HydRA: a System-on-Chip to Run Software in Radiation-Exposed Areas

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European Organisation for Nuclear Research
(CERN)

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Outline

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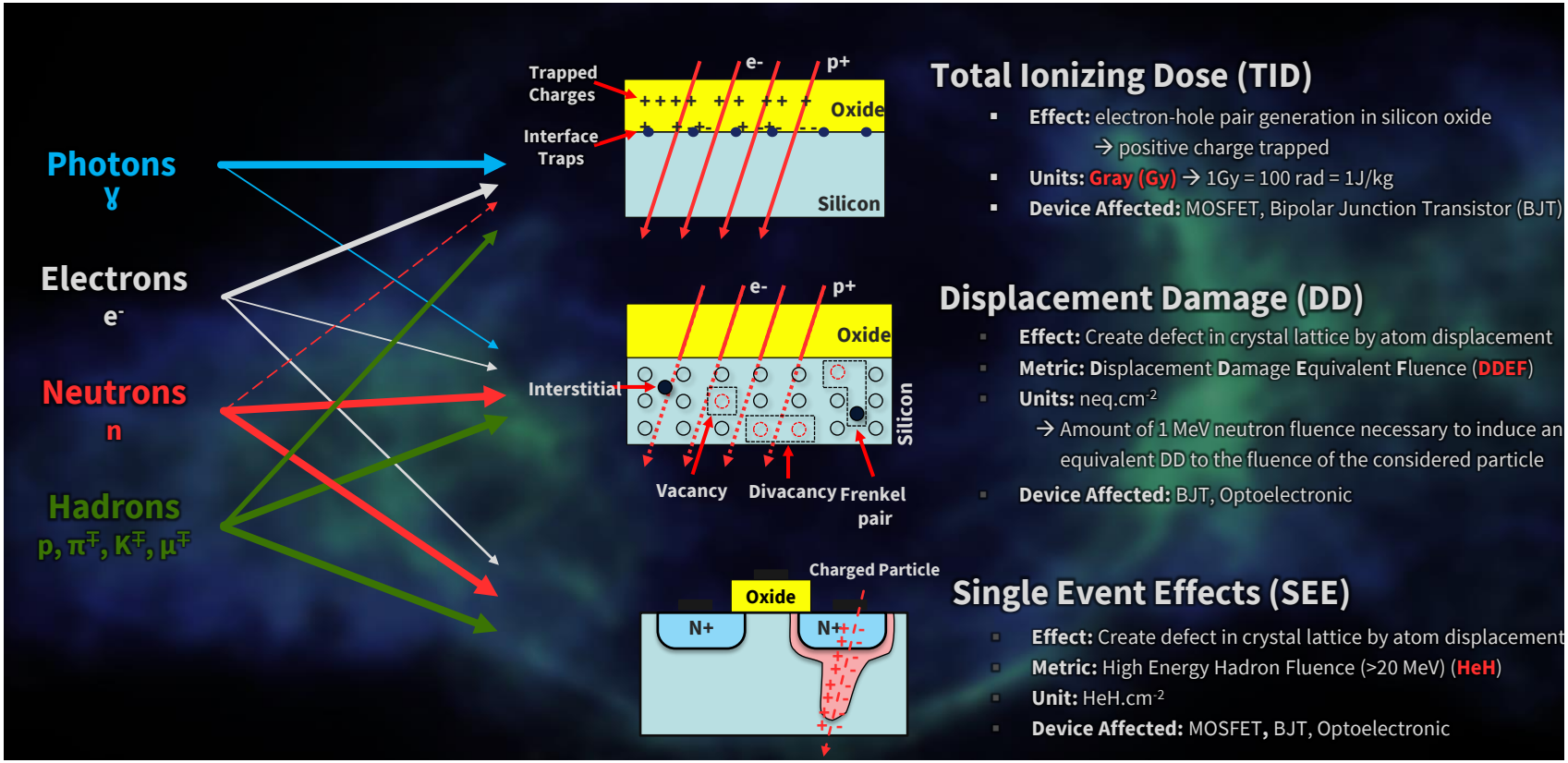
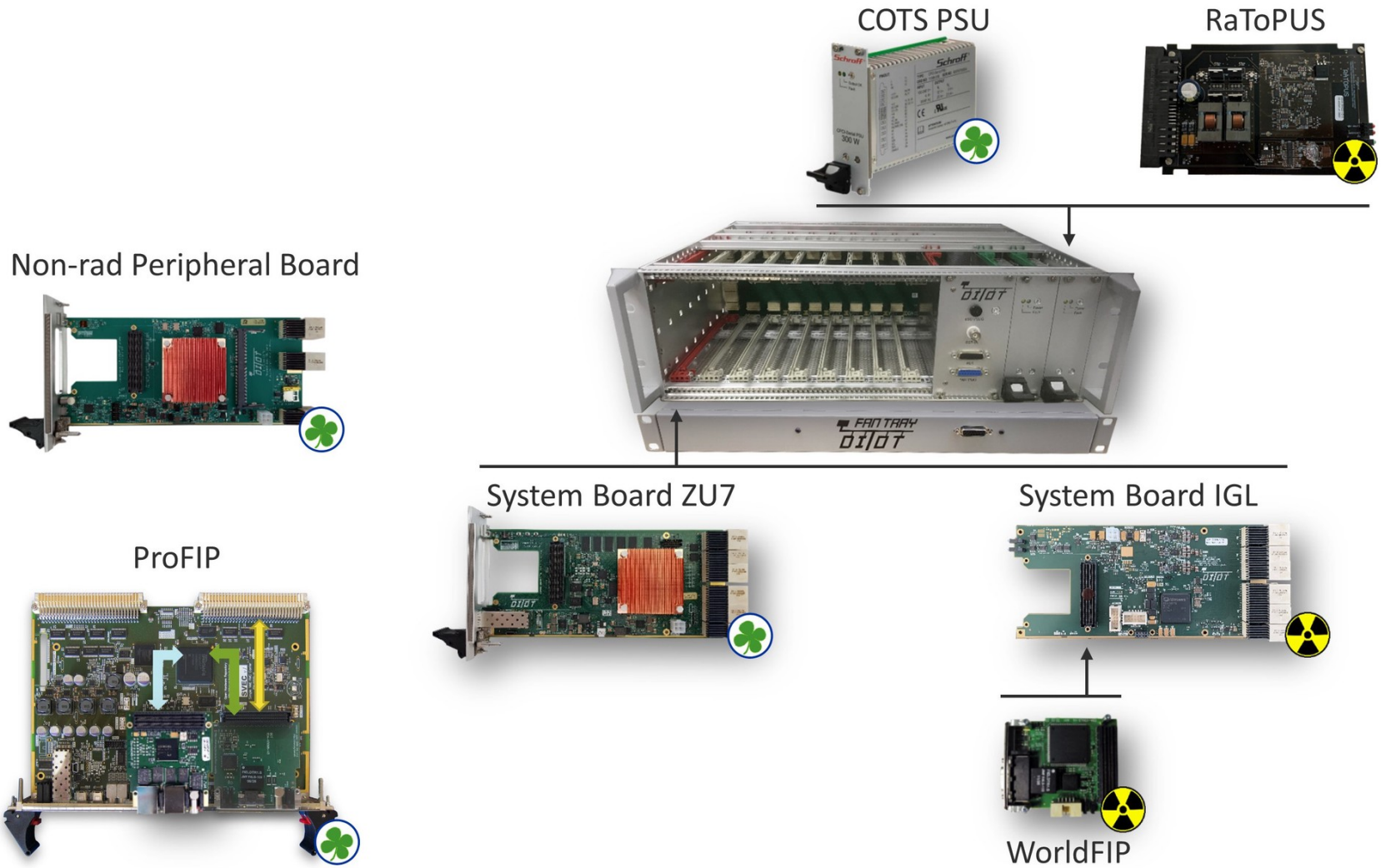
Radiation effects in electronics



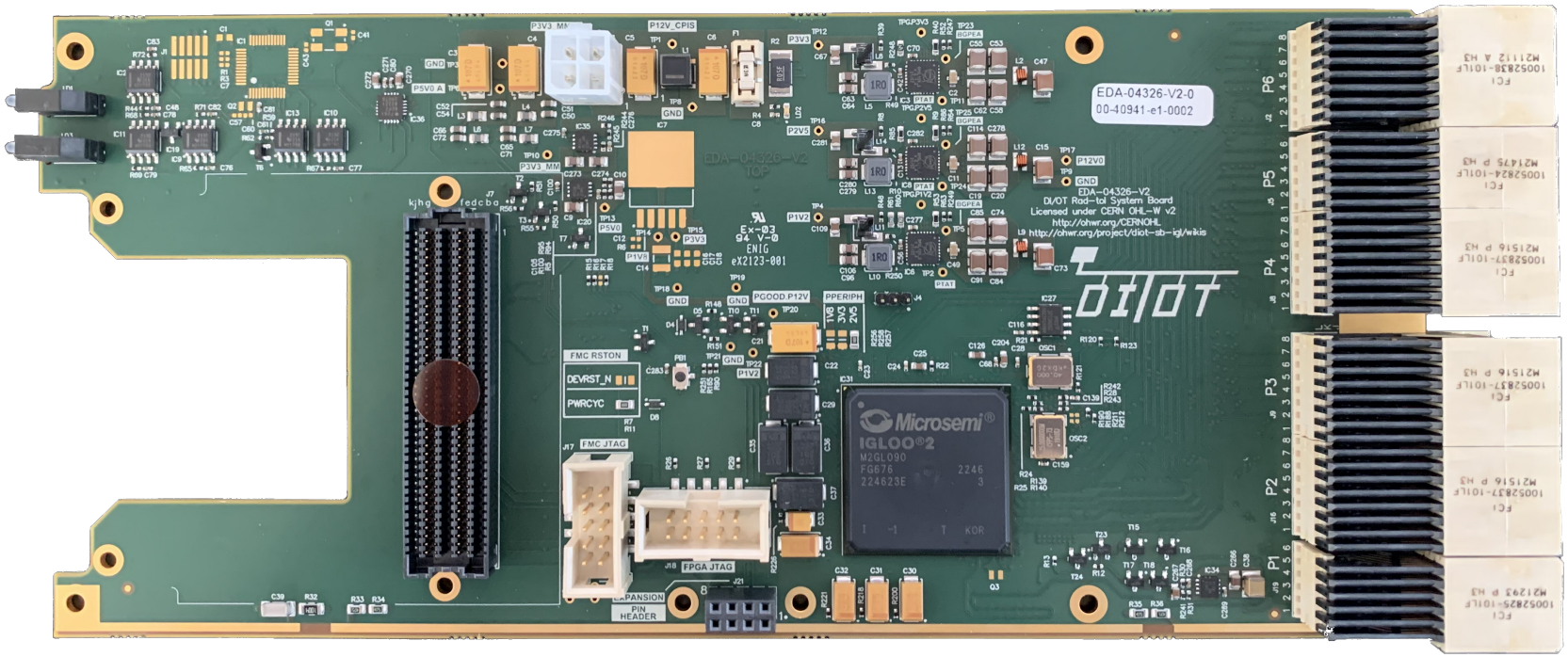
Courtesy Rudy Ferraro. See a recording of his seminar at https://indico.cern.ch/event/1162735/.

Outline

The DI/OT kit


COTS PSU
RaToPUS
Non-rad Peripheral Board
FANTRAY
DI/OT
System Board ZU7
System Board IGL
ProFIP
WorldFIP

The radiation-tolerant system board



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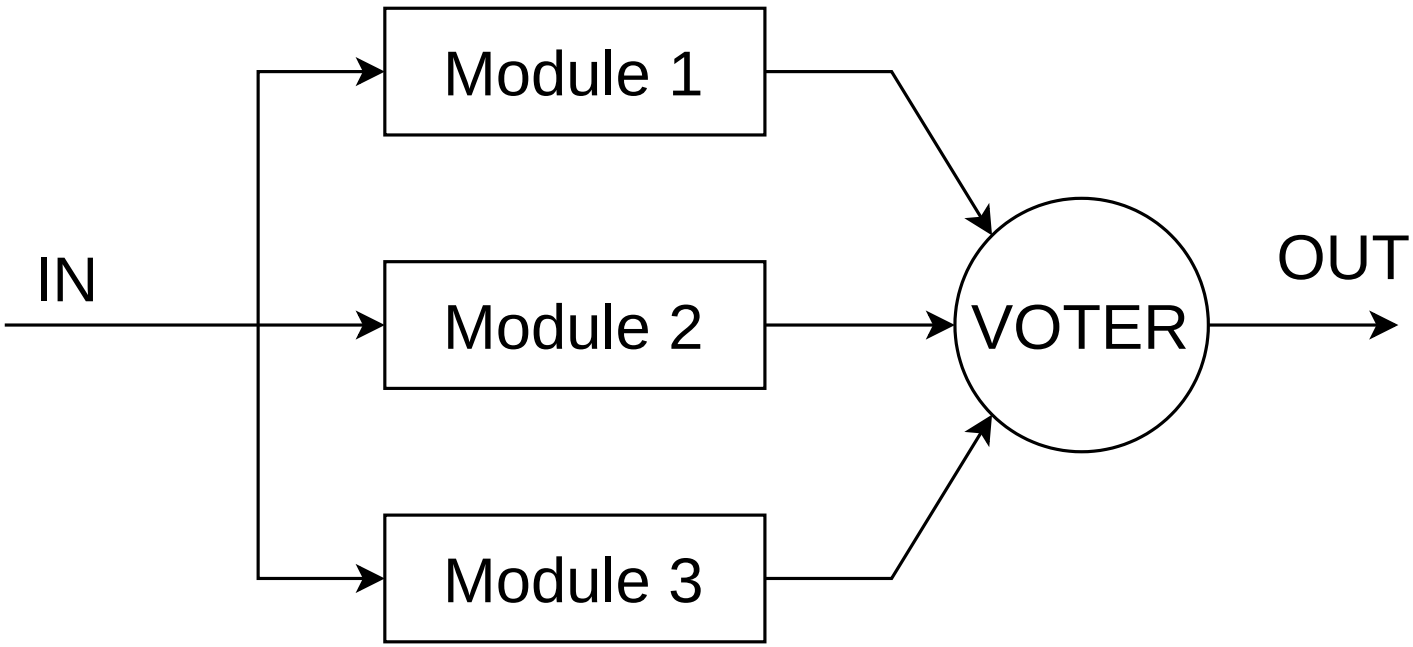
Triple Modular Redundancy (TMR)



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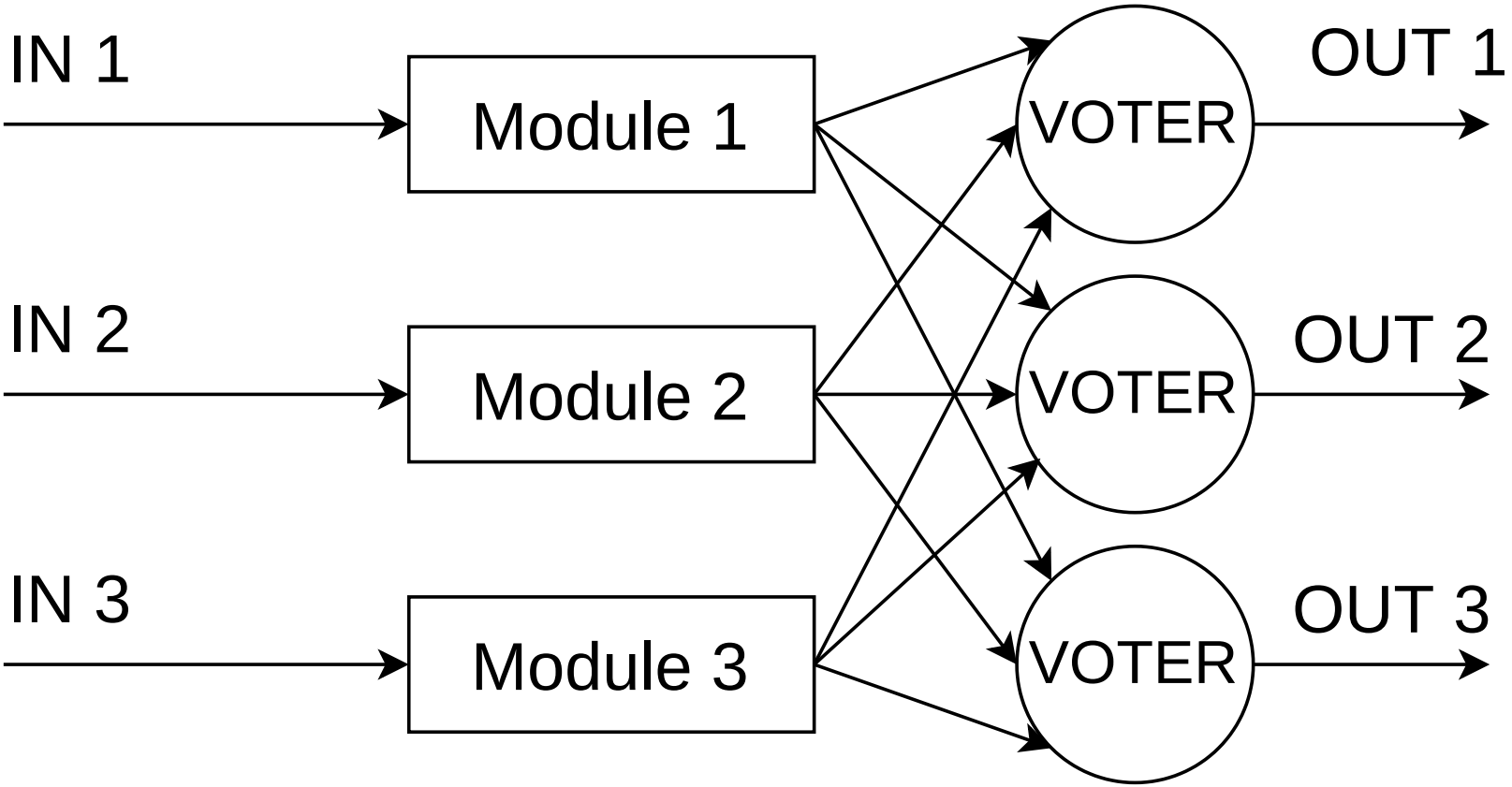

Motivation for a rad-tol SoC

Testing is costly

- Every application in principle requires custom gateware for the IGLOO2 FPGA.
- Radiation-testing campaigns adversely affect iteration time.

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If we can design a rad-tol soft-CPU:

- The gateware is designed and tested once for all applications.
- Customisation ideally requires only firmware (i.e. software) changes. Iteration time is greatly diminished.

Which core to use?

RISC-V

- Instruction Set Architecture (ISA) unencumbered by patents.
- Better support from gcc and llvm. Smaller binaries than for LM32 (the soft CPU we used in the past).
- Adding new instructions is well supported.
- Very widely used. Lots of examples and support.

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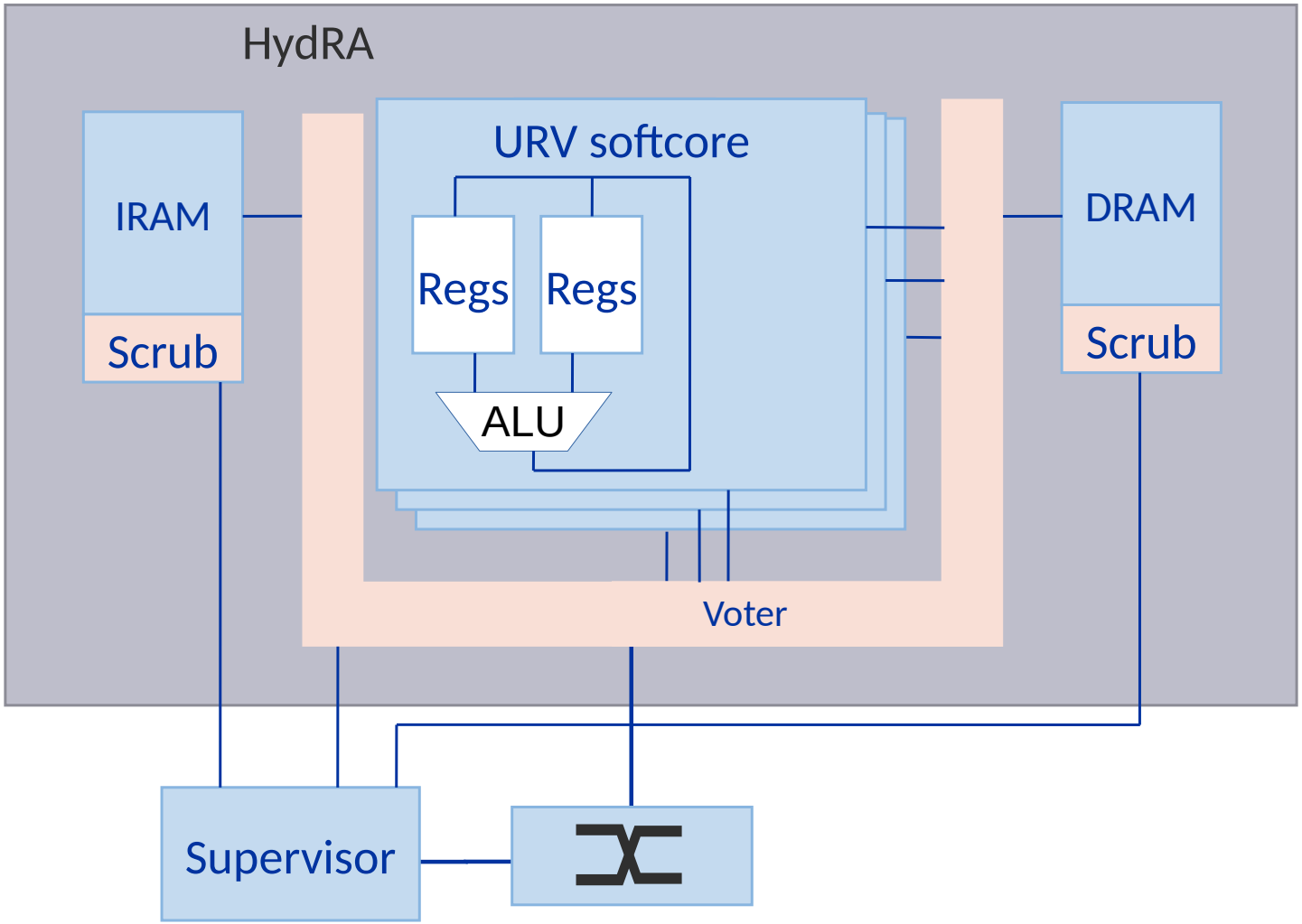
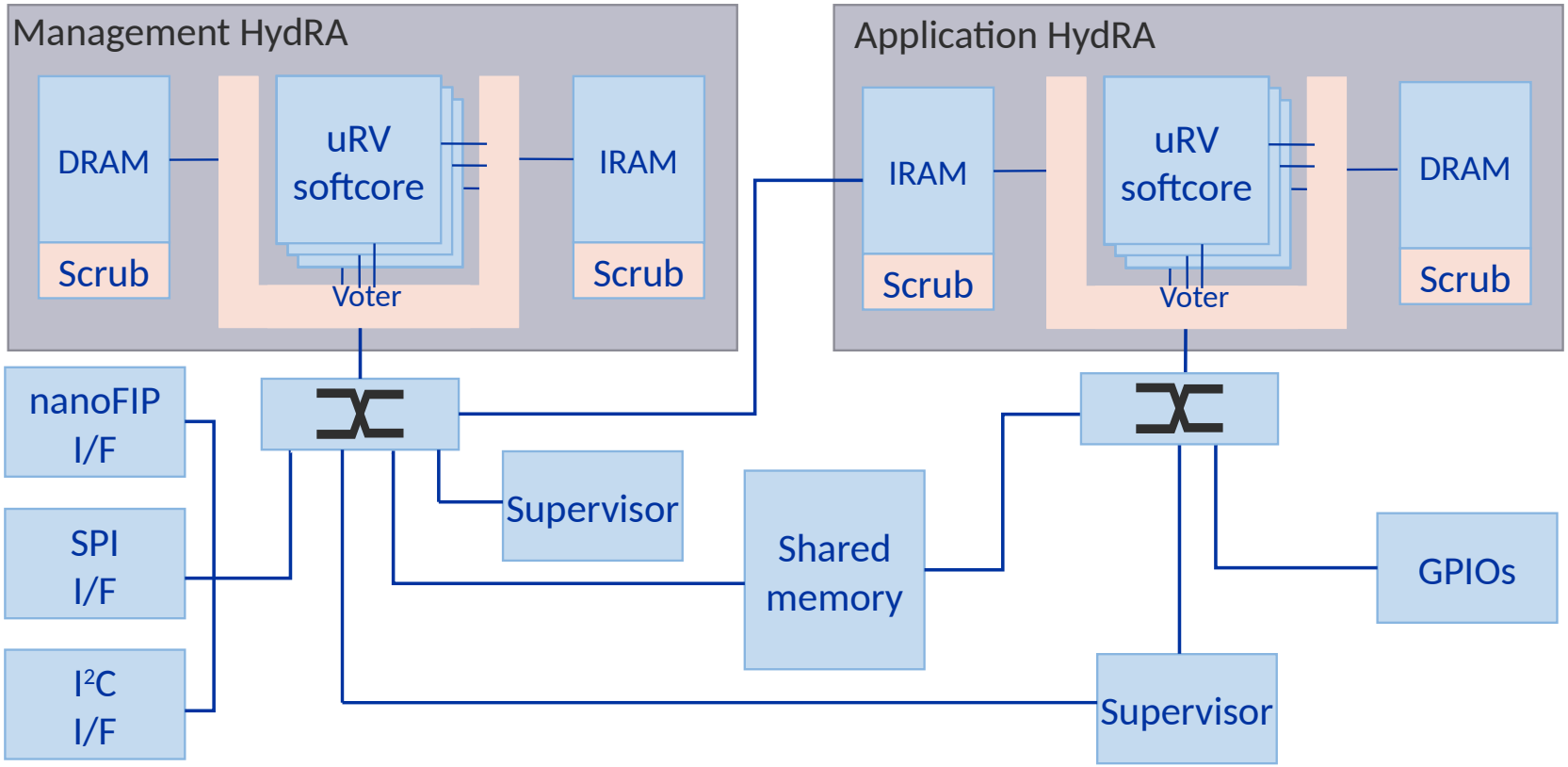
The uRV core

- Already used in other projects in our section. Easy to integrate.
- Open-source (https://ohwr.org/project/urv-core/wikis), small (can fit many in a single FPGA).

HydRA architecture



System architecture



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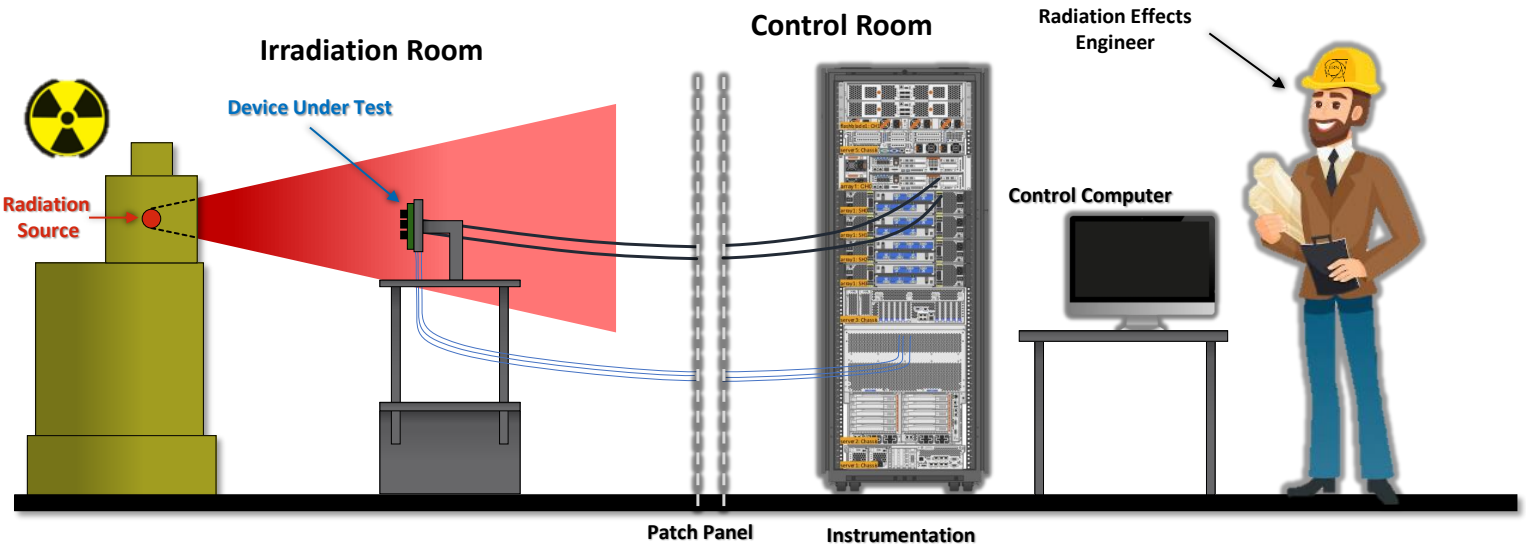
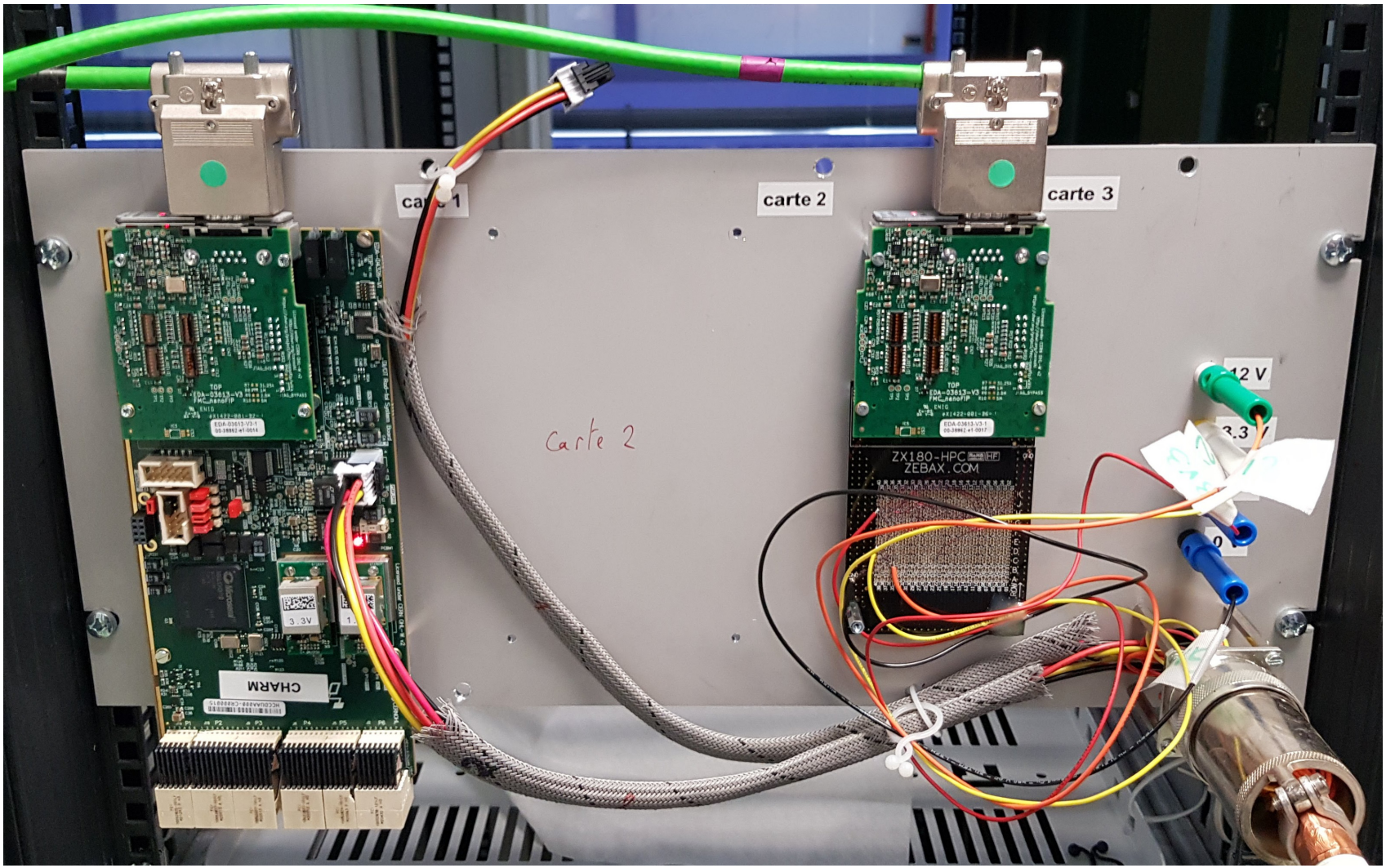
Radiation Test Setup

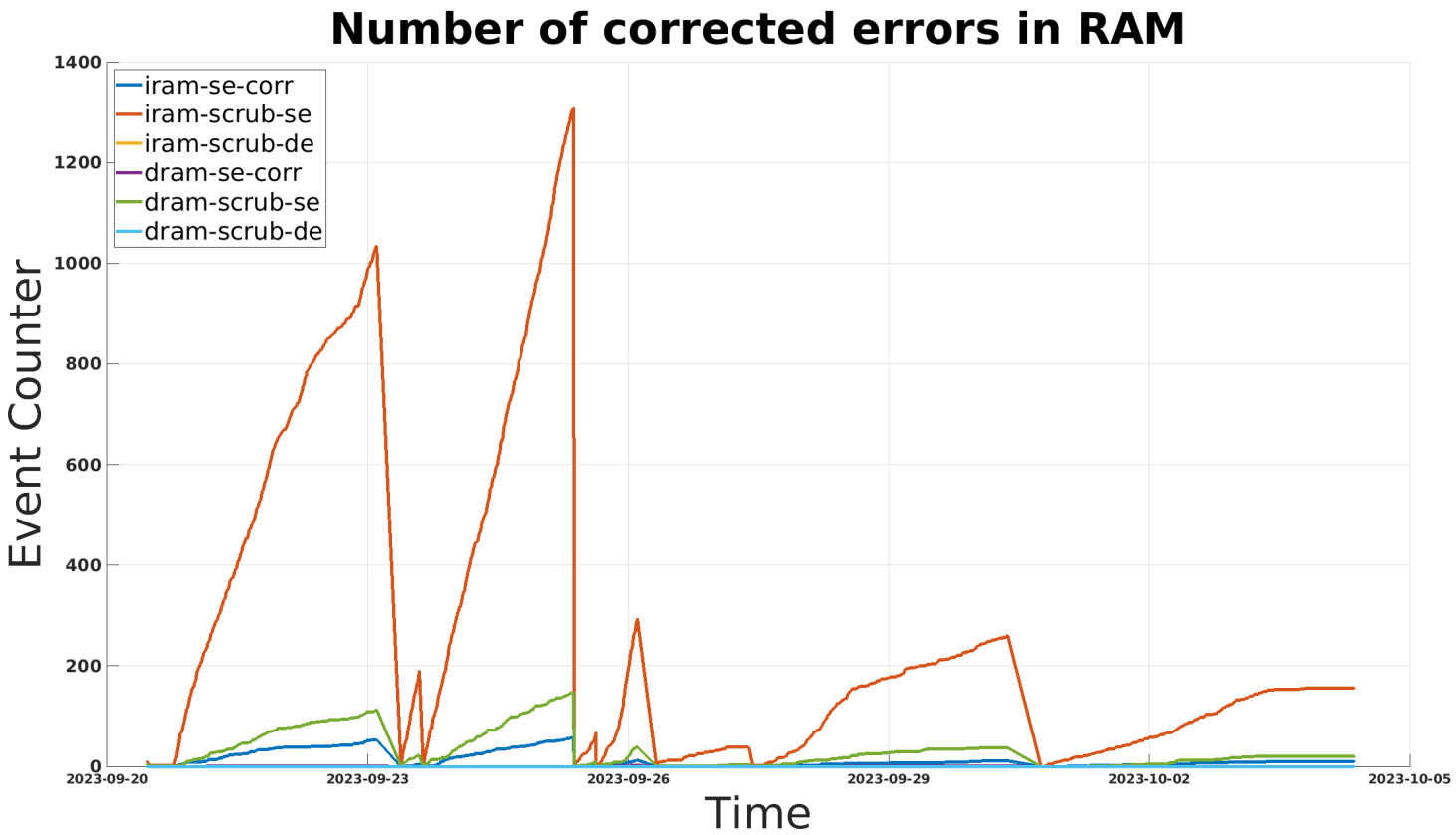


Courtesy Rudy Ferraro.

In practice



Results



Successfully reached 500Gy TID

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Summary and conclusion 1/2

- A rad-tol SoC can greatly improve flexibility and iteration time in the development of controls exposed to radiation.
- HydRA uses flash-based FPGA technology plus triplication and other techniques to provide a solution which is adequate for environments exposed to a few tens of Gy per year.
- HydRA is part of the DI/OT ecosystem, a modular kit which helps develop hardware, gateware, firmware and software for the lowest layer of the control system.

Summary and conclusion 2/2

- To know more about DI/OT: https://ohwr.org/project/diot/wikis
- To know more about HydRA:
  - https://ohwr.org/project/hydra/wikis
  - https://indico.cern.ch/event/1227923 (seminar by Tristan Gingold)