

# Guidelines and Policy for the Dark Energy Survey Strong Lensing Science Team using SPACE WARPS

Aprajita Verma, Phil Marshall & Anupreeta More

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## Abstract

SPACE WARPS was conceived as a strong lens discovery *service* that harnesses the power of citizen scientists. The DES strong lensing group (hereafter DES survey science team or DES SST) can make use of SPACE WARPS within the logistical constraints. In this document we discuss how the DES SST can become involved with SPACE WARPS and the relationship between the DES SST and the SPACE WARPS collaboration. This document includes guidelines for proposing projects, data provision, data policy and for publications of SPACE WARPS-enabled discoveries.

## 1 Introduction to SPACE WARPS

The SPACE WARPS website is designed to motivate and enable tens of thousands of people to perform the scientific tasks of strong gravitational lens identification. SPACE WARPS comprises a primary ‘classification’ interface (<http://spacewarps.org>) that allows citizen scientists to inspect images and mark those that contain potential gravitational lenses. A mandatory part of this inspection is the classification of simulated lenses (appropriate for the survey being conducted). The classification of simulated lenses acts as an interactive training activity that also allows us to establish the citizens’ likelihood of identifying potential lenses and blank fields. This is fed into the SPACE WARPS Analysis Pipeline (SWAPR) that analyses the classifications made per image (or subject in Zooniverse terms) giving a probability of whether an image contains a lens candidate or not.

A key part of the SPACE WARPS project is the ability for all members of the SPACE WARPS collab-

oration (see Section 2) to communicate with each other and discuss interesting candidates through TALK<sup>1</sup>.

In order to use the SPACE WARPS interface, the DES Survey Science Team **must define and propose a project to the SPACE WARPS PIs** who will discuss whether the project is suitable with the SST. The SPACE WARPS PIs will then liaise further with the SST to implement the project in the SPACE WARPS interface. Details are given in Section 3.

The PIs of the SPACE WARPS project are the authors of this document, P. Marshall, A. More and A. Verma, please do not hesitate to contact us if you require any further information or have any questions. The PIs may be collectively contacted via the email address [spacewarpspi@googlegroups.com](mailto:spacewarpspi@googlegroups.com)

## 2 Definition of collaboration member types

In this document, we will refer to the entirety of the DES strong lensing science group and the STRIDES team as the DES Survey Science Team (DES SST) to encompass all of the DES strong lensing community.

We now discuss the relationship between the SPACE WARPS collaboration and the DES SST, who wish to use the SPACE WARPS interface to investigate their data. The DES SSTs will liaise with the SPACE WARPS science and development teams

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<sup>1</sup>TALK (found at <http://talk.spacewarps.org>) is a forum for SPACE WARPS collaborators to discuss individual sources and the SPACE WARPS project in general. Bugs can also be reported. This is the direct portal for communication with the SPACE WARPS community.

to ingest their survey data into the SPACE WARPS interface. There may be some overlap between current SPACE WARPS members and SSTs. In the case of DES, SPACE WARPS PI Anupreeta More is a member of both the SPACE WARPS collaboration and the DES Strong Lensing Science Group.

When we refer to the SPACE WARPS collaboration, it comprises the SPACE WARPS science team, SPACE WARPS development team, and all the volunteers who have logged in<sup>2</sup> and contributed classifications to the project.

If required, an expanded definition of the SPACE WARPS membership is given in the document “SPACE WARPS Publication Policy: CFHT-LS”<sup>3</sup>, however this will not be relevant for SPACE WARPS-DES publications, see Section 6.1 for details.

### 3 Defining a suitable SPACE WARPS science project

The DES SST is expected to propose a project to the SPACE WARPS collaboration that can be best or only be done using the power of citizen scientists. Typically, this involves visual inspection tasks that are too time consuming for the SST themselves to execute. As such, any science programme conducted through SPACE WARPS should be complementary, not in competition, to the lens finding activities being carried out by the SST.

For example, in the first SPACE WARPS project, the collaboration conducted a lens finding search with SPACE WARPS over the entire CFHT-LS survey area. The goal was to increase the completeness of strong lenses in the survey areas. Both RingFinder and ArcFinder algorithms had been used to discover lenses of different types. SPACE WARPS complemented these searches with the potential to find strong lenses missed by these algorithms. The method, proposed by Anupreeta More (who served as the SST for this project), was to inspect the entire survey area by getting citizens

to view  $\sim 430,000$  tiles of the survey area. This was a *blind* search. Such a search could not be conducted by a normal sized SST.

*Targeted* searches are also possible, as we performed in the second SPACE WARPS project on the VICS82 survey area. Here we inspected  $\sim 40,000$  images from the VICS82 survey centred on likely strong lens targets, e.g. LRGs, groups, clusters, quasars. Again, this was more images than the VICS82 SST could manage to inspect alone.

Another approach is to use the SPACE WARPS service to inspect the normally large candidate lists generated by automated algorithms or searches, which are typically dominated by false positives.

#### 3.1 DES specific thoughts

In the case of DES, with its long data release plan and large strong lens group, we request the SST to consider the following:

1. The SPACE WARPS facility should be used for science projects that cannot be completed by the Strong Lens Group itself.
2. Any SPACE WARPS search should be complementary, not in competition, to the lens finding being conducted by the DES SST.
3. While SPACE WARPS uses citizen science, its primary goal is **not outreach**, it is harnessing citizen power for visual classifications (and eventually modelling) to perform science.
4. A duplicate project is not encouraged unless there is sufficient scientific motivation and justification to do so.
5. SPACE WARPS requires volunteers/citizens to give up their personal time to conduct the experiment, this should not be taken lightly, the crowd are motivated by contributing to real science not just doing things for the sake of them. This is the reason the suitability of the project for citizen scientists should be carefully considered. The SPACE WARPS PIs will be able to discuss any planned SPACE WARPS-DES projects with the DES SST. It is important to bear this in mind for long-term surveys like DES, if needed the crowd needs to be engaged and feel like they are contributing while the entire SPACE WARPS-DES project runs.

<sup>2</sup>with a Zooniverse ID. It is possible to classify anonymously, and we count those classification but as we don't know who they are, we are unable to collaborate with them directly.

<sup>3</sup>available from <https://github.com/drphilmarshall/SpaceWarps/blob/master/doc/sw-publication-policy-cfhtls.pdf>

6. The success of SPACE WARPS-DES will rely on input from the DES SST working with the SPACE WARPS collaboration, dedicated effort is required for this and the DES SST should identify team members who can commit time to the SPACE WARPS-DES tasks for this before embarking on a project. The SPACE WARPS PIs will help to establish the main efforts required, these will depend on the actual project put forward by the DES SST (e.g. image preparation, simulations, interacting with volunteers on TALK).

**As such, SPACE WARPS should be considered to be an integral part of the DES SST lens finding strategy, rather than an alternative method.**

The scientific project, process and outcome is the domain of the SST. The SPACE WARPS collaboration enables this work by making it a live project on the website. We do not, per se, expect the SPACE WARPS collaboration lead the resultant papers, we just request some of us are included on discovery papers in return for our help, please see Section 6.1 for more details on the publication policy.

The goal of the SPACE WARPS PIs and the SPACE WARPS collaboration is to enable the DES SST's science project in SPACE WARPS and make it work. Using the automatic analysis pipeline (SWAPR), the SPACE WARPS PIs we will send the DES SST lists of the candidates selected by the citizens (at some regular intervals or at the end of a project), we will then discuss strategies for further analysis based on our experience of previous projects. Some members of the SPACE WARPS PIs and team may become more involved in analysis steps such as grading of the SPACE WARPS candidates or assist with any scientific investigations and follow-up of the candidates, at the DES SST's request.

### 3.2 Previewing images and TALK

We are aware that there is some interest in the DES SST for using the SPACE WARPS web interface to preview images for the SST themselves. This is not the function or purpose of the SPACE WARPS interface or the Zooniverse. However, it will be possible for DES SST members to view the images

in parallel with the crowd through the public interface. The DES SST members who wish to do this will need to register with the Zooniverse to classify. We can extract the classifications of SSTs only to provide an expert selected sample, if required. The images marked by any inspector (SST or citizen) are automatically recorded in an individual's SPACE WARPS/Zooniverse account. These can be accessed through the SPACE WARPS interface and as a 'collection' in TALK. This collection can be explored (and discussed if required) through the TALK interface.

SPACE WARPS TALK is a key and integral part of SPACE WARPS. The DES SST is strongly encouraged to interact with the volunteers on TALK. This exchange allows the crowd to learn from the experts, this in turn has the very positive effect of motivating the citizens to contribute further. In addition it also results in better and informed classification when they return to that task. Thus, engagement of the SST is very important in long-term surveys such as DES.

### 3.3 Possible SPACE WARPS-DES survey strategies

In our experience, a citizen science project like SW cannot function successfully without significant support and co-ordination of the SST. Thus, we recommend that all DES members with an interest in strong lensing are told about SPACE WARPS and how it can complement their lens finding effort. Our goal is to enable your science. While we can't expect the entirety of the DES Strong Lensing Group or the STRIDES consortium to be behind SPACE WARPS-DES, all should be made aware of the projects being undertaken and planned with SPACE WARPS.

We also encourage the DES SST to consider the timing for when they wish to ingest the images into SPACE WARPS so that it is in line with the interests of the DES SST and those of the DES consortium.

Possible projects for the DES SST could consider (just to get a flavour of what can be done)

- **New Data:** Inspection of areas (targeted or blind) that the SST has not had time to inspect, i.e. use the crowd to increase the speed at which potential lens candidates are discovered

- **Comparison of Expert vs Citizen Classification:** DES SST and citizen’s view images in parallel (targeted or blind)
- **Completeness of Expert Classification:** Citizen’s classify images already inspected by the DES SST (targeted or blind)
- **Helping the robots:** Use citizens to weed out false positives from candidate samples generated by algorithm based searches
- **Training sets:** Blind inspection to generate a large training set for machine learning algorithms.

Note that the projects that are proposed to SPACE WARPS need not be one of the above. Multiple projects could also be run in a mixture or phased set of experiments. Please do consider the DES timeline with reference to data release and the searches the DES SST want to make themselves.

If the DES SST wants to inspect targets within the consortium and is concerned about being scooped by the crowd, please be assured that there is little scope or motivation to do this. If the project is well defined, the goal of SPACE WARPS-DES will be a complementary part of the DES SST lens finding strategy. By definition this means that SPACE WARPS is working with the DES SST as it is designed to do. In addition, the images could be stripped of WCS info (described in Section 5), meaning that no-one other than the SST can follow-up or catalogue the targets<sup>4</sup>. The DES SST could also perform their inspection before the images are passed to SPACE WARPS. Any lens candidates discovered by the SST would then be labelled as ‘known lens candidates’ in SPACE WARPS TALK. This applies to candidates discovered through visual inspection or algorithm based searches.

### 3.4 What to do next: Project Proposals

Once the DES SST have narrowed down what search to be conducted SPACE WARPS, please approach the SPACE WARPS PIs (Phil Marshall,

Anupreeta More, Aprajita Verma, collectively contacted via [spacewarpspi@googlegroups.com](mailto:spacewarpspi@googlegroups.com)) with a short description of the project that includes the following information.

- Survey area
- Bands that could be included
- Total number of images to be viewed (approx.)
- Targeted survey or blind field search<sup>5</sup>
- Brief outline of the overall goal(s) of that inspection, highlighting how this is complementary (not competing) with the goals of the DES lens finding group
- Proprietary data issues
- Identify an initial core team who will lead and work closely with SPACE WARPS

Note, the proposed science project(s) should harness citizen classification power to achieve the science goals.

The SPACE WARPS PIs will then arrange a telecon with the DES SST to discuss the project further. This includes discussing the initial effort required and roles for the the SST team for expected tasks.

The original SPACE WARPS papers, by definition, provide a complete description of the system, and its results from the CFHT-LS survey. The SST will be able to read these papers before designing their own SPACE WARPS project, and cite them as justification for some of their experimental decisions. As the SPACE WARPS paper series get published, links to the papers will be given in this draft. Prior to publications, draft papers can also be shared on request by the SPACE WARPS PIs ([spacewarpspi@googlegroups.com](mailto:spacewarpspi@googlegroups.com))

In the remaining sections we look at discovery publications that might arise from future SPACE WARPS projects, and suggest reasonable guidelines for deciding on their authorship. First, however, we remind ourselves about data access via SPACE WARPS.

<sup>4</sup>We cannot exclude the possibility that individual sources might be serendipitously identified e.g. by recognisable morphologies.

<sup>5</sup>Targeted: inspection of a list of candidates; Blind: inspection of tiles of a survey area

## 4 Survey Data Policy

SPACE WARPS is a public website. All images displayed there are by definition in the public domain, and so must be expected to be downloaded, copied and redistributed by any SPACE WARPS user. This is a **good thing**: images of the sky taken with publicly-funded telescopes belong to everyone.

However, some surveys, including DES, come with their own proprietary access policy. It is the responsibility of the DES SST to provide images to SPACE WARPS in a way that is consistent with their own data access rules. There are two things that SSTs can do to in order to respect any proprietary period that they have imposed on themselves:

1. Add a “LICENSE” keyword to the FITS and PNG image headers, explaining what the rules for redistribution of these images are. This will almost certainly be ignored, but it would be a nice reminder that nothing comes free of either cost or responsibility. Other keywords could also be included as well: data provenance is important, and links to useful survey webpages would be most welcome!
2. Remove all WCS information from all images provided. The SPACE WARPS interface “dashboards” do allow FITS and JPG files to be downloaded. If images from a proprietary dataset being made available is a concern for an SST, they should remove the WCS. This also has the consequence that it minimises the potential “scooping” of lens candidates by anyone other than the SST. In practice, the objects contained in the SPACE WARPS images will be too faint for anyone without access to a large telescope to observe, and may also be absent from any public catalogs, so the opportunities for follow-up will be quite limited. Images with field of view less than about 3 arcminutes in diameter are not solvable by **astrometry.net**. **Please note**, however, that we cannot exclude the possibility that object co-ordinates are posted in TALK. For example, co-ordinates of previously published lens candidates or recognisable fields from CFHT-LS have been posted in TALK by a very small number of citizens.

## 5 Data Preparation & the SPACE WARPS interface

### 5.1 Collaborating with SPACE WARPS Science Team

Implementing a new project based on different survey data will require support from the SPACE WARPS consortium, in four respects:

1. In **preparing data** for the site, and uploading it onto the Zooniverse servers. There is a reasonable amount of work in preparing data and images by the DES SST for delivery to SPACE WARPS. The SPACE WARPS team will provide assistance to the DES SST in data preparation. The benefits of using the SPACE WARPS service will far outweigh the time needed to prepare data. The SPACE WARPS Science Team can advise on suitable Training Subjects (images of simulations and false positives) and image display settings, and also on formatting the data ready for ingestion and display. A mandatory element of the training subjects is the production of large samples of simulated lenses. SPACE WARPS will provide resources to assist generating these simulations.
2. In **reconfiguring the site itself** ready for the new data. The DES SST will need to include new Spotter’s Guide images and text, modified tutorial content, and additional survey-specific site content; the SPACE WARPS Science Team can help with all of this.
3. In **maintaining the site** so that it continues to function and deliver correctly. This will involve technical support from the Zooniverse and SPACE WARPS science teams, but will also require the continued engagement of the wider collaboration by the SST in TALK. Since this social filter is a key part of the sample refinement, the latter may involve a significant time commitment.
4. In **running the SPACE WARPS analysis pipeline** (SWAPR) which will be the SPACE WARPS PIs responsibility. This will provide citizen selected candidates to be sent to the DES SST.

## 6 Resulting publications for SPACE WARPS-DES

### 6.1 Journal Papers

In return for the work outlined in Section 5 in setting up the new surveys, the SPACE WARPS PIs will nominate a core SPACE WARPS collaboration members as authors on **papers that present discovery of a lens or sample of lenses enabled by the SPACE WARPS system**. A “discovery” is defined by the announcement of the source(s) to the astronomical community in a journal paper. We would expect the SPACE WARPS author list to be a small number (approx. ten), primarily the Principal Investigators, a few others working on the ingestion of the new data or moderating TALK. All post-discovery follow-up papers would of course be exempt from this (unless individuals from SPACE WARPS team had contributed sufficiently such that the lead author wished to include them).

We request that authors of SPACE WARPS-enabled discovery papers should circulate drafts to the list of SPACE WARPS authors and, if possible, allow a minimum of two weeks to give time for comments. We also request that any papers based on SPACE WARPS enabled discoveries should cite the SPACE WARPS system papers. This policy document will be updated with the correct citations to the SPACE WARPS system papers when available.

SPACE WARPS runs an analysis pipeline (SWAPR) that will be tailored to the science goals of each new survey. Any large changes to the analysis code will be documented by the SPACE WARPS Science Team. The SPACE WARPS Science Team reserve the right to update the SPACE WARPS methodology papers.

### 6.2 Zooniverse LETTERS

Any SPACE WARPS collaboration member, simply by virtue of their Zooniverse registration, may write a Zooniverse Letter<sup>6</sup> describing their investigation of any lens candidate they find in SPACE WARPS. This, along with posts in TALK, is the primary means by which we expect SPACE WARPS-DES collaboration members (citizens participating in the

project) will communicate their findings to the rest of the astronomical community. The investigation of any SPACE WARPS images that are provided without world coordinate system (WCS) information will be necessarily limited but the SPACE WARPS Zooniverse LETTERS will contribute to the collective knowledge and understanding of the presented system(s). Zooniverse LETTERS are citable SPACE WARPS objects, and in some cases will appear listed on ADS<sup>7</sup>.

As SPACE WARPS classifications are a community wide activity, it is impossible to attribute the discovery of a candidate to a single community member, or group of members. Therefore, in recognition of their contribution to the SPACE WARPS project, SPACE WARPS community members will be listed (on their approval) on the SPACE WARPS members web page. This web page will be linked in every ensuing SPACE WARPS publication. If a community member makes a significant contribution e.g. in the further investigation of a lens candidate with modelling tools, they are strongly encouraged to write Zooniverse LETTERS. This may lead to them being invited to join journal publications by the lead author of a “discovery” publication.

## 7 Summary of Publication Guidelines

Any SPACE WARPS series and SPACE WARPS enabled discovery papers should include

- citations to the SPACE WARPS system papers, SPACE WARPS I & II
- a small number of SPACE WARPS authors proposed by the SPACE WARPS PIs (see 6.1).
- the collaboration should be acknowledged in the acknowledgement section with a link to the collaboration membership page (URL: to be confirmed when available).

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<sup>6</sup><http://letters.zooniverse.org>

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<sup>7</sup>To be confirmed.