# Studies of light collection in depolished inorganic scintillators using Monte Carlo Simulations

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**Abstract.** Scintillators are materials which emit light when energetic particles deposit energy in their volume. It is a quasi-universal requirement that the light detected in scintillator setups be maximised. The following project aims to study how the light collection is affected by surface depolishing using the simulation programs GEANT4 [1] and LITRANI [2].

**Keywords:** Cosmic Ray, Scintillator.
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## INTRODUCTION

Scintillators are one of the most commonly used radiation detectors, with applications in nuclear medicine [3], industry [4], and cosmic ray detectors [5]. Many experiments such as GLAST satellite [6] use heavy inorganic scintillators (HIS) with higher densities such as $PbWO_4$ or CsI(Tl). In HIS light trapping effects are typically important due to their high refractive indices. In principle Monte-Carlo simulations can be used for the optimisation of the light yield [7], though difficulties remain for the simulation of depolished surfaces used to reduce light trapping. There are two commonly used programs for simulation of scintillators: GEANT4 [1] and LITRANI [2]. For the simulation of HIS, the second program offers advantages, most notably in the simulation of anisotropy effects, but lacks some of methods for simulating de-polished surfaces of Geant4. The current project aims to add classes for the simulation of de-polished surfaces to Litrani. Once this is complete, studies will be performed for optimising a simple scintillator setup.

## SIMULATION STUDIES

In Litrani, de-polished surfaces are simulated by simulating micro-facets. Any time a photon hits a de-polished surface, the angle of incidence ($\theta_i$) is calculated as $\theta_i$ + a random micro-facet angle sampled from a gaussian distribution with a user defined standard deviation $\sigma$. The problem with this approach is that it cannot reproduce backscatter peaks which are observed in experiments [8]. A more comprehensive model (called UNIFIED), also allows for the direct definition of specular, lobular, diffuse and backscattering coefficients (as in BRDF [9]), whilst keeping the microfacet approach [10]. To use the UNIFIED model, four extra input parameters are necessary, $C_{ss}$: the probability of of specular reflection about the normal of a micro-facet; $C_{sl}$: the probability of diffuse

reflection in the same average direction as $C_{ss}$; $C_{bs}$: the probability of backscattering and; $C_{dl}$: the probability of Lambertian reflection. The four coefficients are related by:

$$C_{ss} + C_{sl} + C_{bs} + C_{dl} = 1$$

In Fig. 1 we show how in a simple setup in Geant4, the number of photons detected depends on the standard deviation of microfacet angles. This figure shows that the number of photons detected can be optimised by using a surface with the right depolish. However to make the simulations realistic, the coefficients from the UNIFIED model will also need to be included.
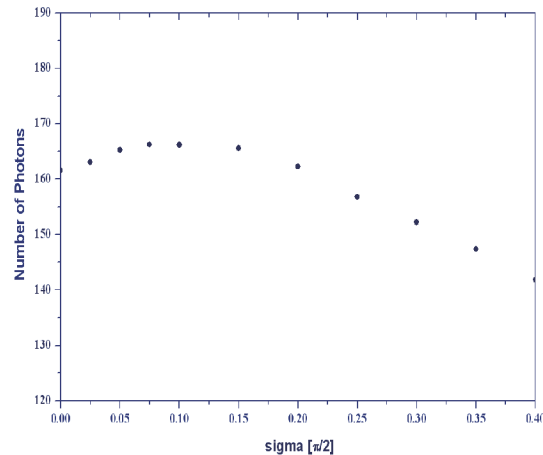


**FIGURE 1.** Number of photons detected vs $\sigma$

# CONCLUSIONS

Litrani presents certain advantaged for the study of HIS, but lacks realistic methods for the simulation of de-polished surfaces. The current works aims to implement the UNIFIED model in Litrani.

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