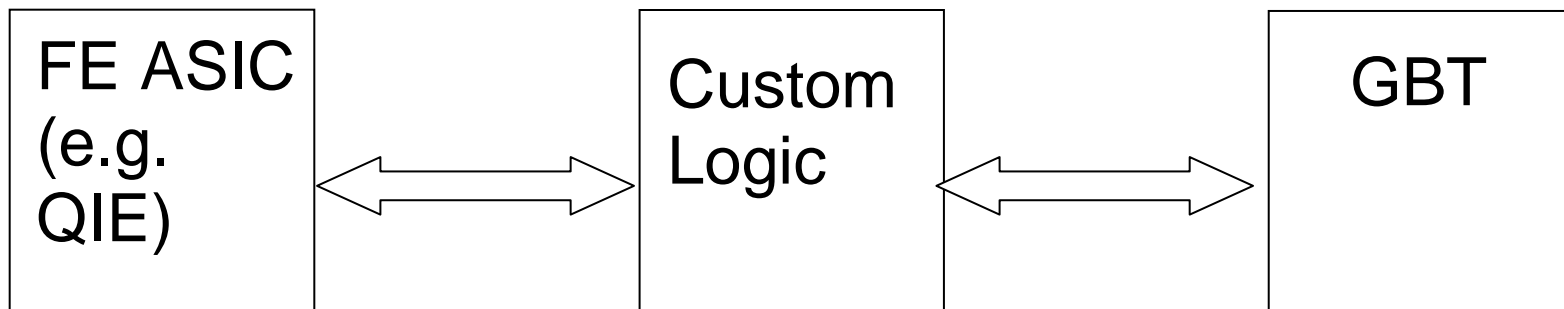


# About using FPGAs in radiation environments

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# Motivations

We may need some "glue logic" between the Front-End ASICs and the GBT (see talk from Chris Tully "HB/HE Strawman Design").



→ investigate the use of FPGAs in radiation environments.

**NB: GBT will have a flexible interface, FPGAs may not be needed.**

# Radiation effects on electronics

1. Total Ionizing Dose (TID) : overall degradation
  - Modern silicon technologies are very robust to TID.
2. Single-Event Latchup (SEL) : “a short-circuit”
3. Single-Event Upset (SEU) : “a flipped bit”
  - data corruption
  - device configuration loss (on reprogrammable FPGAs)

# Vendors of Rad-Hard FPGAs

## **ACTEL:** two families

- 1) Antifuse: one-time programmable
- 2) Flash: non-volatile, reprogrammable

**Aeroflex:** simplest, lowest cost (~800 \$/unit)

**ATMEL**

**XILINX** : most features, most expensive

# ACTEL

Family	RTAX	RT ProASIC3
Technology	Antifuse One-time prog.	Flash Nonvol.reprog
Total Dose (krad)	200	15
SEL im. (MeV-cm <sup>2</sup> /mg)	> 117	> 96
SEU im. (MeV-cm <sup>2</sup> /mg)	> 37	1
Smallest Package	CQFP208	CG484
Gates	> 250k	> 600k
I/Os	single-end, LVDS	single-end, *LVDS
Price(US\$)[1]	5k	5k
Status	active	active

NB: the RT ProASIC3 uses the same silicon technology of the commercial-grade ProASIC3 FPGA.

[1] Phone conversation with Actel rep, Nov2008

# Aeroflex

## Device

UT6325

Technology	One-time programmable
Total Ionizing Dose (krad)	300
SEL Immunity (MeV-cm <sup>2</sup> /mg)	120
Smallest Package	208 CQFP
Gates	320k
I/Os	3.3V single-end
Unit Price (US\$)	816 [quote, Nov2008]
Status	Active

Aeroflex is a close partner of QuickLogic. Aeroflex has "hardened" the silicon process of QuickLogic. They have compatible packages and same software tools.

Aeroflex offers socket adapters.

3.3V I/Os: with the addition of an external resistor, they may also interface to LVDS and LVPECL signals.

# ATMEL

<b>Family</b>	<b>AT40KEL040</b>	<b>ATF280E</b>
Technology	SRAM	SRAM
Total Dose (krad)	300	>300
SEL Im. (MeV-cm <sup>2</sup> /mg)	80	>80
Smallest Package	MQFP160	CQFP256
Gates	50k	280k
I/Os	3.3V single-end	1.8V, 3.3V,
LVDS		
Unit Price (US \$)	7.2k (from 2004)	n.a.
Status	Active	prototyping

Compatible with Atmel commercial FPGAs.

# XILINX

Family	Virtex-4QV	Virtex-II XQR
Technology	SRAM ? (need PROM)	SRAM ? (need PROM)
Total Dose (krad)	>250	200
SEL Im. (MeV-cm <sup>2</sup> /mg)	> 100	> 160
Smallest Package	CF1140	CG717
Gates	> 5M	> 1M
I/Os	many single-end and diff. standards	
Price (US\$)[1]	> 24k	> 10k
Status	In qualification	Full production

[1] from [www.nuhorizons.com](http://www.nuhorizons.com), Nov2008

Configuration PROMs XQR17\* (50 kRad) [ $> 600$  US \$]

Xilinx FPGAs have **lots of features** (DLL, clock divider, DSP blocks, RAM, PowerPC, Ethernet MAC). There are socket adapters, but they are not recommended (not very reliable).



# Radiations effects on FPGAs

1. Total Ionizing Dose (TID) : overall degradation
  - Modern silicon technologies are very robust to TID, and **FPGAs tend to use the latest technologies**
2. Single-Event Latchup (SEL) : “a short-circuit”
  - Happens rarely even without radiation, so some commercial parts have protection circuits. Remains an issue. Protections on the PCB ?
3. Single-Event Upset (SEU) : “a flipped bit”
  - **data corruption** → can detect or correct it with coding
  - **configuration corruption** (on reprogrammable FPGAs)  
→ **avoid SRAM FPGAs**. Flash-based FPGAs ?

# Use of non rad-hard FPGAs in radiation environments

- ALICE and LHCb are low-channel count, low-\$ experiments
- They use commercial-grade FPGAs on the detector,
- They have done irradiation testing:
- [http://alice-proj-ddl.web.cern.ch/alice-proj-ddl/radtol/doc/LECC2006\\_AliceRadtolArticle.pdf](http://alice-proj-ddl.web.cern.ch/alice-proj-ddl/radtol/doc/LECC2006_AliceRadtolArticle.pdf)
- [http://frederic.web.cern.ch/frederic/Irradiation/irradiation\\_table.html](http://frederic.web.cern.ch/frederic/Irradiation/irradiation_table.html)
- They excluded SRAM technology (Altera, Xilinx)
- Actel Antifuse and Flash FPGAs ok up to 20 kRad

# Other considerations

When using a non rad-hard component for a radiation environment, all the chips should be purchased from the same production lot. This is to make sure that they all behave as the parts used for qualifications

There is a lot of literature about using commercial-grade parts in a radiation environment.