Low-cost modular platform for custom electronics in rad-exposed and rad-free areas at CERN

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Beams Department
Controls Group

The DI/OT project

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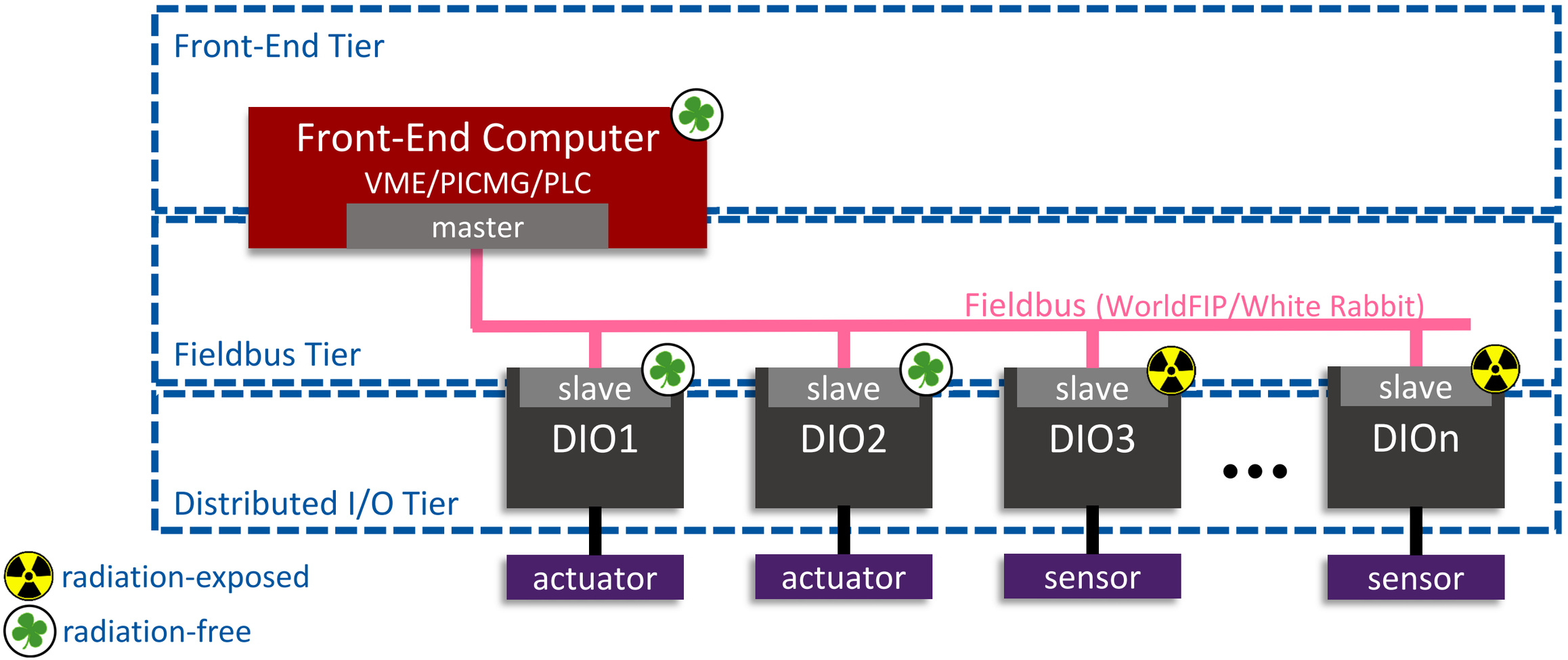
Outline

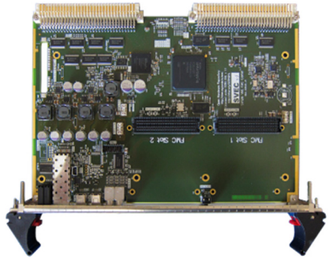
- Motivation
- Hardware kit
- Communication links
- Summary

Custom electronics architecture



Services for custom electronics

Front-End Tier



Fieldbus Tier

WorldFIP
THE EFFECTIVE FIELDBUS

White Rabbit

Distributed I/O Tier

?

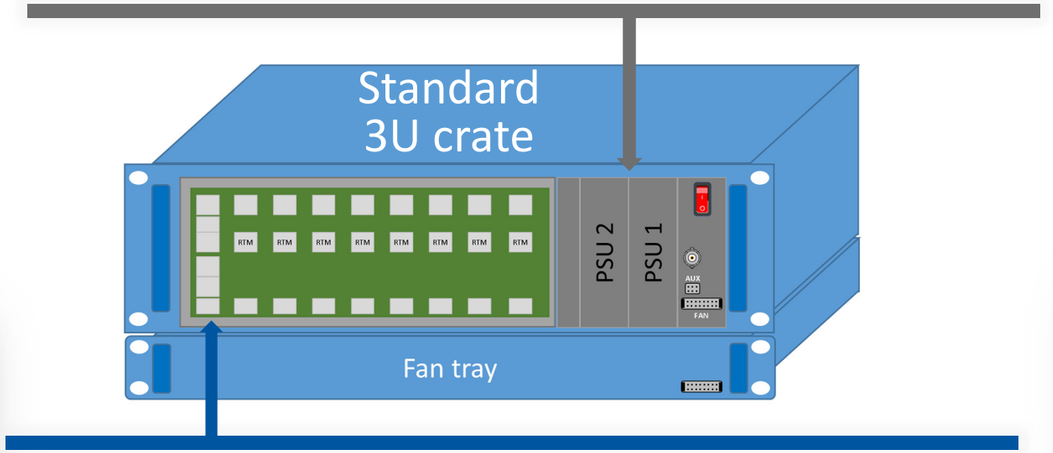
DI/OT motivation

- **Standardize** custom electronics in distributed I/O tier
- Provide **modular** hardware platform
- … **simpler** and **cheaper** than front-end crates
- … based on **industrial standards**
- … with **commercial support**
- Introduce **System-On-Chip** platform to the control system
- Introduce high-speed radiation-tolerant **fieldbus**

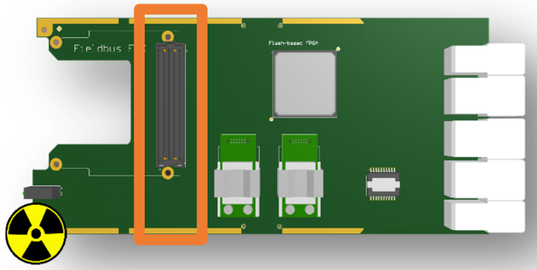
DI/OT hardware kit

Rad-tolerant power supply

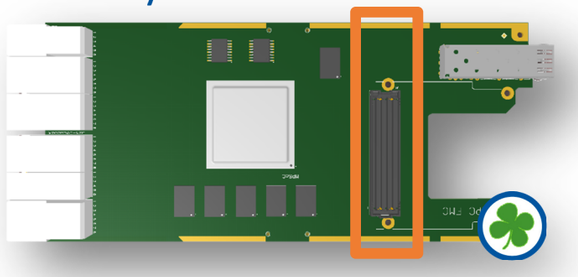
Off-the-shelf PSU



Rad-tolerant System Board

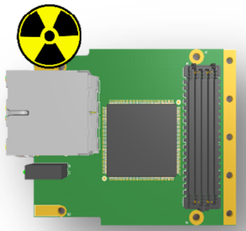


System Board

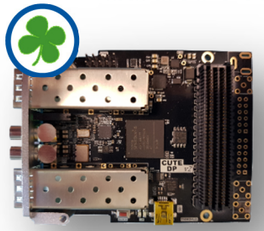


WorldFIP FMC

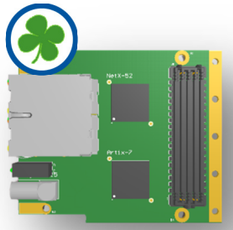
Powerlink FMC



White Rabbit FMC



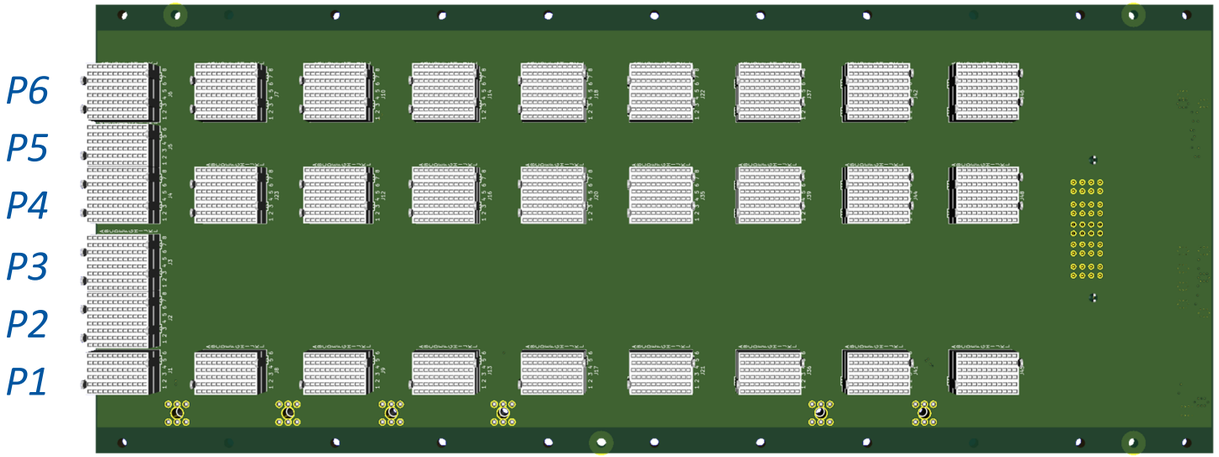
PROFINET FMC



CPCI-S backplane

- 9 slots
- Star of LVDS lanes from System to Peripheral Slots
- Free choice of inter-board protocols

- 6 HP slot width
- Auxiliary voltage connector
- Auxiliary voltages distribution



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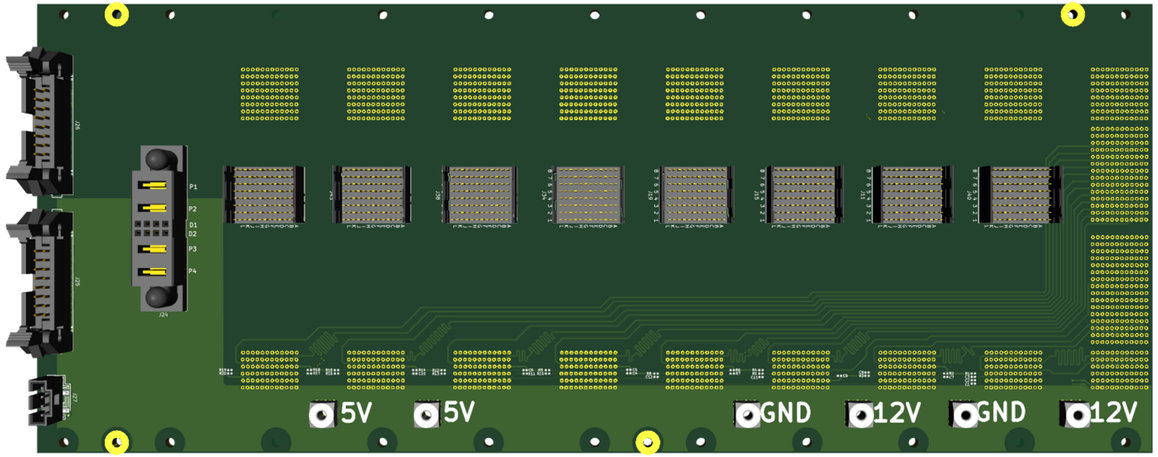
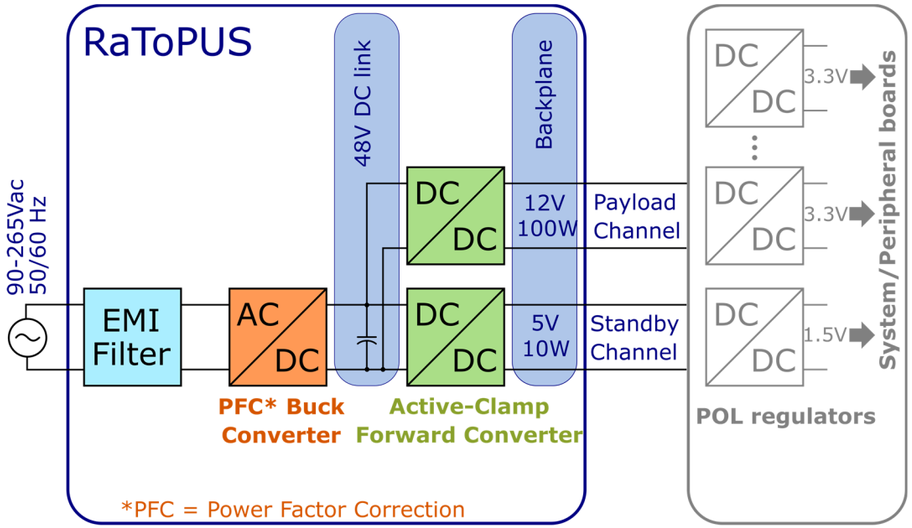


- 6 HP slot width
- Auxiliary voltage connector
- Auxiliary voltages distribution

- Designed in KiCAD, licensed under CERN Open Hardware License

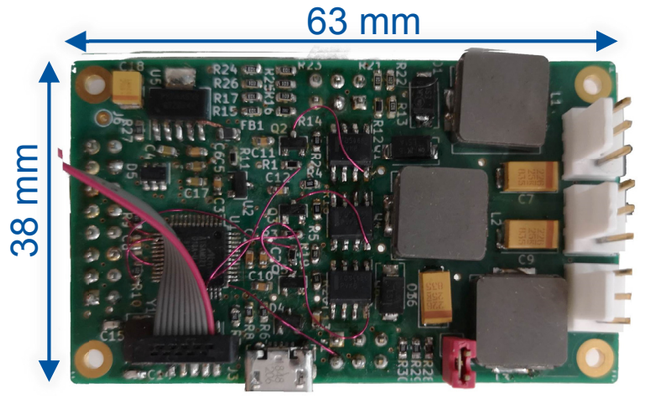
RaToPUS

- Switched-mode AC/DC 100W power supply
- Compatible with CPCI-S power supplies
- Radiation-tolerant by-design
- Two-stage design with intermediate 48 VDC link



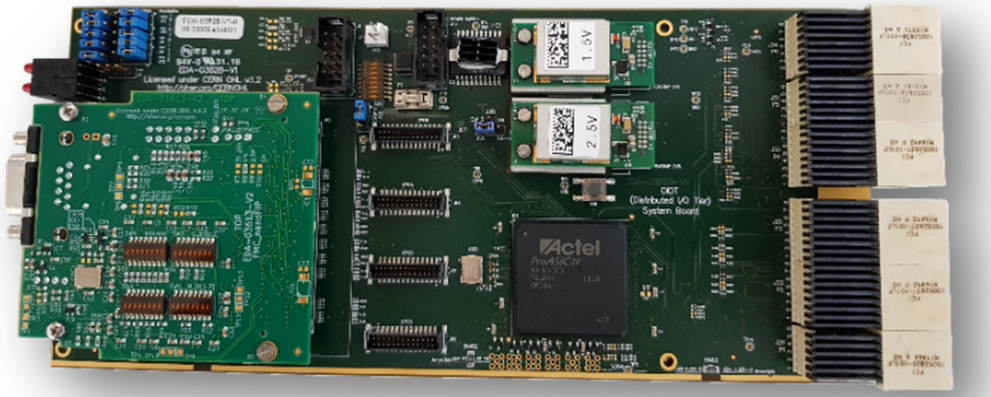
PMBus for monitoring – ***MoniMod***

- General-purpose monitoring module
- Based on Cortex-M0+ (ATSAMD21G18)
- Up to 3 power rails
- Up to 3 externally attached temperature sensors



System Boards

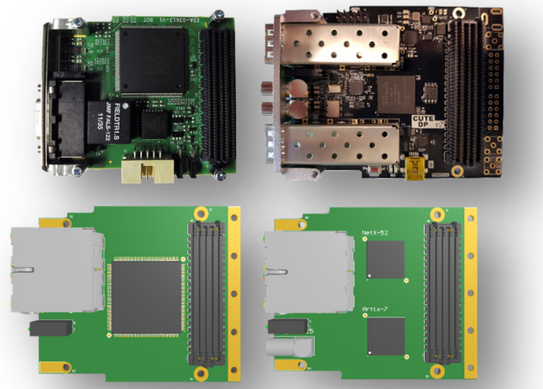
- CPCI-S compliant
- Main FPGA-based board of the crate
- FMC slot for fieldbus communication
- Crate monitoring



- ☢ Early prototype with ProASIC3
  Flash-based FPGA
- ☢ Ongoing evaluation of nanoXplore rad-hard FPGA
- ☘ Ongoing design with Xilinx Zynq Ultrascale+ ZU7-CG and White Rabbit support

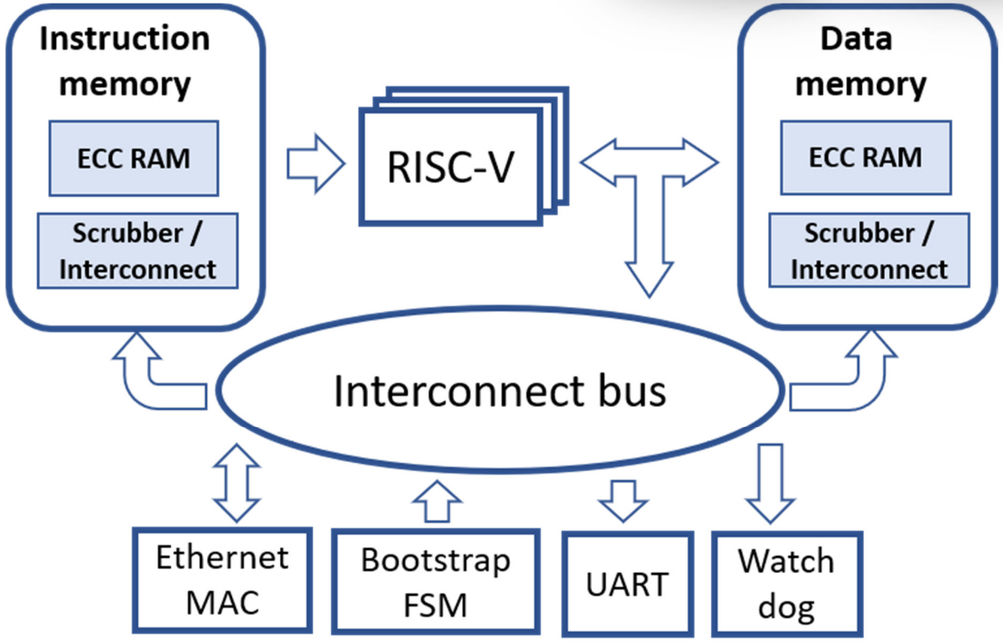
Fieldbus support

- Interchangeable FMC mezzanines
- Available: WorldFIP☢, White Rabbit☘
- Work-in-progress: Ethernet-POWERLINK☢, Profinet☘



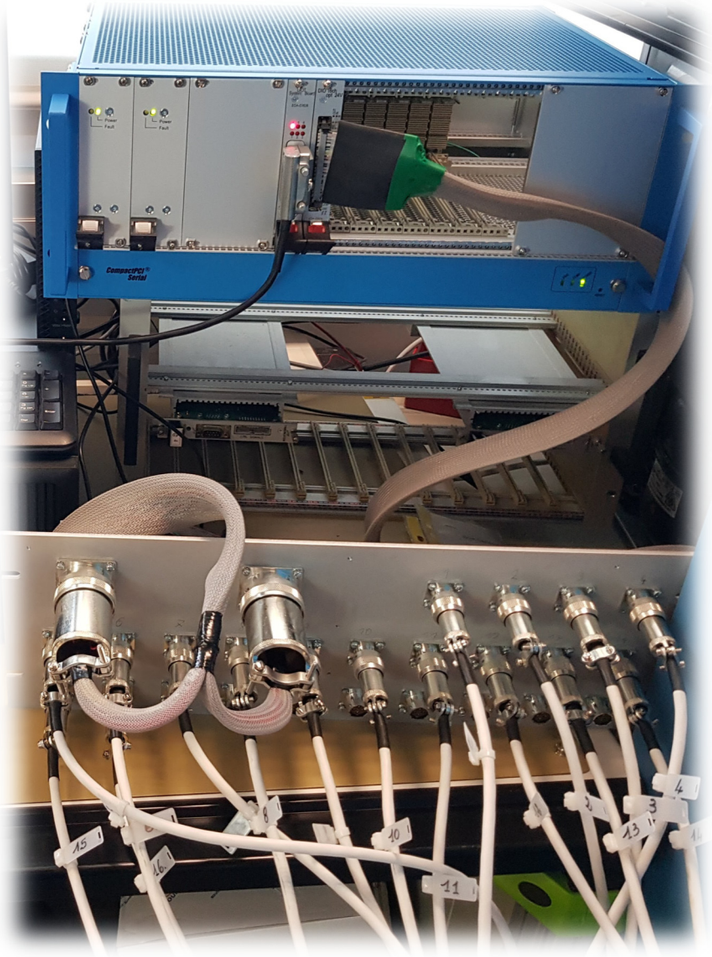
☢Ethernet-POWERLINK:

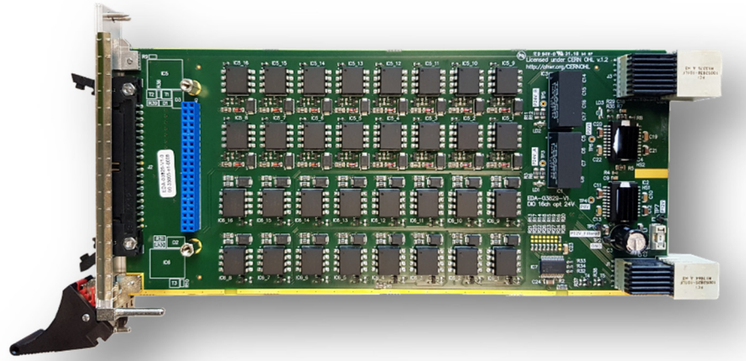
- Radiation-qualified COTS Ethernet PHY
- Simplified openPOWERLINK stack
- Triplicated RISC-V soft-core



Proof of concept

System Board + WorldFIP FMC





16I / 16O Peripheral Board

Project status

Done

- First **proof of concept**
- **Backplane** design
- First prototype of ***RaToPUS* AC/DC** stage and *MoniMod*
- **WorldFIP** and **White Rabbit** fieldbus mezzanines

Ongoing

- Design of **crate mechanics**
- Design of ***RaToPUS***
- Evaluation of ***nanoXplore*** FPGAs
- Design of **non-rad-tol** System Board

mid-2020

- **Non-rad-tol DI/OT available**
- Design of **rad-tol** System Board

2023

- DI/OT kit **commercially available**

Join the project!

https://ohwr.org/project/diot

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DI/OT Summary

- **Low-cost modular** platform for **custom** electronics
- … based on **industrial standards**
- … with **simple interfaces** between modules
- **Radiation-exposed** and **radiation-free** areas
- **Customization** by Peripheral Boards and FPGA firmware
- **Collaboration** between CERN groups, industry and Sinara community

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