Establishing a Center of Excellence for Security Science and Engineering

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Outline

- Introduction
- Progress report
- NNSA proposal to establish

  Center of Excellence for Security Science and Engineering
- Perspective on UNLV-NSTec collaboration

UNLV Center of Excellence for Security Science and Engineering

- Multiple step process:
  - Individual faculty who are interested in security science and engineering
  - NSTec station at UNLV
  - NSTec-UNLV Center of Excellence for Security Science and Technologies
- Center of Excellence in Security Science and Technologies
  - Rotational faculty and student projects
  - Resident researcher team
  - Secured R&D facility on campus to enable NSTec projects
  - Respond to large BAA
  - User facility, or equivalent coordination
  - Ramp up in 3~5 years

Education Value Meets NSTec Staffing Needs

- Graduate students
  - Term projects
  - Master theses
  - Ph.D theses
- Undergraduate students
  - Term projects
  - Undergraduate theses
- Internship
  - Regular academic quarters
  - Summer off-campus

From 29th July 2011 UNLV-NSTec DE&SS Collaboration Forum

Gain External Funding

- Win large BAA
  - Need critical project and academic credentials
  - Need strong team from NSTec and UNLV
- Win large program
  - Need BAA credential
- Center of Excellence for Security Science and Engineering
  - Becomes a research center of security sciences and technologies
  - Becomes a user facility

Good Progress!

Proposal to NNSA Stockpile Stewardship Academic Alliance

Enabling Sciences and Technologies for Next Generation HEDP Diagnostics

Ke-Xun (Kevin) Sun, Ph.D., P.E.
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and

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National Security Technologies (NSTec)

Co-Investigators

William Culbreth	Professor of Mechanical Engineering
Biswajit Das	Professor of Electrical and Computer Engineering
Yingtao Jiang	Associate Professor of Electrical and Computer Engineering
Pushkin Kachroo	Professor of Electrical and Computer Engineering
Eunja Kim	Assistant Professor of Physics
Brendon O'Toole,	Professor of Mechanical Engineering
Tao Pang	Professor of Physics
Emma Regentova	Professor of Electrical and Computer Engineering
Robert Schill	Professor of Electrical and Computer Engineering
Mohamed Trabia	Professor and Associate Dean of College of Engineering
Rama Venkat	Professor of Dean of College of Engineering
Woosoon Yim	Professor of Mechanical Engineering

University of Nevada, Las Vegas

Research and Development Areas Focusing on “Platform” Technologies for Future NIF High Yield Experiments and LIFE

1. Radiation hardness mechanism studies
2. Radiation hard GaN-AlGaN-AlInGaN devices and systems
   - Electronics
   - Optoelectronics
   - Imagers
3. Radiation detection, especially exploration of alternative approaches
4. Plasma sciences and radiation sources
5. Radiation hard robotics systems for unmanned safe operation
6. Computational physics and image analysis.

UNLV Faculty Contributions (I)

- Radiation Hard GaN-AlGaN-AlInGaN Devices and Systems
  - Kevin Sun: GaN Devices & Imagers
  - BJ Das: GaN Growth and Devices
  - Yingtao Jiang: Integrated circuits, Imagers
  - Eunja Kim: GaN Theory
  - Bob Schill: Pulsed Power, Nevada Shocker
  - Rama Venkat: Processing model
- Radiation detection
  - Kevin Sun: GaN Optical readouts,
  - Bob Schill: EM DOT
  - NSTec: Neutron Tracking
- Plasma Sciences and Radiation Sources
  - Bob Schill : DPF, Pinch, X-ray source
  - Kevin Sun: Nanomaterial Enhanced X-ray sources

UNLV Faculty Contributions (II)

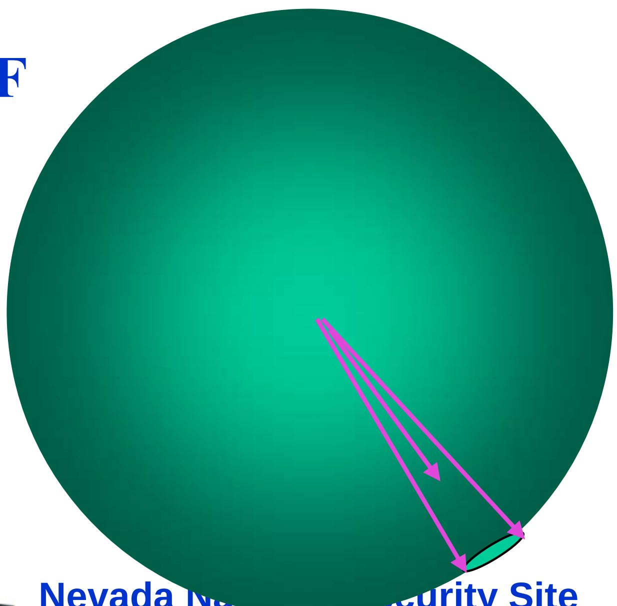
- Radiation hard mechanical materials and robotics
  - Mohamed Trabia: Material Strength
  - Brendan O'Toole: Neutron Irradiation Effects
  - Woosoon Yim: Robotics
  - Kevin Sun: Machine vision materials
- Computational physics and data analysis
  - Pushkin Kachroo: Inverse scattering, MHD theory
  - Emma Regentova: Image analysis
  - Tao Pang: Dynamic Space Charge Effects (Theory)
  - Eunja Kim: Dynamic Space Charge Effects (Computation)
  - Kevin Sun: Dynamic Space Charge Experiments

Why Radiation Hard Detectors

- The current "Rad-Hard" mitigation are films, requiring replacements every shot
  - Radiation hazard for film workers
  - In-efficiency
  - Low performance
- The proposed Radiation Hard semiconductor detectors will work as permanent sensors
  - Long term needs by LIFE and spent fuel re-use
  - No radiation hazard by eliminating film operations
  - Efficiency with real-time data access
  - High performance

DT Fusion and Neutron Fluence Estimate at National Ignition Facility (NIF)

NIF



$$\mathrm{D} + \mathrm{T} \rightarrow \mathrm{He}\ (3.5\ \mathrm{MeV}) + \mathrm{n}\ (14.1\ \mathrm{MeV})$$

- Ignition shot: N~10^{15} neutrons
- Neutron energy ~15 MeV
- Detector placed at 1 m away from target
- Neutron emission per ignition shot ~10^{15}
- Fluence at 1 m away

$$F = \frac{N}{4\pi R^2} \approx 8\times10^{9}\ 1/\mathrm{cm}^2$$

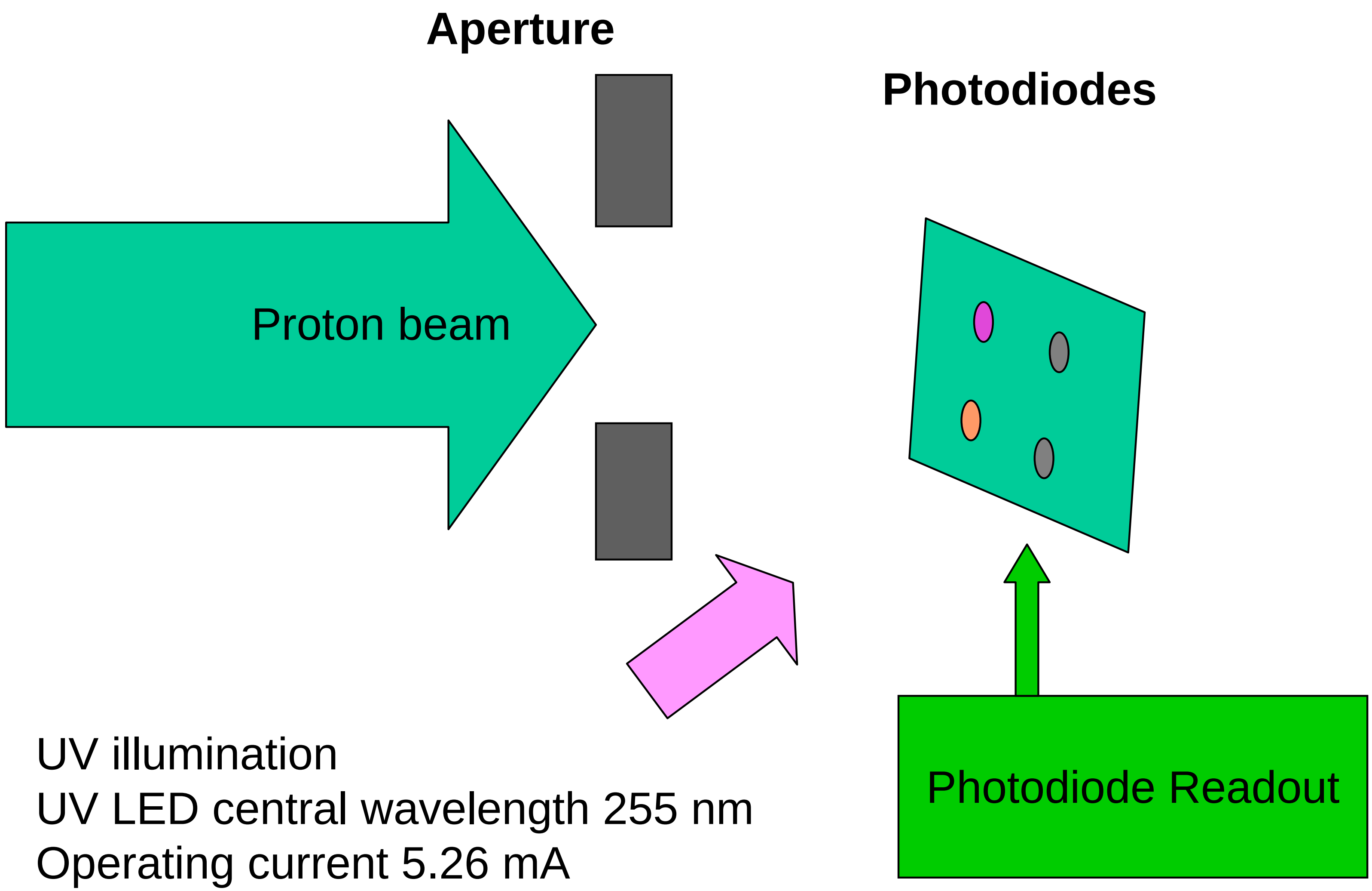
- One year fluence (700 shots)

$$F_{1\mathrm{year}} \approx 5.6\times10^{12}\ \ 1/\mathrm{cm}^2$$

- Proton irradiation test fluence

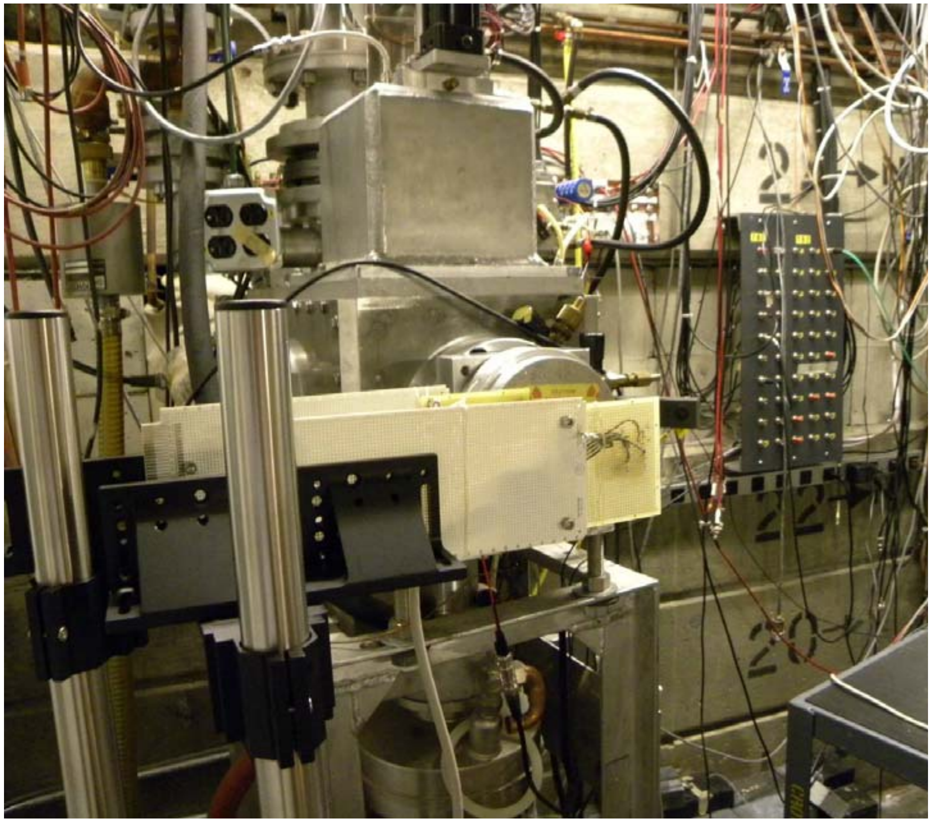
$$F_{\mathrm{test}} \approx (1-5)\times10^{12}\ \ 1/\mathrm{cm}^2$$

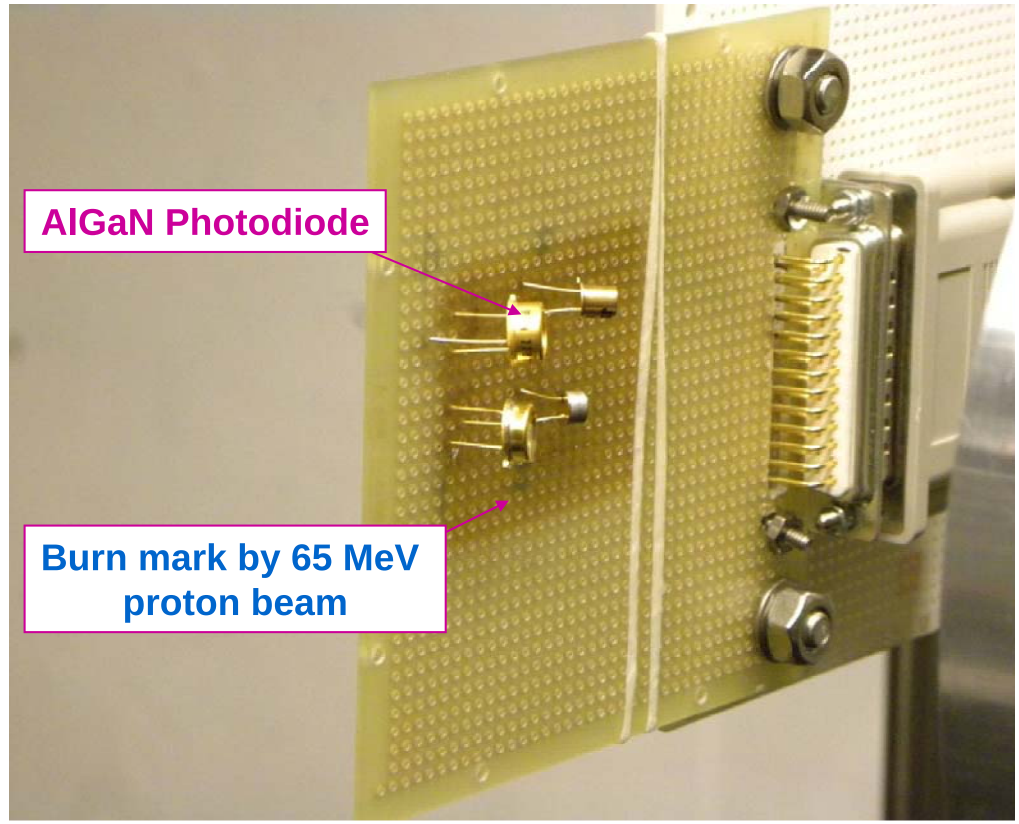
Irradiation Configuration



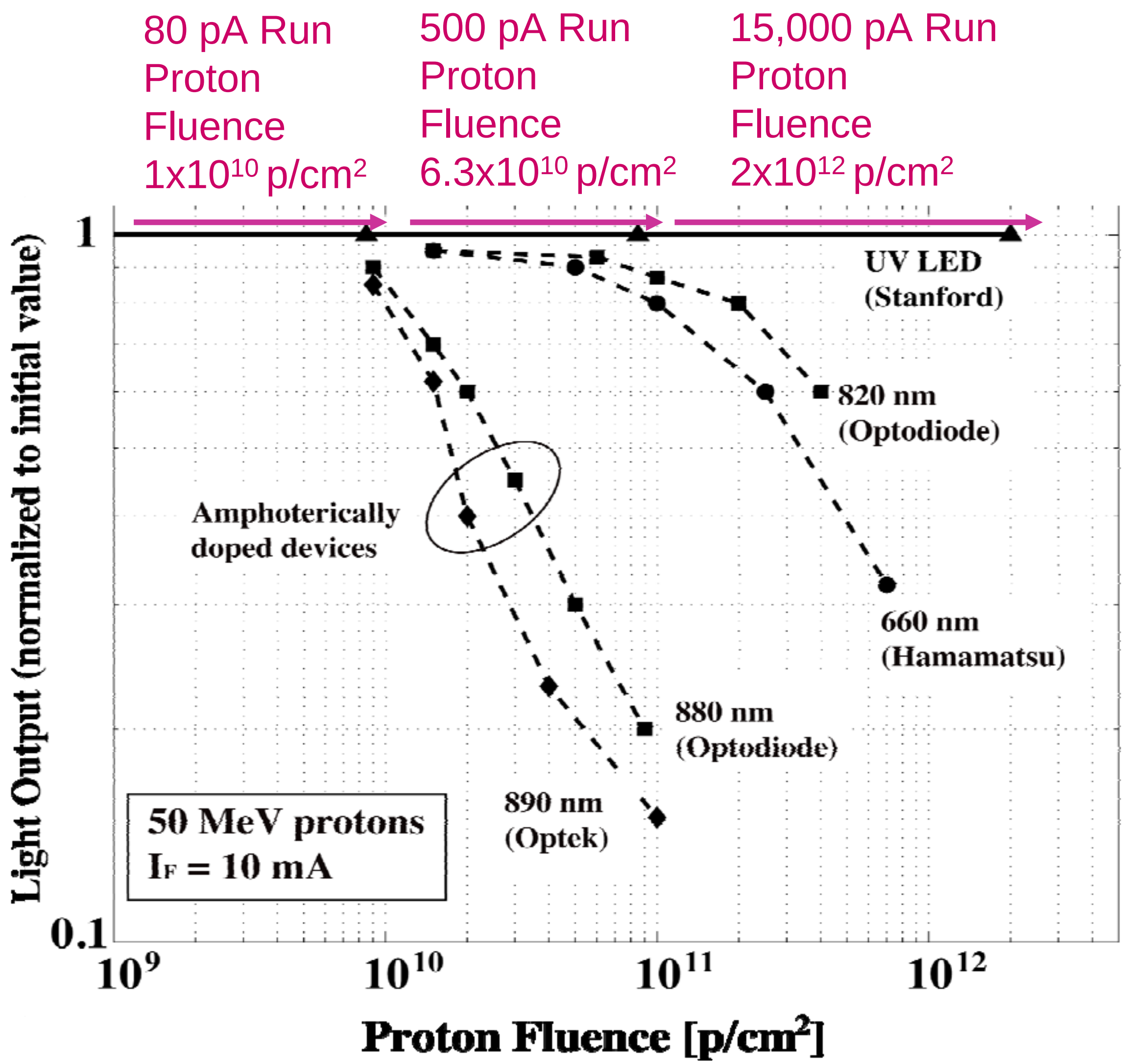
UV illumination
UV LED central wavelength 255 nm
Operating current 5.26 mA
ON/OFF control by power supply

AlGaN UV Photodiode Radiation Hardness Test at 65 MeV Proton Beam Facility





UV LED Radiation Hardness Using Proton Irradiation



UC Davis proton energy:
59 MeV for 80pA & 500 pA
63.8 MeV for 15,000 pA

Space proton energy:
2~5 MeV

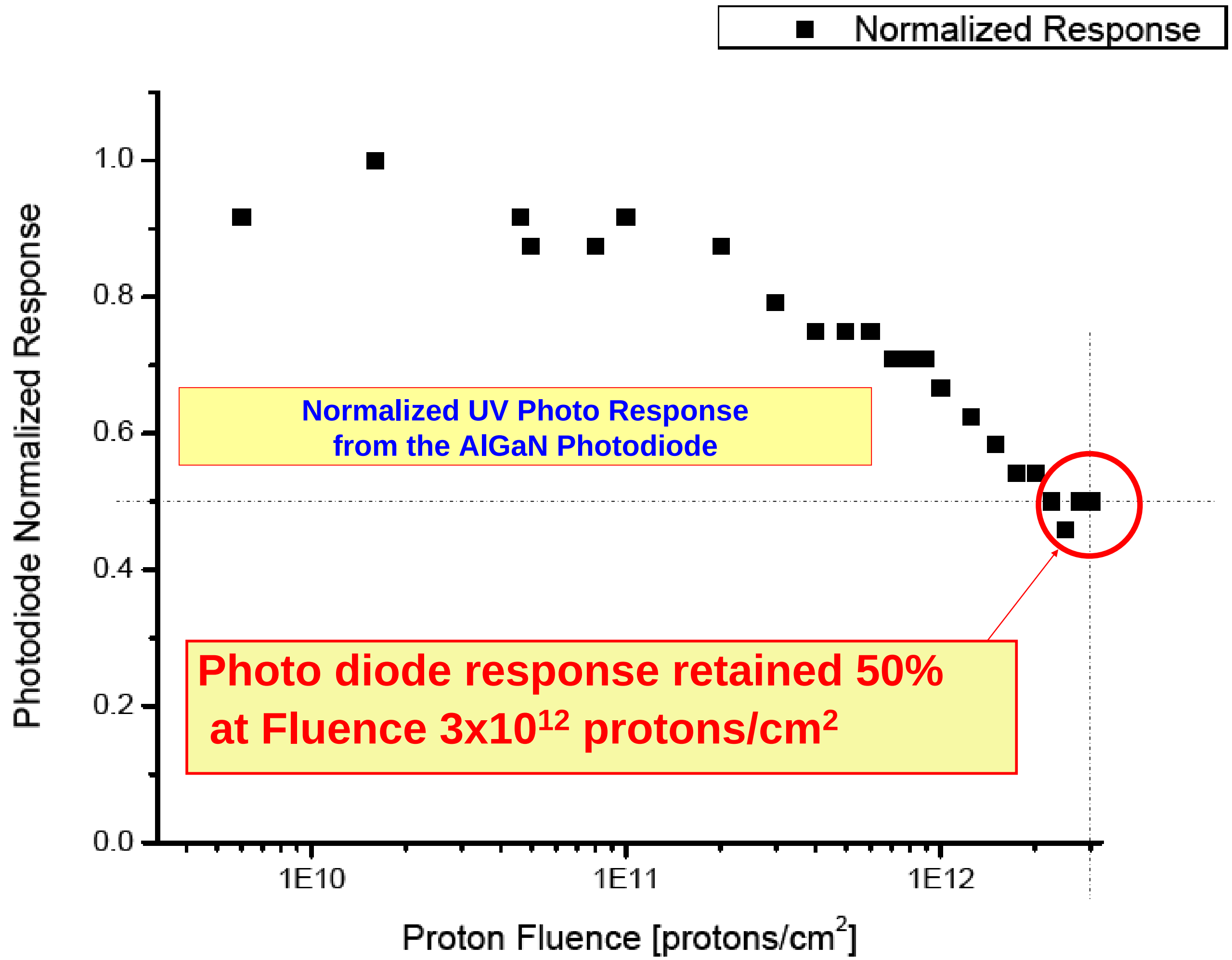
Total fluence: > 100 year proton fluence in LISA orbit

Reference for proton test of other LED and laser diodes:
A. H. Johnston and T. F. Miyahira, "Characterization of Proton Damage in Light-Emitting Diodes", IEEE Trans. Nuclear Science, **47** (6), 1999

Sun, Leindecker, et al, "UV LED Qualification for Space Flight",

AlGaN Photodiode UV Light Response vs. Proton Fluence

- Photodiode in photovoltaic mode
- For each fluence level, measure the photodiode readout for UV light on and off
- The normalized differential reading is defined as the photodiode response to UV light



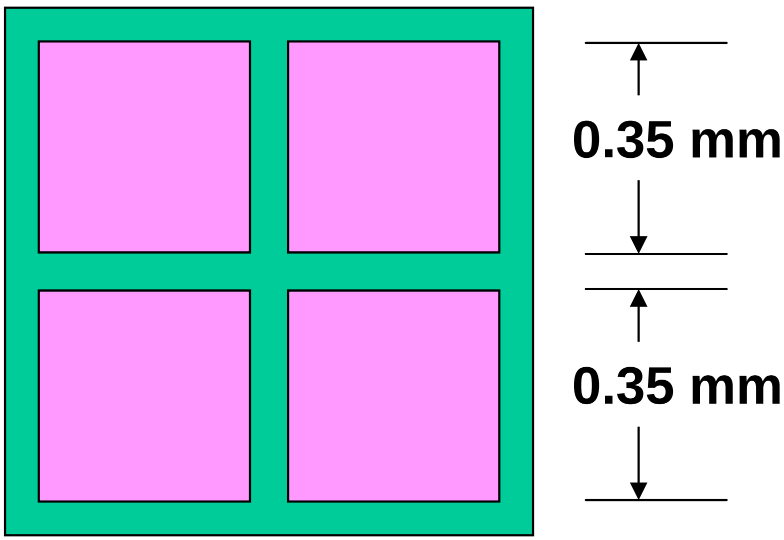
[1] K.-X. Sun and L. MacNeil, "Radiation Hardness of AlGaN Photodiodes," 4th NASA/ESA EJSM Workshop, Jet Propulsion Laboratory, July 26-29, 2010
[2] K.-X. Sun and L. MacNeil, "GaN Radiation Hard Properties and Detectors," SPIE Hard X-ray, Gamma Ray, and Neutron Detection, San Diego, August 1-5, 2010

Work at National Security Technologies, LLC is done under Contract No. DE-AC52-06NA25946 with the U.S. Department of Energy with the U.S. Department of Energy. DOE/NV/25946--1221

AlGaN Detector Arrays

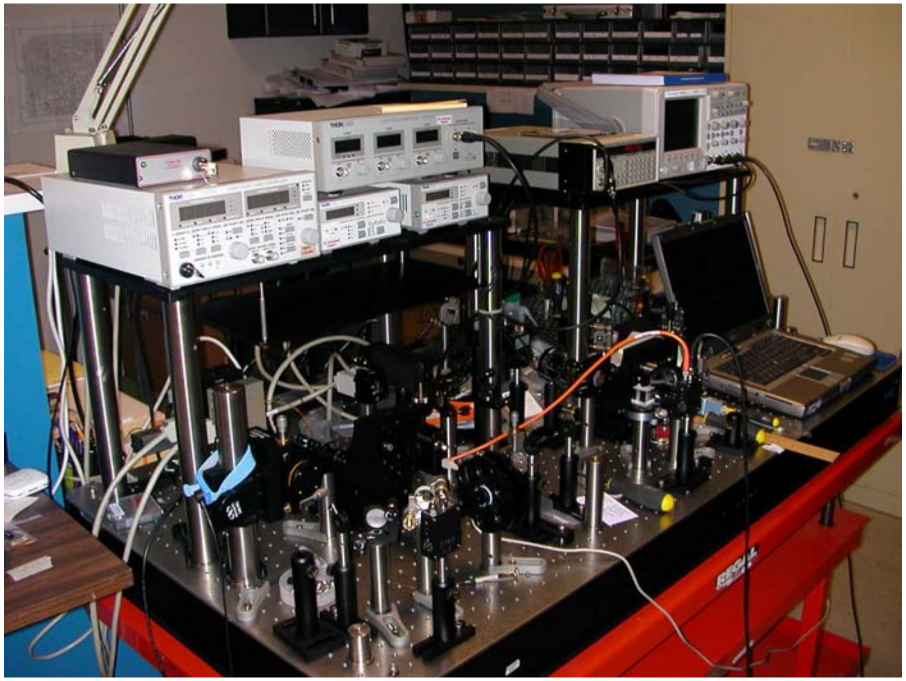
AlGaN Imager: NSTec SDRD FY12

- Photodiode Arrays
  - 2x2 array initial test design
  - Center wavelength 255 nm
  - 2 working batches received (!)

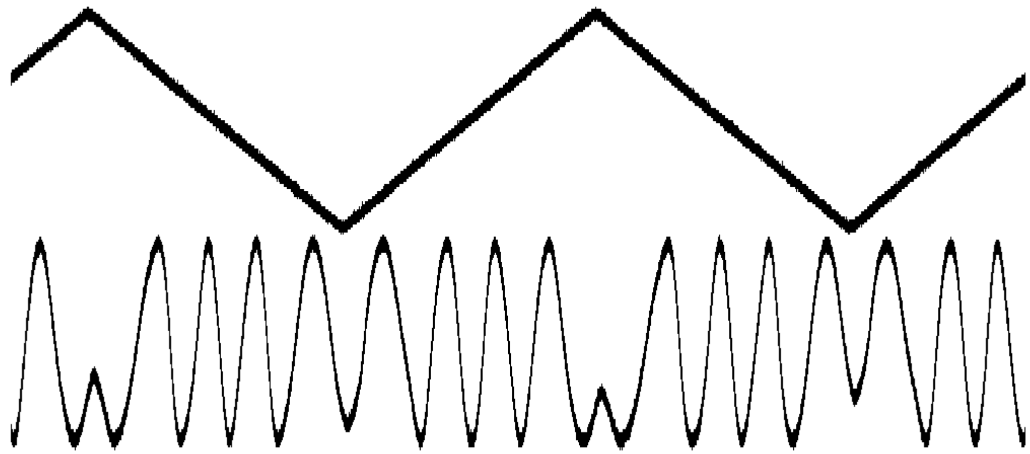


Active Area

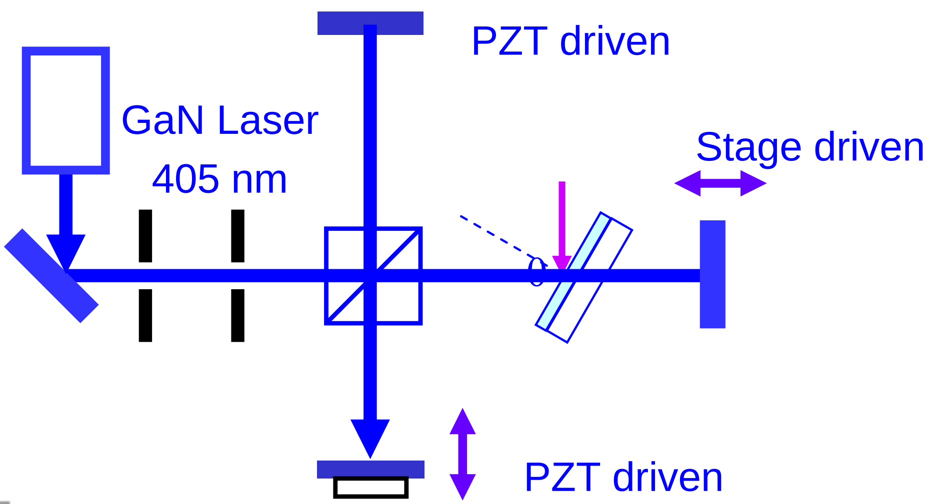
RadOptics Sensor

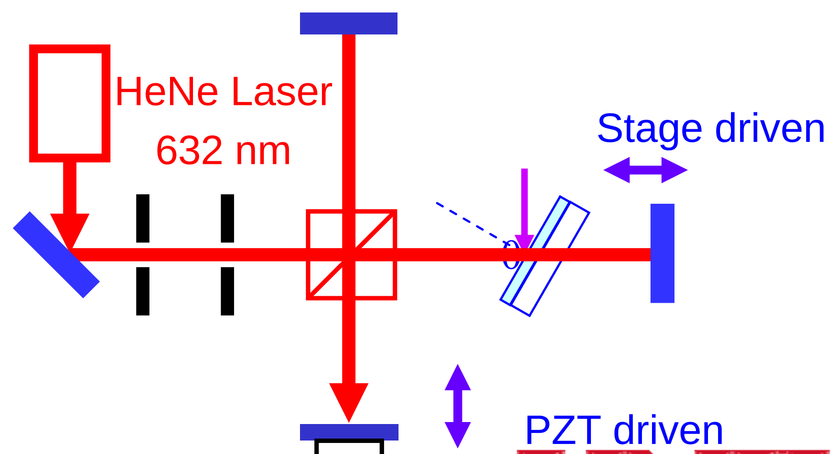


PZT Trace (Displacement ~ 1.8 μm)



Interferometer output 632 nm





Steps to grow UNLV-NSTec Collaborations

- Pilot projects
  - Individual PI collaboration
  - Sun and others
- NSTec seed funding
- Gain External funding
- A NSTec-UNLV Center of Excellence in security science and engineering
  - An collaborative research center
  - A user facility

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