KJCC and Recent System Development Status

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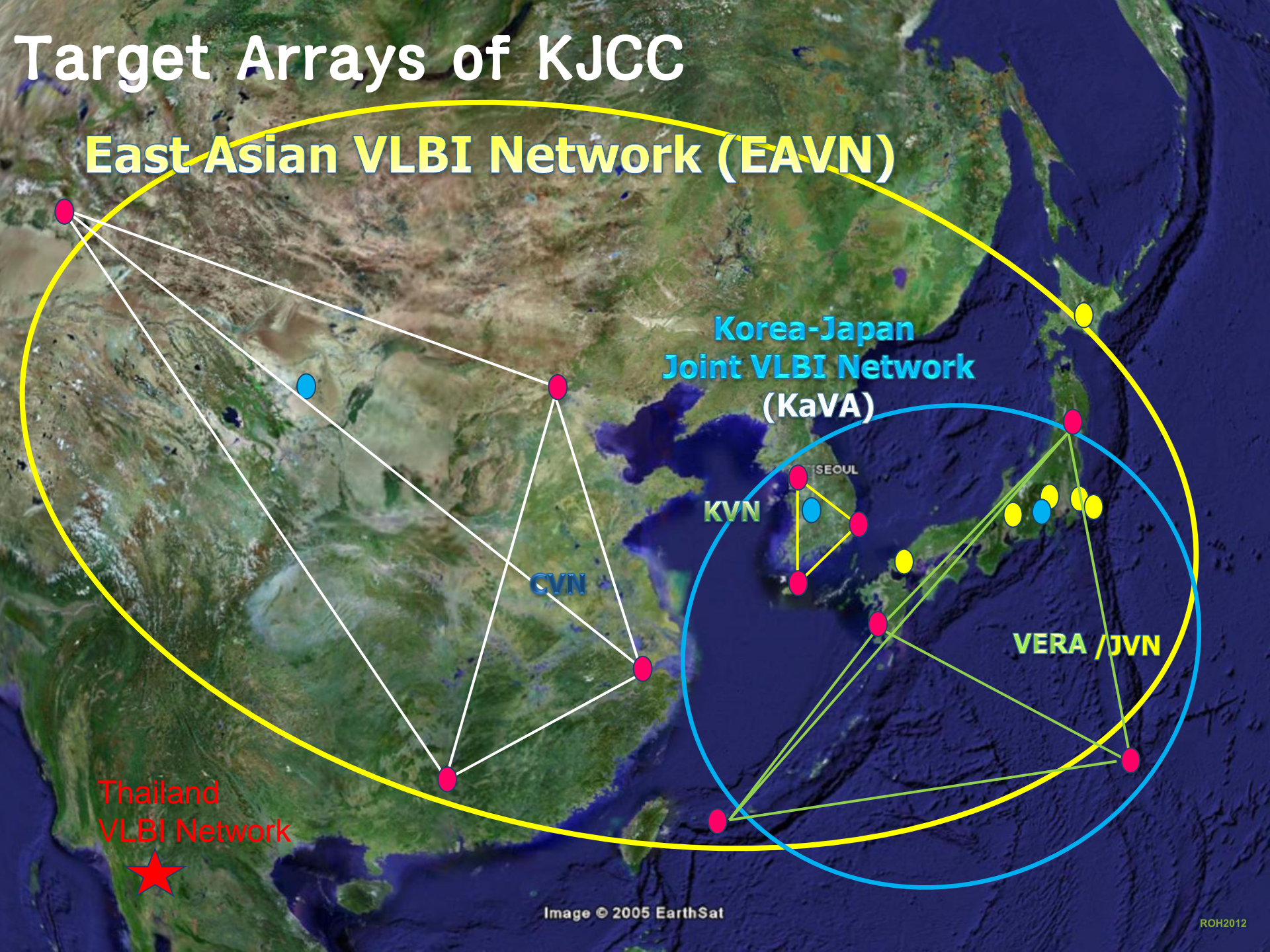
Target Arrays of KJCC

East Asian VLBI Network (EAVN)

Korea-Japan
Joint VLBI Network
(KaVA)

KVN

CVN

VERA /JVN

SEOUL

Thailand
VLBI Network

Image © 2005 EarthSat

ROH2012

Daejeon Correaltor development history

- ❖ 2005.7.7 : Exchange MOU joint development between KASI and NAOJ
- ❖ 2006 : Start development project in each side(NAOJ : develop RVDB & VERA2000, KASI: develop VCS), VCS design was started
- ❖ 2007~2009 : KASI developed and installed VCS
- ❖ 2009 : NAOJ developed and installed VERA2000 Playback and RVDB
- ❖ 2010.5.13 : Open the Korea-Japan Correlation Center
- ❖ 2011.7.20 : Exchange MOA for joint operation between KASI and NAOJ
- ❖ 2012.7.11 : Move the KJCC from Seoul to Daejeon
- ❖ 2013 : normal operation with 1Gbps

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Daejeon Correlator Framework
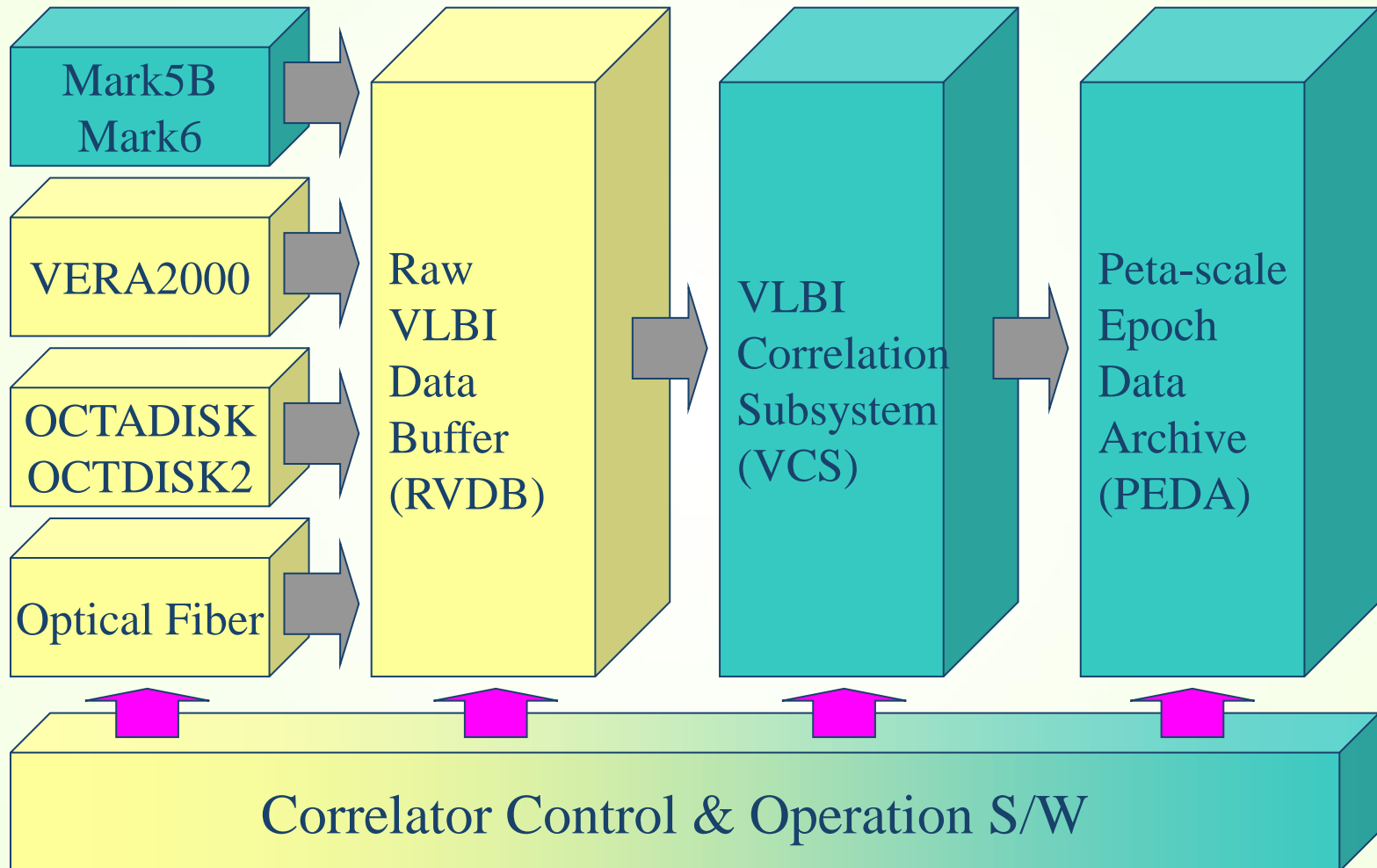
Development of Daejeon correlator
VCS (VLBI Correlation Subsystem) specifications

# of Antennas	16
# of Inputs / Antenna	4 bands (4Fx1P, 2Fx2P,1Fx2P+2Fx1P)
Max. # of Correlations / Input	120 Cross + 16 Auto
Subarray	2 case (12 + 4, 8 + 8)
Bandwidth for each Input	512 MHz
Digitization for each Input	1 Gsps by 2bits/sample
Data Rates per antenna	8 Gbps VSI-H (32 parallels, 64 MHz clock)
Max. Delay compensation	±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

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Playback Systems

- ❖ Mark5B : VSI, 1Gbps recording/playback
  Mark6 : VDIF, 1~8/16/32Gbps recording/playback
- ❖ VERA2000 : 1Gbps, which is modified by NAOJ according to DIR1000, will be used for Playing back DIR2000 tape media for VERA.
- ❖ OCTADISK : VDIF, modified using RVDB with 4Gbps recorder/playback developed by NAOJ.
- ❖ OCTADISK2 : VDIF, 8~32Gbps recording/8Gbps playback
- ❖ Optical Fiber : Capable of dealing with the full data rate of 8 Gbps.

OCTADISK

OCTADISK2

Mk6

Mk5B

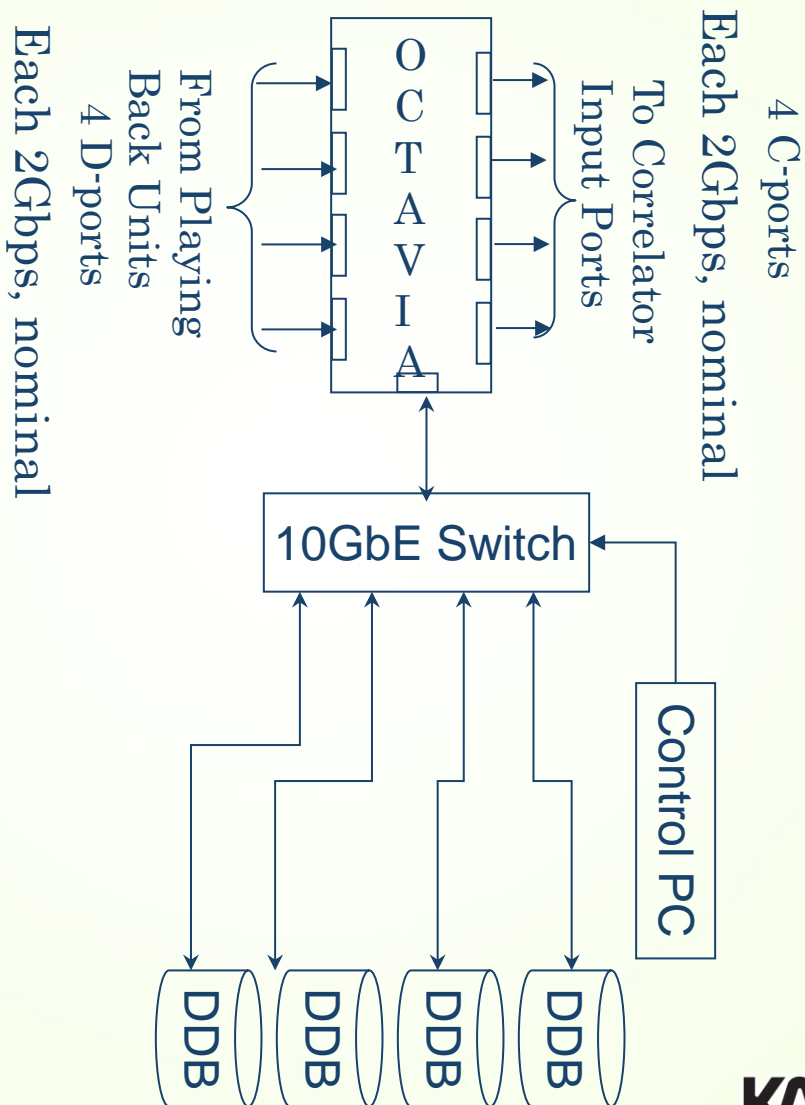VERA2000

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- ❖ Data format adjustment : # of bits per sample, and so on
- ❖ Synchronize easily while playback
- ❖ Buffering between recorder speed and correlation speed

Each 2Gbps, nominal
From Playing Back Units
4 D-ports

Each 2Gbps, nominal

OCTAVIA

4 C-ports
Each 2Gbps, nominal
To Correlator Input Ports

10GbE Switch

Control PC

DDB DDB DDB DDB

VLBI Correlation Subsystem (VCS) (2007.8-2009.7)

- 16 Stations, 2Gbps x 4 sub-streams/station (in total 8Gbps)

- 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

PEDA(Peta-scale Epoch D.A.)

❖ Max. data rate of 1.4GB/sec from VCS (~10% at average operation)

❖ PEDA (specification)

- **Architecture**
  - **Infiniband**
  - **~100 TB**
- **Expected Max. Capacity**
  - **1~3 PB for 1 year (EAVN)**

❖ Introduced this machine in 2009

- It is old and maintenance service from manufacturer will be terminated within 2016
- New machine is needed

~100 TB

New Data Archive System
VDA(VCS Data Archive)

❖ **CPU : Intel ZEON, 32 cores**

❖ **Memory : 32GB**

❖ **Storage : 160TB(RAID 5, 6)**

❖ **Interface :**
- 10GbE x 8 ea, SFP+(4 VCS, 4 External)
- 10GbE x 4ea, 10GBASE-T (Gluster File System)
- 1GbE x 4ea, 1GBASE-T (Control)

❖ **Access speed :**
- Write : max 1.4GB/sec
- Read : max 2.2GB/sec

❖ **Installed and tested last week**

Korea-Japan Correlation Center(KJCC)

Executive Board

Daejeon Correlator

DiFX Correlator on HPC

Correlation Mode

Corr. mode	Band width [MHz]	Output streams	#bits	Output data rate [Mbps]	Clock rate [MHz]
[a]C1	256	1	2	1024	32
C2	128	2	2	1024	32
C3	64	4	2	1024	32
C4	32	8	2	1024	32
C5	16	16	2	1024	32
[b]W1	512 x 4band	4	2	8192	64
W2	512 x 4band	1IF[c]x2P[d] 2IFx1P	2	8192	64
W3	512 x 4band	2IFx2P	2	8192	64

a, Narrow band, b. Wideband, c. IF, d. Polarization

Support wideband over 8Gbps

❖ 8Gbps concept(Total 2048MHz BW)

512 MHz BW	512 MHz BW	512 MHz BW	512 MHz BW
2 Gbps	2 Gbps	2 Gbps	2 Gbps
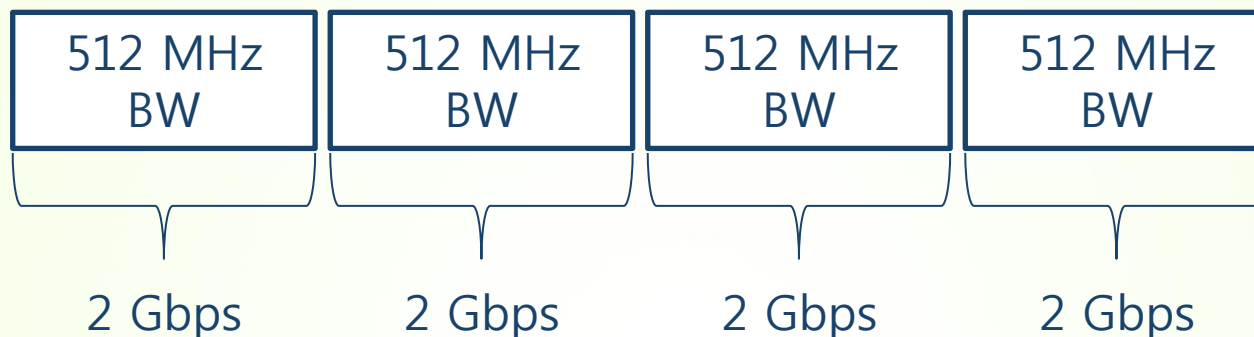
❖ Obs Combination(w/ polarization)

Array	Concept			
KVN	22L/R	43L/R	86L/R	129L/R
KaVA	22L	22R	43L	43R
KVN/NRO 45/CVN	22L	22R	86L	86R
KVN/NRO /CVN	43L	43R	86L	86R

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Data transmission SW

❖ In case of KVN 8Gbps or VDIF format obs data to upload the observed data to RVDB,

- the observed data is needed to be split with 4 streams as time-ordered because the method to upload overall 8192 Mbps to OCTADDB one time as described before.

- Already finished the Data transmission SW development and now used to upload 1 or 2Gbps observation data from the massive server to RVDB with optical link as like bellowing figure.
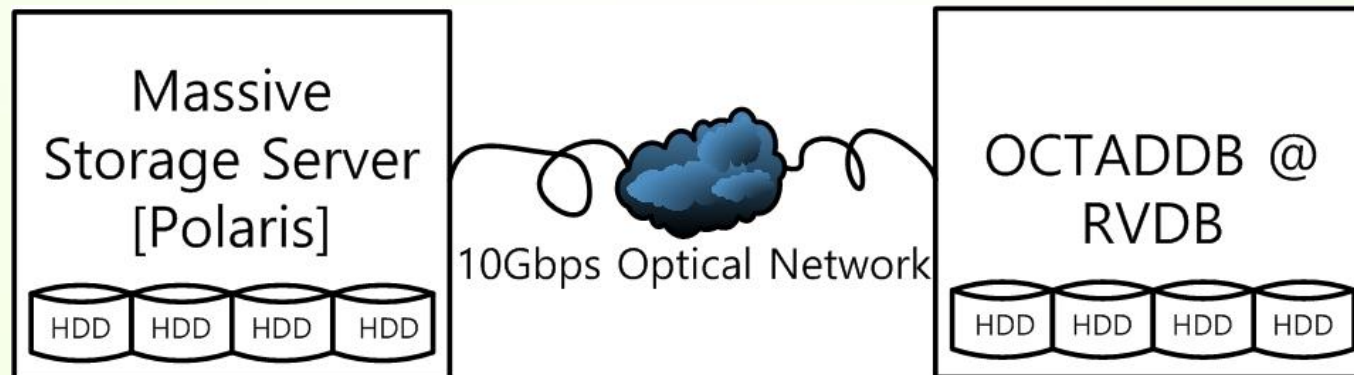
Data conversion SW development

| #	SW	Function
1	Mark5BtoVDIF	Convert Mark5B format to VDIF format
2	VDIFtoMark5B	Convert VDIF format to Mark5B format
3	VDIFtoVDIF	Convert General VDIF format to OCTA-VDIF format
4	Cut_Mark5B	Extract Data from Mark5B format file
5	Cut_VDIF	Extract Data from VDIF format file

CODA/FITS development

- **Multi-frequency Multi-polarization (wideband mode, ex: 8Gbps)**
  - CODA is currently possible to support
  - If selection rule of frequency part will be adopted, CODA/FITS for each IF will be generated
- **Direct FITSgen SW development**
  - Parallel CCcoda will be needed to be developed
  - Development period : about 1month
  - The generation speed of FITS should be considered and needed.
  - Development cost should be considered(Leonid, Kan'ya-san request)
    - About 700,000JPY

- **Dual-polarization mode support**
  - CODAgen SW development was completed.
  - Test obs data was used (s17so01a(k17046a), C2~C5 mode)
  - Please see next pages.

C3(64MHzBW x 4ch) mode(LLRR)
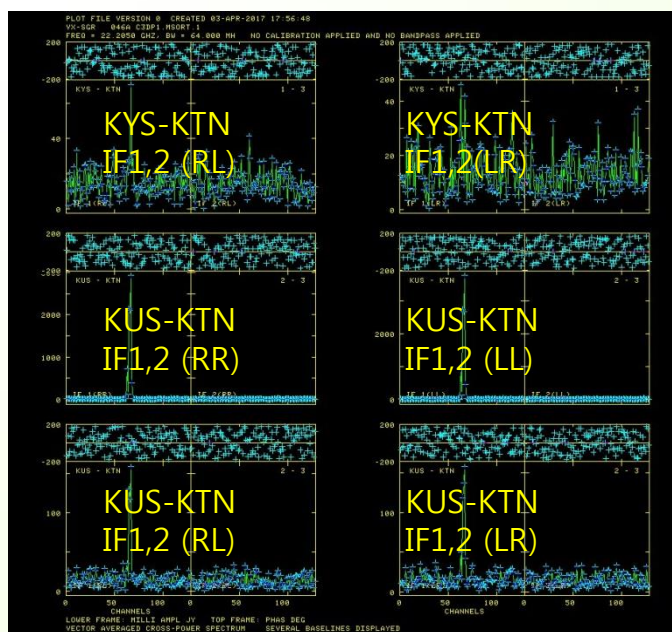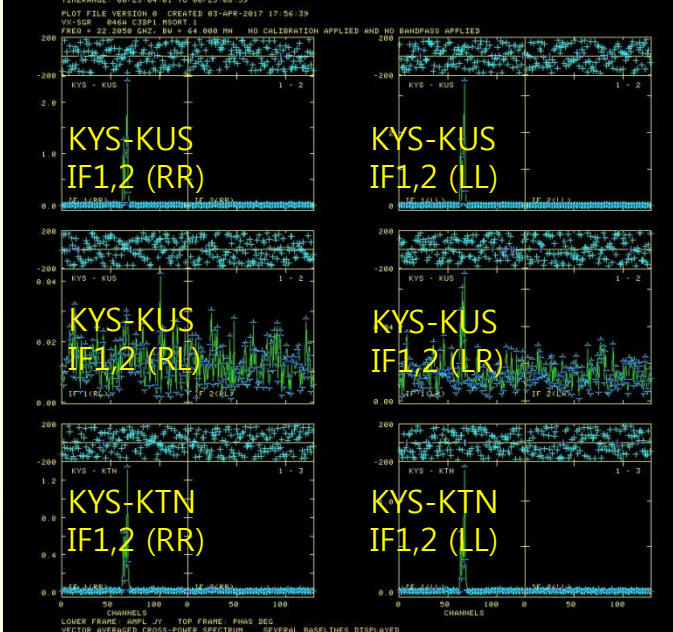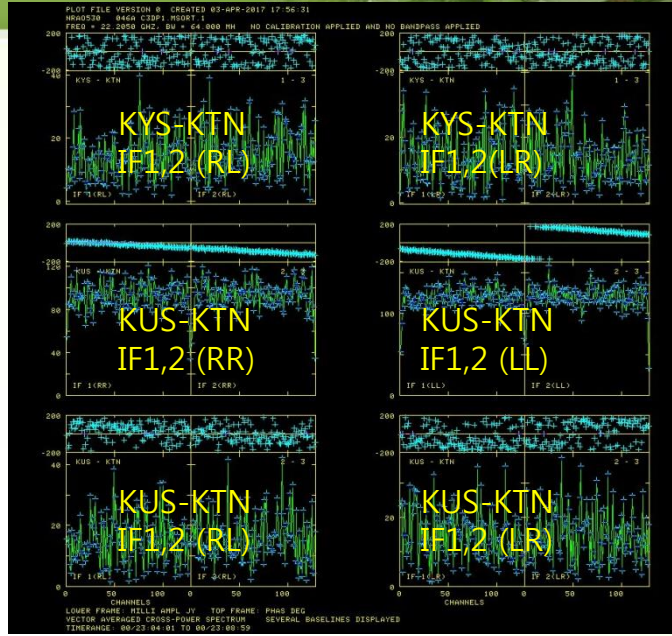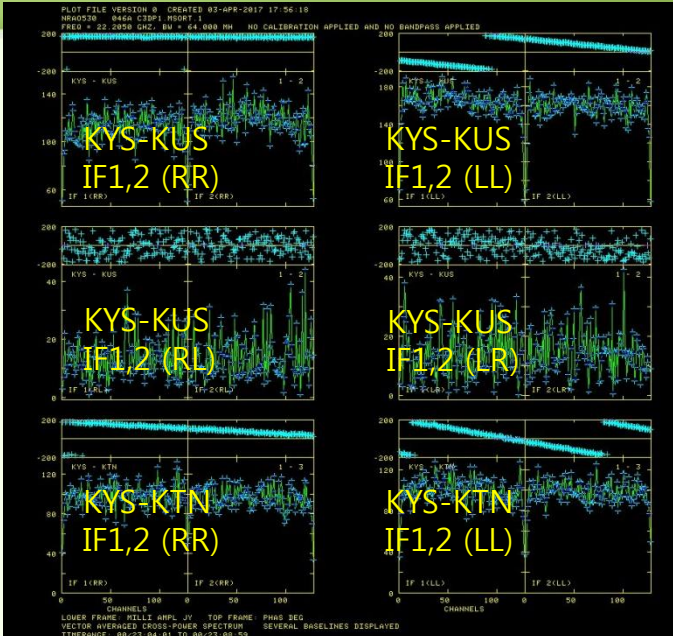
KVN Halcyon recorder (Specification)

□ Target processor : Intel Xeon
□ Target board
  ▪ Asrock X99 extreme11
  ▪ DDR4 RAM 32GBytes
  ▪ Broadcom BCM57711 NIC 10GbE PCIe
□ Operating System : FirmOS(like DOS)
  ▪ include scheduler
  ▪ support multi-core
  ▪ no filesystem
  ▪ DRAM/NIC/SATA control directly
    (without device driver)
□ Build environment: gcc, nasm(boot code)
□ **can make full resources and performance**
  ▪ recording speed 8.224Gbps(VDIF UDP)
  ▪ recordable capacity 90% of SATA HDD
□ very cheap(Mainboard/CPU/RAM/NIC/Chassis)
  ▪ around $5,000 without HDDs

Intel Xeon multi-core Processor

10GbE NIC PCIe
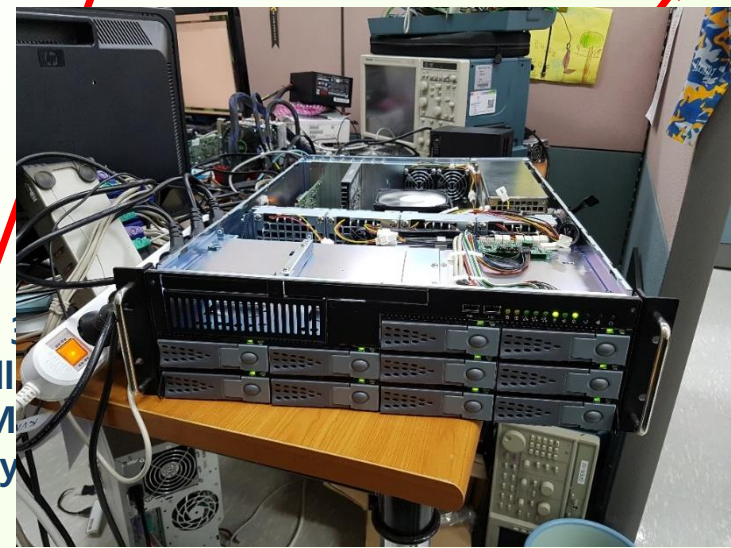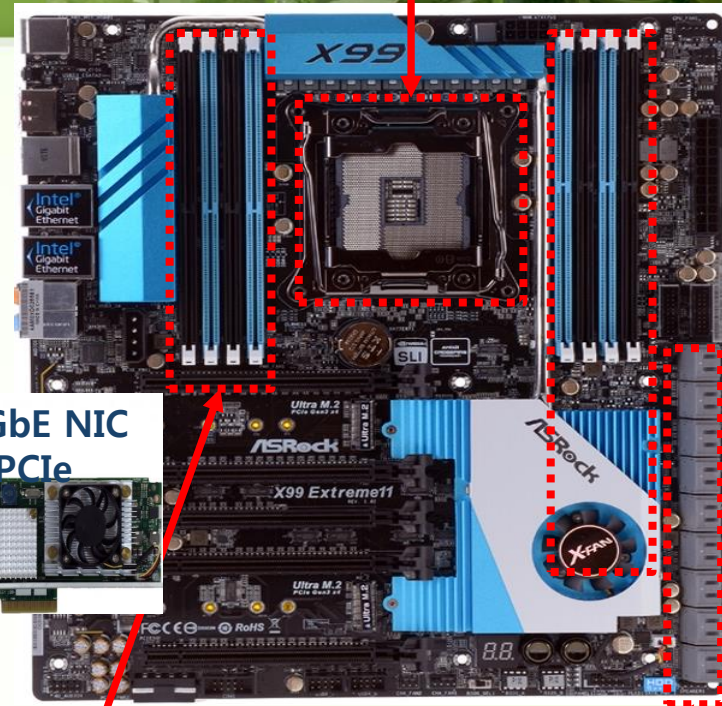
DDR4 RAM
install
(Support M
128GBy

KYS-KTN baseline

1Gbps SNR (MK5) **8Gbps SNR (Halcyon + MK6)**

3C273, 3C279, M87

Empty period according to recorder change
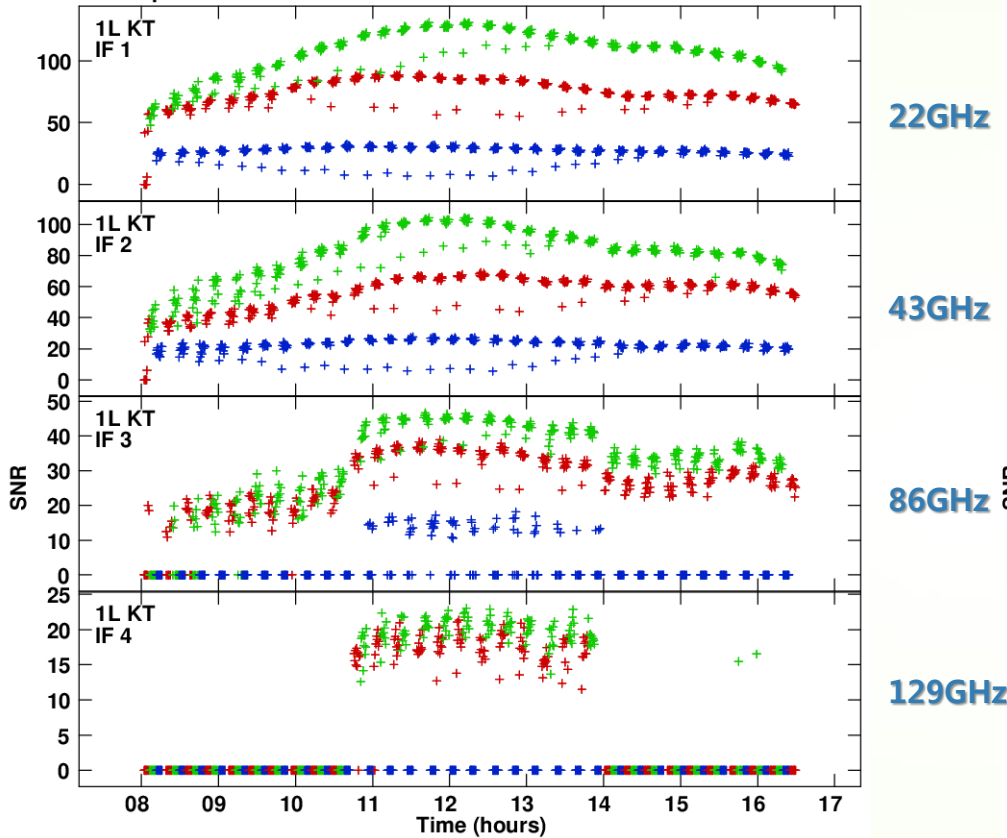
MK5 recorder
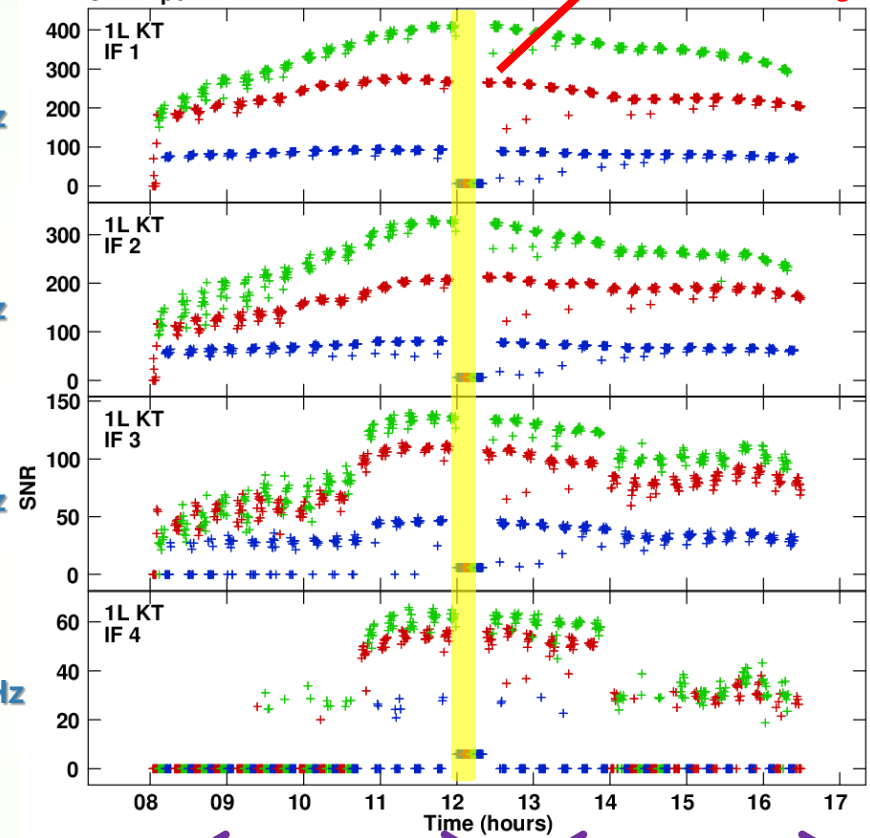
Halcyon recorder   MK6 recorder

※ SNR comparison: 1Gbps(64 MHz BW/4IF) and 8Gbps(512MHz BW/4IF)
Expected value of theoretical sensitivity increment (about 3 times) is well followed according to the bandwidth increase (8 times).
The results of Halcyon are almost same as those of KYS Mark6

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HDD checking system

❖ HDD with huge capacity is used to record high rates of obs data.

❖ In recording at Obs., the data was correctly recorded, but the diskpack was not recognized at Correlator center during playingback

❖ In order to overcome this issue, HDD checking system was developed using FirmOS same as OS of KVN Halcyon recorder.
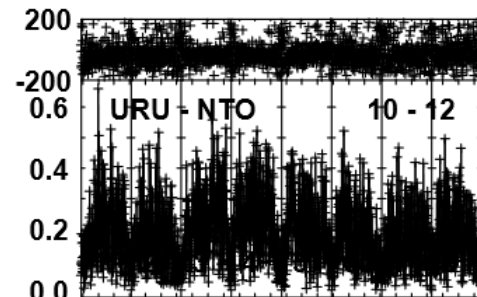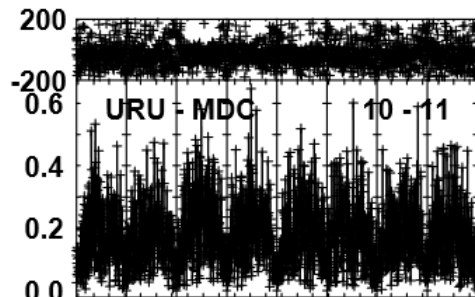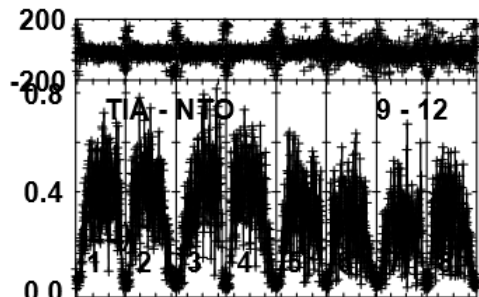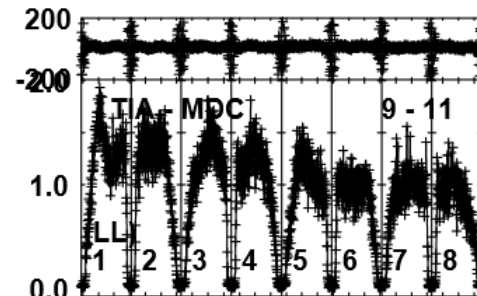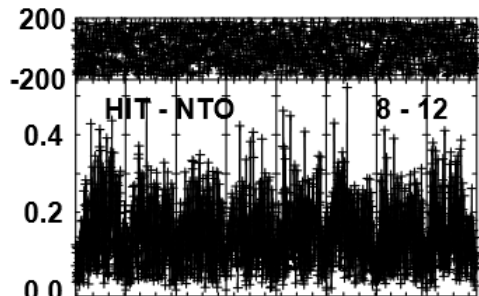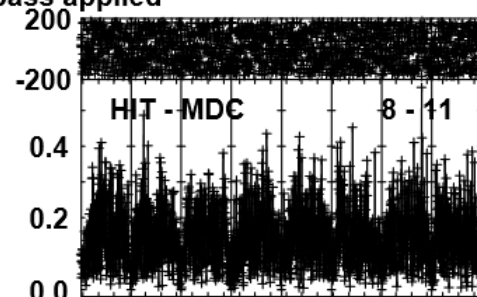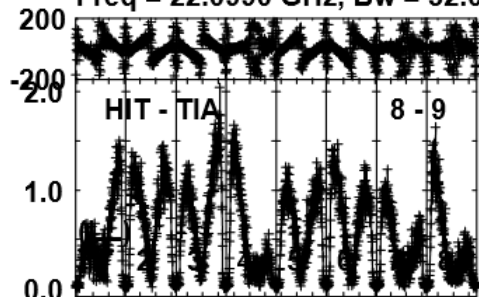
Plot file version 22 created 07-SEP-2017 15:31:46
3C273   A17107A.MSORT.1
Freq = 22.0990 GHz, Bw = 32.000 MH   Calibrated with CL # 3 but no bandpass applied
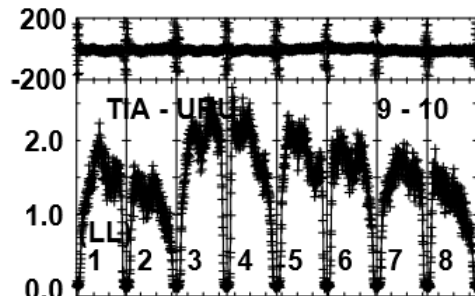
Lower frame: Milli Ampl Jy   Top frame: Phas deg
Vector averaged cross-power spectrum   Several baselines displayed
Timerange: 00/17:43:01 to 00/17:47:59

Correlation Status (2017A)

KVN only (216) by DiFX

Type	Obs time (Hours)	HDD (TB)
1Gbps	1,817.5	2,730.3
2~8Gbps	391.2	3,803.3
Total	**2,208.7**	**6,533.6**

KaVA (86) by Daejeon Corr.

Type	Obs time (Hours)	HDD (TB)
KaVA	570.9	2027.2
KVN (@KaVA)	111.8	237.5
Total	**682.7**	**2,264.7**

EAVN (16) by Daejeon Corr.

Type	Obs time (Hours)	HDD (TB)
EAVN	119.2	494.1
Total	**119.2**	**494.1**

❖ FITS file for KVN only is currently delivered to PI within 2-weeks.

❖ In case of KaVA/EAVN, FITS file is distributed to PI within 1.5 month after arriving the media at KJCC, which depends on the diskpack delivery or data copy, transmission.

❖ In 2017A, FITS deliver period
- AGN : 25days (mostly KaVA obs)
- ES : 22days
- SFR : 58days

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Near Future : Data Transmission

❖ **Data transmission from each Obs.**

- Stardom server were prepared
- Mark5B data for KaVA will be transferred mid of next year