

The reSPECT project for a flexible and fast total body nuclear imaging diagnoses with high-Z organic scintillators

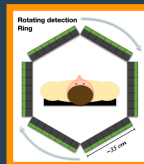
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- Use plastic scintillators instead of inorganic crystals to profit from their fast signal, ease of manipulation and low cost.
- Plastic scintillators are not optimised for the detection of gamma rays via photoelectric effect.
- The idea is to enrich our organic scintillators with high-Z impurities (e.g. Bismuth or Cerium) [1]

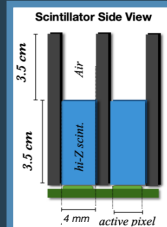
[1] Mattiello L., Patera V.; Belardini A.; Rocco D.; Marafini M.; Organic Scintillator. Patent WO2023156957A1, 2023.

The reSPECT detection system



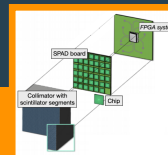
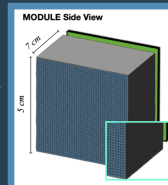
The reSPECT detection system will have a modular structure able to revolve around the patient, enabling multi-angle data acquisition.

Each module will consist of a 3D-printed tungsten frame that serves both as a collimator and as a container of the scintillator segments.



The readout will be performed by SPAD array silicon-based photodetectors arranged in small-size pixels, individually coupled to the scintillator segments. The Polymerisation occurs directly inside the holes.

FPGA matrices will be placed on the back of each module to pre-process the acquired data.



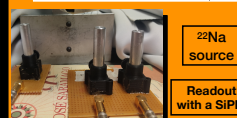
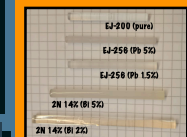
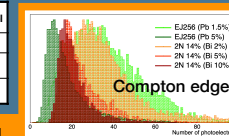
High-Z plastic scintillators

- We produced samples of high-Z organic scintillators
- Transparency turns out to be good up to very high concentrations
- We performed test with laboratory sources and different readout systems



PVT matrix
high-Z impurities
(Bismuth 2-10%)

Sample	Light Output [a.u.]	Ph.e.l
New 2% Bi	100	+
New 4% Bi	71	++
New 10% Bi	67	+++



Expected performances

- The expected performances of the reSPECT detection system have been obtained through Monte Carlo simulations.
- The simulated scintillators have a 10% Bismuth concentration.
- The reSPECT detection system allows to realize a total-body SPECT.

SPECT DETECTION SYSTEM	SENSITIVITY PER MODULE @140 keV	SYSTEM SPATIAL RESOLUTION (FWHM) @10 cm	DECAY TIME	RATE CAPABILITY	TOTAL COST	MRI COMPLIANCE	RADIOMETABOLIC DOSIMETRY COMPLIANCE
Anger Camera (NaI)	170 cpm/μCi	7.4 mm	250 ns	0.25k-3k cps/cm²	\$\$	✗	✗
CTI	190 cpm/μCi	7.6 mm	350 ns	30k-700k cps/cm²	\$\$\$	✓	✗
reSPECT 6 rotating blocks, FoV: 35 x 35 cm²	184 cpm/μCi (energy cut @80 keV)	8.9 mm (2 mm pixels)	2-5 ns	50M-200M cps/cm²	\$	✓	✓

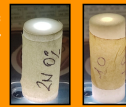
*The spatial resolution can be improved by adjusting the geometrical parameters.

- The performances of the scintillator prototypes produced have been compared with those of the commercial alternatives (Eljen Technology) in terms of light output and time resolution.
- The MC simulations showed that a 10% Bismuth concentration is needed to ensure good imaging performances.

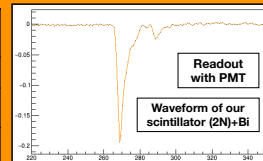
- We realised a 10%-doped sample with promising results: such dopant concentrations are not available on the market.

Sample	Measured #photoelectrons
EJ-256 (Pb)	45 ± 10
EJ-256 (Pb)	14 ± 1
2N 14% (Bi)	42 ± 3
2N 14% (Bi)	17 ± 2
2N 14% (Bi)	21 ± 1

- We produced samples of high-Z organic scintillators polymerised in TEFLON in order to study the matching with this material
- Results show a very good collection efficiency and transparency



Sample	Light Output [a.u.]	Ph.e.l
New 0% Bi	100	-
New 2% Bi	20	To do
New 10% Bi	Ongoing	To do



- Light collection efficiency is crucial in this geometry!

Timing performances

- The scintillator exploited and enriched shows also better performances in terms of timing wrt to commercial loaded scintillators.
- Open possibilities for PET applications.

Sample	Time Resolution (Statistic Error)
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

NEXT STEP