

# Open source software, Open source hardware

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CERN, Geneva, Switzerland

Physics Meets Blockchain  
2nd Discussion Workshop  
Geneva, 11 July 2018

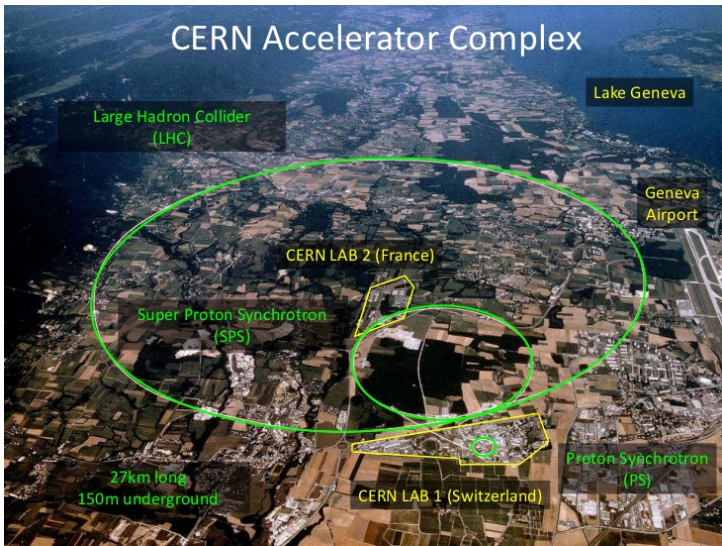
# Outline

- 1 Introduction to CERN
- 2 Introduction to Open Source Hardware
- 3 Open Source Hardware in practice
- 4 How to get organised

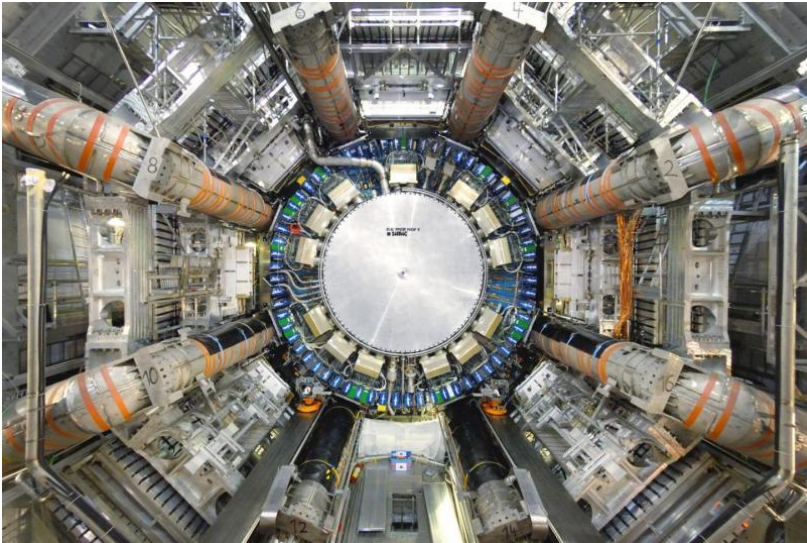
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# Accelerators



# Detectors



# Dissemination



# How to interpret one's dissemination mandate in the 21<sup>st</sup> century

**World Wide Web**

Free and Open Source Software

Open Hardware

Open Data

Open Access

open source

Open Hardware Repository

INSPIRE

An Updated Historical Profile of the Higgs Boson

John Ellis (Imperial Coll London & CERN), Mary K. Gaillard (J.R. Berkeley & UC Berkeley), Dmitry V. Nikolaev (CERN & I.H.E.P., Villefranche & Moscow, Australia)

Apr 27, 2015 - 32 pages

INCL-Ph-TH-2015-02, LCTP-2015-10, CERN-Ph-TH-2015-086  
e-Print arXiv:1504.02217 [hep-ph] | PDF

CERN DD/OC  
Information Management: A Proposal  
Tim Berners-Lee, CERN, DD  
March 1989

Information Management: A Proposal  
Abstract

This proposal examines the management of general information about motivation and requirements at CERN. It discusses the problems of loss of information about complex prototyping systems and derives a solution based on a distributed hypertext system.

Keywords: Hypertext, Computer conferencing, Database retrieval, Information management, Project control

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# Why we use Open Hardware

## Design re-use

- When it's Open, people are more likely to re-use it.
- When it's Open, people are much more likely to contribute.

## Peer review

- Get your design reviewed by experts all around the world.
- Therefore the designs will become better.

## Dissemination of knowledge

- One of CERN's key missions!

# Why we use Open Hardware

## Get a design just the way we want it

- We specify fully the design.

## Healthier relationship with companies

- No vendor-locked situations. Companies selected solely on the basis of technical excellence, good support and price.

## Spend money where you or your funding agencies want

- Makes life easier for public institutions.
- Opens the door to smaller companies with good local support.

# There is an Open Source Hardware definition!

Check out <http://www.oshwa.org/definition/>

- Inspired by the Open Source definition for software.
- Focuses on ensuring freedom to *study, modify, distribute, make and sell* designs or hardware based on those designs.
- Now we know exactly what we mean when we say OSHW!

# CERN Open Hardware License – [ohwr.org/cernohl](http://ohwr.org/cernohl)

## Provides a solid legal basis

- Developed by Knowledge and Technology Transfer Group at CERN.
- Open Software licences not usable (GNU, GPL, ...).

## Practical: makes it easier to work with others

- Upfront clear: anything you give is available to everyone.
- Everyone can use it for free.
- No strings attached. *Really!*

# CERN Open Hardware License – [ohwr.org/cernohl](http://ohwr.org/cernohl)

## Same principles as Open Software

- Anyone can see the source (design documentation).
- Anyone is free to study, modify and share.
- Any modification and distribution under same licence.
- Persistence makes everyone profit from improvements.

## Hardware production

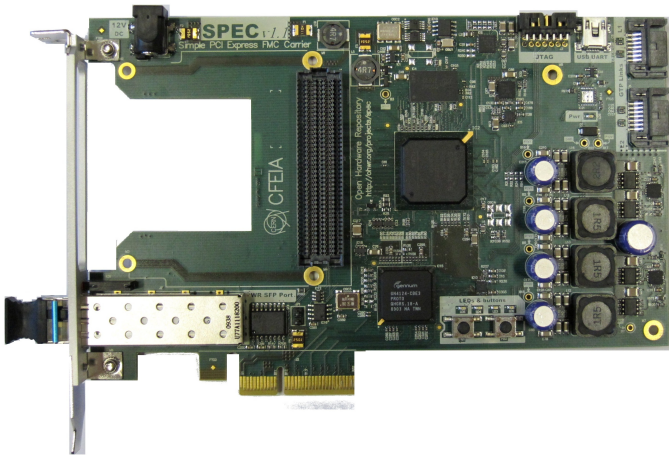
- When produce: licensee is invited to inform the licensor.

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# Example: SPEC - Simple PCI Express FMC carrier

Made in Spain, The Netherlands, Greece & Poland



# Example of a project in the Open Hardware Repository – ohwr.org

Simple PCIe FMC carrier (SPEC) OPEN HARDWARE REPOSITORY

«

- Overview
- Activity
- Mailing List
- Roadmap
- Work packages
- News
- Repository
- Wiki
- Members
- Documents
- Project settings

## Overview

### Project description

A simple 4-lane PCIe carrier for a low pin count FPGA Mezzanine Card (VITA 57). It supports the White Rabbit timing and control network. Commercially available. Linux and Labview drivers available for some mezzanine cards.  
[More info at the Wiki page](#)

Edit

### Members

Manager: Erik van der Bij; Javier Serrano; Matthieu Cattin; Tomasz Wlostowski  
Developer: Alessandro Rubini; Benoit Rat; Carlos Gil Soriano; Federico Vaga; Grzegorz Daniluk; Grzegorz Kasprowic; Mar Brückner; Ralf Wischniewski; Samuel Iglesias Gonsálvez  
Reporter: Cesar Prados; Dietrich Beck

Member View all members

### Project details

- Subprojects: [Getting Started with the SPEC](#), [Simple PCIe FMC carrier \(SPEC\)](#) - Software, [SPEC box 1 Node](#), [SPEC Box 3 Nodes \(Rack 19"\)](#)

### Latest news

[SPEC Fan design files released](#)



# Be Open

## Use OHR to the fullest

- Document everything on OHR:
  - schematics, mechanics, status.
- Discuss over mailing list. Already from start of project.
- Document design review results.
- Track Issues and detected bugs.

## Don't be afraid to show mistakes!

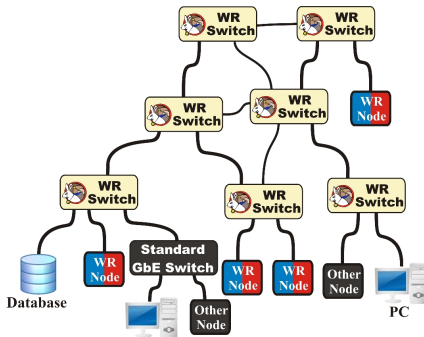
- E.g. SPEC: 86 Issues documented, 40 still 'Open'.
- Issues may help others when adapting a design.
- OHR becomes a teaching tool.

# White Rabbit – Innovation with Open approach

- Hardcore innovation.
- An enabling technology.
- Started at CERN and GSI high-energy physics labs.
- Everything Open: hardware, gateware, software.
- Made extensive use of small companies to develop.
- Companies develop and sell products based on it.

# White Rabbit – is Ethernet

- Bandwidth: 1 Gbps
- Single fiber medium
- Up to 10 km links
- WR Switch: 18 ports
- Ethernet features (VLAN) & protocols (SNMP)
- **Synchronization:**
  - accuracy better than 1 ns
  - precision (tens of ps sdev skew max)



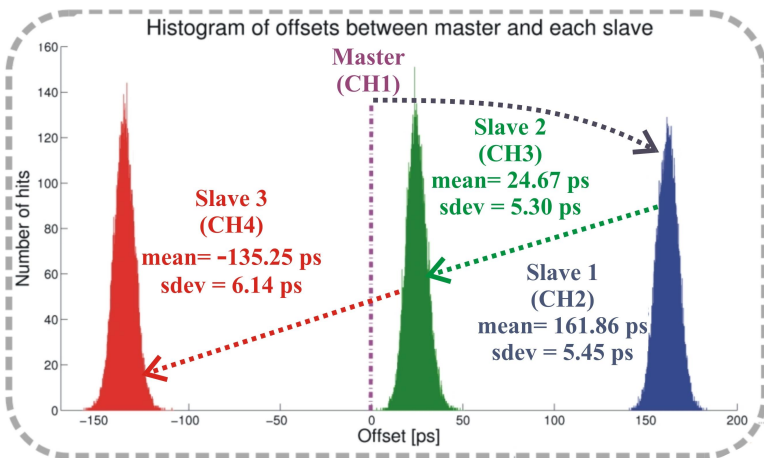
# WR time transfer performance: lab tests

## 3 cascaded switches



# WR time transfer performance: lab tests

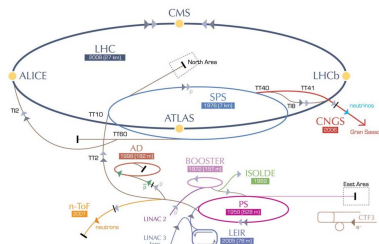
## 3 cascaded switches



# White Rabbit applications

- Particle accelerators
  - CERN (Switzerland/France)
  - GSI (Germany)

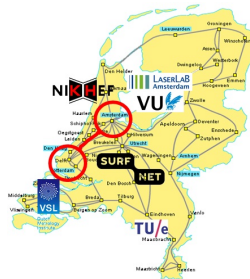
CERN's accelerator complex



# White Rabbit applications

- Particle accelerators
  - CERN (Switzerland/France)
  - GSI (Germany)
- Cosmic ray & neutrinos detectors
  - **LHAASO (China)**
  - **HiSCORE (Siberia)**
  - **KM3NET (Mediterranean)**
- Metrology laboratories
  - **MIKES (Finland)**
  - **VSL (Netherlands)**

## Dutch Metrology Institute



**All users:** [www.ohwr.org/projects/white-rabbit/wiki/WRUsers](http://www.ohwr.org/projects/white-rabbit/wiki/WRUsers)

# How can this map to your project?

What could be your “killer app”?



# Business models

Dispelling the commercial vs open myth

	Commercial	Non-commercial
Open	<b>Winning combination. Best of both worlds.</b>	Whole support burden falls on developers. Not scalable.
Proprietary	Vendor lock-in.	Dedicated non-reusable projects.

# Where the rubber meets the road

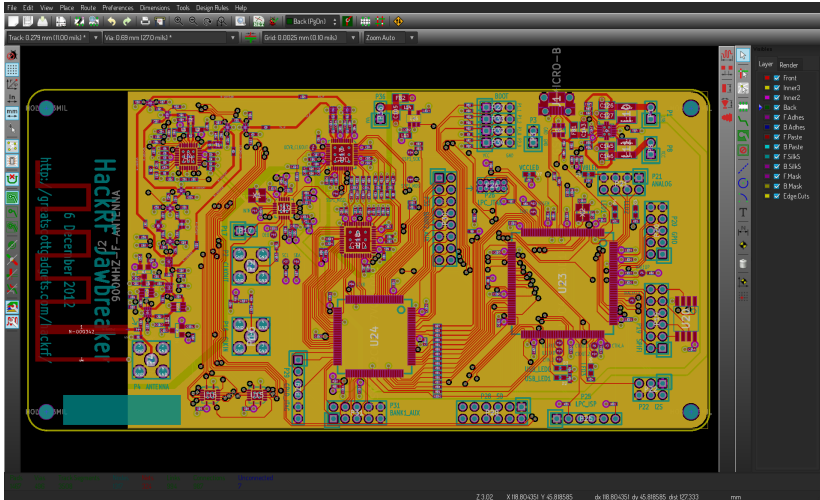
## Eight years of experience at CERN

The collage consists of four overlapping screenshots from different websites:

- Top Left:** SEN Solutions website showing a product page for "WR Switch (18/8 SFPs)". It describes the White Rabbit Switch (WRS) as a key component for precision timing and high synchronization over Ethernet. It lists two standalone SFP versions and main features like Virtex-6 FPGA, ARM, and Ethernet ports.
- Top Right:** INCAA website showing a product page for "4ch 105 Mps 30 MHz 14 bit ADC". It features a 4 channel FMC ADC module with a max sample rate of 105 Mps and analog bandwidth of 30 MHz. It includes a list of features and a photograph of the ADC module.
- Bottom Left:** janztec website showing a product page for a "Simple VME FMC Carrier". A physical image of the carrier is overlaid on this section. The carrier is green with a white label that includes "QC Pass 11/13/105", "JC", "Simple VME FMC Carrier", "VME 105", "40-PIN-SFP", "1000000000", and "HCCV010".
- Bottom Right:** CERN TECH website showing a product page for a "Simple PCIe FMC carrier (SPEC)". It features a large graphic with the text "Create the Impossible" and a list of product variants. A physical image of the carrier is also shown.

# Free-as-in-freedom design tools

The last hurdle to efficient sharing - kicad-pcb.org



# Free-as-in-freedom design tools

Example: similar case in the Quantum Engineering community?

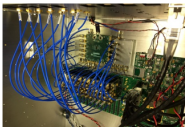
## Tools should be free and open to be able to share

- Simulation tools
- Control software
- Data processing tools
- Quantum Information Software

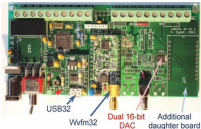
# Hardware for quantum engineering projects

Duplication of effort: different labs build similar equipment

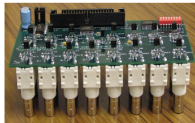
DDS



DAC



Digital IO



AOM driver



slide courtesy of G.Kasprowicz

# Quantum engineering project: Sinara

Open source hardware for quantum applications

## Sinara - [github.com/m-labs/sinara/wiki](https://github.com/m-labs/sinara/wiki)

- Open-source hardware ecosystem designed for use in quantum physics experiments running ARTIQ control software.
- All design files, sources, mechanics, documentation published.
- Project shared under OHL, managed using github.

## International collaboration

- Institutes: NIST Boulder, UMD, ARL, Warsaw WUT, Oxford University, Uni Hannover, PTB
- Industry: Mlabs, Quartiq, Creotech, Technosystem

# Sinara hardware

Licensed under CERN OHL

- DDS (MTCA octal 2.4GS/s, Eurocard quad 1GS/s ). Flexible analog front-ends
- ADC (MTCA octal 125MS/s, Eurocard octal 1MS/s)
- DAC (MTCA, Eurocard 32channel )
- Digital IO (BNC, SMA, LVDS)
- Deterministic real time controller (sub ns)
- Slow control VHDCI breakout
- Camera Link,
- Clock distribution
- 8 channel RF amplifier for AOM
- Many other modules in development (Piezo drivers, HV supplies, temperature controllers, magnetic field stabilisers)
- Control software (ARTIQ:<https://m-labs.hk/artiq/>) written mostly in Python including FPGA HDL, GPL



# Quantum engineering project: Easy $\Phi$

Open source hardware for quantum applications

## Easy $\Phi$ - [easy-ph.ch](http://easy-ph.ch)

- Easy  $\Phi$  is a platform aiming at physicists.
- Developed for the needs of quantum optics, usable for applications in physics or biology.
- Open standard platform.

## Single institute, but Open

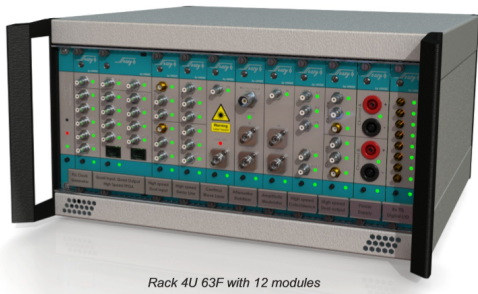
- University of Geneva
  - Group of Applied Physics in Optics



# Easy $\Phi$ hardware

Licensed under CERN OHL

- Dual High-Speed Universal Input
- Dual High-Speed Universal Output
- Dual High-Speed Delay Line
- High speed coincidence
- Thermocouple temperature measurement
- Optical amplitude modulator
- ...



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# Public institutions

They serve the interests of a whole society

- Try to maximise positive impact of decisions.
- Not always easy.

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## Can be “tractor” institutions

- To help take projects to a mature state where they can be sustained commercially.
- Liaising with other public institutions to reach critical mass.
- Also with their procurement hat.

# The funding agencies conundrum



# Issues with “coopetition”

Research groups sometimes end up behaving as private companies (but with public money!) because of wrong incentives by funding agencies.

# The power of getting organised

Look at Open Hardware, Open Access. . . even CERN itself!  
These things looked highly improbable before people got  
organised to make them happen.

# Check out zenodo.org!

## Why?

- Science cannot be open without open data ...
  - ... and software and hardware
- Avoid double pay for tax payers
- Makes sharing research very easy!



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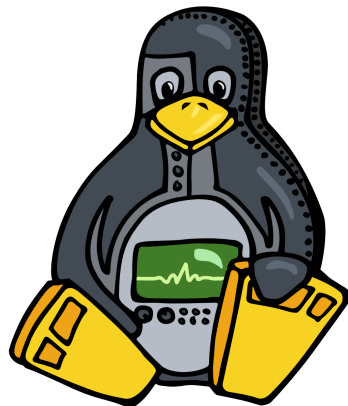
## How?

- Open attitude from day 1
- Communities of interest in Zenodo
- Involving key commercial and non-commercial actors from the start

# OpenX

## How to get organised

- Open Hardware
- Open Software
- Site to collaborate
- Coordination
- Need for a “Tractor” institution?



# So, how can the OpenX Community get organised?

