This poster presents the deployment and optimization process of triple-module redundancy (TMR) under high design constraints against single-event upset (SEU) and single-event transient (SET). It includes modeling of single-event effects (SEE) pulses with TCAD mesh model, TMR deployment strategies, and verification methods. The simulation result shows that the prototype with optimized TMR deployment has high reliability with respect to design requirements. The system can run for more than 5 years without crucial errors. And the equivalent error rate in the working environment is lower than $10^{-8}$.

**ABSTRACT**

**CBM-MVD**

**Compressed Baryonic Matter (CBM) experiment**

The goal is to explore the strong nuclear interact in the region of high baryon densities using high-energy nucleus-nucleus collisions. In order to achieve the required precision, the measurements will be performed at reaction rates up to 10 MHz.

**Micro-Vertex-Detector (MVD)**

- The MVD is situated in the target spectrometer and is the closest detector part with respect to the primary interaction vertex.
- The MVD is a tracking device for charged particles and thus essential for a very precise determination of secondary decay vertices of short-lived particles such as hyperons or mesons with charm or strange quark content.
- The MVD is exposed to the environment of highly ionizing particles. There is an urgent need for protections to ensure the correct operation of the MVD.

**SEEE Pulse Characteristics**

- Identity the type and energy of impact particles
- Simulate the LET range of the particles
- Simulate circuits response in TCAD

**TMR Deployment Strategy**

Control process schedule

- Global Signals
- FSM
- Counter/Status
- Shifter
- PLL
- SRAM

Composition data path

- No TMR
- TMR

The recovery time of an FSM is also considered. TMR helps to guarantee the recovery time of FSM within 1 clock cycle.

**Results & Conclusions**

- The TMR deployment strategy is a low-cost method to design high reliability circuits.
- The SEE model and verification method guide us to optimize the design with respect to requirements.

**References**

