**POST-RADIATION MEMORY CORRECTION USING DIFFERENTIAL
SUBTRACTION FOR PHENIX***

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Post-Radiation Memory Correction Using Differential Subtraction for PHENIX

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In colliders such as RHIC, the radiation levels are well below those of colliders such as LHC. The problem is that there can be enough radiation at the inner detector (Multiplicity-Vertex Detector or MVD) to significantly affect a low-priced, non-radiation-hard CMOS process. If the radiation affects the entire analog memory in a uniform fashion, then a real-time correction should be able to be performed to correct any changes seen in the memory and also the induced correlated noise from detector pickup thus precluding the need for a more expensive rad-hard process. This paper will present testing on memories fabricated in a 'soft' process and exposed to ionizing radiation. We used a single pipeline as a reference to be subtracted in a cell-by-cell basis from each pipe during read out and investigated the spatial effects of using different pipes for the reference. Use of this method reduced the noise which was common to all pipes (common-mode noise) and thus reduced both common-mode input noise and pattern noise generated from address lines being exercised on the AMU. The correlation across the memories (6-, 8-, and 16-channel AMUs fabricated in the Orbit 1.2 μ CMOS process) vs. radiation dose was found to be quite good. Both pre-and post-radiation results are presented on systems designed for PHENIX and WA98 at CERN as well as measured results on the minimization of the effects of injected systematic noise.

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Suggested areas:

Analog and Digital Circuits
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Summary

Real detector electronics systems have a variety of noise sources. These sources include pickup from the detector and associated input wiring, random noise from the preamplifier, pattern noise from the digital circuitry controlling the data acquisition system, and power-supply-induced noise from other circuits on the front-end boards. In addition, electronics such as vertex tracking systems that are close to the beam pipe in colliders can be damaged due to radiation exposure.

There has been little reported on the subject of radiation-hardened analog memory units (AMUs) [1, 2, 3]. In colliders such as RHIC, the radiation levels are well below those of colliders such as LHC. The problem is that there can be enough radiation at the inner detector (Multiplicity-Vertex Detector or MVD) to significantly affect a low-priced, non-radiation-hard CMOS process. If the radiation affects the entire analog memory in a uniform fashion, then a real-time correction should be able to be performed to correct any changes seen in the memory and also the induced correlated noise from detector pickup thus precluding the need for a more expensive rad-hard process. Some work has been performed on differential subtraction [4, 5, 6] but not with emphasis on radiation effects. This paper will present testing on memories fabricated in a 'soft' process and exposed to ionizing radiation. We used a single pipeline as a reference to be subtracted on a cell-by-cell basis from each pipe during read out and investigated the spatial effects of using different pipes for the reference. Use of this method reduced the noise which was common to all pipes (common-mode noise) and thus reduced both common-mode input noise and pattern noise generated from address lines being exercised on the AMU. The correlation across the memories (6-, 8-, and 16-channel AMUs fabricated in the Orbit 1.2 μ CMOS process) vs. radiation dose is quite good as can be seen in Fig. 1. This figure shows the resultant rms memory variation of pipeline number 1 after subtracting each cell of the pipeline shown on the x-axis from pipeline number 1 for 0-, 25-, 50-, and 75KRad ionizing radiation. The operation can be written symbolically as

$$v_{pipe,cell}^{rms} = rms[v_{pipe,cell} - v_{reference,cell}]$$

where *pipe* is the pipeline being corrected, *reference* is the pipeline used for correction, *cell* is the given cell in the pipeline, and *rms* is the root-mean-square operation upon the array of numbers generated from the cell-by-cell subtraction for a given pipeline. As is obvious, the correlation across the chip is excellent. Figure 2 shows the pre- and post-

radiation memory output variations using pipeline number 4 as a correction for the other 7 pipelines after 75KRad ionizing radiation. Both pre-and post-radiation results will be presented on systems designed for PHENIX and WA98 at CERN as well as measured results on the minimization of the effects of injected systematic noise.

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Figure 1. Thin Glenn chip 1, pipe 1 values, 0.5V-0.5V.

Figure 2. Chip 1, 75KRad, channel 4 as reference with 0.5V input.