UNIVERSIDAD NACIONAL DE INGENIERÍA
COLLEGE OF SCIENCES
PHYSICS PROGRAM

Optimization of the geometry of inorganic scintillators applied to high energy physics

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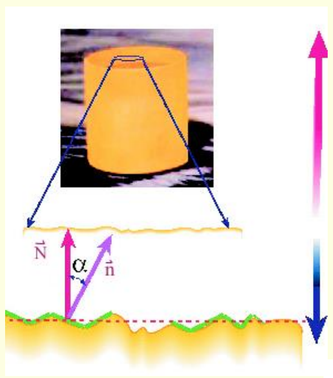
OBJECTIVES

- Check the difference between a rough and a polished surface in the light collection by the detector.
- Find a suitable geometry for the collection of photons in a detector.
- Find a good scintillator to collect light by the detector.

INTRODUCTION

The project is focused on the optimization and characterizationof inorganic scintillators. Scintillators are materials that emitlight (flashes), when an energy particle deposits energy in itsvolume which serves to collect light from the ionization pro-cess and it has a wide range of applications that are found fromthe study of high energy physics.

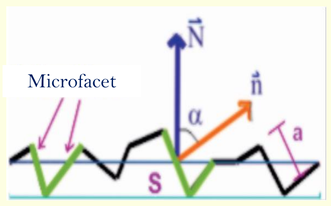
PHYSICAL FOUNDATION



Geometry and parameters of a rough surface

$$I_U(\theta_i,\theta_r,\phi_r) \approx R(\theta_r',n_1,n_2)\left[C_{ls}\,G(\alpha_r;0,\sigma_\alpha) + C_{ss}\,\delta(\theta_i-\theta_r)\,\delta(\phi_r) + C_{bs}\,\delta(\theta_i+\theta_r)\,\delta(\phi_r) + C_{ld}\,cos(\theta_r)\right] + T(\theta_t',n_1,n_2)G(\alpha_t;0,\sigma_\alpha)$$

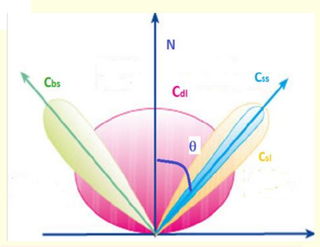
$G(\alpha_r;0,\sigma_\alpha)$ is a Gaussian normal distribution with a mean of 0 and standard deviation σ_α



C_{ss}: Specular Spike probability Constant.
C_{ld}: Diffuse Reflection probability constant.

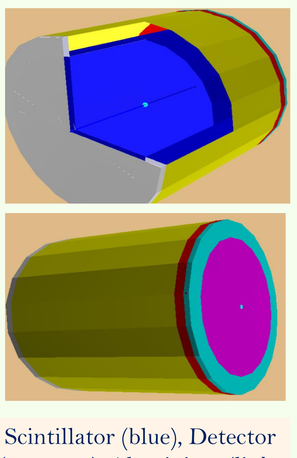
C_{bs}: Retro-reflection probability constant.
C_{ls}: Lobular reflection probability constant.

Reflectance (R)
Transmittance (T).

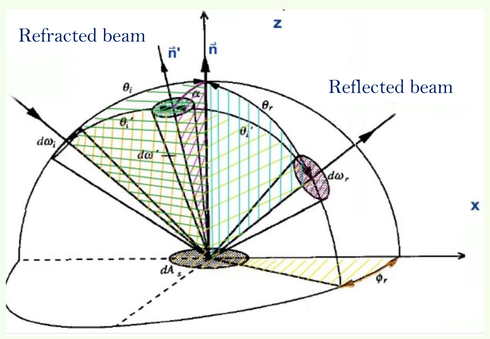


Probability constants C_{nm}

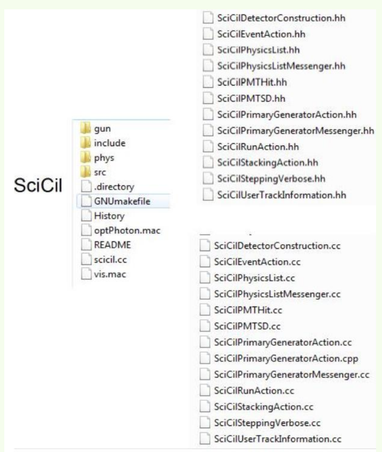
METHODOLOGY



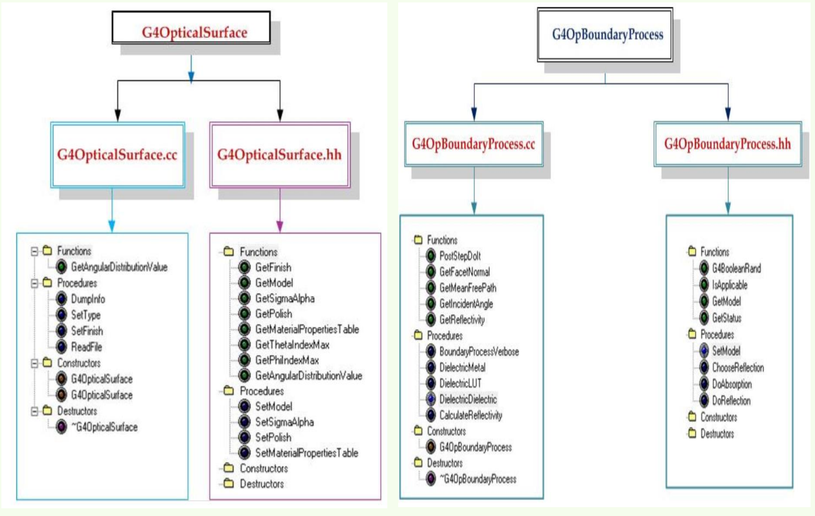
Scintillator (blue), Detector (magenta), Aluminium (light blue), Air(yellow)

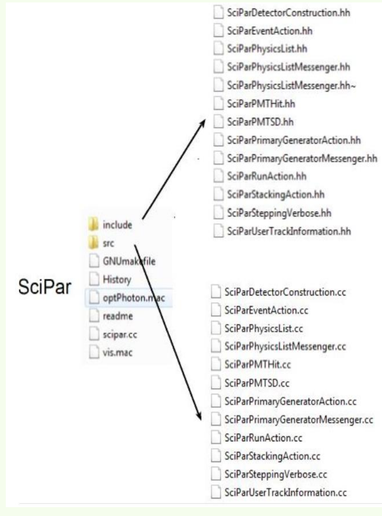


Incidence and reflection of a light beam in space



Modeling of a cylindrical and parallelepiped scintillator in Geant4





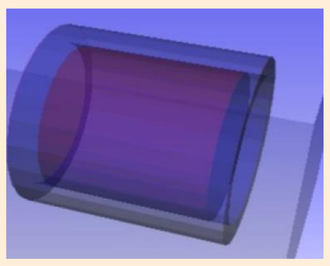
Modeling of the optical part of a rough scintillator in Geant4

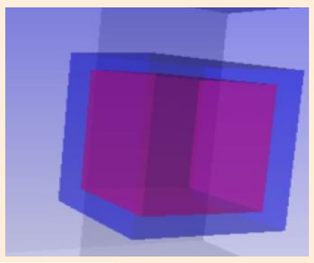
ABSTRACT

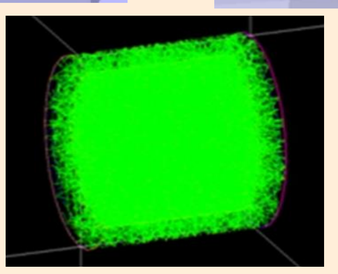
Scintillators have numerous applications in fundamental research and in for commercial use, including being a common detector for particle physics experiments and the basis for many nuclear medecine instruments. It is a quasi-universal requirement that the light detected in scintillator setups be maximised. Inorganic scintillators will be optimized and characterized by the simulation of several types (PWO4, ZnWO4, CaWO4, CdWO4, BGO and LSO) and differents geometries (cylinder and parallelepiped) of scintillators. This simulation will be analyzed in GEANT4 (Geometry ANdTracking), a platform to simulate the passage of particles through matter of photons. Geant4 (GEometry ANd Tracking)

RESULTS AND DISCUSSIONSSC

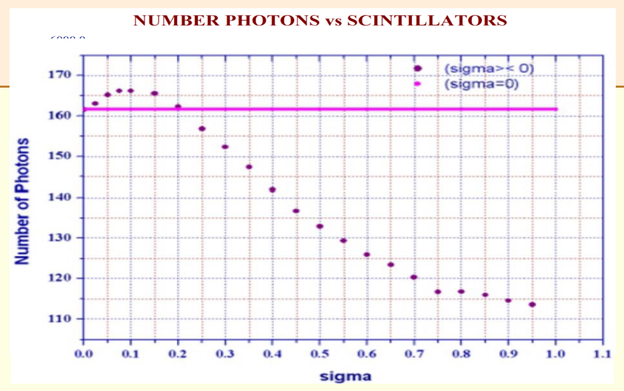
Scintillator simulation







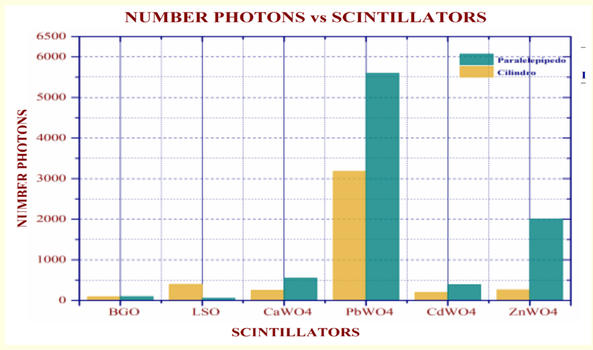
	Number of photons detected	
Material..Geometry	Cilylinder	Paralellepiped
BGO	79.95	96.50
LSO	363.69	528.15
PWO_4	1504.08	5536.05
$ZnWO_4$	240.21	2011.48
$CdWO_4$	181.19	386.64
$CaWO_4$	313.53	530.92

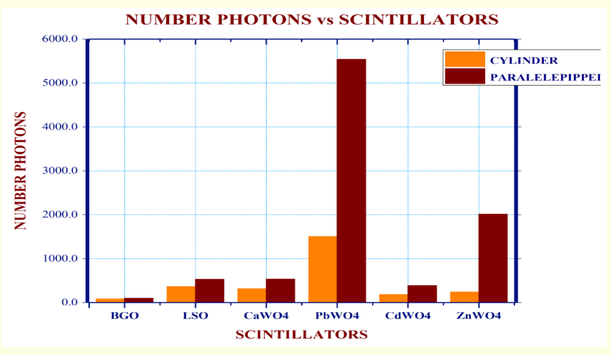


Comparison between a polished and a smooth surface.

Scintillator with aluminium cover

Scintillator with air cover





CONCLUSIONS

The result of the simulation for different crystals and geometries, is obtained

1.- The geometry of the parallelepiped obtains a greater quantity of photons compared with respect to the cylinder.

2.- Among scintillators, the ZnWO4 is better at reflecting photons.

3.- It is verified that the aluminum cover does not let the photons out of the scintillator.

4.- A rough surface allows to collect more photons compared to a smooth surface.

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