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

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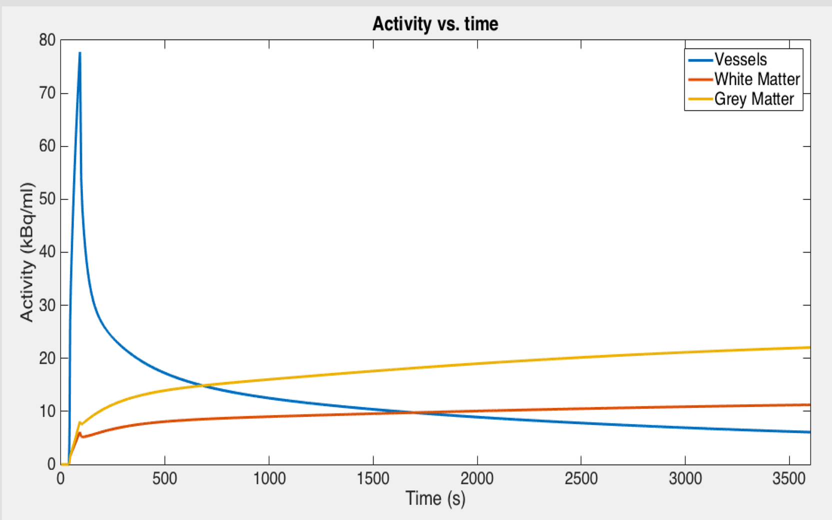
Abstract

Dynamic PET brain studies are common in medical research and are becoming common in clinical applications. Simulation of dynamic PET is an important step to validate techniques and methods e.g. scatter events can be separated from true events. This study compares a GATE simulation running on multi-CPU versus running on multi-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

Dynamic Phantom

The time-activity curves (TACs) generated using PMOD [8]



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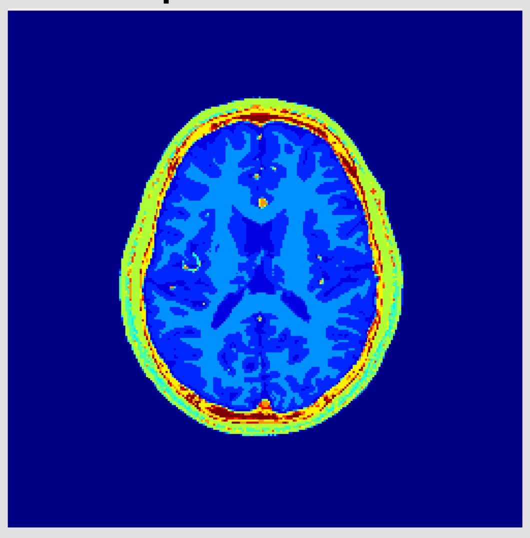
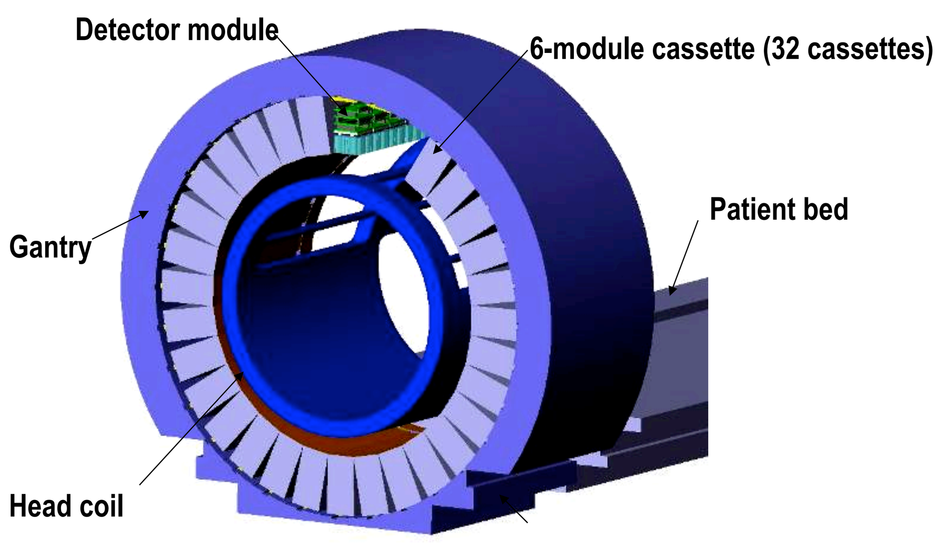
The Brainweb phantom



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** (12-core processors)
- 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 TACs of the whole head were consistently similar with **under 2%** difference across all time points as can be seen in Fig.2 .

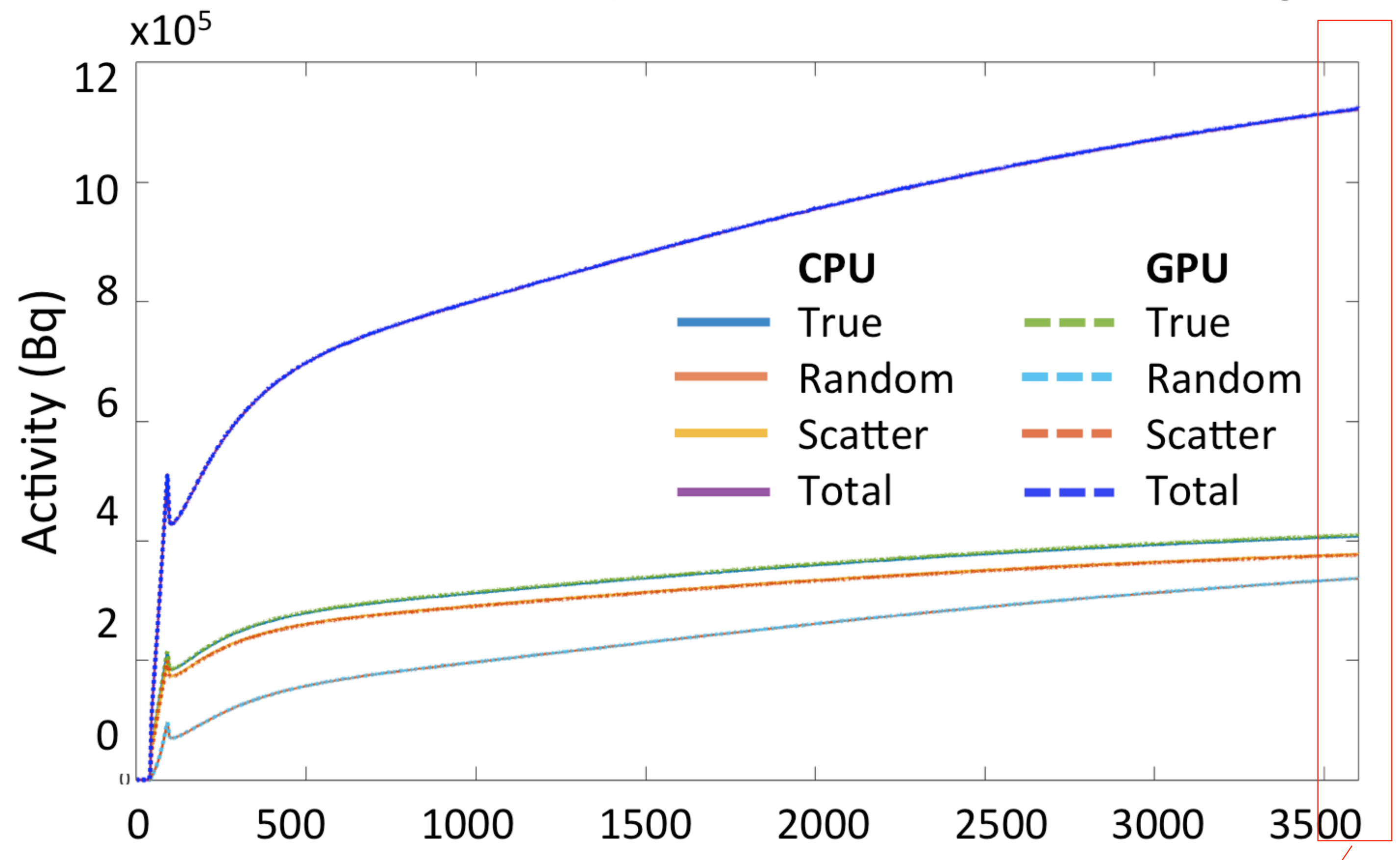


Fig. 2: Detected coincidences over time of GPU and CPU simulation.

Table 1: Quantitative results for second 3599-3600.

Coincidences	CPU	GPU	% diff
Total	1122090	1122396	-0,03
True	407310	408369	-0,26
Scatter	376153	377198	-0,28
Random	338627	336829	0,53

Table 2: Simulation running time for CPU and GPU in different configurations per node (each CPU node consists of 24 cores and the GPU node has 4 cores).

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	GPU: 48 simulations	7:02:22
GATE 7.2 with changes	GPU: 48 simulations	8:48:02

Conclusion

- We adapted GATE to output **phantom scatter** information in GPU code. The coincidence **events are similar in CPU and GPU**.
- We compared the results on a high-performance computer. **A full dynamic simulation** of 1 hour acquisition can be **simulated in a 2-4 days**, that is, in approximately 1000 node hours.
- Code changes to obtain scatter information in GPU will be made available to the GATE community.
- Future: to simulate different dynamic patterns along with a focus on improving the computing performance.

Acknowledgements

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References

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