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Thermal neutron detector based on LaOBr:Ce/LiF

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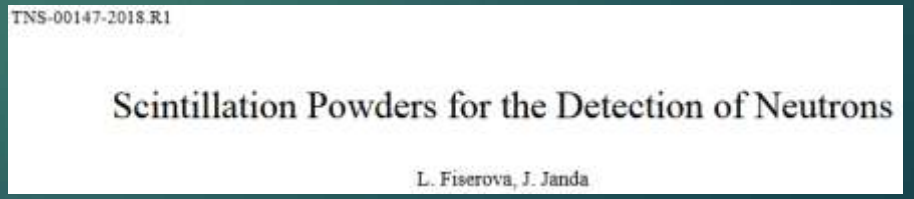
ISMART 2018 CONFERENCE, MINSK, 9. – 12. 10. 2018

Introduction

- ZnS:Ag/^{6}LiF
  - is still the best phosphor mixture for thermal neutron detection?
- Lanthanide oxybromides
  - Cathodoluminescent and X-ray intensifying screens (1970)
  - Oxyhalides of yttrium, lanthanum and gadolinium activated by trivalent cerium or terbium
  - Sensitive for charged particles

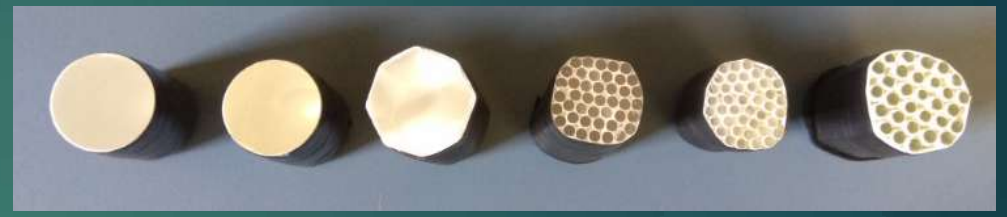
Fiserova, L. 2018, LumDeTr 2018 Conference, Prague

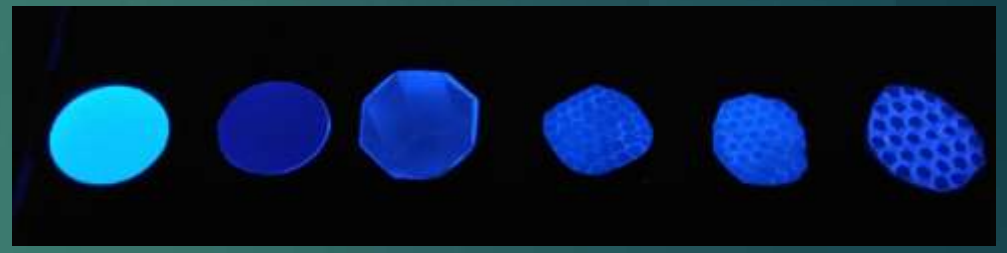


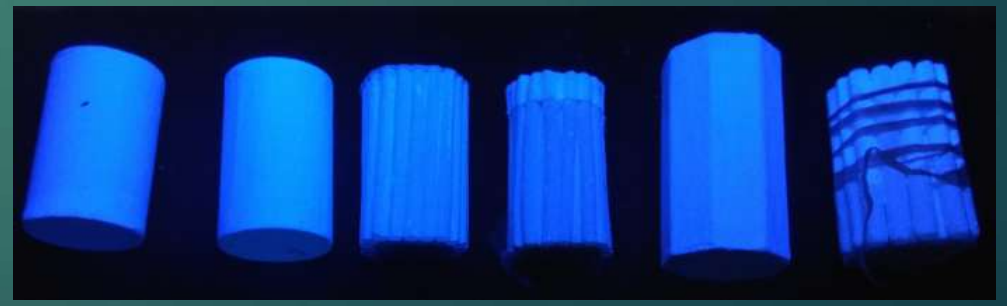
Fiserova, L. 2018, IEEE TRANSACTIONS ON NUCLEAR SCIENCE

Detector construction

- LaOBr:Ce/LiF mixture
- Different types of optical carriers
  - Cyllinder made from plastic scintillator
  - Cyllinder made from PMMA
  - End-glow optical fibers
  - Side-glow optical fibers
  - Optical glass octagon
  - Optical glass fibers





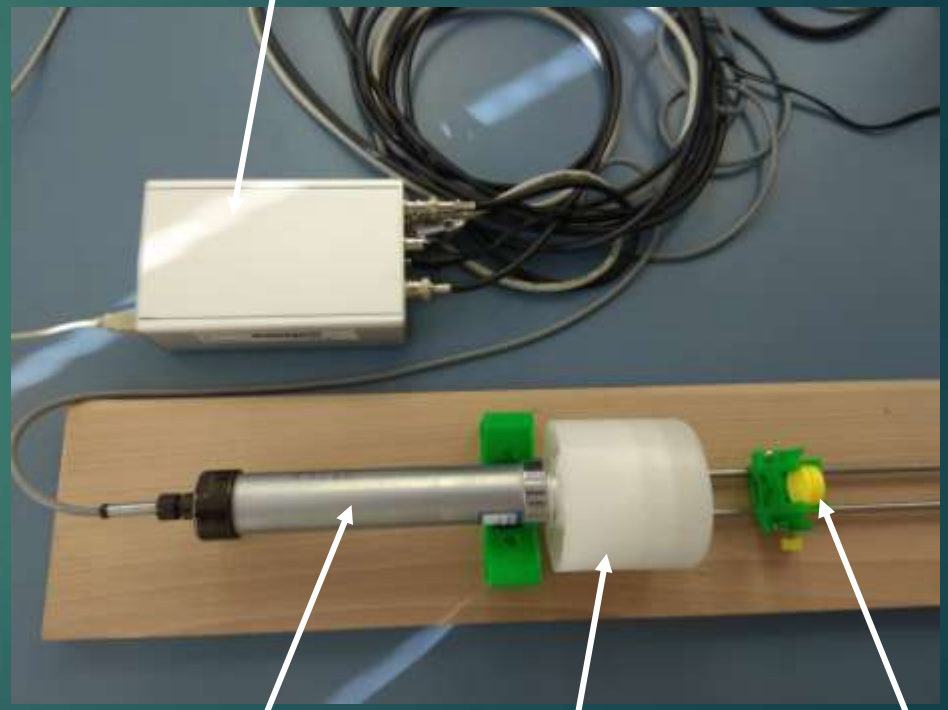


Detector dimensions and areal densities

Type	Dimensions	Total active area [mm^2]	Scintillator area density [mg/cm^2]
Cyllinder made from plastic scintillator	Ø 24 mm, h = 40 mm	3466	50 ± 5
Cyllinder made from PMMA	Ø 24 mm, h = 40 mm	3466	
End-glow optical fibers	Ø 3 mm, h = 40 mm, 43 pcs in cluster	16506	
Side-glow optical fibers	Ø 2.6 mm, h = 40 mm, 40 pcs in cluster	13274	
Optical glass octagon	Ø 2.4 mm, h = 50 mm	4480	
Optical glass fibers	Ø 4 mm, h = 40 mm, 30 pcs in cluster	15448	

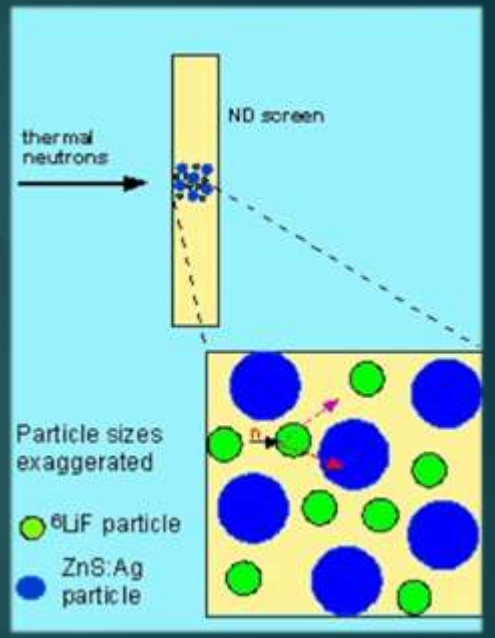
Thermal neutron measurement instrumentation

- Probe: 1“ PMT with scintillator and teflon reflection layer
- Paraffin cylinder
- Cf source at the 30 cm distance
- NuNA MCB-T Multichannel analyser (NUVIA, Czech Republic)
- GAMWIN SW: spectral analysis

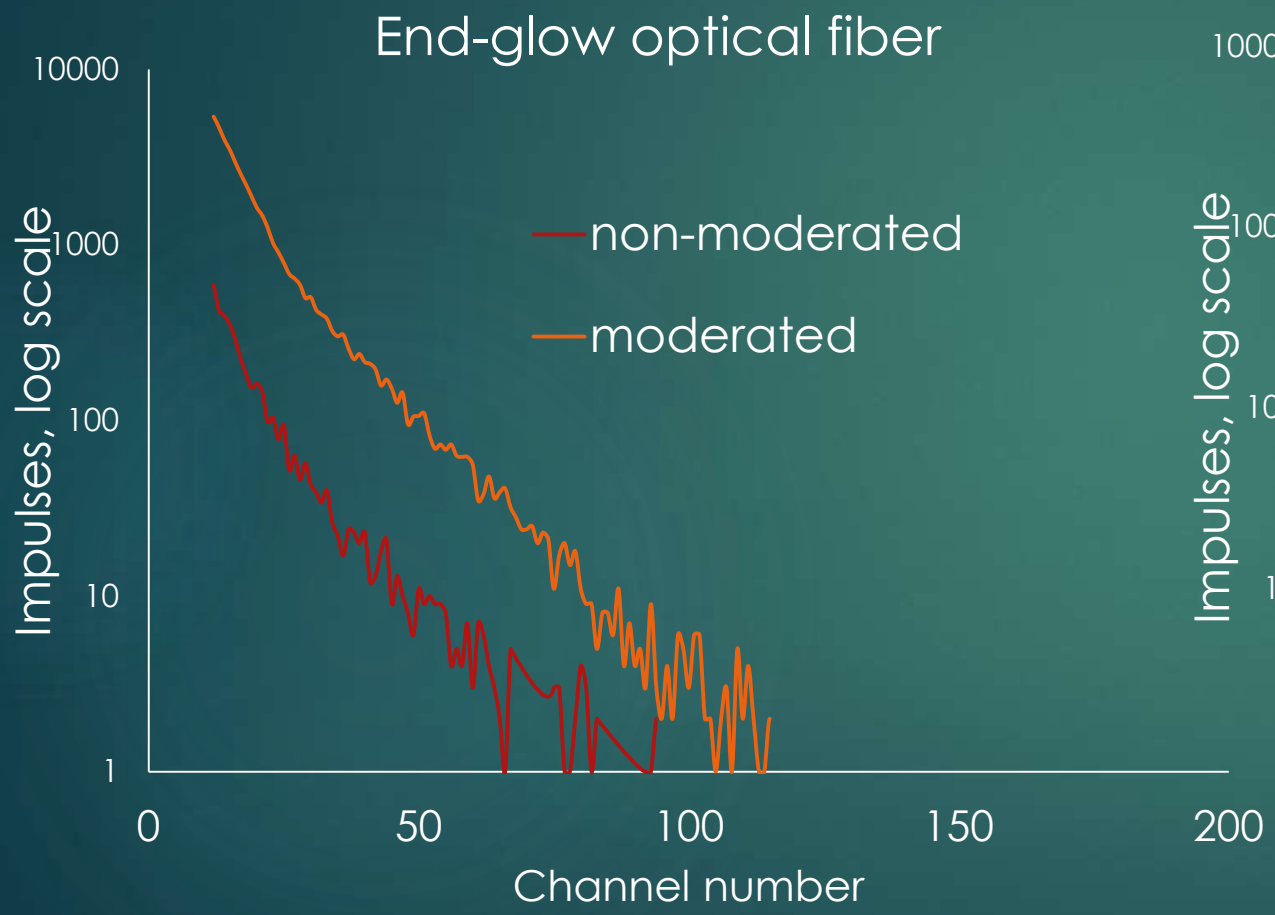


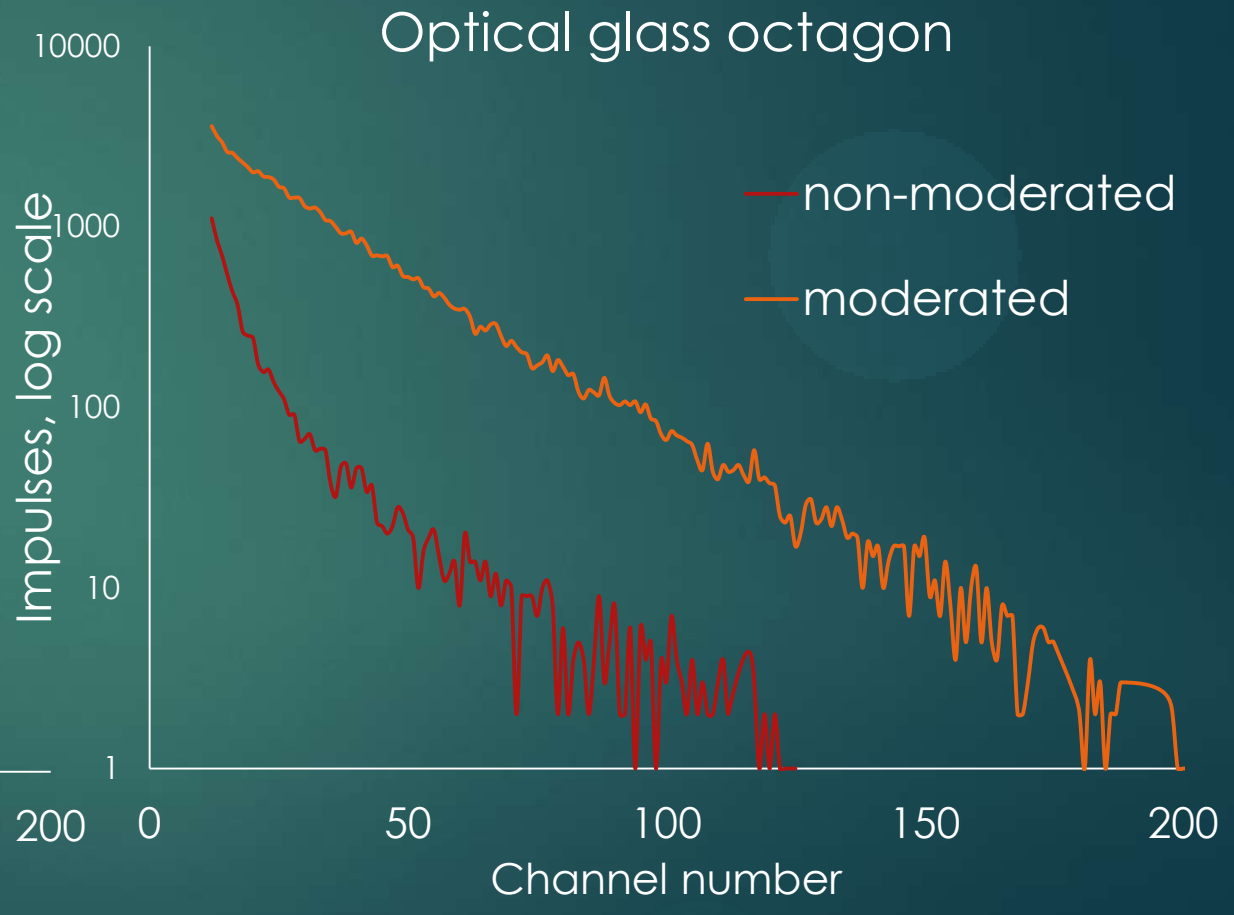
Results

	n_{mod}-n_{nmod} [cps]	n_{mod}/n_{nmod}
Cyllinder made from plastic scintillator	2	1.0
Cyllinder made from PMMA	110	1.3
End-glow optical fibers	148	10.3
Side-glow optical fibers	6	1.5
Optical glass octagon	220	8.6
Optical glass fibers	42	5.0
ZnS:Ag	176	37

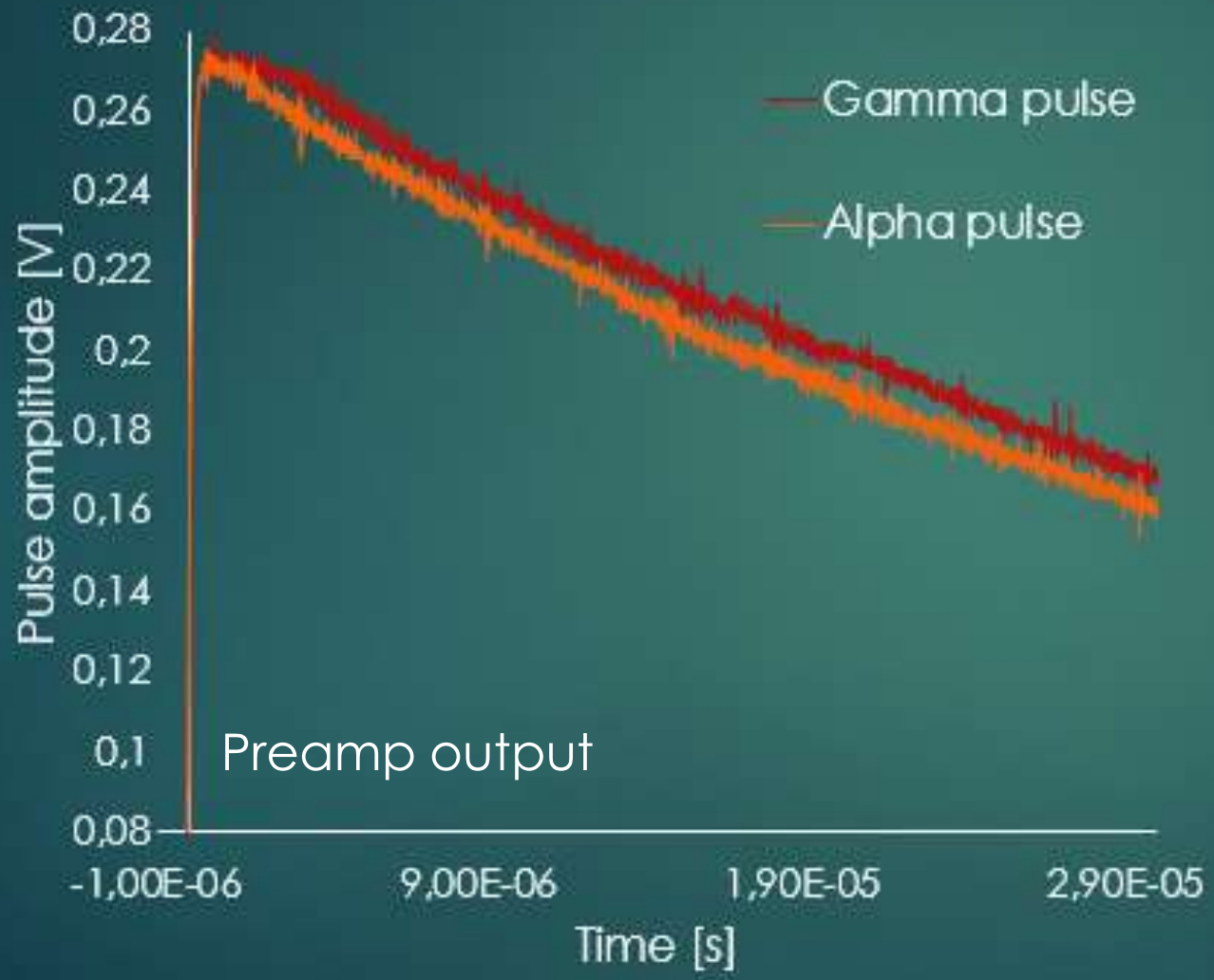


Spectral analysis



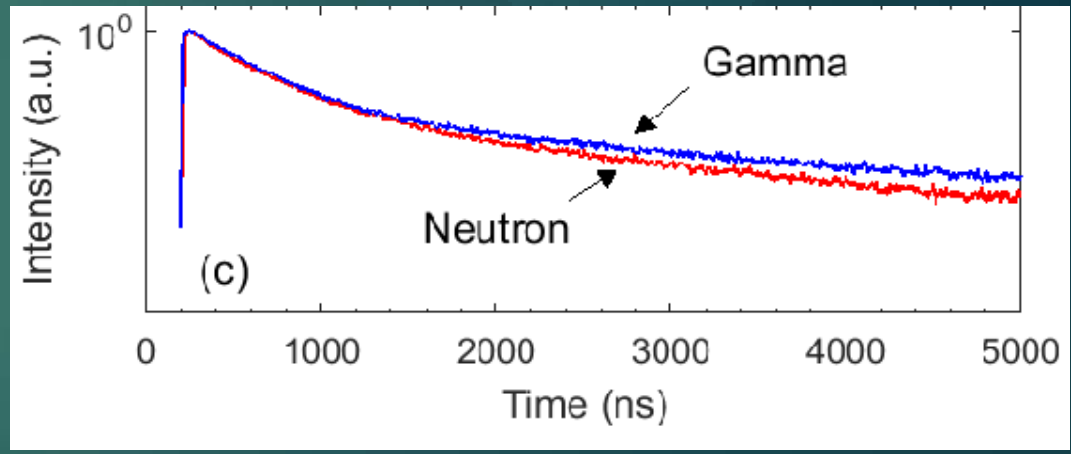


Pulse shape analysis



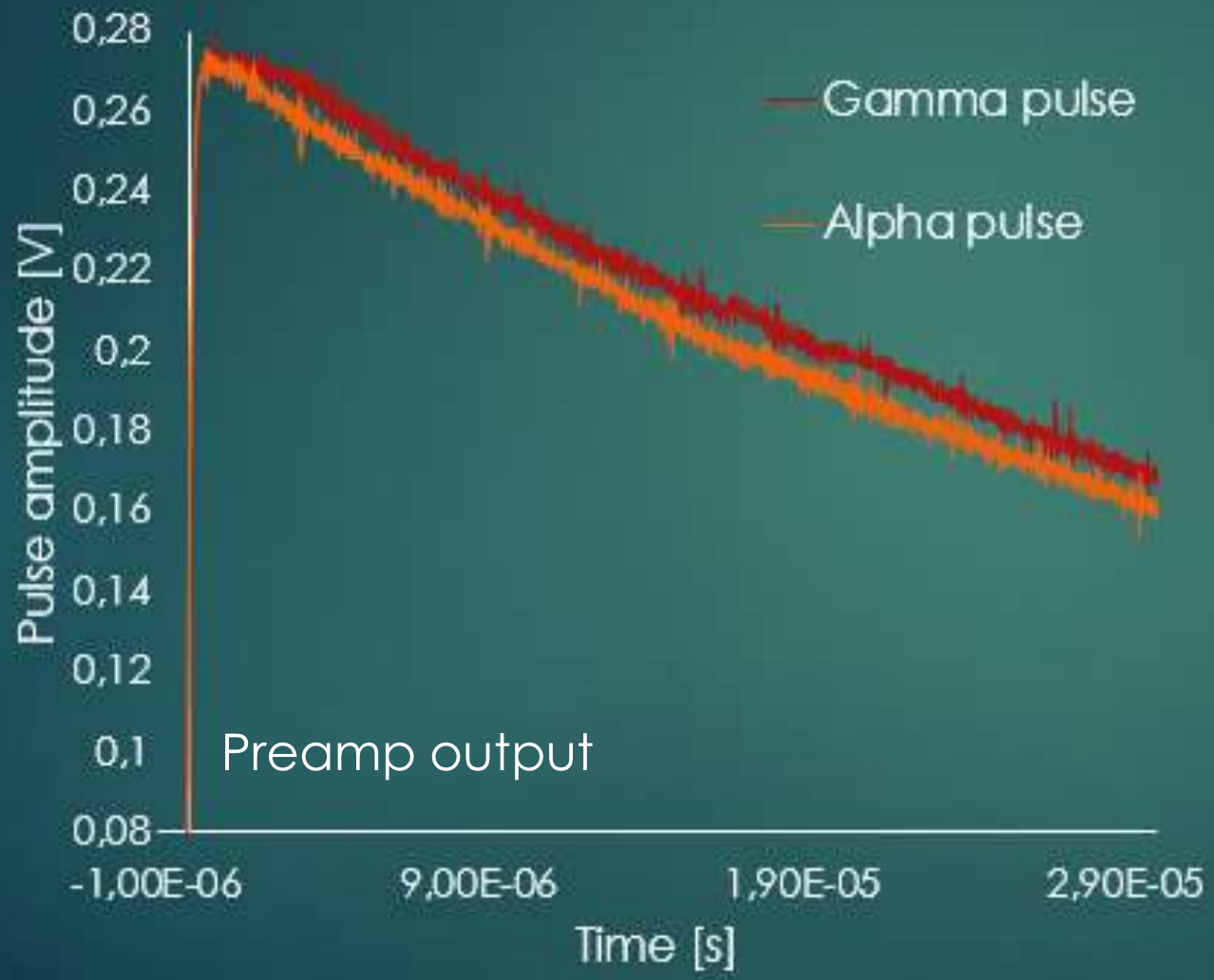
J. Phys. E: Sci. Instrum., Vol. 11, 1978. Printed in Great Britain

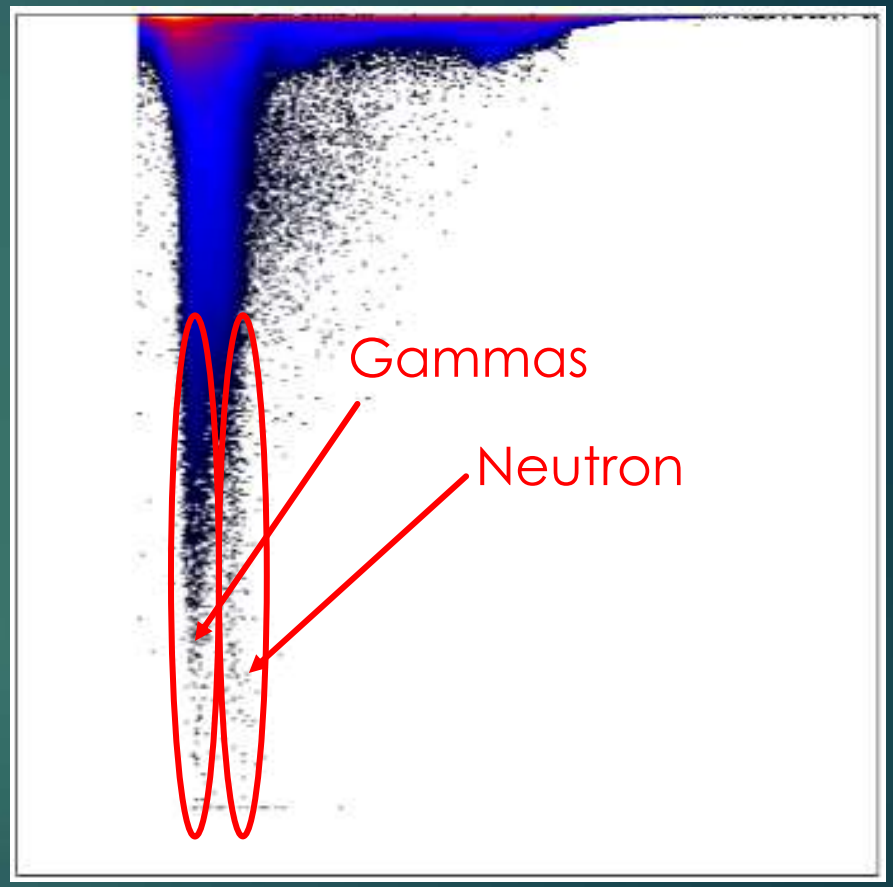
Decay characteristics of inorganic scintillators



YANG, et al. *Li co-doped NaI: Tl (NaIL) — A Large Volume Neutron-Gamma Scintillator with Exceptional Pulse Shape Discrimination*. *IEEE Transactions on Nuclear Science, 2017.*

Pulse shape analysis





Summary

- ZnS:Ag still remains the top in the case of insensivity to gamma radiation but not in detection efficiency
- Shorter decay times of lanthanide oxybromides compared to ZnS:Ag (1000 ns vs 15 ns)
- Effective signal discrimination methods
  - Neural network

Thanks for your attention!

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