

A Novel Neutron Gamma Discrimination Technique for the New LUPIN Pulsed Neutron Detector

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The LUPIN (Long-interval, Ultra-wide dynamic, Pile-up free Neutron REM counter)

• A neutron REM counter for use in pulsed neutron fields (PNF)

- PNF are characterised by a high intensity burst of radiation over a short time period (order of microseconds)
- Instead of working in 'pulse mode' like most REM counters, LUPIN samples the current at a rate of 10 MHz and then reconstructs and outputs the time profile



The LUPIN (Long-interval, Ultra-wide dynamic, Pile-up free Neutron REM counter)

No. Neutrons = $\frac{\text{Integral charge}}{\text{Mean Collected Charge}}$; Mean Collected Charge = 600 fC for BF₃

• Two versions exist: one with a ³He counter and one with a BF₃ counter (pictured below)



Measurements at PSI

- Measured field around a Injector test facility for the future SwissFEL free electron laser (at the Paul Scherrer Institute, Switzerland)
- Both versions of the LUPIN as well as the Thermo WENDI-II, and Berthold LB6411 and LB6419 detectors were used
- Measured using the following beam settings: FEL-Pulse of the order of a few ps and dark current time duration of approx. 1 µs; Repetition rate: 10 Hz; Bunch intensity: 200 pC (neglecting dark current); Beam energy: 250 MeV



WENDI-II



LB 6411



LB 6419





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Measurements at PSI

- The field showed a significant pulsed Gamma component at 4 positions
- LUPIN's usual techniques for gamma discrimination are designed for steady gamma fields and were insufficient



- The structure of the response in the detector allows a novel method of discrimination
- The moderation time of the neutrons in the burst means that the signal can be separated into Gamma and neutron components





- For the BF₃ version this was easily implemented, with well defined Gamma and neutron signals
- For the ³He version, however, it was more complicated



This had an extremely significant impact on the results for BF₃ version:

Position	H*(10) dose per burst without discrimination (nSv/burst)	H*(10) dose per burst with discrimination (nSv/burst)
Pre- Bunch Compressor	11.4 ± 2.2	10.1 ± 1.8
Post– Bunch Compressor	16.5 ± 2.7	7.8 ± 1.8
Dump-Front	29.7 ± 3.6	25.3 ± 3.3
Dump-Lateral	20.5 ± 3.0	17.8 ± 2.8



• And also for the ³He version:

Position	H*(10) dose per burst without discrimination (nSv/burst)	H*(10) dose per burst with discrimination (nSv/burst)
Pre- Bunch Compressor	13.4 ± 2.0	6.3 ± 1.8
Post– Bunch Compressor	22.7 ± 2.6	6.7 ± 1.8
Dump-Front	27.8 ± 2.9	26.9 ± 3.3
Dump-Lateral	18.6 ± 2.4	18.3 ± 2.8



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WENDI 2 Neutron LB6411 LB6419 Continuous Neutron LB6419 Pulsed Neutron LUPIN_HE3 LUPIN_BF3



Conclusions

- First application shows excellent improvement
- Application for the ³He version still needs refinement
- For the BF₃, ready to implement in the device in an FPGA





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Thank you for your attention!





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^[1] M. Caresana, M. Ferrarini, G.P. Manessi, M. Silari, V. Varoli, LUPIN, a new instrument for pulsed neutron fields, Nucl. Instrum. Meth. A 712 (2013) 15-26.

^[2] M. Ferrarini, V. Varoli, A. Favalli, M. Caresana, B. Pedersen, A wide dynamic range BF3 neutron monitor with front-end electronics based on a logarithmic amplifier, Nucl. Instrum. Meth. A 613 (2010) 272-276.

^[3] M. Caresana, A. Denker, A. Esposito, M. Ferrarini, N. Golnik, E. Hohmann, A. Leuschner, M. Luszik-Bhadra, G. Manessi, S. Mayer, K. Ott, J. Röhrich, M. Silari, F. Trompier, M. Wielunski, Intercomparison of radiation protection instrumentation in a pulsed neutron field, Nucl. Instrum. Meth. A, in press.



