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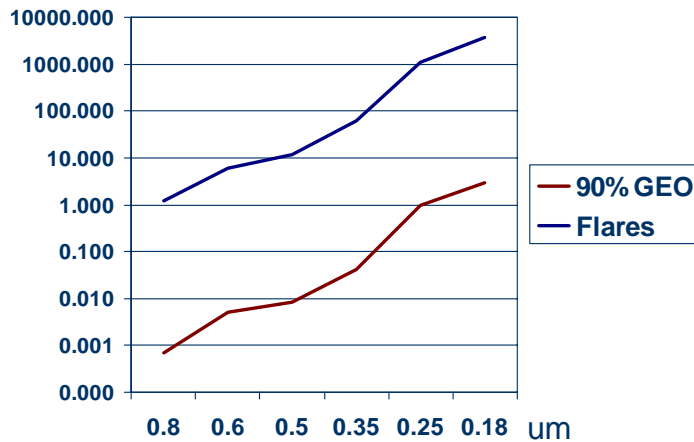
Single Event Effects Solutions For VLIW Microprocessors 2004

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Microprocessors Problems SEU & SEFI

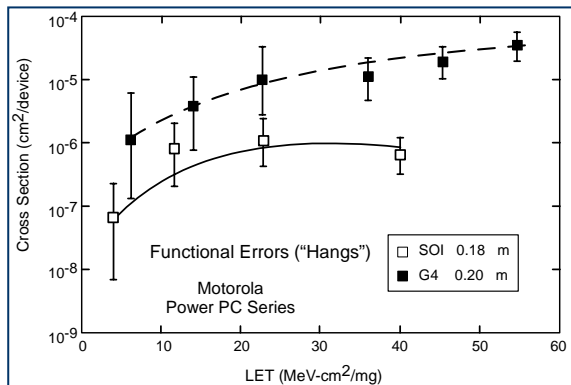
PowerPC SEU Rate



- SEU rate getting worse
 - Trend from 0.8 to 0.18 um

• SEFI (Single Event Functional Interrupts... aka "Hangs")

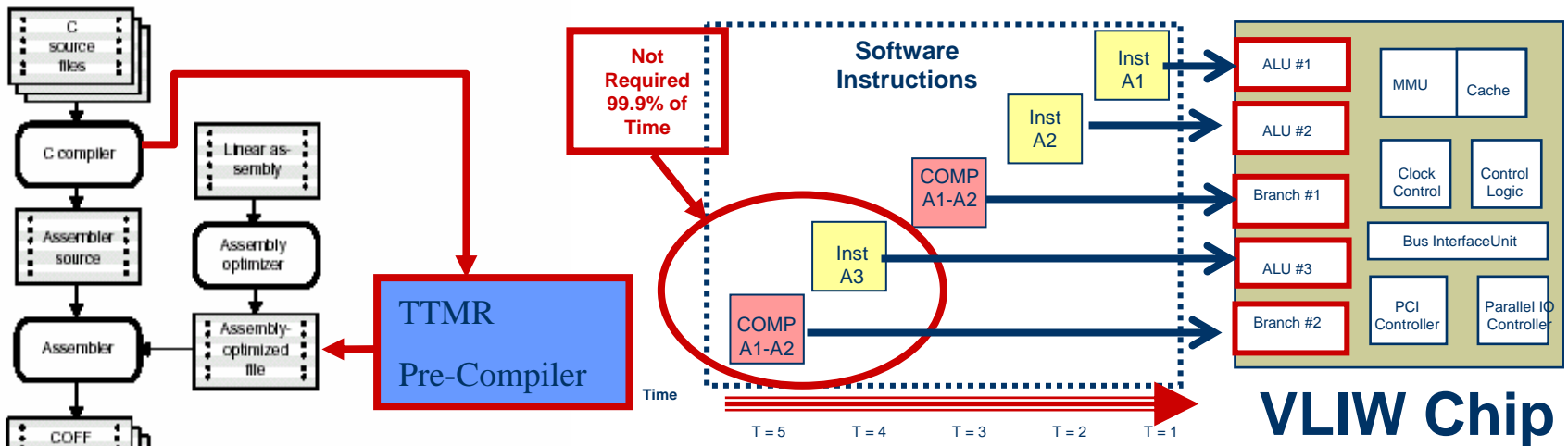
- Processor hangs by SEU
- By protons or heavy ions
- All CPUs are susceptible
- Approx. rate 1 every 100 days – SOI PPC (10x for CMOS)
- **SEFI problem is Severe & not easily solvable**
 - Power down is current industry solution



PowerPC SEFI Data



SEU Correcting Technology: Time-Triple Modular Redundancy



Single DSP solution!

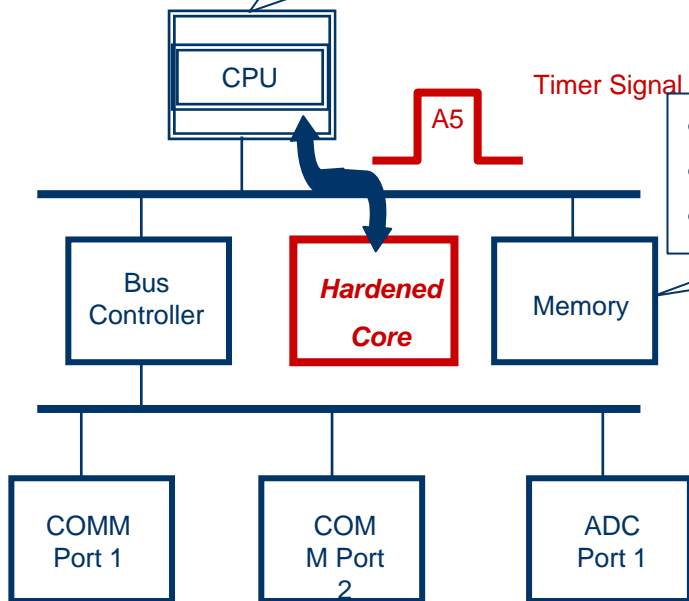
Software

- ◆ TTMR™ Combines Time & Spatial redundancy
- ◆ Takes advantage of VLIW parallel opportunities
- ◆ SEU error rate expected to be equal to TMR
- ◆ Software controllable, selectable performance
 - High speed worse SEU rate
 - 50% speed better SEU rate
- SEFI is NOT fixed with TTMR...see H-Core
- Proton radiation tested



SEFI Solved with Hardened Core: H-Core is More Than a Chip!

- Timer code when NO SEFI
- KILL Threads post SEFI
- Read H-Core Status Flags
- Flush cache & registers
- Recovery routines
- Rollback software routines



- Rollback data stored in Memory
- Store critical variable periodically
- Store instruction pointer locations

- ◆ Tested at UC Davis with 51 MeV Protons
- ◆ Test CPU was Pentium III, Intel, 850 MHz
- ◆ Summary Results:
 - 21 SEFIs induced
 - 21 recoveries by SEFI Watchdog Functions
 - IRQ, NMI and Reset brought back Pentium III
- ◆ *** Patent Pending ***
- ◆ **RESULT: SEFI Watchdog Proven with Protons**

- ◆ Software + hardware
- ◆ Software allows for post SEFI Recovery