Radiation-tolerant DI/OT platform

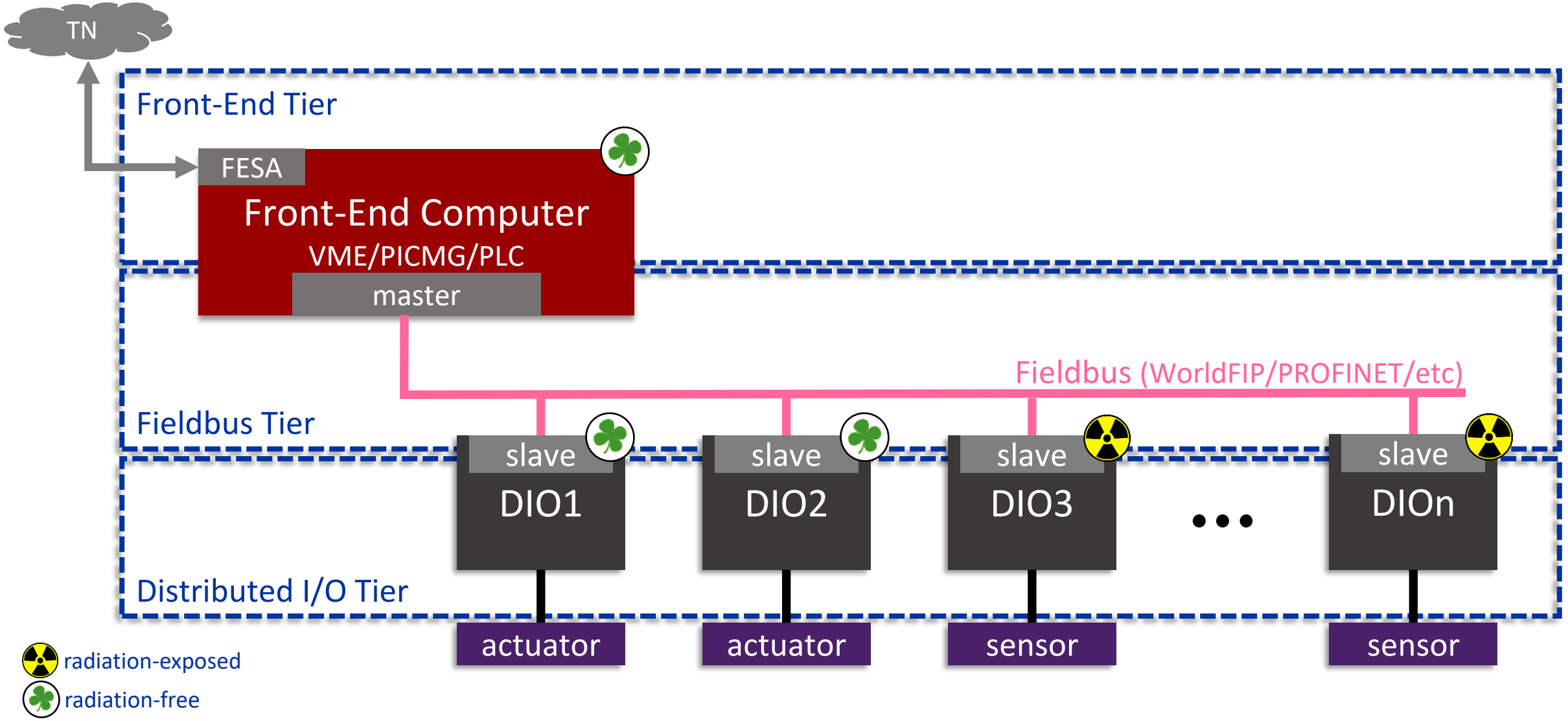
Greg Daniluk (BE-CEM)

on behalf of DI/OT team

RadWG Workshop

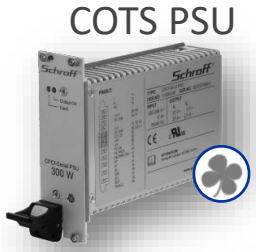
12 Oct 2022

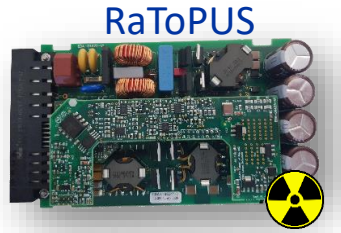
Custom electronics architecture

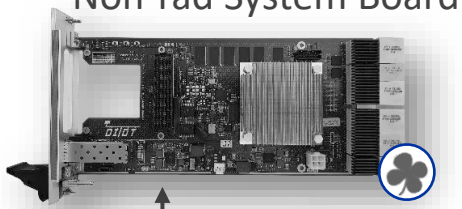


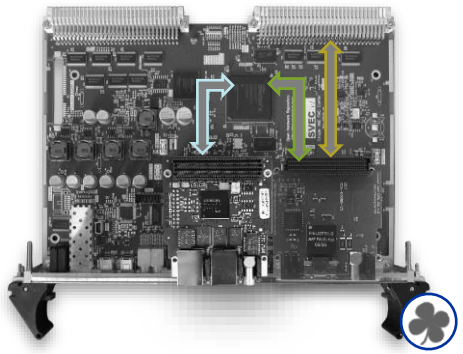
DI/OT project

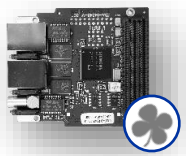
HiLumi HL-LHC PROJECT WP18

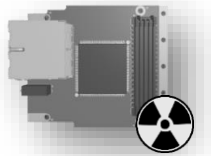












Reliability analysis

Validation tests

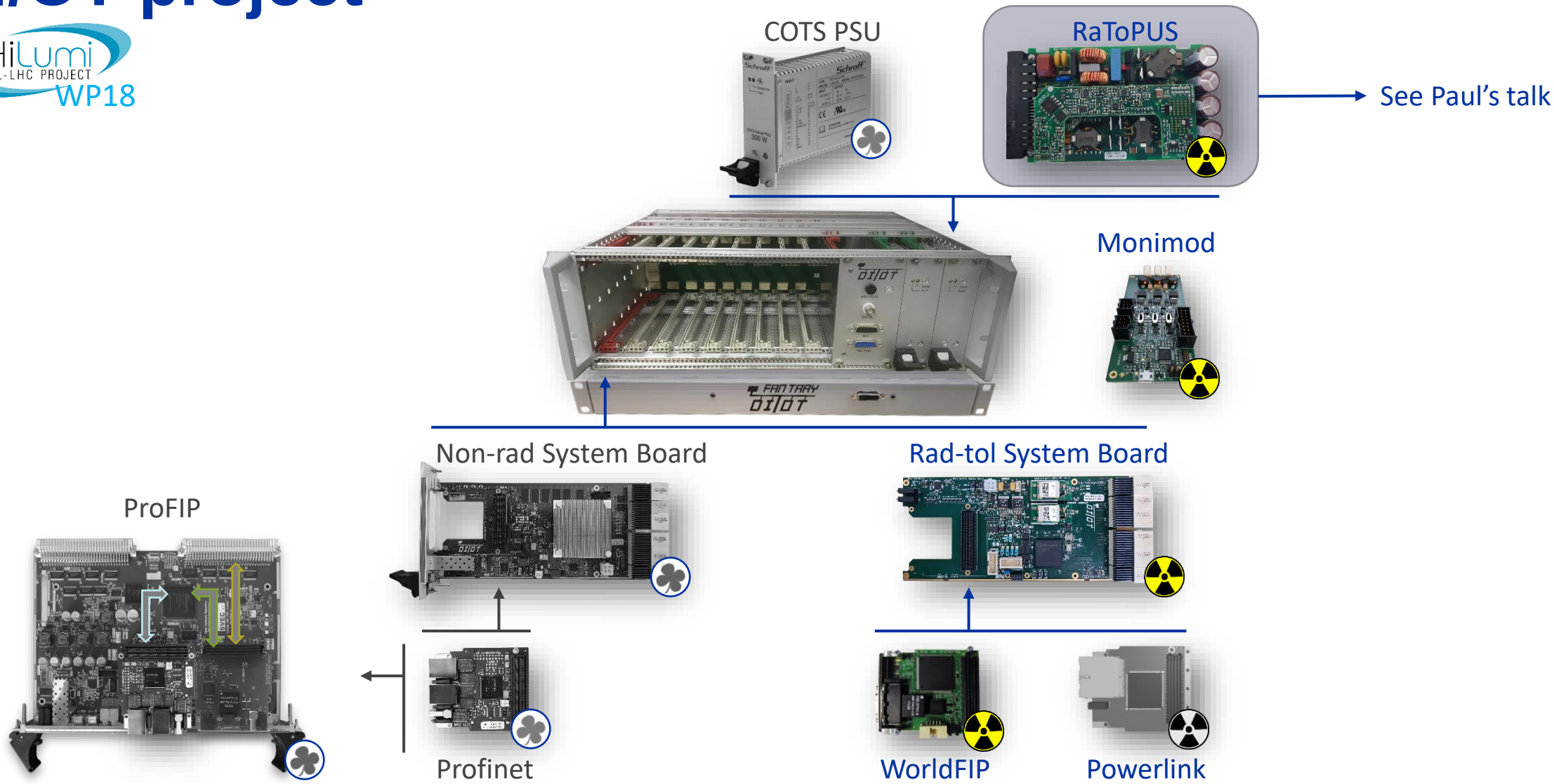
Production Tests (PTS)

Environmental Stress Screening

Reliability demonstration

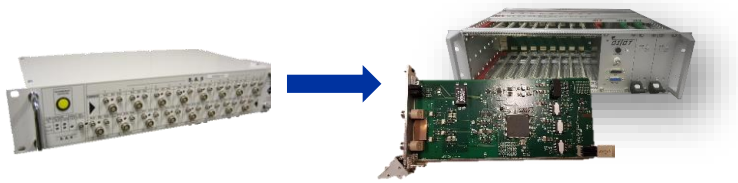
DI/OT project

HiLumi HL-LHC PROJECT WP18

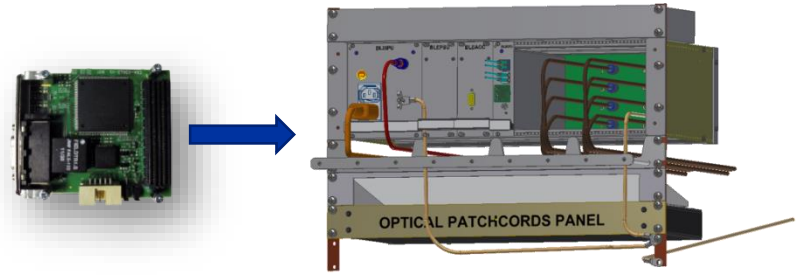


Applications of rad-tol DI/OT

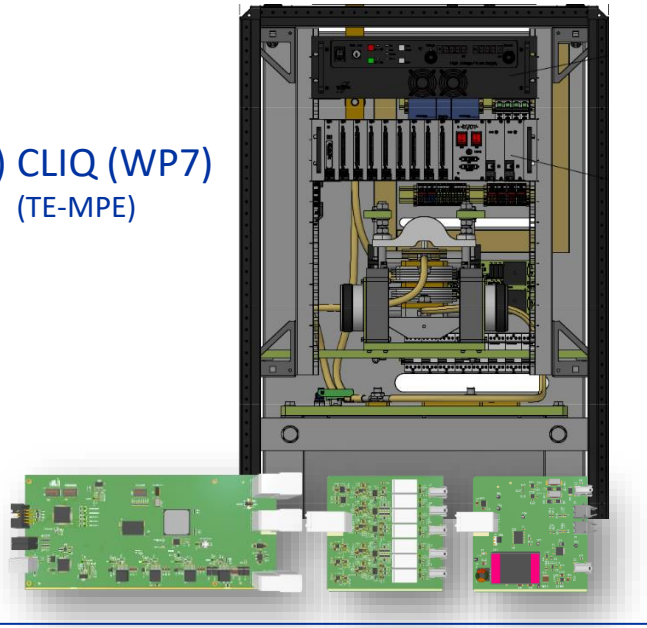
1) Wire Positioning Sensors (WP15.4)
(BE-GM)



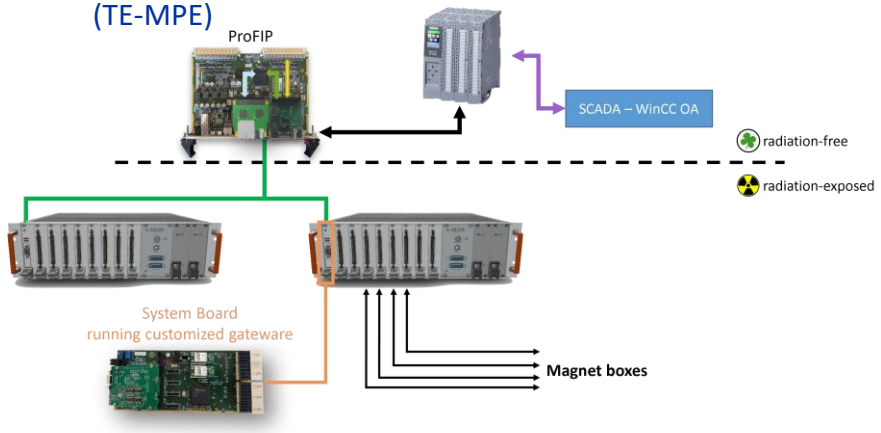
2) BLM & BPM electronics (WP13)



3) CLIQ (WP7)
(TE-MPE)



4) WIC v2
(TE-MPE)



Locations and radiation levels

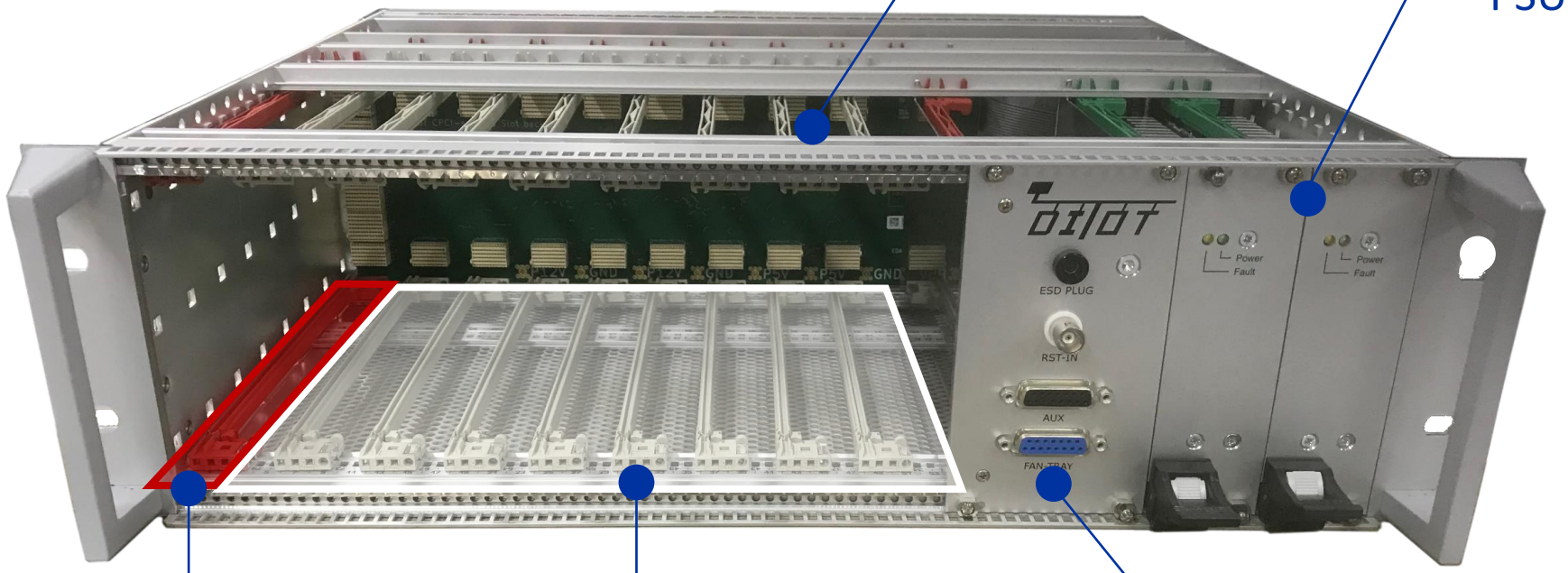
- RRs *3/*7 in P1, P5, P7
- UAs 13/18/53/57
- Transfer lines: Ti2, Ti8, TT41-43

Annual HL-LHC radiation levels[1]

	TID [Gy]	HEH [cm^{-2}]	1MeVn-eq [cm^{-2}]
RR13-17-53-57 L1	25	$1.4 * 10^{10}$	$7 * 10^{10}$
RR13-17-53-57 L0	15	$1 * 10^{10}$	$7 * 10^{10}$

[1] *EDMS No. 2302154 V1.0 Radiation Level Specifications for HL-LHC*

3U Crate



Backplane

Redundant PSUs

System Board

Peripheral Boards
- Application-specific

Front Panel
- Power Cycle Request BNC
- Fan Tray Connector

Produced by:

creo TECH Instruments S.A.

ELMA Your Solution Partner

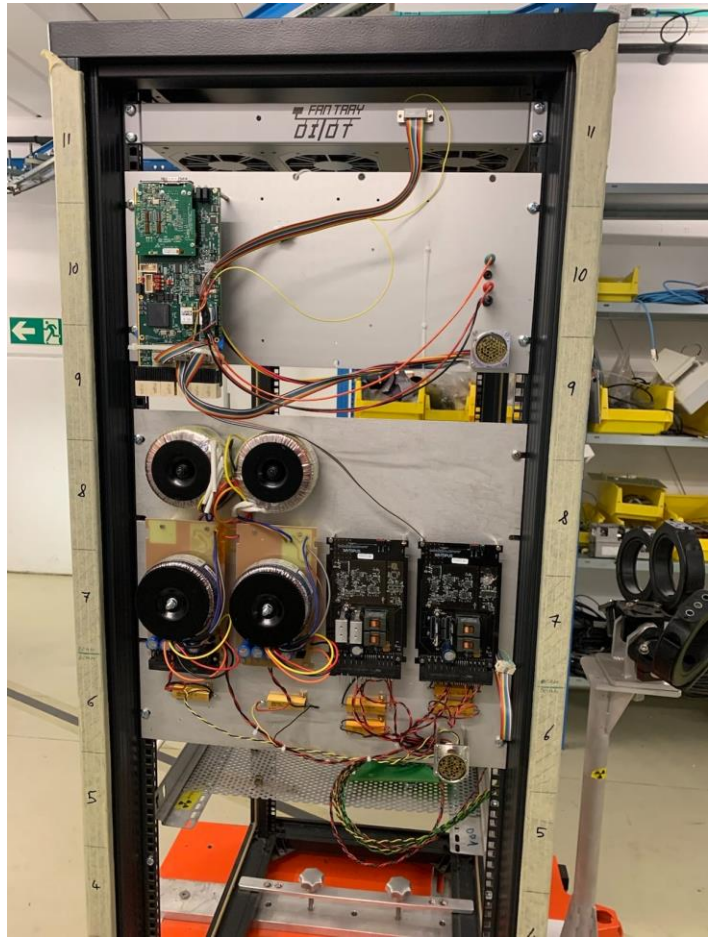
nVent SCHROFF

Fan Tray


3x San Ace 9G1212G101
Tested up to 500Gy
FAN TRAY
DIDT
12V, 5V, PMBus
Monimod-FanTray

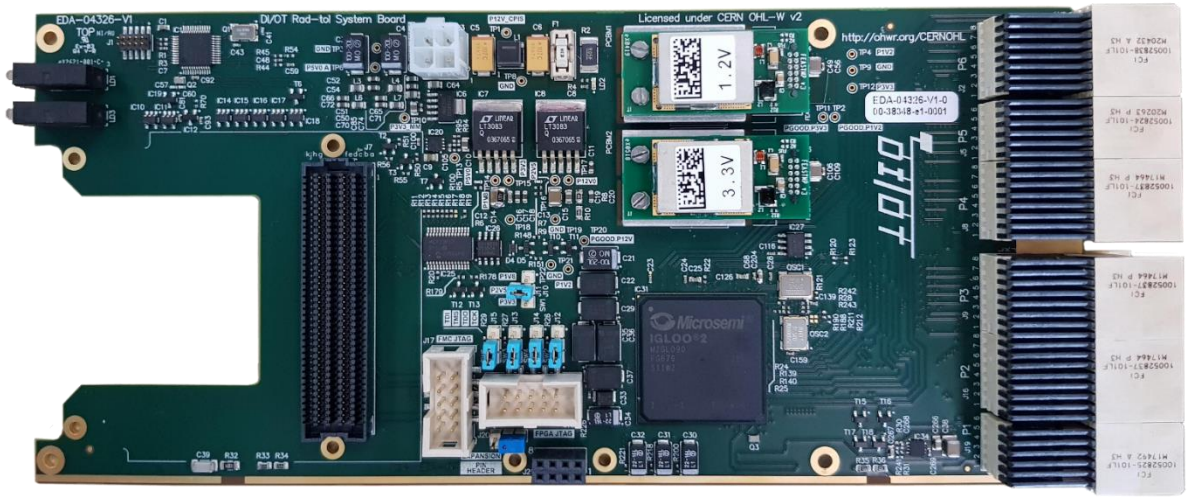
Fan Tray irradiation

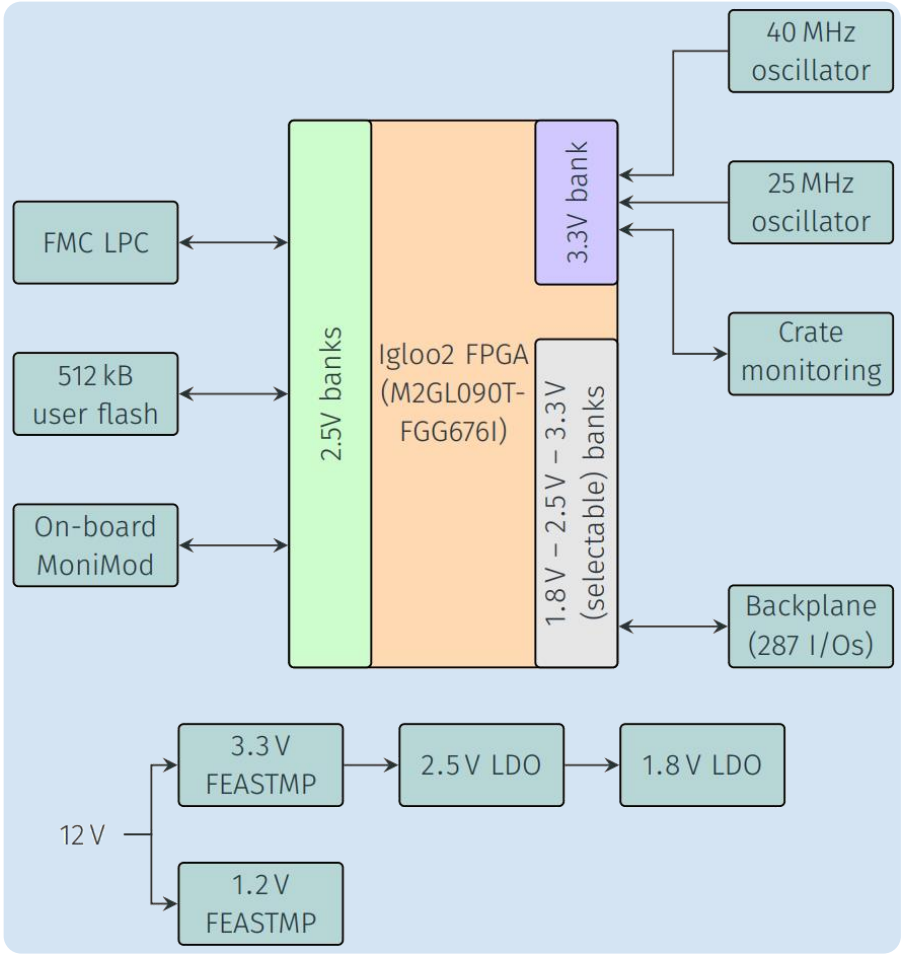
- 1 unit in CHARM position 13 – analysis still ongoing
- Survived ~370Gy
- 10 Monimod (ATSAMD21) freezes + restart issue
  - Shutdown of TPS7A4533DCQ but output still ~1.6V
  - ATSAMD21 still remains powered through I/Os (e.g. pulled-up I^2C lines)
  - Gateware/software fix



System Board

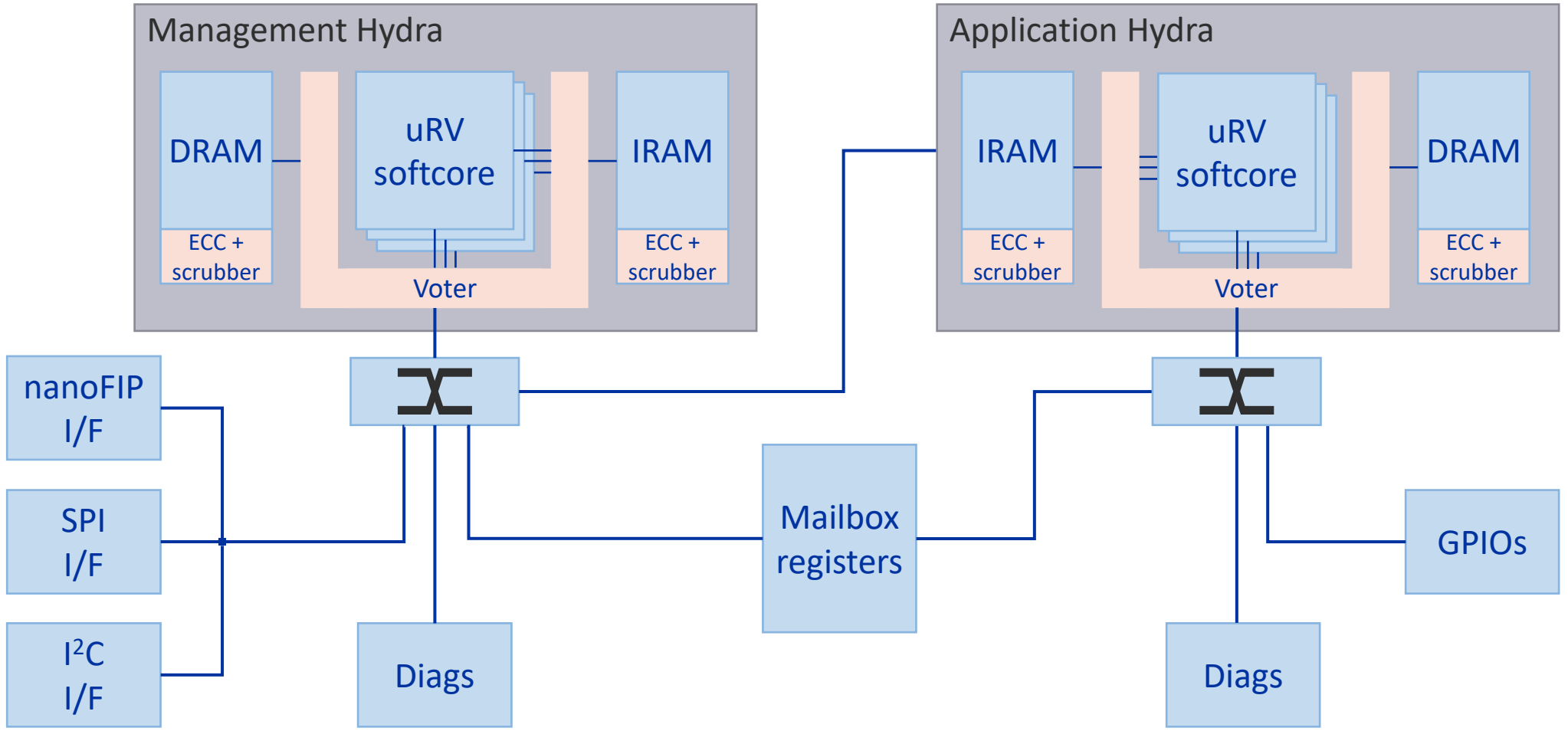
- Crate control + communication via FMC
- Based on IGLOO2 FPGA
- Powered by FEASTMP & LT3083
  - both to be replaced with bPOL12V)
- Successful functional validation & climatic chamber stress tests





C. Gentsos

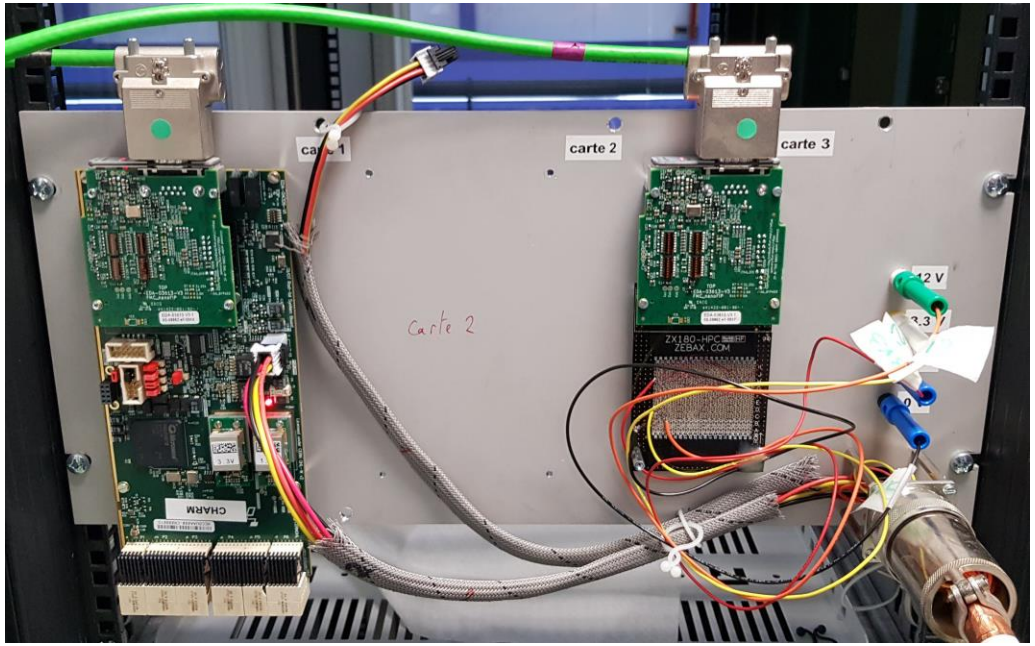
System Board reference gateware



T. Gingold

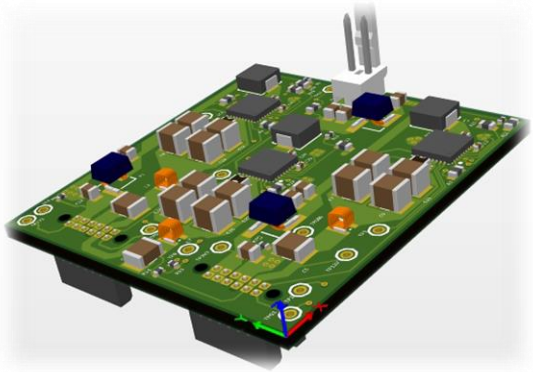
Hydra & System Board irradiations

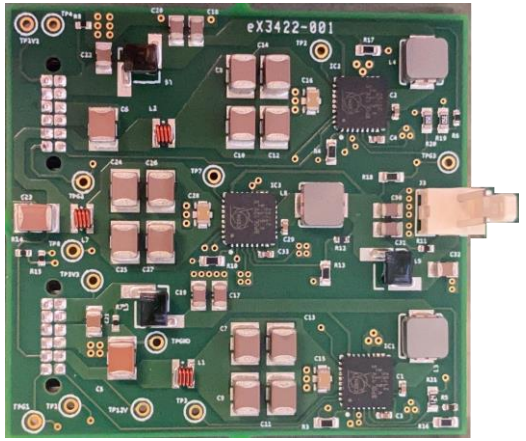
- 3 radiation campaigns (1+1+1 unit) in CHARM position 13
- The only hardware failure: *LT3083* after ~200Gy
  - Will be replaced with bPOL12V
- Campaign 1:
  - many power cycles due to Hydra freezes
- Campaign 2:
  - No freezes in Management CPU until 500Gy
  - Monimod freezes (same issue as with Fan Tray)
- Campaign 3 (finished today):
  - 2x fully TMRed CPU + additional ECC-protected CPU
  - No freezes in Management CPU until 600Gy
  - >1000 single errors in RAM and >100 CPU divergences detected & corrected
  - 10-20 Application CPUs freezes to be investigated



System Board FEAST and LT3083 replacement

- DI/OT-bPOL12 test module
  - Based on dual bPOL12V_MP (EDA-04466)
- 3x bPOL12V to generate 3.3V; 2.5V; 1.2V
- Connector pinout compatible with FEASTMP
- Successful functional validation and long term stability tests
- Pending climatic chamber stress tests

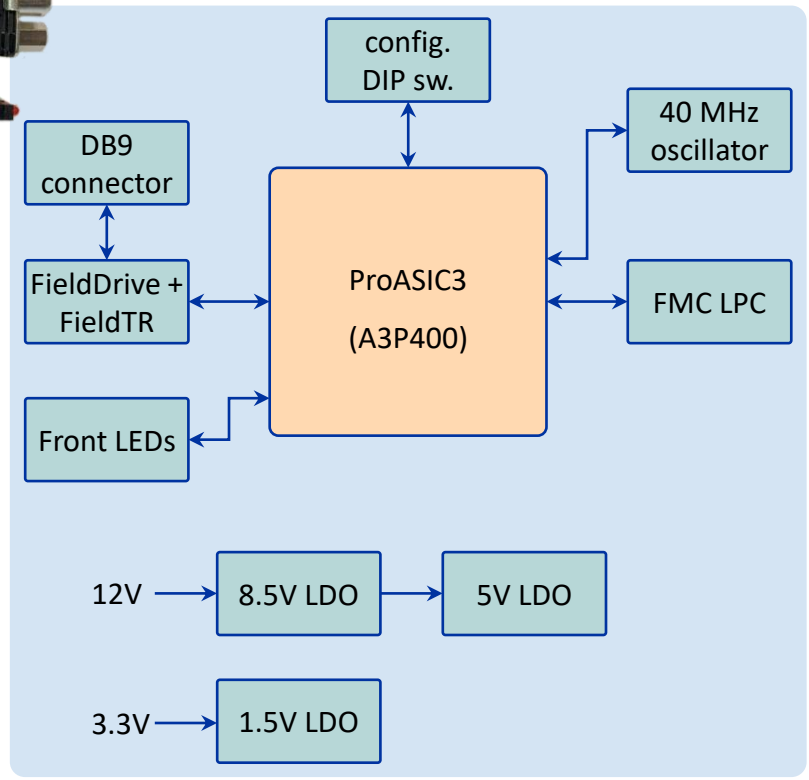




https://ohwr.org/project/diot-sb-igl/tree/master/DIOT-bPOL12V

FMC nanoFIP

- WorldFIP communication up to 2.5Mbps
- Based on nanoFIP @ ProASIC3
- Support for hosted and standalone modes
- Successful v3 redesign and prototype validation



- 5 units irradiated at CHARM position 13
  - 2x 2.5Mbps in stand-alone mode on a passive carrier
    - First data errors at 494Gy and 550Gy
  - 3x 1Mbps in memory mode on DI/OT System Board
    - No data errors until 518Gy

- More details on rad-tol WorldFIP infrastructure will be presented during November meeting.

Summary

- **Modular** platform for **custom** electronics for HL-LHC
- Based **on 3U crate with standardised, generic modules**
- **Final** design phase
- **Functionality** of all hardware prototypes successfully validated
- Numerous **CHARM tests performed**
- Remaining **design improvements and radiation validation** until the end of 2022

https://ohwr.org/project/diot/wikis