Web application for the study of small Solar System bodies through stellar occultations

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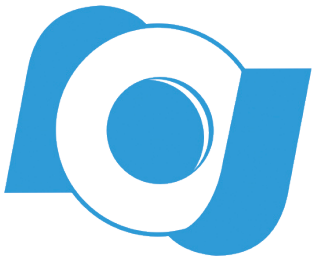


Observatório Nacional

Motivation and Objective

Motivation

- The physical and dynamic properties of small bodies provide important information to access the history and evolution of the Solar System.
- Currently, there are over 1 million small bodies registered at the MPC and the LSST will increase that number by a factor of 10.
- A powerful technique to study these objects is stellar occultation.

Objective

Develop, in collaboration with the LIneA IT team, a web application to analyze big data from large astronomical surveys using the stellar occultation technique.

The first use case: Dark Energy Survey (DES)

The DES has recorded 131,602 exposures ($\sim$ 8 million individual CCD images) during its six years of operation (2013 - 2019). The metadata of all DES CCD images were downloaded and incorporated into the web application.

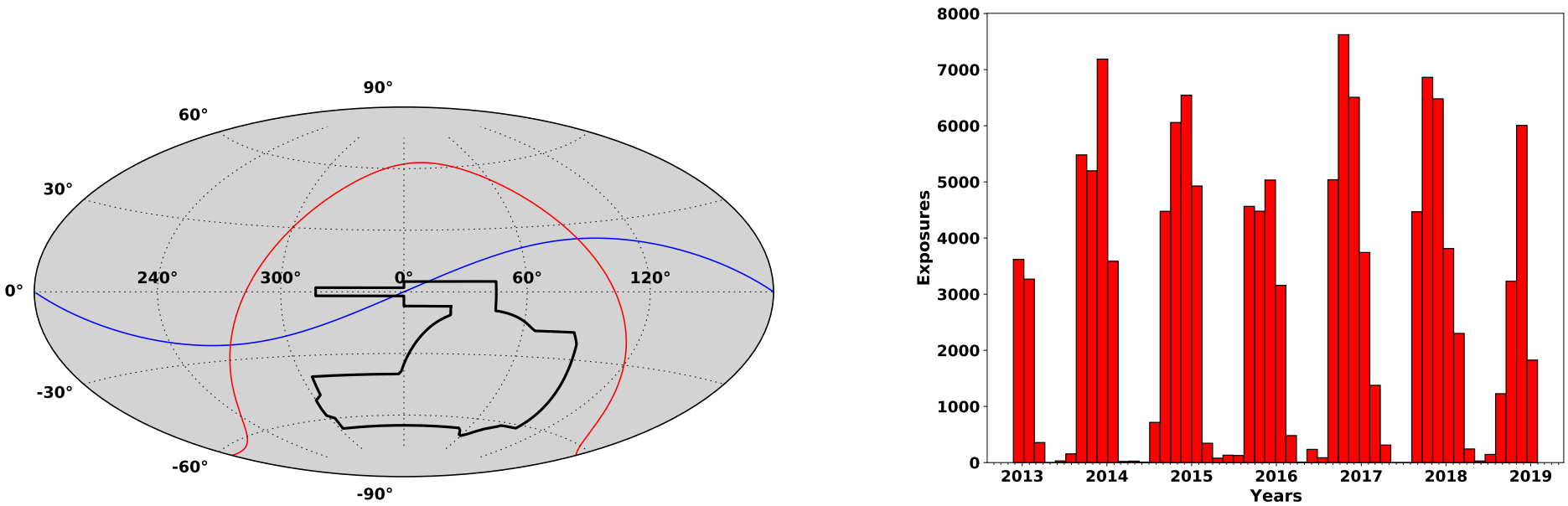


Figure 1: Left: DES Footprint (black line) projected on celestial sphere, showing also the galactic and ecliptic plane represented by red and blue lines respectively. Right: Distribution of DES exposures by year for the six year of operation of the survey.

Methodology

- We develop pipelines in Python to manage codes and services already developed.
- The web application was implemented in a high performance computing environment (machine up to 900 cores for processing).

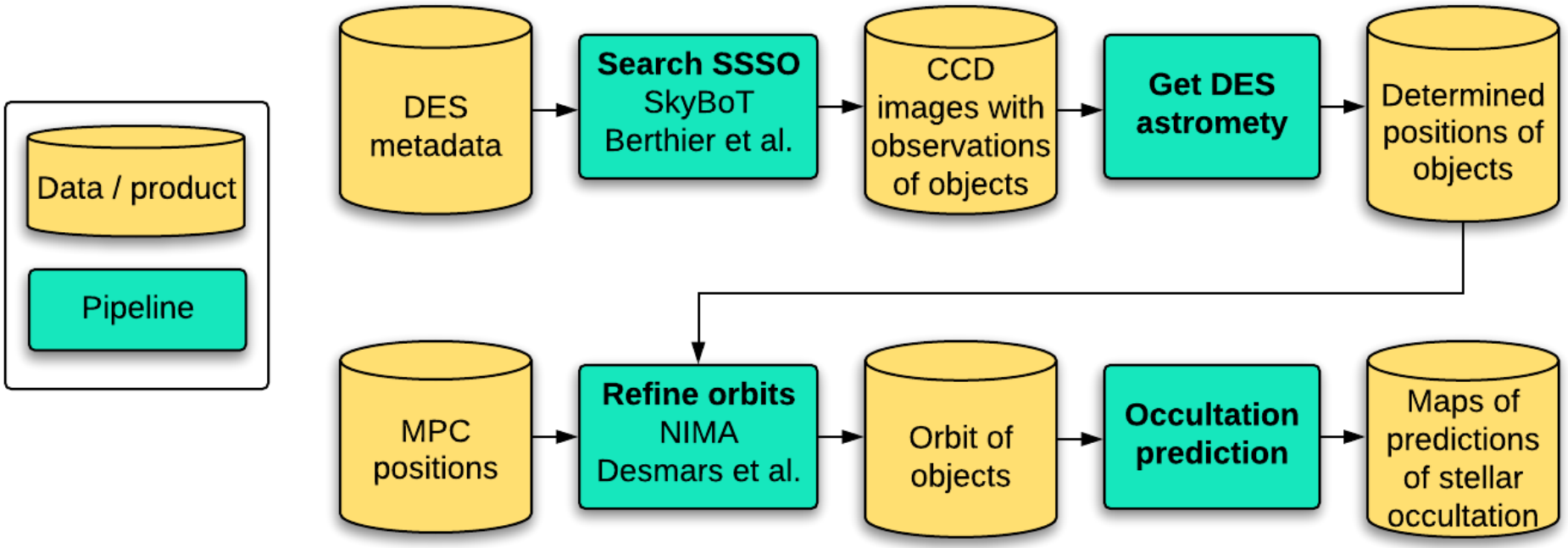
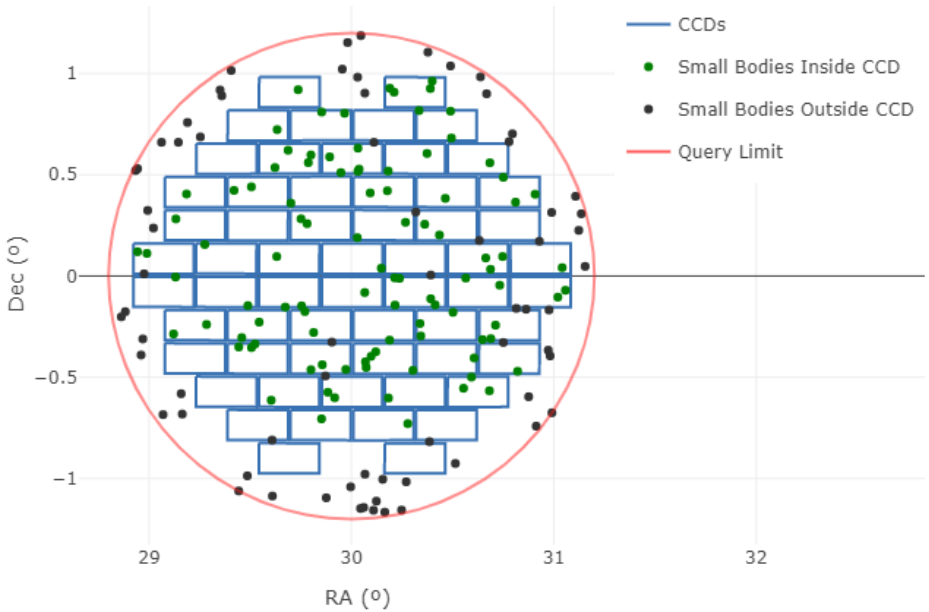


Figure 2: Flowchart of all processes for doing predictions of stellar occultation using DES images.

Identification of moving objects in images

- The web application efficiently manages the SkyBoT service (Berthier, J. et al., 2006) to identify moving objects in astronomical images.
- About 370,000 moving objects were identified in about 4.3 million DES CCD images.



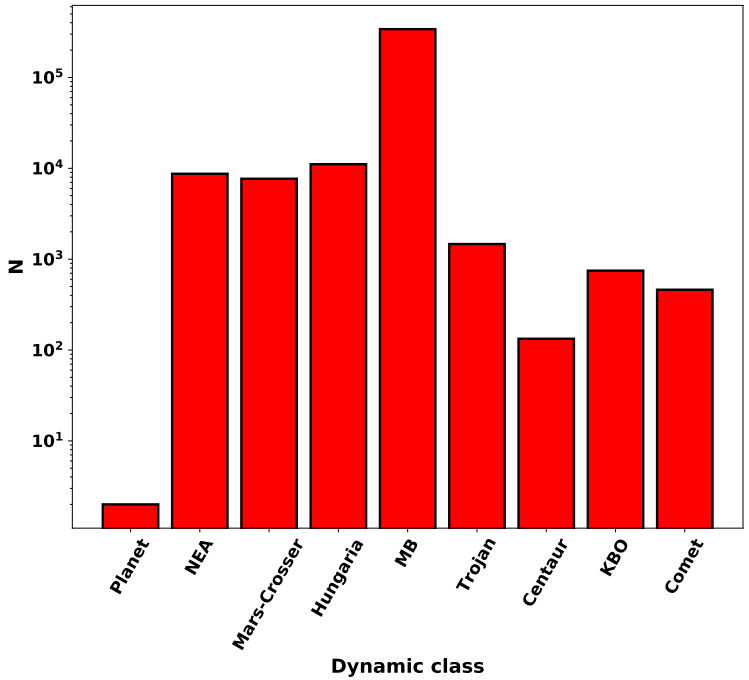


Figure 3: Left: Moving objects (green and black dots) identified in the FoV of a DES image. Right: Distribution of identified moving objects by dynamic class.

Astrometry

Two ways to do astrometry were implemented in the web application.

1. Using the Platform for Reduction of Astronomical Images Automatically (PRAIA; Assafin et al., 2011)
2. Using the DES catalogs with astrometric measurements for most of its images.

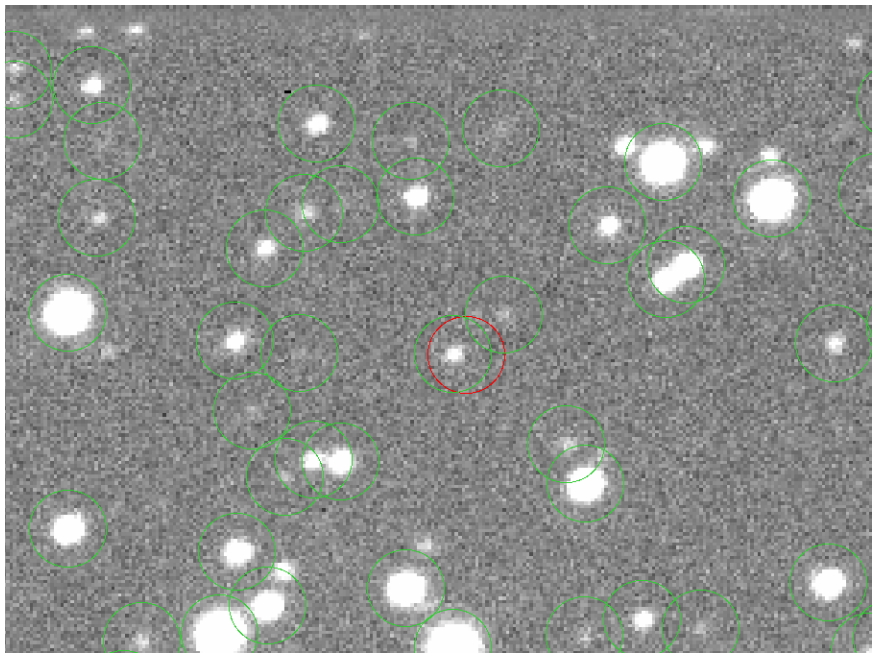


Figure 4: Part of a DES image, where the green circles represent the identified objects using the DES catalogs, and the red circle represents a moving object.

Main interface of the web application

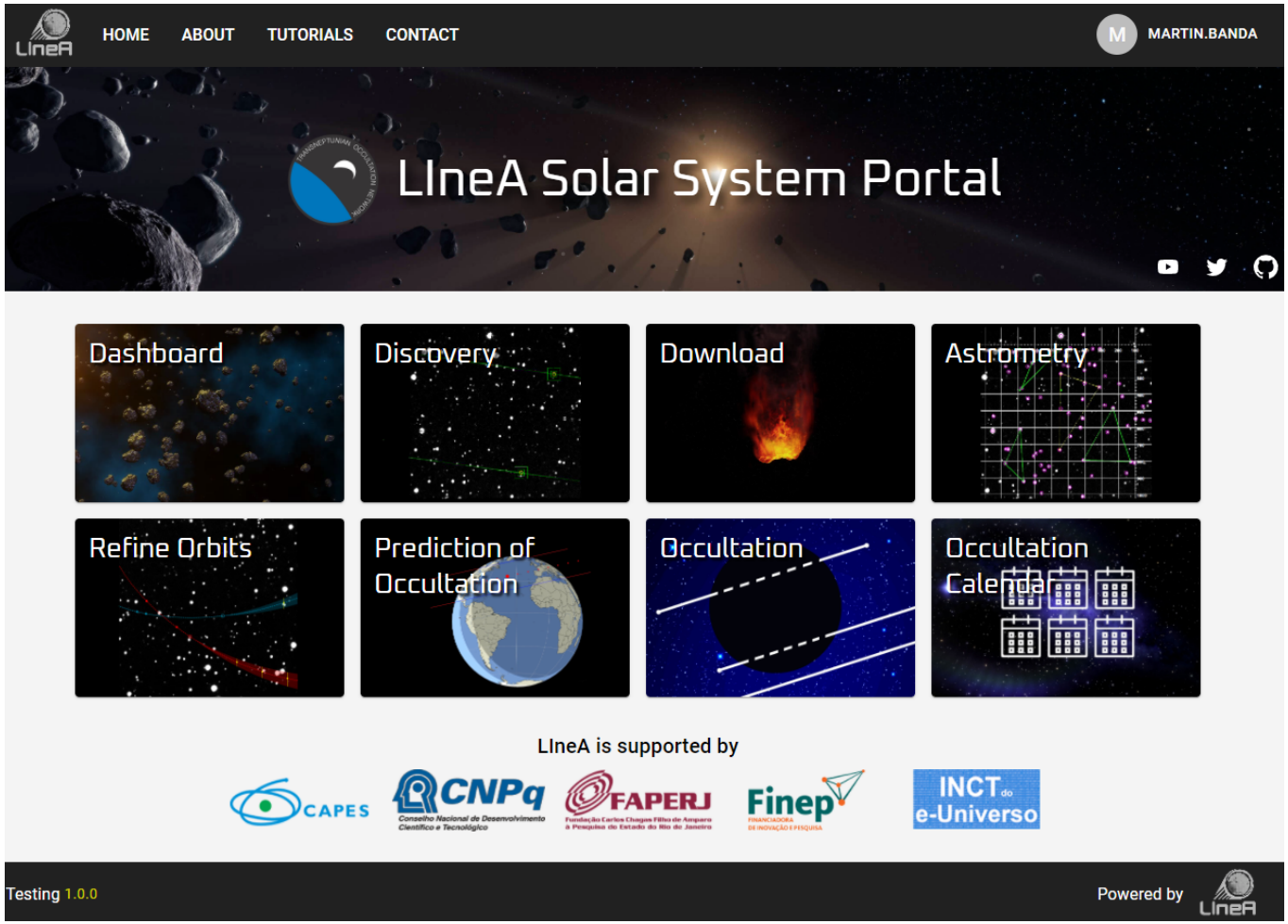


Figure 5: Landing page of the web application with each of its stages, from identification of moving objects (named Discovery) to publication of the occultation predictions.

Interface of the object identification stage

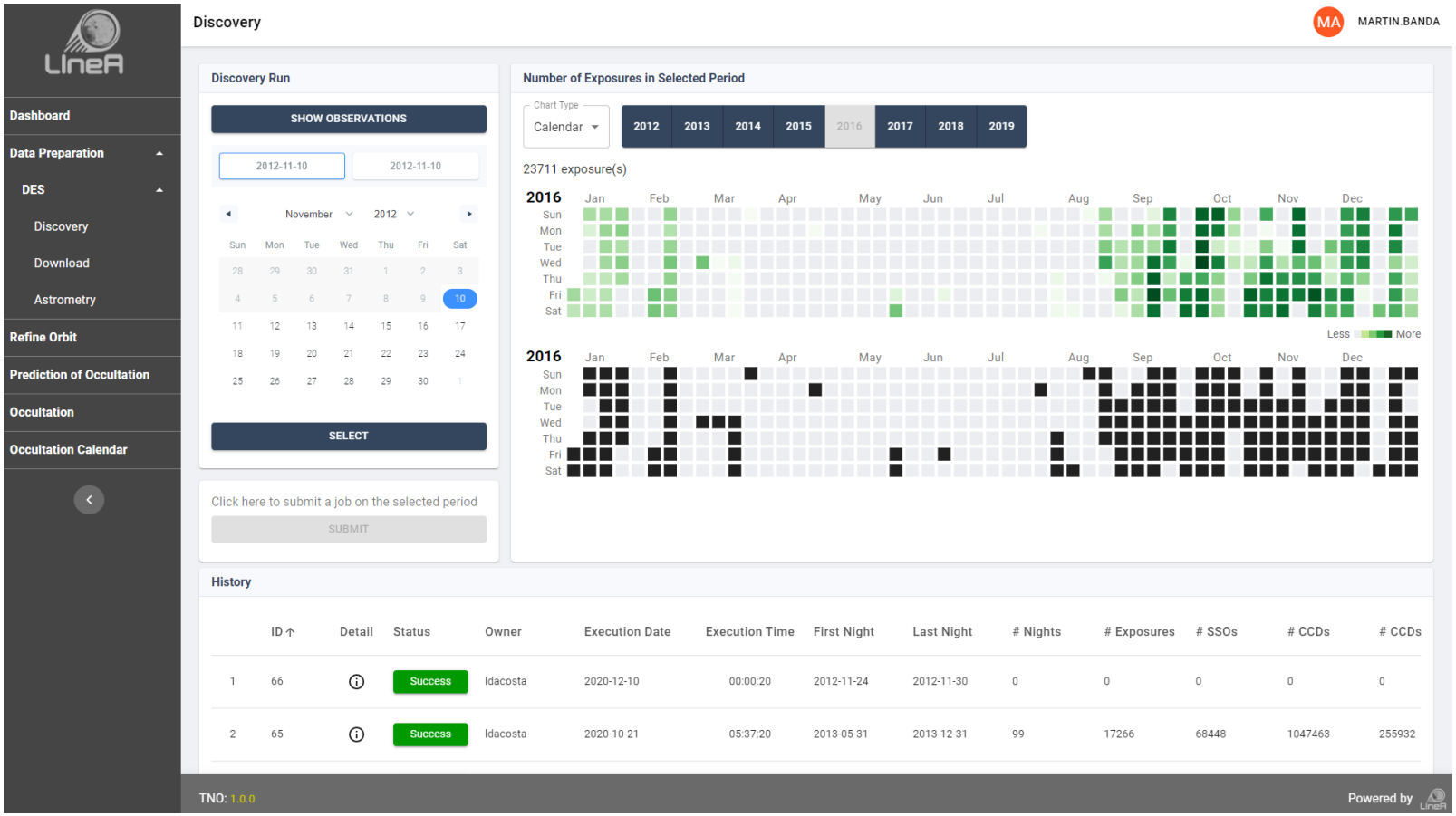


Figure 6: Interface of identification process. Here, the user defines a data range for identifying moving objects in DES exposures. The green squares represent the nights with DES observations and the black squares indicate if these observations have already been analyzed.

Comments and conclusion

- The methodology consolidated in Banda-Huarca, M.V. *et al.*, (2019). was the starting point for the development of the web application.
- The first version of the web application was finalized in march 2020. Then, several improvements (more efficient management of the object identification process, astrometry from DES catalogs, among others) have been implemented.
- We have finalized the restructuring of the orbit refinement and occultation prediction processes and now we are validating the results and organizing the best way to make prediction events available.
- We are getting ready for LSST which will provide about 15 TB of data per night.

References

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