Active Stoppers for Decay Experiments

Valencia, Spain, March 24-26 2025

Exploring Perovskite Scintillators: Potential and Properties for Radiation Detection

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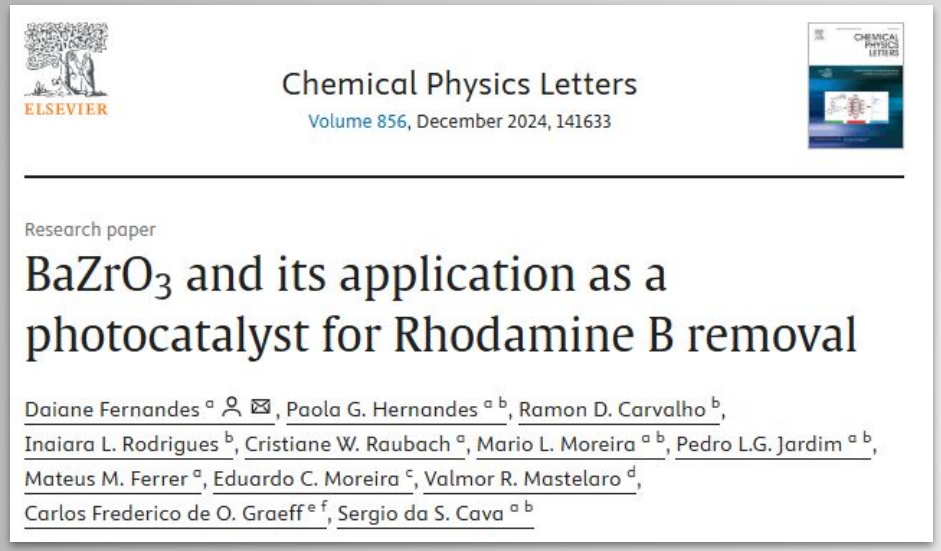
CRESCIMENTO DE CRISTAIS AVANÇADOS E FOTÔNICA

CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

Research group: Advanced crystal growth and photonics

Crescimento de Cristais Avançados e Fotônica (CCAF)

PT-BR



ELSEVIER

Chemical Physics Letters

Volume 856, December 2024, 141633

Research paper

$BaZrO_3$ and its application as a photocatalyst for Rhodamine B removal

Daiane Fernandes [a], Paola G. Hernandes [a b], Ramon D. Carvalho [b], Inaiara L. Rodrigues [b], Cristiane W. Raubach [a], Mario L. Moreira [a b], Pedro L.G. Jardim [a b], Mateus M. Ferrer [a], Eduardo C. Moreira [c], Valmor R. Mastelaro [d], Carlos Frederico de O. Graeff [e f], Sergio da S. Cava [a b]

CCAF

CRESCIMENTO DE CRISTAIS AVANÇADOS E FOTÔNICA

Predicting Wetting Properties for Surfaces with Stochastic Topography

by Caroline Schmechel Schiavon [1,*,†], Nadja Felde [2,†], Sven Schröder [2,†], Mario Lucio Moreira [3,†] and Pedro Lovato Gomes Jardim [3,*,†]

1 Instituto Federal de Educação, Ciência e Tecnologia Sul-rio-grandense, Bagé 96418-400, Brazil
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Physical and Chemical Approaches of Photovoltaic Parameters in Dye-Sensitized Solar Cells to ZnO/ZnS:rGO-Based Photoelectrodes

by Thiago Kurz Pedra [1,*], Ramon Dadalto Carvalho [2], Cristian Dias Fernandes [1], Luciano Timm Gularte [3], Carolina Ferreira de Matos Jauris [4], Eduardo Ceretta Moreira [5], Mateus Meneghetti Ferrer [6], Cristiane Wienke Raubach [6], Sérgio da Silva Cava [1,6], Pedro Lovato Gomes Jardim [1], Elson Longo [2] and Mario Lucio Moreira [1,6,*]

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4 Department of Chemistry, Federal University of Santa Maria, Santa Maria 97105-900, RS, Brazil
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Appl. Sci. **2025**, *15*(1), 291; https://doi.org/10.3390/app15010291

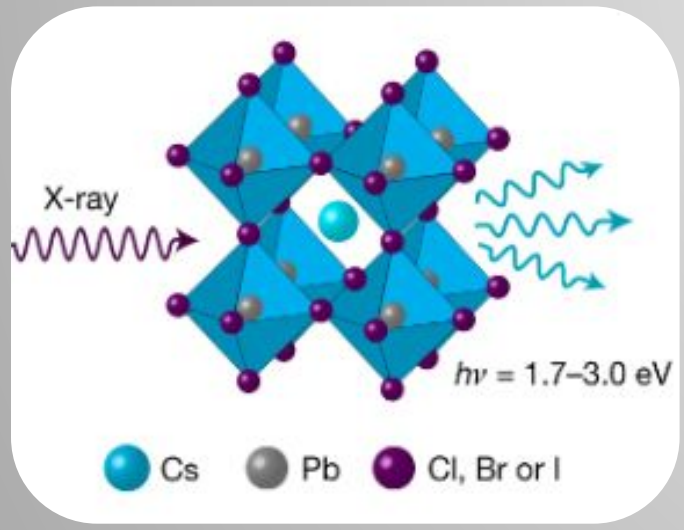
Perovskite Scintillators

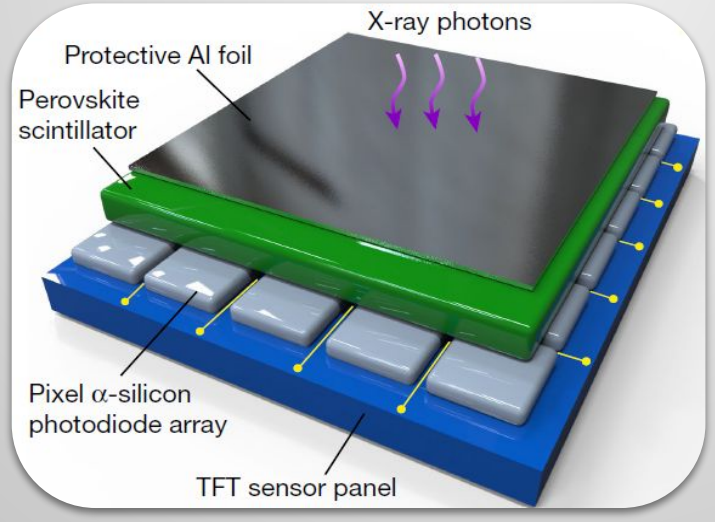
The interest in perovskites has extended to the field of **radiation detectors and scintillators**.

Their characteristics, such as **high light yield, fast response time, and tunable emission**, make them promising candidates to replace conventional scintillators in medical imaging, nuclear security, and high-energy physics applications.

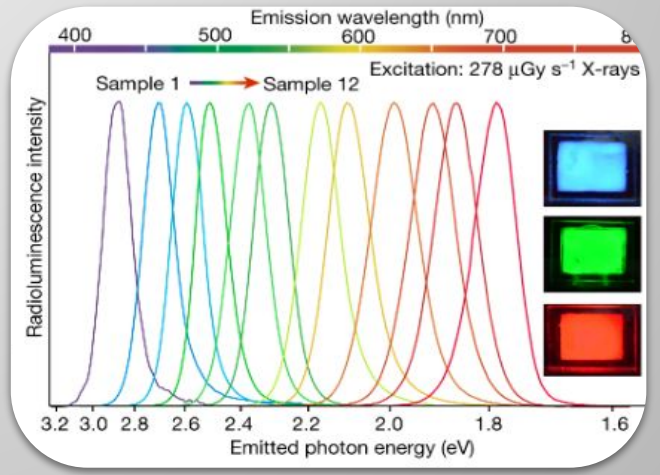
Material	Decay time (ns)
CsI:Tl	1000
LSO:Ce	40
LYSO:Ce	33
$LaBr_3$-Ce	15
LuI_3-Ce	31/140/1000
LuAP:Ce	17
BGO	300
BaF_2[a]	0.8/630
$CsPbBr_3$ NCs	44.6
$CsPbBr_3$ (7 K)	1 (Fast component)[b]
$MAPbBr_3$ (77 K)	0.1/1
$PhePbBr_4$	9.4
	9.9
	11 (81%)/36 (18%)/236 (1%)
$CsPbBr_3$:Cs_4PbBr_6	3[c]
	1.4 (88%)/6.7 (12%)

J. Mater. Chem. C 9, 11588–11604 (2021).



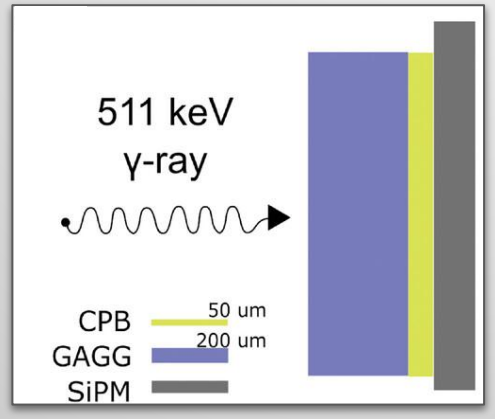


Nature 561, 88–93 (2018).

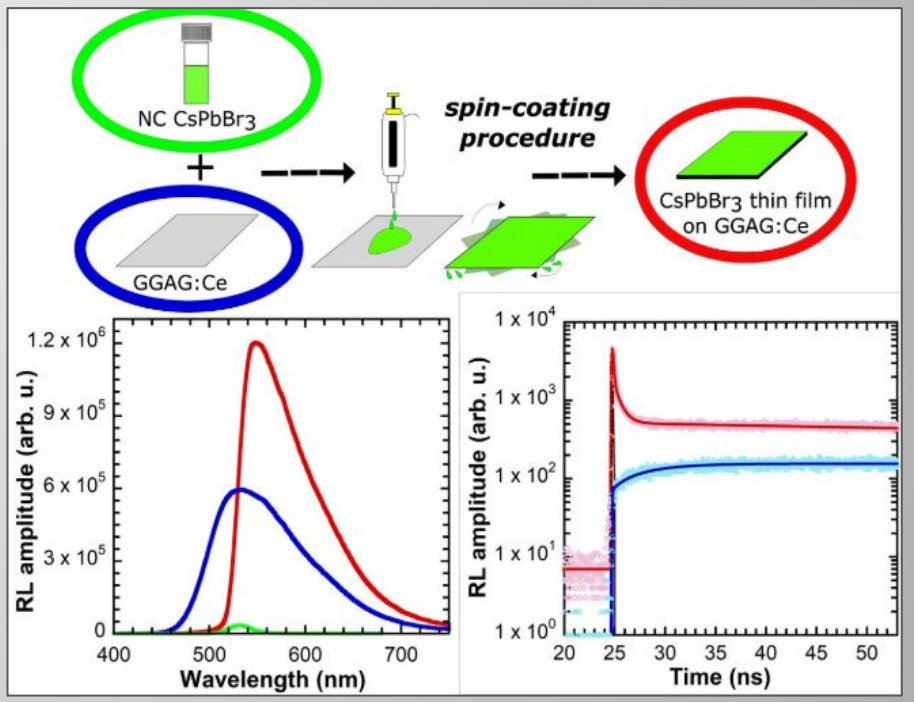


Lead Halide Perovskites $CsPbX_3$

- ➔ These materials have been investigated as hybrid detectors to enhance the energie efficiency from scintillator as GGAG, LYSO and BGO.
- ➔ Promoting the increase in light intensity and consequently affecting the decay time.
- ➔ Also in a recent research the author made a deposition in this same scintillator investigating the time resolution by time-of-flight, achieving more than double the improvement in timing performance.
- ➔ But, to growth this kind a material exposure to a significant toxicity and other perovskites starts to be improved.



Adv. Mater. Interfaces 2024

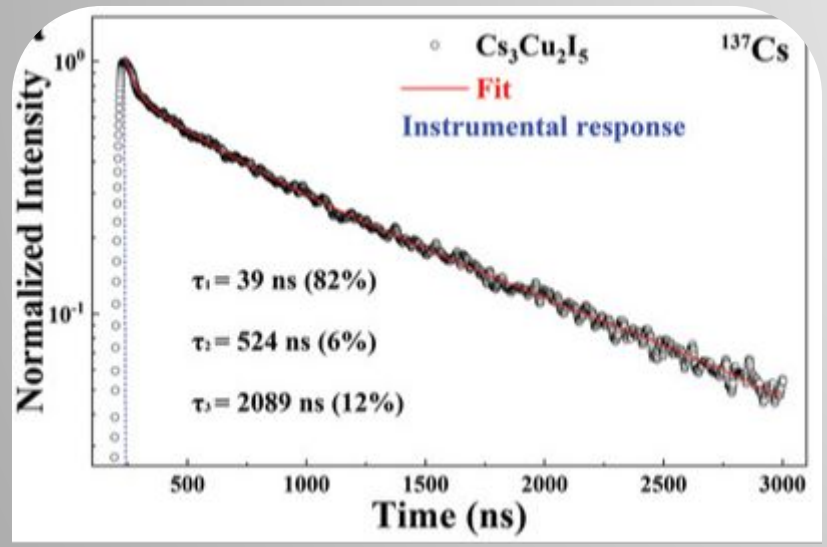


Nanomaterials 2022, 12(1), 14;

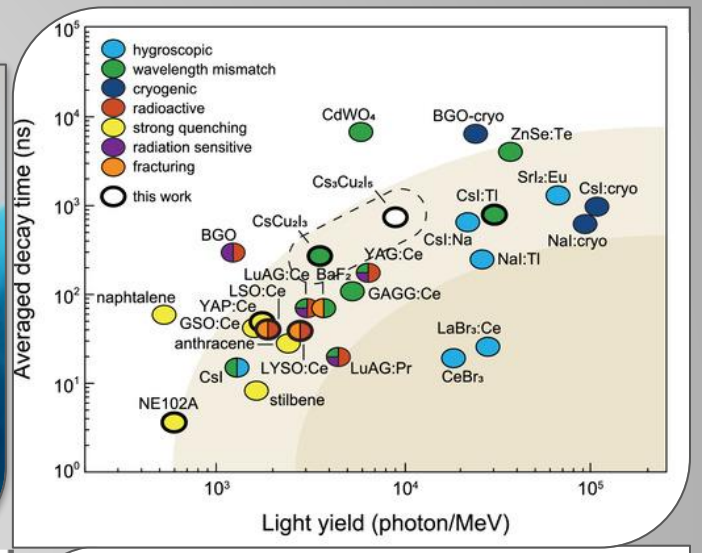
Lead-Free Halide Perovskites CsCuX

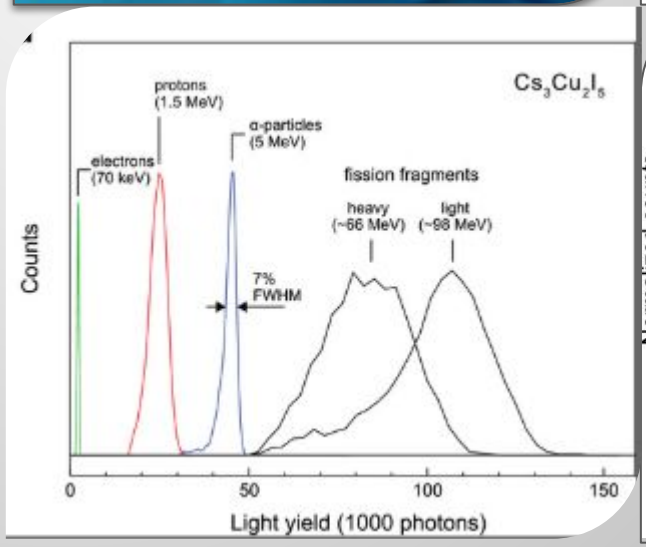
➔ Perovskites of the CsCuX halide type are being investigated with a great LY, exhibiting reasonable energy resolution and decay time.

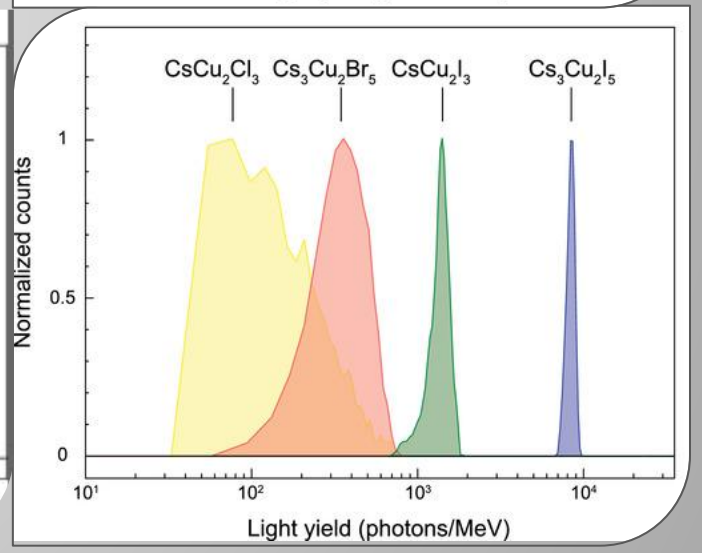
High-Quality $Cs_3Cu_2I_5$ Single-Crystal is a Fast-Decaying Scintillator.



Adv. Optical Mater. 2022, 10, 2201161



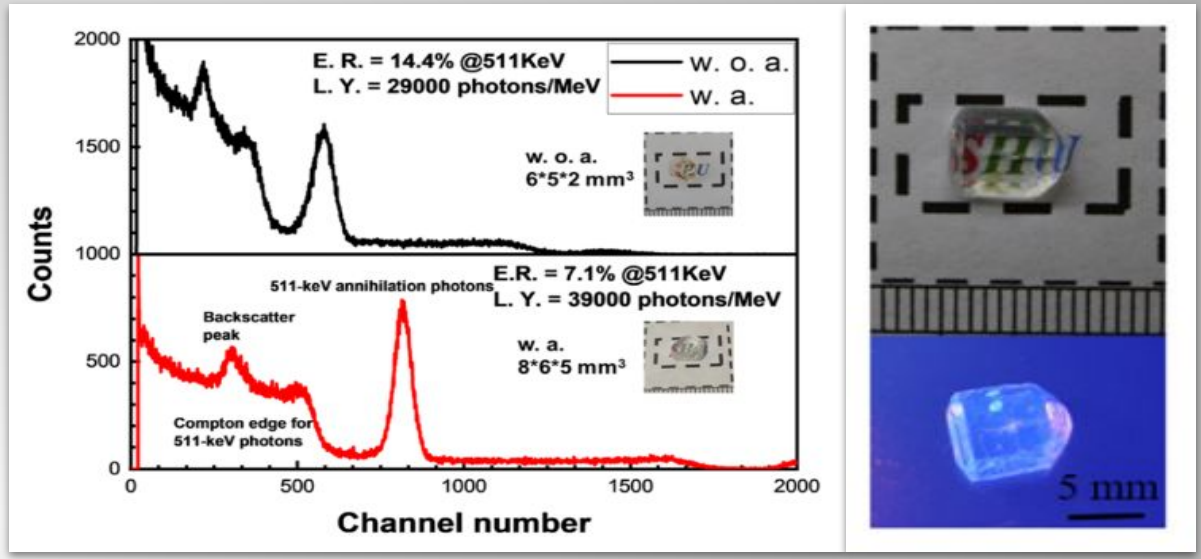




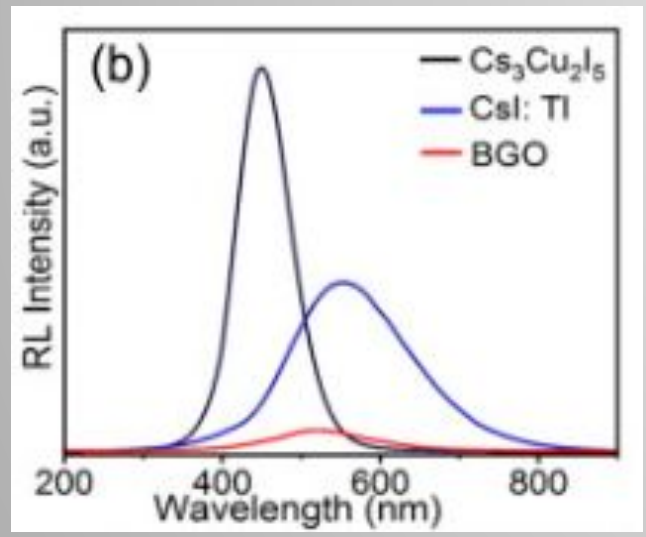
Adv. Funct. Mater. 2022, 32, 2206645

Lead-Free Halide Perovskites CsCuX

- ➔ Achieved better energies resolution, the decay time is more slow.
- ➔ Studies on time coincidence are still scarce.



Cryst. Eng. Comm. 25, 5444–5451 (2023).



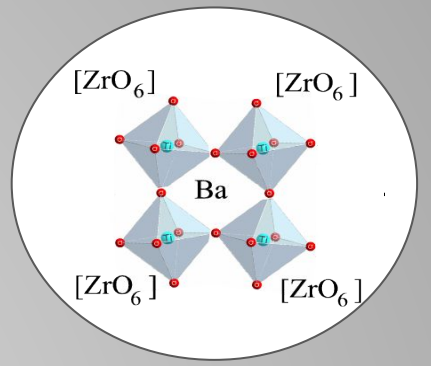
Journal of Energy Chemistry 79, 382–389 (2023).

Source	Channel number	Energy (keV)	Resolution (%)
^{241}Am	30	59	20.54 ± 0.02
^{133}Ba	73	81	17.50 ± 0.09
^{22}Na	904	511	7.30 ± 0.04
^{137}Cs	1160	662	5.80 ± 0.05
^{22}Na	2326	1274	4.50 ± 0.15

Achieved the time resolution about 1082.03 ±13.29 ns.

Nuclear Inst. and Methods in Physics Research, A 1069 (2024).

$BaZrO_3$ Perovskita Scintillator



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ScienceDirect
Scripta Materialia 64 (2011) 118–121
Scripta MATERIALIA
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Radioluminescence properties of decaoctahedral $BaZrO_3$

Mário L. Moreira,[a,*] Diogo P. Volanti,[a] Juan Andrés,[b] Paulo J.R. Montes,[c] Mário E.G. Valerio,[c] José A. Varela[a] and Elson Longo[a]

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Available online 17 September 2010

The search for new materials in this area has led to the identification of the radioluminescent properties of barium zirconate perovskite ($BaZrO_3$).

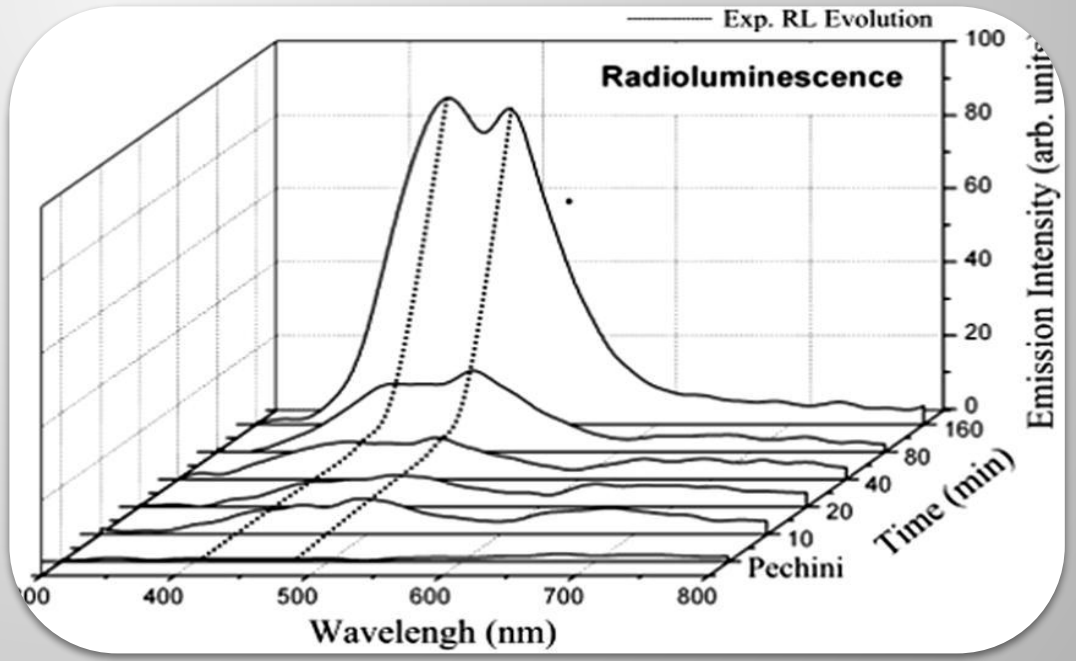
Microwave Assisted
Hydrothermal Method
140 ºC

↓

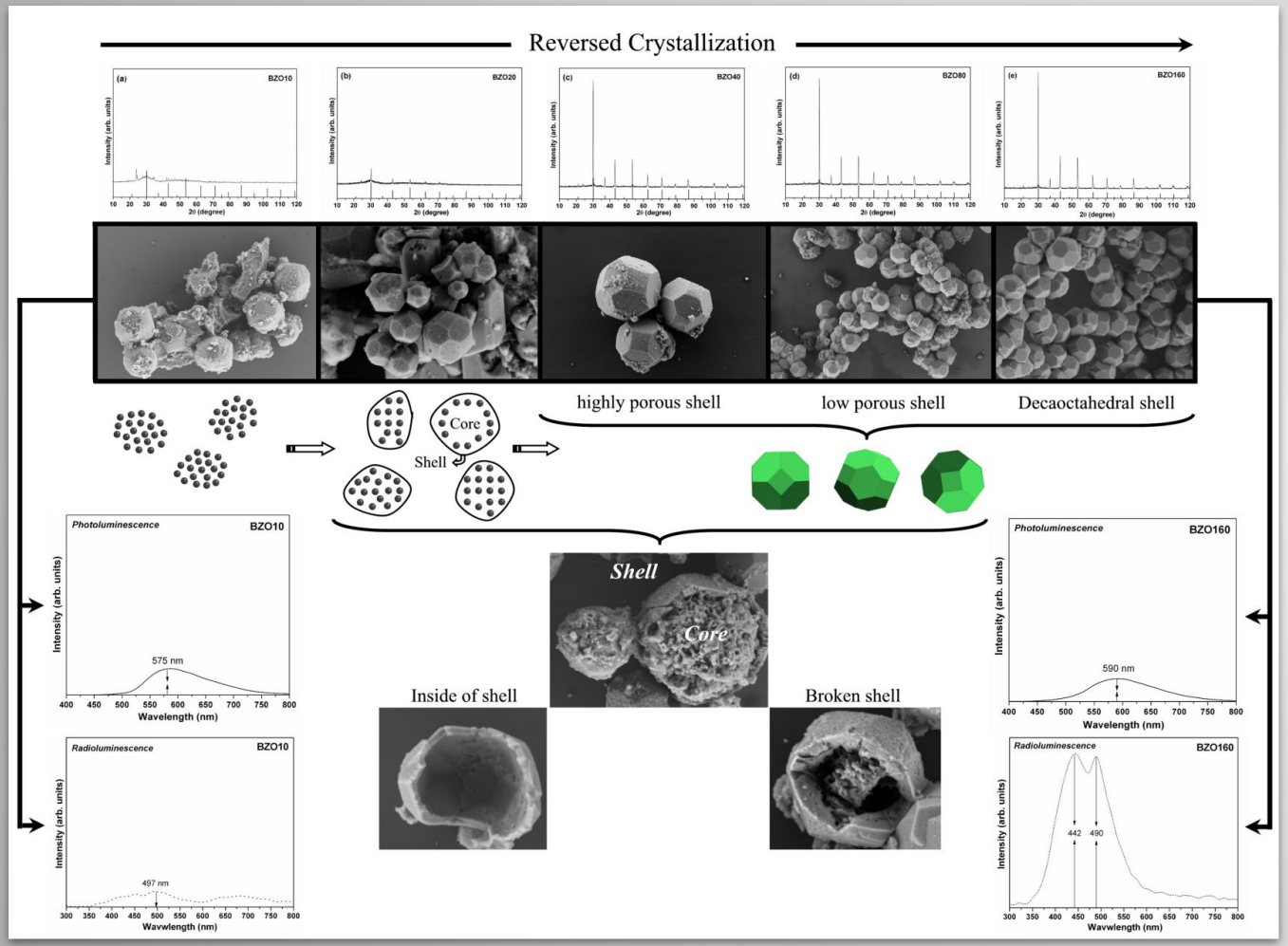
$BaZrO_3$

↓

RL Emission

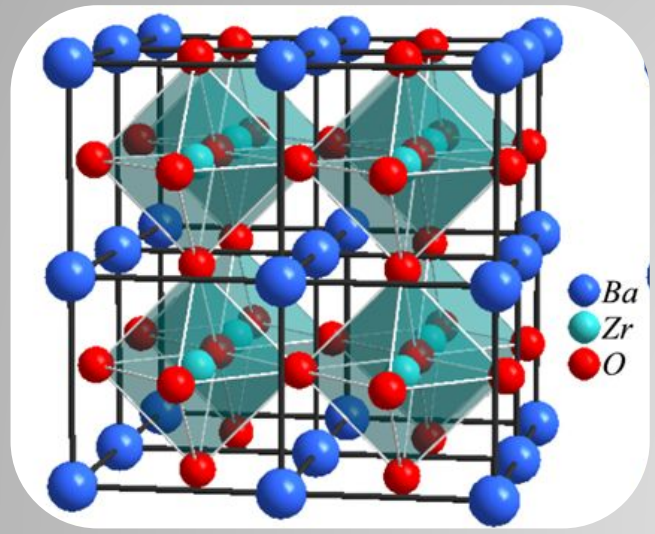


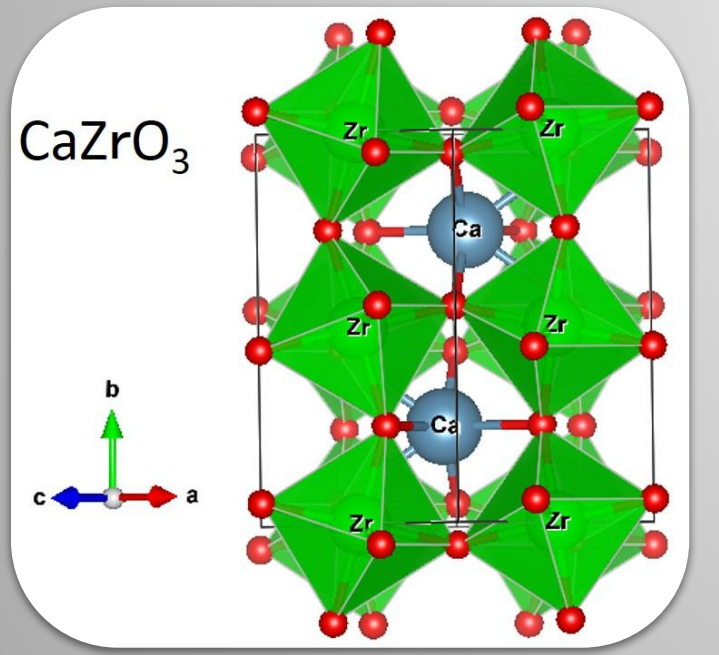
Microwave Assisted Hydrothermal Growth



- Hybrid Route - electromagnetic radiation in heat conduction;
- Temperature Homogeneity;
- High frequency E-field (~2.45 Ghz), that induces rotation of water polarization.

Polycrystalline growth methods





Solid State Reaction

- Temperatures: 1200 to 400 °C
- Time: 2 – 4 h

Polymer method

- Temperatures: 650 hasta 800 °C
- Time: 1 – 4 h

Hydrothermal

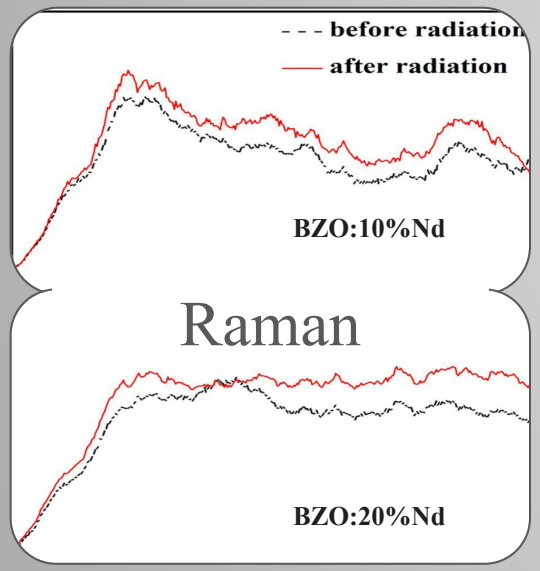
- Temperatures: 180 till 260 °C
- Time: 2 – 240 h

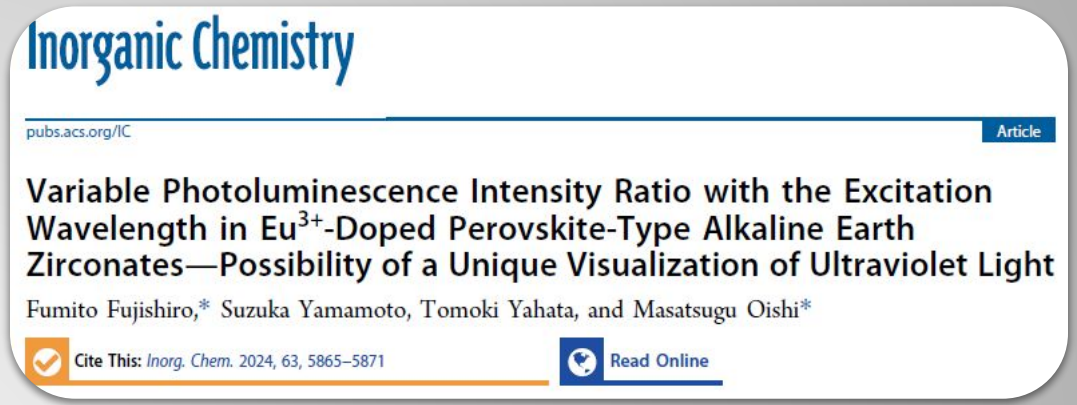
Microwave Assisted Hydrothermal method

- Temperatures: 100 till 180°C
- Time: 1 – 240 min

$BaZrO_3$ Perovskita Scintillator

- ➔ Have been investigated with RE-doped
- ➔ Exhibits structural stability under high doses of irradiation
- ➔ Investigated as a UV detector



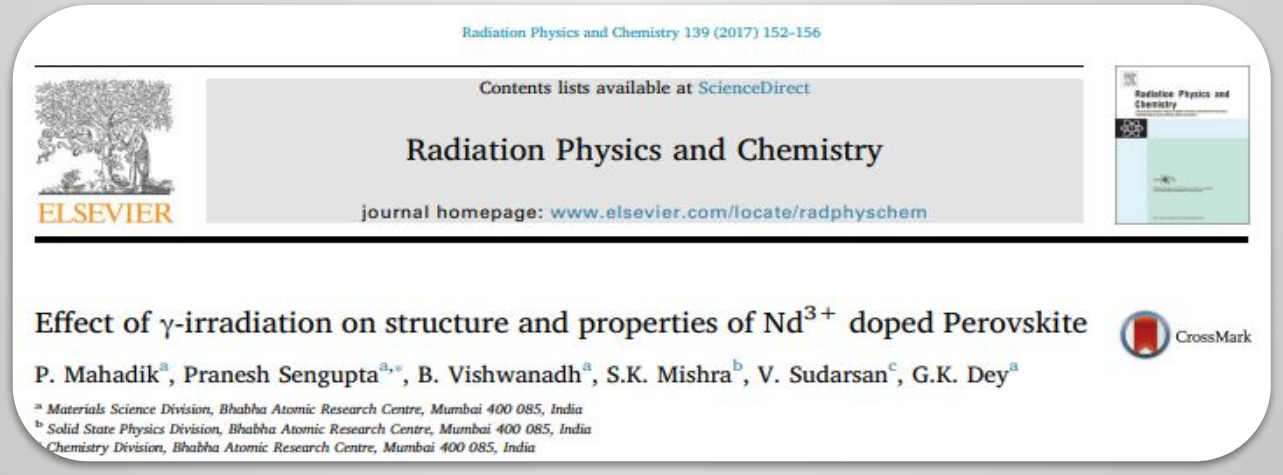

Inorganic Chemistry

pubs.acs.org/IC Article

Variable Photoluminescence Intensity Ratio with the Excitation Wavelength in Eu^{3+}-Doped Perovskite-Type Alkaline Earth Zirconates—Possibility of a Unique Visualization of Ultraviolet Light

Fumito Fujishiro,* Suzuka Yamamoto, Tomoki Yahata, and Masatsugu Oishi*

Cite This: *Inorg. Chem.* 2024, 63, 5865−5871 Read Online


Radiation Physics and Chemistry 139 (2017) 152–156

Contents lists available at ScienceDirect

Radiation Physics and Chemistry

journal homepage: www.elsevier.com/locate/radphyschem

Effect of γ-irradiation on structure and properties of Nd^{3+} doped Perovskite

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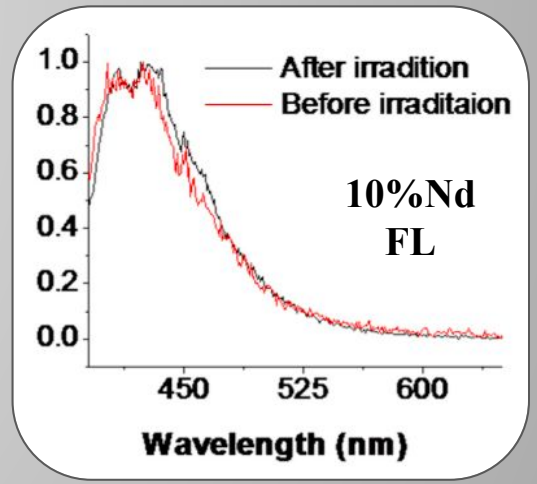
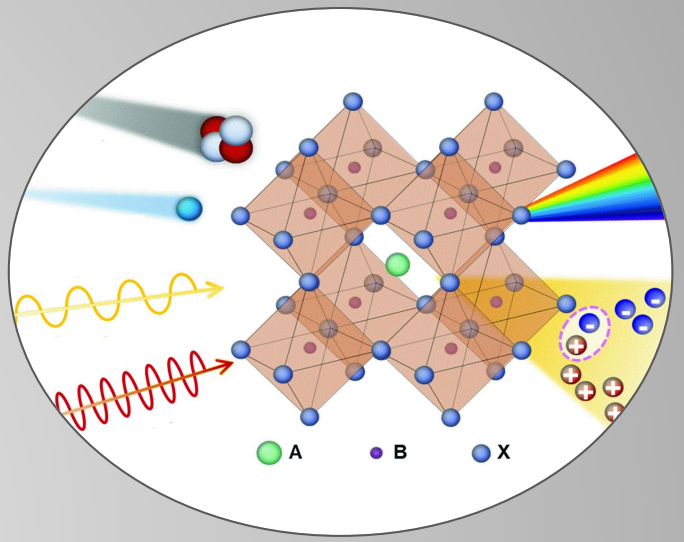


Powder samples (growth by solid state) irradiated with ^{60}Co source of 175 kGy with a rate about 2.6 kGy/h.

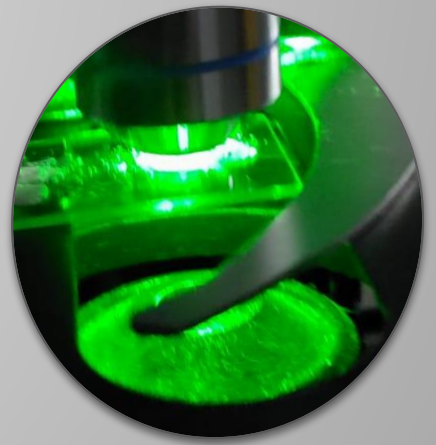
Purpose of this investigation



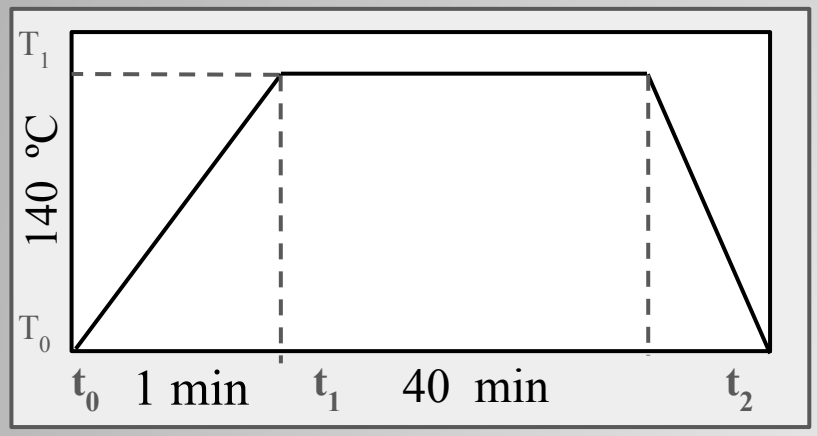
➔ To identified the viability of the $BaZrO_3$ as scintillator detector, this work aims to explore $BaZrO_3$ as an innovative material for ionizing radiation detection free-lead.

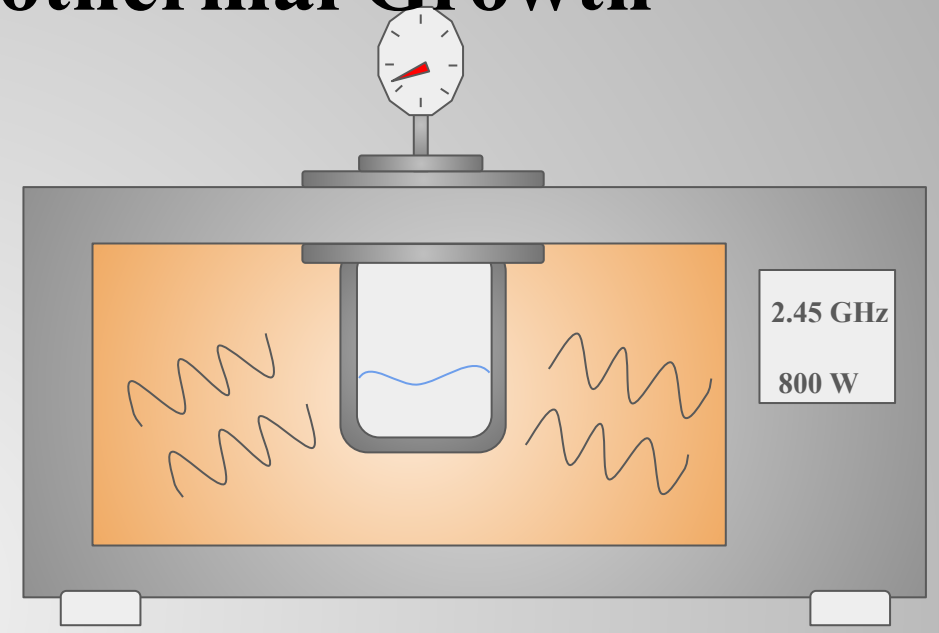
➔ Pure $BaZrO_3$ and rare-earth-doped $BaZrO_3$ materials were grown using the microwave-assisted hydrothermal method and characterized through:

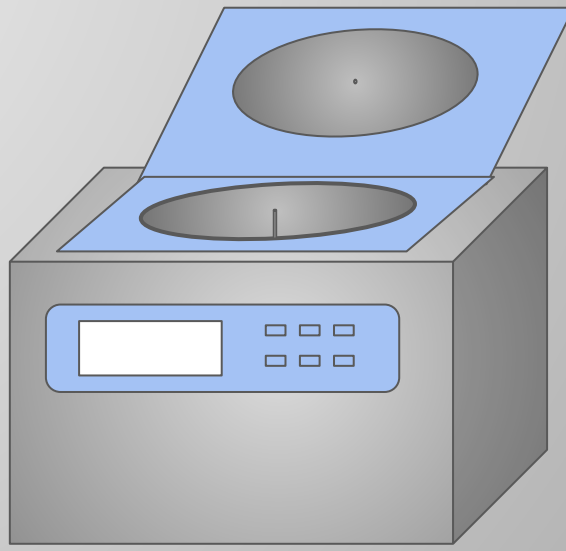
1. Structural Analysis (XDR, SEM and Rietveld Refinement)
2. Optical Analyses: Gap Energie and Radioluminescence
3. TOF

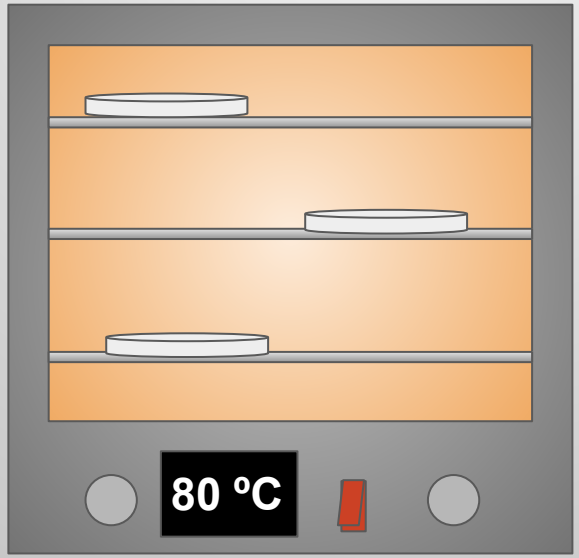


Microwave Assisted Hydrothermal Growth





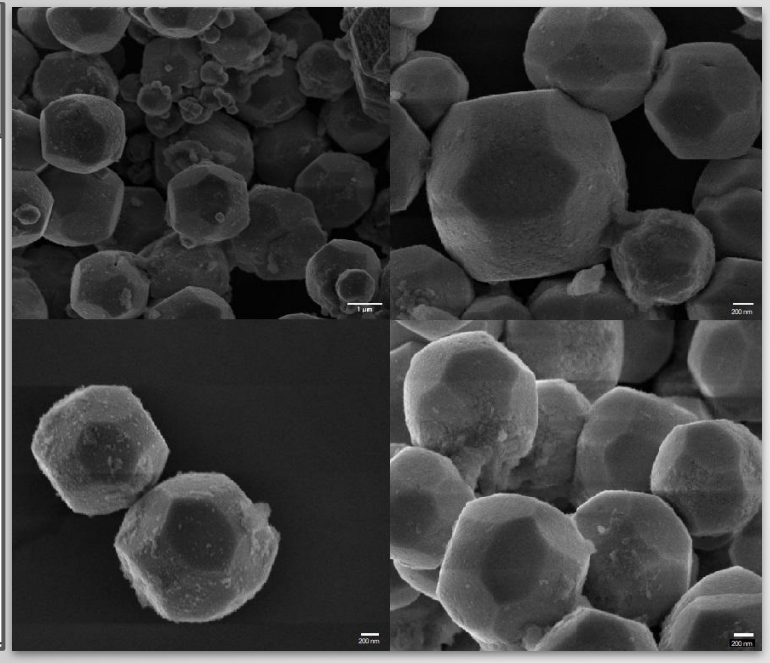




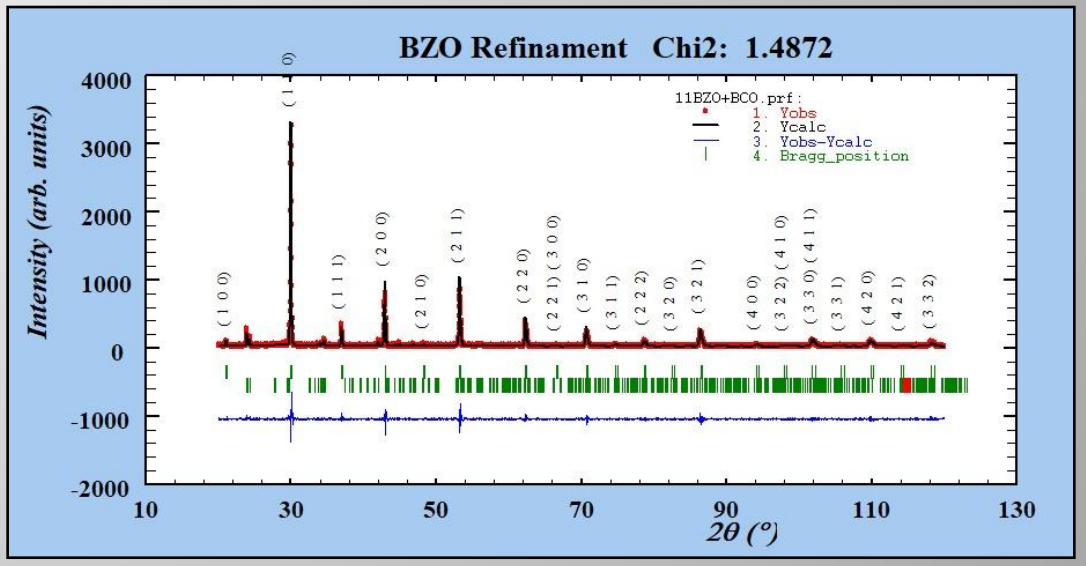
Structural Analysis

Scanning Electron Microscope

Sample	Diâmeter (μm)
$BaZrO_3$	2.3 ± 0.4
0,5%Ce	2.06 ± 0.2
1%Ce	2.6 ± 0.5
2%Ce	2.7 ± 0.4
4%Ce	1.4 ± 0.4
0,5%Er0,5%Ce	1.1 ± 0.2
0,5%Er1%Ce	1.3 ± 0.3
0,5%Er2%Ce	1.3 ± 0.3
0,5%Er4%Ce	1.3 ± 0.3

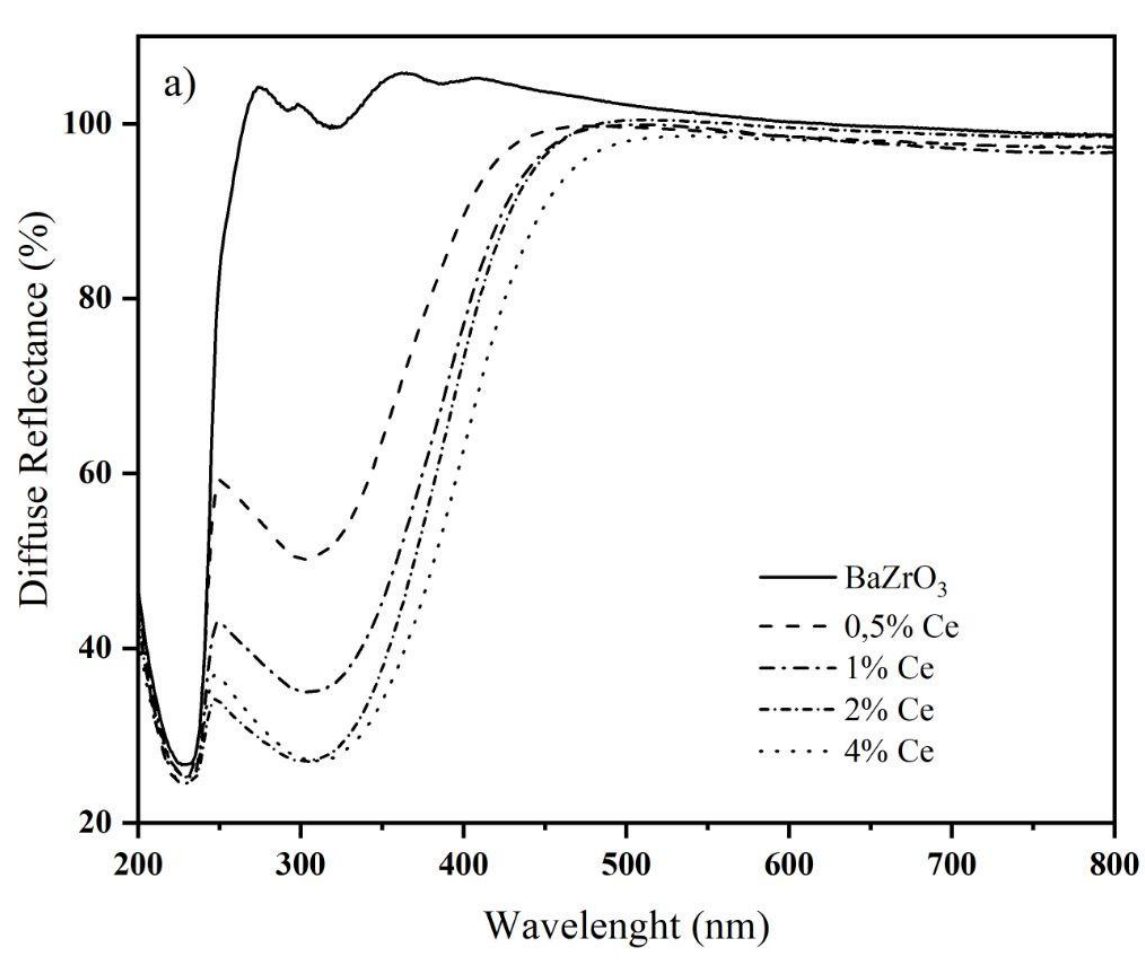


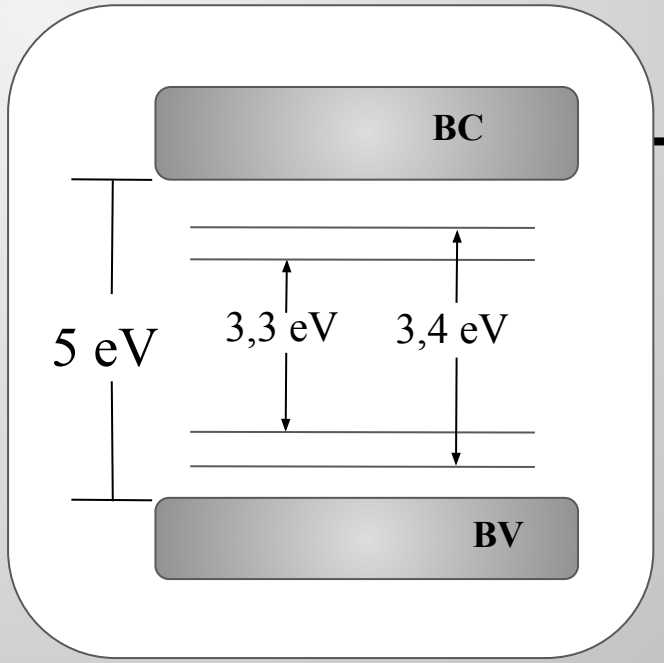
XDR and rietveld refinement
The density (volumic mass) of phase 1 is estimated by 6.154 g/cm3

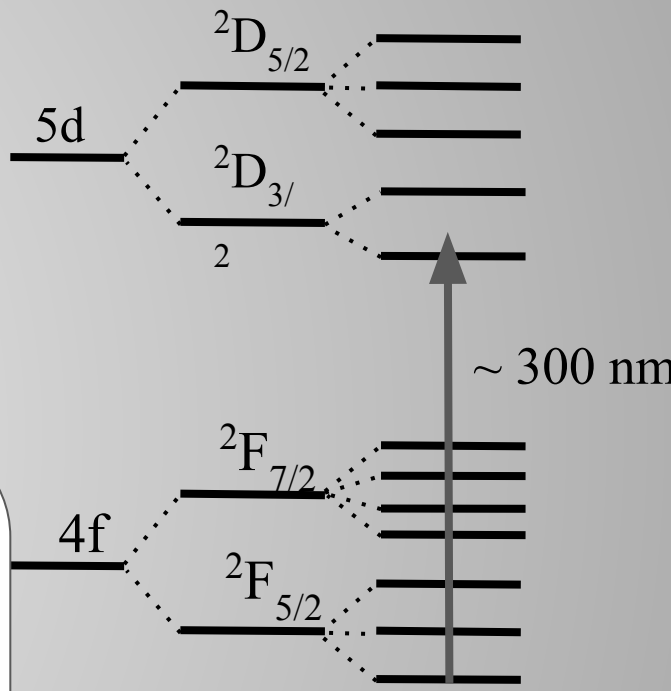


Optical Analysis

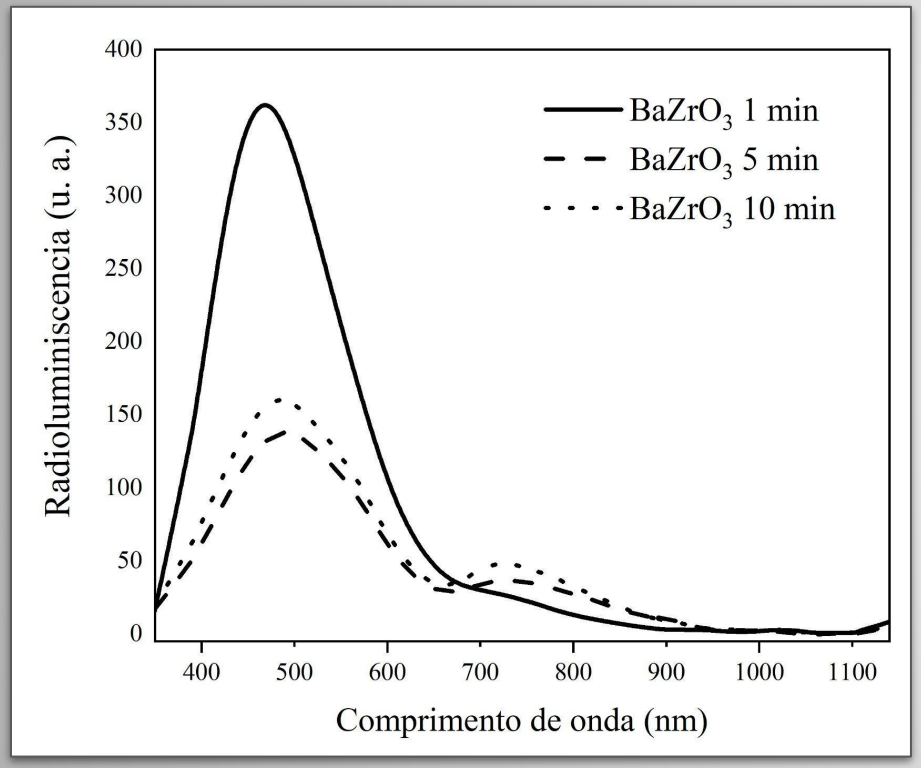
Diffuse Reflectance to estimate the band gap

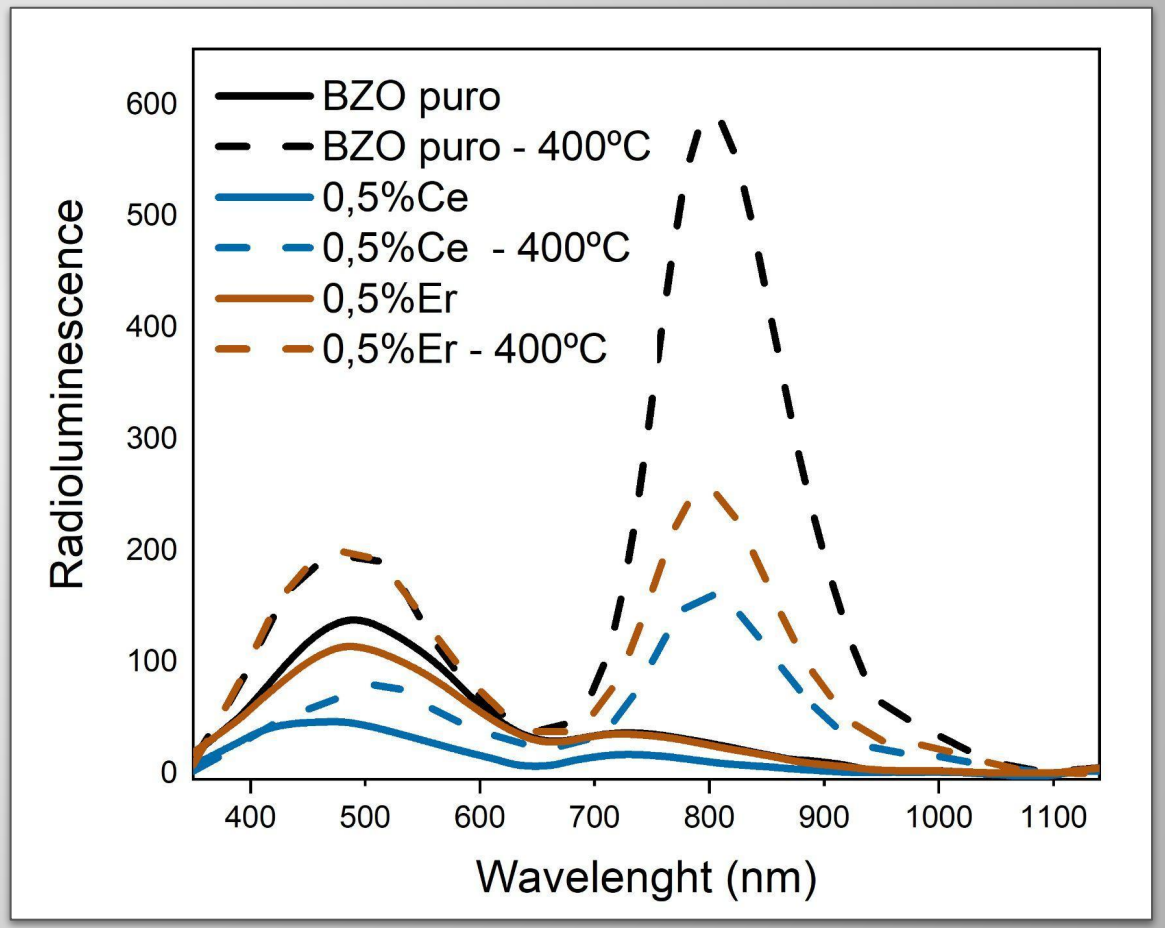






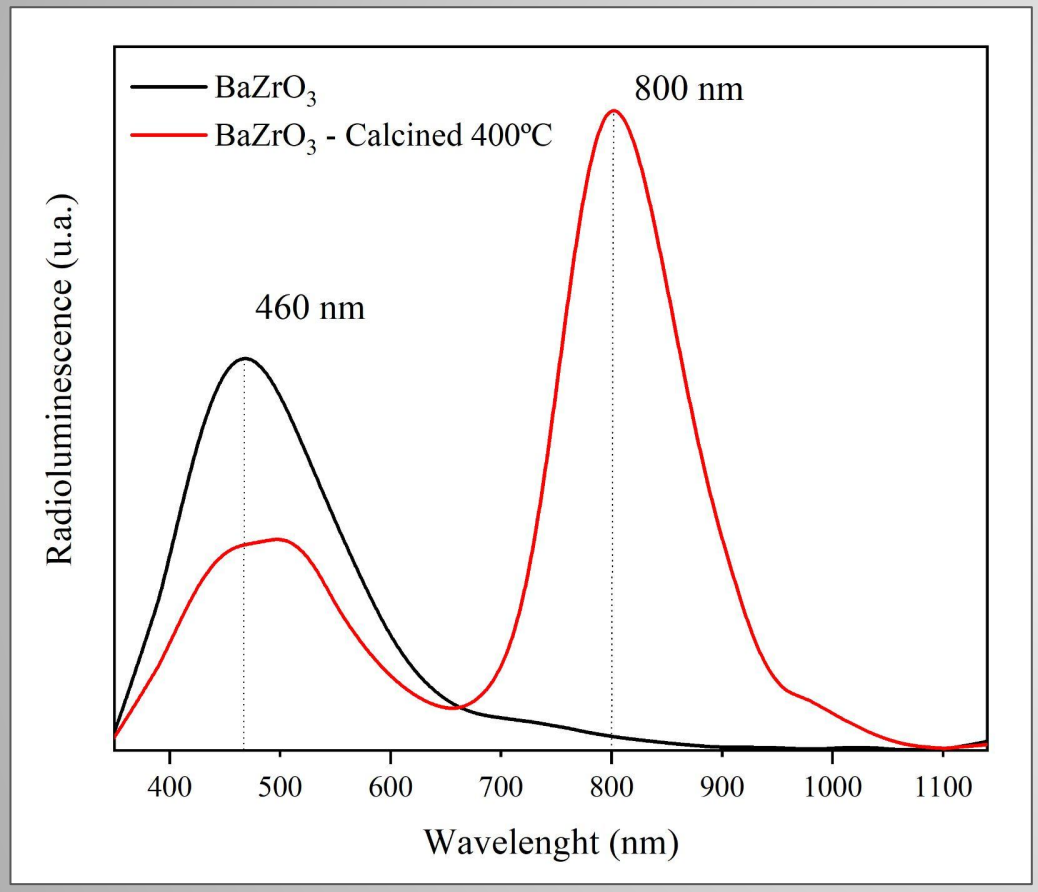
Radioluminescence a room temperature
X-RAY 45 KeV



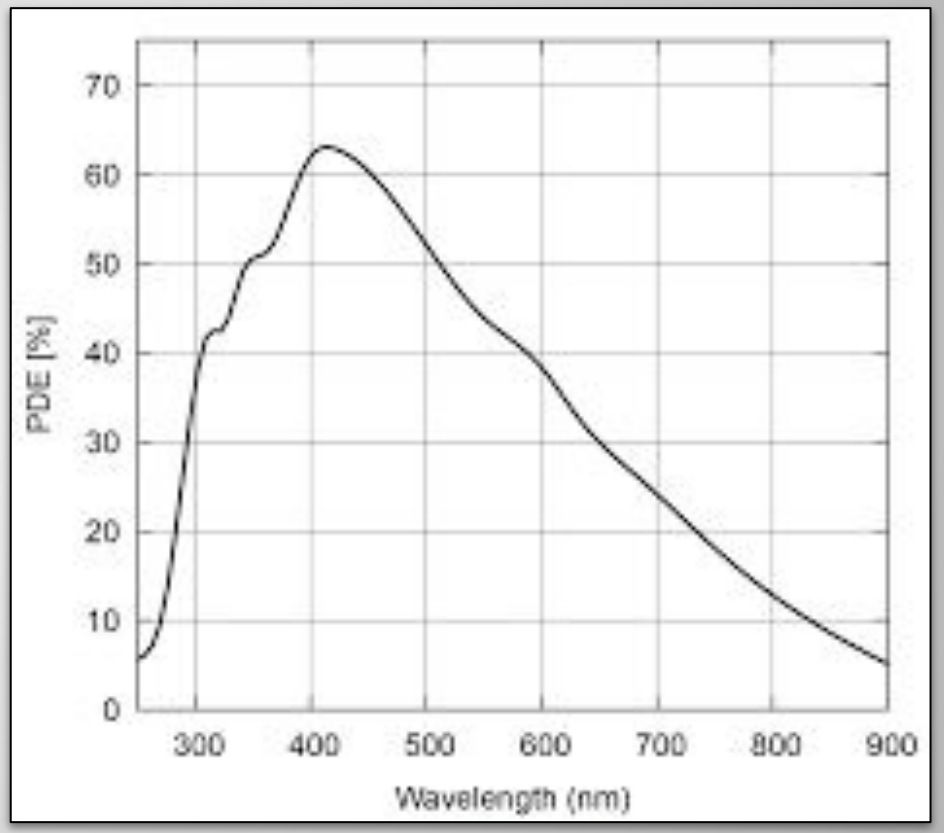


Spectroscopy
Ocean Optics QE 6500 Pro

Radioluminescence a room temperature
X-RAY 45 KeV



Spectroscopy
Ocean Optics QE 6500 Pro



SiPM Photon Detection
Efficiency

CAPES

CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

Rayos-x ✓

BUT

Nuclear Radiation?

UNIVERSIDAD COMPLUTENSE MADRID

Collaboration:

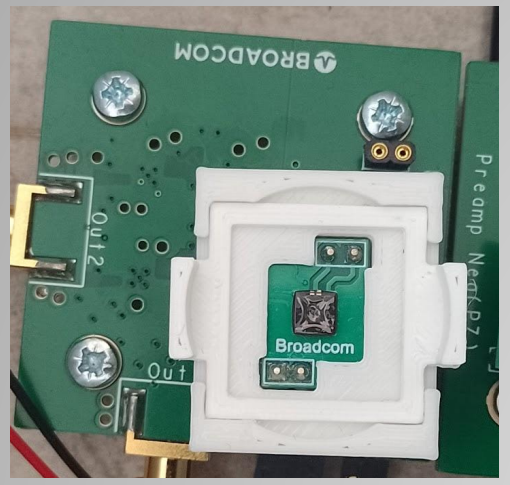
BRAZIL X VENEZUELA X SPAIN

UFPel X IVIC X CSIC

Time-of-Flight

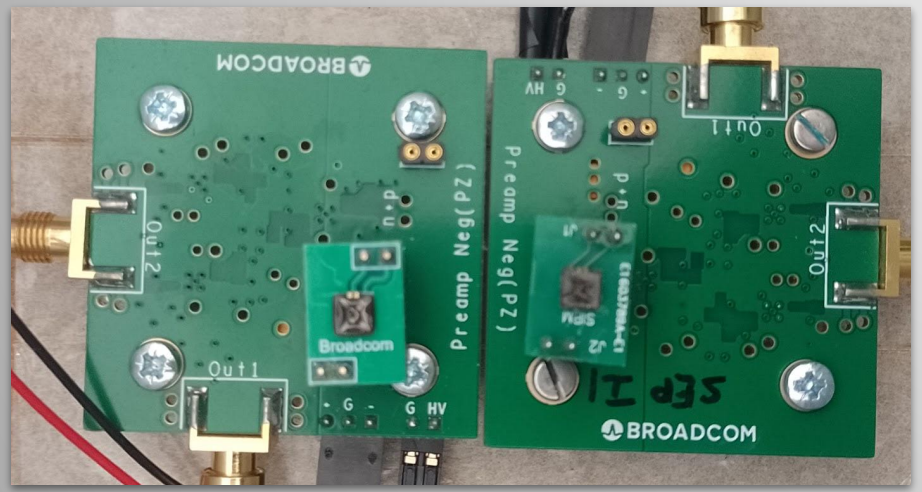
Na-22 Source

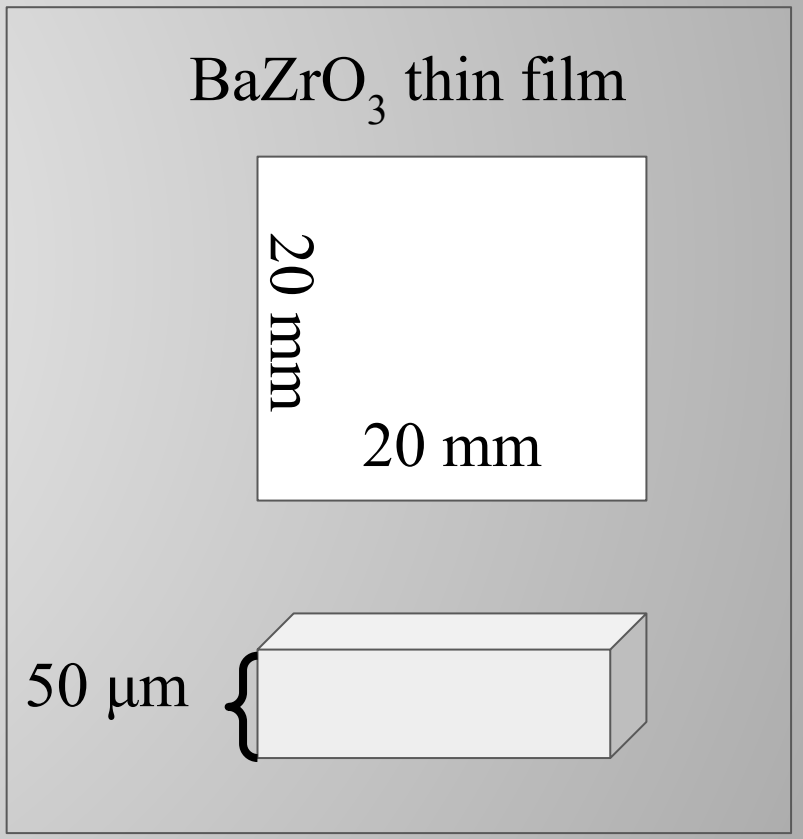
Polycrystalline Thin Film x LYSO



SiPM 4x4 mm

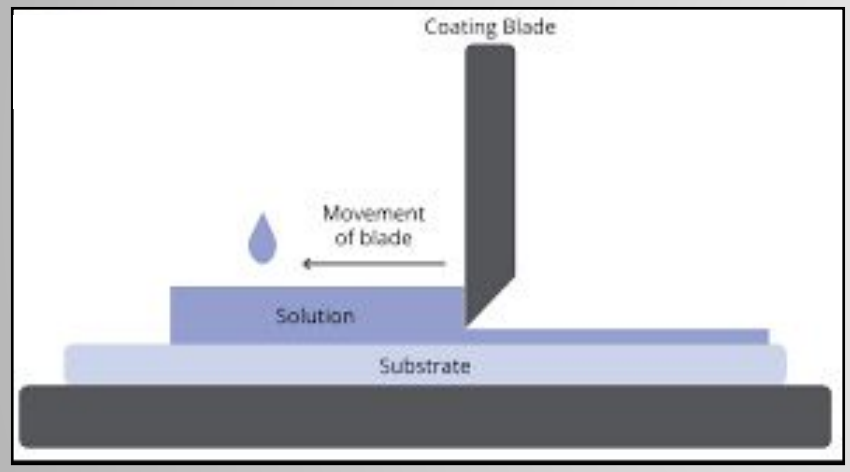
LYSO 4x4x30 mm

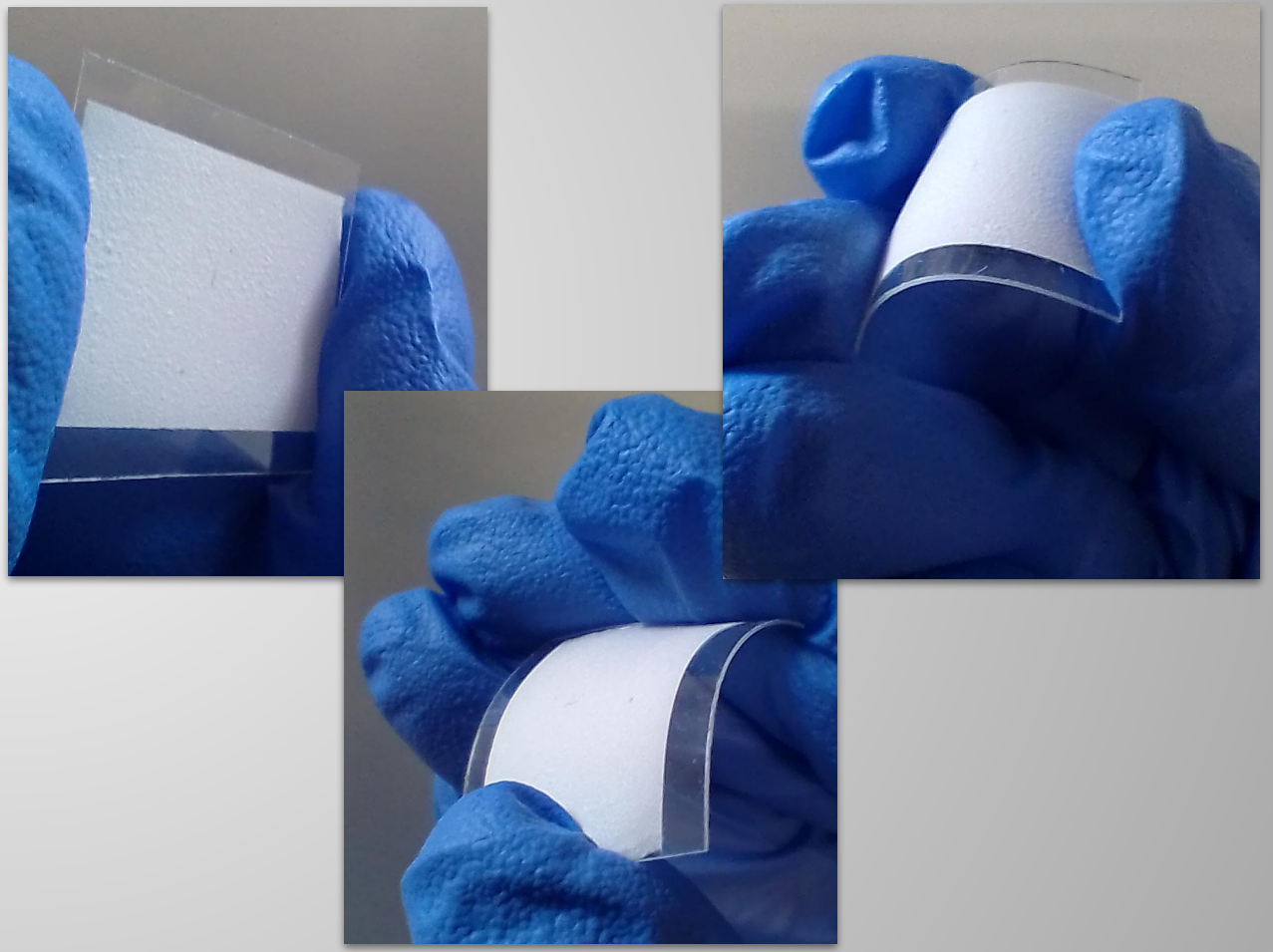


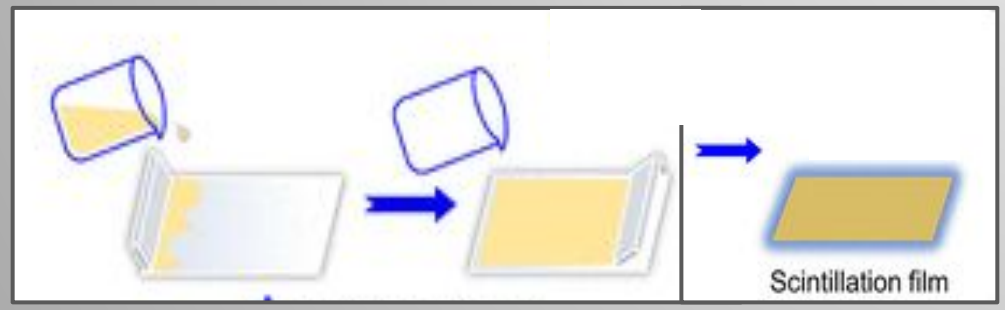


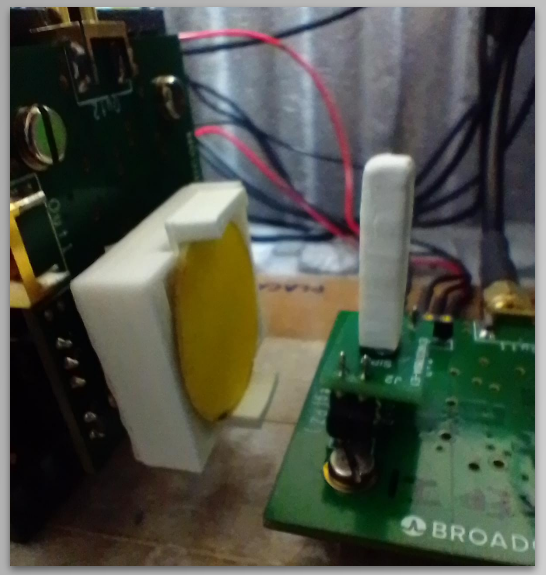
Thin Film - Blade coating technique

Powder + Varnish + Etanol blade coating in Polyvinyl sheet substrate





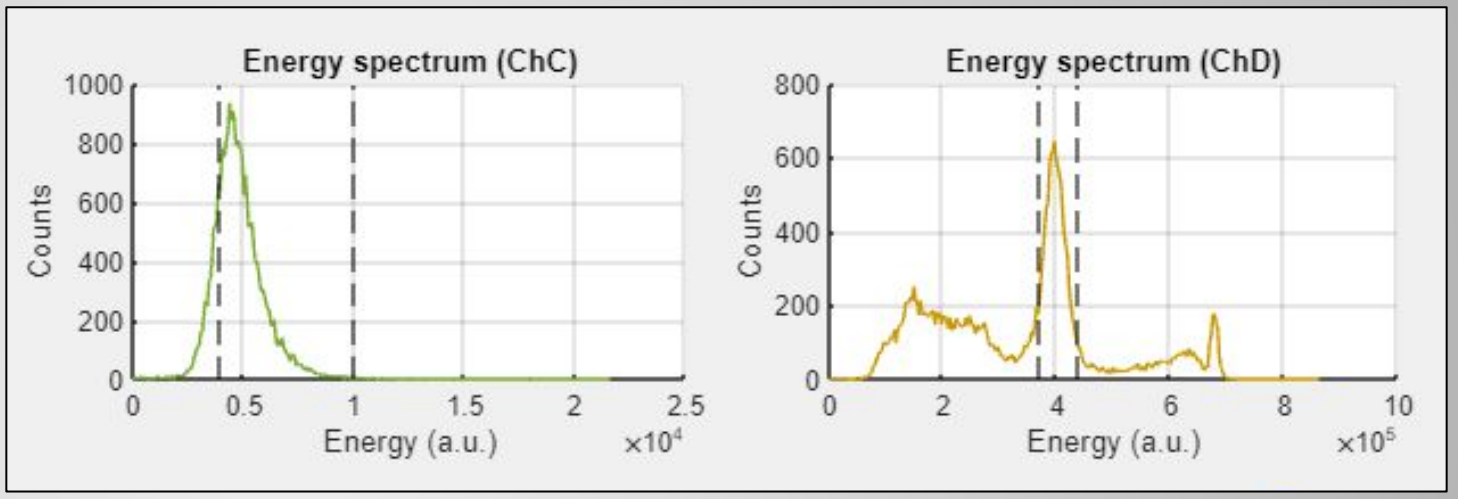




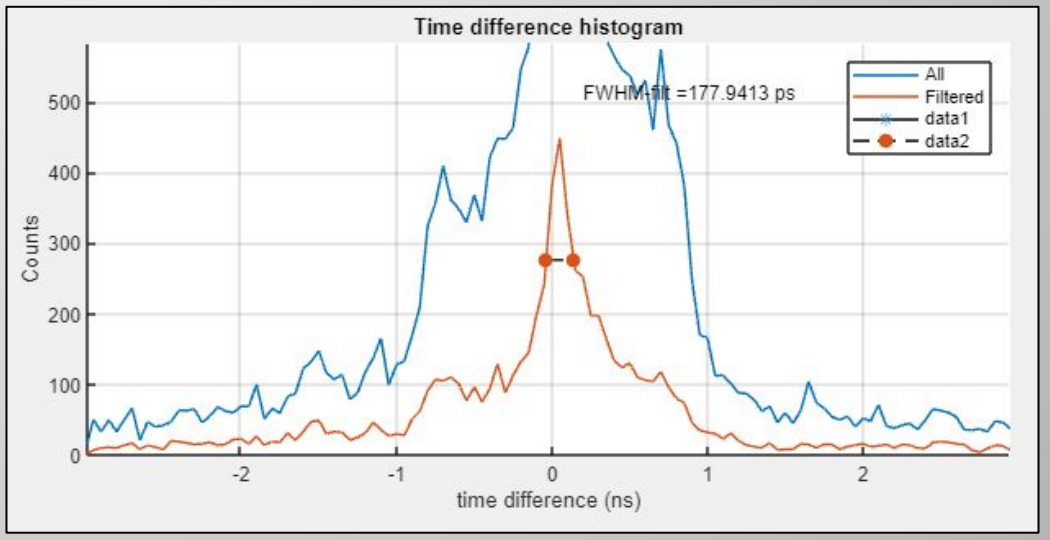
Time-of-Flight

Na-22 Source

Thin Film $BaZrO_3$ 80 µmx LYSO 20mm



Timing resolution ~153 ps

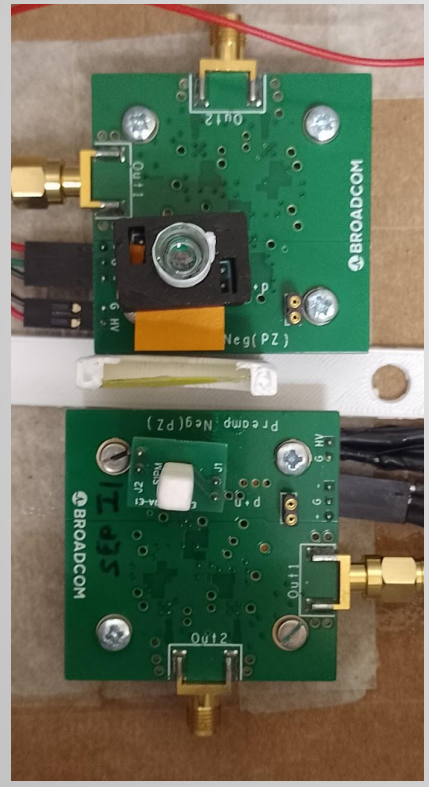


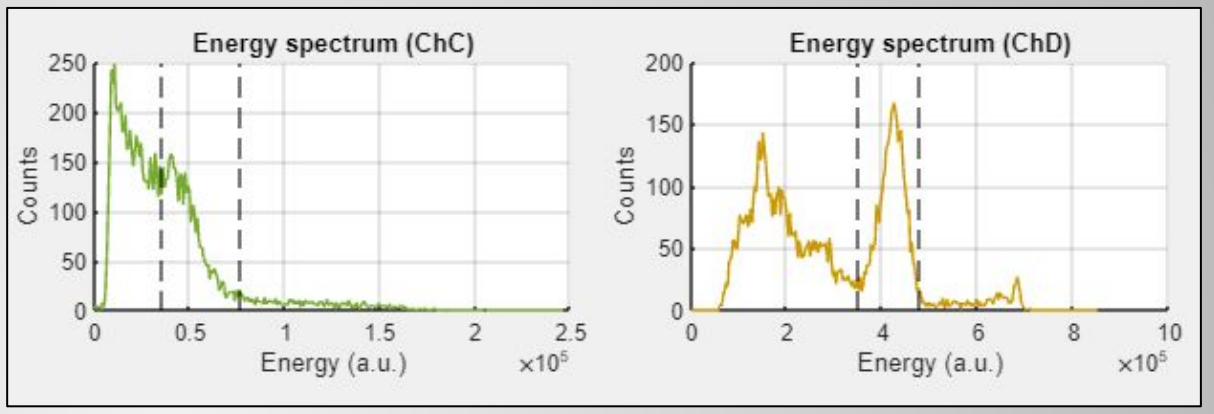
Time-of-Flight

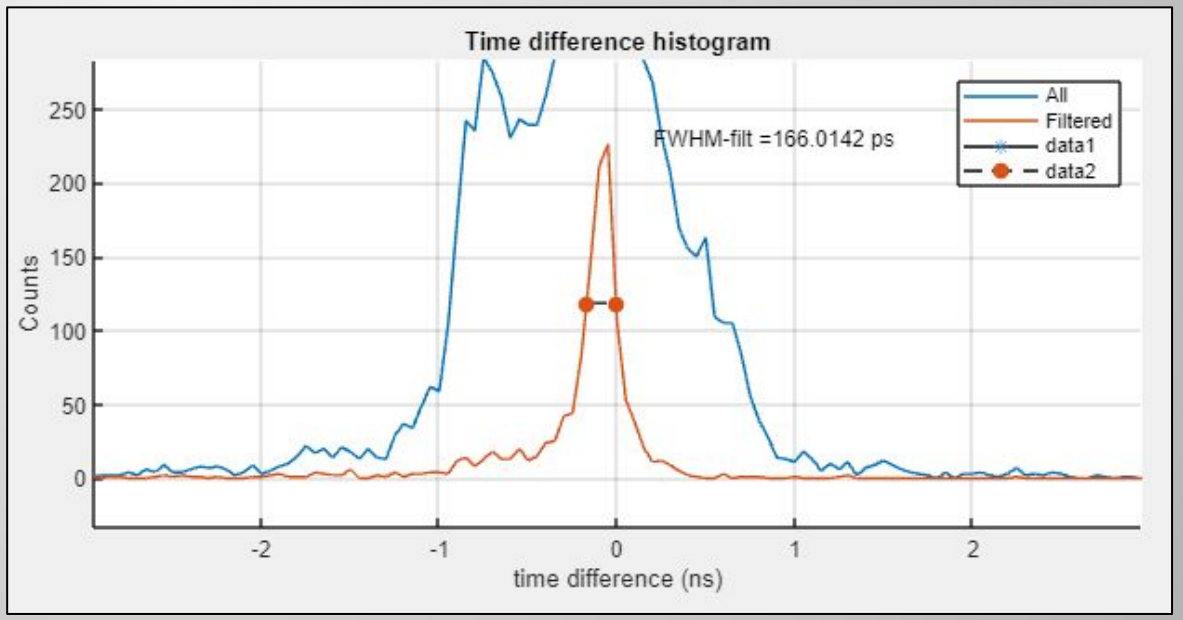
Na-22 Source

Liquid Scintillator PPO x LYSO 20mm

Timing resolution ~166 ps



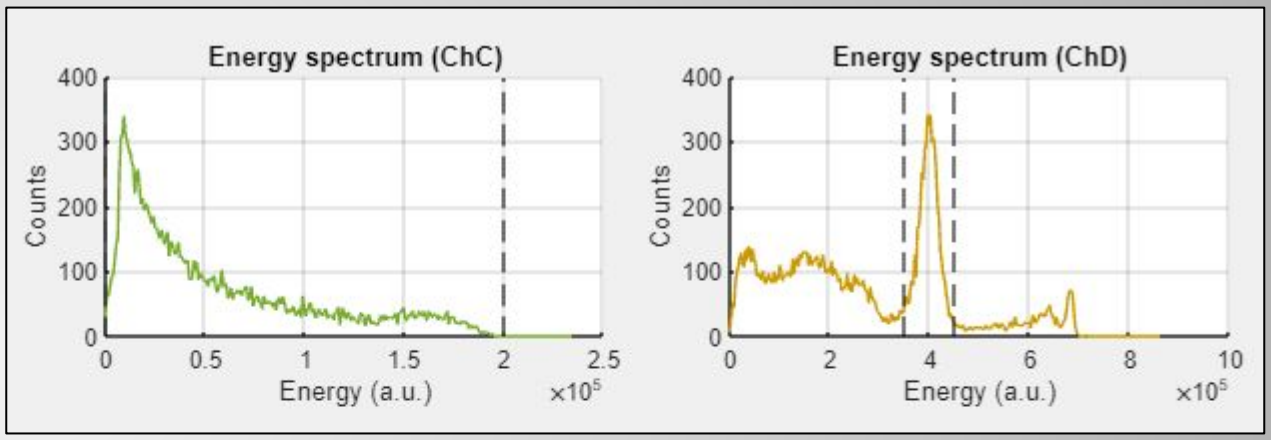




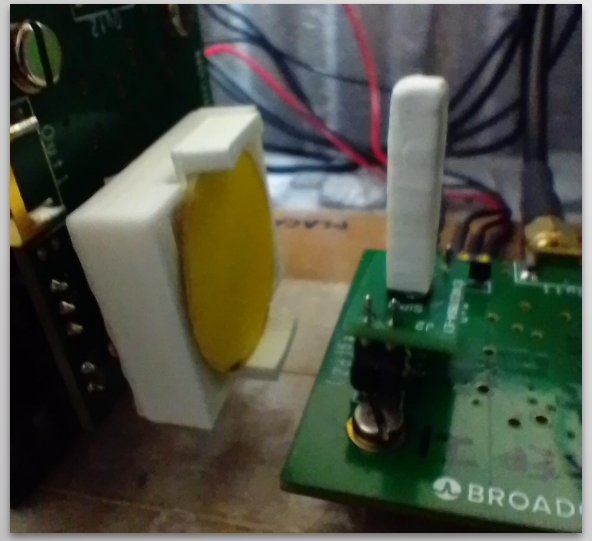
Time-of-Flight

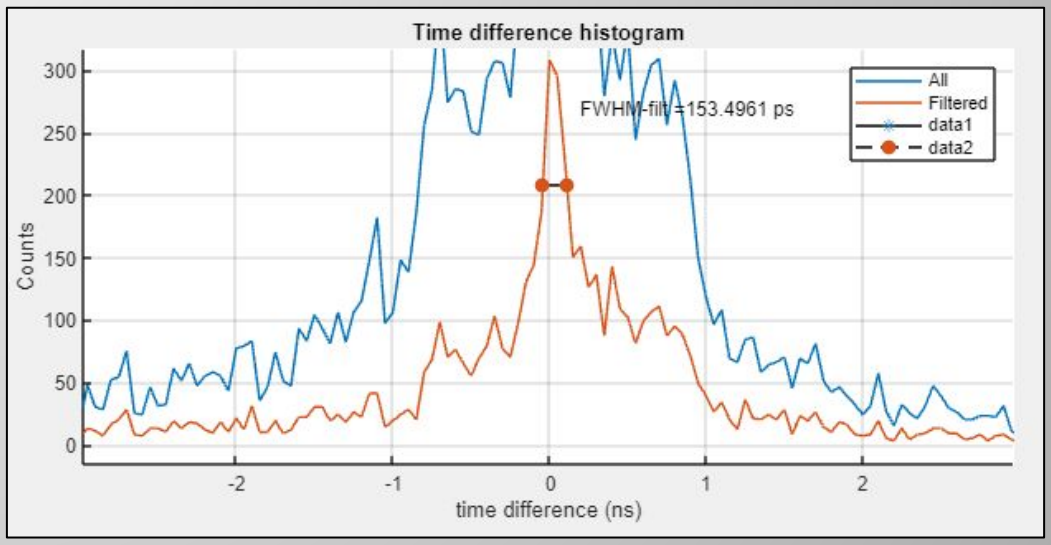
Na-22 Source

LYSO Thin Film 80 μm x LYSO 20mm



Timing resolution ~153 ps



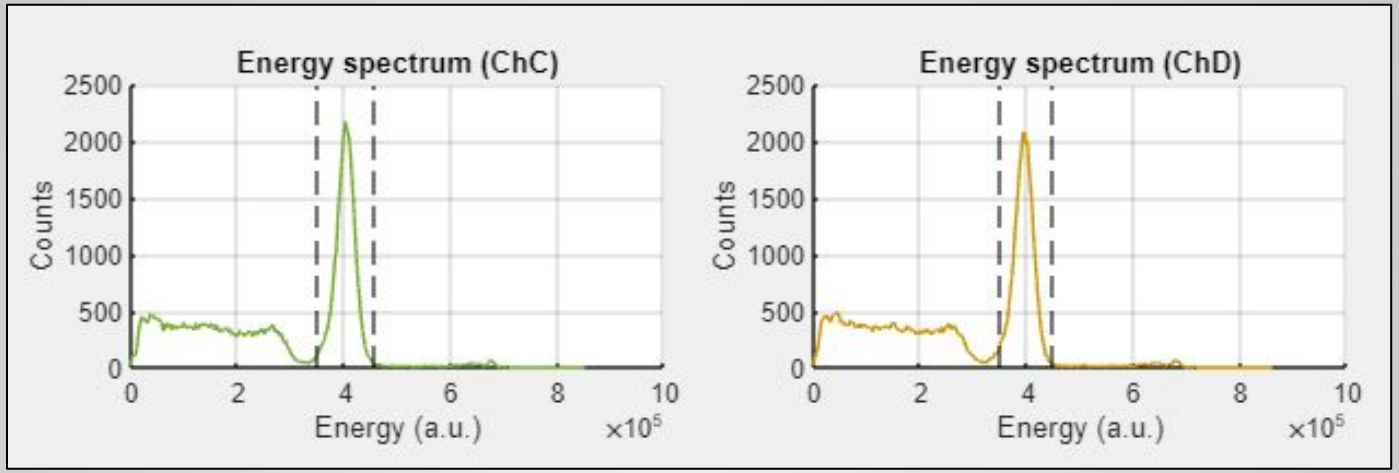


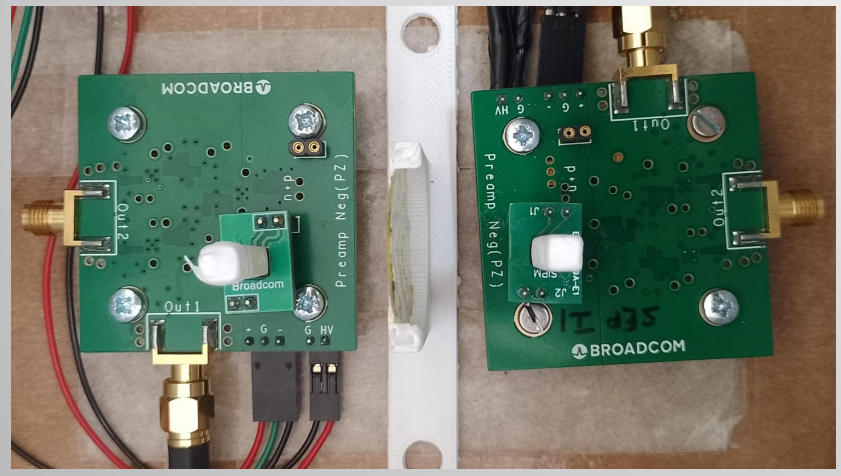
Time-of-Flight

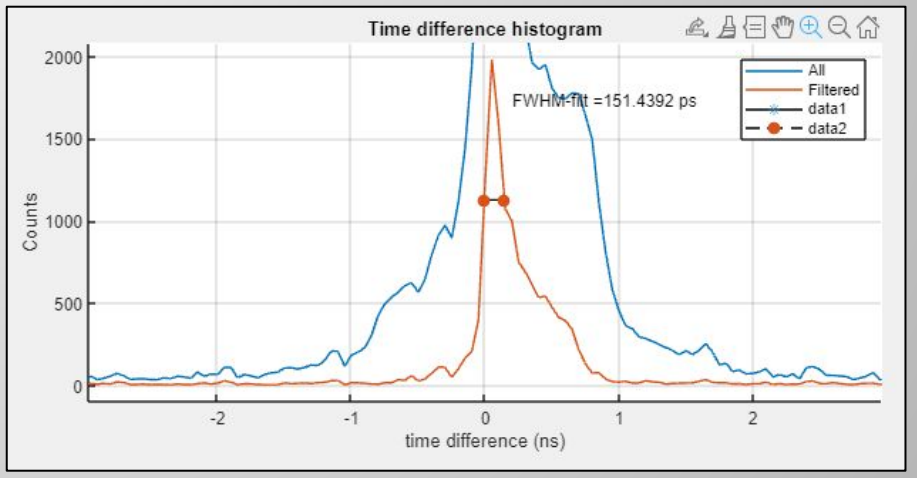
Na-22 Source

LYSO 20mm x LYSO 20mm

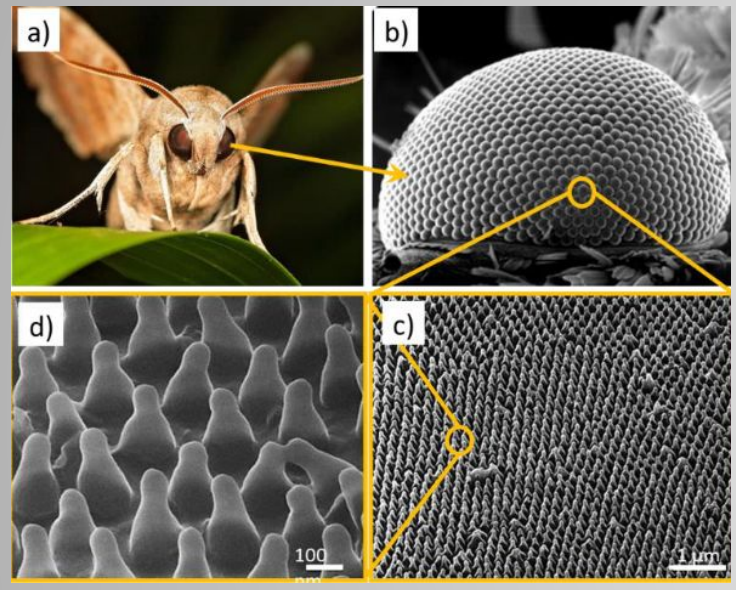
Timing resolution ~151 ps



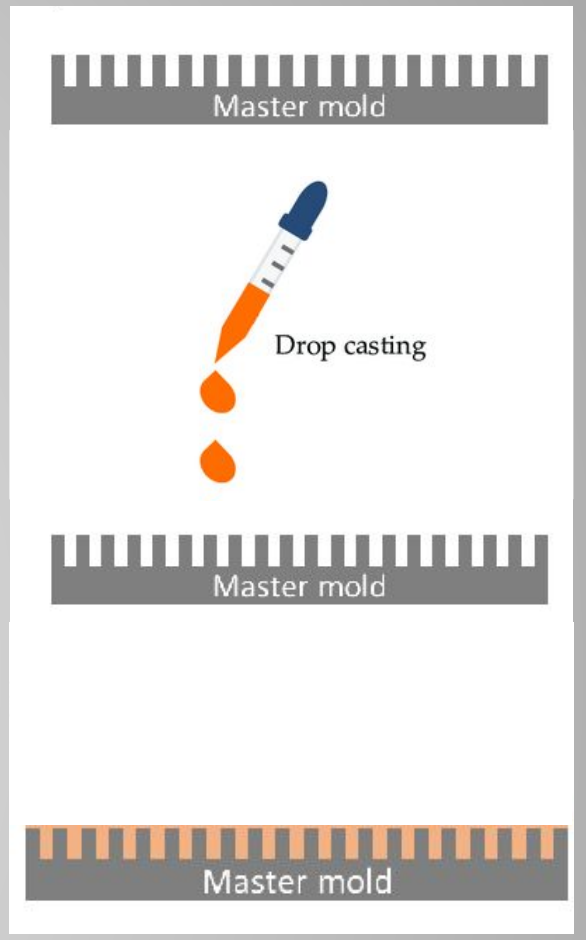


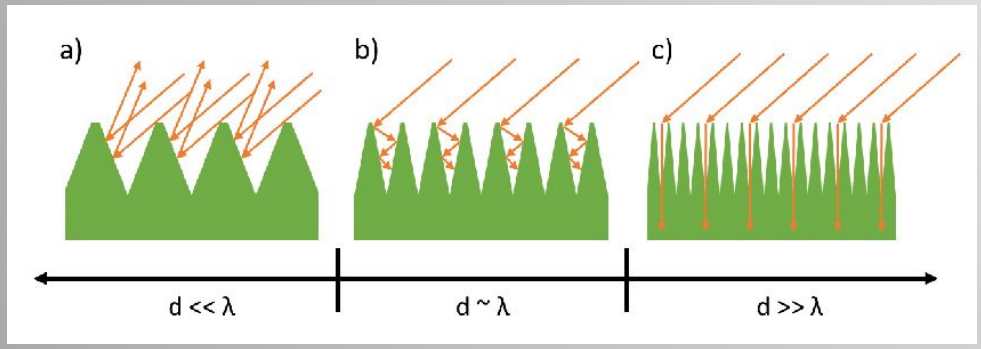


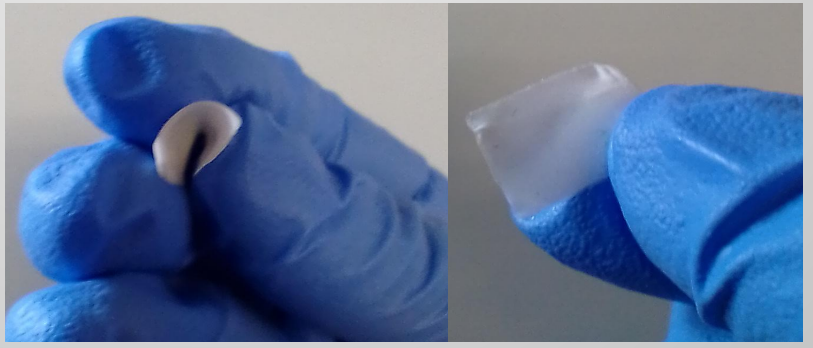
Working in Progress

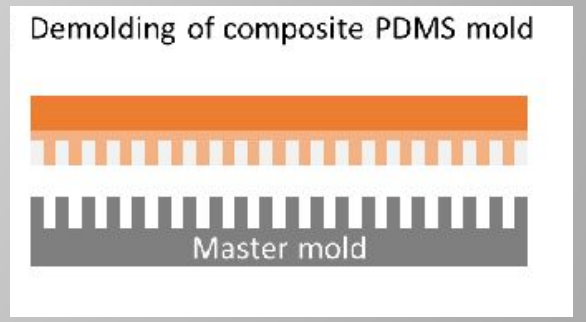


Decreases reflexive light between interfaces with nanostructured anti-reflective surfaces

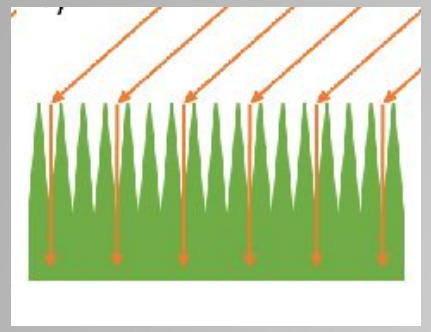




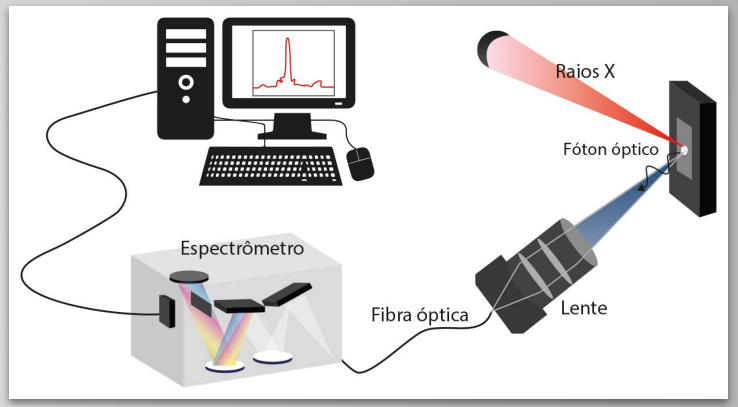


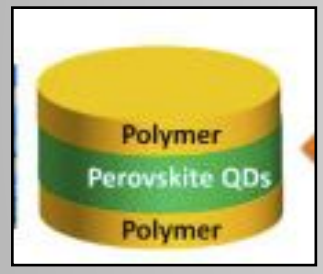


Next Steps



Improve the luminescence emission and transmission to SiPM



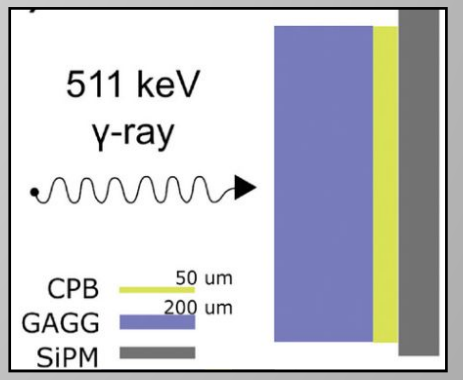


Investigate LY and Decay time

Heterojunction detector

Growth new crystals, others Perovskites and correlates

New analysis and devices in the SIRIUS facilities (Brazilian Synchrotron)



AGRADECIMIENTOS

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CAPES

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CDMF
CENTRO DE DESENVOLVIMENTO DE MATERIAIS FUNCIONAIS

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PROGRAMA DE PÓS-GRADUAÇÃO EM FÍSICA UFPEL

UNIVERSIDAD COMPLUTENSE MADRID

CCAF
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Plataforma Lattes | CNPq

Thank you

CCAF
CRESCIMENTO DE CRISTAIS AVANÇADOS E FOTÔNICA