RF GUN DARK CURRENT SUPPRESSION WITH A TRANSVERSE DEFLECTING CAVITY AT LCLS

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Introduction

A significant source of radiation signals in the LCLS Undulator has been identified as being generated by dark current emitted from the LCLS RF Photocathode Gun. Radiation damage to permanent magnets over time can lead to degraded performance and significant cost for replacement. A method of using an existing transverse deflector cavity with a modified RF pulse has been tested and shows promise for eliminating the radiation dose from RF gun dark current that is generated in time before and after the production beam pulse.

Research

Typical Undulator Dose @ 9.5KeV ≈ 4R/Day

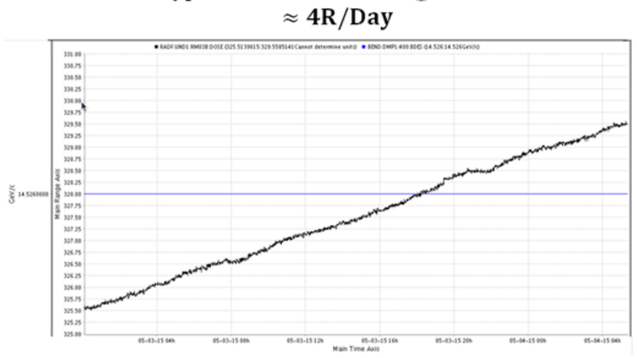

Figure 2. 24 hour RADFET 24 hour dose for 9.5KeV X-Rays.

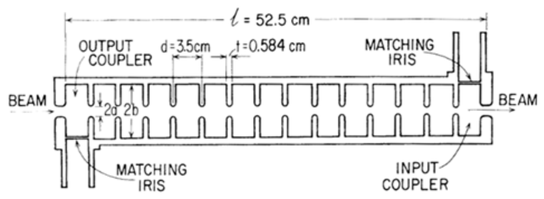

Figure 1. S-Band LOLA Deflector Sketch.[2]

- Fast fill time of traveling wave deflector allow special double pulse rf waveform that has a null electric field which allows production beam to traverse the structure with minimal perturbation.

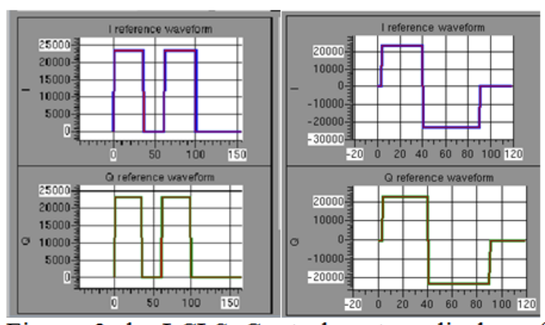

Figure 3a,b. LCLS Control system display of I&Q waveform for Dark Current Sweeper. RHS:150ns gap. LHS- "NoGap"

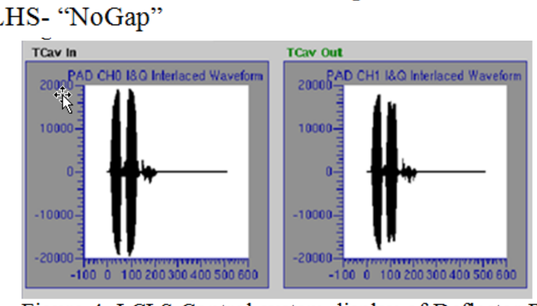

Figure 4. LCLS Control system display of Deflector RF Output with Sweeper 150ns Gap.

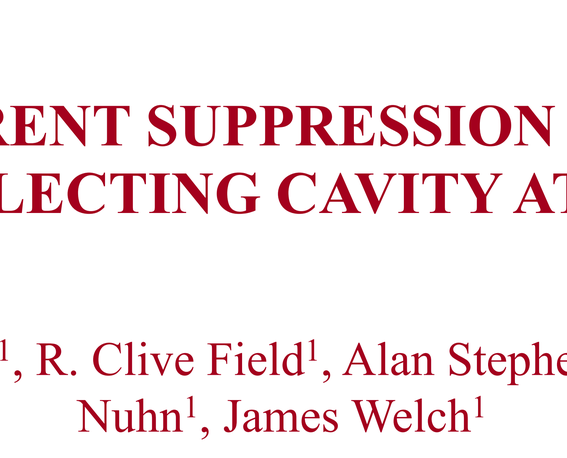

Figure 5. Dark Current Radiation observed in undulator PMT with TCAV suppression off, 9.5KeV FEL.

- Dark Current Signals

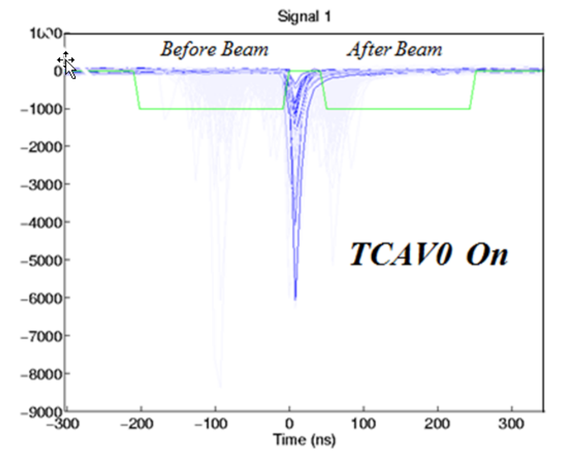

Figure 6. . Dark Current Radiation is no longer observed in undulator when the TCAV is enabled with the double pulse.

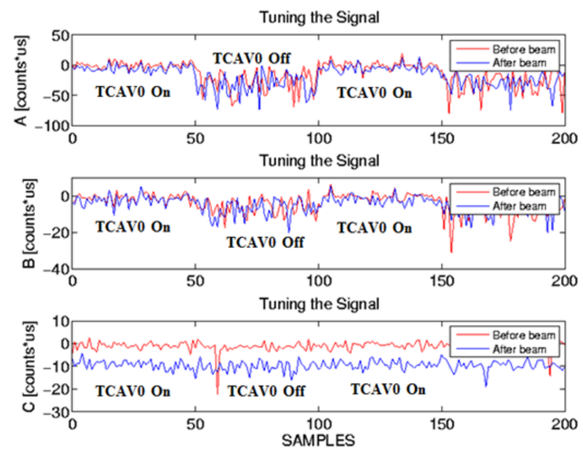

Figure 7. Undulator PMT Radiation "Persistence" Scope Integration strip chart with/without TCAV0 Double Pulse Dark Current Suppression.

- Strip chart of integrated dose windows during 9.5KeV operation with and without sweeper

Figure 8. Typical 300mR/hr Radiation dose during 9.5KeV operation.

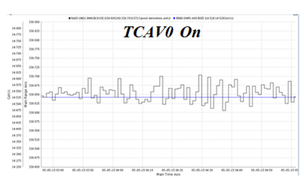

Figure 9. 0mR/hr with TCAV suppression enabled.

- Integrated dose during 9.5KeV operation with and without sweeper

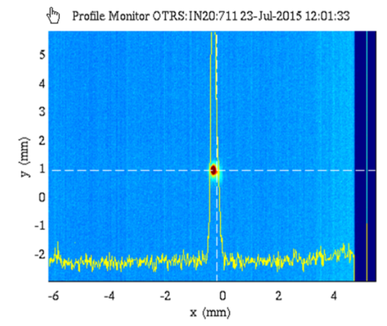

Figure 12. OTR Beam image with Deflector Cavity enabled. Orbit corrected with fine timing of RF drive.

- Beam immediately after passing through deflector cavity.

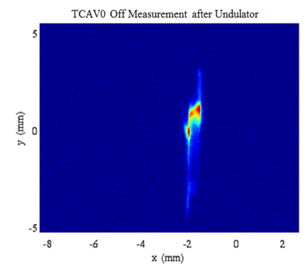

Figure 10. Beam Profile measurement after undulator with Dark Current Sweeper enabled.

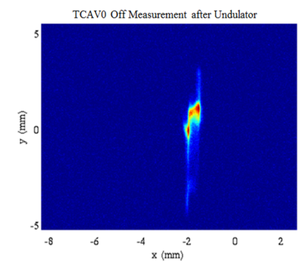

Figure 11. Beam Profile measurement after undulator with Dark Current Sweeper disabled.

- Streak measurement of beam profile after undulator with and without dark current sweeper operating.

Conclusions

A system for sweeping RF-Gun generated dark current away while leaving the production beam unperturbed has been successfully tested at the LCLS FEL operating at 120Hz repletion rate. A reduction in the radiation generated by dark current has been observed when the transverse deflector in the LCLS injector operates using a special "double pulse" configuration. This added functionality can help prolong undulator magnets lifetime by reducing the integrated dose absorbed in the magnetic material over time and also improve experimental conditions by eliminating out of time particles which can contribute to experiment noise. The concept has implications for future higher repetition rate machines such as LCLS-II where the dose rates from this dark current will be much higher. It is hoped that in the upcoming run at LCLS this system can be activated for all runtime activities except those that use the deflector cavity for beam diagnostic functions.

Acknowledgments

REFERENCES

[1] H.-D. Nuhn, C. Field, et al, "Undulator Radiation Damage Experience at LCLS." FEL 2014, SLAC-Pub-16120

[2] O. H. Altenmueller, R. R. Larsen and G. A. Loew, "Investigations of Traveling-Wave Separators for the Stanford Two-Mile Linear Accelerator." Review of Scientific Instruments 35:438 (1964).

[3] V. A. Dolgashev, et al, "Design and Application of Multi Megawatt X-Band Deflectors for Femtosecond Electron Beam Diagnostics." PhysRevSTAB 17, 102801

[4] CPI Model VA-864, 10KW CW klystron. http://www.cpii.com/product.cfm/1/20/48

[5] Private communication with V. A. Dolgashev.