Monte Carlo Processing on a Chip (MCoaC) for medical research

Monte Carlo simulations consider the material science of particle interactions using theoretical models or experimental cross-section data for electromagnetic and nuclear interactions. Along these lines it is thought to be the most precise strategy to figure measurements in radiation treatment. The computational efficiency in Monte Carlo simulation is still not suitable for clinical usage in terms of compute and memory utilization. With a specific end goal to enhance the computation speed we describe the project to meet the needs of the community for ease of use and efficient implementation of TOPAS toolkit. We are also finding methods and working on implementing Monte Carlo simulations on hardware based accelerators like FPGA to reduce simulation time. Amongst the many scientific frameworks benefitted by GEANT4, TOPAS is one which has proven quite adept at use in the clinical research environment. TOPAS wraps and extends the Geant4 simulation toolkit to make advanced Monte Carlo simulation of all forms of radio and particle therapy. Topas is based on Monte Carlo simulation and has been broadly acknowledged in medical area. The research strategy is designed around the need of parallelization of TOPAS and how it is going to affect the simulation speed. There is a clear need for this idea of parallelization and inspection of elements to understand how it is going to impact the biology, physics, and chemistry and going to help in better understanding of radiation effect at DNA level. The analysis need to be done to find the difference in simulation results if we do it with normal TOPAS source code and with parallelization of TOPAS as we have to consider other side effects that the parallelization approach is going to create. There should also be an idea behind validation of parallel code/parallelization. The strategy is to develop the environment to analyse the real need of profiling the code, standard optimization of the code, use of FPGA, perhaps the develop HPC platform in place and then the custom core/custom instruction set unit data. The requirement is to have parallelized custom hardware units with deskside pluggable options to achieve the desired code efficiency. Development of a scalable technology for central processing units (CPUs) that allow optimization and customization of assembly language/instruction sets as well as scaling the code on accelerators like FPGA can be explored. As such, speed ups of fastest standard CPUs will be seen in prior areas of investigation. The collaborative investigation to explore practicality of using FPGA architecture with the TOPAS project need to be explored because of the centrality of Monte Carlo calculations to biological science. As TOPAS project sits on top of GEANT4, these FPGA’s will be useful to the full GEANT4 set of tools and it is hoped that the work will be of significance to the field at large. The work is a collaborative effort of :

1. Centre for Development of Advanced Computing (C-DAC), Pune, India (https://www.cdac.in/) 2. Open Health Systems Laboratory (OHSL), USA, (www.ohsl.us) 3. Society for Applied Microwave Electronics Engineering & Research (SAMEER), Mumbai, India (https://www.sameer.gov.in) 4. Tata Memorial Centre (TMC) , Mumbai, India (https://tmc.gov.in) 5. All India Institute of Medical Sciences (AIIMS), Delhi, India (https://www.aiims.edu/) 6. University of California San Francisco, USA 7. SLAC National Accelerator Laboratory, Menlo Park, USA 8. Massachusetts General Hospital and Harvard Medical School, Boston, USA 9. National Cancer Institute (NCI), Bethesda, USA (https://cancer.nih.gov/)

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