Prospects for using OptiX in GPUs for RICH simulation

ECHEP Workshop: Simulation

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06-07-2020

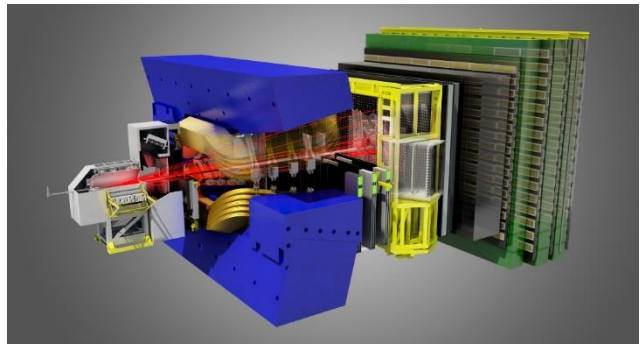
Outline

- RICH and ray tracing of optical photons in simulation
  - *Illustration in LHCb context*
- Success in using OptiX at Daya Bay/JUNO
- Initial tests of GPU software at LHCb-CERN
- Prospects for further development
- Summary

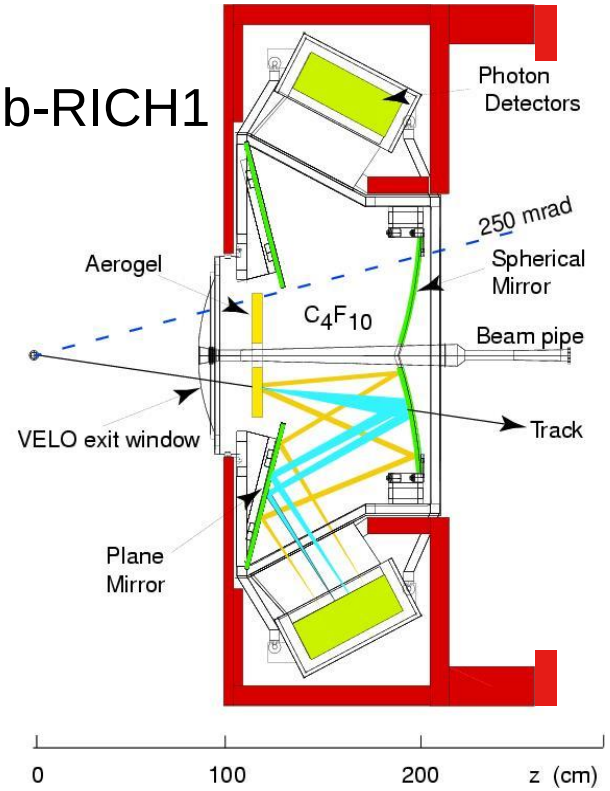
RICH in Simulation

"LHCb Detector Performance", LHCb Collaboration
Int.J.Mod.Phys.A 30(2015) 1530022

LHCb



LHCb-RICH1



- LHCb has two RICH detectors.

- There is an ever increasing need to reduce the CPU time used up by LHCb simulations, as we attempt to simulate billions of events.

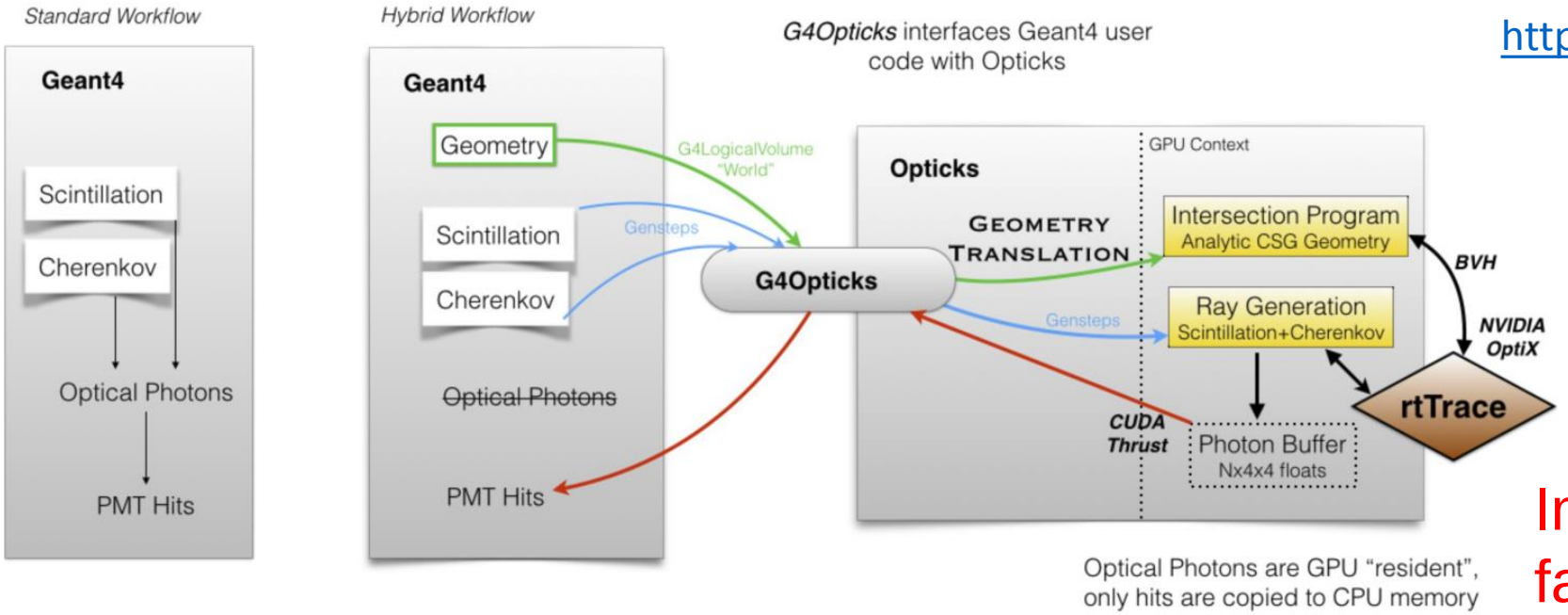
- During LHCb simulation, the RICH takes up approximately 30% of the overall CPU time. A major part of this is in the transport of optical photons. Hence it is useful to focus on improving this.

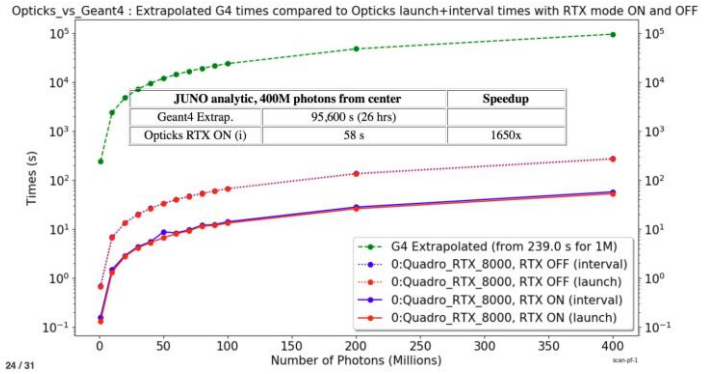
- Typically in an event with ~250 charged tracks at a luminosity of 2×10^{33} $cm^{-2}s^{-1}$ and an average of (41 + 24) signal hits per charged track in (RICH1+RICH2), the number of photons transported is a large number.

Improving the speed using GPUs

- The usage of OptiX is already proven in JUNO/Daya Bay experiments, for the creation and transport of Cherenkov photons in simulation

S.Blyth
Recent HSF workshop
https://indico.cern.ch/event/921244/





Improvement by a factor of 1650 when using GPUs with RTX

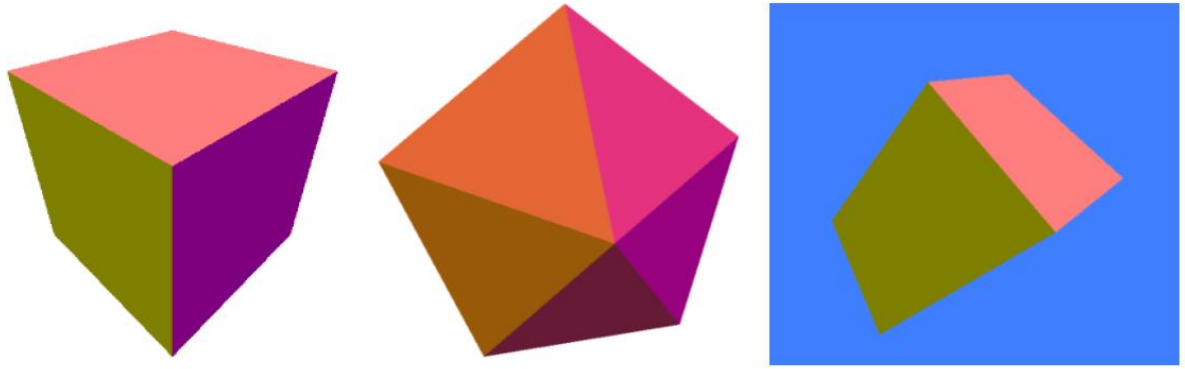
- *Geometry: CSG → BVH*
- *rest of the Geant4 workflow and particle tracking is unaffected.*

- Exploratory studies have started with the goal of implementing this for LHCb

OptiX verification

A.Jenkins

- A version of Opticks and OptiX installed at CERN in a computer with GPUs
  More info in backup pages



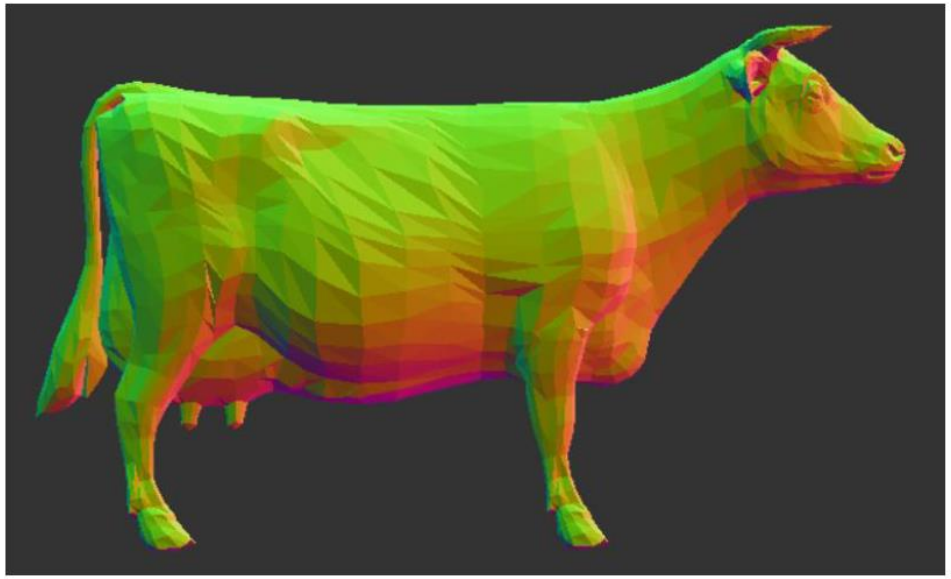


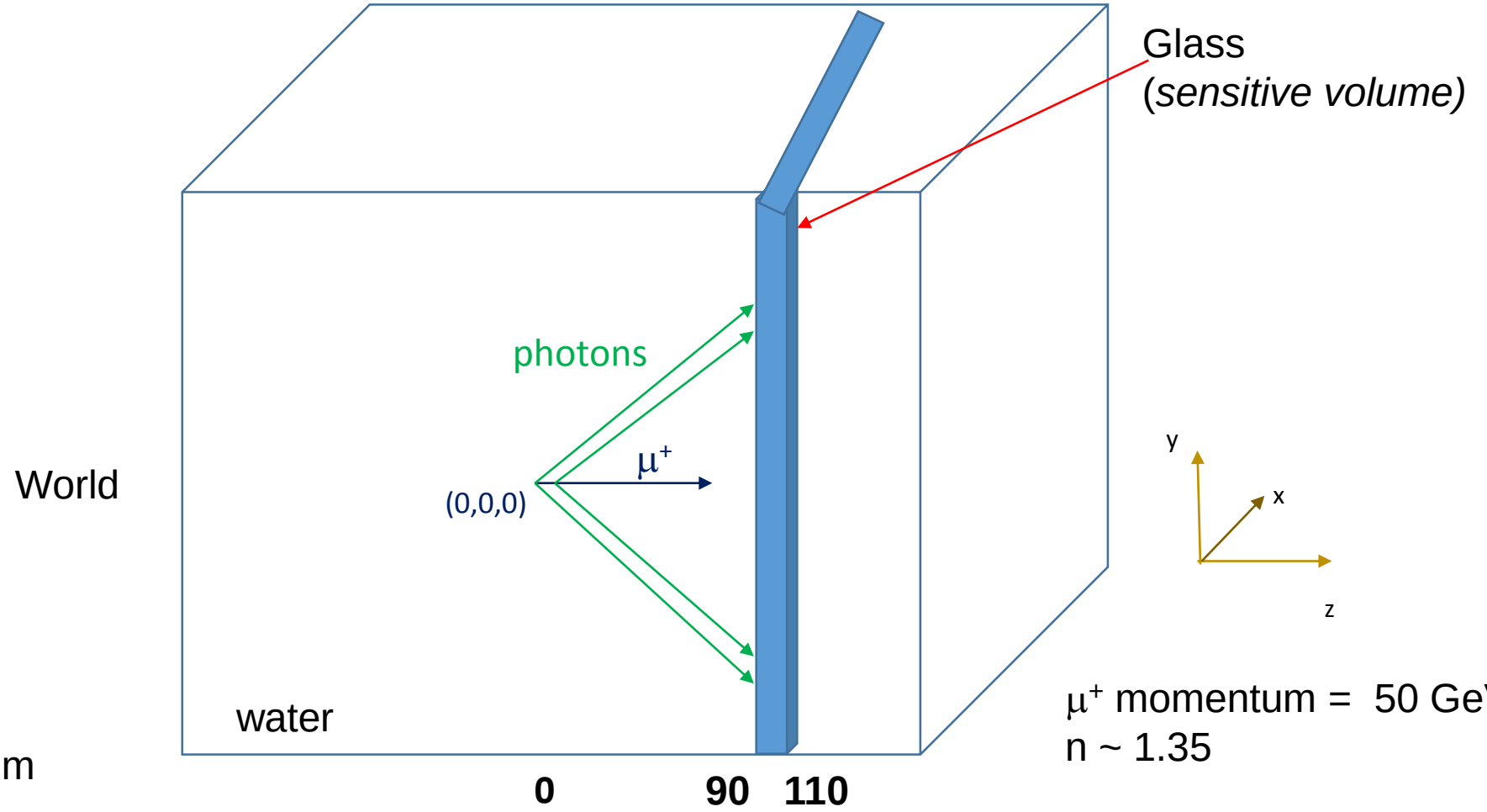
Image assembled using triangles.
Light source at the top left of the image.
Areas in direct light are in green and areas in shadow are in red.

- Used another example which tested basic optical refraction process.
  Improvement in the speed by a factor of 18 observed, when using GPU compared to that from CPU

OptiX and GEANT4

- Simple test with Cherenkov photons

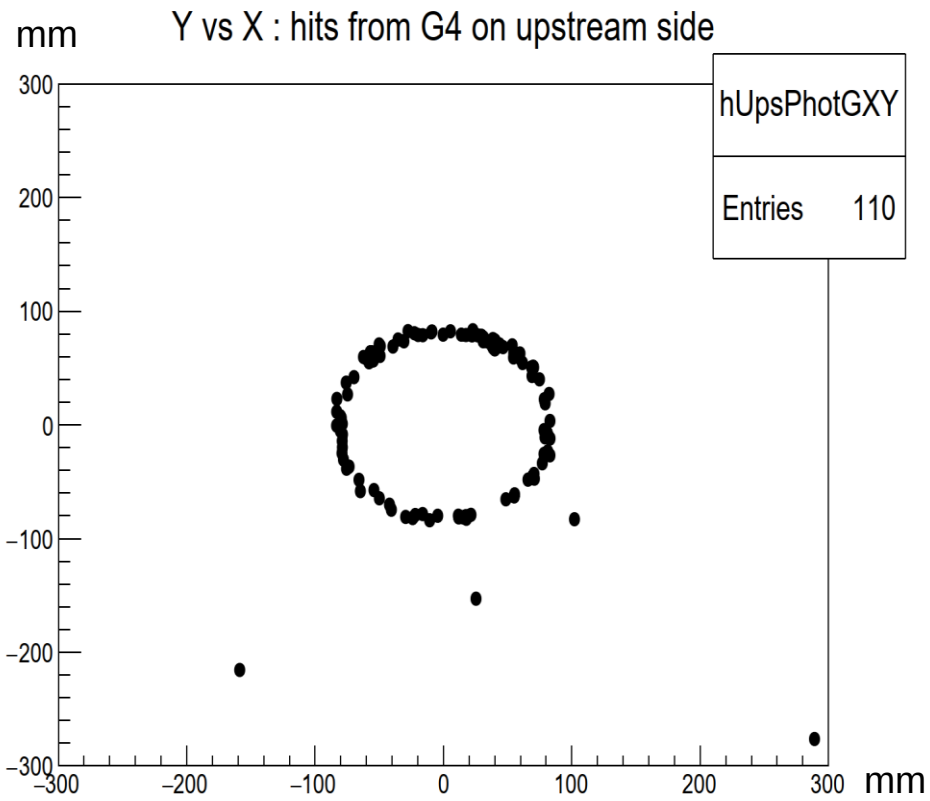
  Adapted version of an example named 'CerenkovMinimal' from Opticks release



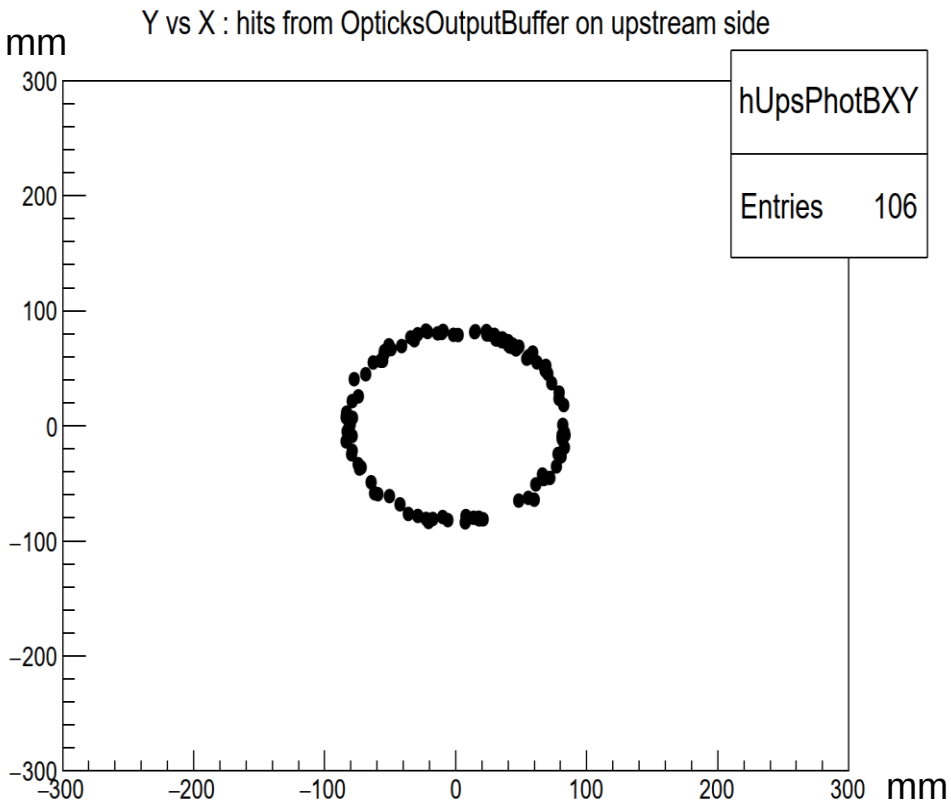
μ^+ momentum = 50 GeV/c
n ~ 1.35

- μ^+ is killed after it travels a fraction of a mm
- Expect a Cherenkov ring of hits, on the plane at Z=90 mm. Radius expected is approximately 82 mm.

OptiX and GEANT4



Hits from Geant4 photon transport



Hits from OptiX ray tracing

- Excellent match between the hits obtained from Geant4 and OptiX on the plane at (0,0,90)
- The 4 extra hits in the left plot are from photons which went through this plane and later got reflected back to the same plane. Their new directions were not part of the set uploaded for ray tracing in OptiX.

Prospects for further development

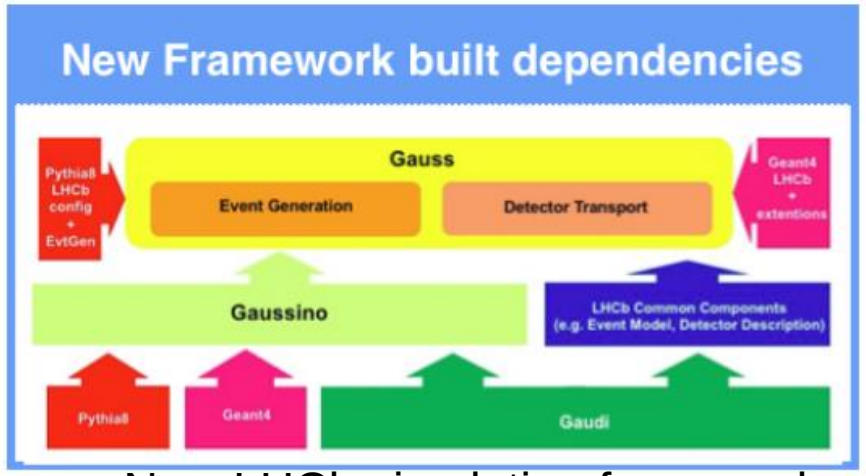
Short term :

- Attempt to use a simplified version of LHCb RICH geometry
- Understand changes needed to convert from LHCb geometry description to Opticks compatible description
- Test more features of the Opticks interface.

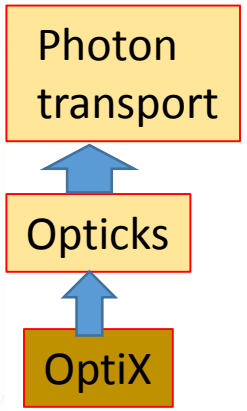
Gaussino –a Gaudi-Based Core Simulation Framework
D.Muller, CHEP2019, Adelaide, Australia
https://indico.cern.ch/event/773049/contributions/3474740/

Medium term:

- General:
  - Address some issues related to Opticks installation and development at CERN
  - Explore upgrade to OptiX 7.



New LHCb simulation framework



- LHCb specific:
  - Create roadmap for full LHCb-RICH geometry description and simulation in OptiX
  - Integrate with new LHCb software framework

Summary

- Exploratory studies of using Opticks and OptiX have started.
- In a simple example with Cherenkov photons, the hits created from GEANT4 transport are compared with those from OptiX and excellent match is found.
- Extension to LHCb RICH geometries is being considered.
- Goal: Make Opticks usable for LHCb RICH simulation and for other experiments.
- Collaboration with Simon will be essential for the success of this project.
  GEANT4 team at CERN also plan to use these ideas and interaction with them is beneficial also.
- This is a long term project and will need funding for acquiring human resources.
- In LHCb the usage of GPUs for data reconstruction in trigger is being explored.
  The RICH simulation also may become another use case, for GPUs in LHCb.

Backup Pages

Using GPU software at CERN

- OptiX : Available from NVIDIA to registered users

- Opticks:
  - Provides the interface between GEANT4 and OptiX
  - Available to registered users, from Simon. *bitbucket now /Git in future*

- GPU:
  - Thanks to colleagues from LHCb online team for providing GPU access
  - Accessing one of the computers and a GPU in LHCb at CERN

- GEANT4, Boost, ROOT, XercesC etc.
  - From /cvmfs/sft.cern.ch/lcg
  - For now, independent of LHCb software framework, Gaudi

Details of version numbers in the last page

Current software configuration at CERN

- Some of the software setup and versions used at CERN are different than that is used in Daya Bay/JUNO
- Hence the necessary adaptations made in various CMAKE configurations to make a working version at CERN

➢ GPU setup:

- CUDA 10.2 with x86_64-centos7-gcc8-opt
- GeForce RTX 2080 Ti , CUDA compute capability 7.5 , driver version 440.33.01
- These are set by our system managers.

- Opticks makes use of CUDA::thrust

➢ GEANT4:

- Version 10. 5 from /sft.cern.ch/lcg area.

➢ Other packages :

- Boost 1.70, XercesC 3.2.2 and all related packages from /cvmfs/sft.cern.ch/lcg
- OptiX 6.5 downloaded from NVIDIA
- Few external packages: mostly for graphics display