E-VLBI Development in NI CT
E-VLBI Activity in NICT

- **E-VLBI Project**
  - JGN2 Sympo07 Demo: real-time e-VLBI with Haystack
  - Realtime e-VLBI (Kashima, Tsukuba, Gifu, Yamaguchi, Usuda)
  - Ultra-rapid UT1 measurement (Onsala, Tsukuba, Metsahovi)
  - 6Gbps S/X observation on Kashima-Koganei (100km) baseline.
  - E-VLBI demonstration (ATNF-Kshima-Seashan) for today

- **Hardware development**
  - Two types of K5 system (K5/VSSP, K5/VSI)
  - ADS-3000plus (DBBC) development

- **Benefit of Standard**
JGN2Sympo2007 with Haystack
Experimental Network (JGN2Symposium07)

NiCT

[Diagram of network setup with various nodes and connections including Kashima, AT98, Router, Obs. PC, and others.]

Mark5B
Within 5 min after the session, UT1 has derived!

Collaborators: R. Haas (Onsala), J. Ritakari, J. Wagner (Metsahovi), S. Kurihara, K. Kokado (GSI)
Work shared collaboration

- Observation and data transport at European side.
- Observation and Correlation processing at Japanese side.
E-VLBI Project

Prediction (Bulletin A), EOPc04, and e-VLBI

Graph showing data over the year 2007 with the x-axis representing the day of the year and the y-axis representing DUT1 in msec.
Rapid Solution (Bulletin-A) and e-VLBI – EOPc04
Success of 8Gbps real-time VLBI

Koganei 11m
Headquater NICT, Tokyo

Kashima 34m
NICT, Kashima

JGN2
10G-Ethernet

VSI-H x4

VOA200
6Gbps routine VLBI for V773tau

- Monitoring of Flux
- S/X dual Freq.
- It is expected flare up with binary orbiting period.
- Variation of Spectrum index associated with orbiting period.

Name: V773 Tau A
d=148pc
Binary stars
M: 1.5M  1.3M
a=0.4AU
P=51 days

E-VLBI Projct(2)

Koganei 11m
Kashima 34m

- Monitoring of Flux
- S/X dual Freq.
- It is expected flare up with binary orbiting period.
- Variation of Spectrum index associated with orbiting period.

Maximal In: 9.416 G (94.16%)  Maximal Out: 39.148 M (0.39%)
Average In: 4.372 G (43.72%)  Average Out: 1.649 M (0.02%)
Current In: 2.836 G (28.36%)  Current Out: 500.517 k (0.01%)
The first real-time e-APT
A brief History of VLBI development in NICT
From K3-system to K5-system

K3 System
1983~
Longitudinal Recorder
Open Reel Tapes
Hardware Correlator
K4 (KSP) System
1990~
Rotary Head Recorder
Cassette Tapes
Hardware Correlator
e-VLBI with ATM(256M)
K5 System
2002~
PC based system
Hard Disks
Software Correlator
e-VLBI with IP
# K5-System (1): K5/VSSP

<table>
<thead>
<tr>
<th></th>
<th>K5/VSSP</th>
<th>K5/VSSP32</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sampling Speed</strong></td>
<td>40, 100, 200, 500kHz, 1, 2, 4, 8, 16 MHz</td>
<td>40, 100, 200, 500kHz, 1, 2, 4, 8, 16, 32, 64MHz,</td>
</tr>
<tr>
<td><strong>Sampling Bits</strong></td>
<td>1, 2, 4, 8</td>
<td>1, 2, 4, 8</td>
</tr>
<tr>
<td><strong>No. Channels</strong></td>
<td>1 or 4 (16 with 4 PCs)</td>
<td>1 or 4 (16 with 4 PCs)</td>
</tr>
<tr>
<td><strong>Max. Data Rate</strong></td>
<td>128 Mbps (512 Mbps with 4 PCs)</td>
<td>256 Mbps (1024Mbps with 4 PCs)</td>
</tr>
<tr>
<td><strong>Interface</strong></td>
<td>PCI (Full Height)</td>
<td>USB2.0</td>
</tr>
</tbody>
</table>

VSSP = Versatile Scientific Sampling Processor
# K5 System (2): K5/VSI

<table>
<thead>
<tr>
<th></th>
<th>ADS1000</th>
<th>ADS2000</th>
<th>ADS3000</th>
<th>ADS3000Plus</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sampling Speed</strong></td>
<td>1024Msps</td>
<td>64Msps</td>
<td>2048Msps</td>
<td>~ 4 Gbps</td>
</tr>
<tr>
<td><strong>Sampling Bits</strong></td>
<td>1 bit or 2 bits</td>
<td>1 bit or 2 bits</td>
<td>8 bits</td>
<td>2/4/8 bit</td>
</tr>
<tr>
<td><strong>No. of Input</strong></td>
<td>1</td>
<td>16</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td><strong>No. Channels</strong></td>
<td>1</td>
<td>16</td>
<td>Programmable</td>
<td>Programmable</td>
</tr>
<tr>
<td><strong>Max. Data Rate</strong></td>
<td>2048Mbps</td>
<td>2048Mbps</td>
<td>4096Mbps</td>
<td>8192Mbps</td>
</tr>
<tr>
<td><strong>Interface</strong></td>
<td>VSI-H (2 ports)</td>
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<td>VSI-H (2 ports)</td>
<td>VSI-H (4 ports)</td>
</tr>
</tbody>
</table>

![ADS1000](image1.png)

![ADS2000](image2.png)

![ADS3000](image3.png)

![ADS3000Plus](image4.png)
K5 System

ADS1000
(1024Msample/sec 1ch 1 or 2bits)

ADS2000
(64Msample/ch·sec, 16ch, 1 or 2bits)

Mark5B sampler
(64Msample/ch·sec, 16ch, 1 or 2bits)

ADS3000
(2048Msample/sec 1ch 8bits + FPGA)

PC-VSI Board
(~2048Mbps)

K5/VSSP32 Unit
(~32Msample/ch·sec, ~4ch, ~8bits)

Correlator
other DAS

Internet

PC : Data Acquisition
Correlation
K5/VSI
DBBC ADサンプラー : ADS3000

4Gbps (2GHz, 2sps) 初フリンジ (2006年1月)
ADS3000 plus under development

- Dual Channel sampler
- For S/X observation
- DBBC Function
- VSI-H Compliant

Sampling Mode

<table>
<thead>
<tr>
<th>Mode</th>
<th>Total Rate/ch</th>
<th>Sample (Mmps)</th>
<th>Quantization</th>
<th>Clock (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1Gbps</td>
<td>128</td>
<td>8bit</td>
<td>32</td>
</tr>
<tr>
<td>B</td>
<td>2Gbps</td>
<td>1024</td>
<td>2bit</td>
<td>32</td>
</tr>
<tr>
<td>C</td>
<td>2Gbps</td>
<td>512</td>
<td>4bit</td>
<td>32</td>
</tr>
<tr>
<td>D</td>
<td>4Gbps</td>
<td>2048</td>
<td>2bit</td>
<td>64</td>
</tr>
<tr>
<td>E</td>
<td>4Gbps</td>
<td>1024</td>
<td>4bit</td>
<td>64</td>
</tr>
<tr>
<td>F</td>
<td>4Gbps</td>
<td>512</td>
<td>8bit</td>
<td>64</td>
</tr>
</tbody>
</table>
ADS3000 + PC-VSI Recorder

4096Mbps recording for 17 hours
Summary

- **VSI-H** was quite successful, and useful.
  - Mark5B-K5@J GN2Symp2007
  - Mark5-VSI B@Ultra-rapid UT1
  - NICT-NAOJ Devices(ADS-X000, VOA100/200, Software Corr(VERA))

- Sharing **standard interface** reduces the cost and brings freedom and benefit for VLBIers.

- E-VLBI era is good chance to make all VLBI system fully compatible/connectable.
  - Handling data via software/network is great advantage.

- We may discuss about standard or framework for taking compatibility.
  - Defining Standard Data Transport protocol
  - Sharing interface software developed by each institutes.
Thank you for attention!