PAUL SCHERRER INSTITUT

PSI

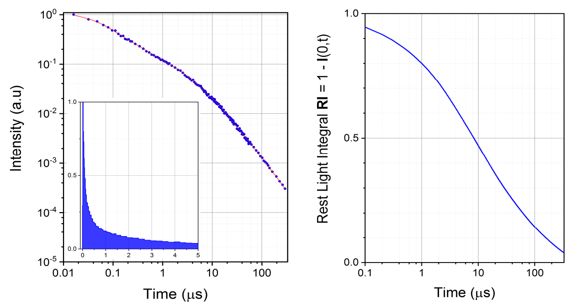
Evaluation of a ZnS:^{6}LiF based scintillation neutron detector at high counting rates

A. Stoykov, J.-B. Mosset, M. Hildebrandt

Paul Scherrer Institut (PSI), Laboratory for Particle Physics, Research Division «Neutrons and Muons», CH-5232 Villigen PSI, Switzerland

Introduction

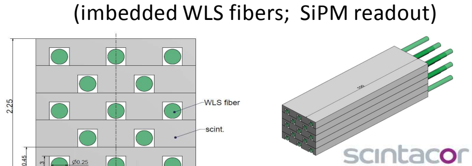
ZnS scintillator loaded with **^{6}Li** neutron absorber is widely used as a sensitive medium in detectors for thermal neutrons. The long afterglow of the scintillator is regarded as a factor preventing operation of this kind of detectors at high counting rates [1,2] . Here we revisit this problem.



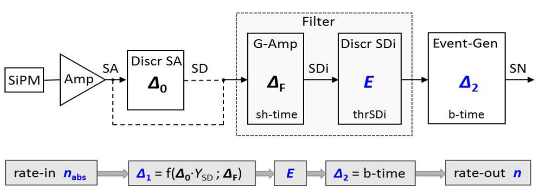
Light decay of **ZnS(Ag):^{6}LiF** in response to thermal neutrons [3]

Detector

single detection element of a multipixel detector (imbedded WLS fibers; SiPM readout)



ZnS(Ag):^{6}LiF (ND2:1)



Discr SA – input discriminator (dead time Δ_0)

G-Amp – Gaussian shaping amplifier (dead time Δ_F)

Discr SDi – leading-edge discriminator (trigger efficiency E)

Event-Gen – non-retriggerable mono-flop (dead time Δ_2)

n_{abs} – neutron absorption rate; n – rate of detected events

$n_{abs} \rightarrow \Delta_1 \rightarrow E \rightarrow n$ $n_{abs} \rightarrow E \rightarrow \Delta_2 \rightarrow n$

$$n = \frac{E\, n_{abs}}{1 + n_{abs}\,\Delta_1} \qquad n = \frac{E\, n_{abs}}{1 + E\, n_{abs}\,\Delta_2}$$

$$n = \frac{E\, n_{abs}}{1 + 0.1\, E\, n_{abs}/n_{max}}$$

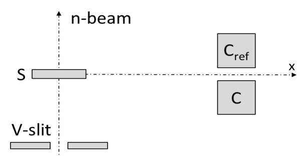
$$n_{max} = \frac{0.1\, E}{\Delta_1} \qquad n_{max} = \frac{0.1}{\Delta_2}$$

n_{max} – count rate capability (max. rate at 10% event losses)

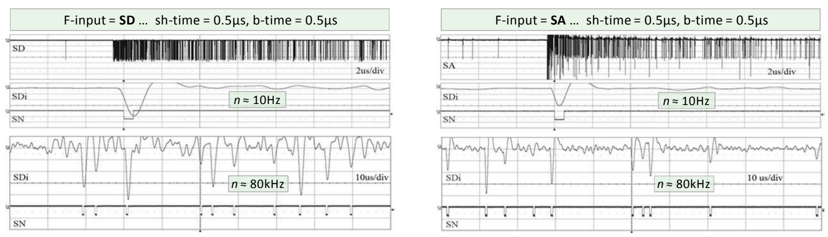
$n_{abs} = k\, n_{ref}$, n_{ref} – rate in a fast reference detector corrected for dead time

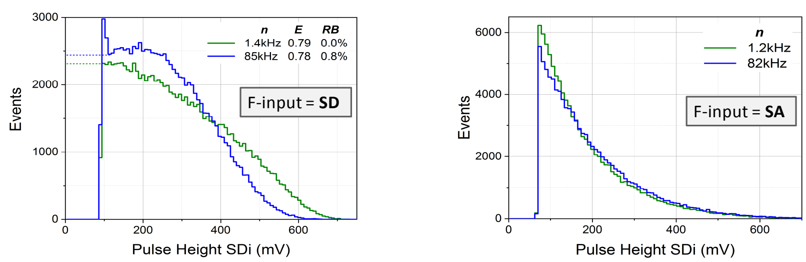
$$n = \frac{A\, n_{ref}}{1 + 0.1\, A\, n_{ref}/n_{max}} \; ; \quad A = k\, E$$

Measurements

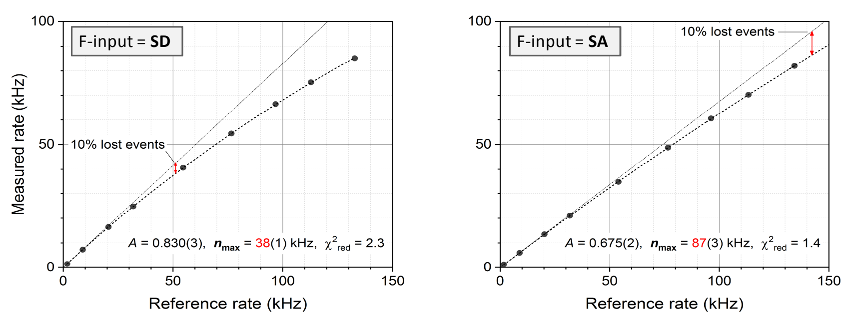


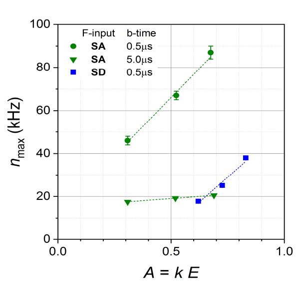
S – Plexiglas sample, $\mathbf{C_{ref}}$ – fast reference detector (GS20 Li-glass, Δ = 160ns), **C** – detector under test, **V-slit** – slit at the end of the neutron guide to adjust the beam intensity at the sample





E, RB – estimated trigger efficiency [4] and the rate-dependent background [3]





<u>Specific for high rate applications</u>:

- detector operation with short blocking times Δ_2
- dead time Δ_1 arising before the stage with an efficiency cut E is the dominating one
- digitization of the input analog signals contributes to Δ_1 and deteriorates the count rate capability n_{max}
- n_{max} increases with increasing E

Conclusion

Operation of a **ZnS:^{6}LiF** based thermal neutron detector at counting rates of **several tens kHz** with event losses **≤ 10%** is proved. Such **count rate capability** substantially exceeds the previously reported values [2] and is comparable to that of ^{3}He based detectors [1].

[1] K.Zeitelhack, Neutron News 23(4) (2012) 10; **[2]** G.J.Sykora *et al.*, NIM A 883 (2018) 75;
[3] M.Hildebrandt *et al.*, IEEE TNS accepted, http://dx.doi.org/10.1109/TNS.2018.2796309; **[4]** A.Stoykov *et al.*, IEEE TNS 63(4) (2016) 2271