Pre-Learning Geometry on GPUs

Accelerating Geant4 Simulations

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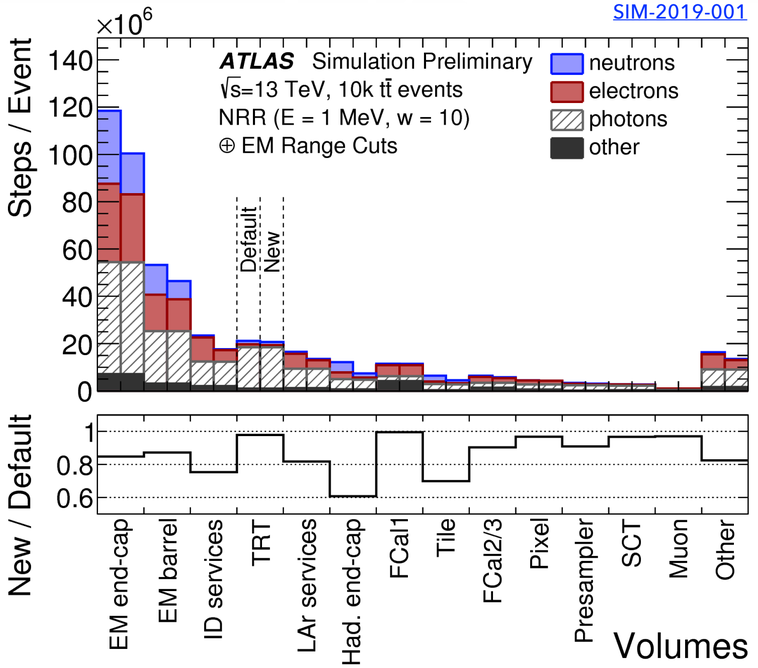
Present Situation

Facts

1. ATLAS EM calorimeters dominate the simulation load (steps).
2. Methods exploring the geometry* are taking significant amount of the simulation time

   * Locate position into geometry tree and calculate distance to next boundary in order to limit step.



Target

Accelerate the execution of expensive algorithms

Photons on EM End-cap

Callees	CPU Time: Total
G4SteppingManager::Stepping	100.0%
G4SteppingManager::DefinePhysicalStepLength	66.7%
G4VProcess::AlongStepGPIL	58.2%
G4Transportation::AlongStepGetPhysicalInteractionLength	51.7%
G4Navigator::ComputeStep	34.1%
G4NormalNavigation::ComputeStep	20.9%
G4VoxelNavigation::ComputeStep	10.8%

The Idea

Could we speed-up the geometry exploration by using a pre-defined/ learned map instead of algorithmic calculations *in each step?*

Machine learning regression technique trained for a particular geometry (e.g. ATLAS EMEC)

Hardware transparent industrial libraries optimized for different hardware architectures (CPU or **GPU**)

Much easier & assured future portability

The Idea

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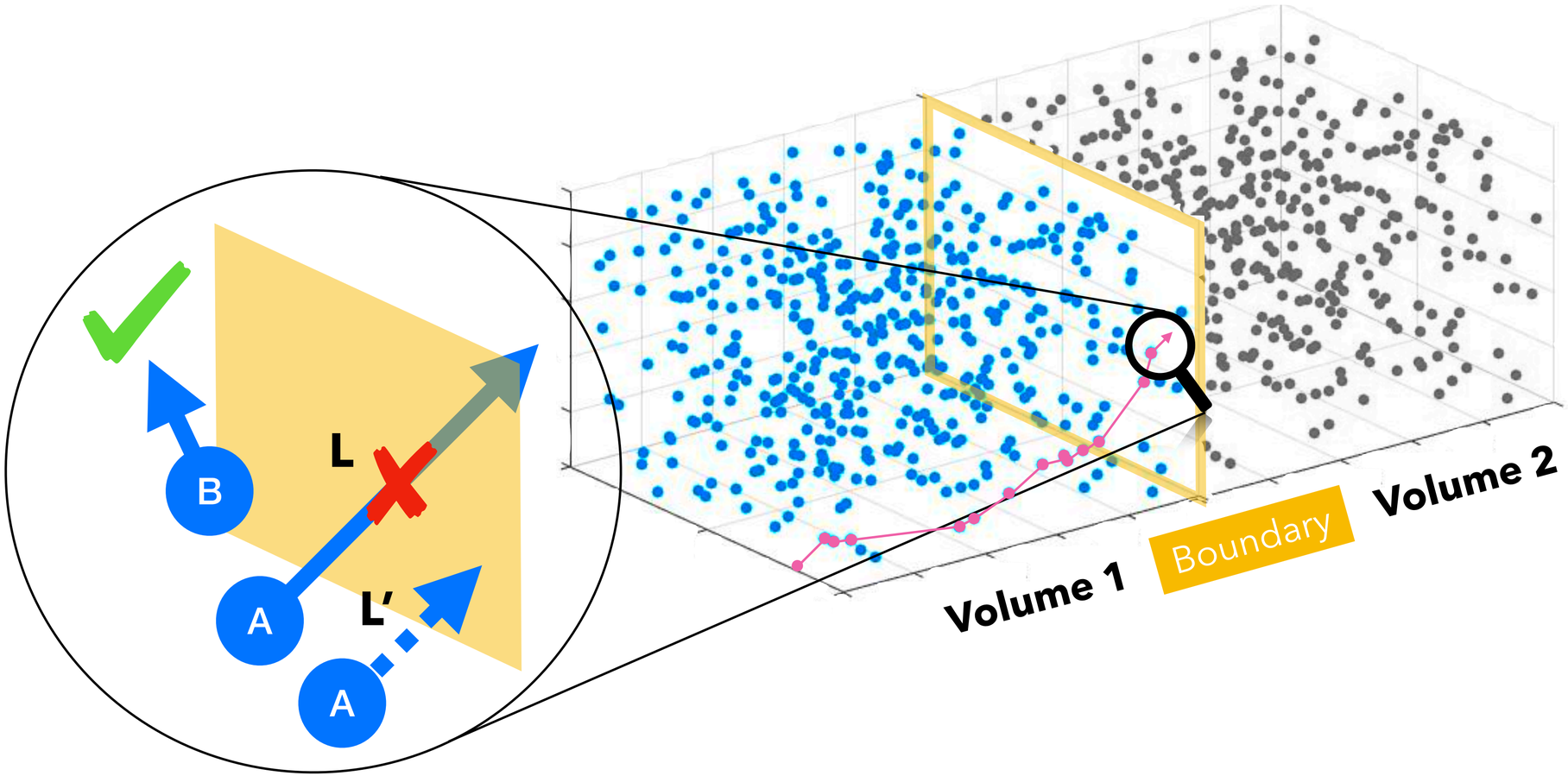


Inputs:

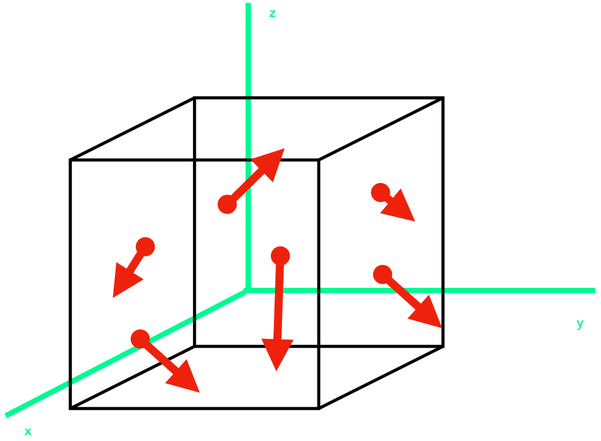
- Position (x, y, z)
- Step direction (x', y', z')

Output:

- Geometrically safe step length (L')

Feasibility Study

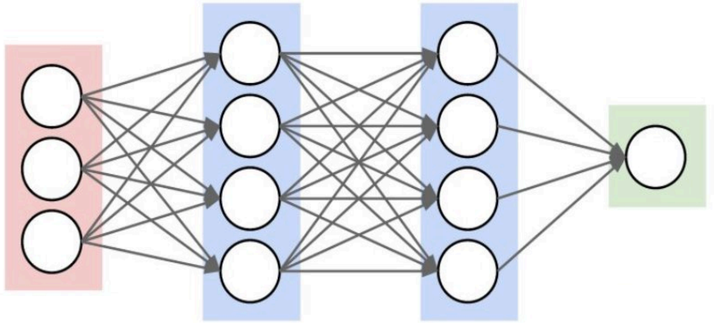
Data Collection



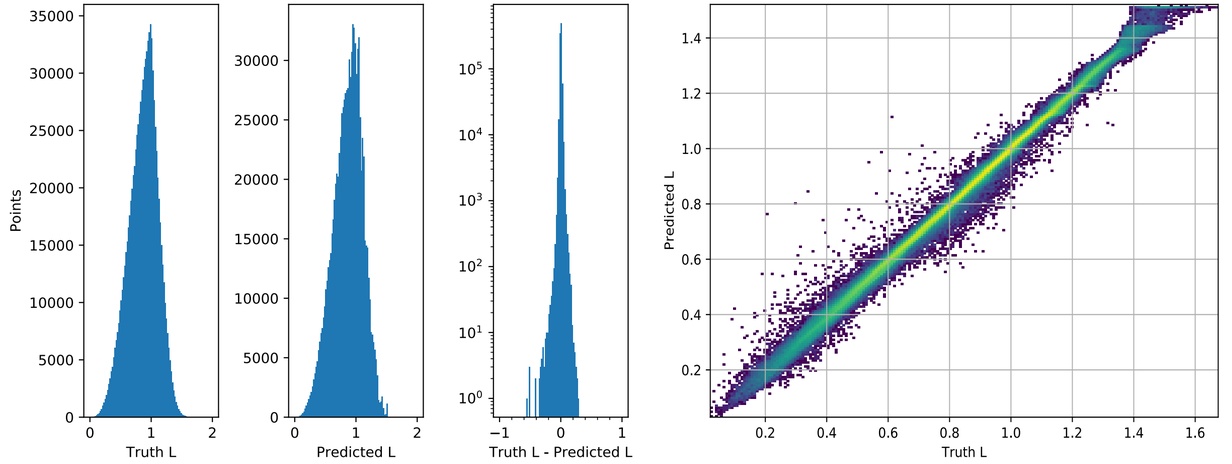
1. Sample simple geometry in random points & directions.
2. Geant4 application shooting *geantinos* and calculating the geometry-limited step length.
3. Write-out the position, direction and calculated length.

Regression DNN

Inputs: position & direction



Output: Geometric safe step length



Considerations

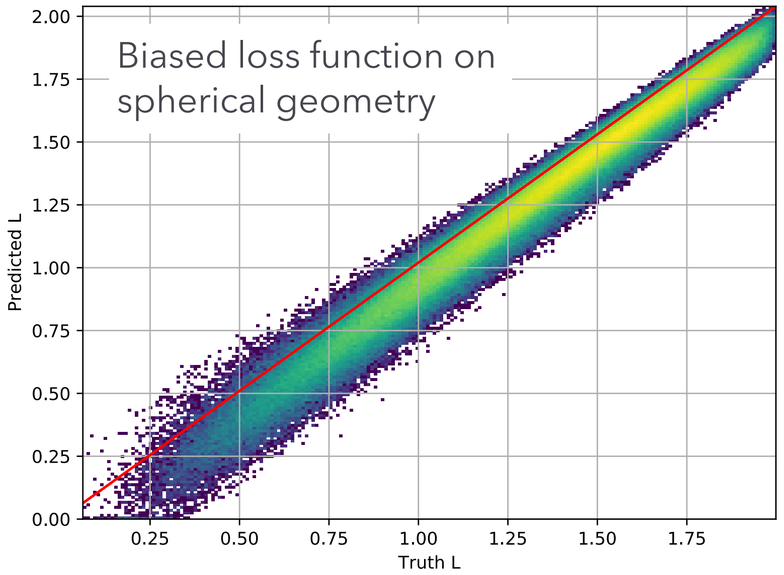
DNN geometry regression

What's the level of **accuracy** we can achieve?

Train in order **not to overestimate** the geometrically limited step.

Could we even **safely skip the distance calculation** completely?

(e.g. in the middle of geometry)



Scale to more complex example (e.g. G4Polycone)

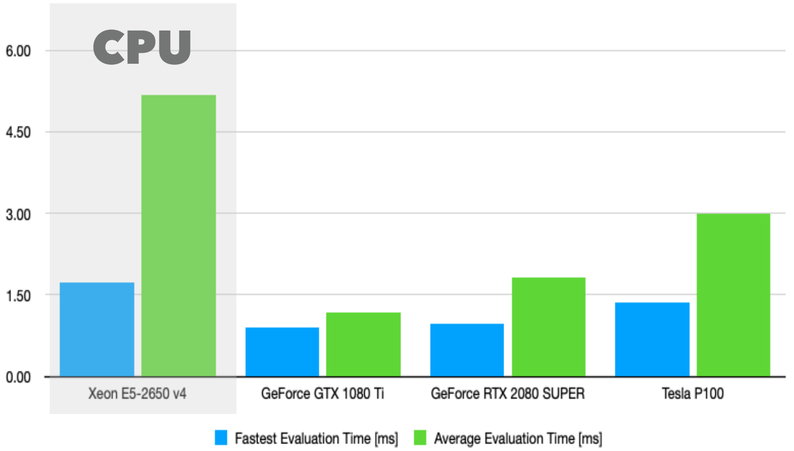
How network architecture evolves with **geometry complexity**?

Could we actually learn a geometry representation?

Evaluation time on GPU

Will the map evaluation be **faster** than Geant4 computation on CPU?

Great benefit: **Parallelism** (stepping on multiple tracks)



NB: G4Box shape calculations take ~0.3 ms