Open Source HW and SW in a Scientific Context
Outline

- Introduction
- Why Open Hardware
- Open Hardware at CERN
- Conclusions
LHC Particle Accelerator
Studying the finest constituents of matter

atom
nucleus
proton
quark

electron
Understand the very first moments of our universe right after the Big Bang
LHC: a complex machine
LHC: a complex machine
Beam Controls: Hundreds of designs
Electronic boards
Electronic boards

- Components purchased from companies
- Components that are programmed
- Bugs: can we fix them ourselves?
- Improvements: can we make it better?
- Produce: can we build it where we want?
- Education: can we learn from it?
Vendor lock-in
Open Hardware
Outline

- Introduction
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Why Open Hardware

Enjoy what other people have done

- Design Reuse
- Well established standards
  - Ethernet, PCIe, WISHBONE
Why Open Hardware

- Design Reuse
  - Enjoy what other people have done
- Well established standards
  - Ethernet, PCIe, WISHBONE

Enjoy contribution from other people

- Peer Review
- Rigorous design process
Why Open Hardware

Make a contribution

- Dissemination of knowledge
- Also a role of CERN
Why Open Hardware

Create healthier relationship with companies

- Not Free as *Free beer*
- Need to make a living!
- Most successful Open projects have paid developers
Why Open Hardware

Create healthier relationship with companies

- Free as *Freedom*
- Need to make a living!
- Most successful Open projects have paid developers
- Manufacturing/Testing quality, Warranty, Support
**Open Hardware can be commercial**

<table>
<thead>
<tr>
<th></th>
<th>Commercial</th>
<th>Non-commercial</th>
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</thead>
<tbody>
<tr>
<td><strong>Open</strong></td>
<td>Winning combination. <em>Best of both worlds.</em></td>
<td>Whole burden falls on developers. Not scalable.</td>
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<tr>
<td><strong>Proprietary</strong></td>
<td>Vendor lock-in.</td>
<td>Dedicated, non-reusable projects.</td>
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Open Hardware at CERN

- site
- license
- tools
Open Hardware at CERN

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- tools
Open Hardware Repository

www.ohwr.org

- Publishes everything needed to
  - Review
  - Modify
  - Manufacture
Open Hardware Repository

www.ohwr.org

- Fully open access
- Built using FOSS
WorldFIP is a deterministic rad-tol fieldbus used at CERN's LHC for a variety of control systems. Cryogenics, Power Converters, Beam Instrumentation and other critical systems are using WorldFIP for the exchange of data between their sensors and actuators and the control and supervision level.

With @Alstom phasing out WorldFIP support in 2009, it was decided to insource this technology at CERN.

The insourcing project has started with nanOFIP, a rad-tol FPGA that acts as an agent in the communication over the WorldFIP fieldbus.
Open Hardware Repository

- 100 active projects
  - 70 initiated by CERN, 30 outside
  - 60 hardware designs, 40 IP blocks

- 140 active developers
  - 12 companies
  - 10 research centers

www.ohwr.org
Open Hardware at CERN

- Site
- License
- Tools
Open Hardware License

CERN OHL

- Developed by CERN Knowledge Transfer
- Defines conditions for using/modifying a design
- Persistent license
- Clear, easy to read
- Makes it easier to work with others
Open Hardware License

Under CERN OHL

- BREADPig Balloon Mapping Kit
- miniEngine
- chirp! the plant watering alarm
- Sufficiency Lab presents: Women Farm
- JERRY DIGITAL EXPERIMENTS
- Led Driver
- TinkerForge
Open Hardware at CERN

site
license
tools
Hardware Tools

- HDL simulator
- Schematics entry
- PCB layout
- Art work
- Drilling
- Pick & place
Hardware Tools

- HDL simulator

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  - PCB layout
  - Art work
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  - Pick & place
Efforts on Open Hardware Tools

- FPGA
  - HDL simulator

- KiCad EDA Software Suite
  - Schematics entry
  - PCB layout
  - Art work
  - Drilling
  - Pick & place

Icarus Verilog
A Success Story

The White Rabbit Case

- CERN needs

Operation coordinated with sub-ns accuracy
Over 10 km ... ... thousands of end points
A Success Story

The White Rabbit Case

- CERN needs
- Based on well established standards
A Success Story

The White Rabbit Case

- CERN needs
- Based on well established standards
- Institutes & Companies building upon
- Peer Review
A Success Story

The White Rabbit Case

- CERN needs
- Based on well established standards
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- Different products available from several companies
- IEEE standardization
## Experience with industry

### Product Design

- Needs additional effort to make CERN designs a Product
  - Particular effort to reduce the Bill of Material
  - Precise production documentation
  - Automated test bench (serious effort)

### The OH concept and Industry

- Open Hardware is new and not always understood
- Need to explain companies the opportunities and risks
- We ask only companies that can also give support (guarantee, repair, improve)
- Needs time from us and guts from companies
### Experience with industry

#### Examples of re-use of work

- Two companies modified SPEC carrier design
  - larger FPGA (for software radio), PXIe bus version
- A company modified ADC100M design
  - other input filter, high-voltage front-end
- A company re-uses White Rabbit specification for own product
- A company re-used nanoFIP code for renovating trains

#### Generates interaction

- Companies work together – building an ecosystem:
  - One sells a carrier, others sell mezzanines
  - One sells a WR switch, others sell WR nodes
  - One reselling production of others
- One company makes all of its own designs available on OHR
**Fun with open**
(in a non-scientific context)

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**F*watch – an Open Hardware watch**

- Team-present for a retiring colleague

- GPS
- Movement sensor
- Pressure sensor
- Compass

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**Showcase of using only Open Tools**

- **KiCAD**: Schematics and PCB layout
- **FreeCAD**: housing and buttons
- **FreeRTOS**: operating system
- **gcc**: C compiler

- Not available
- Project not active anymore
- You still can learn and get inspired!
Open: a Win – Win Situation

- Better designs
  - Review, Optimize
  - More users, more feedback
- Open products are real products
  - CERN has designed over ten Open products
  - Produced, sold and supported by different companies
  - Products used by many institutes and industry
- Designs with added value
  - Freedom to use, improve and produce
  - Manufacturing, Testing, Warranty, Support
- Fun :-)

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