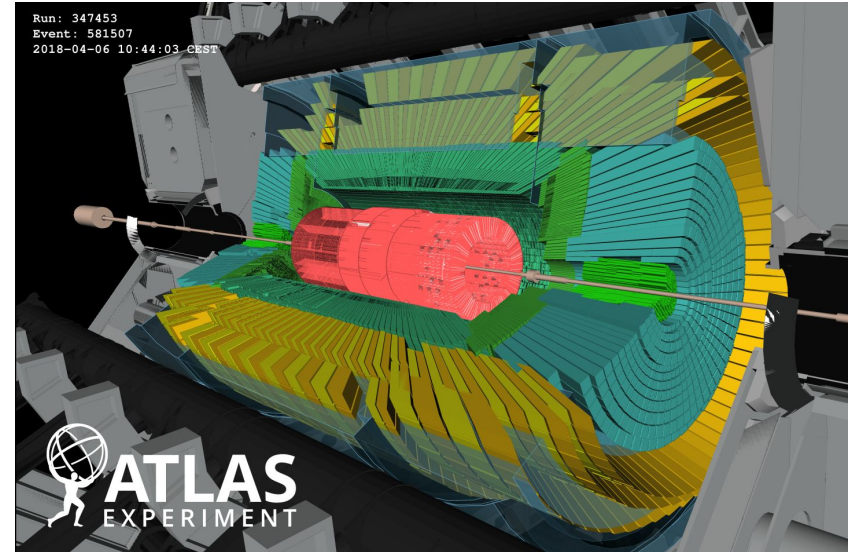


Detector Simulation on GPUs: The AdePT project

Stephan Hageböck
CERN, IT-SC-RD

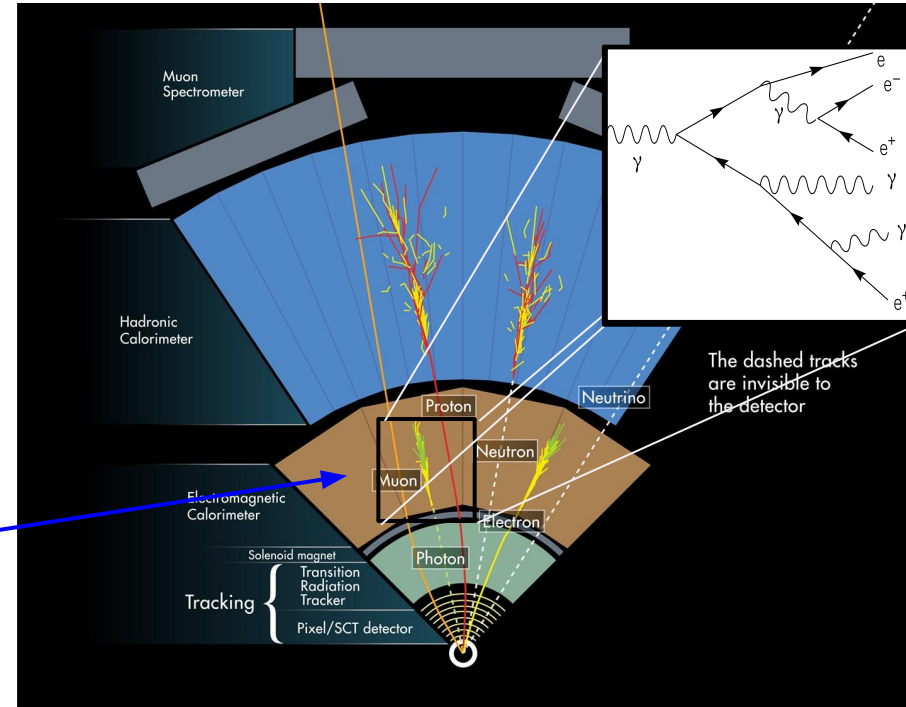
Detector Simulation on GPUs: Why?

- 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?

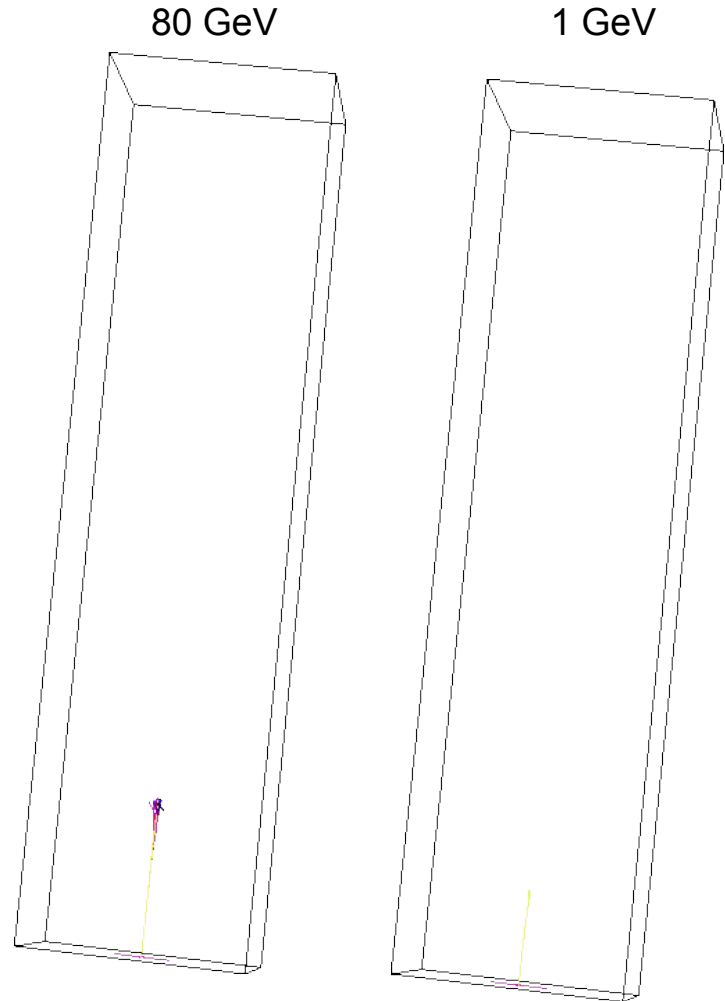


Simulating EM Showers

- 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



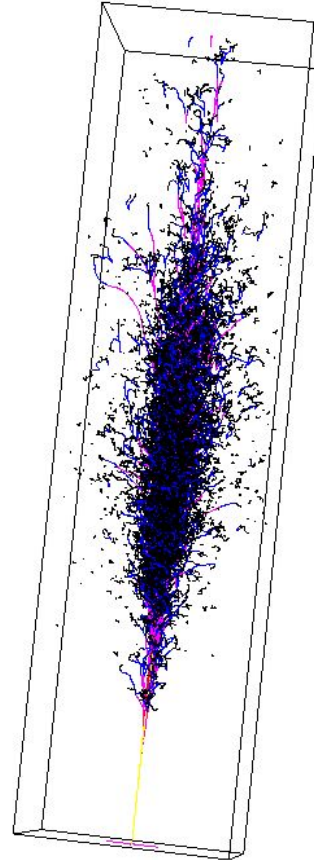
EM Showers are Expensive

- 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
- Modern detectors can have very complicated layouts

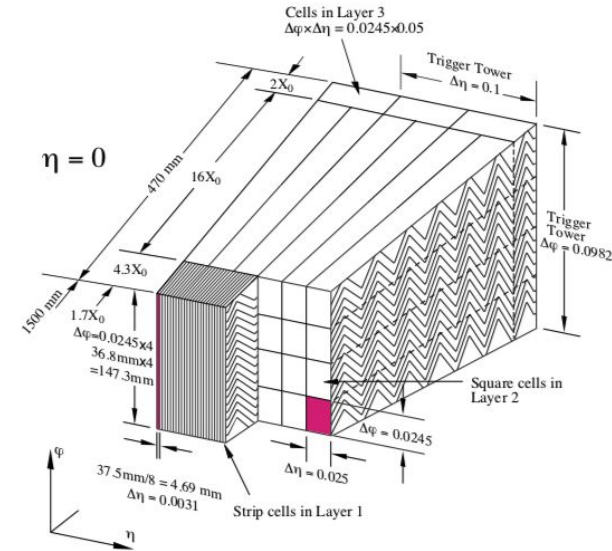
* Completely random:

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

80 GeV

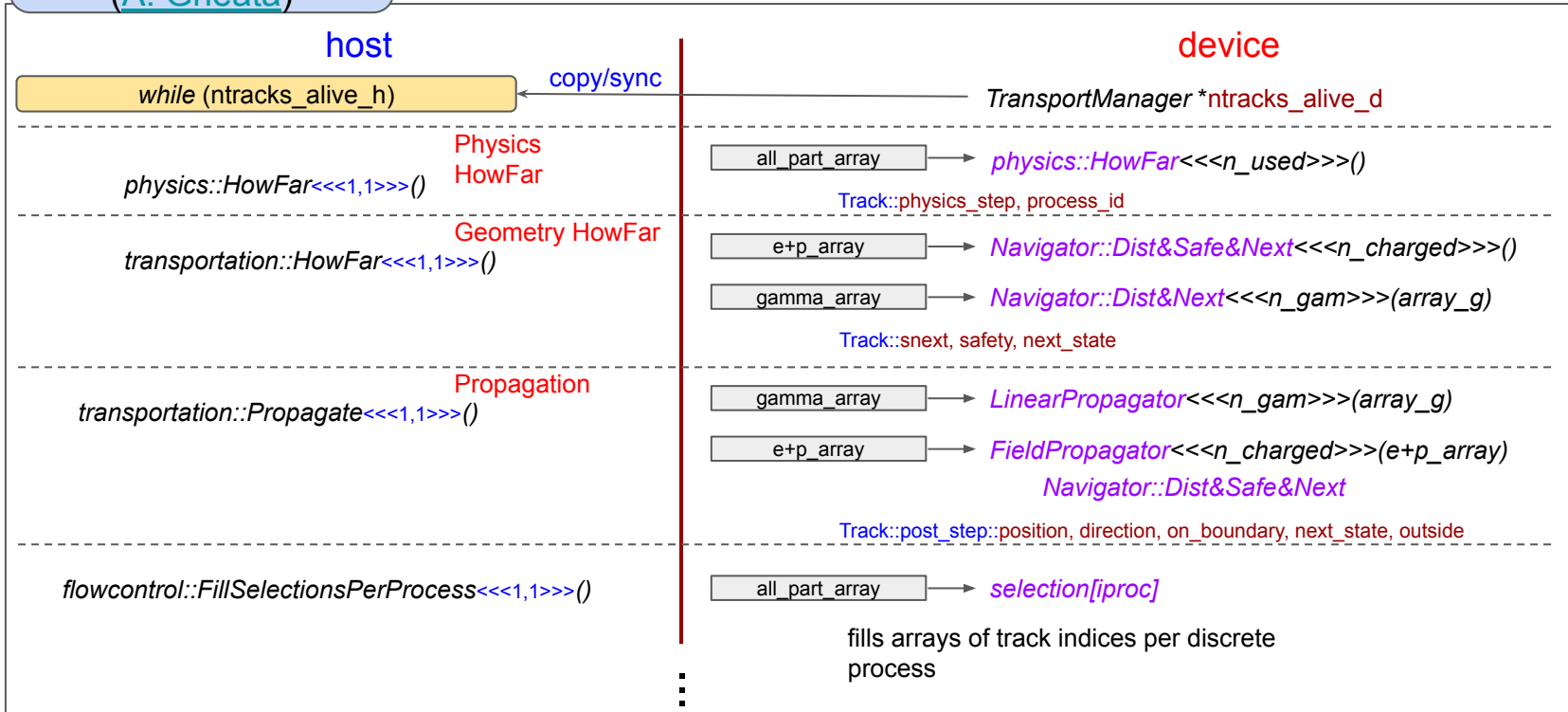


ATLAS EM Calorimeter



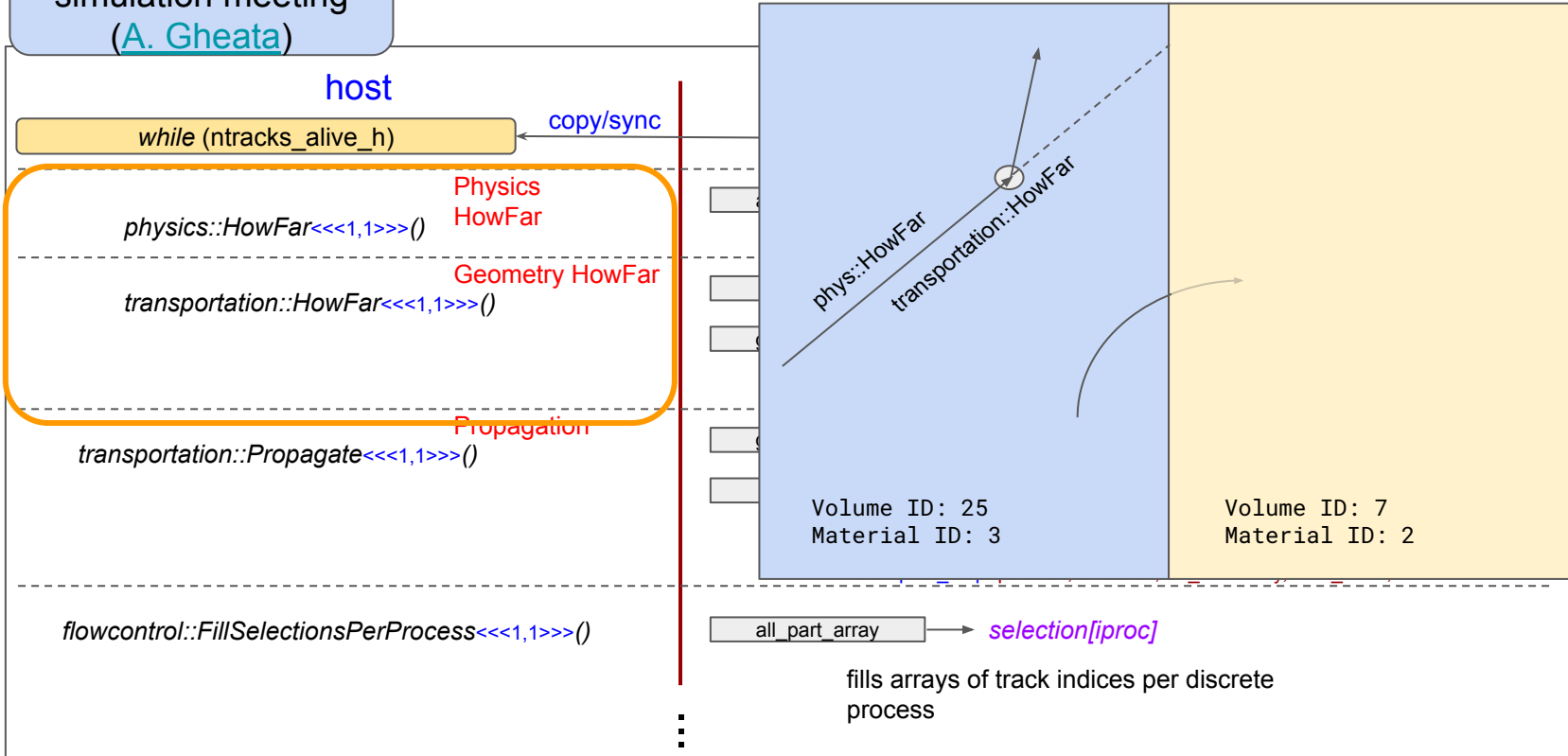
AdePT - Sketch of a Potential Simulation Workflow

From an AdePT simulation meeting
(A. Gheata)



AdePT - Sketch of a Potential Simulation Workflow

From an AdePT simulation meeting
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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

AdePT - Sketch of a Potential Simulation Workflow

A. Gheata

host

device

...Propagation

Physics
continuous

`physics::ContinuousProc<<<1,1>>>()`

Physics
discrete

`physics::Perform<<<1,1>>>()`

Scoring

`tracking::Score<UserFunc_t<<<1,1>>>()`

`flowcontrol::EndStepActions<<<1,1>>>()`

`e+p_array` → `physics::ContinuousKernel<<<n_used>>>()`

Track::e, p, alive, [pos, dir (MSC)], edep

`e+p_array_i` → `ioni::Perform<<<n_e+p>>>()` → `electron_array`

`e+p_array_i` → `brems::Perform<<<n_e+p>>>()` → `gamma_array`

`positron_array_i` → `annih::Perform<<<n_pos>>>(array_p)`

`gamma_array_i` → `pair::Perform<<<n_pos>>>()` → `electron_array`
→ `positron_array`

Track::e, p alive, edep + new tracks

`all_part_array` → `tracking::Score<<<n_tot>>>()` → `hits_array`

Workflow control actions: container compacting, prioritizing, accounting events, copy hit data structure to host, ...

AdePT - Sketch of a Potential Simulation Workflow

A. Gheata

