Fermilab Summer Internship 2004

Eric Benjamín Téllez Ugalde

Universidad Nacional Autónoma de México

UNAM

(National Autonomous University of Mexico)

I worked in the Scintillation Detector Development Technical Center in Lab 6 under the supervision of Dr. Anna Pla-Dalmau.

Introduction

I worked in two projects:

1. I worked with Mrs. Shannon Maza in the Chemistry Laboratory.

2. I worked with Dr. Victor Rykalin in the quality control of the extruded scintillator strips, in the extruder lab.

Project 1

Objective

To make samples of polystyrene with dopants in a little amount, to do several analyses.

Steps in the polymerization

1. Deinhibition of the styrene monomer.
   It is mixed with tert-butylcatechol.

2. Vacuum distillation to purify styrene monomer.

3. Preparation of fourteen test tubes that have been treated chemically.

4. Addition of the measured dopants.

5. Addition of the distilled styrene.

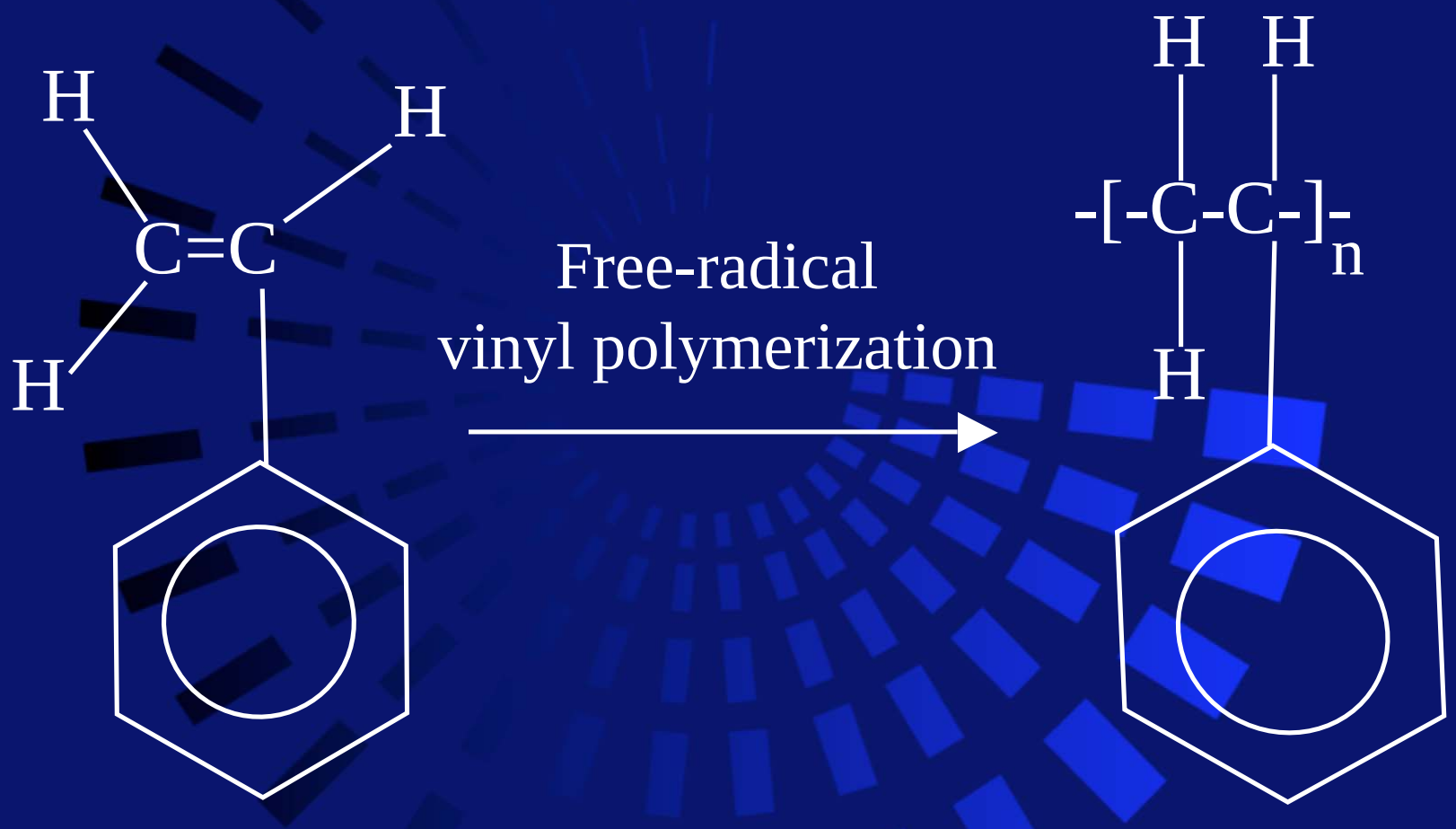
6. The test tubes with the dopants and the styrene are put under vacuum in a carousel and put through a freeze-pump-thaw cycle.

7. The carousel holding the test tubes is put into a hot oil bath, and then put through a thermal cycle which can last from 2 to 5 days.

Carousel

Oil Bath

Polymerization process



Styrene

Polystyrene

8. The test tubes are quenched in liquid nitrogen, put it into a plastic bag and then smashed on the floor.

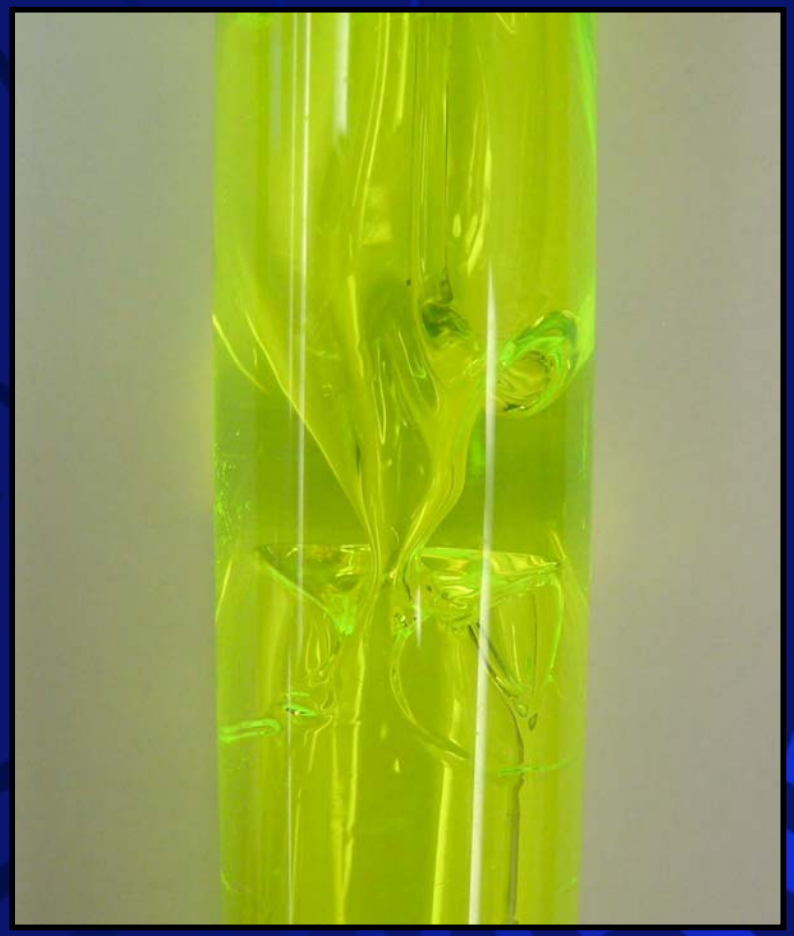
9. If the pieces of plastic do not have bubbles, we can cut it and then analyze it.

Results

We did this process two times.

1. The first time, the plastic had bubbles, then we cannot work on it.

2. The second time, the plastic do not have bubbles. We could work on it.



Not a good sample

Good samples

1.0% PT + 0.01% K27

1.0% PT + 0.01% Bis-MSB

1.0% 3HF + 0.01% R300

1.0% PT + 0.25% 3HF

1.0% PT + 0.02% BBQ + 0.01% O240

1.0% PPQ + 0.01% POPOP

1.0% PT + 0.02% Bis-MSB + 0.01% Y083

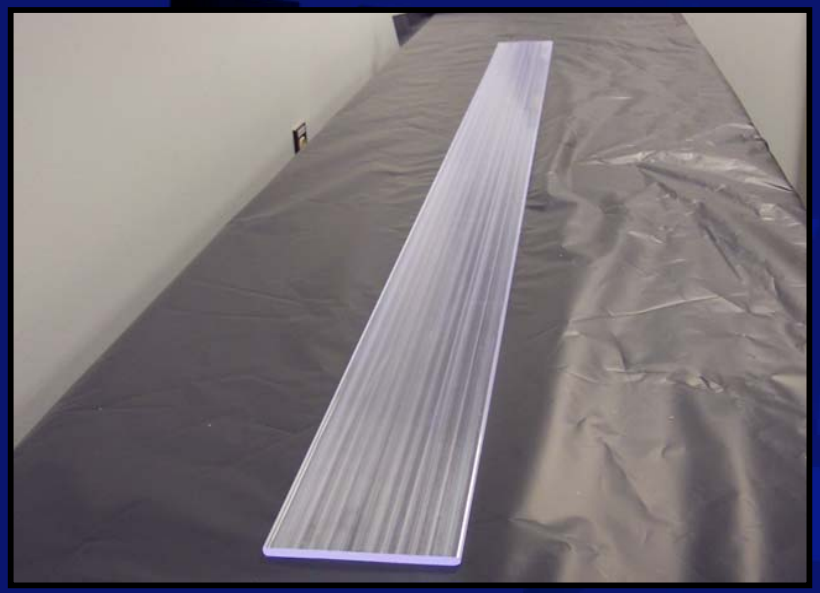
Project 2

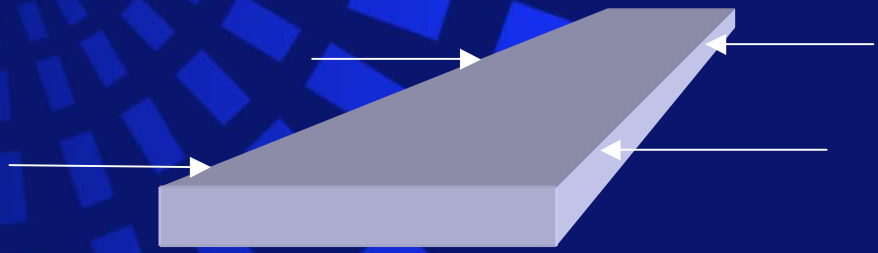
Objective

- Measure the mechanical properties of the polystyrene strips.
- Measure the attenuation of the light inside the strips.

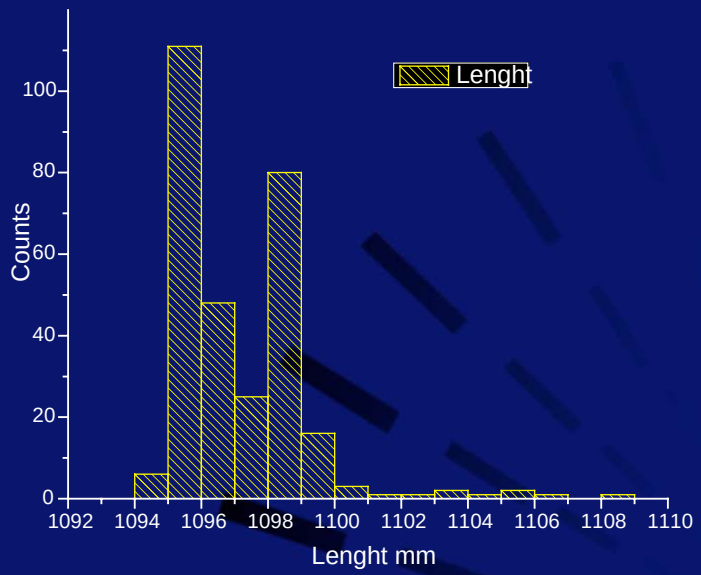
Mechanical measurements

- It measured length, width, and thickness of the scintillators strips.

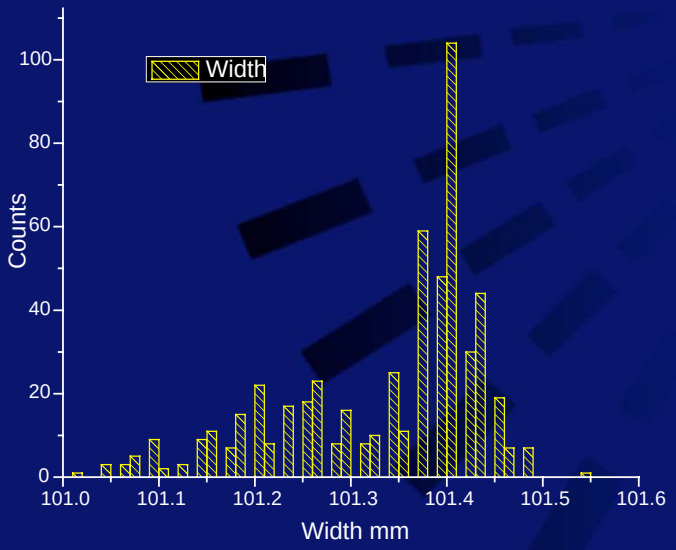




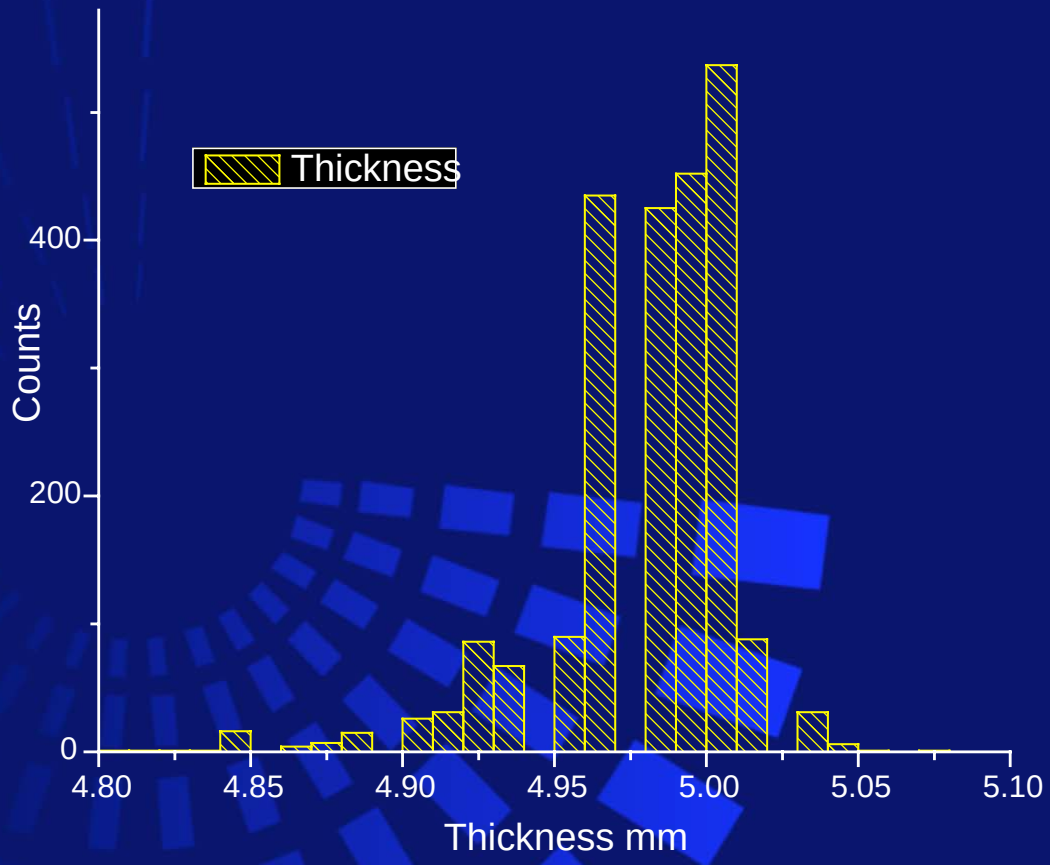
Mechanical tolerances



Length 1097±3 mm



Width101.40±0.04 mm



Thickness 5.00±0.03 mm

Light attenuation

A name given to phenomena of reduction of intensity according to the law

$$\frac{dI}{dt} = -kI \qquad (1)$$

resulting in an exponential decay

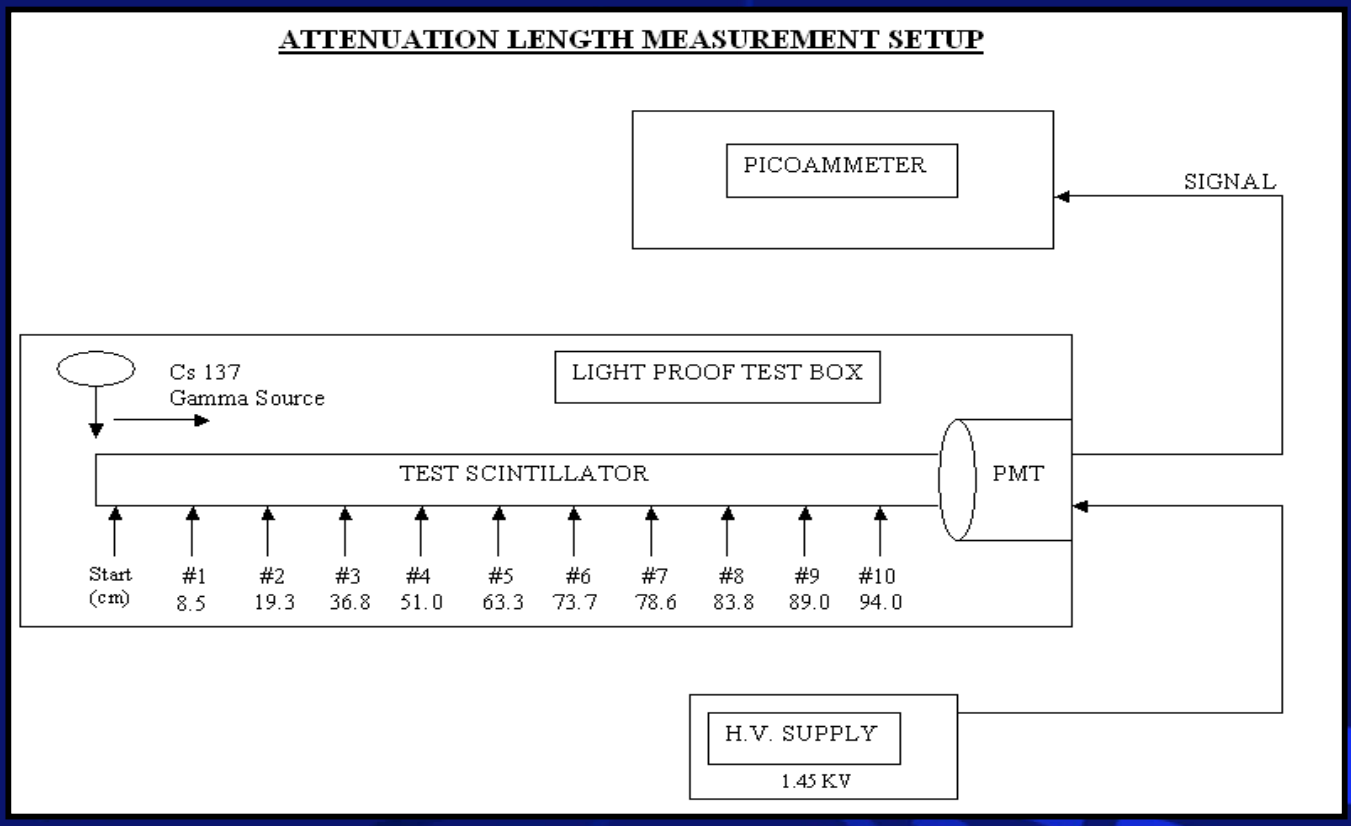
$$I = I_0 e^{-kt} \quad \Rightarrow \quad I = I_0 e^{-\frac{t}{\tau}} \qquad (2)$$

or

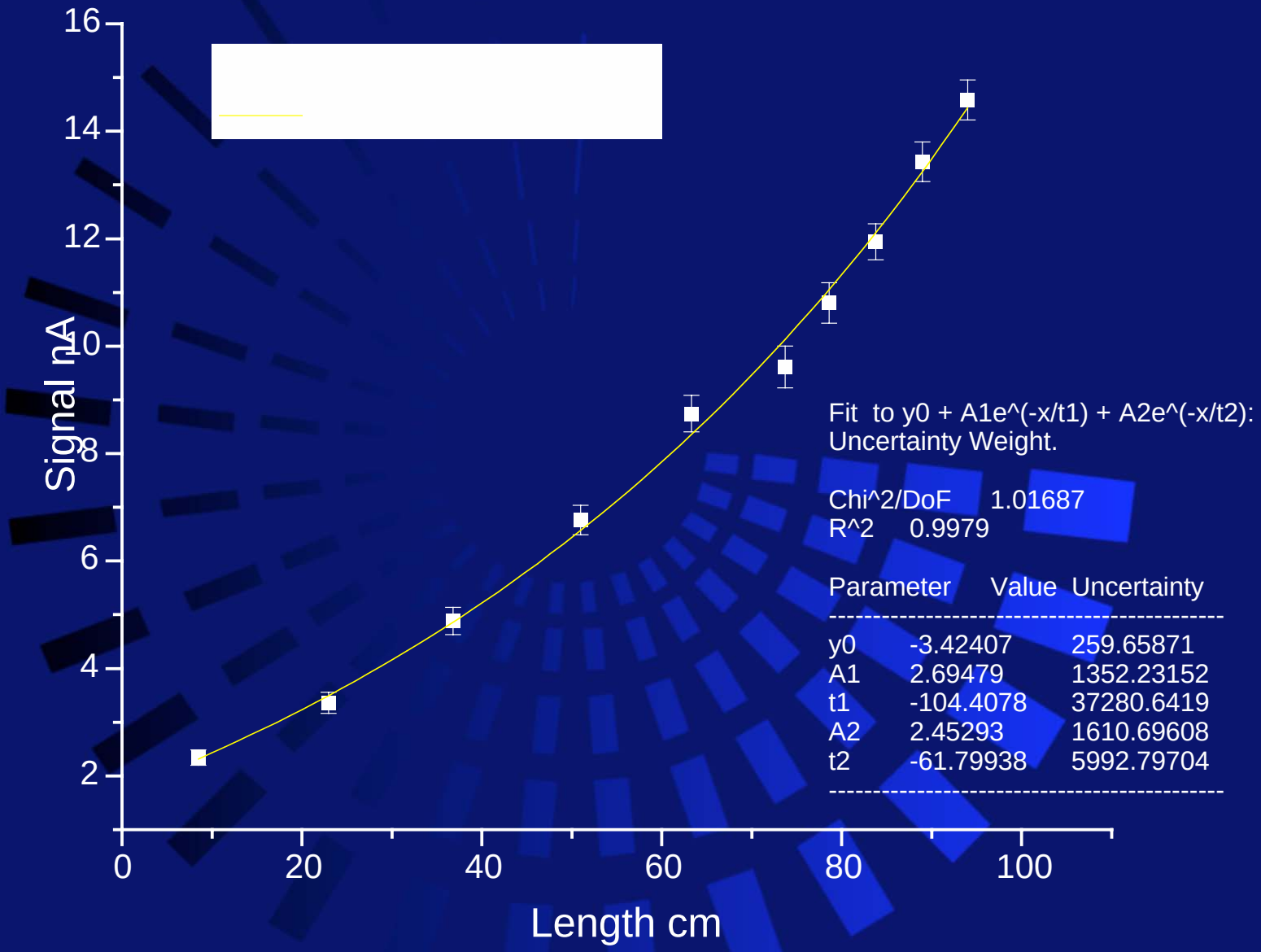
$$I = I_0 \left(e^{-\frac{t}{\tau_1}} + e^{-\frac{t}{\tau_2}} \right) \qquad (3)$$

The *attenuation length* is given by the length over which the intensity is reduced by a factor *e*.

ATTENUATION LENGTH MEASUREMENT SETUP



Results


Signal nA
Length cm
0
20
40
60
80
100
2
4
6
8
10
12
14
16
Fit to y0 + A1e^(-x/t1) + A2e^(-x/t2):
Uncertainty Weight.
Chi^2/DoF 1.01687
R^2 0.9979
Parameter Value Uncertainty
y0 -3.42407 259.65871
A1 2.69479 1352.23152
t1 -104.4078 37280.6419
A2 2.45293 1610.69608
t2 -61.79938 5992.79704

Summary

I learned:

- About plastic scintillation detectors.
- The procedure to produce plastic scintillator samples.
- The necessary tests to verify the quality of the extruded scintillator strips produced in the FNAL/NICADD extrusion line.

Acknowledgements

- Dr. Anna Pla-Dalmau
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