September 12, 2011

CCTF WG on TWSTFT meeting

Introduction of AIST and T&F Activities at NMIJ

National Metrology Institute of Japan (NMIJ)

Contents

Contents

Outline of the National Institute of Advanced Industrial Science and Technology (AIST)


AIST Chugoku


AIST Shikoku


AIST Tsukuba Headquarters / AIST Tsukuba


AIST Hokkaido


AIST Tohoku

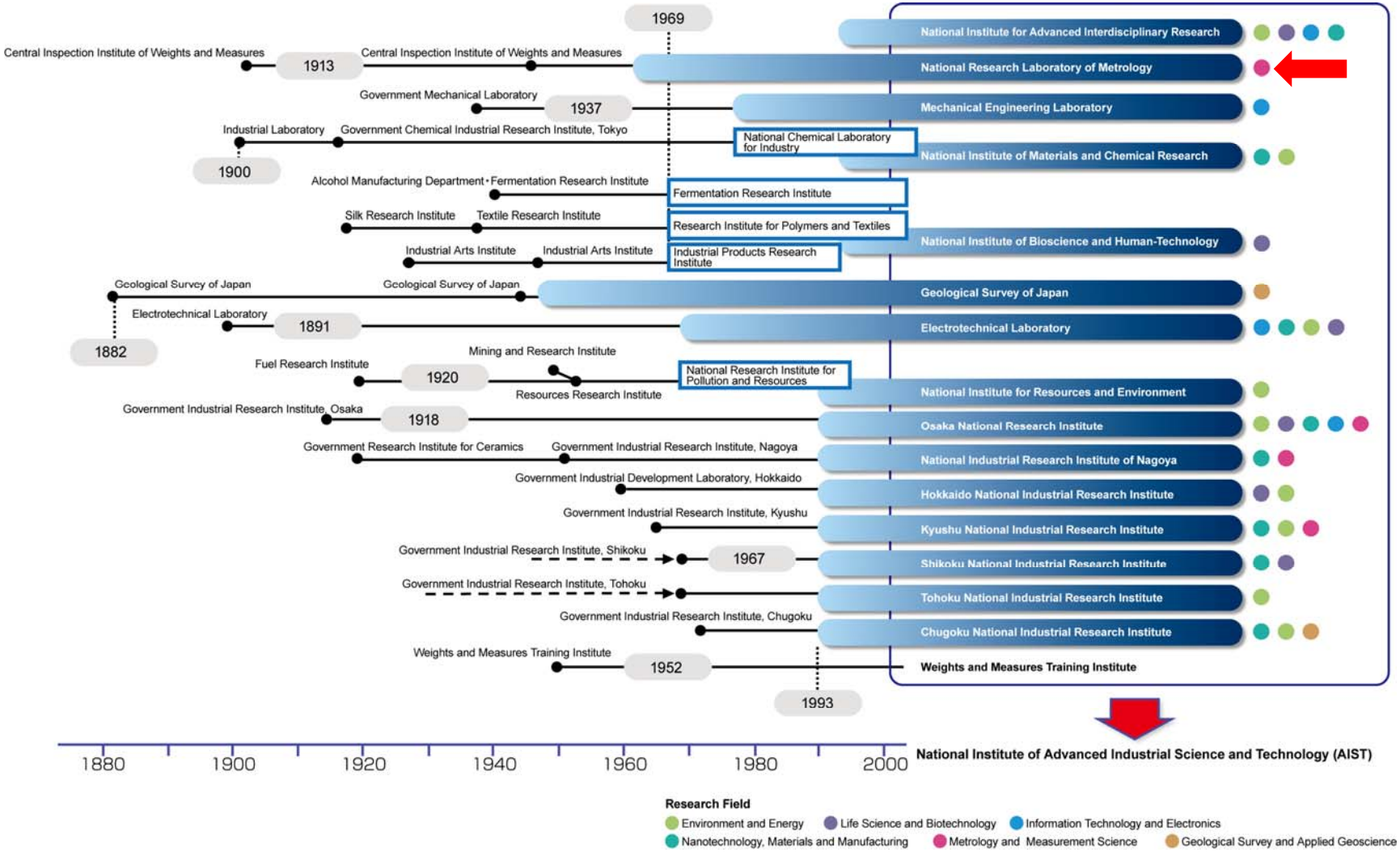

AIST Kyushu


AIST Kansai

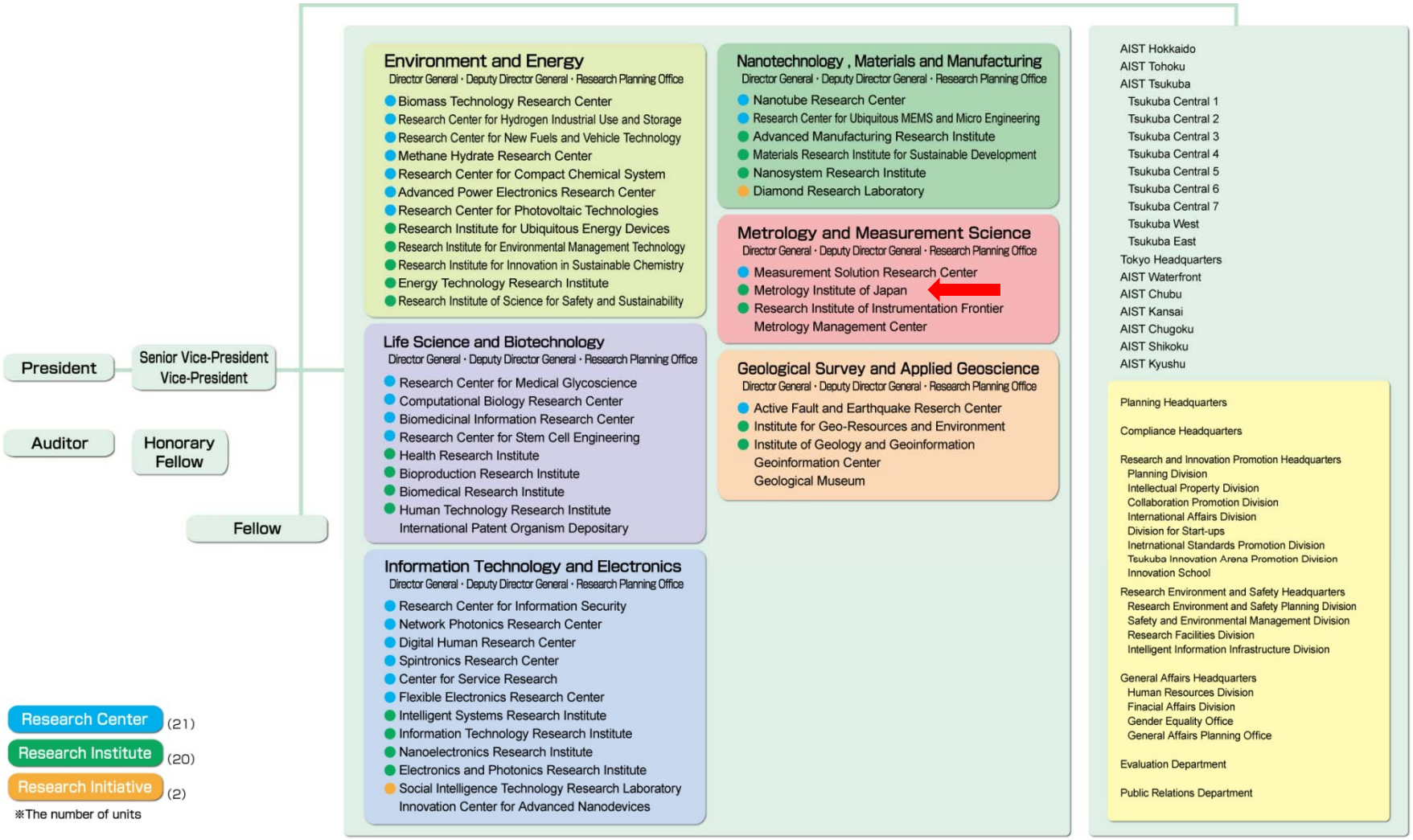

AIST Chubu


AIST Tokyo Waterfront

Integration/Reorganization of 16 Institutes



AIST Organization Chart



(As of April 1, 2011)

AIST DATA –Staff

Researchers (International)	2,337 (83)
• Permanent	2,099
• Fixed term	238
Administrative employees	638

As of April 1, 201 1 ; total number of employees: 3,020 (83)

Executives	13
Visiting researchers	177
Postdoctoral researchers	318
Technical staff	1,671

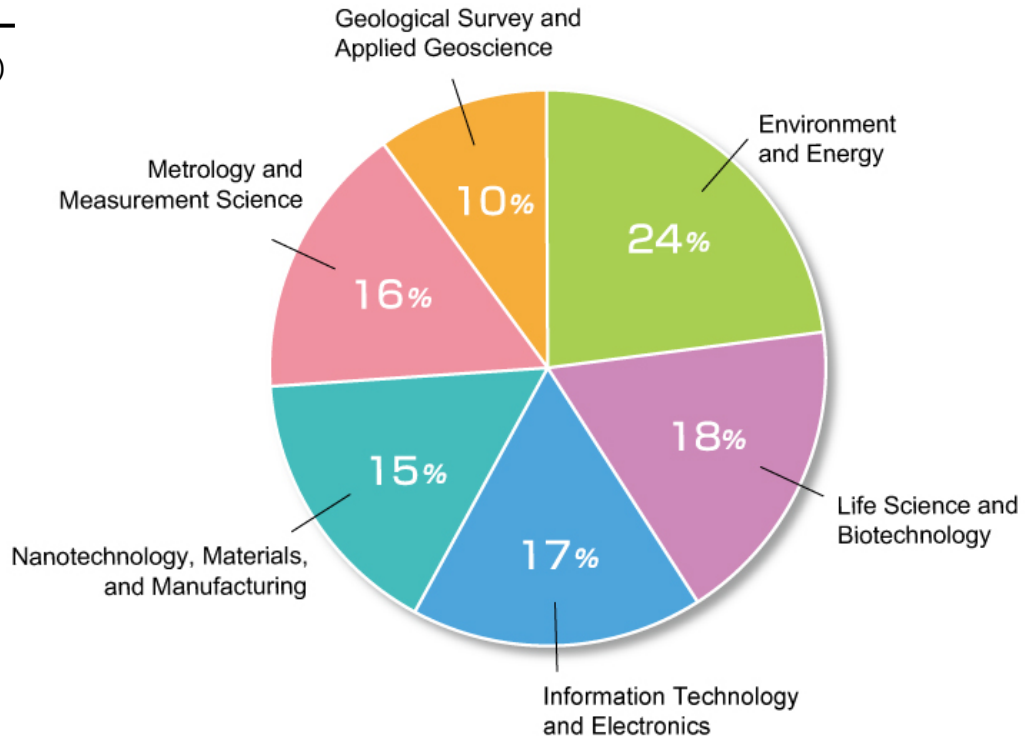
Number of researchers accepted through industry/academia/government partnerships

Companies	Approx. 1,300
Universities	Approx. 2,000
Other organizations	Approx. 1,900 (553 from overseas)

(Total number of researchers accepted in FY 2010)

Composition of research staff by research field

(As of April 1, 2011)



Contents

Structure of T&F division in NMIJ/AIST

Head of T&F standard division: Fang-Lei Hong

(1) Time standards section

Section Chief: Takeshi Ikegami, 5 researchers

- Development of primary frequency standards
- Calibration service of phase noise

(2) Optical Frequency and Wavelength standards section

Section Chief: Fang-Lei Hong, 7 researchers

- Research and application works on optical comb, especially optical fiber comb
- Research and development of optical lattice clocks
- Calibration service of optical wavelength using an optical frequency system

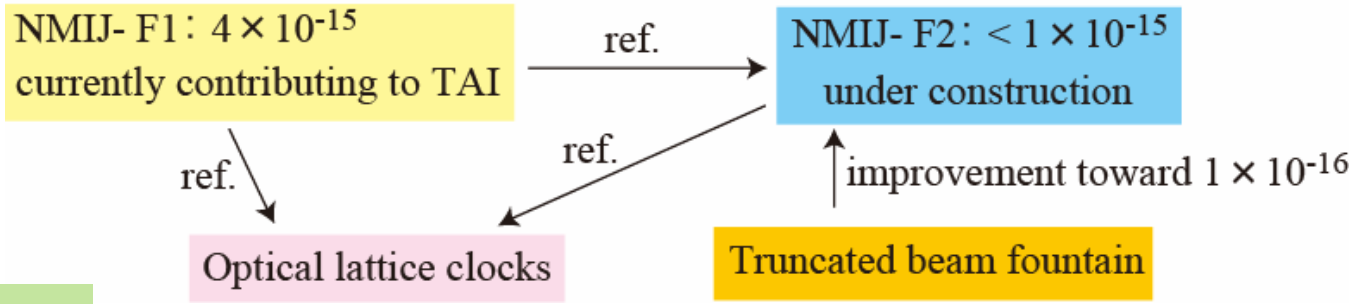
(3) Frequency measurement systems section

Section chief: Masaki Amemiya, 4 researchers, 4 technical staffs

- Time keeping of UTC(NMIJ)
- Time and frequency transfer, such as GPS carrier phase, TWSTFT, and optical fiber
- Calibration service of time and frequency and its R&D work

Contents

Atomic fountains in NMIJ



3 fountains in NMIJ

NMIJ-F1 : Long-term operation with uncertainty of 4×10^{-15}

Frequent reports to BIPM (20 reports to BIPM in recent 4 years).
Reference for NMIJ-F2 and optical lattice clocks on demand.

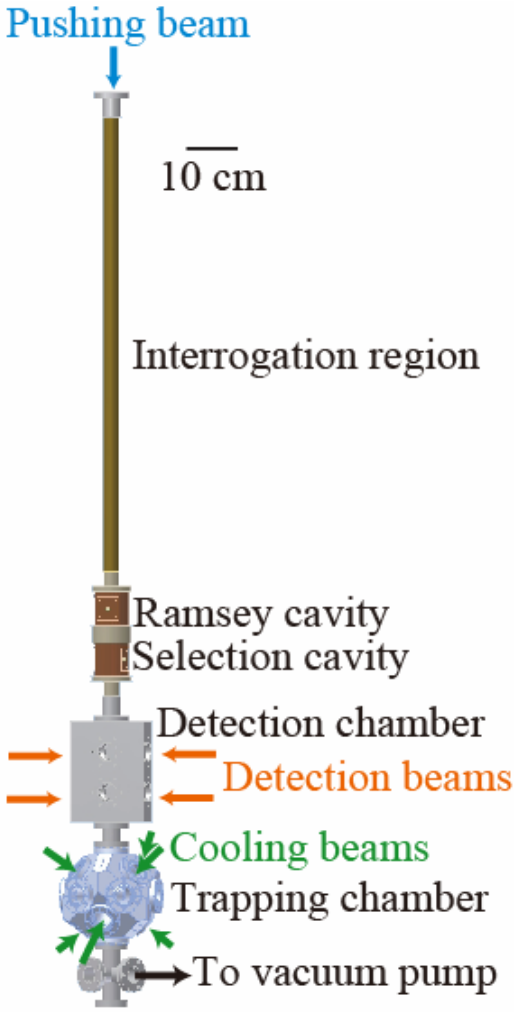
NMIJ-F2 : Under construction. Target uncertainty < 1×10^{-15}

Higher contribution ratio to TAI.
Precise reference for optical lattice clocks.

Truncated beam fountain : New proposal (*Phys.Rev.A* **82** (2010) 013632).

Target uncertainty 1×10^{-16}.
In the step for proof of the principle.

NMIJ-F2



Microwave cavities which are part of the vacuum vessel (S. R. Jefferts et al., Proc. 1998 IEEE Int. Freq. Control Symp. p. 6)

⟶ Decrease of the uncertainty caused by microwave power dependence

(1,1,1) configuration for cooling laser beams
Laser power :100 mW per beam

⟶ Increase of the number of cold atoms

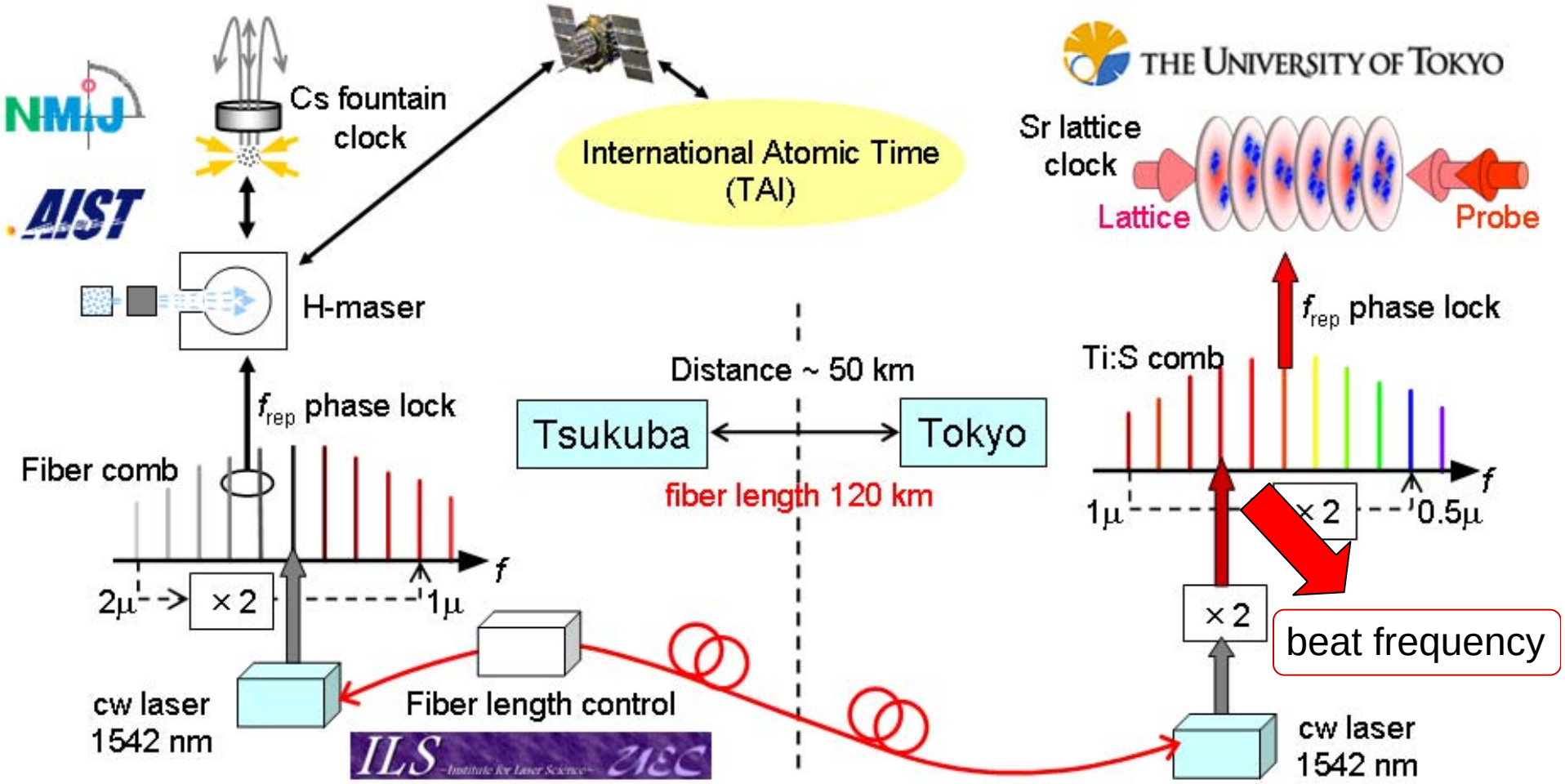
⟶ Higher frequency stability

Due to the difficulty of the optical alignment in (1,1,1) configuration (the observed temperature of optical molassess was 120 μK), we modified the configuration to (0,0,1).

NMIJ-F2
(under construction)

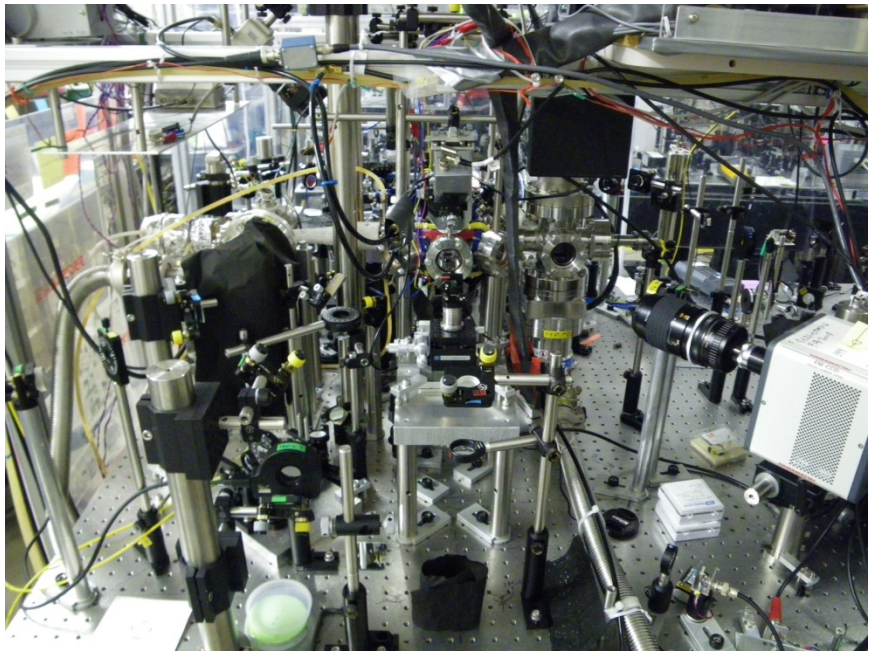
Contents

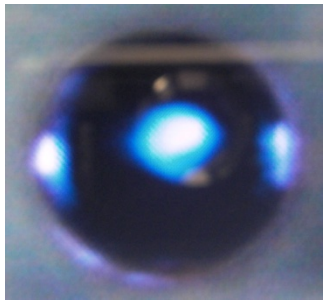
Experimental setup for frequency evaluation of Sr. lattice clock at the University of Tokyo



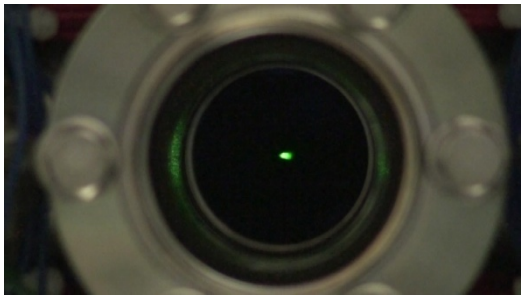
F.-L. Hong et al., Opt. Lett. 34, 692 (2009).

Yb optical lattice clock at NMIJ

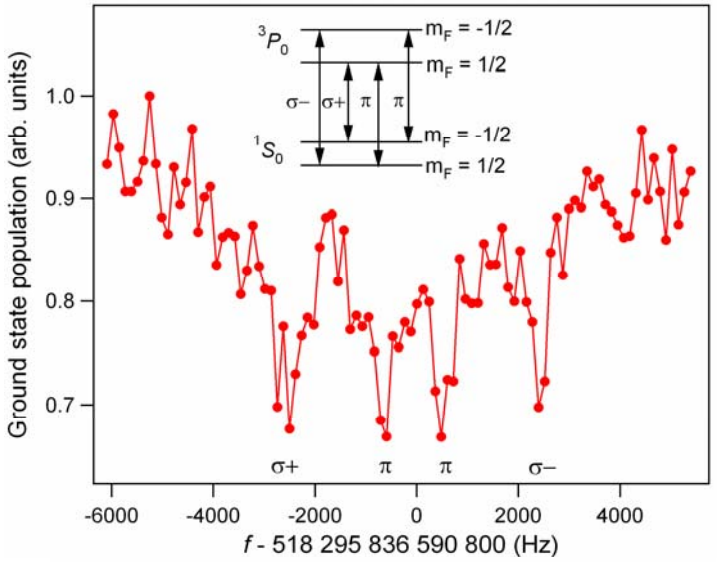


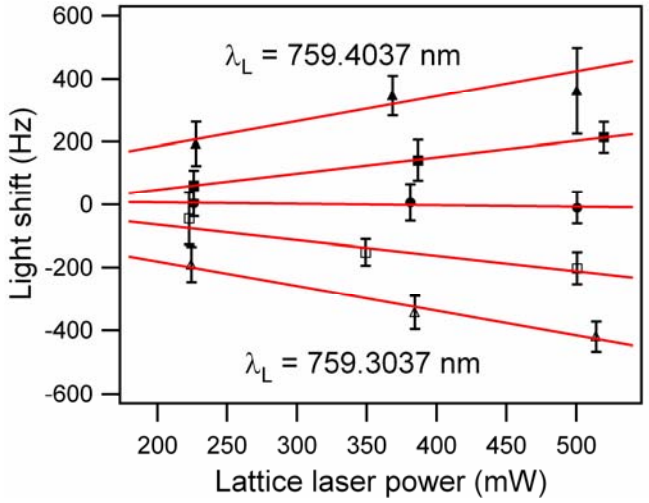


Blue MOT



Green MOT





M. Yasuda, T. Kohno, H. Inaba, Y. Nakajima, K. Hosaka, A. Onae, F.-L. Hong, J. Opt. Soc. Am. B 27, 1388 (2010).

Uncertainty evaluation and result

Effect	Correction (Hz)	Uncertainty (Hz)
Blackbody radiation shift	+ 1.32	0.13
Gravitational shift	- 1.19	0.03
2nd order Zeeman shift	+ 0.4	0.05
Scalar light shift	0	14
Clock laser light shift	- 0.04	< 0.01
Clock laser scan step	0	23
UTC (NMIJ)	0	5
Total	+ 0.49	27

$^1S_0(F = 1/2)$-$^3P_0(F = 1/2)$ transition in ^{171}Yb

***f* = 518 295 836 590 864 (28) Hz**

(Fractional uncertainty 5.4×10^{-14})

T. Kohno *et al.*, Appl. Phys. Express vol. 2, 072501, June 2009.

CIPM Recommended frequency list (June, 2009)

cf. NIST group's GREAT result:

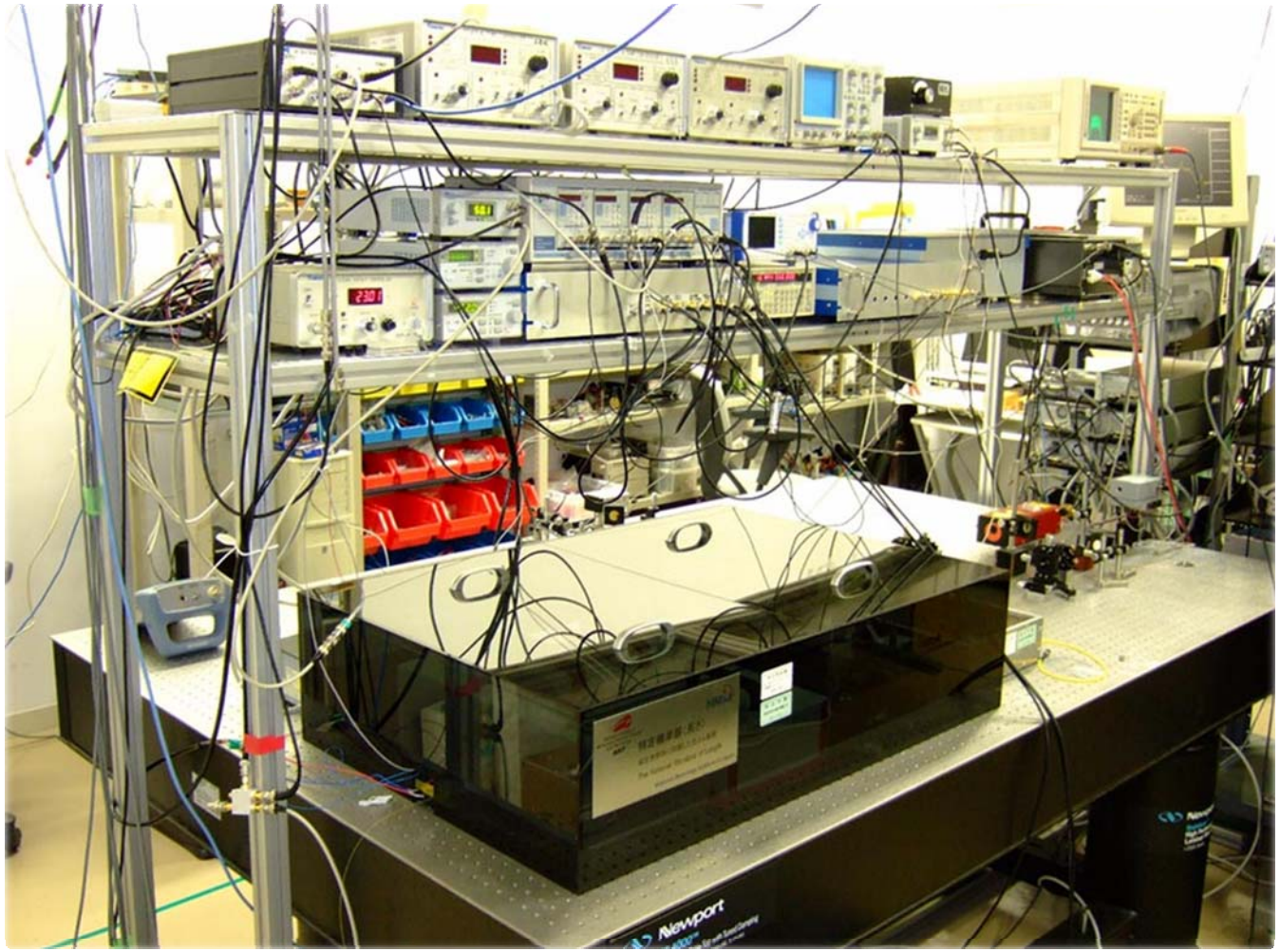
N. D. Lemke *et al.*, "Spin-1/2 Optical Lattice Clock" Phys. Rev. Lett., vol. 103, pp. 063001, August 2009

***f* = 518 295 836 590 865.2(0.7) Hz**

(Fractional uncertainty 1.4×10^{-15})

^{171}Yb clock can be so good!

The National Length Standard
“An optical frequency comb”



Contents

UTC(NMIJ) generation system and time transfer link

- UTC(NMIJ) is generated by reference signal form one hydrogen maser steered by an AOG.

- Clocks at NMIJ
  - 4 hydrogen masers
    - 2 RH401A made by Anritsu
    - 1 SD1T01A made by Anritsu
    - 1 CH1-75A made by KVARZ
  - 3-5 Cs clocks
    - 5071A with high performance beam tube

- Time Transfer Link
  - UTC PPP (GPS carrier phase) using Z12-T: main time transfer tool
  - TWSTFT : backup tool

Cs clocks and H-masers

Temperature controlled chambers for 5071A

CH1-75A

Temperature controlled chamber for SD1T01A

Hydrogen masers (RH401A)

Cs atomic clocks and new hydrogen masers (RH401A, CH1-75A and SD1T01A) are placed in temperature controlled chambers.

The temperature variation of inside of the chambers is better than +/-0.2 deg. C.

CH1-75A is the reference oscillator of UTC(NMIJ)

Measurement system for UTC(NMIJ)

Development of user terminals for remote time and frequency calibration

GCET
Size 480×430×88 mm
Sensitivity -135 dBm
Price about 1 MJPY (Rb type)
NMIJ-DO using NMIJ's Web site

Experimental model of small size terminal

Proto-type model of small size terminal

Terminal size
< 120×100×30 mm
Sensitivity <-160 dBm
Wire-less data communication

Target model

Proto-type models of user terminal under development

α-version

Case size: 190 x 100 x 40 mm

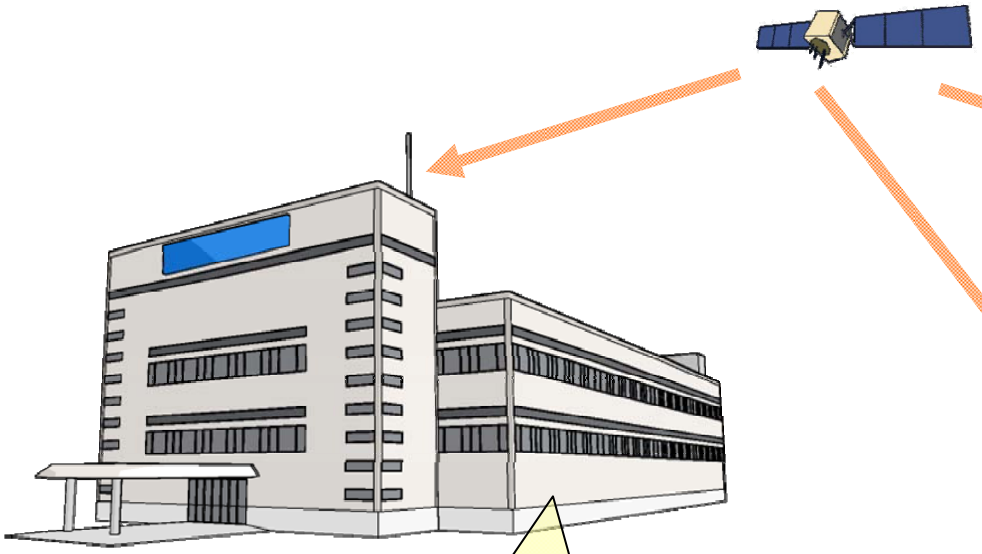
PCB size: 150 x 85 mm

β-version

Case size: 140 x 95 x 40 mm

PCB size: 135 x 85 mm

On-site, On-machine, and Real-time calibration



Automatic calibration for many measurement equipment in the factory

Time calibration in traffic system

Real time calibration of measurement equipment in outdoors

Thank you for your attention !