Current Status of VERA Geodetic VLBI System

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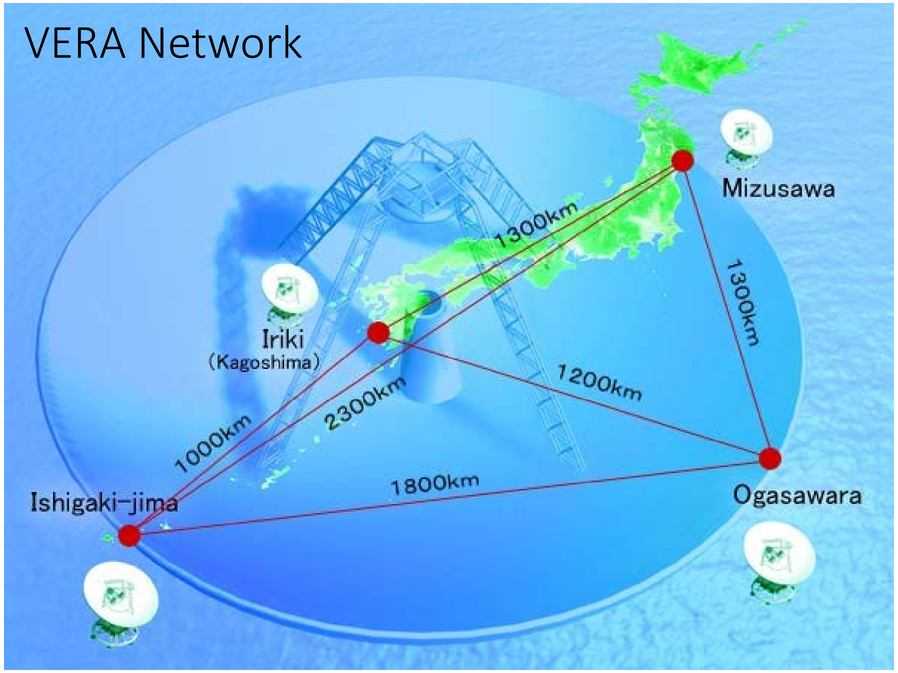
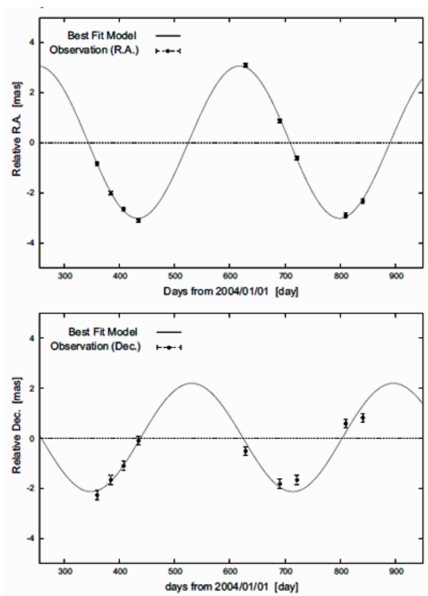


VERA is a Japanese VLBI array aimed for obtaining 3-dimensional map of our Galaxy. With phase-reference VLBI technique, VERA measures distances and motions of radio sources in our Galaxy with a few 10 micro arc-seconds accuracy, unveiling the true structure of our Galaxy. The construction of VERA array was completed in 2002, and it is under regular operation since 2003.

Four 20-m diameter antennas (Mizusawa, Iriki, Ogasawara and Ishigakijima) consist VERA Network in Japan island-arc.



VERA monitors the separation angle between two radio-stars, MASER-emitting molecule cloud and Quasar, for more than two years, and determines a distance to the MASER emitting sources by annual parallax.

T-Lep (Mira Variable), H2O maser (22GHz)
Annual Parallax: 3.06-/+ 0.04 mas, Distance: 327 -/+ 4 per-sec
(Nakagawa, et. al, 2014)

About 200 annual parallaxes are determined for 10 years.

Two kinds of geodetic VLBI operations are performed for guaranteeing the accuracy of VERA astrometry.

▪Specification of VERA Geodetic VLBI observation before Apr. 2017

▪1st purpose and mode: Fixing of the VERA network to TRF
by Participation in the IVS sessions (T2, AOV) - Traditional specification

Specifications	
Typical number of scan	200 - 300
RF bandwidth	S: 2210-2340 MHz, X: 8190-8610 MHz
Number of channels	S: 6ch, X: 8ch
Analog baseband filter	K4 video convertor
Sampling mode	8 MHz sps - 1bit - 16ch, 128 Mbps
Recorder	K5VSSP
Correlation	IVS correlation center (Bonn, Haystack, GSI, etc)

▪2nd purpose and mode: Monitoring of VERA network form with a few mm error
by VERA Internal geodetic VLBI –
The features of this specification are: 1G-bps recording, and use 22-23GHz Band.

Specifications	Specification peculiar to VERA
Typical number of scan	700 - 800
RF bandwidth	22800-23328 MHz
Sampling mode	1024 Msps - 2bit – 1 stream, 2048 Mbps
Digital Filter Mode	32 Msps - 2bit -16 stream, 1024 Mbps
Recorder	DIR2000H (till 2014), OCTADISK (2015 and after)
Correlation	Mitaka FX (till 2014), Mizusawa Software named OCTACOR2 (2015 and after)

<- Total data-rate is reduced to 1 Gbps

It was high technology ten years ago, but, ten years or more have passed since the start of VERA, most HWs have become End-Of-Support.
And, according to some scientific demands, updating for improving observation performance has been needed.

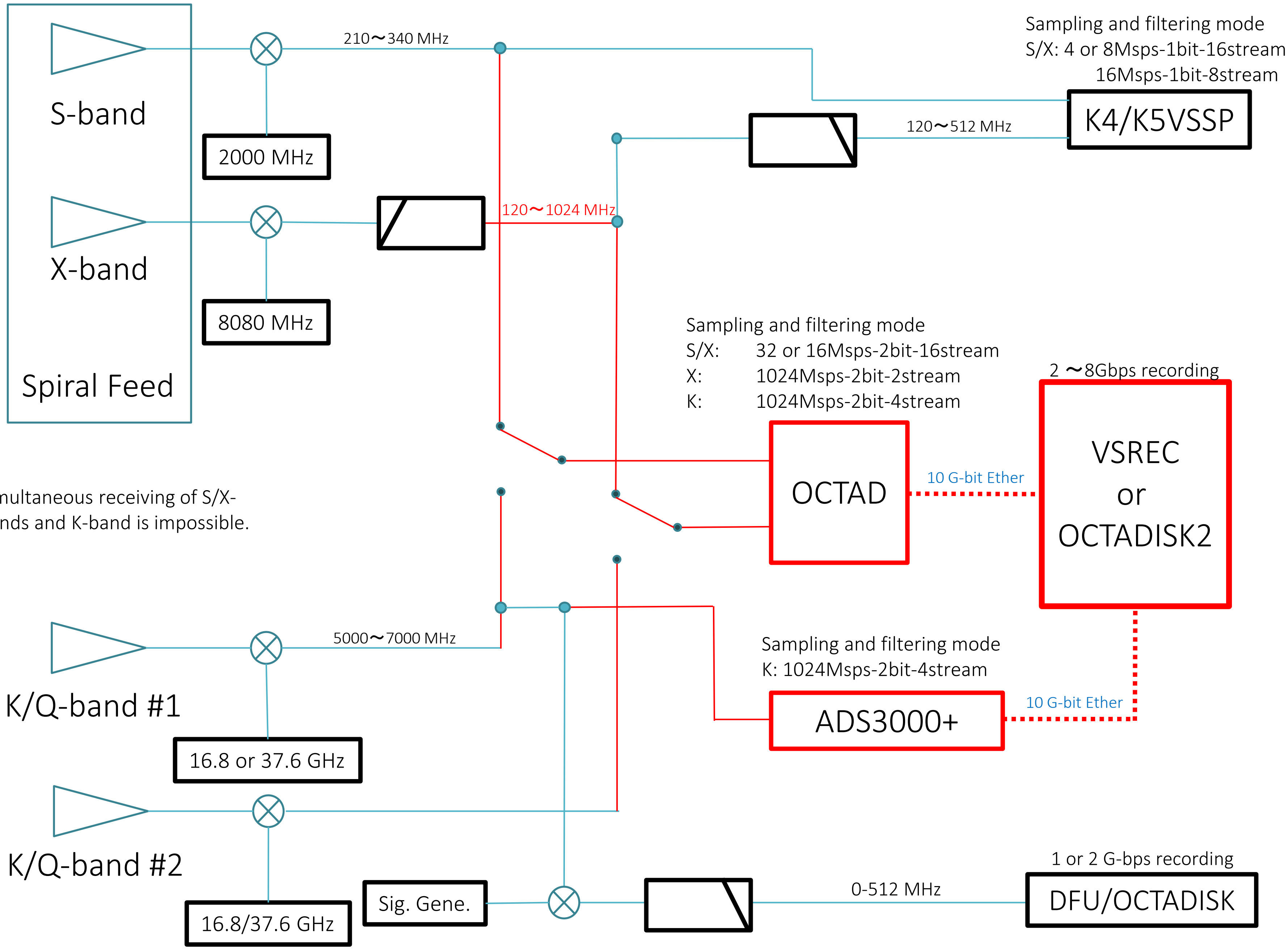
Updating of the VERA Geodetic System responded to renewal of the VERA observation system.

1. Extending of X- I/F band from 400 MHz to 924 MHz BW (from 100 MHz to 1024 MHz)

2. Adopting OCTAD as high-speed sampler and DBBC, and newly setting DBBC mode in OCTAD, 16MHzBW-2bit-16ch, 32MHzBW-2bit-16ch for IVS session and 512MHz-2bit-4ch for VERA Internal session.

3. Raw data format conversion from OCTAD-VDIF (no header) to K5VSSP32 and mk5b

The schematic view of the VERA Geodetic Observation System in and after April, 2017



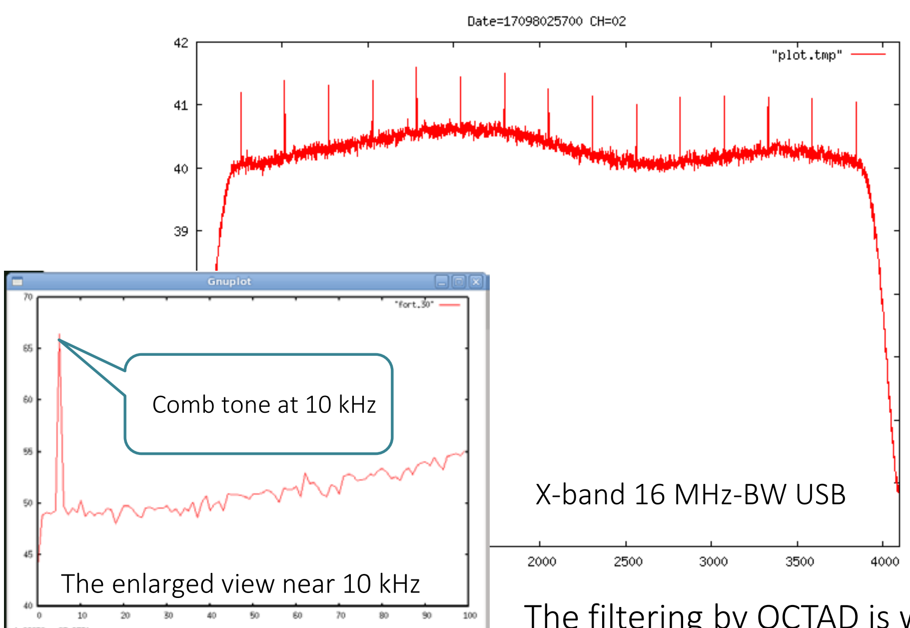
Sampling and Filtering Unit

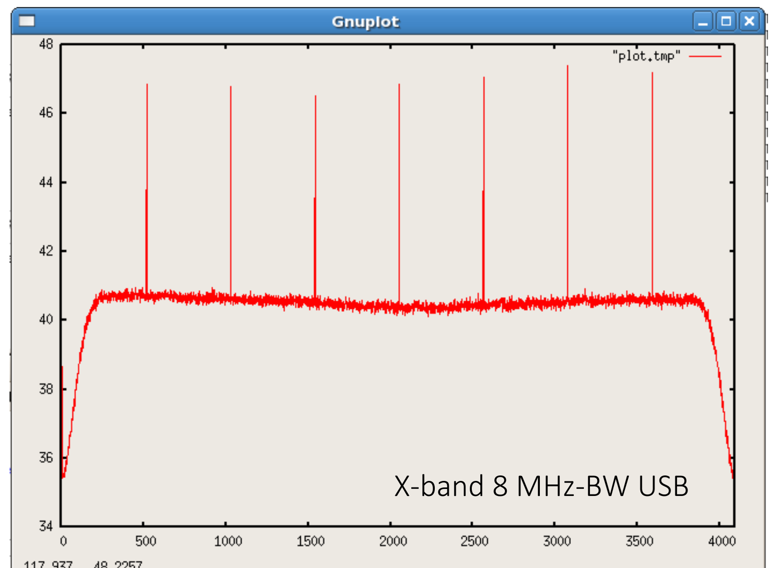
OCTAD (High speed sampler and DBBC)

Specifications:
Maximum sampling rate: 10384 M-bps
Quantifying bit number: 2 bit or 3 bit
Output: 10 G-bit Ethernet
10GbE channel number 4 ch (max)
10GbE application layer protocol: VDIF
Frequency resolution of filtering: 1 kHz

Next Generation system for VERA Astrometry, VERA Geodesy, International VLBI session, and …… .

The Spectrum of BB signal output from OCTAD





The filtering by OCTAD is working as expected.

We are trying the Experimental Geodetic Observation using OCTAD for 2 years, and we get geodetic solutions.

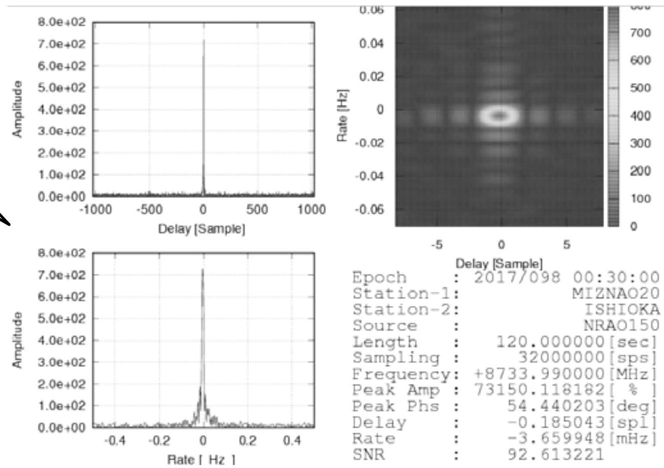
		2Gbps-mode	8Gbps-mode	
	Sampler Sampling mode (Msps-bit-ch)	**ADS3000+** **1024-2-1**	**OCTAD** **1024-2-4**	**Ratio of Error Magnitude**
2016 Jan27	dX, σX (mm) @VERAISGK	-0.6 -/+ 2.9	-0.5 -/+ 2.0	0.69
	dY, σY (mm) @VERAISGK	-1.6 -/+ 3.4	-1.4 -/+ 2.3	0.68
	dZ, σZ (mm) @VERAISGK	1.3 -/+ 2.9	1.1 -/+ 2.0	0.69
	r.m.s. of P.F. Delay Resid (picosec)	22.68	13.85	0.61
2017 Mar30	dX, σX (mm) @VERAISGK	10.8 -/+ 3.6	9.9 -/+ 2.1	0.58
	dY, σY (mm) @VERAISGK	30.8 -/+ 4.5	28.3 -/+ 2.6	0.58
	dZ, σZ (mm) @VERAISGK	-25.1 -/+ 3.9	-23.1 -/+ 2.2	0.56
	r.m.s. of P.F. Delay Resid (picosec)	34.16	19.33	0.55

Since recording bandwidth of 8Gbps-mode is 4 times wider than 2Gbps-mode, the magnitude of white noise delay error of 8Gbps-mode is 0.5 times as small as 2Gbps-mode theoretically.
It is shown that error components other than white noise are contained in the dispersed range of Post Fit Delay Residuals.

Fringe Test of OCTAD in Filter-Mode According to Frequency Arrangement in IVS Schedule.

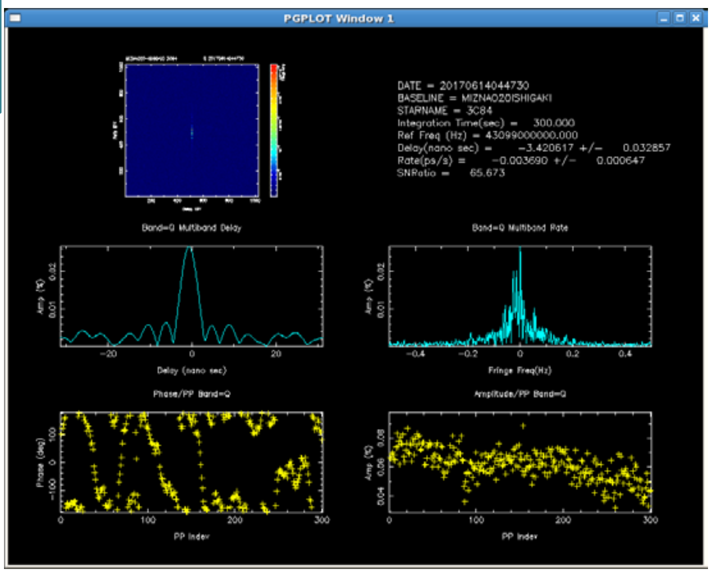
The frequency arrangement is according to schedules of T2 and AOV sessions.

First detection of fringe in OCTAD 1 G bps reduced output mode



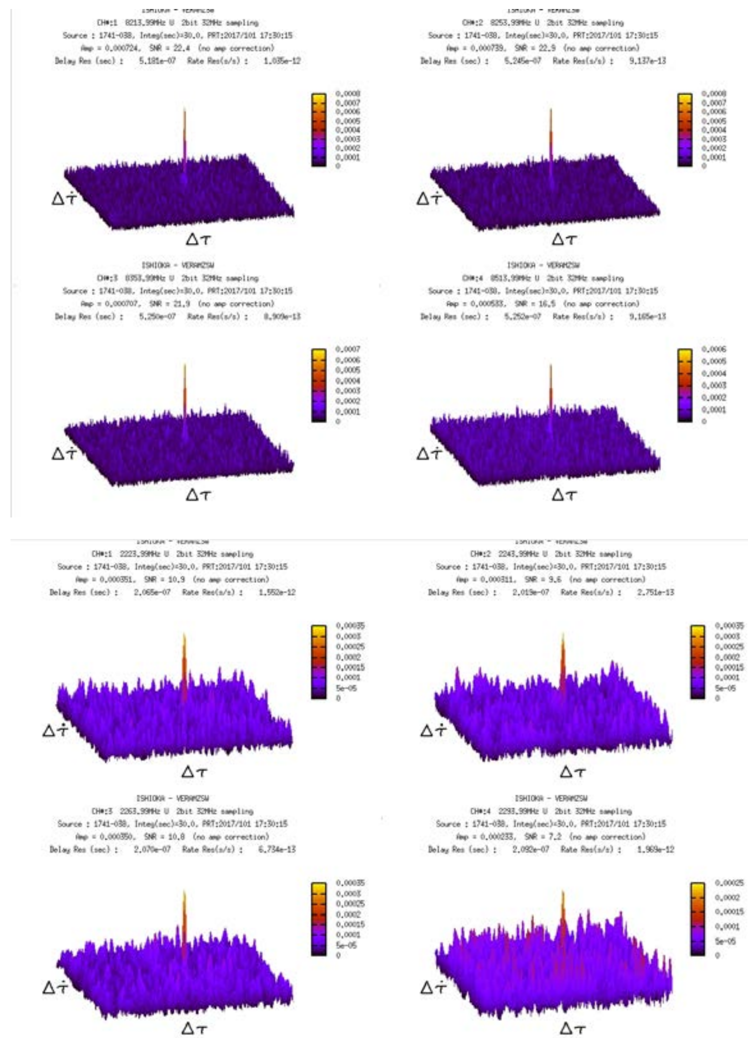
Ishioka(ADS3000+)-Mizusawa (OCTAD)
32Msps-2bit-16ch, X-band

Bad weather changed fringe phases more rapidly than usual.
Fringe peaks are dispersed in the fringe rate direction.



Synthesized fringe, Mizusawa-Ishigaki (OCTAD)
16Msps-2bit-16ch, Q-band

First fringe detection of by the K5 Correlator



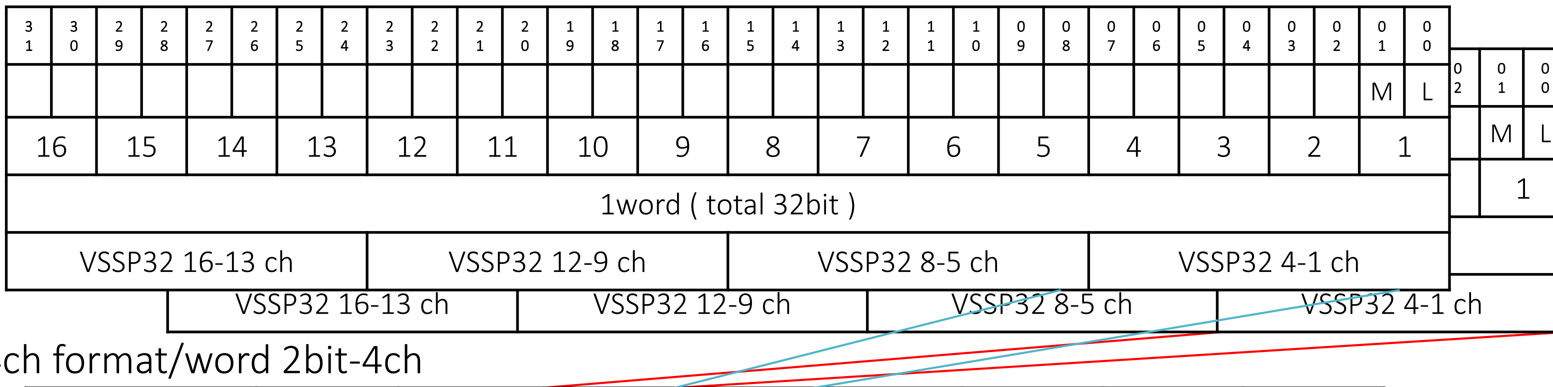
AOV015 Ishioka (ADS3000+)-Mizusawa(OCTAD)
32Msps-2bit-16ch, S/X band

Raw data format conversion for data transfer to IVS Correlator

- OCTAD VDIF (no-header) ←→ K5VSSP32 → mk5b

The format of K5VSSP32 is the same as OCTAD except for a header at 1 word unit. The raw data of OCTAD is divided according to the number of channels per one K5VSSP32 file.

OCTAD format/word 2bit-16ch



K5VSSP32 4ch format/word 2bit-4ch

Bit	31-24	23-16	15-08	07-00	31-24	23-16	15-08	07-00
VSSP32 ch	4--1	4--1	4--1	4--1	4--1	4--1	4--1	4--1
Sample Index	4	3	2	1	8	7	6	5
Word Index	1				2			

The format of raw data which was converted from OCTAD to mk5b via K5VSSP32

→ Fringe was detected.

The format raw data which was changed converted from K5VSSP32 to OCTAD

→ Fringe was detected.

The format conversion of raw data: Capacity of storage is more than 11 terabytes per 24 hours, working hours are nearly equal to observation time.

Future work

Using OCTAD as the main frame of a VERA observation system including geodetic VLBI. Establishment of the stable operation procedure from observation to geodetic analysis.

Experimental adoption of S-band contactless cooling filter for remove interference. This filter is one part of preliminary items for developing low-middle frequency broadband feed.

Thank you for the GSI which cooperated with the fringe test.