Prospects for RICH detector simulation using OptiX in GPUs

HSF meeting : Detector simulation

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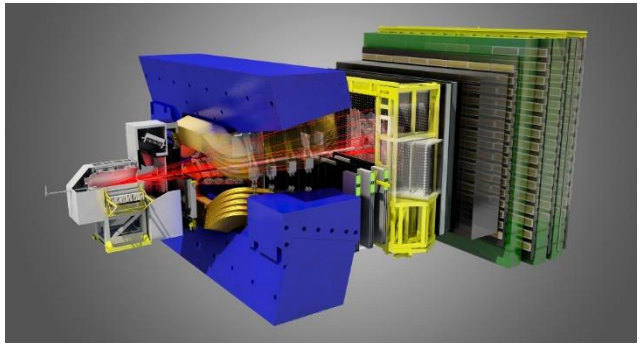
24-06-2020

Outline

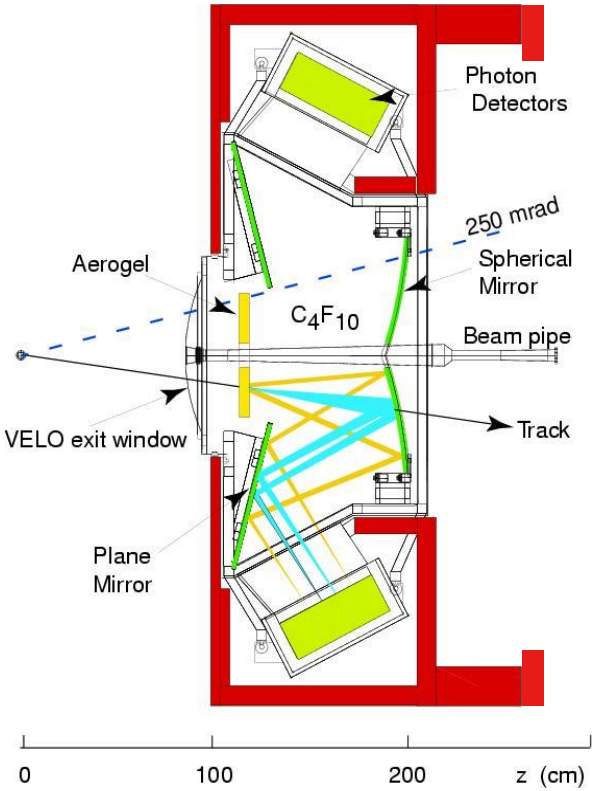
- RICH and optical photons in simulation
  - Description using LHCb context and beyond
- Opticks and OptiX at Daya Bay/JUNO :
  - Talk by Simon Blyth in this forum on May 27
- GPU software in the CERN infrastructure
- Prospects for further development
- Summary

RICH system in LHCb

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



- LHCb has two RICH detectors.



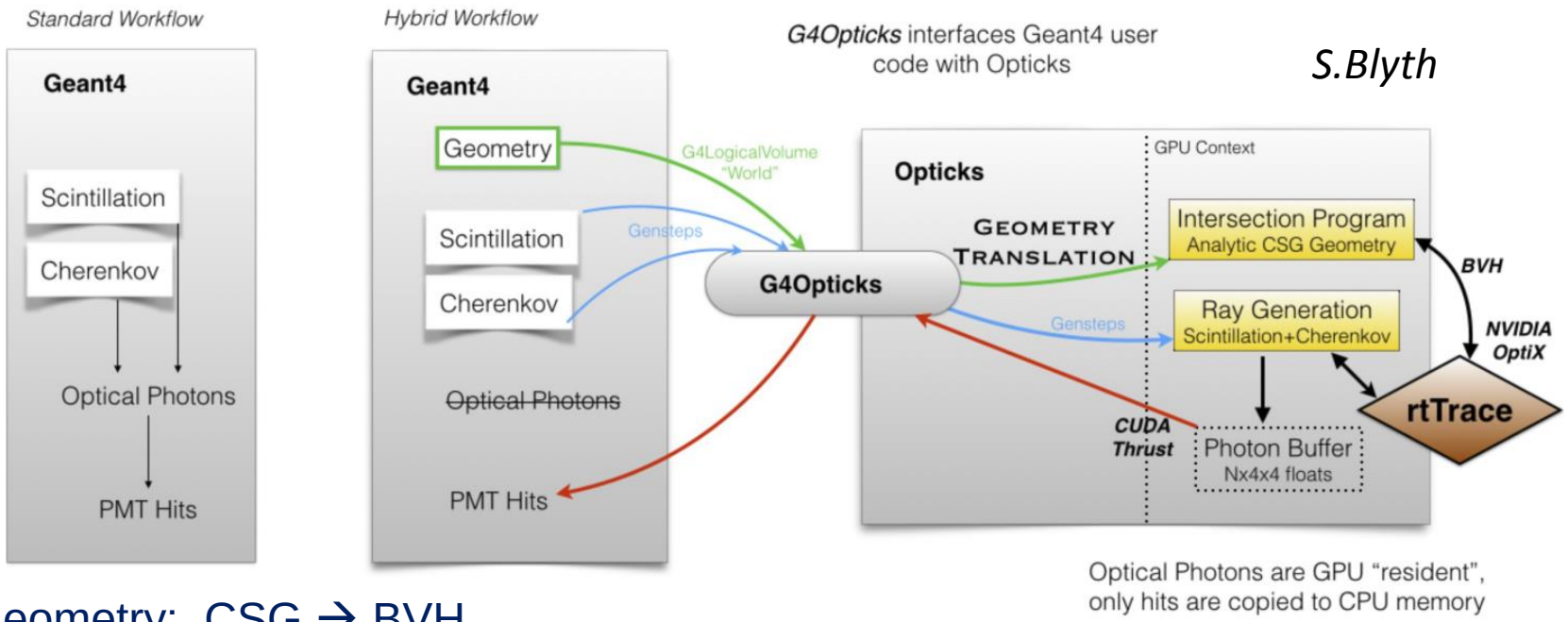
- RICH simulation involves:
  - Creation of photons with Cherenkov and Scintillation process
  - Typically transporting single photons using two mirrors and a quartz window
  - Creating hits in photon detectors like MaPMTs.

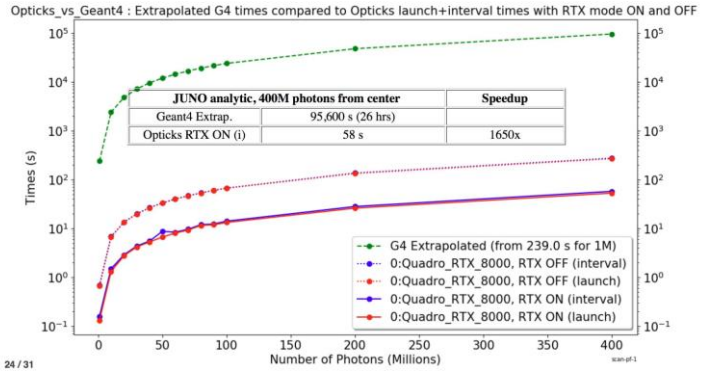
- There is an ever increasing need to reduce the CPU time used up by LHCb simulations, as we attempt to simulate billions of events. During LHCb simulation, the RICH takes up approximately 30% of the overall CPU time

- Majority of the time used by the RICH system is in the transport of optical photons. Hence it is useful to focus on improving the CPU time used for this transport .
- 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 Cherenkov photons.
- Perform exploratory studies for LHCb-RICH.





Improvement by a factor of 1650 with RTX

Geometry: CSG → BVH

- *rest of the Geant4 workflow and particle tracking is unaffected*.

Using GPU software at CERN

- OptiX : Available from NVIDIA to registered users

- Opticks:
  - Provides the interface between GEANT4 and OptiX
  - Available with *bitbucket* to registered users, from Simon
  - New development: Opticks being transferred to *Git* by Simon Blyth

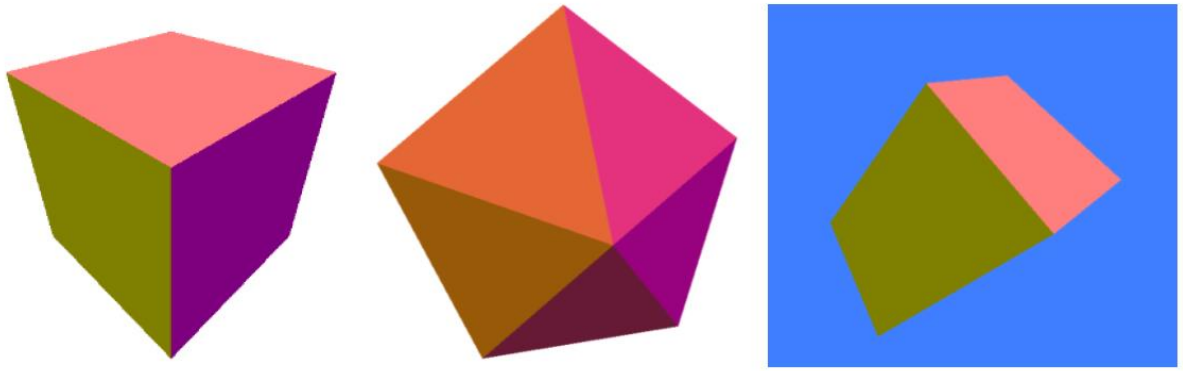
- GPU:
  - Thanks to colleagues from LHCb online team for providing GPU access
  - Accessing one of the computers and a GPU in LHCb at CERN

- GEANT4, Boost, ROOT, XercesC etc.
  - From /cvmfs/sft.cern.ch/lcg
  - For now, independent of LHCb software framework, Gaudi
  - Using Geant4 version 10.5

Details of version numbers in a backup page

OptiX verification

A.Jenkins



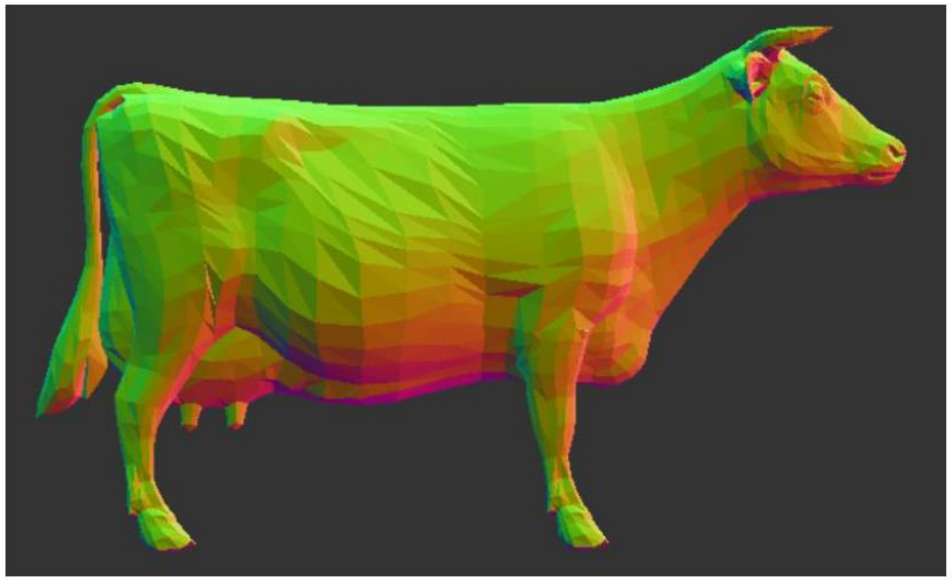
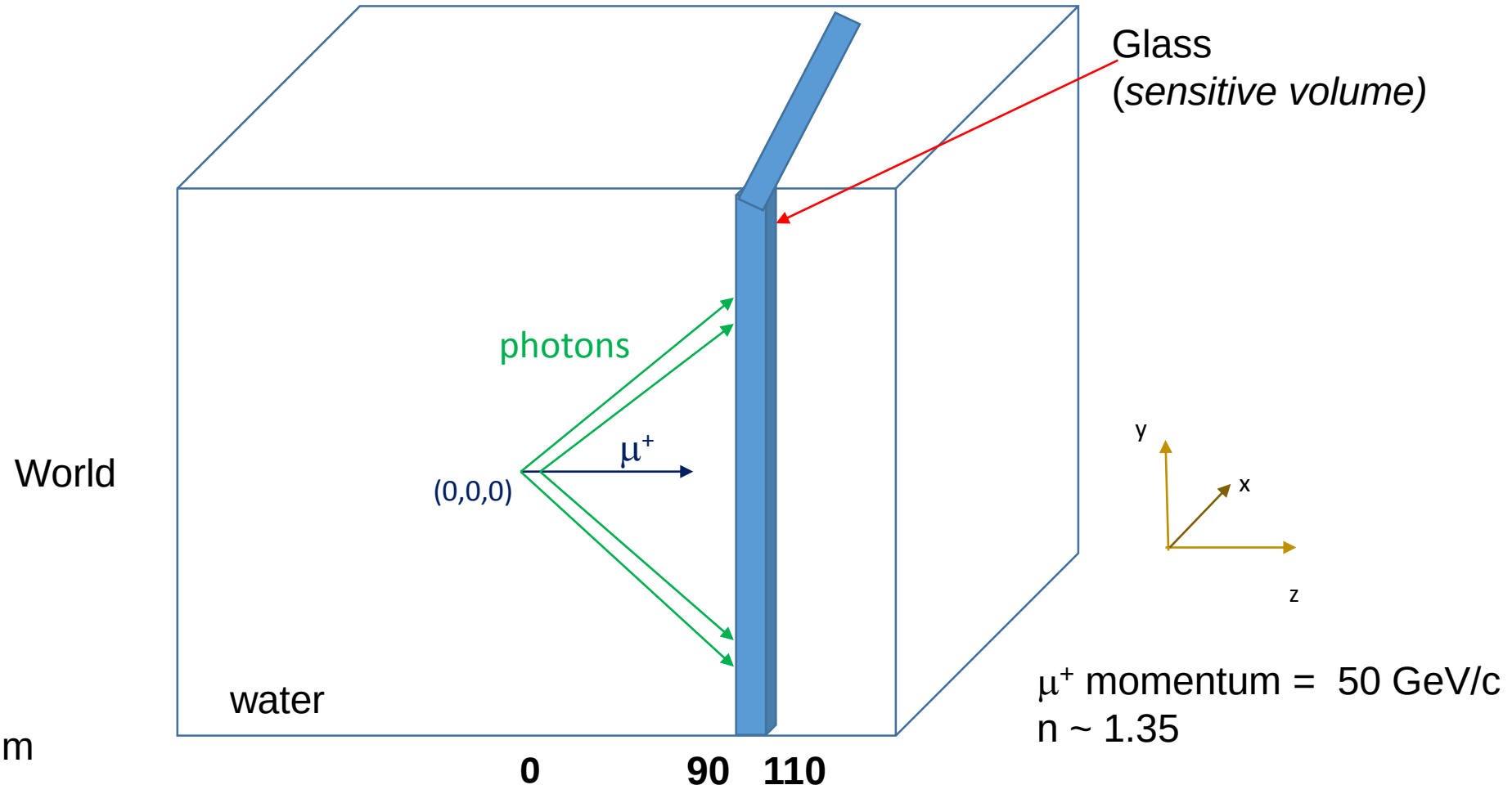


Image assembled using triangles.
Light source at the top left of the image.
Areas in direct light are in green and areas in shadow are in red.

- 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

- Photon propagation in OptiX is compared with that from Geant4 in a simple geometry.
  Adapted version of an example named 'CerenkovMinimal' from Opticks release

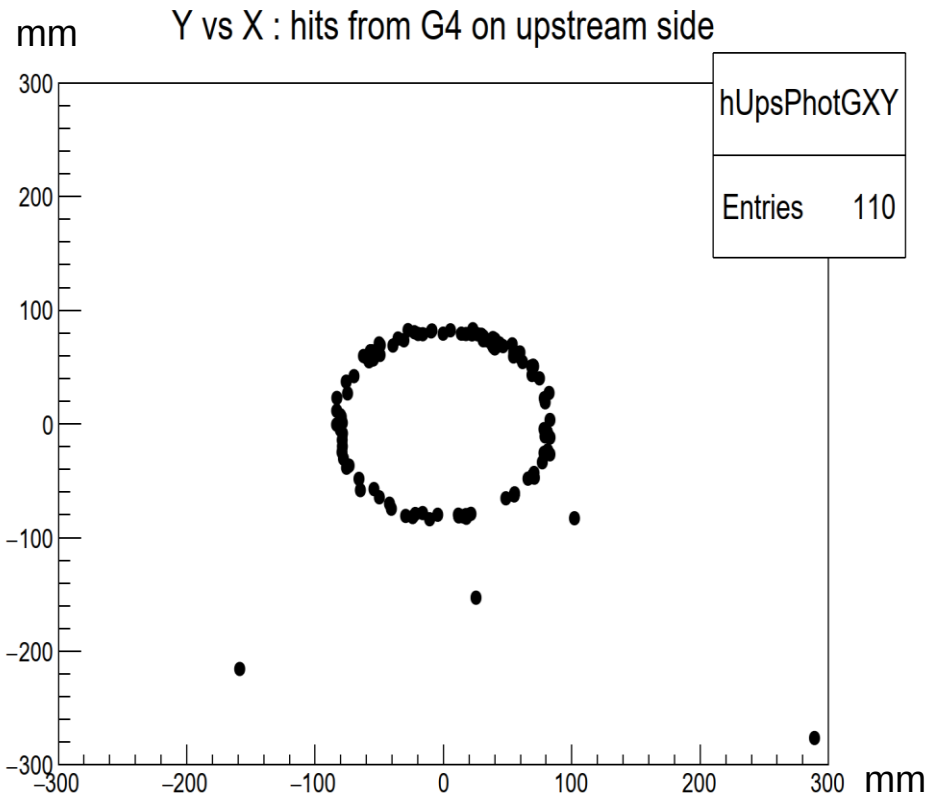


- μ^+ is killed after it travels a fraction of a mm

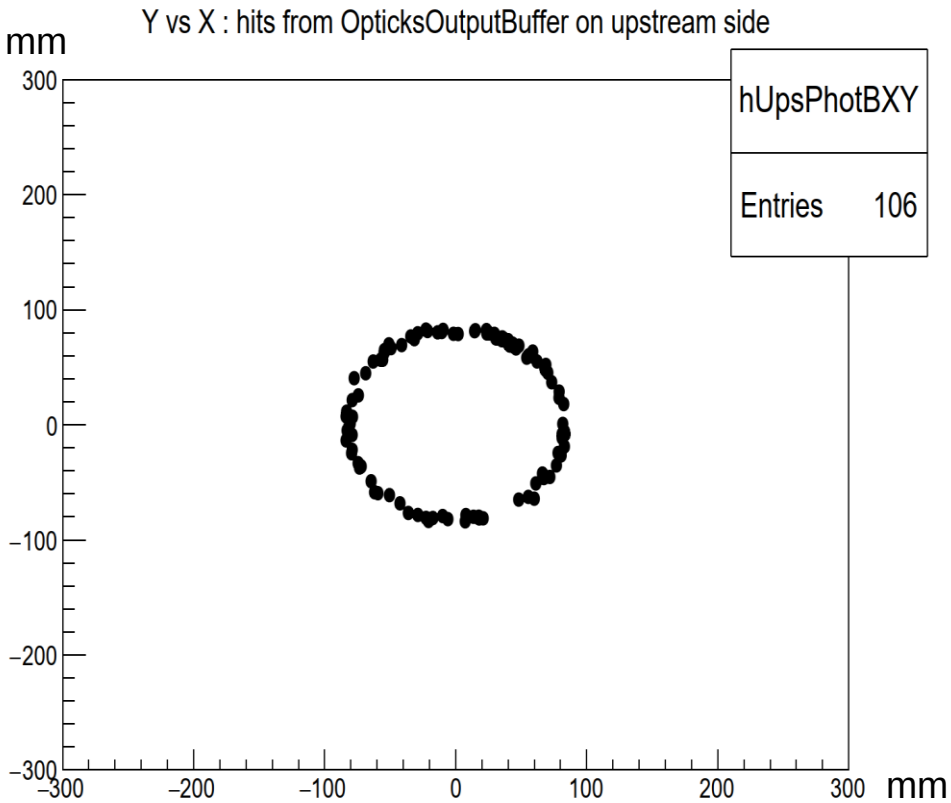
μ^+ momentum = 50 GeV/c
n ~ 1.35

- 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

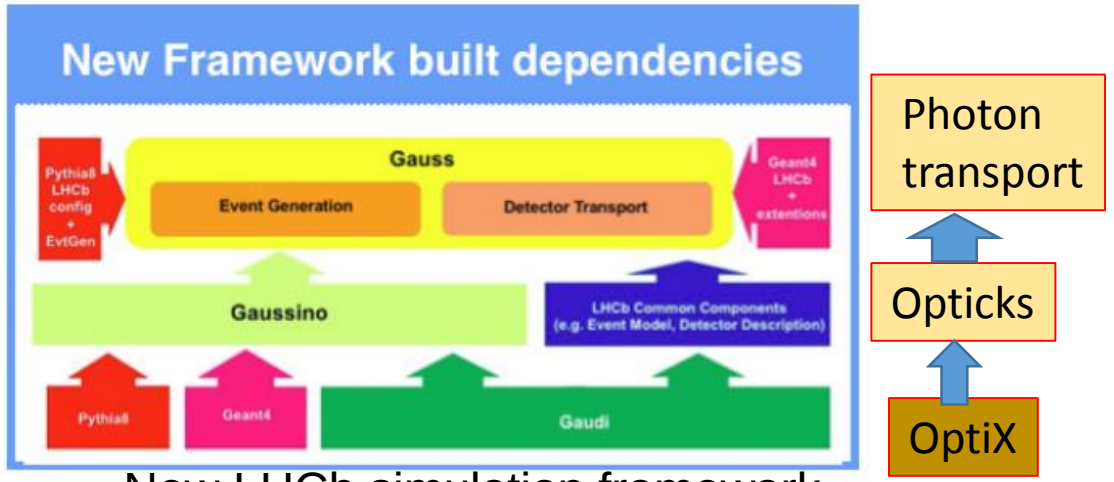
Short term :

- Study performance with RICH geometry.
- Understand changes needed to convert from LHCb geometry description to Opticks compatible description
- Software development and maintenance issues:
  - *example: Upload software such that it is available to Simon to verify the features.*
- Test more features of the Opticks interface.

Medium term:

- General:
  - ➢ Facilitate the installation of Opticks and the associated software at CERN.
  - ➢ Explore upgrade to OptiX 7.
- LHCb specific:
  - ➢ Understand integration within the new LHCb simulation framework
  - ➢ Map out roadmap for full LHCb-RICH geometry description and simulation in OptiX

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



New LHCb simulation 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 under development
- Goal: Make Opticks usable for LHCb RICH simulation and for other experiments.
- Collaboration with Simon and GEANT4 team will be essential.

Backup Pages

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