



Improvement of NEO orbits by data mining of sky surveys



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OUTLINE

The improvement of the orbits of Near Earth Objects (NEO) can be drastically performed when a long enough of time of astrometric observations is available. In case of the detection of new objects, we know that any old observation can be very important for this improvement and consequently for the estimate of the risks of collision. Nowadays, the numerous sky surveys provide a huge amount of astronomical observational data for which their mining requires fast and reliable processing tools in order to detect and identify Solar System objects (SSO), in particular to seek for pre-discovery observations.

For this goal, we have developed a data mining tool within the Virtual Observatory framework - **AstroID** - that performs an identification of the SSO present in today's vast astronomical archives. The guideline of this work is to extract new astrometric observations of SSO from the archives in order to improve our knowledge of their orbits, especially for NEO. Furthermore, we can also obtain very valuable informations on the objects such as multi-wavelength magnitudes, mainly from visible to near infrared.

Keywords: Virtual Observatory, data mining, solar system, sky survey, DENIS

Applications to Planetology

Scientific Goals:

- Improving the orbits of NEO
 - New NEO detected -> Estimating the collision risk
- Other information on NEO: multiwavelength magnitudes (from V to NIR), etc.

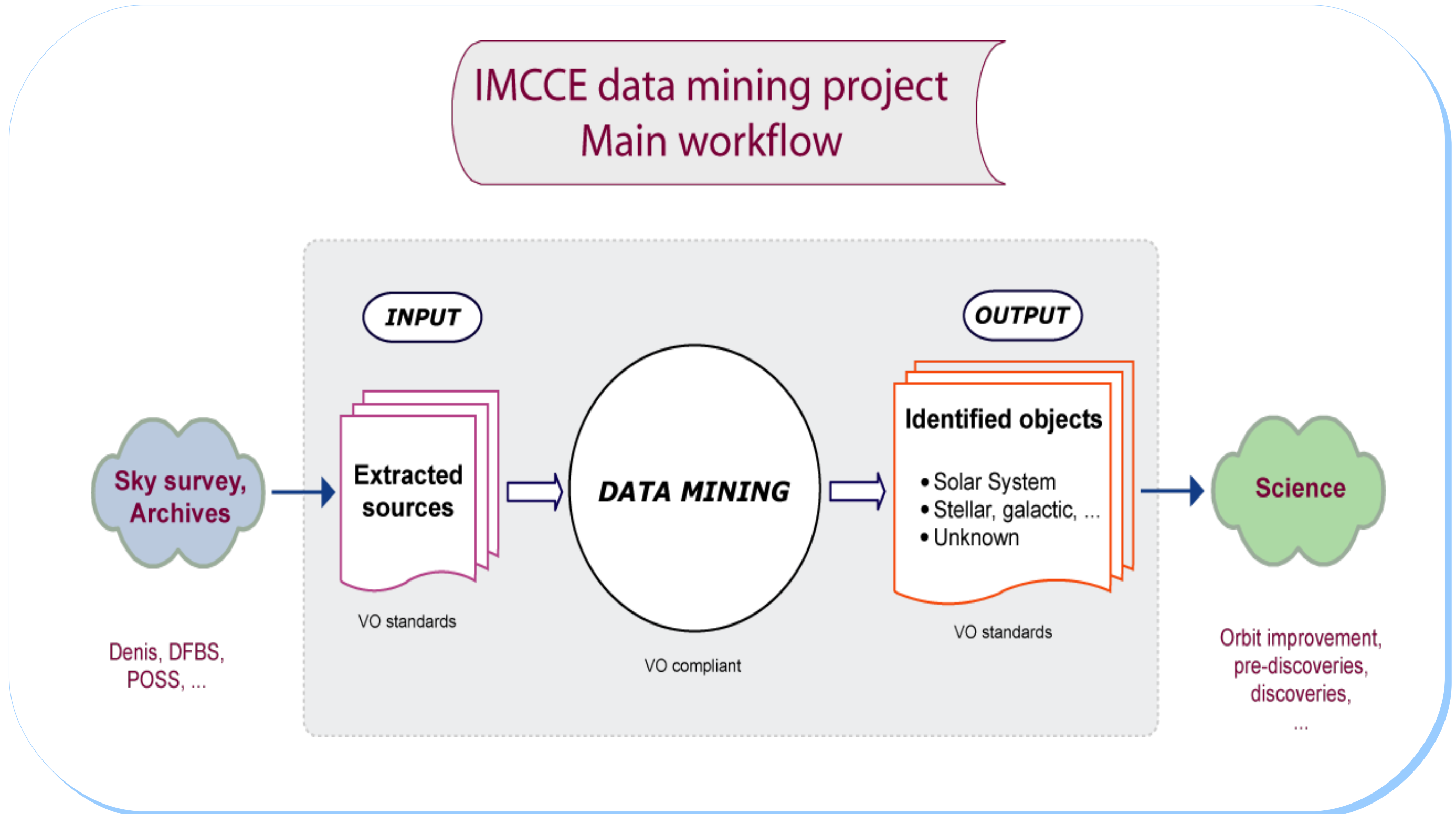
Source of Information:

- Sky Surveys
 - Data mining for NEO
 - Looking of old observations of newly detected NEO -> Pre-discoveries

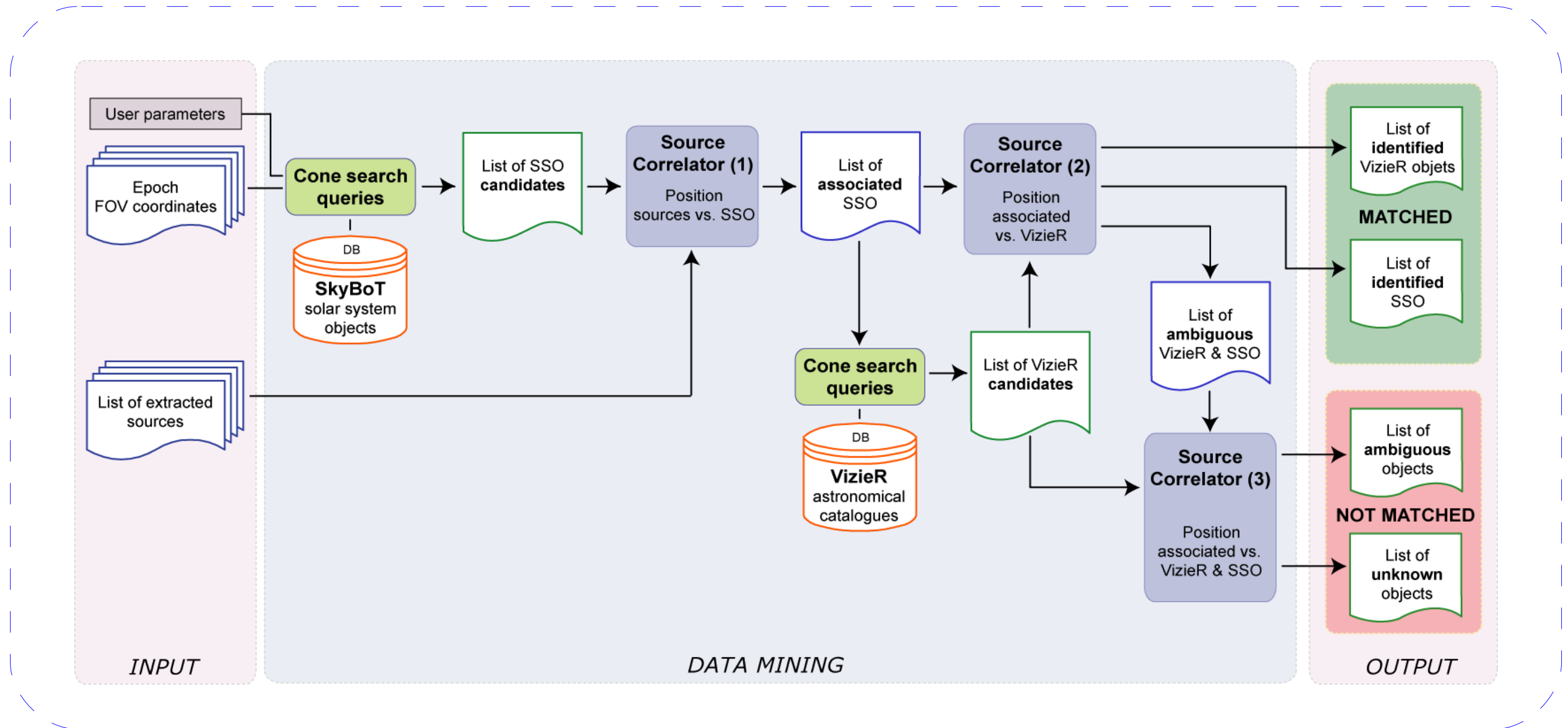
Our Solution:

- **AstroID**: a VO data mining tool of the IMCCE
 - Data mine of sky surveys, looking for asteroids and NEO in particular
 - VO workflow

Astroid, a IMCCE VO-Workflow (I)



Astroid, a IMCCE VO-Workflow (II)



AstroID, a IMCCE VO-Workflow (III)

The input of the pipeline consist in a list of the objects extracted from a set of images. The needed input data are the epoch, the equatorial J2000 coordinates of the sources and their magnitude. The data may be provided in VOTable or CSV document. Some user preferences may also be provided such as the correlation values in position and/or magnitude and the reference object catalogues to be used.

The output of the pipeline is composed of a set of lists (VOTable documents) containing the identified and unidentified sources with respect to the reference sources. By default, all the solar system objects, stellar, galactic, extragalactic, etc. objects which are known (i.e catalogued) are sought among the reference sources.

The extracted sources are cross-matched with catalogued celestial bodies using the VO web services **SkyBoT** (IMCCE) for the solar system and **VizieR** (CDS) for all other celestial objects. The observed positions of the sources (i.e the positions measured in the images) and the catalogued one (i.e taken in a catalogue or computed for solar system objects) are correlated using mainly two parameters: the position and the magnitude reliability between sources. In some cases, the apparent motion of the moving objects or other specific parameters may be used. The pipeline outputs a set of lists which provide:

- the known celestial bodies
- the unknown bodies
- the suspicious objects, artefacts, etc.

First Results: exploration of the DENIS survey (I)

Objective

We are performing of a complete study of the solar system bodies in DENIS in order to extend and complete the previous analysis made by Baudrand et al. (2001, 2004). This analysis had been based on 8,000 asteroids (whereas 340,000 are now known) and “only” 1,931 asteroids have been identified. In comparison, 12,219 asteroids have been found in the 2MASS survey which is very similar.

Science Case

We expect to increase up to 10,000 (or more) the number of asteroids in Denis that will be recovered. This will also increase the number of asteroids commonly found in Denis and 2MASS. At that time, only 75 asteroids are common to DENIS and 2MASS. These results will overlap and extend existing observations of asteroids from the visible to the near-IR where there exist important features arising from common mineralogies. These results will also provide an original set of astrometric positions of asteroids. In particular, pre-discovery positions of NEAs will be useful to improve our dynamical knowledge of these bodies.

First results

The table 1 shows the results of our preliminary analysis of the 5206 DENIS strips. We have achieved our goal of finding, at least, as much asteroids as 2MASS.

DEep Near Infrared Survey of Southern Sky

- ▶ European program: 1995 – 2001
- ▶ 1m telescope at ESO-La Silla
- ▶ I, J & K' spectral bands
- ▶ limiting magnitudes:
 - $I = 18.5, J = 16.5, K' = 13.5$
- ▶ Strategy of observations:
 - 5206 strips (RA fixed, 30° in DEC)
 - 180 frames $12' \times 12'$ per strip
- ▶ Astrometric accuracy: < 1 arsec.
- ▶ Photometric accuracy: < 0.2 mag.

First Results: exploration of the DENIS survey (II)

	* Final results for the 5,206 strips (all DENIS, April 07)	Mean by strip
Number of SSO observations		
Found (SkyBoT)	166,438	31.97
Correlated	20,810	4
Number of SSO bodies		
Found (SkyBoT)	97,882	18.80
Correlated	15,592	3
Number of NEA observations		
Found (SkyBoT)	1,902	0.37
Correlated	313	0.06
Number of NEA bodies		
Found (SkyBoT)	1,180	0.23
Correlated	230	0.0002

“Unknown” Objects (estimation): 7,700 -> future analysis (new SSO??)

* Unclassified source points in the DENIS survey after SSO correlation

Future Work

- **Going Fully VO-Compliant**
- **VO Catalogue of NEO found in DENIS**
- **VO Web Service:**
 - Single-image analysis -> linked to Aladin (CDS graphic VO tool)
 - Entire Sky Survey analysis (available for download)
- **VO Workflow:**
 - Standards inputs and outputs (VOTable)
 - VO standards