U.S. DEPARTMENT OF ENERGY | Nuclear Energy

Office Of Nuclear Energy
Sensors and Instrumentation
Annual Review Meeting

Micro-Pocket Fission Detectors (MPFD)

Troy Unruh
Idaho National Laboratory

September 16-18, 2014

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Project Overview

Goal, and Objectives

- Develop, fabricate, and evaluate the performance of prototype, high temperature, compact, multi-purpose, fast and thermal fission chambers with integral temperature sensors

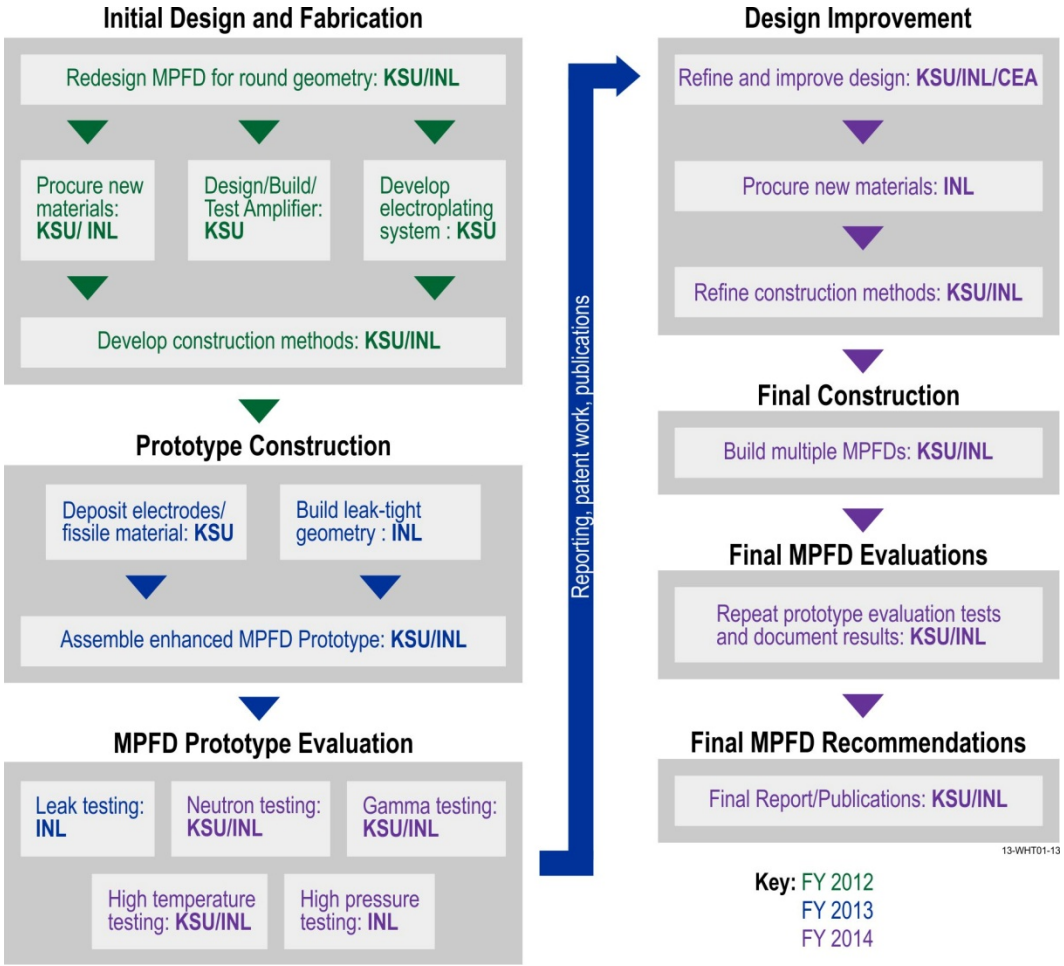
Participants

- Troy Unruh and Joy Rempe; Idaho National Laboratory
- Philip Ugorowski, Douglas McGregor, and Michael Reichenberger; Kansas State University
- Jean-François Villard; Commissariate a l'energie atomique

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Project Overview

Schedule

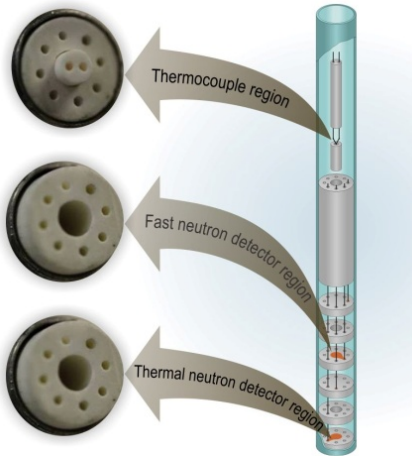


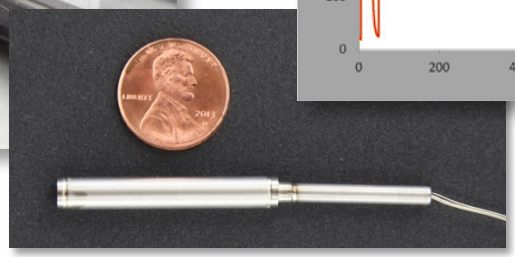
U.S. DEPARTMENT OF ENERGY
Nuclear Energy

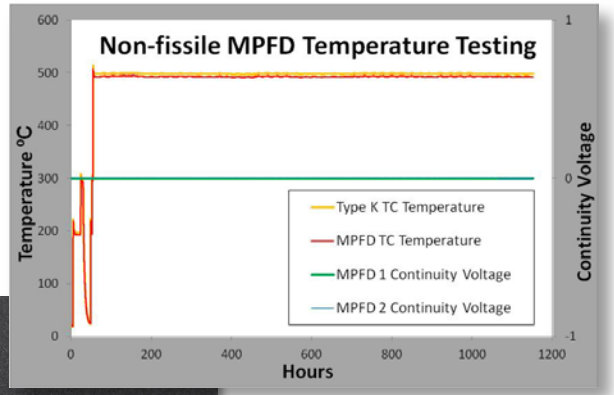
Accomplishments

FY14 Milestones, Deliverables and Outcomes

- Refined MPFD design
- Successfully completed enhanced MPFD for leak-tightness evaluations
- Successfully completed enhanced MPFD long duration performance in high temperature furnaces
- Successfully completed enhanced MPFD evaluations at KSU TRIGA reactor



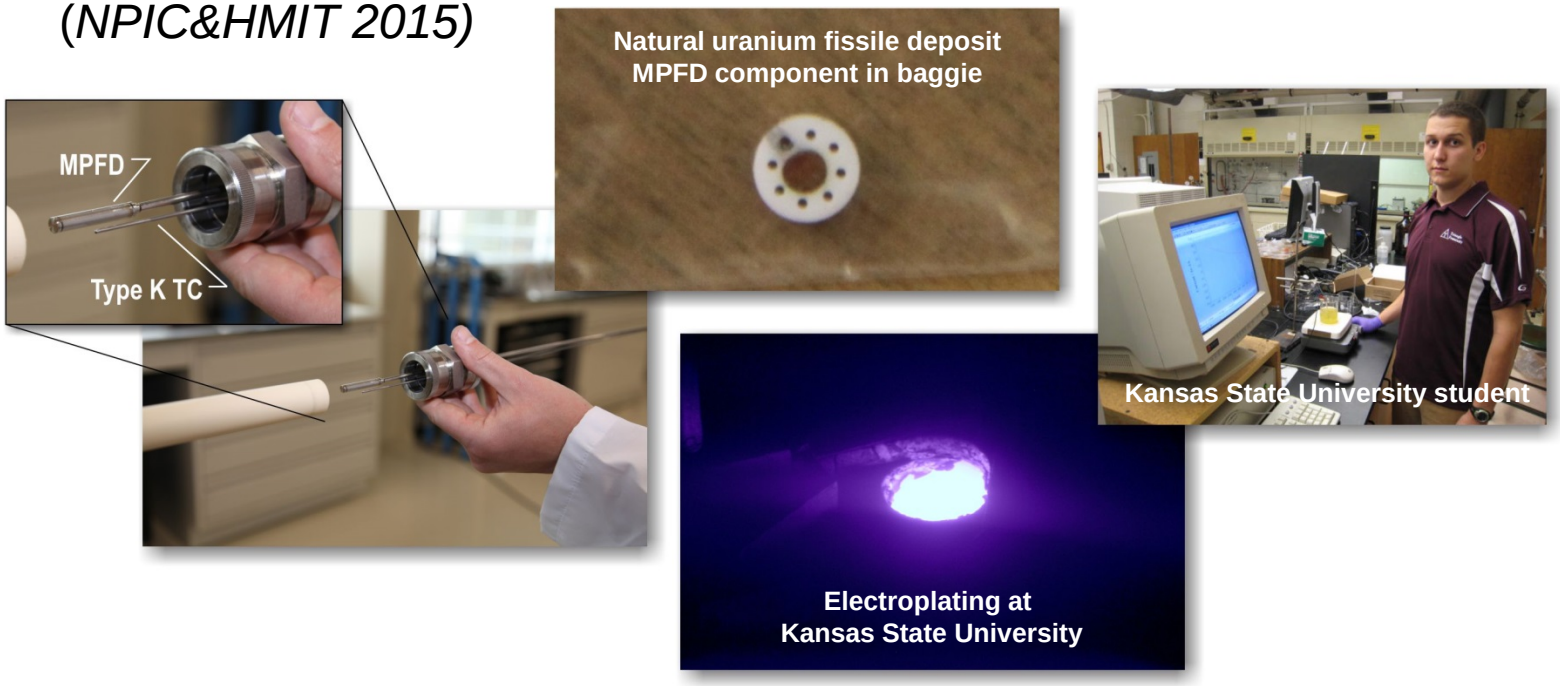




U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Accomplishments

- **FY14 Milestones, Deliverables and Outcomes (cont.)**
  - Issued final program report, INL/EXT-14-33026 "**NEET Micro-Pocket Fission Detector- Final Project Report** "
  - Conference Publication, "Enhanced Micro Pocket Fission Detector Evaluations", for *9th International Topical Meeting on Nuclear Plant Instrumentation, Control, and Human Machine Interface Technologies* (*NPIC&HMIT 2015*)



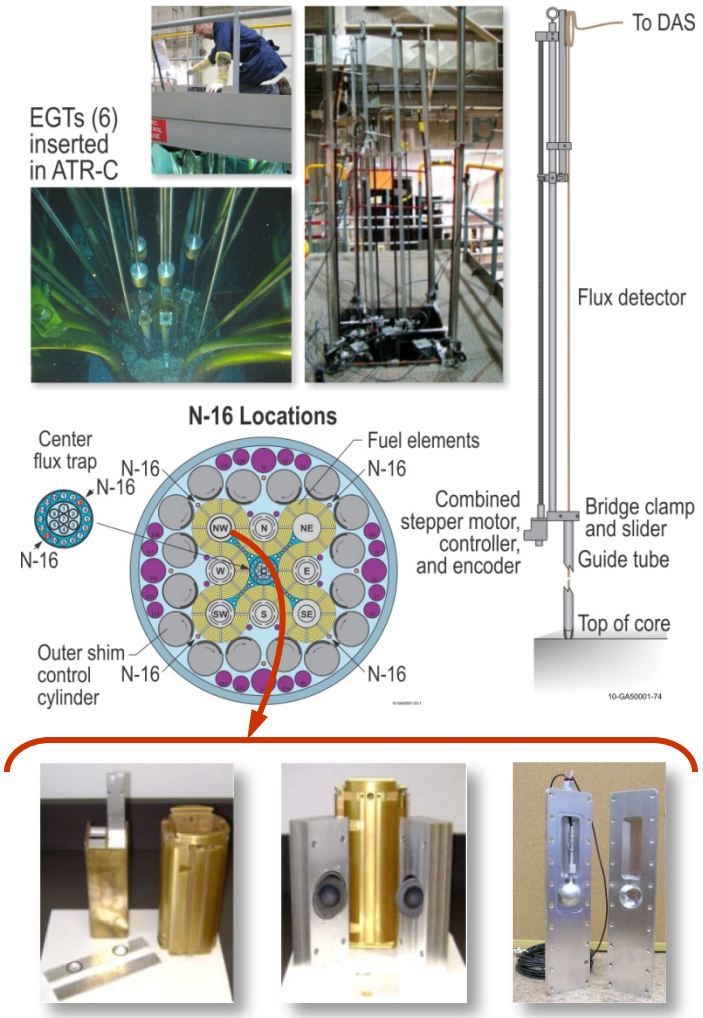
U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Technology Impact

- **Collected list of customer requirements through interactions with cognizant leads in NGNP, ARC, SMR, LWRS, FCRD, TREAT restart, and ATR NSUF programs**
  - Neutron sensitive (BOTH fast and thermal)
  - Temperature sensitive with integral high-temperature thermocouple
  - Compact size
  - Radiation resistant
  - High temperature and pressure compatibility using appropriate materials
  - High accuracy, high resolution
  - Flexibility (variable sensitivities, lifetimes and detector responses)
  - Fast response
  - Long lifetime
- **State-of-the-art sensor positions U.S. for leadership in irradiation testing**
  - Minimizes flux perturbation associated with typical real-time in-core sensors
  - Permits 3D modeling and triangulation of data for validation
  - Higher fidelity data for modeling and simulation of materials and fuels
  - Potential to increase US MTR customer base (DOE-NE, NR, industry, regulators, etc.)

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Technology Impact (Cont.)



FCRD

- Enables in-pile measurement of fast flux, thermal flux, and temperature in high temperature irradiation tests and in transient tests
- Multi-purpose sensors provide high accuracy data required for validating new multi-scale fuel models

ATR NSUF

- Enables in-pile measurement of fast flux, thermal flux, and temperature in high temperature ATR NSUF irradiations
- Provides US MTR users high accuracy, high temperature flux and temperature data
- Ideally suited for cross-calibrations using specialized fixturing from previous NSUF detector calibration project

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Technology Impact (Cont.)

NGNP

- Enables in-pile measurement of fast flux, thermal flux, and temperature in high temperature irradiation tests and on-line monitoring of conditions in first plant
- Multi-purpose sensors provide real-time data to validate model predictions during irradiation and during reactor operation
- Higher temperature version to be developed and evaluated in recently-awarded NEET project.

LWRS / Industry Programs

- Enables in-pile measurement of fast flux, thermal flux, and temperature in fuels and materials irradiation tests
- Multi-purpose sensors provide data required for demonstrating performance of accident tolerant fuels during irradiation testing during steady-state and transient conditions
- Multi-purpose sensors provide real-time data for characterizing conditions during materials irradiations.

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Technology Impact (Cont.)

- **TREAT Restart**
  - Enables in-pile measurement of fast flux, thermal flux, and temperature in irradiation tests
  - To be evaluated in recently-awarded TREAT Instrumentation IRP
  - Multi-purpose sensors provide data for validating new multi-scale models.
- **Advanced SMR**
  - Enables in-pile measurement of fast flux, thermal flux, and temperature in high temperature irradiation tests
  - Multi-purpose sensors provide high temperature real-time data to validate fuel and material properties during irradiation
  - Long lifetime sensor ideal for in-vessel operational measurements where vessel stays closed

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

Conclusions

- Three year Micro-Pocket Fission Detectors (MPFD) NEET project successfully completed all proposed work to develop a viable new sensor for simultaneous detection of thermal flux, fast flux, and temperature.
- Compact, multi-purpose advanced neutron detector is essential for high temperature, high pressure, high flux irradiations identified by LWRS, NGNP, ATR NSUF, FCRD, and Industry Programs
- Data from fast response, accurate, miniature neutron detector will be a critical tool for validating new high-fidelity multi-scale codes under development by DOE-NE