Importance and use of the "frequency comb" in ON - DSHO

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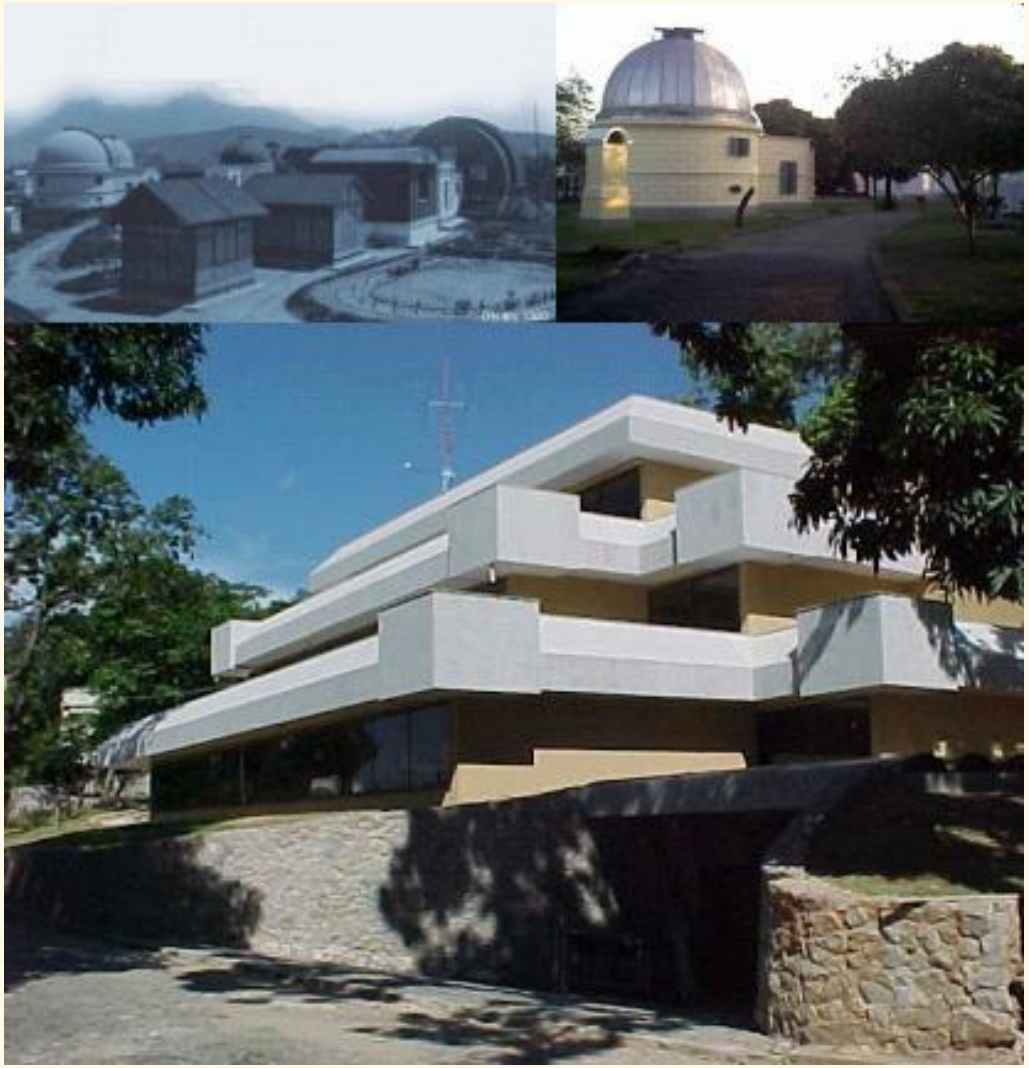
***Nilo Koscheck** – luxkoscheck@on.br*
***Fábio C. Junior** – fabiocj@on.br*



The National Observatory was created on October 15, 1827 by Emperor D. Pedro I

IMPERIAL OBSERVATORY IN MOUTAIN CASTLE (south side)

DSHO/LPTF – 2006

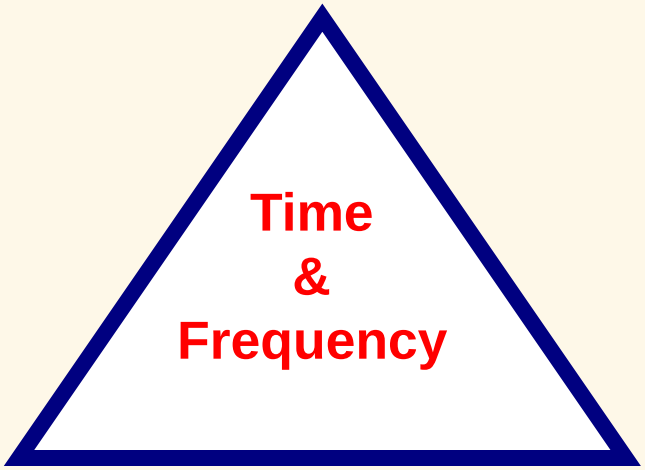
(DSHO) remains the standard for frequency and time interval for Brazil, generating, preserving and disseminating the Brazilian Cool Time (HLB)

Is a Designated Office by the National Institute of Metrology, Standardization and Industrial Quality (INMETRO).

Has the responsibility of Standardization Metrology Reference metrology in Brazil and frequency and time.

Time and frequency metrology

Dissimination



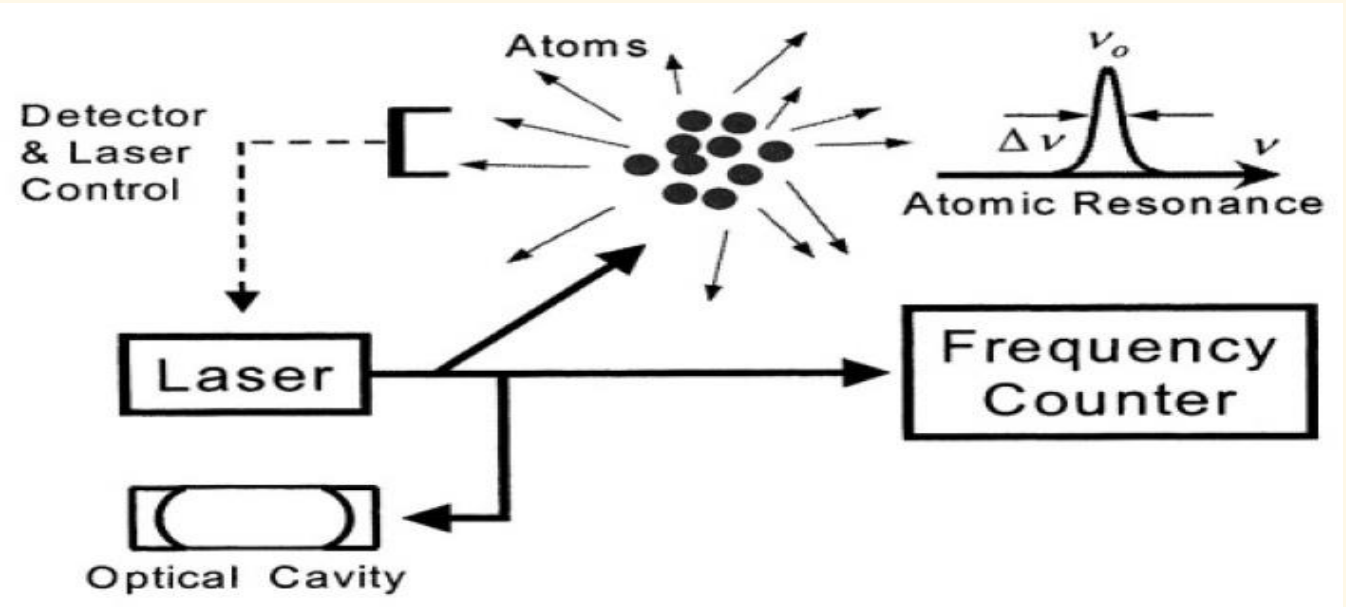
Generation

Conservation

SOURCE FREQUENCY AND CLOCK

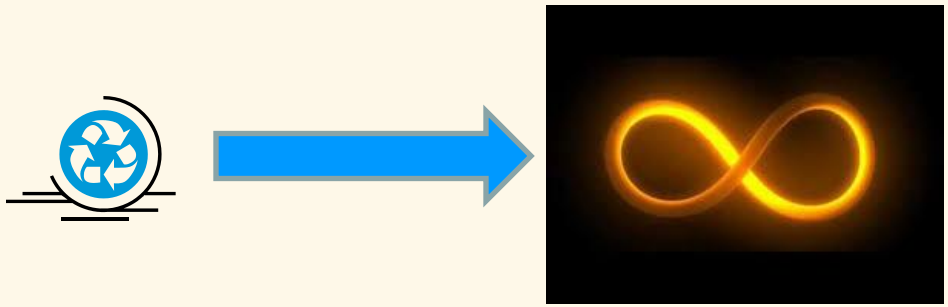
An source frequency is a device that produce a periodic event that repeat at an approximately constant rate.This rate is called Ressonace Frequency

A clock counts cycles of a frequency and records the time interval units, such as seconds, minutes, hours and days. a clock source consisting of a frequency, a counter and a display.



Measure time

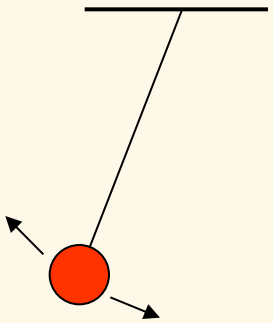
- The clocks are simulators that generate a constant periodic rate.
- Time measurements are comparisons between beats of a clock and the natural time



What's the time?

CLOCK PARTS

REPEAT MOVIMENT + **MECHANISM OF COUNT AND DISPLAY.**



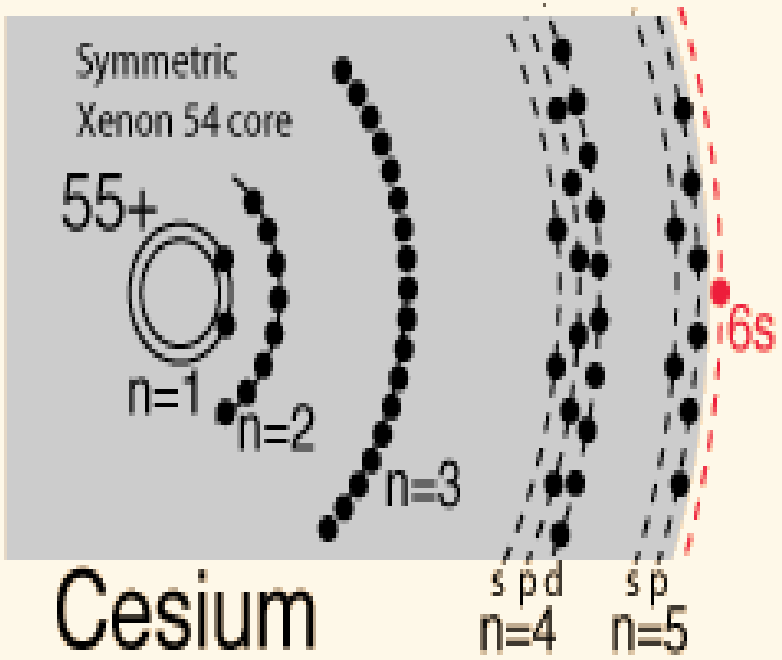
Atomic clocks

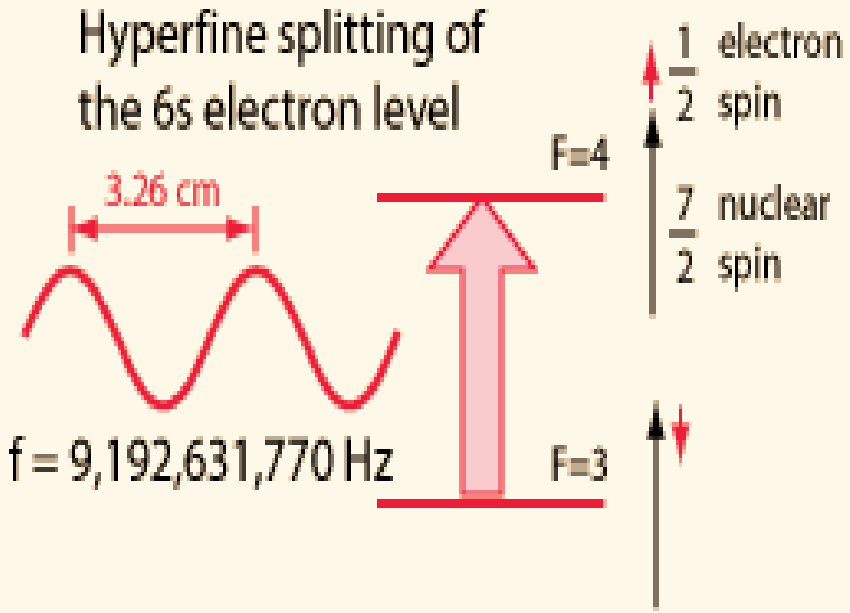
The atomic time by the International System of Units (SI) in 1967 is defined as:

"The second is the duration of 9,192,631,770 periods corresponding to the transition between two hyperfine levels of the ground state of the cesium 133 atom radiation.“

See: http://pcdsh01.on.br/

Transition between two hyperfine levels





Time and Frequency - Traceability

*“A DSHO mantém sob sua guarda os padrões nacionais de tempo e frequência que são a base da Rastreabilidade Metrológica Brasileira de Tempo e Freqüência. Ao nível internacional a rastreabilidade dos padrões nacionais e da HLB (Hora Legal Brasileira) é estabelecida com o *Bureau International des Poids et Mesures* (BIPM), sendo a HLB intercomparada em tempo real por meio do Sistema Interamericano de Metrologia (SIM) acessível via enlace *SIM Time Scale Comparisons via GPS Common-View*, onde o Laboratório Primário de Tempo e Freqüência (LPTF) da DSHO é identificado pela sigla ONRJ”.

Calibração de Tempo e Freqüência

Calibrations of time and frequency follow the same rules used in other areas of metrology. The measure of frequency or time is performed by comparing the magnitude of test against a reference standard.

Obs. O padrão de referência deve superar o desempenho do dispositivo em (TUR = Test Uncertainty Ratio) de 10:1.

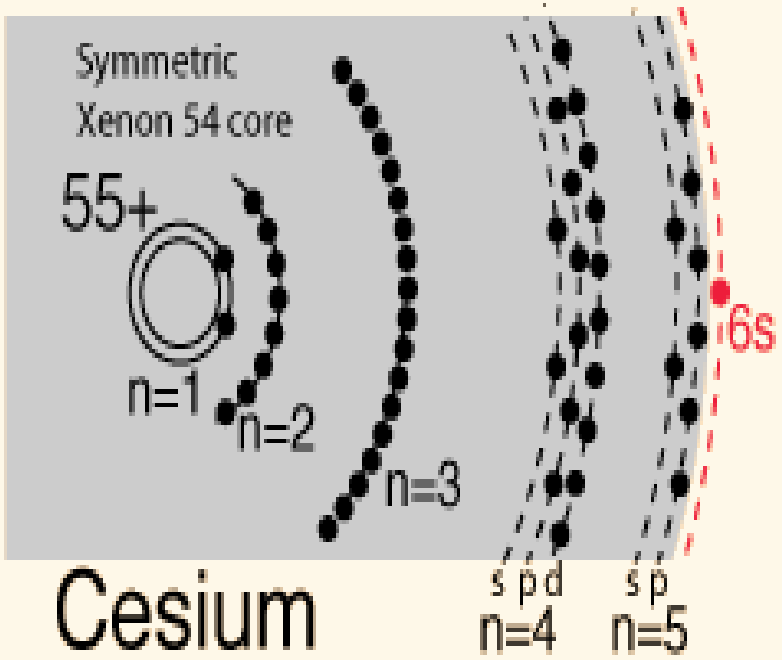
Exatidão (Accuracy)

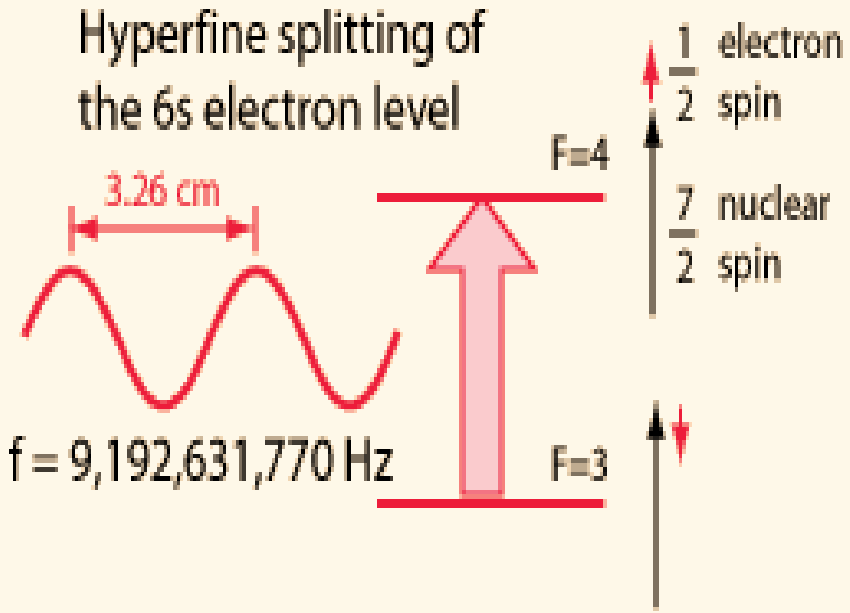
Estabilidade (Stability)

cesium atomic clocks

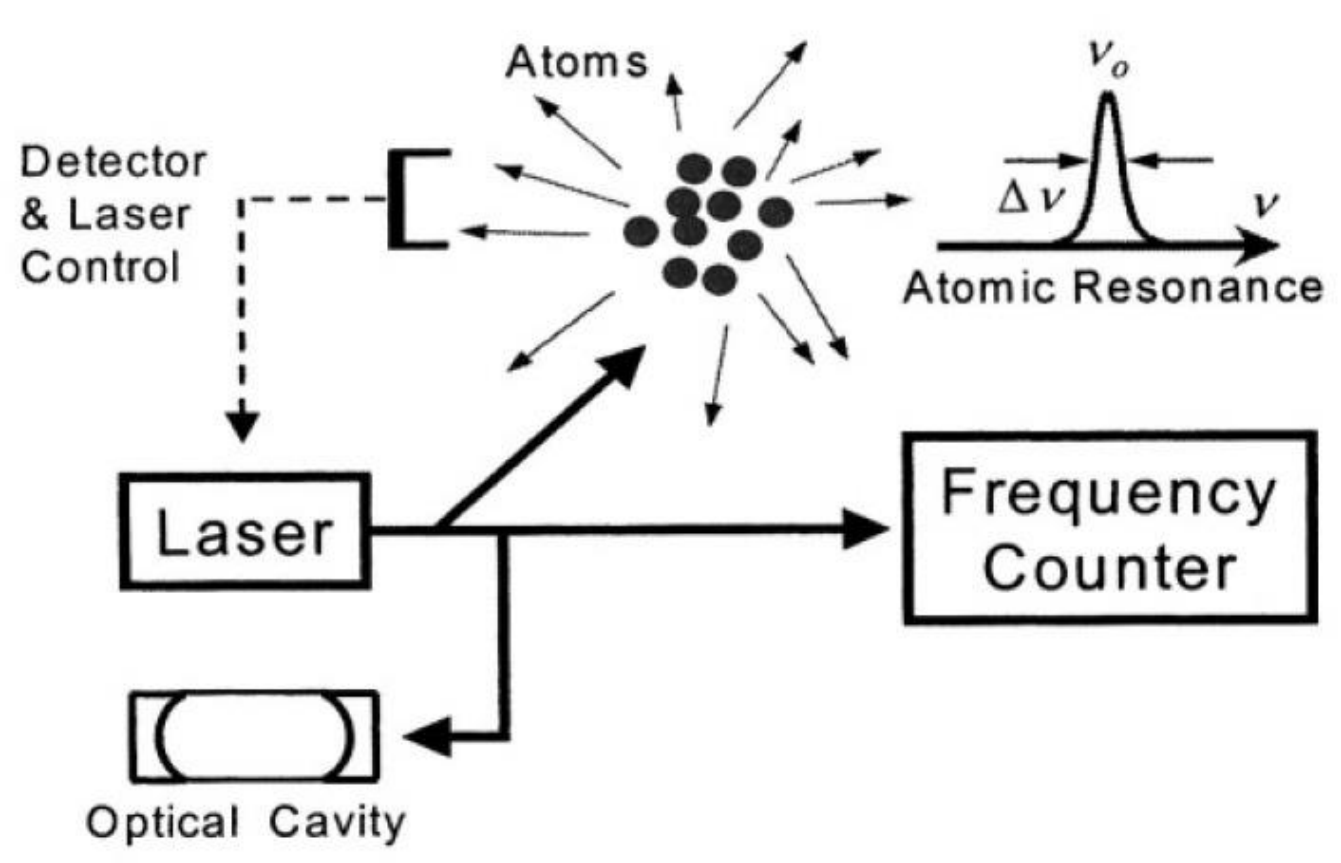
Cesium Atomic Clocks

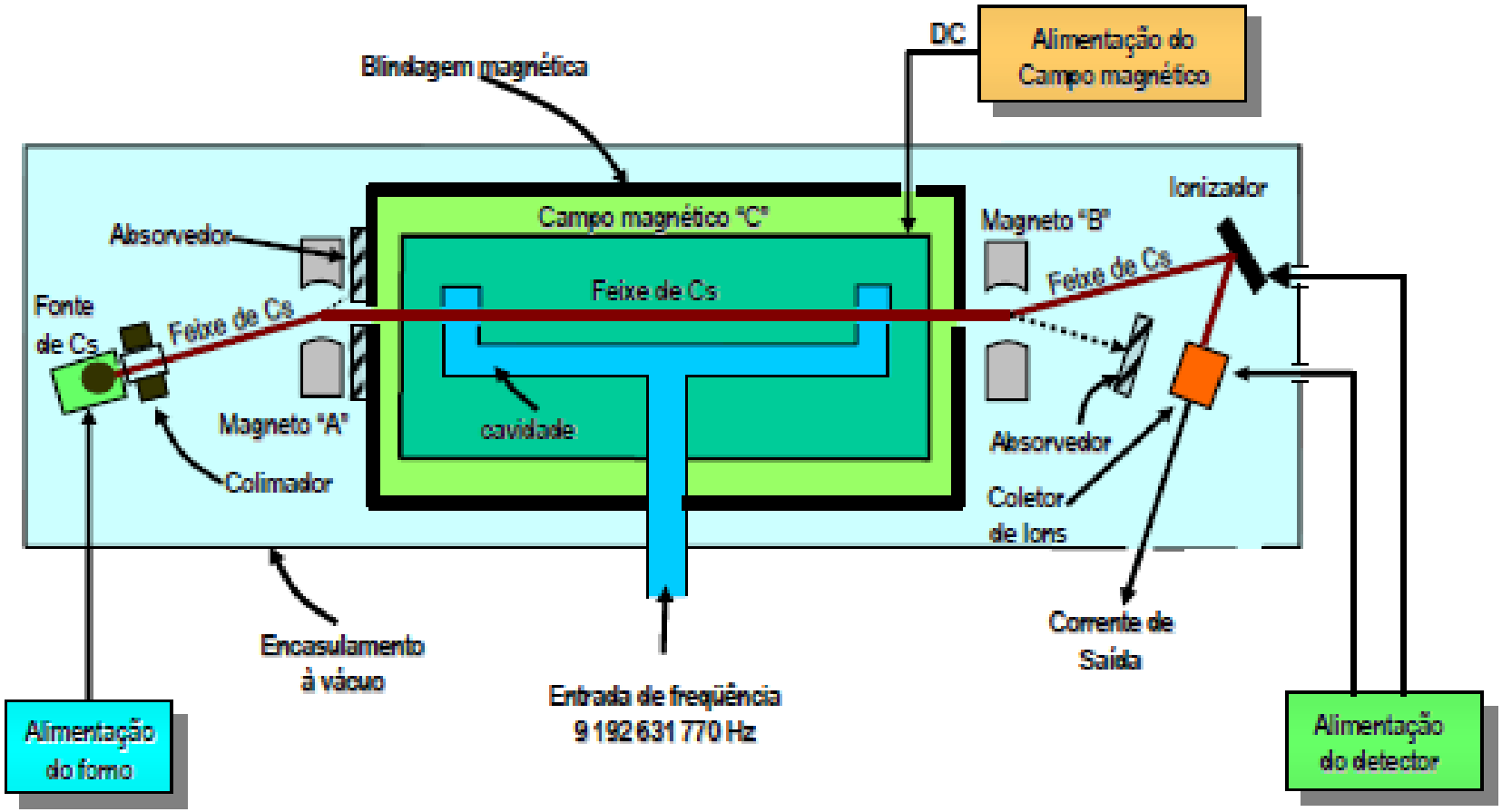
Transition between two hyperfine levels





Classic Optical Clock



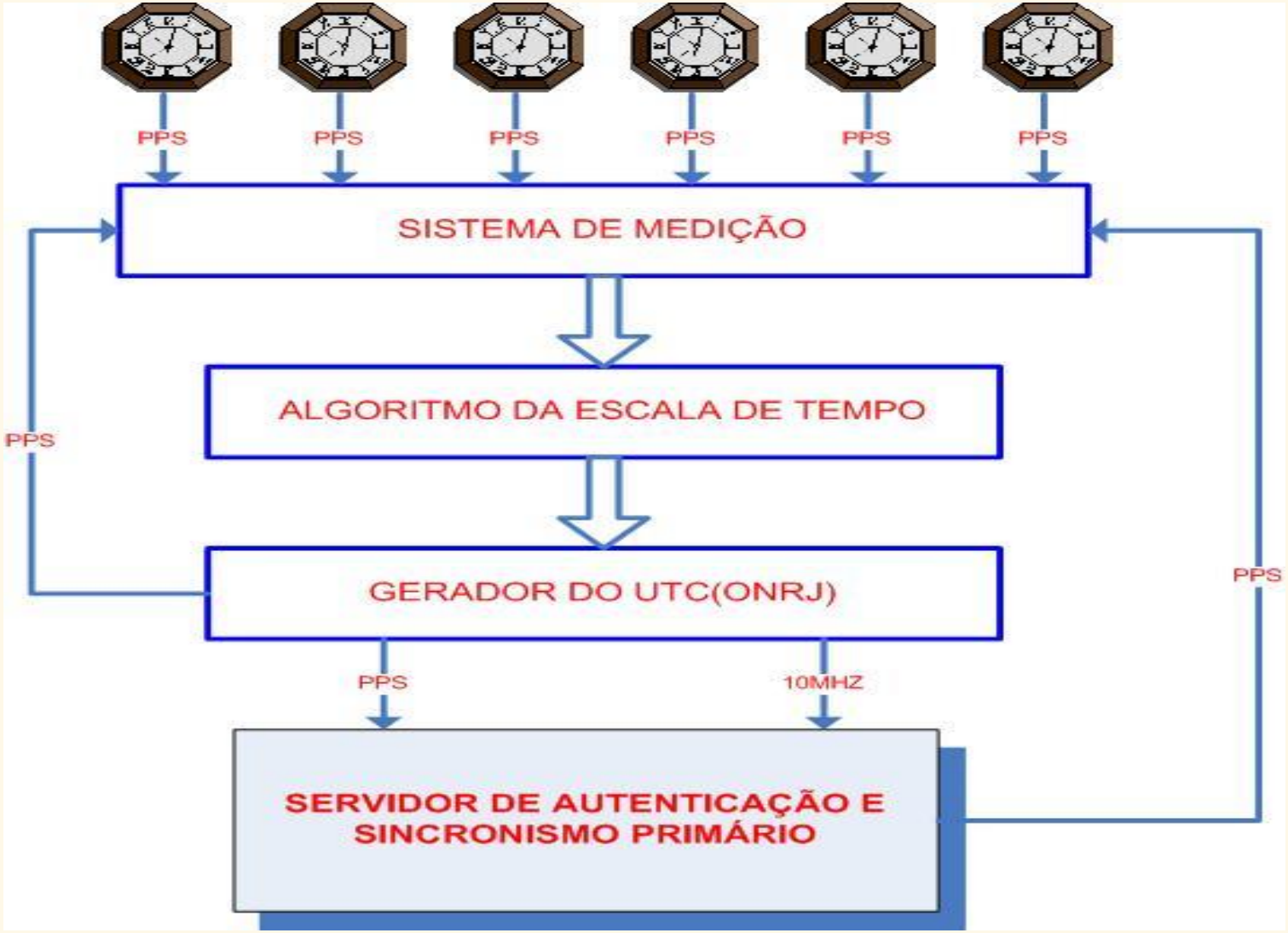

DC
Alimentação do Campo magnético
Blindagem magnética
Campo magnético "C"
Ionizador
Absorvedor
Magneto "B"
Feixe de Cs
Fonte de Cs
Feixe de Cs
Feixe de Cs
Magneto "A"
cavidade
Absorvedor
Colimador
Coletor de Ions
Encasulamento à vácuo
Corrente de Saída
Entrada de freqüência 9 192 631 770 Hz
Alimentação do forno
Alimentação do detector

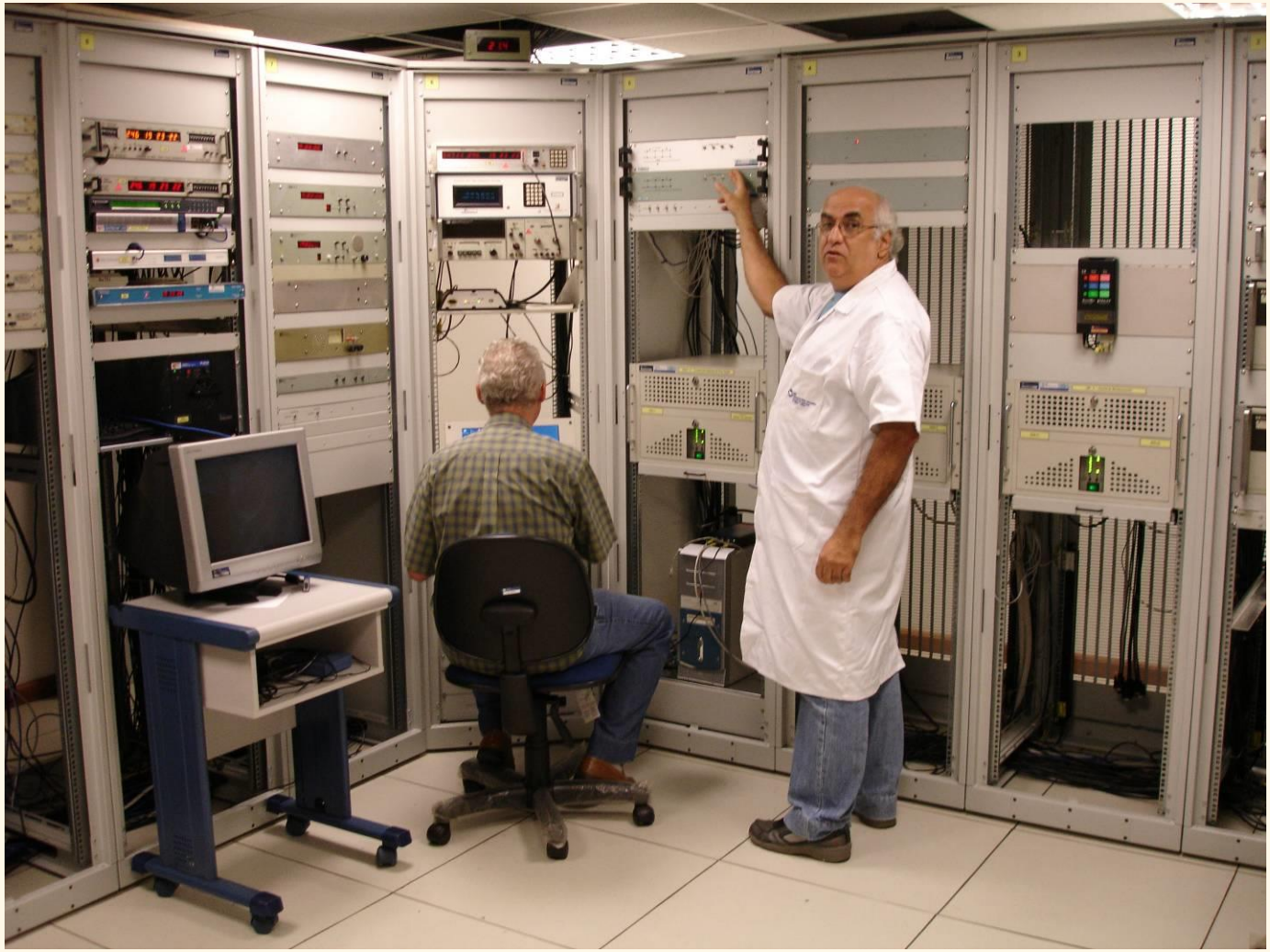
TIME BRAZILIAN LEGAL

Brazilian Standard Time, UTC (ONRJ) is generated by a set of atomic clocks maintained in continuous operation.

Through a measurement system and an algorithm is calculated Scale Atomic Time and Time generated Brazilian Legal UTC (ONRJ).

Brazilian official time





Generation and Dissemination Room

The Network

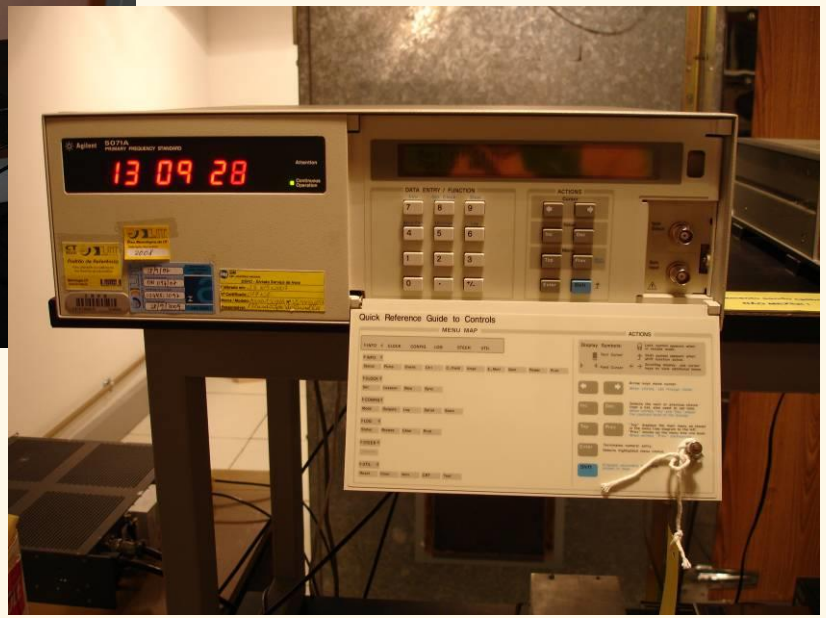
Development and Maintenance

I

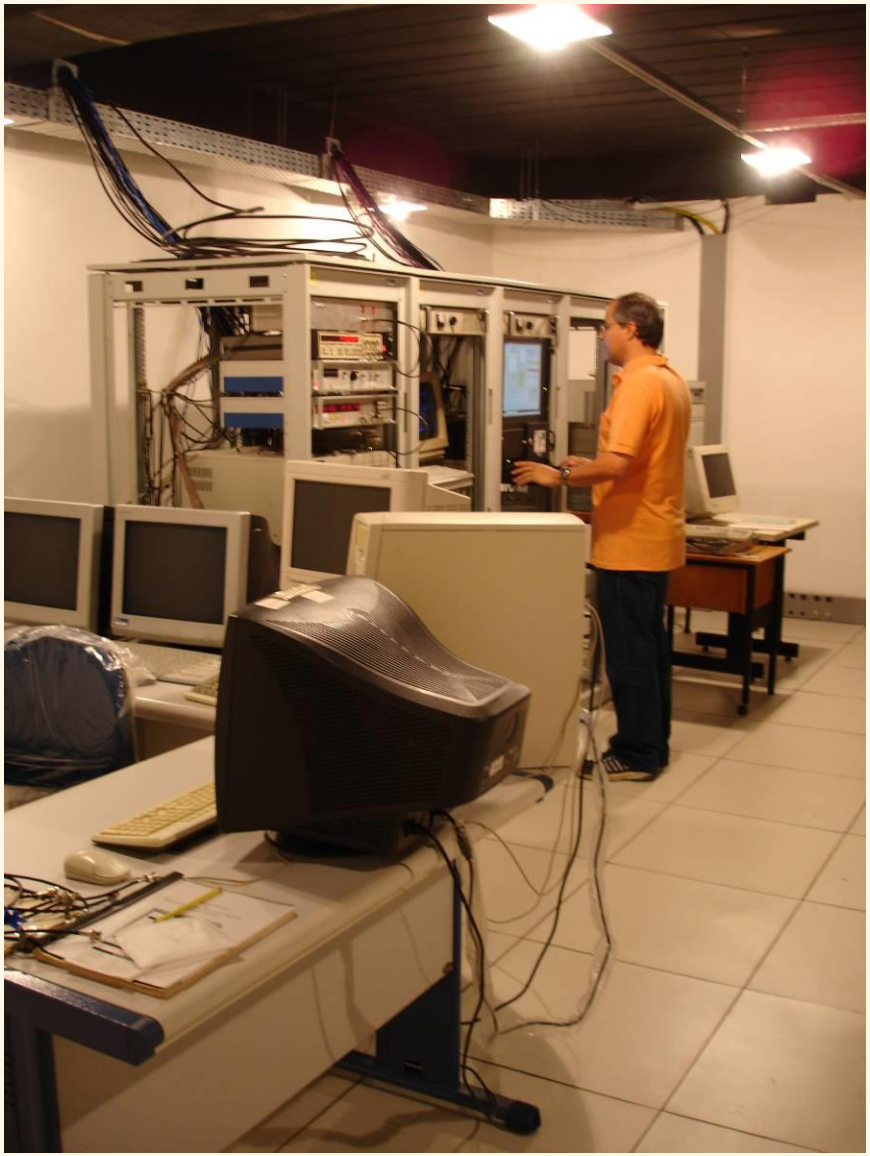
II

Standards

Room Calibration



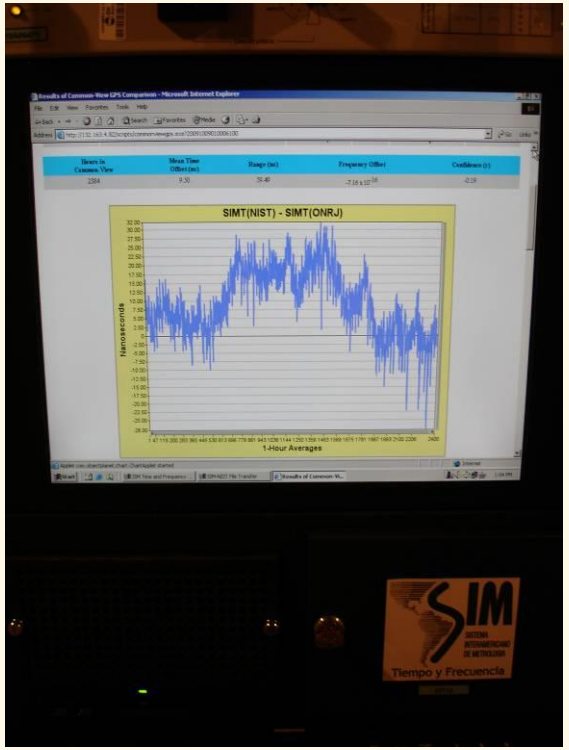
Standard calibration



Hall of Scale Atomic Time and traceability

Equipment for Generation UTC (ONRJ)

GPS Receiver for traceability to BIPM



Traceability Network Time and Frequency
SIM: Inter-American Metrology System

TRACKING THE BRAZILIAN LEGAL TIME
In real time

See

http://gps.nist.gov/scripts/sim_rx_grid.exe

SIM Time Network

(real-time measurement results for the 10-minute period ending on 11-08-2009 at 1050 UTC)

	United States SIMTY(NIST)	Mexico SIMTY(CENAM)	Canada SIMTY(NRC)	Panama SIMTY(CENAMEP)	Brazil SIMTY(ONRJ)	Costa Rica SIMTY(ICE)	Colombia SIMTY(INC)	Argentina SIMTY(INTI)	Guatemala SIMTY(LNM)	Jamaica SIMTY(BSJ)	Uruguay SIMTY(UTE)	Paraguay SIMTY(INTN)	Peru SIMTY(INDI)	Trinidad SIMTY(TTBS)
United States SIMTY(NIST)	-----	-7.6	91.3	-29.2	23.5	95.1	7.1	-11.7	-----	-34.2	11.3	85.0	197.2	-325.7
Mexico SIMTY(CENAM)	7.6	-----	98.0	-23.5	30.1	102.7	13.6	-2.8	-----	-26.3	20.7	92.5	206.3	-318.2
Canada SIMTY(NRC)	-91.3	-98.0	-----	-121.7	-67.4	1.1	-85.0	-100.3	-----	-124.2	-77.2	-4.5	108.5	-416.9
Panama SIMTY(CENAMEP)	29.2	23.5	121.7	-----	55.3	123.3	36.1	22.3	-----	-5.3	45.2	119.2	230.5	-294.7
Brazil SIMTY(ONRJ)	-23.5	-30.1	67.4	-55.3	-----	69.1	-18.6	-32.7	-----	-59.2	-9.4	64.3	182.9	-349.0
Costa Rica SIMTY(ICE)	-95.1	-102.7	-1.1	-123.3	-69.1	-----	-87.5	-107.6	-----	-128.6	-84.6	-10.0	102.8	-417.7
Colombia SIMTY(INC)	-7.1	-13.6	85.0	-36.1	18.6	87.5	-----	-15.0	-----	-41.0	3.1	80.6	194.5	-329.2
Argentina SIMTY(INTI)	11.7	2.8	100.3	-22.3	32.7	107.6	15.0	-----	-----	-21.4	24.4	97.6	212.4	-318.9
Guatemala SIMTY(LNM)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Jamaica SIMTY(BSJ)	34.2	26.3	124.2	5.3	59.2	128.6	41.0	21.4	-----	-----	44.4	117.9	231.3	-290.1
Uruguay SIMTY(UTE)	-11.3	-20.7	77.2	-45.2	9.4	84.6	-3.1	-24.4	-----	-44.4	-----	73.1	188.2	-341.2
Paraguay SIMTY(INTN)	-85.0	-92.5	4.5	-119.2	-64.3	10.0	-80.6	-97.6	-----	-117.9	-73.1	-----	115.7	-412.2
Peru SIMTY(INDI)	-197.2	-206.3	-108.5	-230.5	-182.9	-102.8	-194.5	-212.4	-----	-231.3	-188.2	-115.7	-----	-525.0
Trinidad SIMTY(TTBS)	325.7	318.2	416.9	294.7	349.0	417.7	329.2	318.9	-----	290.1	341.2	412.2	525.0	-----
Last Update (HHMM)	1050	1050	1050	1050	1050	1050	1050	1050	-----	1050	1050	1050	1050	1050

This table was created at 11-08-2009 (MJD 55143) 10:56:20 UTC and will refresh every five minutes. Values are in units of nanoseconds.

Click on a time scale or country name to view a **one-way** GPS graph for the current day (GPS-NIMI). Click on a number to view a **common-view** graph between two laboratories for the current day.

DISSEMINAÇÃO DA HORA LEGAL BRASILEIRA

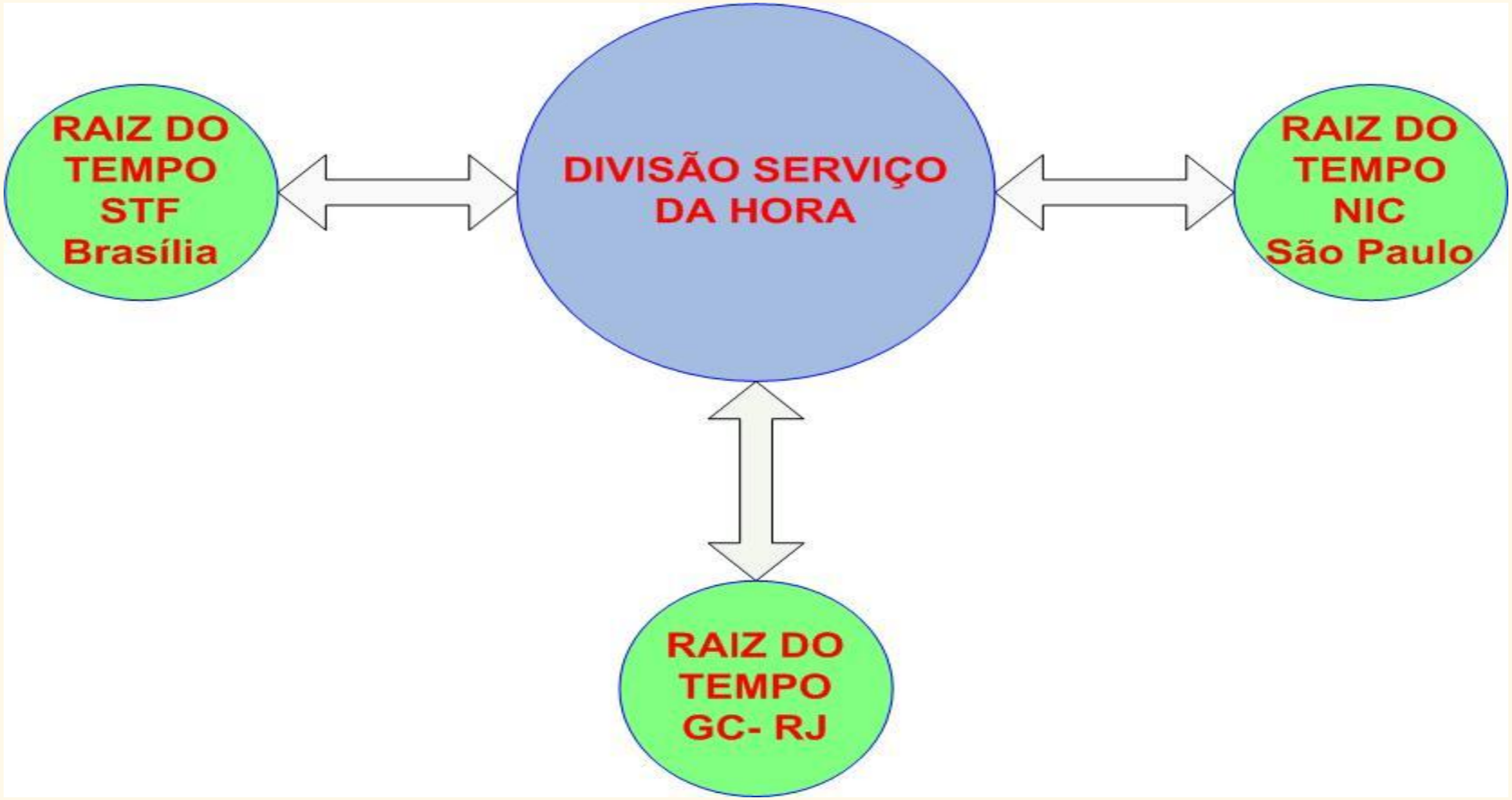
Phone

The program DSHO_SincPCnetV11.exe http://www.horalegalbrasil.mct.on.br NTP servers are available at the addresses 200.201.86.75 and 200.201.86.94 (UDP port 123).

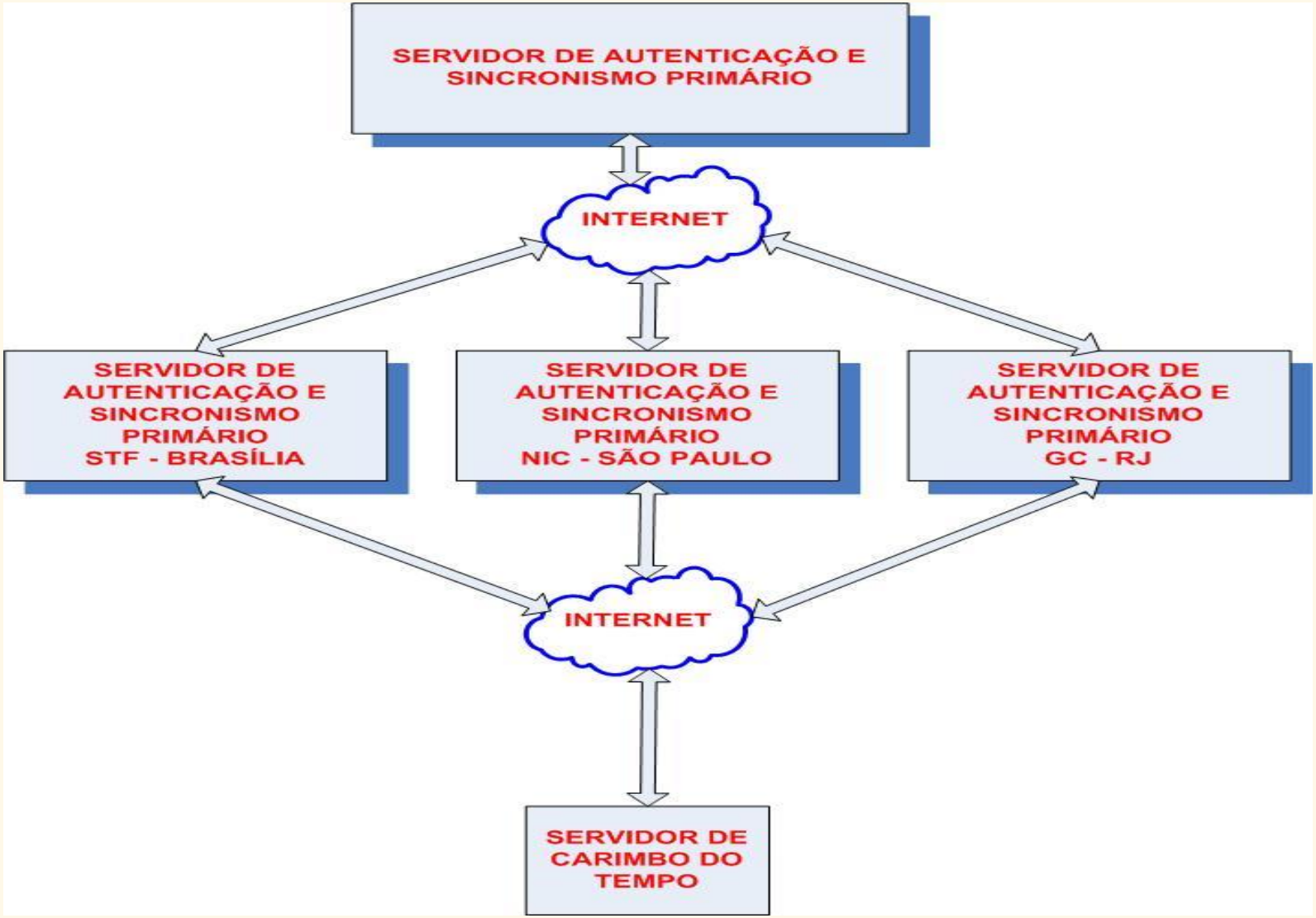
Radio transmission frequency of 10MHz, and the modulation A3H transmission power 1KW.

Room Transmitter

REDE DE CARIMBO DE TEMPO À HORA LEGAL BRASILEIRA

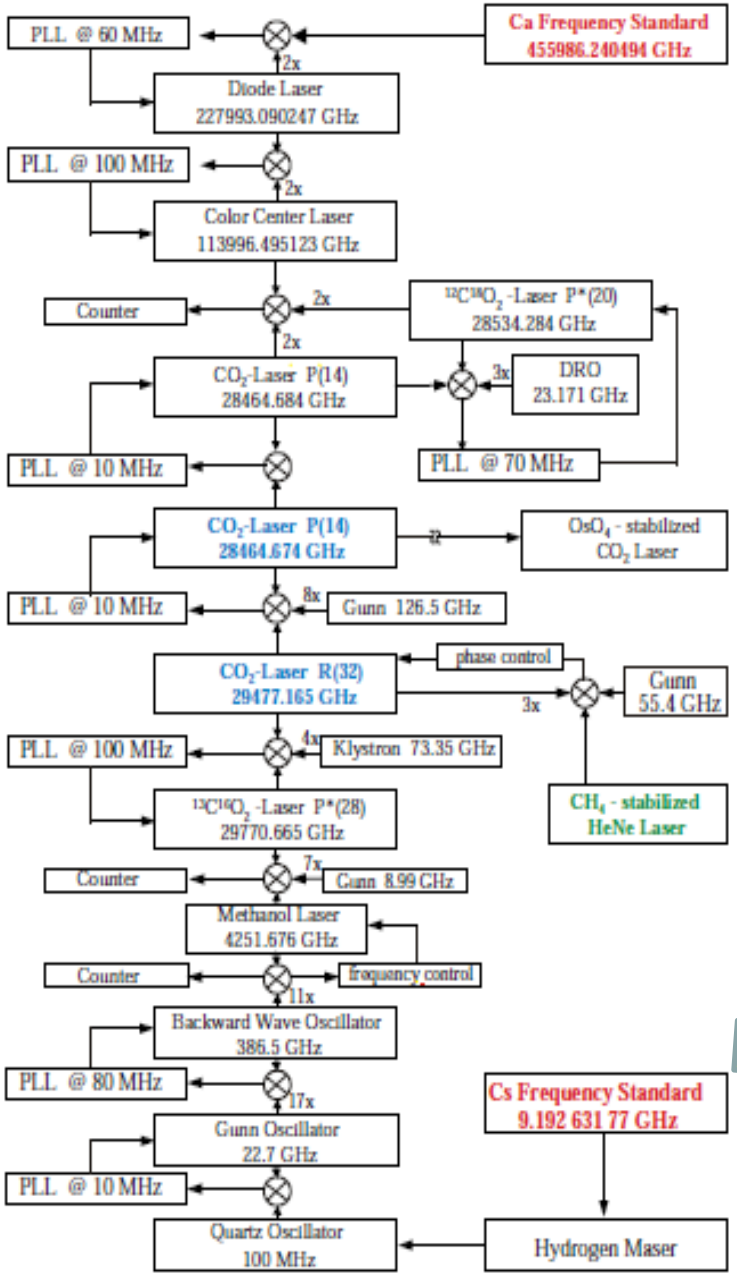


REDE DE CARIMBO DE TEMPO



Optical frequencies measures locked modes

Diagram traditional chain of frequency over the standard 9.2 GHz Cesium



Calcio
455986.240494 GHZ

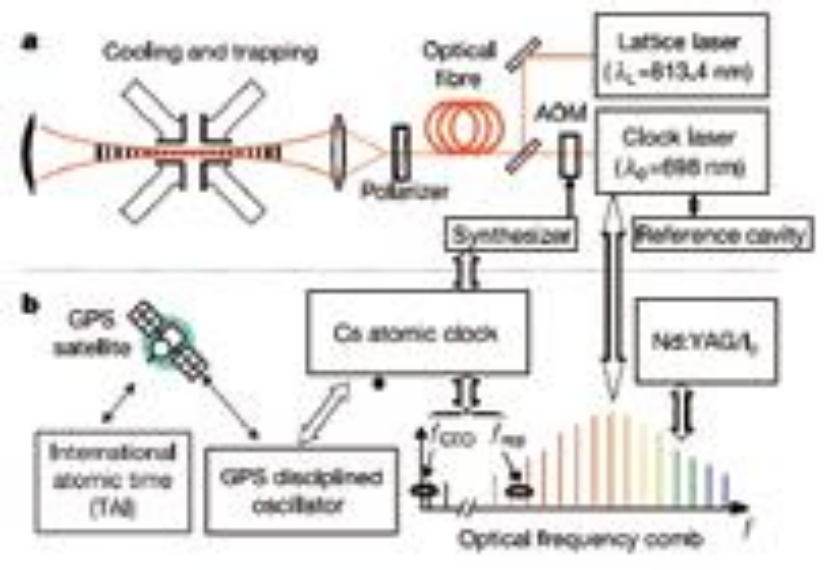
Cesium
9.19263177 GHz

Frequency Comb

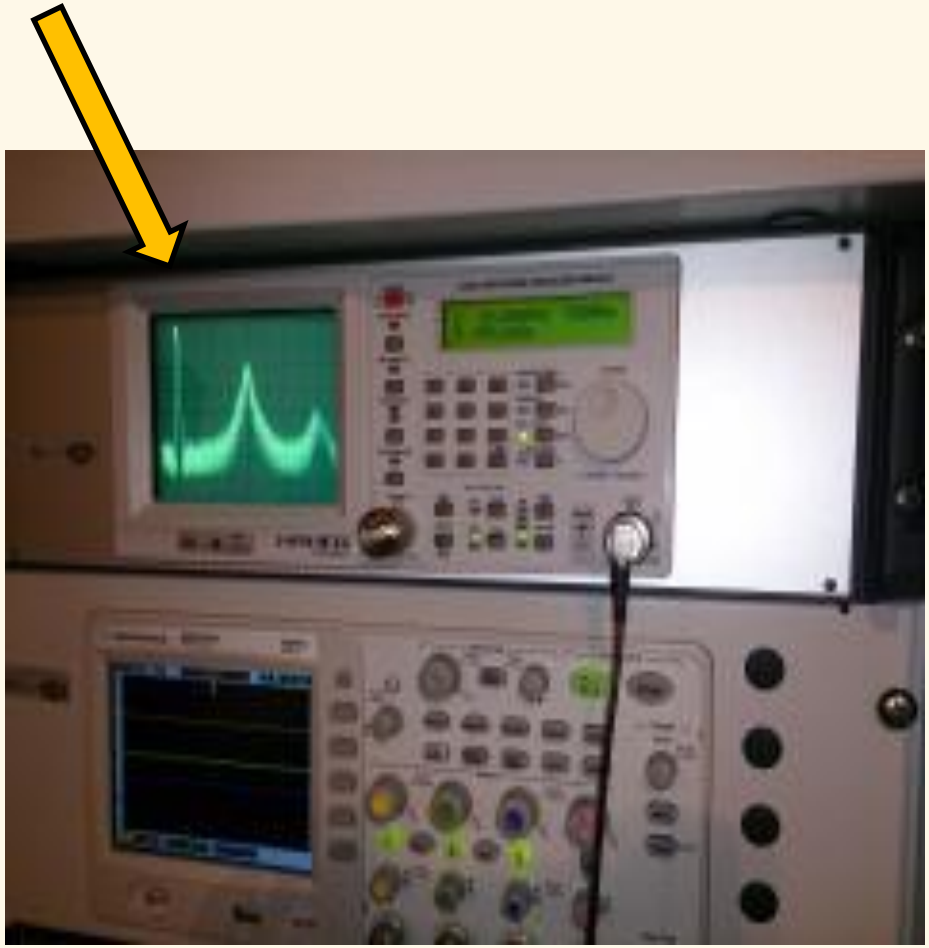
Fc1500-250-wG

Erbium-based Optical Frequency Synthesizer

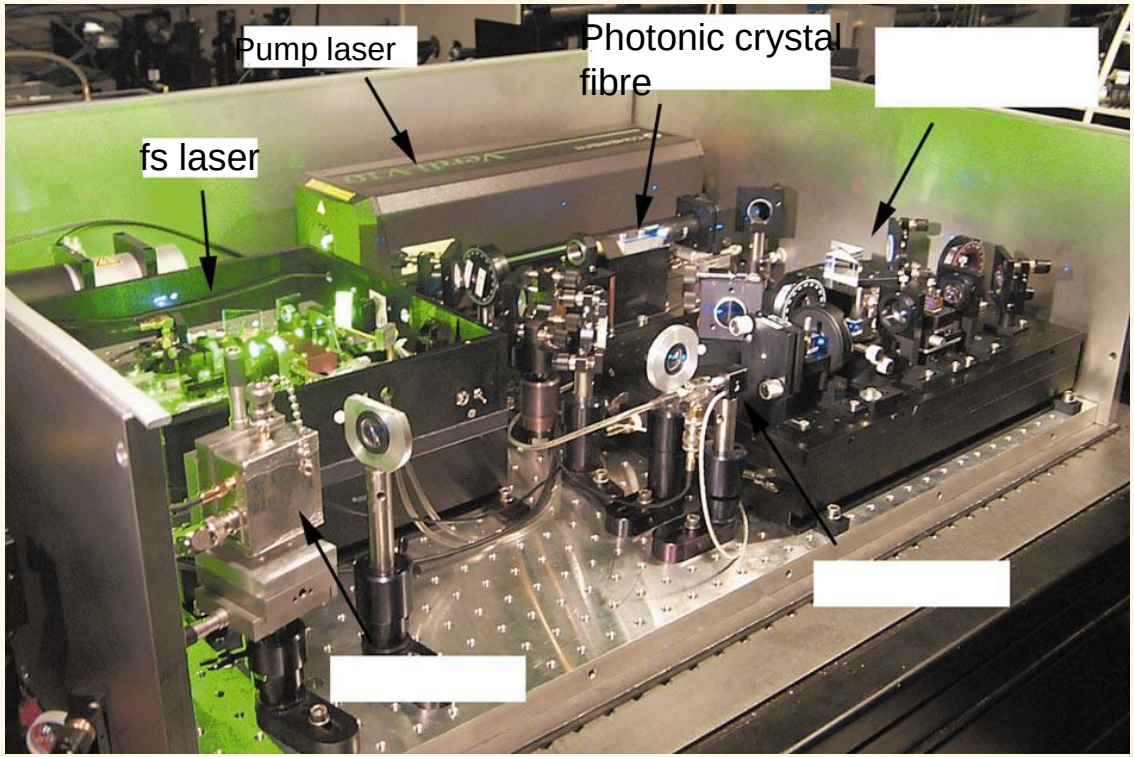
Fc1000-250



Reference



The device consists of one femtosecond

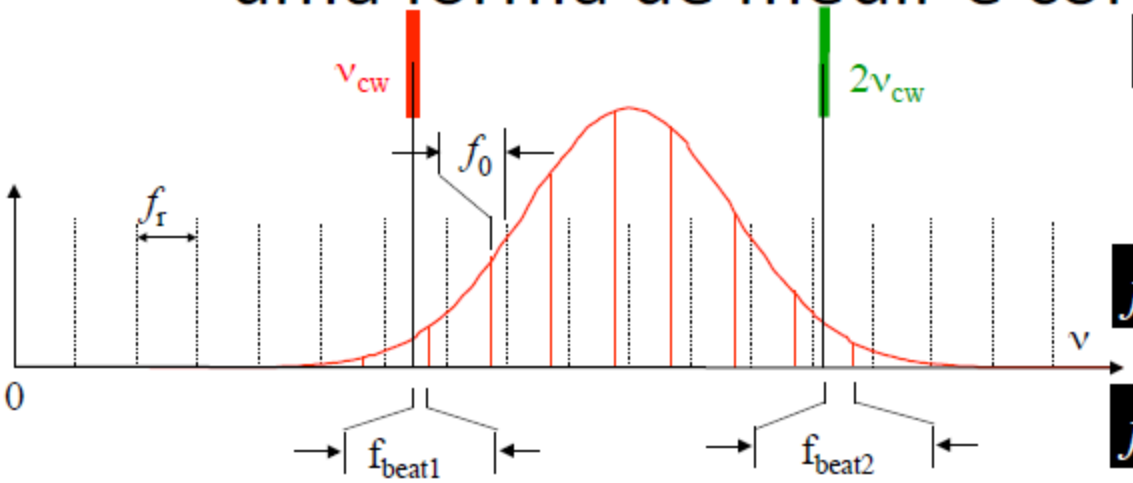


An optical synthesizer in a box.

Laser powered by a green pump laser (Verdi model, Coherent), a photonic crystal fibre and a nonlinear interferometer . It occupies only 1 m2 on an optical bench with the potential for further miniaturization. The synthesizer is capable of linking a 10-MHz radio-frequency reference phase coherently in one step with the optical region, and provides a reference-frequency grid across much of the visible and infrared spectrum with comb lines that are separated by 625 MHz. This makes it an ideal laboratory tool for precision spectroscopy. (www.menlosystems.com), authors (R.H. and T.W.H.

Optical metrology: using combs

Largura de banda óptica de uma oitava: uma forma de medir e controlar f_0



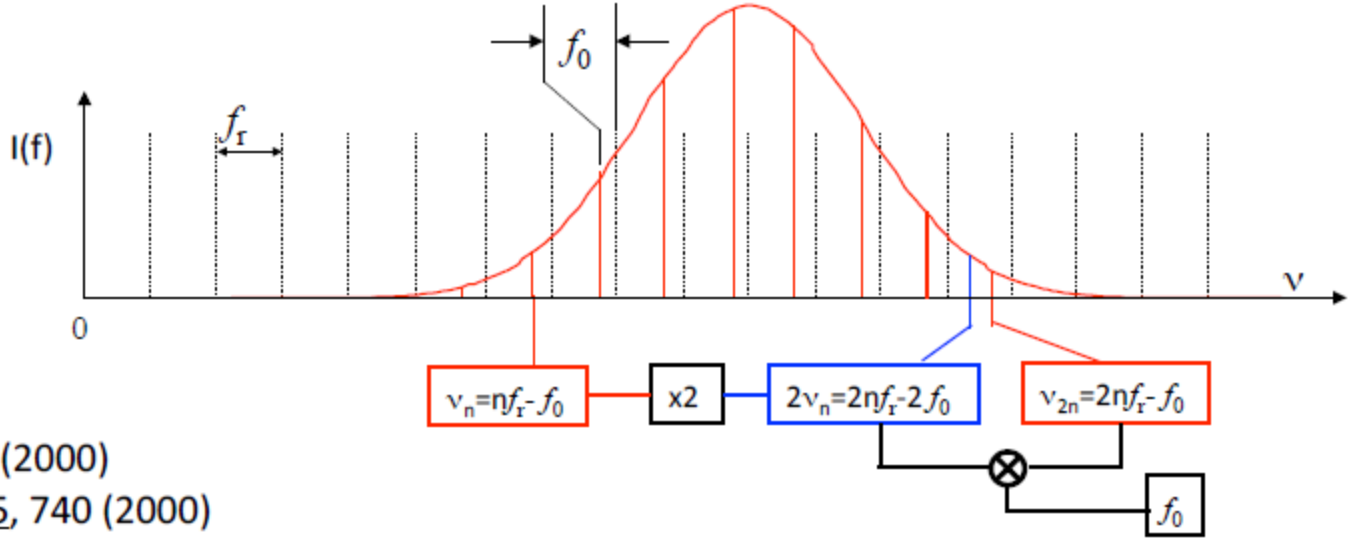
$$f_{beat1} = nf_r + f_0 - \nu_{cw}$$

$$f_{beat2} = 2nf_r + f_0 - 2\nu_{cw}$$

$$f_0 = 2f_{beat1} - f_{beat2}$$

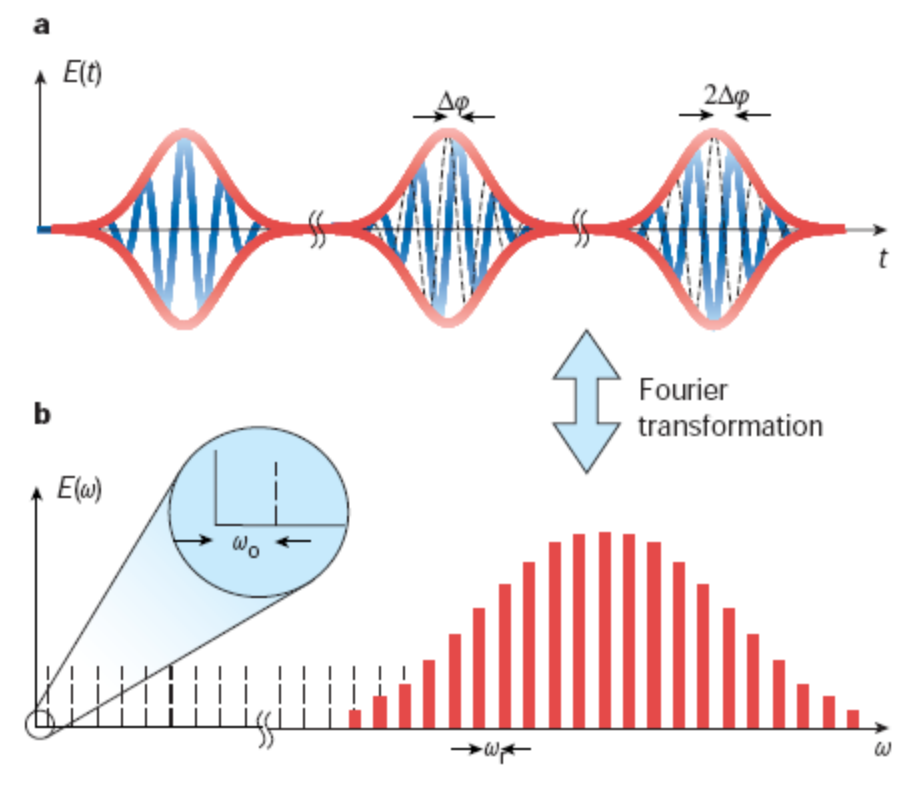
$$f_r = (\nu_{cw} - f_{beat1} - f_0)/n$$

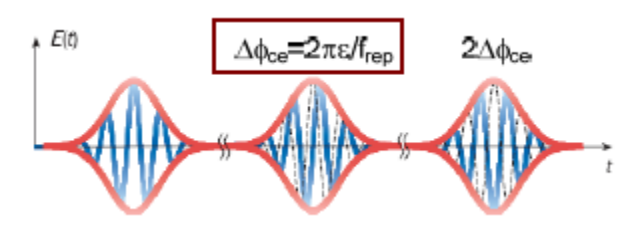
Phys. Rev. Lett. 87, 270801 (2001)

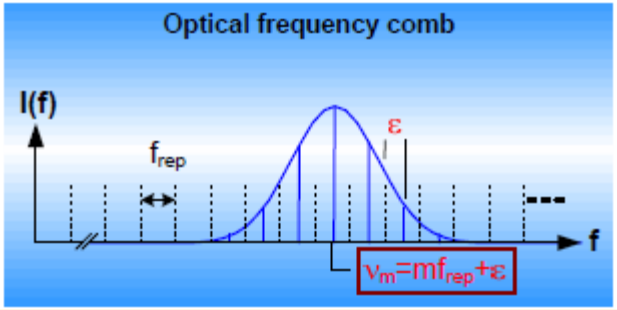


Science 288, 635 (2000)
Phys. Rev. Lett. 85, 740 (2000)

Frequency-domain vs. time-domain
Comb frequency offset directly linked to carrier-envelop phase!

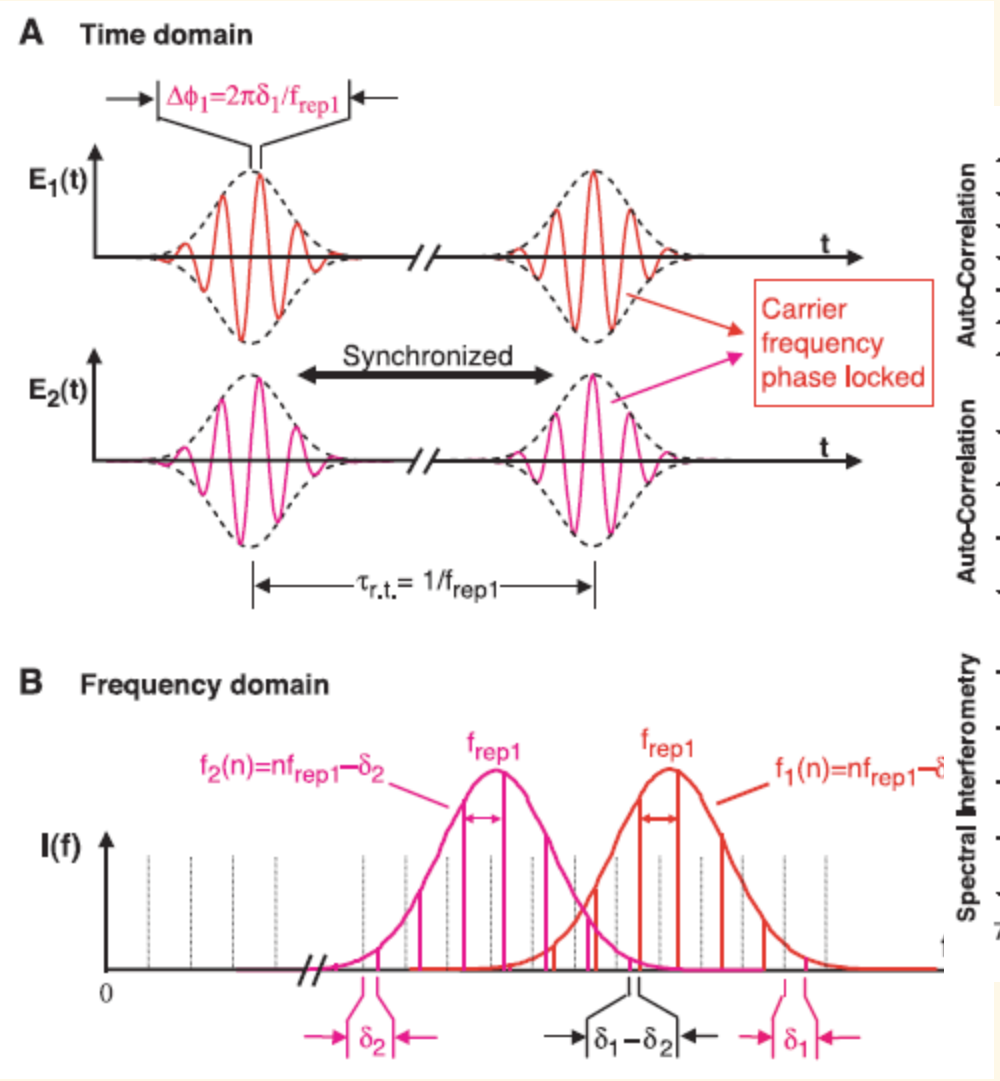


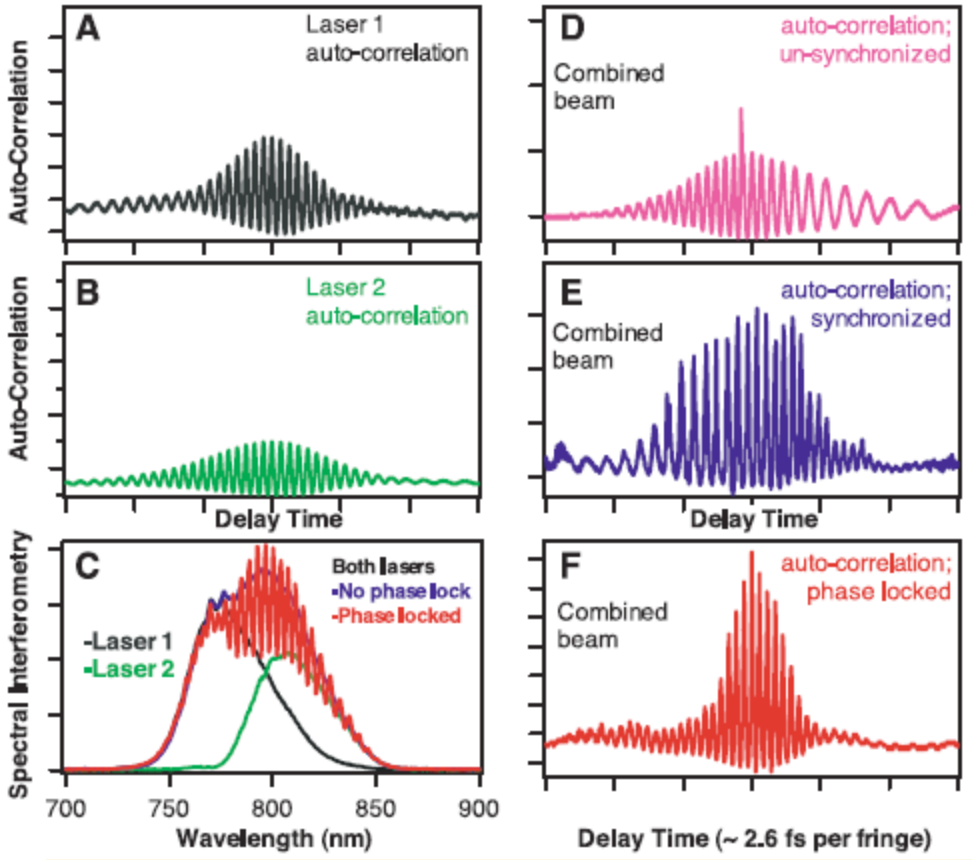




T. Udem, Holzwarth, Hänsch, Nature **416, 233 (2002)**

Synchronization between two combs (in progress)





Shelton et.al,, Science **293, 1286 (2001)**

FIM

OBRIGADO PELA SUA ATENÇÃO

http://www.horalegalbrasil.mct.on.br/