



# Citizen Science with Hubble Space Telescope Data

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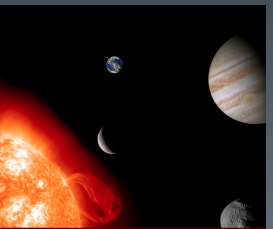
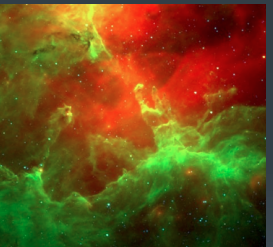
# Citizen *Science*

- Volunteers perform tasks that contribute to research
- Research problems require large numbers of individuals to apply cognitive skills
- Studies cannot be performed through algorithms

## Outcomes

- Refereed research papers
- Machine learning
- Creation of interested community
- Potential for education applications

What  
is it?



# Galaxy Zoo Hubble / Galaxy Zoo 4



- Classifications like Galaxy Zoo - more distant galaxies
- Multi-treasury programs from HST
- Identify bar features and other morphologies
- Bar feature correlated with mass and star formation,, declines with  $z$
- Examine morphology across time

**Is the galaxy simply smooth and rounded, with no sign of a disk?**



Smooth



Features or disk



Star or artifact



# Estimating the Ages of Star Clusters in M83: The Southern Pinwheel Galaxy

About ...

Discuss

The data collecting phase of *Star Date: M83* is officially over. You can continue to use the interface, but the data will not be used for the papers we are currently working on. **Thanks to all our users!**

## STAR DATE: M83

### Uncovering the ages of star clusters in the Southern Pinwheel Galaxy

Most of the billions of stars that reside in galaxies start their lives grouped together into clusters. In this activity, you will pair your discerning eye with Hubble's detailed images to identify the ages of M83's many star clusters. This info helps us learn how star clusters are born, evolve and eventually fall apart in spiral galaxies.

Start Here



# Age Sequence of Identified Clusters

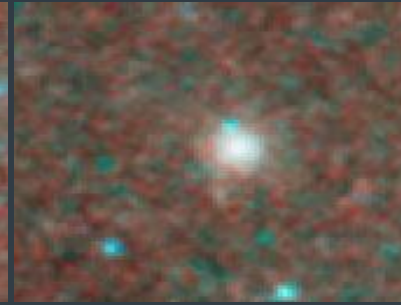
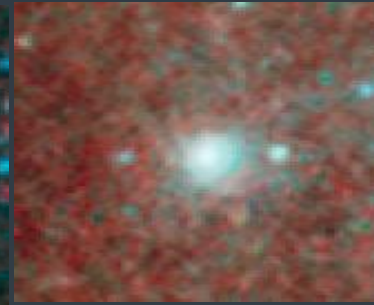
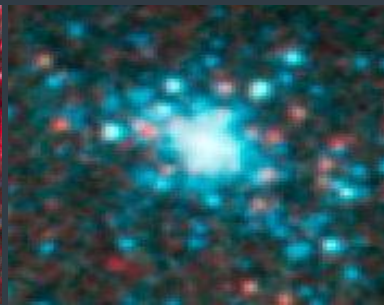
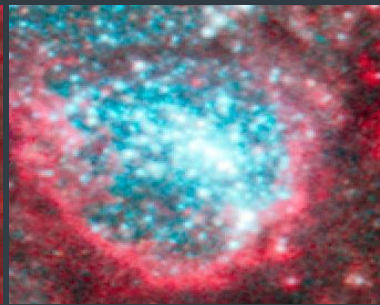
Category 1  
Very Young

Category 2  
Young

Category 3  
Intermediate

Category 4  
Old

Category 5  
Ancient



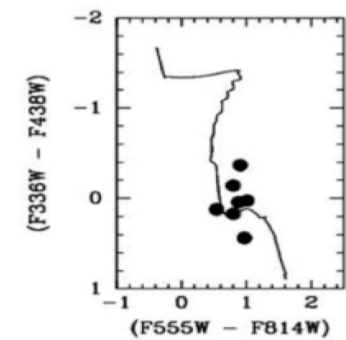
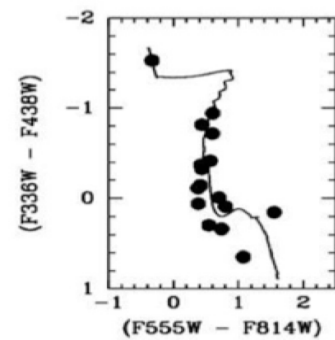
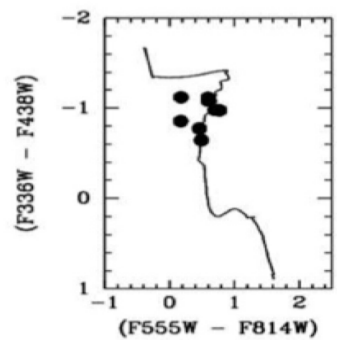
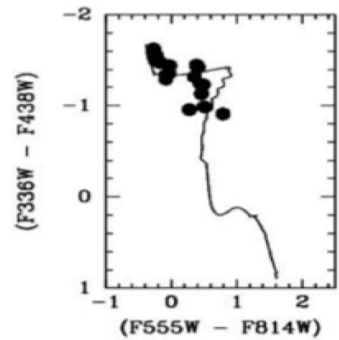
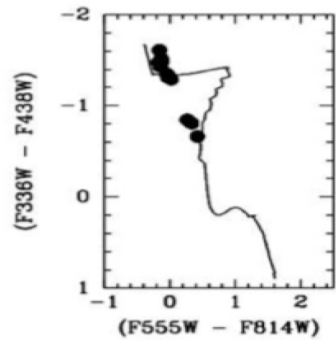
Pink  
surroundings

Bubble

Stars / no  
bubble

Fuzzy blob

Fuzzy, slightly  
reddish






**Pink Clouds?**  
The youngest clusters have pink clouds around them. In this example, there is no pink cloud around the cluster.

Click "No Cloud."


Is there a pinkish cloud roughly centered around the star cluster in the middle of the image?

Examples

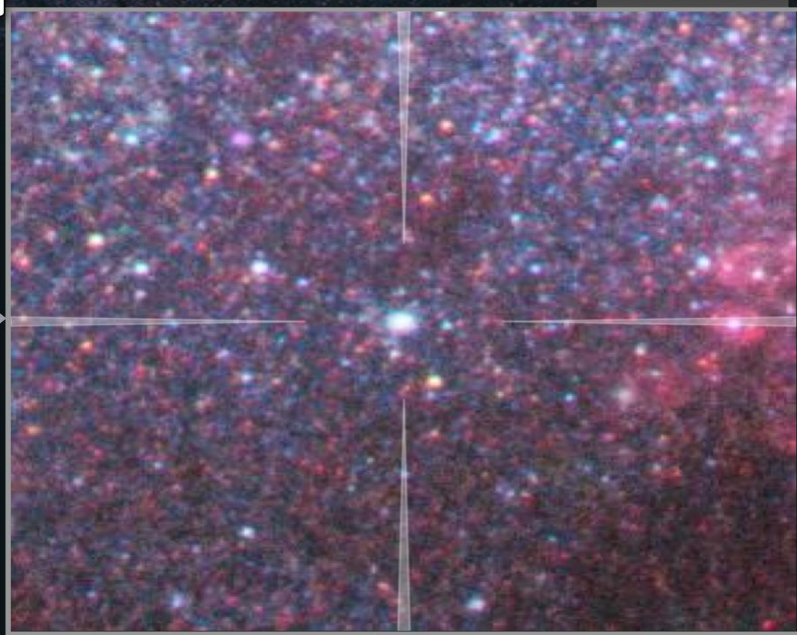
**Cloud**



**No Cloud**



Restart Tutorial



Where am I?

Take the Fast Track...

Estimated age:

Very Young

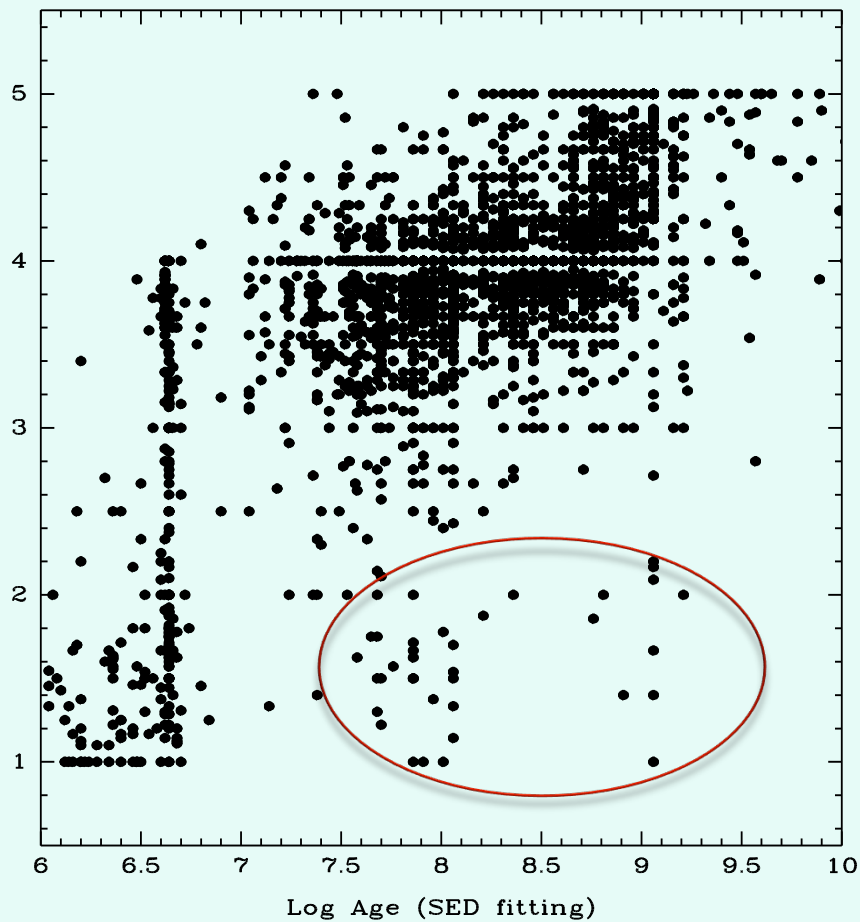
Young

Intermediate

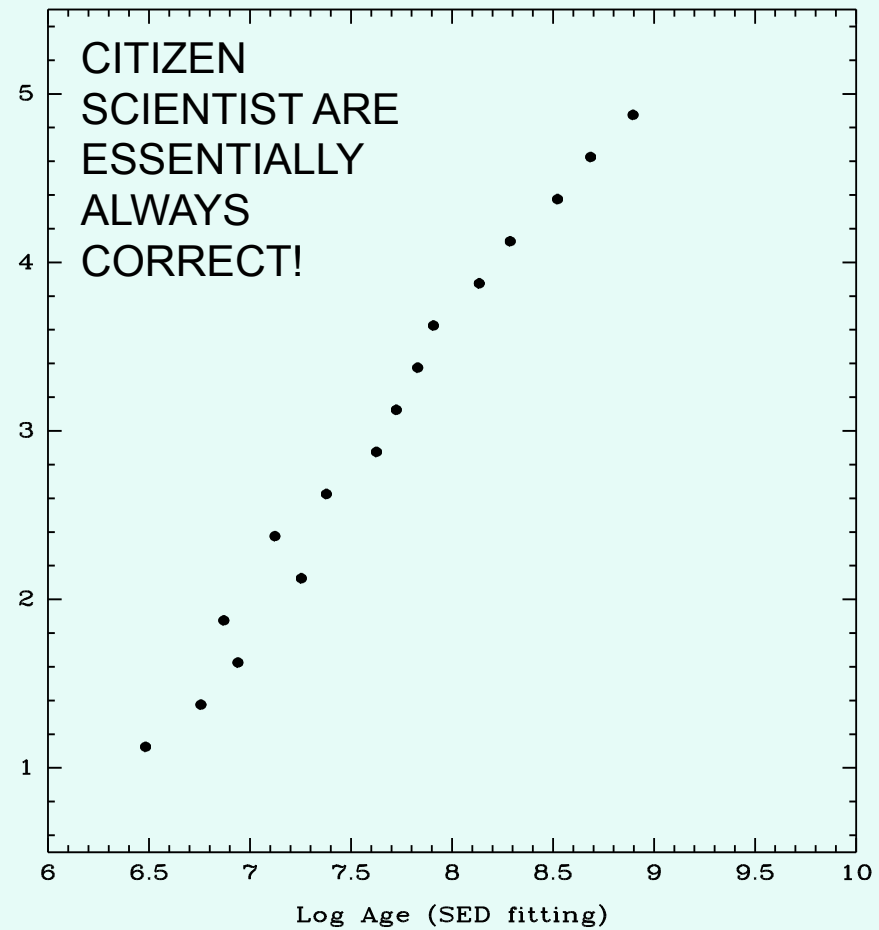
Old

Ancient

Citizen Science Age Category



Citizen Science Age Category



Left: citizen scientist cluster age estimates (each point represents 20 measurements for a specific cluster) versus age estimate using normal SED algorithms.

Right: averages binned by "Age Category" indicating citizen scientist cluster age estimates are generally quite good.



Automatically generated metrics for project team

Participants: 1,194

Clusters evaluated: 2610

Classifications: 52,258



# M31 (Andromeda)

Dalcanton, et al 2012, *ApJ*, **200**, 18.

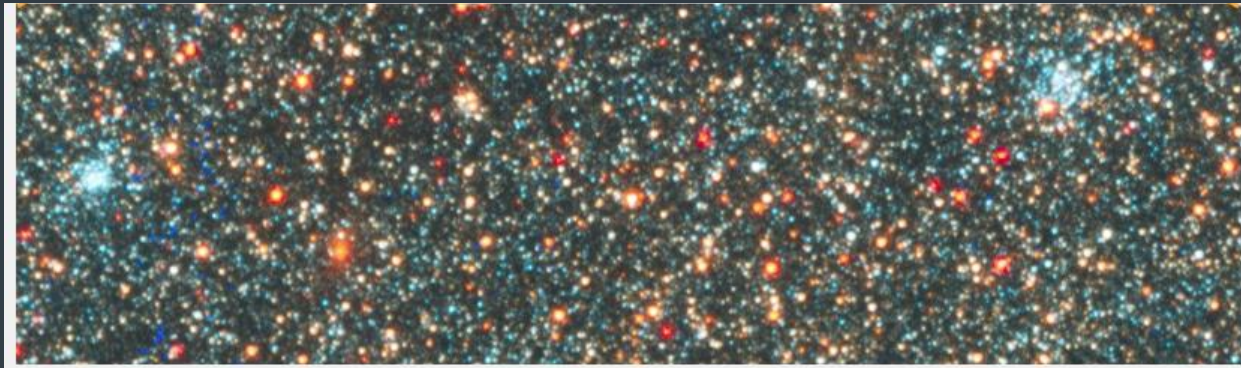
## Panchromatic Hubble Andromeda Treasury (PHAT)



- M31 is nearest large galaxy – companion to our own Milky Way
- Survey used mosaic of HST data obtained over several years
- Covered 1/3 of M31 in 828 orbits using 6 filters (~40,000 exposures)

## Find the Clusters!

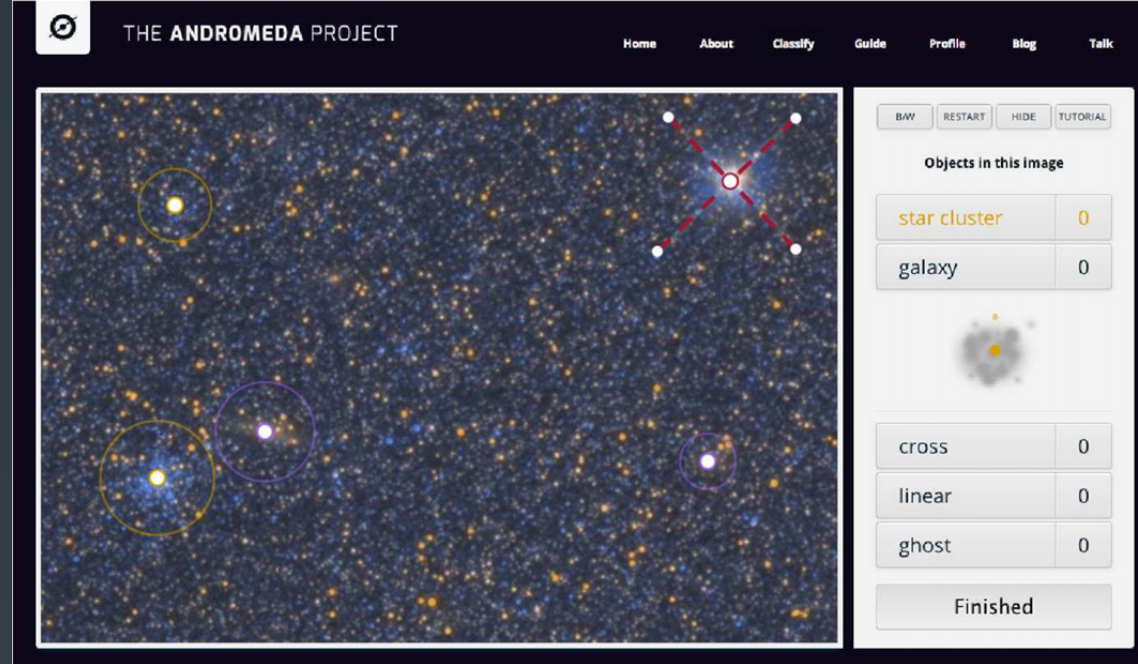
- 8 science team members
- One month searching the first ~20% of the survey's imaging
- Found ~600 likely star clusters
- 4x number previously known in same region



## Citizen volunteers

- Examine images
- Classify objects as clusters (and other)
- Two Rounds of searching in 2012 + 2013
- Volunteers examine ~20,000 images
- ~10,000 unique visitors

- More than 100,000 image classifications first day
- Overall classification rate >one per second!
- >2 million classifications
- >80 individual classifications / image cutout



Courtesy IOP and Zooniverse

At least 3000 clusters found by volunteers  
Clusters cover 4 decades of mass  
50% complete to  $\sim 500 M$   
Initial mass function determined  
Many other ancillary objects found in data also

L. C. Johnson, et al, 2015 ApJ 802, 127 and references therein



RECENT OBJECTS

6yxm1ce

1 collection  
0 mentions



6gzykbl

0 collections  
0 mentions



6i0xcpj

0 collections  
0 mentions



6o8ca3x

1 collection  
0 mentions



Page 1 of 8,258



RECENT COLLECTIONS

S0000g3

1 object

BUTTERFLY CLOUDS



S0000g2

2 objects

NEBULAS



S0000g1

3 objects

STUNNING!



S0000fz

2 objects

THE RABBIT HOLE



Page 1 of 148



FEATURED

chat

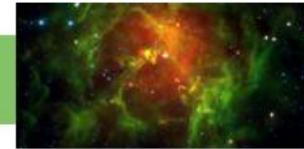
Hi everyone

help

Bugs / Annoyances



Chicken and a Turkey



CMWS00008n - Cool Shapes



RECENT DISCUSSIONS

Updated: In the last day

# CiSci Research Projects:



- Galaxy Zoo Hubble [done, HST data, part of Zooniverse, Galaxy Zoo 2]
- Galaxy Zoo 4 [done, CANDELS HST data, part of Zooniverse]
- Andromeda Project [done 2 rounds, PHAT HST data, part of Zooniverse]
- M83 [done, HST data]
- PlanetHunters [running, external (Yale), Kepler data from MAST, Zooniverse]
- Light Echoes [concept, HST data]
- Star Clusters in other nearby galaxies [concept, HST data]
- Planet Investigators [concept, HST data – comb the archive]
- PanSTARRS [concept, future, PanSTARRS data in MAST]
- Galex Transients [concept, Galex]



# Outcomes, Publications

- Galaxy Zoo (SDSS) - 33 publications

- The Galaxy Zoo survey for giant AGN-ionized clouds: past and present black hole accretion events 2012 W Keel *etal* MNRAS **420** 878
- Galaxy Zoo: reproducing galaxy morphologies via machine learning 2010 M Banerji *etal* MNRAS **408** 342

- Kepler - 5 publications

- Planet Hunters: A Transiting Circumbinary Planet in a Quadruple Star System 2012 M. Schwamb *etal* eprint arXiv:1210.3612
- Planet Hunters: Assessing the Kepler Inventory of Short-period Planets 2012 M Schwamb *etal* ApJ **754** 129S

- Moon Zoo – 11 publications

- Moon Zoo: First Science Results 2010 C. Lintott European Planetary Science Congress

- Andromeda Project > 4 publications

- Delcanton, Johnson and team

→ Challenge is to motivate science teams to consider Citizen Scientist tasks as a critical aspect of data processing pipelines.  
*Worth the investment!*

# Context: HST Public Engagement

**HUBBLESITE**  
Out of the ordinary  
...out of this world

**Get Involved**

*Get Involved!*  
Volunteer • Participate • Interact

**VOLUNTEER YOUR TIME. PARTICIPATE IN CONTESTS.  
INTERACT WITH THE ASTRONOMICAL COMMUNITY.**

Love our celestial images and the science behind em? Get involved! Explore these opportunities to collaborate with experts, contribute your time and talents, or just have fun.

Have a new project idea? [Share it with us.](#)

**Hubble Hangouts**  
Live talks each month! Present your questions or comments, or just watch.

**Citizen Science**  
Join forces with professional astronomers to make new discoveries and better understand our universe. Through the projects

**Hubble Image Processors**  
If you are a photography and/or science enthusiast, try uncovering your own gems in the Hubble archive! Here you'll find guides.