RADIATION HARDNESS OF PLASTIC SCINTILLATING MATERIALS FOR SCINTILLATOR CALORIMETERS

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LABORATÓRIO DE INSTRUMENTAÇÃO E FÍSICA EXPERIMENTAL DE PARTÍCULAS

IDPASC

TÉCNICO LISBOA

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MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

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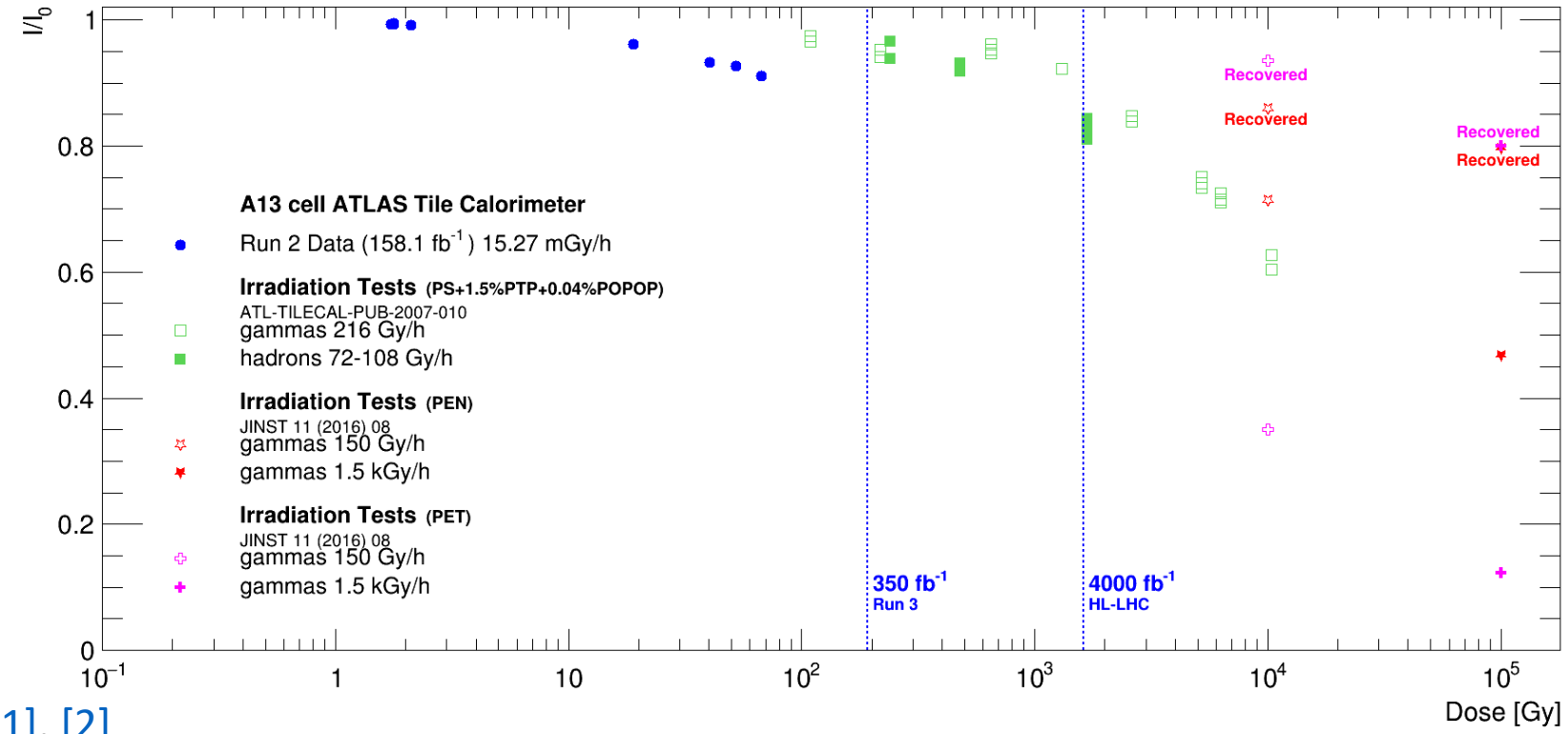
WHY STUDY NEW PLASTIC SCINTILLATORS?

- Plastic scintillators are widely used in nuclear and particle physics for particle detection;
- Their applications are wide-ranging - industry, health care, large detectors, and others;
- Plastic scintillators have low cost/weight and are malleable.

GOAL:

- Characterization of new plastic scintillators;
- Radiation Hardness of Scintillator Plastics (Calorimeters/New Scintillators).

INTRODUCTION MY WORK



[1], [2]

PEN (Polyethylene Naphthalate) and PET (Polyethylene Terephthalate)

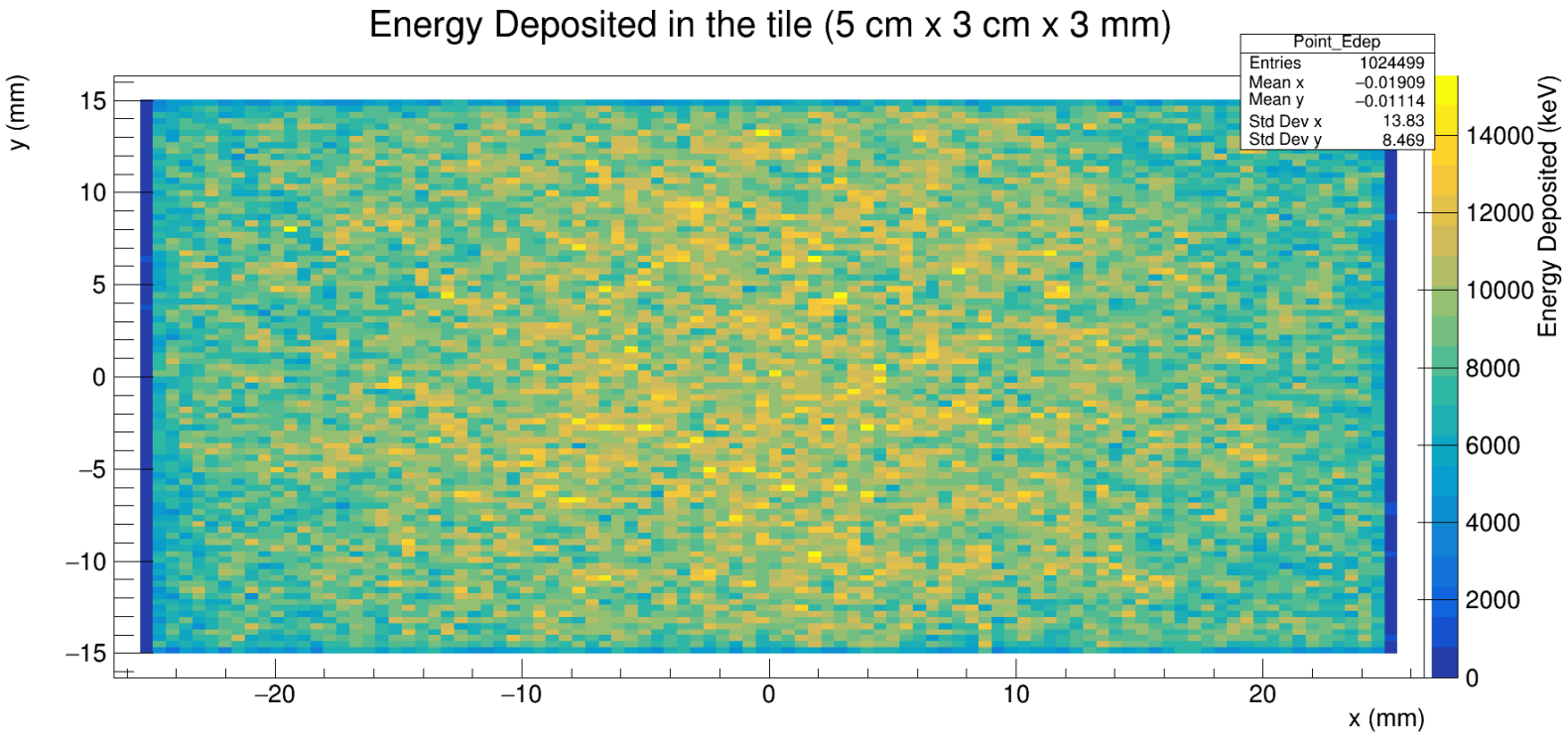
- Doses closer to reality (comparability);
- New materials ⟶ new detectors;

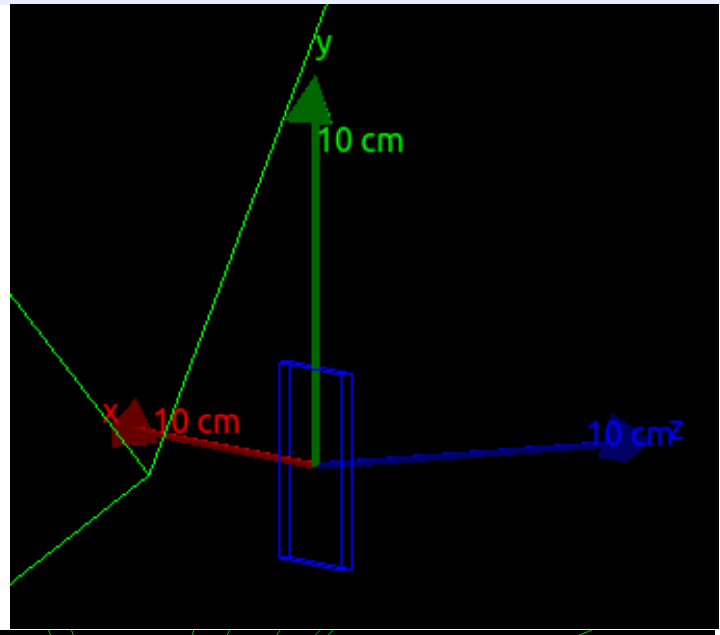
Two points have been worked on:

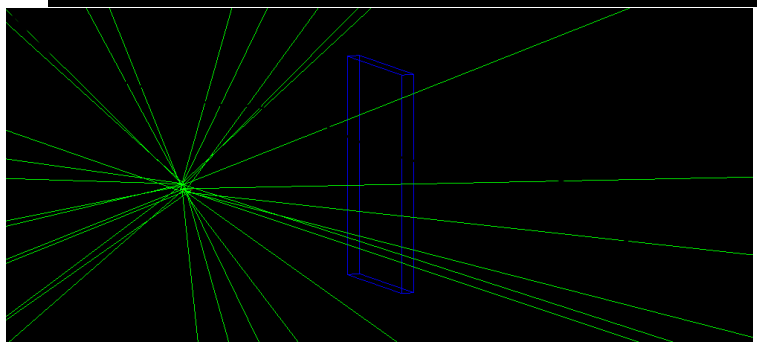
- Irradiation Planning;
- Characterization of new scintillator plastics.

IRRADIATION PLANNING

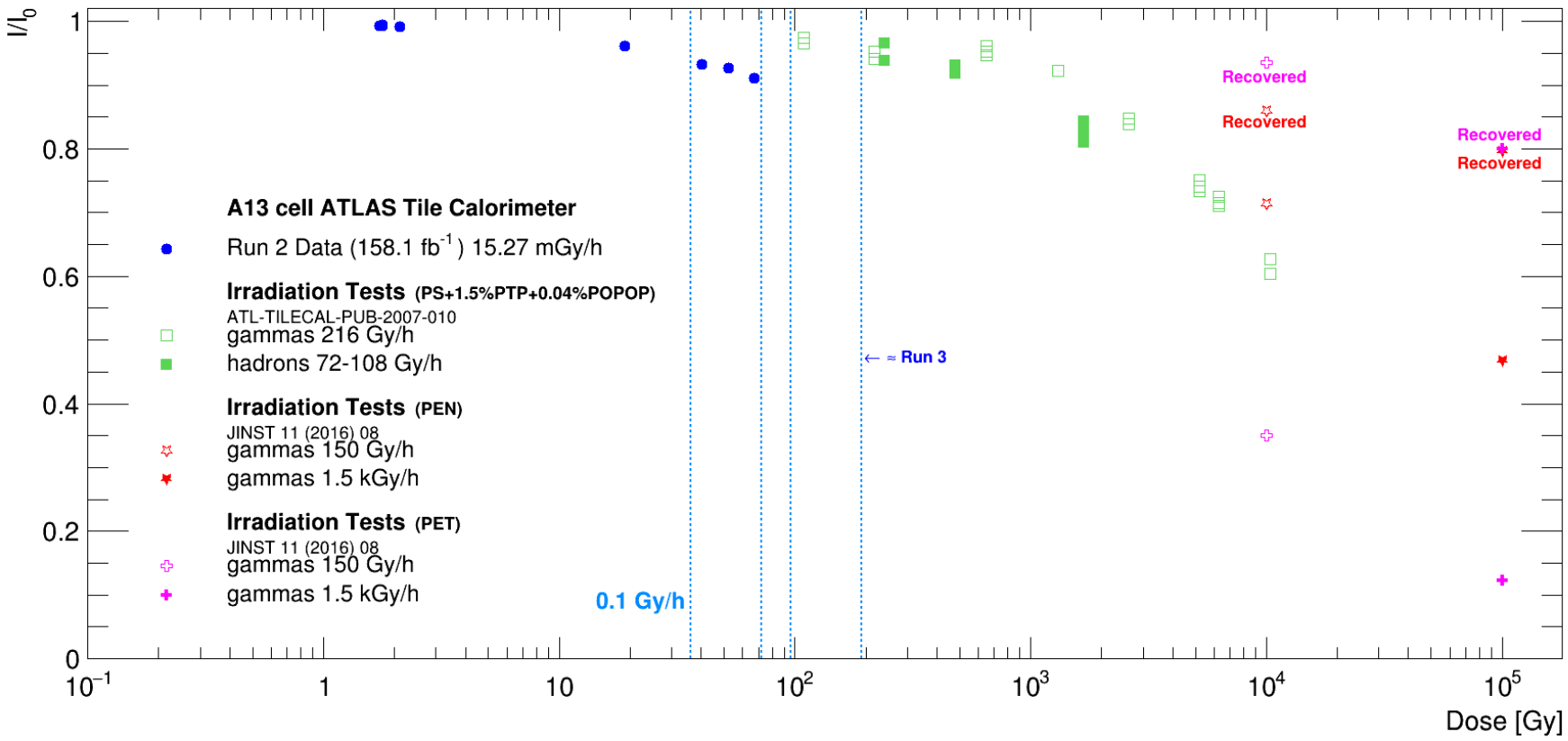
- Simulation in Geant4;
- Data from TileCal Run 2;
- Articles on irradiation tests on scintillator plastics.





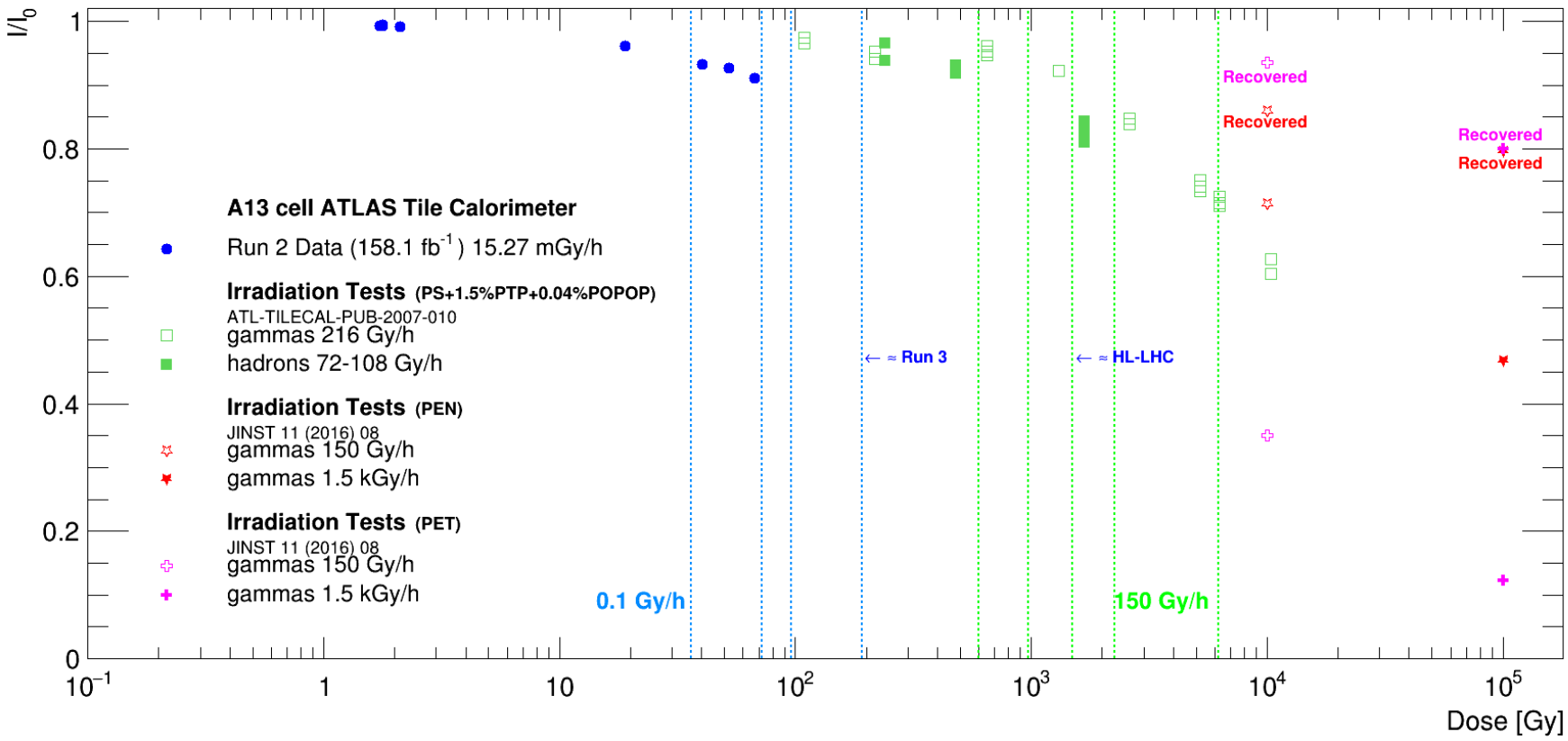


IRRADIATION PLANNING



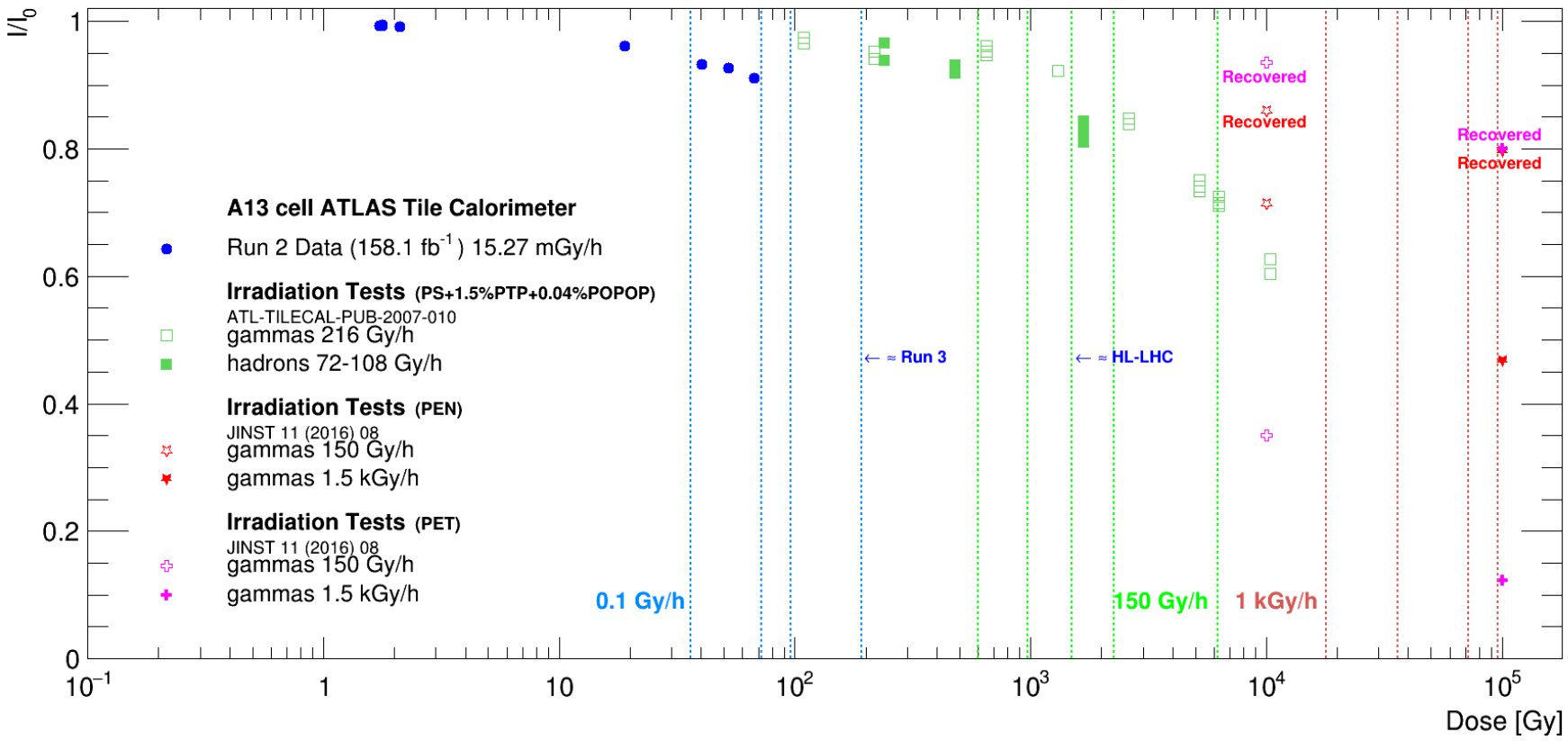
Make Comparison

IRRADIATION PLANNING



Make Comparison

IRRADIATION PLANNING



Irradiations Closer to Real Conditions

IRRADIATION PLANNING

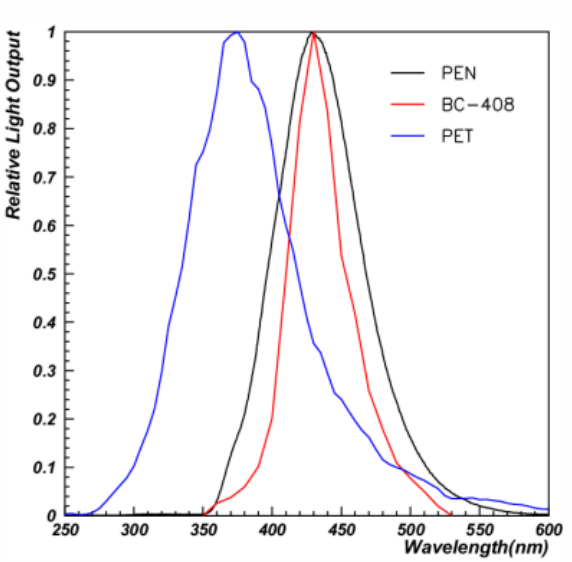
IRRADIATION PLANNING			
Dose Rate	***Distance source***	***Dose (Gy)***	***Irradiation Time***
0.1 Gy/h	15.1 m	36	15 days
		72	30 days
		96	45 days
		192 (~ Run 3)	80 days
150 Gy/h	39 cm	600	4 h
		975	6.5 h
		1500 (~ HL-LHC)	10 h
		2250	20 h
		6200	1 day 16 h
1 kGy/h	15 cm	18000	18 h
		36000	1 day 12 h
		72000	3 days
		96000	4 days

- **Dose rate near Run 2;**
- **Dose rate close to the Irradiation Tests for the Hadronic Calorimeter;**
- **Dose rate near PEN and PET Irradiation Tests.**

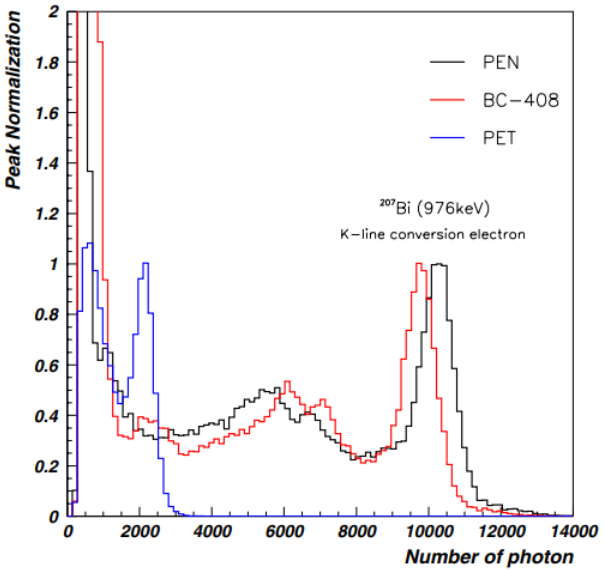
PEN AND PET CHARACTERISTICS

- PEN is a good option for new scintillators [3];
  - * Competitive light yield;
  - * Emits light ≅ in the same λ as other commercial scintillators;
- PET has a good recovery [4].
- PET/PEN good hardness radiation;

Emission spectrum

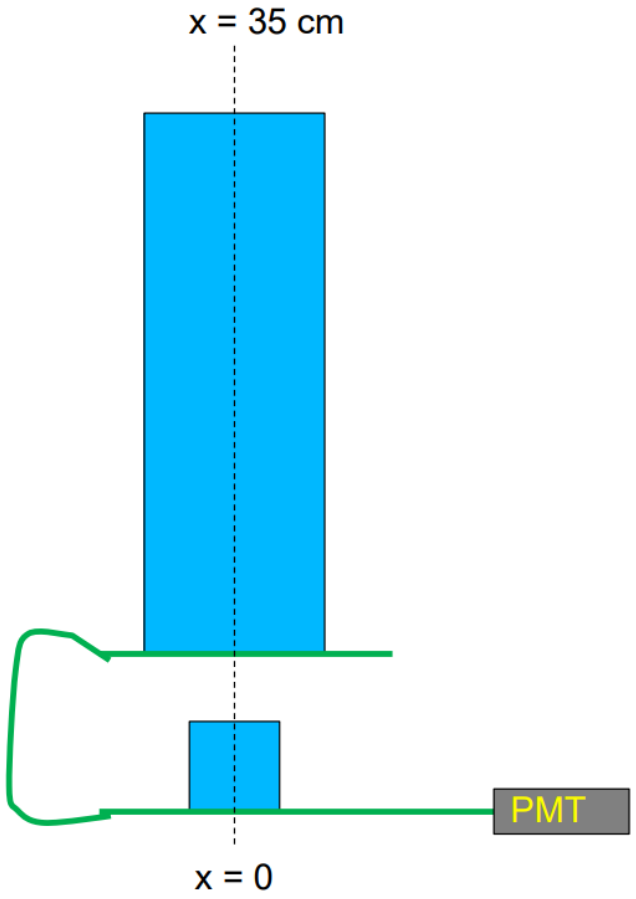


Light output spectra

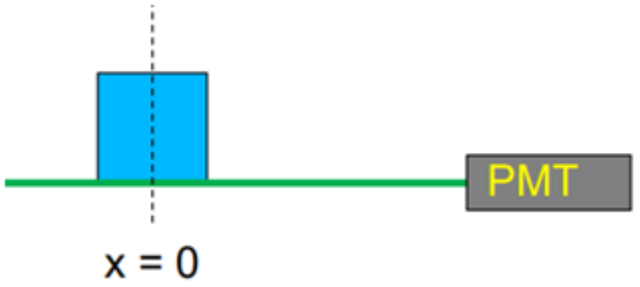


SAMPLE MEASUREMENT PROCEDURE

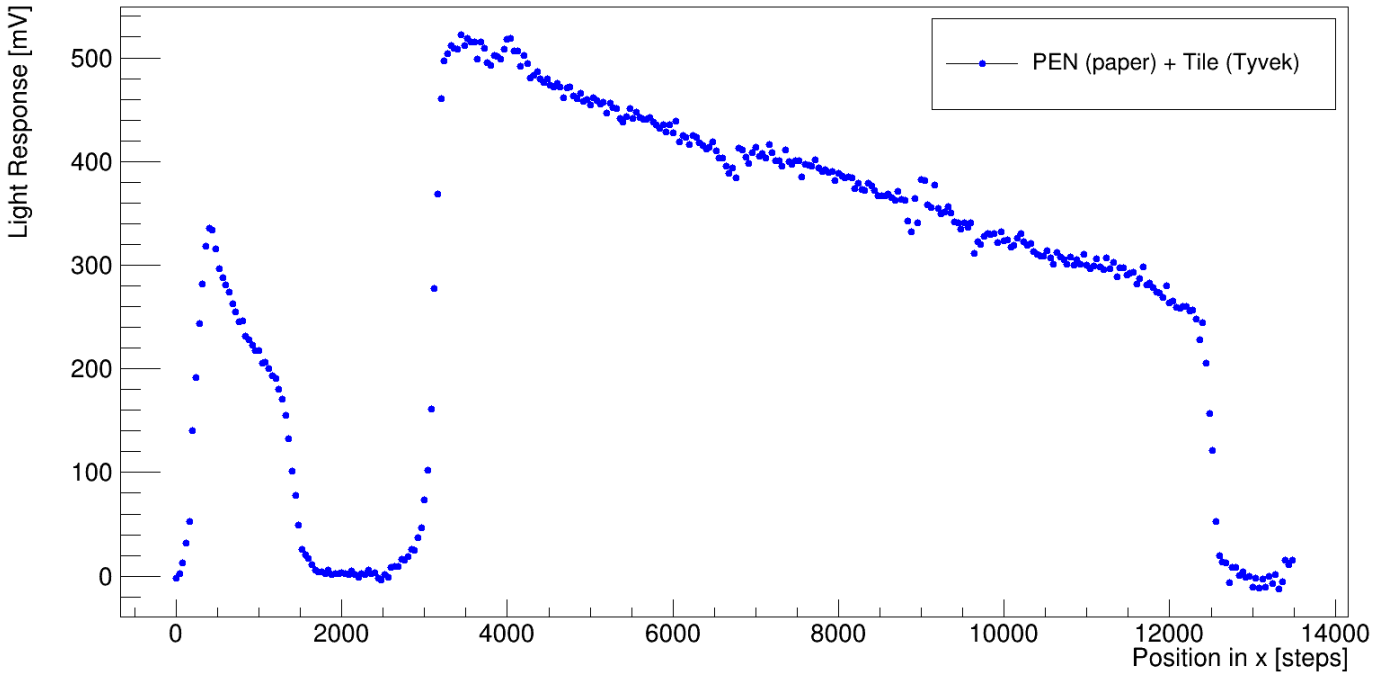
Setup A: SAMPLE (PEN OR PET) + TILE



Setup B: ONLY SAMPLE (PEN OR PET)

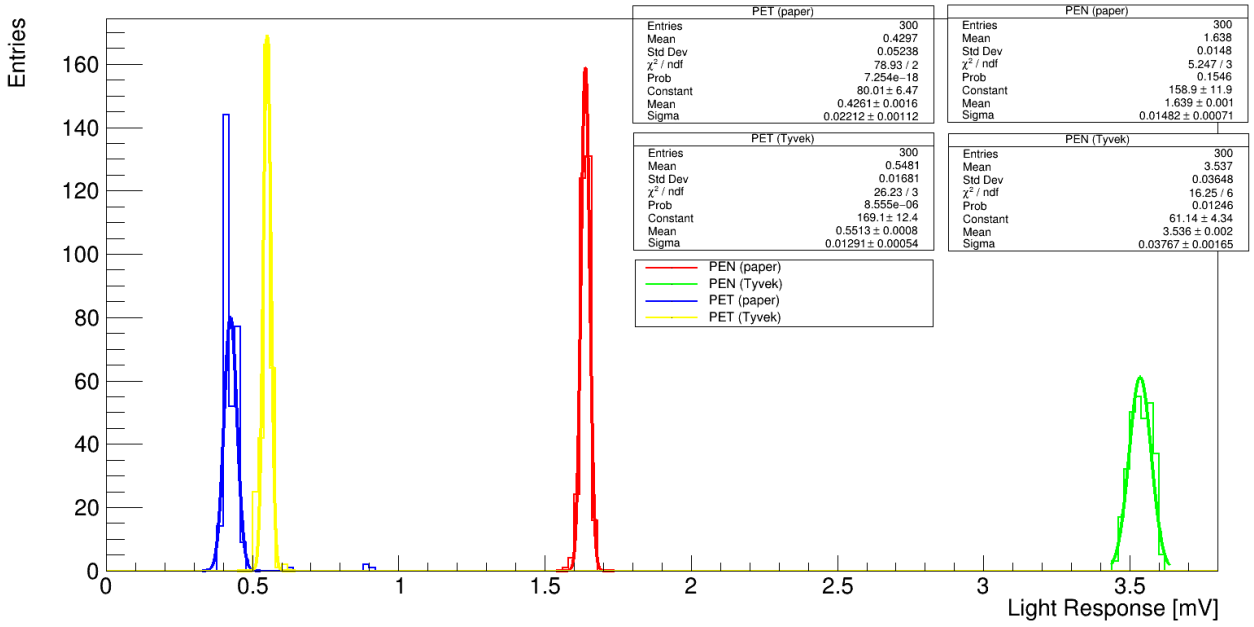


RESPONSE LUMINOSITY OF SAMPLE PEN AND TILE



- The PEN sample shows a light response;
- Difficult to compare the light response of the PEN sample with the Tile (dimensions, fiber coupling, thickness).

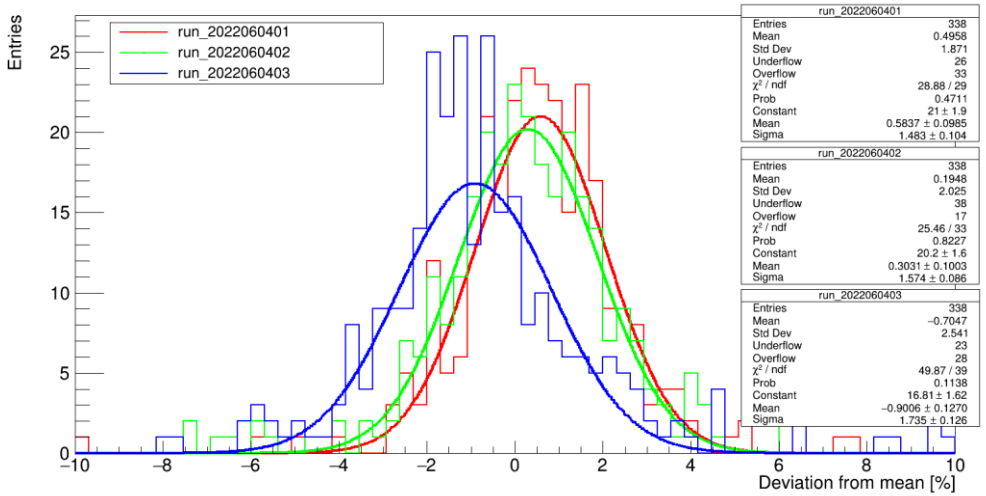
COMPARISON OF THE LIGHT RESPONSE OF PEN AND PET SAMPLES WITH AND WITHOUT TYVEK



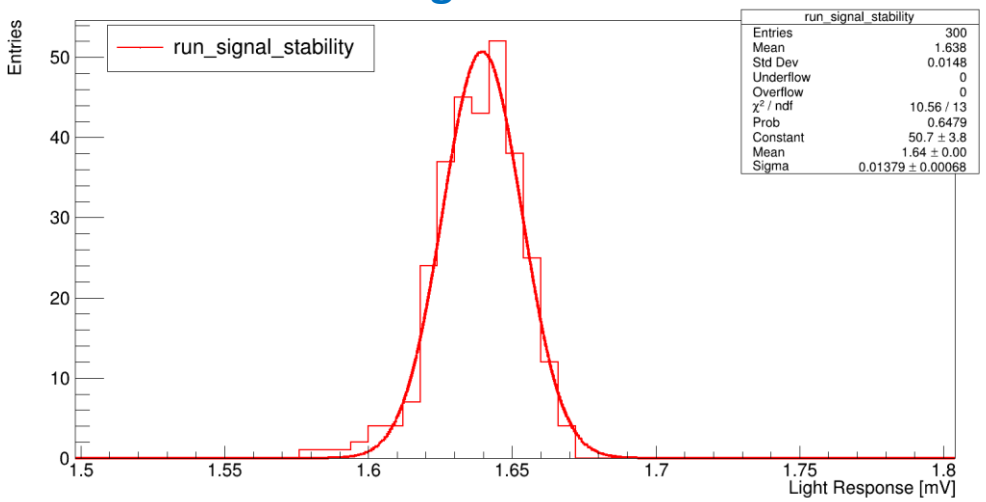
- For PEN, with Tyvek the light response is ~ 2x bigger;
- For PET, with Tyvek the light response is ~ 1.3x bigger.

MEASUREMENT UNCERTAINTY

System Geometric Reproducibility



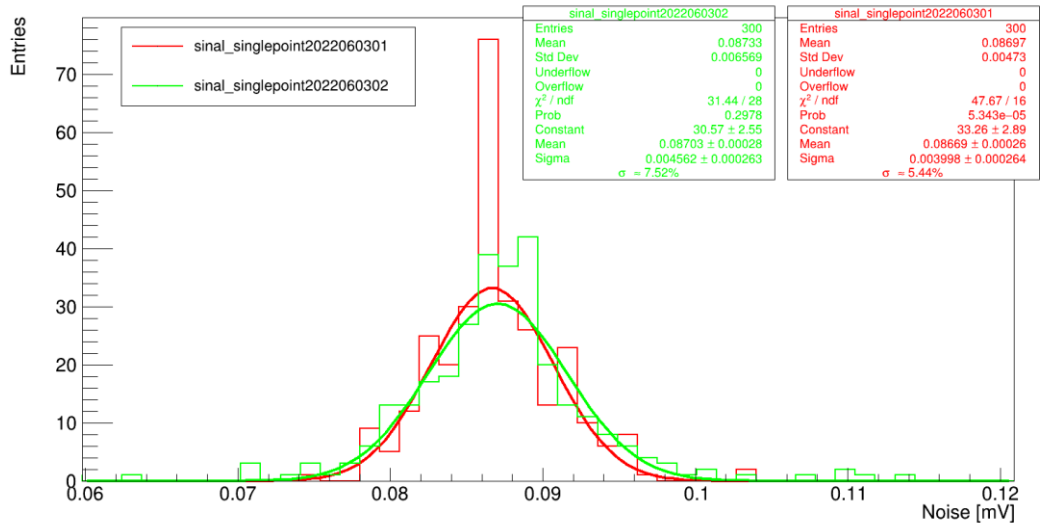
Signal



Uncertainty

- Noise: 0.04 mV (constant noise)
- Signal: 0.8 % (relative – depend signal)
- Geometric Reproducibility of the System: 1.7%
- Uncertainty = Noise + Signal + Geom. Reprod.

Noise



SUMMARY

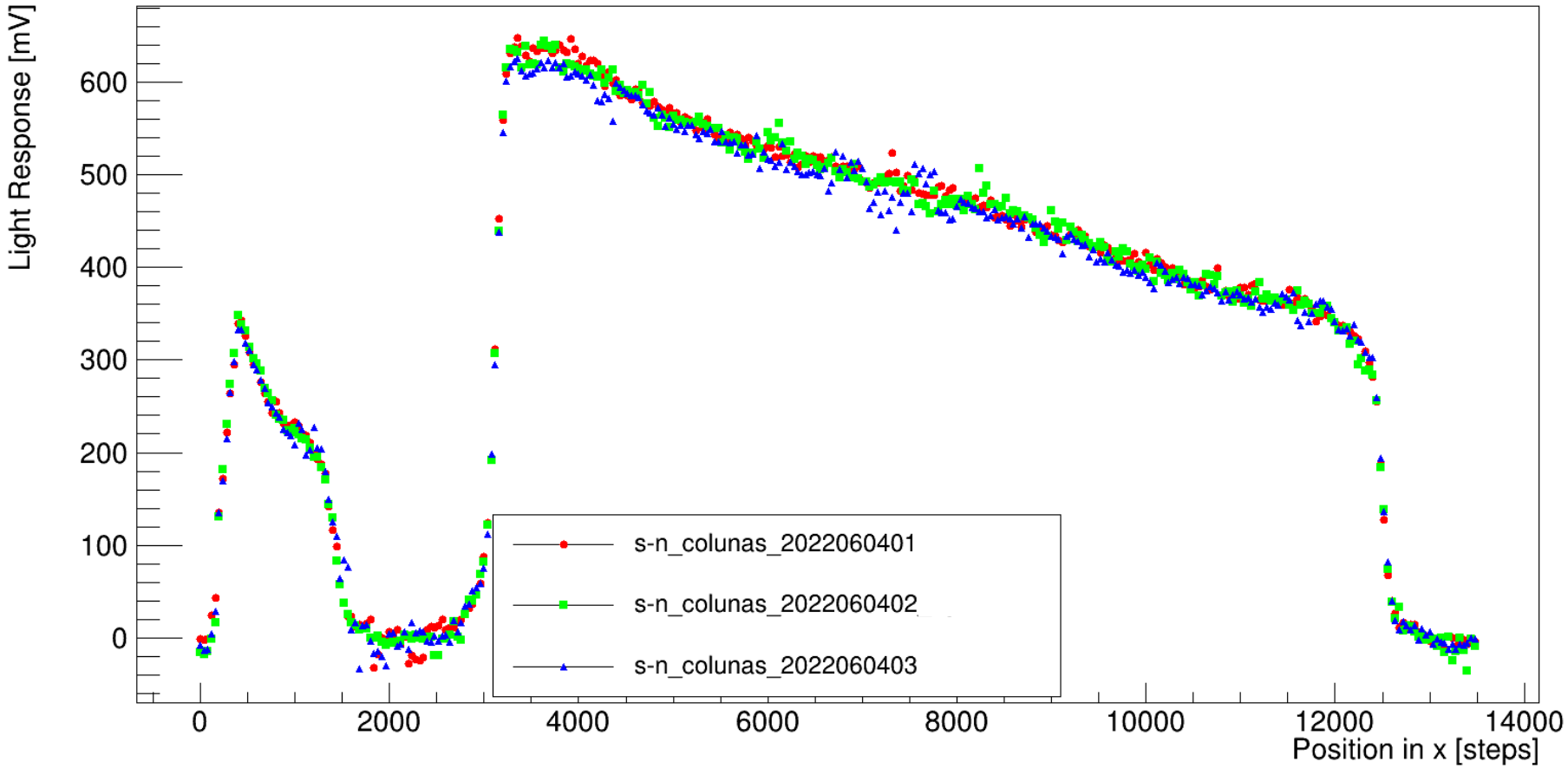
- Irradiation Planning;
- Characterization of new scintillator materials (PEN and PET);

- Preliminary Results
  * Light response of the PEN/PET indicates that our sample scintillates;
  * Difficulty in comparing the sample results with the reference Tile;

- The next steps
  * New simulation in Geant4 - establish Sample/Tile comparability parameters;
  * New measurements with larger and more transparent samples;
  * Irradiate samples (Location to be determined).

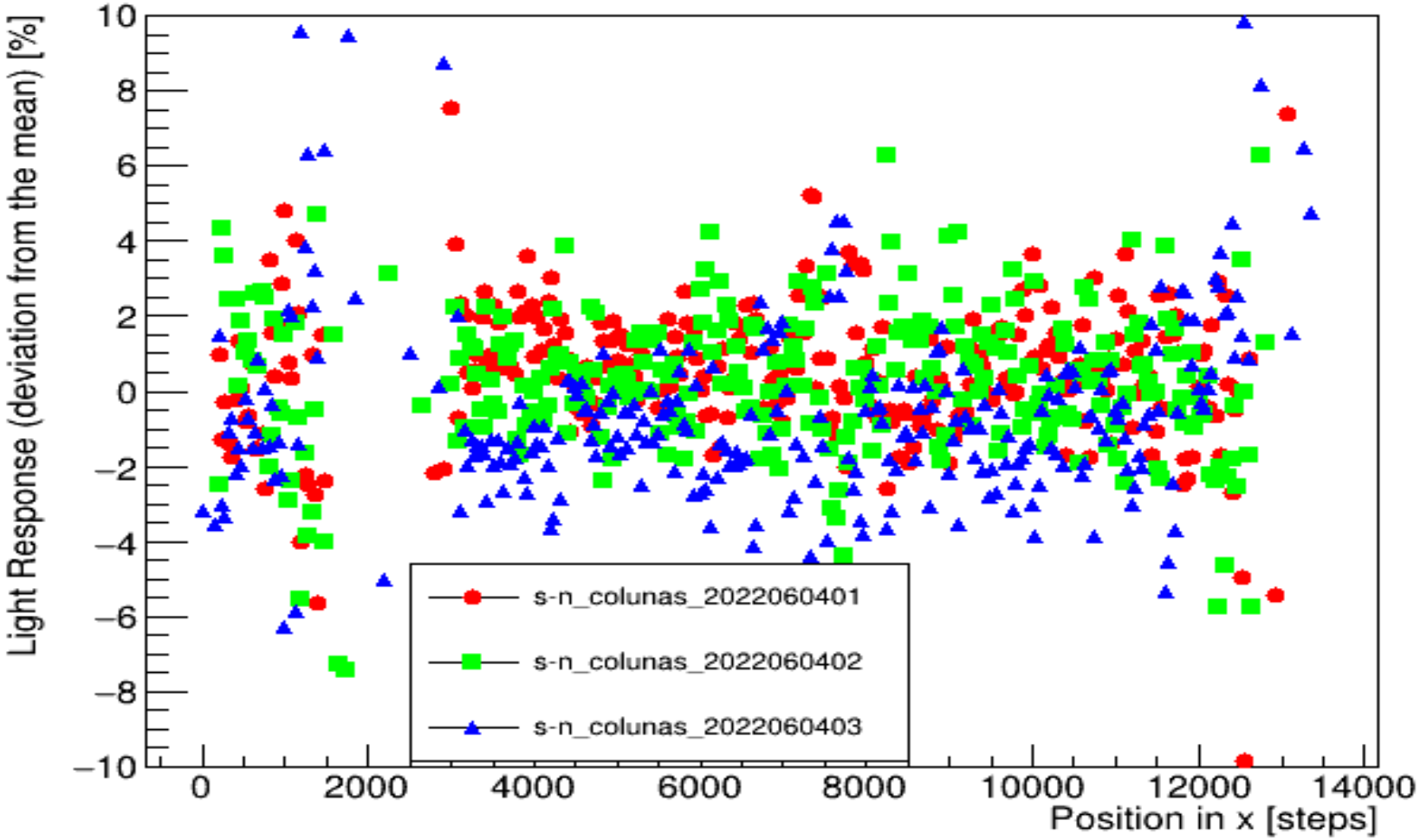
BACKUP

GEOMETRIC REPRODUCIBILITY OF THE SYSTEM

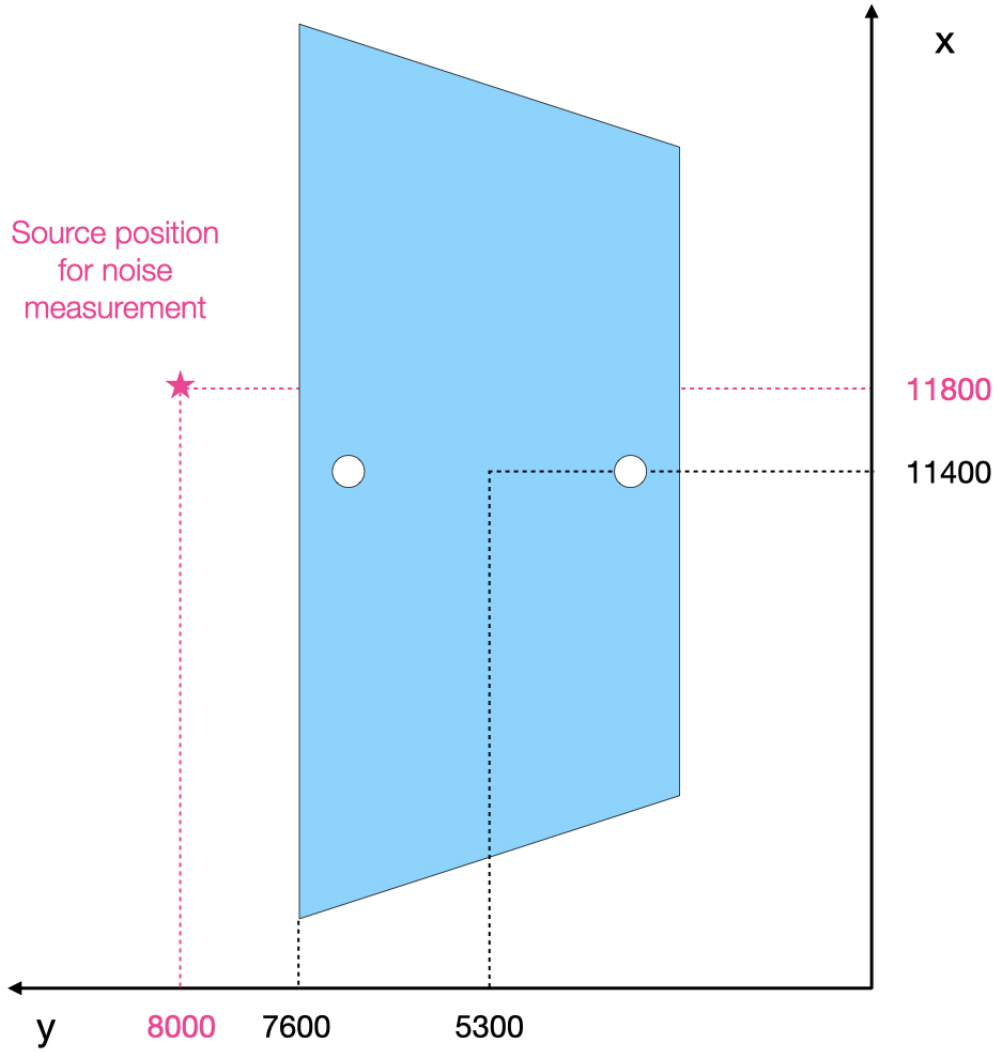


The acquisition system (fiber + sample + Tile + PMT).
The sample is wrapped in white paper and the Tile is wrapped in Tyvek.

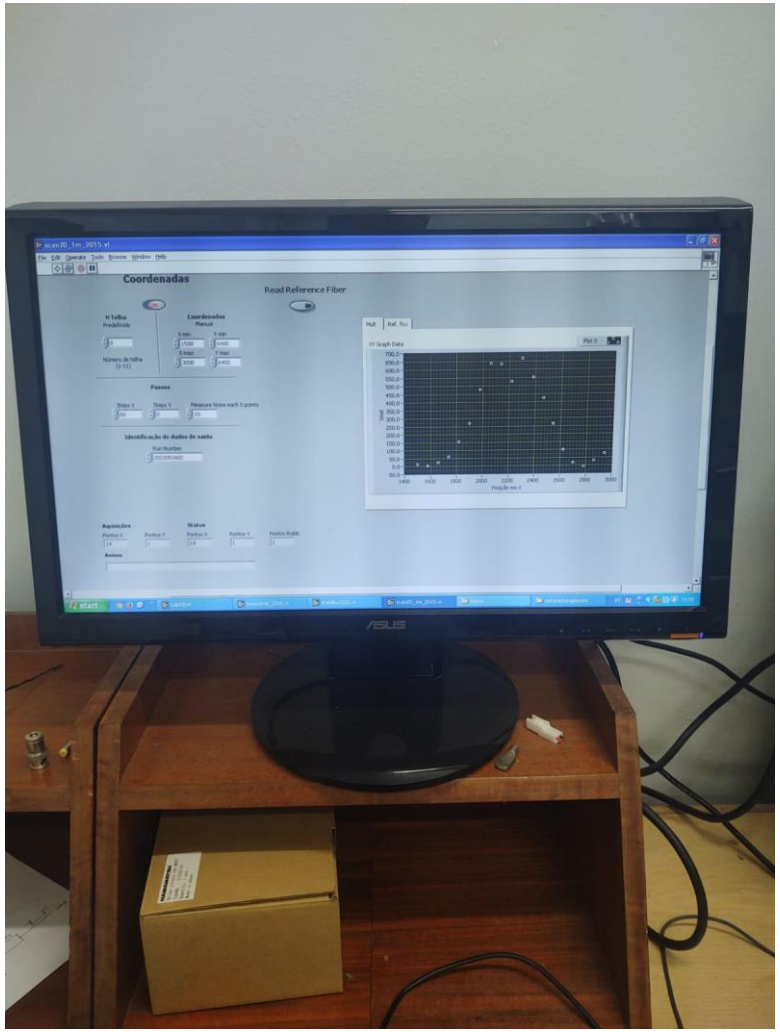
GEOMETRIC REPRODUCIBILITY OF THE SYSTEM

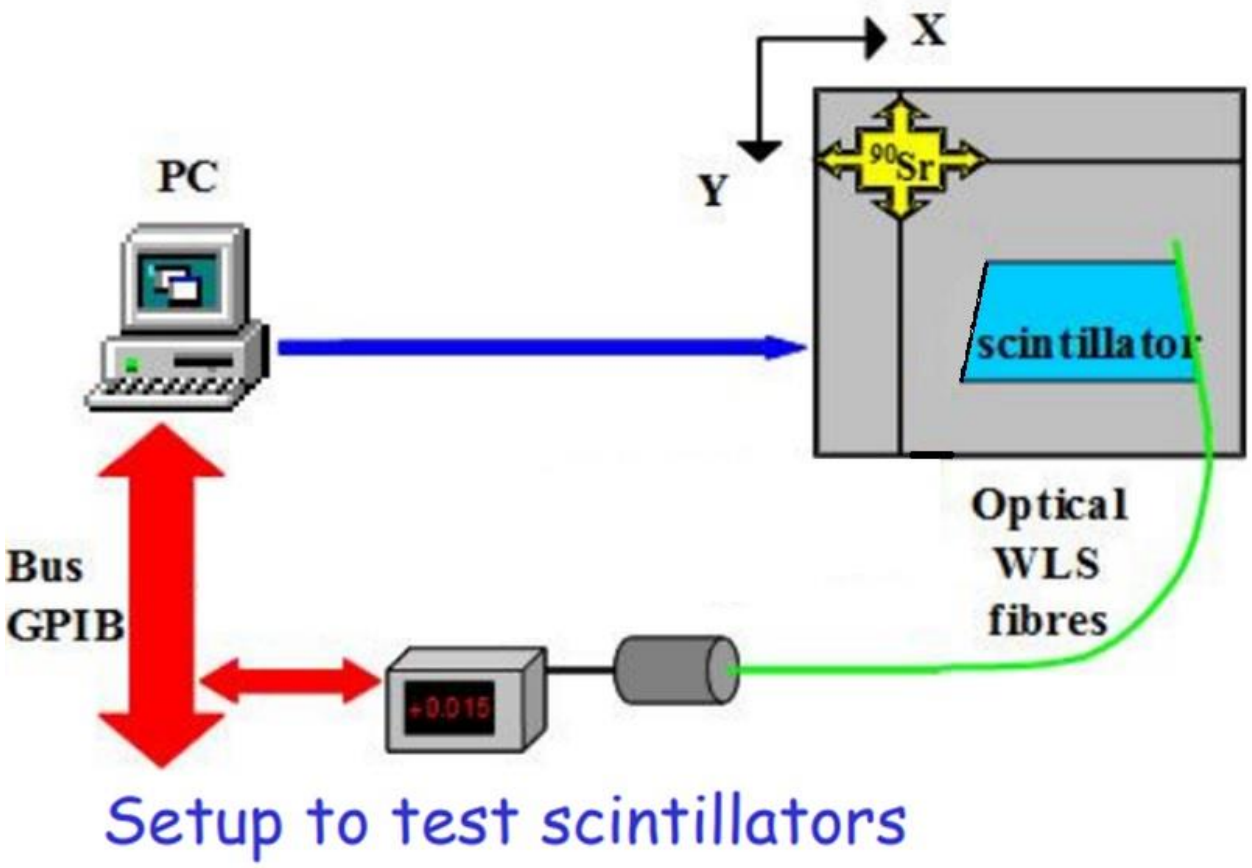


COORDINATES IN THE SCAN FOR NOISE ACQUISITION



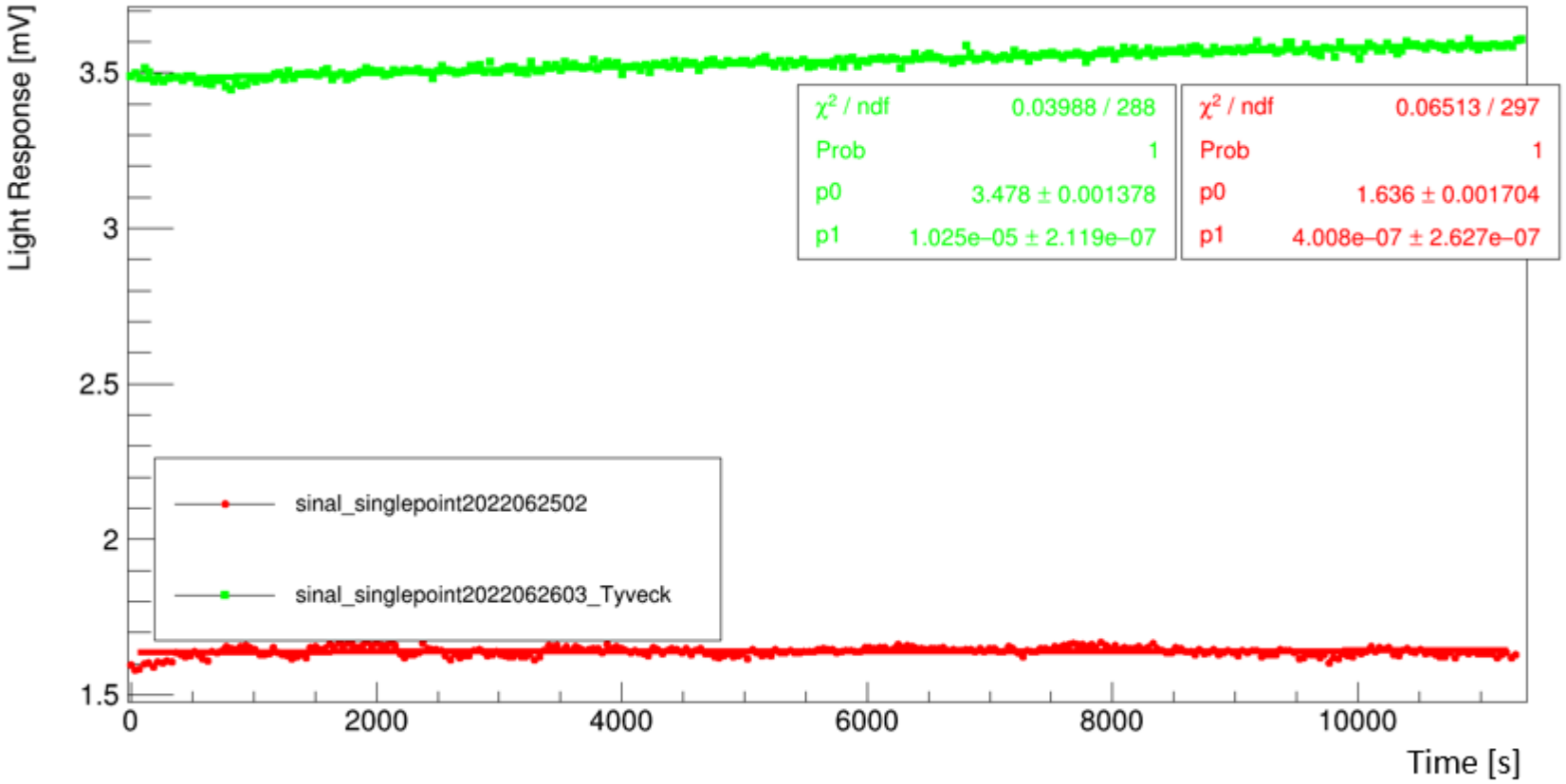
SETUP TILEMETER



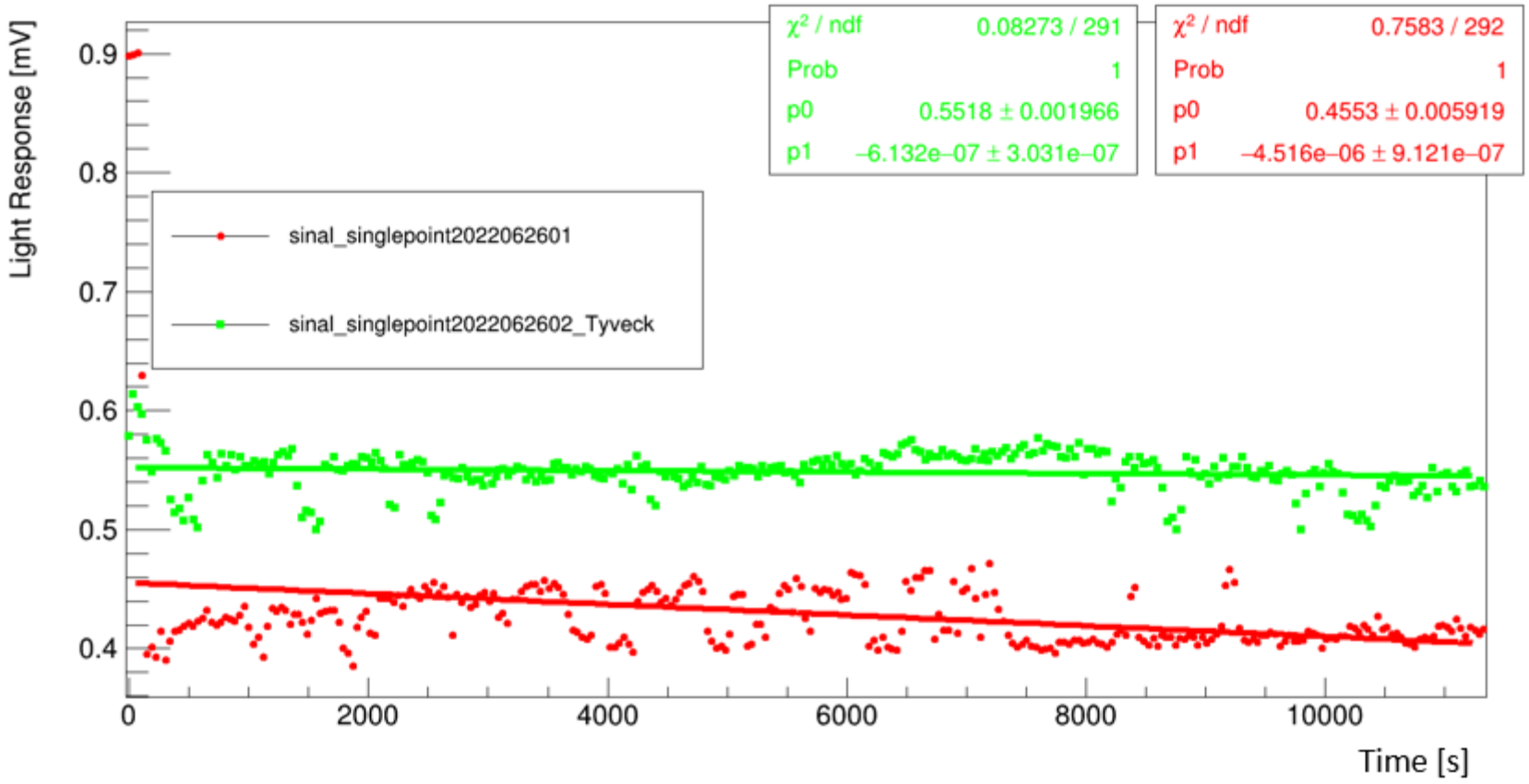


Setup to test scintillators

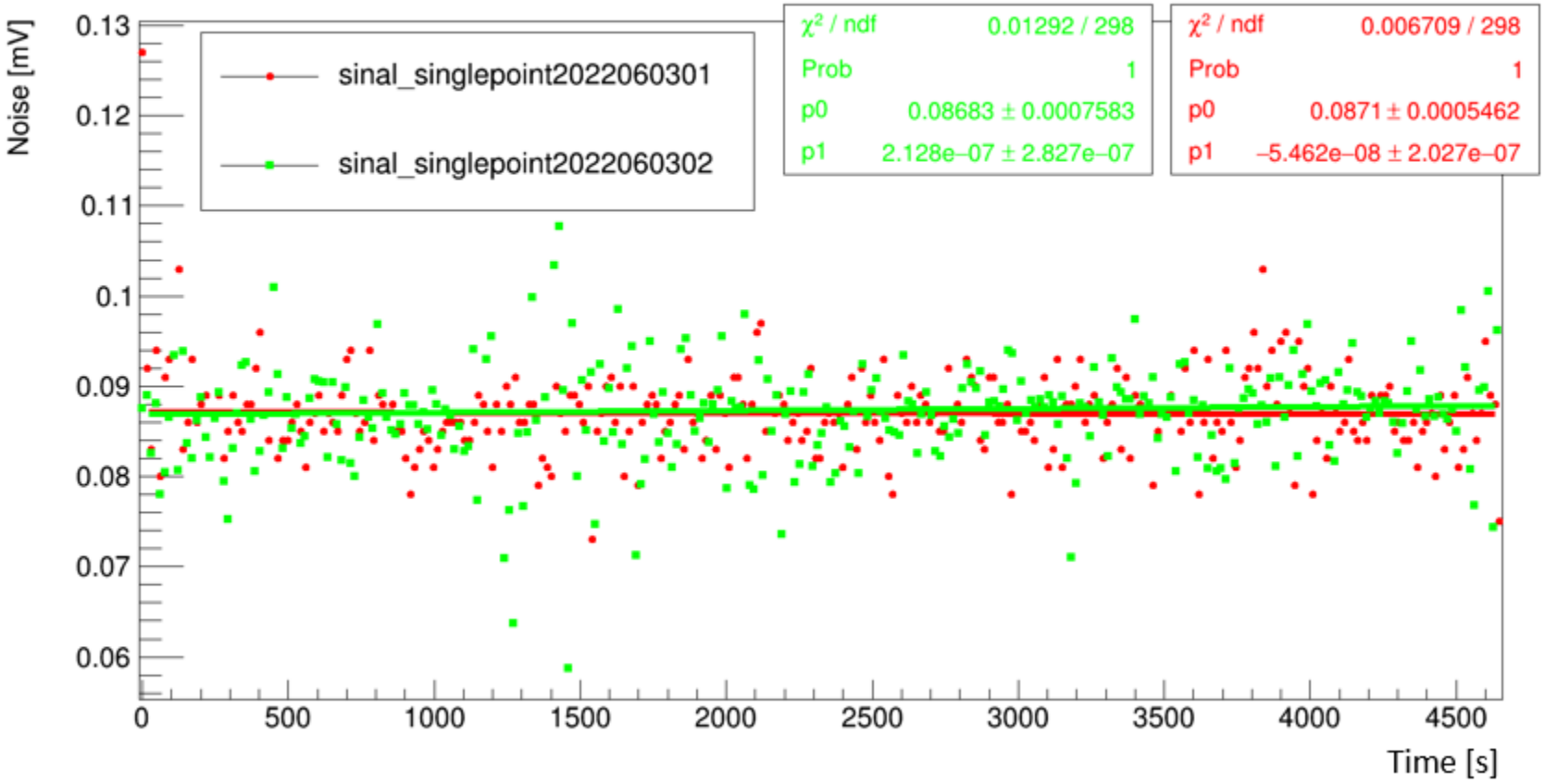
COMPARISON OF SIGNAL STABILITY BETWEEN PEN AND TYVECK-WRAPPED PEN SAMPLE



COMPARISON OF SIGNAL STABILITY BETWEEN PET AND TYVECK-WRAPPED PET SAMPLE



NOISE STABILITY



Comparison of the light response of PEN + Tile TileCal and PEN alone