



Atomic clocks and realization of the Swiss national time scale UTC(CH)

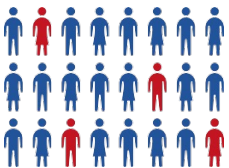
Antoine Jallageas

01 / 09 / 2026 - MJD 61284

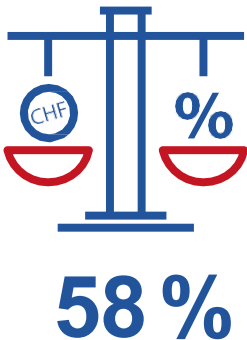
METAS is the Federal Government's competence center for all questions relating to measurement, measuring equipment and measuring methods.

METAS

in figures (31.12.2025)



258
employees



ratio of self-financing



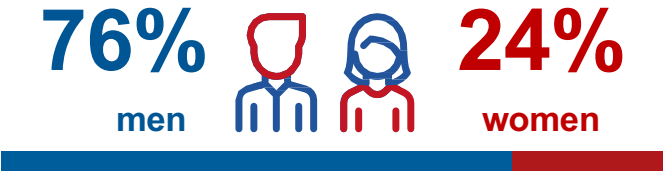
9
apprentices



4
interns



6
doctoral students



METAS: omnipresent



941.27 Loi du 17 juin 2011 sur l'Institut fédéral de métrologie (LIFM)

[Index](#) [Inverser les langues](#) [← Précédent](#) [→ Suivant](#)

◀ Art. 2 Objectifs
▶ Art. 4 Collaboration et recours à des tiers

Art. 3 Tâches

¹ L'Institut est l'institut national de métrologie de la Suisse.

² Il a les tâches suivantes:

- a. mettre à disposition avec la précision requise des unités de mesure reconnues au niveau international;
- b. comparer, à des intervalles appropriés, les étalons à ceux des autres instituts nationaux de métrologie ou des institutions comparables;
- c. diffuser l'heure légale suisse;
- d. entreprendre les travaux techniques et scientifiques et les travaux de développement nécessaires, analyser, notamment, les conséquences des techniques nouvelles et élaborer des méthodes de mesure ayant une application pratique et répondant à l'état le plus récent des connaissances scientifiques;
- e. exercer les tâches qui lui sont conférées par la loi fédérale du 17 juin 2011 sur la métrologie³;
- f. participer à la coopération technique dans le domaine de la métrologie;
- g. conseiller les autorités fédérales dans le domaine de la métrologie;
- h. assurer la traçabilité des étalons des organes d'exécution cantonaux;
- i. diffuser les unités de mesure visées à la let. a par des étalonnages et à l'aide de matériaux de référence.

³ L'Institut participe à l'élaboration des textes législatifs dans les domaines énoncés à l'al. 2.

⁴ Le Conseil fédéral peut autoriser l'Institut à représenter la Confédération dans des organisations et des associations internationales pour les questions concernant la métrologie.

⁵ Il peut attribuer d'autres tâches à l'Institut, contre indemnité, dans le cadre des objectifs visés à l'art. 2.

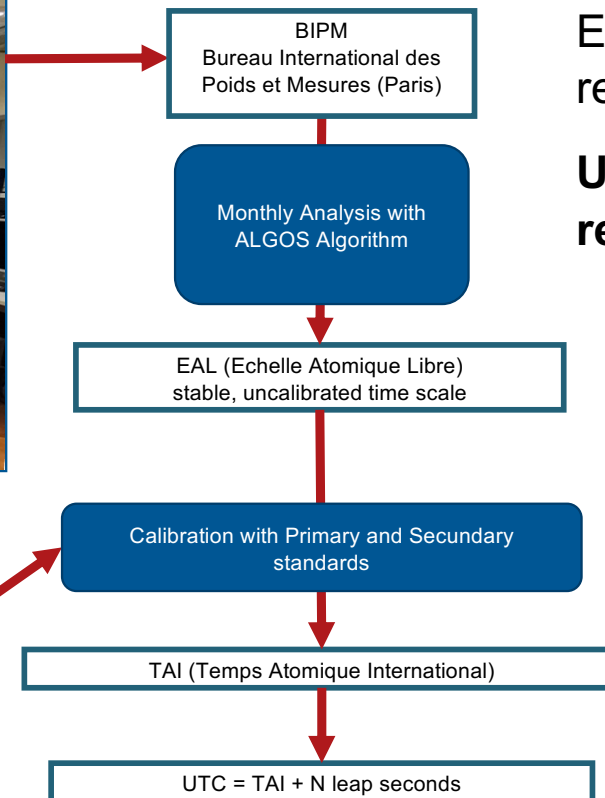
³ RS 941.20; FF 2011 4513



➤ The official time in Switzerland is UTC(CH)

➤ METAS is in charge of the realization and the diffusion of UTC(CH)

UTC Coordinate Universal Time



Each country has its own realization of UTC: **UTC(k)**

UTC(CH) is the Swiss realization of UTC

Not every country has a physical realization of the SI-second but...

METAS has a PFS: FoCS-2

How UTC(CH) is generated?

- What is the minimum number of clocks?

MC = Master Clock

It is the combination of

- 1. A free running clock (CLK)**
- 2. A frequency synthesizer (FS)**

How UTC(CH) is generated?

CLK 1

CLK 2

CLK 3

CLK 4

CLK 5

31.08.26

8

How UTC(CH) is generated?

AHM

PHM

PHM

Cs

Cs

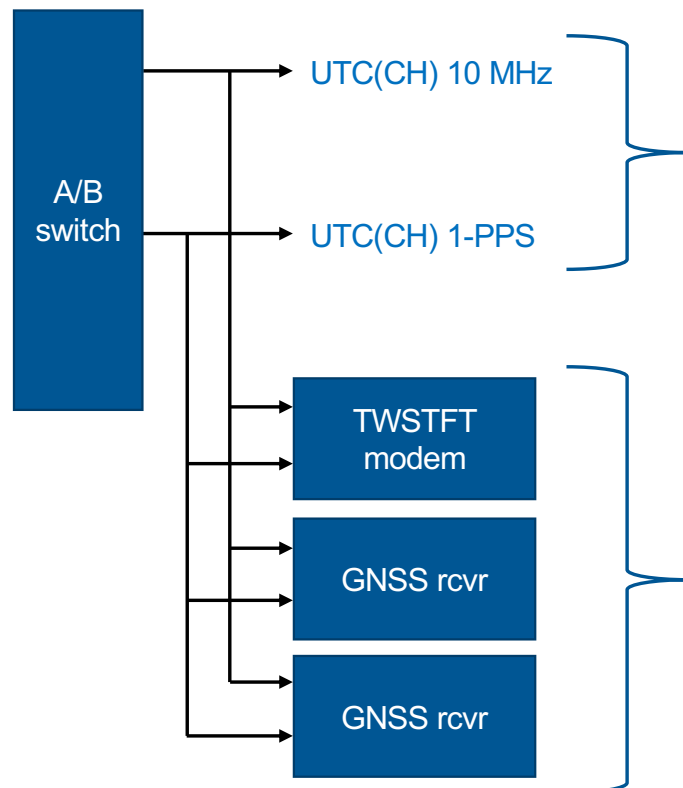


 OSCILLOQUARTZ
A division of Adtran


ROLEX

- As well as redundancy, we wanted to **benefit from the advantages** of each type of clock.
 - An active maser for the short term stability
 - A caesium for the long term stability
- This 'mixing' is achieved by means of time-scale algorithms.

How UTC(CH) is generated?



The signals are used for many different applications:

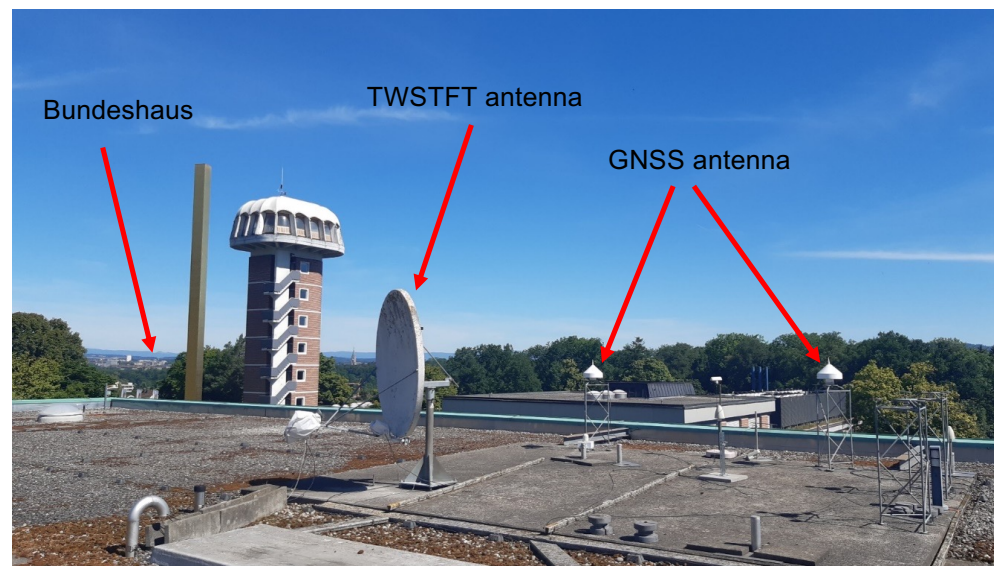
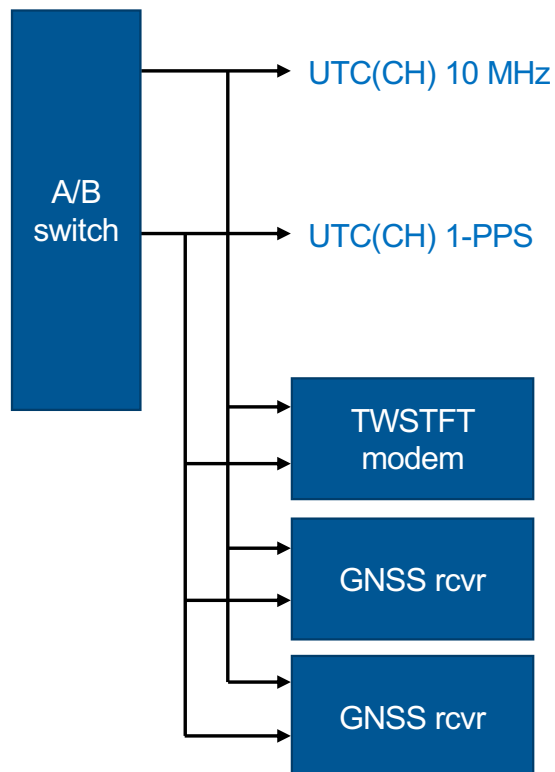
- Frequency dissemination using optical fibre networks
- Time dissemination using fibre-optic networks (White Rabbit)
- Reference for different T&F measurement locations
- FoCS-2
- Reference for frequency comb
- Etc...

UTC(CH) is linked to UTC and TAI via satellite comparisons.

- The main link is the Two-Way Satellite Time and Frequency Transfer (TWSTFT) link.
- We also use 2 GNSS receivers for other international comparisons.

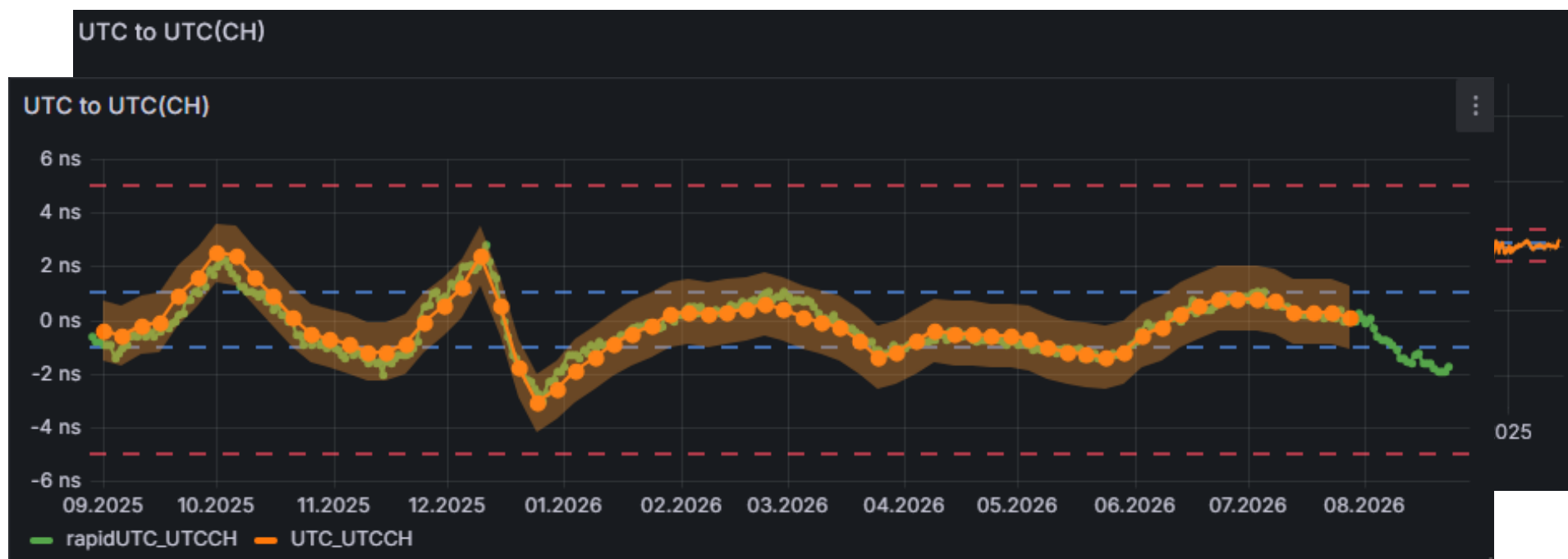
These 3 links are regularly calibrated during calibration campaigns carried out by the BIPM and EURAMET.

How UTC(CH) is generated?



UTC(CH) over the last 20 years

- Today, UTC(CH) is typically within 1 nanosecond in agreement with UTC



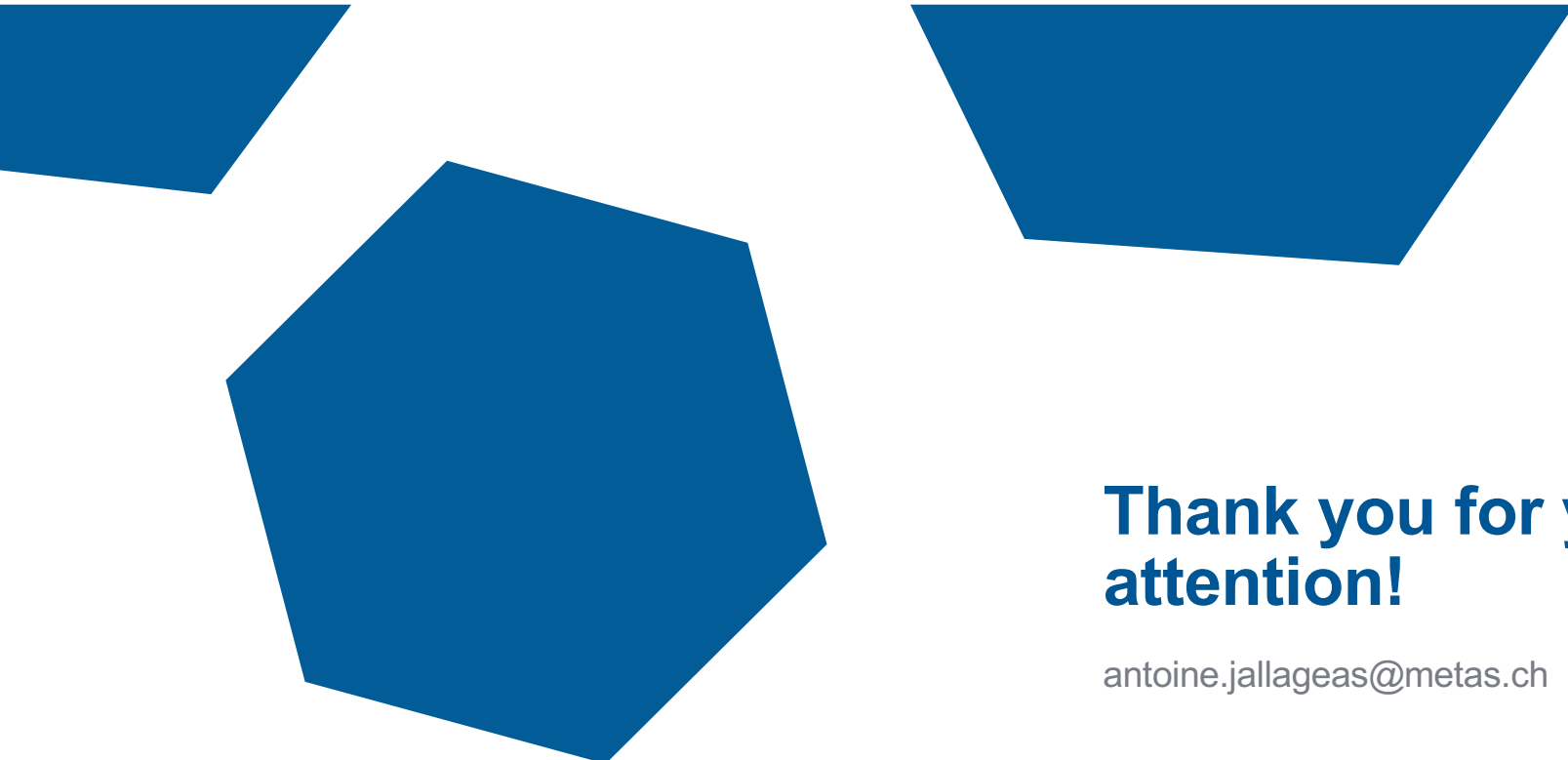
About timescales...

- Today UTC(CH) is already very accurate and stable
- In the future, it will be even better (new generation of atomic clocks, ...)
- But today, we require:
 - Improved **dissemination techniques**
 - New definition of the second
 - Support for large scale projects (quantum networks, particle colliders, astronomy...)
 - Support for industry (distributed systems, telecom, transport...)
 - Variety in techniques to provide **resilience**
 - Resilience to satellite techniques
 - Solution for multi-site time scales

Conclusion/take home messages

- UTC(CH) is the legal time in Switzerland. It is a very accurate and stable time reference.
- Switzerland's industrial base and the diversity of its manufacturers enable an efficient timescale experiment
- It may be disseminated to a wide range of users thanks to various techniques





**Thank you for your
attention!**

antoine.jallageas@metas.ch

What are the needs?

- Contribute to the realization of UTC
 - **Required ns accuracy**
- Reference for Finance
 - **Required μ s accuracy**
- Support for industry
 - **Required various level accuracy**
- Collaboration with research
 - **Required ns accuracy**

Type of trading activity	Description	Maximum divergence from	Granularity of the
	SI-traceable frequency dissemination at 1572.06 nm in a stabilized fiber network with ring topology DOMINIK HUSMANN, ^{1,*} LAURENT-GUY BERNIER, ¹ MATHIEU BERTRAND, ² DAVIDE CALONICO, ³ KONSTANTINOS CHALOULOS, ⁴ GLORIA CLAUSEN, ⁵ CECILIA CLIVATI, ³ JÉRÔME FAIST, ² ERNST HEIRI, ⁴ URS HOLLENSTEIN, ⁵ ANATOLY JOHNSON, ⁶ FABIAN MAUCHLE, ⁴ ZIV MEIR, ⁶ FRÉDÉRIC MERKT, ⁵ ALBERTO MURA, ³ GIACOMO SCALARI, ² SIMON SCHEIDEGGER, ⁵ HANSJÖRG SCHMUTZ, ⁵ MUDIT SINHAL, ⁶ STEFAN WILLITSCH, ⁶ AND JACQUES MOREL ¹ ¹ Federal Institute of Metrology METAS, Lindenweg 50, 3003 Bern-Wabern, Switzerland ² ETH Zurich, Institute for Quantum Electronics, Auguste-Piccard-Hof 1, CH- 8093 Zurich, Switzerland ³ INRIM Istituto Nazionale di Ricerca Metrologica, I- 10135 Torino, Italy ⁴ SWITCH, Werdstrasse 2, 8021 Zurich, Switzerland ⁵ ETH Zurich, Laboratory of Physical Chemistry, CH- 8093 Zurich, Switzerland ⁶ Department of Chemistry, University of Basel, Klingelbergstrasse 80, 4056 Basel, Switzerland *dominik.husmann@metas.ch		

ISSN 1143-1393



Any other trading activity

table.

1 millisecond

better

0.3 1.8 1.8

What are the **new/futures** needs?

- Contribute to the realization of UTC
 - Required ns accuracy
- **New definition of the second**
 - Required sub-ns accuracy
- Reference for Finance
 - Required μ s accuracy
- **Better performance**
- **More resilience**
 - Required new technologies
- Support for industry
 - Required various level accuracy
- **New domains**
 - Required new technologies
- Collaboration with research
 - Required μ s accuracy
 - Required better accuracy and new technologies

- **Geodesy/Topology**
 - 1 m accuracy means 10^{-16}
 - 1 cm means 10^{-18}
- **Astronomy**
 - Very Long Base Interferometry
- **Particle physics**
 - At CERN with White Rabbit
- **Spectroscopy**
 - Need better frequency reference
 - Traceability
- **Quantum physics**
 - Networks for quantum physics
 - Quantum time transfer

Geodetic determination of the gravitational potential difference for an optical lattice clock comparison in the Kanto region in Japan

Yoshiyuki Tanaka¹, Yusuke Aoki², and Ryosuke Nishiyama²
¹University of Tokyo, Earth and Planetary Science, Tokyo, Japan (y.tanaka@eps.s.u-tokyo.ac.jp)
²University of Tokyo, Earthquake Research Institute, Tokyo, Japan

VLBI experiments with the dissemination of a common clock via coherent optical fiber link

R. Ricci¹, M. Negusini, F. Perini, C. Borriotti, M. Roma, G. Maccagnoli, M. Stagni, C. Clivati, A. Mura, F. Levi, D. Calonico, G. Bianco, L. Santamaria Amato, M. Siciliani de Cumis, A. Meis, G. Valente, C. Migoni and N.M. Jacolina

Cerretto, G., Calonico, D., Cantoni, E., Levi, F., Mura, A., Sellone, M., Gnessi, I., "Timing Requirements Analysis for Particle Physics and Astrophysics: A Metrological Point of View," Proceedings of the 52nd Annual Precise Time and Time Interval Systems and Applications Meeting, January 2021, pp. 376-405.
<https://doi.org/10.33012/2021.17794>

SI-traceable frequency dissemination at 1572.06 nm in a stabilized fiber network with ring topology

Dominik Huismann, Laurent-Guy Bernier, Mathieu Bertrand, Davide Calonico, Konstantinos Chaloulos, Gloria Clausen, Cecilia Clivati, Jérôme Faist, Ernst Hein, Uirs Hollenstein, Anatoly Johnson, Fabian Mauchle, Ziv Meir, Frédéric Merkt, Alberto Mura, Giacomo Scalari, Simon Scheidegger, Hans-Jörg Schmutz, Muditi Sinhal, Stefan Willitsch, and Jacques Morel

Fiber-optic two-way quantum time transfer with frequency-entangled pulses

Feyan Hou, Runa Guan, Ruffang Dong, Xiao Xiang, Baihong Li, Tao Liu, Xiaoyan Yang, Hao Li, Lixing You, Zhen Wang, and Shougang Zhang
 Phys. Rev. A **100**, 023849 – Published 29 August 2019

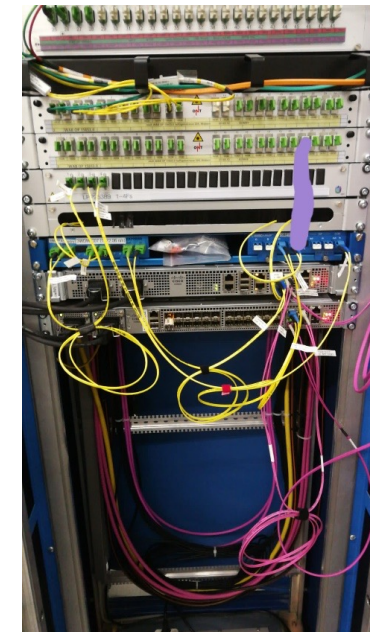
How to disseminate T&F references?



➤ By transportable clocks

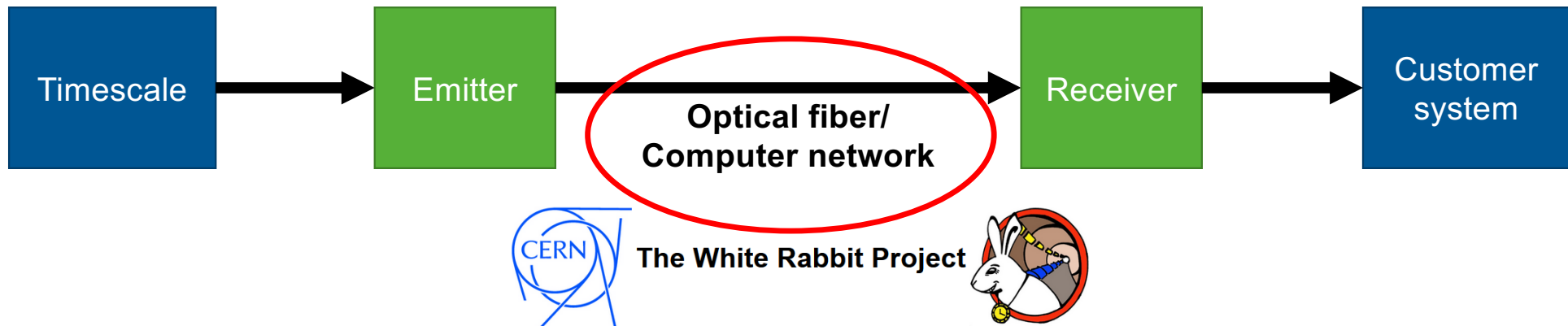


➤ By satellite methods



➤ By optical fiber/network

How to disseminate over a fiber network?



- **Precision Time protocol – WHITE RABBIT (PTP-WR)**

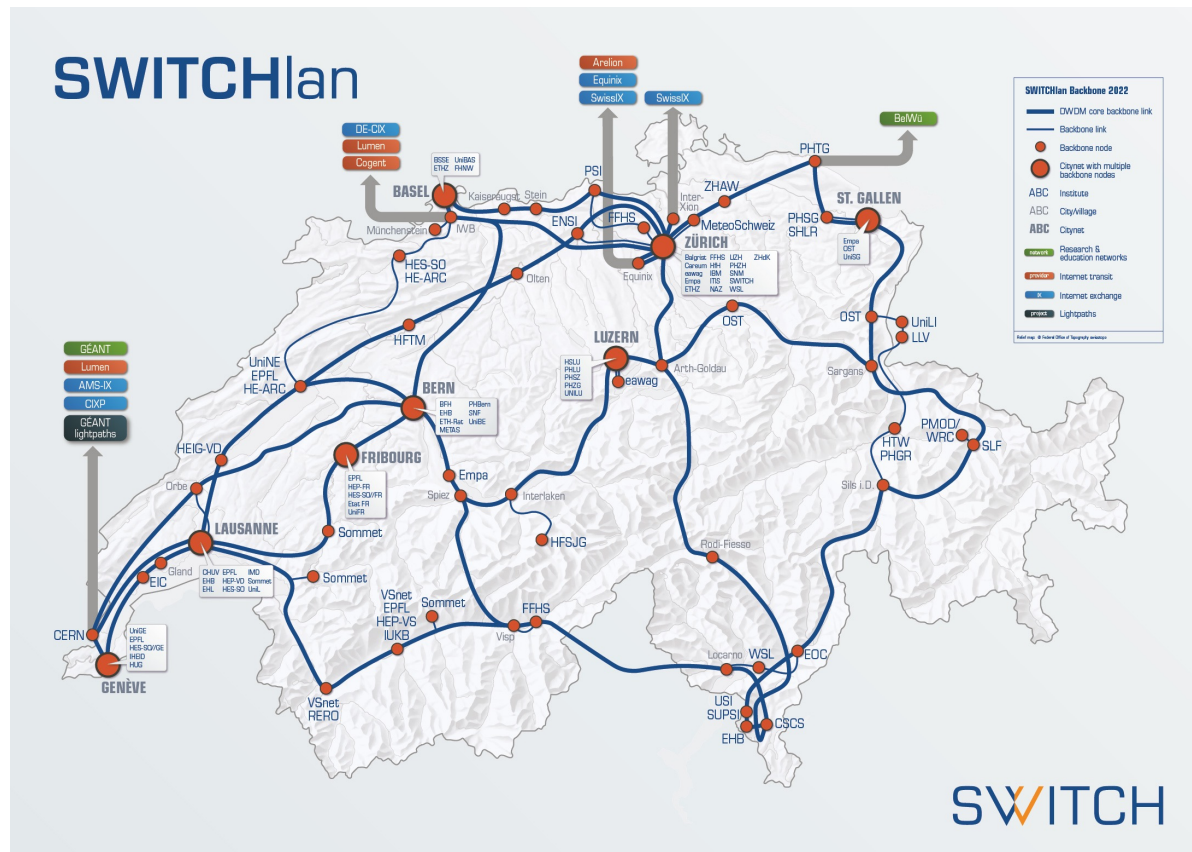
- **Extension of PTP**
- **Allow sub nanosecond accuracy and stability**
- **Offer the perfect redundancy to satellite techniques**
- **Needs calibrations**

- **Fully open:**

- **hardware**
- **software**

- <https://white-rabbit.web.cern.ch/>

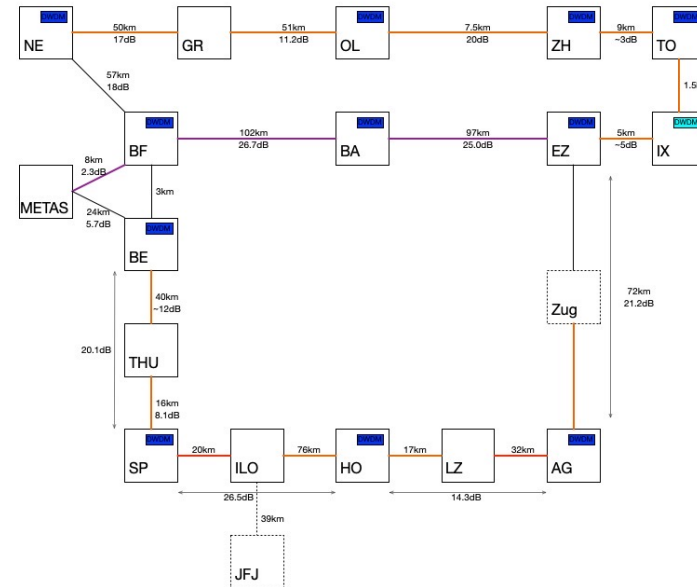
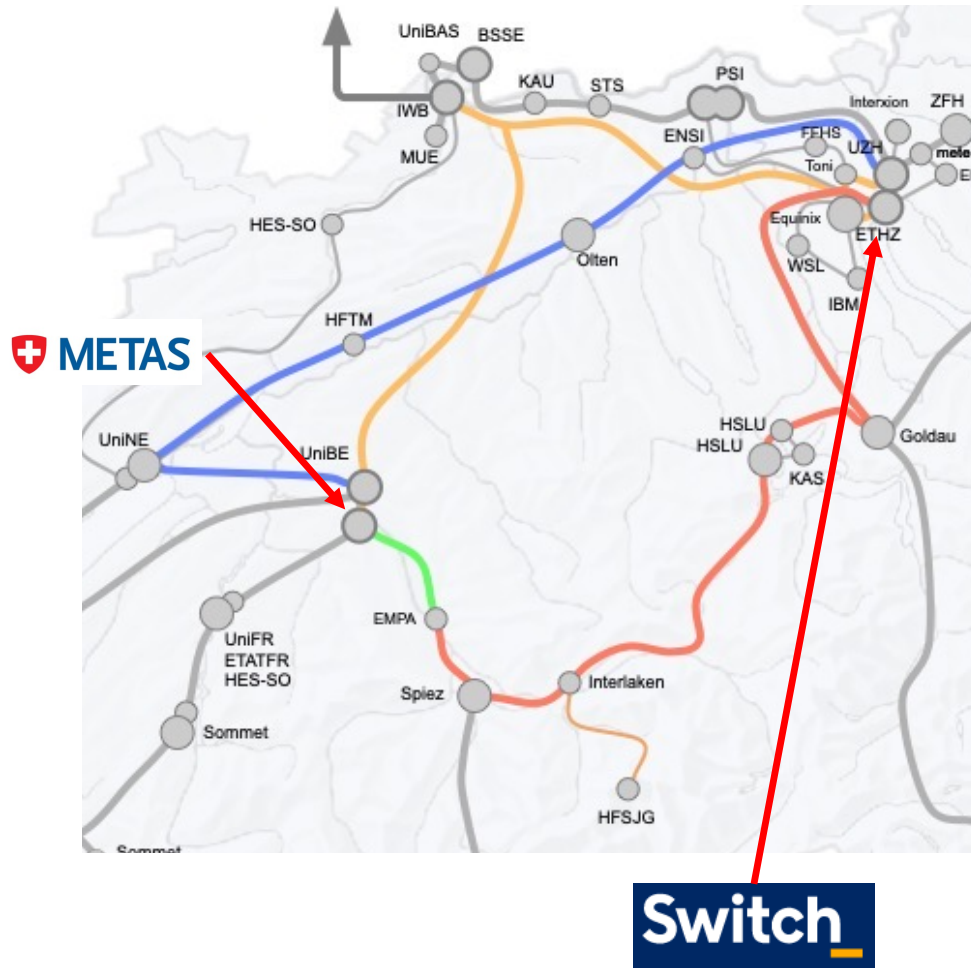
Optical fiber network



■ Foundation SWITCH:

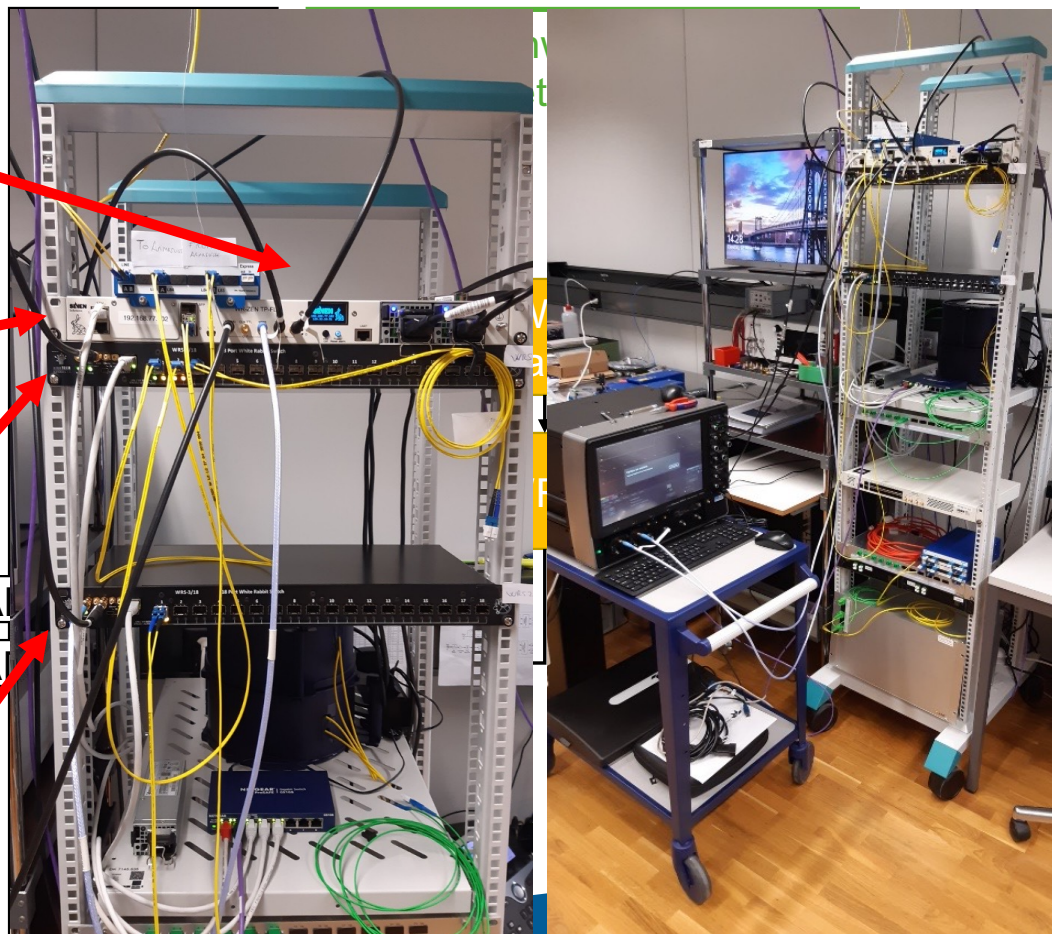
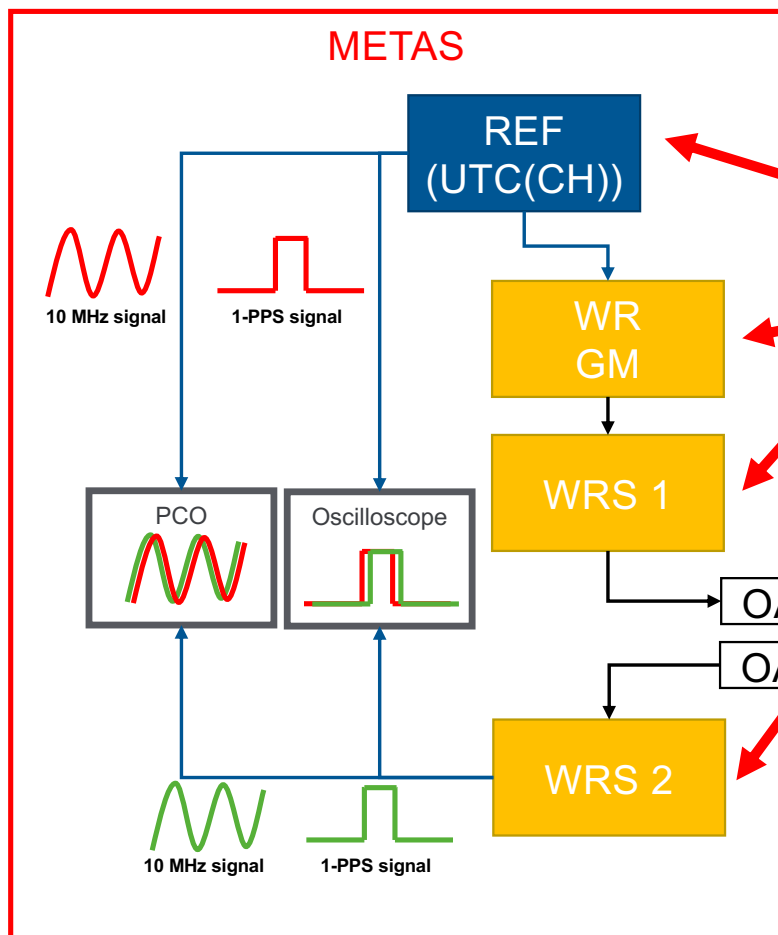
- Connects all universities
- Around 50 points of presence all over Switzerland

White Rabbit Network

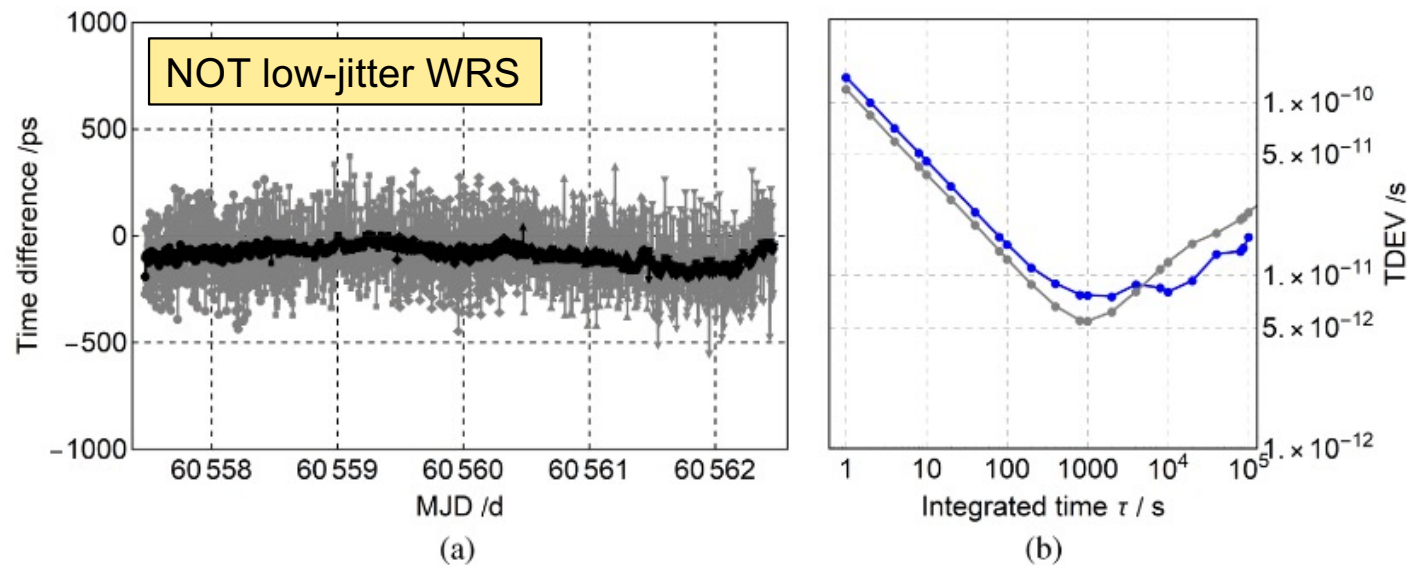


- Loop network
- Total span of 491 km
- Multiplexed into Switch telecommunication network
- DWDM L-band, spectrally separated from data traffic

White Rabbit at METAS



Result



➤ Total uncertainty of disseminated UTC(CH): - 84 +/- 415 ps

Jallageas et al., JOCN,
Vol. 17, Issue 7, 631-637, 2025
[10.1364/JOCN.560593](https://doi.org/10.1364/JOCN.560593)

What is the Time and Frequency Metrology?

- **Realization of the Time and Frequency references**

- Timescales UTC and UTC(k)
- Definition of the second
- Traceability to the International System of Unit

- **Dissemination of the TF references**

- Satellites
- Optical fibers
- Others...

- **Measurement capabilities**

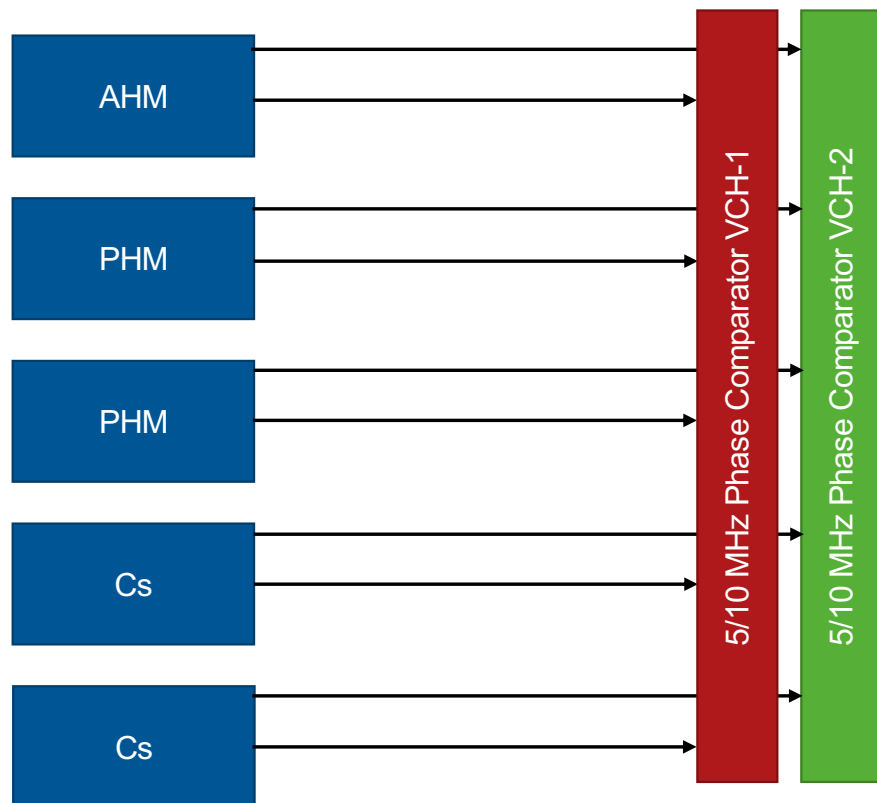
- Time interval
- Frequency
- Stability

- **Support to the research and industry**

- Telecommunication
- Finance
- Networks (internet, electrical etc.)
- Watch industry
- Fundamental and Quantum sciences

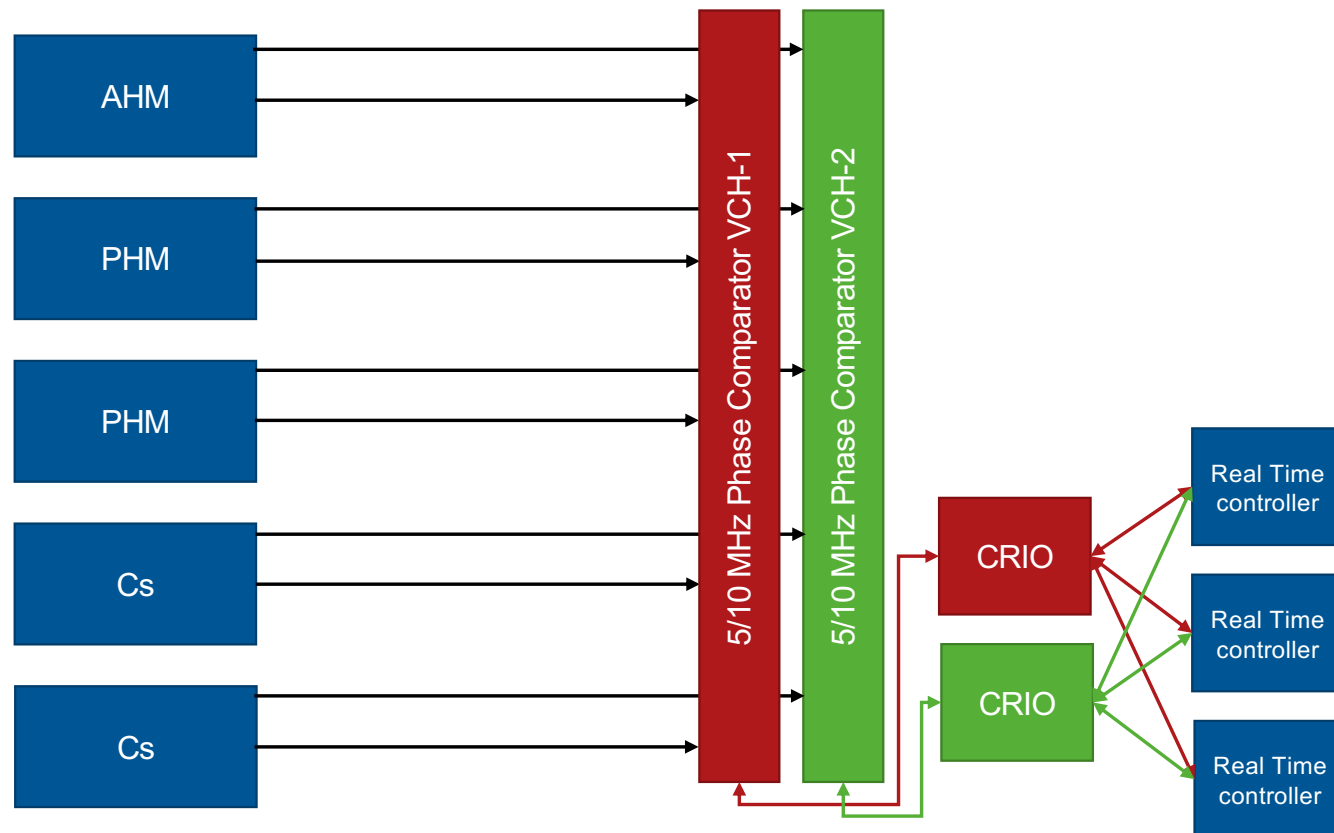


How UTC(CH) is generated?



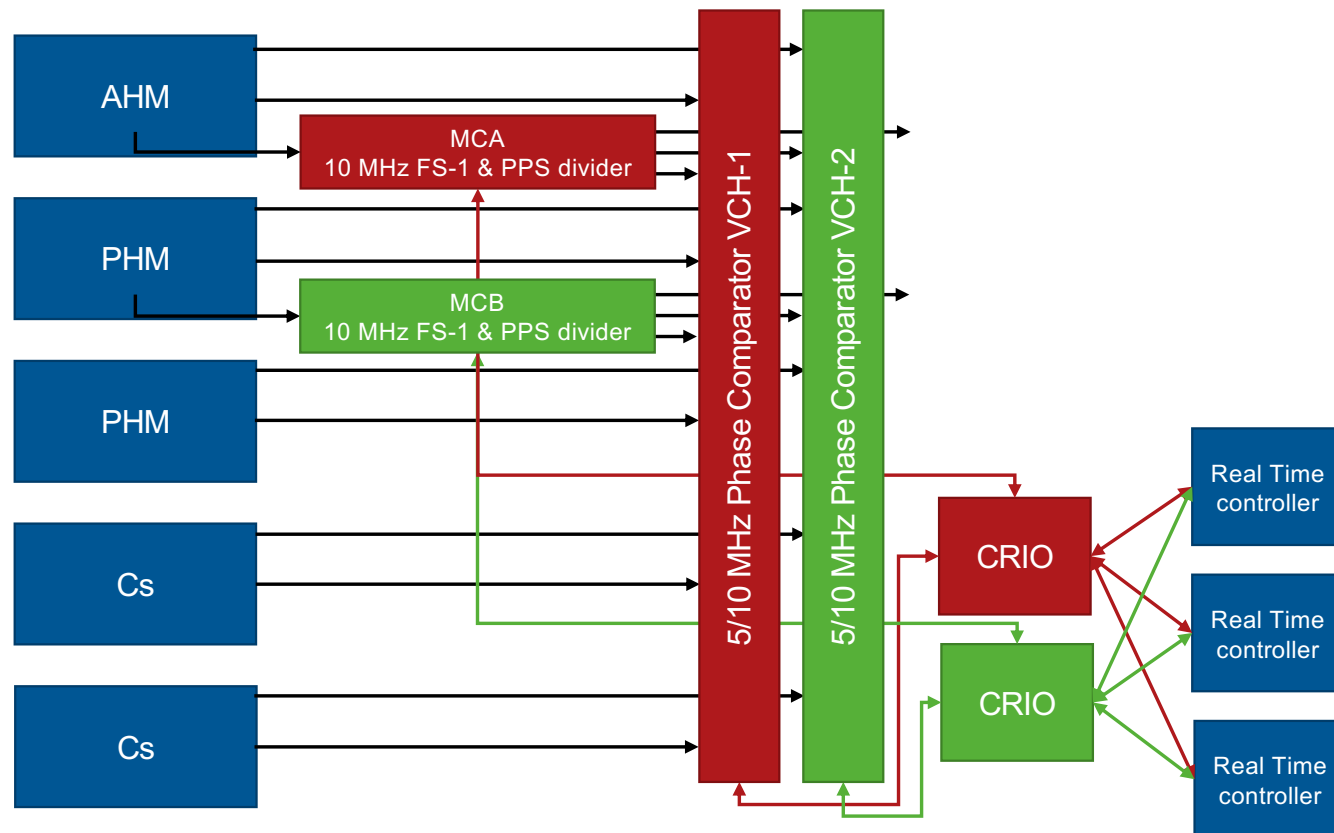
- UTC(CH) must operate continuously without interruption.
- To guarantee this, most of the instruments are doubled

How UTC(CH) is generated?



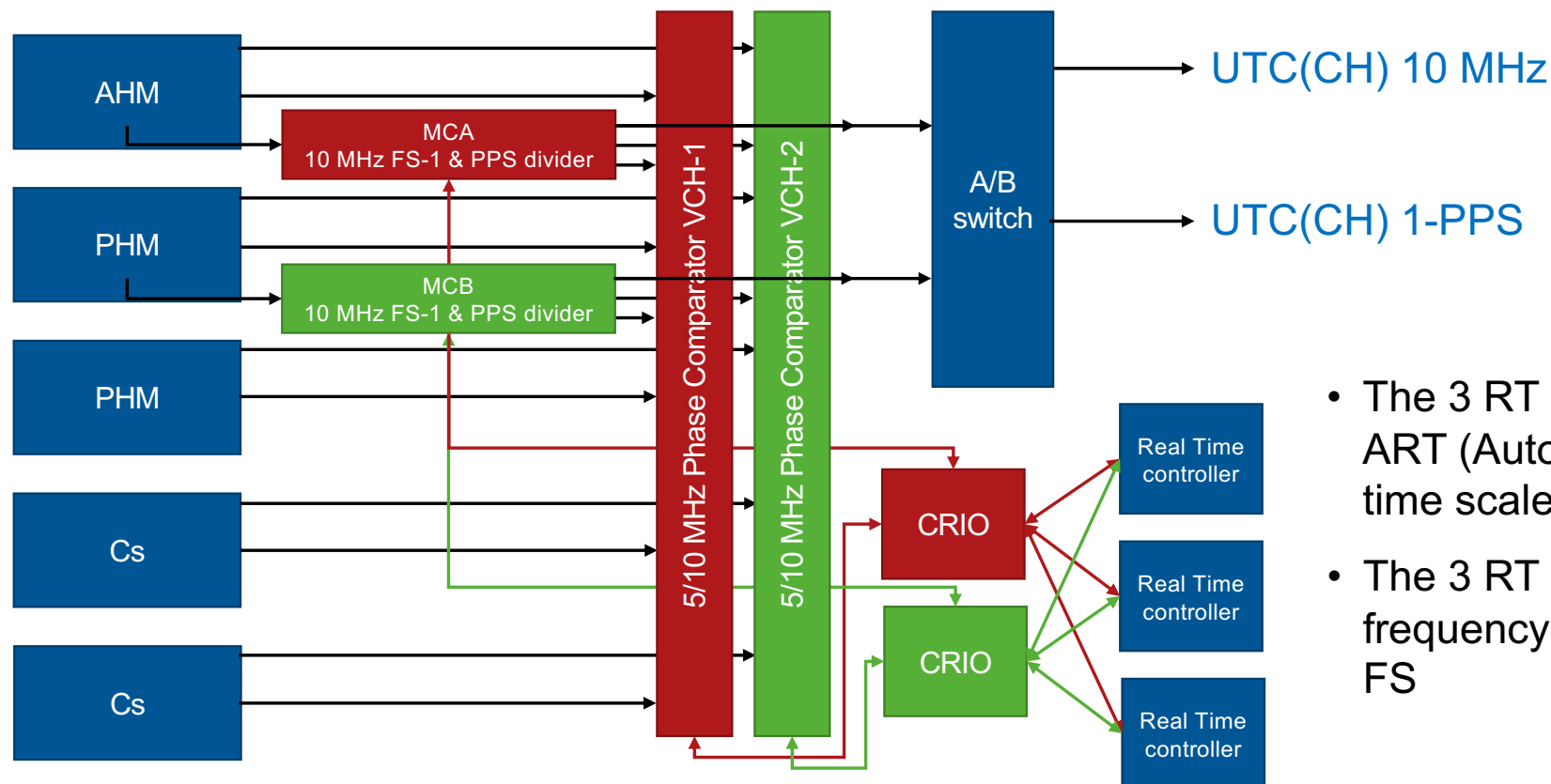
- The 3 RT controllers run the ART (Autotime Real Time) time scale algorithm

How UTC(CH) is generated?



- The 3 RT controllers run the ART (Autotime Real Time) time scale algorithm
- The 3 RT controllers send frequency correction to the FS

How UTC(CH) is generated?



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- The 3 RT controllers send frequency correction to the FS