RDV Processing Using Fourfit

David Gordon[1], Roger Cappallo[2], Mike Titus[2]

[1] NVI, Inc./NASA Goddard Space Flight Center, Greenbelt, MD, USA
[2] MIT Haystack Observatory, Westford, MA, USA

Introduction

VLBA geodetic/astrometric sessions have been processed using the NRAO *AIPS* package since 1995. These include the RDV and earlier geodesy sessions, the VLBA Calibrator sessions, and the K/Q astrometry sessions. *AIPS* was used very successfully for these. For example, the use of 168 *AIPS*-processed sessions in ICRF2 resulted in a much lower noise floor and accounts for ~2/3 of the ICRF2 sources.

The VLBA used a hardware correlator from 1994 until late 2009, when it began using the *difx* software correlator. In 2011, updates to *difx* allowed the VLBA *difx* output to be processed through the Mark4 path, using program *difx2mark4* to convert it into Mark4 format, and *fourfit* for the fringing. In comparison to *AIPS* fringing, *fourfit* has several advantages. Since it can fringe all the channels in a band coherently, it should be more sensitive by SQRT(N), where N is the number of channels, usually 4 in the RDV sessions. Also, *fourfit* is part of the Haystack *HOPS* package, which was designed for geodetic processing and has many useful diagnostic tools, whereas *AIPS* was designed for radio astronomy data processing and imaging. Another advantage is that *difx* can now extract phase cal phases which *fourfit* can apply.

Initial attempts to *fourfit* fringe an RDV session were made at USNO and Haystack with limited success. Successful *fourfit* fringing of the RDV's was subsequently made possible by considerable debugging of various problems and software fixes to *difx2mark4* and *fourfit* made at Haystack Observatory. All six RDV sessions from 2011 have now been fringed using *fourfit* and submitted to IVS. We will continue to use this method of processing for all future RDV's. The following comparisons show the improvements to be gained by this switchover.

Comparison of AIPS and Fourfit Versions

Below is a comparison of the processing statistics for 5 RDV sessions in 2011 that were processed with both *AIPS* and *fourfit*. The *fourfit* versions have an average of 7.5% more good observations in the *Solve* solutions. However, the *Solve* postfit residuals are larger for the *fourfit* versions, probably an indication that the delay formal errors were not properly computed (underestimated) by *AIPS*.

	RDV85 AIPS/fourfit	RDV86 AIPS/fourfit	RDV87 AIPS/fourfit	RDV88 AIPS/fourfit	RDV89 AIPS/fourfit	All AIPS/fourfit
# Stations*	15	15	18	12	16	
# Obs. Scheduled*	16,984	15,954	15,673	9,696	16,419	74,726
# Obs. in Database	16,510/16,566	15,889/15,739	15,305/15,305	9411/9492	15,646/16,218	72,761/73,320
# Potentially Good Obs.	14,842/15,664	14,343/14,991	13,930/14,724	8401/9100	14,077/15,623	65,593/70,102
# Obs. Used in Solution	14,347/15,163	13,955/14,709	13,301/14,183	7819/8485	13,621/15,245	63,043/67,785
Solve Delay Fit (psec)	22.8 / 28.2	25.8 / 27.6	36.6 / 40.4	38.4 /40.2	25.3 /27.4	
Solve Rate Fit (fsec/sec)	155 / 108	152 / 151	255 / 206	194 / 197	127 / 134	

*Adjusted for missing stations

Comparison of Weak Sources

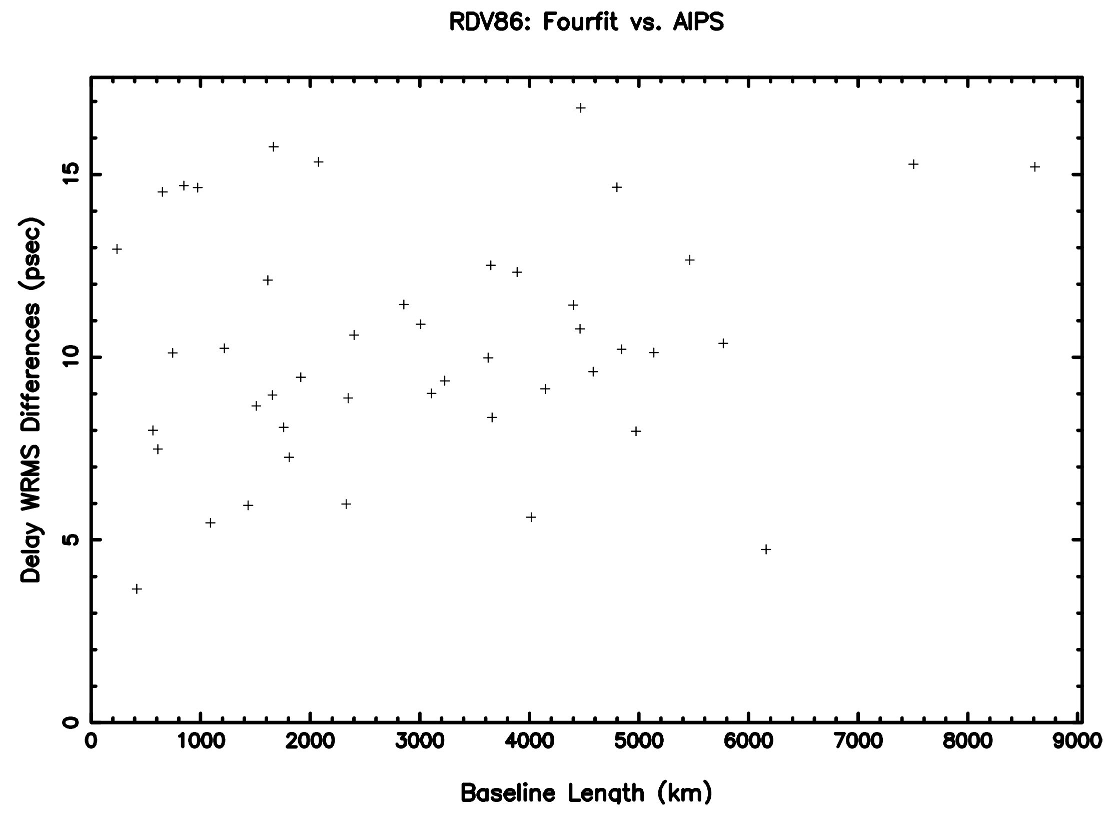
In the RDV's, we regularly observe several new sources requested by members of the astronomical community and several additional sources (usually VCS sources) for which there are only a few observations, in order to improve their positions. These are generally weak sources that either have unknown VLBI positions or relatively noisy VLBI positions. Since the RDV sensitivity should be improved by using *fourfit*, we expect an increased detection ratio in the *fourfit* versions. This is indeed what is seen. The individual source statistics are too lengthy to show here, but below are the overall statistics for the 5 sessions.

# sources	# obs	# *AIPS* detections	# *fourfit* detections
61 weak	5069	3049 (60.1%)	4305 (84.9%)
27 requested	2083	1025 (49.2%)	1317 (63.2%)

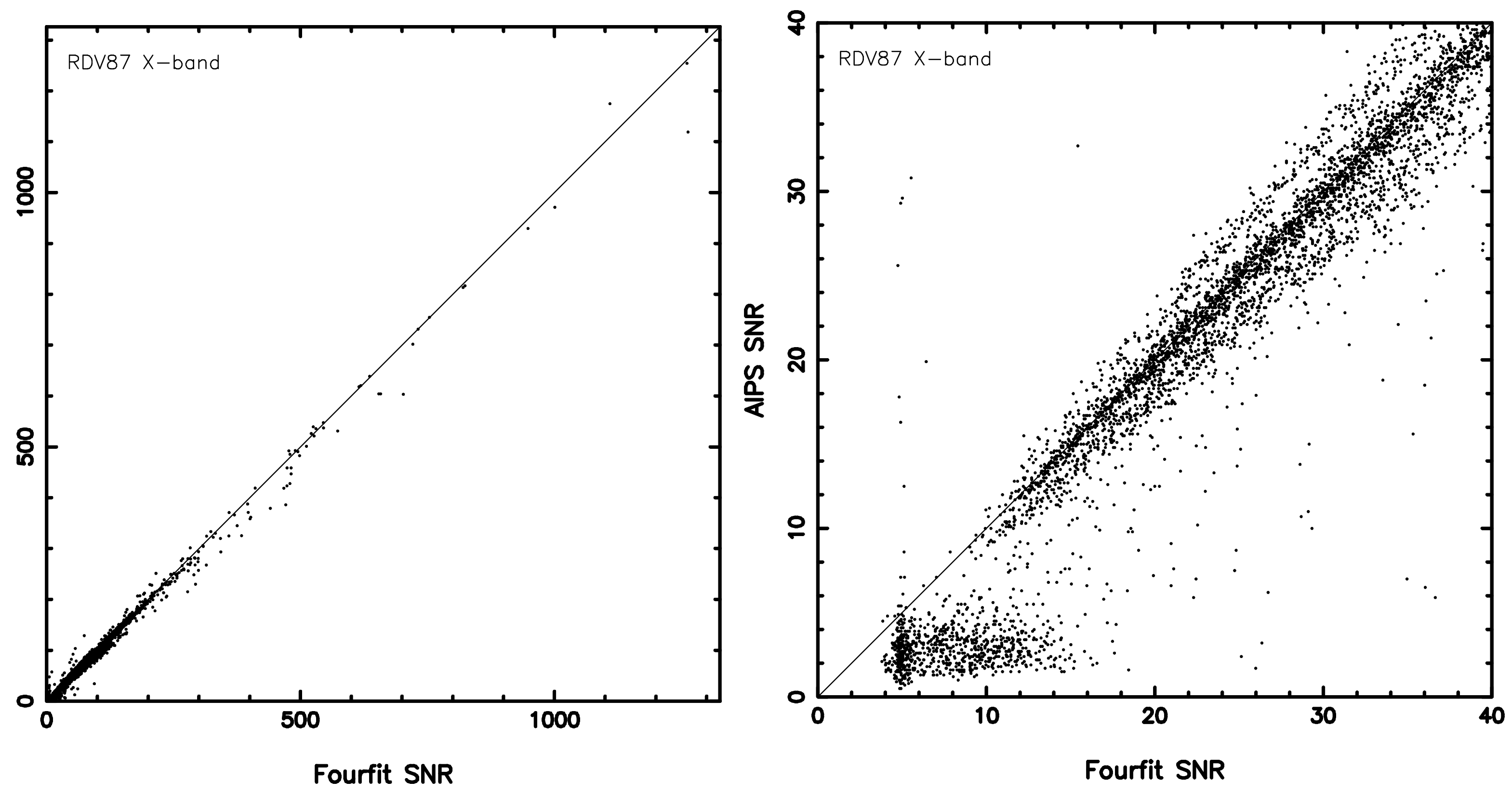
In these 5 sessions, *fourfit* was successful on 41% more observation on the weak/re-observed sources, and 28.5% more on the requested sources. Among the 27 requested sources, 2 were detected by *fourfit* but not by *AIPS*, and 3 were not detected by either.

Delay, SNR and Baseline Length Comparisons

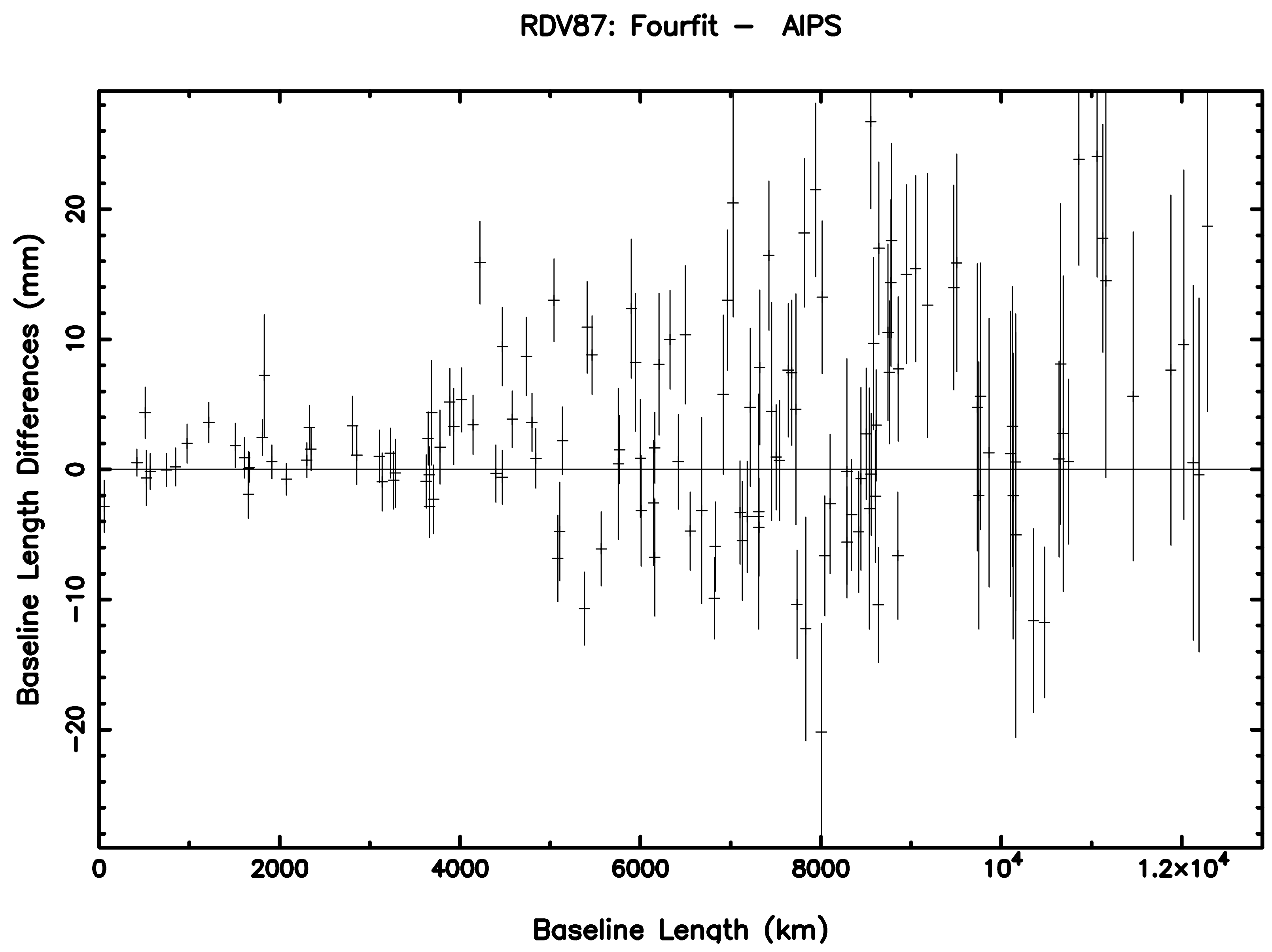
Several of the RDV's were processed a second time in *AIPS* using a time tag file to match time tags with the *fourfit* versions. This allows easy comparisons of the observables between the two versions. For both cases, phase cals were handled the same only for the VLBA stations (measured Pcals used). Below are the WRMS delay differences for the 45 baselines between the VLBA antennas in RDV86.



Below is a comparison of computed SNR's, showing the full range and a blowup of the lower values. When the *AIPS* SNR and delay formal errors were first coded, some incorrect assumptions were made in order to match the computations in the Mark3 *fringe* program. The blowup shows that the *AIPS* fringing begins to fail for *fourfit* SNR's of ~15 and almost completely fails at *fourfit* SNR's below 10. This is one of the reasons for more good observations by *fourfit*.



Below is a plot of the baseline length differences, *fourfit* – *AIPS*, for RDV87 with formal error bars. The scatter is not unusual for single session comparisons, and some of the scatter may be due to differences in phase cal application.



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This work made use of the Swinburne University of Technology software correlator, developed as part of the Australian Major National Research Facilities Programme and operated under license. For a description of the *difx* correlator, see Deller, et al. 2011, *PASP*, **123**, 275.

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Contact author: ***David Gordon***
NVI, Inc./NASA GSFC, Code 698.2
Greenbelt, MD 20771, USA
e-mail: David.Gordon-1@nasa.gov