Laboratório de Instrumentação e Física Experimental de Partículas
L I P

Topography of surfaces and simulation of their optical properties

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Overview

-> How did it start:

AMS radiator description

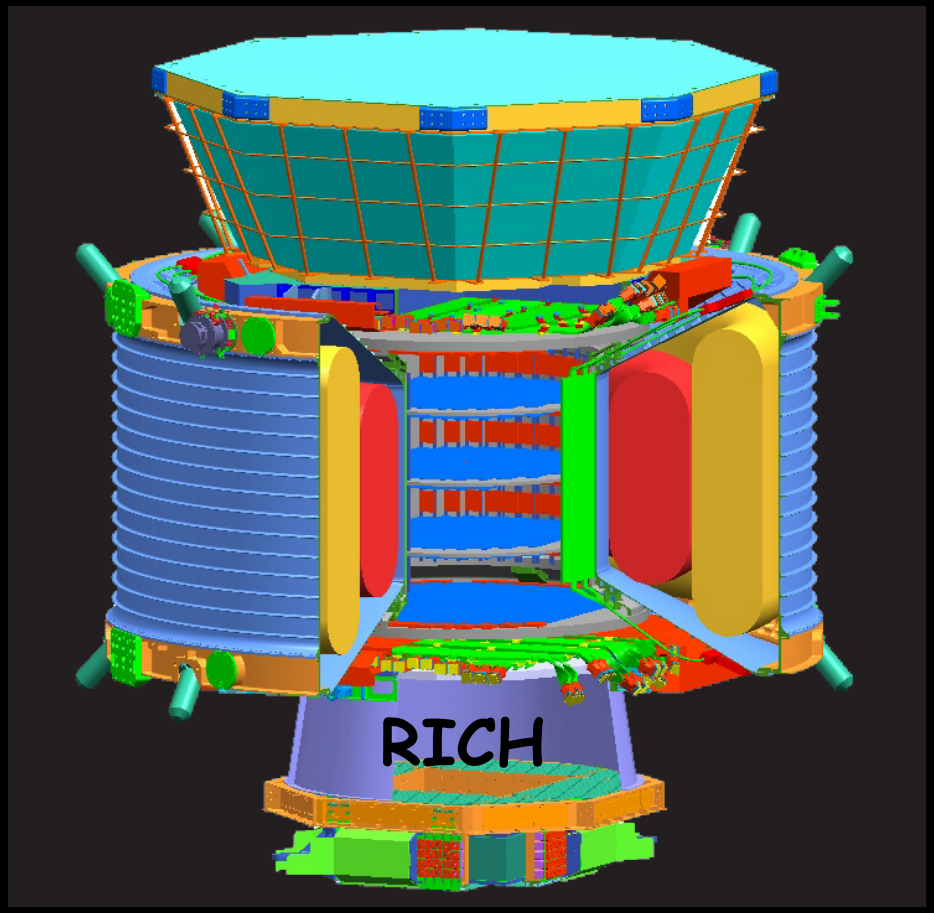
AFM measurements of aerogel surfaces

-> What is the present state:

Implementation of a microfacet sampling model for optical surfaces: with the possibility of reading AFM maps from ascii files

Extension to the UNIFIED model including different possibilities for photon transmission.

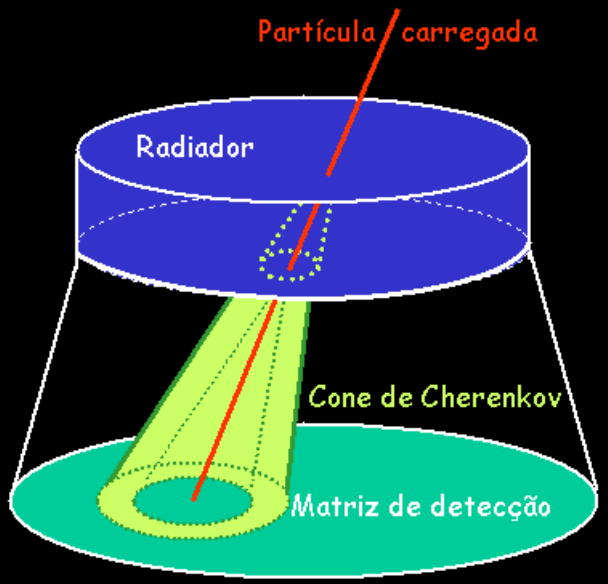
AMS - Alpha Magnetic Spectrometer

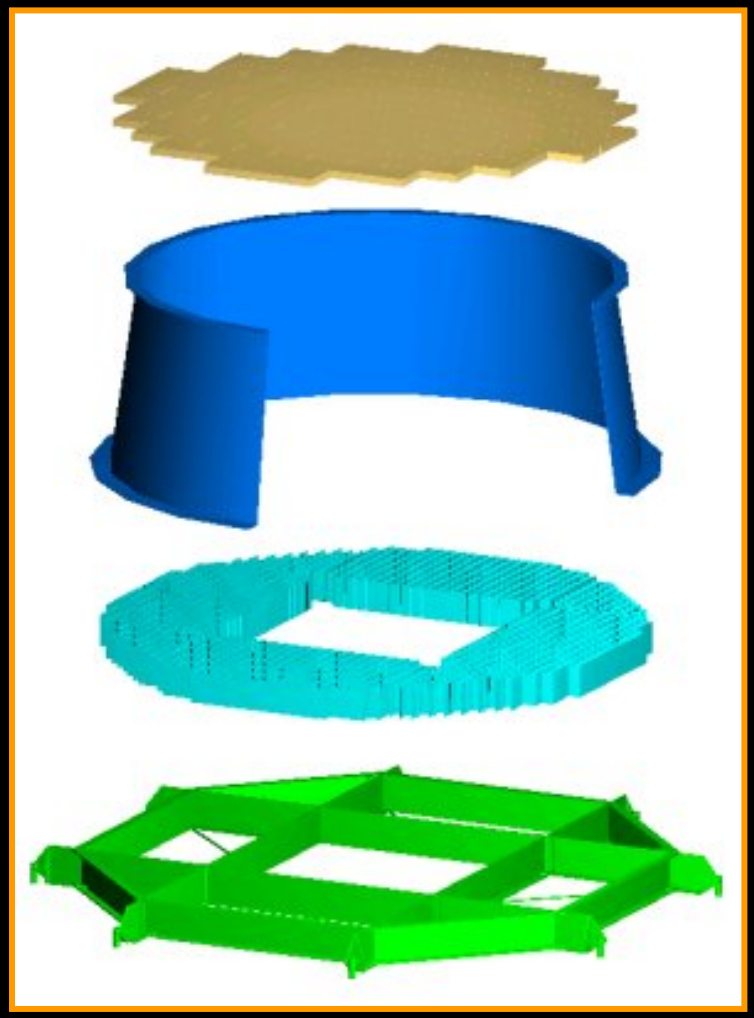


The AMS spectrometer is constituted by different subdetectors surrounded by a superconducting magnet, which aims at characterising cosmic rays before reaching the earth atmosphere.

LIP´s collaboration in AMS is centered in the RICH -Ring Imaging Cherenkov- detector.

The RICH detector of AMS



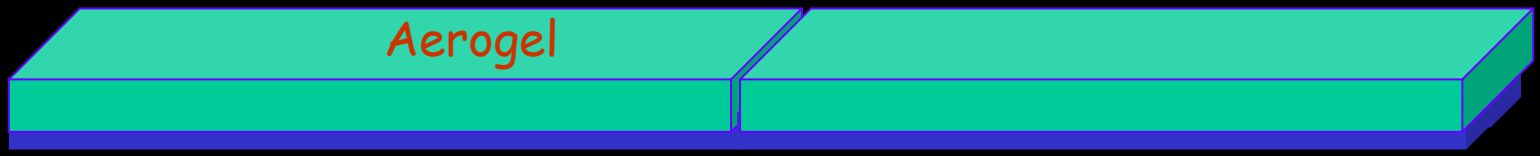


The light emitted by charged particles with velocity greater than the speed of light in the radiator enables to reconstruct their charge and velocity…

The number of photons is proportional to Z^2

The Cherenkov cone opening angle is related to the velocity β, by: $\cos(\theta_c)=1/(\beta\, n)$.

RICH radiator simulation parameters



Aerogel tiles n=1.03 Clarity=0.007598 nm^4/cm Abs_length=100 cm

11.3 cm x 11.3 cm x 3.0 cm , gap 0.1 cm

Variable number NTilesx x NTilesy

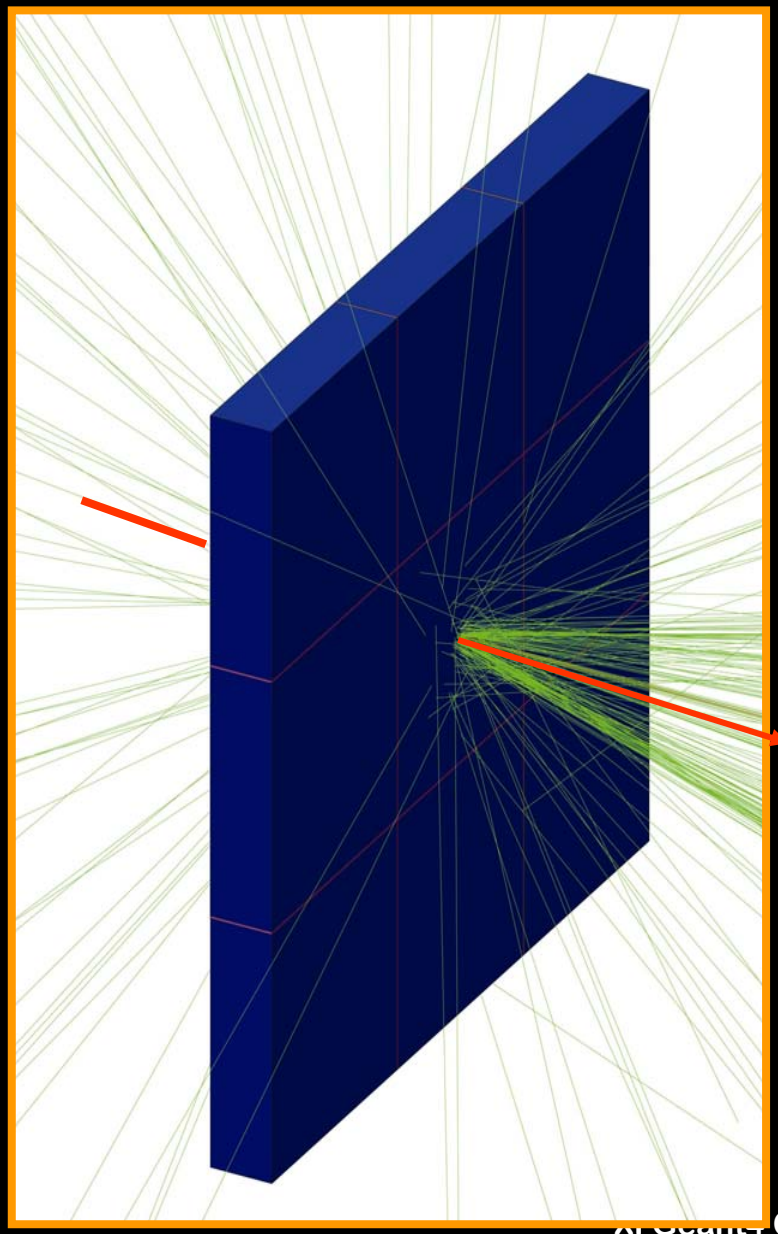
Plexiglas foil n=1.49 Abs_length~100 cm (λ =400 nm)

below the Aerogel tiles (size depends on NTilesx x NTilesy)

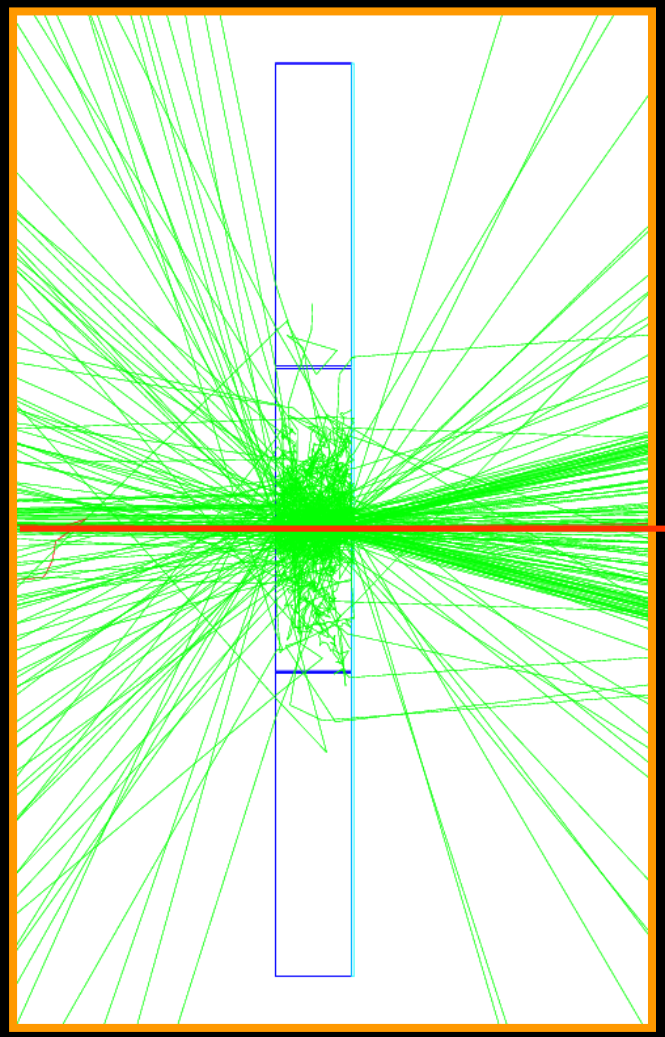
Surface description (for aerogel-air and plexi-air interface)

Type - dielectric_dielectric Model – Unified Finish – Ground

One event in the RICH radiator



80 GeV electron

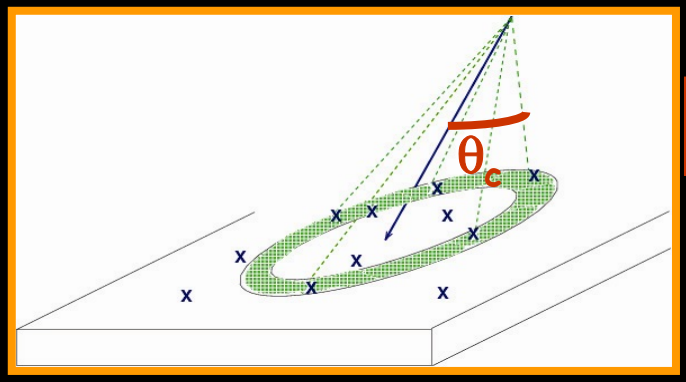


Rayleigh scattering is ON

Velocity reconstruction

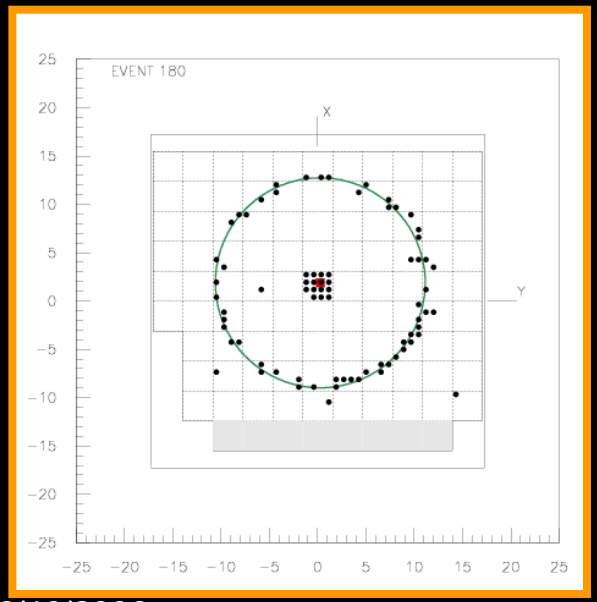
The relevance of the direction of the transmitted photons ....

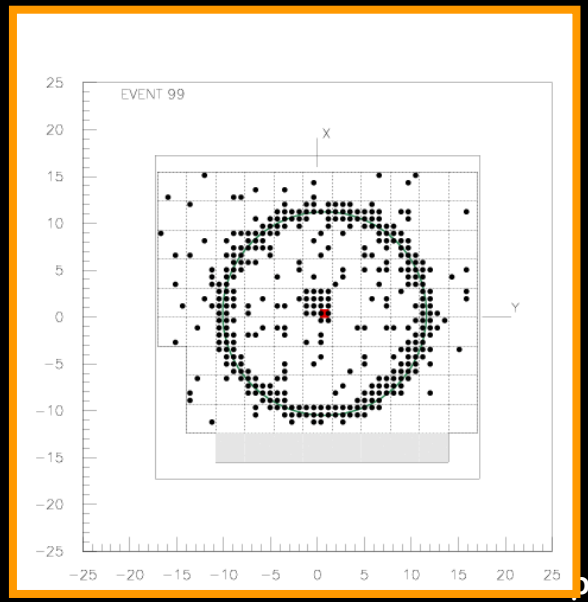
The Cherenkov cone opening angle is related to the velocity β, by:



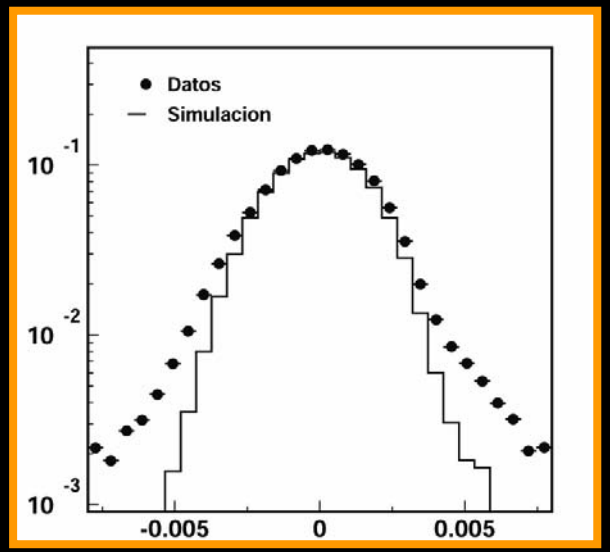
$\cos(\theta_c)=1/(\beta\, n)$. => $\Delta\beta/\beta(\text{hit})=\tan(\theta_c)\,\Delta\theta_c$

Test beam data (2002)





$\beta^{rec.} - \beta^{exp.}$

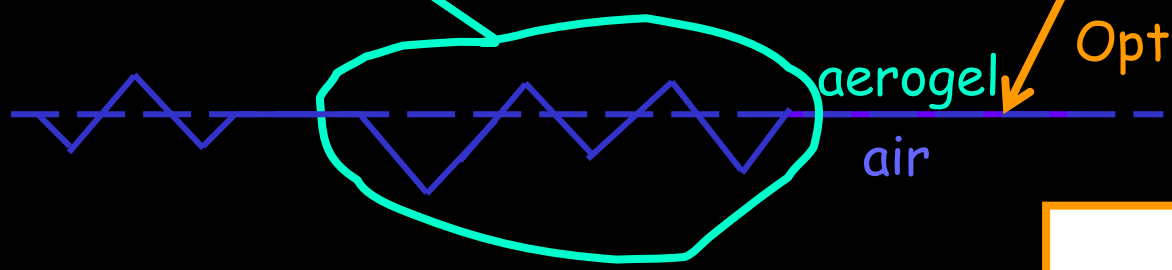


Photon scattering in the aerogel radiator surface

An empirical model with Geant3:

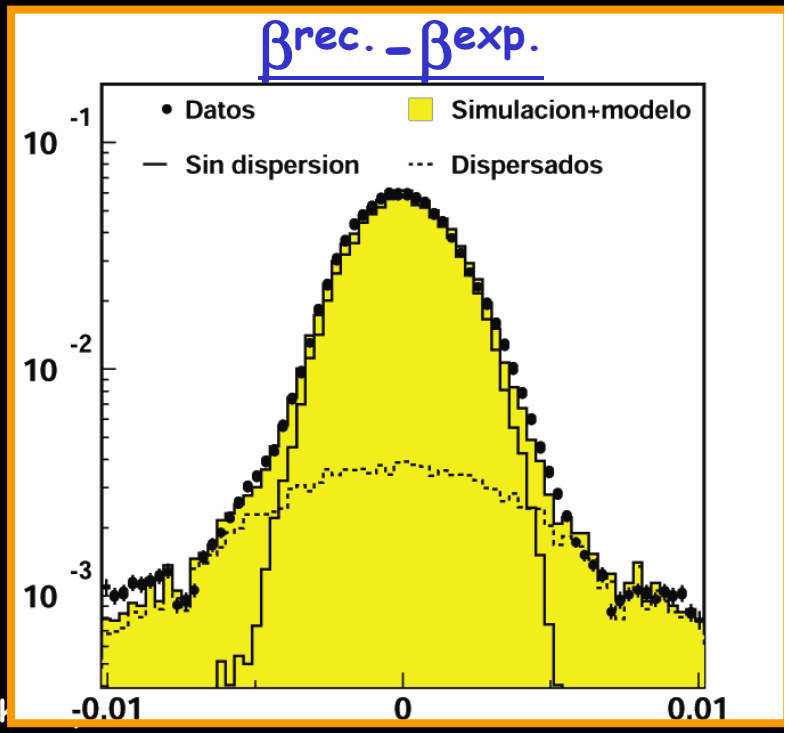
$$p(\alpha)d\alpha \approx \exp\left(-\frac{\sin^2\alpha}{2\sigma_\alpha^{\,2}}\right)d(\sin^2\alpha)$$

for P< P(scattering.)



Fit to data:

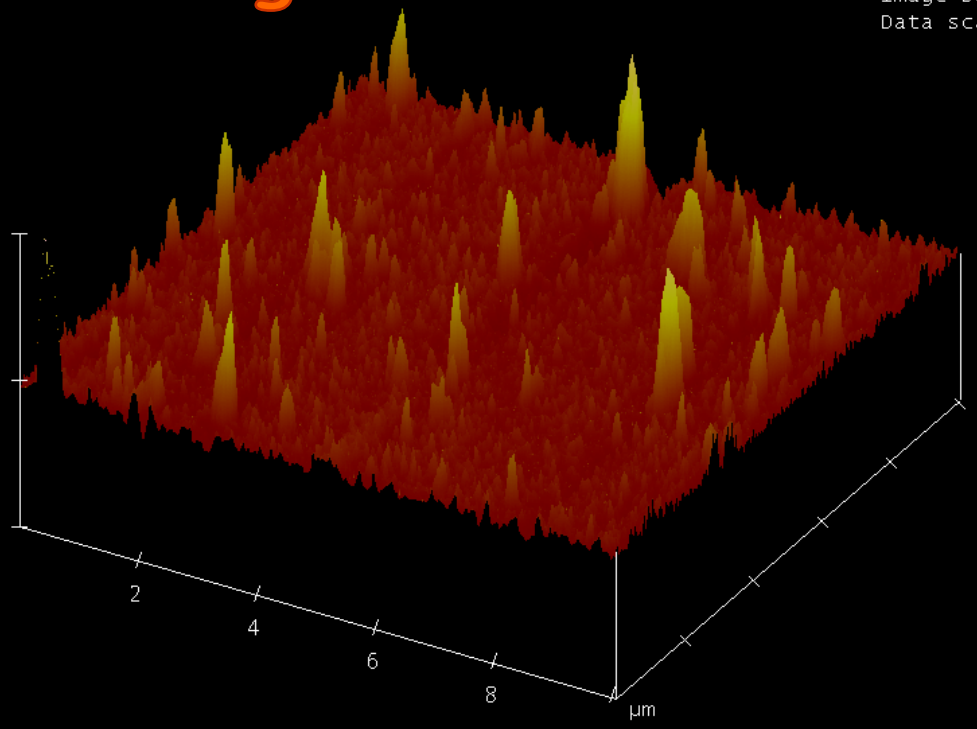
Aerogel	P(scattering)	σ_α(mrad)
Mats. 1.05	0.20±0.02	25±3
Mats. 1.03	0.28±0.02	24±2
Mats. 1.03 n	0.33±0.02	20±3
Nov. 1.03	0.15±0.01	24±1
Nov. 1.04	0.21±0.01	25±4

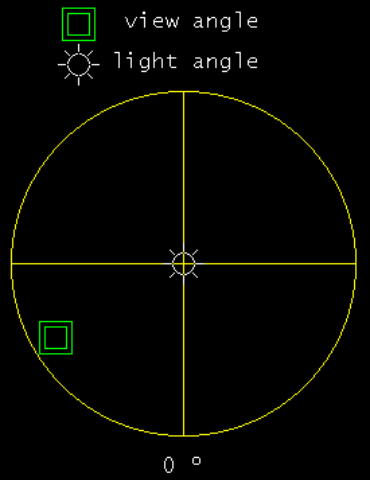


Atomic Force Microscopy

aerogel

Digital Instruments NanoScope
Scan size 10.00 µm
Scan rate 1.001 Hz
Number of samples 256
Image Data Height
Data scale 300.0 nm





X 2.000 µm/div
Z 300.000 nm/div

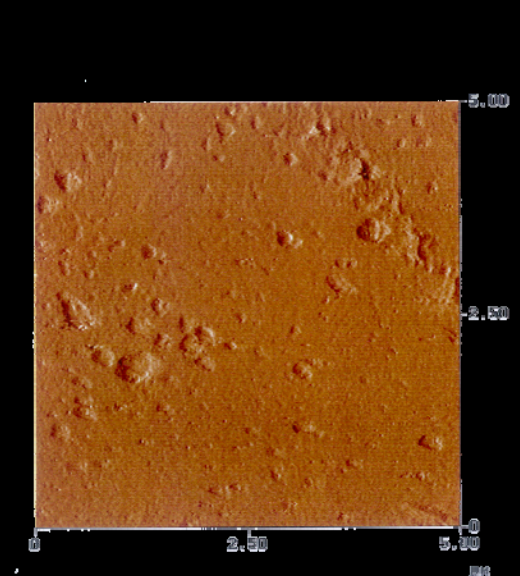
sp50.new010

Measurement of the aerogel surface

A more precise description of photon scattering in aerogel

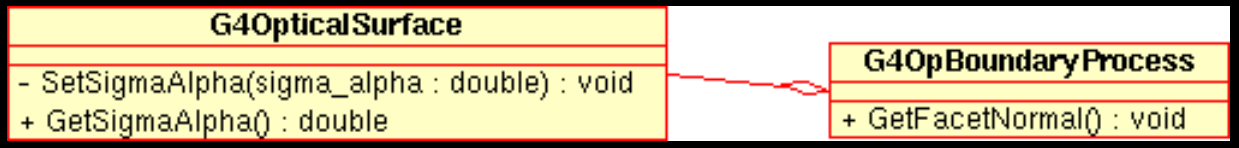
Atomic Force Microscopy (AFM):

Obtain aerogel surface mappings and/or estimate effective parameters for its surface.

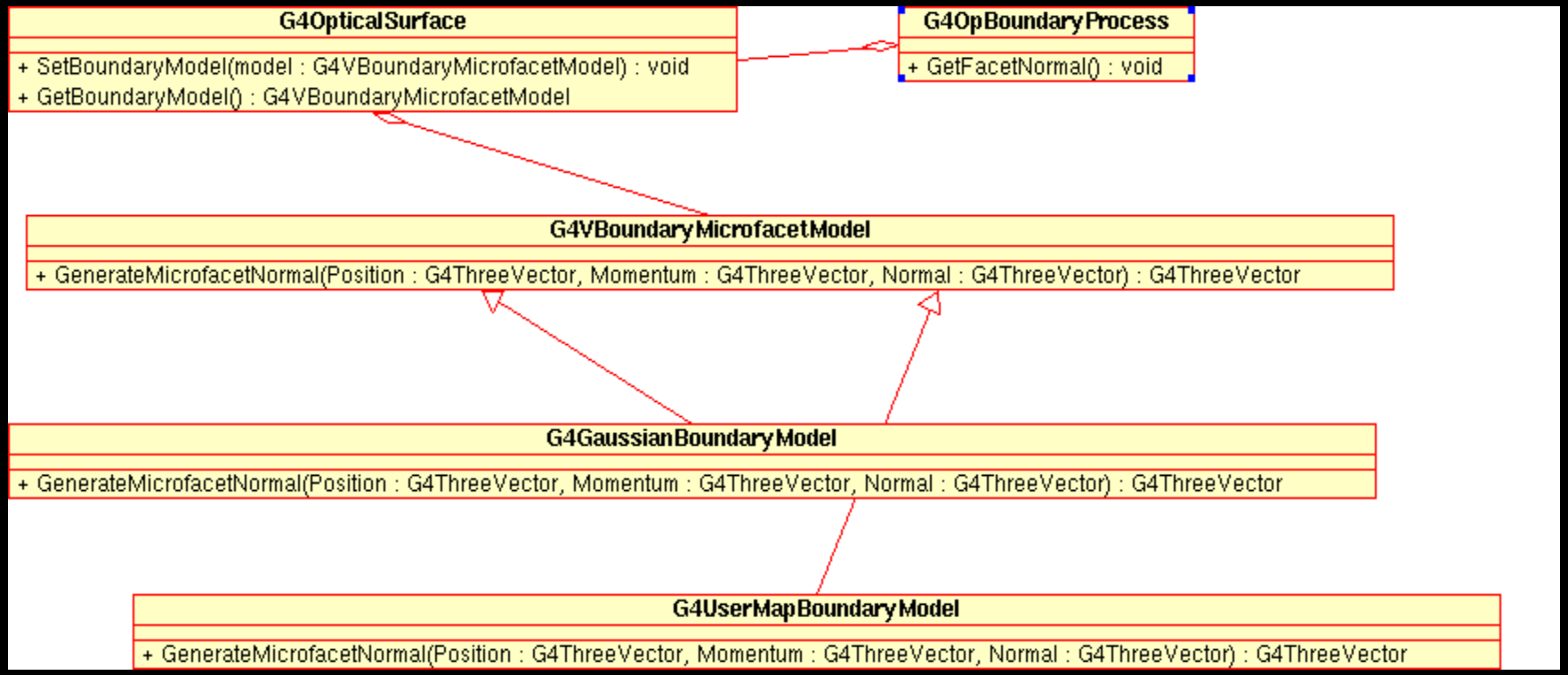


Revisiting the class G4OpBoundaryProcess

STANDARD



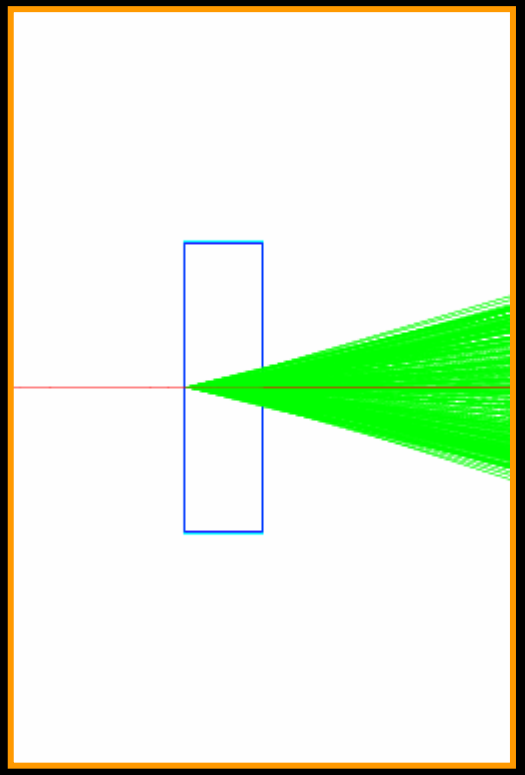
NEW



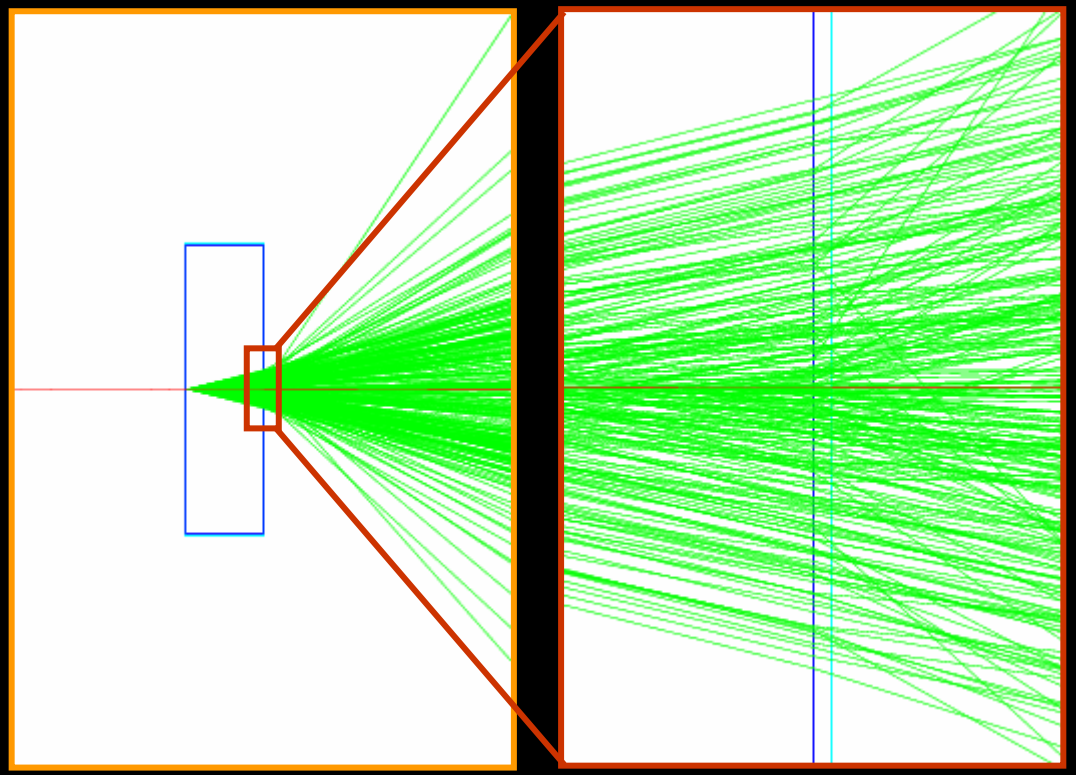
Implementation of surface topography in GEANT 4

For aerogel with n=1.05

Using Standard GEANT4 (4.6.0) version:



Using AFM map: in class G4UserMapBoundaryModel

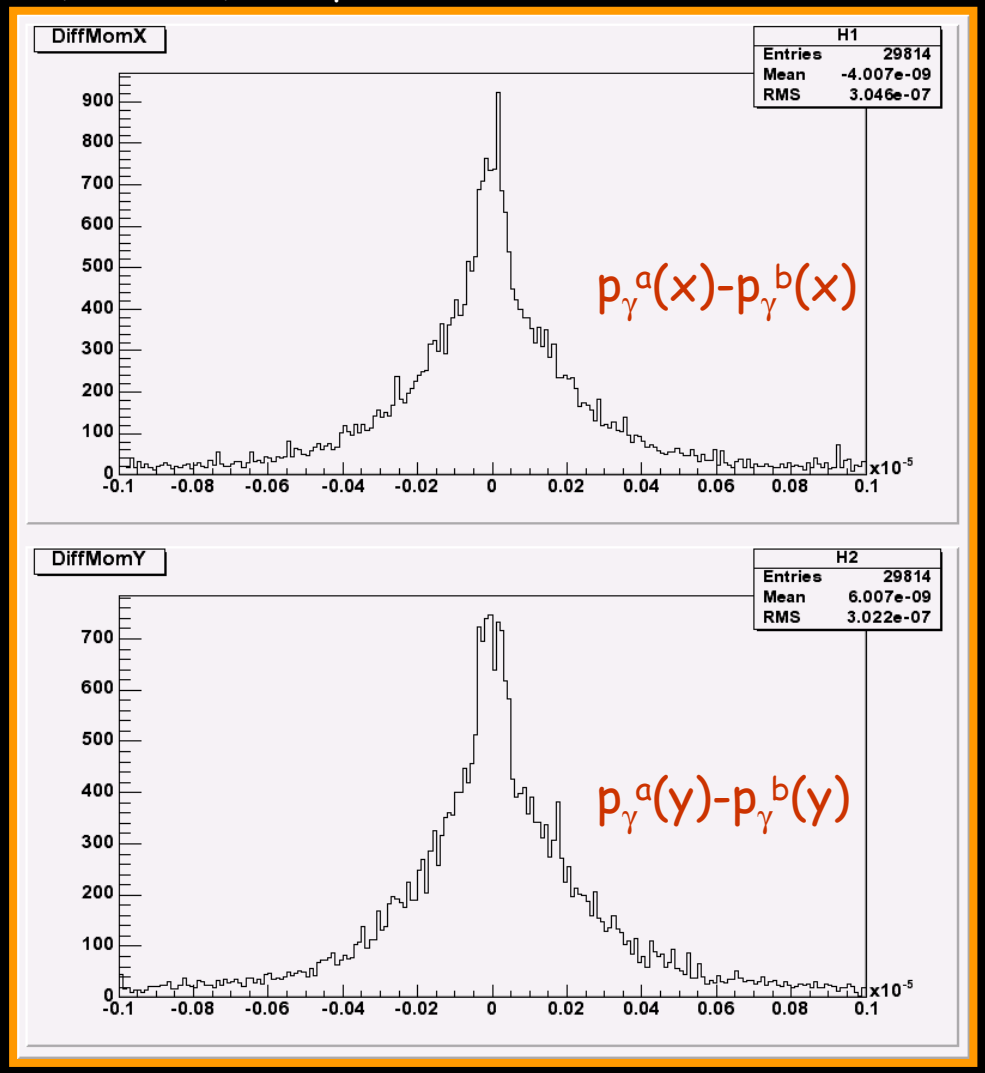


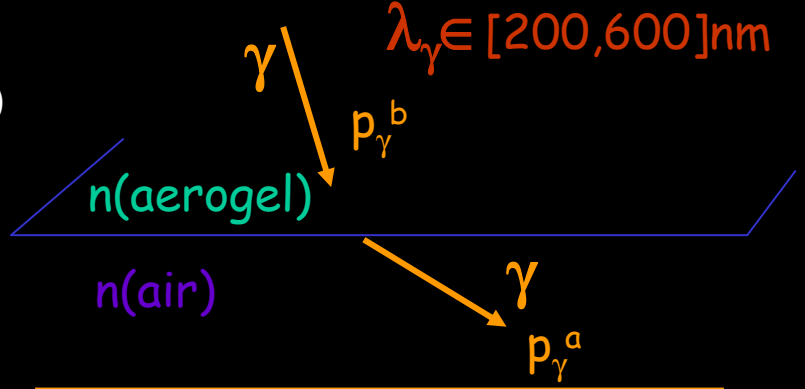
Rayleigh scattering is OFF

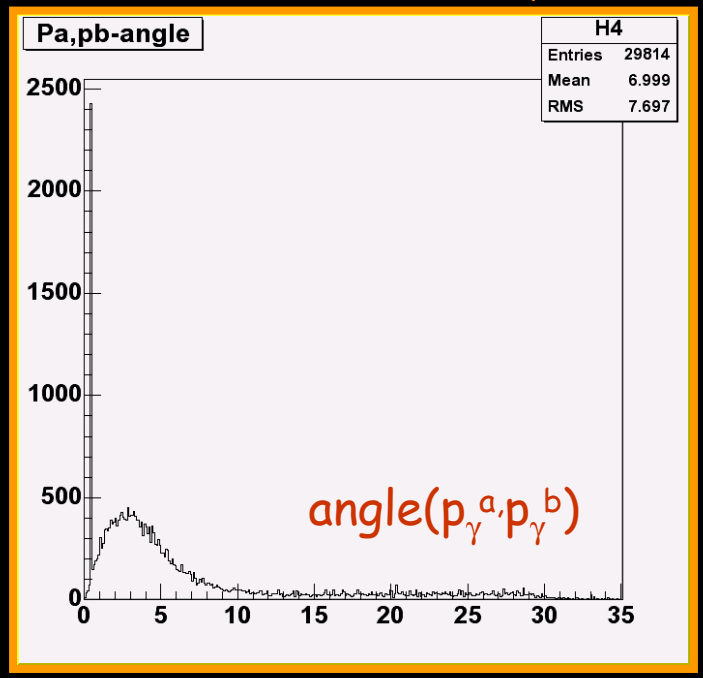
Preliminary results

Using all information in the map (as is *)

* 10 μm X 10 μm map with 256 x 256 bins (~40nm bins in x,y)

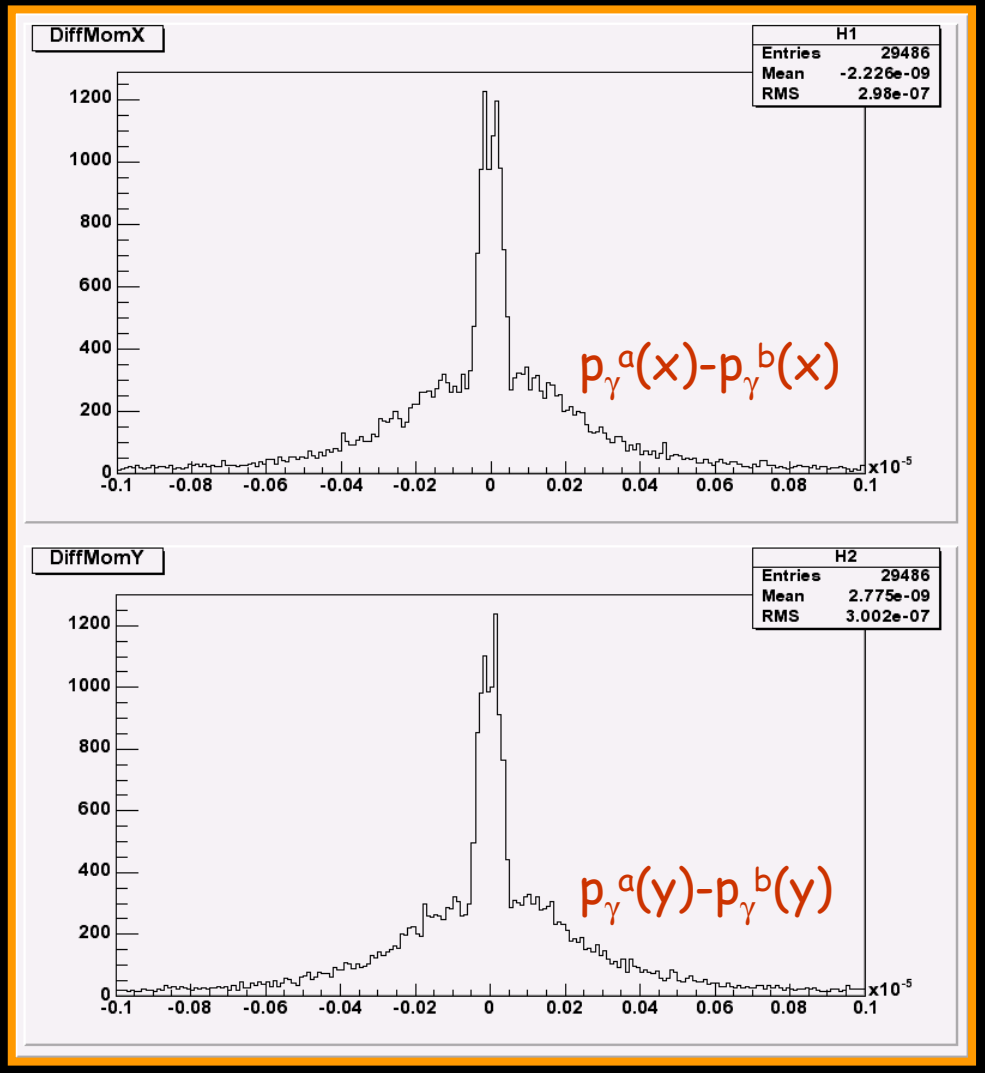


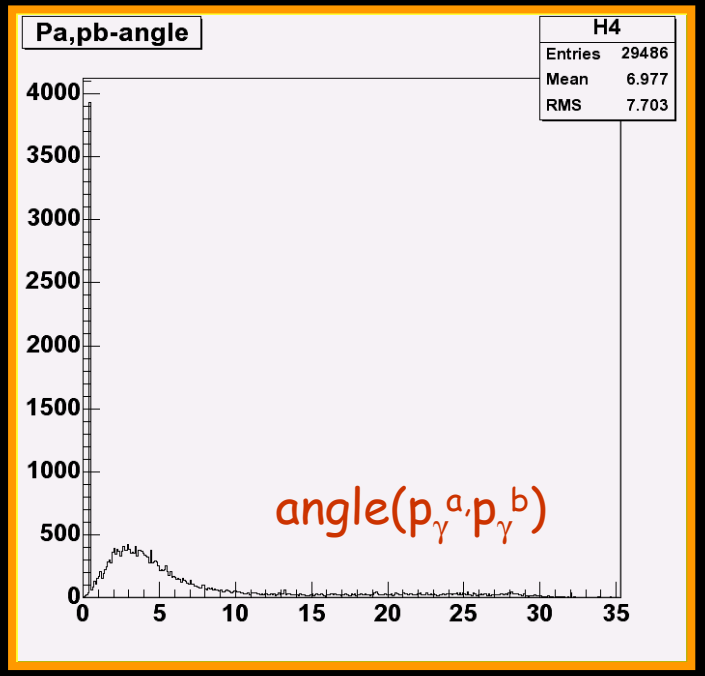




Preliminary results

Requiring that ΔZ(map)> 50 nm (or else =0)



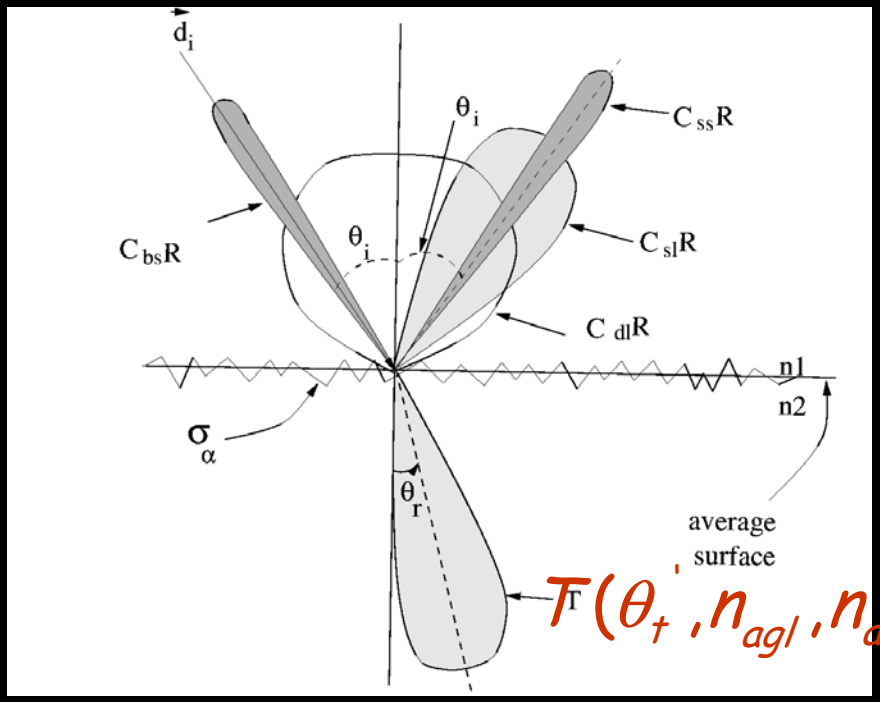


Need to fix criteria to use map information depending on photons wavelength !!!

Describe photons wavelike behavior?

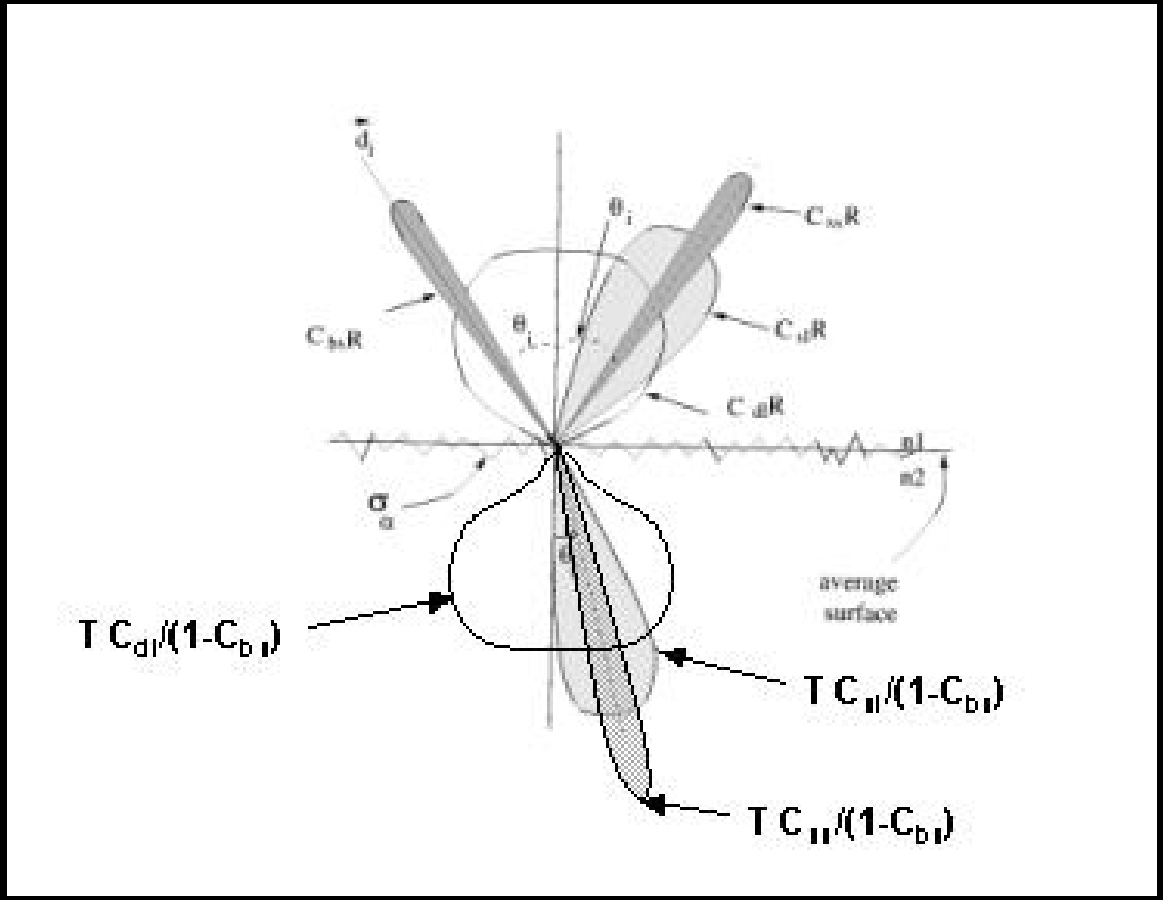
UNIFIED model in Geant4

Can the unified model describe photon scattering in aerogel ?

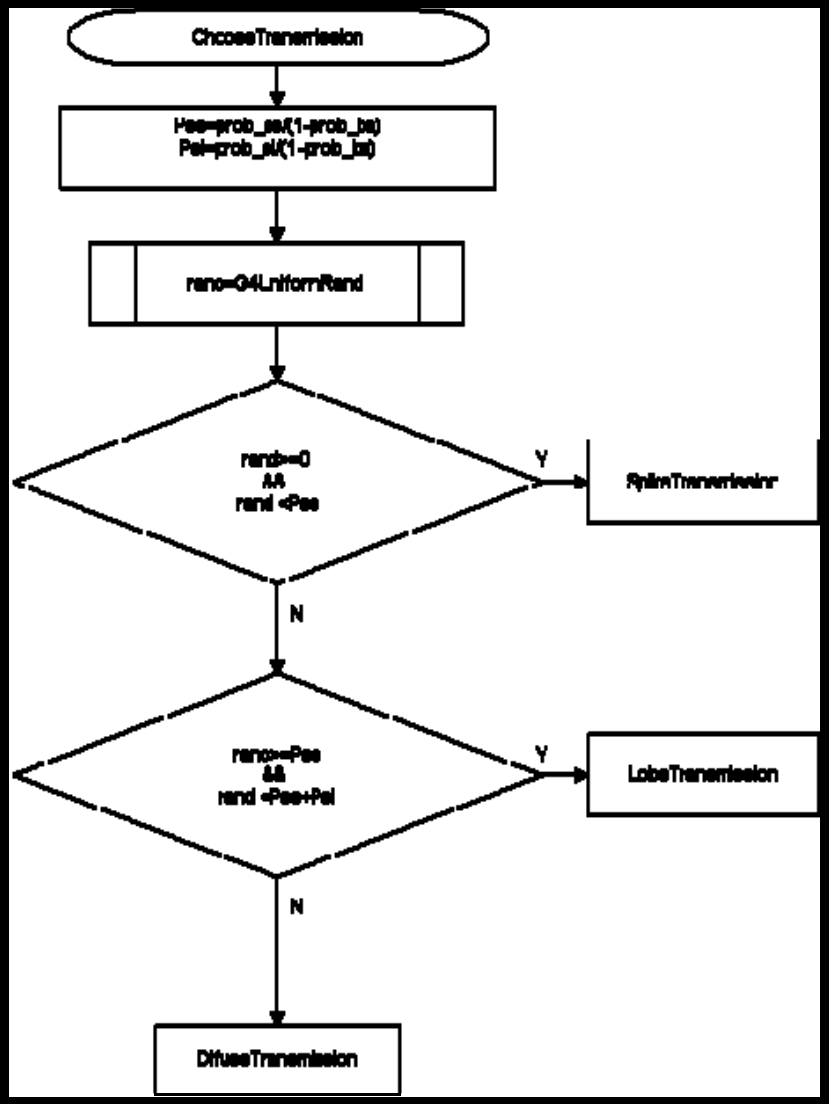


In the unified model the direction of the transmitted photons is only parameterised by a Gaussian distribution of resolution σ_α (α is the difference between the average surface normal and the microfacet slope).

Extending the UNIFIED model in Geant4



Extending the UNIFIED model in Geant4



Implementation with interface class and extension to the UNIFIED model