Recent status of Daejeon hardware correlator and its functional expansion in future

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Contents

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- KJCC Operational Status
- Functional Expansion in Future
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Next Generation Correlator in East Asia

– Joint Correlator Project between Korea and Japan

- We concluded that KASI & NAOJ join together for the best performance.
- 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, 2M$
  Korea : renewed successional project,
  5 years from Jan. 2006, 8M$

Specification (1)

KASI + NAOJ ➔ 2006~2010

Items	Specifications
Number of Antennas	16
Number of Inputs / Antenna - Input Interface - Maximum Data Rates	4 - 2Gbps VSI-H (32parallels, 64 MHz clk) - 8,192 Mbps
Digitization for Each Inputs - Number of Bits - Quantization Levels - Sampling Rates - Input Bandwidth - Sub-stream Specification	 - 2 bits/sample - 4 levels - 1,024 Msamples/sec - 512 MHz - Logically Associated Sub-streams
Maximum Delay Compensation (Largest Baseline Length)	±36,000 km
Maximum Fringe Tracking (Fastest Phase Drift Cancellation)	1,075 kHz
Architecture	FX type, with FPGA and DSP chips

Specification (2)

Items	Specifications
FFT Processing - Freq. Resolution - Size of FFT points - Word length in FFT - Scaling - Re-quantization	 - 0.05km/sec @ 22GHz - 256k/128k/64k/32k/16k/8k Adjustable - 20+20 bits fixed point for real & imaginary - Yes - 16+16 bits fixed point for real & imaginary
△W Correction	Yes
Correlations - Number of Correlation Outputs/Input - Total Number of Correlation Outputs - Polarization Mode - Data compression(Binning) - Word length - min. max Integration Time	 - Max. 120 Cross- and 16 Auto-correlations - Max. 480 Cross- and 64 Auto-correlations - RR or LL ; Full Operation for 16 antennas RR and LL ; Full Operation for 16 antennas RR, RL, LR and LL : Full Op. for 8 antennas - Yes, 8,192 channels / correlation output - 32+32 bits Fixed Point for R & I - 25.6msec ~ 10.24sec
Data Output to Archive (Max.)	1.4 GBytes/sec

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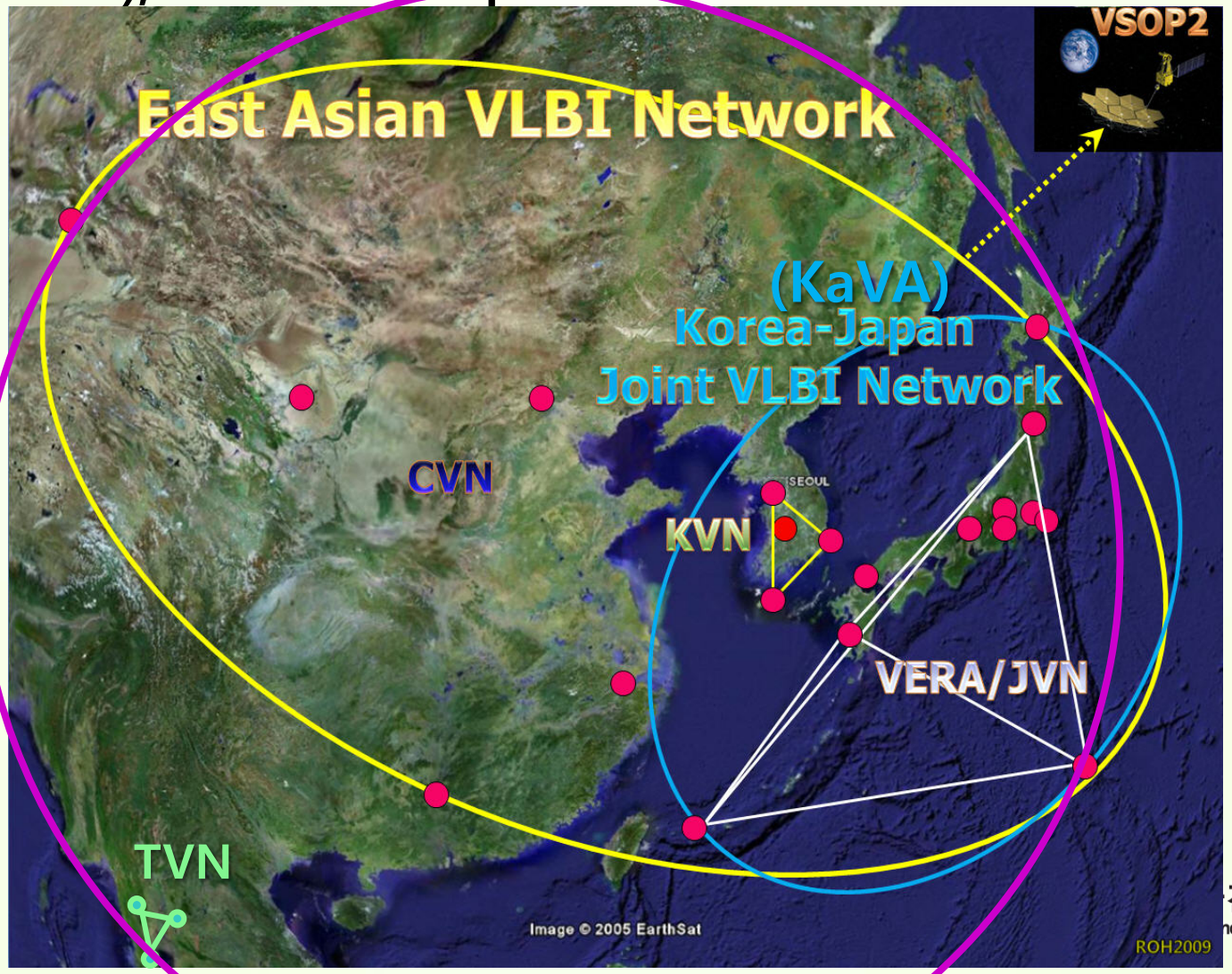
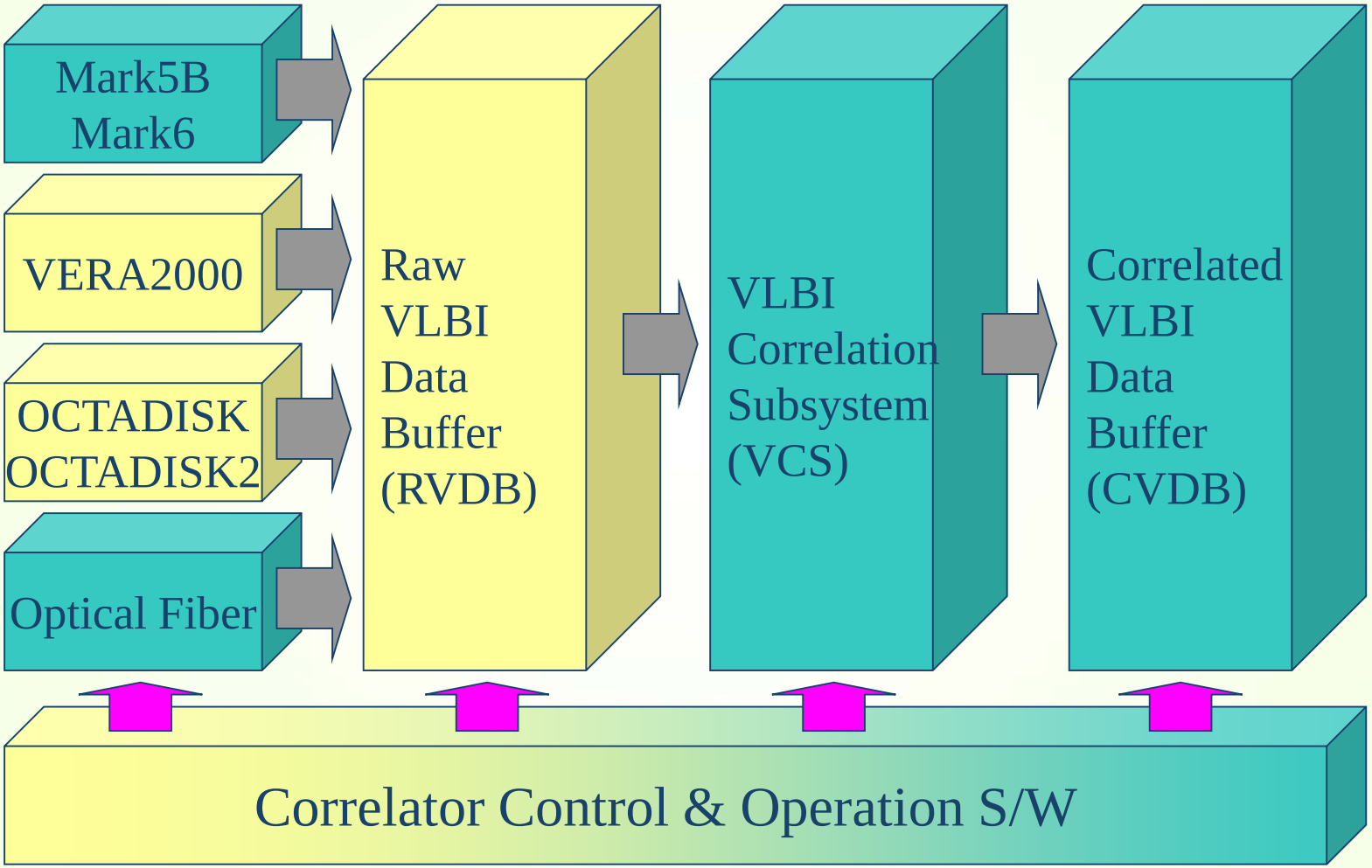
Target Array : EAVN

- For KVN, KaVA(w/ JVN), and EAVN(w/ Thailand VLBI Network), and also for Space-VLBI



Daejeon Correlator Framework



◆Yellow : NAOJ, Green : KASI

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Playback Systems

- **Mark5B playback**
  → VSI compatible : KVN
- **DIR2000 was in use extensively at VERA.**
  - **VERA 2000**, which was modified by NAOJ according to DIR1000, used for Playing back DIR2000 tape media for VERA.
- **OCTADISK : modified using RVDB with 4Gbps recorder/playback developed by NAOJ.**
- **Optical Fiber : Capable of dealing with the full data rate of 8 Gbps.**

Mark5B

Mark6

VERA2000

OCTADISK(VDIF)

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OCTADISK2(removable storage) by NAOJ/Elecs

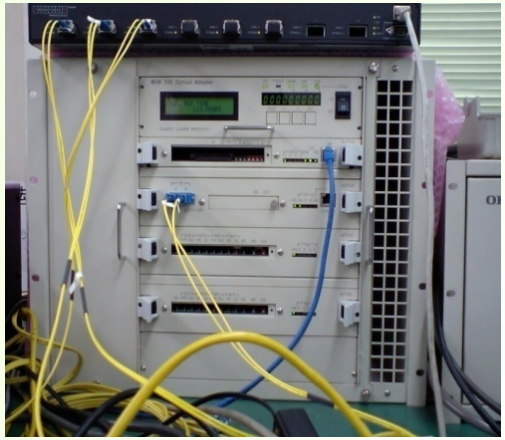
- Record / playback VDIF data stream via 10/40G Ethernet at 8Gbps(standard),16Gbps(high-end),32Gbps(flagship)
- Realizing direct analysis of data stream without file format conversion by adopting Linux file system for the storage
- It will be installed at 2016 in KJCC for supporting VERA.

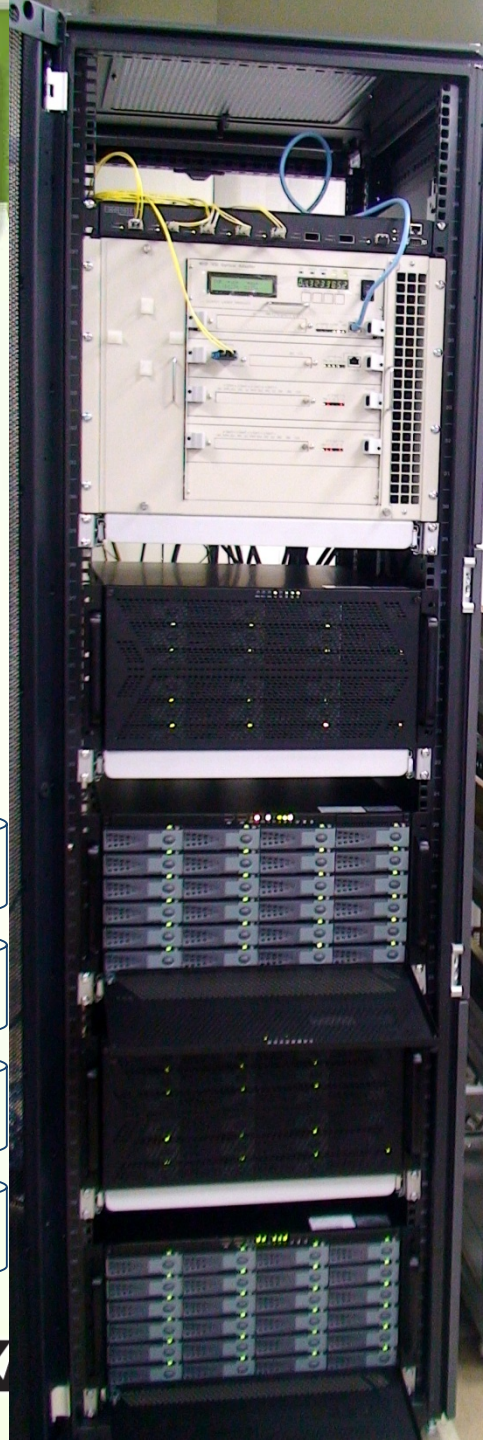
Raw VLBI Data Buffer (RVDB) by NAOJ/Elecs

- **Purpose :**
  - Different recording systems are operated in each country
  - Adjust data format as like # of bits per sample, and so on
  - Easily synchronize the data while playback (heterogeneous recorder models)
  - Maintain the buffering between recorder speed(1 Gbps) and correlation speed(8 Gbps)

Raw VLBI Data Buffer (RVDB)

basic configuration





4 C-ports

2Gbps, nominal

8Gbps=2G x 4

To Correlator Input Ports

VSI Optical Adapter(OCTAVIA)

4 D-ports

2Gbps, nominal

8Gbps=2G x 4

From Playing Back Units

Control PC

10GbE Switch

OCTADISK

OCTADDB

OCTADDB

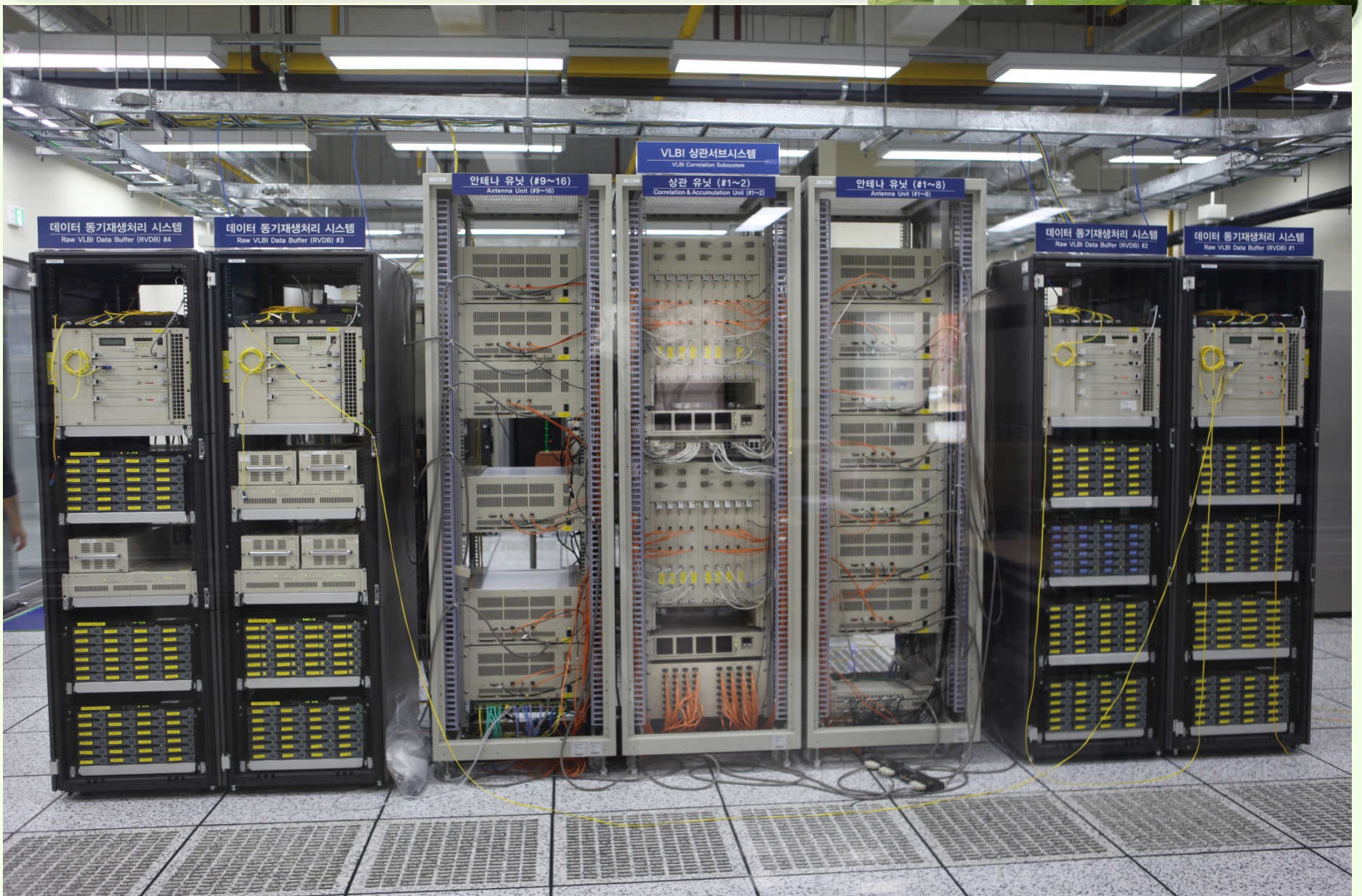
OCTADDB

OCTADDB

VDIF

Daejeon Hardware Correlator(KASI/NAOJ)

2011.07~Joint Operated by KASI/NAOJ



Obs/Corr Mode

Mode	#IF	Bandwidth [MHz]	Max. #Chan	#Bits	Max. Data Rate [Mbps]	Recorder	Operation
C1	1	256	1	2	1,024	Mark5B [KVN] OCTADISK [VERA]	Test Obs
C2	1,2	128	2	2	1,024		Test Obs
C3	1,2,3,4	64	4	2	1,024		Test Obs
C4	1,2,3,4	32	8	2	1,024		Open Use
C5	1,2,3,4	16	16	2	1,024		Open Use
C6	1,2,3,4	8	16	2	512		
C7	1,2,3	64/128	2/1	2	1,024		
C8	1,2,3,4	32/64/128	2/1/1	2	1,024		
C9	1,2,3,4	32/128	4/1	2	1,024		
C10	1,2,3,4	16/32/128	2/3/1	2	1,024		
W1	1	512	1	2	2,048	Mark6 [KVN]	Test Obs
W2,3	1,2,3,4	512	4	2	4 x 2,048 =8Gbps	OCTADISK2 [VERA]	To be tested Obs soon

KJCC Operational Status

KJCC Korea-Japan Correlation Center

http://kjcc.kasi.re.kr

KJCC | Correlation | Database | Contact Us

Correlation status : 2015B | 2015A | 2014B | 2014A | 2013B | 2013A

2015B Correlation List

Season	#Observation	Corr Finished	Remain Corr	Remark	Update
KaVA 2015B	26	18	5	3	2015.11.13

Finished | Doing | Not yet | Suspend | KJCC evaluation | Not related in KJCC

Please click the observation code for more detail procedure!!

Observation Date	Observation Code	PI & SWG	Frequency Band	Corr Mode	Objective	Media POS	Copy Status	Fringe Detection	Correlation Status	FITS release Date
2015.10.30 (15303k)	r15303k	T. Jike	K	GEO1K(C5)	GeodeticExperiment	STN	NY	NY	1:15...	NY
2015.10.30 (15303a)	k15hi01d	H. Imai/ES	K,Q,W,D	VERA7(C5)	ESTEMA	KJC	NY	NY	1:15...	NY
2015.10.29 (15302b)	k15hi01c	H. Imai/ES	K,Q,W,D	VERA7(C5)	ESTEMA	KJC	KVN Done	NY	1:15...	NY
2015.10.29 (15302a)	k15hi01b	H. Imai/ES	K,Q,W,D	VERA7(C5)	ESTEMA	KJC	KVN Done	NY	1:15...	NY
2015.10.28 (15301b)	k15hi01a	H. Imai/ES	K,Q,W,D	VERA7(C5)	ESTEMA	KJC	NY	NY	1:15...	NY
2015.10.28 (15301a)	k15mk04b	M. Kino/AGN	K	GEO1S(C5)	KaVA Observation of PKS1510 at K-band	KJC	KVN Done	All	Finished (15.11.13)	1:2015.11.16
2015.10.27 (15300a)	k15mk01i	M. Kino/AGN	Q	VERA7SIOS (C5)	KaVA AGNWG Sgr A* Q-Band Monitoring (151027)	KJC	KVN Done	All	Finished (15.11.13)	1:2015.11.16

Correlation Status

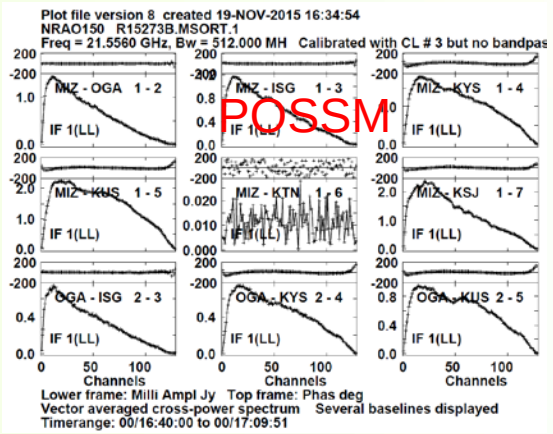
Season	Observation	Corr Finished	Remain Corr	FITS release
2015B	26[~208hrs]	18	5	18
2015A	42[~336hrs]	42	0	42
2014B	30[~240hrs]	30	0	30
2014A	56[~448hrs]	56	0	56

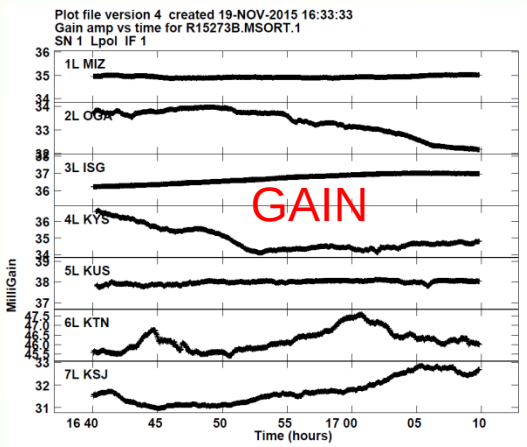
- For KaVA, 500hrs observations are planned in every year. It will be increased to 1000hrs from next year.
- The 1Gbps correlation for KaVA is now conducted normally.
- Test 2Gbps correlation for KaVA was finished without any trouble.
  → So, next year 2Gbps correlation will be also conducted.

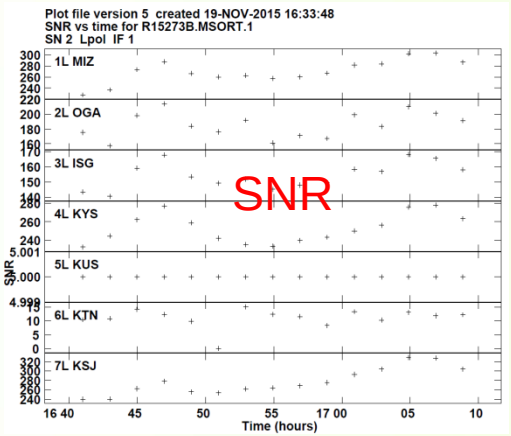
- KVN only observation data is correlated by DiFX.

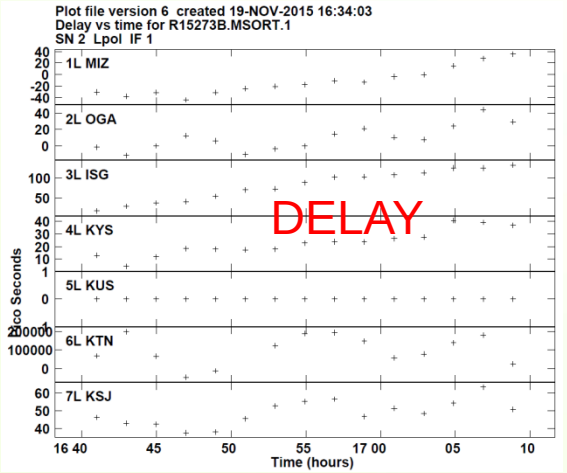
2Gbps test correlation

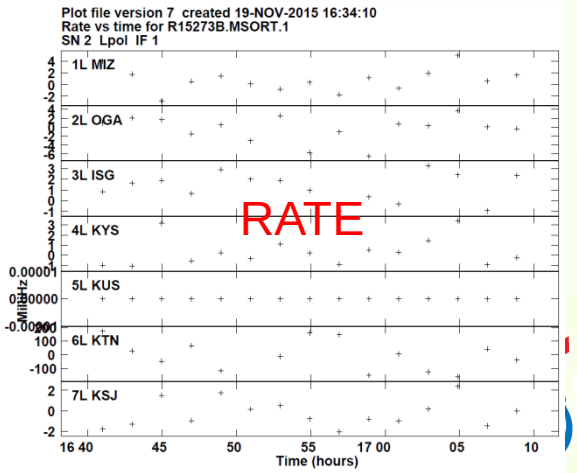
- 7stations(KaVA(6) + Sejong)
- 22GHz, 512MHz BW x 1IF, 2Gbps











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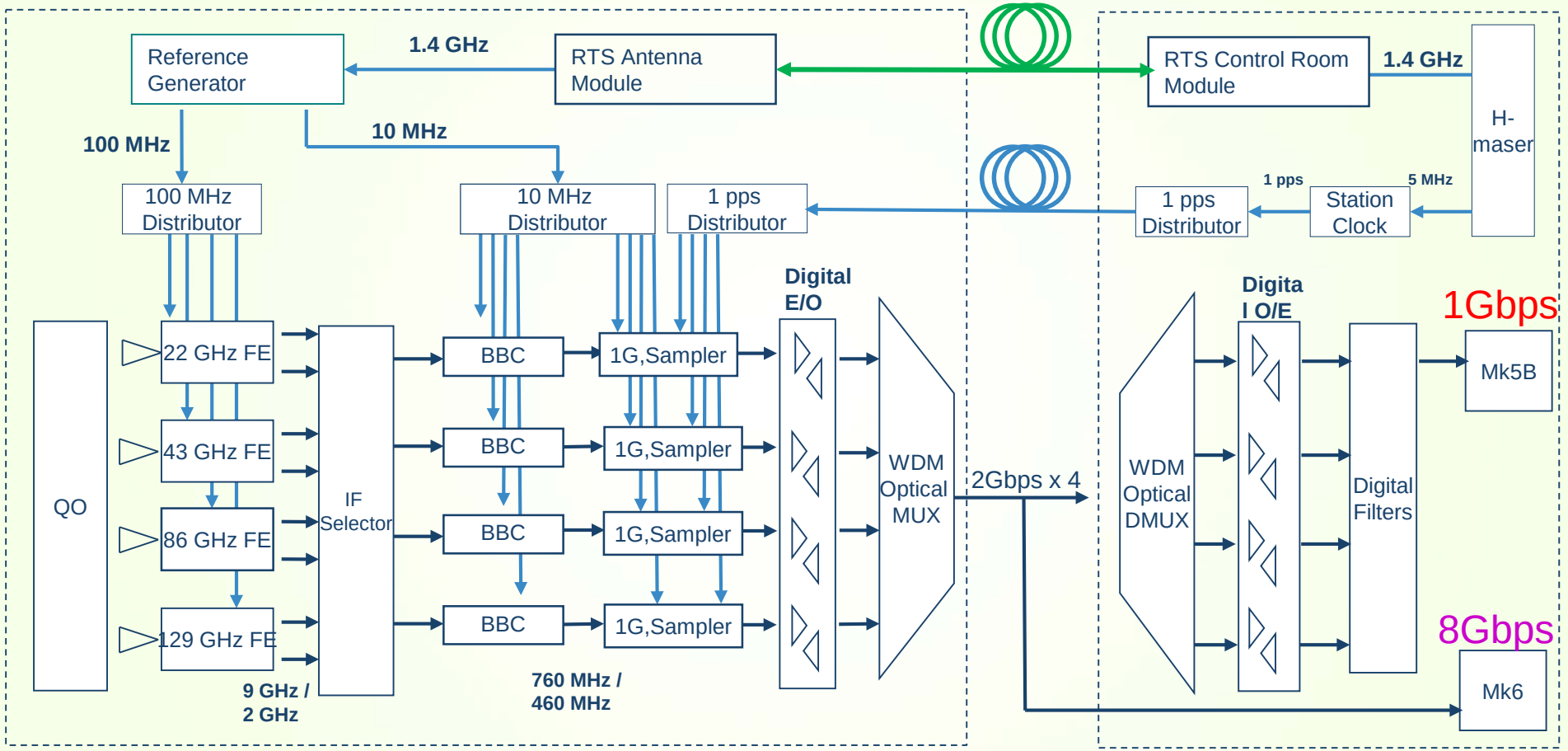
Correlator Functional Expansion in near Future

KVN Backend System (current)



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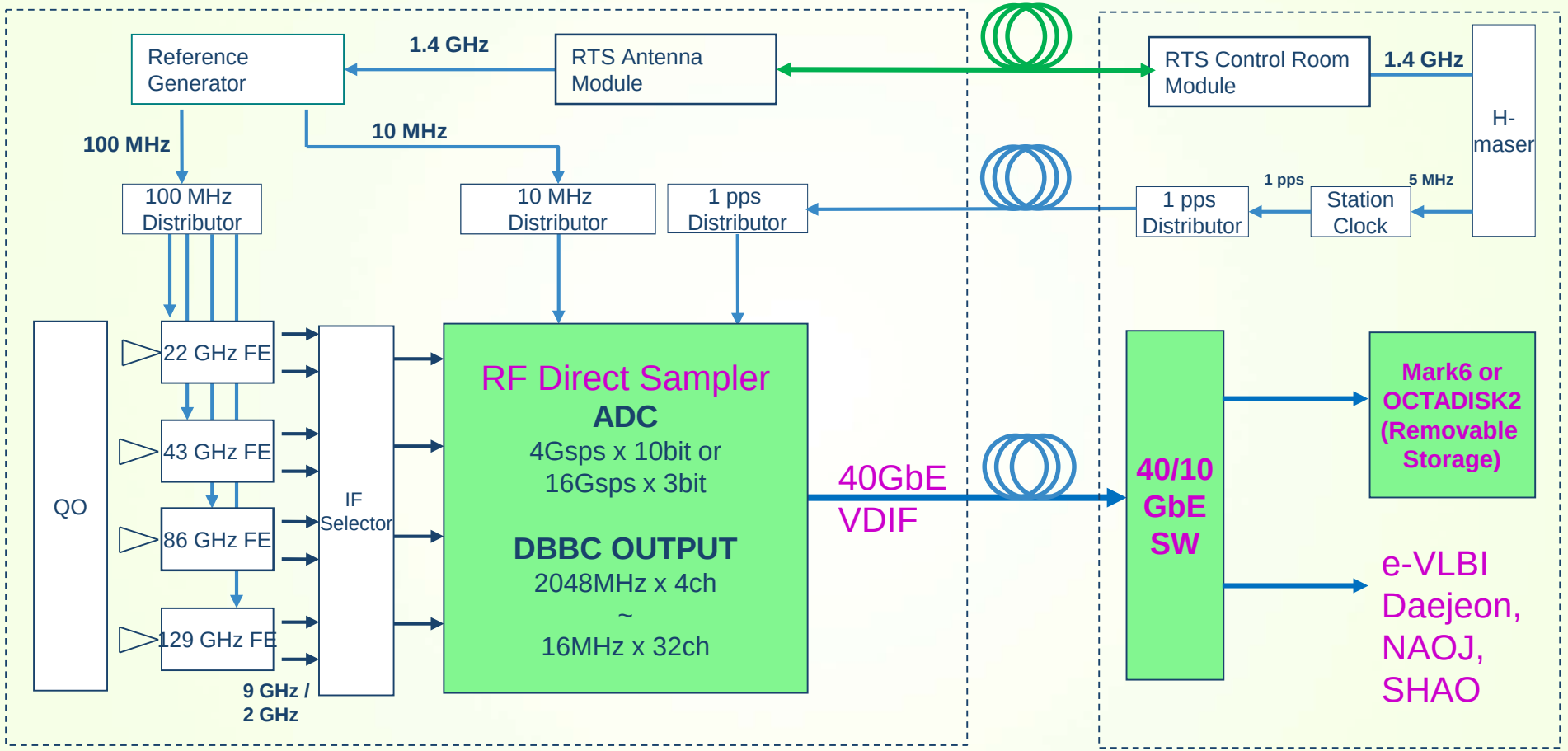
KVN Backend System (upgrade)



➢ KVN plans to introduce RF Direct Sampler next year.

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RF Direct Sampler(OCTAD) by NAOJ/Elecs

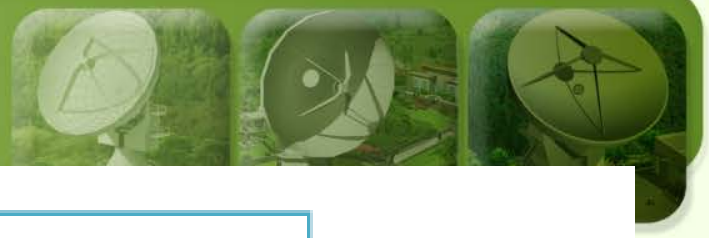
- **Sampling**
  - 20Gsps x3bit, Max freq. 24GHz
  - 4Gsps x10bit, Max freq. 10GHz(Opt 18G)
  - 2Gsps x12bit, Max freq. 3GHz (Opt 18G)
- **DBBC**
  - Output bandwidth : 16~2048 MHz

RF Direct Sampler DBBC output mode

DBBC Output bandwidth [MHz]	Bit / sample	DBBC CH 1 x DSP	DBBC CH 2 x DSP	DBBC CH 3 x DSP	DBBC CH 4 x DSP
2048	2	1	2	3	4
1024	2	2	4	6	8
512	2	4	8	12	16
128	2	4	8	12	16
64	2	8	16	24	32
32	2	8	16	24	32
16	2	8	16	24	32

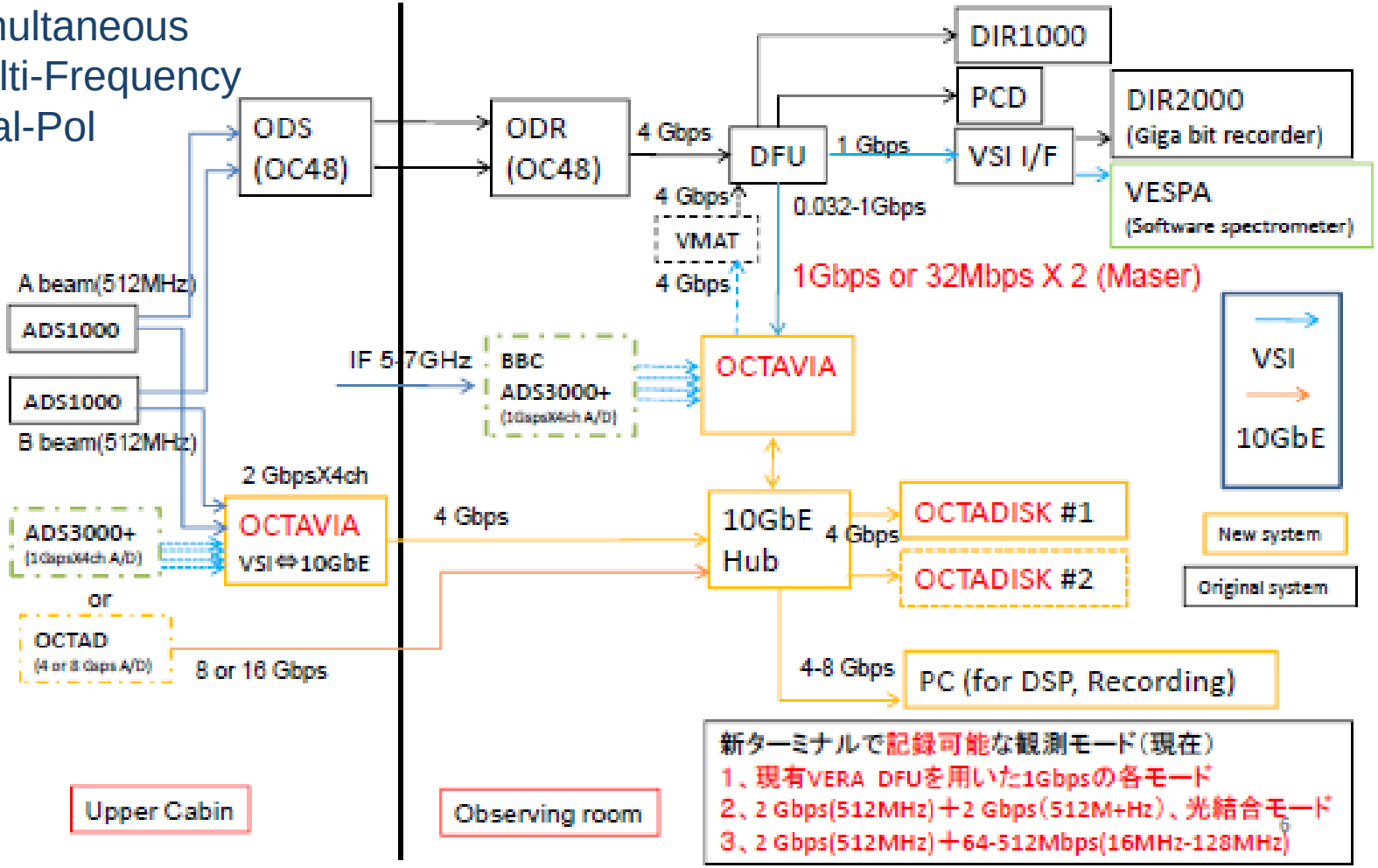
- When FIR Tap number of LPF is 63,the above list is applied.
- The number of DBBC channel changes by the number of FIR Tap.

VERA Backend System

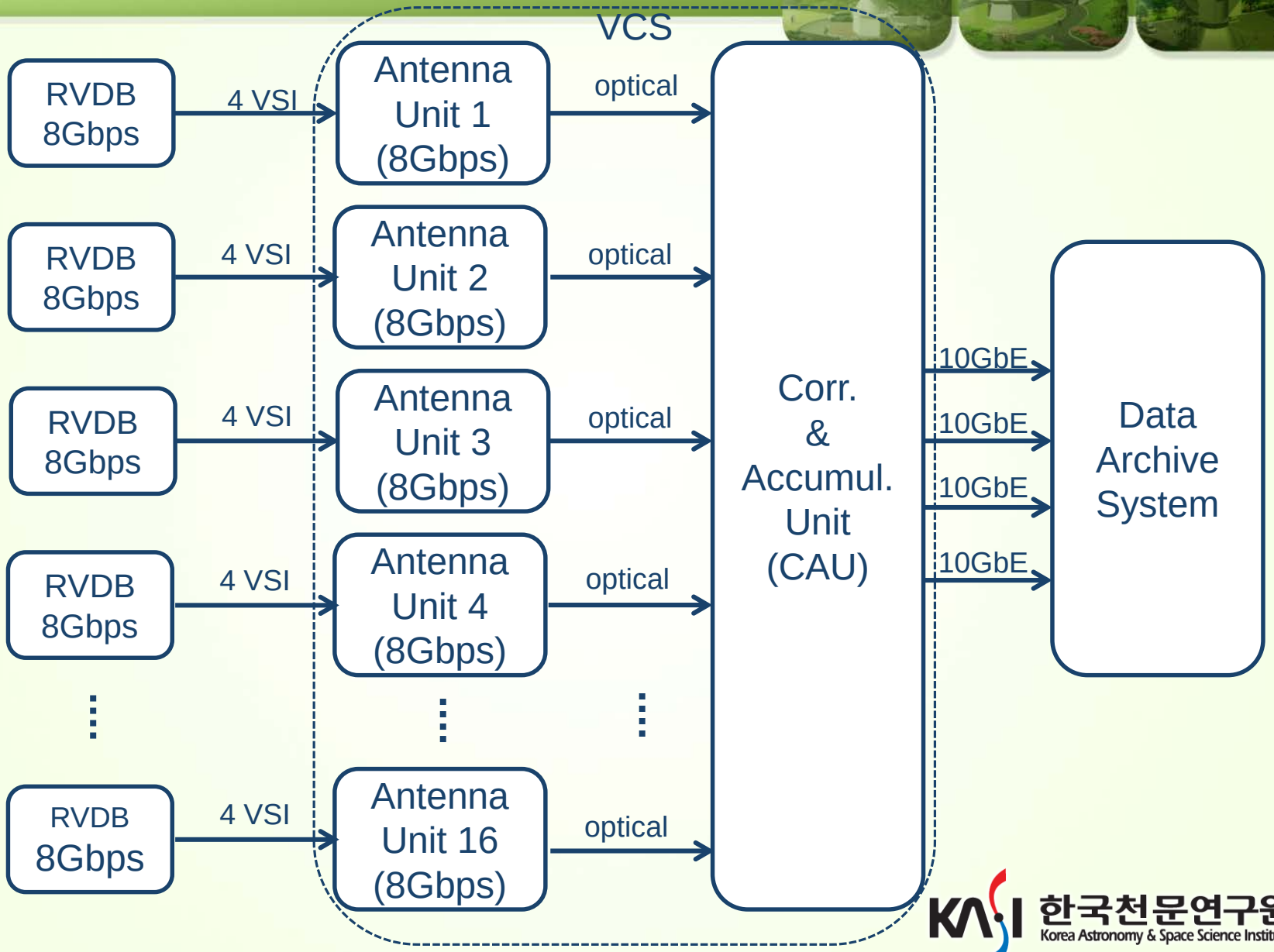


New terminal for ultra wide band at VERA

- Simultaneous Multi-Frequency
- Dual-Pol



8Gbps operation (current, 16stations)



Considering item for 8 Gbps

❖ Needed equipment

- Hardware
  - For KaVA 7 or 8 stations, 4 sets of RVDB2 system are needed. In this case, small costs are expected.
  - It will be simply to implement by introducing RVDB2 system.

★RVDB2 : OCTAVIA2 + OCTADISK2

front

rear

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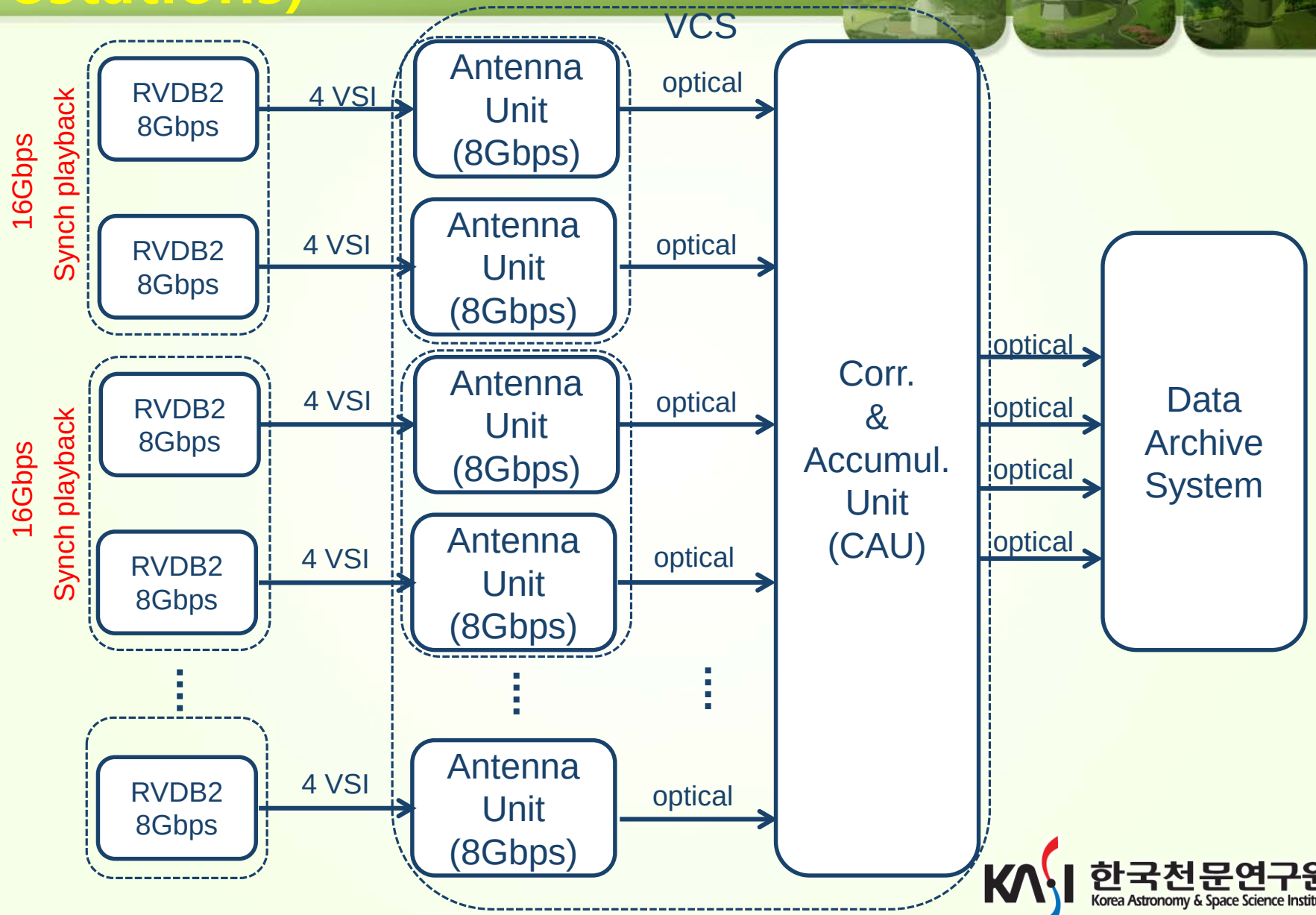
Conceptual considering phase for upgrade (16~32Gbps)

- **How to upgrade**
  - By modifying current equipment?
  - Introducing new design concept?
  - Introducing software correlator?
- **How long take to implement**
  - Planning
- **How much budget will be needed**

➔ briefly introduce the focus on hardware by modifying current system or adopting new design.

16Gbps operation (considering design, 8stations)

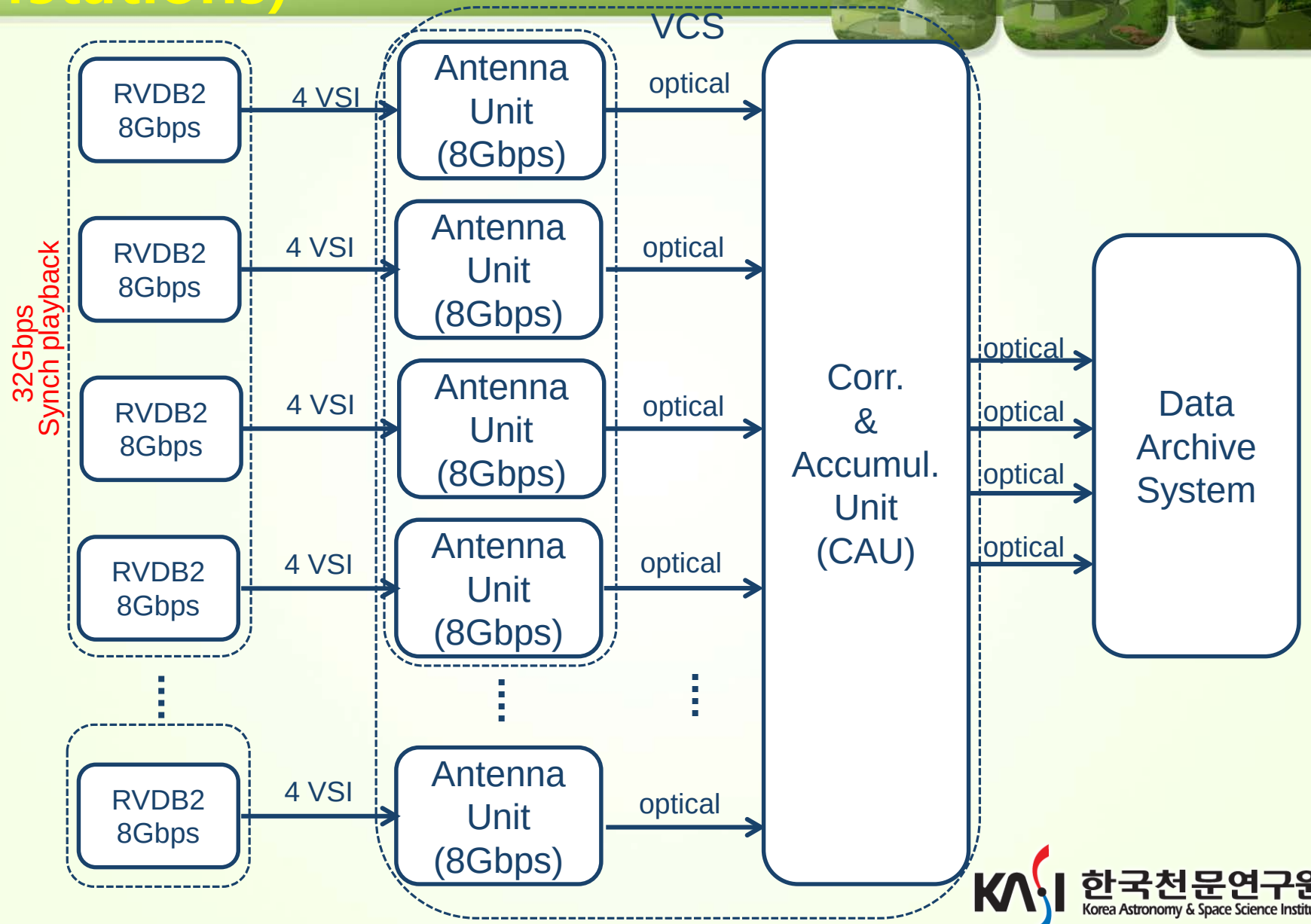


Considering item for 16 Gbps

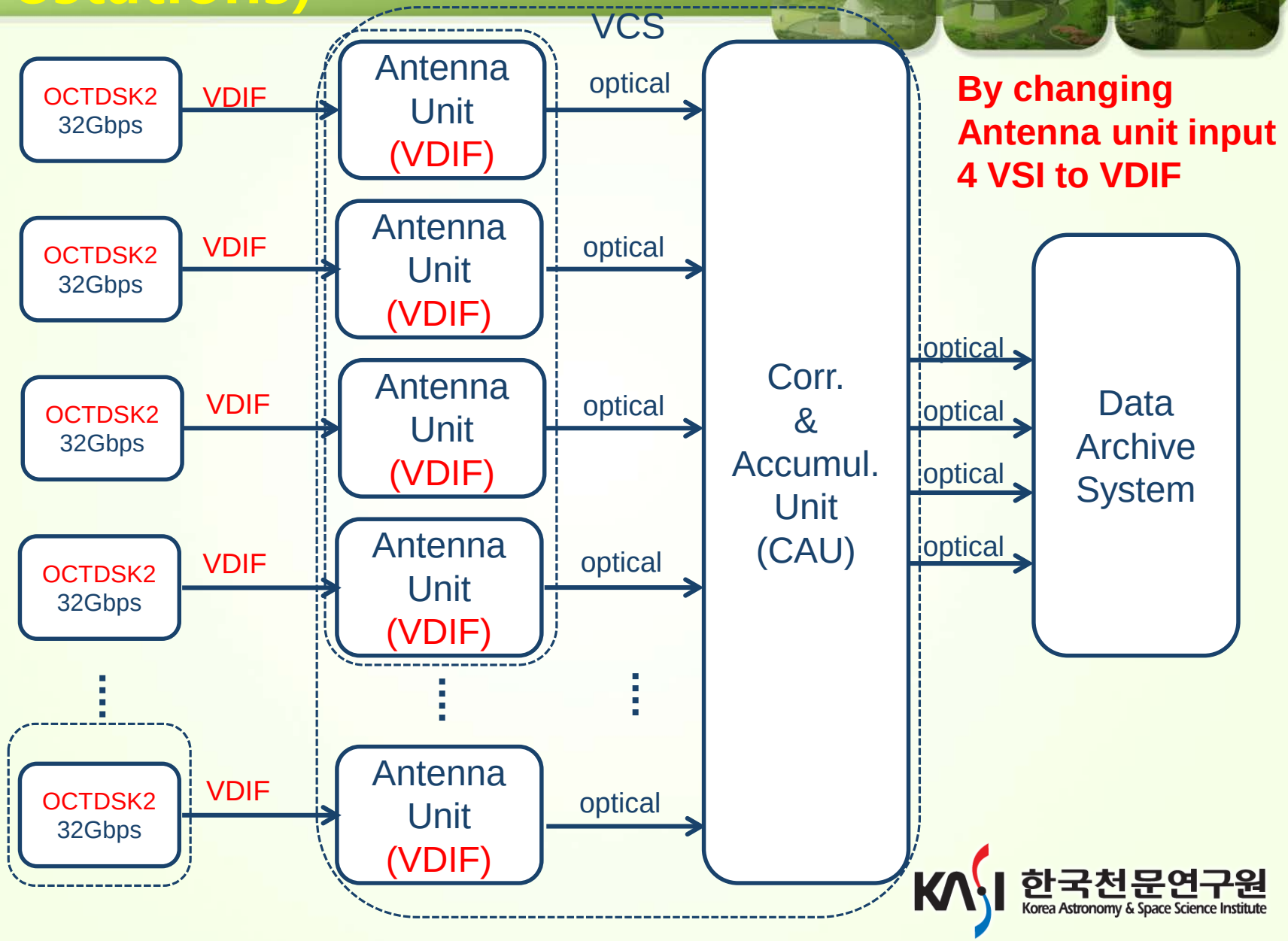
❖ Needed equipment

- Hardware
  - For KVN 3stations, 2 sets of RVDB2 system are needed.
  - For KaVA 7 or 8 stations, 12 sets of RVDB2 system are needed. In this case, big costs are expected.

32Gbps operation (considering design1, 4stations)



32Gbps operation (considering design2, 7~8stations)



By changing Antenna unit input 4 VSI to VDIF

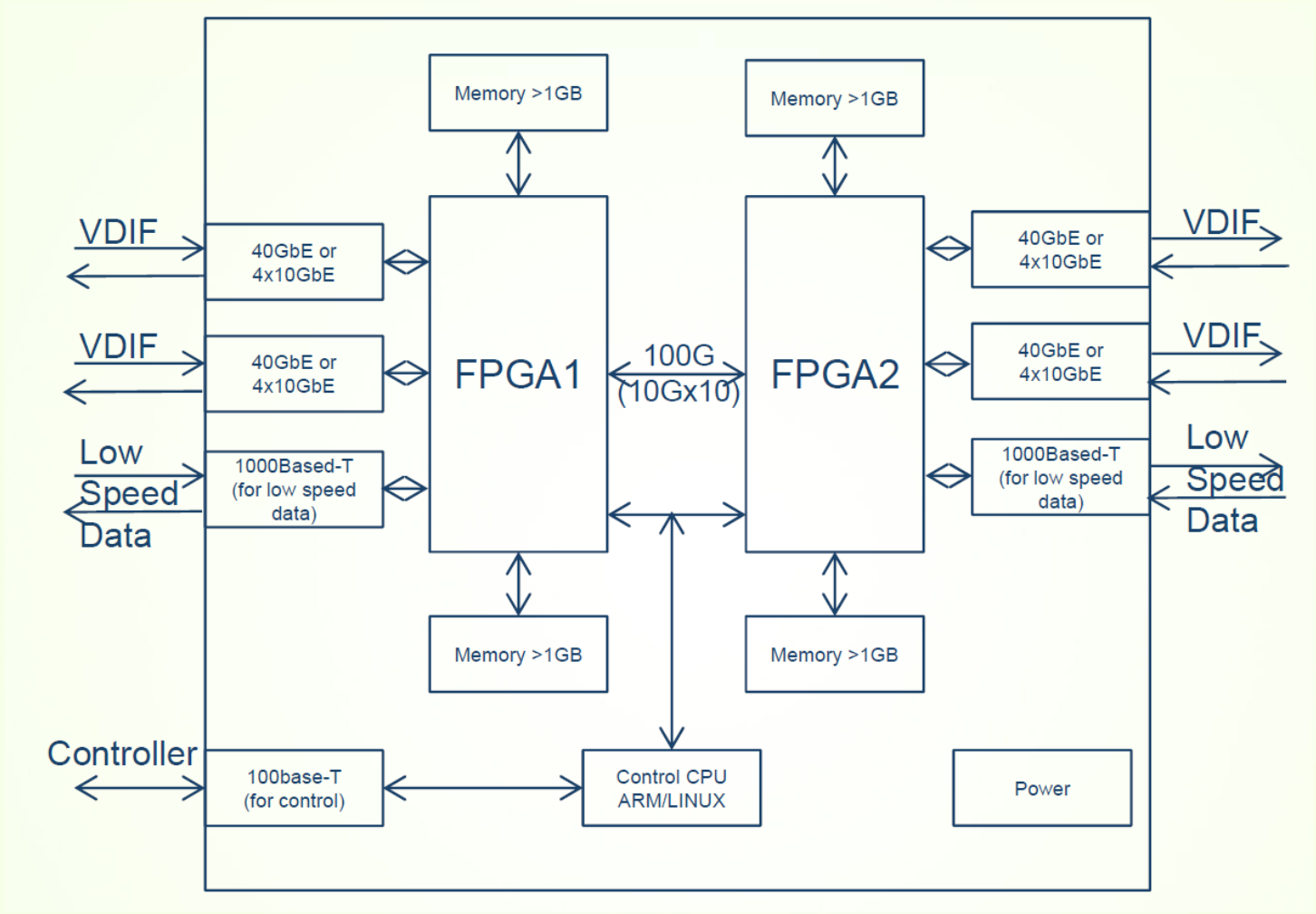
Basic Standard Module by Elecs

- Proposed by Elecs industry Ltd.
- Requirement for Correlator Hardware
  - Flexibility
    - Easy to modifying function for scientific needs.
  - Scalability
    - Small start up, and expansion to a full large scale system.
  - Usability
    - Minimum down time in failure

BSM concept

- Basic Standard Module, BSM
  - FPGA based multi purpose hardware
  - 40GbE base general I/O ports
- Combination of BSMs completes a large scale hardware correlator
  - Small basic blocks form a complex large scale system
  - If one basic module is failed, other module substitute the function

Basic Standard Module



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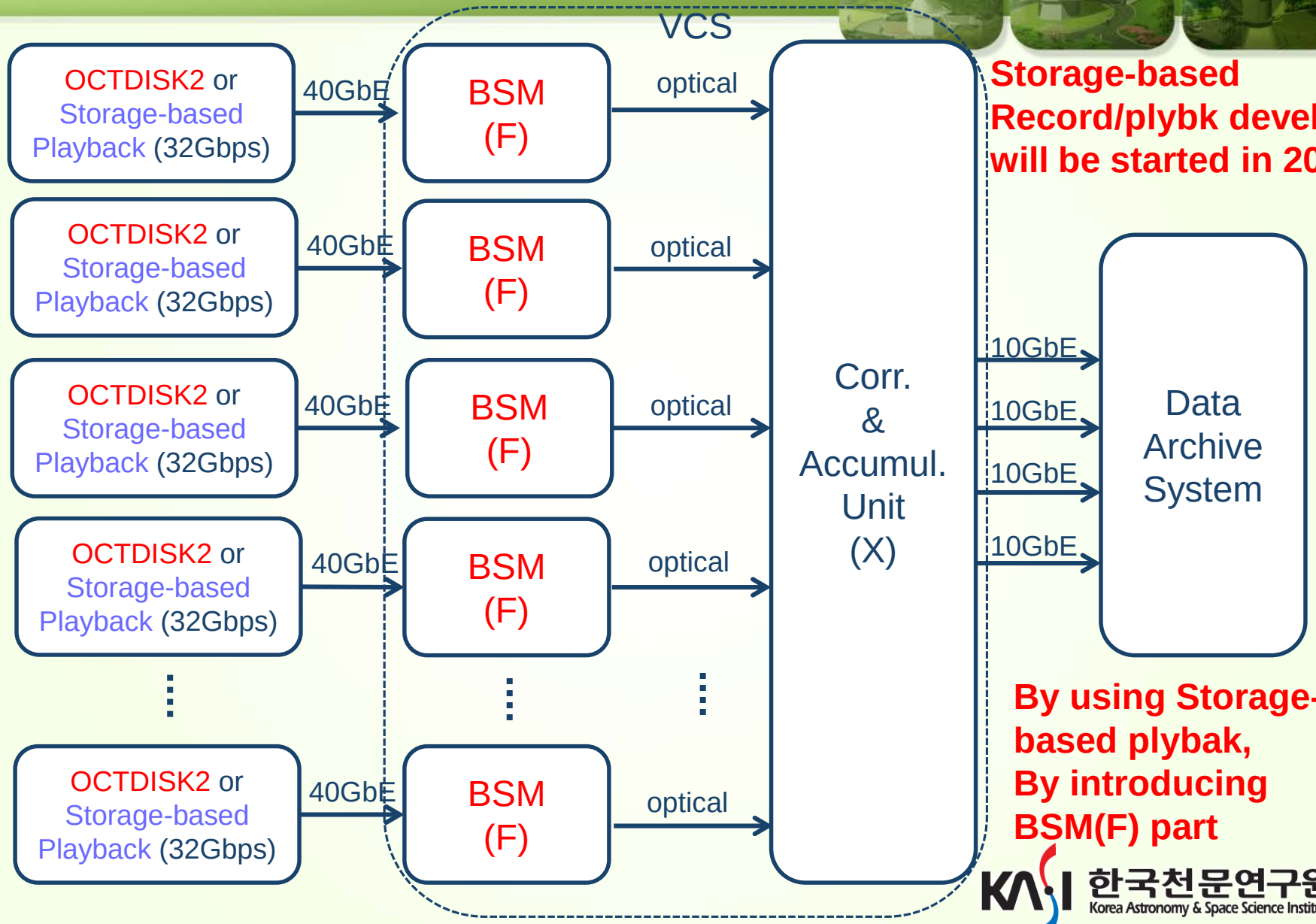
32Gbps operation (considering design3)



Storage-based Record/plybk develop will be started in 2016

By using Storage-based plybak, By introducing BSM(F) part

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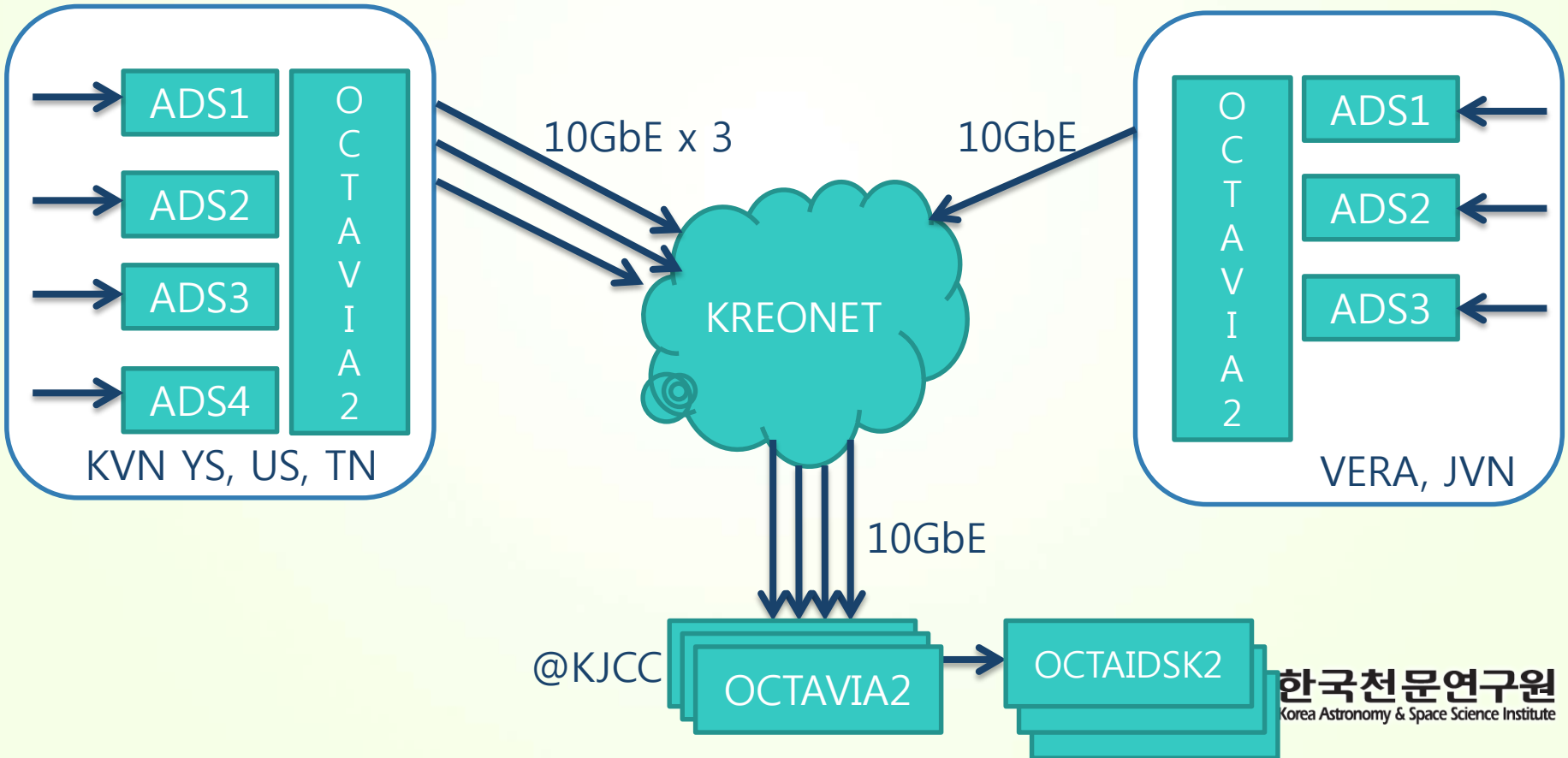
eVLBI @ KVN/KJCC

- **E-shipping is now conducting for KVN**
- **eVLBI by using the KREONET, OCTAIVA2 and OCTADISK2**
  - 2, 4, 8 Gbps/station @ KJCC in near future



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Summary

- **Daejeon correlator**
  - is now normally operating with 1Gbps for KaVA.
  - Will be normally operated with 2Gbps soon.
  - Will conduct 4 or 8Gbps correlation.
- **For functional upgrading of Daejeon correlator**
  - how to make a plan
  - How to implement : design and development
  - How to get the budget