IGLOO2 FPGAS IN MUON SYSTEM

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LHCb electronics-FPGAs, 11th Feb 2016
LHCb Muon Chamber FE control

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THE FLASH FPGA ARE ORDERS OF MAGNITUDE MORE RESISTENT THAN SRAM FPGA. IN LHC MUON ENVIRONMENT NO SEU EFFECT IN THE CONFIGURATION SIDE.

There is no problem in the program side. Flash assure that the functionality still the same

It is not the case of SRAM FPGA (like Xilinx, Altera) where also the program side is affected of SEU and some technics must be used to refresh the configuration.

(V.Bocci et al. https://cds.cern.ch/record/529388/files/p137.pdf)

This was the reason why we were one of the first group in HEP (probably the first) to use FPGA with flash technology (in 2003).
FOR THE LOGIC SIDE WE USE SAME TECHNICS OF ASIC CHIP LIKE TMR (TRIPLE MODULE REDUNDANCY)

- In the old muon front end control system all the registers are TDR, State machines, internal registers
- In any case for muon Front END we have not data processing but only controls.
- if a read or write operation fail we can redo without impact in the data acquisition
FEB CONTROL AND PULSE DISTRIBUTION

Up to 8 Cardiac Board for each lvds i2c branch

- **I2c LVDS signals:** SCL, SDAin, SDAout
- **LVDS TST pulse, TTL Reset**

- **Read Write Dialog Registers**
- Send pulse to measure rate, calibrate DLL, sync pulse, RESET FEB

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NEW PULSE DISTRIBUTION MODULE
SINGLE GBT

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New Service Board Module
(multiple GBT old Backplane)

- GBT-SCA
- I2C
- Long line I2C FE converter
- Test/pulse
- 12 x I2C lines
- Flash FPGA
- E-Link 80 Mbits/s
- CLK40
- BC Pulse
- ttl/lvds converter
- Long line I2C FE converter
- Test/pulse
- 1
- 2
- 3
- Long line I2C FE converter
- Test/pulse
- 1
- 2
- 3
- Long line I2C FE converter
- Test/pulse
- 1
- 2
- 3
- Long line I2C FE converter
- Test/pulse
- 1
- 2
- 3
- 3x LVDS I2c each ELMB

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• Microsemi radiation test Document published in OCTOBER 2014

• Important information: Expected same results from IGLOO2 and Smartfusion 2 (they use same technology and process)

• Very poor statement -> usable with radiation level in aviation application and ground level (“For flight-critical applications, mitigation of data upsets in flip-flops and SRAM blocks is advisable”).

• Tested from microsemi with 24 MeV protons. -> “non-destructive latch-ups in heavy ion radiation testing, at energy levels low enough to cause concern in low earth orbit (LEO) space applications”.

• “SEL onset threshold is in excess of 20 MeV-cm²/mg, and that single-event latchups have not been observed at energy levels relevant for aviation applications”
Total ionizing dose expected in nSB system and IGLOO2 problems

- M2A02 previous run 1 Gy in 3.5 fb-1 => 0.3 Gy/fb-1 (dosimeter measurements)
- Aspected dose in LHCb upgrade X 3 (1.5 (collision) x 2 (location)) => 0.9 Gy/fb-1 => 4.5 Gy/year
- Aspected integrated luminosity 50 fb-1 => 45 Gy
- The previous calculation are without safety factor.
- If we consider a safety factor 2 we have 90 Gy = 9 Krad

Warning from a preliminary test one FPGA lose programmability at 25 Gy
Chengxin Zhao https://indico.cern.ch/event/299180/session/5/contribution/73/material/slides/0.pptx

- IGLOO2 sample failed at 1000 Gy and one SmartFusion at 380 Gy (Chengxin Zhao
https://indico.cern.ch/event/299180/session/5/contribution/73/material/slides/0.pptx)

In 65 nm technology, non-volatile memory N-Flash based FPGA’s TID tolerance is dominated by its N-Flash configuration cell. The softness of N-Flash cell causes the TID tolerance significantly below 100 krad(SiO2).
Can we expect a better IGLOO2 in the future from the TID point of view?

No because the a better IGLOO2 exist is the RTG4 G150 very expensive (The price is order of 15Keuro-20 KEuro piece )

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CONCLUSION FOR LHCB MUON CONTROL SYSTEM AT FEB 2016

• We are confident in the use of FLASH based FPGA.
• In our case the TMR is enough strong to correct Flip-flop SEU.
• In any case our apparatus it is non envolved in Data Acquisition flow but only in configuration and monitoring (we are able to do retry operation in case of SEU).
• The result coming from first test are only indicative we need more data from radiation test and from LHCb simulation
• We are not able to perform test alone (not enough human resource) but we are interested to help/participate to define and build test setup for radiation campaign.