

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.



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

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



Key Goals of IVS Session IYA09

- Strengthen ICRF2 by observing as many sources (243 out of 295) Scientific as possible in a single session. Goals Measure arc-lengths between all sources.
- Press releases through IYA2009 (IAU), IVS and other Outreach Goals organizations. News coverage in regional and national media. Open doors at stations.
- Celebrate 40 years of Geodetic & Astrometric VLBI. Ancillary Demonstrate capability to handle large networks. Goals "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.

Stations in IYA09 Records K5, translated to Mark5B **Comment DB Code Name** AIRA Japanese CHICHI10 Japanese Cc KASHIM34 Japanese Kb SINTOTU3 Japanese Х Χ TSUKUB32 Japanese Native Mark5B BADARY Χ Bd CRIMEA Χ Sm Χ WESTFORD

V

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 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.

Corr	ela	tin	g 9	St	tati	ion	s V	Vit	h 4	Playbac	k Units
Pass #	1	2	3	4	5	6	7	8	9	# NewBl	# Old Bl
1	X	Х	X	Х						6	0
2				Х	Х	Х	Х			6	0
3	X						Х	Х	Х	6	0
4		Х			X	Х			Х	5	1
5			X	Х				Х	Х	4	2
6	X		Х		Х	Х				4	2
7		Х	Х				X	X		3	3
8					Х	Х		Х		2	1
								Тс	otal	36	9

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

SINTOTU3

URUMQI

Channels

DSS13

No AGC

Ys	YEBES40M		X
Nati	ve Mark5A		
Eb	EFLSBERG		X
Ho	HOBART26	1	X
Kk	KOKEE		X
Ma	MATERA		X
Mh	METSAHO	V	X
Nt	NOTO		Х
Ny	NYALES20		X
On	ONSALA60		
Oh	OHIGGINS		
Sh	SESHAN25		Х
Sv	SVETLOE		
Tc	TIGOCONC	1	
Ur	URUMQI		X
Wz	WETTZELL	4	X
Zc	ZELENCHK		
13	DSS13	DSN	
Br	BR-VLBA	VLBA	X
Fd	FD-VLBA	VLBA	X
Hn	HN-VLBA	VLBA	Х
Кр	KP-VLBA	VLBA	Х
La	LA-VLBA	VLBA	Х
N1	NL-VLBA	VLBA	X
Pt	PIETOWN	VLBA	X
Mk	MK-VLBA	VLBA	Х
Ov	OV-VLBA	VLBA	Х
Sc	SC-VLBA	VLBA	Х
Svet	loe could not p	participate b	ecaus



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.



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.

(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.

		в	в	в	в	в	в	в	в	в	A	A	A	A	А	A	A	A	А	A	А	А	A	A	A	A	А	А	A	A	А	A	A	A	А
		0	М	А	J	U	В	Ε	Y	С	b	f	h	k	l	n	р	F	I	Ν	S	W	Ζ	S	Η	K	m	0	L	Q	V	Х	R	Ρ	D
		Kb	S3	Ai	Сс	Ts	Bd	Wf	Ys	Sm	Br	Fd	Hn	Кр	La	Nl	Pt	Eb	Ma	Ny	Nt	Wz	Mh	Sc	Но	Kk	Mk	Ov	Sh	Tc	Ur	On	Zc	Oh	1
З	(Kb		MO	AO	JO	OU	BO	OE	OY	СО	bO	fO	hO	Ok	Ol	On	Op	FO	OI	ON	OS	OW	ΟZ	Os	HO	OK	Om	00	OL	OQ	OV	OX	OR	OP	DO
З	NS3	ОМ		AM	JM	MU	BM	ME	MY	CM	bM	fM	hM	kМ	lM	nM	рМ	FM	IM	NM	SM	MM	ZM	sM	HM	KM	mM	оМI	ML	MQ	MV	XM	MR	PM	DM
З	7Ai	AO	AM		AJ	AU	AB	AE	AY	AC	Ab	Af	Ah	Ak	Al	<mark>An </mark>	Ap	AF	AI	AN	AS	AW	AZ	As	AH	AK	Am	Ao	AL	AQ	AV	AX	AR	AP	AD
3	CCc	JO	JM	AJ		JU	ВJ	JE	JY	JC	bJ	Jf	Jh	Jk	Jl	<mark>Jn </mark>	Jp	JF	JI	JN	JS	JW	JZ	Js	JH	JK	Jm	Jo	JL	JQI	JV	JX	JR	JP	JD
З	lTs	OU	MU	AU	JU		BU	UE	UY	CU	bU	fU	hU	kU	lU	nU	pU	FU	IU	NU	SU	UW	ZU	sU	HU	KU	mU	oU	LU	QU	UV	XU	UR	PU	DU
3	IBd	во	BM	AB	BJ	BU		BE	BY	BC	Bb	Bf	Bh	Bk	Bl	Bn	Bp	BF	BI	BN	BS	BW	BZ	Bs	BH	BK	Bm	Bol	BL	BQ	BV	ΒX	BR	BPX	BD
3	EWf	OE	ME	AE	JE	UE	BE		EY	CE	bE	fE	hE	kE	lE	nE	pE	FE	IE	NE	SE	EW	ZE	sE	HE	KE	mE	oe	LE	QE	VE	XE	ER	PE	DE
З	УYs	OY	MY	AY	JY	UY	BY	EY		CYI	bY	fY	hΥ	kY	lY	nY	pY	FY	IY	NY	SY	WY	ZY	sY	ΗY	ΚY	mΥ	oy	LY	QY	VY	XY	YR	ΡY	DY
3	(Sm	СО	CM	AC	JC	CU	BC	CE	CY		bC	Cf	Ch	Ck	Cl	Cn	Ср	CF	CI	CN	CS	CW	CZ	Cs	CH	CK	Cm	Col	CL	CQI	CV	CX	CR	CP	CD
A	łBr	bO	bM	Ab	bJ	bU	Bb	bE	bY	bC		bf	bh	bk	bl	bn	bp	bF	bI	bN	bS	bW	bΖ	bs	bH	bK	bm	bol	bL	bQ	bV	bX	bR	bP	bD
A	íFd	fO	fM	Af	Jf	fU	Bf	fE	fY	Cf	bf		fh	fk	fl	fn	fp	Ff	fI	fN	fS	fW	fΖ	fs	fH	fK	fm	fo	fL	fQ	fV	fX	fR	fP	Df
A	łHn	hO	hM	Ah	Jh	hU	Bh	hE	hY	Ch	bh	fh		hk	hl	hn	hp	Fh	hI	hN	hS	hW	hZ	hs	hH	hK	hm	ho	hL	hQ	hV	hX	hR	hP	Dh
A	łKp	Ok	kМ	Ak	Jk	kU	Bk	kE	kY	Ck	bk	fk	hk		kl	kn	kp	Fk	kI	kN	kS	kW	kΖ	ks	Hk	Kk	km	ko	kL	kQ	kV	kΧ	kR	kP	Dk
A]La	Ol	lM	Al	Jl	1U	Bl	lE	lY	Cl	bl	fl	hl	kl		ln	lp	Fl	lI	lN	lS	lW	1Z	ls	Hl	Kl	lm	lo	lL	lQ	lV	lX	lR	lP	Dl
A	rNl	On	nM	<mark>An </mark>	Jn	nU	Bn	nE	nY	Cn	bn	fn	hn	kn	ln		np	Fn	In	nN	nS	n₩	Zn	ns	Hn	Kn	mn	no	nL	nQ	nV	nX	nR	nP	Dn
A	₽₽t	Op	рМ	<mark>Ap </mark>	Jp	pU	Bp	pE	pY	Ср	bp	fp	hp	kp	lp	np		Fp	Ip	Np	Sp	рW	Zp	ps	Hp	Кр	mp	op	pL	pQl	pV	Хр	pR	Pp	Dp.
A	IEb	FO	FM	AF	JF	FU	BF	FE	FY	CF	bF	Ff	Fh	Fk	Fl	Fn	Fp		FI	FN	FS	FW	FZ	Fs	FH	FK	Fm	Fol	FL	FQ	FV	FX	FR	FP	DF
A]Ma	OI	IM	AI	JI	IU	BII	IE	IY	CI	bI	fI	hI	kI	lı	In	Ip	FI		IN	IS	IW	IZ	Is	ΗI	KI	Im	Io	ΙL	IQ	IVI	IX	IR	IP	DI
A	My	ON	NM	AN	JN	NU	BN	NE	NY	CN	bN	fN	hN	kN	lN	nN	Np	FN	IN		SN	NW	ZN	Ns	HN	KN	mN	No	NL	NQ	NV	NX	NR	NP	DN
A	SNt	OS	SM	AS	JS	SU	BS	SE	SY	CS	bS	fS	hS	kS	lS	nS	Sp	FS	IS	SN		SW	ZS	Ss	HS	KS	mS	So	SL	SQ	SV	SX	SR	SP	DS
A	₩z	ΟW	MM	AW	JW	UW	BW	EW	WY	CW	b₩	fW	h₩	kW	lW	n₩	p₩	FW	IW	NW	SW		ZW	sW	ΗW	ΚW	m₩	o₩	LW	QW	VW	XW	WR	PW	DW
A	2Mh	ΟZ	ZM	AZ	JZ	ZU	BZ	ZE	ZY	CZ	bΖ	fΖ	hZ	kΖ	lZ	Zn	Zp	FZ	IZ	ZN	ZS	ZW		Zs	ΗZ	ΚZ	Zm	Zo	ΖL	ZQ	ZV	ZX	ZR	ΖP	DZ
A	٤Sc	Os	sM	As	Js	sU	Bs	sE	sY	Cs	bs	fs	hs	ks	ls	ns	ps	Fs	Is	Ns	Ss	s₩∣	Zs		Hs	Ks	ms	<mark>os </mark>	sL	sQ	sV	Xs	sR	Ps	Ds
A	FHO	HO	HM	AH	JH	HU	BH	HE	ΗY	CH	bH	fH	hH	Hk	Hl	Hn	Hp	FH	ΗI	HN	HS	ΗW	ΗZ	Hs		HK	Hm	Ho	HL	HQ	HV	ΗX	HR	HP	DH
A	łKk	OK	KM	AK	JK	KU	BK	KE	ΚY	CK	bK	fK	hK	Kk	Kl	Kn	Кр	FK	KI	KN	KS	KW	ΚZ	Ks	HK		Km	Ko	KL	KQ	KV	KΧ	KR	KP	DK
A	nMk	Om	mM	Am	Jm	mU	Bm	mE	mΥ	Cm	bm	fm	hm	km	lm	mn	mp	Fm	Im	mΝ	mS	m₩	Zm	ms	Hm	Km		mo	mL	mQ	mV	mΧ	mR	mΡ	Dm
A	cOv	00	0M	Ao	Jol	0U	Bol	oe	οYΙ	Col	bo	fo	ho	ko	lo	no	op	Fol	Io	No	So	OW	Zo	<mark>os </mark>	Ho	Ko	mo		oL	oQI	oVI	Xo	oR	Po	Do
A	ISh	OL	ML	AL	JL	LU	BL	LE	LΥ	CL	bL	fL	hL	kL	lL	nL	pL	FL	IL	NL	SL	LW	ΖL	sL	HL	KL	mL	oL		LQ	LV	XL	LR	PL	DL
A	ζTc	OQ	MQ	<mark>AQ </mark>	JQ	QU	BQ	QE	QY	CQI	bQ	fQ	hQ	kQ	lQ	nQ	pQl	FQ	IQ	NQ	SQ	QW	ZQ	<mark>sQ </mark>	HQ	KQ	mQ	oQ	LQ		QV	XQ	QR	<mark>PQ </mark>	DQ:
A	\Ur	OV	MV	AV	JV	UV	BV	VE	VY	CV	bV	fV	hV	kV	lV	nV	pV	FV	IVI	NV	SV	VW	ZV	sV	HV	KV	mV	oVI	LV	QV		XV	VR	PVX	DV
A	YOn	OX	XM	AX	JX	XU	ΒX	XE	XY	CX	bX	fX	hX	kΧ	lX	nX	Хр	FX	IX	NX	SX	WX	ZX	Xs	ΗX	KΧ	mΧ	Xo	XL	XQ	XV		XR	ΡX	DX
A	FZc	OR	MR	AR	JR	UR	BR	ER	YR	CR	bR	fR	hR	kR	lR	nR	pR	FR	IR	NR	SR	WR	ZR	sR	HR	KR	mR	oR	LR	QR	VR	XR		PR	DR.
A	IOh	OP	PM	AP	JP	PU	BPX	PE	ΡY	СР	bP	fP	hP	kР	lP	nP	Pp	FΡ	ΙP	NP	SP	PW	ΖP	Ps	HP	KP	mΡ	Po	PL	PQI	PVX	ΡX	PR		DP
A	I 13	B DOX	DMX	ADX	JDX	DUX	BDX	DEX	DYX	CDX	bDX	DfX	DhX	DkX	Dlx	DnX	DpX	DFX	DIX	DNX	DSX	DWX	DZX	DsX	DHX	DKX	DmX	DoX	DLX	DQX	DVX	DXX	DRX	DPX	

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.

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

4 MHz bandwidth and 8 MSps

AIRA, CHICHI10, CRIMEA,

AIRA, CHICHI10, CRIMEA,

Only 2 X-band and 2 S-band

METSHAOV, NOTO, SINTOTU3

Crimea. Power levels increased for

better 2-bit recording.

Only 2 X-band channels

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.

mode with the following exceptions: 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.

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
Tret	200	100240	2000 08 24	2	11	26	26
Int	200	109240	2009-08-24	Z	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

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.