

## SIMULATION OF THE OPTICAL PROPERTIES OF PLASTIC SCINTILLATING FIBERS FOR DOSIMETRY OF HIGH RESOLUTION

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# RADIATION DOSIMETRY

#### WHAT IS IT?

Radiation dosimetry is the measurement and calculation absorbed by an object (in this case, the human body) exposed to ionizing radiation.

#### IMPORTANT QUANTITIES

LET — Linear energy transfer Absorbed dose — energy absorbed in a material per unit mass.

#### HOW IS IT DONE?

Measurement: dosimeters Calculations: analytical models and simulations



# LET AND BAGG PEAK

#### LET

Linear energy transfer (LET) is a measure of the ionizing energy that a particle transfers to the material traversed per unit distance. Corresponds the electronic stopping power

#### BRAGG PEAK

The Bragg Peak is the region where charged particles deposit the maximum energy (highest LET, dose) in the material.





# PLASTIC Scintillating Fibers

#### ADVANTAGES

- Plastic is similar to tissue
- Linear dose response (except in the Bragg peak)
- Temperature and pressure independent
- They are available with very thin diameter which allows for high-resolution dosimetry

#### DISADVANTAGES

- The signal amplitude depends on the reading system
- Near the Bragg peak the signal is quenched (the signal output is saturated)
- Cross-talk signals can occur in juxtaposed fibers
- Dependence of the signal produced on Cherenkov light for higher energies



## BIRKS' LAW

#### BIRKS' LAW

Birks' law is an empirical formula for the light yield per path length as a function of the energy loss per path length for a particle traversing a scintillator.

$$\frac{dL}{dx} = S \frac{\frac{dE}{dx}}{1 + k_B \frac{dE}{dx}}$$

dL/dx – light yield per unit length travelled in the fiber

S – scintillating efficiency

 $k_{\rm B}$  – Birk's constant that account for the non-linearity of the light output with the energy deposited (quenching)

 $dE/dx \sim LET$ 



# PLASTIC Scintillating Fibers



	Materials	Refractive index	Density (g/cm3)	No. of atom per cm3
CORE	Polystylene(PS)	nD=1.59	1.05	C: 4.9x1022 H: 4.9x1022
CLADDING	Polymethylmethacrylate (PMMA)	nD=1.49	1.19	C: 3.6x1022 H: 5.7x1022 O: 1.4x1022

	Emis	sion		Attonuation
Description	Color	Peak (nm)	(ns)	Length (m)
SCSF-78	Blue	450	2.8	>4.0



# EXPERIMENTAL METHOD



#### PHOTODETECTOR



### RESULTS: LED 380 VS LED 360



$N = N_o$				
	N <sub>0</sub>	µ (cm-1)		
LED 380	1,84	0,001		
LED 360	1,47	0,002		



## FLUKA

#### WHAT IS IT?

FLUKA is a Monte Carlo simulation code, developed at CERN, for the interaction and transport of particles

#### APPLICATIONS

HIGH ENERGY PHYSICS, RADIATION PROTECTION, DOSIMETRY

#### Flair

Interface for FLUKA that facilitates the editing of FLUKA input files, execution of the code and visualization of the output files.

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## **ISOTROPIC VS DIVERGENT**





#### ISOTROPIC







### **RESULTS: PLOTS**



Cross-section spatial distribution at SOURCE position



Cross-section spatial distribution at PMT position





## **RESULTS: ISO VS DIV VS EXPERIMENTAL**

N = N <sub>o</sub>				
	N <sub>0</sub>	L (cm)		
EXPERIMENTAL	1,84	668		
ISO	1,77	1031		
DIV	1,84	721		





## RESULTS: DIV VS DIVALUMINIUM VS EXPERIMENTAL

$N = N_{o}$				
	N <sub>0</sub>	L (cm)		
EXPERIMENTAL	1,84	668		
DIVALUMINIUM	1,84	712		
DIV	1,84	721		

DIV VS DIVALUMINIUM VS EXPERIMENTAL





## RESULTS: DIV VS DIVALUMINIUM VS EXPERIMENTAL



DIV VS DIVALUMINIUM VS EXPERIMENTAL 1,85 1,80 1,75 . • • DIV **Z** 1,70 DIVALUMINIUM 1,65 EXPERIMENTAL . 1,60 1,55 0,00E+002,00E+014,00E+016,00E+018,00E+011,00E+021,20E+021,40E+02

x (cm)



# CONCLUSION

# THANK YOU. QUESTIONS?