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FPGA-Based Digital Design for DAQ and Radiation-Hard CMOS Monolithic Sensors in High-Energy Physics

The development of radiation-hard CMOS Monolithic Active Pixel Sensors (MAPS) is a key advancement for next-generation high-energy physics experiments. These sensors offer improved spatial resolution and integration capabilities but require efficient digital readout and data acquisition (DAQ) systems to operate in high-radiation environments. My research focuses on the FPGA-based digital design for sensor readout and DAQ firmware development, optimizing real-time data processing and signal integrity. A critical aspect is ensuring the radiation tolerance of the electronics, addressing noise suppression and timing performance. As a first-year PhD student, I am beginning with theoretical and software-based digital design, gradually moving towards practical FPGA implementation. My motivation is to contribute to the development of robust and efficient detector electronics that can be used in future particle physics experiments, space applications, and medical imaging.

Significance

This presentation covers novel results by focusing on the development and optimization of FPGA-based digital design for radiation-hard CMOS sensors, which is critical for future high-energy physics experiments. Unlike a status report, the work emphasizes advancements in sensor readout, DAQ systems, and radiation tolerance, providing insights into the early stages of FPGA implementation and software development. These incremental updates show how digital design and radiation-hardness techniques are evolving, with clear contributions to improving sensor performance in challenging environments, which is a key area of innovation for future experiments.

References

[21/08/2022 –01/09/2022] Organized by National Centre for Physics (NCP), Islamabad, Pakistan.
Participated in 11th school of LHC Physics at National Centre for Physics (NCP), Islamabad, Pakistan.
[21/08/2023 –01/09/2023] National Centre for Physics (NCP), Islamabad, Pakistan.
Participated in 12th school of LHC Physics at National Centre for Physics (NCP), Islamabad, Pakistan.
[21/08/2022 –01/09/2022] National Centre for Physics Islamabad, Pakistan (NCP)
Group Presentation on “Searches for Standard Model prediction of four top quarks in the lepton + jets channel in proton proton collosion at National Center for Physics (NCP), Islamabad, Pakistan.
[24/10/2022 –28/10/2022] National Centre for Physics (NCP), Islamabad, Pakistan.
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Participated in 5th International Workshop on Tracking Detectors in High Energy Physics, held at National Centre for Physics (NCP), Islamabad, Pakistan.
[06/11/2023 –10/11/2023] National Centre for Physics (NCP), Islamabad, Pakistan.
Participated in 6th International Workshop on Tracking Detectors in High Energy Physics, held at National Centre for Physics (NCP), Islamabad, Pakistan.
[11/12/2023 –15/12/2023] National Centre for Physics (NCP), Islamabad, Pakistan.
Participated as organizer in 5th International Workshop on Heavy Ion Physics at National Centre for

Physics (NCP), Islamabad, Pakistan.
[14/08/2023 –25/08/2023] DS3 Data Science Summer School Berlin, Germany
Hertie School Data Science Lab
[24/07/2023 –25/07/2023] Organized by Artificial Intelligence Technology (ALTeC) ,National Centre for physics,
Islamabad.
International Symposium on Artificial Intelligence Madical Imaging and Pattern Recognition (ISAIMP-2023)
[07/11/2022 –07/11/2022] Online
Participated in Willey Online Library: Advanced Search (HEC).
[20/08/2023 –20/09/2023] Islamabad, Pakistan
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Experiment context, if any

This research is contextualized by ongoing efforts in high-energy physics experiments that require radiation-hard CMOS detectors, such as those used in particle accelerators and space applications. While the work is not directly tied to a specific experiment yet, it builds upon technologies used in detectors like MAPS for future upgrades in experiments like HL-LHC (High-Luminosity LHC) or space instrumentation projects. The FPGA-based DAQ systems and radiation-tolerant designs will contribute significantly to the performance and reliability of such experiments.

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