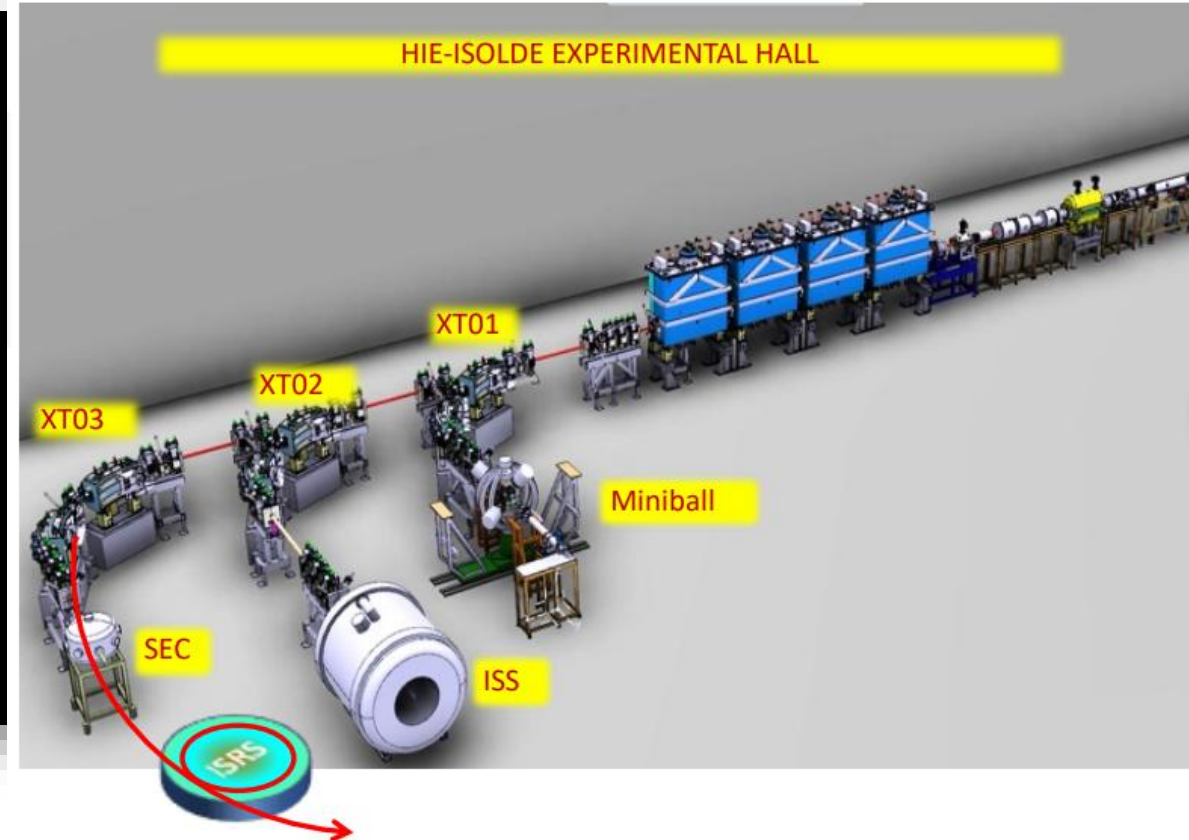
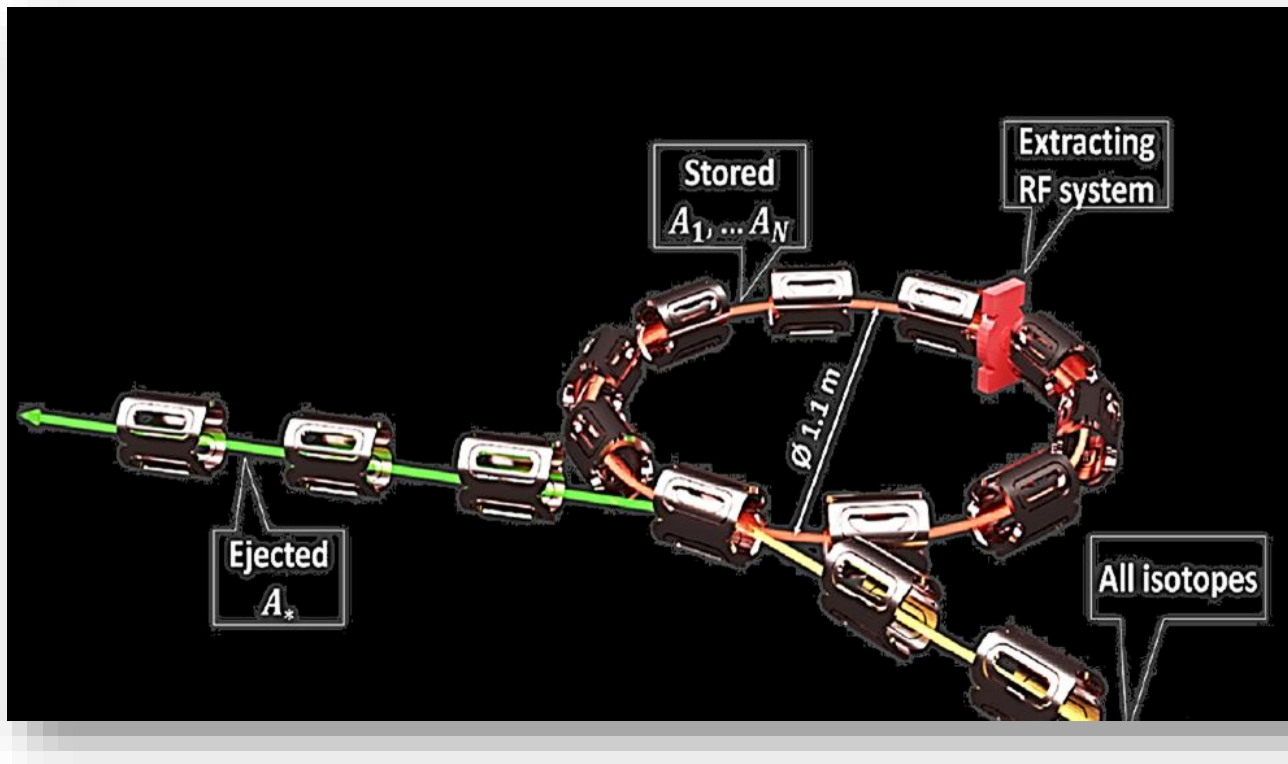


CSIC Institute of Structure of Matter

Prof. Dr. Teresa Kurtukian Nieto

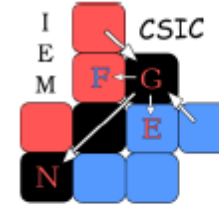
Professor of Research
c/ Serrano 121, E28006 Madrid
Teresa.Kurtukian@csic.es

ISRS (ISOLDE Superconducting Recoil Separator) is a CERN-ISOLDE project (funded by MRR BOE-A-2023-16885 3 M€) aimed at studying radioactive nuclei produced at the energy levels of interest by different reaction mechanisms. ISRS consists of a superconducting storage ring that enables mass identification of nuclei via time-of-flight measurements. The decays of exotic nuclei can be observed by detecting particles or photons using high-resolution detection systems.



CSIC-IEM, Focal Plane Detector and Ion-Optics team :

L. Acosta, A. Alegre, M. J G. Borge, J. Correa, T. Kurtukian, J.F. Linares, A. Perea, S. Sánchez, O. Tengblad



Development of perovskite-based scintillator films for fast timing applications

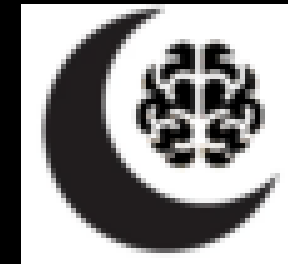
L. Acosta¹, A. Alegre¹, S. España², M.C. Gavilanes⁴, J.F. González-Linares¹,
T. Kurtukian-Nieto¹, D. Mesquita³, B. Olaizola¹

¹Instituto de Estructura de la Materia –CSIC (Madrid, SPAIN)

²Instituto de Tecnologías Físicas y de la Información –CSIC (Madrid, SPAIN)

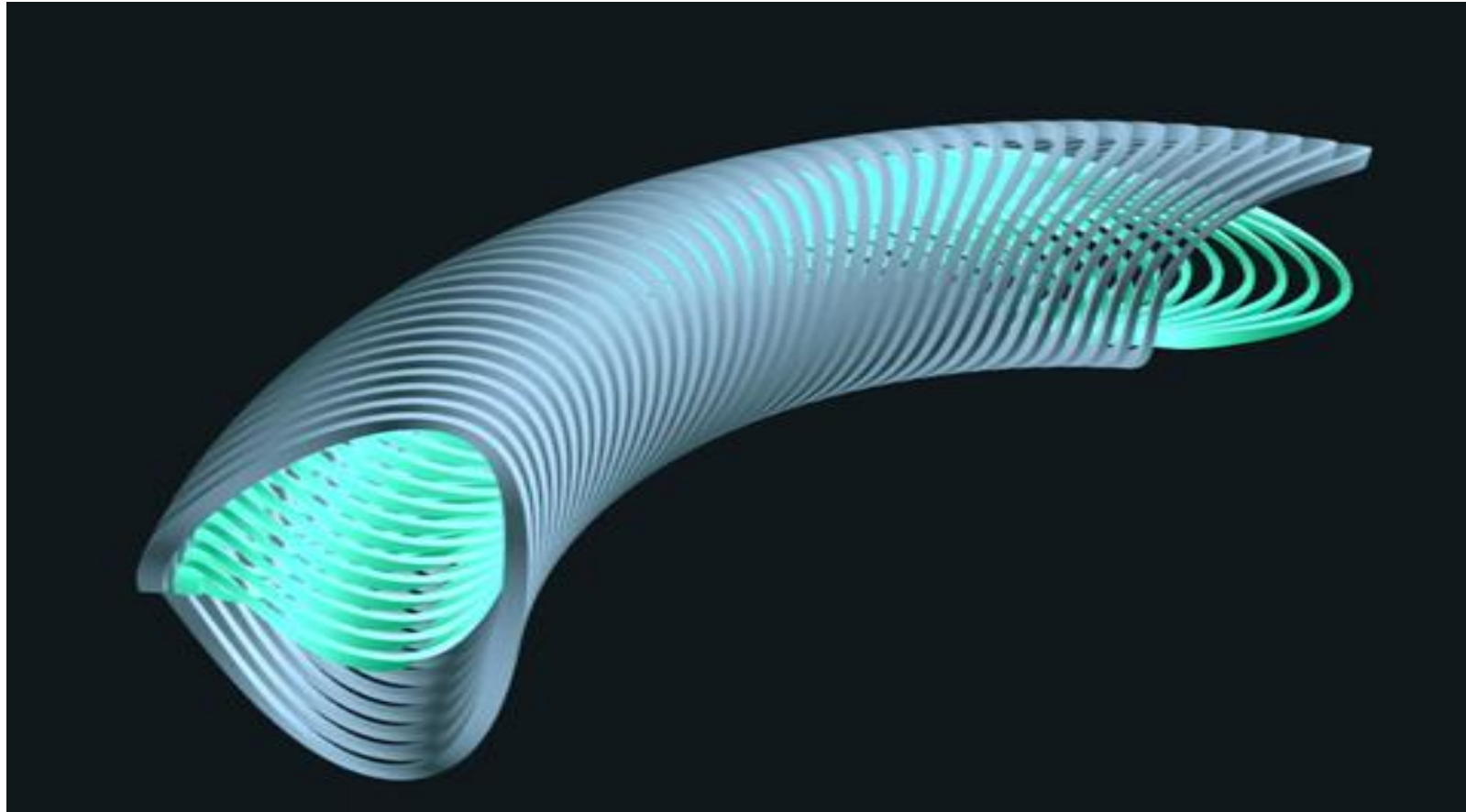
³Universidade Federal de Pelotas (BRAZIL)

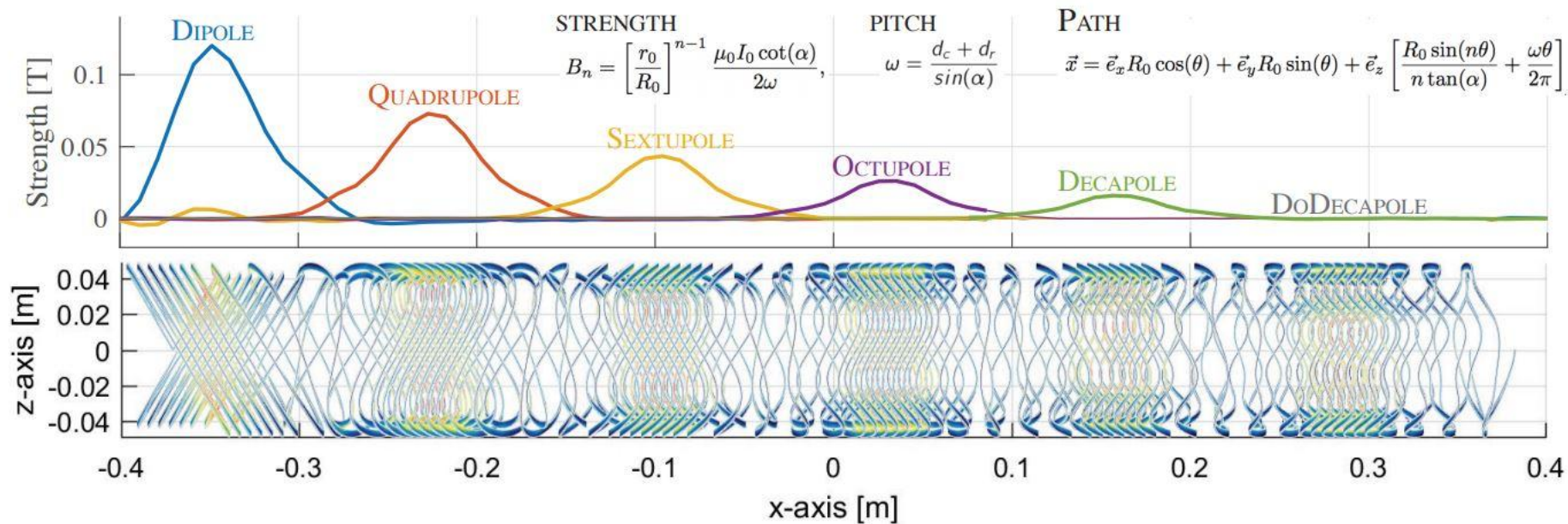
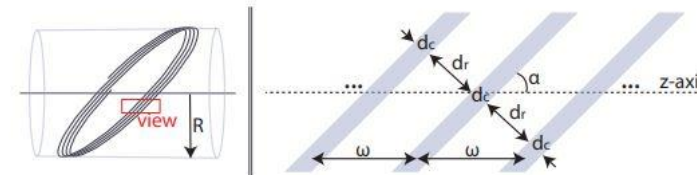
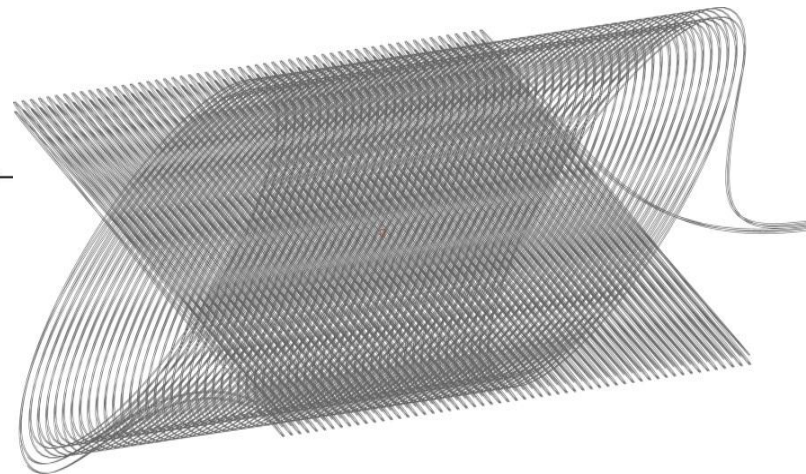
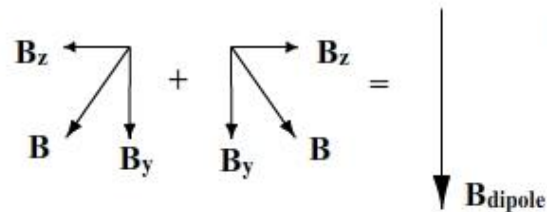
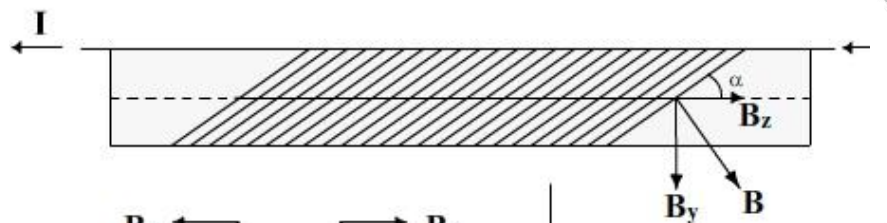
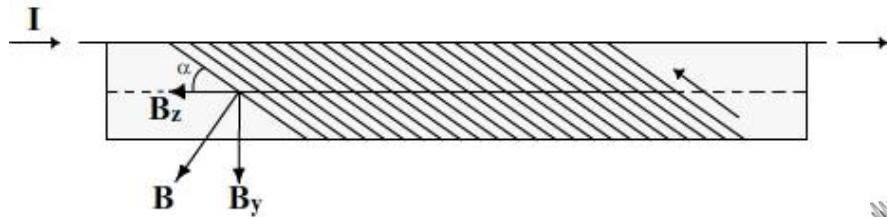
⁴Universidad Complutense de Madrid (Madrid, SPAIN)



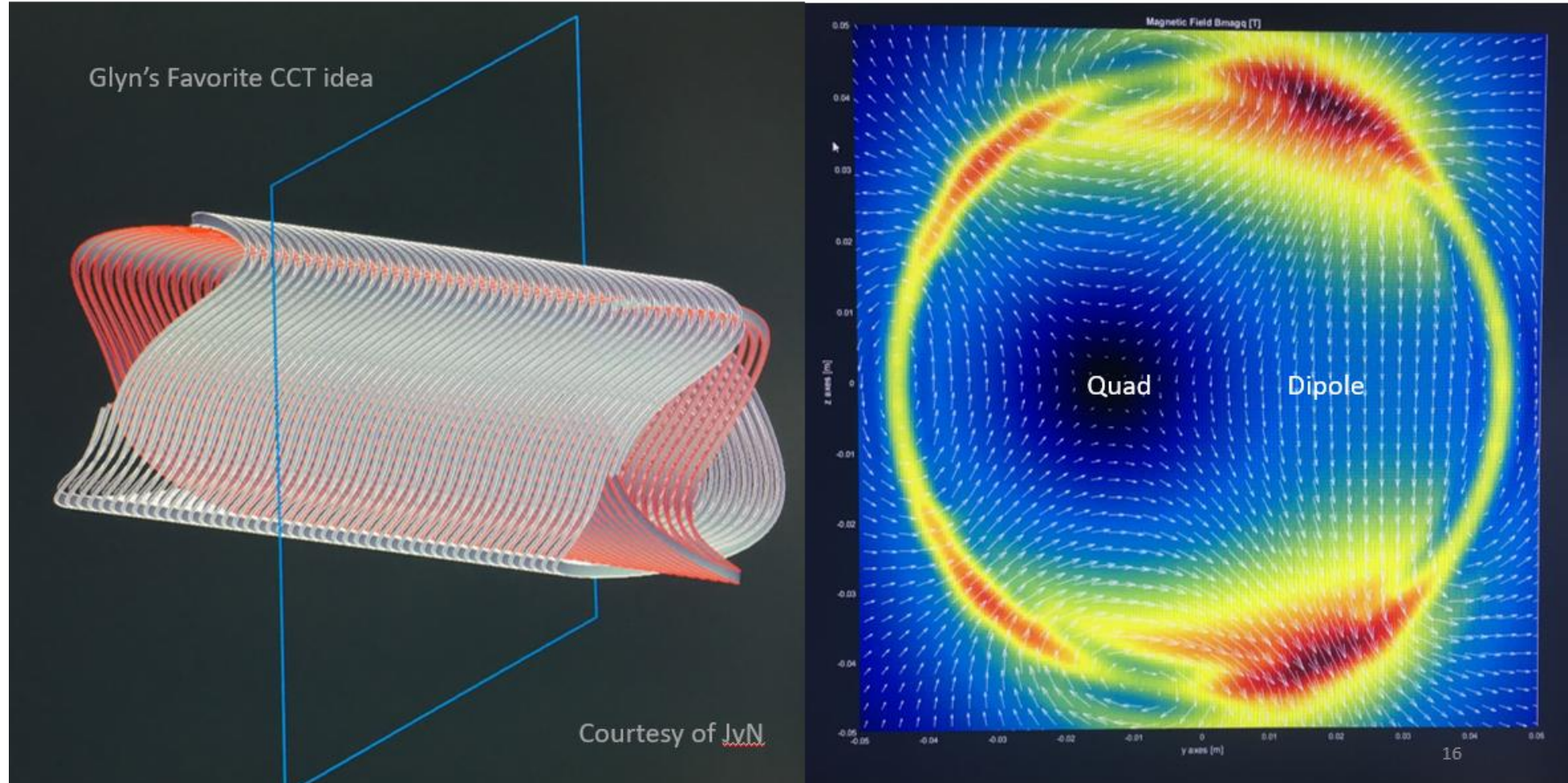
LUNABRAIN
1 M €

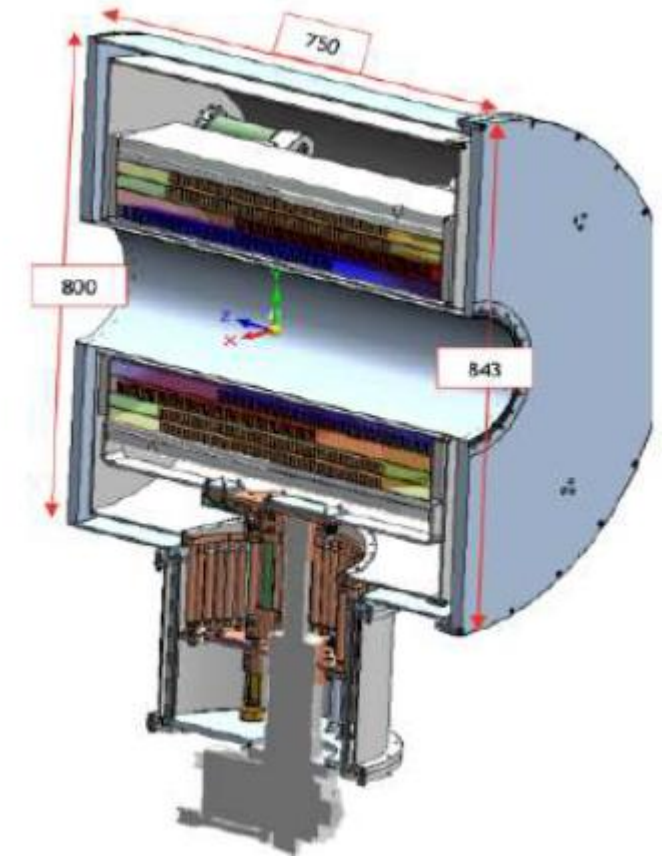
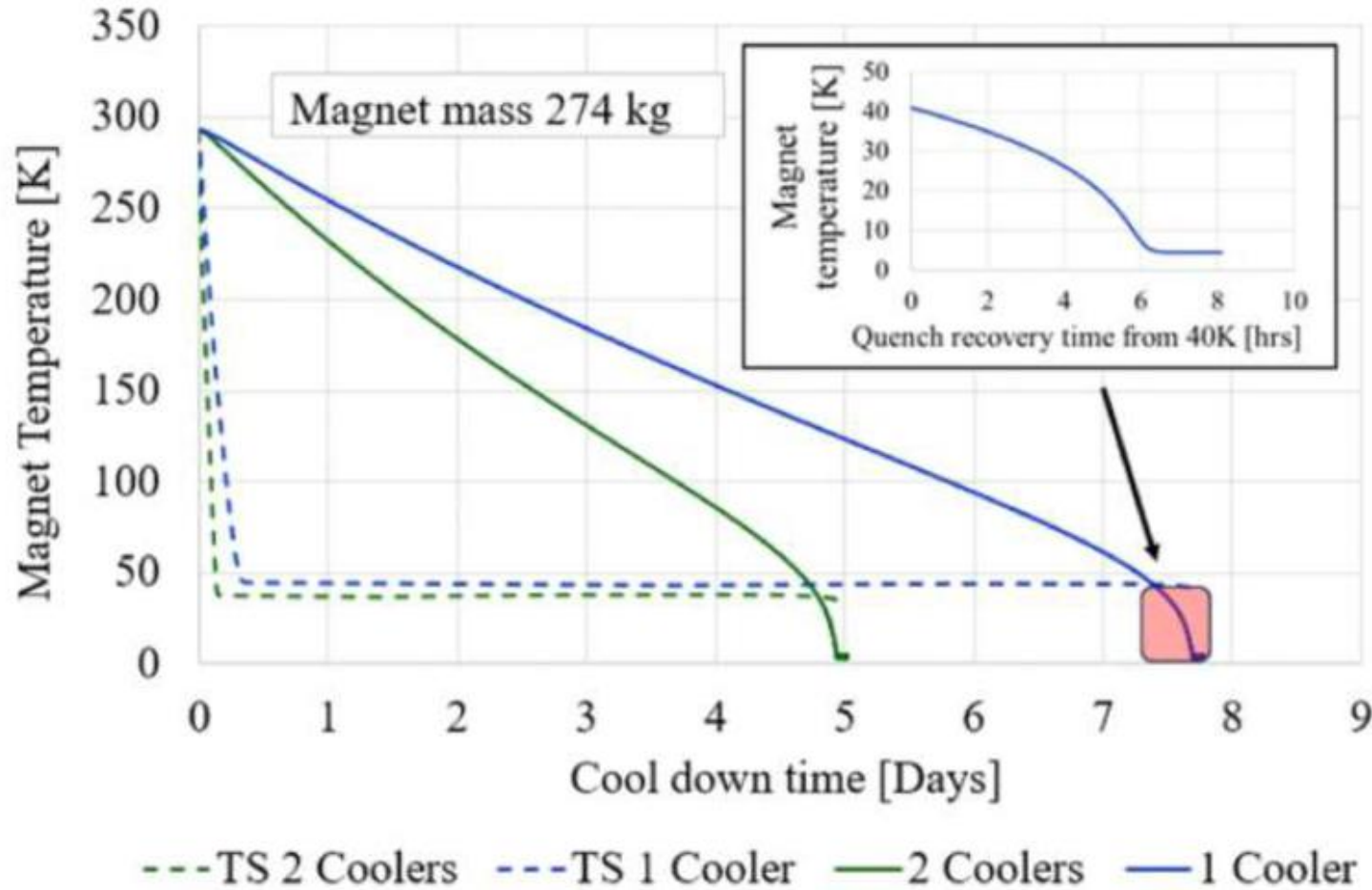
Canted Cosine Theta (CCT)





Flexibility of CCT designs combined function off axis

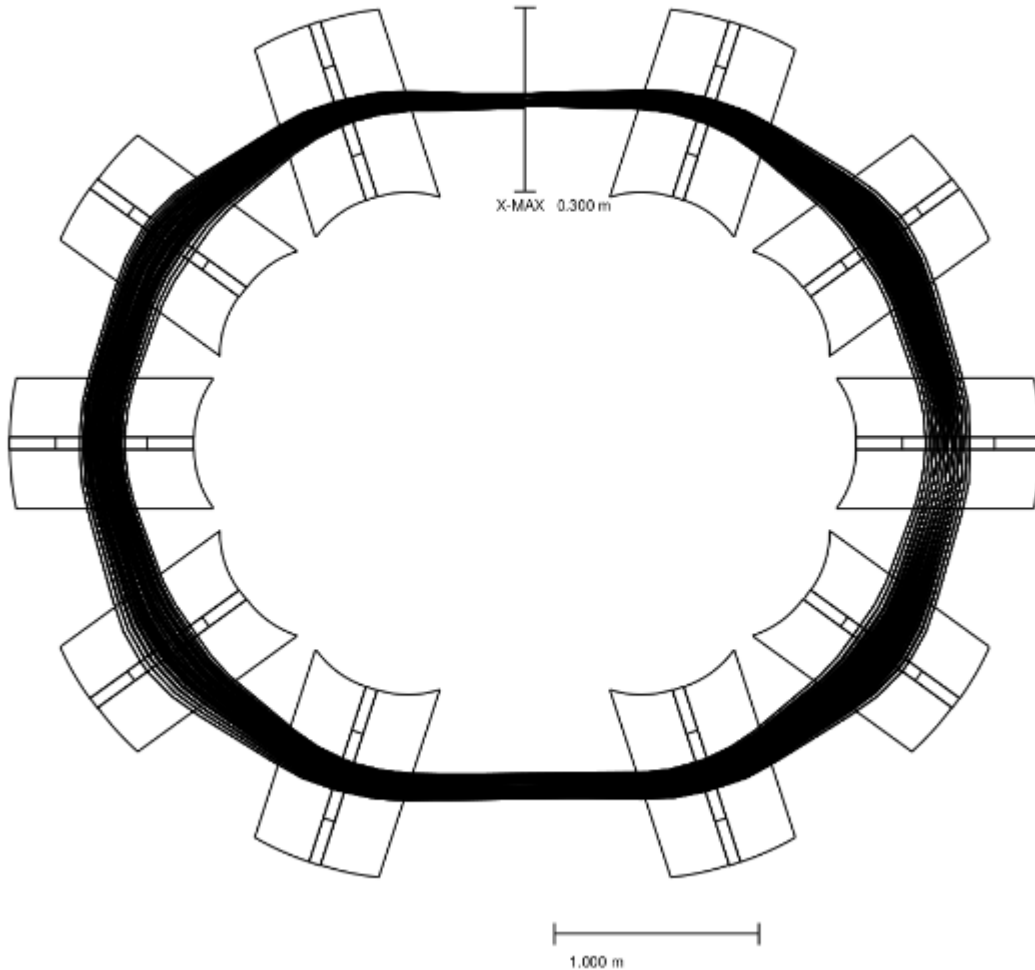




Cost: 250 k € “home-made”
750 k€ commercial

GICOSY RING LATTICE 3RD ORDER

SYSTEM PLOT



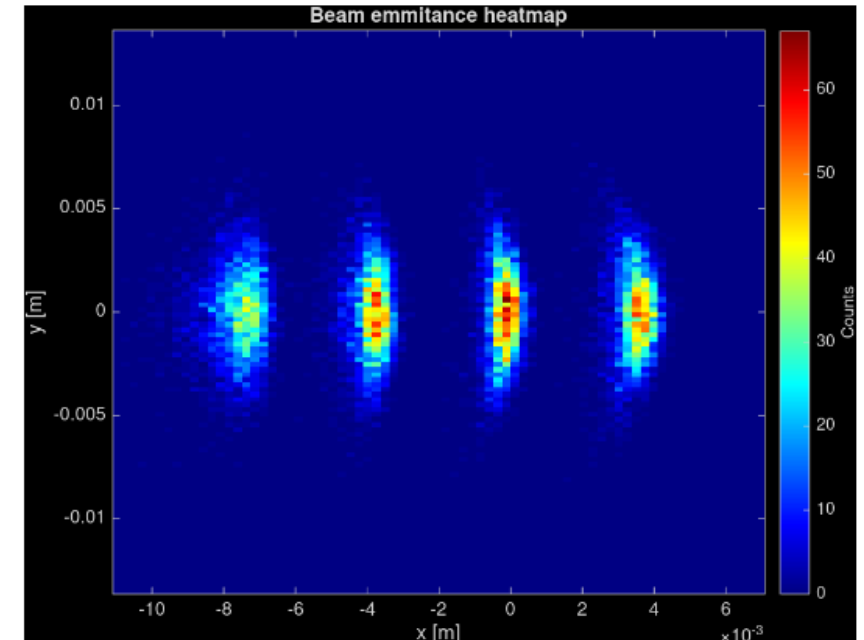
Higher-order effects of magnetic field maps using

GICOSSY

COSY INFINITY

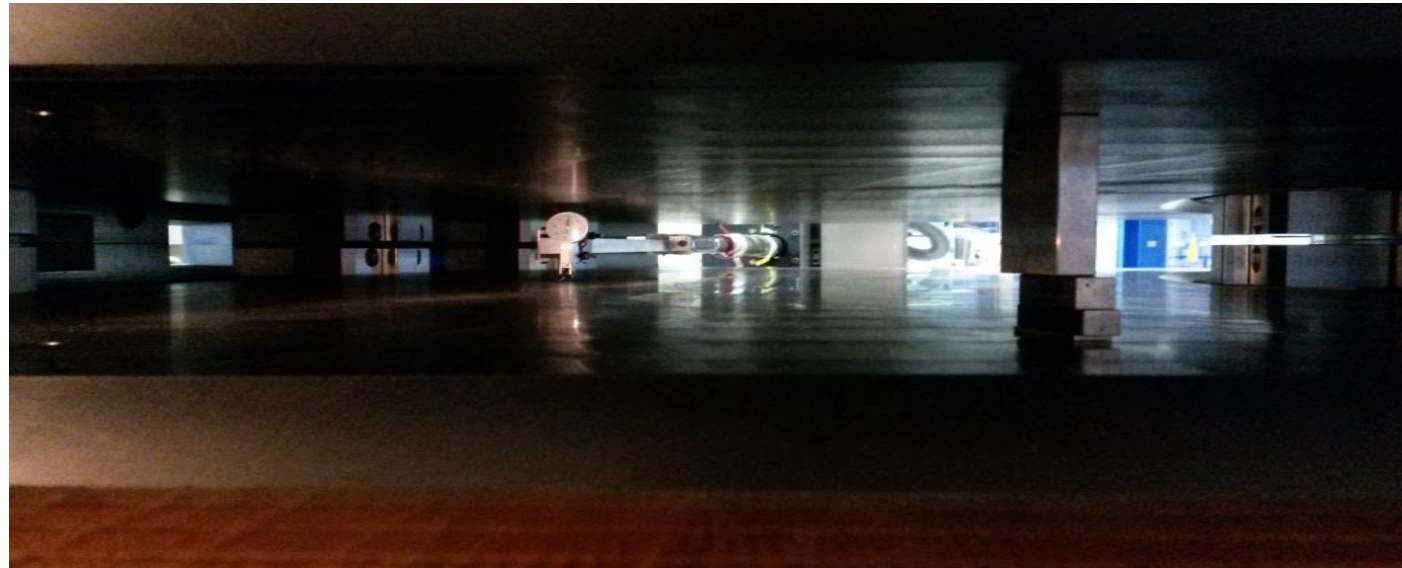
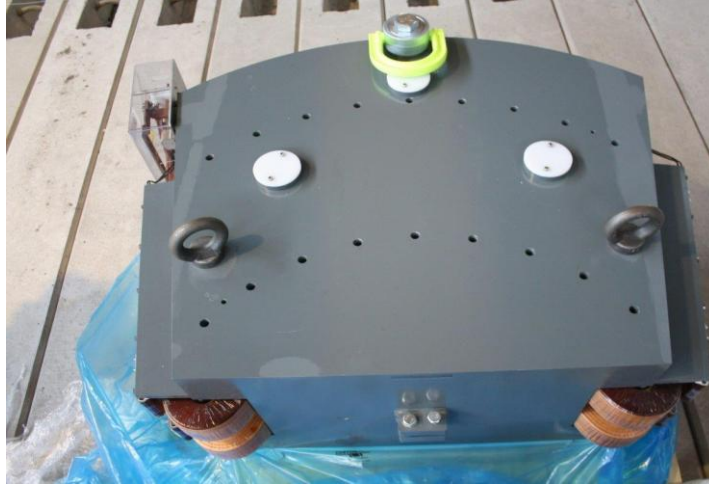
MonteCarlo/ GEANT4 tracking

RAT and OPERA/TOSCA for magnetic design



warm
conducting
magnets

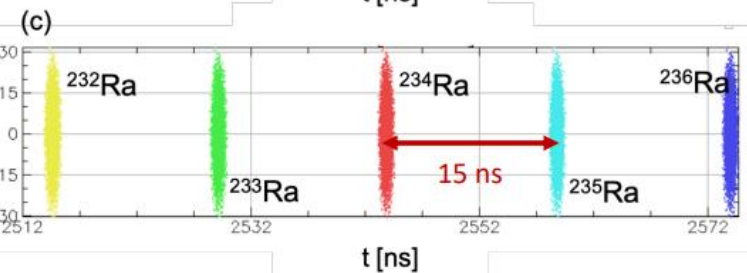
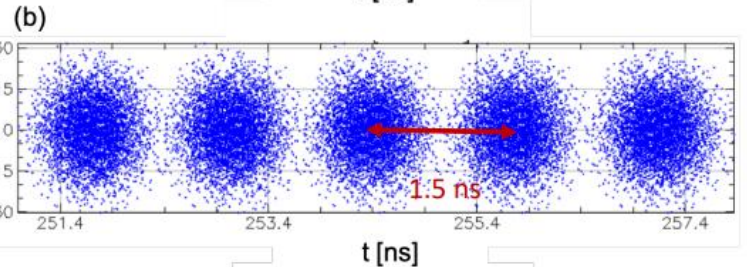
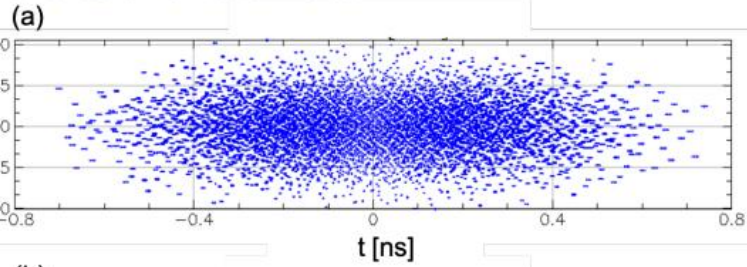
HRS for
SPIRAL2/DESIR



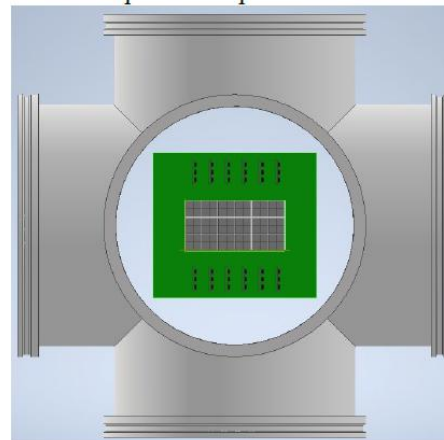
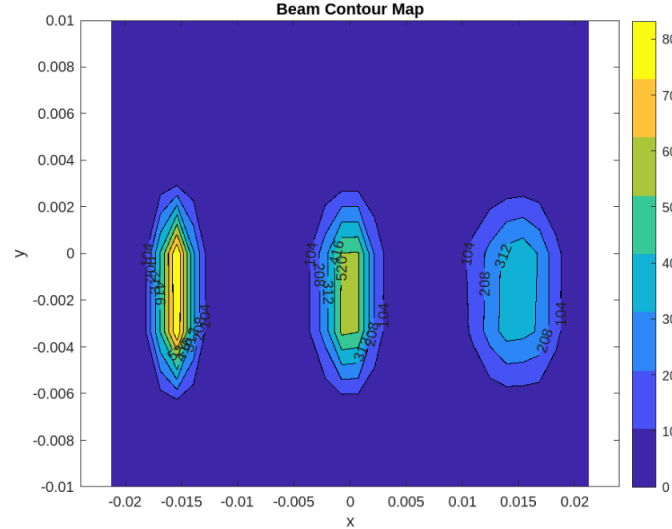
ISRS Focal plane detectors:

SiC detection technology

For the isochronous mode

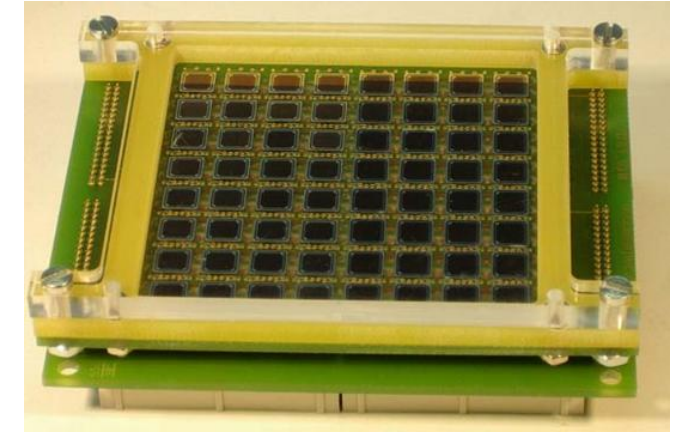


Linear spectrometer mode

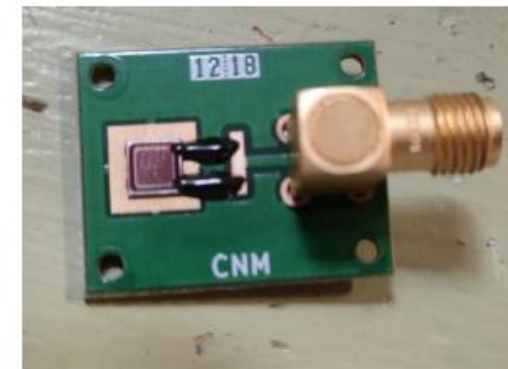


$\Delta E = 30 \text{ keV}$

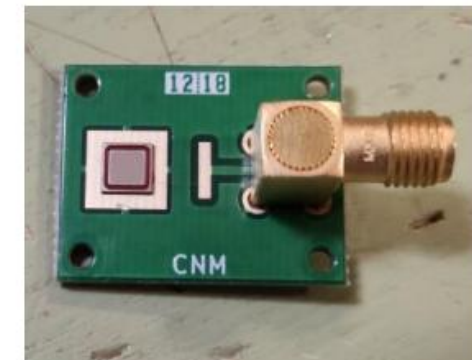
$\Delta t < 1 \text{ ns}$



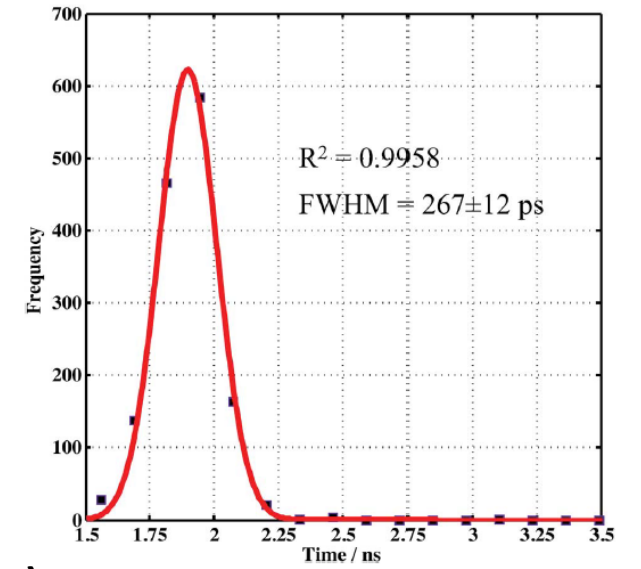
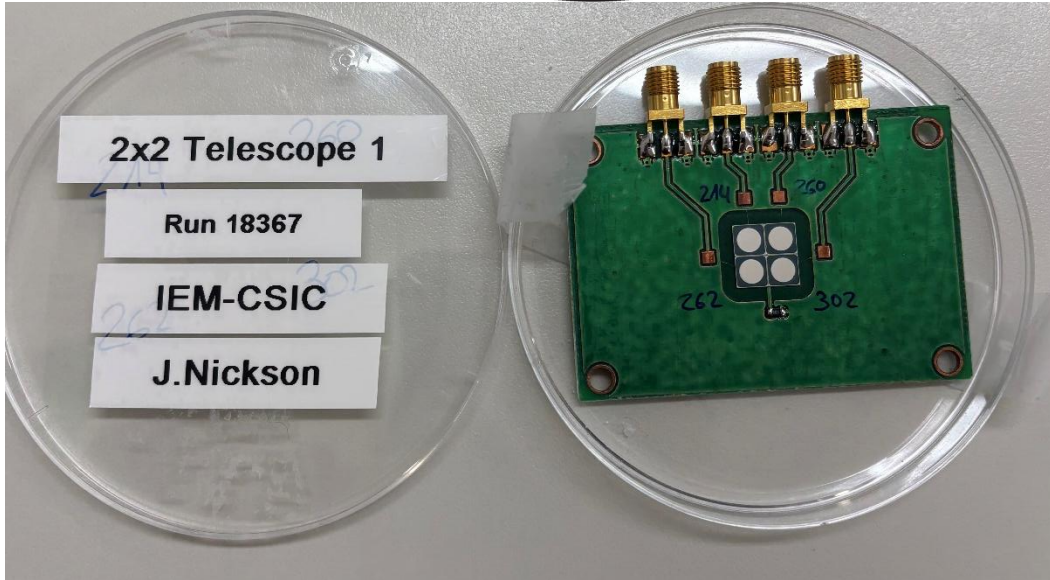
SiC prototypes developed by CNM-IMB Barcelona



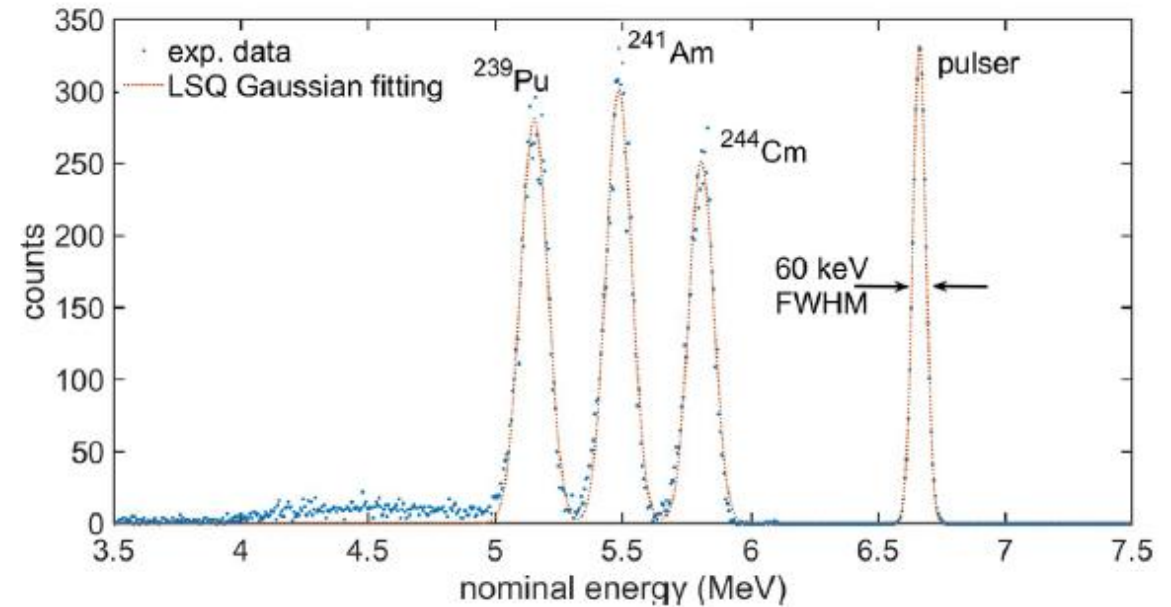
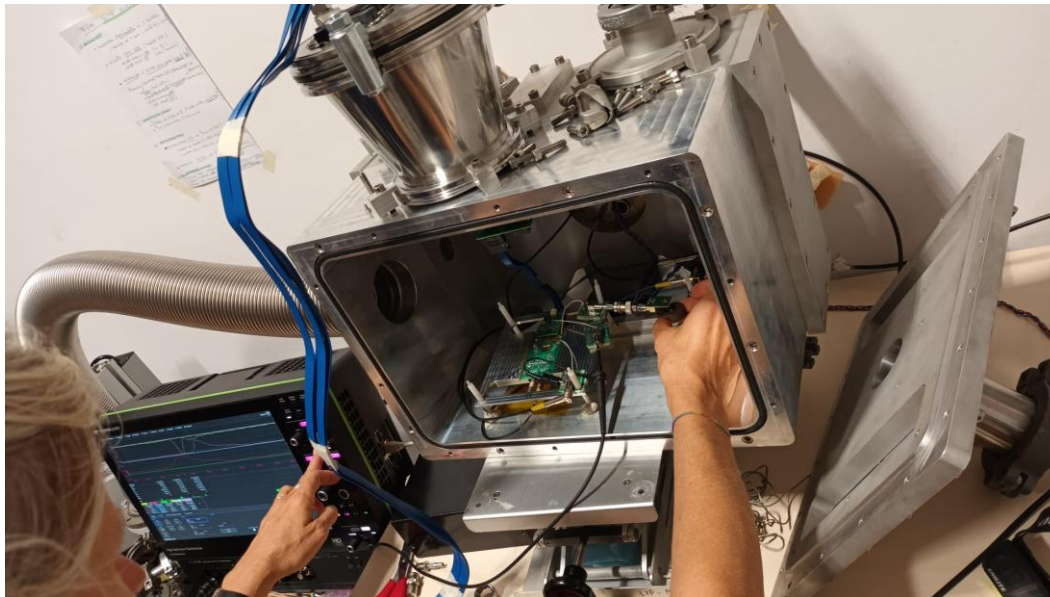
- **No.1:** 100 μm active layer with **thick** bonding



- **No.2:** 100 μm active layer with **thin** bonding (**new**)

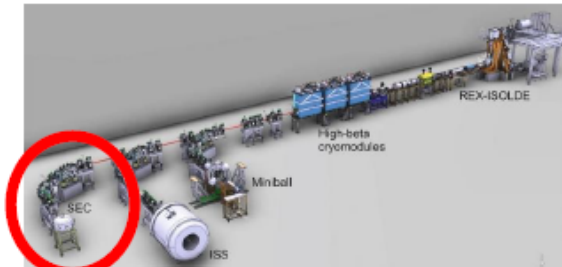


SiC-CSIC test at POLIMI (with MI-ASIC)

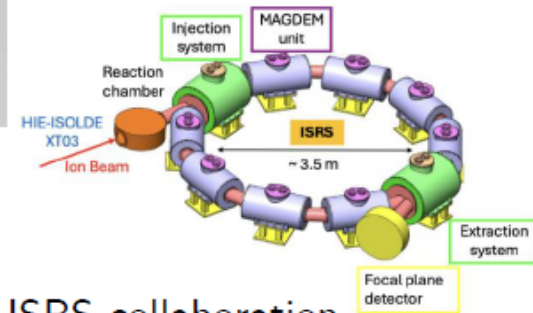


Applications of nanostructured scintillators

- Design of a novel detector for ISRS/SEC line in HIE-ISOLDE (CERN)
- Detector for the study of reactions of light nuclei in gaseous targets at astrophysical energies)
- Sensibility to charged particles or gammas, depending on the material
- Pixelated or stripped detector
- Combination with other fast-timing detectors (silicon carbides)
- Medical applications: ToF-PET

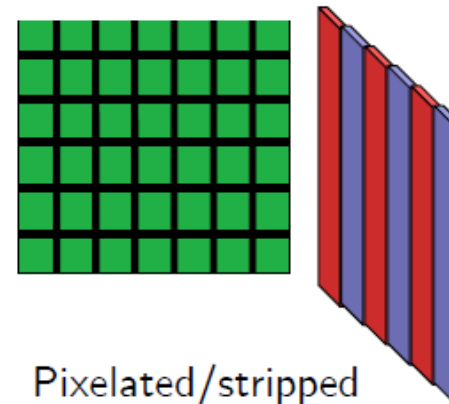


hie-isolde-project.web.cern.ch

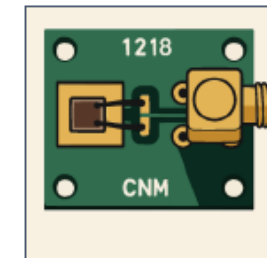


ISRS collaboration

Teresa Kurtukian-Nieto



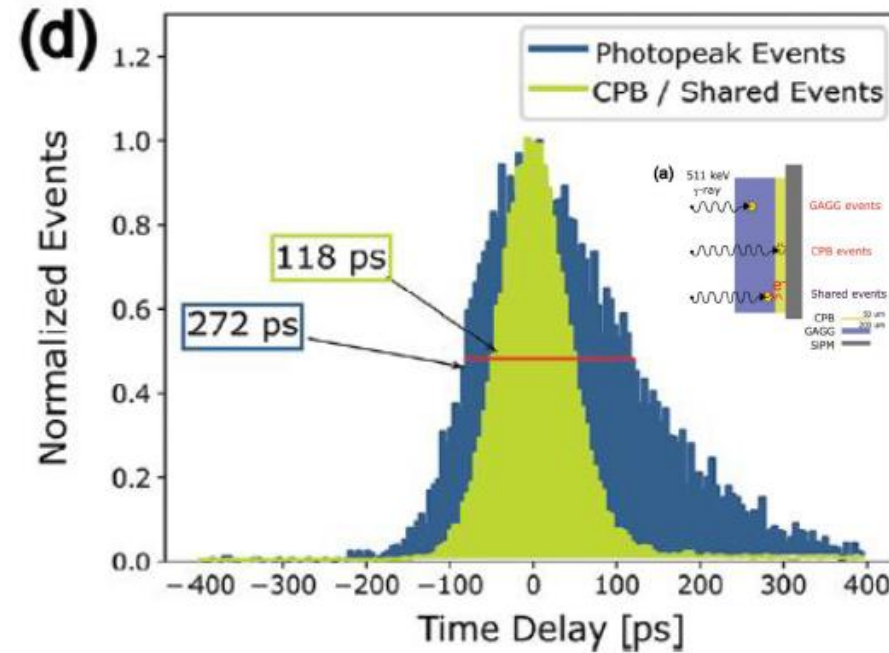
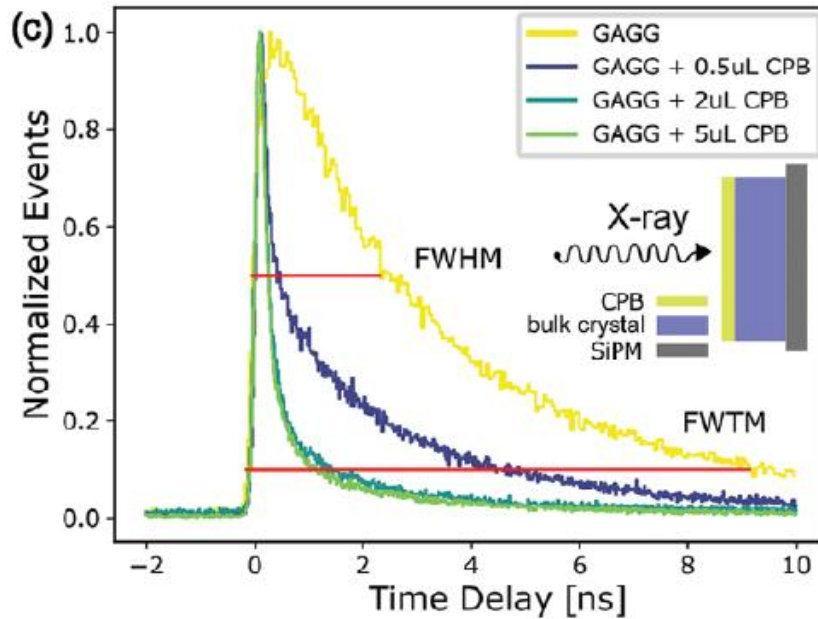
Pixelated/stripped
configurations



Silicon carbide
(made in CNM-IMB)

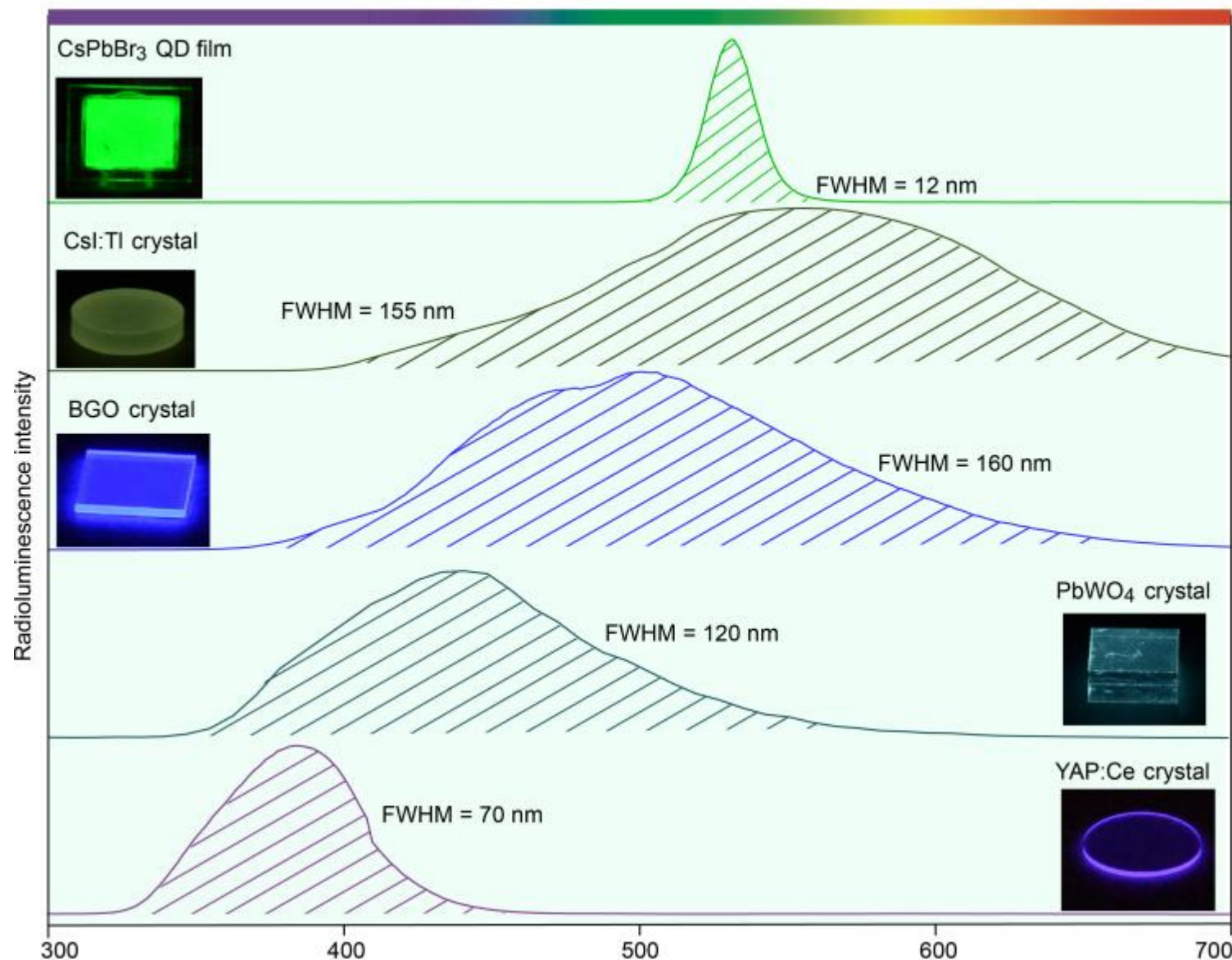
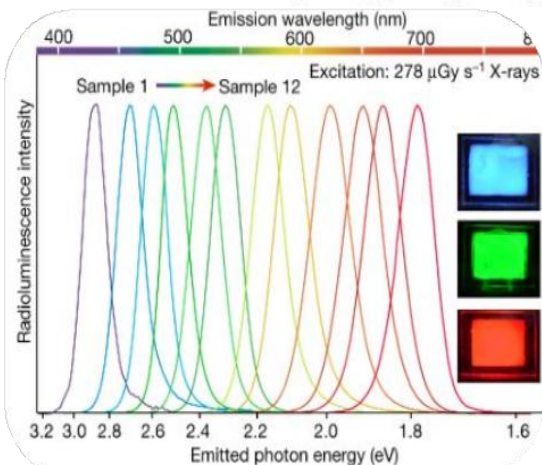
Detector design

- Is it possible to improve commercial scintillators?



F. Pagano et al. *Adv. Mater. Interfaces* 2024, 11

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 ₄ PbBr ₆	3 ^c
	1.4 (88%)/6.7 (12%)

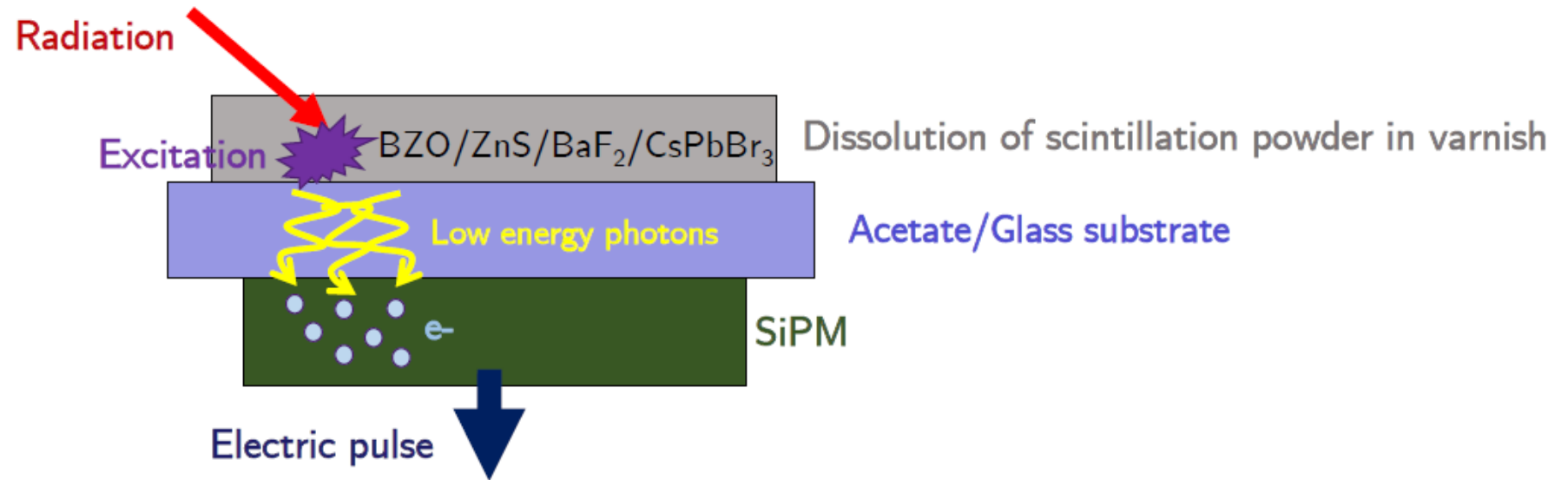


Detector design

- Test detector is designed as a **thin film**:

Scintillation powder + varnish + acetate/glass substrate

coupled to a silicon photomultiplier (SiPM)

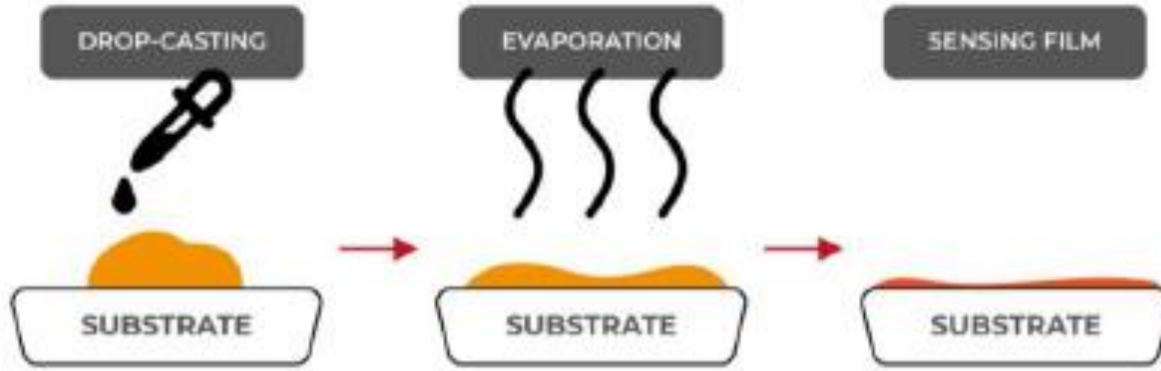


Detection capability test

- To determinate the suitability of use of each scintillator material, a test with every type of radioactive source was carried out:

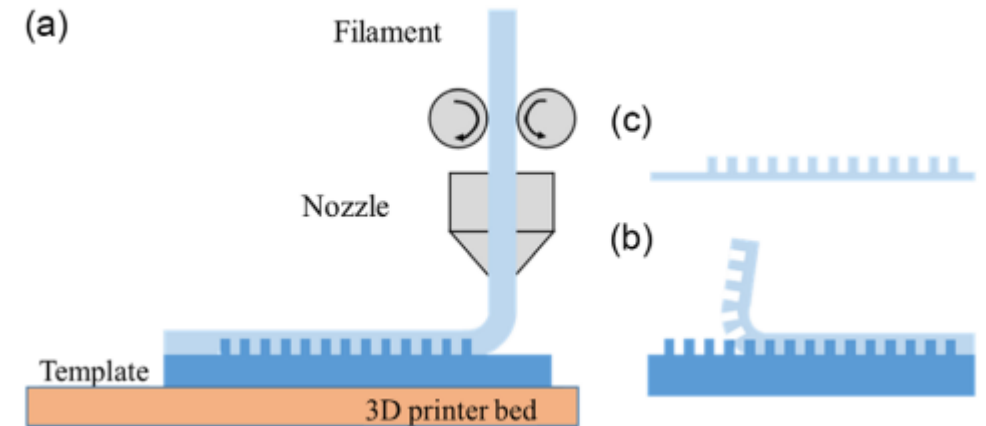
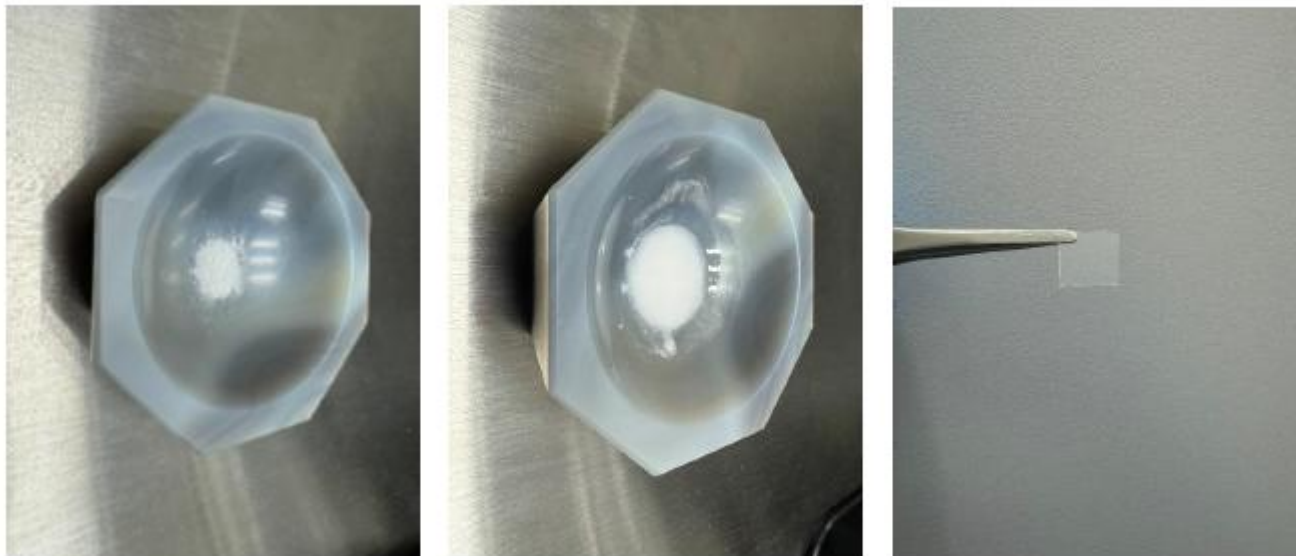
Material	Alphas	Betas	Gammas
ZnS(Ag)	✓*	✓	✗
BZO	✗	✓	✗
BZO + CsPbBr ₃	✗	✓	✓
BaF ₂	✗	✓	✗

*Only films with the least quantity of varnish (50/50)



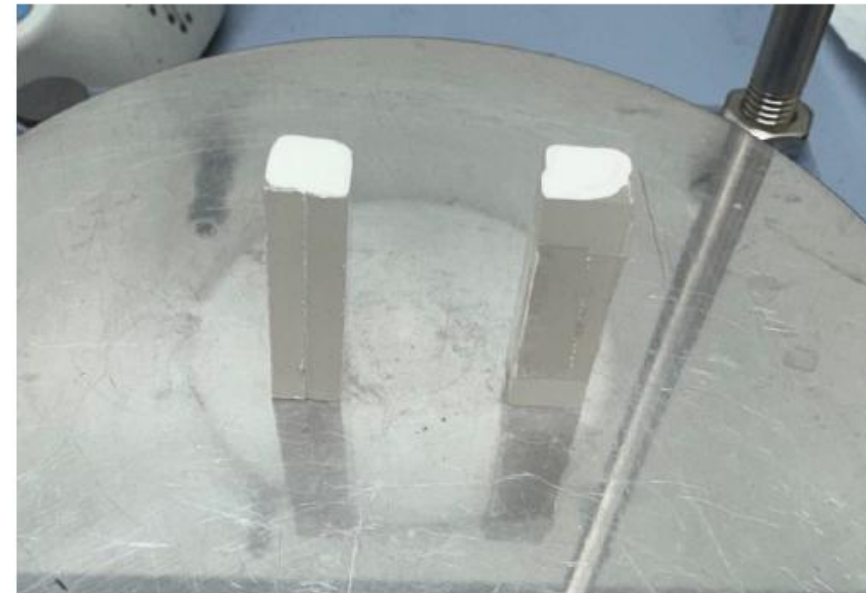
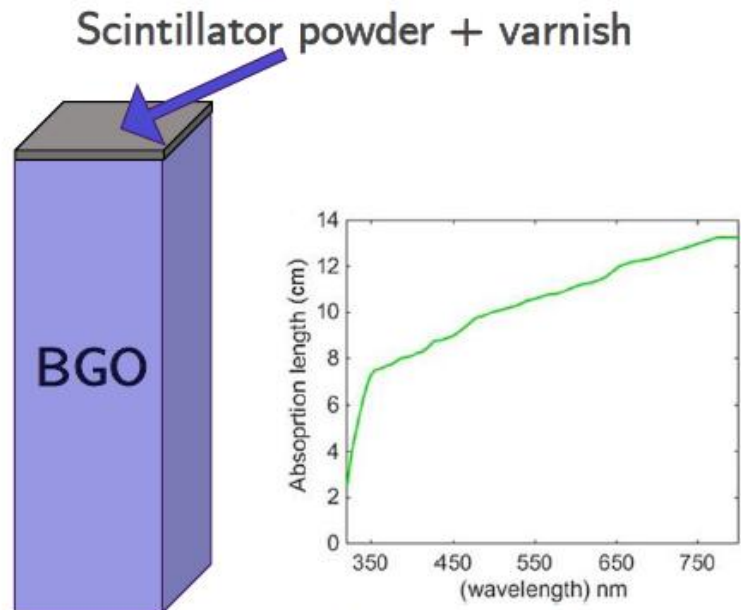
AFBR-S4E001

A.I. Bravo-Sánchez et al. *Discov. App. Sciences* 2025, 7



Detector design

- Production of mixed crystals:
 - Small BGO crystal recycled from another detector, combined with a thin layer of scintillator powder (analog to a phoswich)

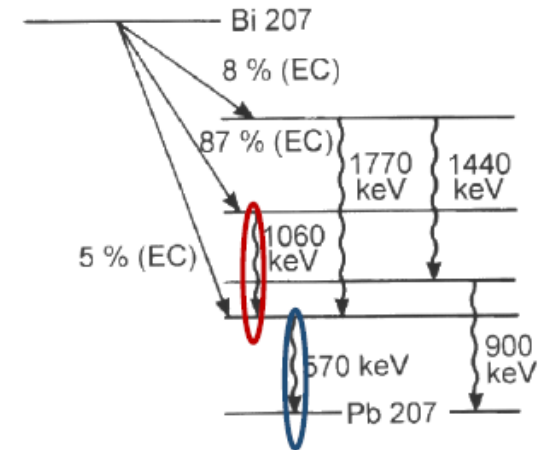
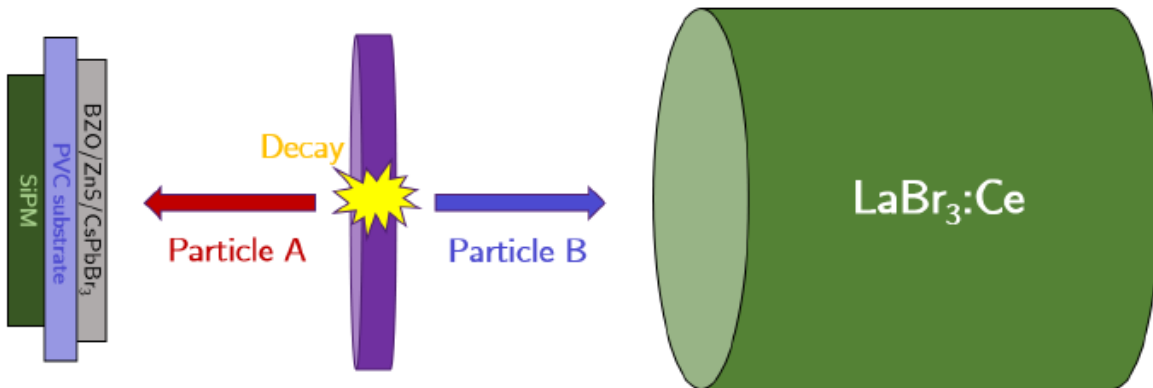


E. Roncali et al. *Biomed. Phys. Eng. Express* 2019, 5

Timing resolution tests

- Timing test: ^{207}Bi radioactive source

- De-excitation via gamma emission or internal conversion electron ($T_{1/2} = 130.5 \text{ ps}$)
- 2 possibilities of coincidence:
 - 1st γ + 2nd e^-
 - 1st e^- + 2nd γ
- e^- are detected in scintillator layer and γ in a $\text{LaBr}_3:\text{Ce}$ (CTR $\sim 300 \text{ ps}$)

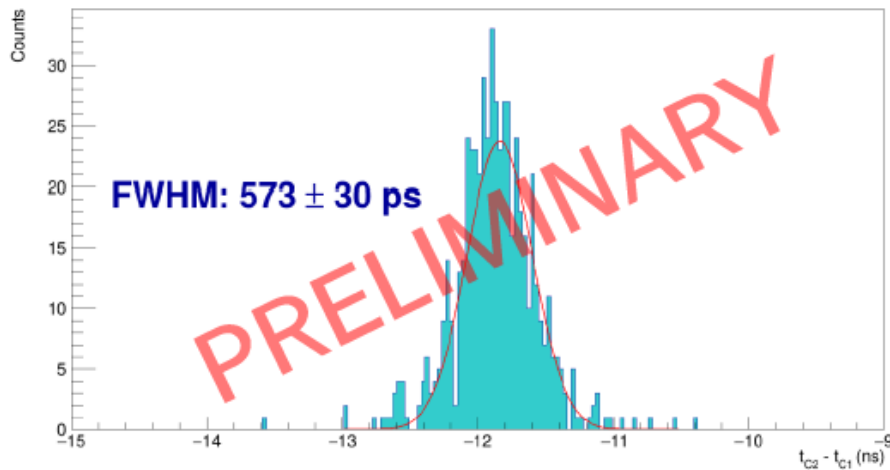


Timing resolution tests

- WavePro Oscilloscope

- 10 GS/s, enough to digitize the signal waveform
- Large dead time and gate at high gamma energies → low statistics!
- Contributions due to DAQ and ^{207}Pb state half-life are not yet analyzed

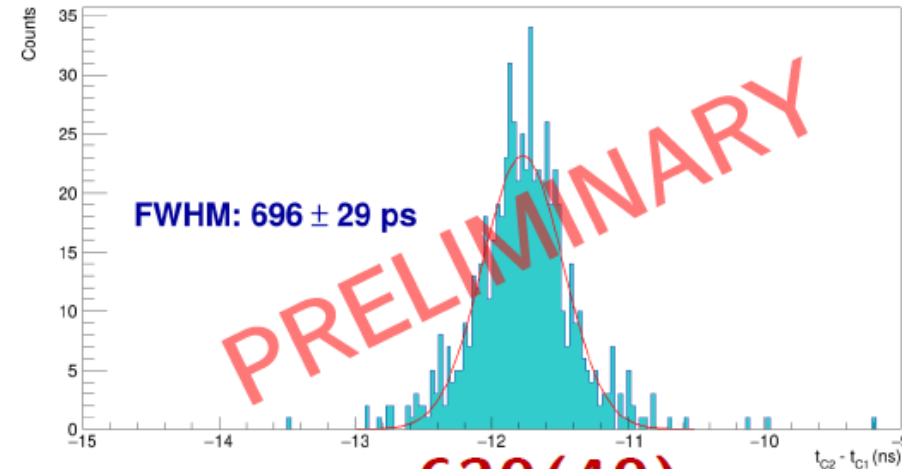
BZO 60 μm



$$\sigma_{\text{BZO}} = 450(40) \text{ ps}$$

Delta T

ZnS 80 μm

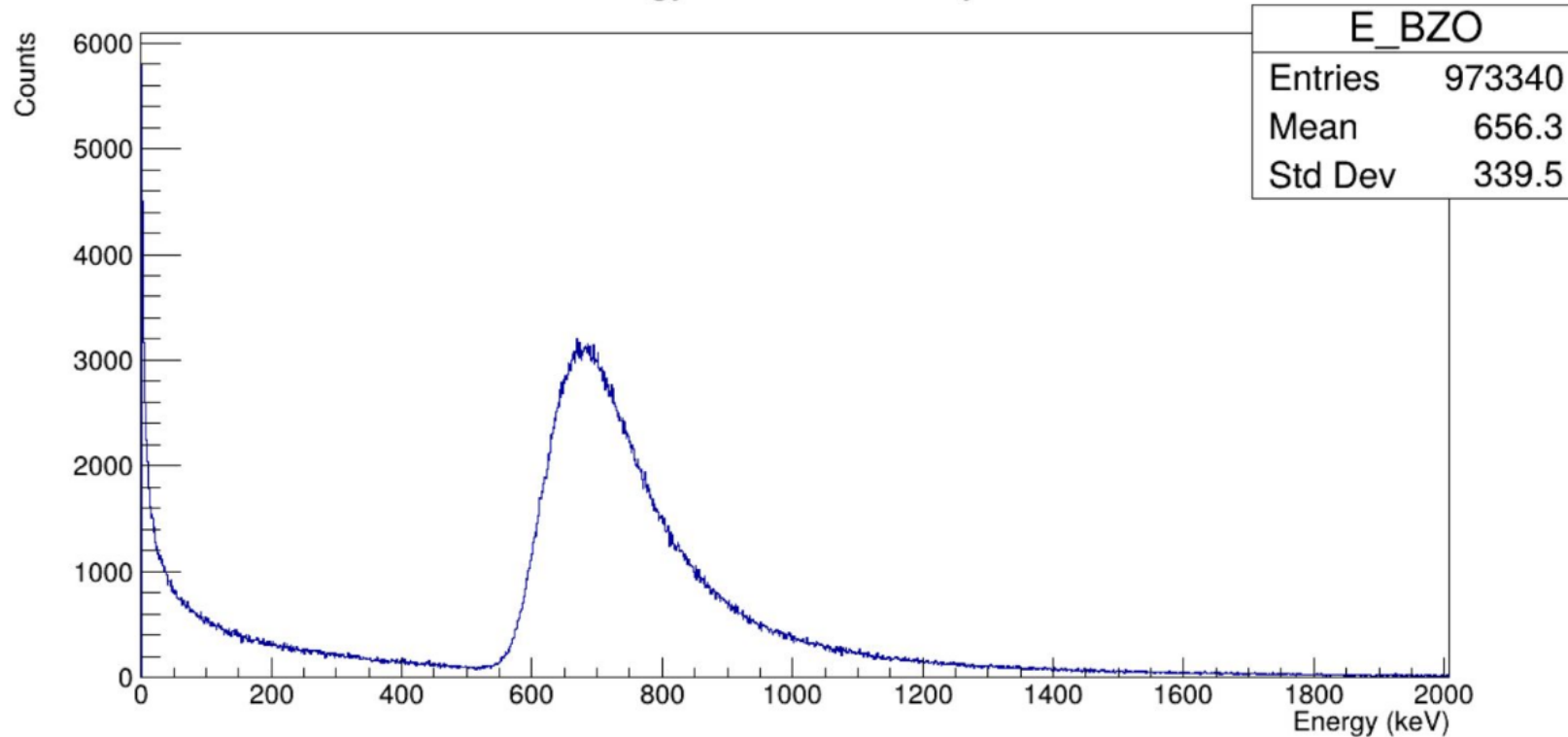


$$\sigma_{\text{ZnS}} = 630(40) \text{ ps}$$

GEANT4 simulations

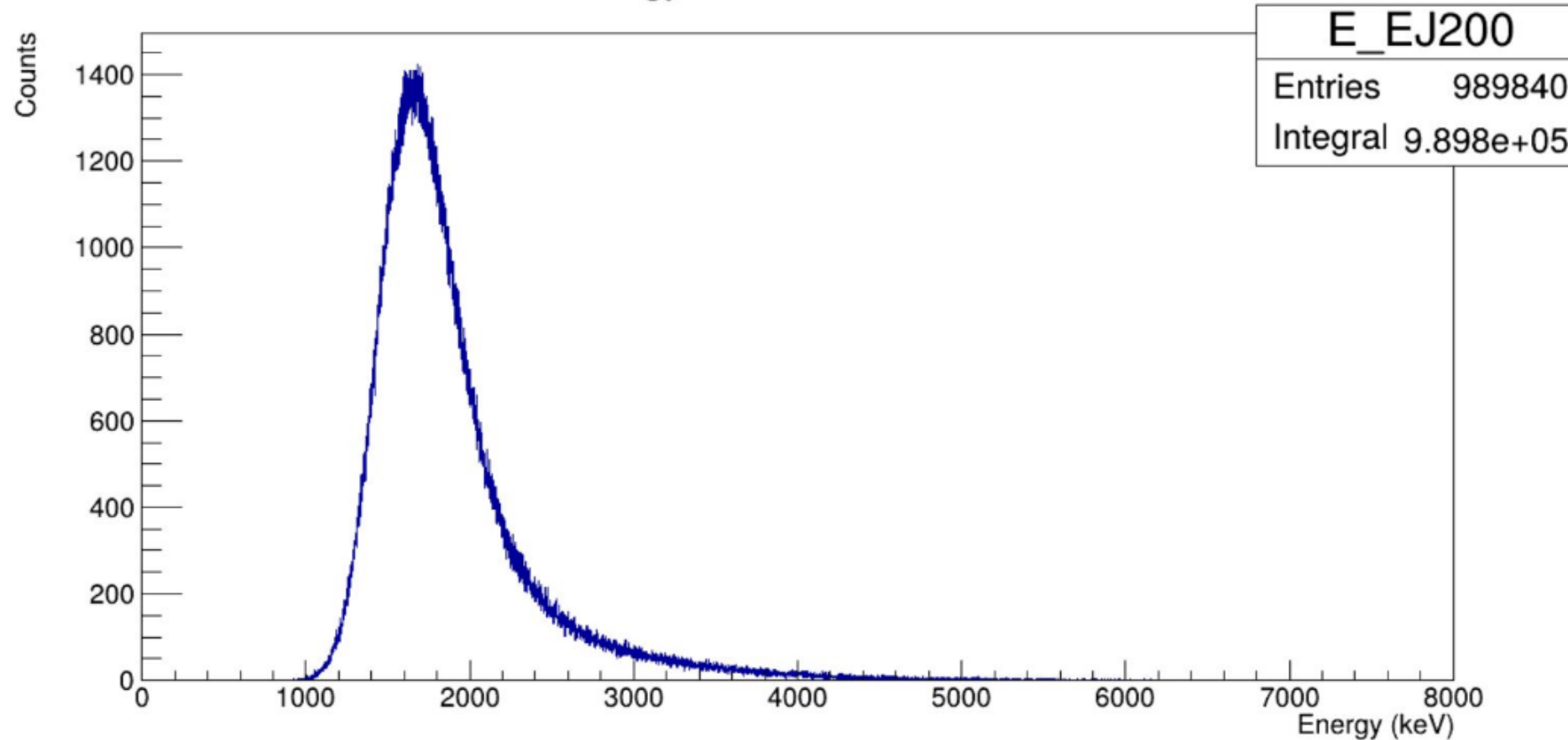
BZO 1 mm - 5 GeV pions

energy in Perovskite layer



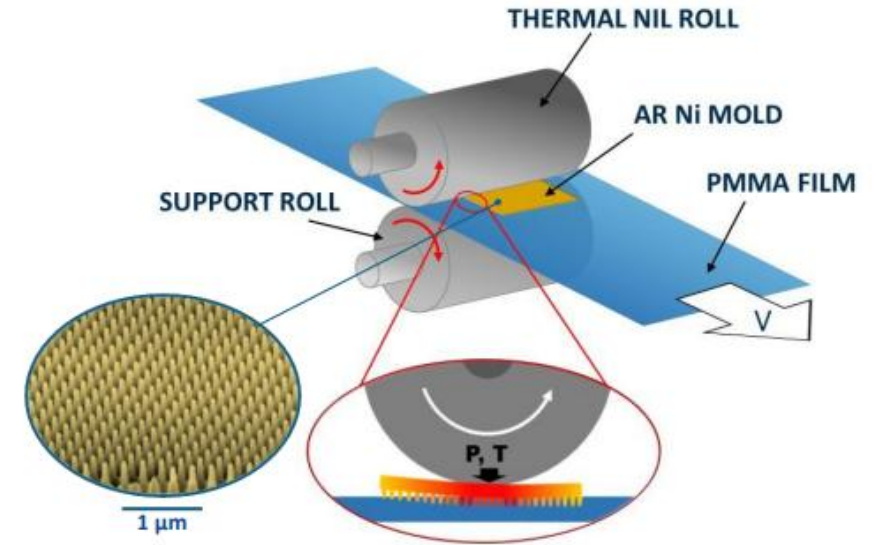
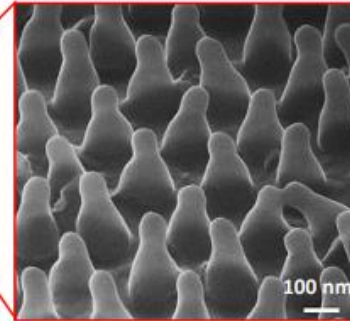
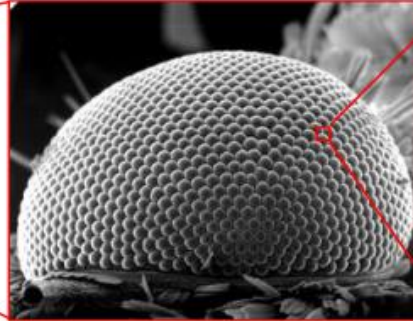
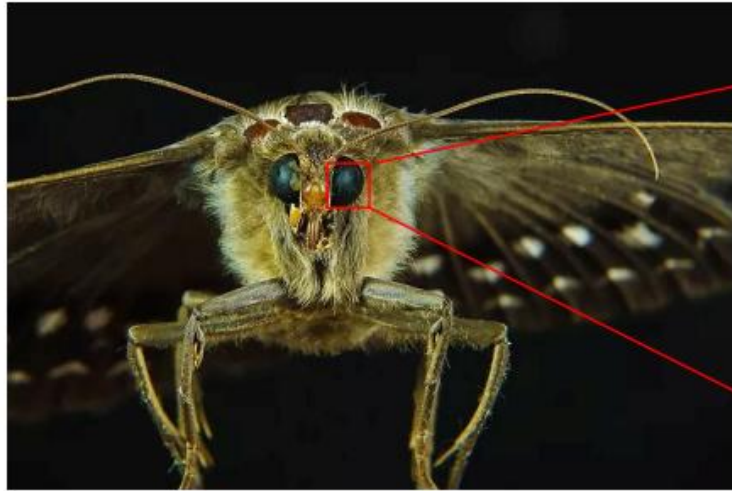
EJ200 1 cm - 5 GeV muons

energy in EJ200 scintillator

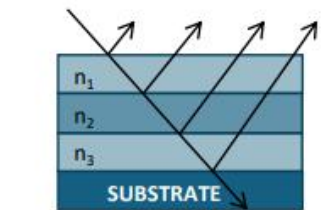
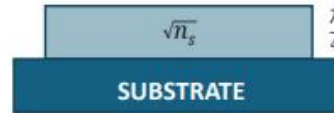


Next Steps

ANTIREFLECTIVE PROPERTIES OF THE MOTH-EYE



IMPROVEMENT OF SOLAR CELL EFFICIENCY



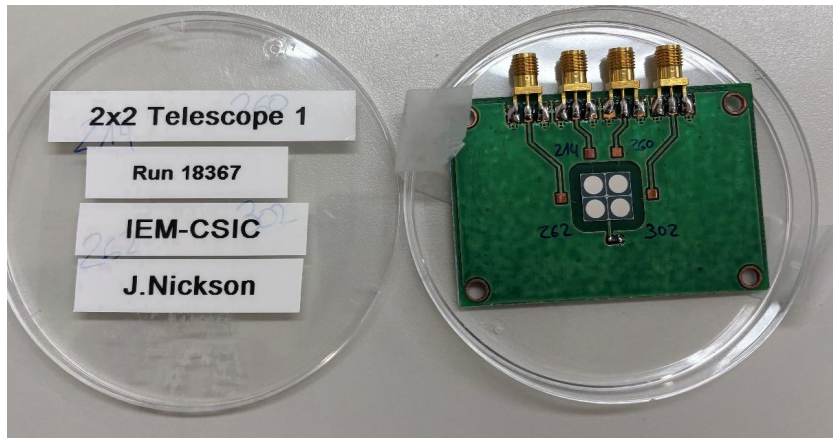
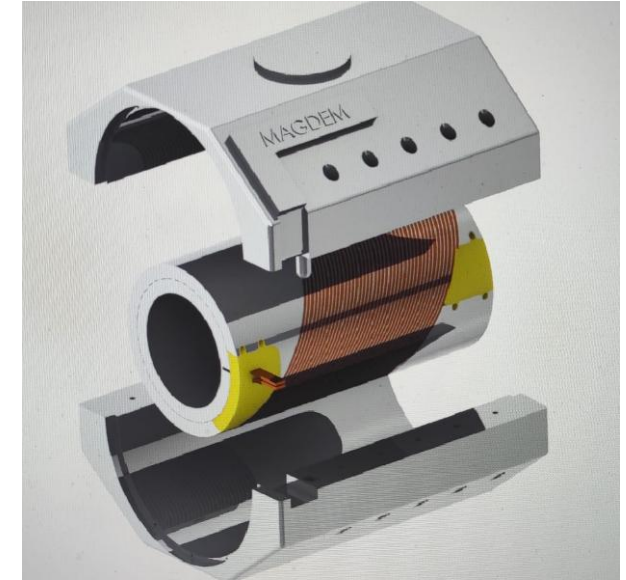
DESTRUCTIVE INTERFERENCE



GRADED REFRACTIVE INDEX

Summary

1. Design and fabrication of multi-function CCT magnets
2. SiC detectors for fast and radiation hardness applications
3. Scintillator nano-composites for fast timing at low costs



Acknowledgments: contract PTA2023-023015-I funded by MICIU/AEI/10.13039/501100011033 and FSE+, LUNABRAIN-CM and PID2023-147569NB-C21



**Comunidad
de Madrid**