EIC-Opticks

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Opticks

- Opticks, uses NVIDIA OptiX framework to simulate photons on GPU
- Ray tracing + Monte Carlo
- Works together with Geant4:
  - Hadronic, EM etc are done on CPU (Geant4), only photons are offloaded to GPU
- Rayleigh scattering, Fresnel reflection, polarization, etc. was added to NVIDIA OptiX
- ~100-200x faster than a single thread of G4 CPU
- Imports “classic” GDML, just need a few tags for sensitive detectors
- How does it integrate with G4?
  - G4DetectorConstruction -> Pass the detector to GPU code
  - G4SteppingAction -> Record optical photons to be passed to GPU
  - G4RunAction / G4EventAction -> Simply call Simulate() on GPU

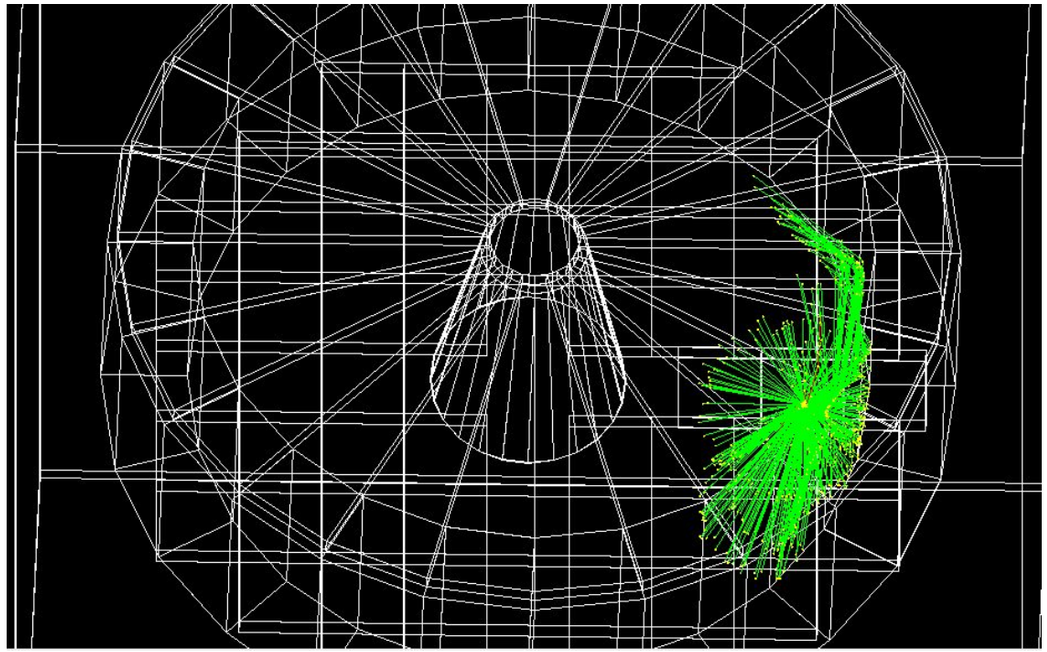
EIC-Opticks

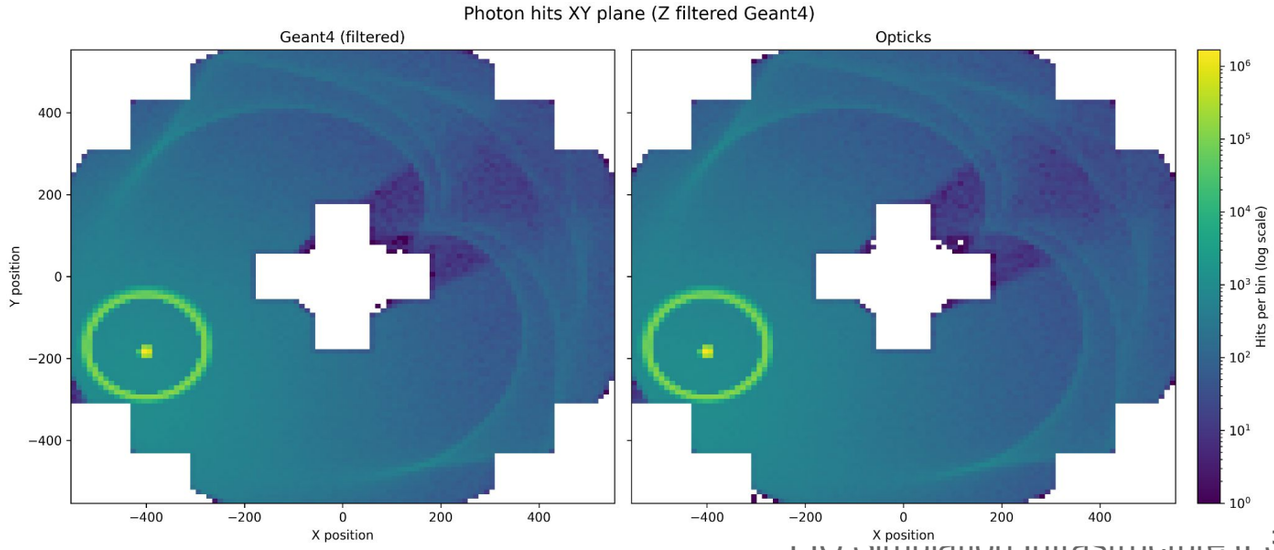
- Modifications:
  - Opticks can only simulate one G4Event in a GPU simulation -> How many photons does hpDIRC have in a single G4event?
    - Large overhead when simulating less than 1M photons in a GPU call
  - EIC-Opticks extended usability to cases with much fewer photons (as in most EIC applications)
    - Added G4Event ID to GPU simulated photons
    - Allows to aggregate photons across events and process on the GPU in bulk
- Created a spack package
  - spack install eic-opticks ^optix-dev@7.9.0
  - EIC-Opticks is containerized, enabling seamless execution on any host with a modern GPU, without installation overhead
- Fixed some bugs, eg. rays were incorrectly blocked by transparent surfaces in certain volumes

Validation and performance

- Had to replace TRD, TRAP volumes in pfRICH GDML: pyramids are flat, single aerogel volume instead of tiles
- Validated EIC-Opticks vs pure Geant4 for a simplified pfRICH geometry
  - 50k 5 GeV e^- a:
    - Geant4 hits : 13840566
    - Opticks hits : 13840638
- Time measurement for EIC-Opticks included:
  - Data movement from CPU -> GPU
  - Ray tracing
  - Copying results from GPU -> CPU
- 160k 5 GeV e^- → ~ 100M photons
  - Single thread G4 CPU ~150 s
  - 20 threads MT G4 CPU ~10.5 s
  - EIC-Opticks (GPU): ~1.1 s

    ~ 137x speed-up wrt. single thread





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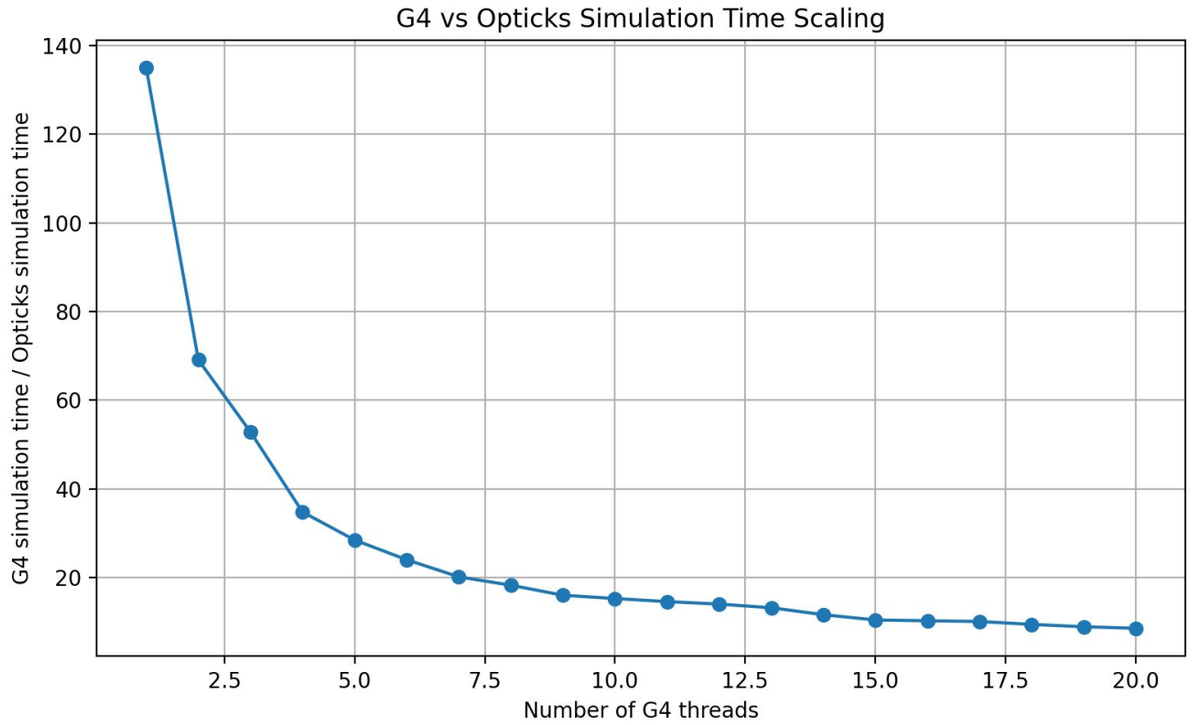
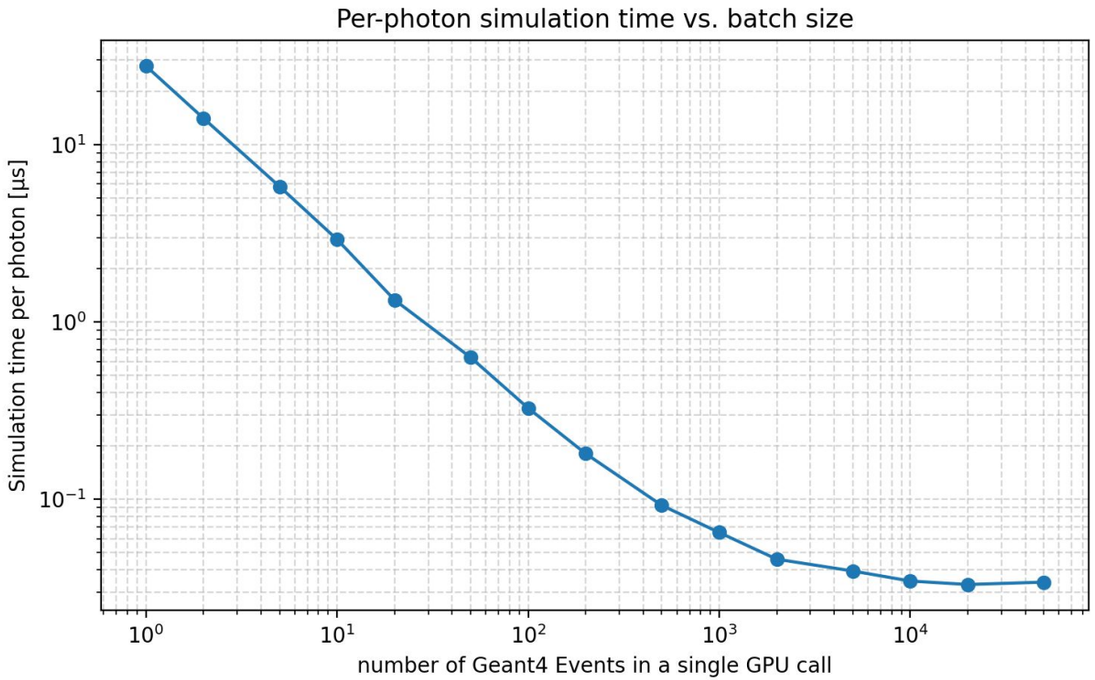
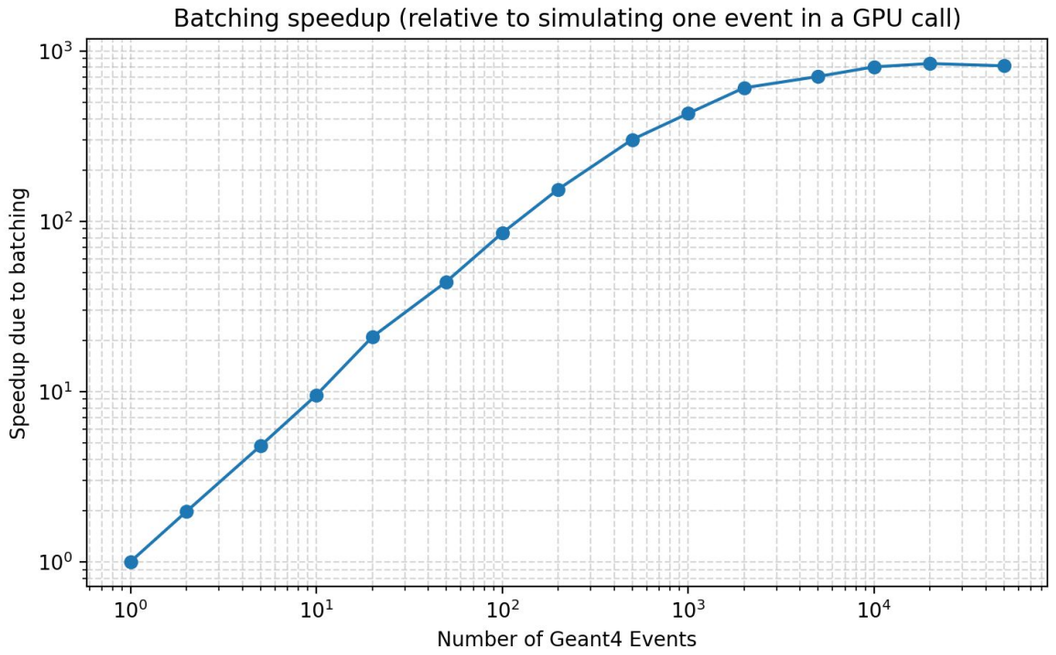


Event batching in EIC-Opticks

- We introduced event batching in EIC-Opticks
- Overhead, to start GPU simulation, run and return results
- For low energy events too high
- We introduced event batching
- In the case of pfRICH batching 50k event speeds up simulation time 1000x





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