Open Source Hardware at CERN

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CERN, Geneva, Switzerland

Open Science: CERN perspectives
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Outline

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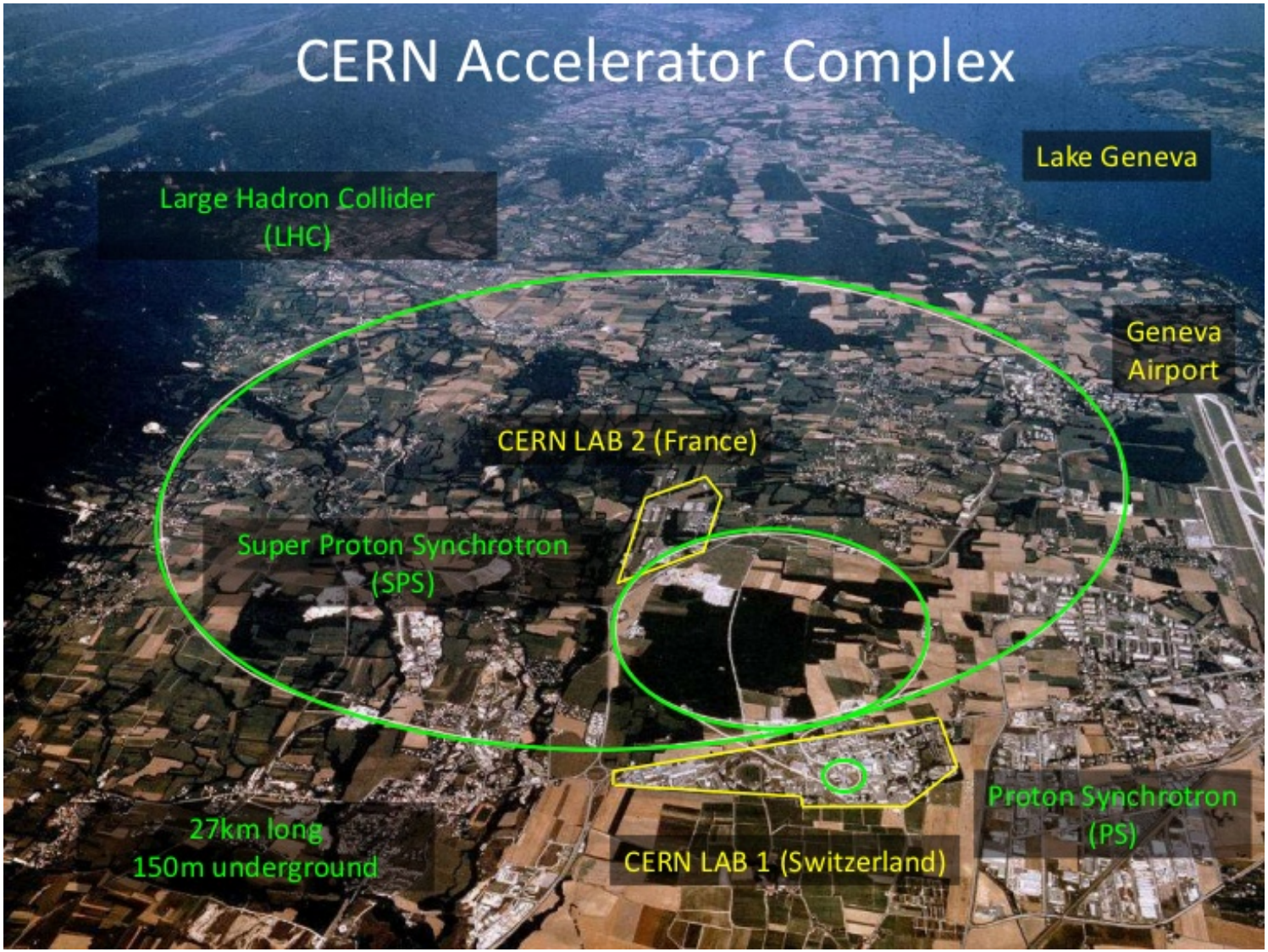
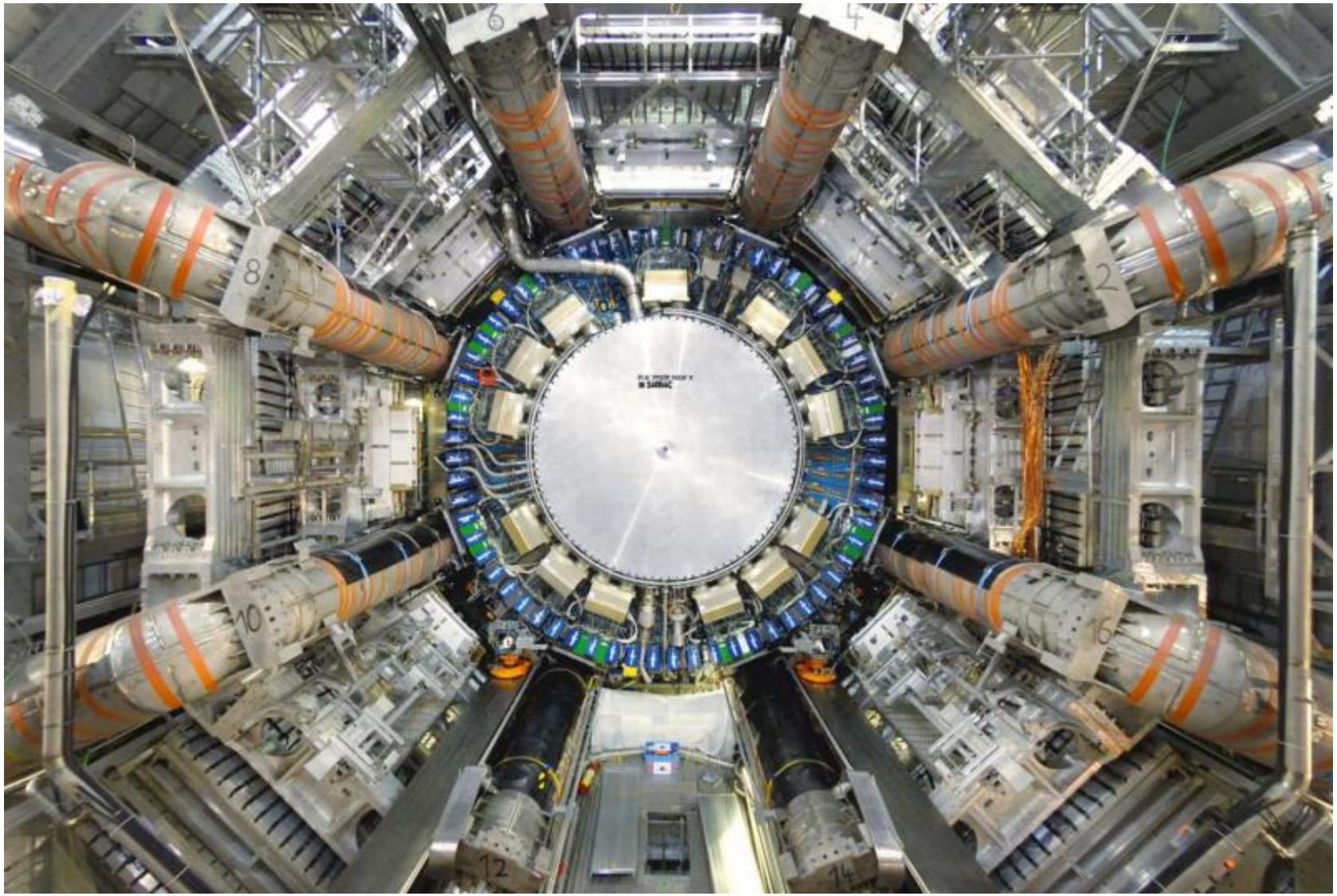
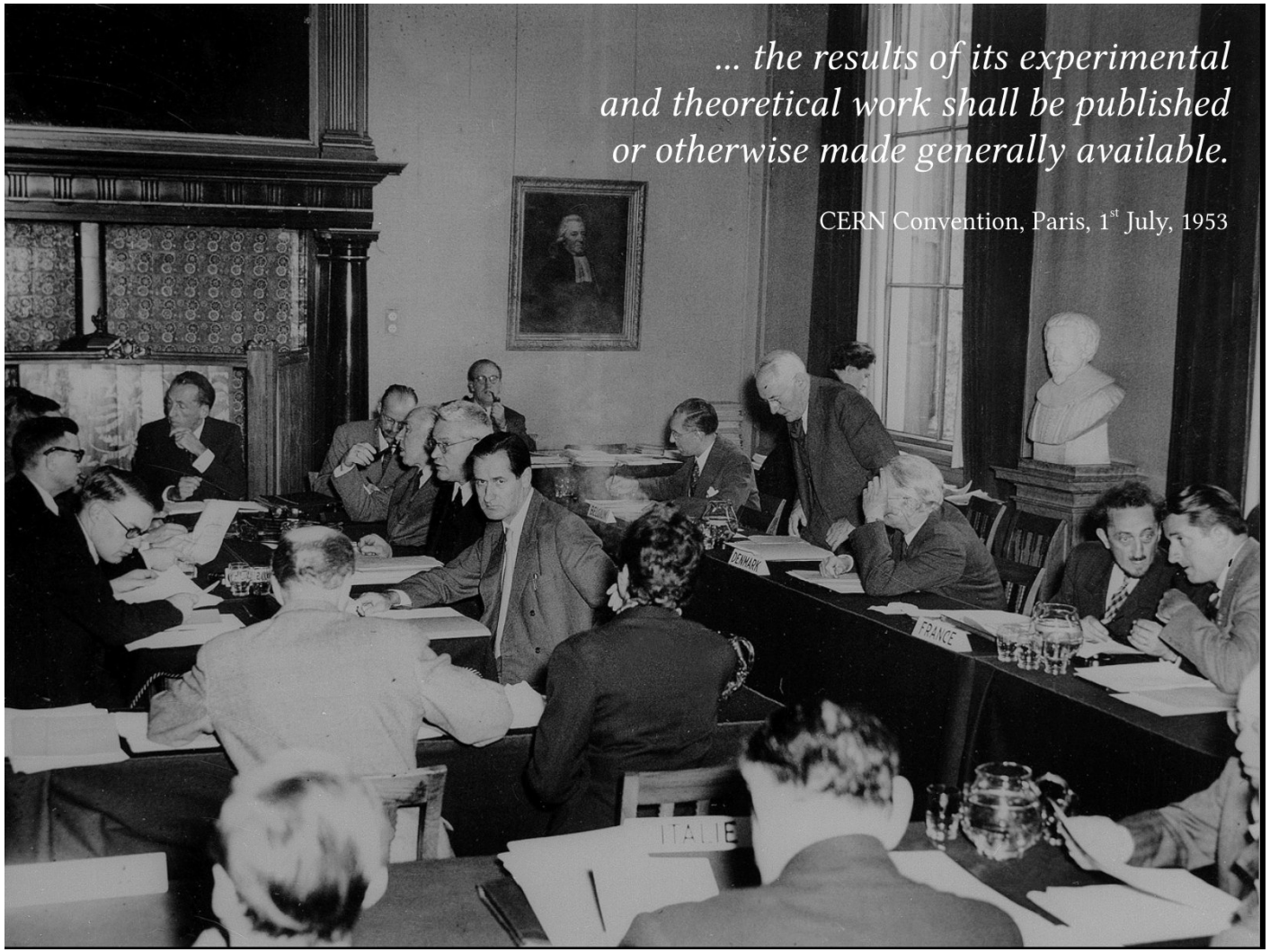
Accelerators



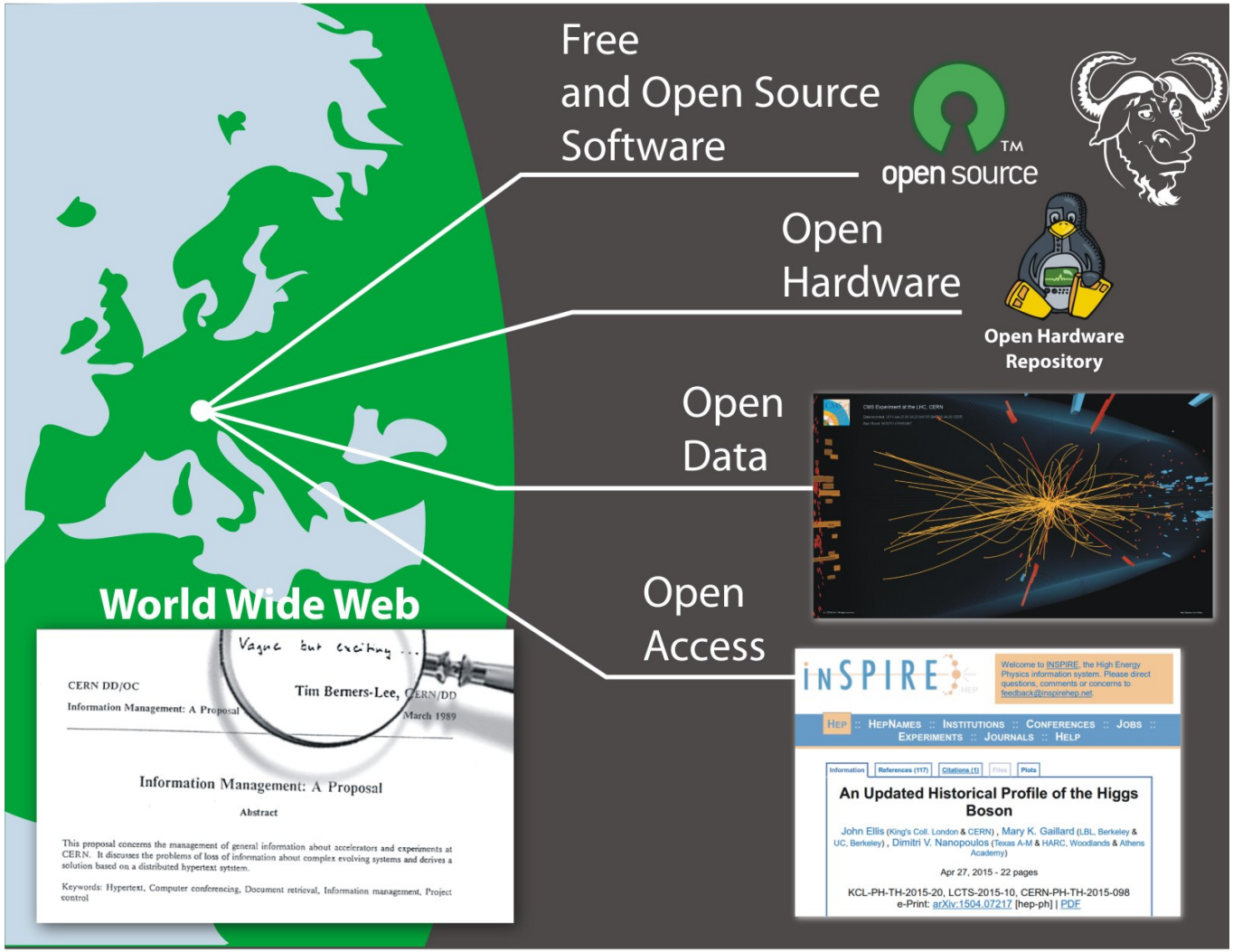
Detectors



Dissemination



How to interpret one's dissemination mandate in the 21st century



Outline

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

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

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.

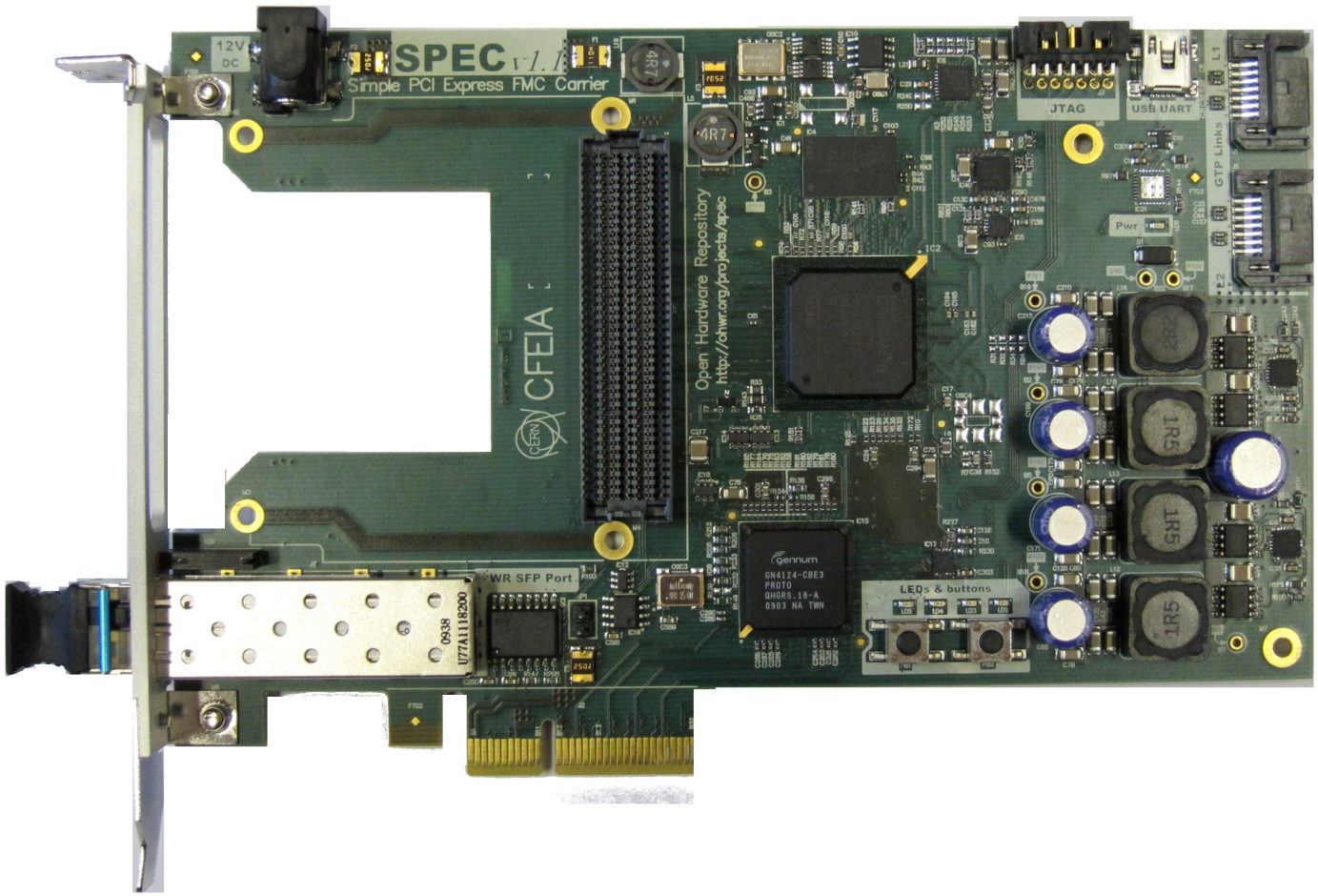
Hardware production

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

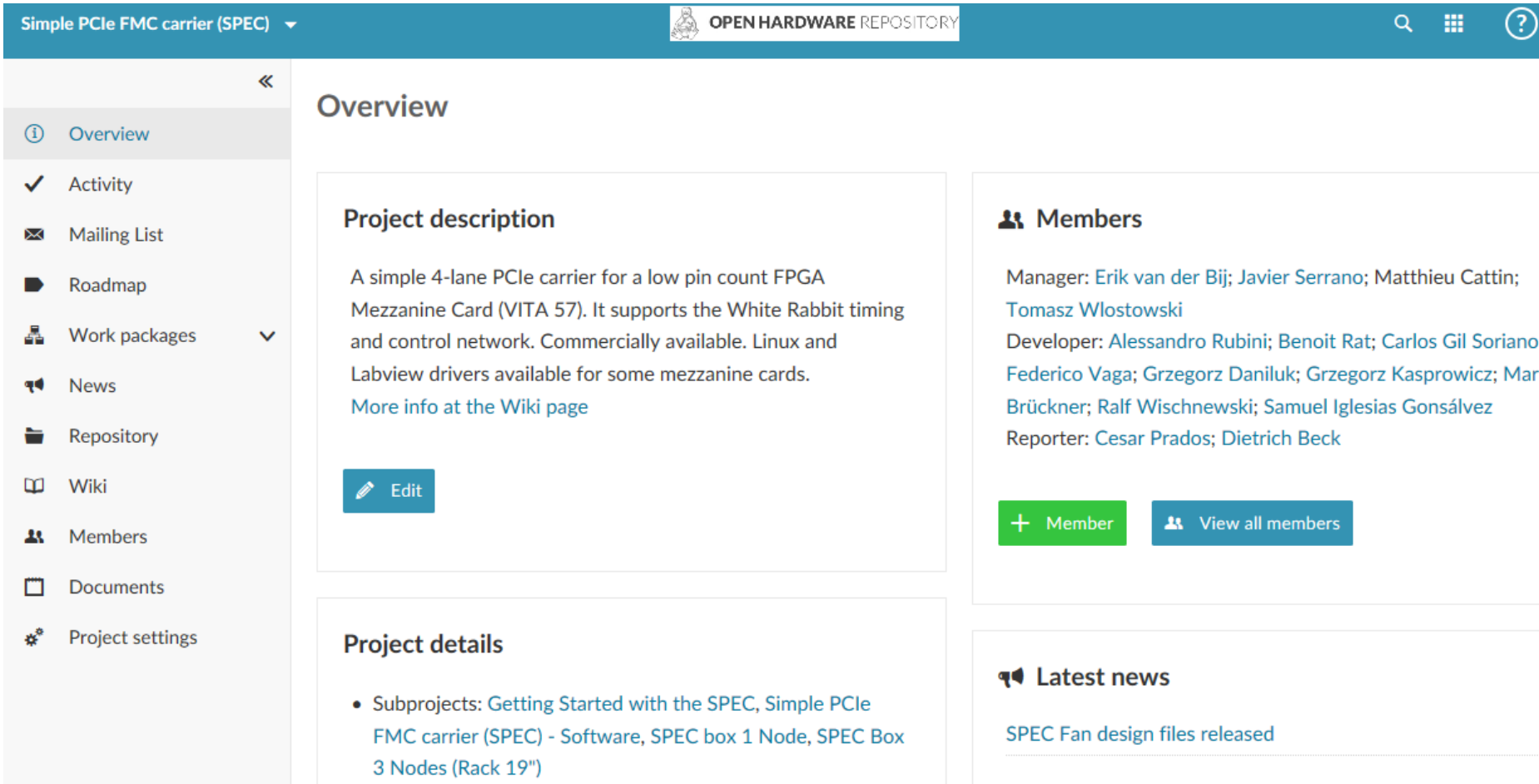
Outline

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



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!

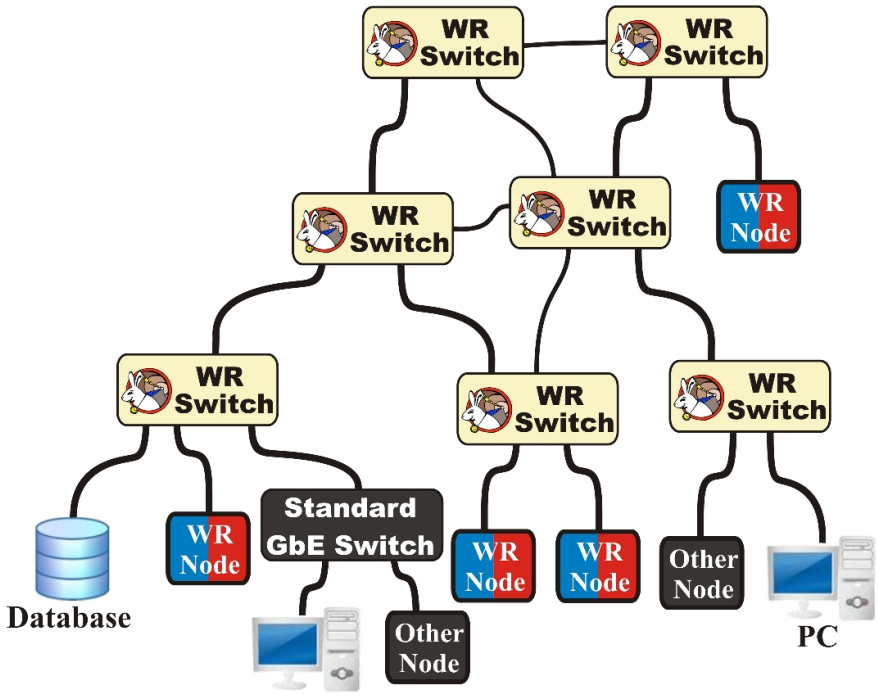
- E.g. SPEC: 86 Issues documented, 40 still 'Open'.
- Issues may help others when adapting a design.
- OHR becomes a teaching tool.

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

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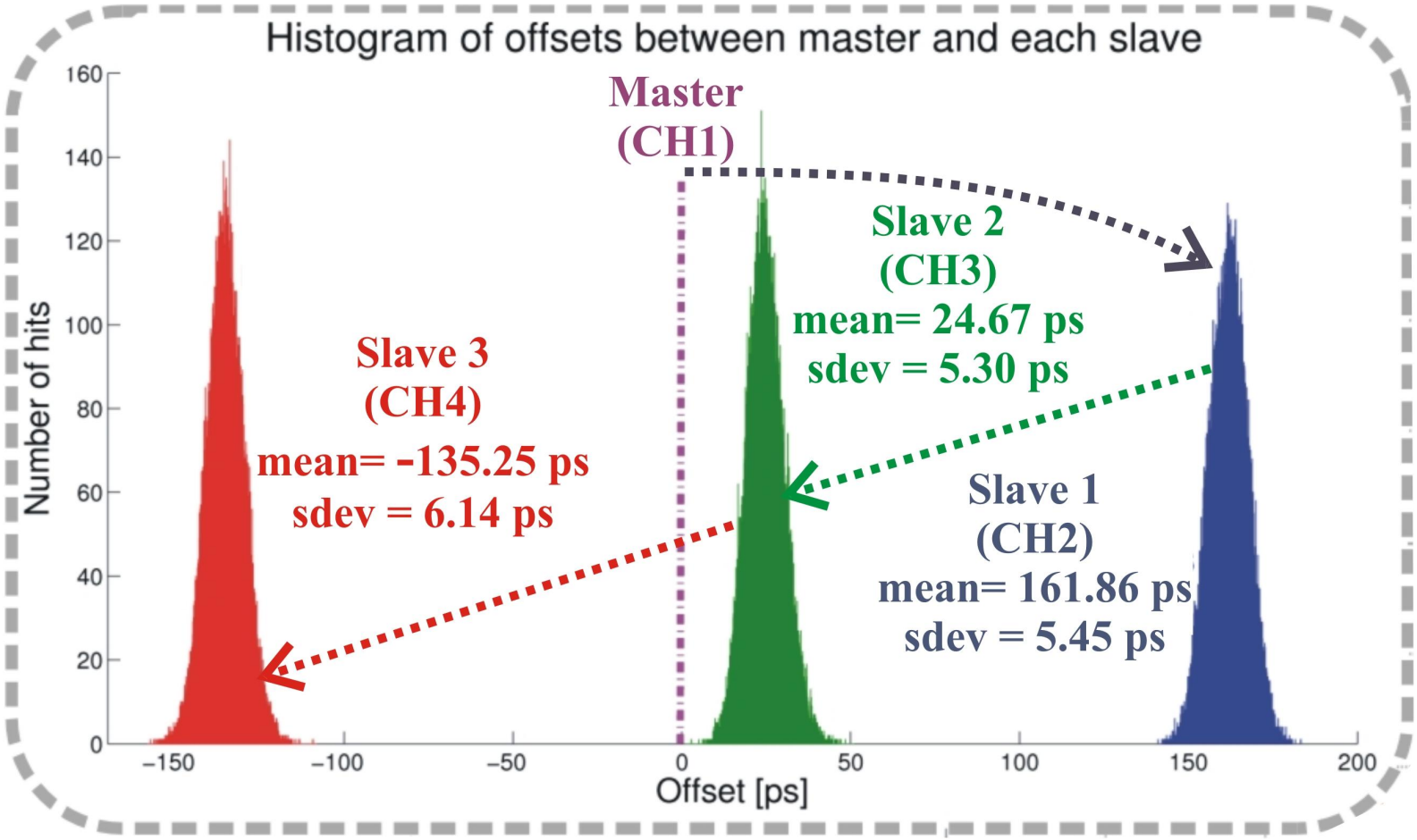
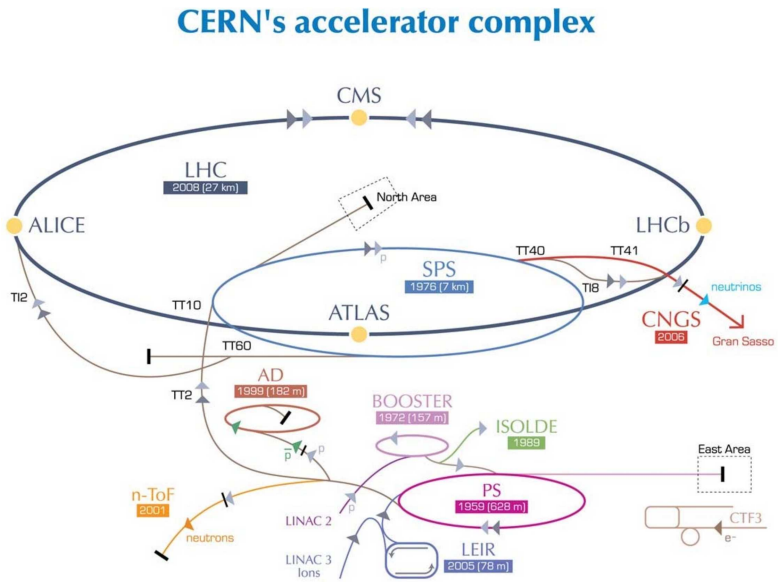
3 cascaded switches



White Rabbit applications

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



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`

How can this map to your project?

What could be your “killer app”?

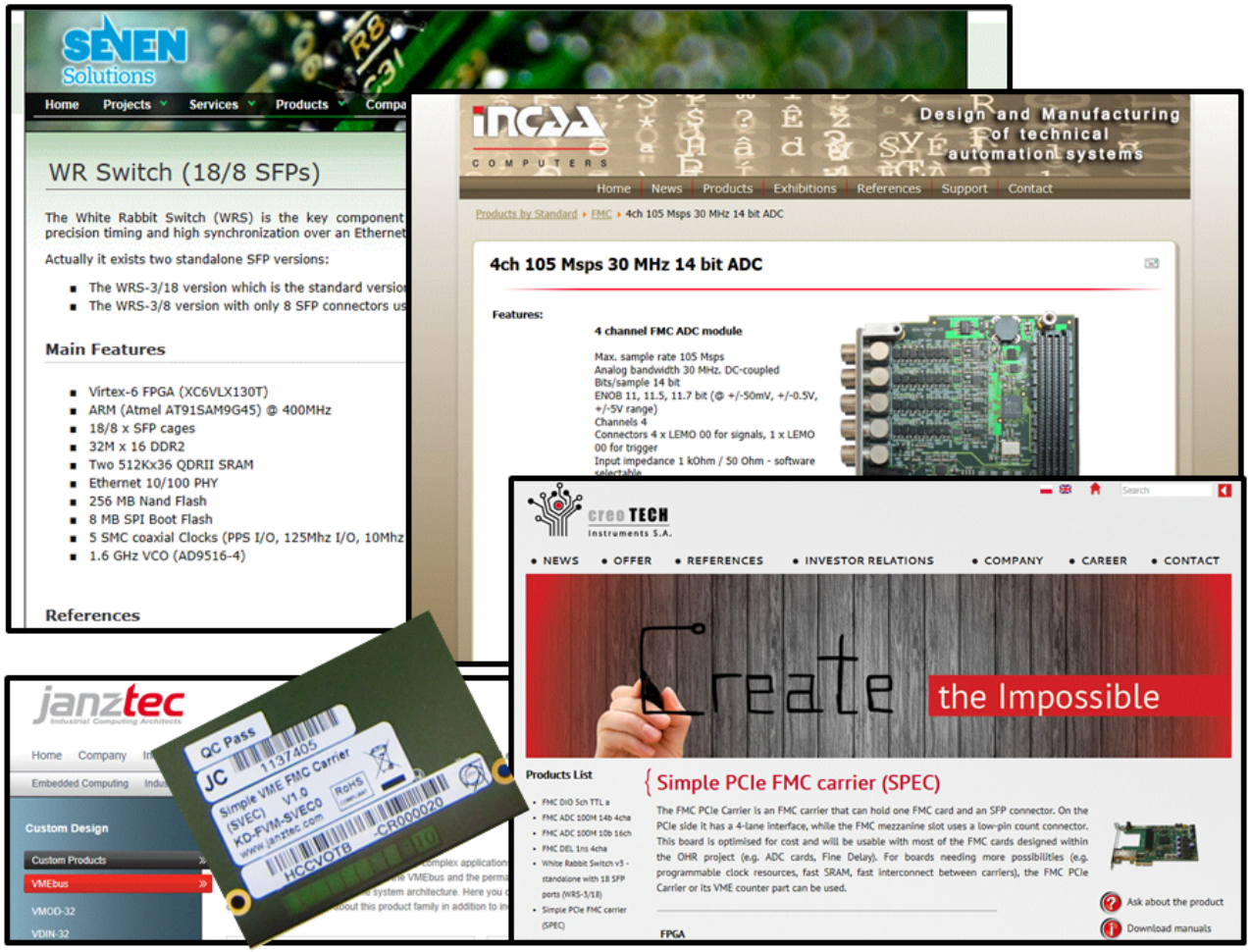
Business models

Dispelling the commercial vs open myth

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

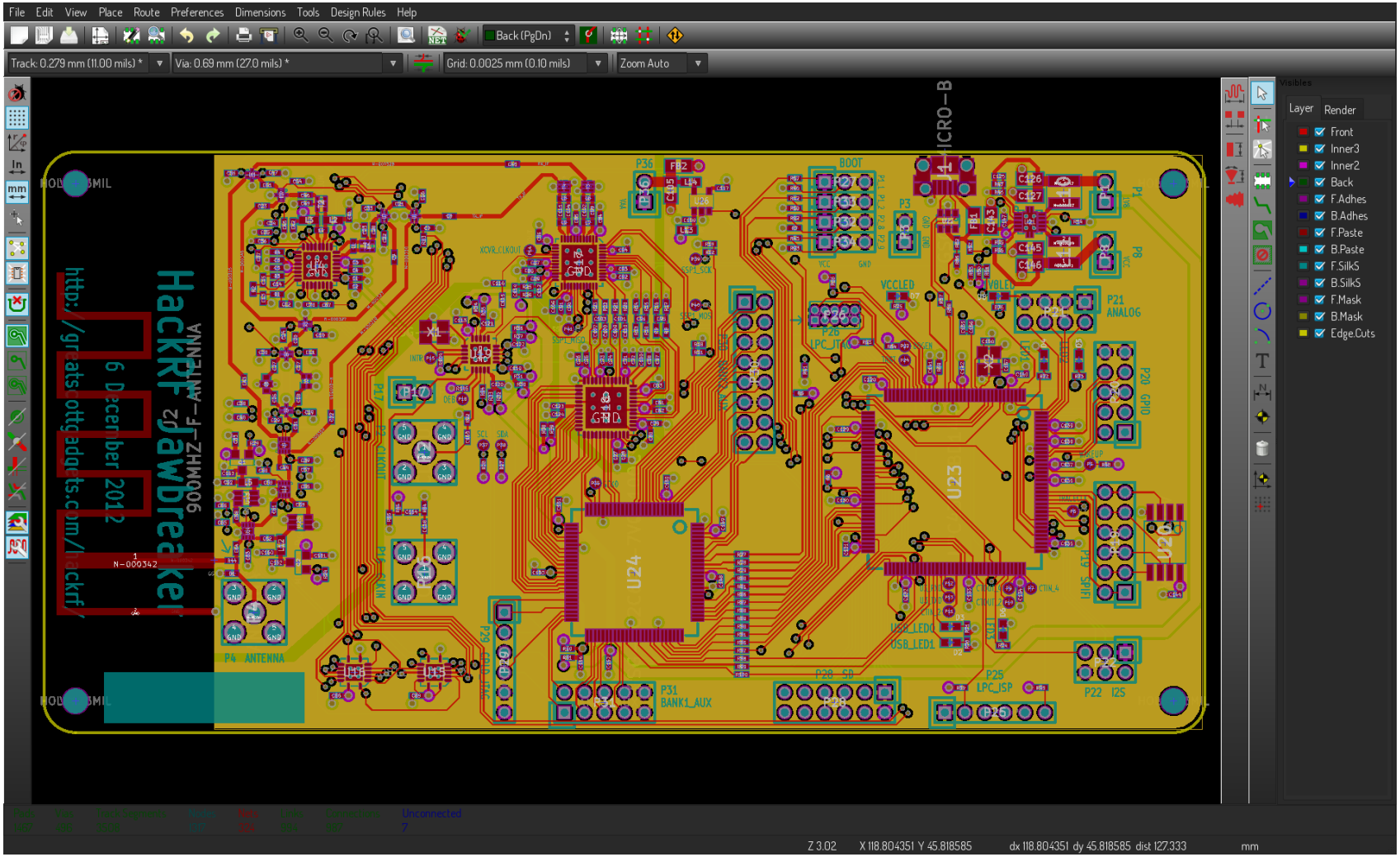
Where the rubber meets the road

Eight years of experience at CERN



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?

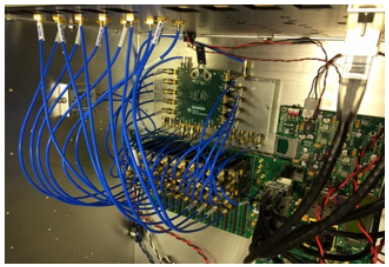
Tools should be free and open to be able to share

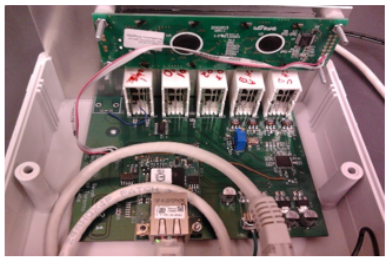
- Simulation tools
- Control software
- Data processing tools
- Quantum Information Software

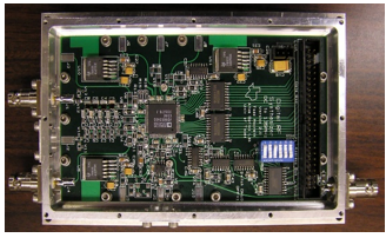
Hardware for quantum engineering projects

Duplication of effort: different labs build similar equipment

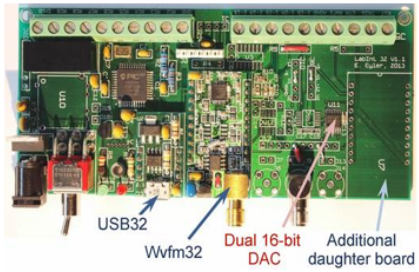
DDS



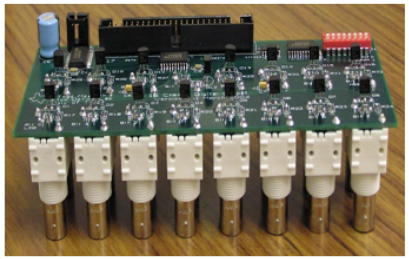




DAC



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

- 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

Licenced 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 Φ

Open source hardware for quantum applications

Easy Φ - easy-ph.ch

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

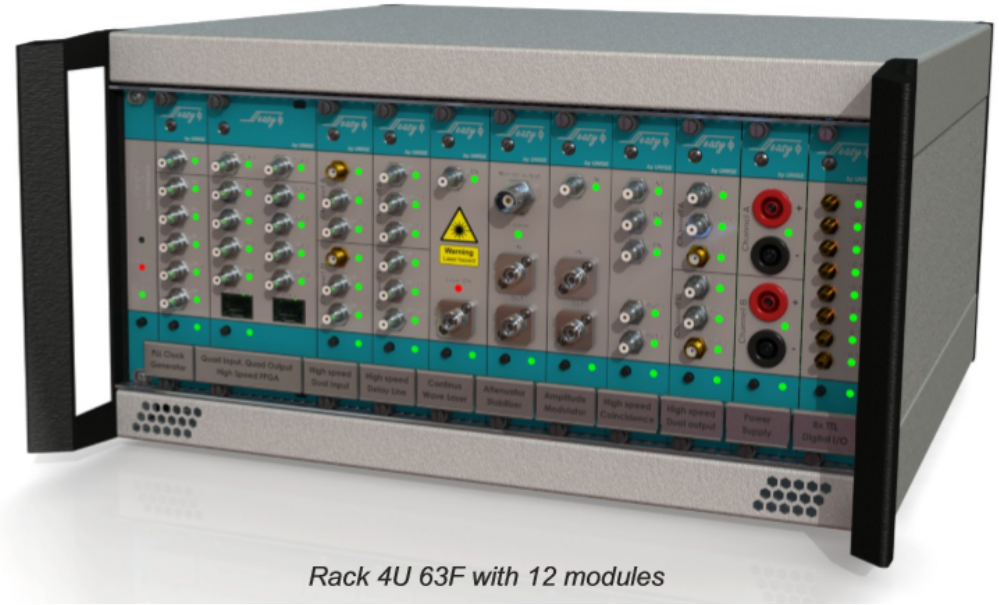
Single institute, but Open

- University of Geneva
  - Group of Applied Physics in Optics

Easy Φ hardware

Licenced 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
- ...



Rack 4U 63F with 12 modules

Outline

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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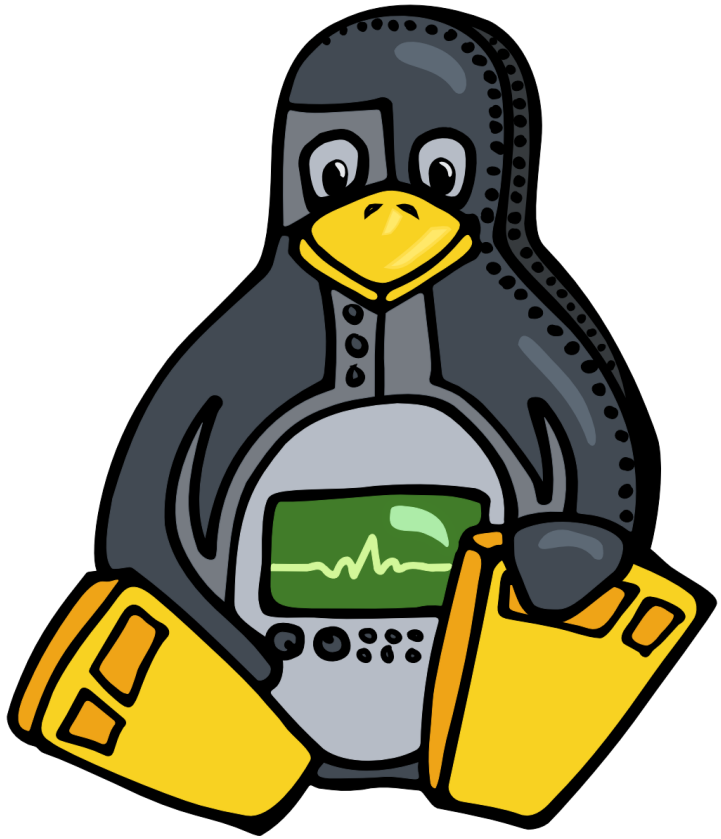
How?

- 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?