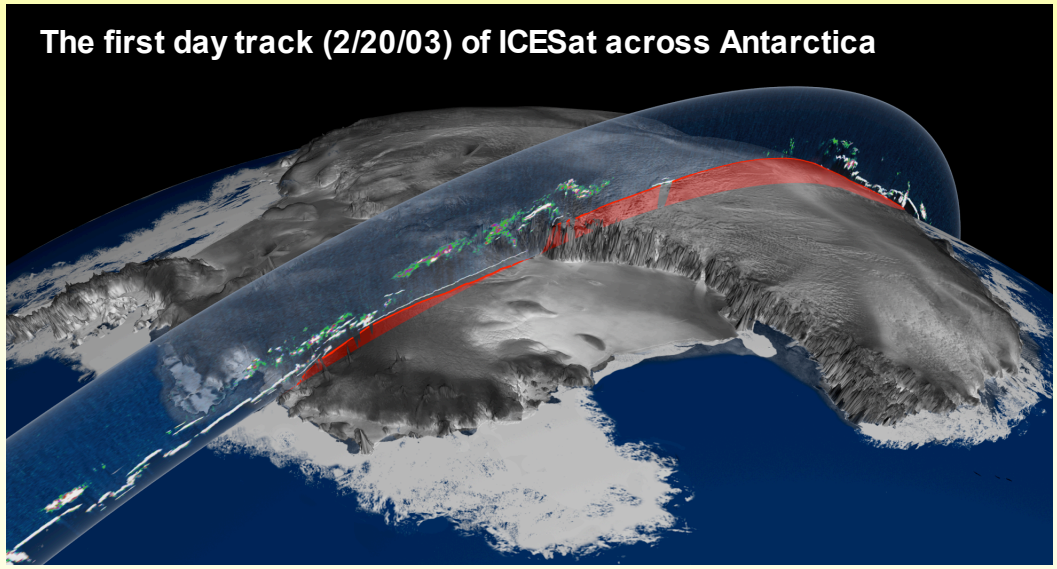
Qualification, Performance Testing and Characterization of Quasi-CW Laser Diode Arrays

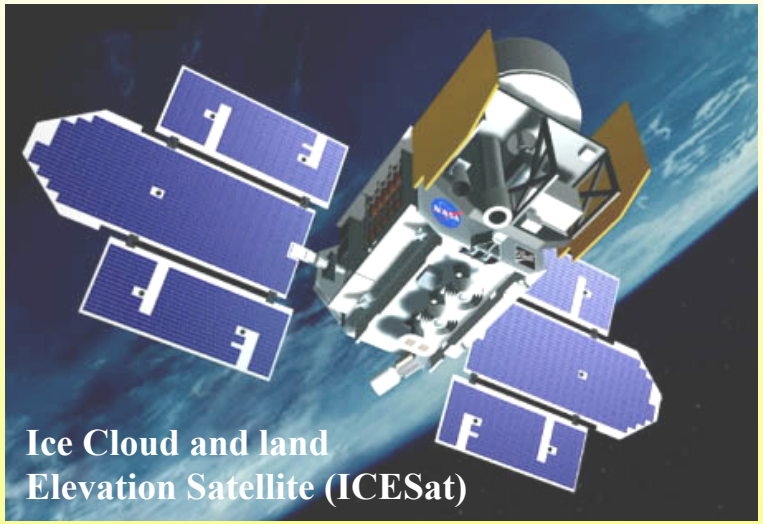
Mark Stephen
NASA - Goddard Space Flight Center
Laser and Electro-Optics Branch

OUTLINE

- Introduction and research objectives
- General characterization measurements
- Performance tests
- Future work

INTRODUCTION





Challenges for QCW LDAs for Space flight

- The arrays are the power source for laser and potentially a single point failure for the instrument
- LDAs are complicated devices with multiple failure mechanisms so predicting reliability is difficult
- QCW operation causes heating with every current pulse which puts repeated thermo-mechanical strain on device
- QCW market does not support the statistically verified reliability testing found in the telecom market.
- QCW LDAs are used in a many applications with different operational parameters which further fractures the QCW market
- Statistics are expensive because of the cost of the arrays
- Vendor designs, procedures, and tests change often in an effort to improve package design which can degrade (or negate) the statistics you gather on previous devices
- It is a competitive business so vendors can come and go

Research Objectives

➔ Develop procedures for purchasing, handling, storage and operation

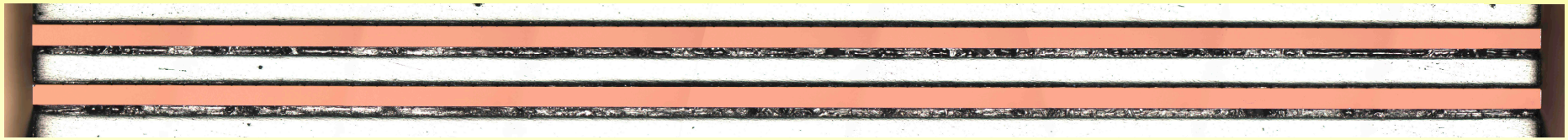
➔ Improve understanding of device operation and failure modes

➔ Quantify affect of operational and environmental parameters on LDA performance

➔ Develop prediction/screening capability

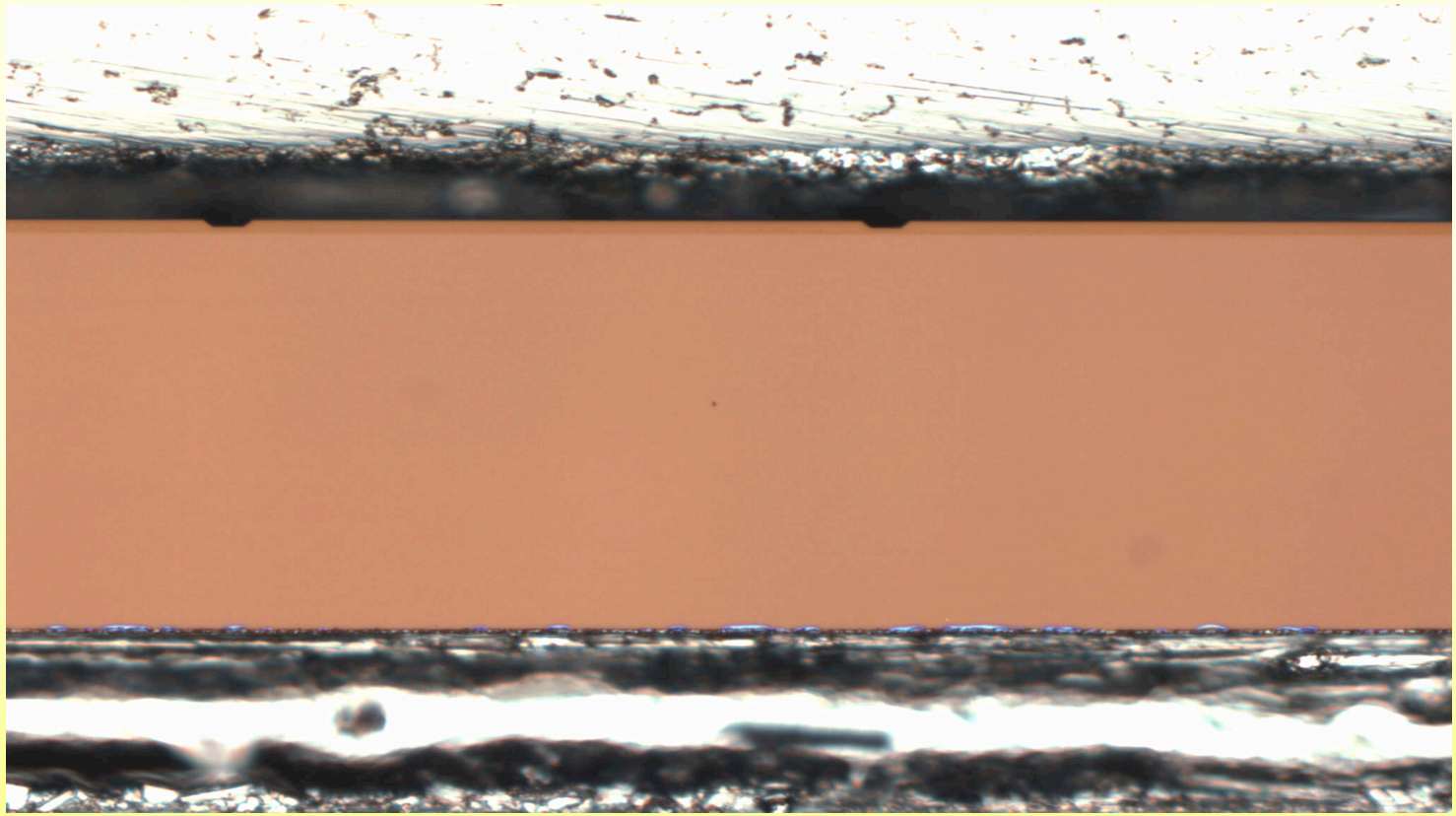
➔ Enable improved reliability and performance of future missions

Microscopic Facet Inspection: Bright Field 50x 200x magnification

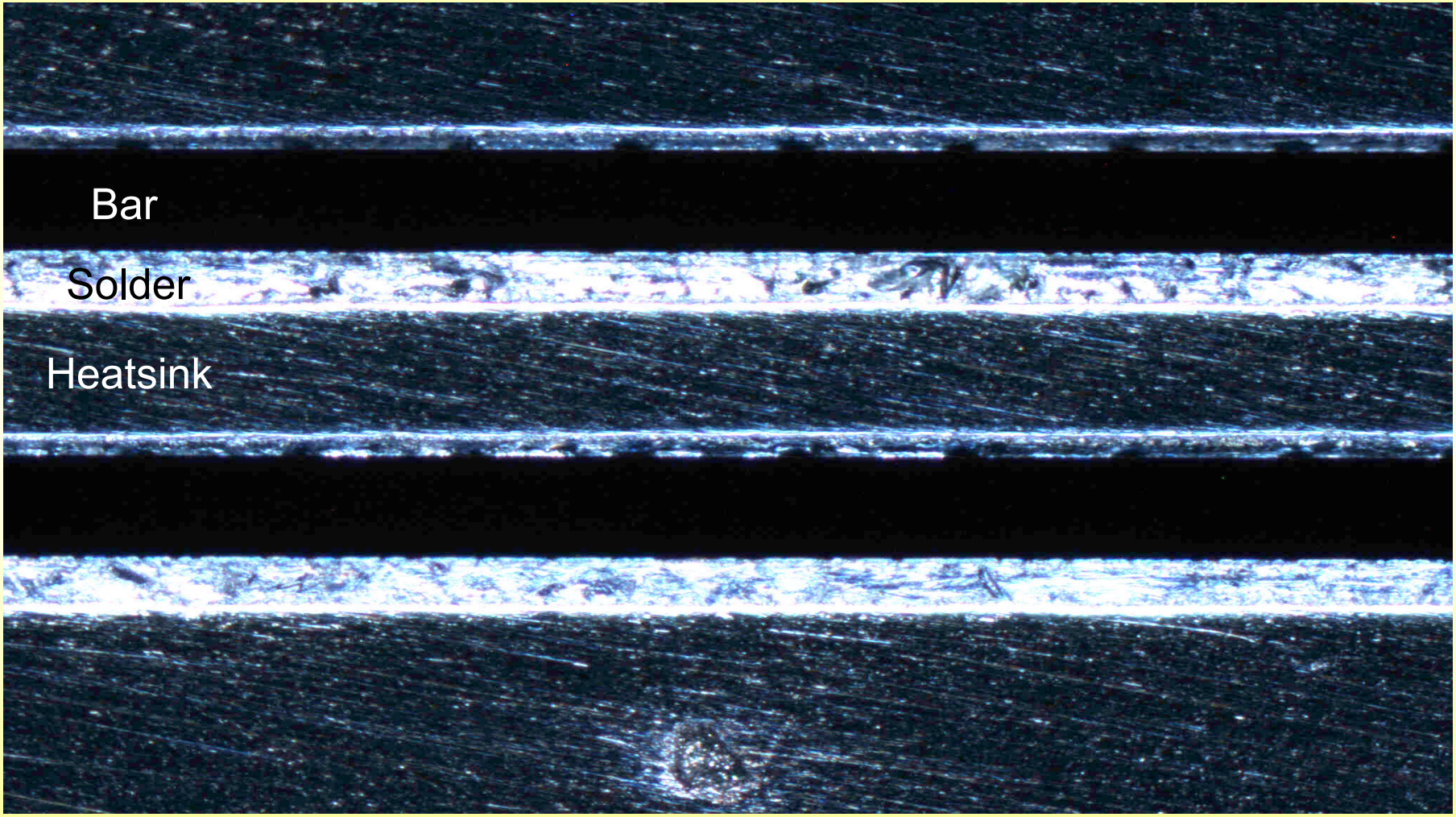


Stitched image of 2-bar array [Bar length is 1 cm]

Single image showing resolution of 200x micrsocopy [Bar height is ~120 μm]

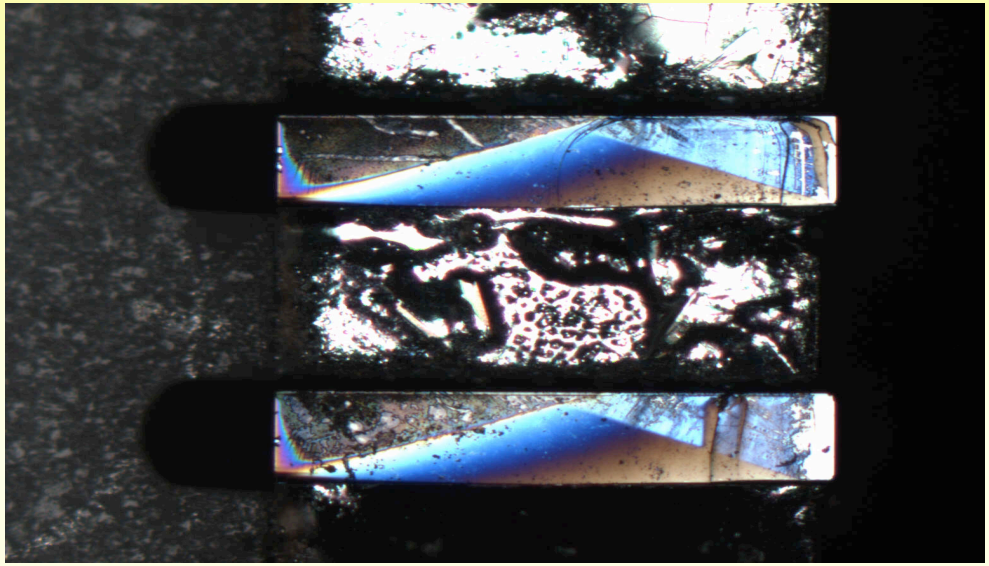


Microscopic Facet Inspection: Dark Field 50x Magnification

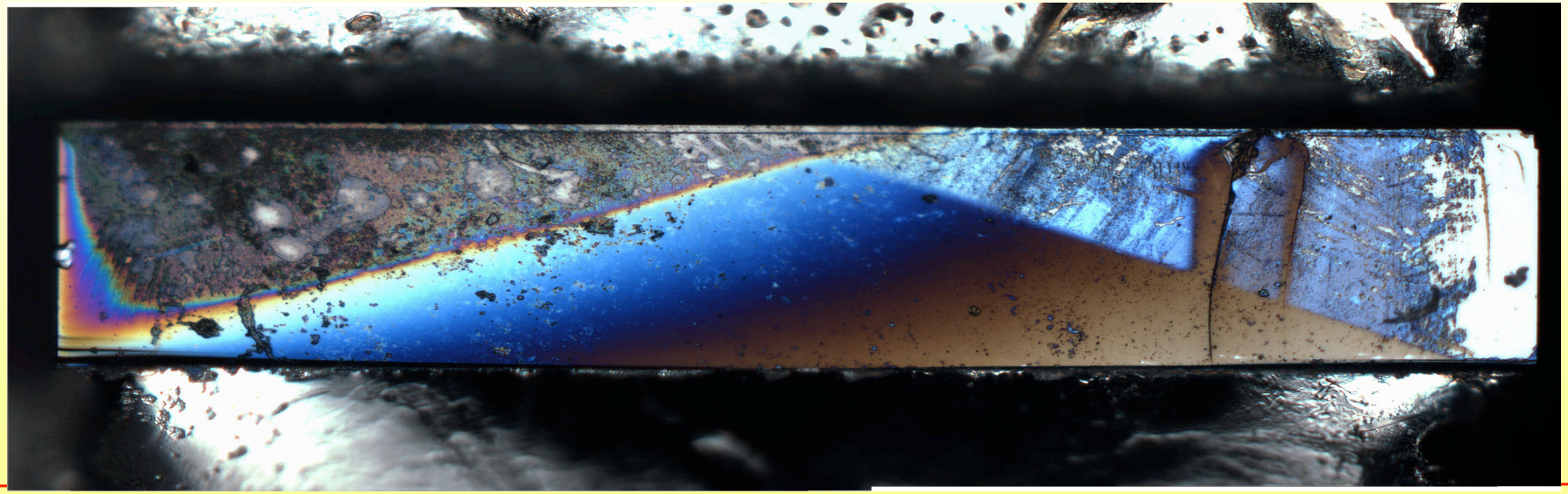


Microscopic Side View Inspection: Bright field 50x, 100x magnification

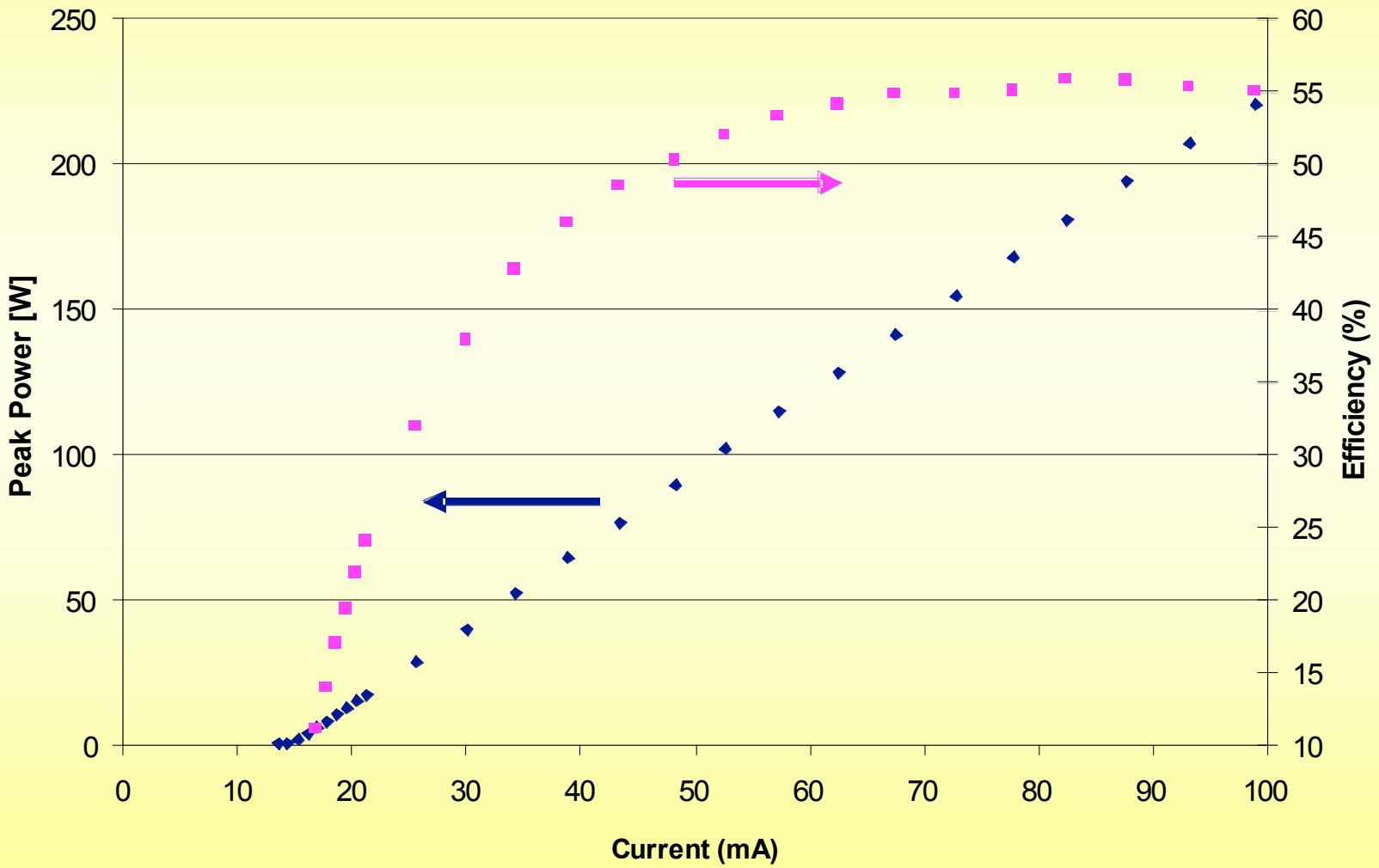
Bright field 50x



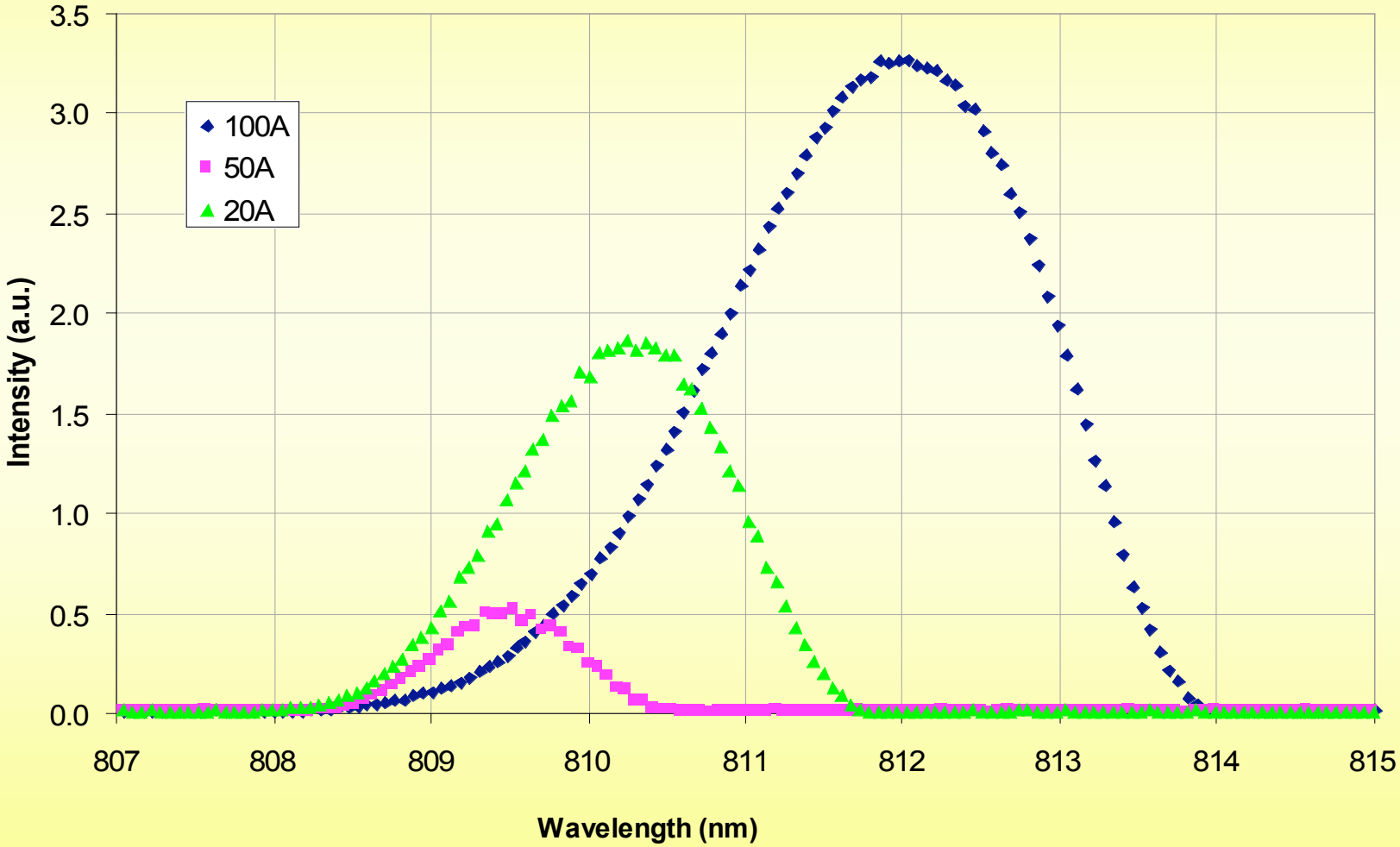
Bright Field 100x (stitched)



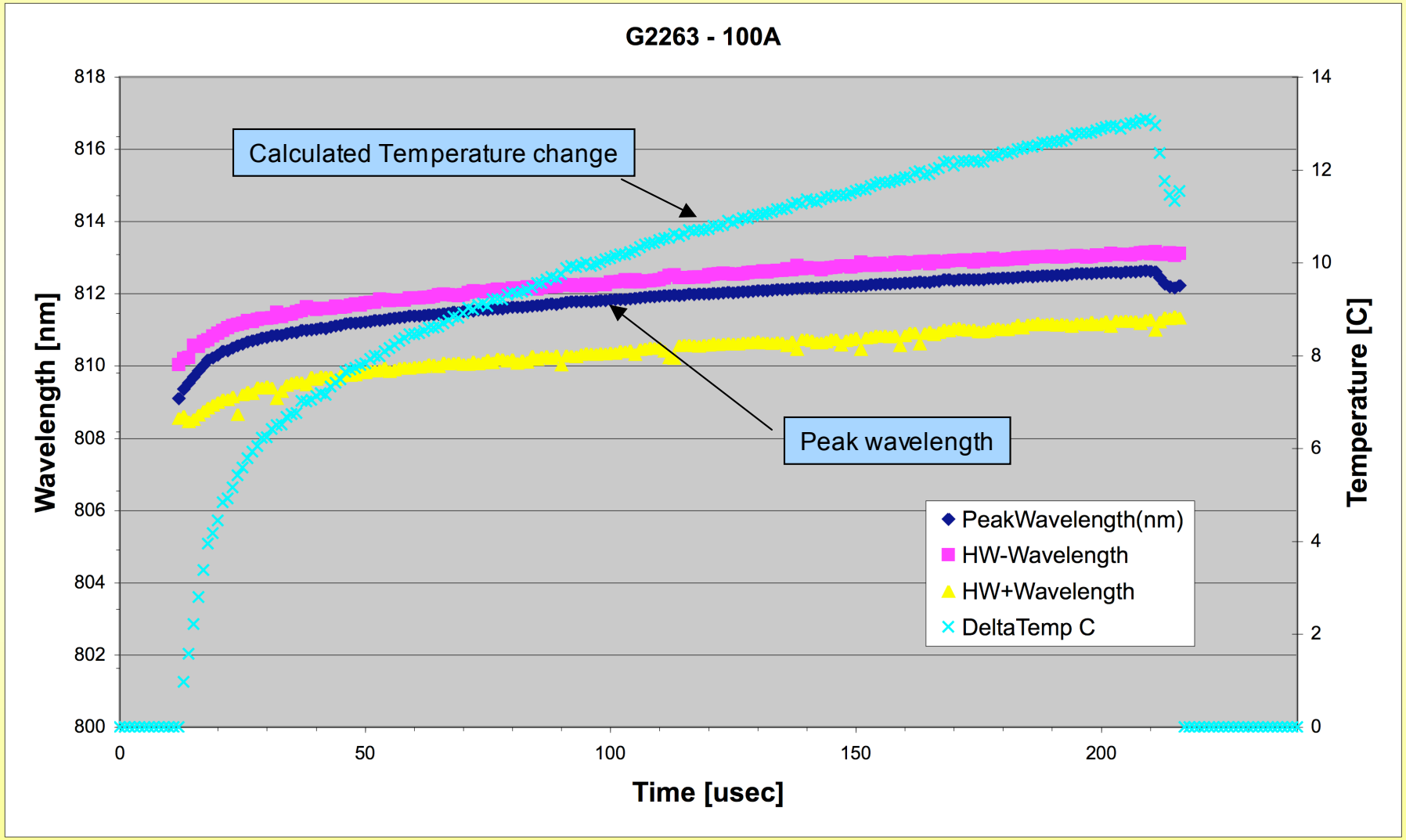
Power and Efficiency vs. Current



Averaged Optical Spectrum



Time-resolved Spectrum



Near Field Inspection – 100A

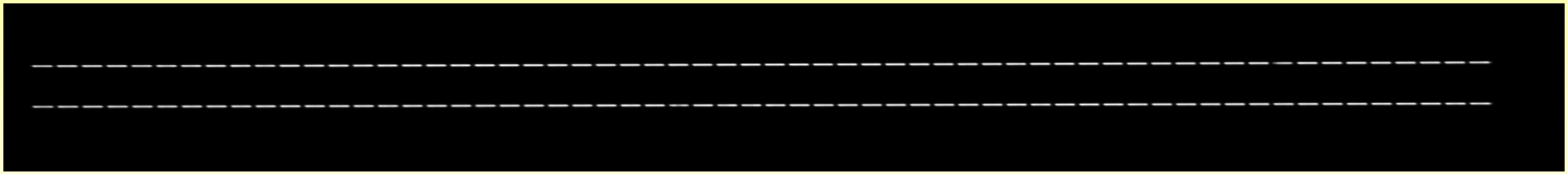
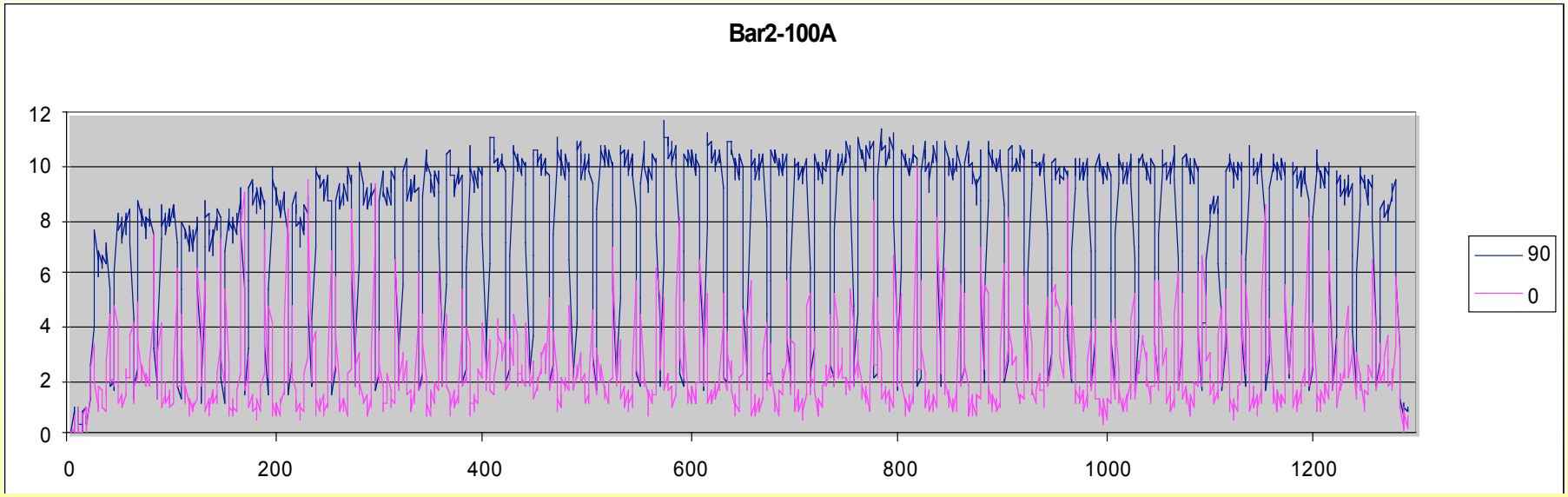
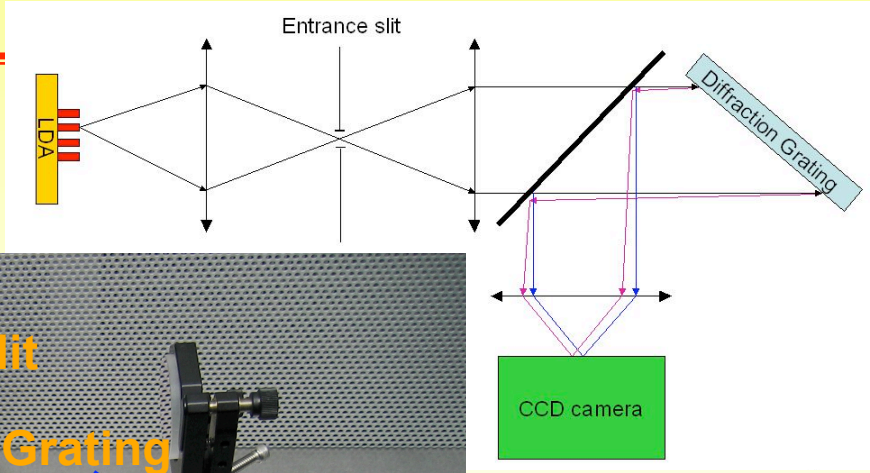


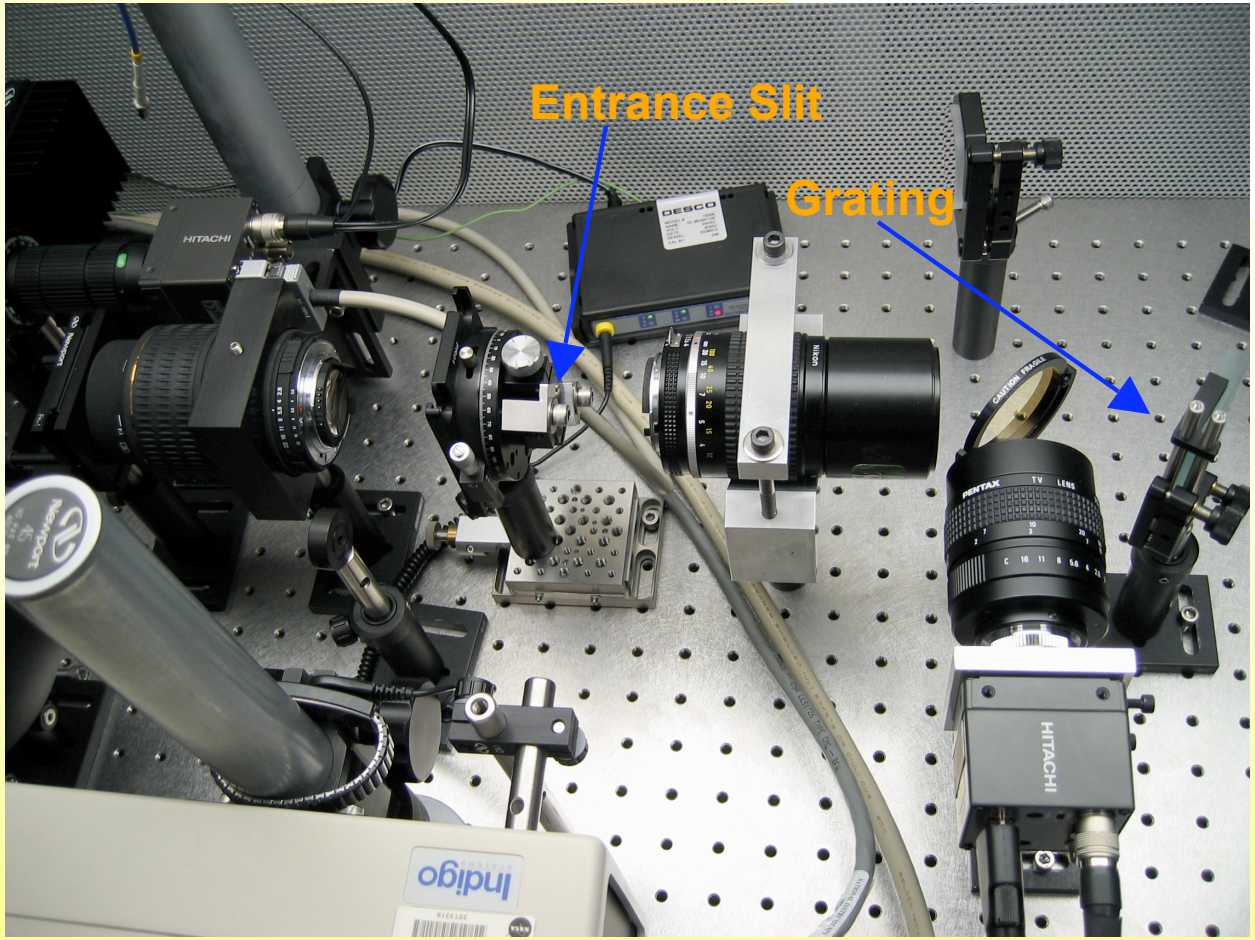
Image of 2-bar array during operation
showing optical power distribution



Polarization resolved near field measurement

Imaging Spectrometer

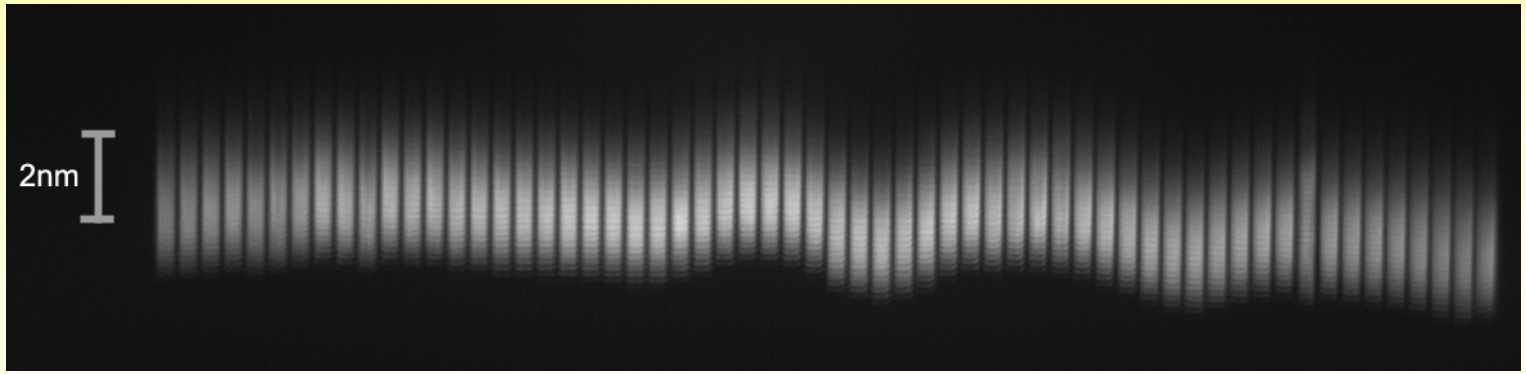




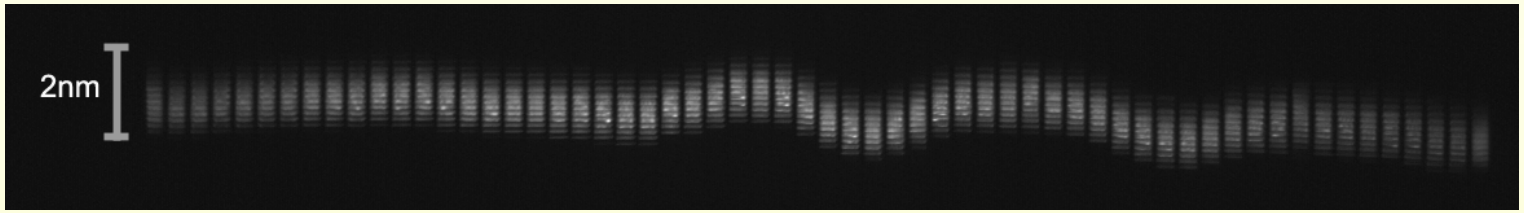
Imaging Spectrometer Measurement

Coherent G2261 bar#2

Wavelength



100A



20A

Emitter Position

NOTE: Bar tilting shown here is due to alignment and not wavelength shift

Zoomed image illustrating spectral resolution and cavity modes

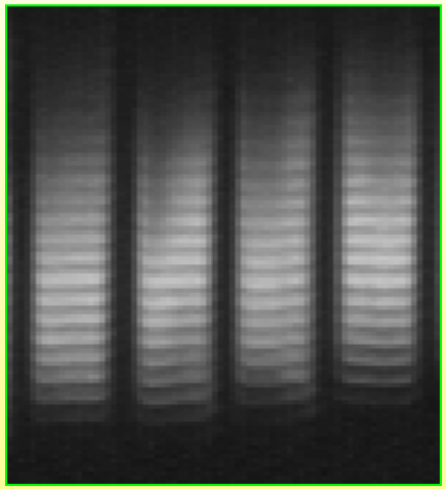
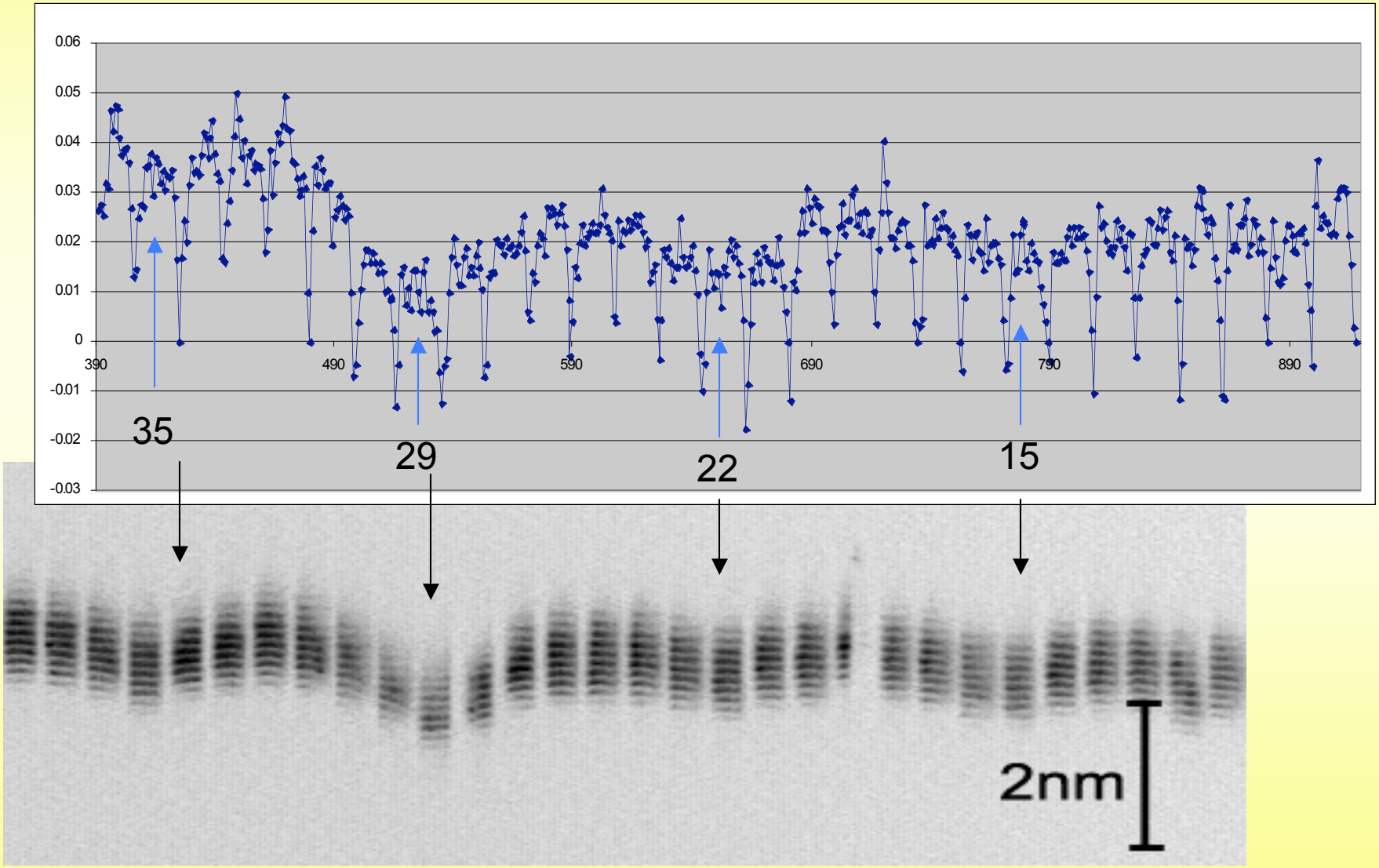
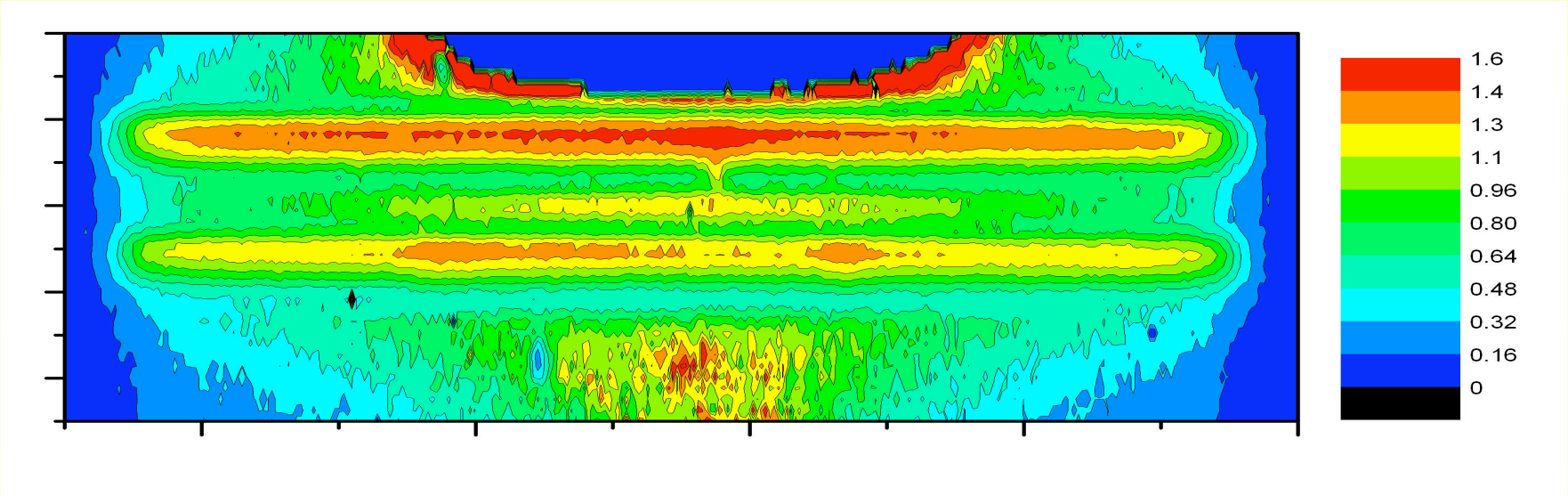


Photo Emission and Imaging Spectrum



Thermal Image using Infra Red (IR) Camera

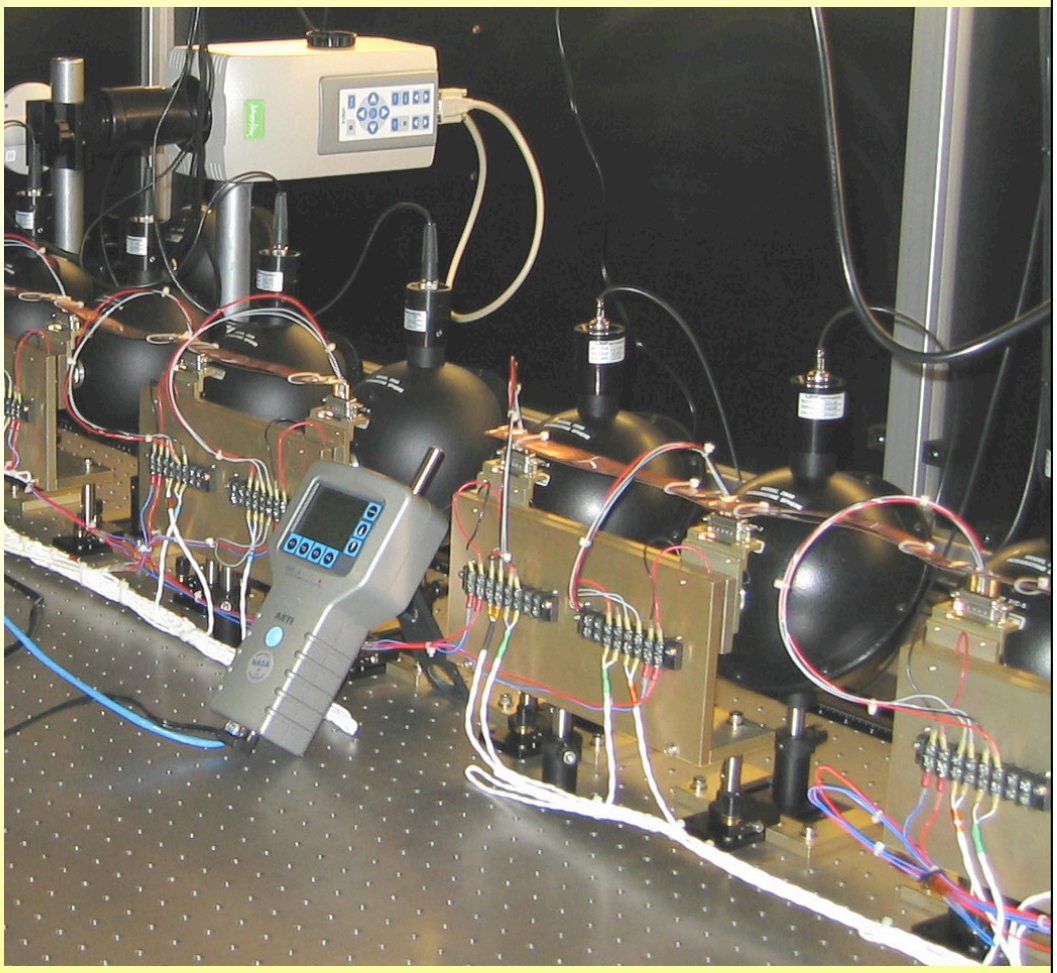


Bar Width (1 cm)

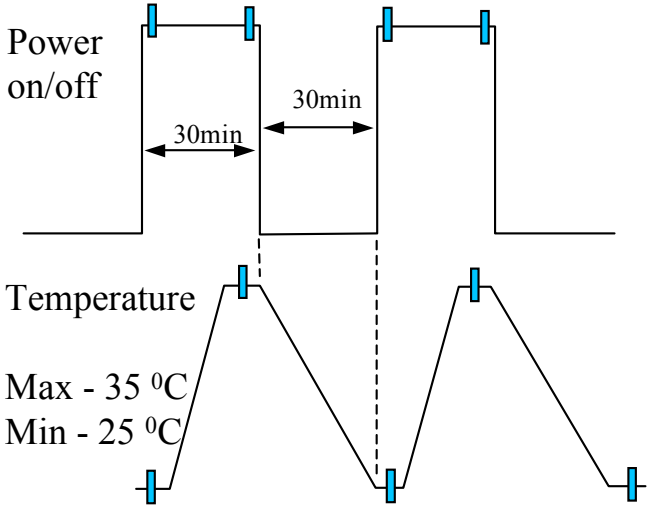
Characterization Procedure

- Microscopic inspection
  - Facet inspections - BF 50x, 200x, DF 50x
  - Side views - BF 50x, 200x
- IR imagery
  - Averaged
- Spectral measurement
  - Spatially and temporally averaged
  - Spatially resolved
  - Temporally resolved
- Optical Power
  - Average, Peak, power /emitter, time-resolved,
- Near Field
  - Normal, polarization resolved
- Electronic Parameters
  - Current Pulse width, Amplitude, Efficiency, voltage, threshold current

Power / Temperature Cycling Test for MLA

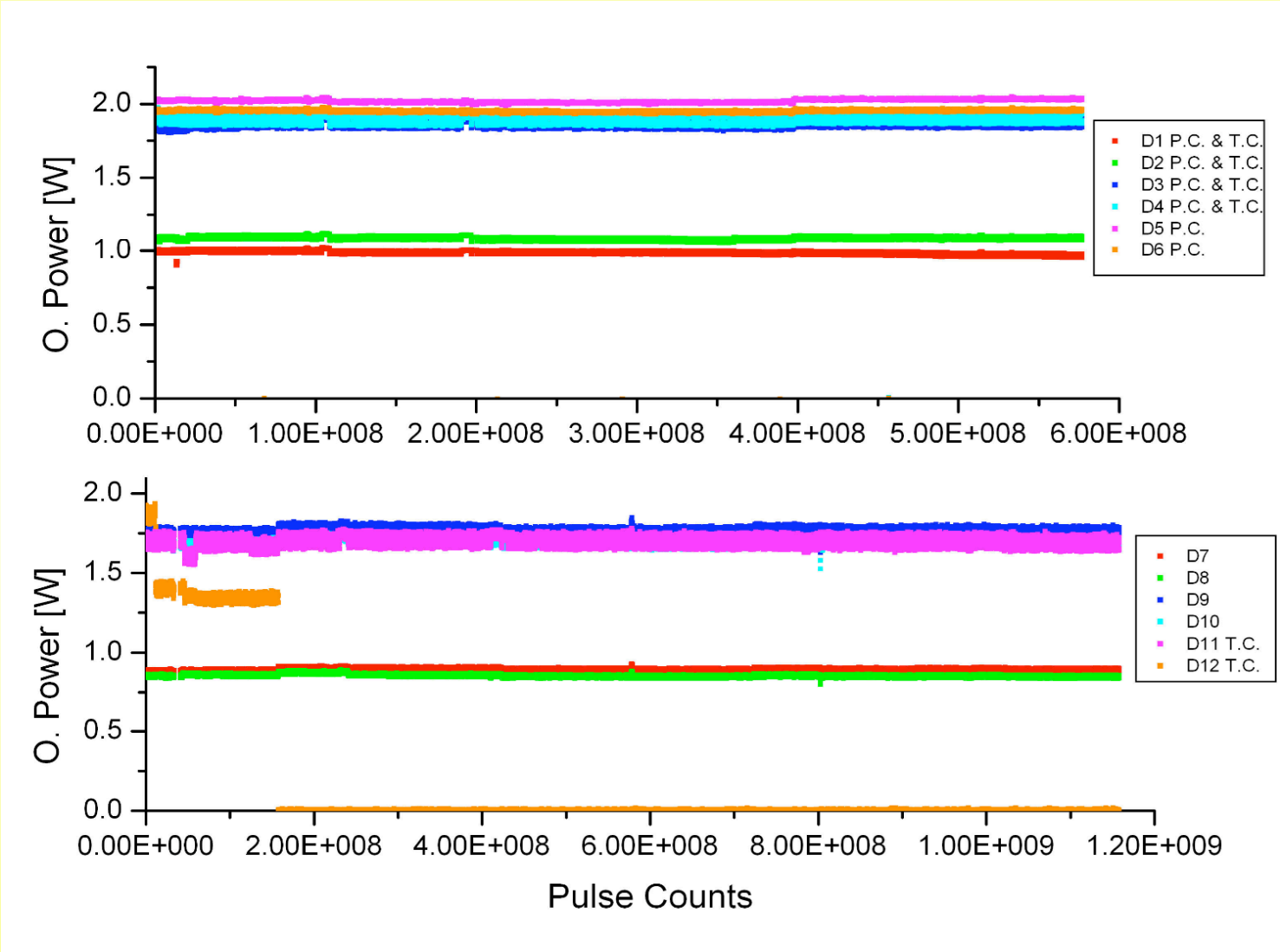


CYCLING PATTERN



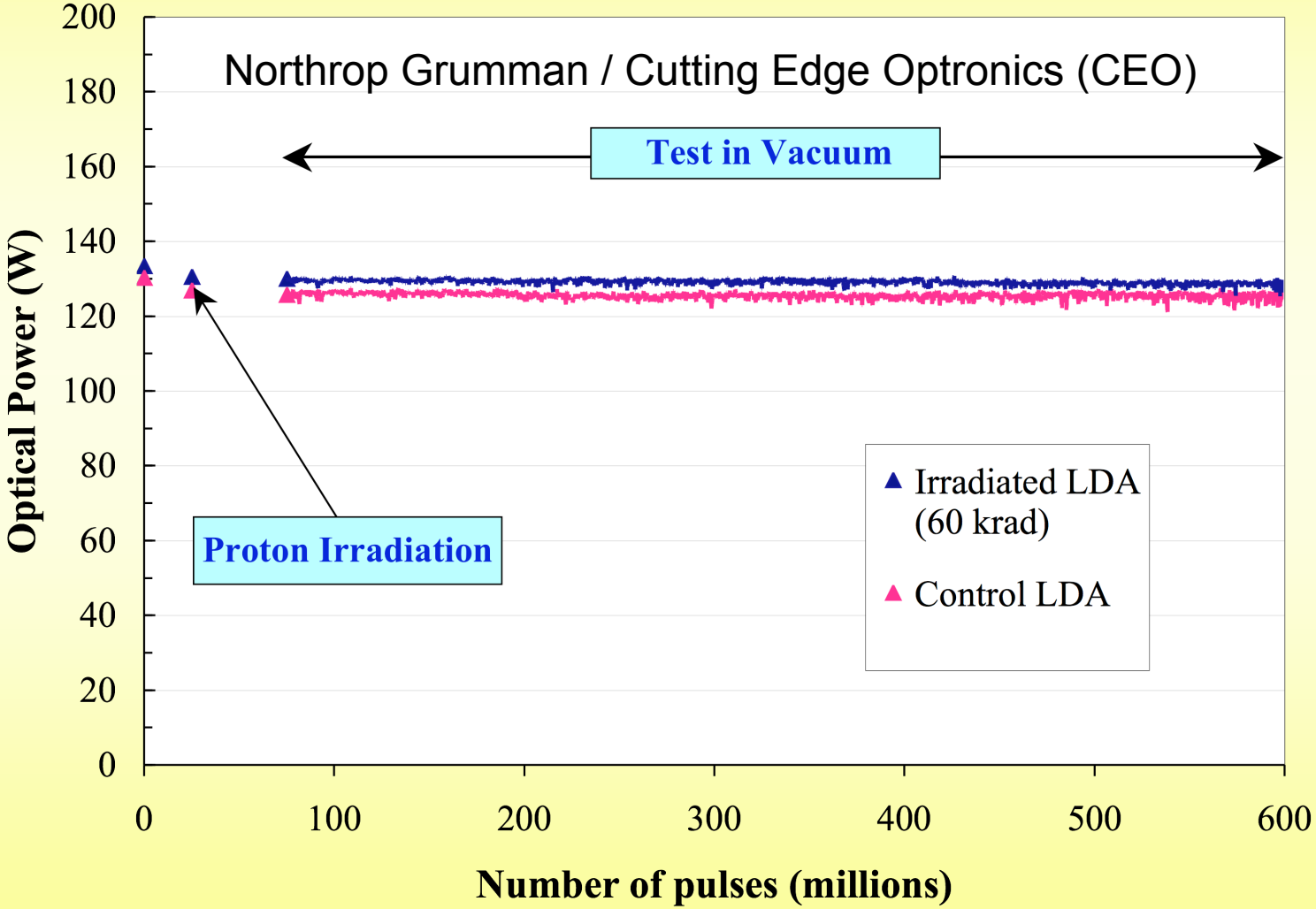
	Constant Temperature	Temperature Cycled
Constant Power	2 G2's 2 G4's	2 G4's
Power Cycled	2 G4's	2 G2's 2 G4's

Optical Power vs. Pulse Count



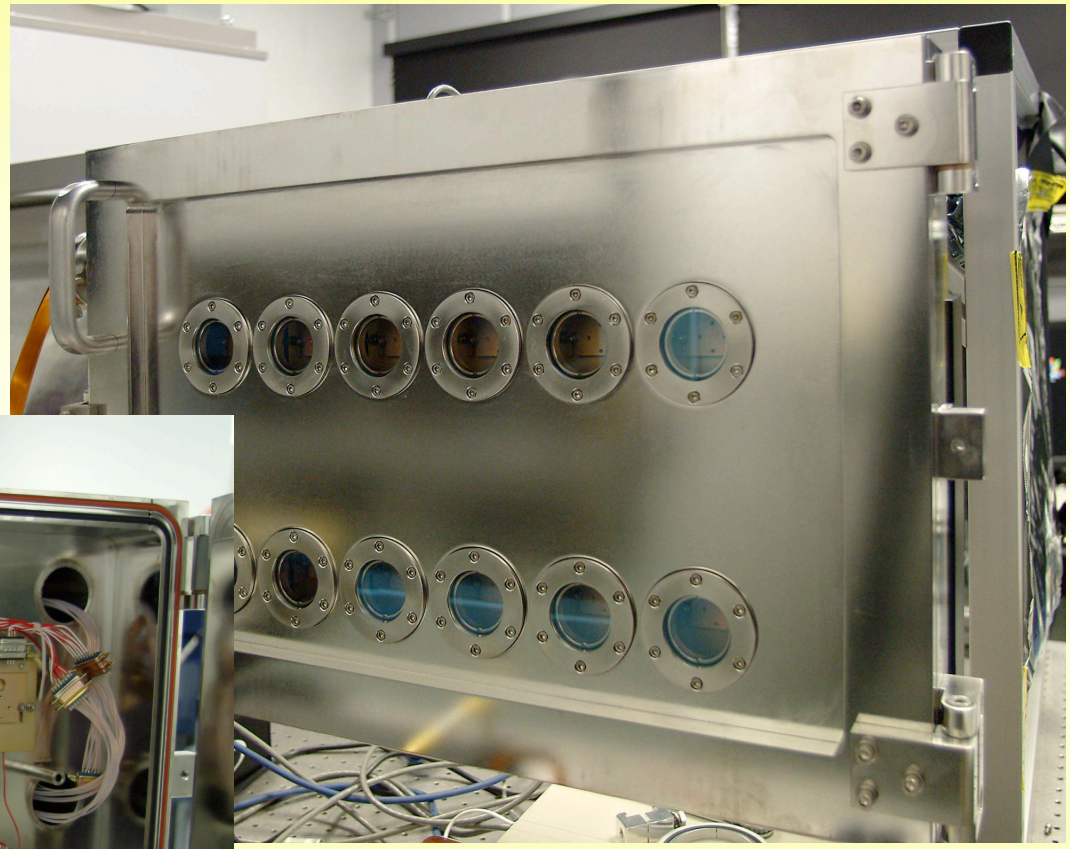
Mercury Laser Altimeter (MLA) era arrays under power and temperature cycling

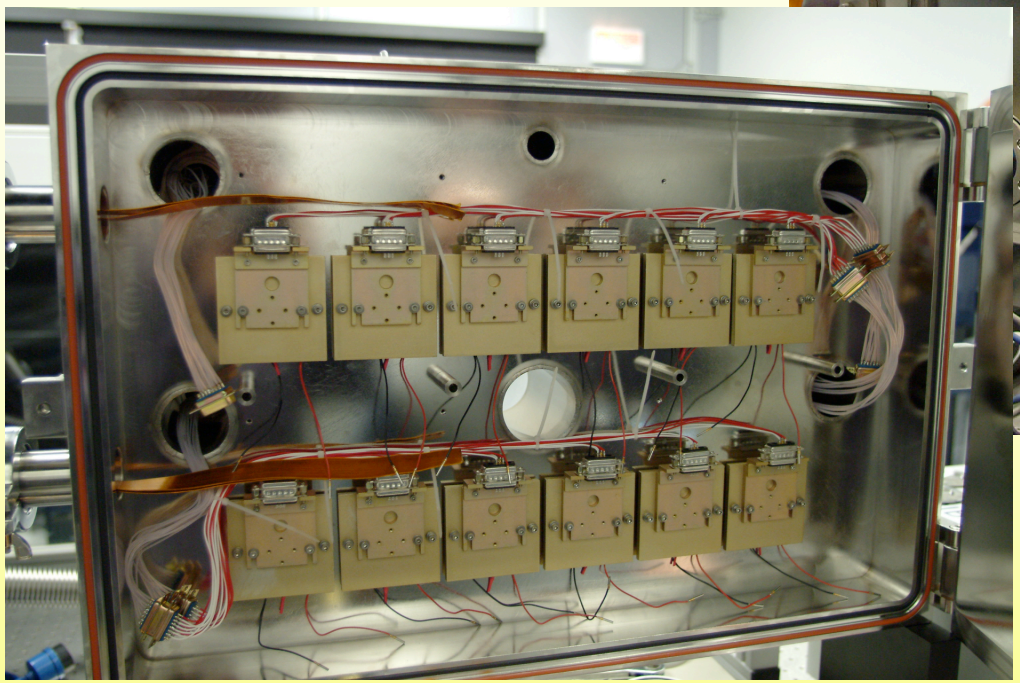
Vacuum Results



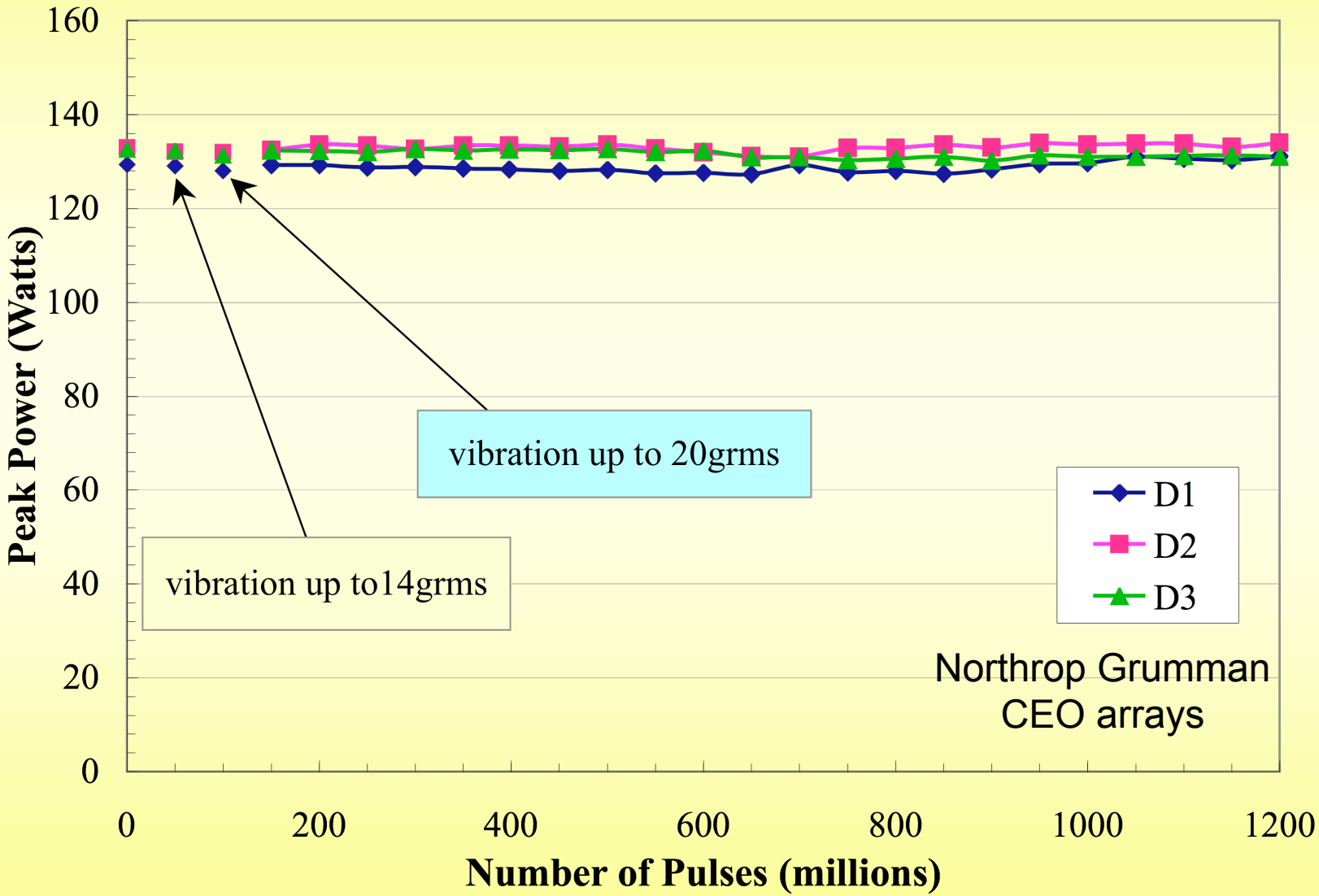
Custom Vacuum Chamber

Custom vacuum chamber with 12 LDA test positions with windows for continuous inspection

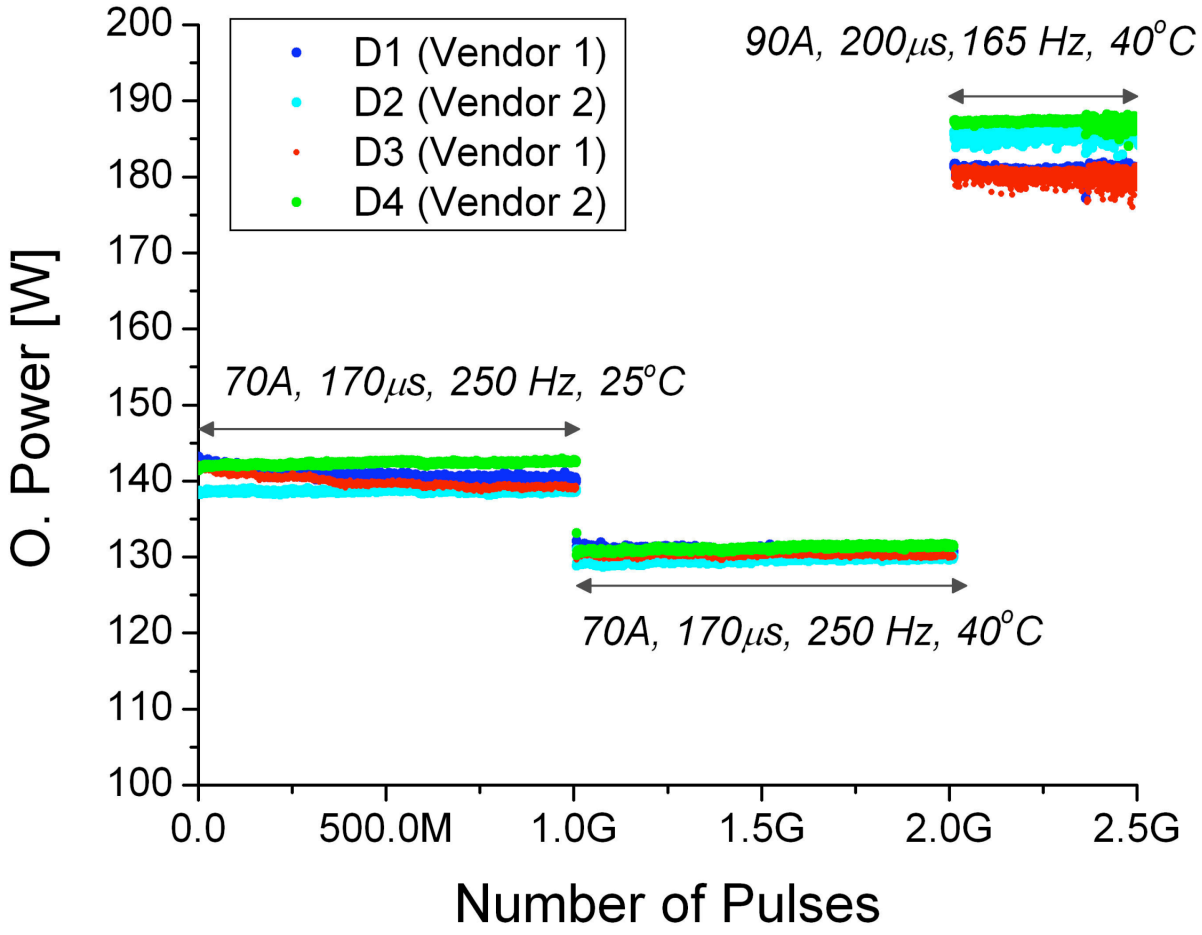




Extended Operation of Vibrated Arrays



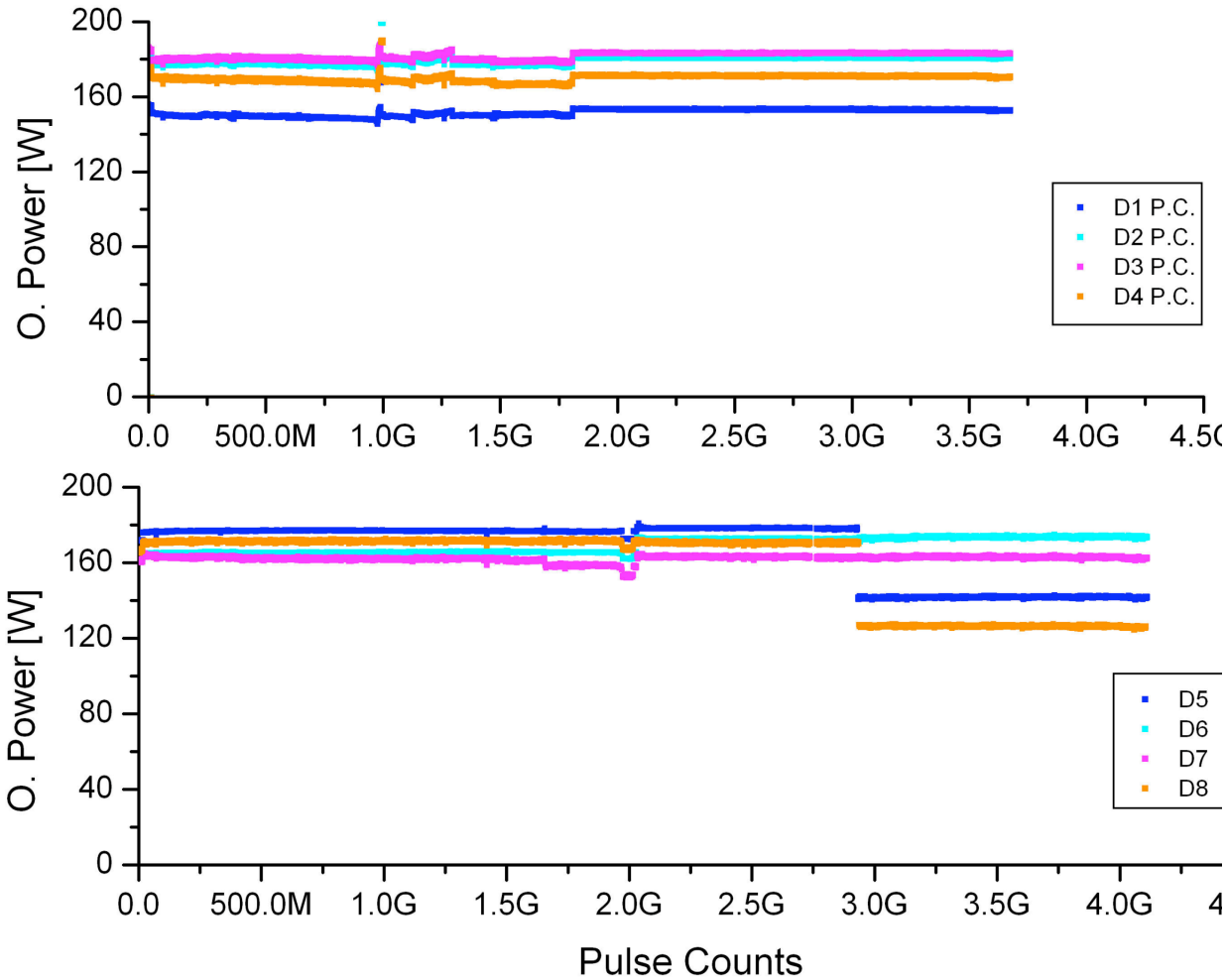
LOLA EM Test
(Nuvonyx & Coherent Arrays)



This is an ongoing, accelerated performance test of 4 LDAs (G2 packages) to qualify two vendors, observe potential problems and compare performance to assist choosing the flight vendor for LOLA mission.

Calculated MTTF - >4 Billion

BioMM Test:
(CEO Arrays)



- Operating Conditions: I = 50 A, PW = 80 µs, f = 242 Hz, T= 25 °C.
- All LDAs have accumulated more than 3.6 billion pulses.
- 4 G-4 LDAs (top) are power cycled: ON cycle is 18 min.; OFF cycle is 2 min. [>14,000 cycles].
- 4 G-4 LDAs (bottom) are at constant power.
- Fluctuations in curves are due to test electronics and not indicative of changes in LDAs.
- Power drops in CW graph near 2.9 Billion pulses indicate bar failure.

Characterized Arrays

VENDOR	TYPE	NUMBER OF LDA	NUMBER OF BARS
SDL	G 11	6	66
	G 16	5	80
	total	*11*	*146*
CEO	G 2	14	28
	G 4	37	148
	G 6	9	54
	G 11	5	55
	G 18	10	180
	total	*75*	*465*
Coherent Inc.	G 2	20	40
	G 4	8	32
	G 6	2	12
	G 16	2	32
	total	*32*	*116*
Nuvonyx	G 2	5	10
	G 4	5	20
	G 11	5	55
	total	*15*	*85*
TOTAL		**133**	**812**

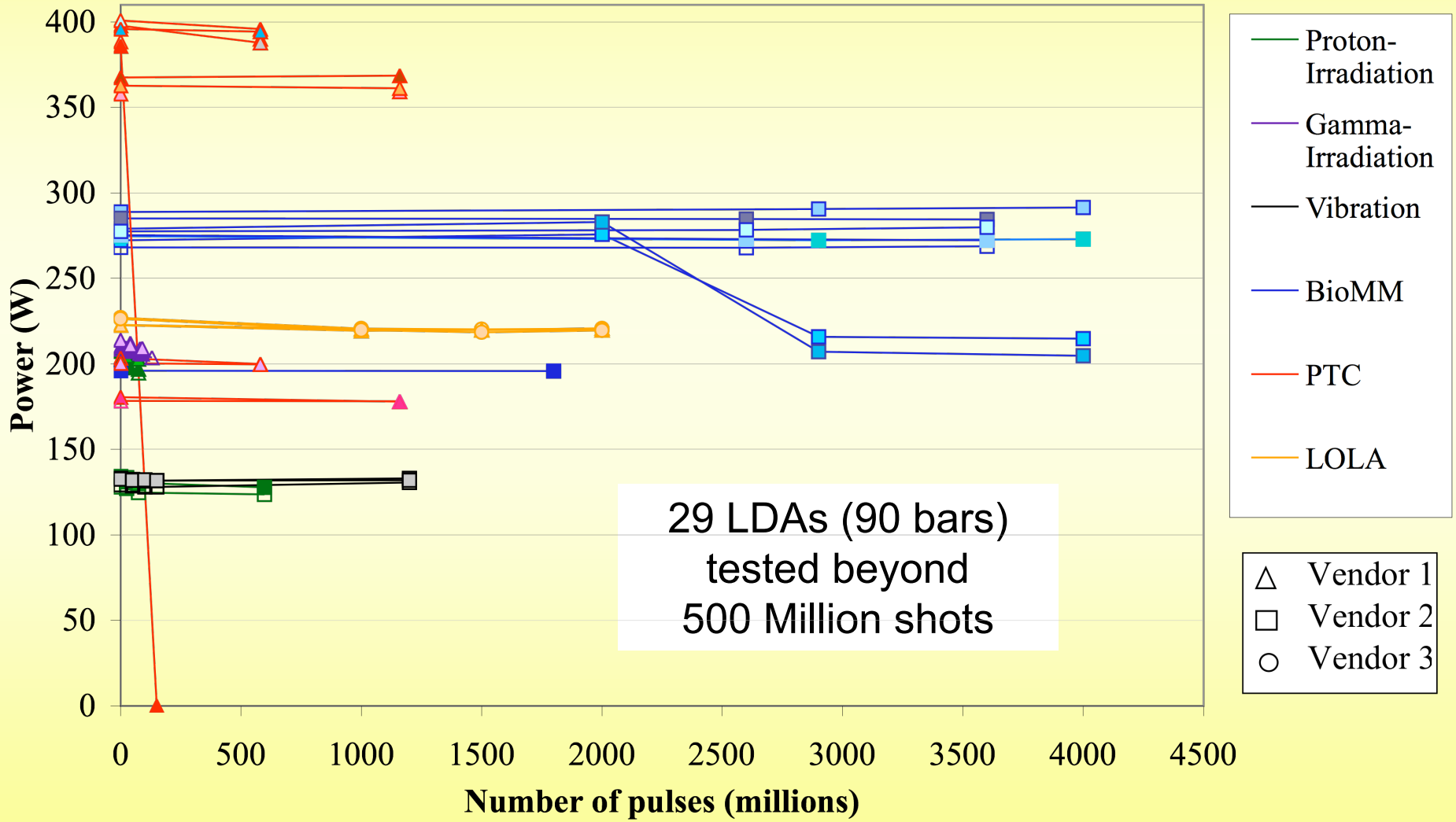
Uncharacterized

Decade	G 2	5	10
	G 4	2	8
	total	*7*	*18*
Lasertel	G 2	5	10
	G 4	2	8
	total	*7*	*18*

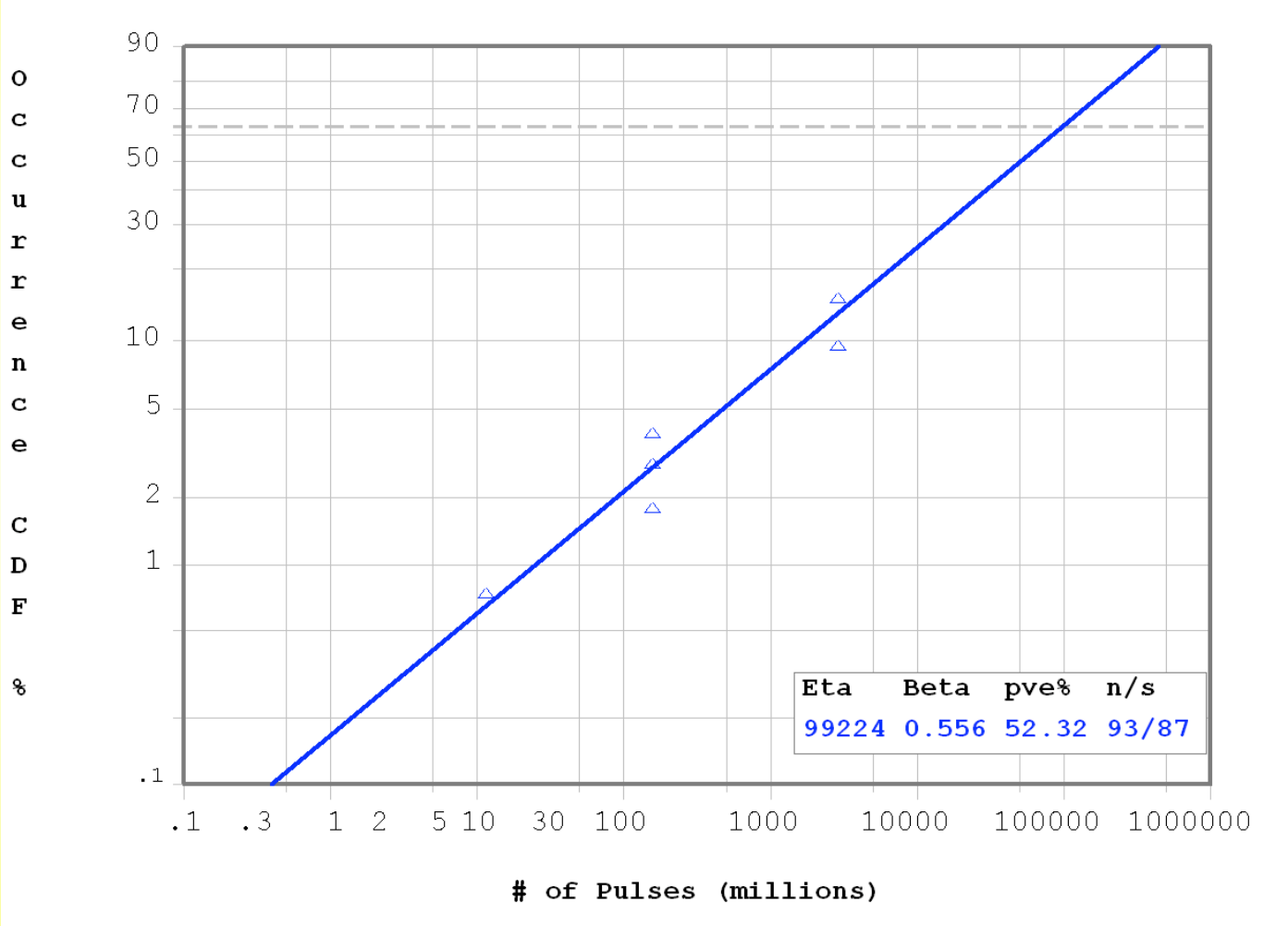
Type	Total number of LDA
G2	39
G4	50
G6	11
G11	16
G16	7
G18	10

TOTALS PER VENDOR	
SDL	11
CEO	75
Coherent	32
Nuvonyx	15

Summary of Extended Testing During Program



Weibull Analysis



Summary and Future

- Characterization measurements
- Power/Temperature cycling (MLA) test - 1.15 billion pulses
- Finished vacuum/radiation test - 600 million pulses
- Finished vibration test - 1.2 billion pulses
- LOLA engineering model LDA test - 2.5 billion pulses
- BioMM test continues - ~4 Billion pulses, >14,000 power cycles
- Compiled results from all extended testing
- Statistical analysis of completed tests is being conducted
- Testing in air and vacuum for LOLA flight arrays is planned for this summer
- Correlate failures to initial measurements