New Organic Materials applied to Plastic Scintillator for Fast Timing Detectors

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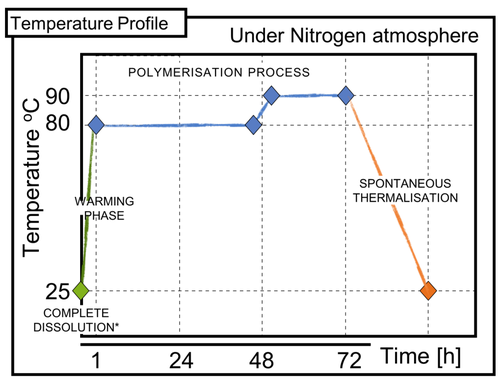
Organic scintillators are largely exploited in a wide range of detectors due to their capability to obtain very good time resolutions. Plastic scintillators are also relatively cheap, easy to manipulate and light (low density) with respect to conventional crystal scintillators and are traditionally used to perform very precise measurements of particle Time of Flight (TOF). The research and development on organic scintillators is always active and in this framework a collaboration between the physics, engineering and chemistry groups of University “Sapienza” of Rome and Centro Studi e Ricerche Enrico Fermi started the TOPS project (Time Of flight Plastic Scintillators) focused on the development of a new class of plastic scintillators.

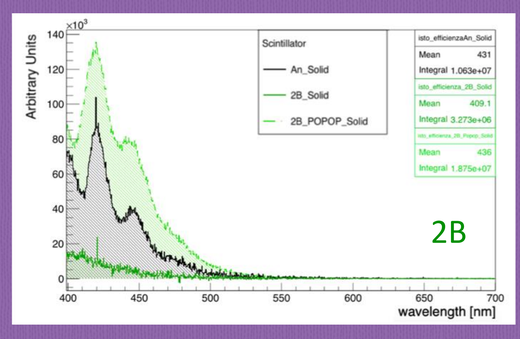
TOPS scintillators have been realised in liquid and solid samples and their intrinsic characteristics have been studied. The samples show light output up to ~ 300 % larger with respect to anthracene and good timing properties. In order to improve the matching between the emission/absorption spectra of the scintillators, doping material have been added as wave-shifter. The use of POPOP/cumarina as doping improved the performances of a fraction of the scintillator samples. Based on the comparison of the light output values obtained in measurements with cosmic rays, a selection of the most promising scintillators has been investigated also from the timing point of view. The scintillation time characteristics of the TOPS plastic samples have been analyzed with minimum ionizing particles, charged particles and laboratory sources. The commercial plastic scintillator BC-412 and EJ-200 has been used as a reference.

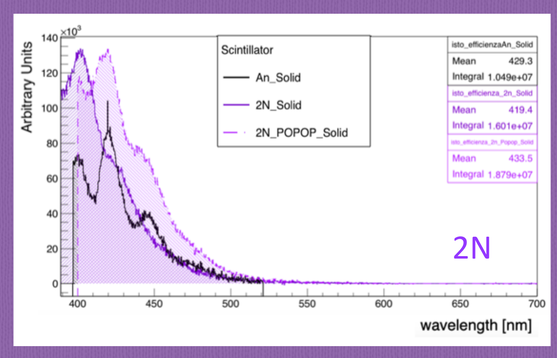
Plastic scintillators preparation

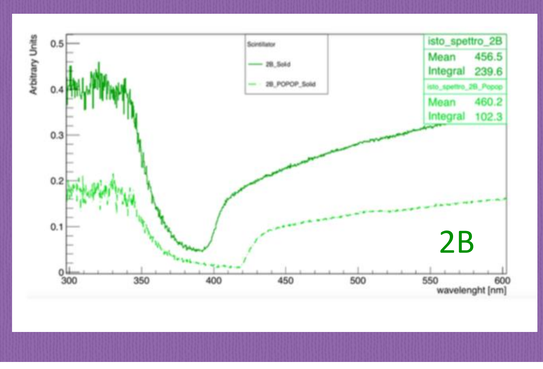


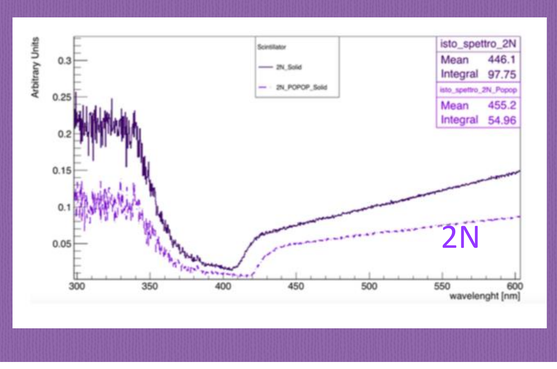
New organic molecules have been synthesised as organic scintillators. The possibility of developing plastic scintillators with our molecules was demonstrated using a system of a polyvinyl-toluene (PVT) polymer matrix loaded with various concentrations of scintillating compounds.

The new plastic scintillator samples have been characterised in terms of **transmittance and emission** with photoluminescence spectroscopy measurements.

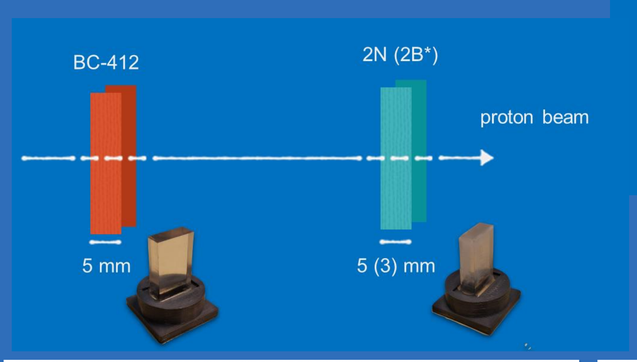








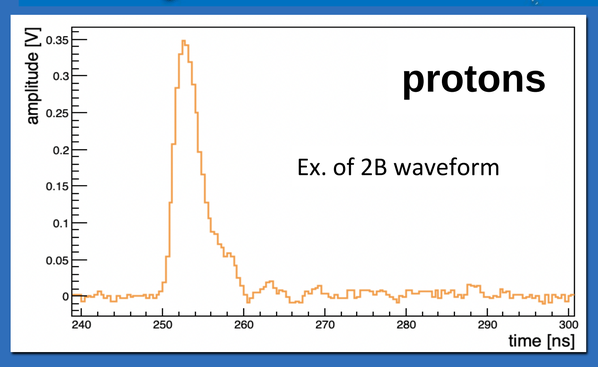
Test Beam with protons/carbons

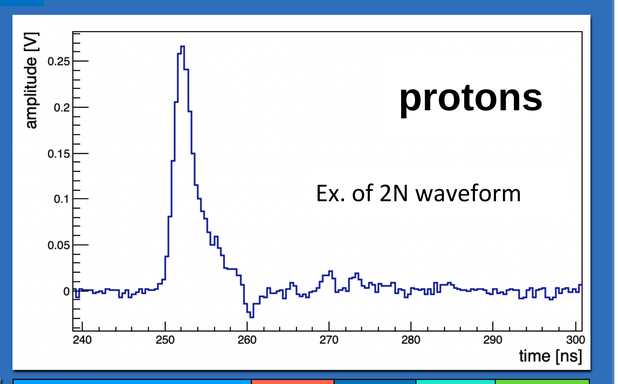


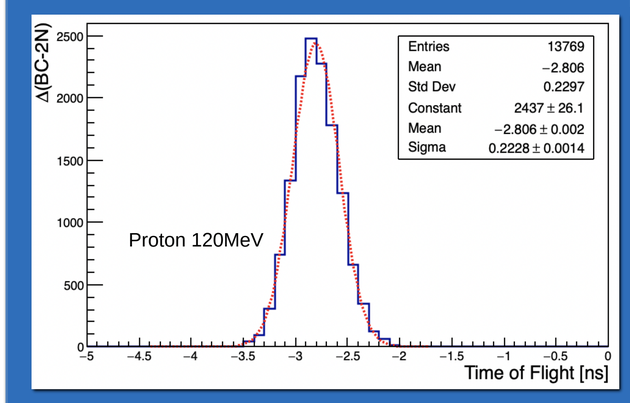
Proton beam@CNAO:
- energy 70- 220 MeV
- sigma ~1cm

Experimental SETUP:
- PMT H10721-210, risetime ~0.57ns
- DAQ LeCroy HDO6104-MS 2.5Gs/s

Carbon beam@GSI
- energy 700 MeV
- sigma ~1 cm
- 2N, 2B, 2T



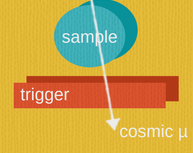




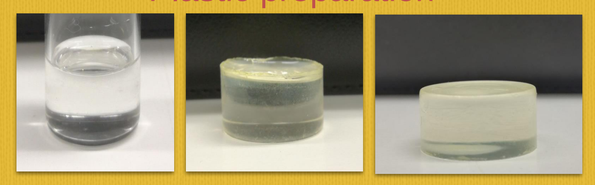
Sample	2N	2B	2T	EJ-200#
Light Output [% EJ]	41%	35%	57%	90-100%
Time Resolution* with Carbon [ps]	130	140	75-100	30-40
Scint. Concentration [%]	7	7	7	-
DVB [%]	5	5	5	-
Doping	-	cumarina 0.3%	cumarin a 0.3%	-
Polymer base [Polyvinyl-toluene]	PVT	PVT	PVT	PVT

Those result are first attempts of exploiting the TOPS scintillators for ToF measurements. Further optimisation, balancing the concentration, improving the transparency and better controlling the polymerisation process, has been made in order to improve the new molecules potentialities.

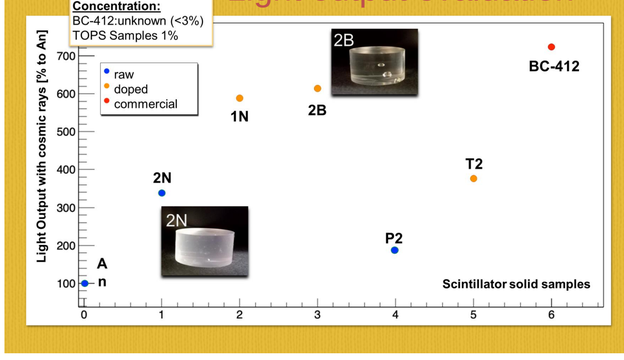
Test with m.i.p.



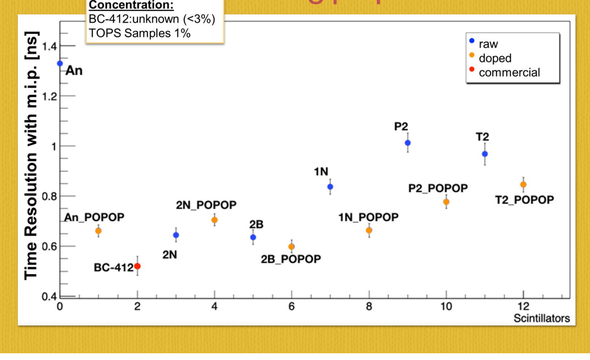
Plastic preparation



Light output evaluation

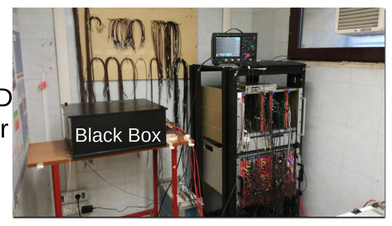


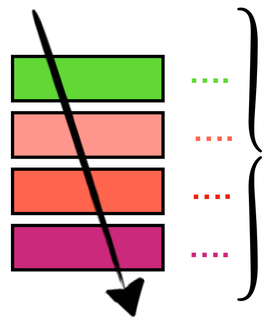
Timing properties evaluation



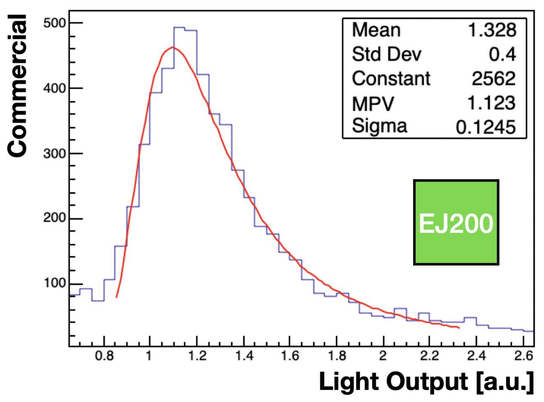
Experimental SETUP:

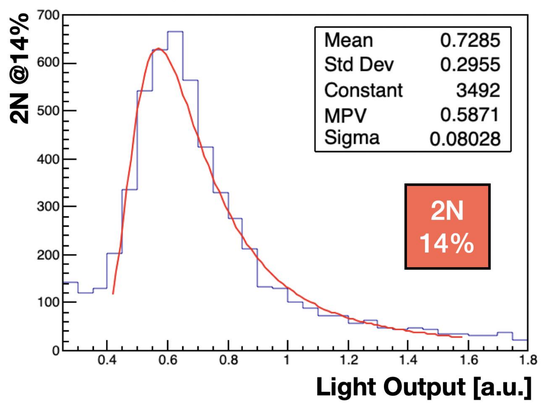
- PMT XP1911 PHOTONIS
- Daq: VME QDC (12 bit) and TDC
- sources: ^{137}Cs, ^{22}Na, ^{60}Co, ^{90}Sr
- cosmics rays

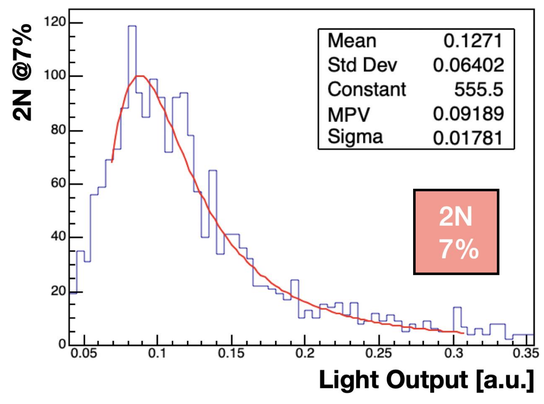


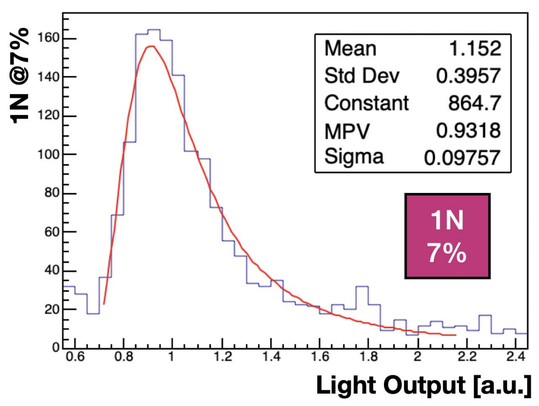


READOUT

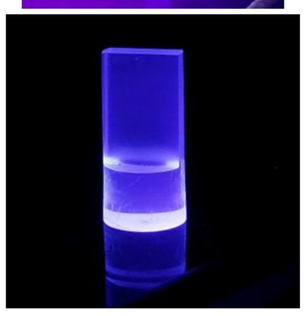








Sample	2N	2N	1N	EJ-200#
Light Output [% EJ]	54%	8%	83%	100%
Time Resolution* with m.i.p. [ps]	144	224	190	170
Width Time [ns]	1.95	1.91	2.8	2.3
Scint. Concentration [%]	14	7	7	?
DVB [%]	5	5	5	?
Doping	-		MDCD 0.3%	?
Polymer base [Polyvinyl-toluene]	PVT	PVT	PVT	PVT



- Plastic scintillators are relatively cheap, easy to manipulate and light (low density) with respect to conventional crystal scintillators => precise measurements of particle Time of Flight (ToF).
- In the framework of the TOPS project tens of new scintillators, in liquid and solid samples, have been prepared and characterised in therm of light output and timing properties with cosmic rays.
- For some samples studies on the light output as a function of different concentrations have been performed as first input for a concentration optimisation.
- Some molecules shows promising time resolution performance. Samples have been irradiated with proton beam at CNAO performing ToF measurements reaching very good results.