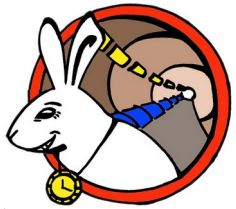
Putting it all together: White Rabbit

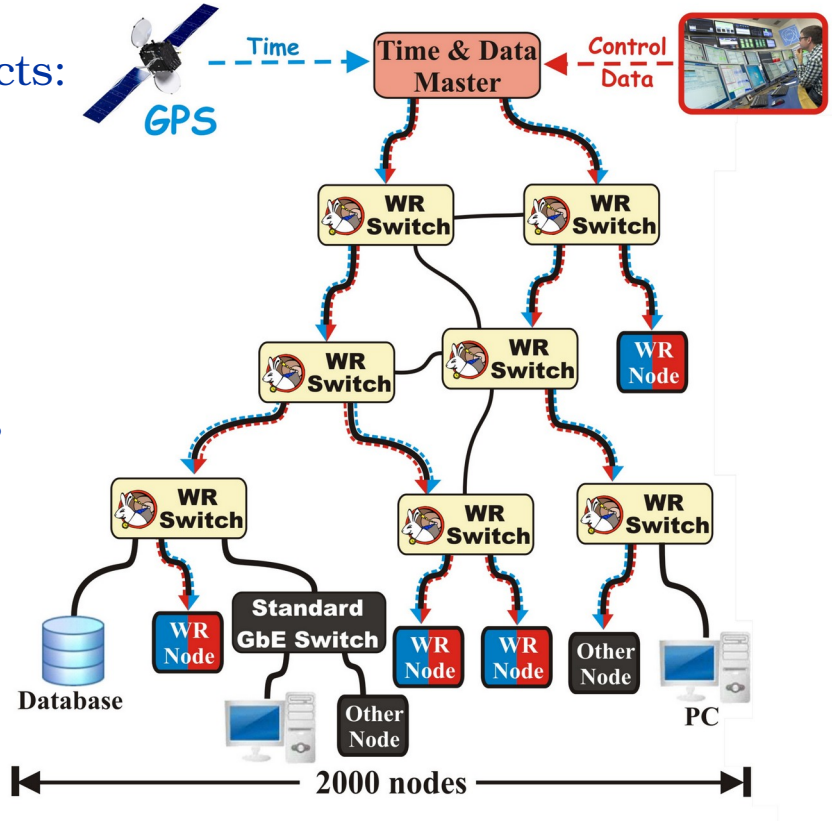


9 May 2025
CERN

Adam Wujek
BE-CEM-EDL

What is White Rabbit?

- Initially meant for Big Physics facilities/projects: CERN, GSI, Nikhef
- Based on well-established standards
  - Ethernet (IEEE 802.3)
  - Bridged Local Area Network (IEEE 802.1Q)
  - Precision Time Protocol (IEEE 1588)
- Extends standards to meet new requirements and provides:
  - Sub-ns synchronisation
  - Deterministic data transfer
- Initial specs: links ≤ 10 km & ≤ 2000 nodes
- Open source and commercially available

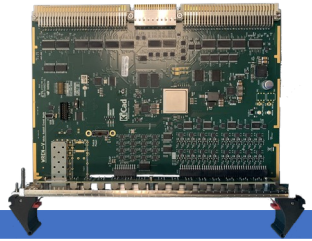


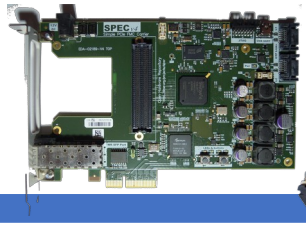
Open **and** commercially available off-the-shelf

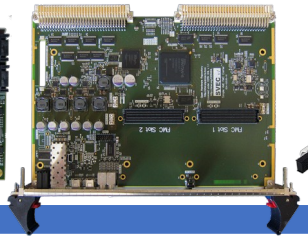
Switch

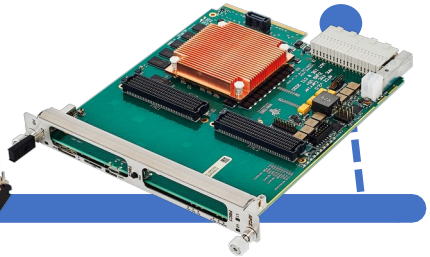
Nodes

WREN-V WREN-Ie SPEC SVEC AFCZ

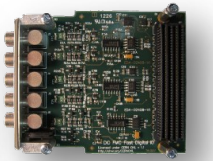


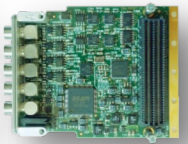






Mezzanines



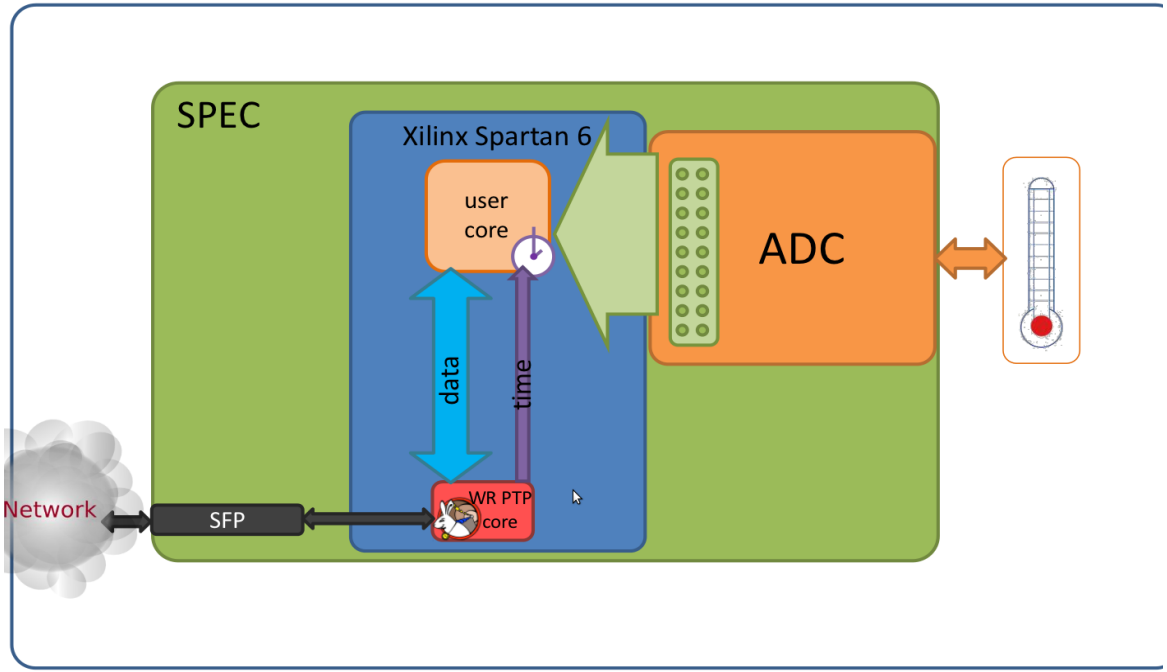


White Rabbit Collaboration (WRC)

- Basic idea:
  - Secure resources to maintain and improve WR Technology from fees of stakeholders
  - Create a platform for collaboration on WR-related developments and applications
  - Facilitate uptake via training materials and dedicated support
- From an idea to reality:
  - 2019: First draft of the idea discussed with industry
  - 2021: KT joins the effort
    - Legal support to draft WRC Terms and Conditions
    - Community coordinator
    - Communications team (movie, LinkedIn campaigns)
    - 2024: Launch with 8 founding members
  - 2025: 19 members and counting

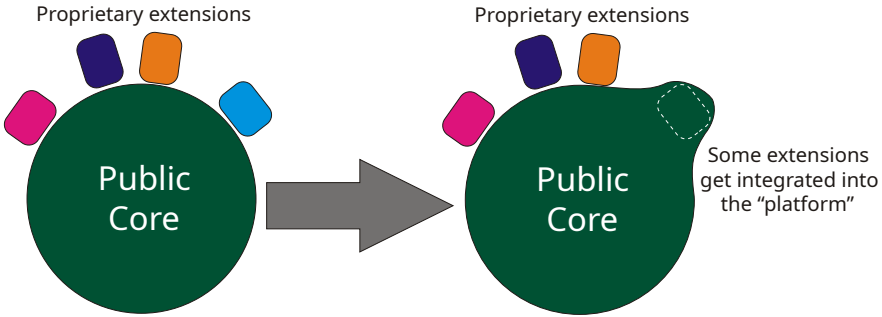
White Rabbit Licensing

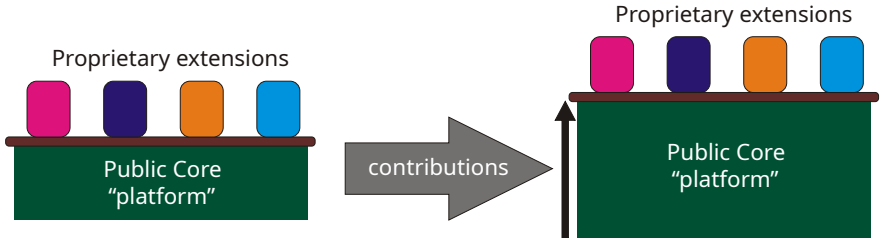
- Reasoning:
  - Weakly reciprocal



White Rabbit Licensing

- Reasoning:
  - Weakly reciprocal
  - To allow proprietary innovation around open-source core
  - To ensure continuous improvements to the core technology





White Rabbit Licensing

Software	Device drivers	GPL-2.0-or-later
	Embedded SW	LGPL-2.1-or-later
	SW Libraries	LGPL-2.1-or-later
	SW Tools	LGPL-2.1-or-later
Gateware	HDL module	CERN-OHL-W-2.0+
	HDL testbench	CERN-OHL-W-2.0+
Hardware	PCB design	CERN-OHL-W-2.0+
	Mechanical design	CERN-OHL-W-2.0+
Other	Documentation	CC-BY-SA-4.0
	Media files	CC-BY-SA-4.0

OHWR, how we use it?

- ohwr.org
  - Created as catalog of open source hardware designs
  - Hosted designs before gitlab/github were available
  - Available to CERN and external users
- Provides:
  - git repositories / wikis / releases / issues / CI
    (moved to gitlab.com)
  - Forum
    - Communication between users/integrators/developers
    - Also users help each other!

OHWR forums

Spanning tree protocol messing with intranet

white-rabbit-dev

avollhar 27d

Hi all,
we would like to integrate the WR Grandmaster and the WR network under it into our intranet, but the spanning tree protocol is interfering with the network (we are almost instantly kicked..). Any ideas how to prevent this from happening? We do not need fiber loops at our premises so we would be even fine with switching off the STP. Maybe setting up VLANs but how exactly should this be done?

ragges 26d

Hi Achim,

What WR grandmaster are you using?
I am not aware of any WR equipment that supports STP, but there of course may be.

I would guess an ordinary WR switch is transparent to STP, so it could be that you have something connected to your WR network talking STP and that then interferes with the network you connect to.

It can also be a security feature in the switch you connect to, perhaps that it detects that there are multiple MAC addresses on the new connection and that is not allowed for policy reasons, or that it detects a loop in your WR network, or something else.

Best regards,
Ragnar

Docker image for building wrpc-sw

white-rabbit-dev

arthur.benemann Feb 16

The following commit has a very basic docker image that contains the required build packages and toolchain:

github.com/arthurbenemann/wrpc-sw

Basic docker image for building wrpc-sw 3

committed Feb 16, 2025 arthurbenemann +55 -0

droddy386 Feb 19

Yes. There is interest. The key interest is in these steps->

USAINZ 28d

Hi there!

I've also developed two containers:

- Package containers/urv-toolchain · GitHub 2
- Package containers/lm32-toolchain · GitHub

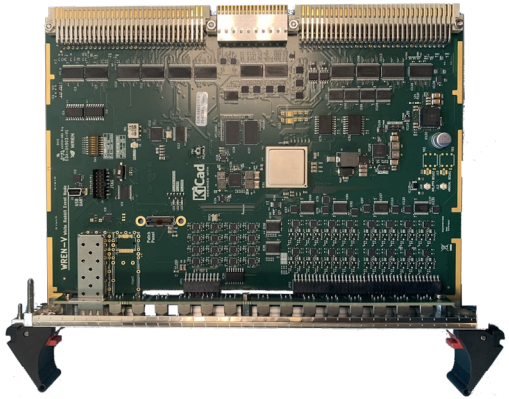
Both are built, published and tested in CI, see Workflow runs · Unike267/Containers · GitHub 1

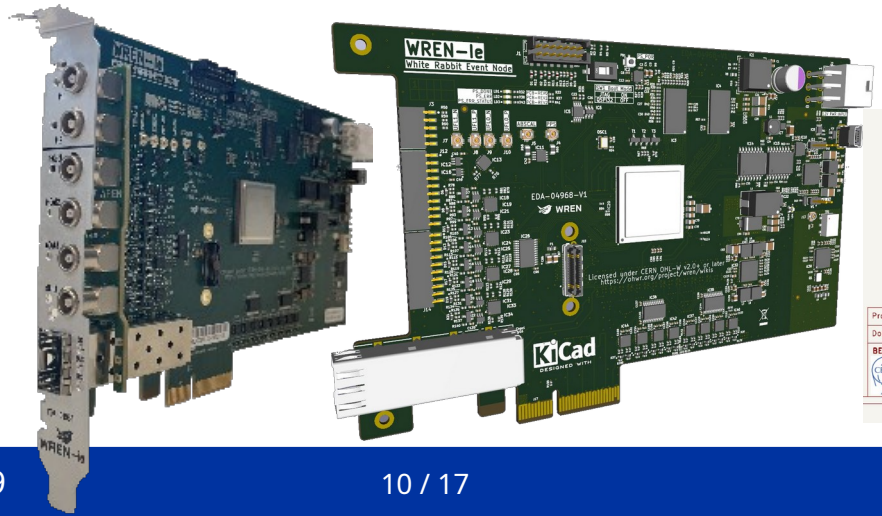
Cheers!

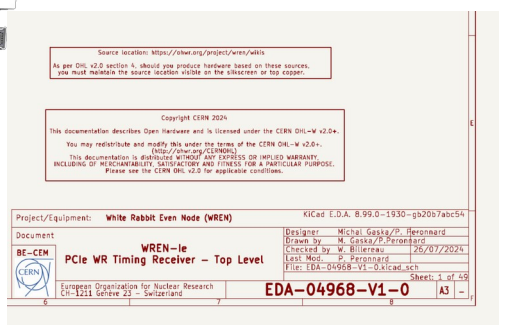
https://forums.ohwr.org/t/docker-image-for-building-wrpc-sw/849396/
https://forums.ohwr.org/t/spanning-tree-protocol-messing-with-intranet/849428

The role of KiCad in WREN design

- Complex SoC-based designs
  - 12 layers, including high-speed differential lines
- To be deployed >1000 in different form factors (PCIe, VME, PXIe)
- Improved KiCad (through KSC) in the process (~10 tickets closed)

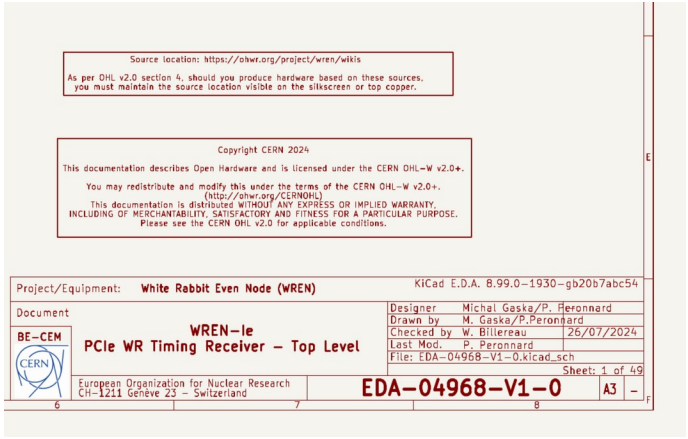






WREN design:
The Role of CERN Electronics Design Office (BE-CEM-EPR)

- Final checks, QA and EDMS#
- ATS-wide HARP (HArdware Review Panel) review, with BE-CEM-EPR participation
- Components procurement
- Production of prototypes (40 units)
- Links to EDMS design files on OHWR


Source location: https://ohwr.org/project/wren/wikis

As per OHL v2.0 section 4, should you produce hardware based on these sources, you must maintain the source location visible on the silkscreen or top copper.

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Project/Equipment: White Rabbit Even Node (WREN)

KiCad E.D.A. 8.99.0-1930-gb20b7abc54

Document

BE-CEM

WREN-Ie

PCIe WR Timing Receiver - Top Level

Designer Michal Gaska/P. Peronnard

Drawn by M. Gaska/P.Peronnard

Checked by W. Billereau 26/07/2024

Last Mod. P. Peronnard

File: EDA-04968-V1-0.kicad_sch

Sheet: 1 of 49

European Organization for Nuclear Research CH-1211 Genève 23 – Switzerland

EDA-04968-V1-0

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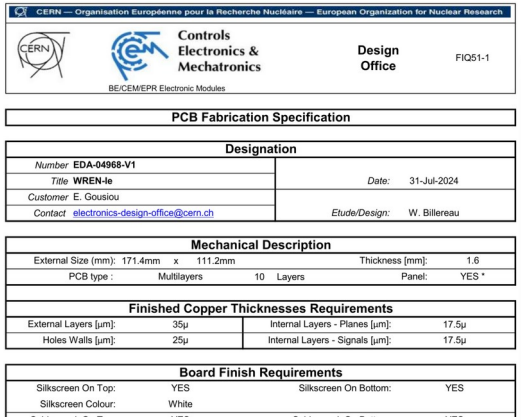

CERN — Organisation Européenne pour la Recherche Nucléaire — European Organization for Nuclear Research

Controls Electronics & Mechatronics

BE/CEM/EPR Electronic Modules

Design Office

FIQ51-1

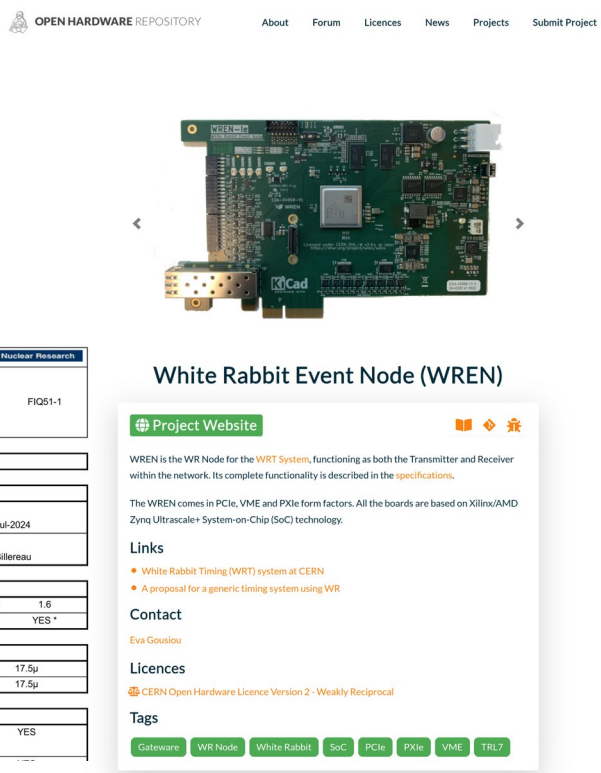
PCB Fabrication Specification

Designation	
Number EDA-04968-V1	
Title WREN-Ie	Date: 31-Jul-2024
Customer E. Gousiou	
Contact electronics-design-office@cern.ch	Etude/Design: W. Billereau

Mechanical Description					
External Size (mm):	171.4mm x 111.2mm		Thickness [mm]:	1.6	
PCB type :	Multilayers	10 Layers	Panel:	YES *	

Finished Copper Thicknesses Requirements			
External Layers [µm]:	35µ	Internal Layers - Planes [µm]:	17.5µ
Holes Walls [µm]:	25µ	Internal Layers - Signals [µm]:	17.5µ

Board Finish Requirements			
Silkscreen On Top:	YES	Silkscreen On Bottom:	YES
Silkscreen Colour:	White		

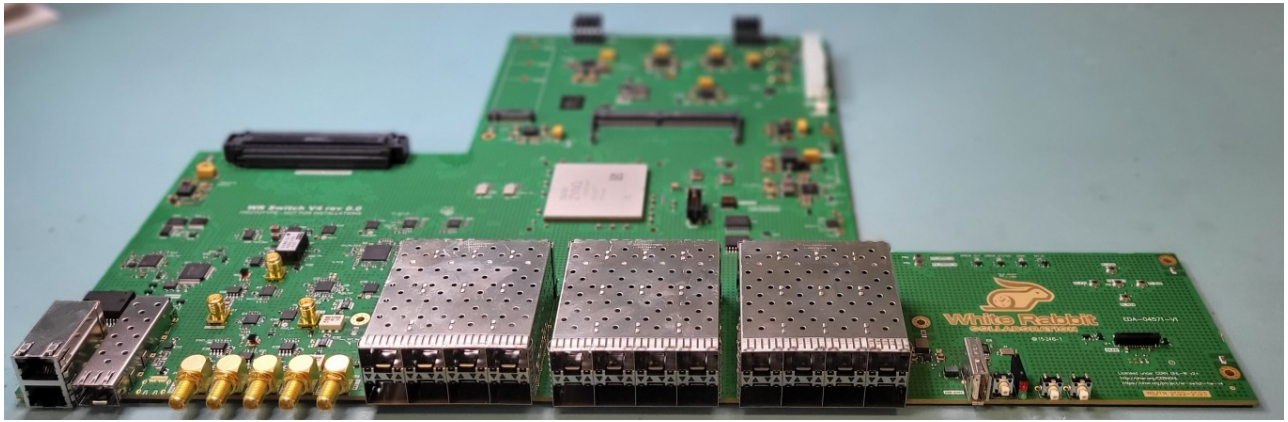


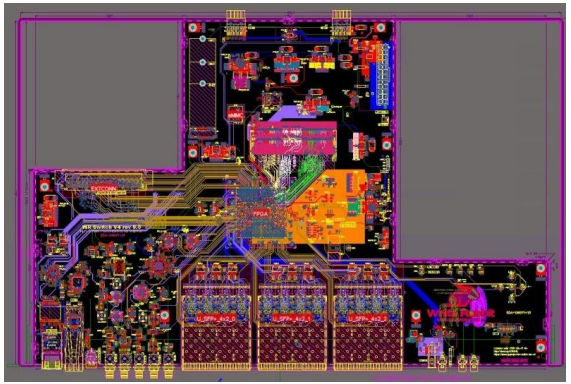
WREN design: The Role of WRC

- Several interested paries:
  - Providers
  - Users
- Target: generalize the CERN design for other facilities as the WR node for a generic Event-based Timing System

WR Switch v4 design

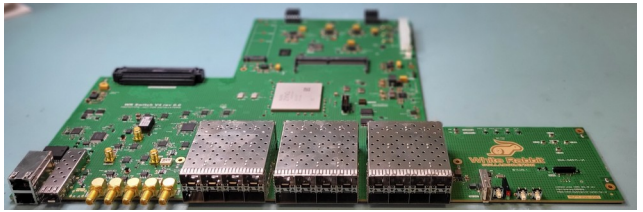
- Altium Design – highly complicated
  - 24 x 10Gbps, 10 x 25Gbps links, 16 layers, large physical size, blind vias, megtron substrate
  - Using CERN Altium libraries





WR Switch v4 design and the Role of CERN electronics design office (BE-CEM-EPR)

- Altium Design – highly complicated
  - 24 x 10Gbps, 10 x 25Gbps links, 16 layers, large physical size, blind vias, megtron substrate
  - Using CERN Altium libraries
- CERN electronics design office (BE-CEM-EPR) role
  - Major contribution to layout design, QA and EDMS#
  - Reviews
  - Coordination with mechanical design
  - Component procurement, technological check
  - Production of prototypes (6 units)
- Outsourced: schematic and mechanical design, simulations
- WRC role:
  - Specifications, management and reviews
  - Additional functionality through an Expansion board



Procurement

- Possible to buy “the same” hardware from multiple companies
  - Unusual case
  - Improve product availability
  - Diversification of supplies and splitting the bid
  - No vendor lock-in
- You get exactly what you want (your open source design)
- Design typically becomes commercial-off-the-shelf
  - Easier to buy more later
  - Product available for other users

Future

- We're happy with the model we use
  - Keep current collaboration model with CERN electronics design office (BE-CEM-EPR) & industry
- Share our experience with others who want to implement the same model
- Boost KiCad tool even more and use it for all designs
- Work with commercial vendors to provide Timing System based on White Rabbit
  - WREN
  - WRS
- 14th White Rabbit Workshop 25-26 June 2025 https://indico.cern.ch/event/1524513/

Questions?