
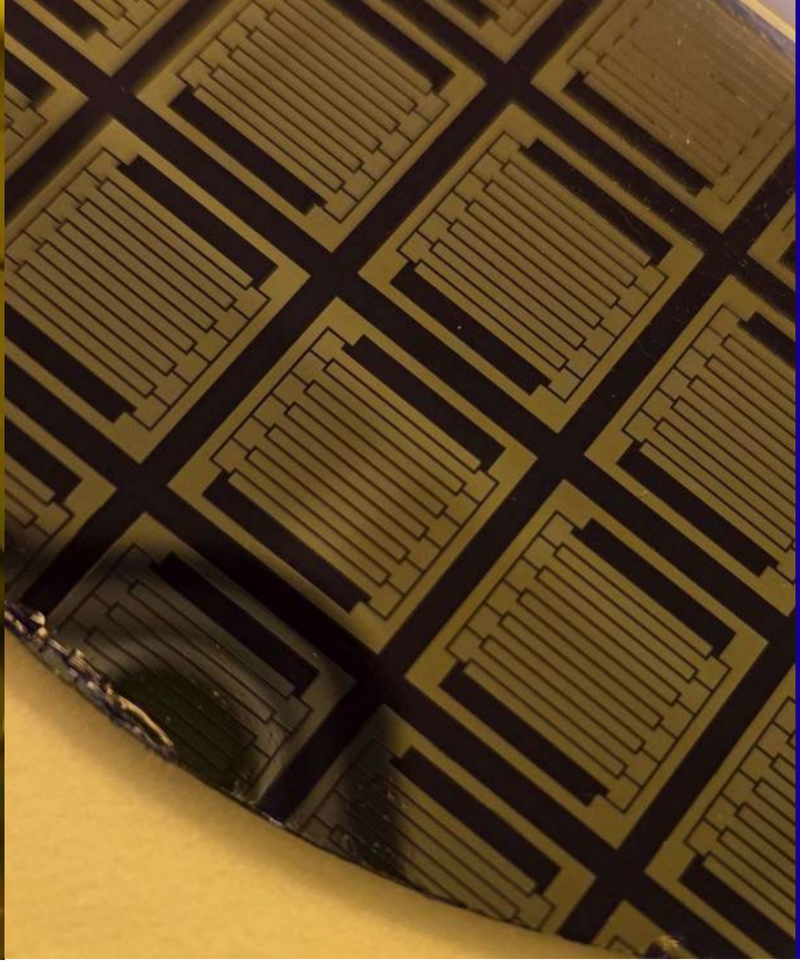

RADIATION DETECTION TECHNOLOGIES, INC.

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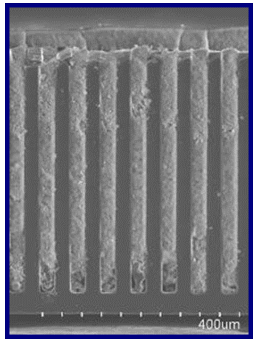
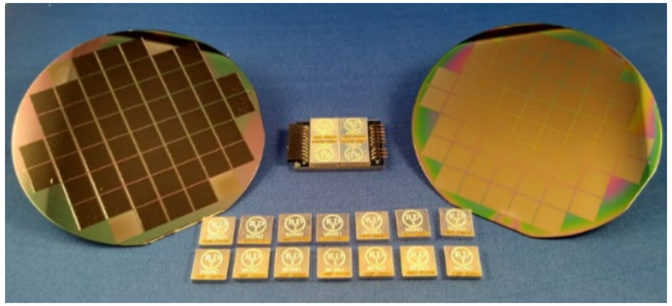
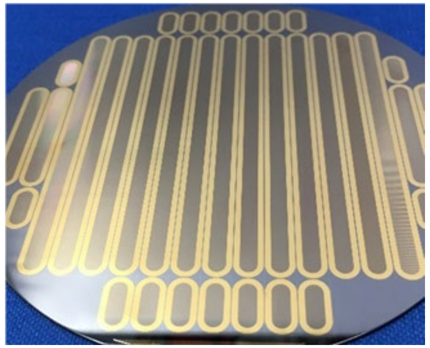
Nondisclosure: This presentation includes data that must not be disclosed outside and must not be duplicated, used, or disclosed-in whole or in part-for any purpose.

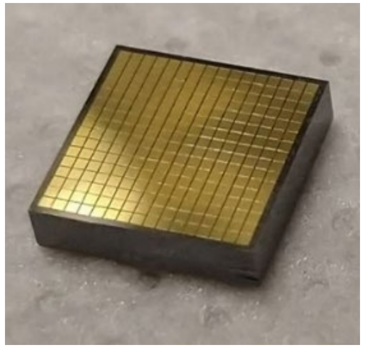
WHO WE ARE

- Technical Focus & Core Capability
  - Semiconductor Device **Design and Foundry Manufacturing**
  - Radiation Detector Device Design & Manufacturing
- Relevant Technical History
  - **32+ SBIR/STTR grants**; DOE , DoD, NIH, NASA
  - Our Sensors have been flown in Space, see here.
  - Transitioned multiple technologies from academia to commercial production.
- Key Resources
  - RDT Production Facilities (Headquarters) + KSU SMARTLab Facilities (leased space)
  - R&D Facilities – Access to: ISO-5 cleanroom VLSI semiconductor processing facility; Nuclear Research Reactor; <1% rel. hum. Dry Room; Crystal Growing Furnaces; Electronics manufacturing; Microscopy & Metrology equipment.
  - Production Facility – 8000 ft^2 building with a 1500sqft ISO-5 cleanroom, 4 crystal growth furnaces, & offices
  - 25 employees: Engineers & Material Scientists; Technicians; Business Operations.





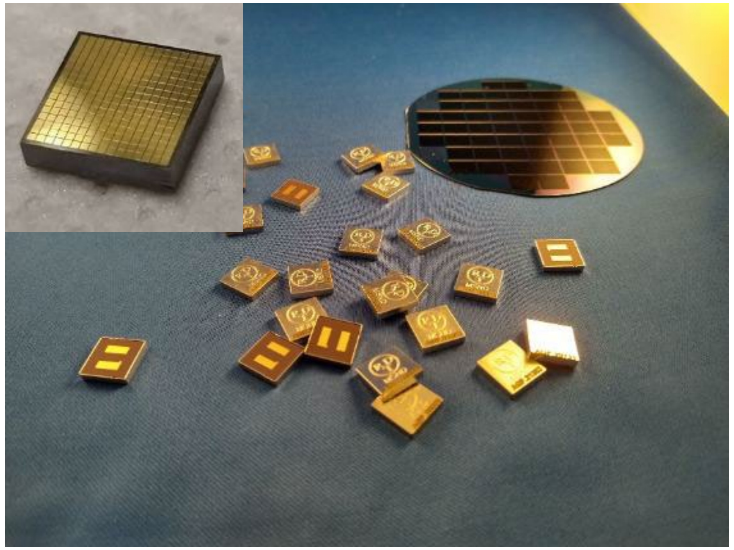




RDT'S THREE TECHNOLOGY PLATFORMS

Radiation Sensors and Monitoring

- Neutron Detectors
  - MSND/Domino
  - Lithium Foil
  - MSND Based Instruments
  - **Micro-Pocket Fission Detectors**
    - **In-core Nuclear Reactor Sensor**
- Gamma Detectors
  - CZT/CdTe - Medical / Industrial



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Semiconductor Materials

- CdZnTe (gamma spec)
- CdTe (solar)
- ZnSe (IR substrates)
- Other III-V, II-VI

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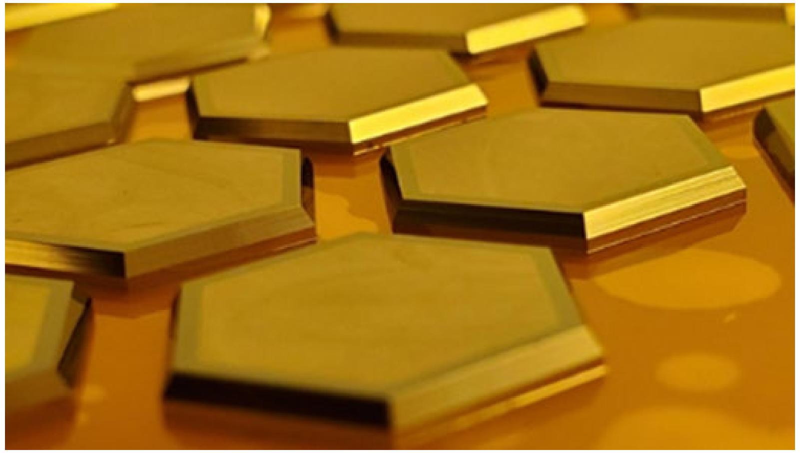
High Power Semiconductor Diodes

- Directed Energy applications
  - Pulsed Power Switches
- Si, pin Diode, Silicon opening Switch (SoS, Silicon closing Switch (ScS), Silicon Avalanching Switch (SAS), Fast Ionization Dynistor (FID)
- Wide bandgap (future)
  - SiC, GOX



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MPFD TECHNOLOGY – MOTIVATION

There is a need for real-time, distributed, in-core neutron flux sensors to support advanced test reactor experiments and development of next-gen reactors

MPFDs can

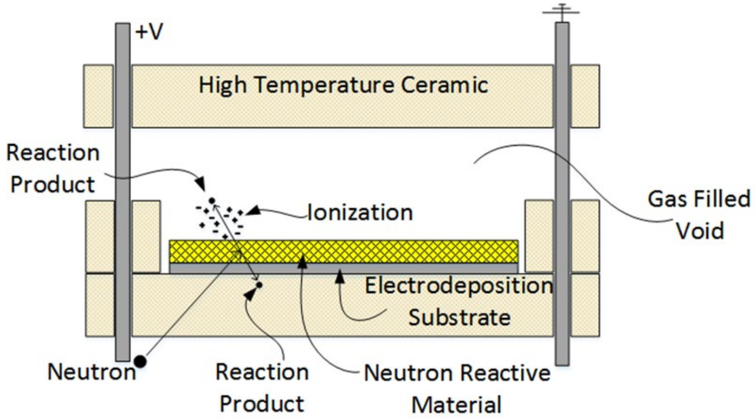
- be deployed in-core with minimal flux perturbation
- reduce need for iron-wire/foil activation fluence measurements
- improve accuracy of neutron radiation monitoring
- deliver multi-nodal and multi-energy group response
- provide a US-based manufacturing option for in-core neutron sensors

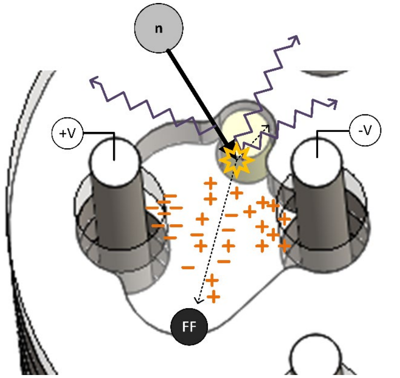
MPFDs have garnered interest from government, university, and commercial nuclear reactor groups

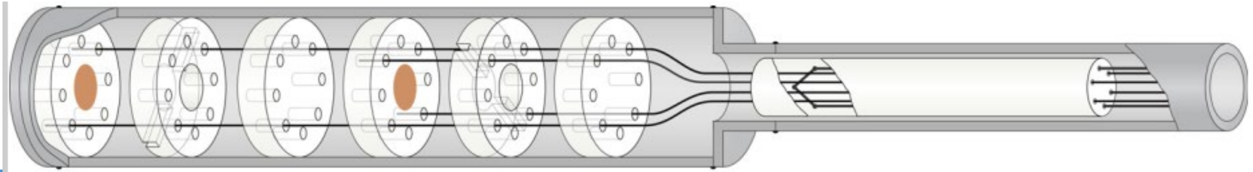
MPFD TECHNOLOGY - OVERVIEW

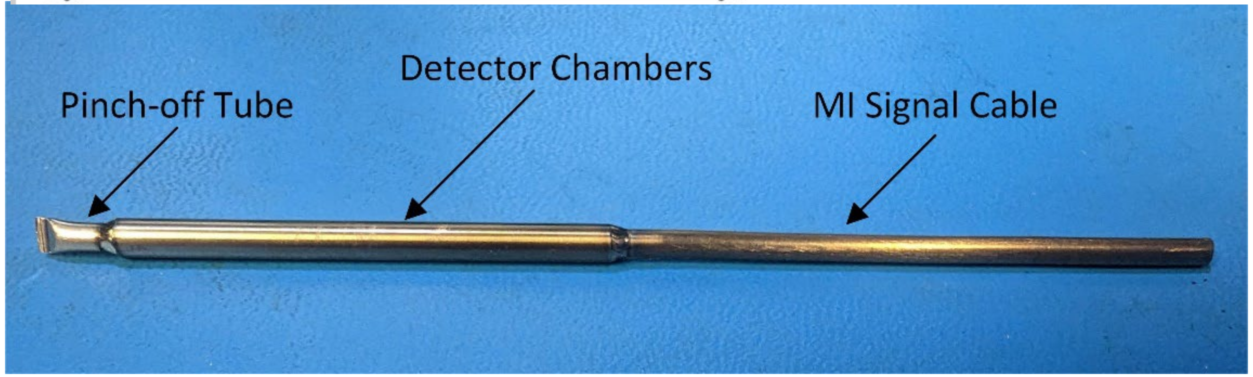
Initial MPFD development performed at Kansas State University and Idaho National Laboratory. RDT is leading commercialization.

- Redesign for reliability and manufacturability
- Tailorable on per customer basis
- Pulse and/or current mode operation
- 0.5-3 mm^3 fission chamber
- Successful deployments at KSU TRIGA, UWNR, and INL-TREAT
- Potential Uses: Startup/performance verification, flux mapping, fluence monitoring for irradiation experiments, power monitoring







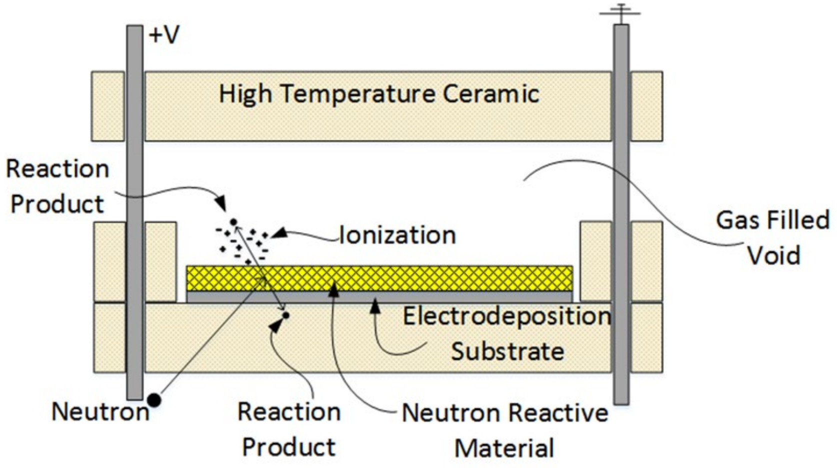


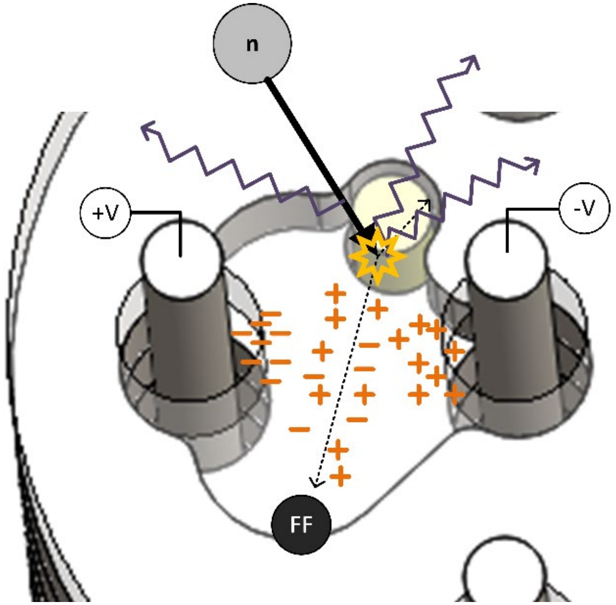
MPFD TECHNOLOGY - OPERATION

- 4-Node, 5-wire design has 4 detectors chambers that share a common cathode. Each anode is read out individually.

<u>Detection Mechanism</u>

1. Neutron is absorbed by fissile coating on neutron conversion wire
2. A fission fragment enters the MPFD chamber and ionizes argon fill gas
3. Electrons and ions are swept out via an applied voltage bias
    - At low flux/interaction rates, individual pulses are read out
    - At high flux/interaction rates, current is read out





PREVIOUS MEASUREMENTS – POWER RAMPING

- Observed linear response with reactor power

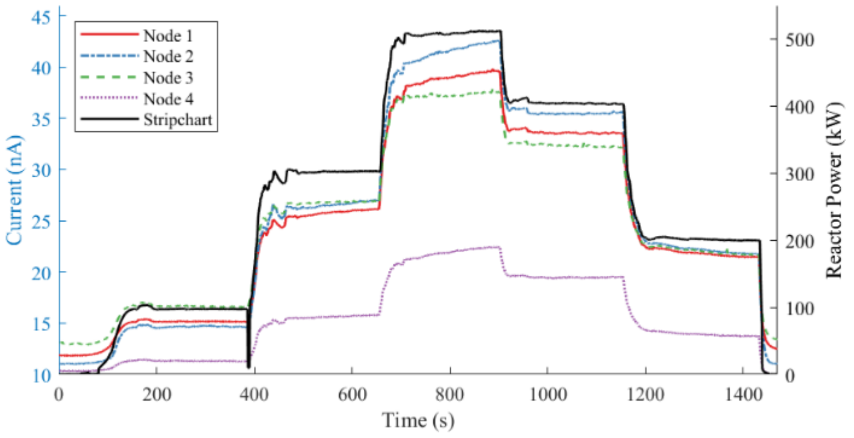


Fig. 5-5. Plot of DRT for MPFD array 3 performed in current mode. Note that raw count rate is presented for MPFD response.

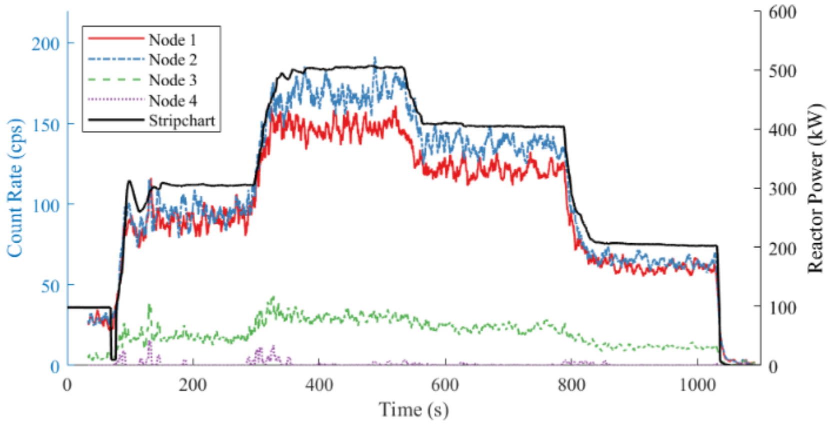


Fig. 5-6. Plot of DRT for MPFD array 3 performed in pulse mode. Note that MPFD data presented is smoothed with a moving average window of 200 data points.

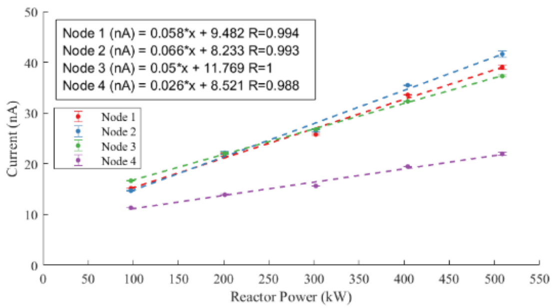


Fig. 5-7. Current mode linearity response of MPFD array 3 based on data presented in Fig. 5-5. Linear least-square equations are shown for each node.

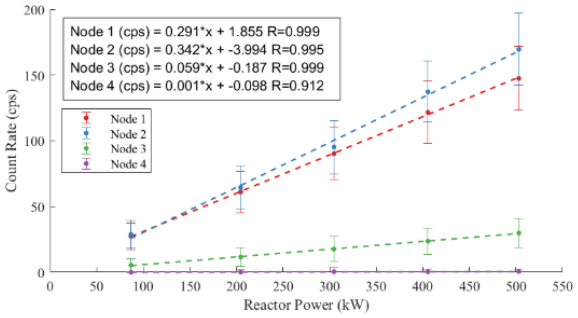


Fig. 5-8. Pulse mode linearity response of MPFD array 3 based on data presented in Fig. 5-6. Linear least-square equations are shown for each node.

D. M. Nichols, "Development and optimization of the micro-pocket fission detector," Mechanical and Nuclear Engineering, Kansas State University, 2022.

M. A. Reichenberger, "Micro-pocket fission detectors: development of advanced, real-time, in-core, neutron-flux sensors," Department of Mechanical and Nuclear Engineering, Kansas State University, 2017.

PREVIOUS MEASUREMENTS – TRANSIENT TRACKING

- Ability to track pulsed transients

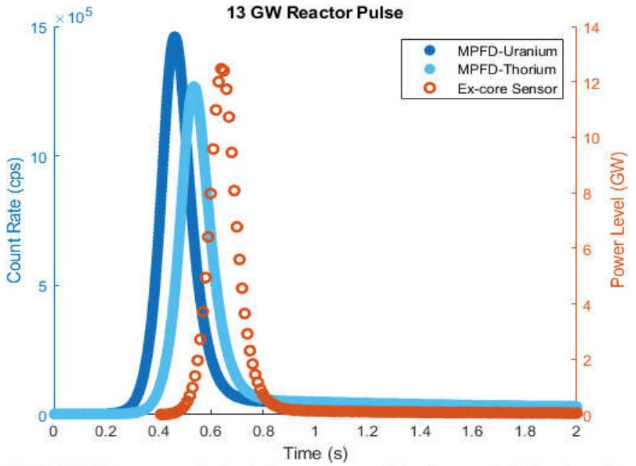


Fig. 9. MPFD response for both the uranium and thorium coated chambers for the 13 GWth reactor pulse.

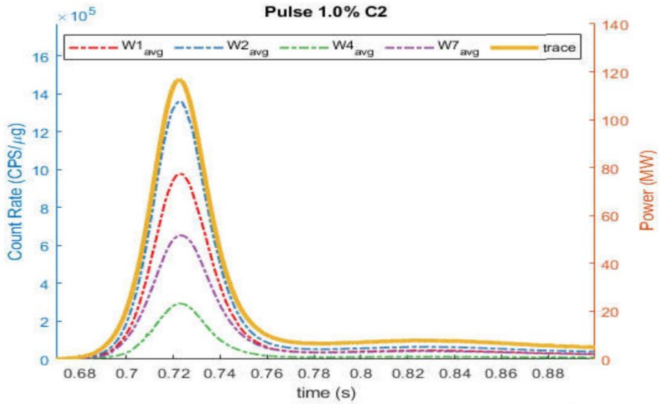


Fig. 7. Averaged response of MPFD wands distributed throughout the UWNR core. These wand locations are indicated in Fig. 2.

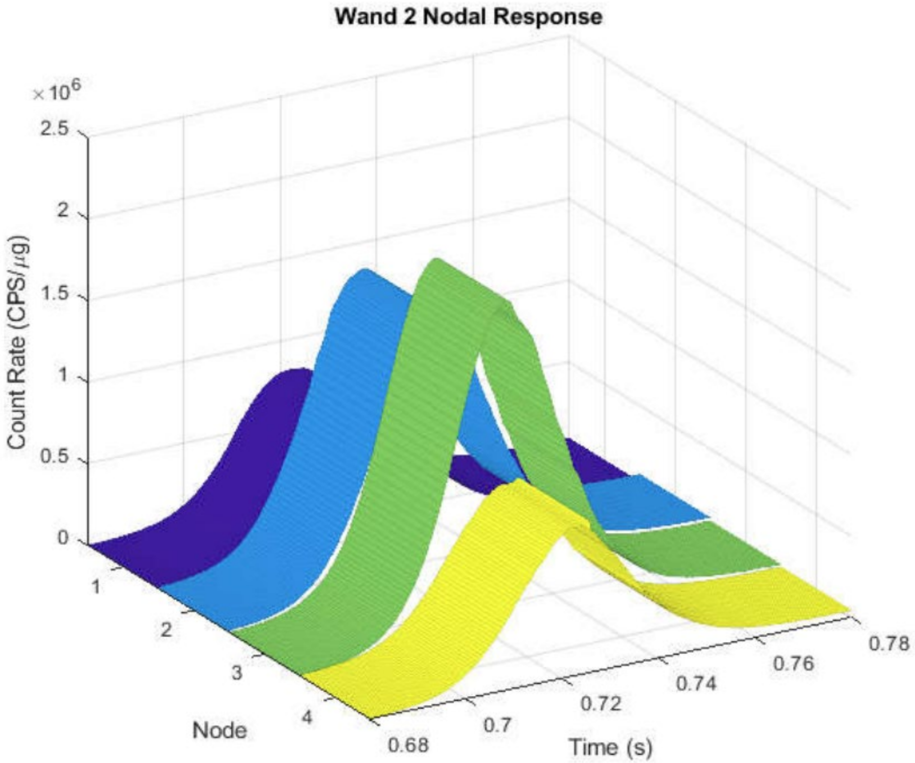
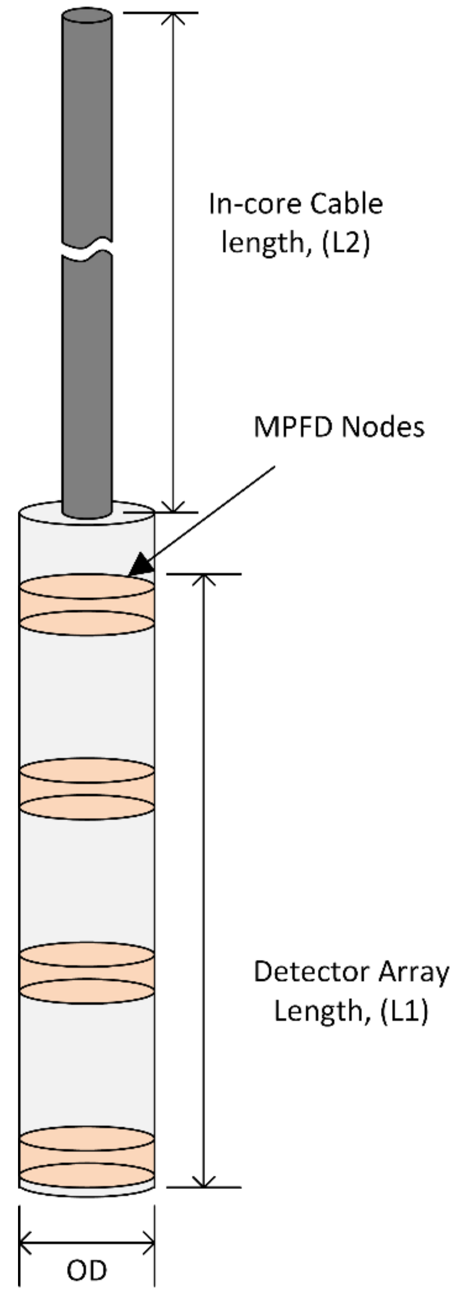


Fig. 8. Axially distributed detector response for Wand 2. Nodes 1, 2, 3, and 4 are located at +4.5, +1.5, -1.5, and -4.5 inches displaced from the center plane of the fuel region respectively.

Data from:
Nichols, D. M., et al. (2019). Reactor Pulse Tracking using Micro-Pocket Fission Detectors in Research Reactors. 2019 IEEE Nucl. Sci. Symp.

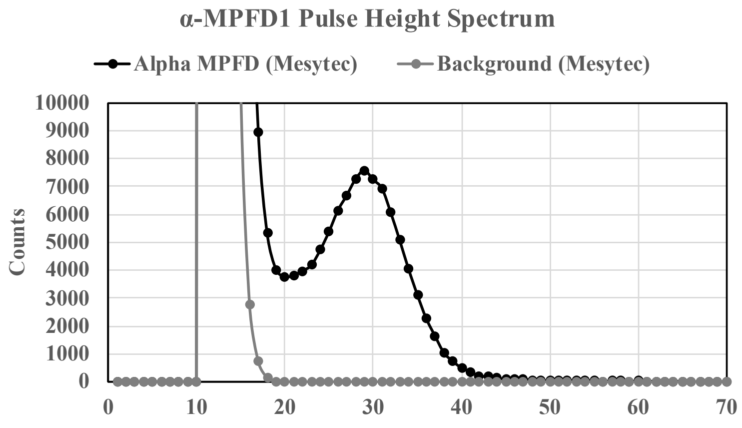
COMMERCIAL MPFD SPECIFICATIONS

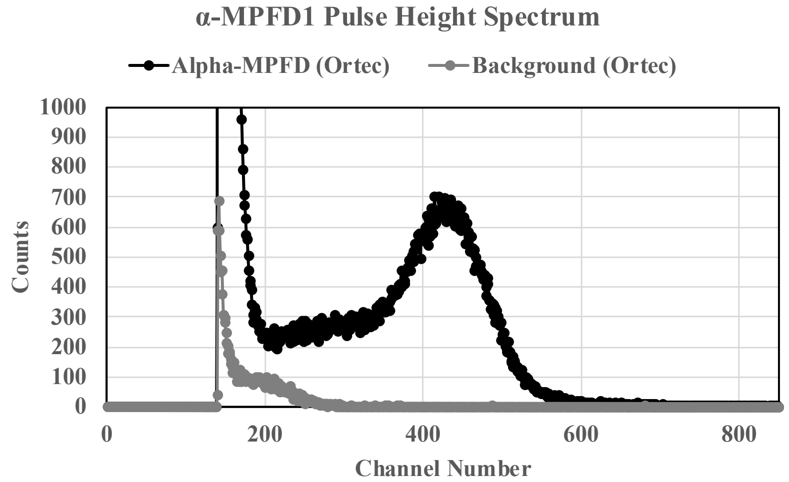
- Number of nodes – 1-4
- Chamber size: 0.5-3 mm^3
- Chamber Tube OD: 4.7 mm (3 mm possible)
- Detector Array Length (L1): up to ~2-3 m
- MIC OD: 3.18 mm
- MIC Length: ~10-15 m (researching upper limit)
- Fissile Coatings: U (up to 19% 235U), Th
- Temperature: Target up to 1000°C
- Flux: Proven 10^8, target 10^{16}
- Total Fluence <5% response change: Target 10^{22}
- Pulse and Current mode operation
- Signal Processing Electronics – COTS, e.g. Instrumentation Technologies, Mesytec, Ortec, etc.

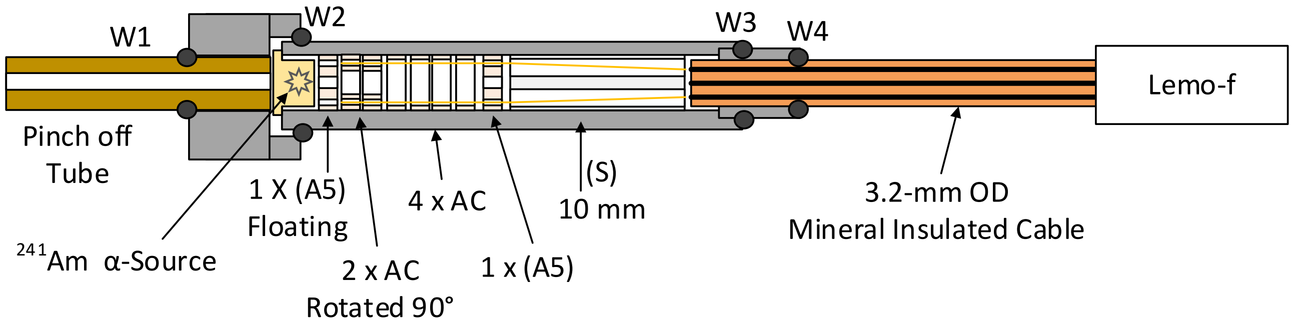


COMMERCIALIZATION PROGRESS

- Redesign for reliability and manufacturability
- Tailorable on per customer basis
- DOE SBIR Phase I (2022-2023): Subcomponent Redesign
- Chamber Redesign, Batch electroplating, Pinch-off tube integration
- SBIR Phase II (Aug 2023): Not awarded
- DOE 2025 Fast Track Phase I-II: Selected for funding/awaiting contract







NEXT STEPS & MARVEL

2026: SBIR restart alongside prototype development, testing, and demonstration

Importance of MARVEL opportunity

Our goal is to demonstrate MPFDs ability to:

- Provide real-time neutron flux monitoring during startup, ramp-up, steady-state, and transient operations.
- Support distributed in-core measurements that enable better understanding of power distribution and reactor kinetics in a microreactor environment.
- Demonstrate survivability and robustness of MPFD designs in an operating microreactor, establishing confidence for broader deployment in DOE-sponsored microreactor and commercial initiatives.

MARVEL EXPERIMENTS

- 2-6 MPFD arrays each with 4 detector nodes

- Target initial measurements/demonstrations dry-criticality when MPFDs can be positioned in-core
  - Expect to demonstrate pulse mode operation (0.1-1,000 cps)
  - Working alongside INL's ASI group to validate and compare MPFD measurements with co-located SPNDs and/or activation wires.
  - Collection of long-term operational data to evaluate detector signal stability under continuous irradiation.

- Second set of measurements performed after coolant loaded, full power
  - MPFDs relocated to core-adjacent position.
  - MPFDs located near heaters to demonstrate higher temperature operation.
  - Demonstrate pulse mode operation and current mode operation.

MARVEL GOALS

- Evaluate MPFD performance in a first-of-its kind microreactor environment
- Demonstrate MPFDs ability to provide higher fidelity performance/operational data to reactor scientist and engineers
- Demonstrate addition of MPFDs to the sensors and instrumentation toolbox that can help usher in a new-era of nuclear energy in the United States

PLEASE CONTACT US

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