Detector Simulation on GPUs: The AdePT project

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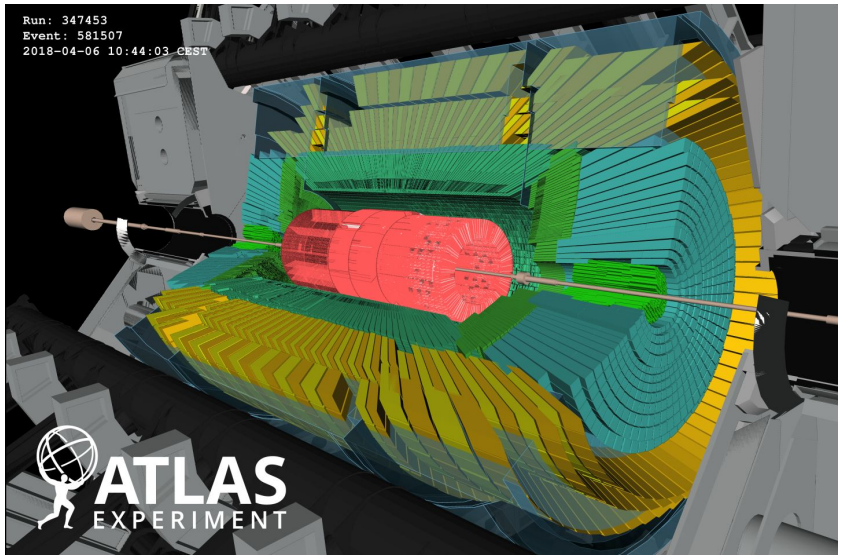
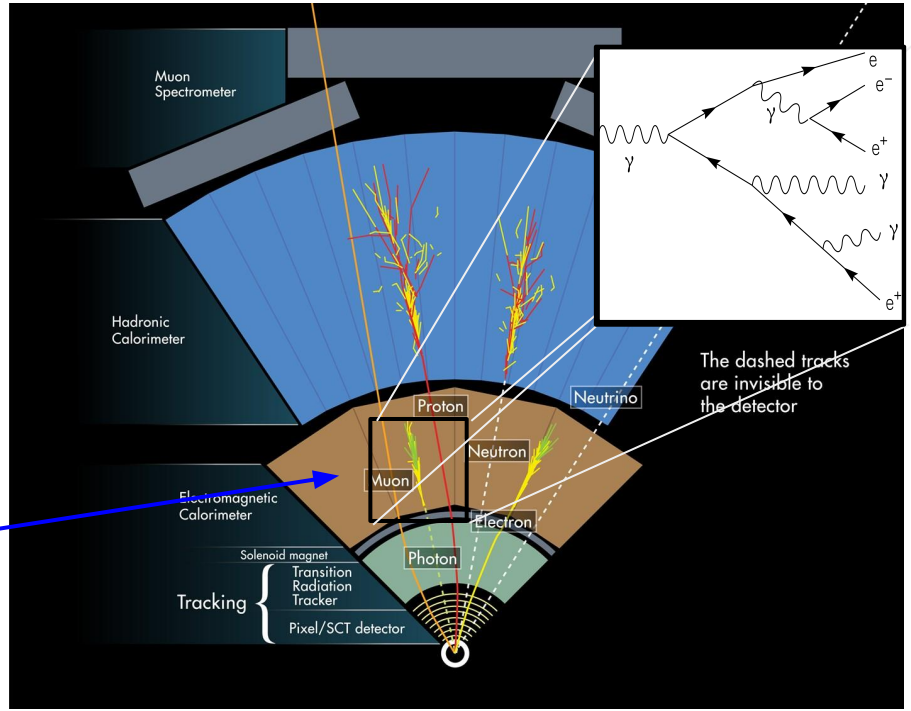
Detector Simulation on GPUs: Why?

- To understand the LHC data, we have to simulate how particles interact with detectors
- Simulation takes ~ 40% of CPU time on WLCG
- Three main steps
  - Simulate particle collisions (~ fast)
  - Simulate what particles do in detector
  - Run reconstruction algorithms as if detector had been hit by real particles
- AdePT's focus: calorimeter simulation



Detector Simulation on GPUs: Why?

- Most detectors have two(+) calorimeters
- Particles create showers of more particles
- Showers grow with energy and pile up
  → LHC detectors have large showers
- Need to measure showers accurately to get to energy of particles
- Geant 4:
  - De-facto standard for simulating interactions of particles with detectors
  - Consumes most of simulation time
- AdePT:
  - Accelerated demonstrator of electromagnetic Particle Transport
  - Replace EM Calo step of a Geant4 simulation?

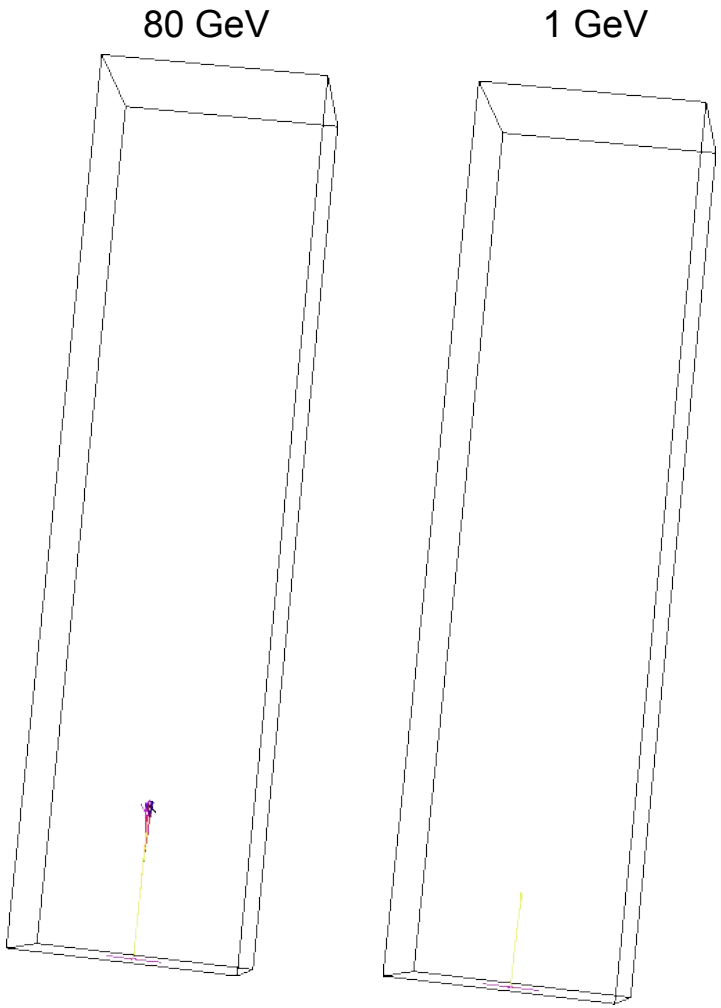


Simulating EM Showers

- These are EM showers in lead glass
- Every thread takes a particle and processes it until it lost its energy
- Particles do completely random* things
  - Cache problems
  - Tricky branch prediction
  - Bad for CPUs
- Modern detectors can have very complicated layouts

* Completely random:

- Physics only predicts *probability* that something happens
- In every step, use random numbers to decide *if* something happens



EM Showers are Expensive

- EM showers in lead glass
- Every thread takes a particle and processes it until it lost its energy
- Particles do completely random* things
  - Cache problems
  - Branch prediction tricky
  - Really bad for CPUs
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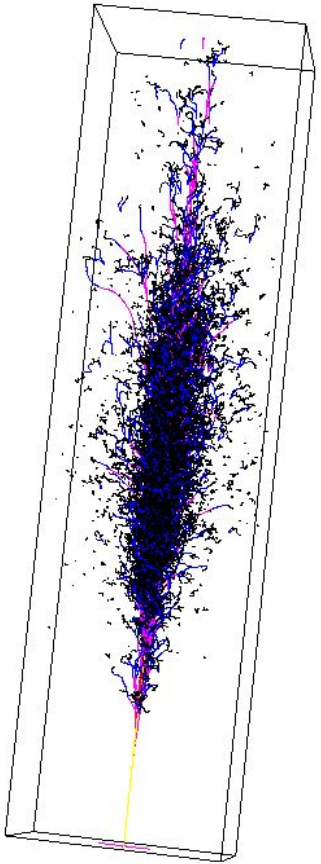
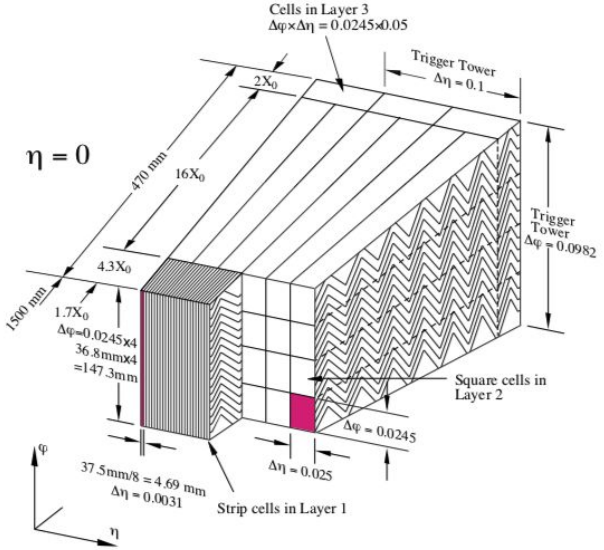
80 GeV

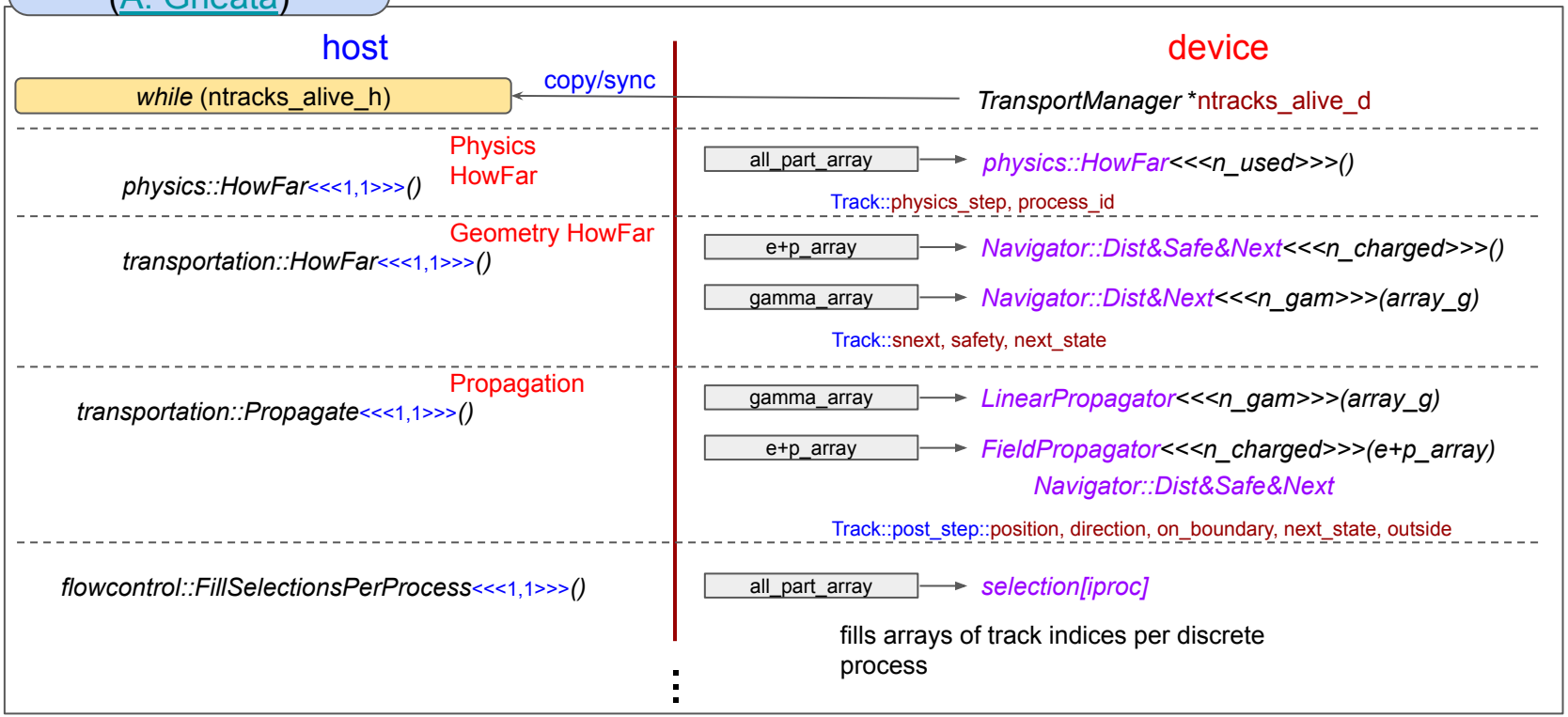


ATLAS EM Calorimeter



AdePT - Sketch of a Potential Simulation Workflow

From an AdePT simulation meeting (A. Gheata)



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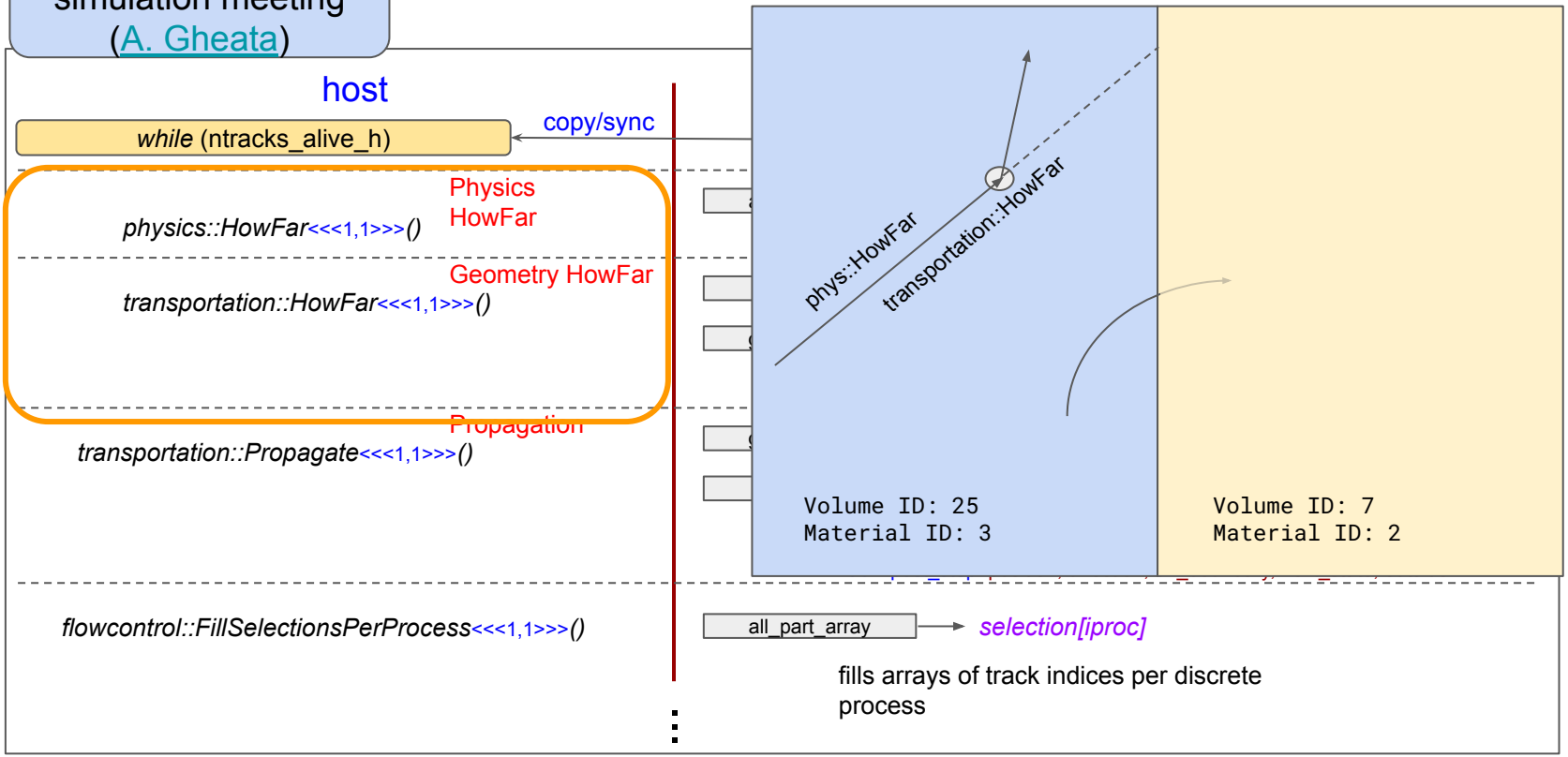

Summary

- Speeding up detector simulation among the important tasks in HEP computing
- AdePT should demonstrate
  - ✅ That one can run EM calorimeter simulation on GPUs
  - ✔️ That one gets comparable results
  - ❌ That it's faster

Backup

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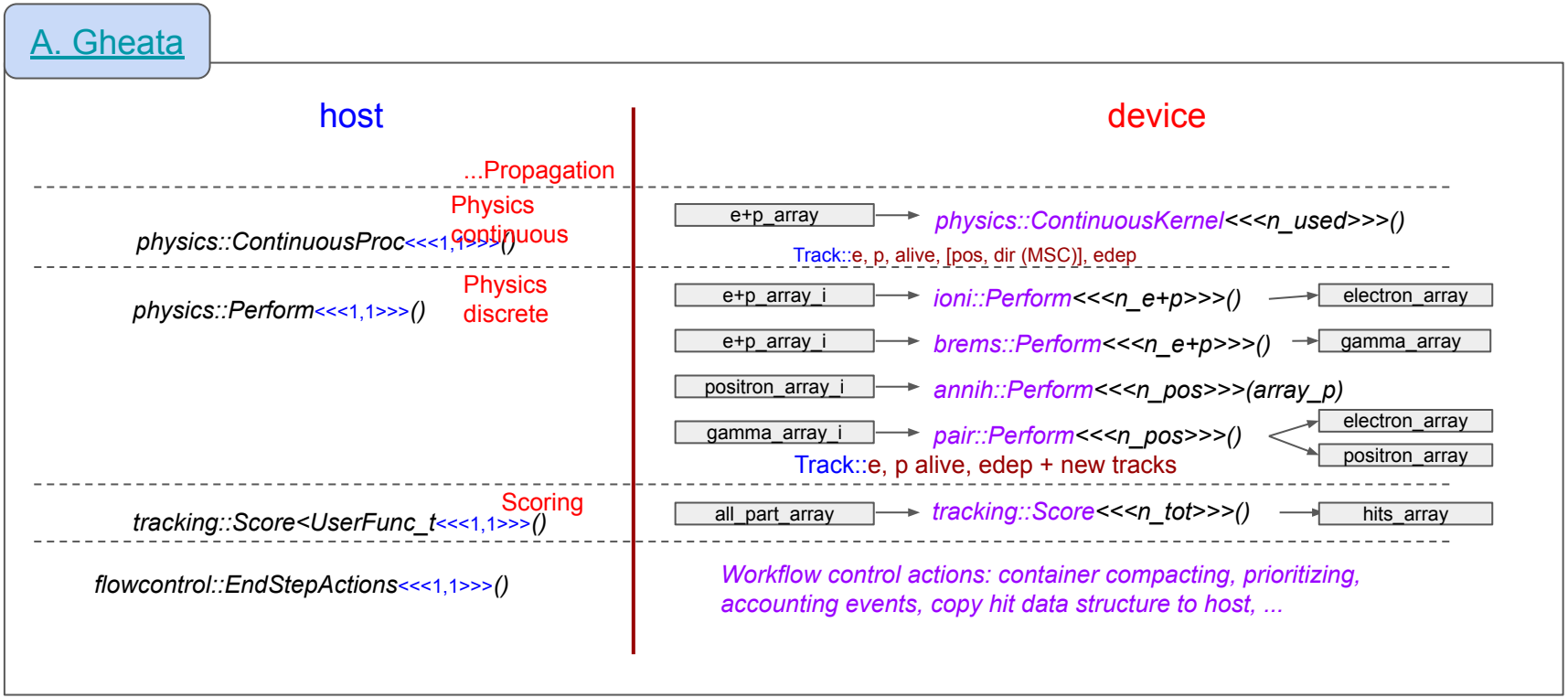
A. Gheata



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