



한국우주전파관측망
KOREAN VLBI NETWORK · KASI



Introduction of Korea-Japan Correlation Center and its Operation Plan

Duk-Gyoo Roh,
and staffs of KASI & NAOJ + Kagoshima Univ.





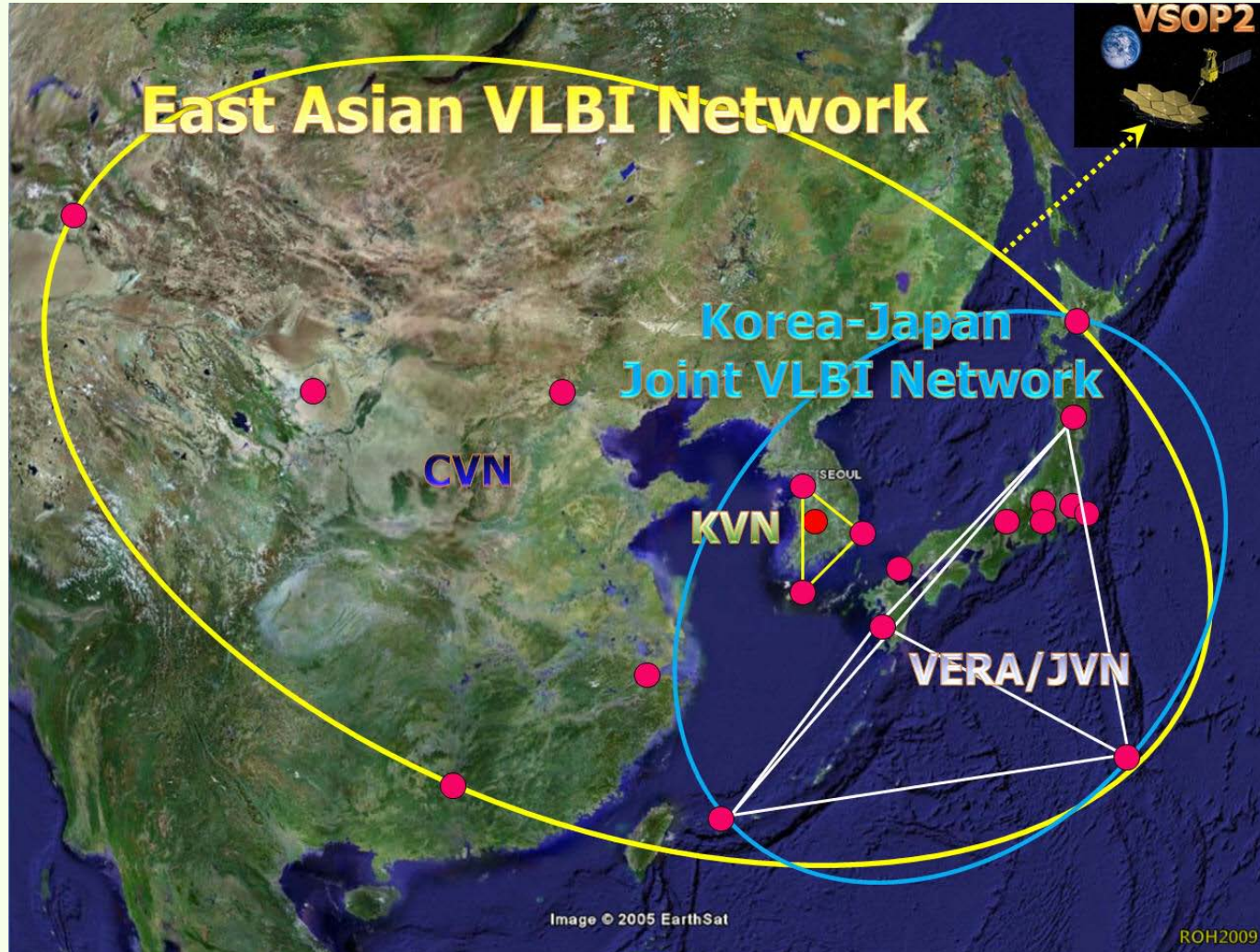
- ❖ **EAVN & KJJVC project**
- ❖ **KJJVC framework and status**
 - Playback Systems
 - RVDB System
 - VLBI Correlation Subsystem
 - Peta-scale Epoch Data Archive
 - Control & Operation Software
 - Some Results from Test Operations
- ❖ **KJCC: Future Works and Operation Plan**



EAVN & KJJVC project

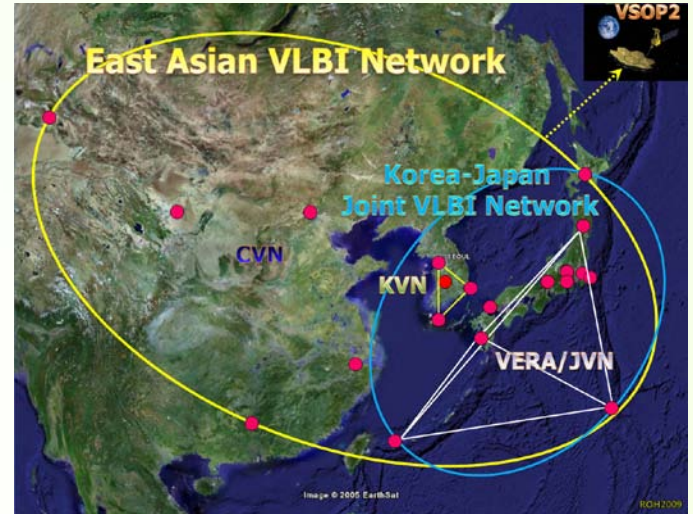
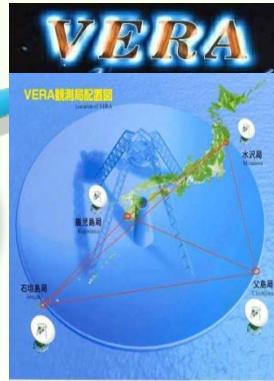
**East Asia VLBI Network
Korea-Japan Joint VLBI Correlator**

VLBI facilities in East Asia





Map of "VLBI at East Asia"



VERA

KVN

KJJVN

EAVN,
VSOP2

CJK Cooperation
in VLBI

KJJVC

Korea-Japan Joint VLBI Correlator

Backgrounds



- ❖ At the beginning of 21C, two correlator plans are there.
 - KVN needs its own High-speed Correlator
 - Japan needs Next Generation Correlator
- ❖ To establish the bigger, more powerful correlator and get the best performance in East Asian VLBI Network, we concluded that KASI & NAOJ join together to develop new Correlator. (~2004)
- ❖ MOU between KASI & NAOJ (2005. 7. 7.)
 - **Sharing the vision, Collaborating together**
 - Development of Korea-Japan Joint VLBI Correlator,
 - Common facility of correlation & data center
- ❖ **Joint Development Project** was initiated respectively.
 - Japan : 5 years from April 2005
 - Korea : 5 years from Jan. 2006

Observation Modes of KVN

Mode	#IF	Bandwidth [MHz]	Max. #Chan	#Bits	Max. Data Rate [Mbps]	Recorder		VERA Modes
						Mk5B		
1	1	256	1	2	1,024	○		VLBI1
2	1,2	128	2	2	1,024	○		VERA1, VLBI2
3	1,2,3,4	64	4	2	1,024	○		VERA2, VLBI3
4	1,2,3,4	32	8	2	1,024	○		VERA4, VSOP1
5	1,2,3,4	16	16	2	1,024	○		VERA7, VERA9, Geo1, Geo2, VSOP2
6	1,2,3,4	8	16	2	512	○		Geo3, Geo4, K4-1
7	1,2,3	64/128	2/1	2	1,024	○		VERA3
8	1,2,3,4	32/64/128	2/1/1	2	1,024	○		VERA5
9	1,2,3,4	32/128	4/1	2	1,024	○		VERA6
10	1,2,3,4	16/32/128	2/3/1	2	1,024	○		VERA8

Note) Digital Filter : Data Output- 32pin x 32MHz.

For Mode 2~6, Digital Filter always operates in full output speed, and Mk5B may select the channels or bits to be recorded for supporting the sub-modes.

With the help of newer data transmission system

- Upgrade version of Mark5B
- Optical fiber from Telescope to Correlator

Observation Modes of KVN (1Gbps Sampler Output)

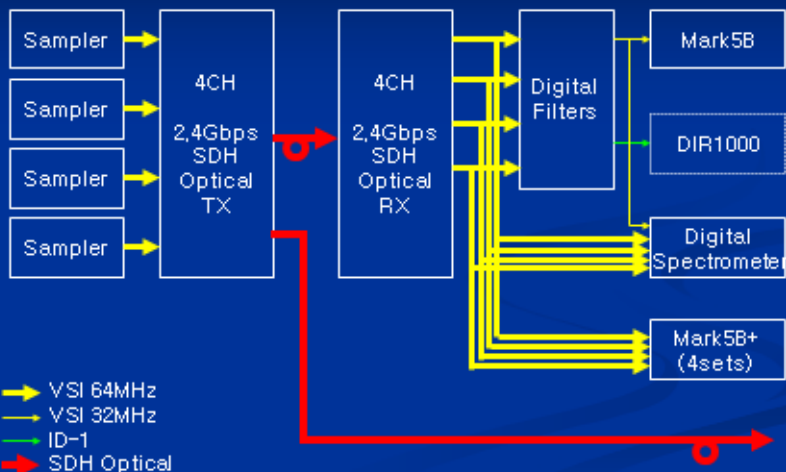
Mode	#IF	Bandwidth [MHz]	#Bits	Data Rate [Mbps]	Data Media	Remark
W1	1	512	2	2,048	Fiber, Mk5B+	
W2	1,2	512 x 2	2	4,096	Fiber, Mk5B+	
W3	1,2,3	512 x 3	2	6,144	Fiber , Mk5B+(?)	
W4	1,2,3,4	512 x 4	2	8,192	Fiber , Mk5B+(?)	

Note) 1Gbps Sampler : Data Output- 32pin x 64MHz

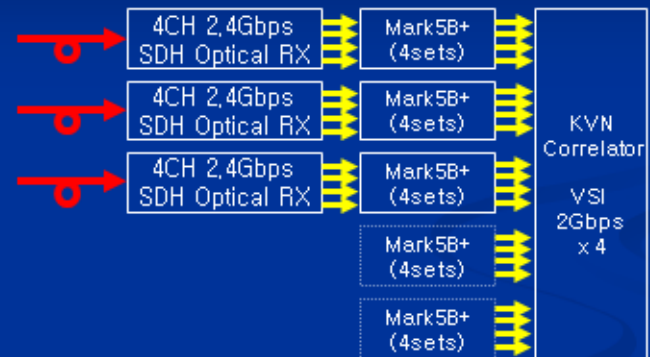
Mk5B+ is a upgrade model for higher recording speed, (x2, x4, x8)

Optical fiber will be used within KVN in near future.

KVN DAS : Future (2)



KVN Correlator : Future(2)



Design Target of KJJVC

2004. 12.



Correlator : Design Target

- Stations (Baselines)
5(10) → 7(21) → 10(45) → 12(66) ?
- Max. Data Rate
1Gbps + 4Ch x 2Gbps
- # of Freq. Channels
4,096 @ each stream
←0.1km/sec (for dynamics study)
7.3 & 28.6 kHz at 22 & 86 GHz

Development of KJJVC

Requirements



- ❖ **Data Rate : Max 8Gbps/station**
8Gbps - 512MHz BW x 4 streams @ 2bits/sample
1Gbps - 16MHz BW x 16 streams @ 2bits/sample
1Gbps - 256MHz BW x 2 streams @ 1bits/sample
- ❖ **# of stations : Max 16**
- ❖ **Freq. Resolution : <math><0.05\text{ km/s}</math> @22GHz**
- ❖ **Field of View : >1 arcmin**
Min. Integ. Time : <math><25\text{ msec}</math>
- ❖ **For Space VLBI, Max. Delay : 36,000 km**
- ❖ **Various Playbacks : Mark5B, DIR2000, K5/VSI, Optical Fiber(e-VLBI)**

Development of KJJVC

Specifications



# of Antennas	16
# of Inputs / Antenna	4 VSI ports (Narrow, Composite, Wide)
Max. # of Correlations / Stream	120 Cross + 16 Auto
Subarray Operation	3 cases (16, 12 + 4, 8 + 8)
Bandwidth for each Input	512 MHz
Digitization for each Input	1 Gbps by 2bits/sample
Data Rates per antenna	2 Gbps VSI-H (32 parallels, 64 MHz clock)
Max. Delay compensation	$\pm 36,000$ km
Max. Fringe Tracking	1,075 kHz
Architecture	FX type, with FPGA and DSP chips
Word length in FFT	16+16 bits fixed point for real & imag.
Integration	25.6 msec ~ 10.24 sec
Data compression (Flexible Binning)	8,192 channels

Development of KJJVC Organization



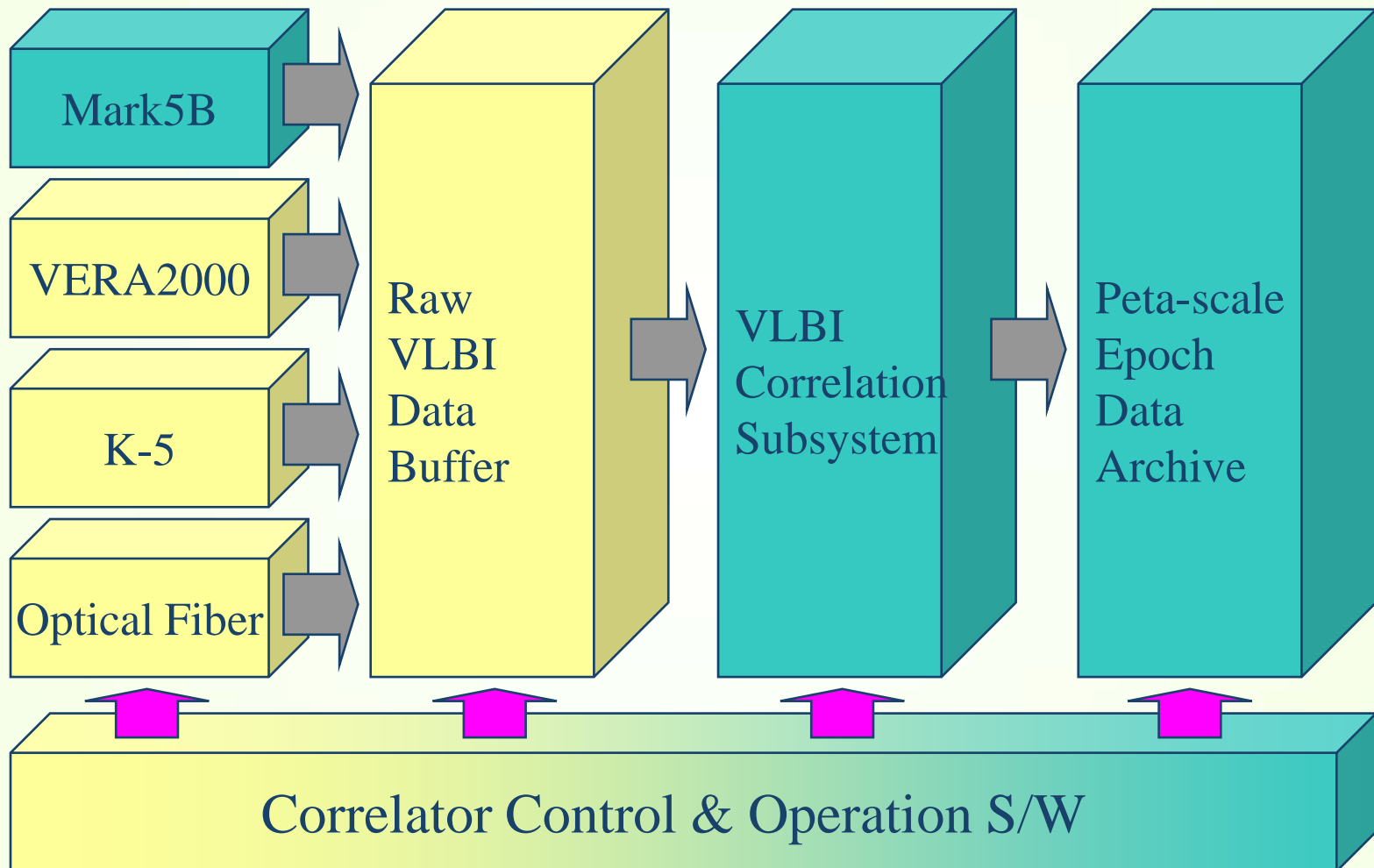
- ❖ Review Committee
- ❖ Working Groups





KJJVC framework and status

KJJVC Framework



Playback Systems



- ❖ Mark5B for KVN, CVN(?), VSOP-2
- ❖ VERA2000 for VERA
 - Playback only version of VERA 2000
- ❖ K5-VSI for JVN (Yamaguchi, ...)
- ❖ Optical Fiber for some on-line sites (upto 8 Gbps for near future)

❖ OCTAVIA

- modified RVDB
- currently 4Gbps, but 8Gbps coming soon.
- High speed Recorder as an upgrade of VERA2000, Mark5B
- and also the replacement of RVDB and VERA2000/Mark5B at KJCC



Raw VLBI Data Buffer

(N. Kawaguchi / NAOJ)

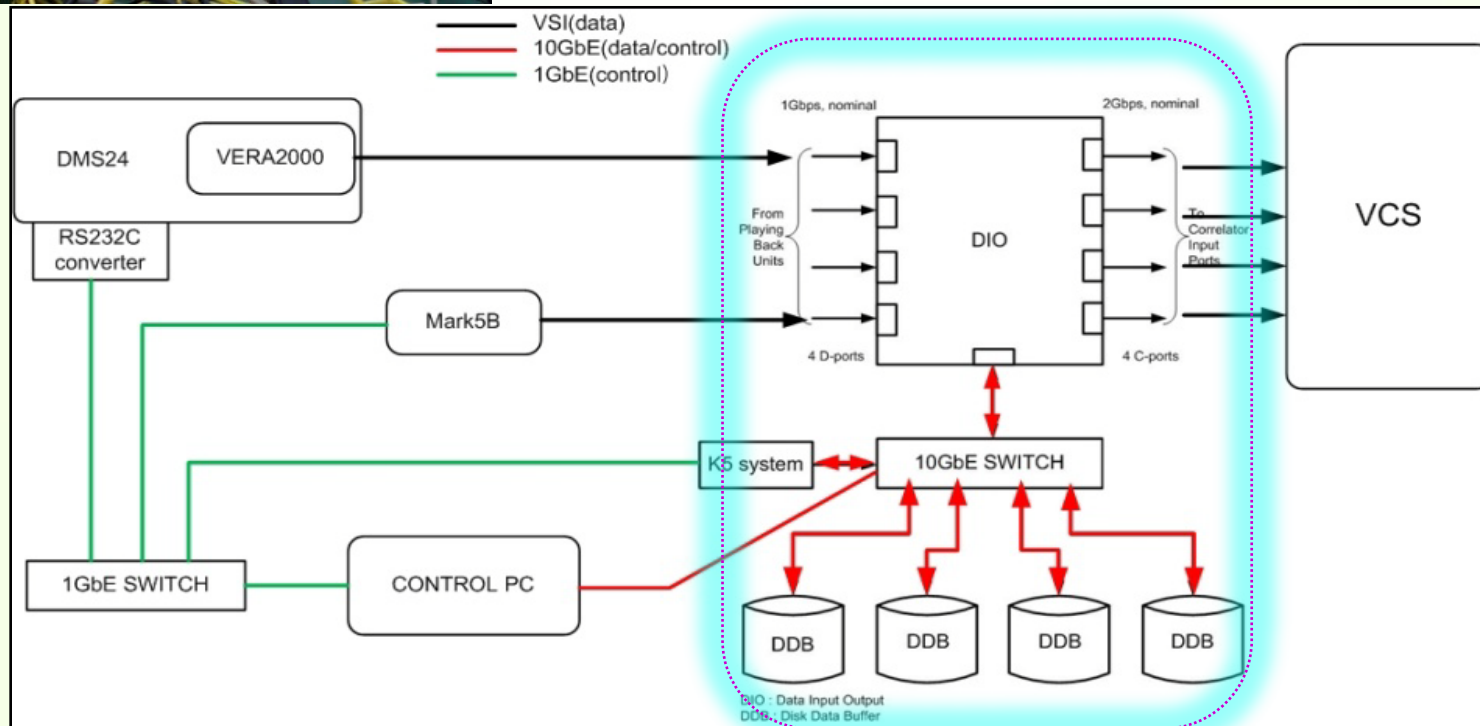
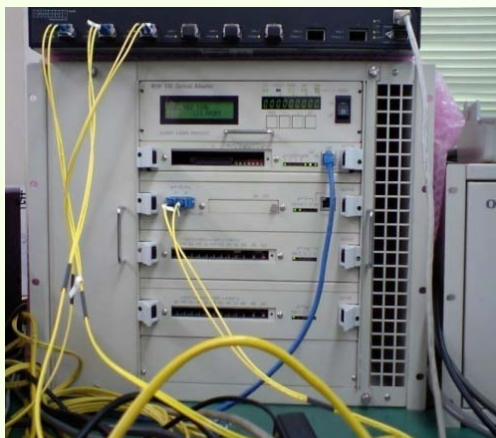


❖ Purpose :

- Data format adjustment : # of bits per sample, and so on
- Easy synchronization while playback (heterogeneous recorder models)
- Buffering between recorder speed(1 Gbps) and correlation speed(8 Gbps)
- Handy switching over to next session

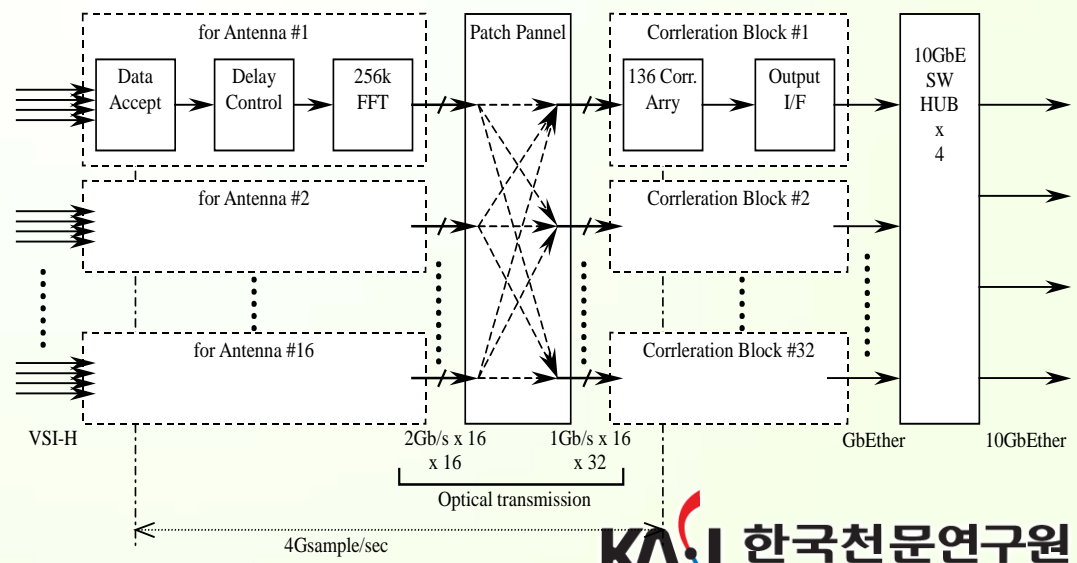
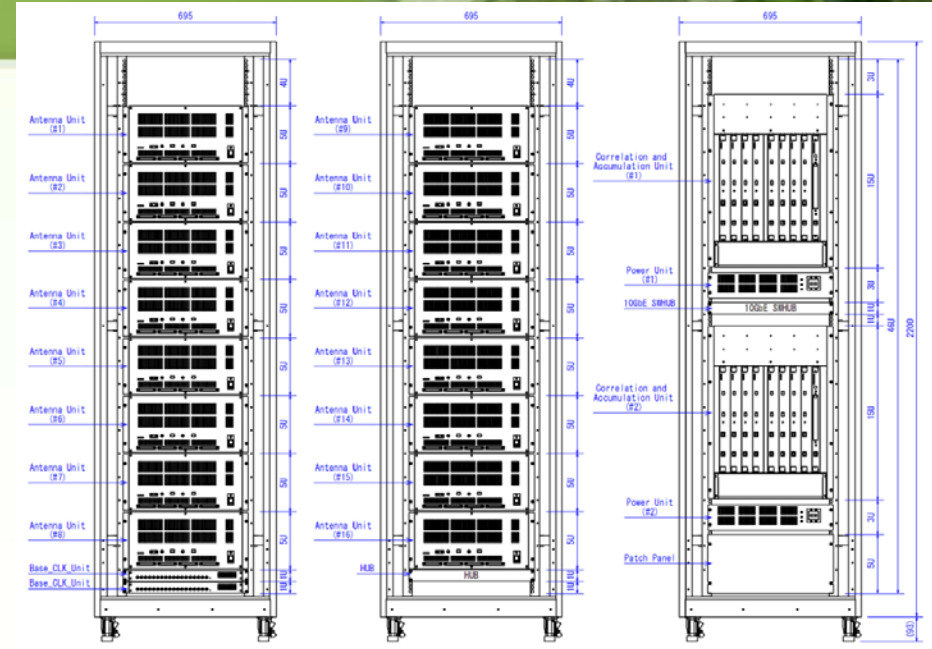
Raw VLBI Data Buffer

basic configuration

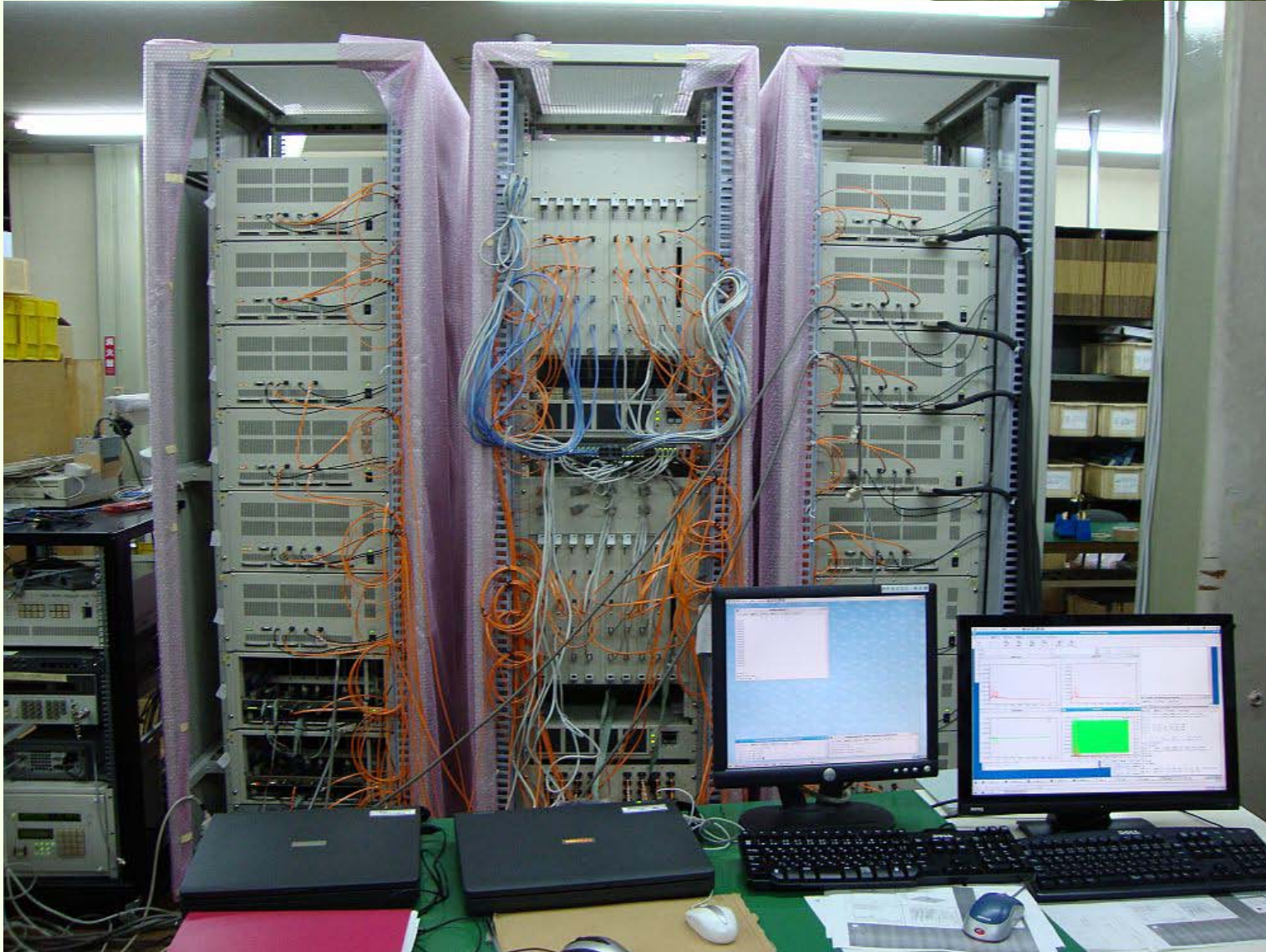


VLBI Correlation Subsystem (VCS) (2007.8-2009.7)

- 16 Stations, 2Gbps x 4 sub-streams/station
- Correlation : (120 Cross + 16 Auto) x 4 sub-stream
- Serialized data sub-streams in time domain, and Parallel processing in frequency channels after FFT.
- Full polarization observation supported (up to 8 stations)
- Two sub-array modes prepared (12+4 and 8+8).
- Max. data output rate of 1.4GB/sec



VCS Factory Test(2009.6.)



PEDA(Peta-scale Epoch Data Archive)



- ❖ Max. data rate of 1.4GB/sec (~10% at average operation)
- ❖ PEDA (specification)
 - **Architecture**
 - Infiniband
 - **Max. Capacity**
 - 1~3 PB for 1 year (EAVN, VSOP-2)
 - 500 TB at initial phase (KVN, KJJVN)
- ❖ CODA File System
 - **Revision of Mitaka Correlator FS with some modification (c++)→CCoda2.1**



~100 TB

Control & Operation SW



- ❖ Playback(VERA2000, including Mk5B GUI) and RVDB control SW development was developed by NAOJ, and are now modifying to adopt new functions.
- ❖ We developed the prototype control & operation SW for final factory test of VCS August 2009.
- ❖ The GUI control & operation SW development was completed the end of March, 2010.
- ❖ The Post-Correlation Post Processing SW development are now underway in close cooperation with Japanese colleagues.
 - CODA file system by NAOJ
 - Global Fringe Search SW by Kagoshima Univ.

RVDB control SW



RVDB MNG

DBID	DBID-CTL	DBID-1	DBID-2	DBID-3	DBID-4
DBID-1	DBID-CTL	DBID-1	DBID-2	DBID-3	DBID-4
NO	PARTITION	OPER	FSER	PORT	
1	partition-000	REC	DIO-1	1	
2	partition-008	PLAY	DIO-1	1	
3					
4					
Partitions: 6 recorded, 18 reserved, Free space: 7344 GB. (1000000/2048000)					

Sub control

RVDB CONTROL (UNIT=2)

DBID-8

SET_XGIP 192.168.010.022 GET

SET_CTLIP 192.168.100.022 GET

ONLINE

DISK

PartNum	Free	Reserved	Recorded
12	00016470	00000000	00001229
1024	022h22m26s	000h00m00s	002h37m34s
2048	011h11m13s	000h00m00s	001h18m47s

SHOW_DISK

SHOW_PLIST

Partition Name	Operation	Size	Record Start	Record End
ISHIGAKI_20073230400	IDLE	15	2007y323d04h00m00s	2007y323d04h01m59s
ISHIGAKI_20073230820	IDLE	15	2007y323d08h20m00s	2007y323d08h21m59s
ISHIGAKI_20000771955	IDLE	15	2000y077d19h55m00s	2000y077d19h56m59s
ISHIGAKI_20000772040	IDLE	15	2000y077d20h40m00s	2000y077d20h41m59s
Playback_20073230359	IDLE	3	2007y323d04h00m12s	2007y323d04h00m26s
REISHCORR_2007323040	IDLE	16	2007y323d04h00m01s	2007y323d04h01m59s
r07323c_3C446_1sg	IDLE	46	2007y323d00h17m04s	2007y323d00h22m59s
r07323c_W49N_1sg	IDLE	46	2007y323d04h00m04s	2007y323d04h05m59s
r08077a_NRA5_30_1sg	IDLE	46	2000y077d20h39m44s	2000y077d20h44m59s
r08077a_SGR02M_1sg	IDLE	46	2000y077d19h53m40s	2000y077d19h58m59s
r09268a_YS_122957_0	IDLE	23	2009y268d12h29m57s	2009y268d12h32m52s
u08019a_Yamagu	IDLE	936	2008y019d18h00m04s	2008y019d18h59m59s

SHOW_POETAIL

DiskSts	PartSize	Rate	SplitFrm	RecordSize	PlayErrCnt
Capa1024	Dport	SplitMode	RecStartTime	CmdRecStartTime	
Operation	Capa2048	Split	RecErrCnt	RecEndTime	CmdRecEndTime

Main control

SEL_VRTPRXFRM [Part1] mix | ALL

SET_VRTPSRC [Part1] 192.168.10.29 192.168.10.29 10 1

CTL_RECORD stop [Part1] 2009y268d12h29m53s 2009y268d12h32m53s 1024

PLAY

Partition2 u08019a_Yamagu

SET_VRTPDOS [Part2] 192.168.10.29 192.168.10.29 10 3

CTL_PLAY stop [Part2] 2009y019d17h59m55s 2009y019d19h00m00s 2048 0

REMOVE

Partition3

CTL_ERASE [Partition3]

COMMAND

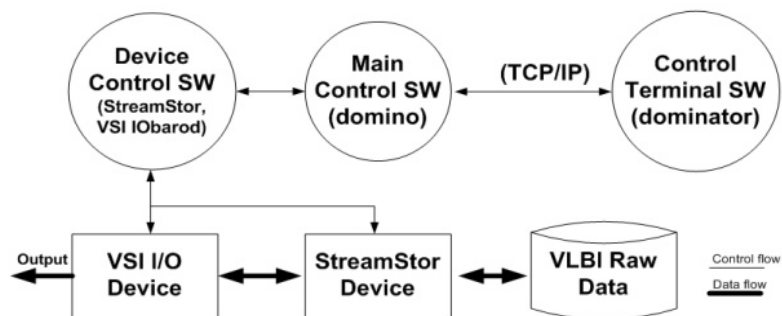
DOB-7

MACRO

```
2009299171001 DOB-8: [ERROR] device offline
2009299171002 DOB-6: [INFO] device online
2009299171003 DOB-7: [INFO] device online
2009299171006 DOB-8: [INFO] device online
```

Mark5B-RVDB GUI interface

Mark5B Playback Control Software



RVDB-MARK5 (UNIT=1, DIO=DIO-1, DPORT=1)

SCHEDULE(fxlog)

FILE: /mk5b/mk5b-1/og/r09295bKYS_MK5_copy.log [START] [STOP] [RUN]

Exper: KYS r09295b VERA7SIO2 2009-295 21:45:12 2009-295 21:55:12

MK5B: A KVN-0006 B

NO	START TIME	END TIME	SCAN	SCAN NAME	BANK	START ADDR
1	2009-295 21:45:12	2009-295 21:55:12	A-10	r09295b_KVNYS_No00008	A	554,998,579,200

RVDB

Record to DDB DIO: 2009-295 21:49:49 [▶]

Partition: DDB-4 r09295bKYSm5no8 [SELECT]

PartRecTime: 2009-295 21:45:12 2009-295 21:55:12 Rate: 1024 Aux: MARK5

MK5B

Media Check: init + scan A KVN-0006 B KVN-0009 SU 8 [▶]

bank_set: Bank-A Bank-B

NO	SCAN	START ADDR	SCAN SIZE	SCAN NAME
1	0	0	7,820,492,800	r09295a_KVNYS_No00004
2	1	7,820,492,800	7,820,492,800	r09295a_KVNYS_No00005
3	2	15,640,985,600	77,051,084,800	r09295b_KVNYS_No00001
4	3	92,692,070,400	77,051,084,800	r09295b_KVNYS_No00002
5	4	169,743,155,200	77,051,084,800	r09295b_KVNYS_No00003
6	5	246,794,240,000	77,051,084,800	r09295b_KVNYS_No00004

Manual Command: [] Macro

```

2010162020900:DDB-4< CTL_RECORD=start:r09295bKYSm5no8'.2009y295d21h45m12s.2009y295d21h55m12s.1024;
2010162020900; DDB RECORD START (DDB-4,r09295bKYSm5no8)
2010162020900:MK5< start 554998579200 .log/r09295b_KVNYS_No00008
2010162020910; MK5B PLAY START (r09295b_KVNYS_No00008)
2010162020920; PLAY VALID (UTC=2009295214512)
    
```

Correlation Control SW(CCS) GUI

The screenshot displays the VCS Control System GUI with several windows open. Red circles with numbers 0 through 10 highlight specific features:

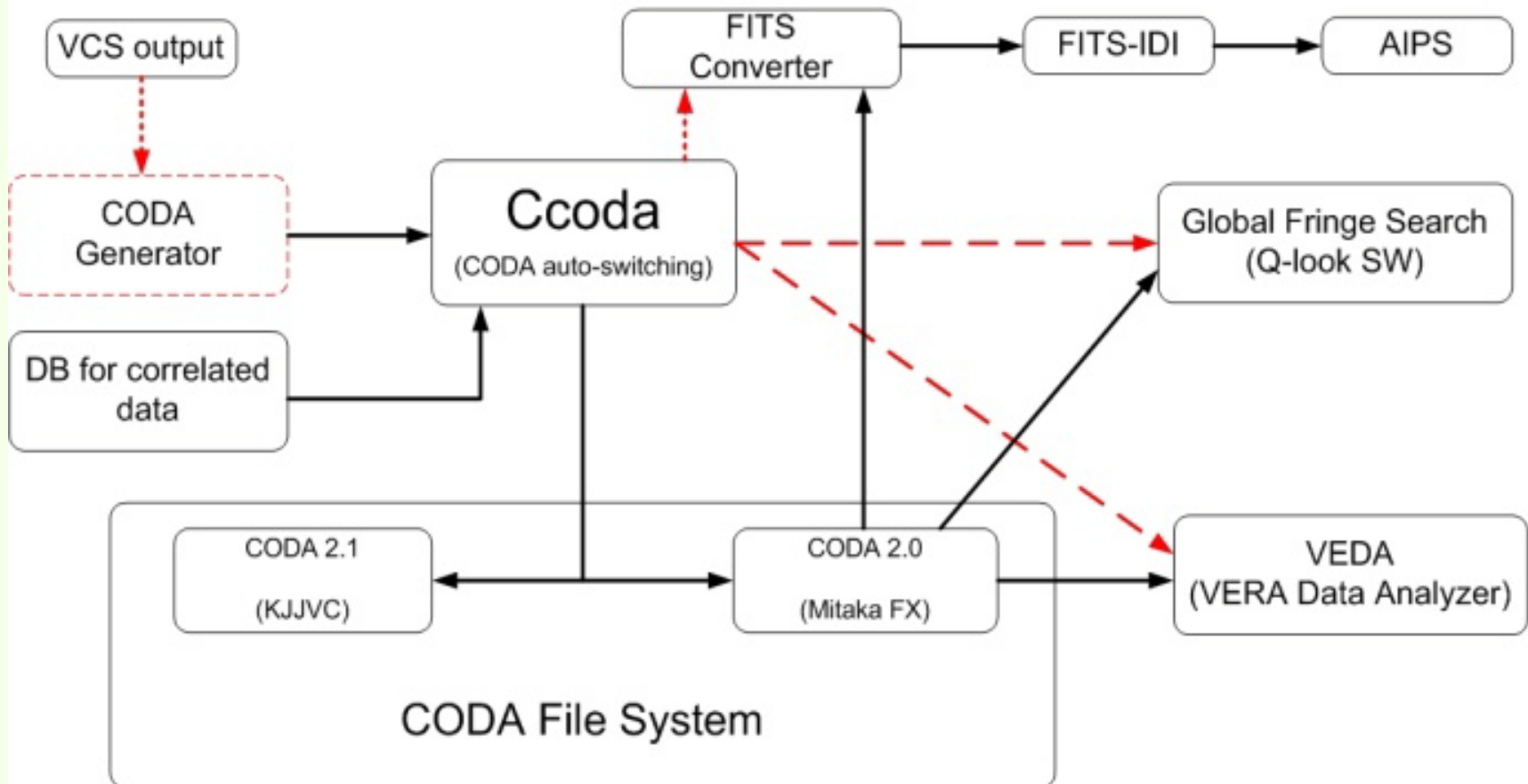
- 0:** The 'Correlation Plan' button in the left sidebar.
- 1:** The 'Initialize All' button in the 'Initialization' window.
- 2:** The 'Stop Time' field in the 'Scan Information' window.
- 3:** The 'CAU STOP' button in the 'Antenna Unit Setting 16 mode' window.
- 4:** The 'Stream' table in the 'Antenna Unit Setting 16 mode' window.
- 5:** The 'Correlation Setting Parameter' field in the 'CAU Setting' window.
- 6:** The 'Apply All' button in the 'Antenna Unit Setting 16 mode' window.
- 7:** The 'CAU STOP' button in the 'Antenna Unit Setting 16 mode' window.
- 8:** The 'CAU STOP' button in the 'Antenna Unit Setting 16 mode' window.
- 9:** The 'Reply from CODA' field in the 'CODA_Delete' window.
- 10:** The 'OK' button in the 'CODA_Delete' window.

The main window shows the 'Antenna Unit Setting 16 mode' configuration, including fields for Experiment Code, Station Name, and various VCS and FFT settings. A terminal window on the right shows command-line output.

CODA Software Tool – Post Correlation



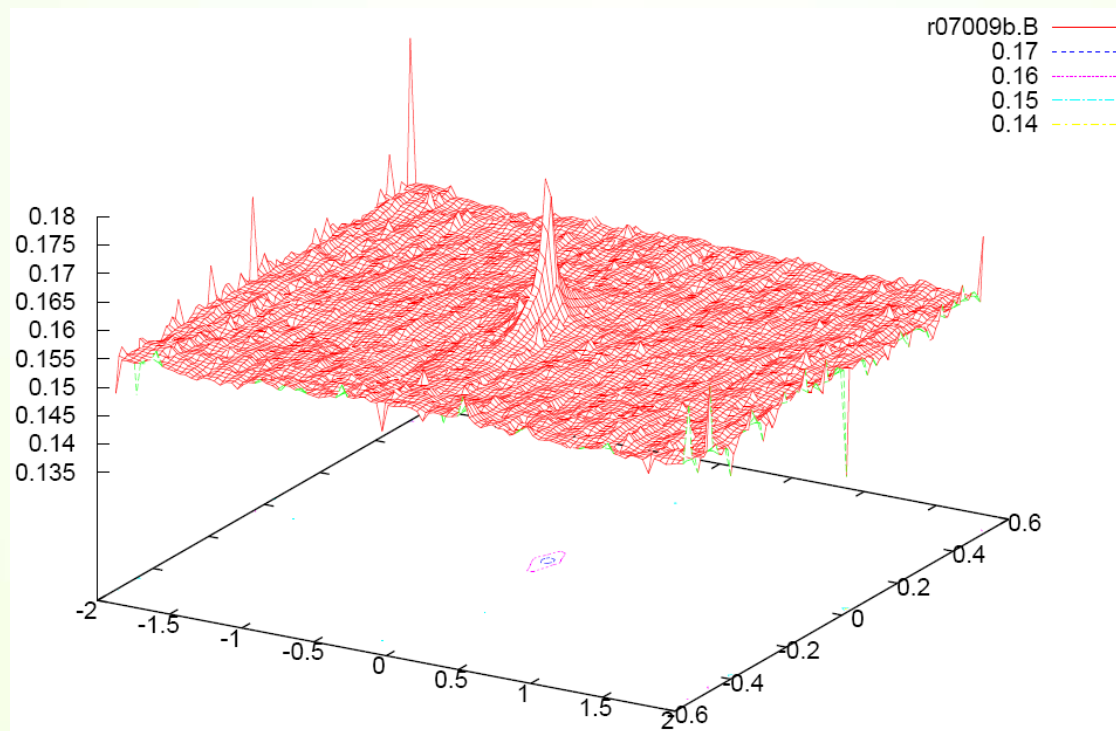
CODA software tools



Global Fringe Search SW



- ❖ Kagoshima Univ.
- ❖ Test with the CODA file system at 2010. 9.



VCS field test (2009.8)



KJJVC integration test (2009.10)



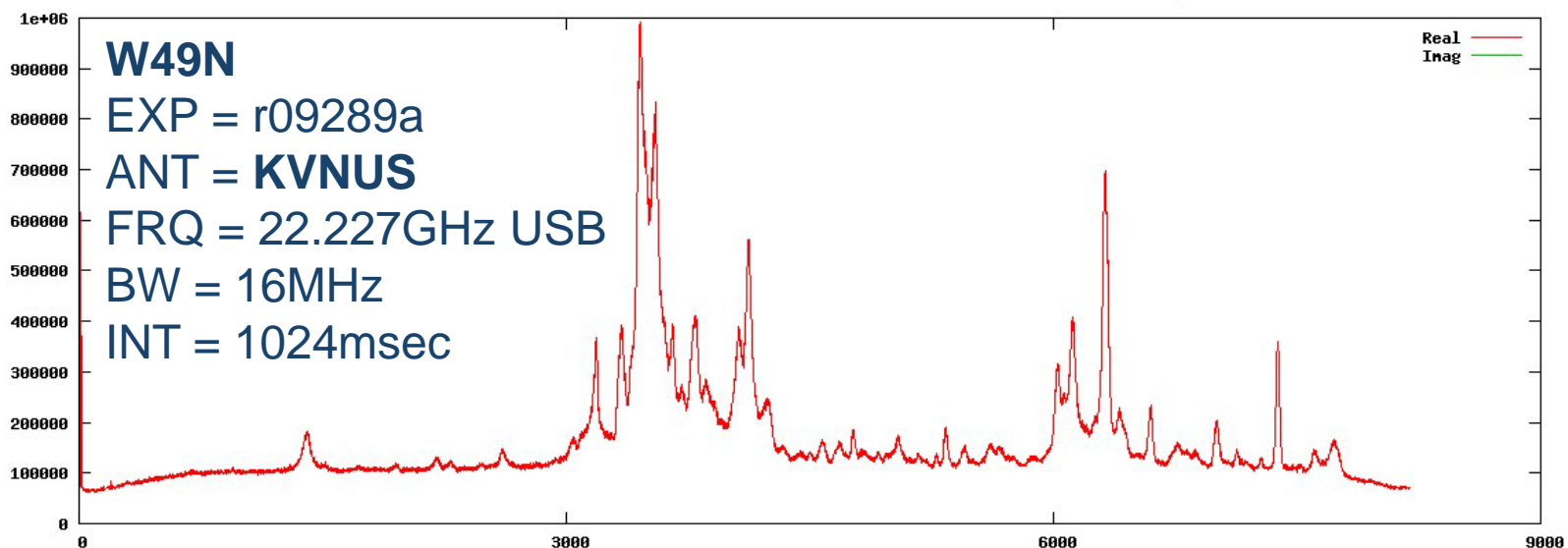
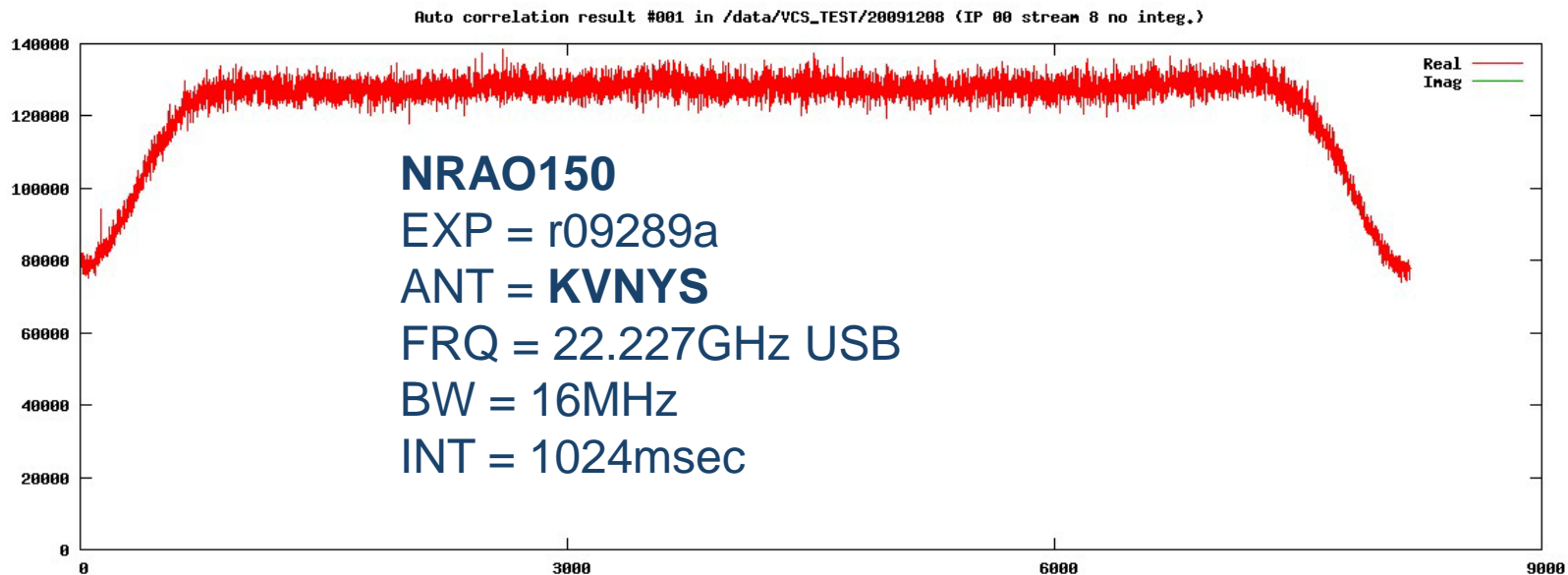
Some Experimental Results



❖ Observation data

- Spectral Line
 - W49N (KVN)
- Continuum
 - NRAO150 (KVN)

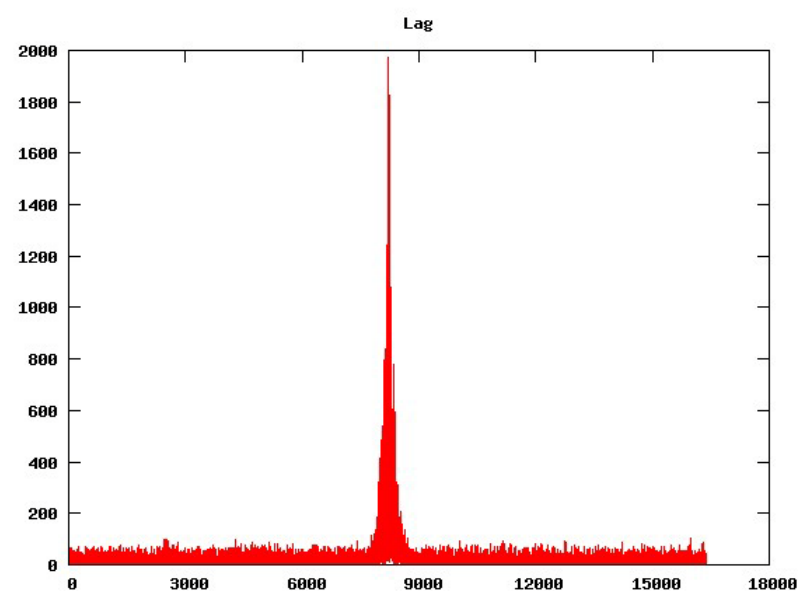
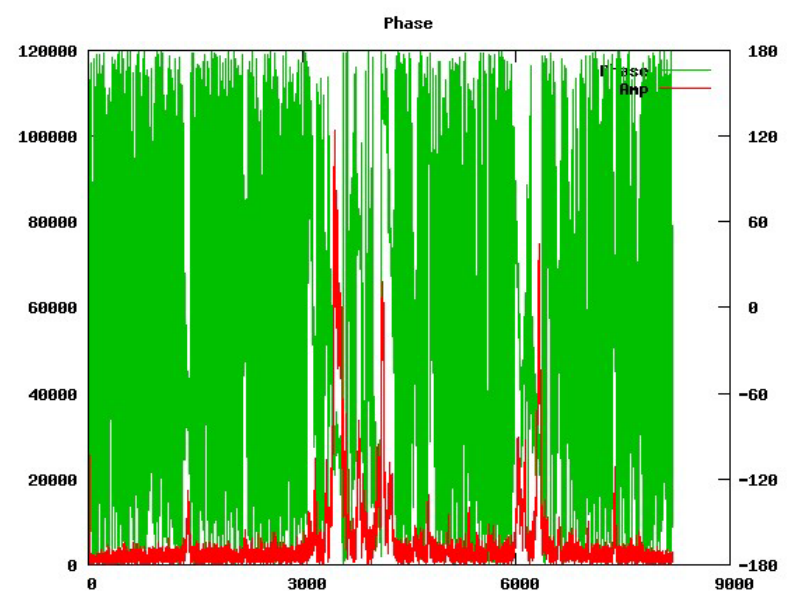
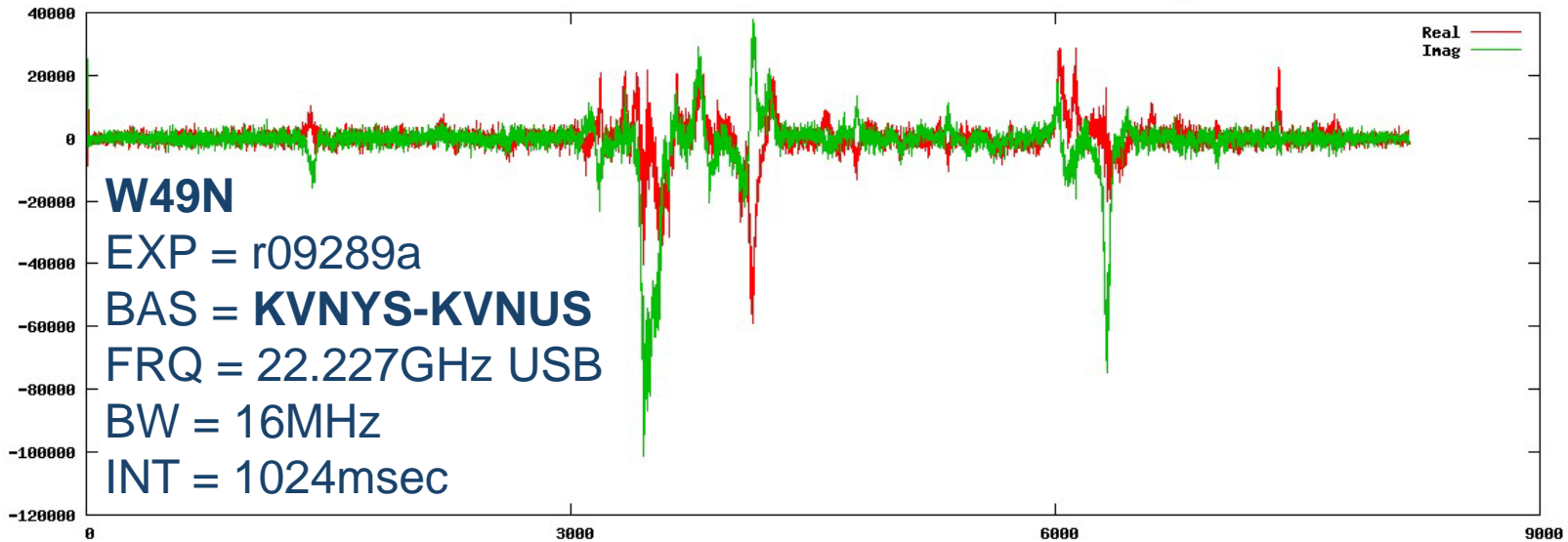
Auto-Correlation Example



Cross-Correlation Example



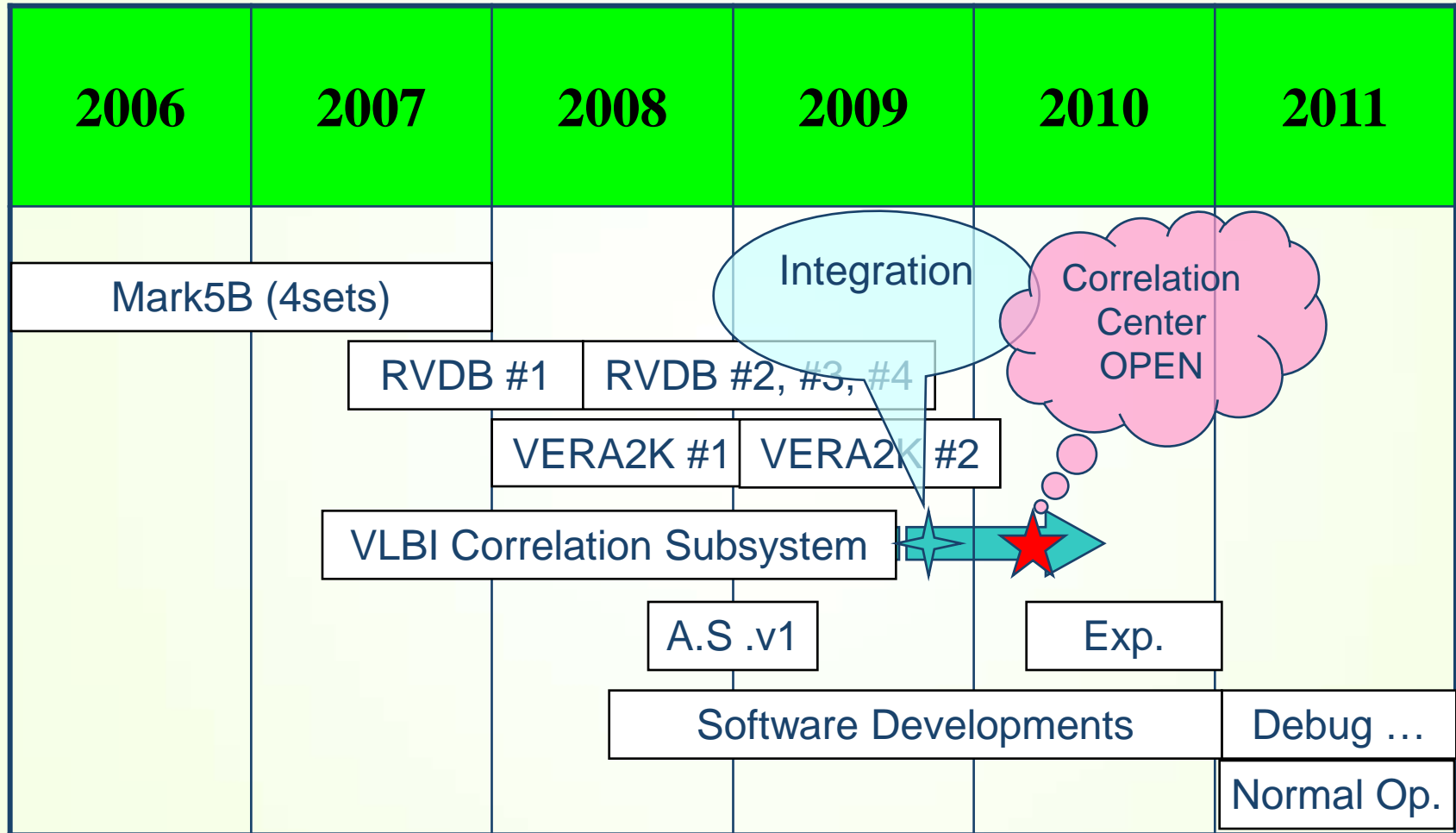
Cross correlation result #002 in /data/VCS_TEST/20091208 (IP 00 stream 8 no integ.)





KJCC: Future Works and Operation Plan

From the First step to the Last one step



KJCC opened at 13 May 2010



**Korea-Japan
Correlation Center**
2010. 5. 13.

Future Works



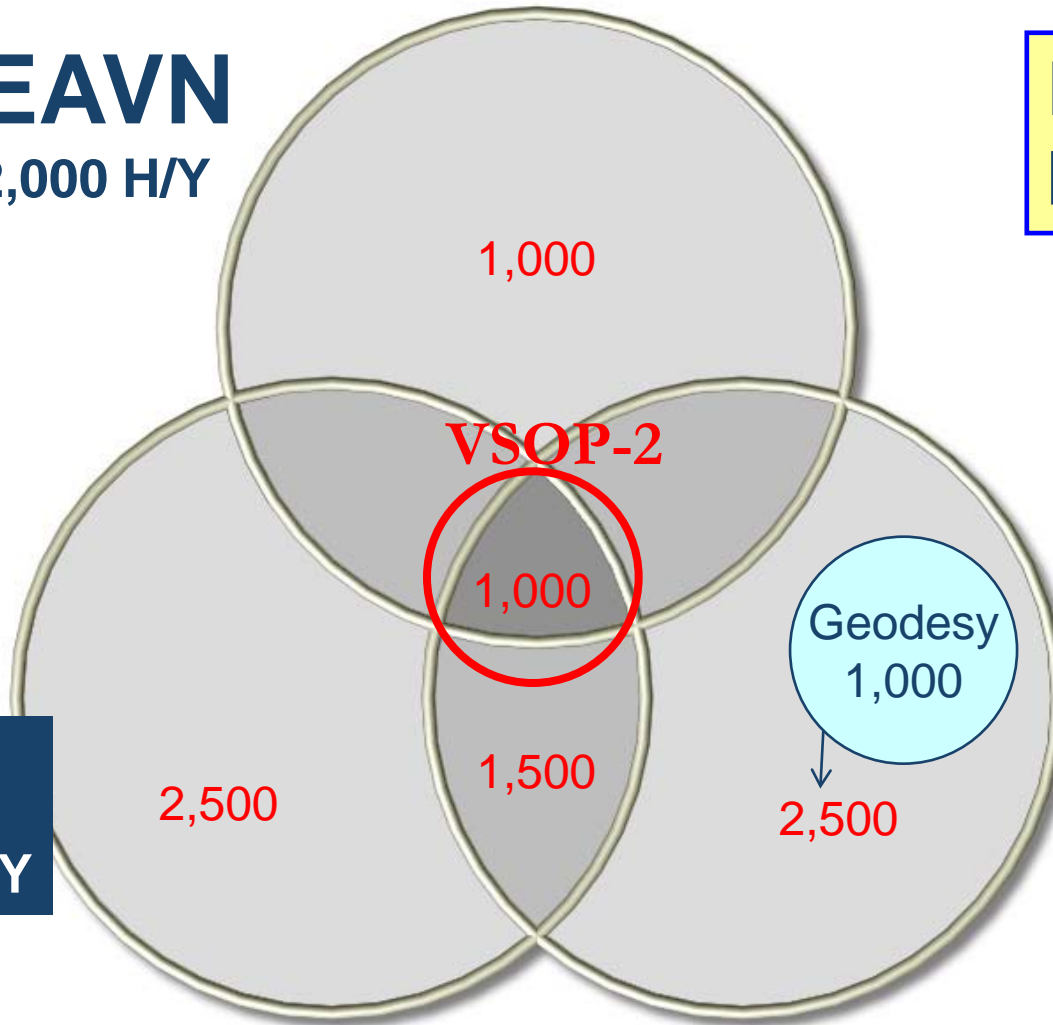
- ❖ Test the Post-Correlation Software Tools (2010 Sep)
- ❖ MoA for joint operation of KJCC between KASI and NAOJ (2010 Dec)
- ❖ **Start the normal operation of KJCC (2011 Jan)**
- ❖ Expand the capacity of Data Archive system, Update Software for further activity (VSOP-2, Dual-Pol Observation etc) (2011 ~)
- ❖ Prepare a well tuned-up pipeline processing, and an Interface to VEDA (2011 ~ 2012)
- ❖ **Move to Daejeon** for New correlation center (~**2012**)
- ❖ Install the Data Archive Back-up system (2012 ~)
- ❖ Fill up the remainder RVDB or OCTAVIA for full 8Gbps system (2012 ~)
- ❖ Ensure the wideband network for e-VLBI capability (2012 ~)

Plan of Full Operation



EAVN
2,000 H/Y

KJCC 6,000 H/Y
Mitaka 2,500 H/Y



KVN
5,000 H/Y

Geodesy
1,000

VERA
5,000 H/Y

KJCC is almost ready to serve YOU.



ありがとうございました。