High-speed Korea-Japan Joint VLBI Correlator (KJJVC) development and its current progress

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KASI, *NAOJ, **Elecs

9th ADASS Annual Conference
4-9 Oct., 2009
Sapporo, Japan

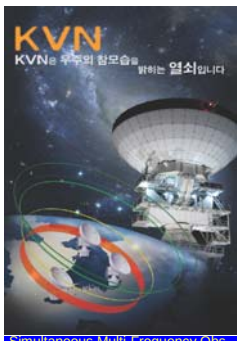
Abstract

The development of Korea-Japan Joint VLBI Correlator (KJJVC) is being progressed in close cooperation with Korea Astronomy and Space Science Institute and National Astronomical Observatory of Japan for Korean VLBI Network (KVN), Korea-Japan Joint VLBI Network (KJJVN), East-Asian VLBI Network (EAVN) including VSOP2. KJJVC is able to perform 8Gbps/station data rate, 16 stations with 8192 output channels. It consists of various playback systems, Raw VLBI Data Buffer (RVDB) system, VLBI Correlation Subsystem (VCS), Peta-scale Epoch Data Archive (PEDA) system, and control and operation software. In case of playback systems, there are many different type of playback system in East-Asian VLBI Network as like Mark5B, VERA2000, and K5 system. And RVDB system will be able to play back the observed data to VCS with same time from various playback systems. VCS is a core product in KJJVC for processing the correlation of data. PEDA is massive data storage to save the correlated results from VCS. It can also support e-VLBI through next generation Gigabit network. The factory and field inspection of VCS was performed and VCS was installed at VLBI Correlator room in June and August 2009, respectively. The overall system integration work will be performed until end of 2009. The Korea-Japan Joint Correlation Center will be opened in Korea next year. In this paper, KJJVC development and its current status will be shown in detail.

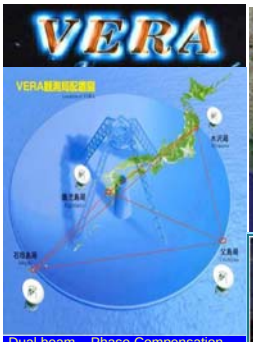
VLBI Facility in Asia

KVN, VERA, CVN, VSOP-2

- **Dedicated VLBI networks**
  - ✓VERA (Since 2002), KVN (From 2008), CVN, VSOP-2(~2013)
- **Other Radio Telescopes**
  - ✓Nobeyama 45m, TRAO 14m, Delingha 14m
  - ✓Others in many Universities and Institutes



Simultaneous Multi-Frequency Obs. – Phase Compensation, mm-VLBI



Dual beam – Phase Compensation, Differential VLBI

Next Generation Correlator in East Asia

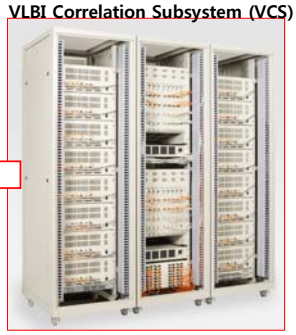
- Joint Correlator Project between Korea and Japan VLBI Facility in Asia

- **MOU between KASI & NAOJ (2005. 7. 7.)**
  - ➢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 : renewed succession project, 5 years from Jan. 2006
- The overall system of KJJVC is under way of integration in close cooperation between Korea-Japan and manufacturer until end of 2009.
- KJJVC would fill the role of heart for East Asian VLBI Network and the Space VLBI with VSOP-2. (East Asia VLBI Consortium Committee, organized at the EAMA6 meeting on Oct. 2004)
- We expect that this project becomes a representative East Asian cooperation in astronomy field. (East Asian Core Observatories Association, organized at Tokyo on Sep. 21, 2005)

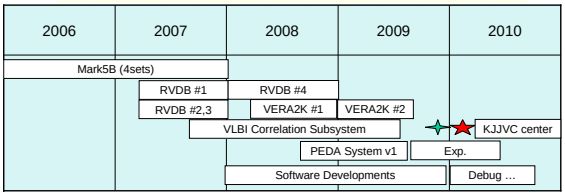
Main specifications of VCS

# of stations	16
# of Inputs / station	Max. 4 inputs
Max. # of Correlations / Input	120 Cross + 16 Auto
Subarray constitution	2 case (12 + 4, 8 + 8)
Observation Frequency	(VSOP2) 45GHz, 130/86/43/22 GHz
Largest Baseline Length	+-36,000 km(+-0.12sec)
Max. Data Output Rate	1.4GBytes/sec
Digitization for each Input	1 Gsps by 2bits/sample
Quantization Levels	4 levels as 00<01<10<11
Interface	VS I-H(32 parallels, 1PPS, VALID, PDATA)
Input Data Rate	2Gbps/1Gbps
Architecture	FX type, with FPGA and DSP chips
FFT points	256k/128k/64k/32k/16k/8k Adjustable
Word length in FFT	16+16 bits fixed point for real & imag.
Integration period	25.6msec-10.24sec
Frequency Binning	1-256 channels bin(2's powers)
Correlation Output Data Interface	10Gbits Ethernet x 4ea

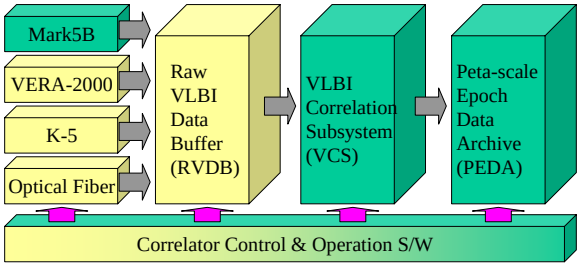
VLBI Correlation Subsystem (VCS)

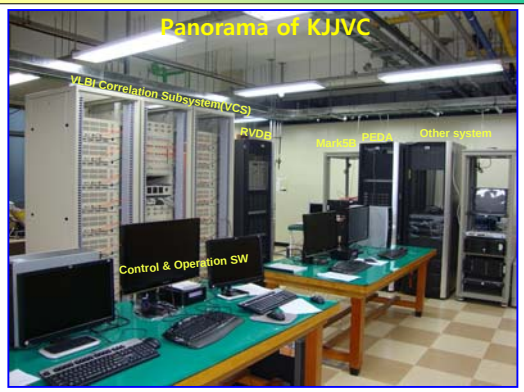


KJJVC Schedule



Korea-Japan Joint VLBI Correlator (KJJVC)





Mark5B

VERA2000

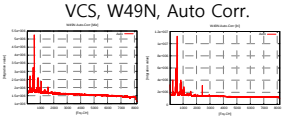
RVDB

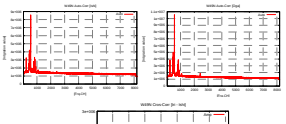
- Mark5B : which is widely used in VLBI and KVN participated in developing Mark5B as int'l consortium member. This is VSI compatible with 1Gbps and consists of 2(two) 8-pack HDD.
- VERA2000 : DIR2000 is in use extensively at VERA. VERA 2000, which is modified by DIR1000, will be used for VERA with 1Gbps.
- K5 : which is one another HDD based system for other institutes and university from NiCT, Japan.
- Optical Fiber : Capable of dealing with the full data rate of 8 Gbps.

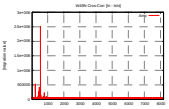
- RVDB (Raw VLBI Data Buffer)
  - ➢Data format adjustment : # of bits per sample, and so on
  - ➢Easy synchronization while playback (heterogeneous recorder models)
  - ➢Buffering between recorder speed(1 Gbps) and correlation speed(8 Gbps)
  - ➢Handy switching over to next session
  - ➢4 sets RVDB system development were completed and basic experiments were successfully performed. And RVDB system are already used in Mitaka Real Time Correlator, Japan.
- PEDA **(Peta-scale Epoch Data Archive)**
  - ➢It is able to process Max. data rate of 1.4GB/sec from VCS
  - ➢Basic system Architecture : Infiniband
  - ➢Max. Capacity : 1~3 PB for 1 year (EAVN, VSOP-2), now we prepared 110TB.
  - ➢This system will adopt CODA file system, which is a modified version of Mitaka FX correlator's file system.
  - ➢Please refer another POSTER, which will be described in detail.

Experimental Results

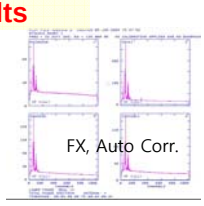
VCS, W49N, Auto Corr.

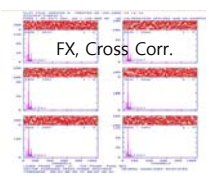


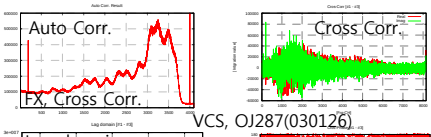




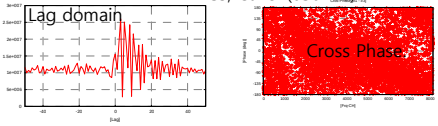
VCS, W49N, Cross Corr.







VCS, OJ287(030126)



- To verify the performance of VCS, we conducted correlation experiments using VERA and JNet data, which is a spectral line source named as W49N and continuum source named as OJ287.
- In case of W49N, the results of VCS was compared with Mitaka FX correlator.