NEW HIGH-Z ORGANIC SCINTILLATORS FOR TOTAL-BODY SPECT AND THERANOSTIC DOSIMETRY

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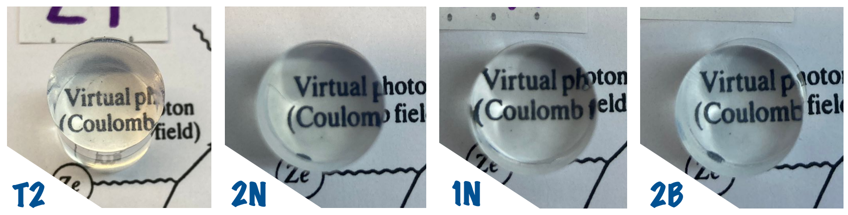
- **Plastic scintillators** are faster, easier to manipulate and cheaper than inorganic crystals. However they are not optimised for the detection of gamma rays via photoelectric effect due to their low atomic number, and thus they are not suitable for medical physics applications, where the detection of the photopeak is crucial to ensure the required diagnostic efficacy.
- Organic scintillators can be doped with high-Z elements to increase their photoelectric interaction probability.
- On the market, the highest available dopant concentration is 5%. Higher concentrations are not recommended due to losses in scintillation efficiency and optical clarity.

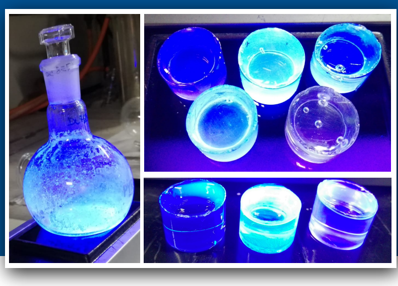
So we decided to build our doped plastic scintillators in house!

- We developed and patented new scintillating fluorophores [1].
- We built samples with a plastic polymer base (PVT) to test the performances of the novel scintillating molecules.
- Their performances in terms of scintillation efficiency and time resolution were measured (readout system based on H10721-210 Hamamatsu PMT) and compared with the commercial alternatives.



[1] Mattiello L.; Patera V.; Belardini A.; Rocco D.; Marafini M.; Organic Scintillator. *Patent* WO2023156957A1, 2023. *10% systematic and statistic error.

Sample	Fluorophore concentration	Light output* (%wrt EJ-232)	Time resolution* (@ 330 mV)	Rise Time*
EJ-232	—	100	208 ps	2.2 ns
BC-400	—	105	234 ps	2.5 ns
T2	14%	70-90	250 ps	2.8 ns
2B	14%	60-65	224 ps	2.4 ns
2N	14%	70-90	264 ps	2.3 ns
1N	14%	70-85	221 ps	2.3 ns

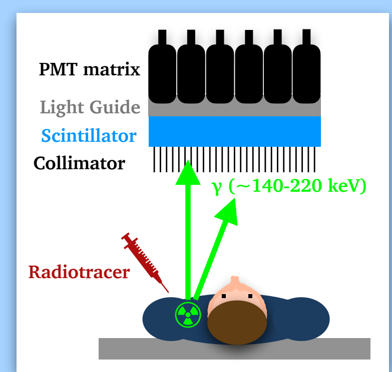


In a synergic project (3dSPARK) our scintillating fluorophores are dissolved in a 3D-printed resin substrate.

PRIN Project (Bando 2022 Prot. 2022C7ESM3)

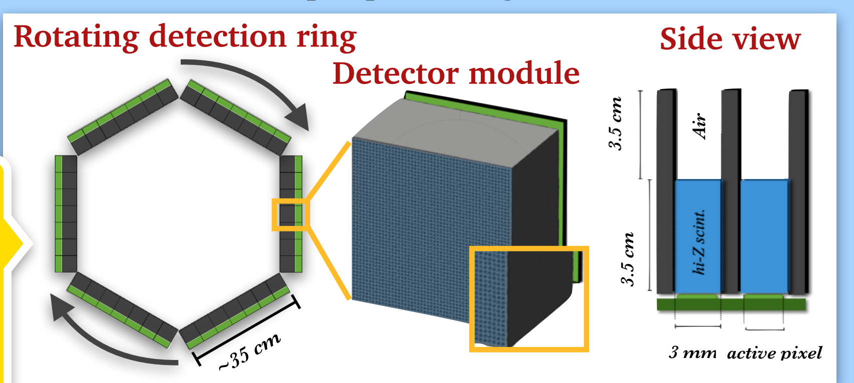
Applications in Medical Physics: total-body SPECT detector - PRIN project (Bando 2022 Prot. 2022Z72Y3K)

reSPECT project



- SPECT (Single-Photon Emission Computed Tomography) is a nuclear imaging technique that allows to diagnose cancers and other pathologies through the detection of the γ emitted by a radiotracer.
- Conventional SPECT detectors involve a monolithic inorganic scintillator with a PMT matrix for the readout.
- The reSPECT project aims at developing a new detection system based on **high-Z plastic scintillators** polymerised directly inside the **3D-printed tungsten collimator** holes, readout with **SiPMs** coupled to each scintillator, **FPGA matrices** for data pre-processing.

The reSPECT detector will be cheaper, modular (thus enabling total-body acquisitions), compliant with MRI, and will be able to sustain 10^4-10^5 higher count rates.

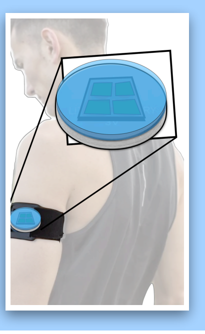


Expected performances of reSPECT are obtained through MC simulations.

SPECT detection system	Sensitivity per module @140 keV	Spatial resolution (FWHM) @10 cm	Decay time	Rate capability	Total cost
Anger Camera (NaI) FoV: 53x39 cm²	170 cpm/μCi	7.4 mm	250 ns	0.25k-3k cps/cm²	$$
reSPECT 6 rotating blocks, FoV: 35x35 cm²	184 cpm/μCi (Energy cut 80 keV)	8.9 mm (For pixel size: 2 mm)	2-5 ns	50M-200M cps/cm²	$

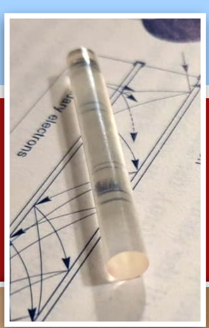
Applications in Medical Physics: theranostic dosimetry - Bando di Ateneo

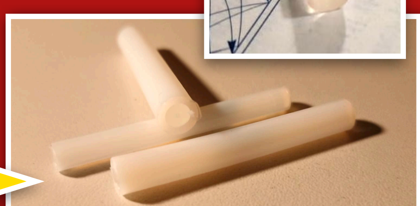
TRONDHEIM project



- The goal of the TRONDHEIM project is developing a portable γ detector to improve the overall survival of prostate cancer patients treated with ^{177}Lu-PSMA-617 radio-metabolic therapy.
- The determination of the radiopharmaceutical wash-out curve of the patient would allow for a customised dose administration, thus reducing the toxicity and increasing the tumour control.
- Our high-Z plastic scintillators allow for the realisation of a light, compact, resistant and inexpensive device. These features are crucial for the use on patients with motion limitations due to metastases.

- 2N was selected to produce scintillator samples doped with Bismuth at concentrations up to 10% (according to MC simulations, 10% is the minimum required for good imaging performances).
- The goal is detecting the photopeak of 140-250 keV photons to allow for nuclear imaging applications.

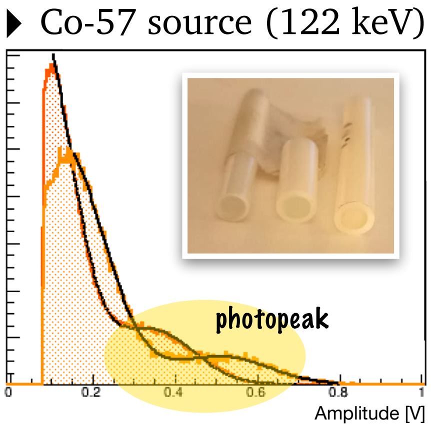




PTFE coating to increase light collection.

Performances of the doped scintillators

- 2N+10%Bi samples
- L = 3.5 cm, L = 5.6 cm
- Co-57 source (122 keV)



Sample	Time resolution
EJ-256 (Pb 1.5%)	(360 ± 17) ps
EJ-256 (Pb 5%)	(520 ± 31) ps
2N 14% (Bi 2%)	(233 ± 13) ps
2N 14% (Bi 5%)	(278 ± 33) ps
2N 14% (Bi 10%)	(340 ± 46) ps

Better timing performances than other commercial loaded plastic scintillators. Possible PET applications!

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