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

Orientadores:
Jorge Miguel Sampaio
João Gentil

Catarina Pimenta
Eng.º Biológica, IST
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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

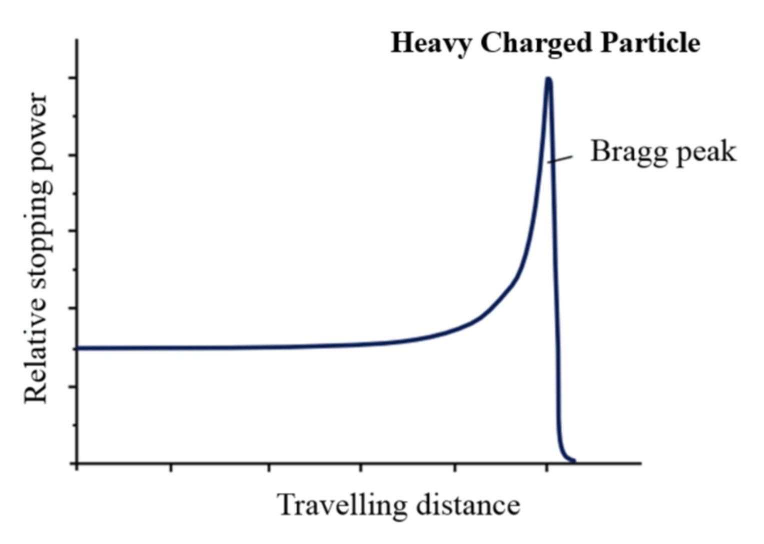
LET AND BAGG PEAK

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.

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

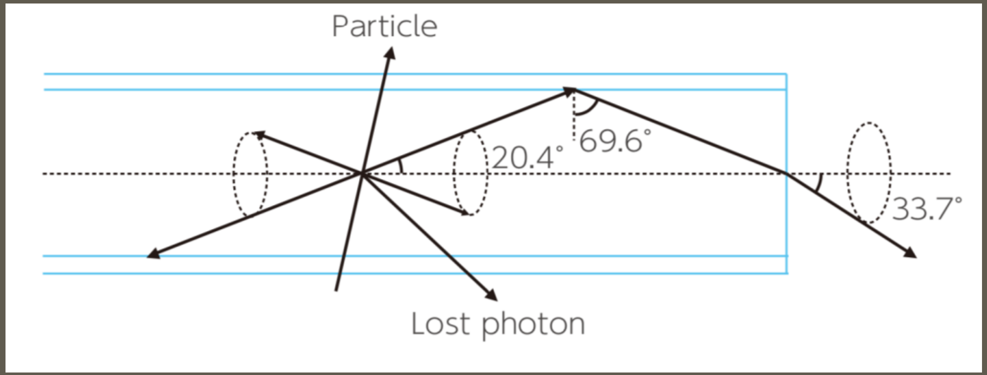
dL/dx – light yield per unit length travelled in the fiber

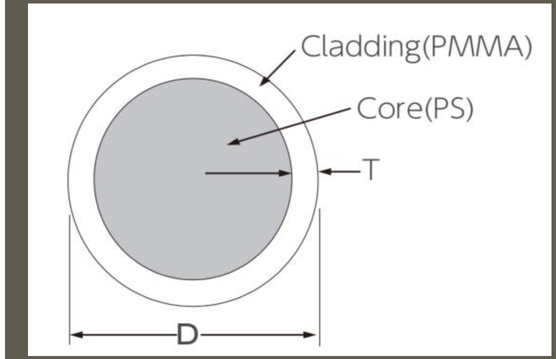
S – scintillating efficiency

k_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

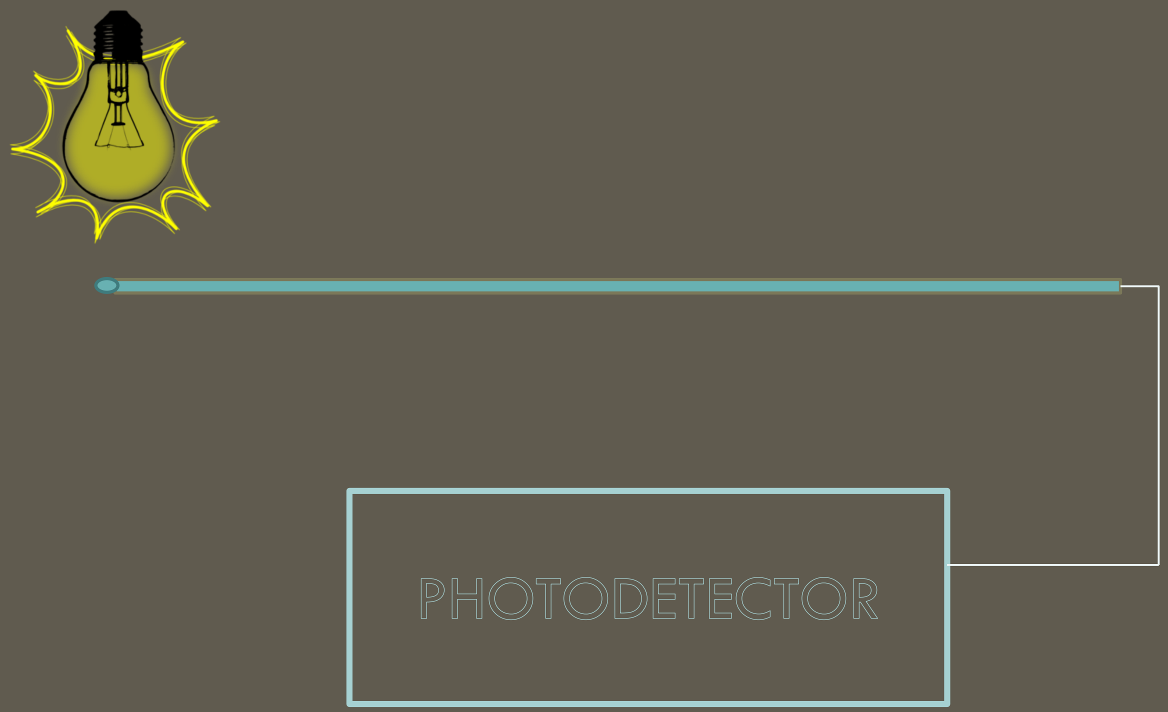




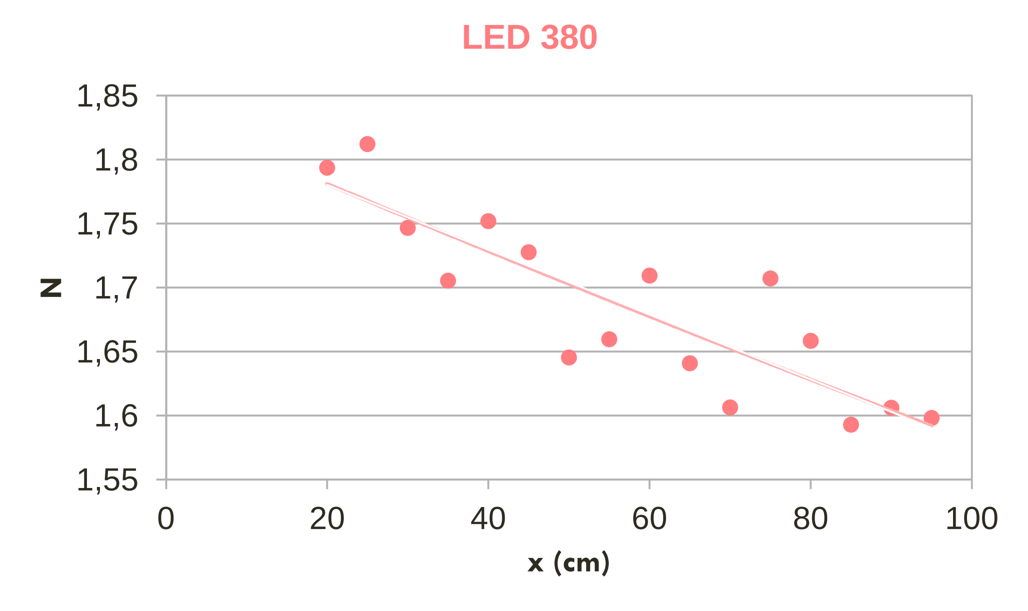
	Materials	Refractive index	Density (g/cm3)	No. of atom per cm3
CORE	Polystylene(PS)	nD=1.59	1.05	C: 4.9x1022 H: 4.9x1022
CLADDING	Polymethylmethacrylate (PMMA)	nD=1.49	1.19	C: 3.6x1022 H: 5.7x1022 O: 1.4x1022

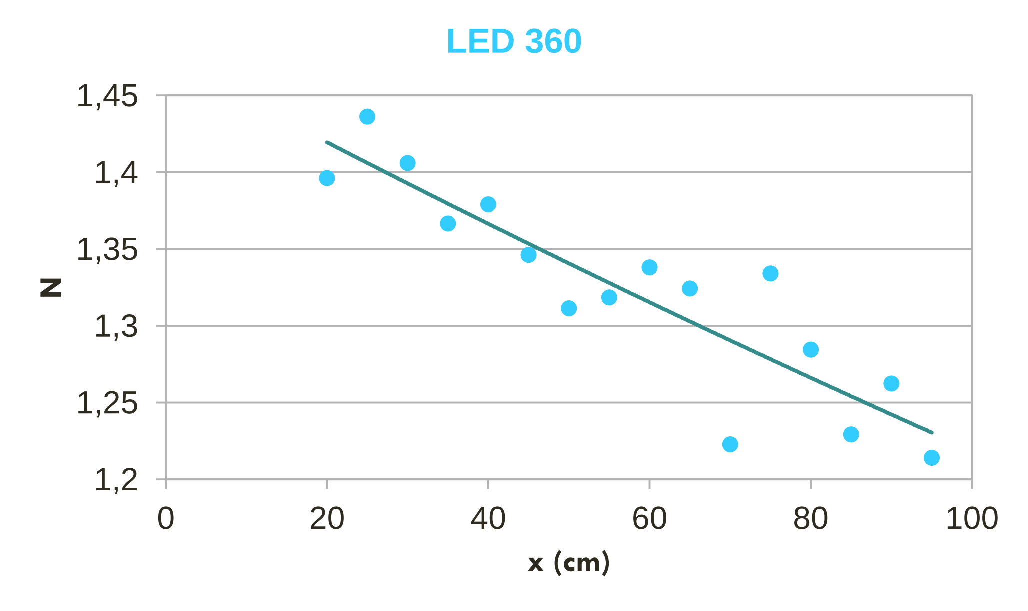
Description	Emission		Decay Time (ns)	Attenuation Length (m)
	Color	Peak (nm)		
SCSF-78	Blue	450	2.8	＞4.0

EXPERIMENTAL METHOD



RESULTS: LED 380 VS LED 360





$N = N_0$		
	N_0	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.

FLAIR

BEAM

BEAMPOS

FLAIR

GEOMETRY

FLAIR

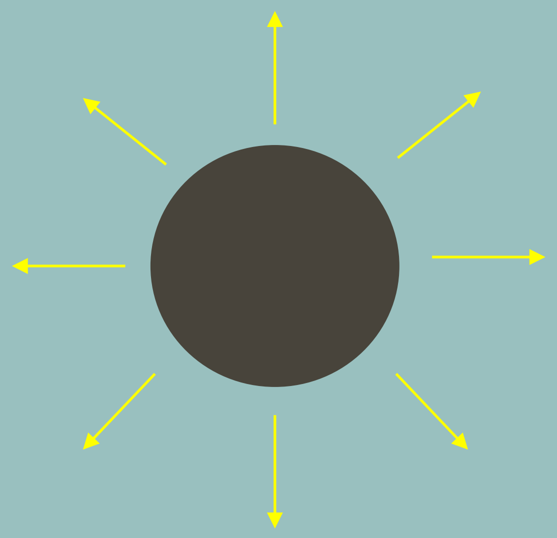
MATERIAL

FLAIR

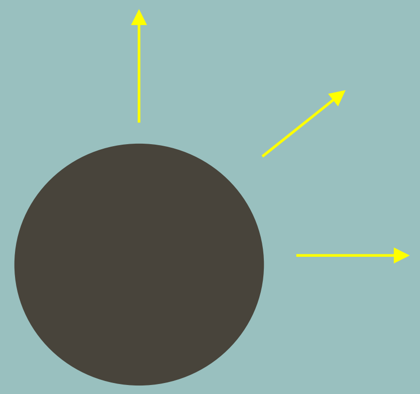
TITLE My Basic Input example
DEFAULTS PRECISIO
BEAM Beam: Momentum p: 3.5 Part: PROTON
Δp: Gauss Δp(FWHM): 0.082425 Δϕ: Gauss Δϕ: 1.7
Shape(X): Rectangular Δx: 0.0 Shape(Y): Rectangular Δy: 0.0
BEAMPOS x: 0.0 y: 0.0 z: -0.1
cosx: 0.0 cosy: 0.0 Type: POSITIVE
GEOBEGIN Log: Acc: Opt:
Inp: Out: Fmt: COMBNAME
Title:
SPH blkbody x: 0.0 y: 0.0 z: 0.0
R: 100000.0
SPH void x: 0.0 y: 0.0 z: 0.0
R: 10000.0
RCC target1 x: 0.0 y: 0.0 z: 0.0
Hx: 0.0 Hy: 0.0 Hz: 10.0
R: 5.0
RCC target2 x: 0.0 y: 0.0 z: 20.0
Hx: 0.0 Hy: 0.0 Hz: 10.0
R: 5.0
RCC target3 x: 0.0 y: 0.0 z: 40.0
Hx: 0.0 Hy: 0.0 Hz: 10.0
R: 5.0
END
REGION BLKBODY Neigh: 5 Volume:
expr: +blkbody -void
REGION VOID Neigh: 5 Volume:
expr: +void -target1 -target2 -target3
REGION TARGET1 Neigh: 5 Volume:
expr: +target1
REGION TARGET2 Neigh: 5 Volume:
expr: +target2
REGION TARGET3 Neigh: 5 Volume:
expr: +target3
END
GEOEND
MATERIAL Name: CHROMIUM #: ρ: 7.18
Z: 24.0 Am: A: dE/dx:
MATERIAL Name: AMMONIA #: ρ: 0.73E-3
Z: 0.0 Am: A: dE/dx:
COMPOUND Name: AMMONIA Mix: Atom Elements: 1..3
f1: 1.0 M1: NITROGEN f2: 3.0 M2: HYDROGEN
f3: M3:
ASSIGNMA Mat: BLCKHOLE Reg: BLKBODY to Reg:
Mat(Decay): Step: Field:
ASSIGNMA Mat: VACUUM Reg: VOID to Reg:
Mat(Decay): Step: Field:
ASSIGNMA Mat: AMMONIA Reg: TARGET3 to Reg:
Mat(Decay): Step: Field:
ASSIGNMA Mat: CHROMIUM Reg: TARGET1 to Reg: TARGET2
RANDOMIZ Unit: 01 Seed: 54217137.
START No.: 1000. Core:
Time: Report: default
STOP

START

ISOTROPIC VS DIVERGENT

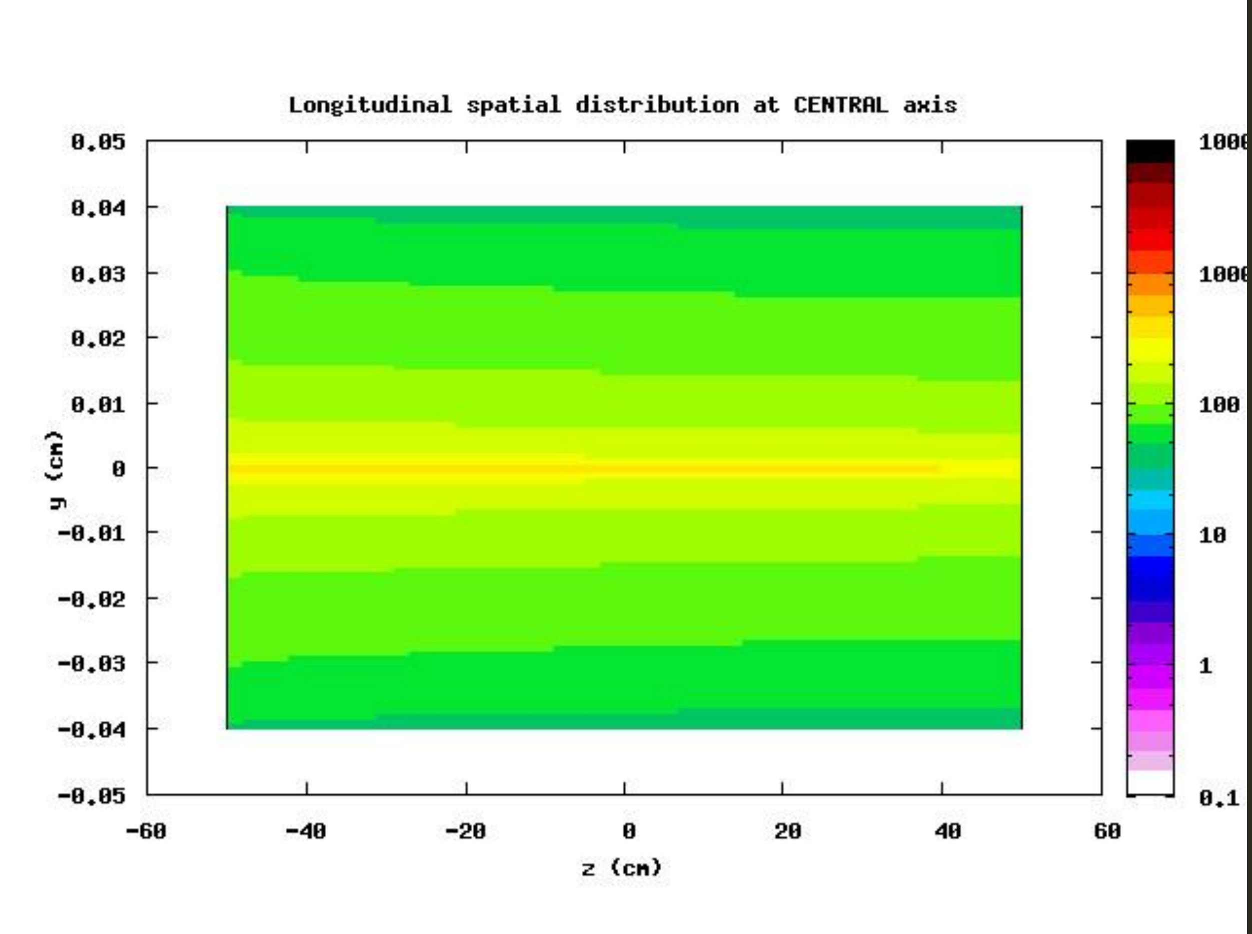


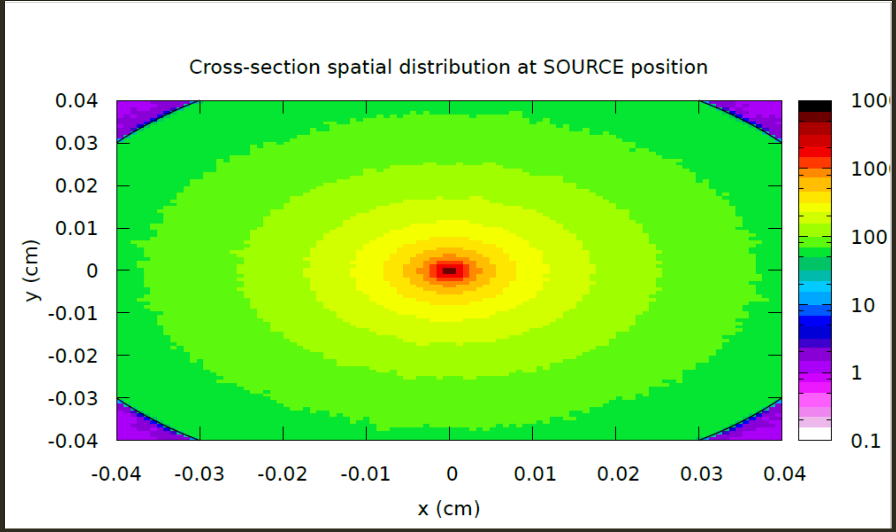
ISOTROPIC

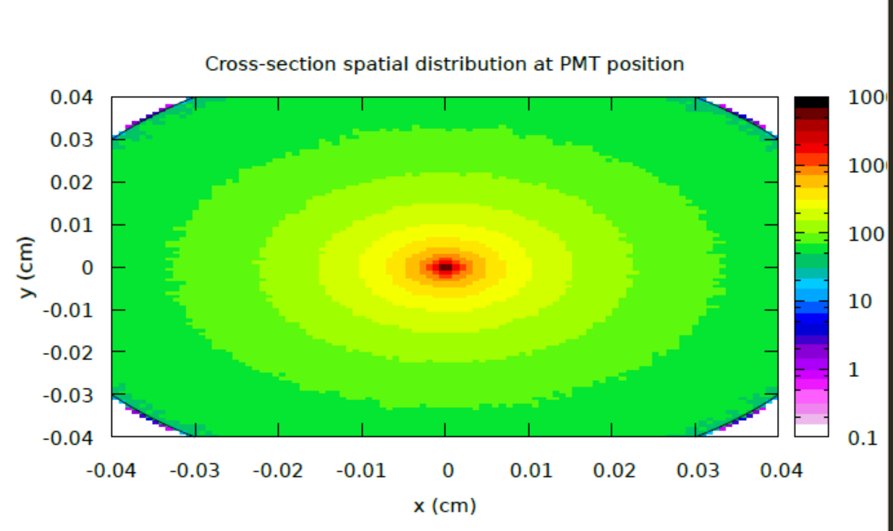


DIVERGENT

RESULTS: PLOTS

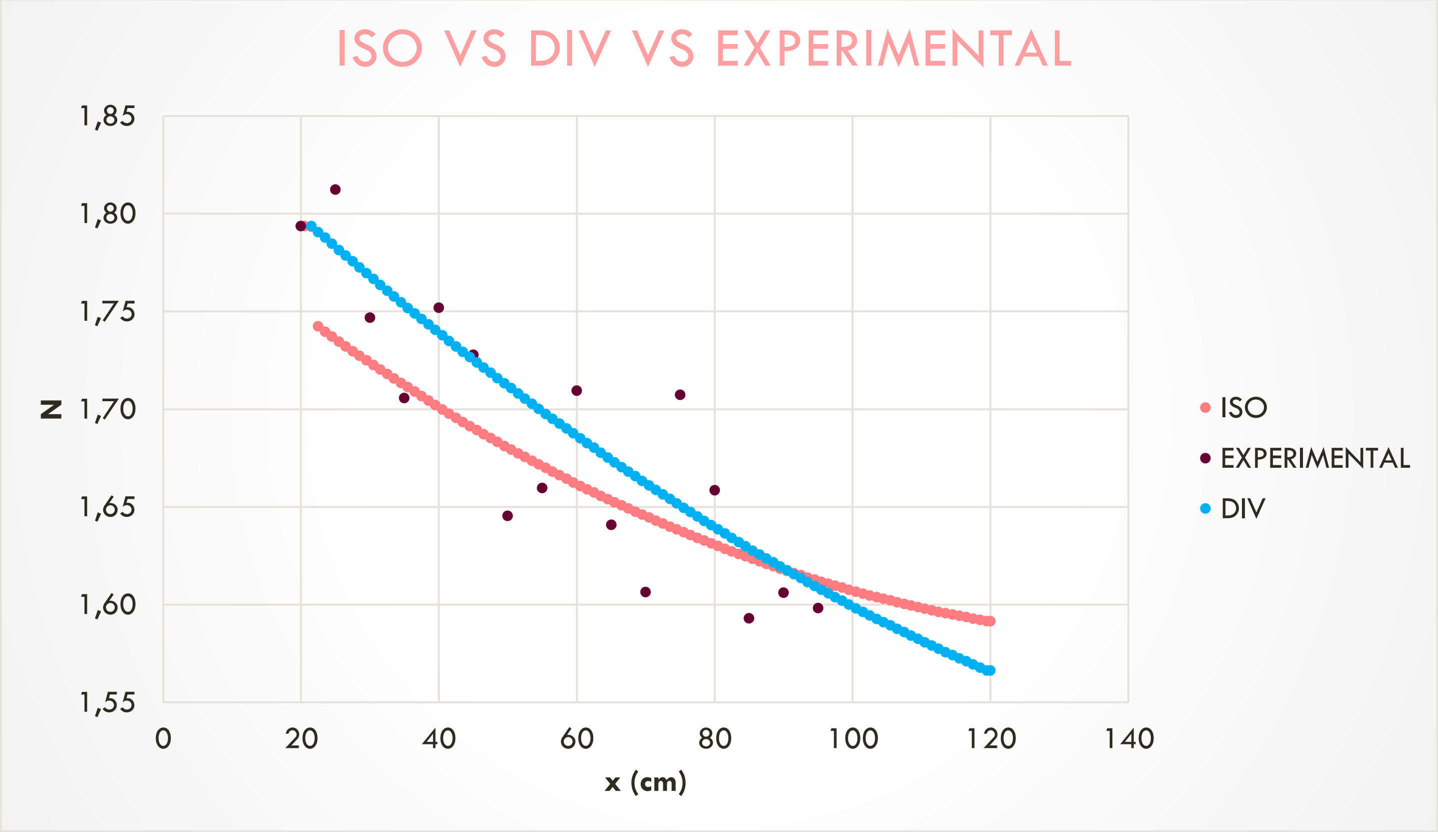






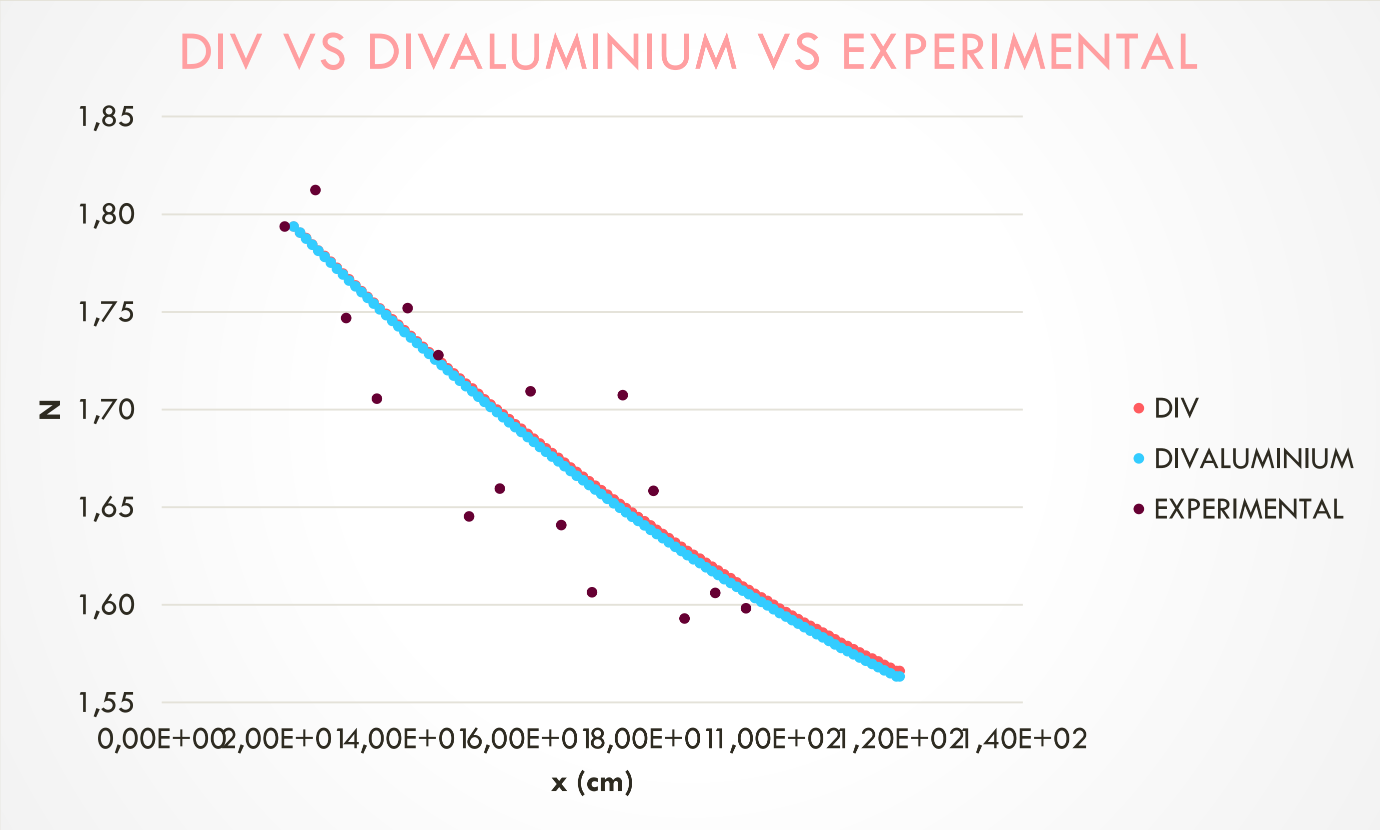
RESULTS: ISO VS DIV VS EXPERIMENTAL

$N = N_0$		
	N_0	L (cm)
EXPERIMENTAL	1,84	668
ISO	1,77	1031
DIV	1,84	721



RESULTS: DIV VS DIVALUMINIUM VS EXPERIMENTAL

$N = N_0$		
	N_0	L (cm)
EXPERIMENTAL	1,84	668
DIVALUMINIUM	1,84	712
DIV	1,84	721



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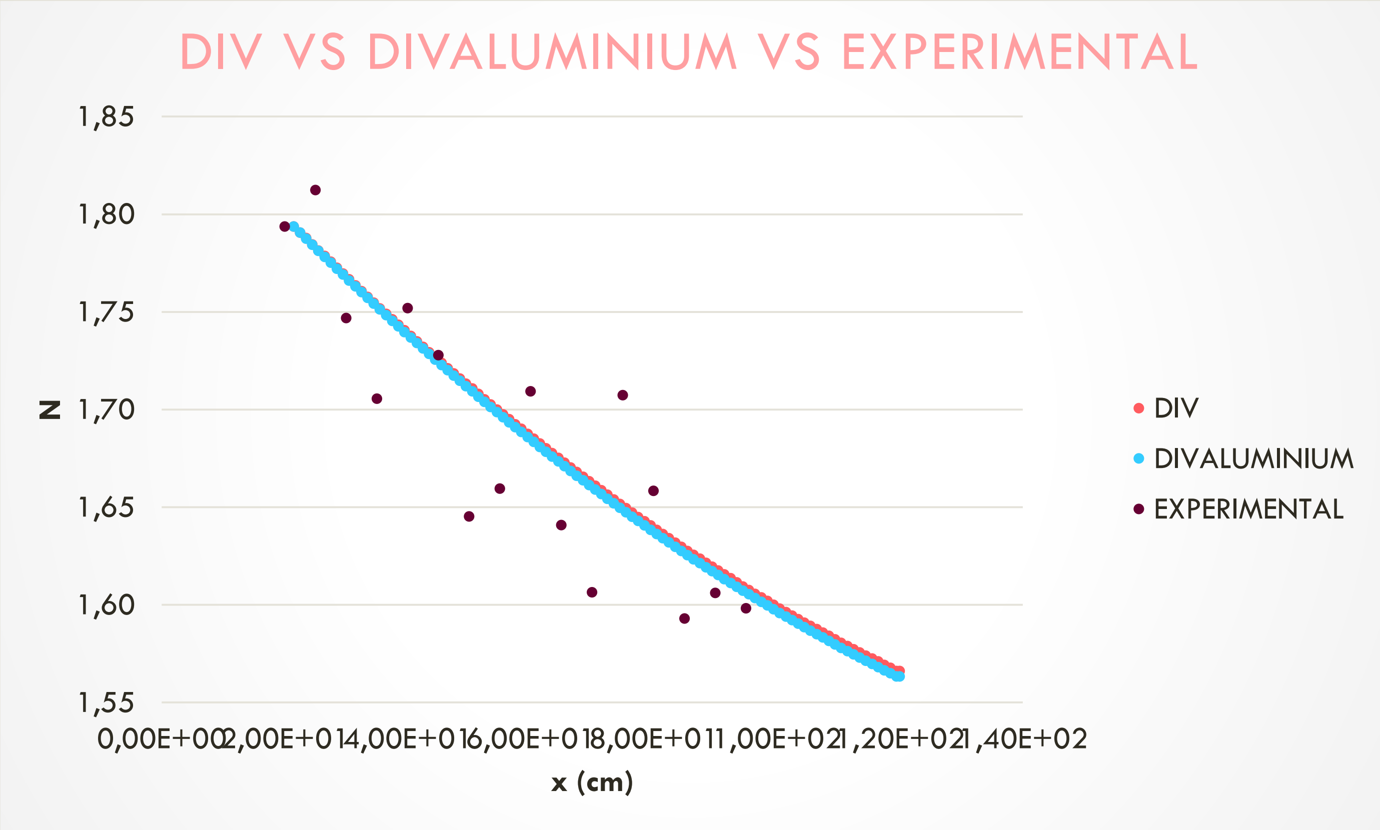

CONCLUSION

THANK YOU.
QUESTIONS?