AdePT physics

HSF Detector Simulation on GPU Community Meeting

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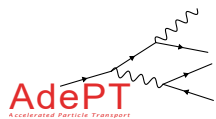

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  - Abstraction of random number generator
    - CLHEP on the CPU when used with GEANT4 (default: MIXMAX)
    - Want to use RANLUX++ on the GPU
      (smaller state, but equally excellent statistical properties)

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- Solution: rework functions for reuse on GPU
  - Split functions into smaller pieces (example: continuous energy loss)
  - Overload functions to also accept explicit pointer to track and RNG (if needed)
- Implemented in a series of PRs: `mnovak42/g4hepem#16`, `mnovak42/g4hepem#21`, `mnovak42/g4hepem#25`, `mnovak42/g4hepem#30`

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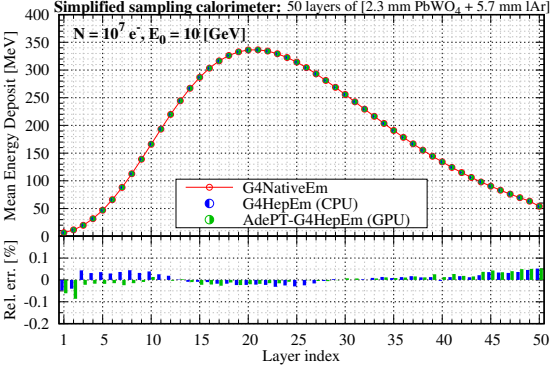
- Tiny wrapper class `G4HepEmRandomEngine` (`mnovak42/g4hepem#18`)
  - Reference to real engine and two function pointers
- Relevant selection and sampling functions take an argument of this class (instead of `G4HepEmTLData`, see previous slide)

Validation: TestEm3, $PbWO_4$ + lAr, 10 GeV electrons

GEANT4 11.0, complete physics including MSC except energy loss fluctuations



Mean values per event of some quantities:

	GEANT4	G4HepEm			
	G4Em (CPU)	HepEm (CPU)	**Rel. err.** [%]	AdePT (GPU)	**Rel. err.** [%]
Energy deposit per material [MeV]					
$PbWO_4$	6730.00	6729.46	-0.008	6729.46	-0.008
lAr	2566.18	2566.55	0.014	2566.52	0.013
Number of secondaries					
γ	4456.06	4454.57	-0.033	4451.46	-0.103
e^-	8066.48	7953.90	-1.40*	7953.22	-1.40*
e^+	429.103	429.146	0.010	429.147	0.010
Number of steps					
charged	36696.7	36283.2	-1.13*	36292.0	-1.10*
neutral	40377.9	40426.6	0.121	40597.9	0.545

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- Influence smaller for more complex geometries
  - Around + 10 % for `cms2018`, compared to 2-3 % on the CPU

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Current conclusion: fluctuations not suitable for simulation on GPU - needed for HEP?

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- Possible to run full EM shower simulation on GPUs!
- Reusing $> 95\,\%$ of the code from G4HepEm
  - After decoupling from `G4HepEmTLData` and abstracting the RNG
- Excellent agreement with GEANT4
  - For the setups and energy ranges required in HEP detectors (see previous talk)