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Full dynamic brain simulation using GATE in a high-performance computer

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Abstract

Dynamic PET brain studies are common in research and are becoming common in clinical applications. Simulation of dynamic PET is an important step to validate techniques and methods. This study compares a GATE simulation running on a CPU versus running on a GPU. We simulated the 3T Siemens MR-BrainPET with dynamic brain activity. The results show close agreement in the number of coincidence events, including phantom scatter. The code will be made available to the GATE community and the simulation data is available to the interested researchers.

Methods

3T MR-BrainPET

Hybrid PET/MR scanner dedicated to brain imaging [6].

- 32 cassettes displayed in a cylinder
- each cassette has 6 detector modules
- each module is a 12x12 LSO crystal matrix
- each crystal is of 2.5x2.5x20 mm^3

Thus, the scanner has 72 ring detectors with 384 crystals, for a total of 27648 crystals. The axial FOV is 19.25 cm.

GATE 7.2

The GPU simulations were performed with a new version of the existing GPU code that additionally produces phantom scatter information. The scatter information is stored as eventIDs in a dedicated output file.

JURECA

Juelich Research on Exascale Cluster Architectures at the Jülich Supercomputing Center [7].

- 1872 compute nodes with **two Intel Xeon E5-2680 v3 Haswell CPUs**
- out of which 75 of the nodes are additionally equipped with **two NVIDIA K80 GPUs**.
- This system uses the workload manager Slurm (Simple Linux Utility for Resource Management).

Fig. 1: Supercomputer JURECA [7] at Jülich Supercomputing Centre (JSC).

Results

The Time-Activity curves were consistently similar with **under 2%** difference across all time points as can be seen in Fig.2 .

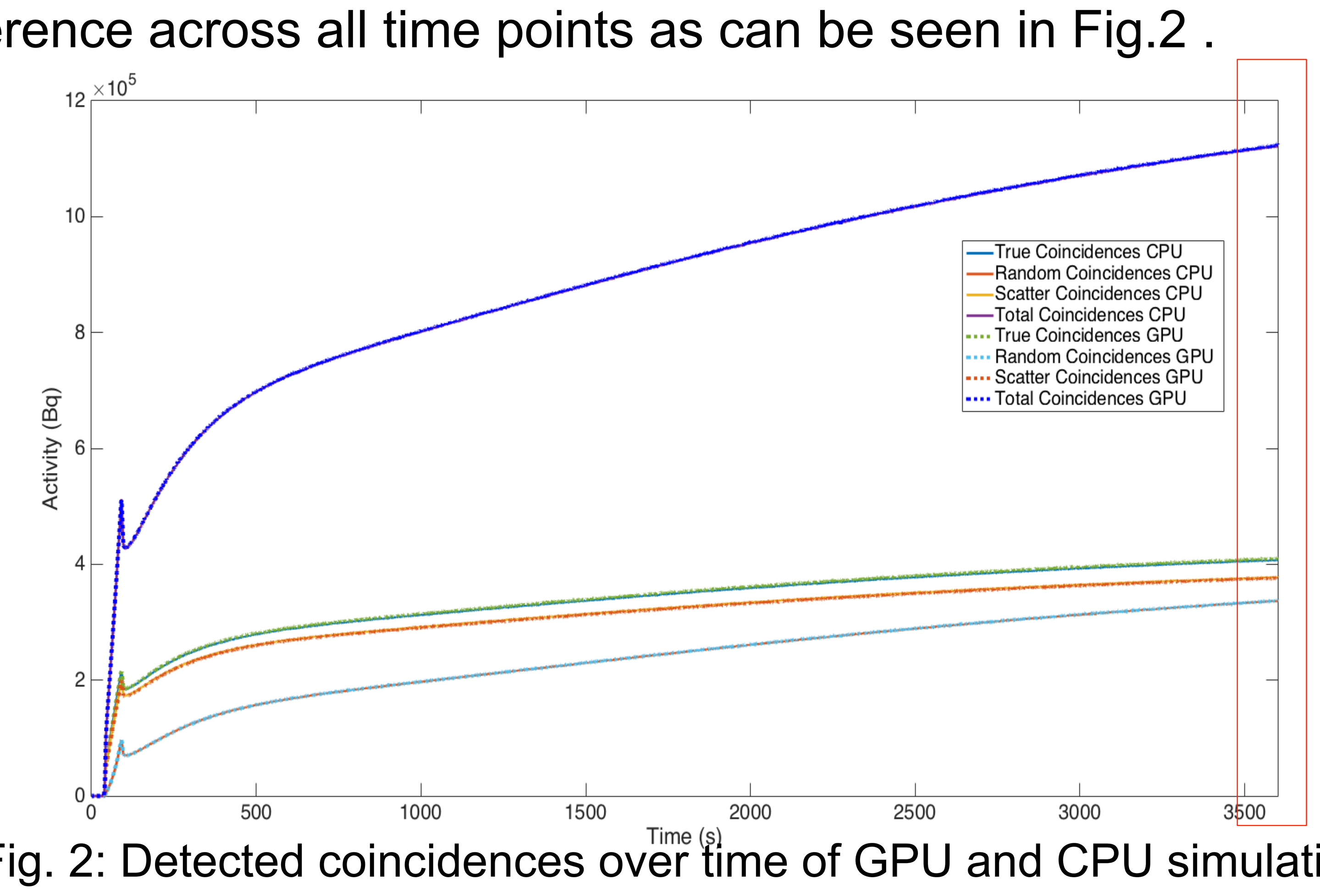

Fig. 2: Detected coincidences over time of GPU and CPU simulation

Coincidences	CPU	GPU
Total	1122090	1122396
True	407310	408369
Scatter	376153	3771198
Random	338627	336829

Table 1: Simulation run time for CPU and GPU in different configurations per node (each CPU node consists of 2 CPUs and the GPU node consists of 2 CPUs with 2 GPUs each).

code	Configuration PER NODE	runtime
GATE 7.2	CPU: 1 simulation	2:20:15
GATE 7.2 with changes	GPU: 1 simulation	0:20:05
GATE 7.2	CPU: 24 simulations	3:01:57
GATE 7.2 with changes	GPU: 48 simulations	8:48:02
GATE 7.2	GPU: 48 simulations	7:02:22

Conclusion

- GATE software includes now **phantom scatter** information in GPU code. The coincidence **events are comparable in CPU and GPU**.
- We compared the results on a high-performance computer. **A full dynamic simulation** of one hour can be **simulated in a few days**, that is, in 1000 node hours.
- Code changes in the GPU part will be made available to the GATE community.
- Future: to simulate different dynamic patterns along with a focus on improving the computing performance.

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References

[1] Slomka, P. J. et al. "Recent advances and future progress in PET instrumentation." (2016). **[2]** Tsoumpas, C.,et al. "A survey of approaches for direct parametric image reconstruction in emission tomography." (2008). **[3]** Häggström, I. et al. "Compartment modeling of dynamic brain PET—The impact of scatter corrections on parameter errors." (2014). **[4]** Jan, S. et al. "GATE V6: a major enhancement of the GATE simulation platform enabling modelling of CT and radiotherapy." (2011). **[5]** Bert, Julien, et al. "Geant4-based Monte Carlo simulations on GPU for medical applications." (2013). **[6]** Herzog, H, et al. "High resolution BrainPET combined with simultaneous MRI." (2011). **[7]** Jülich Supercomputing Centre. (2016). JURECA: General-purpose supercomputer at Jülich Supercomputing Centre. Journal of large-scale research facilities, 2, A62. http://dx.doi.org/10.17815/jlsrf-2-121 **[8]** Caldeira, L. et al. "Effects of regularisation priors and anatomical partial volume correction on dynamic PET data." (2015).