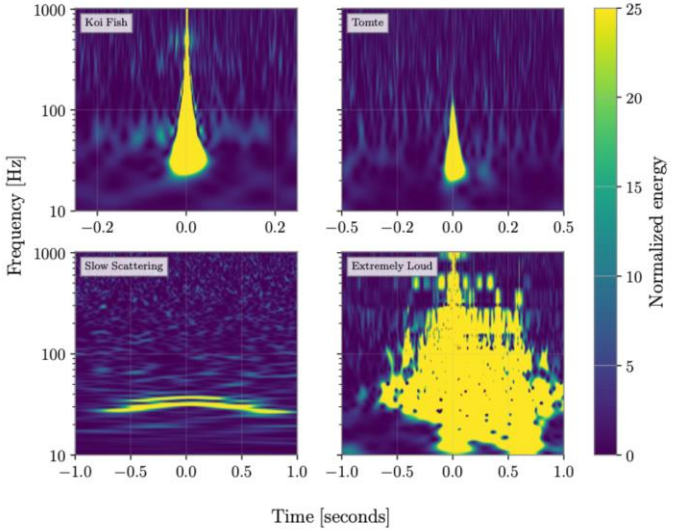
What are the next innovations?

“Levelling up” volunteers through challenging tasks

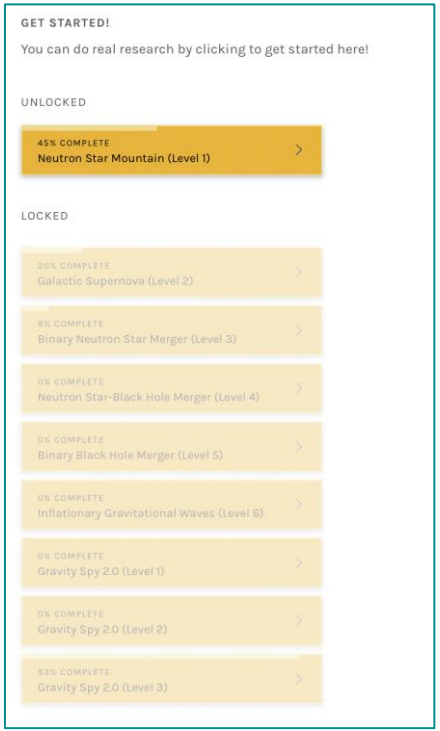
- Gravity Spy
  - Citizen-enabled glitch detection for LIGO/VIRGO



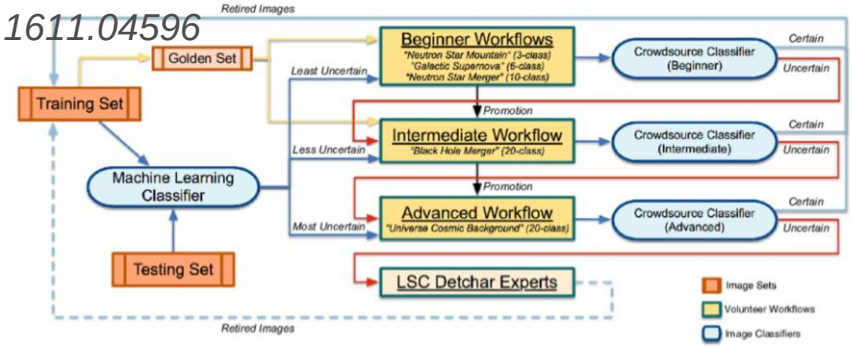
Coughlin et al. arXiv 1903.04058

Soni et al. arXiv 2103.12104

Gravity Spy - “levelling up”



*“Gravity Spy facilitates **a symbiotic relationship** between humans and computers, leveraging human pattern recognition skills as a tool for image recognition and machine learning as a tool for systematic analysis of large datasets” Zevin et al. 2017, arXiv: 1611.04596*

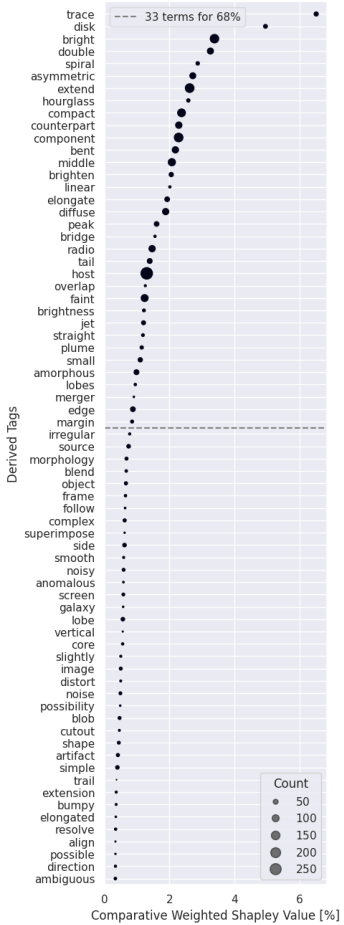


Volunteers can do hard tasks - and do them really well!

What are the next innovations?

Defining classes, groups and descriptors

- Radio Galaxy Zoo EMU
  - Radio Galaxy Morphology Taxonomy
  - *“The result is an extensible framework which is more flexible, more easily communicated, and more sensitive to rare feature combinations which are indescribable using the current framework of radio astronomy classifications.”* *Bowles et al. 2022 arxiv/2304.07171*



Who is Rubin Citizen Science for?

Why is Rubin supporting citizen science projects?

For our scientists
vital/unique tool for complex data

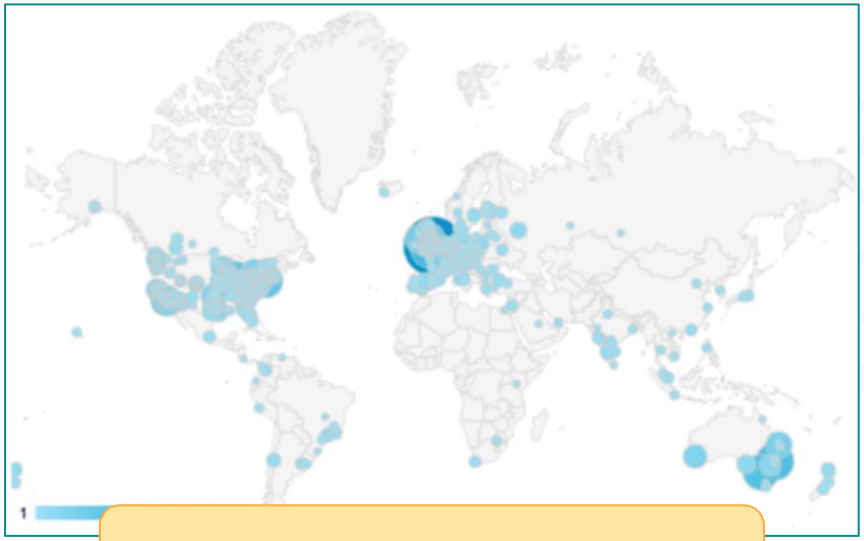
For educators and facilitators
support bringing Rubin science into communities

For the public
get up close with data and participate in research

A note on naming and impact

CitSci is far from perfect…

- Calling it “Citizen Science” is problematic
  - Exclusionary term, but no broadly understood alternative name
- Does not necessarily reach a broader group of participants
  - Takes effort to be a meaningful to the broader community



Current Zooniverse volunteers


That’s the WHY, let's get to the HOW…

How is Rubin supporting CitSci?

Our goal:

Facilitate easy and straightforward project development for project leads and highlight the amazing science from the Rubin Observatory

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Pipeline to connect data directly from Rubin Science Platform (RSP) to the Zooniverse

We provide documentation and support from the CitSci team (EPO & CST)

CitSci Software

- Notebooks crafted for data curation that allow you to programmatically send RSP data to your Zooniverse project

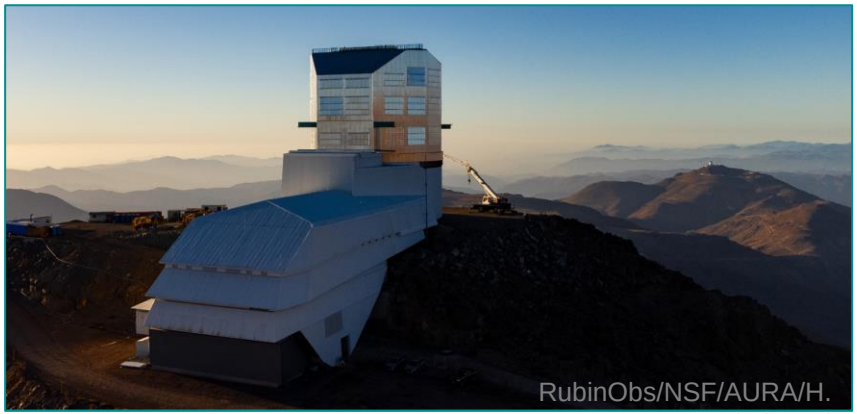
- Three tutorial examples:
  - A “basic” notebook
  - More complex example using a “flipbook”
  - An alert stream example

Want to see the details? Watch a recorded demo at **rubinobservatory.org** or email **cscience@lsst.org**

Citizen Science with Rubin

We are building tools and a community for the Rubin Observatory

We are ready to help **YOU** make projects happen!


RubinObs/NSF/AURA/H. Stockebrand

Why are we doing this:

- Supporting our scientists
  - reducing the effort in starting and maintaining project
- Reaching a broader audience
  - Leveraging EPO's mission/priorities
- Data volume "challenges"
  - Maintaining public interest and momentum
  - Reducing resources for project leads

Citizen Science with Rubin

What we provide:

- Ease of use with our pipeline
- Support from our team
- Communications and engagement strategies

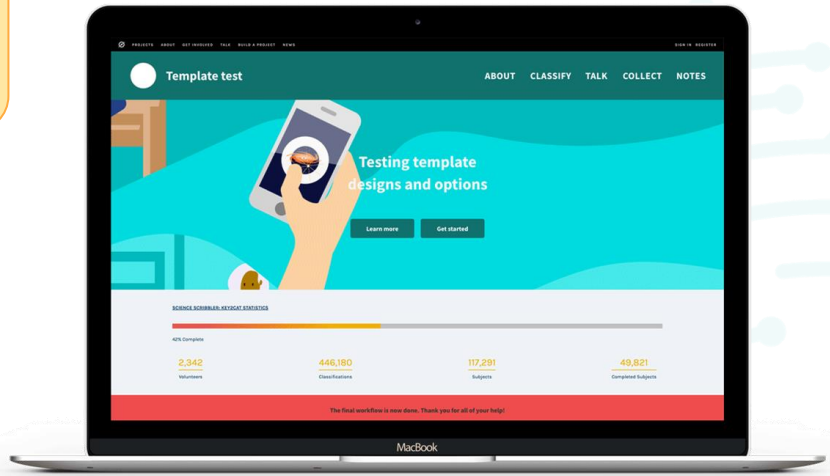
What we encourage:

- Engaged project leads keen to share Rubin with the public
- Coordination and collaboration
- Equity, inclusivity, diversity and accessibility initiatives

/VRubinObs
/rubin_observatory
/company/rubinobservatory
/VRubinObs
/RubinObservatory

Creating a “Rubin family” of projects

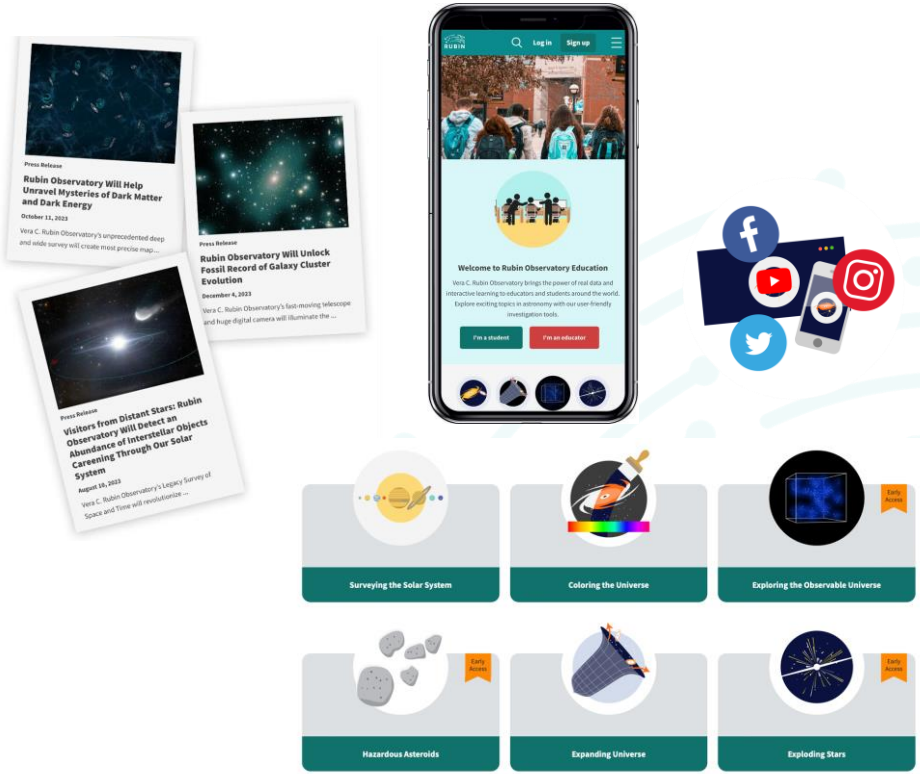
We hope to inspire a community of dedicated Rubin volunteers participating in an exceptional collection of projects



- A Zooniverse + Rubin template
- Connection to other materials
- Translation support

Connections to other EPO initiatives

- Social media and web presence
  - Leveraging our communications strategy
  - Mobile - first, accessible and welcoming
- Preparing the public for Rubin
  - Science Releases
  - Short explainer videos
  - Citizen Science talk series
- Connecting to our formal education program
  - Bringing citizen science into the classroom
  - Extensive teacher support



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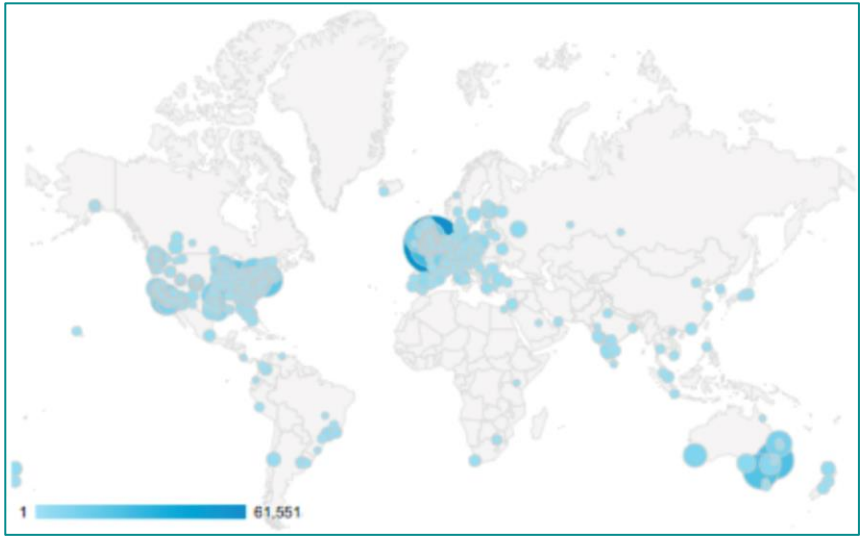


Current Zooniverse volunteers

Formal Education program educators in workshops

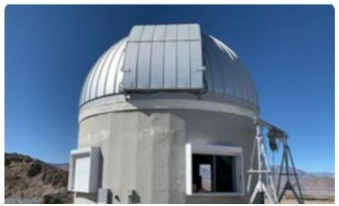
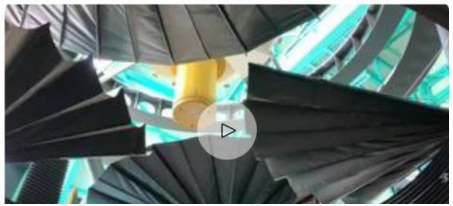
An Aside…

- Gallery
  - http://rubinobservatory.org/gallery
- Coming in 2024
  - media resource kit with key messages; fact sheets; descriptions of novel tech, engineering, and science goals; and links to images, graphics, and videos to use in your own products
- In the future
  - Interactive data and image visualization, summit status dashboard

…and much more!





What to do now as a future project lead?

- Planning and preparation
  - More information coming soon on our website
- Interest form
  - If you want to be kept “in the loop”!
- Reach out - we’d love to hear from you!
  - Developing this pipeline further and we appreciate your input

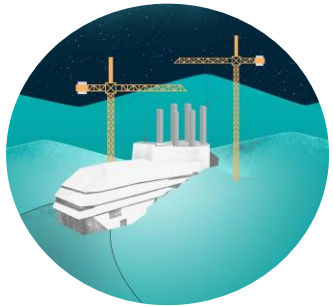
rubinobservatory.org/for-scientists/citizen-science

ls.st/citsciform

cscience@lsst.org

What to do now as a future volunteer?

- Stay tuned for our upcoming series of talks!
  - Advertised on social media, our website or contact cscience@lsst.org to be notified
- Keep in touch!
  - Social media
- Get involved in current projects
  - Check out projects linked on our website



rubinobservatory.org/explore/citizen-science

cscience@lsst.org

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/VRubinObs
/RubinObservatory

What to do now as a future “hype person”?

- Do you see a place for these projects in your classroom, lecture hall, or community?
  - Check out education investigations and other EPO resources
- Is there something we can provide to support you?
  - Let us know!

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RUBIN
Citizen science is a mutually beneficial space to find all kinds of gems!
And many gems have been found (e.g. green peas, PH 1b)
Machine learning and citizen science are a fantastic combination.
Volunteers can do hard tasks very well
Rubin CitSci team is preparing to support our community and their inspiring projects.
We are ready to help YOU lead amazing projects!
Rubin Observatory/NSF/AURA

Thank you!

- Email: **cscience@lsst.org** or **clare.higgs@noirlab.edu**
- Website: **rubinobservatory.org/for-scientists/citizen-science**
- Interest form: **https://ls.st/citsciform**

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