

# Report for 2012 from the Bordeaux IVS Analysis Center

*Patrick Charlot, Antoine Bellanger, Romuald Bouffet, Géraldine Bourda, Arnaud Collioud,  
Alain Baudry*

## Abstract

This report summarizes the activities of the Bordeaux IVS Analysis Center during the year 2012. The work focused on (i) regular analysis of the IVS-R1 and IVS-R4 sessions with the GINS software package; (ii) systematic VLBI imaging of the RDV sessions and calculation of the corresponding source structure index and compactness values; (iii) investigation of the correlation between astrometric position instabilities and source structure variations; and (iv) continuation of our VLBI observational program to identify optically-bright radio sources suitable for the link with the future Gaia frame. Also of importance is the 11th European VLBI Network Symposium, which we organized last October in Bordeaux and which drew much attention from the European and International VLBI communities.

## 1. General Information

The “Laboratoire d’Astrophysique de Bordeaux” (LAB), formerly Bordeaux Observatory, is located in Floirac, near Bordeaux, in the southwest of France. It is funded by the University of Bordeaux and the CNRS (“Centre National de la Recherche Scientifique”). VLBI activities are primarily developed within the M2A team (“Métrologie de l’espace, Astrodynamique, Astrophysique”).

The contribution of the Bordeaux group to the IVS has been mostly concerned with the maintenance, extension, and improvement of the International Celestial Reference Frame (ICRF). This includes regular imaging of the ICRF sources and evaluation of their astrometric suitability, as well as developing specific VLBI observing programs for enhancing the celestial reference frame.

In addition, the group is in charge of the VLBI component in the multi-technique GINS software package [1] as part of a collaborative effort within the French “Groupe de Recherches de Géodésie Spatiale” (GRGS) to combine VLBI and space geodetic data (SLR, GPS, and DORIS) at the observation level. This effort also involves space geodesy groups in Toulouse, Grasse, and Paris.

## 2. Description of the Analysis Center

The Bordeaux IVS group routinely analyzes the weekly IVS-R1 and IVS-R4 sessions with the GINS software package. During the past year, weekly normal equations for all such sessions in 2012 (with six-hour EOP resolution) have been produced and integrated into the multi-technique solutions derived by the GRGS within the framework of the “Combination at the Observation Level” (COL) Working Group. The CONT08 and CONT11 sessions were also analyzed in the same way.

The group is also focused on imaging the ICRF sources on a regular basis by systematic analysis of the data from the RDV sessions, which are conducted six times a year. This analysis is carried out with the AIPS and DIFMAP software packages. The aim of such regular imaging is to characterize the astrometric suitability of the sources based on the so-called “structure index”, and to compare source structural evolution and positional instabilities. Such studies are essential for identifying sources of high astrometric quality, which is required, for example, for the future Gaia link.

### 3. Scientific Staff

During the past year, the group was strengthened by the arrival of a Ph. D. student, Romuald Bouffet. In all, six individuals contributed to IVS analysis and research activities during 2012. A description of what each person worked on, along with the time spent on it, is given below.

- Patrick Charlot (20%): overall responsibility for Analysis Center work and data processing. His research interests include the ICRF densification, extension, and link to the Gaia frame, studies of source structure effects in astrometric VLBI data, and astrophysical interpretation.
- Antoine Bellanger (80%): engineer with background in statistics and computer science. His tasks are to process VLBI data with GINS and to develop procedures and analysis tools to automate such processing. He is also the Web master for the M2A group.
- Romuald Bouffet (30%): Ph. D. student from University of Bordeaux whose thesis is focused on the study of the relationship between radio source structure and position instabilities. To this end, he uses astrometric data and VLBI images produced from IVS sessions.
- Géraldine Bourda (50%): astronomer in charge of developing the VLBI part of GINS and responsible for the analysis results derived from GINS. She also leads a VLBI observational program for linking the ICRF and the future Gaia frame.
- Arnaud Collioud (100%): engineer with background in astronomy and interferometry. His tasks are to image the sources in the RDV sessions using AIPS and DIFMAP, to develop the Bordeaux VLBI Image Database and the *IVS Live* tool, and to conduct VLBI2010 simulations.
- Alain Baudry (10%): radioastronomy expert with specific interest in radio source imaging and astrometric VLBI. Professor Emeritus and under a part-time ESO contract.

### 4. Analysis and Research Activities during 2012

As noted above, a major activity of the Bordeaux group consists of imaging the sources observed during the RDV sessions on a systematic basis. During 2012, two such sessions were processed (RDV86 and RDV88), resulting in 333 VLBI images at either X or S band for 159 different sources. The imaging work load has been shared with USNO since 2007 (starting with RDV61): the USNO group processes the odd-numbered RDV sessions while the Bordeaux group processes the even-numbered ones. The VLBI images are used in a second stage to derive structure correction maps and visibility maps along with values for structure indices and source compactness (see [2, 3] for a definition of these quantities) in order to assess astrometric source quality. All such information is made available through the Bordeaux VLBI Image Database (BVID)<sup>1</sup>. At present, the BVID comprises a total of 3517 VLBI images for 1110 different sources (with links to an additional 7851 VLBI images from the Radio Reference Frame Image Database of USNO at either S, X, K, or Q band) along with 11,368 structure correction maps and as many visibility maps.

In the past year, a collaboration was established with the Paris Observatory Analysis Center in order to look for correlation between astrometric instabilities and source structural variations. The study is focused on a sample of 68 sources with VLBI images available at 20 epochs or more over the

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<sup>1</sup>The BVID may be accessed at <http://www.obs.u-bordeaux1.fr/BVID>

period 1994–2003. The astrometric data consists of all IVS sessions conducted over the same period, analyzed in a way that provides source positions on a monthly basis. A comparison of the time series of source positions with the relative motion of the brightness centroid (as derived from the available VLBI images) indicates similar trends in the evolution of the astrometric and brightness centroid positions. Based on this initial comparison, and awaiting quantitative assessment, an explanation of VLBI source position instabilities in terms of structural variations is thus favored [4].

Additionally, the work to identify and characterize appropriate radio sources to align the ICRF and the future Gaia optical frame was pursued. On the observational side, a total of 119 optically-bright radio sources with high astrometric quality was observed with the combined Very Long Baseline Array (VLBA) and European VLBI Network (EVN) during a dedicated 72-hour astrometric VLBI session conducted in May 2012. These sources were selected from an initial sample of 395 optically-bright weak radio sources, further reduced to 119 sources after assessing their VLBI detectability and astrometric suitability (see [5] for details of the project). Data from this session are being correlated. In parallel to this observational work, all ICRF2 sources (excluding those observed only as part of the VLBA Calibrator Survey) were assessed in terms of optical magnitude and astrometric suitability. This led to the identification of an additional 195 transfer sources, making altogether a total of 314 such sources available for the Gaia link. As a further step, a proposal was submitted to IVS to monitor the position stability and structure of the 195 ICRF2 transfer sources, some of which also require improvement in position accuracy.

## 5. Dissemination and Outreach

The highlight from the past year was the organization of the 11th EVN symposium by the Bordeaux VLBI group. The purpose of the symposium was to share and publicize the latest scientific results and technical developments from VLBI, space VLBI, and e-VLBI. The symposium took place in Bordeaux from the 9<sup>th</sup> to the 12<sup>th</sup> of October and was attended by a total of 122 participants from 47 institutes in 19 countries worldwide. The program of the meeting consisted of 71 oral presentations and 43 posters. Of particular interest to the IVS community was the session entitled “Astrometry and planetary science”. The program also comprised an EVN Users Meeting to foster interaction between the EVN users and the EVN organization. Further details may be found at the symposium Web page available at <http://evn2012.obs.u-bordeaux1.fr/>.

The *IVS Live* Web site [6], dedicated to monitoring IVS sessions and viewing VLBI images of the observed sources, was updated on a regular basis during 2012. It now includes 5302 IVS sessions and more than 1600 sources. The Web site was also enhanced with a few features, including the addition of a “webcams” page. Monitoring of the connections indicates that there were more than 800 visits from around the world (47 countries) during 2012, 70% of which originate from different individuals. On the other hand, the Bordeaux VLBI Image Database was accessed from 39 countries, with more than 900 connections, half of which are from different individuals.

## 6. Outlook

Our plans for the coming year are focused on moving towards operational analysis of the IVS-R1 and IVS-R4 sessions with the GINS software package. Imaging of the RDV sessions and evaluation of the astrometric suitability of the sources will continue along the same lines. On the observational side, the immediate plan will be to analyze the astrometric data that we acquired

about the 119 Gaia transfer sources identified from our program (see Section 4), after correlation. Following our proposal, we also expect the IVS to strengthen observations for the 195 ICRF2 transfer sources identified so far, especially after the launch of the Gaia satellite in Fall 2013. To complete such identification, we would like to characterize the optical magnitude and astrometric suitability of the VLBA Calibrator Survey sources as well. Finally, we expect to contribute to the work towards the next realization of the ICRF because two of us were appointed to the Working Group in charge of this task at the last IAU General Assembly in August 2012.

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