Background	The DI/OT platform	HydRA 0000000	Tests 0000	Summary and conclusion

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

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European Organisation for Nuclear Research (CERN)

ICALEPCS 2023, Cape Town, South Africa

9 October 2023

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- 3 HydRA



5 Summary and conclusion

Background ○●	The DI/OT platform	HydRA 0000000	Tests 0000	Summary and conclusion
Radiatio	n effects in el	ectronics		
	Trapped Charges Interface	***** */* *** Oxide	Total Ionizing Dose (• Effect: electron-hole pair → positive charge	TID) rgeneration in silicon oxide trapped

Silicon

Oxide

pair Charged Particle

N++

/ / p+

Vacancy Divacancy Frenkel

Oxide



Device Affected: MOSFET, Bipolar Junction Transistor (BJT)

Displacement Damage (DD)

- Effect: Create defect in crystal lattice by atom displacement
- Metric: Displacement Damage Equivalent Fluence (DDEF)
- Units: neq.cm⁻²
 - → Amount of 1 MeV neutron fluence necessary to induce an equivalent DD to the fluence of the considered particle
- Device Affected: BJT, Optoelectronic

Single Event Effects (SEE)

- Effect: Create defect in crystal lattice by atom displacement Metric: High Energy Hadron Fluence (>20 MeV) (HeH) Unit: HeH.cm²
- Device Affected: MOSFET, BJT, Optoelectronic

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

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Electrons

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Background	The DI/OT platform ○○●	HydRA 0000000	Tests 0000	Summary and conclusion
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The radiation-tolerant system board



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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.

Background The DI/OT platform HydRA Tests Summary and conclusid	Matheatle	fau a us al tal	0-0		
	Background 00	The DI/OT platform	HydRA ○○○●○○○○	Tests 0000	Summary and conclusion

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.

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.

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Which co	re 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).

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HydRA a	architecture			



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System architecture					



Background	The DI/OT platform	HydRA 0000000	Tests ●○○○	Summary and conclusion
Outline				









Background	The DI/OT platform	HydRA 0000000	Tests ○●○○	Summary and conclusion
Radiation	Test Setup			



Courtesy Rudy Ferraro.

Background	The DI/OT platform	HydRA 0000000	Tests ○o●o	Summary and conclusion



Background	The DI/OT platform	HydRA 0000000	Tests ○○○●	Summary and conclusion
Results				



Successfully reached 500Gy TID

Background	The DI/OT platform	HydRA 0000000	Tests 0000	Summary and conclusion ●○○
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- 4 Tests





- 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.

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Background	The DI/OT platform	HydRA	Tests	Summary and conclusion

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)