Start Counter Developments

New Fast Timing Plastic Scintillators

28/11/2021 - Pavia - FOOT GM

TOPS: Time Of flight Plastic Scintillator

The R&D on fast timing plastic scintillators stared in early 2018 with the chemistry LEOS group of SBAI (L.Mattiello, D.Rocco). Liquid and solid samples have been tested and in the spread panorama of the new elements that we explored so far.. after more than 70 samples, 2 master students, and many many many hours wanting for cosmic rays.. we and up to some promising fluorophores.

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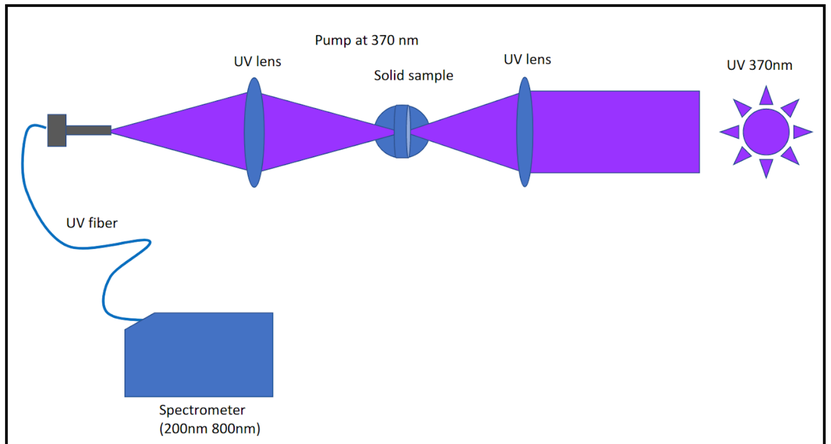
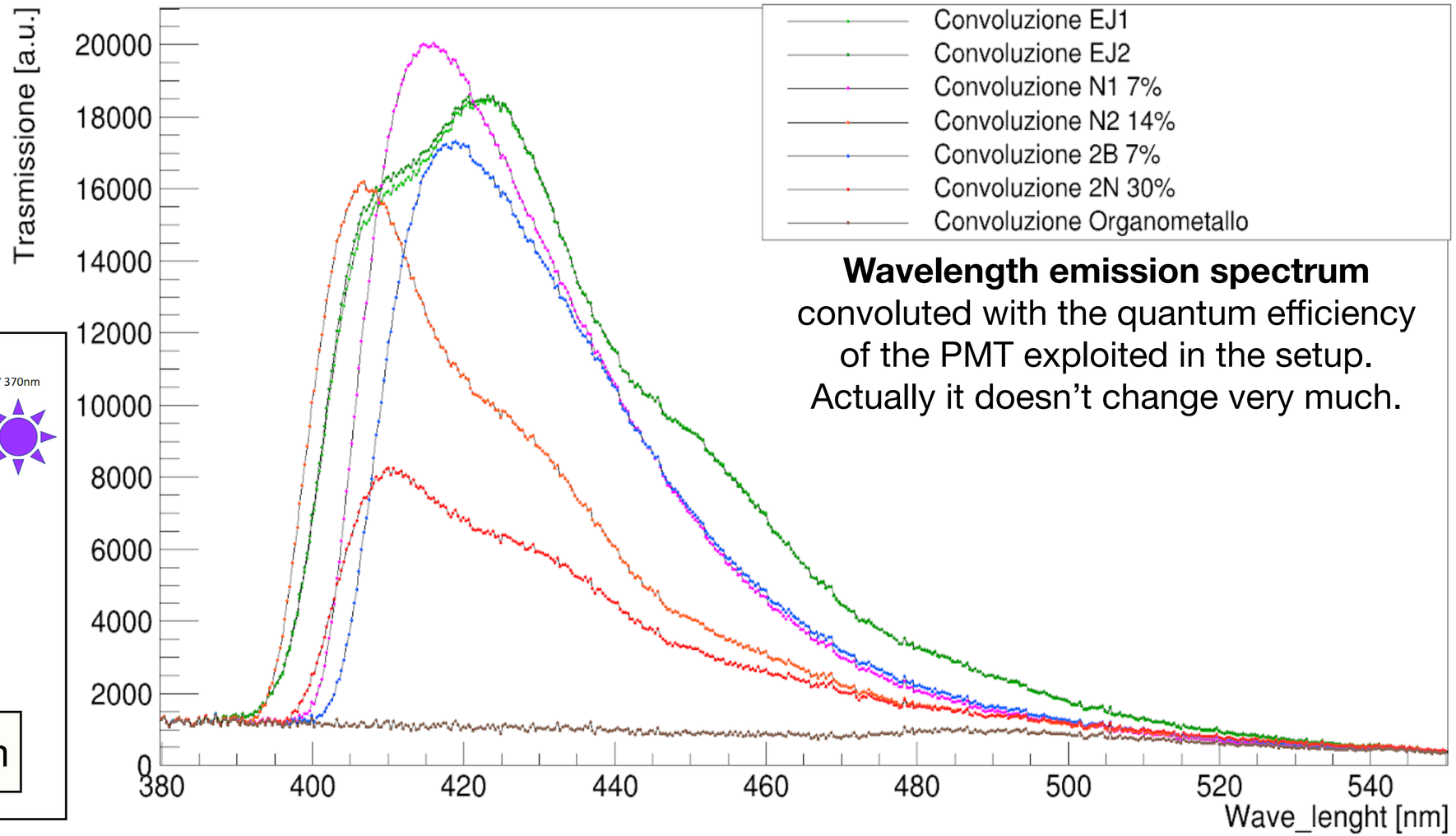


Wavelength emission spectrum



Wavelength emission spectrum convoluted with the quantum efficiency of the PMT exploited in the setup. Actually it doesn't change very much.

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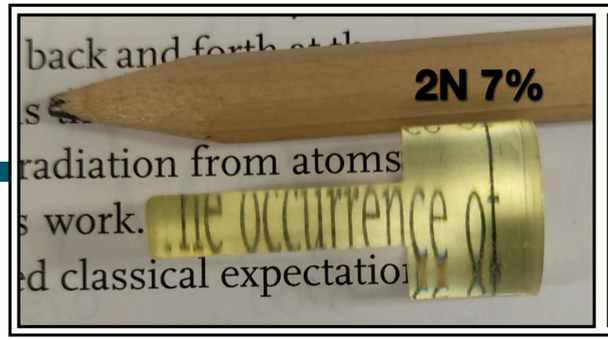
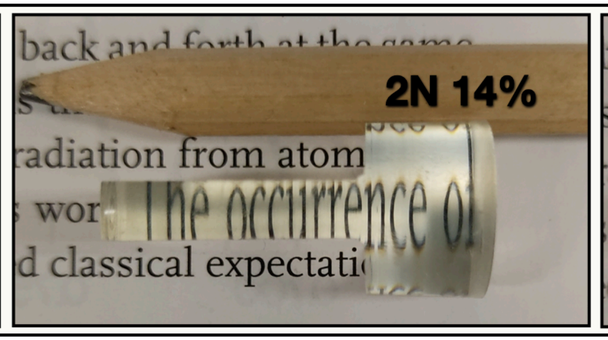
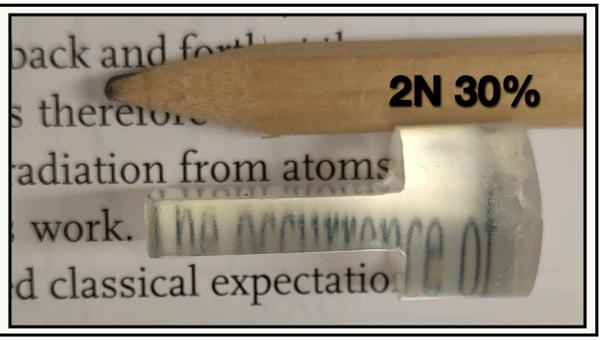
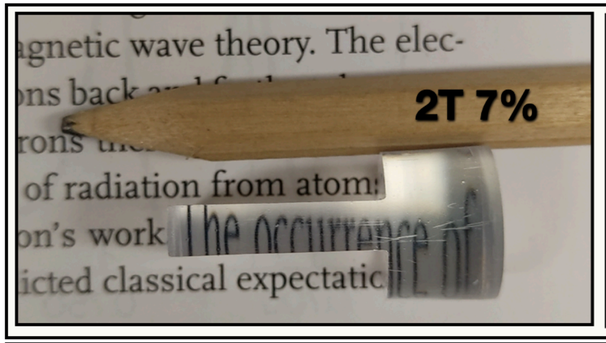
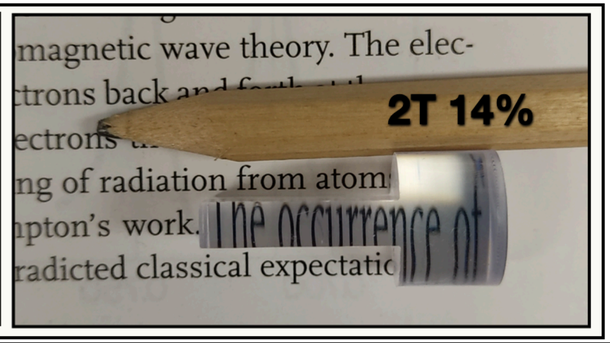


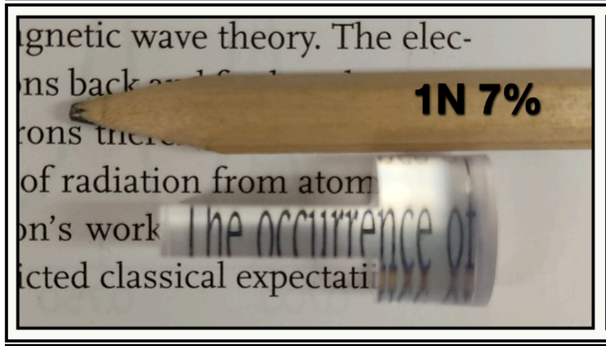


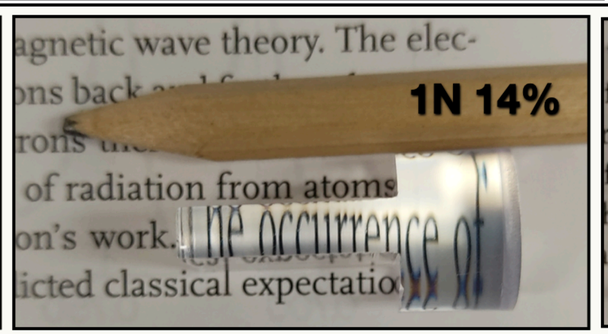


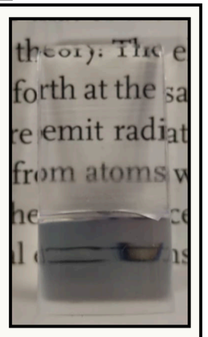


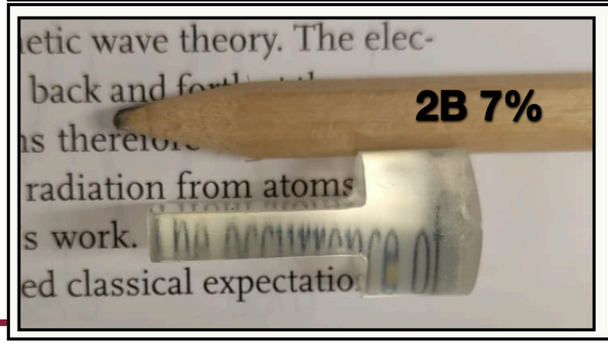


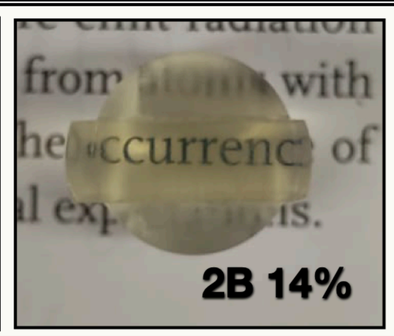
The cylindrical shape is not optimal to take pictures











TOPS: Time Of flight Plastic Scintillator

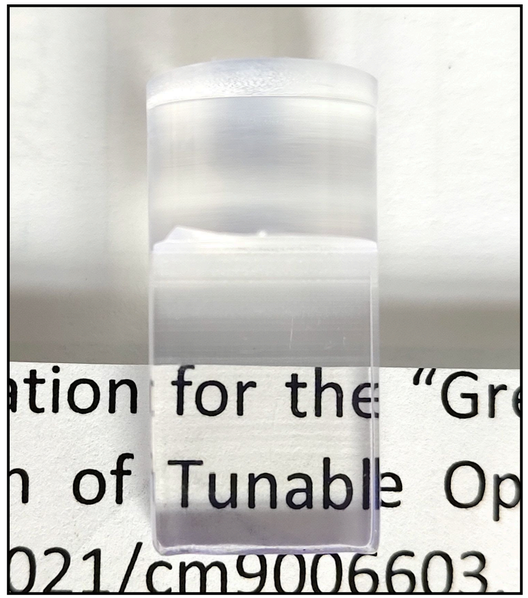
We performed test with cosmics, protons and carbon ions beams in the last 3 years. Finally, with optimised sample shapes, readout coupling and experimental setup we made some tests at SBAI with m.i.p..

Readout system:

- PMT H10721-20
  - quantum efficiency impacts on the final light output (QE peak at 400nm)
  - rise time (from datasheet) 0.57 ps

DAQ system:

- WaveDAQ



Not physicist SBAI Collaborators:

- LEOS Group for the chemistry development
- Marco Magi - SBAI Mechanical Workshop

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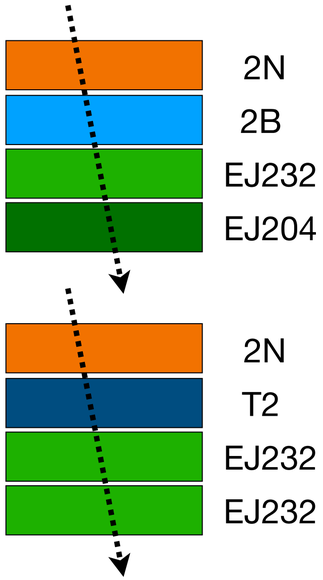
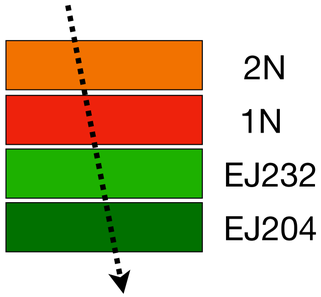
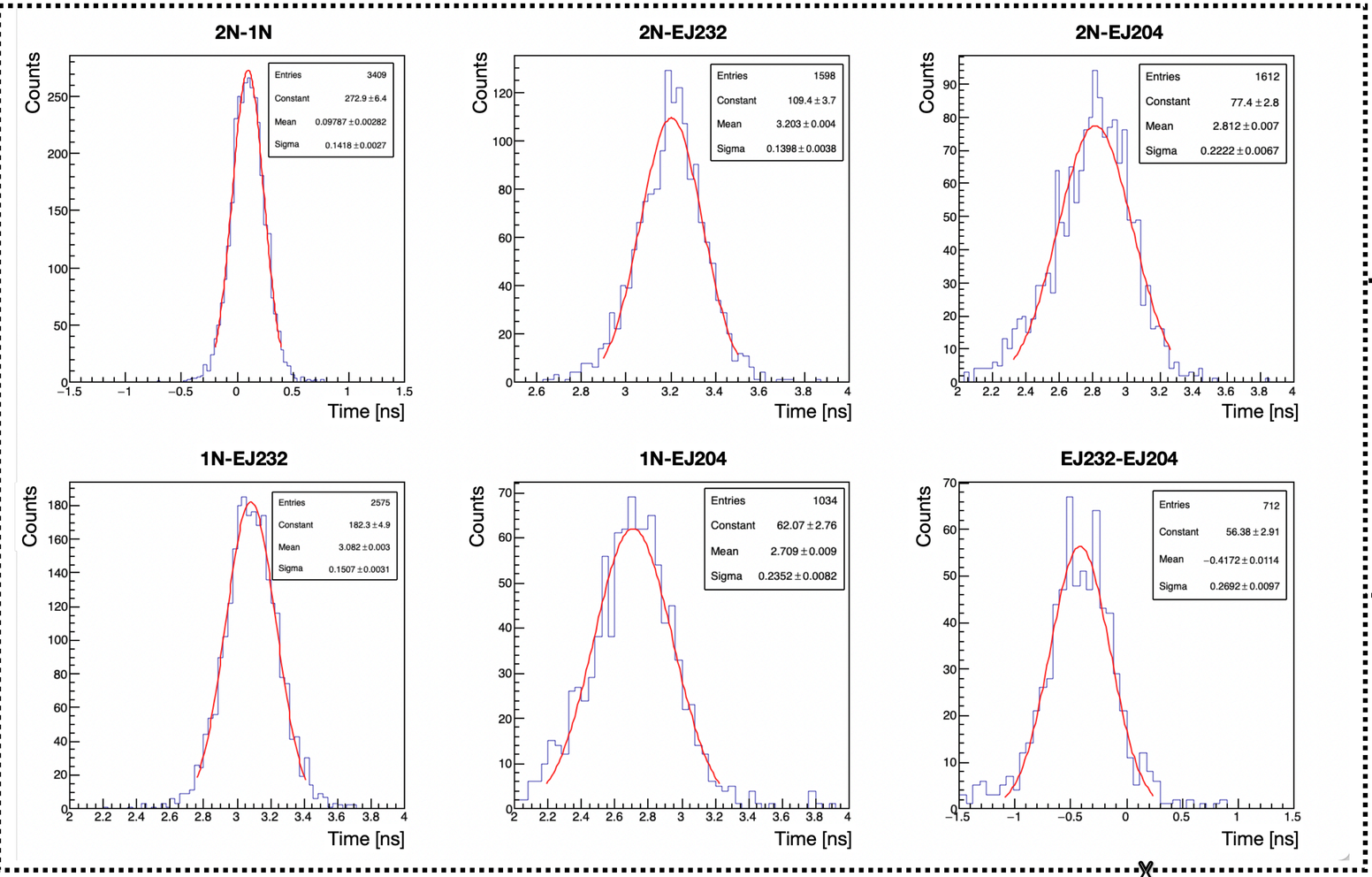




We measure 4 samples at the same time in different combinations and we applied the root Minuit2 minimizer to obtain for each sample time resolution.



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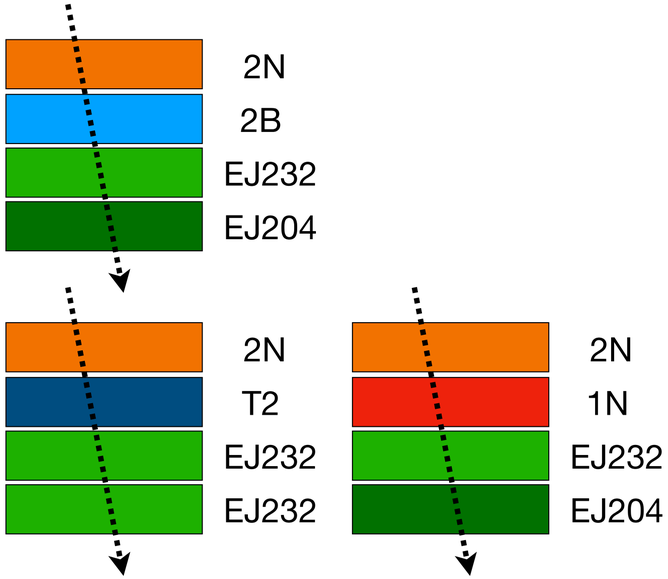
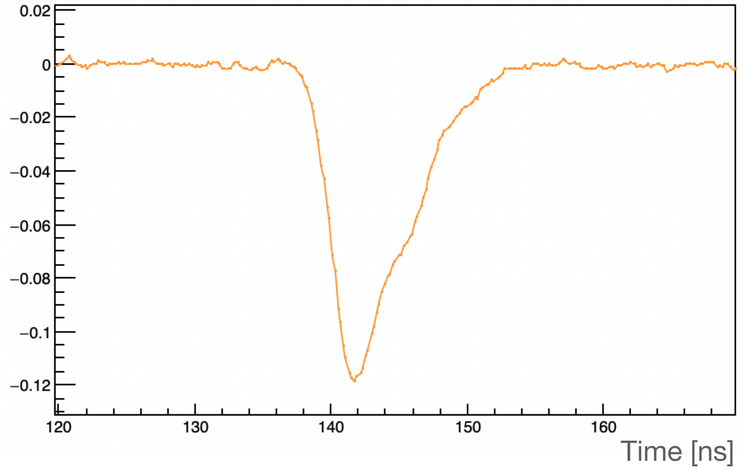
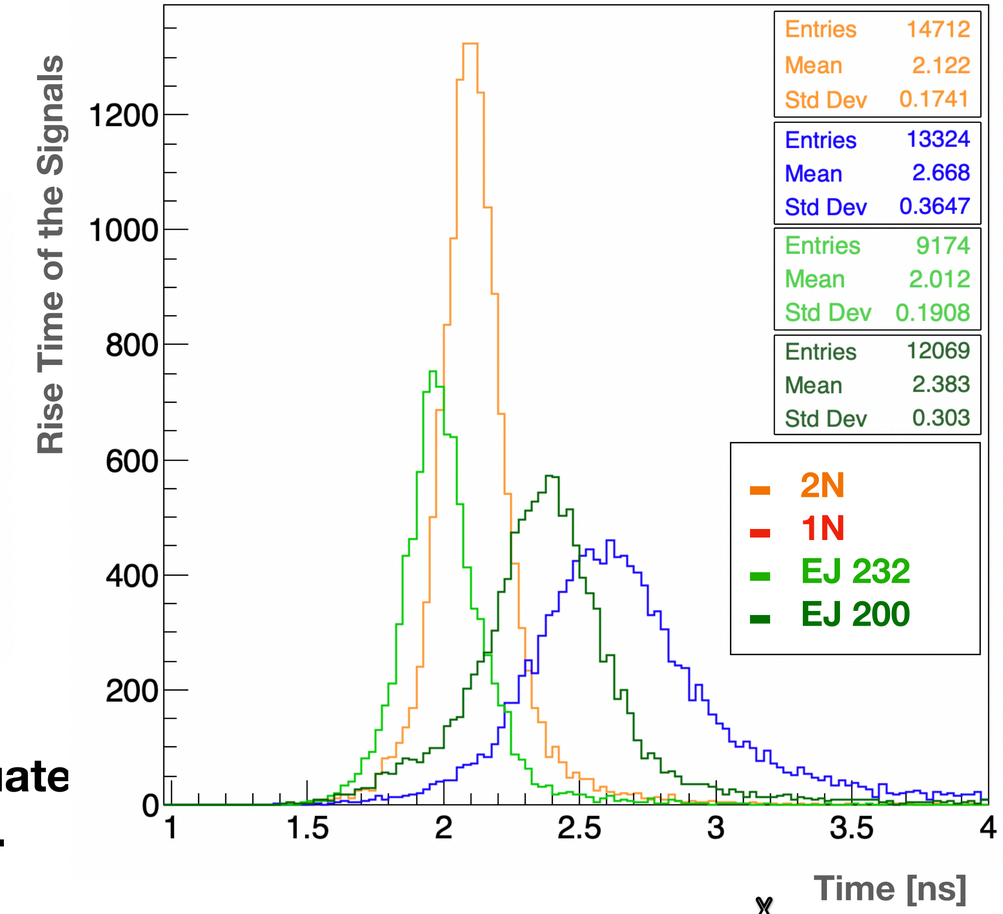




Analysing the waveform of the different scintillators we also evaluate the Rise Time and Signal Width.



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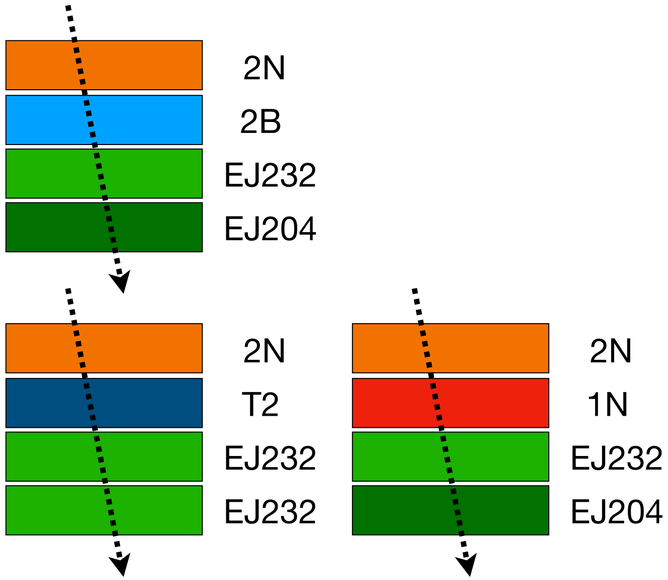

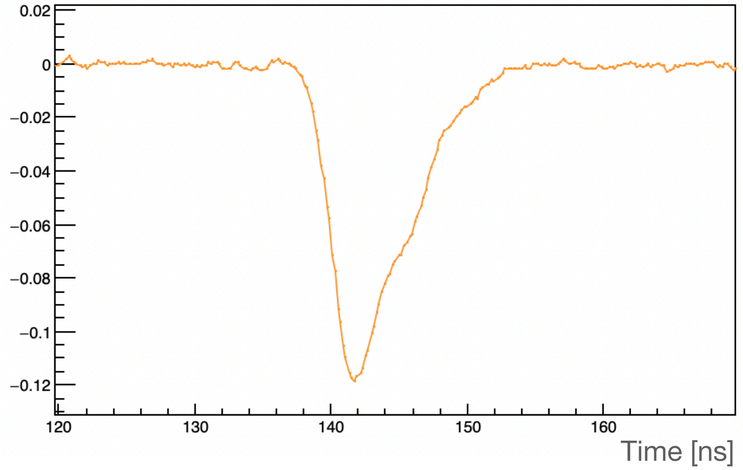

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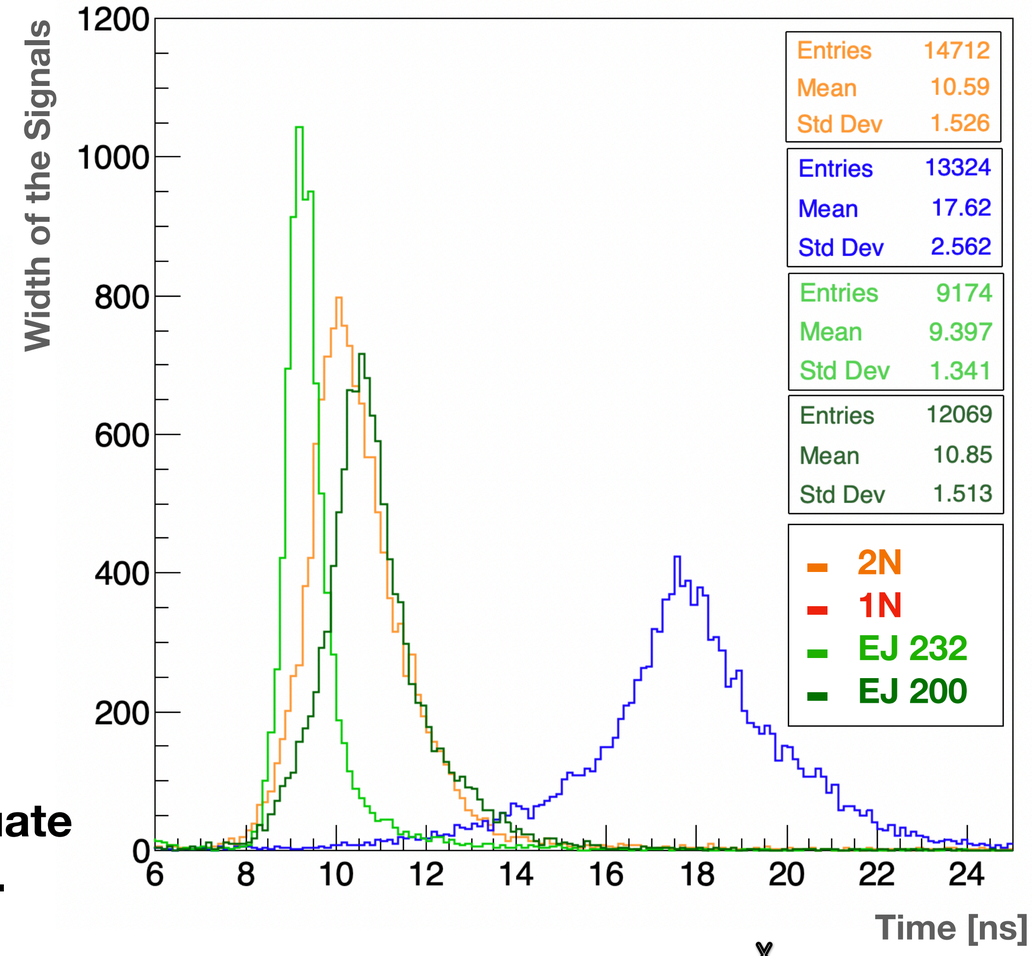

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Concentration %:

- We studied several concentrations of fluorophores, from 1 up to 30%, but the best performances have been obtained with samples at 14%.

Samples	Primary Dopant	Wavelength emission	Light Output* % EJ232	Rise-Time [ns]	Width [ns]	Time Resolution [ps]
	%	[nm]	*systematic and statistics error 10%*			
EJ-232	-	370	100	2	9	123
EJ-204	-	408	200	2.5	11	211
2N	14%	405	110	2	12	81
2T	14%	-	240	3	18	97
1N	14%	415	155	3	17	102
2B	14%	420	160	2.5	14	110

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Possible Applications:

- Timing Detectors
- dE/dx Detectors
- Combination of the two

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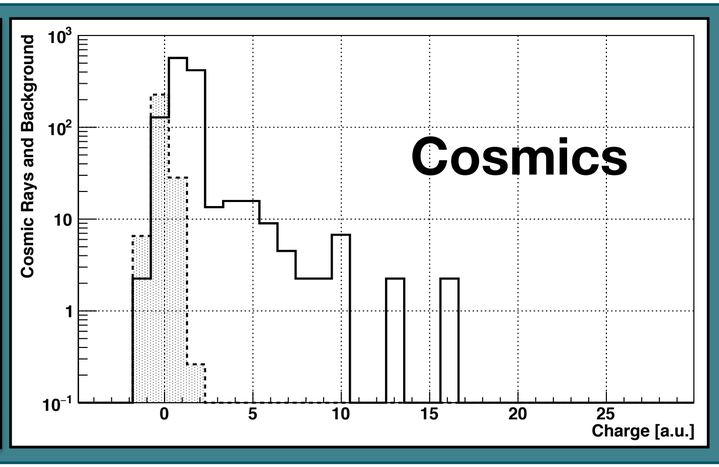
EDIT: 3D plastic scintillator

Funded by a small Bando di Ateneo 2021-2022 (L.Mattiello)

- CREF (MM) and INFN (Silvio M., Valerio P., Silvia M.)'in kind'
- LEOS (chimici) and SBAI

The idea is to exploit the *veroclear* material of the 3D printers and try to integrate in the resin the scintillator.



The samples of scintillator dissolved in *VeroClear* liquid and polymerised by UV, have been irradiated with minimum ionising particles (m.i.p, cosmic rays). The light output of the first prototype obtained with m.i.p. irradiation is shown. The background contribution has been superimposed (dashed line) to the signal (black line). The energy loss (dE/dx) of the muon is clearly contributing to the scintillation response with its typical landau shape.

This would allow to produce also very thin samples

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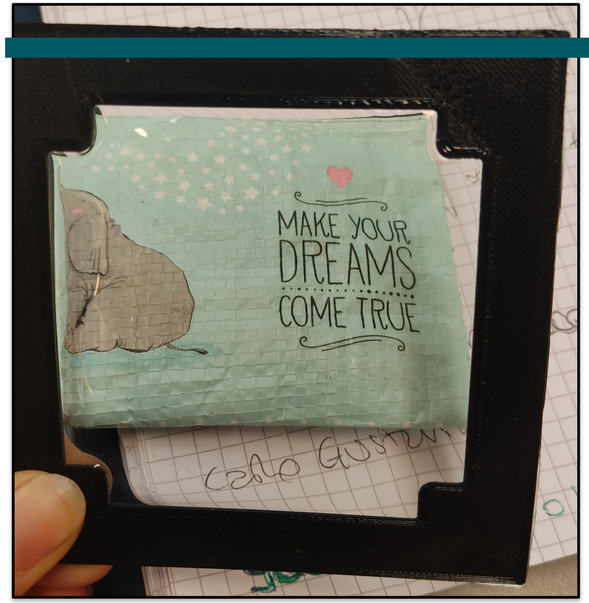
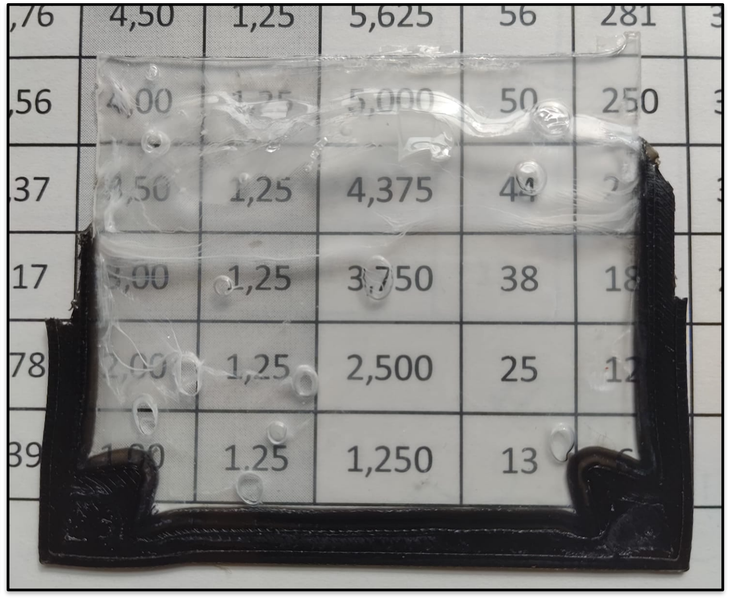


***Veroclear* without scintillator**

***Veroclear* with 2N scintillator**

Promising but not fantastic results with 2N at 14% concentration



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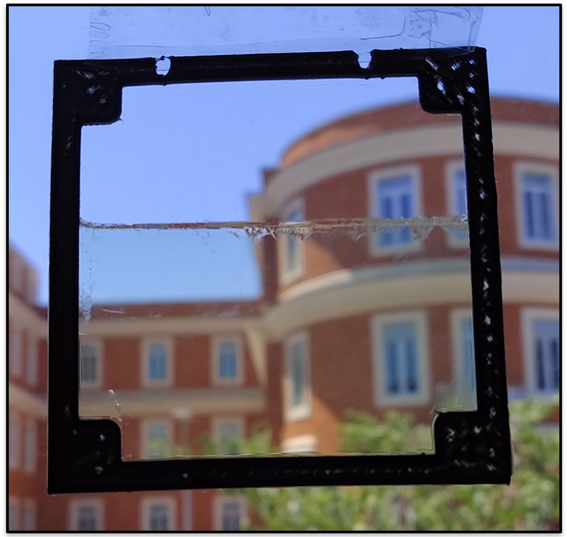
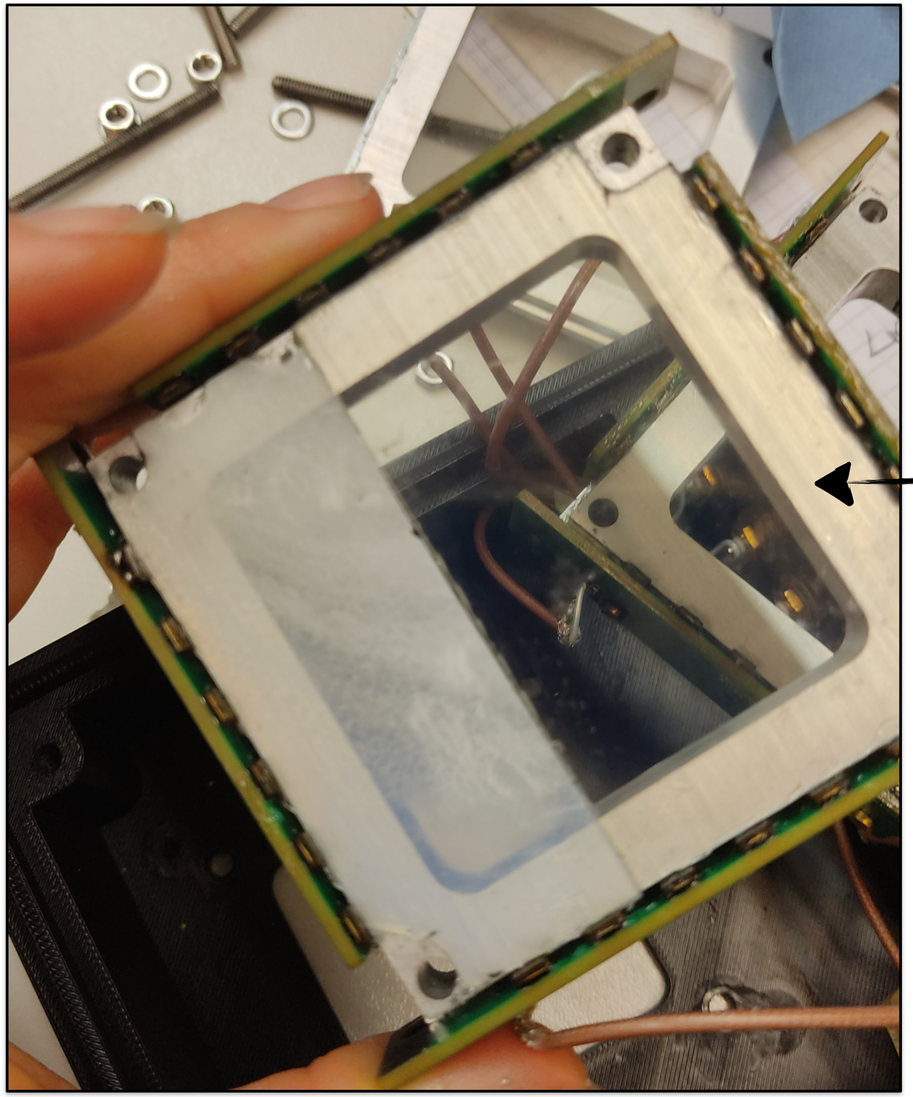
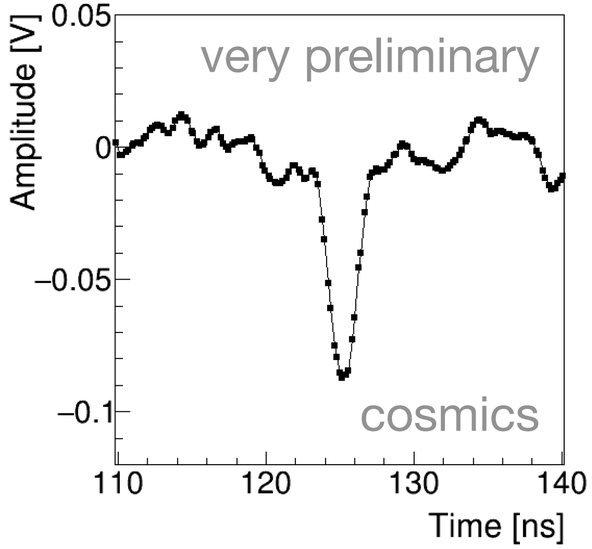
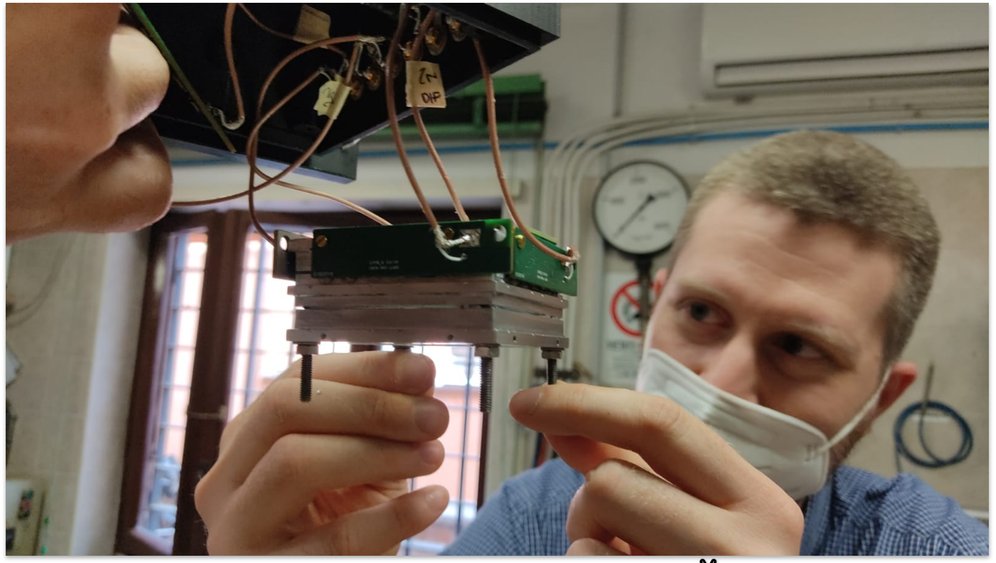




***Veroclear* with 2N scintillator at low % (<10)**





☑ We characterised the samples. Summarising:

- From the emission spectra point of view light is under control (‘in blue’);
- We are able to produce samples of scintillators faster than commercial one;
- We can exploit the light output performances, thanks to the high concentration that we can reach with this fluorophores;
- For high concentrations, up to 30 %: we need to understand if fluorophore saturates or the transparency decrease the light transmission;
- **IF and WHEN we will be able to produce large amount of scintillator.. 2T can be an alternative to ej-232 for next generation of TOFWALL!**
- A thin 4 cm x 4 cm thin 2N scintillator in PVT is under preparation with standard methods thanks to the collaboration with the mechanical and aerospace engineering departement;
- the 3D potentiality is very interesting.. but we have to work..
- **WHEN we will be able to produce thin 2N scintillator we can have an alternative and more performing scintillator to ej-232 for next of MARGHERITA!**

☑ Patent under submission 

☑ Cosmics Performances Paper in Preparation **Poster @IEEE2021**

☑ Measurements at CNAO with protons (12 December 2022)


come fai..SBAI