# 14th White Rabbit Workshop

# Report of Contributions

https://indico.cern.ch/e/1524513

Contribution ID: **1** Type: **not specified**

# Doors Open

**Session Classification:** Morning session

Contribution ID: **2** Type: **not specified**

# Welcome to Event

**Presenter:** SERRANO, Javier (CERN)

**Session Classification:** Morning session

Contribution ID: **3** Type: **not specified**

# The White Rabbit Collaboration

**Presenter:** DIEZ FERNANDEZ, Amanda (CERN)

**Session Classification:** Morning session

Contribution ID: **4** Type: **not specified**

# Status of the current WR Switch version 3

**Presenter:** WUJEK, Adam Artur

**Session Classification:** Morning session

Contribution ID: **5** Type: **not specified**

# Status of the new WR Switch version 4

**Presenter:** WLOSTOWSKI, Tomasz (CERN)

**Session Classification:** Morning session

Contribution ID: **6** Type: **not specified**

# Status of the WRPC version 5

**Presenter:** GINGOLD, Tristan (CERN)

**Session Classification:** Morning session

Contribution ID: **7** Type: **not specified**

# WR-related standardisations

**Presenter:** LIPINSKI, Maciej Marek (CERN)

**Session Classification:** Morning session

Contribution ID: **8** Type: **not specified**

# WR at GSI - Status and near Future

**Presenter:** BECK, Dietrich (GSI - Helmholtzzentrum fur Schwerionenforschung GmbH (DE))

**Session Classification:** Morning session

Contribution ID: **9** Type: **not specified**

# EISCAT_3D, a White Rabbit based Radar

**Presenter:** BROWN, Simon

**Session Classification:** Morning session

Contribution ID: **10** Type: **not specified**

# New timing system for the LOFAR2.0 telescope

**Presenter:** WITVERS, Roel (Astron)

**Session Classification:** Morning session

Contribution ID: **11** Type: **not specified**

# Performance evaluation of a versatile and low-jitter WR board designed for radio-telescopes

**Presenter:** CHARLET, Daniel (CNRS)

**Session Classification:** Morning session

Contribution ID: **12** Type: **not specified**

# Light Rabbit: Implementing a White Rabbit node on COTS AMD development boards without relying on external VCXOs

**Session Classification:** Afternoon session

Contribution ID: **13** Type: **not specified**

# Towards Carrier Grade White Rabbit Switch

**Presenter:** BRAWAŃSKI, Marek (Orange Polska)

**Session Classification:** Afternoon session

Contribution ID: **14** Type: **not specified**

# Distribution of synchronized time, underline the Green Transition in electrical power production, distribution, and safe operation of the power system. Stanett's project COSECTIME

**Presenters:** HAUGLIN, Harald (Statnett); MYHREN, Kjell Petter (Statnett); TUNGLAND, Oddleiv (Statnett)

**Session Classification:** Afternoon session

Contribution ID: **15** Type: **not specified**

# European Radionavigation Plan and pan-European time distribution

**Presenter:** BONENBERG, Łukasz K (European Commission)

**Session Classification:** Afternoon session

Contribution ID: **16** Type: **not specified**

# The CERN Quantum Technology Initiative

**Presenter:** Dr VALLECORSA, Sofia (CERN)

**Session Classification:** Afternoon session

Contribution ID: **17** Type: **not specified**

# Progressing Towards a Nationwide White Rabbit Network in DWDM Telecommunications for REFIMEVE, France's T/F Network for Education and Research

**Presenter:** POTTIE, Paul-Éric (Observatoire de Paris-PSL, CNRS, SU, LNE)

**Session Classification:** Afternoon session

Contribution ID: **18** Type: **not specified**

# Sub-ns long-haul dissemination of UTC(CH) using White Rabbit in Switzerland

**Presenter:** JALLAGEAS, Antoine (METAS)

**Session Classification:** Afternoon session

Contribution ID: **19** Type: **not specified**

# White Rabbit applications: terrestrial PNT networks, the Quantum Internet, and networked digital time scales

**Presenter:** KOELEMEIJ, Jeroen (VU University)

**Session Classification:** Afternoon session

Contribution ID: **20** Type: **not specified**

# Practical single-fibre network-oriented quantum key distribution from a compact source of entangled photons in presence of White Rabbit time synchronisation

**Presenter:** SCHATZ, Karolina (University of York)

**Session Classification:** Afternoon session

Contribution ID: **21** Type: **not specified**

# Towards Quantum Networking: Characterization of Metropolitan-Scale White Rabbit Precision Time Protocol Architectures

**Presenter:** LI-BABOUD, Ya-Shian (NIST)

**Session Classification:** Afternoon session

Contribution ID: **22** Type: **not specified**

# Welcome Coffee

**Session Classification:** Morning session

Contribution ID: **23** Type: **not specified**

# White Rabbit Collaboration Inauguration

**Presenter:** JONES, Rhodri (CERN)

**Session Classification:** Morning session

Contribution ID: **24** Type: **not specified**

# White Rabbit Collaboration Inauguration

**Presenter:** ANELLI, Giovanni (CERN)

**Session Classification:** Morning session

Contribution ID: **25** Type: **not specified**

# The journey of White Rabbit until today

**Presenter:** SERRANO, Javier (CERN)

**Session Classification:** Morning session

Contribution ID: **26** Type: **not specified**

# Plans for the year ahead

**Presenter:** LIPINSKI, Maciej Marek (CERN)

**Session Classification:** Morning session

Contribution ID: **27** Type: **not specified**

# Q&A

**Session Classification:** Morning session

Contribution ID: **28** Type: **not specified**

# WR Use case: Distributing time for SKA, the largest telescope in the world

**Presenter:** RAT, Benoit

**Session Classification:** Morning session

Contribution ID: **29** Type: **not specified**

# 10 years journey of a cute white rabbit: brief history of CUTE WR node and the applications

**Presenter:** GONG, Guanghua (SyncTechnology)

**Session Classification:** Morning session

Contribution ID: **30** Type: **not specified**

# QWRTY: A White Rabbit Switch v4 with Enhanced Holdover Capabilities

**Presenter:** PÍRIZ, Ricardo (GMV)

**Session Classification:** Morning session

Contribution ID: **31** Type: **not specified**

# Adding holdover capability to the WRS v4

**Presenter:** AMEY, Nick (IQD Frequency Products)

**Session Classification:** Morning session

Contribution ID: **32** Type: **not specified**

# The InterOperability Laboratory and WR

**Presenter:** NOSEWORTHY, Bob (University of New Hampshire)

**Session Classification:** Afternoon session

Contribution ID: **33** Type: **not specified**

# Status of WR related work at Nikhef

**Presenter:** JANSWEIJER, Peter (Nikhef National institute for subatomic physics (NL))

**Session Classification:** Afternoon session

Contribution ID: **34** Type: **not specified**

# WR at CERN

**Presenter:** GOUSIOU, Evangelia (CERN)

**Session Classification:** Afternoon session

Contribution ID: **36** Type: **not specified**

# Precision Time in Financial Services

**Presenter:** FRIEDMAN, Seth (Liquid Markets Solutions)

**Session Classification:** Afternoon session

Contribution ID: **37** Type: **not specified**

# White Rabbit use cases and challenges in trading

**Presenter:** SZIKORA, Bence (Jump Trading)

**Session Classification:** Afternoon session

Contribution ID: **38** Type: **not specified**

# The White Rabbit Story at Deutsche Börse

**Presenter:** SAUTHOFF, Georg (Deutsche Börse)

**Session Classification:** Afternoon session

Contribution ID: **39** Type: **not specified**

# Corundum NIC and WR

**Presenter:** FORENCICH, Alex (UC San Diego)

**Session Classification:** Afternoon session

Contribution ID: **40** Type: **not specified**

# Packet Switch Project

**Presenter:** MEGIAS NUNEZ, CARLOS (University of Granada)

**Session Classification:** Afternoon session

Contribution ID: **41** Type: **not specified**

# Closing Remarks

**Session Classification:** Afternoon session

Contribution ID: **42** Type: **not specified**

# Welcome

*Wednesday 25 June 2025 10:30 (5 minutes)*

Welcome to the event and a few words on logistics

**Presenter:** SERRANO, Javier (CERN)

Contribution ID: **43** Type: **not specified**

# WR Collaboration Status and Plan

*Wednesday 25 June 2025 10:35 (25 minutes)*

**Presenter:** SERRANO, Javier (CERN)

Contribution ID: **44** Type: **not specified**

# WR Technology Status and Plans

*Wednesday 25 June 2025 11:00 (30 minutes)*

**Presenters:** WUJEK, Adam Artur (CERN); GENOUD, Quentin (CERN)

Contribution ID: **45** Type: **not specified**

# WR Switch v4 Status and Plans

*Wednesday 25 June 2025 11:30 (30 minutes)*

**Presenters:** LIPINSKI, Maciej Marek (CERN); GENOUD, Quentin (CERN)

Contribution ID: **46** Type: **not specified**

# Ethernet Receiver Design at ASTRON

*Wednesday 25 June 2025 14:00 (20 minutes)*

At ASTRON, the Netherlands Institute for Radio Astronomy, we are designing a new generation of radio telescopes. Traditionally, coaxial cables have been used to transport signals from the antenna to the processing facility. For our future telescopes, we aim to replace coaxial cables with optical fibre interconnects. This change requires a synchronised ADC to be implemented close to the antenna, with the clock reference and data transmitted over the fibre. In radio astronomy, where weak signals are measured and multiple antennas form large arrays, low noise and maintaining high synchronisation are crucial.

We are exploring this concept through two projects: MID4Automotive and Future Network Services (FNS). Our focus areas within these projects include shielding digital noise from sensitive analogue circuitry and ensuring precise synchronisation. Within the MID4Automotive project, we are building a prototype capable of operating up to 100 MHz bandwidth, suitable for a future LOFAR update. For synchronisation, we will employ White Rabbit technology. Within the FNS project, we are designing an Ethernet receiver operating up to 2.5 GHz bandwidth.

In this talk, we present the design choices of the ADC clock tree and how White Rabbit technology is used to synchronise the local sampling clock to the central clock. We will show the first results of the 100 MHz Ethernet receiver. Additionally, we will outline our plans for the next phase, which involves using an AMD RFSoC synchronised with a White Rabbit clock circuit.

**Presenter:** SCHOONDERBEEK, Gijs (ASTRON)

Contribution ID: **47** Type: **not specified**

# Picoseconds-Scale Time Synchronization in Distributed Optical and Cherenkov Telescopes with White Rabbit

*Wednesday 25 June 2025 14:20 (20 minutes)*

In the recent years, Cherenkov telescopes have begun to be used for observations in the optical band using the technique of intensity interferometry. Intensity interferometry requires fast detectors—which Cherenkov telescopes already possess, as their cameras are comprised of photomultiplier tubes (PMTs)—as well as time synchronization between two telescopes to record data simultaneously and enable correlation either in real time or offline.
White Rabbit (WR) is employed for this synchronization, achieving sub-nanosecond accuracy. However, to further increase the signal-to-noise ratio (SNR) and detect fainter sources, even faster detectors are needed—for example, single-photon avalanche diodes (SPADs). These detectors are capable of detecting individual photons and generating corresponding pulses with overall jitter under 10 ps RMS. This imposes even stricter time synchronization requirements: the timing between two telescopes or detectors must match the SPAD-induced jitter, i.e., be below 10 ps.
WR, built upon the Precision Time Protocol (PTP), natively offers sub-nanosecond synchronization with deterministic latency. We demonstrate that a WR network can be efficiently shared between optical and Imaging Atmospheric Cherenkov Telescope (IACT) observatories for joint intensity interferometry observations. We investigate and address key challenges, including the effects of fiber temperature fluctuations and chromatic dispersion, which can impact long-distance timing stability.
Through experimental validation, we achieve 8 ps RMS time synchronization over a 50 km fiber link, demonstrating the feasibility of WR for high-precision astronomical applications. Furthermore, we analyze how WR clock phase coherence affects intensity interferometry sensitivity and discuss the implications for long-baseline and large-scale deployments.

**Presenter:** SLIUSAR, Vitalii (University of Geneva)

Contribution ID: **48** Type: **not specified**

# White Rabbit in Radio Interferometry

*Wednesday 25 June 2025 14:40 (30 minutes)*

We examine the suitability of White Rabbit for the distribution of a reference phase signal in radio interferometers. Receptors in an interferometric array require a stable reference phase, and the phase noise due to the clock distribution could possibly lead to a reduction in the amplitude of the cross product of the signals, an effect known as 'coherence loss', which reduces the sensitivity of the observation.
We develop a method to predict the coherence loss from the measurements of the ADEV and MDEV, including a novel expression for the coherence loss due to flicker phase modulation.

We introduce a new method to calibrate the dispersion parameter alpha, which is especially convenient on already deployed fiber. By using two independent strands of the same fiber cable between two White Rabbit switches, with their wavelengths swapped, we can directly measure the dispersion on the fiber, assuming both links have the same average value. This is achieved by having both links operating simultaneously, which requires only a modification of the firmware. Notably, this method requires no other external parts such as time interval counters or oscilloscopes, and can continuously monitor the dispersion value.

We show how to make a White Rabbit signal co-exist with existing fiber infrastructure that is already in operation with operational traffic on a DWDM network. Our method uses two wavelengths outside of the optical C-band for the counter-propagating White Rabbit signals on a single fiber, and uses bi-directional silicon based optical amplifiers instead of erbium doped fiber amplifiers. This ensures that the requirement of having both directions of the link on the same fiber can still be met, and allows for complete calibration of the link.

Finally, we bring all these methods together by connecting two radio telescopes in the Netherlands, and successfully perform very long baseline interferometry observations using White Rabbit as a phase reference and time distribution method.

**Presenter:** BOVEN, Paul (JIVE)

Contribution ID: **49** Type: **not specified**

# EISCAT Facility Update

*Wednesday 25 June 2025 15:10 (15 minutes)*

The talk will briefly cover the progress in the EISCAT 3D radar project during the last year and give details of the new possibility of time transfer between the radar sites.

**Presenter:** BROWN, Simon (EISCAT)

Contribution ID: **50** Type: **not specified**

# Performance evaluation of White-Rabbit based RF and Timing distribution system for the LHC

*Wednesday 25 June 2025 15:50 (15 minutes)*

To meet the High-Luminosity LHC demand for enhanced phase stability and replace the outdated RF and timing distribution system (called TTC backbone), an upgrade to a White Rabbit-based system is planned. A compliance test showed a phase variation of less than 30 ps in a proof-of-concept system. In order to assess the quality of the new system in real conditions a test campaign was started in several points of LHC monitoring its phase stability with respect to the RF-master frequency and comparing it to the TTC backbone currently in operation. The test campaign will be described and results presented.

**Presenter:** KAFFKA, Lilith (University of Dundee (GB))

Contribution ID: **51** Type: **not specified**

# WR Deployments at CERN

*Wednesday 25 June 2025 15:25 (25 minutes)*

**Presenters:** GOUSIOU, Evangelia (CERN); GINGOLD, Tristan (CERN)

Contribution ID: **52** Type: **not specified**

# DWDM-based White Rabbit Multi-User Time and Frequency Distribution in a Quantum Communication Testbed

*Wednesday 25 June 2025 16:30 (15 minutes)*

In this abstract we report a multi-user time and frequency distribution architecture based on White Rabbit (WR) technology and dense wavelength-division multiplexing. A novel in-situ calibration method of the chromatic dispersion-induced delay asymmetry in a deployed link has been implemented. The calibration procedure provides effective and accurate calibration for the White rabbit time synchronization technology in deployed fiber links from the local master end, without need to perform any measurements at the remote slave end. The scheme has been installed in the Niedersachsen Quantum Link and has been fully characterized in both laboratory and field. The proposed calibration technique has been verified in the field by an independently deployed electronically stabilized time and frequency distribution (ELSTAB) system.
Niedersachsen Quantum Link (NQL) is a quantum key distribution (QKD) testbed, and it consists of a 78 km long pair of dark fibers between the cities of Hannover and Braunschweig. The link connects Leibniz University of Hannover (LUH) and Physikalisch-Technische Bundesanstalt (PTB) Braunschweig. One of the dark fibers is dedicated to quantum applications, while the second fiber is used for the dissemination of time and frequency reference signals as well as classical communication between the two sites. Within LUH campus, the link connects the Institute of Quantum Optics (IQO), Hannover Institute of Technology (HITec), and the Institute for Solid State Physics (FKP) [1]. Currently, an entanglement-based QKD system is installed in NQL, where Alice is located at FKP and Bob at PTB. The aim of the proposed WR scheme is to distribute time and frequency signals from PTB to three distant locations: IQO, HITec, and FKP. The preliminary field measurements show that the instability of the clock output of the WR slave node at FKP is 8.7×10-17 at 105 s of integration time. The achieved pulse-per-second (PPS) time offset error between the Grandmaster at PTB and the slave remote Node at FKP is 139±12 ps, verified by the independently calibrated ELSTAB system.
J.E. Kadum, et al.,“Niedersachsen quantum communications testbed,”Meas.: Sens., 2024. https://doi.org/10.1016/j.measen.20

**Presenter:** KADUM, Jaffar (PTB)

Contribution ID: **53** Type: **not specified**

# Entanglement distribution of photon pairs coexisting with White Rabbit synchronization signals on the same optical fiber

*Wednesday 25 June 2025 16:45 (20 minutes)*

Challenges in building large scale quantum networks are high precision time synchronization, and fluctuating conditions of the fiber links, which impact the quality of entanglement between transmitted photon pairs. White Rabbit (WR) can be used to synchronize two distant quantum network nodes with high precision. Multiplexing the optical WR signals on the same fiber as the quantum signal allows for monitoring and compensating the changes in this fiber, as both signals experience the same conditions. Here, the WR –quantum coexistence experiment which will be performed at CERN is presented, along with the results of power fluctuation tests on the WR signals.

**Presenter:** TEEPE, Annick

Contribution ID: **54** Type: **not specified**

# Discussion Session

*Wednesday 25 June 2025 17:25 (35 minutes)*

Contribution ID: **55** Type: **not specified**

# Instrumental Delay Calibration of White Rabbit Switches for Sub-10 ns Timing in the REFIMEVE Network

*Thursday 26 June 2025 09:30 (20 minutes)*

REFIMEVE is a French national research infrastructure, officially recognized in 2021, based on a fiber-optic network that disseminates ultra-stable time and frequency signals over long distances. Reference signals originate at LTE (former SYRTE) at Paris Observatory and are primarily transported over the optical fibre network backbone of RENATER [1]. It currently connects more than 20 research laboratories across metropolitan France, with a goal to reach over 40 in the next five years. The network also extends internationally through four cross-border links.
Within the T-REFIMEVE project, we aim to establish a national-scale White Rabbit (WR) timing network, targeting time accuracy better than 10 nanoseconds across more than 80 nodes interconnected by over 5,000 km of optical fiber. Unlike the bidirectional optical carrier used in the REFIMEVE infrastructure, this deployment leverages the unidirectional optical amplifiers of the RENATER backbone. WR signals are transmitted as alien wavelengths using standard xWDM technology, which introduces the challenge of mitigating optical path asymmetries inherent in unidirectional links.
A critical first step toward achieving this level of timing precision is the precise calibration of instrumental delays in the White Rabbit Switches (WRS). This work reports on the calibration of instrumental delays of dozens of WRS units.
We performed the calibration according to the CERN procedure [2] and the EMPIR/VSL good practice guide [3], for unidirectional links, using SFP transceivers operating at a wavelength of 1560.61 nm. We defined port 1 of one of our WRS to be our golden calibrator, while choosing to leave its ingress and egress delays at their default firmware values, and then used it to calibrate port 1 of another WRS, thus constituting the usual pair of reference ports in a slightly unusual way. We then used these two ports to calibrate all other WRS ports. As expected the synchronisation was already good using the default delays, with offsets of up to approximately 300 ps, and improved to within ±20 ps after calibration. (All of the presented measurements used the same slave port, which had been previously calibrated to the golden calibrator.)
We review the sources of uncertainty in our calibration process and present a preliminary uncertainty budget.
Finally, we briefly report on the in-field implementation of White Rabbit within REFIMEVE and discuss the estimation of asymmetric delays introduced by various components of the active network-such as amplifiers, attenuators, multiplexers, and fiber length differences along the transmission and reception paths of the WR link.

References:
[1] O. Lopez et al., « Frequency and time transfer for metrology and beyond using telecommunication network fibres », Comptes Rendus Physique, vol. 16, no 5, p. 531-539, juin 2015, doi: 10.1016/j.crhy.2015.04.005.
[2] G. Daniluk, “White Rabbit calibration procedure,”2015 https://white-rabbit.web.cern.ch/documents/WR_Calibration-v1.1-20151109.pdf
[3] Dierickx, Erik and X. Yan, “WR Good practice guide,”May 2019 https://gitlab.com/ohwr/project/white-rabbit/wikis/uploads/7df19b6a4d0e90bf6d7b8ae32b3b32c4/WR_Good_Practice_Guide.pdf

**Presenter:** NEELAM, Yadav (OBSPM)

Contribution ID: **56** Type: **not specified**

# Long-haul White Rabbit

*Thursday 26 June 2025 09:50 (20 minutes)*

The long-haul reach capability of White Rabbit technology is remarkable and plays a vital role far beyond National Research and Education Networks (NRENs). It enables ultra-precise time and frequency synchronization over vast distances, benefiting a wide range of industries including telecommunications, finance, and power grid management. This presentation will explore current methods to achieve long-haul synchronization with White Rabbit and discuss potential advancements for future implementations.

**Presenter:** VOJTĚCH, Josef (CESNET)

Contribution ID: **57** Type: **not specified**

# UberNIC: latest updates and use cases

*Thursday 26 June 2025 14:50 (25 minutes)*

**Presenter:** FRIEDMAN, Seth (LMS)

Contribution ID: **58** Type: **not specified**

# TBC

Contribution ID: **59** Type: **not specified**

# Adding relevant holdover capability to the WRS v4

*Thursday 26 June 2025 11:10 (25 minutes)*

In March 2024 IQD presented at the White Rabbit Collaboration workshop. We gave the first details of a project in which we build an expansion board to be used in the new WRv4 switch. We had some great feedback last year regarding specific use cases for holdover in a White Rabbit environment.
This year we are happy to be back again and to be giving an update on the progress of this project. We have taken on board the feedback from last year and have some first test results to share.
The card should be available to market in Nov 2026 and will be capable of meeting the requirements we were given at last year's workshop. In this presentation we will give an update on the progress since March 2024, and the milestones between now and Nov 2026

**Presenter:** AMEY, Nick (IQD Frequency Products)

Contribution ID: **60** Type: **not specified**

# Crossing the White Rabbit Hole

Combining WhiteRabbit with AtomiChron HA (High Accuracy) real-time PPP GNSS service, allows for WhiteRabbit links to extend beyond the need for Fiber Optic availability and connect WR networks anywhere in the world. Real-time PPP enables WR links by jumping any distance at similar performance levels to WR. Besides this possible hybrid approach combining the 2 technologies, the UTC(k) reference will be able to real-time align any node in the system to UTC(PTB) or UTC(NIST) with other UTC(k) labs to follow to sub-ns accuracy. Last but not least, real-time PPP is able to calibrate and monitor WR links, independent from the Fiber Optic network. Improving resilience, because, let's be honest, GNSS might not be 100% reliable, but neither are FO links!

We'll present measurement data from our recent measurement campaign with PTB, RI.SE and Deutsch Telekom, showcasing the performance of the UTC(k) as well as the underlying real-time PPP service based on COTS hardware. Please note that it's a proposal to combine the two technologies, it hasn't been carried out yet. I will prove what we can do though supported by measurements.

**Presenter:** DE VRIES, Roel (Fugro)

Contribution ID: **61** Type: **not specified**

# Innovative applications for WR nanosecond sync for Ang Lee, Beyonce, Netflix and Coldplay in the Film, TV and Live Event industries

*Thursday 26 June 2025 11:35 (20 minutes)*

An overview of the current real world problems on the Stage and Screen, alongside a brief overview of the current work we are carrying out at XPLOR & Production Park.

**Presenter:** ADLAM, Phil (XPLOR)

Contribution ID: **62** Type: **not specified**

# Update on NSF POSE Project: Open PHASE, and WRC Certification efforts

*Thursday 26 June 2025 16:05 (25 minutes)*

The NSF POSE funded Open PHASE effort hosted by UNH-IOL is entering its second year and nearing readiness to support the needs of the White Rabbit Collaboration's certification process. This talk will update the WR Workshop attendees on the goals and mission of the Open PHASE effort, how to participate, steer and benefit from the effort.

**Presenter:** NOSEWORTHY, Bob (University of New Hampshire)

Contribution ID: **63** Type: **not specified**

# Yet Another White Rabbit running on a low-cost, generic FPGA board

*Thursday 26 June 2025 14:00 (30 minutes)*

In 2022, PTP became available to the masses thanks to the availability of the Raspberry Pi Compute Module 4 and its PTP compatible network interface [1], and now the Compute Module 5.
In the meantime, PTP High Accuracy's White Rabbit has remained confined to dedicated boards providing the external oscillators needed to generate the beatnote for fine phase measurement, until 2024's Missing Link Electronics presentation of the Light Rabbit Implementation targetting the Ettus Research X310 SDR and demonstrated on the ZC706 board [2]. Thanks to this breakthrough contribution shared as open-source software on the OpenHardware repository, and relying on Nikhef's CLBv3 design [3], we demonstrate the functional implementation of White Rabbit on Enjoy Digital's Acorn CLE125 board [4].
In this presentation we detail the steps needed to achieve a functional demonstration and some phase noise and Allan deviation stability measurements as a function of software-phase locked loop gain parameters. These results open the path towards integrating White Rabbit into Enjoy Digital's M2SDR software defined radio board [5] and reaching the target of a network of coherent, distributed software defined radio transceivers for large scale beamforming or direction of arrival measurements, including passive RADAR
applications.
The results of these developments are documented at https://github.com/oscimp/wr_acorn
aimed at helping the audience to reproduce and expand the results.

**Co-authors:** DECOUX, Emilien (Femto ST); FRIEDT, Jean Michel (Femto ST)

**Presenters:** DECOUX, Emilien (Femto ST); FRIEDT, Jean Michel (Femto ST)

Contribution ID: **64** Type: **not specified**

# LockSweep (on BabyWR) status and progress

*Thursday 26 June 2025 15:40 (25 minutes)*

Usually the WR reference clock is the source of the WR timing signals (10MHz and PPS), however, for low phase noise it is profitable to use the output of the local oscillator.
In many White Rabbit systems the local oscillator has a different frequency than the White Rabbit reference clock which leads to a fixed number of possible phase lock positions.
Using the local oscillator directly means that it must be phase aligned with the PPS in the WR reference clock domain.
The process of aligning the phase of the external oscillator in the proper phase position is called LockSweep.
LockSweep is explained and progress is reported based on experience with BabyWR.

**Co-author:** JANSWEIJER, Peter (Nikhef)

**Presenters:** ASTERIOU, Konstantinos (Nikhef); JANSWEIJER, Peter (Nikhef)

Contribution ID: **65** Type: **not specified**

# White Rabbit development on Altera platform

*Thursday 26 June 2025 14:30 (20 minutes)*

In this presentation, we will showcase the metrological evaluation of a newly developed electronic architecture—a custom carrier board built around the Altera Arria10 FPGA—which integrates White Rabbit technology. This system is an original platform tailored for high-performance frequency and time distribution, as well as precise timing capture for phased-array detectors. We will present detailed performance results, highlighting outstanding short-term jitter and long-term stability of the generated clock and Pulse-Per-Second signals. These results demonstrate cutting-edge timing precision and spectral purity in FPGA-based time transfer systems, with impactful implications for time-frequency metrology, radio astronomy, particle physics, and distributed instrumentation, particularly in systems relying on optical fiber networks.

**Presenter:** Mr BACK, Antoine (IJCLAB)

Contribution ID: **66** Type: **not specified**

# WR at MLE - Updates on Dormouse FMC Card, Light Rabbit and Further Contributions

*Wednesday 25 June 2025 17:05 (20 minutes)*

This talk provides an overview about the most major steps on White Rabbit within MLE. We present our journey with the Dormouse Card and the enablement of it for ZCU102, ZCU106, ZCU111 platforms. Based on this development a bistatic RADAR setup has been built together with and at KIT. The respective setup is also used in 6G massive MIMO experiments.
As a side effect of the Dormouse related developments some basic FMC Card support, SiT3521 operation, extensions to the HMC7044 CLI command, GTY transceiver support, etc. have been added, which currently wait for MRs to be opened.
In parallel a ZC706 and X310 based White Rabbit implementation has been put together using the PICXO approach, which is used in one of the research projects. The same project received refined GNSS support, which is publicly available as an MR already.
To enhance the accuracy of the AMD devkit based MLE WR nodes an initial absolute calibration session has been carried out together and at KIT.
We also provide a peek into our test infrastructure and an outlook into what we plan to achieve throughout the rest of this year.

Contribution ID: **67** Type: **not specified**

# Discussion and concluding remarks

*Thursday 26 June 2025 16:30 (30 minutes)*

**Presenter:** SERRANO, Javier (CERN)

Contribution ID: **68** Type: **not specified**

# Carrier Class Expectations concerning White Rabbit Development

*Thursday 26 June 2025 11:00 (10 minutes)*

Contribution ID: **69** Type: **not specified**

# Precision Timing over Telecom Networks: A Comparative Study of White Rabbit-PTP and PTP

*Thursday 26 June 2025 10:10 (20 minutes)*

This paper presents the establishment and performance evaluation of White Rabbit (WR-PTP) and Precision Time Protocol (PTP) over a 12 km round-trip optical fiber link based on a telecom network, implemented at the Council of Scientific and Industrial Research –National Physical Laboratory (CSIR–NPL), New Delhi, India. Precise time and frequency synchronization is essential for a wide range of applications, including navigation, power grid management, mobile communications, and scientific research. The objective of this study is to strengthen national capabilities in terrestrial time and frequency transfer by assessing the feasibility and performance of WR-PTP and PTP over existing telecommunication infrastructure. A comparative analysis of both technologies was conducted using a common testbed of telecom network to ensure consistency. The WR-PTP system achieved a time transfer uncertainty of approximately in picoseconds between the Grandmaster and slave nodes, while PTP demonstrated a performance of sub nanoseconds between its Grandmaster and client. This work highlights the potential of both technologies and lays the foundation for future deployment over large-scale Dense Wavelength Division Multiplexing (DWDM)-based telecom networks.

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