Introduction of
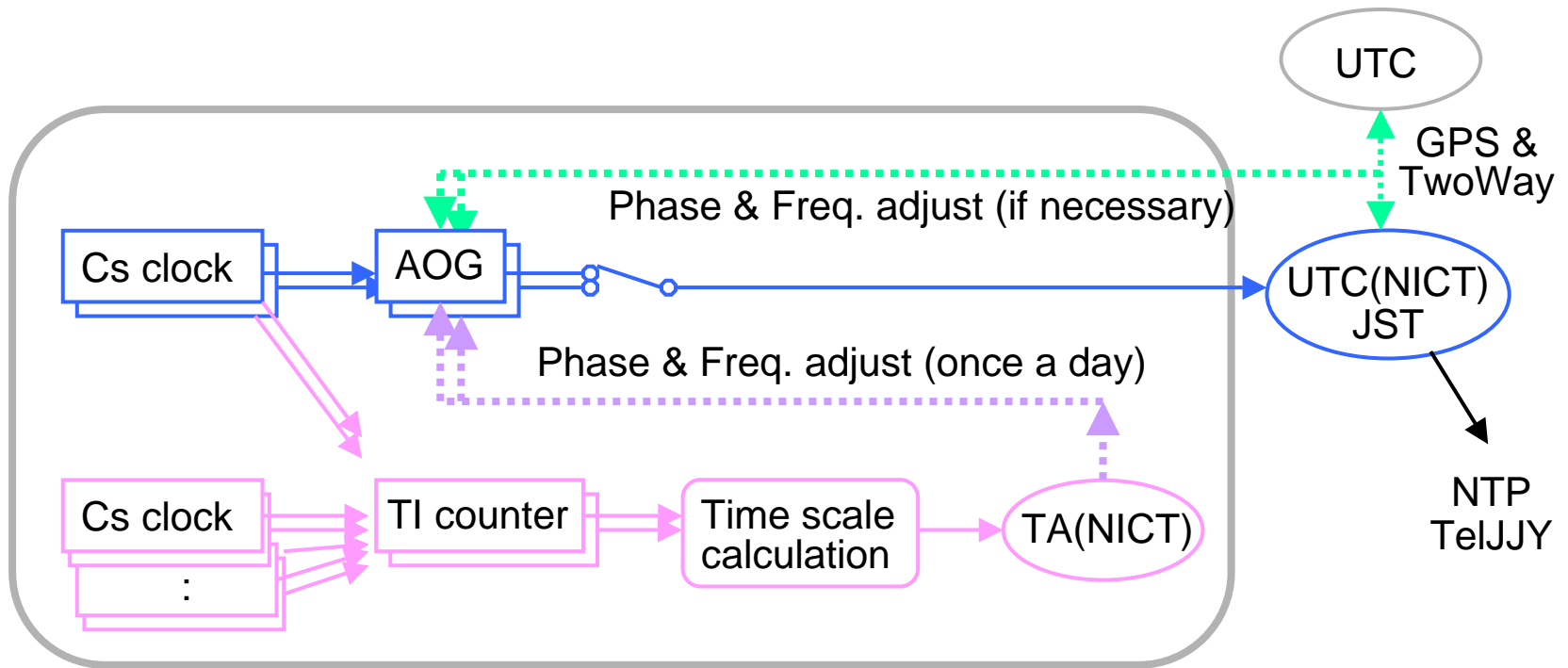# New generation system of
Japan Standard Time

Y. Hanado, K. Imamura, N. Kotake,
F. Nakagawa, Y. Shimizu,
R. Tabuchi, L. Q. Tung,
Y. Takahashi, M. Hosokawa and T. Morikawa

National Institute of
Information and Communications Technology (NICT)
JAPAN

Process of development

■ **Generation system of Japan Standard Time was greatly renewed.** Trigger is a moving of the system to a new building.

■ **New system was designed to improve**

a synchronization with UTC, |UTC   UTC(NICT)| 10ns,
a short-term frequency stability,   introduction of H-maser,
a measurement precision,   development of Multi-ch DMTD,
and a reliability.   ex. Back-ups, Monitors, Securities.

■ **Project started in 2002,   and a regular operation of the new system started on   Feb. 7 2006.**
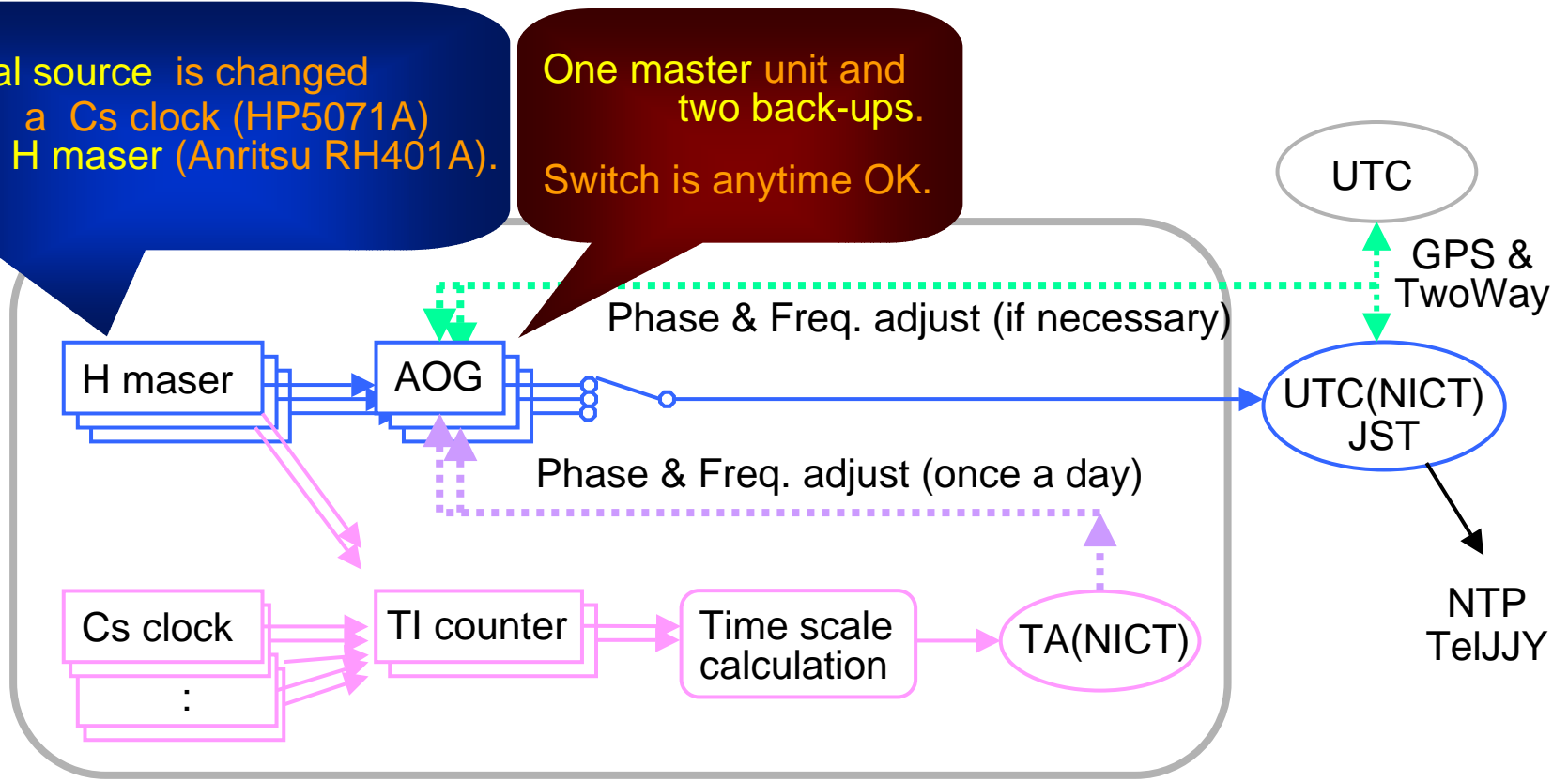
The former generation system of Japan Standard Time

Points of the New system

Signal source is changed from a Cs clock (HP5071A) to a H maser (Anritsu RH401A).
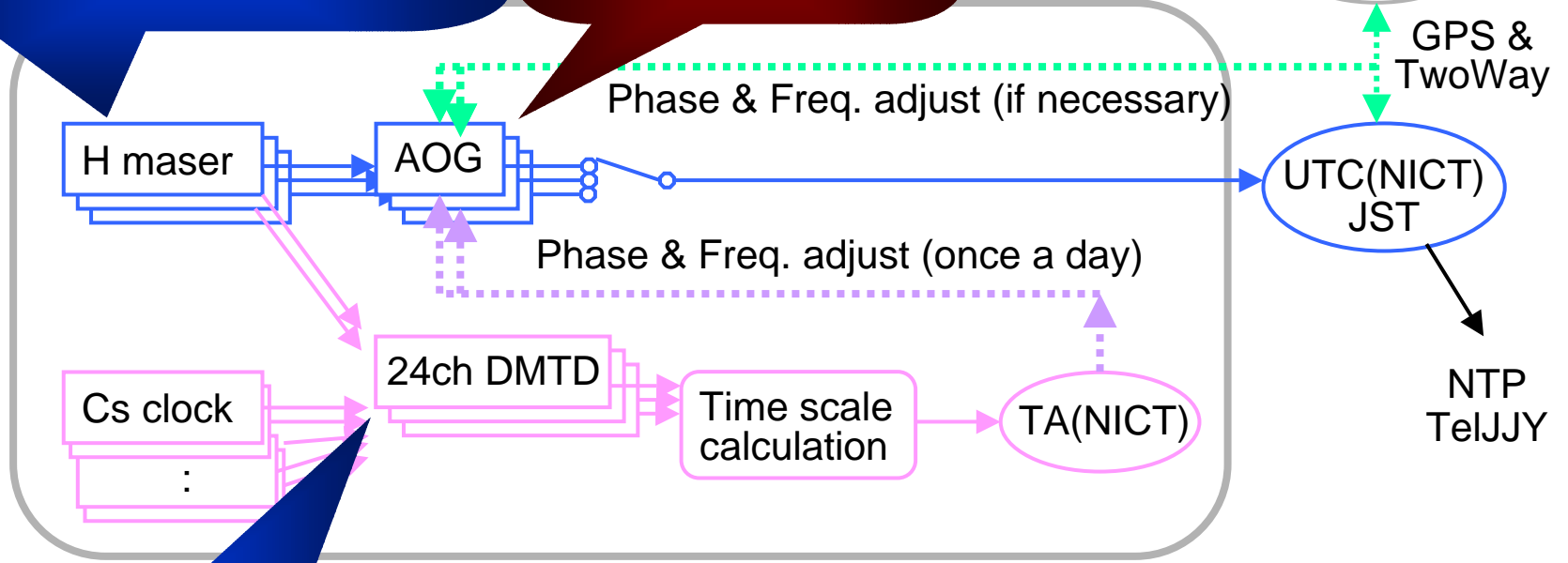
One master unit and two back-ups.

Switch is anytime OK.

UTC

GPS & TwoWay

Phase & Freq. adjust (if necessary)

H maser

AOG

UTC(NICT) JST

Phase & Freq. adjust (once a day)

NTP TelJJY

Cs clock
:

TI counter

Time scale calculation

TA(NICT)

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GPS & TwoWay

Phase & Freq. adjust (if necessary)

H maser → AOG → UTC(NICT) JST

Phase & Freq. adjust (once a day)

Cs clock

:

24ch DMTD → Time scale calculation → TA(NICT)

NTP TelJJY

Newly developed 24ch DMTD using 5MHz is main device of measurement.

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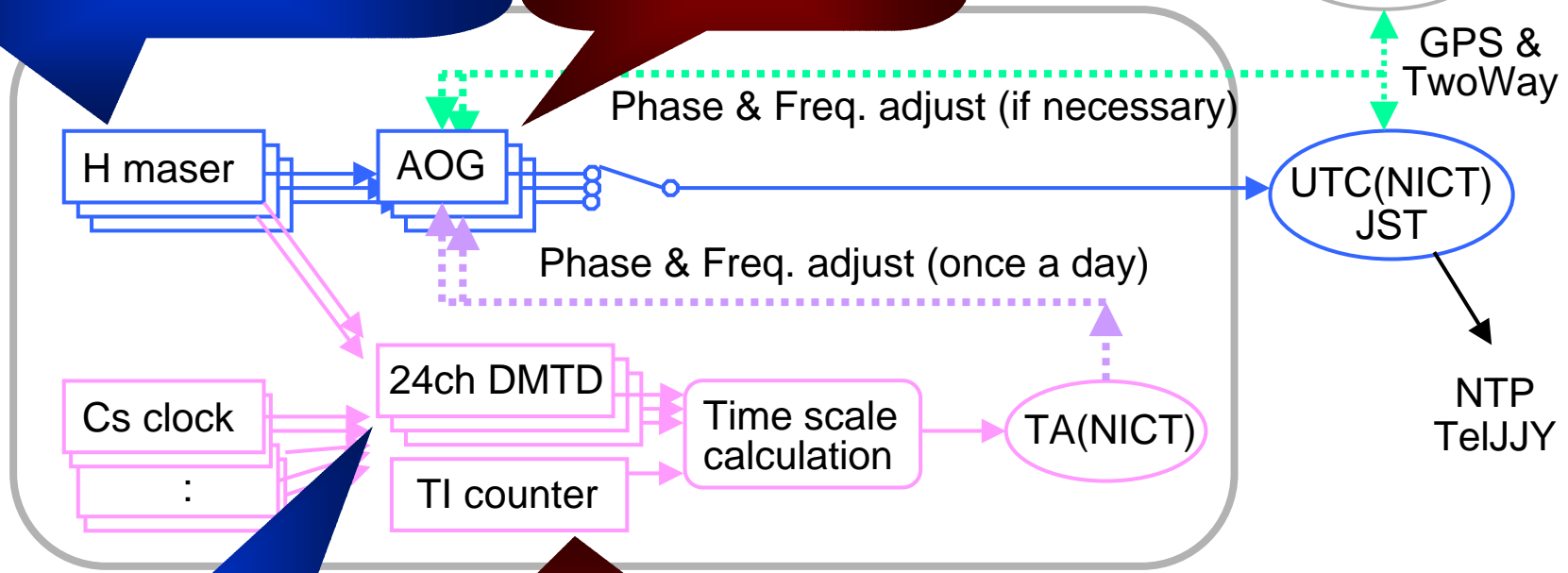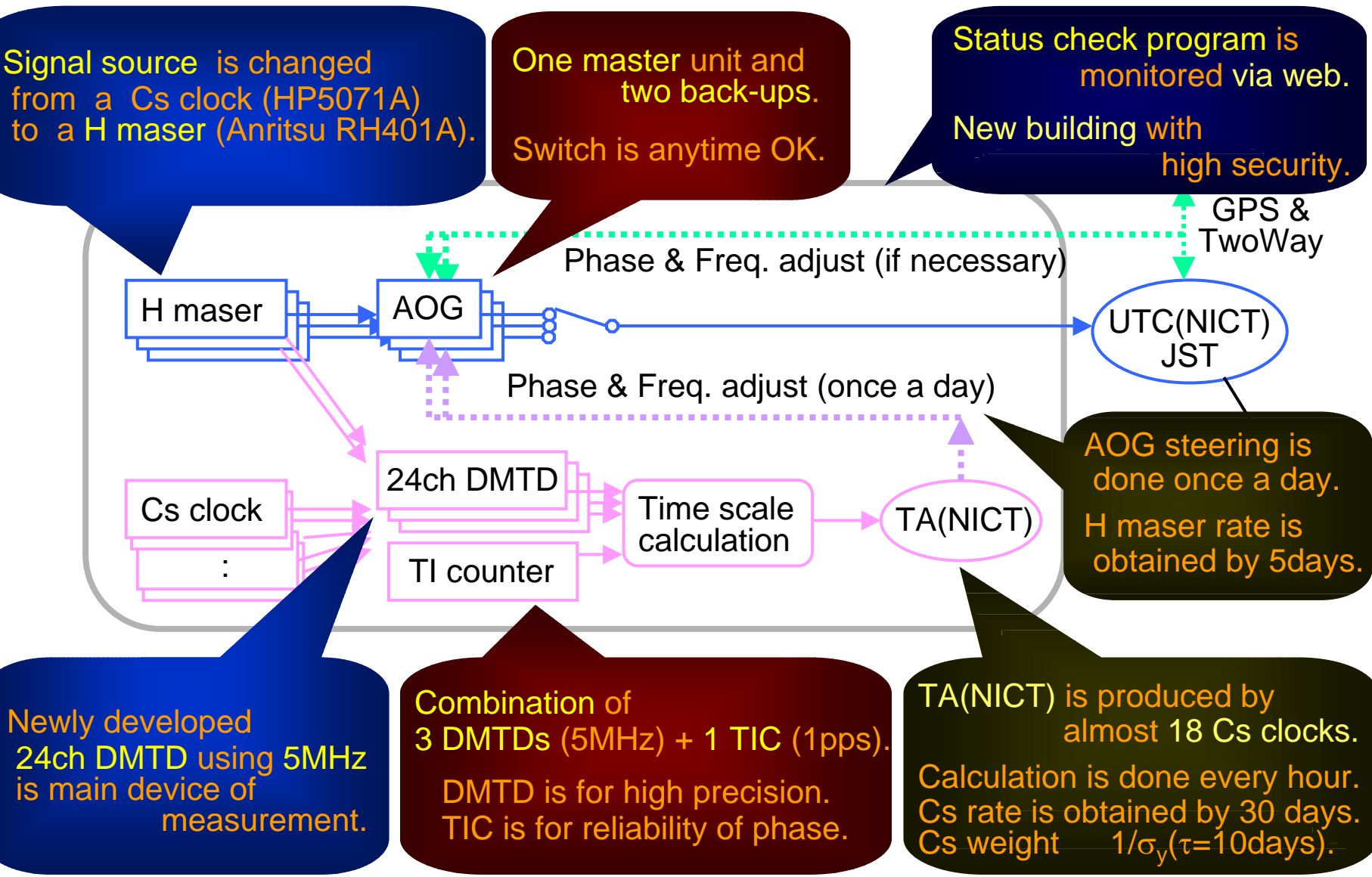One master unit and two back-ups.

Switch is anytime OK.

UTC

GPS & TwoWay

Phase & Freq. adjust (if necessary)

H maser

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UTC(NICT) JST

Phase & Freq. adjust (once a day)

NTP TelJJY

24ch DMTD

Cs clock

:

Time scale calculation

TA(NICT)

TI counter

Newly developed 24ch DMTD using 5MHz is main device of measurement.

Combination of 3 DMTDs (5MHz) + 1 TIC (1pps).

DMTD is for high precision. TIC is for reliability of phase.

Points of the New system

Signal source is changed from a Cs clock (HP5071A) to a H maser (Anritsu RH401A).

One master unit and two back-ups.

Switch is anytime OK.

Status check program is monitored via web.

New building with high security.

GPS & TwoWay

Phase & Freq. adjust (if necessary)

H maser

AOG

UTC(NICT) JST

Phase & Freq. adjust (once a day)

AOG steering is done once a day.

H maser rate is obtained by 5days.

Cs clock

:

24ch DMTD

Time scale calculation

TA(NICT)

TI counter

Newly developed 24ch DMTD using 5MHz is main device of measurement.

Combination of 3 DMTDs (5MHz) + 1 TIC (1pps).

DMTD is for high precision.
TIC is for reliability of phase.

TA(NICT) is produced by almost 18 Cs clocks.

Calculation is done every hour.
Cs rate is obtained by 30 days.
Cs weight $1/\sigma_y(\tau=10\text{days})$.

Outlook of the main units   24ch-DMTD system

DMTD5
(Japan Communication Equipment Co., Ltd.)

- Beat down: 5MHz   1kHz.
- Output :   average of 100 sampling
                data   in every second.
- Precision: 0.2ps.
- Auto counting of cycle-slip.

Hydrogen maser (RH401A / Anritsu Corp.)

(log scale)

Allan deviation

Short-term stability becomes better.

HP5071A

Anritsu H-maser

TI Counter

DMTD

Precision becomes better.

Allan deviation

-11
-12
-13
-14
-15
-16
-17

Averaging time(s)

1   10   100   1000 10^4 10^5

- Outputs   5,10,100MHz,1pps
- Stability σ_y 4×10^{-13} (τ=1s)
  σ_y 2×10^{-15} (τ=1000s)
- Auto-tuning mode and monitoring software are equipped.
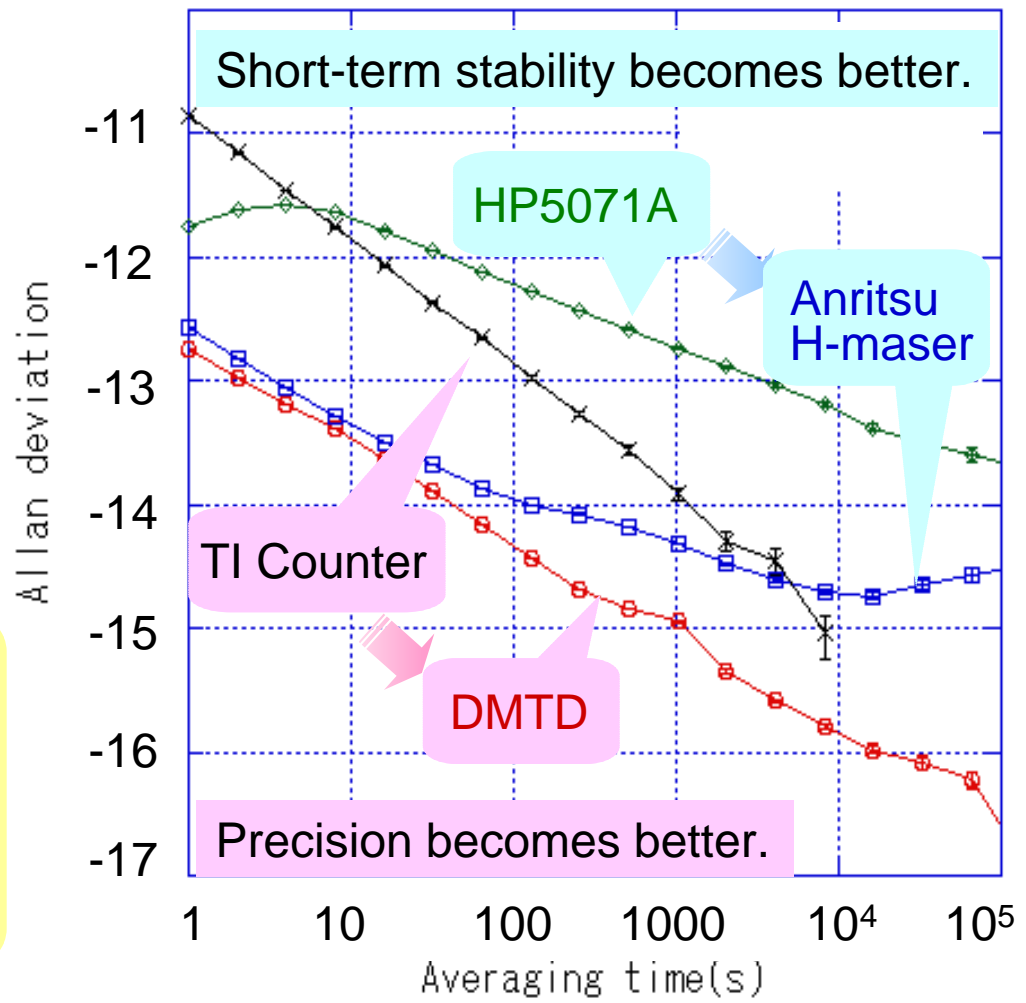
Recent motion of UTC(NICT) against UTC
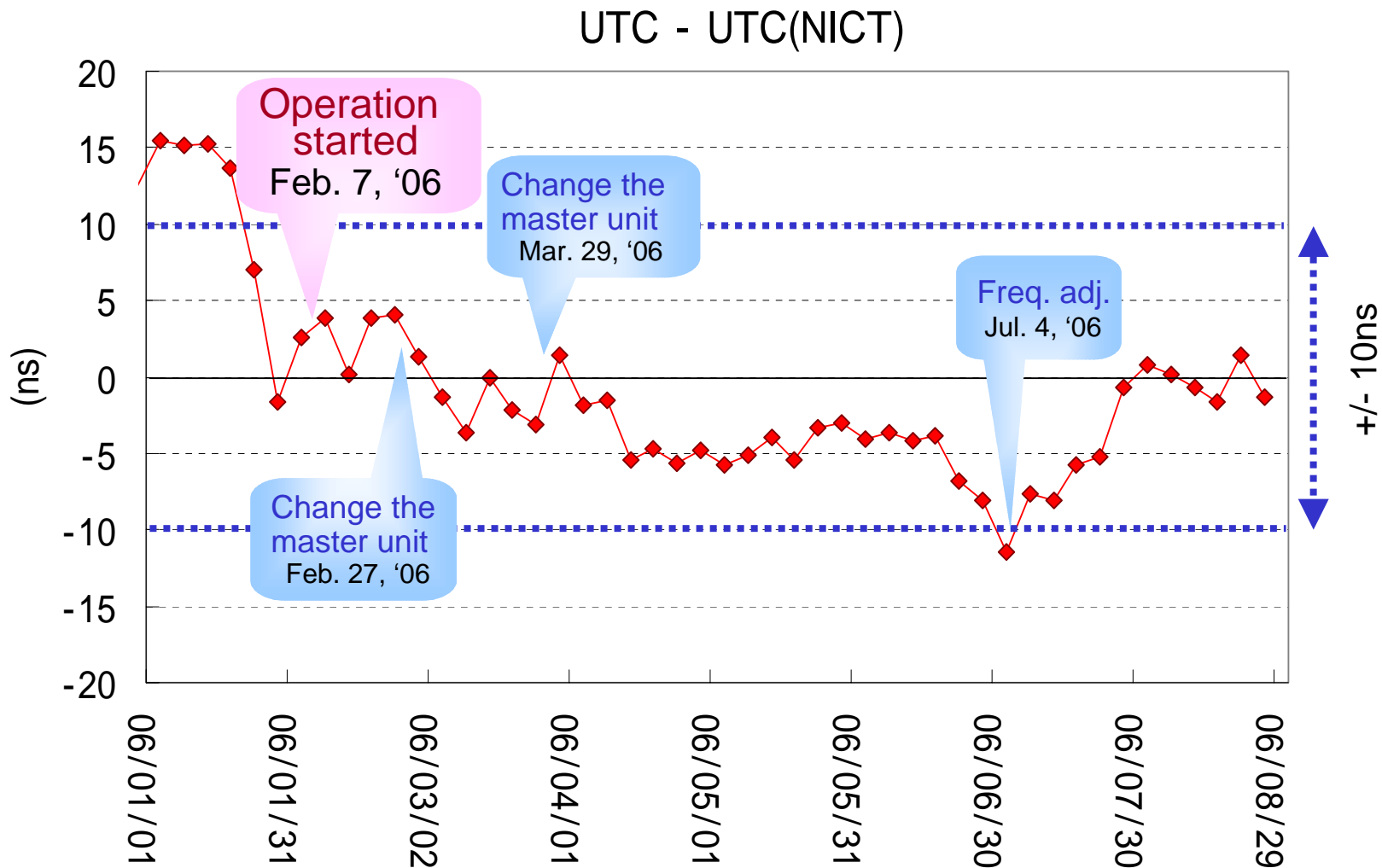
Summary

- New generation system of Japan Standard Time
  started a regular operation since Feb.7 2006.

- New system achieved
  a better short-term frequency stability by introduction of H-maser,
  a better measurement precision by development of 24ch-DMTD,
  and a synchronization with UTC within almost 10ns.
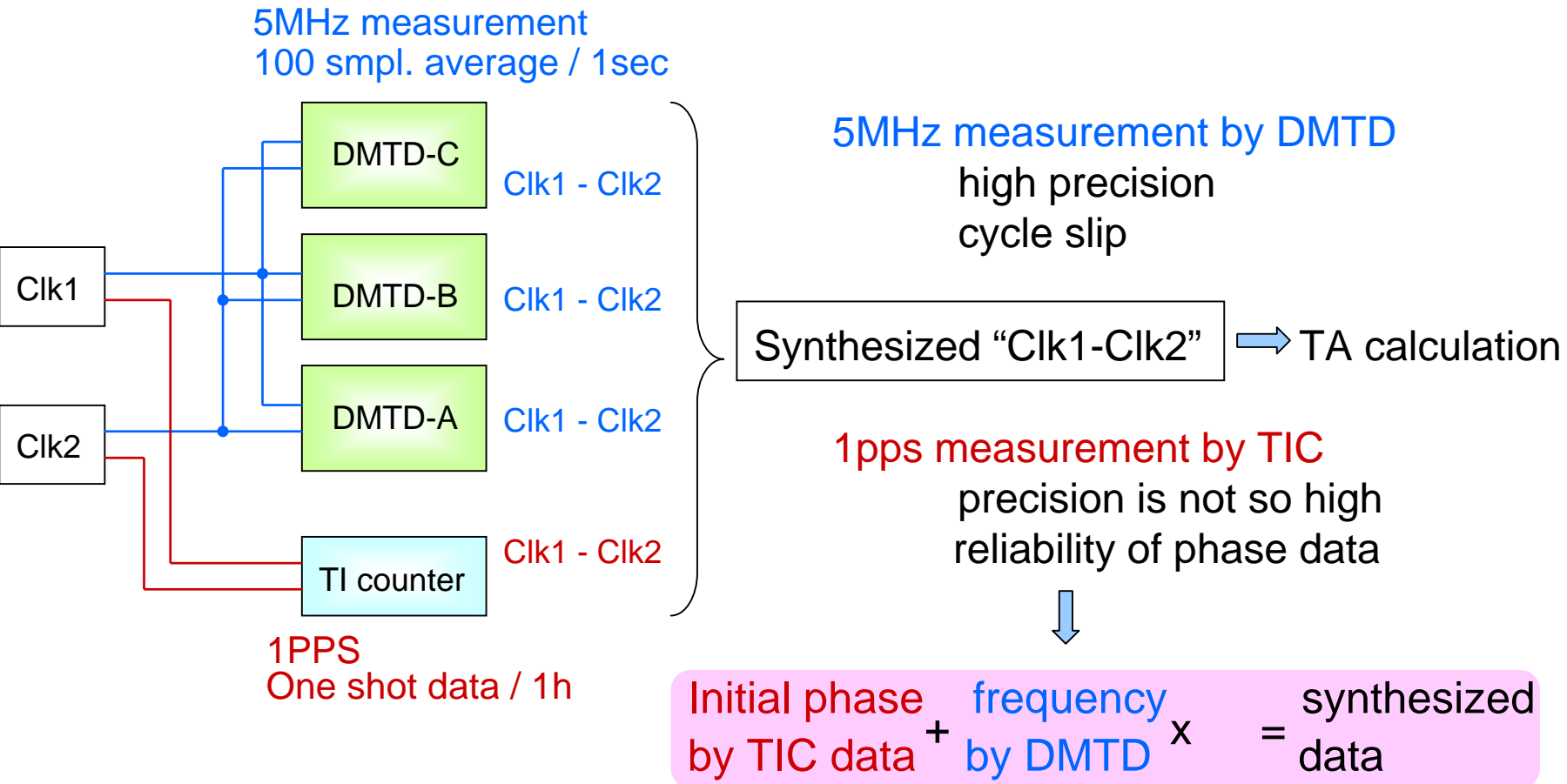
Current problem

- Health of the hydrogen masers.
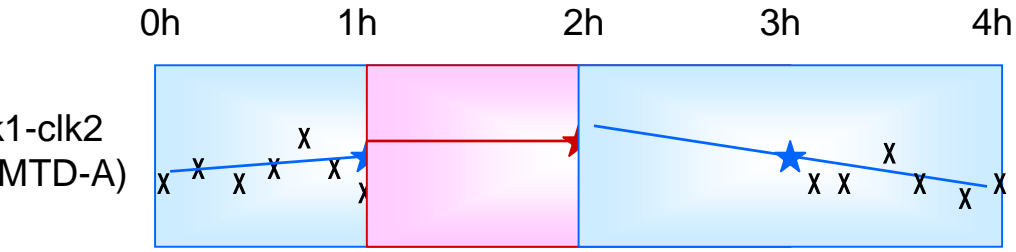- Stable operation of Cs clocks (Life-time, environmental problems,,) .

Future plan

- Improvement of algorithm of TA(NICT) and
  steering method of UTC(NICT).

- Link with the primary atomic frequency standard at NICT.

Synthesized data using DMTD TIC

Synthesized data using the 3 DMTDs & TIC (sets of data).

5MHz measurement
100 smpl. average / 1sec

DMTD-C   Clk1 - Clk2

Clk1

DMTD-B   Clk1 - Clk2

DMTD-A   Clk1 - Clk2

Clk2

Clk1 - Clk2

TI counter

1PPS
One shot data / 1h

5MHz measurement by DMTD
    high precision
    cycle slip

Synthesized "Clk1-Clk2" ⇨ TA calculation

1pps measurement by TIC
    precision is not so high
    reliability of phase data

⬇

Initial phase   frequency   synthesized
by TIC data + by DMTD x   = data

Data processing for DMTD

0h   1h   2h   3h   4h

clk1-clk2
(DMTD-A)

1   2   3

Phase data in each device has a systematic offset.

Thus we use the frequency to synthesize the data obtained by these devices.

1

T
C
B
A

1 S

S_0 S_0 S_1 S_1

(1) ϕ_1 at 1^h is obtained by the linear fitting of DMTD raw data during 0^h - 2^h.

(2) $f_1 = (\phi_2 - \phi_1) / 3600^s$.
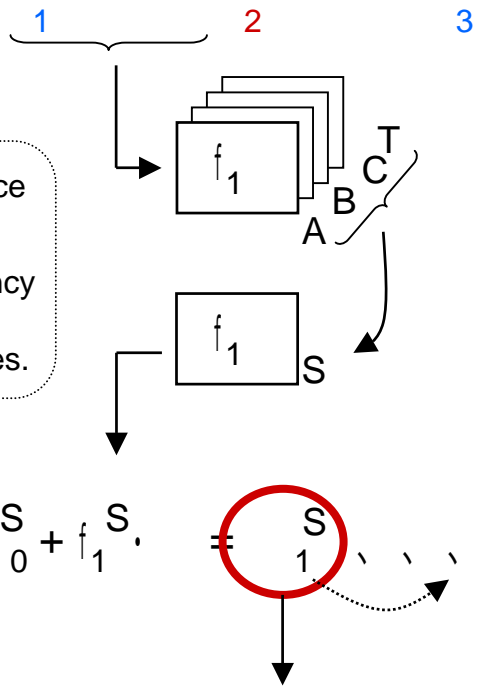
(3) Two good f_1s are selected as follows.
   1. $S^A = |f^A - f^B| + |f^A - f^C| + |f^A - f^T|$, and S^B, S^C, S^T are calculated similarly.
   2. We select the minor two Ss.
   3. If they are S^B and S^C, f^B and f^C are selected.

(4) f_1^S = average of these two f_1s.

(5) ϕ_n^S is obtained by accumulation of f_1^S.

(6) Initial ϕ_0^S is derived from TIC data.

These values are used for TA calculation as the "measured data of clk1-clk2".