GEANT4 Primer

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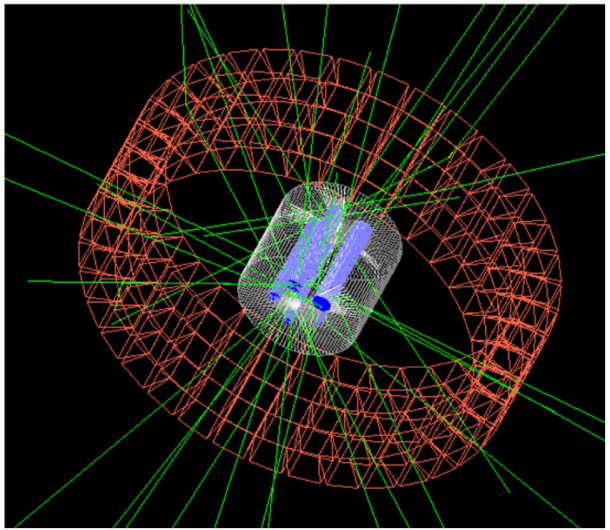
What is GEANT4?

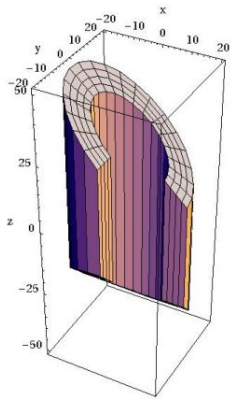
- **Ge**ometry **An**d **T**racking
- Make a detector and specify materials
- Shoot particles or make particles decay around your detector
- Track the way the particles interact with your detector
- Used in:
  - Particle/nuclear physics
  - Detector design
  - Medical physics



https://www.nature.com/articles/s41467-021-22907-5

Geometry construction

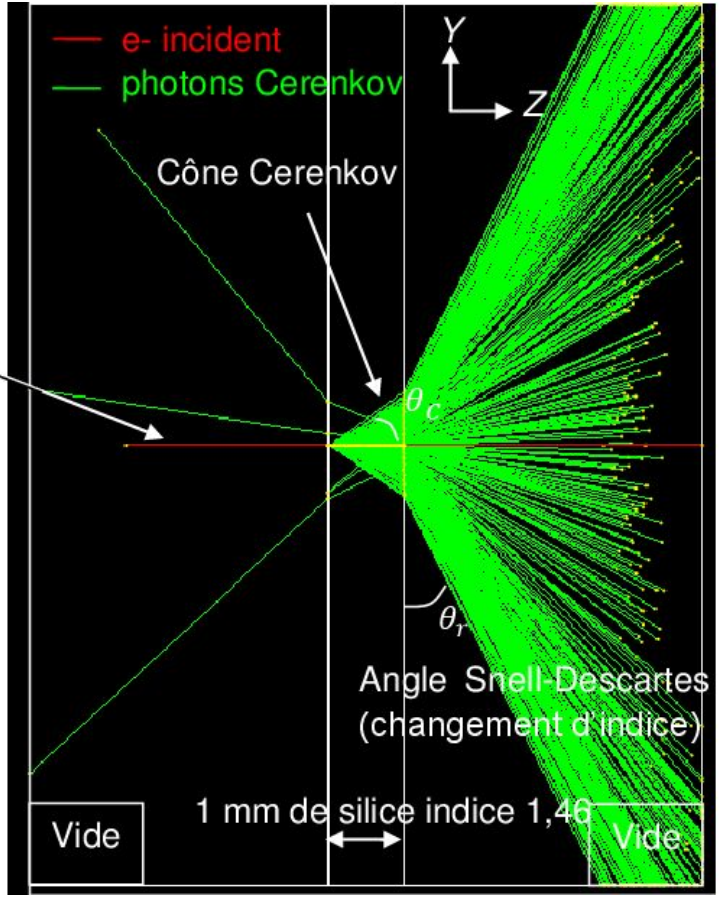
```
G4CutTubs(const G4String& pName,
                G4double pRMin,
                G4double pRMax,
                G4double pDz,
                G4double pSPhi,
                G4double pDPhi,
                G4ThreeVector pLowNorm,
                G4ThreeVector pHighNorm)
```



In the picture:
`pRMin = 12, pRMax = 20, pDz = 30, pSPhi = 0, pDPhi = 1.5*pi, pLowNorm = (0,-0.7,-0.71), pHighNorm = (0.7,0,0.71)`

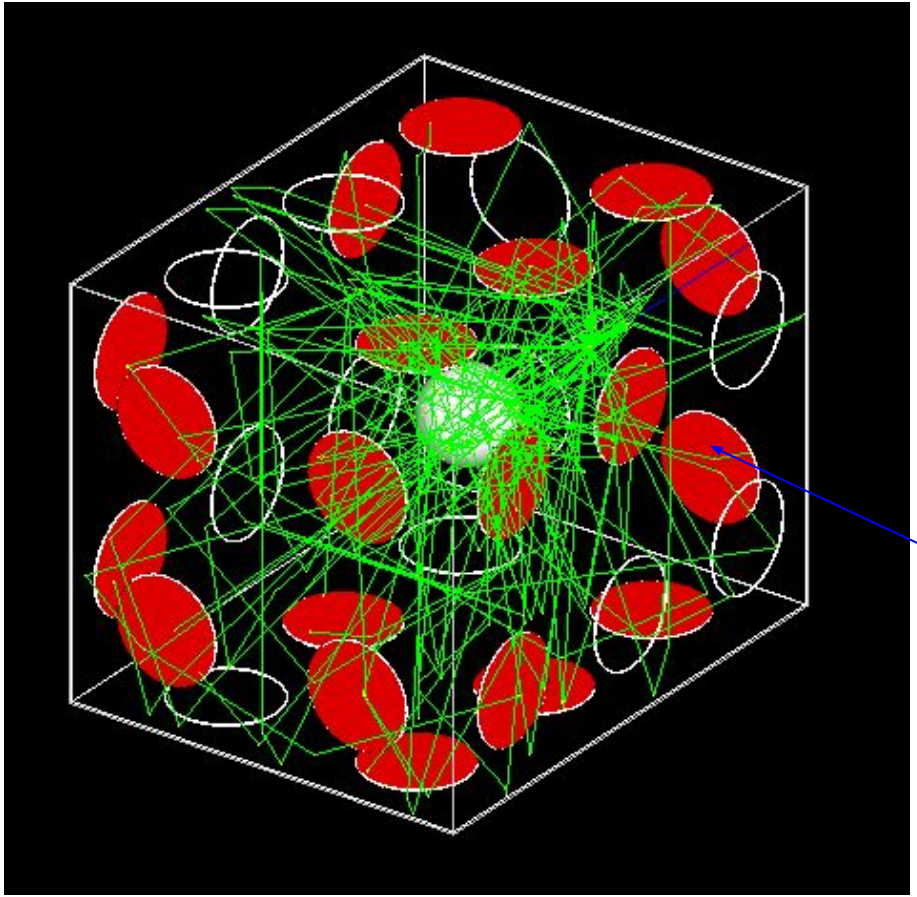
- Solid volume: The pure geometry
- Logical volume: Geometry + material
- Physical volume:
  - Placement of logical volumes
  - Copy number for logical volumes
  - Add boundary effects between materials (e.g. reflectivity)

Physics lists



- Includes the physical processes that you want to simulate
- E.g.: Cerenkov process can create optical photons

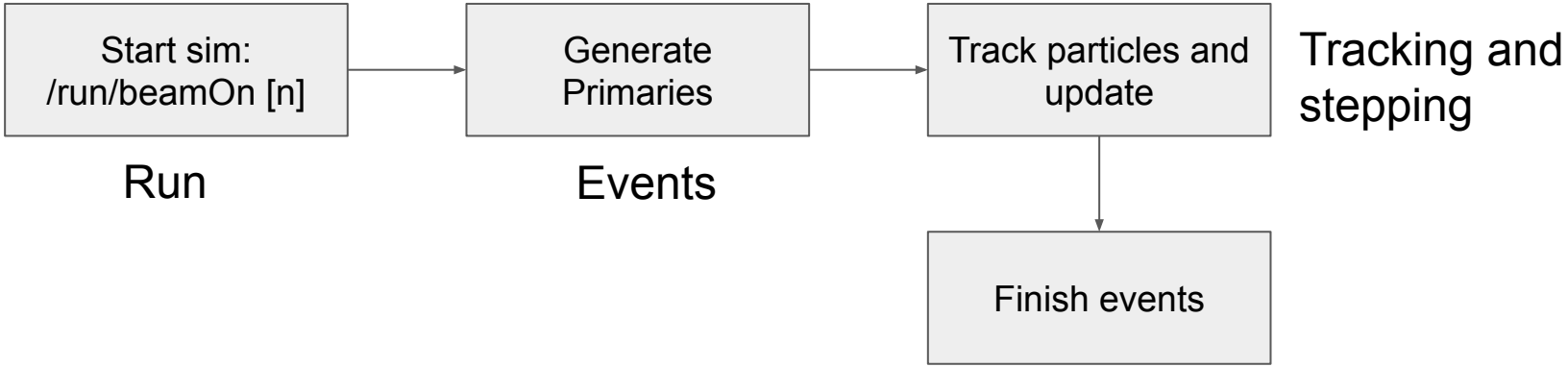
Sensitive detectors



- Make some of your logical volumes able to process interactions within them
- These volumes are called *sensitive detectors*
- The interactions within them are *hits*

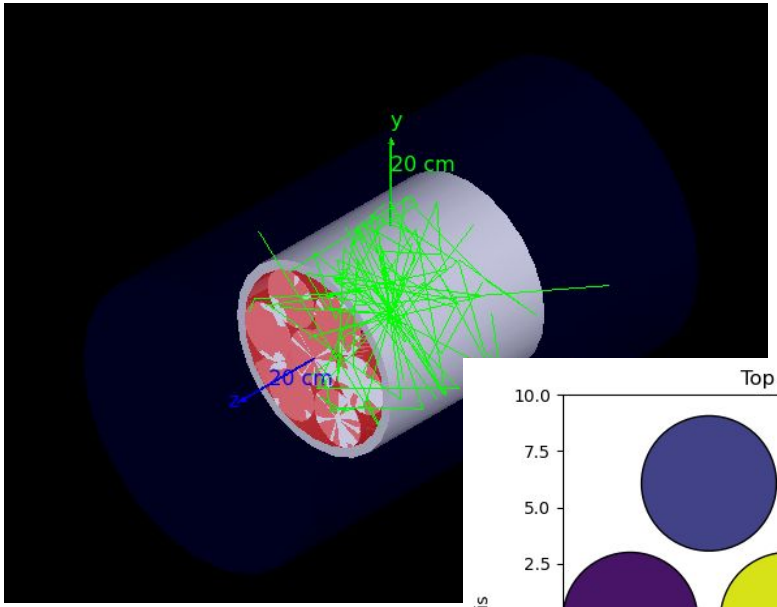
Sensitive detector in LXe example turns red when hits are present

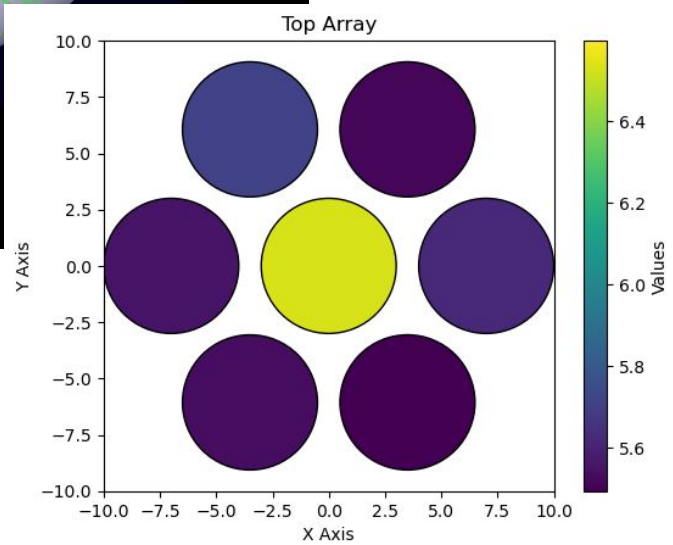
What happens when you start a simulation?



- Before and after each Run, Event, Track, or Step, the user can intervene
- Interventions can be:
  - Color a sensitive detector if there are hits
  - Kill a track if it reaches a given volume
  - Write data to file

HEPCAT G4





- Build a LXe detector with:
  - PTFE reflector wall
  - 7 PMTs on top and bottom
- Simulate optical photons as they bounce around
- See PMT hitpatterns for different positions