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Stacked, Filtered Multi-Channel X-ray Diode Array

SPIE Paper : 9595-21

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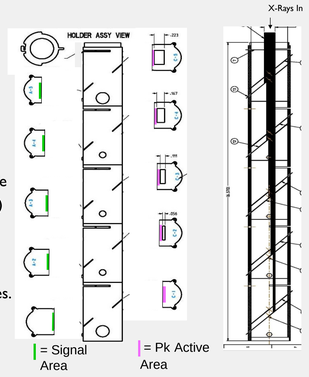
Introduction and Motivation

This system meets the need for a low cost, robust X-ray diode array to use for experiments in hostile environments on multiple platforms, and for experiments utilizing forces that may destroy the diode(s). Since these uses require a small size with a minimal single line-of-sight, a parallel array often cannot be used. So, a stacked, filtered multi-channel X-ray diode array was developed that was called the **MiniXRD**. The design was modeled, built, and tested at National Security Technologies, LLC (NSTec) Livermore Operations (LO) to determine fundamental characteristics. Then, several different systems were fielded as ancillary 'ride-along' diagnostics at several national facilities to allow us to iteratively improve the design and usability. Presented here are design considerations and experimental results. This filtered diode array is currently at Technical Readiness Level (TRL) 6.

Diagnostic Design

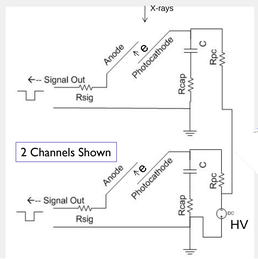
The MiniXRD plate spacing is small enough to allow <300 ps pulses, with a bias of 200 V - 1 kV. The stacked design allows multiple channels to be read through a 4 - 10 mm aperture.

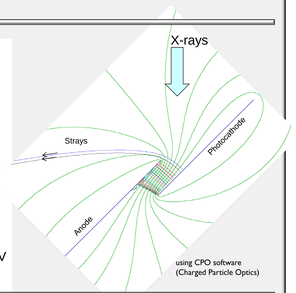
- Uses a modular design where each channel has:
  - Rexolite tube body
  - Coated Alloy 42 Photocathode (Pk) and anode
  - Custom filters (e.g. metal on Mylar on holder)
  - Circuit with charge supply capacitor and isolation and termination resistors.
- Rexolite base holds a stack and mounts to flange
- Aperture in front directs X-rays to photocathodes.
- Rexolite parts attached with Rexolite glue.
- Stepped alignment tool for plate alignment
- Simple assembly and field repair



Models

Beyond the standard CAD models, performance models were also prepared covering electron ballistics, impedance, crosstalk, filter and photocathode determination, and flux and temperature determination for stacked arrays.



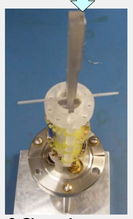


Assembly

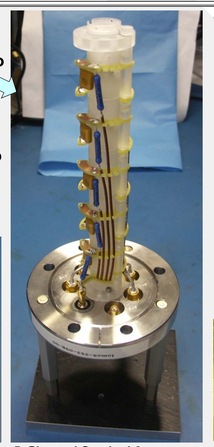
5-Channel Stacked Array CAD model showing plate layout

5-Channel MiniXRD
- 4 ½" flange
- Single high voltage
- Upgrade to 6 signals

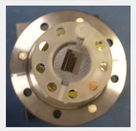
2-Channel MiniXRD
- 2 ¾" flange,
- Single high voltage
- 2 signal channels



2-Channel MiniXRD showing alignment tool



5-Channel Stacked Array MiniXRD on prep stand prior to use

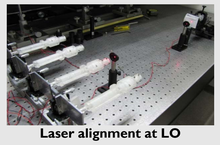


Front views showing stacked photocathodes

Filters made in-house mount on holders that slide into slots

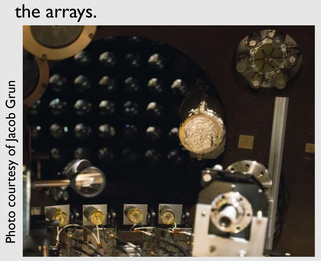
Experimental Setup

Adjustable mounts were designed to hold the diode array in vacuum at the various facilities. Detachable laser pointers were used to align the arrays.

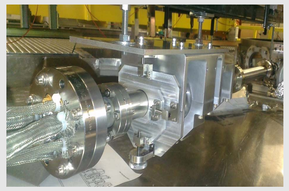


Laser alignment at LO

Photo courtesy of Jacob Grun



Ball / Socket with 5-Channel, Quad 2 channel, and parallel array at NRL / NIKE



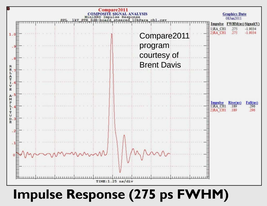
Ball / Socket used with 5-Channel MiniXRD at UNR / ZEBRA

Data

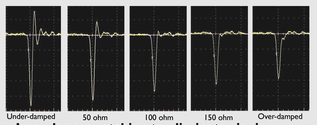
Test Facility	Rev	TRL	Test Summary	Result
Manson at LO	0,1	1-3	Basic X-ray detection	0.2-80 pA
Short Pulse Laser at LO (UV)	0-3	1-3	Response Time, Dynamic Range	300 ps FWHM, DR=1000
Long Pulse Laser at LO (UV)	1-3	2-5	Shape Symmetry, Charge Storage	Within 5%, 100 ns
Microwave Optics Lab at LO	2-3	3-5	Impedance Matching	Ringing < 5%
Omega at LLE	2-3	4-5	Shape and Response Comparisons	Shape match 10%
Beamlines U3C & X8A at BNL	2-3b	3-5	Spectral Response (photocathodes and filters) and low energy channel	Energy range of 200 eV - 5 keV
NIKE at NRL	3, 3b	5	Multichannel max range and alignment	Power at diode 3×10^{4} W
ZEBRA at UNR	3, 3b	6	Multichannel alignment and response	Flux, Temp, DR>5000

BNL = Brookhaven National Lab
LLE = Laboratory of Laser Energetics

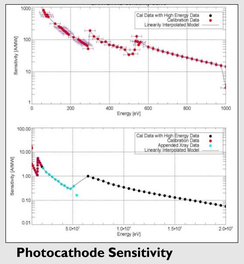
NRL = Naval Research Lab
UNR = University of Nevada, Reno



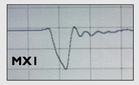
Impulse Response (275 ps FWHM)

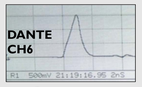


Impedance matching to eliminate ringing

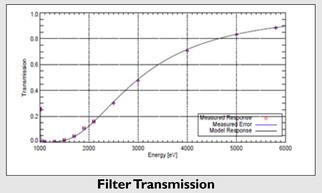


Photocathode Sensitivity

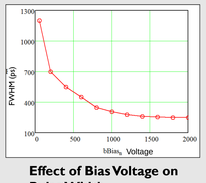




Comparative shots at Omega

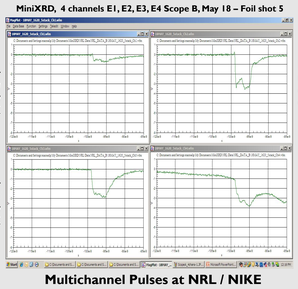


Filter Transmission



Effect of Bias Voltage on Pulse Width

MiniXRD, 4 channels E1, E2, E3, E4 Scope B, May 18 – Foil shot 5

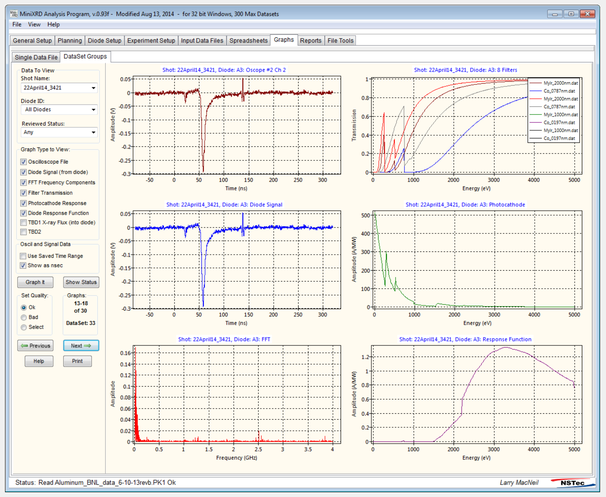


E1 – high energy OK
E2 – mid energy OK
E3 – mid energy OK
E4 – front low energy broken filter allows UV signal on tail end

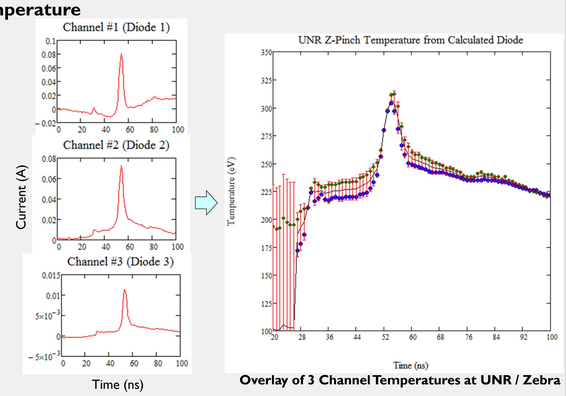
Multichannel Pulses at NRL / NIKE

Analysis

Dataset Metrics



Temperature



Time (ns)

Overlay of 3 Channel Temperatures at UNR / Zebra

Future Work

- Final TRL 7-9 validation (incorporation into mission-level experiments)
- Additional development of analysis methods and software (future paper)
- Additional development of Low Energy channel (SPIE paper: 9591-7)

Acknowledgements

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Poster Information

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