

# Lensing galaxies in the CFHT Legacy Survey

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The Space Warps project enables citizen-science volunteers to search for gravitational-lens candidates by visual inspection of survey data. The first batch of discoveries consists of 56 new lens candidates from archival images of the CFHT Legacy Survey.

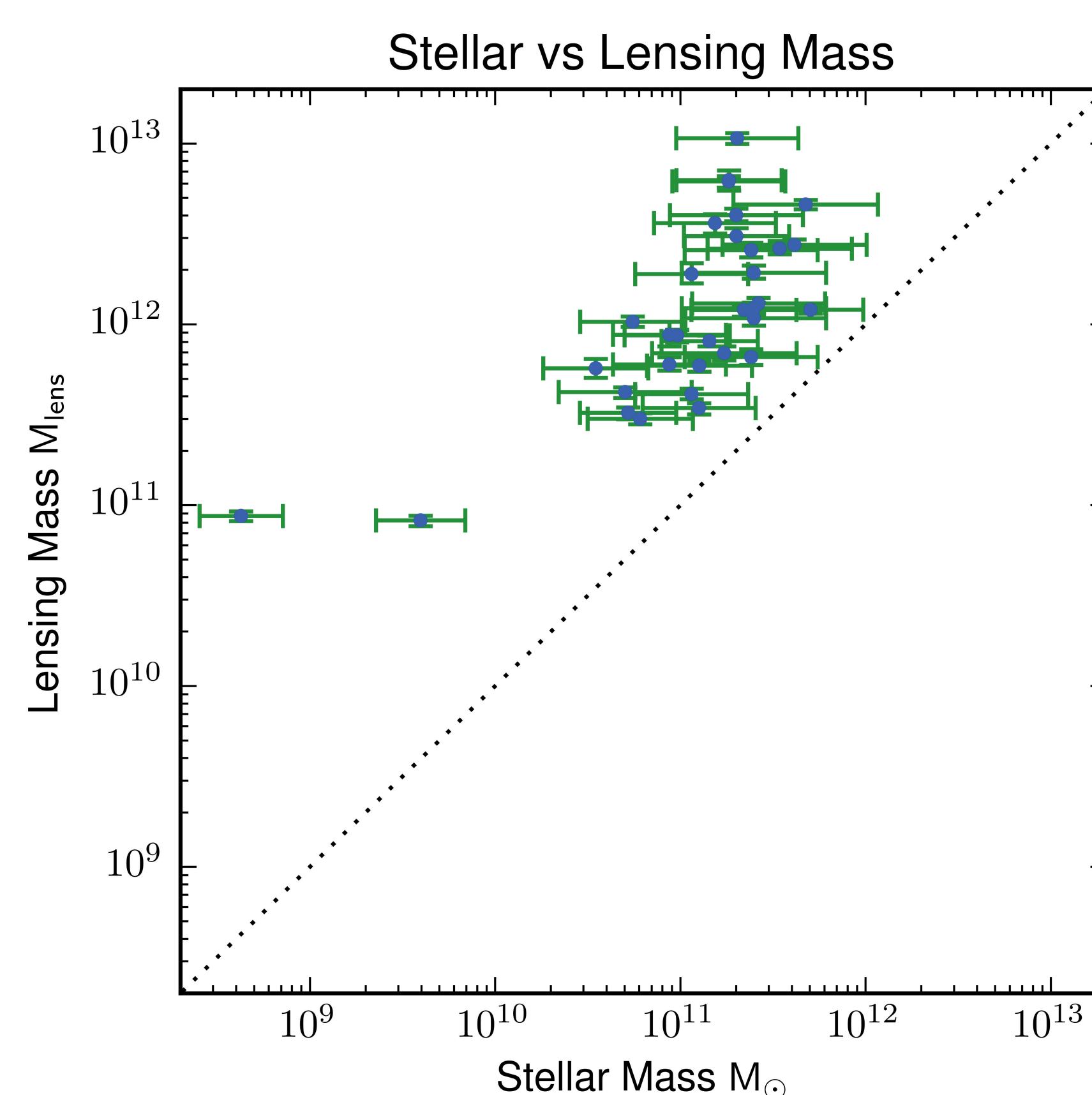
SpaghettiLens is a method to enable collaborative modeling of gravitational lenses and lens candidates. It's designed with simplicity in mind, such that it can be used by professionals and non – professional enthusiasts as well.

It's aimed to fill the void between the increasing amount of lens candidates that are and will be discovered and the demand for models of those. In particular, we try to motivate the more involved volunteers of citizen science projects like SpaceWarps to engage in a more demanding task, gravitational lens modeling.

In this work we present lens models of these candidates, produced collaboratively by experienced members of the volunteer community.

Preliminary results show the stellar-mass fraction in the candidate lensing galaxies to be of order 20 percent, with a decreasing trend for the most massive galaxies. Outliers may be non-lenses, as the sample has not yet been spectroscopically confirmed.

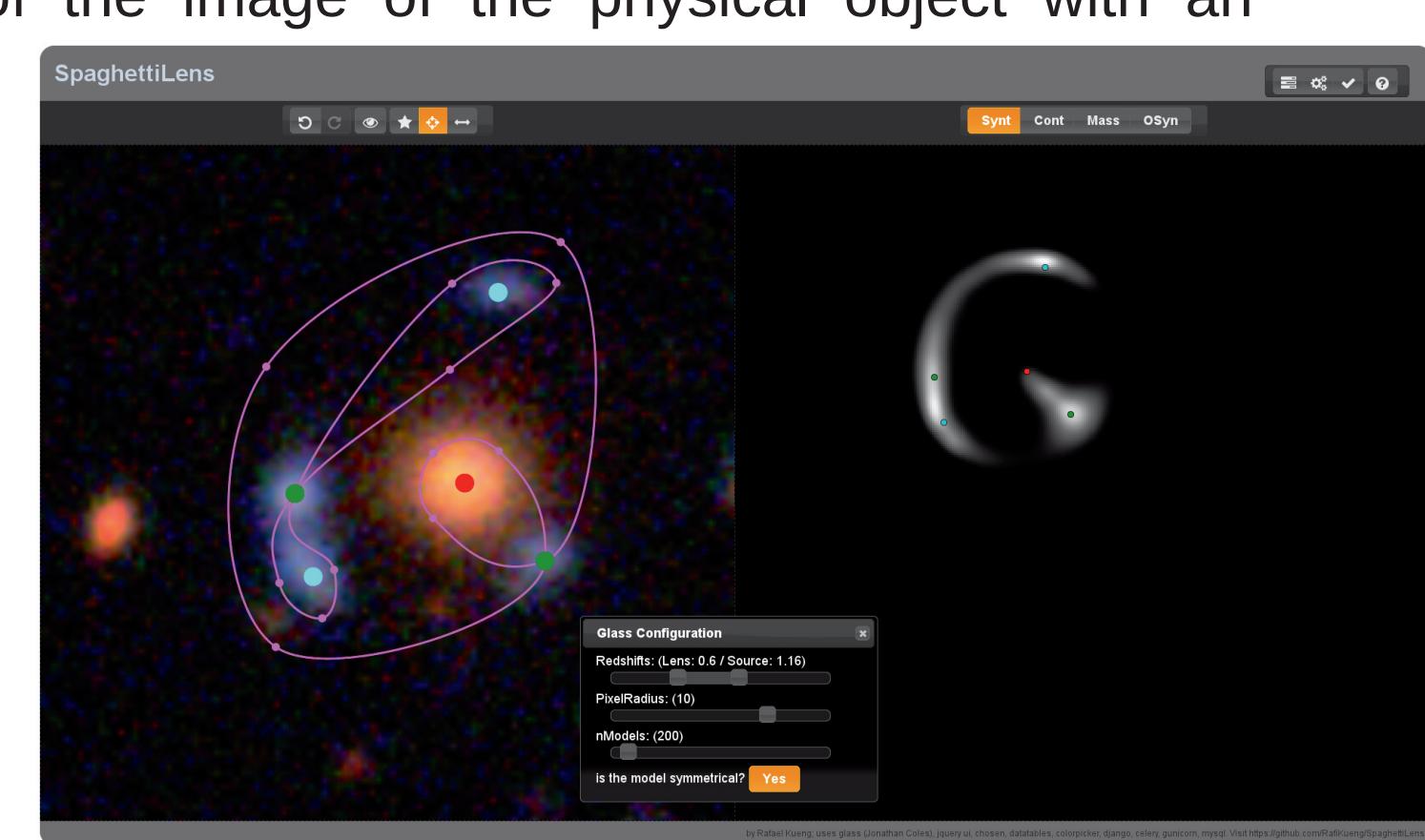
Space Warps and the CFHTLS lens candidates are introduced in Marshall et al (2015) and More et al (2015). Stellar population models by Ignacio Ferreras.



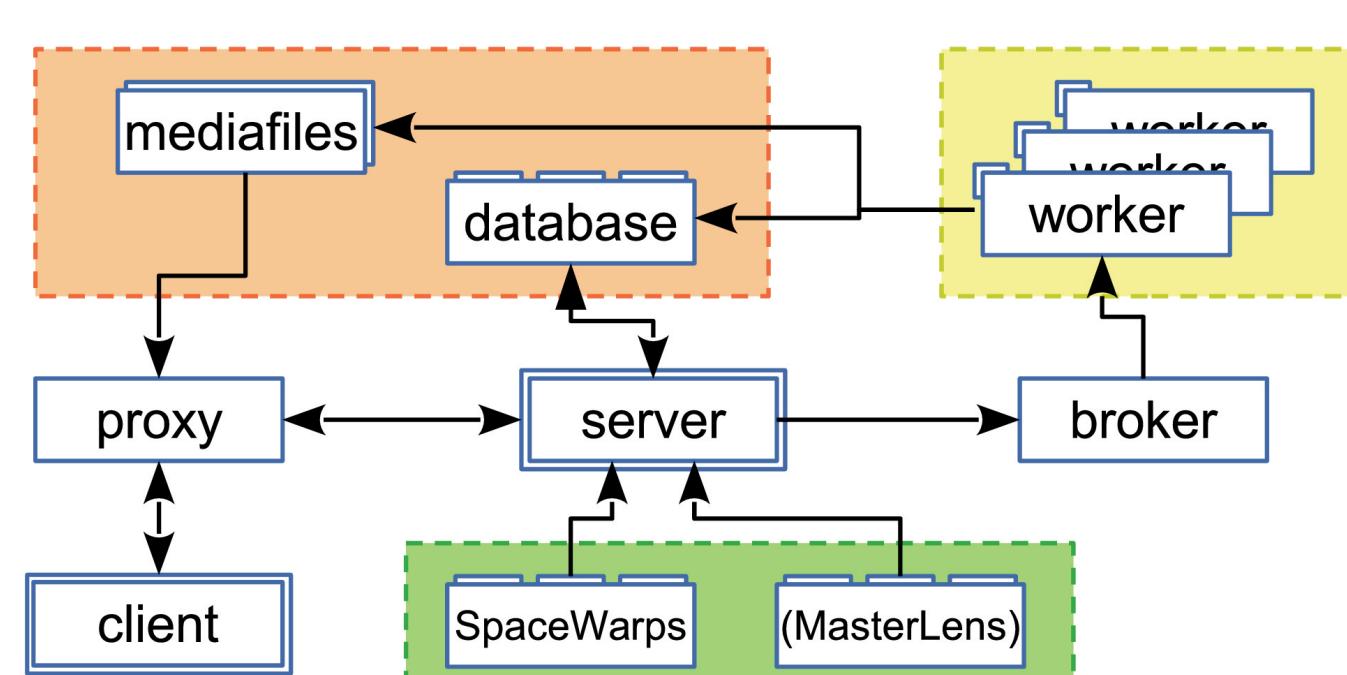
## SpaghettiLens



SpaghettiLens (<http://labs.spacewarps.org/spaghetti>) is a web based application. It builds upon an existing free form modeling program (GLASS), but allows to create models by sketching the expected arrival time surface and visually comparing the rendering of the resulting model to the original image. It's user interface shows a side by side comparison of the image of the physical object with an overlay of the users input and a rendered synthetic image of the generated model. Other output like the mass distribution or arrival time surface can also be consulted. When working on a model, a user enters an initial guess by sketching the arrival time surface.



SpaghettiLens is a classical client server application. The server can possibly access several remote data sources to get images, that can then be loaded into the UI and modeled. The actual task of creating models for a user input is distributed to dedicated worker nodes, generating the models and rendering them.



For more on SpaghettiLens, see Küng et al (2015).

## Acknowledgment

We thank Ignacio Ferreras for providing the stellar-population models used to estimate the stellar mass.

A special thank for all the SpaceWarps volunteers who help creating all the models.

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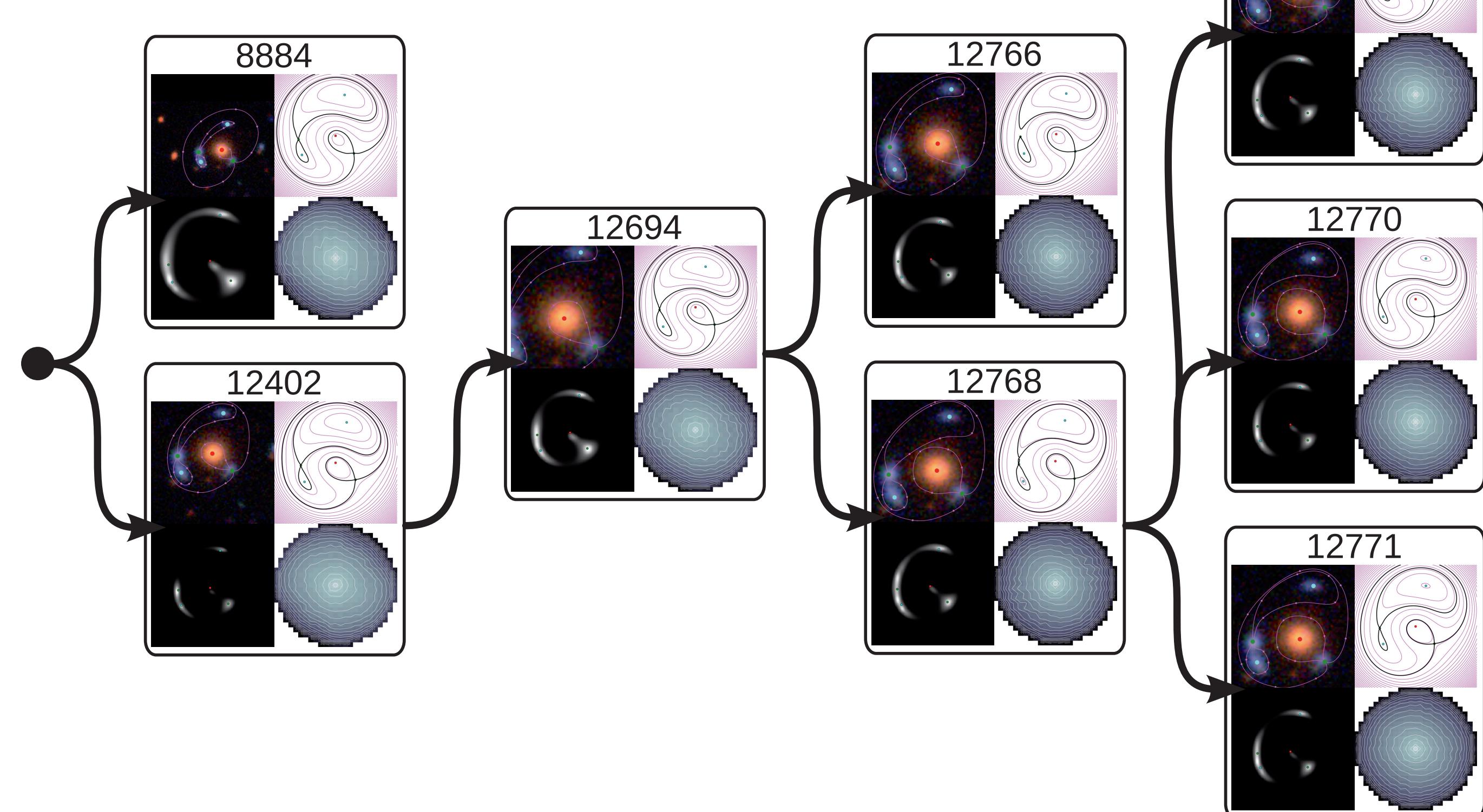
## Collaborative Modelling



Users creating models are encouraged to share and discuss their created models. The system generates links to models that can easily be passed around and for example posted to an Internet forum. (<http://talk.spacewarps.org/#/boards/BSW0000006>)

The discussion among the volunteers and with scientists helps to increase the skill of the modellers. The volunteers also can easily try to revise existing models shared by others. This leads to tree of models (like the one depicted below), that can be debated upon and pruned again in discussion.

Here is an example of a tree of models for the lens candidate SW05 J143454.4+522850



For further details on collaborative modelling strategies see <http://letters.zooniverse.org> on this topic.

## References

Küng et al.  
Gravitational lens modelling in a citizen science context  
03/2015, MNRAS, 447, 2170



More et al.  
Space Warps II. New Gravitational Lens Candidates from the CFHTLS Discovered through Citizen Science  
04/2015, arXiv:1504.05587



Marshall et al.; Space Warps: I. Crowd-sourcing the Discovery of Gravitational Lenses  
04/2015, arXiv:1504.06148

And even more

