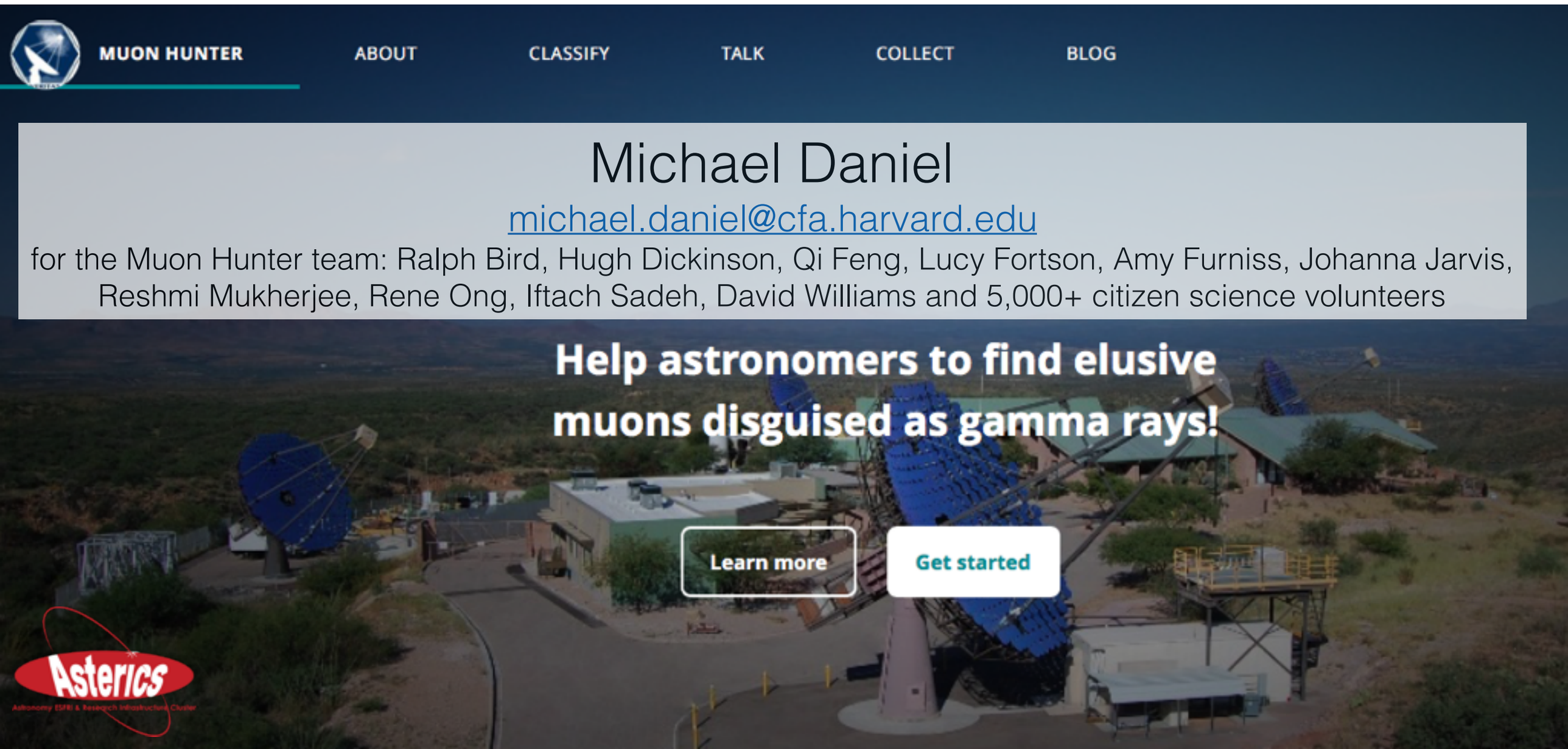
Muon Hunter:
A Zooniverse Project



Michael Daniel
michael.daniel@cfa.harvard.edu
for the Muon Hunter team: Ralph Bird, Hugh Dickinson, Qi Feng, Lucy Fortson, Amy Furniss, Johanna Jarvis, Reshmi Mukherjee, Rene Ong, Iftach Sadeh, David Williams and 5,000+ citizen science volunteers

ALL DISCIPLINES

ARTS

BIOLOGY

CLIMATE

HISTORY

LANGUAGE

What is the Zooniverse?

The world's largest and most powerful platform for people-powered research

At the Zooniverse, anyone can be a researcher

You don't need any specialised background, training, or expertise to participate.

Volunteers and professionals make real discoveries together

Zooniverse projects are constructed with the aim of converting volunteers' efforts into measurable results. They have produced a large number of published research papers, open source data sets and even scientifically significant discoveries.

http://www.zooniverse.org/about

Ten years since Galaxy Zoo launched, now 100+ projects

VERITAS

LITERATURE

MEDICINE

NATURE

PHYSICS

SOCIAL SCIENCE

SPACE

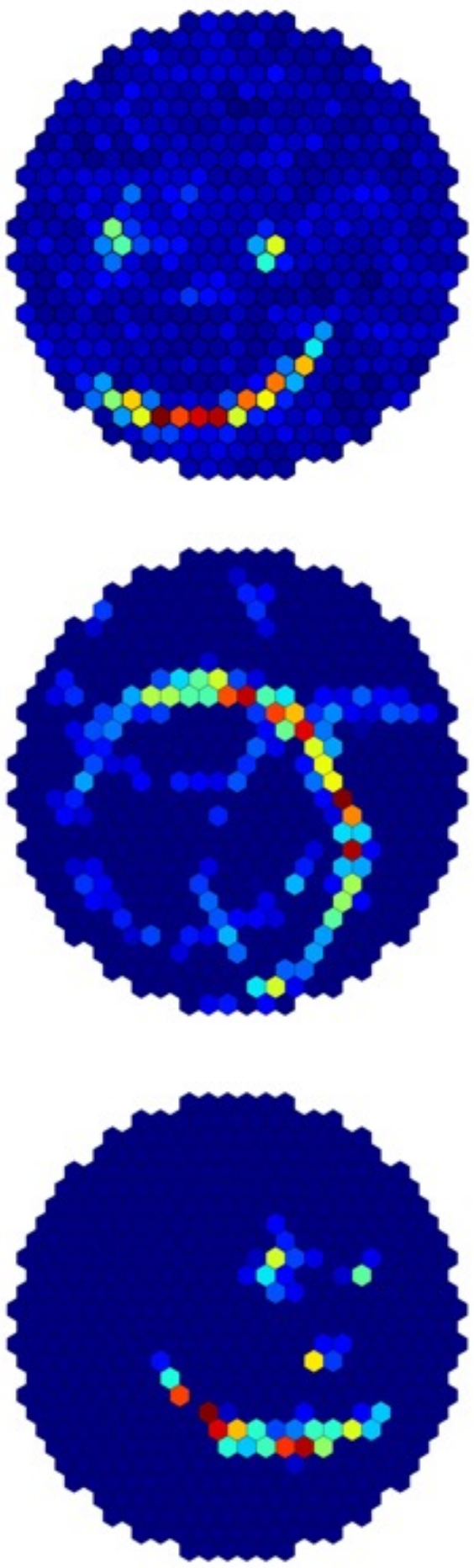
http://muonhunters.org/

Citizen Science Muon Ring Finder

Goal: Train machines to classify events and identify muon images for

- background rejection
- calibration events

Instead of solely using simulations or hard coded search algorithms we explore the power of people to get a good clean set of muon ring images for the training.



Start: a random VERITAS image

Can you see a muon ring in this image?

No

Done: not a muon

Yes

Draw a circle that is your best guess at a muon ring

Additional questions about the ring:

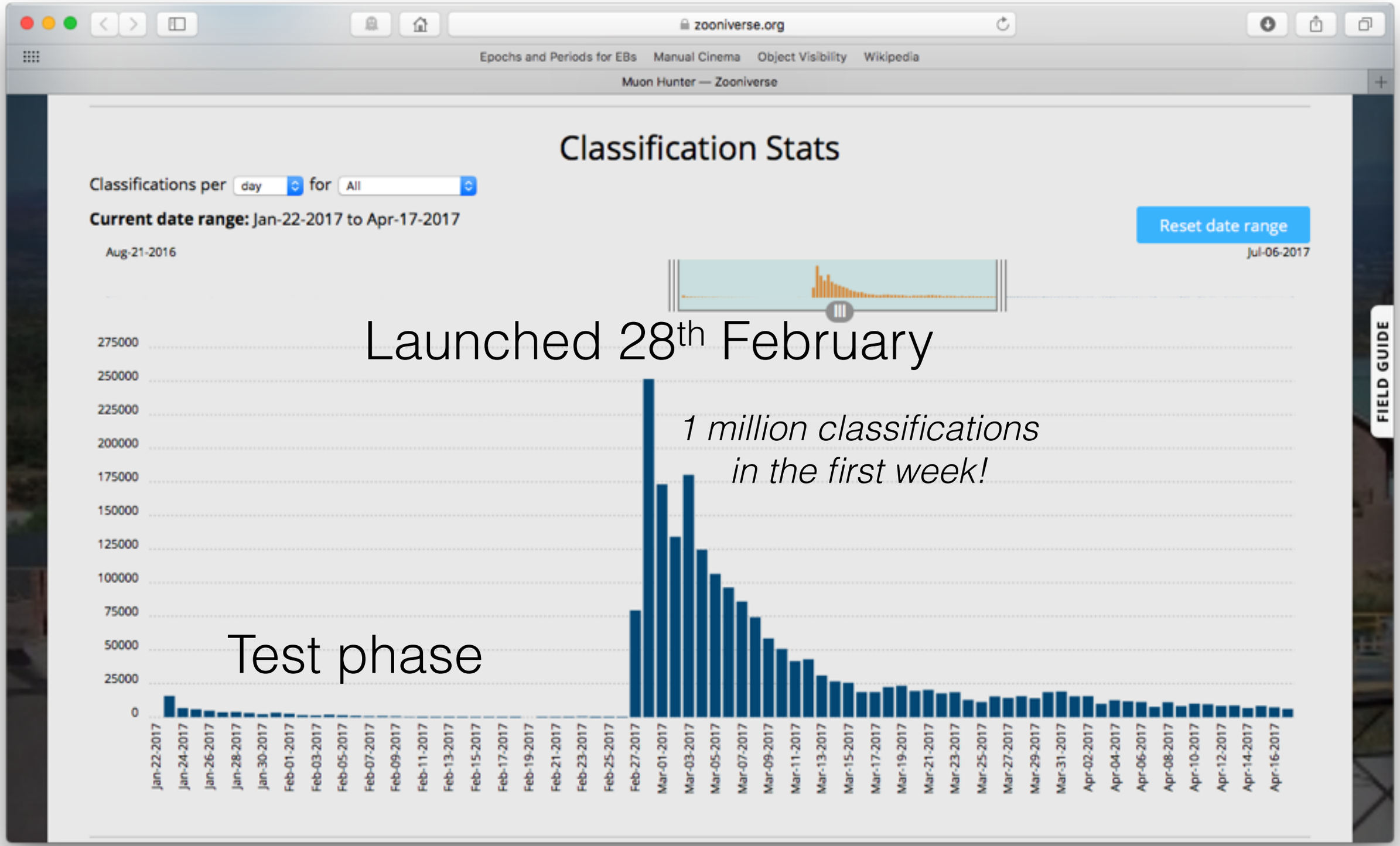
- ➡ Is the ring you drew completely in the camera?
- ➡ Is the ring complete?
- ➡ Is the part of the ring in the camera complete?

Done: a muon

Examples & instructions are provided at the beginning

Field Guide

Retire an image when classified 15 times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Epochs and Periods for EBs
Manual Cinema
Object Visibility
Wikipedia
Muon Hunter — Zooniverse
Classification Stats
Classifications per day for All
Current date range: Jan-22-2017 to Apr-17-2017
Reset date range
Aug-21-2016
Jul-06-2017
Launched 28th February
1 million classifications
in the first week!
Test phase
FIELD GUIDE

CBS NEWS NEWS SHOWS VIDEO MORE

CBS/AP / *February 28, 2017, 5:30 PM*

Amazon Web Services outage causes widespread internet problems

5 Comments / Share / Tweet / Stumble / Email

Last Updated Feb 28, 2017 6:03 PM EST

NEW YORK -- Amazon's cloud-computing service, Amazon Web Services, experienced an outage in its eastern U.S. region Tuesday afternoon, causing unprecedented and widespread problems for thousands of websites and apps.

Amazon is the largest provider of cloud computing services in the U.S. Beginning around midday Tuesday on the East Coast, one region of its "S3" service based in Virginia began to experience what Amazon, on its service site, called "increased error rates."

In a statement, Amazon said as of 4 p.m. E.T. it was still experiencing "high error rates" that were "impacting various AWS services."

"We are working hard at repairing S3, believe we understand root cause, and are working on implementing what we believe will remediate the issue," the company said.

But less than an hour later, an update offered good news: "As of 1:49 PM PST, we

Some affected websites had fun with the crash, treating it like a snow day:

Adobe Customer Care @AdobeCare Follow

Hi all, some Adobe services are down due to the AWS outage: bit.ly/2ll864T Here's a puppy stampede to take your mind off of it.

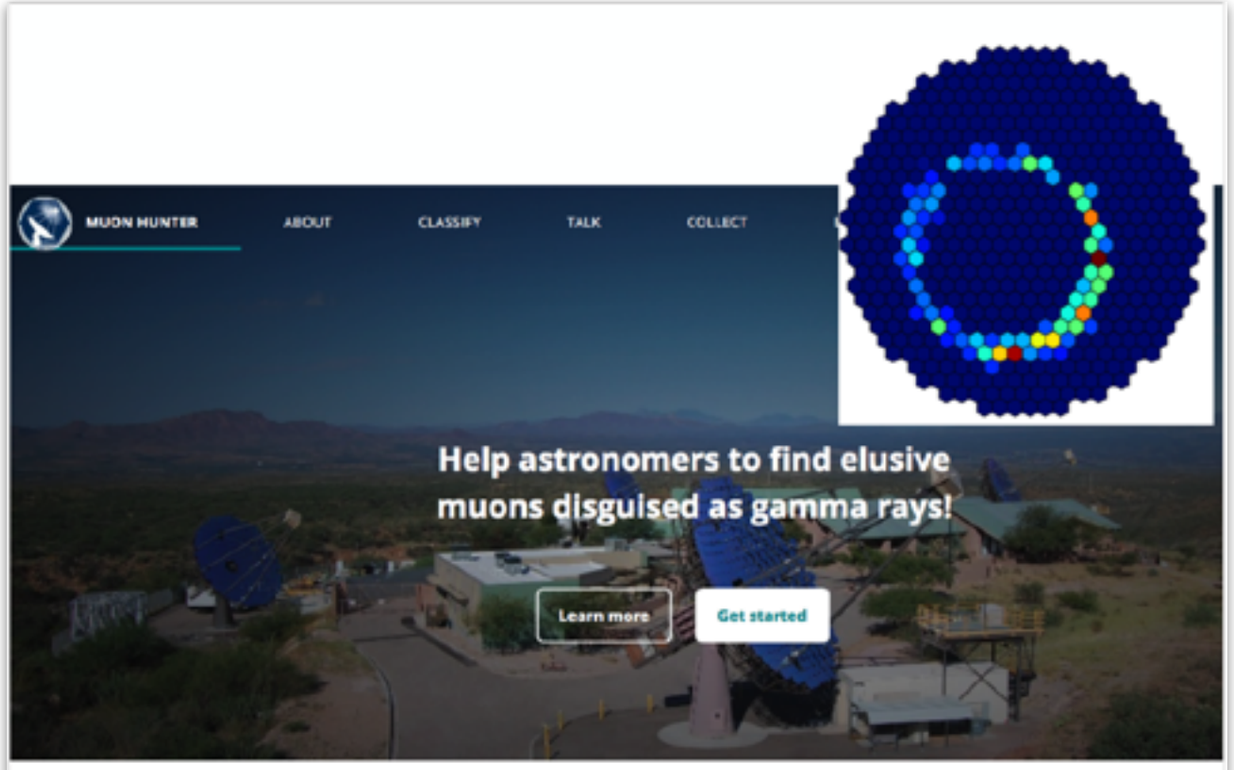
12:21 PM - 28 Feb 2017

60 74

In a twist of irony, the website Down Detector, which tracks web outages across the internet, was itself crippled by the outage:

Also recruite/engage volunteers with social media presence

Even a postcard to hand out, e.g. school science fairs, FLWO visitor centre, etc



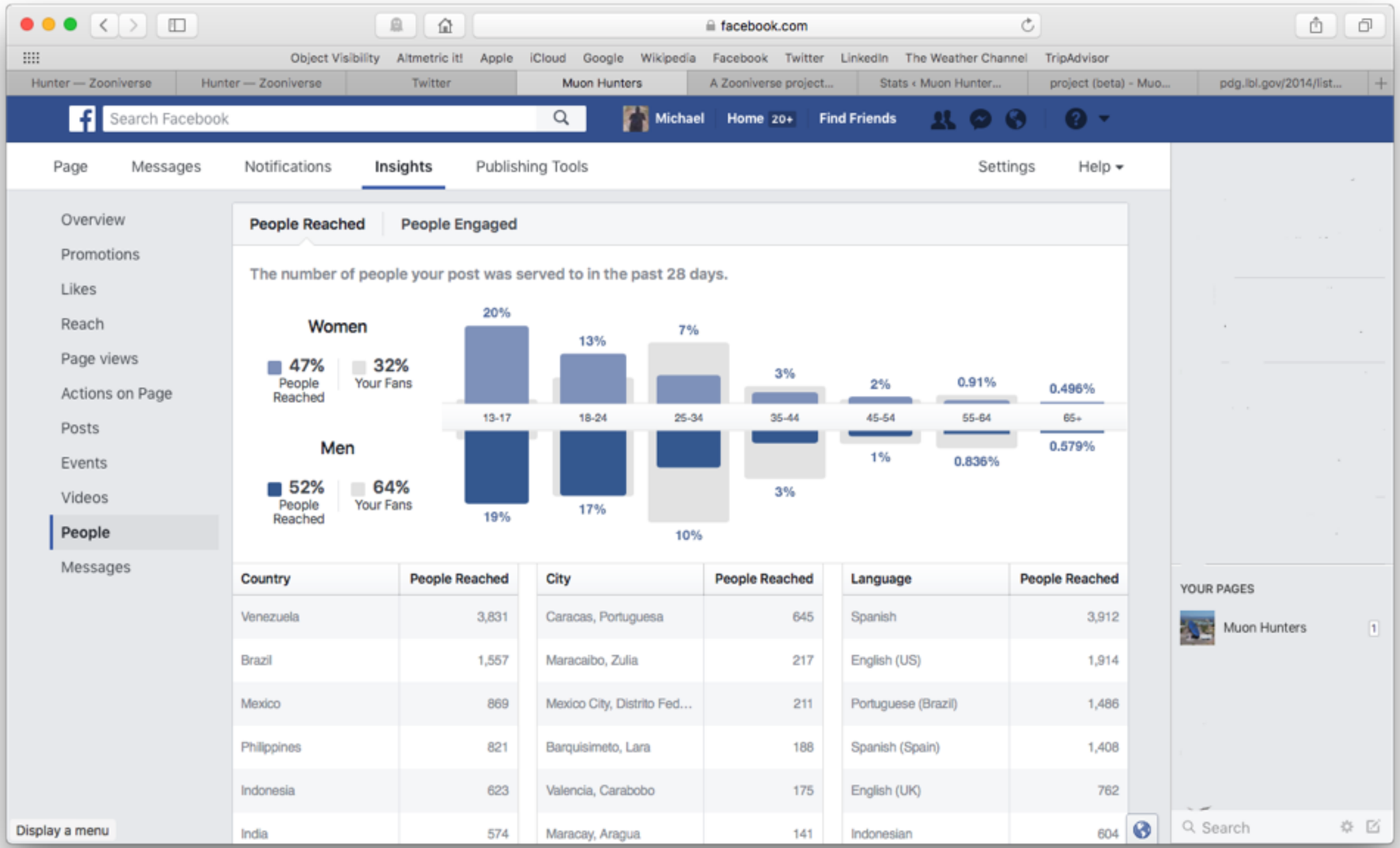
http://www.muonhunter.org/

Muon Hunter: a Zooniverse project

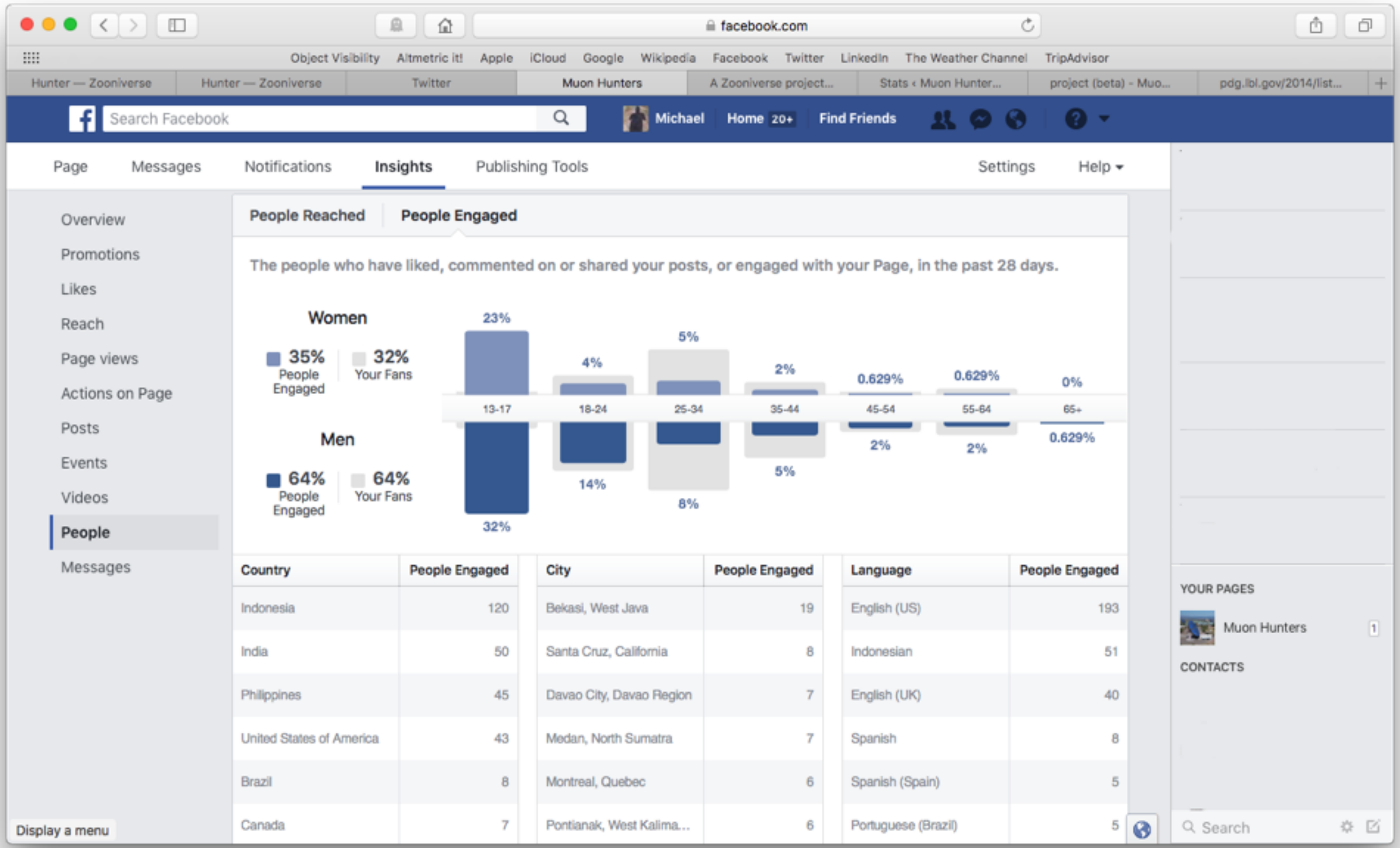
Astronomers using the VERITAS telescopes to detect some of the highest-energy photons in the Universe need your help!

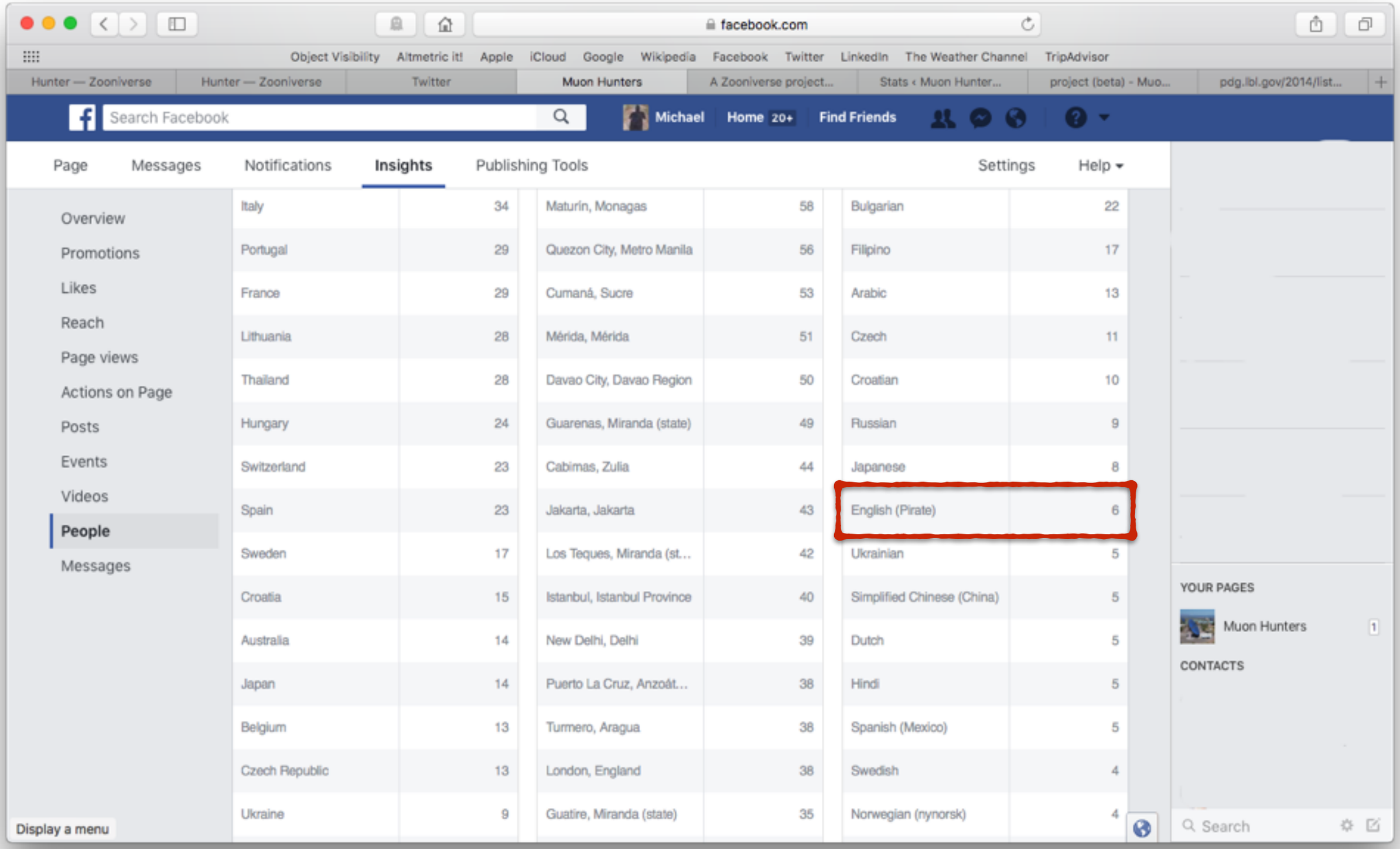
Gamma-rays originate in astrophysical environments like supernova explosion blast waves, or jets streaming from active galaxies at close to light speed. Muons (a particle like an electron, only heavier!) are a prominent background contaminant when observing these gamma-rays on Earth. They leave a distinctive ring-like shape making them obvious to the human eye, but incomplete or truncated rings can appear very gamma-ray-like to automatic analysis algorithms. We need your help to identify camera images that contain muon rings so we can teach computers to better identify such images and efficiently filter out those pesky muons that are masquerading as gamma rays.

People Reached



People Engaged

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Reach
Page views
Actions on Page
Posts
Events
Videos
People
Messages
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Portugal 29
France 29
Lithuania 28
Thailand 28
Hungary 24
Switzerland 23
Spain 23
Sweden 17
Croatia 15
Australia 14
Japan 14
Belgium 13
Czech Republic 13
Ukraine 9
Maturín, Monagas 58
Quezon City, Metro Manila 56
Cumaná, Sucre 53
Mérida, Mérida 51
Davao City, Davao Region 50
Guarenas, Miranda (state) 49
Cabimas, Zulia 44
Jakarta, Jakarta 43
Los Teques, Miranda (st... 42
Istanbul, Istanbul Province 40
New Delhi, Delhi 39
Puerto La Cruz, Anzoát... 38
Turmero, Aragua 38
London, England 38
Guatire, Miranda (state) 35
Bulgarian 22
Filipino 17
Arabic 13
Czech 11
Croatian 10
Russian 9
Japanese 8
English (Pirate) 6
Ukrainian 5
Simplified Chinese (China) 5
Dutch 5
Hindi 5
Spanish (Mexico) 5
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Norwegian (nynorsk) 4
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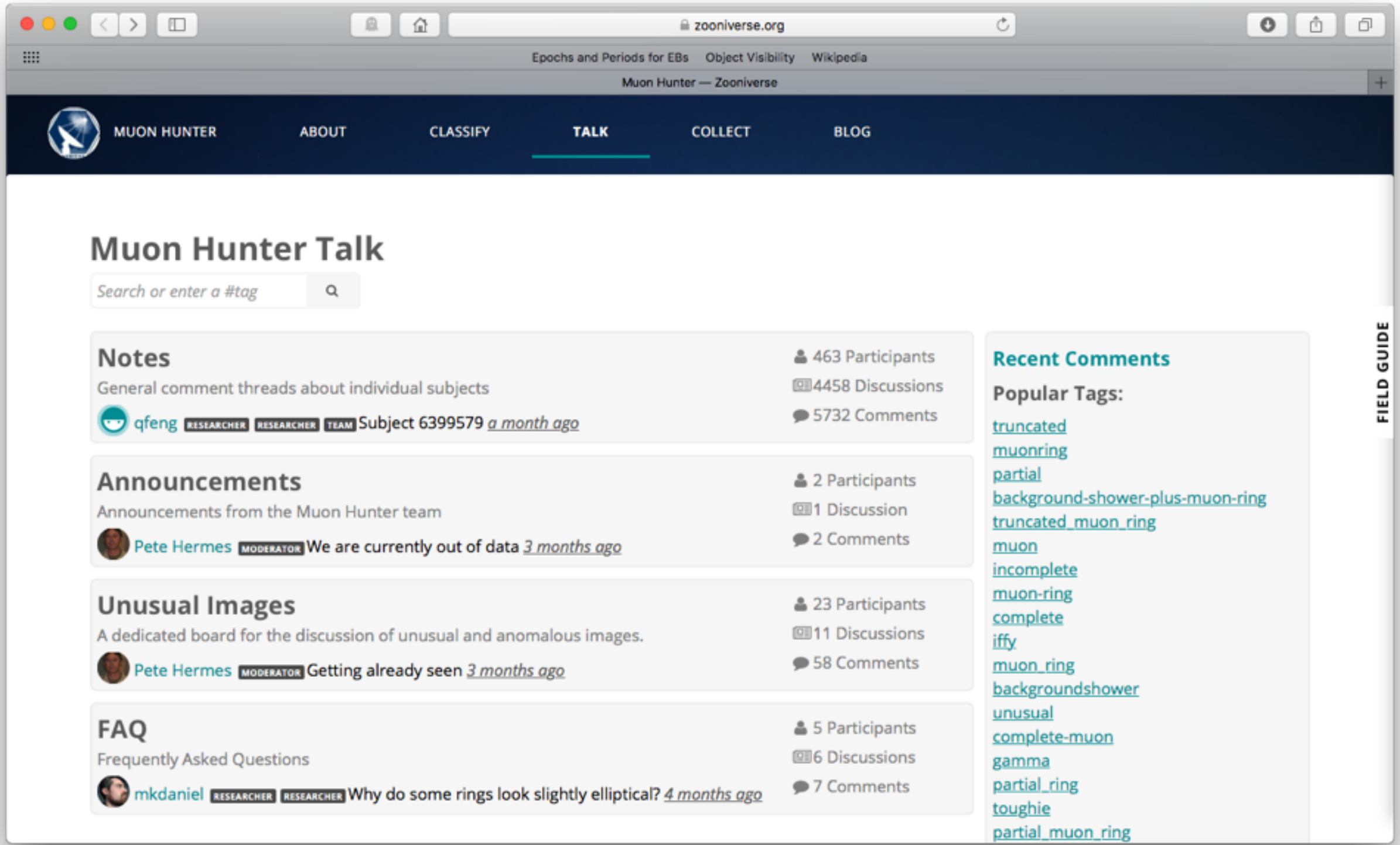
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COLLECT
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Notes
General comment threads about individual subjects
463 Participants
4458 Discussions
5732 Comments
qfeng RESEARCHER RESEARCHER TEAM Subject 6399579 a month ago
Announcements
Announcements from the Muon Hunter team
2 Participants
1 Discussion
2 Comments
Pete Hermes MODERATOR We are currently out of data 3 months ago
Unusual Images
A dedicated board for the discussion of unusual and anomalous images.
23 Participants
11 Discussions
58 Comments
Pete Hermes MODERATOR Getting already seen 3 months ago
FAQ
Frequently Asked Questions
5 Participants
6 Discussions
7 Comments
mkdaniel RESEARCHER RESEARCHER Why do some rings look slightly elliptical? 4 months ago
Recent Comments
Popular Tags:
truncated
muonring
partial
background-shower-plus-muon-ring
truncated_muon_ring
muon
incomplete
muon-ring
complete
iffy
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backgroundshower
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complete-muon
gamma
partial_ring
toughie
partial_muon_ring
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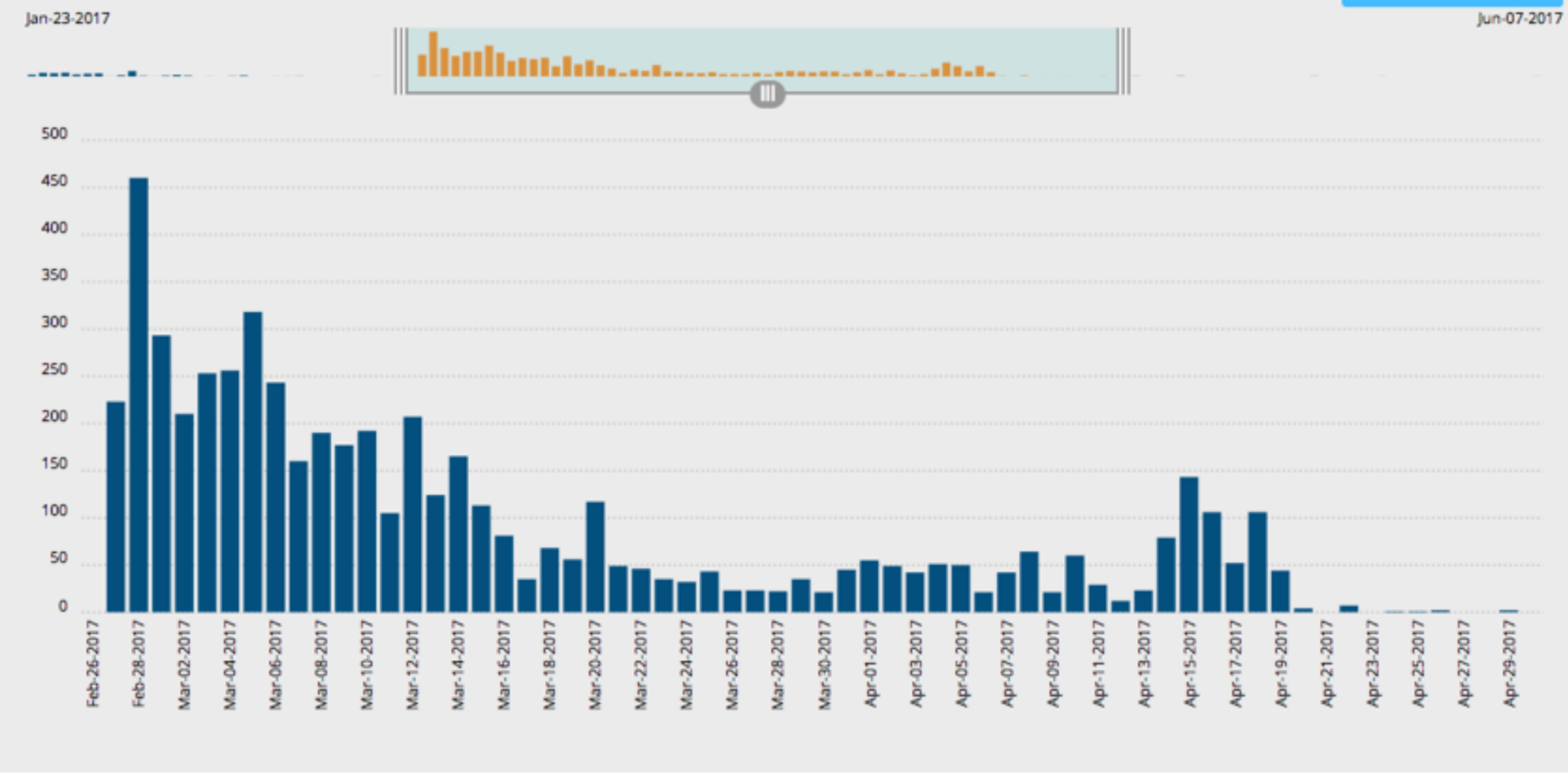
Talk Stats

Comments per day

Current date range: Feb-26-2017 to Apr-30-2017

Reset date range



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zooniverse.org

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million muons to pass through every minute.

Each image is about a 20ns exposure, which means we expect about 0.02 muons every ns to be the average rate. The probability of seeing 1, 2 , or 3, etc muons is described by something called a Poisson distribution which relates the average rate of an event to the likelihood of seeing it. If 97.7% of the time we see no muons, 2.2% we see 1 muon, 0.02% of the time we see 2 muons, 0.0002% (or only 1 in 5,000) times we see three muons and so on.

In reality that is an oversimplification because the arrival rate of muons is not completely random: the cosmic rays arrive randomly, the air showers they then create contain many thousands of muons arriving just a few nanoseconds apart (and not minutes) spread over an area of a few thousand square metres. Also other particles will create similar rings, e.g. when a muon decays it creates an electron which will produce a similar ring to its parent muon and you will see both rings in the image just slightly separated.

But the general conclusion still holds: most images will contain no muons, a good many will contain one muon, a very few will contain two, and it becomes increasingly rarer still to see any more than that in the same image. We have many hundreds of thousands of images in our dataset so even some rare events have a chance of turning up, such as here.

Helpful (3) Reply Link

FIELD GUIDE

BrianaG
@BrianaG

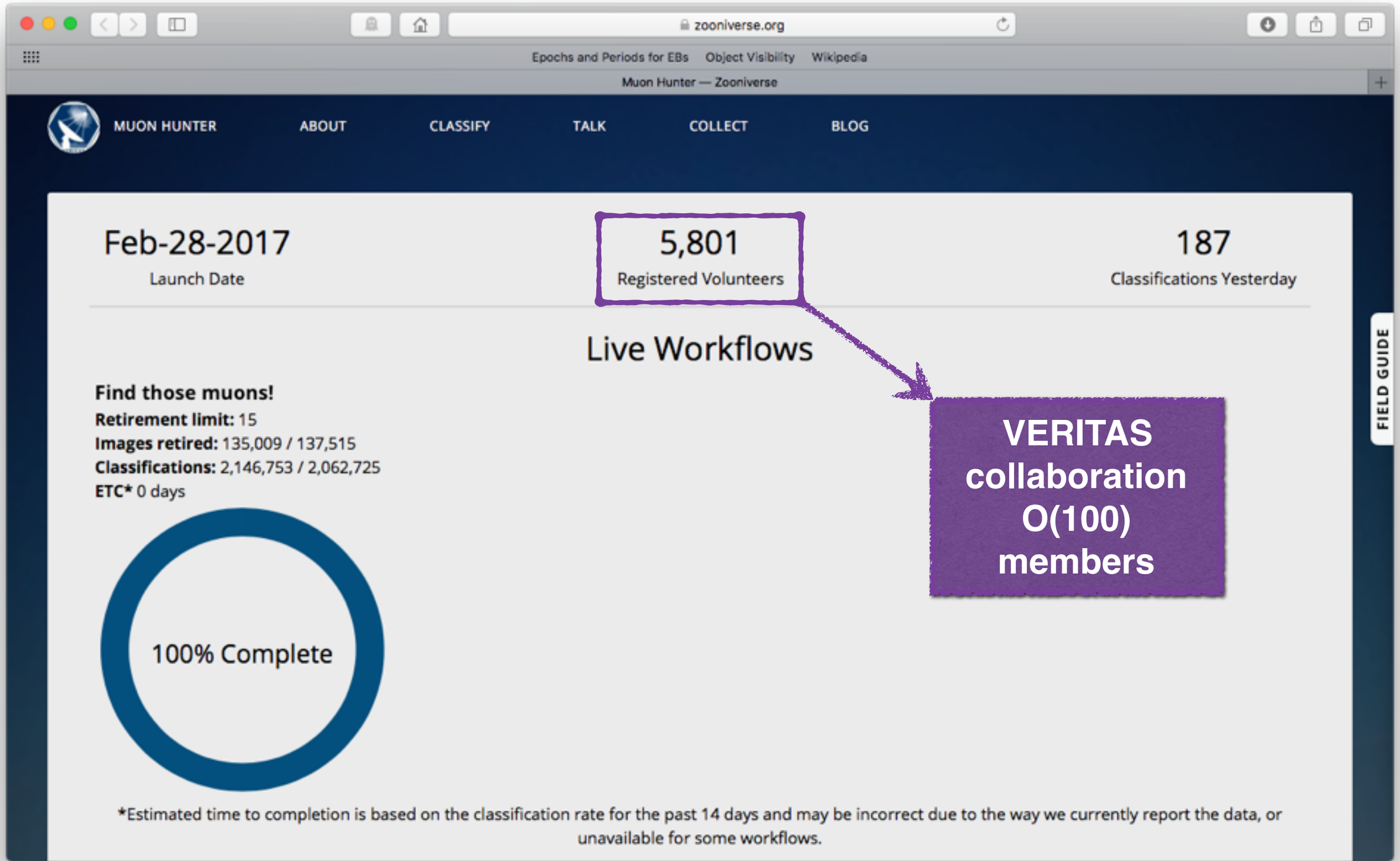
March 28th 2017, 12:06 am

I am so glad to have seen someone use the Poisson distribution, @mkdaniel I thought I'd never see it again after college!

Glad I didn't have to sort 5000 images to see one, though. Thanks @Huskynator for flagging this!

Helpful (0) Reply Link

~1 month after launch

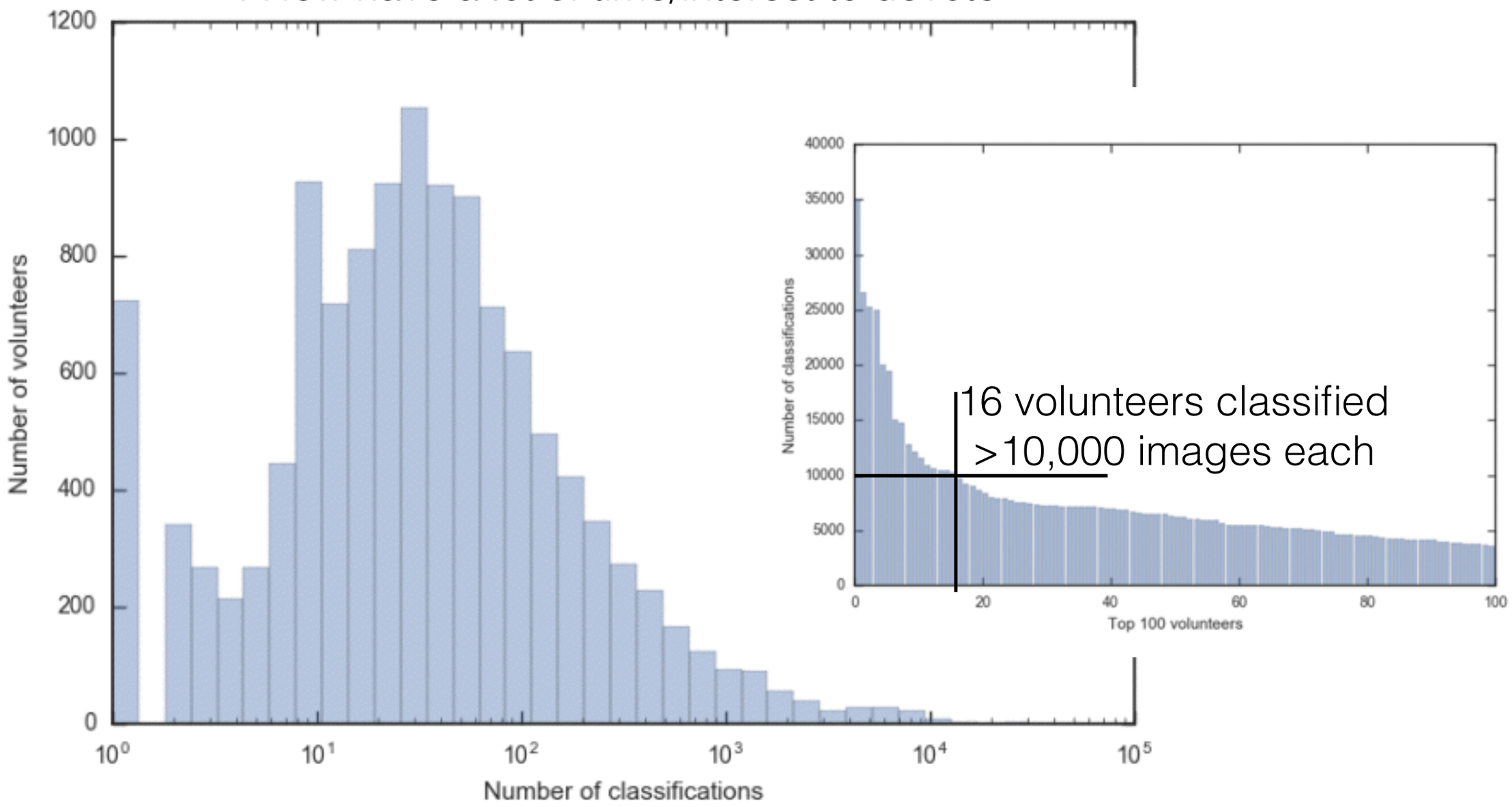


VERITAS collaboration O(100) members

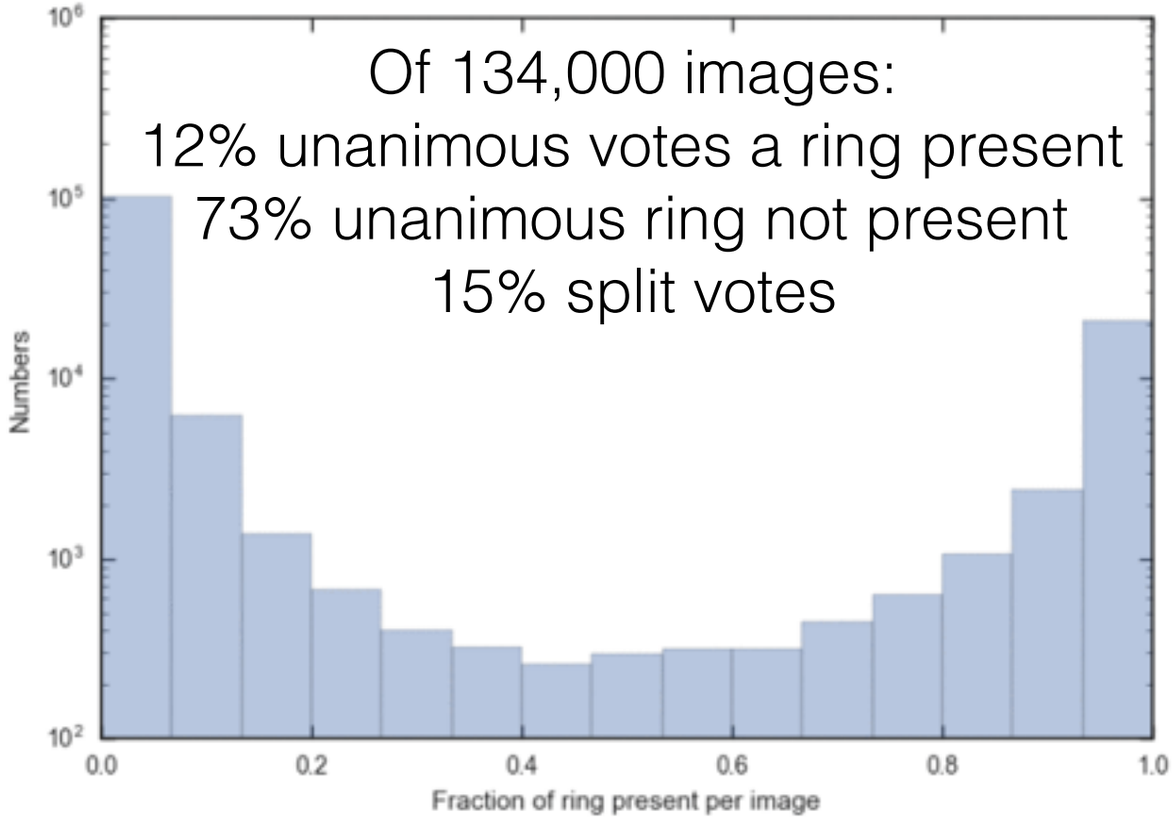
The median number of image classifications per volunteer is 30

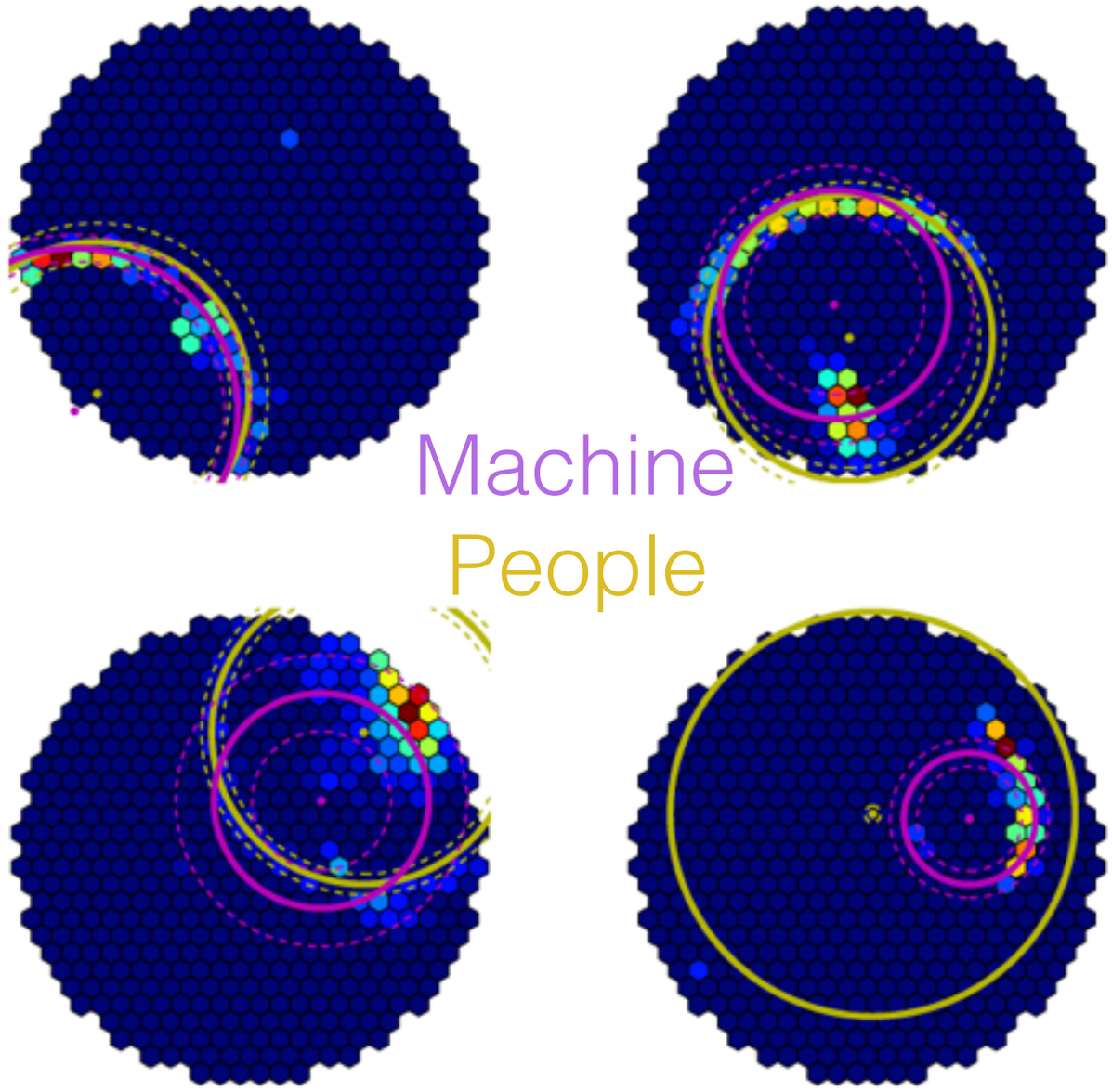
Gini co-efficient = 0.83 (0 = equally shared, 1 = one dominates)

Most have less time to commit, but contribute what they can.
A few have a lot of time/interest to devote



https://muonhunterblog.wordpress.com/2017/05/24/a-quick-look-at-the-volunteer-input/





Treating all images with ≥9/15 votes for ring as muon events
trained a convolutional neural network model with score of 0.97
cf previous algorithm score of 0.95

Summary

- Citizen science is a great resource for both outreach and practical science.

- People are willing (& able) to look through a mountain of data in the search for circles
  ➡ Having a simple, clearly defined project task helped a lot with the success of the project.

- They are also likely to find other interesting things when parsing that much data
  ➡ Feeds into what projects to do next…