Pile-Up Correction and Rejection for γ-ray spectroscopy with $LaBr_3$:(Ce) scintillators at ultra high count rates

HK 39.1

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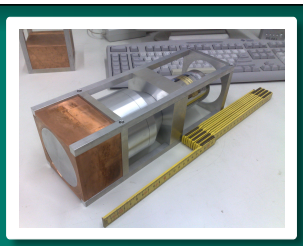
1| Characterization of a large $LaBr_3$:Ce scintillator (3x3" BrilLanCe 380)

Properties:

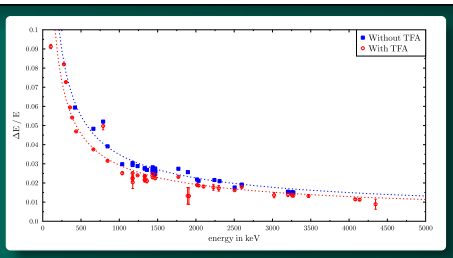
- 3x3" $LaBr_3$:(Ce) scintillator
- PMT and divider for fast timing
- Excellent light yield and linearity
- Excellent thermal stability



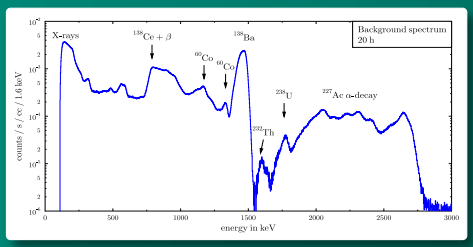
Reduced voltage readout to counteract PMT saturation

Additional TFA stage to match ADC input range.

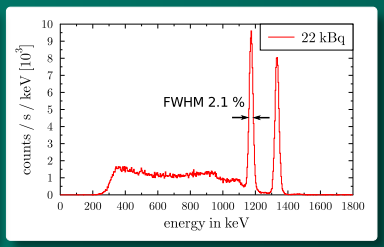
Relative resolution 2.1 % at 1.3 MeV



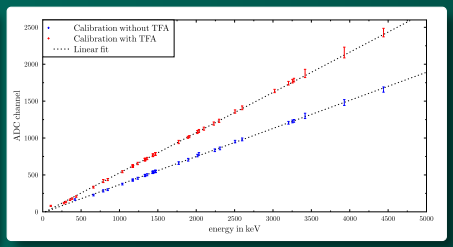
Natural Background spectrum
Contributions mainly from ^{138}La decay



Energy spectrum of ^{60}Co calibration source at low count rates (22 kHz)



Linear behavior up to 4 MeV



2| Pile-Up Correction at high count rates

Issue:

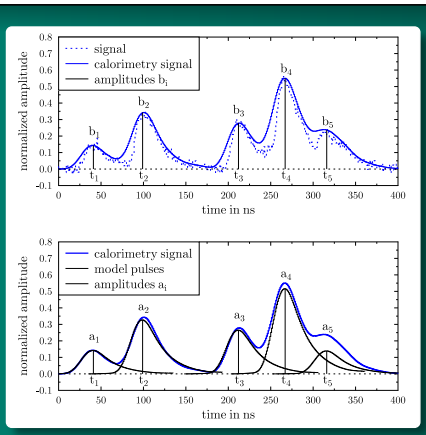
Measured amplitudes b_i are over-estimated due to pile-up effects.

Method:

Trace is treated as linear combination of single pulse shapes [1]:

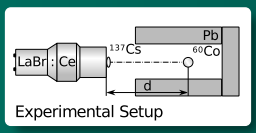
$$b_i = \sum_j m_{ij} a_i$$

=> Solution of the linear system of equations yields true amplitudes a_i.

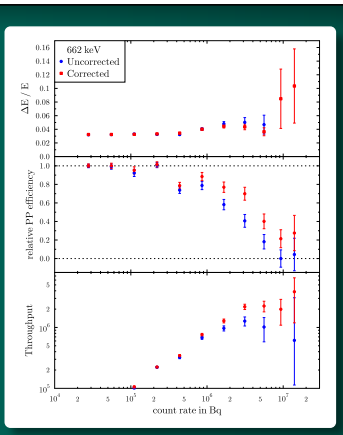


Results:

- Spectroscopic measurements up to detection rates > 10 MHz.
- Resolution is improved with pile-up correction
- Photo peak efficiency is partly recovered.
- Maximum throughput is doubled



Experimental Setup



3| Further Development

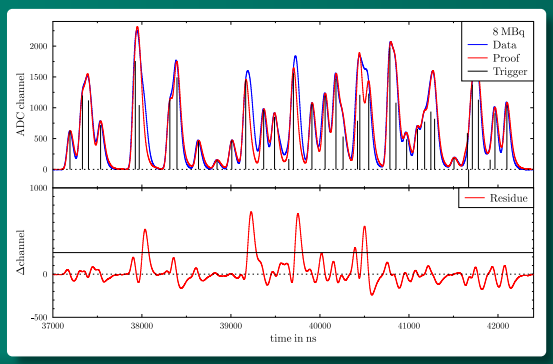
Problem:

Pile-Up Correction needs every single trigger time as input.

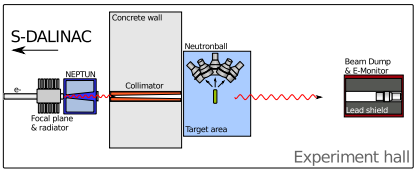
False triggers (e.g. on noise) or missed triggers lead to incorrect results.

Solution

Generate "proof" signal from corrected amplitudes and compare to original.



Application at the Low-Energy Photon Tagger NEPTUN [2]



- Use $LaBr_3$:(Ce) detector as 0° energy monitor
- Measurement of photon flux
- Lead shielding + detector act as "active beam dump"

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[1] Vencelj, M., Bučar, K., Novak, R., & Wörtche, H. J. (2009). Nucl. Instr. Meth. A, 607(3), 581-586. doi: 10.1016/j.nima.2009.06.014.
[2] Savran, D., Lindenberg, K., Glorius, J., Löher, B. et al. (2010). Nucl. Instr. Meth. A, 613(2), 232-239. doi: 10.1016/j.nima.2009.11.038.

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