A short reference of Cherenkov photon implementation in GEANT4 and ATHENA dRICH / pfRICH

Materials

- Given the refractive index parameterization as a function of wavelength n(λ) GEANT4 predicts **absolute** Cherenkov photon yield

$$\frac{d^2N}{dxd\lambda} = \frac{2\pi\alpha z^2}{\lambda^2}\left(1 - \frac{1}{\beta^2 n^2(\lambda)}\right)$$

- Optical photons are produced *in a proper polarization state*

	GEANT4	aerogel	C_2F_6	C_4F_{10}
n(λ)	+	+	+	+
Rayleigh scattering	+	+		
Absorption	+	+	+	+
Mie Scattering	+			

→ generation & refraction

→ propagation through the *optical materials* of the experimental setup

- ATHENA dRICH / pfRICH parameterizations are taken from existing experimental data, *when possible*

Surfaces

- GEANT4 *automatically performs photon propagation*, provided user described material properties and boundaries (sane defaults exist):
  - reflection (diffuse or specular) & refraction
  - dielectric-dielectric or dielectric-metal interface
  - surface roughness

For now ATHENA dRICH / pfRICH implementation is more or less “ideal” except for dRICH mirror reflectivity is taken to be 90% in the appropriate wavelength range

Sensors & other stuff

- Here we are on our own:
  - GEANT4 part ends with (optional) description of sensor material composition (e.g. optical resin + silicon in case of the SiPMs) -> *not implemented for dRICH / pfRICH yet*
    - Reflection at normal incidence must be taken into account in manufacturer PDE specs
    - Angular variation vs photon polarization state in actually pretty weak for our typical angles of incidence (and does not necessarily match the actual sensor performance)
  - Package(s) like G4SiPM exist, but can not be interfaced to ATHENA environment easily
  - Geometric efficiency (sensor dead area accounting) we perform by hand
  - Manufacturer PDE is typically given based on the measured photocathode current
    - Does not include collection efficiency -> we apply 70% safety factor, but it may not be enough
  - Detected wavelength spectrum is a convolution of $dN/d\lambda$, absorption & PDE

Peculiarities of practical G4 implementations (also scintillation & WLS): https://arxiv.org/pdf/1612.05162.pdf