Ultra rapid dUT1 e-VLBI sessions with two Europe-Japan baselines

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Ultra Rapid dUT1 e-VLBI Session

- Intensive type (~1 hour) sessions optimally scheduled for dUT1 measurements
- Stations
  - Kashima (34m)
  - Tsukuba (32m)
  - Onsala (20m)
  - Metsähovi (14m)
  - plus Wettzell (20m) if INT2 session is used
- Realtime data transfer and quasi-realtime correlation for rapid dUT1 estimation

How

Metsahovi (14m)

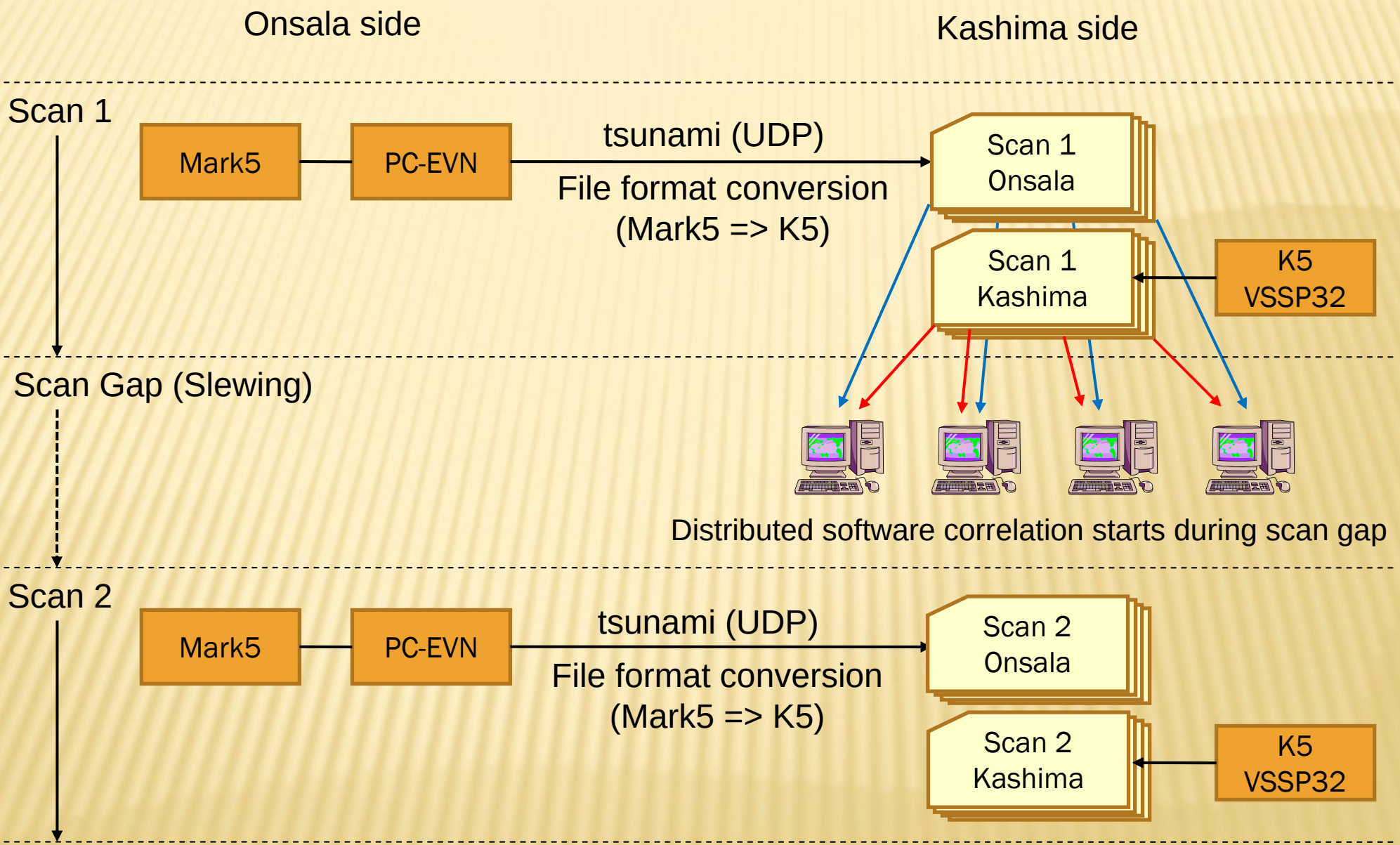
Onsala (20m)

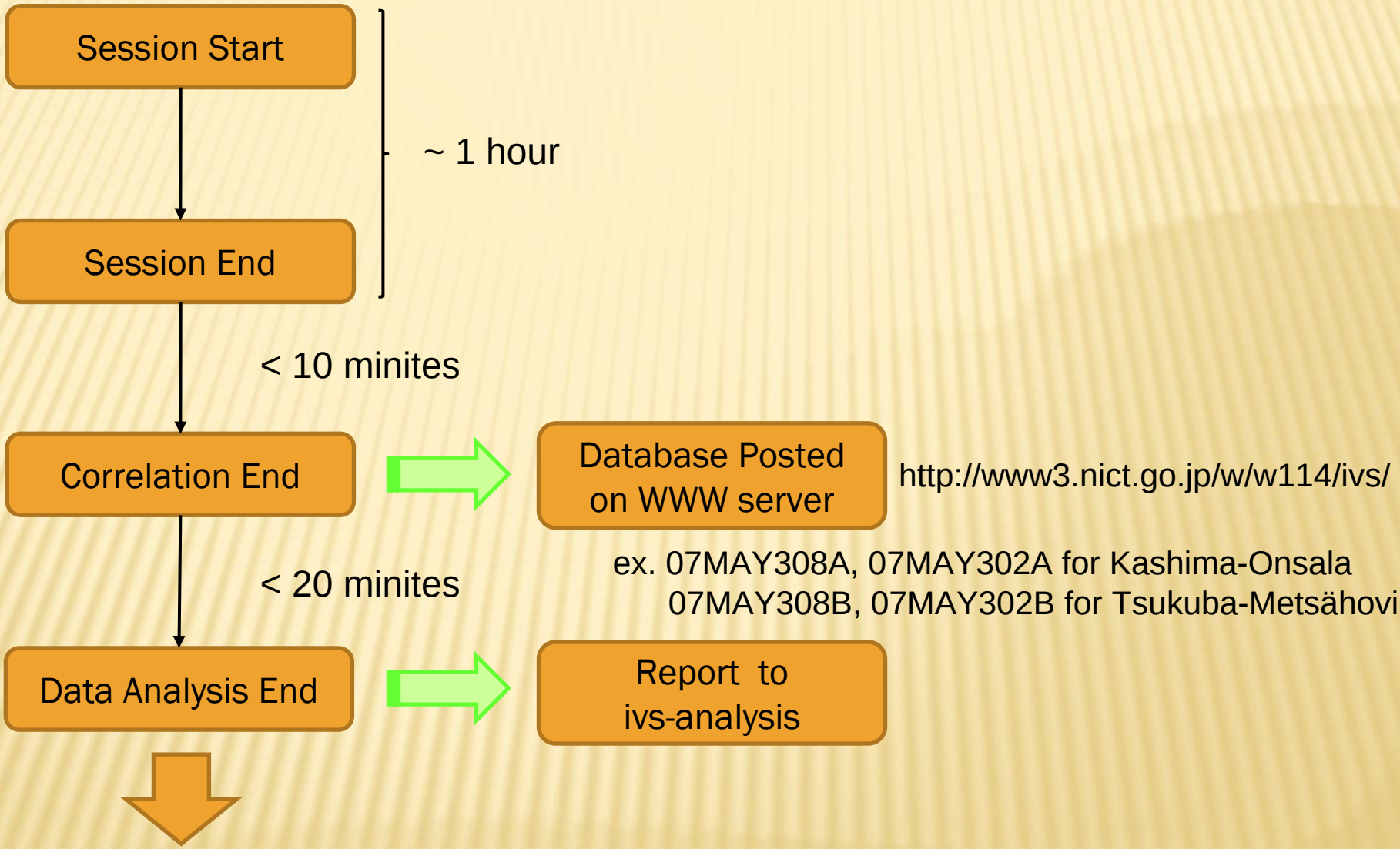
Tsunami (UDP)
Data transfer in real-time

Tsunami (UDP)
Data transfer in real-time

Tsukuba (32m)

Kashima (34m)


Onsala side
Kashima side
Scan 1
Mark5
PC-EVN
tsunami (UDP)
File format conversion
(Mark5 => K5)
Scan 1
Onsala
Scan 1
Kashima
K5
VSSP32
Scan Gap (Slewing)
Distributed software correlation starts during scan gap
Scan 2
Mark5
PC-EVN
tsunami (UDP)
File format conversion
(Mark5 => K5)
Scan 2
Onsala
Scan 2
Kashima
K5
VSSP32



Remaining 4 baselines are correlated after the session off-line, and the database files will be posted on the server at NICT.

Purpose

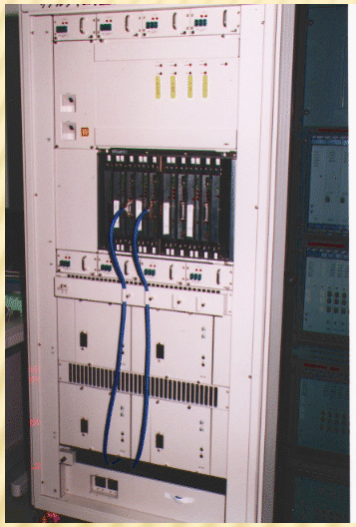
- To demonstrate ultra-rapid capability of estimating dUT1 value from intensive type e-VLBI sessions.
  - Develop and improve software so that all the processes run smoothly and reliably.
  - Make steady progress for regular IVS intensive sessions.
- To answer these questions :
  - Does ultra-rapid software correlation give consistent results with the other routine IVS sessions?
  - Do the dUT1 results on almost parallel baselines agree?
  - How close to real-time can the dUT1 results be derived routinely?
  - What is the impact of different scheduling options on the dUT1 results?
  - What is the impact of different data rates (e.g. 128, 256, 512 Mbps) on the dUT1 results?

Proposal to IVS Observing Program Committee

- Official proposal to the IVS Observing Program Committee was submitted in July 2007.
- The proposal was approved and endorsed by the committee.
  - Various comments and suggestions : Use existing intensive sessions (like INT2 with Tsukuba-Wettzell baseline) if Metsähovi station is not available.

e-VLBI in the beginning

Key Stone Project (1995-2000)

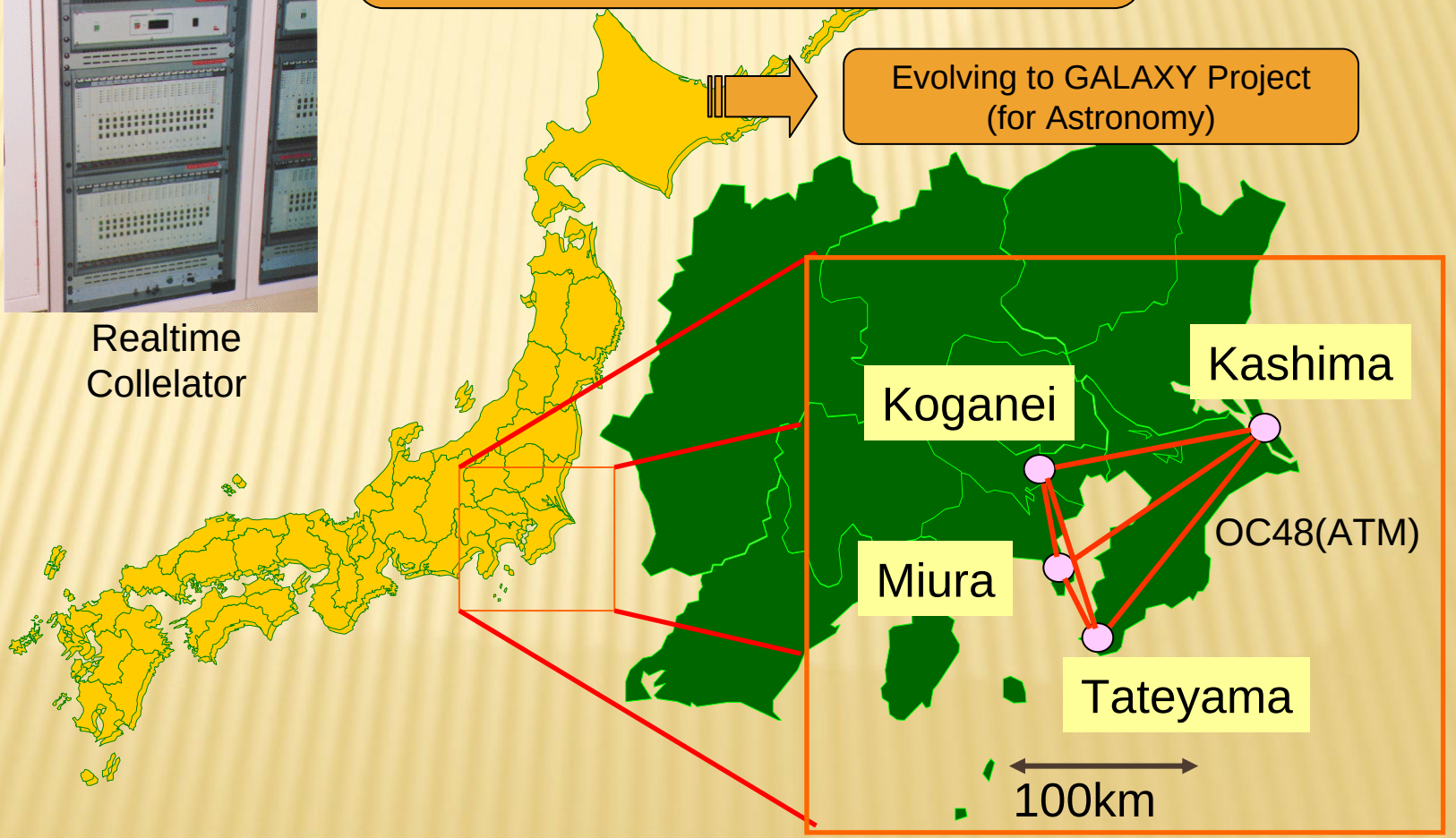


ATM Data Transfer Unit

Realtime Collelator

Realtime e-VLBI at 256Mbps (1998~)
Automated Observations & Processing

Evolving to GALAXY Project (for Astronomy)



VLBI Systems : From K3 to K5

K3 Correlator (Center)
K3 Recorder (Right)

K3 System

1983~
Longitudinal Recorder
Open Reel Tapes
Hardware Correlator

K4 Terminal

K4 Correlator

K4 System

1990~
Rotary Head Recorder
Cassette Tapes
Hardware Correlator
e-VLBI with ATM

K5 Data Acquisition Terminal

K5 System

2000~
PC based system
Hard Disks
Software Correlator
e-VLBI with IP

Concept of the K5 System

	K3	K4	K5
Data Recorders	Magnetic Tapes Longitudinal Recorders	Magnetic Tapes Rotary Head Recorders	Hard Disks
e-VLBI	Telephone Line	ATM	IP
Correlators	Hardware	Hardware	Software
	1983~	1990~	2002~
	M96 Recorder, K3 Formatter, K3 VC, K3 Correlator	DIR-1000, -L -M, DFC1100, DFC2100, K4 VC (Type-1, 2), TDS784, ADS1000, GBR1000, GBR2000D, K4 Correlator, KSP Correlators, GICO, GICO2	IP-VLBI (K5/VSSP, K5/VSSP32), PC-VSI (K5/VSI), ADS1000, ADS2000, ADS3000

Global e-VLBI : Historical Record

Rapid dUT1 Estimation – 2004.6.29 –

Baseline Length : 9502km

Kashima 34m

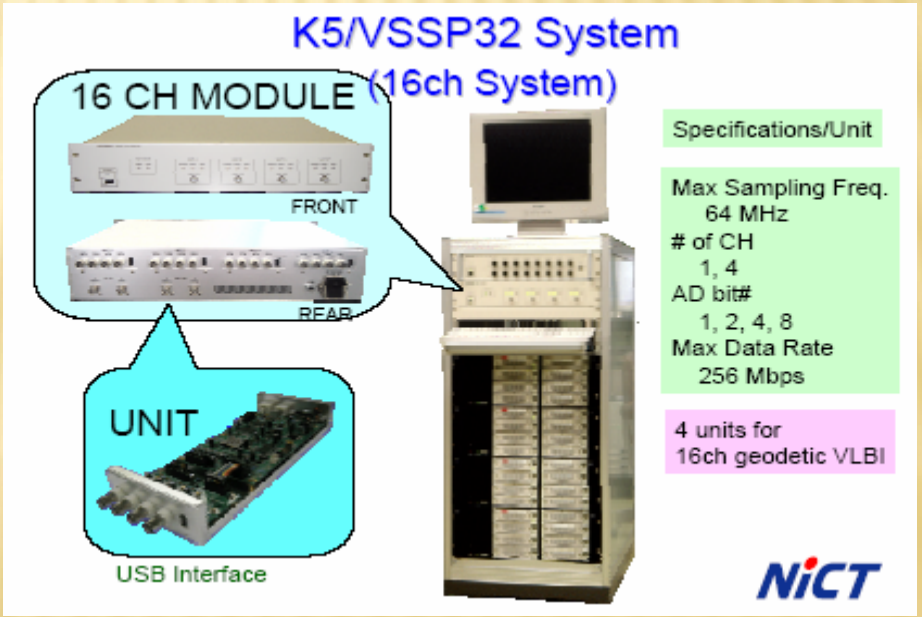
Westford 18m

- Estimated UT1 (variation of the Earth's rotation) in 4.5 hours.
- Software Correlation (20 CPUs).
- Observed data were recorded on hard disks and then transferred.
- K5 system was used at Kashima and Mark5 system was used at Westford.
- It has become routine operation for IVS (International VLBI Service) sessions.

K5/VSSP32 System

- Supports data rate up to 1024Mbps with 16ch.
- Easy to install to off-the-shelf Linux PC systems.
- Directly records data files to Linux file system.
- 5 Systems have been deployed.
  - 1 at Tsukuba and 4 at Kashima
- Reliability has been improved and now used in the regular IVS sessions at Tsukuba and Kashima.
- Data transfer and correlation can be performed in parallel with recording.

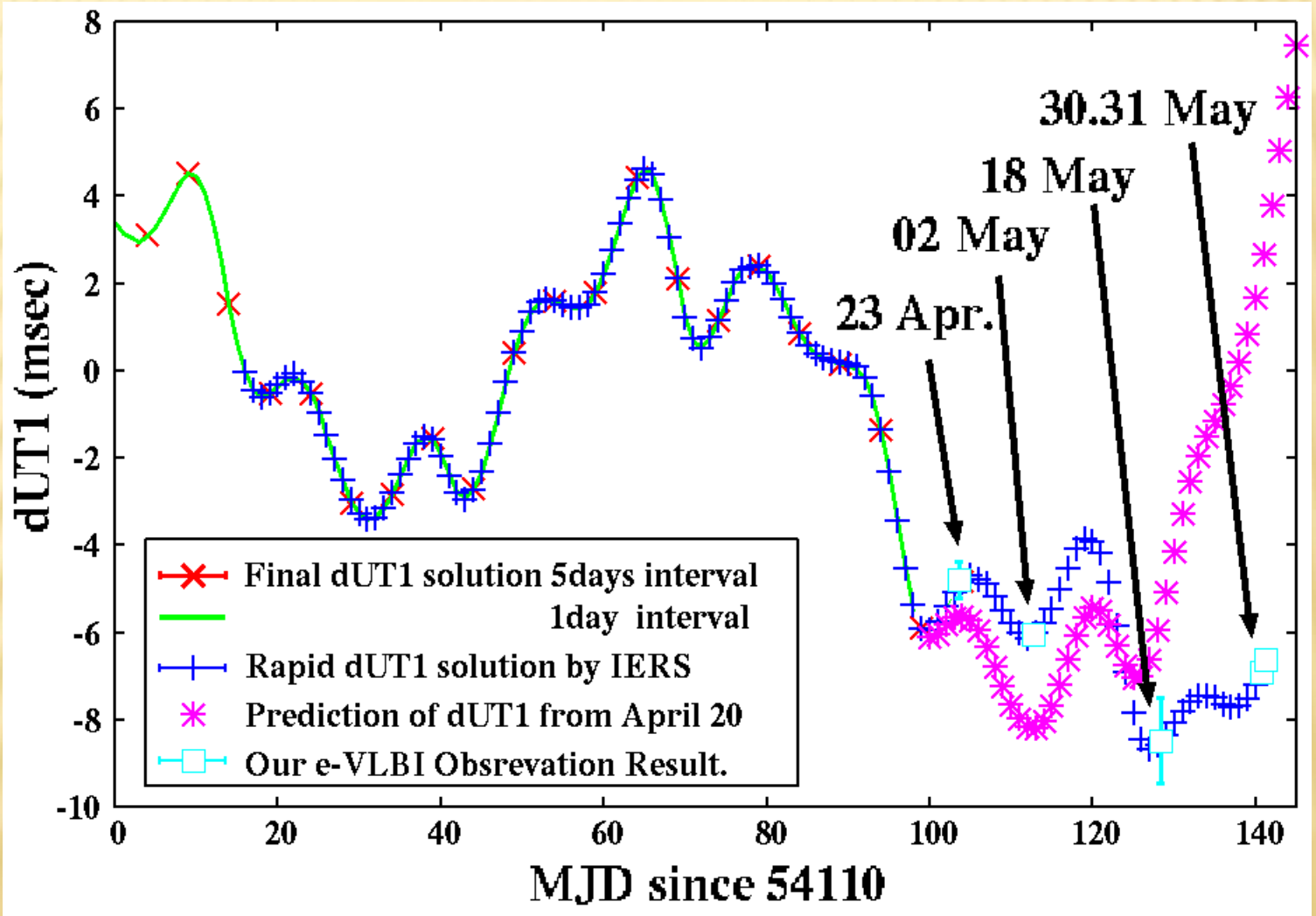
K5/VSSP32 Unit
(~32Msample/ch·sec, ~4ch, ~8bits)



Kashima-Onsala pilot experiment

- May 30, 2007
  - Data Rate : 128Mbps
  - Duration : 1 hour
  - Correlation completed within a few minutes after the session.
  - Version 1 database files were generated within less than 10 minutes after the session.
  - Data analysis completed within less than 30 minutes after the session.

Comparisons of dUT1 from IERS Bulletin and Our Results



Sessions after the official proposal

- July 14, 2007
  - Onsala and Kashima in parallel with INT2 session between Wettzell and Tsukuba baseline (256Mbps). Online processing not successful. Offline processing was successful.

Baseline	UT1-TAI (ms)	sigma (usec)
Tsukuba-Wettzell	-	6.80
Tsukuba-Onsala	-	7.40
Kashima-Wettzell	-	5.33
Kashima-Onsala	- 33162.0781	9.25

- July 15, 2007
  - Onsala-Kashima baseline : Technical Test.
- September 4, 2007
  - Onsala-Metsähovi-Tsukuba : Trial to transfer two stations' data to Tsukuba simultaneously. Not successful from unknown reason. Off-line processing in progress.

Things to do

- Developments of automated database generation.
  - A new database file structure based on NetCDF being developed.
  - NetCDF ⇔ Mark3 Database file conversion utility completed and available.
  - Necessity to rely on Mark3 database handler library has been removed.
- Automated data analysis.
  - Being realized with OCCAM software and NetCDF Database.
- Demonstrate robustness and reliability, and then introduce the same procedure to existing Intensive sessions (INT2)

Short term future plan

- Dry-run tests with four stations.
  - Test without operating antenna. Just for data transfer and processing.
- Actual tests.
  - Onsala-Kashima baseline + Metsähovi-Tsukuba baseline.
  - Repeat several sessions.
- Preliminary reports.
  - At IVS General Meeting : March 2008.

Conclusions

- Ultra-rapid dUT1 estimation within 30 minutes after the session was successfully demonstrated. Estimated results seem to be consistent with the final values from IERS Bulletin B.
- R&D proposal was submitted to IVS Observing Program Committee and was approved.
- Software developments and improvements are still necessary to fully automate the entire process, but it seems the work is straight forward.