

# Bordeaux Observatory Analysis Center Report

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## Abstract

This report summarizes the activities of the Bordeaux Observatory Analysis Center in 2008. During this period, we continued our VLBI imaging activity and produced a total of 581 VLBI maps by processing three RDV sessions. Structure indices and source compactness were derived from these images to assess the astrometric source quality. A pipeline is also being developed to model-fit the VLBI structures in an automatic way and extract relevant physical information for astrophysics. Other activities focused on regular analysis of the IVS-R1 and IVS-R4 sessions and simulations to study the imaging capabilities of the next generation VLBI system. On the observational side, we further pursued our project to identify new reference frame sources for the link with the future Gaia frame, and we imaged 105 weak candidate sources for this link. Plans for 2009 follow the same analysis and research lines.

## 1. General Information

The Bordeaux Observatory is located in Floirac, near the city of Bordeaux, in the southwest of France. It is funded by the University of Bordeaux and the CNRS (National Center for Scientific Research). VLBI analysis and research activities are primarily developed within the M2A group (“Métrologie de l’espace, Astrodynamique, Astrophysique”).

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

In addition, the group is in charge of the VLBI component in the multi-technique GINS software package [1, 2] 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, DORIS) at the observation level. This effort also involves space geodesy groups in Toulouse, Grasse, and Paris.

## 2. Description of Analysis Center

The Bordeaux Observatory Analysis Center routinely analyzes the weekly IVS-R1 and IVS-R4 sessions by using the GINS software package. Current work in this area includes the testing of the recently released Linux version of GINS (GINS-PC) and the development of operational procedures. In addition, specific solutions targeted to the construction of the ITRF2008 have been produced in the framework of the GRGS multi-technique combination at the observation level.

Another activity is focused on producing VLBI maps of the ICRF sources by analysis of data from the RDV sessions. This analysis is conducted with the AIPS and DIFMAP calibration and imaging 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 especially important in the framework of the ongoing work for the realization of the next ICRF by a joint IAU/IVS/IERS working group.

The Bordeaux group is also involved in the VLBI2010 activities and as such was tasked to

develop simulations of source structure maps to evaluate the imaging capabilities of the next generation VLBI system and its potential for modeling source structural effects on a routine basis.

### 3. Scientific Staff

The IVS group in Bordeaux comprises the following six individuals who are involved either part-time or full-time in VLBI analysis and research activities, as described 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 main role is to conduct initial VLBI data processing and to develop analysis tools as needed. He is also the Web master for the M2A group.
- Géraldine Bourda (40%): post-doc fellow funded by the French space agency (CNES). She is in charge of the VLBI analysis with GINS for combining space geodesy data at the observation level. She also leads an observational program for linking the ICRF and the Gaia frame.
- Arnaud Collioud (100%): engineer with background in astronomy and interferometry. His tasks are to process the RDV sessions with AIPS and DIFMAP to image the sources, to maintain the Bordeaux VLBI Image Database (BVID), and to develop VLBI2010 simulations.
- Ming Zhang (20%): post-doc fellow funded by the CNRS (in the group since October 2008). His work is targeted towards finding automatic ways to model-fit VLBI structures and extract physical information with the aim of studying the evolution of the sources from the BVID.
- Alain Baudry (10%): radioastronomy expert with specific interest in radio source imaging and astrometric VLBI.

### 4. Analysis and Research Activities during 2008

As noted above, a significant portion of our activity consists of imaging the sources observed during the RDV sessions on a systematic basis. During the past year, three such sessions were processed (RDV66, RDV68, and RDV70), resulting in 581 VLBI images at either X or S band for 215 different extragalactic sources. The imaging work load has been shared between USNO and Bordeaux Observatory 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 to derive structure correction maps and visibility maps along with values for structure indices and source compactness (see [3, 4] for a definition of these quantities). These indicators are useful for categorizing the sources according to their structures and identifying those that have the highest astrometric quality (e.g. for defining the next ICRF). All such information is made available through the recently-opened Bordeaux VLBI Image Database (BVID)<sup>1</sup>. At present, the BVID comprises a total of 1530 VLBI images (with links to an additional 6820 VLBI images from the Radio Reference Frame Image Database (RRFID) of the USNO, at either S, X, K or Q band) along with 8350 structure correction maps and as many visibility maps.

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

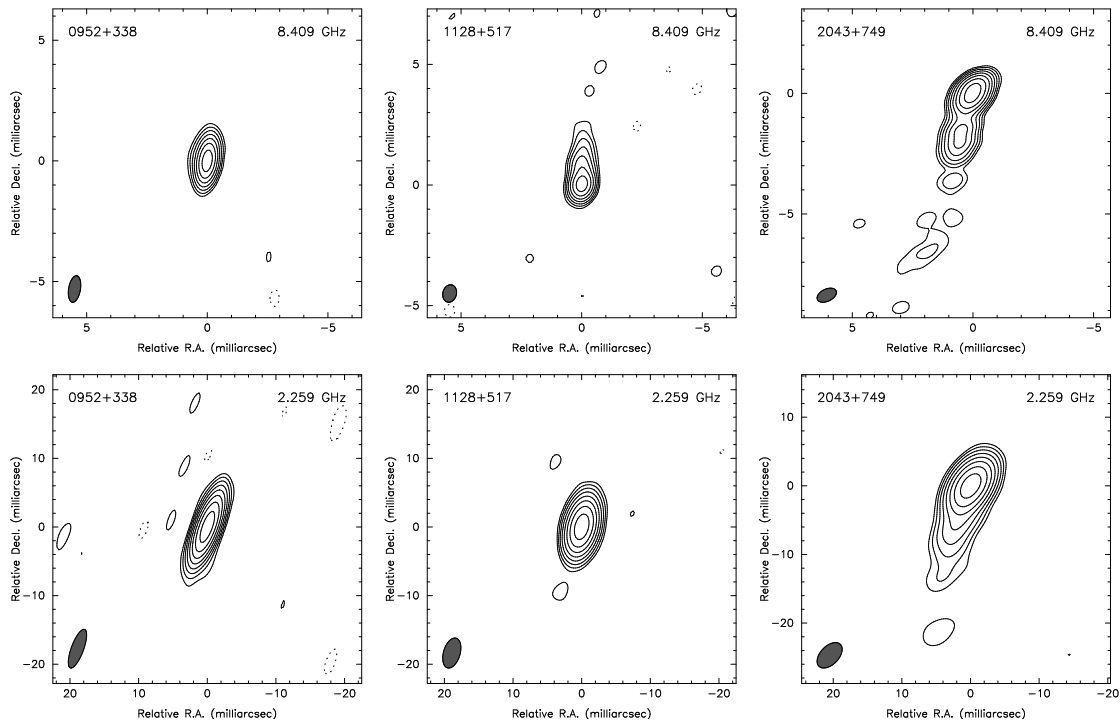


Figure 1. VLBI images of three candidate sources for linking the ICRF and the future Gaia frame. The total flux density of these sources is 50, 37, and 181 mJy at X band (upper panels) and 72, 114, and 202 mJy at S band (lower panels). Contour levels in the images are drawn from 0.5% or 1% of the peak brightness.

Additional work aimed at studying the evolution of these structures over time was also recently initiated to exploit the BVID for astrophysics. For this purpose, a pipeline is being developed to model-fit VLBI structures in an automatic way and extract physical information. Initial results show that the program works out fairly well for simple VLBI structures, but for extended or complicated structures, the fitted models could be degenerate or erroneous, thereby still requiring manual care. Despite this limitation, it is anticipated that this pipeline, when fully operational, should save a lot of time in the modeling of the thousands of VLBI structures contained in the BVID.

During the past year, our multi-stage VLBI observational program to identify and characterize new sources to link the ICRF and the future Gaia frame was also pursued further. As reported in [5], we detected 398 candidate sources for this link based on initial observations with the European VLBI Network (EVN). The second stage of the program, aimed at imaging these sources, began in March 2008 with an observation of 105 candidates using a 16-station network combining the EVN and the Very Long Baseline Array. All 105 sources have been successfully imaged from these data, a large portion of which show compact structures suitable for precise astrometry (see Fig. 1 for a sample of images). Future steps will consist of imaging the remainder of these sources and determining accurate astrometric positions for the most promising candidates.

Studies of the imaging capabilities of the VLBI2010 system continued during 2008 with focus on weaker sources to supplement the results previously obtained for high-SNR sources [6]. The simulations for both weak and strong sources demonstrate that the standard hypothetical 16-

station network of the VLBI2010 system is generally well-suited to producing high-quality images but fails to recover extended structures for far south sources due to the lack of short baselines in the Southern Hemisphere. Further tests showed that adding two stations at carefully selected locations mitigates that problem and improves the recovery of extended structures, giving simulated images at southern declinations that have a quality comparable to those for northern sources.

## 5. Outlook

For the year 2009, our plans include the following:

- Keep on analyzing the new IVS-R1 and IVS-R4 sessions as they become available and move towards operational analysis with GINS.
- Continue the processing of the RDV sessions in cooperation with USNO to monitor the X- and S-band structural variability of the ICRF sources and evaluate their astrometric suitability based on the structure index and source compactness criteria.
- Make our new source maps, structure correction maps, structure index and source compactness indicators available through the Bordeaux VLBI Image Database (BVID).
- Finalize the pipeline to model-fit VLBI structures in an automatic way and start massive processing of the BVID data with this pipeline.
- Contribute to the realization of the next ICRF, focusing on the selection of defining sources and the identification of unstable sources from the structural information in the BVID.
- Pursue further our VLBI observational program to identify and characterize new sources to link the ICRF and the future Gaia optical frame.
- Generate structure correction maps from simulated VLBI2010 images and assess the accuracy of the structural corrections derived from these images.

## References

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