Coordinating, Scheduling, Processing and Analyzing IYA09

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1. Introduction

To commemorate 400 years of optical telescopic observing, the IAU declared 2009 the "International Year of Astronomy".

2009 also marked the:

- 40th anniversary of geodetic VLBI
- 30th anniversary of regular S/X observing
- 10th anniversary of the IVS.

In recognition of these anniversaries, the IVS decided to schedule the most ambitious VLBI session to date.

Key Goals of IVS Session IYA09

Scientific Goals	Strengthen ICRF2 by observing as many sources (243 out of 295) as possible in a single session. Measure arc-lengths between all sources.
Outreach Goals	Press releases through IYA2009 (IAU), IVS and other organizations. News coverage in regional and national media. Open doors at stations.
Ancillary Goals	Celebrate 40 years of Geodetic & Astrometric VLBI. Demonstrate capability to handle large networks. "Dry run" for VLBI 2010 where there will be much more data. Tie "new" stations into global frame.

2. Designing the Session

Call for Participation

Twenty-five stations responded positively to a call for participation, including some stations that had never participated in an IVS session.

Following feasibility discussions with the VLBA, the Coordinating Center submitted a "target of opportunity" proposal to the VLBA which was accepted. The total number of stations rose to 35.

Media

There were numerous discussions concerning media availability. There were two related issues. First, the session involved many more stations than a typical IVS session. Second, because the correlator would have to make many passes (~20), the recording media would be tied up for many months while being processed. Ultimately resources were identified for this session.

Observing Mode

After extensive discussions, we settled on the standard 8 channel RDV mode. The primary argument in favor was the participation of the VLBA, and because many stations had experience with this mode. We also considered a mixed mode, where the VLBA would observe 8 channels, and other stations 14. This would have had greater sensitivity for the non-VLBA stations, but was ruled out because of insufficient media.

RDV mode

4 X-band channels
4 S-band channels
8 MHz BW per channel
16 MSps sample rate per channel
2-bit sampling
Total 256 Mbps data rate.

Most stations could observe this mode with the following exceptions:

4 MHz bandwidth and 8 MSps
AIRA, CHICHI10, CRIMEA, SINTOTU3

Only 2 X-band channels
AIRA, CHICHI10, CRIMEA, METSHAOV, NOTO, SINTOTU3 URUMQI

Only 2 X-band and 2 S-band Channels
DSS13

No AGC
Crimea. Power levels increased for better 2-bit recording.

Stations in IYA09

Code	Name	Comment	DB
Records K5, translated to Mark5B			
Ai	AIRA	Japanese	
Cc	CHICHI10	Japanese	
Kb	KASHIM34	Japanese	
S3	SINTOTU3	Japanese	X
Ts	TSUKUB32	Japanese	X
Native Mark5B			
Bd	BADARY		X
Sm	CRIMEA		X
Wf	WESTFORD		X
Ys	YEBES40M		X
Native Mark5A			
Eb	EFLSBERG		X
Ho	HOBART26		X
Kk	KOKEE		X
Ma	MATERA		X
Mh	METSAHOV		X
Nt	NOTO		X
Ny	NYALES20		X
On	ONSALA60		
Oh	OHIGGINS		
Sh	SESHAN25		X
Sv	SVETLOE		
Tc	TIGOCONC		
Ur	URUMQI		X
Wz	WETTZELL		X
Zc	ZELENCHK		
13	DSS13	DSN	
Br	BR-VLBA	VLBA	X
Fd	FD-VLBA	VLBA	X
Hn	HN-VLBA	VLBA	X
Kp	KP-VLBA	VLBA	X
La	LA-VLBA	VLBA	X
Nl	NL-VLBA	VLBA	X
Pt	PIETOWN	VLBA	X
Mk	MK-VLBA	VLBA	X
Ov	OV-VLBA	VLBA	X
Sc	SC-VLBA	VLBA	X

Svetloe could not participate because of hardware problems.
During correlation Haystack discovered problems with one of the 2 X-band channels of DSS13 and the station was dropped.
Stations used in the preliminary solve solution have an X in the DB . Column.

Scheduling

Because of the challenges involved in scheduling this session, GSFC was responsible for scheduling the session.

Correlating

Haystack will correlate the session.

Analysis

GSFC will perform the preliminary analysis and submit the database to the IVS.

3. Scheduling and Pre-Session Checkout

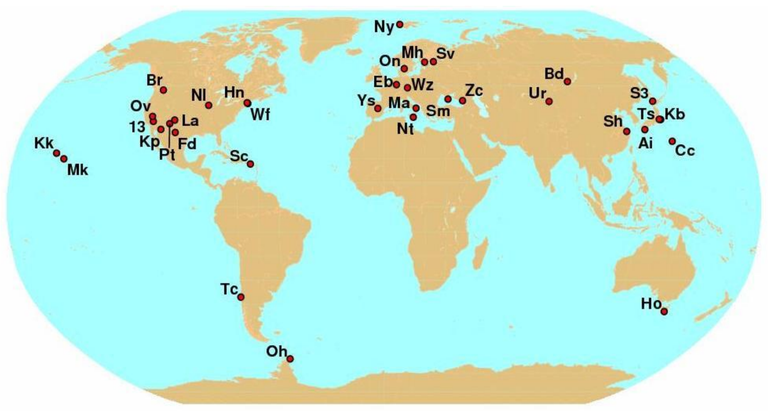


Figure 1. 35 Stations participated in the IVS IYA09 session. This set a record for astrometric observing. The previous record was 23 stations. Unfortunately, the coverage in the south was sparse

IYA09 was by far the largest network ever scheduled. To be able to schedule it, we increased the maximum number of stations in *sked* from 32 to 64 stations, and made this a changeable parameter.

Sources

The source list was the 295 defining sources in ICRF2. A design goal was to observe as many of these sources as possible.

Flux Models

To reliably schedule these sources we need good flux models. For most of the sources we used flux models generated from IVS data. For some of the sources we put in flux models obtained externally. Lastly, for some of the sources we assumed fluxes of 0.25 mJy.

Scheduling

We generated a reference schedule with "plain vanilla" *sked* settings. This schedule had about 45,000 observations. Unfortunately, about 80 sources were observed sparsely or not at all. Four sources were too close to the sun to be observed. Most of the remaining sources were in the far South.

We used the **astrometric mode** of sked to try to increase the number of observations of these southern sources. In spite of this, many of the sources in the far south were not observed. Further investigation showed that it was impossible to meet the SNR targets on these sources because of the small size of 2 of the 3 Southern stations.

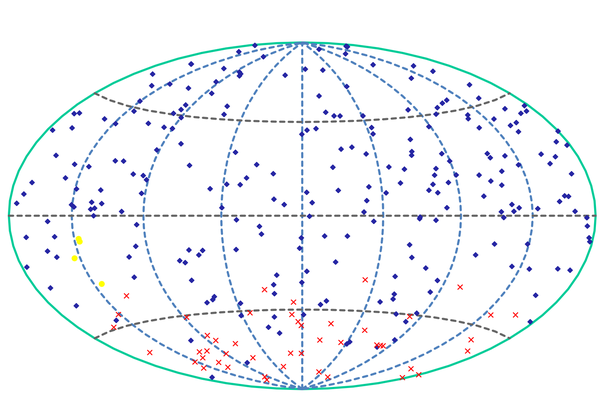
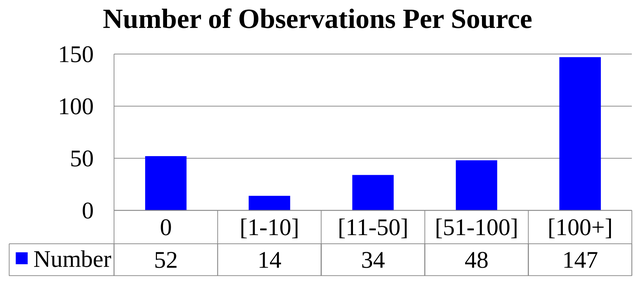


Figure 2. The 295 defining sources of ICRF2. Sources with no observations in IYA09 appear as red crosses. Yellow circles are sources close to the sun.

Number of Observations Per Source



	0	[1-10]	[11-50]	[51-100]	[100+]
Number	52	14	34	48	147

Special Considerations

We spent much time prior to the session to ensure that all stations would perform well. The Network Coordinator paid particular attention to the stations that hadn't participated in the RDVs.

GSFC generated snap files for 8 of the stations.

Haystack tested the data path from the Japanese stations, which involved e-transferring the data and then translating the format.

Comparison of IYA2009 with Typical IVS Sessions

Kind	#/Yr	Typical	Date	# Stats	# Srcs	# Scans	# Obs
Int	200	I09240	2009-08-24	2	11	26	26
R1	52	R1397	2009-09-29	8	60	687	4376
Euro	6	Euro97	2009-05-25	9	53	288	6473
RDV	6	RDV77	2009-10-07	15	94	791	22044
-	-	IYA09	2009-11-19	35	243	721	37236

4. Correlation

Correlation of IYA09 is presently underway at Haystack.

All of the data is now at Haystack. The Japanese data was recorded on K5 disks, and then e-transferred to Haystack. It was subsequently translated into Mark5B format. This was done to reduce the number of Mark5A stations.

Due to station problems, SVETLOE did not participate in IYA09. During correlation, Haystack discovered problems with one of the two X-band channels of DSS13 and the station will be dropped.

The final correlation will involve 33 stations, distributed as follows:
24 Mark5A stations
9 Mark5B stations

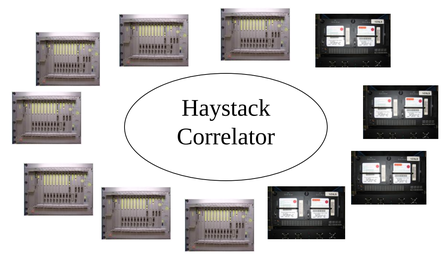


Figure 3. The Haystack correlator has 7 Mark4A and 4 Mark5B playback units.

The number of playback units determines the number of passes required to correlate the data. Originally we hoped to increase the number of playback units temporarily. Unfortunately we discovered that one of the programs limited the number of playback units to 11.

Correlating 9 Stations With 4 Playback Units

Pass #	1	2	3	4	5	6	7	8	9	# NewBl	# Old Bl
1	X	X	X	X						6	0
2				X	X	X	X			6	0
3	X						X	X	X	6	0
4		X			X	X			X	5	1
5			X	X				X	X	4	2
6	X		X		X	X				4	2
7		X	X				X	X		3	3
8					X	X		X		2	1
									Total	**36**	**9**

Corresponding Baselines

	1	2	3	4	5	6	7	8	9
1		12	13	14	15	16	17	18	19
2	12		23	24	25	26	27	28	29
3	13	23		34	35	36	37	38	39
4	14	24	34		45	46	47	48	49
5	15	25	35	45		56	57	58	59
6	16	26	36	46	56		67	68	69
7	17	27	37	47	57	67		78	79
8	18	28	38	48	58	68	78		89
9	19	29	39	49	59	69	79	89	

Figure 4. As illustrated here, it takes a minimum of 8 passes to correlate the Mark5B stations. **It takes a minimum of 18 passes to correlate the Mark5A stations. This sets the floor on the number of correlator passes.** The Mark5A and Mark5B units also need to be correlated with each other, but this can be easily accommodated while processing the Mark5A units.

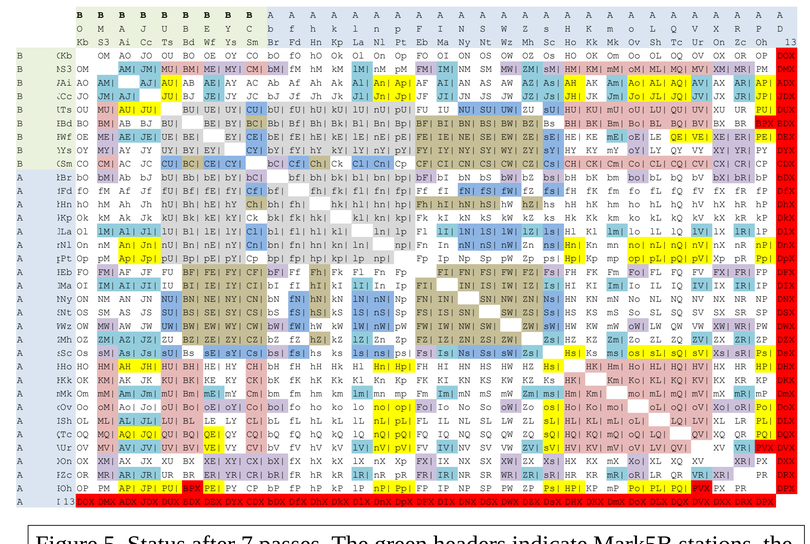


Figure 5. Status after 7 passes. The green headers indicate Mark5B stations, the light blue Mark5A stations. Red indicates that there are no observations on a baseline. Because of hardware problems, DSS13 was dropped. The remaining colors indicate which pass a baseline was correlated in.

5. Preliminary Analysis

On January 25, Haystack released a preliminary version after 4 passes. This was made into S- and X- band databases at GSFC.

The database contained 29 stations, ~14500 observations and 240 sources. 26 of the stations, indicated with an "X" in Table 1, were usable in a *solve* solution. Most stations performed well. There were 168 usable baselines, and the session fit was 20 ps. The full dataset could contain up to 33 stations and 528 baselines.

Currently the VLBI analysis software *solve* has a hard limit of 32 stations. This limit will be increased so that we can process the IYA09 data.

6. Conclusions

The IYA09 session is the most ambitious VLBI session scheduled to date. It has posed, and continues to pose challenges to all aspects of data analysis and dataflow. It is a useful precursor to VLBI2010 data.

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