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Online mass participation experiment and its educational resources

ASTERICS GA DELIVERABLE: D2.7 and D2.8

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Abstract

In this report we describe two deliverables, 2.7 and 2.8, describing a new citizen science experiment and its associated educational resources. Because they are closely linked, we have opted to combine their narrative descriptions in this single report, which will be submitted to the Commission for both deliverables.

I. COPYRIGHT NOTICE

II. DELIVERY SLIP

	Name	Partner/WP	Date
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III. DOCUMENT LOG

Issue	Date	Comment	Author/Partner
1	27 April 2018	Final version	Stephen Serjeant
2			
3			
4			

IV. APPLICATON AREA

This document is a formal deliverable for the GA of the project, applicable to all members of the ASTERICS project, beneficiaries and third parties, as well as its collaborating projects.

V. TERMINOLOGY

A complete project glossary is provided at the following page:
http://www.asterics2020.eu/glossary/

VI. PROJECT SUMMARY

ASTERICS (Astronomy ESFRI & Research Infrastructure Cluster) aims to address the cross-cutting synergies and common challenges shared by the various Astronomy ESFRI facilities (SKA, CTA, KM3Net & E-ELT). It brings together for the first time, the astronomy, astrophysics and particle astrophysics communities, in addition to other related research infrastructures. The major objectives of ASTERICS are to support and accelerate the implementation of the ESFRI telescopes, to enhance their performance beyond the current state-of-the-art, and to see them interoperate as an integrated, multi-wavelength and multi-messenger facility. An important focal point is the management, processing and scientific exploitation of the huge datasets the ESFRI facilities will generate. ASTERICS will seek solutions to these problems outside of the traditional channels by directly engaging and collaborating with industry and specialised SMEs. The various ESFRI pathfinders and precursors will present the perfect proving ground for new methodologies and prototype systems. In addition, ASTERICS will enable astronomers from across the member states to have broad access to the reduced data products of the ESFRI telescopes via a seamless interface to the Virtual Observatory framework. This will massively increase the scientific impact of the telescopes, and greatly encourage use (and re-use) of the data in new and novel ways, typically not foreseen in the original proposals. By demonstrating cross-facility synchronicity, and by harmonising various policy aspects, ASTERICS will realise a distributed and interoperable approach that ushers in a new multi-messenger era for astronomy. Through an active dissemination programme, including direct engagement with all relevant stakeholders, and via the development of citizen scientist mass participation experiments, ASTERICS has the ambition to be a flagship for the scientific, industrial and societal impact ESFRI projects can deliver.

VII. EXECUTIVE SUMMARY

This document describes deliverables 2.8 and 2.7, which are the new citizen science experiment and its associated educational resources, respectively.

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1. Introduction

1.1 Summary of Deliverable 2.8: Online Mass Participation Experiment

In this Deliverable we present a new citizen science experiment, *Euclid: Challenge The Machines*. The experiment can be accessed at https://www.zooniverse.org/lab/4949 and is currently open to the public for beta-testing. It will be advertised to the Zooniverse community shortly.

This is in addition to our enormously successful citizen science experiment that we delivered in Deliverable 2.4, *Muon Hunter*: https://www.zooniverse.org/projects/zooniverse/muon-hunter. This experiment has now been completed, and was a spectacular runaway success, with 1.3 million classifications in the first five days. In total the project involved 2.1 classifications and the project is now complete.

Both of these experiments originated in part from our ASTERICS citizen science workshop discussions. The VERITAS team had been particularly keen to launch a major new citizen science experiment in the run-up to the Cherenkov Telescope Array, and in our first ASTERICS workshop we had a stimulating discussion of the options available for the participant workflows and the science goals.

We funded an additional visit to the UK from our US collaborators in VERITAS to discuss further high energy astroparticle physics experiments, but a surprising and unexpected outcome of this discussion was a new citizen science experiment based on simulated date from the Euclid telescope. A description of this experiment is given below. This experiment was also discussed and honed during our second ASTERICS citizen science workshop.

There are several other citizen science experiments that we expect will result from our ASTERICS work, though not necessarily on a timescale suitable for the formal deliverable deadline.

The science goal of our new citizen science experiment is to see whether human volunteer classifiers can find strong gravitational lens events better than machine learning. The Euclid consortium recently ran a Strong Gravitational Lensing Challenge, in which teams contributed machine learning algorithms to find lensing events in simulated Euclid imaging data. One valiant expert volunteer visually classified the entire ~100,000 image set. One of the great surprises of this challenge was that the valiant expert did not win the challenge. Several machine learning algorithms were more effective than the human expert in finding lenses. But this is a feature recognition problem in which a non-expert can be very well trained, so the question is whether the artificial intelligence has exceeded human abilities or whether some humans can still beat the machine.

1.2 Summary of Deliverable 2.7: Educational Resources for Online Mass Participation Experiment

Our tactic for educational resources associated with the mass participation experiments is to embed the material directly into the citizen science workflow. This means that the participant volunteers can be introduced gently to the science context as their involvement in the project extends.

2. Plan

The description of the experiment for volunteers is as follows: "Gravitational lensing is where you can see warps in space. Everything warps space, even you right now, but it's easiest to see around things as big as entire galaxies. If you have one galaxy almost exactly lined up behind another one, the background one is seen through a foreground warp, so it looks stretched and distorted. These gravitational lenses are extremely useful in cosmology, but they're also rare alignments. Currently, looking at images by eye is the best technique for finding gravitational lenses in images. Scientists are making artificial intelligences to find them more quickly. Recently these artificial intelligences were tested against simulated data, and they did better than a human astronomer! We would like your help to find out if the artificial intelligences can beat any human. Are humans still better at classifying? Can you beat the machines?"

3. Content

Figure 1 shows the front page of the beta-test version of our latest experiment. Figure 2 shows an example of the educational resources from the first of our citizen science experiments, *Muon Hunter*. As the volunteers continue their work, they can find out more about the science context, as well as communicating directly with each other and with the science team through dedicated online forums. Figures 3 and 4 show some samples of the new educational resources for our *Euclid: Challenge The Machines* experiment.

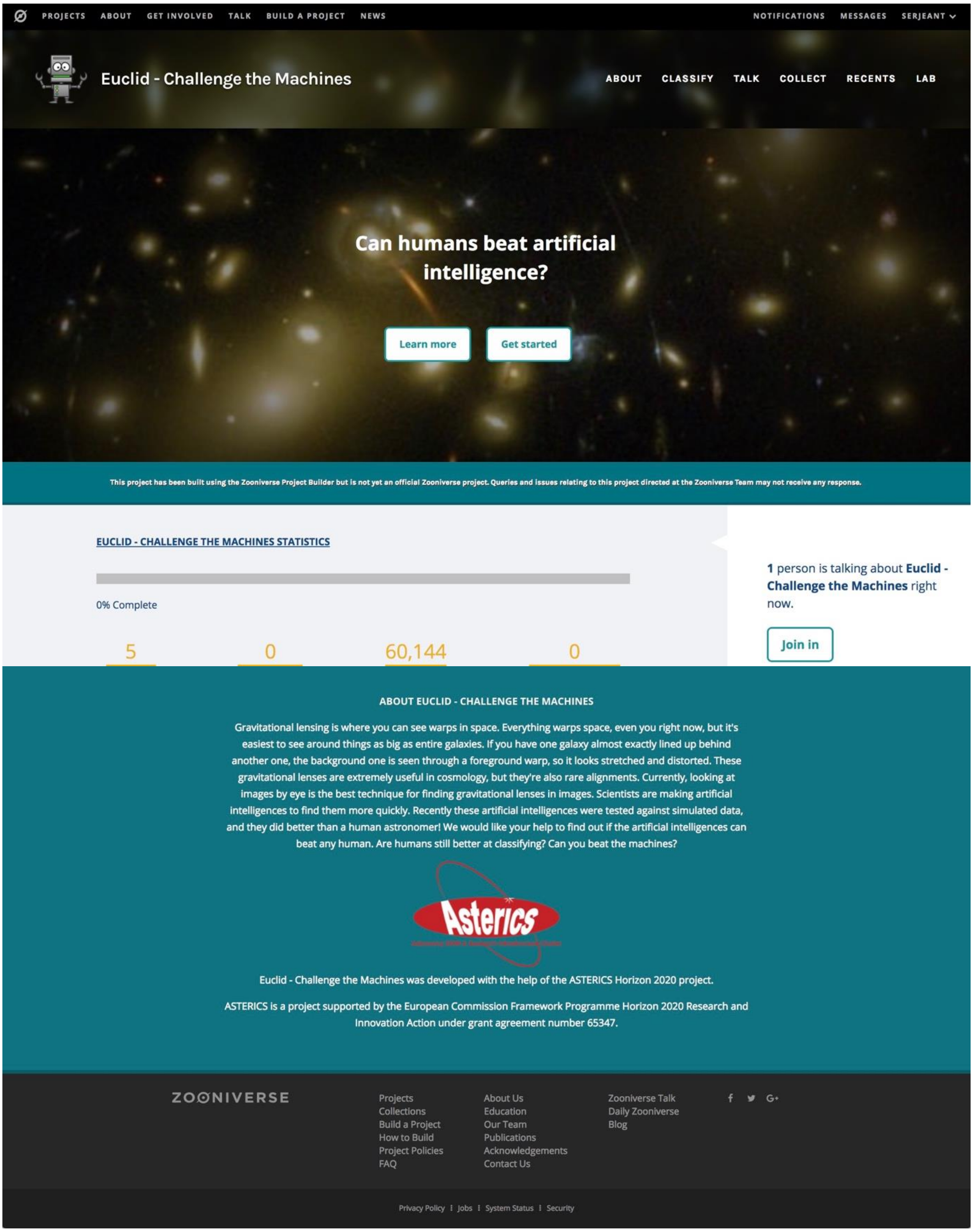


Figure 1: Front page of the beta-test version the EUCLID Citizen Science experiment

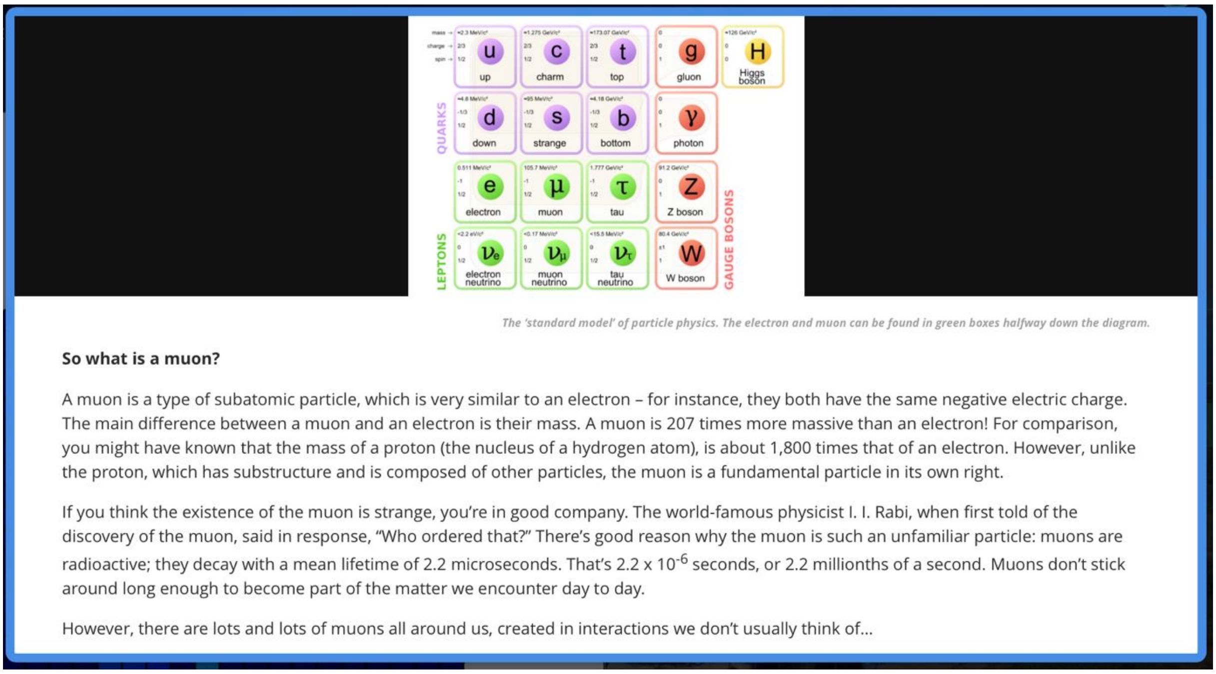


Figure 2: Sample of the new educational resources for our Muon Hunter experiment.

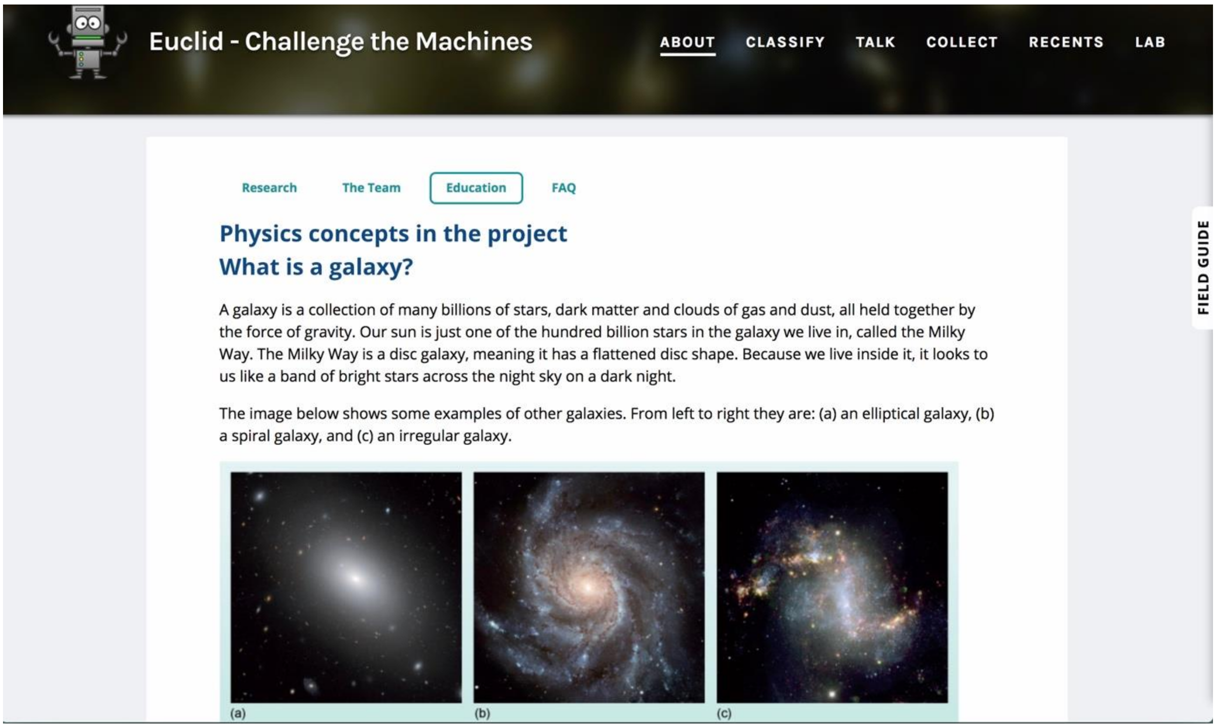


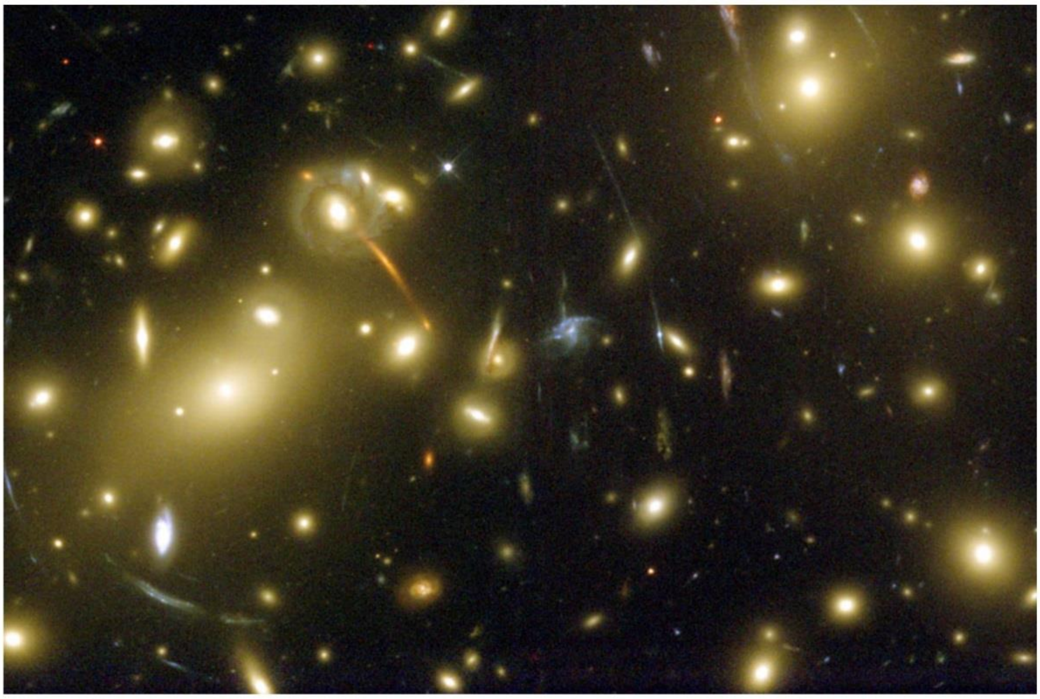
Figure 3: Sample of the new educational resources for our Euclid: Challenge The Machines experiment.

What is gravitational lensing?

Einstein's theory of gravity, known as general relativity, predicts that every object in the Universe curves the space and time around it. Right now, you are curving the space around you. This curvature is too tiny to measure directly, but for giant objects in astronomy like galaxies or clusters of galaxies, this curvature becomes measurable.

The way it is measured is to deflect the paths that light takes. This becomes visible to us when we have a background object and a foreground object lined up almost exactly along our line of sight. In this situation, the background object is being seen through the warped space of the foreground one. The larger the mass of the foreground massive object, the more the light's path is deflected.

The image below shows a foreground cluster of galaxies, in an image captured by the Hubble Space Telescope. The foreground galaxies are the orange-yellow elliptical galaxies. The background galaxies are being warped into long thin arcs, because we are seeing them through the warped space of the foreground galaxy cluster. This warping of background galaxies by foreground matter is called gravitational lensing.



(Image credit: Andrew Fruchter (STScI) et al., WFPC2, HST, NASA. Image from Astronomy Picture of the Day.)

Figure 4: Sample of the new educational resources for our Euclid: Challenge The Machines experiment.

4. Analysis

Reasons for the project selection

We selected the Euclid experiment for several reasons:

- It is the first of several similar Euclid challenges, so new versions of the crowdsourcing experiment could be run at later dates.
- There is a precedent for successful crowdsourcing in strong gravitational lensing, in the Spacewarps experiment.
- Similar morphological searches for strong gravitational lenses can also be made in other ASTERICS and ASTERICS-related facilities, such as the SKA, the Large Synoptic Survey Telescope, the Hubble Space Telescope, and others.

Besides the particular science objectives of the experiment, we were also aiming to find experiments that are in some way aligned with the primary science goals of the facility, and which are likely to have some longer-term traction or application to other facilities. In the case of Euclid, the enormous hundred-fold increase in known strong gravitational lensed systems that Euclid will bring will provide independent statistical constraints on dark energy parameters.

The drafting of the experiment itself and its associated educational resources was done very quickly and efficiently on the Zooniverse's Panoptes platform. We helped in the creation of the new mobile app functionality for Zooniverse, using a "Tinder"-like swiping left and right to indicate a binary classification. Our new citizen science experiment will be one of the first to pioneer this new citizen science interface.

However, that is not to say that all aspects of this project were trivial to create. The classification data set was examined carefully by ourselves and by our collaborators in the Zooniverse Spacewarps project. We discovered that while most of the simulated data sets were representative of the known gravitational lens systems discovered in the COSMOS survey by the Hubble Space Telescope, there was also a significant subset of outlier systems that appeared to be unphysical. Typically, these were systems in which there was an unusually faint foreground lensing galaxy with the background galaxy warped into a wide Einstein ring. Since the ring radius is a reliable proxy for the total mass of the system, this would mean that the simulated galaxies either have an unphysical mass-to-light ratio or have been placed at unphysically high redshifts (i.e. greater distances).

We therefore took care to pre-filter the data set to be classified, in order to better reflect the observed parameter distributions in the known Hubble Space Telescope gravitational lenses. This process took several months. It should be added that none of these anomalies that we discovered had been uncovered by any of the AI algorithms or human inspections of the data set prior to our work.

5. Deviations from the plan

Unfortunately, during the development of our materials for Deliverable 2.7 and 2.8, one of our ASTERICS-funded staff had to be granted long-term sick leave due to a serious illness, and as a result these deliverables are one month late.

For this reason, we unfortunately also had to descope our ambitions for the projects that could be made available by the time of this deliverable deadline, though still nevertheless meeting the formal requirements of the project deliverables.

There are other projects and results that, although delayed beyond this deliverable deadline, will be made available by the ASTERICS project completion:

- An online Massive Open Online Course, presented at the Open University as a "Badged Open Course", on an introduction to astronomy and to the Virtual Observatory tool Stellarium. At the time of writing, four out of the eight units that comprise the course have been written. The main constraint in progressing this further has been the availability of other staff to take on the workload of the staff member who is on long-term sick leave.
- A further citizen science experiment, the Cosmic Ray Extremely Distributed Observatory (CREDO) and its associated crowdsourced analysis the Dark Universe Welcome. The aim of this project is to use people's mobile phones as charged particle detectors. These charged particles could be caused by Cherenkov showers of extremely high energy cosmic rays (e.g. 1-10 Joules) impacting on the interplanetary medium and solar wind in our own Solar System. The incidence rate of extremely high energy cosmic rays, with energies 1-10 Joules, is still unknown. Cherenkov showers from such high energy cosmic rays would result in a worldwide, synchronous set of charged particle detections. The idea of this experiment is to use mobile phones as a worldwide network of charged particle detectors. When a charge particle impacts on the Charged Coupled Device in a mobile phone, it appears as a glitch in the image that is read out. When mobile phones are charged they are typically left horizontally, and the data can be tagged with location and timing information, so a charging mobile phone can be used as a very effective cosmic ray detector. An Android app has already been developed to be run while a phone is charging. The Dark Universe Welcome project aims to crowdsource the analysis of the worldwide data set that will be compiled from this app, and this component of the project is still under development and review. The lead on Dark Universe Welcome was the staff member who is now on long-term sick leave but this work will be resumed by other staff in the ASTERICS project.

We also had some minor scheduling difficulties in phasing the beta testing period of our experiment with other Zooniverse activities, but this was successfully resolved by liaising with other project partners.

6. Results

Successes of the project

As the project is still in a beta phase, it is too early to declare our project an overall success, but we can at least claim a success in pioneering the use of the mobile platform for the Zooniverse in this experiment.

Lessons learned

We were pleased with the engagement of our attendees at our citizen science workshops, which were sufficient in size to stimulate new crowdsourcing ideas. However, a larger attendance may also have had advantages. In future we would advertise the citizen science workshops more widely and with greater notice in order to increase the subject-specialist diversity in the attendees and increase the numbers of participants. This may have the effect of resulting in a wider range of options for citizen science experiments. Funding and staffing permitting, we may hold another ASTERICS citizen science workshop, and/or incorporate citizen science element into other ASTERICS meetings.

7. Next steps

Following the beta test, we will be assessing the lessons learned and then launching the experiment to the general public later this year. The results will be analysed as part of a PhD thesis to be submitted by the end of this calendar year. There is also a plan for a second Euclid strong gravitational lensing machine learning challenge at some point in the coming year, which we will also deploy to the crowdsourcing volunteers.

In addition, we will launch our Massive Open Online Course in introductory astronomy by the end of the project, as well as our CREDO / Dark Universe Welcome project. The CREDO concept has already been published and is available at the arXiv open-access repository (Dhital et al. 2017, http://arxiv.org/abs/1709.05230).

8. Conclusion

We have created a new citizen science experiment, *Euclid: Challenge the Machines* that is available to the public for beta testing, and which contains embedded educational resources for participants to take their interest further. The results will form the basis of part of a PhD thesis for an early-career researcher.