Citizen Science with Hubble Space Telescope Data

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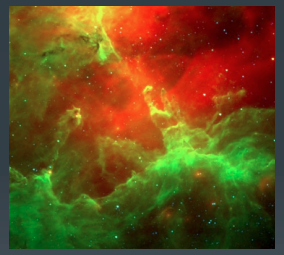
C. Christian 2015, Computing in Sci & Eng, **17**, 12.

GALAXY ZOO



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

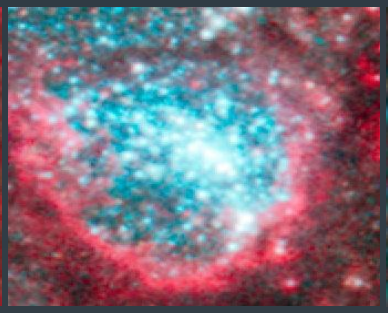
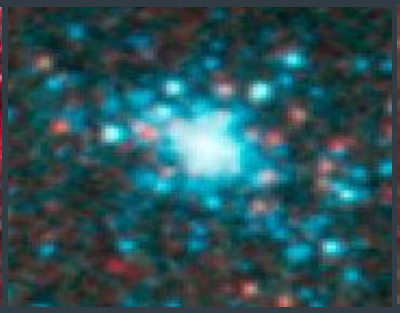
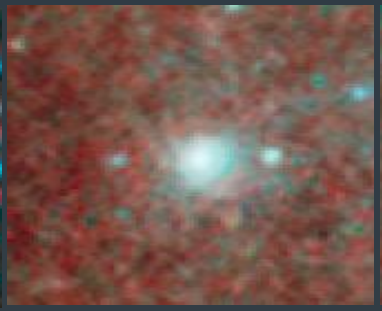
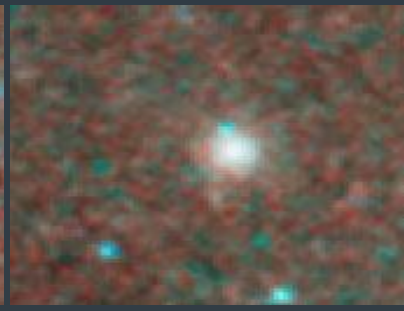
Is the galaxy simply smooth and rounded, with no sign of a disk?

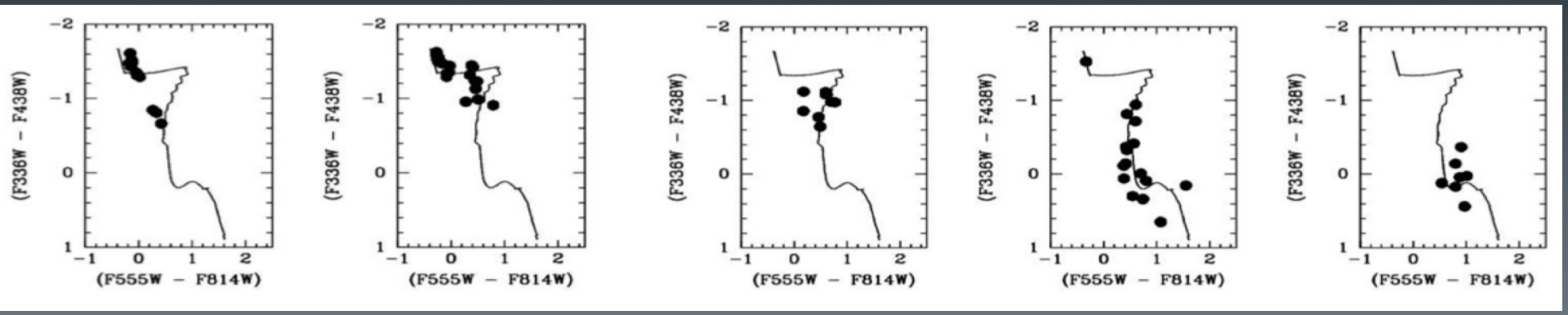
Smooth | Features or disk | Star or artifact

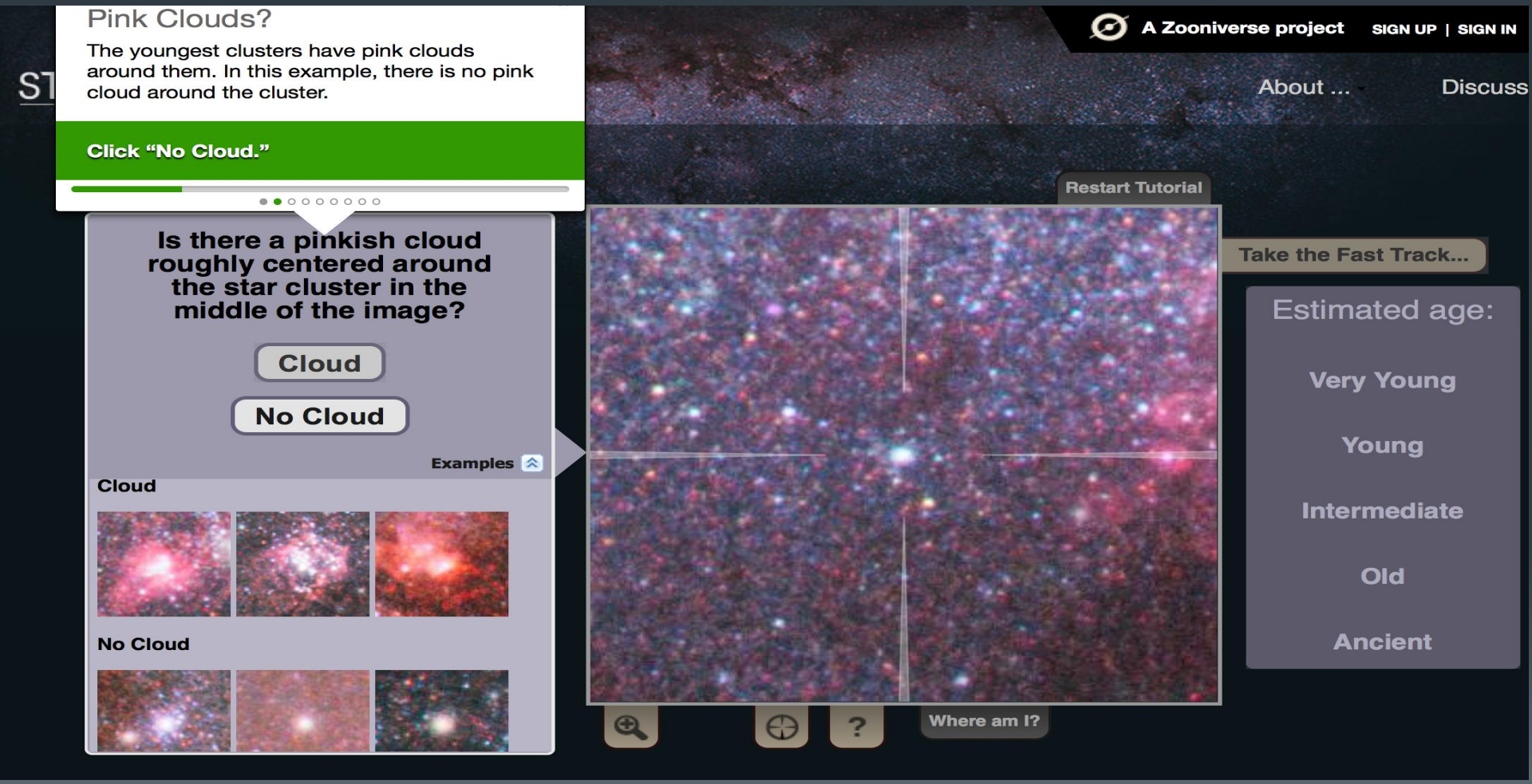
Estimating the Ages of Star Clusters in M83: The Southern Pinwheel Galaxy

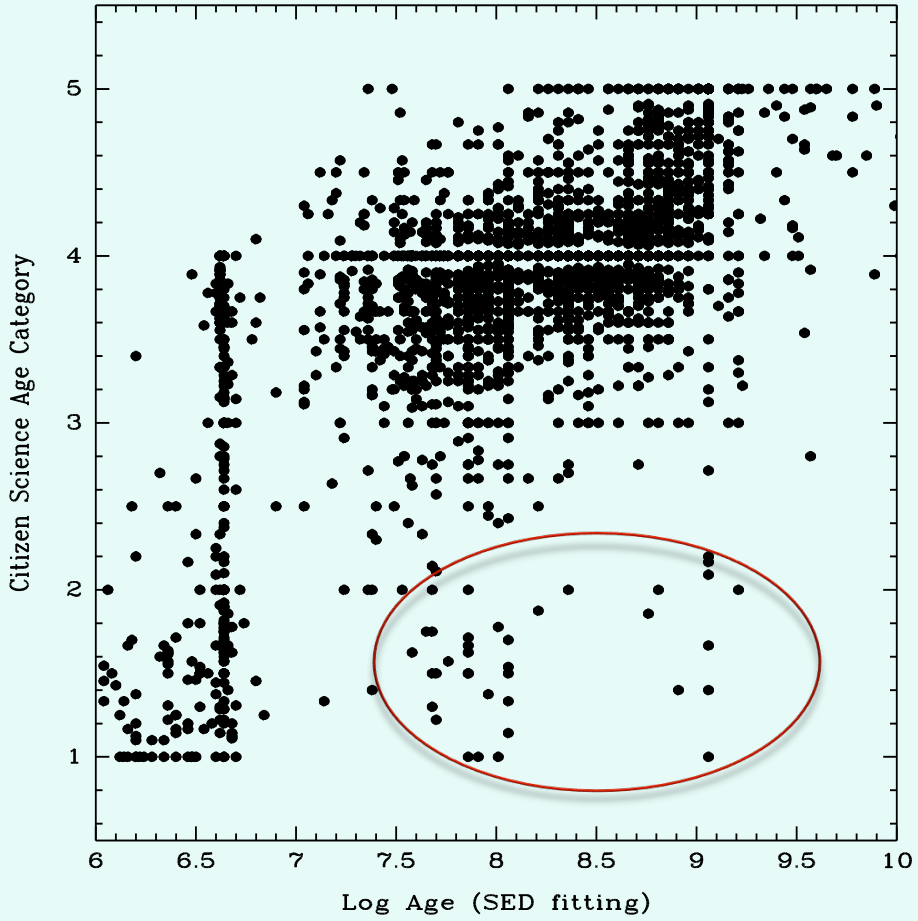
www.projectstardate.org

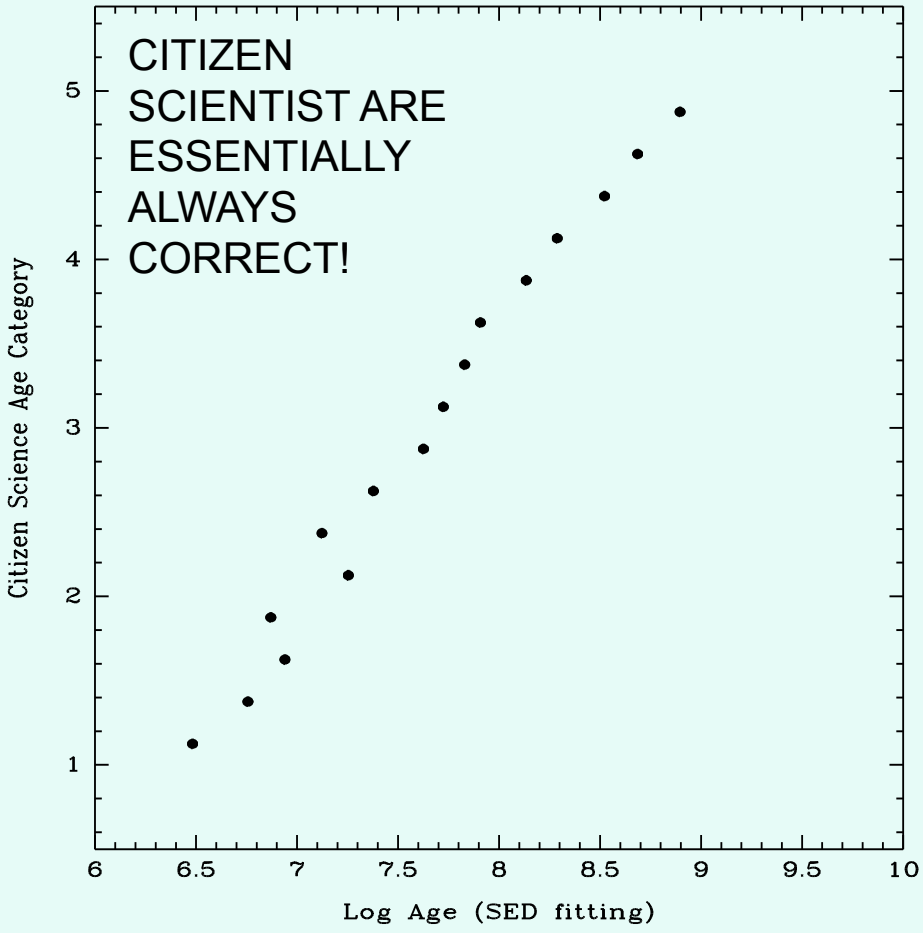
Age Sequence of Identified Clusters

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.”
A Zooniverse project
SIGN UP | SIGN IN
About ...
Discuss
Restart Tutorial
Take the Fast Track...
Is there a pinkish cloud roughly centered around the star cluster in the middle of the image?
Cloud
No Cloud
Examples
Cloud
No Cloud
Estimated age:
Very Young
Young
Intermediate
Old
Ancient
Where am I?





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

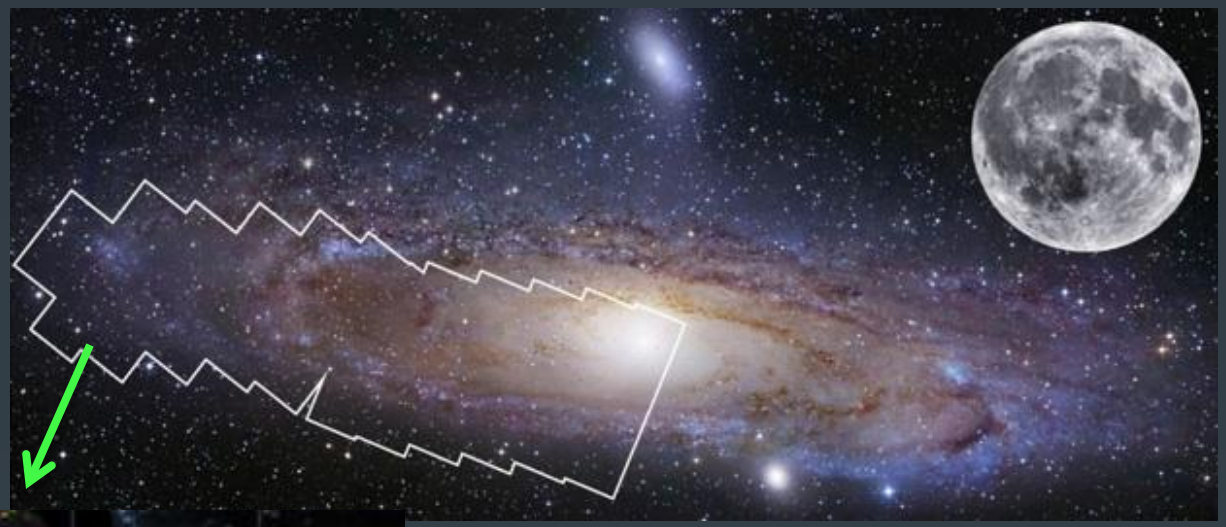
Clusters evaluated: 2610

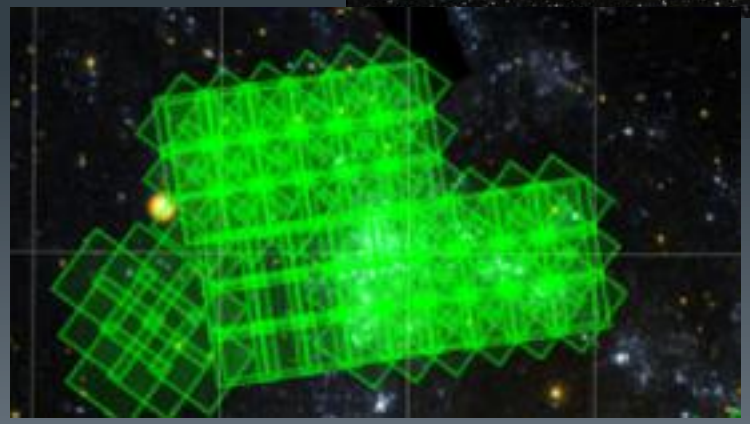
Classifications: 52,258

M31 (Andromeda)

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

Panchromatic Hubble Andromeda Treasury (PHAT)

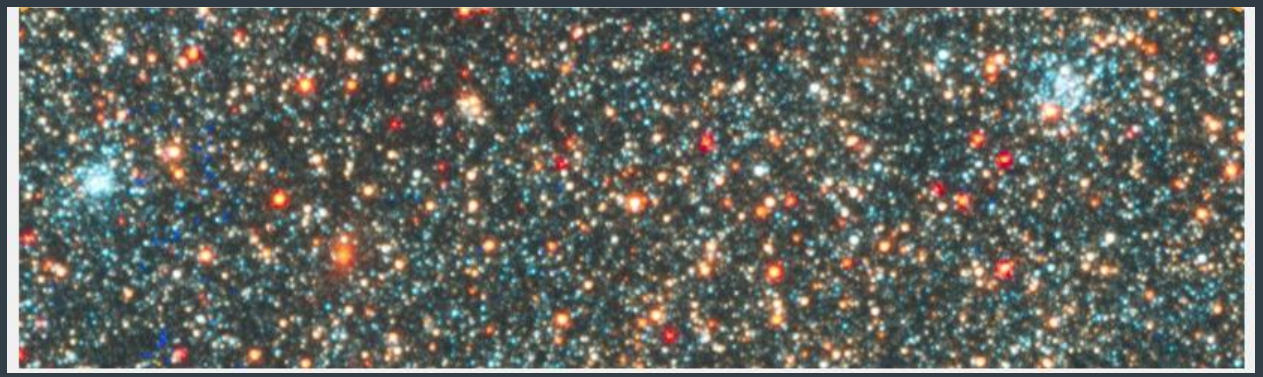




- M31 is nearest large galaxy – companion to our own Milky Way
- Survey used mosaic of HST data obtained over several years
- Covered 1/3 of M31 in 828 orbits using 6 filters (~40,000 exposures)

Find the Clusters!

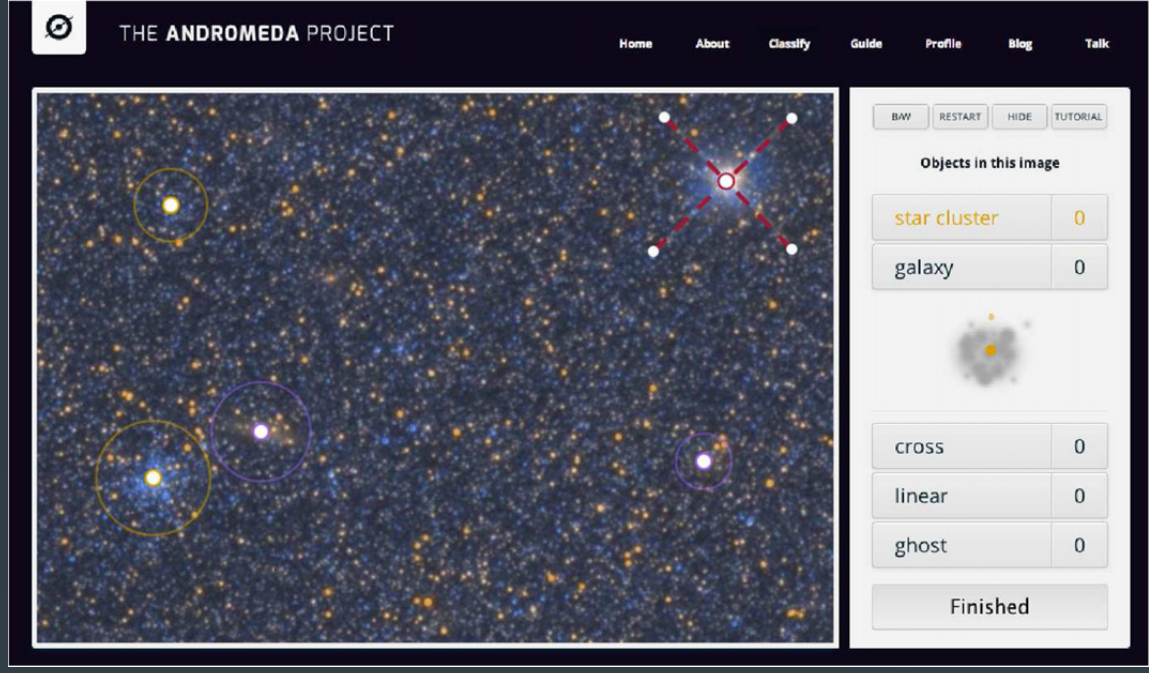
- 8 science team members
- One month searching the first ~20% of the survey's imaging
- Found ~600 likely star clusters
- 4x number previously known in same region



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

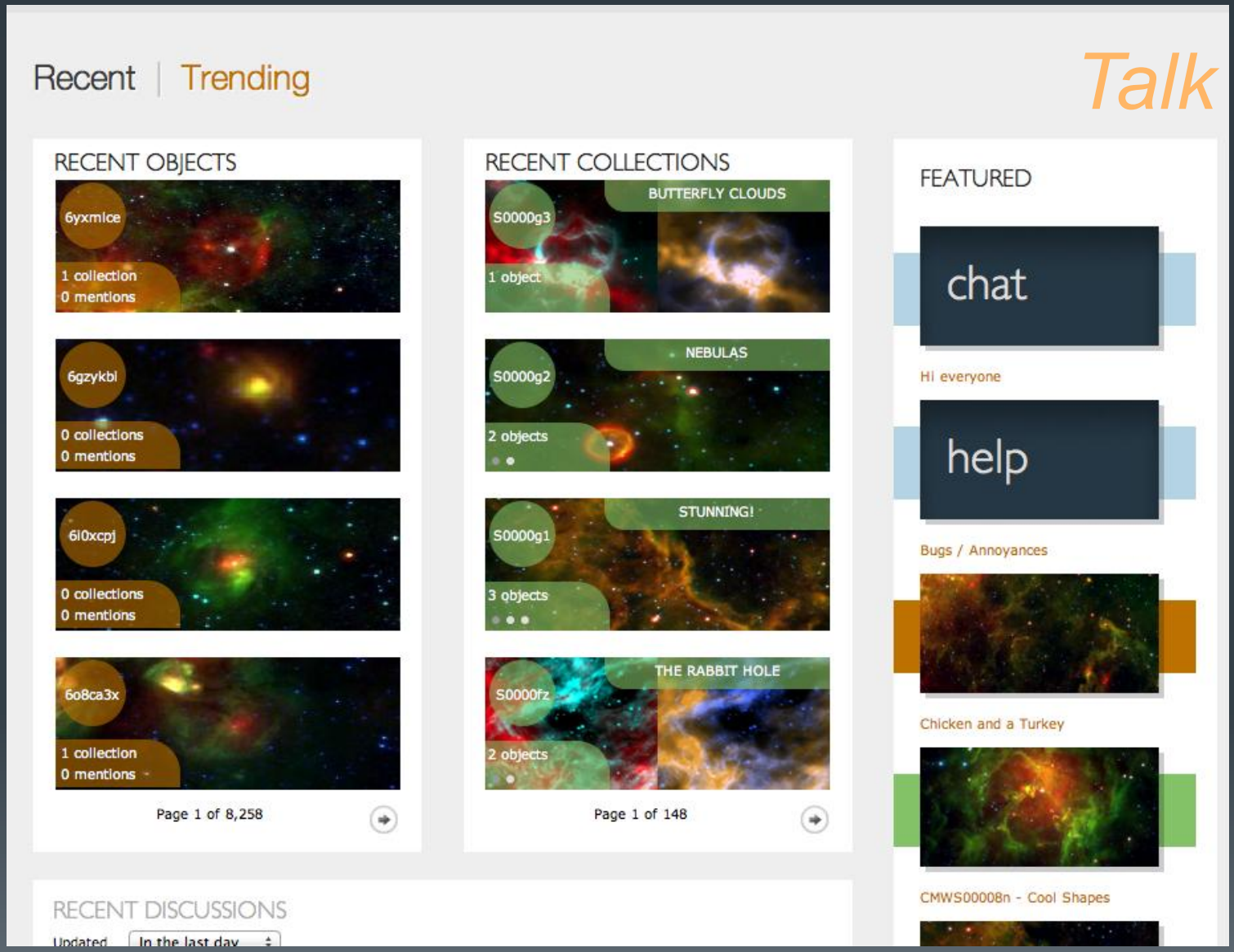
50% complete to ~500 M

Initial mass function determined

Many other ancillary objects found in data also

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

Talk


Recent | Trending
RECENT OBJECTS
6yxmlce
1 collection
0 mentions
6gzykbl
0 collections
0 mentions
6l0xcpj
0 collections
0 mentions
6o8ca3x
1 collection
0 mentions
Page 1 of 8,258
RECENT COLLECTIONS
BUTTERFLY CLOUDS
S0000g3
1 object
NEBULAS
S0000g2
2 objects
STUNNING!
S0000g1
3 objects
THE RABBIT HOLE
S0000fz
2 objects
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]
- PlanetHhunters [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